Netherlands Enterprise Agency

Geotechnical Report / Investigation Data

Geotechnical Borehole Locations
Borssele Wind Farm Site IV

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Netherlands Enterprise Agency (RVO.nl)
Croeselaan 15 | 3521 BJ | Utrecht
P.O. Box 8242 | 3503 RE| Utrecht
Netherlands

Det Norske Veritas, Danmark A/S
Energy
Technical
Tuborg Parkvej 8, 2nd Floor
DK2900 Hellerup
Denmark
Tel: +45 39 45 48 00
Fax: +45 39 45 48 01

Date:	**Our reference**:	**Your reference**:
2016-02-23	DNV Doc. No: 1KI2TUA-14Rev.2 Sign: MICWAG Corresp. No.:	

Zone Borssele Site Data – Preliminary Geotechnical Investigations

The following geotechnical reports produced by Fugro Engineers B.V. have been reviewed by DNV GL:

1. Geotechnical Report / Investigation Data / Geotechnical Borehole Locations / Wind Farm Site III / Borssele Wind Farm Zone / Dutch Sector, North Sea / Report No. N6083/01 Issue 4 / 10-02-2016
2. Geotechnical Report / Investigation Data / Seafloor In Situ Test Locations / Wind Farm Site III / Borssele Wind Farm Zone / Dutch Sector, North Sea / Report No. N6083/02 Issue 3 / 18-12-2015
3. Geotechnical Report / Investigation Data / Geotechnical Borehole Locations / Wind Farm Site IV / Borssele Wind Farm Zone / Dutch Sector, North Sea / Report No. N6083/03 Issue 4 / 10-02-2016
4. Geotechnical Report / Investigation Data / Seafloor In Situ Test Locations / Wind Farm Site IV / Borssele Wind Farm Zone / Dutch Sector, North Sea / Report No. N6083/04 Issue 3 / 18-12-2015

Comments to the documents listed above have been given in the referenced Verification Comments Sheets (Reference /A/ and /B/).
Please note that meanwhile document 1 and 3 were updated to issue 4. However, the verification documented with /A/ and /B/ is still valid.

DNV GL has found that the above referenced reports provide sufficient information to improve the understanding of the geotechnical and geological conditions in the given wind farm areas WFS III and WFS IV. The data in these reports can be used for establishing a Design Basis for Offshore Wind Turbine Structures in accordance with DNV-OS-J101. The chosen sites for the conducted investigations are sufficient to develop an illustration of lateral and vertical soil and seabed variations.

References:

/A/: Verification Comment Sheet "644235-VCS-10"
Revision 01, dated 25.01.2016
Doc-ID: 644235-VCS-10-rev02-Geotechnical_Investigations WFSIII

/B/: Verification Comment Sheet "644235-VCS-11"
Revision 01, dated 25.01.2016
Doc-ID: 644235-VCS-11-rev02-Geotechnical_Investigations WFSIV

Please note that detailed geotechnical investigations will need to be performed in correspondence to the final choice of foundations for the wind turbines in future design phases.

Sincerely
for Det Norske Veritas, Danmark A/S

Erik Asp Hansen
Principal Engineer

Mobile: +45 20 27 38 71
Direct: +45 39 45 48 71
Erik.Asp@dnvgl.com

Michael Wagner
Senior Engineer

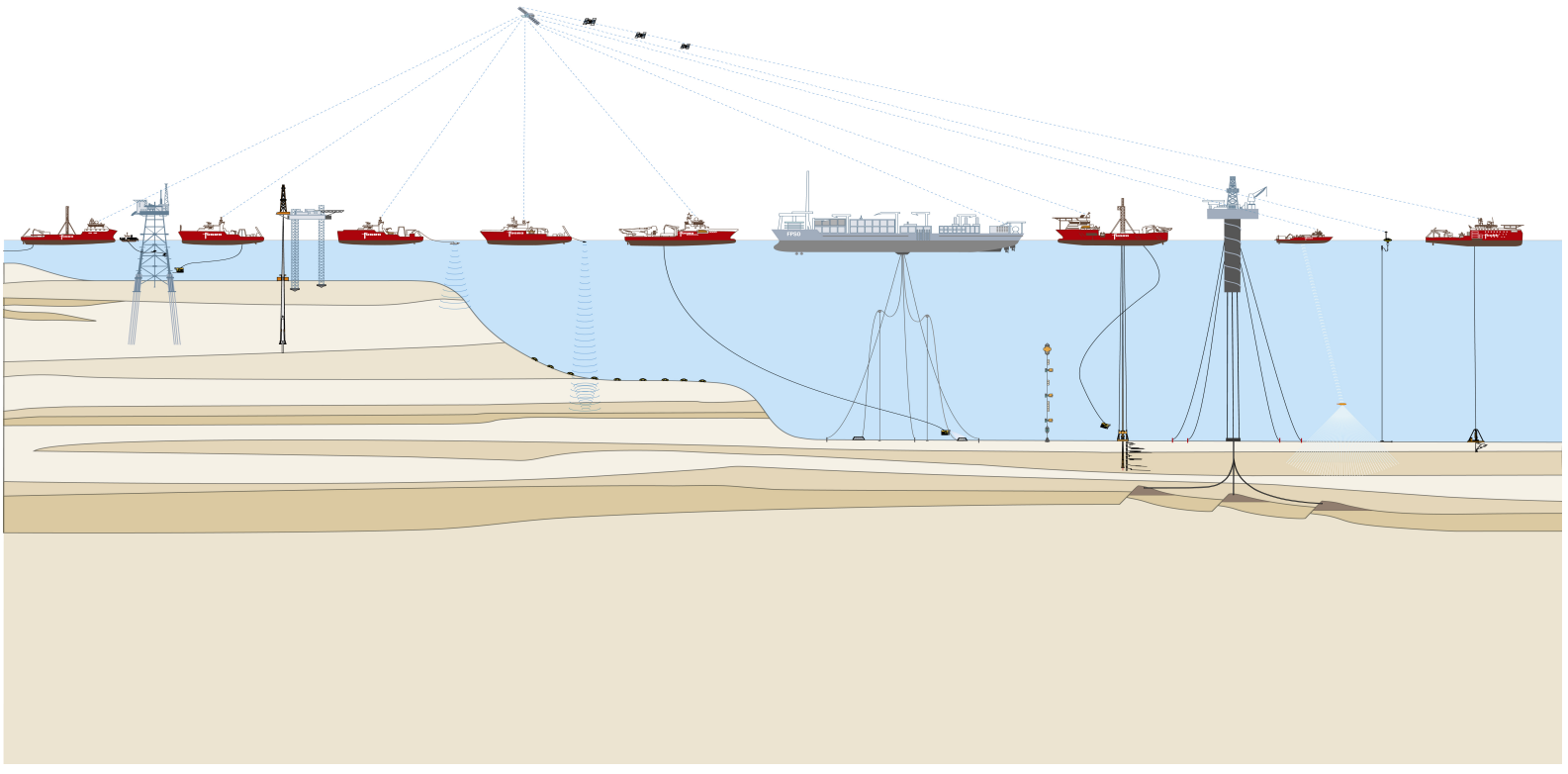
Direct: +49 40 36149 7914
Michael.Wagner@dnvgl.com

Geotechnical Report
Investigation Data
Geotechnical Borehole Locations
Wind Farm Site IV
Borssele Wind Farm Zone
Dutch Sector, North Sea

Client Reference No. WOZ1500010
Fugro Report No. N6083/03
Issue 4

Rijksdienst voor Ondernemend Nederland

Rijksdienst voor Ondernemend Nederland (RVO)



Geotechnical Report
Investigation Data
Geotechnical Borehole Locations
Wind Farm Site IV
Borssele Wind Farm Zone
Dutch Sector, North Sea

Client	Rijksdienst voor Ondernemend Nederland (RVO)
Client Address	Croeselaan 15 3521 BJ Utrecht The Netherlands
Client Reference No.	WOZ1500010
Fugro Report No.	**N6083/03 (4)**

Report Issue No.	Date	Report Status	Approved
4	10-Feb-2016	Revised Final	MKL
3	11-Dec-2015	Final	MKL
2	19-Nov-2015	Fugro approved draft	MKL
1	19-Oct-2015	Provisional data – Field report	-
0	Various	Provisional data – Individual logs and CPT data	-

Prismastraat 4
P.O. Box 130
2630 AC Nootdorp
The Netherlands
Phone: 31-70-3111444
E-Mail: febvinfo@fugro.nl

Rijksdienst voor Ondernemend Nederland (RVO)
Croeselaan 15
3521 BJ UTRECHT
The Netherlands

Attention: Mr R. de Bruijne

Our ref: N6083/03(4)/ESE/EMG

Nootdorp, 10 February 2016

Geotechnical Report – Investigation Data – Geotechnical Borehole Locations
Wind Farm Site IV – Borssele Wind Farm Zone – Dutch Sector, North Sea

This report presents geotechnical information. The report was prepared in accordance with Contract WOZ1500010 between Rijksdienst voor Ondernemend Nederland (RVO) and Fugro Engineers B.V., dated 8 September 2015.

The principal team members for report preparation were Mr J. Marçal Liça, Mr H. Lohman and Ms L. Both (Geotechnical Engineers). We acknowledge the valuable assistance of Mr R. de Bruijne, who acted as Client contact for this project.

Thank you for the opportunity to be of service. Please do not hesitate to contact us if you require any additional information.

Yours faithfully
FUGRO ENGINEERS B.V.

E. Schoute
Senior Project Engineer

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REPORT ISSUE CONTROL

Section	Page No.	Plate No.	Issue No.	Revision
Section C1	-	C1-7	4	Corrections to compression parameters C_c, C_s, CR and RR in Oedometer Summary Table
Summary/ Samenvatting	All	-	3	Editorial corrections and additions
Main Text	1, 5, 6, 8	-	3	Editorial corrections and additions; Clark & Walker reference added
Plates following Main Text	-	2-1	3	Geodetic parameters updated
Section A	All	-	3	Editorial corrections and additions, data format (AGS) added including literature references; Clark & Walker reference added including literature reference
Section A	-	All	3	Updates and corrections to strata descriptions and layer boundaries; laboratory test results added; CPT-derived data updated
Section B1	All	-	3	Unit weight selection comment added; editorial corrections and additions; data format (ASCII) added including literature references
Section B1	-	Various	3	Plates "Cone Penetration Test; q_t, q_n, R_f and B_q" and "Parameter Values for Net Cone Resistance Calculation" updated with different unit weight value selections
Section B3	B3-1	-	3	Editorial corrections and additions
Section C	ToC	-	3	Section C5 and C6 added to Table of Contents for Section C
Section C1	All	-	3	Editorial corrections and additions to text and Table C1.1; data format (AGS) added including literature reference; editorial corrections and additions Comment about CRS oedometer test added; literature reference for BS 1377:Part 8 added
Section C1	-	Various	3	Editorial corrections and additions of test results to Summary Tables
Section C2.1	-	Various	3	Organic content description corrected
Section C2.3	-	C2.3-1	3	Literature reference to BS 5930:1999 corrected
Section C4.2	-	Various	3	CIU triaxial test results added
Section C6.2	-	Various	3	Constant rate of strain oedometer test results added
Appendix 2	All	All	3	Positioning Report added
Appendix 3	All	All	3	Recovery Lists added
Appendix 4	All	All	3	Calibration Certificates added

Notes:

1) The definitive copy of this report is held in Fugro's information system
2) Report distribution is restricted to project participants approved by the Client
3) The *report* issue number is the same as the highest issue number of any individual page
4) Pages of this report are at Issue 2, except those pages listed above
5) The number at the bottom left-hand corner of each page shows the Fugro report number and page issue number. The number in brackets indicates the issue number of the page

QUALITY MANAGEMENT RECORD

Project Lead: W. Sotthewes/E. Schoute - Senior Project Engineer

Report Review and Approval: M. Klein – Principal Geotechnical Engineer

Report Section	Prepared By	Checked By
Main Text	JLI	ESE
Plates following Main Text	LHT	ESE
A Geotechnical Logs	JLI/LBH	BBK
B In Situ Test Results		
– Cone Penetration Tests	JLI/LBH	WSO
– Seismic Cone Penetration Tests	HLM/JLI	JTE
– Pore Pressure Dissipation Tests	LBH	WSO
C Geotechnical Laboratory Test Results		
– Laboratory Testing Overview	HLM/JLI	ESE
– Index Laboratory Tests	HLM/JLI	ESE
– Sample Photographs	HLM/SS	ESE
– Triaxial Tests	HLM	ESE
– Ring Shear Tests	HLM	ESE
– Oedometer Tests	HLM	ESE

Person(s):

BBK: B. Klosowska
ESE: E. Schoute
HLM: H. Lohman
JLI: J. Marçal Liça
JTE: J. Terwindt
LBH: L. Both
LHT: L. van der Horst
SS: S. Soekhoe
WSO: W. Sotthewes

SUMMARY

The Dutch Government has developed a systematic framework under which offshore wind farm zones are designated. Within the designated wind farm zones the government decides the specific sites where wind farms can be constructed. Site development will be tendered. Winners of these site development tenders will be granted a permit to build a wind farm, a SDE+ grant, and will be offered a grid connection to the main land. The Ministry of Economic Affairs provides site data, which can be used for the preparation of bids for these tenders. This system is expected to contribute to cost savings. As part of the tender preparations, the Netherlands Enterprise Agency (RVO), henceforth referred to as 'Client', has requested Fugro to perform a geotechnical investigation of Wind Farm Site WFS III & IV of the Borssele Wind Farm Zone (WFZ). The Borssele Wind Farm Zone is located in the Dutch Sector of the North Sea, approximately 36 km from the coastline (refer to "Vicinity Map" on Page v and "Detailed Location Plan" on Page vi).

The objective of the geotechnical investigation and associated laboratory testing programme for WFS III and WFS IV is to:

- Improve the geological and geotechnical understanding;
- Update an earlier geological and geophysical model;
- Provide a detailed geological ground model;
- Determine the vertical and lateral variation in seabed conditions;
- Provide relevant geotechnical data to progress the design of windfarm foundation elements, including, but not limited to foundations and cables.

The offshore phase of the geotechnical investigation includes geotechnical borehole drilling with downhole sampling and in situ testing, seafloor in situ testing and geotechnical laboratory testing. An office programme of geotechnical laboratory testing and reporting of results followed the offshore phase.

This report is one of a set of Fugro reports. This particular report provides geotechnical results for WFS IV and comprises the following:

- Geotechnical logs for boreholes at seven locations which include results from downhole sampling and cone penetration testing;
- Geotechnical logs for additional boreholes at two of the seven locations and for boreholes at two other locations which include interpreted results from downhole cone penetration testing;
- Results of downhole cone penetration testing from all boreholes at these nine locations;
- Results of downhole seismic cone penetration testing at two of the nine locations;
- Results of downhole pore pressure dissipation testing at one of the nine locations;
- Results of geotechnical laboratory tests on a selection of samples.

The offshore phase of the geotechnical investigation which included the geotechnical borehole drilling was conducted from the geotechnical drilling vessel Gargano between 13 September 2015 and 11 October 2015. The water depths at the investigated locations ranged from approximately 28 m to 36 m reduced to Lowest Astronomical Tide (LAT). This report is one in a series of reports prepared as part of this project (refer to "List of Project Reports" on Page vii). Two companion reports for WFS IV contain results of seafloor in situ tests carried out at five of the borehole locations plus another nineteen locations without boreholes, and describe a geological ground model for site WFS IV including geological setting, stratigraphy, lateral variability, geohazards and basic geotechnical parameter values respectively.

SAMENVATTING

De Nederlandse overheid heeft een systematisch kader ontwikkeld waarin zones voor windparken op zee zijn aangewezen. De overheid bepaalt in welke specifieke gebieden binnen deze aangewezen zones windparken kunnen worden aangelegd. Ontwikkeling van de gebieden zal volgens subsidie- en vergunningstenders worden gegund. Winnaars van deze tenders zullen een vergunning ontvangen voor de bouw en exploitatie van een windpark, een SDE+ subsidie, en kunnen gebruik maken van een verbinding naar het elektriciteitsnet op het vaste land. Het Ministerie van Economische Zaken stelt locatiegegevens beschikbaar welke gebruikt kunnen worden bij het opstellen van biedingen voor de subsidie- en vergunningstenders. Dit systeem zal naar verwachting bijdragen aan kostenreductie. T.b.v. de voorbereiding van de inschrijvingen heeft de Rijksdienst Voor Ondernemend Nederland (RVO) Fugro gecontracteerd voor een geotechnisch onderzoek in de kavels WFS III & IV van windgebied Borssele (WFZ). Het windgebied Borssele ligt in het Nederlandse deel van de Noordzee, ongeveer 36 km voor de kust (zie “Vicinity Map” op Page v en “Detailed Location Plan” op Page vi).

Het doel van het geotechnisch onderzoek en bijbehorend programma van laboratoriumproeven is om:

- Inzicht te verkrijgen in de geologische en geotechnische omstandigheden;
- Het bestaande geofysische en geologische model te verfijnen;
- Een gedetailleerd geologisch grondmodel te genereren;
- De verticale en laterale variabiliteit van de grond te bepalen;
- Relevante geotechnische data voor de ontwikkeling van het ontwerp van windpark funderingsconstructies beschikbaar te stellen, inclusief maar niet gelimiteerd tot funderingen en kabels.

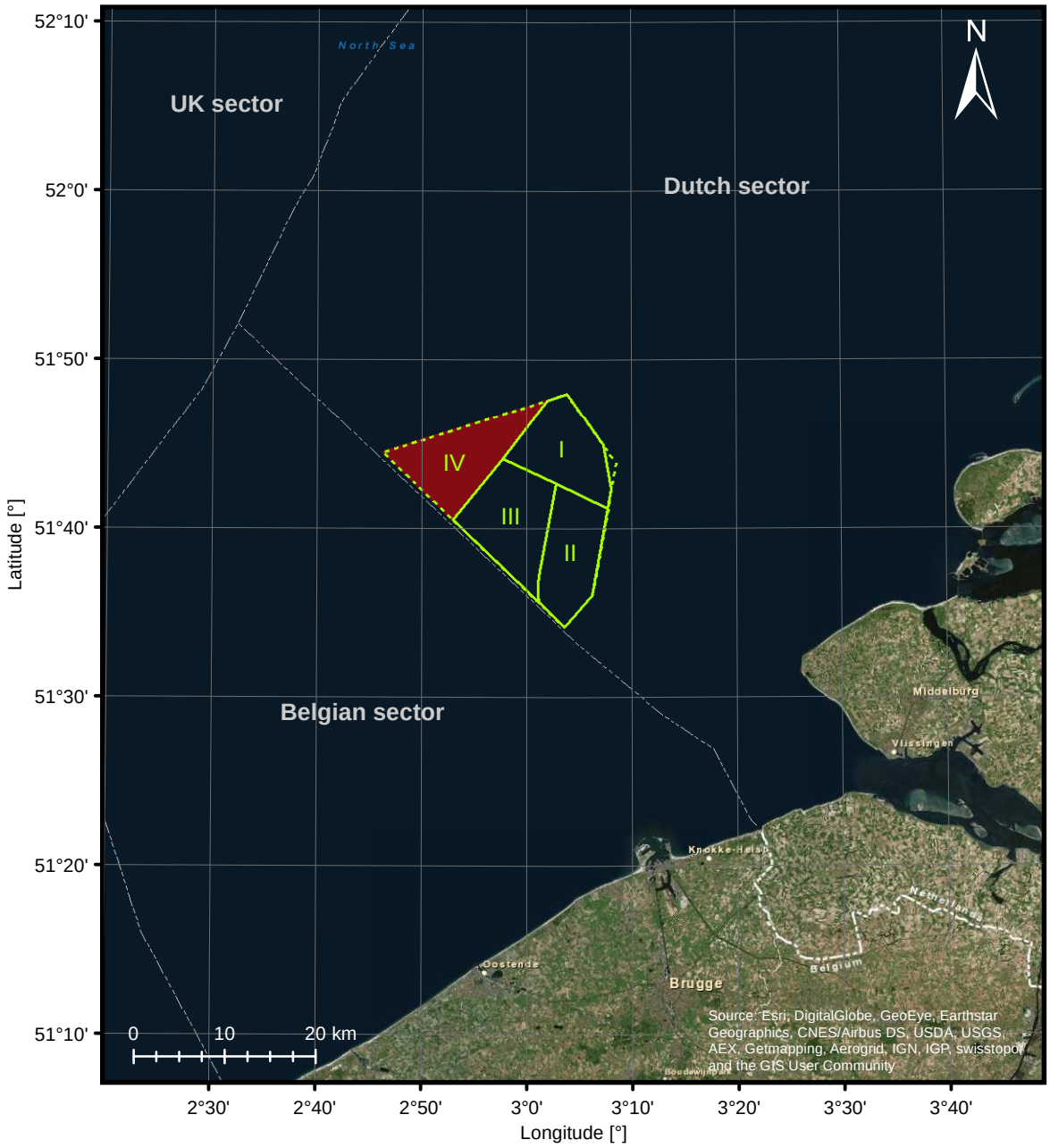
Het geotechnisch onderzoek op de boorgat locatie bestond uit geotechnische boorgaten met monsternames en in situ testen, sonderingen vanaf de zeebodem en geotechnische laboratoriumproeven. Vervolgens zijn op kantoor een geotechnisch laboratorium testprogramma en rapportage van de resultaten uitgevoerd.

Dit rapport maakt deel uit van een serie van Fugro rapporten. Dit rapport bevat resultaten van geotechnisch onderzoek voor WFS IV en omvat het volgende:

- Geotechnische boorstaten voor boorgaten op zeven locaties met resultaten van monstername en sonderingen uitgevoerd in het boorgat;
- Geotechnische boorstaten voor additionele boorgaten op twee van de zeven locaties en nog twee additionele boorgaten met geïnterpreteerde resultaten van sonderingen uitgevoerd in het boorgat;
- Resultaten van sonderingen, uitgevoerd in het boorgat, op deze negen locaties;
- Resultaten van seismische sonderingen, uitgevoerd in het boorgat, op twee van de negen locaties;
- Resultaten van een dissipatietest, uitgevoerd in het boorgat, op één van de negen locatie;
- Resultaten van geotechnische laboratoriumproeven op een selectie van monsters.

Het geotechnisch onderzoek op de boorgat locatie is vanaf het geotechnisch boorschip Gargano uitgevoerd tussen 13 september en 11 oktober 2015. De waterdiepte op de testlocaties varieerde van ongeveer 28 m tot 36 m beneden het laagste astronomische getij (LAT).

Dit rapport maakt deel uit van een serie van rapporten t.b.v. dit project (zie “List of Project Reports” op Page vii). Twee andere rapporten die WFS IV behandelen bevatten respectievelijk: de resultaten van de in situ testlocaties vanaf de zeebodem, en een geologisch grondmodel voor WFS IV voorzien van informatie over het geologisch kader, stratigrafie, laterale variabiliteit geo-risico’s, en algemene geotechnische parameters.



Investigation Area IV (subject of this report)

Outline of Borssele Wind Farm Zone

Outline Borssele Investigation Area (Roman numeral indicates area number)

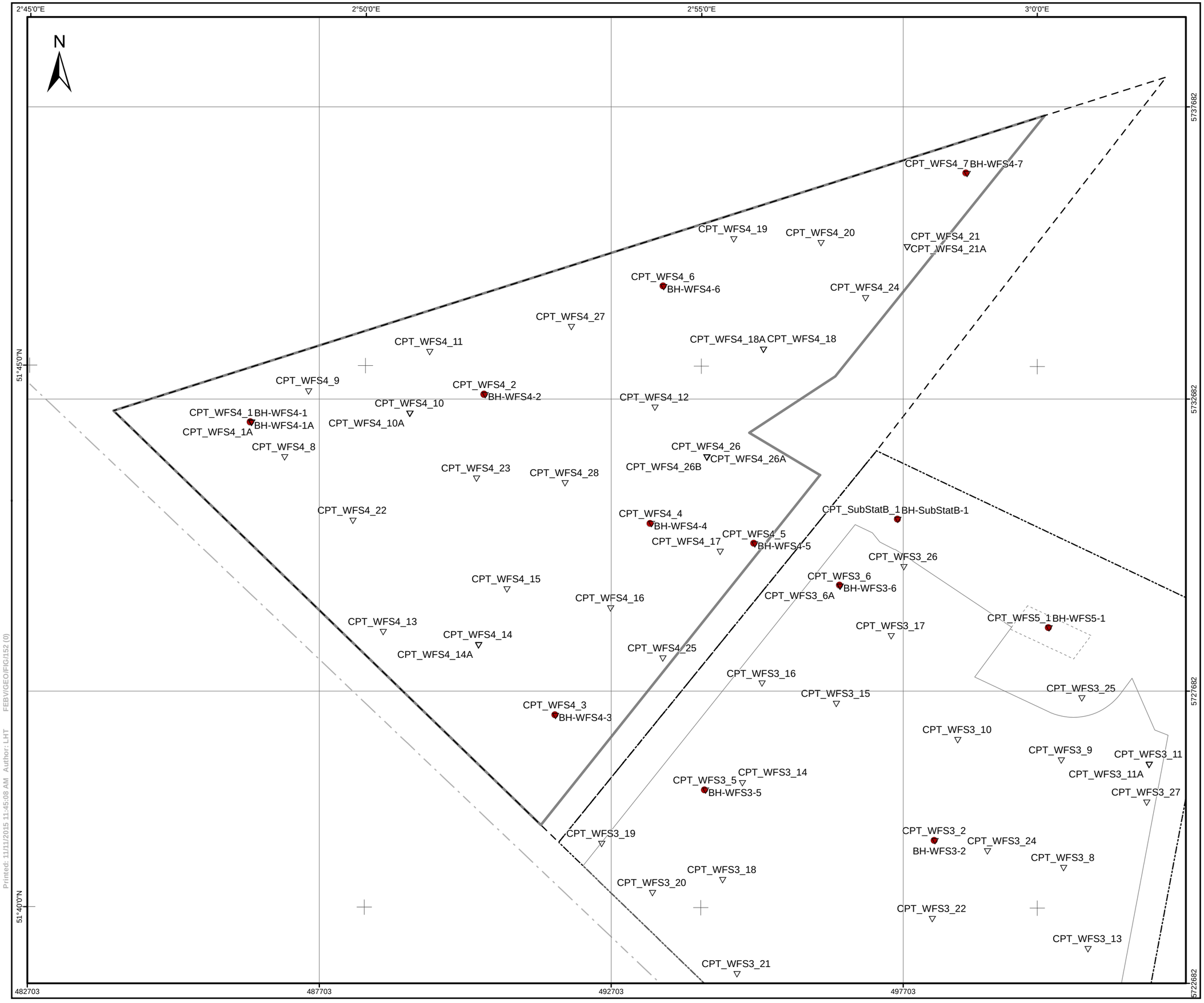
Maritime Boundary

Ellipsoid: GRS 1980
Datum: ETRS 1989

Printed: 10/13/2015 8:56:56 AM

VICINITY MAP

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Printed: 11/11/2015 11:45:08 AM Author: LHT FEBV/GEO/FIG/152 (0)

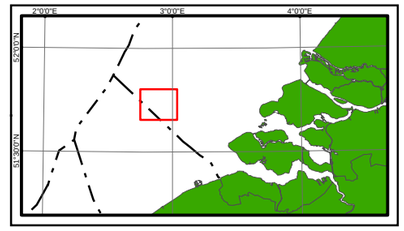
LEGEND:

- CPT location
- BH location
- Outline of WFS III
- Outline of WFS V
- Investigation Area IV
- Investigation Area III
- Outline of WFS IV
- Maritime Boundary

NOTES:

GEODETIC PARAMETERS:

DATUM	ETRS89
Ellipsoid	GRS80
Semi major axis	a = 6 378 137.000
Inverse flattening	1/f = 298.257222101
PROJECTION	UTM, Zone 31 North
Central Meridian (CM)	3° 00' 00" E
Latitude of Origin	0° 00' 00" N
False Easting	500 000 m
False Northing	000 000 m
Scale factor	0.9996
Units	metres/degrees



Rijksdienst voor Ondernemend Nederland (RVO)
Croeselaan 15, 3521 BJ, Utrecht - THE NETHERLANDS

Fugro
Prismastraat 4, 2631 RT, Nootdorp - THE NETHERLANDS

DETAILED LOCATION PLAN

BORSSELE WIND FARM ZONE, WFS IV
DUTCH SECTOR, NORTH SEA

Scale 1:60,000
at original A3 page size

0 500 1,000 1,500 2,000 metres

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Report Number	Title	Contents
N6083/01	Geotechnical Report - Investigation Data - Geotechnical Borehole Locations Wind Farm Site III Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including geotechnical logs, results from downhole (seismic) cone penetration tests, pore pressure dissipation tests and results from geotechnical laboratory tests.
N6083/02	Geotechnical Report - Investigation Data - Seafloor In Situ Test Locations Wind Farm Site III Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including interpreted geotechnical logs, results from seafloor cone penetration tests and pore pressure dissipation tests.
N6083/03	Geotechnical Report - Investigation Data - Geotechnical Borehole Locations Wind Farm Site IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including geotechnical logs, results from downhole (seismic) cone penetration tests, pore pressure dissipation tests and results from geotechnical laboratory tests.
N6083/04	Geotechnical Report - Investigation Data - Seafloor In Situ Test Locations Wind Farm Site IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including interpreted geotechnical logs, results from seafloor cone penetration tests and pore pressure dissipation tests.
N6083/05	Geological Ground Model Wind Farm Site III Borssele Wind Farm Zone - Dutch Sector, North Sea	Geological ground model including, stratigraphy, lateral soil variability, geohazards, basic geotechnical parameter values and assessment of geotechnical suitability of selected types of structures.
N6083/06	Geological Ground Model Wind Farm Site IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Geological ground model including, stratigraphy, lateral soil variability, geohazards, basic geotechnical parameter values and assessment of geotechnical suitability of selected types of structures.
N6083/07	Geotechnical Report - Laboratory Test Data Wind Farm Sites III & IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Results of advanced static and cyclic laboratory tests and microscopic analysis.

ISSUE 04

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LIST OF FUGRO REPORTS
BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

1. INTRODUCTION

1.1 Purpose of Report

The Dutch Government has developed a systematic framework under which offshore wind farm zones are designated. Within the designated wind farm zones the government decides the specific sites where wind farms can be constructed. Site development will be tendered. Winners of these site development tenders will be granted a permit to build a wind farm, a SDE+ grant, and will be offered a grid connection to the main land. The Ministry of Economic Affairs provides site data, which can be used for the preparation of bids for these tenders. This system is expected to contribute to cost savings.

As part of the tender preparations, the Netherlands Enterprise Agency (RVO), henceforth referred to as 'Client', has requested Fugro to perform a geotechnical investigation of Wind Farm Site WFS III & IV of the Borssele Wind Farm Zone (WFZ). The Borssele Wind Farm Zone is located in the Dutch Sector of the North Sea, approximately 36 km from the coastline (refer to "Vicinity Map" on Plate 1-1 and "Detailed Location Plan" on Plate 1-2).

The objective of the geotechnical investigation and associated laboratory testing programme for WFS III and WFS IV is to:

- Improve the geological and geotechnical understanding;
- Update an earlier geological and geophysical model;
- Provide a detailed geological ground model;
- Determine the vertical and lateral variation in seabed conditions;
- Provide relevant geotechnical data to progress the design of windfarm foundation elements, including, but not limited to foundations and cables.

The offshore phase of the geotechnical investigation includes geotechnical borehole drilling with downhole sampling and in situ testing, seafloor in situ testing and geotechnical laboratory testing. An office programme of geotechnical laboratory testing and reporting of results followed the offshore phase.

1.2 Scope of Report

This report is one of a set of Fugro reports. This particular report provides geotechnical results for WFS IV and comprises the following:

- Geotechnical logs for boreholes at seven locations which include results from downhole sampling and cone penetration testing;
- Geotechnical logs for additional boreholes at two of the seven locations and for boreholes at two other locations which include interpreted results of downhole Cone Penetration Tests (CPT);
- Results of downhole cone penetration testing from all boreholes at these nine locations;
- Results of downhole seismic cone penetration testing at two of the nine locations;
- Results of downhole pore pressure dissipation testing at one of the nine locations;
- Results of geotechnical laboratory tests on a selection of samples.

The term 'location' used in this report refers to a specified target location. A location can consist of (a) single or multiple borehole(s), whereby the term 'borehole' is defined as a downhole sampling and/or testing operation. Boreholes designated with a suffix A refer to additional operations at a specific location. For instance, BH-WFS4-1A is an additional borehole at location WFS4-1, performed after borehole BH-WFS4-1 was terminated (refer to Section A for details). The term 'test point' refers to an individual seafloor CPT (results presented in a companion report, see Plate 1-3).

Results presented in this report are for an area demarcated as Investigation Area IV (Plates 1-1 and 1-2). WFS IV is within this area. The boundaries of WFS IV may be subject to change within Investigation Area IV.

1.3 Project Responsibilities and Use of Report

This report presents information according to a project specification determined and monitored by the Client. Particularly, the Client approved test locations and depths, monitored and approved data acquisition and supplied information for geotechnical project use.

This report must be read in conjunction with "Guide for Use of Report", Section D.

Fugro understands that this report will be used for the purpose described in this "Introduction" section. That purpose was a significant factor in determining the scope and level of the services. Results must not be used if the purpose for which the report was prepared or the Client's proposed development or activity changes. Results may possibly suit alternative use. Suitability must be verified.

1.4 Report Format

This report is one in a series of reports. Refer to Plate 1-3 for a list of Fugro reports prepared as part of this project. Two companion reports for WFS IV contain results of seafloor in situ tests carried out at five of the borehole locations plus another nineteen locations without boreholes, and describe a geological ground model for site WFS IV including geological setting, stratigraphy, lateral variability, geohazards and basic geotechnical parameter values respectively.

This report uses and summarises information from sources listed in Section 2. The reader should consult the source information for details. Understanding of site conditions improves upon further data acquisition and interpretation. This means that some of the source interpretations may be superseded by information presented in this report. Similarly, interpretations given in this report may require updating in the future.

The principal sections of this report are the Summary, Main Text, Plates following Main Text, and Sections A, B and C. Comments are as follows:

- The Summary section allows a quick-scan management overview. It includes a selection of plates. The selected plates are duplicates from a larger set of Plates following Main Text;
- Section 2 of the Main Text focuses on methodology;
- Sections A, B and C provide the principal information as described in Section 1.2 “Scope of Report”. These sections should be read in conjunction with the Plates following Main Text, where applicable;
- Each of the Sections A, B and C start with primary information, which may consist of links to Plates following Main Text. Plate numbering starts with a section number, e.g. Plate B1-1 belongs to Section B1;
- Section D and Appendix 1 provide general practice statements and terminology. This background information supports the Main Text. It will be familiar to expert users of the type of information presented in this report.

2. STUDY OVERVIEW

2.1 Sources of Information

This report uses and summarises selected information.

Inspection of Client-supplied information yielded the following:

- Boundaries and coordinates Wind Farm Zone Borssele (RVO, 2015a; Periplus, 2015);
- Geotechnical scope of work (RVO, 2015b);
- Geological desk study (CRUX, 2014);
- Results of a geophysical survey including: bathymetry, side scan sonar and magnetometer (Fugro, 2015);
- Results of 2D UHR multi-channel seismic (sparker) and sub-bottom profiling (pinger) surveys (Fugro, 2015).

Survey of documents held in the Fugro database provided additional information, including information about the regional geology and general geotechnical data.

2.2 Investigation Programme

2.2.1 Project-specific Data Acquisition

This report includes results from a project-specific geotechnical investigation. The Client planned the investigation programme. During the investigation, the Client's programme was adjusted to suit as-found conditions and operational constraints, such as minor deviations from target locations or changes in type of cone used. The scope of the report includes the results of the final programme.

The offshore part of the investigation which included the geotechnical borehole drilling was conducted from the geotechnical drilling vessel Gargano, between 13 September 2015 and 11 October 2015. The investigation included downhole sampling and in situ testing. Recovered samples were processed in the site laboratory. Samples were stored on-board in a temperature-controlled environment and transferred to shore for additional laboratory testing and storage.

The following sub-sections provide details.

2.2.2 Positioning Survey and Water Depth Measurement

The borehole locations are displayed on Plate 1-2. Coordinates and water depths at the borehole locations are presented on Plate 2-2. The coordinate reference system uses ETRS89 as datum with spheroid GRS80. The horizontal projection is Universal Transverse Mercator (UTM) with a Central Meridian of 3° East (Zone 31N), refer to Plate 2-1 for details.

Sub-surface positioning was performed using an Ultra Short Base Line (USBL) system with a transmitter mounted on the seabed frame. Sound velocity profiles were obtained by lowering a CTD-probe (measuring pressure, conductivity and temperature) to seafloor.

Lowest Astronomical Tide (LAT) and seafloor are used as vertical reference levels for water depth measurement and geotechnical sampling and testing.

Water depths were measured using:

- A pressure sensor, i.e. CTD-probe, mounted on the seabed frame;
- An echo sounder mounted on the hull of the vessel;
- The drill string by direct sounding when drilling was initiated.

Charted bathymetric data was used as a verification of the water depth measurements (Fugro, 2015). Bathymetric data is included on Plates 2-2 and 2-3.

The user of the geodetic information presented must consider the accuracy of measurements, particularly where use may differ from original intentions. For example, the presented water depth measurements serve to establish the penetration depth below seafloor (bsf).

2.2.3 Drilling, Sampling and In Situ Testing

The drilling, sampling and in situ testing programme included nine boreholes (including re-drills, i.e. additional boreholes) with alternate downhole sampling and cone penetration testing to depths ranging between approximately 7 m and 60 m below seafloor (bsf) performed at seven locations. Two Pore Pressure Dissipation Tests (PPDT) were performed at 8.9 m and 21.8 m bsf in borehole BH-WFS4-7. Additionally, seven boreholes with (semi-continuous) downhole cone penetration testing were carried out at four locations. Of these seven boreholes, three (i.e. CPT_WFS4_1, CPT_WFS4_21 and CPT_WFS4_21A) included seismic cone penetration tests (SCPT). The investigation depth and recovery for each location are presented in Table 2.1.

Table 2.1: Sample and Test Recoveries

Borehole Location	Penetration Depth[(1)] [m]	Sample Recovery [m]	In Situ Test Recovery [m]	Number of SCPTs Performed [-]	Sample and Test Recovery [%]
BH-WFS4-1	7.0	2.7	-	-	38
BH-WFS4-1A	51.9	15.7	22.8	-	82[(2)]
BH-WFS4-2	8.4	6.0	-	-	71
BH-WFS4-2A	52.2	10.8	25.3	-	81[(2)]
BH-WFS4-3	60.0	19.7	29.0	-	81
BH-WFS4-4	50.4	14.2	22.9	-	74
BH-WFS4-5	52.2	15.7	24.0	-	76
BH-WFS4-6	50.4	15.0	23.6	-	77
BH-WFS4-7	51.9	18.5	23.8	-	82
CPT_WFS4_1	40.9	-	38.5	9	94
CPT_WFS4_1A	51.9	-	11.7	-	98[(2)]
CPT_WFS4_7	49.9	-	46.4	-	93
CPT_WFS4_18	10.9	-	10.5	-	96
CPT_WFS4_18A	51.6	0.9[(3)]	36.7	-	90[(2)]
CPT_WFS4_21	2.0	-	2.0	1	100
CPT_WFS4_21A	51.1	-	41.7	10	85[(2)]

Notes: Values are rounded to nearest 0.1 m.
Key:
BH : Borehole which included downhole sampling and cone penetration testing
CPT : Borehole which included downhole cone penetration testing
SCPT : Seismic Cone Penetration Test
(1) : Penetration depth is the deepest point reached by either drilling, sampling or in situ testing
(2) : Drill out is excluded from Sample and Test Recovery calculation
(3) : Location not considered as alternate sample/CPT borehole location. Oversamples excluded from Sample and Test Recovery calculation

The employed drilling method was rotary drilling with direct circulation. Water and Pure-Bore based mud were used as drill fluids. Borehole drilling included the use of a seabed frame equipped with a SEACLAM system, for re-entry and axial and lateral support of the drill string at seafloor.

Push sampling and in situ testing employed a WIP Sampler and WISON® downhole tools. The sampler was fitted with flush stainless steel Shelby tubes. Downhole tools were operated and retrieved by a hydraulic-electrical umbilical system which provides real-time control of the in situ testing and sampling process. CPTs were performed using cone penetrometers with a 500 mm^2 and 1000 mm^2 cone tip area. The PPDTs were performed at selected depths during a CPT. SCPTs were performed using a double array cone. The seismic source consisted of a Hydraulic Underwater Shearwave Hammer (HUSH) box, consisting of a spring-driven steel mass hammered to a steel striking plate, mounted on the seabed frame.

Refer to Section A “Geotechnical Logs” and Section B “In Situ Test Results” for details and test results.

2.2.4 Sample Handling

Important stages in sample handling included:

- Measurement of sample recovery in tube;
- On-site sample extrusion, sample photography and geotechnical sample logging;
- On-site laboratory testing on selected sample sections;
- Sample packaging, labelling and storage in a temperature-controlled container on board;
- Sample offloading and transport to the Fugro geotechnical laboratory in Wallingford in the United Kingdom (UK).

Further details on sample handling are provided in Section C, “Geotechnical Laboratory Test Results”.

2.2.5 Laboratory Tests

On-site geotechnical laboratory testing included (where appropriate) visual soil classification and description of samples according to BS 5930 (BSI, 1999) and Clark & Walker (1977), sample photography, geotechnical index and index strength.

Office geotechnical laboratory testing included (where appropriate) geotechnical index, geochemical, (index) strength and compressibility.

Laboratory test results are provided in Section C, “Geotechnical Laboratory Test Results”, and summaries of selected test results are presented on the geotechnical logs in Section A.

2.3 Geotechnical Data Processing

Geotechnical data processing included:

- Preparation of geotechnical logs by interpreting and integrating sample descriptions, laboratory test results and CPT data, where applicable;
- Correlation of borehole and CPT data, where possible;
- Evaluation, basic verification where practicable and incorporation of selected information supplied by Client.

Further details on geotechnical data processing are described in Section A “Geotechnical Logs”, Section B “In Situ Test Results”, and Section C “Geotechnical Laboratory Test Results”, where appropriate.

3. REFERENCES

BSI British Standards Institution (1999), "Code of Practice for Site Investigations", British Standard BS 5930:1999.

Clark, A.R. and Walker, B.F. (1977). "A Proposed Scheme for the Classification and Nomenclature for Use in the Engineering Description of Middle Eastern Sedimentary Rocks", Géotechnique, Vol. 27, No. 1, pp. 94-99.

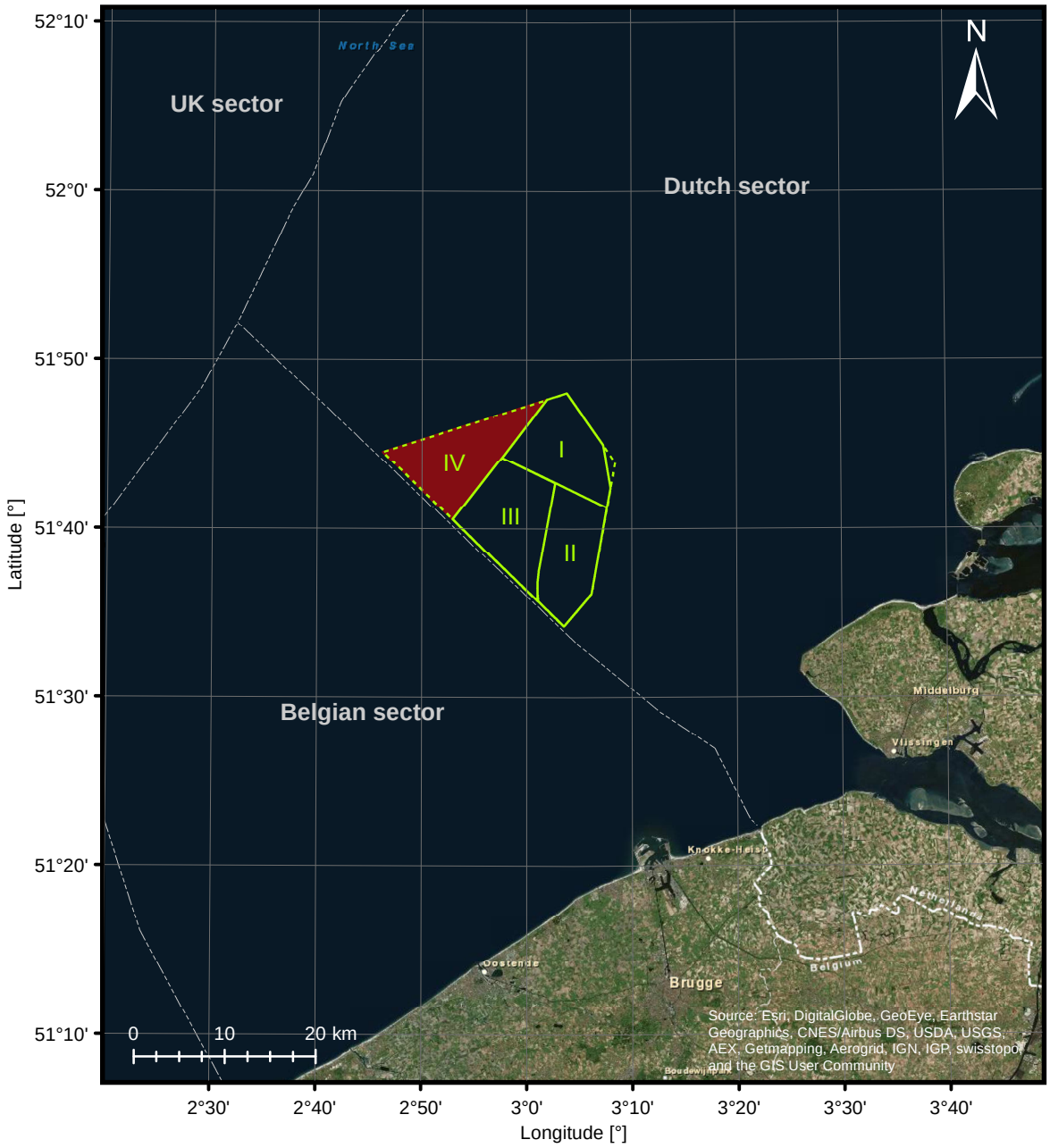
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Fugro (2015), “Geophysical Site Investigation Survey – Borssele Wind Farm Development Zone – Wind Farm Site IV”, Final Issue (Rev A), 14 August 2015.

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Rijksdienst voor Ondernemend Nederland (2015a), “Site Studies Wind Farm Zone Borssele – Boundaries & Coordinates Wind Farm Zone”, 23 July 2015.

Rijksdienst voor Ondernemend Nederland (2015b), “Soil Investigations Wind Farm Zones – Section IV-d. Scope of Work Geotechnical Survey - Borssele Wind Farm Zone - Wind Farm Site III & IV”, 8 September 2015.



Investigation Area IV (subject of this report)

Outline of Borssele Wind Farm Zone

Outline of Borssele Investigation Area (Roman numeral indicates area number)

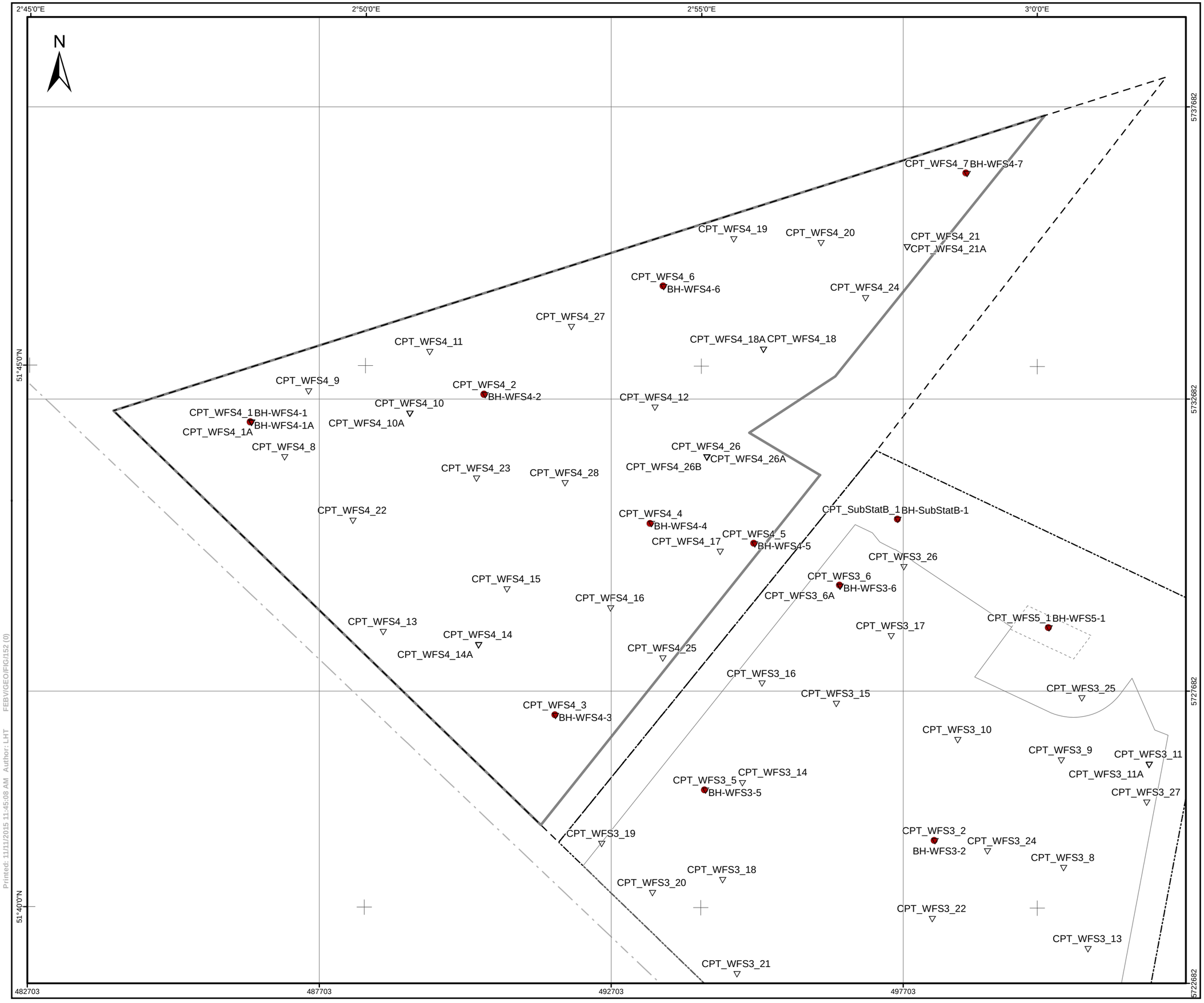
Maritime Boundary

Ellipsoid: GRS 1980
Datum: ETRS 1989

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VICINITY MAP

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



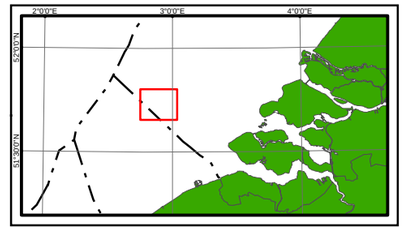
LEGEND:

- CPT location
- BH location
- Outline of WFS III
- Outline of WFS V
- Investigation Area IV
- Investigation Area III
- Outline of WFS IV
- Maritime Boundary

NOTES:

GEODETIC PARAMETERS:

DATUM	ETRS89
Ellipsoid	GRS80
Semi major axis	a = 6 378 137.000
Inverse flattening	1/f = 298.257222101
PROJECTION	UTM, Zone 31 North
Central Meridian (CM)	3° 00' 00" E
Latitude of Origin	0° 00' 00" N
False Easting	500 000 m
False Northing	000 000 m
Scale factor	0.9996
Units	metres/degrees



Rijksdienst voor Ondernemend Nederland (RVO)
Croeselaan 15, 3521 BJ, Utrecht - THE NETHERLANDS

Fugro
Prismastraat 4, 2631 RT, Nootdorp - THE NETHERLANDS

DETAILED LOCATION PLAN

BORSSELE WIND FARM ZONE, WFS IV
DUTCH SECTOR, NORTH SEA

Scale 1:60,000
at original A3 page size

0 500 1,000 1,500 2,000 metres

Fugro Report No. N6083/03	Issue 2	Plate 1-2

Printed: 11/11/2015 11:45:08 AM Author: LHT FEBV/GEO/FIG/152 (0)

Report Number	Title	Contents
N6083/01	Geotechnical Report - Investigation Data - Geotechnical Borehole Locations Wind Farm Site III Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including geotechnical logs, results from downhole (seismic) cone penetration tests, pore pressure dissipation tests and results from geotechnical laboratory tests.
N6083/02	Geotechnical Report - Investigation Data - Seafloor In Situ Test Locations Wind Farm Site III Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including interpreted geotechnical logs, results from seafloor cone penetration tests and pore pressure dissipation tests.
N6083/03	Geotechnical Report - Investigation Data - Geotechnical Borehole Locations Wind Farm Site IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including geotechnical logs, results from downhole (seismic) cone penetration tests, pore pressure dissipation tests and results from geotechnical laboratory tests.
N6083/04	Geotechnical Report - Investigation Data - Seafloor In Situ Test Locations Wind Farm Site IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Geotechnical data including interpreted geotechnical logs, results from seafloor cone penetration tests and pore pressure dissipation tests.
N6083/05	Geological Ground Model Wind Farm Site III Borssele Wind Farm Zone - Dutch Sector, North Sea	Geological ground model including, stratigraphy, lateral soil variability, geohazards, basic geotechnical parameter values and assessment of geotechnical suitability of selected types of structures.
N6083/06	Geological Ground Model Wind Farm Site IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Geological ground model including, stratigraphy, lateral soil variability, geohazards, basic geotechnical parameter values and assessment of geotechnical suitability of selected types of structures.
N6083/07	Geotechnical Report - Laboratory Test Data Wind Farm Sites III & IV Borssele Wind Farm Zone - Dutch Sector, North Sea	Results of advanced static and cyclic laboratory tests and microscopic analysis.

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FEBV/CDE/TAB/052

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LIST OF FUGRO REPORTS

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

DGPS Geodetic Parameters		
Datum		WGS84 (World Geodetic System 1984)
Spheroid		WGS84 (World Geodetic System 1984)
Semi-Major Axis, a		6378137.000 m
Inverse Flattening, 1/f		298.257223563
Transformation Parameters (from WGS84 to Local Grid for Epoch 2015.742465753 (28 September 2015))		
Source Shift		
dX		+0.05367 m
dY		+0.05087 m
dZ		- 0.08684 m
Rotation and Scale		
rX		- 0.002166“
rY		- 0.013104”
rZ		+0.021180”
dS (Scale Factor)		0.002599 ppm
Local Grid Geodetic Parameters		
Datum		ETRS89 (European Terrestrial Reference System 1989)
Ellipsoid		GRS80 (Geodetic Reference System 1980)
Semi-Major Axis, a		6378137.000 m
Inverse Flattening, 1/f		298.257222101
Local Projection Parameters		
Projection		Universal Transverse Mercator
UTM Zone		31 North
Central Meridian (CM)		03^{o} 00’ 00” E
Latitude of Origin		00^{o} 00’ 00” N
False Easting		500 000 m
False Northing		000 000
Scale Factor on CM		0.9996
Units		metres
Example Coordinates		
Local grid coordinates	Easting	503819.64 m
	Northing	5738442.18 m
Local geographical coordinates	Latitude	51^{o} 47’ 48.5644” N
	Longitude	03^{o} 03’ 19.3986” E
WGS84 geographical coordinates	Latitude	51^{o} 47’ 48.5803” N
	Longitude	03^{o} 03’ 19.4204” E

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GEODETIC PARAMETERS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

COORDINATES

Testing Point	Penetration Depth [m]	Easting [m]	Northing [m]	Latitude [deg]	Longitude [deg]
BH-WFS4-1	7.0	486525	5732292	51°44'29.0" N	2°48'17.4" E
BH-WFS4-1A	51.9	486523	5732290	51°44'28.9" N	2°48'17.3" E
CPT_WFS4_1	40.9	486530	5732298	51°44'29.1" N	2°48'17.7" E
CPT_WFS4_1A	51.9	486532	5732302	51°44'29.3" N	2°48'17.8" E
BH-WFS4-2	8.4	490527	5732767	51°44'44.6" N	2°51'46.1" E
BH-WFS4-2A	52.2	490526	5732763	51°44'44.5" N	2°51'46.0" E
BH-WFS4-3	60.0	491740	5727279	51°41'47.0" N	2°52'49.8" E
BH-WFS4-4	50.4	493371	5730553	51°43'33.1" N	2°54'14.5" E
BH-WFS4-5	52.2	495145	5730213	51°43'22.2" N	2°55'47.0" E
BH-WFS4-6	50.4	493593	5734621	51°45'44.8" N	2°54'25.8" E

Datum : ETRS89 Projection : Universal Transverse Mercator
Ellipsoid : GRS80 Central Meridian : 3° E
Penetration Depth: deepest point reached by sampling and/or in situ testing, relative to seafloor

WATER DEPTH

Testing Point	Date	Echo Sounder Reduced [m]	CTD Probe Reduced [m]	Drill String Reduced [m]	Bathymetry chart Reduced [m]
BH-WFS4-1	03-Oct-2015	29.8	29.7	29.9	30.4
BH-WFS4-1A	03-Oct-2015	29.8	29.7	29.6	30.3
CPT_WFS4_1	09-Oct-2015	29.5	29.5	30.0	29.8
CPT_WFS4_1A	10-Oct-2015	29.5	28.9	29.0	29.1
BH-WFS4-2	29-Sep-2015	35.3	35.3	35.5	35.8
BH-WFS4-2A	04-Oct-2015	35.1	35.6	35.4	35.6
BH-WFS4-3	02-Oct-2015	28.3	28.4	28.5	28.6
BH-WFS4-4	29-Sep-2015	32.7	33.0	32.8	33.3
BH-WFS4-5	28-Sep-2015	35.8	35.7	35.8	35.9
BH-WFS4-6	05-Oct-2015	29.8	30.2	30.0	30.2

Reduced water depths are relative to Lowest Astronomical Tide (LAT)

GeODin/Coordinates and Water Depth Downhole.GLO/2015-11-16 08:43:21

COORDINATES AND WATER DEPTH

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

COORDINATES

Testing Point	Penetration Depth [m]	Easting [m]	Northing [m]	Latitude [deg]	Longitude [deg]
BH-WFS4-7	51.9	498779	5736551	51°46'47.4" N	2°58'56.3" E
CPT_WFS4_7	49.9	498785	5736557	51°46'47.6" N	2°58'56.6" E
CPT_WFS4_18	10.9	495297	5733553	51°45'10.3" N	2°55'54.7" E
CPT_WFS4_18A	51.6	495295	5733549	51°45'10.2" N	2°55'54.6" E
CPT_WFS4_21	2.0	497760	5735306	51°46'7.1" N	2°58'3.1" E
CPT_WFS4_21A	51.1	497757	5735303	51°46'7.0" N	2°58'3.0" E

Datum : ETRS89 Projection : Universal Transverse Mercator
Ellipsoid : GRS80 Central Meridian : 3° E
Penetration Depth: deepest point reached by sampling and/or in situ testing, relative to seafloor

WATER DEPTH

Testing Point	Date	Echo Sounder Reduced [m]	CTD Probe Reduced [m]	Drill String Reduced [m]	Bathymetry chart Reduced [m]
BH-WFS4-7	06-Oct-2015	34.7	34.5	35.1	35.0
CPT_WFS4_7	14-Sep-2015	34.8	35.0	35.0	34.9
CPT_WFS4_18	06-Oct-2015	34.4	34.9	35.1	34.4
CPT_WFS4_18A	08-Oct-2015	34.4	34.6	35.1	34.2
CPT_WFS4_21	08-Oct-2015	31.7	32.1	32.8	32.1
CPT_WFS4_21A	08-Oct-2015	31.7	31.8	32.1	32.2

Reduced water depths are relative to Lowest Astronomical Tide (LAT)

GeODin/Coordinates and Water Depth Downhole.GLO/2015-11-16 08:43:21

COORDINATES AND WATER DEPTH

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SECTION A: GEOTECHNICAL LOGS

TEXT – SECTION A: Page

A. GEOTECHNICAL LOGS

A.1 COMMENTS ON RESULTS A1 to A6
A.2 PRACTICE FOR GEOTECHNICAL LOG A7 to A8
A.3 PRACTICE FOR GEOTECHNICAL BOREHOLE A9 to A10

LIST OF PLATES IN SECTION A: Plate

BH-WFS4-1 & BH-WFS4-1A A1 to A2
CPT_WFS4_1 & CPT_WFS4_1A A3 to A4

BH-WFS4-2 & BH-WFS4-2A A5 to A6

BH-WFS4-3 A7 to A8

BH-WFS4-4 A9 to A10

BH-WFS4-5 A11 to A12

BH-WFS4-6 A13 to A14

BH-WFS4-7 A15 to A16
CPT_WFS4_7 A17 to A18

CPT_WFS4_18 & CPT_WFS4_18A A19 to A20

CPT_WFS4_21 & CPT_WFS4_21A A21 to A22

A. GEOTECHNICAL LOGS

A.1 COMMENTS ON RESULTS

A total of eleven geotechnical logs covering nine separate locations are presented in this section. Seven logs include the results of combined downhole sampling and in situ testing in single boreholes whilst four logs include the results of semi-continuous downhole cone penetration testing, of which two are from adjacent boreholes and two are from other locations. For the geotechnical logs from the boreholes with downhole sampling and in situ testing, the adjacent CPT data (either semi-continuous downhole or continuous from seafloor) have been included in the logs for reference purposes. Individual test results of the seafloor CPTs can be found in a companion report (refer to Plate 1-3 following Main Text titled “List of Fugro Reports” for details).

Borehole BH-WFS4-1 was terminated at 7.0 m below seafloor (bsf) due to presence of a cobble and/or boulder below the drill bit. Similarly, borehole BH-WFS4-2 was terminated at 8.4 m bsf due to adverse weather conditions. The CPT_WFS4_1, CPT_WFS4_18 and CPT_WFS4_21 boreholes were terminated at 40.9 m, 10.9 m, and 2.0 m bsf respectively due to operational constraints. At these locations, additional boreholes (BH-WFS4-1A, BH-WFS4-2A, CPT_WFS4_1A, CPT_WFS4_18A and CPT_WFS4_21A) were drilled at approximately 5 m distance from the intended borehole location. Information from both boreholes is combined into a single geotechnical log.

Table A.1 below presents an overview of the distance between the boreholes which include alternating sampling and in situ testing and the associated nearby boreholes/test points which include CPTs only.

Table A.1: Lateral Distance between Sample/CPT Borehole and CPT

Boreholes with Downhole Sampling and In Situ Testing	Borehole with Downhole In Situ Testing or Seafloor Cone Penetration Testing	Distance between Locations [m]
BH-WFS4-1	CPT_WFS4_1 & CPT_WFS4_1A	7.6 & 12.8
BH-WFS4-1A	CPT_WFS4_1 & CPT_WFS4_1A	10.1 & 15.3
BH-WFS4-2	CPT_WFS4_2	8.5
BH-WFS4-2A	CPT_WFS4_2	12.0
BH-WFS4-3	CPT_WFS4_3	6.4
BH-WFS4-4	CPT_WFS4_4	16.3
BH-WFS4-5	CPT_WFS4_5	9.4
BH-WFS4-6	CPT_WFS4_6	3.2
BH-WFS4-7	CPT_WFS4_7	8.8

The geotechnical logs include a geotechnical unit identification. Division into geotechnical units and sub-units is based on:

- Geological formations and formation members’ boundaries interpreted from seismic reflection data;
- Geotechnical characteristics identified from the available in situ and laboratory test data;
- Thicknesses of soil layers (i.e. main soil types) and their lateral continuity across the site.

The following naming convention was used:

- Capital letters have been assigned to each geological formation (i.e. A, B, C etc.);
- Numbers have been assigned to each geological formation member;
- Where difference in distinct geotechnical characteristics is evident within a formation member, lower case letters were assigned to a soil layer of considerable thickness (i.e. very thick beds, thus thicker than 2 m) that are laterally continuous across the site.

Companion Fugro Report N6083/06 (refer to plate titled "List of Fugro Reports" following the Main Text) provides a detailed description of the geological formations (members) and geotechnical units. General stratigraphy for WFS III & IV is reproduced in Table A.2.

Table A.2: Stratigraphical Division of WFS III & IV

Unit	Sub-unit	Formation (Member)	Unit Description	Lower Unit Boundary Differentiators
A	-	Southern Bight (-)	Very loose to very dense (fine to) medium SAND, locally (slightly) gravelly and with beds of (slightly) gravelly clayey sand or clay	– Locally at base a bed of (slightly) gravelly clayey sand or clay – Locally, clear colour change observed – Frequently difficult to discriminate from the unit below. Where geotechnical boundary was not clear, the lower boundary is based on seismic data
B	-	Kreftenheye/ Eem (-)	– Medium dense to very dense fine to medium SAND, locally (slightly) gravelly – Unit has chaotic character on seismic data	– Typically sharp, erosional and clearly defined from the seismic data – Generally clear change in pore pressure response – Regularly relatively higher cone tip resistance than unit below
C1	-	Westkapelle Ground / Brielle Ground (-)	Alternation of dense fine SAND and stiff to very stiff CLAY	Typically sharp with relatively lower cone tip resistance than unit below (Unit C2)
C2	-	Westkapelle Ground / Brielle Ground (-)	Dense to very dense fine to coarse silty SAND, locally slightly gravelly	– Typically sharp, erosional on seismic data – Occasionally short and gradual transition from very dense sand to clay of unit below. This transition interval is included in Unit C2
D	-	Rupel (Rupel Clay)	Stiff to very stiff CLAY	Typically gradual from clay to very clayey sand. This transition interval is included in Unit E1
E1	-	Tongeren (Ruisbroek Sand)	Medium dense to very dense fine SAND, locally silty, locally (very) clayey, locally with beds of glauconitic sand	– Unit spatially variable and locally similar to Unit E2 – Where observed, the boundary was taken at a shift in friction ratio to above 2% and decrease in cone resistance
E2	-	Tongeren (Watervliet Clay)	– Very stiff to hard (sandy) CLAY, locally with beds of sand – Medium dense clayey or silty fine SAND	– Unit spatially variable and locally similar to Unit E3 – Where observed, the boundary was taken at shift in cone tip resistance towards higher values and decrease in friction ratio
E3	-	Tongeren (Bassevelde 3 Sand)	Medium dense to very dense silty fine to medium SAND, locally with beds of glauconitic sand, locally with beds of clay or clayey sand	Typically sharp, at top of very dense sand of Unit E4

Unit	Sub-unit	Formation (Member)	Unit Description	Lower Unit Boundary Differentiators
E4	-	Tongeren (Bassevelde 2 Sand)	– Very dense fine to medium SAND – High cone tip resistance (frequent refusals)	Typically sharp, taken at base of very dense sand
E5	E5a	Tongeren (Bassevelde 1 Sand)	– Dense to very dense (slightly) silty fine SAND – Locally very silty	Typically taken at start of intervals (beds) with high friction ratios (>2%), associated with increased presence of glauconitic sands
	E5b		– Medium dense to dense (slightly) silty fine SAND, locally with beds of glauconitic sand – Locally very silty	Typically gradual; the transition interval is given to unit below
F1	F1a	Dongen (Onderdijke)	Very stiff to hard (slightly/very) sandy CLAY, with beds of (very) sandy clay, with beds of ((very) clayey) sand, locally with pockets of sand	Typically sharp
	F1b		– Hard (slightly/very) sandy CLAY – Locally silt	– Typically sharp – Clear boundary in seismic reflection data (a seismo-stratigraphic boundary)
	F1c		Stiff to very stiff (sandy) CLAY, fissured	Sharp or gradual; the transition interval is given to unit below
F2	-	Dongen (Buisputten)	Dense to very dense becoming medium dense to dense clayey or silty SAND, locally with a bed of very clayey sand	Typically gradual, the transition interval is included in Unit F2.
F3	-	Dongen (Zomergem)	Very stiff to hard CLAY, fissured, locally with pockets of sand	Not penetrated - end of borehole

Notes:
- The table describes the stratigraphy for both WFSIII and IV. Not all units may have been investigated or are present across both WFS III and WFS IV.
- The Lower Unit Boundary Differentiators were used for interpretation of stratigraphy at the borehole and seafloor CPT locations, not all differentiators are applicable for every individual location

Typically good agreement is seen between data from the combined sample/CPT boreholes and the adjacent CPT locations, both for the downhole CPT and seafloor CPT locations. Nevertheless, differences between interpreted layer boundaries are evident. Such differences are attributed to lateral variability and/or variations in seafloor level, for example due to sand waves. An example of differences due to varying seafloor level can be seen between borehole locations BH-WFS4-2, BH-WFS4-2A and seafloor CPT location CPT_WFS4_2. Water depth at BH-WFS4-2A is 35.1 m, while in CPT_WFS4_2 is 35.8 m. Similar difference is observed in the thickness of Unit A - in BH-WFS4-2A is 1.9 m thick, whereas in CPT_WFS4_2 is 0.8 m thick. Units observed below are approximately the same thickness. Layer changes interpreted from CPT_WFS4_2 are 0.4 m to 1.1 m shallower than interpreted for boreholes BH-WFS4-2 and BH-WFS4-2A. An example of differences due to lateral variability can be seen between borehole locations BH-WFS4-7 and CPT_WFS4_7, where layer thicknesses interpreted from CPT data vary slightly.

The information at the bottom of the geotechnical logs, including date commenced, coordinates and water depth, recovery and penetration, is applicable to the location listed first in the legend.

In order to maximise recovery and sample quality, and to prevent damage to equipment if adverse soil conditions were expected, the most suitable combination of sampler and sample tube was selected prior to deployment. WIP Sampler was used and samples are marked with a 'W' on the geotechnical logs. Sampling

recoveries are in line with expected recoveries for the encountered soil conditions and used sampling techniques.

Two Pore Pressure Dissipation Tests were performed in borehole BH-WFS4-7 during CPT1 and CPT4, at 8.9 m and at 21.8 m bsf respectively (presented in Section B3). The test intervals were sampled after the cone penetration at these depths; therefore these samples are marked as disturbed.

Strata descriptions presented on the geotechnical logs are an interpretation of the available data sources, including sample descriptions, laboratory tests and CPT data where available. The strata descriptions may differ from the individual sample descriptions, presented in report Section C titled “Geotechnical Laboratory Test Results”. The sample descriptions are based on on-site visual classification of the individual samples, whereas the strata descriptions consider additional data sources.

Strata descriptions that are based on CPT data interpretation only use the Robertson (1990) and Robertson (2009) methodology for interpretation of strata descriptions from CPT data, and have been updated to BSI (1999). Strata descriptions are supported by knowledge of local geology and the results from sampling and in situ testing at nearby sample/CPT boreholes.

The geotechnical logs plot CPT derived undrained shear strength (s_u) for fine-grained cohesive layers and D_r for coarse-grained cohesionless layers. Distinction between s_u and D_r was made for soil layers or sub layers with a thickness of 0.6 m (i.e. thick beds) or thicker. In other cases the CPT interpretation for the dominant soil type was maintained.

If less than 0.3 m of CPT data is available for the (deepest) layer, no relative density or undrained shear strength description is provided in the strata description.

In coarse-grained cohesionless layers, significant reduction in cone resistance (q_c) is occasionally observed and is associated with an increase of the fines fraction, i.e. the silt and clay fractions. Where applicable, these have been interpreted as beds of (very) clayey sand.

For correlation of s_u with CPT data (net cone resistance) typical cone factors (N_k) of 15 to 20 have been used. Site, layer or test type specific N_k assessment was beyond the scope of this report. Such assessment may be appropriate for specific use of CPT derived strength values.

The relative density presented on the logs is estimated using an empirical expression recommended by Jamiolkowski et al. (2003) for silica sands. Jamiolkowski et al. (2003) proposes a relationship between cone resistance (q_c) and D_r for silica sands (for details refer to document titled “Cone Penetration Test Interpretation” in Appendix 1). This relationship has limited applicability in layers with a high percentage of fines (i.e. >10% silt and/or clay fractions) and in layers from seafloor to about 2 m to 3 m bsf. Relative density interpretation for these layers should be used with caution.

The geotechnical logs present unit weight values from direct measurement using volume mass calculation and derived from water content measurements. Unit weight values derived from water content measurements assume (a) full saturation and (b) typical values for the density of solid particles of 2.65 Mg/m^3 for coarse-grained cohesionless material and 2.70 Mg/m^3 for fine-grained cohesive material. There is an unusually large

difference between unit weight values derived from water content measurements and direct measurements for borehole locations BH-WFS4-2 between 9 m and 14 m bsf and BH-WFS4-5 between 5 m and 14 m bsf. The depth intervals roughly correlate with Unit B. This difference may be attributed to the use of a 2" diameter WIP sample tube with a core catcher which may have increased sample disturbance, combined with the presence of shells and shell fragments in the sand. Unit weight values derived from water content measurements are in agreement with expected range for unit weights of the soils tested.

High sleeve frictions and friction ratios were noted in various CPTs within sand layers. These high values were attributed to the presence of glauconite, refer to Section B.1 for details. The precise quantity and distribution of glauconite is likely to vary spatially within the various soil units. Also, a precise relation between the quantity of glauconite and associated CPT response was not established during this project, nor was such relationship found within literature available within the public domain. A descriptive terminology was selected for the geotechnical logs, i.e. "with beds of glauconitic sand", and does not indicate the quantity of glauconite within these beds. Microscopic verification of selected samples is presented in companion report N6083/07 (see Plate 1-3).

CPT and sample data from soil unit F1a and F1b indicate that these layers consist of a mixture of fine-grained and coarse-grained material. This is in line with particle size distribution data which indicate significant coarse-grained fraction within certain test specimens, i.e. between 25% and 68%. Atterberg limits indicate predominantly cohesive behaviour for these units. Both units have been described as (slightly to very) sandy clay as applicable. Variation within these units is evident and local beds of coarse-grained cohesionless material may be present. These beds may not have always been captured by available data.

In coarse-grained cohesionless layers, on-site visual sample grading frequently under-estimated the coarse-grained fractions. Strata descriptions were updated using PSD data where applicable.

Carbonate content testing occasionally indicates $CaCO_3$ percentages higher than 10%. These high values can be related to the actual particle type, i.e. calcareous silica sands or calcareous clay or to locally higher percentages of shell and shell fragments. Strata descriptions were updated where no significant content of shells and shell fragments was evident.

Organic content was typically lower than 1% in coarse-grained cohesionless layers, indicating traces of organic matter. In fine-grained cohesive layers, organic content was generally between 2% and 6%, indicating slightly organic clay. Soil descriptions are updated according to these results.

The majority of the Atterberg limits test results plot above the A-line on the plasticity chart and are in agreement with the soil classification during on-site sample logging. Five test results plot slightly below the A-line, which indicates the material shows 'silt behaviour'. Main soil description of 'clay' is maintained and silt is identified as a local feature.

The general trends in s_u values measured by Unconsolidated Undrained (UU) and Isotropically Consolidated Undrained (CIU) triaxial compression tests, pocket penetrometer tests, torvane tests, and as interpreted from CPT data are similar. Undrained shear strength values measured by UU and CIU triaxial compression tests are occasionally lower than values as interpreted from CPT data and pocket penetrometer tests. This may be caused by preferential shearing planes within fissured and sandy clay layers. Undrained shear strength values

measured by UU triaxial tests on remoulded specimens occasionally plot higher than s_u values measured on undisturbed specimens. Refer to Section C “Geotechnical Laboratory Test Results” for more discussion about triaxial test results.

Undrained shear strength values measured with pocket penetrometer tests may overestimate undrained shear strength of the clays due to presence of pockets of silt or sand, and/or presence of pyrite concretions. UU triaxial compression tests results may underestimate the s_u in structured clays. Results should be used with caution.

The layer boundary between Units E5a and E5b is sometimes difficult to identify clearly. As stated in Table A.2, top of Unit E5b is characterised by beds of glauconitic sand commonly identified by an increase in friction ratio. When this layer change occurs between CPTs, top of Unit E5b is defined at the start of the bottom CPT.

A.2 PRACTICE FOR GEOTECHNICAL LOG

Geotechnical Log

Purpose:	Support of planning and design of subsea structures, e.g. foundations and cables
General Procedure:	According to BSI (1999) and Clark & Walker (1977)

Results

Data Processing and Interpretation:	– UNIPLOT software – GeODin® software – Graphical scales selected to suit general presentation of data – No display of data outside of chart limits, i.e. some values may not be shown – Geotechnical description is an interpretation of processed data available at the time of preparation; for example, interfaces between strata may be more gradual than a log indicates – Level of detail and accuracy in geotechnical description and interpretation depend on factors such as investigation system(s), logging/ test data, sample size, quality, coverage, availability of supplementary information, and project requirements
Data Format(s):	– PDF for viewing and printing (this primary document) – AGS 3.1 (AGS, 2005) and AGS 4.0 (AGS, 2011) digital tabular data (separate deliverables, secondary to this document)
Matching Test, Sample and Logging Data:	Geotechnical log based on in situ test and sample data acquired in borehole
Ground Description:	– According to documents titled “Soil Description” and “Cone Penetration Test Interpretation” presented in Appendix 1, as applicable – Sample description updated to BSI (1999) – CPT interpretation according to Robertson (1990) and Robertson (2009), updated to BSI (1999)
Unit Weight derived from In Situ Test:	Not applicable
Relative Density derived from In Situ Test:	If applicable: – refer to document titled “Cone Penetration Test Interpretation” presented in Appendix 1 – according to Jamiolkowski et al. (2003) for saturated coarse-grained cohesionless soil behaviour, Ticino Sand correlation – based on earth pressure coefficient values K_0 = 0.5 and 1.0
Undrained Shear Strength derived from In Situ Test:	If applicable: – refer to document titled “Cone Penetration Test Interpretation” presented in Appendix 1 – applies to interpreted fine-grained cohesive soil behaviour – based on cone factor of N_k = 15 and 20
Coordinates and Water Depth:	– Applicable to borehole location – In case additional borehole is performed, the coordinates and water depth of the test plotted applicable to the deepest results are presented
Water Depth Reference:	As obtained from echo sounder readings at start of drilling, sampling or testing, reduced to LAT
Depth Reference Correction:	None applied, downhole sampling assumed continuous from sampling depth with no continuity gaps, downhole CPT continuous from CPT depth

References

– AGS Association of Geotechnical and Geoenvironmental Specialists (2005), “Electronic Transfer of Geotechnical and Geoenvironmental Data”, AGS Edition 3.1 (including Addendum).

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- AGS Association of Geotechnical and Geoenvironmental Specialists (2011), “Electronic Transfer of Geotechnical and Geoenvironmental Data”, AGS Edition 4.0.
- Computer Program UNIPLOT, Processing, Presentation and Analysis of In Situ Test Data.
- Computer Program GeODin®, Recording, Presentation and Analysis of Geo-data.
- BSI British Standards Institution (1999), "Code of Practice for Site Investigations", British Standard BS 5930:1999.
- Clark, A.R. and Walker, B.F. (1977). "A Proposed Scheme for the Classification and Nomenclature for Use in the Engineering Description of Middle Eastern Sedimentary Rocks", Géotechnique, Vol. 27, No. 1, pp 94-99.
- Jamiolkowski, M., Lo Presti, D.C.F. and Manassero, M. (2003), "Evaluation of Relative Density and Shear Strength of Sands from CPT and DMT", in Germaine, J.T., Sheahan, T.C. and Whitman, R.V. (Eds.), Soil Behavior and Soft Ground Construction: Proceedings of the Symposium, October 5-6, 2001, Cambridge, Massachusetts, Geotechnical Special Publication, No. 119, American Society of Civil Engineers, Reston, pp. 201-238.
- Robertson, P.K. (1990), “Soil Classification using the Cone Penetration Test”, Can. Geotech. Jnl., Vol. 27, No. 1, pp. 151-158.
- Robertson, P.K. (2009), “Performance Based Earthquake Design Using the CPT”, in Kokusho, T., Tsukamoto, Y. and Yoshimine, M. (Eds.), Performance-Based Design in Earthquake Geotechnical Engineering – from Case History to Practice: Proceedings of the International Conference on Performance-Based Design in Earthquake Geotechnical Engineering (IS-Tokyo 2009), 15-18 June 2009, CRC Press, Boca Raton, pp. 3-20.

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A.3 PRACTICE FOR GEOTECHNICAL BOREHOLE

Borehole Stage Control

General Procedure:	Refer to document titled “Geotechnical Borehole” presented in Appendix 1
Set-up Stage:	Location approved by Client
Depth Reference Level:	Seafloor, particularly: – no evidence for extremely soft ground at seafloor but no specific measurements performed – base of seabed frame assumed level with seafloor at start of drilling, sampling or testing – depth accuracy assessment of “Downhole – Favourable”; refer to document titled Positioning Survey and Depth Measurement presented in Appendix 1
Drilling Stage:	Open-hole rotary drilling
Sampling and Testing:	– Locations with combined sampling and cone penetration testing: semi-continuous push sampling to 15 m depth with maximum untested section of 0.5 m followed by alternate 3 m cone penetration testing and 2 m push sampling in fine-grained cohesive soil and alternate 3 m cone penetration testing and 1 m push sampling in coarse-grained cohesionless soil with maximum untested section of 1 m – Locations with cone penetration testing only: semi-continuous cone penetration test to borehole target depth – Seismic Cone Penetration Test (SCPT) in selected boreholes – Pore Pressure Dissipation Test (PPDT) in selected boreholes – Sequences of sampling and in situ testing were adjusted to suit operations and site-specific constraints
Borehole Water Level Monitoring:	Not applicable
Borehole Termination Stage:	Whichever occurs first: – as instructed by Client – reaching target borehole depth – circumstances at the discretion of the equipment operator, such as risk of equipment damage or risk to personnel safety
Test Site Restoration:	– No borehole backfill – Local seabed disturbance – Possibility of local seafloor depression(s) and drill cuttings on seafloor

Drilling

Working Platform:	Geotechnical drilling vessel Gargano
Drilling Method:	Open-hole rotary drilling
Type and Make of Drill Rig:	R50 drill rig with 14.5 m travel, load capacity 50 tonnes, WIRTH power swivel
Drill Support:	SEACLAM seabed frame
Drill Pipe:	API-type 4.5 inch ID
Drill Bit:	9 inch OD 5 wing drag bit or 6 chisel claw bit
Core Barrel:	Not applicable
Drill Fluid:	Water and/or Pure-Bore drill mud
Initial Borehole Orientation:	Vertical

In Situ Test – CPT

Refer to sub-section “Practice for Cone Penetration Test” presented in report section titled “In Situ Test Results”

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In Situ Test – SCPT

Refer to sub-section “Practice for Seismic Cone Penetration Test” presented in report section titled “In Situ Test Results”

In Situ Test – PPDT

Refer to sub-section “Practice for In Situ Pore Pressure Dissipation Test” presented in report section titled “In Situ Test Results”

Push Sampling

Sampling System:	Downhole WIP Sampler
Sampler Insertion Equipment:	Jacking unit with maximum thrust capacity of 60 kN to 80 kN and penetration rate of about 20 mm/s
Reaction Equipment:	Self-weight of drill pipes, drill collars and SEACLAM seabed frame
Open-Tube Sampler:	– Thin-walled 3 inch cylindrical sample tube, 76 mm OD, 72 mm ID – Thick-walled 3 inch cylindrical sample tube, 80 mm OD, 72 mm ID – Thick-walled 2 inch cylindrical sample tube, 60 mm OD, 53 mm ID
Core Catcher:	Applicable in case of limited sample recovery in coarse-grained cohesionless soils.
Push Sampling Termination:	Whichever occurs first: – reaching maximum permissible sample tube penetration – reaching maximum capacity of sample insertion equipment and/or sample tube – reaching maximum capacity of reaction equipment – circumstances at the discretion of the equipment operator, such as risk of equipment damage or risk to personnel safety

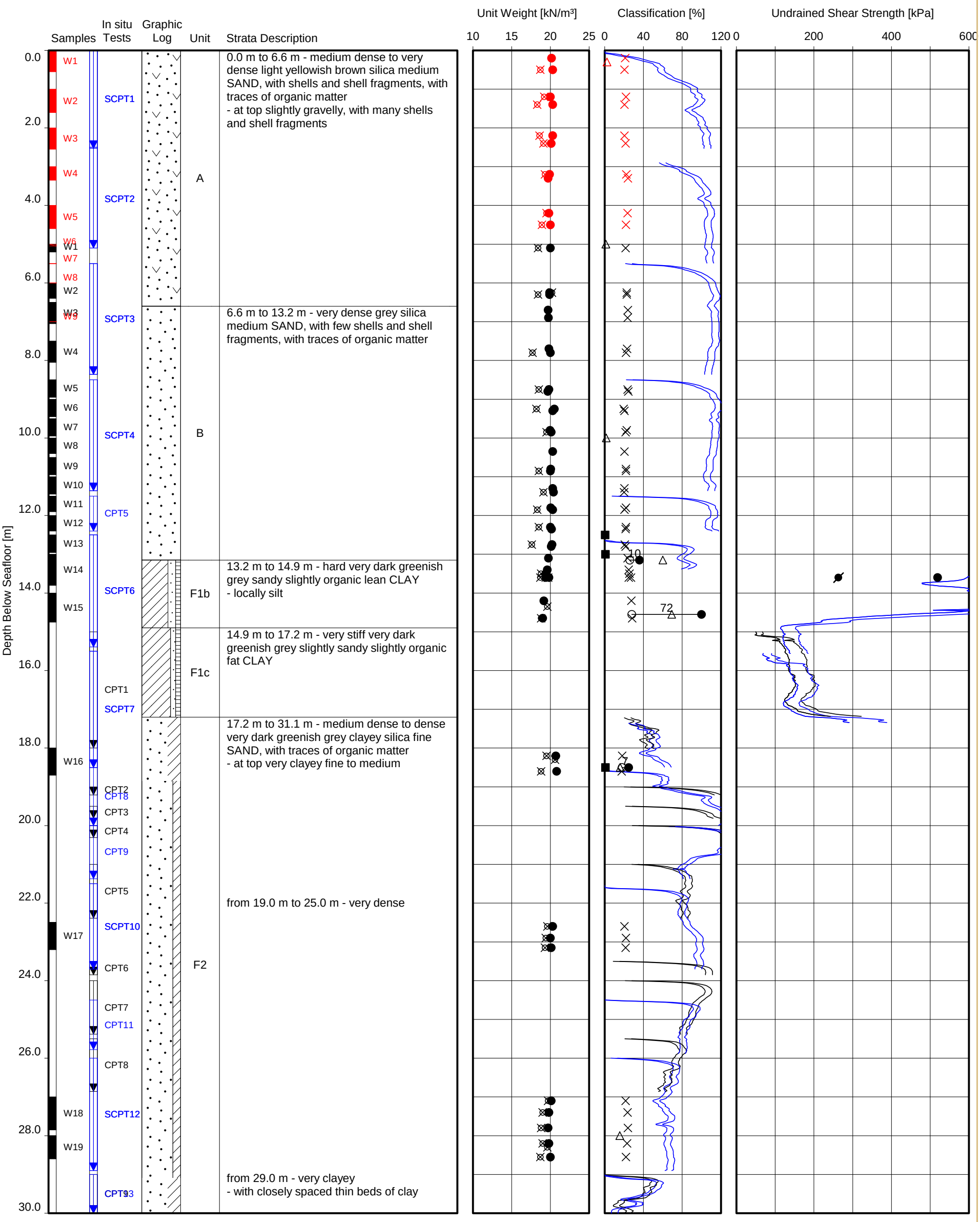
Sample Handling

Refer to sub-section “Practice for Sample Handling and Laboratory Testing” presented in report section titled “Geotechnical Laboratory Test Results”

References

Computer Program GeODin®, Recording, Presentation and Analysis of Geo-data.

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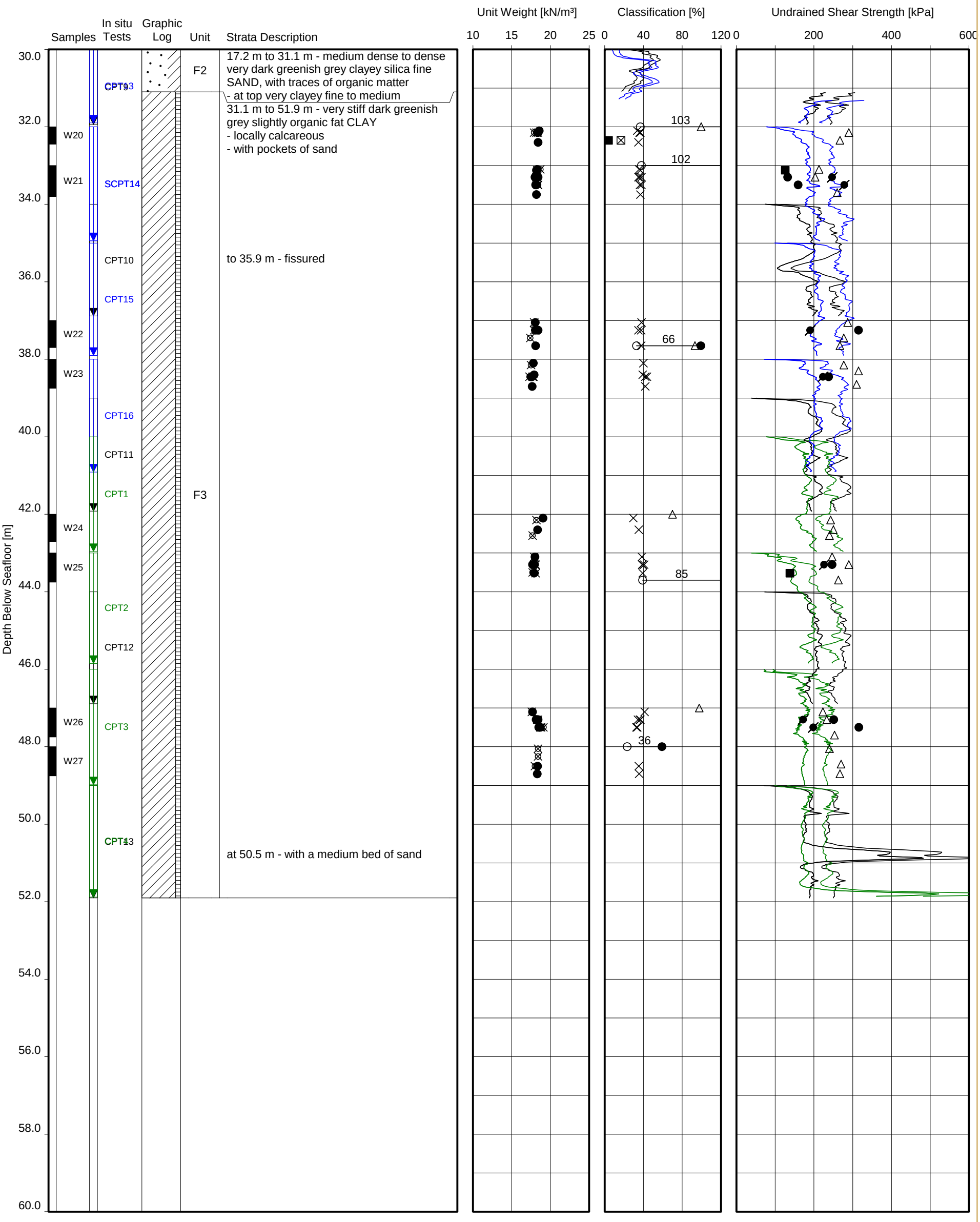
Date commenced : 03-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.9 m below seafloor
Penetration depth : to 51.9 m below seafloor
Water depth : 29.8 m
Coordinates : 486523 m E 5732290 m N

Location(s):
BH-WFS4-1A
BH-WFS4-1
CPT_WFS4_1
CPT_WFS4_1A

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



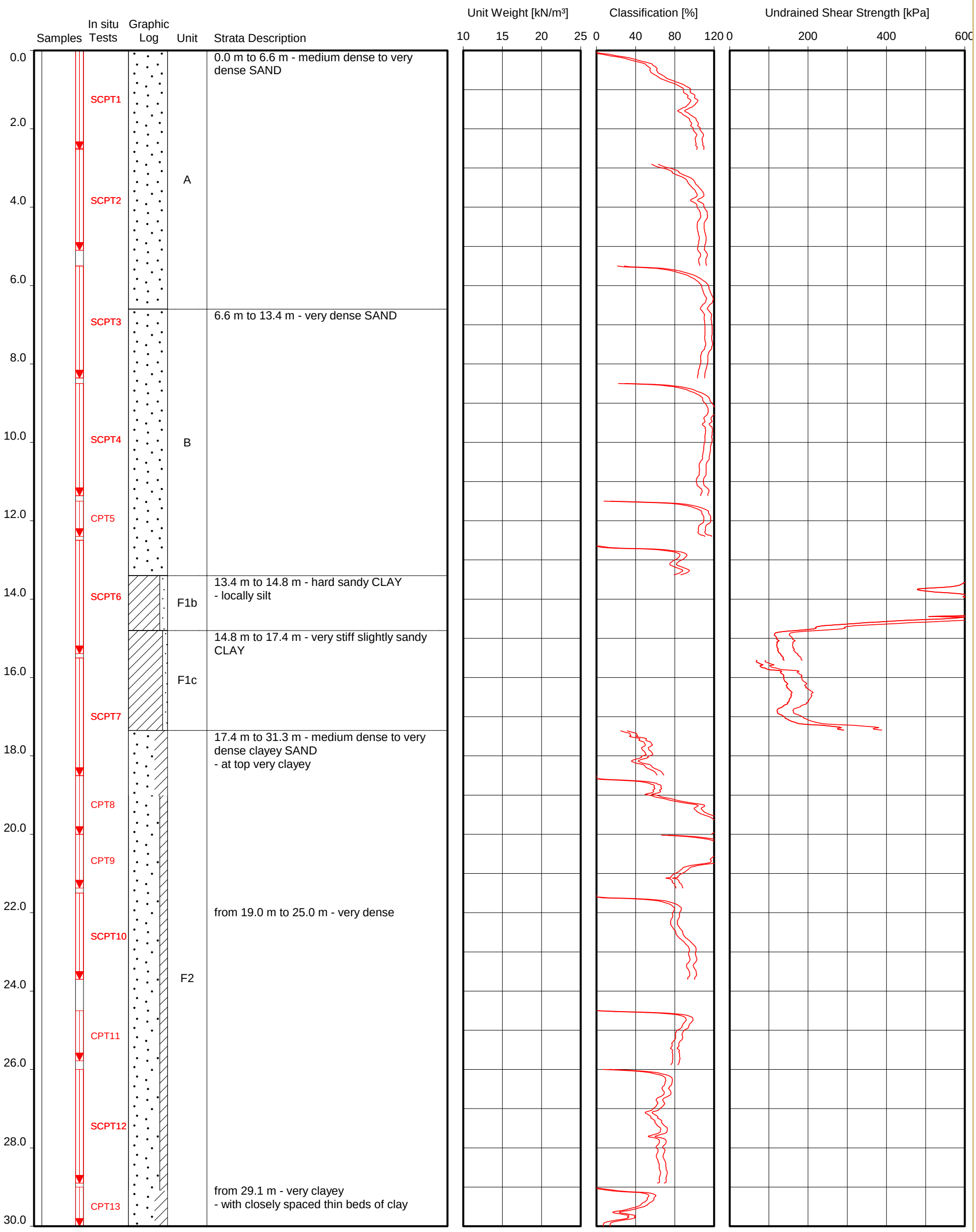
Date commenced : 03-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.9 m below seafloor
Penetration depth : to 51.9 m below seafloor
Water depth : 29.8 m
Coordinates : 486523 m E 5732290 m N

Location(s):
BH-WFS4-1A
BH-WFS4-1
CPT_WFS4_1
CPT_WFS4_1A

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
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- CU-triaxial
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- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



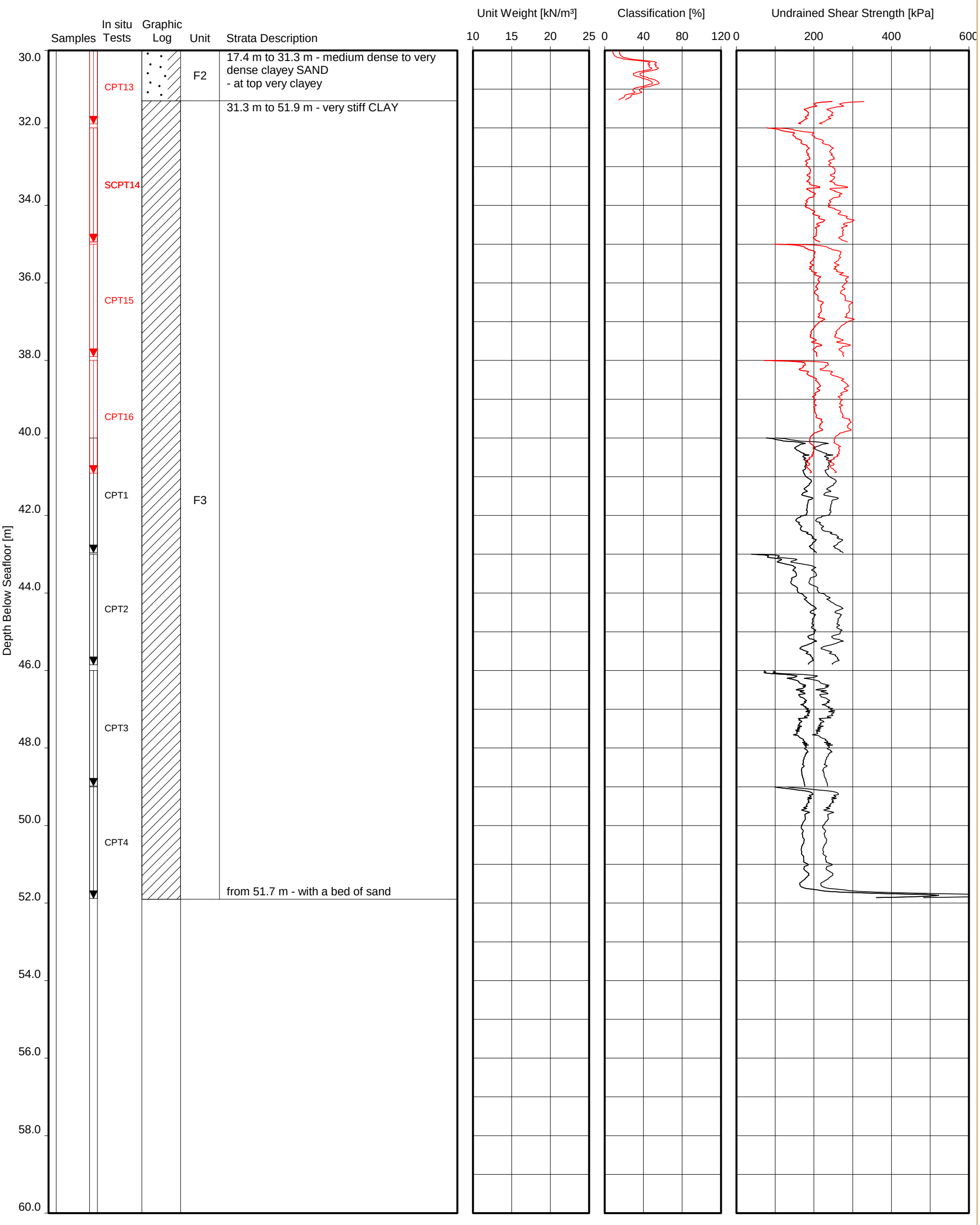
Date commenced : 09-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.9 m below seafloor
Penetration depth : to 51.9 m below seafloor
Water depth : 29.5 m
Coordinates : 486532 m E 5732302 m N

Location(s):
CPT_WFS4_1A
CPT_WFS4_1

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



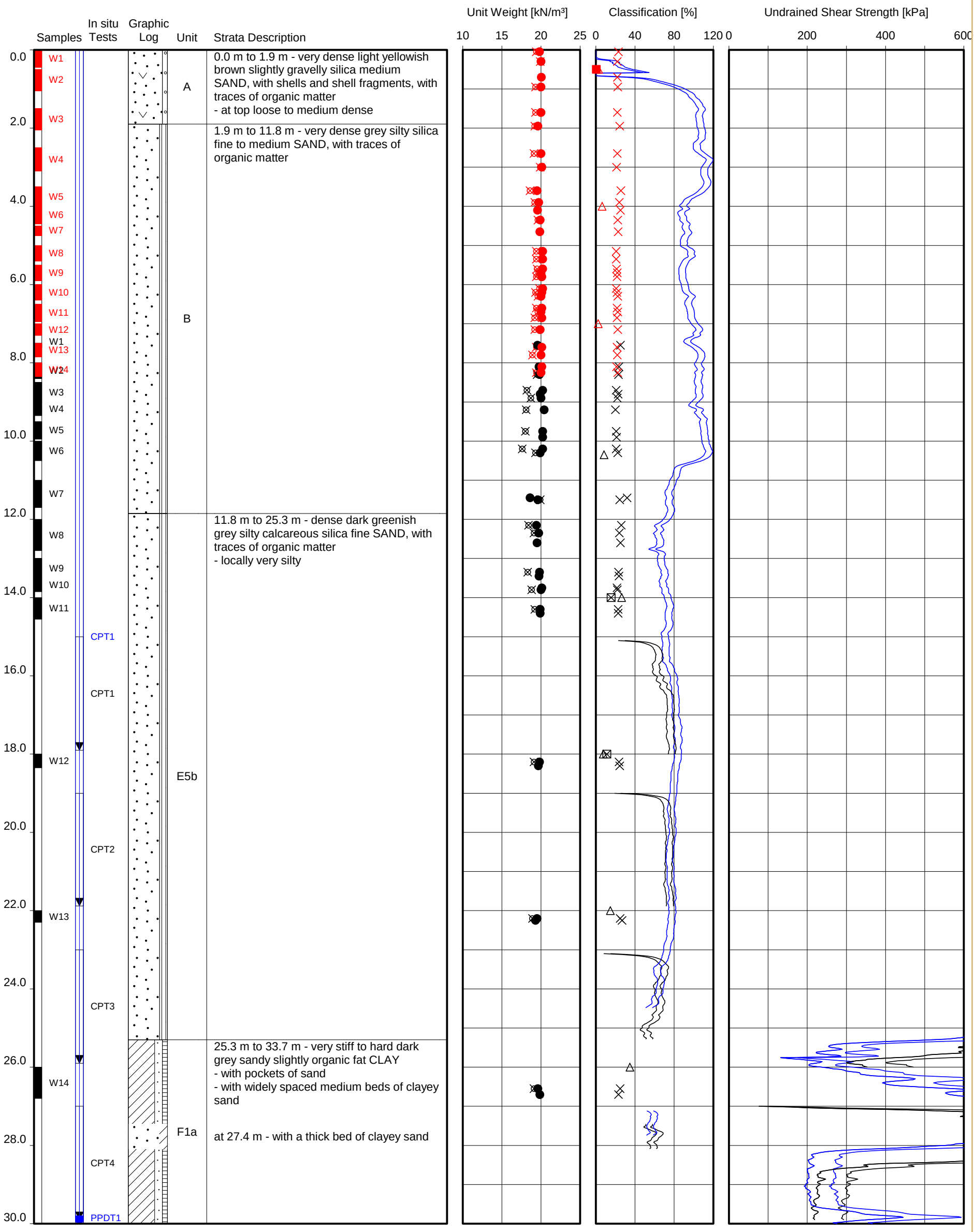
Date commenced : 09-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.9 m below seafloor
Penetration depth : to 51.9 m below seafloor
Water depth : 29.5 m
Coordinates : 486532 m E 5732302 m N

Location(s):
CPT_WFS4_1A
CPT_WFS4_1

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



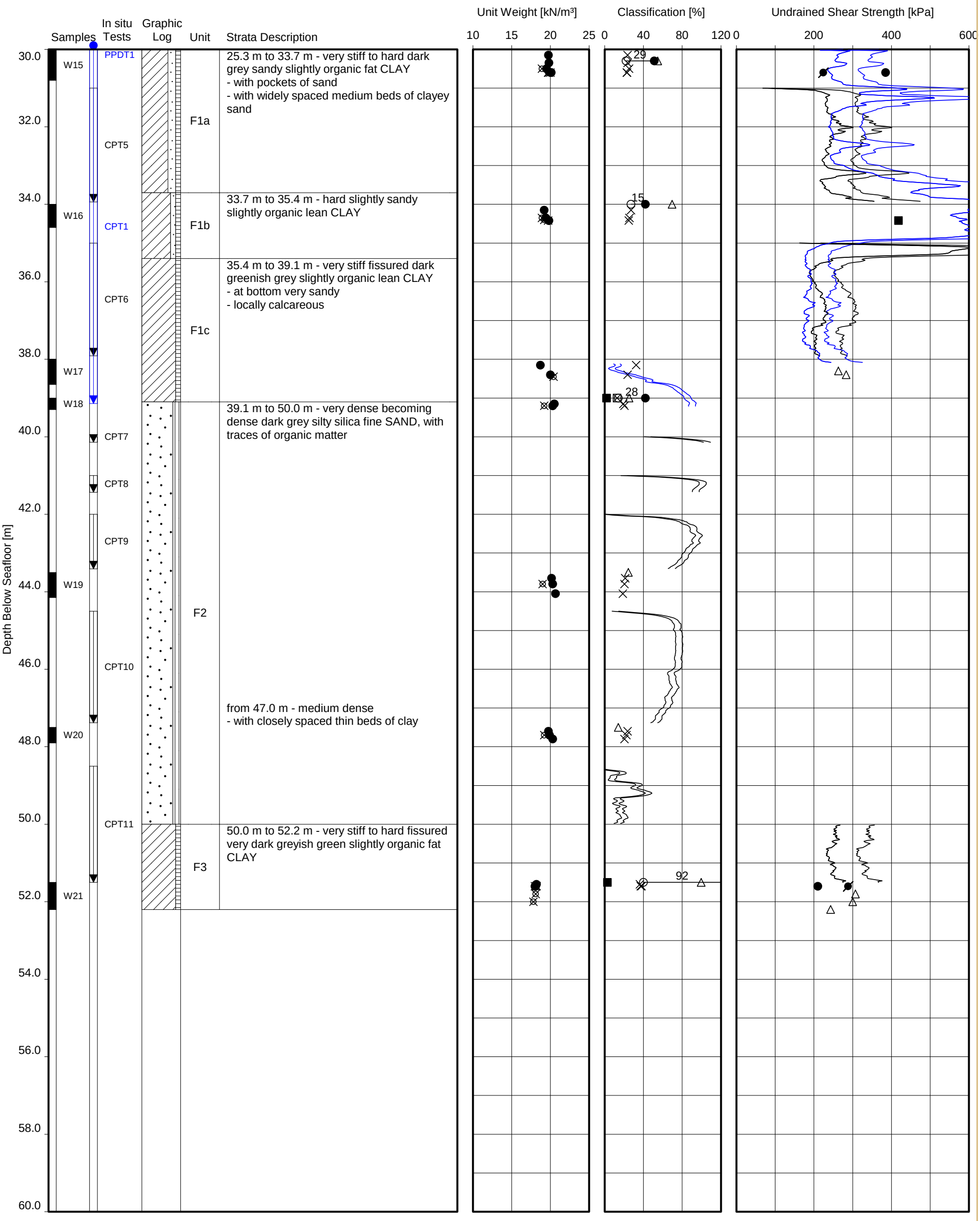
Date commenced : 03-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 52.2 m below seafloor
Penetration depth : to 52.2 m below seafloor
Water depth : 35.1 m
Coordinates : 490526 m E 5732763 m N

Location(s):
BH-WFS4-2A
BH-WFS4-2
CPT_WFS4_2

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



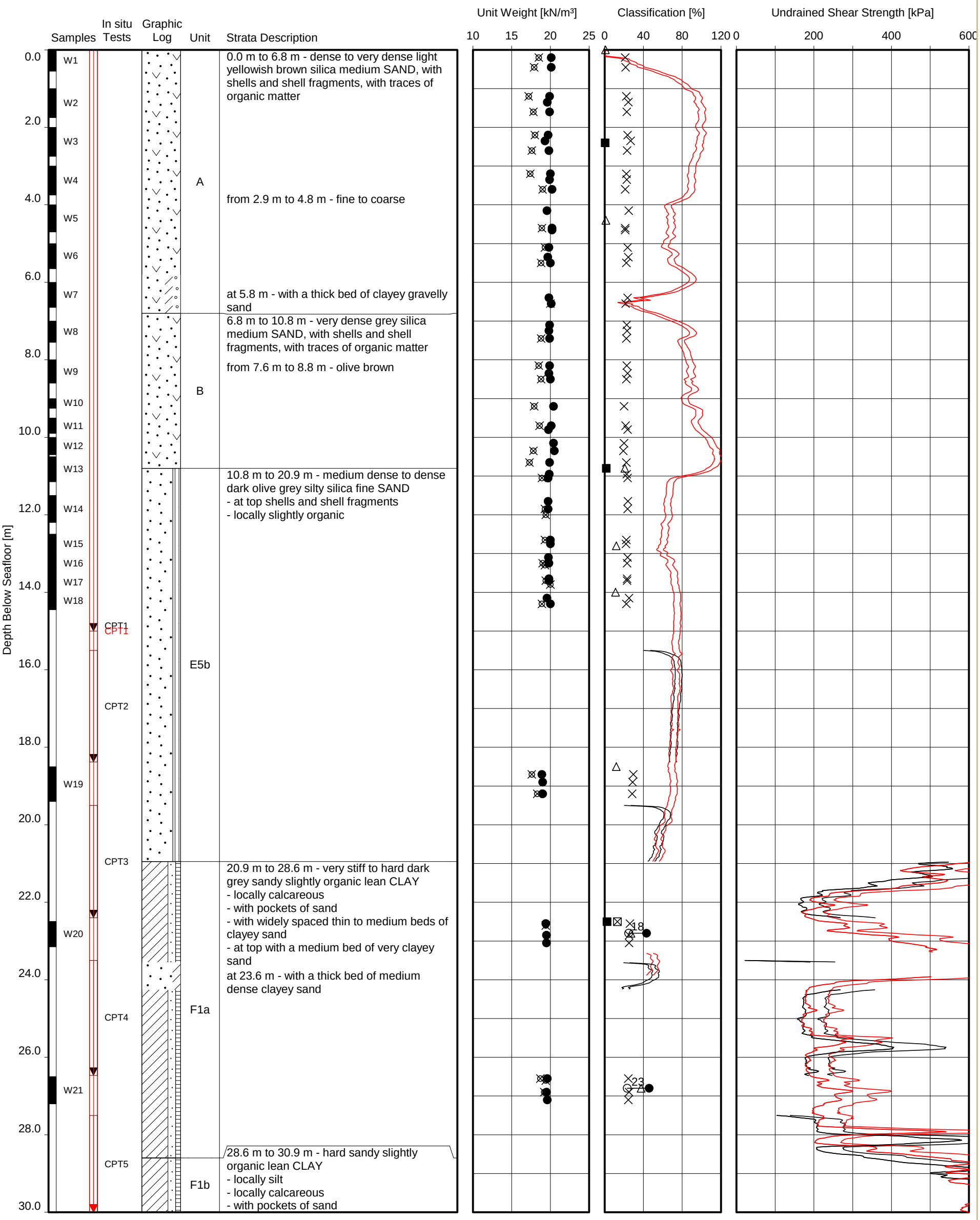
Date commenced : 03-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 52.2 m below seafloor
Penetration depth : to 52.2 m below seafloor
Water depth : 35.1 m
Coordinates : 490526 m E 5732763 m N

Location(s):
BH-WFS4-2A
BH-WFS4-2
CPT_WFS4_2

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



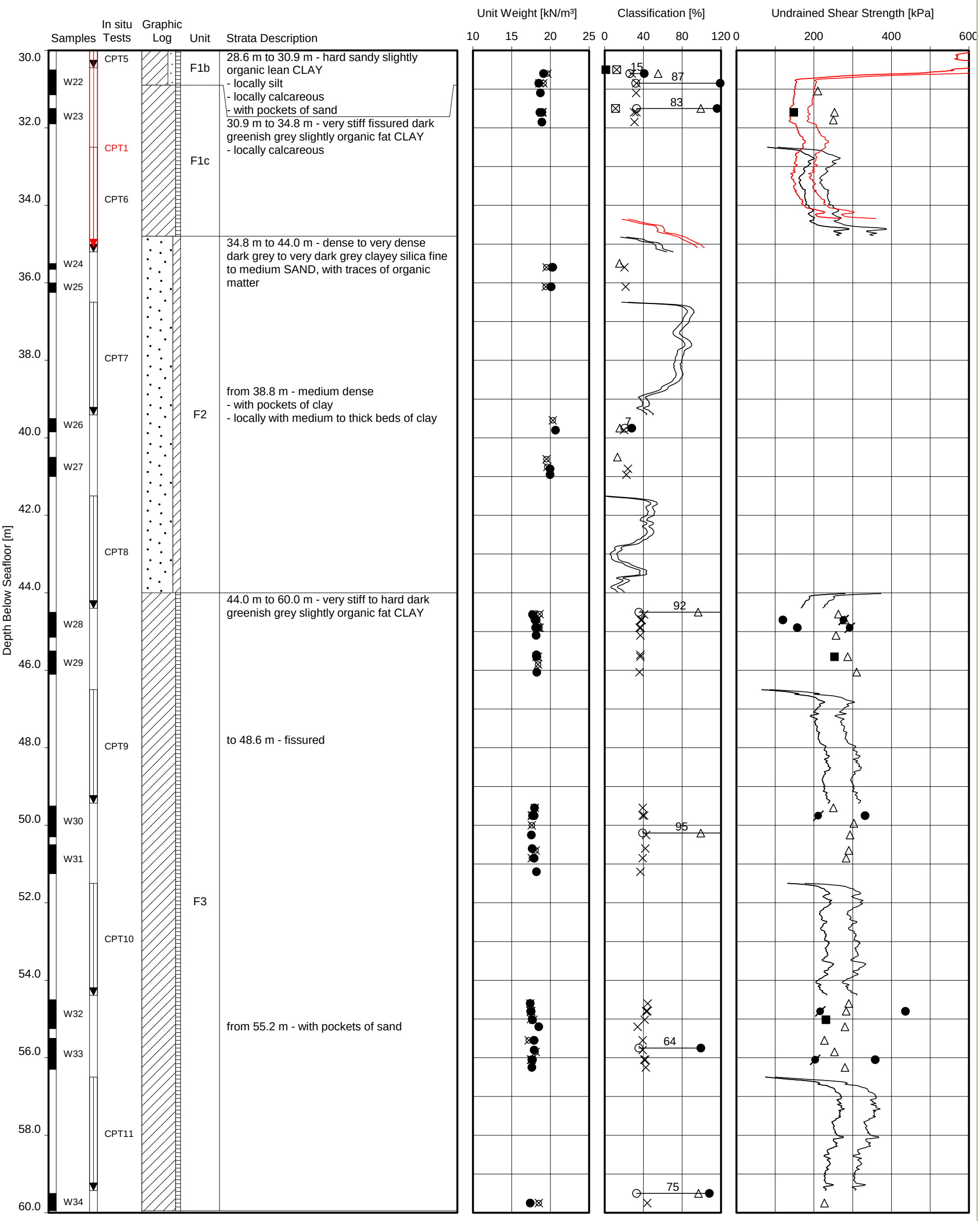
Date commenced : 02-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 60.0 m below seafloor
Penetration depth : to 60.0 m below seafloor
Water depth : 28.3 m
Coordinates : 491740 m E 5727279 m N

Location(s):
BH-WFS4-3
CPT_WFS4_3

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



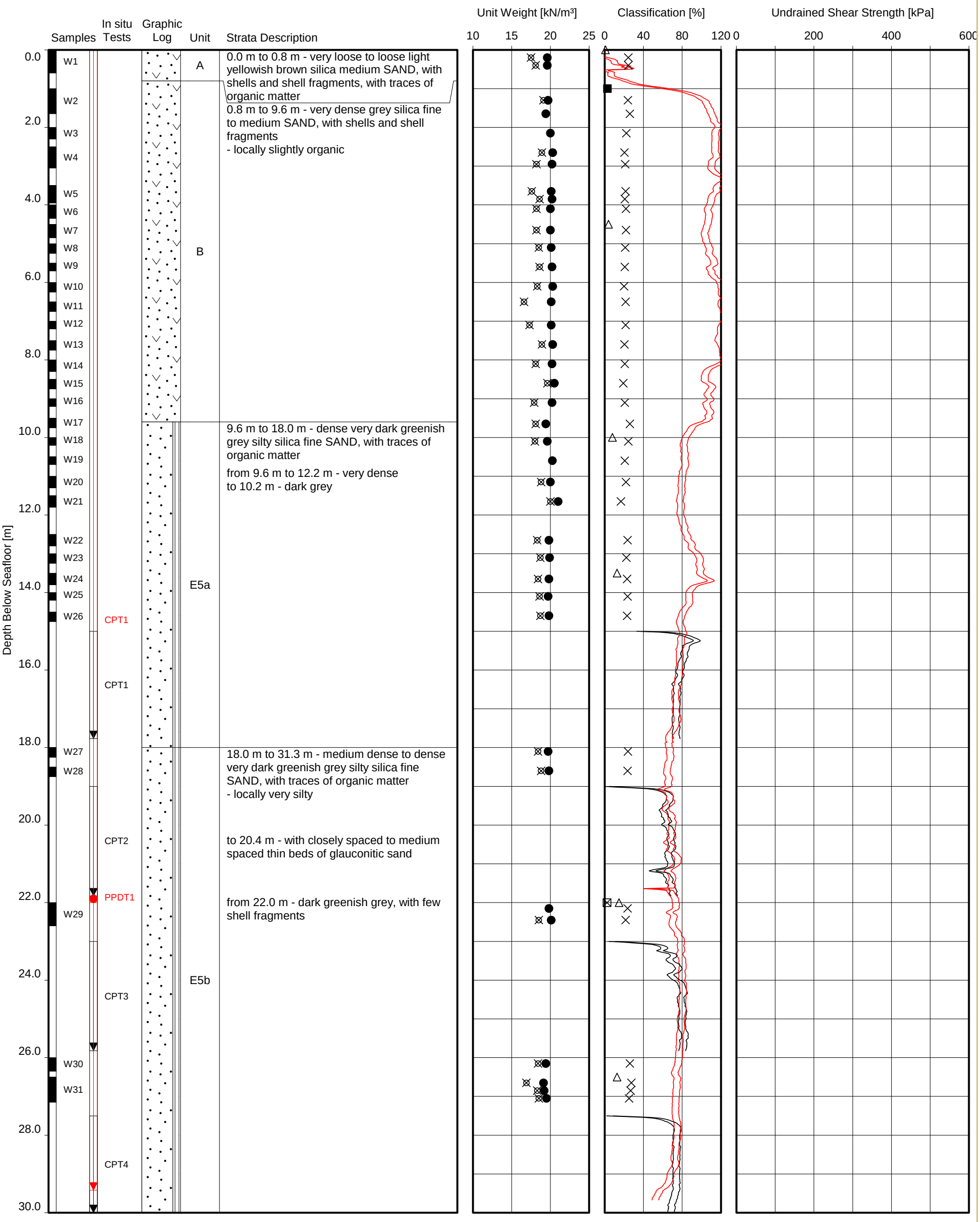
Date commenced : 02-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 60.0 m below seafloor
Penetration depth : to 60.0 m below seafloor
Water depth : 28.3 m
Coordinates : 491740 m E 5727279 m N

Location(s):
BH-WFS4-3
CPT_WFS4_3

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



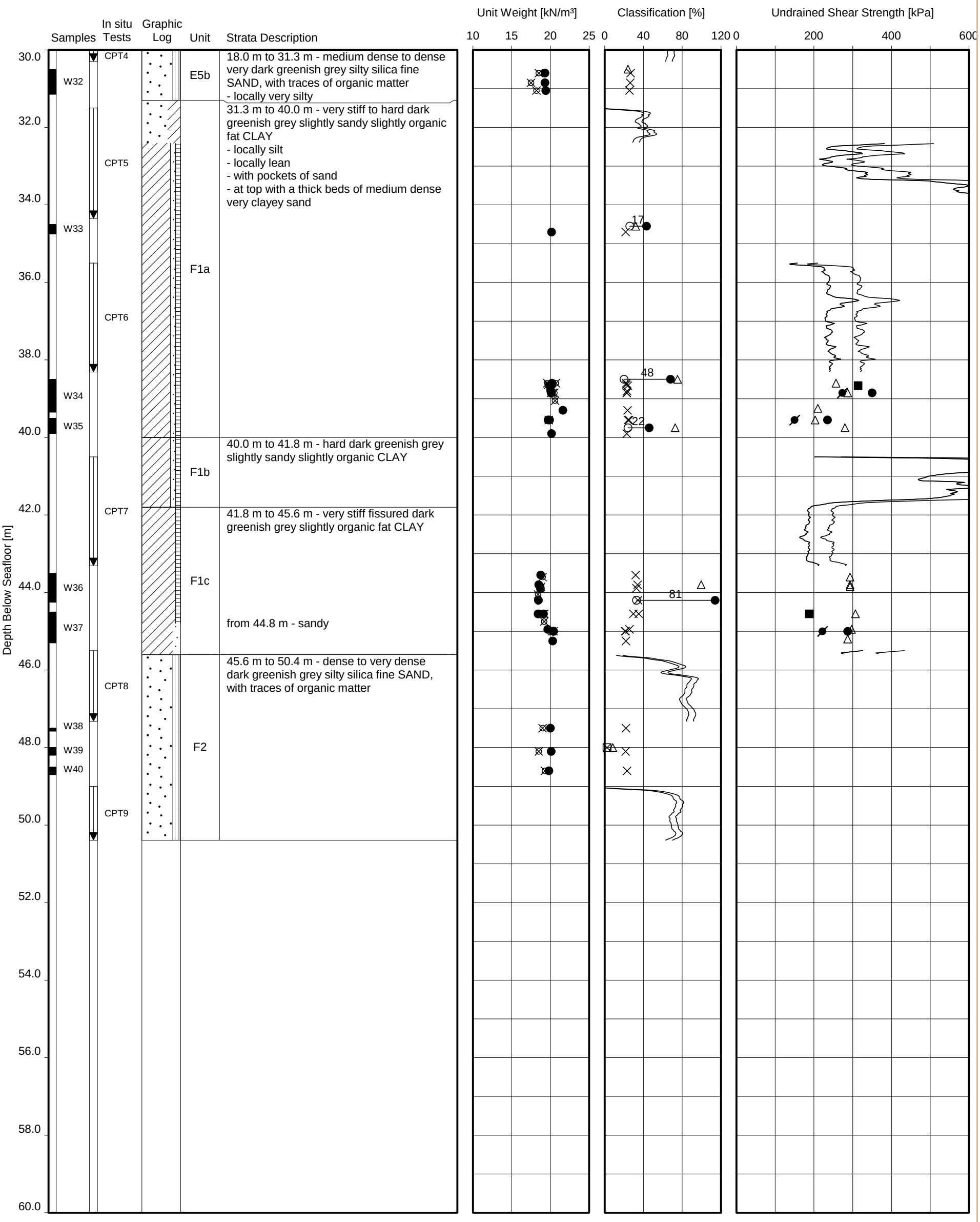
Date commenced : 29-Sep-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 50.4 m below seafloor
Penetration depth : to 50.4 m below seafloor
Water depth : 32.7 m
Coordinates : 493371 m E 5730553 m N

Location(s):
BH-WFS4-4
CPT_WFS4_4

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



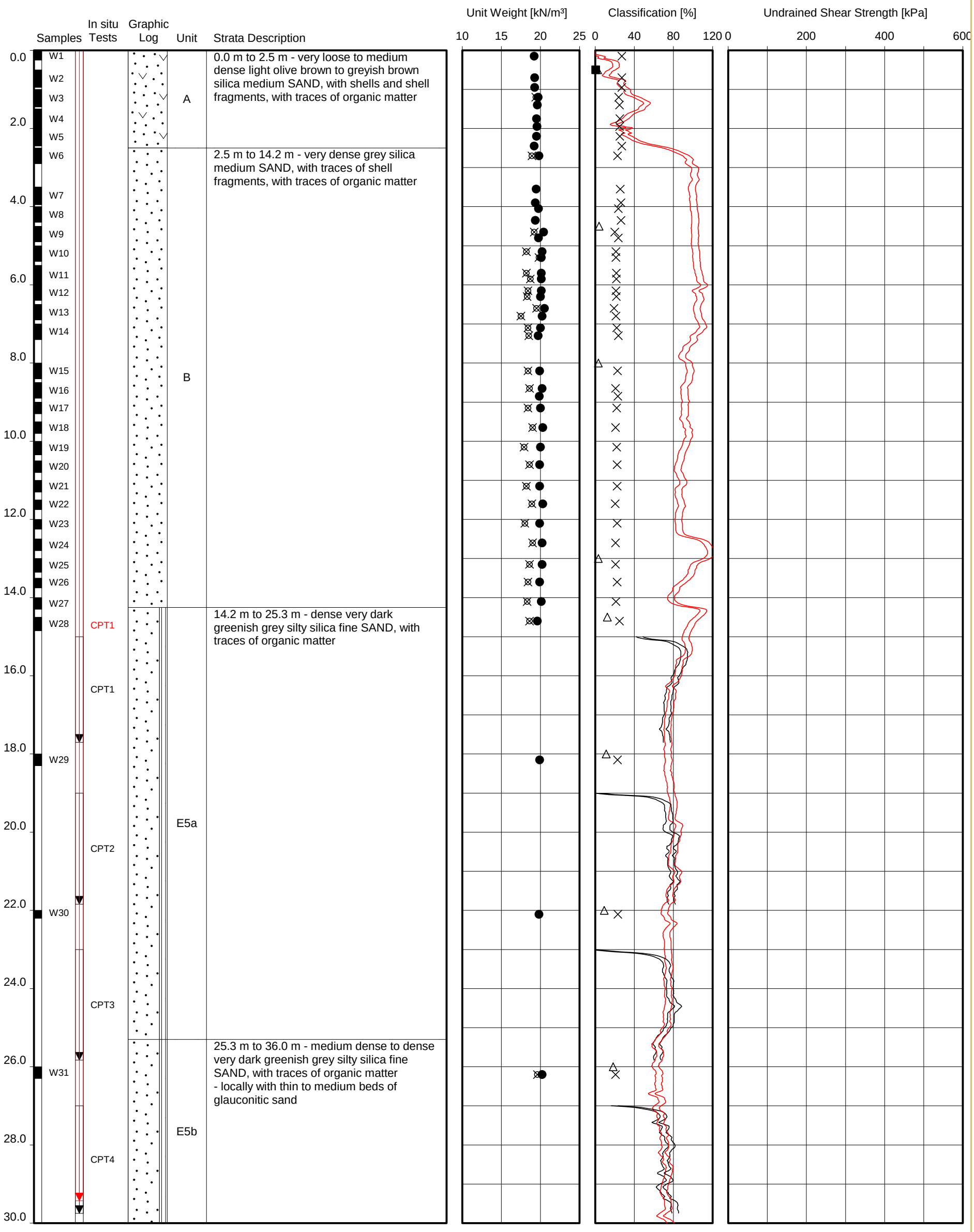
Date commenced : 29-Sep-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 50.4 m below seafloor
Penetration depth : to 50.4 m below seafloor
Water depth : 32.7 m
Coordinates : 493371 m E 5730553 m N

Location(s):
BH-WFS4-4
CPT_WFS4_4

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
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- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



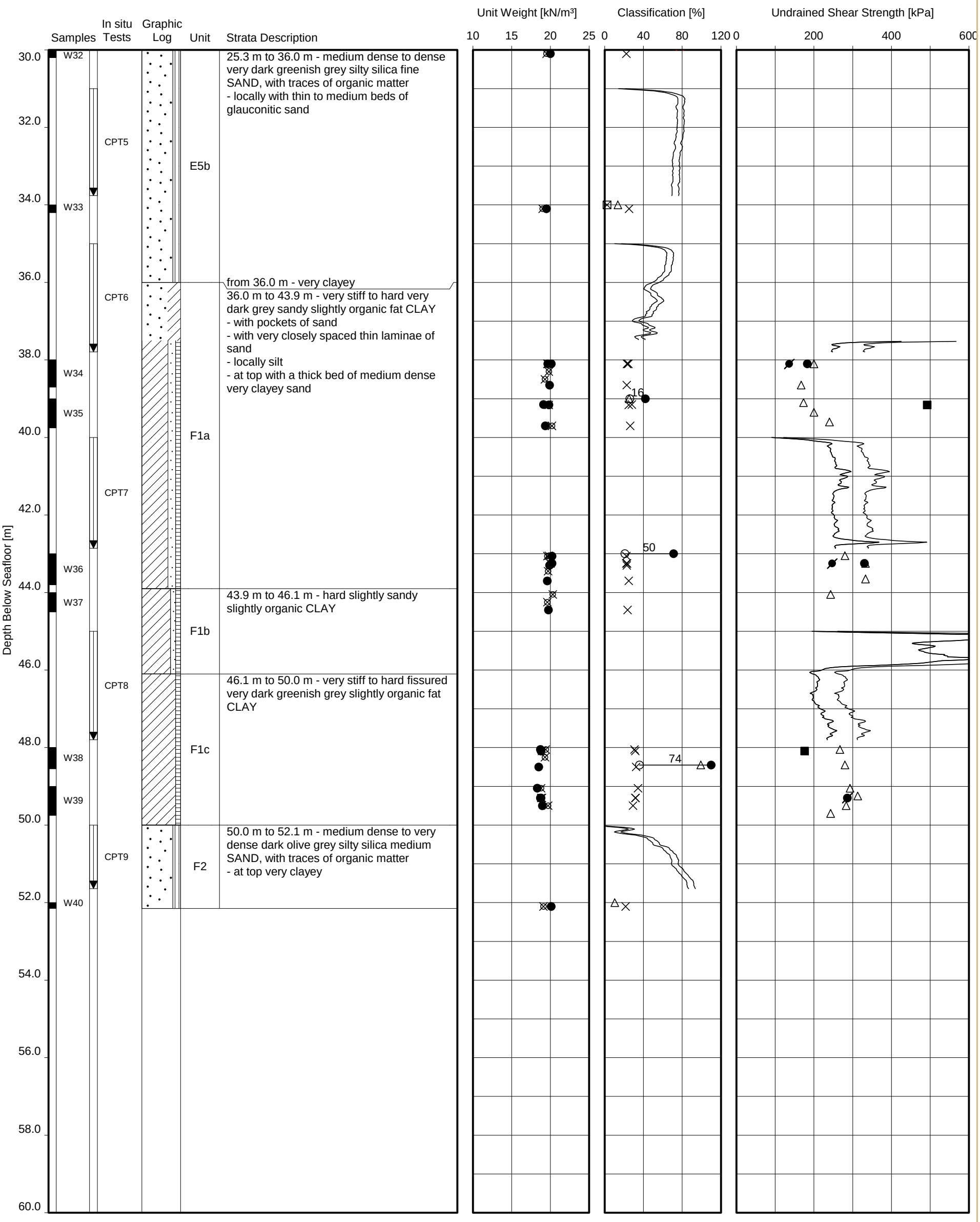
Date commenced : 28-Sep-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 52.2 m below seafloor
Penetration depth : to 52.2 m below seafloor
Water depth : 35.8 m
Coordinates : 495145 m E 5730213 m N

Location(s):
BH-WFS4-5
CPT_WFS4_5

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



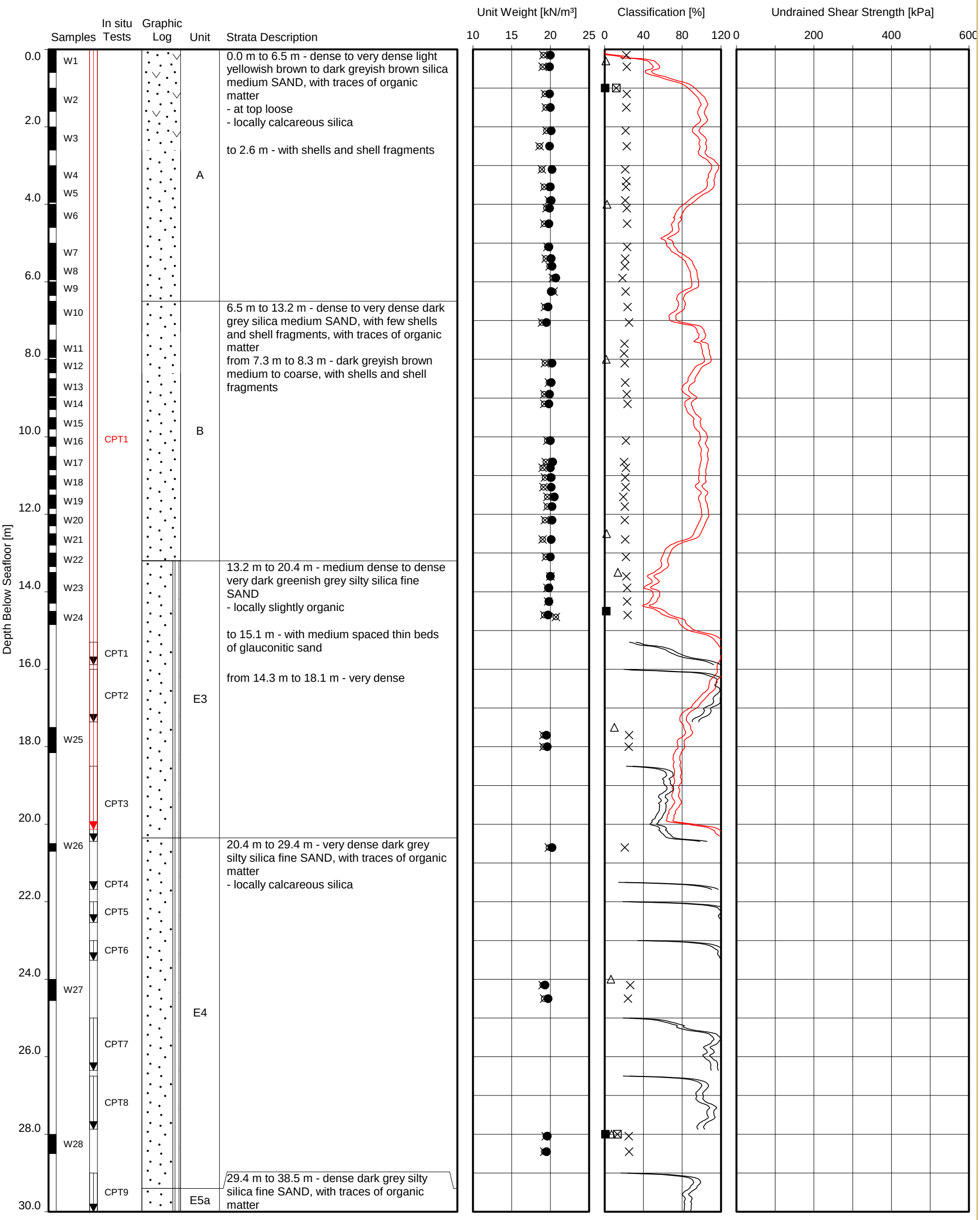
Date commenced : 28-Sep-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 52.2 m below seafloor
Penetration depth : to 52.2 m below seafloor
Water depth : 35.8 m
Coordinates : 495145 m E 5730213 m N

Location(s):
BH-WFS4-5
CPT_WFS4_5

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



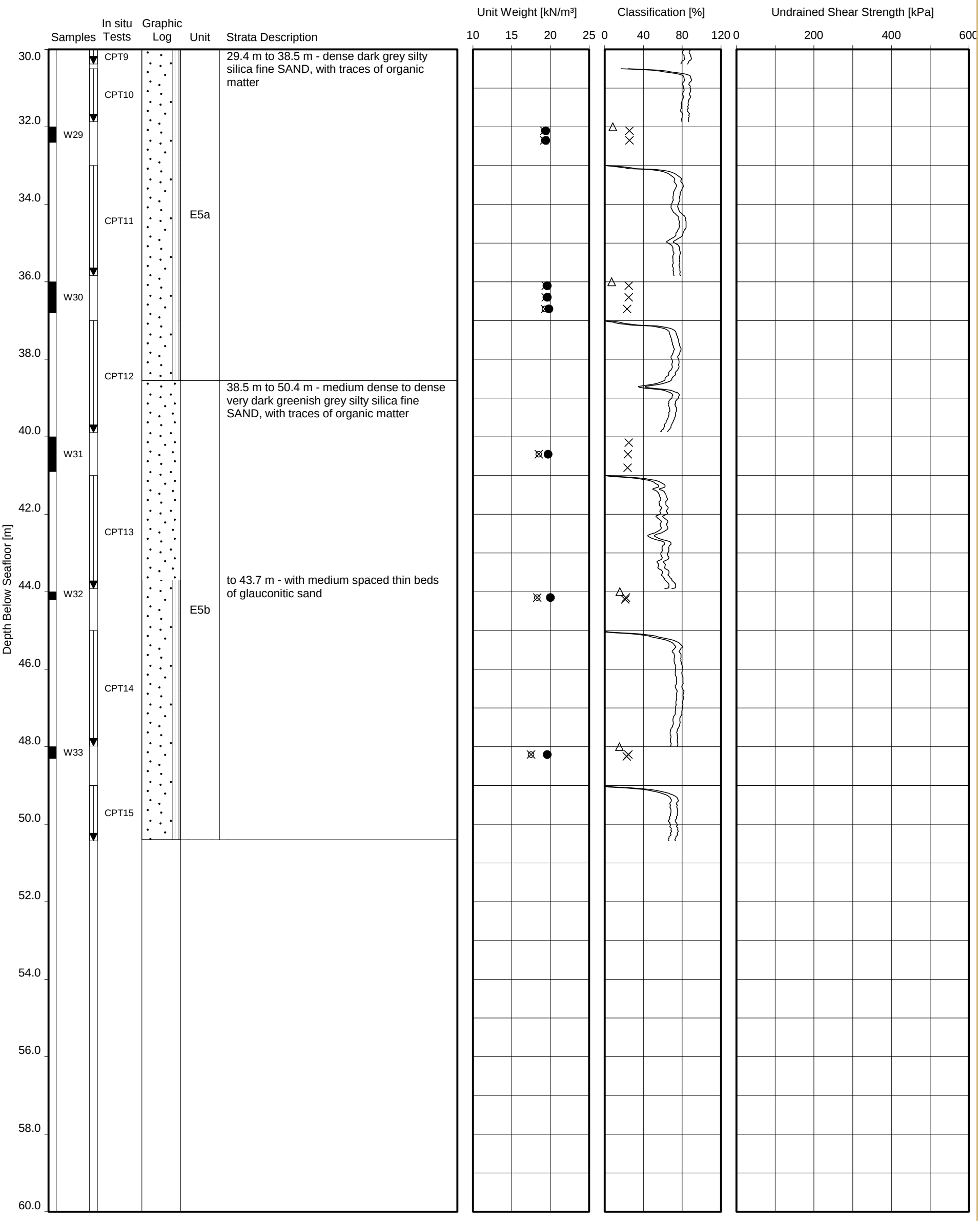
Date commenced : 04-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 50.4 m below seafloor
Penetration depth : to 50.4 m below seafloor
Water depth : 29.8 m
Coordinates : 493593 m E 5734621 m N

Location(s):
BH-WFS4-6
CPT_WFS4_6

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



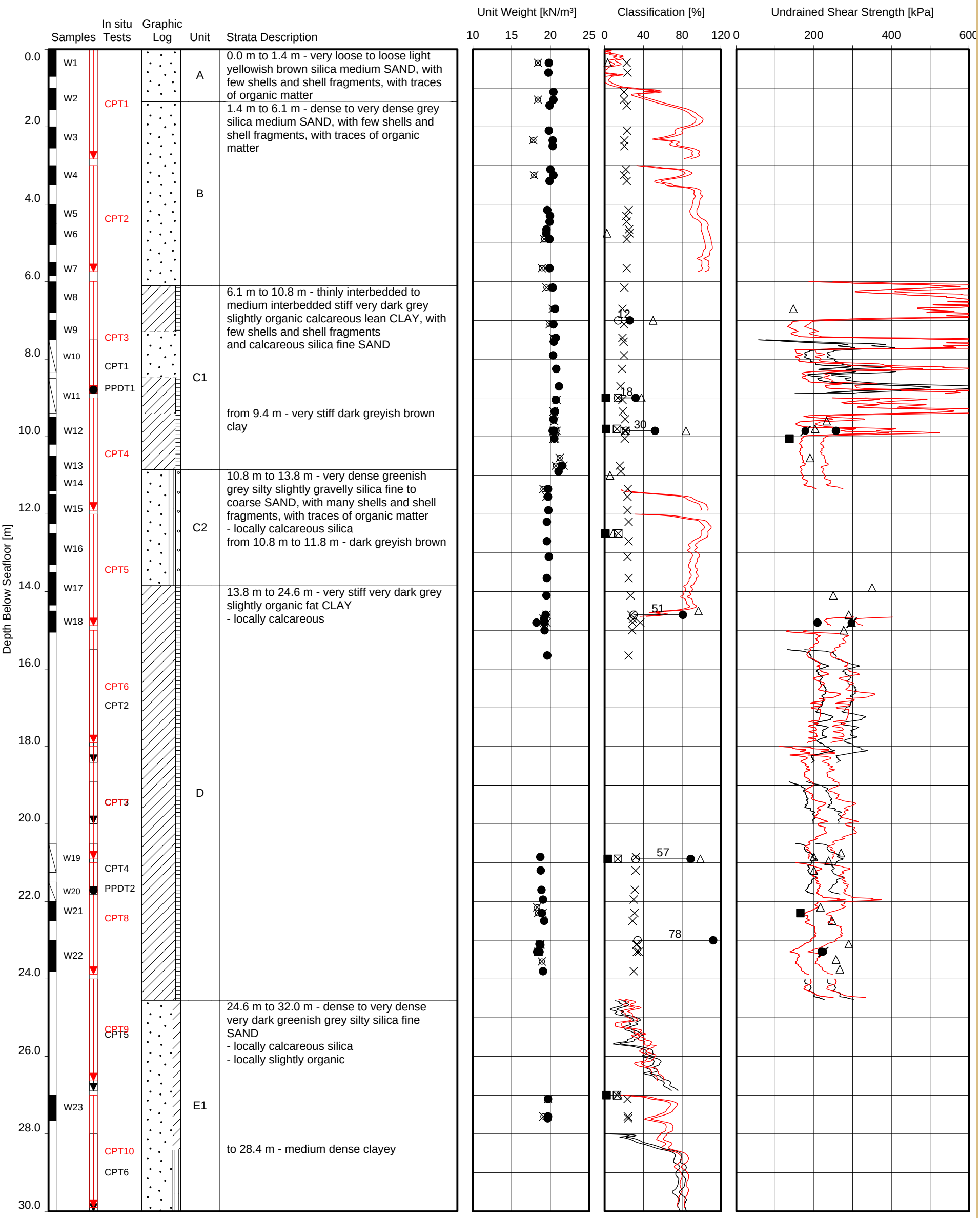
Date commenced : 04-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 50.4 m below seafloor
Penetration depth : to 50.4 m below seafloor
Water depth : 29.8 m
Coordinates : 493593 m E 5734621 m N

Location(s):
BH-WFS4-6
CPT_WFS4_6

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



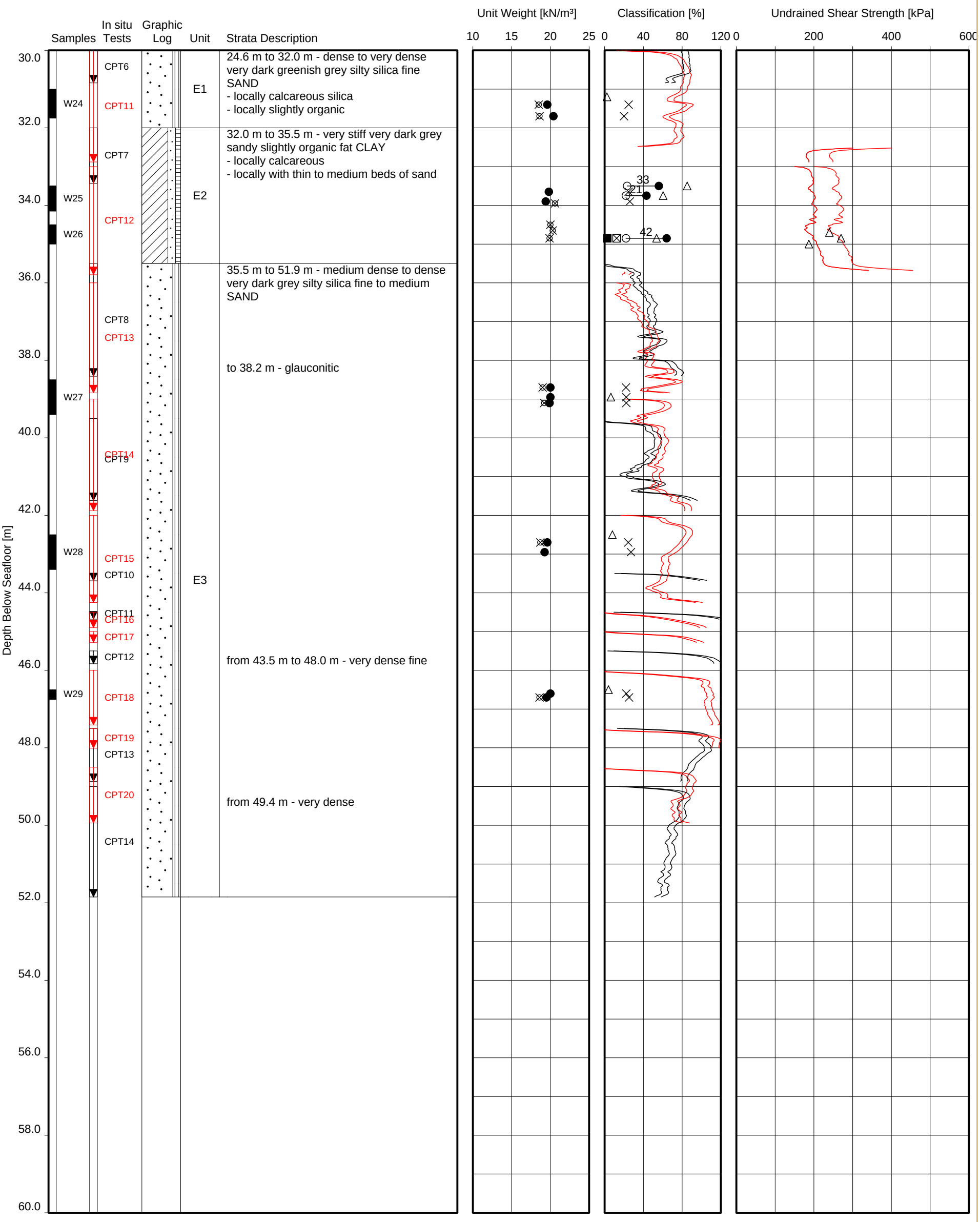
Date commenced : 05-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.9 m below seafloor
Penetration depth : to 51.9 m below seafloor
Water depth : 34.7 m
Coordinates : 498779 m E 5736551 m N

Location(s):
BH-WFS4-7
CPT_WFS4_7

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



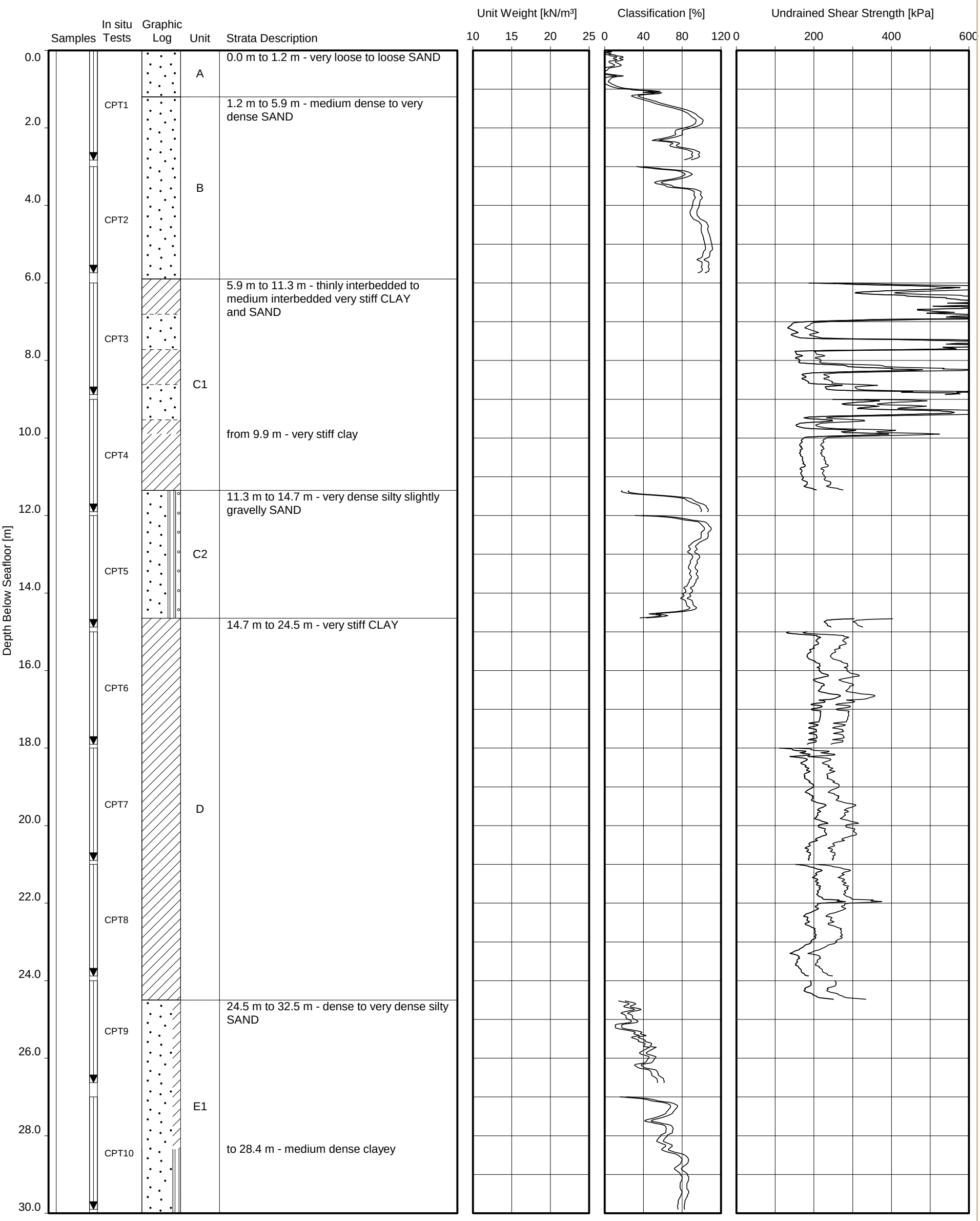
Date commenced : 05-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.9 m below seafloor
Penetration depth : to 51.9 m below seafloor
Water depth : 34.7 m
Coordinates : 498779 m E 5736551 m N

Location(s):
BH-WFS4-7
CPT_WFS4_7

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



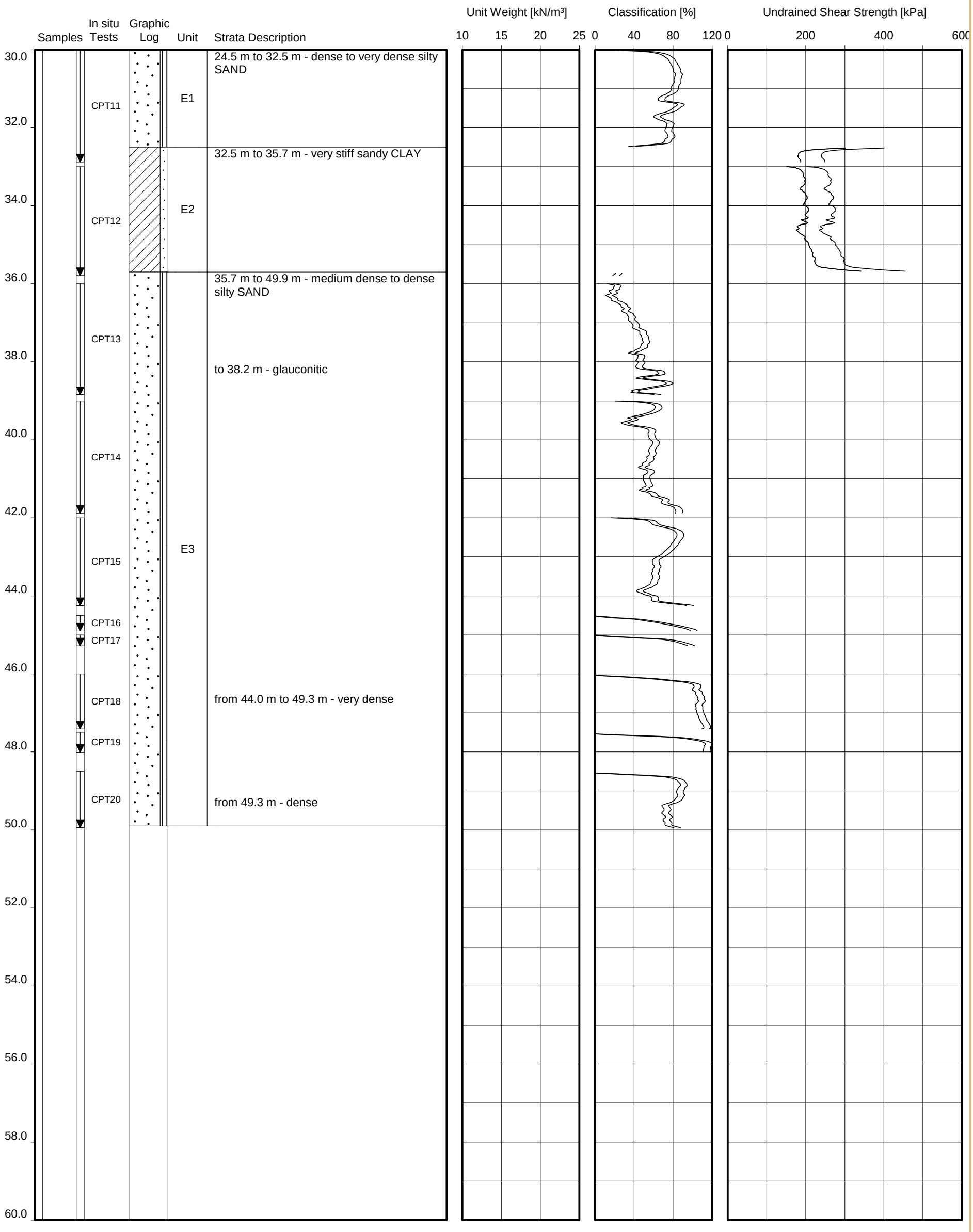
Date commenced : 13-Sep-2015
Method : Rotary borehole drilling and testing
Recovery depth : to 49.9 m below seafloor
Penetration depth : to 49.9 m below seafloor
Water depth : 34.8 m
Coordinates : 498785 m E 5736557 m N

Location(s):
CPT_WFS4_7

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



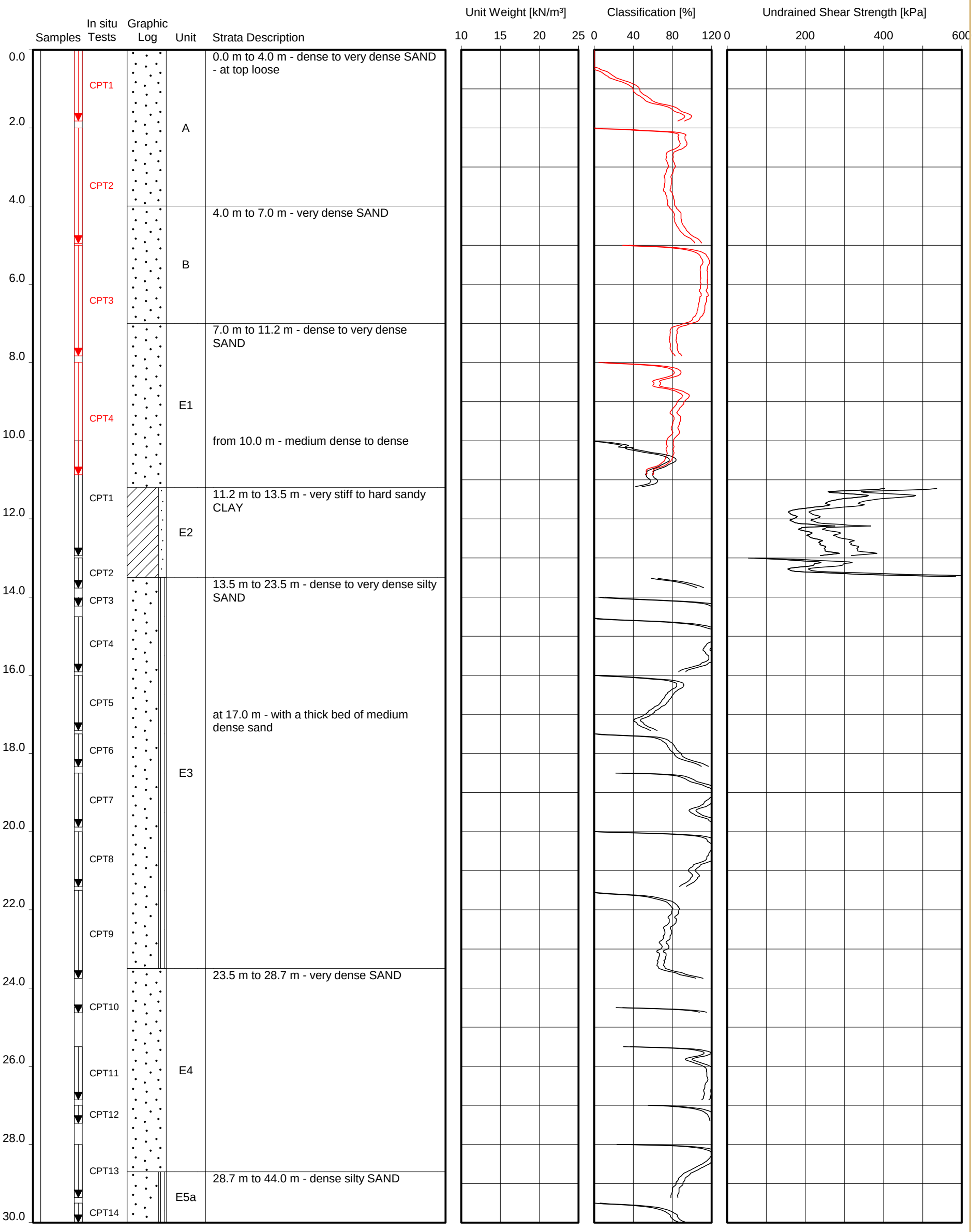
Date commenced : 13-Sep-2015
Method : Rotary borehole drilling and testing
Recovery depth : to 49.9 m below seafloor
Penetration depth : to 49.9 m below seafloor
Water depth : 34.8 m
Coordinates : 498785 m E 5736557 m N

Location(s):
CPT_WFS4_7

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



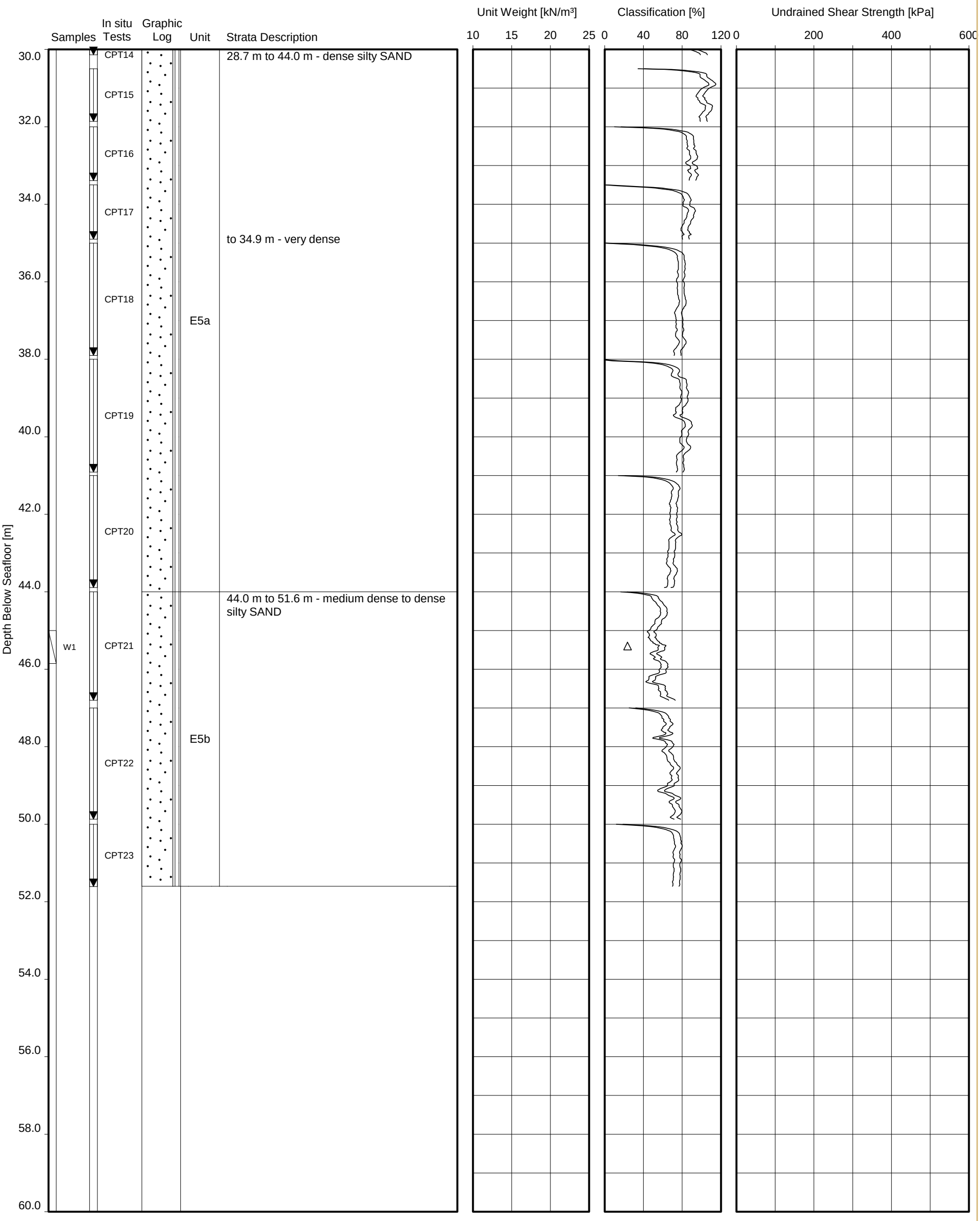
Date commenced : 07-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.6 m below seafloor
Penetration depth : to 51.6 m below seafloor
Water depth : 34.4 m
Coordinates : 495295 m E 5733549 m N

Location(s):
CPT_WFS4_18A
CPT_WFS4_18

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



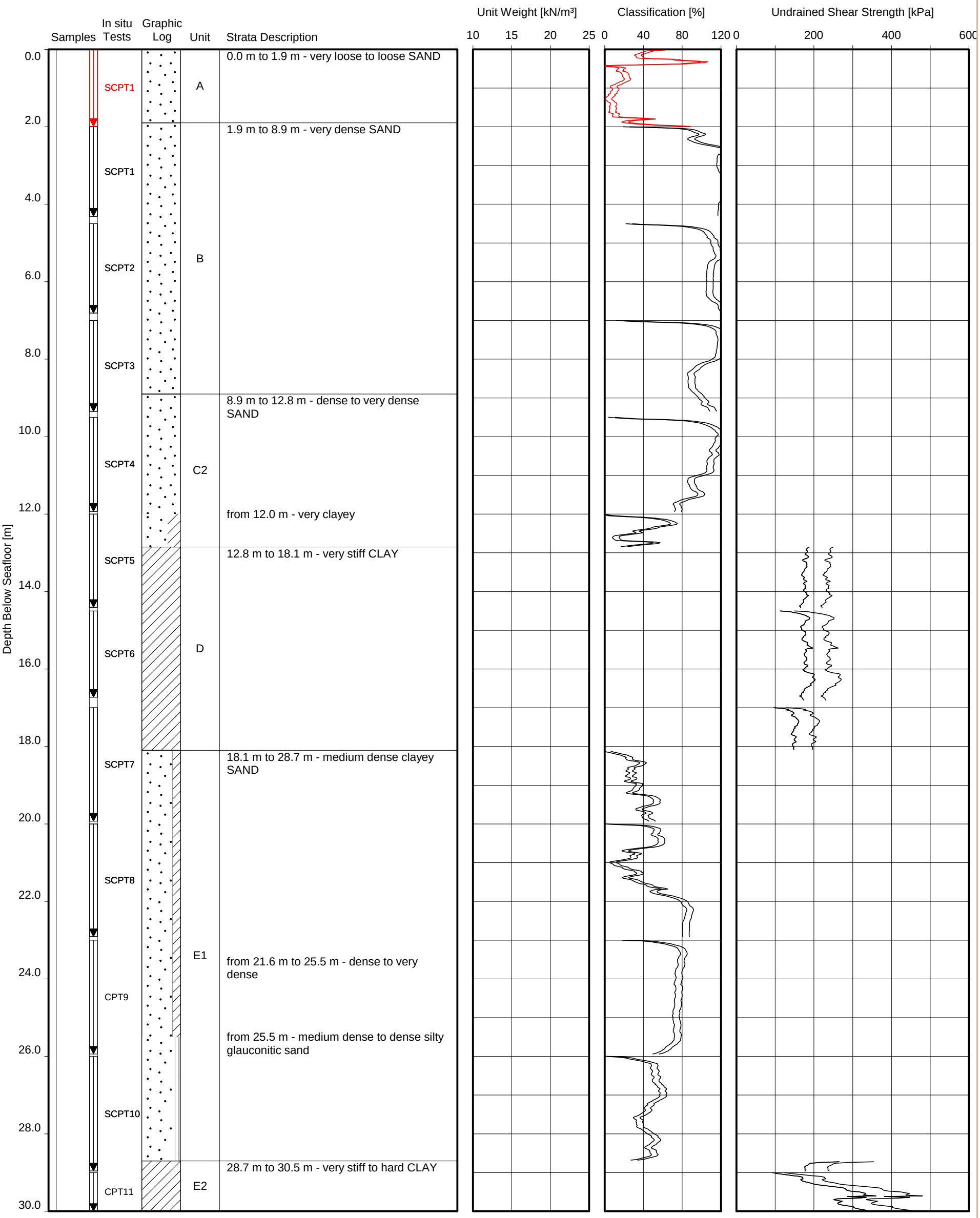
Date commenced : 07-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.6 m below seafloor
Penetration depth : to 51.6 m below seafloor
Water depth : 34.4 m
Coordinates : 495295 m E 5733549 m N

Location(s):
CPT_WFS4_18A
CPT_WFS4_18

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



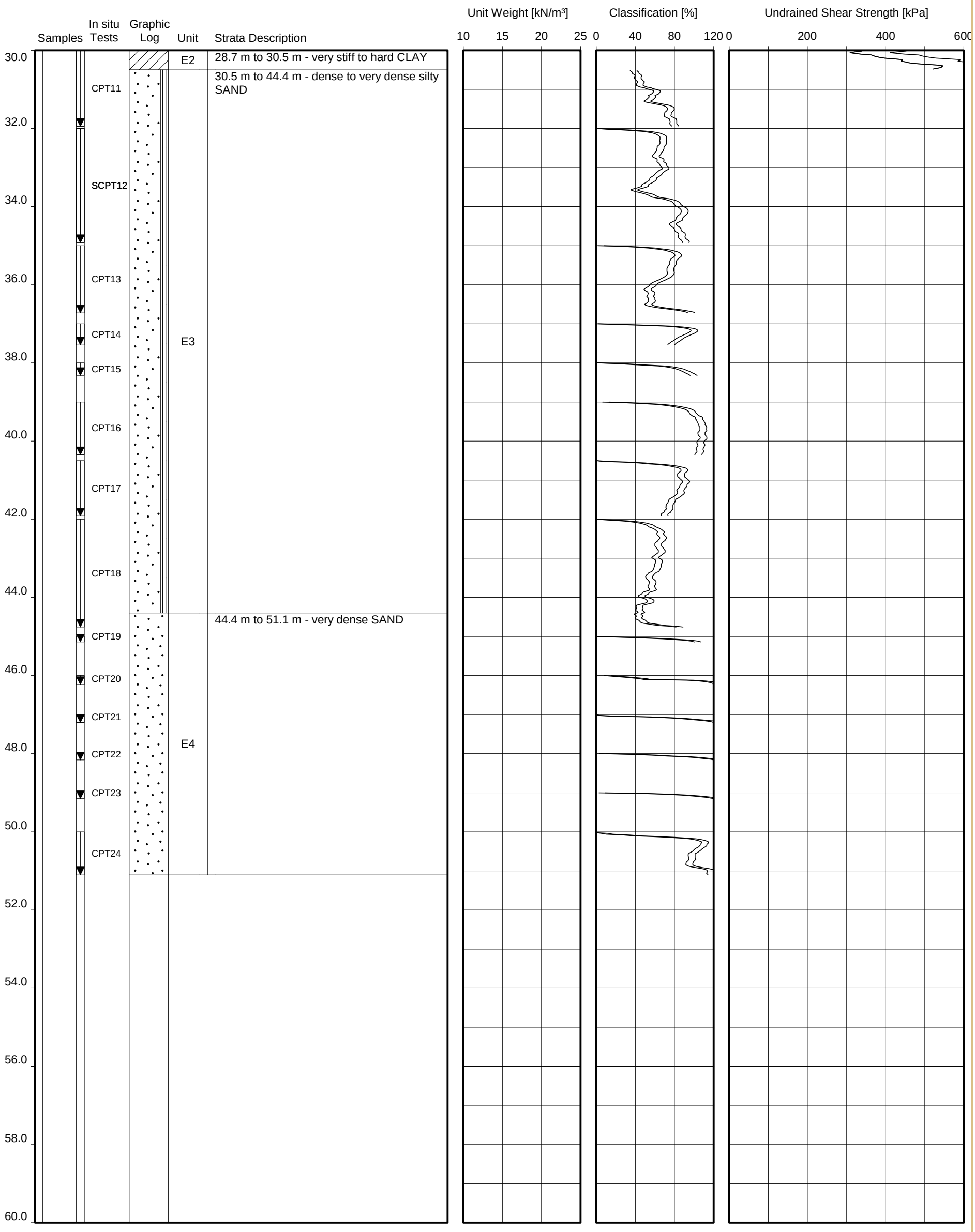
Date commenced : 08-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.1 m below seafloor
Penetration depth : to 51.1 m below seafloor
Water depth : 31.7 m
Coordinates : 497757 m E 5735303 m N

Location(s):
CPT_WFS4_21A
CPT_WFS4_21

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
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- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



Date commenced : 08-Oct-2015
Method : Rotary borehole drilling, sampling and testing
Recovery depth : to 51.1 m below seafloor
Penetration depth : to 51.1 m below seafloor
Water depth : 31.7 m
Coordinates : 497757 m E 5735303 m N

Location(s):
CPT_WFS4_21A
CPT_WFS4_21

- Unit weight derived from water content
- Unit weight derived from volume mass calculation
- Unit weight derived from CPT (Mayne 2010)
- Water content
- Plastic limit
- Liquid limit
- Plasticity index
- Percentage fines
- Carbonate content
- Organic content
- Relative density derived from CPT
- Pocket penetrometer
- Torvane
- Fallcone
- Hand vane
- Laboratory vane
- UU-triaxial
- CU-triaxial
- Direct simple shear
- In situ vane shear test
- Undrained shear strength derived from CPT
- Slashed symbol refers to test on remoulded soil

GEOTECHNICAL LOG

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SECTION B: IN SITU TEST RESULTS

SECTION B1: CONE PENETRATION TESTS
SECTION B2: SEISMIC CONE PENETRATION TESTS
SECTION B3: PORE PRESSURE DISSIPATION TESTS

SECTION B1: CONE PENETRATION TESTS

TEXT – SECTION B1: Page

B1. CONE PENETRATION TESTS

B1.1 COMMENTS ON RESULTS B1-1 to B1-2

B1.2 PRACTICE FOR CONE PENETRATION TEST B1-3 to B1-4

LIST OF PLATES IN SECTION B1: Plate

WFS4-1

CPT_WFS4_1

Cone Penetration Test; q_c, f_s and u_2 B1-1 to B1-3

Cone Penetration Test; q_t, q_n, R_f and B_q B1-4 to B1-6

Parameter Values for Net Cone Resistance Calculation B1-7

Cone Penetration Test: Zero Load Drift B1-8

CPT_WFS4_1A

Cone Penetration Test; q_c, f_s and u_2 B1-9 to B1-10

Cone Penetration Test; q_t, q_n, R_f and B_q B1-11 to B1-12

Parameter Values for Net Cone Resistance Calculation B1-13

Cone Penetration Test: Zero Load Drift B1-14

BH-WFS4-1A

Cone Penetration Test; q_c, f_s and u_2 B1-15 to B1-17

Cone Penetration Test; q_t, q_n, R_f and B_q B1-18 to B1-20

Parameter Values for Net Cone Resistance Calculation B1-21

Cone Penetration Test: Zero Load Drift B1-22

WFS4-2A

BH-WFS4-2A

Cone Penetration Test; q_c, f_s and u_2 B1-23 to B1-25

Cone Penetration Test; q_t, q_n, R_f and B_q B1-26 to B1-28

Parameter Values for Net Cone Resistance Calculation B1-29

Cone Penetration Test: Zero Load Drift B1-30

WFS4-3

BH-WFS4-3

Cone Penetration Test; q_c, f_s and u_2 B1-31 to B1-33

Cone Penetration Test; q_t, q_n, R_f and B_q B1-34 to B1-36

Parameter Values for Net Cone Resistance Calculation B1-37

Cone Penetration Test: Zero Load Drift B1-38

LIST OF PLATES IN SECTION B1: Plate

WFS4-4

BH- WFS4-4

Cone Penetration Test; q_c, f_s and u_2 B1-39 to B1-41

Cone Penetration Test; q_t, q_n, R_f and B_q B1-42 to B1-44

Parameter Values for Net Cone Resistance Calculation B1-45

Cone Penetration Test: Zero Load Drift B1-46

WFS4-5

BH- WFS4-5

Cone Penetration Test; q_c, f_s and u_2 B1-47 to B1-49

Cone Penetration Test; q_t, q_n, R_f and B_q B1-50 to B1-52

Parameter Values for Net Cone Resistance Calculation B1-53

Cone Penetration Test: Zero Load Drift B1-54

WFS4-6

BH-WFS4-6

Cone Penetration Test; q_c, f_s and u_2 B1-55 to B1-57

Cone Penetration Test; q_t, q_n, R_f and B_q B1-58 to B1-60

Parameter Values for Net Cone Resistance Calculation B1-61

Cone Penetration Test: Zero Load Drift B1-62

WFS4-7

CPT_WFS4_7

Cone Penetration Test; q_c, f_s and u_2 B1-63 to B1-66

Cone Penetration Test; q_t, q_n, R_f and B_q B1-67 to B1-70

Parameter Values for Net Cone Resistance Calculation B1-71

Cone Penetration Test: Zero Load Drift B1-72

BH-WFS4-7

Cone Penetration Test; q_c, f_s and u_2 B1-73 to B1-76

Cone Penetration Test; q_t, q_n, R_f and B_q B1-77 to B1-80

Parameter Values for Net Cone Resistance Calculation B1-81

Cone Penetration Test: Zero Load Drift B1-82

LIST OF PLATES IN SECTION B1: Plate

WFS4-18

CPT_WFS4_18
Cone Penetration Test; q_c, f_s and u_2 B1-83
Cone Penetration Test; q_t, q_n, R_f and B_q B1-84
Parameter Values for Net Cone Resistance Calculation B1-85
Cone Penetration Test: Zero Load Drift B1-86

CPT_WFS4_18A
Cone Penetration Test; q_c, f_s and u_2 B1-87 to B1-90
Cone Penetration Test; q_t, q_n, R_f and B_q B1-91 to B1-94
Parameter Values for Net Cone Resistance Calculation B1-95
Cone Penetration Test: Zero Load Drift B1-96

WFS4-21

CPT_WFS4_21
Cone Penetration Test; q_c, f_s and u_2 B1-97
Cone Penetration Test; q_t, q_n, R_f and B_q B1-98
Parameter Values for Net Cone Resistance Calculation B1-99
Cone Penetration Test: Zero Load Drift B1-100

CPT_WFS4_21A
Cone Penetration Test; q_c, f_s and u_2 B1-101 to B1-104
Cone Penetration Test; q_t, q_n, R_f and B_q B1-105 to B1-108
Parameter Values for Net Cone Resistance Calculation B1-109
Cone Penetration Test: Zero Load Drift B1-110

B1. CONE PENETRATION TESTS

B1.1 COMMENTS ON RESULTS

Test results are within expected ranges considering soil conditions and regional experience. Cone Penetration Test (CPT)-derived values and interpretations are in line with other data sources, e.g. laboratory test data.

CPTs were performed using penetrometers with a 500 mm^2 (CP5) cone tip or a 1000 mm^2 (CP10) cone tip area, which measure cone resistance (q_c) and sleeve friction (f_s). The CP10 cone additionally measures pore pressure at the shoulder of the cone (u_2). Calculated cone values such as net cone resistance (q_n), total cone resistance (q_t) and pore pressure ratio (B_q) are therefore presented only for the CPTs performed with the CP10 cones, as these parameters require the pore pressure to be calculated. CP5 cones were used if very dense sands were expected due to its more robust design allowing a higher thrust to be applied onto the cone. This gives typically additional penetration, compared to a CP10 cone and minimises the risk of damage to equipment.

A value of 10 kN/m^3 was used for the average unit weight of seawater and the unit weight of the drill fluid for calculating the theoretical hydrostatic pressure at the bottom of a borehole. The hydrostatic pressure is compared with u_2 cone measurements prior to testing and is used when calculating the total cone resistance.

Soil unit weight is assessed per unit, based on test data from the various borehole locations within WFS IV and information about the regional geology, and is presented on plates titled “Parameter Values for Net Cone Resistance Calculation”. The unit weight is used as an input for calculations of the effective vertical stress used to calculate the net cone resistance. Measured unit weight in coarse-grained cohesionless layers is less accurate than in fine-grained cohesive layers due to sample disturbance. Selected unit weight values also consider other factors such as grain size distribution and relative density.

Deck measurements, referred to as “zero reading”, were taken before the start and after the end of each test to check the cone performance during testing and condition of the equipment. Plates titled “Cone Penetration Test: Zero Load Drift” present the results of this comparison. This zero load verification showed satisfactory cone performance during testing at the various locations. Data recording was accidently started late at location CPT_WFS4_1 in SCPT_6, and therefore zero readings at the start of the test are not representative. Zero load drift is therefore not presented for this test. Comparison was made with the zero loads of the next SCPT and test data of SCPT_6 were assessed to be reliable.

Typically, CPTs show negative pore pressures upon penetration of dense to very dense and/or (silty) fine sands. This is not uncommon. This is primarily related to the piezo-cone filter located at the cylindrical extension above the base of the cone (u_2 location). During cone penetration negative pore pressures exist around the u_2 location (Lunne et al., 1997)[1] such that cavitation occurs. Particularly, this may occur at the time of penetration of dense sands, silty fine sands or overconsolidated clay layers. Loss of saturation usually causes a negative or sluggish pore pressure response during penetration of ground below the zone causing desaturation of the pore pressure filter around the pressure sensor. Negative pore pressure measurements affect derived values such as

[1] Lunne, T., Robertson, P.K. and Powell, J.J.M. (1997), “Cone Penetration Testing in Geotechnical Practice”, Blackie Academic & Professional, London.

net cone resistance and pore pressure ratio. The influence of the negative pore pressure is to be considered when using the derived values.

Various CPTs show high sleeve friction values, for example in boreholes BH-WFS4-4 in CPT_5, BH-WFS4-7 in CPT_8, and BH-WFS4-21A in SCPT_10. This behaviour is believed to be the result of crushing of glauconite particles during cone penetration. Typical CPT behaviour may be described by a relatively constant cone resistance and high (increased) sleeve friction values. It may be noted that the geological formations in which the high sleeve friction values were observed, have been reported to contain significant quantities of glauconite (Alboom et al., 2012)[1]. Samples were taken in selected boreholes from zones where high sleeve friction values were observed. These samples have been tested for the presence of glauconite.

[1] Alboom, G. van, Dupont, H., Maertens, J. and Haelterma, K. (2012), "Glauconiethoudende zanden", Geotechniek, Vol. 16, No. 2, pp. 32-37.

B1.2 PRACTICE FOR CONE PENETRATION TEST

Test Control – Penetration

General Procedure:	– According to ISO (2014) – Refer to document titled “Cone Penetration Test” presented in Appendix 1
Metrological Confirmation:	Refer to document titled “Metrological Confirmation System for In Situ Test” presented in Appendix 1
Target Application Class:	Class 3 of ISO (2014), refer to document titled “Cone Penetration Test” presented in Appendix 1
Set-up Stage:	Location as directed by Client
Additional Measurements:	– Seismic downhole testing in accordance with sub-section "Practice for SCPT” presented in Section B2 – Pore pressure dissipation in accordance with sub-section “Practice for In Situ Pore Pressure Dissipation Test” presented in Section B3
Test Stage:	Refer to document titled “Geotechnical Borehole” presented in Appendix 1
Test Termination:	Refer to document titled “Cone Penetration Test” presented in Appendix 1
Drill-Out:	Refer to document titled “Geotechnical Borehole” presented in Appendix 1
Test Site Restoration:	Refer to sub-section "Practice for Geotechnical Borehole" presented in Section A

CPT Apparatus

Thrust Machine:	WISON® wireline hydraulic jacking unit, nominal 100 kN thrust capacity and 1.5 m (CP5) or 3 m (CP10) stroke
Reaction Equipment:	Self-weight of drill pipes, drill collars and SEACLAM seabed frame
Push Rod:	25.5 mm (CP5) and 36 mm (CP10) push rod outer diameter
Penetrometer Type:	– CP10-CF50PB10(SN2) cone penetrometer, 50 kN load sensors (100 kN for overloading), 10 MPa pressure sensor (2.5 MPa calibration range), HDPE filter in cylindrical extension above base of cone, 1000 mm^2 cone base area, 15,000 mm^2 sleeve area, net area ratio of 0.75 ((SN2) refers to cones with non-directional inclinometer) – CP5-CF80 cone penetrometer, 90 kN load sensors (180 kN for overloading), 500 mm^2 cone base area, 10,000 mm^2 sleeve area, net area ratio of 0.5

Test Results

Data Processing and Management:	– Refer to document titled “Cone Penetration Test” presented in Appendix 1 – UNIPLOT software – Graphical scales selected to suit general presentation of data and requirements of standards, where practicable – No display of data outside of chart limits, i.e. some values may not be shown
Data Format(s):	– PDF for viewing and printing (this primary document) – ASCII (ANSI, 2007) (separate deliverables, secondary to this document)
Water Depth Reference:	Refer to sub-section "Practice for Geotechnical Log" presented in Section A
Depth Reference Level:	Seafloor, refer to sub-section "Practice for Geotechnical Borehole" (in Section A) for depth accuracy assessment
Depth Correction for Penetrometer Inclination:	Not applicable
Soil Unit Weight:	Based on laboratory test results for nearby samples and regional knowledge where available

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Parameter Values for Data Processing:	Refer to plate(s) titled “Parameter Values for Net Cone Resistance Calculation”

References

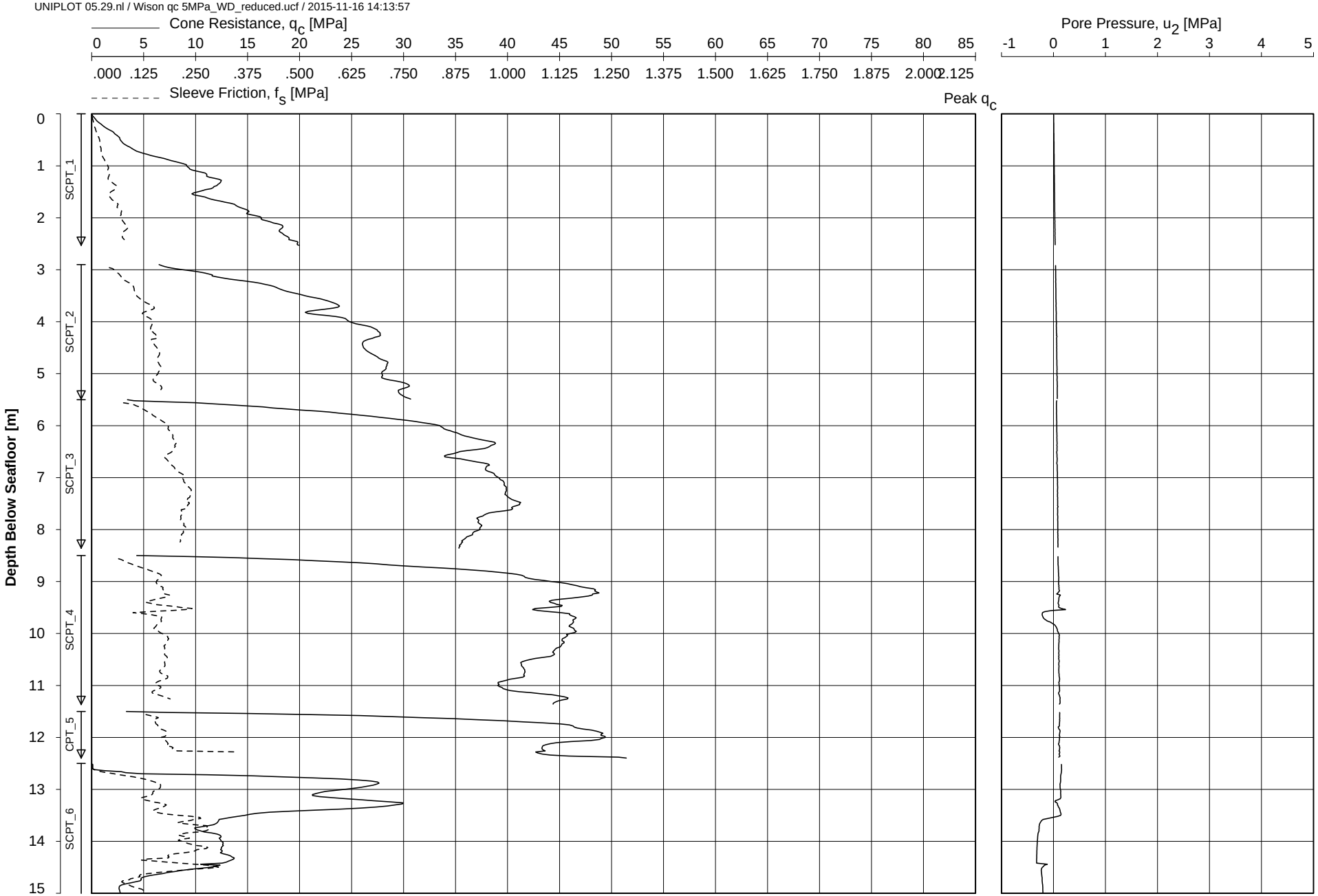
- ANSI American National Standards Institute, Inc. (2007), “Coded Character Sets – 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII), 14 June 2007.
- Computer Program UNIPLOT, Processing of CPT data
- ISO International Organization for Standardization (2014), “Petroleum and Natural Gas Industries - Specific Requirements for Offshore Structures – Part 8: Marine Soil Investigations”, International Standard ISO 19901-8:2014.

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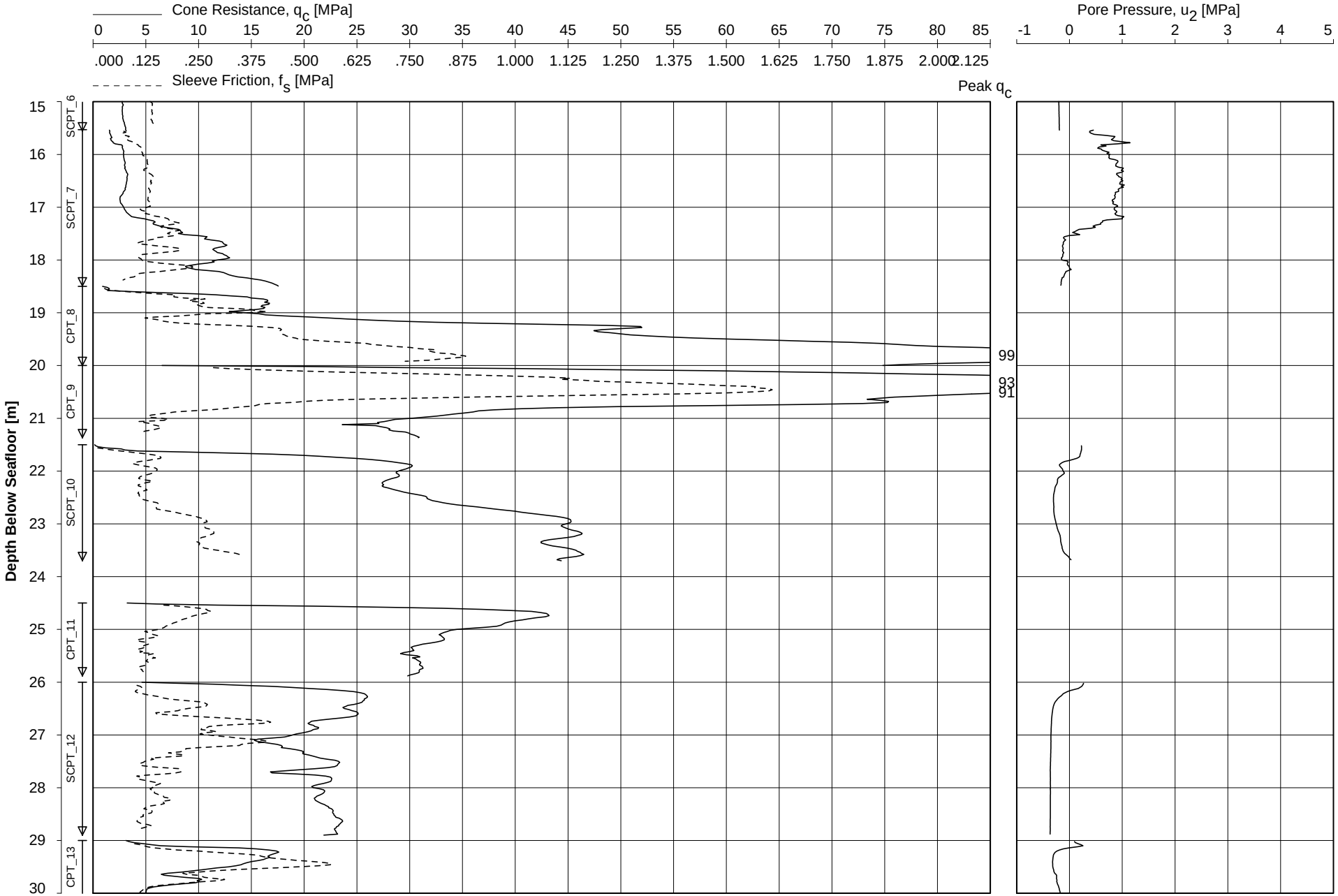
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Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486530 N5732298

CONE PENETRATION TEST

CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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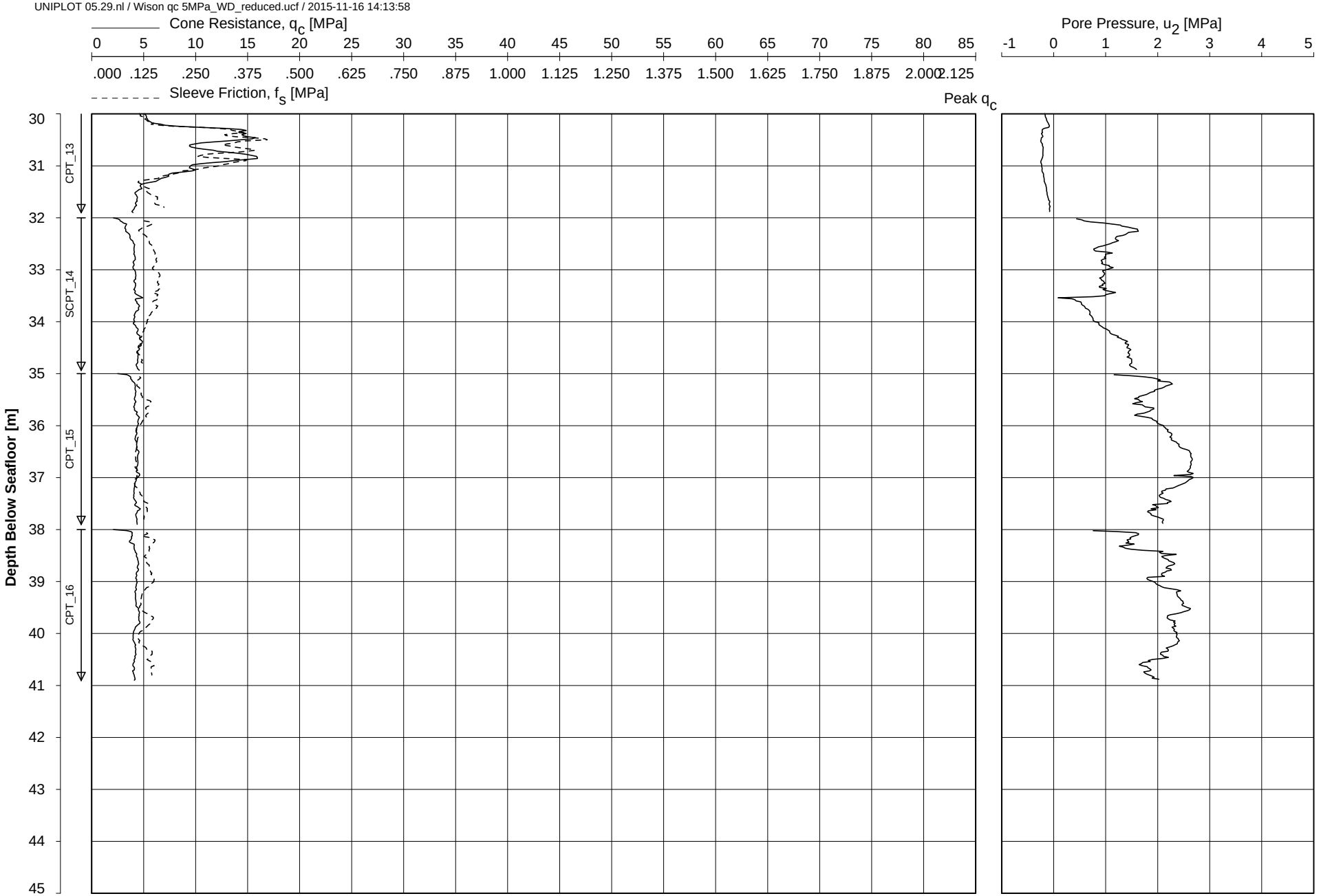
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Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486530 N5732298

CONE PENETRATION TEST

CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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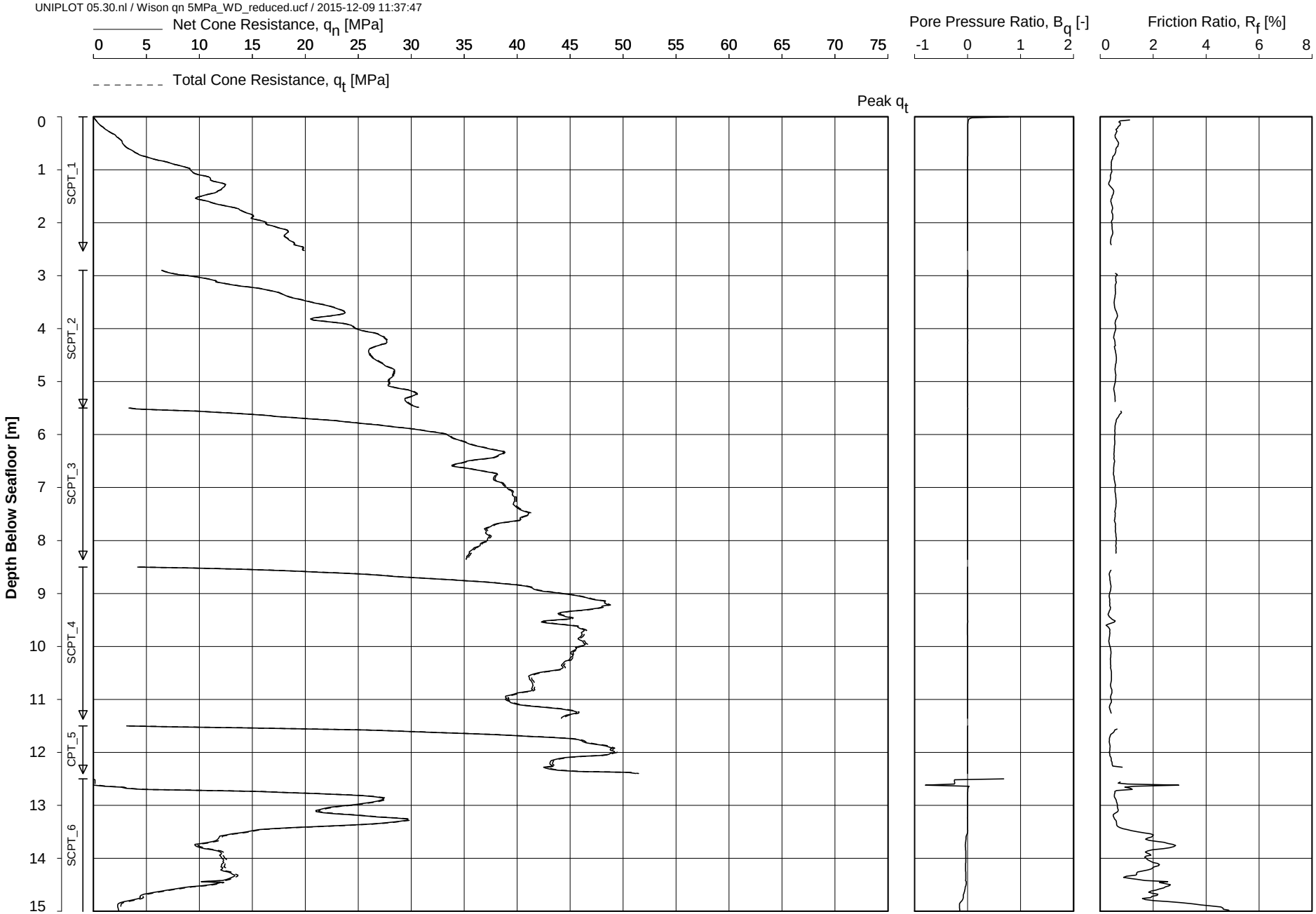
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Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486530 N5732298

CONE PENETRATION TEST

CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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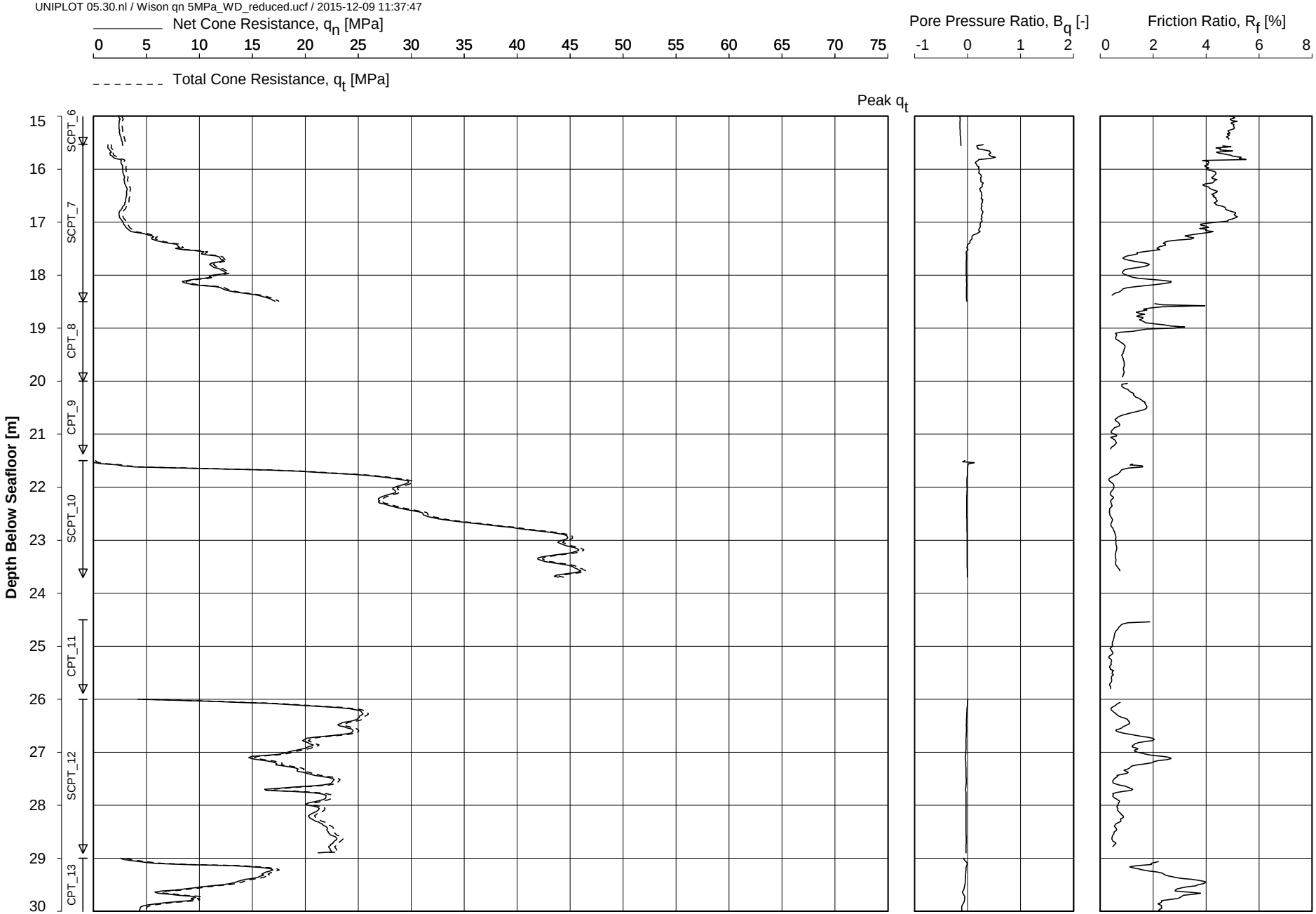
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Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486530 N5732298

CONE PENETRATION TEST

CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:37:47



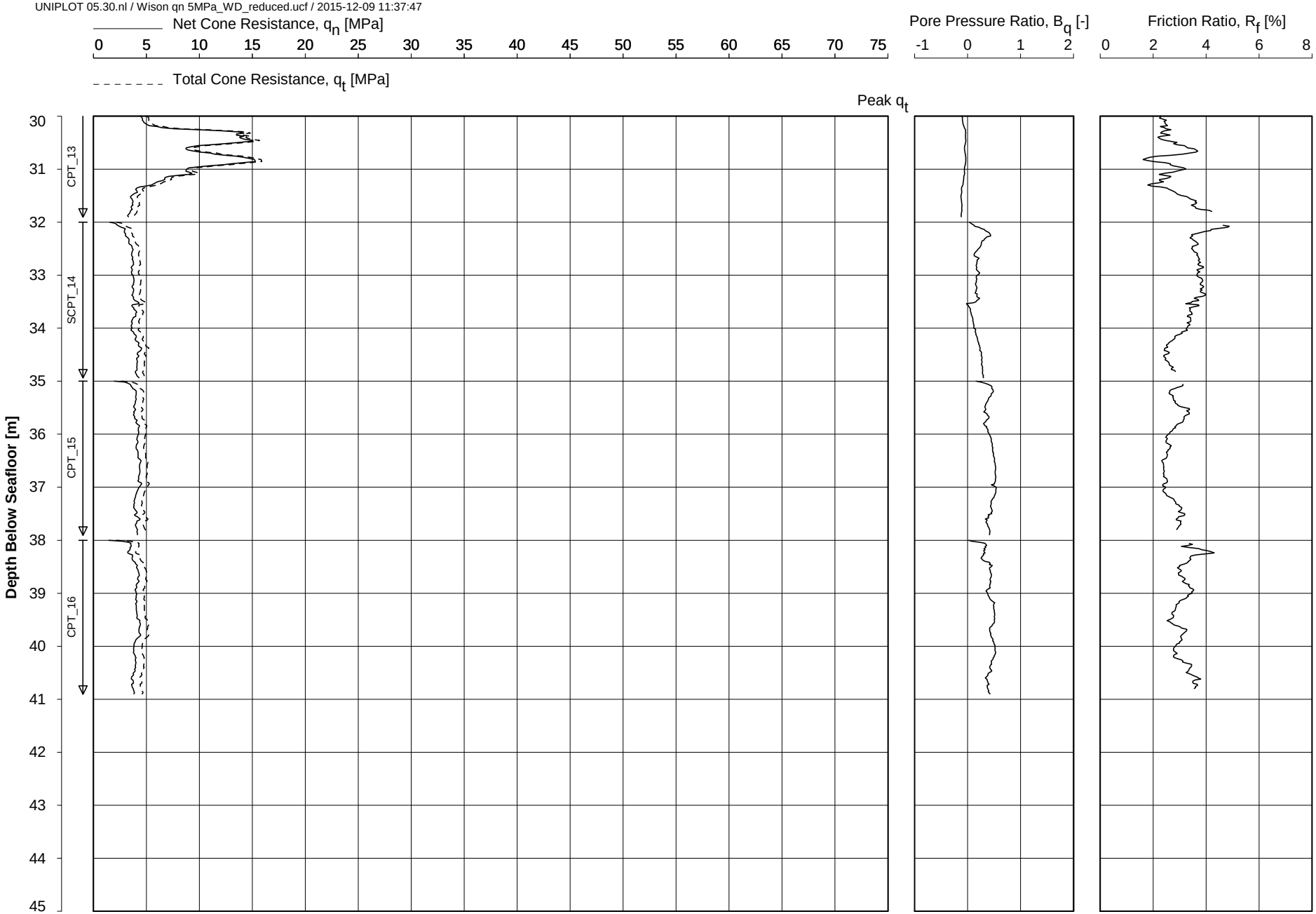
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Coordinates [m] : E486530 N5732298

CONE PENETRATION TEST

CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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Date Of Testing : 09-Oct-2015
Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486530 N5732298

CONE PENETRATION TEST

CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
CPT_WFS4_1	0.00 to 6.60 6.60 to 13.40 13.40 to 14.80 14.80 to 17.35 17.35 to 31.30 31.30 to bottom	20.00 20.50 19.50 18.50 20.00 18.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
CPT_WFS4_1	SCPT_1	0.115	-0.002	0.000	-0.032	0.001	-0.001	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_1	SCPT_2	0.112	-0.003	-0.002	-0.046	0.001	0.000	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_1	SCPT_3	0.112	-0.002	-0.002	-0.031	0.000	-0.001	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_1	SCPT_4	0.298	0.000	-0.005	-0.038	0.001	0.000	CP10-CF50PB10SN2	1706-2364	0.750
CPT_WFS4_1	CPT_5	0.287	0.001	-0.006	-0.073	-0.002	-0.001	CP10-CF50PB10SN2	1706-2364	0.750
CPT_WFS4_1	SCPT_6	---	---	---	---	---	---	CP10-CF50PB10SN2	1706-2364	0.750
CPT_WFS4_1	SCPT_7	0.262	-0.002	-0.006	-0.024	0.000	0.000	CP10-CF50PB10SN2	1706-2364	0.750
CPT_WFS4_1	CPT_8	0.104	-0.003		-0.078	0.003		CP5-CF80	1709-0002	0.500
CPT_WFS4_1	CPT_9	0.055	0.000		0.004	0.000		CP5-CF80	1709-0002	0.500
CPT_WFS4_1	SCPT_10	0.271	-0.001	-0.005	36.753	0.344	0.533	CP10-CF50PB10SN2	1706-2364	0.750
CPT_WFS4_1	CPT_11	0.074	-0.001		0.004	-0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_1	SCPT_12	0.274	-0.002	-0.005	-0.013	0.000	-0.001	CP10-CF50PB10SN2	1706-2364	0.750
CPT_WFS4_1	CPT_13	0.074	0.009	-0.003	-0.027	0.002	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_1	SCPT_14	0.276	-0.002	-0.006	0.008	-0.001	0.000	CP10-CF50PB10SN2	1706-2364	0.750
CPT_WFS4_1	CPT_15	0.057	0.012	-0.003	0.001	-0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_1	CPT_16	0.056	0.013	-0.004	1.392	-0.003	1.909	CP10-CF50PB20	1706-2185	0.750

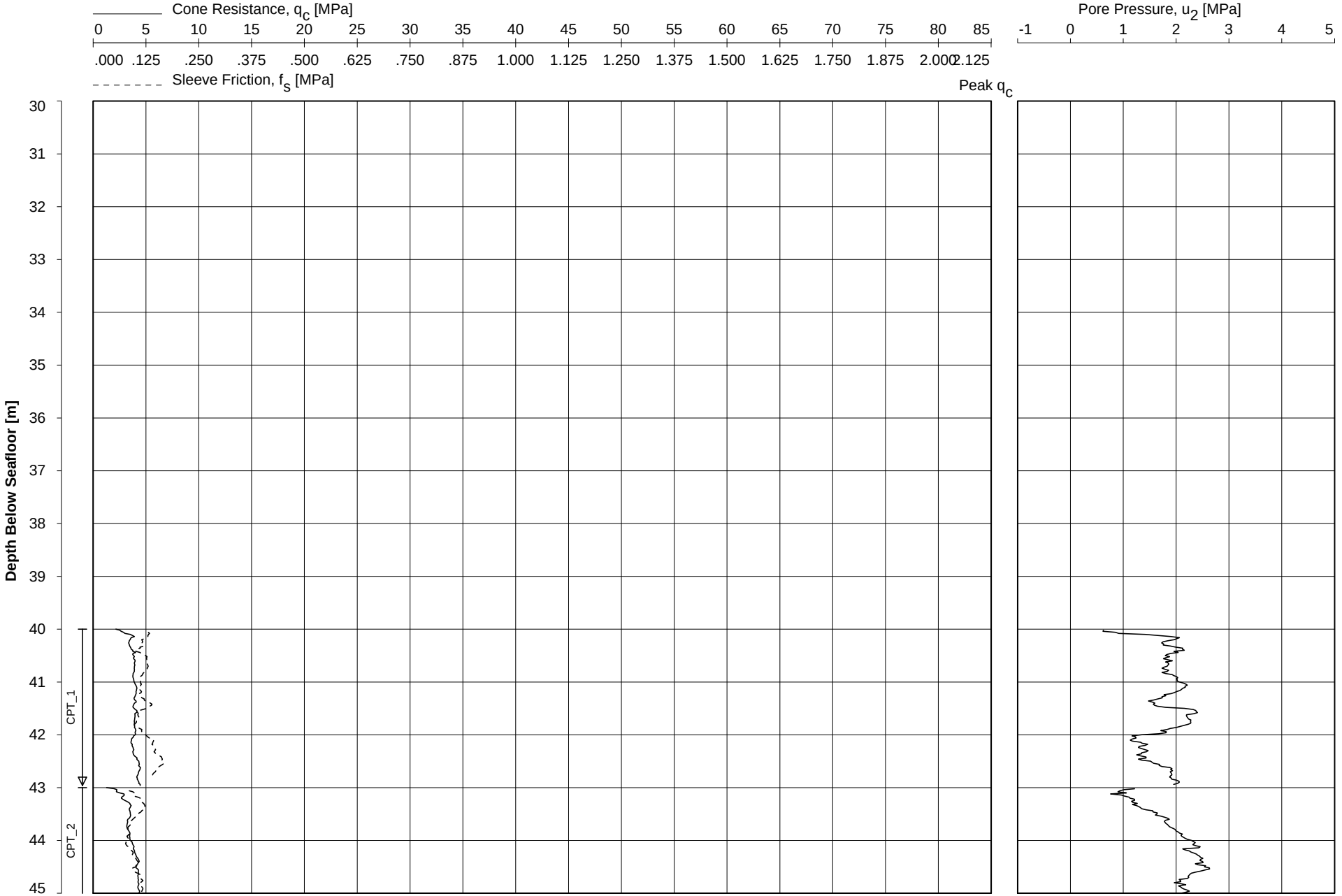
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

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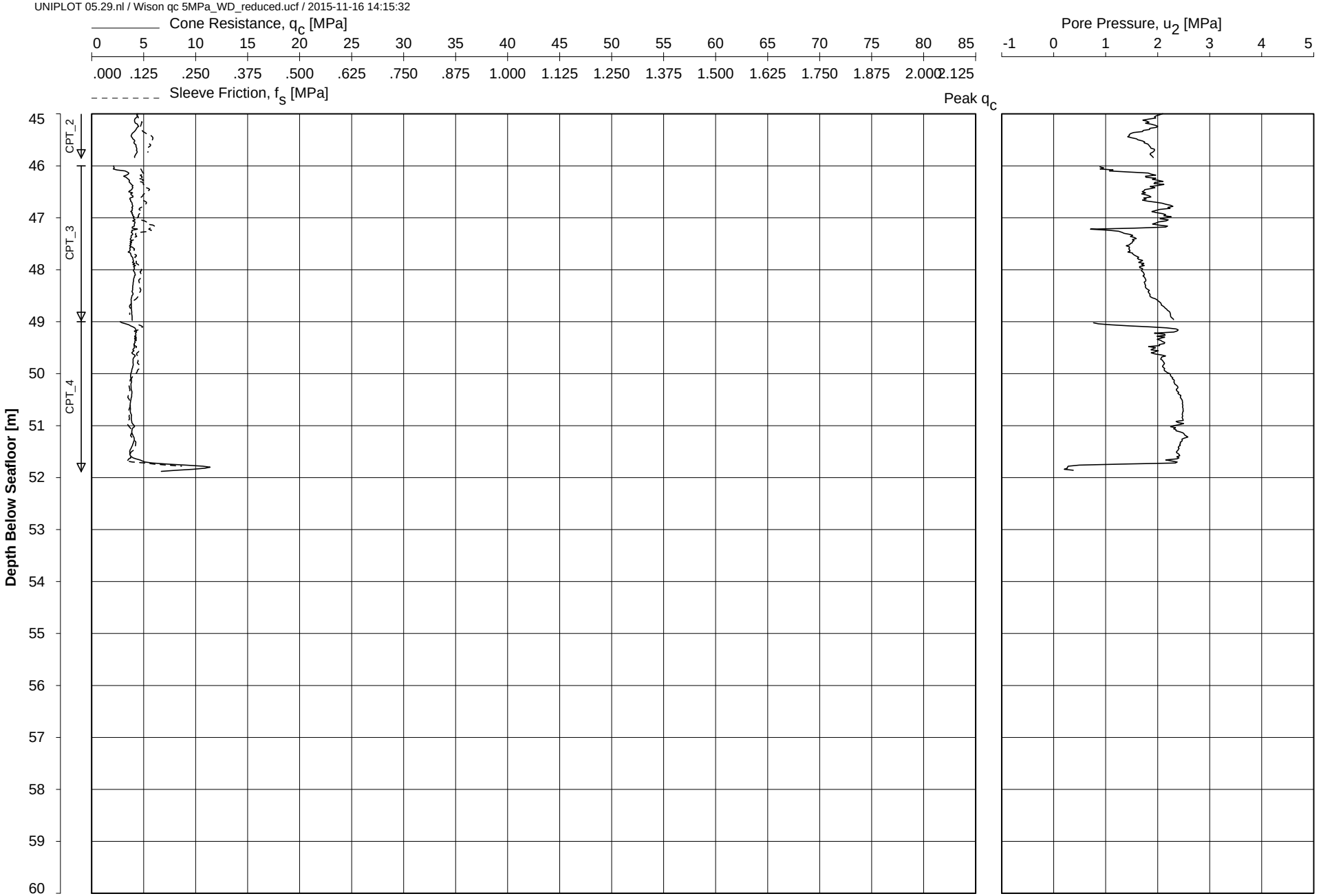
Date Of Testing : 10-Oct-2015
Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486533 N5732302

CONE PENETRATION TEST

CPT_WFS4_1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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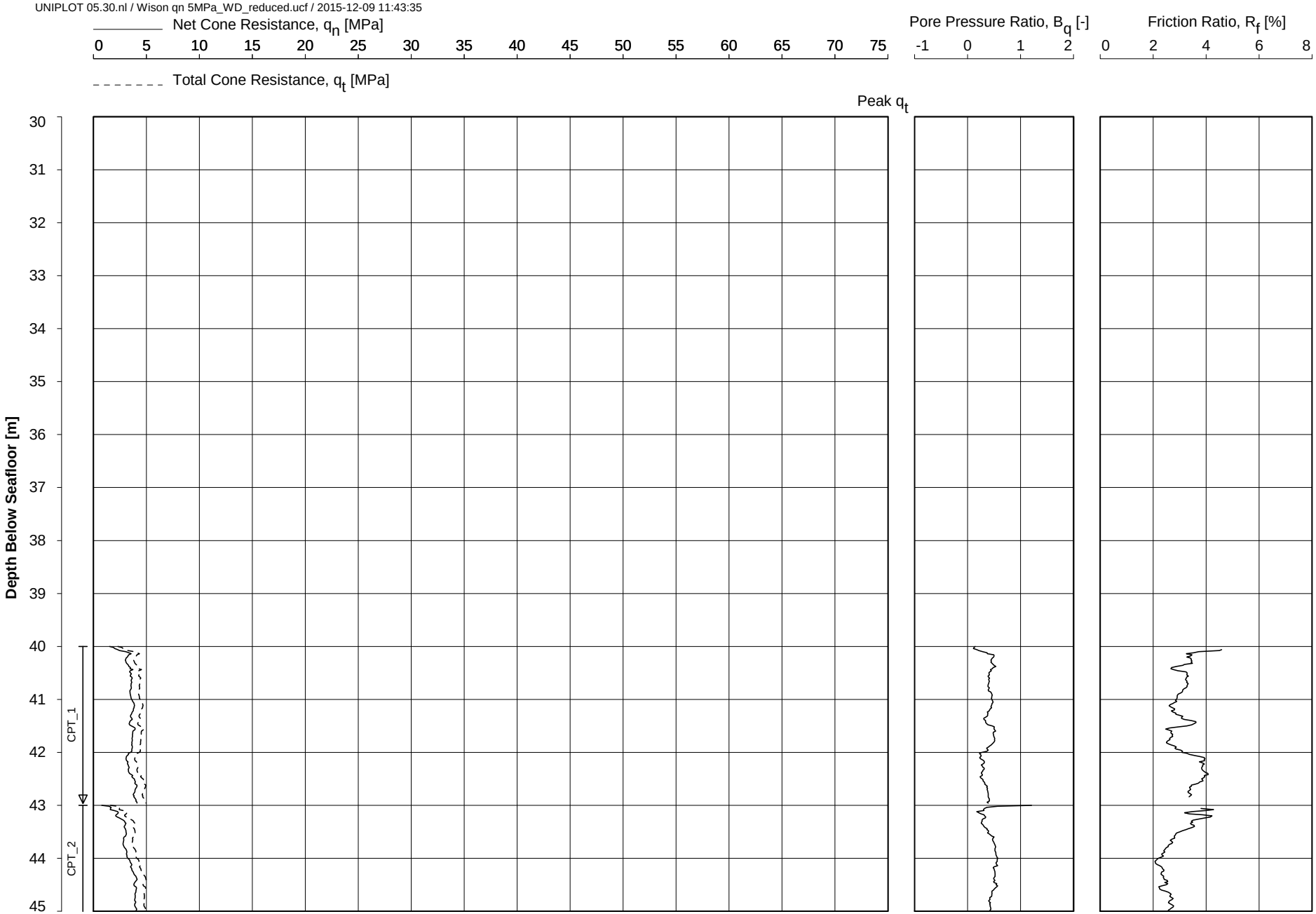
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CONE PENETRATION TEST

CPT_WFS4_1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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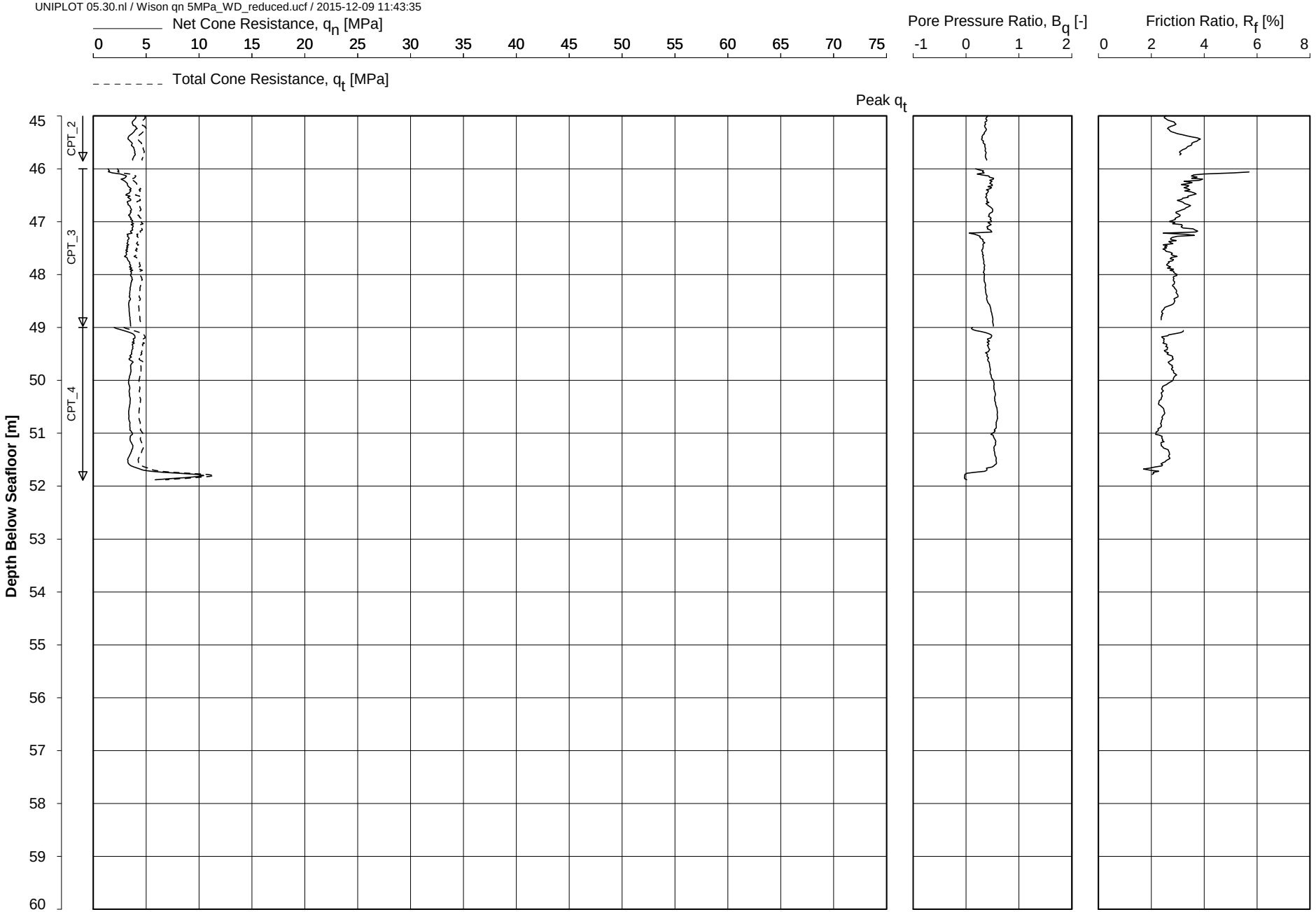
Date Of Testing : 10-Oct-2015
Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486533 N5732302

CONE PENETRATION TEST

CPT_WFS4_1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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Date Of Testing : 10-Oct-2015
Water Depth [m] : 29.5 m LAT
Coordinates [m] : E486533 N5732302

CONE PENETRATION TEST

CPT_WFS4_1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
CPT_WFS4_1A	0.00 to 6.60 6.60 to 13.40 13.40 to 14.80 14.80 to 17.40 17.40 to 31.30 31.30 to 51.88 51.88 to bottom	20.00 20.50 19.50 18.50 20.00 18.00 18.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
CPT_WFS4_1A	CPT_1	0.067	0.010	-0.013	-0.016	0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_1A	CPT_2	0.062	0.012	-0.012	-0.011	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_1A	CPT_3	0.064	0.011	-0.012	-0.010	0.000	0.003	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_1A	CPT_4	0.059	0.012	-0.011	0.006	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750

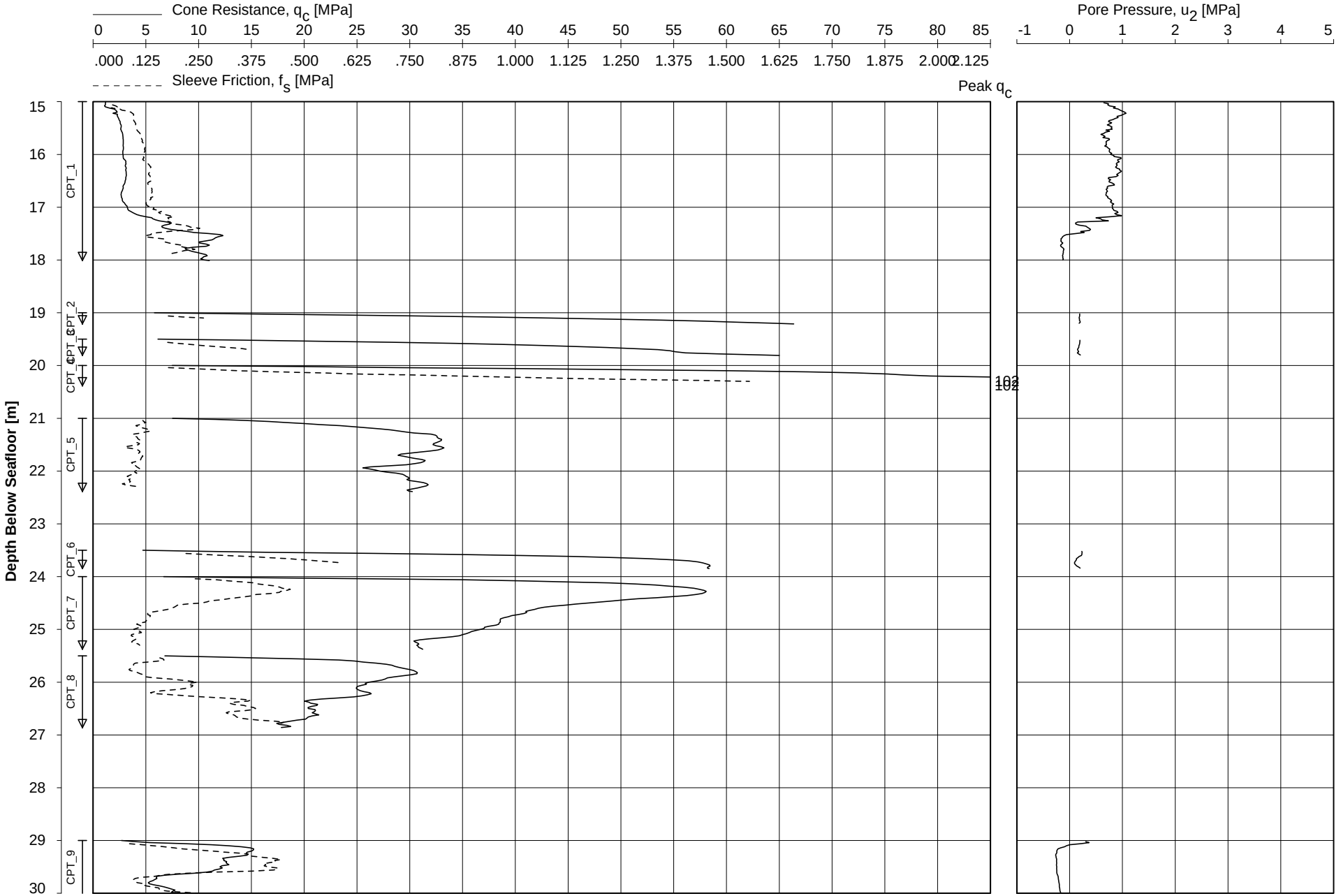
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

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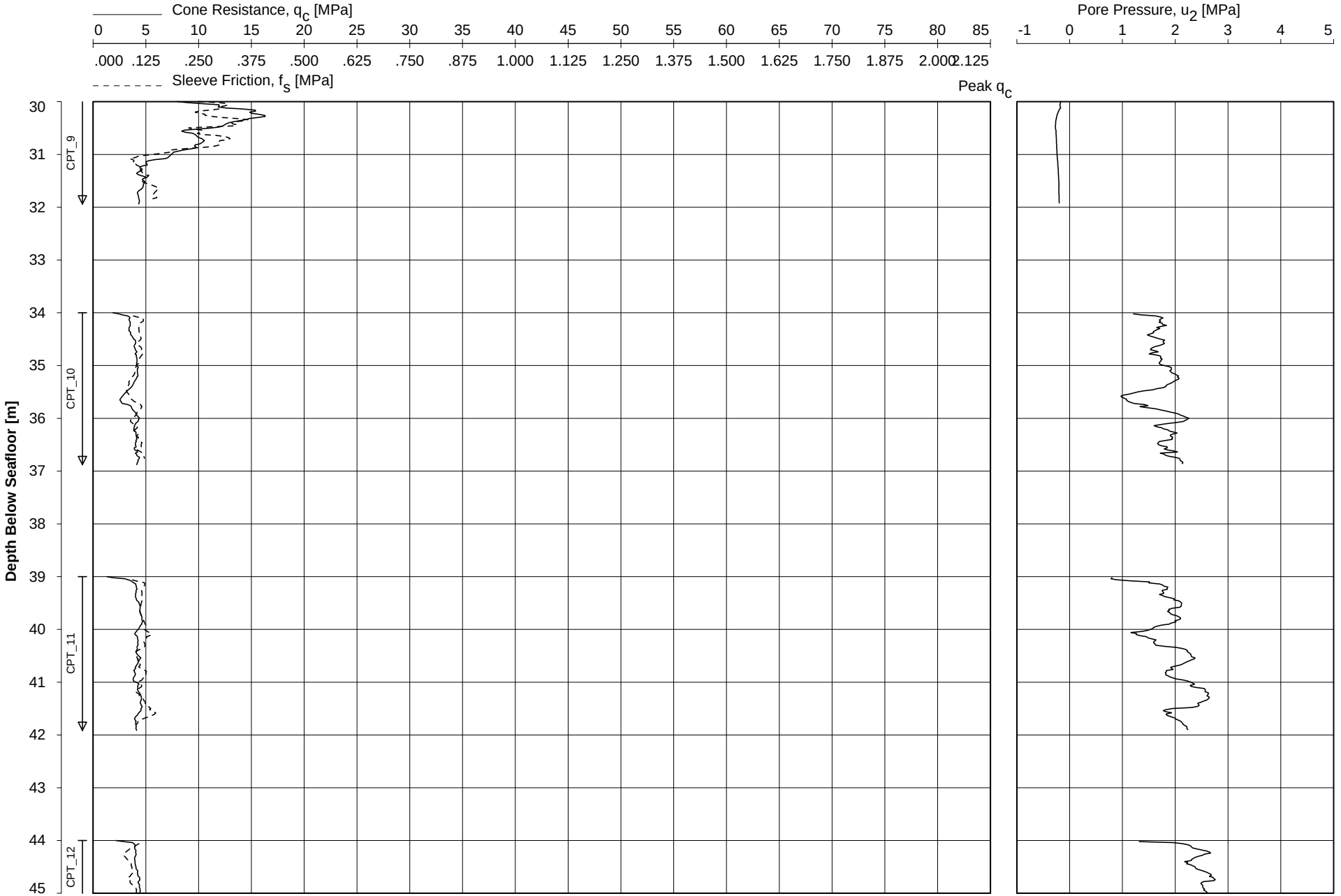
Date Of Testing : 03-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E486523 N5732290

CONE PENETRATION TEST

BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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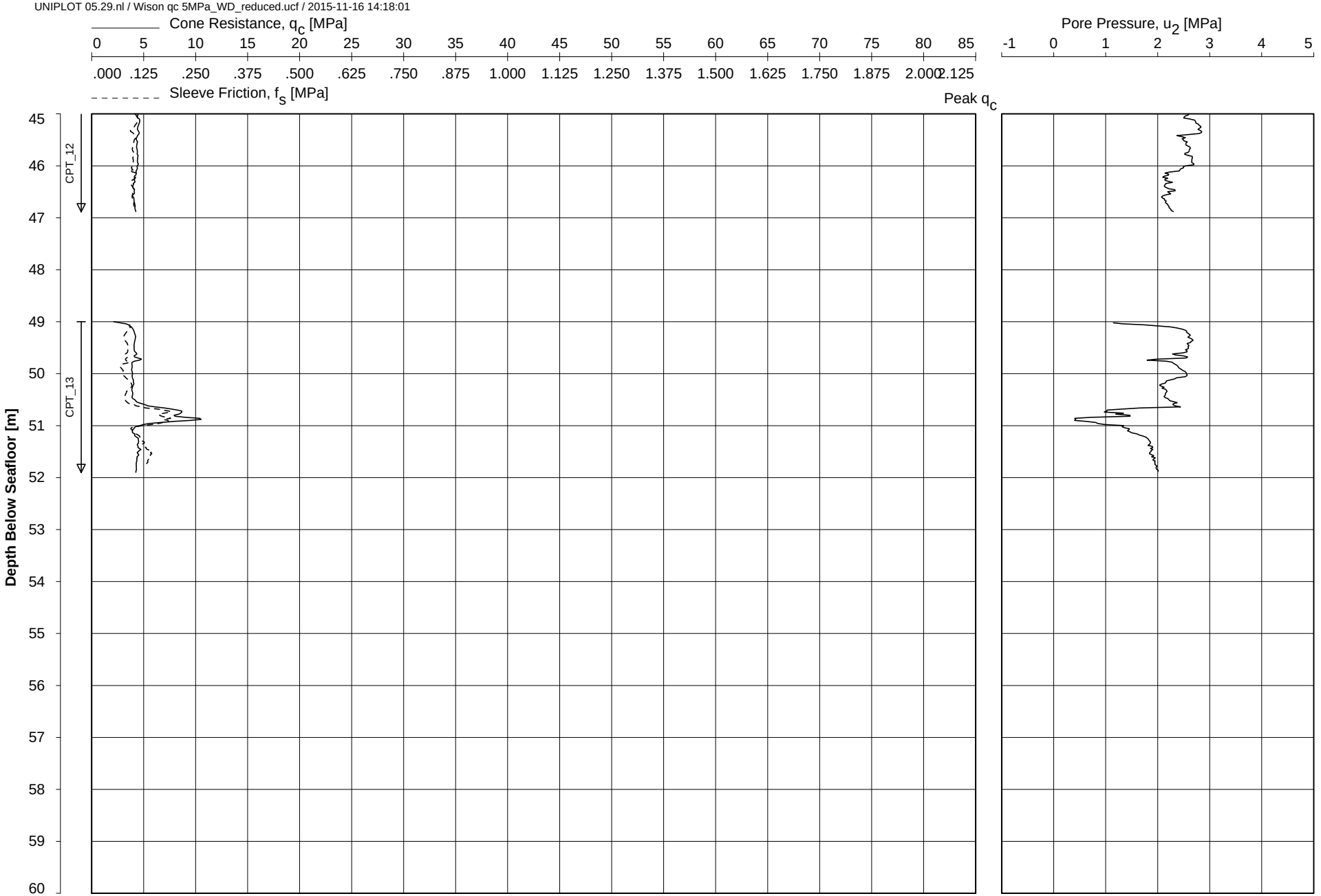
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Water Depth [m] : 29.8 m LAT
Coordinates [m] : E486523 N5732290

CONE PENETRATION TEST

BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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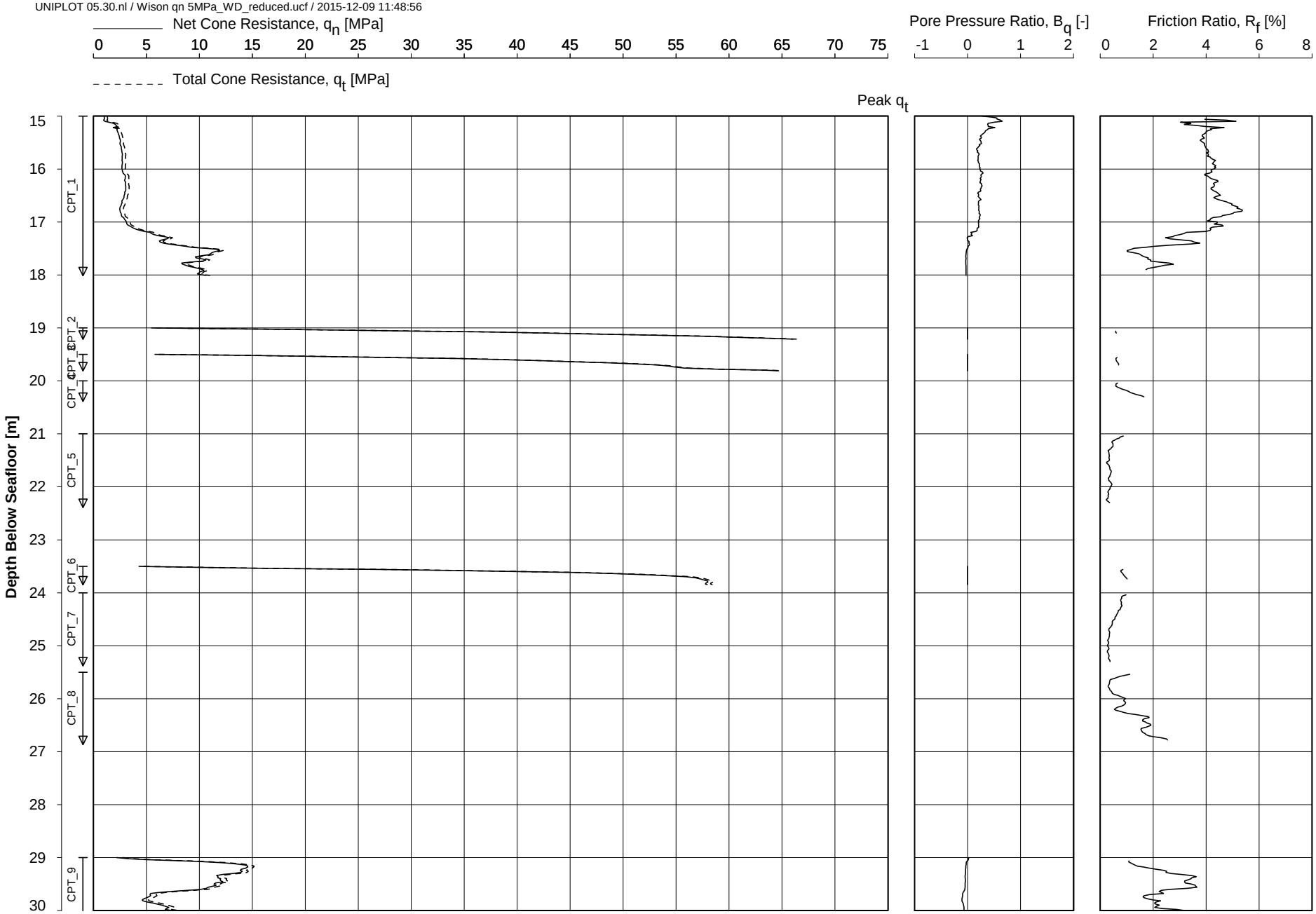
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Water Depth [m] : 29.8 m LAT
Coordinates [m] : E486523 N5732290

CONE PENETRATION TEST

BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:48:56



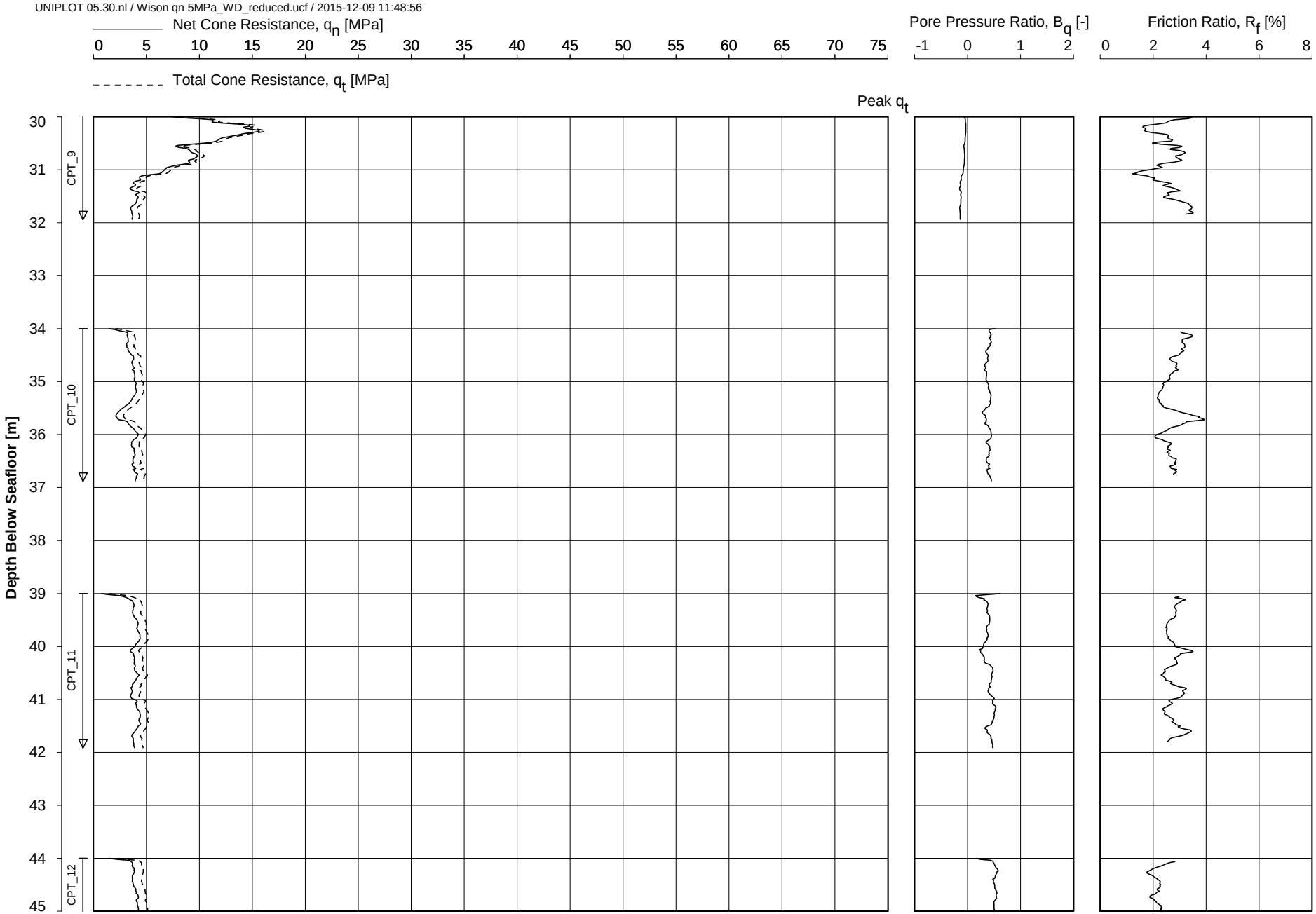
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Water Depth [m] : 29.8 m LAT
Coordinates [m] : E486523 N5732290

CONE PENETRATION TEST

BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:48:56



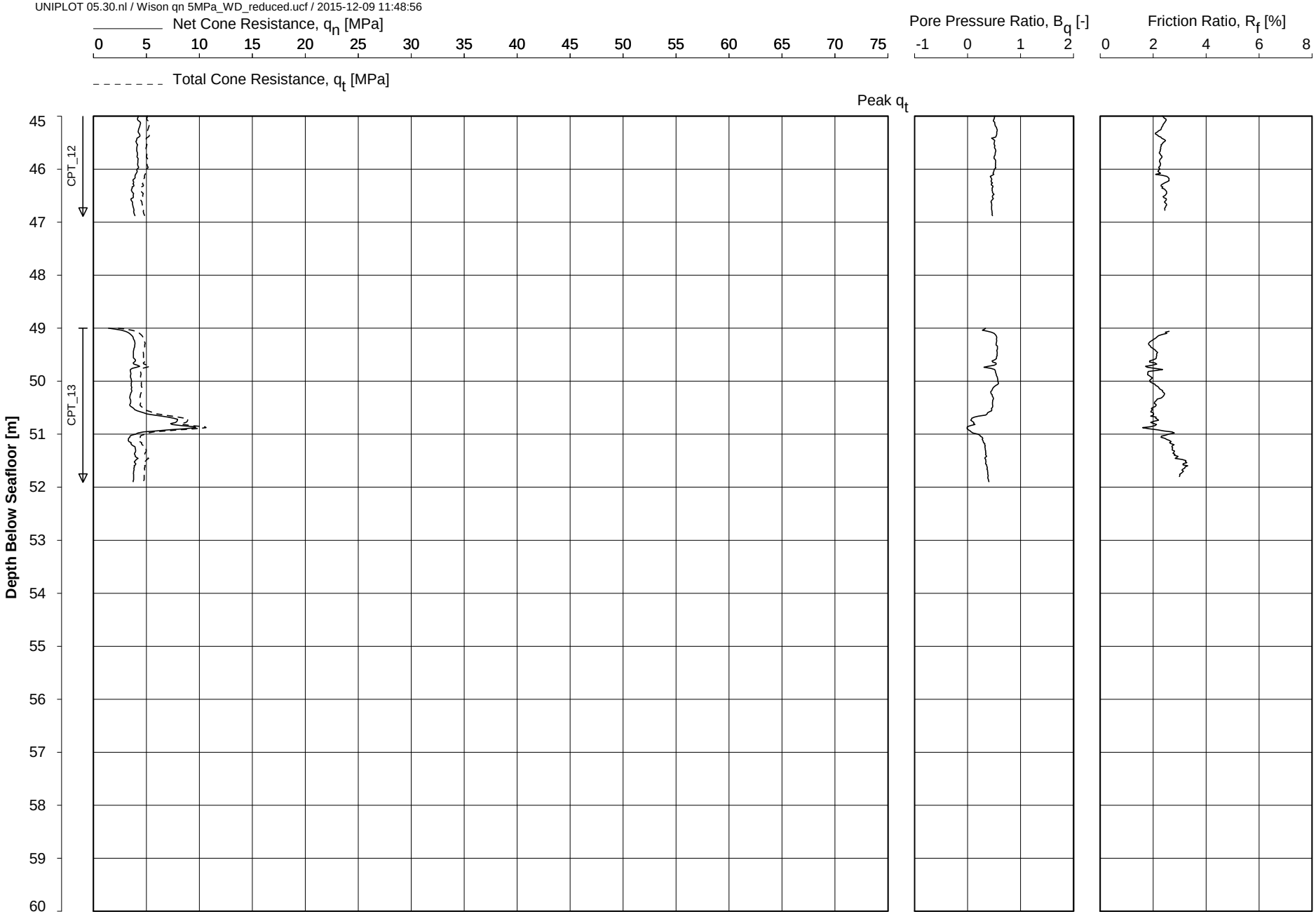
Date Of Testing : 03-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E486523 N5732290

CONE PENETRATION TEST

BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:48:56



Date Of Testing : 03-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E486523 N5732290

CONE PENETRATION TEST

BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
BH-WFS4-1A	0.00 to 6.60 6.60 to 13.20 13.20 to 14.90 14.90 to 17.20 17.20 to 31.10 31.10 to bottom	20.00 20.50 19.50 18.50 20.00 18.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 11:50:16

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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UNIPLOT 05.29.nl / Wison QaQc zero load - landscape.ucf / 2015-11-16 14:18:28

CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
BH-WFS4-1A	CPT_1	0.055	0.002	-0.015	-0.010	-0.001	0.004	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_2	0.060	0.001	-0.015	0.023	0.002	0.005	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_3	0.060	0.001	-0.014	0.016	0.001	0.004	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_4	0.055	0.001		-0.039	-0.001		CP5-CF80	1721-1713	0.500
BH-WFS4-1A	CPT_5	0.001	0.000		0.005	-0.002		CP5-CF80	1721-1713	0.500
BH-WFS4-1A	CPT_6	0.075	0.002	-0.014	-0.006	0.000	0.004	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_7	0.035	-0.002		0.017	0.000		CP5-CF80	1721-1713	0.500
BH-WFS4-1A	CPT_8	0.018	-0.002		0.033	0.000		CP5-CF80	1721-1713	0.500
BH-WFS4-1A	CPT_9	0.070	0.002	-0.012	0.023	-0.002	0.004	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_10	0.061	0.002	-0.013	-0.014	-0.001	0.001	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_11	0.068	0.004	-0.012	0.043	-0.004	0.003	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_12	0.066	0.001	-0.013	0.025	0.000	0.002	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-1A	CPT_13	0.068	0.004	-0.014	0.009	-0.004	0.002	CP10-CF50PB10	1706-1269	0.750

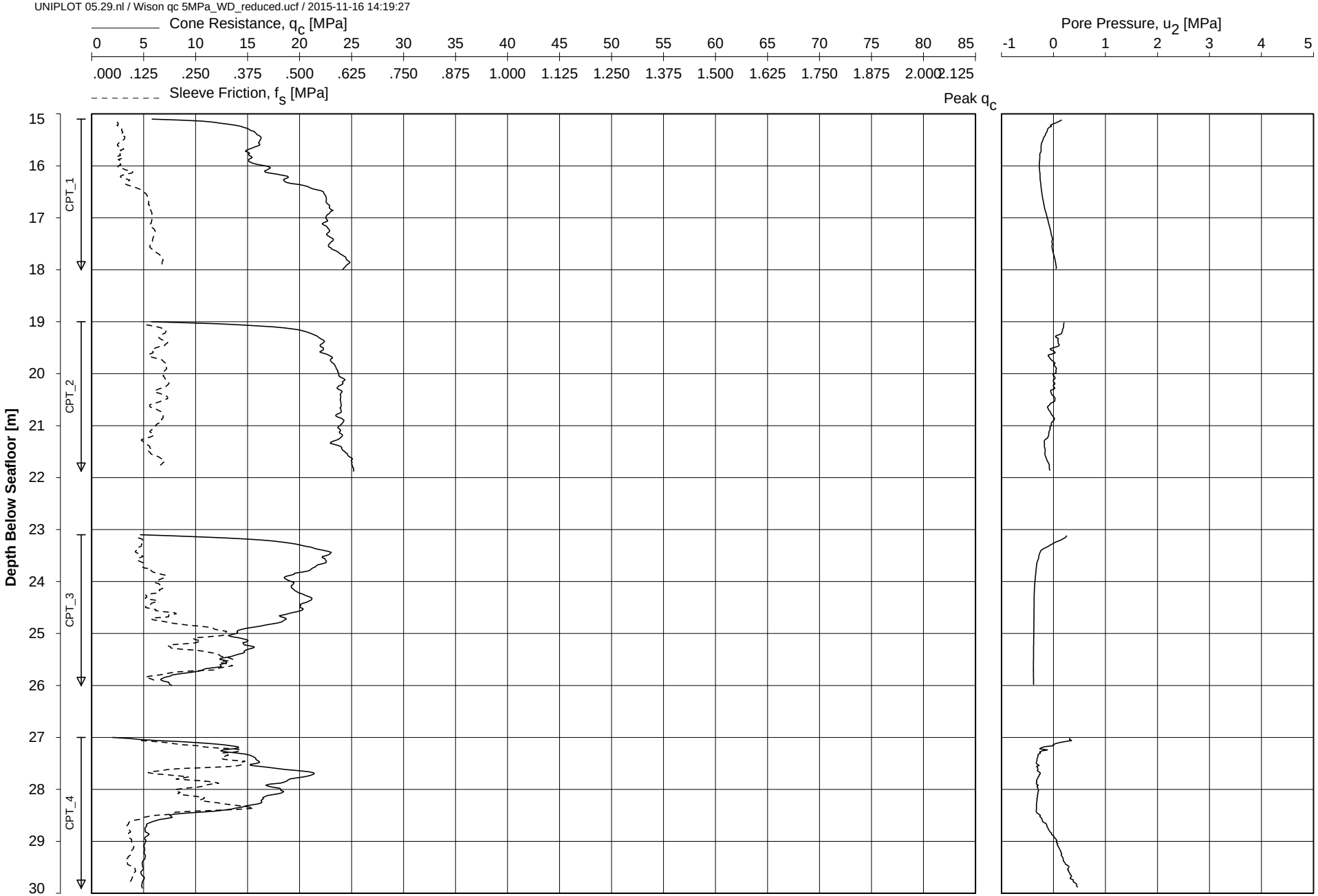
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:19:27



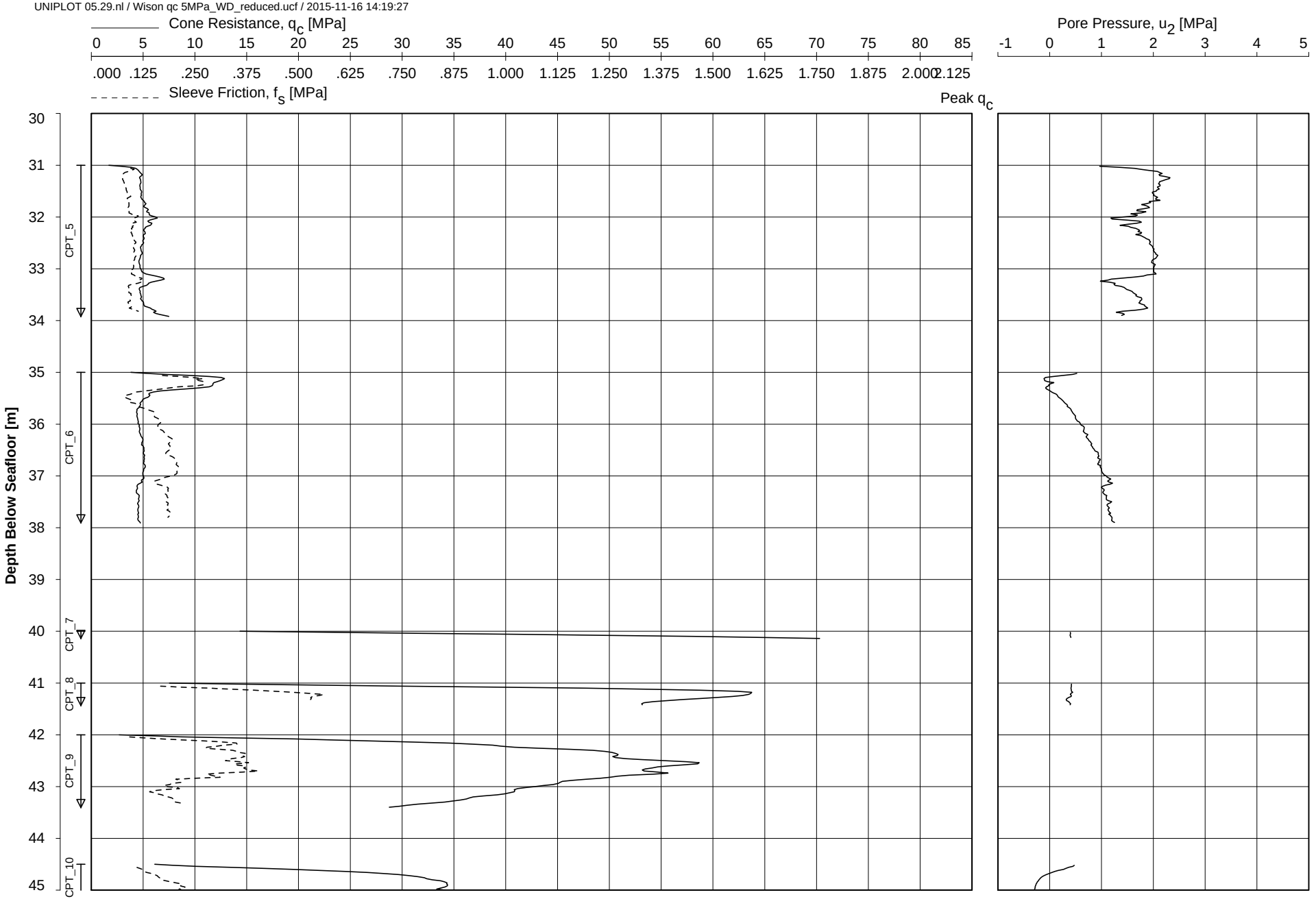
Date Of Testing : 04-Oct-2015
Water Depth [m] : 35.1 m LAT
Coordinates [m] : E490526 N5732763

CONE PENETRATION TEST

BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:19:27



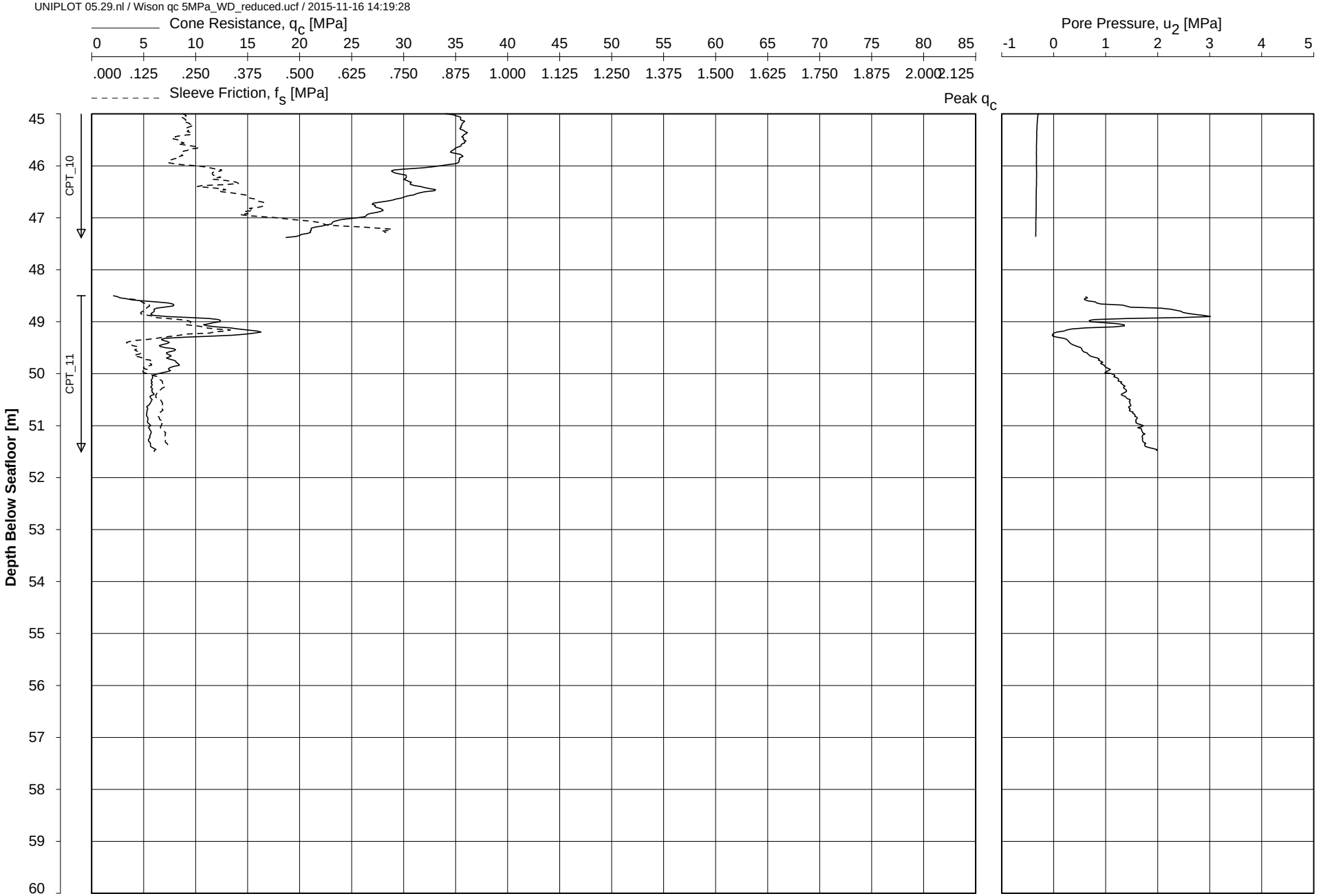
Date Of Testing : 04-Oct-2015
Water Depth [m] : 35.1 m LAT
Coordinates [m] : E490526 N5732763

CONE PENETRATION TEST

BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:19:28



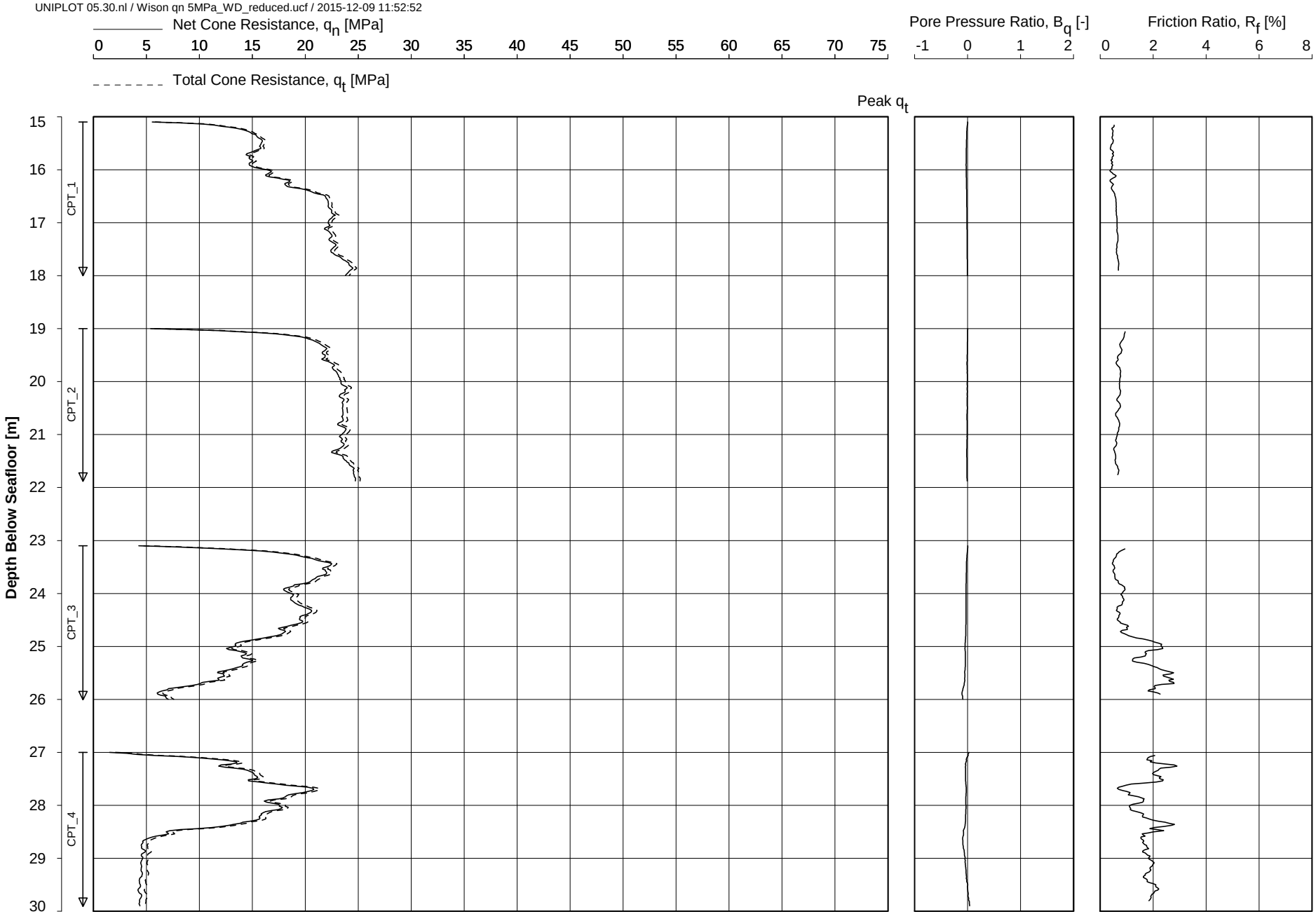
Date Of Testing : 04-Oct-2015
Water Depth [m] : 35.1 m LAT
Coordinates [m] : E490526 N5732763

CONE PENETRATION TEST

BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:52:52



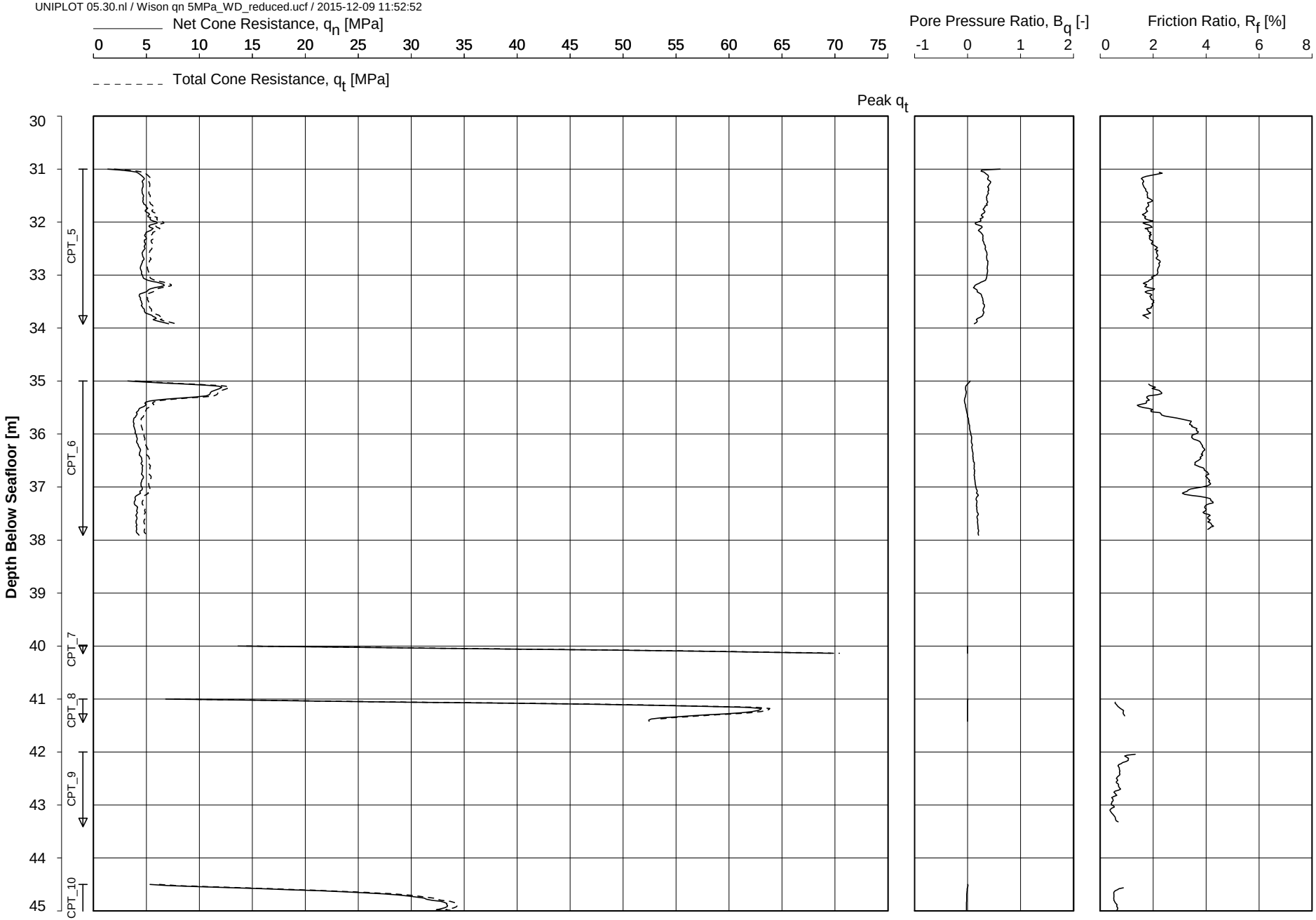
Date Of Testing : 04-Oct-2015
Water Depth [m] : 35.1 m LAT
Coordinates [m] : E490526 N5732763

CONE PENETRATION TEST

BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:52:52



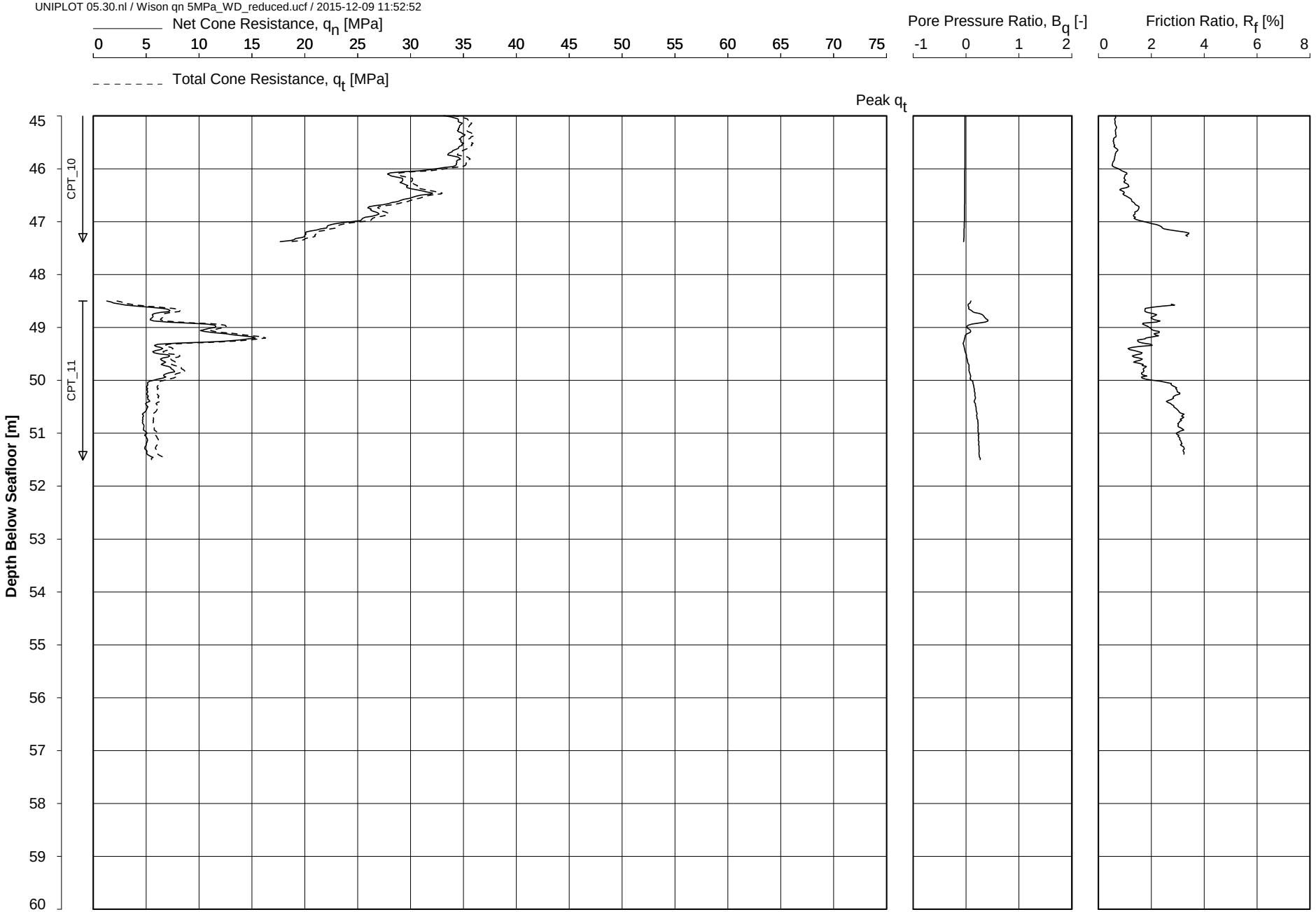
Date Of Testing : 04-Oct-2015
Water Depth [m] : 35.1 m LAT
Coordinates [m] : E490526 N5732763

CONE PENETRATION TEST

BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:52:52



Date Of Testing : 04-Oct-2015
Water Depth [m] : 35.1 m LAT
Coordinates [m] : E490526 N5732763

CONE PENETRATION TEST

BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
BH-WFS4-2A	0.00 to 1.90	20.00	10.0	---
	1.90 to 11.80	20.50		
	11.80 to 25.30	20.00		
	25.30 to 27.45	19.50		
	27.45 to 28.10	19.50		
	28.10 to 33.70	19.50		
	33.70 to 35.40	19.50		
	35.40 to 39.10	18.50		
	39.10 to 50.00	20.00		
	50.00 to bottom	18.00		

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 11:55:00

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
BH-WFS4-2A	CPT_1	-0.005	0.002	-0.005	-0.014	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_2	0.000	0.002	-0.006	-0.018	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_3	0.001	0.004	-0.005	-0.016	-0.001	0.000	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_4	-0.006	0.004	-0.006	-0.003	-0.002	0.000	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_5	-0.007	0.003	-0.005	-0.008	-0.002	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_6	-0.008	0.002	-0.006	-0.006	-0.001	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_7	-0.004	0.002	-0.006	-0.007	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_8	-0.004	0.003	-0.006	-0.011	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_9	0.040	-0.001		-0.002	0.000		CP5-CF80	1721-1713	0.500
BH-WFS4-2A	CPT_10	-0.001	0.003	-0.004	-0.019	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-2A	CPT_11	-0.001	0.004	-0.005	0.001	-0.003	0.001	CP10-CF50PB20	1706-2185	0.750

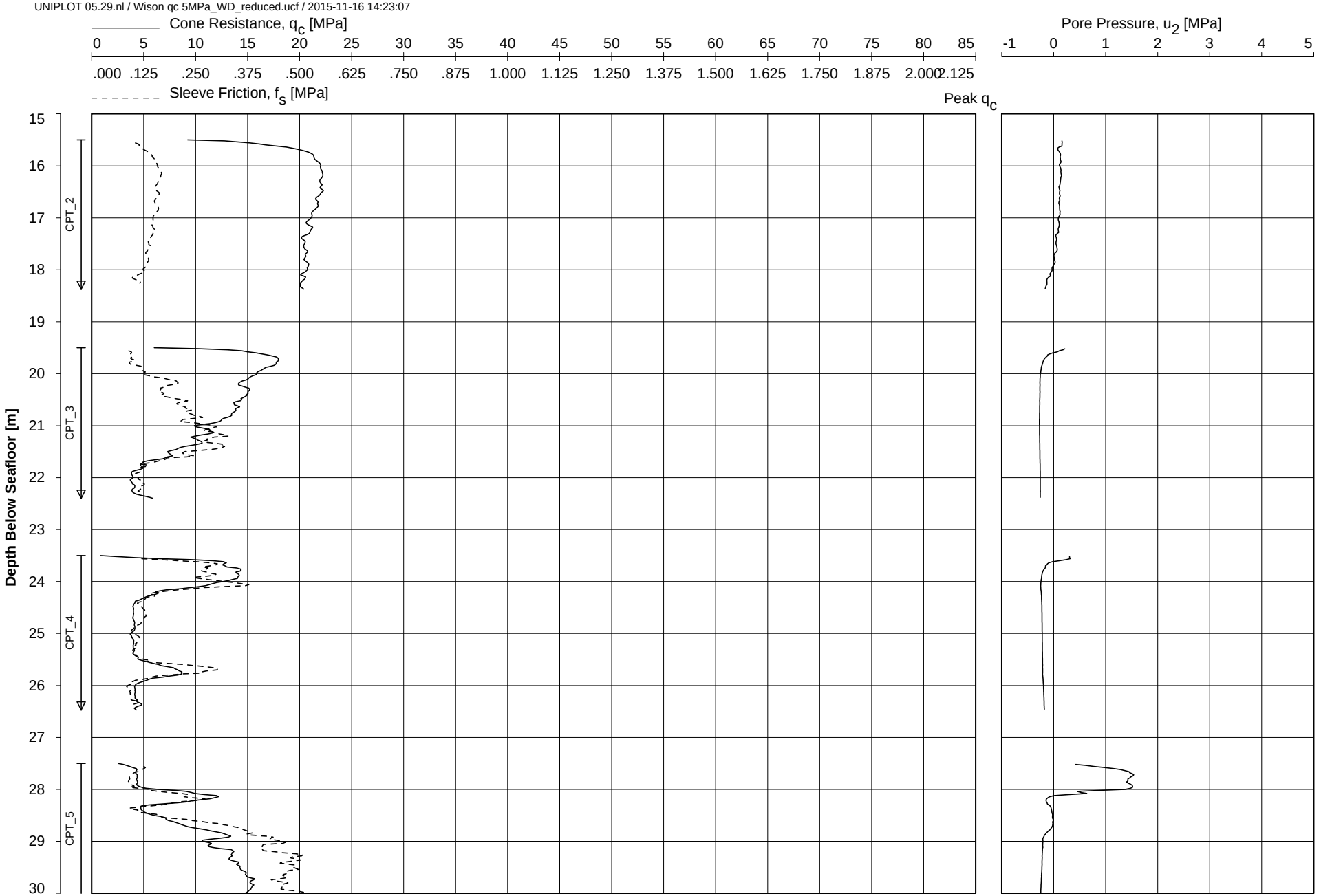
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:23:07



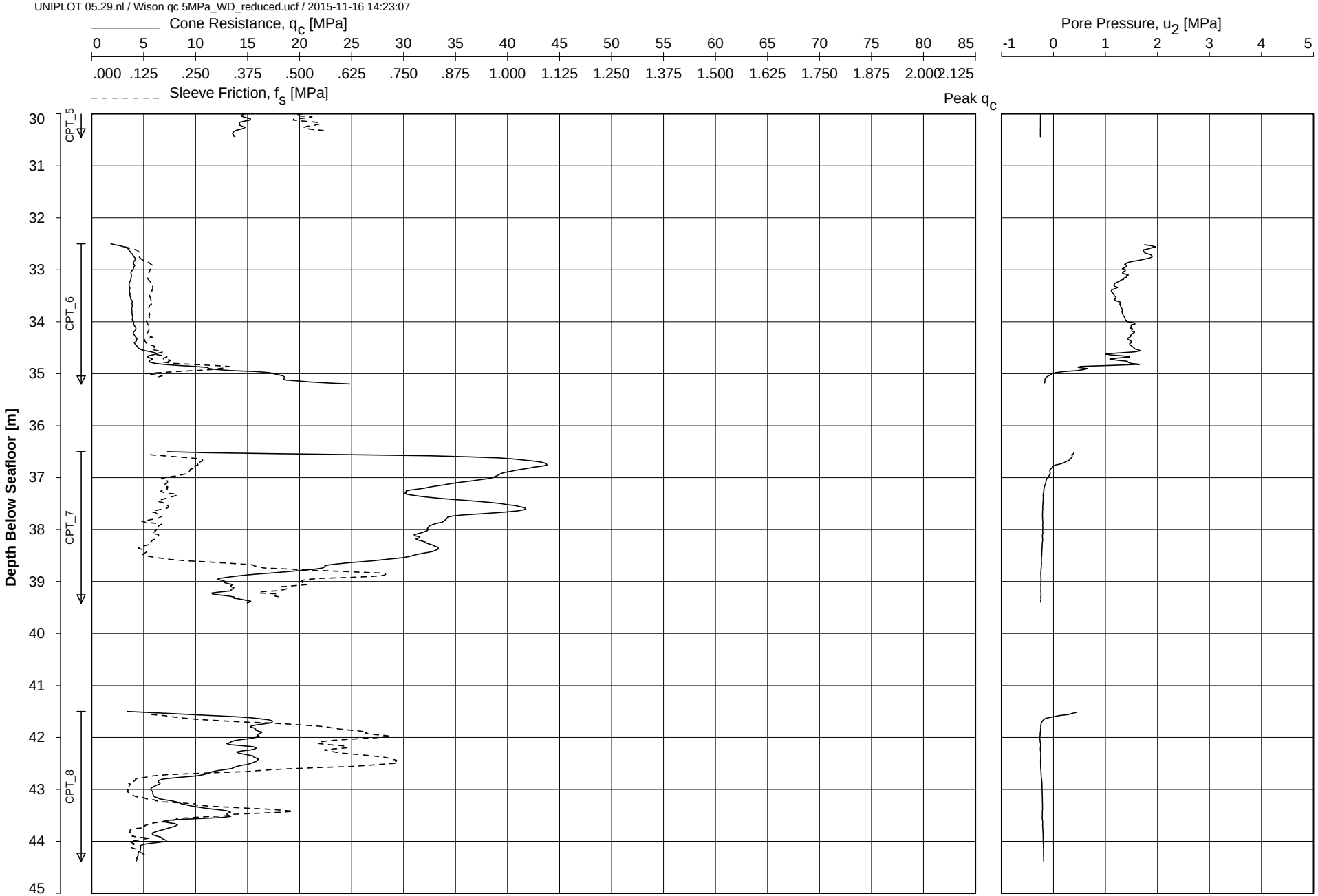
Date Of Testing : 02-Oct-2015
Water Depth [m] : 28.3 m LAT
Coordinates [m] : E491740 N5727279

CONE PENETRATION TEST

BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:23:07



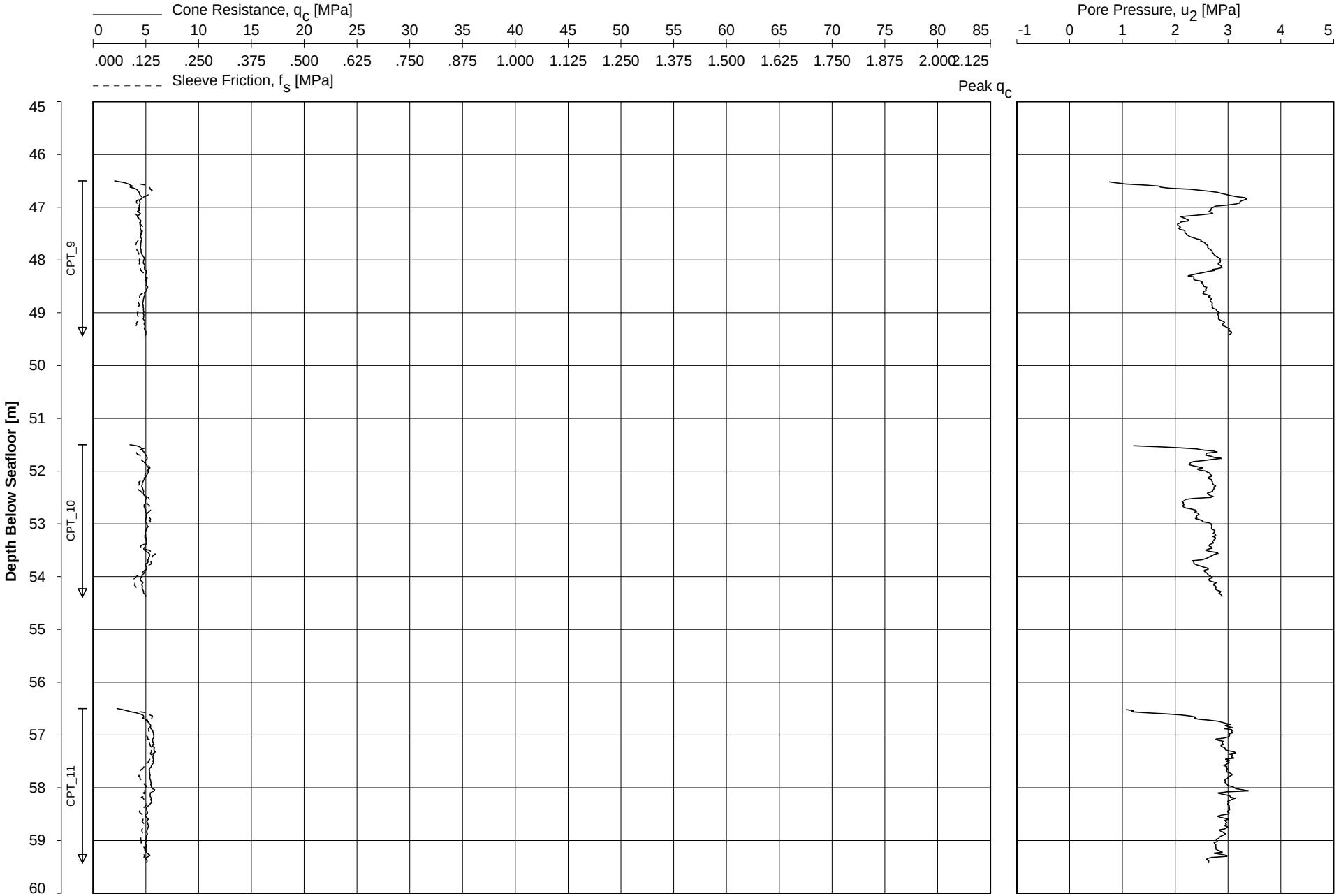
Date Of Testing : 02-Oct-2015
Water Depth [m] : 28.3 m LAT
Coordinates [m] : E491740 N5727279

CONE PENETRATION TEST

BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:23:08



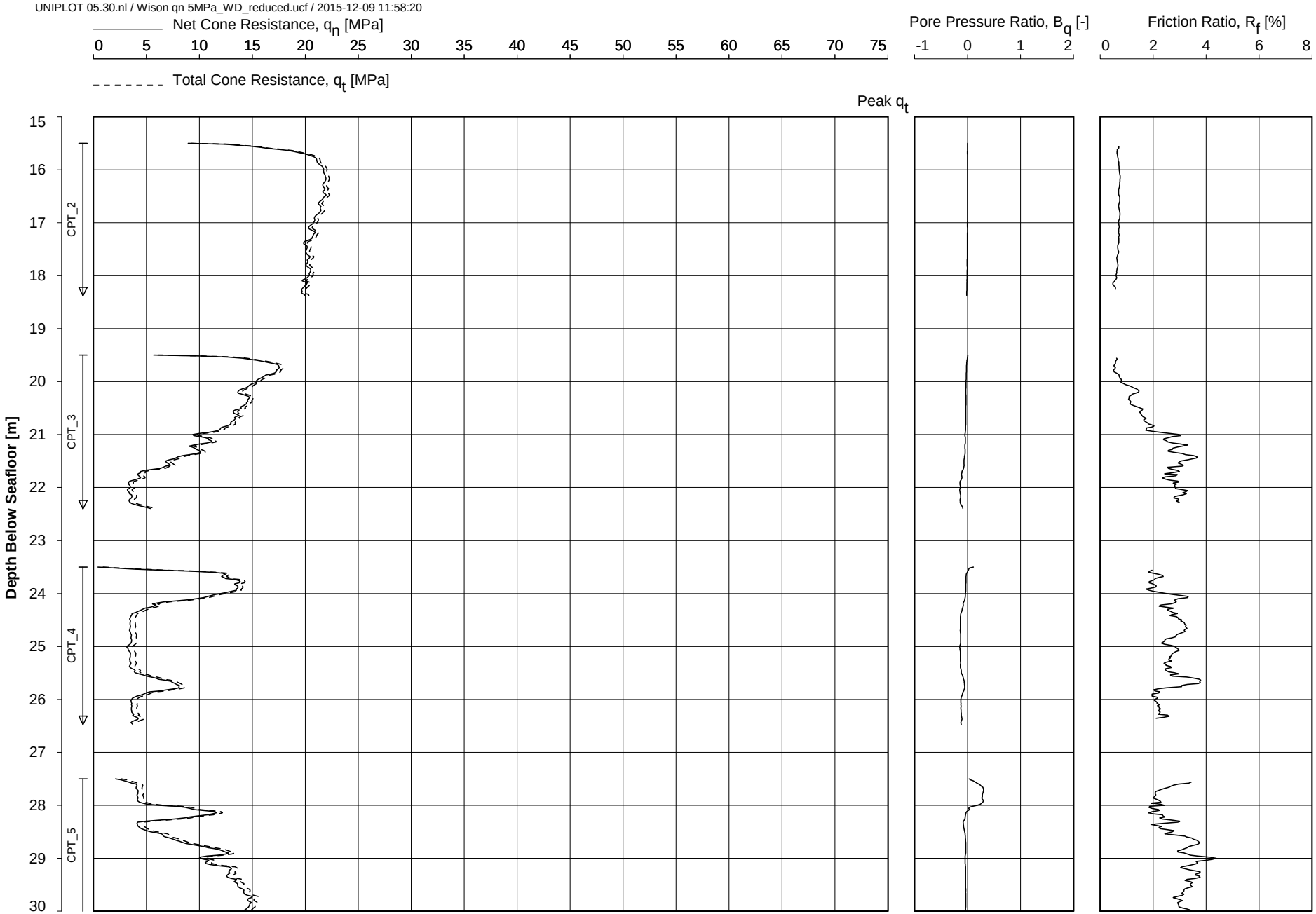
Date Of Testing : 02-Oct-2015
Water Depth [m] : 28.3 m LAT
Coordinates [m] : E491740 N5727279

CONE PENETRATION TEST

BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:58:20



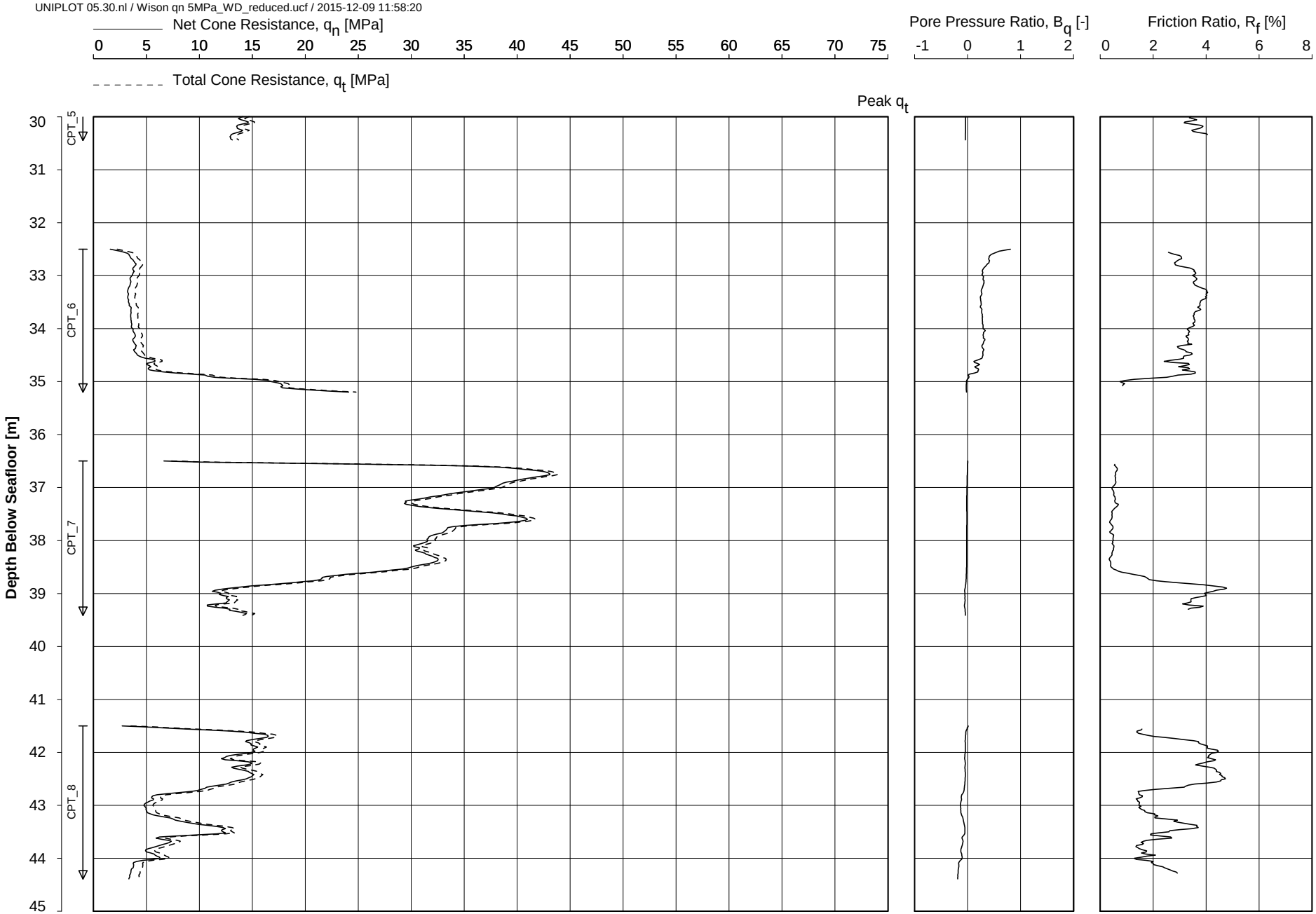
Date Of Testing : 02-Oct-2015
Water Depth [m] : 28.3 m LAT
Coordinates [m] : E491740 N5727279

CONE PENETRATION TEST

BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:58:20



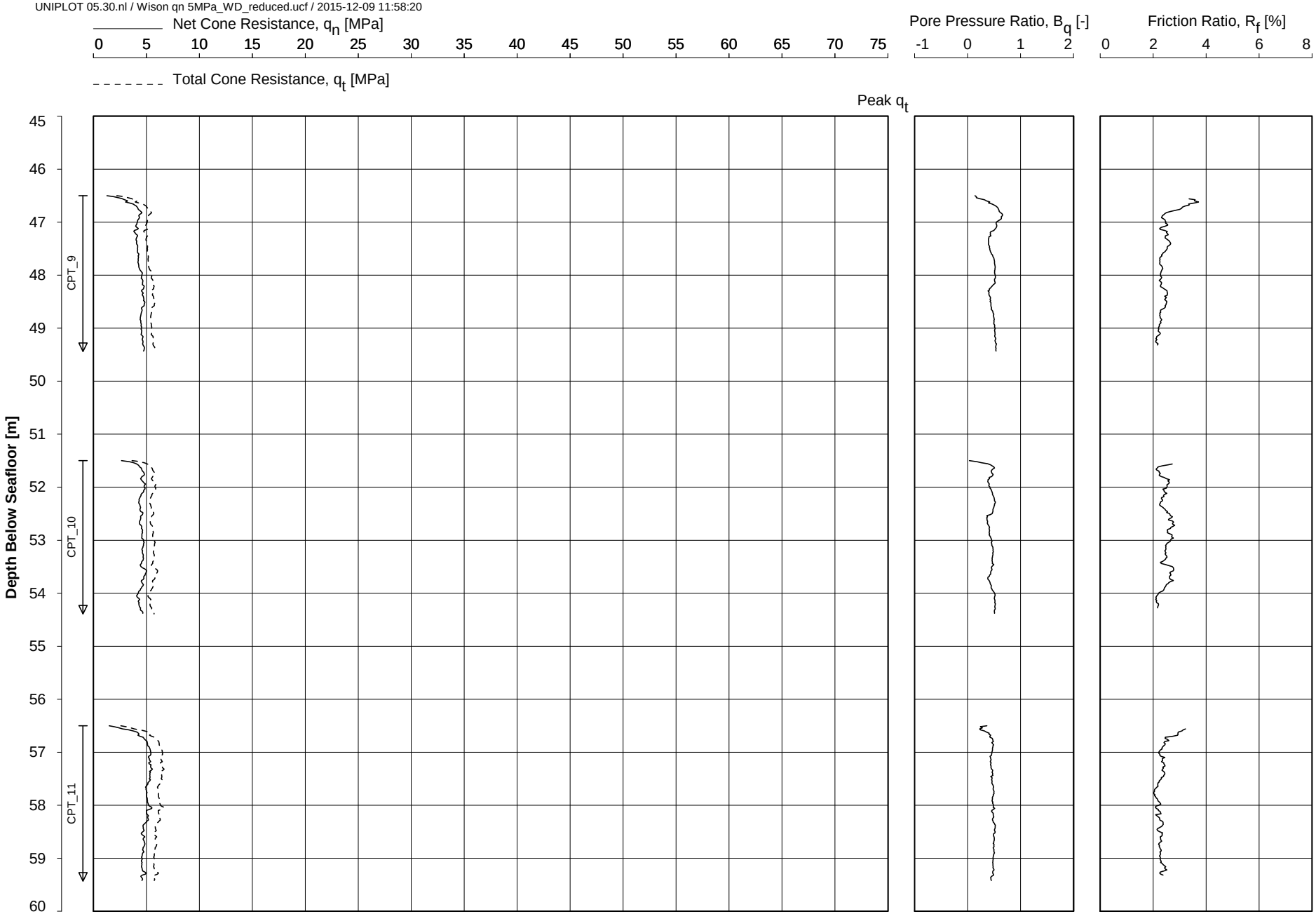
Date Of Testing : 02-Oct-2015
Water Depth [m] : 28.3 m LAT
Coordinates [m] : E491740 N5727279

CONE PENETRATION TEST

BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 11:58:20



Date Of Testing : 02-Oct-2015
Water Depth [m] : 28.3 m LAT
Coordinates [m] : E491740 N5727279

CONE PENETRATION TEST

BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
BH-WFS4-3	0.00 to 6.80 6.80 to 10.80 10.80 to 20.95 20.95 to 23.55 23.55 to 24.25 24.25 to 28.60 28.60 to 30.85 30.85 to 34.80 34.80 to 44.00 44.00 to bottom	20.00 20.50 20.00 19.50 19.50 19.50 19.50 18.50 20.00 18.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 12:00:04

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONE PENETRATION TEST - ZERO DRIFT

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
BH-WFS4-3	CPT_2	0.041	0.000	-0.012	-0.028	0.001	0.002	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_3	0.055	0.001	-0.014	-0.009	-0.001	0.004	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_4	0.052	0.001	-0.014	-0.010	-0.001	0.021	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_5	0.052	0.000	-0.014	-0.013	0.000	0.003	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_6	0.063	0.001	-0.014	0.009	0.000	0.004	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_7	0.076	0.001	-0.014	-0.026	-0.002	0.004	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_8	0.077	0.000	-0.013	0.015	0.000	0.005	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_9	0.068	0.001	-0.013	0.003	0.001	0.017	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_10	0.072	0.001	-0.014	0.014	0.000	0.003	CP10-CF50PB10	1706-1269	0.750
BH-WFS4-3	CPT_11	0.076	0.001	-0.014	0.020	0.000	0.003	CP10-CF50PB10	1706-1269	0.750

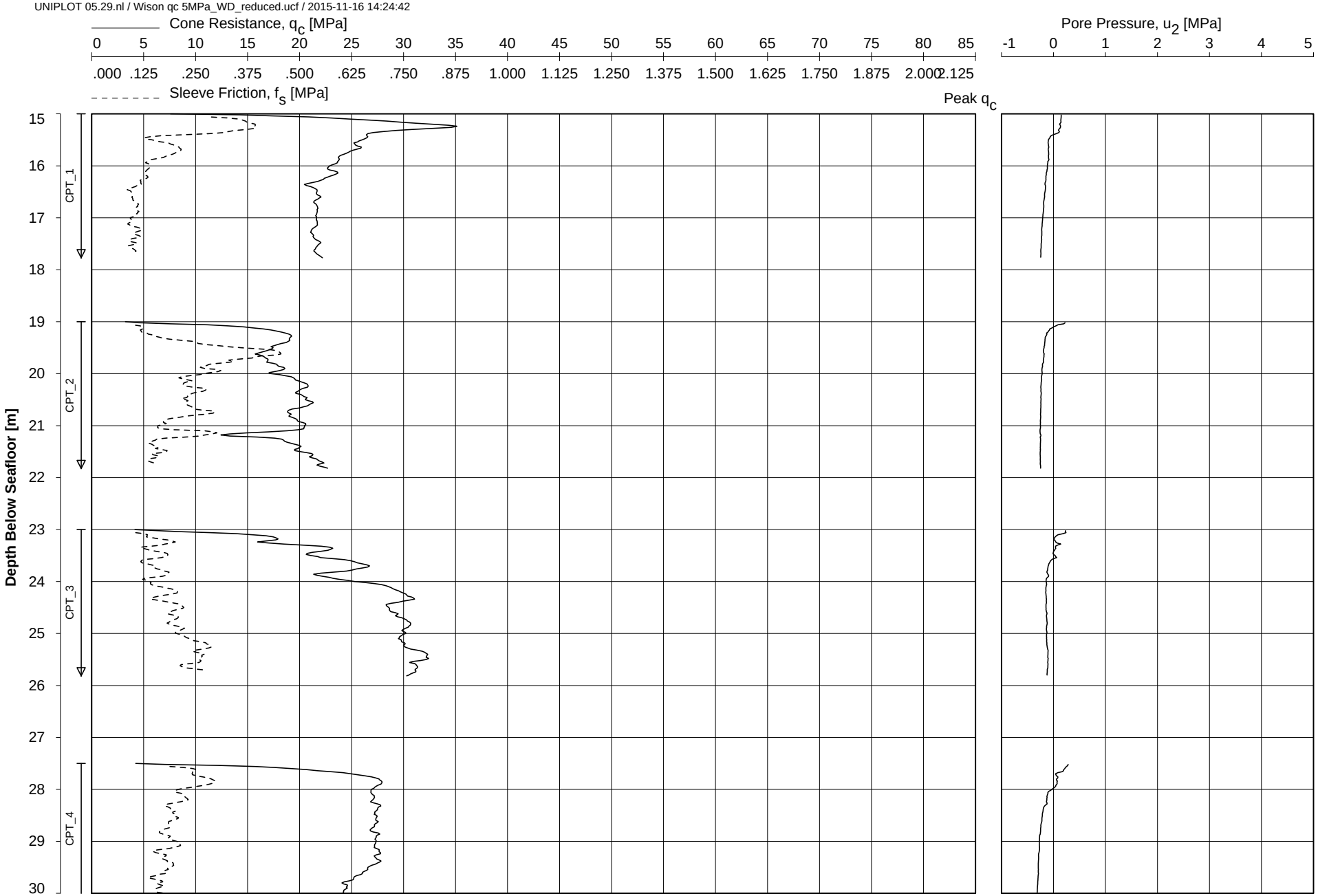
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:24:42



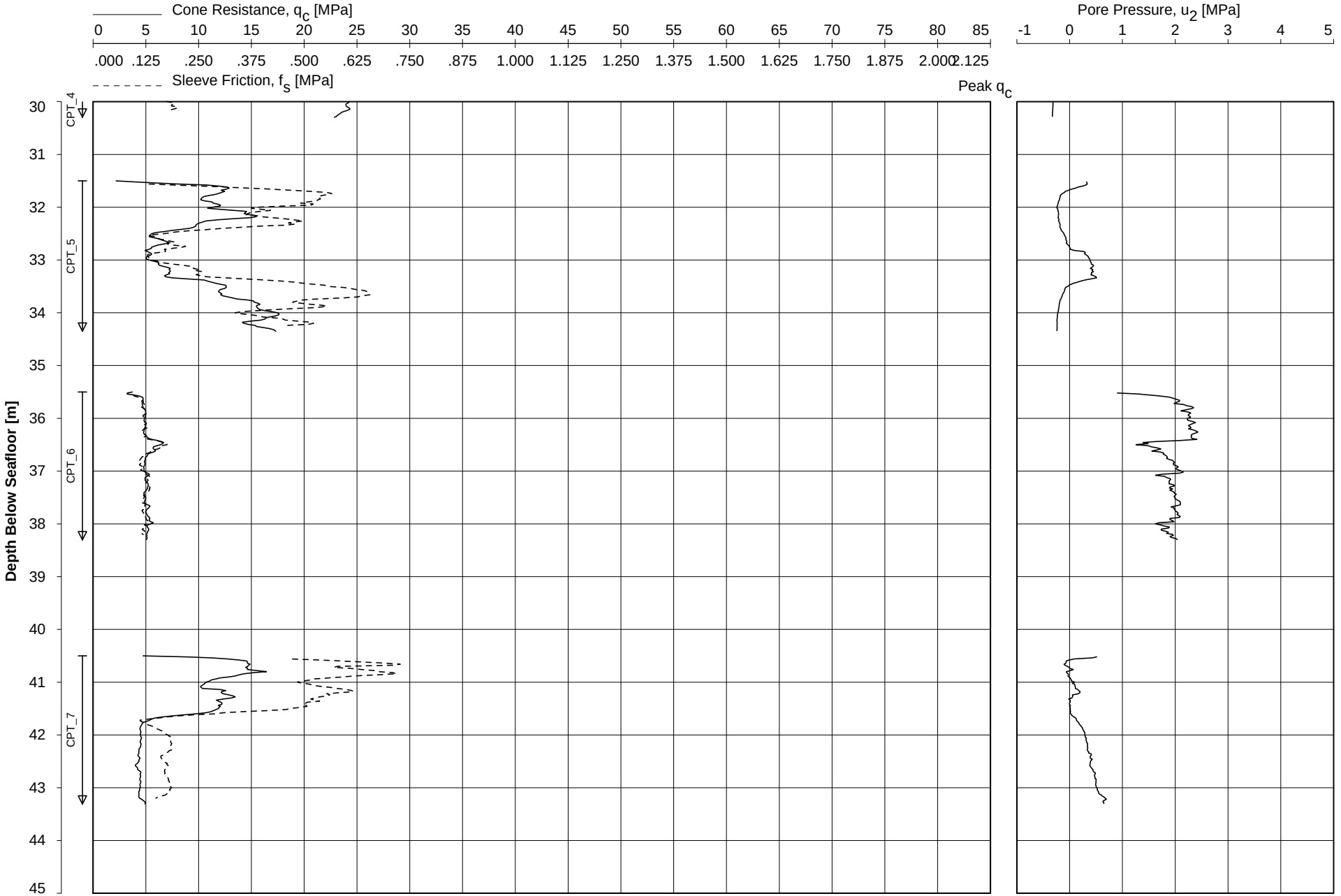
Date Of Testing : 29-Sep-2015
Water Depth [m] : 32.70 m LAT
Coordinates [m] : E493371 N5730553

CONE PENETRATION TEST

BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:24:43



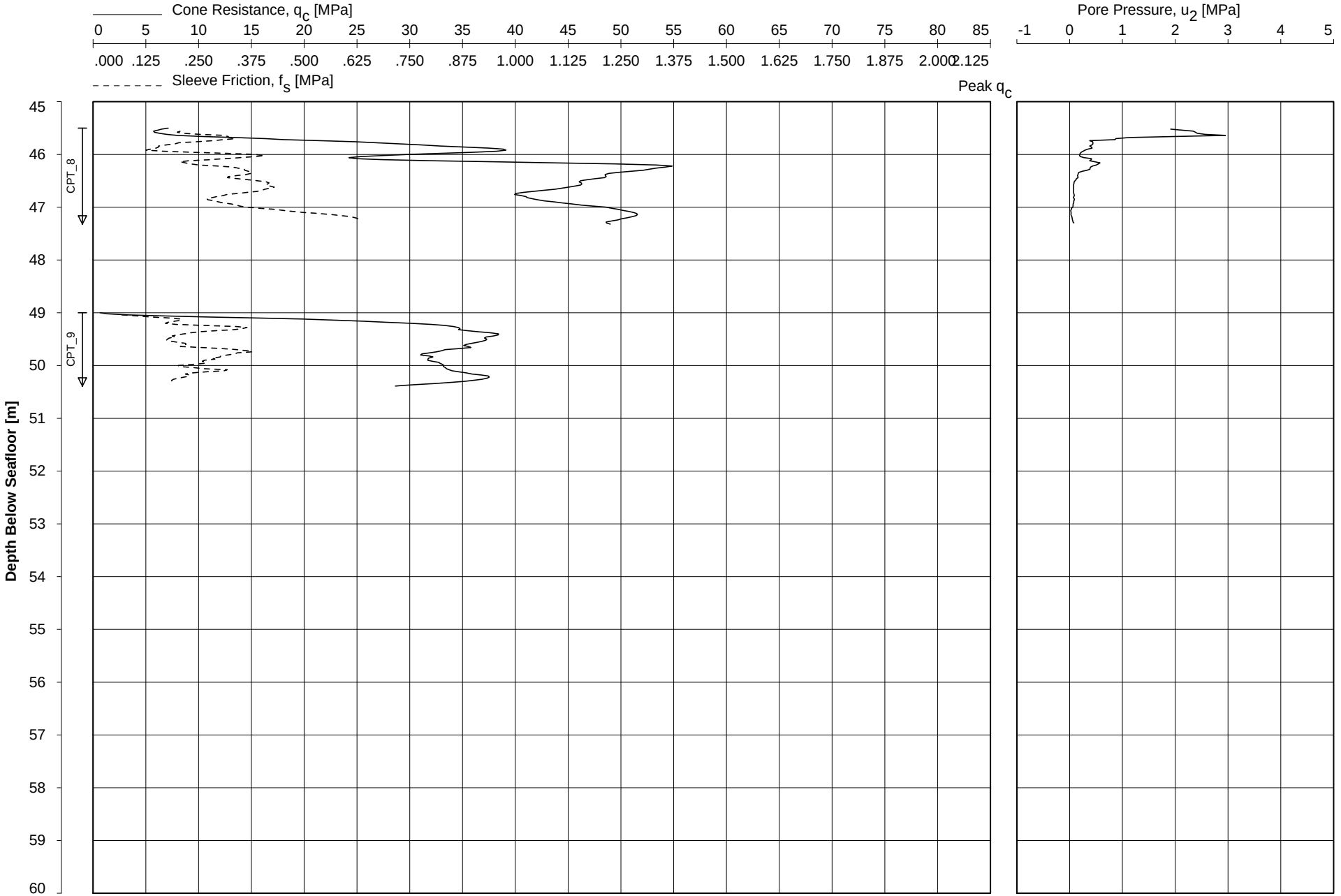
Date Of Testing : 29-Sep-2015
Water Depth [m] : 32.70 m LAT
Coordinates [m] : E493371 N5730553

CONE PENETRATION TEST

BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:24:44



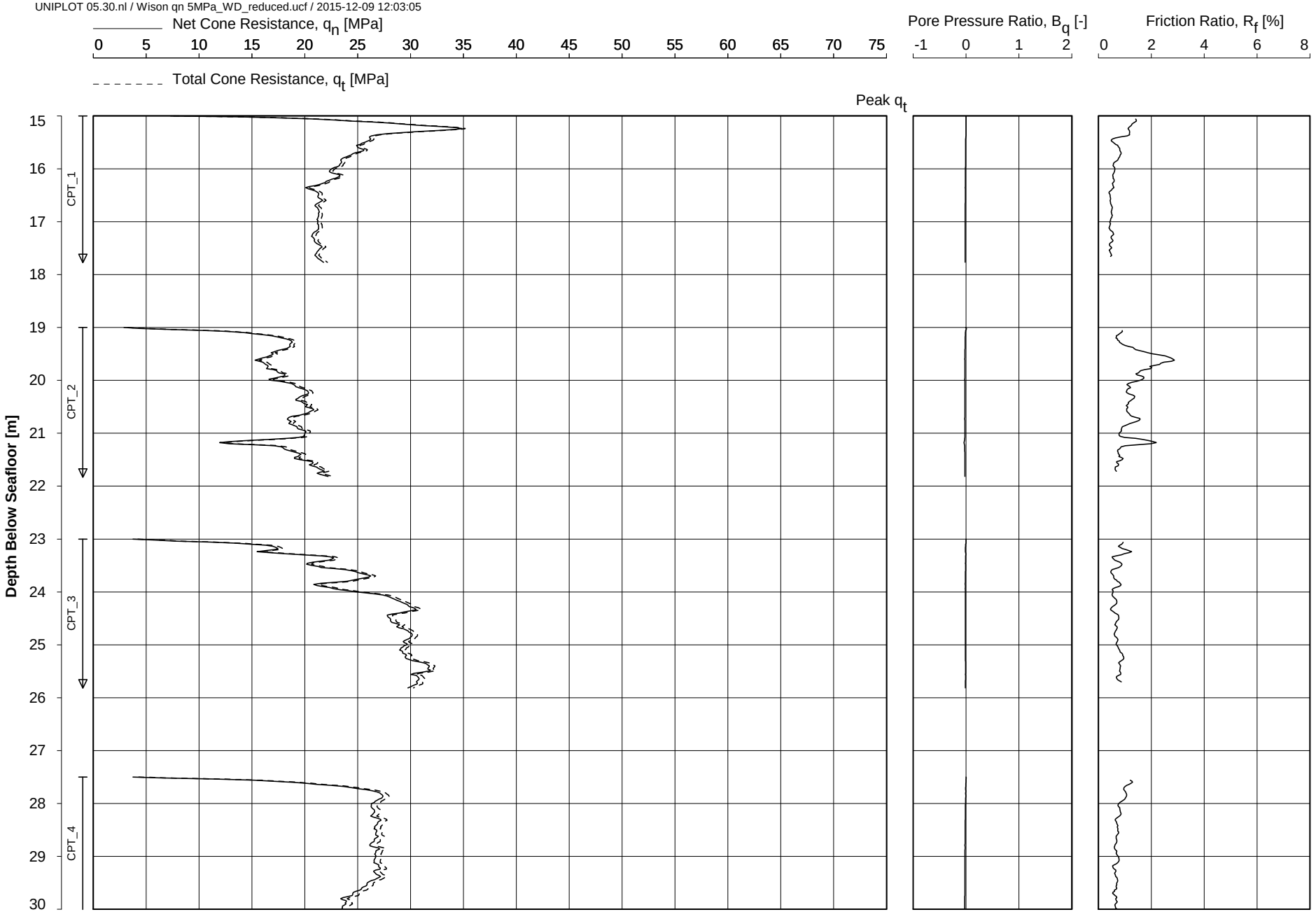
Date Of Testing : 29-Sep-2015
Water Depth [m] : 32.70 m LAT
Coordinates [m] : E493371 N5730553

CONE PENETRATION TEST

BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:03:05



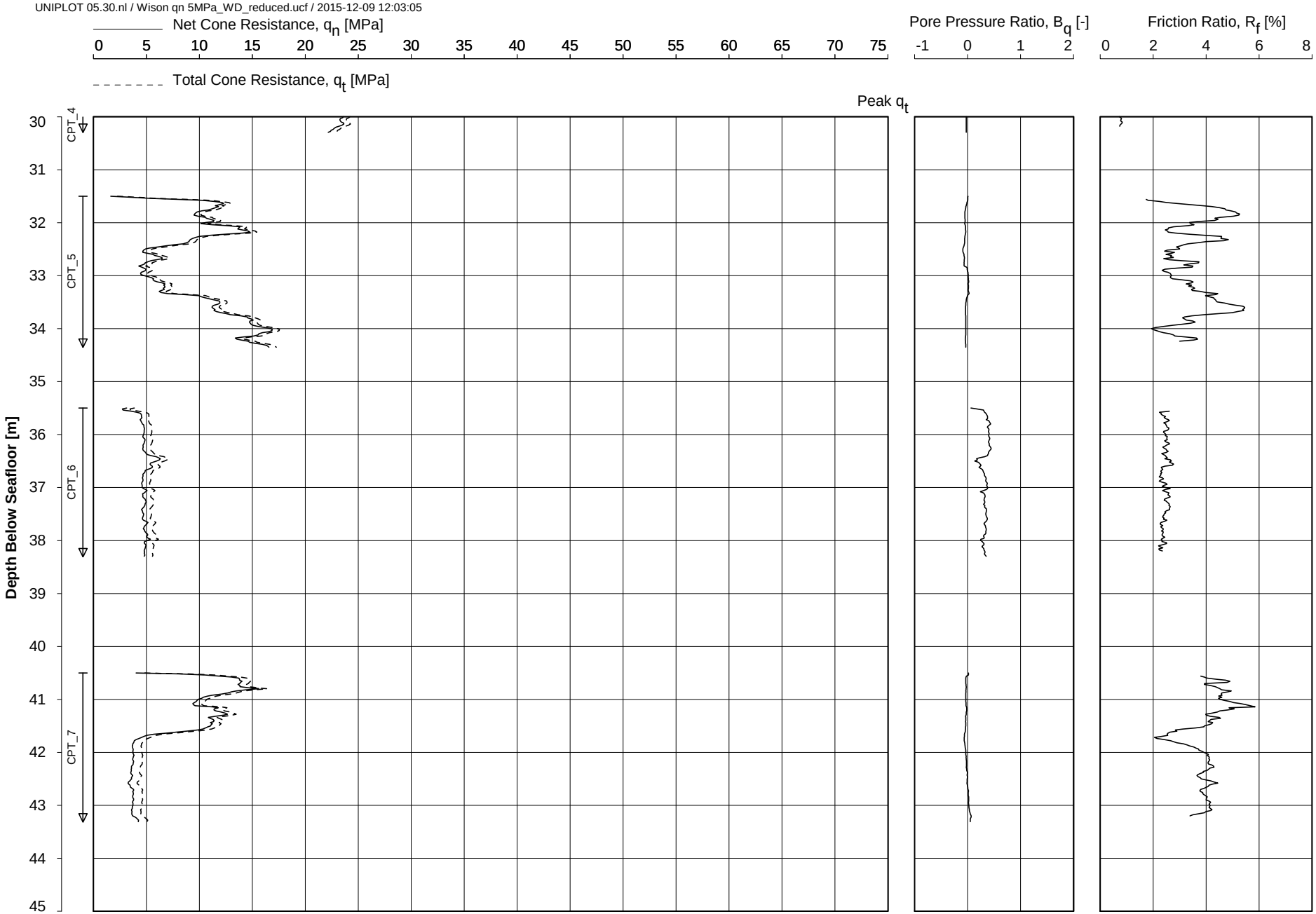
Date Of Testing : 29-Sep-2015
Water Depth [m] : 32.70 m LAT
Coordinates [m] : E493371 N5730553

CONE PENETRATION TEST

BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:03:05



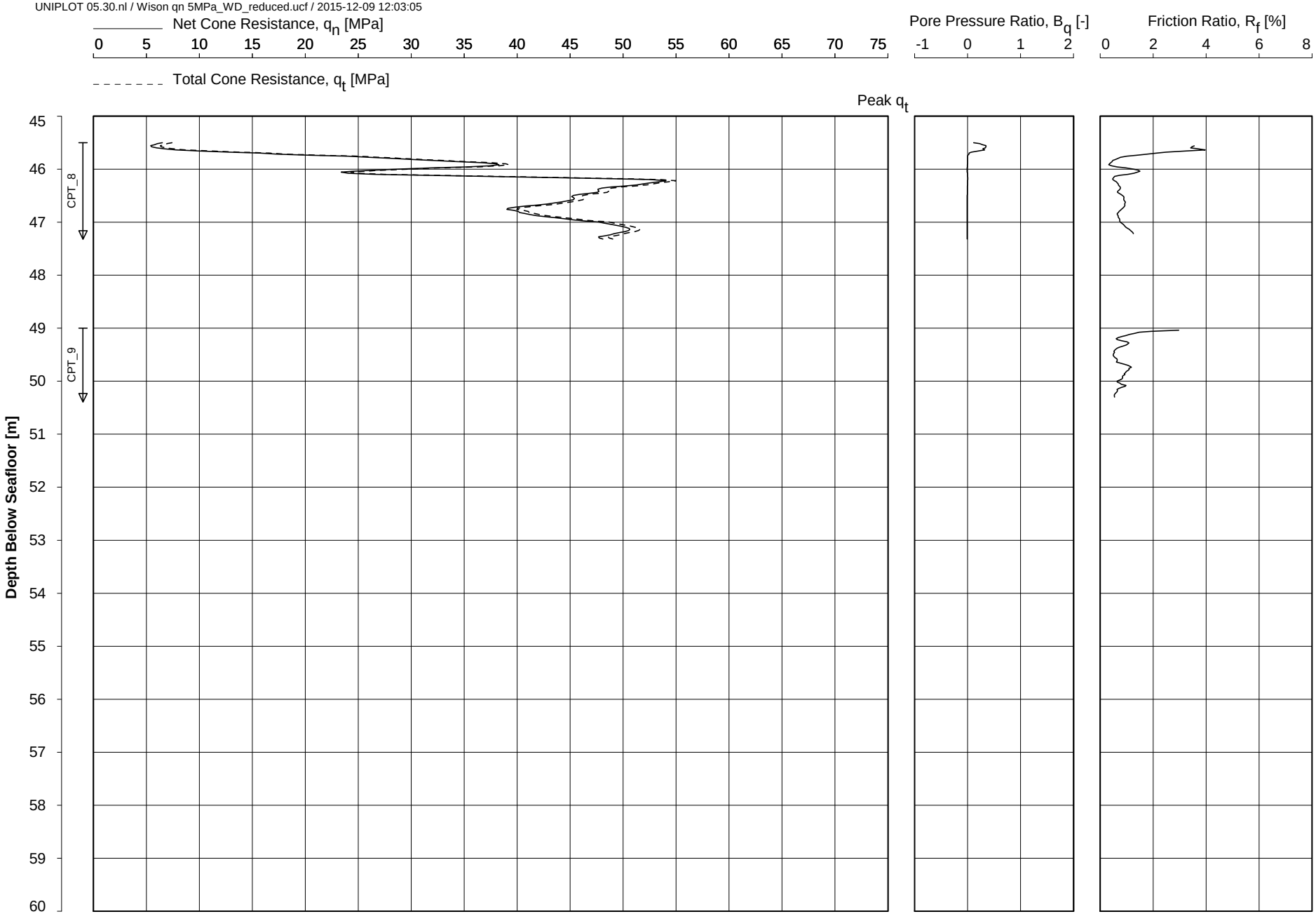
Date Of Testing : 29-Sep-2015
Water Depth [m] : 32.70 m LAT
Coordinates [m] : E493371 N5730553

CONE PENETRATION TEST

BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:03:05



Date Of Testing : 29-Sep-2015
Water Depth [m] : 32.70 m LAT
Coordinates [m] : E493371 N5730553

CONE PENETRATION TEST

BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
BH-WFS4-4	0.00 to 0.80 0.80 to 9.60 9.60 to 18.00 18.00 to 31.30 31.30 to 32.40 32.40 to 40.00 40.00 to 41.80 41.80 to 45.60 45.60 to bottom	20.00 20.50 20.00 20.00 19.50 19.50 19.50 18.50 20.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 12:04:41

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONE PENETRATION TEST - ZERO DRIFT

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
BH-WFS4-4	CPT_1	0.071	-0.002	-0.004	-0.050	0.002	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_2	0.058	-0.001	-0.005	-0.026	0.001	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_3	0.055	-0.001	-0.005	-0.037	0.002	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_4	0.056	-0.001	-0.005	-0.059	0.002	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_5	0.055	0.000	-0.005	-0.047	0.000	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_6	0.050	0.000	-0.005	-0.016	0.000	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_7	0.060	0.000	-0.005	-0.010	0.000	0.001	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_8	0.058	0.000	-0.006	-0.025	0.002	0.001	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-4	CPT_9	-0.059	-0.009		0.065	-0.001		CP5-CF80	1709-0001	0.500

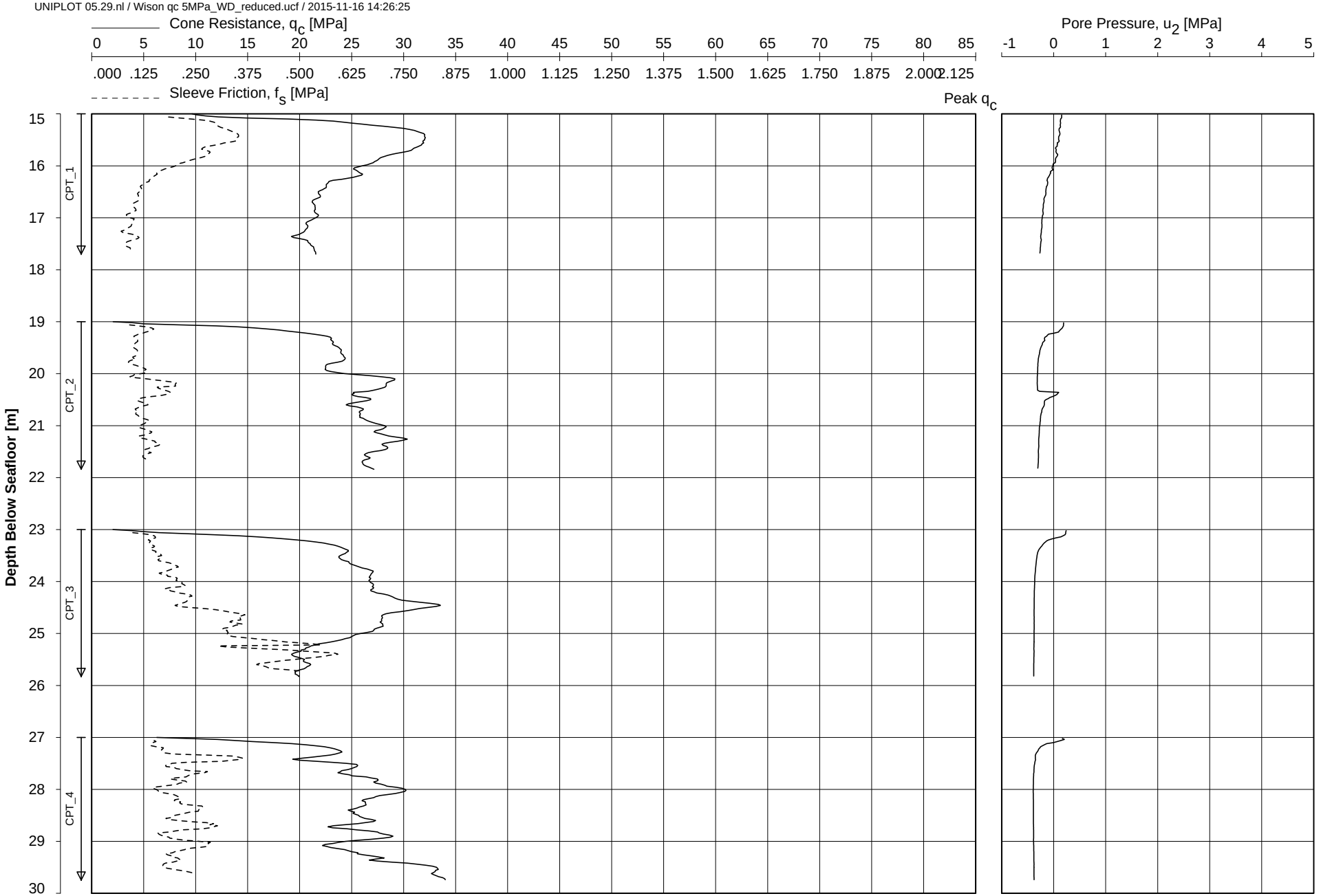
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:26:25



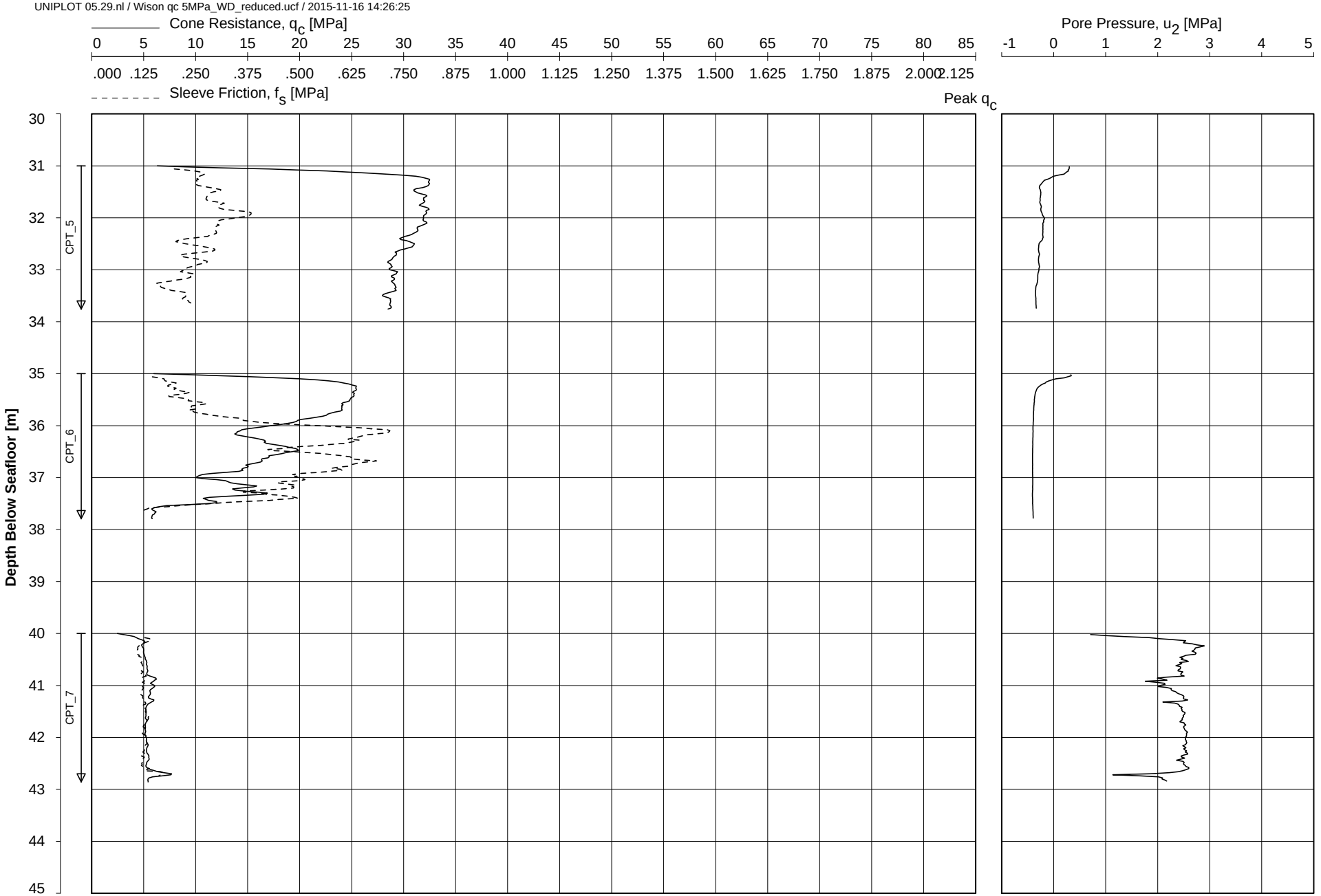
Date Of Testing : 28-Sep-2015
Water Depth [m] : 35.8 m LAT
Coordinates [m] : E495145 N5730213

CONE PENETRATION TEST

BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:26:25



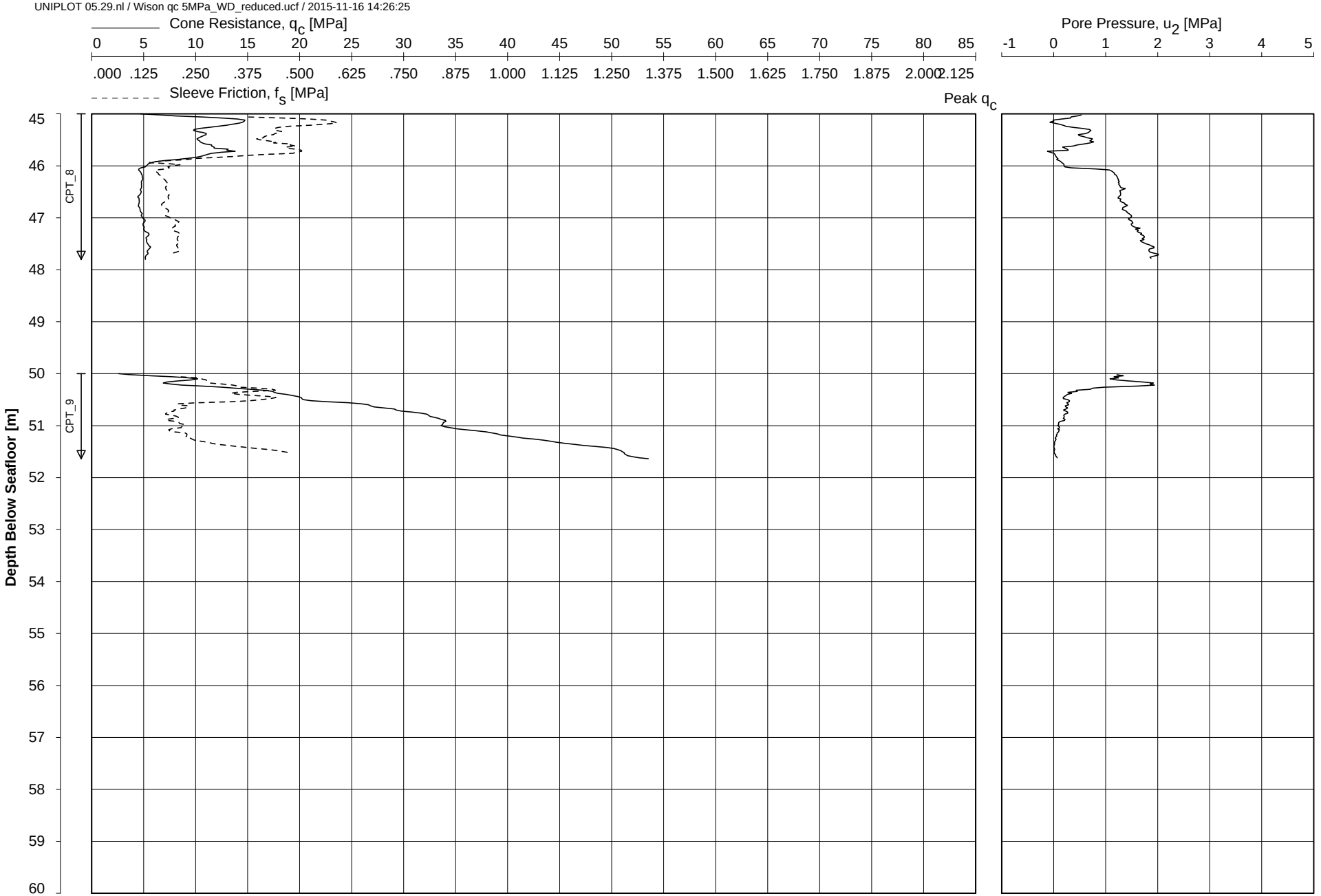
Date Of Testing : 28-Sep-2015
Water Depth [m] : 35.8 m LAT
Coordinates [m] : E495145 N5730213

CONE PENETRATION TEST

BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:26:25



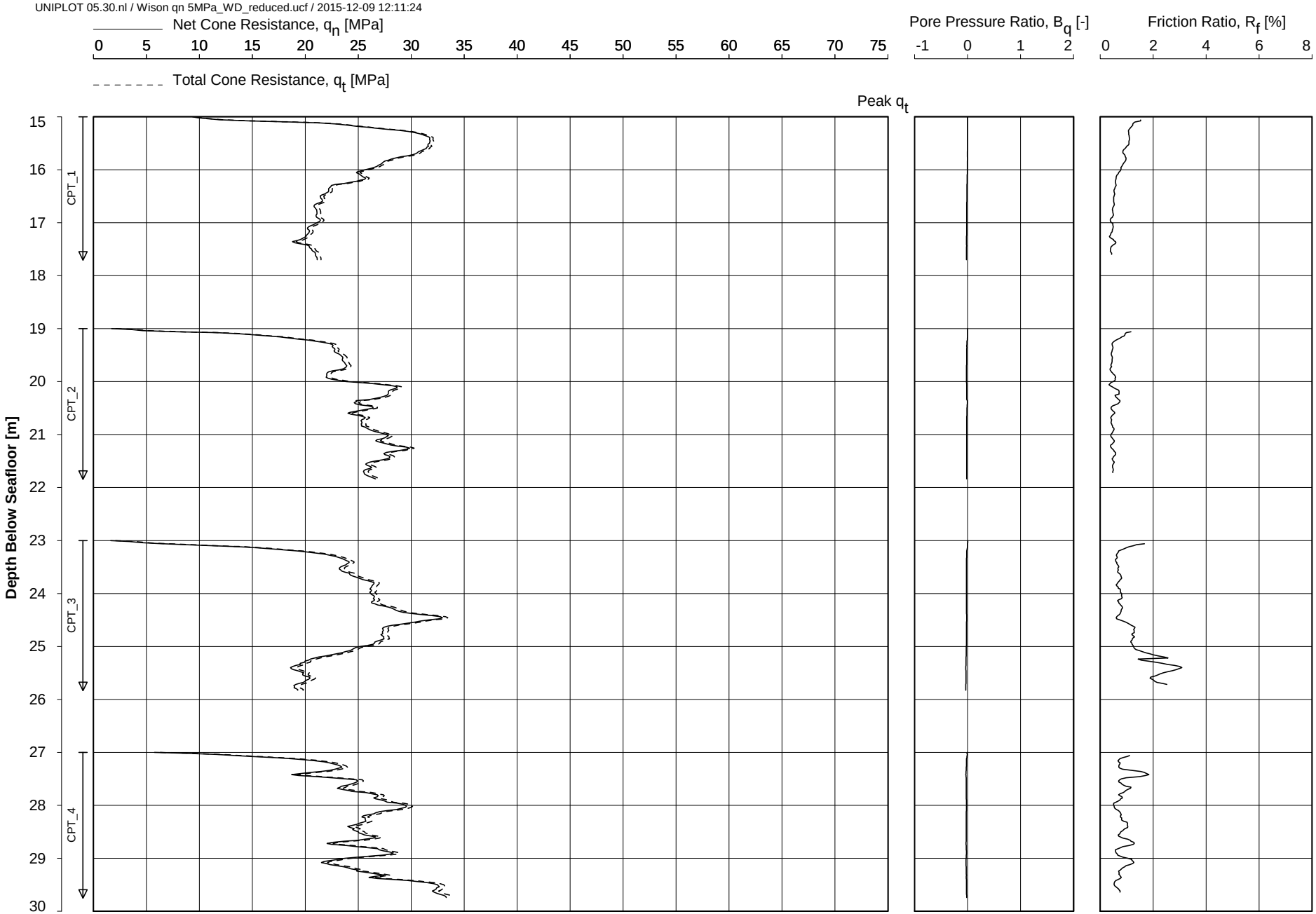
Date Of Testing : 28-Sep-2015
Water Depth [m] : 35.8 m LAT
Coordinates [m] : E495145 N5730213

CONE PENETRATION TEST

BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:11:24



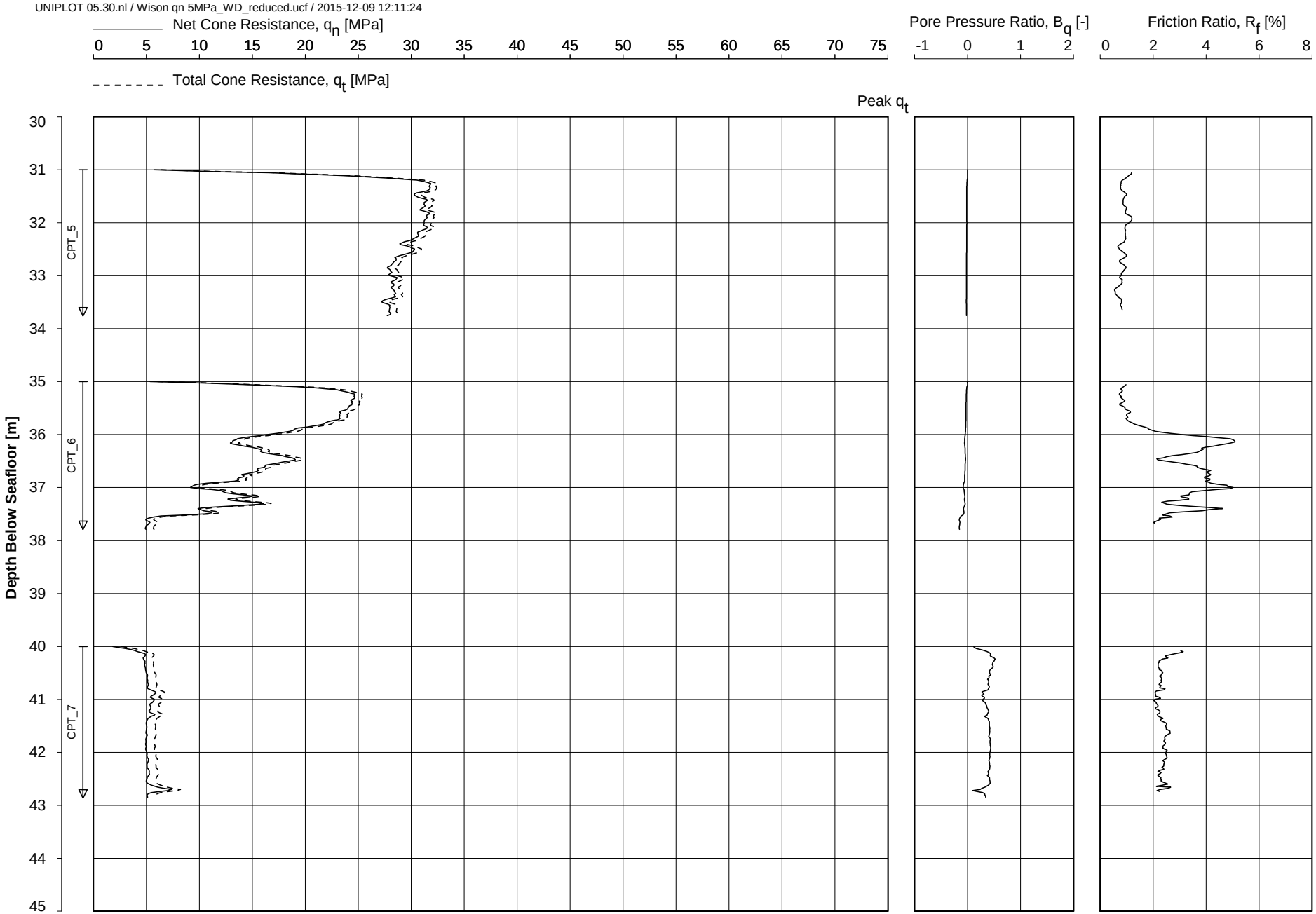
Date Of Testing : 28-Sep-2015
Water Depth [m] : 35.8 m LAT
Coordinates [m] : E495145 N5730213

CONE PENETRATION TEST

BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:11:24



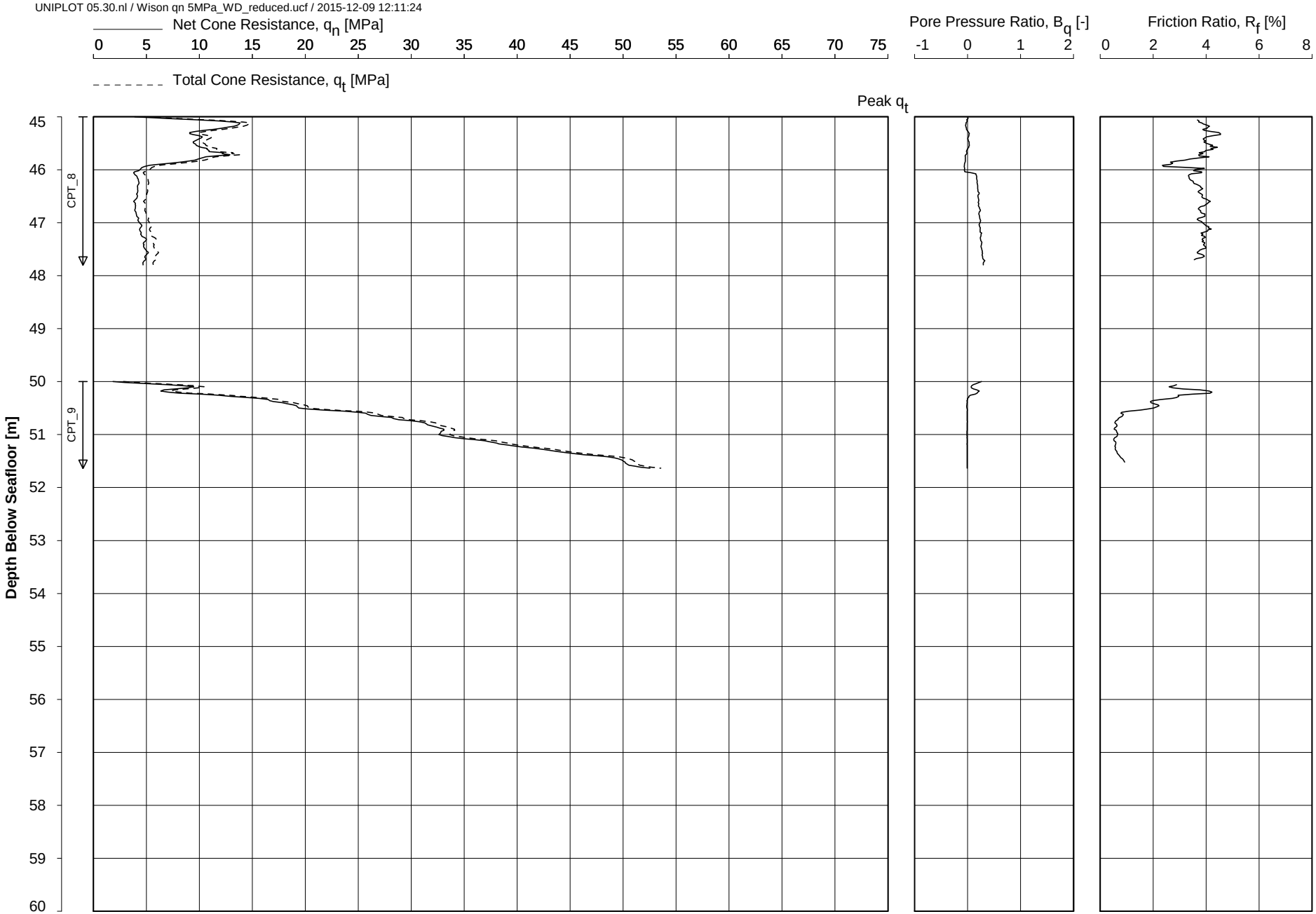
Date Of Testing : 28-Sep-2015
Water Depth [m] : 35.8 m LAT
Coordinates [m] : E495145 N5730213

CONE PENETRATION TEST

BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:11:24



Date Of Testing : 28-Sep-2015
Water Depth [m] : 35.8 m LAT
Coordinates [m] : E495145 N5730213

CONE PENETRATION TEST

BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
BH-WFS4-5	0.00 to 2.50 2.50 to 14.25 14.25 to 25.30 25.30 to 36.00 36.00 to 37.50 37.50 to 43.90 43.90 to 46.10 46.10 to 50.00 50.00 to bottom	20.00 20.50 20.00 20.00 19.50 19.50 19.50 18.50 20.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 12:12:54

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONE PENETRATION TEST - ZERO DRIFT

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
BH-WFS4-5	CPT_1	0.058	-0.001	-0.005	-0.004	0.001	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_2	0.063	-0.001	-0.005	-0.015	0.002	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_3	0.068	-0.002	-0.005	-0.037	0.003	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_4	0.045	0.000	-0.004	-0.034	0.002	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_5	0.047	0.000	-0.004	-0.060	0.001	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_6	0.046	0.000	-0.005	-0.017	0.001	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_7	0.049	-0.001	-0.005	0.015	0.001	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_8	0.061	0.000	-0.006	0.009	0.000	0.000	CP10-CF50PB10	1706-2196	0.750
BH-WFS4-5	CPT_9	0.053	0.000	-0.005	-0.040	0.002	0.000	CP10-CF50PB10	1706-2196	0.750

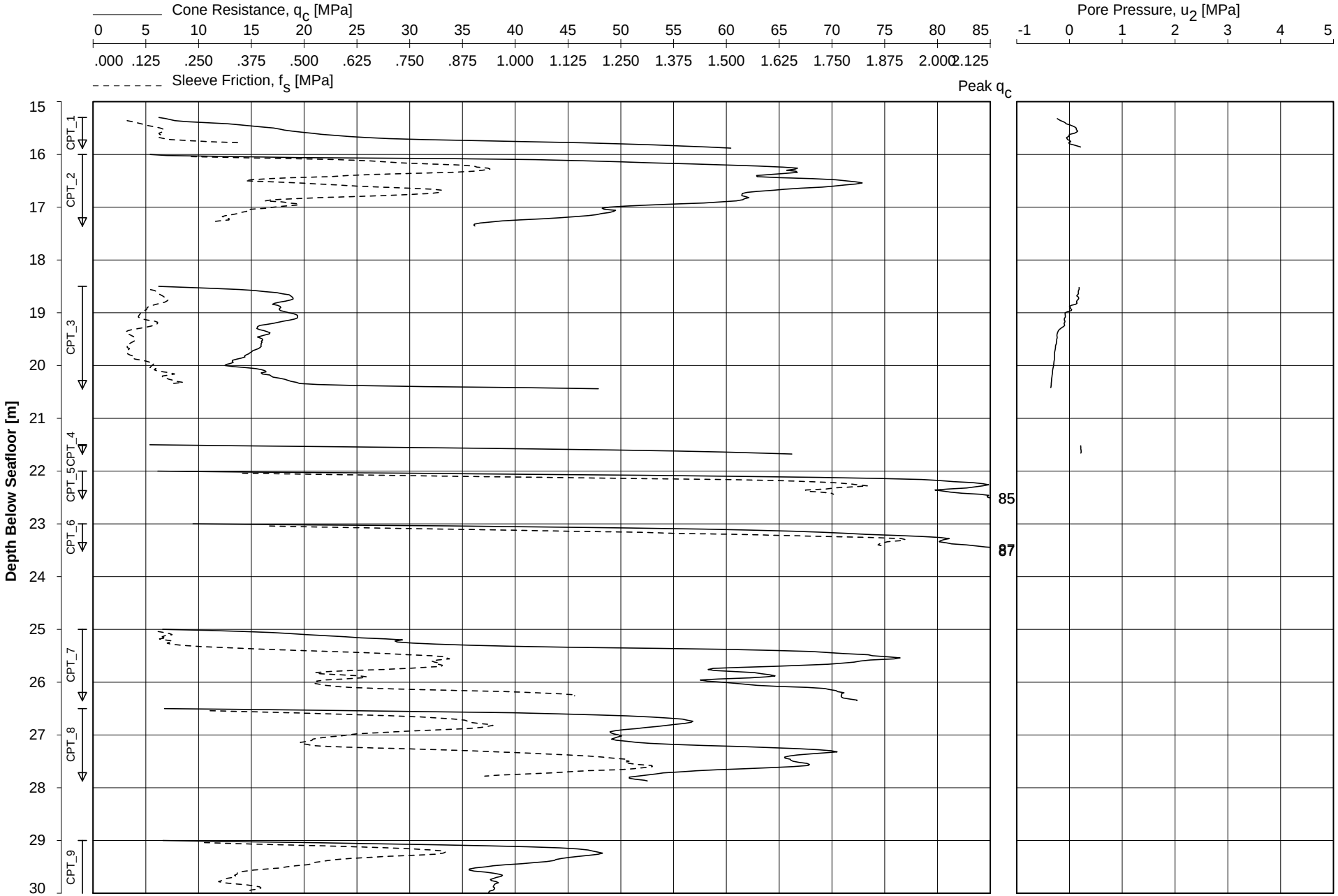
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:28:00



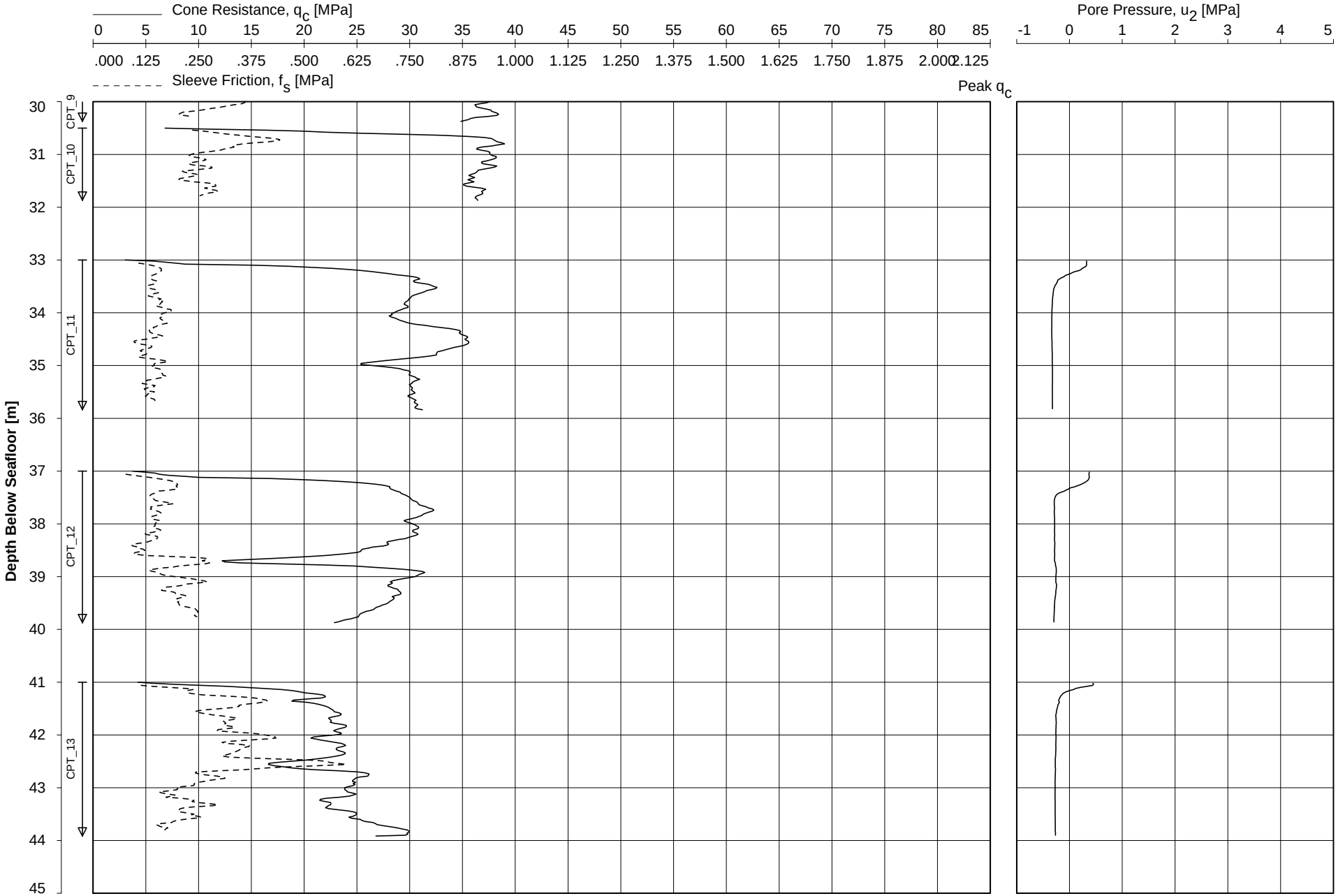
Date Of Testing : 04-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E493593 N5734621

CONE PENETRATION TEST

BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:28:00



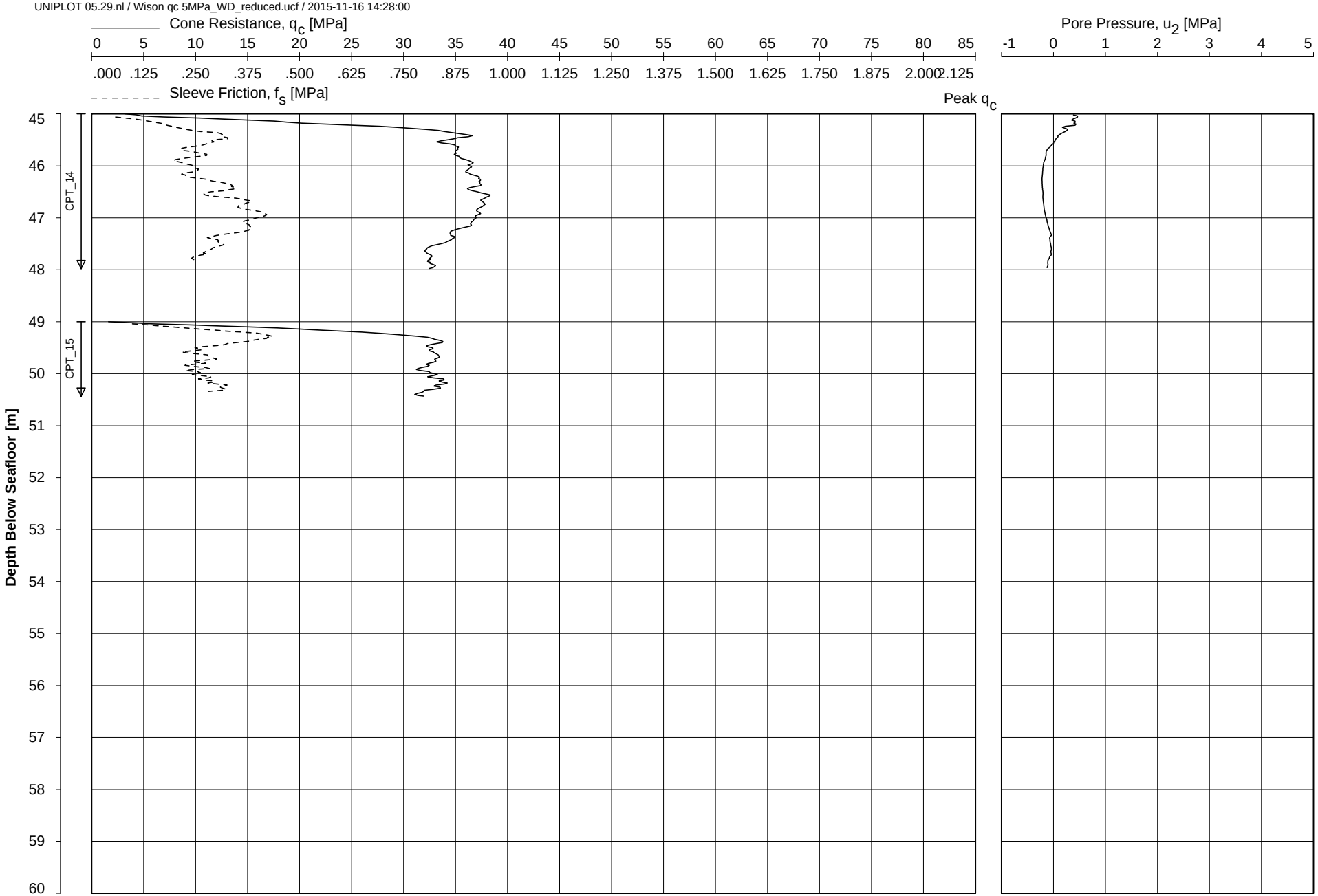
Date Of Testing : 04-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E493593 N5734621

CONE PENETRATION TEST

BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:28:00



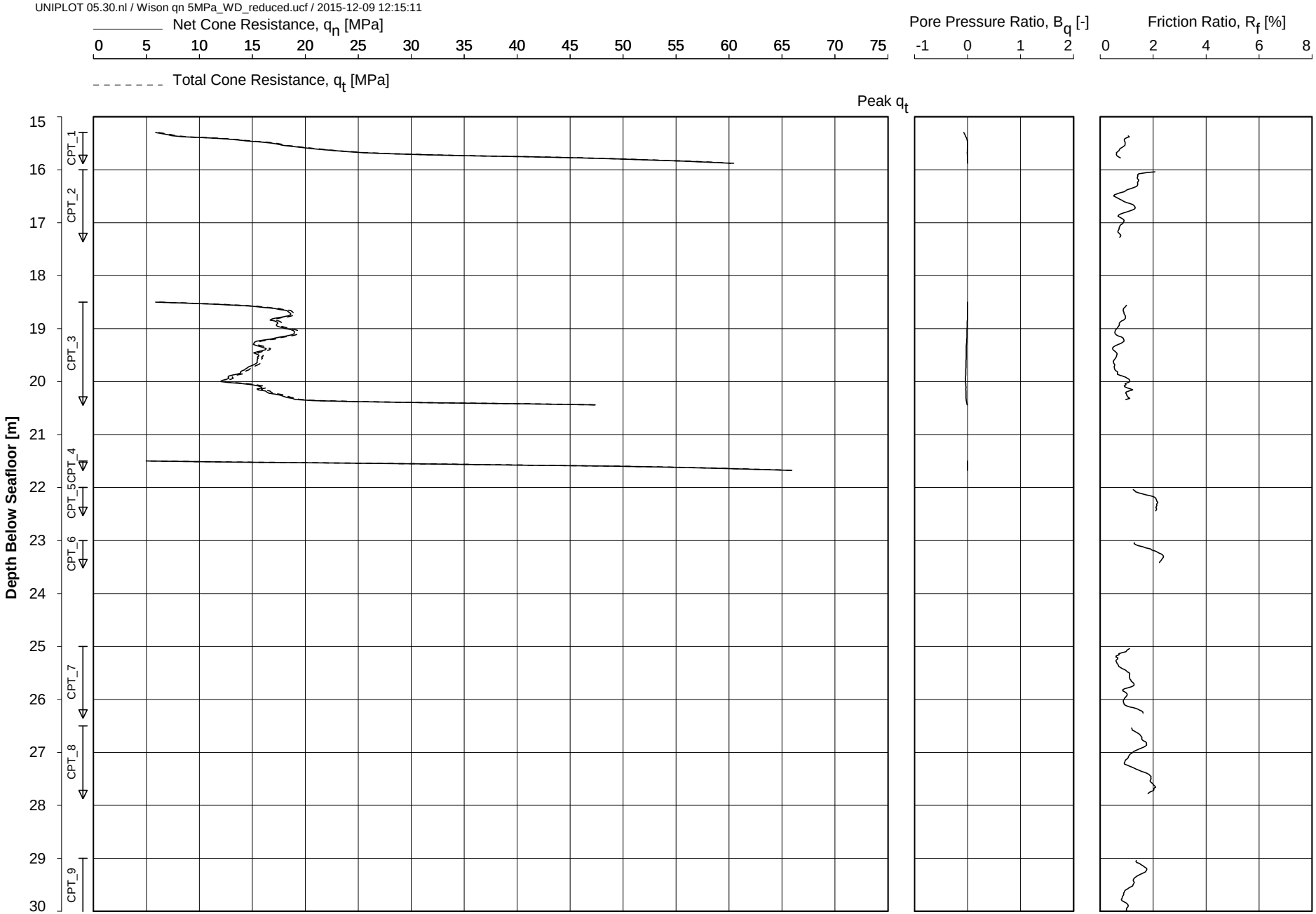
Date Of Testing : 05-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E493593 N5734621

CONE PENETRATION TEST

BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:15:11



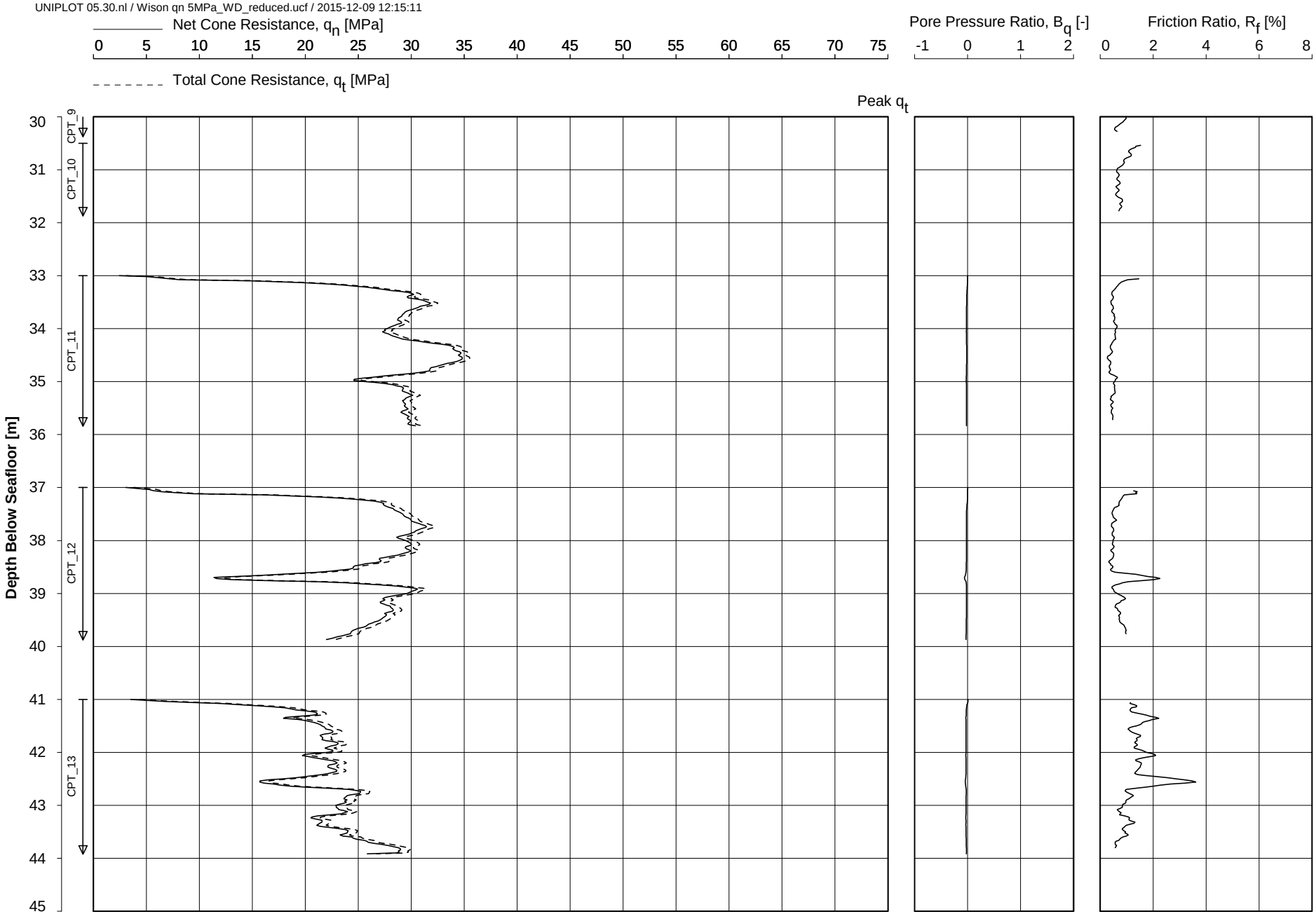
Date Of Testing : 04-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E493593 N5734621

CONE PENETRATION TEST

BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:15:11



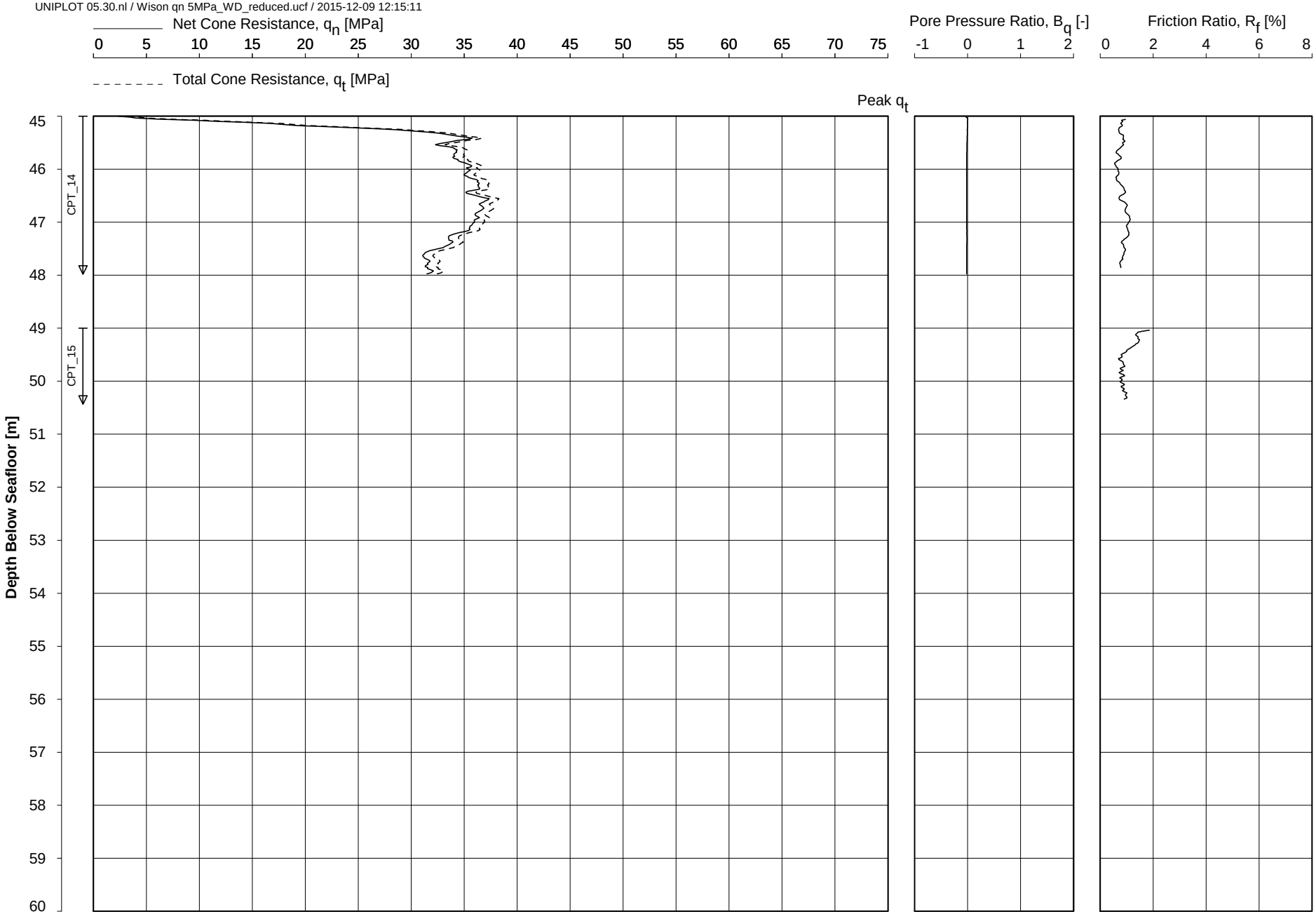
Date Of Testing : 04-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E493593 N5734621

CONE PENETRATION TEST

BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:15:11



Date Of Testing : 05-Oct-2015
Water Depth [m] : 29.8 m LAT
Coordinates [m] : E493593 N5734621

CONE PENETRATION TEST

BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
BH-WFS4-6	0.00 to 6.50 6.50 to 13.20 13.20 to 20.35 20.35 to 29.40 29.40 to 38.55 38.55 to bottom	20.00 20.50 20.50 20.50 20.00 20.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 12:17:05

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
BH-WFS4-6	CPT_1	0.006	0.006	-0.005	-0.007	-0.002	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-6	CPT_2	0.054	-0.001		-0.001	-0.007		CP5-CF80	1721-1713	0.500
BH-WFS4-6	CPT_3	-0.048	0.007	-0.004	0.021	-0.004	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-6	CPT_4	0.000	0.005	-0.005	-0.004	-0.002	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-6	CPT_5	0.064	-0.007		-0.029	-0.001		CP5-CF80	1721-1713	0.500
BH-WFS4-6	CPT_6	0.055	-0.008		-0.028	0.001		CP5-CF80	1721-1713	0.500
BH-WFS4-6	CPT_7	0.053	-0.007		-0.018	0.000		CP5-CF80	1721-1713	0.500
BH-WFS4-6	CPT_8	0.032	-0.005		-0.024	0.000		CP5-CF80	1721-1713	0.500
BH-WFS4-6	CPT_9	0.019	-0.005		-0.015	-0.001		CP5-CF80	1721-1713	0.500
BH-WFS4-6	CPT_10	0.012	-0.004		-0.036	0.000		CP5-CF80	1721-1713	0.500
BH-WFS4-6	CPT_11	0.015	0.005	-0.005	-0.060	-0.001	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-6	CPT_12	0.002	0.004	-0.005	-0.047	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-6	CPT_13	-0.002	0.004	-0.006	-0.027	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-6	CPT_14	-0.009	0.004	-0.006	-0.022	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-6	CPT_15	0.060	-0.005		-0.008	0.001		CP5-CF80	1721-1713	0.500

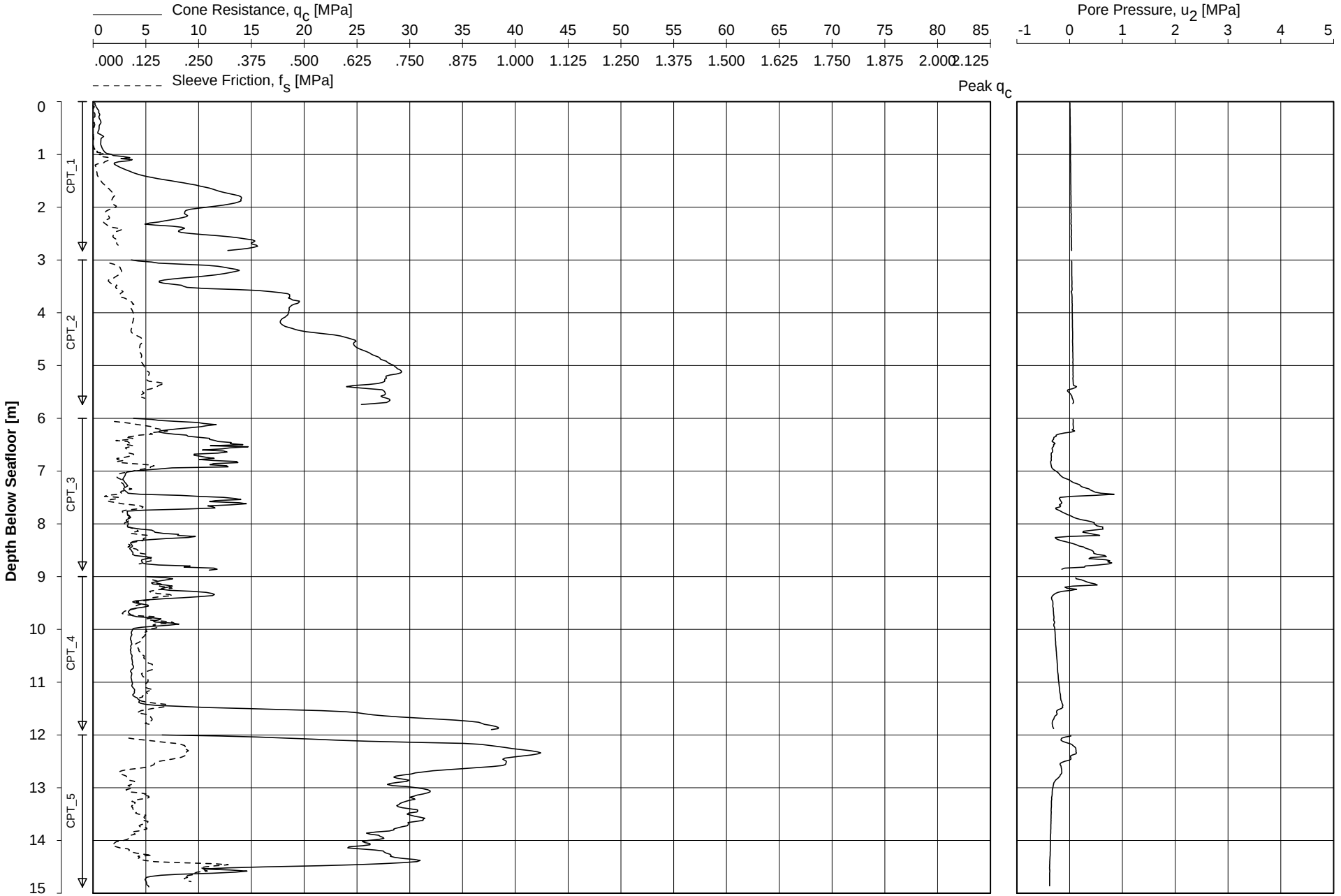
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:38:33



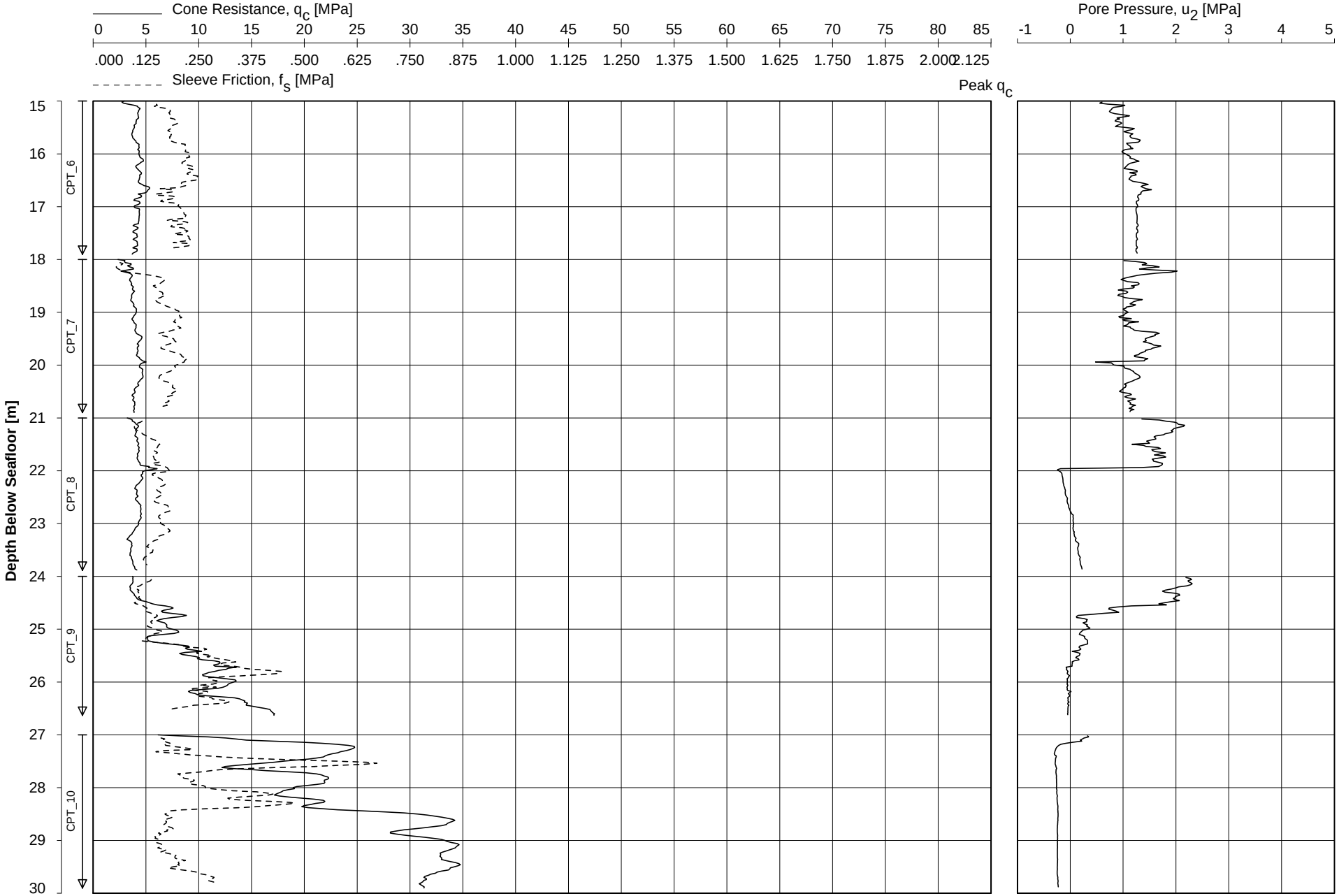
Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:38:33



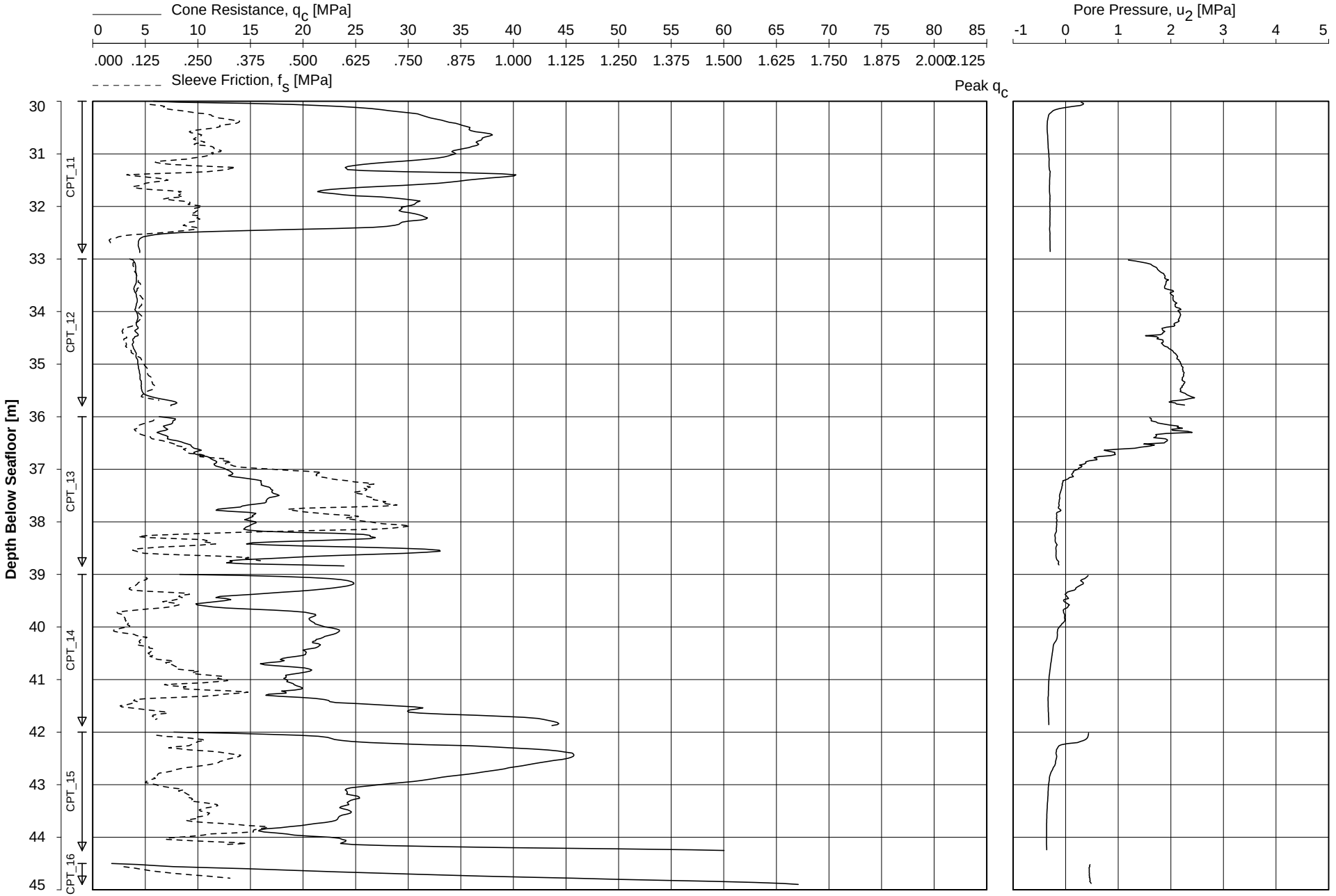
Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:38:34



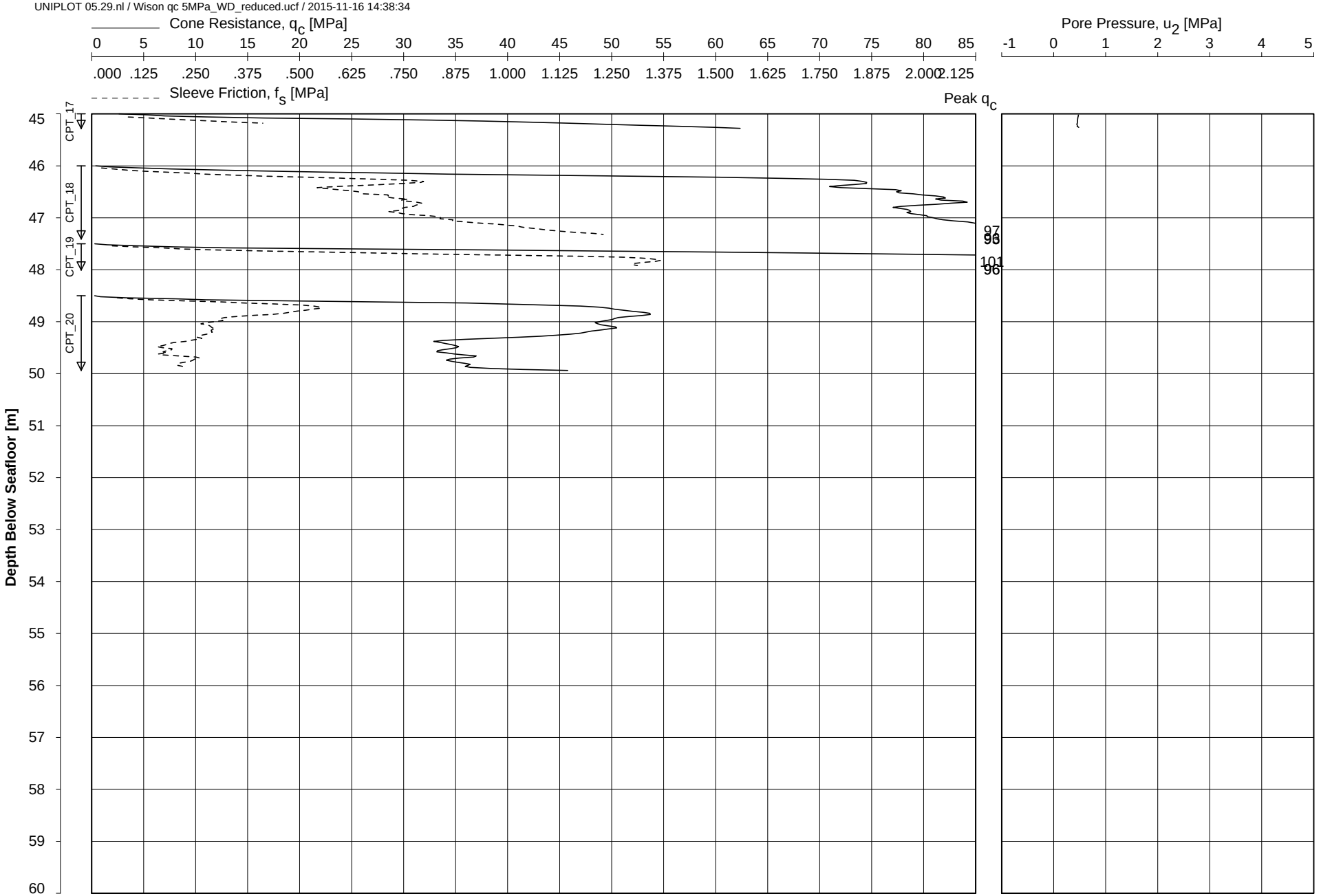
Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:38:34



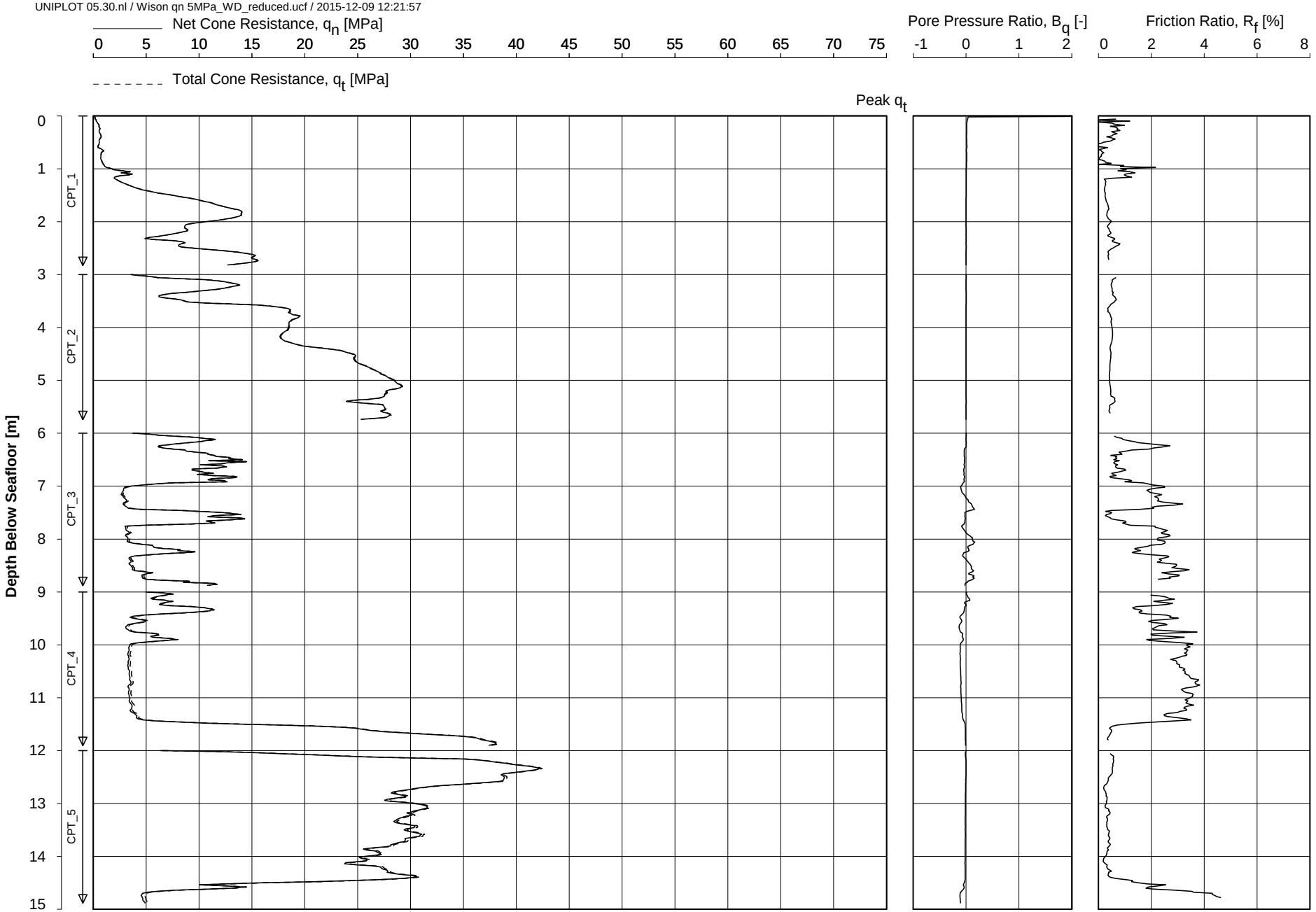
Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:21:57



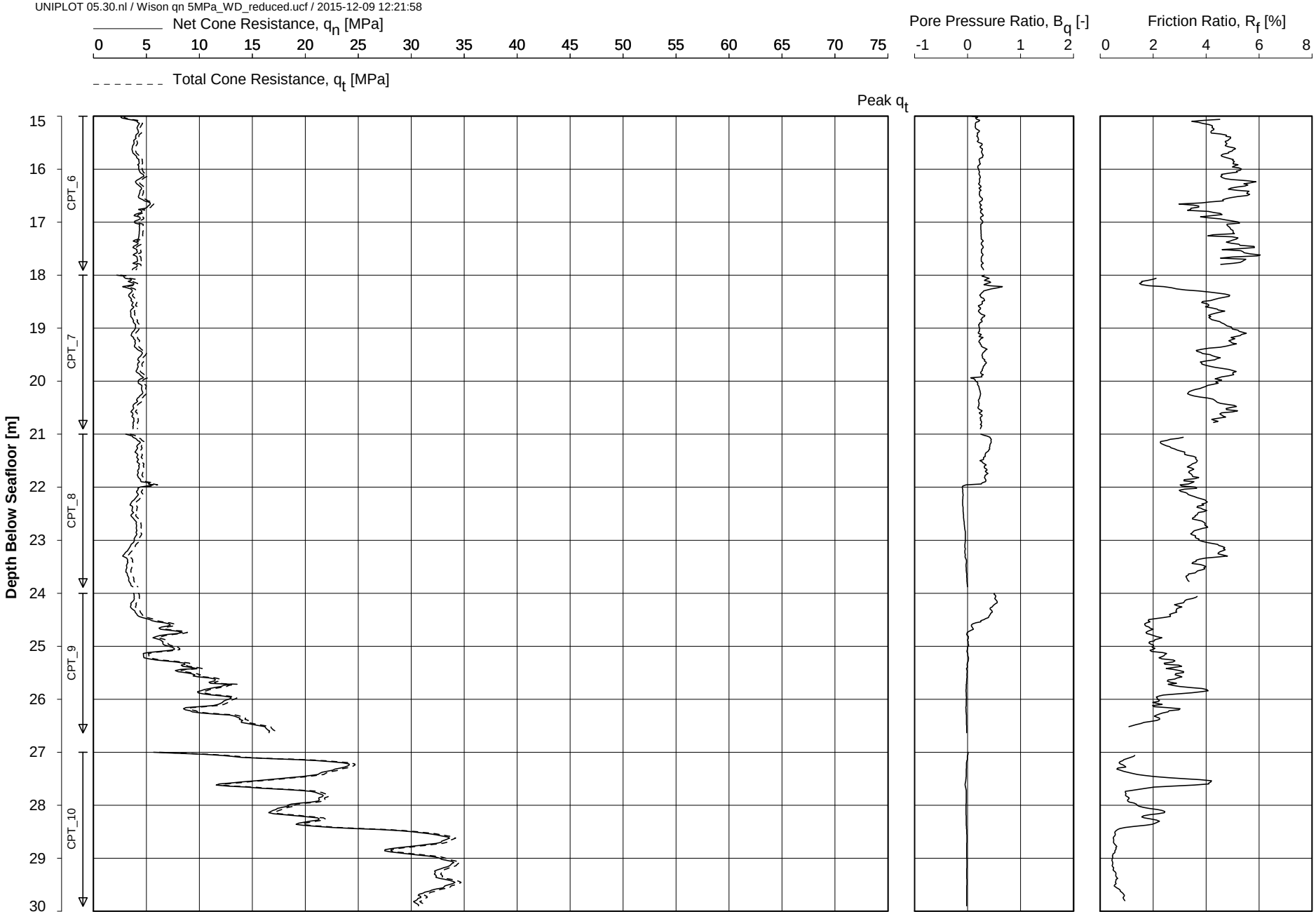
Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:21:58



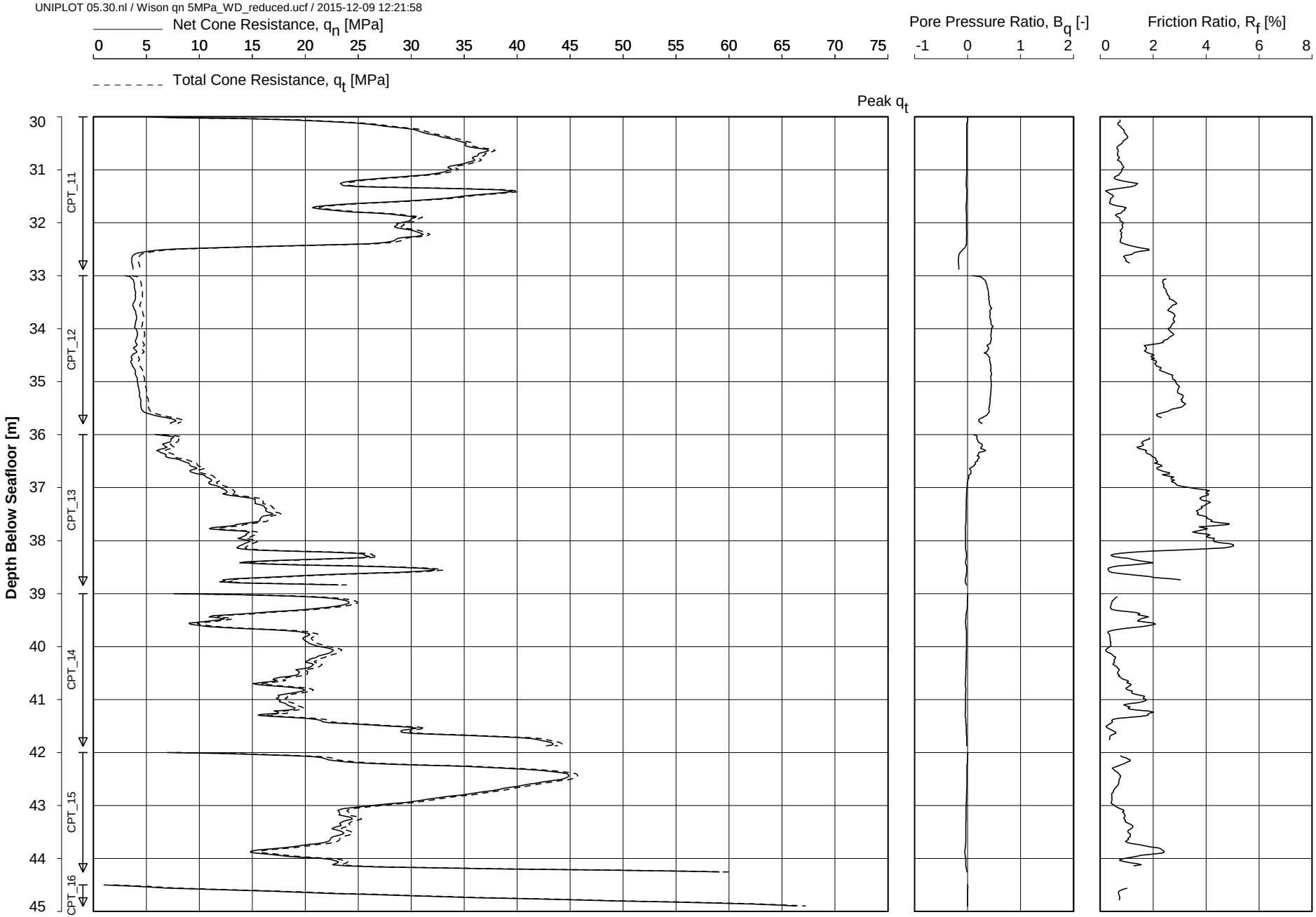
Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:21:58



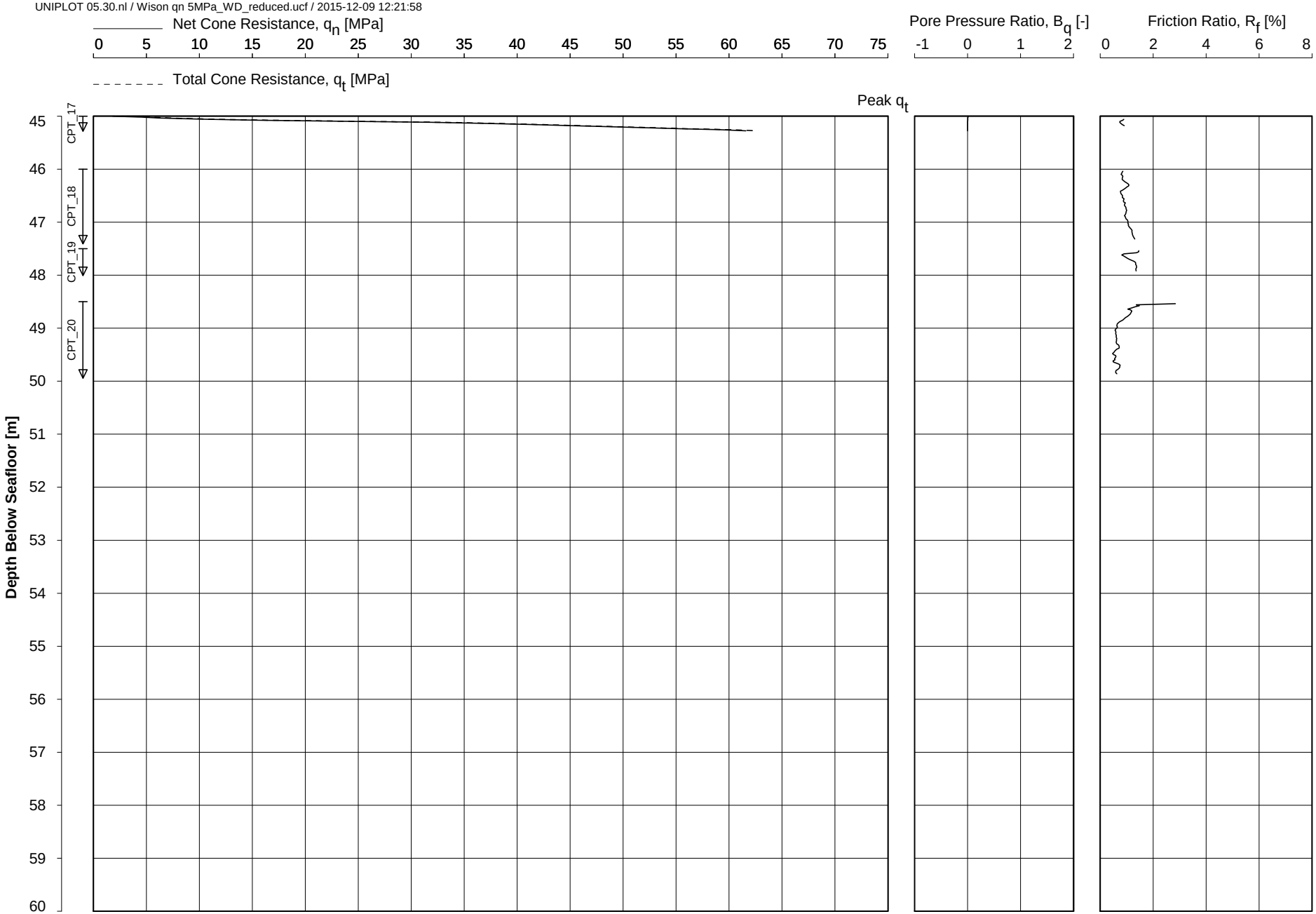
Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:21:58



Date Of Testing : 14-Sep-2015
Water Depth [m] : 34.8 m LAT
Coordinates [m] : E498785 N5736557

CONE PENETRATION TEST

CPT_WFS4_7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
CPT_WFS4_7	0.00 to 1.20 1.20 to 5.90 5.90 to 11.35 11.35 to 14.65 14.65 to 24.50 24.50 to 32.50 32.50 to 35.70 35.70 to bottom	20.00 20.50 20.00 20.00 19.50 20.00 20.00 20.50	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 12:25:47

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
CPT_WFS4_7	CPT_1	-0.062	0.001	-0.015	-0.014	-0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_2	-0.069	0.000	-0.015	-0.011	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_3	-0.064	0.000	-0.016	-0.009	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_4	-0.072	0.000	-0.016	-0.003	-0.002	0.007	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_5	-0.063	0.000	-0.017	-0.020	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_6	-0.065	0.000	-0.016	0.007	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_7	-0.056	0.000	-0.015	0.012	0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_8	-0.061	0.001	-0.014	-0.002	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_9	-0.059	0.002	-0.013	-0.012	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_10	-0.056	0.003	-0.013	-0.034	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_11	-0.056	0.003	-0.013	-0.026	0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_12	-0.060	0.003	-0.012	0.009	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_13	-0.058	0.002	-0.012	-0.004	0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_14	-0.057	0.002	-0.012	-0.016	0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_15	-0.056	0.003	-0.011	-0.007	0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_16	-0.056	0.003	-0.011	0.002	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_17	-0.056	0.002	-0.011	0.014	0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_7	CPT_18	0.147	-0.004		-0.080	0.001		CP5-CF80	1721-1889	0.500
CPT_WFS4_7	CPT_19	0.077	-0.003		-0.008	0.001		CP5-CF80	1721-1889	0.500
CPT_WFS4_7	CPT_20	0.058	-0.002		0.040	-0.002		CP5-CF80	1721-1889	0.500

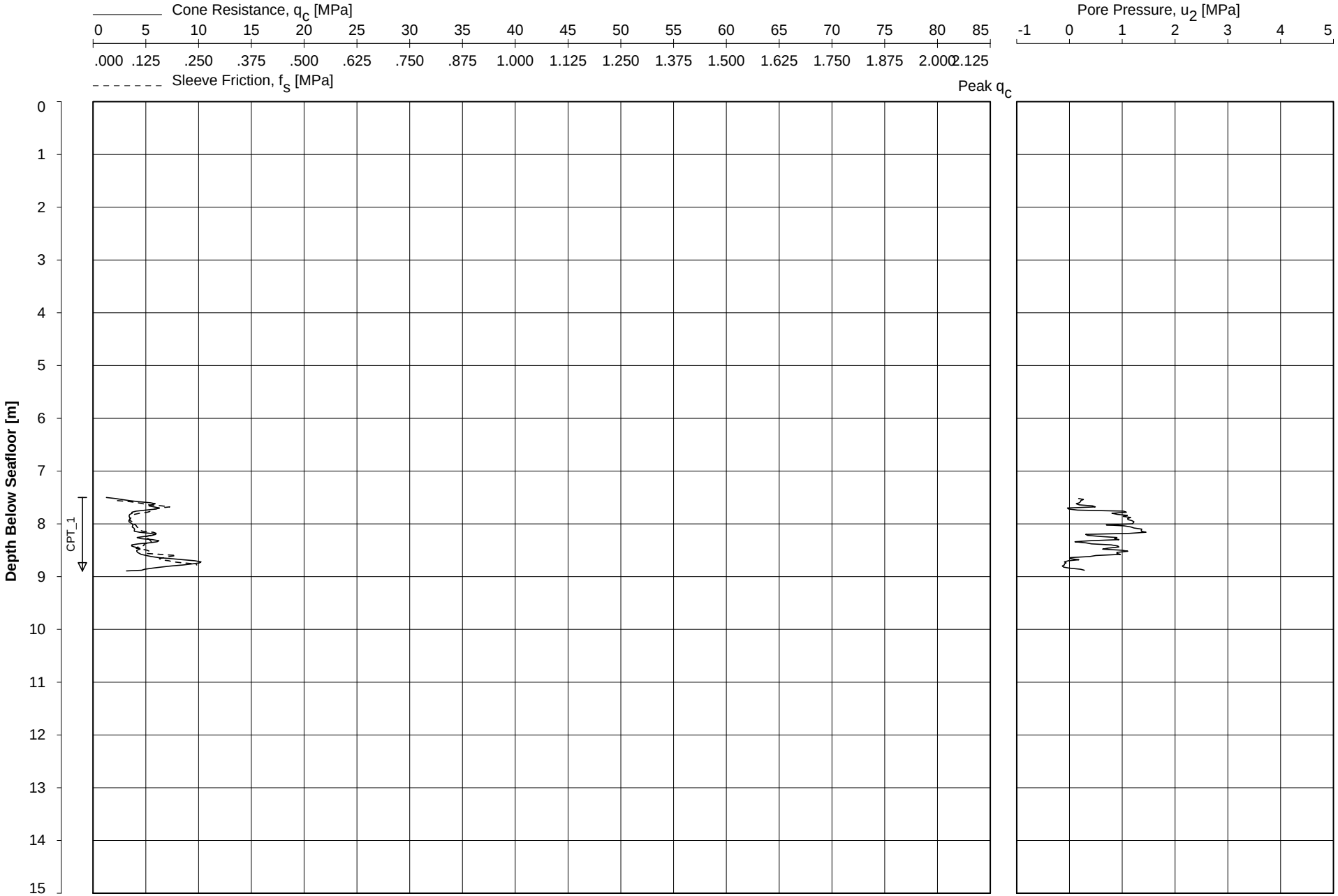
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:40:17



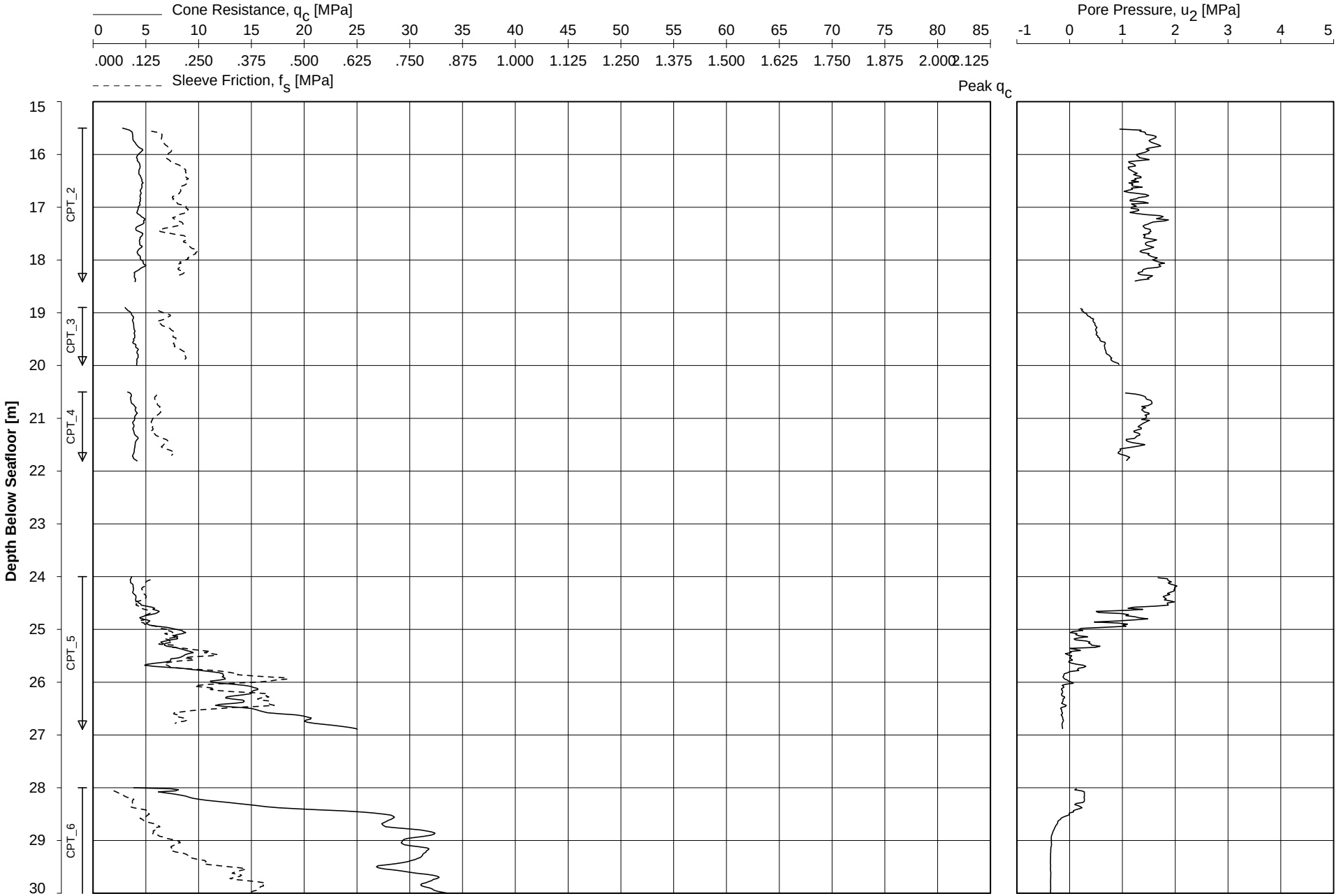
Date Of Testing : 05-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:40:17



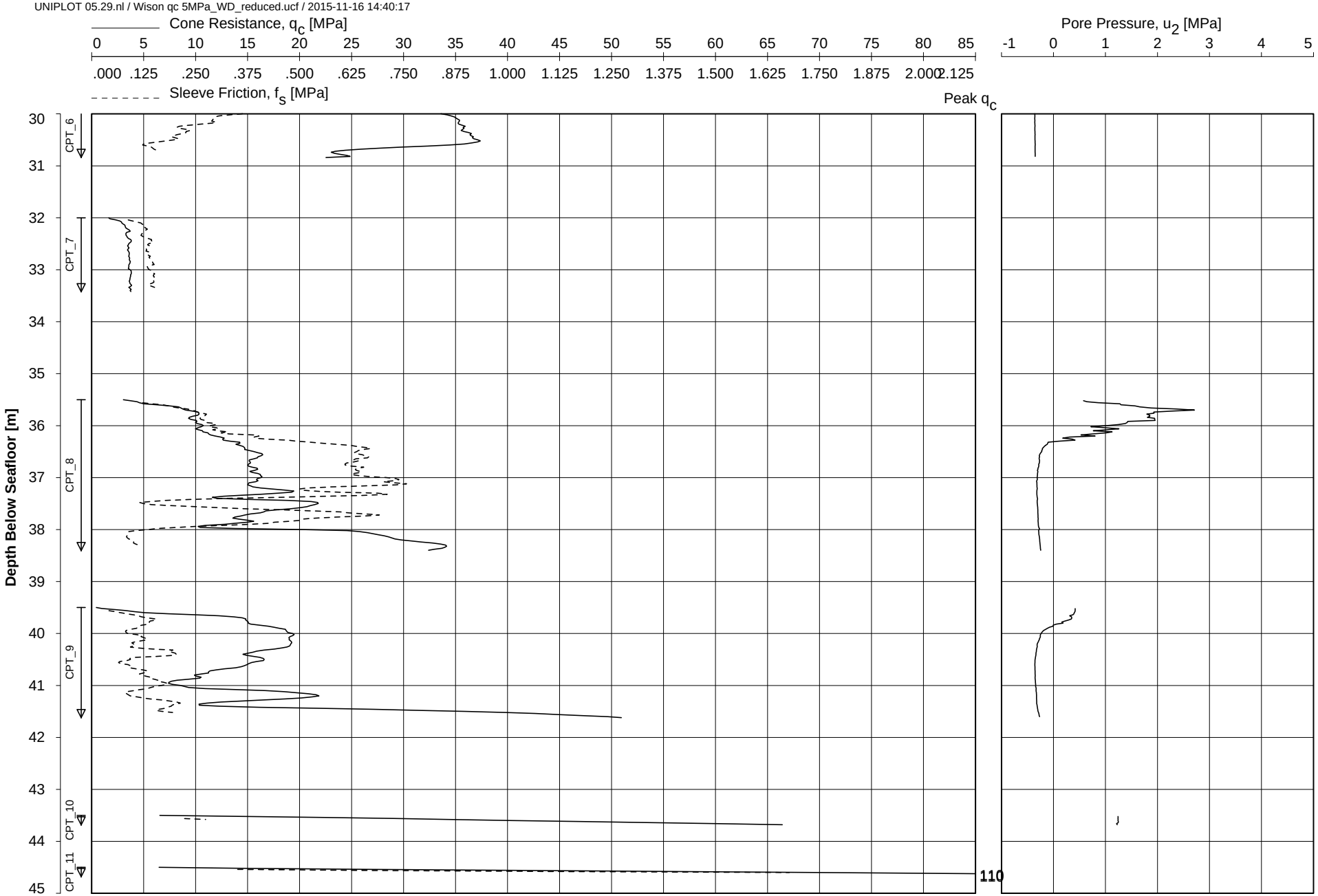
Date Of Testing : 05-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:40:17



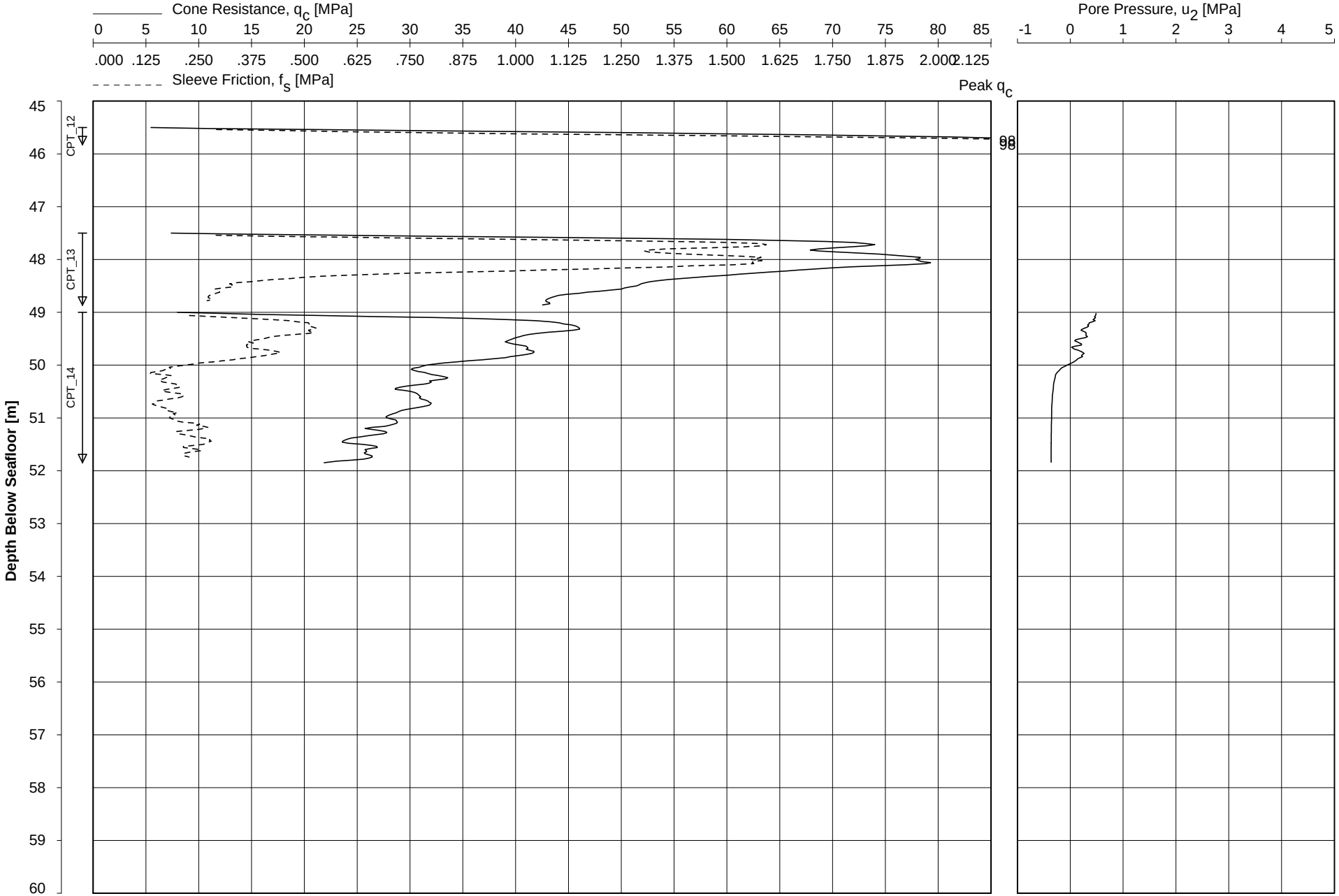
Date Of Testing : 05-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:40:17



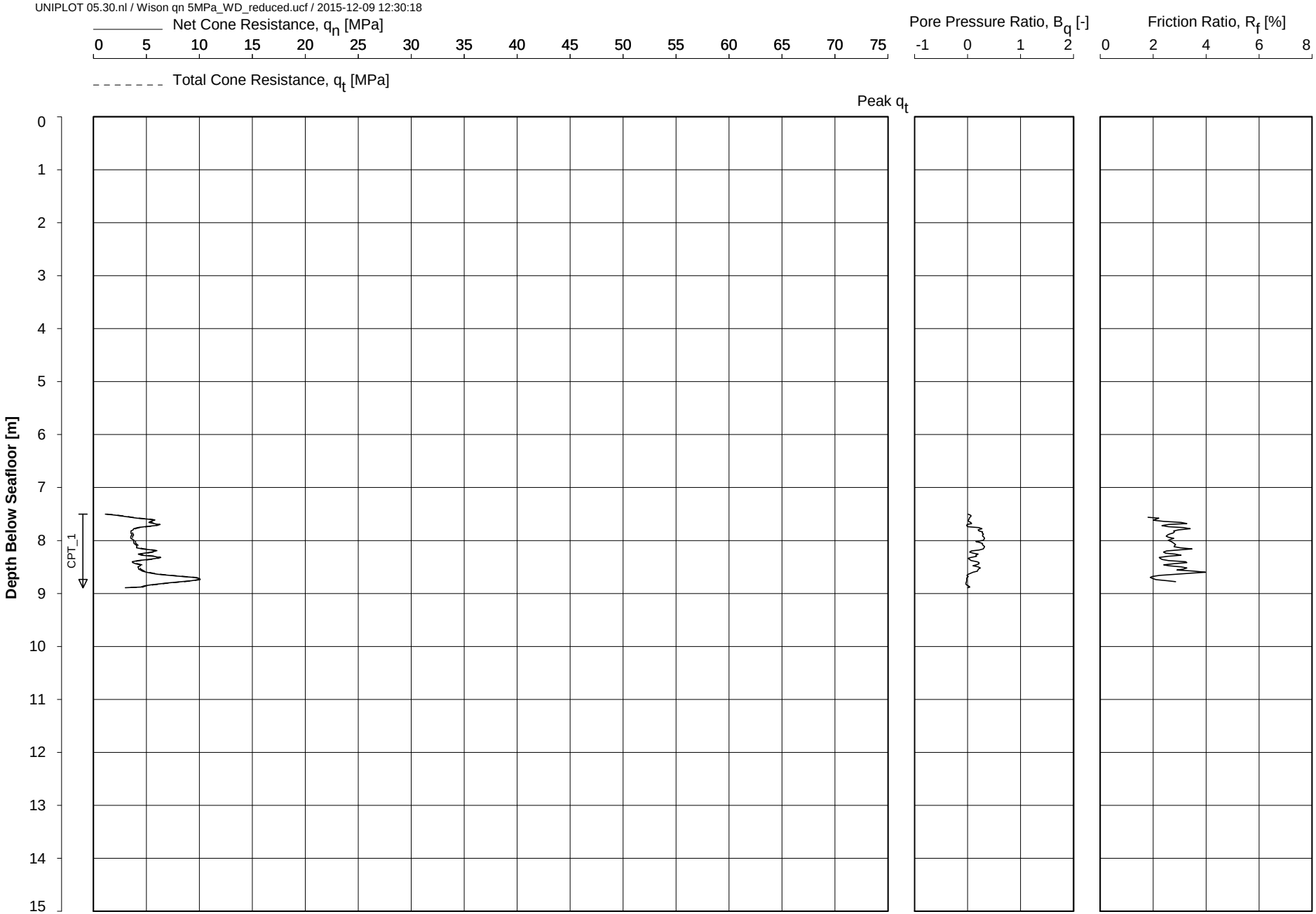
Date Of Testing : 06-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:30:18



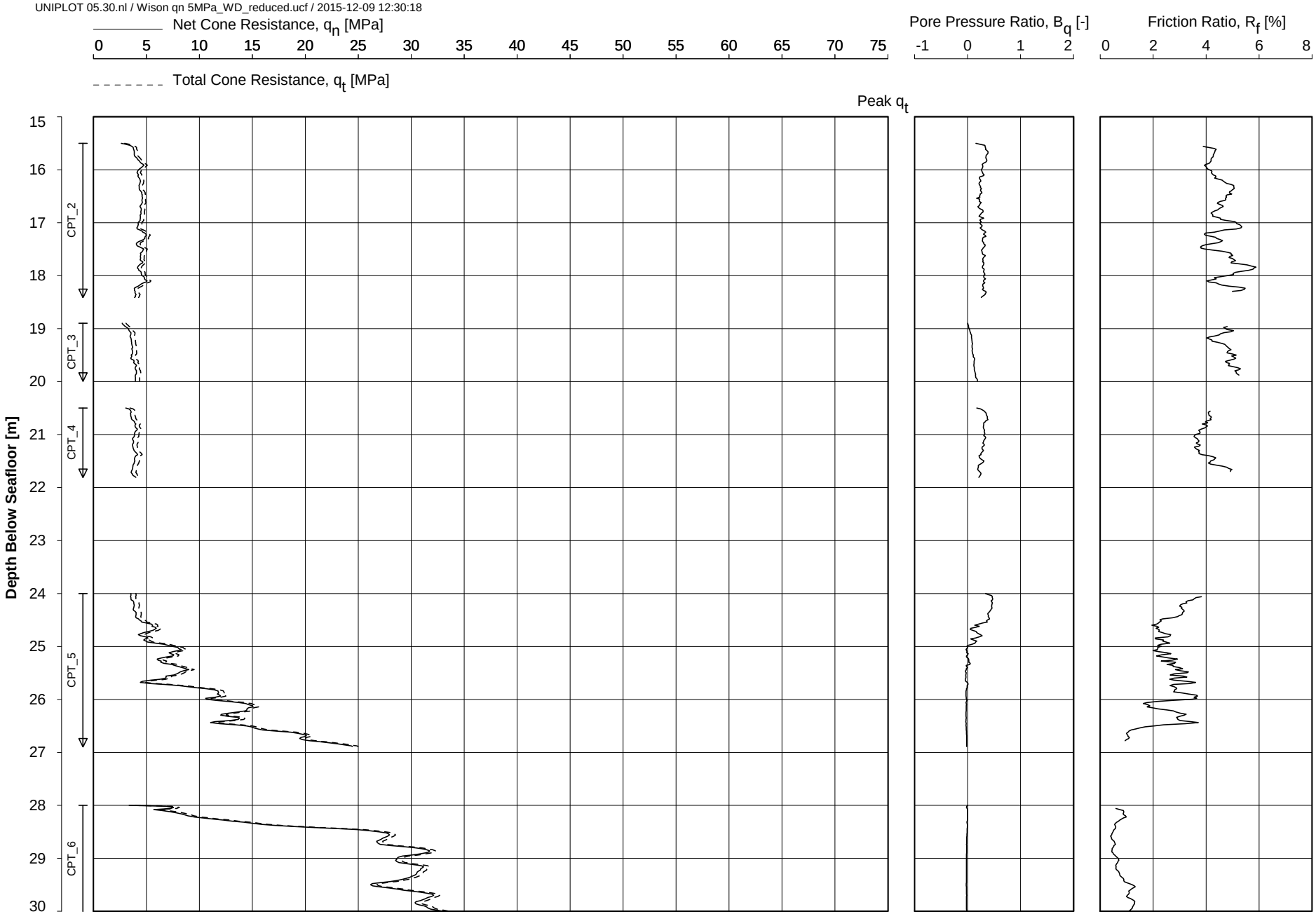
Date Of Testing : 05-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:30:18



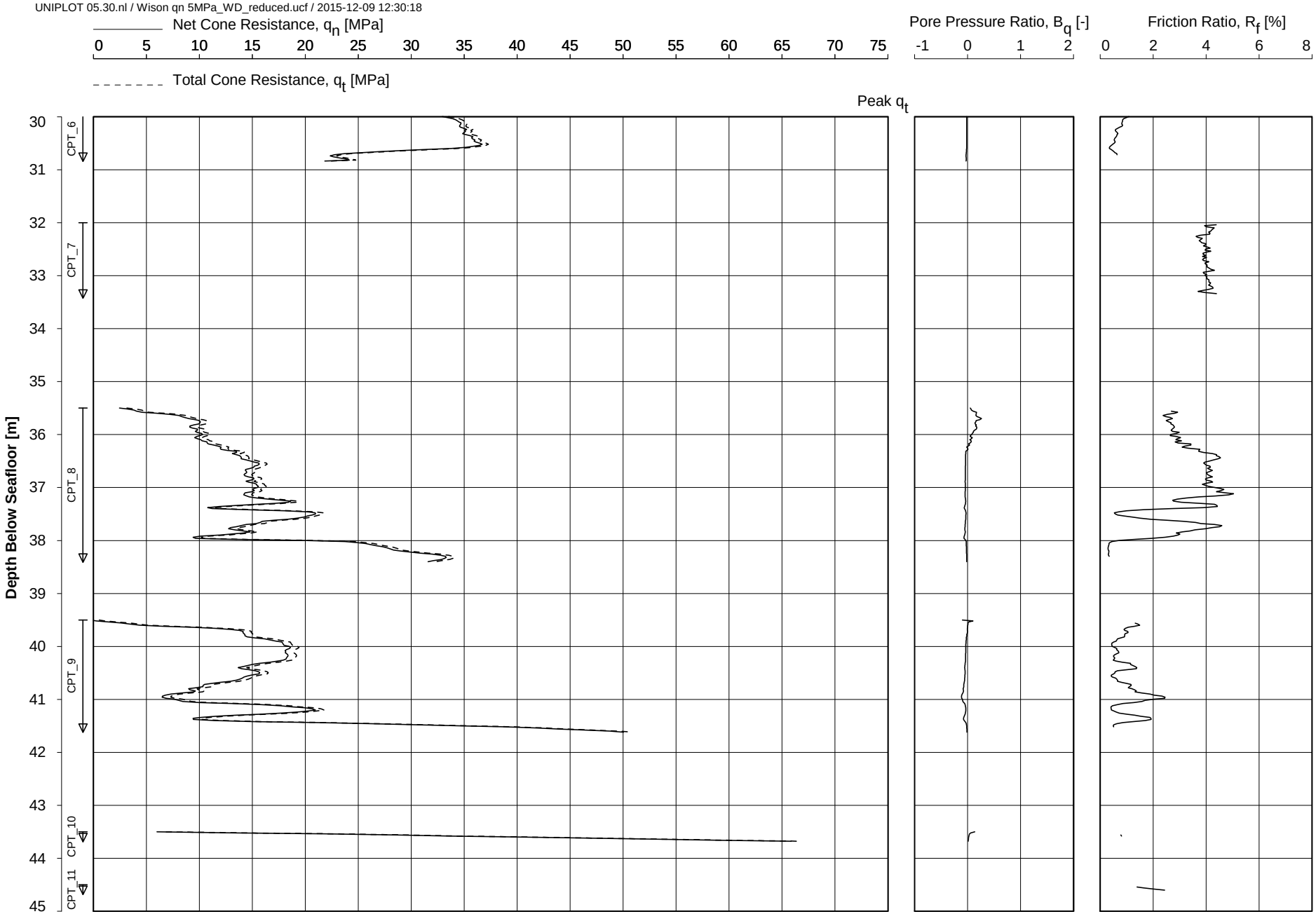
Date Of Testing : 05-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:30:18



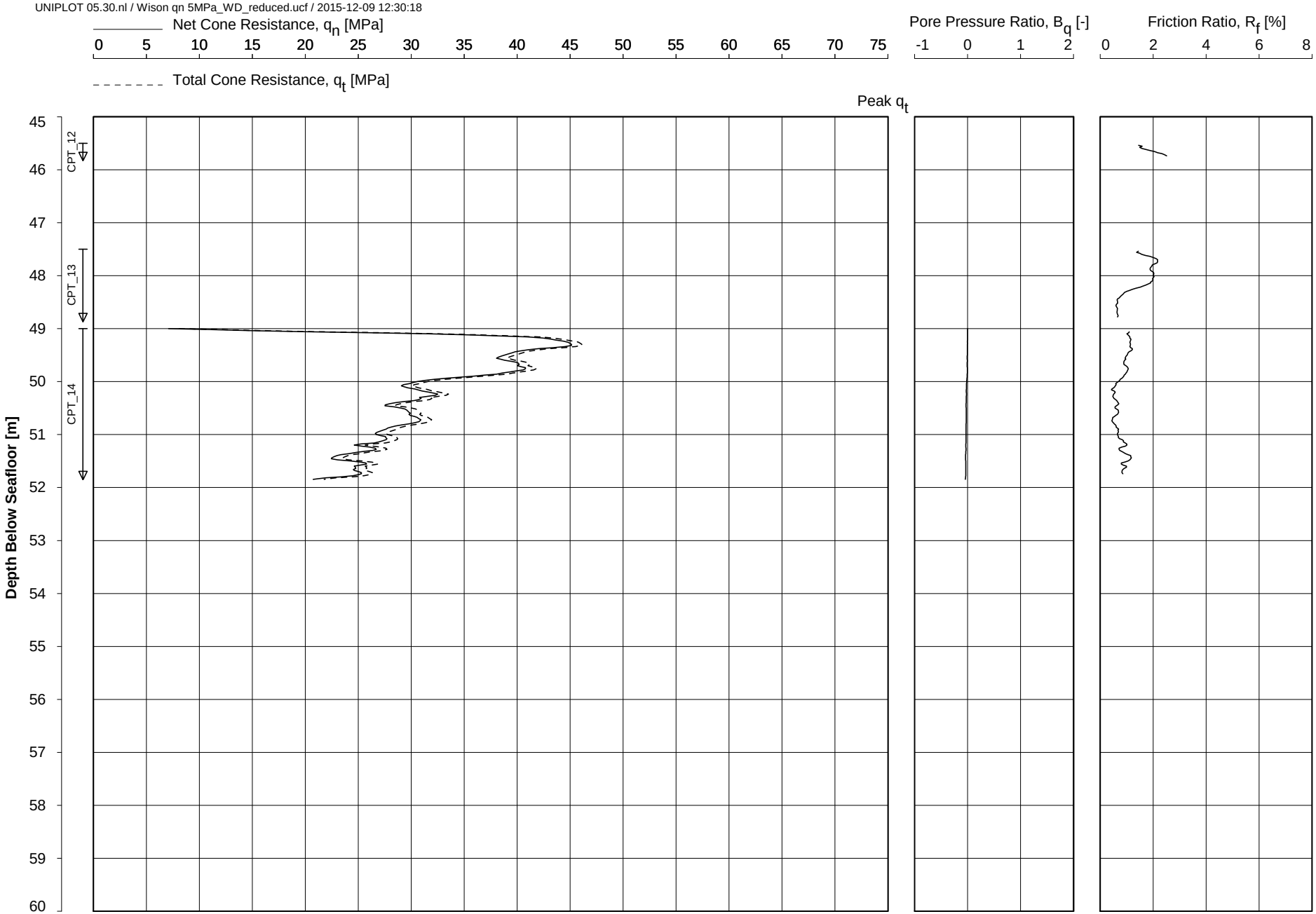
Date Of Testing : 05-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 12:30:18



Date Of Testing : 06-Oct-2015
Water Depth [m] : 34.7 m LAT
Coordinates [m] : E498779 N5736551

CONE PENETRATION TEST

BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
BH-WFS4-7	0.00 to 1.35 1.35 to 6.10 6.10 to 10.85 10.85 to 13.85 13.85 to 24.55 24.55 to 32.00 32.00 to 35.50 35.50 to bottom	20.00 20.50 20.00 20.00 19.50 20.00 20.00 20.50	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 12:32:27

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
BH-WFS4-7	CPT_1	0.013	0.003	-0.005	0.024	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_2	0.011	0.003	-0.005	-0.007	-0.002	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_3	0.010	0.003	-0.006	0.021	-0.001	0.000	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_4	0.007	0.004	-0.007	0.017	-0.001	0.000	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_5	0.011	0.003	-0.007	-0.015	0.001	0.001	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_6	0.012	0.003	-0.007	-0.035	0.002	0.002	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_7	0.047	-0.004		0.004	0.000		CP5-CF80	1721-1713	0.500
BH-WFS4-7	CPT_8	0.012	0.006	-0.006	-0.014	-0.001	0.000	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_9	0.006	0.006	-0.006	-0.008	-0.001	0.000	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_10	0.011	0.005	-0.006	-0.004	0.000	0.000	CP10-CF50PB20	1706-2185	0.750
BH-WFS4-7	CPT_11	0.046	-0.004		0.001	-0.003		CP5-CF80	1721-1713	0.500
BH-WFS4-7	CPT_12	0.042	-0.006		0.025	-0.001		CP5-CF80	1721-1713	0.500
BH-WFS4-7	CPT_13	0.058	-0.006		-0.003	-0.001		CP5-CF80	1721-1713	0.500
BH-WFS4-7	CPT_14	0.014	0.006	-0.005	-0.041	-0.001	0.000	CP10-CF50PB20	1706-2185	0.750

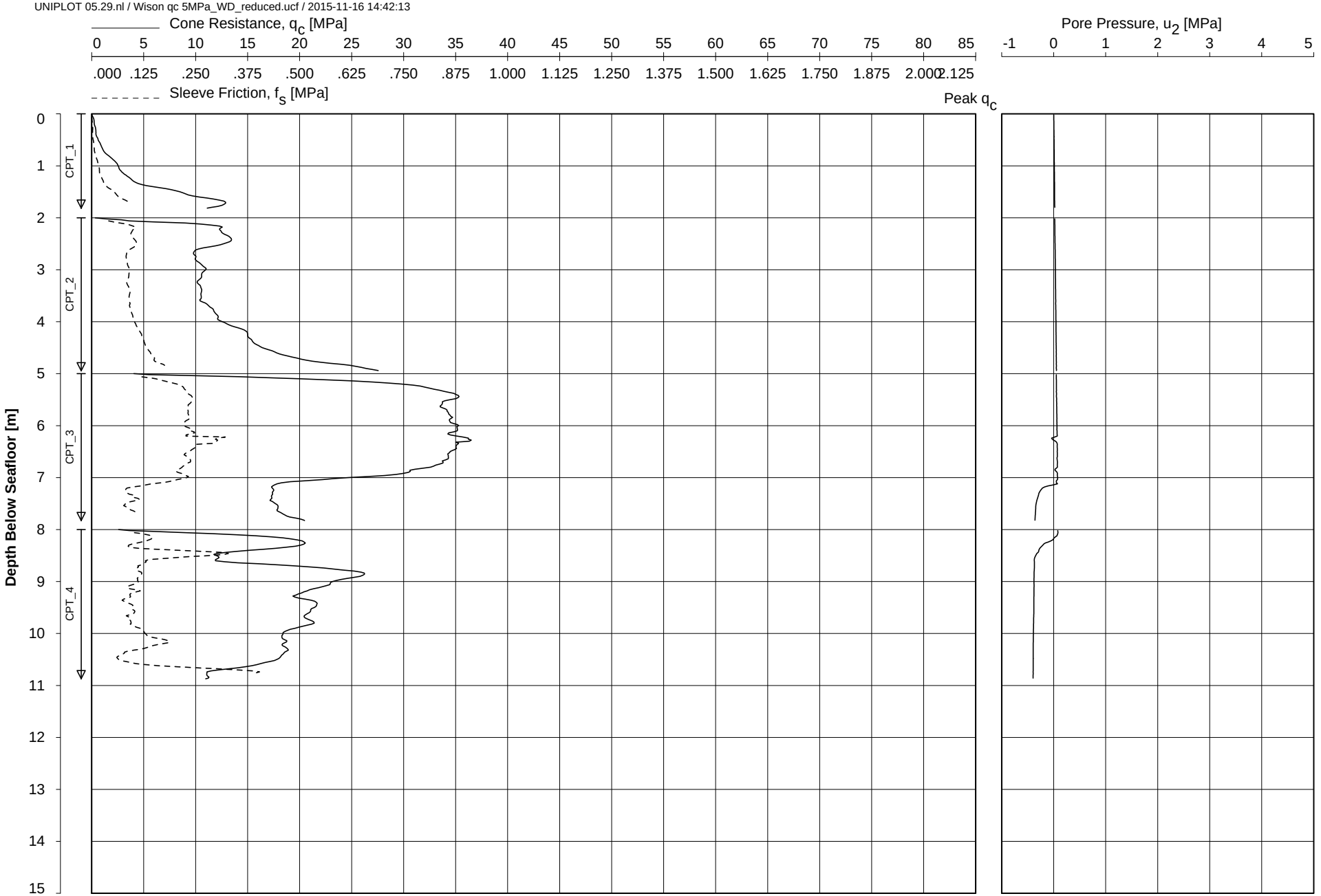
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:42:13



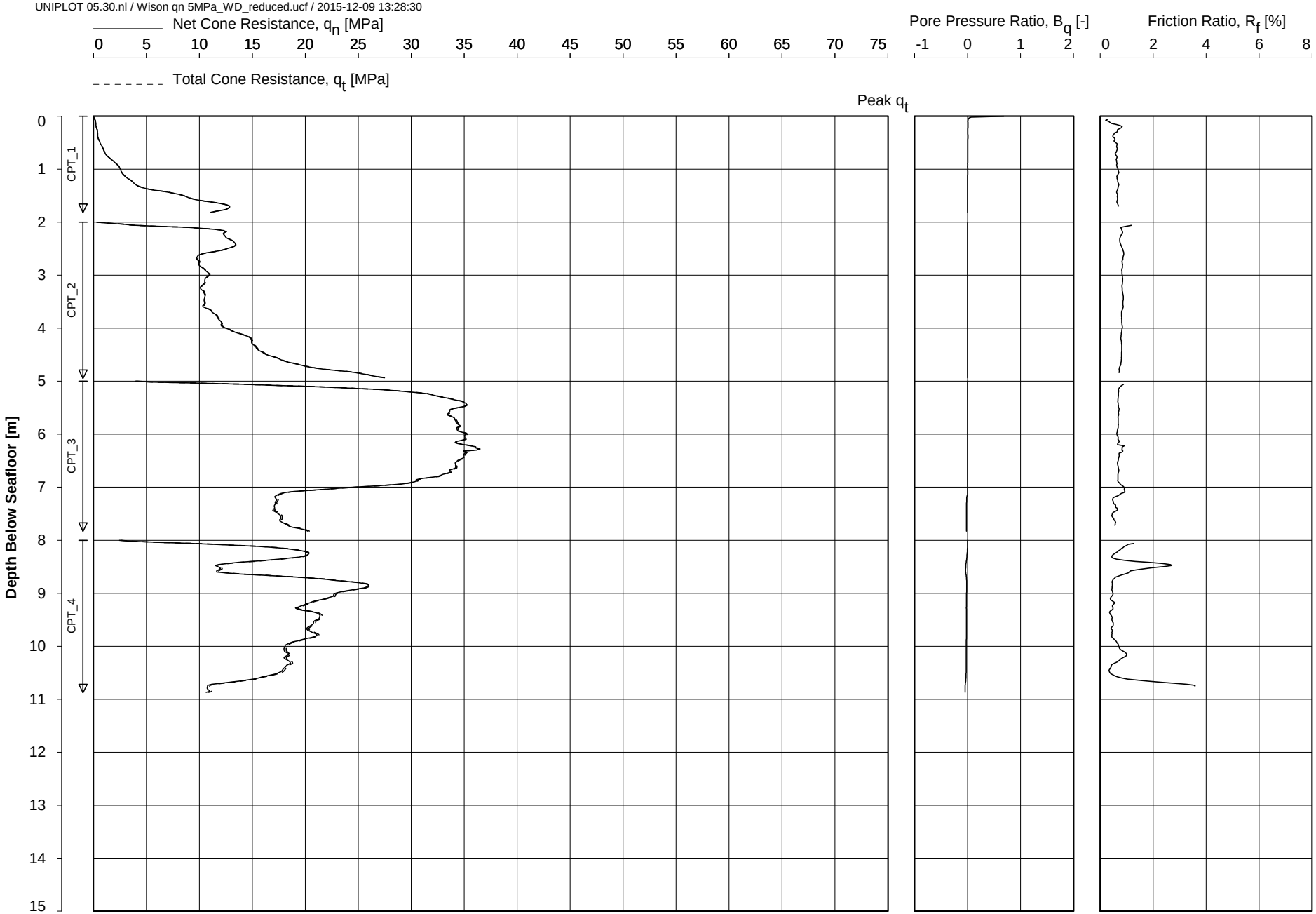
Date Of Testing : 06-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495297 N5733553

CONE PENETRATION TEST

CPT_WFS4_18

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:28:30



Date Of Testing : 06-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495297 N5733553

CONE PENETRATION TEST

CPT_WFS4_18

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
CPT_WFS4_18	0.00 to 4.00 4.00 to 7.00 7.00 to bottom	20.00 20.50 20.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 13:08:21

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
CPT_WFS4_18	CPT_1	0.010	0.006	-0.008	-0.010	0.002	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18	CPT_2	0.008	0.008	-0.008	-0.023	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18	CPT_3	0.009	0.009	-0.008	-0.064	-0.002	0.003	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18	CPT_4	0.009	0.010	-0.008	-0.014	-0.001	0.002	CP10-CF50PB20	1706-2185	0.750

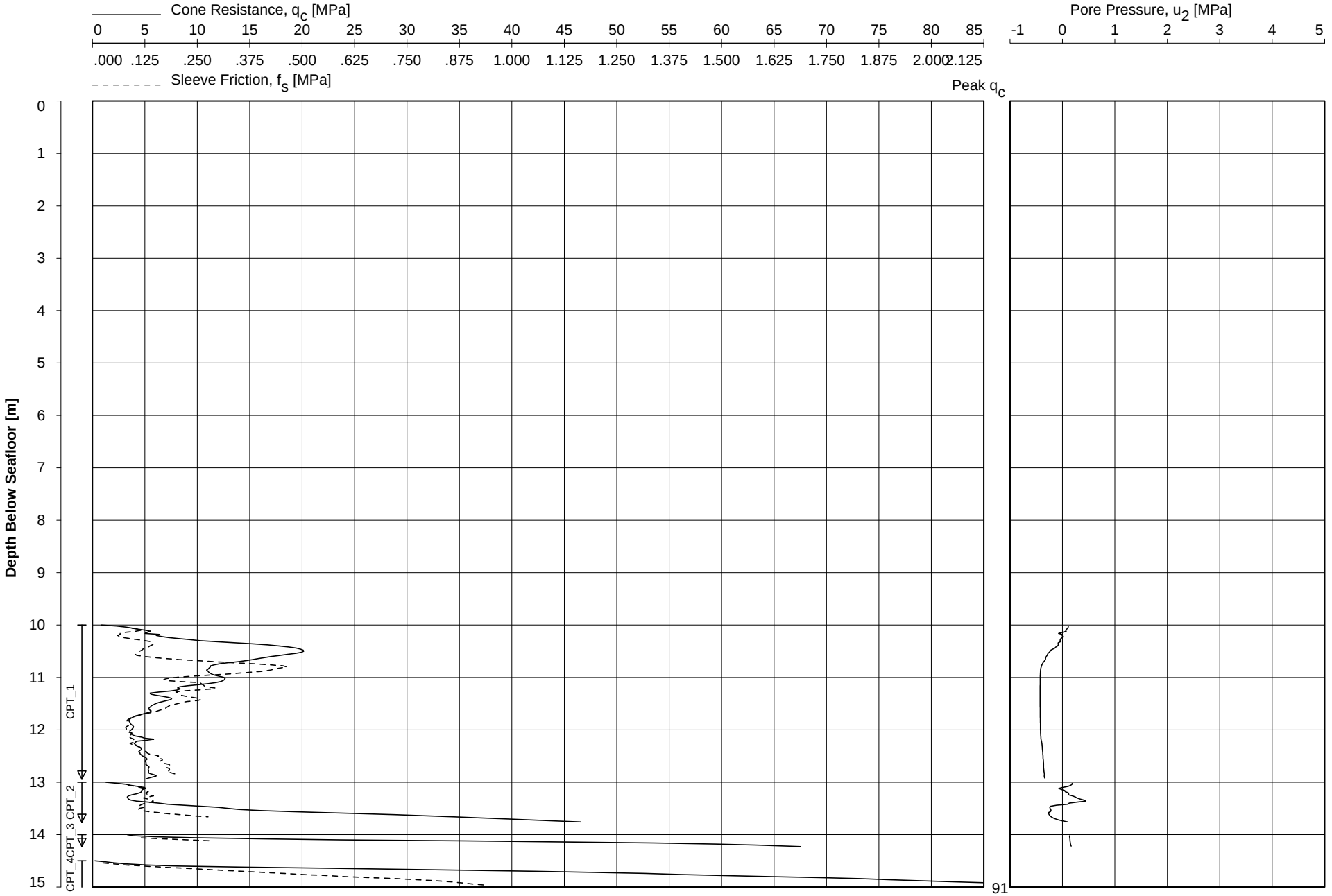
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:58:21



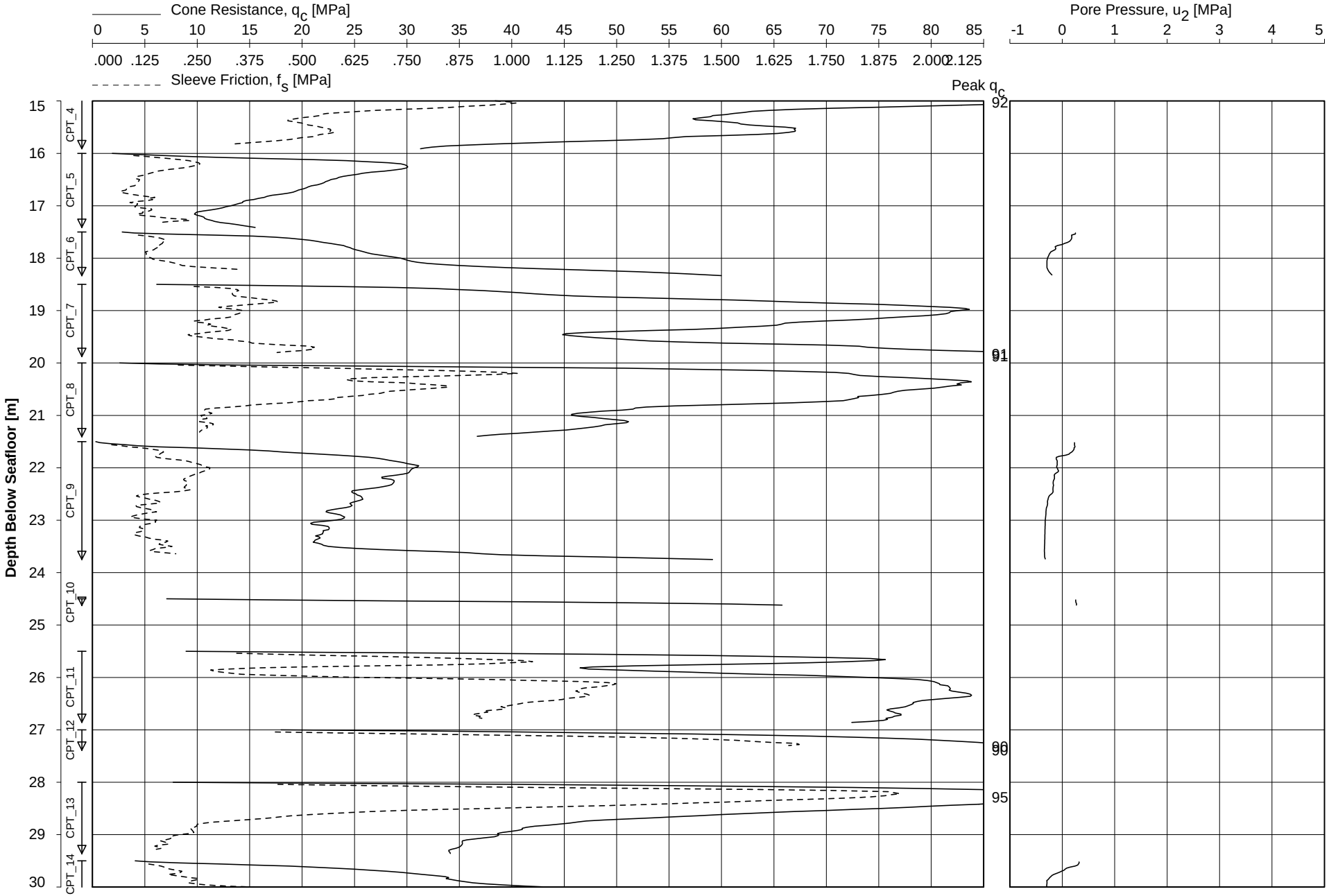
Date Of Testing : 07-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:58:21



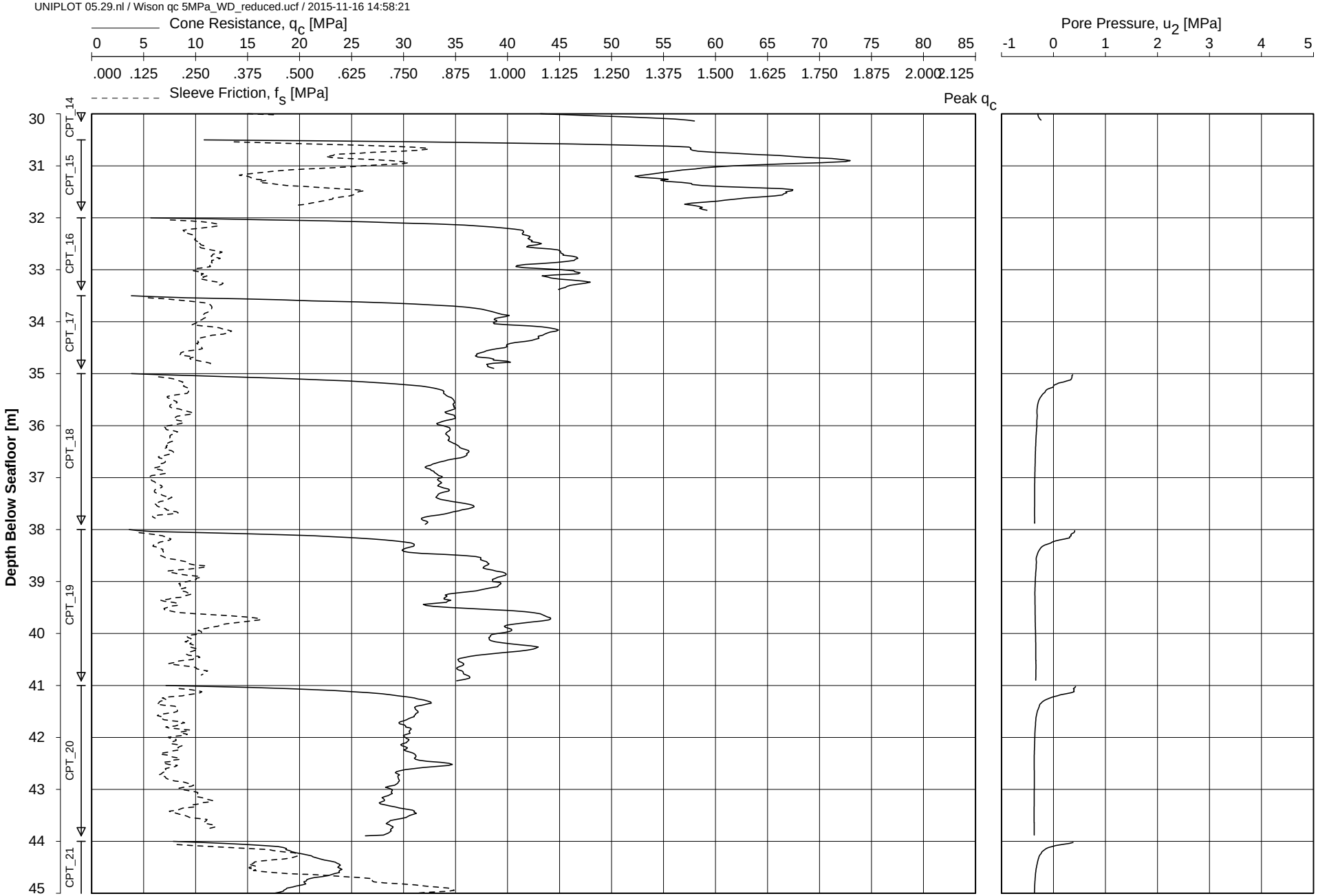
Date Of Testing : 07-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:58:21



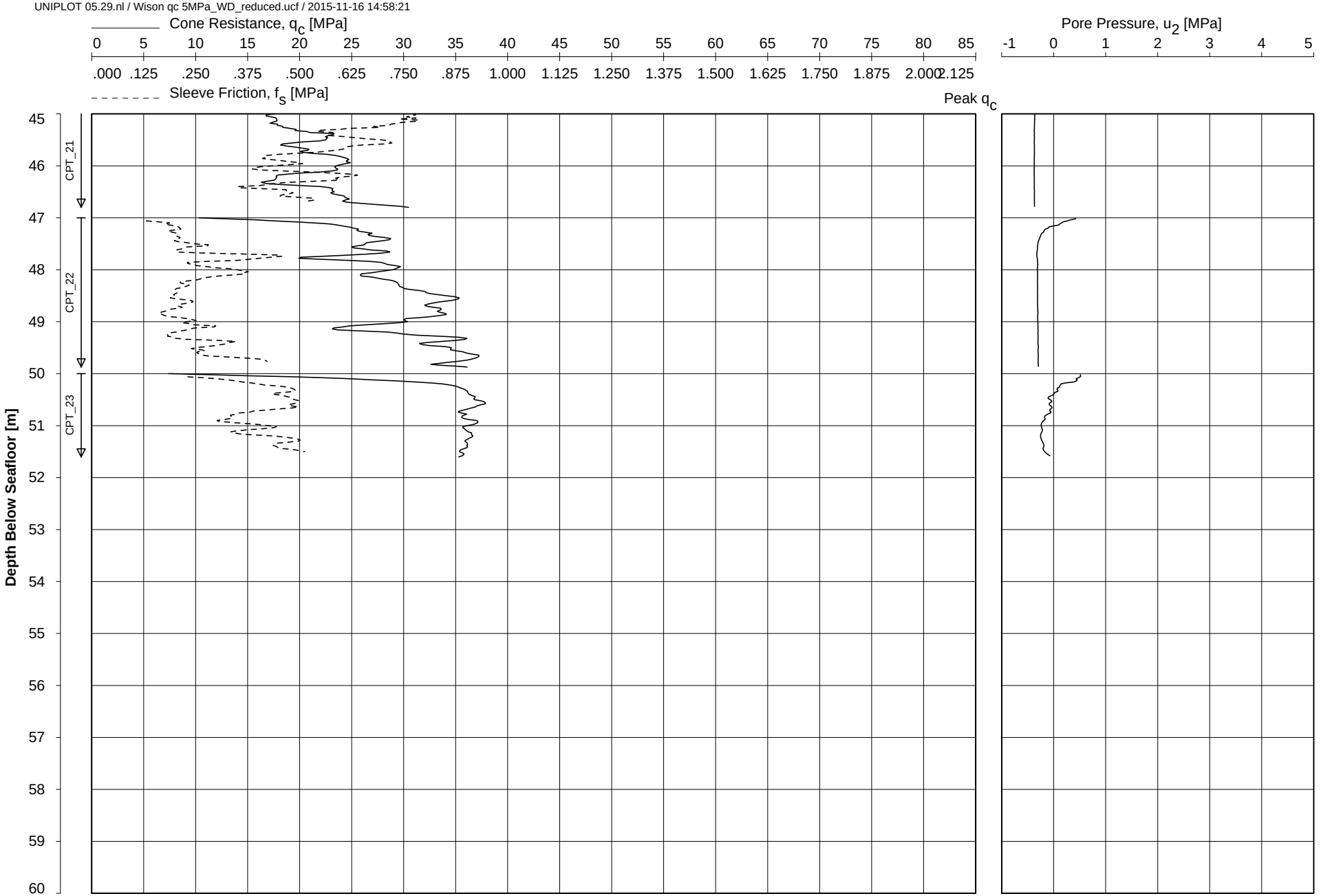
Date Of Testing : 08-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 14:58:21



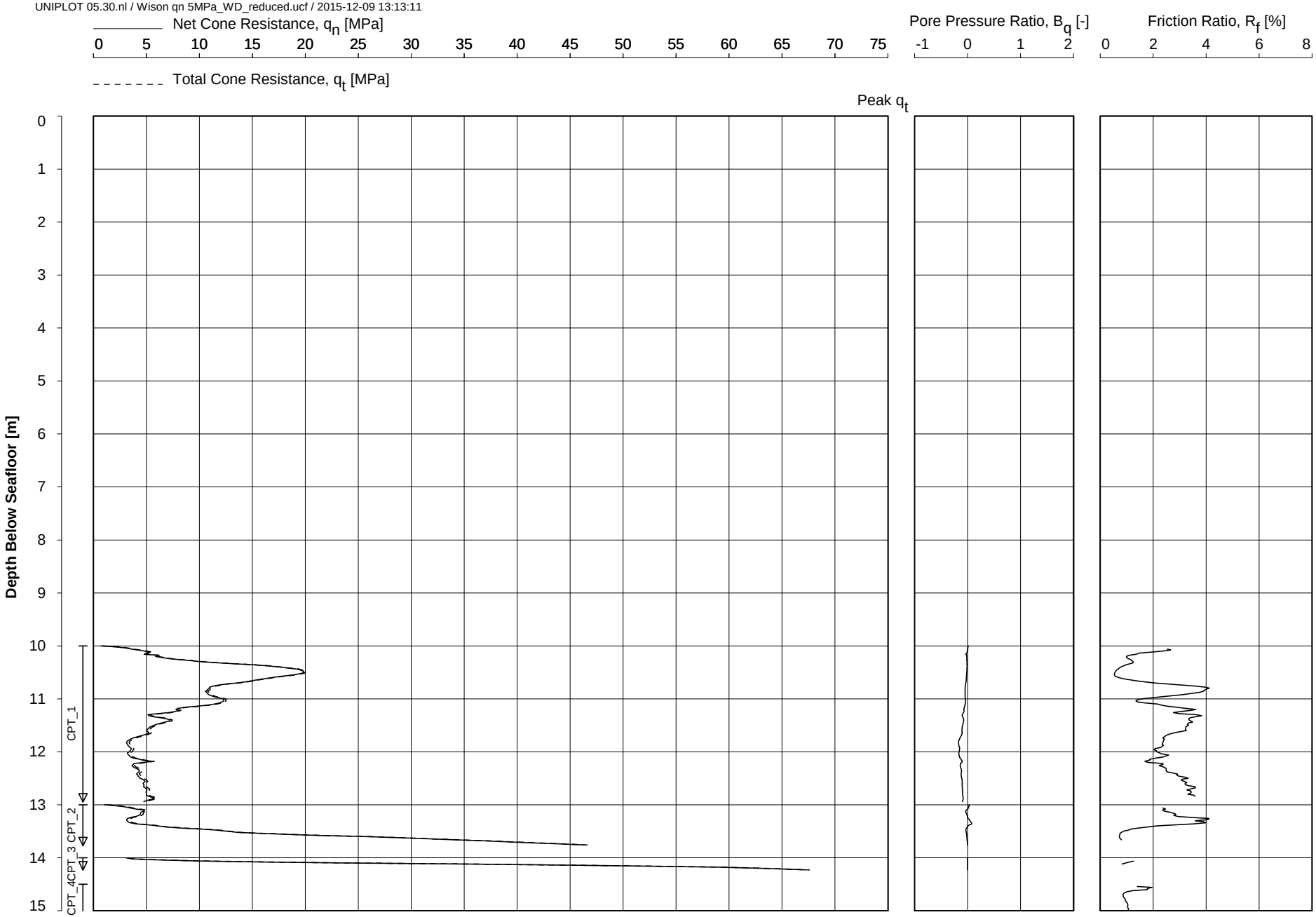
Date Of Testing : 08-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:13:11



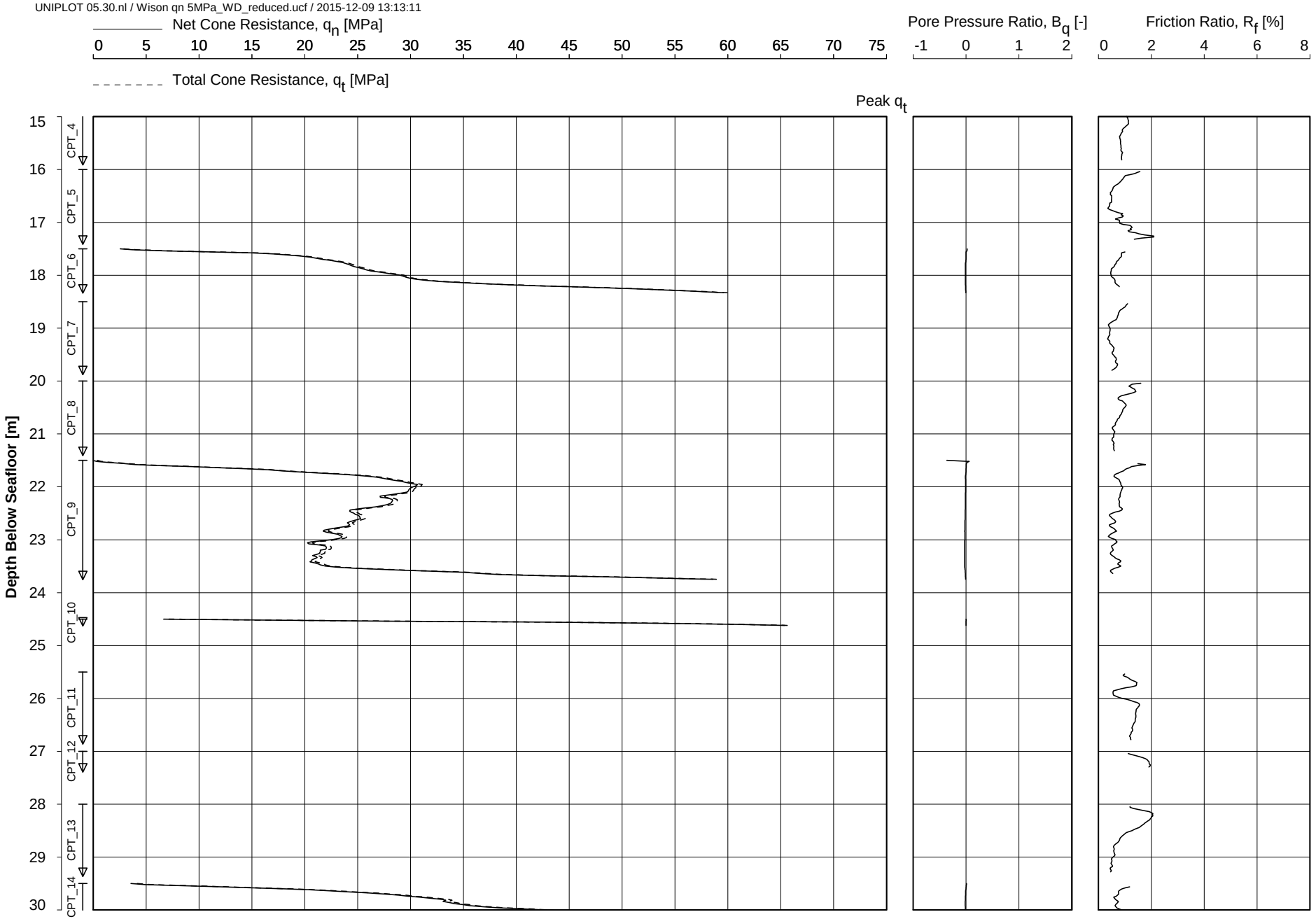
Date Of Testing : 07-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:13:11



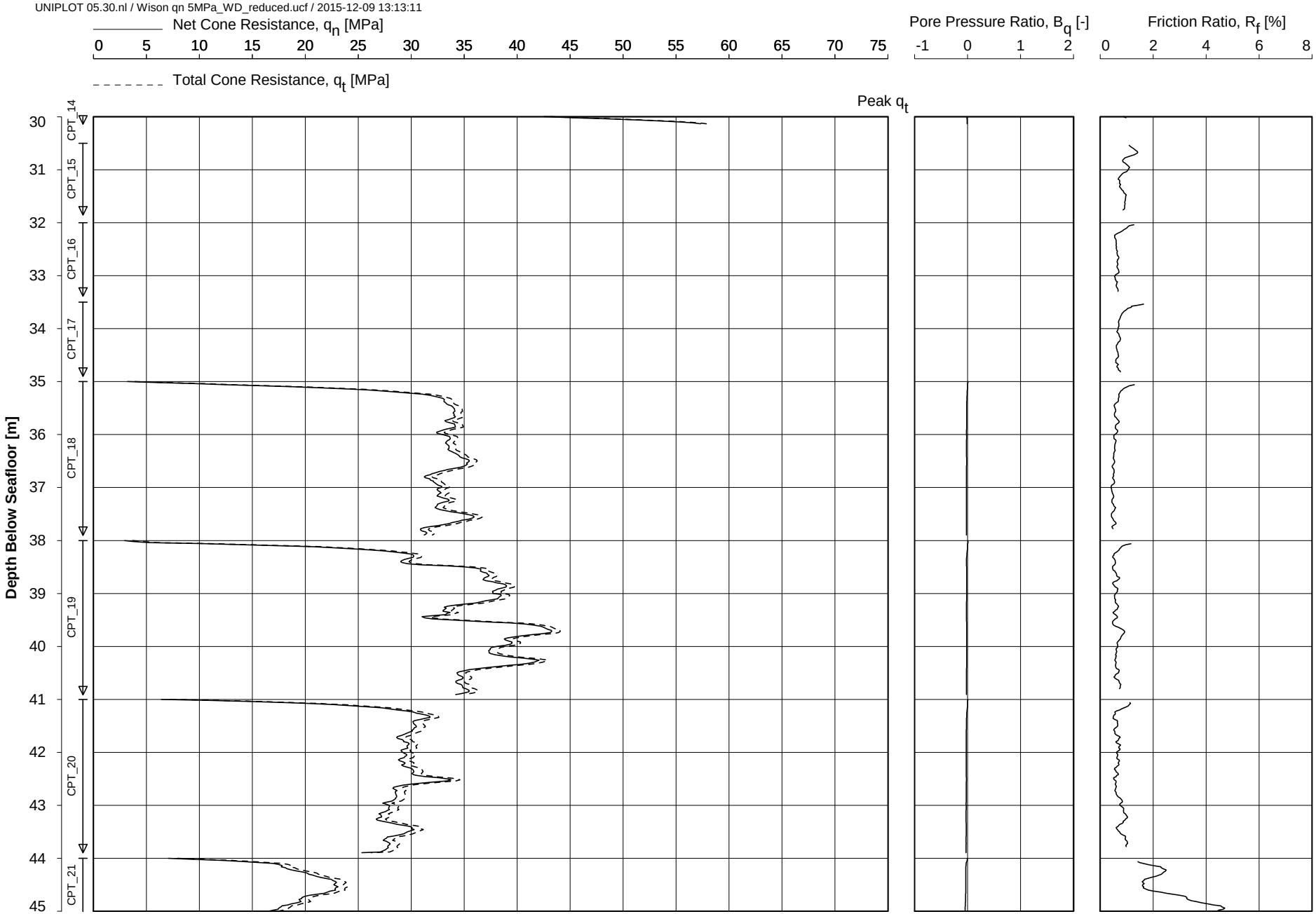
Date Of Testing : 07-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:13:11



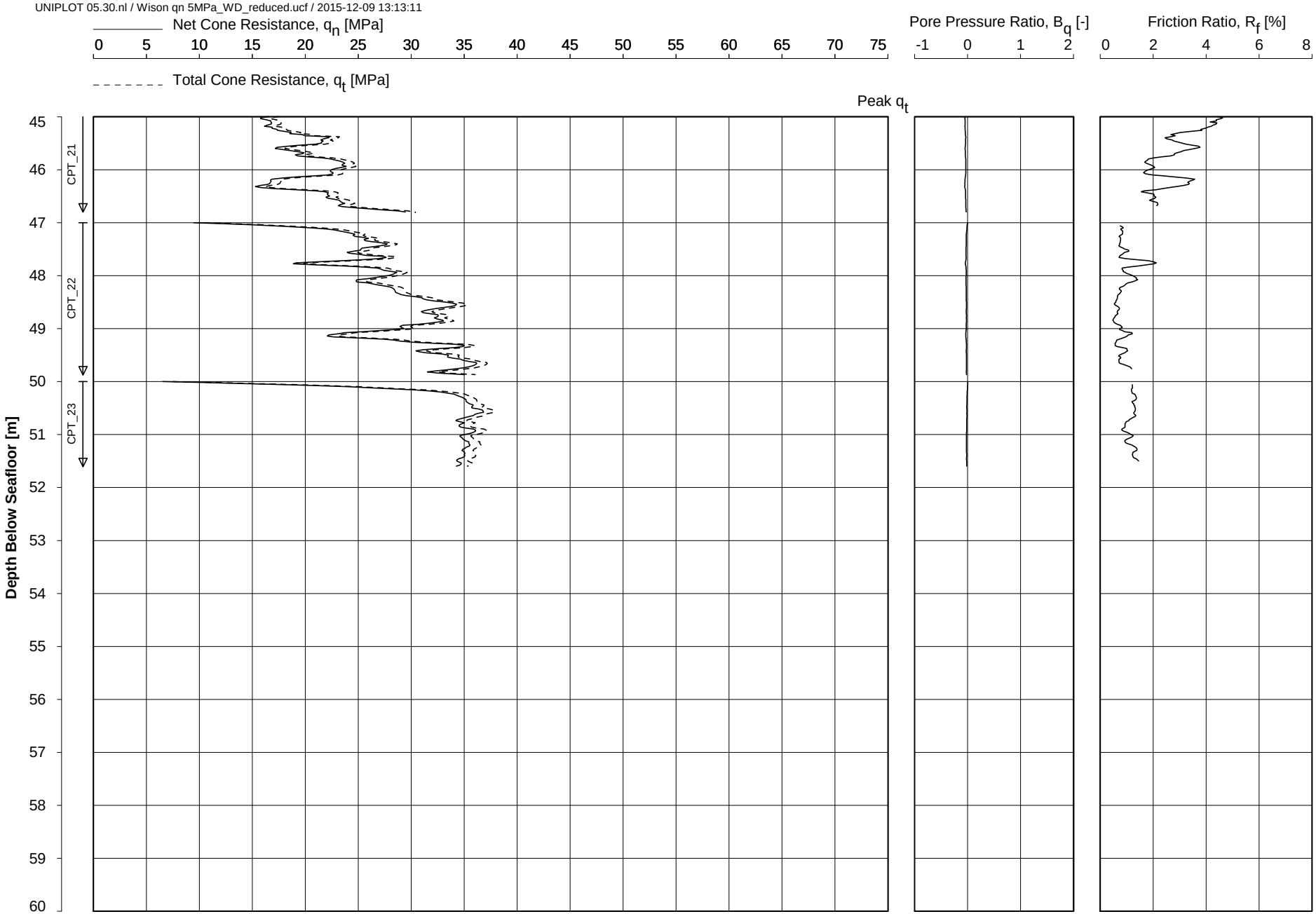
Date Of Testing : 08-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:13:11



Date Of Testing : 08-Oct-2015
Water Depth [m] : 34.4 m LAT
Coordinates [m] : E495295 N5733549

CONE PENETRATION TEST

CPT_WFS4_18A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
CPT_WFS4_18A	0.00 to 4.00 4.00 to 7.00 7.00 to 11.20 11.20 to 13.50 13.50 to 23.50 23.50 to 28.70 28.70 to 44.00 44.00 to bottom	20.00 20.50 20.00 20.00 20.50 20.50 20.00 20.00	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 13:14:19

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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UNIPLOT 05.29.nl / Wison QaQc zero load - landscape.ucf / 2015-11-16 14:59:37

CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
CPT_WFS4_18A	CPT_1	0.032	0.010	-0.010	-0.005	-0.002	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_2	0.027	0.009	-0.010	-0.010	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_3	0.021	0.009	-0.010	0.005	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_4	0.050	0.000		-0.097	-0.002		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_5	0.035	0.000		-0.034	0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_6	0.038	0.011	-0.009	-0.028	-0.003	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_7	0.047	0.000		-0.051	0.002		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_8	0.008	0.002		-0.004	-0.002		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_9	0.036	0.010	-0.009	-0.060	-0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_10	0.022	0.011	-0.009	-0.043	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_11	0.040	0.001		0.001	-0.002		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_12	0.044	0.000		-0.025	0.000		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_13	0.034	0.001		-0.008	-0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_14	0.023	0.012	-0.006	-0.011	-0.003	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_15	0.031	0.001		-0.008	-0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_16	0.044	0.001		-0.025	0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_17	0.040	0.001		-0.028	0.000		CP5-CF80	1709-0002	0.500
CPT_WFS4_18A	CPT_18	0.038	0.010	-0.007	-0.060	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_19	0.028	0.010	-0.007	-0.046	0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_20	0.024	0.010	-0.007	-0.037	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_21	0.019	0.010	-0.007	-0.037	0.000	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_22	0.023	0.010	-0.007	-0.025	0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_18A	CPT_23	0.018	0.010	-0.007	-0.012	0.001	0.002	CP10-CF50PB20	1706-2185	0.750

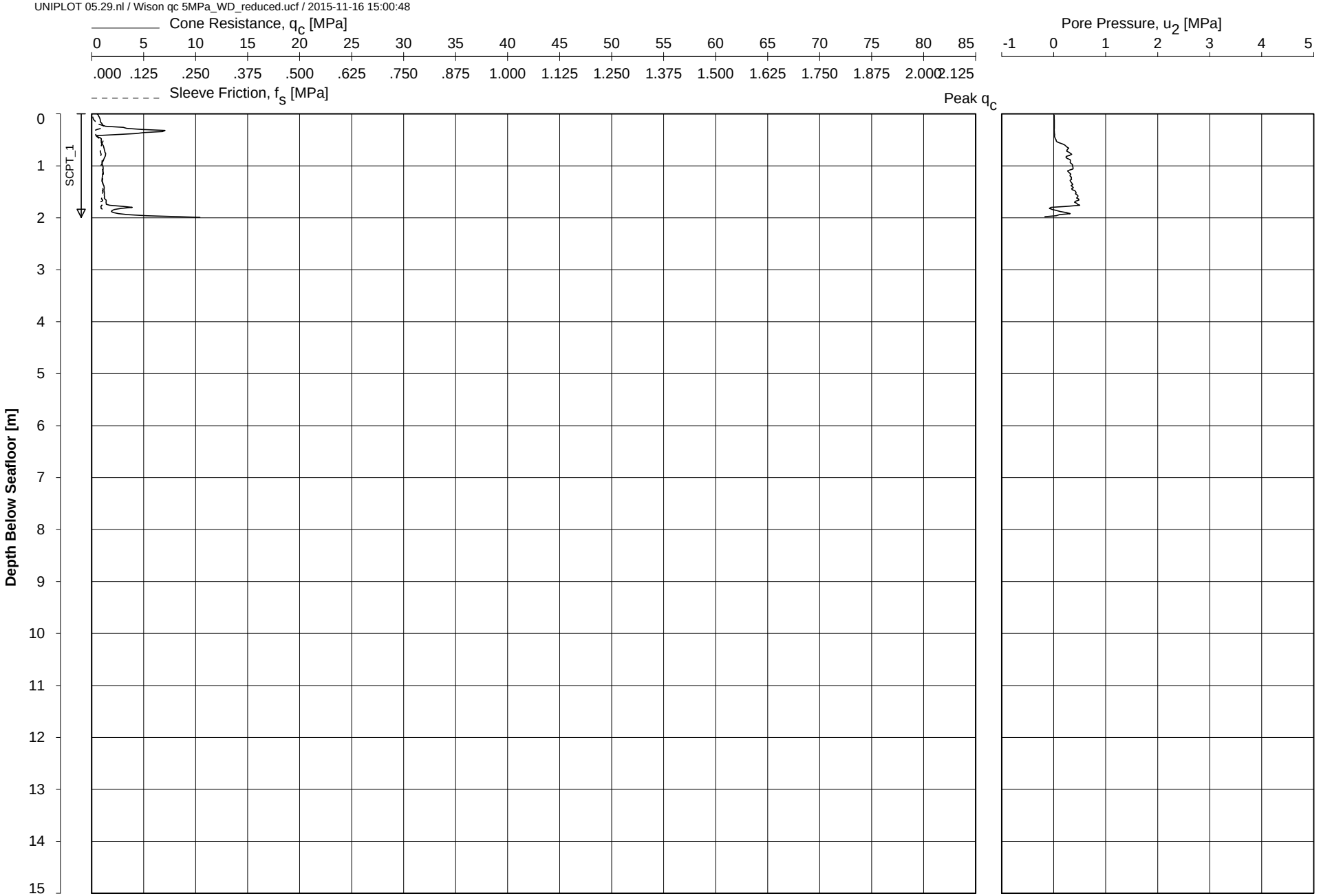
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 15:00:48



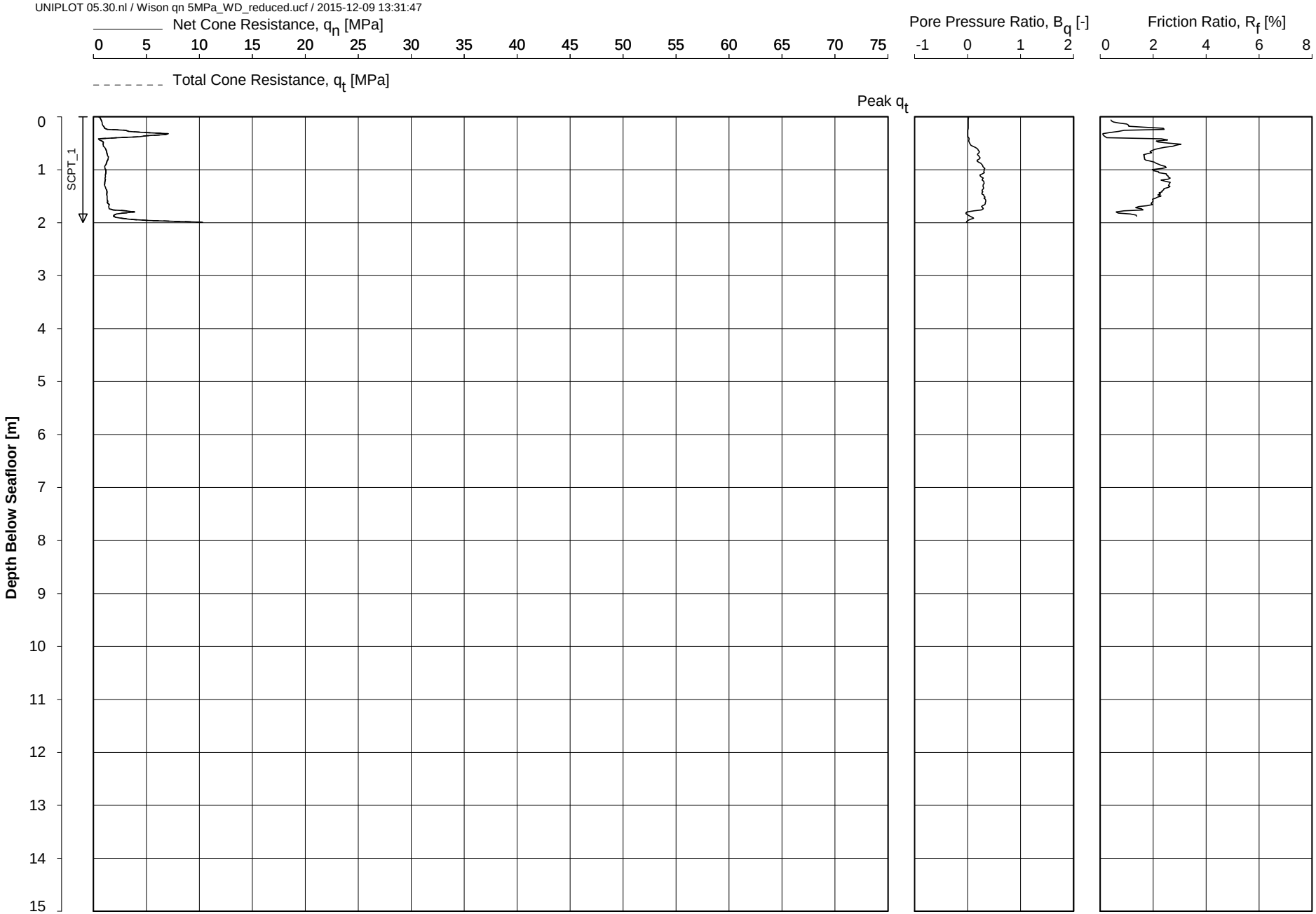
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497760 N5735306

CONE PENETRATION TEST

CPT_WFS4_21

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:31:47



Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497760 N5735306

CONE PENETRATION TEST

CPT_WFS4_21

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
CPT_WFS4_21	0.00 to 1.90 1.90 to bottom	20.00 20.50	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
CPT_WFS4_21	SCPT_1	0.079	0.000	-0.009	-0.005	-0.001	0.000	CP10-CF50PB20	1706-1831	0.750

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONE PENETRATION TEST - ZERO DRIFT

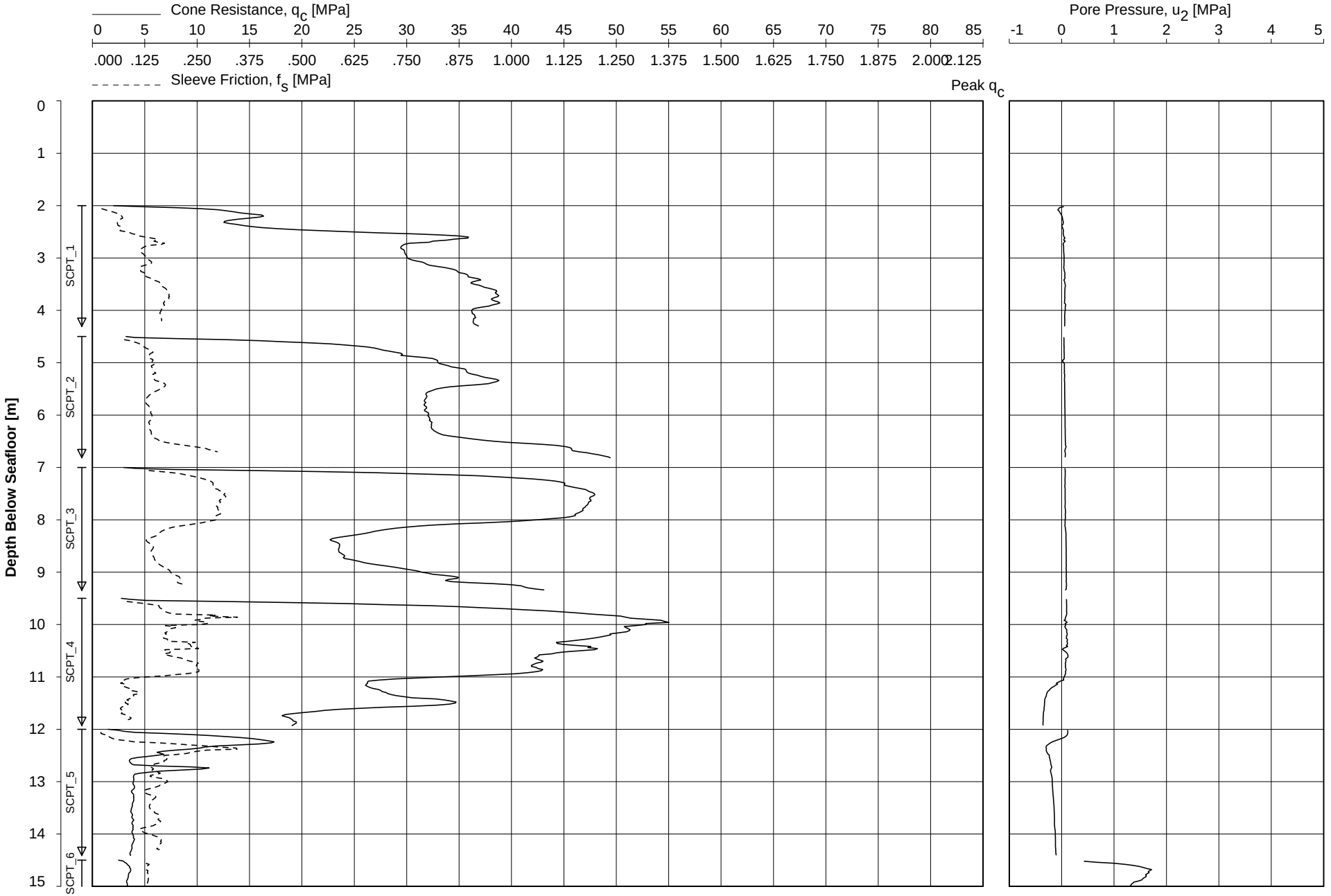
Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 15:02:24



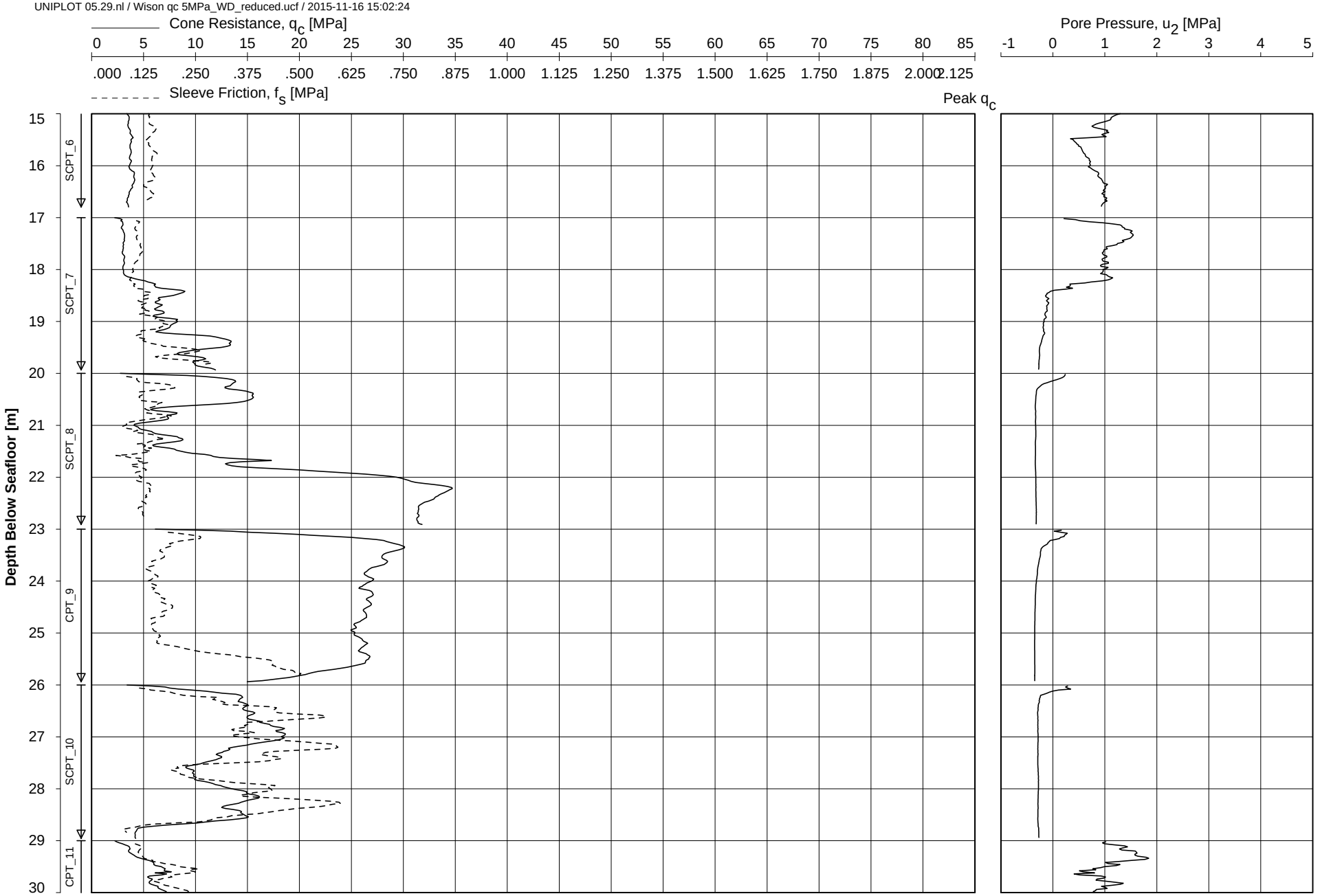
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 15:02:24



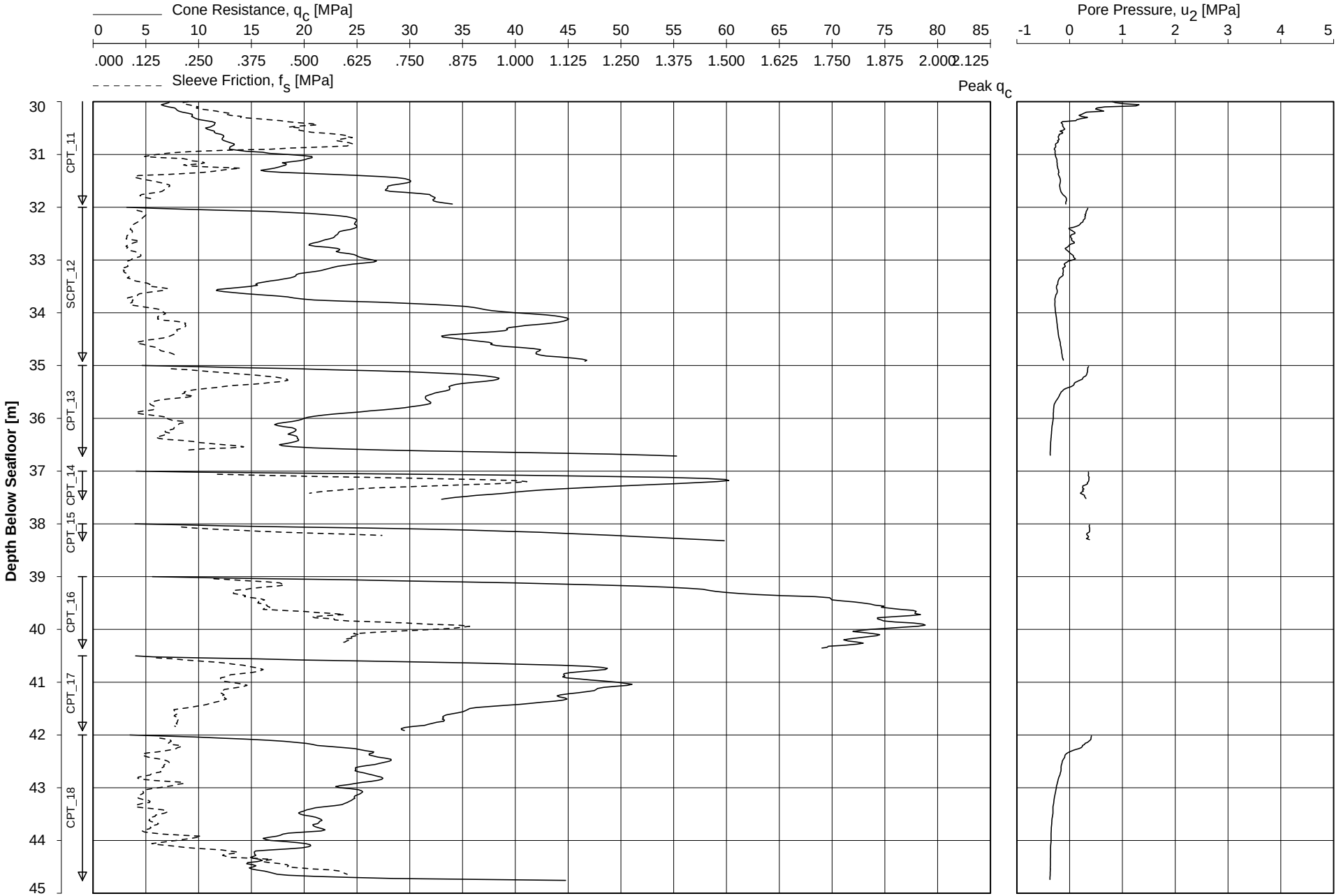
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 15:02:24



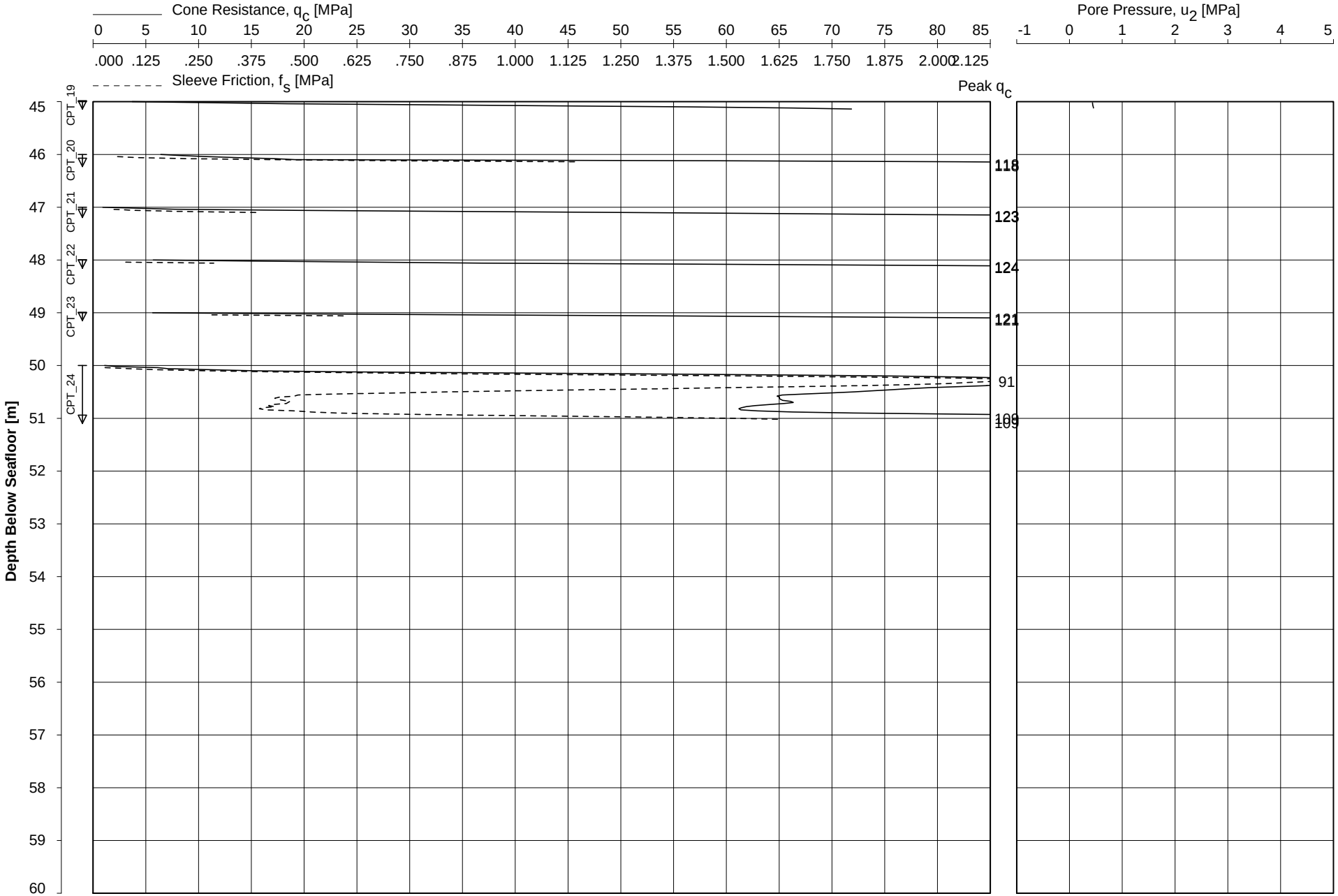
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl / Wison qc 5MPa_WD_reduced.ucf / 2015-11-16 15:02:24



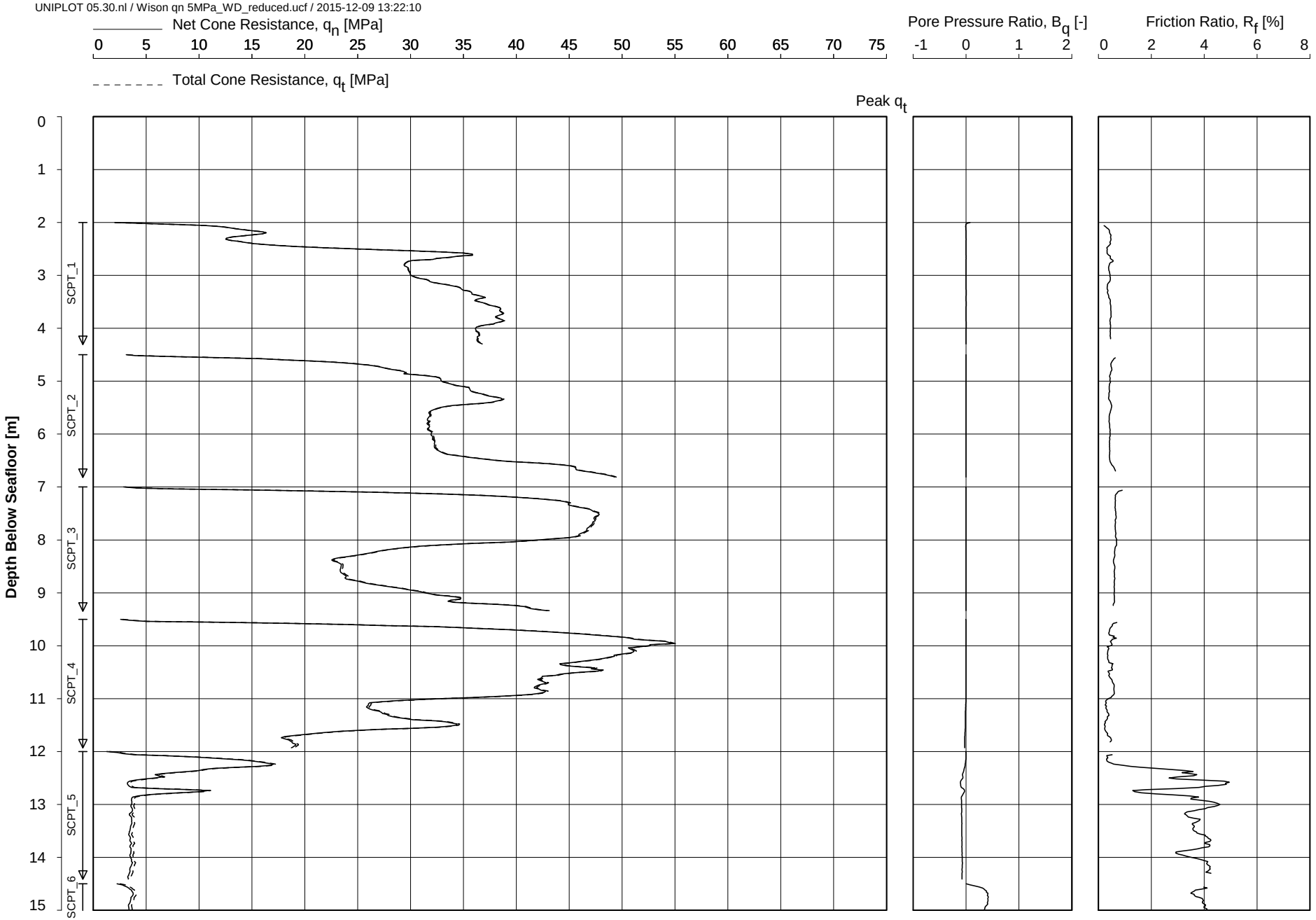
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:22:10



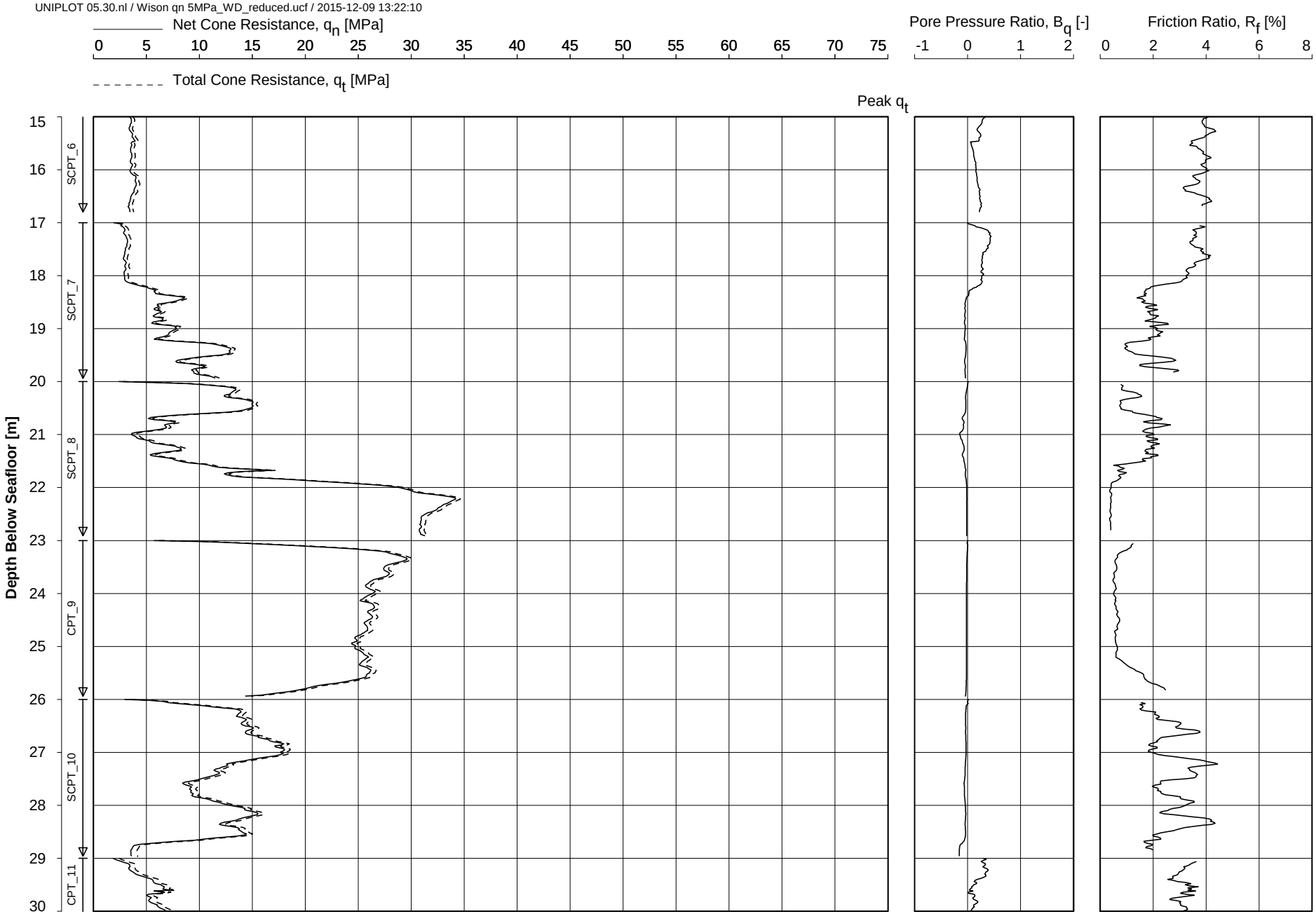
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:22:10



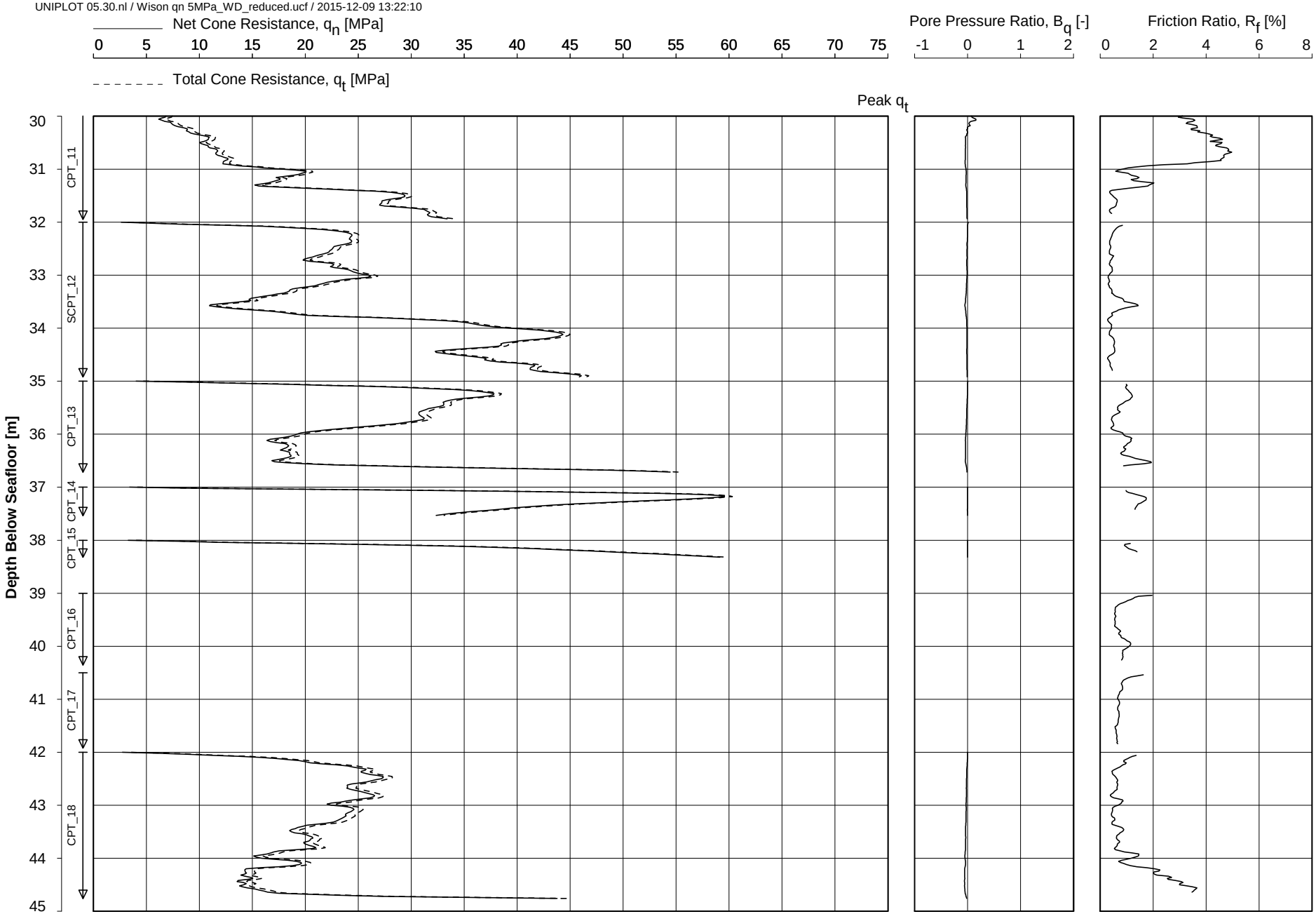
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:22:10



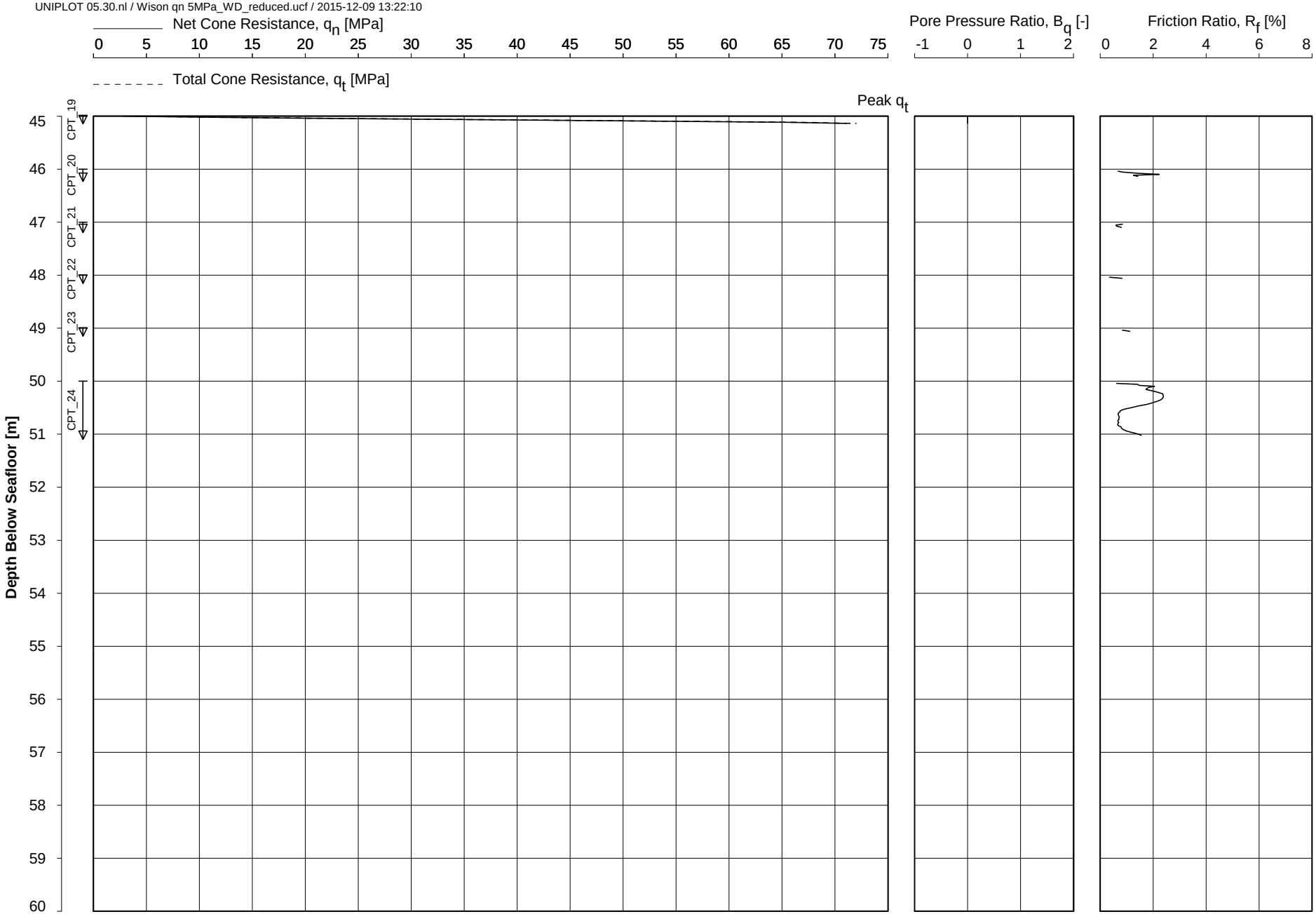
Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.30.nl / Wison qn 5MPa_WD_reduced.ucf / 2015-12-09 13:22:10



Date Of Testing : 08-Oct-2015
Water Depth [m] : 31.7 m LAT
Coordinates [m] : E497757 N5735303

CONE PENETRATION TEST

CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Depth Range [m]	Unit Weight γ		Pore Pressure Adjustment Factor K [-]
		Ground [kN/m^3]	Ground Water [kN/m^3]	
CPT_WFS4_21A	0.00 to 1.90 1.90 to 8.90 8.90 to 12.85 12.85 to 18.10 18.10 to 28.70 28.70 to 30.50 30.50 to 44.40 44.40 to bottom	20.00 20.50 20.00 19.50 20.00 20.00 20.50 20.50	10.0	---

Note:
1. The adjustment factor K applies only to probes with a pore pressure filter in the face of the cone.

UNIPLOT 05.30.nl/Wison QaQc parameter values.ucf/2015-12-09 13:24:34

PARAMETER VALUES FOR NET CONE RESISTANCE CALCULATION

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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CONE PENETRATION TEST - ZERO DRIFT

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Borehole/ Location	Test No.	Zero Reading at Start of Test			Zero Drift			Probe		Net Area Ratio
		q_c [MPa]	f_s [MPa]	u [MPa]	q_c [MPa]	f_s [MPa]	u [MPa]			a [-]
CPT_WFS4_21A	SCPT_1	0.072	0.000	-0.007	0.001	0.000	0.000	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	SCPT_2	0.091	-0.001	-0.005	-0.021	0.001	0.000	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	SCPT_3	0.092	-0.001	-0.005	-0.018	0.001	0.001	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	SCPT_4	0.091	-0.001	-0.005	-0.021	-0.001	0.000	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	SCPT_5	0.094	-0.002	-0.005	0.012	0.000	0.002	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	SCPT_6	0.088	-0.002	-0.003	0.009	-0.001	0.002	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	SCPT_7	0.088	-0.002	-0.002	-0.009	0.000	0.001	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	SCPT_8	0.095	-0.003	-0.004	-0.031	0.001	-0.001	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	CPT_9	0.052	0.012	-0.004	-0.045	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_21A	SCPT_10	0.091	-0.003	-0.002	-0.019	0.001	0.000	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	CPT_11	0.047	0.012	-0.005	-0.033	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_21A	SCPT_12	0.091	-0.002	-0.002	-0.021	0.000	0.001	CP10-CF50PB20	1706-1831	0.750
CPT_WFS4_21A	CPT_13	0.054	0.014	-0.004	-0.040	-0.001	0.001	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_21A	CPT_14	0.045	0.012	-0.005	-0.040	-0.001	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_21A	CPT_15	0.044	0.012	-0.005	-0.033	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_21A	CPT_16	0.078	-0.001		0.005	0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_21A	CPT_17	0.065	-0.002		0.023	0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_21A	CPT_18	0.040	0.012	-0.004	-0.025	0.000	0.002	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_21A	CPT_19	0.038	0.012	-0.004	0.026	0.000	0.017	CP10-CF50PB20	1706-2185	0.750
CPT_WFS4_21A	CPT_20	0.071	-0.001		-0.030	0.000		CP5-CF80	1709-0002	0.500
CPT_WFS4_21A	CPT_21	0.069	-0.001		0.005	0.003		CP5-CF80	1709-0002	0.500
CPT_WFS4_21A	CPT_22	0.074	-0.001		0.026	0.003		CP5-CF80	1709-0002	0.500
CPT_WFS4_21A	CPT_23	0.080	-0.001		0.041	0.001		CP5-CF80	1709-0002	0.500
CPT_WFS4_21A	CPT_24	0.084	-0.001		0.010	0.000		CP5-CF80	1709-0002	0.500

Key:

q_c : cone resistance f_s : sleeve friction u : pore water pressure

Note:

1. Zero Drift is the difference between the zero output at the start of the test and the zero output at the end of the test. Offshore tests may show Reference Readings. The Zero Reading or Reference Reading at Start of Test is a value presented in units of measurement result. The value itself is a conversion from system output, usually in mV or in bits. It has no explicit physical meaning.
2. --- : Zero Drift was not monitored. The drift can be assessed from the start values of successive tests.

SECTION B2: SEISMIC CONE PENETRATION TESTS

TEXT – SECTION B2: Page

B2. SEISMIC CONE PENETRATION TESTS

B2.1 COMMENTS ON RESULTS B2-1

B2.2 PRACTICE FOR SEISMIC CONE PENETRATION TEST B2-2 to B2-3

LIST OF PLATES IN SECTION B2: Plate

CPT_WFS4_1

Recorded Shear Wave Traces versus Depth (X-Component) B2-1

Recorded Shear Wave Traces versus Depth (Y-Component) B2-2

Shear Wave Velocity versus Depth B2-3

CPT_WFS4_21 and CPT_WFS4_21A

Recorded Shear Wave Traces versus Depth (X-Component) B2-4

Recorded Shear Wave Traces versus Depth (Y-Component) B2-5

Shear Wave Velocity versus Depth B2-6

B2. SEISMIC CONE PENETRATION TESTS

B2.1 COMMENTS ON RESULTS

Seismic Cone Penetration Tests (SCPT) were performed in downhole mode in boreholes CPT_WFS4_1, CPT_WFS4_21 and CPT_WFS4_21A. Seismic cones include geophones in addition to the standard sensor set of a 1000 mm^2 (CP10) cone. Shear wave velocities are interpreted using two sets of geophone arrays (dual geophone). The upper array (x_1-y_1 geophones) and the lower array (x_2-y_2 geophones) are 500 mm apart, with the lower positioned 238 mm above the cone tip.

Seismic data was stacked and filtered to improve the signal-to-noise ratio. A band pass filter of 10 Hz to 65 Hz was applied to all tests. Shear wave velocities were interpreted from travel times of seismic waves in the 0.5 m interval between the geophone arrays using a cross correlation technique. These interpreted shear wave velocities were subsequently compared to shear wave velocities calculated from CPT data in accordance with Robertson and Cabal (2010)[1]. Measured and CPT derived values are generally in line with each other.

Sea water wave interference effects can prevent accurate interpretation of test results obtained close to seafloor, i.e. typical in the depth range from 0 m to 5 m below seafloor (bsf). Further, seismic velocities for the upper few metres below seafloor may show influence from the seabed frame used to support geotechnical drilling, sampling and testing. Therefore interpretation of seismic test data in the first 5 m bsf should be done with caution.

Signal interference may also result from shear wave refraction and reflection. For example, refraction can occur along an interface between a low-velocity upper layer and a high-velocity lower layer. Signal interference for this data set appears limited and cannot be excluded. Refer to document titled “Cone Penetration Test Interpretation” and “Seismic Downhole Test” presented in Appendix 1 for further details.

CPT_WFS4_21 consisted of only one SCPT to 2.0 m bsf after which the borehole was terminated (refer to Section A). This SCPT data is therefore presented together with data from the additional location, CPT_WFS4_21A.

Plates B2-1 to B2-2 and B2-4 to B2-5 present the recorded shear wave traces of x and y components versus depth for boreholes CPT_WFS4_1 and CPT_WFS4_21 (including CPT_WFS4_21A) respectively. The X-component traces are shown in red colour and the Y-component traces are shown in blue colour.

Comparison of the interpreted and CPT derived shear wave velocities versus depth is presented on Plates B2-3 and B2-6 for boreholes CPT_WFS4_1 and CPT_WFS4_21 (including CPT_WFS4_21A) respectively. Interpreted and CPT derived values generally correlate well with each other.

[1] Robertson, P.K. and Cabal, K.L. (2010), “Guide to Cone Penetration Testing for Geotechnical Engineering”, 4th ed., Gregg Drilling & Testing, Inc., Signal Hill.

B2.2 PRACTICE FOR SEISMIC CONE PENETRATION TEST

CPT Practice

Refer to sub-section titled “Practice for Cone Penetration Test” presented in report Section B1

SCPT Stage Control

General Procedure:	– Refer to document titled “Seismic Downhole Test” presented in Appendix 1 – According to ISO (2014)
Target Accuracy:	Average shear wave velocity of ± 10%, for a straight-line slant distance from source to receiver and assumed zero depth uncertainty
Test Method:	Average shear wave velocity (in between the two receivers)
Set-up Stage:	Location as directed by Client
Test Stage:	– SCPT at selected depths, typically at 2.5 or 3.0 m depth below bottom of borehole – On-site monitoring of seismic trace quality
Test Stage Termination:	Refer to document titled “Seismic Downhole Test” presented in Appendix 1
Test Sequence Termination:	Whichever occurs first: – according to document titled “Seismic Downhole Test” presented in Appendix 1 – according to sub-section titled “Practice for Cone Penetration Test” presented in report Section B1 – as instructed by Client

SCPT Apparatus

Seismic Cone Penetrometer Type:	– Seismic cone penetrometers based on a CP10 lead cone with dual seismic probe – Dual array with 3 geophone seismic receivers with natural frequency of 28 Hz, in lower and upper array for every dimension, 6 receivers in total – 500 mm fixed distance between both arrays – X and Y axes represent the orientation of two horizontal perpendicular geophones
Seismic Source:	– Hydraulic Underwater Shearwave Hammer (HUSH) box, consisting of a spring-driven steel mass hammered to a steel striking plate, mounted on the seabed frame – Mass and spring horizontally mounted, giving single near-horizontal strike direction, tangential relative to axis of borehole
Seismic Source Offset:	1.53 m radial offset
Striking Plate:	Steel beam with vertical fins to improve beam/soil contact
Time Break Unit:	HUSH box mounted piezo-trigger
Seismic Recorder:	SECAS, PC-based 6 channel seismograph with digital storage facilities

Test Results

Data Processing and Management:	– Refer to document titled “Seismic Downhole Test” and "Cone Penetration Test Interpretation" presented in Appendix 1 – SC3-RAV software for seismic data processing – UNIPLOT software for CPT-based prediction of shear wave velocity – Graphical scales selected to suit general presentation of data and requirements of standards, where practicable – No display of data outside of chart limits, i.e. some values may not be shown

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Data Format(s):	– PDF for viewing and printing (this primary document) – Excel digital tabular data (separate deliverables, secondary to this document)
Seismic Frequency Filter(s):	Band pass filter of 10 Hz to 65 Hz
Shear Wave Velocity – Measured:	– Calculation from records with adjoining depth increments – Assumed travel path takes account of seismic source offset and is straight line from source to receiver
Shear Wave Velocity – CPT-based Correlation:	According to Robertson and Cabal (2010), refer to document titled "Cone Penetration Test Interpretation" presented in Appendix 1.
Pressure Wave Velocity:	Not considered
Low-Strain Shear Modulus – Inferred:	Not applicable
Low-Strain Shear Modulus – CPT-based Correlation:	Not applicable
Parameter Values for Data Processing:	Refer to plate(s) titled “Parameter Values for Net Cone Resistance Calculation”

References

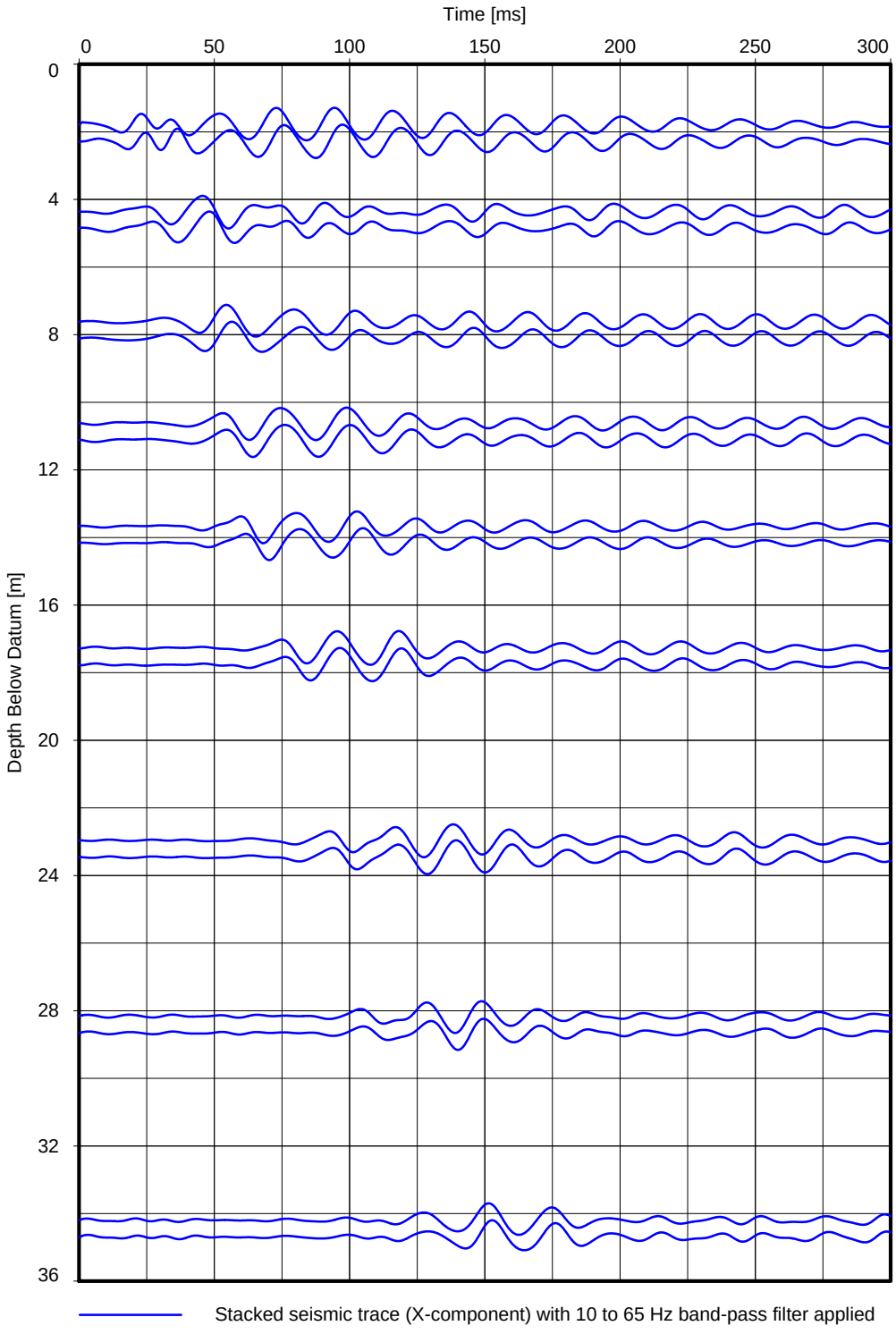
- Computer Program SC3-RAV, Processing of Seismic Downhole Data
- Computer Program UNIPLOT, Processing of CPT data
- ISO International Organization for Standardization (2014), “Petroleum and Natural Gas Industries - Specific Requirements for Offshore Structures – Part 8: Marine Soil Investigations”, International Standard ISO 19901-8:2014.
- Robertson, P.K. and Cabal, K.L. (2010), “Guide to Cone Penetration Testing for Geotechnical Engineering”, 4th ed., Gregg Drilling & Testing, Inc., Signal Hill.

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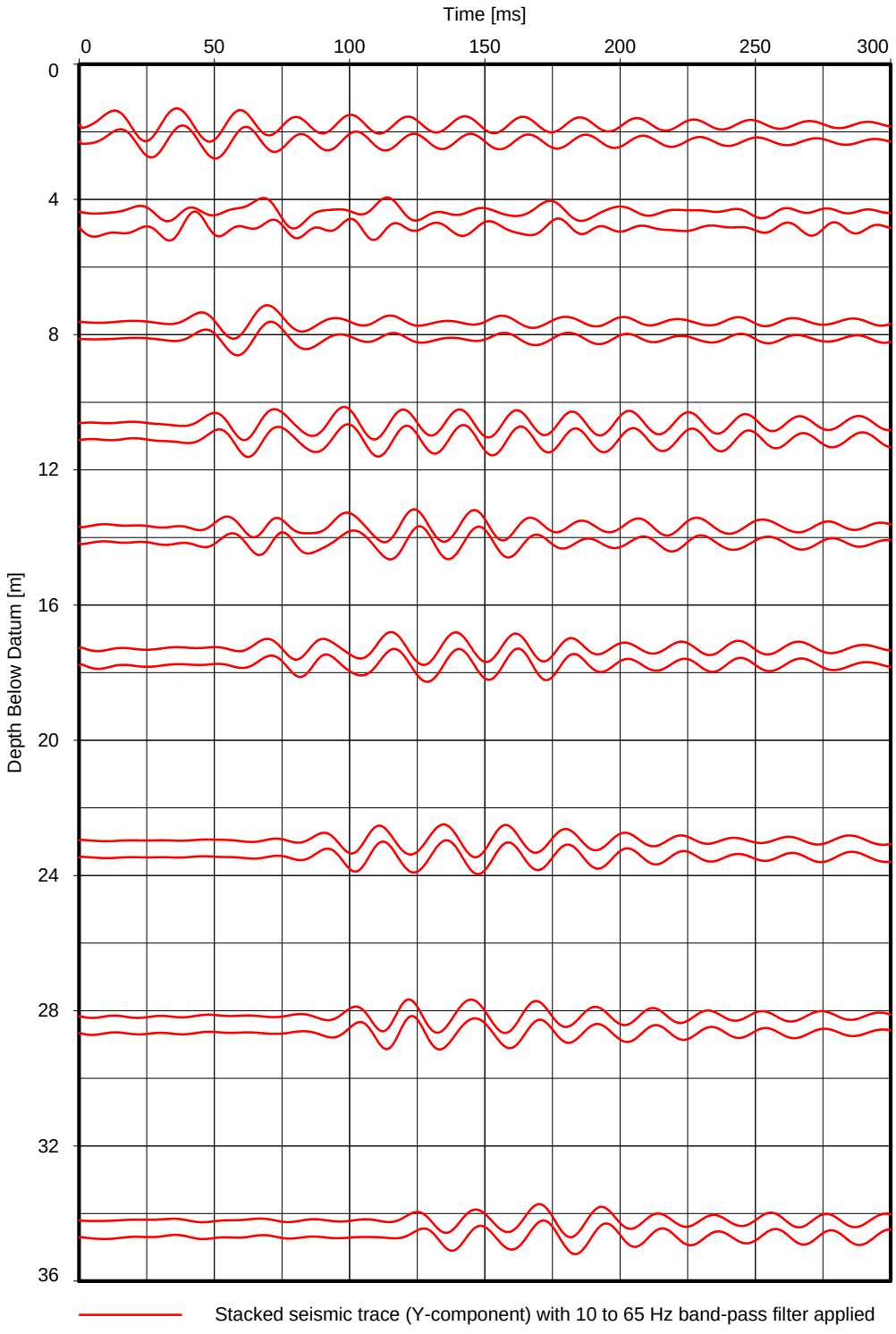
RECORDED SHEAR WAVE TRACES VERSUS DEPTH (X-COMPONENT)

LOCATION CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

PPPWIN 03.26.nl/B2-1_CPT_WFS4_1_X_traces.ppp/2015-10-15 11:13:40

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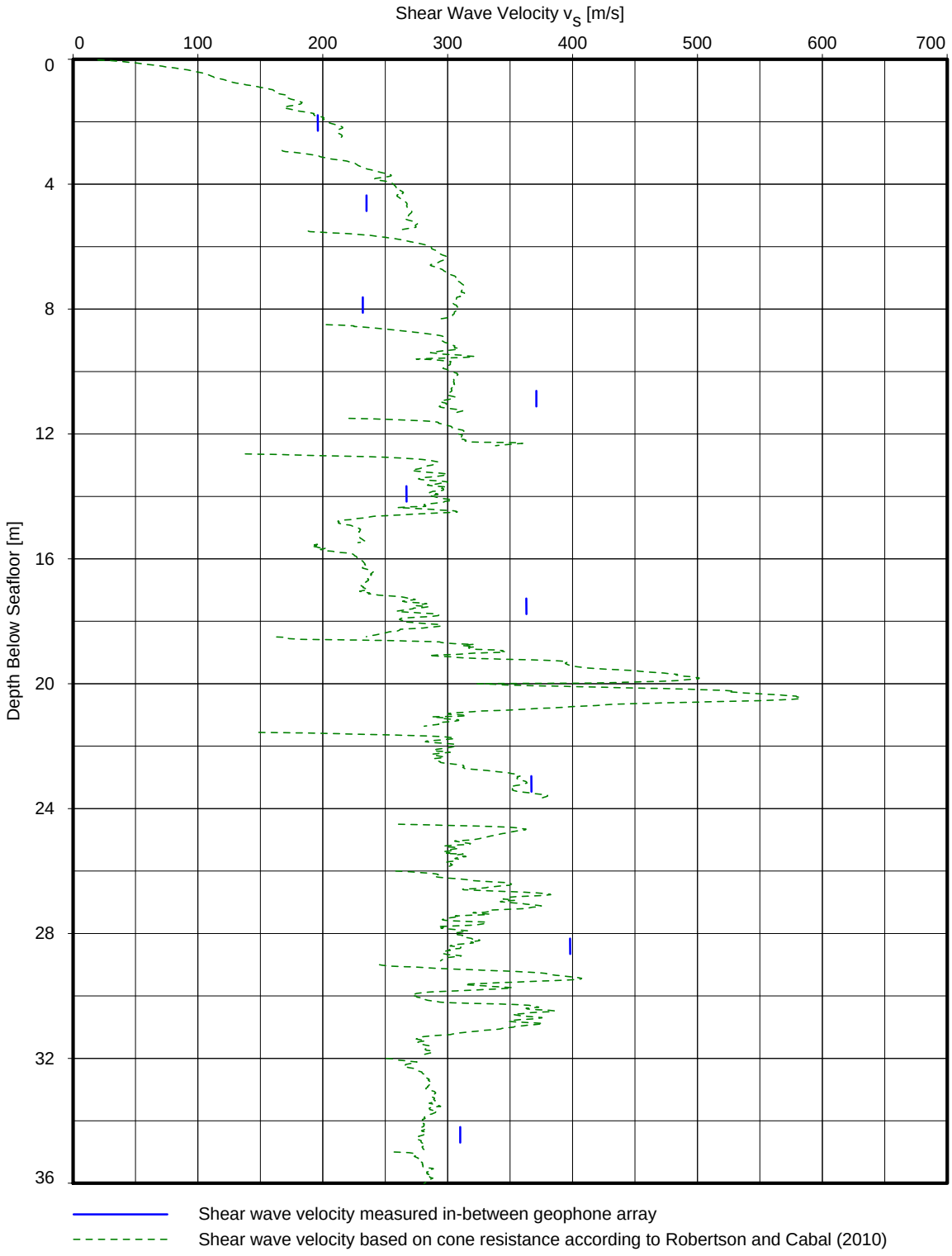
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RECORDED SHEAR WAVE TRACES VERSUS DEPTH (Y-COMPONENT)

LOCATION CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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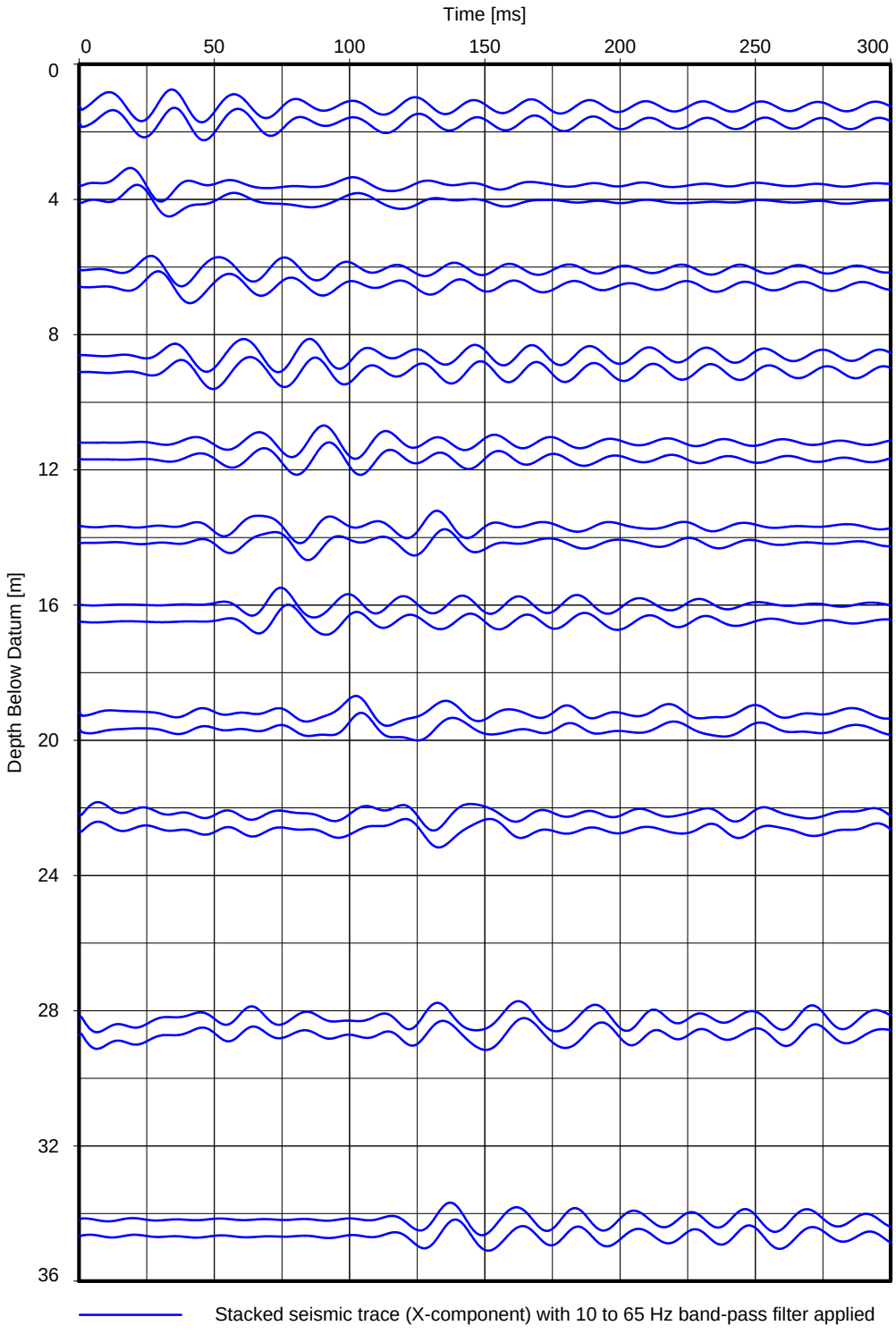
PPPWIN 03.26.nl/B2-3_CPT_WFS4_1 Shear Wave Velocity vs Depth.ppp/2015-11-13 13:51:56

SHEAR WAVE VELOCITY VERSUS DEPTH

LOCATION CPT_WFS4_1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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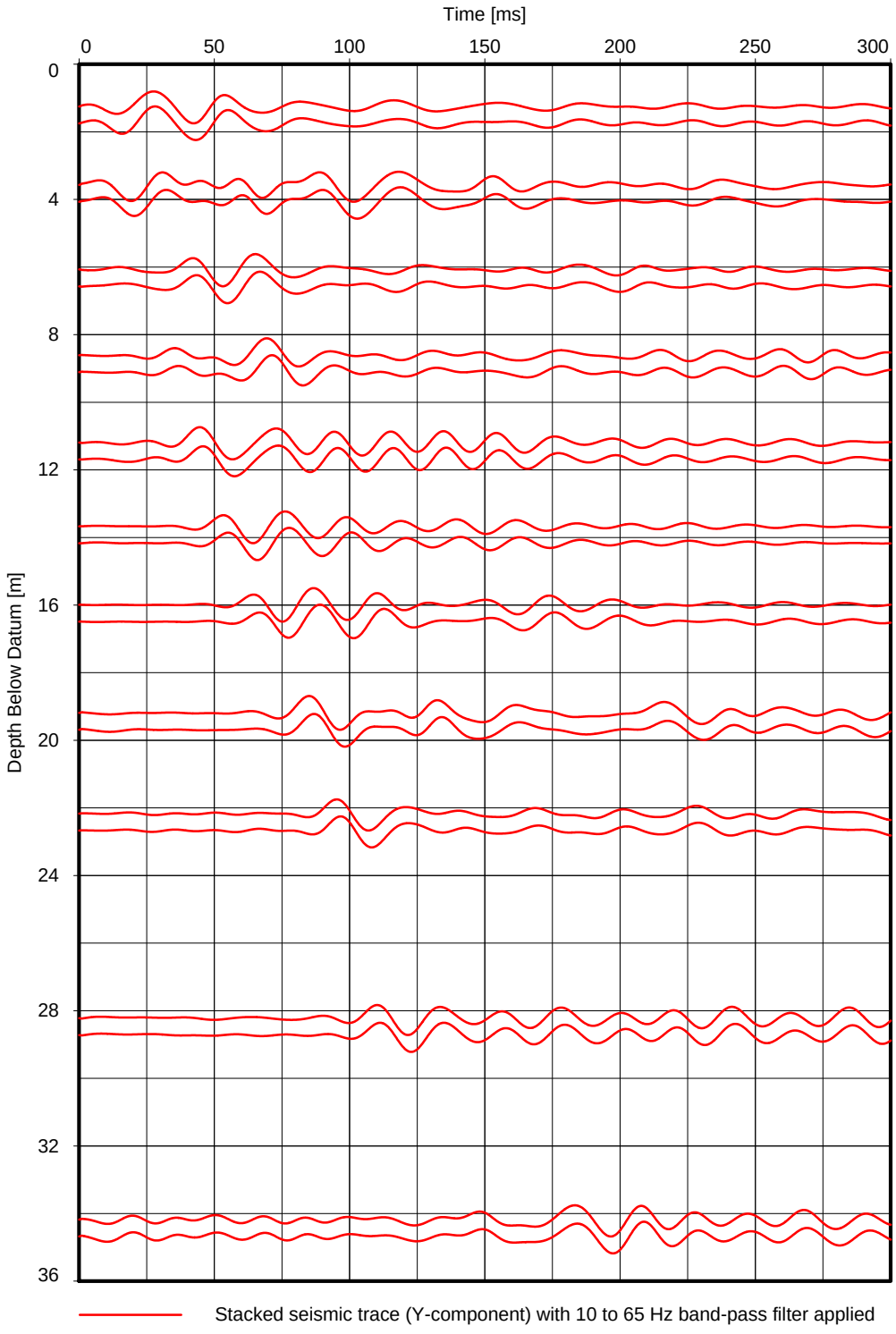
RECORDED SHEAR WAVE TRACES VERSUS DEPTH (X-COMPONENT)

LOCATIONS CPT_WFS4_21 AND CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

PPPWIN 03.26.nl/21(A)_X_traces.ppp/2015-11-17 14:29:18

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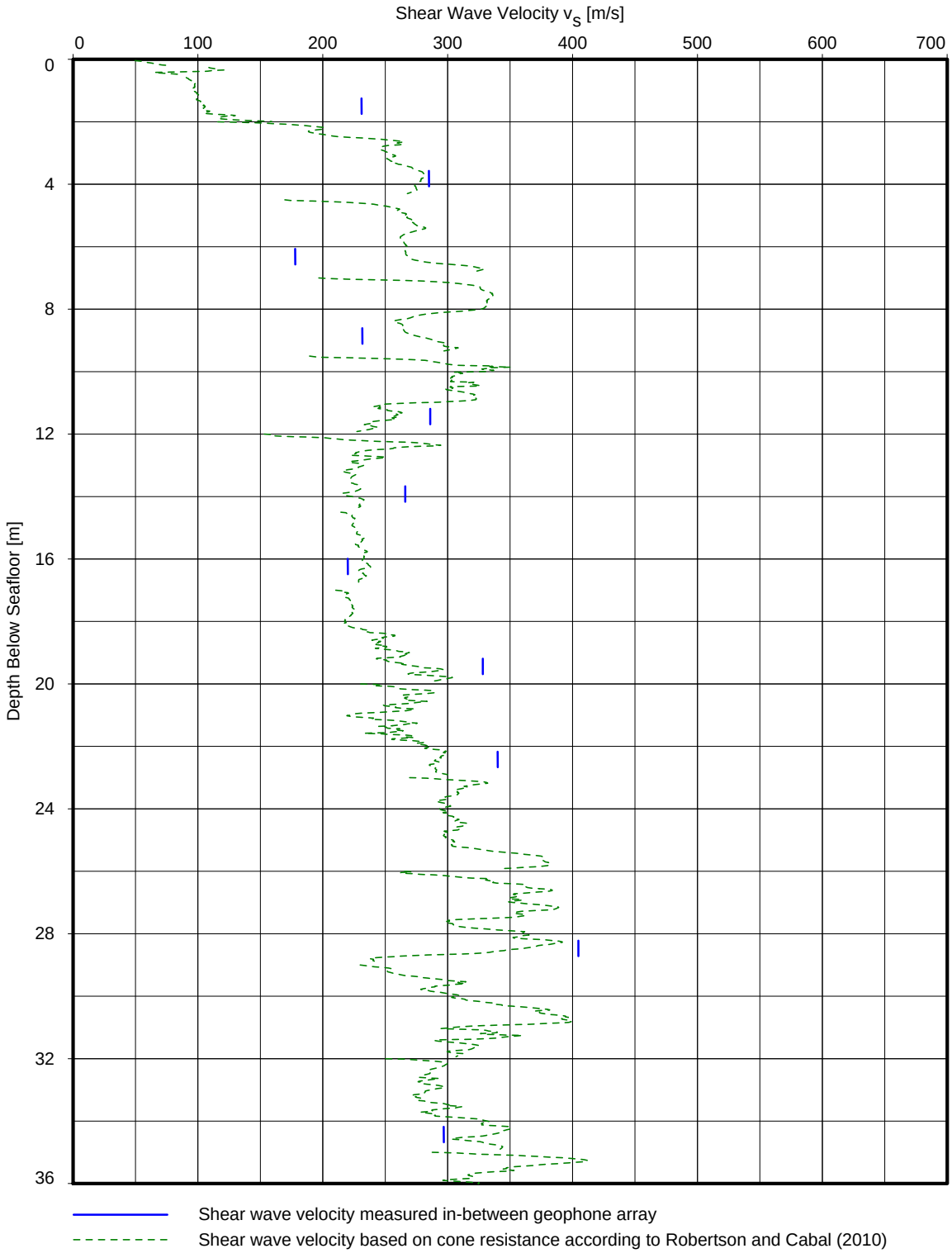
PPPWIN 03.26.nl/21(A)_Y_traces.ppp/2015-11-17 14:30:42

RECORDED SHEAR WAVE TRACES VERSUS DEPTH (Y-COMPONENT)

LOCATIONS CPT_WFS4_21 AND CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

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PPPWIN 03.26.nl/21(A) Shear Wave Velocity vs Depth.ppp/2015-11-13 14:12:11

SHEAR WAVE VELOCITY VERSUS DEPTH

LOCATIONS CPT_WFS4_21 AND CPT_WFS4_21A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SECTION B3: PORE PRESSURE DISSIPATION TESTS

TEXT – SECTION B3: Page

B3. PORE PRESSURE DISSIPATION TESTS

B3.1 COMMENTS ON RESULTS B3-1

B3.2 PRACTICE FOR PORE PRESSURE DISSIPATION TEST B3-2

LIST OF PLATES IN SECTION B3: Plate

Pore Pressure Dissipation Test Results B3-1 to B3-2

B3. PORE PRESSURE DISSIPATION TESTS

B3.1 COMMENTS ON RESULTS

Two Pore Pressure Dissipation Tests (PPDTs) were performed at location BH-WFS4-7, using a piezo-cone penetrometer. The first PPDT had a duration of 15 minutes and was performed at a depth of 8.9 m below seafloor (bsf) in clayey sand, the second PPDT was carried out during 120 minutes, at a depth of 21.8 m bsf in clay. Results are presented on Plates B3-1 and B3-2 as graphs showing pore pressure relative to atmospheric pressure and cone resistance relative to bottom of the borehole during dissipation on a logarithmic time scale.

Water depth presented on the plate is the measured water depth (not reduced to LAT) at the start of each PPDT obtained from echo sounder measurements. These water depths represent the water column present at the start of test and differ from the water depth for this location presented elsewhere in this report.

Both test results show small and regular fluctuations in measured cone resistance. This is likely caused by small axial and/or lateral movements of the cone. Acquired test data shows an expected dissipation trend. Pore pressure at the end of the PPDT is close to the theoretical hydrostatic pressure. Results of PPDT_2 in clay show that dissipation is still continuing at the end of the test with pore pressure well above theoretical hydrostatic pore pressure at test depth.

For more detailed information about PPDTs and measured or calculated parameters refer to the document titled “Pore Pressure Dissipation Test”, presented in Appendix 1.

B3.2 PRACTICE FOR PORE PRESSURE DISSIPATION TEST

Test Control – Penetration

Refer to sub-section titled “Practice for Cone Penetration Test”, presented in Section B1

Test Control – Dissipation

General Procedure:	Refer to document titled “In Situ Pore Pressure Dissipation Test” presented in Appendix 1
Test Method:	Monitoring of pore pressure for estimation of equilibrium in situ pore water pressure
Test Stage:	– Dissipation test at depths as directed by Client – Real-time monitoring of pore pressures
Termination Stage:	Whichever occurs first: – reaching ~100% dissipation of excess pore pressure – as instructed by Client – unfavourable test conditions – circumstances at the discretion of test operator, such as risk of equipment damage or risk to personnel safety

Piezo-Cone Apparatus

Refer to plate titled “Practice for Cone Penetration Test”, presented in Section B1

Test Results

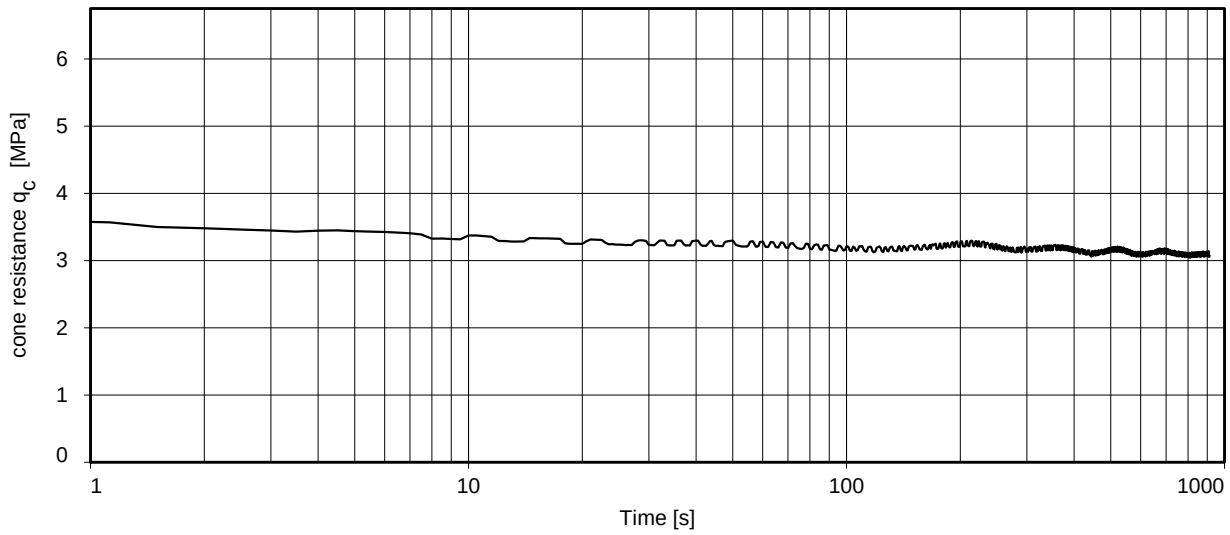
Data Processing and Management:	– Refer to document titled “In Situ Pore Pressure Dissipation Test” presented in Appendix 1 – UNIPLOT software – Graphical scales selected to suit general presentation of data and requirements of standards, where practicable – Start of logarithmic time scale is at 1 s; the value of pore pressure at 0 s is numerically presented under “pore pressure at start” – No display of data outside of chart limits, i.e. some values may not be shown
Data recording:	During lowering: 0.2 Hz; during penetration: 2 Hz; during dissipation from 0 s to 900 s: 2 Hz, during dissipation >900 s: 1 Hz, during dissipation >6000 s: 0.2 Hz; during hoisting: 0.2 Hz
Water Depth Reference:	As obtained from echo sounder readings at start of test (not reduced to LAT)
Depth Reference Correction:	None applied
Depth Correction for Probe Inclination:	Not applicable
Pressure Reference Level:	Zero pressure is equal to atmospheric pressure
Parameter Values for Data Processing:	Refer to Section Text

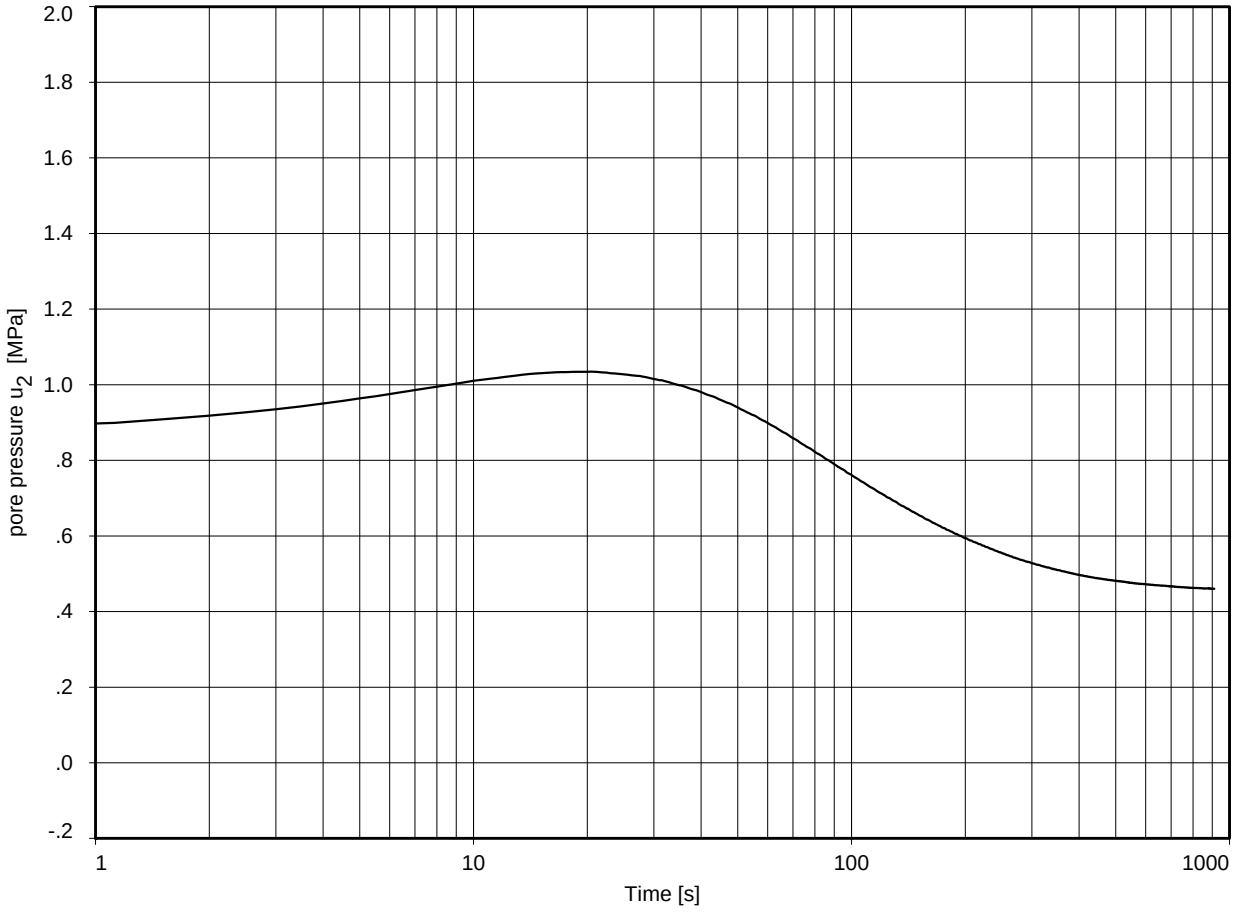
References

Computer Program UNIPLOT, Processing of Pore Pressure Dissipation Data

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file: CPT_1 (at 9 m below ML).000





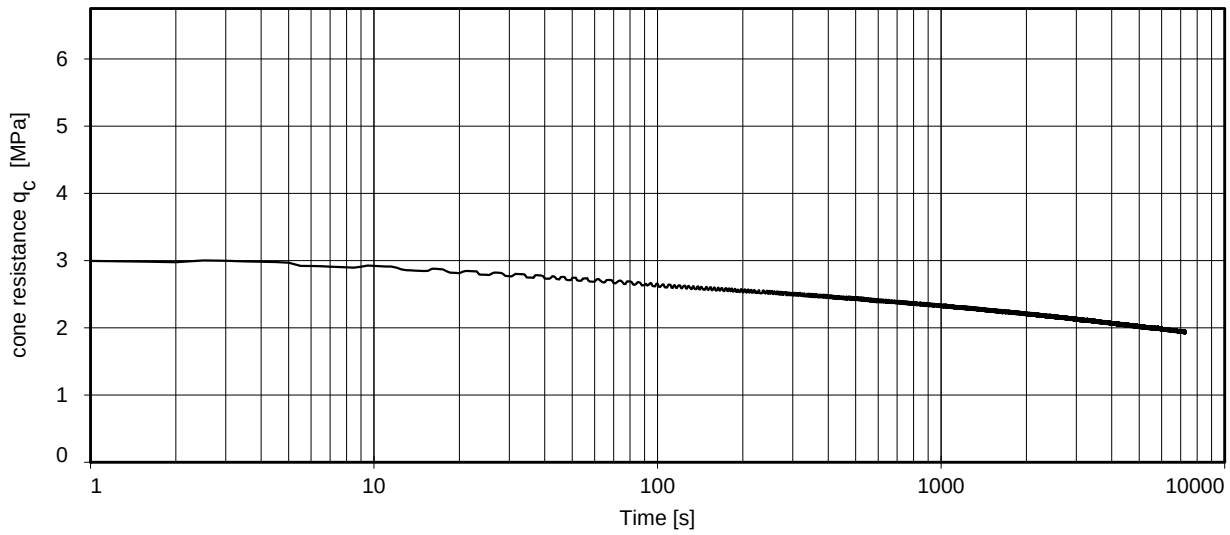
location	:	BH-WFS4-7	pore pressure at start	:	0.878 MPa
date of testing	:	05-Oct-2015	pore pressure at end	:	0.460 MPa
dissipation test depth	:	8.89 m below seafloor			
measured water depth	:	34.7 m			
water depth reduced to LAT	:	35.9 m			
note	:	pressures relative to atmospheric			

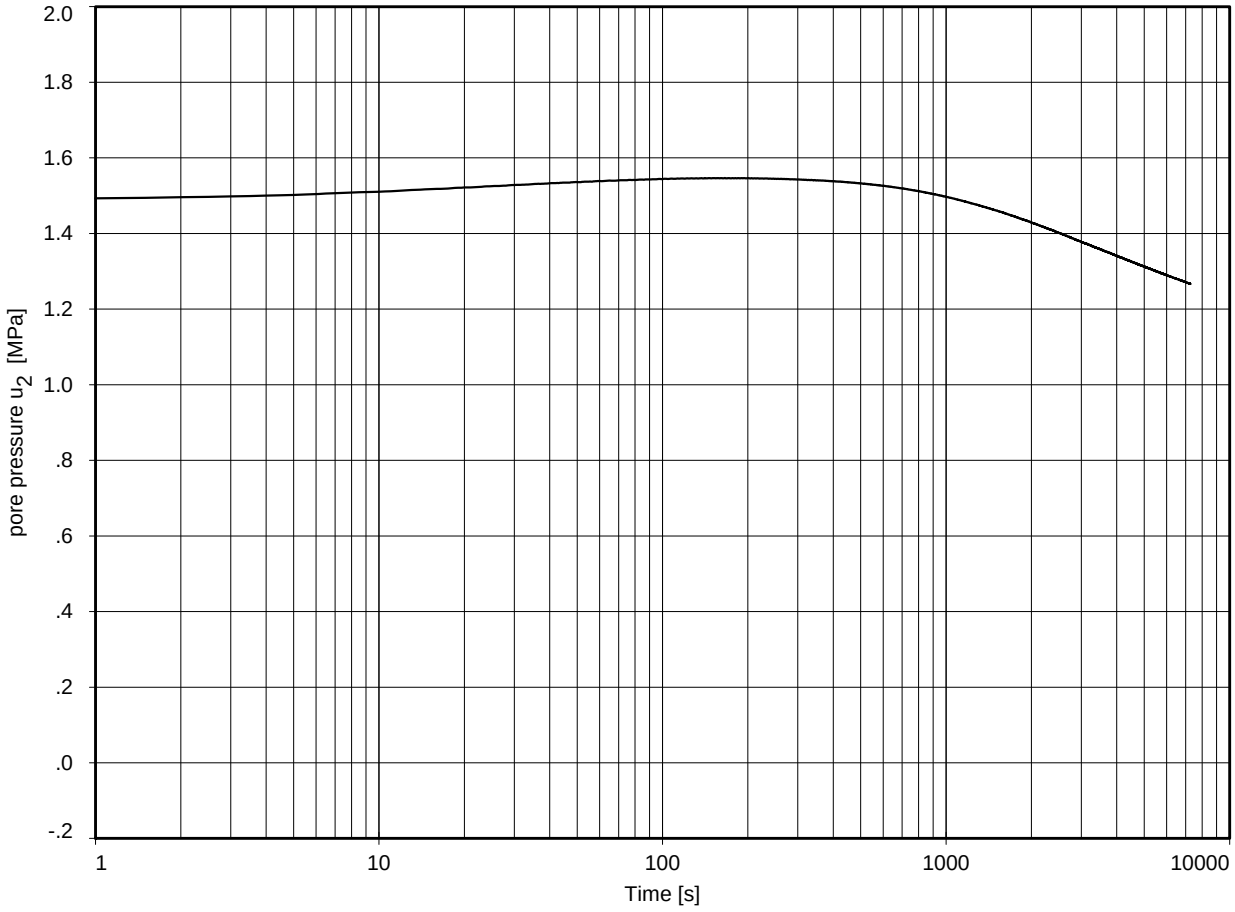
UNIPLOT 05.29.nl/Diss logTime u2 - fixed scale_clay_CPT1./2015-10-15 13:26:28

PORE PRESSURE DISSIPATION TEST

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

file: CPT_4 (at 22 m below ML),000





location	:	BH-WFS4-7		pore pressure at start	:	1.489 MPa
date of testing	:	05-Oct-2015		pore pressure at end	:	1.267 MPa
dissipation test depth	:	21.81	m below seafloor			
measured water depth	:	34.7	m			
water depth reduced to LAT	:	37.1	m			
note	:	pressures relative to atmospheric				

PORE PRESSURE DISSIPATION TEST

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

UNIPLOT 05.29.nl/Diss logTime u2 - fixed scale_clay_CPT4./2015-10-15 13:27:13

SECTION C: GEOTECHNICAL LABORATORY TEST RESULTS

SECTION C1: LABORATORY TESTING OVERVIEW
SECTION C2: INDEX LABORATORY TESTS
SECTION C3: SAMPLE PHOTOGRAPHS
SECTION C4: TRIAXIAL TESTS
SECTION C5: RING SHEAR TESTS
SECTION C6: OEDOMETER TESTS

SECTION C1: LABORATORY TESTING OVERVIEW

TEXT – SECTION C1: Page

C1. LABORATORY TESTING OVERVIEW

C1.1 SUMMARY OF LABORATORY TESTS C1-1
C1.2 QUALITY OF RESULTS C1-2
C1.3 PRACTICE FOR SAMPLE HANDLING AND LABORATORY TESTING C1-3 to C1-4
C1.4 INDEX LABORATORY TESTS C1-5
C1.5 SAMPLE PHOTOGRAPHS C1-5
C1.6 TRIAXIAL TESTS C1-5 to C1-7
C1.7 RING SHEAR TESTS C1-7
C1.8 OEDOMETER TESTS C1-7 to C1-8
C1.9 REFERENCES C1-8

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Summary of Unconsolidated Undrained Triaxial Compression Test Results C1-1 to C1-2
Summary of Isotropically Consolidated Undrained Triaxial Compression Test Results C1-3
Summary of Consolidated Drained Triaxial Compression Test Results C1-4
Summary of Soil-Soil Ring Shear Test Results C1-5
Summary of Soil-Steel Ring Shear Test Results C1-6
Summary of Oedometer Test Results C1-7

C1. LABORATORY TESTING OVERVIEW

C1.1 SUMMARY OF LABORATORY TESTS

Main Text Section 2.2.5 titled “Laboratory Tests” presents a brief overview of the geotechnical laboratory test programme. This section presents results from the laboratory tests performed both on-site and in-office. Table C1.1 presents a summary of the number of each laboratory test completed, along with references to the adopted test procedures. For further details on test procedure and methodology refer to the document “Geotechnical Laboratory Tests” presented in Appendix 1. Note that water content, unit weight and pocket penetrometer tests are not presented in this table.

Laboratory test results are presented per test type in sub-sections of this report section. Selected test results are also presented on the geotechnical logs presented in Section A. Effective vertical stress presented on Plates C1-1 to C1-7 is calculated using the unit weight profiles presented in Section B1, refer to Plates titled “Parameter Values for Net Cone Resistance Calculation”.

Table C1.1: Overview of Laboratory Testing

Test Type	Number of Tests	Test Procedure
Index Laboratory Tests		
Density of Solid Particles (Small Pycnometer)	39	BS1377:Part 2:1990:Clause 8.3
Particle Size Analysis (Sieving and Pipette)	95	BS1377:Part 2:1990:Clause 9.2+9.4/ Fugro in-house procedure
Minimum and Maximum Index Unit Weight	21	BS1377:Part 4:1990:Clause 3.7/ Fugro in-house procedures
Atterberg Limits	38	BS1377:Part 2:1990:Clauses 4+5
Carbonate Content	18	DETS in-house procedure
Organic Content	22	DETS in-house procedure
Triaxial Tests		
Unconsolidated Undrained Triaxial compression - Undisturbed (UU)	24	BS1377:Part 7:1990:Clause 8
Unconsolidated Undrained Triaxial compression - Remoulded (UUr)	24	BS1377:Part 7:1990:Clause 8
Isotropically Consolidated Undrained Triaxial in compression (CIUc)	12	BS1377:Part 8:1990:Clauses 4+5.4+6+7/ Fugro in-house procedures
Isotropically Consolidated Drained Triaxial in compression (CIDc)	15	BS1377:Part 8:1990:Clauses 4+5.3+6+8/ Fugro in-house procedures
Ring Shear Tests		
Ring Shear (Soil-Soil Interface)	7	BS1377:Part 7:1990:Clause 6
Ring Shear (Soil-Steel Interface)	7	Jardine et al. (2005)/ICP Method
Oedometer Tests		
Incremental Loading (IL) Oedometer Test	2	BS1377:Part 5:1990:Clause 3
Constant Rate of Strain (CRS) Oedometer Test	9	Fugro in-house procedures based on ASTM D4186-12

C1.2 QUALITY OF RESULTS

In general, laboratory test results are considered to be of good quality. Assessed quality of laboratory test data is according to expectations for used sampling practice and laboratory test methods.

Results of geotechnical laboratory tests are generally consistent with the visual descriptions and in situ test interpretations. It is noted that the majority of the (index) strength tests results correlate reasonably well with the shear strength derived from in situ tests, although some scatter is observed. This is likely attributed to heterogeneity of the test specimens in combination with differences between the various testing techniques used. The pocket penetrometer test for example, tends to show higher shear strength values than other methods, however is considered to be less accurate for very stiff to hard (structured) sandy clays.

According to ISO (2014), an indication of sample quality may be derived from the recompression stage in an oedometer or CIU triaxial compression test (refer to document “Geotechnical Laboratory Tests” presented in Appendix 1). The method however applies to a limited range of soil conditions.

Void ratio change ($\Delta e/e_0$) for CIU triaxial compression test specimens ranges between 0.002 and 0.057. ISO (2014) undisturbed sample quality indication for these specimens classifies as “very good to excellent” to “poor” – this indication must be used with caution for soils outside the specified range.

Void ratio change ($\Delta e/e_0$) for oedometer test specimens ranges between 0.053 and 0.091. ISO (2014) undisturbed sample quality indication for these specimens classifies as “poor” – this indication must be used with caution for soils outside the specified range.

C1.3 PRACTICE FOR SAMPLE HANDLING AND LABORATORY TESTING

Practice

Procedure:	According to ISO (2014)
Data Processing and Management:	– Laboratory-specific software and GeODin® software, as applicable – Graphical scales selected to suit general presentation of data – No display of data outside of chart limits, i.e. some values may not be shown
Data Format(s):	– PDF for viewing and printing (this primary document) – AGS 3.1 (AGS, 2005) and AGS 4.0 (AGS, 2011) digital tabular data (separate deliverables, secondary to this document)

Initial Sample Handling

Open-Tube Sampler:	Identification/labelling and transfer of sample tube to site laboratory

Site Geotechnical Laboratory

Test Programme:	Geotechnical description, geotechnical index, and index strength
Programme Adjustment:	Assessment of feasibility of a test (by sample inspection) and, if required, selection of alternative test specimen if adequate test completion proves impracticable
Sample Description:	– Geotechnical sample description is an interpretation of processed data available at the time of preparation – Level of detail and accuracy in geotechnical description and interpretation depend on factors such as test data, sample size, quality, coverage, availability of supplementary information, and project requirements
Laboratory Air Temperature:	Typically about 20°C
Tube Sample:	– Sample extrusion – Visual geotechnical description including visual carbonate content assessment – Photography of selected sample section(s) – Geotechnical classification and index testing (water content, unit weight, pocket penetrometer, torvane, unconsolidated undrained triaxial compression - undisturbed and remoulded) – Selection and labelling of geotechnical sample sections for undisturbed preservation and/or disturbed preservation

Sample Protection

Packaging of Selected Sample Sections:	– Undisturbed sample sections wrapped in aluminium and/or plastic foil, and waxed into labelled cardboard tubes – Disturbed sample sections placed in double set of plastic bags, and labelled – Placement in labelled shipping container
On-Site Sample/Core Storage:	– On-board storage area – Storage temperature within the range +2°C and +35°C – Protection from direct sunlight

Sample Transport

Fugro Sample Transport:	– Shipping containers off-loading from drilling vessel at port of demobilisation – Road-freight to Fugro-nominated laboratory
Client Sample Transport	Not applicable

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Test Programme	Geotechnical index, geochemical, (index) strength and compressibility
Programme Adjustment	– Assessment of feasibility of a test (by sample inspection) prior to start of specimen preparation – Decision by laboratory: (1) to proceed with test, (2) not to proceed with test, (3) to advise adjustments to test procedure – Selection by laboratory of alternative test specimen if decision is "not to proceed" or when adequate test completion proves impracticable
Ground Description	– No update of geotechnical sample descriptions made with in-office laboratory data or in situ test data, i.e. retention of original recorded data – Geotechnical sample description is an interpretation of processed data available at the time of preparation – Level of detail and accuracy in geotechnical sample description and interpretation depend on factors such as test data, sample size, quality, coverage, availability of supplementary information, and project requirements
Laboratory Air Temperature	Typically about 20°C
Sample Waxed in Cardboard Tube	– Removal of sample from tube by cutting – Photography of selected sample section(s) – Geotechnical index testing (density of solid particles, sieving and hydrometer, Atterberg limits, unconsolidated undrained triaxial compression - undisturbed and remoulded, isotropically consolidated undrained triaxial compression, isotropically consolidated drained triaxial compression, ring shear - soil-soil and soil-steel, oedometer - incremental loading and constant rate of strain) – If applicable, selection and labelling of left-over sample sections for undisturbed preservation and/or disturbed preservation
Sample in Plastic Bags	– Geotechnical index testing (density of solid particles, sieving and hydrometer, Atterberg limits, organic and carbonate content, minimum and maximum unit weight, unconsolidated undrained triaxial compression - remoulded, isotropically consolidated drained triaxial compression, ring shear - soil-soil and soil-steel) – If applicable, selection and labelling of left-over sample sections for disturbed preservation)

Sample Storage and Disposition

Sample Storage:	– Storage period of 12 months after issue of final report – Storage temperature within the range +2°C and +35°C – Protection from direct sunlight
Transport:	Not applicable
Final Disposition:	In accordance with office laboratory procedures

References

– AGS Association of Geotechnical and Geoenvironmental Specialists (2005), "Electronic Transfer of Geotechnical and Geoenvironmental Data", AGS Edition 3.1 (including Addendum).
– AGS Association of Geotechnical and Geoenvironmental Specialists (2011), "Electronic Transfer of Geotechnical and Geoenvironmental Data", AGS Edition 4.0.
– Computer Program GeODin®, Recording, Presentation and Analysis of Geo-data
– ISO International Organization for Standardization (2014), "Petroleum and Natural Gas Industries - Specific Requirements for Offshore Structures – Part 8: Marine Soil Investigations", International Standard ISO 19901-8:2014.

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C1.4 INDEX LABORATORY TESTS

Results of the geotechnical index tests are generally consistent with the visual descriptions and in situ test results.

Individual on-site sample descriptions together with results of geotechnical index tests are presented on plates titled “Laboratory Classification Test Results” in Section C2. On-site sample descriptions presented in Section C2 are not updated with results from office laboratory testing or with in situ test data.

Particle density values of 2.65 Mg/m^3 for coarse-grained cohesionless and 2.70 Mg/m^3 and fine-grained cohesive soils were used to derive unit weight from water content data. Results from the particle density tests support these selected values.

The results of the Atterberg limit determination are presented on a plasticity chart in Section C2. Individual test results are included on plates titled “Laboratory Classification Test Results”. Two originally scheduled Atterberg limits tests could not be performed as the specimens were determined to be non-plastic (BH-WFS4-3 Sample 15WaxB and BH-WFS4-7 Sample 28WaxA).

C1.5 SAMPLE PHOTOGRAPHS

Some sample photographs of coarse-grained cohesionless material presented in Section C3 show cuts in the intact sample. Cuts were sometimes made during the extrusion process to facilitate improved extrusion of the sample material from the sampling tube.

For some samples, only one sample photograph (either the intact or split) is available. This was due to operator error. In case a photo is missing this is indicated on the plates in Section C3.

Photographs of the specimens used for CIUc triaxial test and CRS Oedometer tests are included with the individual test results, presented in Sections C4 and C6 respectively.

C1.6 TRIAXIAL TESTS

A total of 24 UU triaxial compression tests were performed. Tests were done on both undisturbed and remoulded specimens. A summary table of UU results is presented on Plates C1-1 to C1-2. Individual test results are presented in Section C4.

All UU tests were performed at a cell pressure of 1000 kPa and with a rate of strain of 2%/min. When no distinct specimen failure was reached prior to 20% axial deformation, the undrained shear strength (s_u) was taken as half the deviator stress at 20% axial strain.

Some tests were terminated prior to applying 20% axial strain due to operational limitations, such as observed leakage of the membrane, or maximum allowable load on the load cell being achieved (Sample 14WaxC from BH-WFS4-1A). The undisturbed UU test on this sample shows a very high undrained shear strength value (in excess of 500 kPa). This is most likely due to a high sand content in the sample.

Test results from BH-WFS4-4 (Sample 35BagUU) and BH-WFS4-5 (Sample 34BagUU) show an inflection on the incline of the undisturbed tests. This behaviour is not uncommon for hard sandy clays. Test results are considered valid.

Processing of bedding errors from the start of a test may result in a minor reduction (1% to 2%) of the final achieved axial strain of the test.

Unconsolidated Undrained triaxial compression test results are generally in reasonable agreement with soil descriptions and with the s_u range derived from in situ testing data (cone penetration tests) and other index strength test data. Occasionally, the remoulded shear strength is higher than s_u measured in undisturbed conditions. This is not uncommon in these overconsolidated structured clays. Comments are as follows:

- The soil unit from which samples were tested was described as including a platy and/or fissured structure. The clay structure may result in local discontinuities which serve as preferential shear planes during testing, thereby reducing the measured undisturbed undrained shear strength.
- Undisturbed test specimens may have included laminae and/or pockets of coarser material (silt and/or fine sand) which may not necessarily develop the same pore pressures over time as the fine-grained materials in the specimen. In contrast to the undisturbed specimen, the remoulded specimen is 'artificially' homogeneous, and can therefore develop more homogenous pore pressures over the test sample over time, potentially resulting in a higher undrained shear strength measurement.
- Stress relief and swelling of the samples during sampling and/or sample handling may have resulted in sample disturbance of the undisturbed specimen. Sample disturbance will tend to reduce the undisturbed sample shear strength.

Comparison of measured water contents between undisturbed and remoulded specimens for UU triaxial compression tests sometimes shows differences in excess of 2%. This is observed in 4 out of 24 tests. Minor changes in water contents (1% to 2%) can be expected. Larger differences can likely be attributed to measurement errors, decrease in water content due to drying of sample material during sample handling, or increase in water content due to for example residual water present on the sample processing surface. The overall behaviour of specimens observed during UU triaxial testing is consistent, and the variation in water content is considered to have a negligible effect on the test results.

Eight CIUc triaxial tests were performed in the in-office laboratory. Tests were carried out as single stage tests. Results of the CIUc triaxial tests are summarised on Plate C1-3 and presented in Section C4.

Previous experience indicated that the clays present across WFS IV can be prone to swelling. This is likely attributed to clay mineralogy and overconsolidated nature of the clay samples. Swelling of a test specimen can occur when, during saturation of the specimen, it is allowed to take on significant quantities of fluid. To account for this, triaxial test specimens were saturated using a so-called "constant moisture content" method similar to Clause 5.4 of BS 1377:Part 8 (BSI, 1990). Specimen saturation is achieved by raising the cell pressure in increments, without applying back-pressure. For several tests this procedure was not sufficient to allow full saturation. For these tests back-pressure was applied while carefully monitoring the intake of water. Water intake was limited to the calculated volume of voids of the specimen. The saturation procedure used was satisfactory as none of the specimens showed significant swelling during the saturation stage.

Generally, the CIU triaxial tests results compare with UU triaxial tests results. Results generally show the typical behaviour expected of (overconsolidated) clays: a sharp initial increase in deviator stress q, a non-linear p'/q relationship and an initial increase of pore water pressure followed by a decrease proportional to the overconsolidation ratio (the higher the overconsolidation ratio, the larger the pore water pressure decrease).

CIUc triaxial test on Sample 35C from borehole BH-WFS4-5 gives a significantly higher shear strength than the adjacent UU triaxial test and in situ test results. This is likely due to the sample having a high sand content.

Similar to what is described for UU test results above, local discontinuities and structures within the test specimens may serve as preferential shear planes during testing. These shear planes may also act as preferential drainage paths for pore fluid, during the saturation and/or consolidation stage, which in turn acts to lubricate the structure surface, thereby also potentially causing premature sample failure.

One originally scheduled CIU test was not performed (BH-WFS4-1A Sample 15WaxB) as the sample cracked on removal of the sample from its packaging.

Fifteen Isotropically Consolidated Drained (CID) triaxial compression tests were performed in the office laboratory. Tests were carried out as multi stage and multi specimen tests with three consolidation and loading stages of increasing pressure performed on three separate specimens. Results of the CID triaxial tests are summarised on Plate C1-4 and presented in Section C4.

The CID triaxial test results showed behaviour during shearing which is typical for the selected initial sample density, sample grading and fines content. Test specimens with low (dry) densities generally show contractive behaviour during shearing. Specimens prepared at higher (dry) densities generally showed dilative behaviour.

Failure envelopes for the CID triaxial tests have been derived considering a best fit to the Mohr's circles for each individual set of tests. Therefore, some envelopes are not tangent to all three circles presented.

C1.7 RING SHEAR TESTS

Ring Shear (RS) tests were performed on a selection of coarse-grained specimens. Results of the RS tests are summarised on Plates C1-5 and C1-6 for soil-soil interface and soil-steel interface tests respectively, and are presented in full in Section C5.

Seven soil-soil interface RS tests were performed on samples from shallow depths (1.50 m to 4.50 m below seafloor (bsf)) and were tested according to Clause 6 of BS1377:Part 7 (BSI, 1990). Each test consists of three stages, each with a doubling of the applied normal stress. Each specimen was sheared at two different rates (0.16°/min and 674°/min).

Seven soil-steel interface RS tests were performed according to the ICP method (Jardine et al., 2005) on specimens obtained from between 6.55 m and 36.0 m bsf. Each test consists of two stages. In Stage 1 the specimen is consolidated to the estimated in situ effective horizontal stress and sheared at a rate of 500 mm/min. In Stage 2, the specimen is consolidated to 1.67 times the consolidation pressure used for the first stage, and subsequently sheared at a rate of 0.018 mm/min.

C1.8 OEDOMETER TESTS

Results of Incremental Loading (IL) and Constant Rate of Strain (CRS) oedometer tests are summarised on Plate C1-7. Individual test results are presented in Section C6.

Oedometer tests were performed on undisturbed fine-grained cohesive specimens to aid in the evaluation of stress history and settlement parameters of the soil under one-dimensional loading conditions. Two IL oedometer tests and three CRS oedometer tests were performed. Preconsolidation pressure (σ'_p) for both IL and CRS oedometer tests was assessed with the graphical Casagrande method (Casagrande, 1936) and is presented on Plate C1-7. Stress history conditions and compression parameters interpreted for IL and CRS oedometer tests were similar.

The test results show a relatively steep slope during the unloading stages compared to the primary compression index at the start of the curve. This steep 'rebound' is unusual and indicates that the clay specimens are prone to swelling. Such swelling behaviour can be attributed to clay mineralogy. The clay's activity (plasticity index divided by the percentage of clay particles) indicates a high montmorillonite and illite content which are both minerals prone to swelling. Also, it may be noted that the geological formations from which the specimens were taken have been reported to show swelling behaviour related to mineralogy of the clays (Jacobs and Coninck, 1992).

C1.9 REFERENCES

BSI British Standards Institution (1990), "British Standard Methods of Test for Soils for Civil Engineering Purposes. Part 7. In-Situ Tests (Total Stress)", BS 1377:Part 7:1990.

BSI British Standards Institution (1990), "British Standard Methods of Test for Soils for Civil Engineering Purposes. Part 8. Shear Strength Tests (Effective Stress)", BS 1377:Part 8:1990. (With Amendment No. 1, published January 1995)

Casagrande, A. (1936), "The Determination of the Pre-consolidation Load and its Practical Significance", in Proceedings, First International Conference on Soil Mechanics and Foundation Engineering, Cambridge, Massachusetts, Vol. 3, pp. 60-64.

ISO International Organization for Standardization (2014), "Petroleum and Natural Gas Industries – Specific Requirements for Offshore Structures – Part 8: Marine Soil Investigations", International Standard ISO 19901-8:2014.

Jacobs, P and Coninck, F de (1992), "Qualitative Clay Mineralogy of the Middle and Upper Eocene in North-West Belgium", Bulletin van het Koninklijk Belgisch Instituut voor Natuurwetenschappen

Jardine, R., Chow, F.C., Overy, R.F. and Standing, J.R. (2005), "ICP Design Methods for Driven Piles in Sands and Clays", Thomas Telford Ltd., London.

SUMMARY OF UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Location	Sample No.	Depth	Test Type	σ'_{v0}	Initial Conditions		At Peak Deviator Stress			
					w_i	γ_i	s_u	ε_a	ε_{50}	s_u/σ'_{v0}
		[m bsf]		[kPa]	[%]	[kN/m³]	[kPa]	[%]	[%]	[-]
BH-WFS4-1A	14WaxC	13.60	U	144	24.8	19.4	519	19.5	5.3	3.7
	14WaxC	13.60	R	144	27.3	19.7	263	20.0	10.9	1.9
	21BagUU	33.30	U	328	36.0	18.2	132	6.0	0.6	0.4
	21BagUU	33.30	R	328	38.0	18.2	247	9.5	1.1	0.8
	21WaxC	33.50	U	330	37.9	18.4	159	2.1	0.4	0.5
	21WaxC	33.50	R	330	36.4	18.4	278	9.0	1.2	0.9
	22BagUU	37.25	U	359	34.8	17.9	315	2.3	0.6	0.9
	22BagUU	37.25	R	359	37.6	18.1	190	13.2	1.2	0.5
	23WaxD	38.45	U	368	43.5	17.8	238	2.6	0.3	0.7
	23WaxD	38.45	R	368	42.1	17.7	223	8.0	1.0	0.6
	25BagUU	43.30	U	405	39.4	18.1	247	1.5	0.5	0.6
	25BagUU	43.30	R	405	40.8	18.0	226	8.5	1.0	0.6
	26BagUU	47.30	U	436	36.5	18.3	251	9.8	3.5	0.6
	26BagUU	47.30	R	436	34.5	18.4	172	11.8	1.1	0.4
	26WaxC	47.50	U	437	33.7	19.1	316	5.0	0.7	0.7
	26WaxC	47.50	R	437	32.7	18.8	198	11.3	1.3	0.5
BH-WFS4-2A	15WaxC	30.60	U	321	23.4	19.8	385	14.0	1.2	1.2
	15WaxC	30.60	R	321	22.8	20.0	224	19.8	2.8	0.7
	21WaxB	51.60	U	517	38.1	18.0	210	4.2	0.7	0.4
	21WaxB	51.60	R	517	37.4	18.2	288	8.8	0.9	0.6
BH-WFS4-3	28BagUU	44.70	U	445	37.5	18.3	120	1.8	0.3	0.3
	28BagUU	44.70	R	445	38.3	18.3	276	9.6	1.0	0.6
	28WaxC	44.90	U	447	37.2	18.6	157	1.6	0.3	0.3
	28WaxC	44.90	R	447	35.9	18.4	292	8.8	1.1	0.6
	30BagUU	49.75	U	484	39.4	17.6	332	6.7	2.6	0.7
	30BagUU	49.75	R	484	41.0	17.7	211	11.3	1.1	0.4

Key:

U = undisturbed

R = remoulded

σ'_{v0} = estimated effective in situ vertical stress

w_i = initial water content

γ_i = initial unit weight

s_u = undrained shear strength at peak deviator stress

ε_a = axial strain at failure

ε_{50} = axial strain at 50% of peak deviator stress

bsf = below seafloor

SUMMARY OF UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Location	Sample No.	Depth	Test Type	σ'_{v0}	Initial Conditions		At Peak Deviator Stress			
					w_i	γ_i	s_u	ε_a	ε_{50}	s_u/σ'_{v0}
		[m bsf]		[kPa]	[%]	[kN/m³]	[kPa]	[%]	[%]	[-]
BH-WFS4-3	32BagUU	54.80	U	523	42.8	17.5	436	3.9	1.4	0.8
	32BagUU	54.80	R	523	43.5	17.5	216	8.6	1.0	0.4
	33BagUU	56.05	U	533	40.9	17.5	358	3.8	1.2	0.7
	33BagUU	56.05	R	533	41.9	17.6	203	10.7	1.2	0.4
BH-WFS4-4	34WaxD	38.85	U	407	22.9	20.1	350	10.7	0.9	0.9
	34WaxD	38.85	R	407	22.8	20.5	273	20.0	1.9	0.7
	35BagUU	39.55	U	414	24.2	19.8	235	18.7	7.0	0.6
	35BagUU	39.55	R	414	25.2	19.8	150	20.0	4.0	0.4
	37BagUU	45.00	U	464	21.5	20.2	287	9.2	0.9	0.6
	37BagUU	45.00	R	464	21.3	20.4	222	12.8	1.0	0.5
BH-WFS4-5	34BagUU	38.10	U	404	23.0	19.6	183	19.8	8.6	0.5
	34BagUU	38.10	R	404	23.2	19.7	136	19.9	1.5	0.3
	36BagUU	43.25	U	454	23.0	20.0	330	10.9	2.8	0.7
	36BagUU	43.25	R	454	22.4	20.0	247	17.7	2.8	0.5
	39BagUU	49.30	U	509	31.5	18.9	286	3.1	0.9	0.6
	39BagUU	49.30	R	509	32.1	18.8	286	10.1	1.1	0.6
BH-WFS4-7	12WaxD	9.85	U	99	22.0	20.8	257	9.1	2.0	2.6
	12WaxD	9.85	R	99	21.0	20.6	178	19.6	2.1	1.8
	18WaxD	14.80	U	148	28.9	19.5	209	5.5	0.2	1.4
	18WaxD	14.80	R	148	37.0	19.2	297	11.2	1.0	2.0
	22BagUU	23.30	U	230	33.3	18.4	220	4.5	1.1	1.0
	22BagUU	23.30	R	230	35.4	18.5	224	11.3	1.2	1.0

Key:

U = undisturbed

R = remoulded

σ'_{v0} = estimated effective in situ vertical stress

w_i = initial water content

γ_i = initial unit weight

s_u = undrained shear strength at peak deviator stress

ε_a = axial strain at failure

ε_{50} = axial strain at 50% of peak deviator stress

bsf = below seafloor

SUMMARY OF CONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Location	Sample No.	Depth	Test Type	σ'_{v0}	Initial Conditions			At Peak Deviator Stress					At Peak Principal Effective Stress Ratio			$\Delta e/e_0$
					w_i	γ_i	e_0	s_u	ε_a	ε_{50}	s_u/σ'_{v0}	E_{50}	s_u	ε_a	s_u/σ'_{v0}	
		[m bsf]		[kPa]	[%]	[kN/m^3]	[-]	[kPa]	[%]	[%]	[-]	[MPa]	[kPa]	[%]	[-]	[-]
BH-WFS4-1A	21WaxB	33.12	CIUc	327	36.6	18.3	0.976	127	6.3	0.4	0.39	30.0	127	5.8	0.39	-0.003
	25WaxC	43.52	CIUc	407	39.3	18.1	1.055	138	0.9	0.2	0.34	73.6	138	0.9	0.34	0.004
BH-WFS4-2A	16WaxB	34.42	CIUc	358	24.6	19.7	0.658	419	9.5	1.5	1.20	28.6	312	3.3	0.90	0.040
BH-WFS4-3	23WaxB	31.60	CIUc	323	30.6	18.9	0.812	148	2.6	0.3	0.46	54.4	148	2.6	0.46	-0.010
	29WaxB	45.65	CIUc	453	36.6	18.2	0.991	253	7.0	1.6	0.55	15.6	250	6.3	0.55	0.006
	32WaxC	55.02	CIUc	525	41.3	17.8	1.109	231	1.9	0.4	0.44	51.8	231	1.8	0.44	0.017
BH-WFS4-4	34WaxB	38.66	CIUc	406	24.0	20.0	0.644	314	7.5	1.7	0.77	18.8	284	4.3	0.70	0.009
	37WaxB	44.55	CIUc	460	29.8	19.1	0.797	189	9.7	1.1	0.41	16.5	180	7.4	0.39	-0.004
BH-WFS4-5	35WaxB	39.16	CIUc	416	24.6	19.8	0.662	492	16.0	2.5	1.18	19.5	343	5.3	0.82	0.057
	38WaxB	48.09	CIUc	499	31.5	18.9	0.860	176	5.4	0.8	0.35	23.0	176	5.1	0.35	0.002
BH-WFS4-7	12WaxE	10.05	CIUc	101	20.6	20.6	0.551	137	6.5	0.8	1.36	16.8	127	4.2	1.25	-0.033
	21WaxC	22.30	CIUc	225	30.9	19.0	0.818	165	4.8	0.6	0.73	27.8	165	4.8	0.73	0.856

Key:

CIUc = isotropically consolidated undrained triaxial compression test

σ'_{v0} = estimated effective in situ vertical stress

w_i = initial water content

γ_i = initial unit weight

e_0 = initial void ratio

bsf = below seafloor

s_u = undrained shear strength

ε_a = axial strain at peak principal effective stress ratio

ε_{50} = axial strain at 50% of peak deviator stress

E_{50} = Young's modulus at 50% of peak deviator stress in compression

Δe = change in void ratio from initial to estimated effective in situ vertical stress

SUMMARY OF CONSOLIDATED DRAINED TRIAXIAL TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Location	Sample No.	Depth	Test Type	Stage 1			Stage 2			Stage 3			φ'	c'
		[m bsf]		p' [kPa]	w_1 [%]	γ_1 [kN/m³]	p' [kPa]	w_2 [%]	γ_2 [kN/m³]	p' [kPa]	w_3 [%]	γ_3 [kN/m³]	[°]	[kPa]
BH-WFS4-1A	17BagA	22.50	CIDc	240	21.6	20.1	480	21.6	20.1	960	21.4	20.1	33.5	50
BH-WFS4-2A	10BagA	13.50	CIDc	160	23.3	19.8	320	23.3	19.8	640	22.3	20.0	32.0	5
	19BagB	43.80	CIDc	440	20.7	20.3	880	18.9	20.7	1760	18.7	20.7	31.0	0
BH-WFS4-3	8BagA	7.00	CIDc	70	19.7	20.4	140	19.9	20.4	280	19.6	20.5	37.0	16
	18BagA	14.00	CIDc	170	24.1	19.7	340	23.6	19.8	680	23.2	19.8	32.5	21
BH-WFS4-4	18BagA	10.00	CIDc	100	22.6	19.9	200	23.4	19.8	400	23.4	19.8	36.0	0
	29BagA	22.00	CIDc	250	23.0	19.9	500	21.7	20.1	1000	21.2	20.2	31.5	2
BH-WFS4-5	15BagA	8.00	CIDc	80	20.2	20.4	160	20.4	20.3	320	20.0	20.4	38.0	21
	31BagA	26.00	CIDc	280	23.3	20.0	560	22.3	20.2	1120	20.3	20.5	28.0	57
BH-WFS4-6	20BagA	12.00	CIDc	120	18.2	20.7	240	18.2	20.7	480	17.6	20.9	40.0	0
	27BagA	24.00	CIDc	260	21.6	20.1	520	21.4	20.1	1040	21.5	20.1	35.0	49
	30BagA	36.00	CIDc	380	23.0	19.9	760	21.7	20.2	1520	21.9	20.1	31.0	10
BH-WFS4-7	15BagB	11.75	CIDc	140	18.8	20.6	280	18.2	20.7	560	17.7	20.8	35.0	18
	23BagB	27.35	CIDc	270	22.3	20.3	540	21.5	20.4	1080	20.3	20.7	30.0	10
	28BagA	42.50	CIDc	410	23.0	20.0	820	22.5	20.1	1640	22.0	20.2	30.0	0

Key:

CIDc = isotropically consolidated drained triaxial compression test

w_1 = water content per stage

γ_1 = unit weight after consolidation immediately prior to shearing per stage

bsf = below seafloor

p' = effective consolidation pressure

φ' = effective angle of internal friction

c' = effective cohesion

SUMMARY OF SOIL-SOIL RING SHEAR TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Location	Sample No.	Depth	Interface	Index Properties		Setup conditions		Slow Shear			Fast Shear		
				w_i	w_f	Stage	σ'_n	φ_r	τ_r	τ_r/σ'_n	φ_r	τ_r	τ_r/σ'_n
		[m bsf]		[%]	[%]		[kPa]	[°]	[kPa]	[-]	[°]	[kPa]	[-]
BH-WFS4-1	3BagA	2.00	S-S	10.9	19.9	1	30	29.8	17.3	0.58	27.6	15.8	0.53
						2	60	29.9	34.4	0.57	29.7	34.1	0.57
						3	120	28.2	64.2	0.54	27.9	63.4	0.53
BH-WFS4-2	3BagA	1.50	S-S	8.9	21.0	1	15	28.3	7.8	0.52	21.8	5.8	0.39
						2	30	32.7	19.5	0.65	26.3	15.1	0.50
						3	60	30.5	35.2	0.59	27.6	31.3	0.52
BH-WFS4-3	4BagA	3.00	S-S	8.6	22.7	1	30	29.1	17.0	0.57	28.4	16.4	0.55
						2	60	32.0	37.4	0.62	30.8	35.7	0.59
						3	120	30.6	70.7	0.59	28.9	66.1	0.55
BH-WFS4-4	7BagA	4.50	S-S	10.0	19.9	1	45	29.5	25.4	0.57	27.1	23.0	0.51
						2	90	29.5	51.1	0.57	28.4	48.8	0.54
						3	180	28.6	97.9	0.54	28.1	96.1	0.53
BH-WFS4-5	8BagA	4.00	S-S	10.2	22.1	1	40	29.1	22.4	0.56	24.9	18.7	0.47
						2	80	30.9	47.6	0.59	28.6	43.3	0.54
						3	160	28.6	87.5	0.55	28.7	87.7	0.55
BH-WFS4-6	3BagA	2.00	S-S	10.5	23.6	1	20	27.3	10.0	0.50	22.8	8.1	0.41
						2	40	28.8	22.2	0.55	28.9	22.2	0.56
						3	80	28.5	43.1	0.54	26.6	39.7	0.50
BH-WFS4-7	5BagA	4.00	S-S	10.1	21.1	1	40	27.1	20.6	0.52	26.0	19.6	0.49
						2	80	32.6	50.9	0.64	30.7	47.1	0.59
						3	160	30.7	95.1	0.59	27.7	84.0	0.53

Key:

S-S = Soil - Soil interface

w_i = initial water content

w_f = final water content

σ'_n = effective normal stress

bsf = below seafloor

τ_r = residual shear stress

φ'_r = residual interface friction angle

Slow Shear Rate : 0.16°/min

Fast Shear Rate : 674°/min

SUMMARY OF SOIL-STEEL RING SHEAR TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Location	Sample No.	Depth [m bsf]	Interface	Index Properties		Stage 1		Stage 2							
				w_i [%]	w_f [%]	σ_n [kPa]	Δh [mm]	σ'_n [kPa]	Δh [mm]	τ_{peak} [kPa]	τ_{peak}/σ'_n [-]	δ'_{peak} [°]	τ_r [kPa]	τ_r/σ'_n [-]	δ'_r [°]
BH-WFS4-1A	3BagB	6.55	S-ST	9.8	20.6	70	0.71	115	0.96	62.3	0.54	28.5	59.8	0.52	27.5
	18BagA	27.00	S-ST	10.2	16.6	265	0.70	445	0.99	240.8	0.54	28.4	223.7	0.50	26.7
BH-WFS4-3	25BagA	36.00	S-ST	10.5	20.4	360	0.69	600	1.01	327.0	0.54	28.6	304.5	0.51	26.9
BH-WFS4-4	24BagA	13.50	S-ST	17.1	19.6	170	0.64	285	0.84	162.0	0.57	29.6	151.6	0.53	28.0
BH-WFS4-6	25BagA	17.50	S-ST	10.0	21.2	195	0.70	325	1.09	172.8	0.53	28.0	168.4	0.52	27.4
	28BagA	28.00	S-ST	10.2	21.1	270	0.71	450	1.22	245.4	0.55	28.6	231.2	0.51	27.2
BH-WFS4-7	16BagB	12.80	S-ST	9.6	17.7	160	0.72	265	0.96	140.7	0.53	28.0	137.7	0.52	27.5

Key:

S-ST = Soil - Steel interface

w_i = initial water content

w_f = final water content

σ_n = normal stress

σ'_n = effective normal stress

bsf = below seafloor

Δh = vertical displacement during shearing stage

τ_{peak} = peak shear stress

τ_r = residual shear stress

δ'_{peak} = peak interface friction angle

δ'_r = residual interface friction angle

SUMMARY OF OEDOMETER TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Location	Sample No.	Depth	Test Type	e_0	σ'_{v0}	σ'_{p0}	Compression Parameters					$\Delta e/e_0$
							OCR	C_c	C_s	CR	RR	
		[m bsf]		[-]	[kPa]	[kPa]	[-]	[-]	[-]	[-]	[-]	[-]
BH-WFS4-1A	20WaxB	32.15	IL	0.990	325	950	2.9	0.392	0.180	0.197	0.012	0.056
	20WaxB	32.15	CRS	1.045	325	950	2.9	1.288	0.155	0.630	0.150	-0.014
BH-WFS4-3	22WaxD	30.85	CRS	0.806	311	2300	7.4	0.964	0.111	0.534	0.124	-0.006
	28WaxB	44.55	CRS	1.082	444	1500	3.4	0.537	0.133	0.258	0.205	-0.073
BH-WFS4-4	34WaxB	38.60	IL	0.660	394	900	2.3	0.207	0.045	0.125	0.036	0.091
	34WaxB	38.64	CRS	0.647	394	900	2.3	0.257	0.046	0.156	0.052	0.057
	36WaxD	43.89	CRS	0.880	443	800	1.8	0.322	0.048	0.171	0.083	-0.068
BH-WFS4-5	36WaxB	43.06	CRS	0.655	441	1400	3.2	0.242	0.047	0.146	0.049	0.053
BH-WFS4-7	13WaxC	10.75	CRS	0.487	112	1400	12.5	0.119	0.010	0.080	0.033	0.066
	18WaxB	14.70	CRS	0.785	152	1500	9.9	0.313	0.120	0.176	0.104	-0.089
	22WaxB	23.12	CRS	0.877	233	1200	5.1	0.721	0.139	0.384	0.132	0.031

Key:

e_0 = initial void ratio

σ'_{v0} = estimated effective in situ vertical stress

σ'_{p0} = preconsolidation pressure according to Casagrande's construction (1936)

C_c = Compression index, denotes the slope of the virgin compression line

C_s = Swelling index, denotes the slope of the unload loop

Δe = change in void ratio from initial conditions to estimated effective in situ vertical stress condition

bsf = below seafloor

IL = Incremental Loading

CRS = Constant Rate of Strain

OCR = Overconsolidation Ratio, calculated as $\sigma'_{p0}/\sigma'_{v0}$

CR = Compression Ratio ($CR = C_c/(1+e_0)$)

RR = Recompression Ratio ($RR = C_s/(1+e_0)$)

SECTION C2: INDEX LABORATORY TESTS

LIST OF PLATES IN SECTION C2: Plate

Laboratory Classification Test Results	C2.1-1 to C2.1-51
Particle Size Distribution	C2.2-1 to C2.2-27
Plasticity Chart	C2.3-1

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
1	0.00 m to 0.55 m - light yellowish brown silica fine to medium SAND, with many shells and shell fragments	0.00																
		0.20	21.3	20.2														
		0.30						2.69						2				
		0.50	20.2	20.3	18.7													
2	1.00 m to 1.60 m - light yellowish brown silica fine to medium SAND, with shells and shell fragments	1.00																
		1.20	22.2	20.0	19.2													
		1.40	20.5	20.3	18.3													
3	2.00 m to 2.55 m - grey silica fine to medium SAND, with shell fragments	2.00				1.5	1.9											
		2.20	20.6	20.3	18.6													
		2.40	21.4	20.1	19.1													
4	3.00 m to 3.35 m - grey becoming light yellowish brown silica fine to medium SAND, with traces of shell fragments	3.00																
		3.20	22.6	19.9	19.3													
		3.30	24.2	19.7														
5	4.00 m to 4.60 m - light yellowish brown becoming grey silica fine to medium SAND, with traces of shell fragments - at top with one coarse gravel	4.00																
		4.20	23.4	19.8	19.5													
		4.50	22.1	20.0	18.9													
6	5.00 m to 5.05 m - GRAVEL	5.00																
7	no recovery	5.50																
8	no recovery	6.00																

Key:
- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
9	no recovery	7.00																

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- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
1	5.00 m to 5.20 m - light yellowish brown silica fine to medium SAND, with few shells and shell fragments	5.00						2.66						1				
		5.10	21.8	20.0	18.4													
2	6.00 m to 6.40 m - light yellowish brown silica fine to medium SAND, with few shells and shell fragments	6.00																
		6.25	22.8	19.9	20.2													
		6.30	22.7	19.9	18.4													
3	6.50 m to 6.55 m - light yellowish brown silica fine to medium SAND, with few shell fragments	6.50																
	6.55 m to 7.05 m - grey silica fine to medium SAND, with few shell fragments	6.55				1.5	1.9											
		6.70	23.9	19.7														
		6.90	23.7	19.8														
4	7.50 m to 8.05 m - grey silica fine to medium SAND, with traces of shell fragments	7.50																
		7.70	23.3	19.8														
		7.80	21.9	20.0	17.7													
5	8.50 m to 8.95 m - grey silica fine to medium SAND, with traces of shell fragments	8.50																
		8.75	23.4	19.8	18.5													
		8.80	24.5	19.6														
6	9.00 m to 9.45 m - grey silica fine to medium SAND, with traces of shell fragments	9.00																
		9.25	19.5	20.5	18.2													
		9.30	20.6	20.3														
7	9.50 m to 9.95 m - grey silica fine to medium SAND, with few shell fragments	9.50																

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- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		9.80	22.6	19.9														
		9.85	21.5	20.1	19.5													
8	10.00 m to 10.40 m - grey silica fine to medium SAND, with shell fragments	10.00												2				
		10.35	20.6	20.3														
9	10.50 m to 10.95 m - grey silica fine to medium SAND, with few shell fragments	10.50																
		10.80	21.9	20.1														
		10.85	21.9	20.0	18.5													
10	11.00 m to 11.45 m - grey silica fine to medium SAND, with shell fragments	11.00																
		11.30	20.4	20.3														
		11.40	20.0	20.4	19.1													
11	11.50 m to 11.90 m - grey silica fine to medium SAND, with shell fragments	11.50																
		11.80	22.0	20.0														
		11.85	20.6	20.3	18.3													
12	12.00 m to 12.40 m - grey silica fine to medium SAND, with many shells and shell fragments - with a pocket of clay	12.00																
		12.30	21.9	20.0	18.5													
		12.35	21.4	20.1														
13	12.50 m to 12.95 m - grey silica fine to medium SAND, with many shell fragments - at bottom traces of organic matter	12.50								1								
		12.75	20.8	20.2	17.6													
		12.80	21.7	20.1														

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- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
14	13.00 m to 13.15 m - grey silica fine to medium SAND - at top traces of organic matter	13.00								1								
		13.10	23.7	19.8														
	13.15 m to 13.80 m - very dark greenish grey sandy CLAY	13.15									26	36	10	60				
		13.40	24.7	19.6														
		13.50	25.5	19.4	18.8													
		13.60	27.3	19.4	19.7												263r	
		13.60	24.8	19.8	19.4 18.7												519	
15	14.00 m to 14.75 m - very dark greenish grey sandy CLAY - at bottom pockets of clay	14.00																
		14.20	27.5	19.2														
		14.35			19.6			2.68										
		14.55									28	100	72	69				
		14.65	28.4	19.0	18.8													
16	18.00 m to 18.70 m - very dark greenish grey very silty silica fine SAND	18.00																
		18.20	18.2	20.7	19.5													
		18.30			20.6													
		18.50								1	18	25	7	16				
		18.60	17.7	20.8	18.8													
17	22.50 m to 23.20 m - very dark greenish grey very silty silica fine SAND	22.50				1.4	1.9	2.65										
		22.60	20.4	20.3	19.6													
		22.90	21.9	20.0	19.4													

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- ρ_S : density of solid particles
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- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		23.15	21.7	20.1	19.3													
18	27.00 m to 27.85 m - very dark greenish grey very silty silica fine SAND	27.00																
		27.10	21.4	20.1	19.7													
		27.40	23.5	19.8	19.0													
		27.80	24.1	19.7	18.8													
19	28.00 m to 28.60 m - very dark greenish grey very silty silica fine SAND	28.00												16				
		28.20	23.4	19.8	19.0													
		28.30			19.6													
		28.55	21.8	20.0	18.7													
20	32.00 m to 32.45 m - very stiff fissured dark greenish grey CLAY	32.00						2.72			37	140	103	100				
		32.10	33.7	18.6														
		32.15	35.8	18.4	18.2													
		32.15	36.6	18.3	18.4 17.9										290			
		32.35							17	4					267			
		32.40	34.9	18.4														
21	33.00 m to 33.80 m - very stiff fissured dark greenish grey CLAY	33.00									38	140	102					
		33.10	35.8	18.3	18.7										213			
		33.12	36.6	18.2	18.3													
		33.30	36.0	18.3	18.2												132	
		33.30	34.8 38.0	18.0 18.4	18.2										203		247r	

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- γ_{dmin} : minimum index unit weight
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- ρ_S : density of solid particles
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- Org.Cont. : organic matter content
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- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		33.50	36.4	18.2	18.4												278r	
		33.50	37.9	18.1	18.4												159	
					18.4													
		33.70													260			
		33.75	36.7	18.2														
22	37.00 m to 37.70 m - very stiff greenish grey CLAY - with pockets of light grey fine sand	37.00																
		37.05	37.9	18.1	17.9										287			
		37.25	34.8	18.4	17.9												315	
		37.25	37.6	18.1	18.1												190r	
		37.45			17.4										277			
		37.65	37.6	18.1							33	99	66	93	267			
23	38.00 m to 38.75 m - very stiff to hard greenish grey CLAY	38.00																
		38.10	40.1	17.8														
		38.15			17.5										277			
		38.20	42.1	17.6	17.3													
		38.30													315			
		38.40	39.3	17.9														
		38.45	43.5	17.5	17.8												238	
		38.45	42.1	17.6	17.7												223r	
					17.3													
		38.65													310			
		38.70	42.0	17.6														
24	42.00 m to 42.70 m - very stiff greenish grey slightly sandy CLAY	42.00												70				

Key:

- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		42.10	29.8	19.1														
		42.15			18.2										243			
		42.40	35.4	18.3											250			
		42.55			17.7										240			
25	43.00 m to 43.75 m - very stiff greenish grey slightly sandy CLAY - with pockets of light grey fine sand	43.00																
		43.10	38.3	18.0	17.9										247			
		43.30	39.4	17.9	18.1												247	
		43.30	38.8 40.8	17.7 18.0	18.0										290		226r	
		43.50			17.7													
		43.52	39.3	17.9	18.1													
		43.70						2.71			39	124	85		263			
26	47.00 m to 47.75 m - very stiff greenish grey slightly sandy CLAY - with pockets of light grey fine sand	47.00												98				
		47.10	41.4	17.7	17.6										223			
		47.30	36.5	18.2	18.3												251	
		47.30	37.0 34.5	18.4 18.2	18.4										233		172r	
		47.50	32.7	18.7	18.8												198r	
		47.50	33.7	18.5	19.1 18.7												316	
		47.70													253			

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- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-1A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
27	48.00 m to 48.75 m - very stiff greenish grey slightly sandy CLAY - with pockets of light grey fine sand - at top extremely closely spaced thin laminae of sand	48.00									23	59	36					
		48.05			18.4										240			
		48.25			18.4													
		48.45													270			
		48.50	35.2	18.4	18.0													
		48.70	35.6	18.3											267			

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- γ_{dmin} : minimum index unit weight
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- ρ_S : density of solid particles
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- w_p : plastic limit
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- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample No.	Ground Description	Test Depth [m]	w [%]	Unit Weight [kN/m³] γ_1	γ_2	γ_d min.	γ_d max.	ρ_S [Mg/m³]	Carb. Cont. [%]	Org. Cont. [%]	Atterberg Limits w_p [%]	w_L [%]	I_p [%]	Fines [%]	s_u [kPa] PP	TV	UU	LV
1	0.00 m to 0.45 m - light yellowish brown silica fine to medium SAND, with shells and shell fragments	0.00																
		0.05	23.4	19.8	19.4													
		0.30	22.0	20.0	19.9													
2	0.50 m to 1.05 m - light yellowish brown silica fine to medium SAND, with many shells and shell fragments - at top gravelly and traces of organic matter	0.50								0				3				
		0.70	22.0	20.0														
		0.95	22.3	20.0	19.3													
3	1.50 m to 1.90 m - light yellowish brown silica fine to medium SAND, with few shells and shell fragments	1.50				1.6	1.9											
		1.60	21.9	20.0	19.3													
	1.90 m to 2.05 m - grey calcareous silica fine SAND	1.90																
		1.95	24.6	19.6	19.2													
4	2.50 m to 3.10 m - grey calcareous silica fine SAND, with traces of shells and shell fragments	2.50																
		2.65	22.1	20.0	19.1													
		3.00	21.2	20.1	19.9													
5	3.50 m to 4.00 m - grey calcareous silica fine SAND	3.50																
		3.60	25.5	19.5	18.6													
		3.90	24.1	19.7	19.2													
6	4.00 m to 4.45 m - grey calcareous silica fine SAND, with traces of organic matter	4.00						2.66						7				
		4.10	25.1	19.5														
		4.35	22.4	19.9	19.6													

Key:
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- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample No.	Ground Description	Test Depth [m]	w [%]	Unit Weight [kN/m³] γ_1	γ_2	γ_d min.	γ_d max.	ρ_S [Mg/m³]	Carb. Cont. [%]	Org. Cont. [%]	Atterberg Limits w_p [%]	w_L [%]	I_p [%]	Fines [%]	s_u [kPa] PP	TV	UU	LV
7	4.50 m to 4.75 m - grey calcareous silica fine to medium SAND, with traces of shells and shell fragments	4.50																
		4.65	23.0	19.9														
8	5.00 m to 5.40 m - grey calcareous silica fine to medium SAND, with traces of shells and shell fragments - at top piece of wood	5.00																
		5.15	20.8	20.2	19.4													
		5.35	20.7	20.2	19.4													
9	5.50 m to 5.90 m - grey calcareous silica fine to medium SAND, with traces of shells and shell fragments	5.50																
		5.60	21.2	20.2	19.5													
		5.70	21.9	20.0	19.7													
		5.80	21.6	20.1	19.4													
10	6.00 m to 6.40 m - grey calcareous silica fine to medium SAND, with traces of shells and shell fragments	6.00																
		6.10	20.9	20.2	19.8													
		6.20	21.6	20.1	19.3													
		6.30	22.3	20.0	19.6													
11	6.50 m to 6.95 m - grey calcareous silica fine to medium SAND	6.50																
		6.60	21.6	20.1	19.4													
		6.70	22.3	20.0	19.6													
		6.85	21.8	20.1	19.2													
12	7.00 m to 7.30 m - grey calcareous silica fine to medium SAND, with traces of shells and shell fragments - at bottom light grey fine sand	7.00												2				
		7.15	22.5	19.9	19.2													

Key:
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- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
13	7.50 m to 7.85 m - grey calcareous silica fine to medium SAND, with traces of shells and shell fragments	7.50																
		7.60	21.8	20.1	19.4													
		7.80	22.1	20.0	18.9													
14	8.00 m to 8.35 m - grey calcareous silica fine to medium SAND, with traces of shells and shell fragments	8.00																
		8.10	21.4	20.1	19.9													
		8.25	22.3	20.0	19.4													

Key:
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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
1	7.50 m to 7.60 m - grey silica fine to medium SAND, with few shells and shell fragments	7.50																
		7.55	25.0	19.5														
2	8.00 m to 8.40 m - grey silica fine to medium SAND - at top with one coarse gravel	8.00																
		8.10	23.6	19.8														
		8.30	23.0	19.8	19.5													
3	8.50 m to 9.00 m - grey silica fine to medium SAND, with traces of shells and shell fragments	8.50																
		8.70	20.7	20.2	18.2													
		8.80	22.8	19.9														
		8.90	22.1	20.0	18.7													
4	9.00 m to 9.35 m - grey silica fine to medium SAND, with traces of shells and shell fragments, with traces of organic matter	9.00																
		9.20	20.1	20.4	18.1													
5	9.50 m to 9.95 m - grey silica fine to medium SAND, with traces of shells and shell fragments	9.50																
		9.75	20.7	20.2	18.0													
		9.90	21.2	20.2														
6	10.00 m to 10.50 m - grey silica fine to medium SAND, with traces of shell fragments - at bottom pockets of organic matter	10.00																
		10.20	20.9	20.2	17.6													
		10.30	22.4	19.9	19.3													
		10.35												9				

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- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
7	11.00 m to 11.70 m - grey silica fine to medium SAND, with traces of shell fragments, with traces of organic matter - at bottom extremely closely spaced thin laminae of peat	11.00																
		11.45	31.8	18.6														
		11.50	24.3	19.6	19.9													
8	12.00 m to 12.80 m - very dark greenish grey silica fine SAND	12.00																
		12.15	25.9	19.4	18.4													
		12.35	23.9	19.7	19.1													
		12.60	25.2	19.5														
9	13.00 m to 13.50 m - very dark greenish grey silica fine SAND, with traces of shell fragments	13.00																
		13.35	23.3	19.8	18.3													
		13.45	23.6	19.8														
10	13.50 m to 13.85 m - very dark greenish grey silica fine SAND	13.50																
		13.75	21.6	20.1														
		13.80	22.1	20.0	18.8													
11	14.00 m to 14.55 m - very dark greenish grey silica fine SAND, with traces of shell fragments	14.00						2.67	16					26				
		14.30	22.7	19.9	19.2													
		14.40	22.9	19.9														
12	18.00 m to 18.35 m - dark grey silty silica fine SAND	18.00							11					8				
		18.20	23.5	19.8	19.1													
		18.30	24.3	19.7														

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample No.	Ground Description	Test Depth [m]	w [%]	Unit Weight [kN/m³] γ_1	γ_2	γ_d min.	γ_d max.	ρ_S [Mg/m³]	Carb. Cont. [%]	Org. Cont. [%]	Atterberg Limits w_p [%]	w_L [%]	I_p [%]	Fines [%]	s_u [kPa] PP	TV	UU	LV
13	22.00 m to 22.30 m - dark grey silty silica fine SAND	22.00												15				
		22.20	25.0	19.5	18.9													
		22.25	26.7	19.3														
14	26.00 m to 26.80 m - dark grey very silty silica fine SAND	26.00						2.66						35				
		26.55	24.7	19.6	19.1													
		26.70	23.1	19.9														
15	30.00 m to 30.80 m - dark grey sandy CLAY	30.00																
		30.15	23.6	19.8														
		30.30									22	51	29	55				
		30.35	23.5	19.8														
		30.50	25.2	19.5	18.9													
		30.60	22.8	20.1	20.0												224r	
		30.60	23.4	20.0	19.8 19.7												385	
16	34.00 m to 34.60 m - dark grey very sandy CLAY	34.00						2.67			27	42	15	70				
		34.15	27.2	19.2														
		34.35	25.7	19.4	18.9													
		34.40			19.2													
		34.42	24.6	19.8	19.7													
17	38.00 m to 38.65 m - very stiff to hard fissured dark greenish grey CLAY	38.00																
		38.15	32.3	18.7														
		38.30													263			

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- w_p : plastic limit
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample No.	Ground Description	Test Depth [m]	w [%]	Unit Weight [kN/m³] γ_1	γ_2	γ_d min.	γ_d max.	ρ_S [Mg/m³]	Carb. Cont. [%]	Org. Cont. [%]	Atterberg Limits w_p [%]	w_L [%]	I_p [%]	Fines [%]	s_u [kPa] PP	TV	UU	LV
		38.40	23.6	20.0											283			
		38.45			20.4													
18	39.00 m to 39.10 m - very stiff to hard fissured dark greenish grey CLAY	39.00							13	2	14	42	28	25				
	39.10 m to 39.30 m - very dark grey slightly silty silica fine to medium SAND	39.10																
		39.15	19.3	20.5														
		39.20	20.3	20.3	19.2													
19	43.50 m to 44.15 m - dark grey silty silica fine SAND - with medium spaced pockets of clay	43.50						2.67						24				
		43.65	21.4	20.2														
		43.80	20.3	20.3	19.0													
		44.05	18.6	20.7														
20	47.50 m to 47.90 m - dark grey silty silica fine SAND	47.50												14				
		47.60	23.7	19.8														
		47.70	22.5	19.9	19.2													
		47.80	20.5	20.3														
21	51.50 m to 52.20 m - very stiff to hard fissured very dark greyish green CLAY, with traces of organic matter	51.50								3	40	132	92	100				
		51.55	36.5	18.2														
		51.60	37.4	18.1	18.2												288r	
		51.60	38.1	18.0	18.0 18.2												210	
		51.80			18.1										307			
		52.00			17.8										300			

Key:
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-2A

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		52.20													243			

Key:
- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample				Unit Weight [kN/m³]							Atterberg Limits				s_u [kPa]			
No.	Ground Description	Test Depth [m]	w [%]	γ_1	γ_2	γ_d min.	γ_d max.	ρ_S [Mg/m³]	Carb. Cont. [%]	Org. Cont. [%]	w_P [%]	w_L [%]	I_P [%]	Fines [%]	PP	TV	UU	LV
1	0.00 m to 0.35 m - light yellowish brown silica fine to medium SAND, with shells and shell fragments	0.00						2.66						1				
		0.20	21.3	20.1	18.5													
	0.35 m to 0.55 m - grey silica fine to medium SAND, with shells and shell fragments	0.35																
		0.45	21.4	20.1	17.9													
2	1.00 m to 1.75 m - grey silica fine to medium SAND, with shells and shell fragments	1.00																
		1.20	22.5	19.9	17.2													
		1.35	24.5	19.6														
		1.60	22.8	19.9	17.8													
3	2.00 m to 2.75 m - grey silica fine to medium SAND, with shells and shell fragments	2.00																
		2.20	23.7	19.7	18.0													
		2.35	26.7	19.3														
		2.40								0								
		2.60	23.3	19.8	17.6													
4	3.00 m to 3.75 m - grey silica fine to coarse SAND, with shell fragments	3.00				1.5	1.9											
		3.20	22.2	20.0	17.4													
		3.35	22.8	19.9														
		3.60	21.1	20.2	19.0													
5	4.00 m to 4.70 m - grey silica fine to coarse SAND, with shell fragments	4.00																
		4.15	24.9	19.6														
		4.40												1				

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- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
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- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		4.60	21.0	20.2	18.9													
		4.65	21.2	20.2														
6	5.00 m to 5.65 m - grey silica fine to medium SAND, with shells and shell fragments	5.00																
		5.10	23.5	19.8	19.3													
		5.35	24.4	19.6														
		5.50	22.3	20.0	18.8													
7	6.00 m to 6.65 m - grey calcareous silica fine to medium SAND - at bottom with two coarse gravels - at 30 cm with a coarse gravel-sized lump of slightly cemented sand	6.00																
		6.40	23.6	19.8														
		6.55	21.7	20.1	20.0													
8	7.00 m to 7.55 m - grey silica fine to medium SAND, with few shell fragments - at bottom becoming olive brown	7.00				1.6	1.9											
		7.10	22.8	19.9														
		7.25	23.3	19.8														
		7.45	22.4	19.9	18.8													
9	8.00 m to 8.60 m - olive brown silica fine to medium SAND, with few shell fragments - at top with one coarse gravel	8.00																
		8.15	22.7	19.9	18.5													
		8.35	23.5	19.8														
		8.50	22.3	20.0	18.8													
10	9.00 m to 9.25 m - grey silica fine to medium SAND, with many shell fragments	9.00																

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		9.20	19.8	20.4	17.9													
11	9.50 m to 9.90 m - grey silica fine to medium SAND, with few shell fragments - at top with one medium gravel	9.50																
		9.70	21.7	20.1	18.6													
		9.80	23.7	19.8														
12	10.00 m to 10.45 m - grey silica fine to medium SAND, with shell fragments	10.00																
		10.15	20.0	20.4														
		10.35	19.3	20.5	17.8													
13	10.50 m to 10.80 m - grey silica fine to medium SAND, with many shell fragments	10.50																
		10.65	22.6	19.9	17.3													
	10.80 m to 11.15 m - dark olive grey slightly clayey silica fine SAND	10.80						2.69		2				21				
		10.95	23.0	19.9														
		11.05	23.8	19.7	18.9													
14	11.50 m to 12.20 m - dark olive grey slightly silty silica fine SAND, with shells and shell fragments	11.50																
		11.65	24.1	19.7														
		11.85	23.6	19.7	19.3													
		12.00			19.4													
15	12.50 m to 13.00 m - dark olive grey slightly silty silica fine SAND	12.50																
		12.65	22.4	20.0	19.3													
		12.75	22.1	20.0														

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		12.80												12				
16	13.00 m to 13.50 m - dark olive grey slightly silty silica fine SAND	13.00																
		13.10	23.7	19.8														
		13.25	23.1	19.8	19.0													
		13.30			19.3													
17	13.50 m to 14.00 m - dark olive grey slightly silty silica fine SAND, with traces of shell fragments	13.50																
		13.65	23.3	19.8														
		13.70	23.2	19.8	19.4													
		13.80			20.0													
18	14.00 m to 14.45 m - dark olive grey slightly silty silica fine SAND	14.00												11				
		14.15	25.1	19.5														
		14.30	22.2	20.0	18.9													
19	18.50 m to 19.40 m - dark olive grey silty silica fine SAND	18.50												12				
		18.70	29.4	18.9	17.6													
		18.90	28.7	19.0														
		19.20	28.3	19.0	18.3													
20	22.50 m to 23.15 m - dark olive grey sandy CLAY	22.50						2.68	13	2								
		22.55	25.9	19.4														
		22.60			19.4													
		22.80									25	43	18	27				
		22.85	25.2	19.5														

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		23.05	25.3	19.5														
21	26.50 m to 27.20 m - dark olive grey sandy CLAY	26.50																
		26.55	24.5	19.6	18.7													
		26.60			19.4													
		26.80						2.68			23	46	23	38				
		26.90	25.1	19.5	19.2													
		27.10	24.6	19.6														
22	30.50 m to 30.85 m - dark olive grey very sandy CLAY	30.50						2.66	13	1								
		30.60	28.1	19.1	19.6						26	41	15	55				
	30.85 m to 31.15 m - very stiff fissured dark greenish grey CLAY	30.85			18.6						32	119	87					
		31.05													210			
		31.10	32.6	18.7														
23	31.50 m to 31.90 m - very stiff fissured dark greenish grey CLAY	31.50						2.76	11		33	116	83	99				
		31.60	32.7	18.7	19.0										253			
		31.80													250			
		31.85	30.8	18.9														
24	35.50 m to 35.65 m - dark grey slightly clayey silica fine to medium SAND	35.50												15				
		35.60	20.3	20.3	19.5													
25	36.00 m to 36.25 m - dark grey slightly clayey silica fine to medium SAND	36.00																
		36.10	21.7	20.1	19.4													

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- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
26	39.50 m to 39.85 m - very dark grey very sandy CLAY - with pockets of light grey fine sand	39.50																
		39.55			20.3													
		39.75									21	28	7	16				
		39.80	20.0	20.6														
27	40.50 m to 41.00 m - very dark grey very clayey silica fine SAND	40.50												13				
		40.55			19.5													
		40.75			19.6													
		40.80	23.9	20.0														
		40.95	22.5	19.9														
28	44.50 m to 45.15 m - very stiff fissured dark greenish grey CLAY	44.50						2.70			35	127	92	96				
		44.55			18.6										263			
		44.70	37.5	18.1	18.3												120	
		44.70	37.3 38.3	18.0 18.1	18.3										280		276r	
		44.90	35.9	18.3	18.4												292r	
		44.90	37.2	18.1	18.6 18.4												157	
		45.10	36.8	18.2											257			
29	45.50 m to 46.10 m - very stiff to hard fissured dark greenish grey CLAY	45.50																
		45.60	36.8	18.2														
		45.65	36.6	18.2	18.2 18.4										287			

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		45.85			18.4													
		46.05	36.1	18.3											310			
30	49.50 m to 50.30 m - very stiff to hard greenish grey CLAY - at 49.95 m - with a pocket of cemented clay	49.50																
		49.55	39.0	17.9	18.0										250			
		49.75	39.4	17.9	17.6												332	
		49.75	41.0	17.7	17.7												211r	
		49.95													303			
		50.00			17.6													
		50.20									39	134	95	99				
		50.25	42.8	17.5											293			
31	49.50 m to 50.30 m - very stiff to hard greenish grey CLAY - at 51.10 m - with a coarse gravel sized pyrite inclusion	50.50						2.69										
		50.60	41.9	17.6														
		50.65			18.1										290			
		50.85	39.2	17.9	17.6										283			
		51.20	36.8	18.2														
32	54.50 m to 55.25 m - very stiff greenish grey CLAY - at bottom pockets of light grey fine sand	54.50																
		54.60	44.5	17.4	17.4										290			
		54.80	42.8	17.5	17.5												436	
		54.80	43.9 43.5	17.5 17.4	17.5										283		216r	
		55.00			17.5													
		55.02	41.3	17.7	17.8													

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-3

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		55.20	34.1	18.5											280			
33	55.50 m to 56.30 m - very stiff greenish grey CLAY - with pockets of light grey fine sand	55.50																
		55.55	39.1	17.9	17.2										227			
		55.75									35	99	64					
		55.80	39.4	17.9														
		55.85			18.1										253			
		56.05	40.9	17.7	17.5												358	
		56.05	41.9	17.6	17.6												203r	
		56.25	42.4	17.6											280			
34	59.50 m to 59.95 m - very stiff greenish grey CLAY - with pockets of light grey fine sand	59.50									33	108	75	97				
		59.75	44.1	17.4	18.5										227			

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
1	0.00 m to 0.60 m - light yellowish brown silica fine to medium SAND, with shell fragments, with traces of organic matter	0.00												1				
		0.20	24.5	19.6	17.5													
		0.40	24.5	19.6	18.1													
2	1.00 m to 1.65 m - grey silica fine to medium SAND, with shell fragments, with traces of organic matter - with at top medium size gravel	1.00								3								
		1.30	23.9	19.7	19.1													
		1.65	25.9	19.4														
3	2.00 m to 2.30 m - grey silica fine to medium SAND, with shell fragments - with at top medium size gravels	2.00																
		2.15	22.3	20.0														
4	2.50 m to 3.05 m - grey silica fine to medium SAND, with traces of shell fragments - with at top fine to medium gravels	2.50																
		2.65	20.3	20.3	18.9													
		2.95	21.1	20.2	18.2													
5	3.50 m to 3.95 m - grey silica fine to medium SAND, with traces of shell fragments	3.50																
		3.65	21.8	20.1	17.6													
		3.85	21.0	20.2	18.6													
6	4.00 m to 4.35 m - grey silica fine to medium SAND, with shell fragments	4.00																
		4.10	22.2	20.0	18.2													
7	4.50 m to 4.85 m - grey silica fine to medium SAND, with shell fragments	4.50				1.5	1.9	2.74						4				

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- w_p : plastic limit
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- Fines : mass percentage of material passing 63 µm or 75 µm sieve
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- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		4.65	21.9	20.0	18.2													
8	5.00 m to 5.25 m - grey silica fine to medium SAND, with traces of shell fragments	5.00																
		5.10	21.3	20.1	18.5													
9	5.50 m to 5.70 m - grey silica fine to medium SAND, with shell fragments	5.50																
		5.60	20.7	20.2	18.6													
10	6.00 m to 6.25 m - grey silica fine to medium SAND, with shells and shell fragments	6.00																
		6.10	20.2	20.3	18.3													
11	6.50 m to 6.75 m - grey silica fine to medium SAND, with shell fragments	6.50	21.4	20.1	16.6													
12	7.00 m to 7.20 m - grey silica fine to medium SAND, with shell fragments	7.00																
		7.10	21.5	20.1	17.3													
13	7.50 m to 7.75 m - grey silica fine to medium SAND, with shell fragments	7.50																
		7.60	20.3	20.3	18.9													
14	8.00 m to 8.30 m - grey silica fine to medium SAND, with shell fragments	8.00																
		8.10	21.0	20.2	18.1													
15	8.50 m to 8.75 m - grey silica fine to medium SAND, with shell fragments	8.50																
		8.60	19.1	20.5	19.6													
16	9.00 m to 9.20 m - grey silica fine to medium SAND, with shell fragments	9.00																
		9.10	20.7	20.2	17.9													

Key:
- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
17	9.50 m to 9.55 m - grey silica fine to medium SAND, with shell fragments	9.50																
	9.55 m to 9.75 m - dark grey silica fine SAND	9.55																
		9.65	26.1	19.4	18.1													
18	10.00 m to 10.20 m - dark grey silica fine SAND	10.00				1.4	1.9							8				
		10.10	24.3	19.6	18.0													
19	10.50 m to 10.70 m - grey silica fine to medium SAND, with many shell fragments	10.50																
		10.60	20.8	20.2														
20	11.00 m to 11.30 m - very dark greenish grey silty silica fine SAND	11.00																
		11.15	21.9	20.0	18.8													
21	11.50 m to 11.80 m - very dark greenish grey silty silica fine SAND	11.50																
		11.65	16.7	21.0	20.0													
22	12.50 m to 12.80 m - very dark greenish grey silty silica fine SAND	12.50																
		12.65	23.5	19.8	18.3													
23	13.00 m to 13.25 m - very dark greenish grey silty silica fine SAND	13.00																
		13.10	22.5	19.9	18.7													
24	13.50 m to 13.80 m - very dark greenish grey silty silica fine SAND	13.50						2.69						13				
		13.65	23.2	19.8	18.4													
25	14.00 m to 14.20 m - very dark greenish grey slightly silty silica fine SAND	14.00																
		14.10	23.7	19.7	18.6													

Key:
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- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample No.	Ground Description	Test Depth [m]	w [%]	Unit Weight [kN/m³] γ_1	γ_2	γ_d min.	γ_d max.	ρ_S [Mg/m³]	Carb. Cont. [%]	Org. Cont. [%]	Atterberg Limits w_p [%]	w_L [%]	I_p [%]	Fines [%]	s_u [kPa] PP	TV	UU	LV
26	14.50 m to 14.75 m - very dark greenish grey slightly silty silica fine SAND	14.50																
		14.60	23.4	19.8	18.7													
27	18.00 m to 18.25 m - very dark greenish grey silty silica fine SAND	18.00																
		18.10	23.9	19.7	18.4													
28	18.50 m to 18.75 m - very dark greenish grey silty silica fine SAND	18.50																
		18.60	23.4	19.8	18.8													
29	22.00 m to 22.60 m - dark greenish grey silty silica fine SAND, with traces of shell fragments	22.00							3					15				
		22.15	23.5	19.8														
		22.45	21.6	20.1	18.5													
30	26.00 m to 26.35 m - dark greenish grey silty silica fine SAND	26.00																
		26.15	25.8	19.4	18.4													
31	26.50 m to 27.15 m - dark greenish grey silty silica fine SAND, with traces of shell fragments	26.50												13				
		26.65	27.5	19.1	16.9													
		26.85	26.9	19.2	18.3													
		27.05	25.2	19.5	18.5													
32	30.50 m to 31.15 m - dark greenish grey silty silica fine SAND	30.50												24				
		30.60	26.7	19.3	18.5													
		30.85	26.4	19.3	17.5													
		31.05	25.6	19.4	18.2													

Key:
- w : water content
- γ_1 : unit weight derived from water content
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- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
33	34.50 m to 34.75 m - dark greenish grey silty silica fine SAND - with very thin beds of clay - with pockets of sand	34.50																
		34.55									26	43	17	32				
		34.70	21.4	20.1														
34	38.50 m to 39.35 m - very stiff dark greenish grey sandy CLAY - with pockets of sand	38.50									20	68	48	75				
		38.60	22.5	20.2	20.7 19.6										257			
		38.64	22.4	20.2	19.7													
		38.66	24.0	19.9	20.0													
		38.80	23.2	20.1														
		38.85	22.8	20.1	20.5												273r	
		38.85	22.9	20.1	20.1 20.3										287		350	
		39.05			20.6													
		39.25													210			
		39.30	23.6	21.6														
35	39.50 m to 39.90 m - very stiff dark greenish grey sandy CLAY - with pockets of light grey fine sand	39.50																
		39.55	24.2	19.9	19.8												235	
		39.55	25.2	19.7	19.8										203		150r	
		39.75									24	46	22	73	280			
		39.90	22.6	20.2														

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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-4

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
36	43.50 m to 44.25 m - very stiff fissured dark greenish grey CLAY	43.50																
		43.55	31.9	18.8														
		43.60			19.0										293			
		43.80	33.9	18.5										100	293			
		43.85			18.8										293			
		43.89	32.6	18.7	18.7													
		44.05			18.4													
		44.20	34.4	18.5							33	114	81					
37	44.50 m to 45.30 m - very stiff fissured dark greenish grey CLAY	44.50																
		44.55	35.0	19.1	19.1										307			
			29.8	18.4	19.2													
		44.75			19.2													
		44.95	25.6	19.7											297			
		45.00	21.5	20.4	20.2												287	
		45.00	21.3	20.4	20.4												222r	
		45.20													287			
		45.25	21.8	20.3														
38	47.50 m to 47.58 m - dark greenish grey silica fine SAND	47.50	22.2	20.0	19.0													
39	48.00 m to 48.20 m - dark greenish grey silica fine SAND	48.00						2.67	2					8				
		48.10	21.4	20.1	18.5													
40	48.50 m to 48.70 m - dark greenish grey silica fine SAND	48.50																
		48.60	23.2	19.8	19.3													

Key:
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- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
1	0.00 m to 0.25 m - light olive brown silica fine to medium SAND, with shell fragments, with traces of organic matter	0.00																
		0.15	27.2	19.2														
2	0.50 m to 0.95 m - light olive brown silica fine to medium SAND, with traces of shell fragments, with traces of organic matter	0.50								1				3				
		0.70	27.1	19.2														
		0.95	27.1	19.2														
3	1.00 m to 1.45 m - greyish brown silica fine to medium SAND, with traces of shell fragments	1.00																
		1.20	24.2	19.7	19.4													
		1.40	24.7	19.6														
4	1.50 m to 2.00 m - greyish brown silica fine to medium SAND, with many shells and shell fragments	1.50																
		1.75	25.3	19.5														
		1.95	25.0	19.6														
5	2.00 m to 2.45 m - greyish brown silica fine to medium SAND - at top many shell fragments	2.00																
		2.20	25.3	19.5														
		2.45	27.3	19.2														
6	2.50 m to 2.90 m - grey silica fine to medium SAND, with traces of shell fragments	2.50																
		2.70	23.0	19.8	18.9													
7	3.50 m to 3.95 m - grey silica fine to medium SAND, with traces of shell fragments	3.50																
		3.55	25.6	19.5														

Key:
- w : water content
- γ_1 : unit weight derived from water content
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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		3.90	26.4	19.3														
8	4.00 m to 4.40 m - grey silica fine to medium SAND, with traces of shell fragments	4.00				1.5	1.9											
		4.05	23.7	19.8														
		4.35	26.2	19.4														
9	4.50 m to 4.90 m - grey silica fine to medium SAND, with traces of shell fragments	4.50						2.67						4				
		4.65	20.0	20.4	19.2													
		4.80	23.8	19.7														
10	5.00 m to 5.40 m - grey silica fine to medium SAND, with traces of shell fragments	5.00																
		5.15	21.1	20.2	18.2													
		5.30	21.3	20.1	19.8													
11	5.50 m to 6.00 m - grey silica fine to medium SAND, with shell fragments	5.50																
		5.70	21.6	20.1	18.2													
		5.85	21.6	20.1	18.7													
12	6.00 m to 6.40 m - grey silica fine to medium SAND, with shell fragments	6.00																
		6.15	21.3	20.1	18.4													
		6.30	21.8	20.0	18.3													
13	6.50 m to 6.90 m - grey silica fine to medium SAND, with shell fragments	6.50																
		6.60	19.2	20.5	19.5													
		6.80	21.0	20.2	17.5													

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
14	7.00 m to 7.40 m - grey silica fine to medium SAND, with shell fragments	7.00																
		7.10	22.1	20.0	18.4													
		7.30	23.7	19.7	18.5													
15	8.00 m to 8.40 m - grey silica fine to medium SAND, with shell fragments	8.00				1.5	1.9							3				
		8.20	23.0	19.9	18.4													
16	8.50 m to 8.90 m - grey silica fine to medium SAND, with shell fragments	8.50																
		8.65	21.0	20.2	18.6													
		8.85	23.0	19.9														
17	9.00 m to 9.30 m - grey silica fine to medium SAND, with traces of shell fragments	9.00																
		9.15	22.0	20.0	18.4													
18	9.50 m to 9.80 m - grey silica fine to medium SAND, with traces of shell fragments	9.50																
		9.65	20.6	20.3	19.0													
19	10.00 m to 10.35 m - grey silica fine to medium SAND, with traces of shell fragments	10.00																
		10.15	22.2	20.0	17.9													
20	10.50 m to 10.80 m - grey silica fine to medium SAND, with traces of shell fragments	10.50																
		10.60	22.6	19.9	18.6													
21	11.00 m to 11.30 m - grey silica fine to medium SAND, with traces of shell fragments	11.00																
		11.15	22.6	19.9	18.2													

Key:

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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
22	11.50 m to 11.75 m - grey silica fine to medium SAND, with traces of shell fragments	11.50																
		11.60	20.5	20.3	18.9													
23	12.00 m to 12.25 m - grey silica fine to medium SAND, with traces of shell fragments, with traces of organic matter	12.00																
		12.10	22.5	19.9	18.0													
24	12.50 m to 12.80 m - grey silica fine to medium SAND, with shells and shell fragments	12.50																
		12.60	20.9	20.2	19.0													
25	13.00 m to 13.35 m - grey silica fine to medium SAND, with shell fragments	13.00												3				
		13.15	20.8	20.2	18.6													
26	13.50 m to 13.75 m - grey silica fine to medium SAND	13.50																
		13.60	22.4	19.9	18.4													
27	14.00 m to 14.25 m - grey silica fine to medium SAND, with shells and shell fragments	14.00																
		14.10	21.3	20.1	18.3													
	14.25 m to 14.30 m - very dark greenish grey silica fine SAND	14.25																
28	14.50 m to 14.85 m - very dark greenish grey silica fine SAND	14.50												13				
		14.60	24.7	19.6	18.6													
29	18.00 m to 18.30 m - very dark greenish grey silica fine SAND	18.00						2.68						11				
		18.15	22.7	19.9														
30	22.00 m to 22.20 m - very dark greenish grey silica fine SAND, with shells and shell fragments	22.00												9				

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- Fines : mass percentage of material passing 63 µm or 75 µm sieve
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test	w	Unit Weight [kN/m³]				ρ_S	Carb.	Org.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description	Depth		γ_1	γ_2	γ_d min.	γ_d max.		Cont.	Cont.	w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		22.10	23.4	19.8														
31	26.00 m to 26.30 m - very dark greenish grey silica fine SAND - at bottom silty	26.00						2.69						19				
		26.20	20.9	20.2	19.6													
32	30.00 m to 30.20 m - very dark greenish grey silica fine SAND	30.00																
		30.10	22.3	20.0	19.5													
33	34.00 m to 34.20 m - very dark greenish grey silica fine SAND	34.00							2					13				
		34.10	25.3	19.5	19.0													
34	38.00 m to 38.70 m - very stiff very dark grey sandy CLAY - with pockets of light grey fine sand	38.00																
		38.10	23.0	20.1	19.6												183	
		38.10	24.4 23.2	20.1 19.6	19.7										200		136r	
		38.30			19.8													
		38.50			19.3													
		38.65	22.8	19.9											167			
35	39.00 m to 39.75 m - very stiff very dark grey sandy CLAY - with pockets of light grey fine sand - with very closely spaced thin laminae of sand	39.00						2.70			26	42	16	25				
		39.10													173			
		39.15	28.0	19.1	19.6													
		39.16	24.6	19.8	19.8													
		39.35													200			
		39.60													240			

Key:
- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		39.70	26.4	19.3	20.2													
36	43.00 m to 43.80 m - very stiff very dark grey sandy CLAY - with pockets of light grey fine sand - with very closely spaced thin laminae of sand	43.00									21	71	50					
		43.05			19.8										280			
		43.06	22.5	20.2	19.6													
		43.25	23.0	20.1	20.0												330	
		43.25	22.4	20.2	20.0										333		247r	
		43.30	22.7	19.9														
		43.45			19.7													
		43.65													333			
		43.70	24.7	19.6														
37	44.00 m to 44.50 m - very stiff very dark grey sandy CLAY - with pockets of light grey fine sand - with very closely spaced thin laminae of sand	44.00																
		44.05			20.3										243			
		44.25			19.6													
		44.45	23.8	19.7														
38	48.00 m to 48.55 m - very stiff fissured very dark greenish grey CLAY	48.00						2.73										
		48.05	30.8	18.7	19.4										267			
		48.09	31.5	18.8	18.9													
		48.25			19.3													
		48.45									36	110	74	99	280			
		48.50	32.4	18.5														

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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-5

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
39	49.00 m to 49.50 m - very stiff to hard fissured very dark greenish grey CLAY	49.00																
		49.05	34.3	18.3	18.8										293			
		49.25													313			
		49.30	31.5	18.8	18.9												286	
		49.30	32.1	18.7	18.8												286r	
	49.50 m to 49.75 m - very stiff very dark grey sandy CLAY - with pockets of light grey fine sand - with very closely spaced thin laminae of sand	49.50	29.2	18.9	19.7										283			
		49.70													243			
40	52.00 m to 52.15 m - dark olive grey slightly silty silica fine SAND	52.00												11				
		52.10	21.5	20.1	19.1													

Key:
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- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
1	0.00 m to 0.60 m - light yellowish brown silica fine to medium SAND, with shells and shell fragments	0.00																
		0.15	22.3	20.0	19.1													
		0.30												1				
		0.45	22.9	19.9	19.0													
2	1.00 m to 1.60 m - grey silica fine to medium SAND, with shells and shell fragments, with traces of organic matter - at bottom light yellowish brown	1.00							12	0								
		1.15	22.6	19.9	19.3													
		1.50	22.4	20.0	19.4													
3	2.00 m to 2.60 m - light yellowish brown silica fine to medium SAND, with shells and shell fragments	2.00				1.5	1.9											
		2.10	21.8	20.1	19.5													
		2.50	22.8	19.9	18.6													
4	3.00 m to 3.50 m - olive brown silica fine to medium SAND, with traces of shells and shell fragments	3.00																
		3.10	21.1	20.2	18.9													
		3.40	22.2															
5	3.50 m to 3.95 m - olive brown silica fine to medium SAND, with traces of shells and shell fragments	3.50																
		3.55	22.0	20.0	19.2													
		3.90	21.3	20.1	19.8													
6	4.00 m to 4.60 m - dark greyish brown silica fine to medium SAND, with traces of shells and shell fragments	4.00												3				
		4.10	22.8	19.9	19.5													
		4.50	23.2	19.8	19.2													

Key:
- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test	w	Unit Weight [kN/m³]				ρ_S	Carb.	Org.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description	Depth		γ_1	γ_2	γ_d min.	γ_d max.		Cont.	Cont.	w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
7	5.00 m to 5.50 m - grey calcareous silica fine to medium SAND, with shells and shell fragments - with a thin bed of shells and shell fragments	5.00																
		5.10	23.0	19.8	19.6													
		5.40	21.2	20.1	19.4													
8	5.50 m to 5.95 m - grey calcareous silica fine SAND, with few shells and shell fragments	5.50																
		5.60	20.7	20.2	19.9													
		5.90	18.4	20.7	20.3													
9	6.00 m to 6.35 m - grey calcareous silica fine SAND, with traces of shells and shell fragments - at bottom with a thick lamination of clay	6.00																
		6.25	21.6	20.1	20.4													
10	6.50 m to 7.10 m - dark grey slightly silty calcareous silica fine SAND - at bottom with a coarse gravel	6.50																
		6.65	23.8	19.7	19.3													
		7.05	25.0	19.5	18.9													
11	7.50 m to 7.95 m - grey slightly gravelly silica medium to coarse SAND, with shells and shell fragments	7.50						2.66										
		7.60	20.4															
		7.85	20.1															
12	8.00 m to 8.35 m - grey to dark grey silica medium to coarse SAND, with few shells and shell fragments	8.00												2				
		8.10	20.8	20.2	19.3													
13	8.50 m to 8.95 m - grey silica fine to medium SAND	8.50																
		8.60	21.3	20.1	19.8													

Key:
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- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		8.90	22.7	19.9	19.2													
14	9.00 m to 9.30 m - dark grey silica fine SAND	9.00																
		9.15	23.4	19.8	19.2													
15	9.50 m to 9.80 m - dark grey silica fine to medium SAND, with traces of shells and shell fragments	9.50																
16	10.00 m to 10.25 m - dark grey silica fine to medium SAND, with traces of shells and shell fragments	10.00																
		10.10	22.2	20.0	19.6													
17	10.50 m to 10.85 m - dark grey silica fine to medium SAND, with few shells and shell fragments, - at 10.70 m - with many shells and shell fragments	10.50																
		10.65	20.2	20.3	19.4													
		10.80	22.2	20.0	19.0													
18	11.00 m to 11.35 m - dark grey silica fine to medium SAND, with few shells and shell fragments	11.00																
		11.05	21.3	20.1	19.3													
		11.30	21.6	20.1	19.1													
19	11.50 m to 11.85 m - dark grey silica fine to medium SAND, with traces of shells and shell fragments	11.50																
		11.55	19.3	20.5	19.6													
		11.80	21.0	20.2	19.6													
20	12.00 m to 12.30 m - dark grey silica fine to medium SAND, with few shells and shell fragments	12.00				1.5	1.9											
		12.15	20.8	20.2	19.3													
21	12.50 m to 12.80 m - dark grey silica fine to medium SAND, with few shells and shell fragments	12.50												2				
		12.65	21.4	20.1	19.0													

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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
22	13.00 m to 13.20 m - dark grey silica fine to medium SAND, with shells and shell fragments	13.00																
		13.10	22.1	20.0	19.4													
	13.20 m to 13.35 m - very dark greenish grey very silty silica fine SAND	13.20																
23	13.50 m to 14.30 m - very dark greenish grey very silty silica fine SAND	13.50												14				
		13.60	22.2	20.0	20.0													
		13.90	23.2	19.8	19.6													
		14.25	23.2	19.8	19.7													
24	14.50 m to 14.85 m - very dark greenish grey very silty silica fine SAND	14.50								2								
		14.60	23.8	19.7	19.2													
		14.65			20.7													
25	17.50 m to 18.15 m - very dark greenish grey very silty silica fine SAND	17.50				1.3	1.9	2.68						10				
		17.70	25.4	19.5	19.1													
		18.00	24.7	19.6	19.1													
26	20.50 m to 20.70 m - dark grey silty silica fine SAND	20.50																
		20.60	20.7	20.2	19.8													
27	24.00 m to 24.55 m - dark grey silty silica fine SAND - at bottom with a thin lamination of clay	24.00				1.3	1.9							7				
		24.15	26.2	19.3	19.0													
		24.50	23.9	19.7	19.2													
28	28.00 m to 28.50 m - dark grey silty silica fine SAND - at bottom shells and shell fragments	28.00				1.3	1.8	2.67	13	1				7				

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- ρ_S : density of solid particles
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- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-6

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		28.05	24.7	19.6	19.4													
		28.45	25.2	19.5	19.2													
29	32.00 m to 32.40 m - dark grey silty silica fine SAND	32.00												8				
		32.10	25.6	19.4	19.2													
		32.35	25.6	19.4	19.2													
30	36.00 m to 36.80 m - dark grey silty silica fine SAND - at bottom with traces of shells and shell fragments	36.00				1.3	2.0	2.67						7				
		36.10	24.6	19.6	19.4													
		36.40	24.6	19.6	19.4													
		36.70	23.3	19.8	19.3													
31	40.00 m to 40.90 m - dark grey silty silica fine SAND	40.00																
		40.15	24.8															
		40.45	24.1	19.7	18.5													
		40.80	23.6															
32	44.00 m to 44.20 m - dark grey silty silica fine SAND	44.00						2.67						16				
		44.15	22.0	20.0	18.3													
		44.20	21.3															
33	48.00 m to 48.30 m - dark grey silty silica fine SAND	48.00												15				
		48.20	24.2	19.6	17.5													
		48.25	22.6															

Key:
- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample No.	Ground Description	Test Depth [m]	w [%]	Unit Weight [kN/m³] γ_1	γ_2	γ_d min.	γ_d max.	ρ_S [Mg/m³]	Carb. Cont. [%]	Org. Cont. [%]	Atterberg Limits w_p [%]	w_L [%]	I_p [%]	Fines [%]	s_u [kPa] PP	TV	UU	LV
1	0.00 m to 0.60 m - light yellowish brown silica fine to medium SAND, with few shells and shell fragments	0.00																
		0.35	23.0	19.8	18.4									3				
		0.60	23.7	19.8														
2	1.00 m to 1.35 m - light yellowish brown silica fine to medium SAND, with few shells and shell fragments	1.00																
		1.10	19.9	20.4														
		1.30	19.9	20.4	18.4													
	1.35 m to 1.55 m - grey silica fine to medium SAND, with traces of shell fragments	1.35																
		1.45	22.8	19.9														
3	2.00 m to 2.55 m - grey silica medium SAND, with many shell fragments - at top with one coarse gravel	2.00																
		2.10	23.3	19.8														
		2.35	20.6	20.3	17.8													
		2.50	20.4	20.3														
4	3.00 m to 3.50 m - grey silica fine to medium SAND, with shell fragments - at bottom with a piece of wood	3.00																
		3.10	22.1	20.0														
		3.25	20.0	20.4	17.9													
		3.40	22.8	19.9														
5	4.00 m to 4.50 m - grey silica fine to medium SAND	4.00				1.5	1.9											
		4.15	24.6	19.6														
		4.30	22.4	20.0														

Key:
- w : water content
- γ_1 : unit weight derived from water content
- γ_2 : unit weight derived from volume mass calculation
- γ_{dmin} : minimum index unit weight
- γ_{dmax} : maximum index unit weight
- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		4.45	22.9	19.9														
6	4.00 m to 4.50 m - grey silica fine to medium SAND - with a piece of wood	4.50																
		4.65	25.2	19.5														
		4.75	25.6	19.5				2.66						3				
		4.90	22.6	19.9	19.2													
7	5.50 m to 5.85 m - grey silica fine to medium SAND, with few shells and shell fragments	5.50																
		5.65	22.7	19.9	18.9													
8	6.00 m to 6.10 m - grey silica fine to medium SAND, with shells and shell fragments, with traces of organic matter	6.00																
	6.10 m to 6.80 m - thinly interbedded to medium interbedded stiff very dark grey CLAY, with few shells and shell fragments, with traces of organic matter and very dark grey fine SAND	6.10																
		6.15	20.4	20.3	19.5													
		6.70	18.5	20.6	20.3										147			
9	7.00 m to 7.50 m - thinly interbedded to medium interbedded stiff very dark grey CLAY, with few shells and shell fragments, with traces of organic matter and very dark grey fine SAND	7.00						2.69			14	26	12	50				
		7.10	20.1	20.4	19.9													
		7.45	18.3	20.7	20.4													
10	7.50 m to 8.35 m - thinly interbedded to medium interbedded stiff very dark grey CLAY, with few shells and shell fragments, with traces of organic matter and very dark grey fine SAND	7.50																
		7.55	19.7	20.4														
		7.90	20.1	20.4														

Key:
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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		8.25	18.0	20.8														
11	8.50 m to 9.40 m - thinly interbedded to medium interbedded stiff very dark grey CLAY, with few shells and shell fragments, with traces of organic matter and very dark grey fine SAND	8.50																
		8.70	16.3	21.1														
		9.00						2.70	14	1	14	32	18	38				
		9.05	18.4	20.7	20.8													
		9.35	18.6	20.6	20.4													
12	9.50 m to 10.20 m - very stiff dark greyish brown CLAY, with traces of shells and shell fragments	9.50																
		9.55	21.3	20.4														
		9.60			20.5										233			
		9.80							13	2					203			
		9.85	21.0	20.5	20.6												178r	
		9.85	21.1 22.0	20.3 20.4	20.8 20.4						22	52	30	84			257	
		10.05			20.4													
13	10.50 m to 10.85 m - very stiff dark greyish brown CLAY, with traces of shells and shell fragments	10.50																
		10.55			21.2										190			
		10.75	15.6	21.5	21.7 20.7													
	10.85 m to 11.00 m - dark greyish brown slightly clayey silica fine SAND, with few shells and shell fragments	10.85																
		10.90	16.7	21.0														

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- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
14	11.00 m to 11.40 m - dark greyish brown slightly clayey silica fine SAND, with few shells and shell fragments	11.00												5				
		11.35	24.2	19.7	19.1													
15	11.50 m to 11.75 m - dark greyish brown slightly clayey silica fine SAND, with few shells and shell fragments	11.50																
		11.55	23.7	19.7	19.5													
	11.75 m to 12.25 m - greenish grey slightly clayey silica fine to medium SAND, with many shells and shell fragments	11.75				1.3	2.1											
		11.90	23.6	19.8														
		12.20	24.9	19.6														
16	12.50 m to 13.30 m - greenish grey slightly clayey silica fine to medium SAND, with many shells and shell fragments - with putrid odour	12.50							14	1				9				
		12.70	24.9	19.6														
		12.80				1.2	2.2											
		13.10	23.5	19.8														
17	13.50 m to 13.85 m - greenish grey slightly clayey silica fine to medium SAND, with many shells and shell fragments	13.50																
		13.65	24.8	19.6														
	13.85 m to 14.35 m - very stiff to hard very dark grey CLAY	13.85																
		13.90													350			
		14.10	26.8	19.5											250			
18	14.50 m to 15.05 m - very stiff very dark grey CLAY	14.50						2.70						97				
		14.60	27.5	19.4	19.5						30	81	51		290			

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- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		14.80	37.0	18.2	19.2												297r	
		14.80	28.9	19.2	19.5 19.2										297		209	
		15.00	28.5	19.2											277			
19	20.50 m to 21.25 m - very stiff very dark grey CLAY	20.50																
		20.75													270			
		20.85	32.3	18.7											200			
		20.90							14	3	32	89	57	99				
		20.95													238			
		21.20	32.1	18.7											200			
20	21.50 m to 22.00 m - very stiff very dark grey CLAY	21.50																
		21.70	31.3	18.9														
		21.95	29.9	19.0														
21	22.00 m to 22.50 m - very stiff very dark grey slightly sandy CLAY	22.00																
		22.15			18.3										217			
		22.30			18.4													
		22.50	28.7	19.2											247			
22	23.00 m to 23.80 m - very stiff very dark grey slightly sandy CLAY	23.00									34	112	78					
		23.10	33.2	18.6	18.7										290			
		23.30	33.3	18.6	18.4												220	
		23.30	35.4	18.3	18.5												224r	
		23.50													257			

Key:
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- w_p : plastic limit
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- I_p : plasticity index
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- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		23.55			18.9													
		23.75													267			
		23.80	29.9	19.0														
23	27.00 m to 27.65 m - very dark greenish grey silty silica fine SAND	27.00						2.72	13	2				14				
		27.10	23.7	19.7	19.7													
		27.35				1.3	2.2											
		27.55	23.9	19.7	19.1													
		27.60	24.2	19.7														
24	31.00 m to 31.20 m - very dark greenish grey silty silica fine SAND	31.00																
	31.20 m to 31.30 m - very dark greenish grey slightly gravelly silica coarse SAND	31.20												3				
	31.30 m to 31.75 m - very dark greenish grey silty silica fine SAND	31.30																
		31.40	24.6	19.6	18.5													
		31.70	19.8	20.4	18.6													
25	33.50 m to 33.75 m - very dark grey very sandy CLAY	33.50									23	56	33	85				
		33.65	24.9	19.8														
	33.75 m to 34.15 m - very dark grey very clayey silica fine SAND	33.75									22	43	21	61				
		33.90	26.0	19.4														
		33.95			20.6													
26	34.50 m to 35.00 m - very stiff to hard very dark grey CLAY	34.50			20.0													
		34.65			20.3													

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- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
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- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
- 10d : d refers to test on disturbed soil

LABORATORY CLASSIFICATION TEST RESULTS

LOCATION BH-WFS4-7

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test	w	Unit Weight [kN/m³]				ρ_S	Carb.	Org.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description	Depth		γ_1	γ_2	γ_d min.	γ_d max.		Cont.	Cont.	w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
		34.70													240			
		34.85			19.9				13	3	22	64	42	53	270			
		35.00													187			
27	38.50 m to 39.40 m - very dark grey slightly silty silica fine to medium SAND	38.50																
		38.70	22.0	20.0	19.0													
		38.95	22.3	20.0										6				
		39.10	22.5	19.9	19.2													
28	42.50 m to 43.40 m - very dark grey slightly silty silica fine to medium SAND - with widely spaced pockets of clay	42.50				1.3	2.1	2.69						8				
		42.70	24.6	19.6	18.7													
		42.95	27.1	19.2														
29	46.50 m to 46.75 m - dark grey silica fine SAND	46.50												4				
		46.60	22.3	20.0														
		46.70	25.1	19.5	18.6													

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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
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LABORATORY CLASSIFICATION TEST RESULTS

LOCATION CPT_WFS4_18A

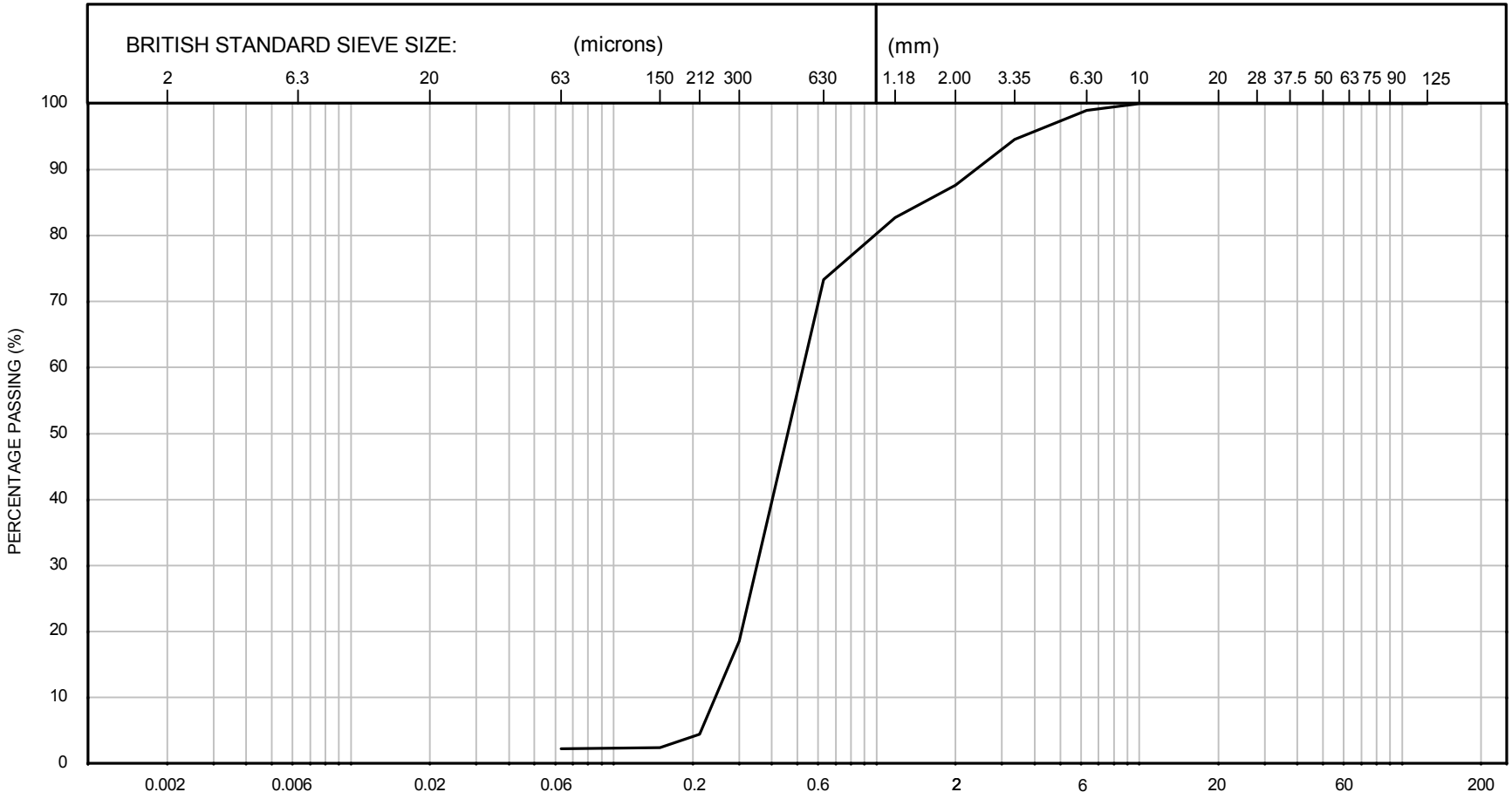
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Sample		Test Depth	w	Unit Weight [kN/m³]				ρ_S	Carb. Cont.	Org. Cont.	Atterberg Limits			Fines	s_u [kPa]			
No.	Ground Description			γ_1	γ_2	γ_d min.	γ_d max.				w_p	w_L	I_p		PP	TV	UU	LV
		[m]	[%]					[Mg/m³]	[%]	[%]	[%]	[%]	[%]	[%]				
1	45.00 m to 45.85 m - very dark greyish olive silty silica fine SAND, possibly glauconitic	45.00 45.40						2.69						24				

Key:
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- ρ_S : density of solid particles
- Carb.Cont. : carbonate content
- Org.Cont. : organic matter content
- w_p : plastic limit
- w_L : liquid limit
- I_p : plasticity index
- Fines : mass percentage of material passing 63 µm or 75 µm sieve
- PP : pocket penetrometer
- TV : torvane
- UU : undrained unconsolidated triaxial
- LV : laboratory vane
- s_u : undrained shear strength
- 10r : r refers to test on remoulded soil
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PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
—	BH-WFS4-1	1BagB	0.30	9.2	N/A	0	2	86	12	0

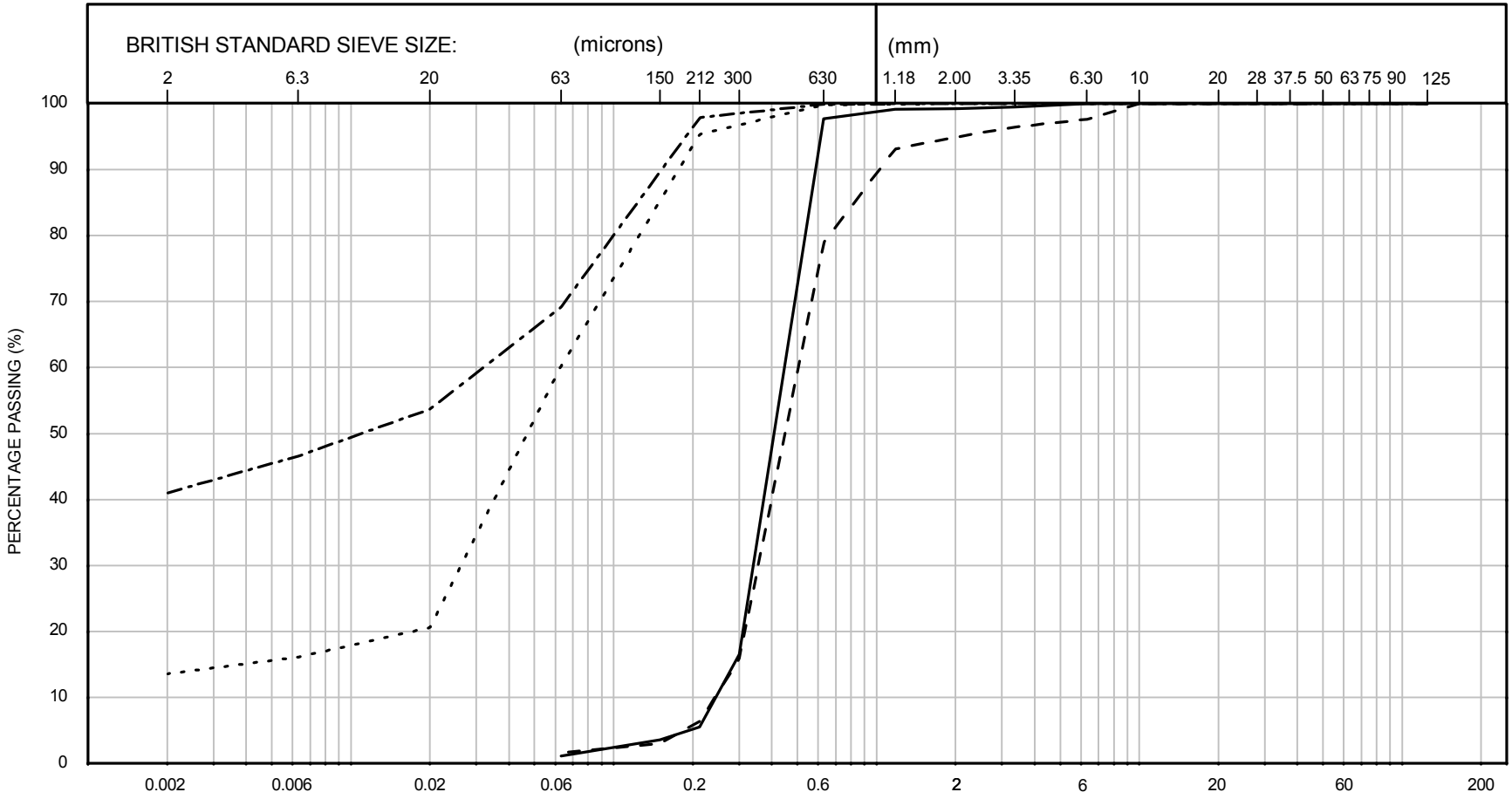
† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-1A	1BagB	5.01	9.2	N/A	0	1	99	0	0
– – –	BH-WFS4-1A	8BagA	10.00	9.2	N/A	0	1	94	5	0
· · · ·	BH-WFS4-1A	14BagB	13.15	9.4	N/A	14	43	43	0	0
– · – ·	BH-WFS4-1A	15BagC	14.55	9.4	N/A	41	27	32	0	0

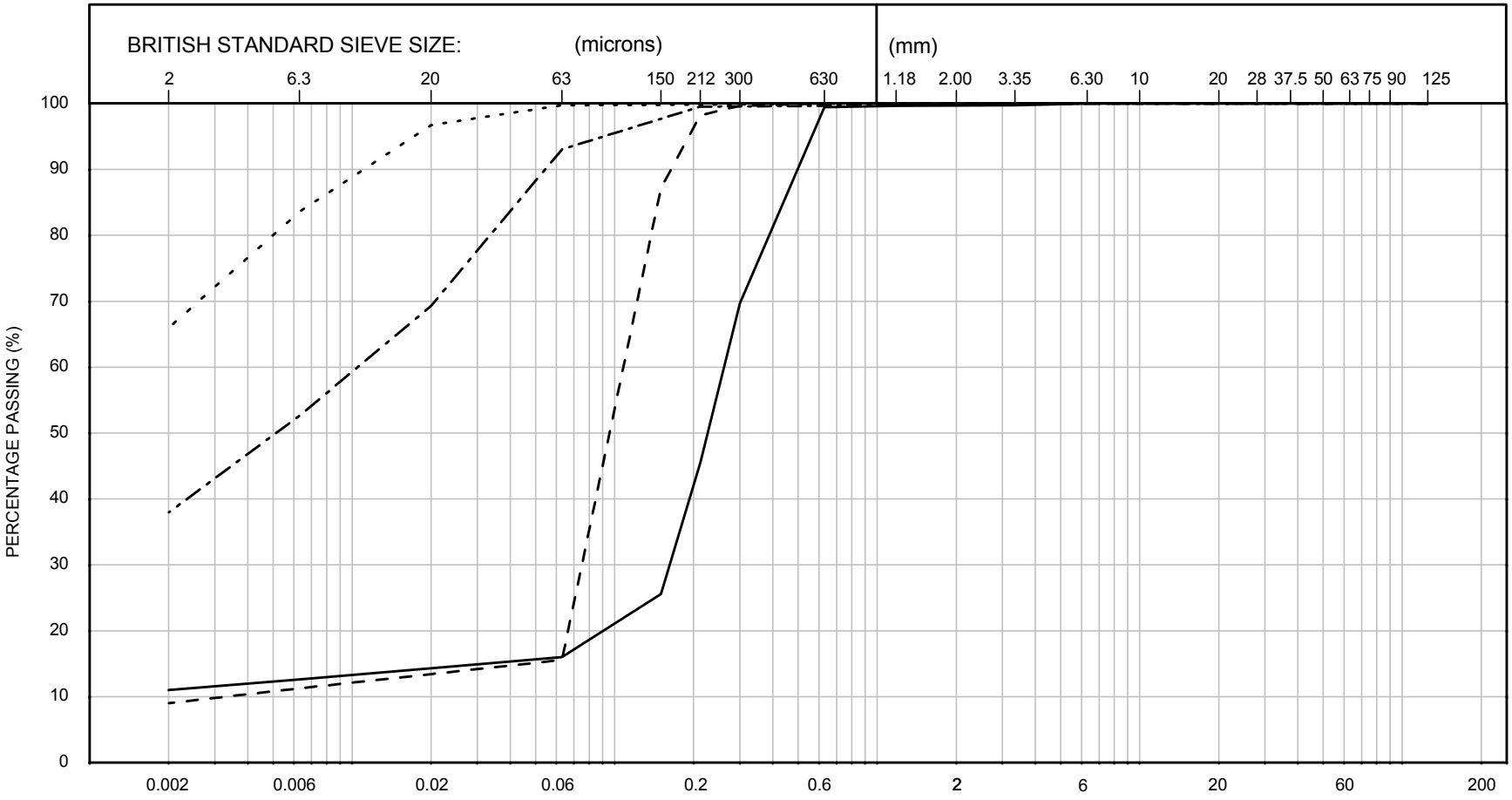
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9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-1A	16BagC	18.50	9.2/9.4	N/A	11	4	85	0	0
– – –	BH-WFS4-1A	19BagA	28.00	9.2/9.4	N/A	9	6	85	0	0
- - -	BH-WFS4-1A	20BagA	32.00	9.4	N/A	66	33	1	0	0
—·—	BH-WFS4-1A	22BagD	37.65	9.4	N/A	38	53	9	0	0

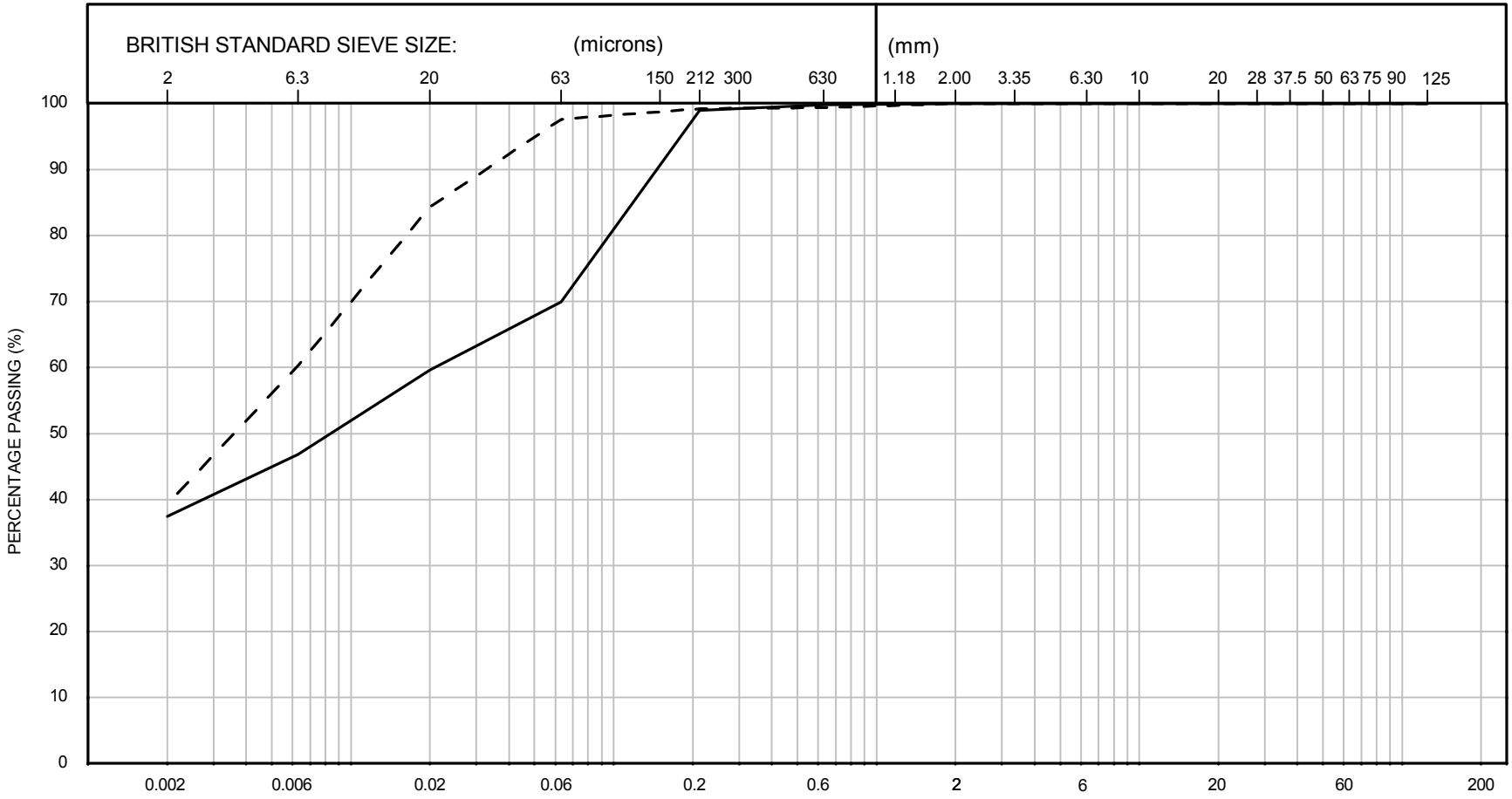
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9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-1A	24BagA	42.00	9.4	N/A	37	31	32	0	0
– –	BH-WFS4-1A	26BagA	47.00	9.4	N/A	39	57	4	0	0

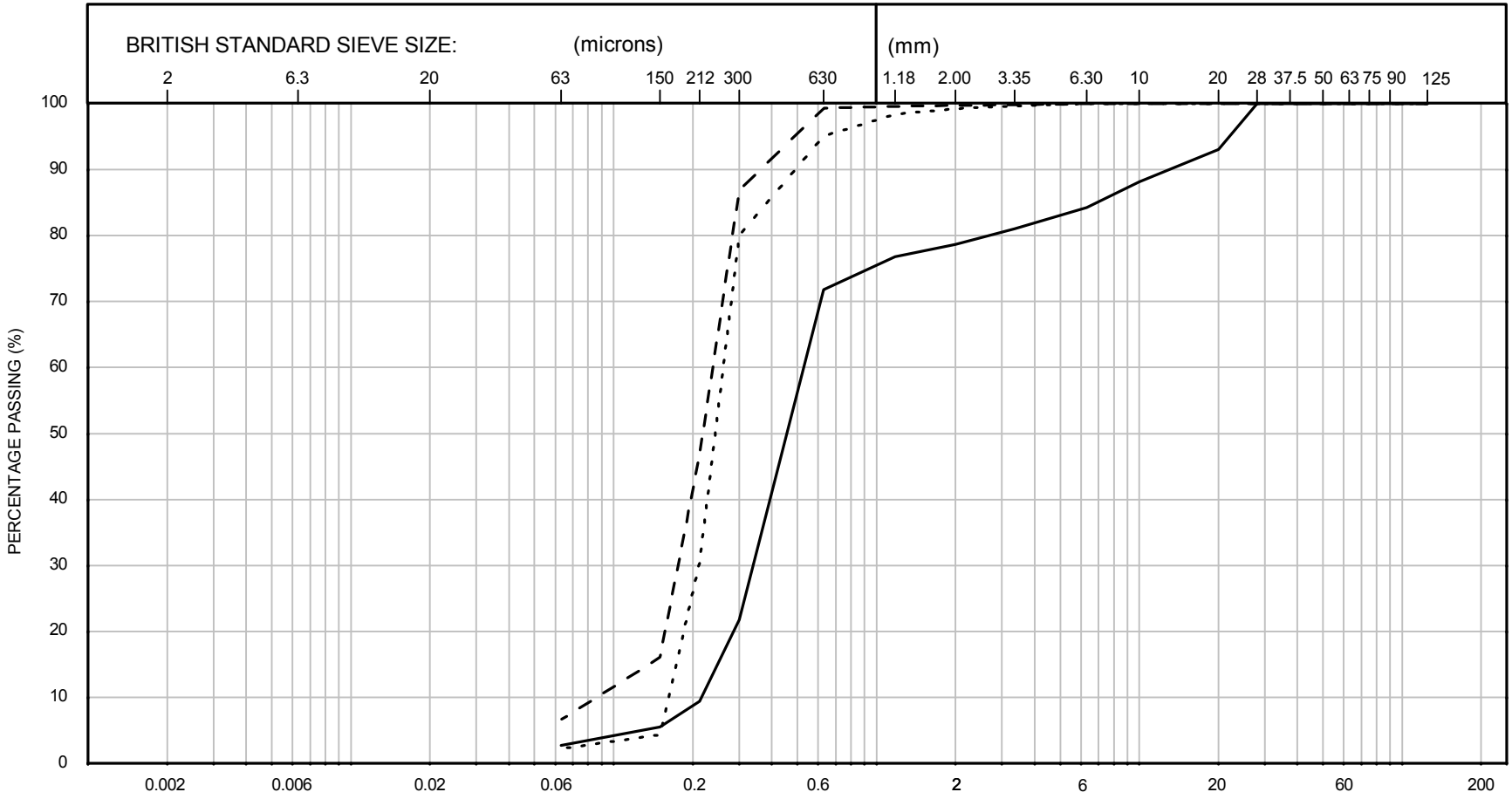
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-2	2BagA	0.50	9.2	N/A	0	2	77	21	0
– – –	BH-WFS4-2	6BagA	4.00	9.2	N/A	0	6	94	0	0
- - -	BH-WFS4-2	12BagA	7.00	9.2	N/A	0	2	98	0	0

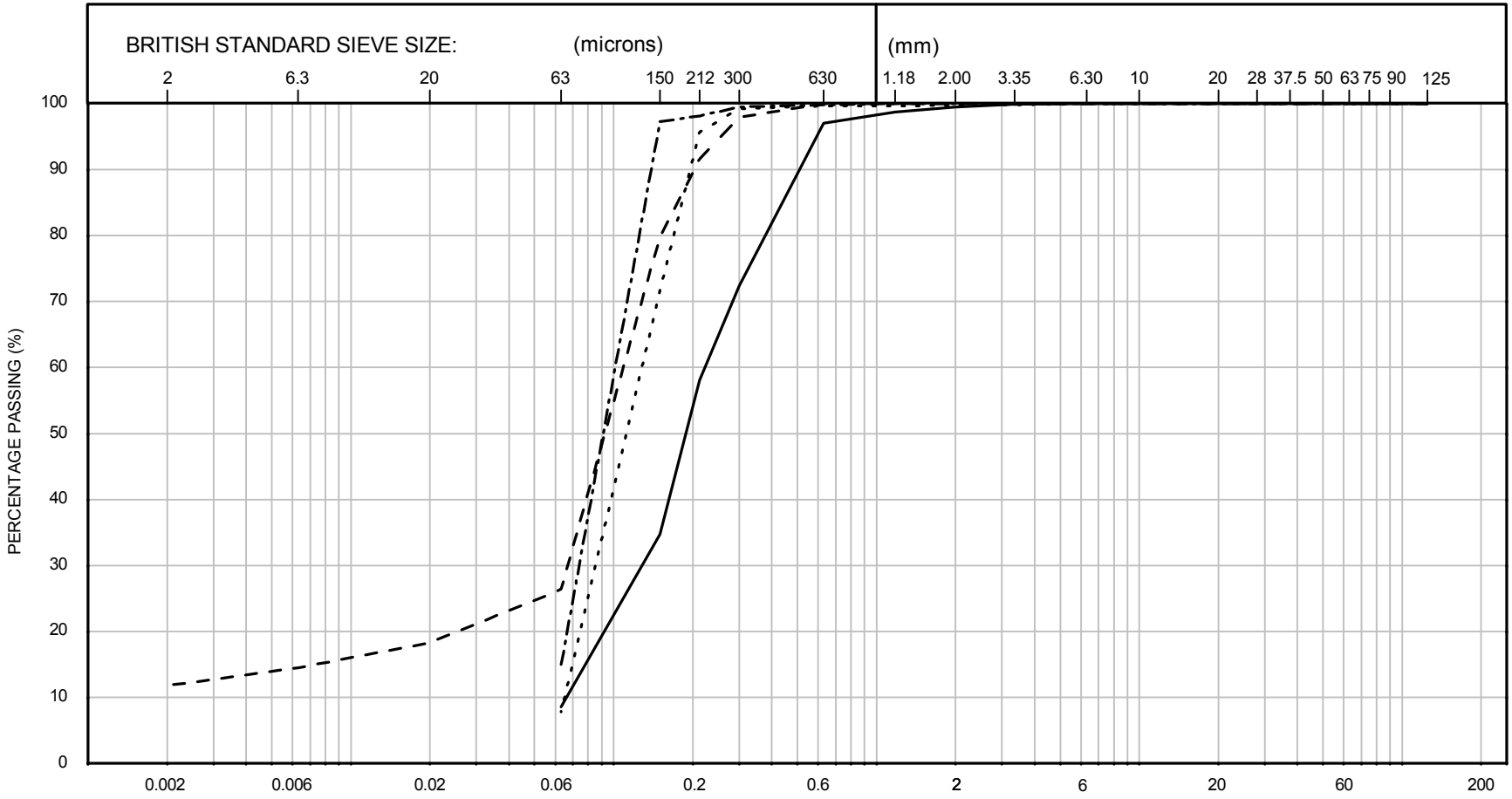
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-2A	6BagB	10.35	9.2	N/A	0	8	92	0	0
– – –	BH-WFS4-2A	11BagA	14.00	9.2/9.4	N/A	12	13	75	0	0
- - -	BH-WFS4-2A	12BagA	18.00	9.2	N/A	0	7	93	0	0
——– –	BH-WFS4-2A	13BagA	22.00	9.2	N/A	0	14	86	0	0

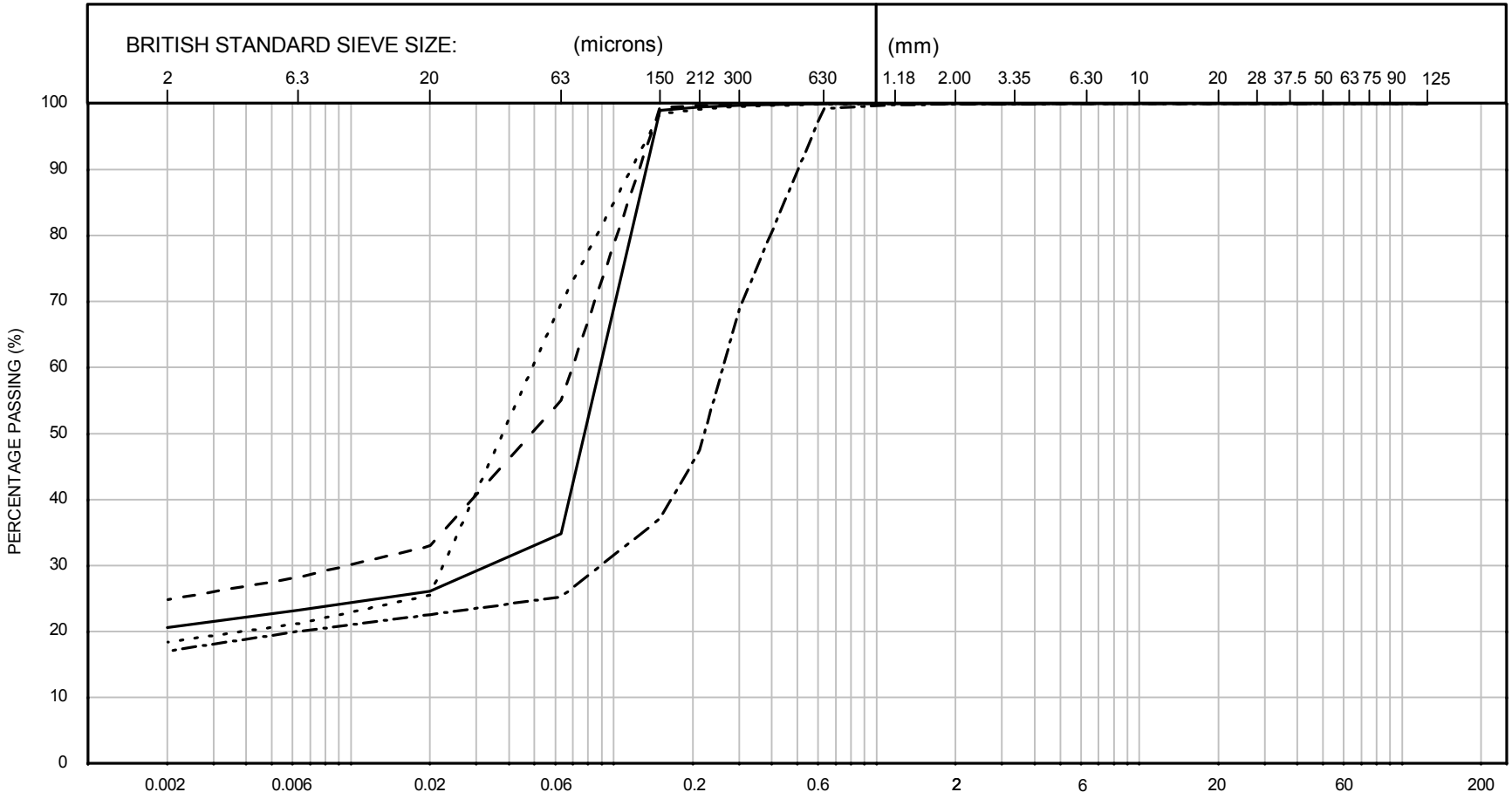
† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-2A	14BagA	26.00	9.2/9.4	N/A	21	13	66	0	0
– –	BH-WFS4-2A	15BagB	30.30	9.2/9.4	N/A	25	28	47	0	0
· · ·	BH-WFS4-2A	16BagA	34.00	9.2/9.4	N/A	18	48	34	0	0
–·–	BH-WFS4-2A	18BagA	39.00	9.2/9.4	N/A	17	8	75	0	0

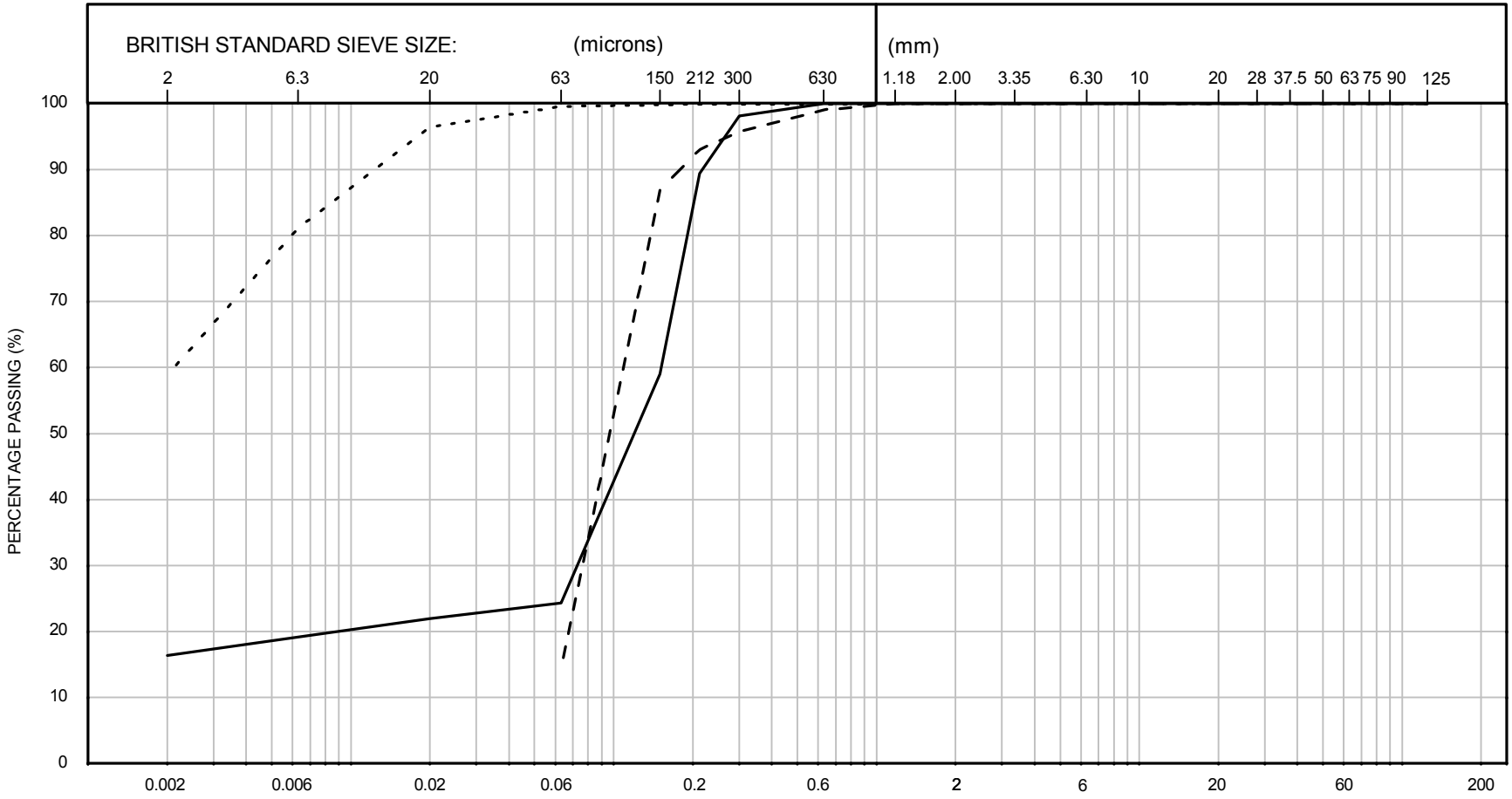
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-2A	19BagA	43.50	9.2/9.4	N/A	16	7	77	0	0
– – –	BH-WFS4-2A	20BagA	47.50	9.2	N/A	0	14	86	0	0
- - -	BH-WFS4-2A	21BagA	51.50	9.4	N/A	59	40	1	0	0

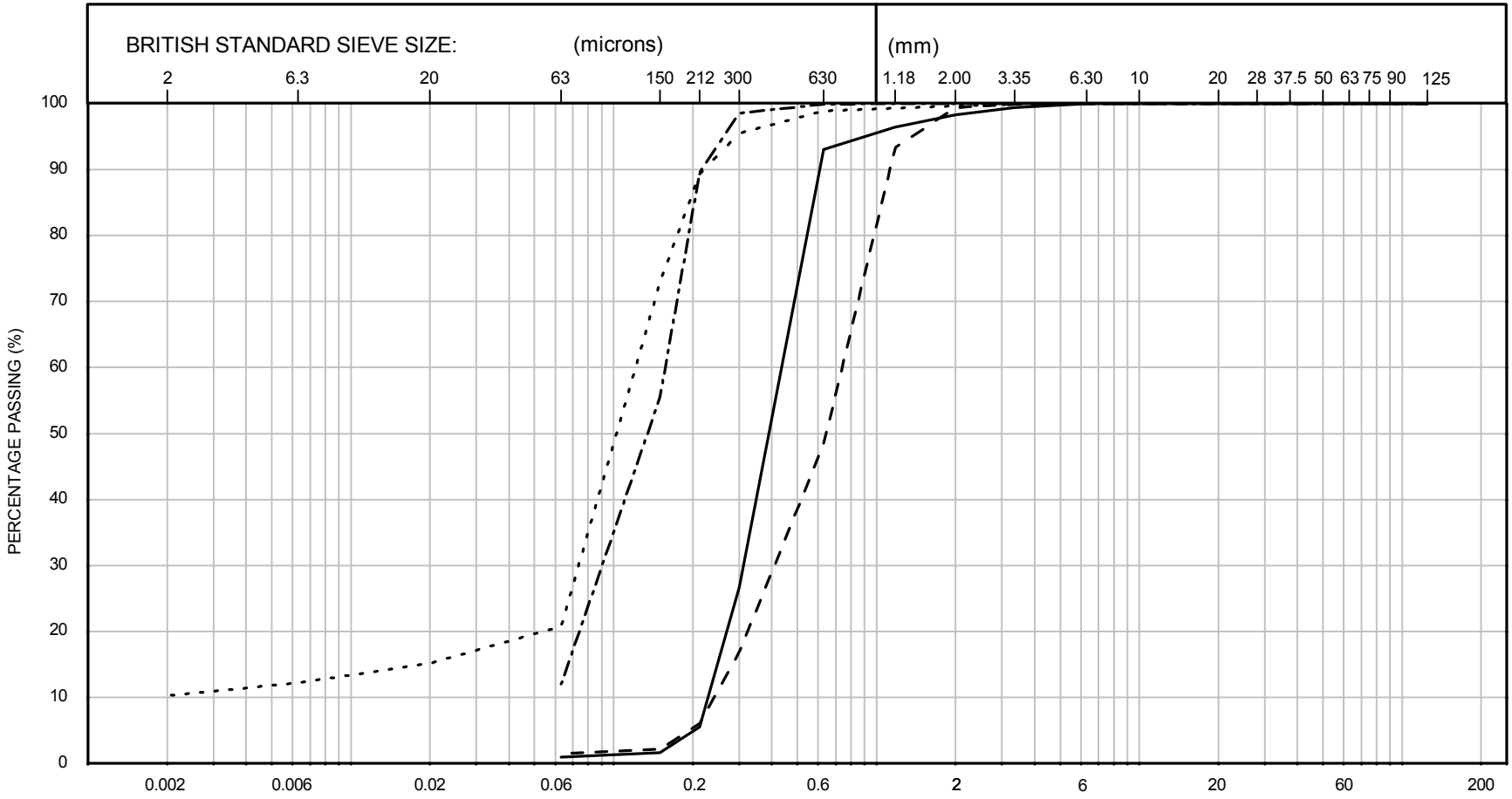
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-3	1BagA	0.00	9.2	N/A	0	0	99	1	0
– – –	BH-WFS4-3	5BagB	4.40	9.2	N/A	0	1	99	0	0
· · · ·	BH-WFS4-3	13BagA	10.80	9.2/9.4	N/A	10	10	80	0	0
– · – ·	BH-WFS4-3	15BagB	12.80	9.2	N/A	0	11	89	0	0

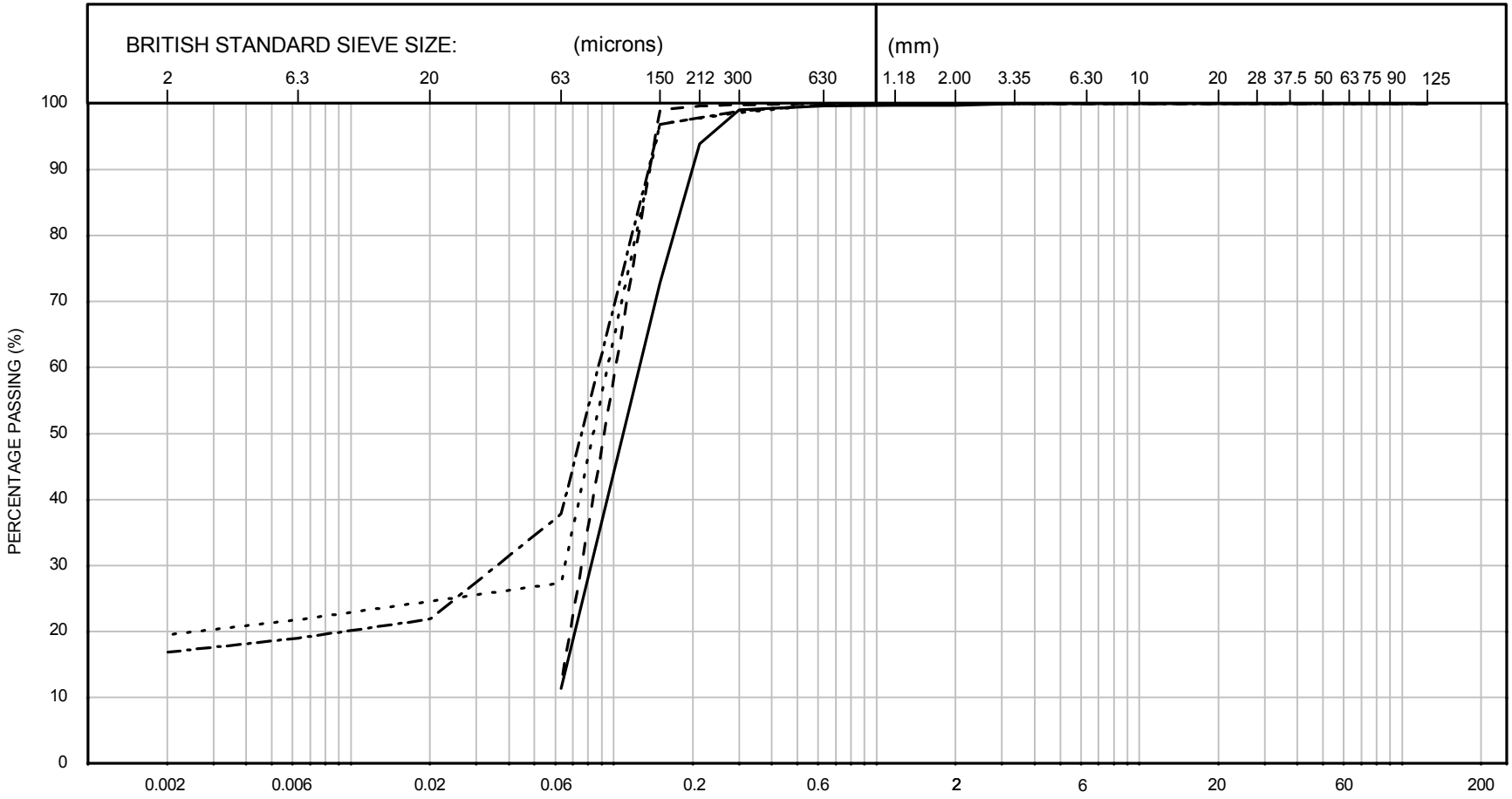
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9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

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PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-3	18BagA	14.00	9.2	N/A	0	11	89	0	0
– – –	BH-WFS4-3	19BagA	18.50	9.2	N/A	0	12	88	0	0
· · · ·	BH-WFS4-3	20BagC	22.80	9.2/9.4	N/A	19	7	74	0	0
– · – ·	BH-WFS4-3	21BagC	26.80	9.2/9.4	N/A	17	19	64	0	0

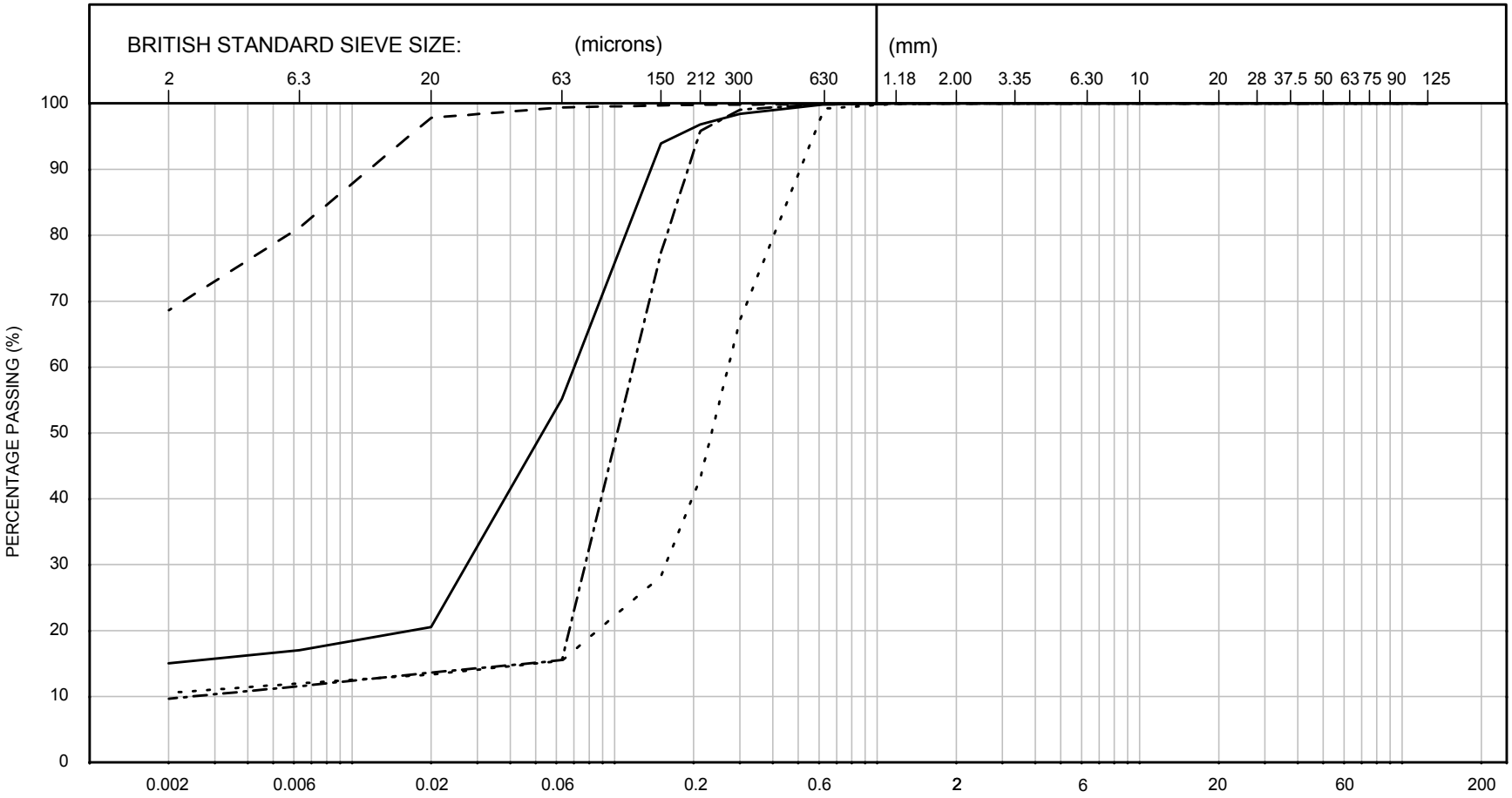
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-3	22WaxA	30.60	9.2/9.4	N/A	15	37	48	0	0
– – –	BH-WFS4-3	23BagA	31.50	9.4	N/A	69	30	1	0	0
- - -	BH-WFS4-3	24BagA	35.50	9.2/9.4	N/A	11	4	85	0	0
—·—	BH-WFS4-3	26BagC	39.75	9.2/9.4	N/A	10	5	85	0	0

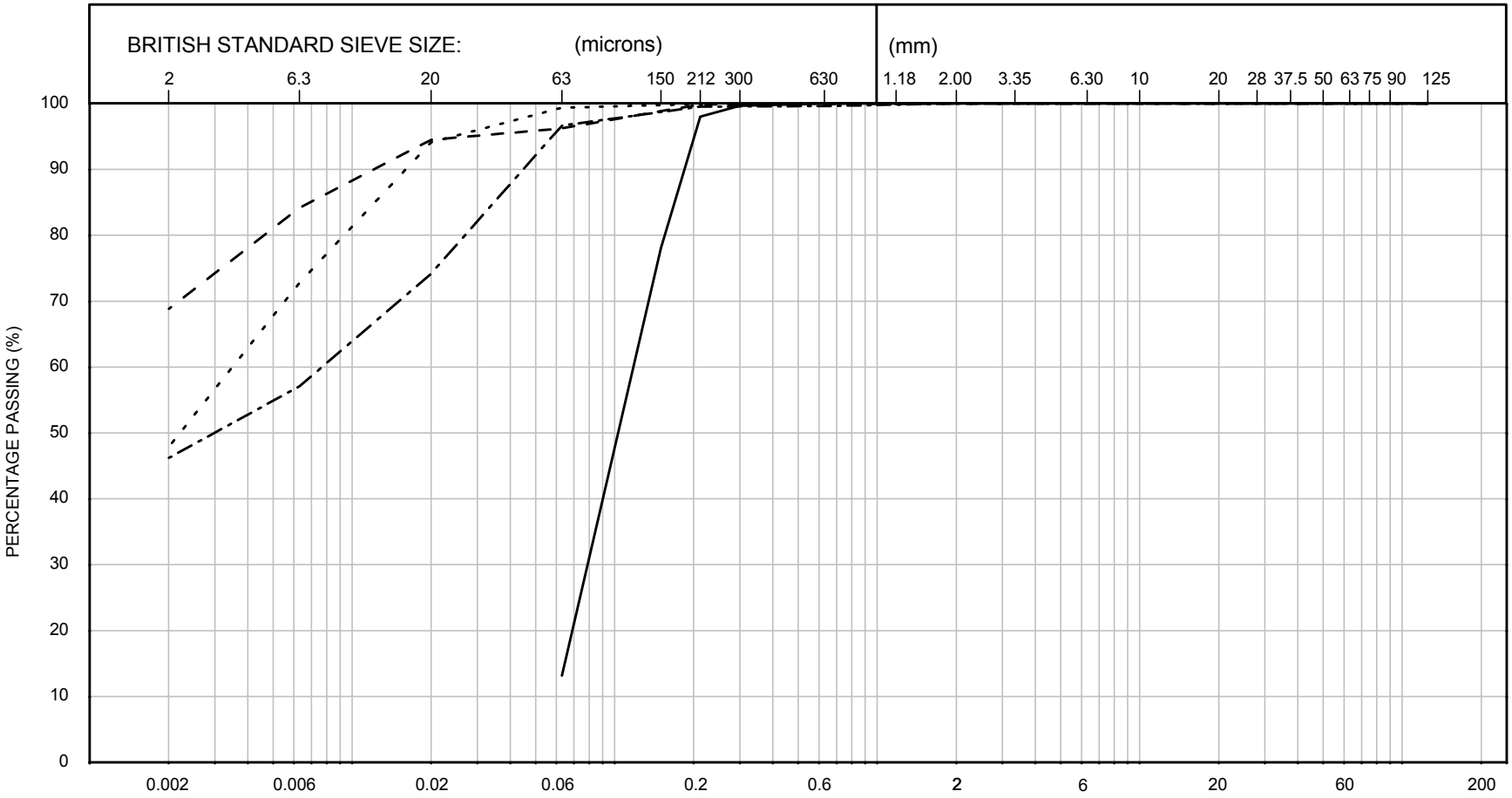
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9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-3	27BagA	40.50	9.2	N/A	0	13	87	0	0
– – –	BH-WFS4-3	28BagA	44.50	9.4	N/A	69	27	4	0	0
- - -	BH-WFS4-3	30BagE	50.20	9.4	N/A	48	51	1	0	0
—·—	BH-WFS4-3	34BagA	59.50	9.4	N/A	46	48	6	0	0

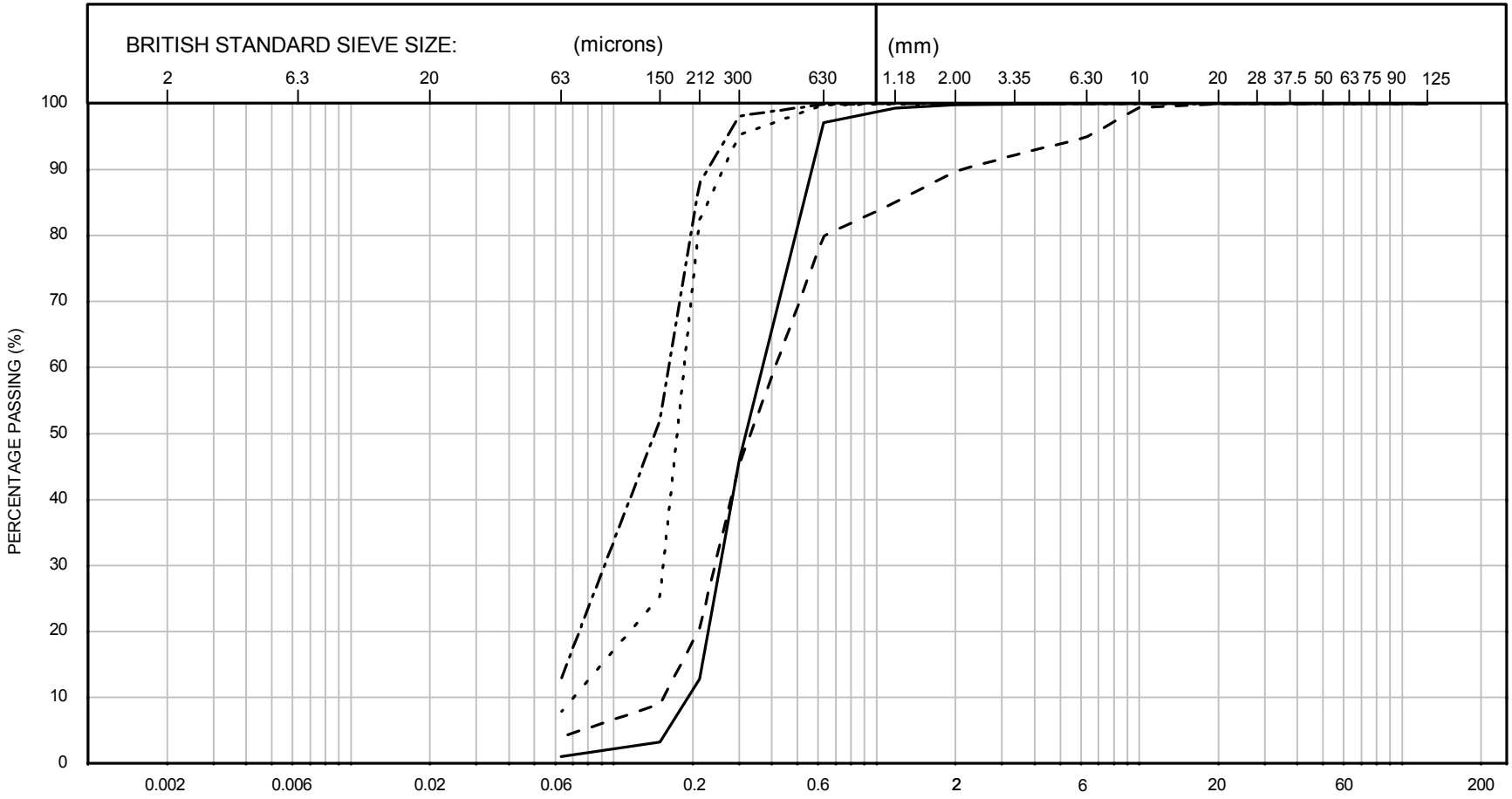
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9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-4	1BagA	0.00	9.2	N/A	0	0	100	0	0
– – –	BH-WFS4-4	7BagA	4.50	9.2	N/A	0	4	86	10	0
- - -	BH-WFS4-4	18BagA	10.00	9.2	N/A	0	7	93	0	0
—– –	BH-WFS4-4	24BagA	13.50	9.2	N/A	0	12	88	0	0

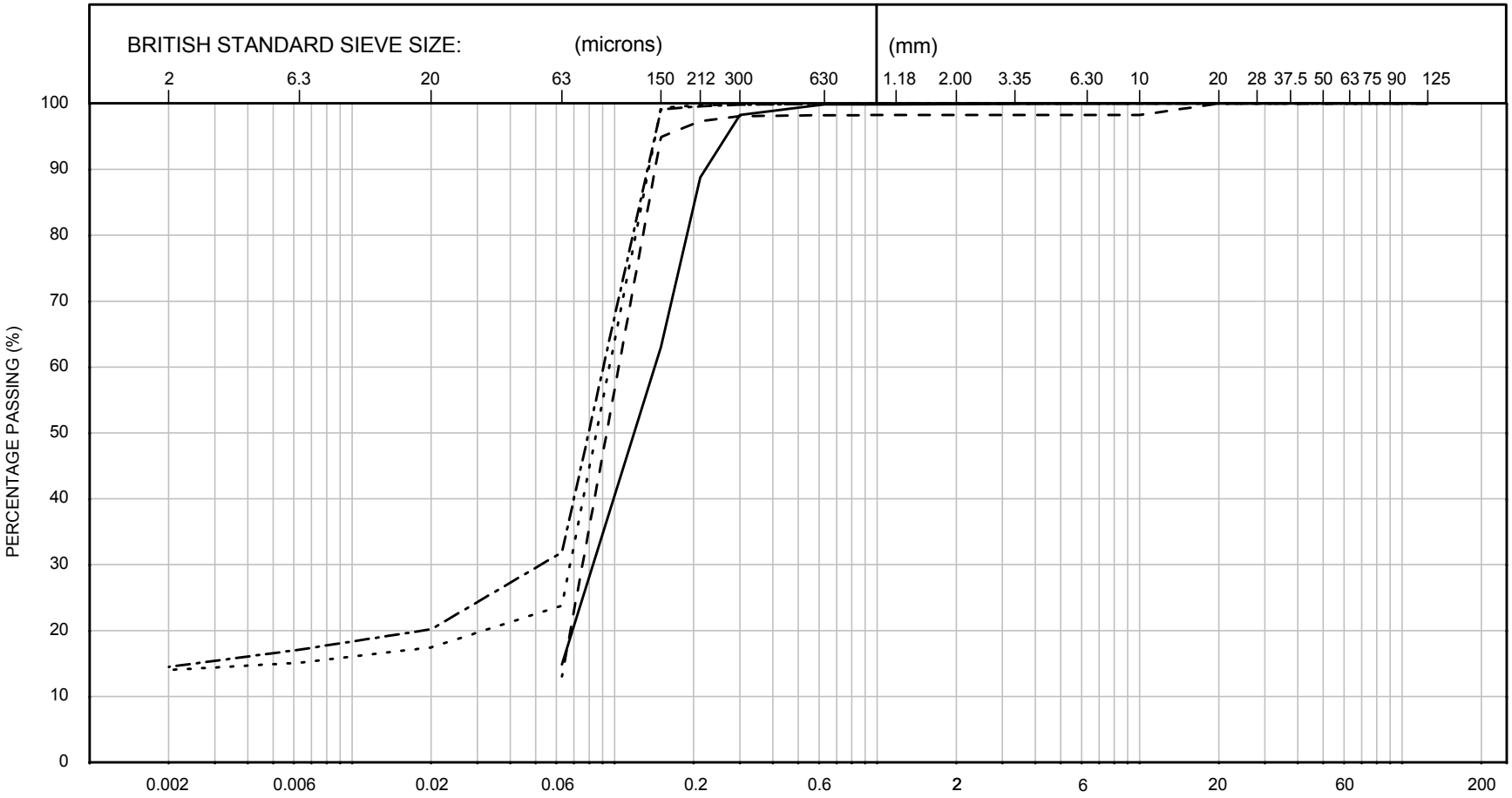
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† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-4	29BagA	22.00	9.2	N/A	0	14	86	0	0
– – –	BH-WFS4-4	31BagA	26.50	9.2	N/A	0	13	86	1	0
- - -	BH-WFS4-4	32BagA	30.50	9.2/9.4	N/A	14	9	77	0	0
—·—	BH-WFS4-4	33WaxB	34.55	9.2/9.4	N/A	14	16	70	0	0

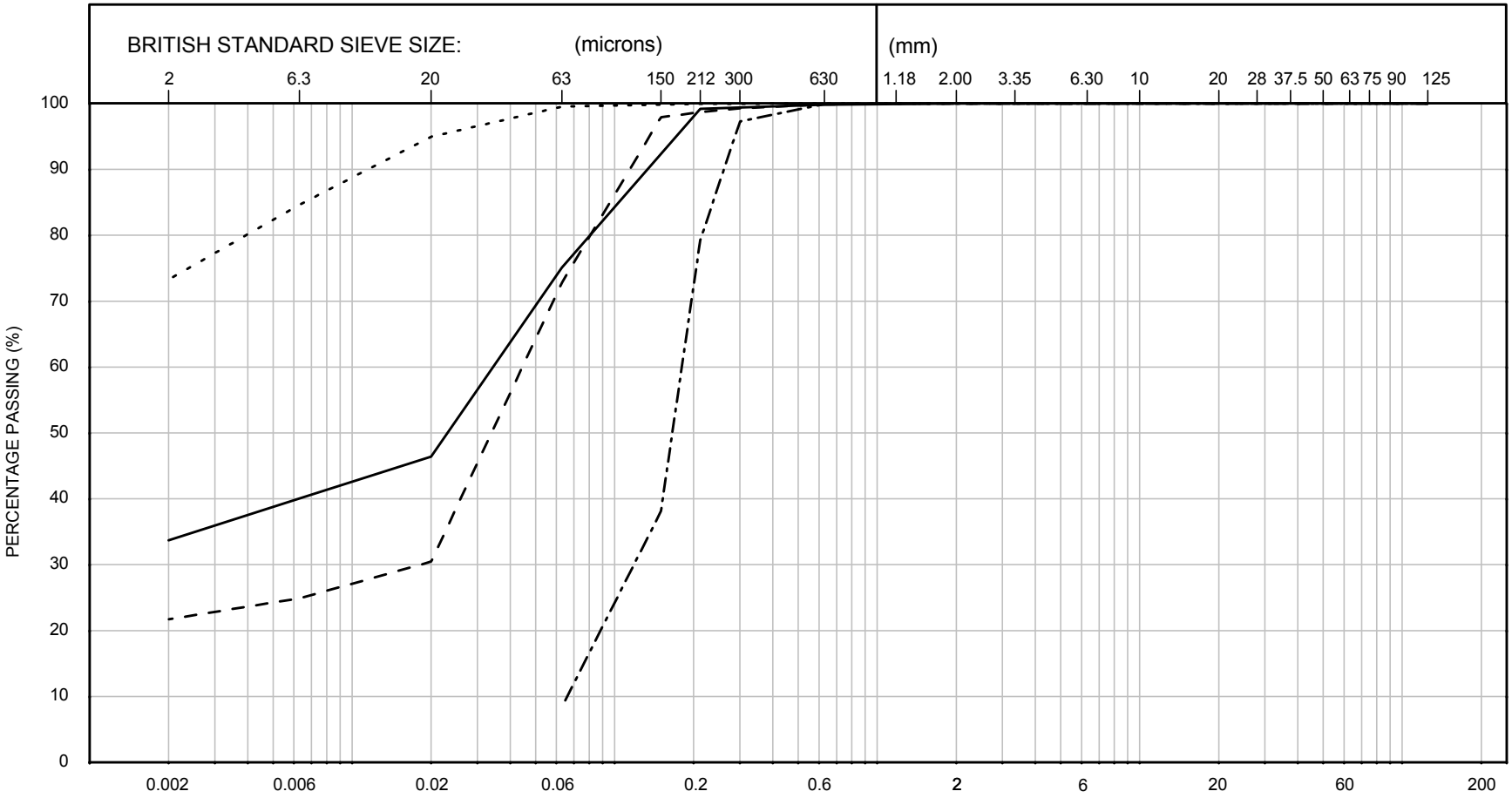
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9.3	Dry sieve
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9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-4	34BagA	38.50	9.4	N/A	34	39	27	0	0
– – –	BH-WFS4-4	35BagB	39.75	9.2/9.4	N/A	22	48	30	0	0
- - -	BH-WFS4-4	36BagC	43.80	9.4	N/A	73	25	2	0	0
—·—	BH-WFS4-4	39BagA	48.00	9.2	N/A	0	8	92	0	0

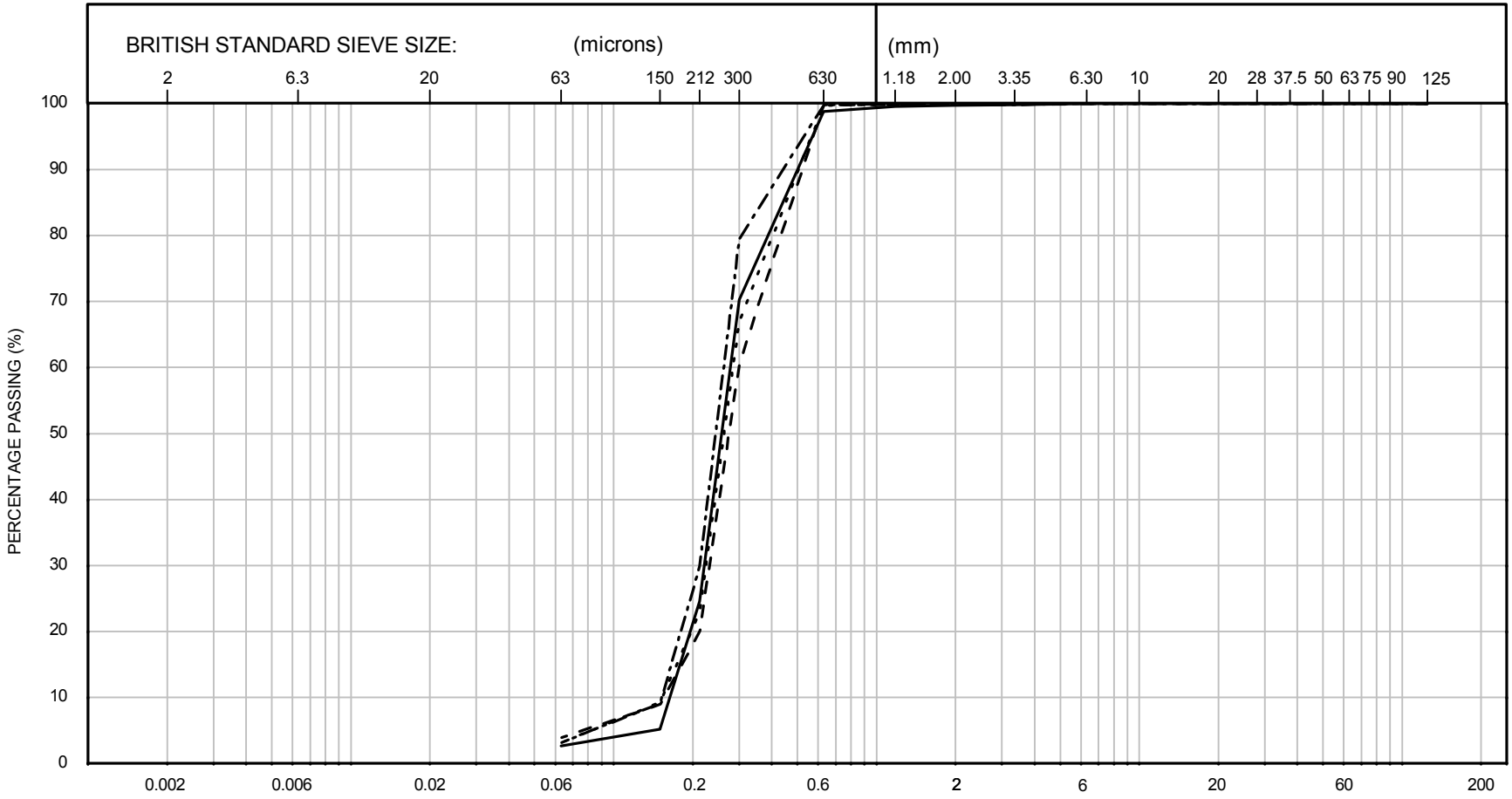
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9.2	Wet sieve
9.3	Dry sieve
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9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-5	2BagA	0.50	9.2	N/A	0	2	98	0	0
– – –	BH-WFS4-5	9BagA	4.50	9.2	N/A	0	3	97	0	0
- - -	BH-WFS4-5	15BagA	8.00	9.2	N/A	0	3	97	0	0
—– –	BH-WFS4-5	25BagA	13.00	9.2	N/A	0	3	97	0	0

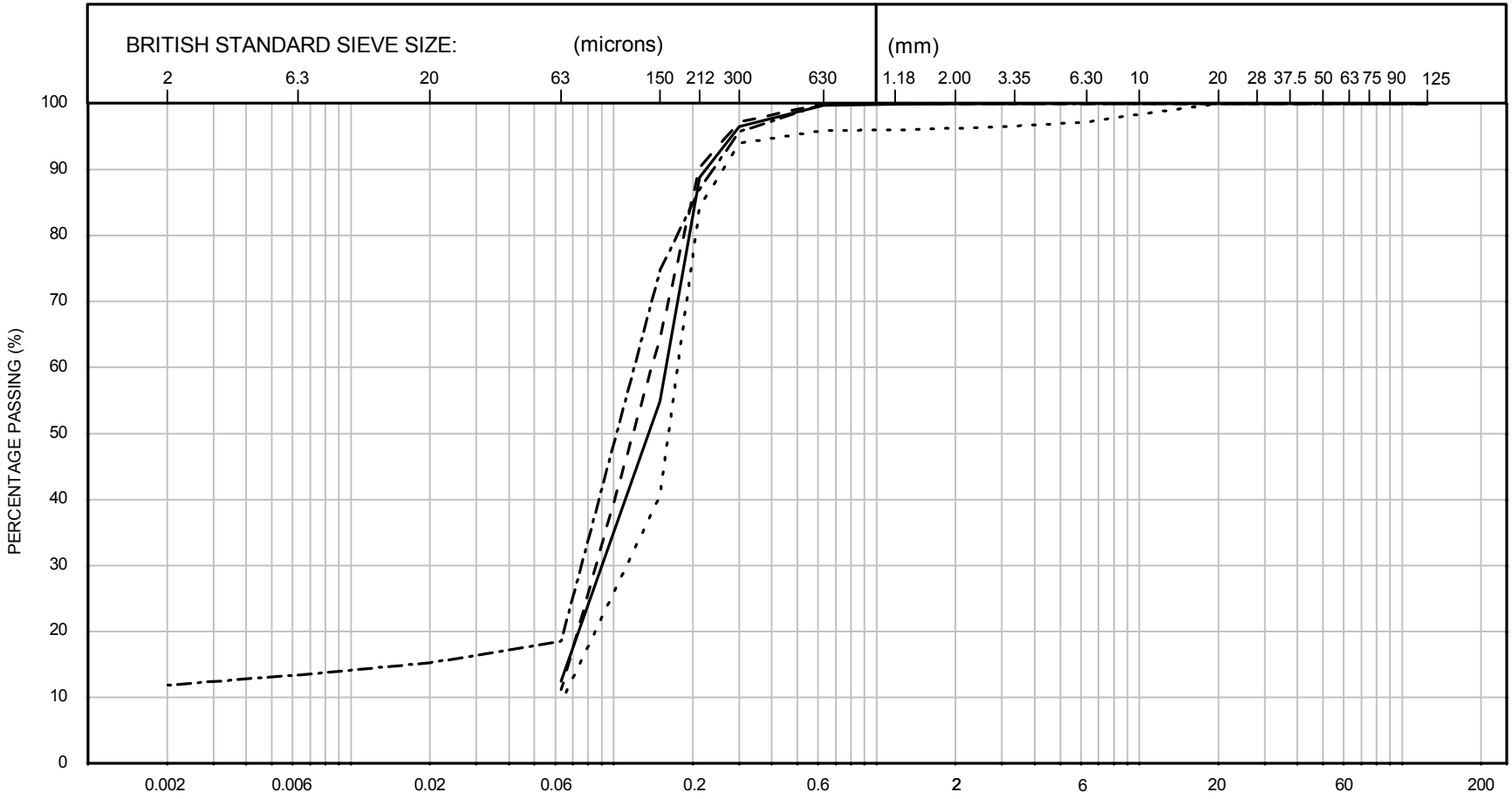
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9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-5	28BagA	14.50	9.2	N/A	0	12	88	0	0
– – –	BH-WFS4-5	29BagA	18.00	9.2	N/A	0	11	89	0	0
· · · ·	BH-WFS4-5	30BagA	22.00	9.2	N/A	0	9	88	3	0
——–	BH-WFS4-5	31BagA	26.00	9.2/9.4	N/A	12	6	82	0	0

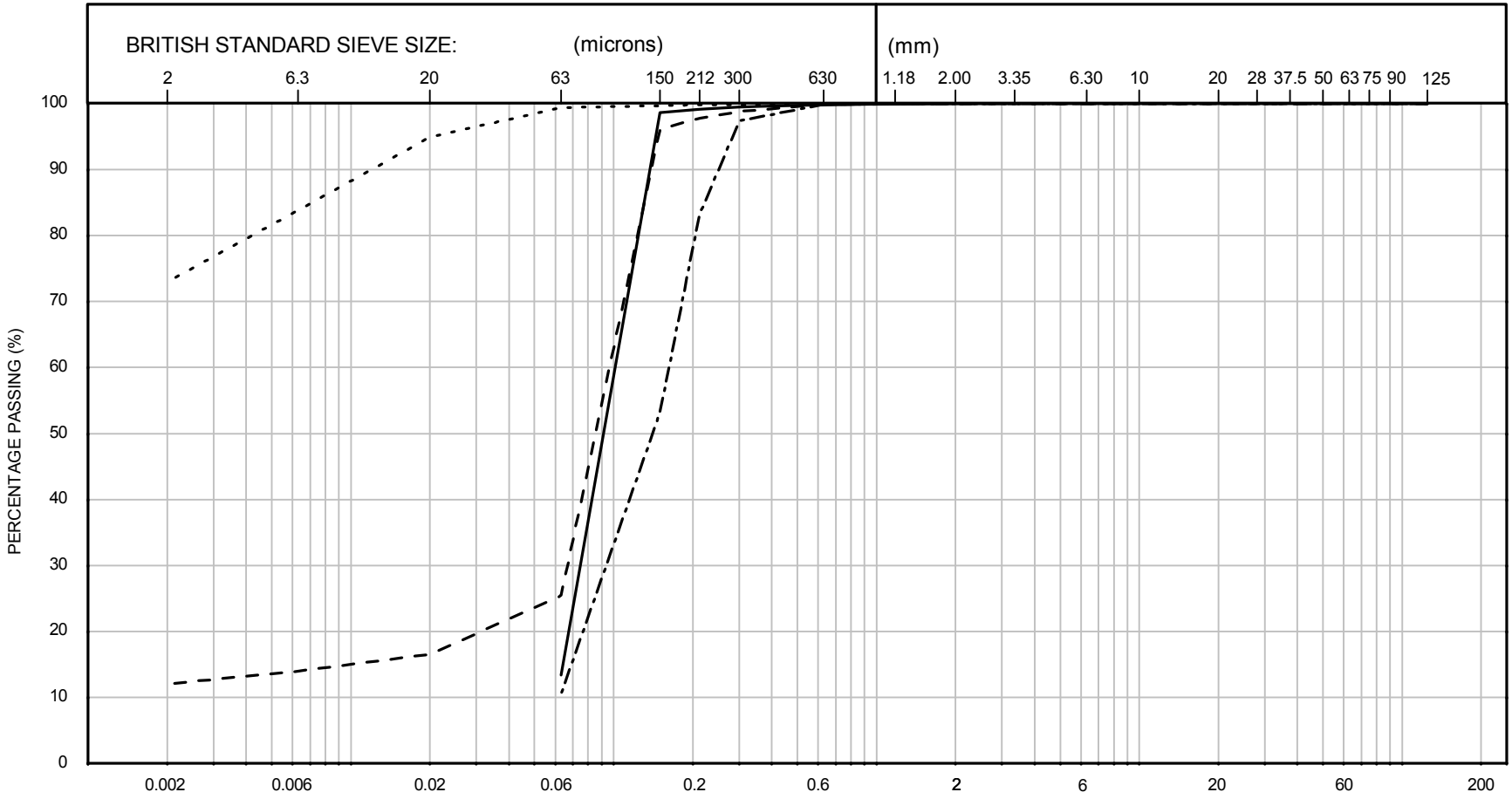
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9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-5	33BagA	34.00	9.2	N/A	0	13	87	0	0
– – –	BH-WFS4-5	35BagA	39.00	9.2/9.4	N/A	12	12	76	0	0
· · · ·	BH-WFS4-5	38BagD	48.45	9.4	N/A	73	26	1	0	0
——·——	BH-WFS4-5	40BagA	52.00	9.2	N/A	0	10	90	0	0

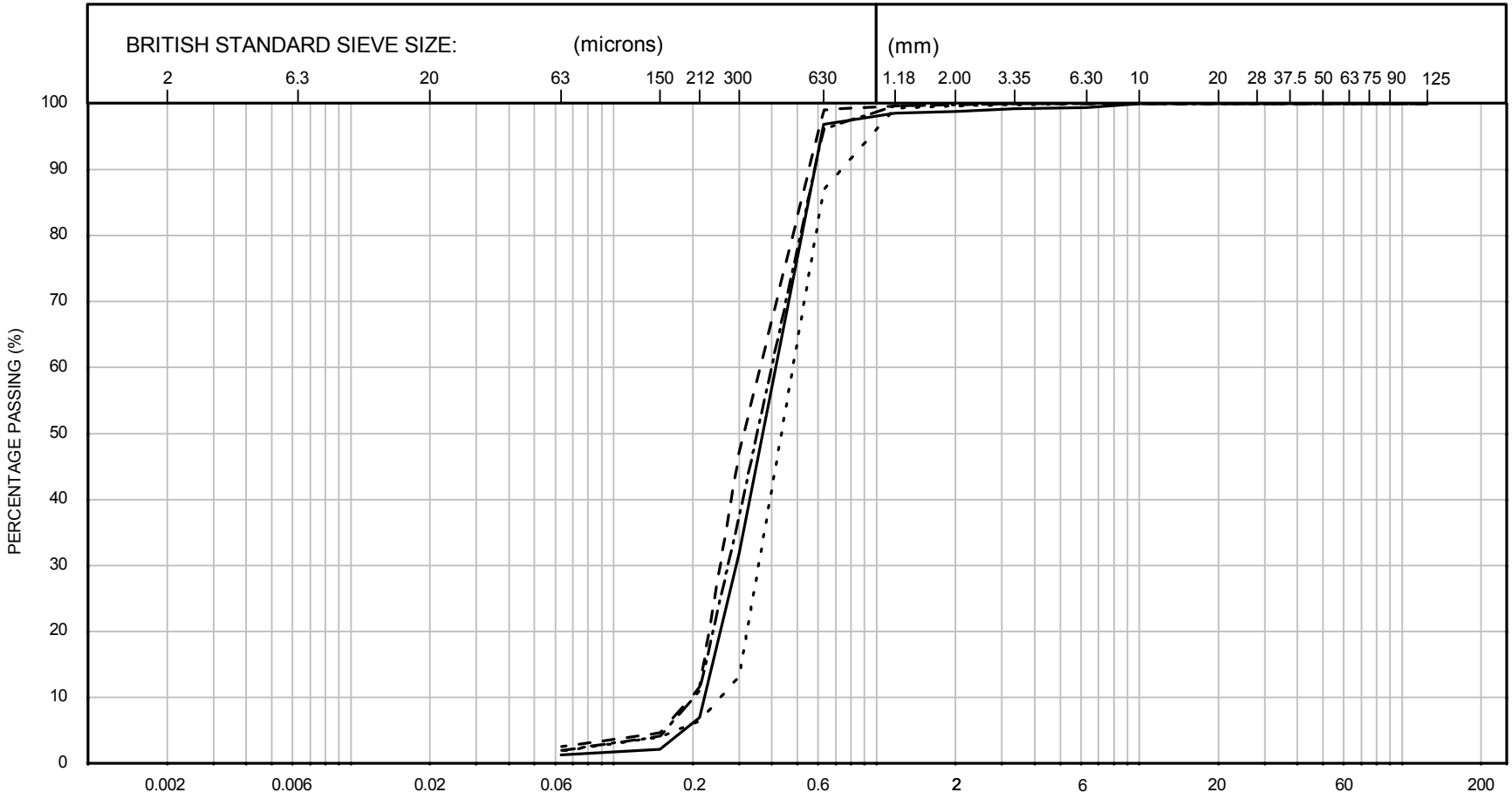
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9.2	Wet sieve
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PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-6	1BagB	0.30	9.2	N/A	0	1	98	1	0
— —	BH-WFS4-6	6BagA	4.00	9.2	N/A	0	2	98	0	0
- - -	BH-WFS4-6	12BagA	8.00	9.2	N/A	0	1	99	0	0
—- —-	BH-WFS4-6	21BagA	12.50	9.2	N/A	0	1	99	0	0

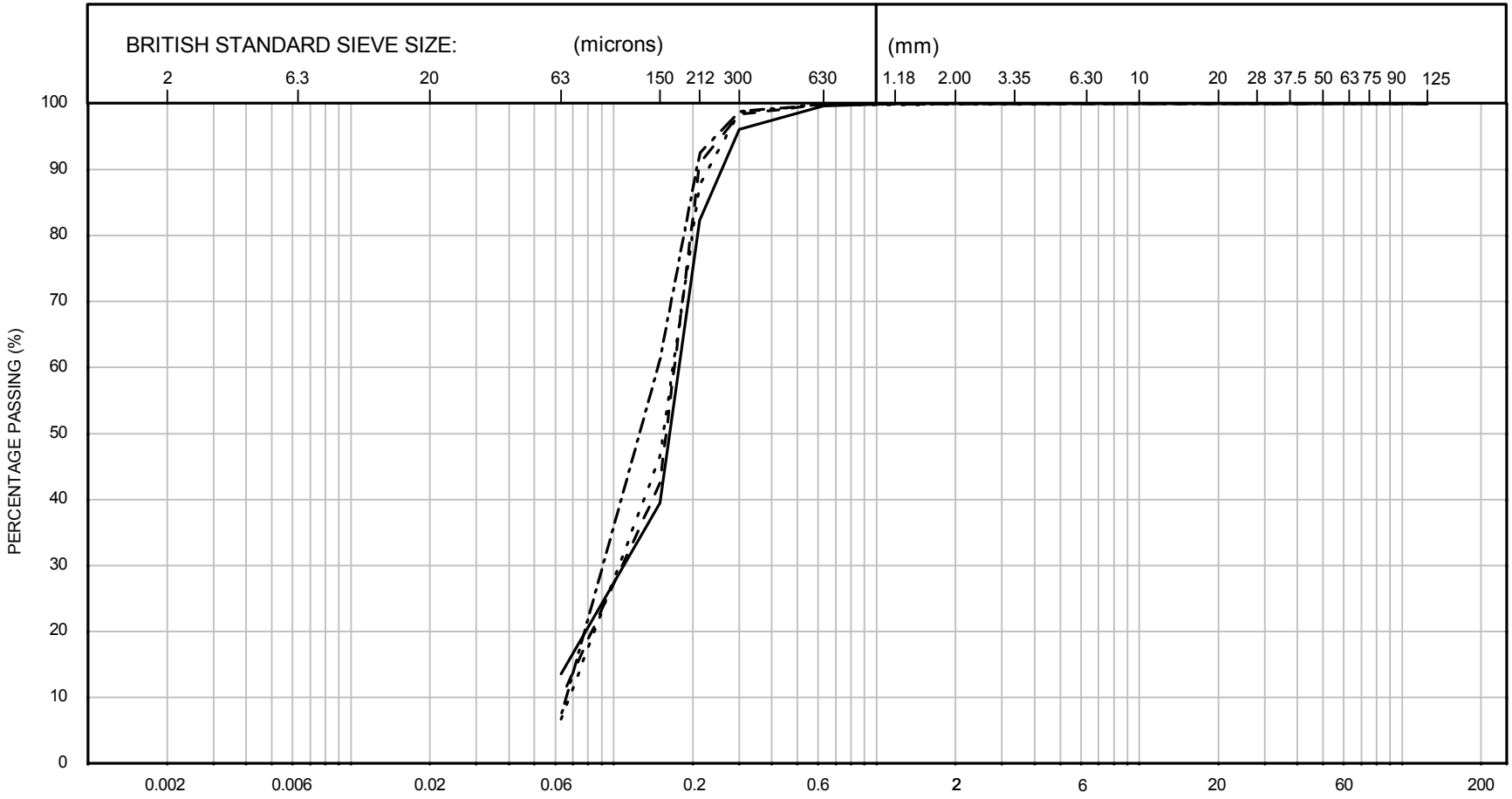
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9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-6	23BagA	13.50	9.2	N/A	0	13	87	0	0
— — —	BH-WFS4-6	25BagA	17.50	9.2	N/A	0	9	91	0	0
- - - -	BH-WFS4-6	27BagA	24.00	9.2	N/A	0	6	94	0	0
— - - —	BH-WFS4-6	28BagA	28.00	9.2	N/A	0	7	93	0	0

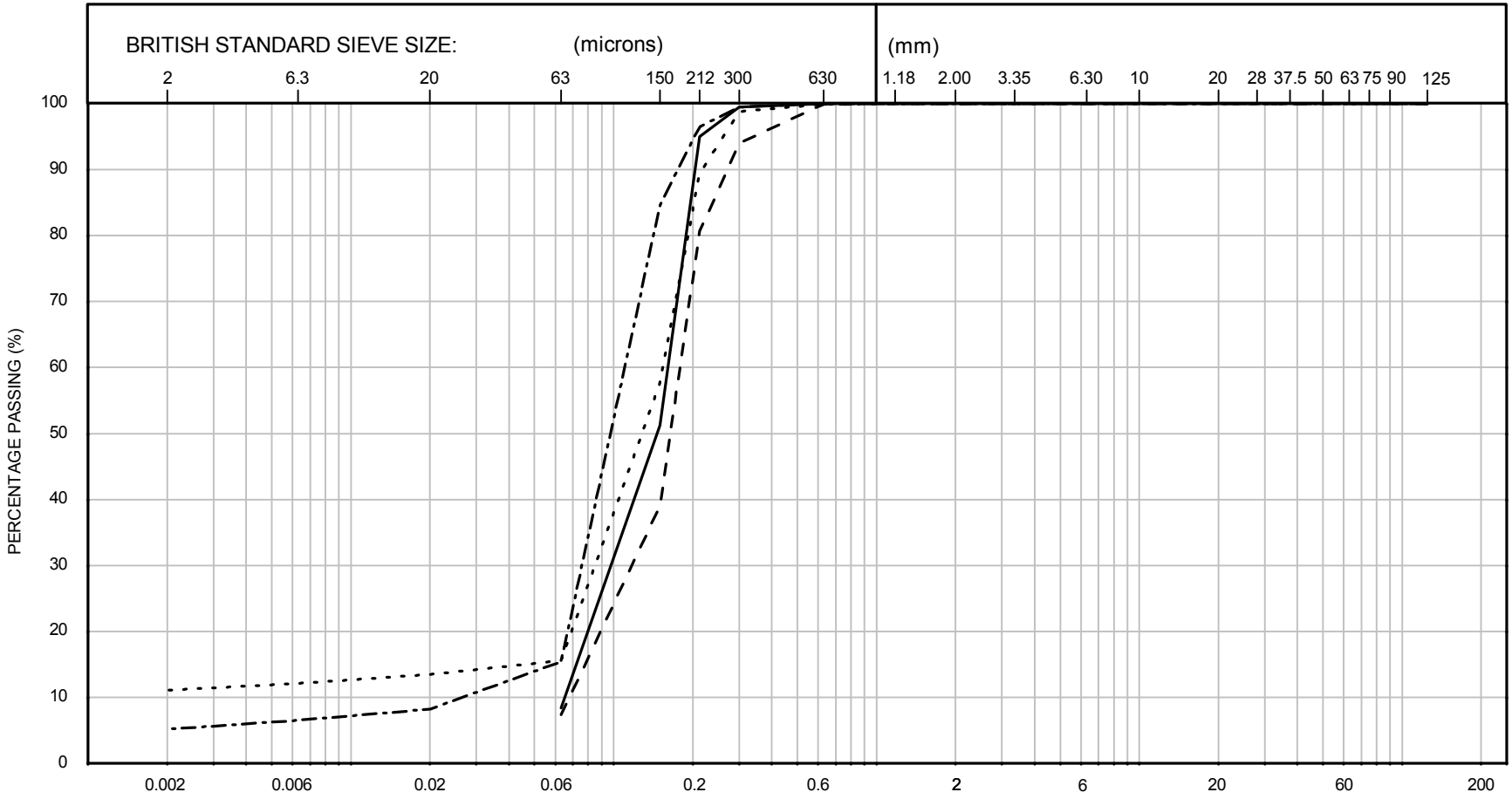
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9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

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PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-6	29BagA	32.00	9.2	N/A	0	8	92	0	0
– – –	BH-WFS4-6	30BagA	36.00	9.2	N/A	0	7	93	0	0
· · · ·	BH-WFS4-6	32BagA	44.00	9.2/9.4	N/A	11	4	85	0	0
– · – ·	BH-WFS4-6	33BagA	48.00	9.2/9.4	N/A	5	9	86	0	0

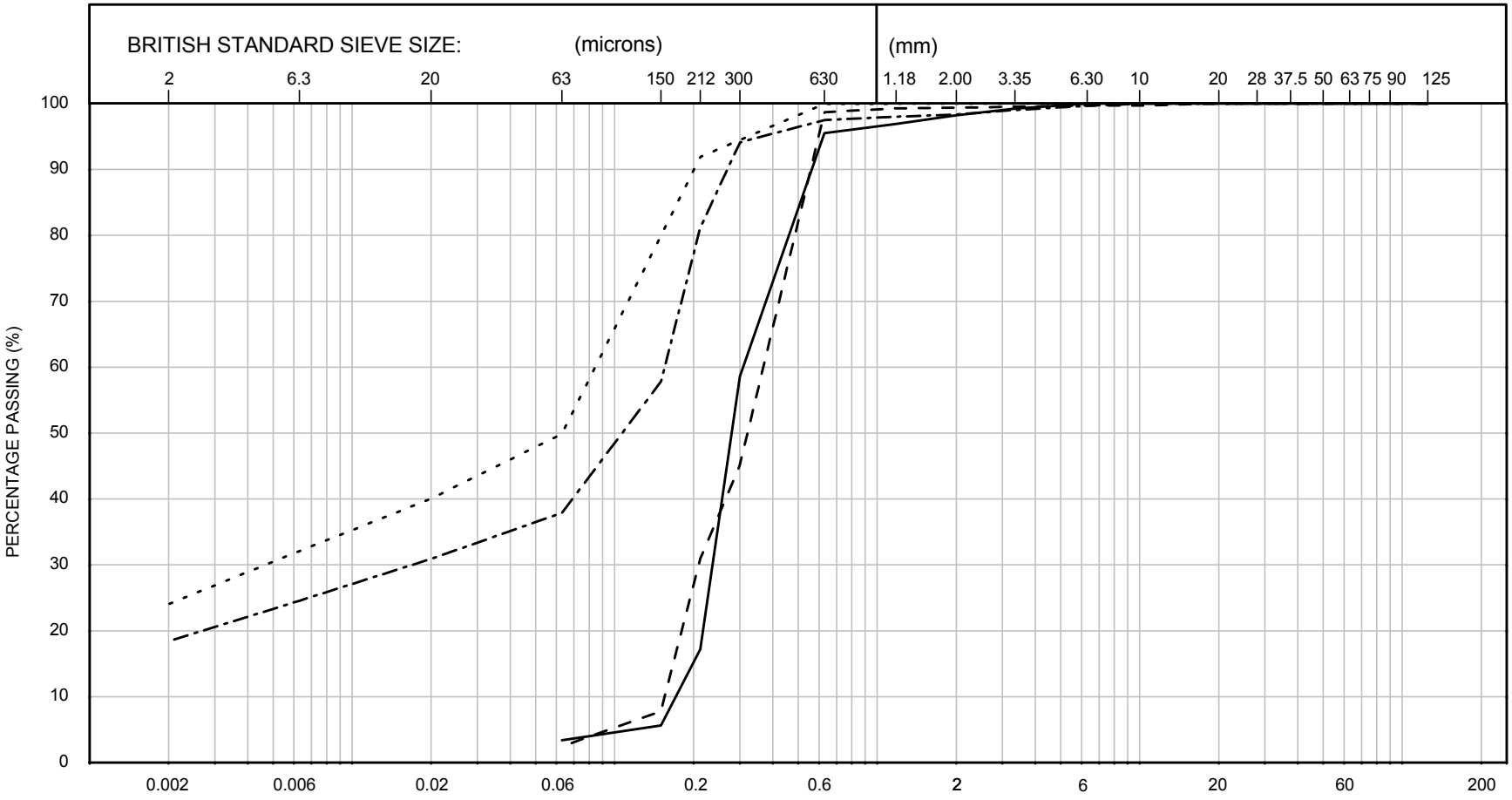
† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-7	1BagB	0.35	9.2	N/A	0	3	96	1	0
– – –	BH-WFS4-7	6BagB	4.75	9.2	N/A	0	2	98	0	0
- - -	BH-WFS4-7	9BagA	7.00	9.4	N/A	24	25	51	0	0
—·—	BH-WFS4-7	11BagB	9.00	9.2/9.4	N/A	18	18	63	1	0

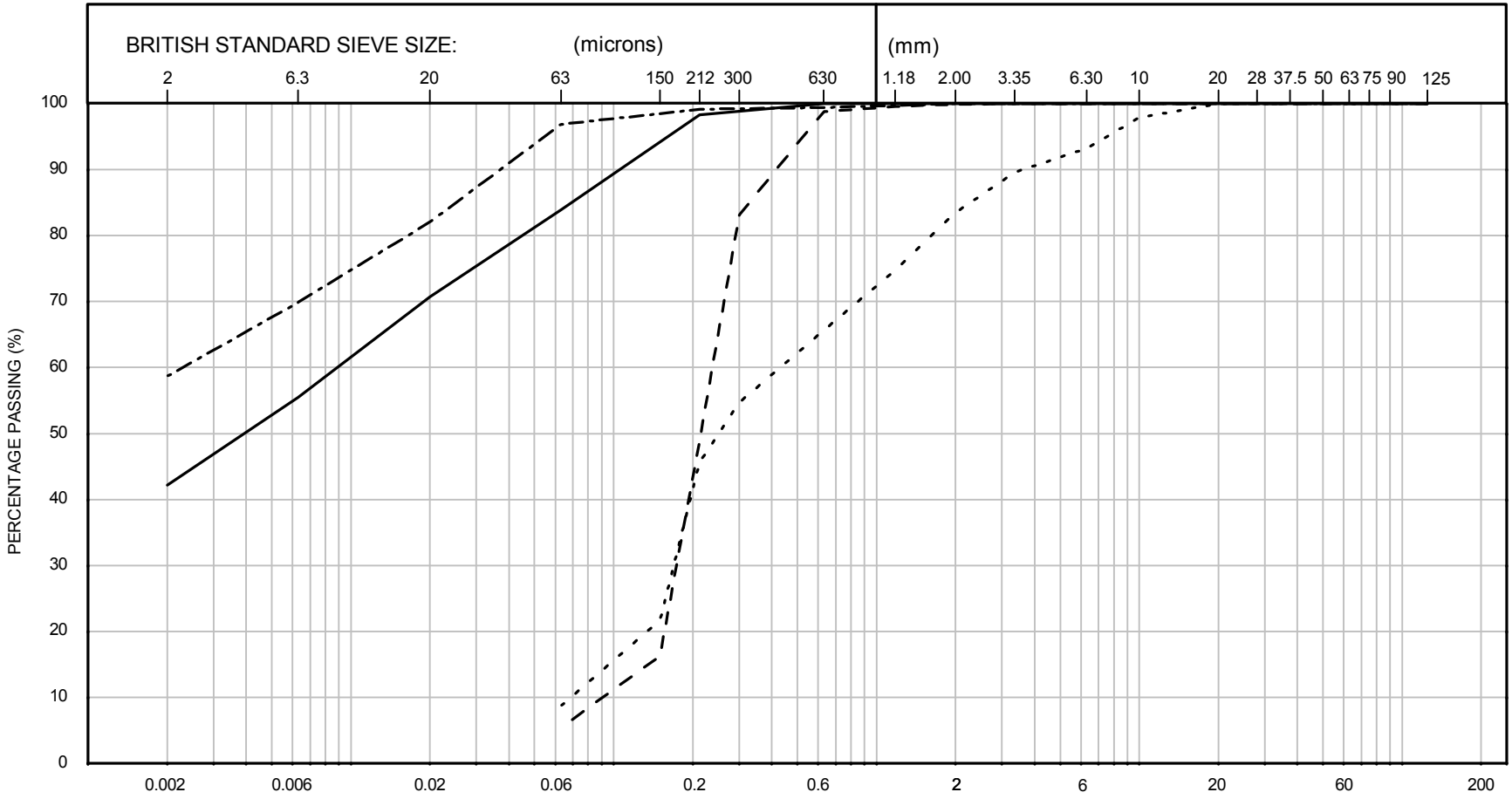
† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	BH-WFS4-7	12WaxD	9.85	9.4	N/A	42	40	18	0	0
– – –	BH-WFS4-7	14BagA	11.00	9.2	N/A	0	5	95	0	0
- - -	BH-WFS4-7	16BagA	12.50	9.2	N/A	0	8	76	16	0
——–	BH-WFS4-7	18BagA	14.50	9.4	N/A	59	37	4	0	0

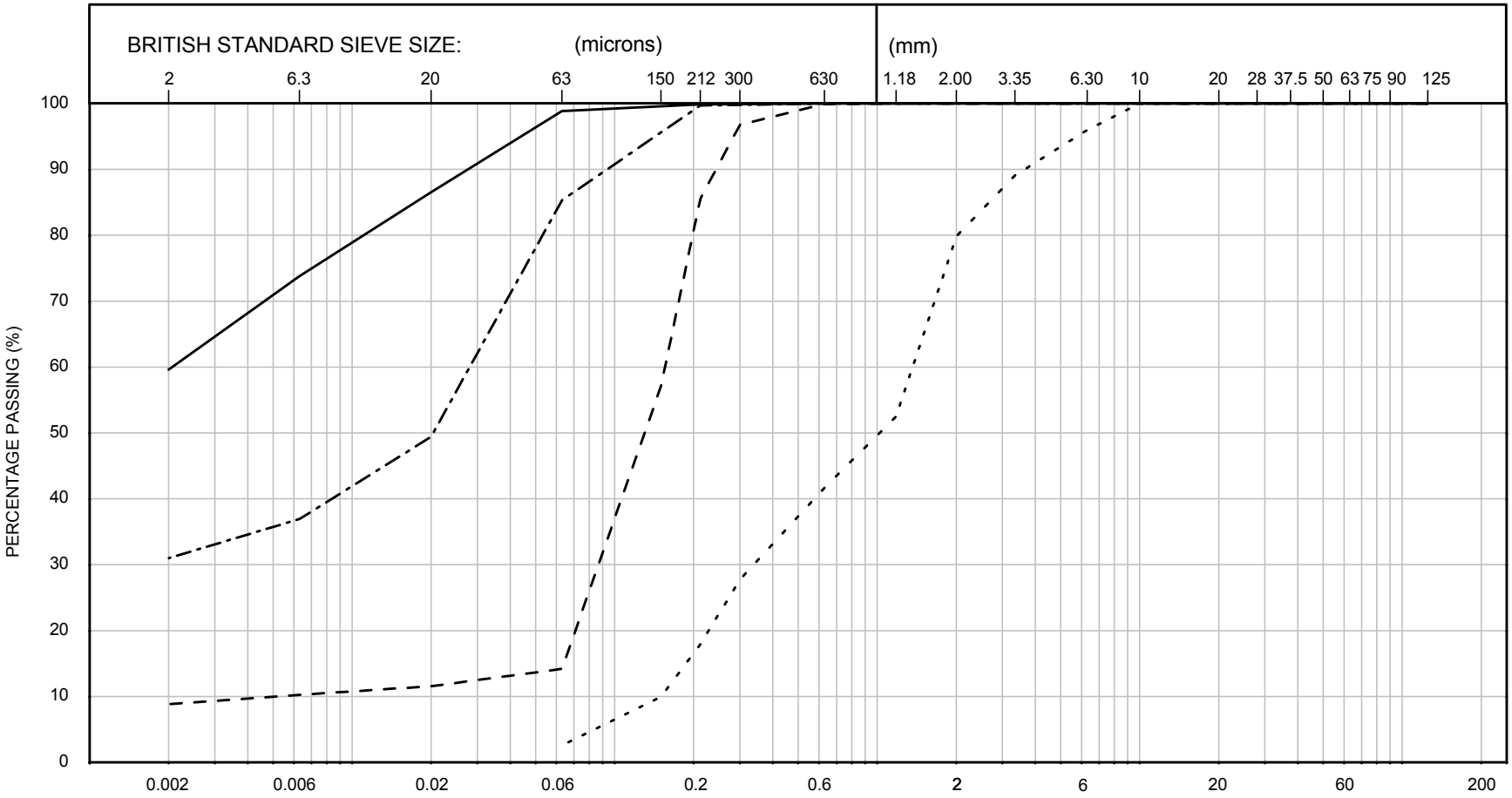
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-7	19BagB	20.90	9.4	N/A	60	38	2	0	0
– – –	BH-WFS4-7	23BagA	27.00	9.2/9.4	N/A	9	5	86	0	0
- - -	BH-WFS4-7	24BagB	31.20	9.2	N/A	0	2	78	20	0
—·—	BH-WFS4-7	25BagA	33.50	9.4	N/A	31	51	18	0	0

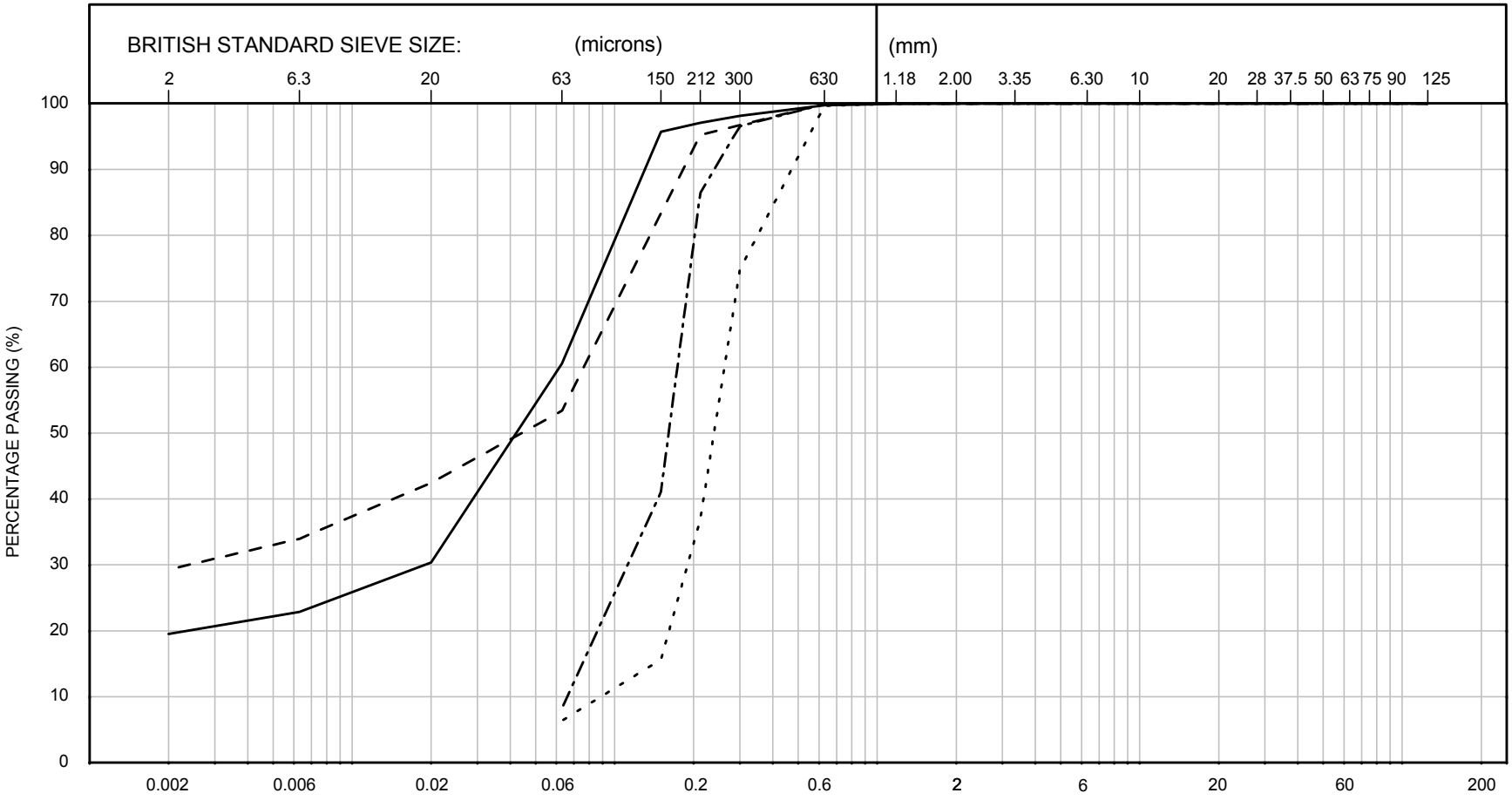
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	BH-WFS4-7	25BagB	33.75	9.2/9.4	N/A	20	38	42	0	0
– –	BH-WFS4-7	26WaxC	34.85	9.4	N/A	29	23	48	0	0
- - -	BH-WFS4-7	27BagB	38.95	9.2	N/A	0	6	94	0	0
—·—	BH-WFS4-7	28BagA	42.50	9.2	N/A	0	8	92	0	0

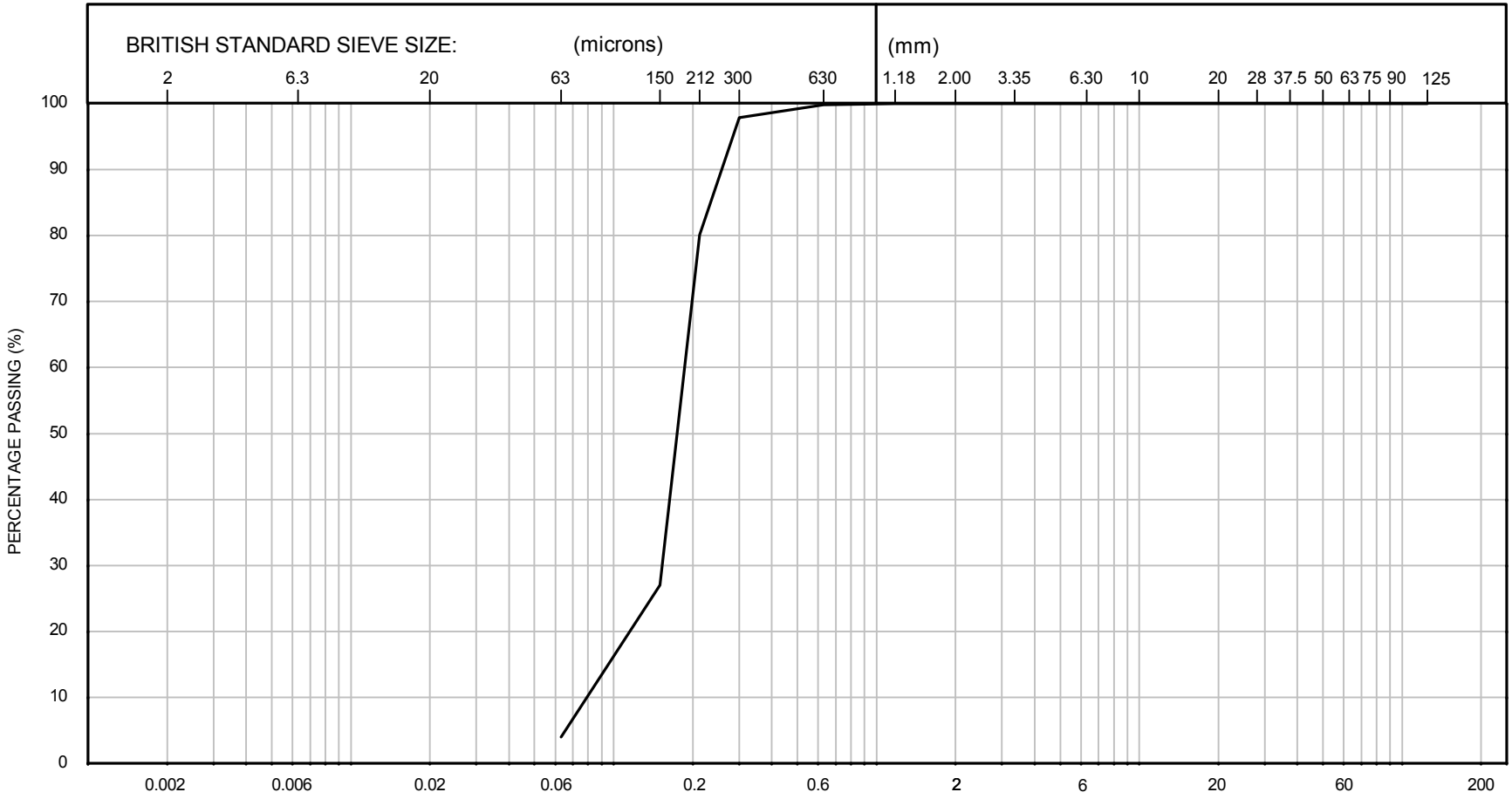
† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
⊢⊣	BH-WFS4-7	29BagA	46.50	9.2	N/A	0	3	97	0	0

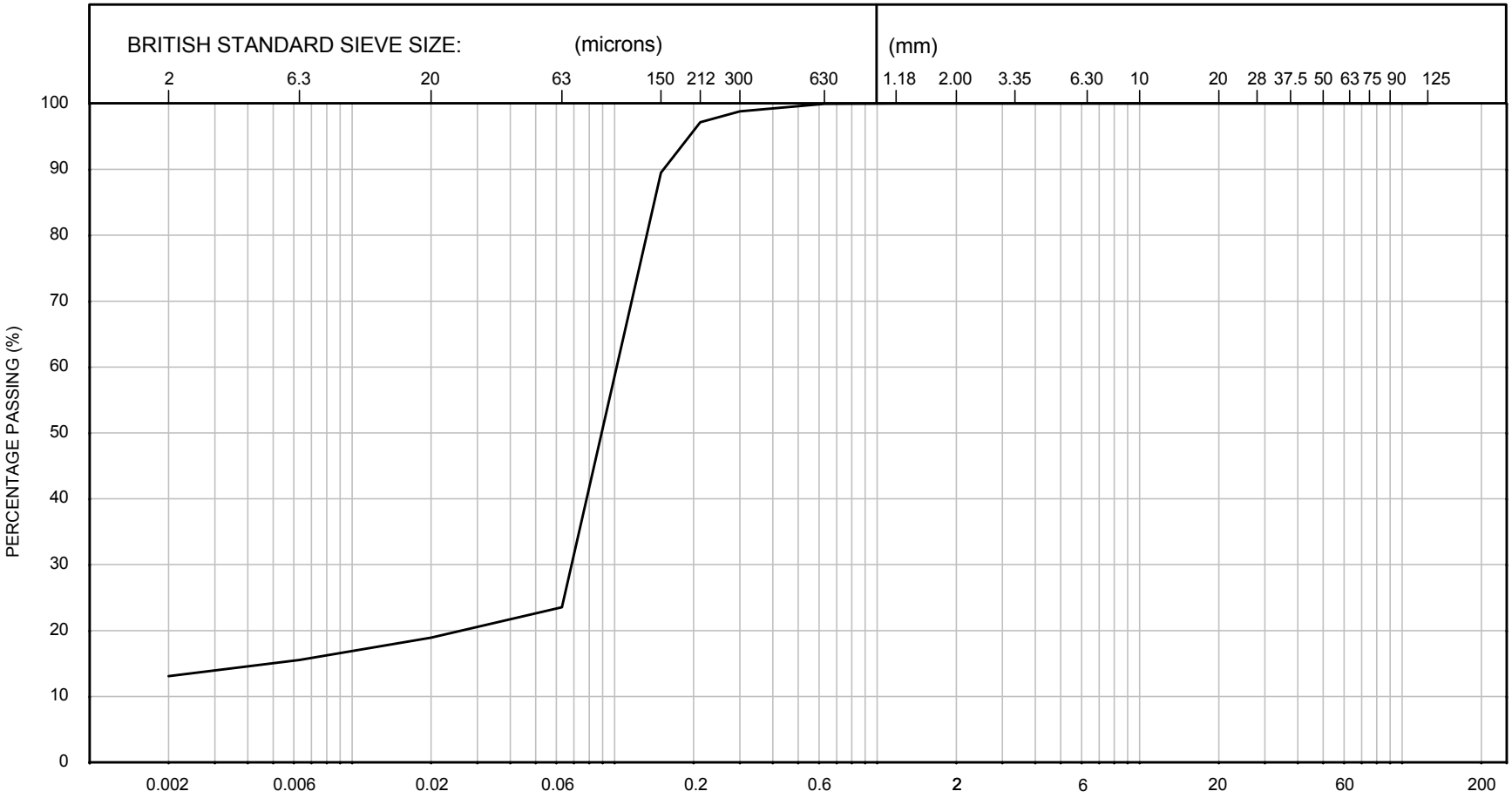
† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



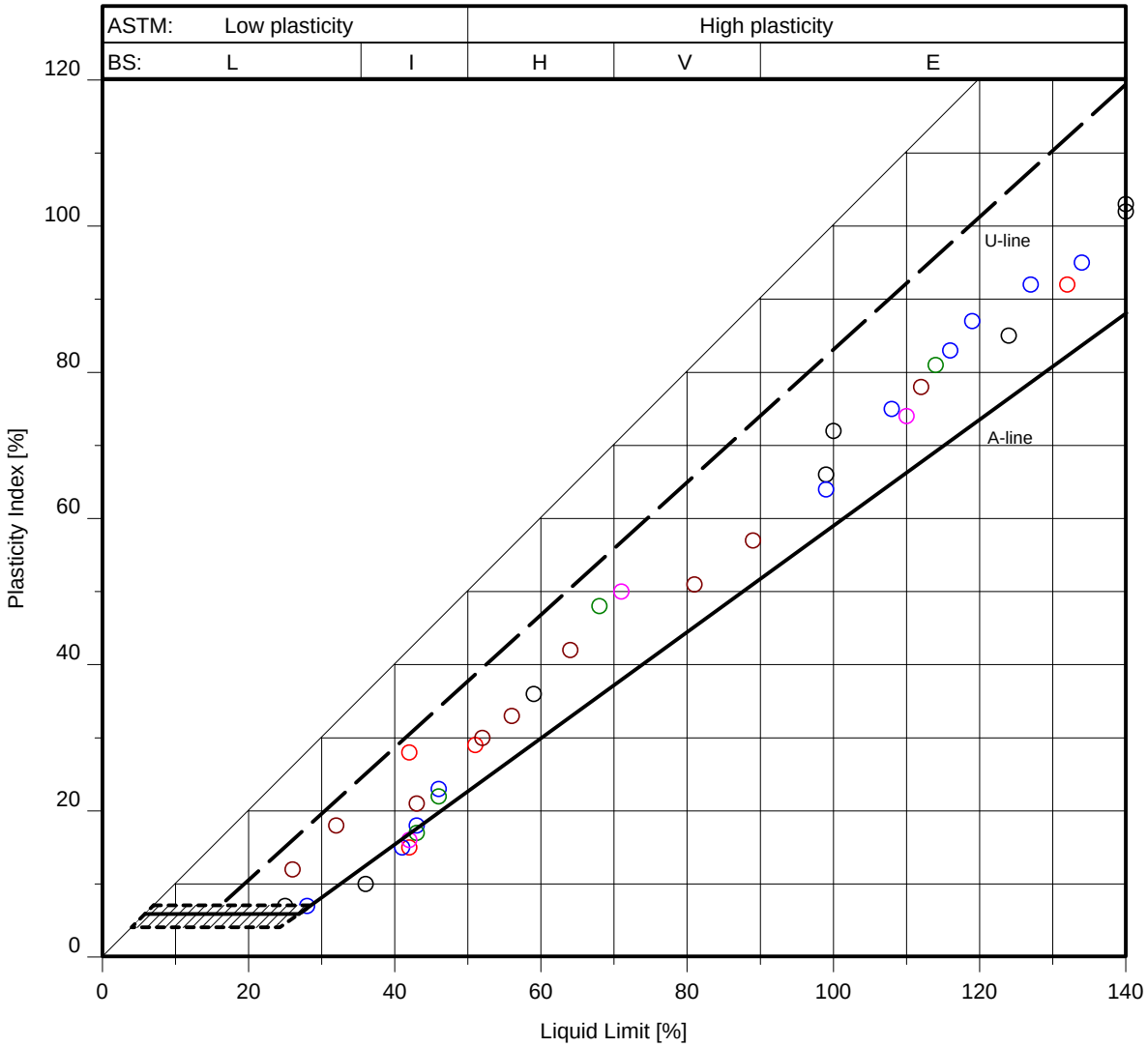
CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
——	CPT-WFS4-18A	1BagB	45.40	9.2/9.4	N/A	13	10	77	0	0

† Note: Where a sedimentation test was not carried out, this figure represents total fines, i.e., particles of diameter less than 63 microns

* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

9.2	Wet sieve
9.3	Dry sieve
9.4	Sedimentation by pipette
9.5	Sedimentation by hydrometer



○	Atterberg limits
▨	ASTM CL-ML zone
L	Low plasticity
I	Intermediate plasticity
H	High plasticity
V	Very high plasticity
E	Extremely high plasticity
BS	British Standard 5930:1999
ASTM	ASTM D2487-11

Location(s):
BH-WFS4-1A
BH-WFS4-2A
BH-WFS4-3
BH-WFS4-4
BH-WFS4-5
BH-WFS4-7

GeODin/Plasticity chart.GLO/2015-12-03 16:12:38

PLASTICITY CHART

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SECTION C3: SAMPLE PHOTOGRAPHS

LIST OF PLATES IN SECTION C3: Plate

Sample Photographs C3-1 to C3-244



Location	:	BH-WFS4-1
Sample	:	WIP01
Depth [m bsf]	:	0.00 to 0.55
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1
Sample	:	WIP01
Depth [m bsf]	:	0.00 to 0.55
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-1
Sample : WIP02
Depth [m bsf] : 1.00 to 1.60
Note(s) : Date on photograph is incorrect. Correct date is 03-10-2015.



Location : BH-WFS4-1
Sample : WIP02
Depth [m bsf] : 1.00 to 1.60
Note(s) : SPLIT
Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-1
Sample : WIP03
Depth [m bsf] : 2.00 to 2.55
Note(s) : Date on photograph is incorrect. Correct date is 03-10-2015.



Location : BH-WFS4-1
Sample : WIP03
Depth [m bsf] : 2.00 to 2.55
Note(s) : SPLIT
Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-1
Sample	:	WIP04
Depth [m bsf]	:	3.00 to 3.35
Note(s)	:	Top 5 cm considered to be cuttings. Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1
Sample	:	WIP04
Depth [m bsf]	:	3.00 to 3.35
Note(s)	:	SPLIT, top 5 cm considered to be cuttings. Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



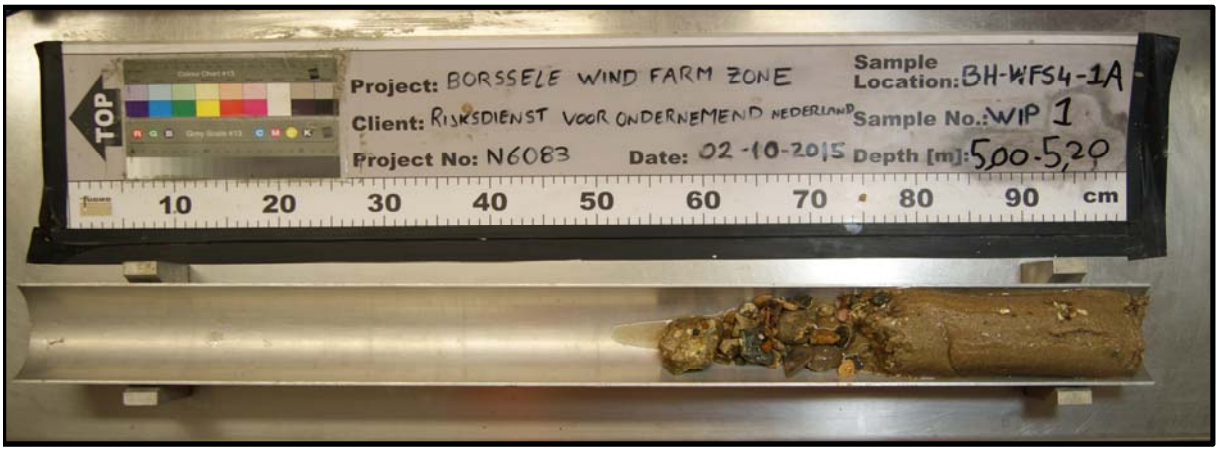
Location : BH-WFS4-1
Sample : WIP05
Depth [m bsf] : 4.00 to 4.60
Note(s) : Date on photograph is incorrect. Correct date is 03-10-2015.



Location : BH-WFS4-1
Sample : WIP05
Depth [m bsf] : 4.00 to 4.60
Note(s) : SPLIT
Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-1A
Sample	:	WIP01
Depth [m bsf]	:	5.00 to 5.20
Note(s)	:	Top 5 cm considered to be cuttings. Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP01
Depth [m bsf]	:	5.00 to 5.20
Note(s)	:	SPLIT, top 5 cm considered to be cuttings. Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-1A
Sample : WIP02
Depth [m bsf] : 6.00 to 6.40
Note(s) : Date on photograph is incorrect. Correct date is 03-10-2015.



Location : BH-WFS4-1A
Sample : WIP02
Depth [m bsf] : 6.00 to 6.40
Note(s) : SPLIT
Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-1A
Sample : WIP03
Depth [m bsf] : 6.50 to 7.05
Note(s) : Date on photograph is incorrect. Correct date is 03-10-2015.



Location : BH-WFS4-1A
Sample : WIP03
Depth [m bsf] : 6.50 to 7.05
Note(s) : SPLIT
Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



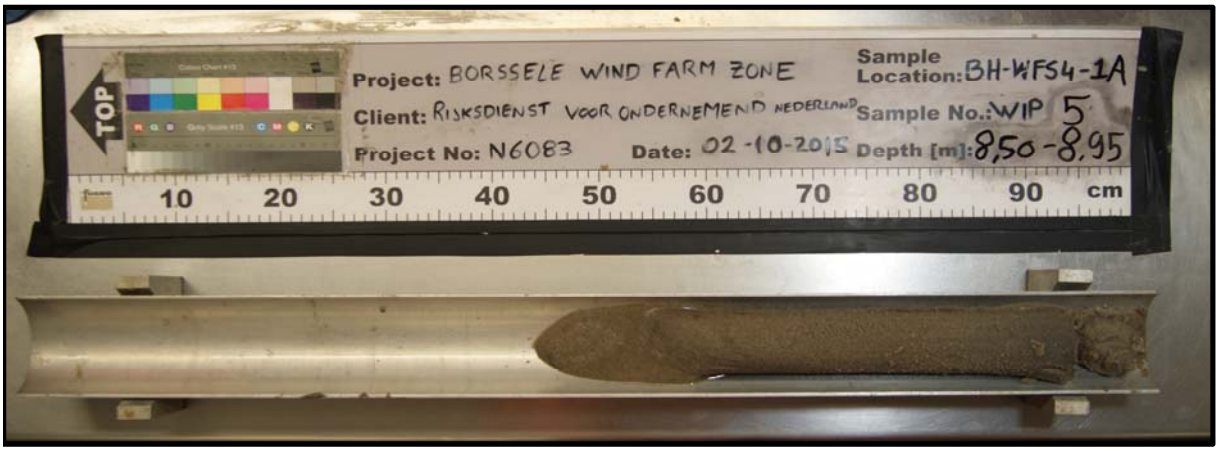
Location	:	BH-WFS4-1A
Sample	:	WIP04
Depth [m bsf]	:	7.50 to 8.05
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.

Missing Photograph

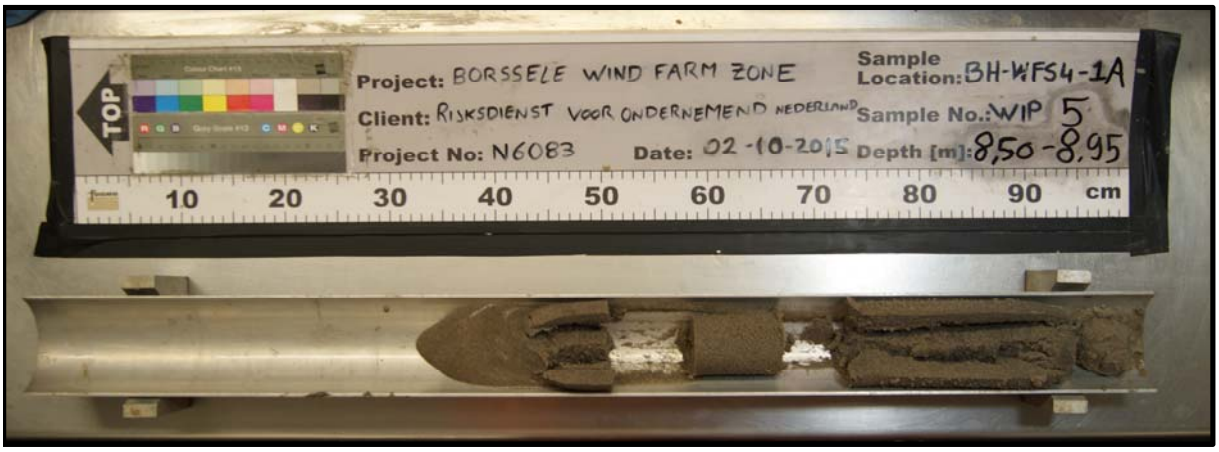
Location	:	BH-WFS4-1A
Sample	:	WIP04
Depth [m bsf]	:	7.50 to 8.05
Note(s)	:	SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-1A
Sample	:	WIP05
Depth [m bsf]	:	8.50 to 8.95
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP05
Depth [m bsf]	:	8.50 to 8.95
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



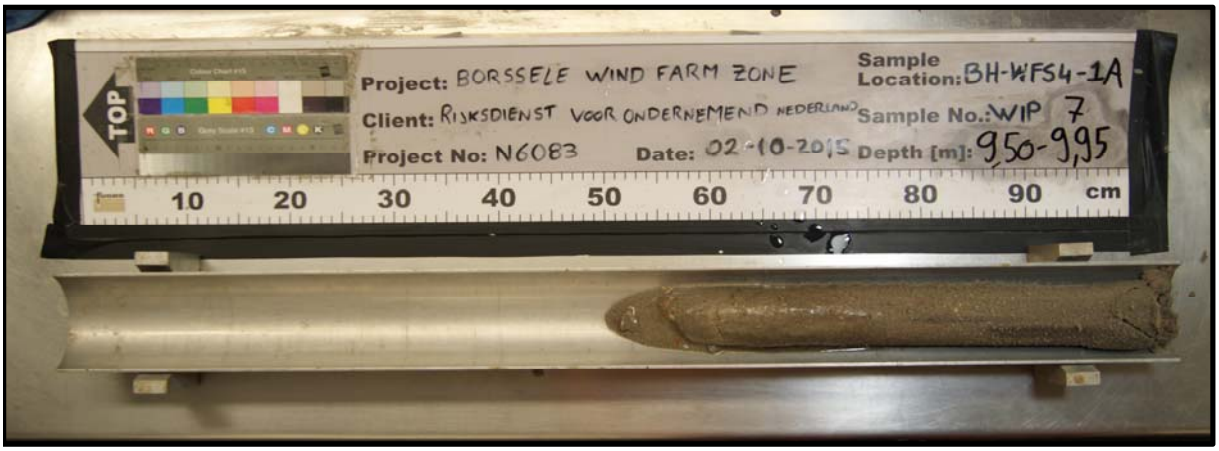
Location	:	BH-WFS4-1A
Sample	:	WIP06
Depth [m bsf]	:	9.00 to 9.45
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP06
Depth [m bsf]	:	9.00 to 9.45
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-1A
Sample	:	WIP07
Depth [m bsf]	:	9.50 to 9.95
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



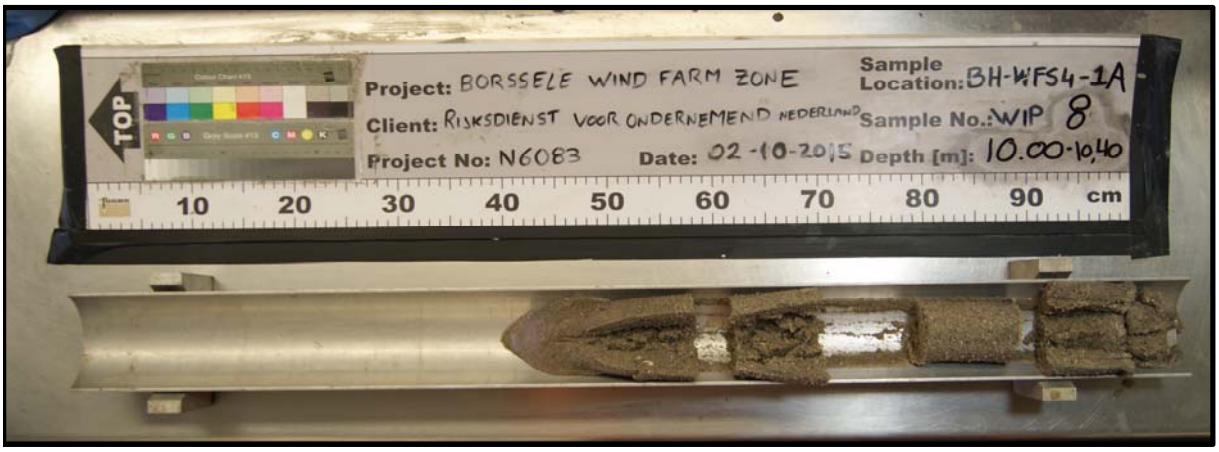
Location	:	BH-WFS4-1A
Sample	:	WIP07
Depth [m bsf]	:	9.50 to 9.95
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-1A
Sample : WIP08
Depth [m bsf] : 10.00 to 10.40
Note(s) : Date on photograph is incorrect. Correct date is 03-10-2015.



Location : BH-WFS4-1A
Sample : WIP08
Depth [m bsf] : 10.00 to 10.40
Note(s) : SPLIT
Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-1A
Sample	:	WIP09
Depth [m bsf]	:	10.50 to 10.95
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP09
Depth [m bsf]	:	10.50 to 10.95
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

Location	:	BH-WFS4-1A
Sample	:	WIP10
Depth [m bsf]	:	11.00 to 11.45
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-1A
Sample	:	WIP10
Depth [m bsf]	:	11.00 to 11.45
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

Location	:	BH-WFS4-1A
Sample	:	WIP11
Depth [m bsf]	:	11.50 to 11.90
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-1A
Sample	:	WIP11
Depth [m bsf]	:	11.50 to 11.90
Note(s)	:	SPLIT, laboratory unit weight tool left in sample. Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-1A
Sample	:	WIP12
Depth [m bsf]	:	12.00 to 12.40
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



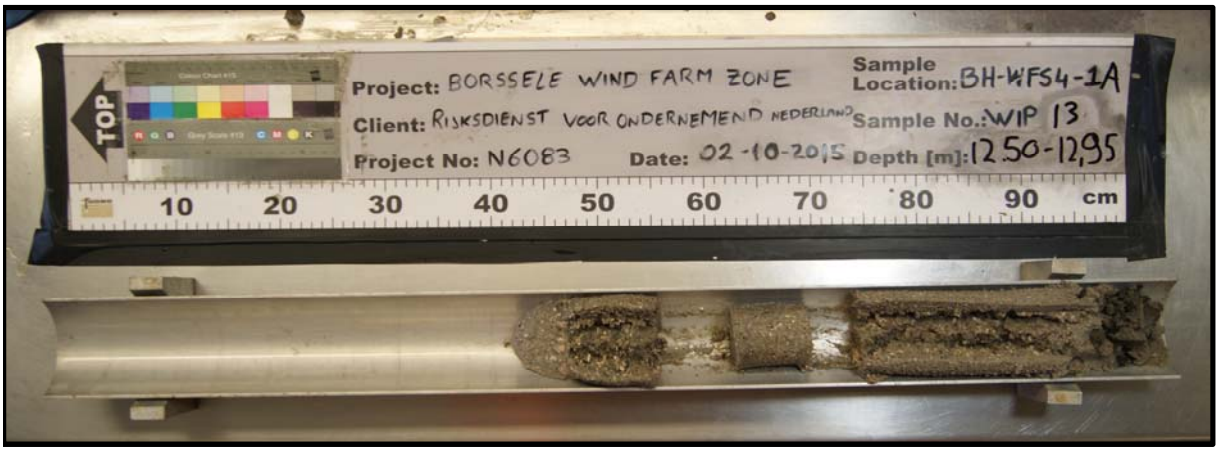
Location	:	BH-WFS4-1A
Sample	:	WIP12
Depth [m bsf]	:	12.00 to 12.40
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



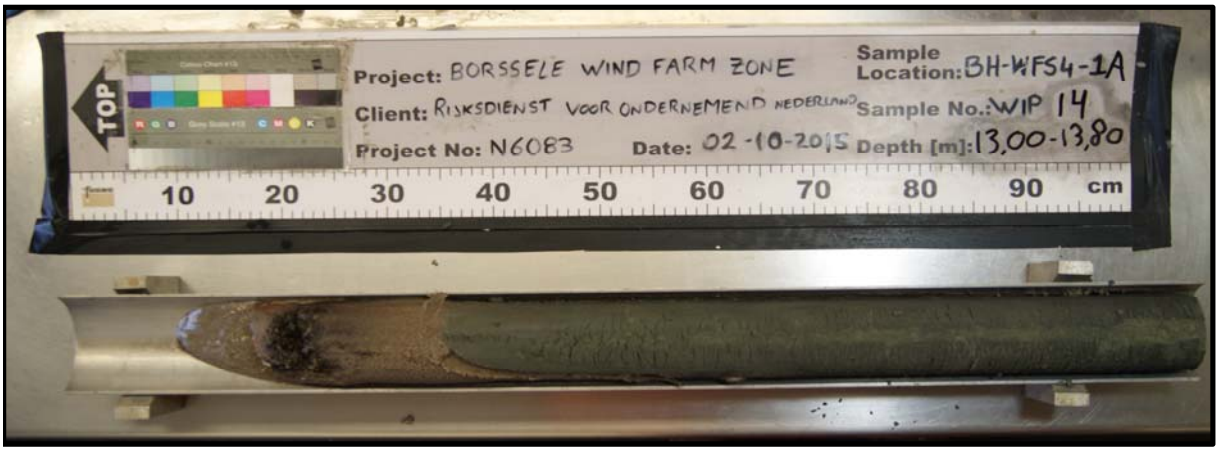
Location	:	BH-WFS4-1A
Sample	:	WIP13
Depth [m bsf]	:	12.50 to 12.95
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP13
Depth [m bsf]	:	12.50 to 12.95
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



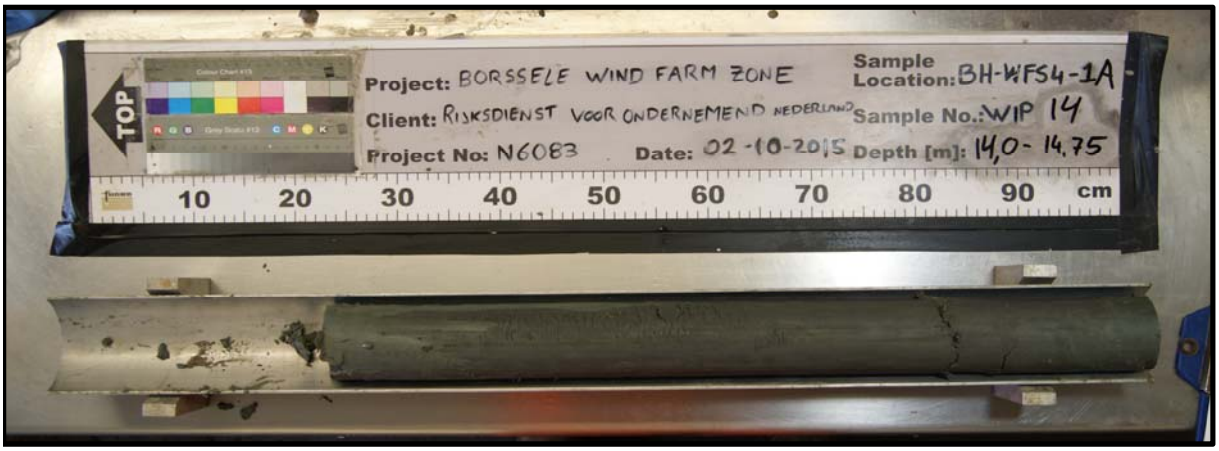
Location	:	BH-WFS4-1A
Sample	:	WIP14
Depth [m bsf]	:	13.00 to 13.80
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP14
Depth [m bsf]	:	13.00 to 13.80
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



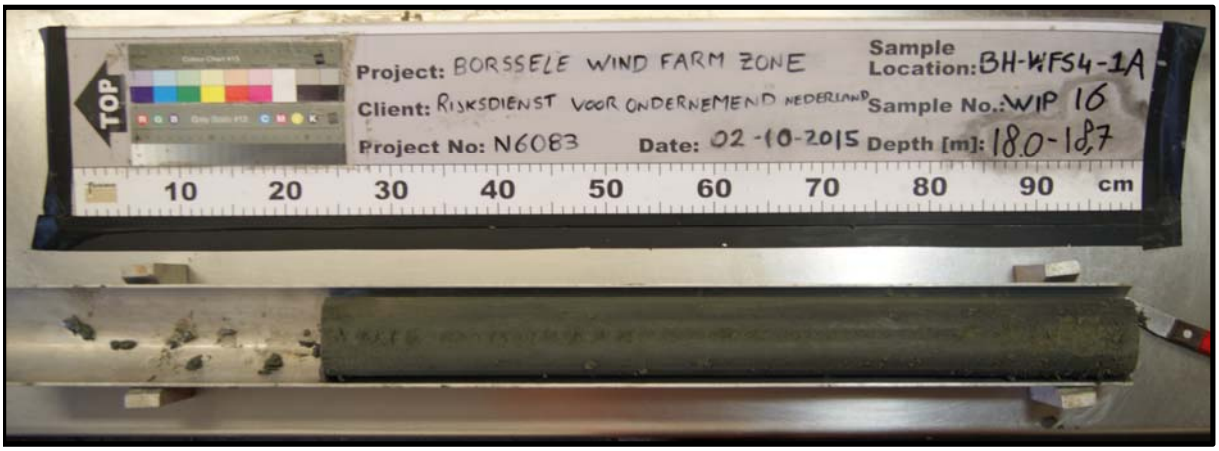
Location	:	BH-WFS4-1A
Sample	:	WIP15
Depth [m bsf]	:	14.00 to 14.75
Note(s)	:	Incorrect sample number on photograph Date on photograph is incorrect. Correct date is 03-10-2015.



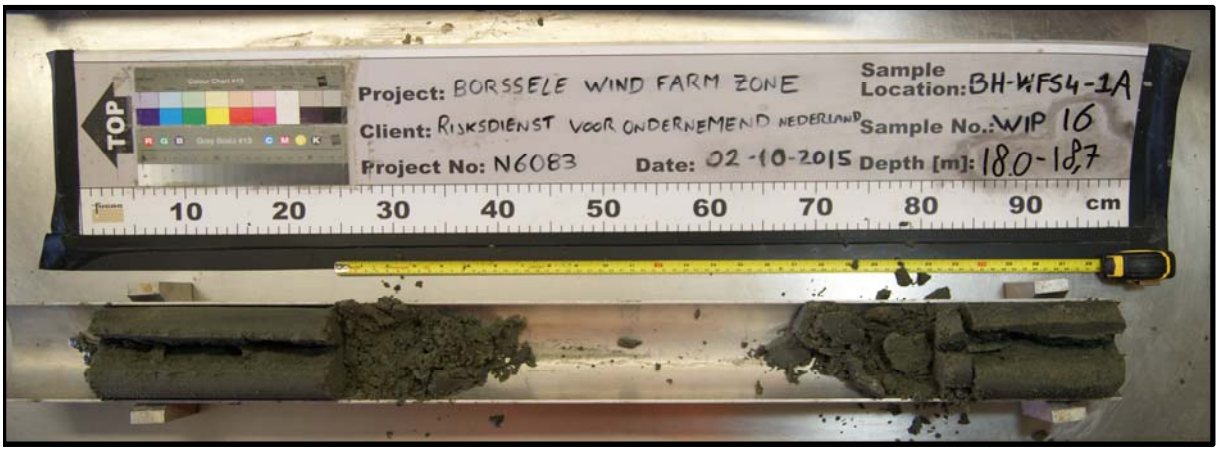
Location	:	BH-WFS4-1A
Sample	:	WIP15
Depth [m bsf]	:	14.00 to 14.75
Note(s)	:	SPLIT, incorrect sample number on photograph Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



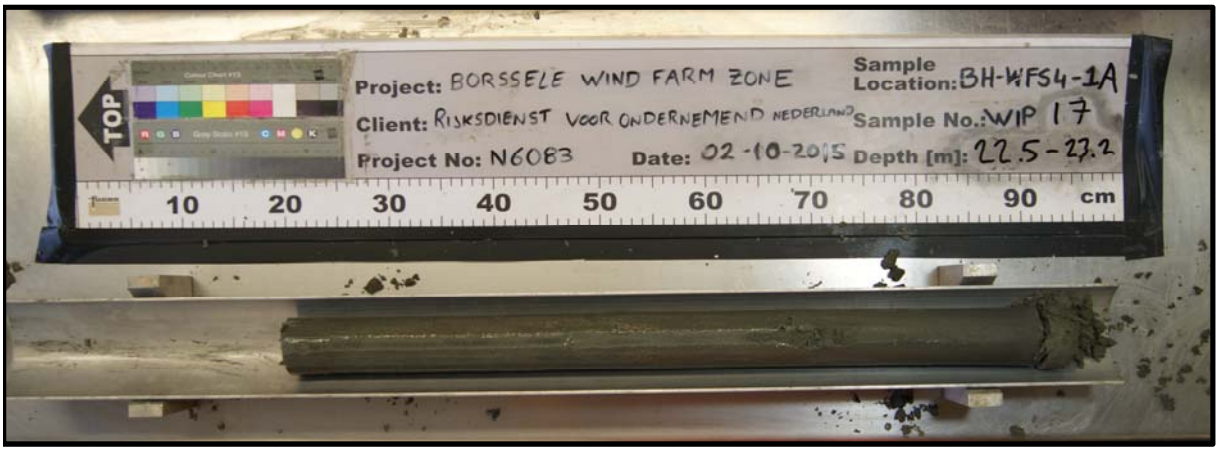
Location	:	BH-WFS4-1A
Sample	:	WIP16
Depth [m bsf]	:	18.00 to 18.70
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP16
Depth [m bsf]	:	18.00 to 18.70
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



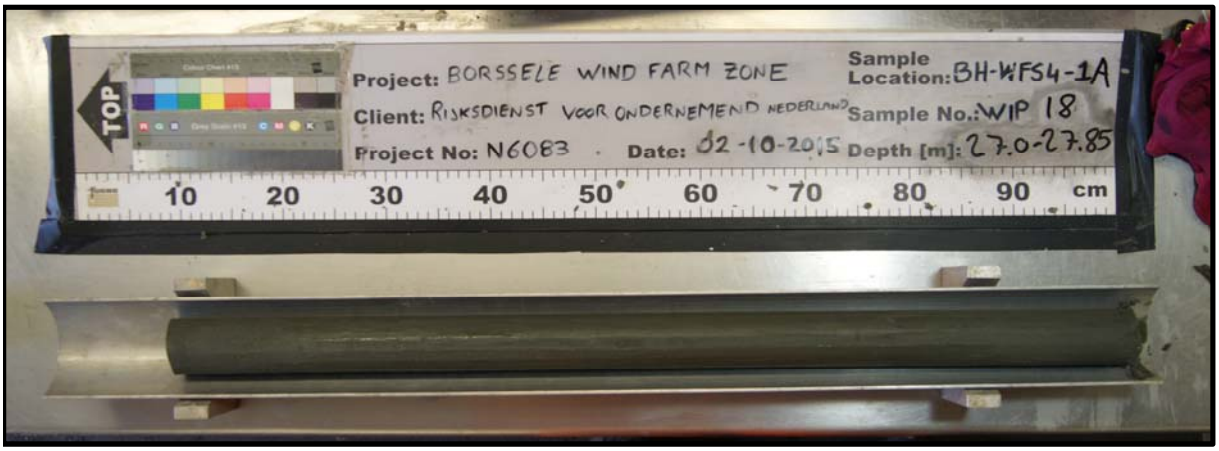
Location	:	BH-WFS4-1A
Sample	:	WIP17
Depth [m bsf]	:	22.50 to 23.72
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



Location	:	BH-WFS4-1A
Sample	:	WIP17
Depth [m bsf]	:	22.50 to 23.72
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-1A
Sample : WIP18
Depth [m bsf] : 27.00 to 27.85
Note(s) : Date on photograph is incorrect. Correct date is 03-10-2015.



Location : BH-WFS4-1A
Sample : WIP18
Depth [m bsf] : 27.00 to 27.85
Note(s) : SPLIT
Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-1A
Sample	:	WIP19
Depth [m bsf]	:	28.00 to 28.60
Note(s)	:	Date on photograph is incorrect. Correct date is 03-10-2015.



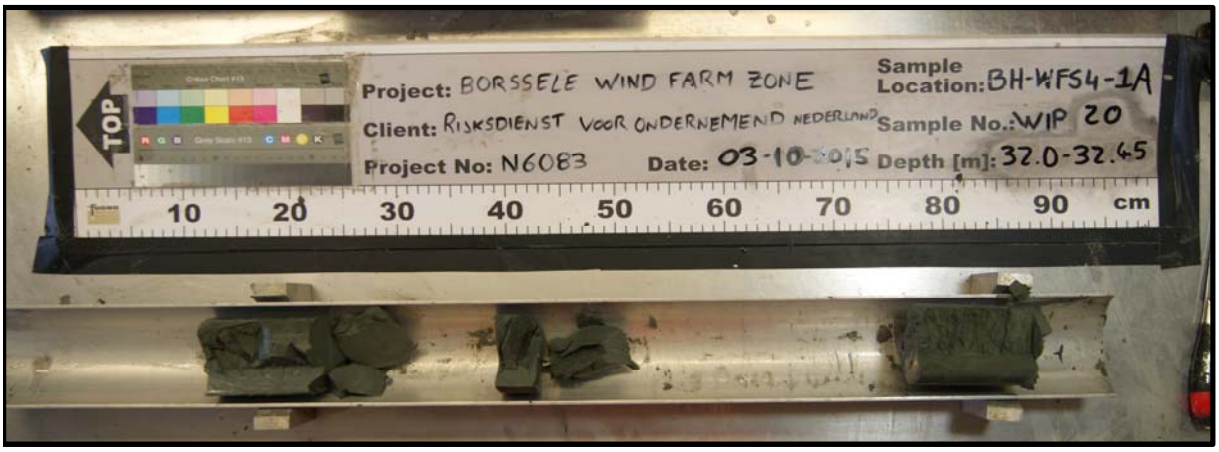
Location	:	BH-WFS4-1A
Sample	:	WIP19
Depth [m bsf]	:	28.00 to 28.60
Note(s)	:	SPLIT Date on photograph is incorrect. Correct date is 03-10-2015.

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



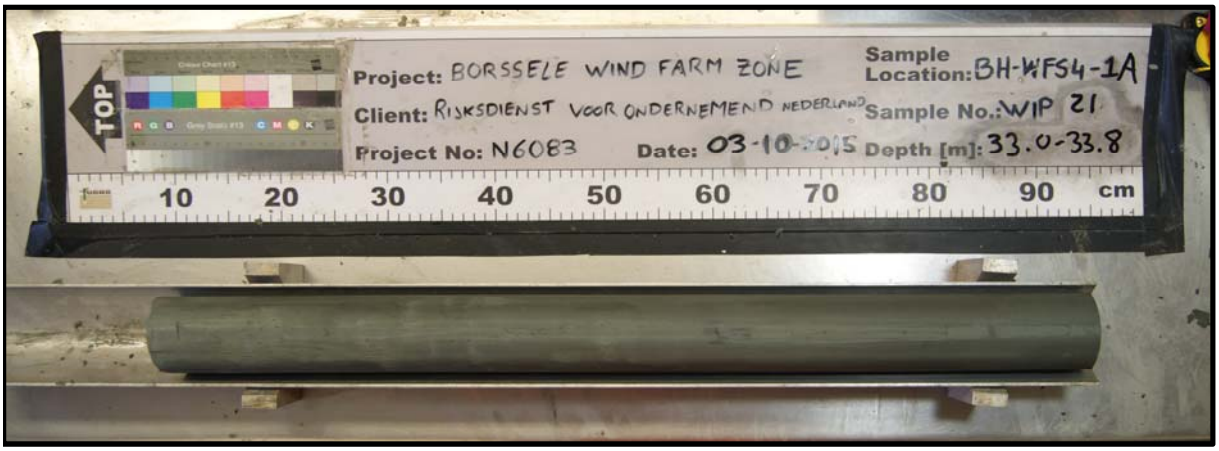
Location : BH-WFS4-1A
Sample : WIP20
Depth [m bsf] : 32.00 to 32.45



Location : BH-WFS4-1A
Sample : WIP20
Depth [m bsf] : 32.00 to 32.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



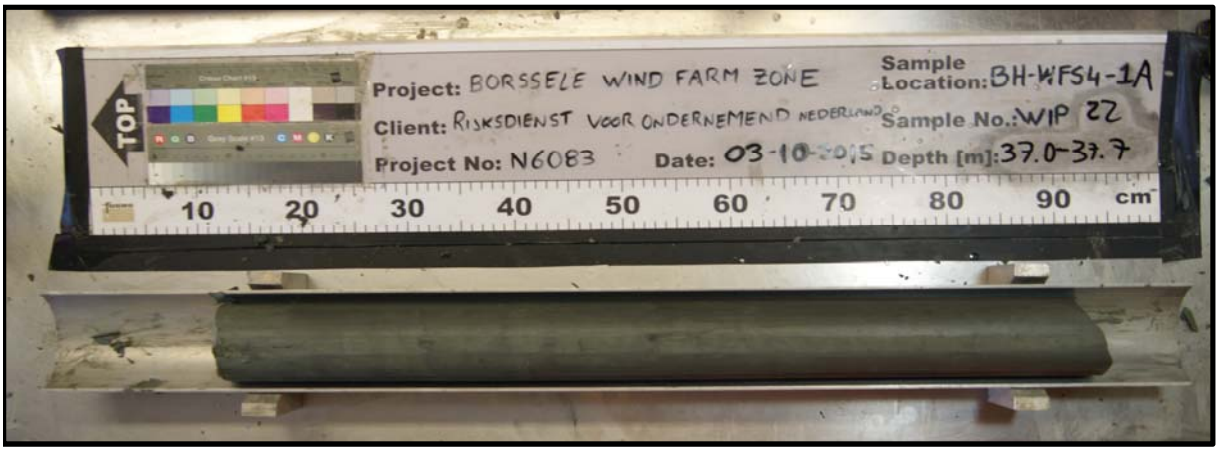
Location : BH-WFS4-1A
Sample : WIP21
Depth [m bsf] : 33.00 to 33.80



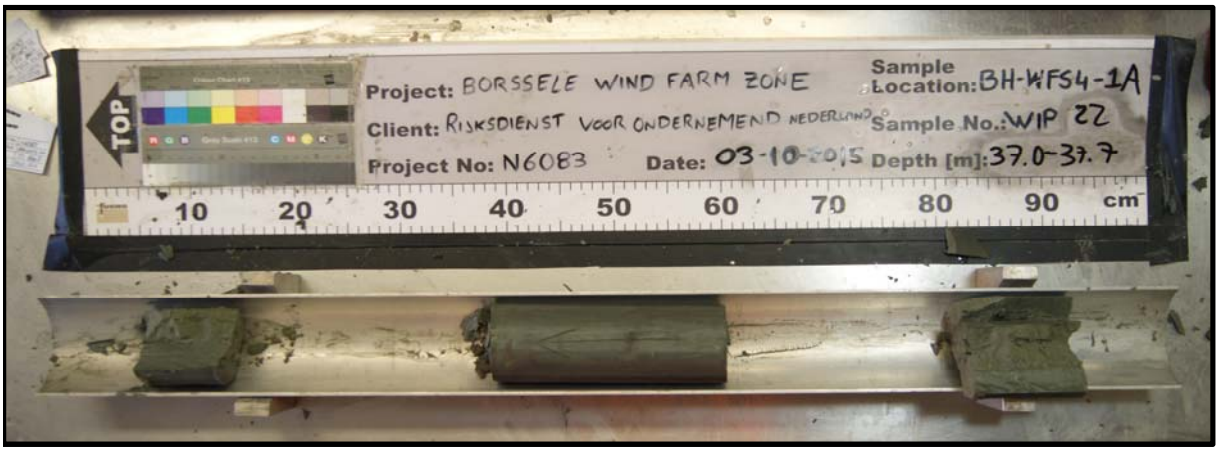
Location : BH-WFS4-1A
Sample : WIP21
Depth [m bsf] : 33.00 to 33.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



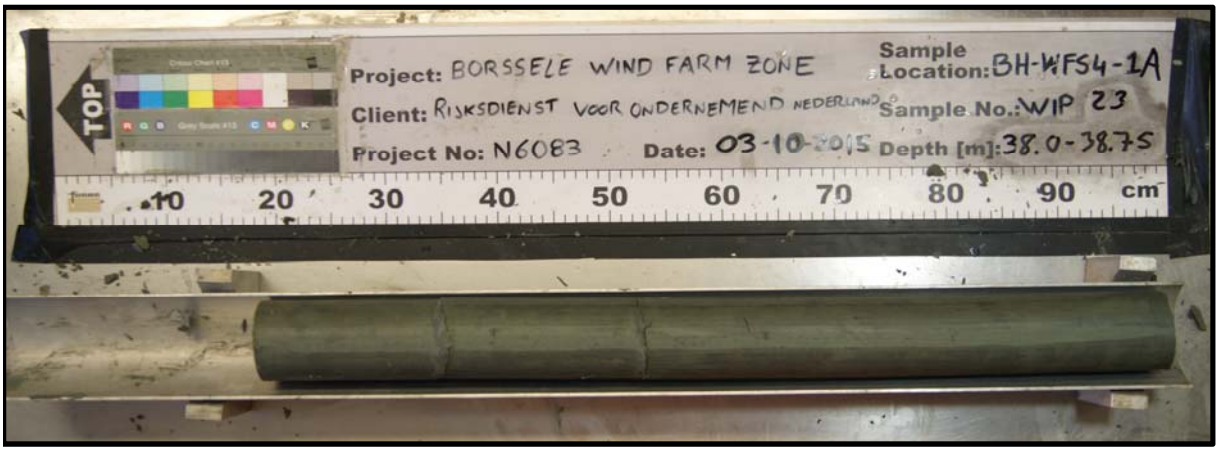
Location : BH-WFS4-1A
Sample : WIP22
Depth [m bsf] : 37.00 to 37.70



Location : BH-WFS4-1A
Sample : WIP22
Depth [m bsf] : 37.00 to 37.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



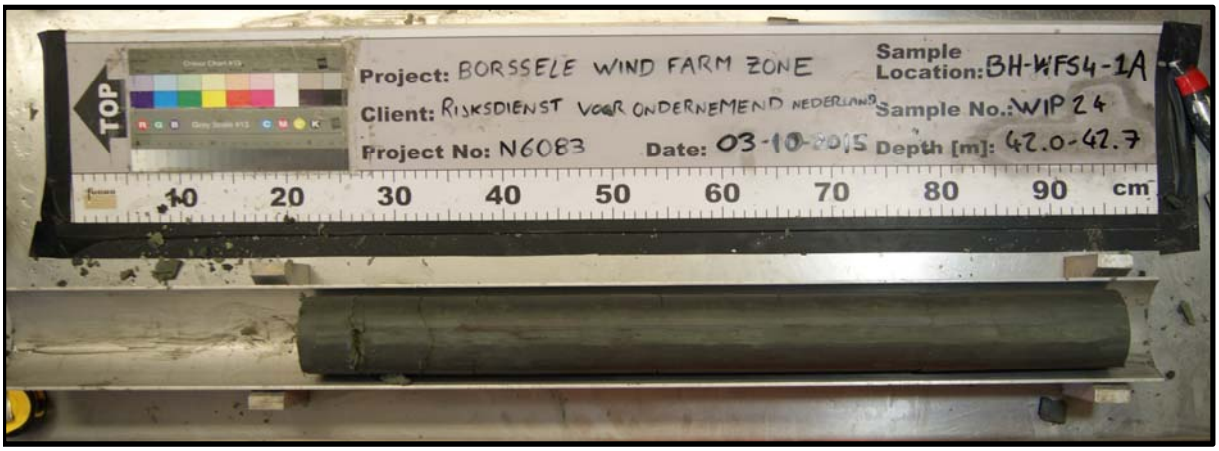
Location : BH-WFS4-1A
Sample : WIP23
Depth [m bsf] : 38.00 to 38.75



Location : BH-WFS4-1A
Sample : WIP23
Depth [m bsf] : 38.00 to 38.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



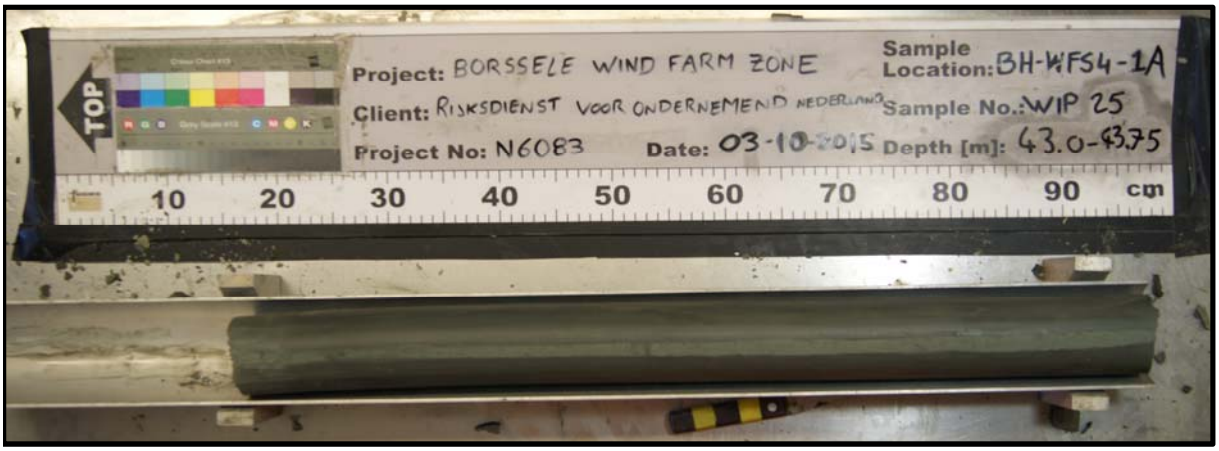
Location : BH-WFS4-1A
Sample : WIP24
Depth [m bsf] : 42.00 to 42.70



Location : BH-WFS4-1A
Sample : WIP24
Depth [m bsf] : 42.00 to 42.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



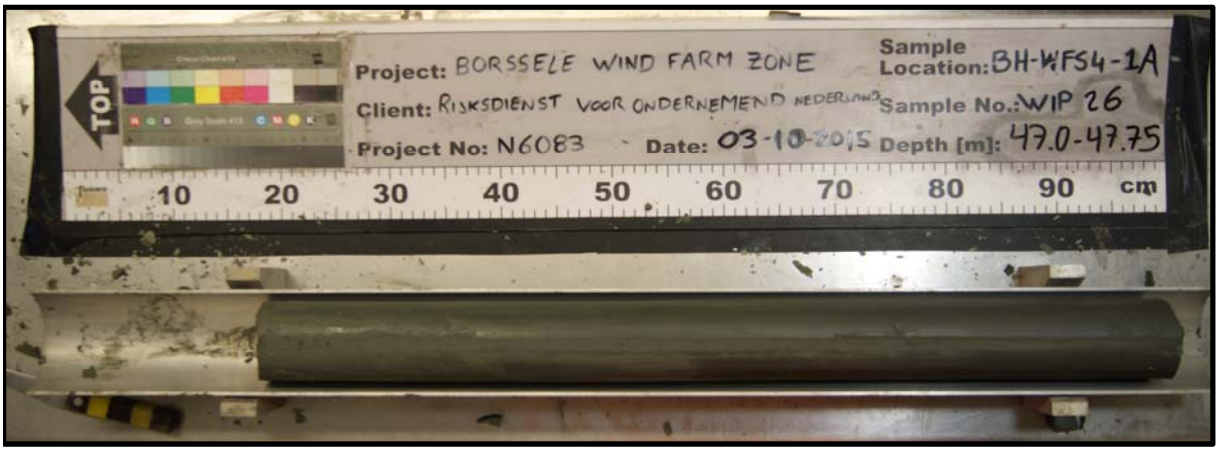
Location : BH-WFS4-1A
Sample : WIP25
Depth [m bsf] : 43.00 to 43.75



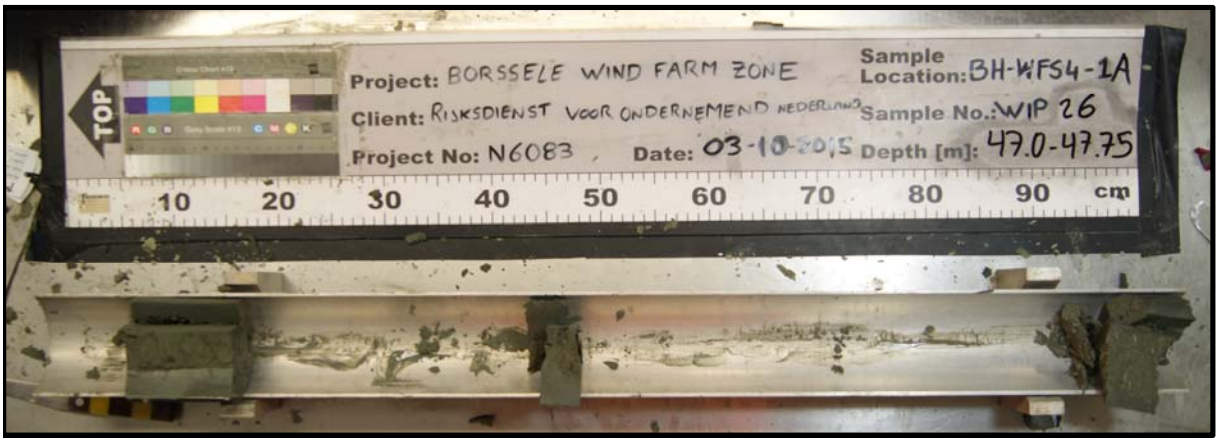
Location : BH-WFS4-1A
Sample : WIP25
Depth [m bsf] : 43.00 to 43.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



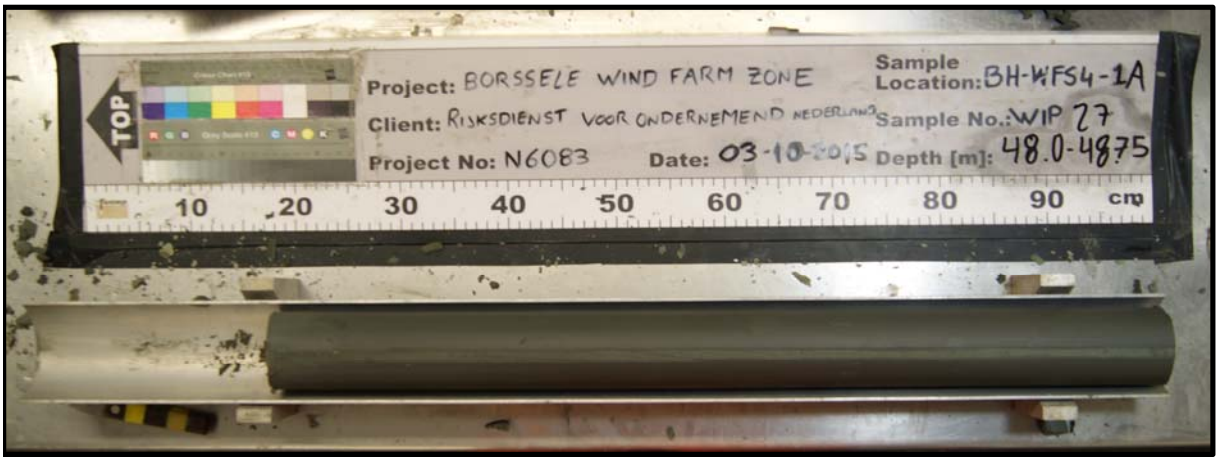
Location : BH-WFS4-1A
Sample : WIP26
Depth [m bsf] : 47.00 to 47.75



Location : BH-WFS4-1A
Sample : WIP26
Depth [m bsf] : 47.00 to 47.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-1A
Sample : WIP27
Depth [m bsf] : 48.00 to 48.75



Location : BH-WFS4-1A
Sample : WIP27
Depth [m bsf] : 48.00 to 48.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2
Sample : WIP01
Depth [m bsf] : 0.00 to 0.45



Location : BH-WFS4-2
Sample : WIP01
Depth [m bsf] : 0.00 to 0.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2
Sample : WIP02
Depth [m bsf] : 0.50 to 1.05



Location : BH-WFS4-2
Sample : WIP02
Depth [m bsf] : 0.50 to 1.05
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



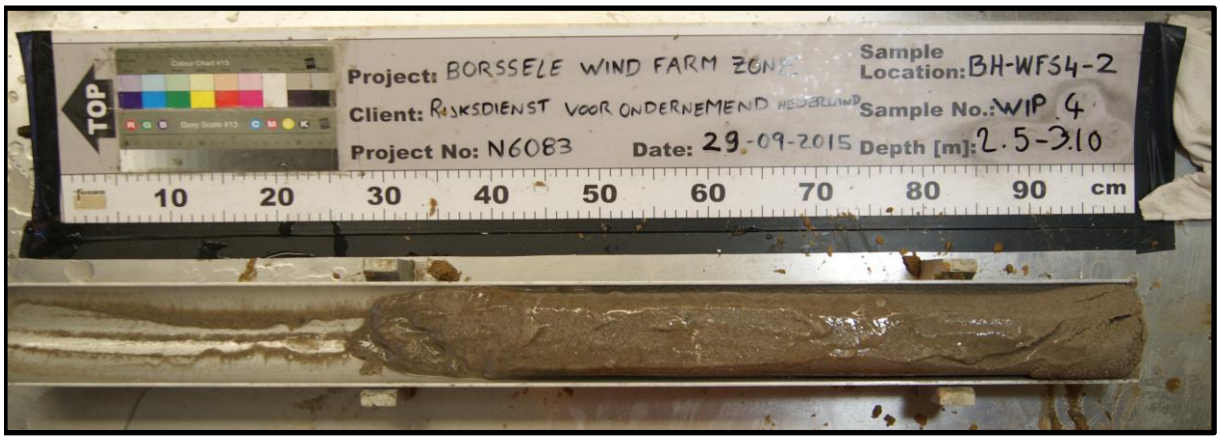
Location : BH-WFS4-2
Sample : WIP03
Depth [m bsf] : 1.50 to 2.05



Location : BH-WFS4-2
Sample : WIP03
Depth [m bsf] : 1.50 to 2.05
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2
Sample : WIP04
Depth [m bsf] : 2.50 to 3.10



Location : BH-WFS4-2
Sample : WIP04
Depth [m bsf] : 2.50 to 3.10
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2
Sample : WIP05
Depth [m bsf] : 3.50 to 4.00



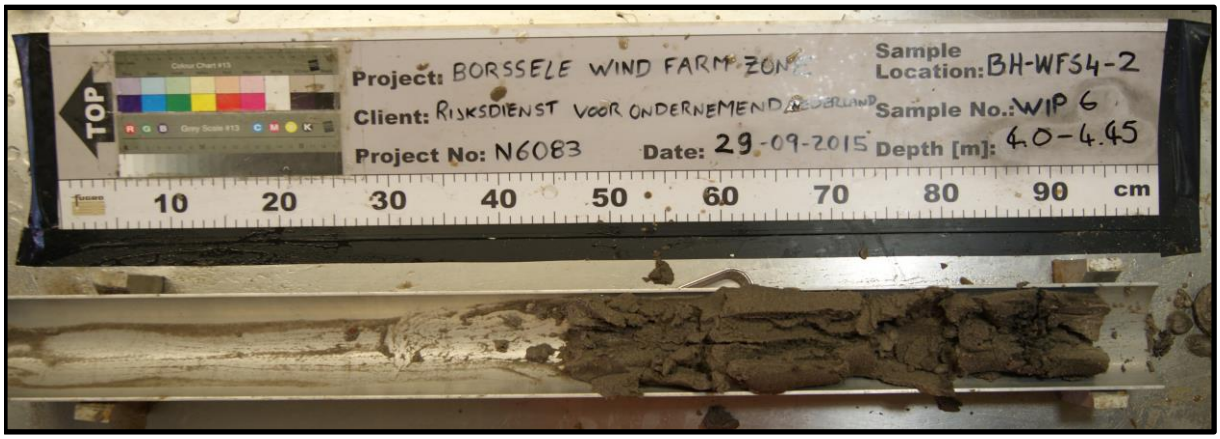
Location : BH-WFS4-2
Sample : WIP05
Depth [m bsf] : 3.50 to 4.00
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



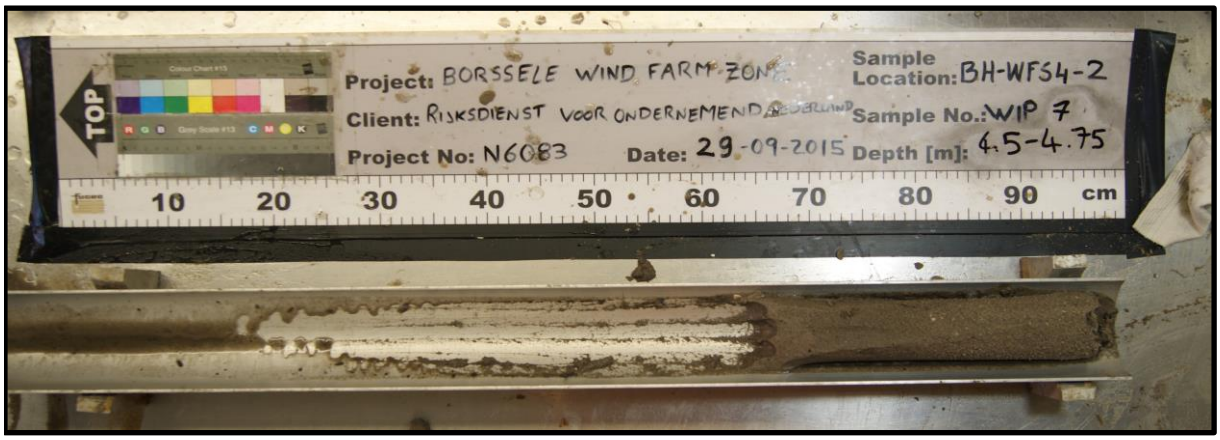
Location : BH-WFS4-2
Sample : WIP06
Depth [m bsf] : 4.00 to 4.45



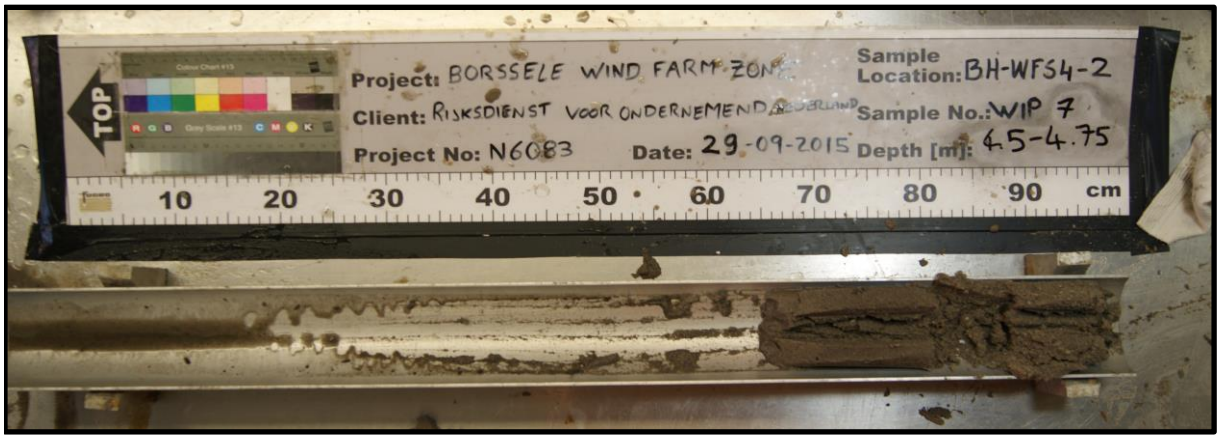
Location : BH-WFS4-2
Sample : WIP06
Depth [m bsf] : 4.00 to 4.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



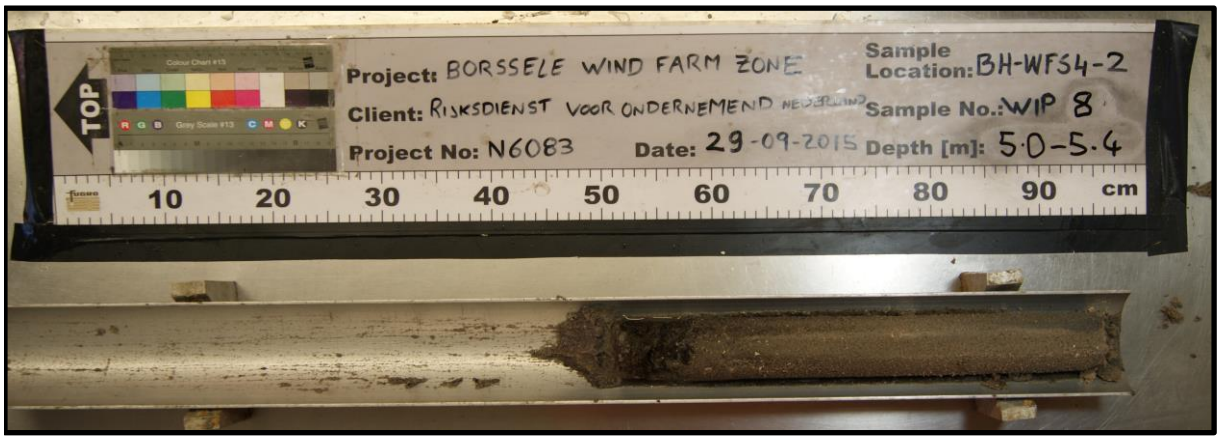
Location : BH-WFS4-2
Sample : WIP07
Depth [m bsf] : 4.50 to 4.75



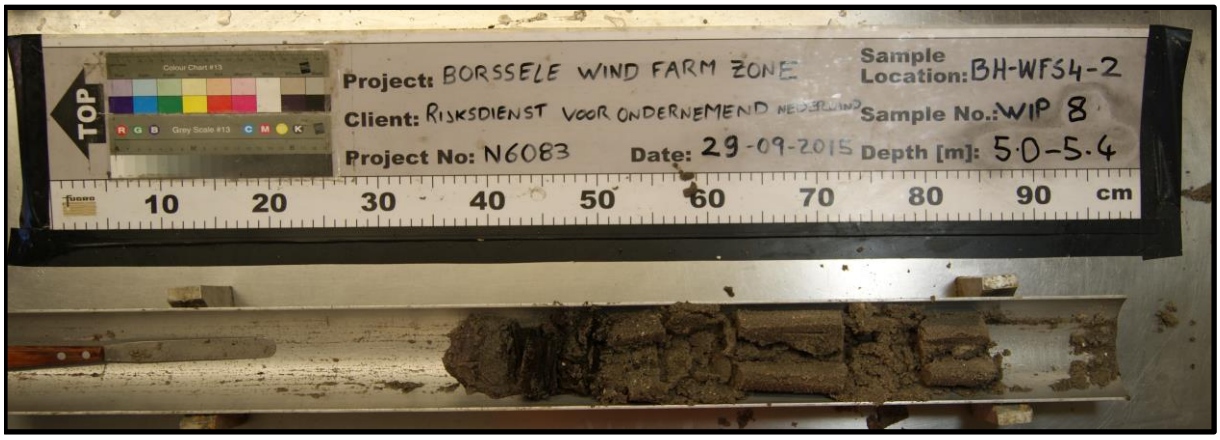
Location : BH-WFS4-2
Sample : WIP07
Depth [m bsf] : 4.50 to 4.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



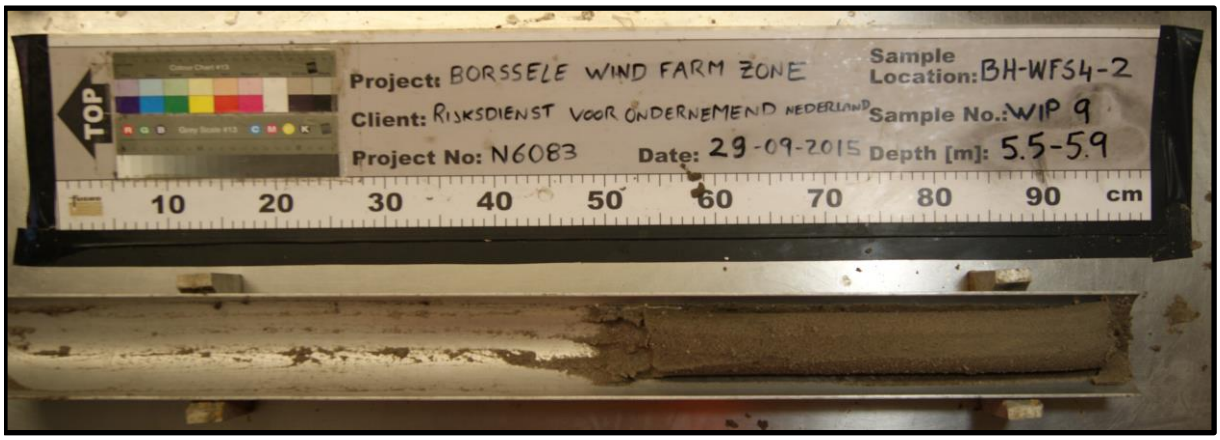
Location : BH-WFS4-2
Sample : WIP08
Depth [m bsf] : 5.00 to 5.40



Location : BH-WFS4-2
Sample : WIP08
Depth [m bsf] : 5.00 to 5.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



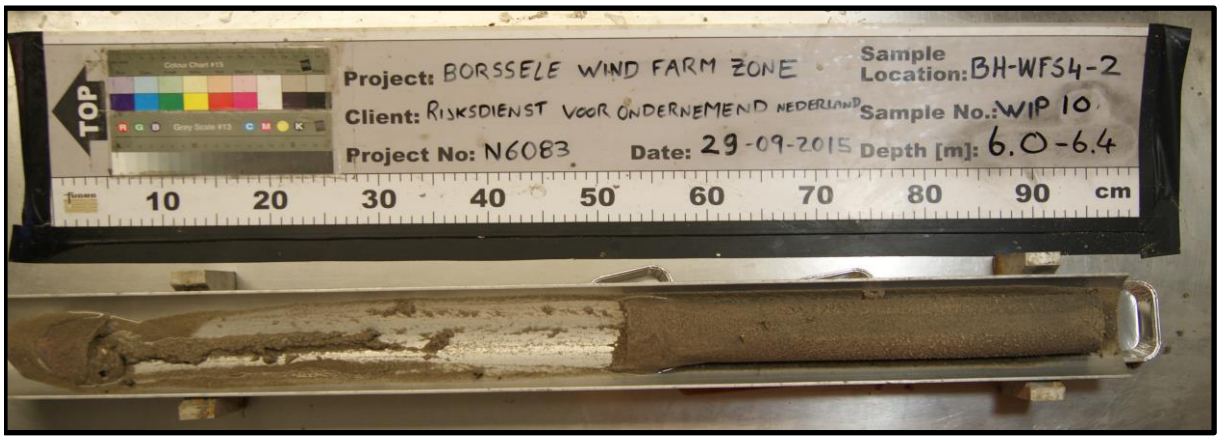
Location : BH-WFS4-2
Sample : WIP09
Depth [m bsf] : 5.50 to 5.90



Location : BH-WFS4-2
Sample : WIP09
Depth [m bsf] : 5.50 to 5.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2
Sample : WIP10
Depth [m bsf] : 6.00 to 6.40



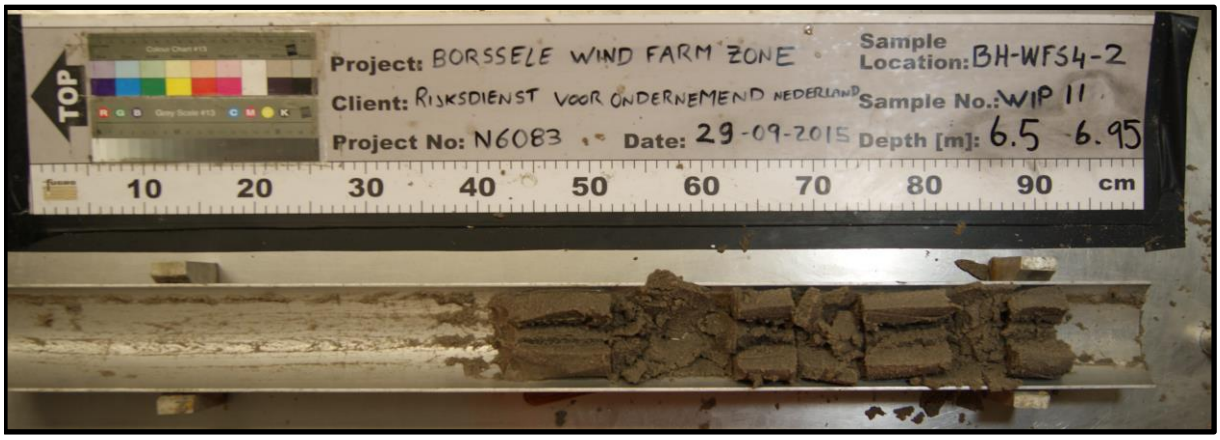
Location : BH-WFS4-2
Sample : WIP10
Depth [m bsf] : 6.00 to 6.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2
Sample : WIP11
Depth [m bsf] : 6.50 to 6.95



Location : BH-WFS4-2
Sample : WIP11
Depth [m bsf] : 6.50 to 6.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2
Sample : WIP12
Depth [m bsf] : 7.00 to 7.30



Location : BH-WFS4-2
Sample : WIP12
Depth [m bsf] : 7.00 to 7.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

Location	:	BH-WFS4-2
Sample	:	WIP13
Depth [m bsf]	:	7.50 to 7.85
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-2
Sample	:	WIP13
Depth [m bsf]	:	7.50 to 7.85
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

Location	:	BH-WFS4-2
Sample	:	WIP14
Depth [m bsf]	:	8.00 to 8.35
Note(s)	:	Sample photograph is missing



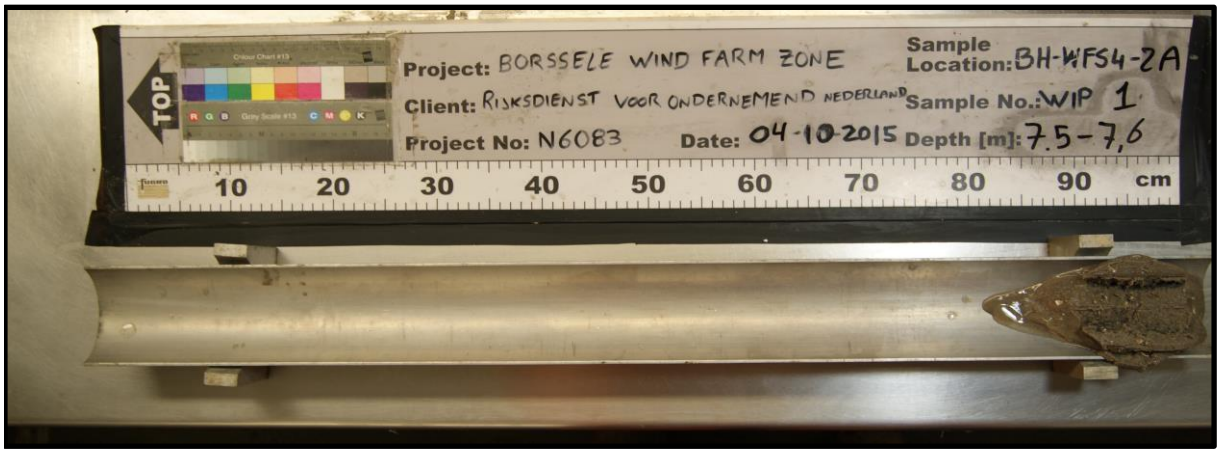
Location	:	BH-WFS4-2
Sample	:	WIP14
Depth [m bsf]	:	8.00 to 8.35
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2A
Sample : WIP01
Depth [m bsf] : 7.50 to 7.60



Location : BH-WFS4-2A
Sample : WIP01
Depth [m bsf] : 7.50 to 7.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2A
Sample : WIP02
Depth [m bsf] : 8.00 to 8.40



Location : BH-WFS4-2A
Sample : WIP02
Depth [m bsf] : 8.00 to 8.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

Location	:	BH-WFS4-2A
Sample	:	WIP03
Depth [m bsf]	:	8.50 to 9.00
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-2A
Sample	:	WIP03
Depth [m bsf]	:	8.50 to 9.00
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2A
Sample : WIP04
Depth [m bsf] : 9.00 to 9.35



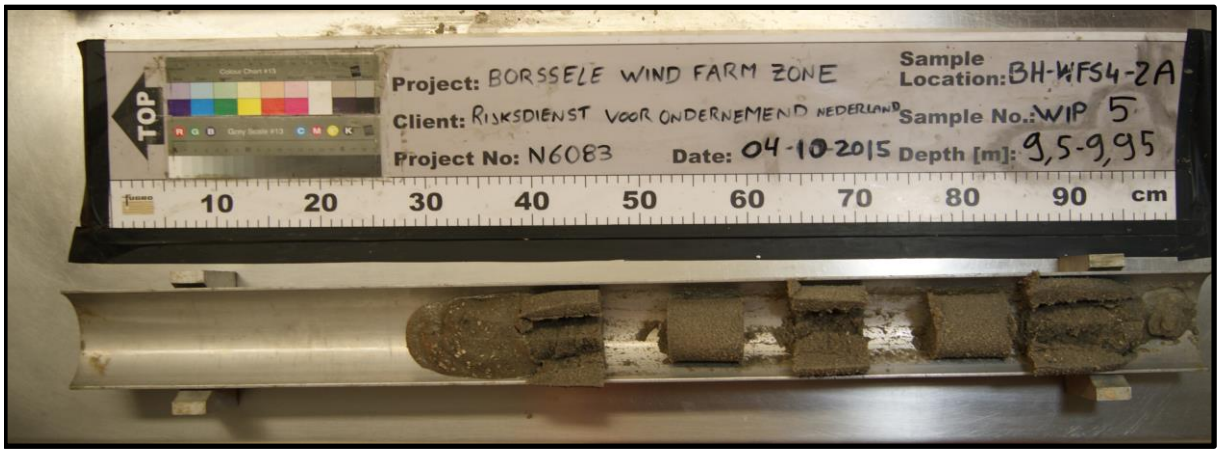
Location : BH-WFS4-2A
Sample : WIP04
Depth [m bsf] : 9.00 to 9.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2A
Sample : WIP05
Depth [m bsf] : 9.50 to 9.95



Location : BH-WFS4-2A
Sample : WIP05
Depth [m bsf] : 9.50 to 9.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2A
Sample : WIP06
Depth [m bsf] : 10.00 to 10.50



Location : BH-WFS4-2A
Sample : WIP06
Depth [m bsf] : 10.00 to 10.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

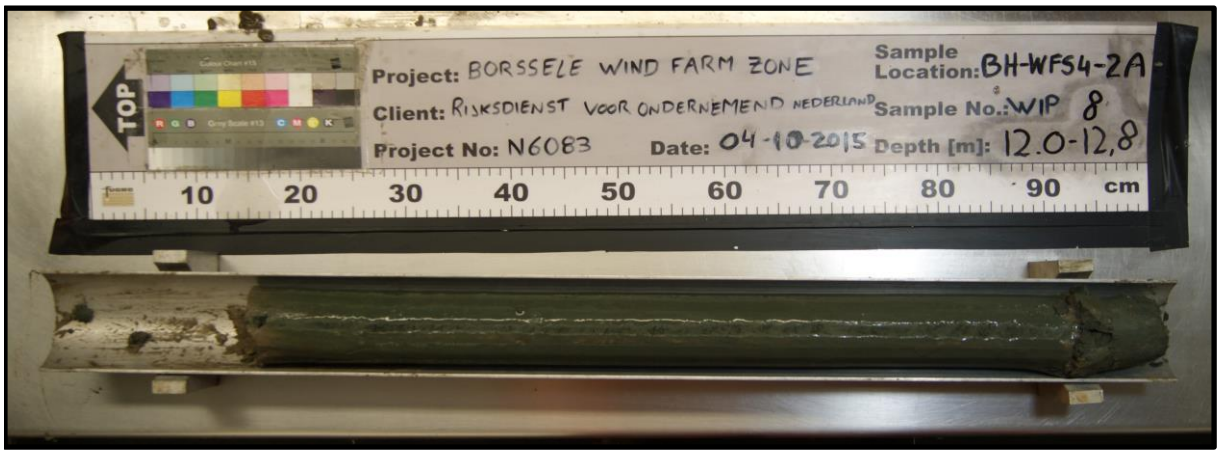
Location	:	BH-WFS4-2A
Sample	:	WIP07
Depth [m bsf]	:	11.00 to 11.70
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-2A
Sample	:	WIP07
Depth [m bsf]	:	11.00 to 11.70
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



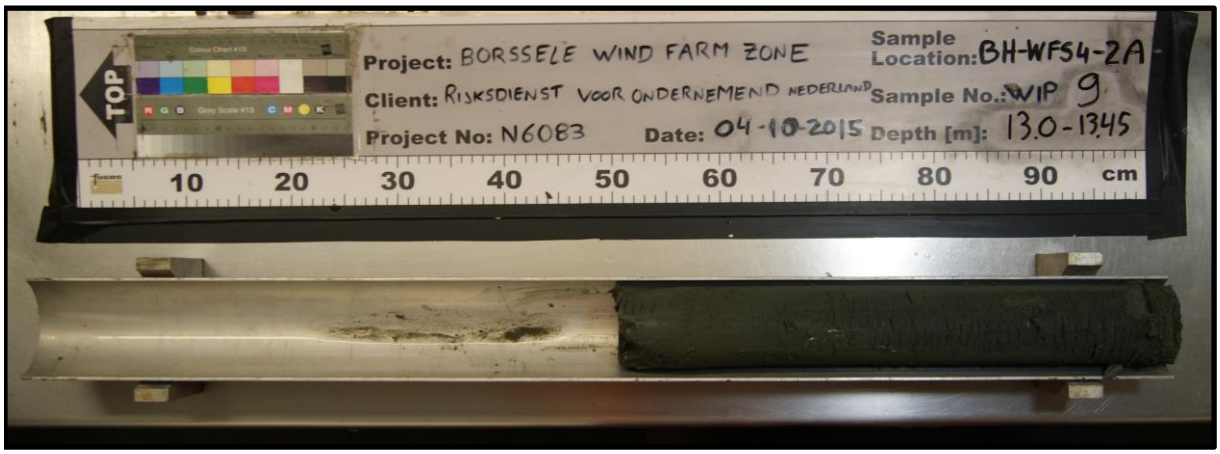
Location : BH-WFS4-2A
Sample : WIP08
Depth [m bsf] : 12.00 to 12.80



Location : BH-WFS4-2A
Sample : WIP08
Depth [m bsf] : 12.00 to 12.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



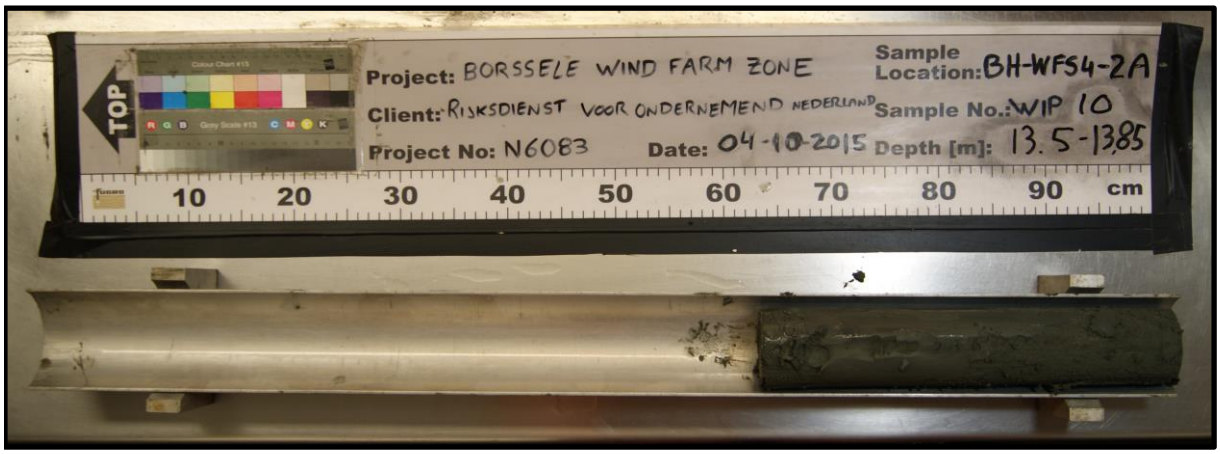
Location : BH-WFS4-2A
Sample : WIP09
Depth [m bsf] : 13.00 to 13.45



Location : BH-WFS4-2A
Sample : WIP09
Depth [m bsf] : 13.00 to 13.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



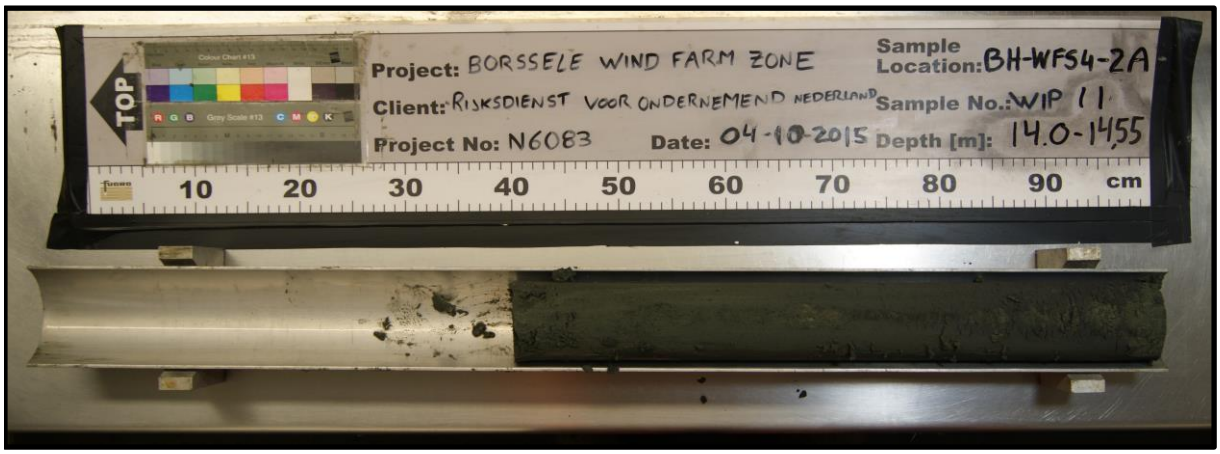
Location : BH-WFS4-2A
Sample : WIP10
Depth [m bsf] : 13.50 to 13.85



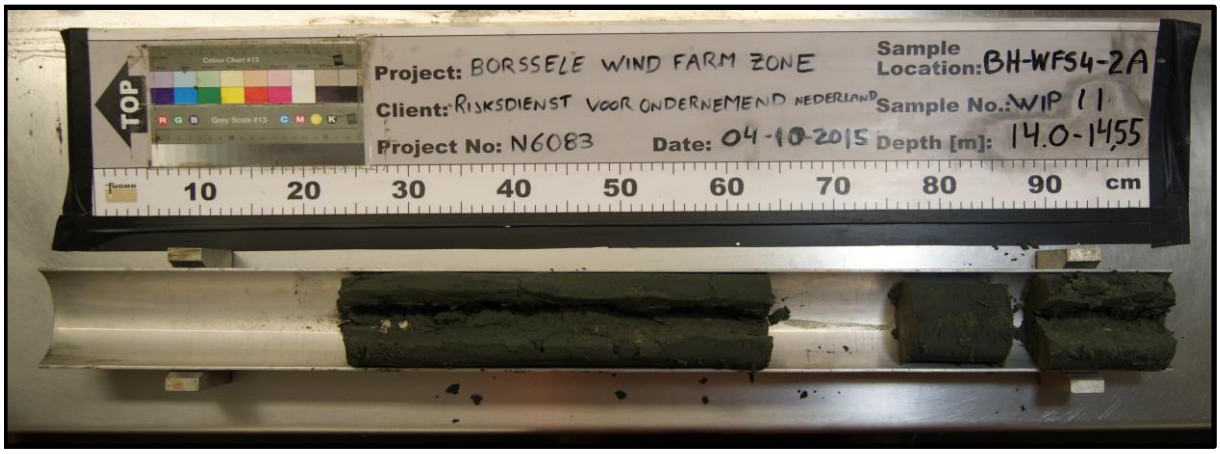
Location : BH-WFS4-2A
Sample : WIP10
Depth [m bsf] : 13.50 to 13.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



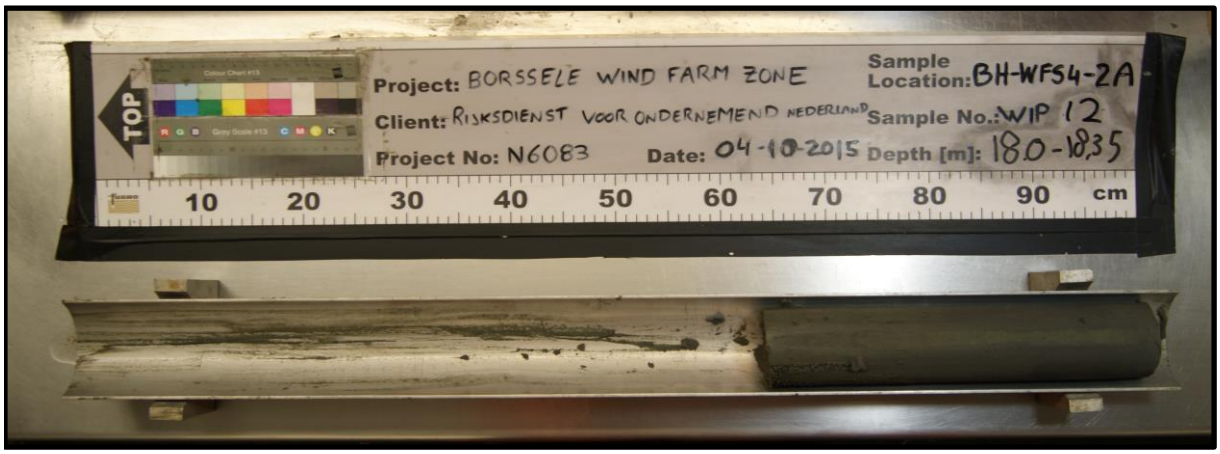
Location : BH-WFS4-2A
Sample : WIP11
Depth [m bsf] : 14.00 to 14.55



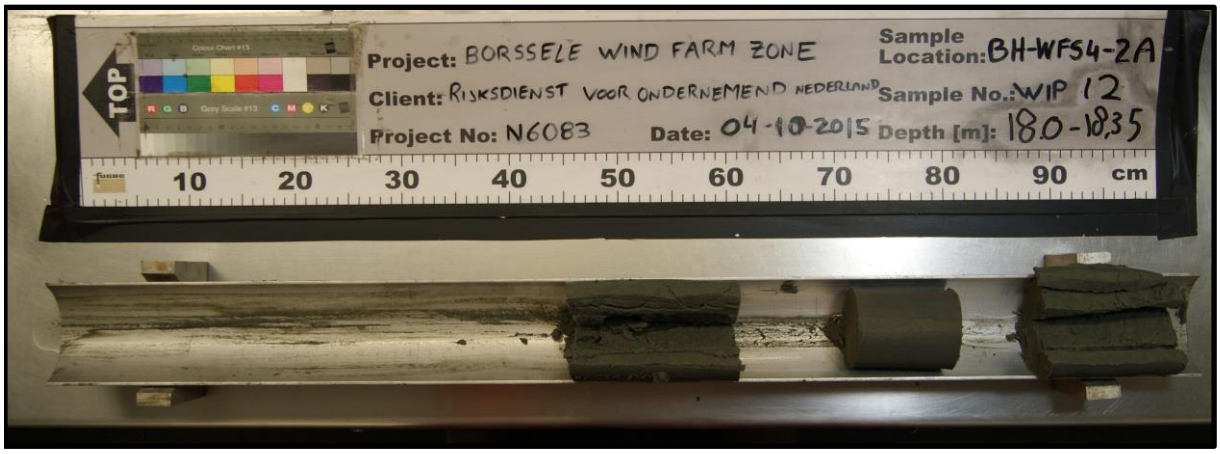
Location : BH-WFS4-2A
Sample : WIP11
Depth [m bsf] : 14.00 to 14.55
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



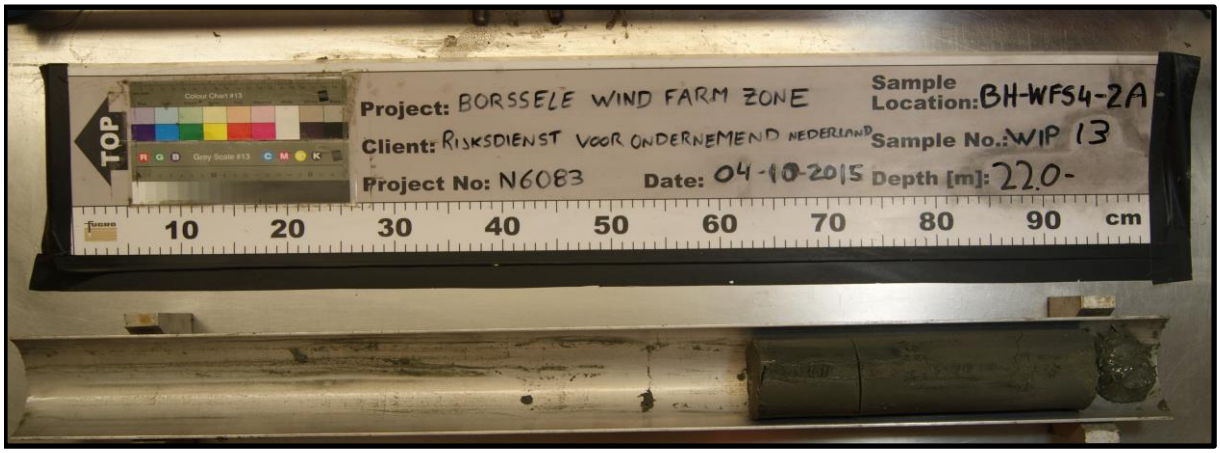
Location : BH-WFS4-2A
Sample : WIP12
Depth [m bsf] : 18.00 to 18.35



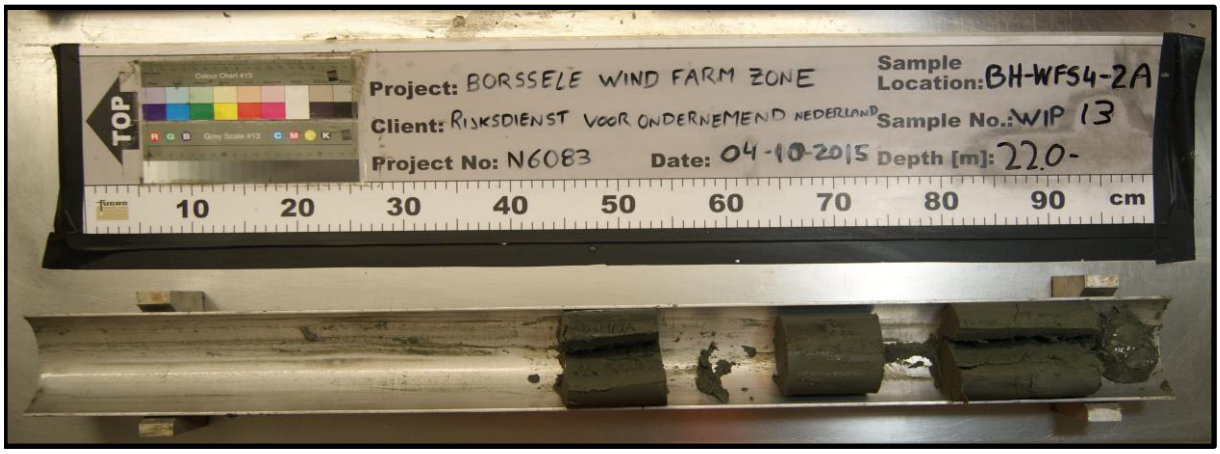
Location : BH-WFS4-2A
Sample : WIP12
Depth [m bsf] : 18.00 to 18.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



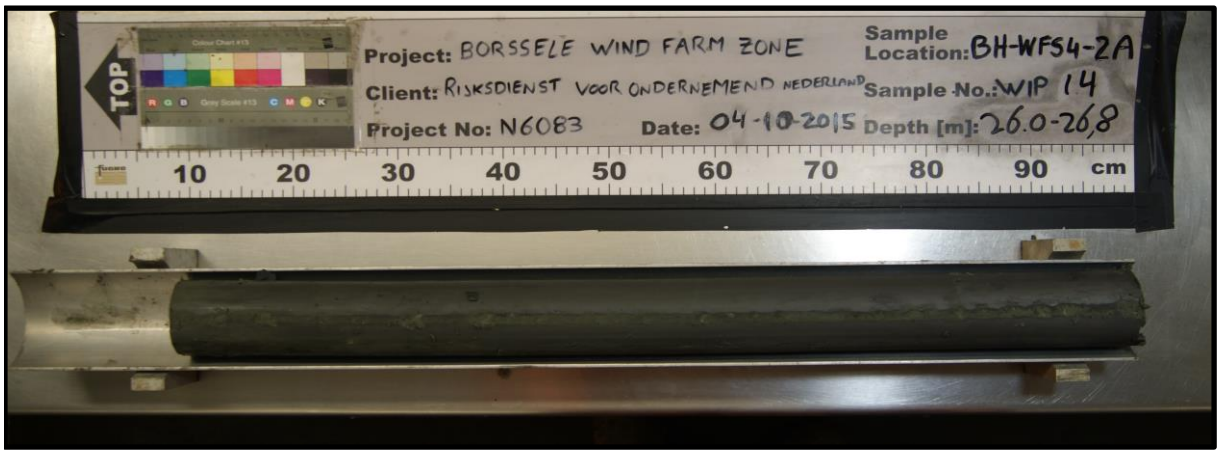
Location	:	BH-WFS4-2A
Sample	:	WIP13
Depth [m bsf]	:	22.00 to 22.30
Note(s)	:	Incorrect depth on sample photograph



Location	:	BH-WFS4-2A
Sample	:	WIP13
Depth [m bsf]	:	22.00 to 22.30
Note(s)	:	SPLIT, incorrect depth on sample photograph

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



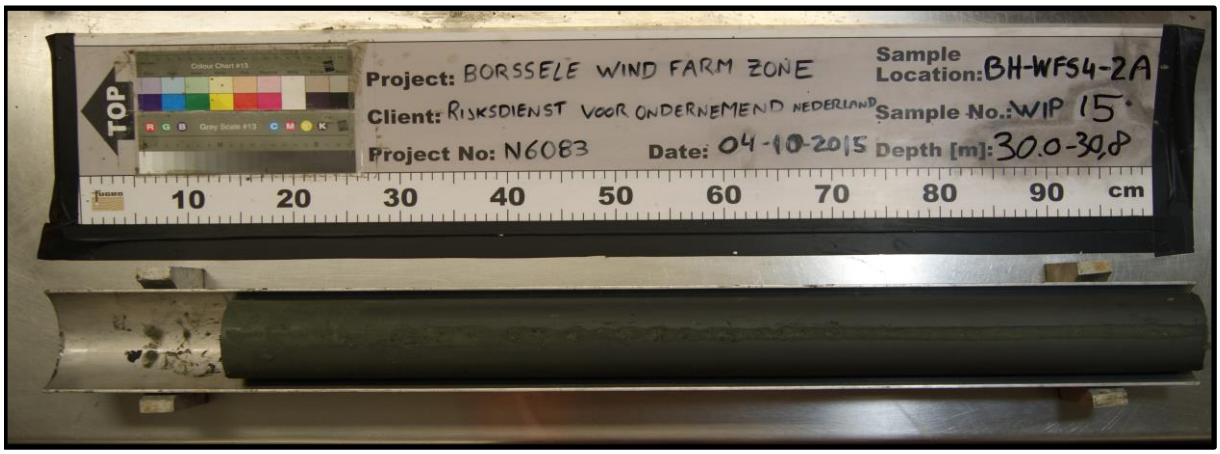
Location : BH-WFS4-2A
Sample : WIP14
Depth [m bsf] : 26.00 to 26.80



Location : BH-WFS4-2A
Sample : WIP14
Depth [m bsf] : 26.00 to 26.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



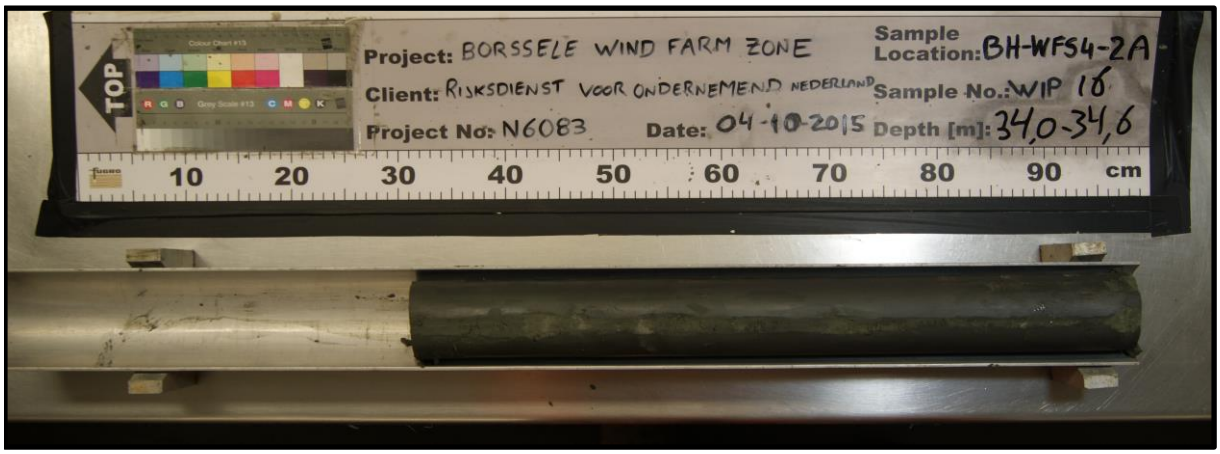
Location : BH-WFS4-2A
Sample : WIP15
Depth [m bsf] : 30.00 to 30.80



Location : BH-WFS4-2A
Sample : WIP15
Depth [m bsf] : 30.00 to 30.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



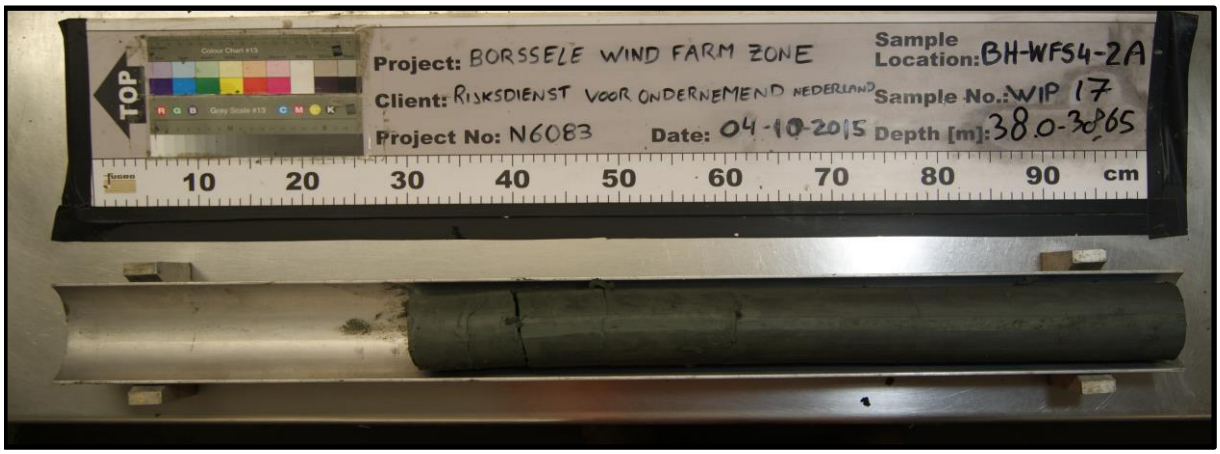
Location : BH-WFS4-2A
Sample : WIP16
Depth [m bsf] : 34.00 to 34.60



Location : BH-WFS4-2A
Sample : WIP16
Depth [m bsf] : 34.00 to 34.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-2A
Sample : WIP17
Depth [m bsf] : 38.00 to 38.65



Location : BH-WFS4-2A
Sample : WIP17
Depth [m bsf] : 38.00 to 38.65
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



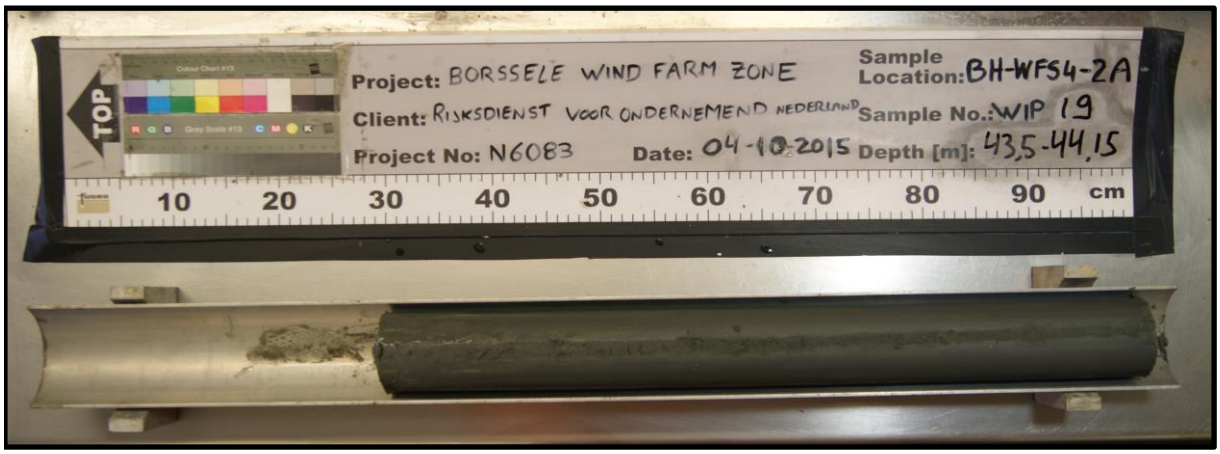
Location : BH-WFS4-2A
Sample : WIP18
Depth [m bsf] : 39.00 to 39.30



Location : BH-WFS4-2A
Sample : WIP18
Depth [m bsf] : 39.00 to 39.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



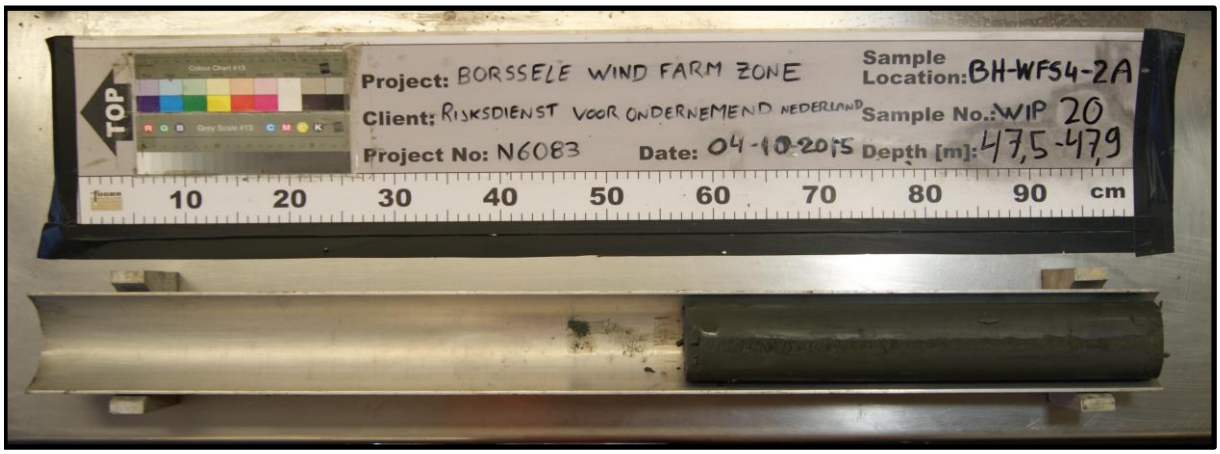
Location : BH-WFS4-2A
Sample : WIP19
Depth [m bsf] : 43.50 to 44.15



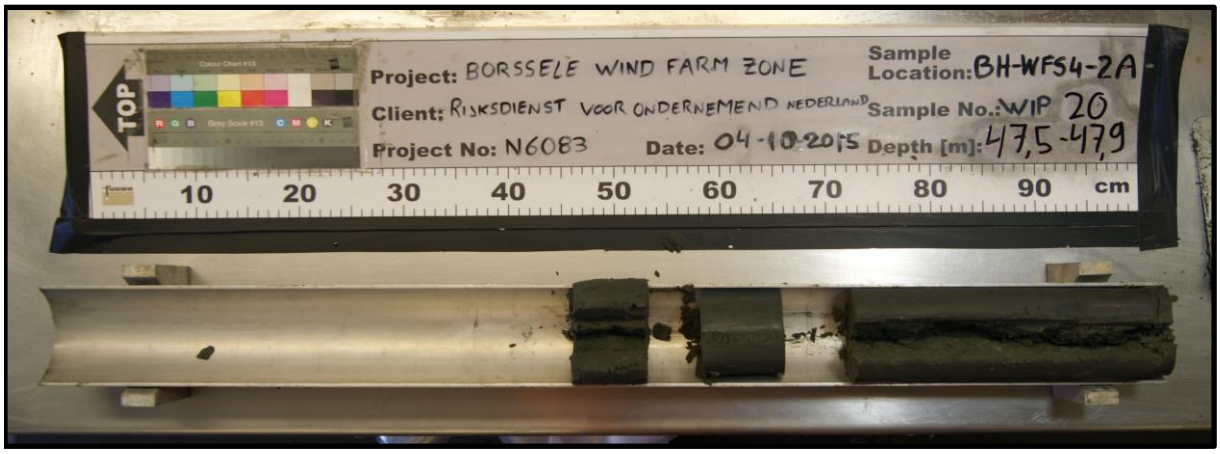
Location : BH-WFS4-2A
Sample : WIP19
Depth [m bsf] : 43.50 to 44.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



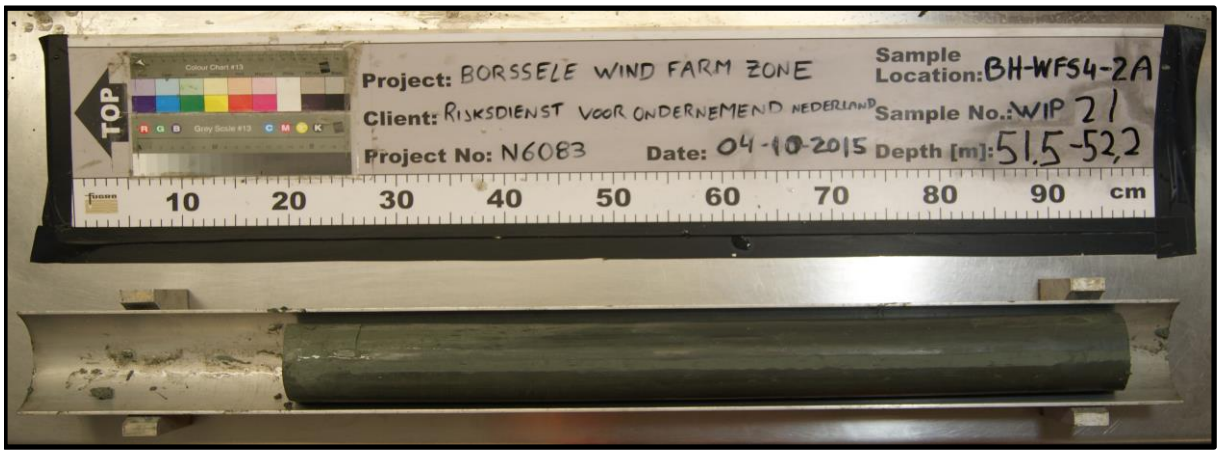
Location : BH-WFS4-2A
Sample : WIP20
Depth [m bsf] : 47.50 to 47.90



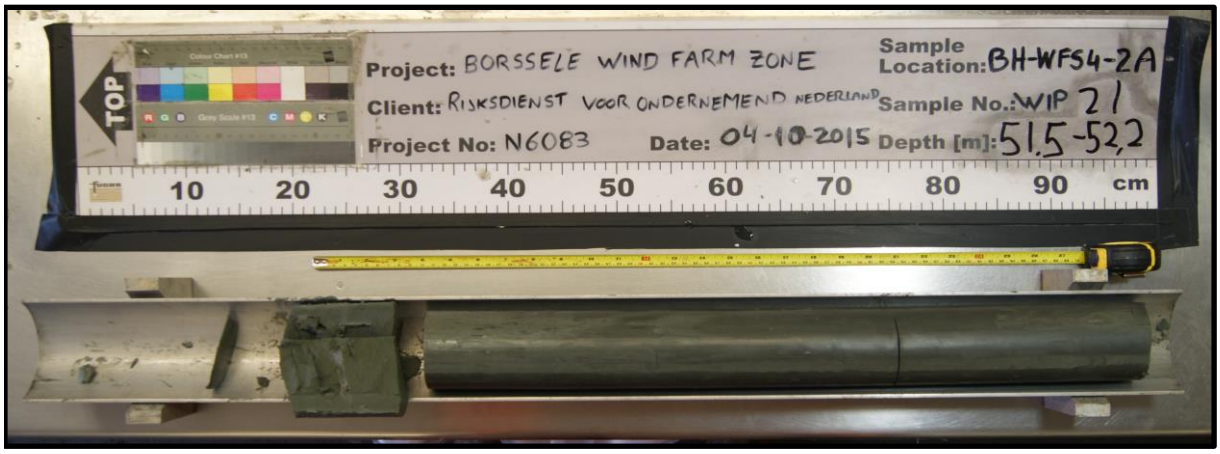
Location : BH-WFS4-2A
Sample : WIP20
Depth [m bsf] : 47.50 to 47.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



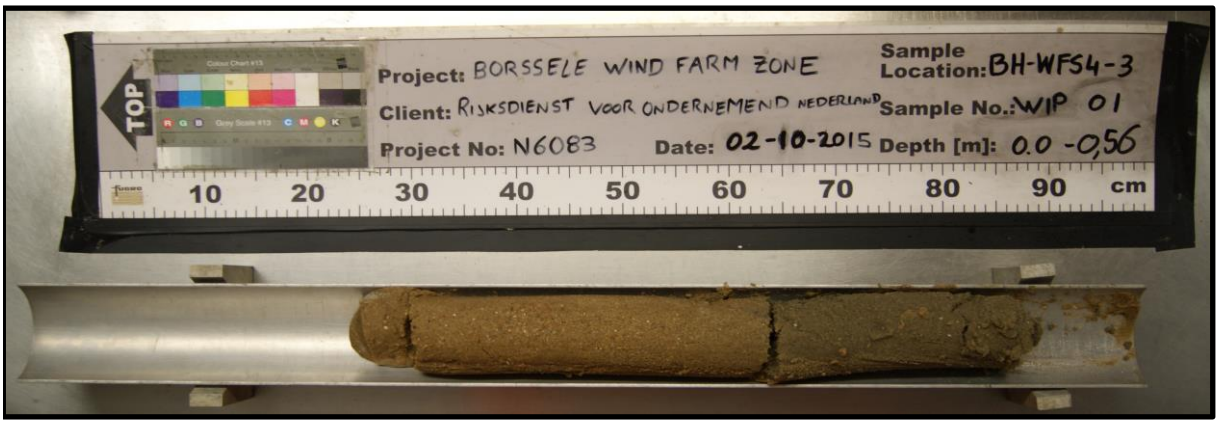
Location : BH-WFS4-2A
Sample : WIP21
Depth [m bsf] : 51.50 to 52.20



Location : BH-WFS4-2A
Sample : WIP21
Depth [m bsf] : 51.50 to 52.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



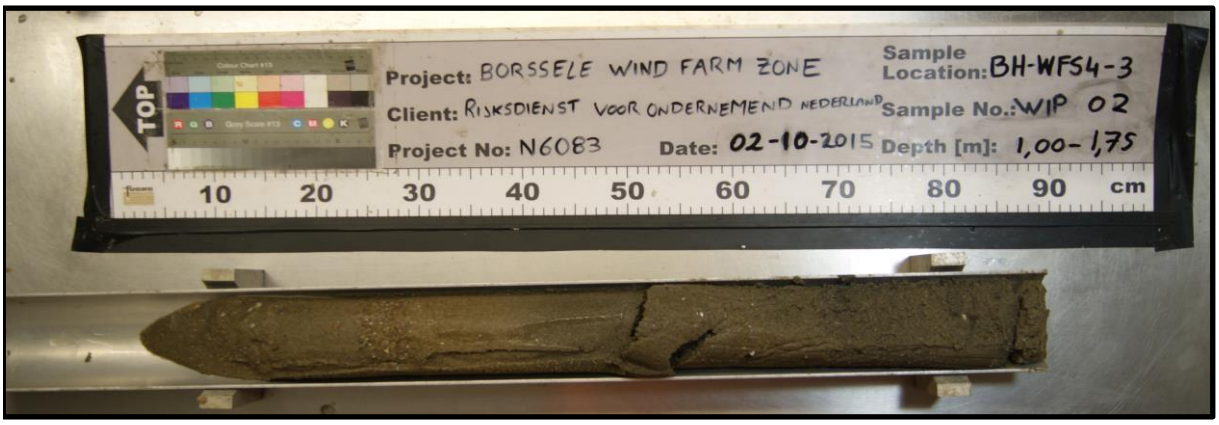
Location	:	BH-WFS4-3
Sample	:	WIP01
Depth [m bsf]	:	0.00 to 0.55
Note(s)	:	Incorrect depth on sample photograph



Location	:	BH-WFS4-3
Sample	:	WIP01
Depth [m bsf]	:	0.00 to 0.55
Note(s)	:	SPLIT, incorrect depth on sample photograph

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



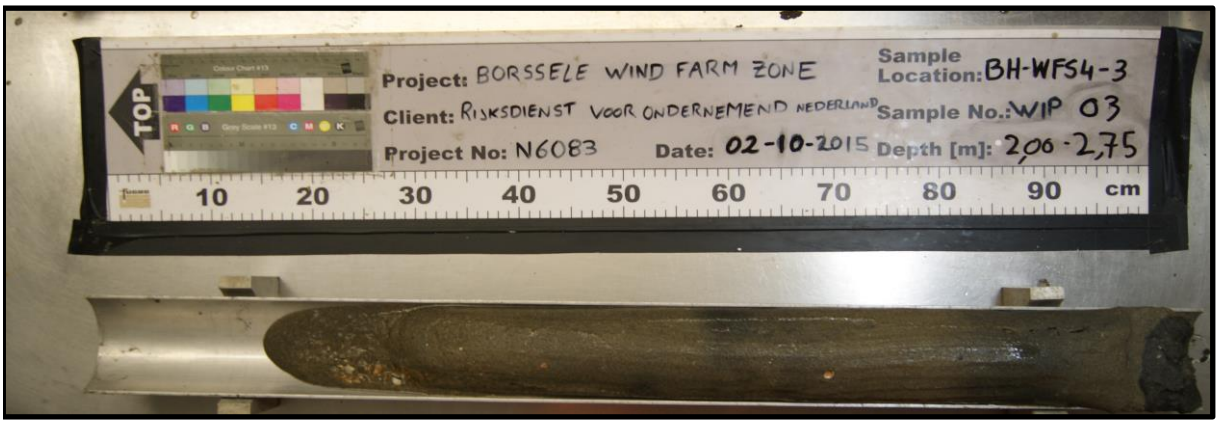
Location : BH-WFS4-3
Sample : WIP02
Depth [m bsf] : 1.00 to 1.75



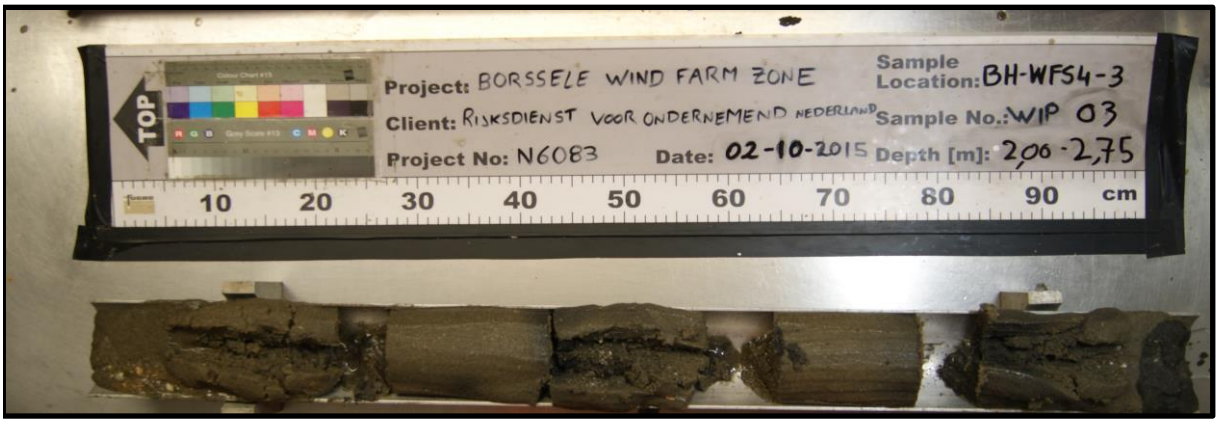
Location : BH-WFS4-3
Sample : WIP02
Depth [m bsf] : 1.00 to 1.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-3
Sample : WIP03
Depth [m bsf] : 2.00 to 2.75



Location : BH-WFS4-3
Sample : WIP03
Depth [m bsf] : 2.00 to 2.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



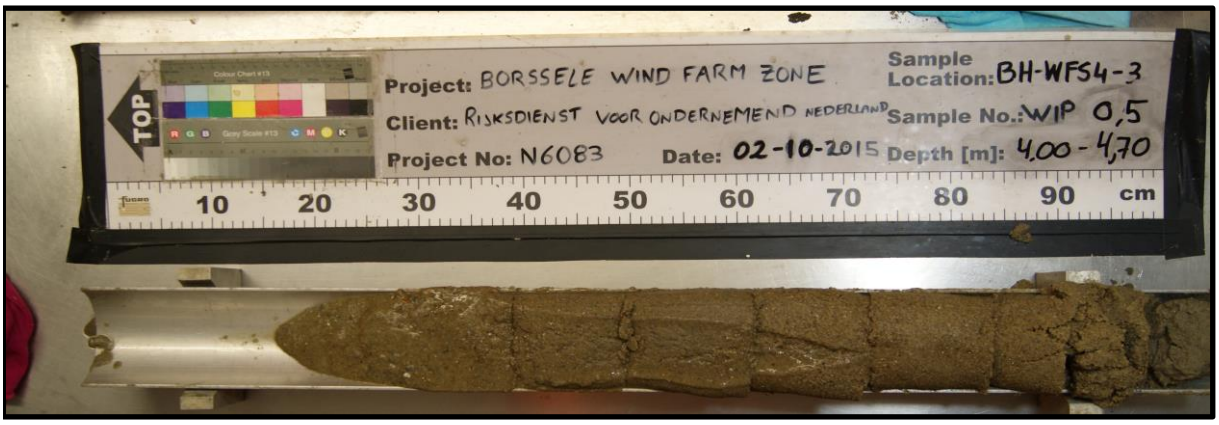
Location : BH-WFS4-3
Sample : WIP04
Depth [m bsf] : 3.00 to 3.75



Location : BH-WFS4-3
Sample : WIP04
Depth [m bsf] : 3.00 to 3.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-3
Sample : WIP05
Depth [m bsf] : 4.00 to 4.70



Location : BH-WFS4-3
Sample : WIP05
Depth [m bsf] : 4.00 to 4.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



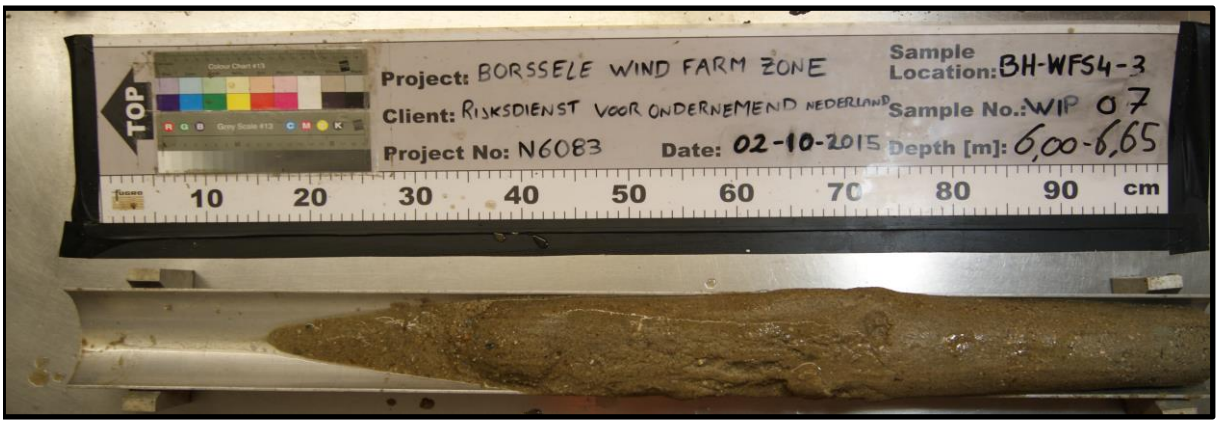
Location : BH-WFS4-3
Sample : WIP06
Depth [m bsf] : 5.00 to 5.65



Location : BH-WFS4-3
Sample : WIP06
Depth [m bsf] : 5.00 to 5.65
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



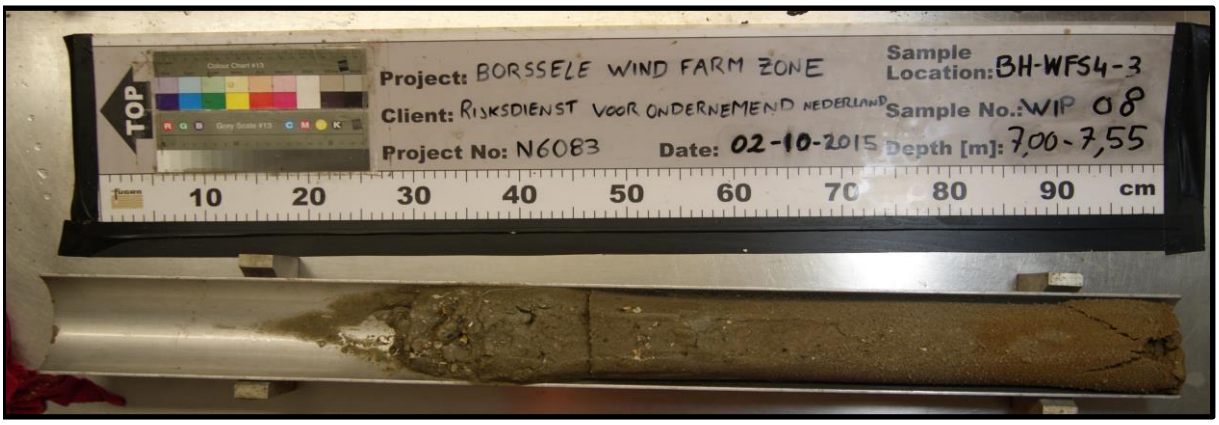
Location : BH-WFS4-3
Sample : WIP07
Depth [m bsf] : 6.00 to 6.65

Missing Photograph

Location : BH-WFS4-3
Sample : WIP07
Depth [m bsf] : 6.00 to 6.65
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



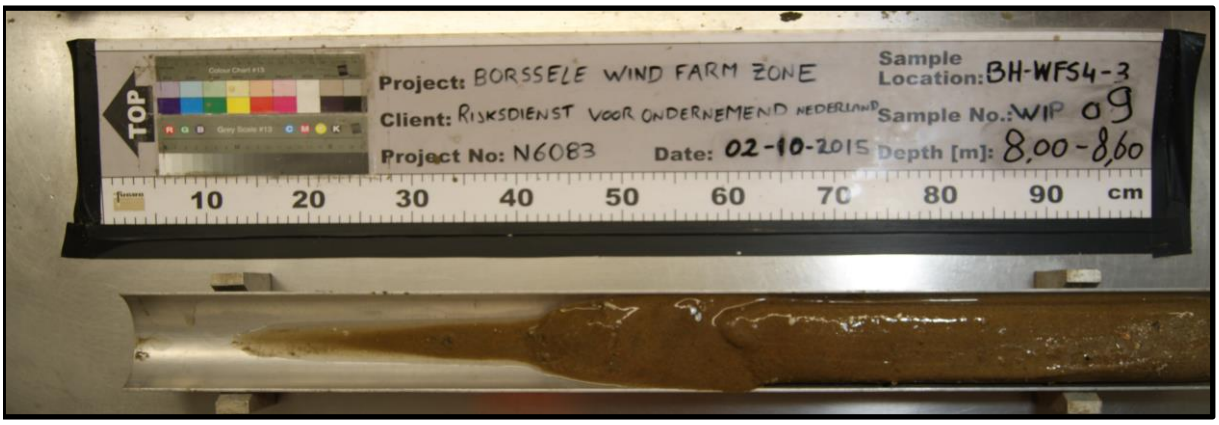
Location : BH-WFS4-3
Sample : WIP08
Depth [m bsf] : 7.00 to 7.55



Location : BH-WFS4-3
Sample : WIP08
Depth [m bsf] : 7.00 to 7.55
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



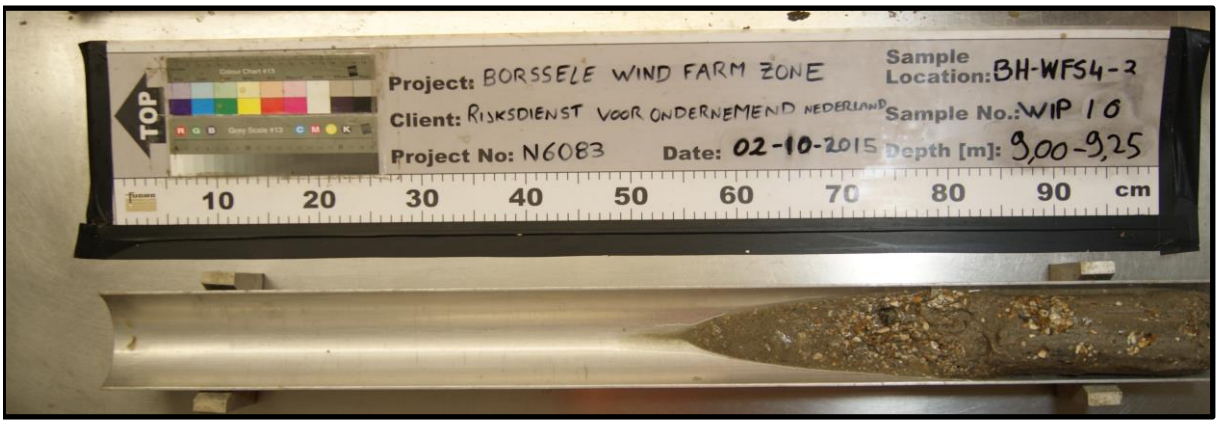
Location : BH-WFS4-3
Sample : WIP09
Depth [m bsf] : 8.00 to 8.60



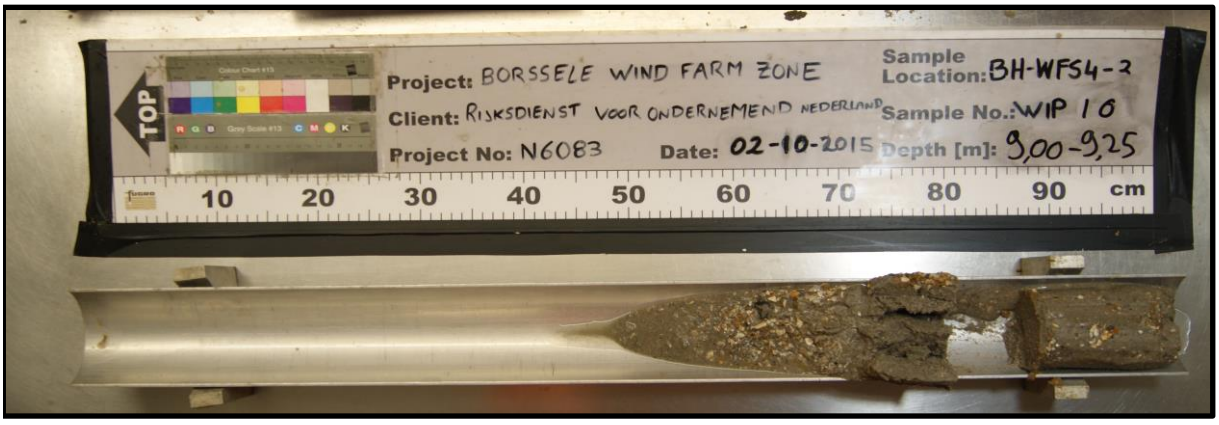
Location : BH-WFS4-3
Sample : WIP09
Depth [m bsf] : 8.00 to 8.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



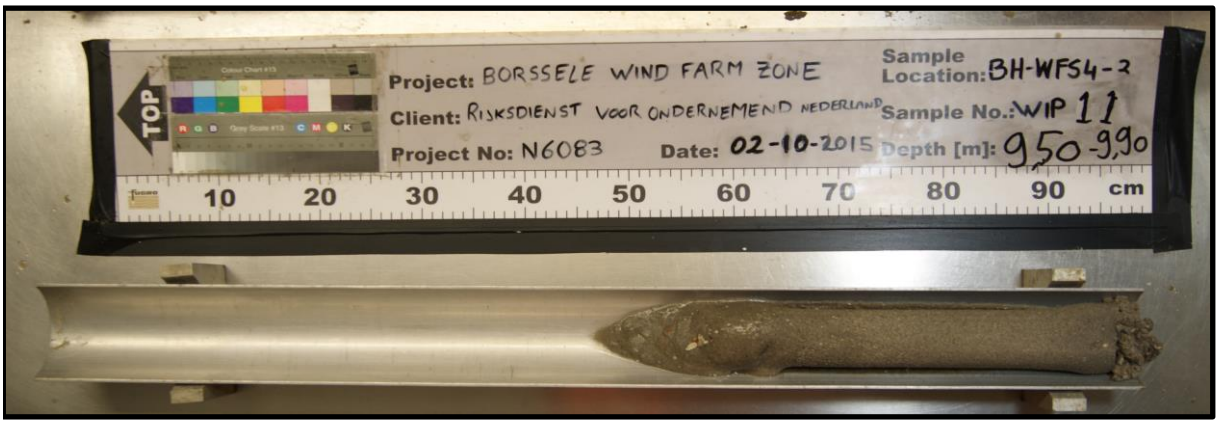
Location : BH-WFS4-3
Sample : WIP10
Depth [m bsf] : 9.00 to 9.25



Location : BH-WFS4-3
Sample : WIP10
Depth [m bsf] : 9.00 to 9.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



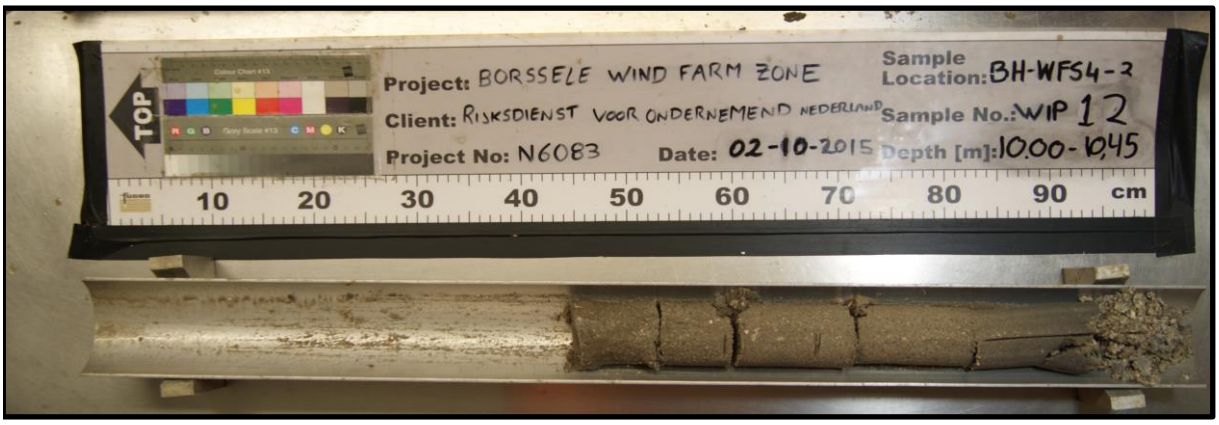
Location : BH-WFS4-3
Sample : WIP11
Depth [m bsf] : 9.50 to 9.90



Location : BH-WFS4-3
Sample : WIP11
Depth [m bsf] : 9.50 to 9.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



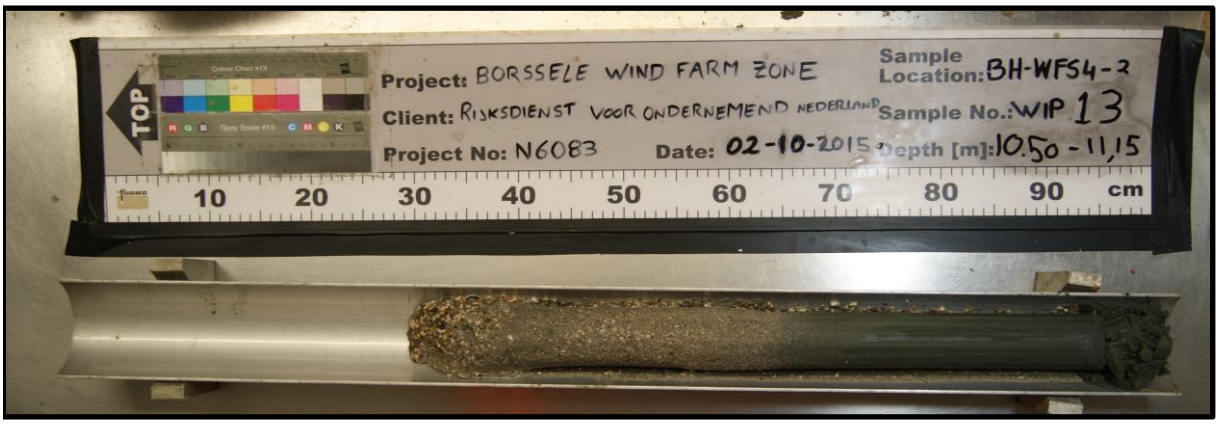
Location : BH-WFS4-3
Sample : WIP12
Depth [m bsf] : 10.00 to 10.45



Location : BH-WFS4-3
Sample : WIP12
Depth [m bsf] : 10.00 to 10.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



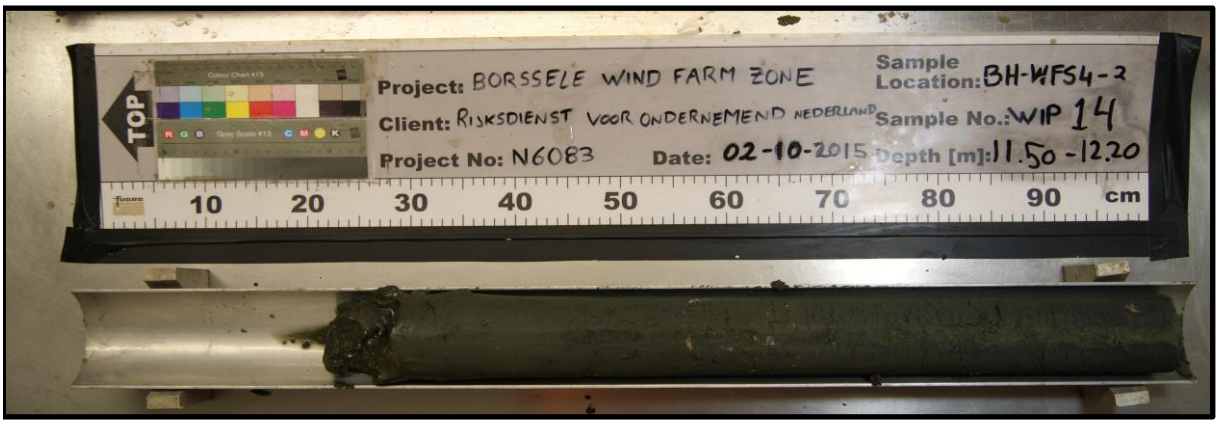
Location : BH-WFS4-3
Sample : WIP13
Depth [m bsf] : 10.50 to 11.15



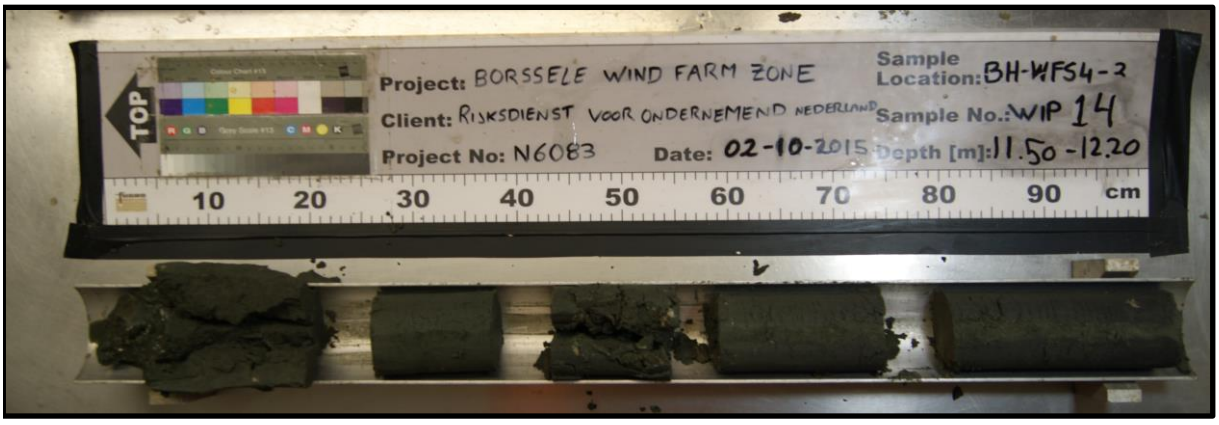
Location : BH-WFS4-3
Sample : WIP13
Depth [m bsf] : 10.50 to 11.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



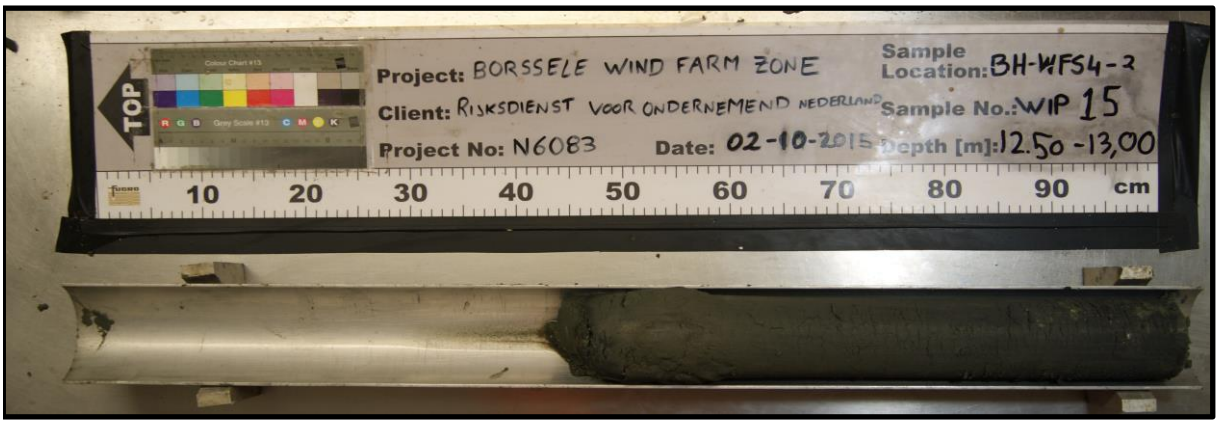
Location : BH-WFS4-3
Sample : WIP14
Depth [m bsf] : 11.50 to 12.20



Location : BH-WFS4-3
Sample : WIP14
Depth [m bsf] : 11.50 to 12.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



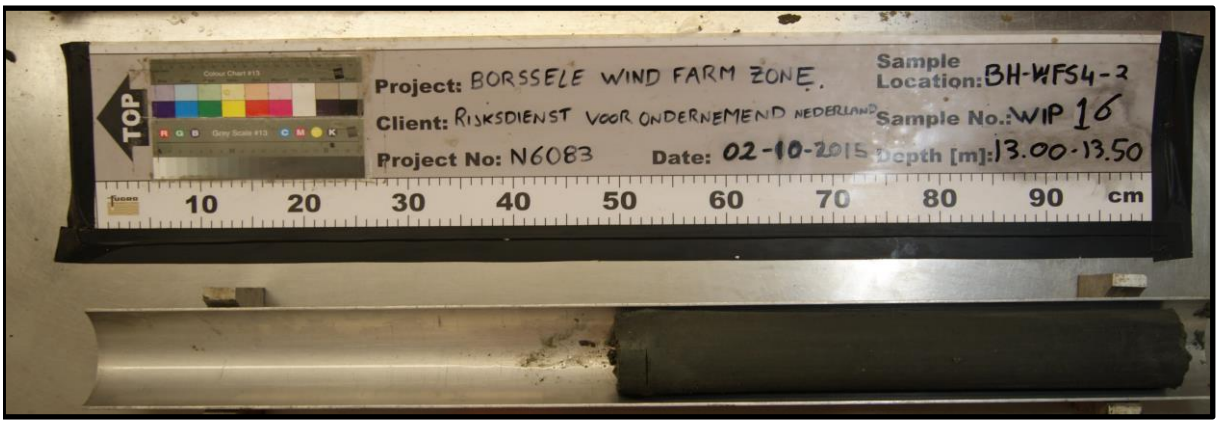
Location : BH-WFS4-3
Sample : WIP15
Depth [m bsf] : 12.50 to 13.00

Missing Photograph

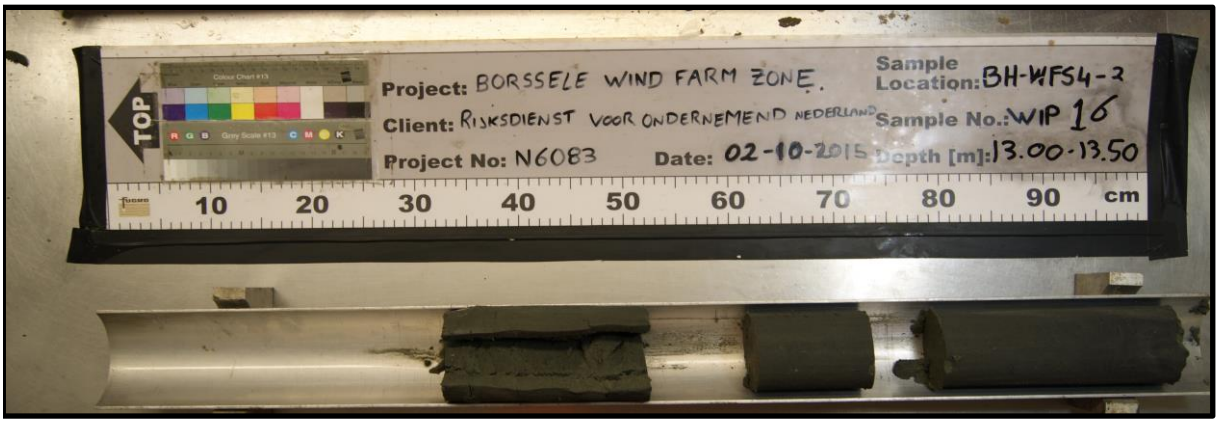
Location : BH-WFS4-3
Sample : WIP15
Depth [m bsf] : 12.50 to 13.00
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-3
Sample : WIP16
Depth [m bsf] : 13.00 to 13.50



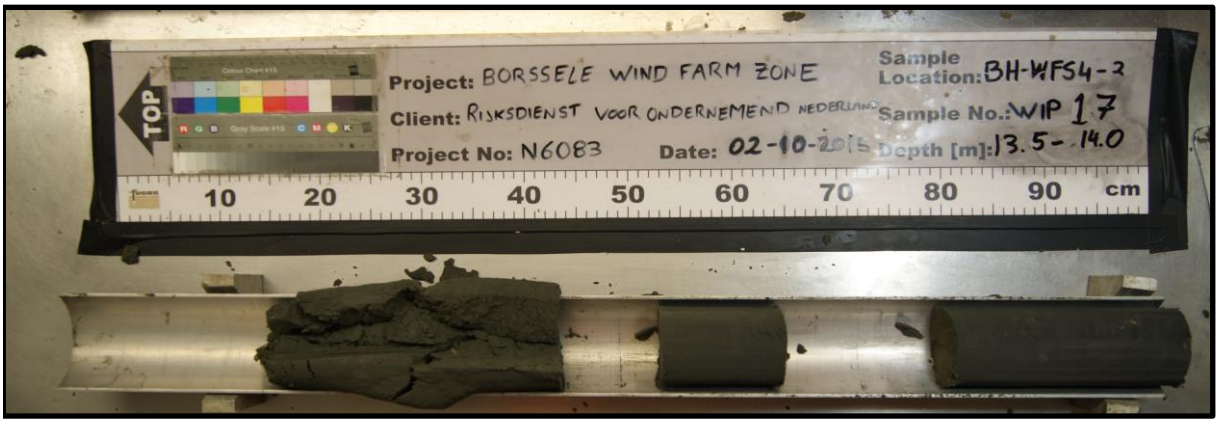
Location : BH-WFS4-3
Sample : WIP16
Depth [m bsf] : 13.00 to 13.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-3
Sample : WIP17
Depth [m bsf] : 13.50 to 14.00



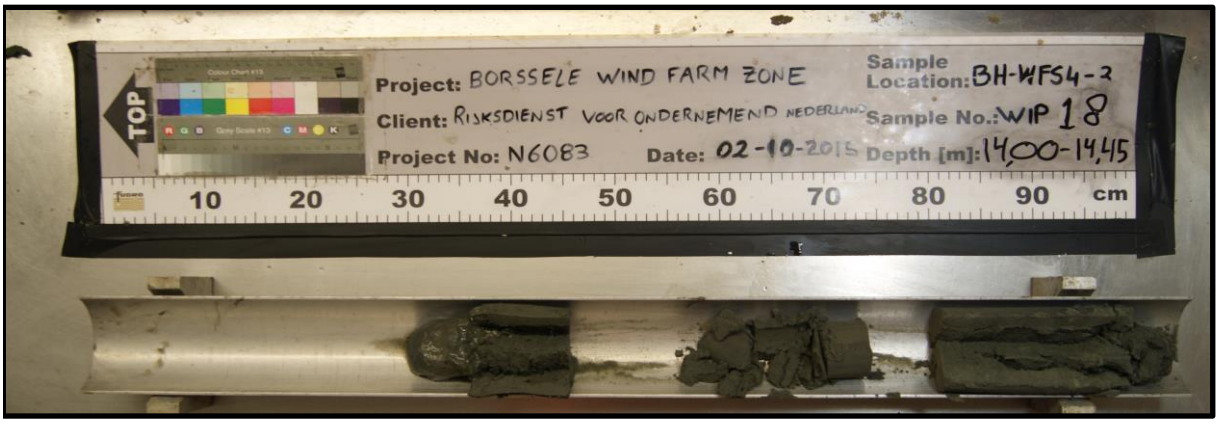
Location : BH-WFS4-3
Sample : WIP17
Depth [m bsf] : 13.50 to 14.00
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



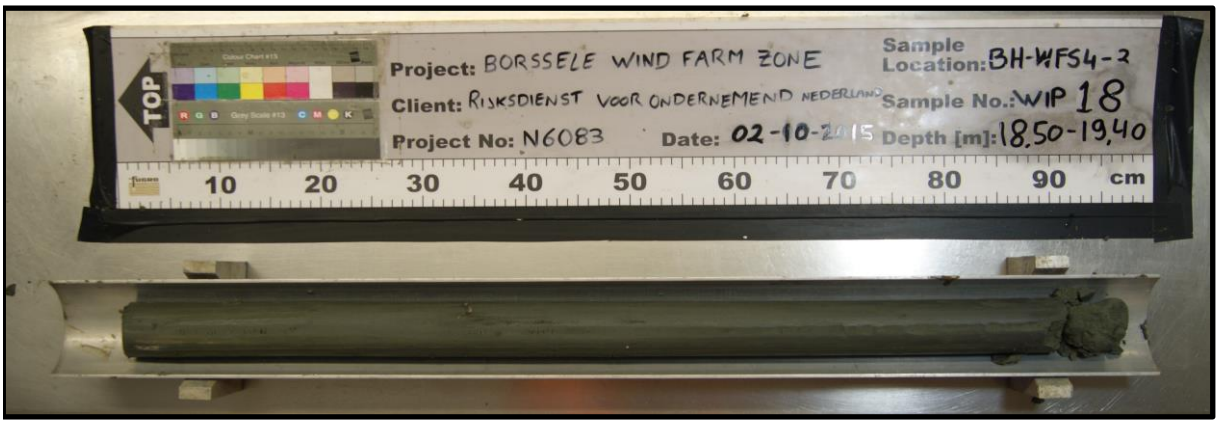
Location : BH-WFS4-3
Sample : WIP18
Depth [m bsf] : 14.00 to 14.45



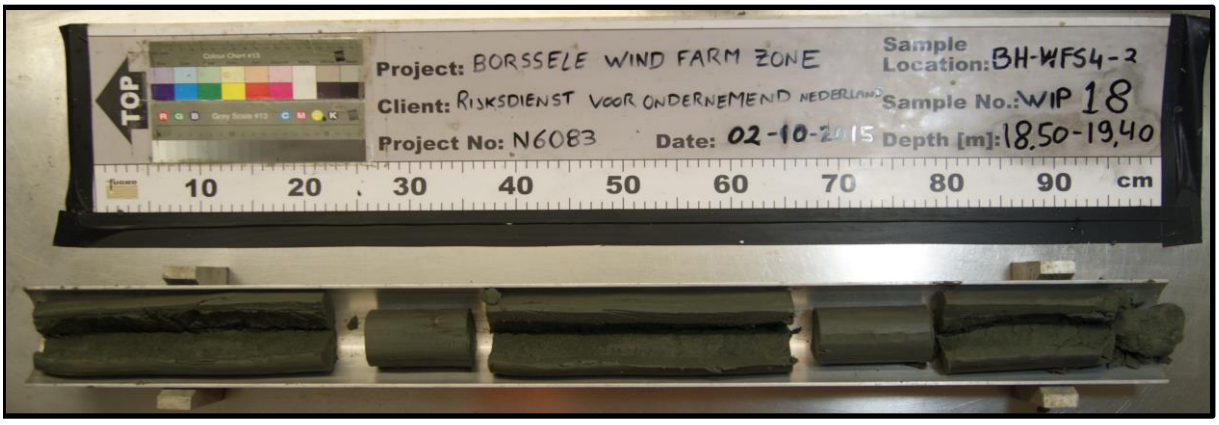
Location : BH-WFS4-3
Sample : WIP18
Depth [m bsf] : 14.00 to 14.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



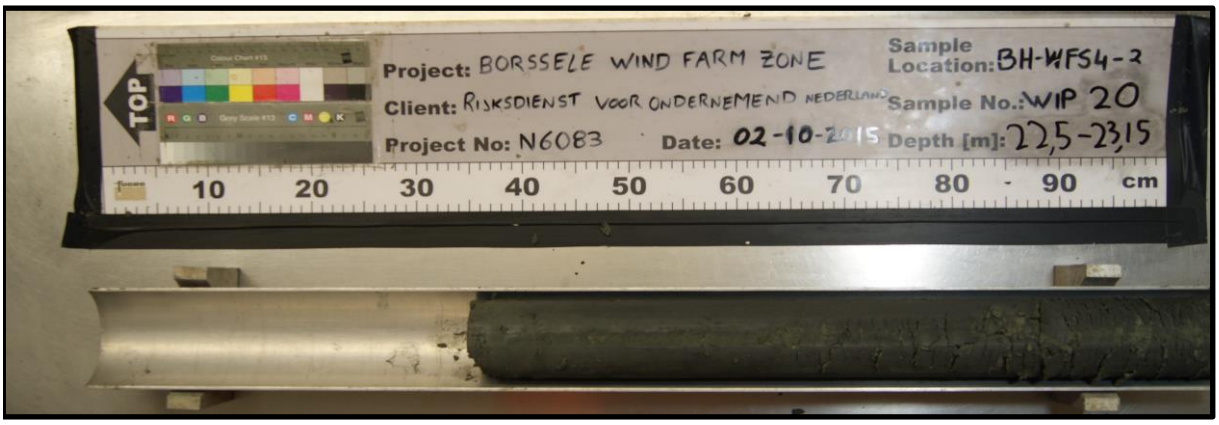
Location	:	BH-WFS4-3
Sample	:	WIP19
Depth [m bsf]	:	18.50 to 19.40
Note(s)	:	Incorrect sample number on photograph



Location	:	BH-WFS4-3
Sample	:	WIP19
Depth [m bsf]	:	18.50 to 19.40
Note(s)	:	SPLIT, incorrect sample number on photograph

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



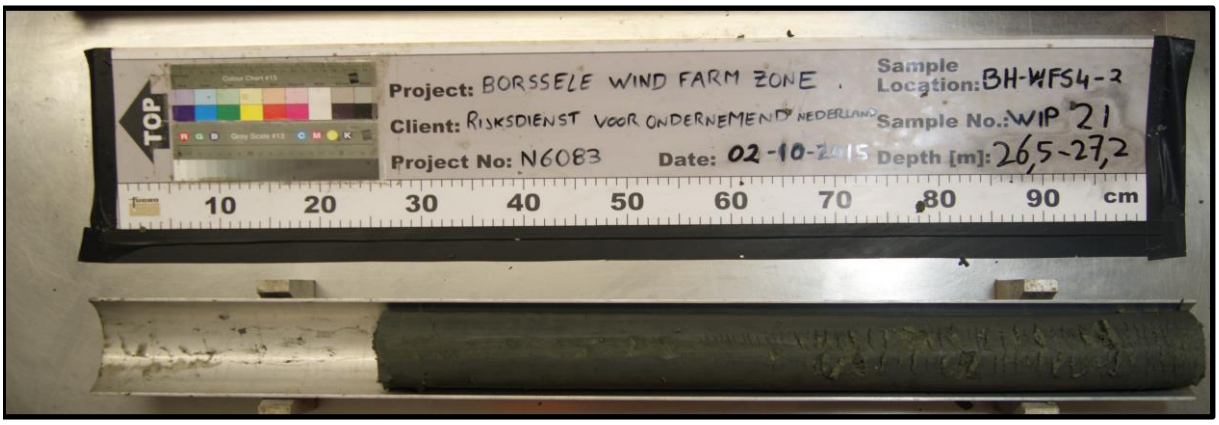
Location : BH-WFS4-3
Sample : WIP20
Depth [m bsf] : 22.50 to 23.15



Location : BH-WFS4-3
Sample : WIP20
Depth [m bsf] : 22.50 to 23.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



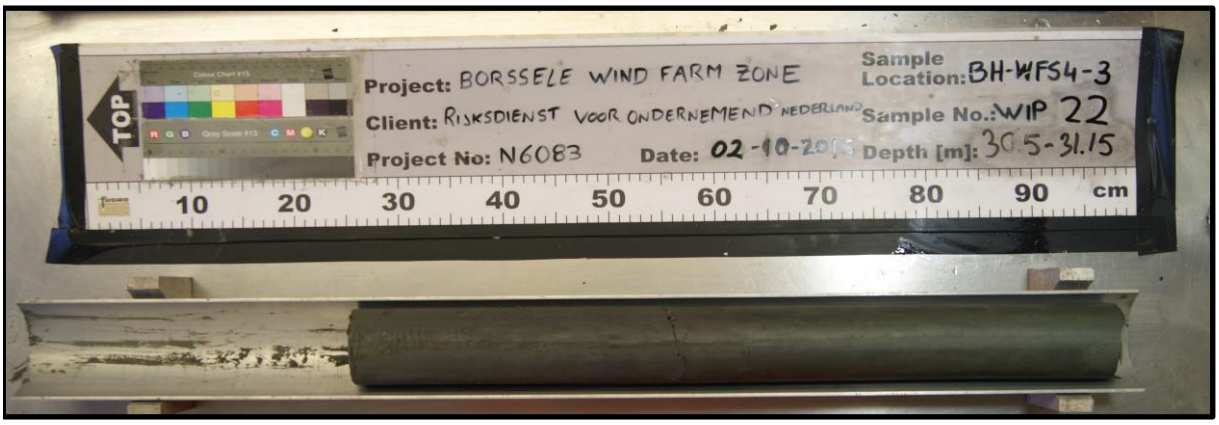
Location : BH-WFS4-3
Sample : WIP21
Depth [m bsf] : 26.50 to 27.20



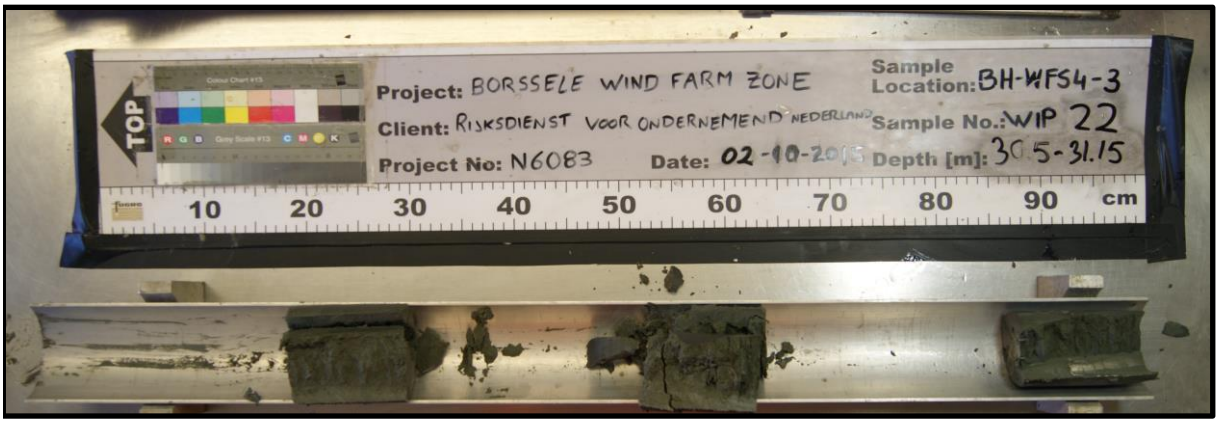
Location : BH-WFS4-3
Sample : WIP21
Depth [m bsf] : 26.50 to 27.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



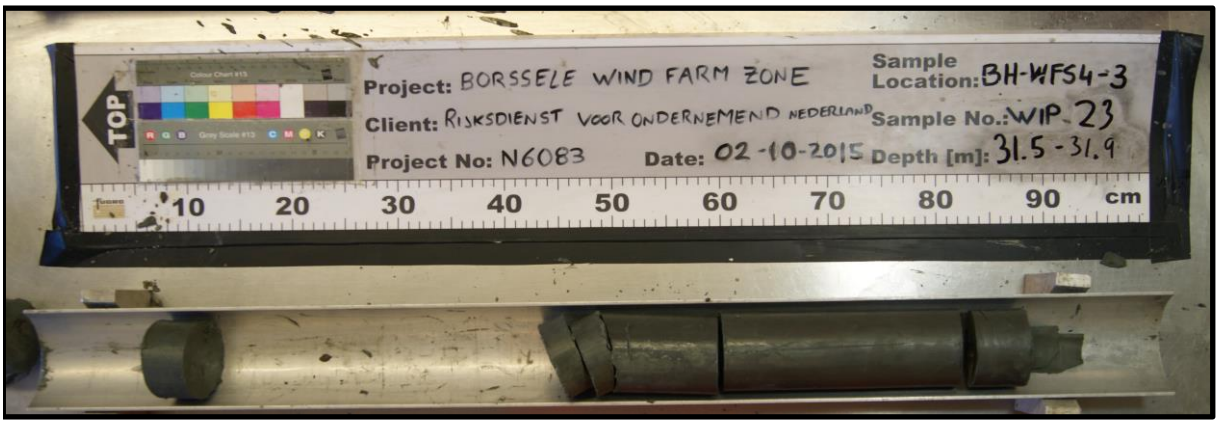
Location : BH-WFS4-3
Sample : WIP22
Depth [m bsf] : 30.50 to 31.15



Location : BH-WFS4-3
Sample : WIP22
Depth [m bsf] : 30.50 to 31.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



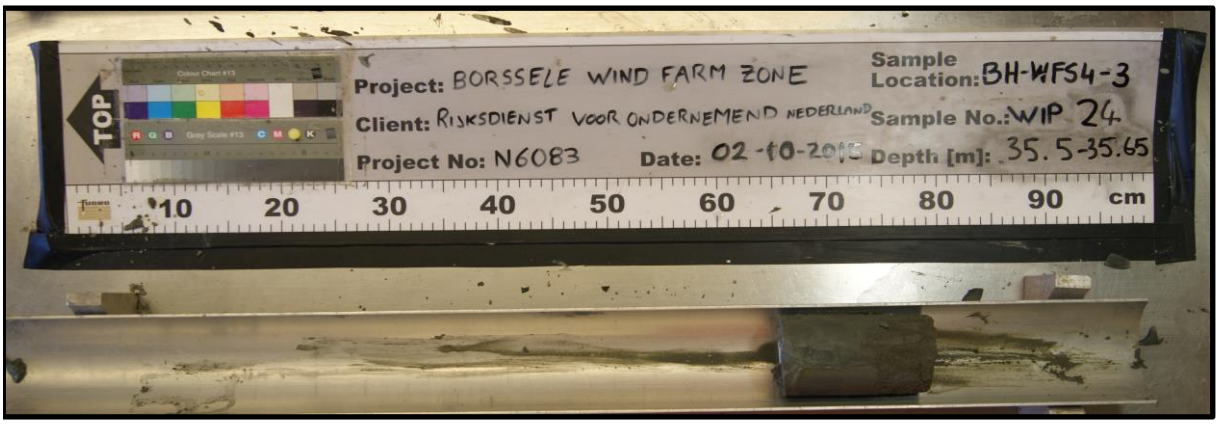
Location : BH-WFS4-3
Sample : WIP23
Depth [m bsf] : 31.50 to 31.90



Location : BH-WFS4-3
Sample : WIP23
Depth [m bsf] : 31.50 to 31.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



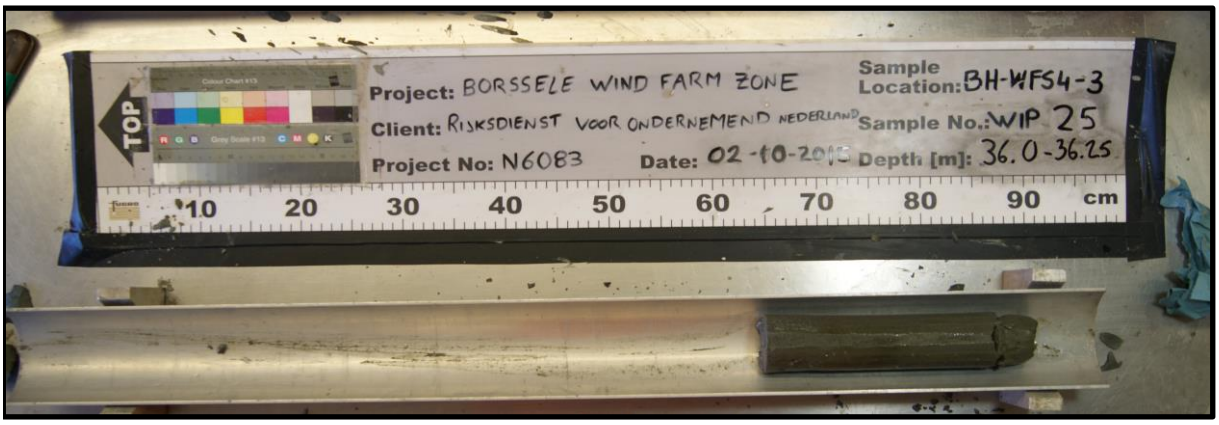
Location : BH-WFS4-3
Sample : WIP24
Depth [m bsf] : 35.50 to 35.65



Location : BH-WFS4-3
Sample : WIP24
Depth [m bsf] : 35.50 to 35.65
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



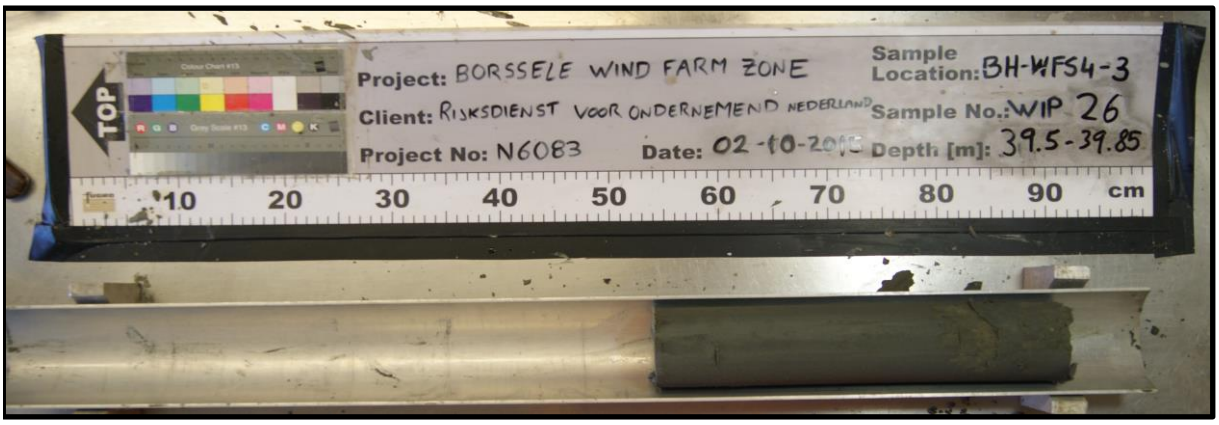
Location : BH-WFS4-3
Sample : WIP25
Depth [m bsf] : 36.00 to 36.25



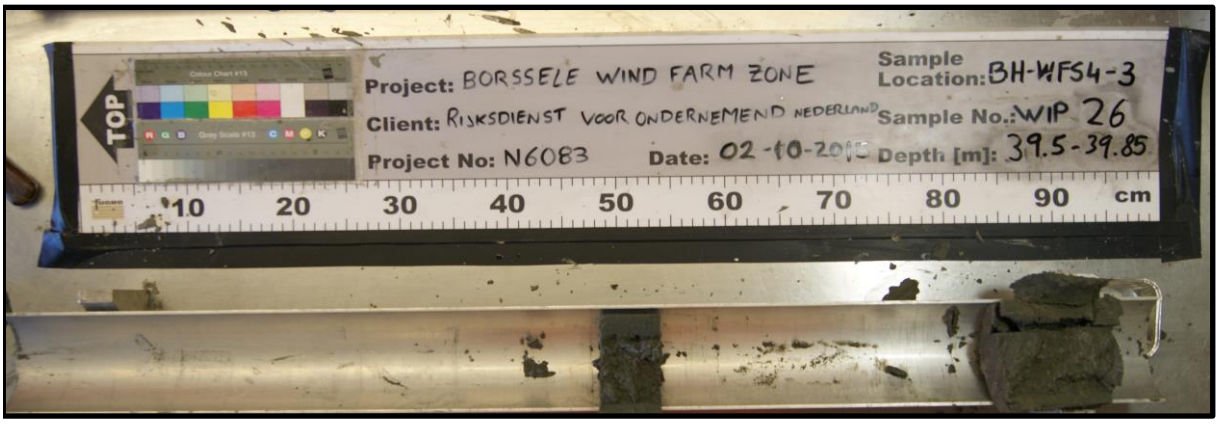
Location : BH-WFS4-3
Sample : WIP25
Depth [m bsf] : 36.00 to 36.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



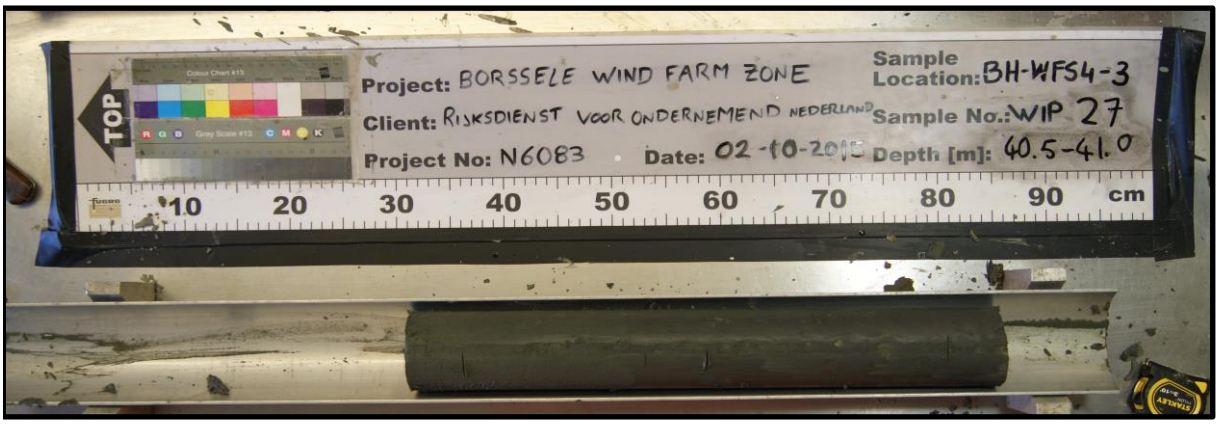
Location : BH-WFS4-3
Sample : WIP26
Depth [m bsf] : 39.50 to 39.85



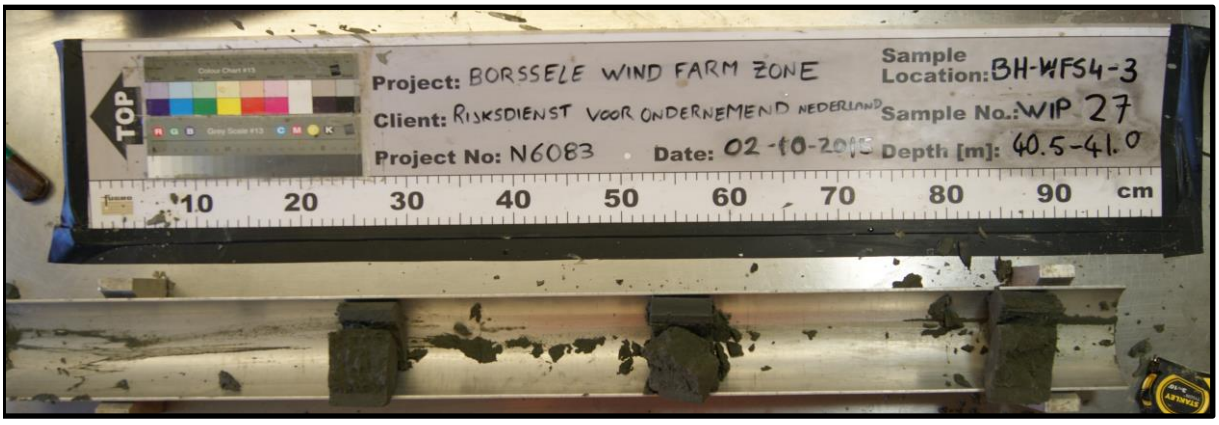
Location : BH-WFS4-3
Sample : WIP26
Depth [m bsf] : 39.50 to 39.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



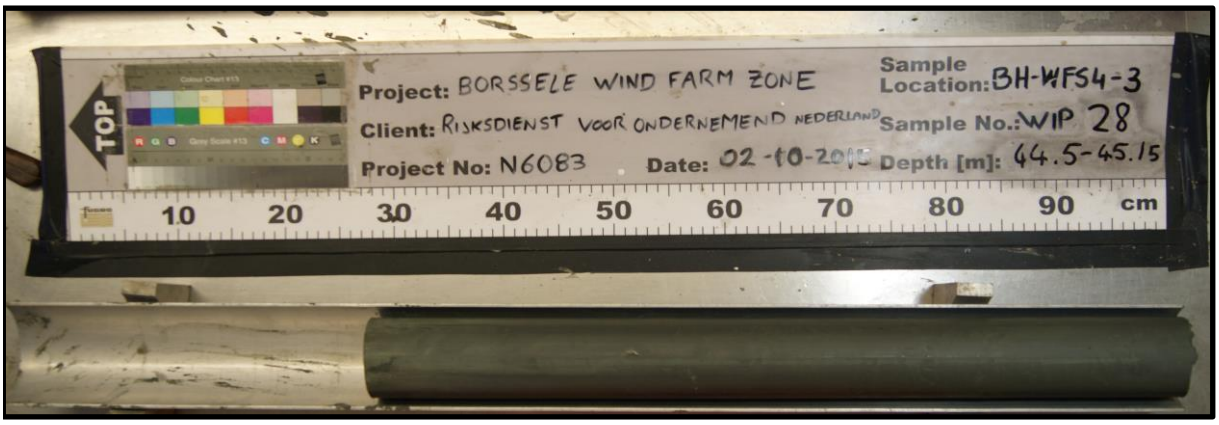
Location : BH-WFS4-3
Sample : WIP27
Depth [m bsf] : 40.50 to 41.00



Location : BH-WFS4-3
Sample : WIP27
Depth [m bsf] : 40.50 to 41.00
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



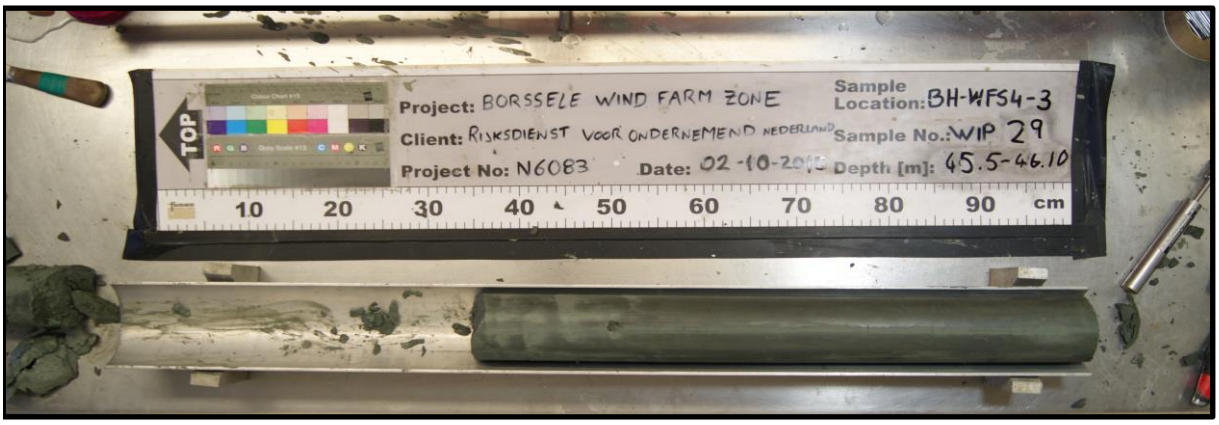
Location : BH-WFS4-3
Sample : WIP28
Depth [m bsf] : 44.50 to 45.15



Location : BH-WFS4-3
Sample : WIP28
Depth [m bsf] : 44.50 to 45.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



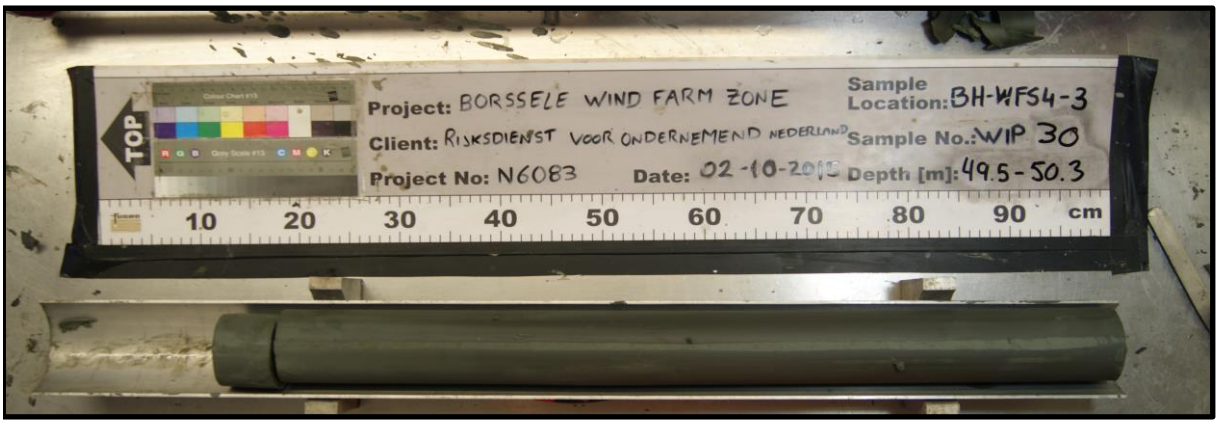
Location : BH-WFS4-3
Sample : WIP29
Depth [m bsf] : 45.50 to 46.10



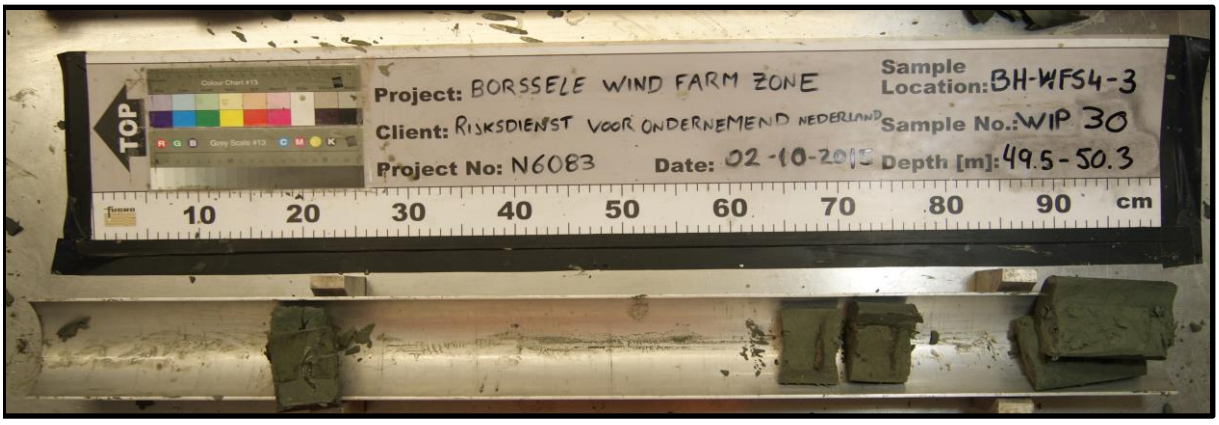
Location : BH-WFS4-3
Sample : WIP29
Depth [m bsf] : 45.50 to 46.10
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



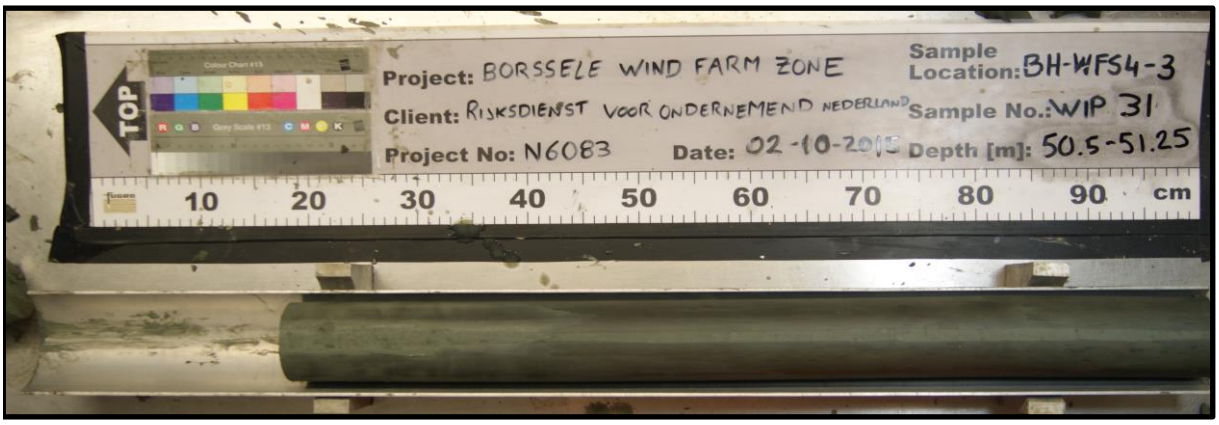
Location	:	BH-WFS4-3
Sample	:	WIP30
Depth [m bsf]	:	49.50 to 50.30



Location	:	BH-WFS4-3
Sample	:	WIP30
Depth [m bsf]	:	49.50 to 50.30
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



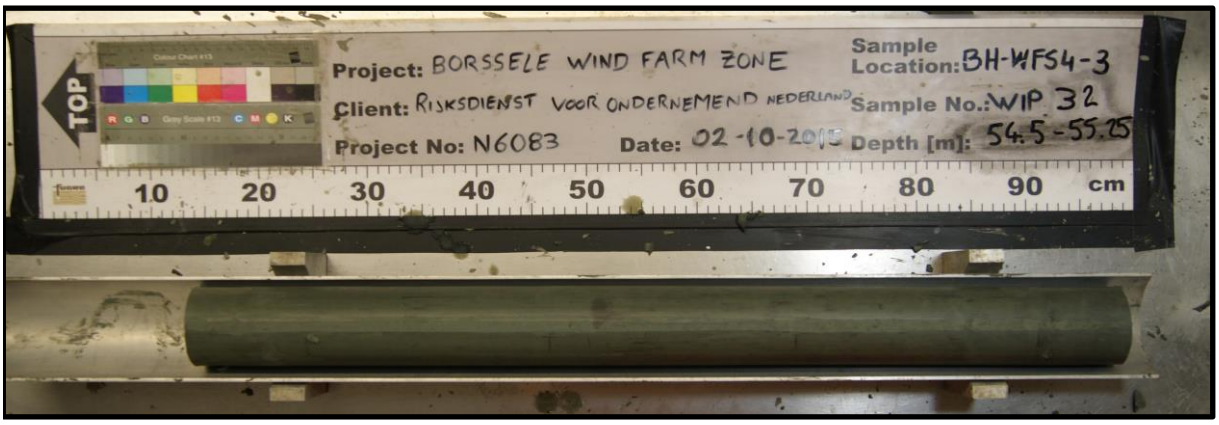
Location : BH-WFS4-3
Sample : WIP31
Depth [m bsf] : 50.50 to 51.25



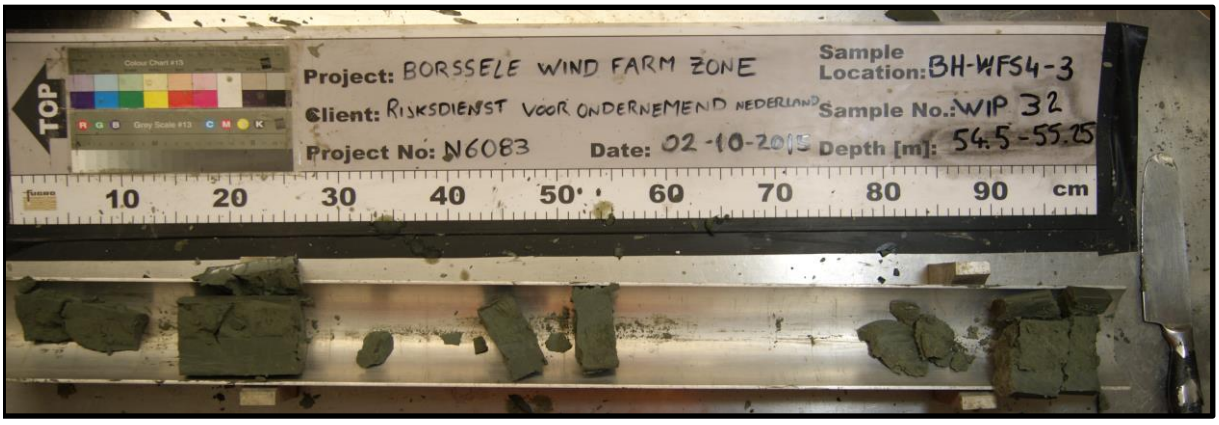
Location : BH-WFS4-3
Sample : WIP31
Depth [m bsf] : 50.50 to 51.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



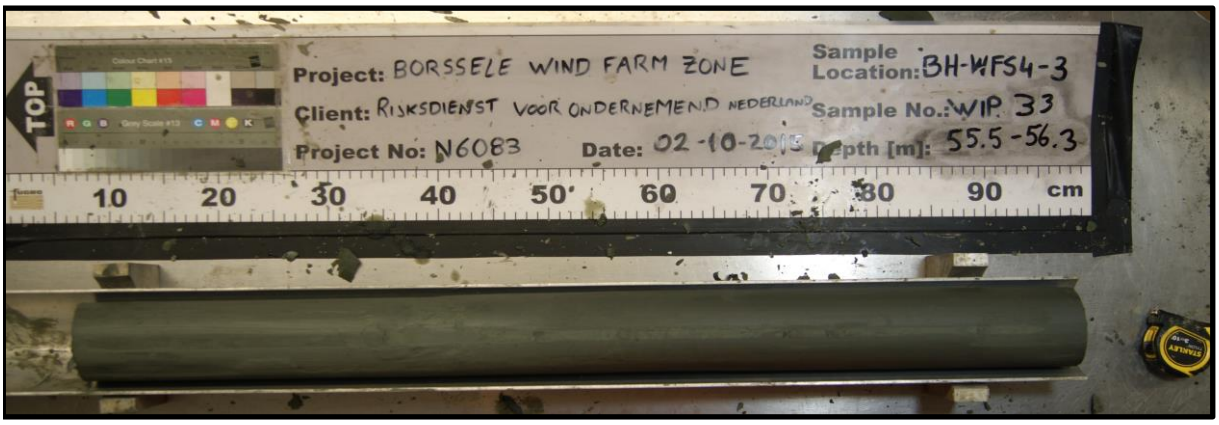
Location : BH-WFS4-3
Sample : WIP32
Depth [m bsf] : 54.50 to 55.25



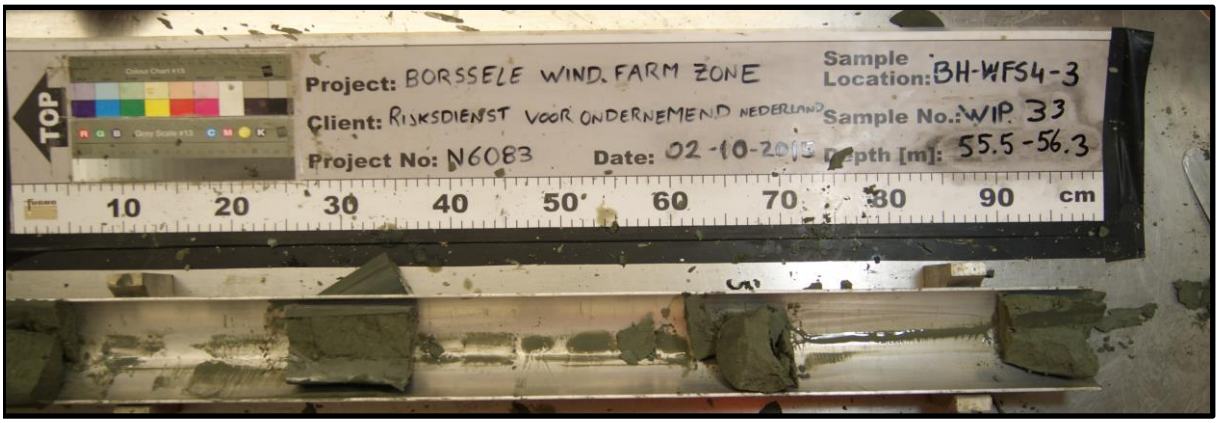
Location : BH-WFS4-3
Sample : WIP32
Depth [m bsf] : 54.50 to 55.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



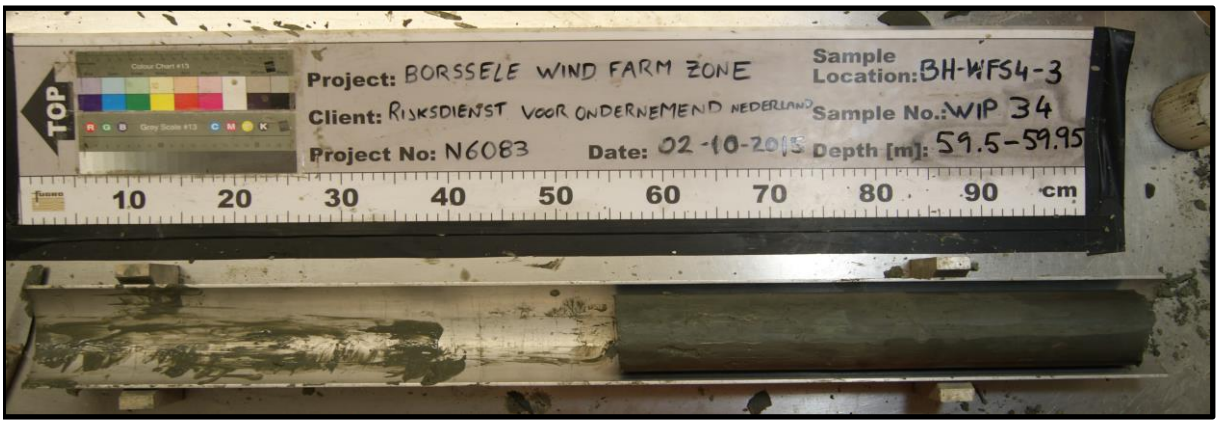
Location : BH-WFS4-3
Sample : WIP33
Depth [m bsf] : 55.50 to 56.30



Location : BH-WFS4-3
Sample : WIP33
Depth [m bsf] : 55.50 to 56.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-3
Sample : WIP34
Depth [m bsf] : 59.50 to 59.95

Missing Photograph

Location : BH-WFS4-3
Sample : WIP34
Depth [m bsf] : 59.50 to 59.95
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP01
Depth [m bsf] : 0.00 to 0.60



Location : BH-WFS4-4
Sample : WIP01
Depth [m bsf] : 0.00 to 0.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP02
Depth [m bsf] : 1.00 to 1.65



Location : BH-WFS4-4
Sample : WIP02
Depth [m bsf] : 1.00 to 1.65
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP03
Depth [m bsf] : 2.00 to 2.30



Location : BH-WFS4-4
Sample : WIP03
Depth [m bsf] : 2.00 to 2.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP04
Depth [m bsf] : 2.50 to 3.05



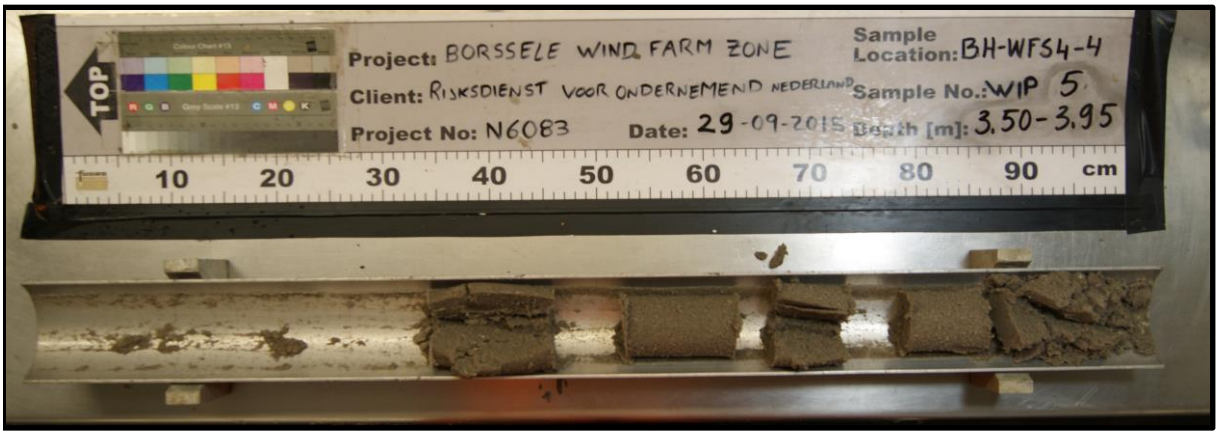
Location : BH-WFS4-4
Sample : WIP04
Depth [m bsf] : 2.50 to 3.05
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



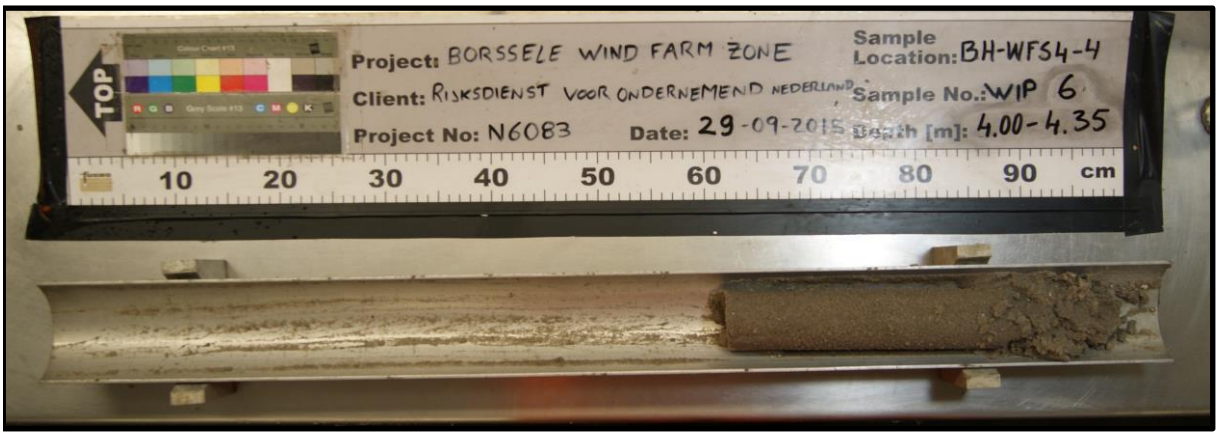
Location : BH-WFS4-4
Sample : WIP05
Depth [m bsf] : 3.50 to 3.95



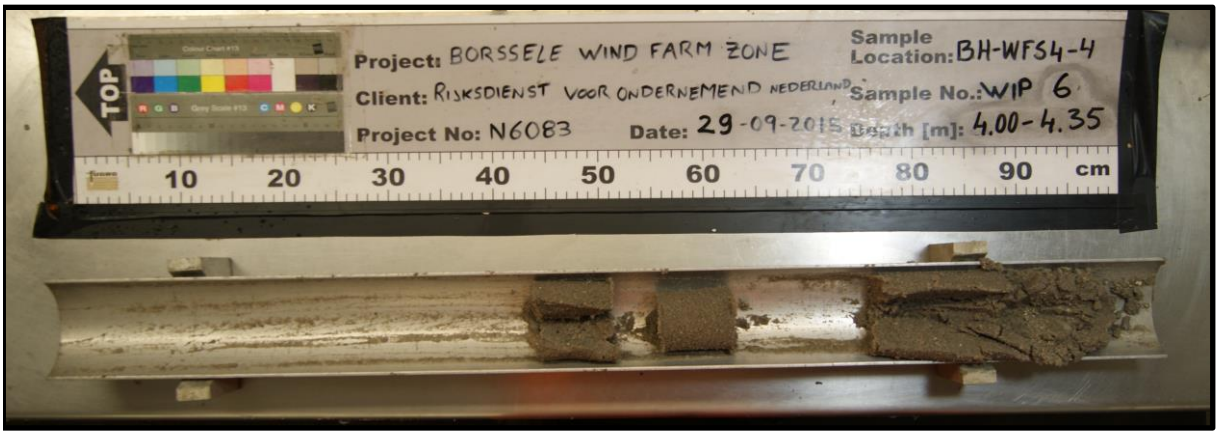
Location : BH-WFS4-4
Sample : WIP05
Depth [m bsf] : 3.50 to 3.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP06
Depth [m bsf] : 4.00 to 4.35



Location : BH-WFS4-4
Sample : WIP06
Depth [m bsf] : 4.00 to 4.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



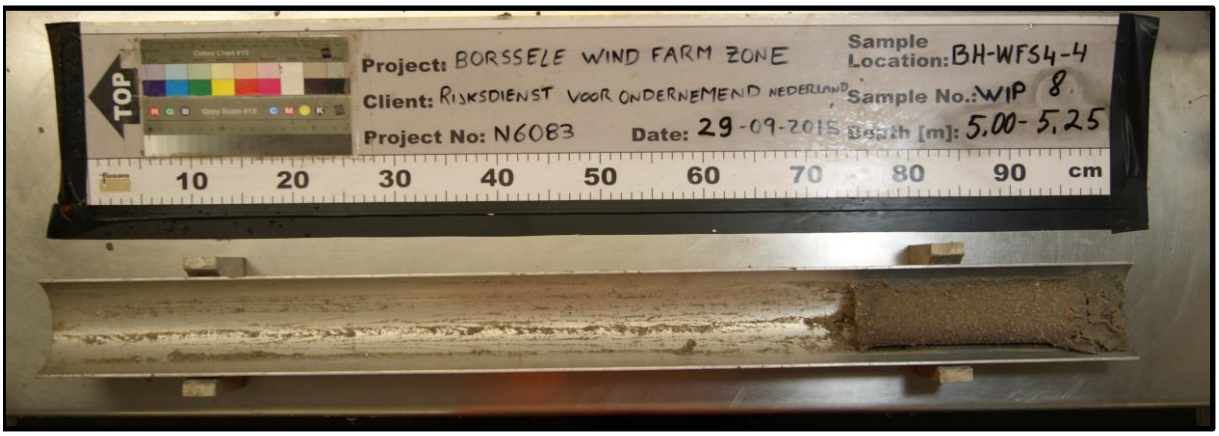
Location : BH-WFS4-4
Sample : WIP07
Depth [m bsf] : 4.50 to 4.85



Location : BH-WFS4-4
Sample : WIP07
Depth [m bsf] : 4.50 to 4.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP08
Depth [m bsf] : 5.00 to 5.25



Location : BH-WFS4-4
Sample : WIP08
Depth [m bsf] : 5.00 to 5.25
Note(s) : SPLIT, laboratory unit weight tool left in sample

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP09
Depth [m bsf] : 5.50 to 5.70



Location : BH-WFS4-4
Sample : WIP09
Depth [m bsf] : 5.50 to 5.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP10
Depth [m bsf] : 6.00 to 6.25



Location : BH-WFS4-4
Sample : WIP10
Depth [m bsf] : 6.00 to 6.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



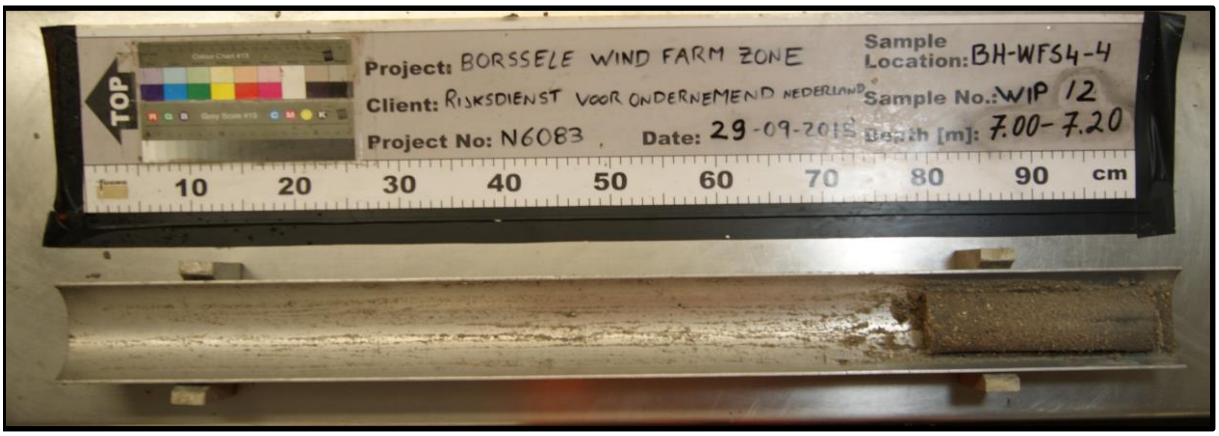
Location : BH-WFS4-4
Sample : WIP11
Depth [m bsf] : 6.50 to 6.75



Location : BH-WFS4-4
Sample : WIP11
Depth [m bsf] : 6.50 to 6.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



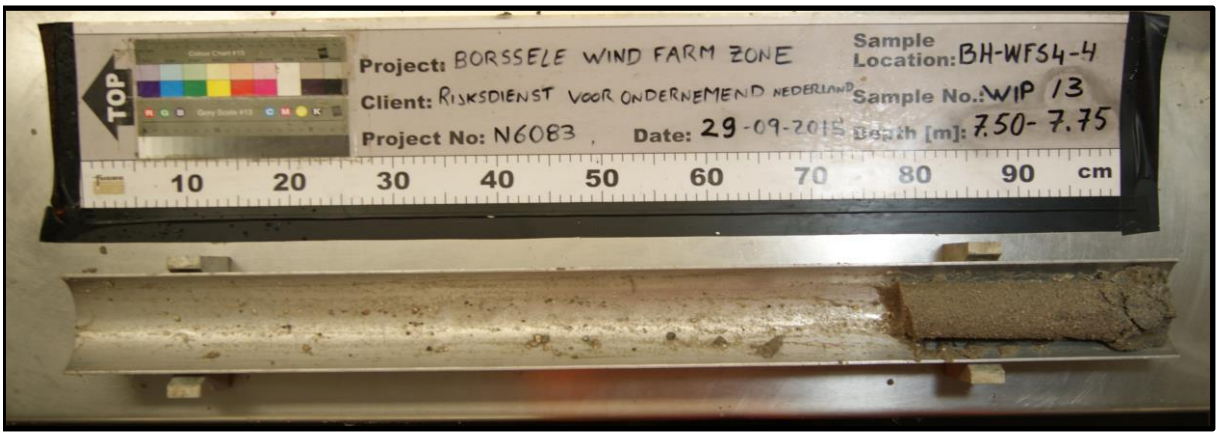
Location : BH-WFS4-4
Sample : WIP12
Depth [m bsf] : 7.00 to 7.20



Location : BH-WFS4-4
Sample : WIP12
Depth [m bsf] : 7.00 to 7.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP13
Depth [m bsf] : 7.50 to 7.75



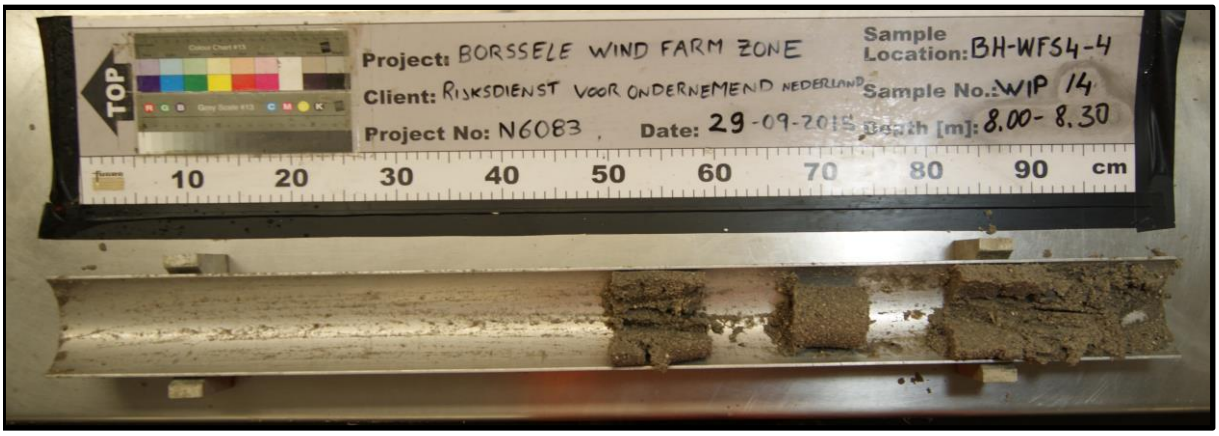
Location : BH-WFS4-4
Sample : WIP13
Depth [m bsf] : 7.50 to 7.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP14
Depth [m bsf] : 8.00 to 8.30



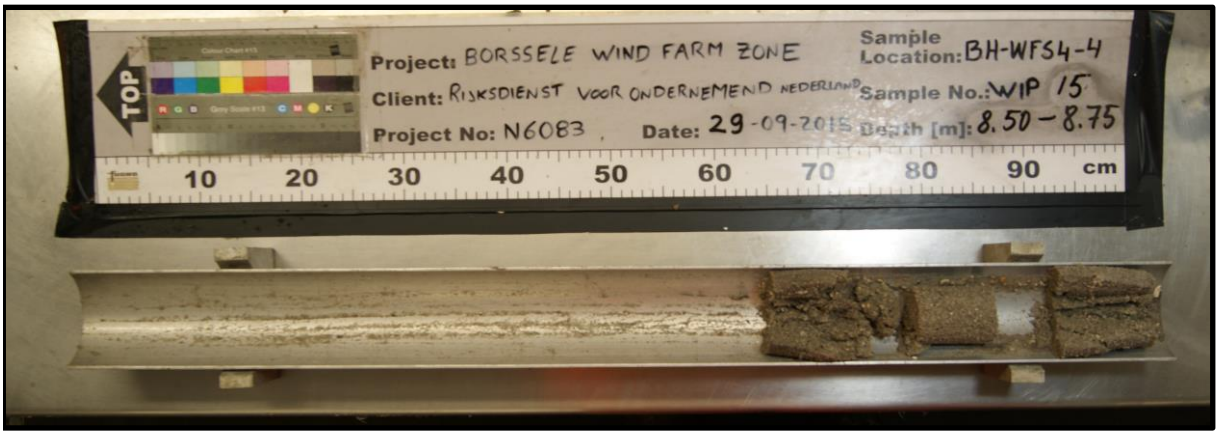
Location : BH-WFS4-4
Sample : WIP14
Depth [m bsf] : 8.00 to 8.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP15
Depth [m bsf] : 8.50 to 8.75



Location : BH-WFS4-4
Sample : WIP15
Depth [m bsf] : 8.50 to 8.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP16
Depth [m bsf] : 9.00 to 9.20



Location : BH-WFS4-4
Sample : WIP16
Depth [m bsf] : 9.00 to 9.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

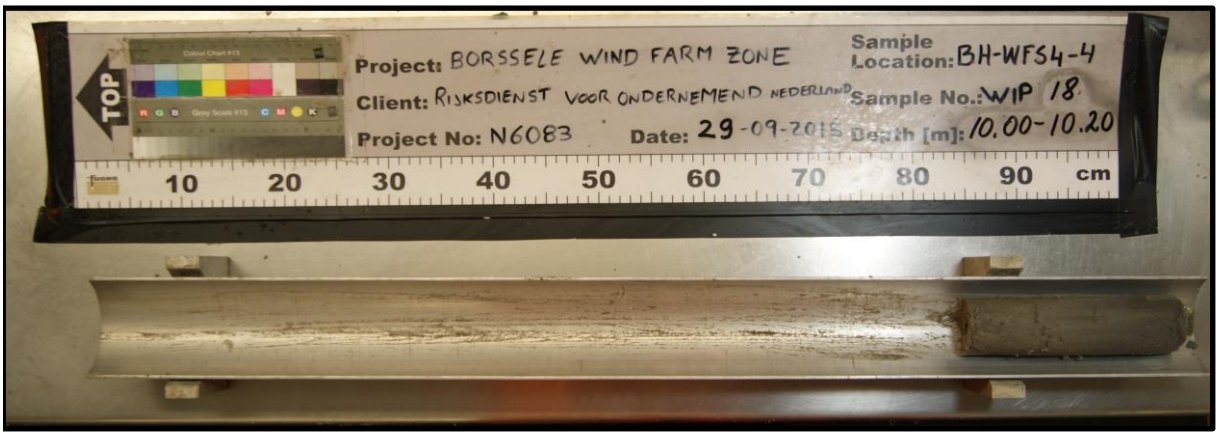
Location	:	BH-WFS4-4
Sample	:	WIP17
Depth [m bsf]	:	9.50 to 9.75
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-4
Sample	:	WIP17
Depth [m bsf]	:	9.50 to 9.75
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



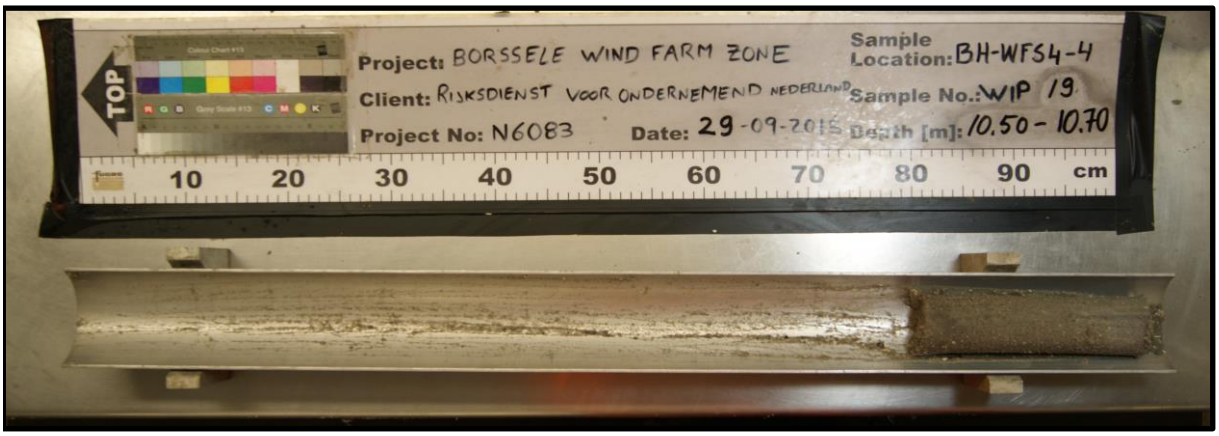
Location : BH-WFS4-4
Sample : WIP18
Depth [m bsf] : 10.00 to 10.20



Location : BH-WFS4-4
Sample : WIP18
Depth [m bsf] : 10.00 to 10.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP19
Depth [m bsf] : 10.50 to 10.70



Location : BH-WFS4-4
Sample : WIP19
Depth [m bsf] : 10.50 to 10.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP20
Depth [m bsf] : 11.00 to 11.30



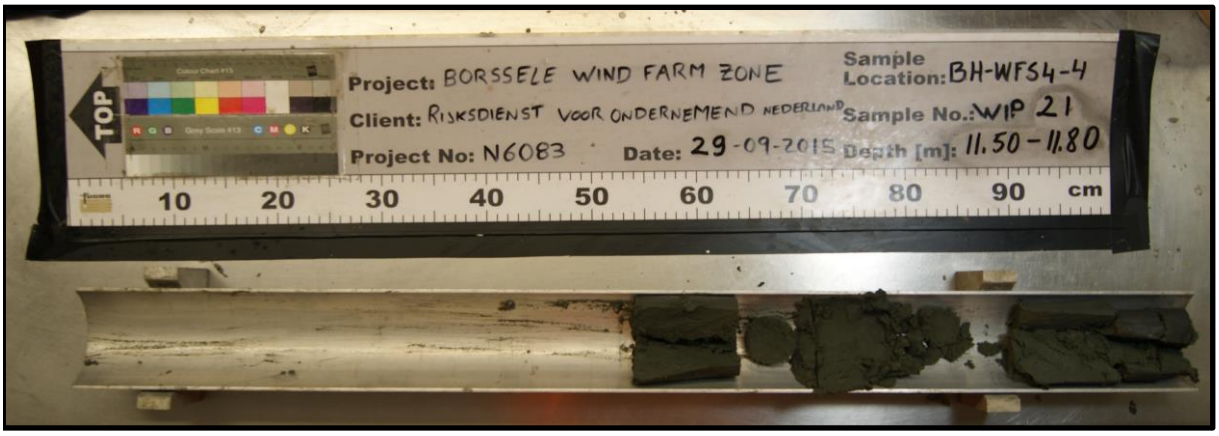
Location : BH-WFS4-4
Sample : WIP20
Depth [m bsf] : 11.00 to 11.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

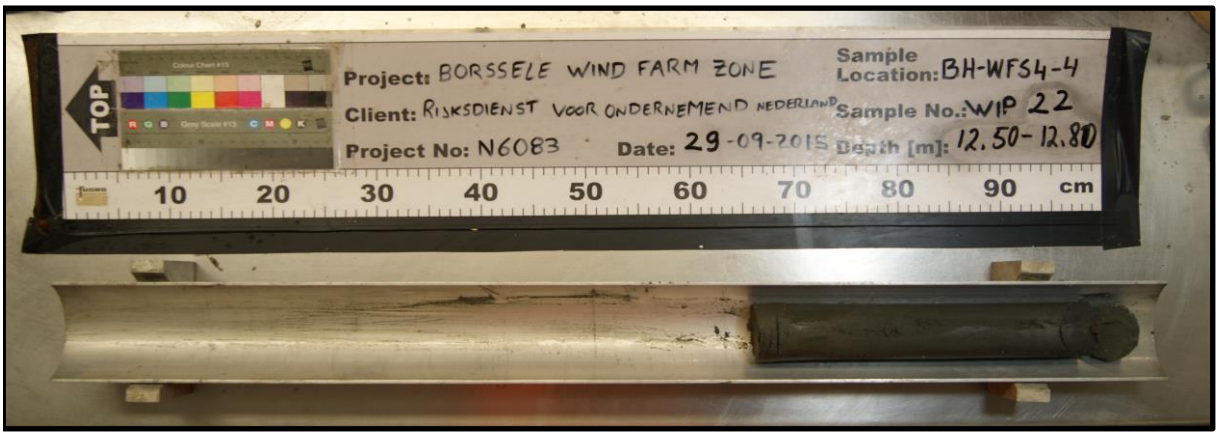
Location	:	BH-WFS4-4
Sample	:	WIP21
Depth [m bsf]	:	11.50 to 11.80
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-4
Sample	:	WIP21
Depth [m bsf]	:	11.50 to 11.80
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



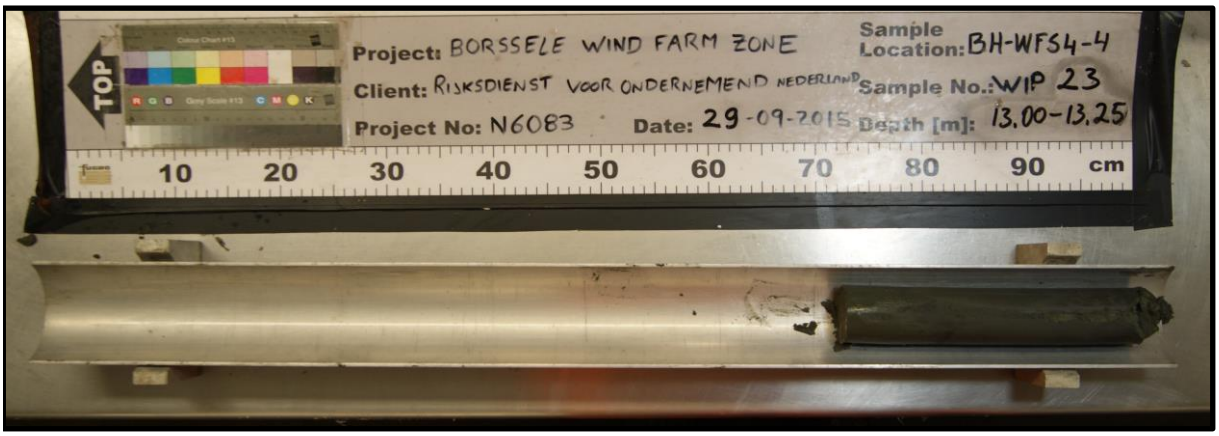
Location : BH-WFS4-4
Sample : WIP22
Depth [m bsf] : 12.50 to 12.80



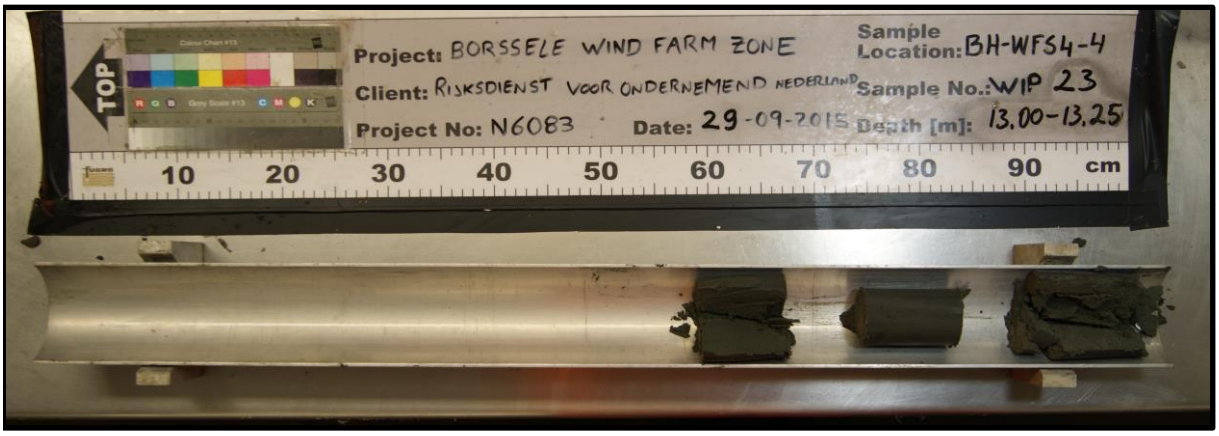
Location : BH-WFS4-4
Sample : WIP22
Depth [m bsf] : 12.50 to 12.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP23
Depth [m bsf] : 13.00 to 13.25



Location : BH-WFS4-4
Sample : WIP23
Depth [m bsf] : 13.00 to 13.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP24
Depth [m bsf] : 13.50 to 13.80



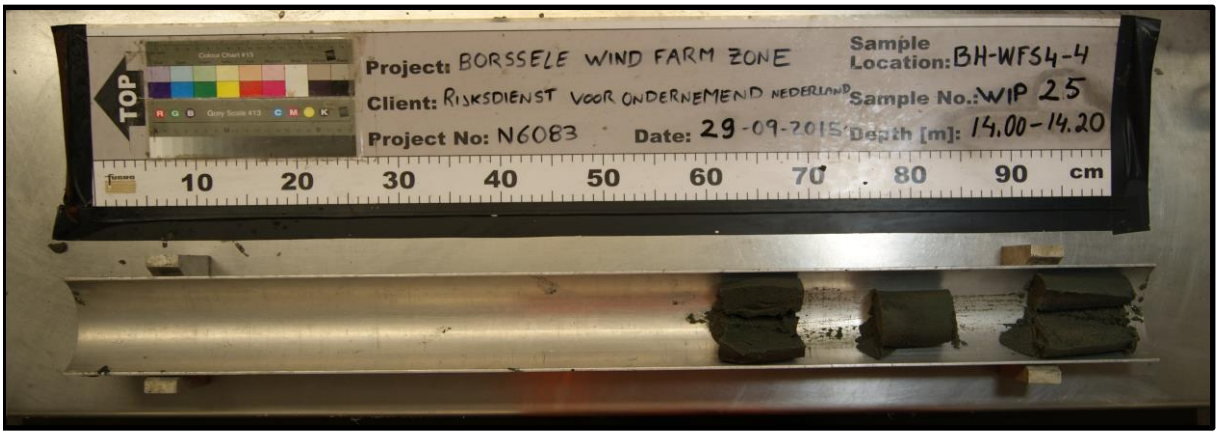
Location : BH-WFS4-4
Sample : WIP24
Depth [m bsf] : 13.50 to 13.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP25
Depth [m bsf] : 14.00 to 14.20



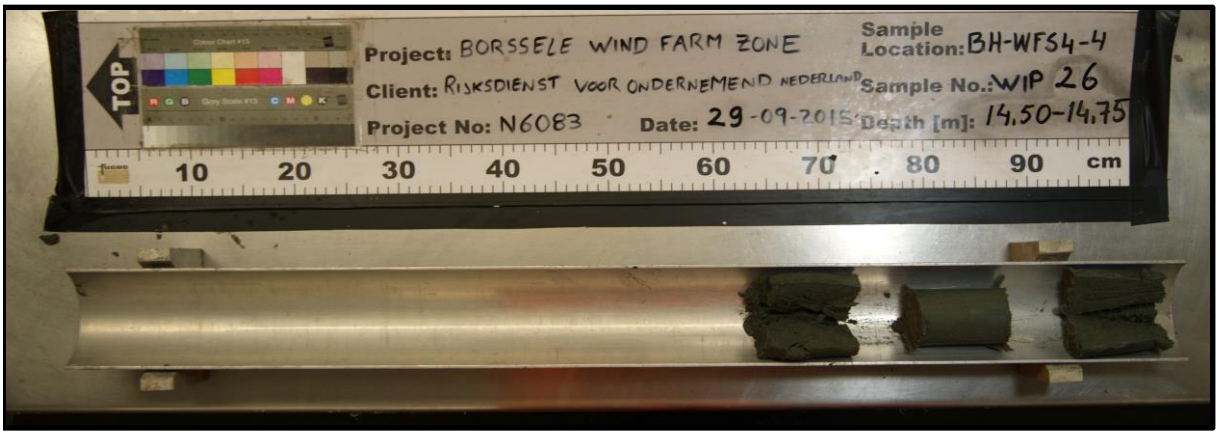
Location : BH-WFS4-4
Sample : WIP25
Depth [m bsf] : 14.00 to 14.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



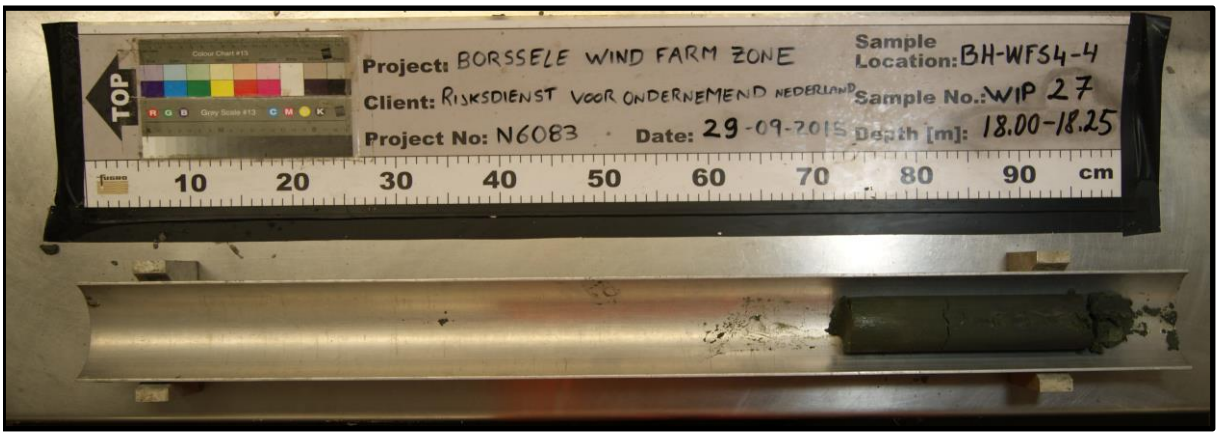
Location : BH-WFS4-4
Sample : WIP26
Depth [m bsf] : 14.50 to 14.75



Location : BH-WFS4-4
Sample : WIP26
Depth [m bsf] : 14.50 to 14.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP27
Depth [m bsf] : 18.00 to 18.25



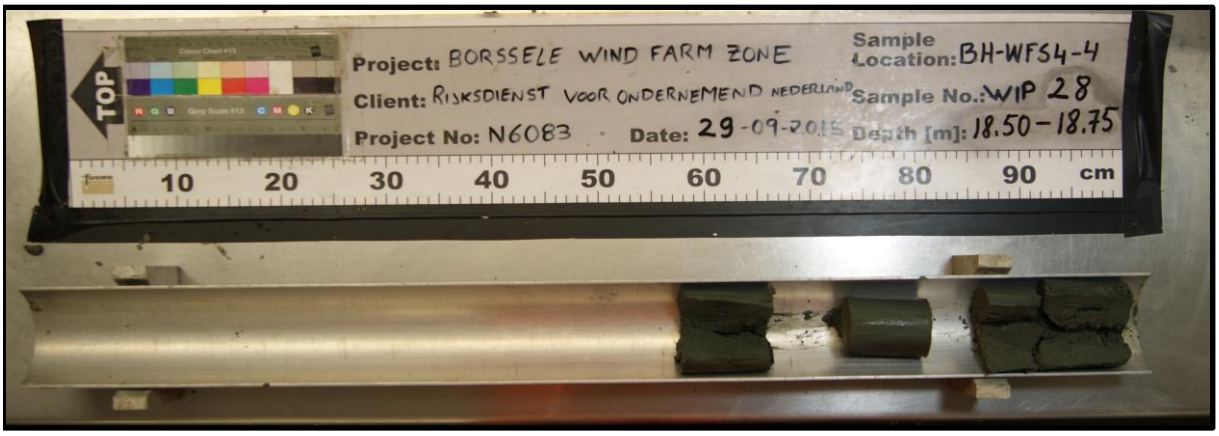
Location : BH-WFS4-4
Sample : WIP27
Depth [m bsf] : 18.00 to 18.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP28
Depth [m bsf] : 18.50 to 18.75



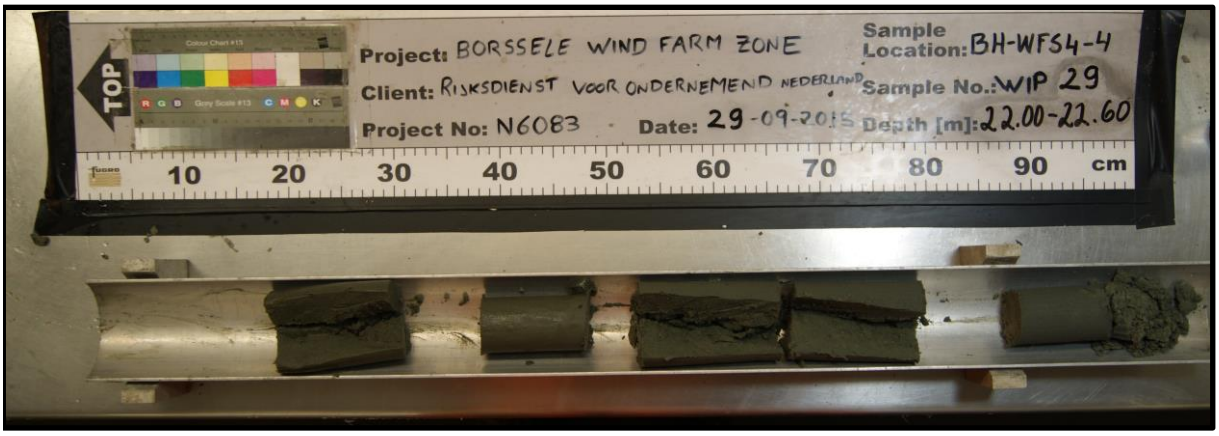
Location : BH-WFS4-4
Sample : WIP28
Depth [m bsf] : 18.50 to 18.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

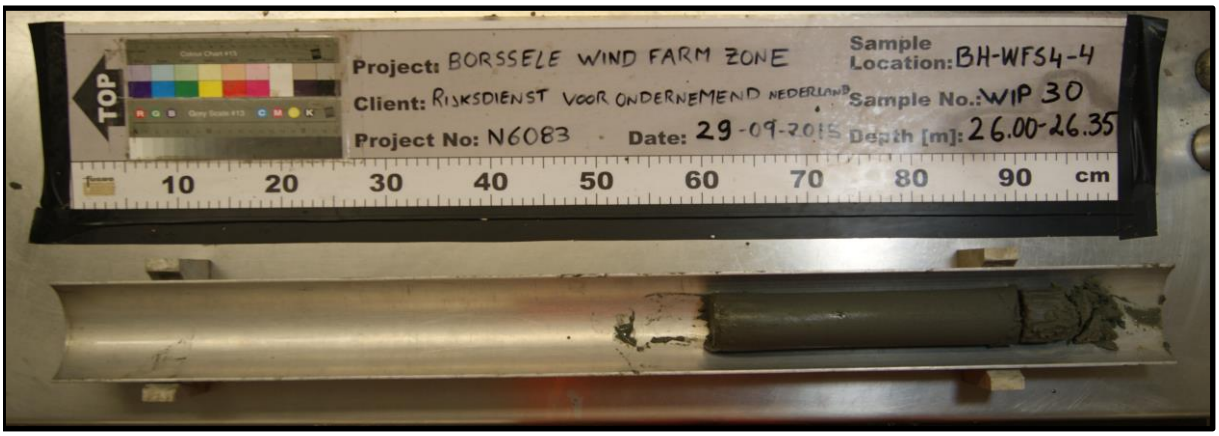
Location	:	BH-WFS4-4
Sample	:	WIP29
Depth [m bsf]	:	22.00 to 22.60
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-4
Sample	:	WIP29
Depth [m bsf]	:	22.00 to 22.60
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



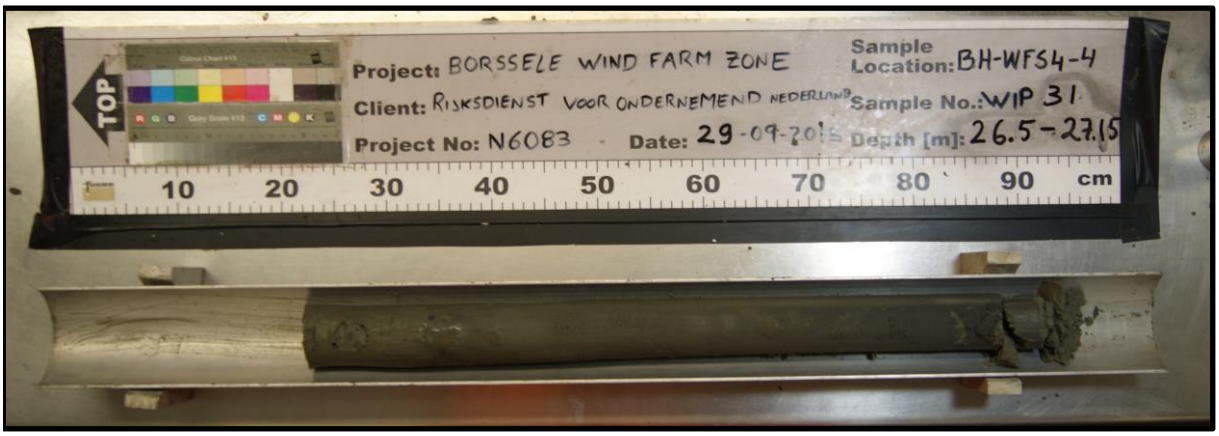
Location : BH-WFS4-4
Sample : WIP30
Depth [m bsf] : 26.00 to 26.35



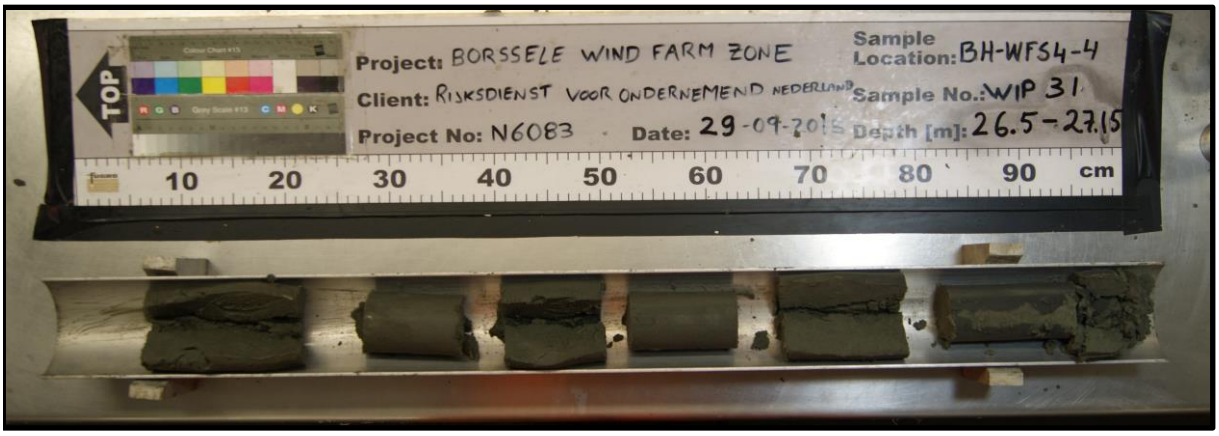
Location : BH-WFS4-4
Sample : WIP30
Depth [m bsf] : 26.00 to 26.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



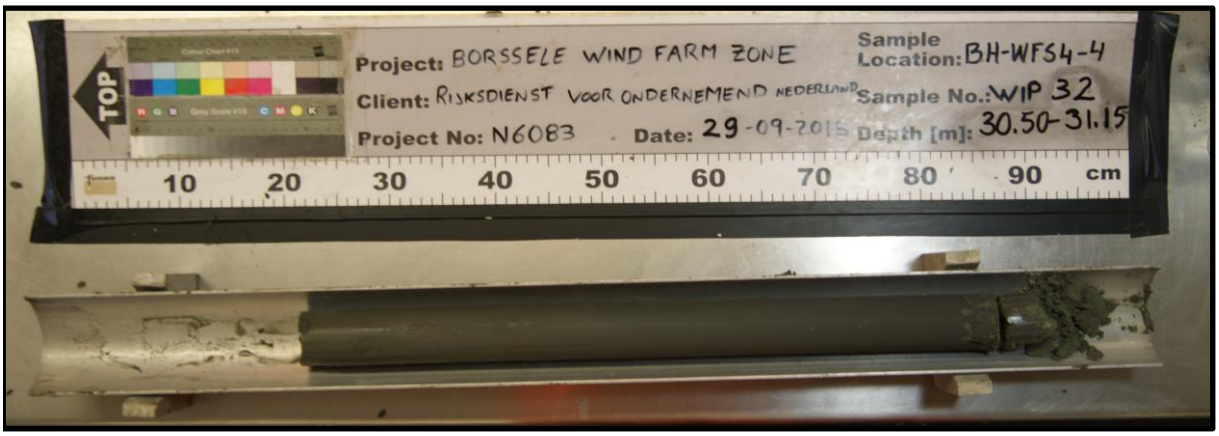
Location : BH-WFS4-4
Sample : WIP31
Depth [m bsf] : 26.50 to 27.15



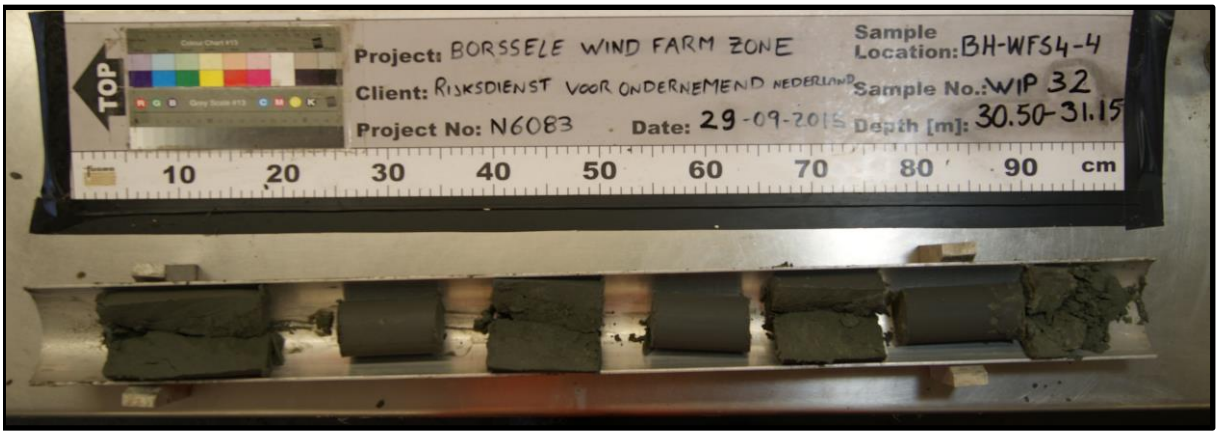
Location : BH-WFS4-4
Sample : WIP31
Depth [m bsf] : 26.50 to 27.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP32
Depth [m bsf] : 30.50 to 31.15



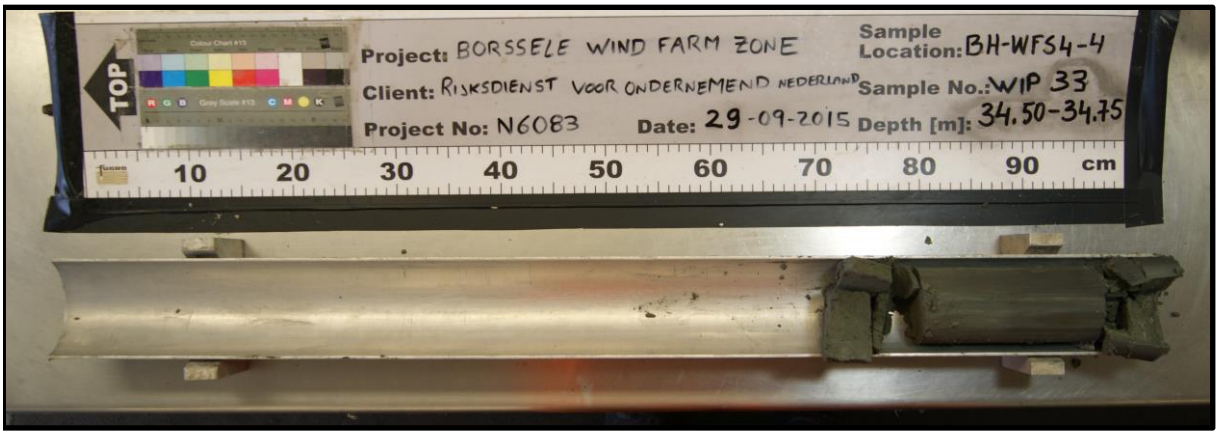
Location : BH-WFS4-4
Sample : WIP32
Depth [m bsf] : 30.50 to 31.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



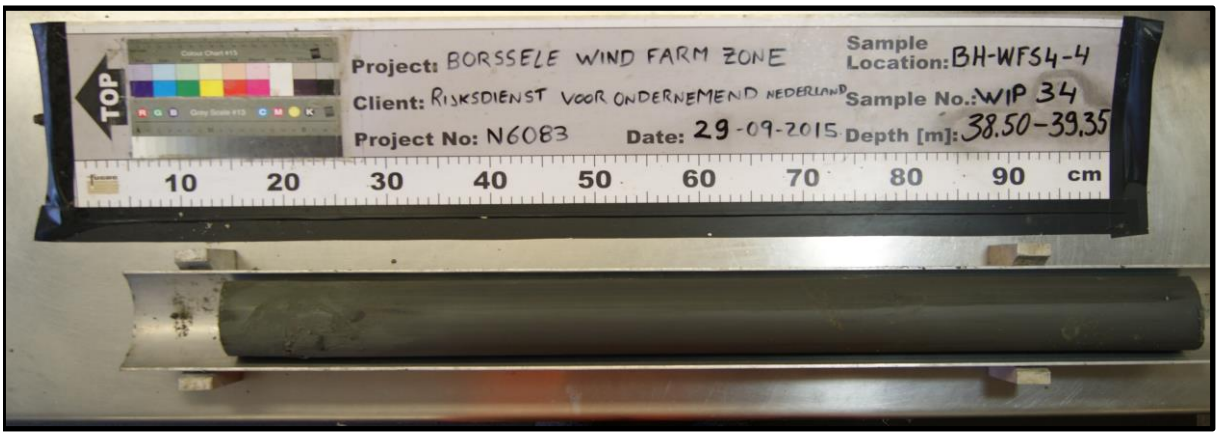
Location : BH-WFS4-4
Sample : WIP33
Depth [m bsf] : 34.50 to 34.75



Location : BH-WFS4-4
Sample : WIP33
Depth [m bsf] : 34.50 to 34.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



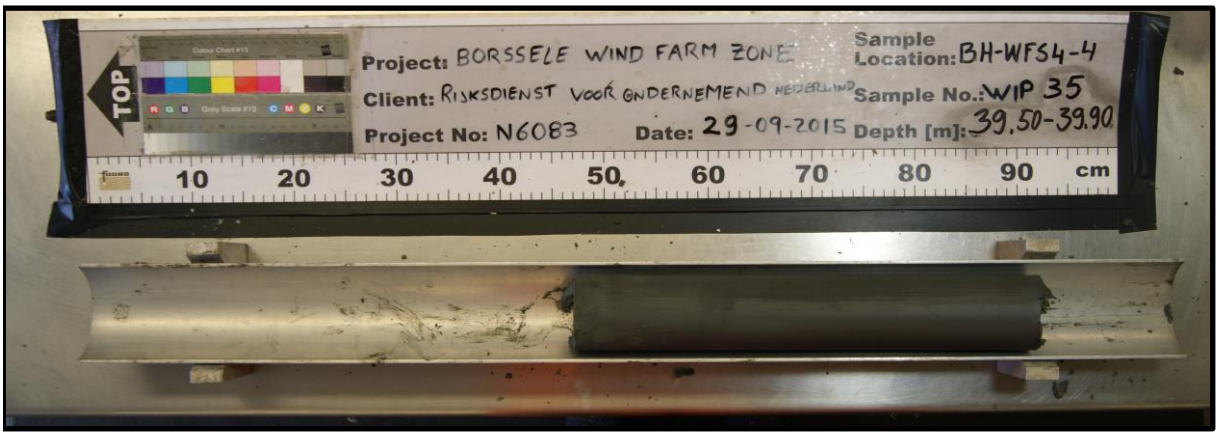
Location : BH-WFS4-4
Sample : WIP34
Depth [m bsf] : 38.50 to 39.35

Missing Photograph

Location : BH-WFS4-4
Sample : WIP34
Depth [m bsf] : 38.50 to 39.35
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



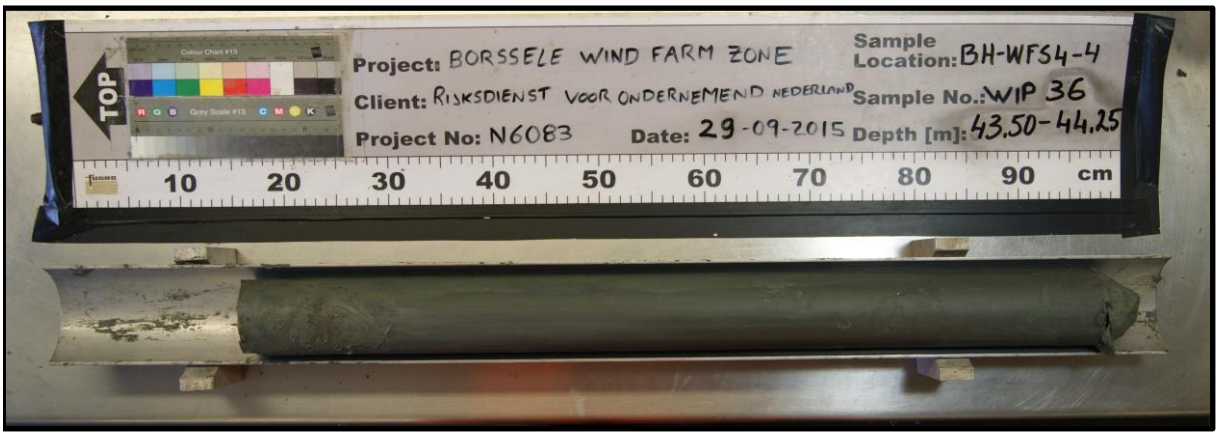
Location : BH-WFS4-4
Sample : WIP35
Depth [m bsf] : 39.50 to 39.90



Location : BH-WFS4-4
Sample : WIP35
Depth [m bsf] : 39.50 to 39.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-4
Sample : WIP36
Depth [m bsf] : 43.50 to 44.25



Location : BH-WFS4-4
Sample : WIP36
Depth [m bsf] : 43.50 to 44.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-4
Sample	:	WIP37
Depth [m bsf]	:	44.50 to 45.30

Missing Photograph

Location	:	BH-WFS4-4
Sample	:	WIP37
Depth [m bsf]	:	44.50 to 45.30
Note(s)	:	SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



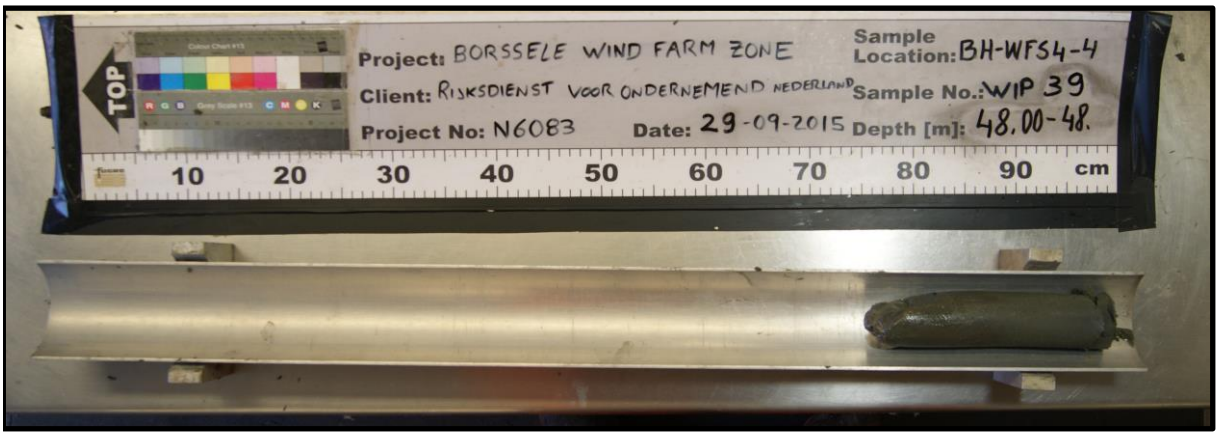
Location	:	BH-WFS4-4
Sample	:	WIP38
Depth [m bsf]	:	47.50 to 47.60
Note(s)	:	Incorrect depth on sample photograph

Missing Photograph

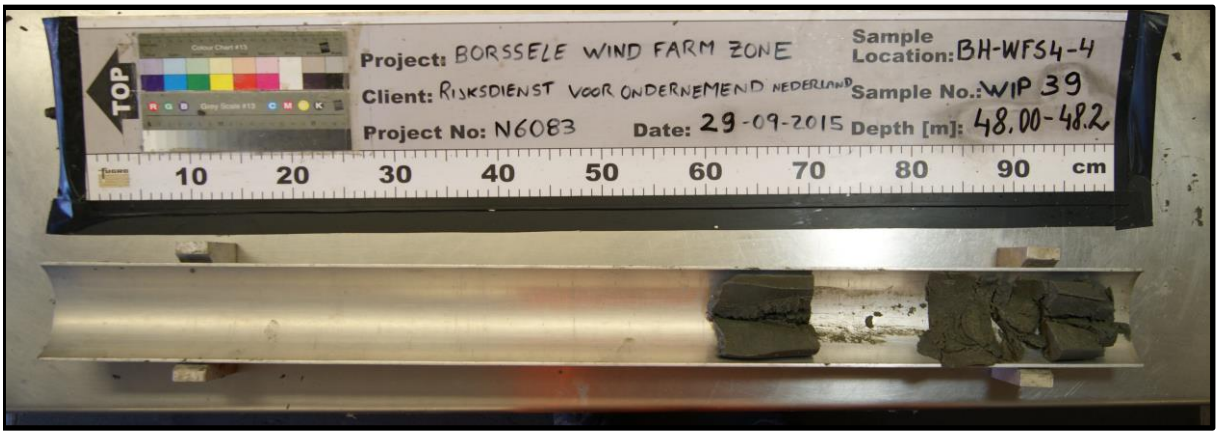
Location	:	BH-WFS4-4
Sample	:	WIP38
Depth [m bsf]	:	47.50 to 47.60
Note(s)	:	SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



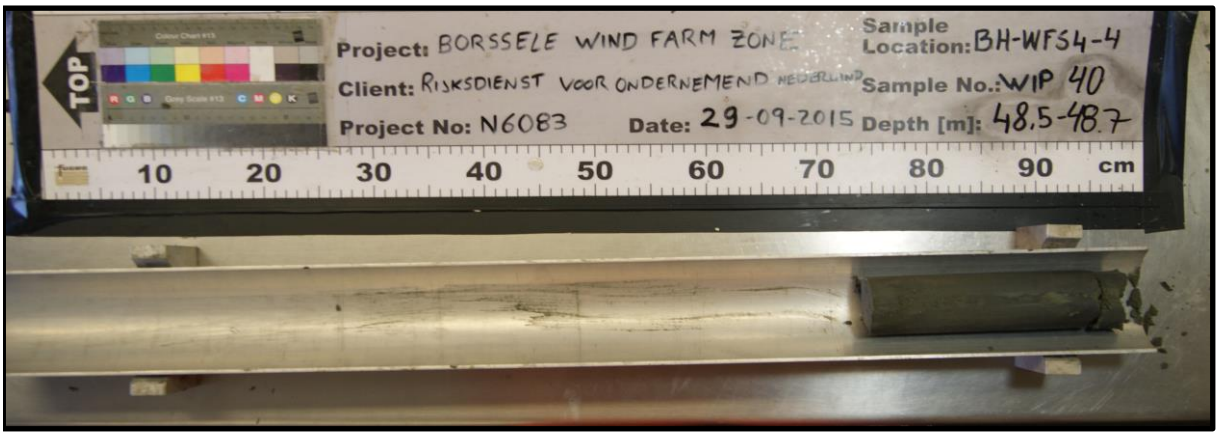
Location : BH-WFS4-4
Sample : WIP39
Depth [m bsf] : 48.00 to 48.20
Note(s) : Incorrect depth on sample photograph



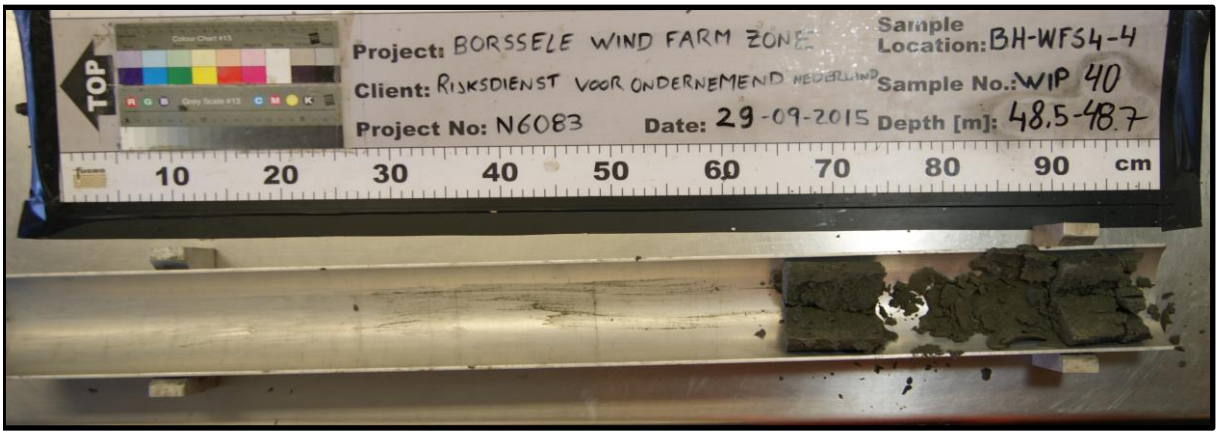
Location : BH-WFS4-4
Sample : WIP39
Depth [m bsf] : 48.00 to 48.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



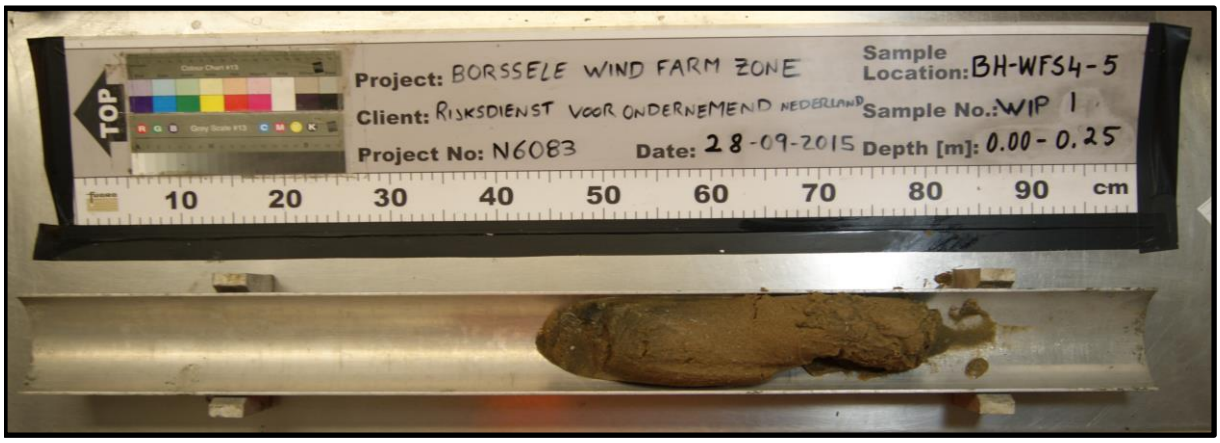
Location : BH-WFS4-4
Sample : WIP40
Depth [m bsf] : 48.50 to 48.70



Location : BH-WFS4-4
Sample : WIP40
Depth [m bsf] : 48.50 to 48.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP01
Depth [m bsf] : 0.00 to 0.25



Location : BH-WFS4-5
Sample : WIP01
Depth [m bsf] : 0.00 to 0.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



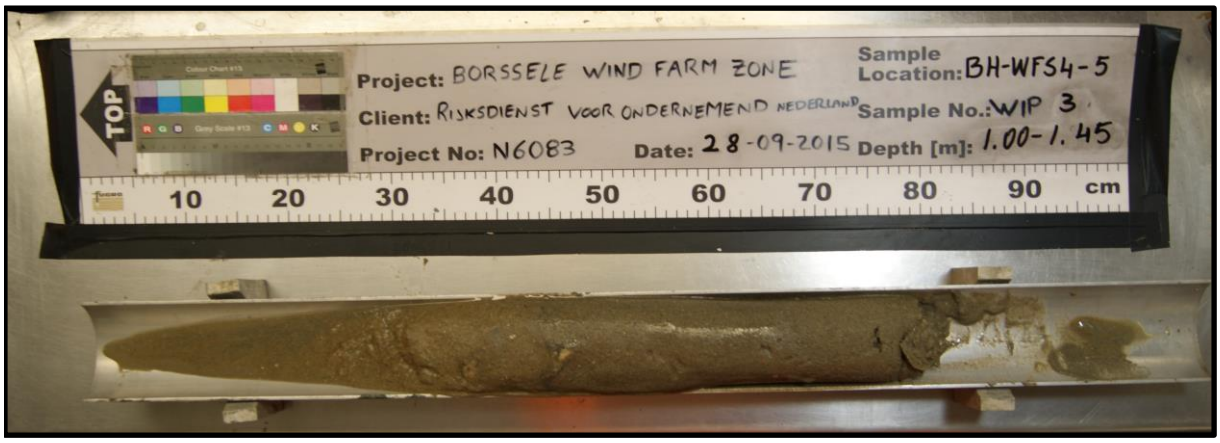
Location : BH-WFS4-5
Sample : WIP02
Depth [m bsf] : 0.50 to 0.95



Location : BH-WFS4-5
Sample : WIP02
Depth [m bsf] : 0.50 to 0.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



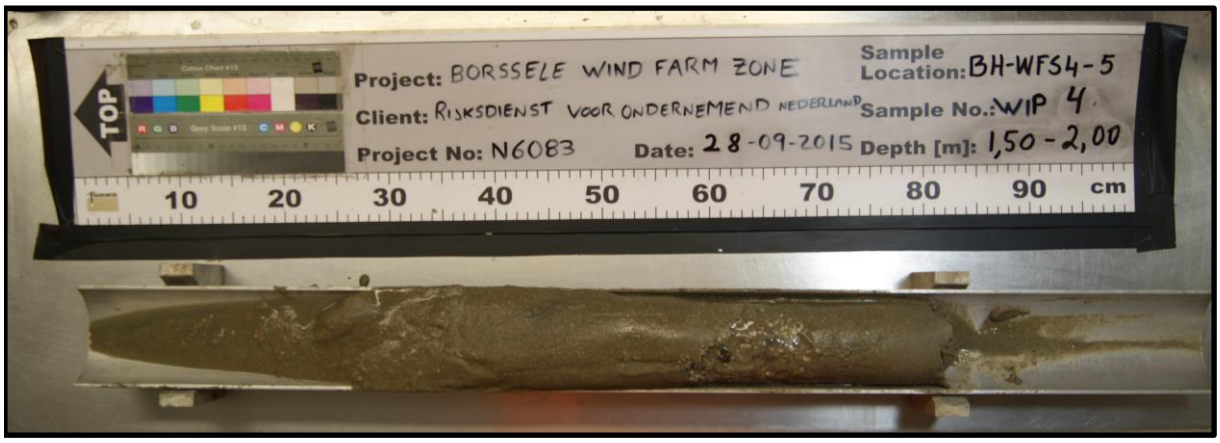
Location : BH-WFS4-5
Sample : WIP03
Depth [m bsf] : 1.00 to 1.45



Location : BH-WFS4-5
Sample : WIP03
Depth [m bsf] : 1.00 to 1.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



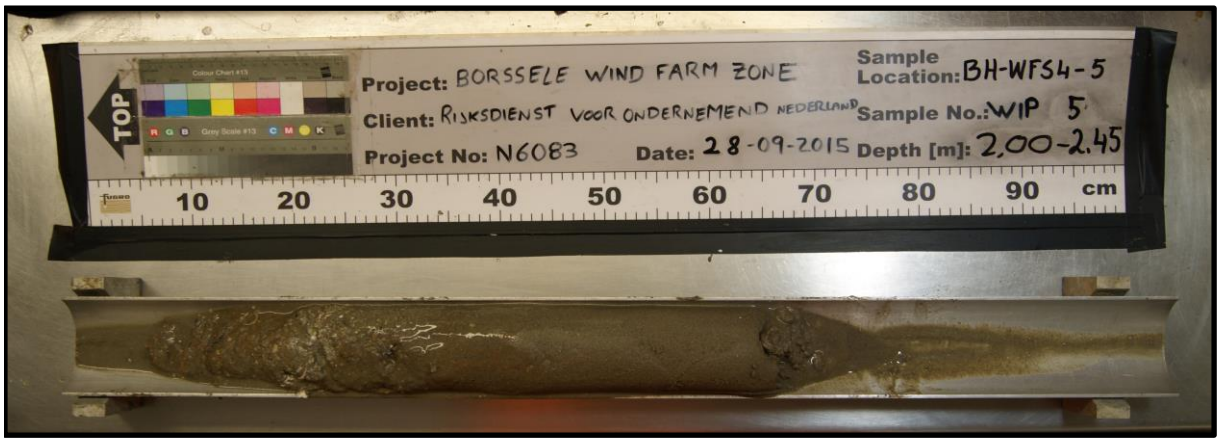
Location : BH-WFS4-5
Sample : WIP04
Depth [m bsf] : 1.50 to 2.00



Location : BH-WFS4-5
Sample : WIP04
Depth [m bsf] : 1.50 to 2.00
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP05
Depth [m bsf] : 2.00 to 2.45



Location : BH-WFS4-5
Sample : WIP05
Depth [m bsf] : 2.00 to 2.45
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



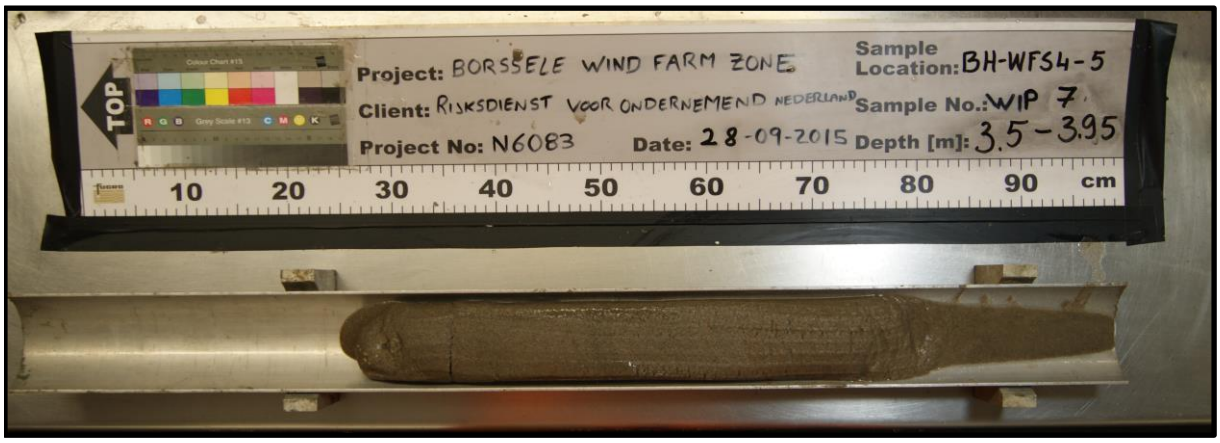
Location : BH-WFS4-5
Sample : WIP06
Depth [m bsf] : 2.50 to 2.90



Location : BH-WFS4-5
Sample : WIP06
Depth [m bsf] : 2.50 to 2.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



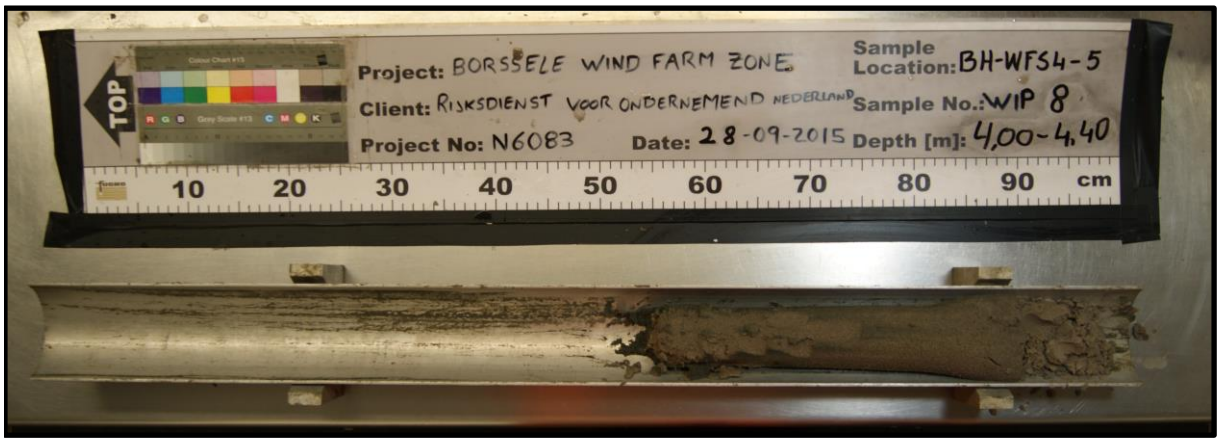
Location : BH-WFS4-5
Sample : WIP07
Depth [m bsf] : 3.50 to 3.95



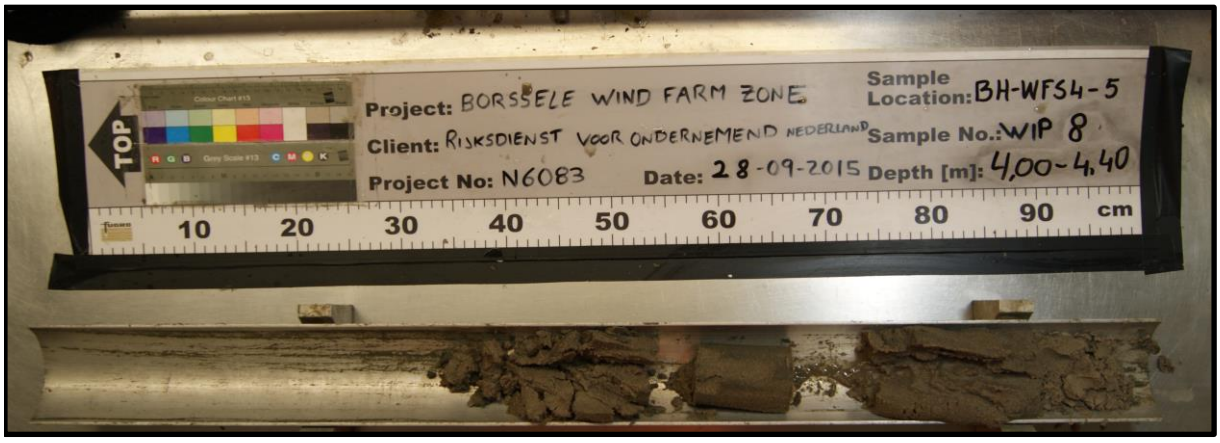
Location : BH-WFS4-5
Sample : WIP07
Depth [m bsf] : 3.50 to 3.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



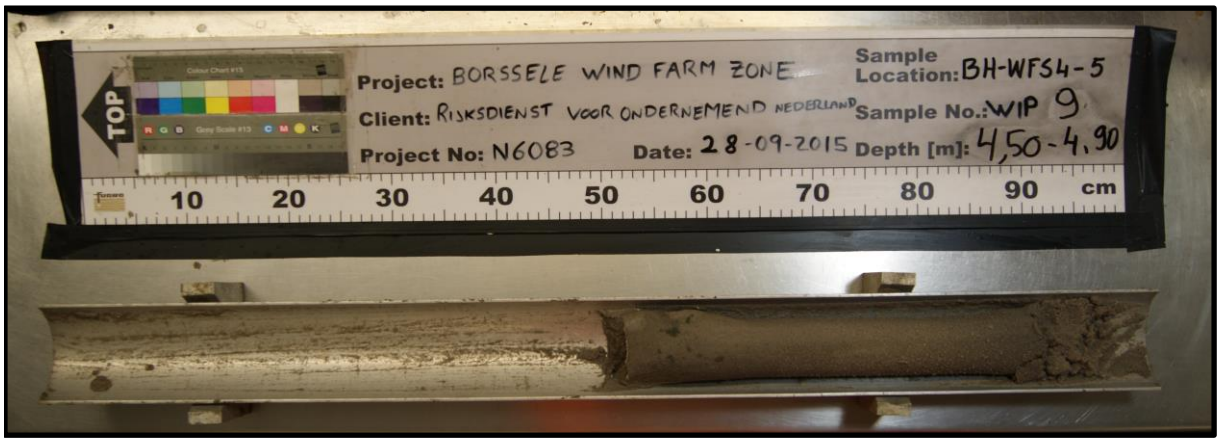
Location : BH-WFS4-5
Sample : WIP08
Depth [m bsf] : 4.00 to 4.40



Location : BH-WFS4-5
Sample : WIP08
Depth [m bsf] : 4.00 to 4.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



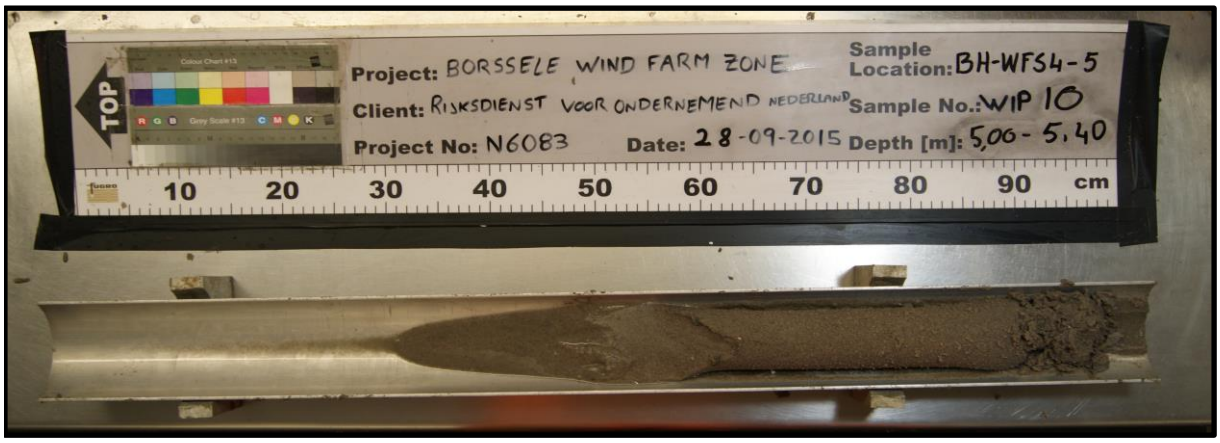
Location : BH-WFS4-5
Sample : WIP09
Depth [m bsf] : 4.50 to 4.90



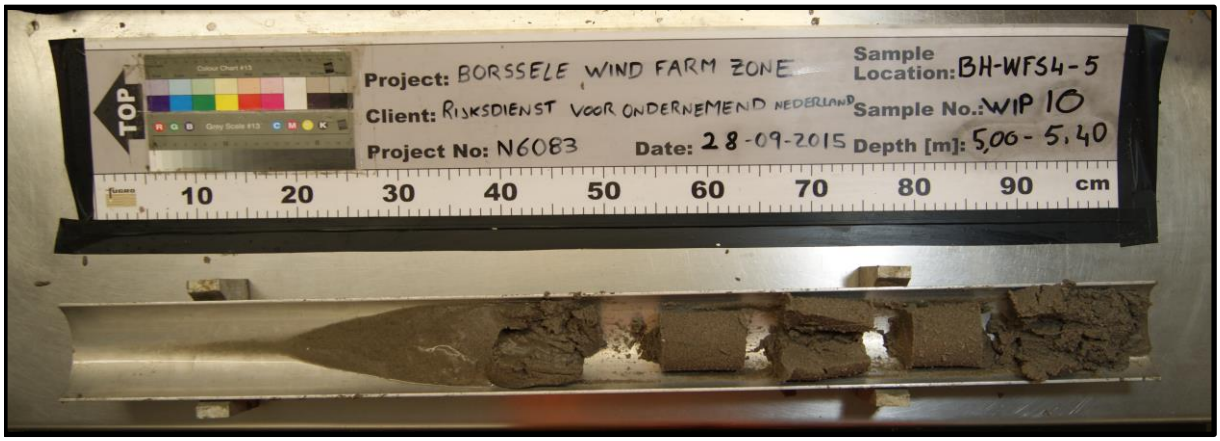
Location : BH-WFS4-5
Sample : WIP09
Depth [m bsf] : 4.50 to 4.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



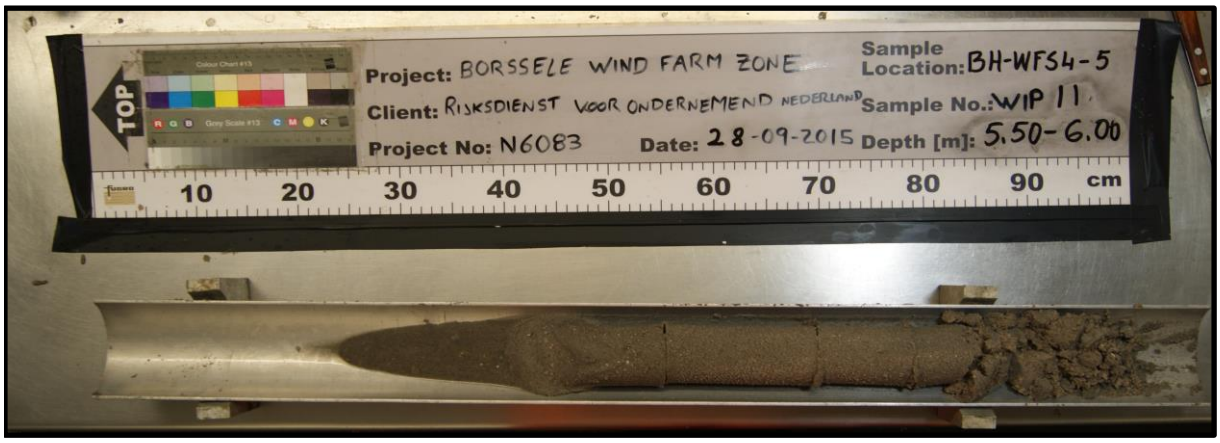
Location : BH-WFS4-5
Sample : WIP10
Depth [m bsf] : 5.00 to 5.40



Location : BH-WFS4-5
Sample : WIP10
Depth [m bsf] : 5.00 to 5.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



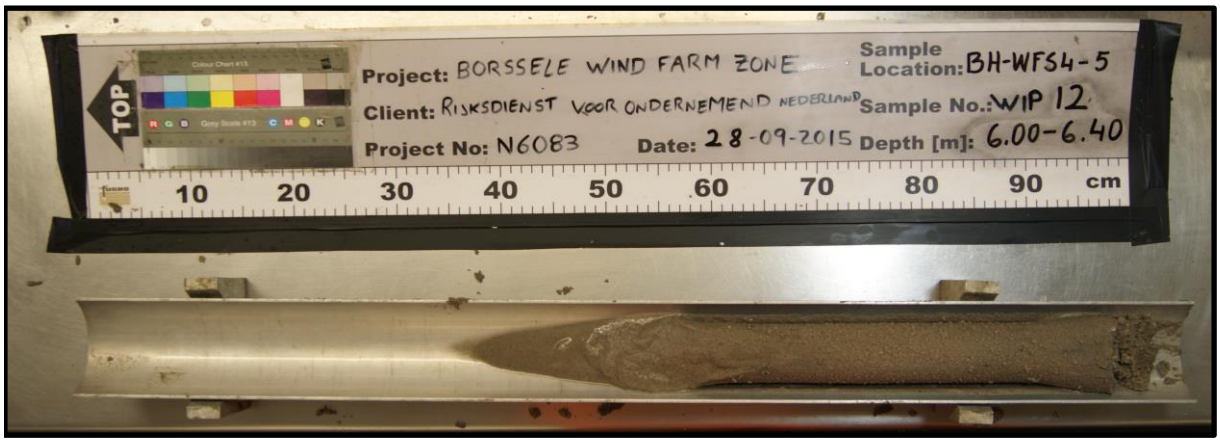
Location : BH-WFS4-5
Sample : WIP11
Depth [m bsf] : 5.50 to 6.00



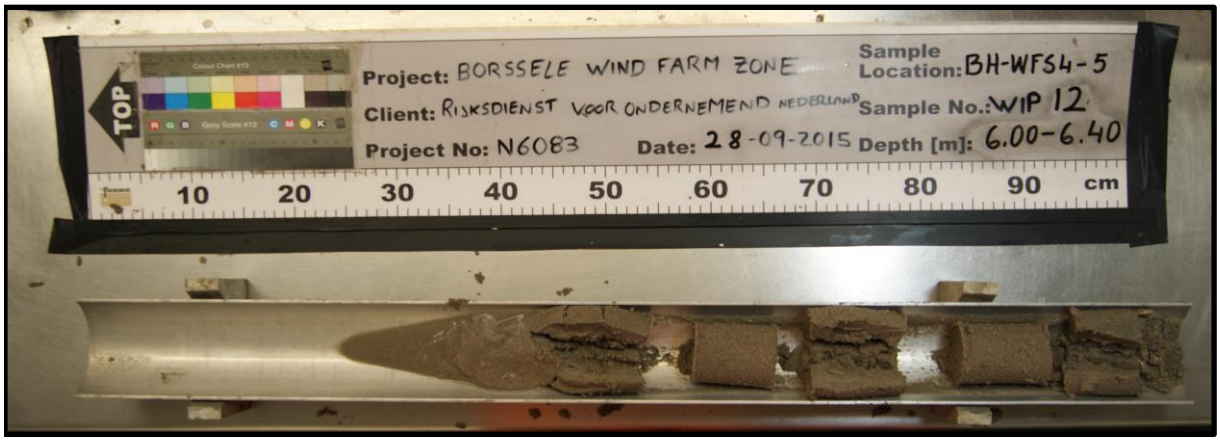
Location : BH-WFS4-5
Sample : WIP11
Depth [m bsf] : 5.50 to 6.00
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP12
Depth [m bsf] : 6.00 to 6.40



Location : BH-WFS4-5
Sample : WIP12
Depth [m bsf] : 6.00 to 6.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP13
Depth [m bsf] : 6.50 to 6.90



Location : BH-WFS4-5
Sample : WIP13
Depth [m bsf] : 6.50 to 6.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



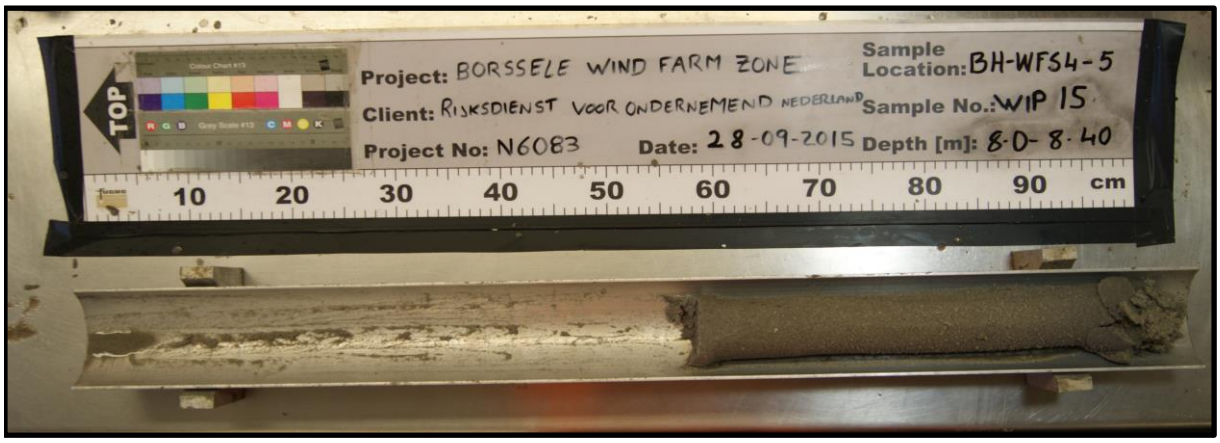
Location : BH-WFS4-5
Sample : WIP14
Depth [m bsf] : 7.00 to 7.40



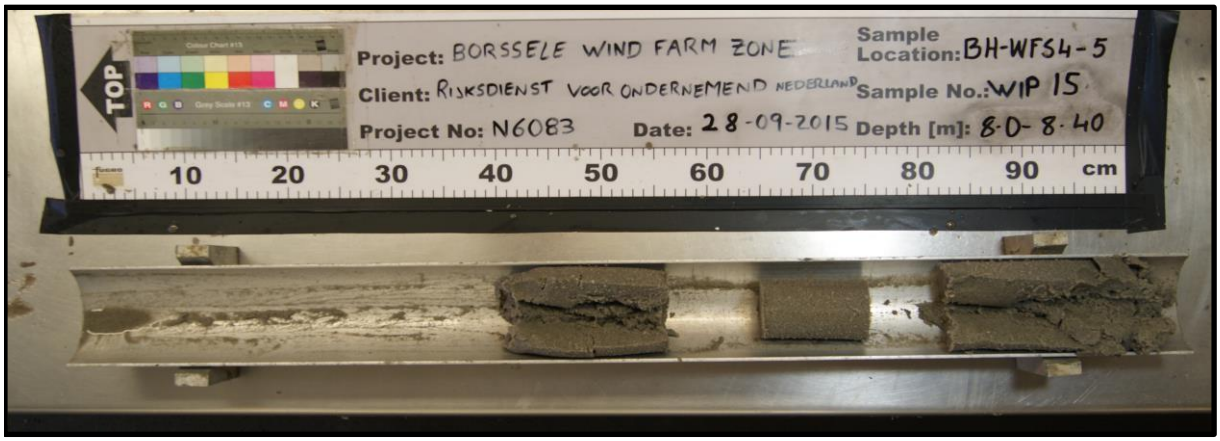
Location : BH-WFS4-5
Sample : WIP14
Depth [m bsf] : 7.00 to 7.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



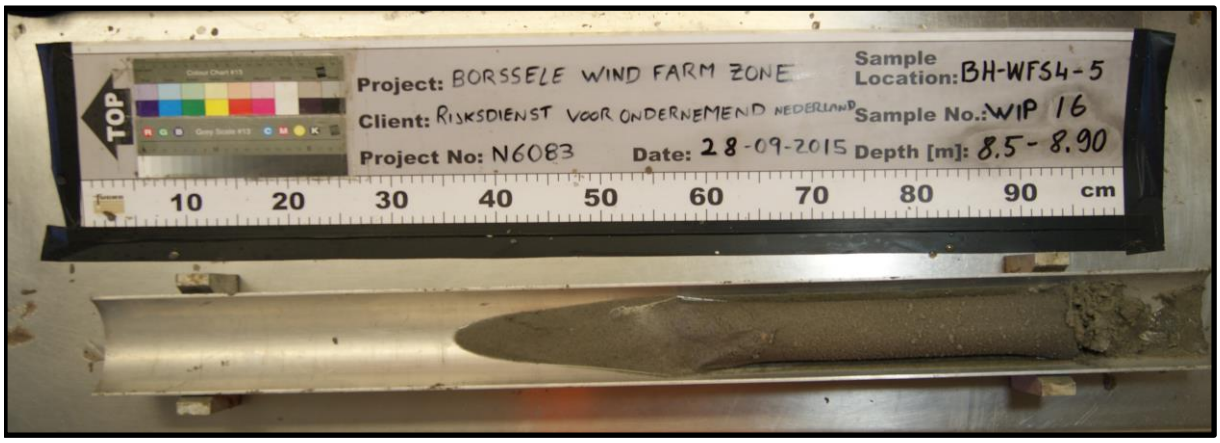
Location : BH-WFS4-5
Sample : WIP15
Depth [m bsf] : 8.00 to 8.40



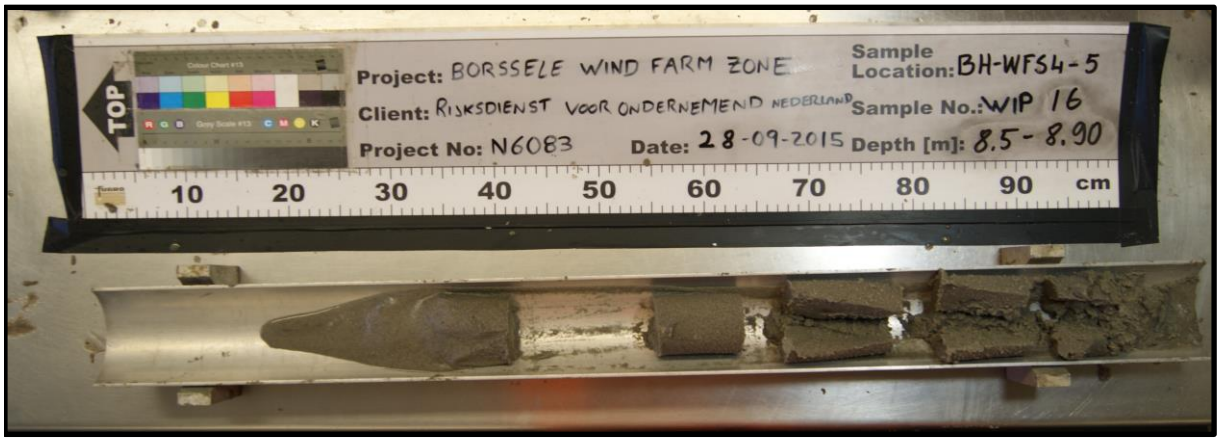
Location : BH-WFS4-5
Sample : WIP15
Depth [m bsf] : 8.00 to 8.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



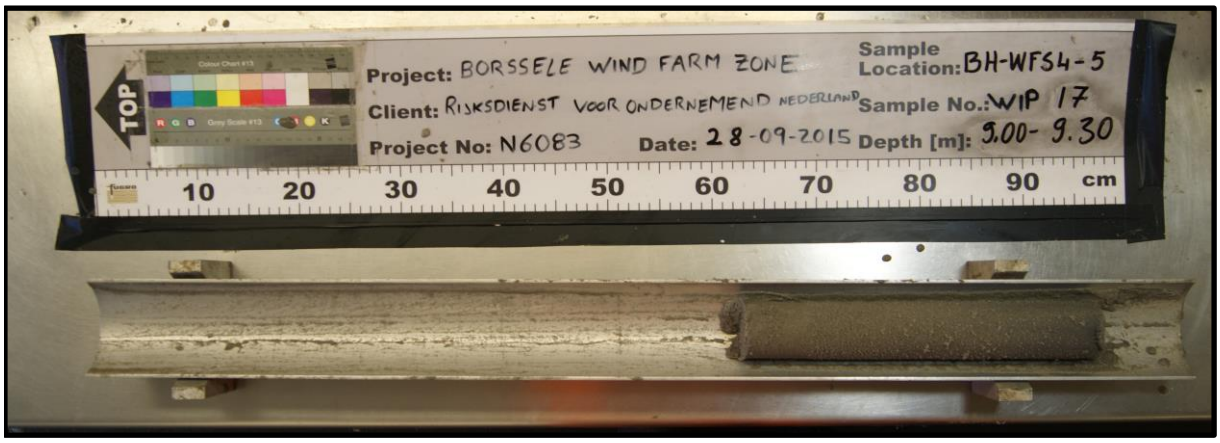
Location : BH-WFS4-5
Sample : WIP16
Depth [m bsf] : 8.50 to 8.90



Location : BH-WFS4-5
Sample : WIP16
Depth [m bsf] : 8.50 to 8.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



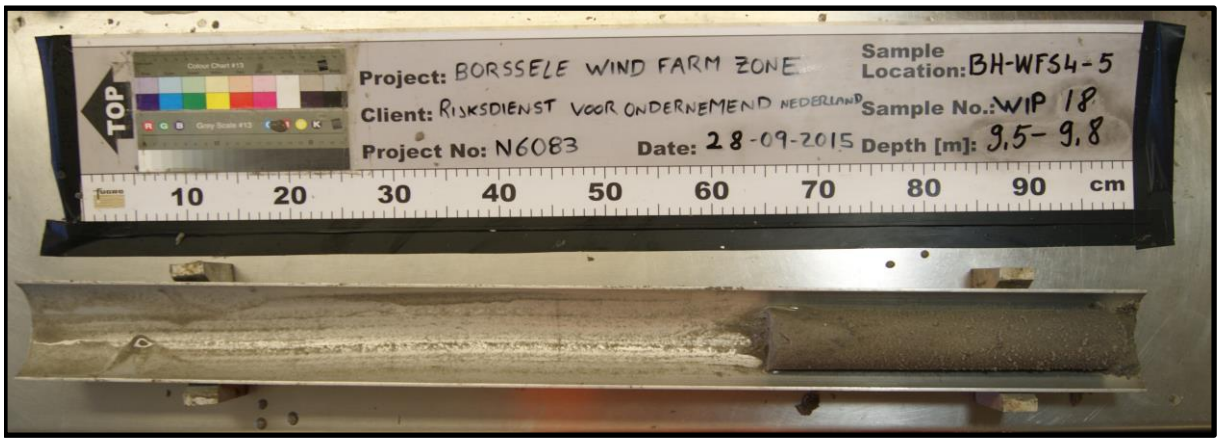
Location : BH-WFS4-5
Sample : WIP17
Depth [m bsf] : 9.00 to 9.30



Location : BH-WFS4-5
Sample : WIP17
Depth [m bsf] : 9.00 to 9.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



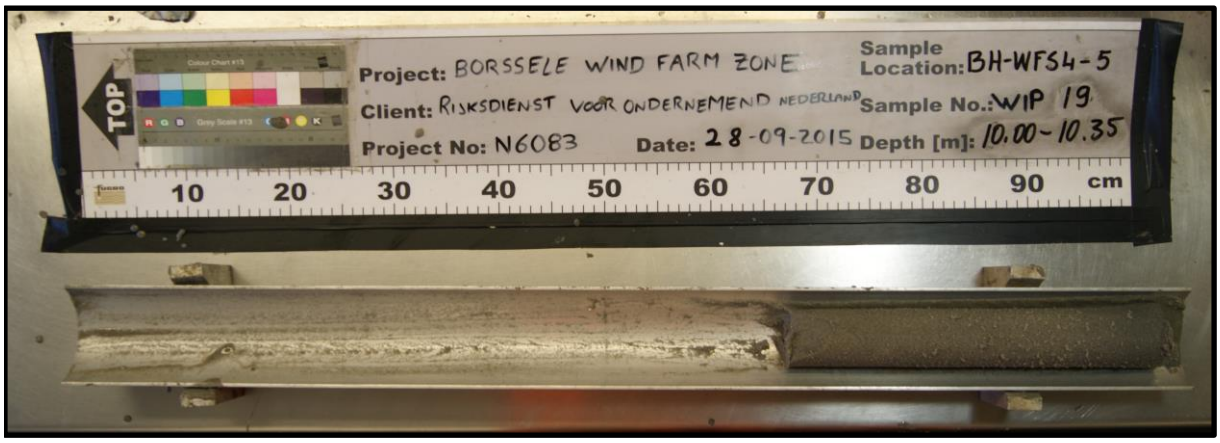
Location : BH-WFS4-5
Sample : WIP18
Depth [m bsf] : 9.50 to 9.80

Missing Photograph

Location : BH-WFS4-5
Sample : WIP18
Depth [m bsf] : 9.50 to 9.80
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



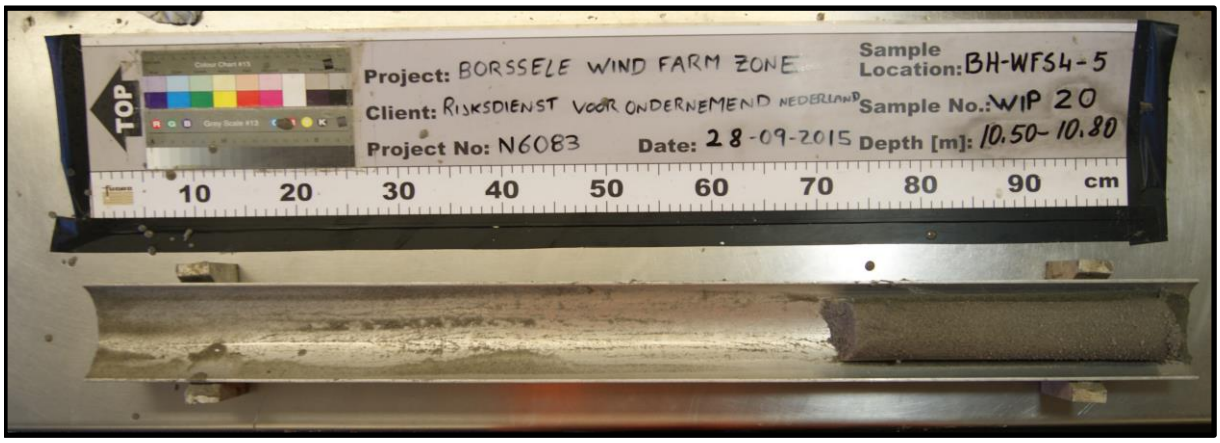
Location : BH-WFS4-5
Sample : WIP19
Depth [m bsf] : 10.00 to 10.35



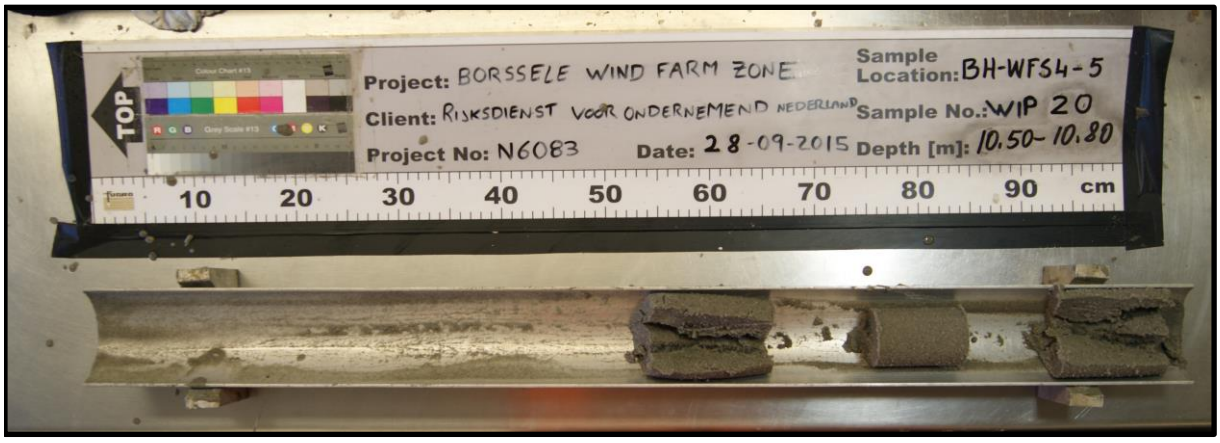
Location : BH-WFS4-5
Sample : WIP19
Depth [m bsf] : 10.00 to 10.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



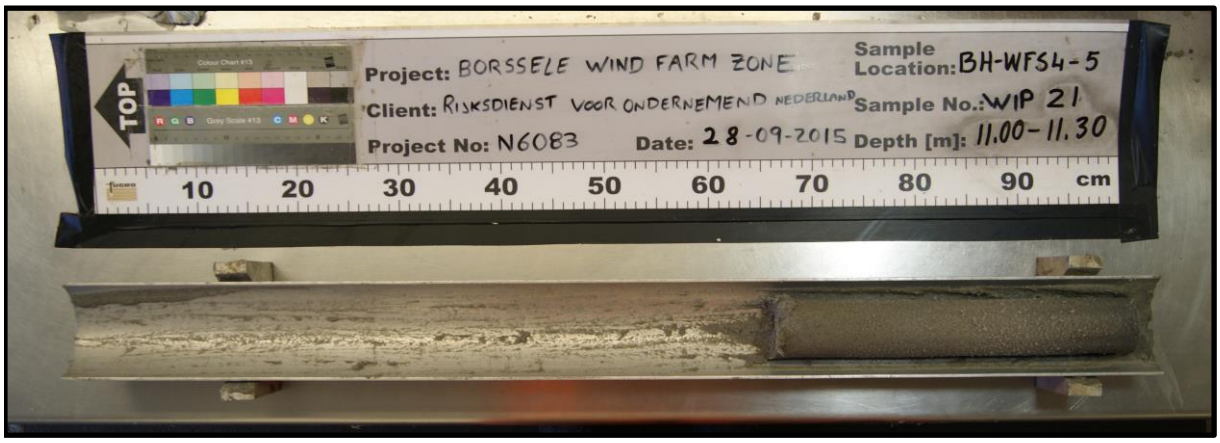
Location : BH-WFS4-5
Sample : WIP20
Depth [m bsf] : 10.50 to 10.80



Location : BH-WFS4-5
Sample : WIP20
Depth [m bsf] : 10.50 to 10.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



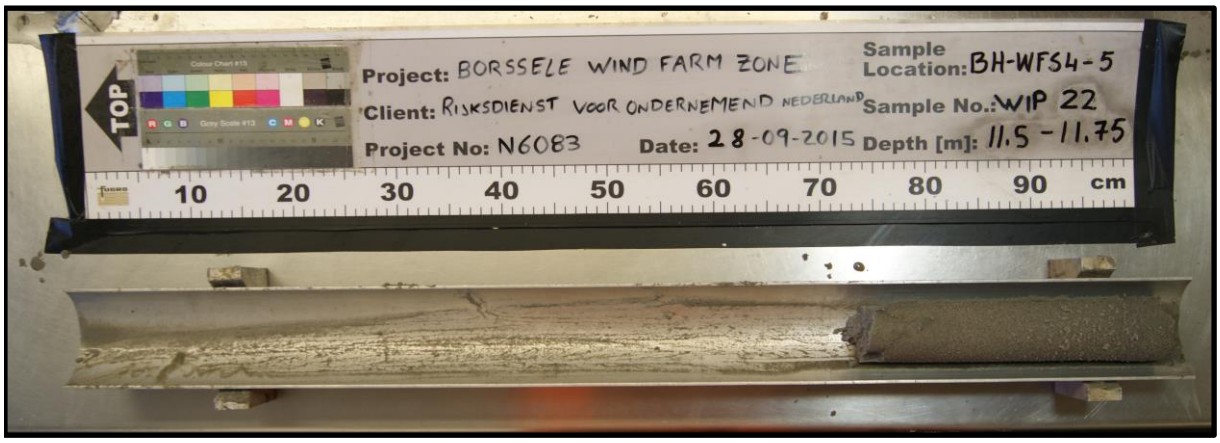
Location : BH-WFS4-5
Sample : WIP21
Depth [m bsf] : 11.00 to 11.30



Location : BH-WFS4-5
Sample : WIP21
Depth [m bsf] : 11.00 to 11.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP22
Depth [m bsf] : 11.50 to 11.75



Location : BH-WFS4-5
Sample : WIP22
Depth [m bsf] : 11.50 to 11.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

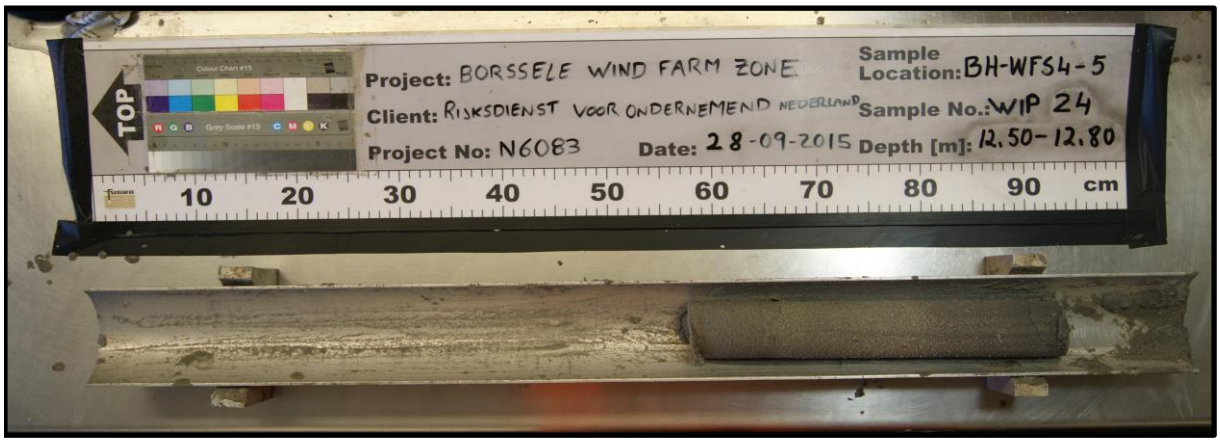
Location	:	BH-WFS4-5
Sample	:	WIP23
Depth [m bsf]	:	12.00 to 12.25
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-5
Sample	:	WIP23
Depth [m bsf]	:	12.00 to 12.25
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP24
Depth [m bsf] : 12.50 to 12.80



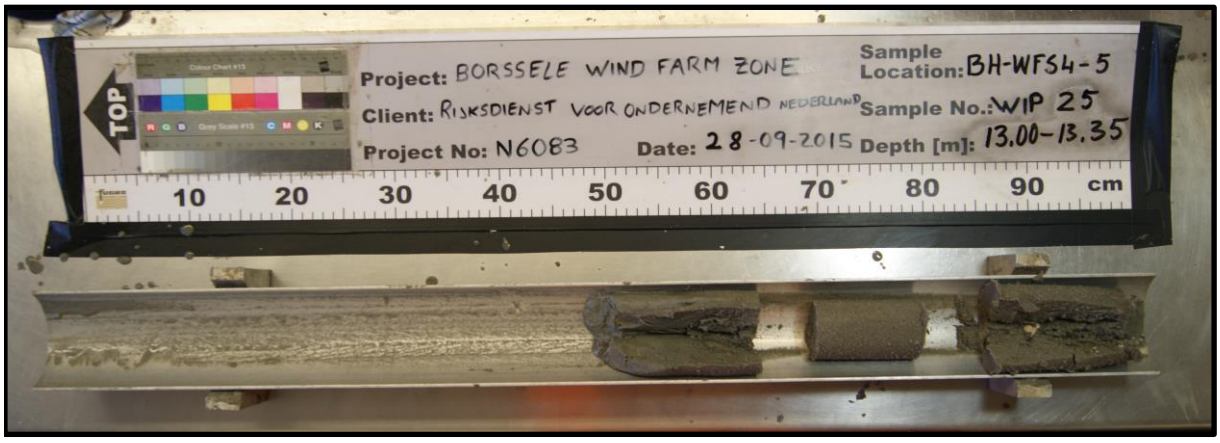
Location : BH-WFS4-5
Sample : WIP24
Depth [m bsf] : 12.50 to 12.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



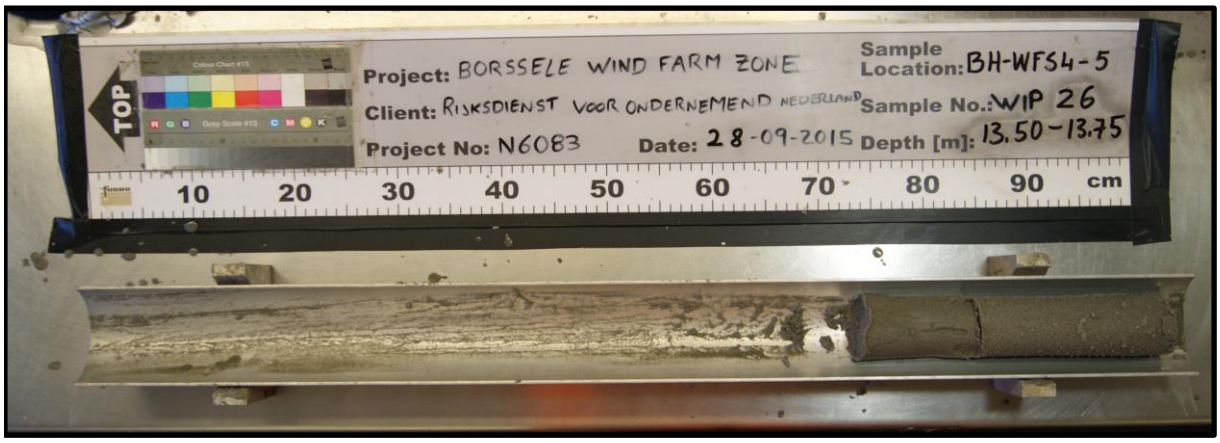
Location : BH-WFS4-5
Sample : WIP25
Depth [m bsf] : 13.00 to 13.35



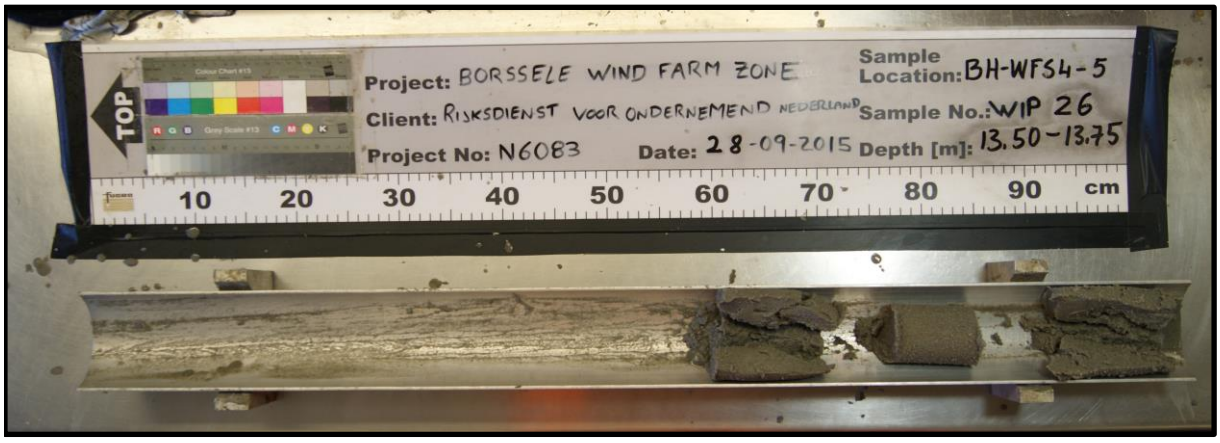
Location : BH-WFS4-5
Sample : WIP25
Depth [m bsf] : 13.00 to 13.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



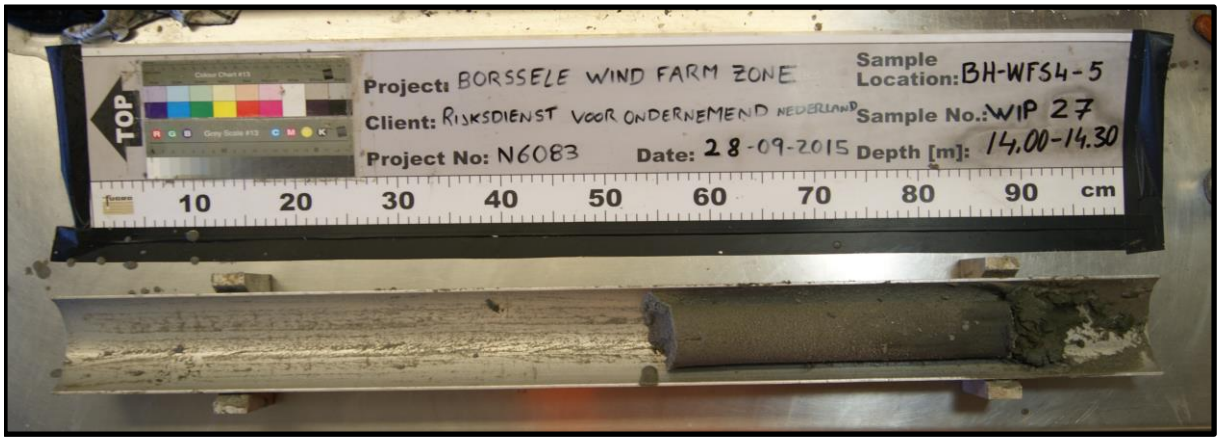
Location : BH-WFS4-5
Sample : WIP26
Depth [m bsf] : 13.50 to 13.75



Location : BH-WFS4-5
Sample : WIP26
Depth [m bsf] : 13.50 to 13.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



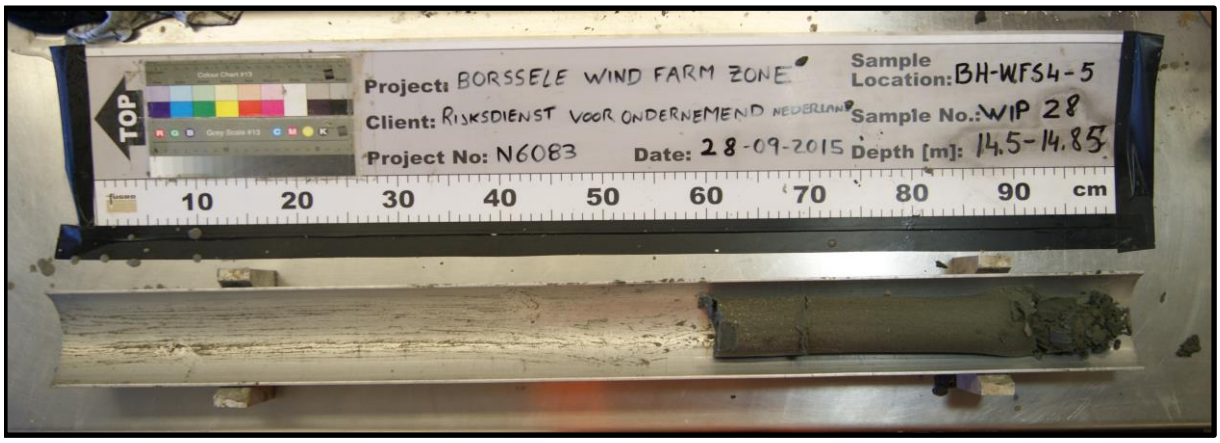
Location : BH-WFS4-5
Sample : WIP27
Depth [m bsf] : 14.00 to 14.30



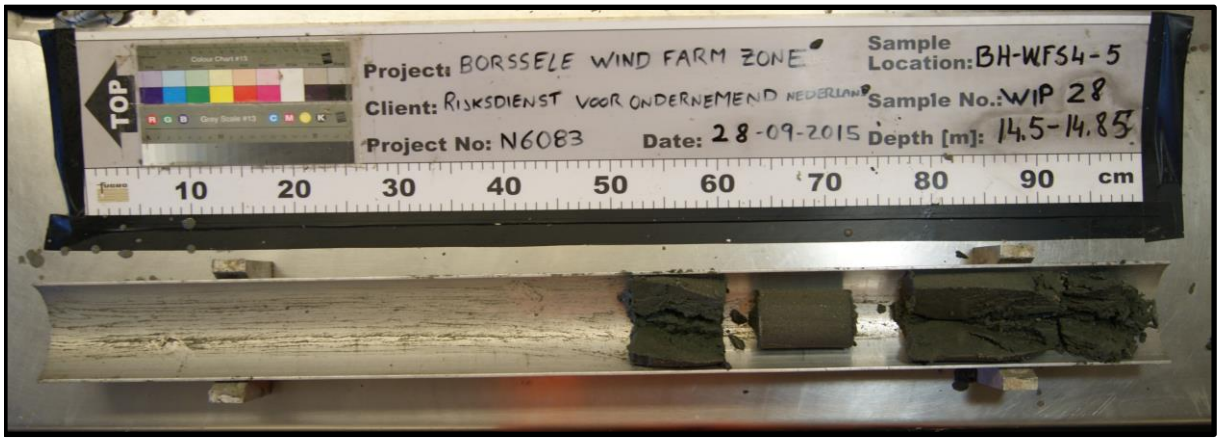
Location : BH-WFS4-5
Sample : WIP27
Depth [m bsf] : 14.00 to 14.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



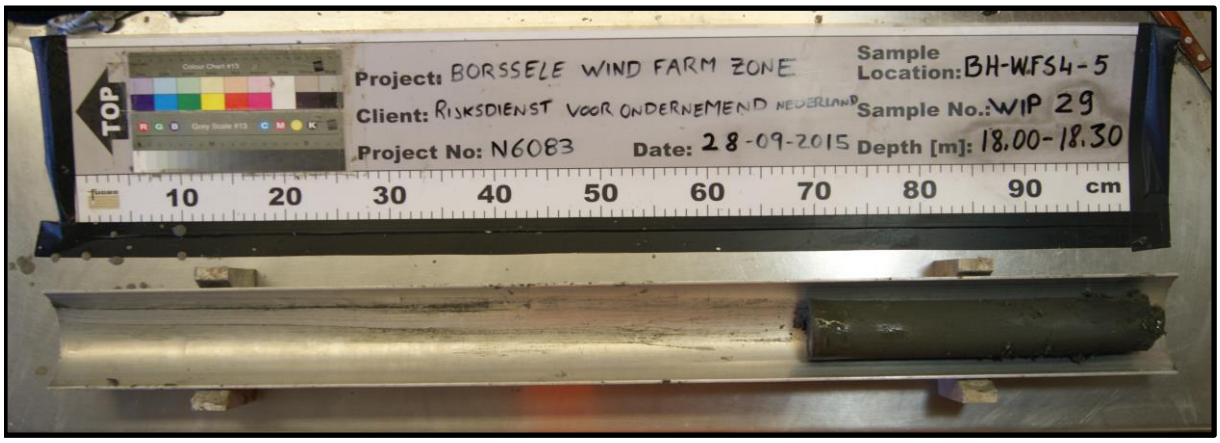
Location : BH-WFS4-5
Sample : WIP28
Depth [m bsf] : 14.50 to 14.85



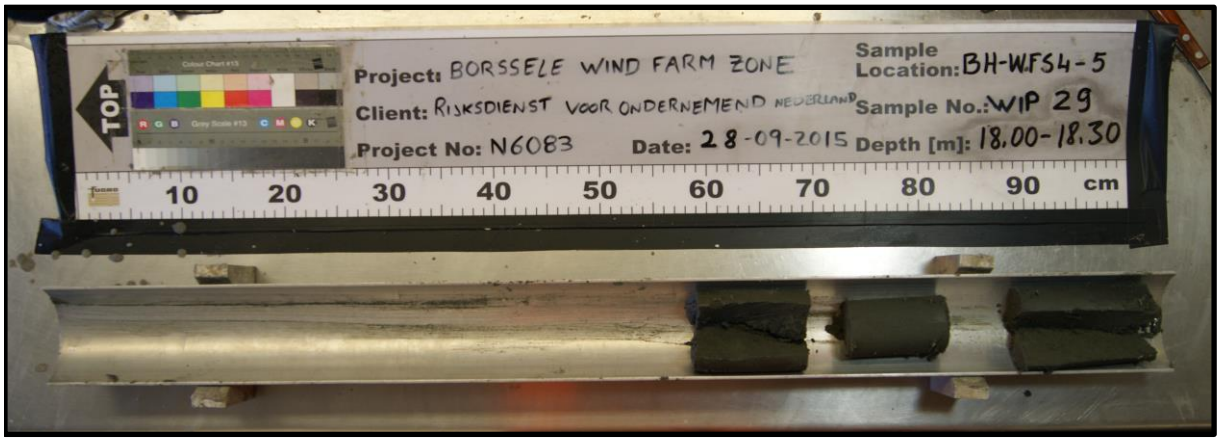
Location : BH-WFS4-5
Sample : WIP28
Depth [m bsf] : 14.50 to 14.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



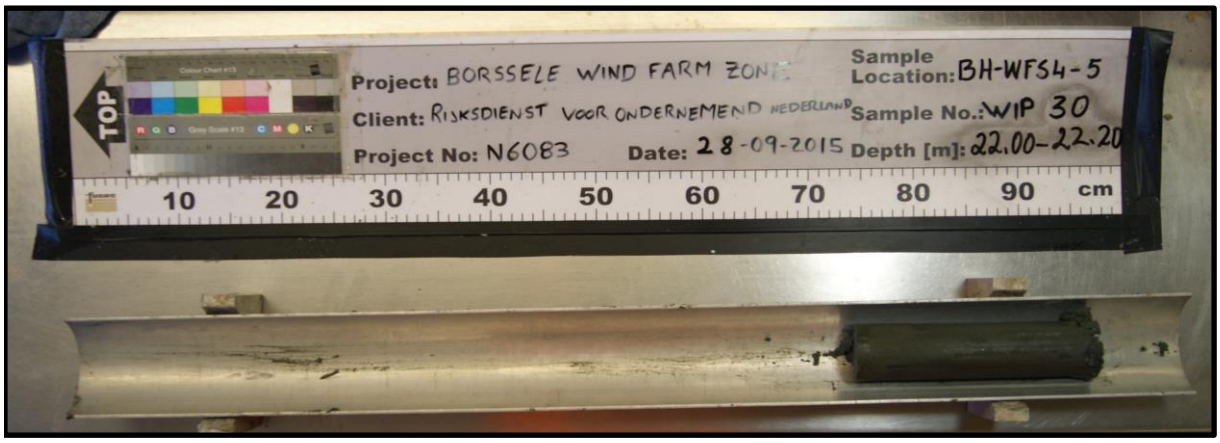
Location : BH-WFS4-5
Sample : WIP29
Depth [m bsf] : 18.00 to 18.30



Location : BH-WFS4-5
Sample : WIP29
Depth [m bsf] : 18.00 to 18.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



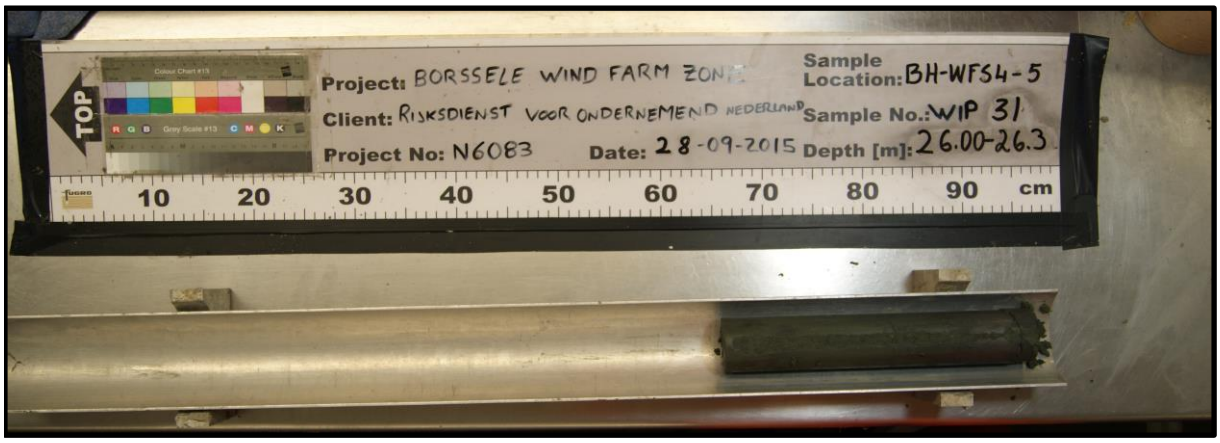
Location : BH-WFS4-5
Sample : WIP30
Depth [m bsf] : 22.00 to 22.20



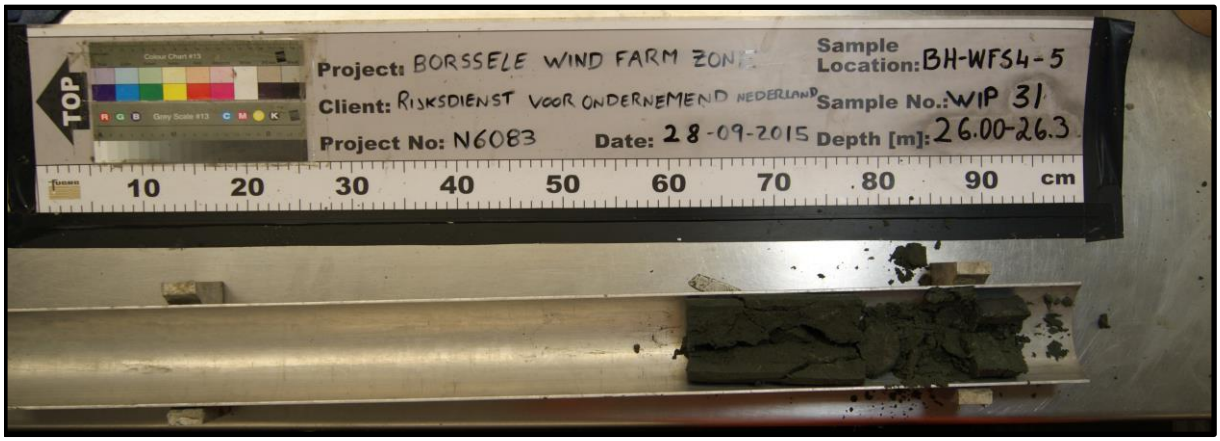
Location : BH-WFS4-5
Sample : WIP30
Depth [m bsf] : 22.00 to 22.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



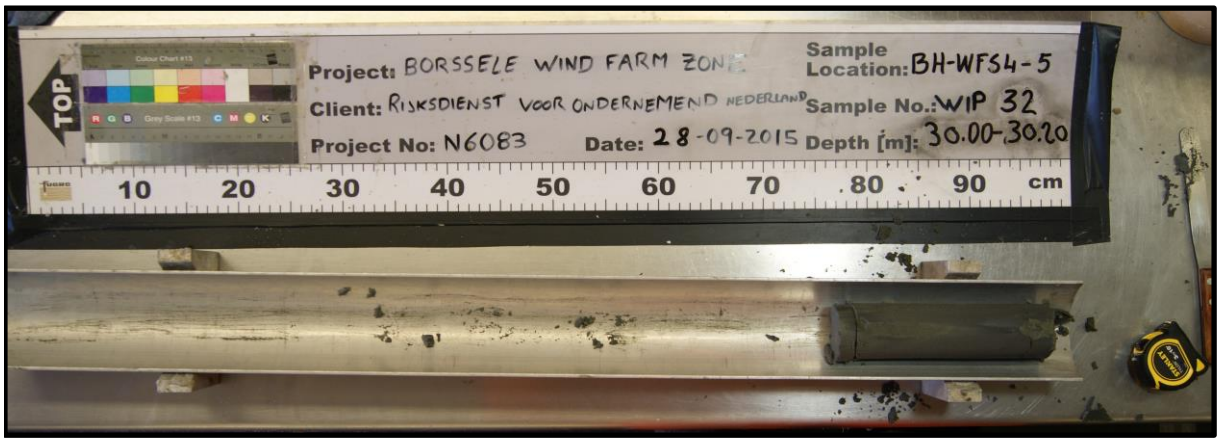
Location : BH-WFS4-5
Sample : WIP31
Depth [m bsf] : 26.00 to 26.30



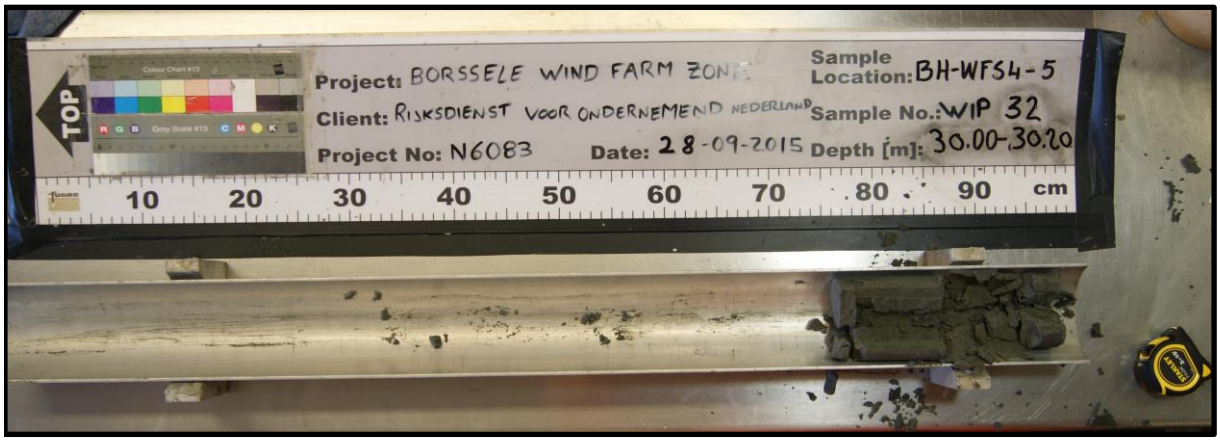
Location : BH-WFS4-5
Sample : WIP31
Depth [m bsf] : 26.00 to 26.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



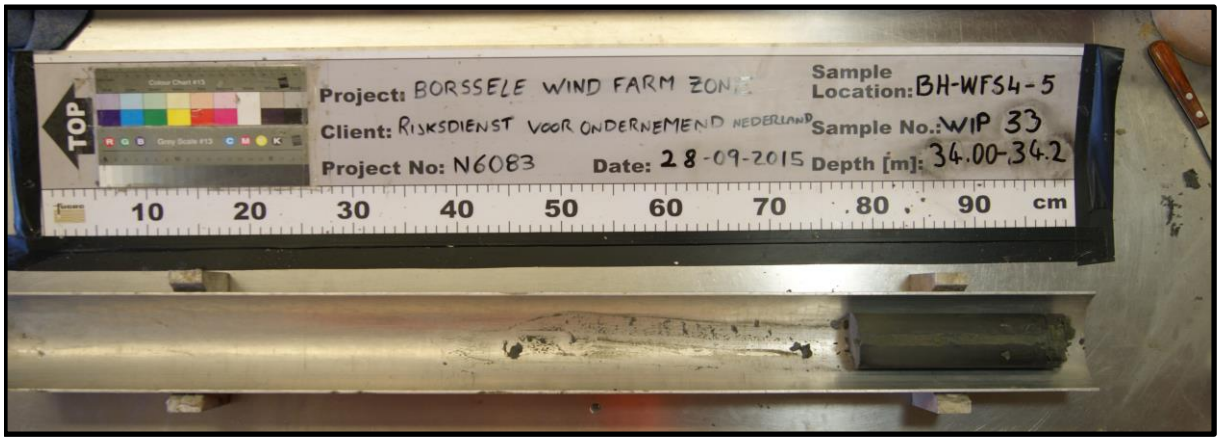
Location : BH-WFS4-5
Sample : WIP32
Depth [m bsf] : 30.00 to 30.20



Location : BH-WFS4-5
Sample : WIP32
Depth [m bsf] : 30.00 to 30.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



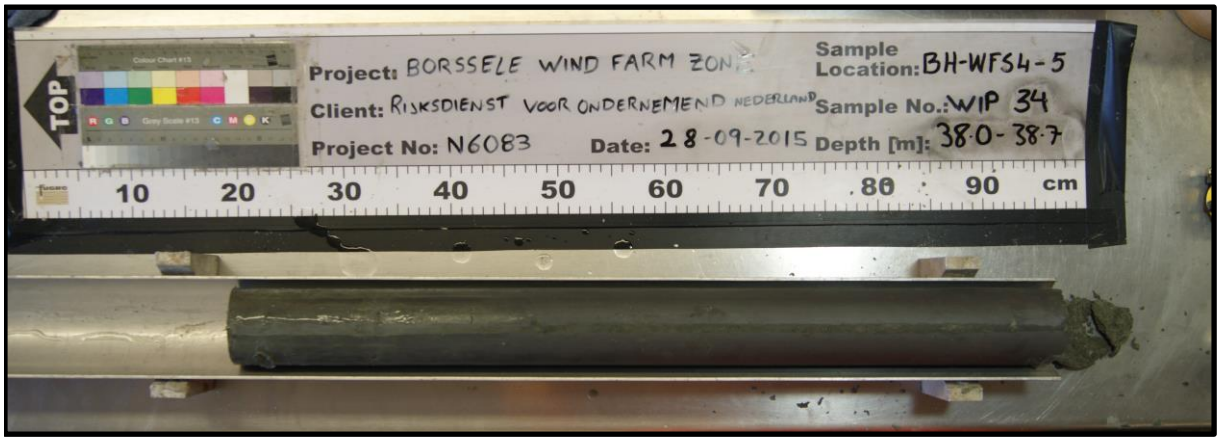
Location : BH-WFS4-5
Sample : WIP33
Depth [m bsf] : 34.00 to 34.20



Location : BH-WFS4-5
Sample : WIP33
Depth [m bsf] : 34.00 to 34.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP34
Depth [m bsf] : 38.00 to 38.70



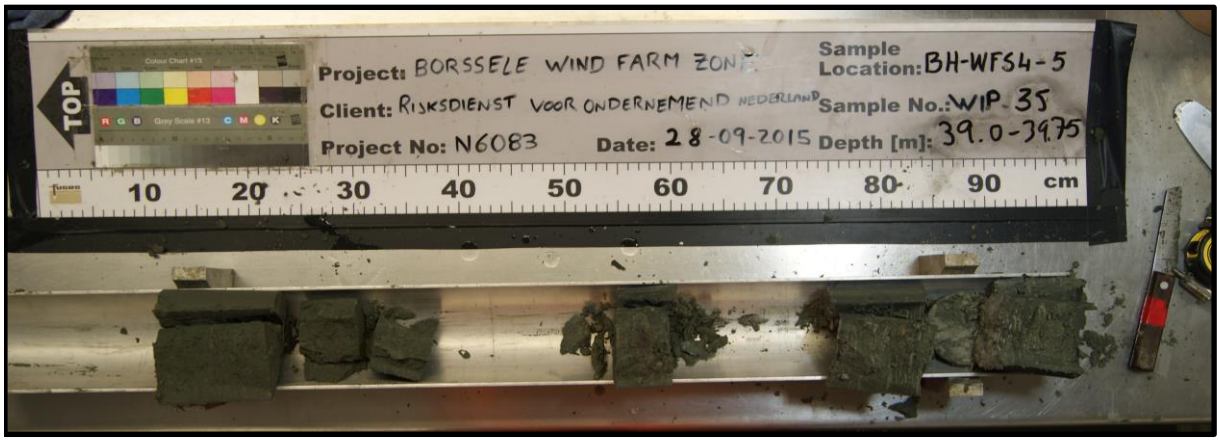
Location : BH-WFS4-5
Sample : WIP34
Depth [m bsf] : 38.00 to 38.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

Location	:	BH-WFS4-5
Sample	:	WIP35
Depth [m bsf]	:	39.00 to 39.75
Note(s)	:	Sample photograph is missing



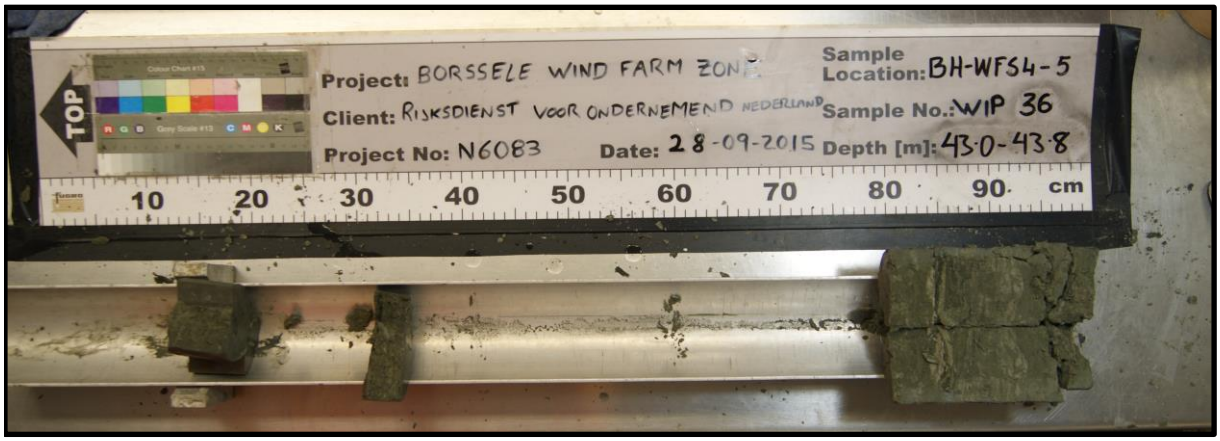
Location	:	BH-WFS4-5
Sample	:	WIP35
Depth [m bsf]	:	39.00 to 39.75
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



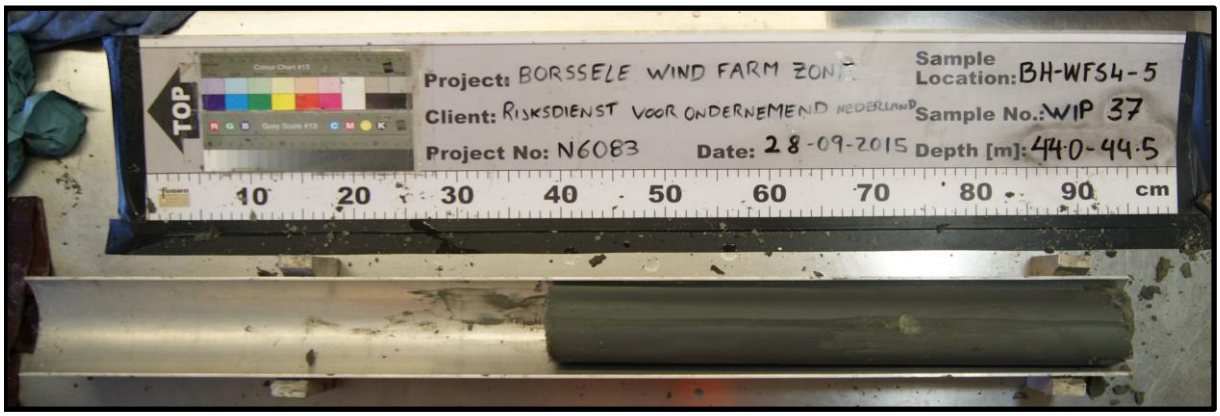
Location : BH-WFS4-5
Sample : WIP36
Depth [m bsf] : 43.00 to 43.80



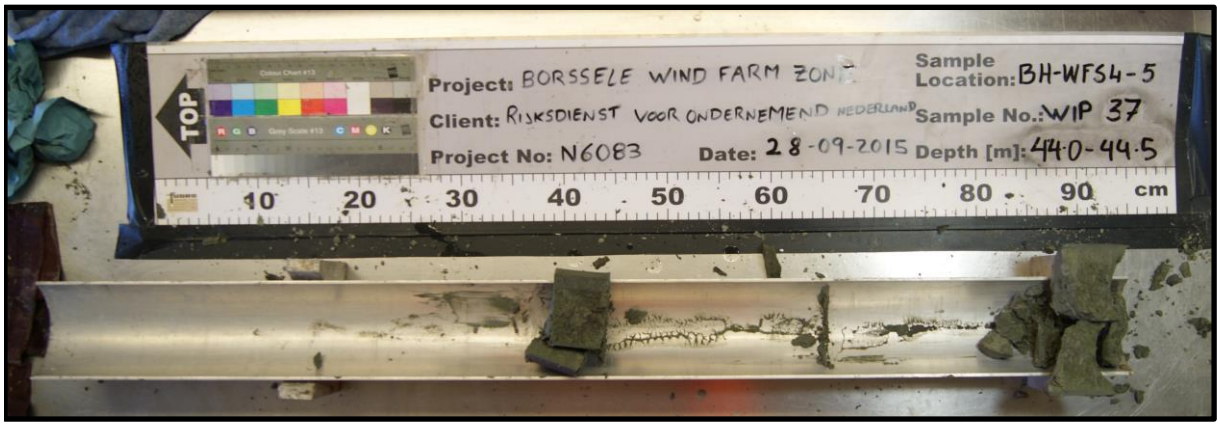
Location : BH-WFS4-5
Sample : WIP36
Depth [m bsf] : 43.00 to 43.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP37
Depth [m bsf] : 44.00 to 44.50



Location : BH-WFS4-5
Sample : WIP37
Depth [m bsf] : 44.00 to 44.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP38
Depth [m bsf] : 48.00 to 48.55



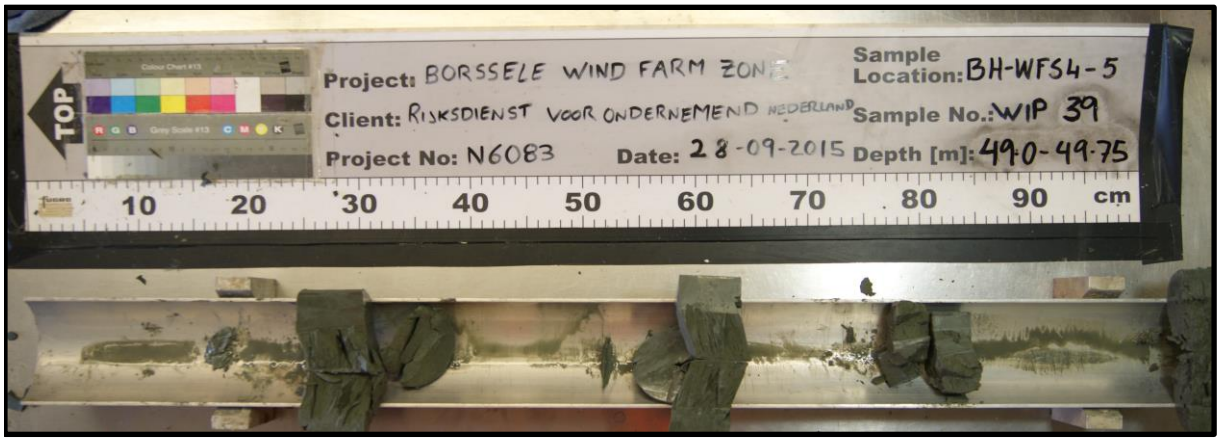
Location : BH-WFS4-5
Sample : WIP38
Depth [m bsf] : 48.00 to 48.55
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP39
Depth [m bsf] : 49.00 to 49.75



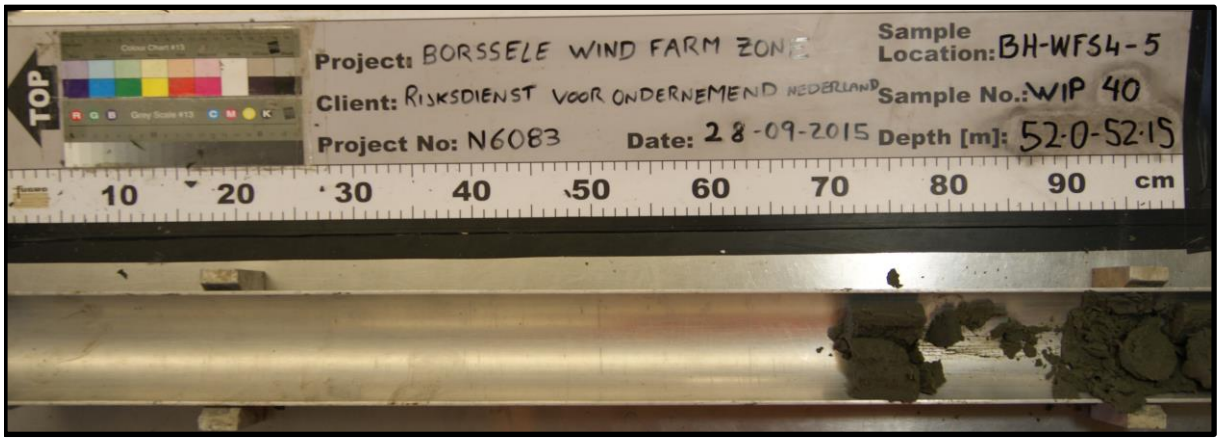
Location : BH-WFS4-5
Sample : WIP39
Depth [m bsf] : 49.00 to 49.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-5
Sample : WIP40
Depth [m bsf] : 52.00 to 52.15



Location : BH-WFS4-5
Sample : WIP40
Depth [m bsf] : 52.00 to 52.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



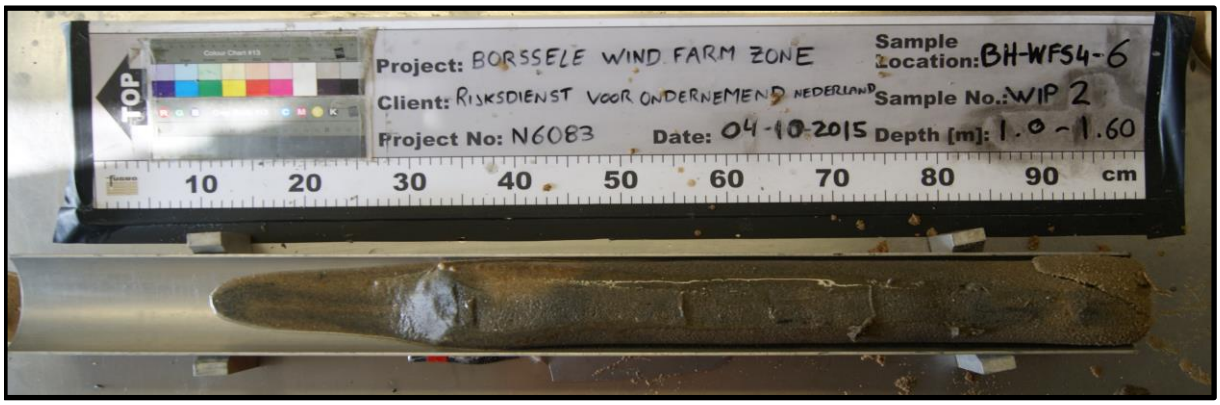
Location : BH-WFS4-6
Sample : WIP01
Depth [m bsf] : 0.00 to 0.60



Location : BH-WFS4-6
Sample : WIP01
Depth [m bsf] : 0.00 to 0.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP02
Depth [m bsf] : 1.00 to 1.60



Location : BH-WFS4-6
Sample : WIP02
Depth [m bsf] : 1.00 to 1.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP03
Depth [m bsf] : 2.00 to 2.60



Location : BH-WFS4-6
Sample : WIP03
Depth [m bsf] : 2.00 to 2.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



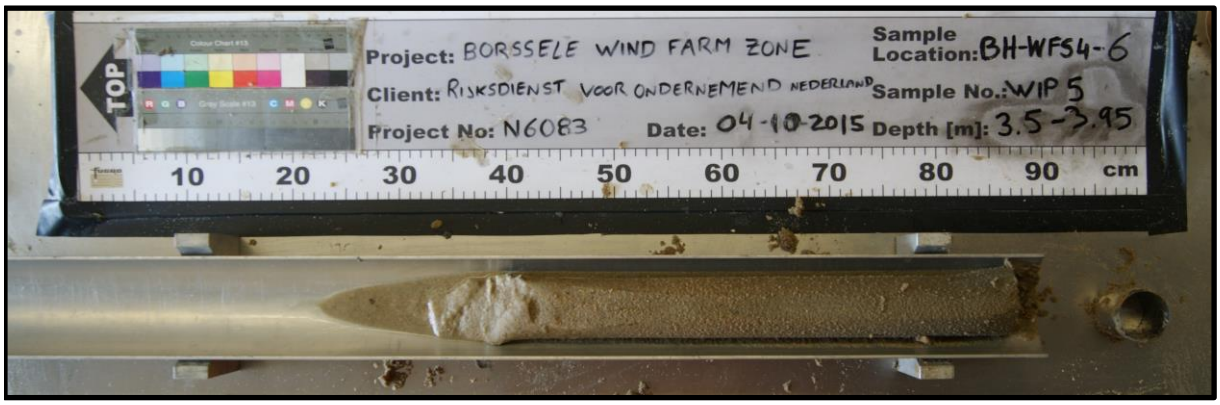
Location : BH-WFS4-6
Sample : WIP04
Depth [m bsf] : 3.00 to 3.50



Location : BH-WFS4-6
Sample : WIP04
Depth [m bsf] : 3.00 to 3.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



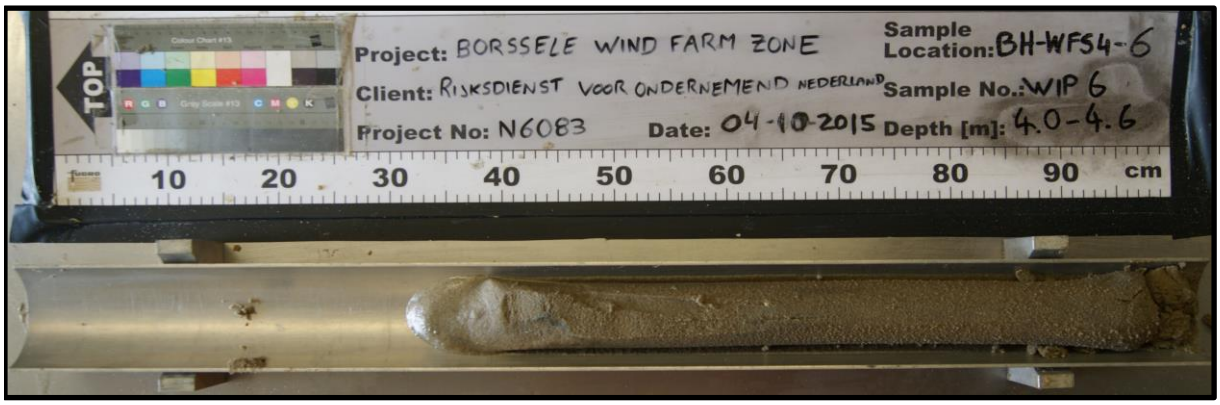
Location : BH-WFS4-6
Sample : WIP05
Depth [m bsf] : 3.50 to 3.95



Location : BH-WFS4-6
Sample : WIP05
Depth [m bsf] : 3.50 to 3.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP06
Depth [m bsf] : 4.00 to 4.60
Note(s) :



Location : BH-WFS4-6
Sample : WIP06
Depth [m bsf] : 4.00 to 4.60
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP07
Depth [m bsf] : 5.00 to 5.50

Missing Photograph

Location : BH-WFS4-6
Sample : WIP07
Depth [m bsf] : 5.00 to 5.50
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP08
Depth [m bsf] : 5.50 to 5.95



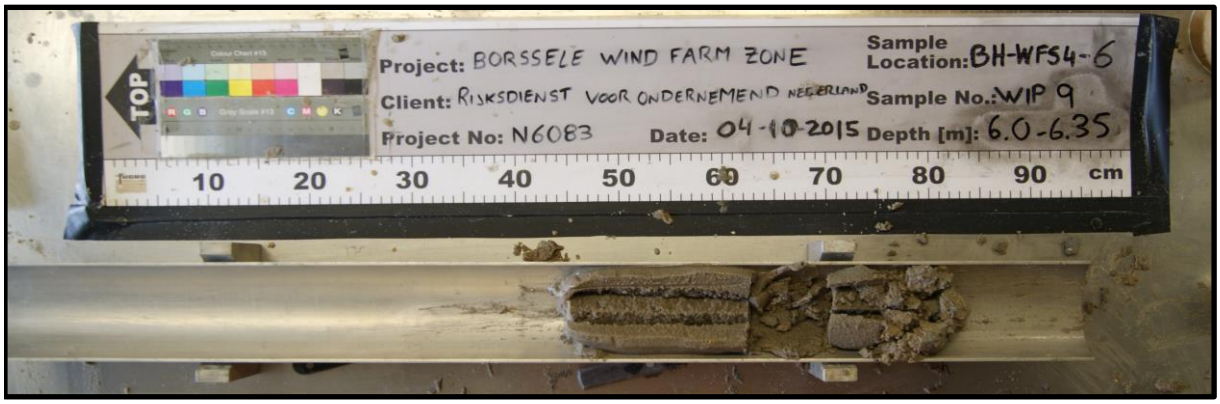
Location : BH-WFS4-6
Sample : WIP08
Depth [m bsf] : 5.50 to 5.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP09
Depth [m bsf] : 6.00 to 6.35



Location : BH-WFS4-6
Sample : WIP09
Depth [m bsf] : 6.00 to 6.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP10
Depth [m bsf] : 6.50 to 7.10



Location : BH-WFS4-6
Sample : WIP10
Depth [m bsf] : 6.50 to 7.10
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



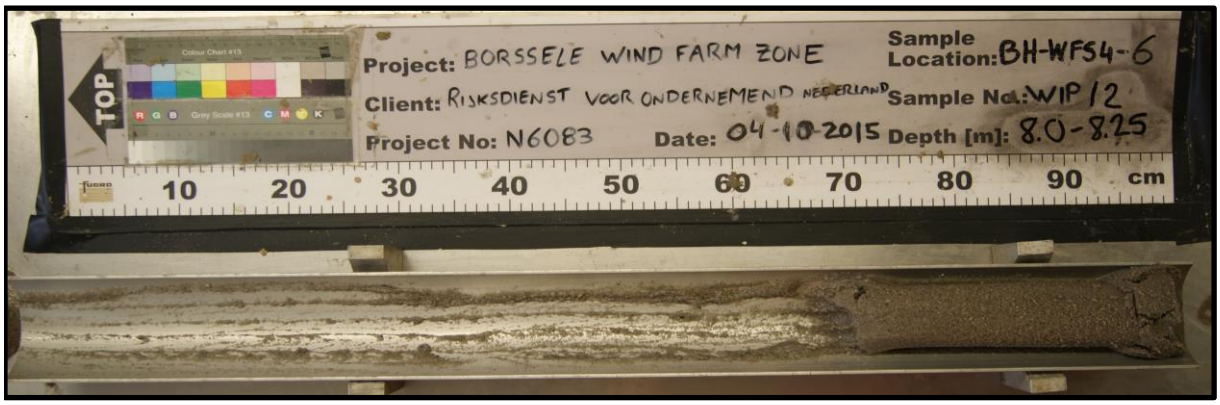
Location : BH-WFS4-6
Sample : WIP11
Depth [m bsf] : 7.50 to 7.95



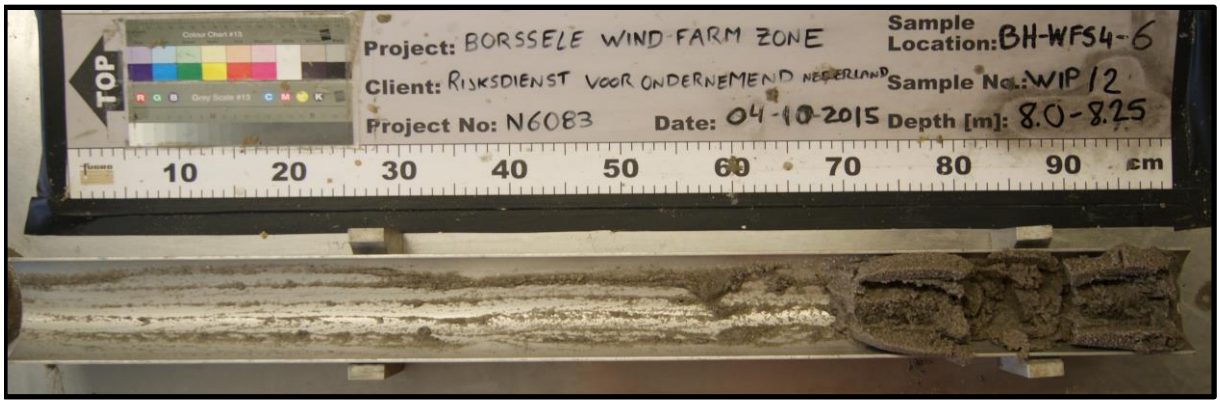
Location : BH-WFS4-6
Sample : WIP11
Depth [m bsf] : 7.50 to 7.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP12
Depth [m bsf] : 8.00 to 8.25



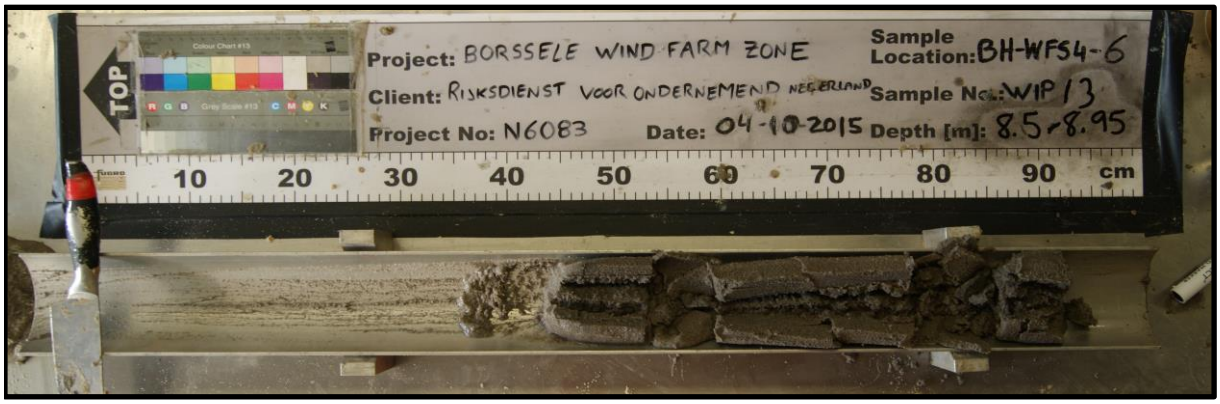
Location : BH-WFS4-6
Sample : WIP12
Depth [m bsf] : 8.00 to 8.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



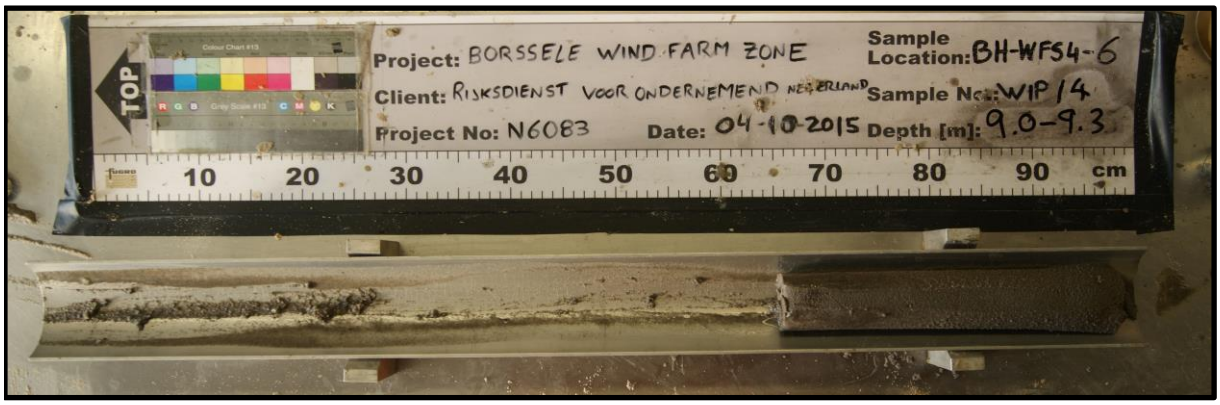
Location : BH-WFS4-6
Sample : WIP13
Depth [m bsf] : 8.50 to 8.95



Location : BH-WFS4-6
Sample : WIP13
Depth [m bsf] : 8.50 to 8.95
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP14
Depth [m bsf] : 9.00 to 9.30



Location : BH-WFS4-6
Sample : WIP14
Depth [m bsf] : 9.00 to 9.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



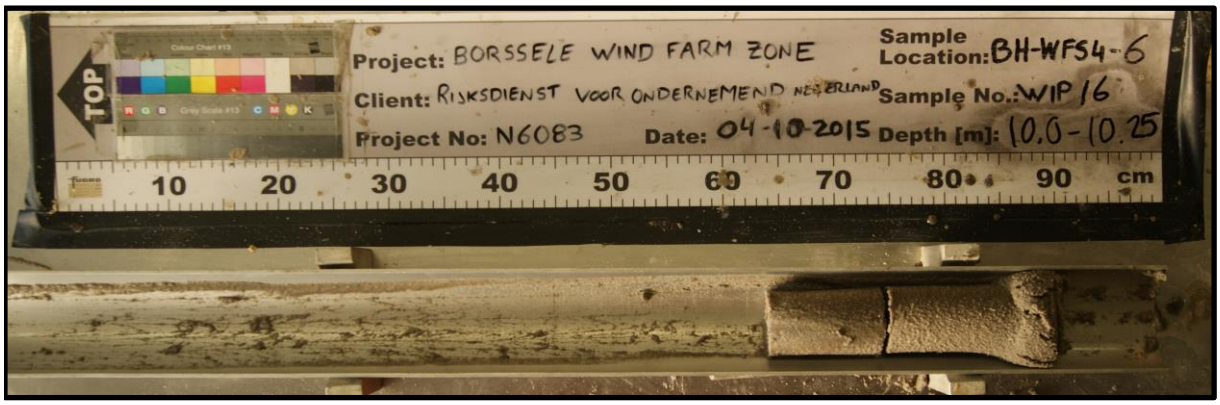
Location : BH-WFS4-6
Sample : WIP15
Depth [m bsf] : 9.50 to 9.80



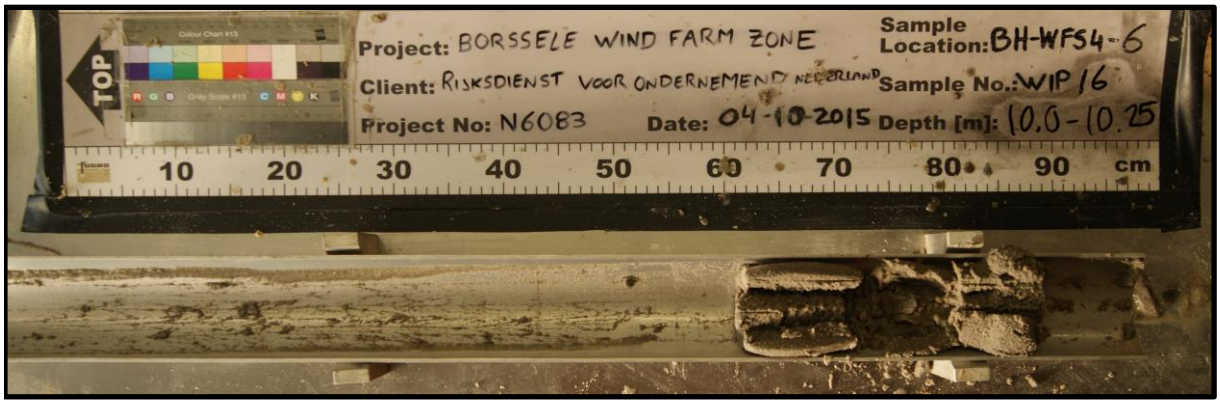
Location : BH-WFS4-6
Sample : WIP15
Depth [m bsf] : 9.50 to 9.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP16
Depth [m bsf] : 10.00 to 10.25



Location : BH-WFS4-6
Sample : WIP16
Depth [m bsf] : 10.00 to 10.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP17
Depth [m bsf] : 10.50 to 10.85



Location : BH-WFS4-6
Sample : WIP17
Depth [m bsf] : 10.50 to 10.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP18
Depth [m bsf] : 11.00 to 11.35



Location : BH-WFS4-6
Sample : WIP18
Depth [m bsf] : 11.00 to 11.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP19
Depth [m bsf] : 11.50 to 11.85



Location : BH-WFS4-6
Sample : WIP19
Depth [m bsf] : 11.50 to 11.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



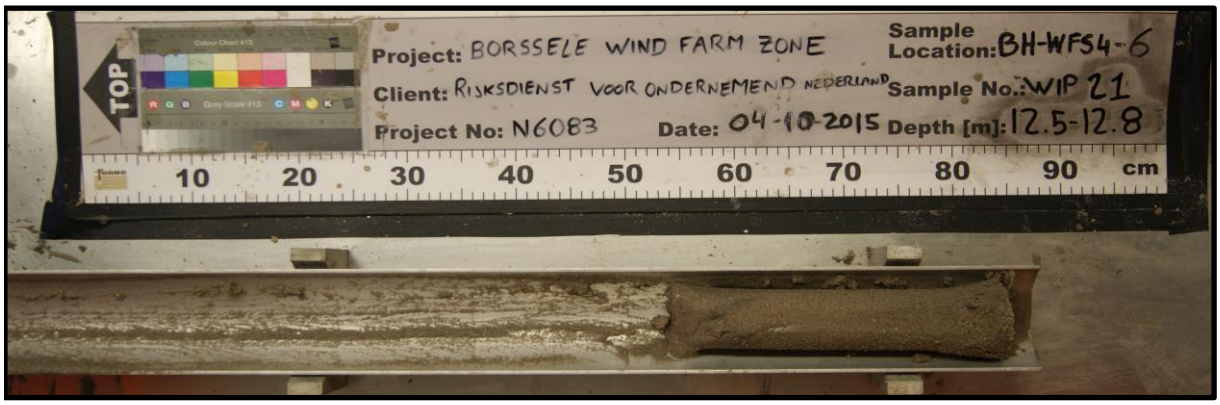
Location : BH-WFS4-6
Sample : WIP20
Depth [m bsf] : 12.00 to 12.30



Location : BH-WFS4-6
Sample : WIP20
Depth [m bsf] : 12.00 to 12.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP21
Depth [m bsf] : 12.50 to 12.80



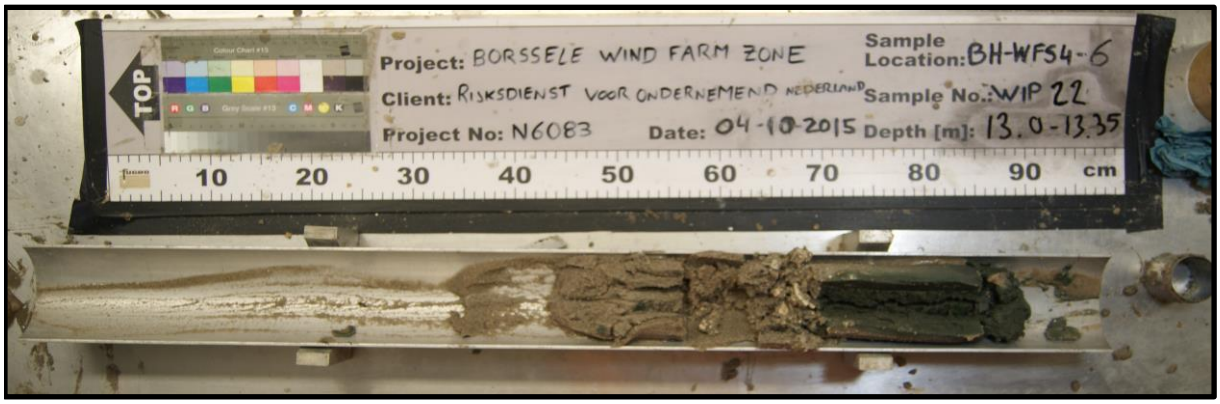
Location : BH-WFS4-6
Sample : WIP21
Depth [m bsf] : 12.50 to 12.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP22
Depth [m bsf] : 13.00 to 13.35



Location : BH-WFS4-6
Sample : WIP22
Depth [m bsf] : 13.00 to 13.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP23
Depth [m bsf] : 13.50 to 14.30



Location : BH-WFS4-6
Sample : WIP23
Depth [m bsf] : 13.50 to 14.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



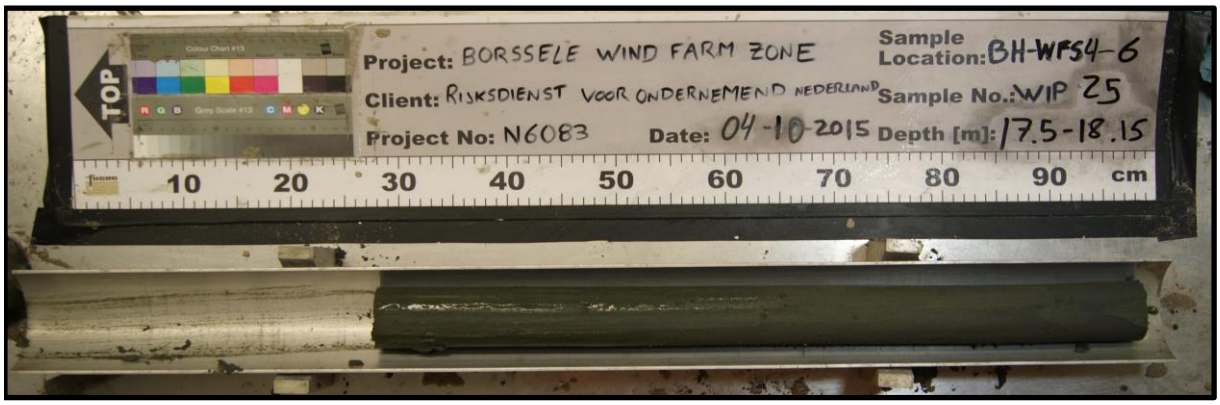
Location : BH-WFS4-6
Sample : WIP24
Depth [m bsf] : 14.50 to 14.85



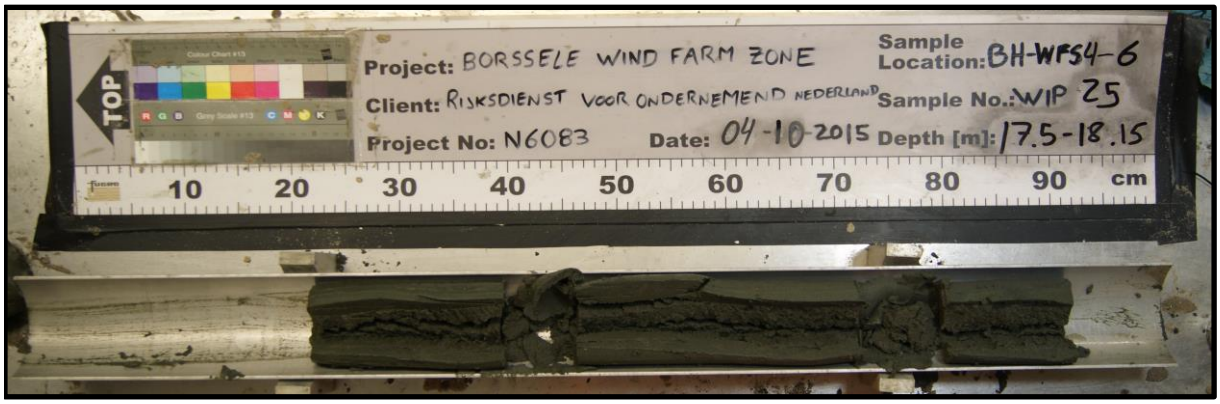
Location : BH-WFS4-6
Sample : WIP24
Depth [m bsf] : 14.50 to 14.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP25
Depth [m bsf] : 17.50 to 18.15



Location : BH-WFS4-6
Sample : WIP25
Depth [m bsf] : 17.50 to 18.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

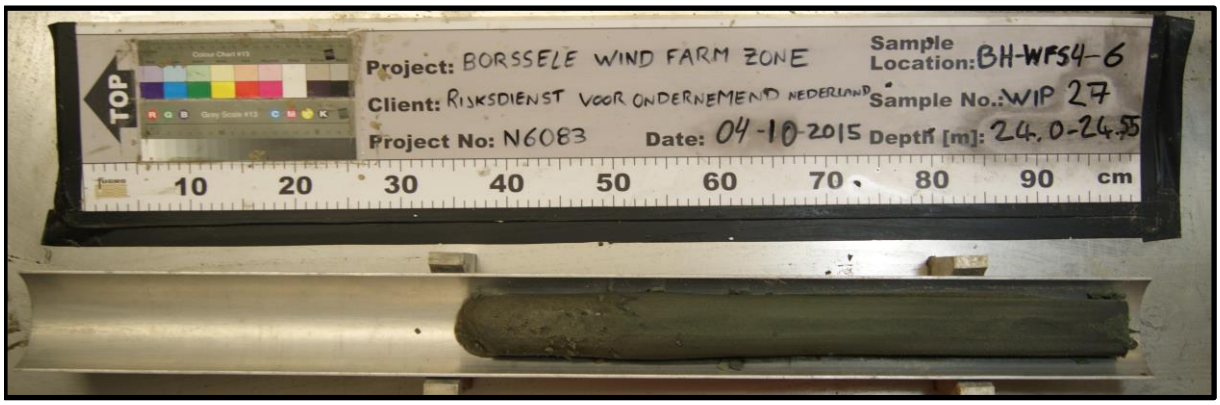
Location	:	BH-WFS4-6
Sample	:	WIP26
Depth [m bsf]	:	20.50 to 20.70
Note(s)	:	Sample photograph is missing



Location	:	BH-WFS4-6
Sample	:	WIP26
Depth [m bsf]	:	20.50 to 20.70
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-6
Sample : WIP27
Depth [m bsf] : 24.00 to 24.55



Location : BH-WFS4-6
Sample : WIP27
Depth [m bsf] : 24.00 to 24.55
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



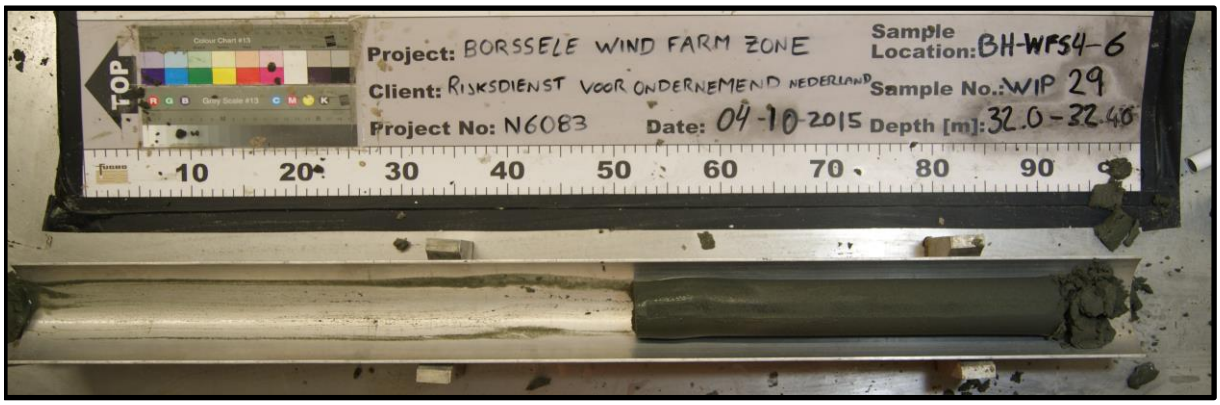
Location : BH-WFS4-6
Sample : WIP28
Depth [m bsf] : 28.00 to 28.50



Location : BH-WFS4-6
Sample : WIP28
Depth [m bsf] : 28.00 to 28.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



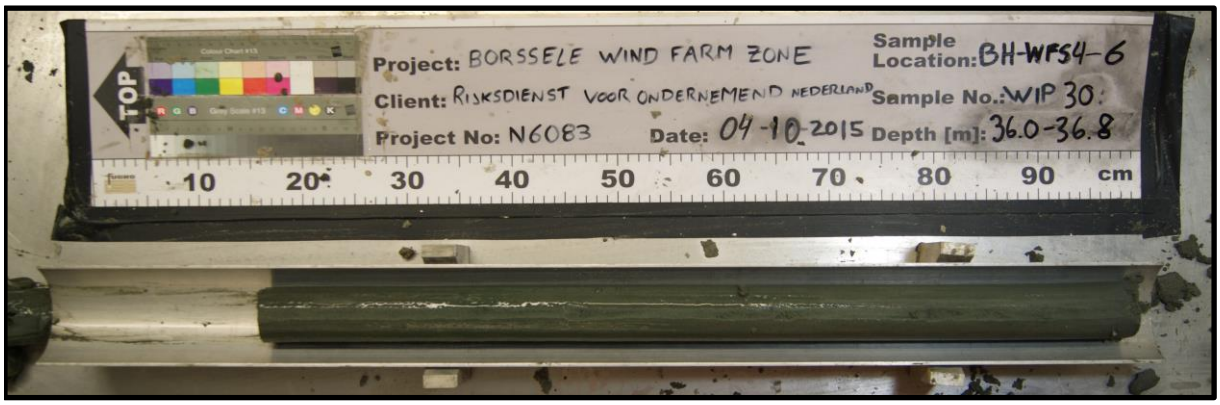
Location : BH-WFS4-6
Sample : WIP29
Depth [m bsf] : 32.00 to 32.40



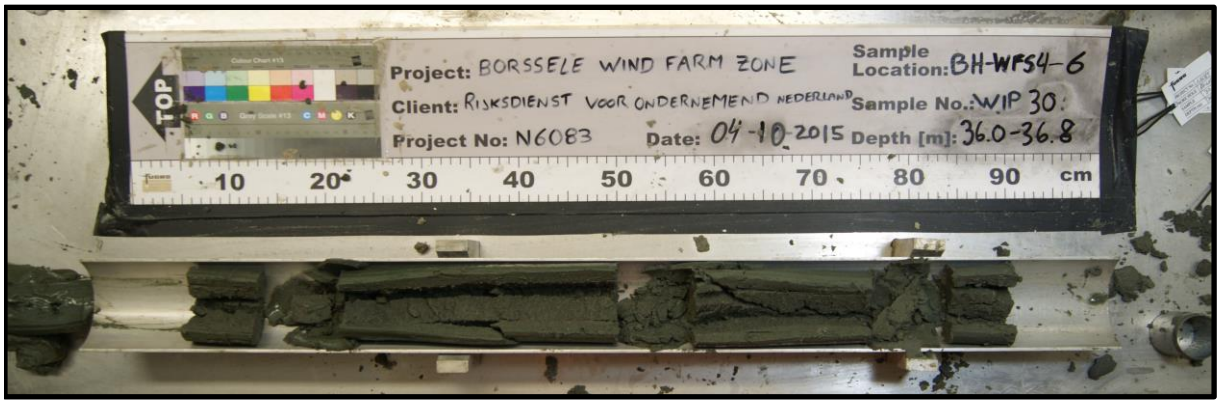
Location : BH-WFS4-6
Sample : WIP29
Depth [m bsf] : 32.00 to 32.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



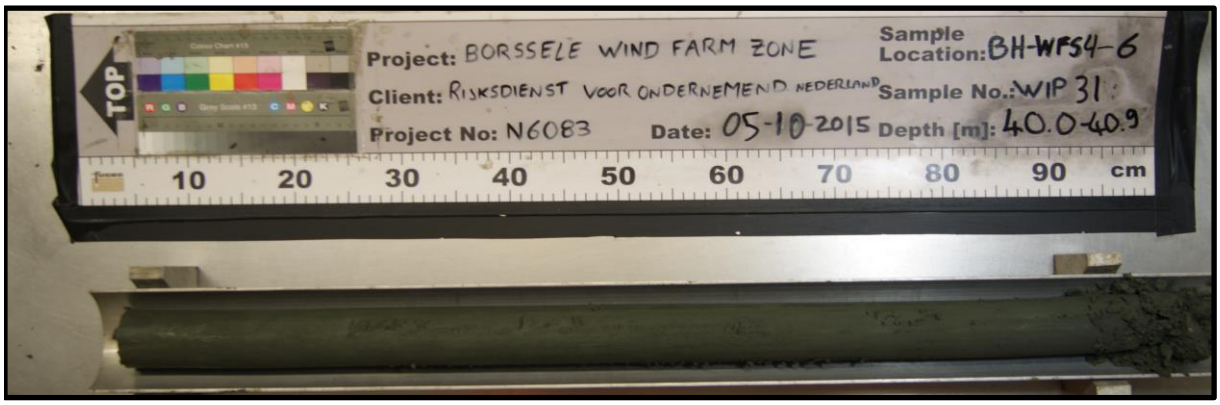
Location : BH-WFS4-6
Sample : WIP30
Depth [m bsf] : 36.00 to 36.80



Location : BH-WFS4-6
Sample : WIP30
Depth [m bsf] : 36.00 to 36.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



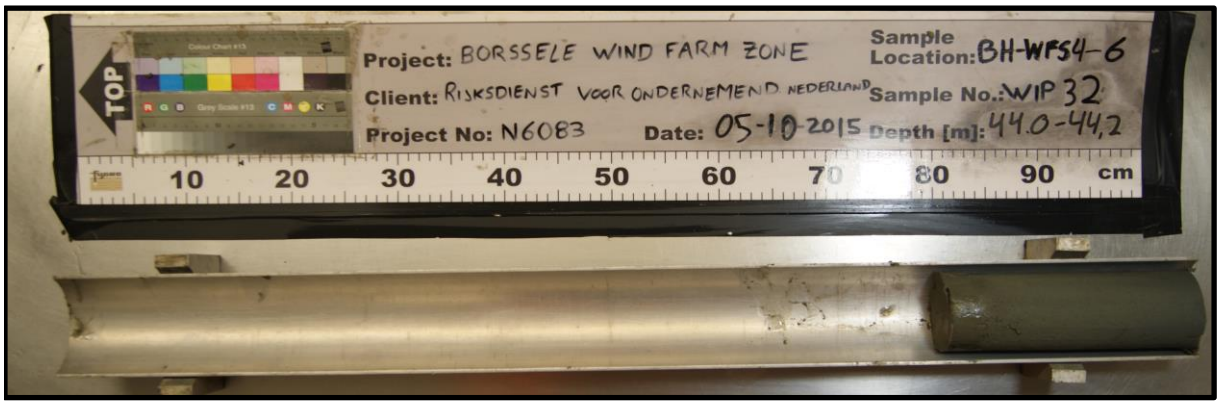
Location : BH-WFS4-6
Sample : WIP31
Depth [m bsf] : 40.00 to 40.90



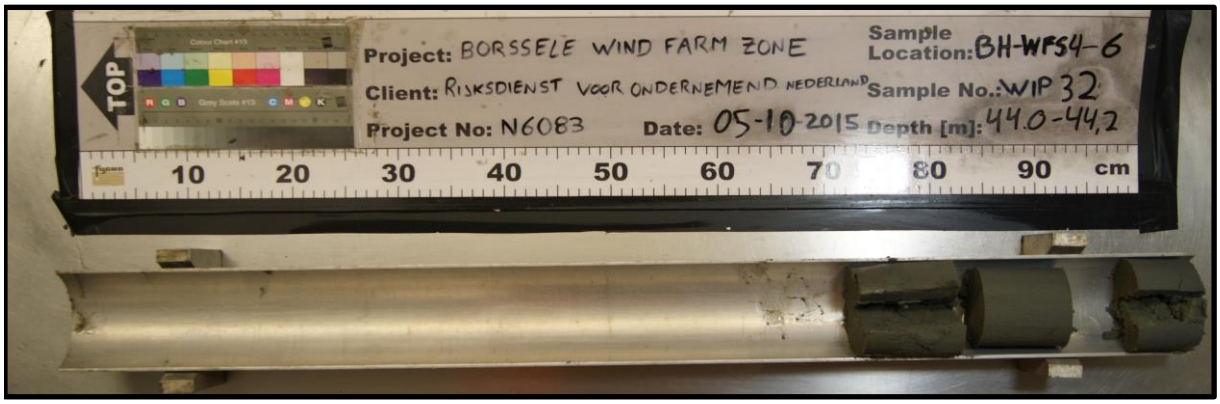
Location : BH-WFS4-6
Sample : WIP31
Depth [m bsf] : 40.00 to 40.90
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



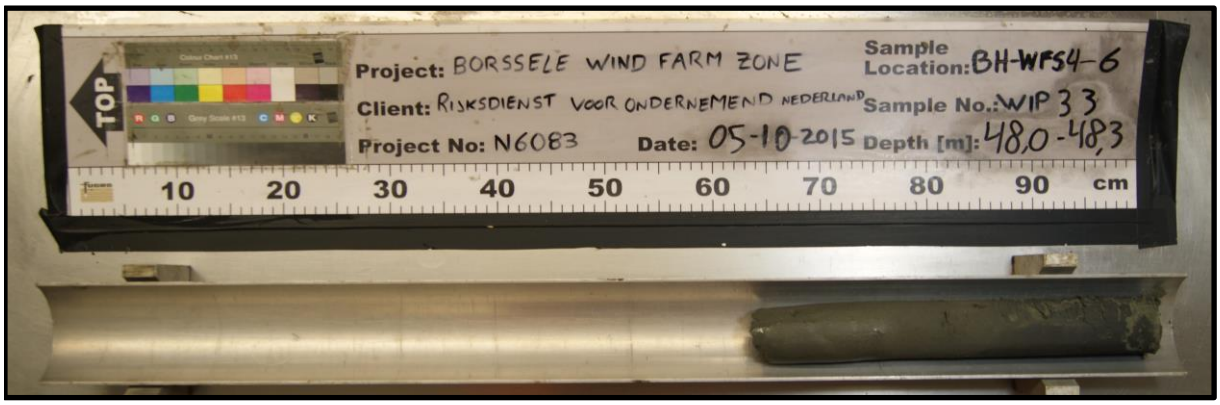
Location : BH-WFS4-6
Sample : WIP32
Depth [m bsf] : 44.00 to 44.20



Location : BH-WFS4-6
Sample : WIP32
Depth [m bsf] : 44.00 to 44.20
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



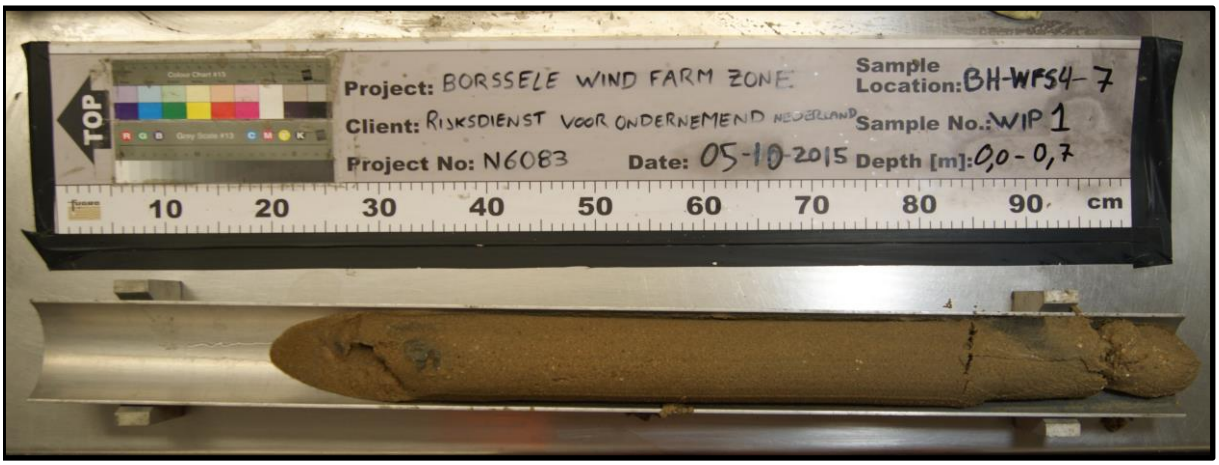
Location : BH-WFS4-6
Sample : WIP33
Depth [m bsf] : 48.00 to 48.30



Location : BH-WFS4-6
Sample : WIP33
Depth [m bsf] : 48.00 to 48.30
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



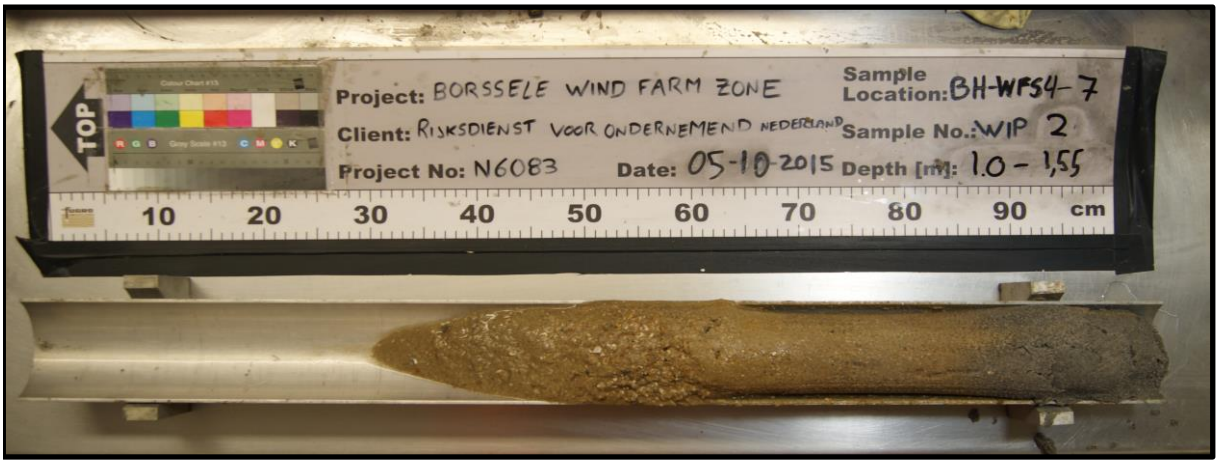
Location : BH-WFS4-7
Sample : WIP01
Depth [m bsf] : 0.00 to 0.70



Location : BH-WFS4-7
Sample : WIP01
Depth [m bsf] : 0.00 to 0.70
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP02
Depth [m bsf] : 1.00 to 1.55



Location : BH-WFS4-7
Sample : WIP02
Depth [m bsf] : 1.00 to 1.55
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP03
Depth [m bsf] : 2.00 to 2.55



Location : BH-WFS4-7
Sample : WIP03
Depth [m bsf] : 2.00 to 2.55
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

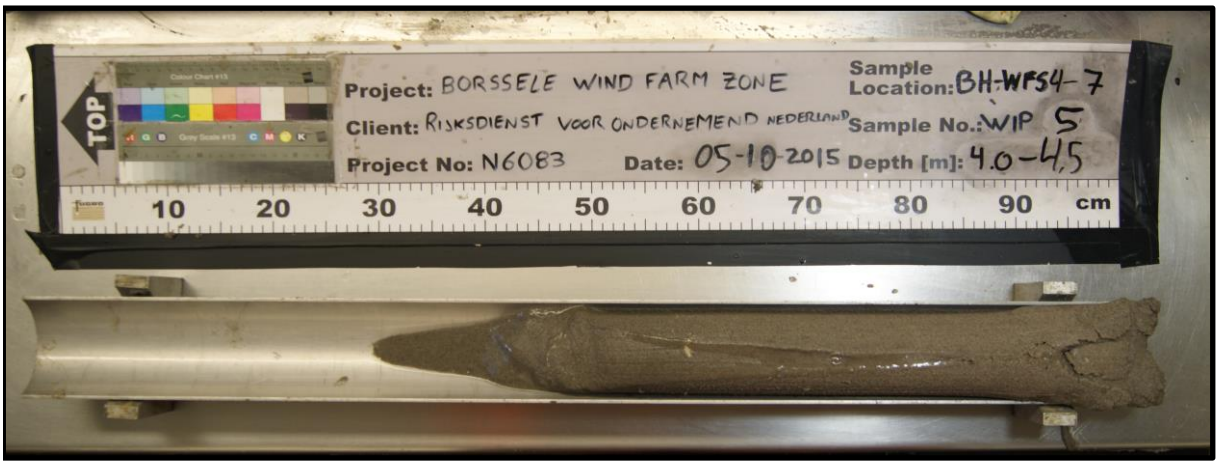
Location	:	BH-WFS4-7
Sample	:	WIP04
Depth [m bsf]	:	3.00 to 3.55
Note(s)	:	Sample photograph is missing



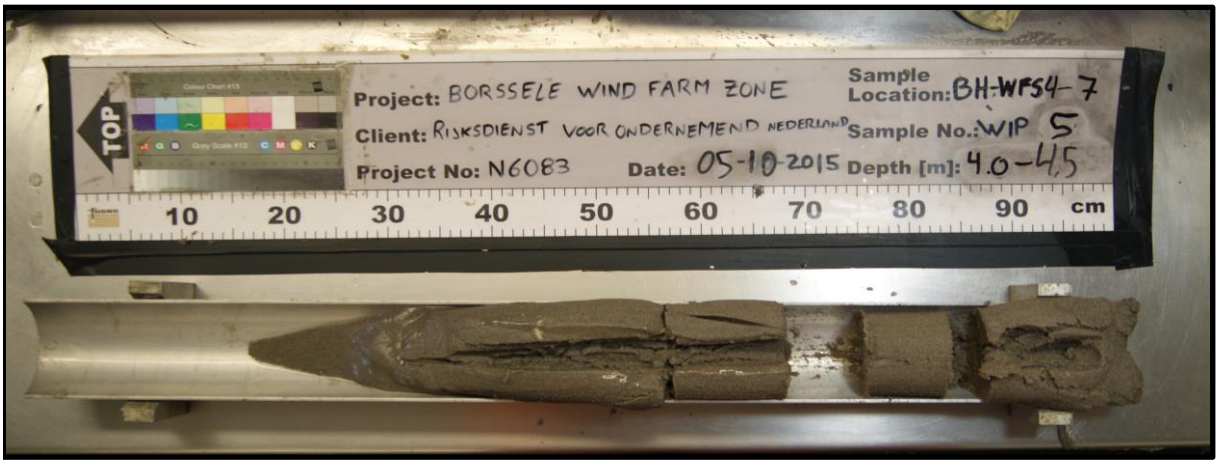
Location	:	BH-WFS4-7
Sample	:	WIP04
Depth [m bsf]	:	3.00 to 3.55
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



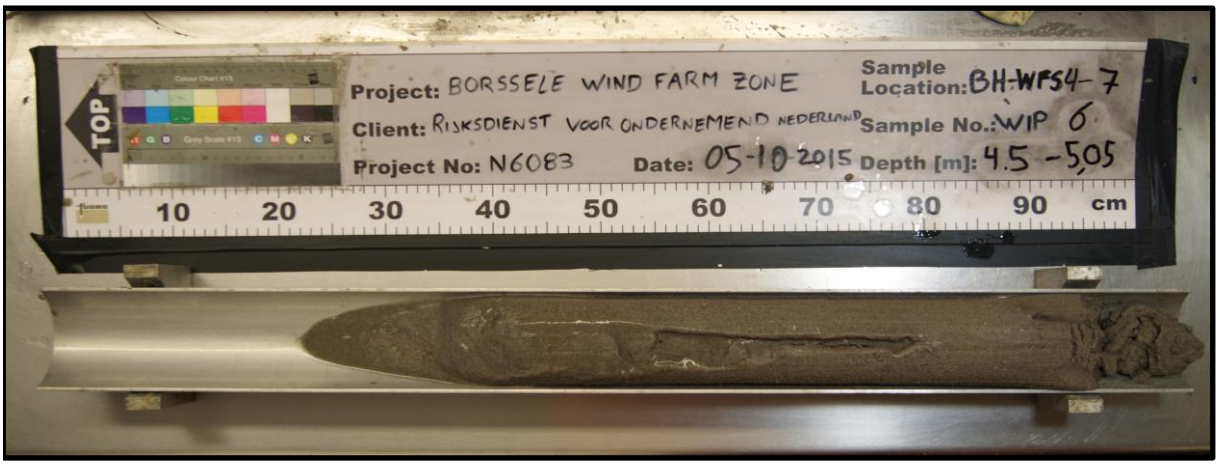
Location : BH-WFS4-7
Sample : WIP05
Depth [m bsf] : 4.00 to 4.50



Location : BH-WFS4-7
Sample : WIP05
Depth [m bsf] : 4.00 to 4.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



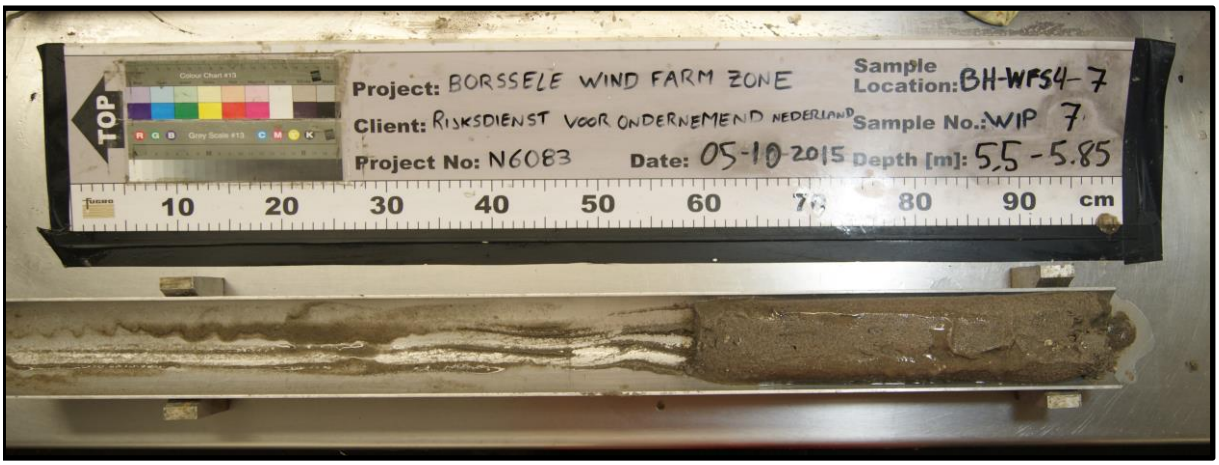
Location : BH-WFS4-7
Sample : WIP06
Depth [m bsf] : 4.50 to 5.05



Location : BH-WFS4-7
Sample : WIP06
Depth [m bsf] : 4.50 to 5.05
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



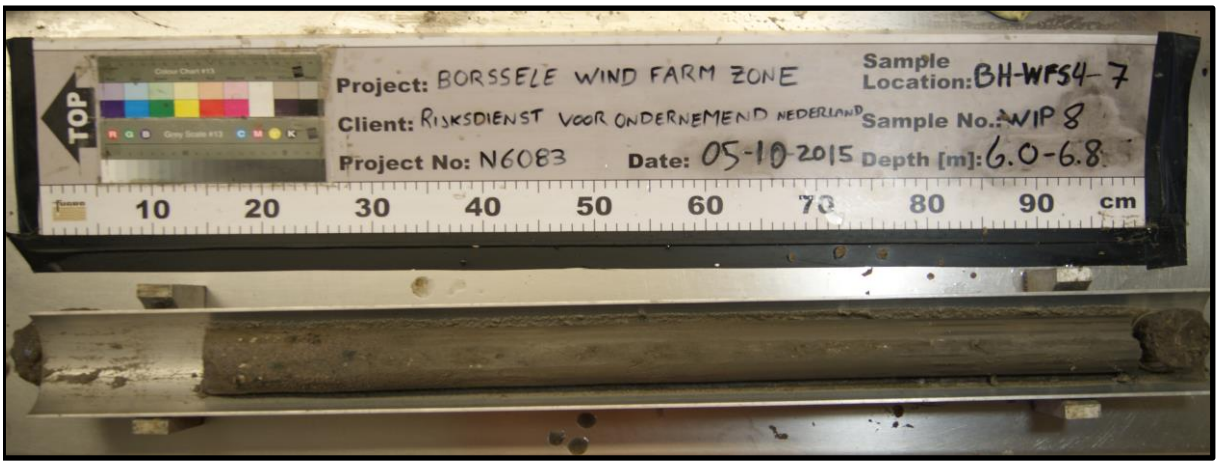
Location : BH-WFS4-7
Sample : WIP07
Depth [m bsf] : 5.50 to 5.85



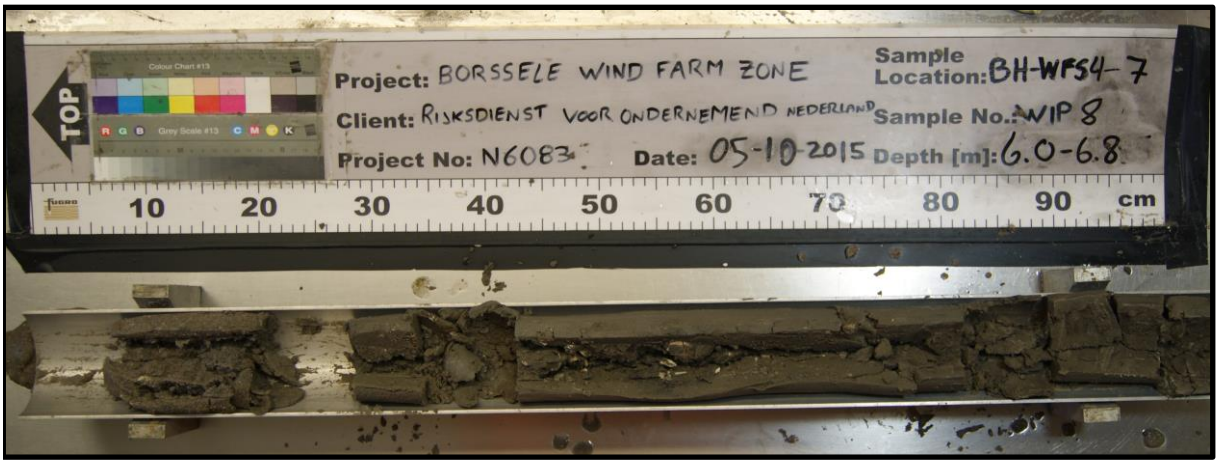
Location : BH-WFS4-7
Sample : WIP07
Depth [m bsf] : 5.50 to 5.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP08
Depth [m bsf] : 6.00 to 6.80



Location : BH-WFS4-7
Sample : WIP08
Depth [m bsf] : 6.00 to 6.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

Missing Photograph

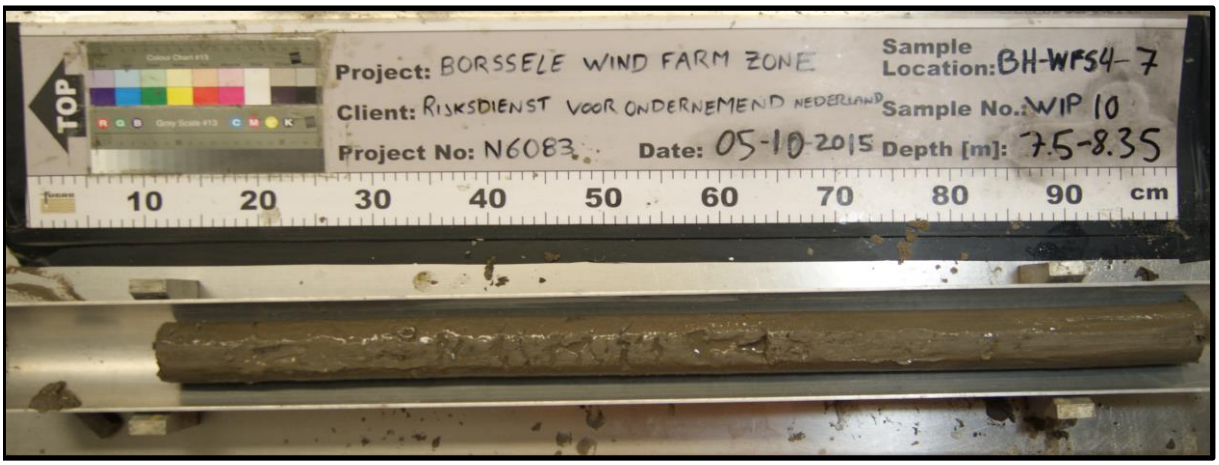
Location	:	BH-WFS4-7
Sample	:	WIP09
Depth [m bsf]	:	7.00 to 7.50
Note(s)	:	Sample photograph is missing



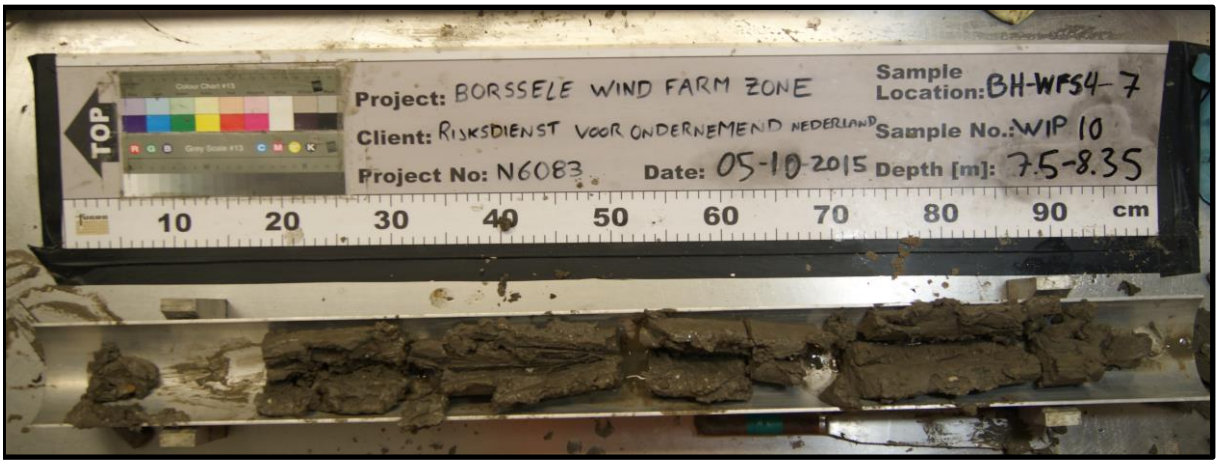
Location	:	BH-WFS4-7
Sample	:	WIP09
Depth [m bsf]	:	7.00 to 7.50
Note(s)	:	SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



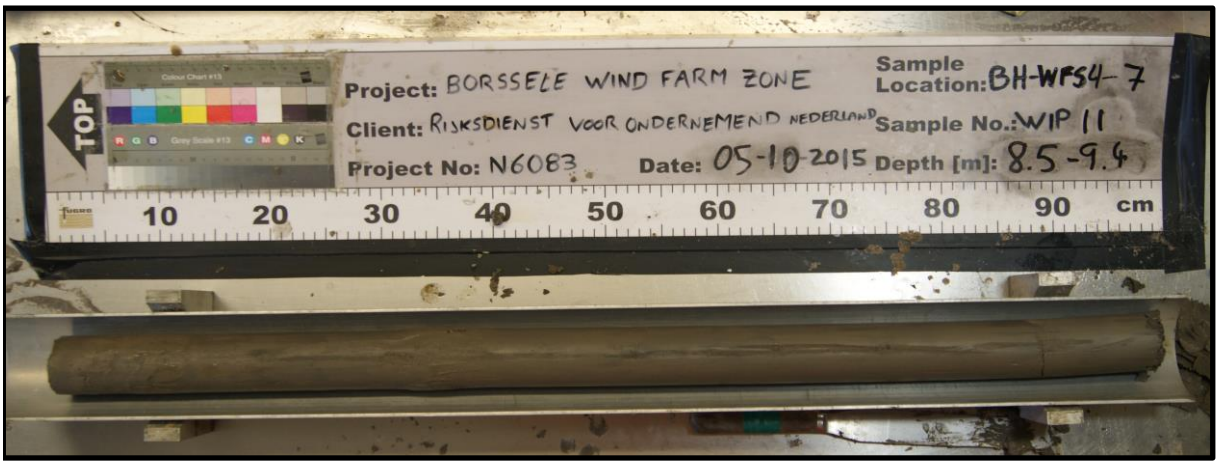
Location : BH-WFS4-7
Sample : WIP10
Depth [m bsf] : 7.50 to 8.35



Location : BH-WFS4-7
Sample : WIP10
Depth [m bsf] : 7.50 to 8.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP11
Depth [m bsf] : 8.50 to 9.40



Location : BH-WFS4-7
Sample : WIP11
Depth [m bsf] : 8.50 to 9.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location	:	BH-WFS4-7
Sample	:	WIP12
Depth [m bsf]	:	9.50 to 10.20
Note(s)	:	Incorrect sample number on photograph



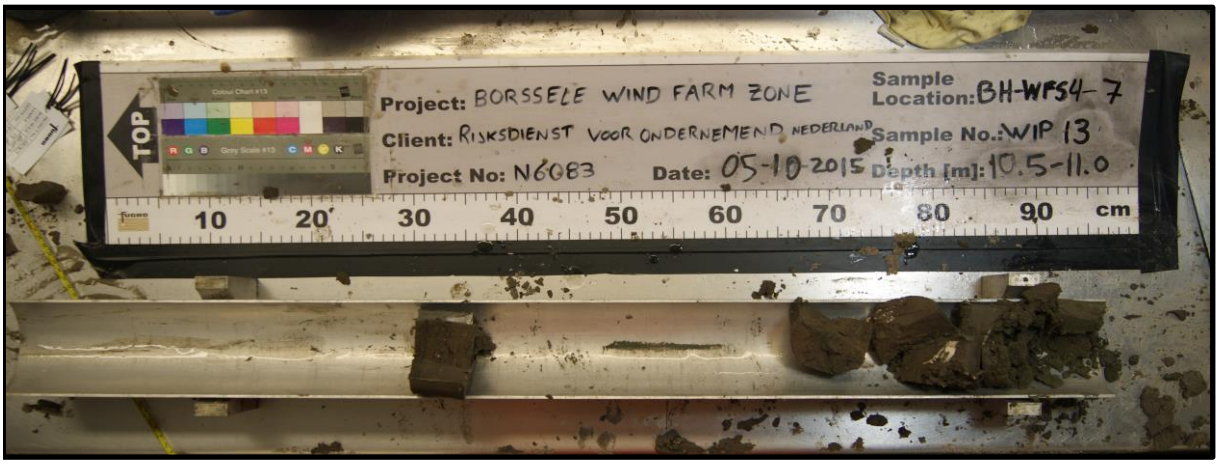
Location	:	BH-WFS4-7
Sample	:	WIP12
Depth [m bsf]	:	9.50 to 10.20
Note(s)	:	SPLIT, incorrect sample number on photograph

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



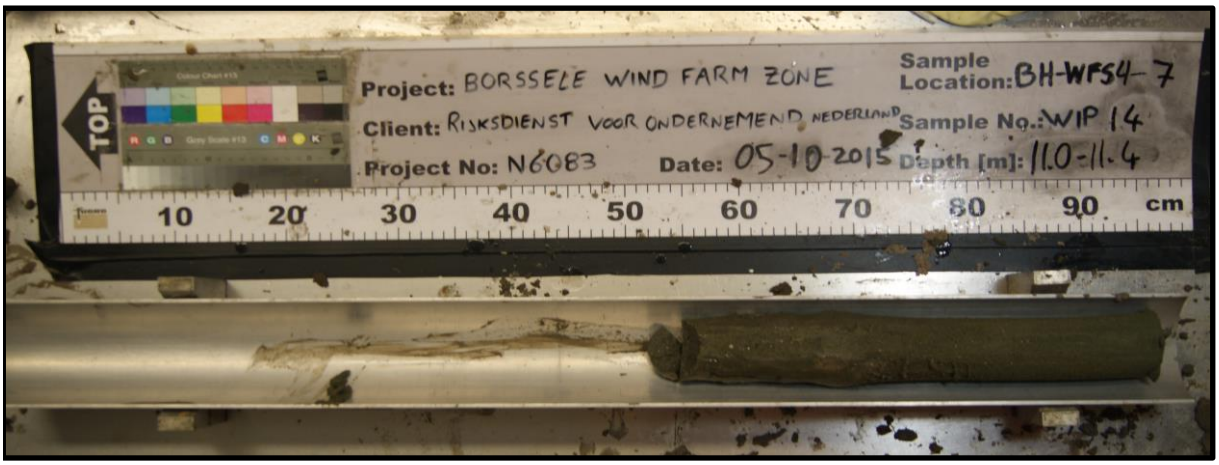
Location : BH-WFS4-7
Sample : WIP13
Depth [m bsf] : 10.50 to 11.00



Location : BH-WFS4-7
Sample : WIP13
Depth [m bsf] : 10.50 to 11.00
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



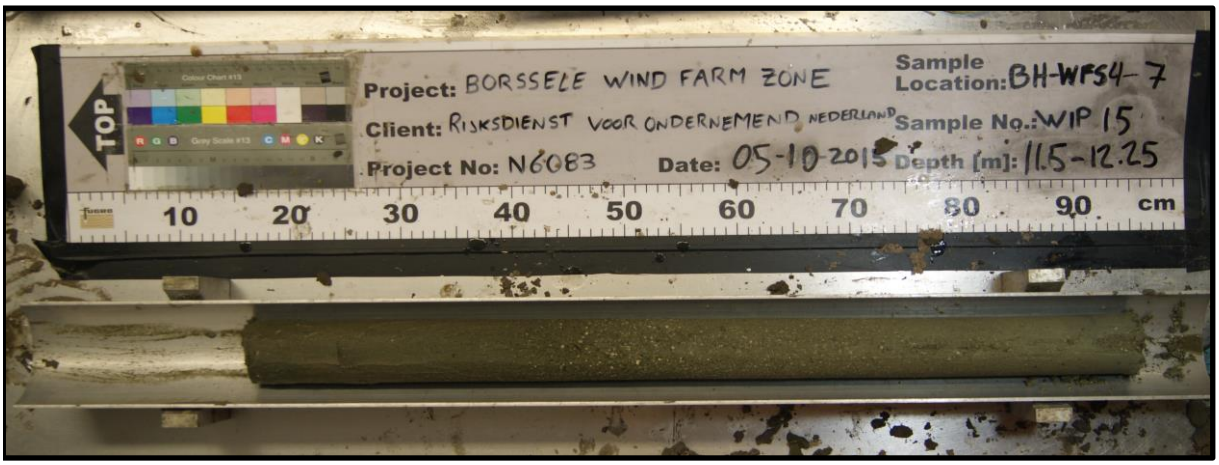
Location : BH-WFS4-7
Sample : WIP14
Depth [m bsf] : 11.00 to 11.40



Location : BH-WFS4-7
Sample : WIP14
Depth [m bsf] : 11.00 to 11.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP15
Depth [m bsf] : 11.50 to 12.25



Location : BH-WFS4-7
Sample : WIP15
Depth [m bsf] : 11.50 to 12.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP16
Depth [m bsf] : 12.50 to 13.50



Location : BH-WFS4-7
Sample : WIP16
Depth [m bsf] : 12.50 to 13.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



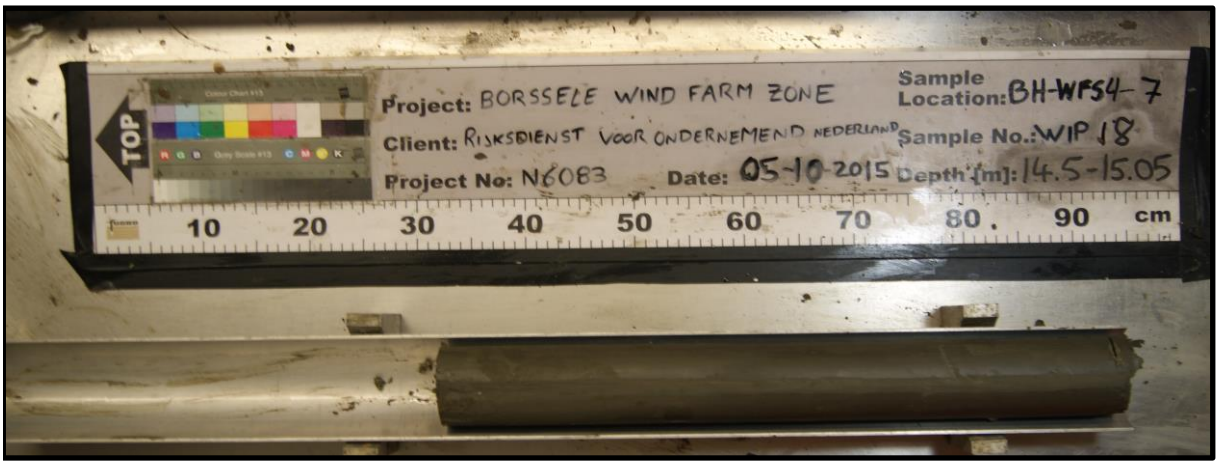
Location : BH-WFS4-7
Sample : WIP17
Depth [m bsf] : 13.50 to 14.35



Location : BH-WFS4-7
Sample : WIP17
Depth [m bsf] : 13.50 to 14.35
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



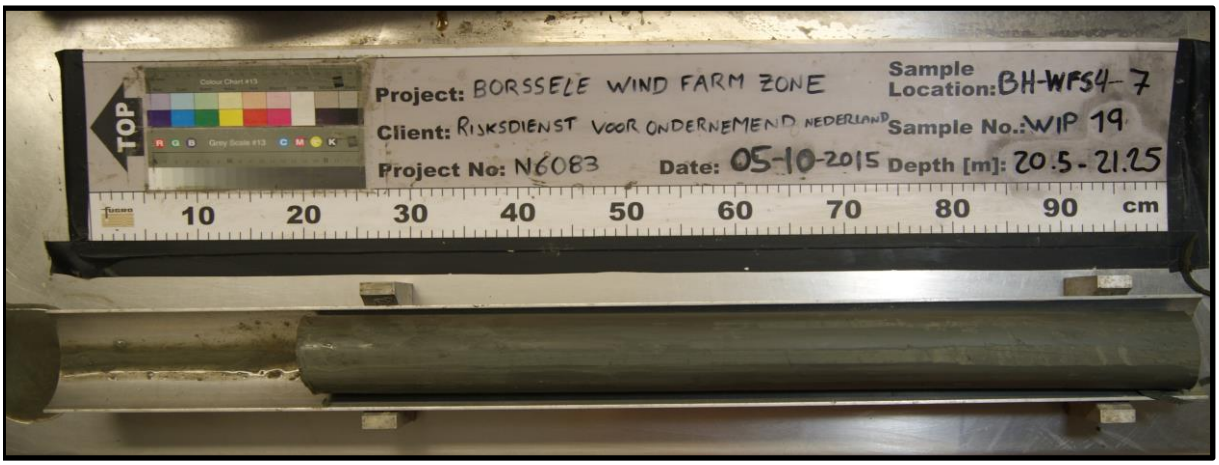
Location : BH-WFS4-7
Sample : WIP18
Depth [m bsf] : 14.50 to 15.05



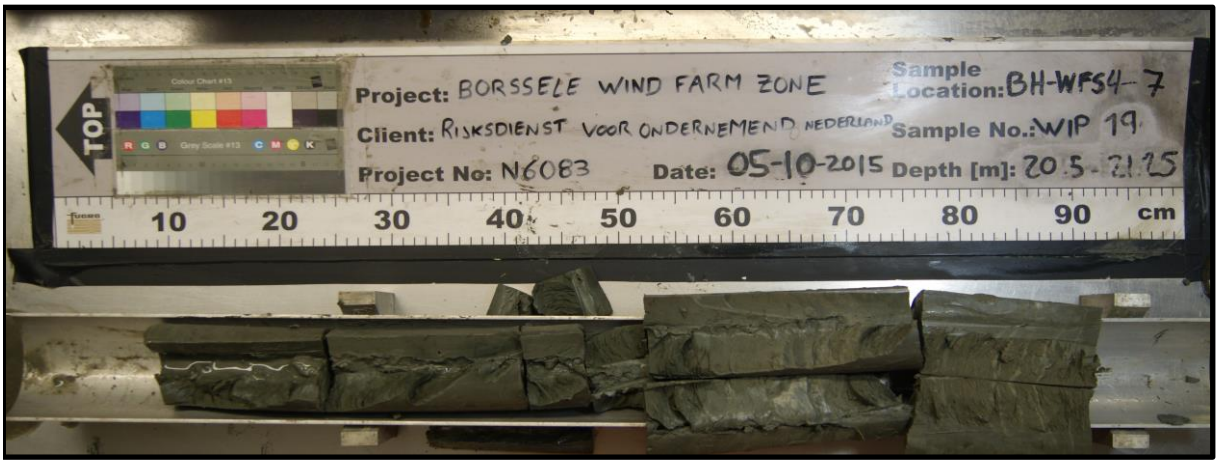
Location : BH-WFS4-7
Sample : WIP18
Depth [m bsf] : 14.50 to 15.05
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



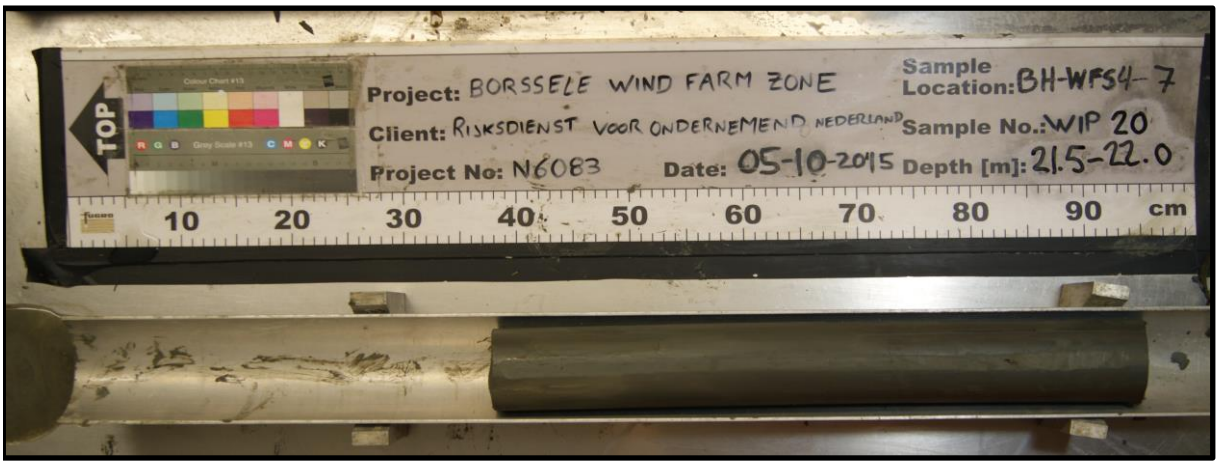
Location : BH-WFS4-7
Sample : WIP19
Depth [m bsf] : 20.50 to 21.25



Location : BH-WFS4-7
Sample : WIP19
Depth [m bsf] : 20.50 to 21.25
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP20
Depth [m bsf] : 21.50 to 22.00



Location : BH-WFS4-7
Sample : WIP20
Depth [m bsf] : 21.50 to 22.00
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



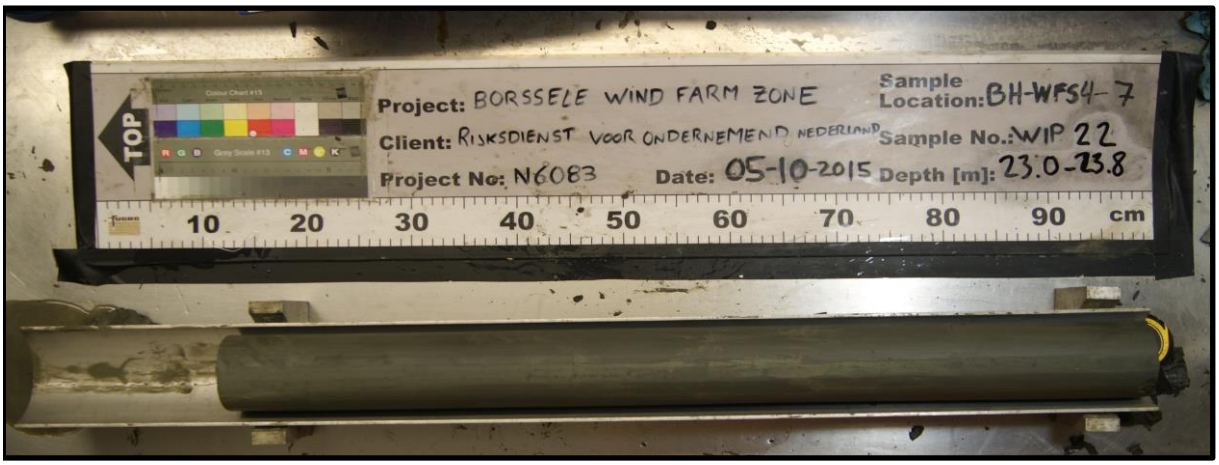
Location : BH-WFS4-7
Sample : WIP21
Depth [m bsf] : 22.00 to 22.50



Location : BH-WFS4-7
Sample : WIP21
Depth [m bsf] : 22.00 to 22.50
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



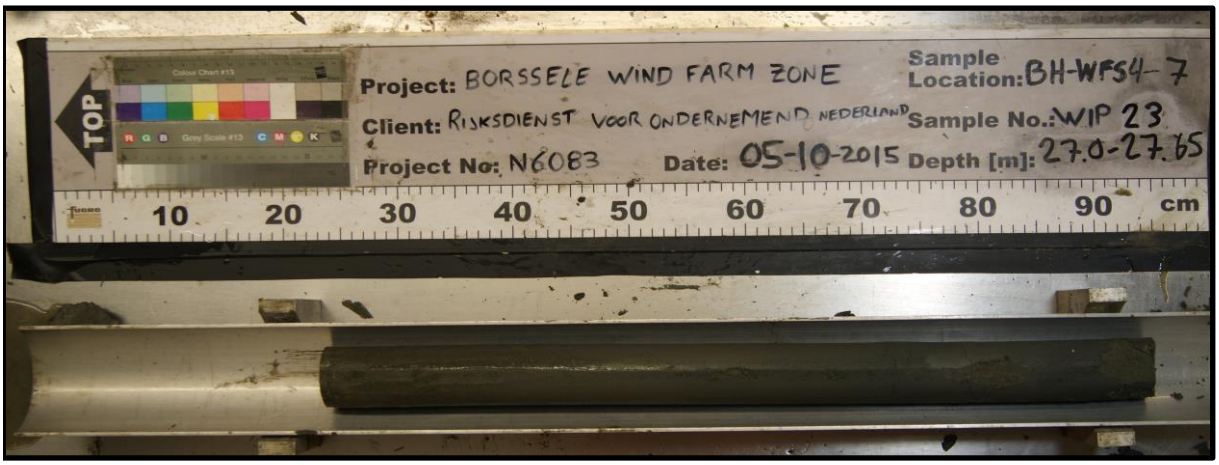
Location : BH-WFS4-7
Sample : WIP22
Depth [m bsf] : 23.00 to 23.80



Location : BH-WFS4-7
Sample : WIP22
Depth [m bsf] : 23.00 to 23.80
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



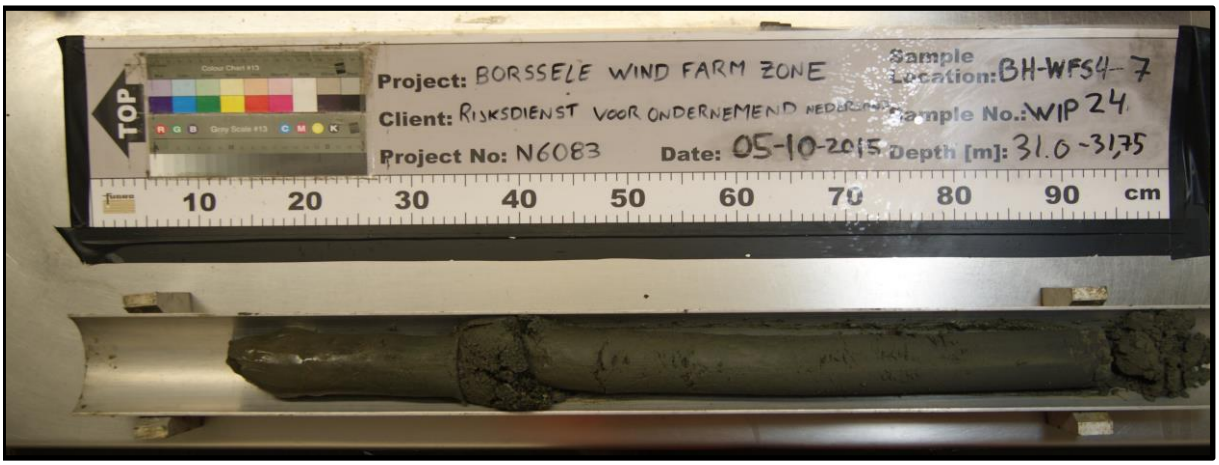
Location : BH-WFS4-7
Sample : WIP23
Depth [m bsf] : 27.00 to 27.65

Missing Photograph

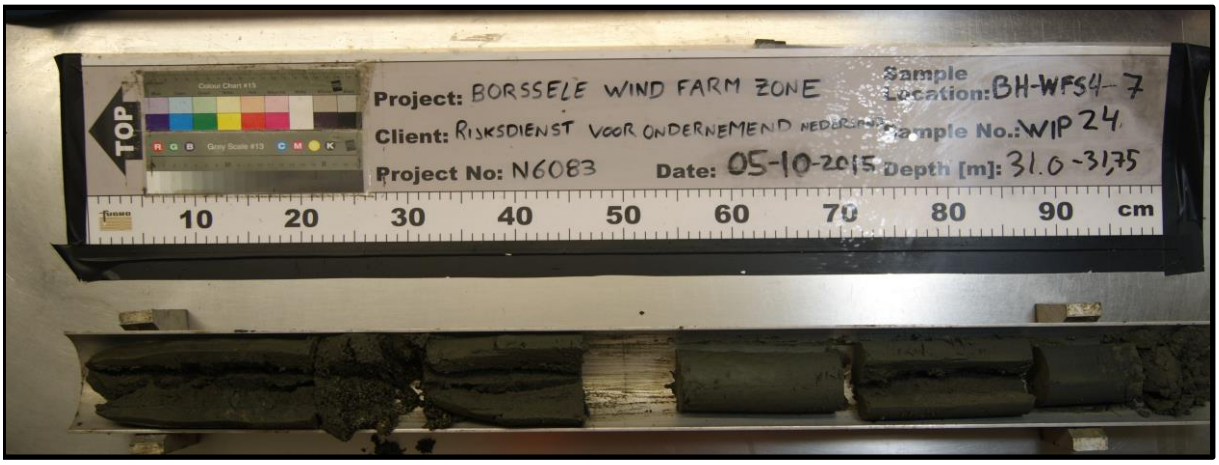
Location : BH-WFS4-7
Sample : WIP23
Depth [m bsf] : 27.00 to 27.65
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : BH-WFS4-7
Sample : WIP24
Depth [m bsf] : 31.00 to 31.75



Location : BH-WFS4-7
Sample : WIP24
Depth [m bsf] : 31.00 to 31.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



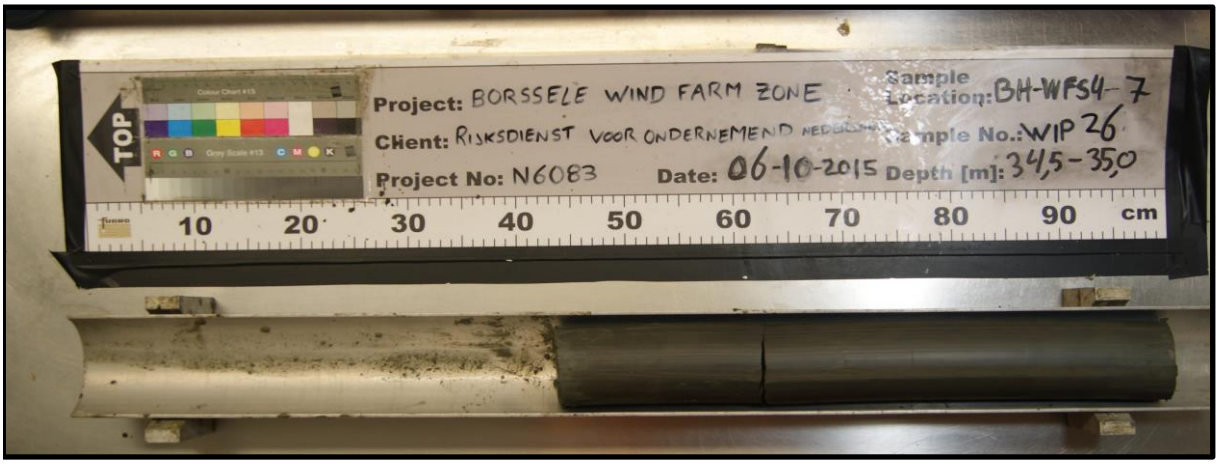
Location : BH-WFS4-7
Sample : WIP25
Depth [m bsf] : 33.50 to 34.15



Location : BH-WFS4-7
Sample : WIP25
Depth [m bsf] : 33.50 to 34.15
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



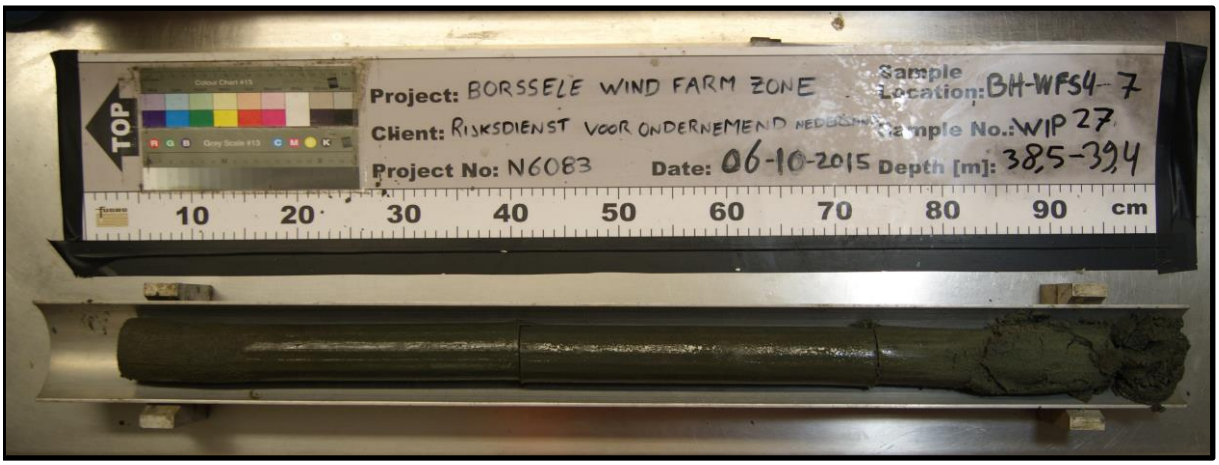
Location : BH-WFS4-7
Sample : WIP26
Depth [m bsf] : 34.50 to 35.00

Missing Photograph

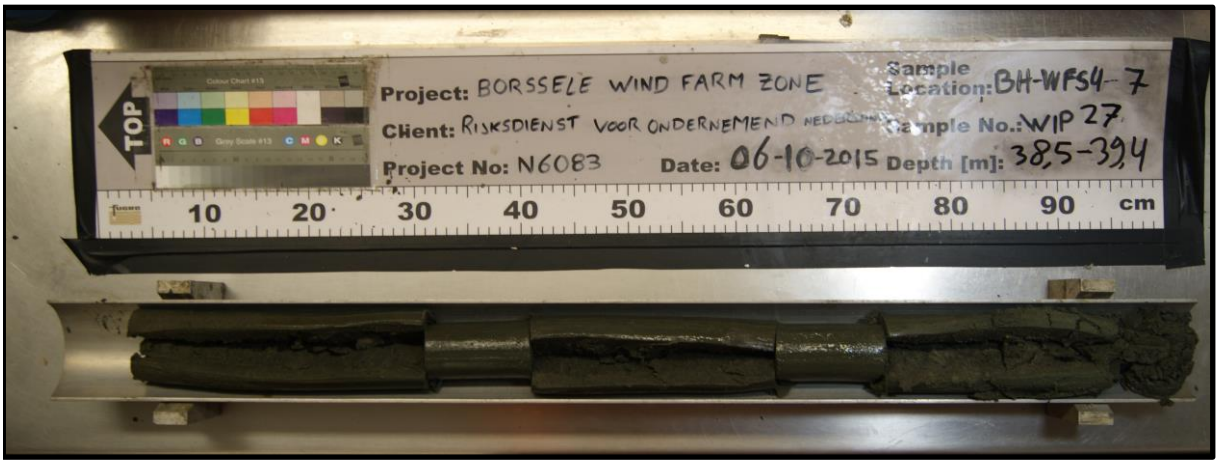
Location : BH-WFS4-7
Sample : WIP26
Depth [m bsf] : 34.50 to 35.00
Note(s) : SPLIT, sample photograph is missing

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



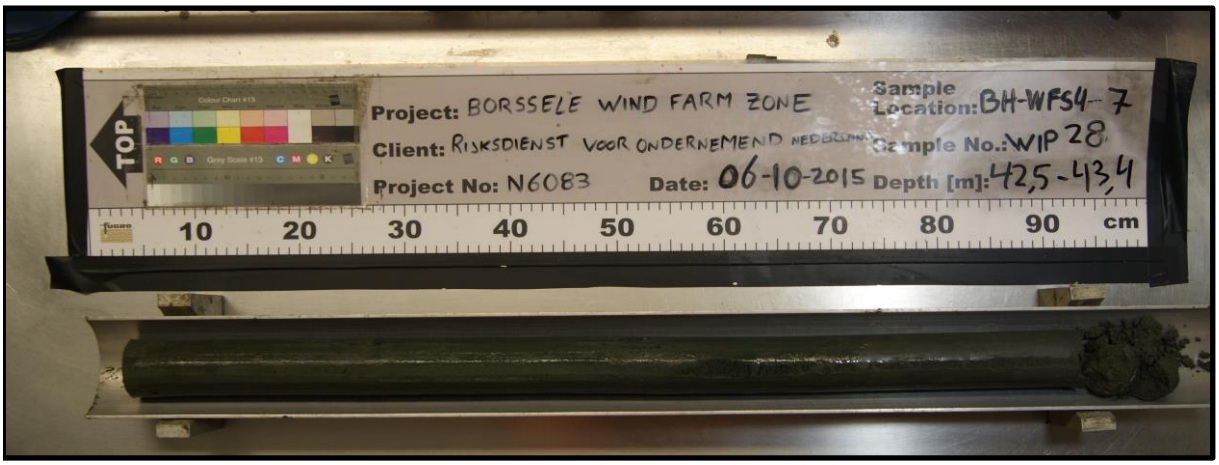
Location : BH-WFS4-7
Sample : WIP27
Depth [m bsf] : 38.50 to 39.40



Location : BH-WFS4-7
Sample : WIP27
Depth [m bsf] : 38.50 to 39.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



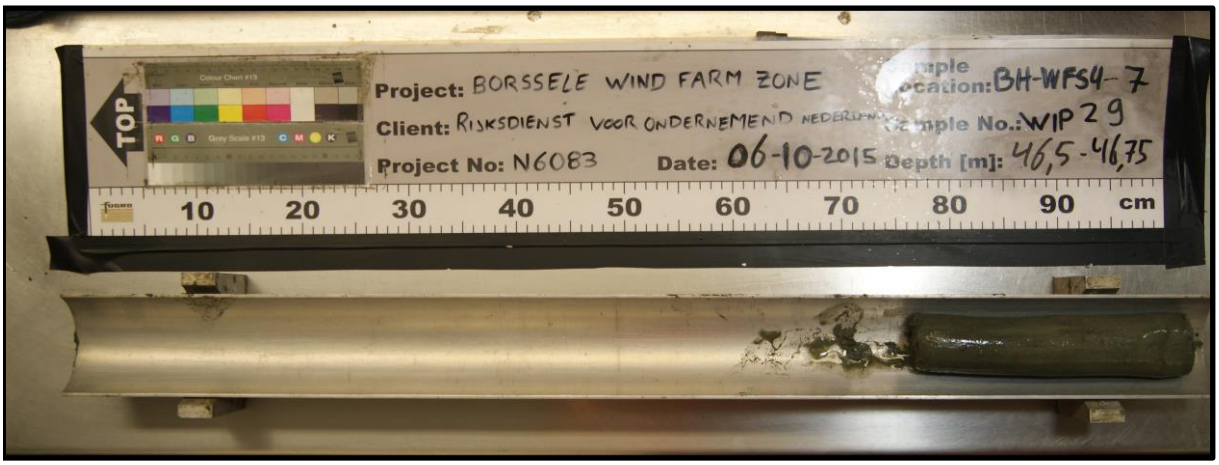
Location : BH-WFS4-7
Sample : WIP28
Depth [m bsf] : 42.50 to 43.40



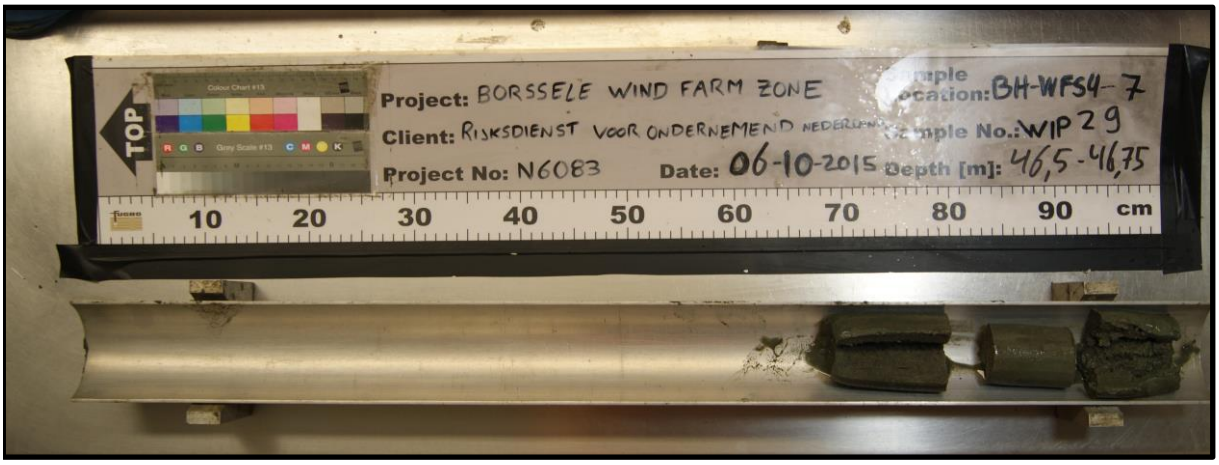
Location : BH-WFS4-7
Sample : WIP28
Depth [m bsf] : 42.50 to 43.40
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



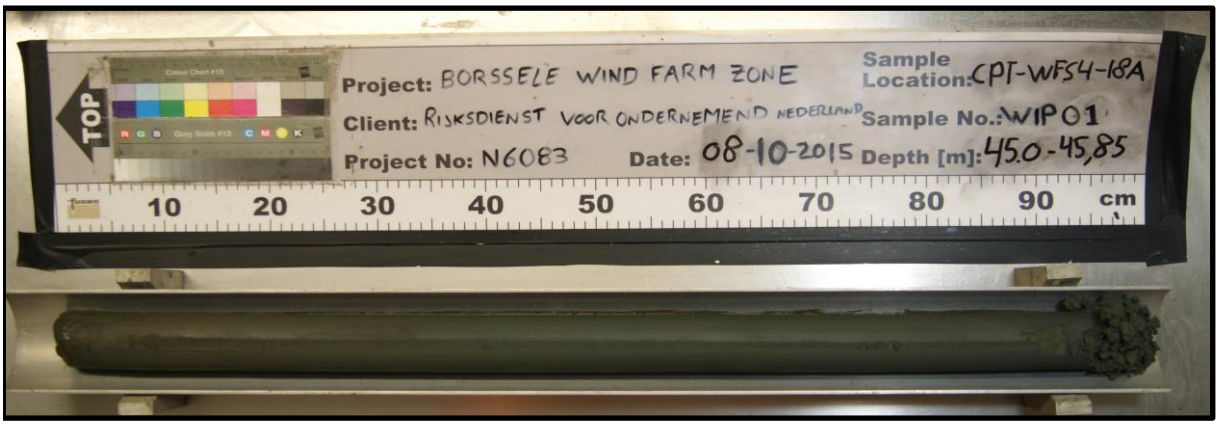
Location : BH-WFS4-7
Sample : WIP29
Depth [m bsf] : 46.50 to 46.75



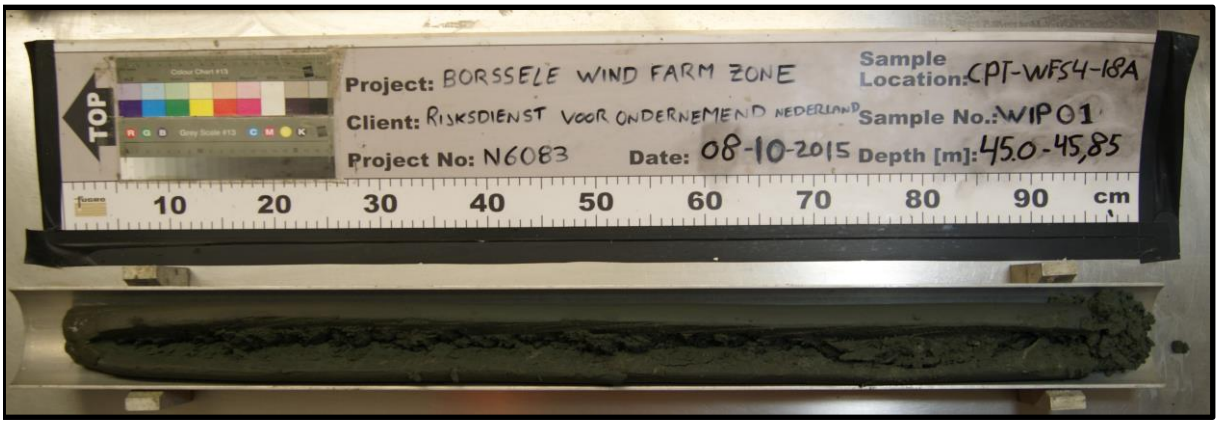
Location : BH-WFS4-7
Sample : WIP29
Depth [m bsf] : 46.50 to 46.75
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA



Location : CPT_WFS4_18A
Sample : WIP01
Depth [m bsf] : 45.00 to 45.85



Location : CPT_WFS4_18A
Sample : WIP01
Depth [m bsf] : 45.00 to 45.85
Note(s) : SPLIT

SAMPLE PHOTOGRAPH

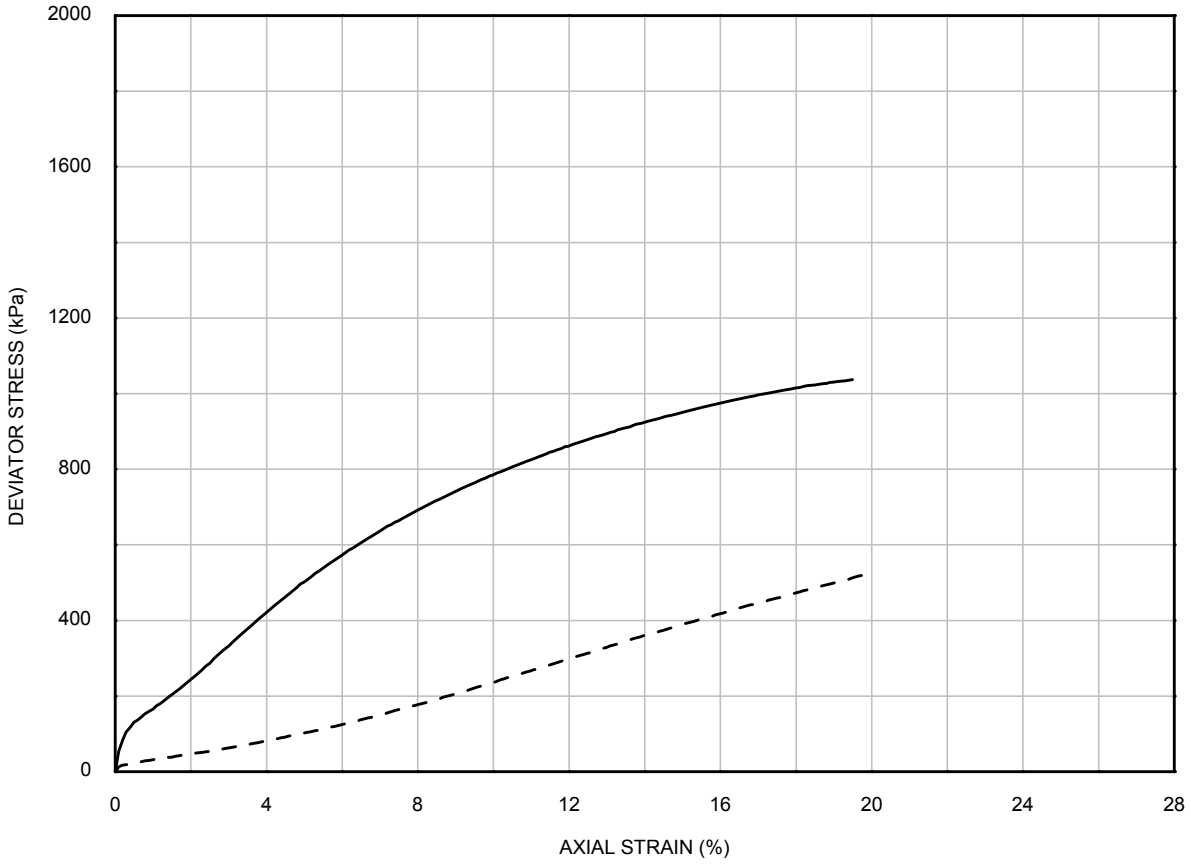
BORSSELE WIND FARM ZONE, WFS IV – DUTCH SECTOR, NORTH SEA

SECTION C4: TRIAXIAL TESTS

LIST OF PLATES IN SECTION C4: Plate

Unconsolidated Undrained Triaxial Test	C4.1-1 to C4.1-24
Isotropically Consolidated Undrained Triaxial Compression Test	C4.2-1 to C4.2-72
Isotropically Consolidated Drained Triaxial Compression Test	C4.3-1 to C4.3-90

Date: 15/10/2015
Drawn by: ER
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_14WaxC_uu.OPJ
Template Issue: 3:4
Date : 20/10/2015
Checked by: ALB
Date : 27/10/2015
Approved by: PH



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	2	3
Corrected deviator stress	(kPa)	1037	526
Strain at failure	(%)	19.5	20.0
Undrained shear strength	(kPa)	519	263

Undisturbed

Barrel failure

Remoulded

Barrel failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	138.8	100.9
Sample diameter	(mm)	71.0	48.6
Membrane thickness	(mm)	0.48	0.38
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.98	2.01
Dry density	(Mg/m^3)	1.58	1.58
Moisture content	(%)	24.8	27.3

Borehole : BH-WFS4-1A

Sample : 14WaxC

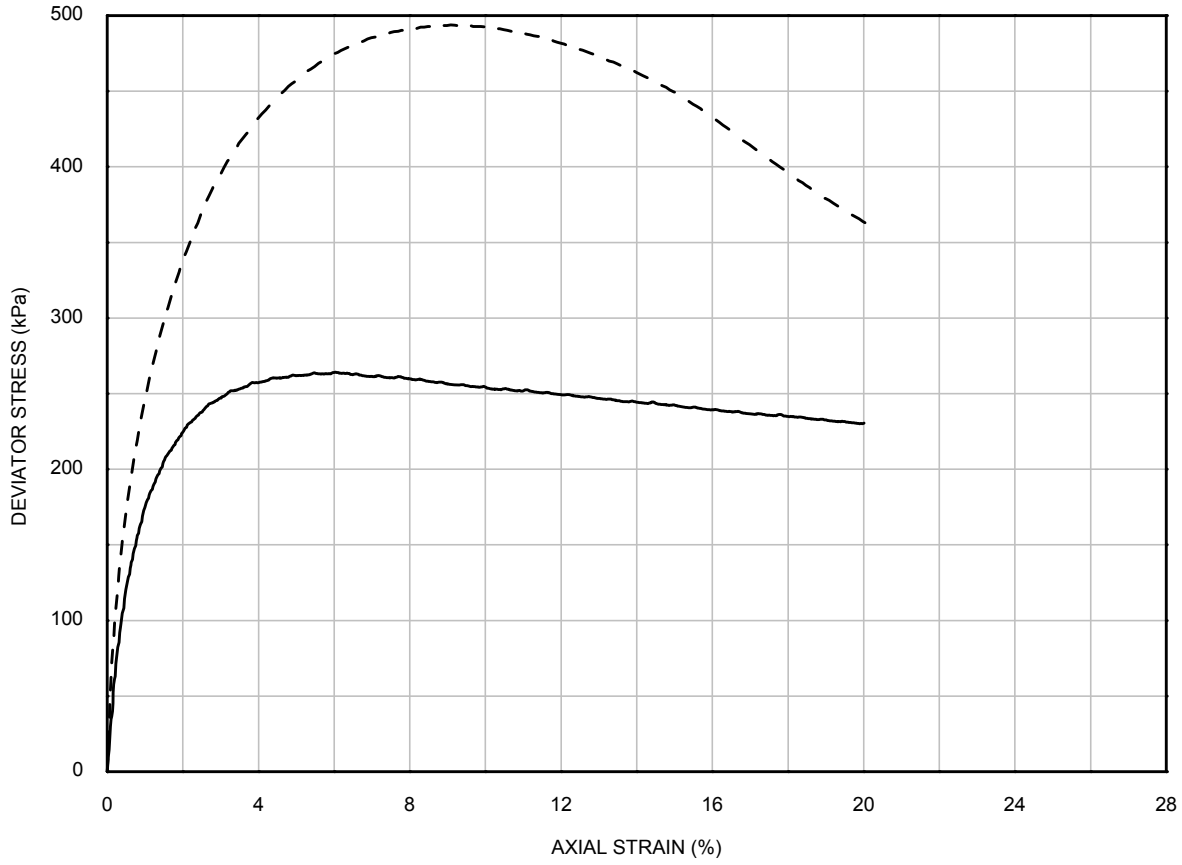
Depth (m): 13.60

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ER
Template Issue: 3:4
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_21BagUU_uu.OPJ
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	264	494
Strain at failure	(%)	6.0	9.5
Undrained shear strength	(kPa)	132	247

Undisturbed

Shear failure

Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.1	102.6
Sample diameter	(mm)	72.3	48.9
Membrane thickness	(mm)	0.25	0.38
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.86	1.85
Dry density	(Mg/m^3)	1.37	1.34
Moisture content	(%)	36.0	38.0

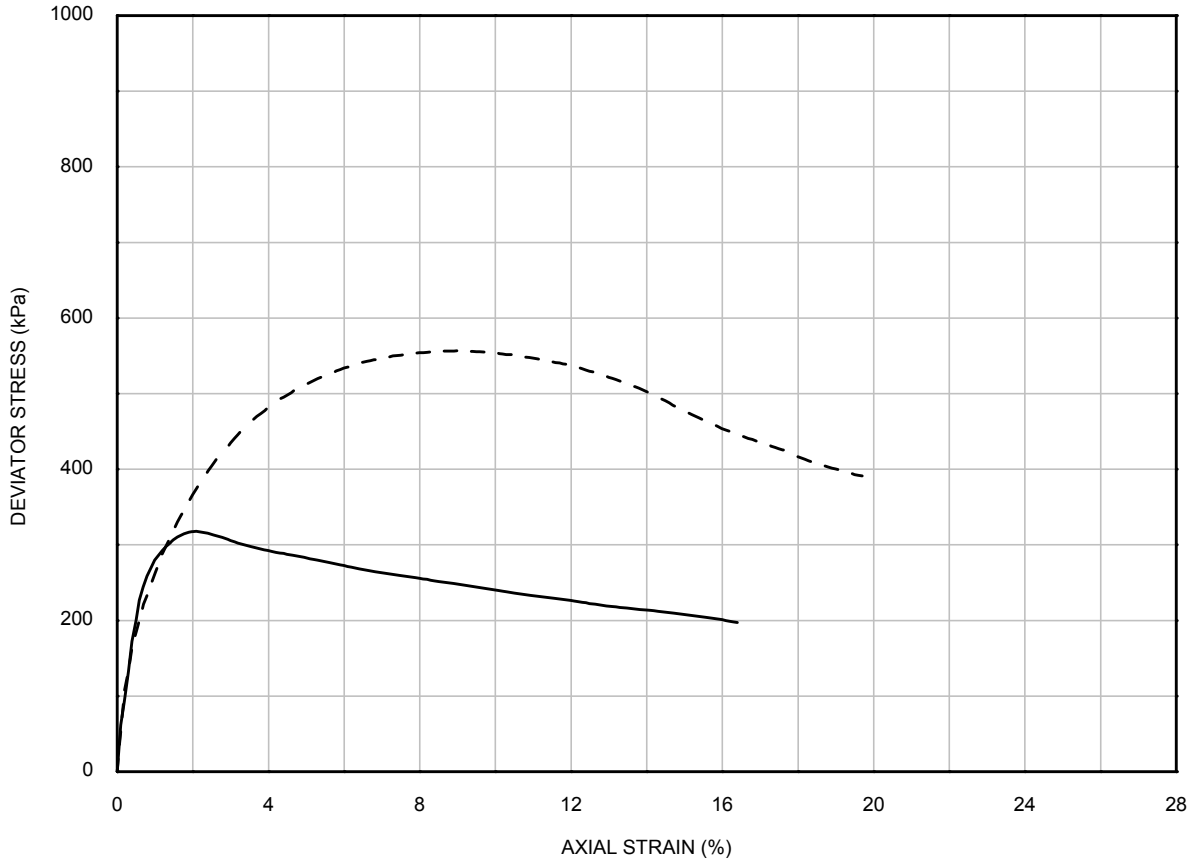
Shear failure

Borehole : BH-WFS4-1A
Sample : 21BagUU
Depth (m): 33.30

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	318	557
Strain at failure	(%)	2.1	9.0
Undrained shear strength	(kPa)	159	278

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	139.1	102.1
Sample diameter	(mm)	72.0	48.8
Membrane thickness	(mm)	0.42	0.40
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.88	1.88
Dry density	(Mg/m^3)	1.37	1.38
Moisture content	(%)	37.9	36.4

Borehole : BH-WFS4-1A

Sample : 21WaxC

Depth (m) : 33.50

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

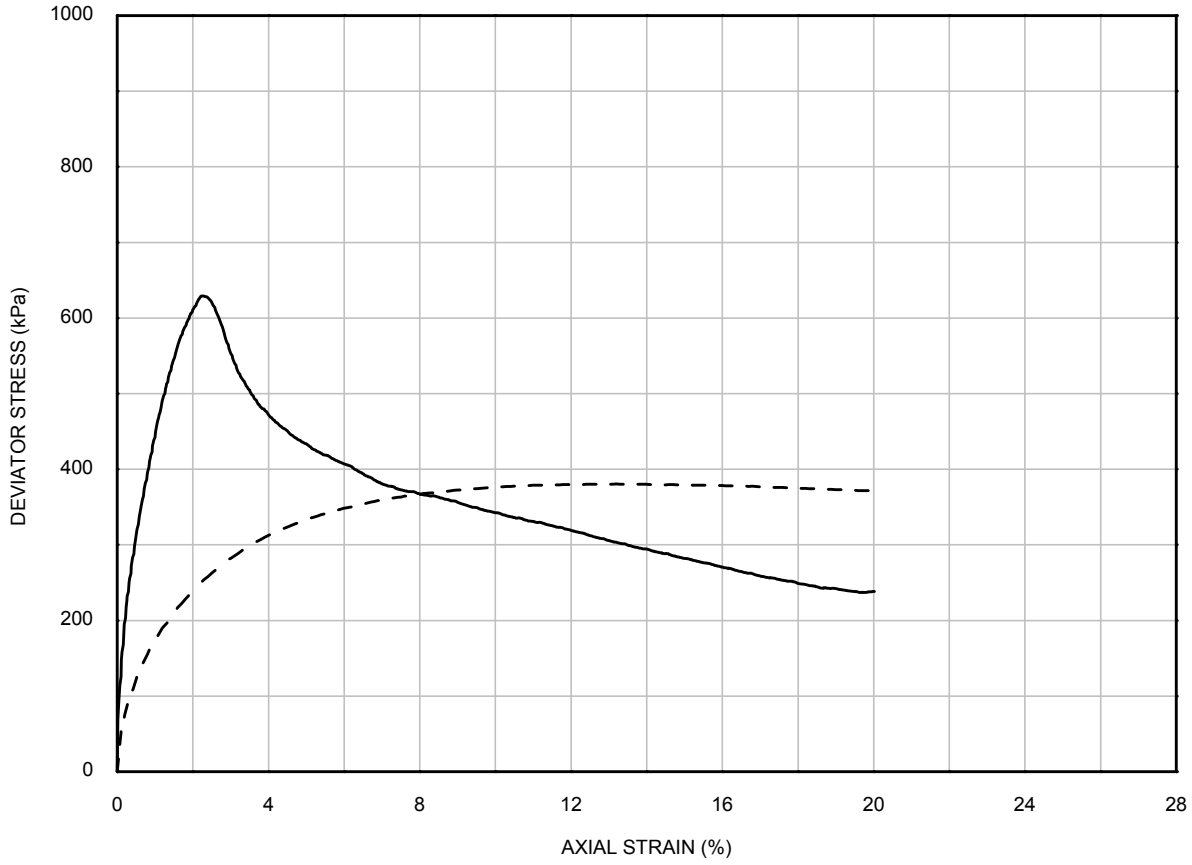
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 16/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_21WaxC_uu.OPJ Template Issue: 3:4

Checked by: ALB Date : 20/10/2015

Approved by: PH Date : 27/10/2015



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Undisturbed

Shear failure

Remoulded

Barrel failure

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	629	380
Strain at failure	(%)	2.3	13.2
Undrained shear strength	(kPa)	315	190

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	145.9	102.3
Sample diameter	(mm)	71.5	48.8
Membrane thickness	(mm)	0.25	0.42
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.83	1.84
Dry density	(Mg/m^3)	1.36	1.33
Moisture content	(%)	34.8	37.6

Borehole : BH-WFS4-1A

Sample : 22BagUU

Depth (m): 37.25

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 22/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_22BagUU_uu.OPJ

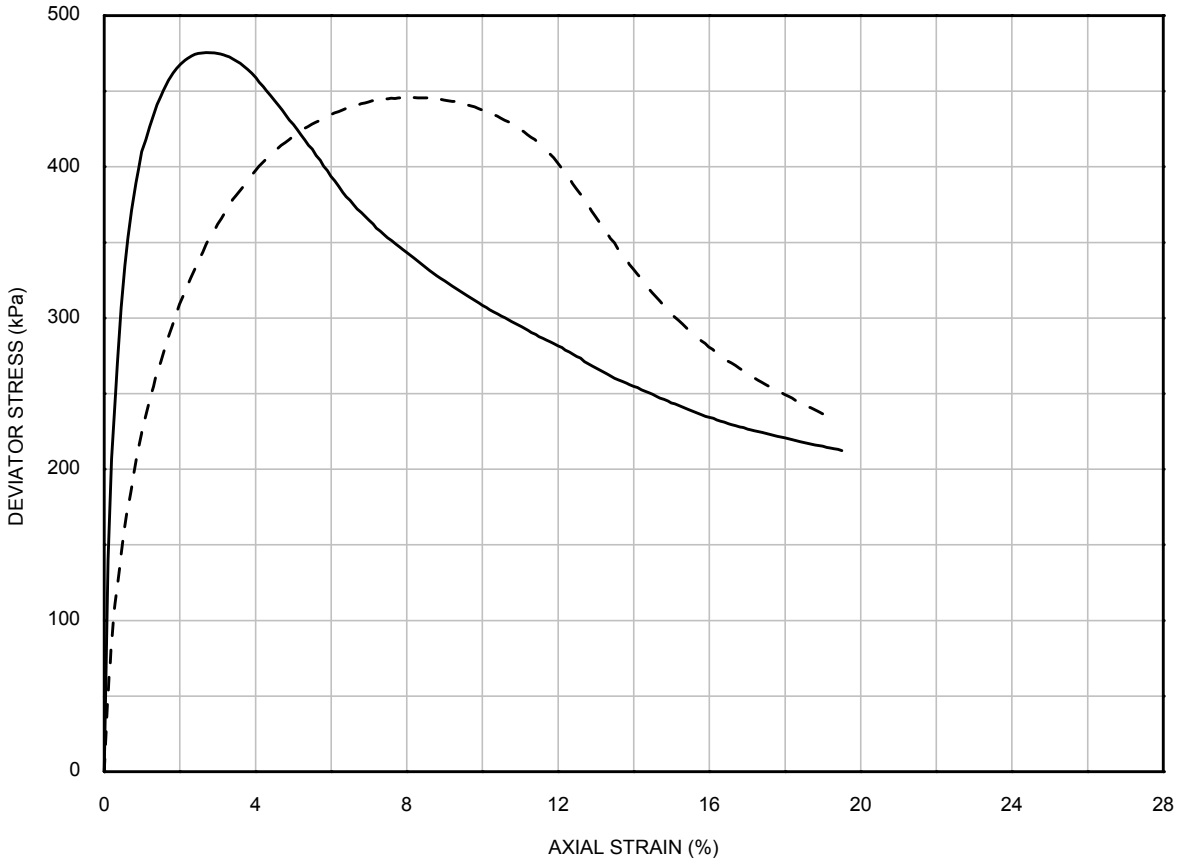
Template Issue: 3:4

Date : 29/10/2015

Checked by: PH

Date : 29/10/2015

Approved by: PH



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	475	446
Strain at failure	(%)	2.6	8.0
Undrained shear strength	(kPa)	238	223

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	138.6	102.7
Sample diameter	(mm)	71.0	48.9
Membrane thickness	(mm)	0.48	0.41
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.81	1.80
Dry density	(Mg/m^3)	1.26	1.27
Moisture content	(%)	43.5	42.1

Borehole : BH-WFS4-1A

Sample : 23WaxD

Depth (m) : 38.45

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 16/10/2015

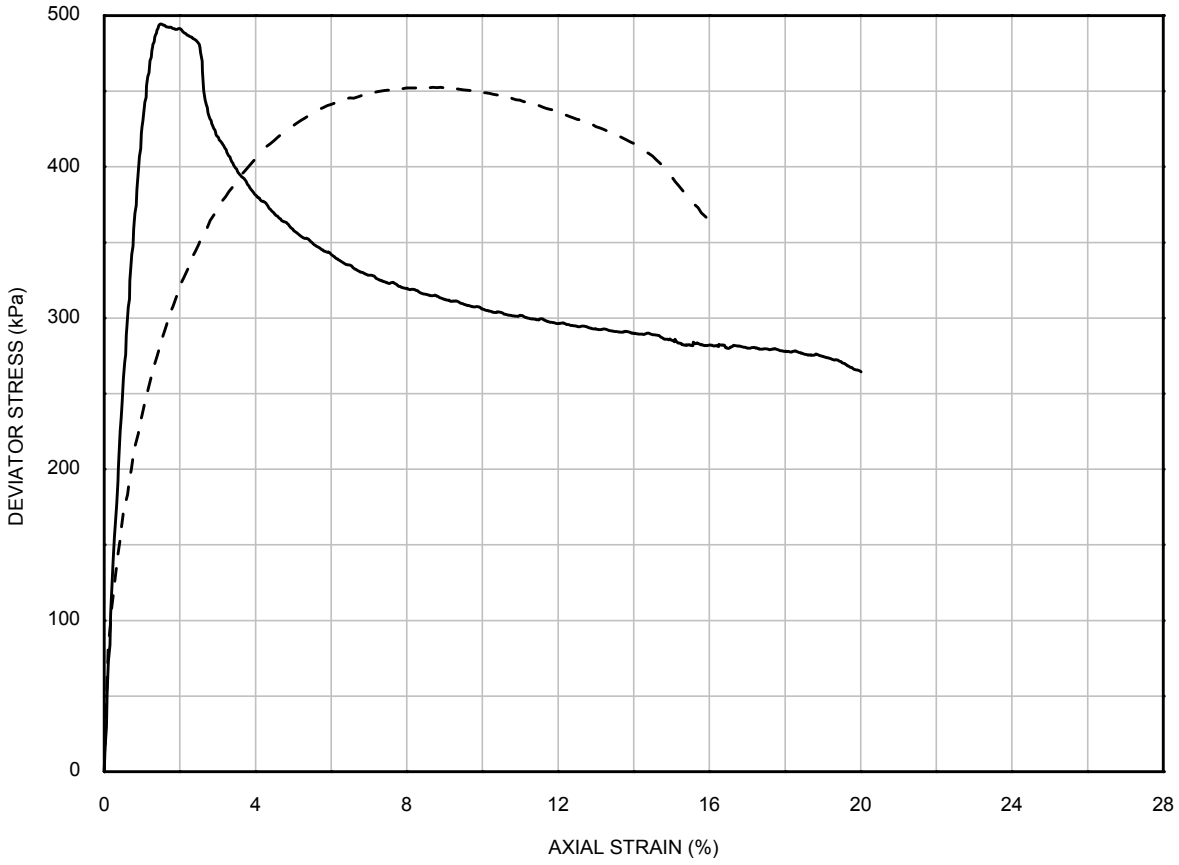
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_23WaxD_uu.OPJ

Template Issue: 3:4 Date : 20/10/2015

Checked by: ALB Date : 27/10/2015

Approved by: PH

Date: 22/10/2015
Drawn by: ER
Template Issue: 3:4
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_25BagUU_uu.OPJ
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	495	453
Strain at failure	(%)	1.5	8.5
Undrained shear strength	(kPa)	247	226

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	145.9	102.9
Sample diameter	(mm)	71.2	48.8
Membrane thickness	(mm)	0.25	0.38
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.84	1.83
Dry density	(Mg/m^3)	1.32	1.30
Moisture content	(%)	39.4	40.8

Borehole : BH-WFS4-1A

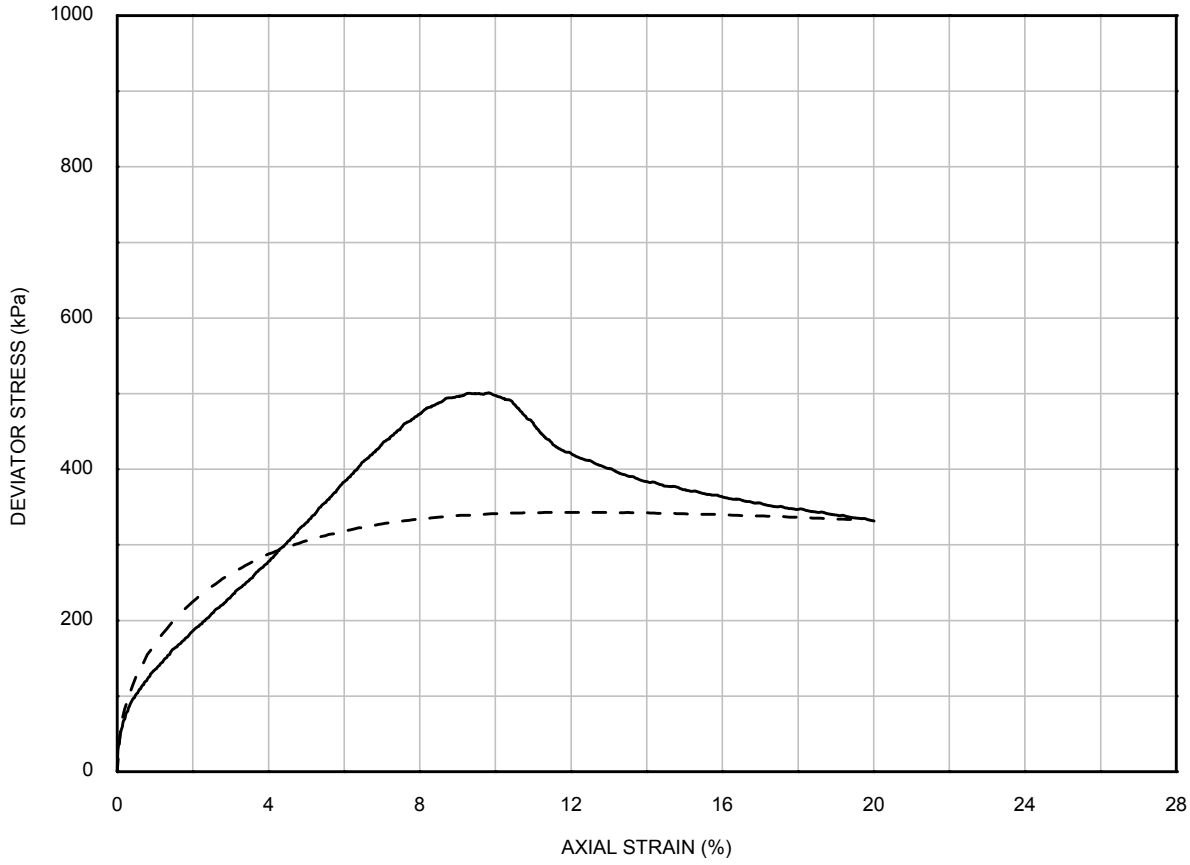
Sample : 25BagUU

Depth (m): 43.30

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Undisturbed

Shear failure

Remoulded

Compound failure

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	501	343
Strain at failure	(%)	9.8	11.8
Undrained shear strength	(kPa)	251	172

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.4	101.7
Sample diameter	(mm)	73.3	48.9
Membrane thickness	(mm)	0.25	0.38
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.86	1.88
Dry density	(Mg/m^3)	1.36	1.40
Moisture content	(%)	36.5	34.5

Borehole : BH-WFS4-1A

Sample : 26BagUU

Depth (m): 47.30

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 22/10/2015

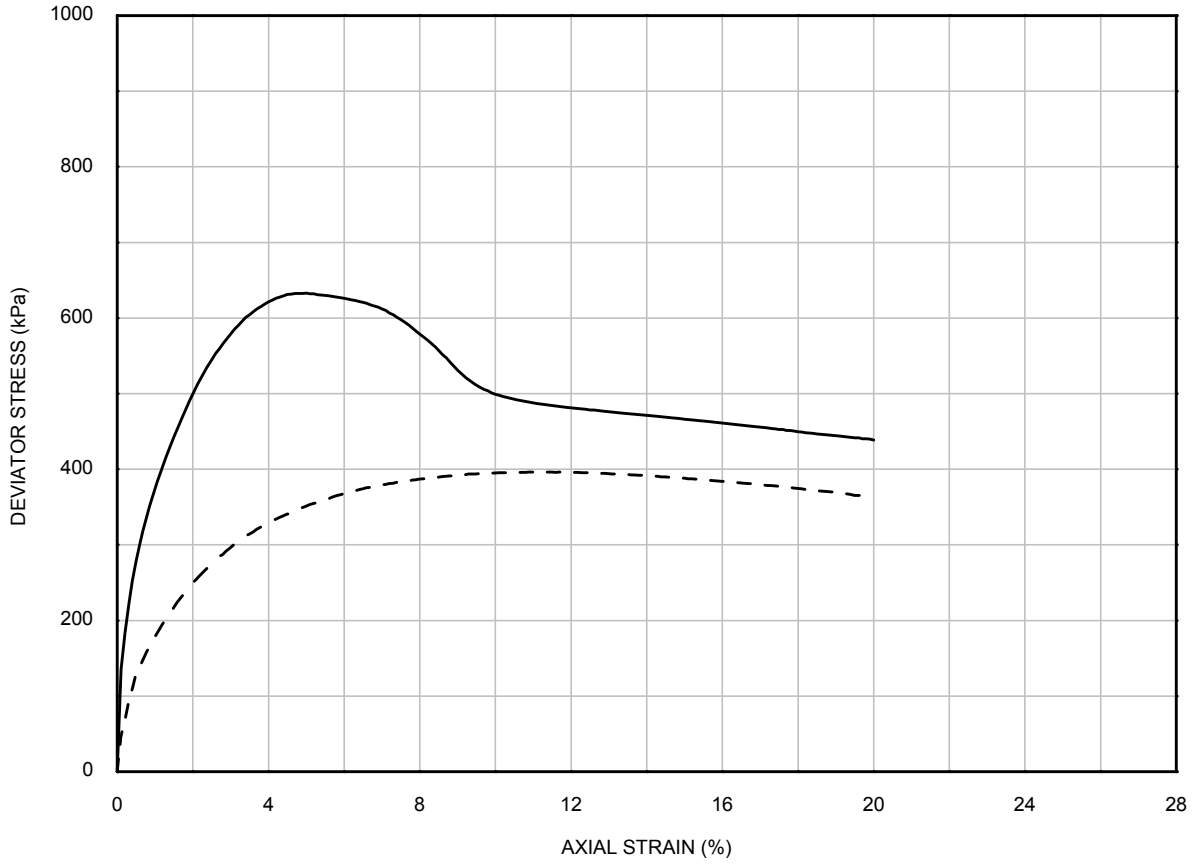
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_26BagUU_uu.OPJ

Template Issue: 3:4

Checked by: PH Date : 29/10/2015

Approved by: PH Date : 29/10/2015

Date: 16/10/2015
Drawn by: ALB
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-1A_26WaxC_uu.OPJ
Template Issue: 3:4
Date : 20/10/2015
Checked by: ALB
Date : 27/10/2015
Approved by: PH



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	633	396
Strain at failure	(%)	5.0	11.3
Undrained shear strength	(kPa)	316	198

Undisturbed

Shear failure

Remoulded

Compound failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	138.7	104.3
Sample diameter	(mm)	71.3	48.7
Membrane thickness	(mm)	0.48	0.40
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.95	1.92
Dry density	(Mg/m^3)	1.46	1.45
Moisture content	(%)	33.7	32.7

Borehole : BH-WFS4-1A

Sample : 26WaxC

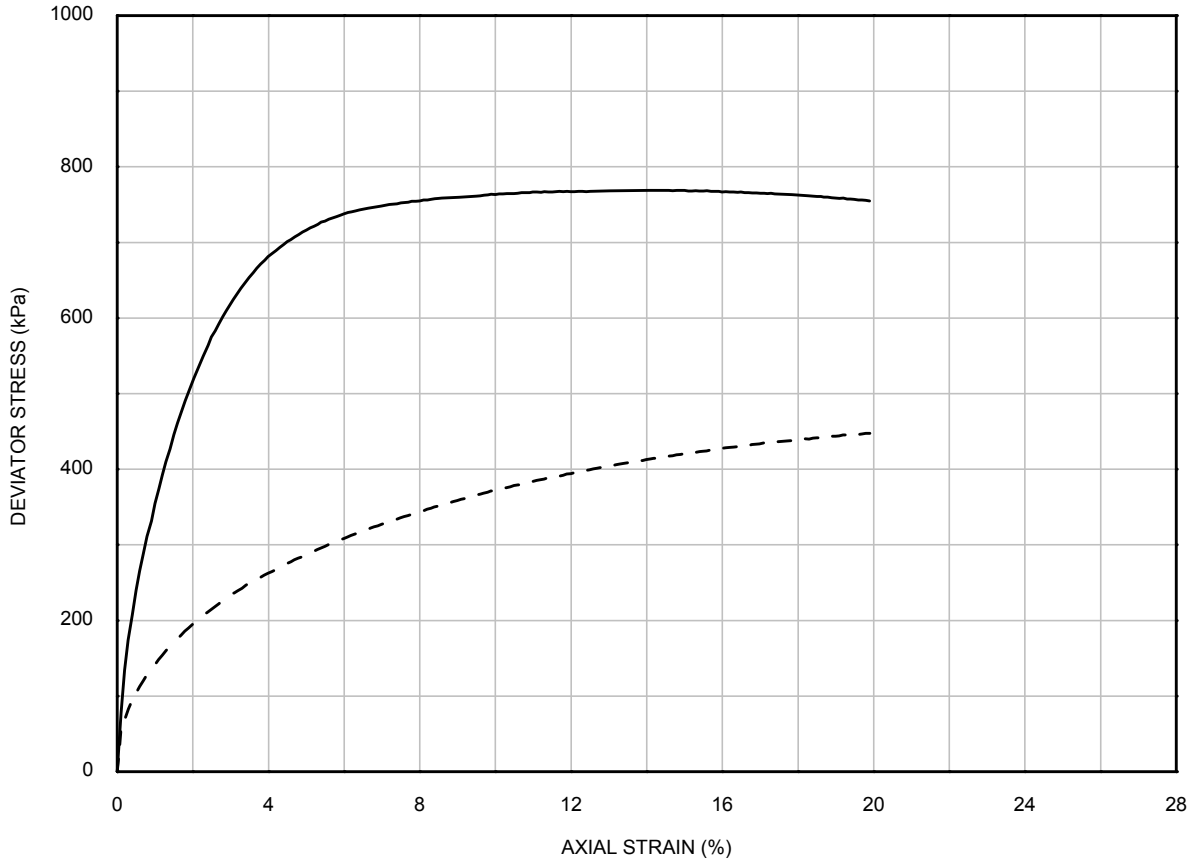
Depth (m): 47.50

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 15/10/2015
Drawn by: ER
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-2A_15WaxC_uu.OPJ
Template Issue: 3:4
Date : 20/10/2015
Checked by: ALB
Date : 27/10/2015
Approved by: PH



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	2	3
Corrected deviator stress	(kPa)	769	448
Strain at failure	(%)	14.0	19.8
Undrained shear strength	(kPa)	385	224

Failure Shapes:

Undisturbed

Compound failure

Remoulded

Barrel failure

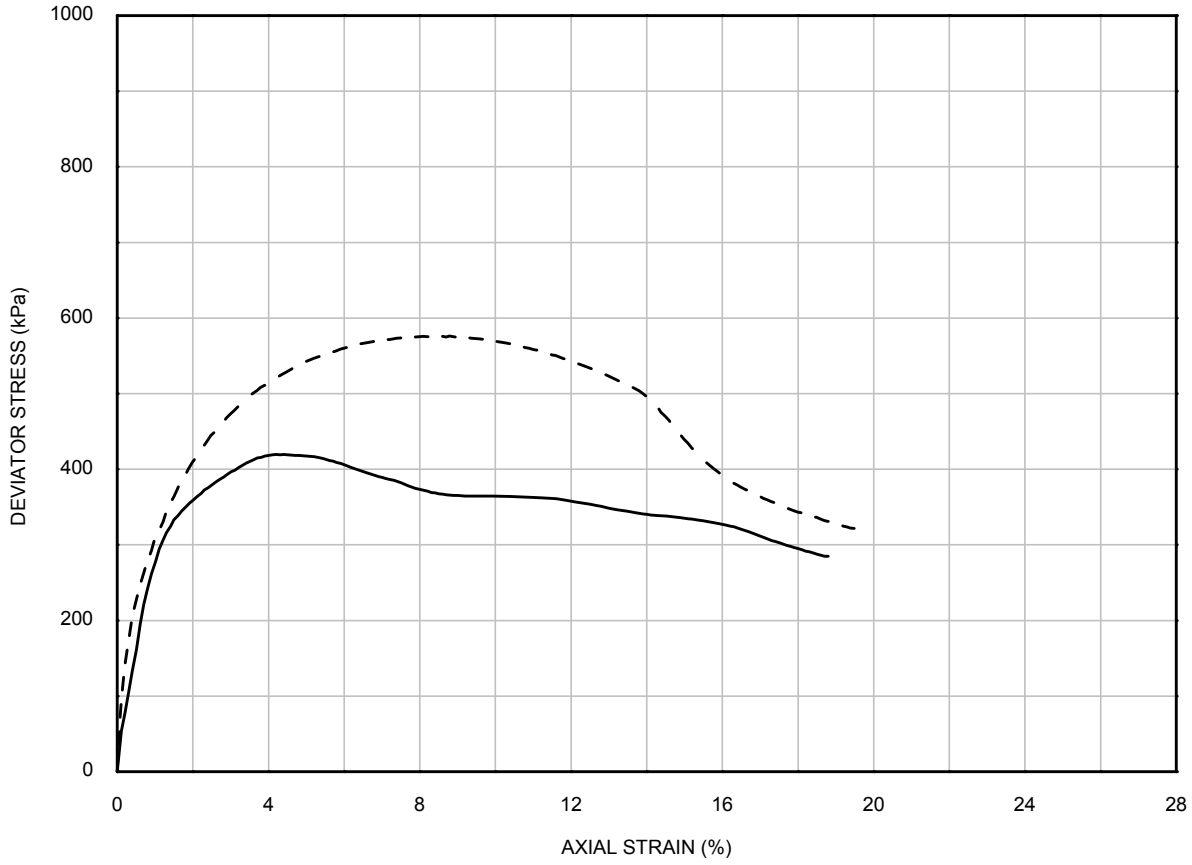
Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	138.6	101.5
Sample diameter	(mm)	72.0	48.8
Membrane thickness	(mm)	0.48	0.44
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	2.02	2.04
Dry density	(Mg/m^3)	1.63	1.66
Moisture content	(%)	23.4	22.8

Borehole : BH-WFS4-2A
Sample : 15WaxC
Depth (m): 30.60

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	419	576
Strain at failure	(%)	4.2	8.8
Undrained shear strength	(kPa)	210	288

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	138.9	101.1
Sample diameter	(mm)	72.9	48.9
Membrane thickness	(mm)	0.49	0.40
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.83	1.85
Dry density	(Mg/m^3)	1.32	1.35
Moisture content	(%)	38.1	37.4

Borehole : BH-WFS4-2A

Sample : 21WaxB

Depth (m): 51.60

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

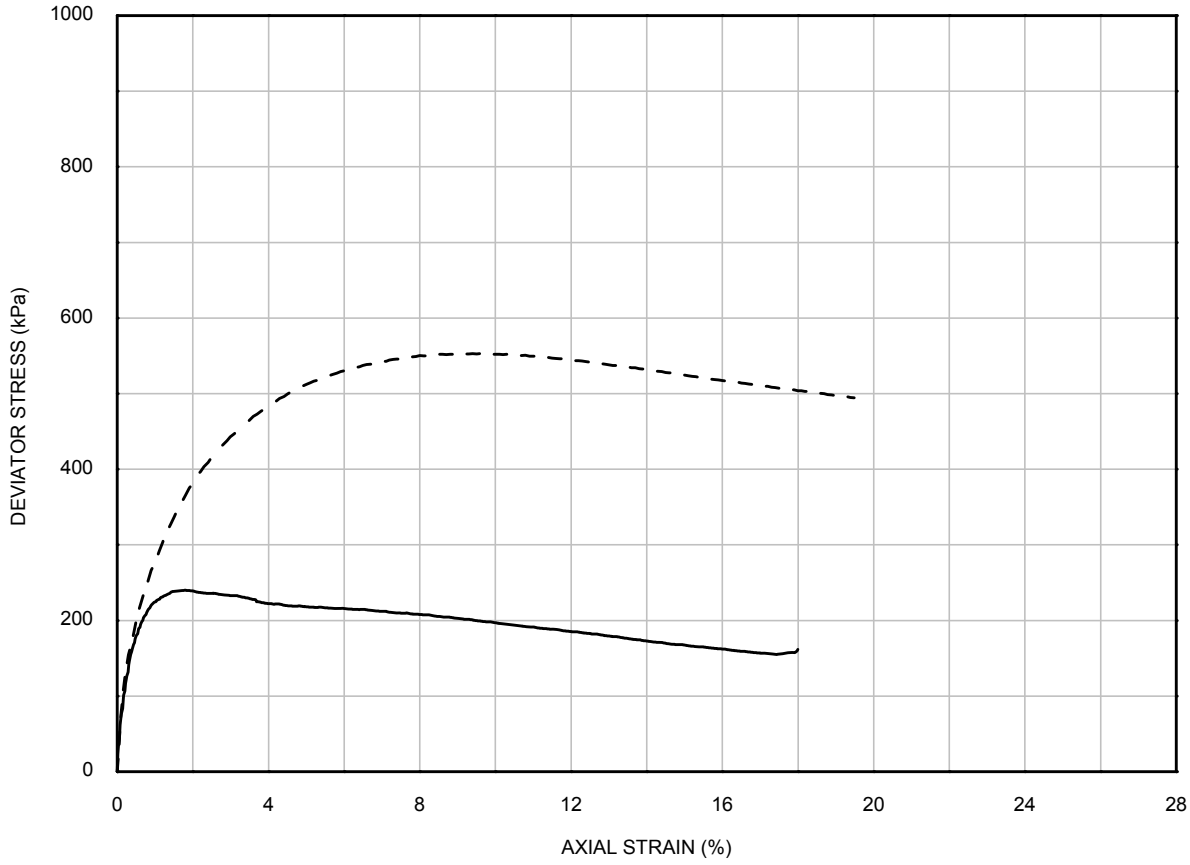
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 16/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-2A_21WaxB_uu.OPJ Template Issue: 3:4

Checked by: ALB Date : 20/10/2015

Approved by: PH Date : 27/10/2015



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Undisturbed

Barrel failure

Remoulded

Shear failure

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	240	553
Strain at failure	(%)	1.8	9.6
Undrained shear strength	(kPa)	120	276

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.2	101.6
Sample diameter	(mm)	72.4	48.9
Membrane thickness	(mm)	0.25	0.40
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.86	1.86
Dry density	(Mg/m^3)	1.35	1.35
Moisture content	(%)	37.5	38.3

Borehole : BH-WFS4-3

Sample : 28BagUU

Depth (m) : 44.70

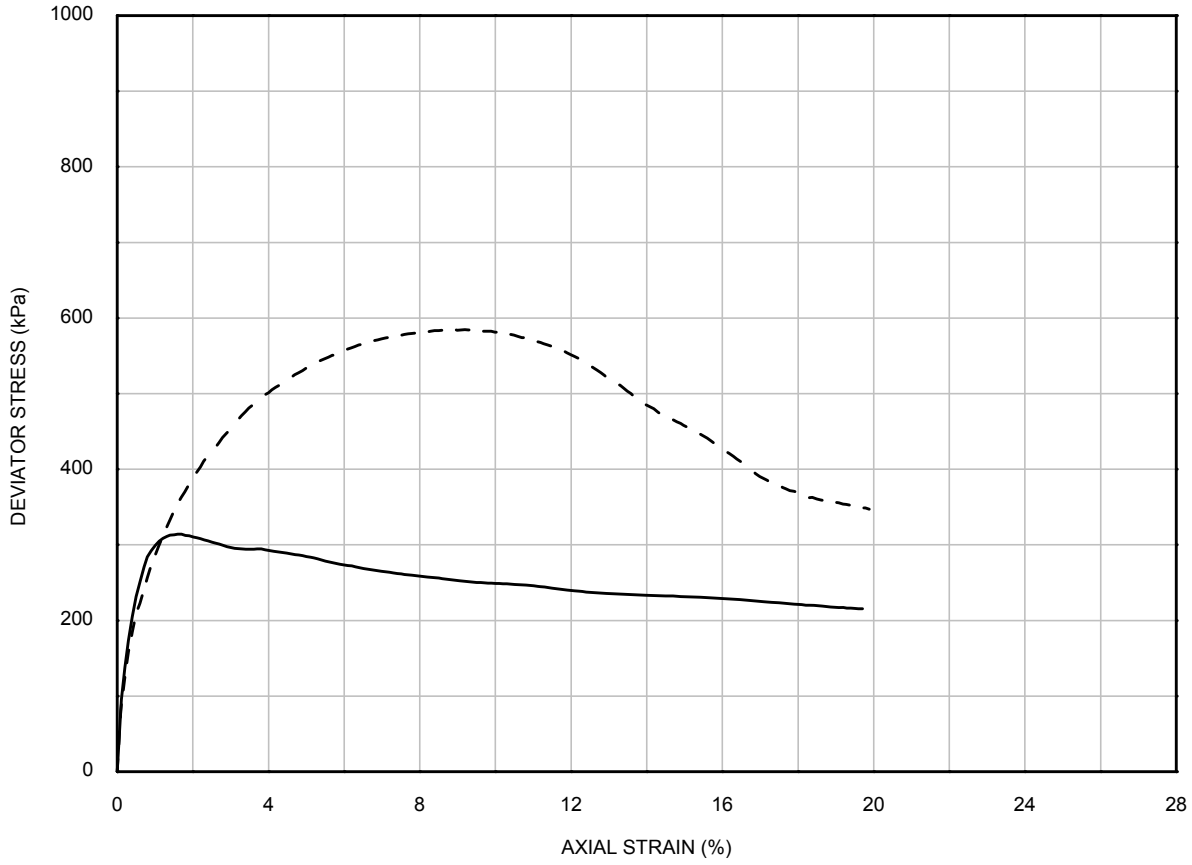
Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ER
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-3_28BagUU_uu.OPJ
Template Issue: 3:4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH

Drawn by: ALB Date: 16/10/2015
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-3_28WaxC_uu.OPJ
Template Issue: 3:4
Date : 20/10/2015
Checked by: ALB
Date : 27/10/2015
Approved by: PH



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	314	585
Strain at failure	(%)	1.6	8.8
Undrained shear strength	(kPa)	157	292

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	139.3	103.3
Sample diameter	(mm)	71.8	48.9
Membrane thickness	(mm)	0.43	0.38
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.90	1.88
Dry density	(Mg/m^3)	1.38	1.38
Moisture content	(%)	37.2	35.9

Borehole : BH-WFS4-3

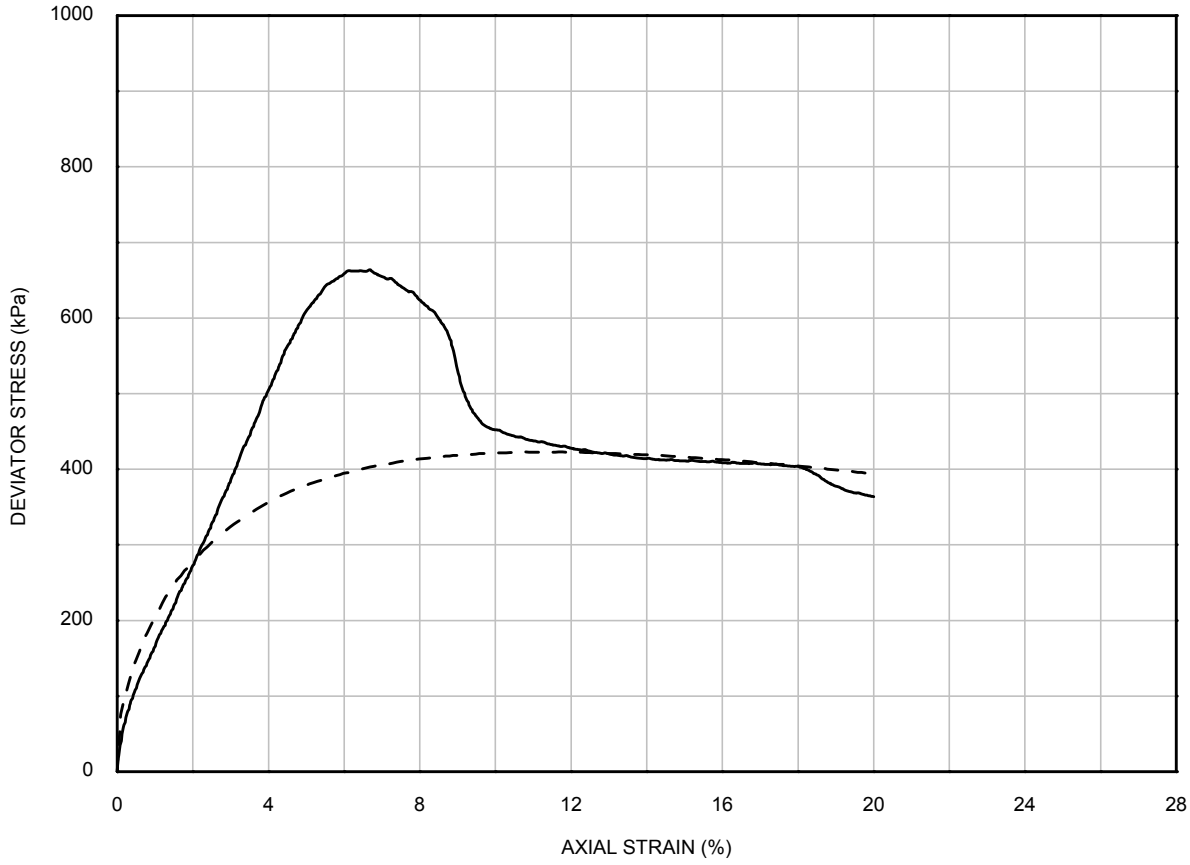
Sample : 28WaxC

Depth (m) : 44.90

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Undisturbed

Shear failure

Remoulded

Compound failure

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	1
Corrected deviator stress	(kPa)	664	423
Strain at failure	(%)	6.7	11.3
Undrained shear strength	(kPa)	332	211

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	102.0
Sample diameter	(mm)	73.0	48.8
Membrane thickness	(mm)	0.25	0.28
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.79	1.80
Dry density	(Mg/m^3)	1.29	1.28
Moisture content	(%)	39.4	41.0

Borehole : BH-WFS4-3

Sample : 30BagUU

Depth (m) : 49.75

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

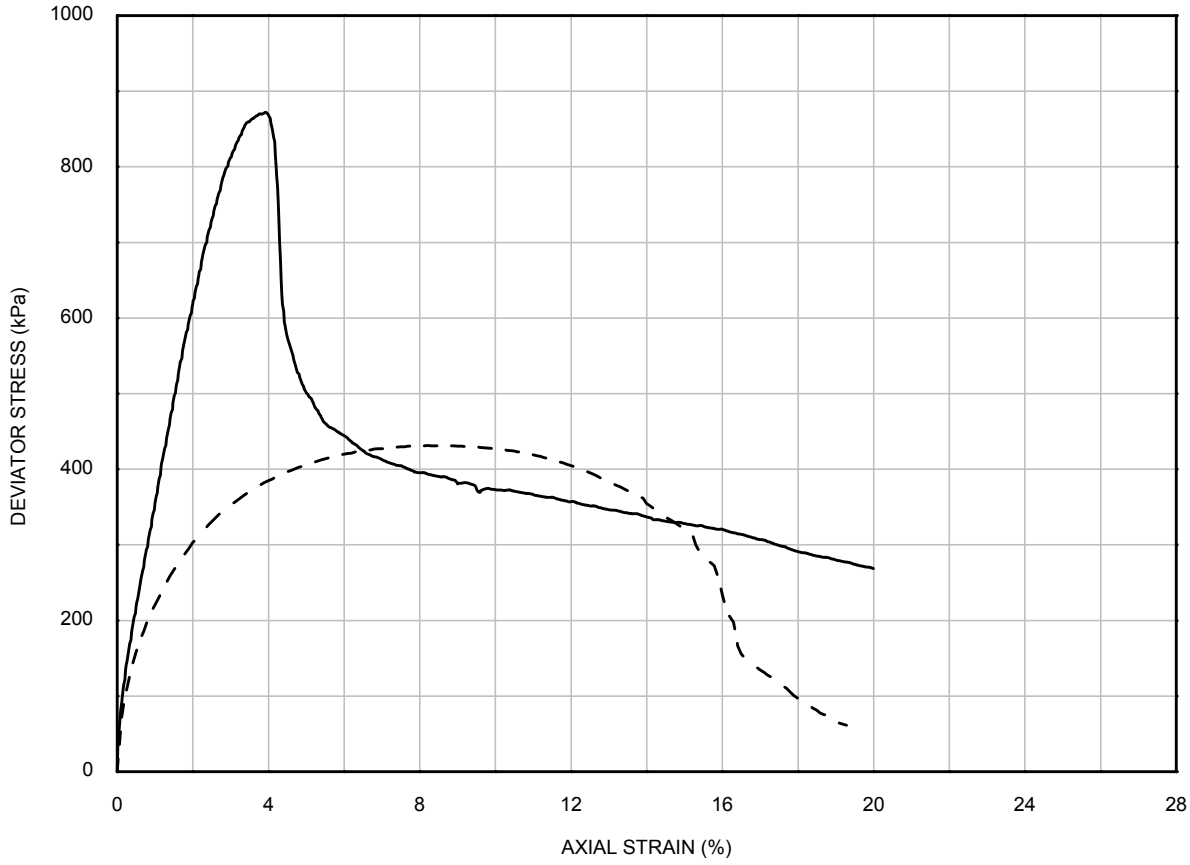
Drawn by: ER Date: 22/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-3_30BagUU_uu.OPJ

Template Issue: 3:4

Date : 29/10/2015 Checked by: PH

Date : 29/10/2015 Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	872	431
Strain at failure	(%)	3.9	8.6
Undrained shear strength	(kPa)	436	216

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.0	101.9
Sample diameter	(mm)	71.8	48.8
Membrane thickness	(mm)	0.25	0.39
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.78	1.78
Dry density	(Mg/m^3)	1.25	1.24
Moisture content	(%)	42.8	43.5

Borehole : BH-WFS4-3

Sample : 32BagUU

Depth (m) : 54.80

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 22/10/2015

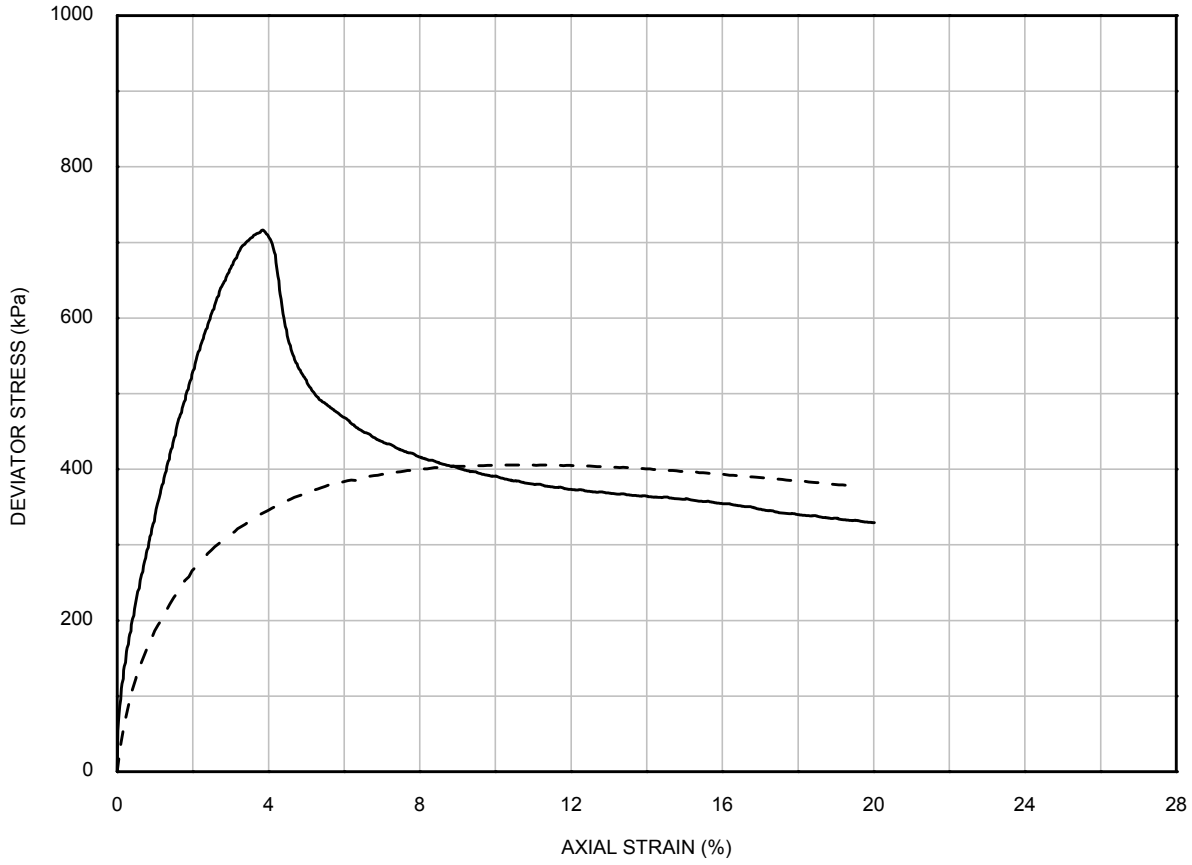
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Template Issue: 3:4

Date : 29/10/2015 Checked by: PH

Date : 29/10/2015 Approved by: PH

Date: 22/10/2015
Drawn by: ER
Template Issue: 3:4
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-3_33BagUU_uu.OPJ
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Undisturbed

Shear failure

Remoulded

Compound failure

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	716	406
Strain at failure	(%)	3.8	10.7
Undrained shear strength	(kPa)	358	203

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.2	102.1
Sample diameter	(mm)	72.4	48.8
Membrane thickness	(mm)	0.25	0.42
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.78	1.79
Dry density	(Mg/m^3)	1.26	1.26
Moisture content	(%)	40.9	41.9

Borehole : BH-WFS4-3

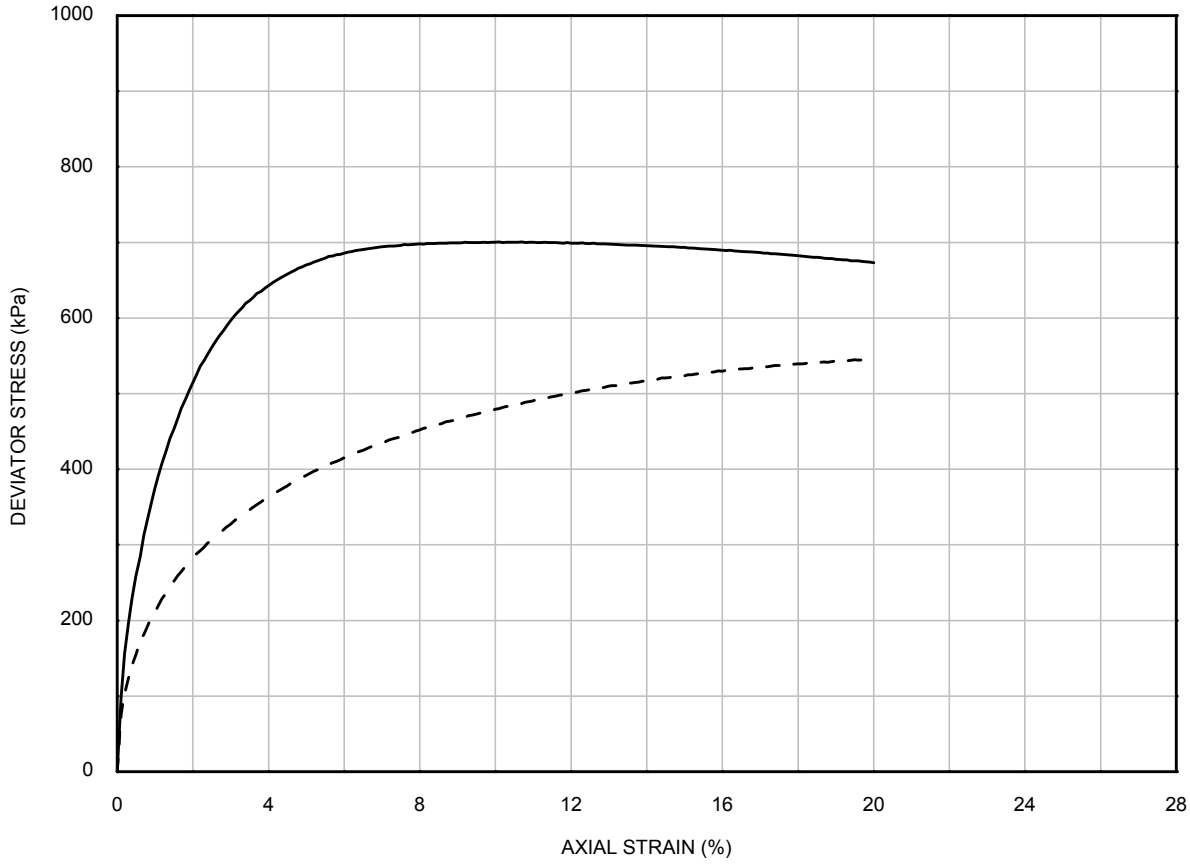
Sample : 33BagUU

Depth (m) : 56.05

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



Undisturbed : Sample tested ONSHORE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	2	2
Corrected deviator stress	(kPa)	700	546
Strain at failure	(%)	10.7	20.0
Undrained shear strength	(kPa)	350	273

Undisturbed

Compound failure

Remoulded

Barrel failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	139.3	99.4
Sample diameter	(mm)	71.8	48.6
Membrane thickness	(mm)	0.46	0.30
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	2.05	2.09
Dry density	(Mg/m^3)	1.67	1.70
Moisture content	(%)	22.9	22.8

Borehole : BH-WFS4-4

Sample : 34WaxD

Depth (m): 38.85

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

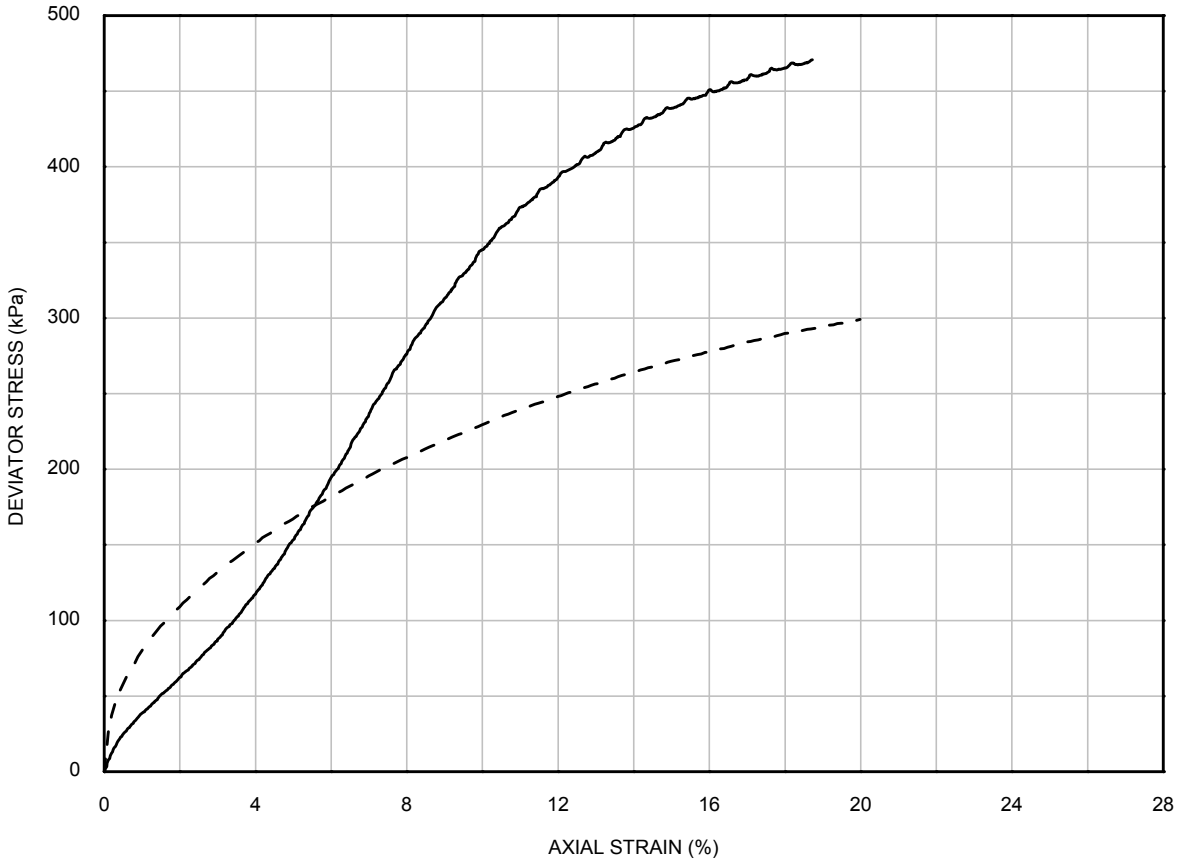
Drawn by: ER Date: 13/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-4_34WaxD_uu.OPJ

Template Issue: 3:4 Date : 14/10/2015

Checked by: ALB Date : 27/10/2015

Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	3
Corrected deviator stress	(kPa)	471	299
Strain at failure	(%)	18.7	20.0
Undrained shear strength	(kPa)	235	150

Undisturbed

Barrel failure

Remoulded

Barrel failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	147.3	101.6
Sample diameter	(mm)	72.0	48.9
Membrane thickness	(mm)	0.25	0.38
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	2.02	2.02
Dry density	(Mg/m^3)	1.63	1.62
Moisture content	(%)	24.2	25.2

Borehole : BH-WFS4-4

Sample : 35BagUU

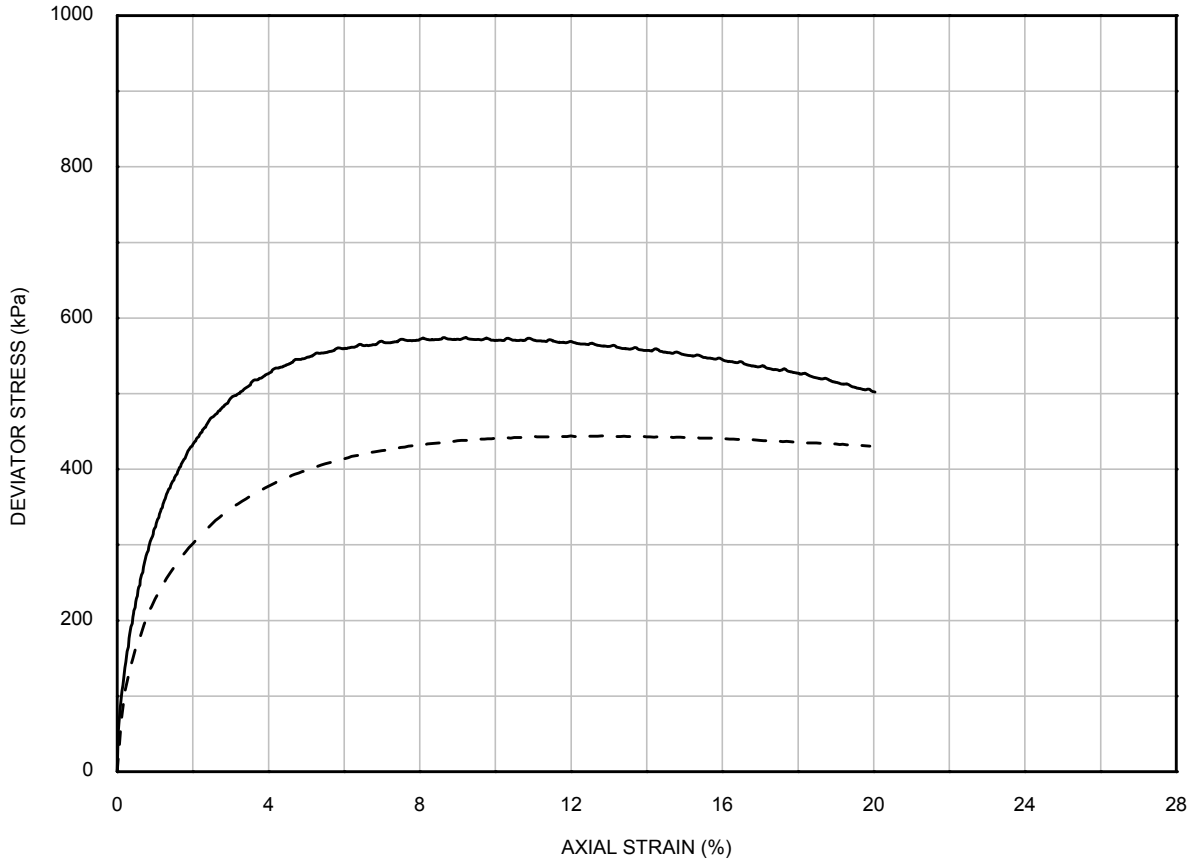
Depth (m) : 39.55

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ER
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-4_35BagUU_uu.OPJ
Template Issue: 3:4
Date : 27/10/2015
Checked by: PH
Date : 27/10/2015
Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	574	444
Strain at failure	(%)	9.2	12.8
Undrained shear strength	(kPa)	287	222

Undisturbed

Barrel failure

Remoulded

Barrel failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	145.7	100.9
Sample diameter	(mm)	72.0	48.9
Membrane thickness	(mm)	0.25	0.40
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	2.06	2.08
Dry density	(Mg/m^3)	1.70	1.71
Moisture content	(%)	21.5	21.3

Borehole : BH-WFS4-4

Sample : 37BagUU

Depth (m) : 45.00

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 22/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-4_37BagUU_uu.OPJ

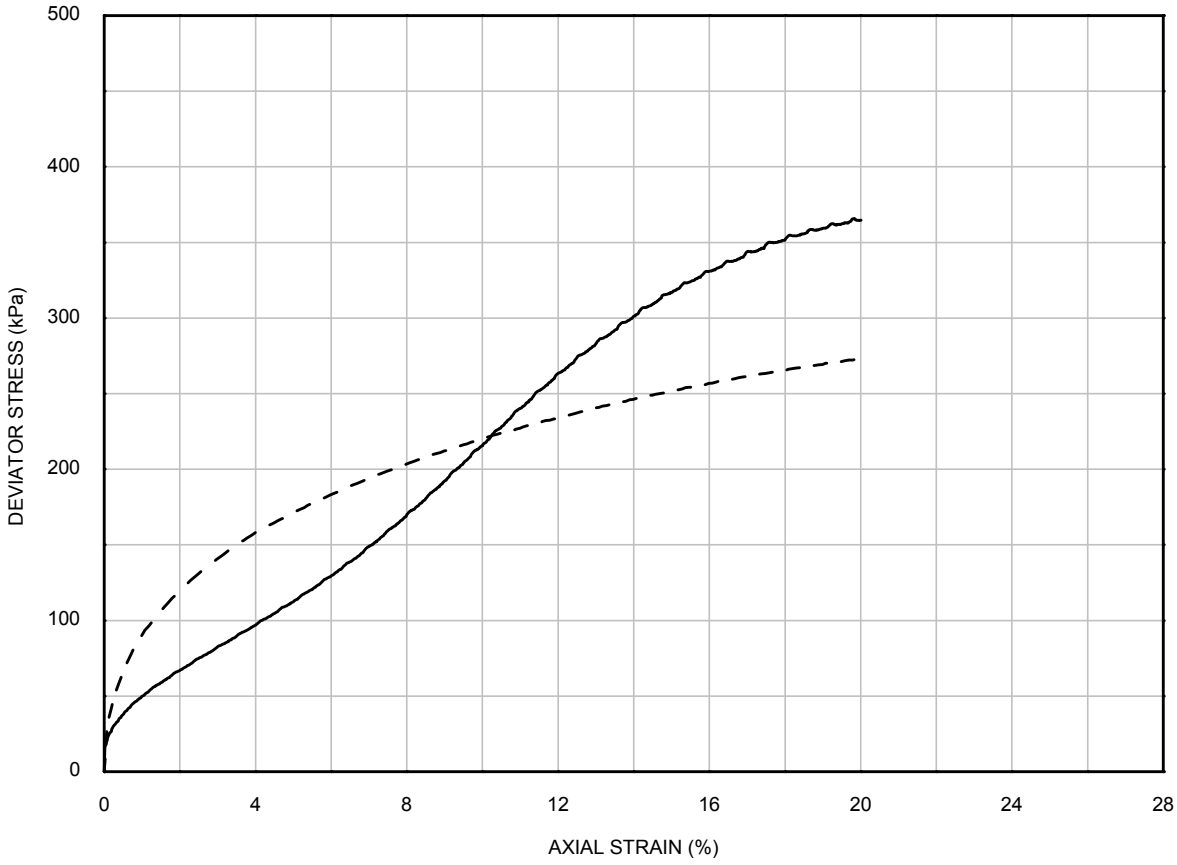
Template Issue: 3:4

Date : 27/10/2015

Checked by: PH

Date : 27/10/2015

Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	3
Corrected deviator stress	(kPa)	366	273
Strain at failure	(%)	19.8	19.9
Undrained shear strength	(kPa)	183	136

Undisturbed

Barrel failure

Remoulded

Barrel failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.1	100.9
Sample diameter	(mm)	72.3	49.0
Membrane thickness	(mm)	0.25	0.42
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	2.00	2.01
Dry density	(Mg/m^3)	1.63	1.63
Moisture content	(%)	23.0	23.2

Borehole : BH-WFS4-5

Sample : 34BagUU

Depth (m) : 38.10

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 22/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-5_34BagUU_uu.OPJ

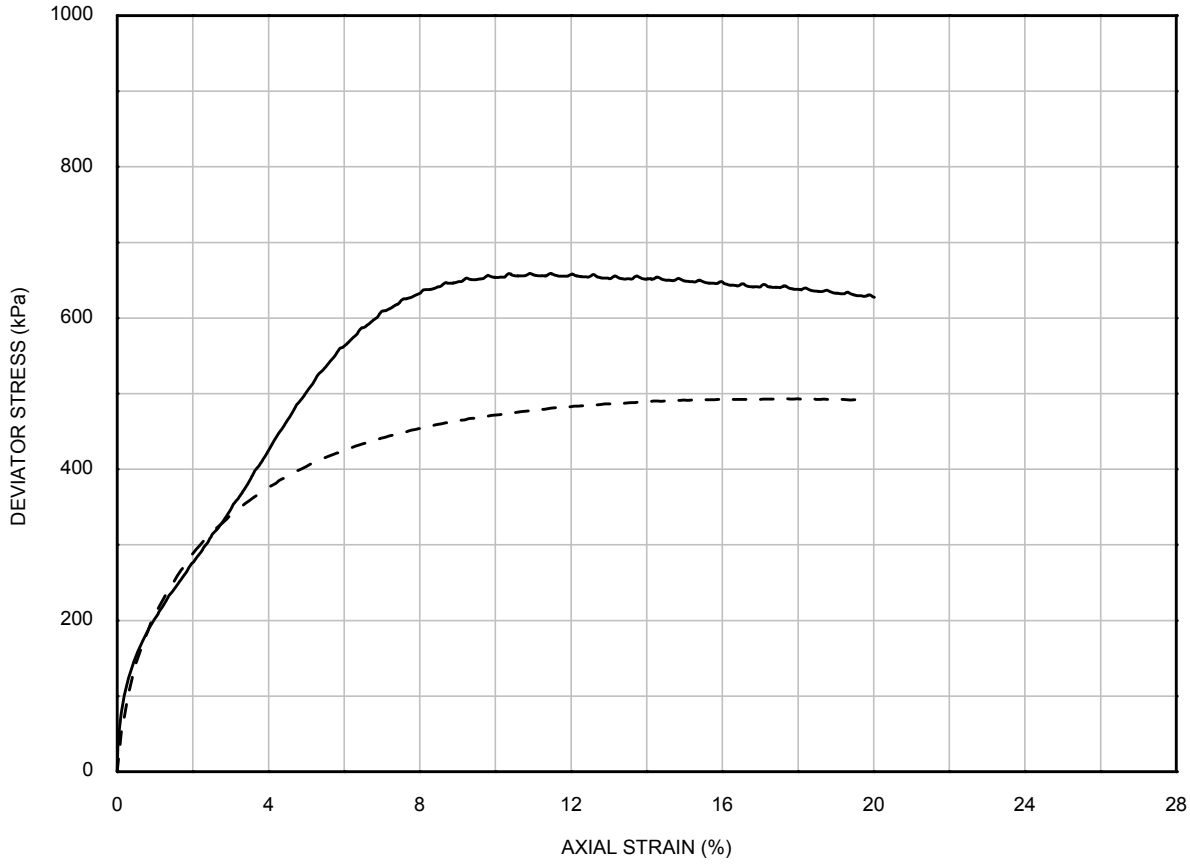
Template Issue: 3:4

Date : 29/10/2015

Checked by: PH

Date : 29/10/2015

Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	1
Corrected deviator stress	(kPa)	659	493
Strain at failure	(%)	10.9	17.7
Undrained shear strength	(kPa)	330	247

Undisturbed

Barrel failure

Remoulded

Barrel failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	145.7	101.7
Sample diameter	(mm)	72.1	48.9
Membrane thickness	(mm)	0.25	0.20
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	2.04	2.04
Dry density	(Mg/m^3)	1.66	1.67
Moisture content	(%)	23.0	22.4

Borehole : BH-WFS4-5

Sample : 36BagUU

Depth (m) : 43.25

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 22/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-5_36BagUU_uu.OPJ

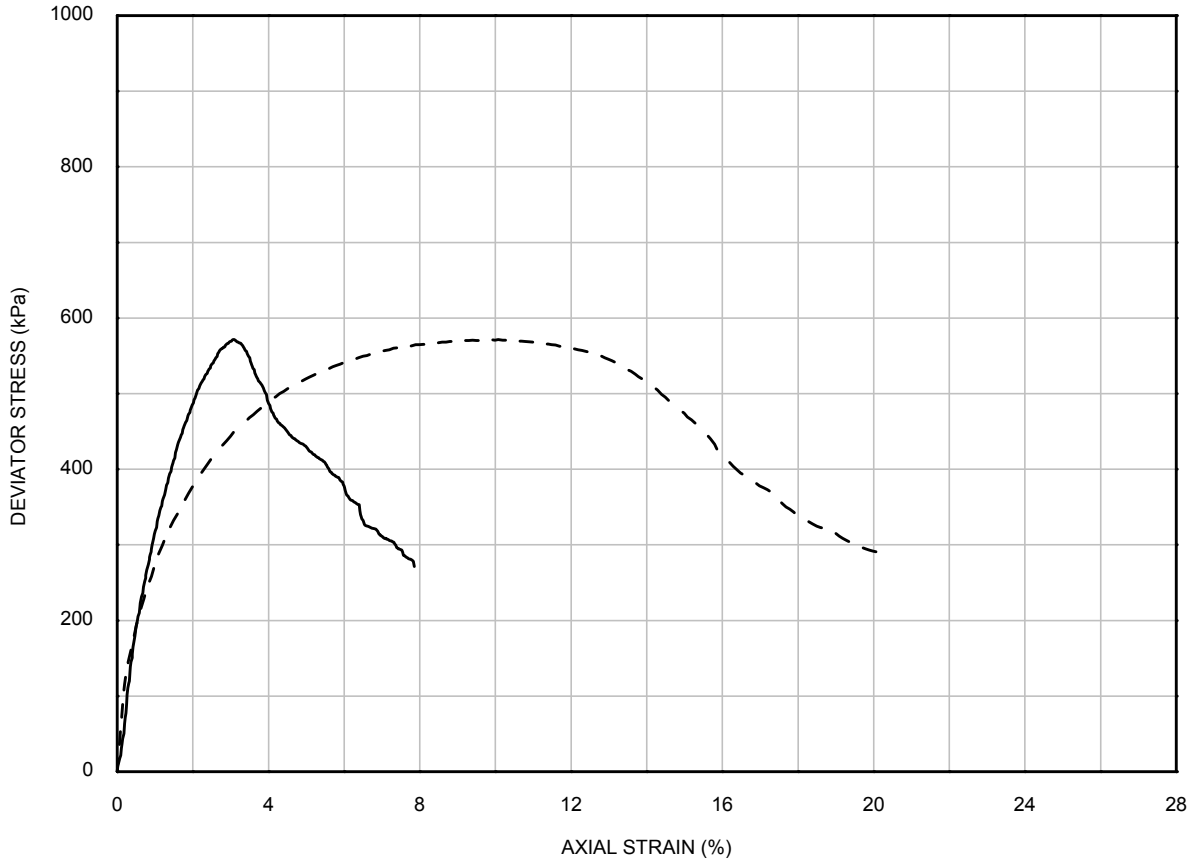
Template Issue: 3:4

Date : 29/10/2015

Checked by: PH

Date : 29/10/2015

Approved by: PH



Undisturbed : Sample tested ON-SITE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	572	571
Strain at failure	(%)	3.1	10.1
Undrained shear strength	(kPa)	286	286

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.0	101.9
Sample diameter	(mm)	71.5	48.9
Membrane thickness	(mm)	0.25	0.40
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.93	1.92
Dry density	(Mg/m^3)	1.47	1.46
Moisture content	(%)	31.5	32.1

Borehole : BH-WFS4-5

Sample : 39BagUU

Depth (m) : 49.30

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 22/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-5_39BagUU_uu.OPJ

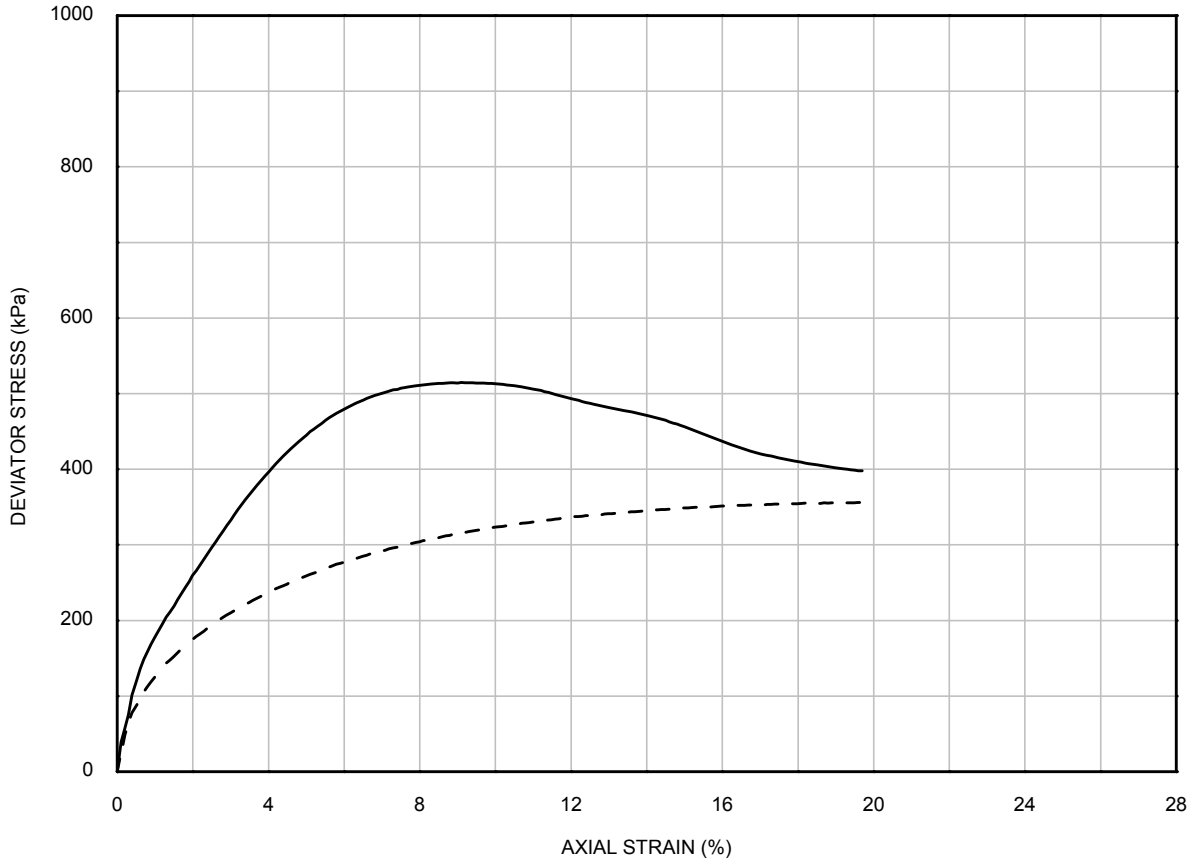
Template Issue: 3:4

Date : 29/10/2015

Checked by: PH

Date : 29/10/2015

Approved by: PH



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	515	356
Strain at failure	(%)	9.1	19.6
Undrained shear strength	(kPa)	257	178

Undisturbed

Shear failure

Remoulded

Compound failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	139.1	102.0
Sample diameter	(mm)	71.2	48.9
Membrane thickness	(mm)	0.48	0.30
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	2.12	2.10
Dry density	(Mg/m^3)	1.74	1.74
Moisture content	(%)	22.0	21.0

Borehole : BH-WFS4-7

Sample : 12WaxD

Depth (m): 9.85

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

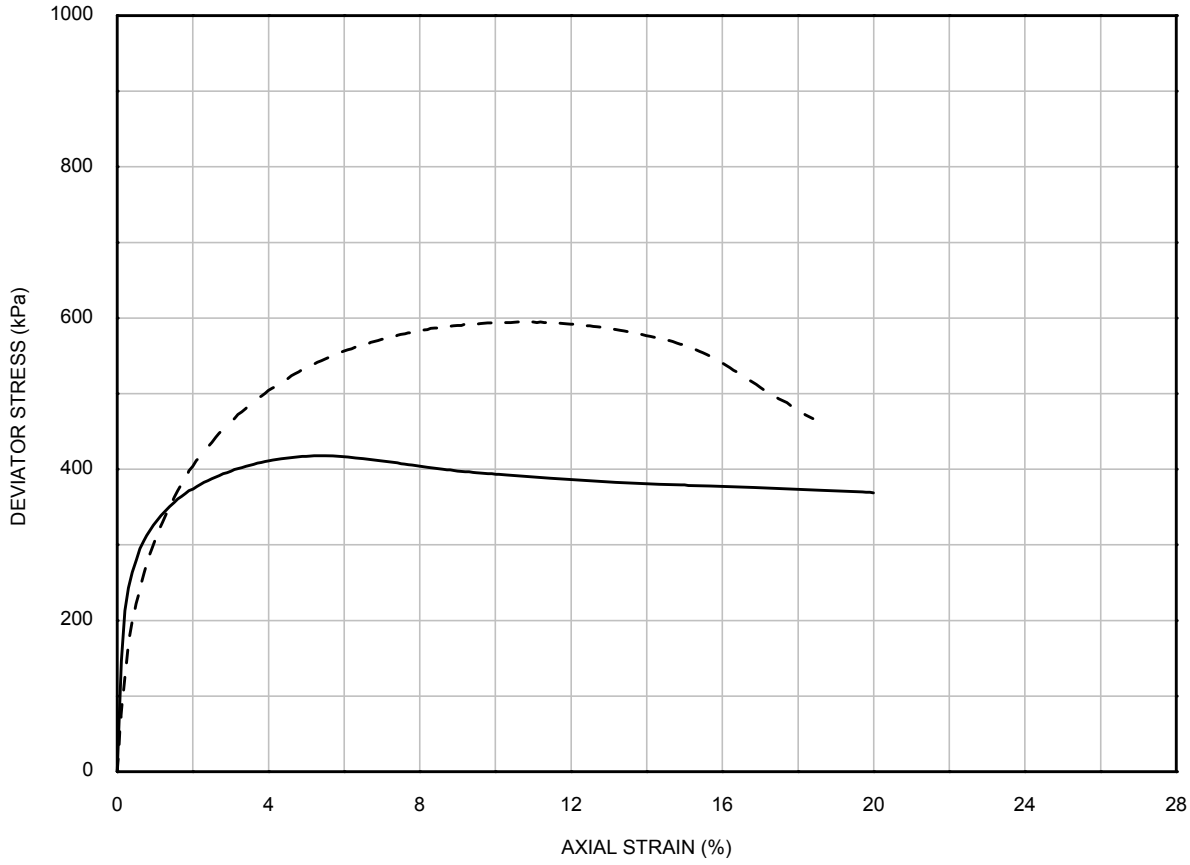
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 16/10/2015

Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-7_12WaxD_uu.OPJ Template Issue: 3:4

Checked by: ER Date : 20/10/2015

Approved by: PH Date : 27/10/2015



Undisturbed : Sample tested IN-OFFICE
Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	418	595
Strain at failure	(%)	5.5	11.2
Undrained shear strength	(kPa)	209	297

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	138.8	103.1
Sample diameter	(mm)	71.5	48.9
Membrane thickness	(mm)	0.48	0.40
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.99	1.96
Dry density	(Mg/m^3)	1.54	1.43
Moisture content	(%)	28.9	37.0

Borehole : BH-WFS4-7
Sample : 18WaxD
Depth (m) : 14.80

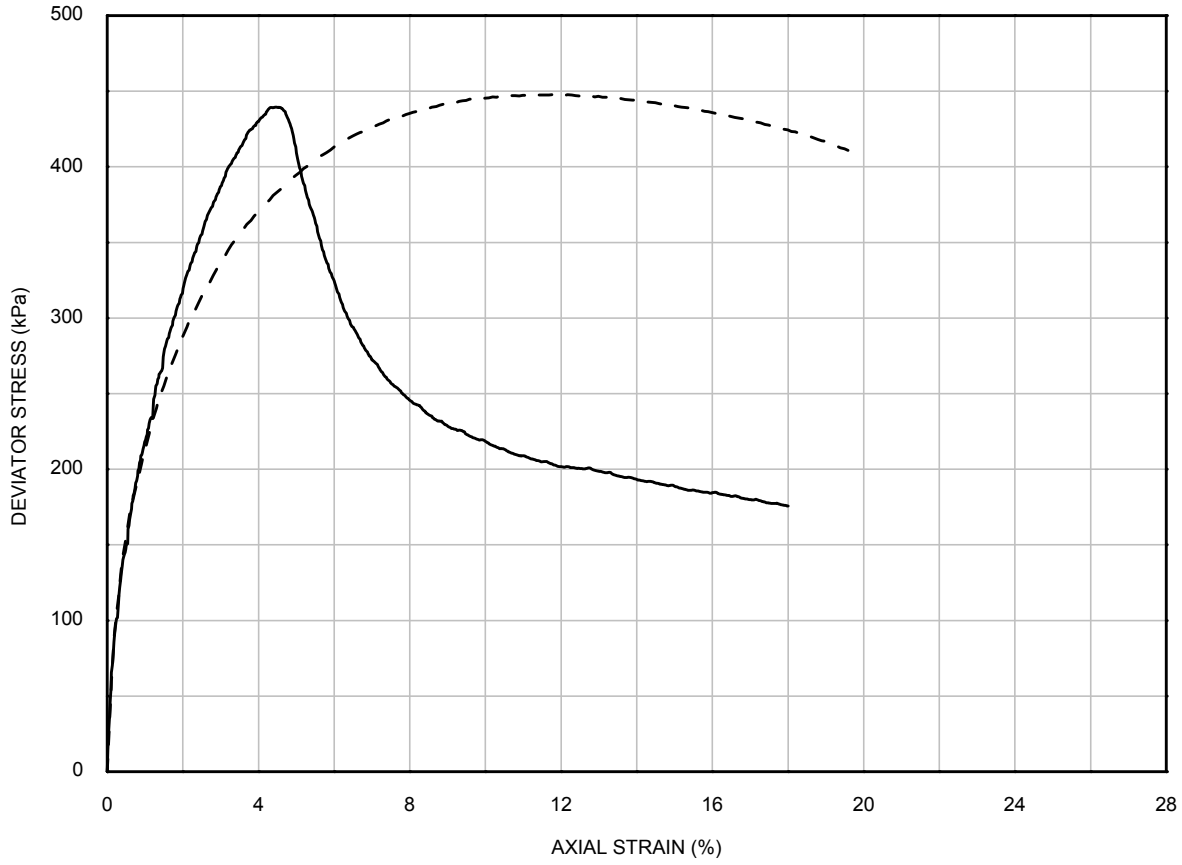
Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 16/10/2015
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-7_18WaxD_uu.OPJ
Template Issue: 3:4
Checked by: ER Date : 20/10/2015
Approved by: PH Date : 27/10/2015

Date: 22/10/2015
Drawn by: ER
Template Issue: 3:4
Filename: J11302 \ Labdata \ Triaxial \ BH-WFS4-7_22BagUU_uu.OPJ
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH



—— Undisturbed : Sample tested ON-SITE
– – – Remoulded : Sample tested IN-OFFICE

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1000	1000
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	440	448
Strain at failure	(%)	4.5	11.3
Undrained shear strength	(kPa)	220	224

Undisturbed

Shear failure

Remoulded

Shear failure

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.5	101.1
Sample diameter	(mm)	71.7	48.8
Membrane thickness	(mm)	0.25	0.38
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m^3)	1.88	1.89
Dry density	(Mg/m^3)	1.41	1.40
Moisture content	(%)	33.3	35.4

Borehole : BH-WFS4-7

Sample : 22BagUU

Depth (m) : 23.30

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (On-site tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 11/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-1A_21WaxB_CU.XLS
Template Issue: 2
Date: 16/11/2015
Checked by: PH
Date: 16/11/2015
Approved by: PH

VISUAL DESCRIPTION
High strength dark greenish grey CLAY.

GENERAL	
Date test started	26/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	72.3
Length	(mm)	139.6
Moisture content	(%)	36.6
Bulk density	(Mg/m^3)	1.87
Dry density	(Mg/m^3)	1.37
Void ratio		0.976
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	50
Differential pressure used	(kPa)	300
Pore pressure on completion	(kPa)	567
Cell pressure on completion	(kPa)	900
B value achieved		1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-1A
Sample	21WaxB
Depth (m)	33.12

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 11/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-1A_21WaxB_CU.XLS
Date: 16/11/2015
Checked by: PH
Date: 16/11/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	900
Back pressure	(kPa)	560
Effective cell pressure	(kPa)	340
Pore pressure on completion	(kPa)	560
Pore pressure dissipation	(%)	100
Moisture content	(%)	36.7
Bulk density	(Mg/m³)	1.87
Dry density	(Mg/m³)	1.36
Void ratio		0.979
Degree of saturation	(%)	100
Volumetric strain	(%)	0.02

Mode of failure: Compound failure

Borehole	BH-WFS4-1A
Sample	21WaxB
Depth (m)	33.12

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SHEARING		
Initial pore pressure	(kPa)	560
Initial effective cell pressure	(kPa)	340
Rate of strain	(%/hour)	0.28
At peak deviator stress		
Corrected deviator stress	(kPa)	253
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	6.29
Excess pore pressure	(kPa)	105
Major principal effective stress	(kPa)	488
Minor principal effective stress	(kPa)	235
Principal effective stress ratio		2.08
Epsilon 50 (ε 50)	(%)	0.42
Secant modulus (E50) at ε 50	(kPa)	30037
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	253
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	5.79
Excess pore pressure	(kPa)	106
Major principal effective stress	(kPa)	487
Minor principal effective stress	(kPa)	234
Principal effective stress ratio		2.08
At 10% axial strain		
Corrected deviator stress	(kPa)	233
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	91
Major principal effective stress	(kPa)	482
Minor principal effective stress	(kPa)	249
Principal effective stress ratio		1.93

FINAL CONDITIONS		
Moisture content	(%)	36.7
Bulk density	(Mg/m³)	1.87
Dry density	(Mg/m³)	1.36

Borehole	BH-WFS4-1A
Sample	21WaxB
Depth (m)	33.12

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 11/11/2015 Drawn by: ER Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS4-1A_21WaxB_CU.XLS Date: 16/11/2015 Checked by: PH Date: 16/11/2015 Approved by: PH

Drawn by: ER Date: 11/11/2015

Template Issue: 2

Filename: J11302 / EFFECTIV / BH-WFS4-1A_21WaxB_CU.XLS

Checked by: PH Date: 16/11/2015

Approved by: PH Date: 16/11/2015

SPECIMEN PHOTOGRAPHS



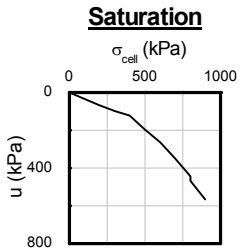


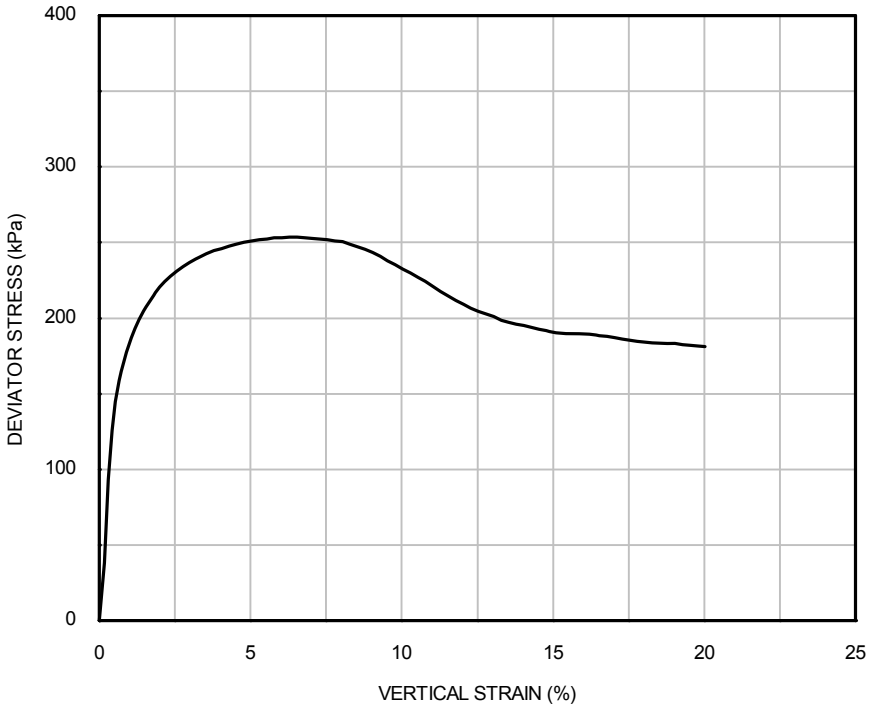
Borehole	BH-WFS4-1A
Sample	21WaxB
Depth (m)	33.12

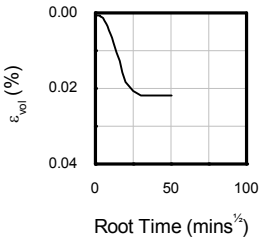
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

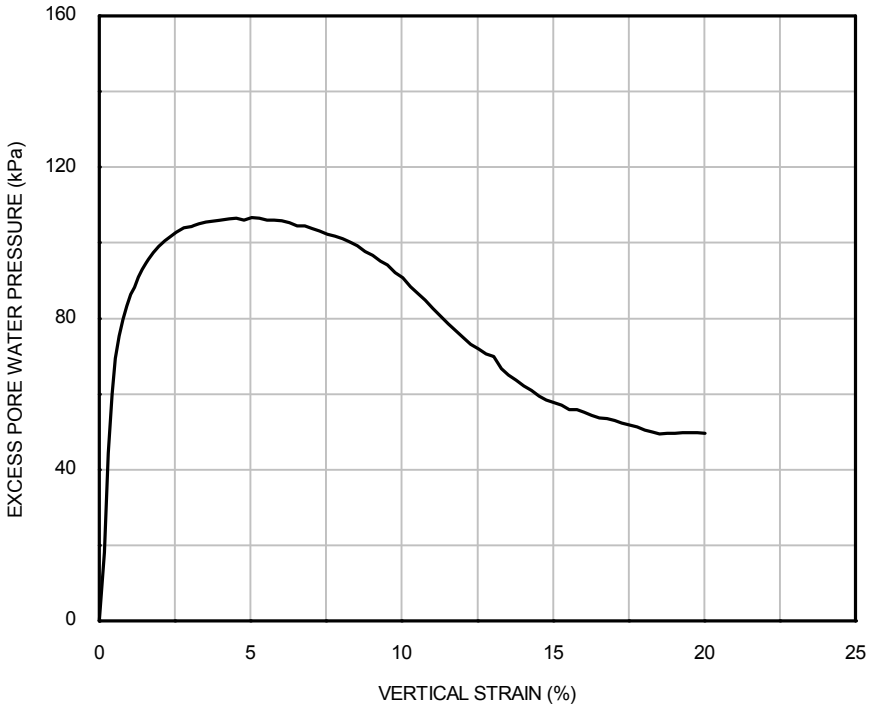
Drawn by: ER Date: 11/11/2015
Template Issue: 4.1
Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_21WaxB_CU.OPJ
Date : 16/11/2015
Checked by: PH
Date : 16/11/2015
Approved by: PH







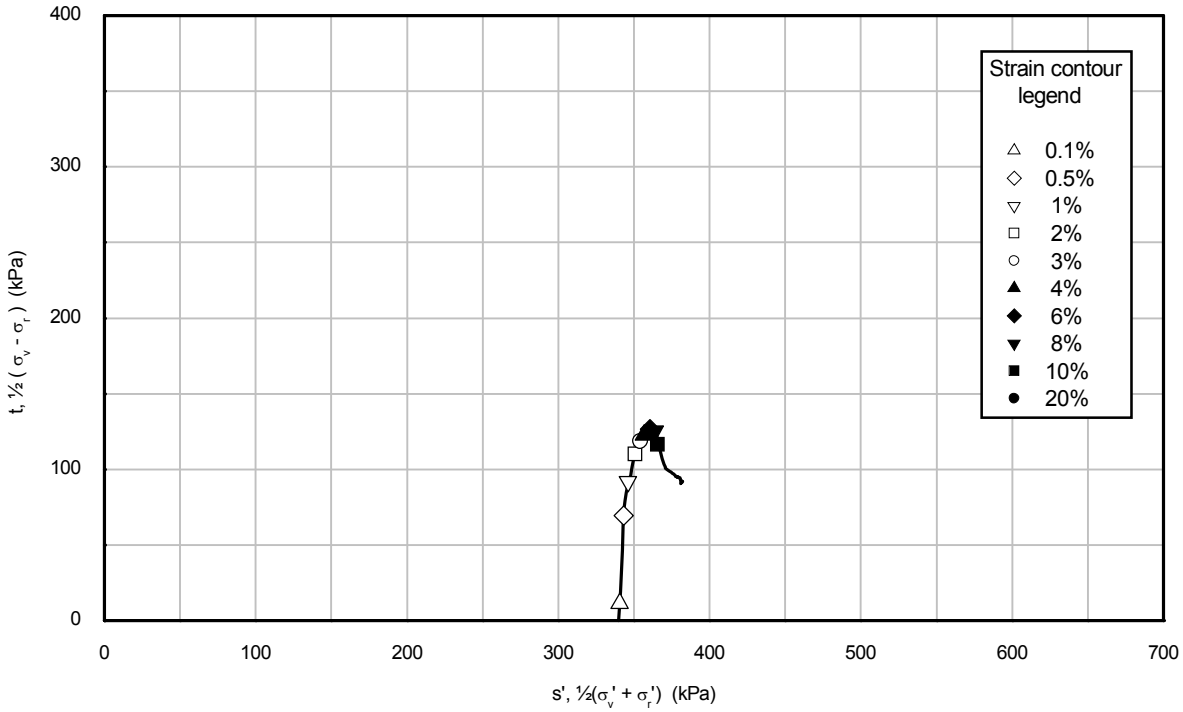
Consolidation

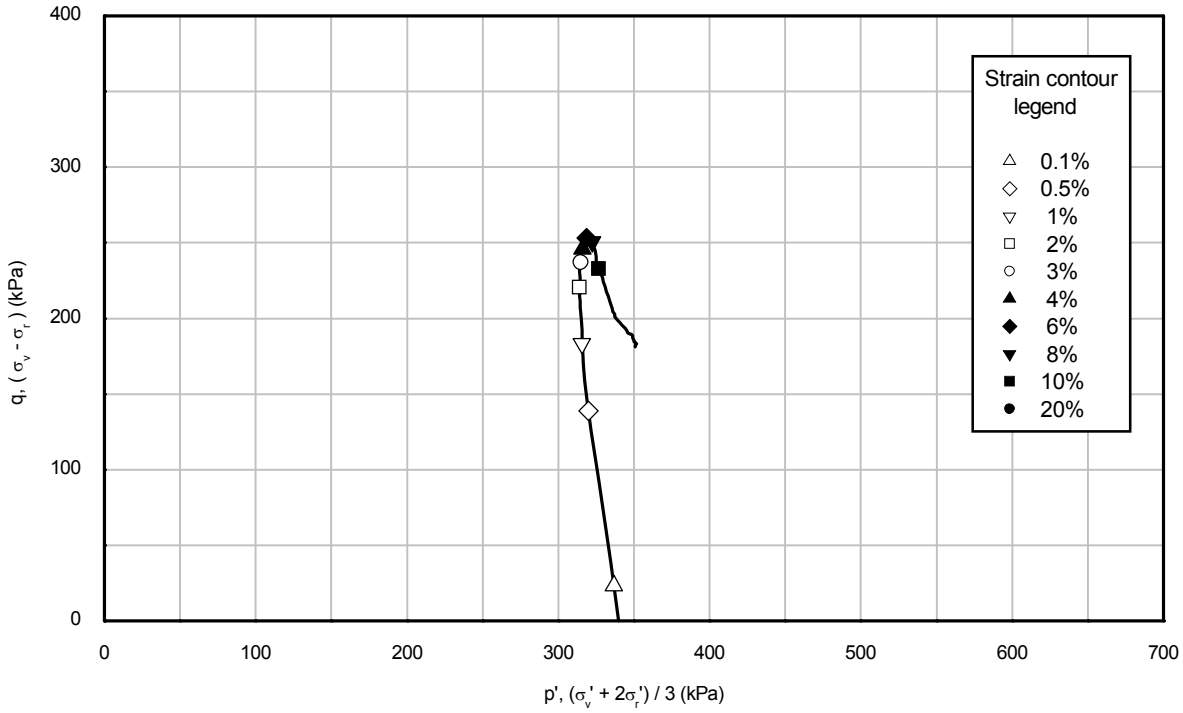


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	320	320	BH-WFS4-1A	21WaxB	33.12

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	320	320	BH-WFS4-1A	21WaxB	33.12

Drawn by: ER Date: 11/11/2015

Template Issue: 4.1

Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_21WaxB_CU.OPJ

Date : 16/11/2015

Checked by: PH

Date : 16/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 09/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-1A_25WaxC_CU.XLS
Template Issue: 2
Date: 10/11/2015
Checked by: AB
Date: 11/11/2015
Approved by: PH

VISUAL DESCRIPTION
High strength greenish grey CLAY.

GENERAL	
Date test started	30/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.2
Length	(mm)	139.7
Moisture content	(%)	39.3
Bulk density	(Mg/m³)	1.84
Dry density	(Mg/m³)	1.32
Void ratio		1.055
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	848
Cell pressure on completion	(kPa)	1180
B value achieved		1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-1A
Sample	25WaxC
Depth (m)	43.52

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 09/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-1A_25WaxC_CU.XLS
Date: 10/11/2015
Checked by: AB
Date: 11/11/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	1180
Back pressure	(kPa)	800
Effective cell pressure	(kPa)	380
Pore pressure on completion	(kPa)	800
Pore pressure dissipation	(%)	100
Moisture content	(%)	39.2
Bulk density	(Mg/m³)	1.84
Dry density	(Mg/m³)	1.32
Void ratio		1.051
Degree of saturation	(%)	100
Volumetric strain	(%)	0.19

Mode of failure: Brittle failure

Borehole	BH-WFS4-1A
Sample	25WaxC
Depth (m)	43.52

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 09/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-1A_25WaxC_CU.XLS
Template Issue: 2
Date: 10/11/2015
Checked by: AB
Date: 11/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	800
Initial effective cell pressure	(kPa)	380
Rate of strain	(%/hour)	0.29
At peak deviator stress		
Corrected deviator stress	(kPa)	275
Membrane correction applied	(kPa)	0.1
Drain correction applied	(kPa)	0
Axial strain	(%)	0.88
Excess pore pressure	(kPa)	139
Major principal effective stress	(kPa)	516
Minor principal effective stress	(kPa)	241
Principal effective stress ratio		2.14
Epsilon 50 (ε 50)	(%)	0.19
Secant modulus (E50) at ε 50	(kPa)	73636
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	275
Membrane correction applied	(kPa)	0.1
Drain correction applied	(kPa)	0
Axial strain	(%)	0.88
Excess pore pressure	(kPa)	139
Major principal effective stress	(kPa)	516
Minor principal effective stress	(kPa)	241
Principal effective stress ratio		2.14
At 10% axial strain		
Corrected deviator stress	(kPa)	210
Membrane correction applied	(kPa)	1.0
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	91
Major principal effective stress	(kPa)	499
Minor principal effective stress	(kPa)	289
Principal effective stress ratio		1.73

FINAL CONDITIONS		
Moisture content	(%)	39.2
Bulk density	(Mg/m³)	1.84
Dry density	(Mg/m³)	1.32

Borehole	BH-WFS4-1A
Sample	25WaxC
Depth (m)	43.52

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

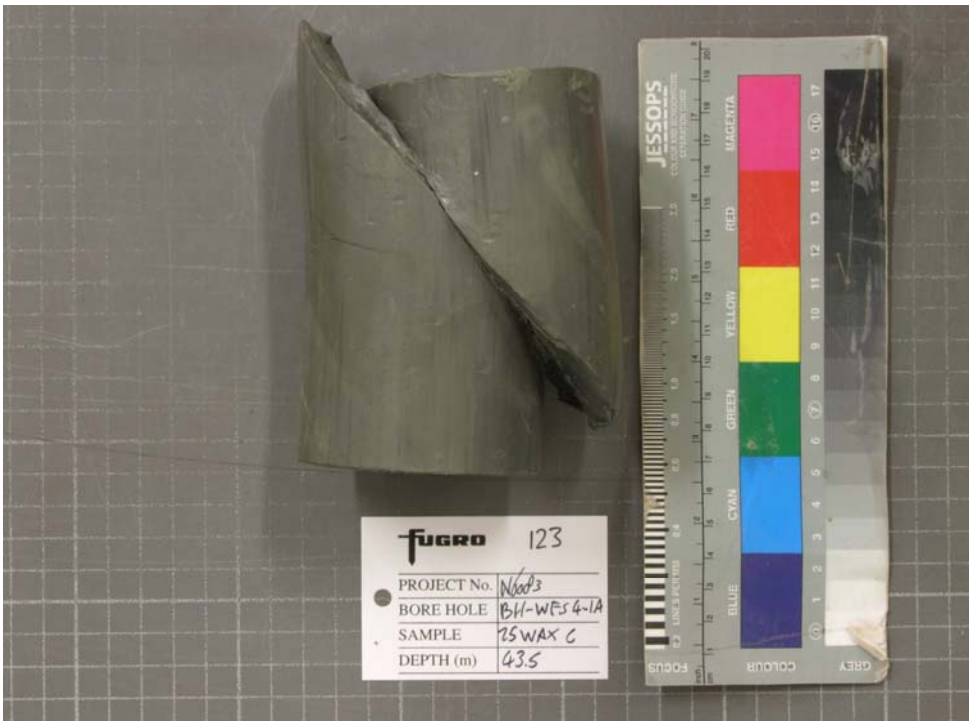
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Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS4-1A_25WaxC_CU.XLS

Checked by: AB Date: 10/11/2015

Approved by: PH Date: 11/11/2015

SPECIMEN PHOTOGRAPHS





Borehole	BH-WFS4-1A
Sample	25WaxC
Depth (m)	43.52

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 09/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_25WaxC_CU.OPJ

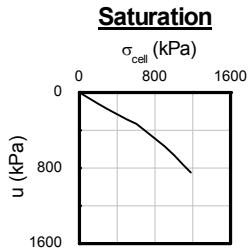
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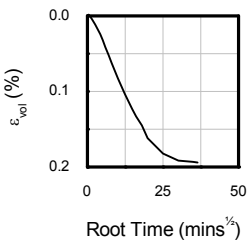
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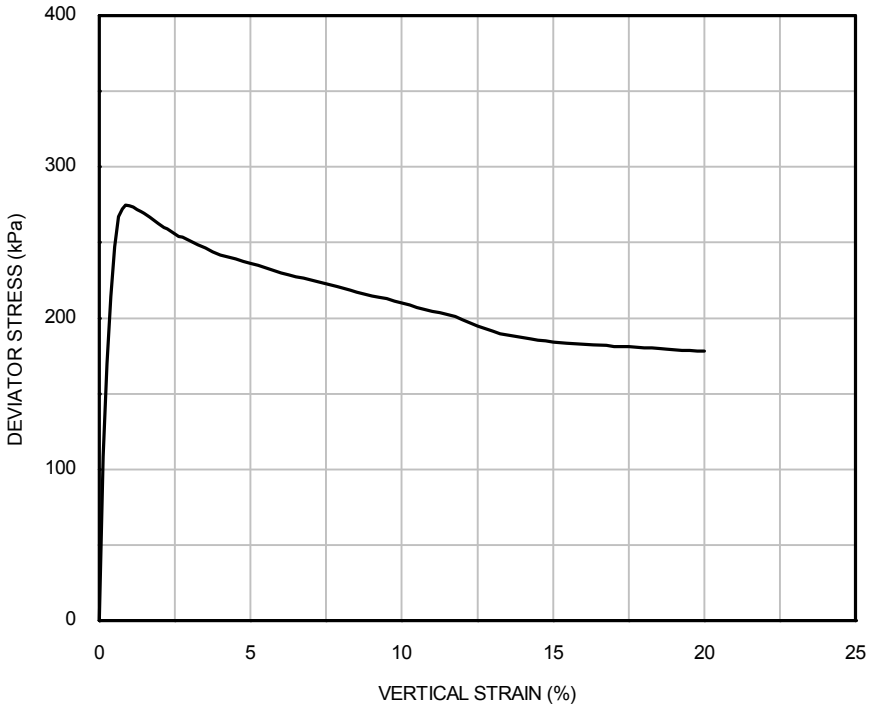
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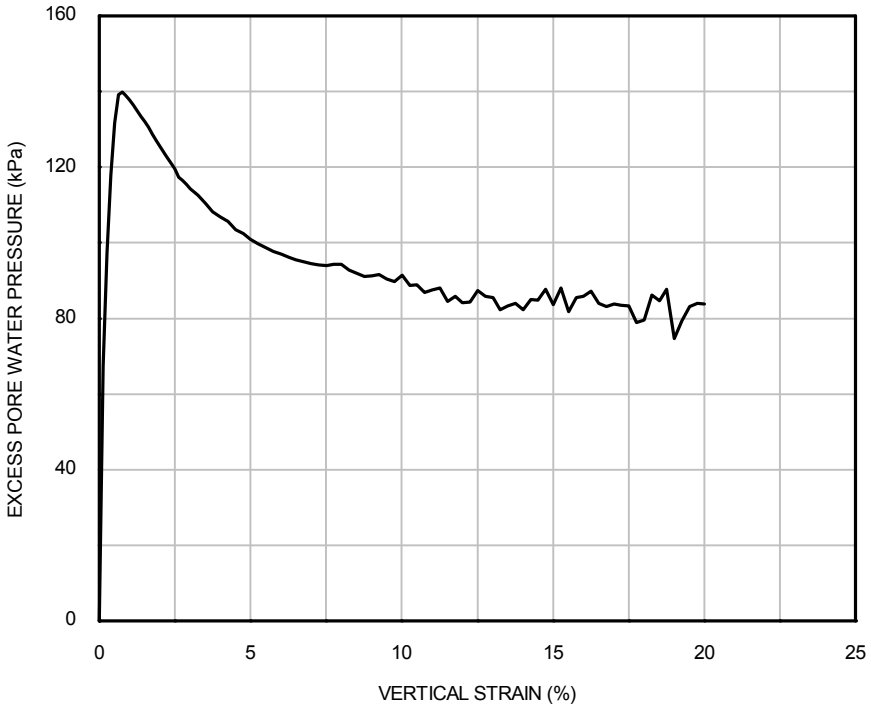
Approved by: PH





Consolidation

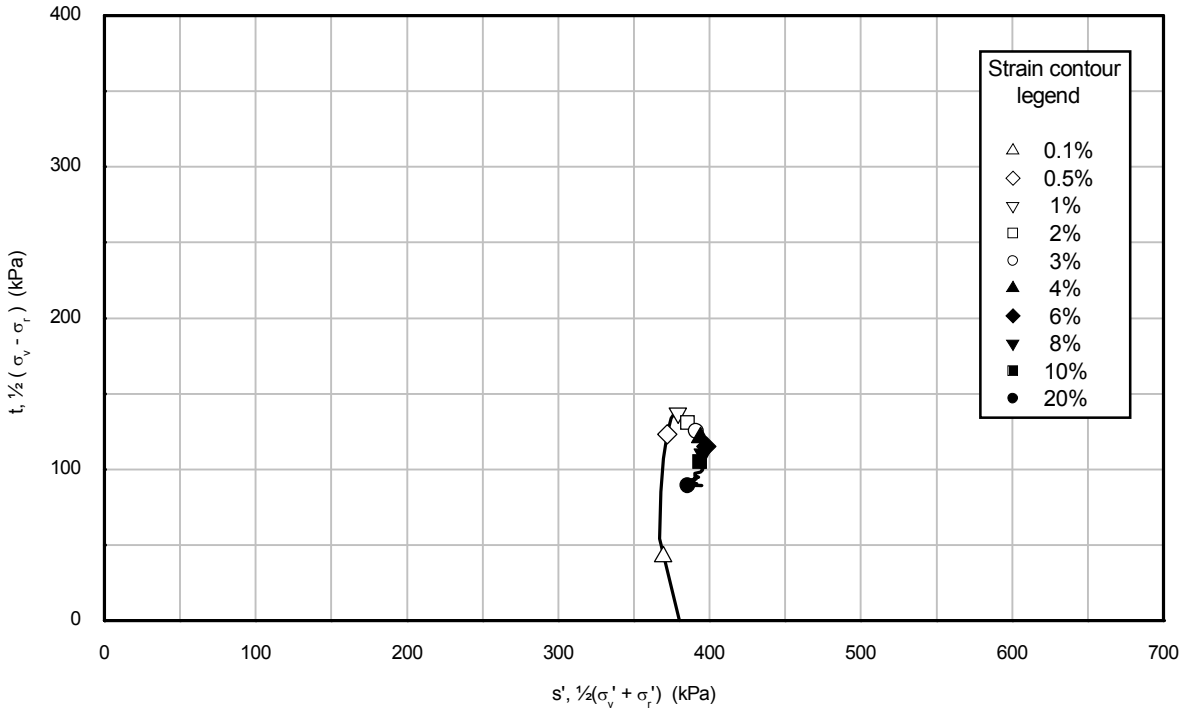


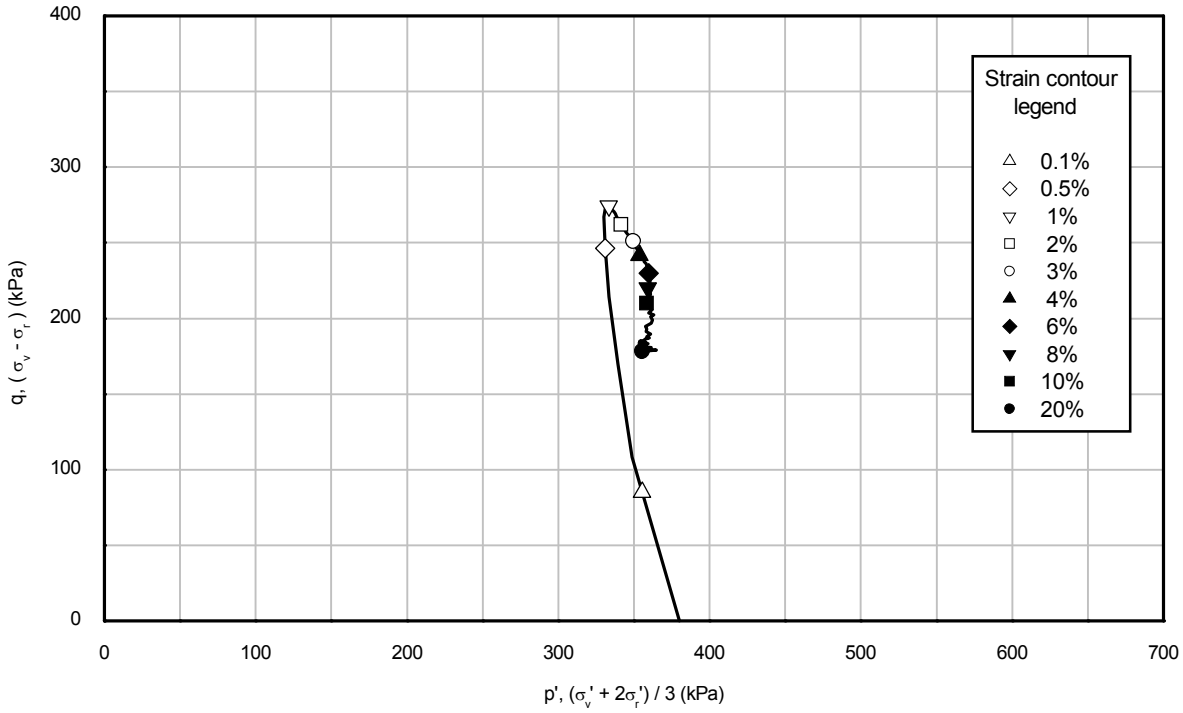


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	380	380	BH-WFS4-1A	25WaxC	43.52

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	380	380	BH-WFS4-1A	25WaxC	43.52

Drawn by: ER Date: 09/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_25WaxC_CU.OPJ

Template Issue: 4.1

Date : 10/11/2015

Checked by: ALB

Date : 11/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 02/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-2A_16WaxB_CU.XLS
Date: 03/11/2015
Checked by: PH
Date: 03/11/2015
Approved by: PH

VISUAL DESCRIPTION
Extremely high strength dark greenish grey slightly sandy CLAY with pockets of light grey silt.

GENERAL	
Date test started	23/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	70.9
Length	(mm)	139.5
Moisture content	(%)	24.6
Bulk density	(Mg/m³)	2.01
Dry density	(Mg/m³)	1.61
Void ratio		0.658
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	639
Cell pressure on completion	(kPa)	770
B value achieved		0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-2A
Sample	16WaxB
Depth (m)	34.42

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 02/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-2A_16WaxB_CU.XLS
Date: 03/11/2015
Checked by: PH
Date: 03/11/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	770
Back pressure	(kPa)	400
Effective cell pressure	(kPa)	370
Pore pressure on completion	(kPa)	400
Pore pressure dissipation	(%)	100
Moisture content	(%)	23.6
Bulk density	(Mg/m³)	2.02
Dry density	(Mg/m³)	1.64
Void ratio		0.632
Degree of saturation	(%)	100
Volumetric strain	(%)	1.53

Mode of failure: Compound Failure

Borehole	BH-WFS4-2A
Sample	16WaxB
Depth (m)	34.42

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 02/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-2A_16WaxB_CU.XLS
Template Issue: 2
Date: 03/11/2015
Checked by: PH
Date: 03/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	370
Rate of strain	(%/hour)	0.83
At peak deviator stress		
Corrected deviator stress	(kPa)	837
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	9.50
Excess pore pressure	(kPa)	10
Major principal effective stress	(kPa)	1197
Minor principal effective stress	(kPa)	360
Principal effective stress ratio		3.32
Epsilon 50 (ε 50)	(%)	1.46
Secant modulus (E50) at ε 50	(kPa)	28584
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	624
Membrane correction applied	(kPa)	0.3
Drain correction applied	(kPa)	0
Axial strain	(%)	3.25
Excess pore pressure	(kPa)	145
Major principal effective stress	(kPa)	850
Minor principal effective stress	(kPa)	225
Principal effective stress ratio		3.77
At 10% axial strain		
Corrected deviator stress	(kPa)	833
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	13
Major principal effective stress	(kPa)	1190
Minor principal effective stress	(kPa)	357
Principal effective stress ratio		3.33

FINAL CONDITIONS		
Moisture content	(%)	23.6
Bulk density	(Mg/m³)	2.02
Dry density	(Mg/m³)	1.64

Borehole	BH-WFS4-2A
Sample	16WaxB
Depth (m)	34.42

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 02/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-2A_16WaxB_CU.XLS
Checked by: PH Date: 03/11/2015
Approved by: PH Date: 03/11/2015

SPECIMEN PHOTOGRAPHS



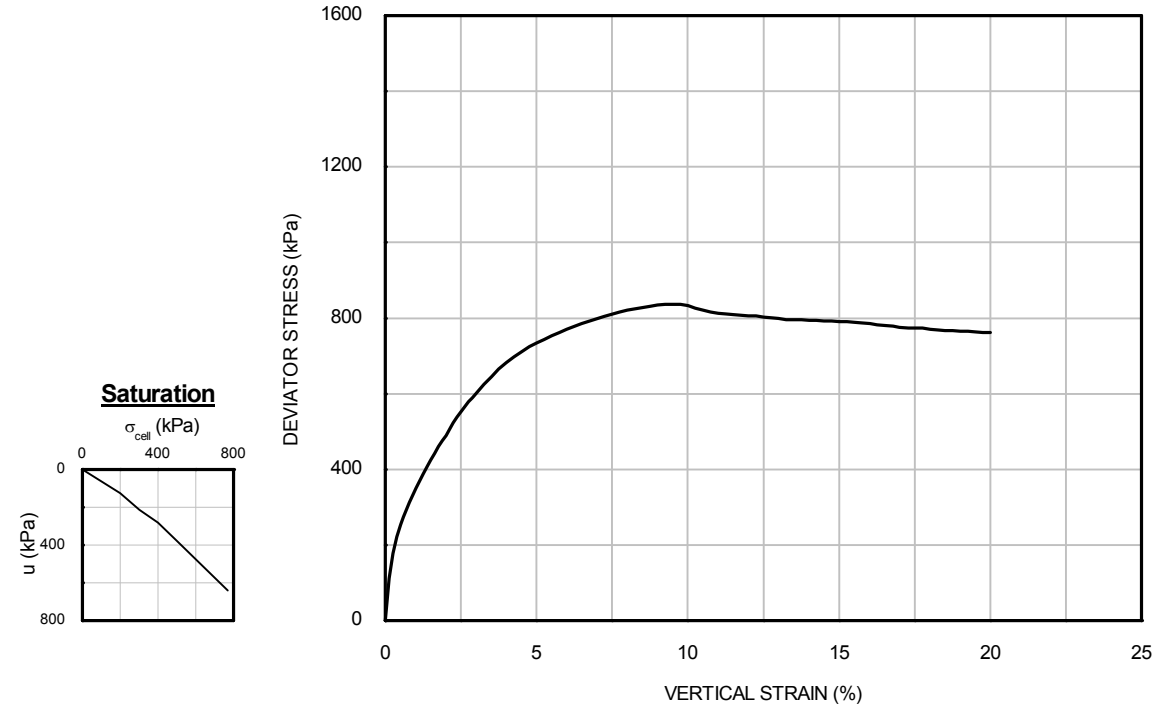


Borehole	BH-WFS4-2A
Sample	16WaxB
Depth (m)	34.42

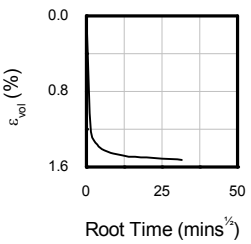
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

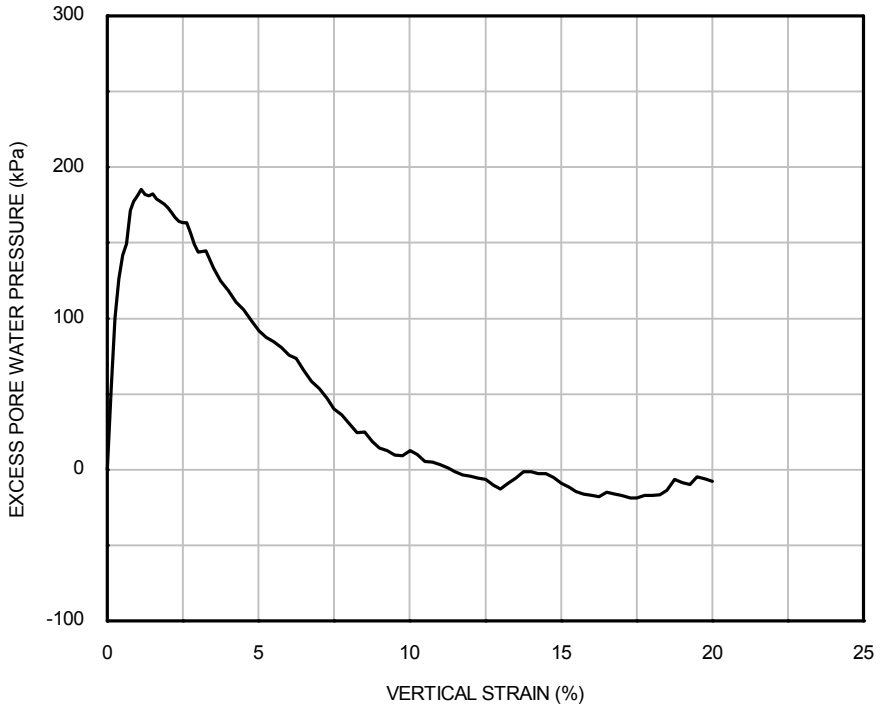
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Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_16WaxB_CU.OPJ
Template Issue: 4.1
Date : 03/11/2015
Checked by: PH
Date : 03/11/2015
Approved by: PH



Saturation



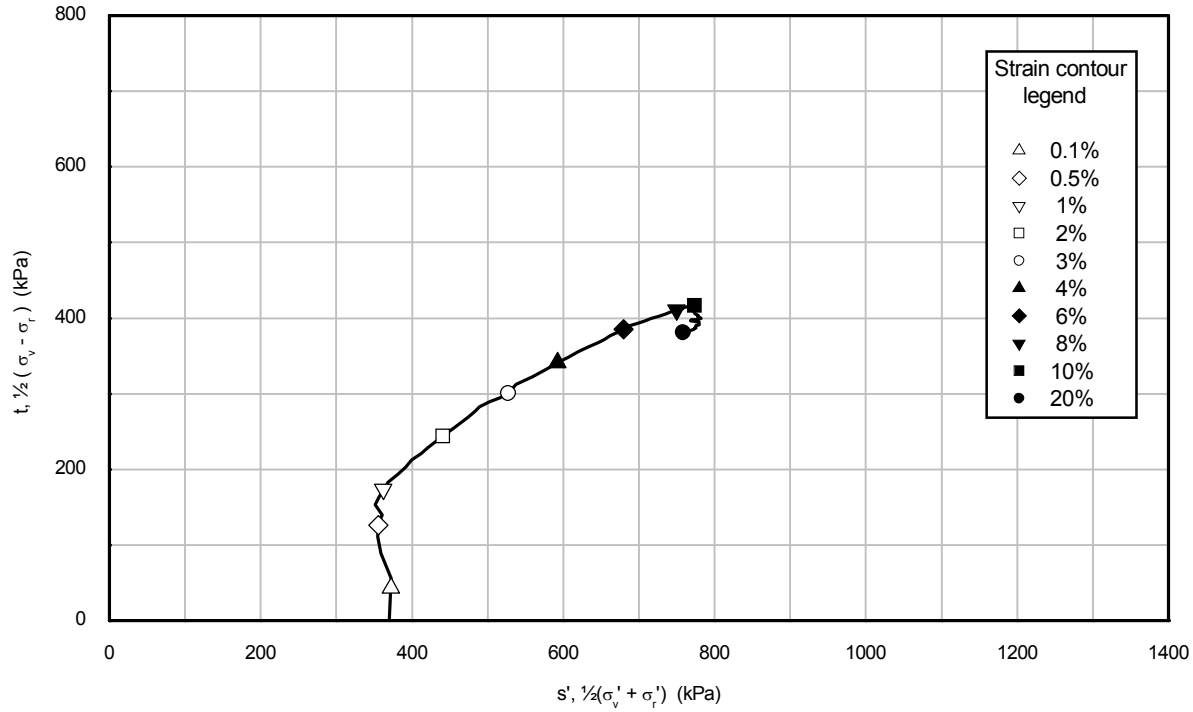
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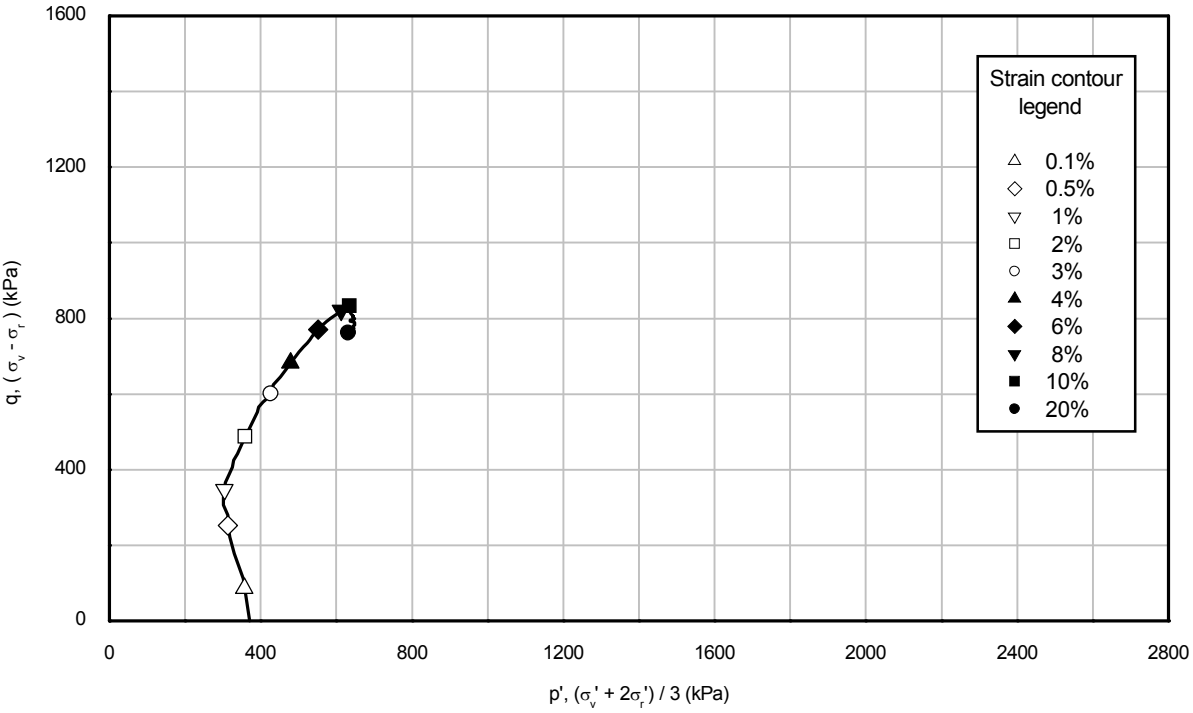


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	370	370	BH-WFS4-2A	16WaxB	34.42

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	370	370	BH-WFS4-2A	16WaxB	34.42

Drawn by: ER Date: 02/11/2015

Template Issue: 4.1 Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_16WaxB_CU.OPJ

Date : 03/11/2015 Date : 03/11/2015

Checked by: PH Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 23/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-3_23WaxB_CU.XLS
Date: 26/11/2015
Checked by: PH
Date: 26/11/2015
Approved by: PH

VISUAL DESCRIPTION
High strength dark greenish grey CLAY.

GENERAL	
Date test started	30/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.8
Length	(mm)	139.7
Moisture content	(%)	30.6
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.48
Void ratio		0.812
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	300
Pore pressure on completion	(kPa)	908
Cell pressure on completion	(kPa)	1220
B value achieved		0.95

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-3
Sample	23WaxB
Depth (m)	31.60

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	1220
Back pressure	(kPa)	900
Effective cell pressure	(kPa)	320
Pore pressure on completion	(kPa)	900
Pore pressure dissipation	(%)	100
Moisture content	(%)	31.0
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.47
Void ratio		0.820
Degree of saturation	(%)	100
Volumetric strain	(%)	0.03

Mode of failure: Brittle failure

Borehole	BH-WFS4-3
Sample	23WaxB
Depth (m)	31.60

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 23/11/2015 Drawn by: ALB Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS4-3_23WaxB_CU.XLS Date: 26/11/2015 Checked by: PH Date: 26/11/2015 Approved by: PH

Date: 23/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-3_23WaxB_CU.XLS
Date: 26/11/2015
Checked by: PH
Date: 26/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	900
Initial effective cell pressure	(kPa)	320
Rate of strain	(%/hour)	0.29
At peak deviator stress		
Corrected deviator stress	(kPa)	295
Membrane correction applied	(kPa)	0.3
Drain correction applied	(kPa)	0
Axial strain	(%)	2.62
Excess pore pressure	(kPa)	119
Major principal effective stress	(kPa)	496
Minor principal effective stress	(kPa)	201
Principal effective stress ratio		2.47
Epsilon 50 (ε 50)	(%)	0.27
Secant modulus (E50) at ε 50	(kPa)	54407
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	295
Membrane correction applied	(kPa)	0.3
Drain correction applied	(kPa)	0
Axial strain	(%)	2.62
Excess pore pressure	(kPa)	119
Major principal effective stress	(kPa)	496
Minor principal effective stress	(kPa)	201
Principal effective stress ratio		2.47
At 10% axial strain		
Corrected deviator stress	(kPa)	259
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	81
Major principal effective stress	(kPa)	498
Minor principal effective stress	(kPa)	239
Principal effective stress ratio		2.09

FINAL CONDITIONS		
Moisture content	(%)	31.0
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.47

Borehole	BH-WFS4-3
Sample	23WaxB
Depth (m)	31.60

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 23/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-3_23WaxB_CU.XLS
Checked by: PH Date: 26/11/2015
Approved by: PH Date: 26/11/2015

SPECIMEN PHOTOGRAPHS



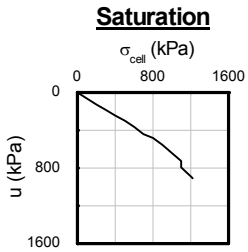


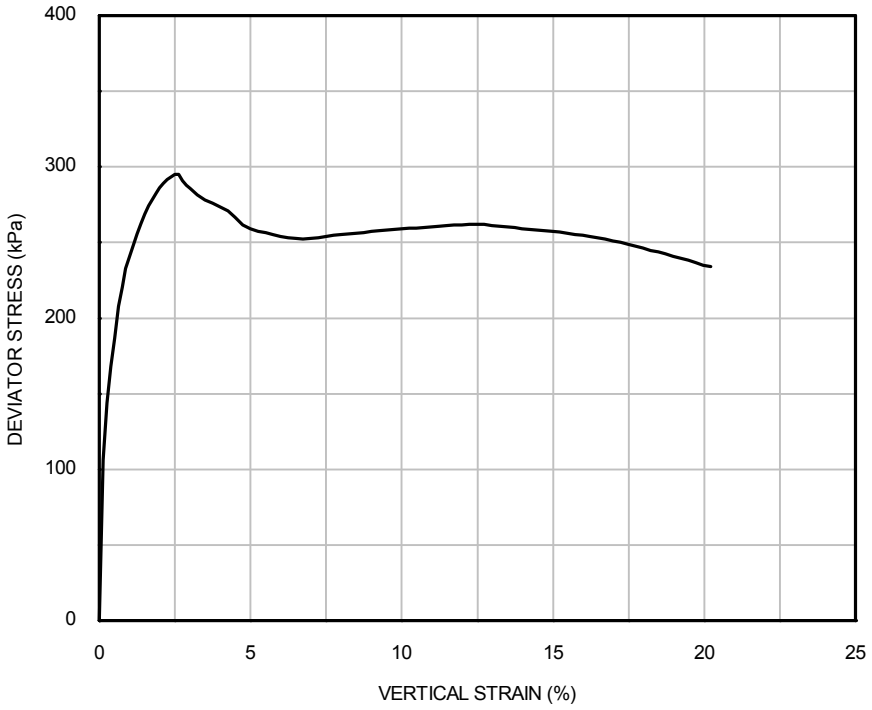
Borehole	BH-WFS4-3
Sample	23WaxB
Depth (m)	31.60

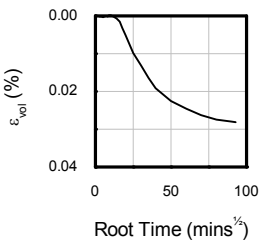
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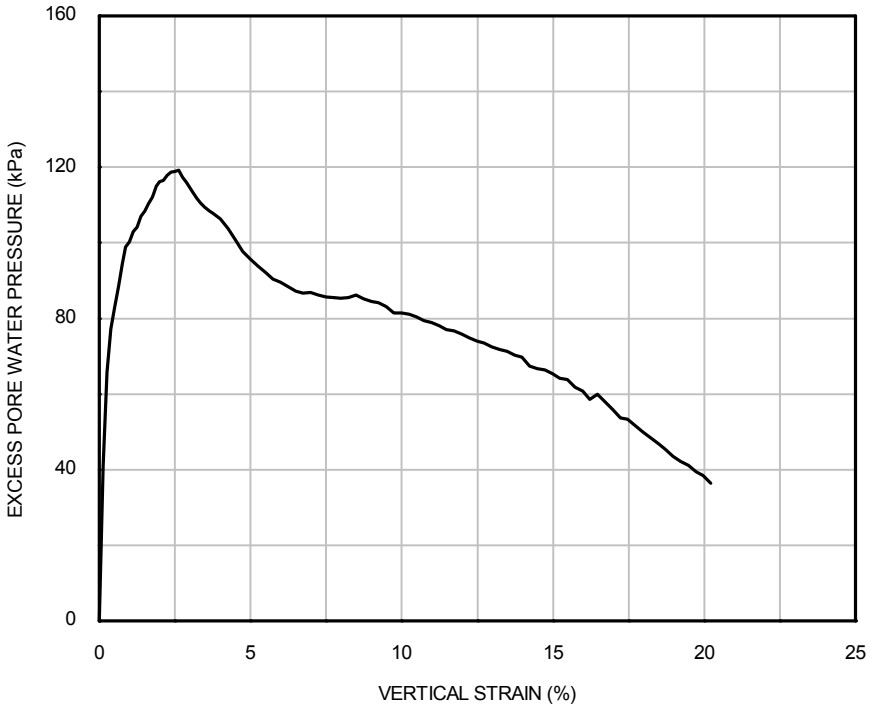
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 23/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-3_23WaxB_CU.OPJ
Template Issue: 4.1
Date : 26/11/2015
Checked by: PH
Date : 26/11/2015
Approved by: PH





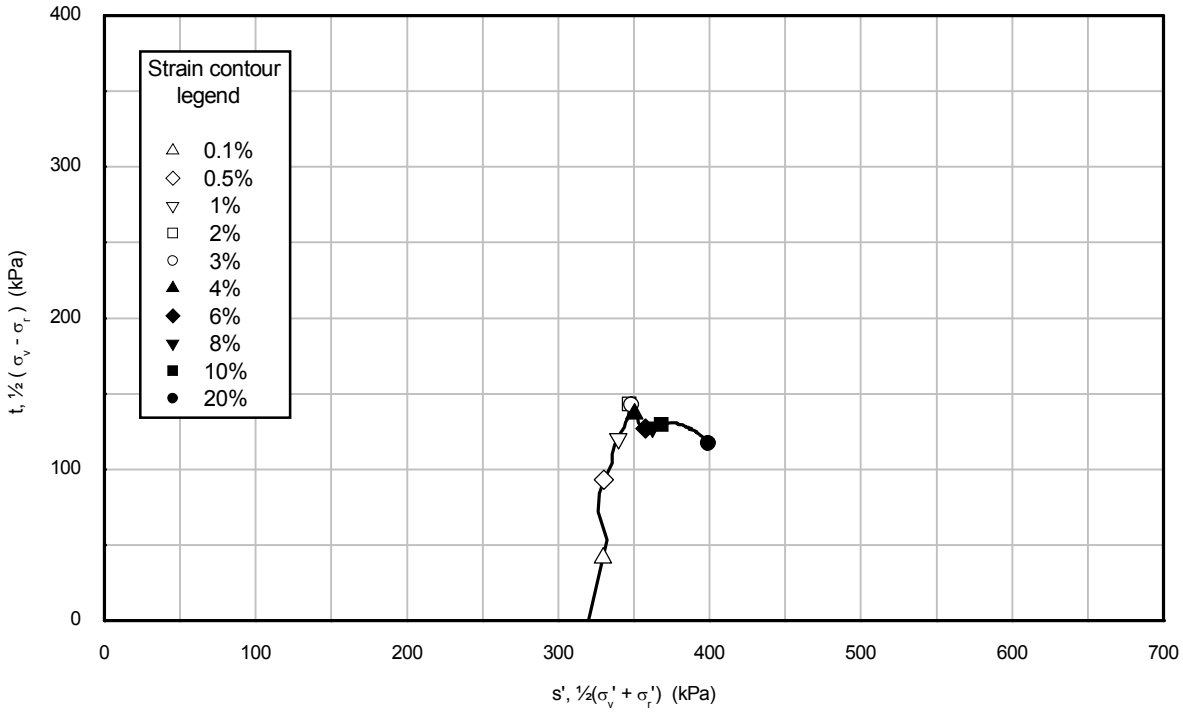


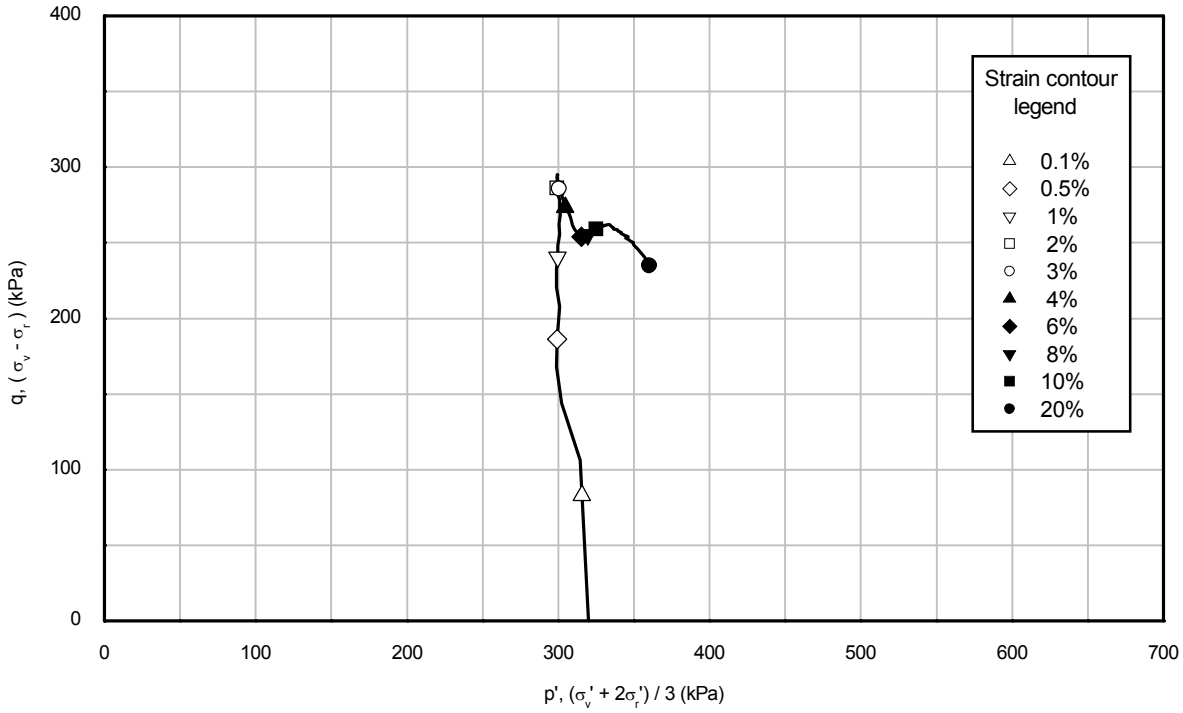


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	320	320	BH-WFS4-3	23WaxB	31.60

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	320	320	BH-WFS4-3	23WaxB	31.60

Drawn by: ALB Date: 23/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-3_23WaxB_CU.OPJ

Template Issue: 4.1

Date : 26/11/2015

Checked by: PH

Date : 26/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 06/10/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS4-3_29WaxB_CU.XLS
Template Issue: 2
Date: 06/10/2015
Checked by: PH
Date: 06/10/2015
Approved by: PH

VISUAL DESCRIPTION
Very high strength dark greenish grey CLAY

GENERAL	
Date test started	23/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	72.2
Length	(mm)	139.6
Moisture content	(%)	36.6
Bulk density	(Mg/m³)	1.85
Dry density	(Mg/m³)	1.36
Void ratio		0.991
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	556
Cell pressure on completion	(kPa)	920
B value achieved		0.98

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-3
Sample	29WaxB
Depth (m)	45.65

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	920
Back pressure	(kPa)	500
Effective cell pressure	(kPa)	420
Pore pressure on completion	(kPa)	500
Pore pressure dissipation	(%)	100
Moisture content	(%)	36.4
Bulk density	(Mg/m³)	1.85
Dry density	(Mg/m³)	1.36
Void ratio		0.985
Degree of saturation	(%)	100
Volumetric strain	(%)	0.30

Mode of failure: Shear failure

Borehole	BH-WFS4-3
Sample	29WaxB
Depth (m)	45.65

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 06/10/2015 Drawn by: ALB Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS4-3_29WaxB_CU.XLS Date: 06/10/2015 Checked by: PH Date: 06/10/2015 Approved by: PH

Date: 06/10/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-3_29WaxB_CU.XLS
Date: 06/10/2015
Checked by: PH
Date: 06/10/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	500
Initial effective cell pressure	(kPa)	420
Rate of strain	(%/hour)	0.12
At peak deviator stress		
Corrected deviator stress	(kPa)	506
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	7.00
Excess pore pressure	(kPa)	28
Major principal effective stress	(kPa)	898
Minor principal effective stress	(kPa)	392
Principal effective stress ratio		2.29
Epsilon 50 (ε 50)	(%)	1.62
Secant modulus (E50) at ε 50	(kPa)	15604
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	500
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	6.25
Excess pore pressure	(kPa)	33
Major principal effective stress	(kPa)	887
Minor principal effective stress	(kPa)	387
Principal effective stress ratio		2.29
At 10% axial strain		
Corrected deviator stress	(kPa)	484
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	8.2
Major principal effective stress	(kPa)	896
Minor principal effective stress	(kPa)	412
Principal effective stress ratio		2.18

FINAL CONDITIONS		
Moisture content	(%)	36.4
Bulk density	(Mg/m³)	1.85
Dry density	(Mg/m³)	1.36

Borehole	BH-WFS4-3
Sample	29WaxB
Depth (m)	45.65

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 06/10/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-3_29WaxB_CU.XLS
Checked by: PH
Date: 06/10/2015
Approved by: PH
Date: 06/10/2015

SPECIMEN PHOTOGRAPHS

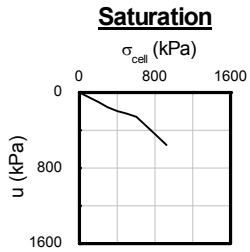


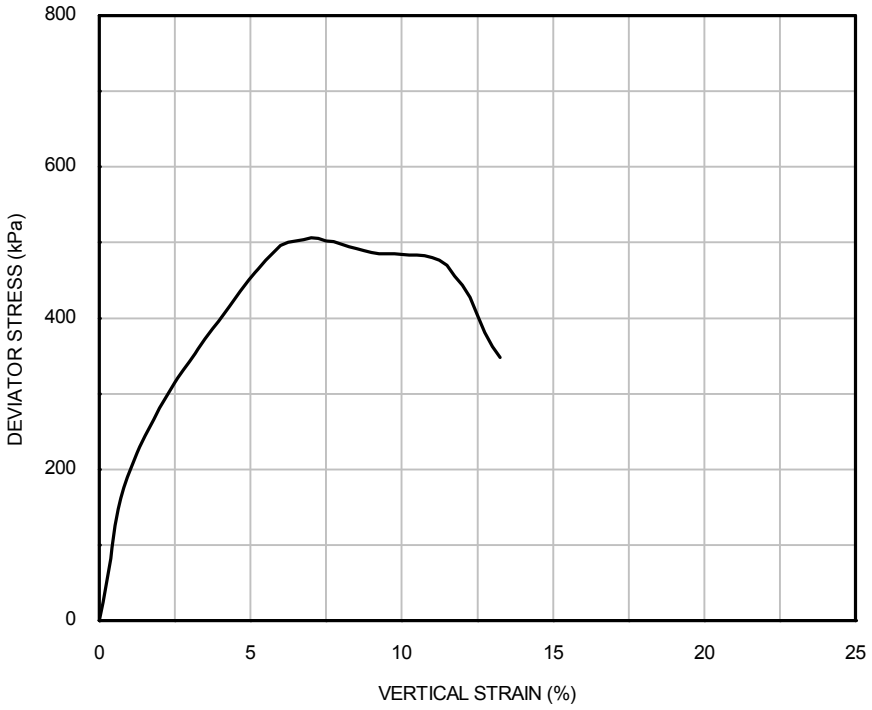
Borehole	BH-WFS4-3
Sample	29WaxB
Depth (m)	45.65

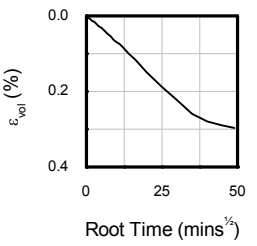
SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

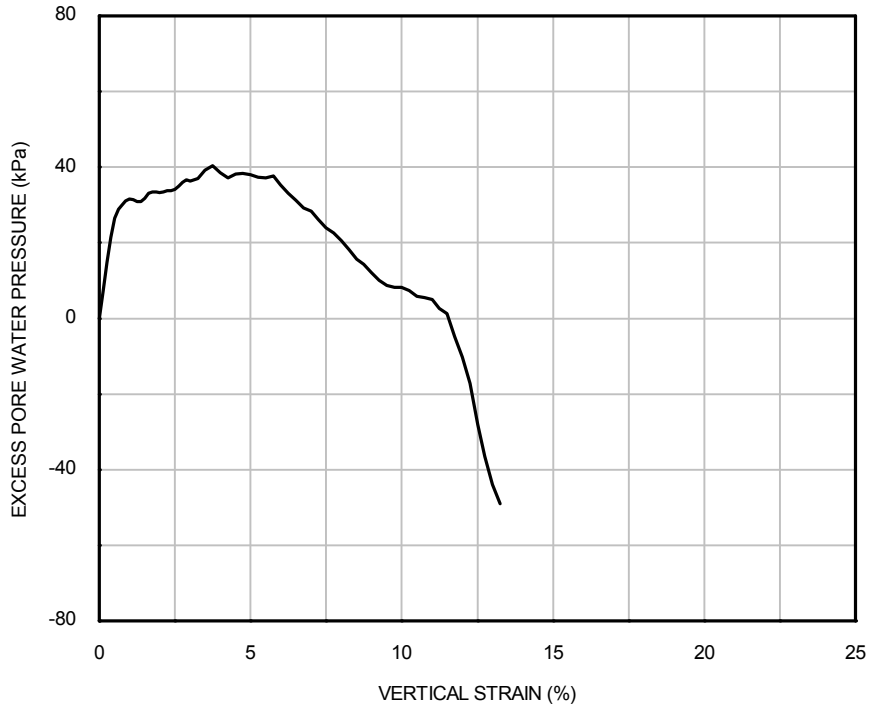
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Filename: J11302 \ EFFECTIV \ BH-WFS4-3_29WaxB_CU.OPJ
Template Issue: 4.1
Date : 06/11/2015
Checked by: PH
Date : 06/11/2015
Approved by: PH







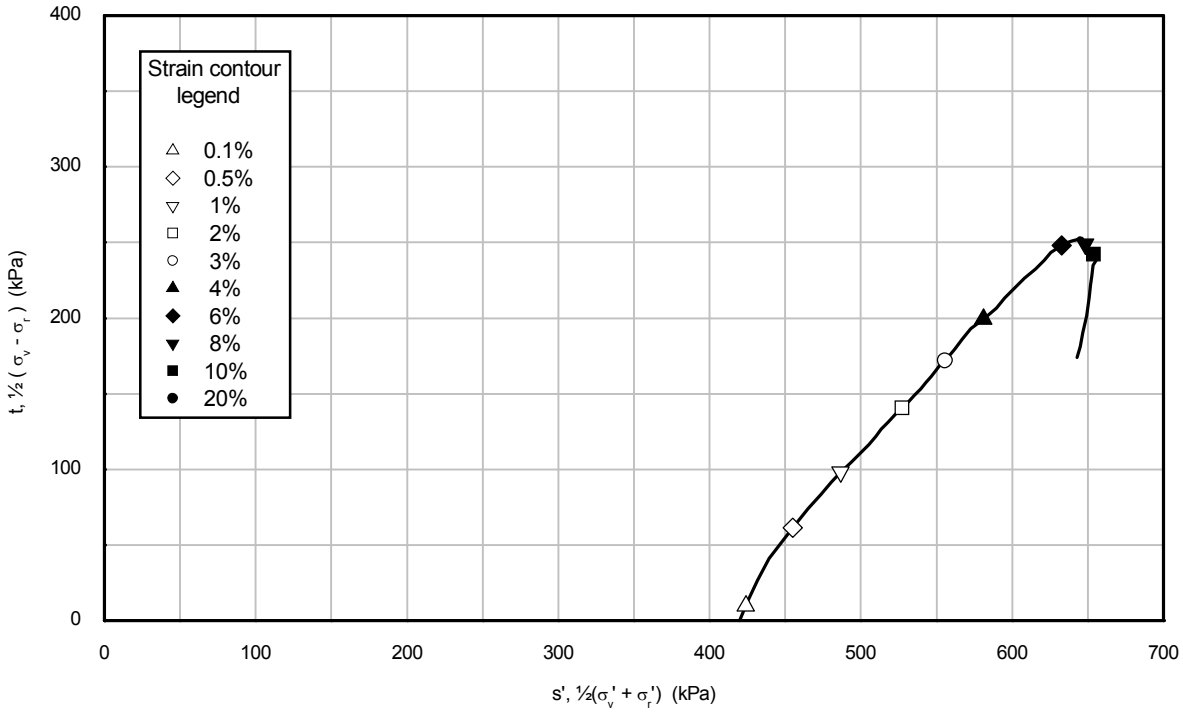
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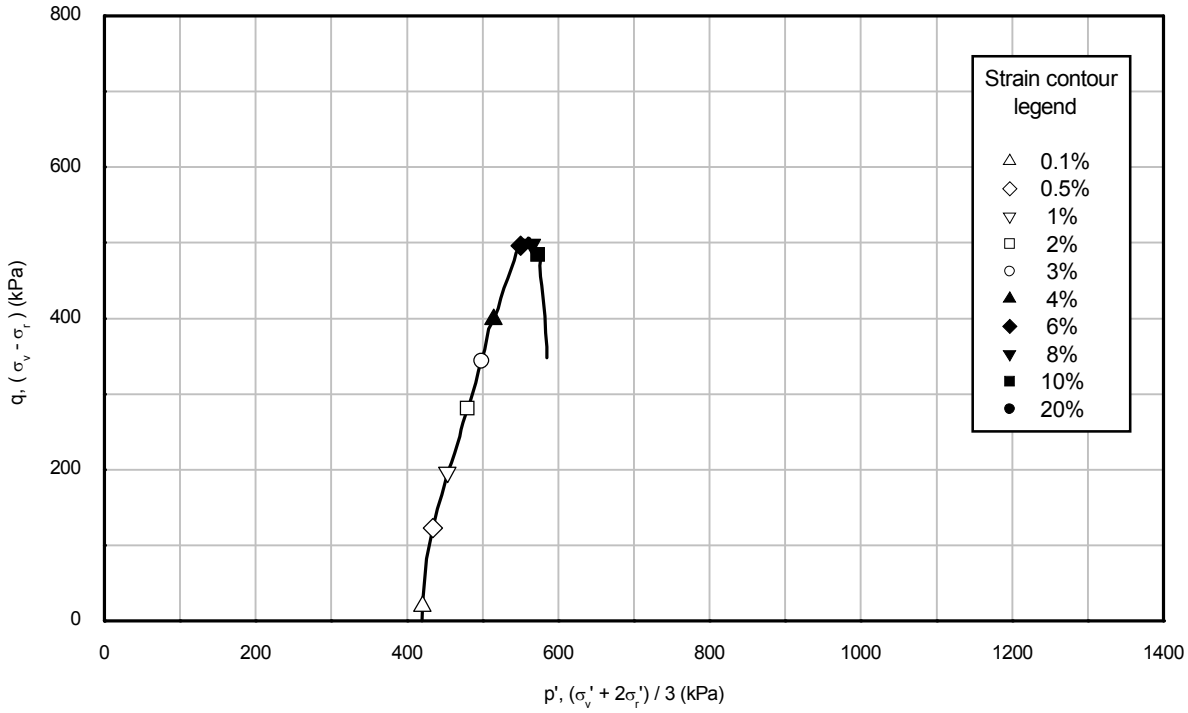


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	420	420	BH-WFS4-3	29WaxB	45.65

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	420	420	BH-WFS4-3	29WaxB	45.65

Drawn by: ALB Date: 06/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-3_29WaxB_CU.OPJ

Template Issue: 4.1

Date : 06/11/2015

Checked by: PH

Date : 06/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 09/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-3_32WaxC_CU.XLS
Template Issue: 2
Date: 10/11/2015
Checked by: AB
Date: 11/11/2015
Approved by: PH

VISUAL DESCRIPTION
Very high strength dark greenish grey CLAY with some pockets of silt.

GENERAL	
Date test started	30/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.4
Length	(mm)	139.8
Moisture content	(%)	41.3
Bulk density	(Mg/m³)	1.81
Dry density	(Mg/m³)	1.28
Void ratio		1.109
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	782
Cell pressure on completion	(kPa)	1080
B value achieved		0.99

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-3
Sample	32WaxC
Depth (m)	55.02

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	1080
Back pressure	(kPa)	600
Effective cell pressure	(kPa)	480
Pore pressure on completion	(kPa)	600
Pore pressure dissipation	(%)	100
Moisture content	(%)	40.6
Bulk density	(Mg/m³)	1.82
Dry density	(Mg/m³)	1.29
Void ratio		1.090
Degree of saturation	(%)	100
Volumetric strain	(%)	0.90

Mode of failure: Brittle Failure

Borehole	BH-WFS4-3
Sample	32WaxC
Depth (m)	55.02

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 09/11/2015
Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS4-3_32WaxC_CU.XLS
Checked by: AB Date: 10/11/2015
Approved by: PH Date: 11/11/2015

Date: 09/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-3_32WaxC_CU.XLS
Template Issue: 2
Date: 10/11/2015
Checked by: AB
Date: 11/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	600
Initial effective cell pressure	(kPa)	480
Rate of strain	(%/hour)	0.42
At peak deviator stress		
Corrected deviator stress	(kPa)	461
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	1.89
Excess pore pressure	(kPa)	220
Major principal effective stress	(kPa)	721
Minor principal effective stress	(kPa)	260
Principal effective stress ratio		2.77
Epsilon 50 (ε 50)	(%)	0.44
Secant modulus (E50) at ε 50	(kPa)	51790
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	461
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	1.76
Excess pore pressure	(kPa)	221
Major principal effective stress	(kPa)	720
Minor principal effective stress	(kPa)	259
Principal effective stress ratio		2.78
At 10% axial strain		
Corrected deviator stress	(kPa)	317
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	159
Major principal effective stress	(kPa)	639
Minor principal effective stress	(kPa)	321
Principal effective stress ratio		1.99

FINAL CONDITIONS		
Moisture content	(%)	40.6
Bulk density	(Mg/m³)	1.82
Dry density	(Mg/m³)	1.29

Borehole	BH-WFS4-3
Sample	32WaxC
Depth (m)	55.02

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Checked by: AB Date: 10/11/2015 Template Issue: 2 Drawn by: ER Date: 09/11/2015

Approved by: PH Date: 11/11/2015 Filename: J11302 / EFFECTIV / BH-WFS4-3_32WaxC_CU.XLS

SPECIMEN PHOTOGRAPHS



Borehole	BH-WFS4-3
Sample	32WaxC
Depth (m)	55.02

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 09/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-3_32WaxC_CU.OPJ

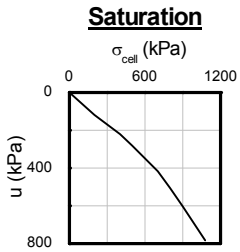
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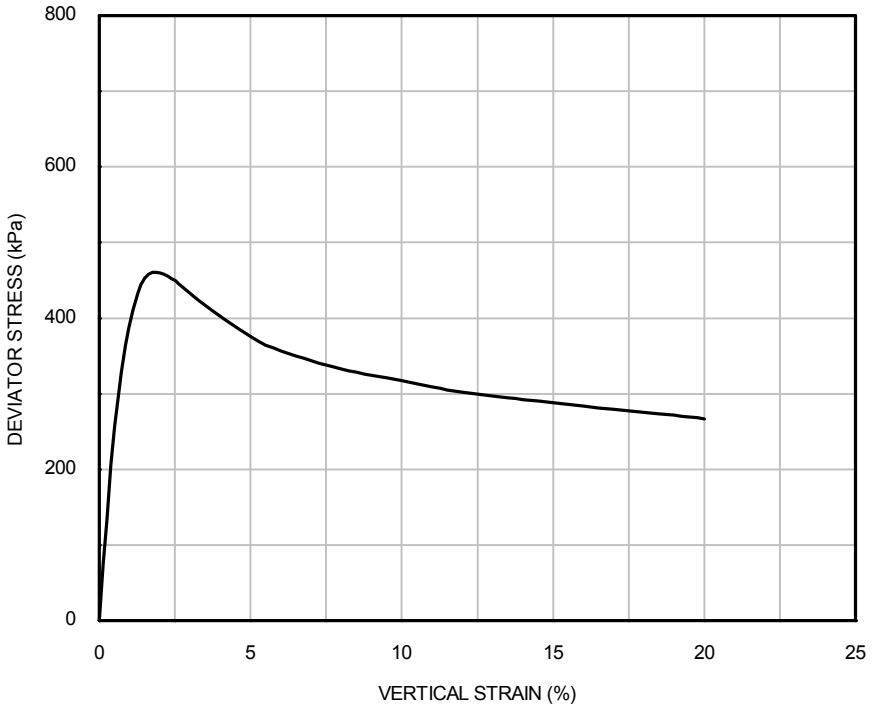
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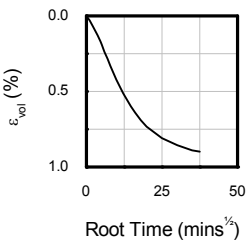
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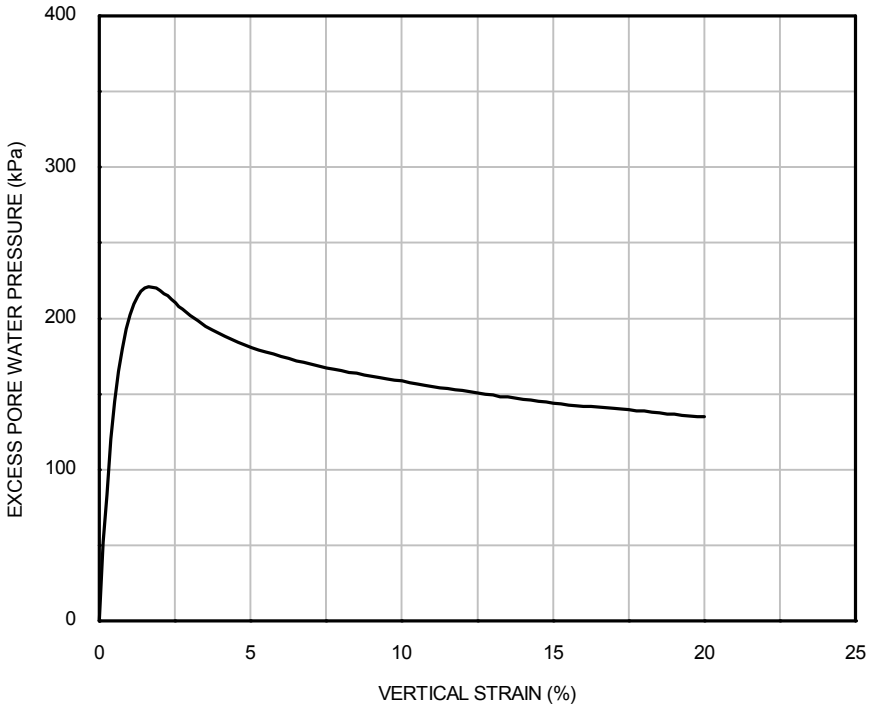
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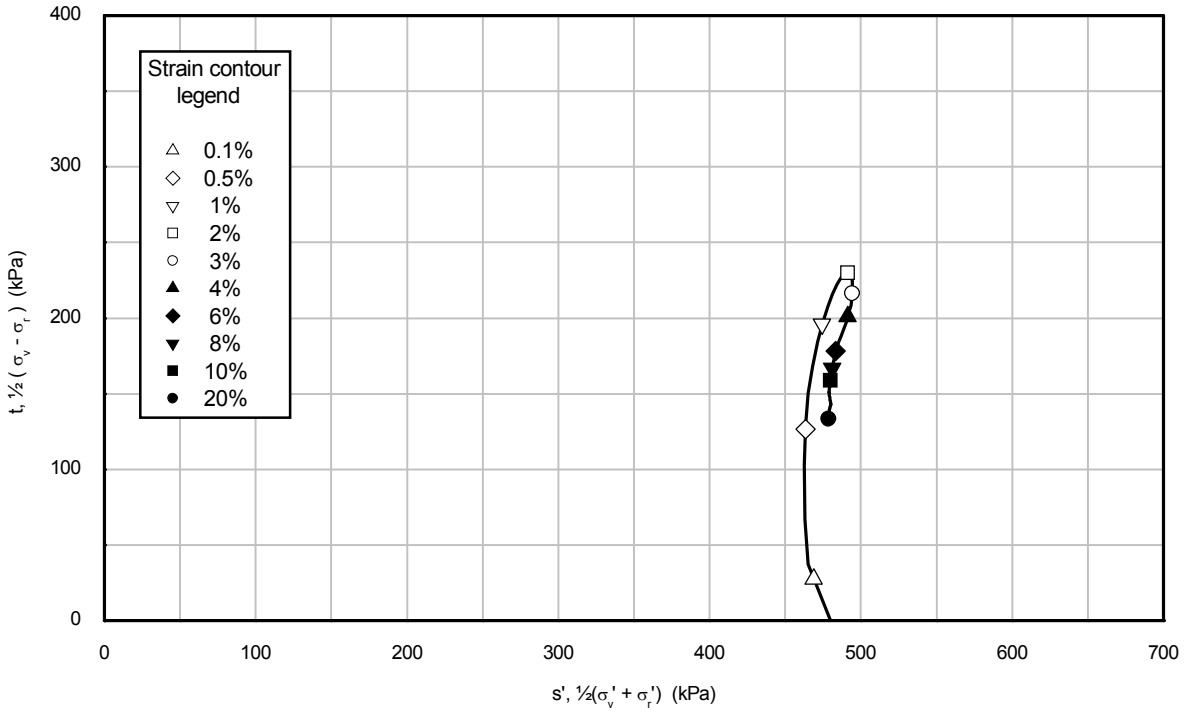
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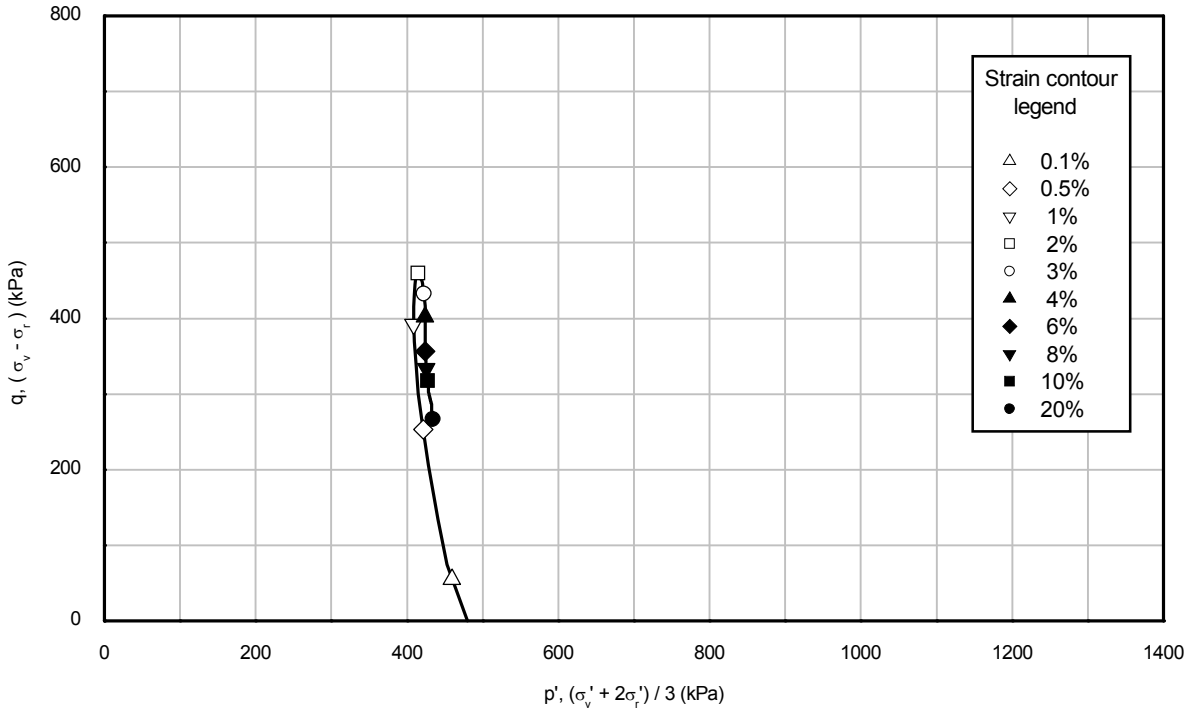


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	480	480	BH-WFS4-3	32WaxC	55.02

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	480	480	BH-WFS4-3	32WaxC	55.02

Drawn by: ER Date: 09/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-3_32WaxC_CU.OPJ

Template Issue: 4.1

Date : 10/11/2015

Checked by: ALB

Date : 11/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 09/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-4_34WaxB_CU.XLS
Template Issue: 2
Date: 10/11/2015
Checked by: AB
Date: 11/11/2015
Approved by: PH

VISUAL DESCRIPTION
Extremely high dark olive grey fine sandy CLAY.

GENERAL	
Date test started	30/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	49.7
Length	(mm)	99.8
Moisture content	(%)	24.2
Bulk density	(Mg/m³)	2.04
Dry density	(Mg/m³)	1.64
Void ratio		0.644
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	574
Cell pressure on completion	(kPa)	900
B value achieved		0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-4
Sample	34WaxB
Depth (m)	38.66

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	900
Back pressure	(kPa)	500
Effective cell pressure	(kPa)	400
Pore pressure on completion	(kPa)	500
Pore pressure dissipation	(%)	100
Moisture content	(%)	24.0
Bulk density	(Mg/m³)	2.04
Dry density	(Mg/m³)	1.65
Void ratio		0.638
Degree of saturation	(%)	100
Volumetric strain	(%)	0.35

Mode of failure: Plastic failure

Borehole	BH-WFS4-4
Sample	34WaxB
Depth (m)	38.66

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 09/11/2015 Drawn by: ER Filename: J11302 / EFFECTIV / BH-WFS4-4_34WaxB_CU.XLS Template Issue: 2 Date: 10/11/2015 Checked by: AB Date: 11/11/2015 Approved by: PH

Date: 09/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-4_34WaxB_CU.XLS
Template Issue: 2
Date: 10/11/2015
Checked by: AB
Date: 11/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	500
Initial effective cell pressure	(kPa)	400
Rate of strain	(%/hour)	0.28
At peak deviator stress		
Corrected deviator stress	(kPa)	628
Membrane correction applied	(kPa)	1.0
Drain correction applied	(kPa)	0
Axial strain	(%)	7.53
Excess pore pressure	(kPa)	98
Major principal effective stress	(kPa)	930
Minor principal effective stress	(kPa)	302
Principal effective stress ratio		3.08
Epsilon 50 (ε 50)	(%)	1.67
Secant modulus (E50) at ε 50	(kPa)	18798
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	567
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	4.28
Excess pore pressure	(kPa)	163
Major principal effective stress	(kPa)	804
Minor principal effective stress	(kPa)	237
Principal effective stress ratio		3.39
At 10% axial strain		
Corrected deviator stress	(kPa)	626
Membrane correction applied	(kPa)	1.3
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	67
Major principal effective stress	(kPa)	958
Minor principal effective stress	(kPa)	333
Principal effective stress ratio		2.88

FINAL CONDITIONS		
Moisture content	(%)	24.0
Bulk density	(Mg/m³)	2.04
Dry density	(Mg/m³)	1.65

Borehole	BH-WFS4-4
Sample	34WaxB
Depth (m)	38.66

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 09/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-4_34WaxB_CU.XLS
Checked by: AB
Date: 10/11/2015
Approved by: PH
Date: 11/11/2015

SPECIMEN PHOTOGRAPHS

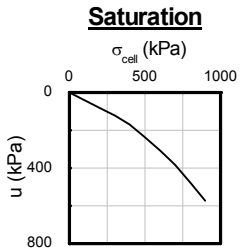


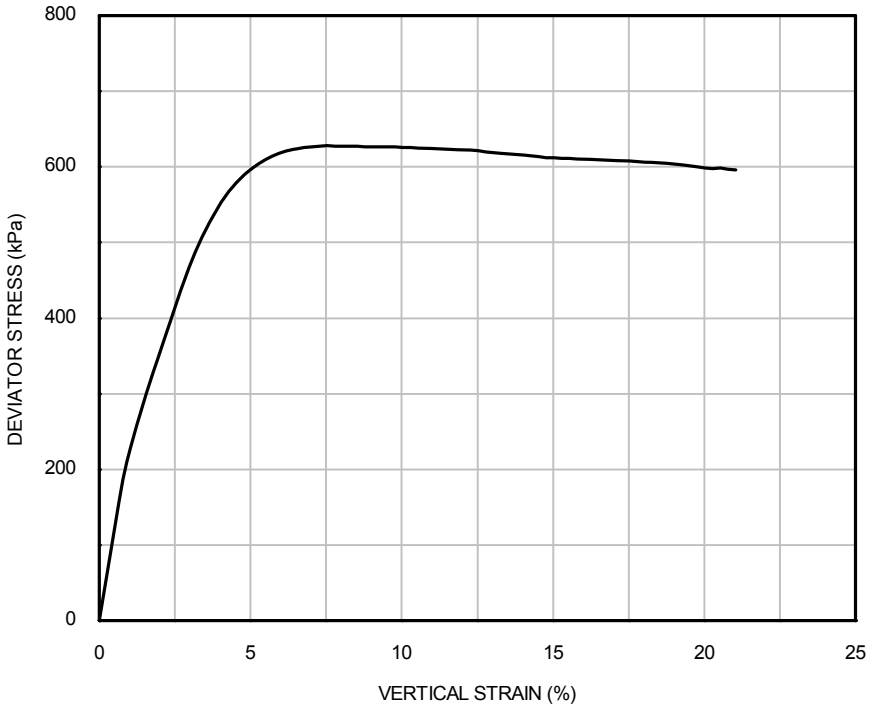
Borehole	BH-WFS4-4
Sample	34WaxB
Depth (m)	38.66

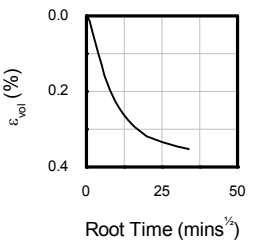
SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

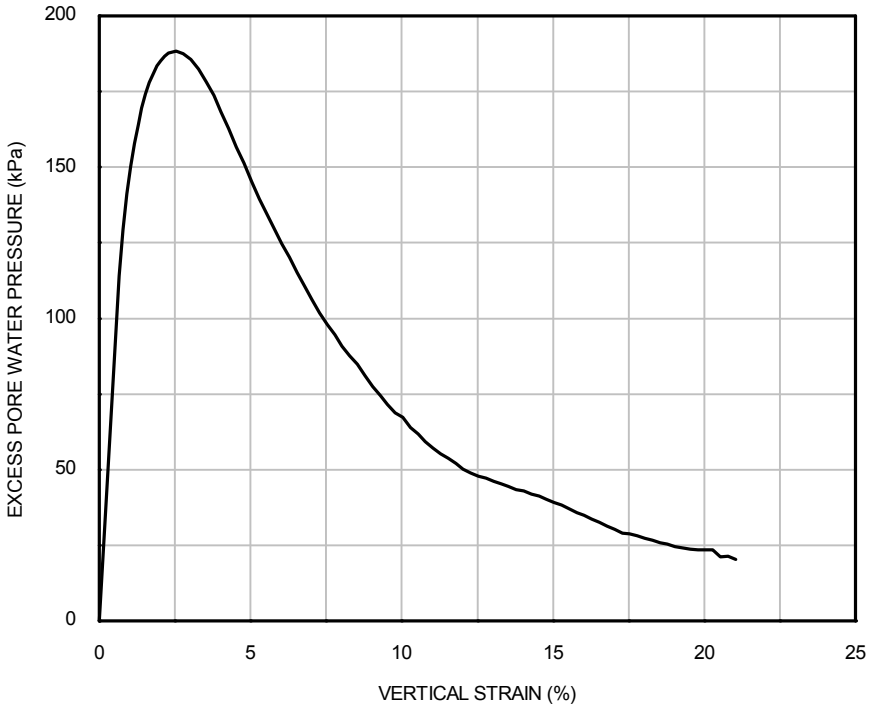
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Template Issue: 4.1 Filename: J11302 \ EFFECTIV \ BH-WFS4-4_34WaxB_CU.OPJ
Date : 10/11/2015 Date : 11/11/2015
Checked by: ALB Approved by: PH







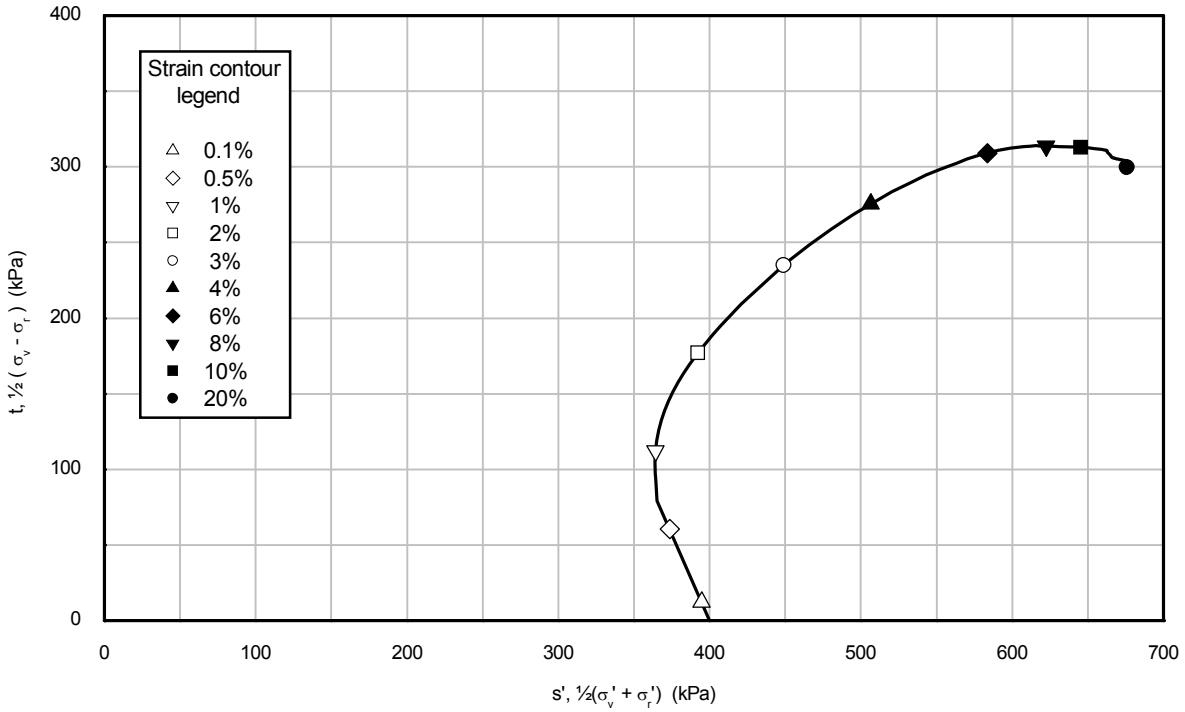
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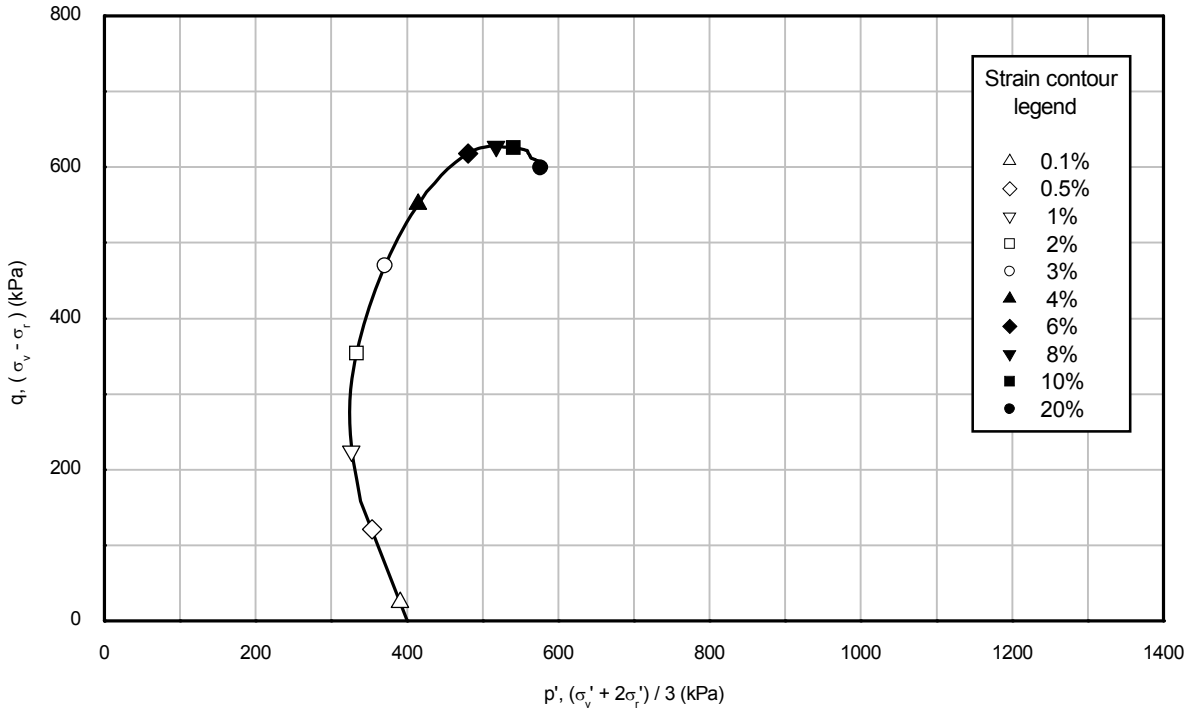


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	400	400	BH-WFS4-4	34WaxB	38.66

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	400	400	BH-WFS4-4	34WaxB	38.66

Drawn by: ER Date: 09/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-4_34WaxB_CU.OPJ

Template Issue: 4.1

Date : 10/11/2015

Checked by: ALB

Date : 11/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 18/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-4_37WaxB_CU.XLS
Date: 26/11/2015
Checked by: PH
Date: 26/11/2015
Approved by: PH

VISUAL DESCRIPTION
Very high strength dark greenish grey CLAY.

GENERAL	
Date test started	30/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	72.4
Length	(mm)	139.7
Moisture content	(%)	29.8
Bulk density	(Mg/m³)	1.95
Dry density	(Mg/m³)	1.50
Void ratio		0.797
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	400
Pore pressure on completion	(kPa)	707
Cell pressure on completion	(kPa)	1140
B value achieved		1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-4
Sample	37WaxB
Depth (m)	44.55

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 18/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-4_37WaxB_CU.XLS
Date: 26/11/2015
Checked by: PH
Date: 26/11/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	1140
Back pressure	(kPa)	700
Effective cell pressure	(kPa)	440
Pore pressure on completion	(kPa)	700
Pore pressure dissipation	(%)	100
Moisture content	(%)	29.9
Bulk density	(Mg/m³)	1.95
Dry density	(Mg/m³)	1.50
Void ratio		0.800
Degree of saturation	(%)	100
Volumetric strain	(%)	0.09

Mode of failure: Brittle failure

Borehole	BH-WFS4-4
Sample	37WaxB
Depth (m)	44.55

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 18/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-4_37WaxB_CU.XLS
Date: 26/11/2015
Checked by: PH
Date: 26/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	700
Initial effective cell pressure	(kPa)	440
Rate of strain	(%/hour)	0.12
At peak deviator stress		
Corrected deviator stress	(kPa)	377
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	9.69
Excess pore pressure	(kPa)	48
Major principal effective stress	(kPa)	768
Minor principal effective stress	(kPa)	392
Principal effective stress ratio		1.96
Epsilon 50 (ε 50)	(%)	1.14
Secant modulus (E50) at ε 50	(kPa)	16502
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	360
Membrane correction applied	(kPa)	0.7
Drain correction applied	(kPa)	0
Axial strain	(%)	7.44
Excess pore pressure	(kPa)	117
Major principal effective stress	(kPa)	683
Minor principal effective stress	(kPa)	323
Principal effective stress ratio		2.11
At 10% axial strain		
Corrected deviator stress	(kPa)	376
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	42
Major principal effective stress	(kPa)	774
Minor principal effective stress	(kPa)	398
Principal effective stress ratio		1.95

FINAL CONDITIONS		
Moisture content	(%)	29.9
Bulk density	(Mg/m³)	1.95
Dry density	(Mg/m³)	1.50

Borehole	BH-WFS4-4
Sample	37WaxB
Depth (m)	44.55

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 18/11/2015

Template Issue: 2

Filename: J11302 / EFFECTIV / BH-WFS4-4_37WaxB_CU.XLS

Checked by: PH Date: 26/11/2015

Approved by: PH Date: 26/11/2015

SPECIMEN PHOTOGRAPHS





Borehole	BH-WFS4-4
Sample	37WaxB
Depth (m)	44.55

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

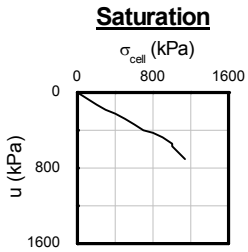
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

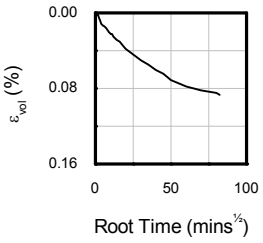
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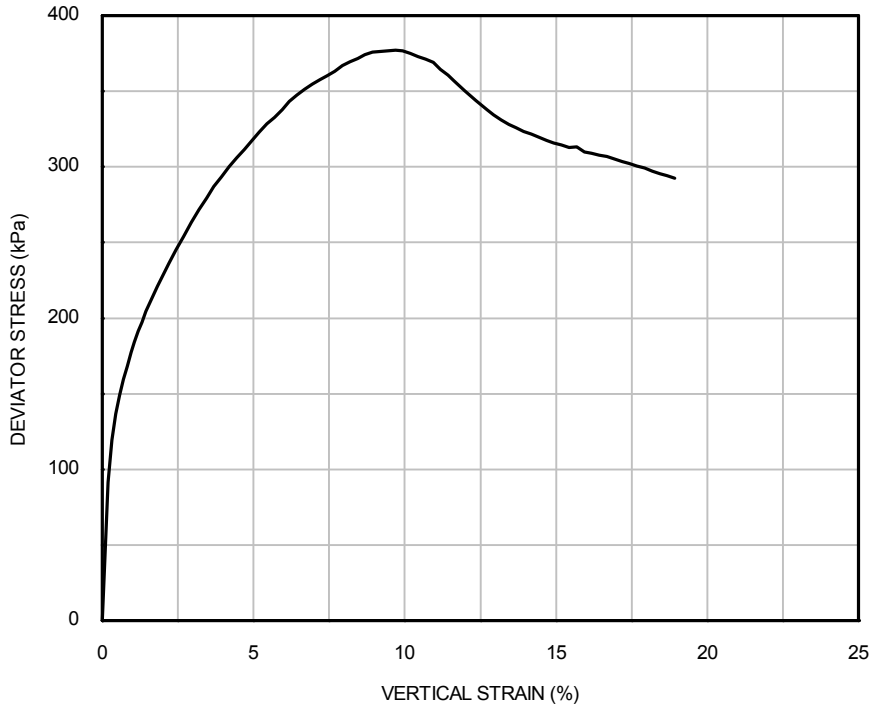
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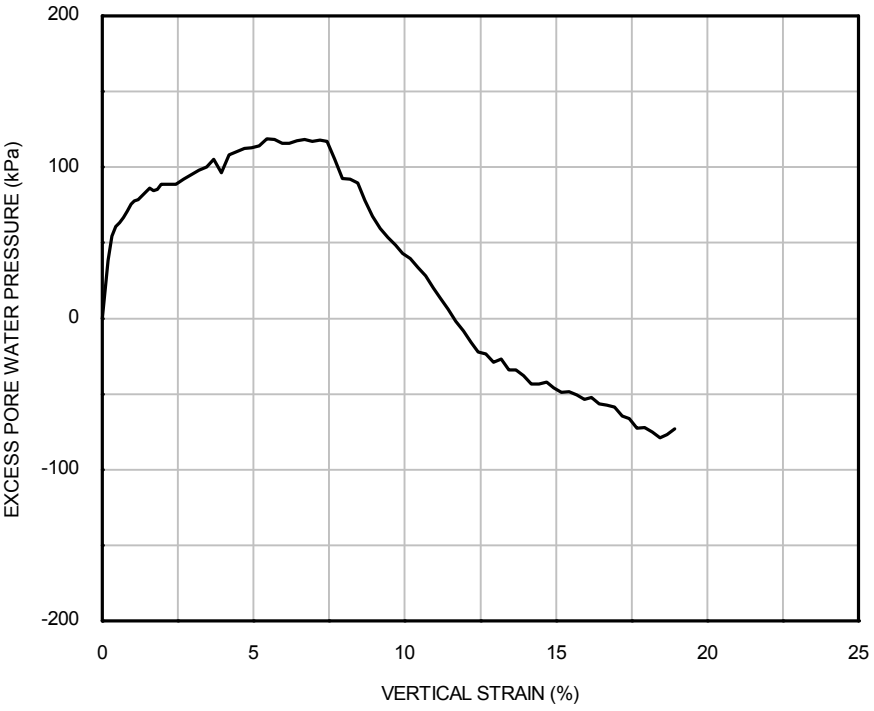
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Consolidation

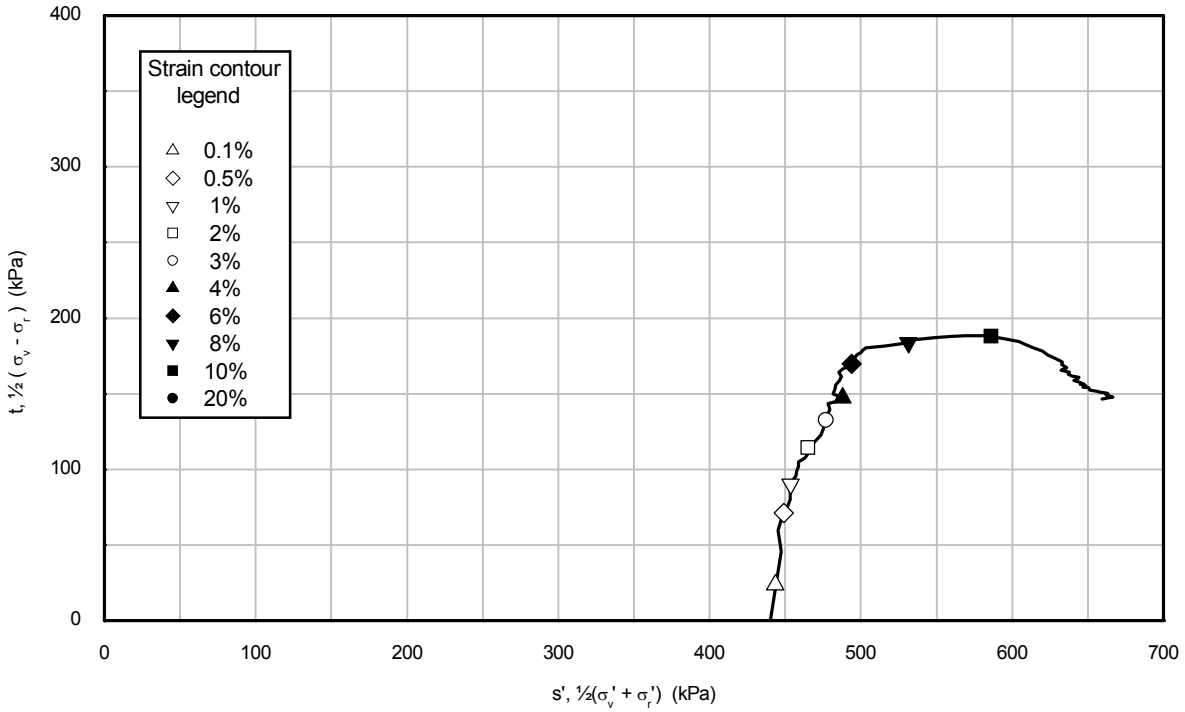


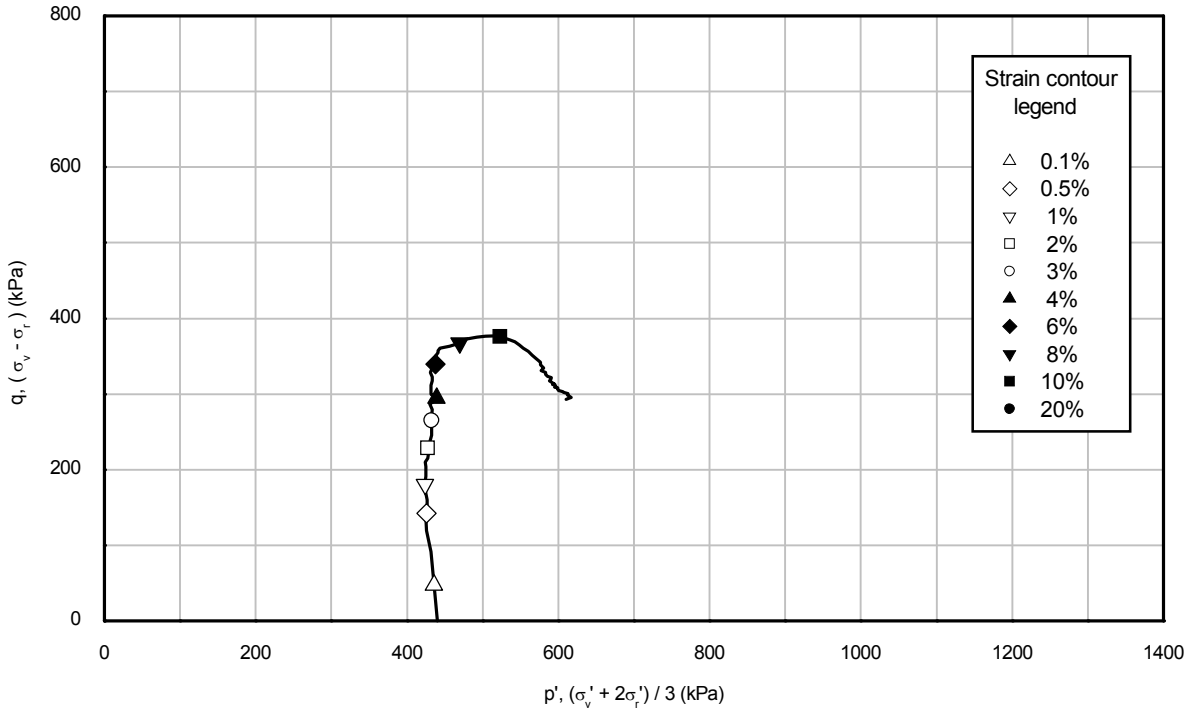


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	440	440	BH-WFS4-4	37WaxB	44.55

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	440	440	BH-WFS4-4	37WaxB	44.55

Drawn by: ALB Date: 18/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-4_37WaxB_CU.OPJ Date : 26/11/2015

Template Issue: 4.1 Date : 26/11/2015

Checked by: PH Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 03/11/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS4-5_35WaxB_CU.XLS
Template Issue: 2
Date: 05/11/2015
Checked by: PH
Date: 05/11/2015
Approved by: PH

VISUAL DESCRIPTION
Extremely high strength dark greenish grey clayey fine to medium SAND with pockets of light grey silt.

GENERAL	
Date test started	30/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.8
Length	(mm)	139.8
Moisture content	(%)	24.6
Bulk density	(Mg/m³)	2.02
Dry density	(Mg/m³)	1.62
Void ratio		0.662
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	752
Cell pressure on completion	(kPa)	810
B value achieved		0.98

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-5
Sample	35WaxB
Depth (m)	39.16

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	810
Back pressure	(kPa)	400
Effective cell pressure	(kPa)	410
Pore pressure on completion	(kPa)	400
Pore pressure dissipation	(%)	100
Moisture content	(%)	23.1
Bulk density	(Mg/m³)	2.05
Dry density	(Mg/m³)	1.66
Void ratio		0.624
Degree of saturation	(%)	100
Volumetric strain	(%)	2.30

Mode of failure: Brittle failure

Borehole	BH-WFS4-5
Sample	35WaxB
Depth (m)	39.16

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 03/11/2015 Drawn by: ALB Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS4-5_35WaxB_CU.XLS Date: 05/11/2015 Checked by: PH Date: 05/11/2015 Approved by: PH

Date: 03/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-5_35WaxB_CU.XLS
Date: 05/11/2015
Checked by: PH
Date: 05/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	410
Rate of strain	(%/hour)	0.44
At peak deviator stress		
Corrected deviator stress	(kPa)	984
Membrane correction applied	(kPa)	1.3
Drain correction applied	(kPa)	0
Axial strain	(%)	16.01
Excess pore pressure	(kPa)	-28
Major principal effective stress	(kPa)	1422
Minor principal effective stress	(kPa)	438
Principal effective stress ratio		3.25
Epsilon 50 (ε 50)	(%)	2.52
Secant modulus (E50) at ε 50	(kPa)	19492
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	686
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	5.25
Excess pore pressure	(kPa)	139
Major principal effective stress	(kPa)	957
Minor principal effective stress	(kPa)	271
Principal effective stress ratio		3.53
At 10% axial strain		
Corrected deviator stress	(kPa)	881
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	52
Major principal effective stress	(kPa)	1239
Minor principal effective stress	(kPa)	358
Principal effective stress ratio		3.46

FINAL CONDITIONS		
Moisture content	(%)	23.1
Bulk density	(Mg/m³)	2.05
Dry density	(Mg/m³)	1.66

Borehole	BH-WFS4-5
Sample	35WaxB
Depth (m)	39.16

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Checked by: PH Date: 05/11/2015 Approved by: PH Date: 05/11/2015 Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS4-5_35WaxB_CU.XLS Drawn by: ALB Date: 03/11/2015

SPECIMEN PHOTOGRAPHS



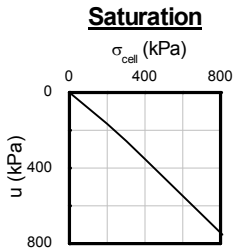


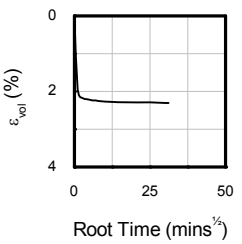
Borehole	BH-WFS4-5
Sample	35WaxB
Depth (m)	39.16

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

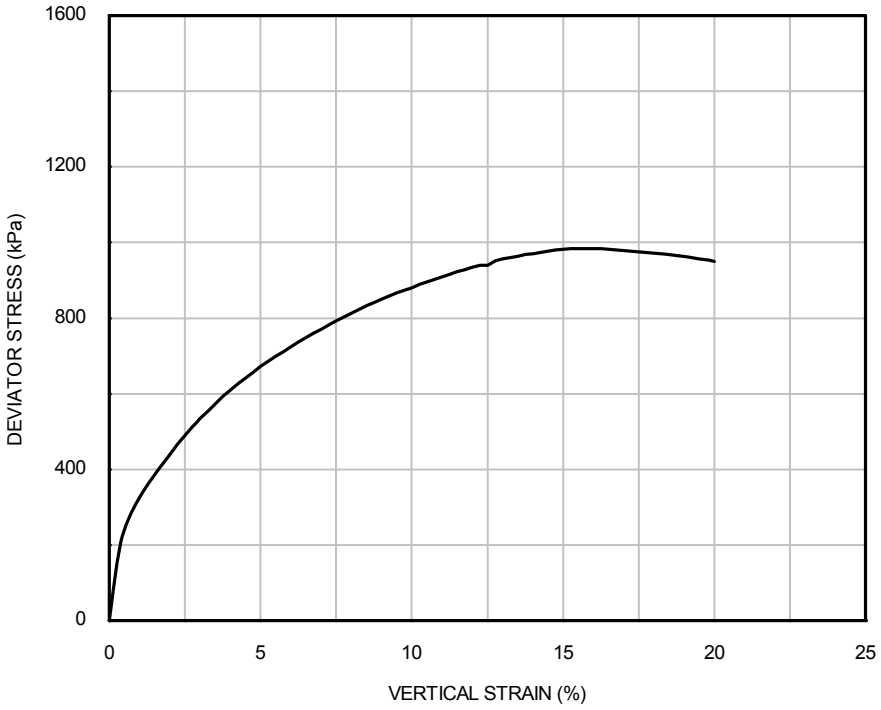
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

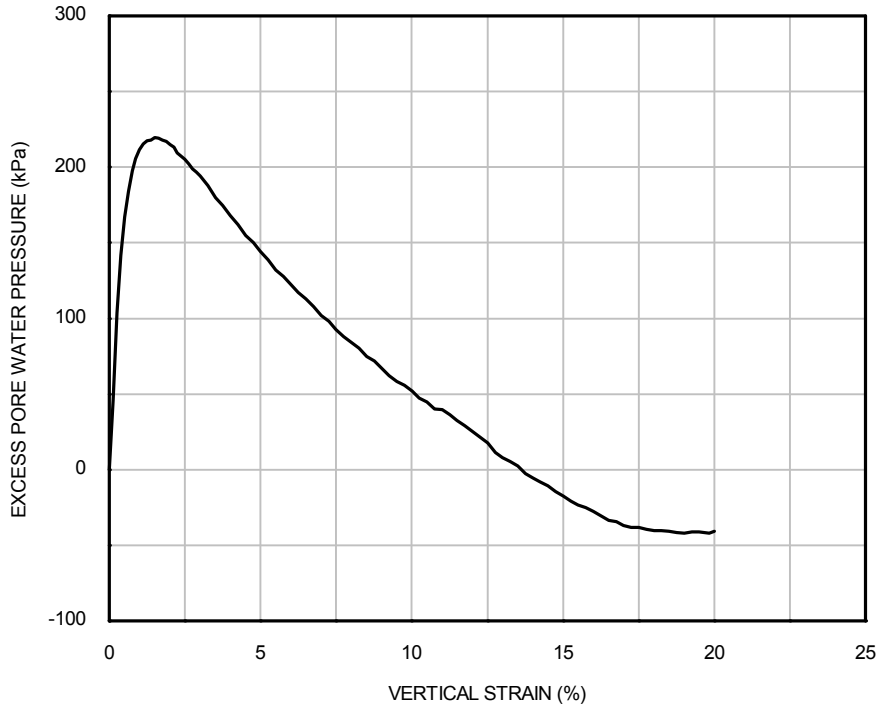
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Filename: J11302 \ EFFECTIV \ BH-WFS4-5_35WaxB_CU.OPJ
Template Issue: 4.1
Date : 06/11/2015
Checked by: PH
Date : 06/11/2015
Approved by: PH





Consolidation

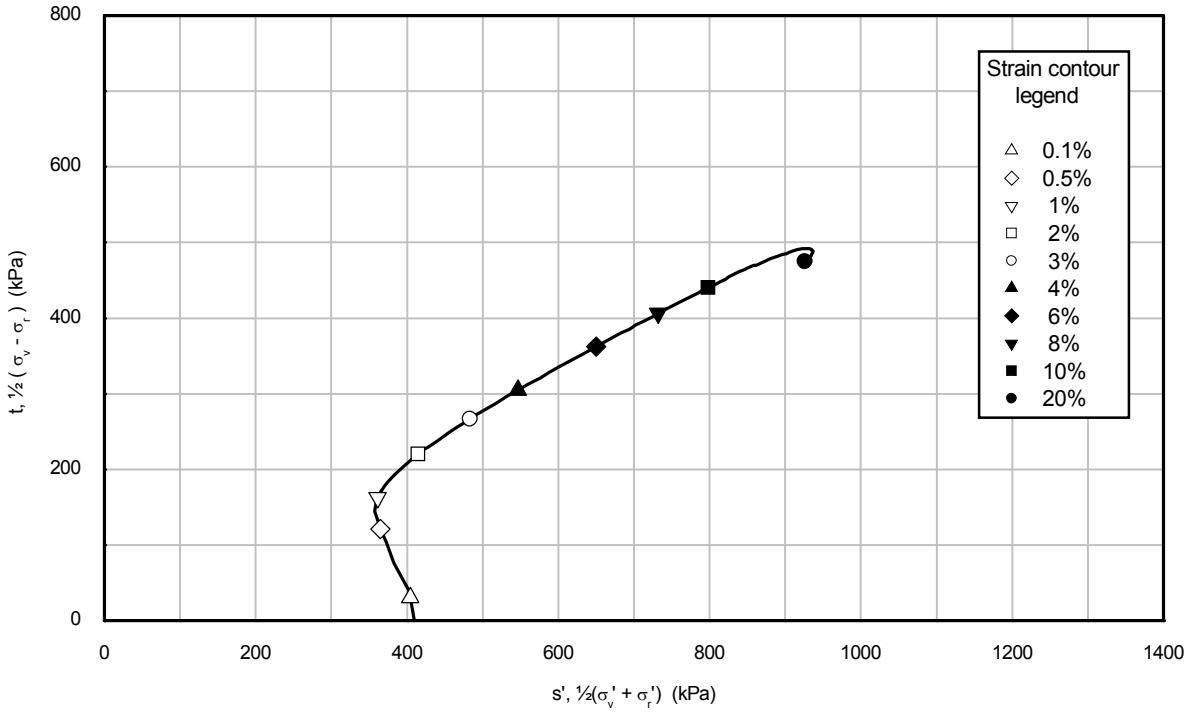


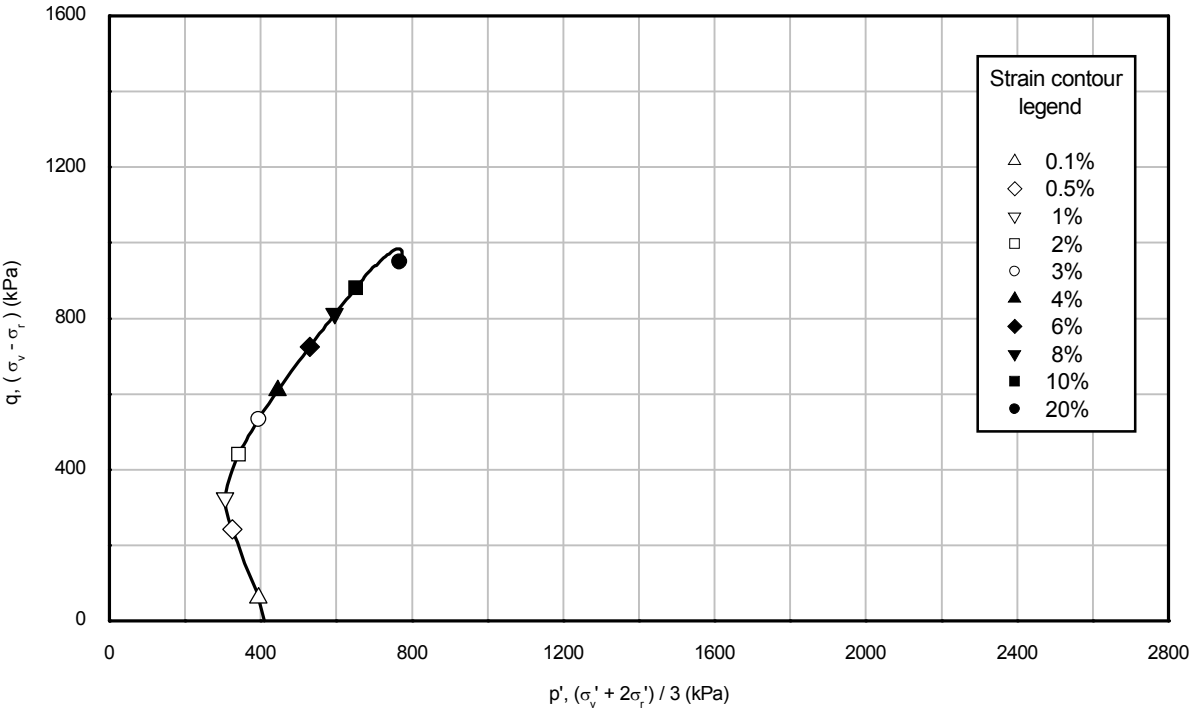


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	410	410	BH-WFS4-5	35WaxB	39.16

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	410	410	BH-WFS4-5	35WaxB	39.16

Drawn by: ALB Date: 03/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-5_35WaxB_CU.OPJ

Template Issue: 4.1

Date : 06/11/2015

Checked by: PH

Date : 06/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 13/11/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-5_38WaxB_CU.XLS
Template Issue: 2
Date: 16/11/2015
Checked by: AB
Date: 16/11/2015
Approved by: PH

VISUAL DESCRIPTION
Very high strength dark greenish grey CLAY.

GENERAL	
Date test started	30/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	73.2
Length	(mm)	139.5
Moisture content	(%)	31.5
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.47
Void ratio		0.860
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	50
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	523
Cell pressure on completion	(kPa)	960
B value achieved		1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-5
Sample	38WaxB
Depth (m)	48.09

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 13/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-5_38WaxB_CU.XLS
Date: 16/11/2015
Checked by: AB
Approved by: PH
Date: 16/11/2015

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	960
Back pressure	(kPa)	500
Effective cell pressure	(kPa)	460
Pore pressure on completion	(kPa)	500
Pore pressure dissipation	(%)	100
Moisture content	(%)	31.4
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.47
Void ratio		0.858
Degree of saturation	(%)	100
Volumetric strain	(%)	0.13

Mode of failure: Brittle failure

Borehole	BH-WFS4-5
Sample	38WaxB
Depth (m)	48.09

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 13/11/2015
Drawn by: ER
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-5_38WaxB_CU.XLS
Date: 16/11/2015
Checked by: AB
Date: 16/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	500
Initial effective cell pressure	(kPa)	460
Rate of strain	(%/hour)	0.42
At peak deviator stress		
Corrected deviator stress	(kPa)	352
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	5.36
Excess pore pressure	(kPa)	136
Major principal effective stress	(kPa)	676
Minor principal effective stress	(kPa)	324
Principal effective stress ratio		2.09
Epsilon 50 (ε 50)	(%)	0.77
Secant modulus (E50) at ε 50	(kPa)	23011
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	352
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	5.11
Excess pore pressure	(kPa)	139
Major principal effective stress	(kPa)	673
Minor principal effective stress	(kPa)	321
Principal effective stress ratio		2.10
At 10% axial strain		
Corrected deviator stress	(kPa)	251
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	67
Major principal effective stress	(kPa)	643
Minor principal effective stress	(kPa)	393
Principal effective stress ratio		1.64

FINAL CONDITIONS		
Moisture content	(%)	31.4
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.47

Borehole	BH-WFS4-5
Sample	38WaxB
Depth (m)	48.09

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Checked by: AB Date: 16/11/2015 Approved by: PH Date: 16/11/2015 Filename: J11302 / EFFECTIV / BH-WFS4-5_38WaxB_CU.XLS Template Issue: 2 Drawn by: ER Date: 13/11/2015

SPECIMEN PHOTOGRAPHS



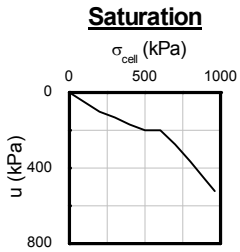


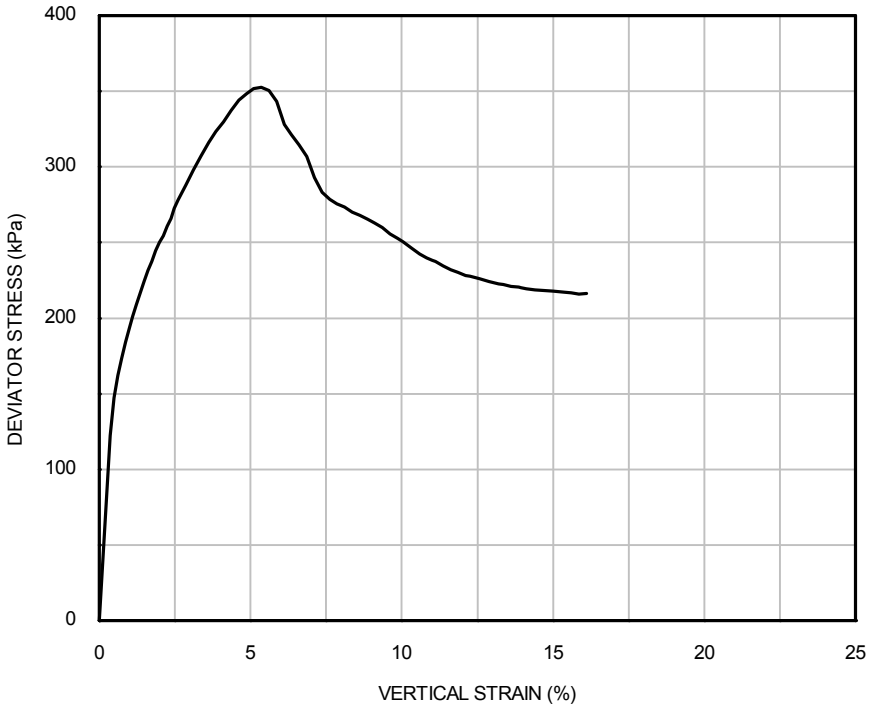
Borehole	BH-WFS4-5
Sample	38WaxB
Depth (m)	48.09

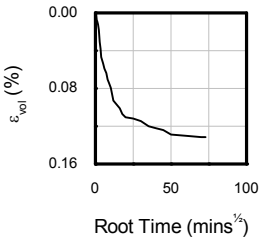
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

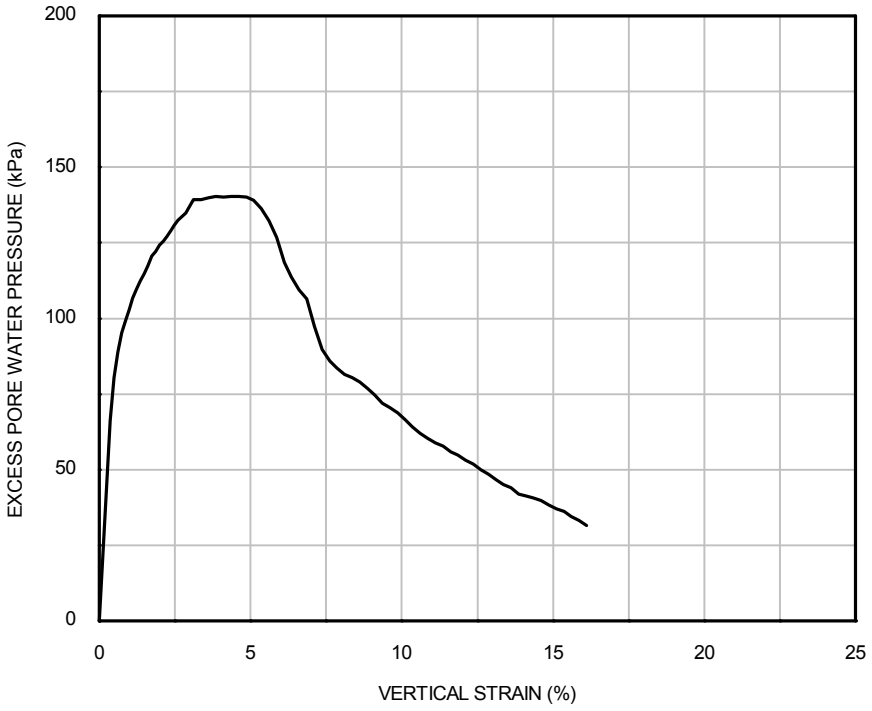
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 13/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-5_38WaxB_CU.OPJ
Template Issue: 4.1
Date : 16/11/2015
Checked by: ALB
Date : 16/11/2015
Approved by: PH





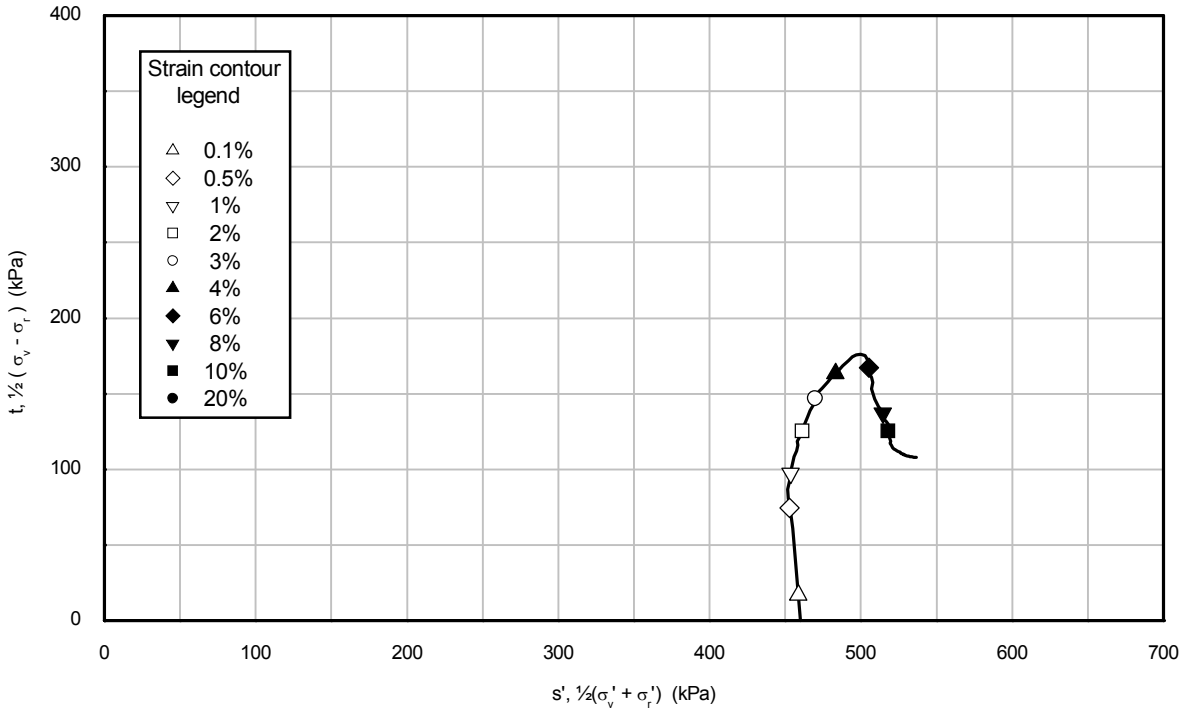


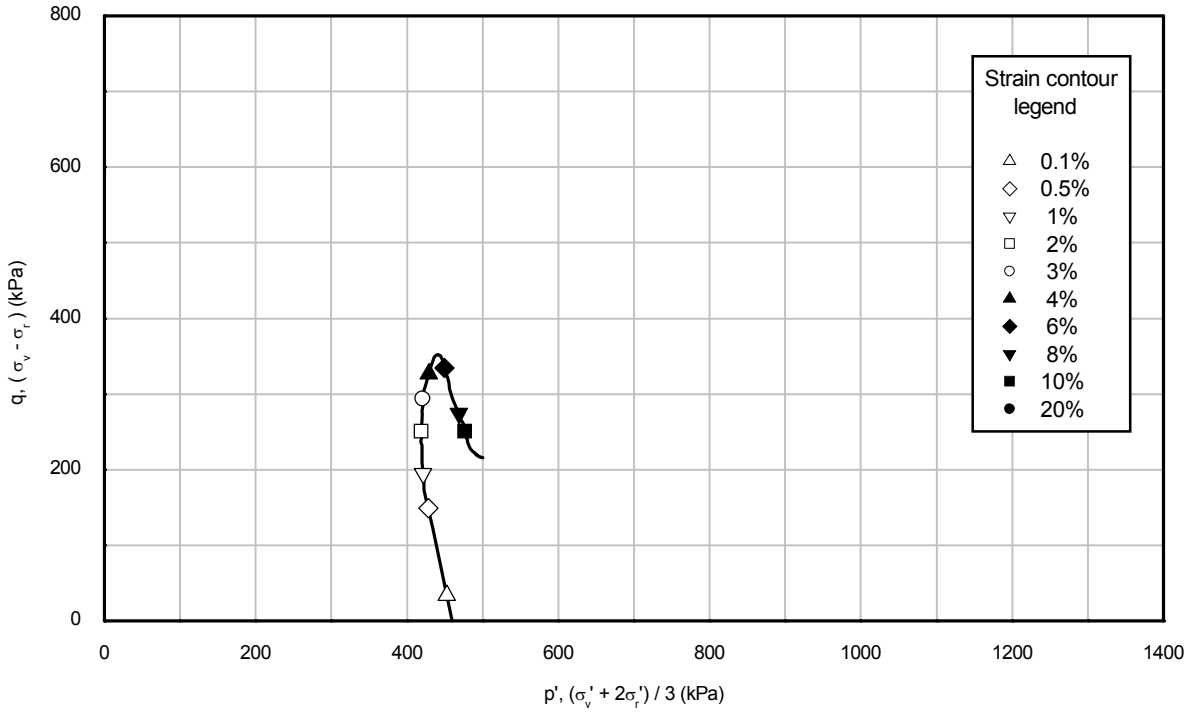


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	460	460	BH-WFS4-5	38WaxB	48.09

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	460	460	BH-WFS4-5	38WaxB	48.09

Drawn by: ER Date: 13/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-5_38WaxB_CU.OPJ

Template Issue: 4.1

Date : 16/11/2015

Checked by: ALB

Date :

Approved by:

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 17/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-7_12WaxE_CU.XLS
Date: 19/11/2015
Checked by: PH
Date: 19/11/2015
Approved by: PH

VISUAL DESCRIPTION
High strength very dark greyish brown CLAY with pockets of fine sand.

GENERAL	
Date test started	15/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.7
Length	(mm)	139.7
Moisture content	(%)	20.6
Bulk density	(Mg/m³)	2.10
Dry density	(Mg/m³)	1.74
Void ratio		0.551
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	100
Pore pressure on completion	(kPa)	581
Cell pressure on completion	(kPa)	750
B value achieved		0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-7
Sample	12WaxE
Depth (m)	10.05

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 17/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-7_12WaxE_CU.XLS
Date: 19/11/2015
Checked by: PH
Date: 19/11/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	750
Back pressure	(kPa)	550
Effective cell pressure	(kPa)	200
Pore pressure on completion	(kPa)	550
Pore pressure dissipation	(%)	100
Moisture content	(%)	21.2
Bulk density	(Mg/m³)	2.09
Dry density	(Mg/m³)	1.72
Void ratio		0.569
Degree of saturation	(%)	100
Volumetric strain	(%)	-0.47

Mode of failure: Brittle failure

Borehole	BH-WFS4-7
Sample	12WaxE
Depth (m)	10.05

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 17/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-7_12WaxE_CU.XLS
Date: 19/11/2015
Checked by: PH
Date: 19/11/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	550
Initial effective cell pressure	(kPa)	200
Rate of strain	(%/hour)	0.28
At peak deviator stress		
Corrected deviator stress	(kPa)	274
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	6.48
Excess pore pressure	(kPa)	-33
Major principal effective stress	(kPa)	507
Minor principal effective stress	(kPa)	233
Principal effective stress ratio		2.17
Epsilon 50 (ε 50)	(%)	0.81
Secant modulus (E50) at ε 50	(kPa)	16814
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	253
Membrane correction applied	(kPa)	0.4
Drain correction applied	(kPa)	0
Axial strain	(%)	4.23
Excess pore pressure	(kPa)	-8
Major principal effective stress	(kPa)	461
Minor principal effective stress	(kPa)	208
Principal effective stress ratio		2.21
At 10% axial strain		
Corrected deviator stress	(kPa)	250
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	-51
Major principal effective stress	(kPa)	501
Minor principal effective stress	(kPa)	251
Principal effective stress ratio		2.00

FINAL CONDITIONS		
Moisture content	(%)	21.2
Bulk density	(Mg/m³)	2.09
Dry density	(Mg/m³)	1.72

Borehole	BH-WFS4-7
Sample	12WaxE
Depth (m)	10.05

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 17/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-7_12WaxE_CU.XLS
Checked by: PH Date: 19/11/2015
Approved by: PH Date: 19/11/2015

SPECIMEN PHOTOGRAPHS



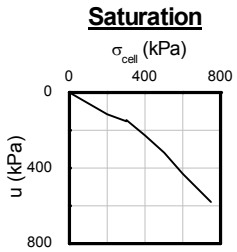


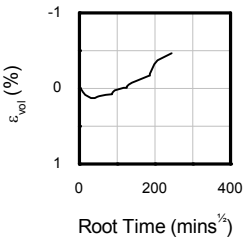
Borehole	BH-WFS4-7
Sample	12WaxE
Depth (m)	10.05

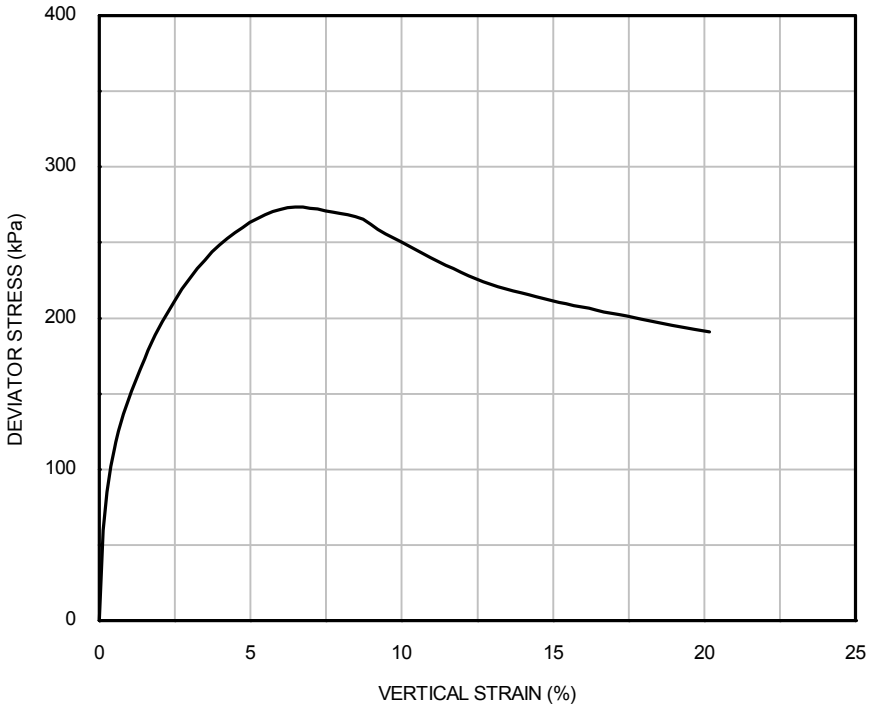
SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

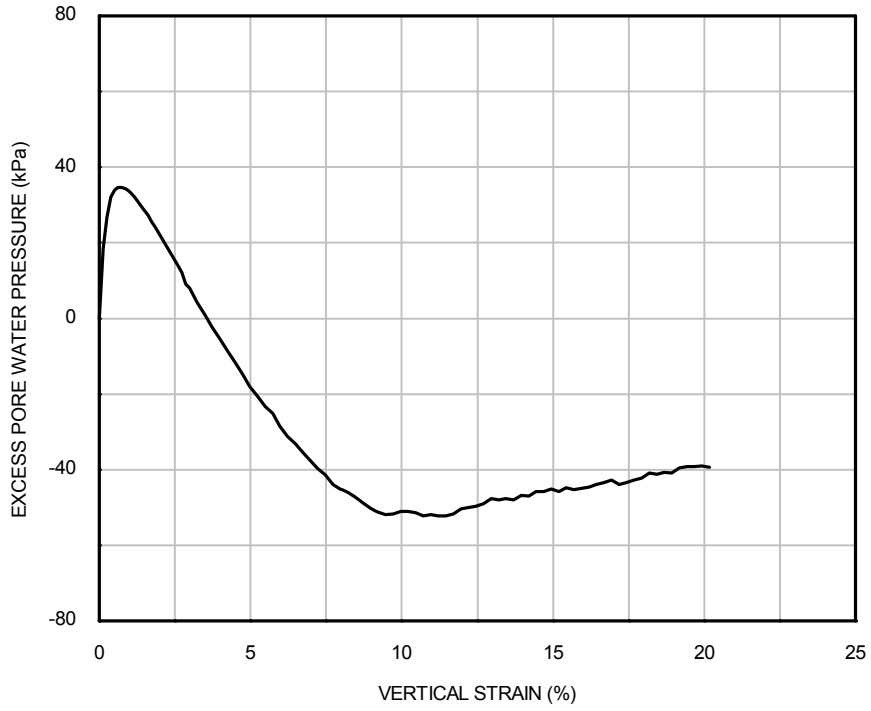
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 17/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-7_12WaxE_CU.OPJ Template Issue: 4.1
Date : 19/11/2015
Checked by: PH
Date : 19/11/2015
Approved by: PH





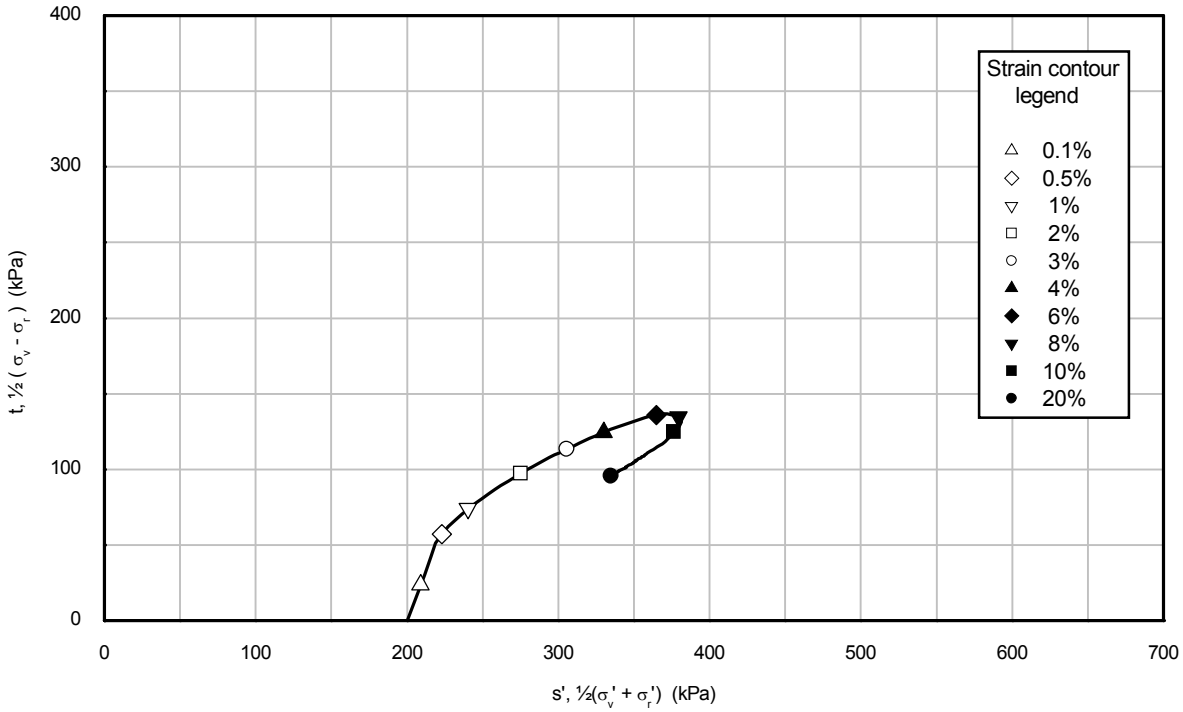


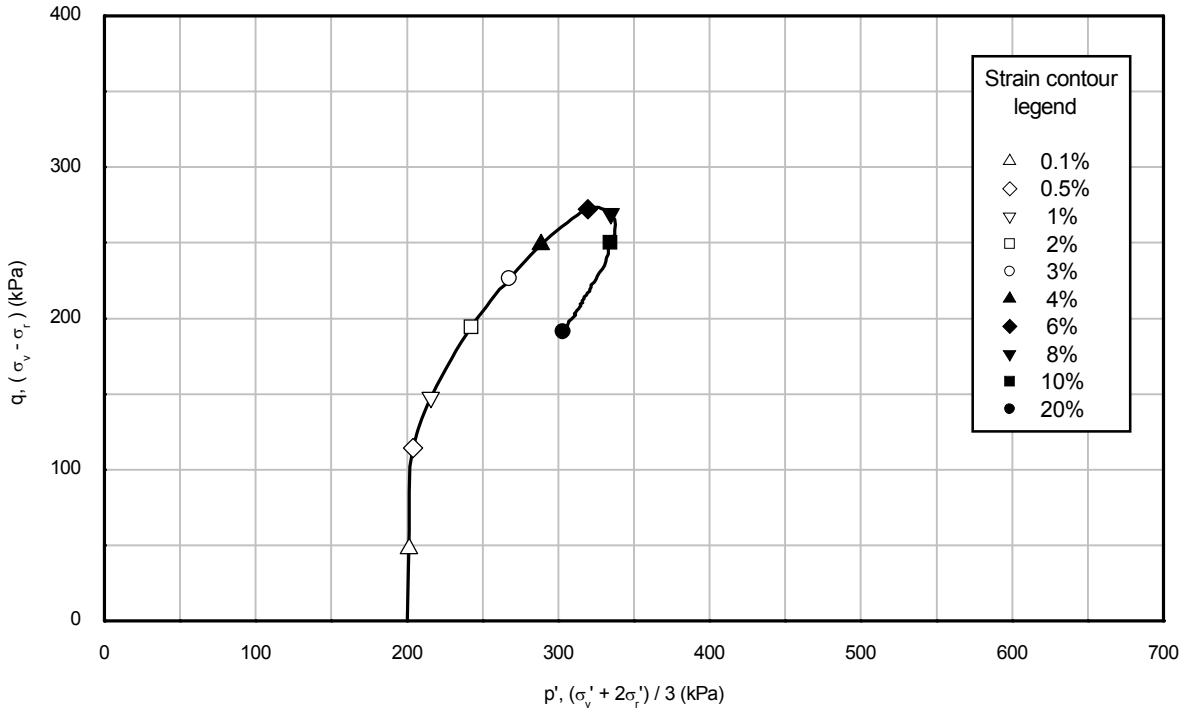


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	120	120	BH-WFS4-7	12WaxE	10.05

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	120	120	BH-WFS4-7	12WaxE	10.05

Drawn by: ALB Date: 17/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-7_12WaxE_CU.OPJ

Template Issue: 4.1

Date : 19/11/2015

Checked by: PH

Date : 19/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 01/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS4-7_21WaxC_CU.XLS
Template Issue: 2
Date: 09/12/2015
Checked by: PH
Date: 09/12/2015
Approved by: PH

VISUAL DESCRIPTION
Very high strength dark greenish grey CLAY.

GENERAL	
Date test started	15/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.0
Length	(mm)	139.5
Moisture content	(%)	30.9
Bulk density	(Mg/m³)	1.94
Dry density	(Mg/m³)	1.49
Void ratio		0.818
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	532
Cell pressure on completion	(kPa)	810
B value achieved		0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-7
Sample	21WaxC
Depth (m)	22.30

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	810
Back pressure	(kPa)	450
Effective cell pressure	(kPa)	360
Pore pressure on completion	(kPa)	450
Pore pressure dissipation	(%)	100
Moisture content	(%)	30.6
Bulk density	(Mg/m³)	1.95
Dry density	(Mg/m³)	1.49
Void ratio		0.811
Degree of saturation	(%)	100
Volumetric strain	(%)	0.36

Mode of failure: Brittle failure

Borehole	BH-WFS4-7
Sample	21WaxC
Depth (m)	22.30

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 01/12/2015
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-7_21WaxC_CU.XLS
Checked by: PH Date: 09/12/2015
Approved by: PH Date: 09/12/2015

Date: 01/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS4-7_21WaxC_CU.XLS
Date: 09/12/2015
Checked by: PH
Date: 09/12/2015
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	450
Initial effective cell pressure	(kPa)	360
Rate of strain	(%/hour)	0.23
At peak deviator stress		
Corrected deviator stress	(kPa)	330
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	4.75
Excess pore pressure	(kPa)	72
Major principal effective stress	(kPa)	619
Minor principal effective stress	(kPa)	288
Principal effective stress ratio		2.15
Epsilon 50 (ε 50)	(%)	0.59
Secant modulus (E50) at ε 50	(kPa)	27813
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	330
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	4.75
Excess pore pressure	(kPa)	72
Major principal effective stress	(kPa)	619
Minor principal effective stress	(kPa)	288
Principal effective stress ratio		2.15
At 10% axial strain		
Corrected deviator stress	(kPa)	225
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	8
Major principal effective stress	(kPa)	577
Minor principal effective stress	(kPa)	352
Principal effective stress ratio		1.64

FINAL CONDITIONS		
Moisture content	(%)	30.6
Bulk density	(Mg/m³)	1.95
Dry density	(Mg/m³)	1.49

Borehole	BH-WFS4-7
Sample	21WaxC
Depth (m)	22.30

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 01/12/2015

Template Issue: 2

Filename: J11302 / EFFECTIV / BH-WFS4-7_21WaxC_CU.XLS

Checked by: PH Date: 09/12/2015

Approved by: PH Date: 09/12/2015

SPECIMEN PHOTOGRAPHS



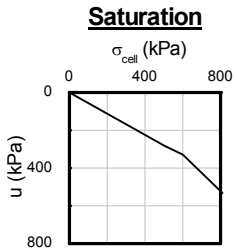


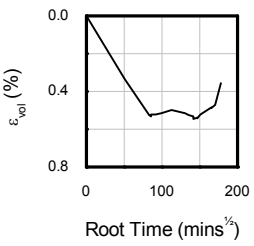
Borehole	BH-WFS4-7
Sample	21WaxC
Depth (m)	22.30

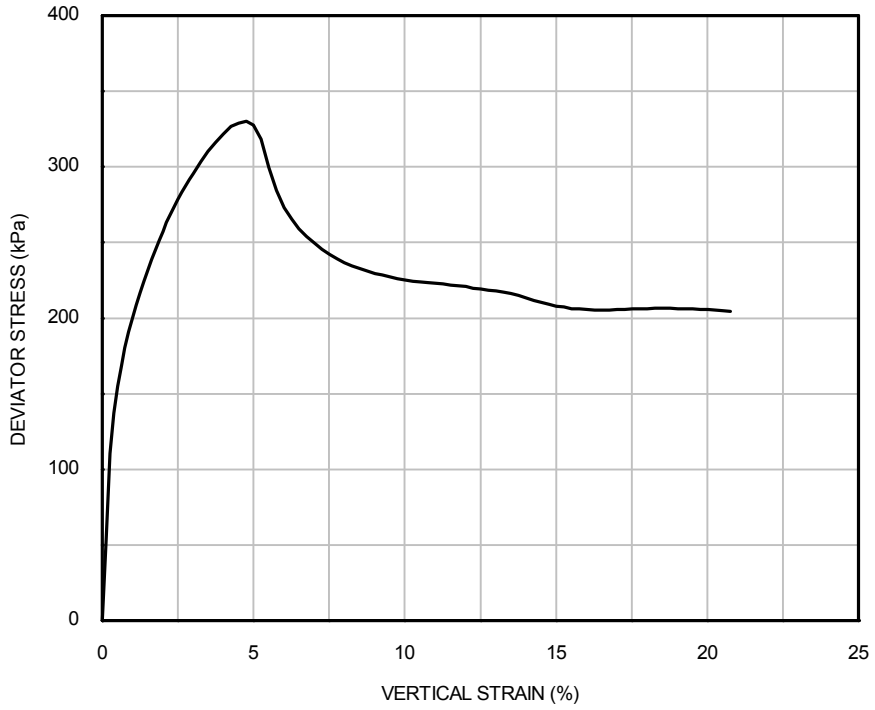
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

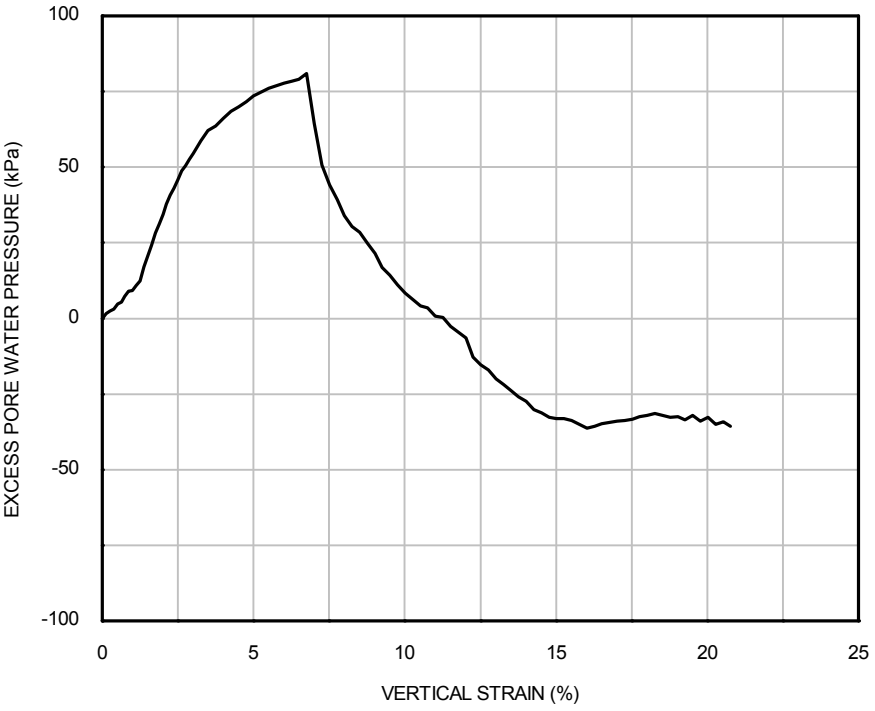
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 01/12/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-7_21WaxC_CU.OPJ
Template Issue: 4.1
Date : 09/12/2015
Checked by: PH
Date : 09/12/2015
Approved by: PH





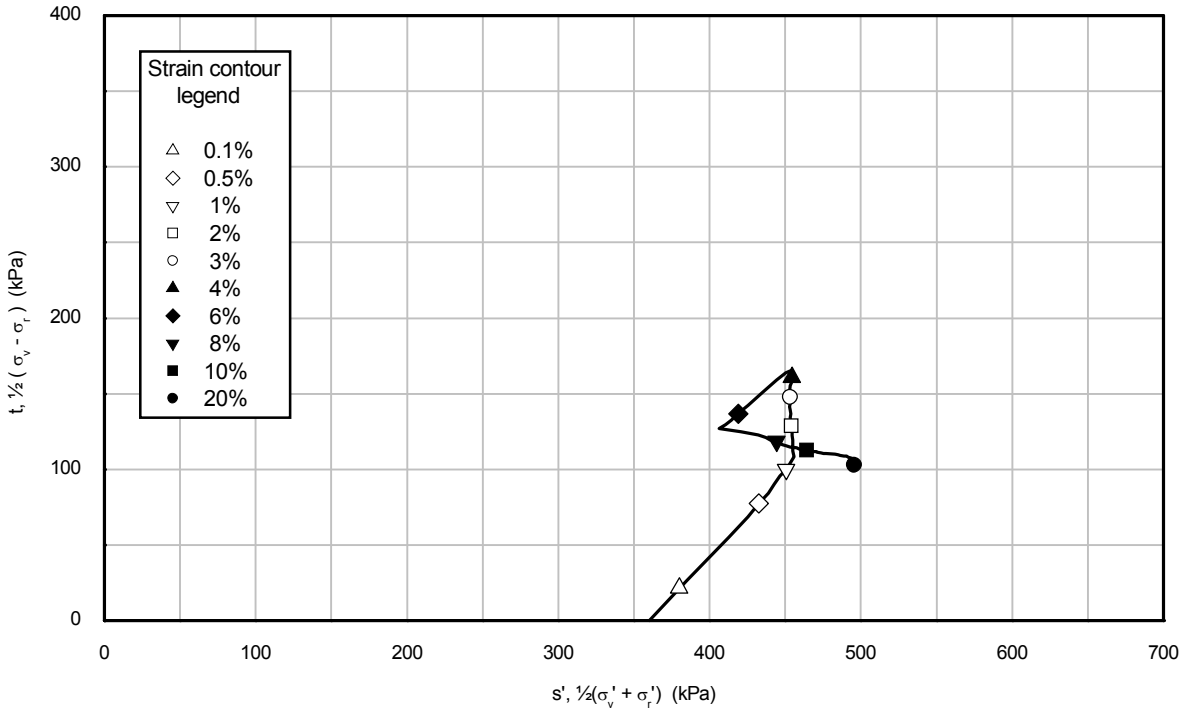


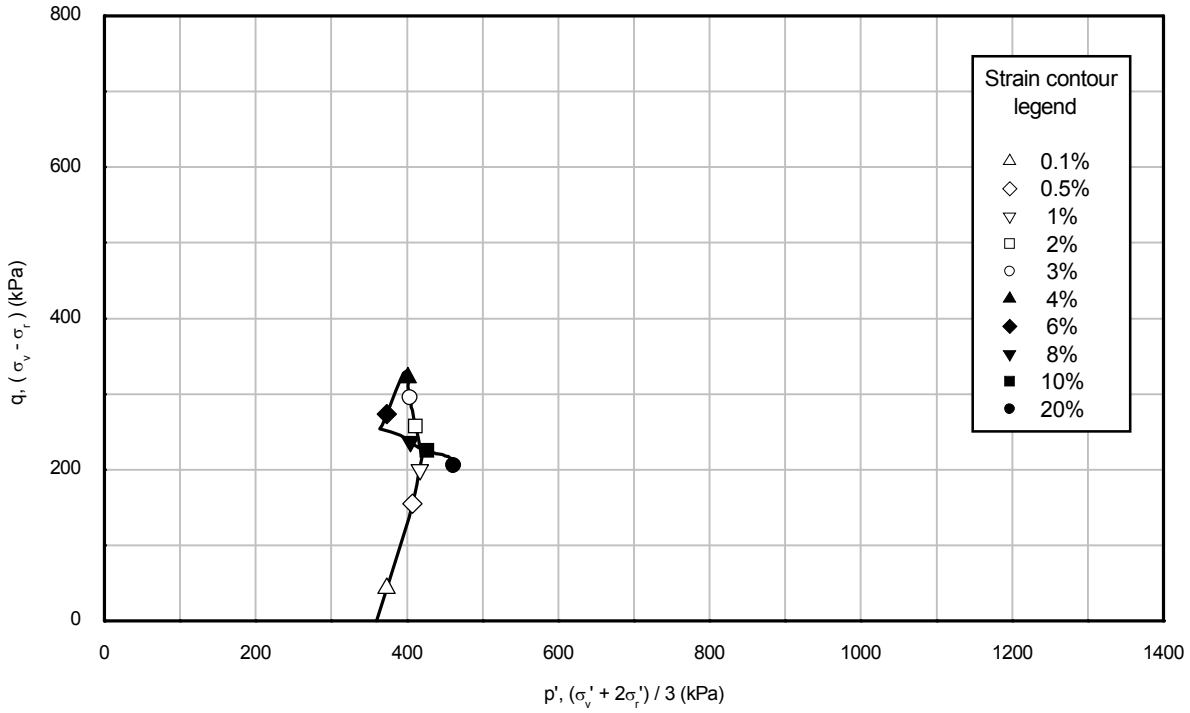


Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	220	220	BH-WFS4-7	21WaxC	22.30

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	220	220	BH-WFS4-7	21WaxC	22.30

Drawn by: ALB Date: 01/12/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-7_21WaxC_CU.OPJ Template Issue: 4.1

Date : 09/12/2015

Checked by: PH

Date : 09/12/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS4-1A_17BagA_D3.XLS
Template Issue: 7
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

VISUAL DESCRIPTION
Dark greyish brown fine to medium SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	19/10/2015	19/10/2015	19/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	9.6	9.6	9.6
Bulk density	(Mg/m³)	1.82	1.82	1.82
Dry density	(Mg/m³)	1.66	1.66	1.66
Void ratio		0.592	0.600	0.600
Degree of saturation	(%)	43	42	42

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	571	759	1302
Cell pressure on completion	(kPa)	590	780	1360
B value achieved		0.96	0.98	0.95

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-1A	BH-WFS4-1A	BH-WFS4-1A
Sample	17BagA	17BagA	17BagA
Depth (m)	22.50	22.50	22.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	590	780	1360
Back pressure	(kPa)	350	300	400
Effective cell pressure	(kPa)	240	480	960
Pore pressure on completion	(kPa)	350	300	400
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	21.6	21.6	21.4
Bulk density	(Mg/m^3)	2.05	2.05	2.05
Dry density	(Mg/m^3)	1.68	1.69	1.69
Void ratio		0.574	0.573	0.568
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	1.14	1.69	1.99
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-1A	BH-WFS4-1A	BH-WFS4-1A
Sample	17BagA	17BagA	17BagA
Depth (m)	22.50	22.50	22.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 22/10/2015
Filename: J11302 / EFFECTIV / BH-WFS4-1A_17BagA_D3.XLS
Template Issue: 7
Checked by: PH Date: 29/10/2015
Approved by: PH Date: 29/10/2015

Date: 22/10/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS4-1A_17BagA_D3.XLS
Template Issue: 7
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	350	300	400
Initial effective cell pressure	(kPa)	240	480	960
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	781	1384	2555
Membrane correction applied	(kPa)	0.8	0.9	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	5.25	6.00	7.96
Volumetric strain	(%)	-0.74	-0.14	-0.24
Major principal effective stress	(kPa)	1022	1865	3515
Minor principal effective stress	(kPa)	241	481	961
Principal effective stress ratio		4.23	3.88	3.66
Epsilon 50 (ε 50)	(%)	0.72	0.73	0.88
Secant modulus (E50) at ε 50	(kPa)	54447	94397	145532
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	781	1384	2554
Membrane correction applied	(kPa)	0.8	0.9	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	5.25	6.00	7.71
Volumetric strain	(%)	-0.74	-0.14	-0.20
Major principal effective stress	(kPa)	1022	1865	3514
Minor principal effective stress	(kPa)	241	481	960
Principal effective stress ratio		4.23	3.88	3.66
At 10% axial strain				
Corrected deviator stress	(kPa)	727	1220	2530
Membrane correction applied	(kPa)	1.3	1.3	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-2.26	-0.87	-0.61
Major principal effective stress	(kPa)	969	1702	3491
Minor principal effective stress	(kPa)	242	482	961
Principal effective stress ratio		4.00	3.53	3.63

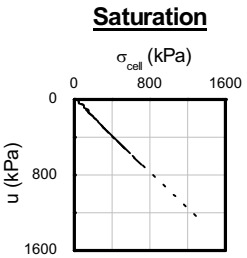
FINAL CONDITIONS				
Moisture content	(%)	24.0	22.2	22.6
Bulk density	(Mg/m³)	2.01	2.04	2.03
Dry density	(Mg/m³)	1.62	1.67	1.66

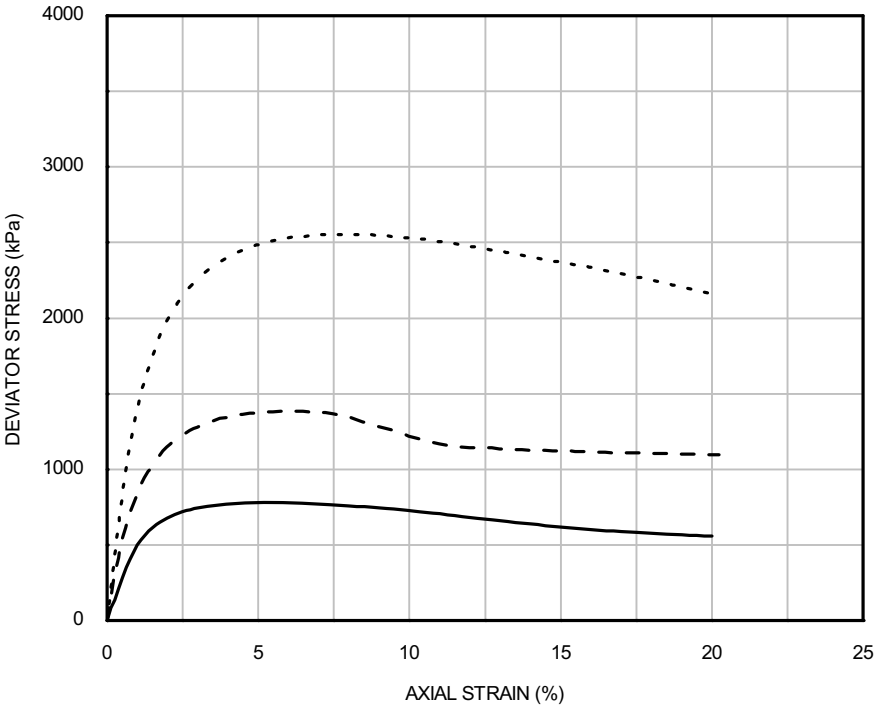
Borehole	BH-WFS4-1A	BH-WFS4-1A	BH-WFS4-1A
Sample	17BagA	17BagA	17BagA
Depth (m)	22.50	22.50	22.50

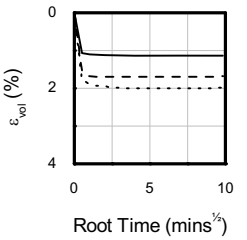
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

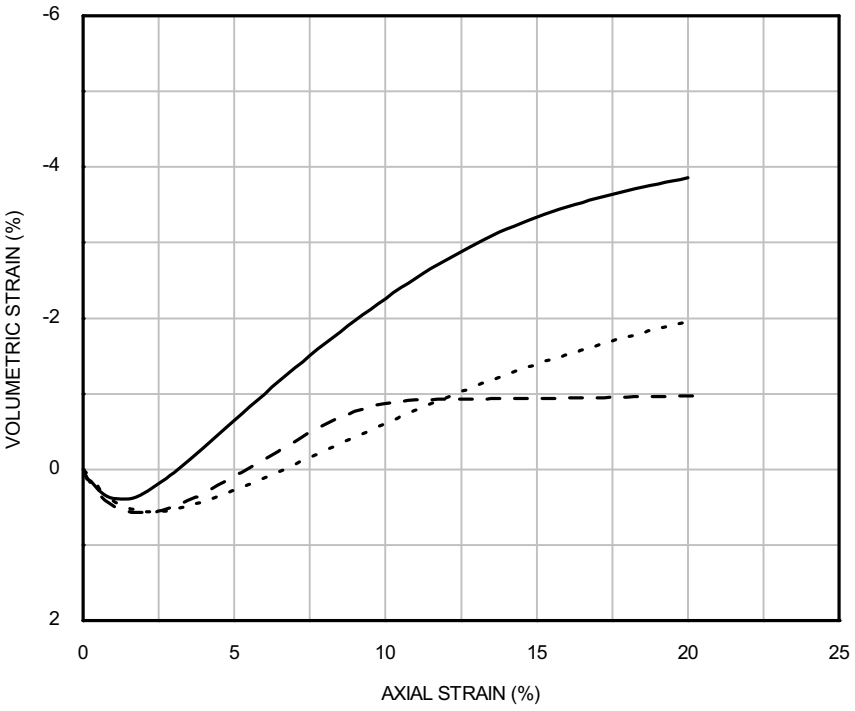
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_17BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH





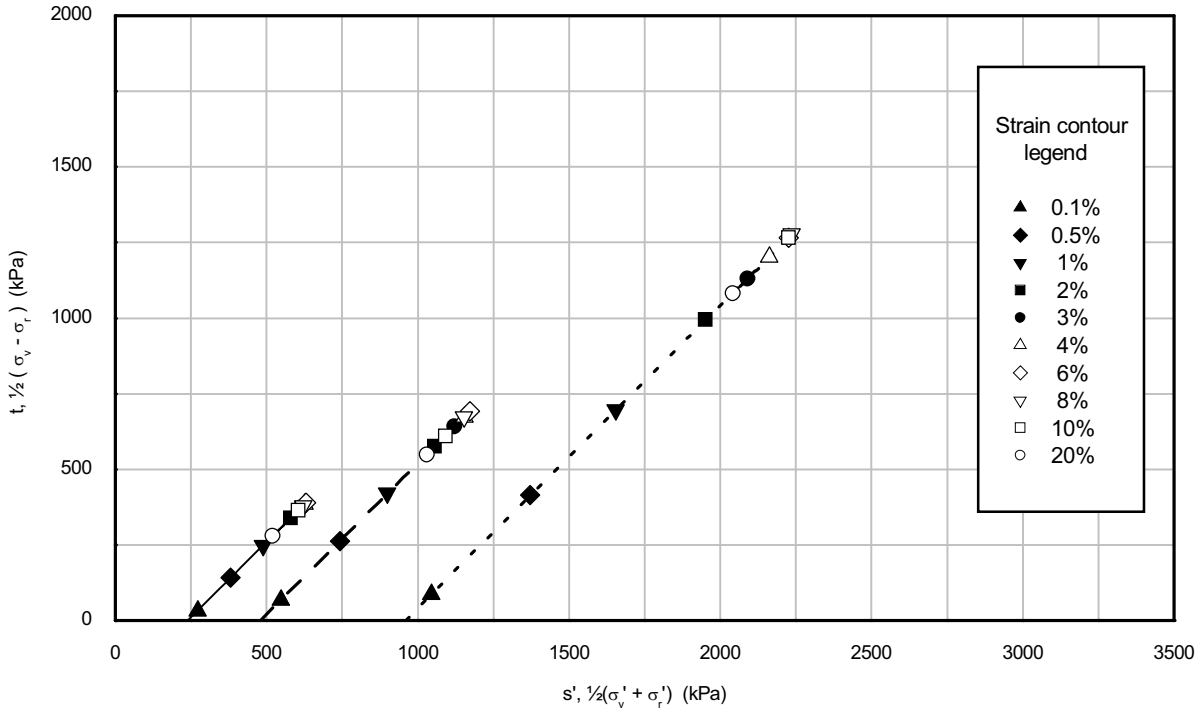


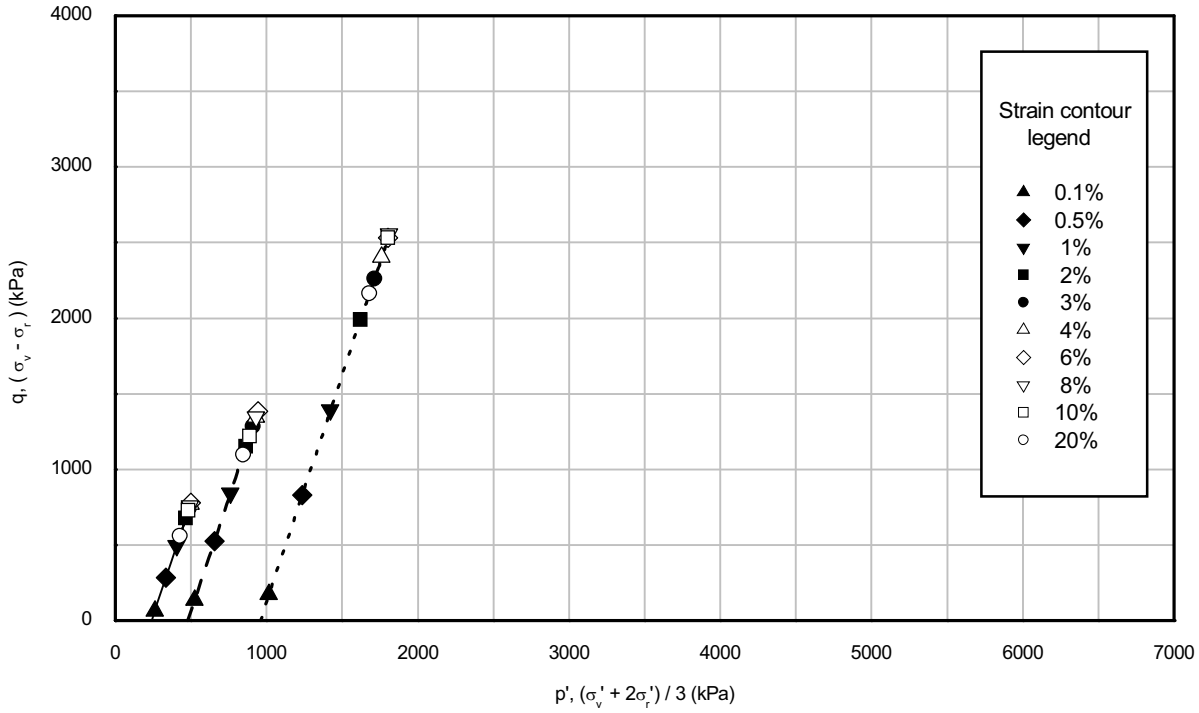


Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	240	240	BH-WFS4 -1A	17BagA	22.50
– –	2	480	480			
· · · ·	3	960	960			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



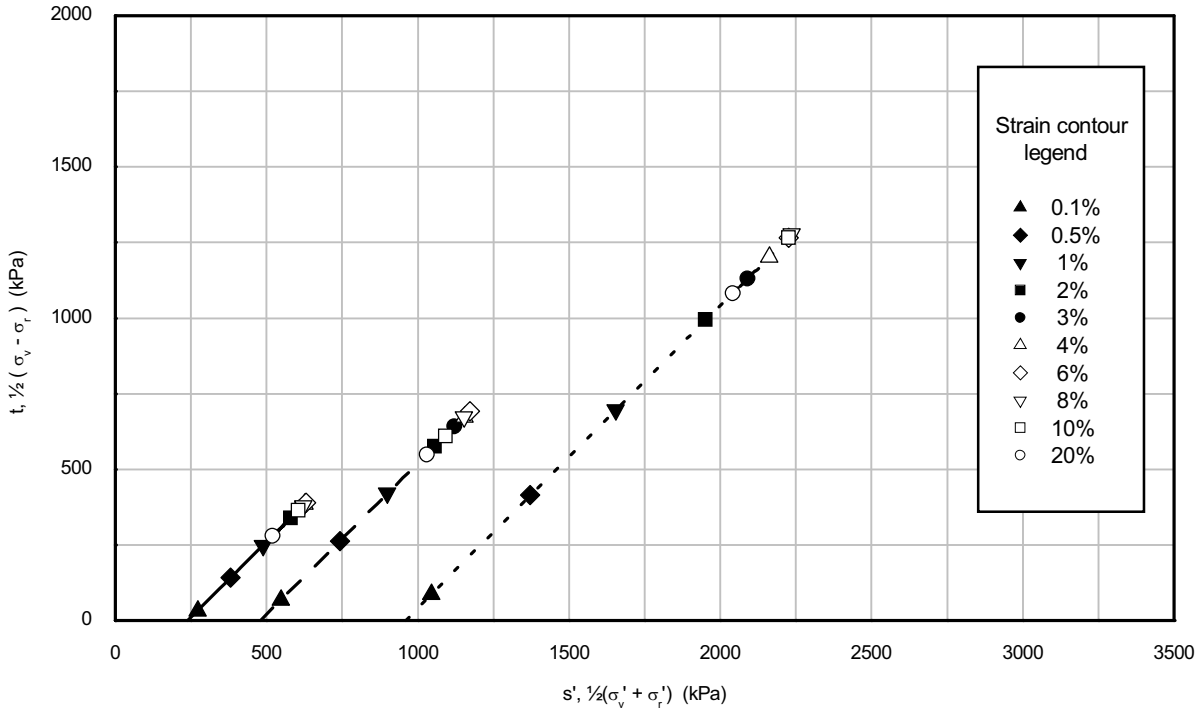


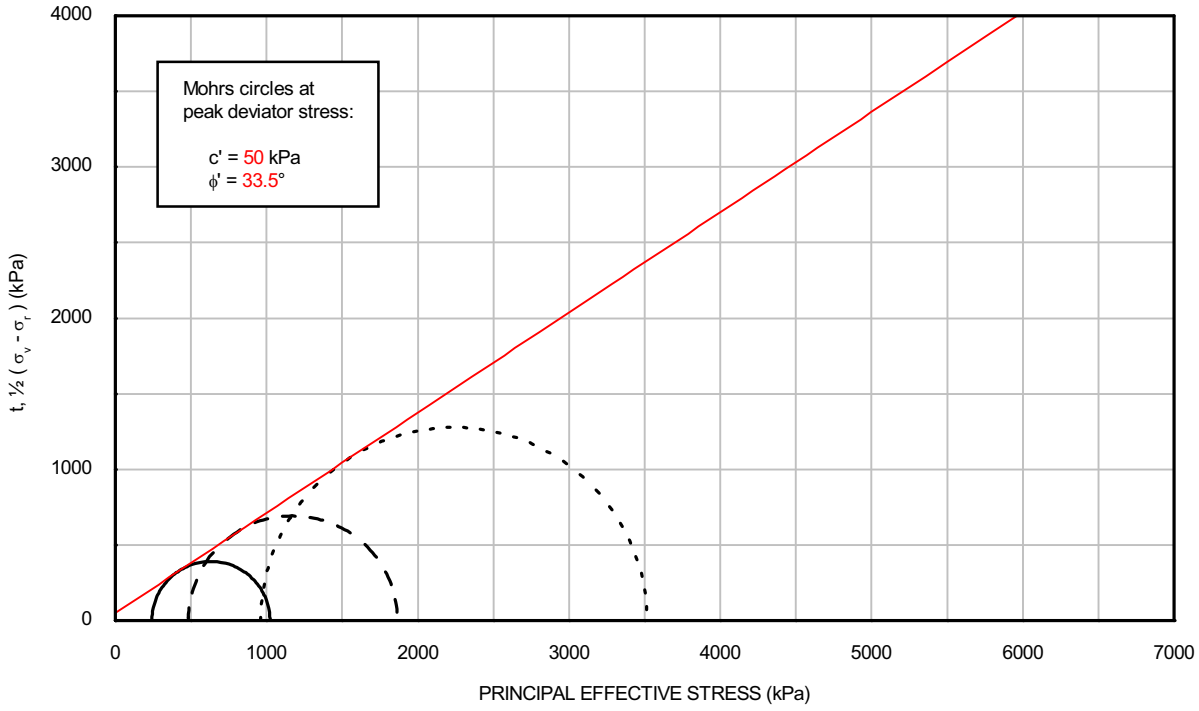
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	240	240	BH-WFS4 -1A	17BagA	22.50
– –	2	480	480			
- - - -	3	960	960			

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_17BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	240	240	BH-WFS4 -1A	17BagA	22.50
– –	2	480	480			
- - - -	3	960	960			

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_17BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-2A_10BagA_D3.XLS
Date: 29/10/2015
Date: 29/10/2015
Checked by: PH
Approved by: PH

VISUAL DESCRIPTION
Dark olive grey silty fine SAND.

GENERAL		Specimen 1	Specimen 2	Specimen 3
Date test started		20/10/2015	20/10/2015	21/10/2015
Type of sample		Recompacted	Recompacted	Recompacted
Specimen orientation		Vertical	Vertical	Vertical
Type of drains fitted		One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.1	10.1	9.4
Bulk density	(Mg/m³)	1.74	1.73	1.74
Dry density	(Mg/m³)	1.58	1.57	1.59
Void ratio		0.682	0.683	0.670
Degree of saturation	(%)	39	39	37

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	445	603	907
Cell pressure on completion	(kPa)	460	620	940
B value achieved		0.97	0.98	0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-2A	BH-WFS4-2A	BH-WFS4-2A
Sample	10BagA	10BagA	10BagA
Depth (m)	13.50	13.50	13.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-2A_10BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	460	620	940
Back pressure	(kPa)	300	300	300
Effective cell pressure	(kPa)	160	320	640
Pore pressure on completion	(kPa)	300	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	23.3	23.3	22.3
Bulk density	(Mg/m^3)	2.02	2.02	2.04
Dry density	(Mg/m^3)	1.64	1.64	1.67
Void ratio		0.617	0.619	0.590
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	3.86	3.82	4.79
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-2A	BH-WFS4-2A	BH-WFS4-2A
Sample	10BagA	10BagA	10BagA
Depth (m)	13.50	13.50	13.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS4-2A_10BagA_D3.XLS
Template Issue: 7
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	300
Initial effective cell pressure	(kPa)	160	320	640
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	379	718	1440
Membrane correction applied	(kPa)	1.9	2.1	2.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	14.82	16.51	19.10
Volumetric strain	(%)	3.07	3.79	3.97
Major principal effective stress	(kPa)	538	1038	2078
Minor principal effective stress	(kPa)	159	319	638
Principal effective stress ratio		3.37	3.25	3.26
Epsilon 50 (ε 50)	(%)	1.59	1.94	2.58
Secant modulus (E50) at ε 50	(kPa)	11911	18546	27887
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	378	718	1440
Membrane correction applied	(kPa)	2.0	2.1	2.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	15.07	16.51	19.10
Volumetric strain	(%)	3.08	3.79	3.97
Major principal effective stress	(kPa)	538	1038	2078
Minor principal effective stress	(kPa)	159	319	638
Principal effective stress ratio		3.38	3.25	3.26
At 10% axial strain				
Corrected deviator stress	(kPa)	364	671	1294
Membrane correction applied	(kPa)	1.4	1.4	1.4
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	2.91	3.48	3.53
Major principal effective stress	(kPa)	523	990	1931
Minor principal effective stress	(kPa)	159	319	638
Principal effective stress ratio		3.28	3.10	3.03

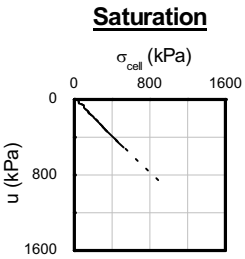
FINAL CONDITIONS				
Moisture content	(%)	21.4	21.0	19.9
Bulk density	(Mg/m³)	2.05	2.06	2.08
Dry density	(Mg/m³)	1.69	1.70	1.74

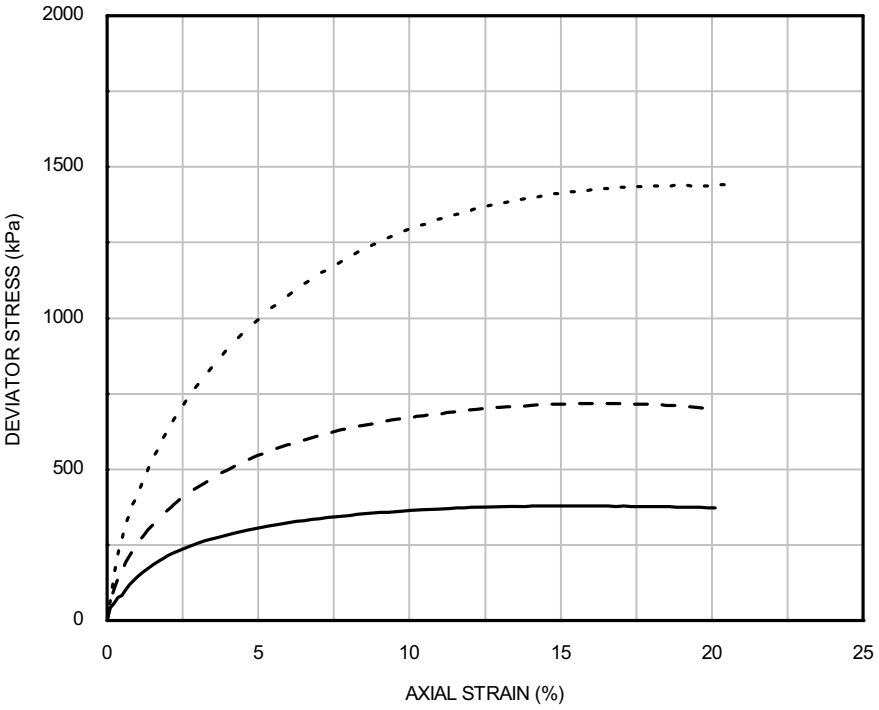
Borehole	BH-WFS4-2A	BH-WFS4-2A	BH-WFS4-2A
Sample	10BagA	10BagA	10BagA
Depth (m)	13.50	13.50	13.50

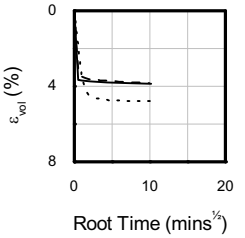
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

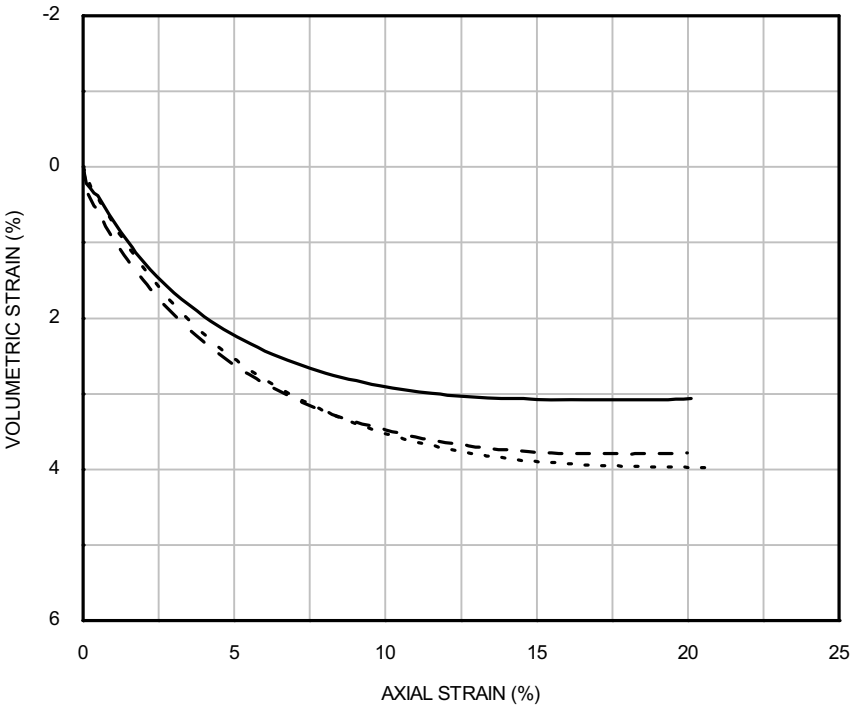
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_10BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH





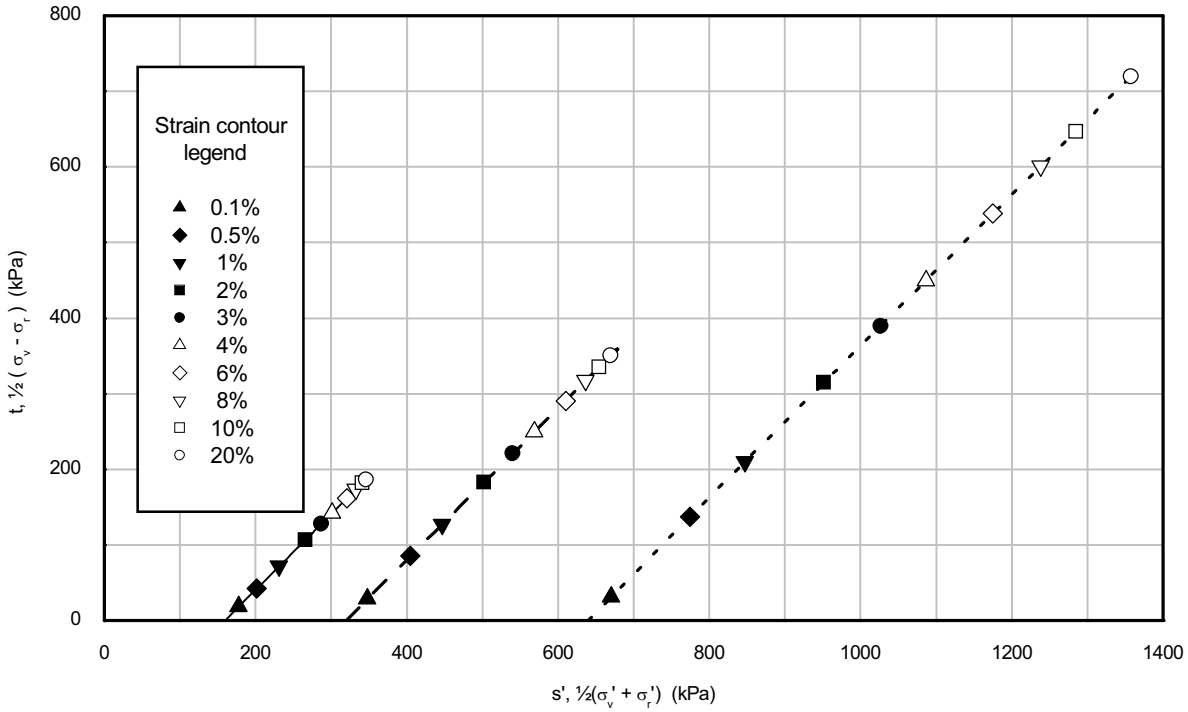


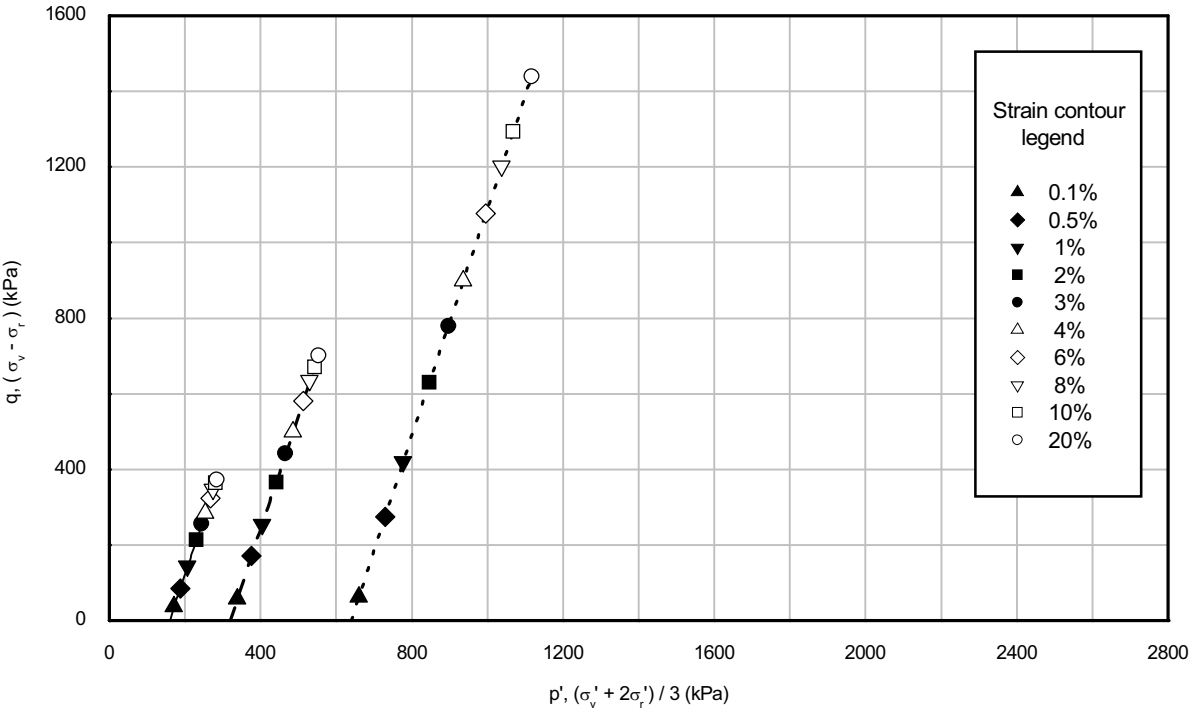


Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	160	160	BH-WFS4 -2A	10BagA	13.50
– –	2	320	320			
- - - -	3	640	640			

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



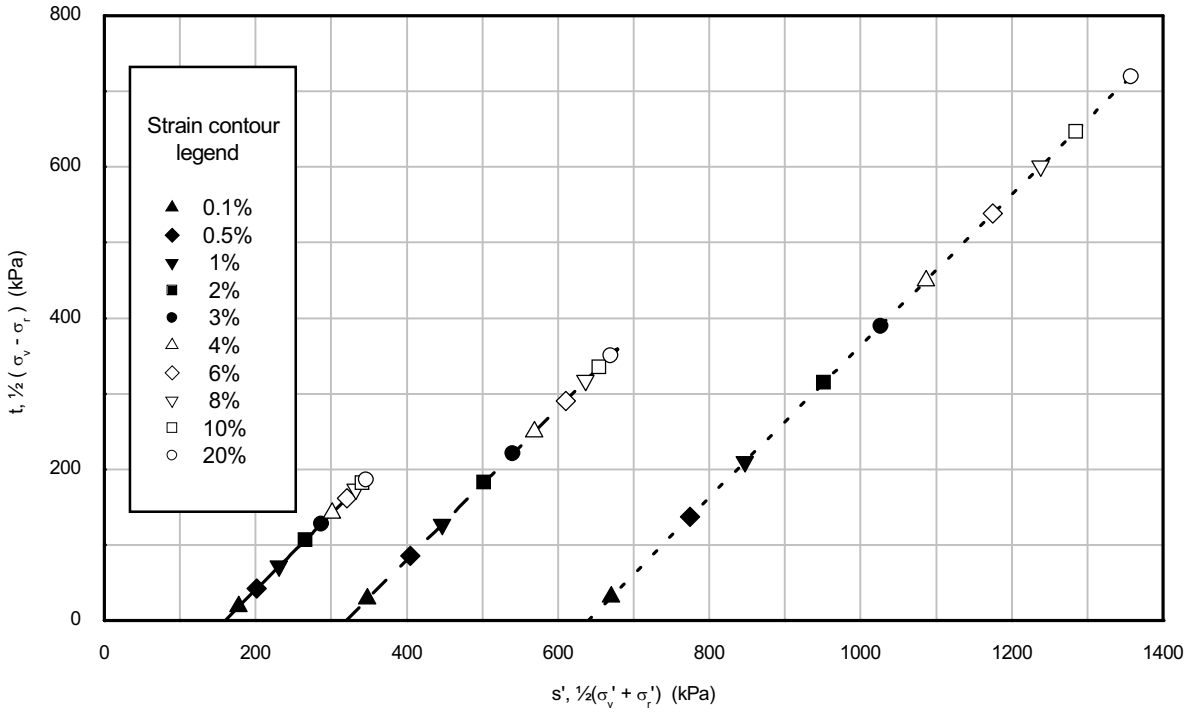


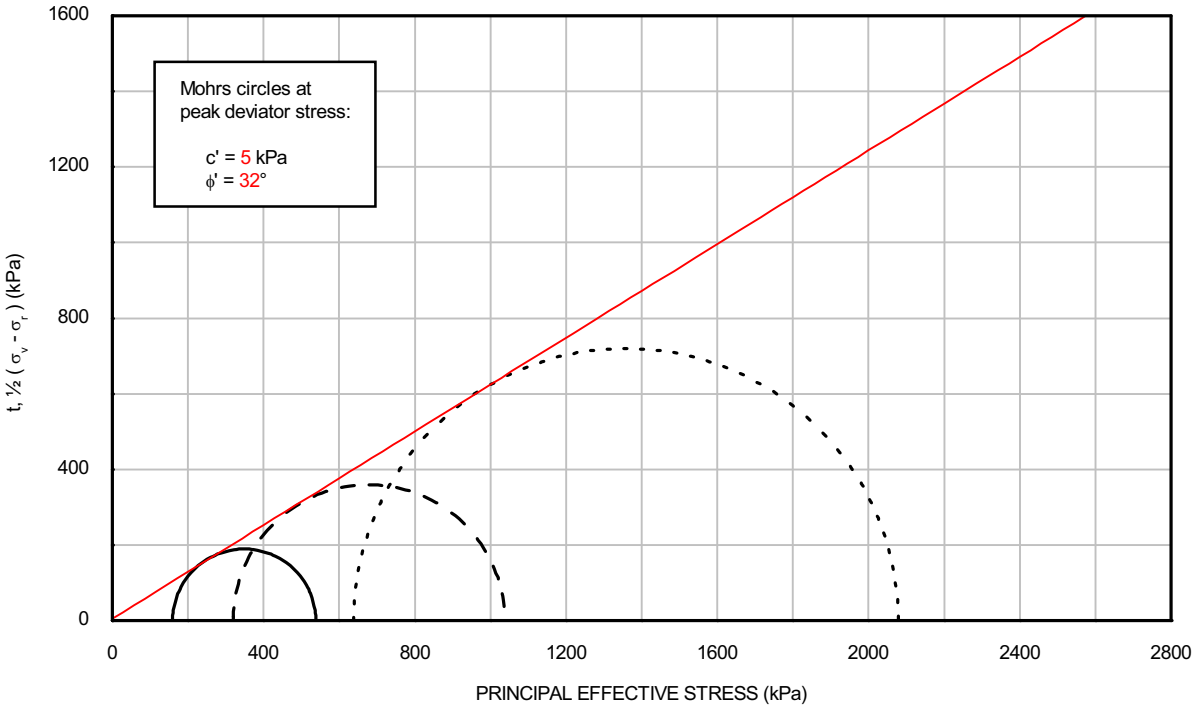
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	160	160	BH-WFS4 -2A	10BagA	13.50
– –	2	320	320			
- - - -	3	640	640			

Drawn by: ALB Date: 22/10/2015
Template Issue: 4 Date : 29/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_10BagA_D3.OPJ Date : 29/10/2015
Checked by: PH Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	160	160	BH-WFS4 -2A	10BagA	13.50
– – –	2	320	320			
- - - -	3	640	640			

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_10BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 02/11/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-2A_19BagB_D3.XLS
Date: 03/11/2015
Checked by: PH
Date: 03/11/2015
Approved by: PH

VISUAL DESCRIPTION
Dark greyish brown silty fine SAND

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	22/10/2015	22/10/2015	22/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.6	10.6	10.6
Bulk density	(Mg/m³)	1.80	1.80	1.80
Dry density	(Mg/m³)	1.63	1.63	1.63
Void ratio		0.639	0.639	0.638
Degree of saturation	(%)	44	44	44

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	812	1150	1975
Cell pressure on completion	(kPa)	840	1180	2060
B value achieved		0.96	0.98	0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-2A	BH-WFS4-2A	BH-WFS4-2A
Sample	19BagB	19BagB	19BagB
Depth (m)	43.80	43.80	43.80

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	840	1180	2060
Back pressure	(kPa)	400	300	300
Effective cell pressure	(kPa)	440	880	1760
Pore pressure on completion	(kPa)	400	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	20.7	18.9	18.7
Bulk density	(Mg/m³)	2.07	2.11	2.11
Dry density	(Mg/m³)	1.72	1.77	1.78
Void ratio		0.554	0.505	0.499
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	5.17	8.20	8.48

Mode of failure:	Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-2A	BH-WFS4-2A	BH-WFS4-2A
Sample	19BagB	19BagB	19BagB
Depth (m)	43.80	43.80	43.80

Drawn by: ALB Date: 02/11/2015

Template Issue: 7 Filename: J11302 / EFFECTIV / BH-WFS4-2A_19BagB_D3.XLS

Checked by: PH Date: 03/11/2015

Approved by: PH Date: 03/11/2015

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 02/11/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-2A_19BagB_D3.XLS
Date: 03/11/2015
Checked by: PH
Date: 03/11/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	400	300	300
Initial effective cell pressure	(kPa)	440	880	1760
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	992	1658	3773
Membrane correction applied	(kPa)	2.0	1.8	2.0
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	20.01	17.27	20.12
Volumetric strain	(%)	4.20	4.83	6.01
Major principal effective stress	(kPa)	1435	2535	5528
Minor principal effective stress	(kPa)	442	878	1755
Principal effective stress ratio		3.24	2.89	3.15
Epsilon 50 (ε 50)	(%)	2.73	2.78	3.56
Secant modulus (E50) at ε 50	(kPa)	18172	29813	52980
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	992	1658	3773
Membrane correction applied	(kPa)	2.0	1.8	2.0
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	20.01	17.27	20.12
Volumetric strain	(%)	4.20	4.83	6.01
Major principal effective stress	(kPa)	1435	2535	5528
Minor principal effective stress	(kPa)	442	878	1755
Principal effective stress ratio		3.24	2.89	3.15
At 10% axial strain				
Corrected deviator stress	(kPa)	893	1501	3171
Membrane correction applied	(kPa)	1.2	1.2	1.2
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	3.79	4.26	4.74
Major principal effective stress	(kPa)	1342	2378	4924
Minor principal effective stress	(kPa)	448	877	1753
Principal effective stress ratio		2.99	2.71	2.81

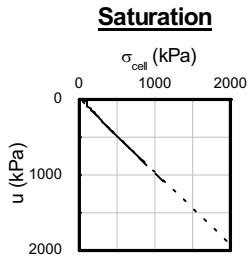
FINAL CONDITIONS				
Moisture content	(%)	18.3	16.2	15.3
Bulk density	(Mg/m³)	2.12	2.17	2.18
Dry density	(Mg/m³)	1.79	1.86	1.89

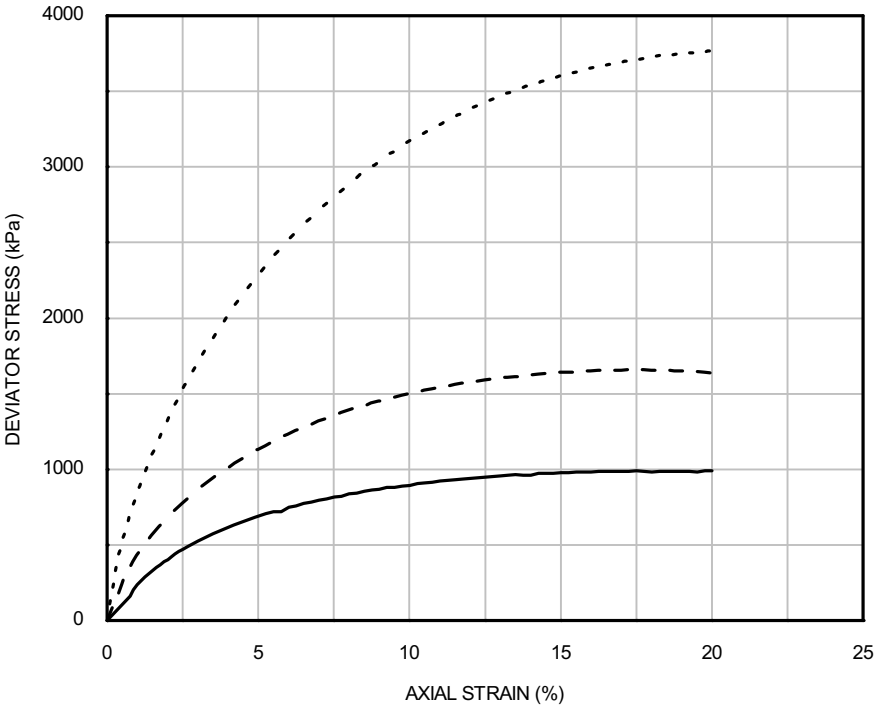
Borehole	BH-WFS4-2A	BH-WFS4-2A	BH-WFS4-2A
Sample	19BagB	19BagB	19BagB
Depth (m)	43.80	43.80	43.80

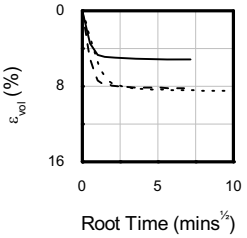
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

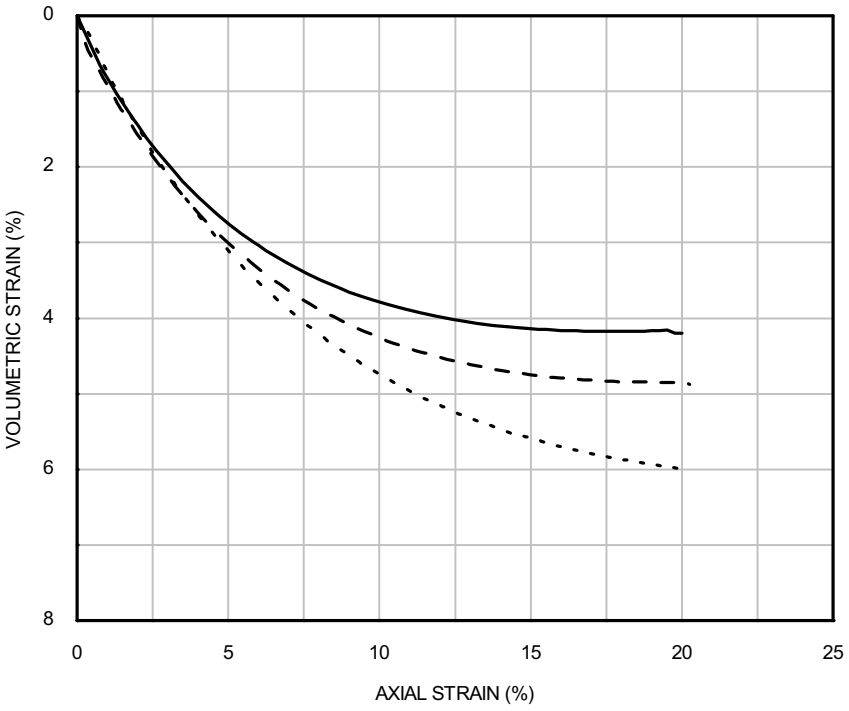
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 02/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_19BagB_D3.OPJ
Template Issue: 4
Date : 03/11/2015
Checked by: PH
Date : 03/11/2015
Approved by: PH







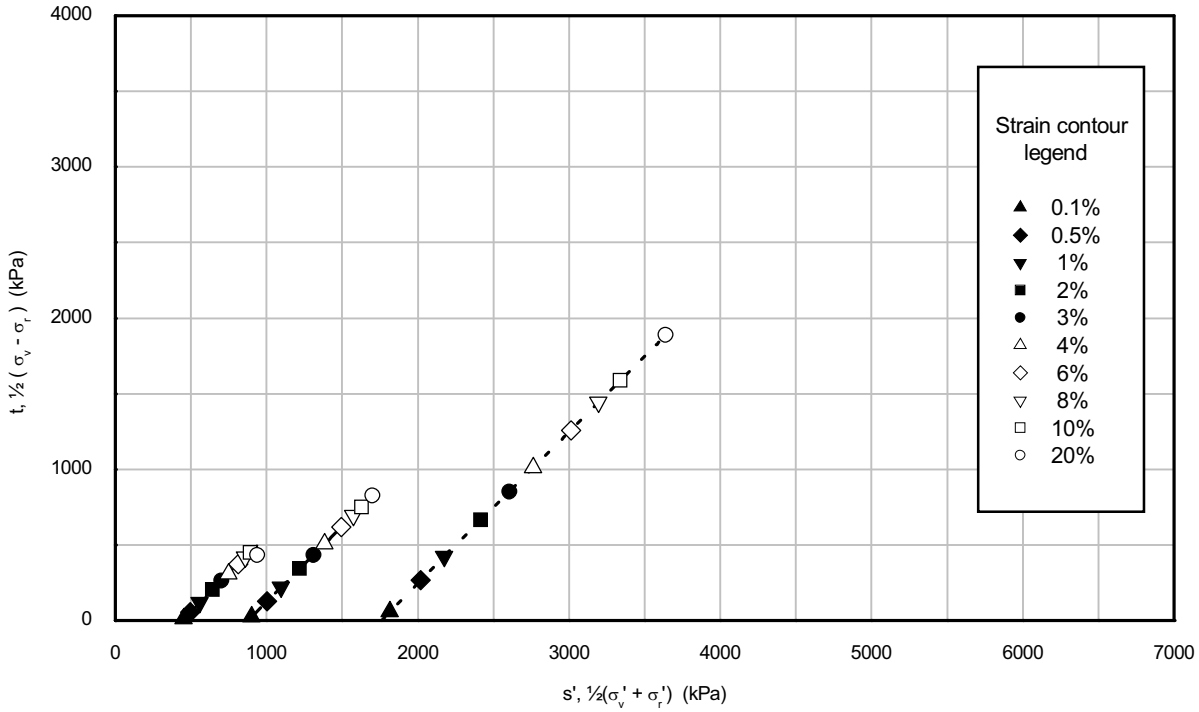


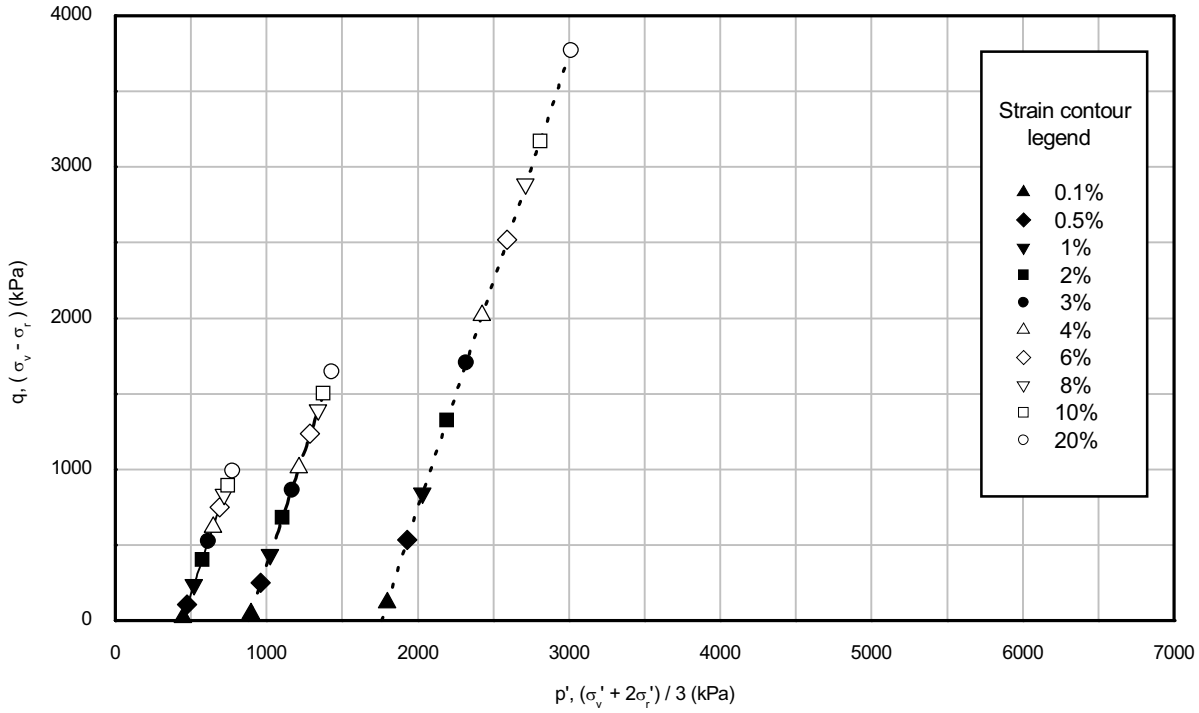
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	440	440
– –	2	880	880
· · · ·	3	1760	1760

Borehole	Sample	Depth (m)
BH-WFS4-2A	19BagB	43.80

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



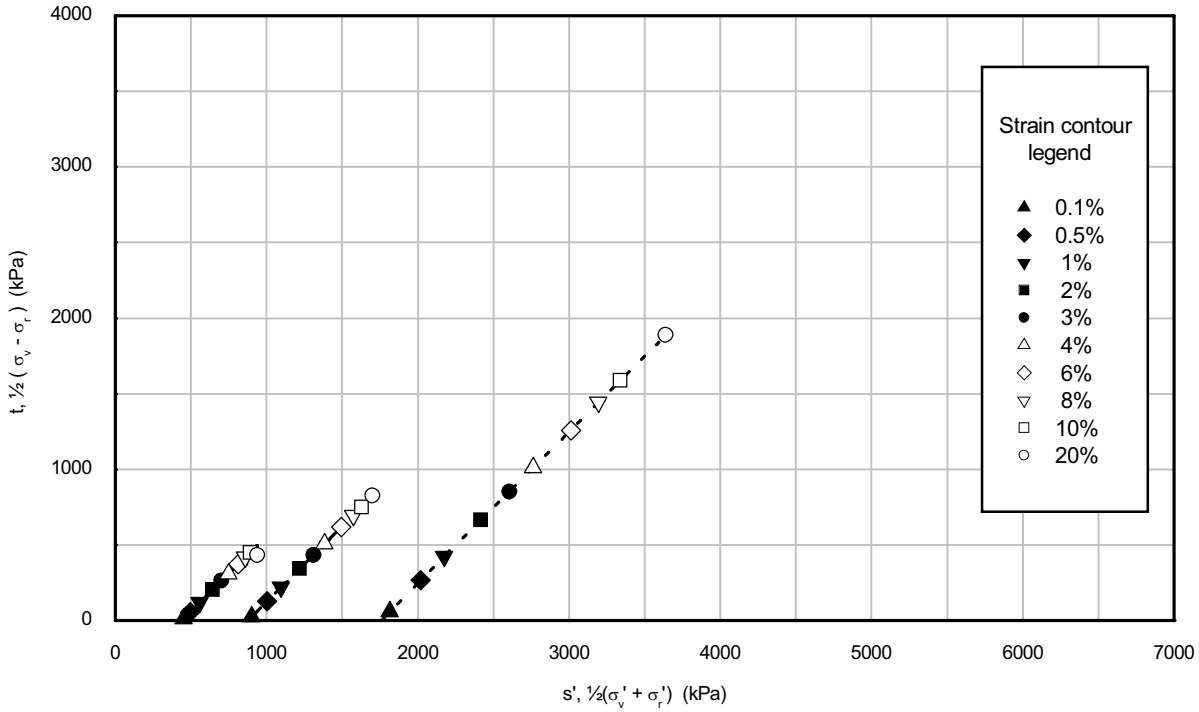


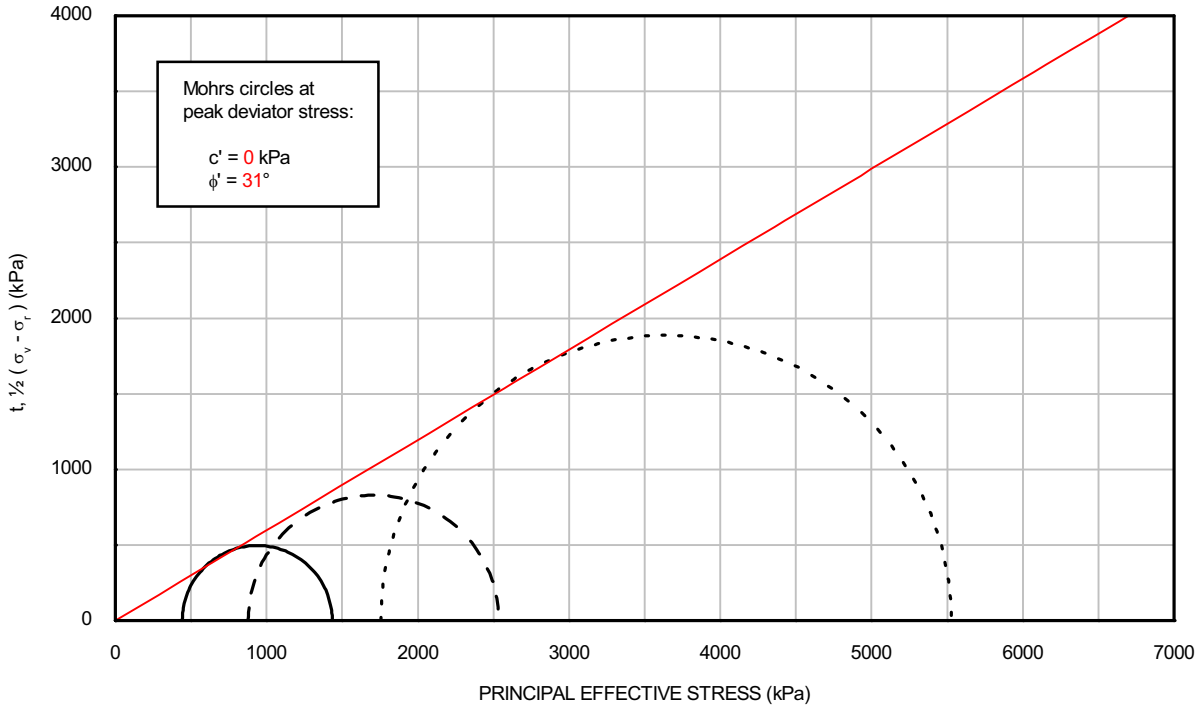
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	440	440	BH-WFS4-2A	19BagB	43.80
– –	2	880	880			
- - - -	3	1760	1760			

Drawn by: ALB Date: 02/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_19BagB_D3.OPJ
Template Issue: 4
Date : 03/11/2015
Checked by: PH
Date : 03/11/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	440	440	BH-WFS4-2A	19BagB	43.80
– –	2	880	880			
- - - -	3	1760	1760			

Drawn by: ALB Date: 02/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-2A_19BagB_D3.OPJ
Template Issue: 4
Date : 03/11/2015
Checked by: PH
Date : 03/11/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-3_8BagA_D3.XLS
Template Issue: 7
Date: 28/10/2015
Date: 29/10/2015
Checked by: ALB
Approved by: PH

VISUAL DESCRIPTION
Brown fine to medium SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	26/10/2015	26/10/2015	26/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	11.1	11.1	11.1
Bulk density	(Mg/m³)	1.92	1.91	1.91
Dry density	(Mg/m³)	1.73	1.72	1.72
Void ratio		0.530	0.539	0.544
Degree of saturation	(%)	55	54	54

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	507	473	567
Cell pressure on completion	(kPa)	520	490	580
B value achieved		0.96	0.95	0.99

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-3	BH-WFS4-3	BH-WFS4-3
Sample	8BagA	8BagA	8BagA
Depth (m)	7.00	7.00	7.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	520	490	580
Back pressure	(kPa)	450	350	300
Effective cell pressure	(kPa)	70	140	280
Pore pressure on completion	(kPa)	450	350	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	19.7	19.9	19.6
Bulk density	(Mg/m³)	2.08	2.08	2.09
Dry density	(Mg/m³)	1.74	1.74	1.74
Void ratio		0.522	0.527	0.519
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	0.49	0.79	1.63
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-3	BH-WFS4-3	BH-WFS4-3
Sample	8BagA	8BagA	8BagA
Depth (m)	7.00	7.00	7.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-3_8BagA_D3.XLS
Date: 28/10/2015
Checked by: ALB
Date: 29/10/2015
Approved by: PH

Date: 27/10/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-3_8BagA_D3.XLS
Template Issue: 7
Date: 28/10/2015
Checked by: ALB
Date: 29/10/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	450	350	300
Initial effective cell pressure	(kPa)	70	140	280
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	288	499	928
Membrane correction applied	(kPa)	0.2	0.3	0.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	1.88	2.50	2.47
Volumetric strain	(%)	-0.49	-0.66	-0.11
Major principal effective stress	(kPa)	360	641	1209
Minor principal effective stress	(kPa)	72	141	281
Principal effective stress ratio		5.03	4.53	4.30
Epsilon 50 (ε 50)	(%)	0.28	0.34	0.49
Secant modulus (E50) at ε 50	(kPa)	50724	73800	94223
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	288	499	928
Membrane correction applied	(kPa)	0.2	0.3	0.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	1.75	2.50	2.47
Volumetric strain	(%)	-0.40	-0.66	-0.11
Major principal effective stress	(kPa)	359	641	1209
Minor principal effective stress	(kPa)	71	141	281
Principal effective stress ratio		5.04	4.53	4.30
At 10% axial strain				
Corrected deviator stress	(kPa)	209	331	719
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-3.50	-2.33	-2.20
Major principal effective stress	(kPa)	282	473	1001
Minor principal effective stress	(kPa)	72	142	282
Principal effective stress ratio		3.90	3.33	3.55

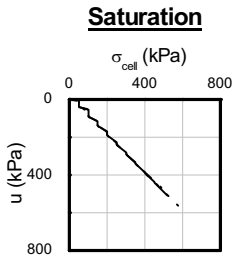
FINAL CONDITIONS				
Moisture content	(%)	22.5	21.2	20.9
Bulk density	(Mg/m³)	2.03	2.06	2.06
Dry density	(Mg/m³)	1.66	1.70	1.71

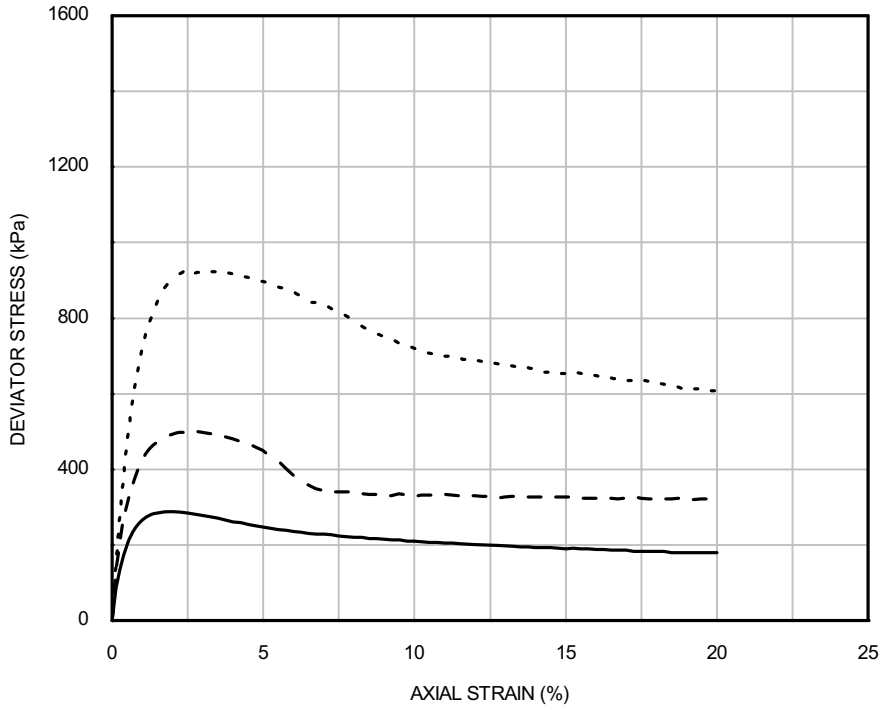
Borehole	BH-WFS4-3	BH-WFS4-3	BH-WFS4-3
Sample	8BagA	8BagA	8BagA
Depth (m)	7.00	7.00	7.00

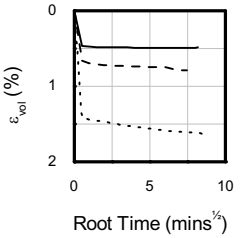
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

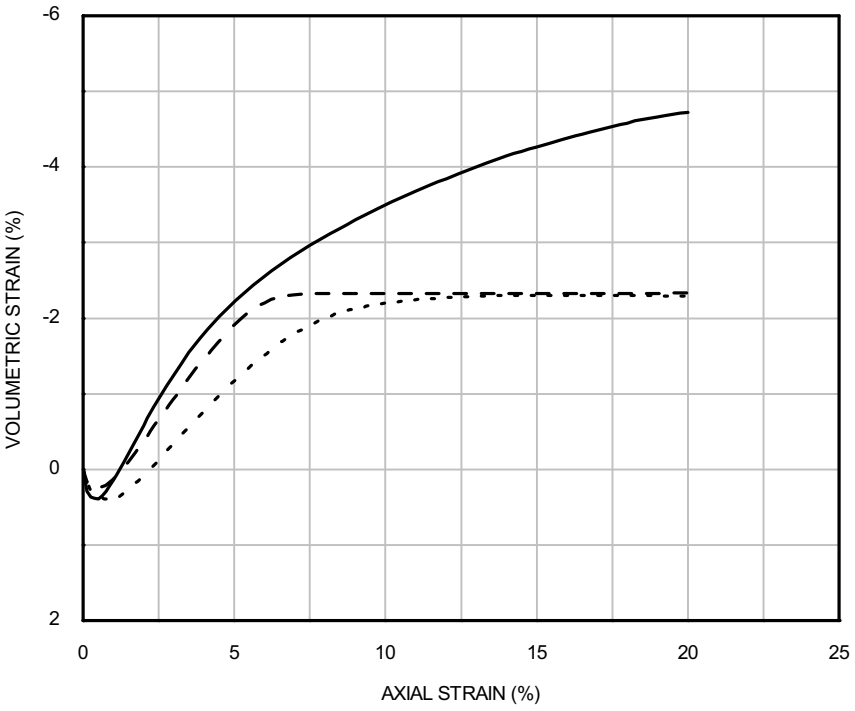
Drawn by: ER Date: 27/10/2015
Template Issue: 4 Filename: J11302 \ EFFECTIV \ BH-WFS4-3_8BagA_D3.OPJ
Date : 29/10/2015 Date : 29/10/2015
Checked by: PH Approved by: PH







Consolidation

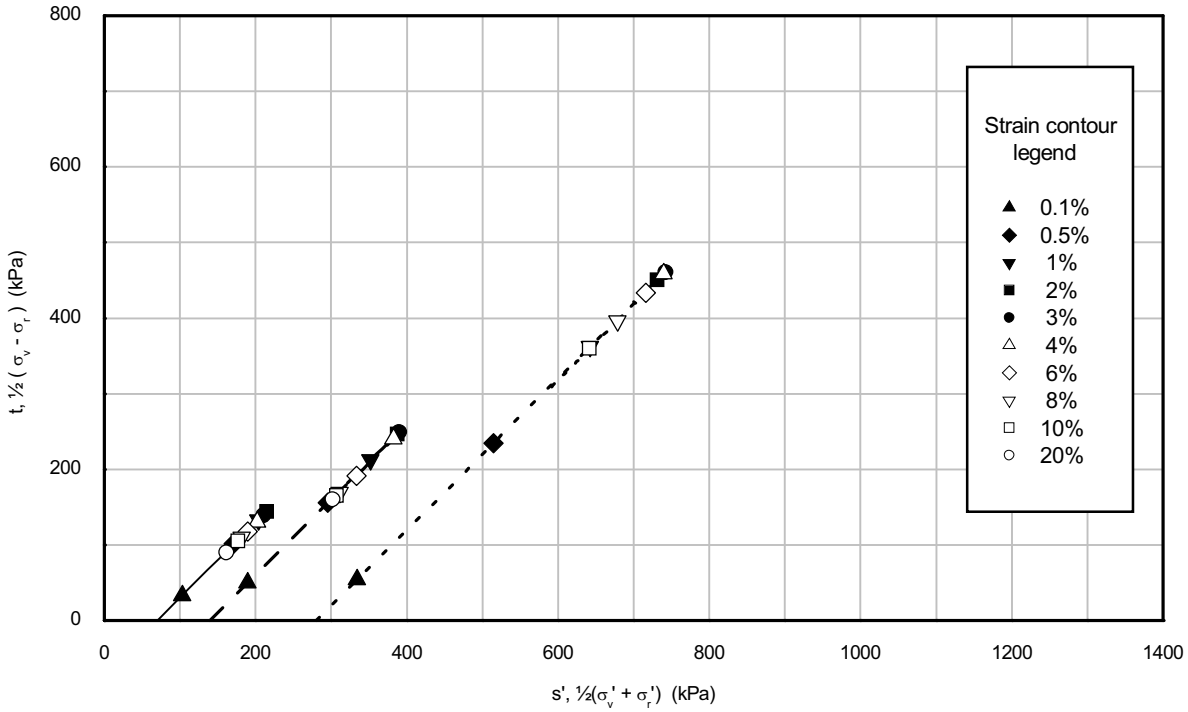


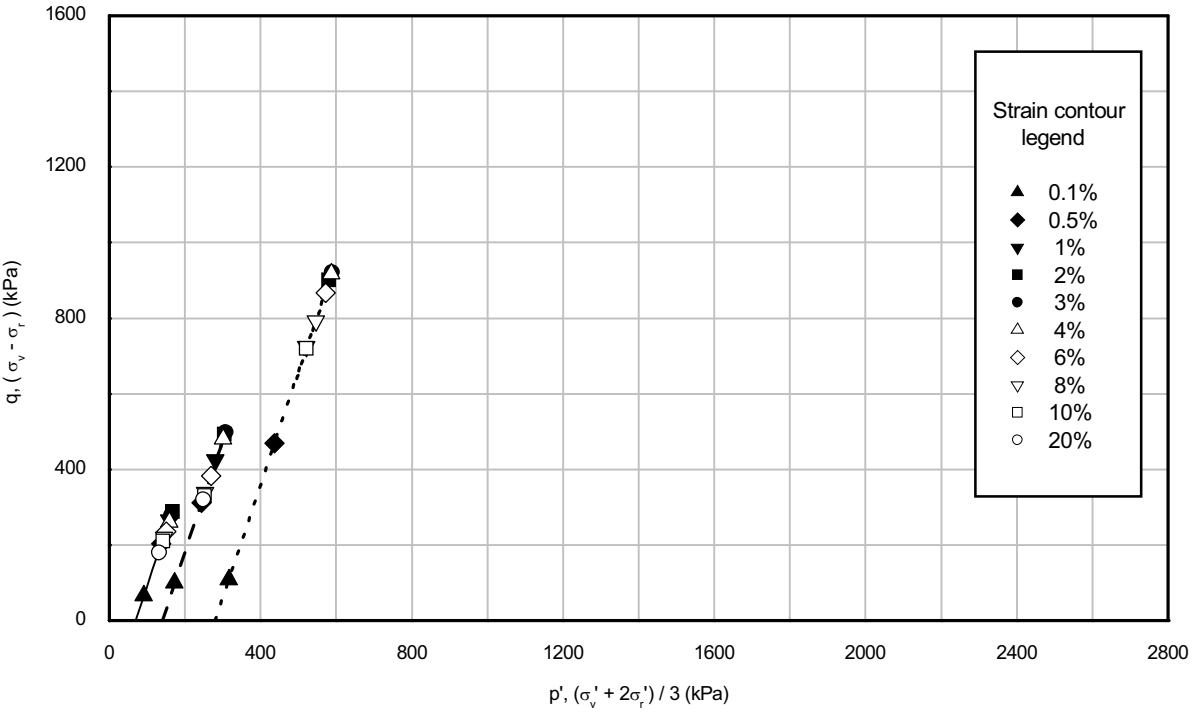
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	70	70
– –	2	140	140
· · · ·	3	280	280

Borehole	Sample	Depth (m)
BH-WFS4-3	8BagA	7.00

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	70	70	BH-WFS4-3	8BagA	7.00
– –	2	140	140			
- - - -	3	280	280			

Drawn by: ER Date: 27/10/2015

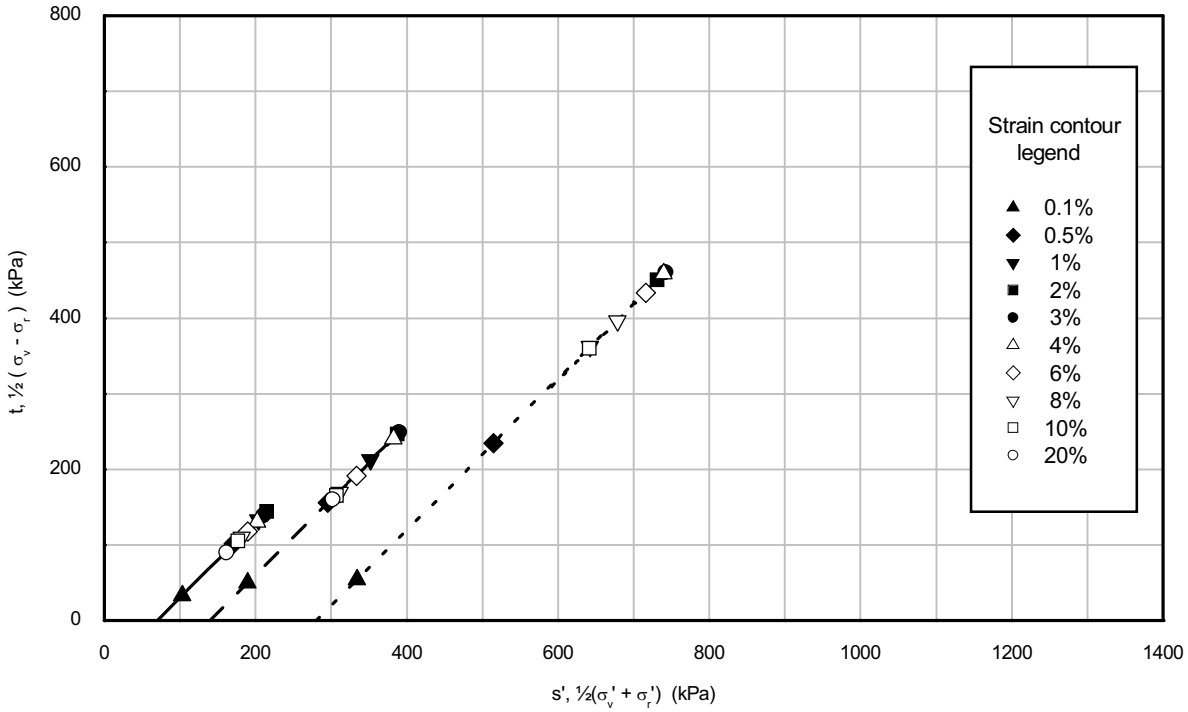
Filename: J11302 \ EFFECTIV \ BH-WFS4-3_8BagA_D3.OPJ Date : 29/10/2015

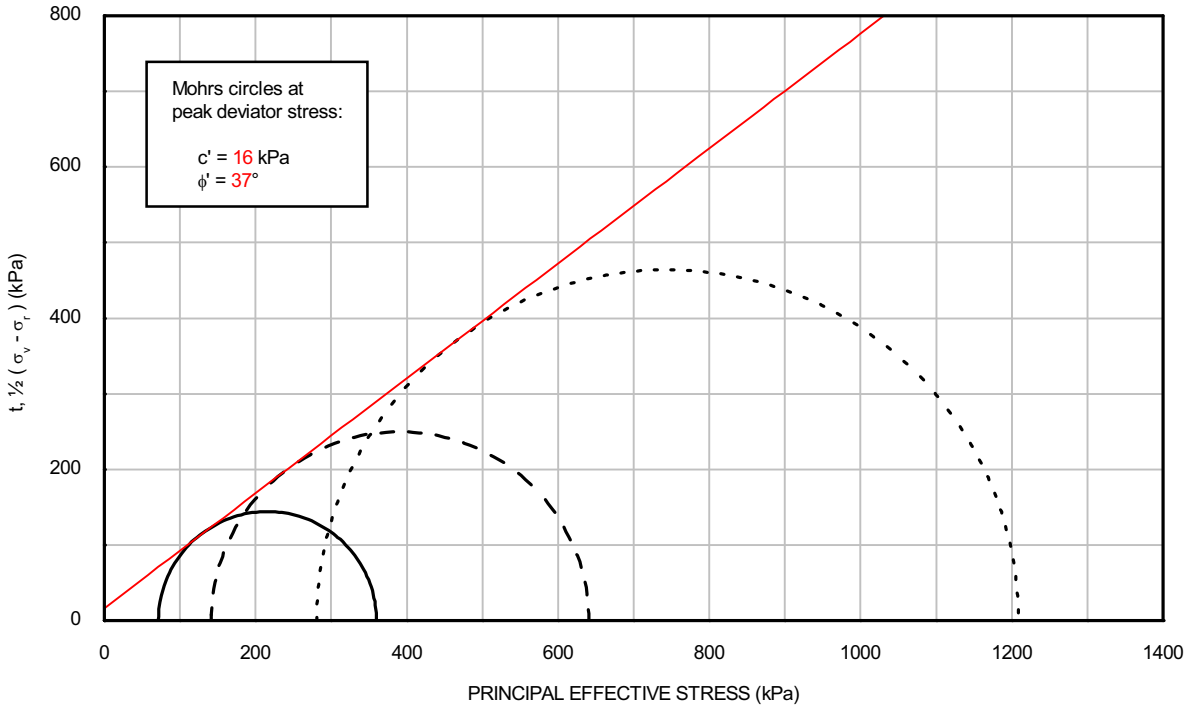
Template Issue: 4 Date : 29/10/2015

Checked by: PH Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	70	70	BH-WFS4-3	8BagA	7.00
– – –	2	140	140			
- - - -	3	280	280			

Drawn by: ER Date: 27/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-3_8BagA_D3.OPJ

Template Issue: 4

Date : 29/10/2015

Checked by: PH

Date : 29/10/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-3_18BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

VISUAL DESCRIPTION
Brown silty fine SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	21/10/2015	21/10/2015	21/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.7	10.7	10.7
Bulk density	(Mg/m³)	1.77	1.77	1.77
Dry density	(Mg/m³)	1.60	1.60	1.60
Void ratio		0.656	0.655	0.654
Degree of saturation	(%)	43	43	43

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	455	613	944
Cell pressure on completion	(kPa)	470	640	980
B value achieved		0.97	0.95	0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-3	BH-WFS4-3	BH-WFS4-3
Sample	18BagA	18BagA	18BagA
Depth (m)	14.00	14.00	14.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-3_18BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	470	640	980
Back pressure	(kPa)	300	300	300
Effective cell pressure	(kPa)	170	340	680
Pore pressure on completion	(kPa)	300	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	24.1	23.6	23.2
Bulk density	(Mg/m^3)	2.01	2.02	2.02
Dry density	(Mg/m^3)	1.62	1.63	1.64
Void ratio		0.640	0.625	0.614
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	0.97	1.86	2.39
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole		BH-WFS4-3	BH-WFS4-3	BH-WFS4-3
Sample		18BagA	18BagA	18BagA
Depth (m)		14.00	14.00	14.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-3_18BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	300
Initial effective cell pressure	(kPa)	170	340	680
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	464	879	1652
Membrane correction applied	(kPa)	1.1	1.1	1.5
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	7.87	8.25	11.50
Volumetric strain	(%)	0.06	0.17	0.90
Major principal effective stress	(kPa)	635	1220	2333
Minor principal effective stress	(kPa)	170	341	681
Principal effective stress ratio		3.72	3.58	3.43
Epsilon 50 (ε 50)	(%)	0.71	0.77	1.13
Secant modulus (E50) at ε 50	(kPa)	32533	57089	73335
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	464	878	1652
Membrane correction applied	(kPa)	1.1	1.2	1.5
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	7.87	8.75	11.75
Volumetric strain	(%)	0.06	0.11	0.88
Major principal effective stress	(kPa)	635	1219	2333
Minor principal effective stress	(kPa)	170	340	681
Principal effective stress ratio		3.72	3.58	3.43
At 10% axial strain				
Corrected deviator stress	(kPa)	459	872	1645
Membrane correction applied	(kPa)	1.3	1.3	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-0.24	-0.04	1.01
Major principal effective stress	(kPa)	630	1213	2325
Minor principal effective stress	(kPa)	171	341	681
Principal effective stress ratio		3.69	3.56	3.42

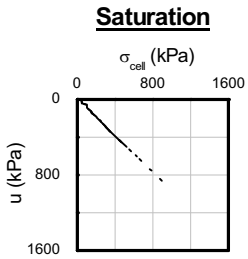
FINAL CONDITIONS				
Moisture content	(%)	24.9	23.9	23.1
Bulk density	(Mg/m³)	1.99	2.01	2.02
Dry density	(Mg/m³)	1.60	1.62	1.64

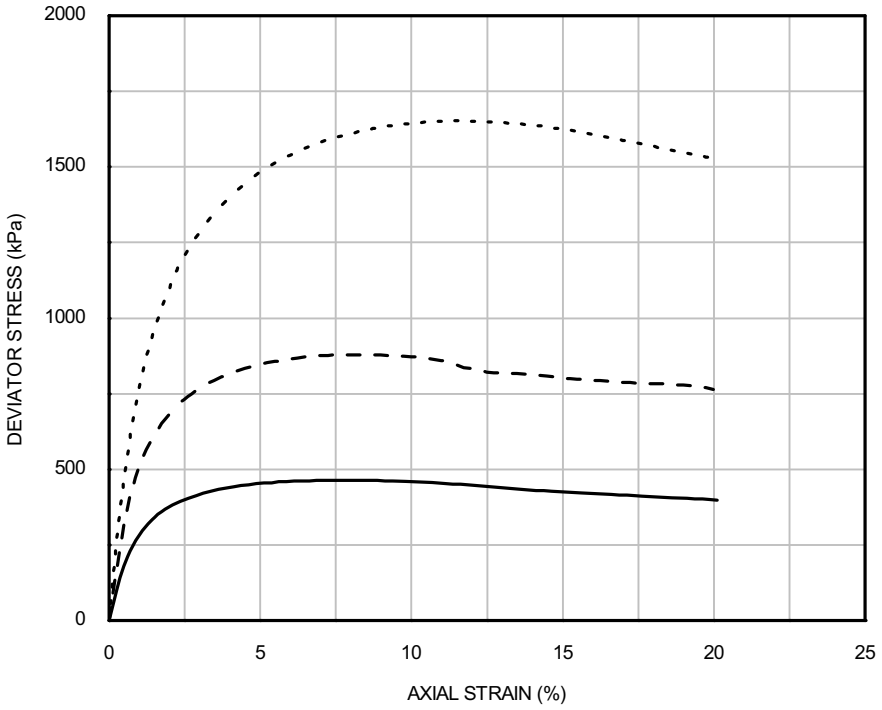
Borehole	BH-WFS4-3	BH-WFS4-3	BH-WFS4-3
Sample	18BagA	18BagA	18BagA
Depth (m)	14.00	14.00	14.00

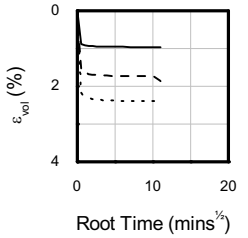
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

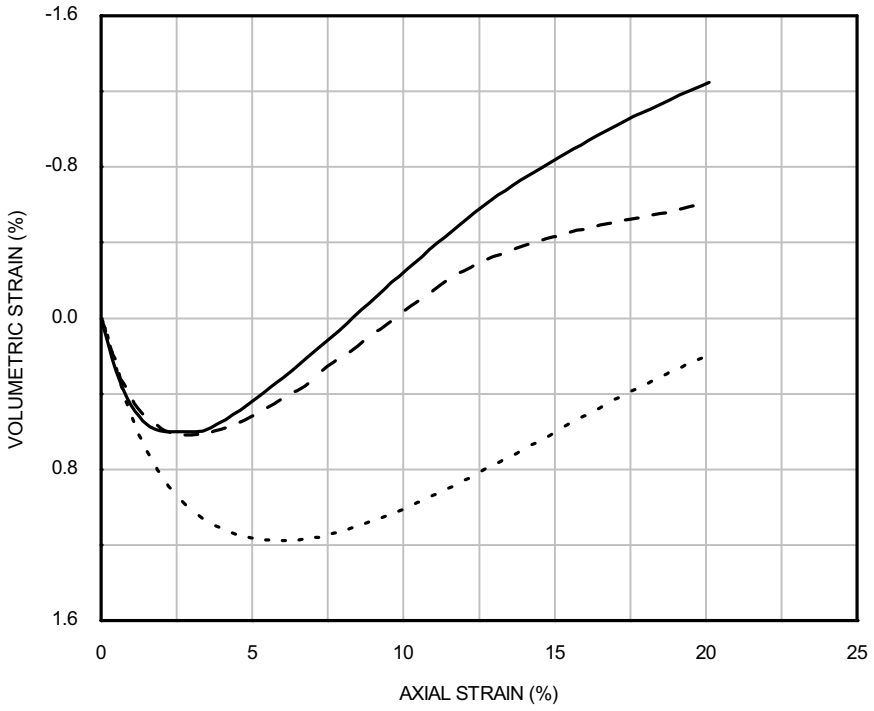
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 27/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-3_18BagA_D3.OPJ
Template Issue: 4 Date : 29/10/2015
Checked by: PH Date : 29/10/2015
Approved by: PH







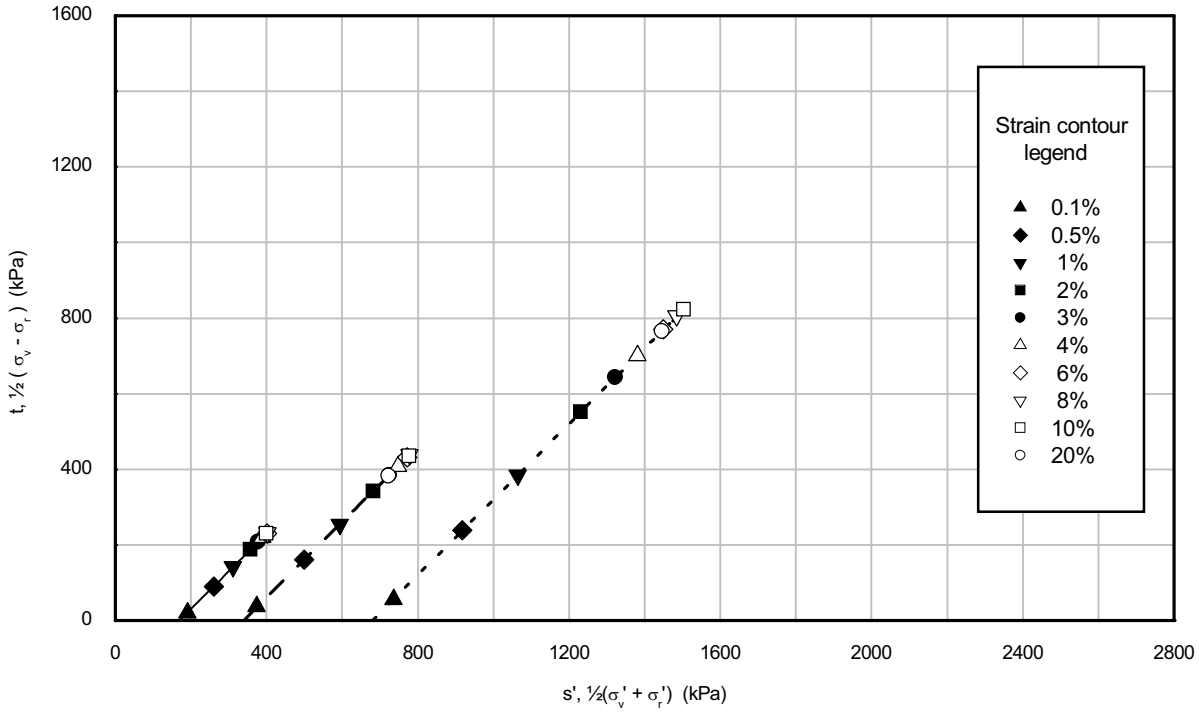


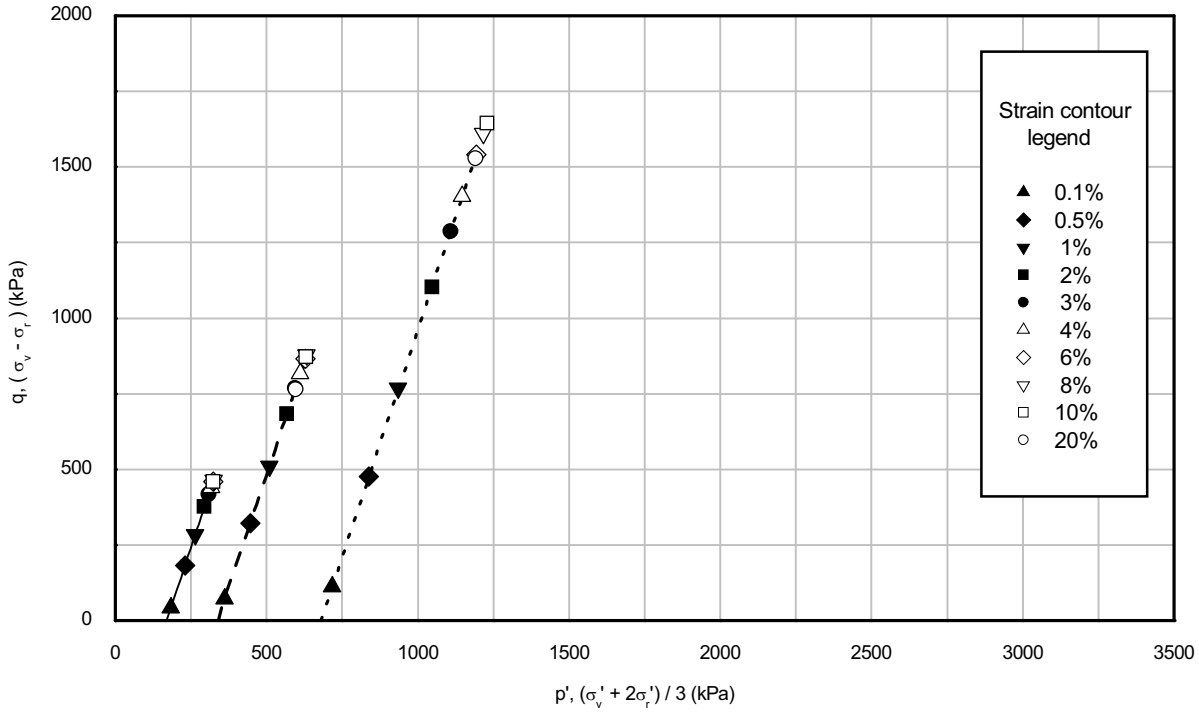
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	170	170
– –	2	340	340
- - - -	3	680	680

Borehole	Sample	Depth (m)
BH-WFS4-3	18BagA	14.00

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	170	170	BH-WFS4-3	18BagA	14.00
– –	2	340	340			
- - - -	3	680	680			

Drawn by: ALB Date: 27/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-3_18BagA_D3.OPJ

Template Issue: 4

Date : 29/10/2015

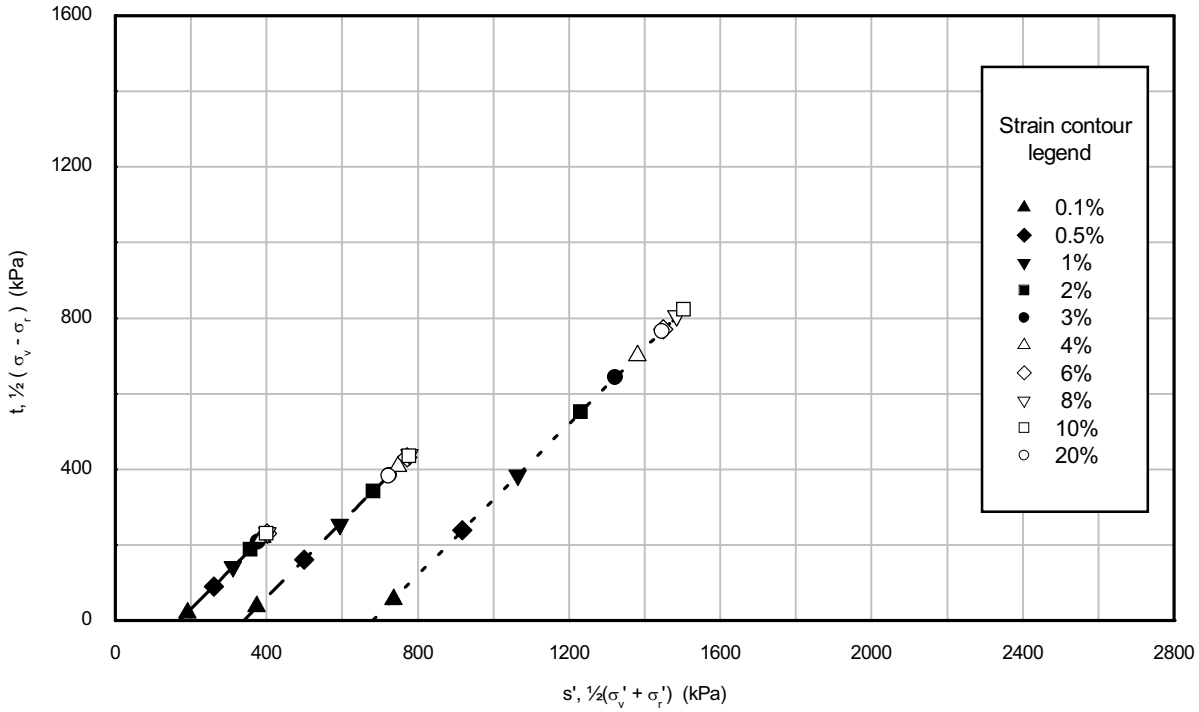
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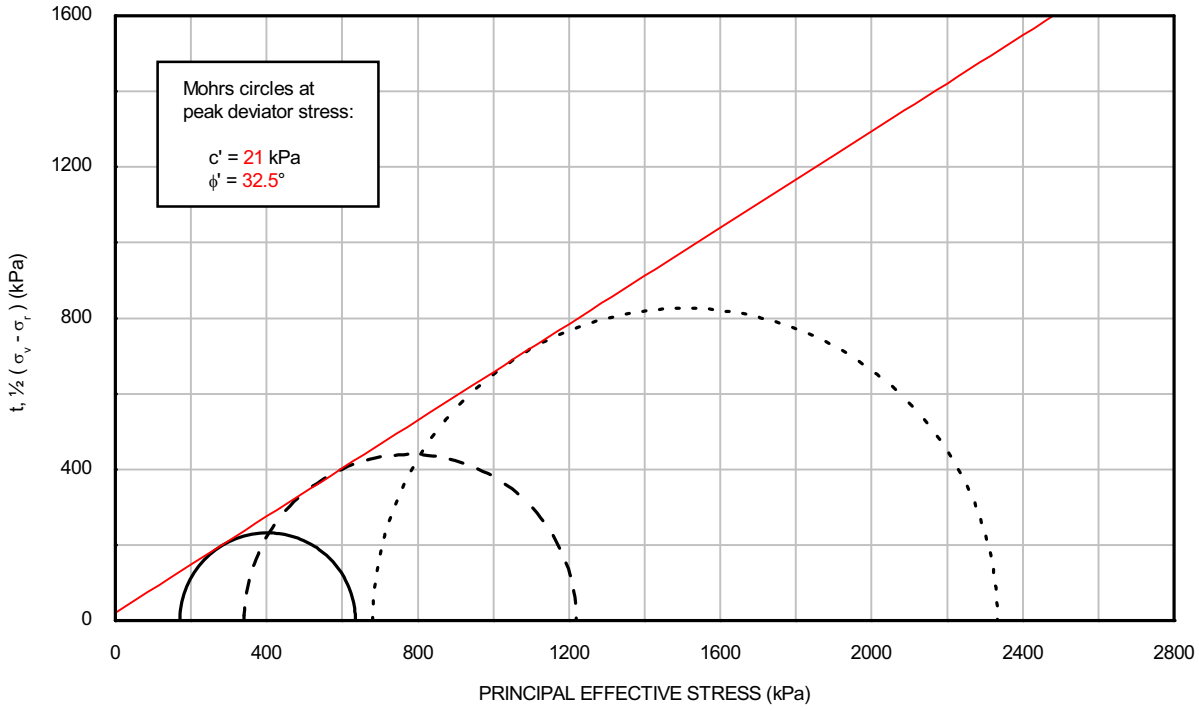
Date : 29/10/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	170	170	BH-WFS4-3	18BagA	14.00
– – –	2	340	340			
- - - -	3	680	680			

Drawn by: ALB Date: 27/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-3_18BagA_D3.OPJ

Template Issue: 4

Date : 29/10/2015

Checked by: PH

Date : 29/10/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-4_18BagA_D3.XLS
Template Issue: 7
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

VISUAL DESCRIPTION
Grey fine and medium SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	16/10/2015	23/10/2015	27/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	9.7	9.9	10.1
Bulk density	(Mg/m³)	1.79	1.78	1.78
Dry density	(Mg/m³)	1.63	1.62	1.62
Void ratio		0.623	0.634	0.638
Degree of saturation	(%)	41	41	42

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	437	528	723
Cell pressure on completion	(kPa)	450	550	750
B value achieved		0.97	0.94	0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-4	BH-WFS4-4	BH-WFS4-4
Sample	18BagA	18BagA	18BagA
Depth (m)	10.00	10.00	10.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-4_18BagA_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	450	550	750
Back pressure	(kPa)	350	350	350
Effective cell pressure	(kPa)	100	200	400
Pore pressure on completion	(kPa)	350	350	350
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	22.6	23.4	23.4
Bulk density	(Mg/m^3)	2.03	2.02	2.02
Dry density	(Mg/m^3)	1.66	1.64	1.64
Void ratio		0.599	0.620	0.621
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	1.47	0.86	1.09
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-4	BH-WFS4-4	BH-WFS4-4
Sample	18BagA	18BagA	18BagA
Depth (m)	10.00	10.00	10.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-4_18BagA_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	350	350	350
Initial effective cell pressure	(kPa)	100	200	400
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	241	648	1174
Membrane correction applied	(kPa)	0.5	0.6	0.8
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	3.11	4.48	6.00
Volumetric strain	(%)	-0.13	-0.65	-0.37
Major principal effective stress	(kPa)	341	850	1577
Minor principal effective stress	(kPa)	100	201	404
Principal effective stress ratio		3.40	4.22	3.91
Epsilon 50 (ε 50)	(%)	0.63	0.67	0.77
Secant modulus (E50) at ε 50	(kPa)	19075	48412	75833
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	241	648	1173
Membrane correction applied	(kPa)	0.5	0.6	0.8
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	3.11	4.48	5.75
Volumetric strain	(%)	-0.13	-0.65	-0.30
Major principal effective stress	(kPa)	341	850	1576
Minor principal effective stress	(kPa)	100	201	403
Principal effective stress ratio		3.40	4.22	3.91
At 10% axial strain				
Corrected deviator stress	(kPa)	209	572	1128
Membrane correction applied	(kPa)	1.3	1.3	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-0.81	-2.04	-1.38
Major principal effective stress	(kPa)	310	775	1532
Minor principal effective stress	(kPa)	100	203	404
Principal effective stress ratio		3.08	3.81	3.79

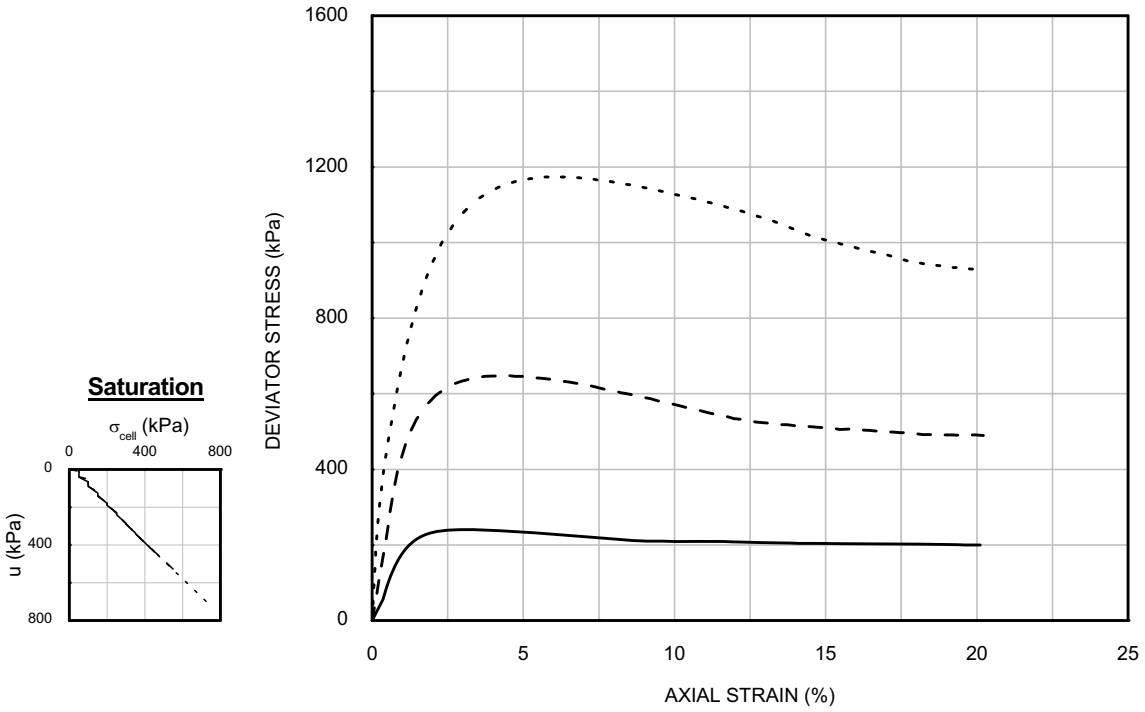
FINAL CONDITIONS				
Moisture content	(%)	23.2	25.0	25.1
Bulk density	(Mg/m³)	2.02	1.99	1.99
Dry density	(Mg/m³)	1.64	1.59	1.59

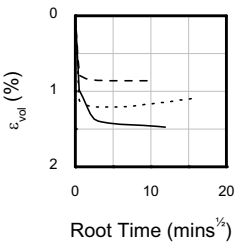
Borehole	BH-WFS4-4	BH-WFS4-4	BH-WFS4-4
Sample	18BagA	18BagA	18BagA
Depth (m)	10.00	10.00	10.00

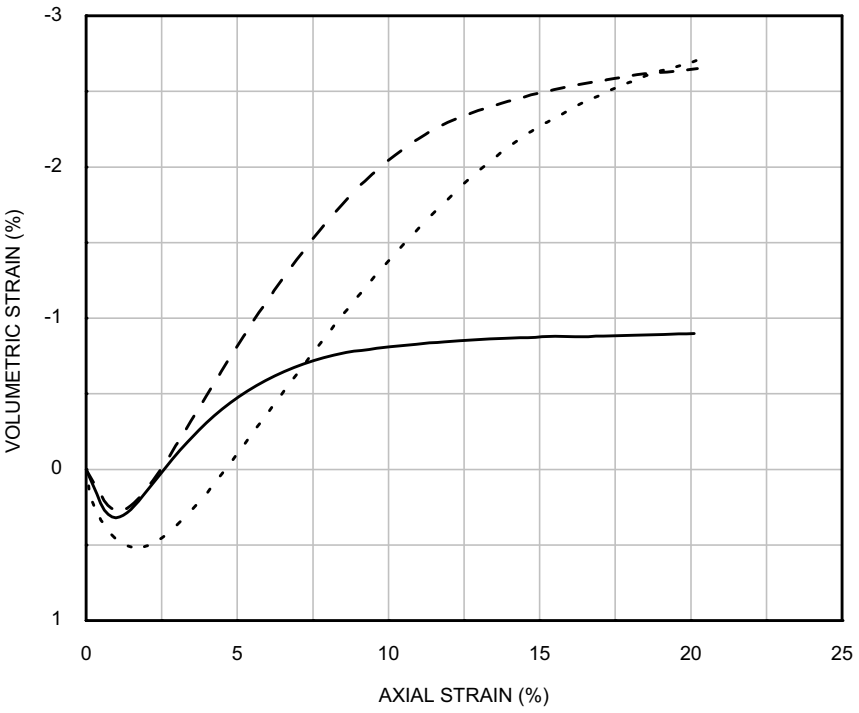
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 29/10/2015
Template Issue: 4 Date : 30/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-4_18BagA_D3.OPJ Date : 30/10/2015
Checked by: ALB
Approved by: RMB





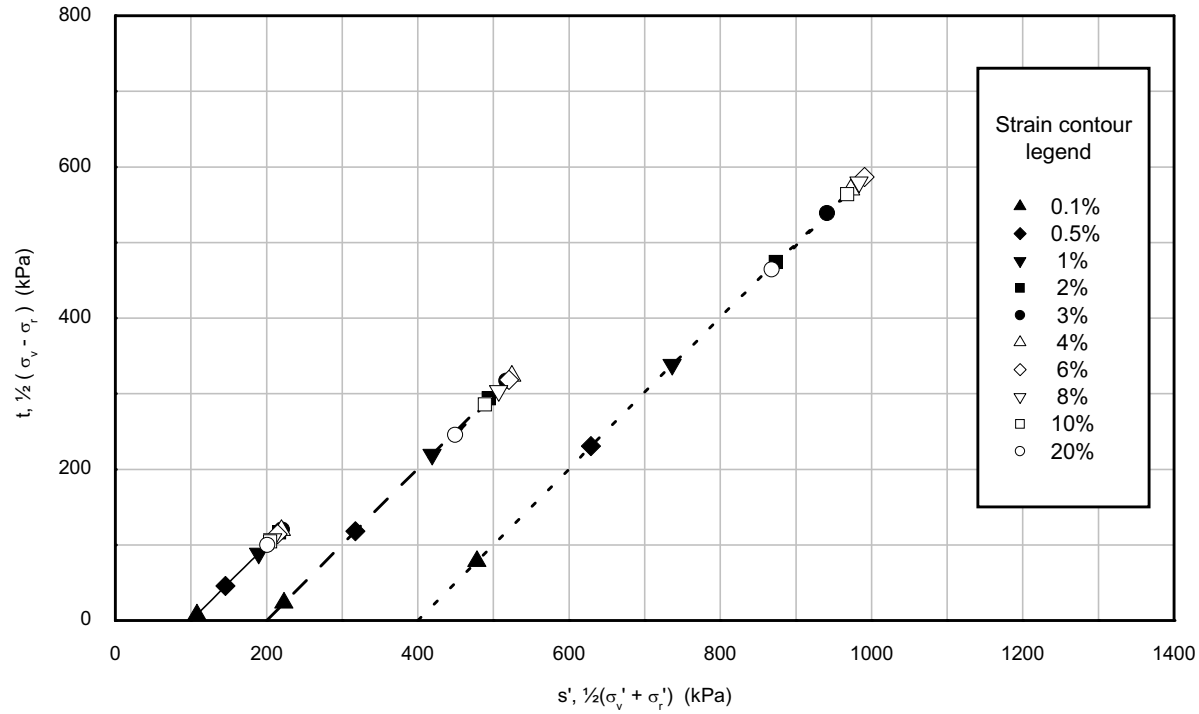


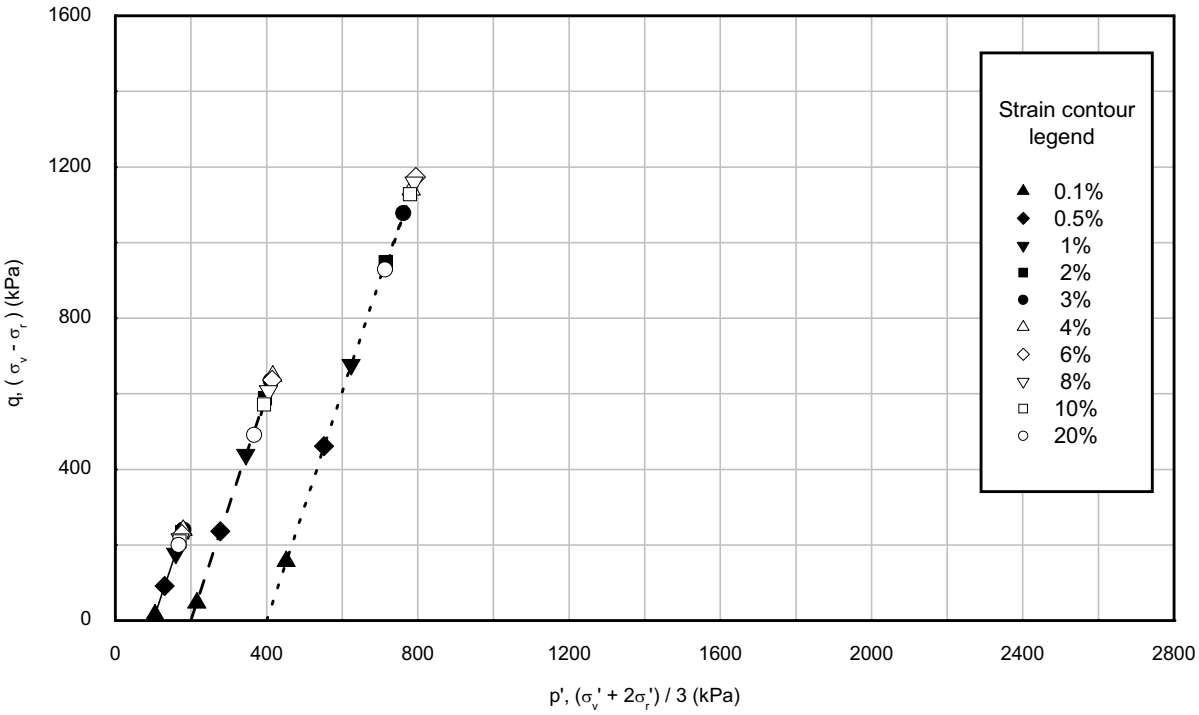
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	100	100
– –	2	200	200
- - - -	3	400	400

Borehole	Sample	Depth (m)
BH-WFS4-4	18BagA	10.00

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



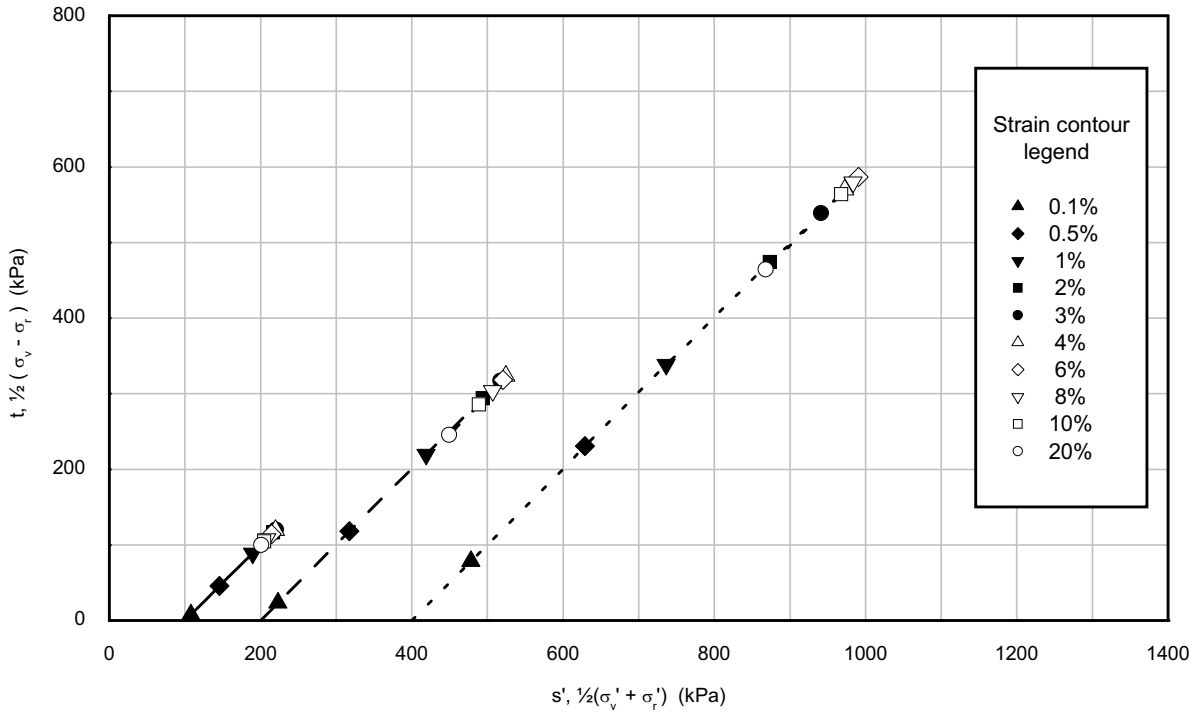


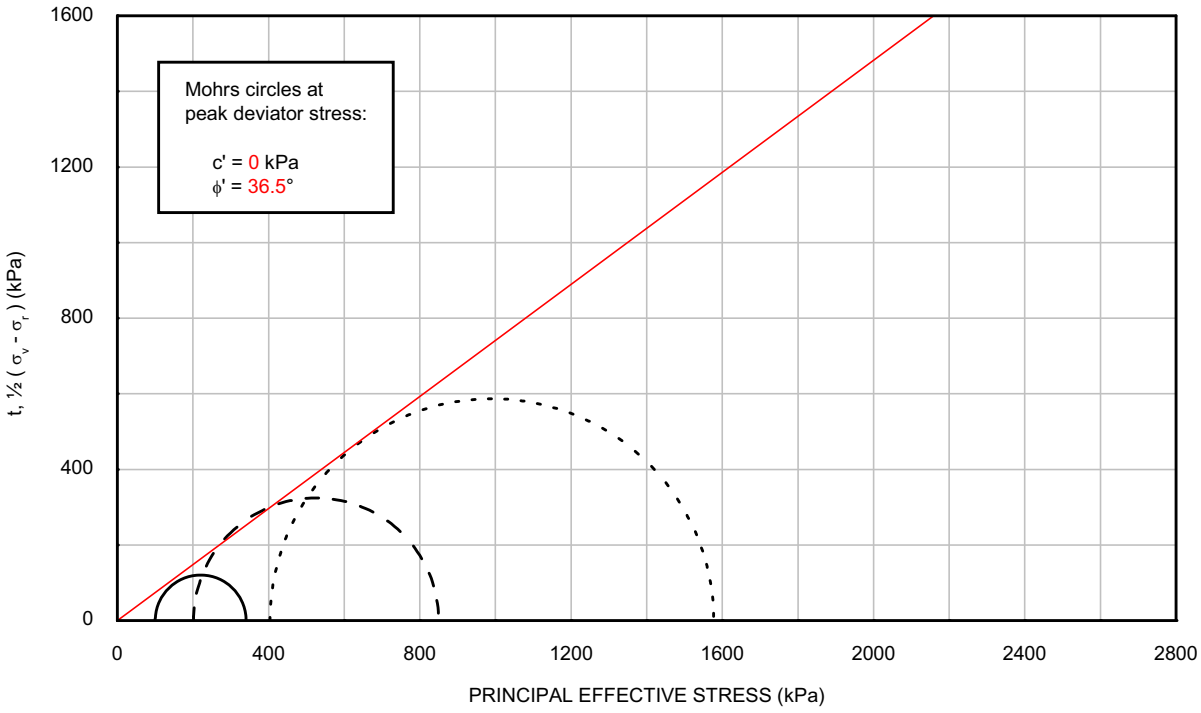
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	100	100	BH-WFS4-4	18BagA	10.00
– –	2	200	200			
- - - -	3	400	400			

Drawn by: ER Date: 29/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-4_18BagA_D3.OPJ
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ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	100	100	BH-WFS4-4	18BagA	10.00
– –	2	200	200			
- - - -	3	400	400			

Drawn by: ER Date: 29/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-4_18BagA_D3.OPJ Date : 30/10/2015

Template Issue: 4 Date : 30/10/2015

Checked by: ALB Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-4_29BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

VISUAL DESCRIPTION
Dark brown silty fine SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	21/10/2015	21/10/2015	21/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.3	10.3	10.3
Bulk density	(Mg/m³)	1.78	1.78	1.78
Dry density	(Mg/m³)	1.61	1.61	1.61
Void ratio		0.645	0.645	0.641
Degree of saturation	(%)	43	43	43

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	533	785	1283
Cell pressure on completion	(kPa)	550	800	1300
B value achieved		0.97	0.99	0.99

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-4	BH-WFS4-4	BH-WFS4-4
Sample	29BagA	29BagA	29BagA
Depth (m)	22.00	22.00	22.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-4_29BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	550	800	1300
Back pressure	(kPa)	300	300	300
Effective cell pressure	(kPa)	250	500	1000
Pore pressure on completion	(kPa)	300	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	23.0	21.7	21.2
Bulk density	(Mg/m^3)	2.03	2.05	2.06
Dry density	(Mg/m^3)	1.65	1.68	1.70
Void ratio		0.609	0.574	0.561
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	2.20	4.27	4.93
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-4	BH-WFS4-4	BH-WFS4-4
Sample	29BagA	29BagA	29BagA
Depth (m)	22.00	22.00	22.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-4_29BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	300
Initial effective cell pressure	(kPa)	250	500	1000
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	609	1025	2220
Membrane correction applied	(kPa)	1.9	1.9	2.0
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	16.01	16.26	17.94
Volumetric strain	(%)	1.78	2.91	3.72
Major principal effective stress	(kPa)	860	1524	3217
Minor principal effective stress	(kPa)	250	498	997
Principal effective stress ratio		3.43	3.06	3.23
Epsilon 50 (ε 50)	(%)	1.71	1.64	2.48
Secant modulus (E50) at ε 50	(kPa)	17828	31349	44750
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	609	1025	2220
Membrane correction applied	(kPa)	1.9	1.9	2.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	16.01	16.26	18.44
Volumetric strain	(%)	1.78	2.91	3.72
Major principal effective stress	(kPa)	860	1524	3217
Minor principal effective stress	(kPa)	250	498	997
Principal effective stress ratio		3.43	3.06	3.23
At 10% axial strain				
Corrected deviator stress	(kPa)	583	969	2024
Membrane correction applied	(kPa)	1.3	1.3	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	2.02	2.95	3.41
Major principal effective stress	(kPa)	833	1467	3020
Minor principal effective stress	(kPa)	250	498	996
Principal effective stress ratio		3.34	2.95	3.03

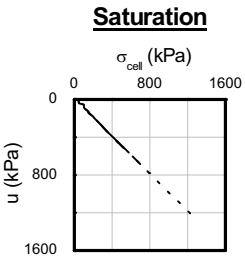
FINAL CONDITIONS				
Moisture content	(%)	22.0	20.0	19.0
Bulk density	(Mg/m³)	2.04	2.08	2.10
Dry density	(Mg/m³)	1.67	1.73	1.76

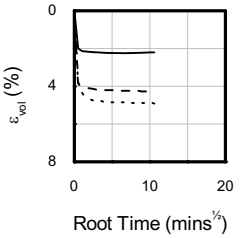
Borehole	BH-WFS4-4	BH-WFS4-4	BH-WFS4-4
Sample	29BagA	29BagA	29BagA
Depth (m)	22.00	22.00	22.00

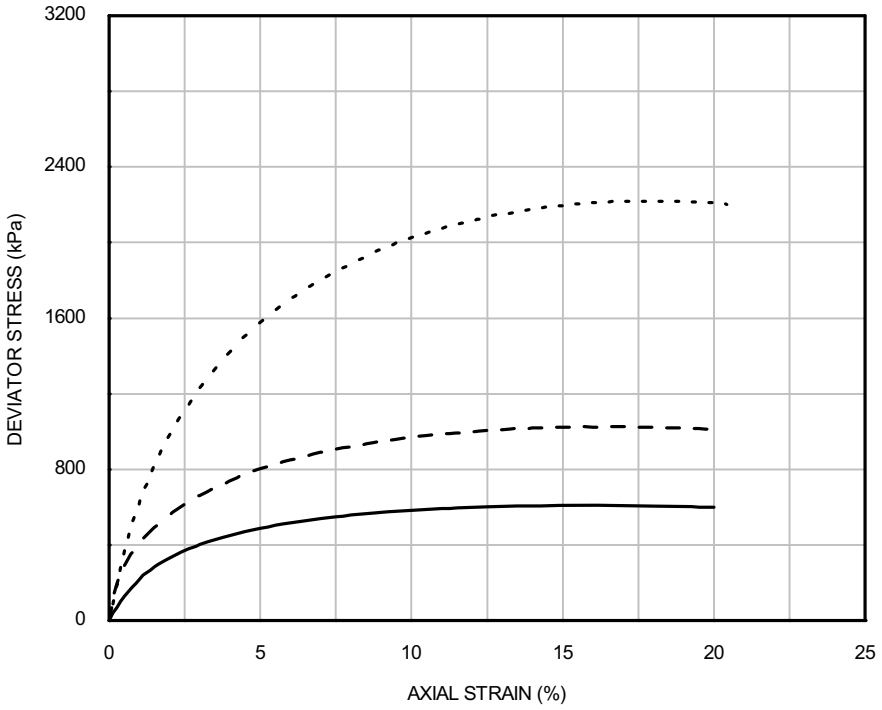
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

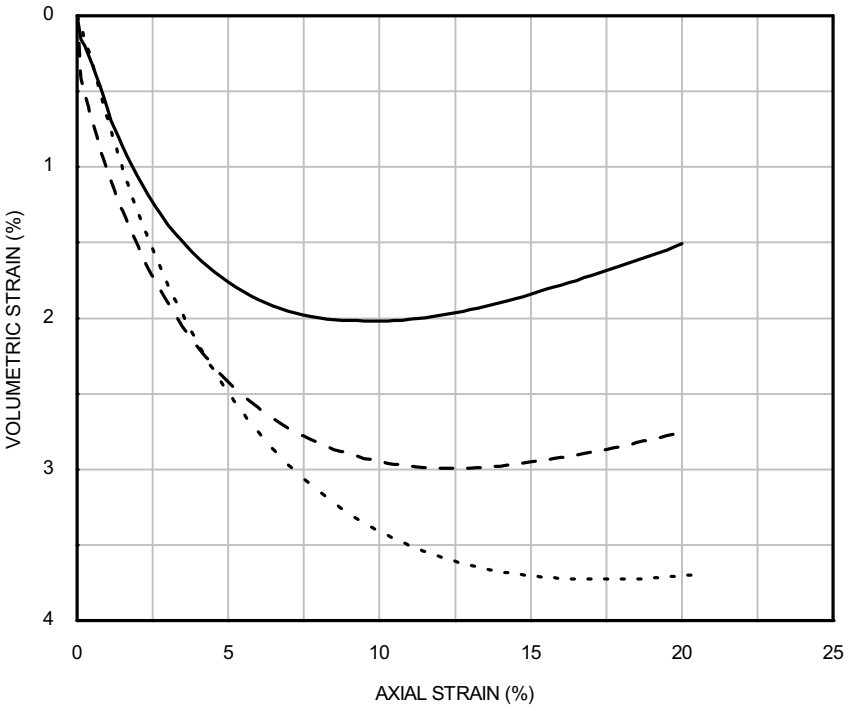
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 27/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-4_29BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH







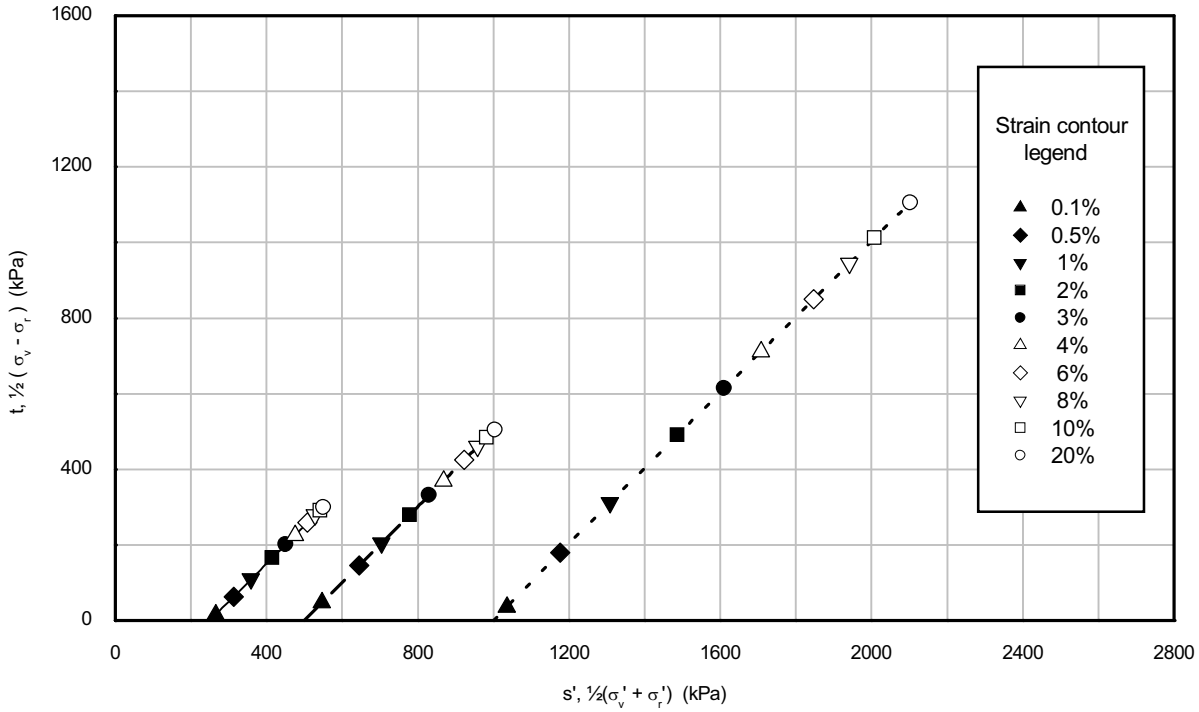


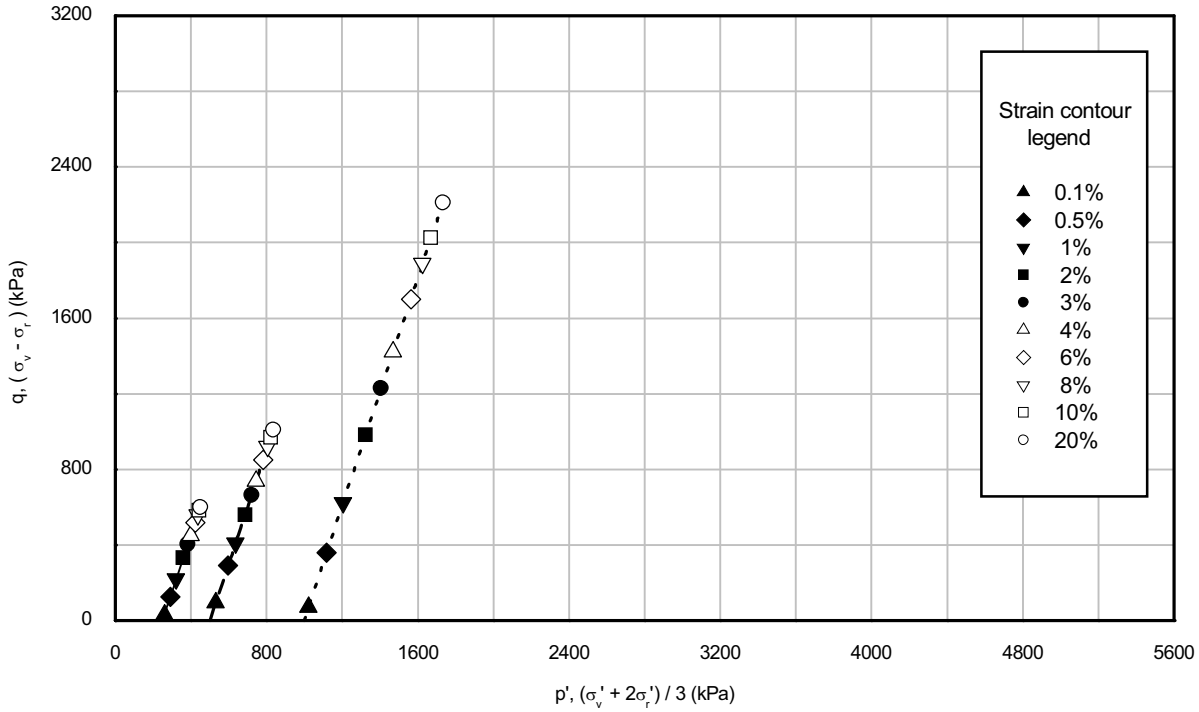
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	250	250
– –	2	500	500
· · · ·	3	1000	1000

Borehole	Sample	Depth (m)
BH-WFS4-4	29BagA	22.00

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	250	250	BH-WFS4-4	29BagA	22.00
– –	2	500	500			
- - - -	3	1000	1000			

Drawn by: ALB Date: 27/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-4_29BagA_D3.OPJ

Template Issue: 4

Date : 29/10/2015

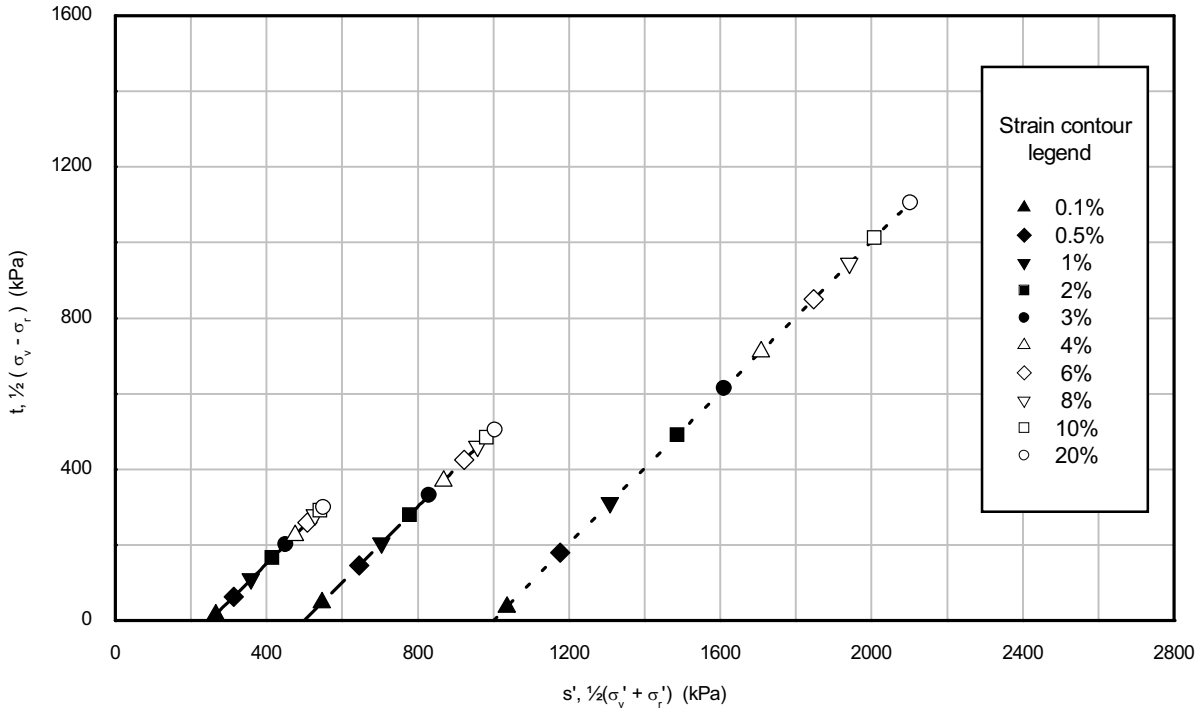
Checked by: PH

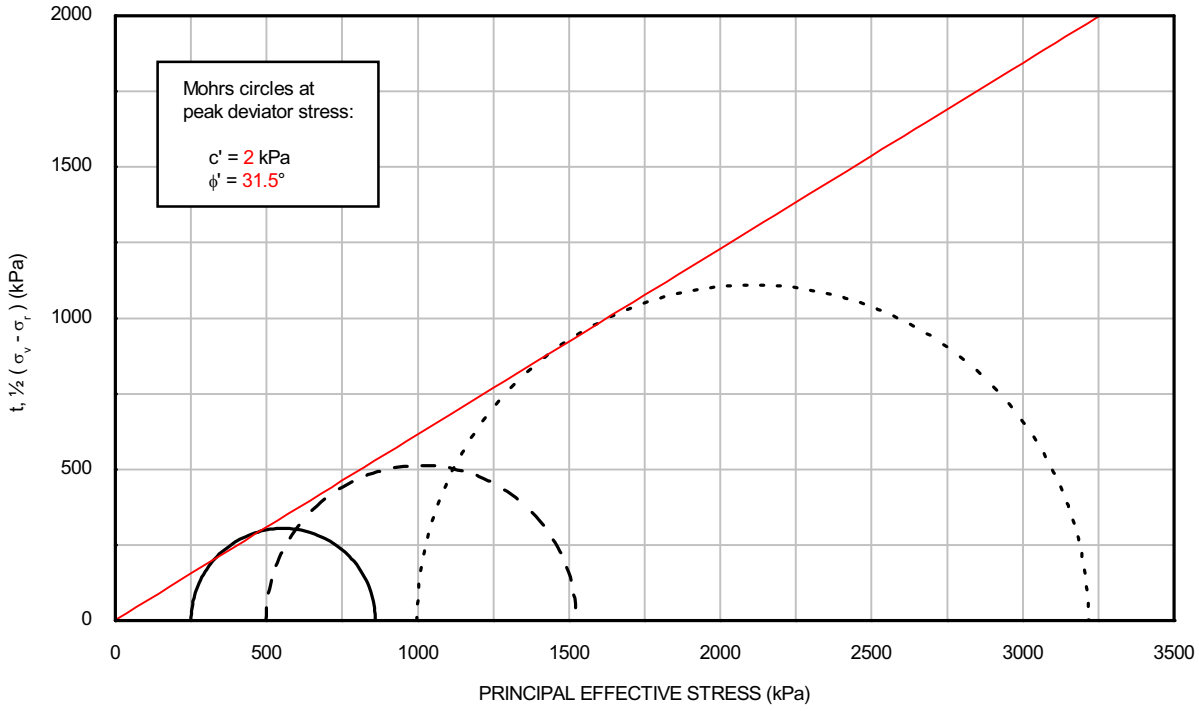
Date : 29/10/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	250	250	BH-WFS4-4	29BagA	22.00
– –	2	500	500			
- - - -	3	1000	1000			

Drawn by: ALB Date: 27/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-4_29BagA_D3.OPJ

Template Issue: 4

Date : 29/10/2015

Checked by: PH

Date : 29/10/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS4-5_15BagA_D3.XLS
Template Issue: 7
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

VISUAL DESCRIPTION
Grey fine to medium SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	16/10/2015	16/10/2015	16/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.6	10.6	10.6
Bulk density	(Mg/m³)	1.90	1.89	1.89
Dry density	(Mg/m³)	1.72	1.71	1.71
Void ratio		0.542	0.553	0.553
Degree of saturation	(%)	52	51	51

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	466	442	695
Cell pressure on completion	(kPa)	480	460	720
B value achieved		0.95	0.95	0.95

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-5	BH-WFS4-5	BH-WFS4-5
Sample	15BagA	15BagA	15BagA
Depth (m)	8.00	8.00	8.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	480	460	720
Back pressure	(kPa)	400	300	400
Effective cell pressure	(kPa)	80	160	320
Pore pressure on completion	(kPa)	400	300	400
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	20.2	20.4	20.0
Bulk density	(Mg/m^3)	2.08	2.07	2.08
Dry density	(Mg/m^3)	1.73	1.72	1.73
Void ratio		0.534	0.540	0.531
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	0.49	0.82	1.38
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-5	BH-WFS4-5	BH-WFS4-5
Sample	15BagA	15BagA	15BagA
Depth (m)	8.00	8.00	8.00

Date: 22/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-5_15BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 22/10/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-5_15BagA_D3.XLS
Date: 29/10/2015
Checked by: PH
Date: 29/10/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	400	300	400
Initial effective cell pressure	(kPa)	80	160	320
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	347	628	1138
Membrane correction applied	(kPa)	0.4	0.5	0.5
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.50	3.25	3.62
Volumetric strain	(%)	-0.95	-1.04	-0.99
Major principal effective stress	(kPa)	429	789	1459
Minor principal effective stress	(kPa)	81	161	321
Principal effective stress ratio		5.28	4.90	4.54
Epsilon 50 (ε 50)	(%)	0.57	0.55	0.64
Secant modulus (E50) at ε 50	(kPa)	30364	56632	88966
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	347	628	1138
Membrane correction applied	(kPa)	0.4	0.5	0.5
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.37	3.25	3.62
Volumetric strain	(%)	-0.84	-1.04	-0.99
Major principal effective stress	(kPa)	428	789	1459
Minor principal effective stress	(kPa)	81	161	321
Principal effective stress ratio		5.29	4.90	4.54
At 10% axial strain				
Corrected deviator stress	(kPa)	228	406	918
Membrane correction applied	(kPa)	1.3	1.3	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-3.98	-3.00	-3.80
Major principal effective stress	(kPa)	310	567	1240
Minor principal effective stress	(kPa)	82	161	322
Principal effective stress ratio		3.80	3.52	3.85

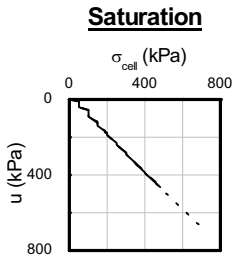
FINAL CONDITIONS				
Moisture content	(%)	22.8	22.4	22.9
Bulk density	(Mg/m³)	2.03	2.04	2.03
Dry density	(Mg/m³)	1.65	1.66	1.65

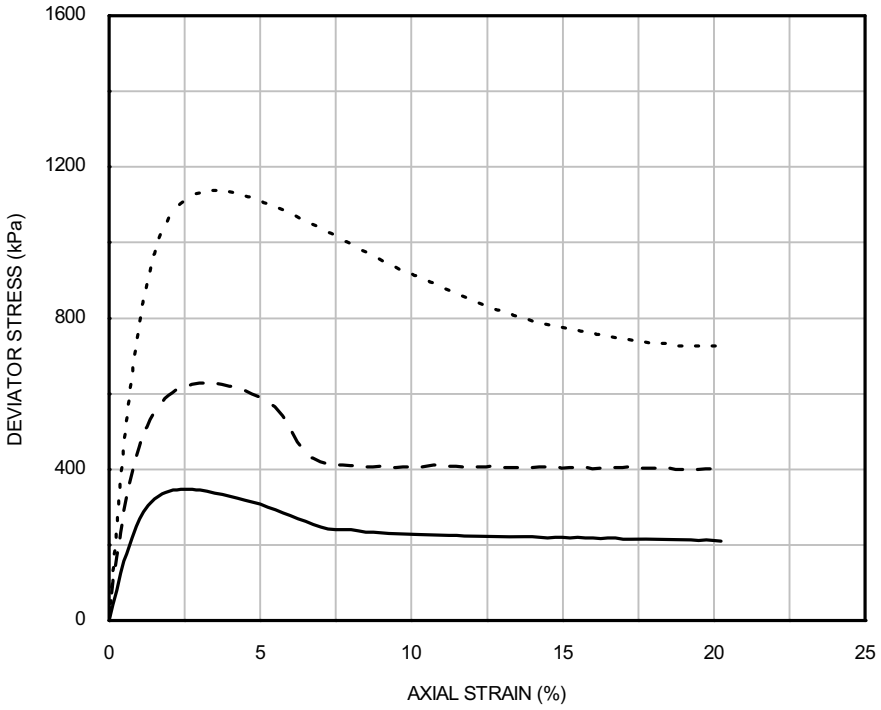
Borehole	BH-WFS4-5	BH-WFS4-5	BH-WFS4-5
Sample	15BagA	15BagA	15BagA
Depth (m)	8.00	8.00	8.00

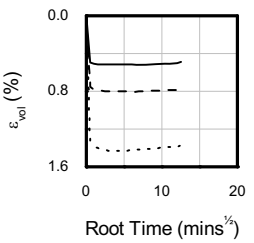
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

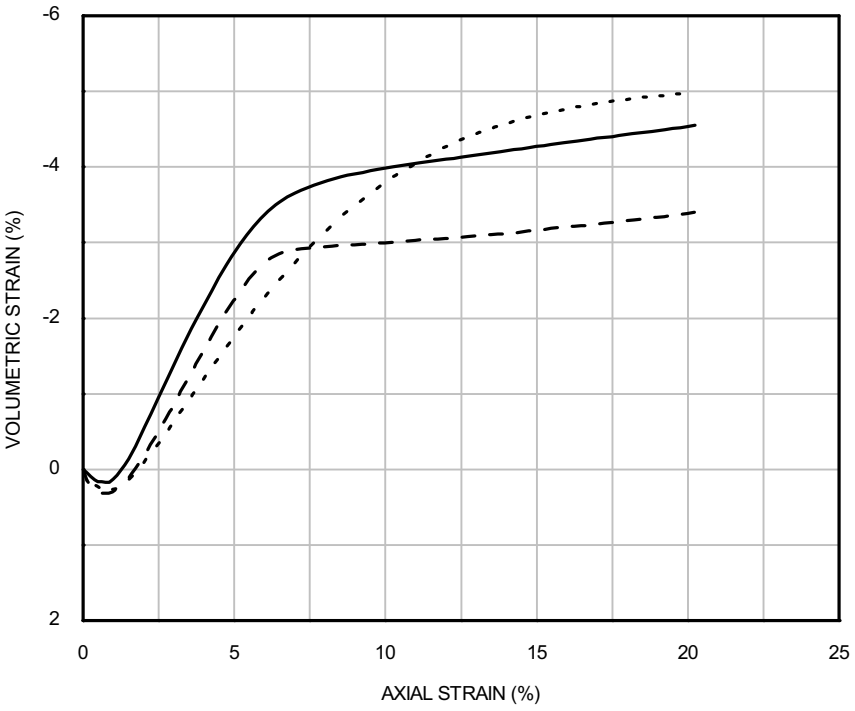
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-5_15BagA_D3.OPJ
Template Issue: 4 Date : 29/10/2015
Checked by: PH Date : 29/10/2015
Approved by: PH





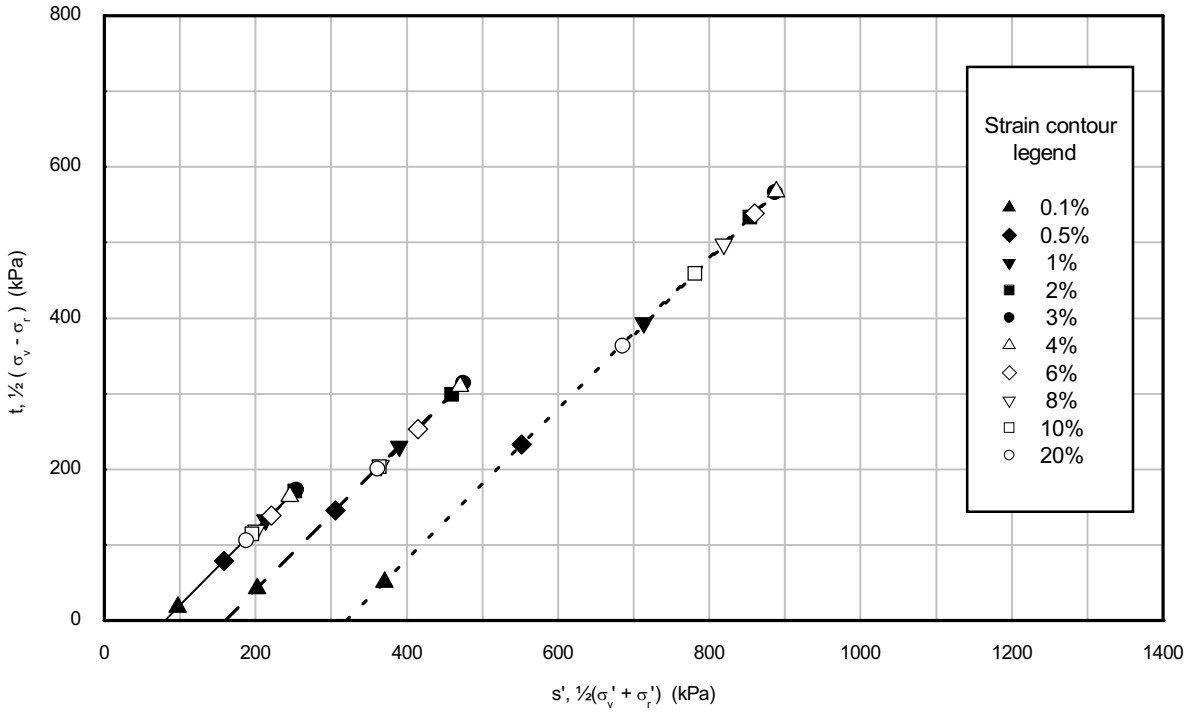


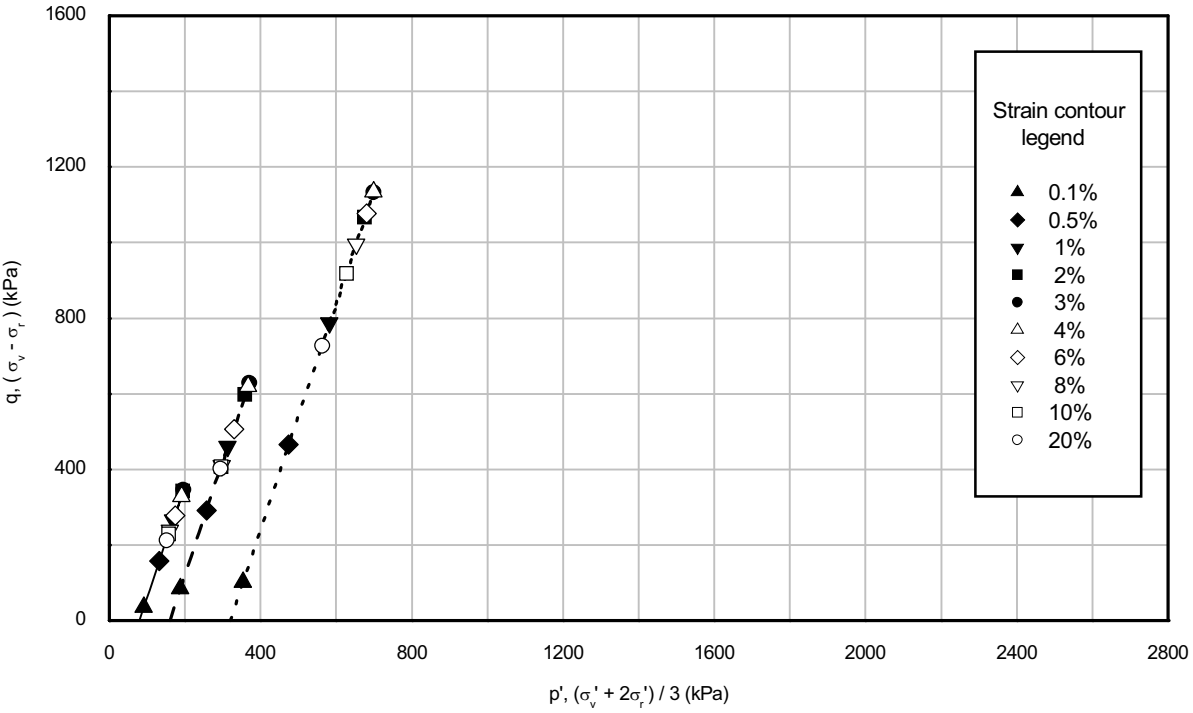


Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	80	80	BH-WFS4-5	15BagA	8.00
– –	2	160	160			
· · · ·	3	320	320			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



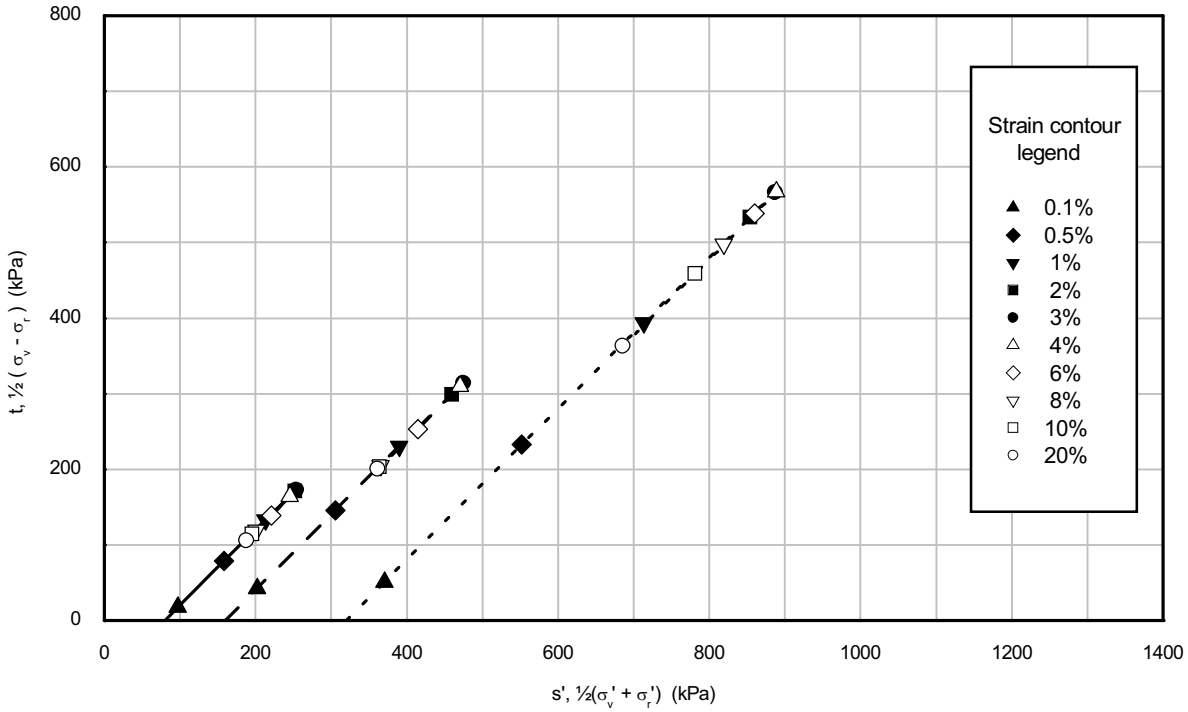


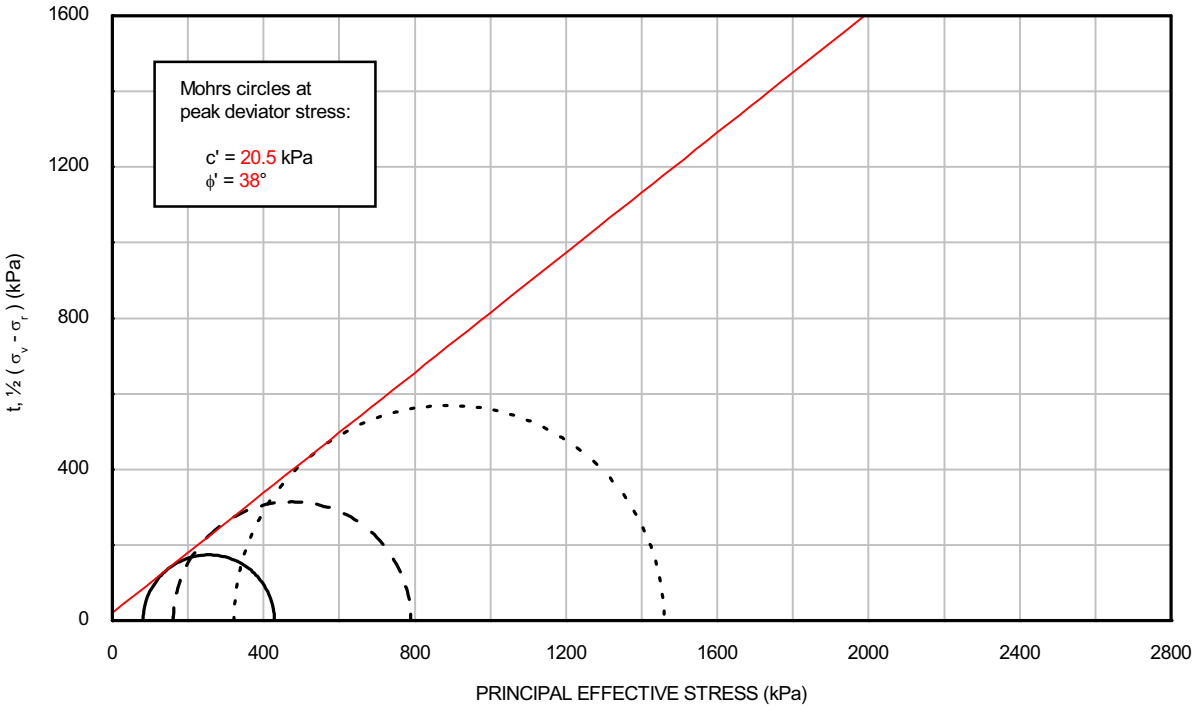
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	80	80	BH-WFS4-5	15BagA	8.00
– –	2	160	160			
- - - -	3	320	320			

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-5_15BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	80	80	BH-WFS4-5	15BagA	8.00
– –	2	160	160			
- - - -	3	320	320			

Drawn by: ALB Date: 22/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-5_15BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: PH
Date : 29/10/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-5_31BagA_D3.XLS
Date: 30/10/2015
Date: 03/11/2015
Checked by: ALB
Approved by: PH

VISUAL DESCRIPTION
Dark brown silty fine SAND

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	21/10/2015	21/10/2015	27/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.8	10.8	10.8
Bulk density	(Mg/m³)	1.78	1.78	1.78
Dry density	(Mg/m³)	1.61	1.61	1.61
Void ratio		0.676	0.674	0.675
Degree of saturation	(%)	43	43	43

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	561	838	1400
Cell pressure on completion	(kPa)	580	860	1420
B value achieved		0.97	0.98	0.99

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-5	BH-WFS4-5	BH-WFS4-5
Sample	31BagA	31BagA	31BagA
Depth (m)	26.00	26.00	26.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	580	860	1420
Back pressure	(kPa)	300	300	300
Effective cell pressure	(kPa)	280	560	1120
Pore pressure on completion	(kPa)	300	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	23.3	22.3	20.3
Bulk density	(Mg/m³)	2.04	2.06	2.09
Dry density	(Mg/m³)	1.65	1.68	1.74
Void ratio		0.628	0.599	0.545
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	2.87	4.47	7.75
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-5	BH-WFS4-5	BH-WFS4-5
Sample	31BagA	31BagA	31BagA
Depth (m)	26.00	26.00	26.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-5_31BagA_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 03/11/2015
Approved by: PH

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-5_31BagA_D3.XLS
Date: 30/10/2015
Date: 03/11/2015
Checked by: ALB
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	300
Initial effective cell pressure	(kPa)	280	560	1120
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	645	1263	2152
Membrane correction applied	(kPa)	1.6	1.9	1.9
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	15.43	19.61	19.33
Volumetric strain	(%)	3.27	4.31	5.67
Major principal effective stress	(kPa)	924	1824	3266
Minor principal effective stress	(kPa)	279	561	1114
Principal effective stress ratio		3.31	3.25	2.93
Epsilon 50 (ε 50)	(%)	1.75	1.88	2.89
Secant modulus (E50) at ε 50	(kPa)	18423	33585	37181
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	645	1262	2152
Membrane correction applied	(kPa)	1.6	1.8	1.9
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	15.18	18.36	19.33
Volumetric strain	(%)	3.27	4.31	5.67
Major principal effective stress	(kPa)	924	1822	3266
Minor principal effective stress	(kPa)	279	560	1114
Principal effective stress ratio		3.31	3.25	2.93
At 10% axial strain				
Corrected deviator stress	(kPa)	617	1162	1892
Membrane correction applied	(kPa)	1.2	1.2	1.2
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	3.07	3.81	4.73
Major principal effective stress	(kPa)	896	1722	3002
Minor principal effective stress	(kPa)	279	560	1109
Principal effective stress ratio		3.21	3.07	2.71

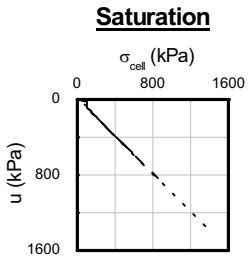
FINAL CONDITIONS				
Moisture content	(%)	21.4	19.7	17.0
Bulk density	(Mg/m³)	2.07	2.10	2.16
Dry density	(Mg/m³)	1.71	1.76	1.85

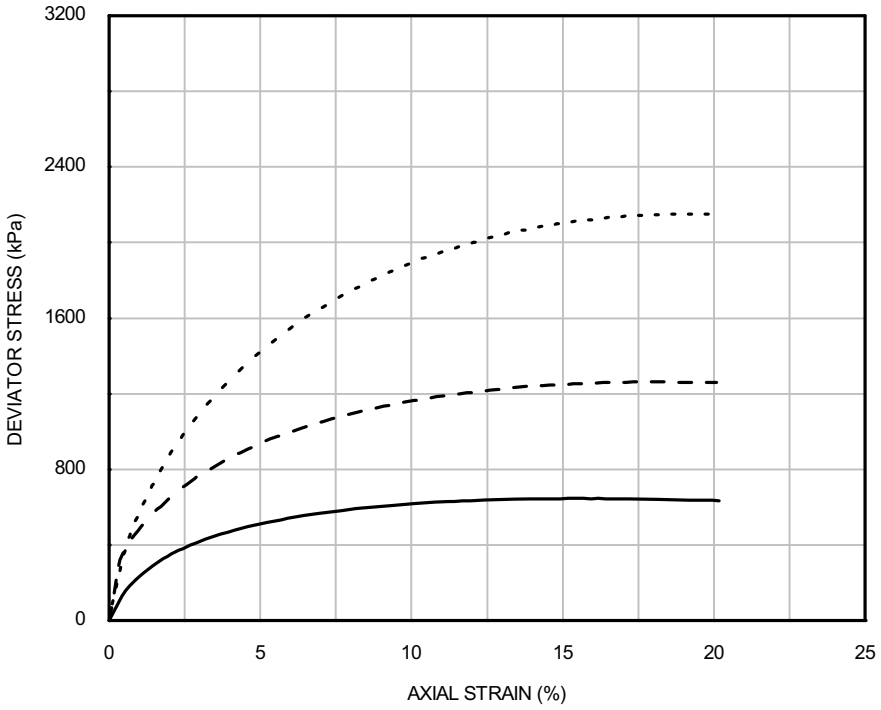
Borehole	BH-WFS4-5	BH-WFS4-5	BH-WFS4-5
Sample	31BagA	31BagA	31BagA
Depth (m)	26.00	26.00	26.00

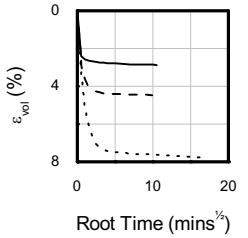
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

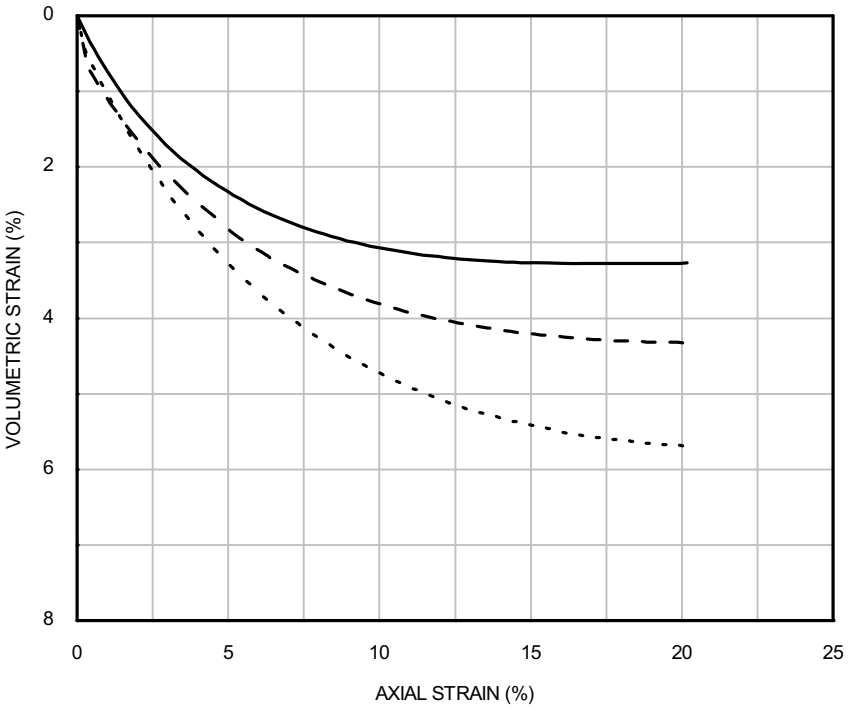
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 29/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-5_31BagA_D3.OPJ
Template Issue: 4 Date : 30/10/2015
Checked by: ALB Date : 03/11/2015
Approved by: PH







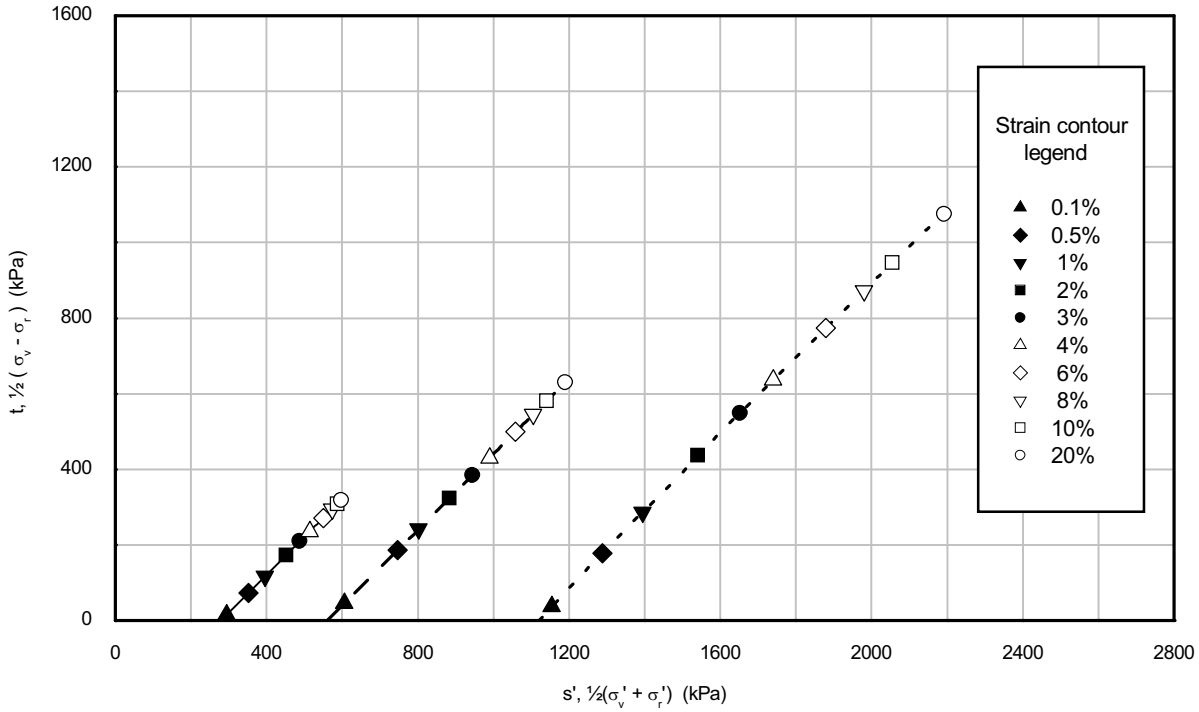


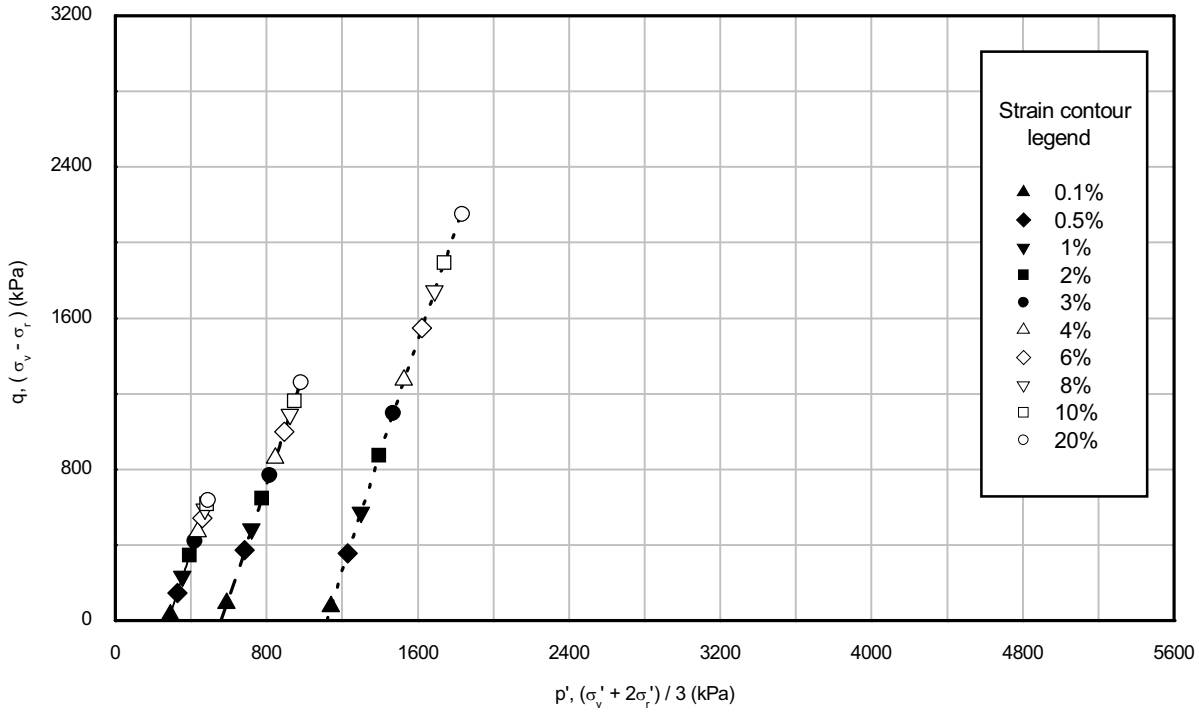
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	280	280
– –	2	560	560
· · · ·	3	1120	1120

Borehole	Sample	Depth (m)
BH-WFS4-5	31BagA	26.00

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	280	280	BH-WFS4-5	31BagA	26.00
– –	2	560	560			
- - - -	3	1120	1120			

Drawn by: ER Date: 29/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-5_31BagA_D3.OPJ

Template Issue: 4

Date : 30/10/2015

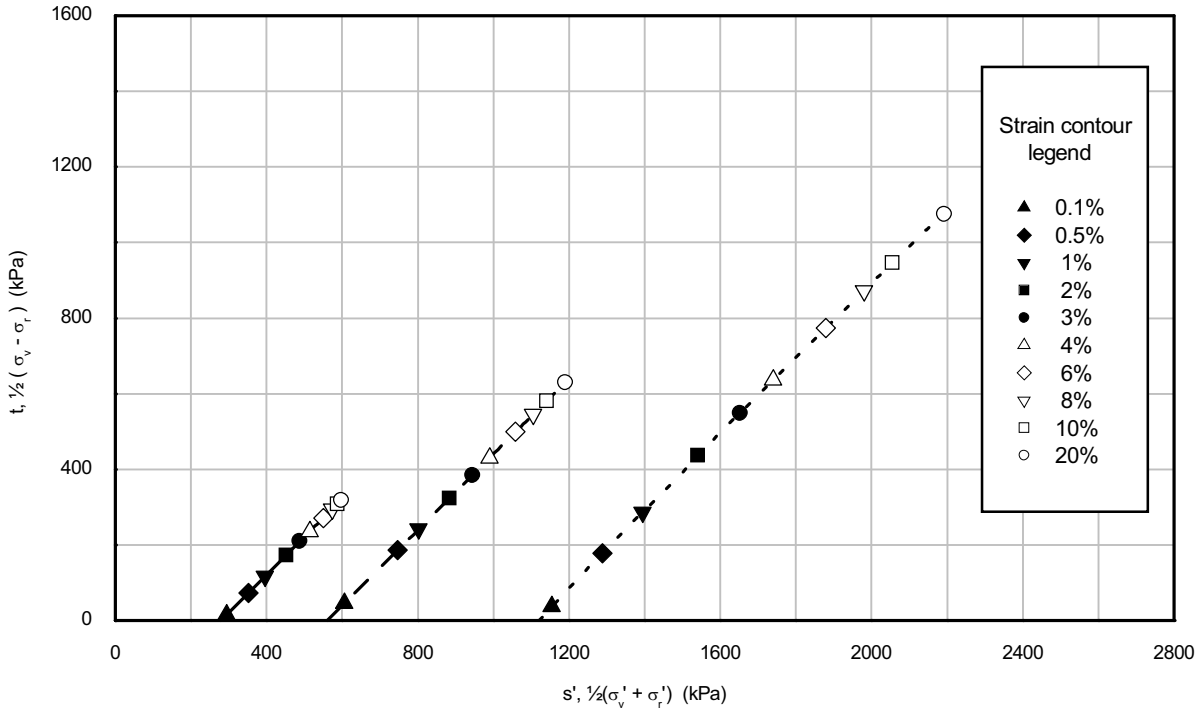
Checked by: ALB

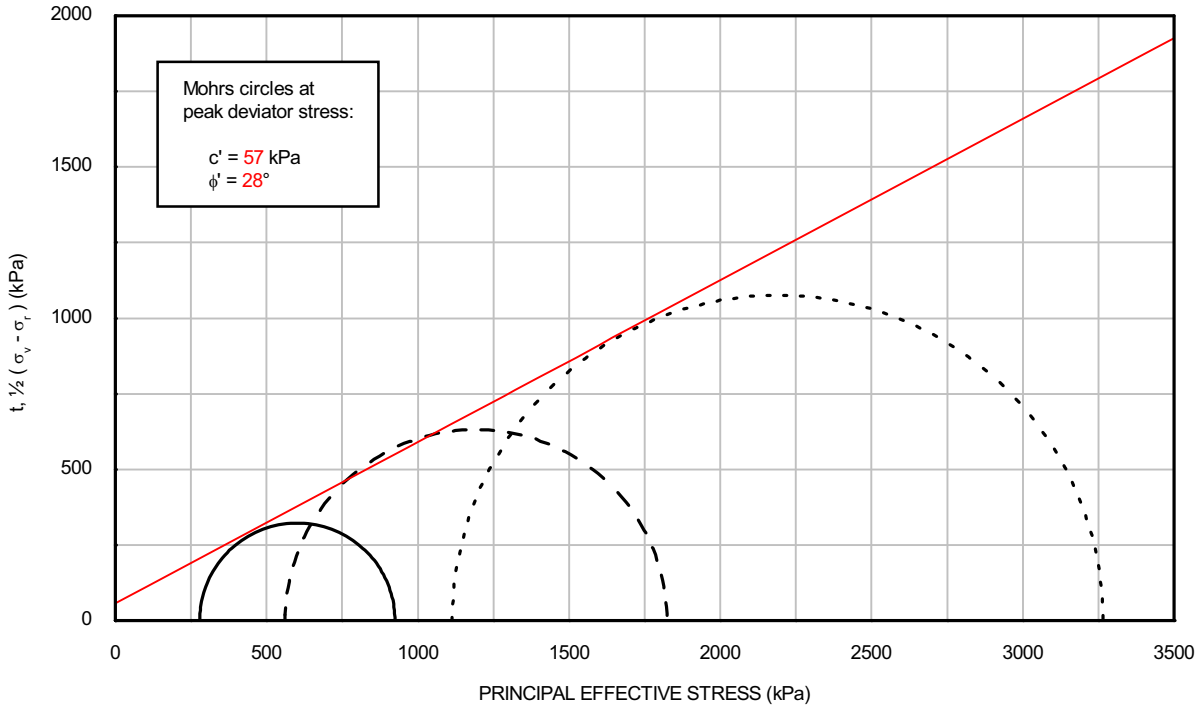
Date : 03/11/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	280	280	BH-WFS4-5	31BagA	26.00
– –	2	560	560			
- - - -	3	1120	1120			

Drawn by: ER Date: 29/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-5_31BagA_D3.OPJ
Template Issue: 4
Date : 30/10/2015
Checked by: ALB
Date : 03/11/2015
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 30/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-6_20BagA_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

VISUAL DESCRIPTION
Grey to brown fine and medium SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	26/10/2015	26/10/2015	28/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.3	10.3	10.1
Bulk density	(Mg/m³)	1.96	1.94	1.96
Dry density	(Mg/m³)	1.77	1.76	1.78
Void ratio		0.494	0.503	0.490
Degree of saturation	(%)	55	54	54

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	500	570	946
Cell pressure on completion	(kPa)	520	590	980
B value achieved		0.92	0.96	0.95

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	20BagA	20BagA	20BagA
Depth (m)	12.00	12.00	12.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	520	590	980
Back pressure	(kPa)	400	350	500
Effective cell pressure	(kPa)	120	240	480
Pore pressure on completion	(kPa)	400	350	500
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	18.2	18.2	17.6
Bulk density	(Mg/m^3)	2.11	2.11	2.13
Dry density	(Mg/m^3)	1.79	1.79	1.81
Void ratio		0.482	0.482	0.465
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	0.80	1.40	1.66
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	20BagA	20BagA	20BagA
Depth (m)	12.00	12.00	12.00

Drawn by: ER Date: 30/10/2015

Template Issue: 7 Filename: J11302 / EFFECTIV / BH-WFS4-6_20BagA_D3.XLS

Checked by: ALB Date: 30/10/2015

Approved by: RMB Date: 30/10/2015

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 30/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-6_20BagA_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	400	350	500
Initial effective cell pressure	(kPa)	120	240	480
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	505	749	1760
Membrane correction applied	(kPa)	0.4	0.4	0.4
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.99	3.45	3.50
Volumetric strain	(%)	-0.67	-0.76	-0.73
Major principal effective stress	(kPa)	626	987	2243
Minor principal effective stress	(kPa)	121	238	483
Principal effective stress ratio		5.19	4.15	4.65
Epsilon 50 (ε 50)	(%)	0.92	0.76	0.60
Secant modulus (E50) at ε 50	(kPa)	27448	49151	146485
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	505	749	1760
Membrane correction applied	(kPa)	0.4	0.4	0.4
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.99	3.45	3.50
Volumetric strain	(%)	-0.67	-0.76	-0.73
Major principal effective stress	(kPa)	626	987	2243
Minor principal effective stress	(kPa)	121	238	483
Principal effective stress ratio		5.19	4.15	4.65
At 10% axial strain				
Corrected deviator stress	(kPa)	357	480	1202
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-2.95	-2.55	-2.49
Major principal effective stress	(kPa)	479	718	1686
Minor principal effective stress	(kPa)	121	238	483
Principal effective stress ratio		3.95	3.02	3.49

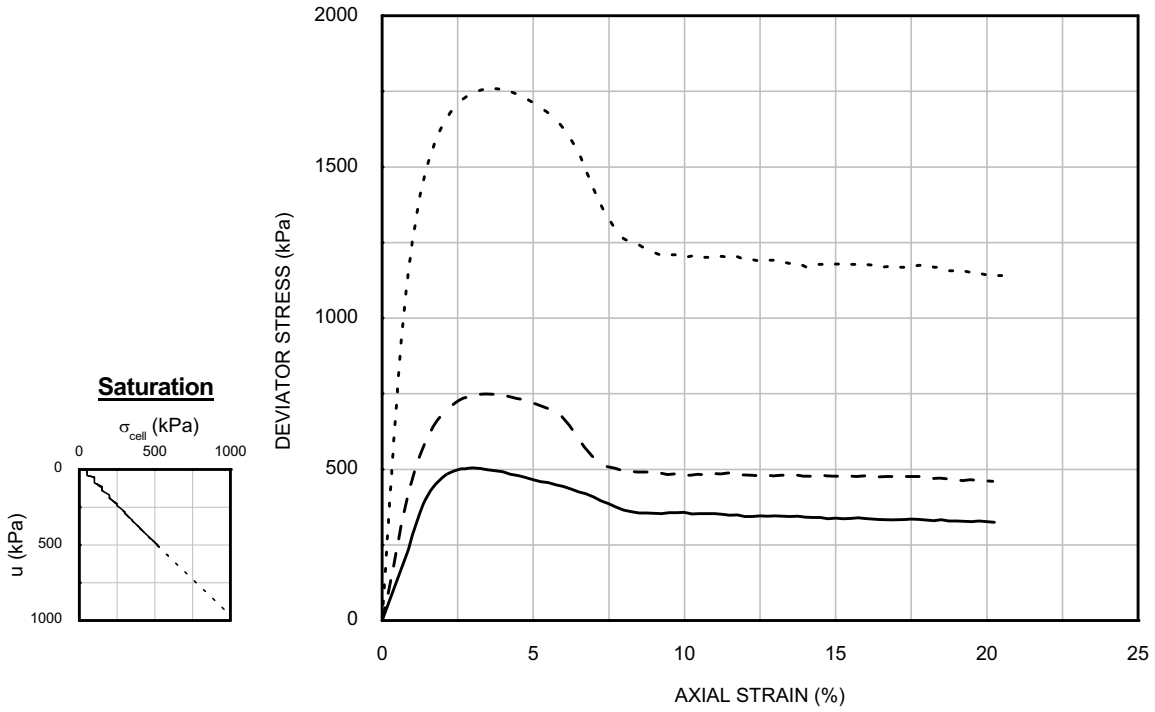
FINAL CONDITIONS				
Moisture content	(%)	20.0	19.6	19.1
Bulk density	(Mg/m³)	2.08	2.09	2.10
Dry density	(Mg/m³)	1.73	1.74	1.76

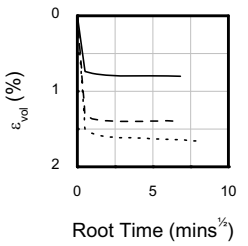
Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	20BagA	20BagA	20BagA
Depth (m)	12.00	12.00	12.00

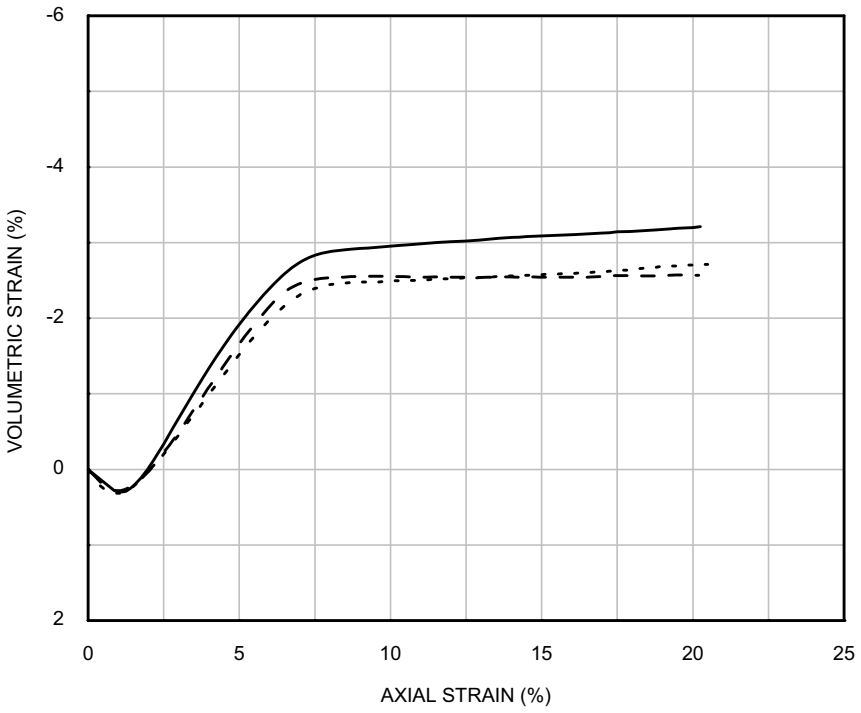
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 30/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-6_20BagA_D3.OPJ
Template Issue: 4
Date : 30/10/2015
Checked by: ALB
Date : 30/10/2015
Approved by: RMB





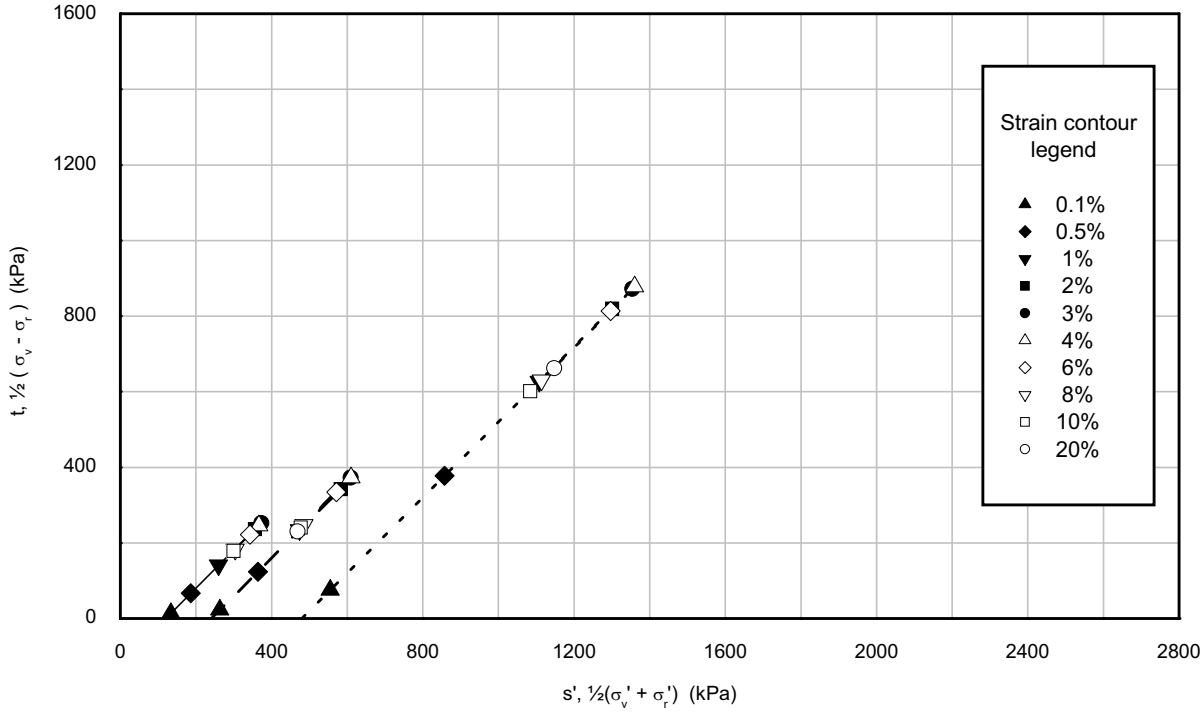


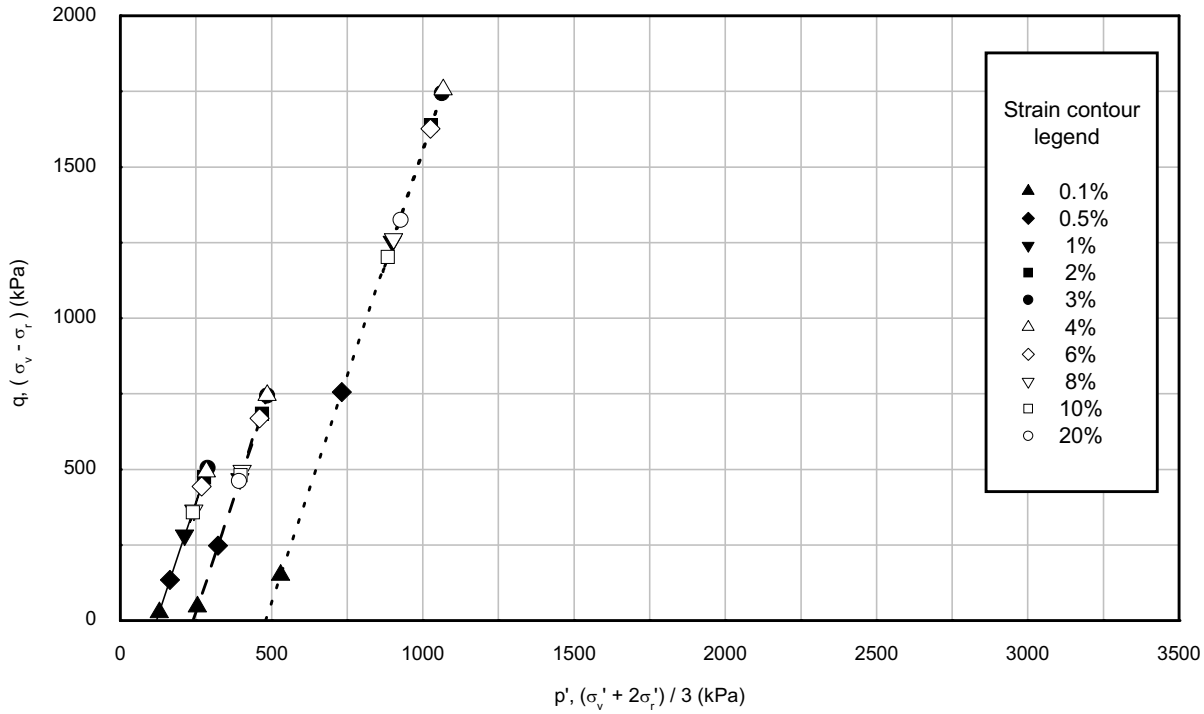
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	120	120
– –	2	240	240
- - - -	3	480	480

Borehole	Sample	Depth (m)
BH-WFS4-6	20BagA	12.00

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	120	120	BH-WFS4-6	20BagA	12.00
– –	2	240	240			
- - - -	3	480	480			

Drawn by: ER Date: 30/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-6_20BagA_D3.OPJ

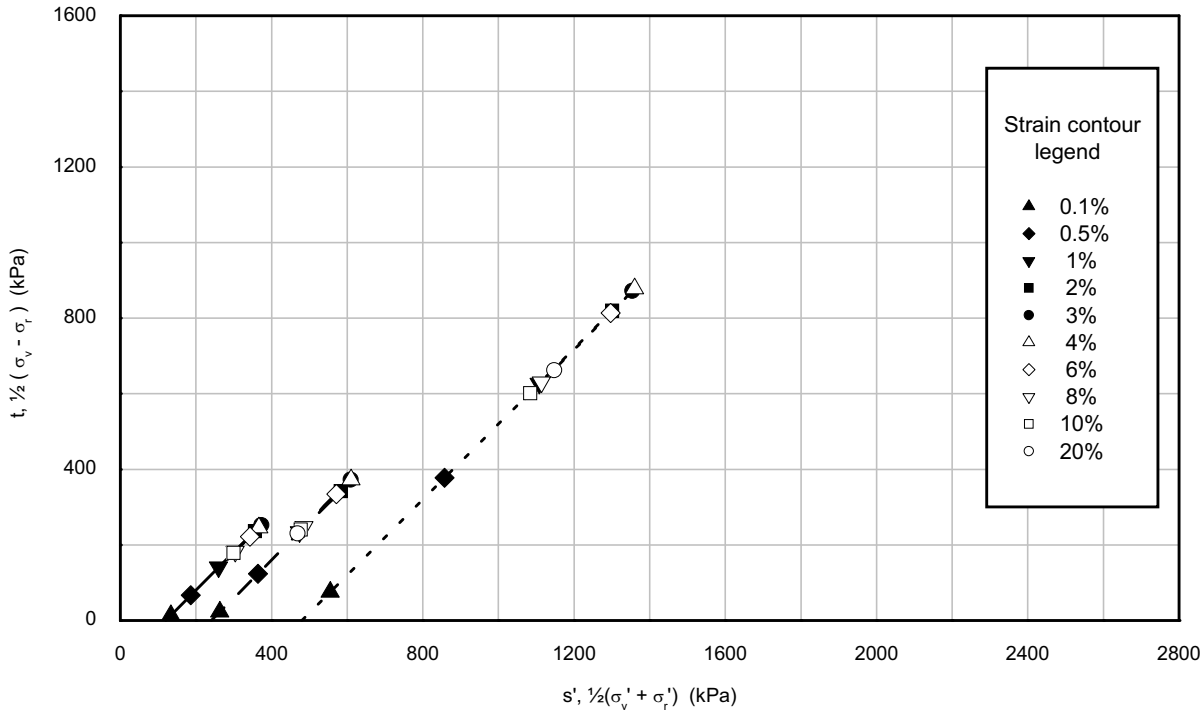
Template Issue: 4 Date : 30/10/2015

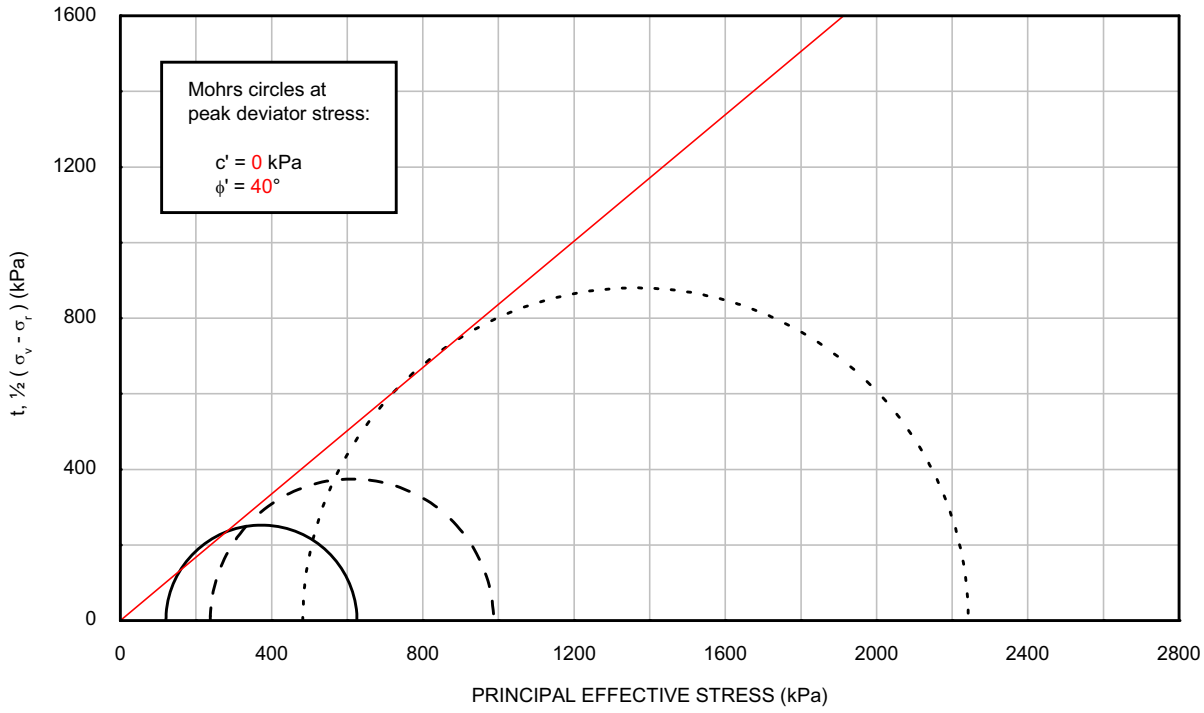
Checked by: ALB Date : 30/10/2015

Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	120	120	BH-WFS4-6	20BagA	12.00
– –	2	240	240			
- - - -	3	480	480			

Drawn by: ER Date: 30/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-6_20BagA_D3.OPJ

Template Issue: 4

Date : 30/10/2015

Date : 30/10/2015

Checked by: ALB

Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-6_27BagA_D3.XLS
Date: 29/10/2015
Date: 30/10/2015
Checked by: ALB
Approved by: RMB

VISUAL DESCRIPTION
Dark grey to green fine silty SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	26/10/2015	26/10/2015	27/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	9.9	9.9	9.9
Bulk density	(Mg/m³)	1.84	1.83	1.84
Dry density	(Mg/m³)	1.67	1.67	1.67
Void ratio		0.587	0.589	0.585
Degree of saturation	(%)	45	45	45

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	542	774	1352
Cell pressure on completion	(kPa)	560	820	1440
B value achieved		0.97	0.93	0.93

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	27BagA	27BagA	27BagA
Depth (m)	24.00	24.00	24.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	560	820	1440
Back pressure	(kPa)	300	300	400
Effective cell pressure	(kPa)	260	520	1040
Pore pressure on completion	(kPa)	300	300	400
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	21.6	21.4	21.5
Bulk density	(Mg/m³)	2.05	2.05	2.05
Dry density	(Mg/m³)	1.69	1.69	1.69
Void ratio		0.571	0.567	0.569
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	0.99	1.35	1.02
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	27BagA	27BagA	27BagA
Depth (m)	24.00	24.00	24.00

Date: 29/10/2015 Drawn by: ER Template Issue: 7 Filename: J11302 / EFFECTIV / BH-WFS4-6_27BagA_D3.XLS

Date: 29/10/2015 Checked by: ALB Date: 30/10/2015 Approved by: RMB

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-6_27BagA_D3.XLS
Date: 29/10/2015
Date: 30/10/2015
Checked by: ALB
Approved by: RMB

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	400
Initial effective cell pressure	(kPa)	260	520	1040
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	909	1588	3010
Membrane correction applied	(kPa)	0.4	0.6	0.7
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	3.71	4.75	5.70
Volumetric strain	(%)	-0.82	-0.60	-0.37
Major principal effective stress	(kPa)	1171	2109	4053
Minor principal effective stress	(kPa)	262	521	1043
Principal effective stress ratio		4.47	4.05	3.89
Epsilon 50 (ε 50)	(%)	0.89	0.73	0.63
Secant modulus (E50) at ε 50	(kPa)	51001	109441	238597
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	908	1588	3010
Membrane correction applied	(kPa)	0.4	0.6	0.7
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	3.46	4.75	5.70
Volumetric strain	(%)	-0.69	-0.60	-0.37
Major principal effective stress	(kPa)	1170	2109	4053
Minor principal effective stress	(kPa)	262	521	1043
Principal effective stress ratio		4.47	4.05	3.89
At 10% axial strain				
Corrected deviator stress	(kPa)	708	1270	2722
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-3.11	-1.87	-1.35
Major principal effective stress	(kPa)	970	1791	3765
Minor principal effective stress	(kPa)	262	521	1043
Principal effective stress ratio		3.70	3.44	3.61

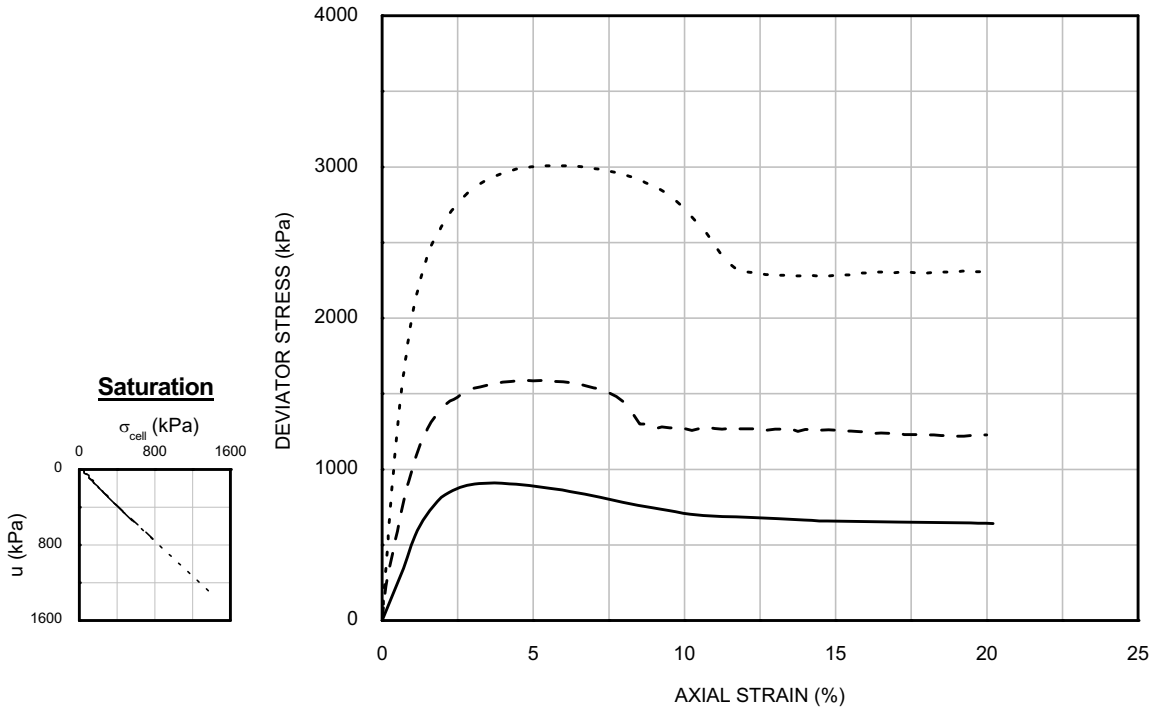
FINAL CONDITIONS				
Moisture content	(%)	23.8	22.7	22.3
Bulk density	(Mg/m³)	2.01	2.03	2.04
Dry density	(Mg/m³)	1.63	1.66	1.67

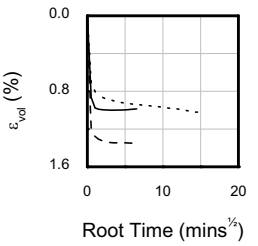
Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	27BagA	27BagA	27BagA
Depth (m)	24.00	24.00	24.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

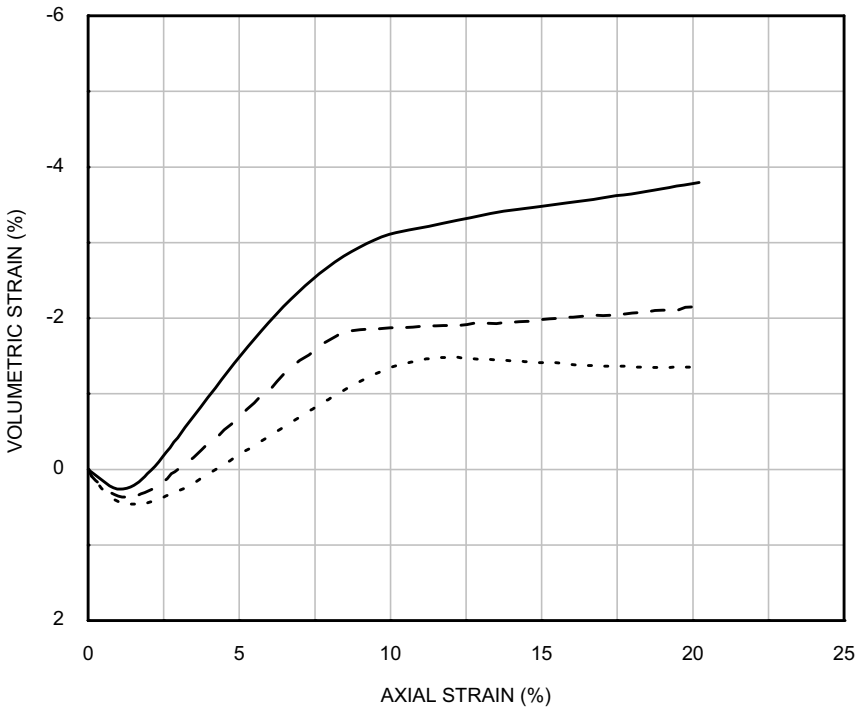
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 29/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-6_27BagA_D3.OPJ
Template Issue: 4
Date : 29/10/2015
Checked by: ALB
Date : 30/10/2015
Approved by: RMB





Consolidation

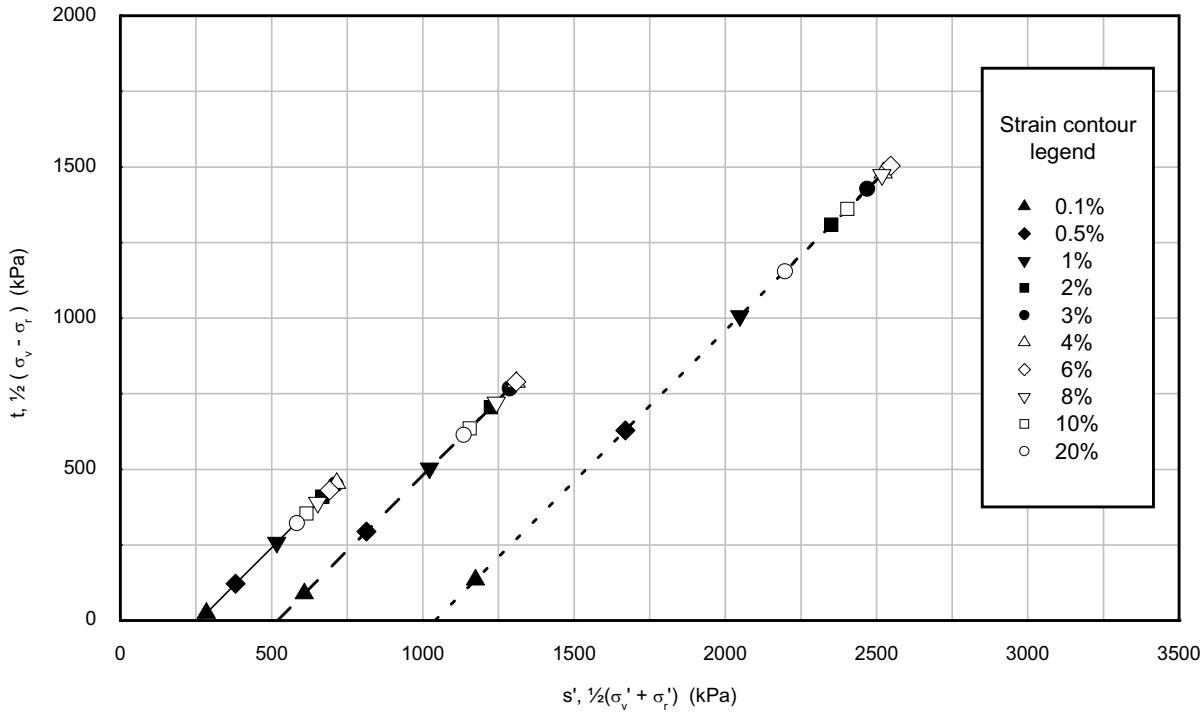


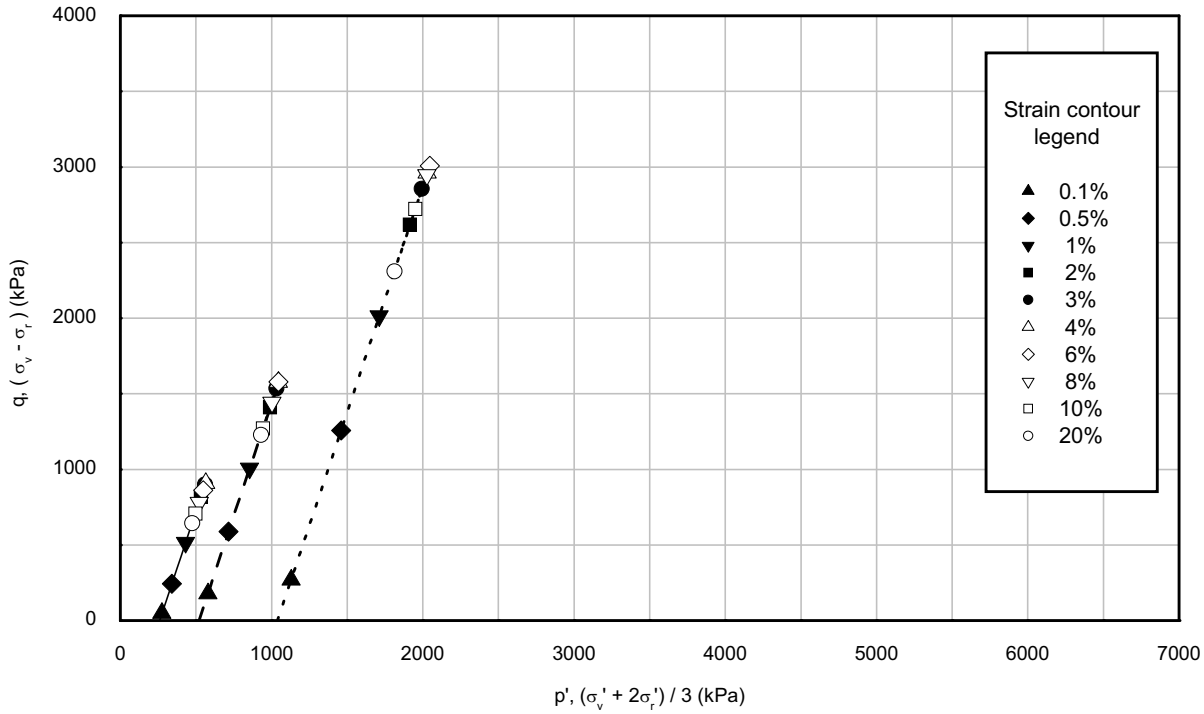
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	260	260
– – –	2	520	520
· · · ·	3	1040	1040

Borehole	Sample	Depth (m)
BH-WFS4-6	27BagA	24.00

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	260	260	BH-WFS4-6	27BagA	24.00
– –	2	520	520			
- - - -	3	1040	1040			

Drawn by: ER Date: 29/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-6_27BagA_D3.OPJ

Template Issue: 4

Date : 29/10/2015

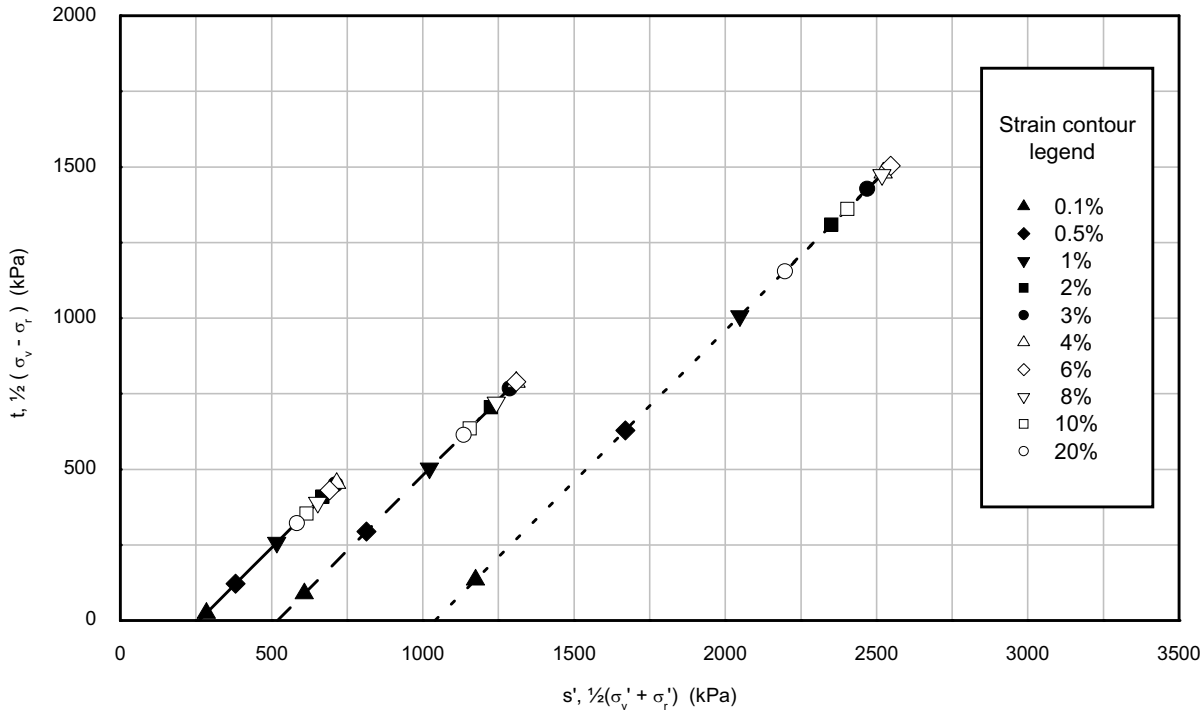
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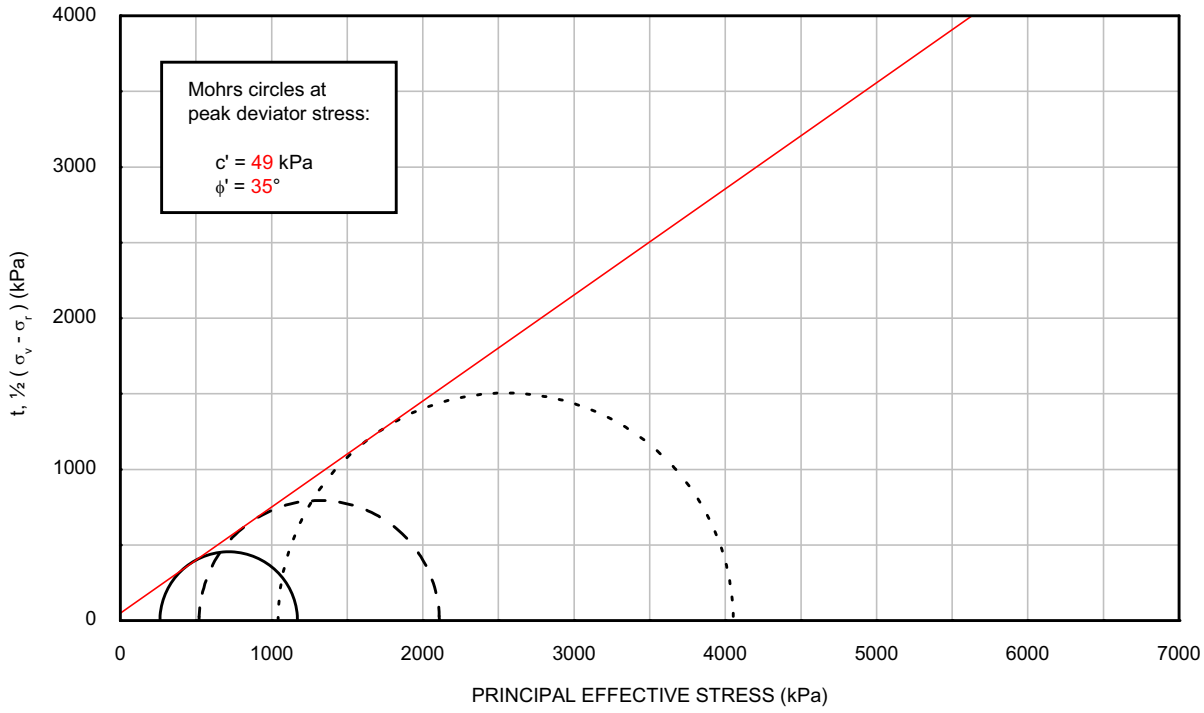
Date : 30/10/2015

Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	260	260
– –	2	520	520
- - - -	3	1040	1040

Borehole	Sample	Depth (m)
BH-WFS4-6	27BagA	24.00

Drawn by: ER Date: 29/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-6_27BagA_D3.OPJ

Template Issue: 4

Date : 29/10/2015

Checked by: ALB

Date : 30/10/2015

Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 05/11/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-6_30BagA_D3.XLS
Date: 11/11/2015
Checked by: PH
Date: 11/11/2015
Approved by: PH

VISUAL DESCRIPTION
Very dark greenish grey fine to medium SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	02/11/2015	02/11/2015	04/11/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	9.8	9.8	10.3
Bulk density	(Mg/m³)	1.79	1.80	1.80
Dry density	(Mg/m³)	1.63	1.64	1.64
Void ratio		0.640	0.625	0.631
Degree of saturation	(%)	41	42	43

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	813	1162	1941
Cell pressure on completion	(kPa)	830	1210	2020
B value achieved		0.98	0.95	0.95

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	30BagA	30BagA	30BagA
Depth (m)	36.00	36.00	36.00

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	830	1210	2020
Back pressure	(kPa)	450	450	500
Effective cell pressure	(kPa)	380	760	1520
Pore pressure on completion	(kPa)	450	450	500
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	23.0	21.7	21.9
Bulk density	(Mg/m³)	2.03	2.06	2.05
Dry density	(Mg/m³)	1.65	1.69	1.68
Void ratio		0.614	0.578	0.585
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	1.59	2.83	2.87

Mode of failure:	Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	30BagA	30BagA	30BagA
Depth (m)	36.00	36.00	36.00

Drawn by: ALB Date: 05/11/2015

Template Issue: 7 Filename: J11302 / EFFECTIV / BH-WFS4-6_30BagA_D3.XLS

Checked by: PH Date: 11/11/2015

Approved by: PH Date: 11/11/2015

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 05/11/2015
Drawn by: ALB
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-6_30BagA_D3.XLS
Date: 11/11/2015
Checked by: PH
Date: 11/11/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	450	450	500
Initial effective cell pressure	(kPa)	380	760	1520
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	929	1551	3314
Membrane correction applied	(kPa)	1.7	1.7	1.8
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	12.75	13.25	13.64
Volumetric strain	(%)	0.58	1.80	2.70
Major principal effective stress	(kPa)	1314	2304	4831
Minor principal effective stress	(kPa)	385	754	1517
Principal effective stress ratio		3.41	3.06	3.18
Epsilon 50 (ε 50)	(%)	0.74	1.53	1.50
Secant modulus (E50) at ε 50	(kPa)	62523	50572	110779
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	926	1547	3314
Membrane correction applied	(kPa)	1.6	1.7	1.8
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	12.00	12.75	13.64
Volumetric strain	(%)	0.63	1.81	2.70
Major principal effective stress	(kPa)	1309	2298	4831
Minor principal effective stress	(kPa)	383	751	1517
Principal effective stress ratio		3.42	3.06	3.18
At 10% axial strain				
Corrected deviator stress	(kPa)	912	1524	3192
Membrane correction applied	(kPa)	1.4	1.4	1.4
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	0.74	1.91	2.53
Major principal effective stress	(kPa)	1296	2278	4709
Minor principal effective stress	(kPa)	384	754	1517
Principal effective stress ratio		3.37	3.02	3.10

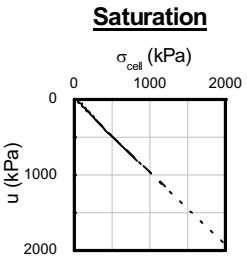
FINAL CONDITIONS				
Moisture content	(%)	22.9	20.8	20.3
Bulk density	(Mg/m³)	2.04	2.07	2.08
Dry density	(Mg/m³)	1.66	1.72	1.73

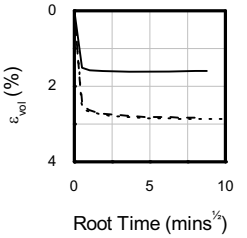
Borehole	BH-WFS4-6	BH-WFS4-6	BH-WFS4-6
Sample	30BagA	30BagA	30BagA
Depth (m)	36.00	36.00	36.00

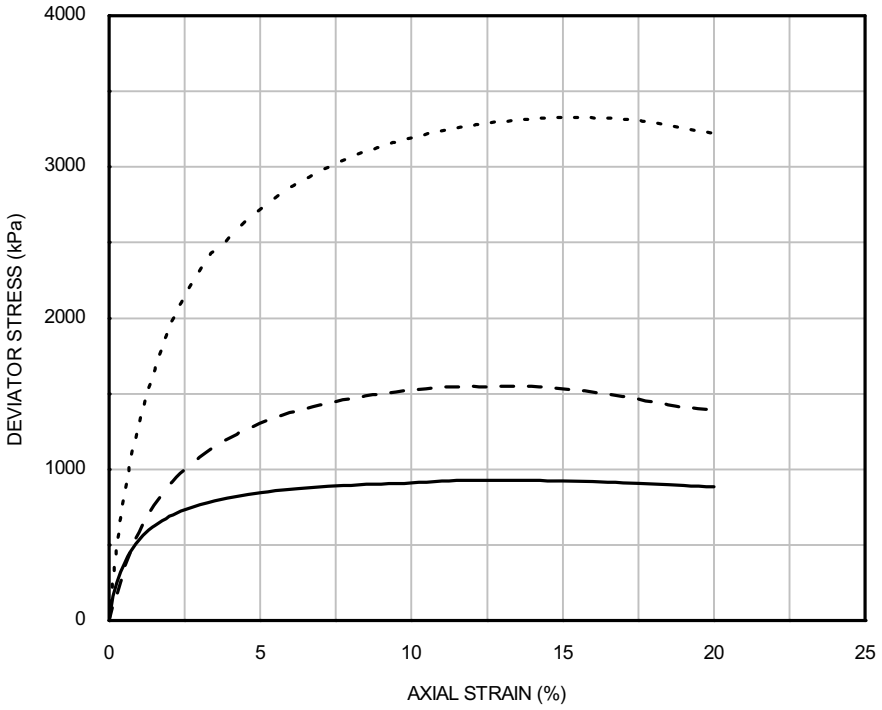
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

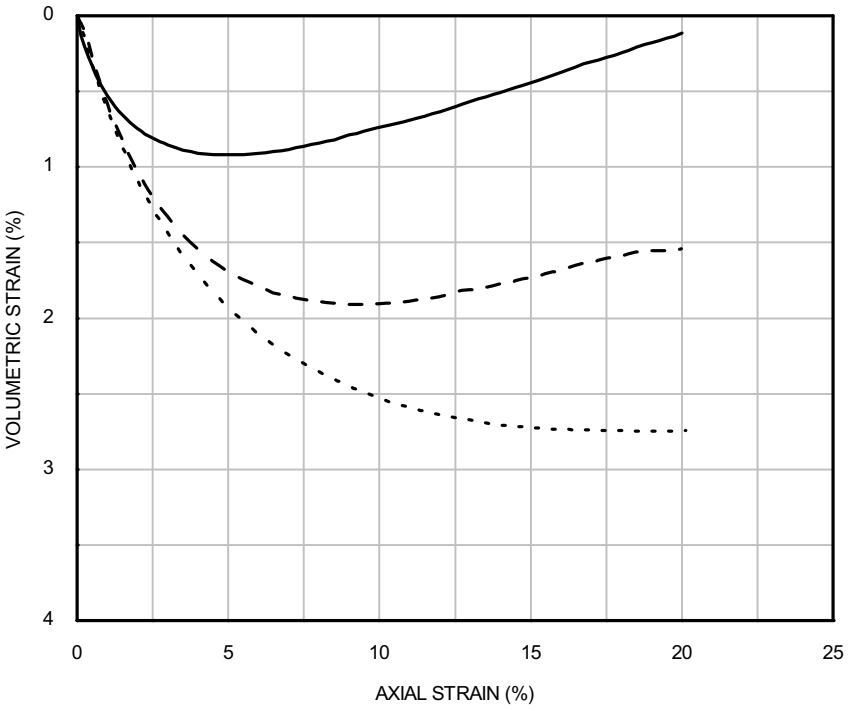
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 05/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-6_30BagA_D3.OPJ
Template Issue: 4
Date : 11/11/2015
Checked by: PH
Date : 11/11/2015
Approved by: PH





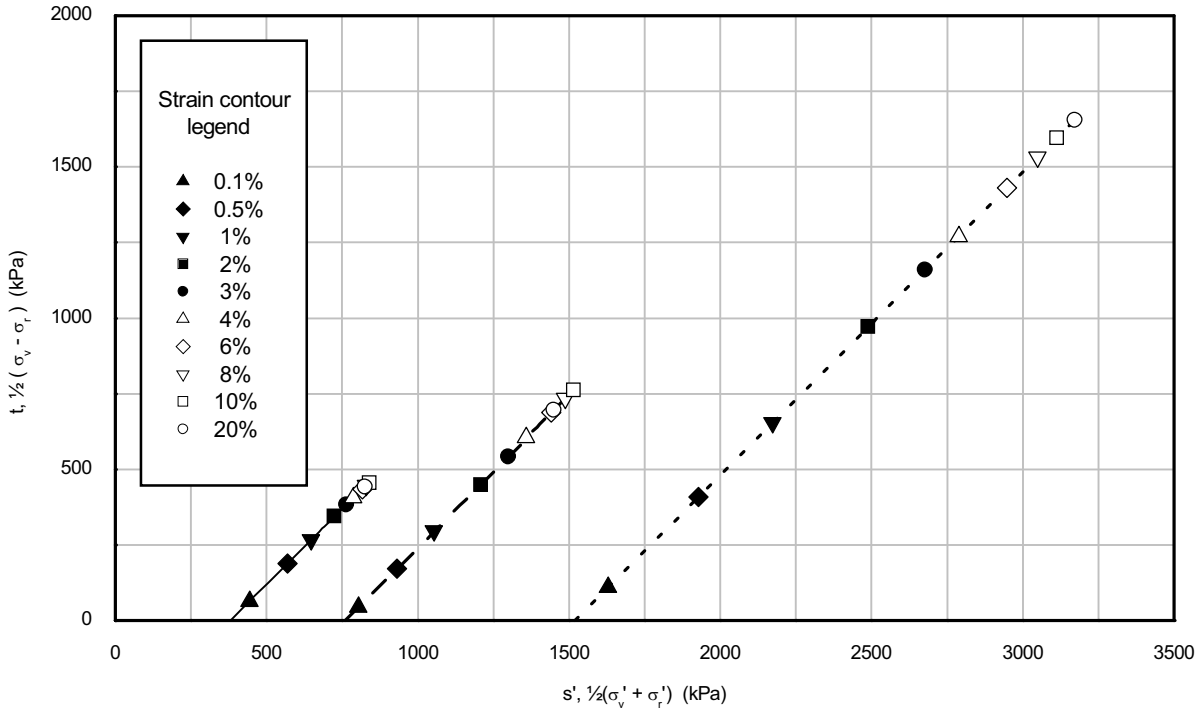


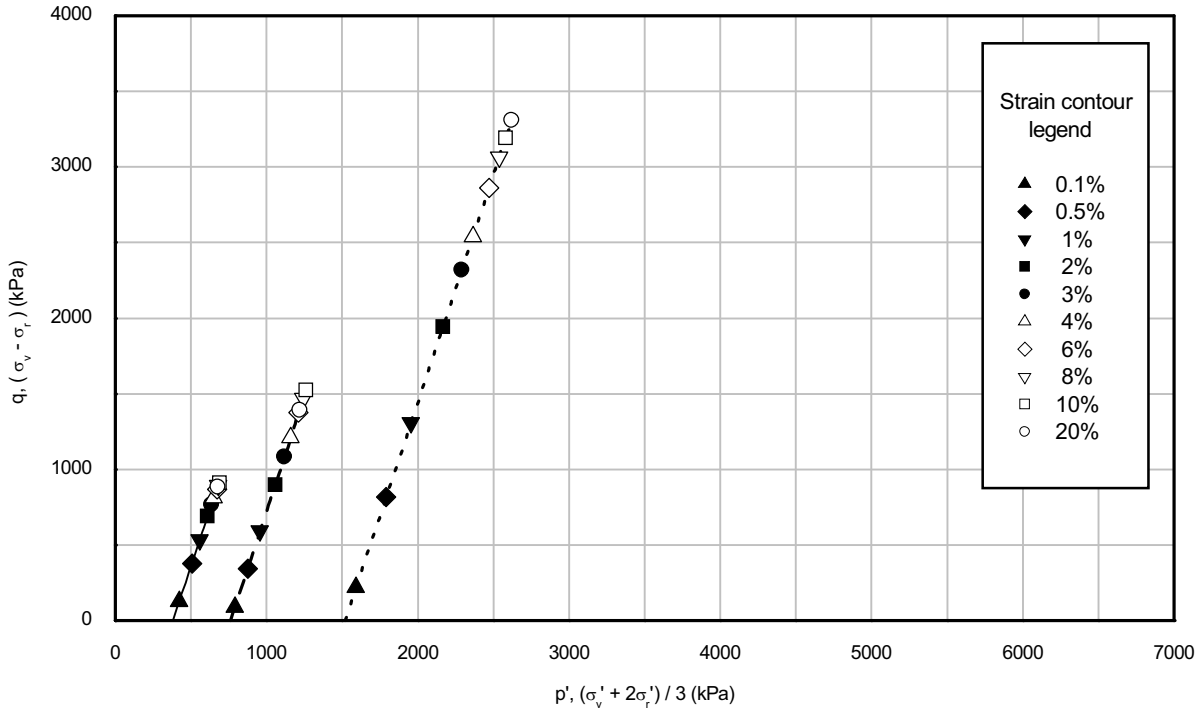


Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	380	380	BH-WFS4-6	30BagA	36.00
– –	2	760	760			
· · · ·	3	1520	1520			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	380	380	BH-WFS4-6	30BagA	36.00
– –	2	760	760			
- - - -	3	1520	1520			

Drawn by: ALB Date: 05/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-6_30BagA_D3.OPJ

Template Issue: 4

Date : 11/11/2015

Checked by: PH

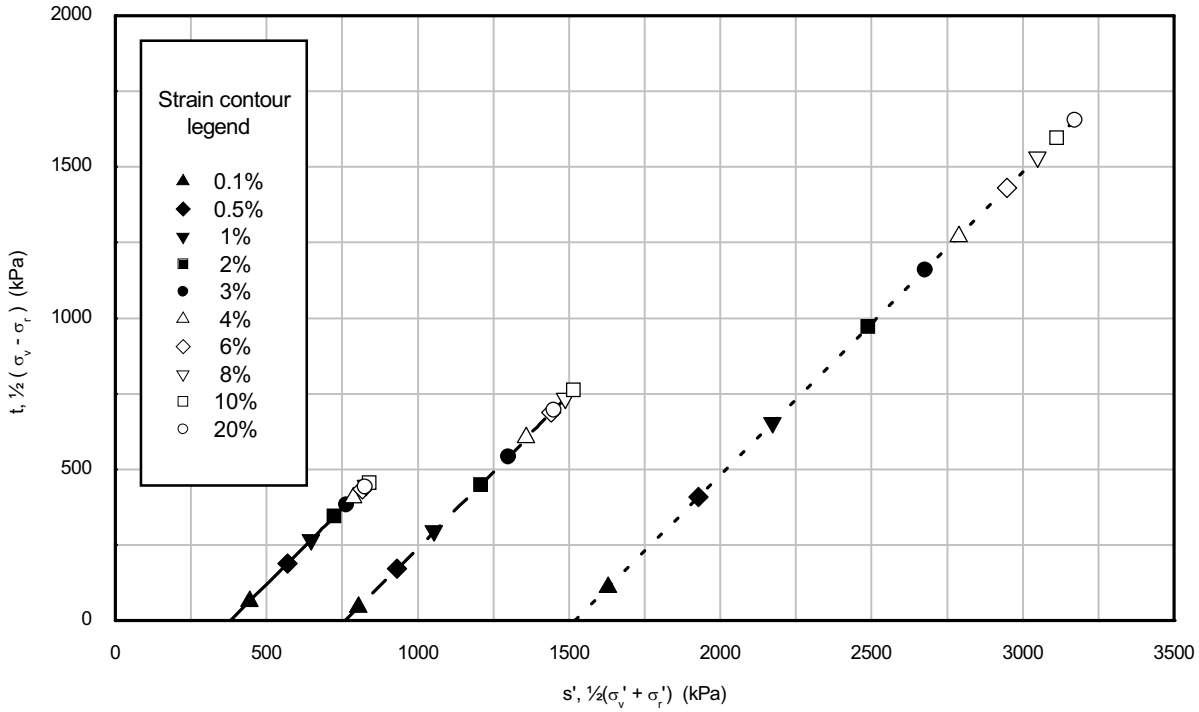
Date : 11/11/2015

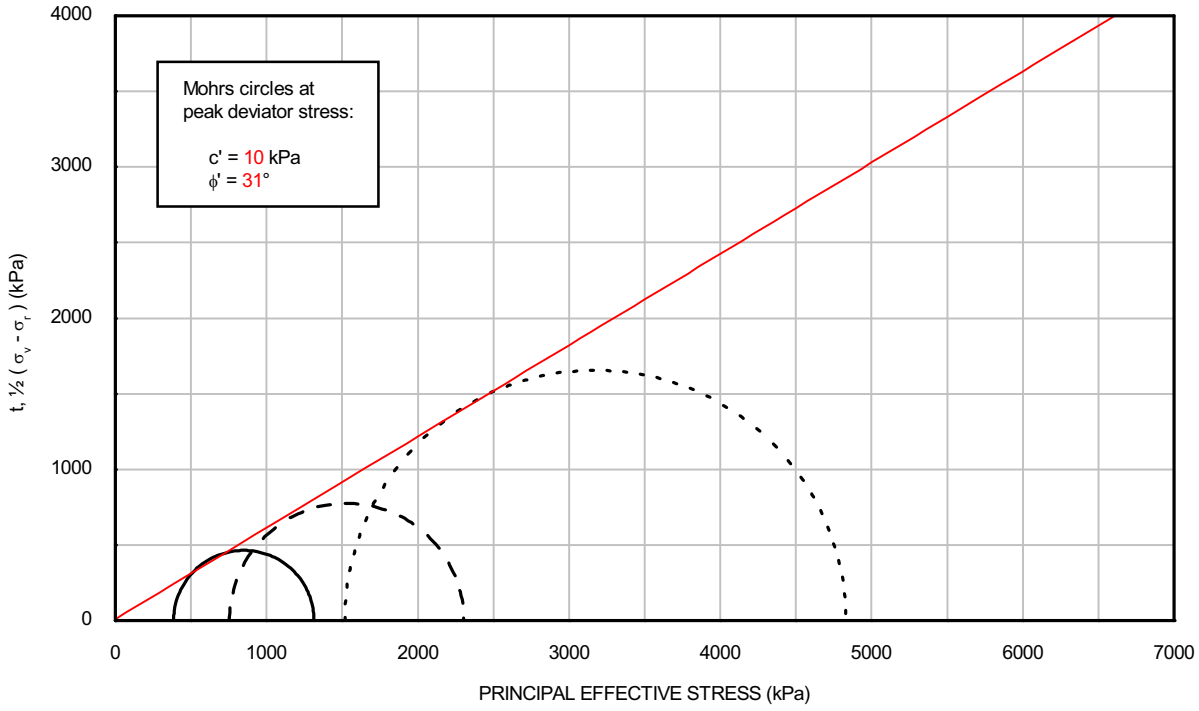
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 05/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-6_30BagA_D3.OPJ
Template Issue: 4
Date : 11/11/2015
Checked by: PH
Date : 11/11/2015
Approved by: PH





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	380	380	BH-WFS4-6	30BagA	36.00
– – –	2	760	760			
- - - -	3	1520	1520			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-7_15BagB_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

VISUAL DESCRIPTION
Dark green to brown SAND with fragments of shell.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	23/10/2015	23/10/2015	23/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	6.5	6.5	6.5
Bulk density	(Mg/m³)	1.87	1.87	1.87
Dry density	(Mg/m³)	1.75	1.76	1.75
Void ratio		0.511	0.509	0.510
Degree of saturation	(%)	33	34	34

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	424	557	856
Cell pressure on completion	(kPa)	440	580	910
B value achieved		0.96	0.95	0.92

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	15BagB	15BagB	15BagB
Depth (m)	11.75	11.75	11.75

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-7_15BagB_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	440	580	910
Back pressure	(kPa)	300	300	350
Effective cell pressure	(kPa)	140	280	560
Pore pressure on completion	(kPa)	300	300	350
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	18.8	18.2	17.7
Bulk density	(Mg/m³)	2.10	2.11	2.12
Dry density	(Mg/m³)	1.77	1.79	1.80
Void ratio		0.498	0.483	0.470
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	0.88	1.74	2.68
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	15BagB	15BagB	15BagB
Depth (m)	11.75	11.75	11.75

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-7_15BagB_D3.XLS
Date: 30/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	350
Initial effective cell pressure	(kPa)	140	280	560
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	433	835	1559
Membrane correction applied	(kPa)	1.1	1.2	1.8
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	8.08	9.00	15.54
Volumetric strain	(%)	0.84	1.70	3.53
Major principal effective stress	(kPa)	574	1115	2120
Minor principal effective stress	(kPa)	141	280	561
Principal effective stress ratio		4.07	3.99	3.78
Epsilon 50 (ε 50)	(%)	0.87	1.30	1.78
Secant modulus (E50) at ε 50	(kPa)	24890	32065	43691
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	433	835	1559
Membrane correction applied	(kPa)	1.1	1.2	1.8
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	8.08	9.00	15.29
Volumetric strain	(%)	0.84	1.70	3.52
Major principal effective stress	(kPa)	574	1115	2119
Minor principal effective stress	(kPa)	141	280	560
Principal effective stress ratio		4.07	3.99	3.79
At 10% axial strain				
Corrected deviator stress	(kPa)	432	834	1503
Membrane correction applied	(kPa)	1.3	1.3	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	0.76	1.68	3.18
Major principal effective stress	(kPa)	573	1114	2063
Minor principal effective stress	(kPa)	141	280	560
Principal effective stress ratio		4.06	3.98	3.68

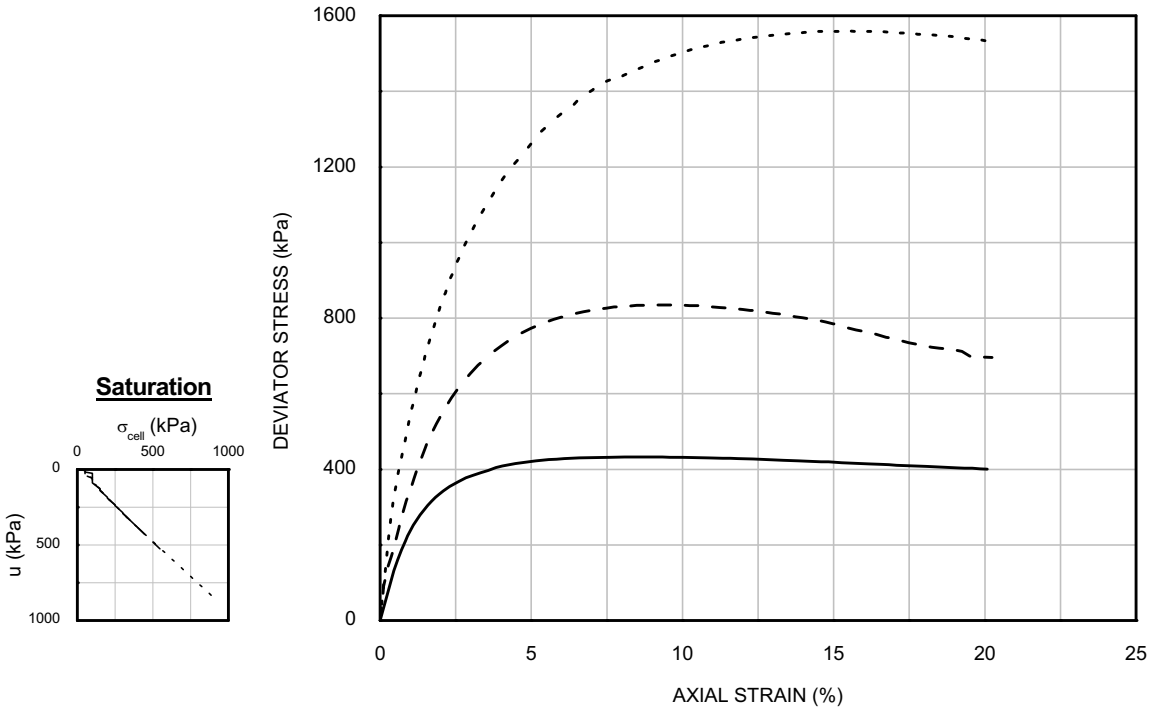
FINAL CONDITIONS				
Moisture content	(%)	18.6	17.2	15.7
Bulk density	(Mg/m³)	2.10	2.13	2.17
Dry density	(Mg/m³)	1.77	1.82	1.87

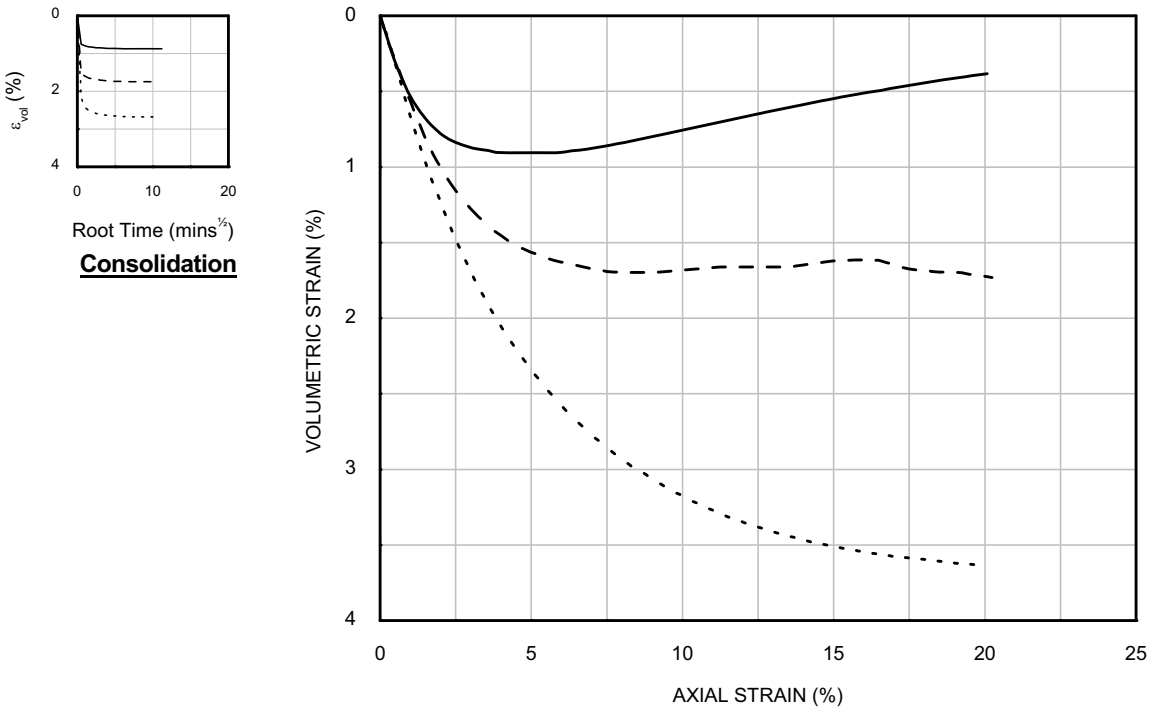
Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	15BagB	15BagB	15BagB
Depth (m)	11.75	11.75	11.75

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 29/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-7_15BagB_D3.OPJ
Template Issue: 4 Date : 30/10/2015
Checked by: ALB Approved by: RMB Date : 30/10/2015



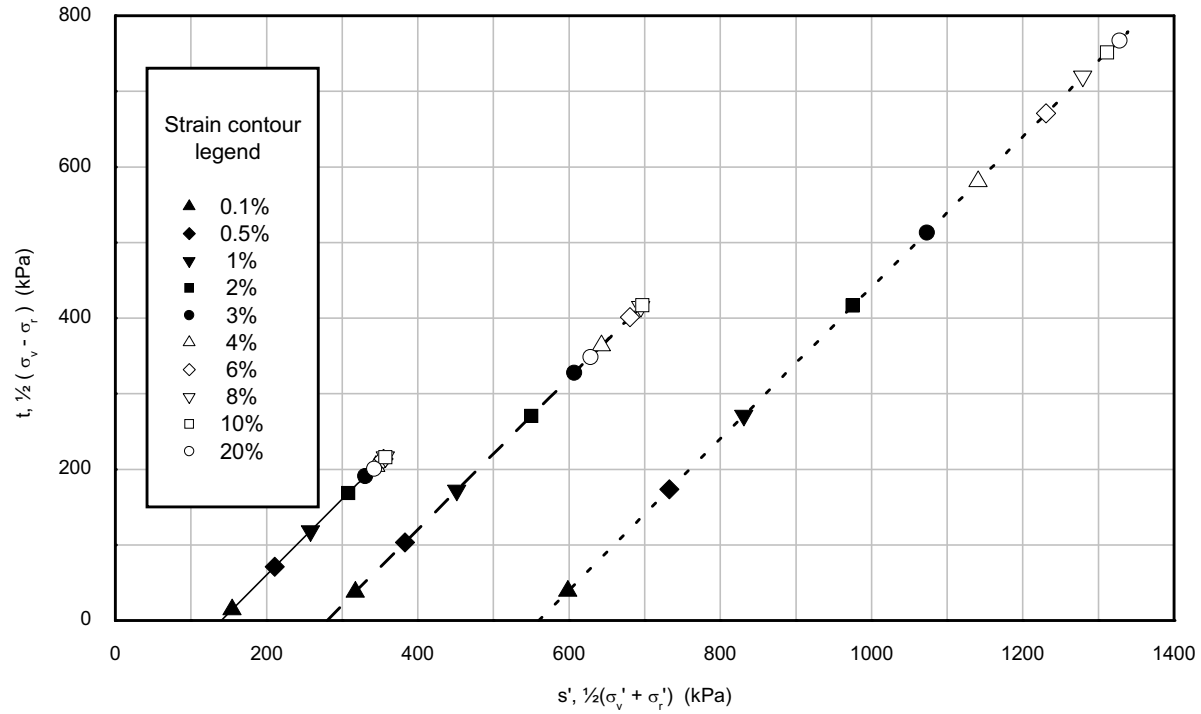


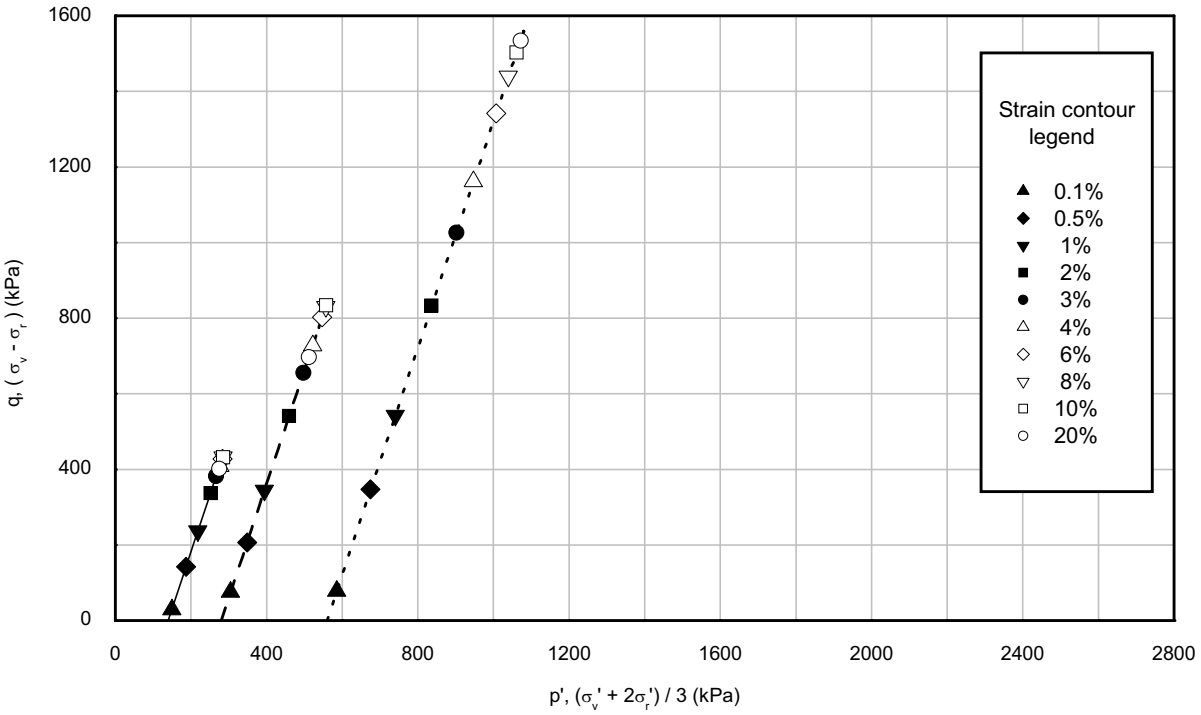
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	140	140
– –	2	280	280
· · · ·	3	560	560

Borehole	Sample	Depth (m)
BH-WFS4-7	15BagB	11.75

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	140	140	BH-WFS4-7	15BagB	11.75
– –	2	280	280			
- - - -	3	560	560			

Drawn by: ER Date: 29/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-7_15BagB_D3.OPJ

Template Issue: 4

Date : 30/10/2015

Checked by: ALB

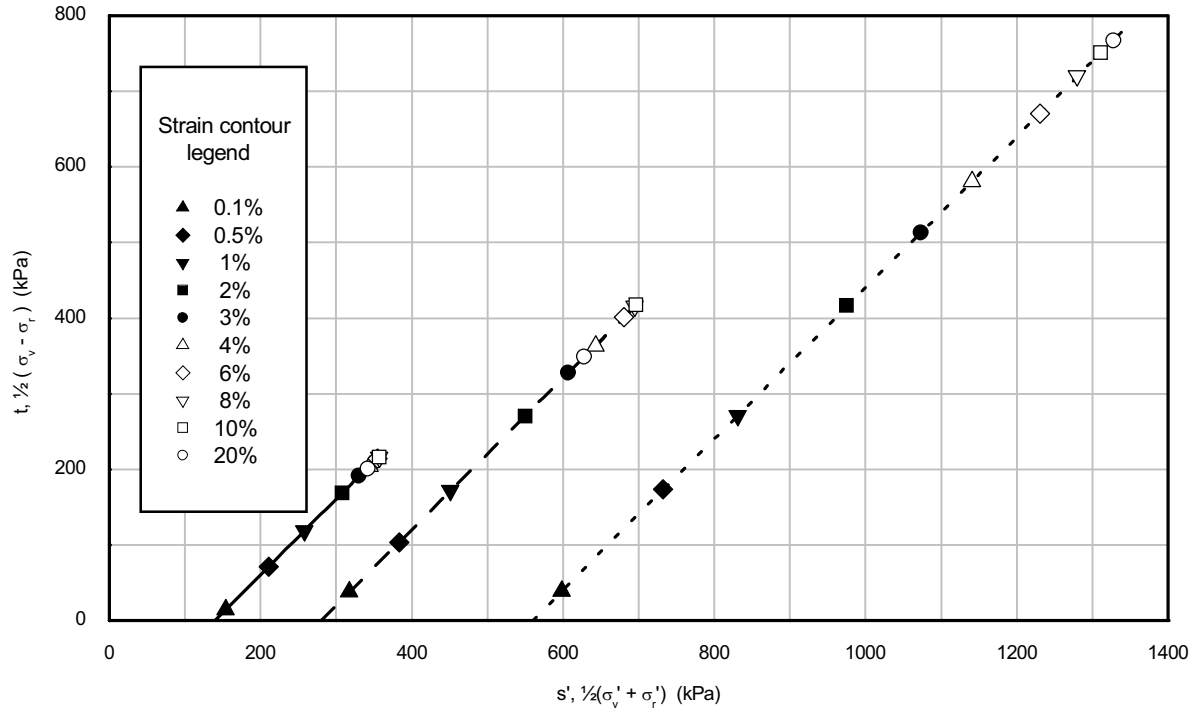
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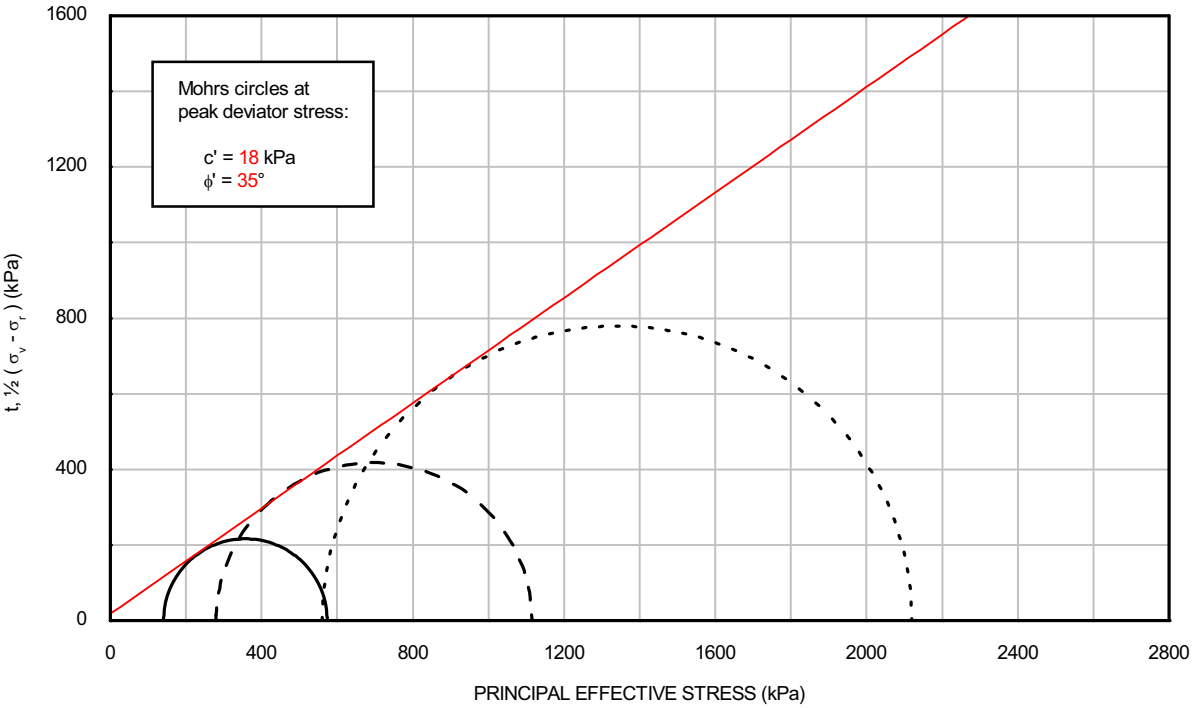
Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 4
Filename: J11302 \ EFFECTIV \ BH-WFS4-7_15BagB_D3.OPJ
Date : 30/10/2015
Checked by: ALB
Date : 30/10/2015
Approved by: RMB





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	140	140	BH-WFS4-7	15BagB	11.75
– –	2	280	280			
- - - -	3	560	560			

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-7_23BagB_D3.XLS
Date: 29/10/2015
Date: 30/10/2015
Checked by: ALB
Approved by: RMB

VISUAL DESCRIPTION
Dark brown silty fine SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	21/10/2015	22/10/2015	27/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10.7	10.7	10.7
Bulk density	(Mg/m³)	1.78	1.78	1.78
Dry density	(Mg/m³)	1.61	1.61	1.61
Void ratio		0.691	0.692	0.691
Degree of saturation	(%)	42	42	42

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	552	790	1355
Cell pressure on completion	(kPa)	570	840	1380
B value achieved		0.97	0.93	0.99

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	23BagB	23BagB	23BagB
Depth (m)	27.35	27.35	27.35

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-7_23BagB_D3.XLS
Date: 29/10/2015
Checked by: ALB
Date: 30/10/2015
Approved by: RMB

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	570	840	1380
Back pressure	(kPa)	300	300	300
Effective cell pressure	(kPa)	270	540	1080
Pore pressure on completion	(kPa)	300	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	22.3	21.5	20.3
Bulk density	(Mg/m³)	2.07	2.08	2.11
Dry density	(Mg/m³)	1.69	1.72	1.75
Void ratio		0.608	0.586	0.552
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	4.90	6.29	8.21
Mode of failure:		Plastic failure	Plastic failure	Plastic failure

Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	23BagB	23BagB	23BagB
Depth (m)	27.35	27.35	27.35

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-7_23BagB_D3.XLS
Template Issue: 7
Date: 29/10/2015
Date: 30/10/2015
Checked by: ALB
Approved by: RMB

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	300
Initial effective cell pressure	(kPa)	270	540	1080
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	590	1133	2239
Membrane correction applied	(kPa)	2.0	1.8	1.9
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	19.99	17.33	19.40
Volumetric strain	(%)	4.04	4.38	5.10
Major principal effective stress	(kPa)	862	1671	3318
Minor principal effective stress	(kPa)	271	539	1079
Principal effective stress ratio		3.18	3.10	3.08
Epsilon 50 (ε 50)	(%)	3.21	3.50	3.65
Secant modulus (E50) at ε 50	(kPa)	9183	16175	30704
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	590	1132	2239
Membrane correction applied	(kPa)	2.0	1.8	1.9
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	19.99	16.83	19.40
Volumetric strain	(%)	4.04	4.38	5.10
Major principal effective stress	(kPa)	862	1670	3318
Minor principal effective stress	(kPa)	271	538	1079
Principal effective stress ratio		3.18	3.10	3.08
At 10% axial strain				
Corrected deviator stress	(kPa)	516	994	1795
Membrane correction applied	(kPa)	1.2	1.2	1.2
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	3.76	3.87	4.11
Major principal effective stress	(kPa)	781	1528	2873
Minor principal effective stress	(kPa)	265	533	1078
Principal effective stress ratio		2.95	2.86	2.66

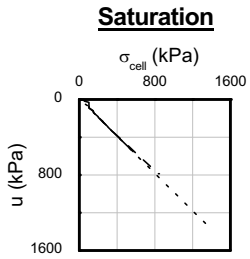
FINAL CONDITIONS				
Moisture content	(%)	20.0	19.0	17.4
Bulk density	(Mg/m³)	2.11	2.13	2.17
Dry density	(Mg/m³)	1.76	1.79	1.85

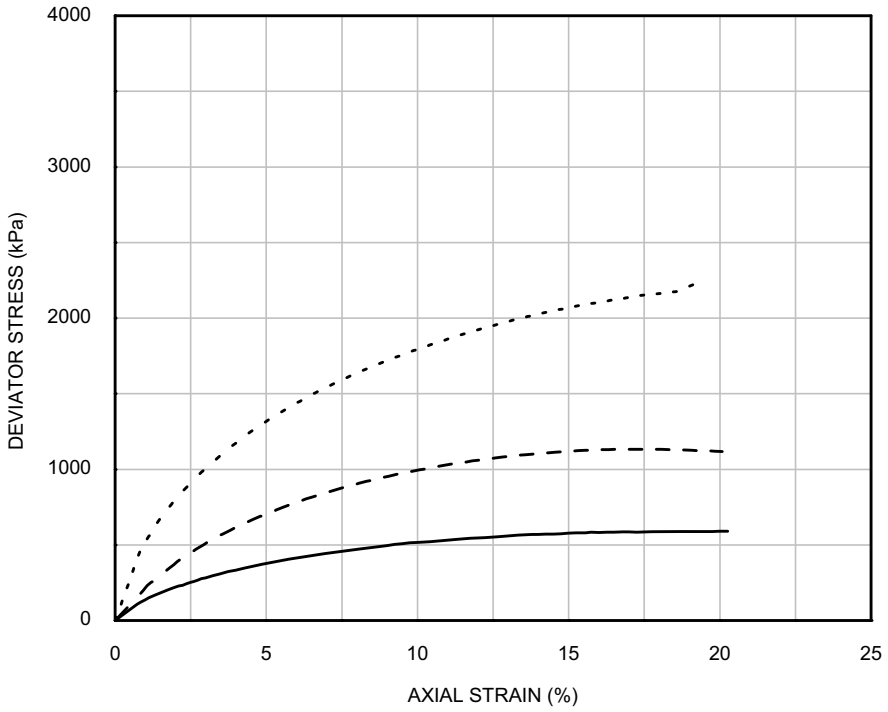
Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	23BagB	23BagB	23BagB
Depth (m)	27.35	27.35	27.35

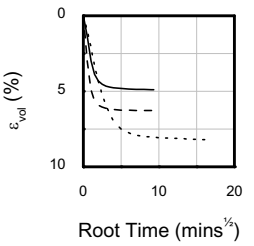
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

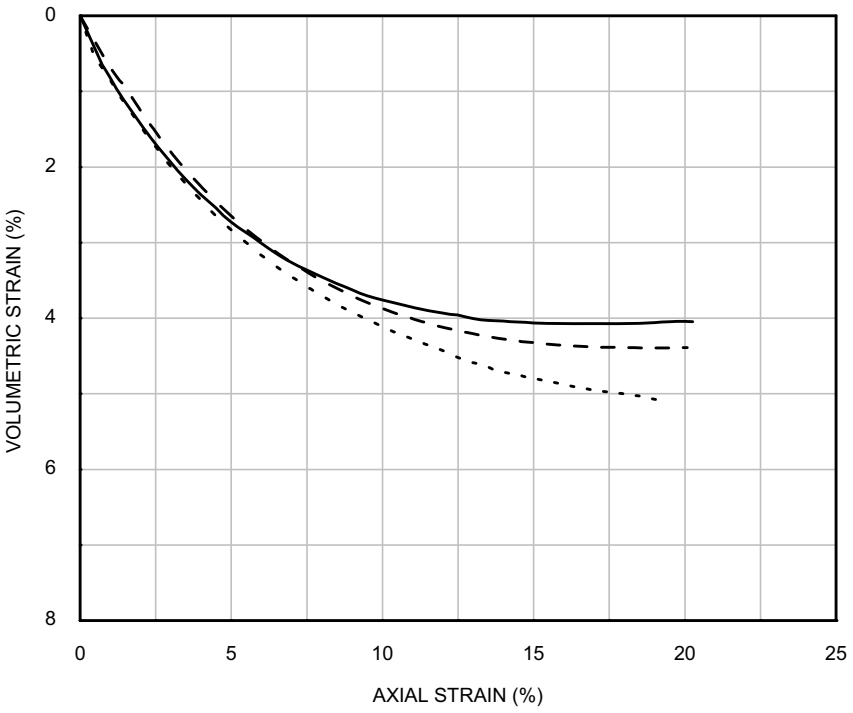
Drawn by: ER Date: 29/10/2015
Template Issue: 4
Filename: J11302 \ EFFECTIV \ BH-WFS4-7_23BagB_D3.OPJ
Date : 29/10/2015
Checked by: ALB
Date : 30/10/2015
Approved by: RMB







Consolidation

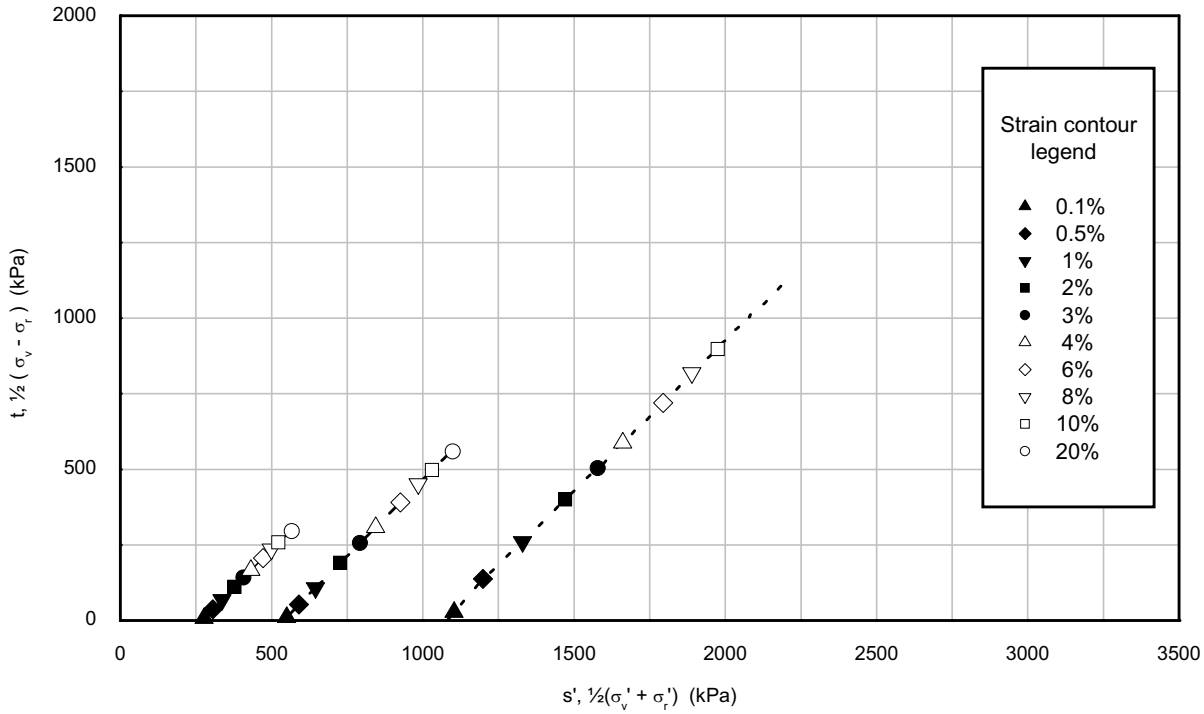


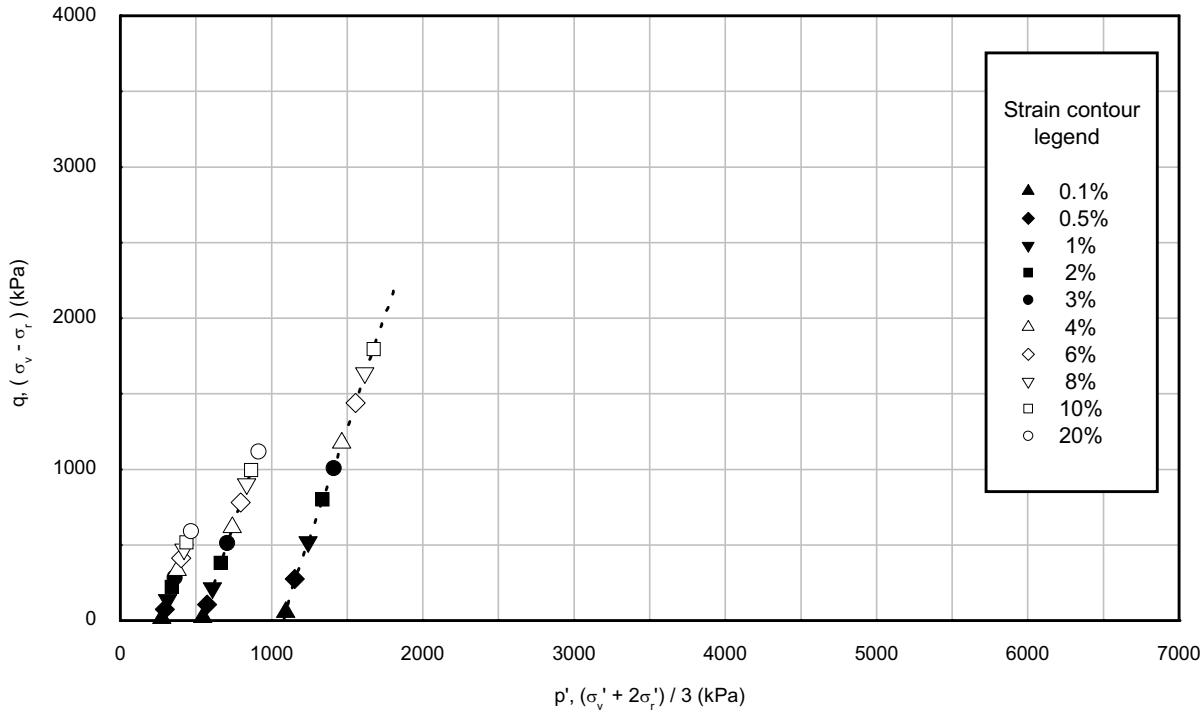
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	270	270
– –	2	540	540
- - - -	3	1080	1080

Borehole	Sample	Depth (m)
BH-WFS4-7	23BagB	27.35

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
———	1	270	270	BH-WFS4-7	23BagB	27.35
– –	2	540	540			
- - - -	3	1080	1080			

Drawn by: ER Date: 29/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-7_23BagB_D3.OPJ

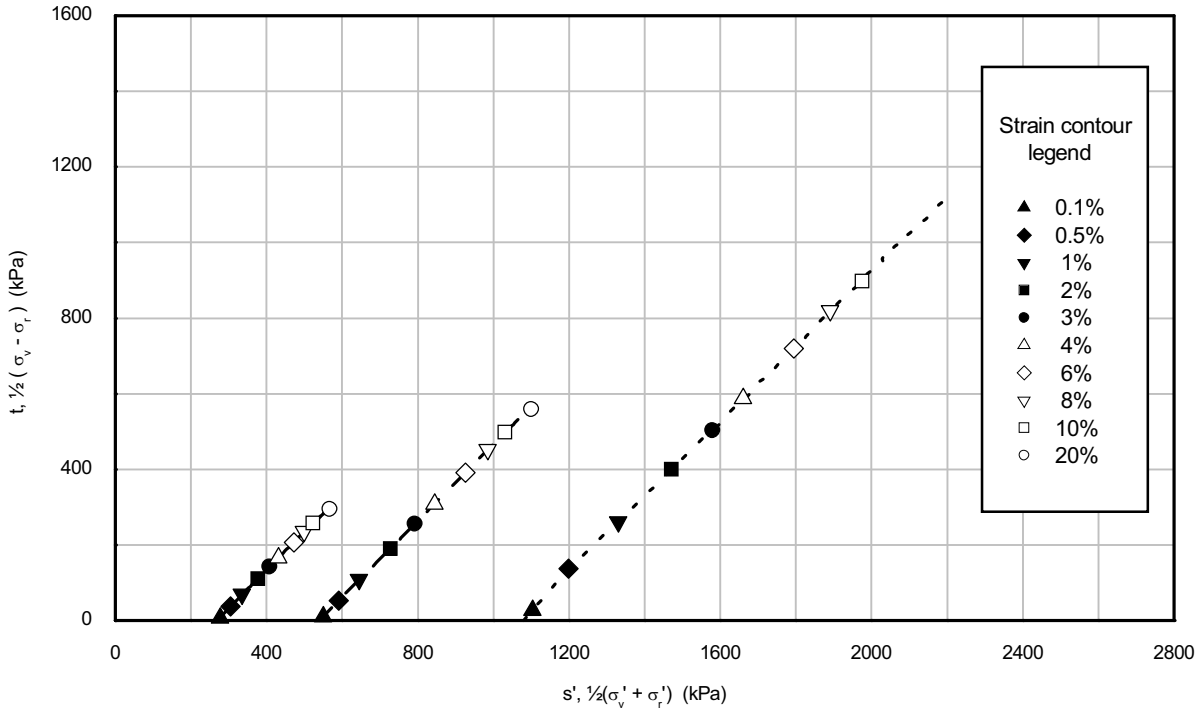
Template Issue: 4 Date : 30/10/2015

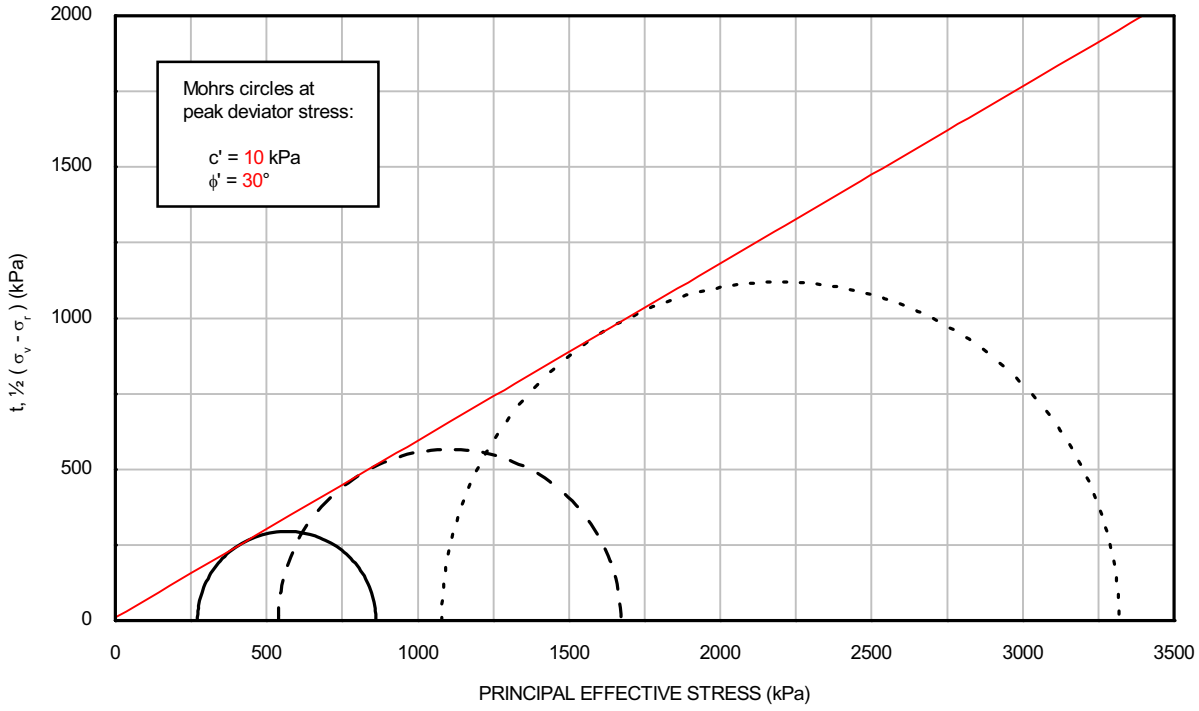
Checked by: ALB Date : 29/10/2015

Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	270	270	BH-WFS4-7	23BagB	27.35
– –	2	540	540			
- - - -	3	1080	1080			

Drawn by: ER Date: 29/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-7_23BagB_D3.OPJ

Template Issue: 4

Date : 29/10/2015

Checked by: ALB

Date : 30/10/2015

Approved by: RMB

ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 21/10/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-7_28BagA_D3.XLS
Template Issue: 7
Date: 22/10/2015
Checked by: ALB
Date: 29/10/2015
Approved by: PH

VISUAL DESCRIPTION
Very dark brown silty fine SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	19/10/2015	19/10/2015	19/10/2015
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	51.5	51.5	51.5
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	11.6	11.6	11.6
Bulk density	(Mg/m³)	1.82	1.82	1.82
Dry density	(Mg/m³)	1.63	1.63	1.63
Void ratio		0.654	0.653	0.652
Degree of saturation	(%)	48	48	48

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	740	1186	1938
Cell pressure on completion	(kPa)	760	1220	2040
B value achieved		0.98	0.97	0.94

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	28BagA	28BagA	28BagA
Depth (m)	42.50	42.50	42.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	760	1220	2040
Back pressure	(kPa)	350	400	400
Effective cell pressure	(kPa)	410	820	1640
Pore pressure on completion	(kPa)	350	400	400
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	23.0	22.5	22.0
Bulk density	(Mg/m³)	2.04	2.05	2.06
Dry density	(Mg/m³)	1.66	1.68	1.69
Void ratio		0.619	0.604	0.591
Degree of saturation	(%)	100	100	100
Volumetric strain	(%)	2.11	2.93	3.67
Mode of failure:		Compound failure	Compound failure	Compound failure

Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	28BagA	28BagA	28BagA
Depth (m)	42.50	42.50	42.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 21/10/2015
Drawn by: ER
Filename: J11302 / EFFECTIV / BH-WFS4-7_28BagA_D3.XLS
Template Issue: 7
Date: 22/10/2015
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Date: 21/10/2015
Drawn by: ER
Template Issue: 7
Filename: J11302 / EFFECTIV / BH-WFS4-7_28BagA_D3.XLS
Date: 22/10/2015
Checked by: ALB
Date: 29/10/2015
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	350	400	400
Initial effective cell pressure	(kPa)	410	820	1640
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	939	1542	3342
Membrane correction applied	(kPa)	1.7	1.8	2.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	14.61	15.50	19.79
Volumetric strain	(%)	2.22	3.93	6.16
Major principal effective stress	(kPa)	1348	2361	4980
Minor principal effective stress	(kPa)	409	819	1639
Principal effective stress ratio		3.30	2.88	3.04
Epsilon 50 (ε 50)	(%)	1.29	1.32	2.51
Secant modulus (E50) at ε 50	(kPa)	36260	58506	66670
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	939	1542	3342
Membrane correction applied	(kPa)	1.7	1.8	2.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	14.61	15.50	19.79
Volumetric strain	(%)	2.22	3.93	6.16
Major principal effective stress	(kPa)	1348	2361	4980
Minor principal effective stress	(kPa)	409	819	1639
Principal effective stress ratio		3.30	2.88	3.04
At 10% axial strain				
Corrected deviator stress	(kPa)	920	1489	2933
Membrane correction applied	(kPa)	1.3	1.3	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	2.12	3.43	4.60
Major principal effective stress	(kPa)	1329	2307	4571
Minor principal effective stress	(kPa)	409	819	1639
Principal effective stress ratio		3.25	2.82	2.79

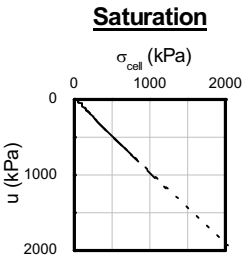
FINAL CONDITIONS				
Moisture content	(%)	21.7	20.0	18.3
Bulk density	(Mg/m³)	2.07	2.10	2.13
Dry density	(Mg/m³)	1.70	1.75	1.80

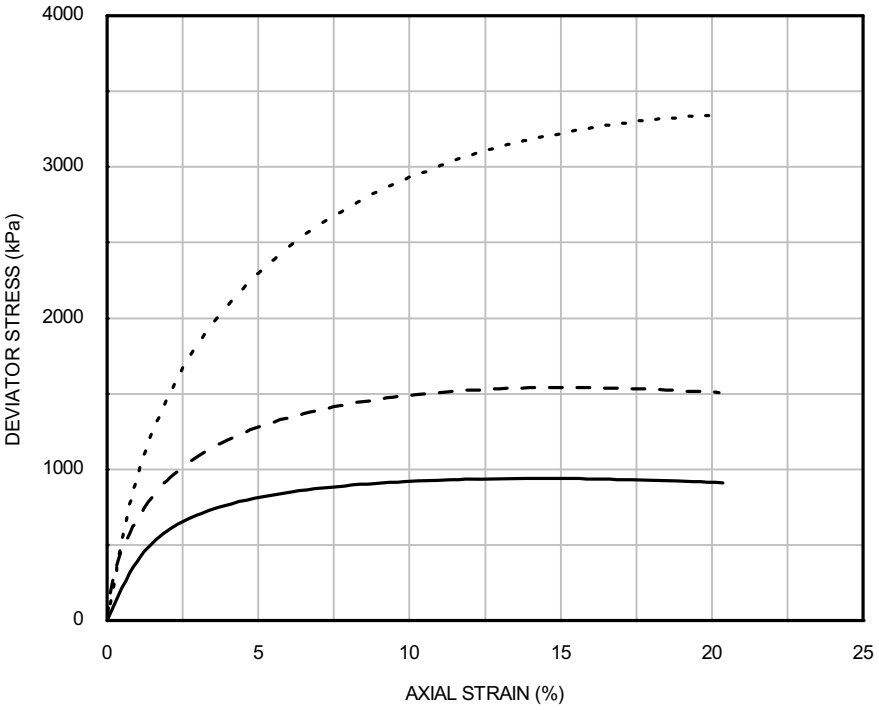
Borehole	BH-WFS4-7	BH-WFS4-7	BH-WFS4-7
Sample	28BagA	28BagA	28BagA
Depth (m)	42.50	42.50	42.50

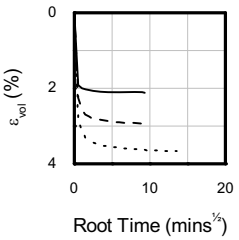
SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

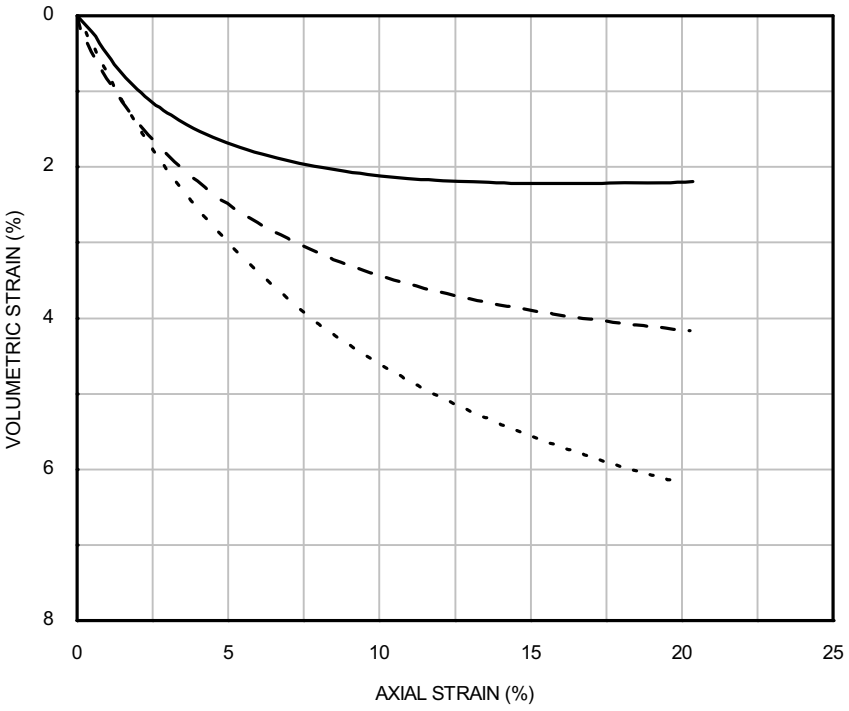
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 21/10/2015
Drawn by: ER
Template Issue: 4
Filename: J11302 \ EFFECTIV \ BH-WFS4-7_28BagA_D3.OPJ
Date : 22/10/2015
Checked by: ALB
Date : 29/10/2015
Approved by: PH









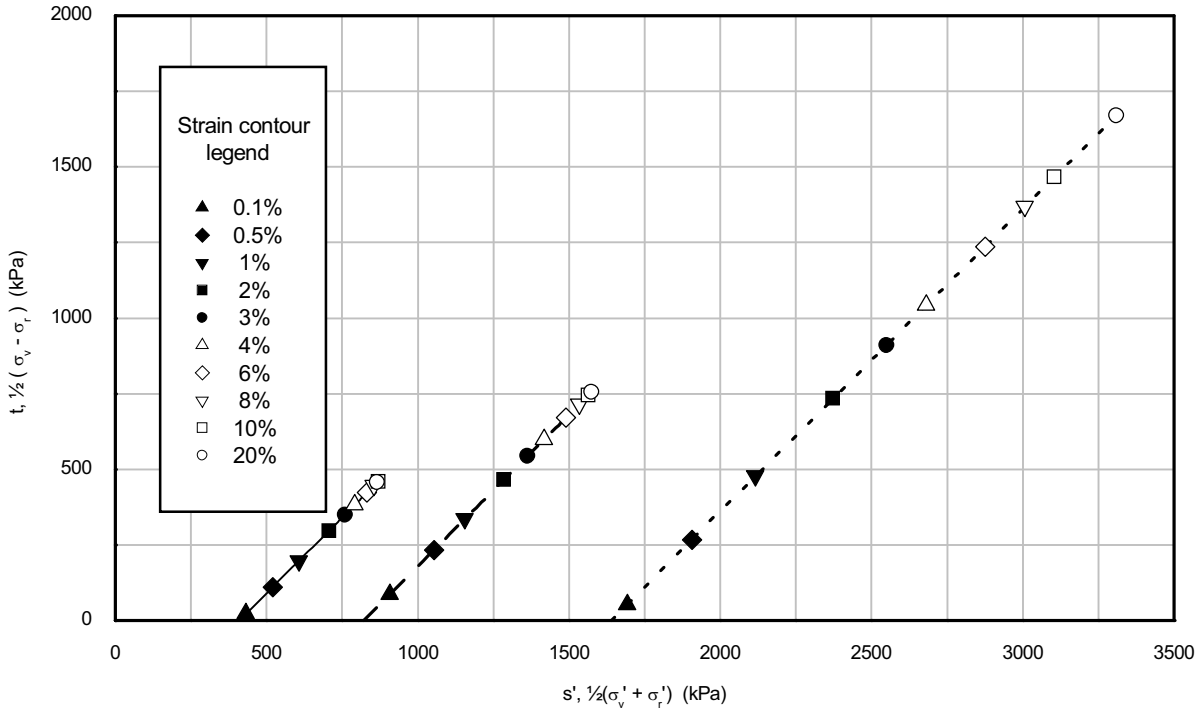
Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)
———	1	410	410
– –	2	820	820
- - - -	3	1640	1640

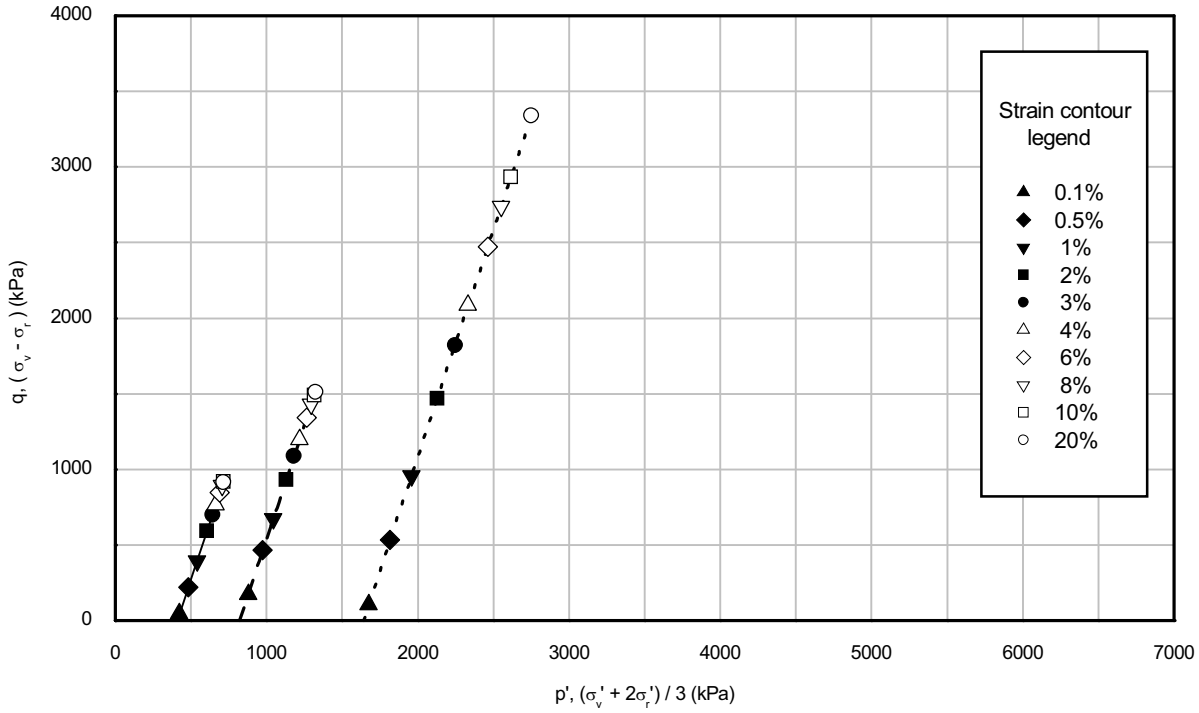
Borehole	Sample	Depth (m)
BH-WFS4-7	28BagA	42.50

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 21/10/2015
Filename: J11302 \ EFFECTIV \ BH-WFS4-7_28BagA_D3.OPJ
Template Issue: 4
Date : 22/10/2015
Checked by: ALB
Date : 29/10/2015
Approved by: PH

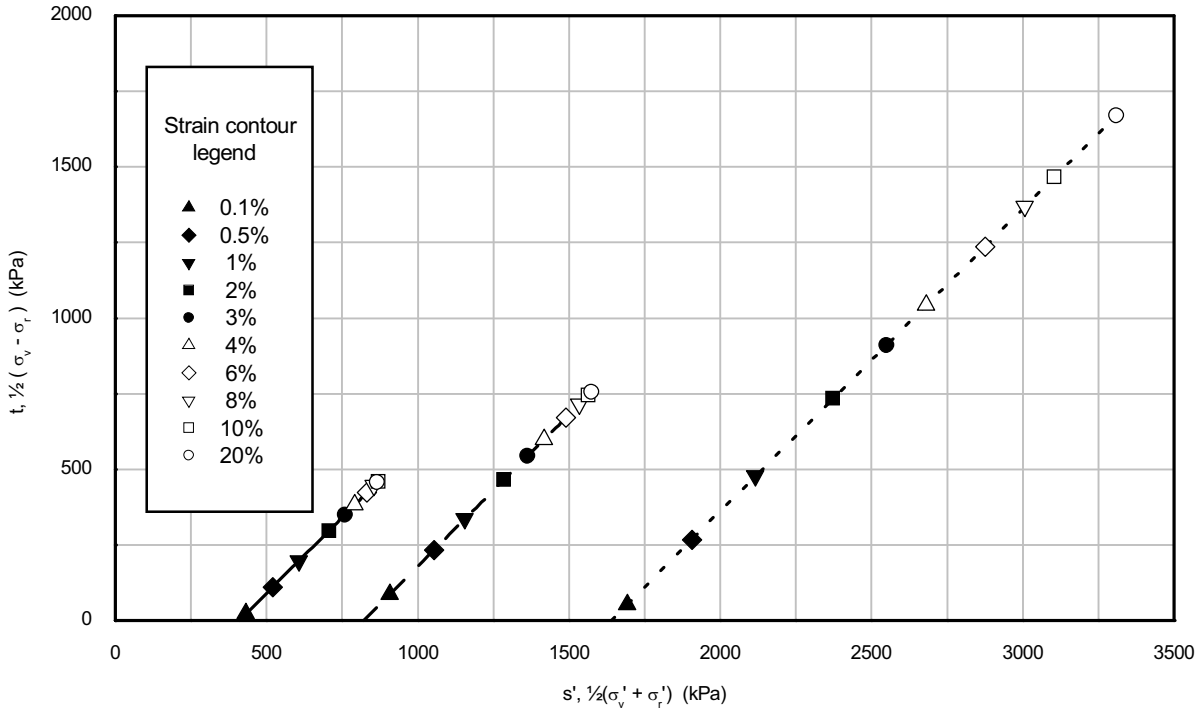


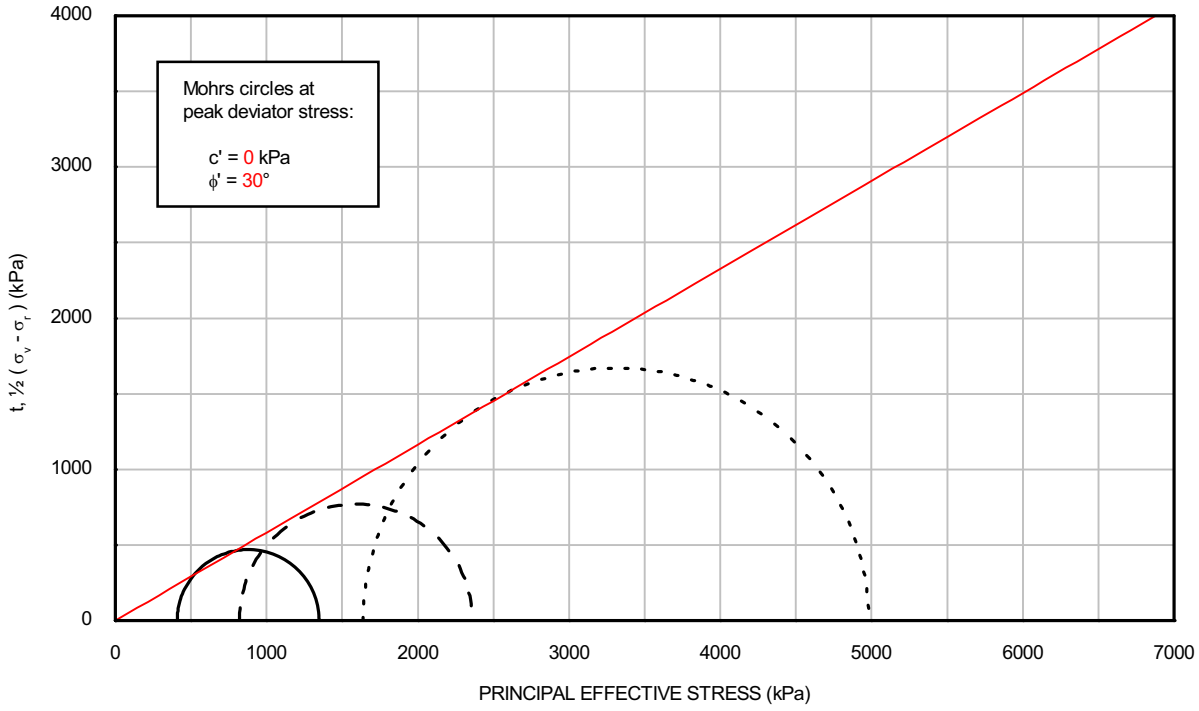


Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	410	410	BH-WFS4-7	28BagA	42.50
– –	2	820	820			
- - - -	3	1640	1640			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Curve	Specimen(3)	σ_{rc}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
——	1	410	410	BH-WFS4-7	28BagA	42.50
– –	2	820	820			
- - - -	3	1640	1640			

Drawn by: ER Date: 21/10/2015

Filename: J11302 \ EFFECTIV \ BH-WFS4-7_28BagA_D3.OPJ

Template Issue: 4

Date : 22/10/2015

Checked by: ALB

Date : 29/10/2015

Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

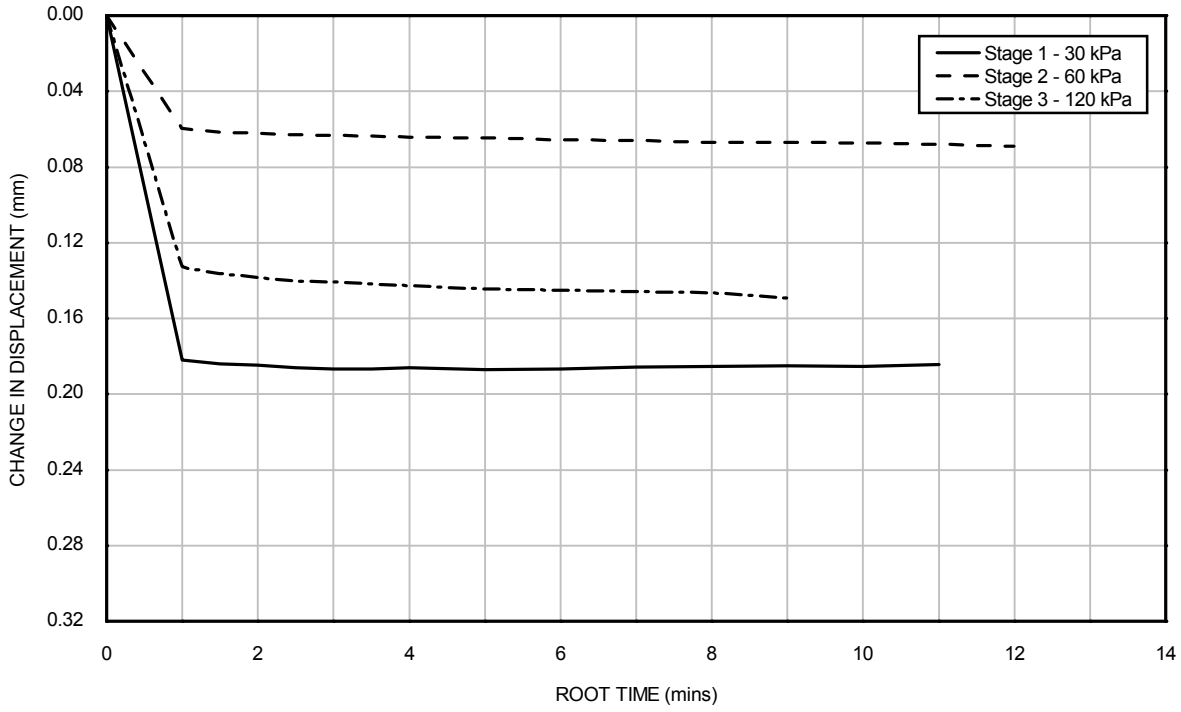
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SECTION C5: RING SHEAR TESTS

LIST OF PLATES IN SECTION C5: Plate

Ring Shear Test – Soil-Soil Interface	C5.1-1 to C5.1-28
Ring Shear Test – Soil-Steel Interface	C5.2-1 to C5.2-7

Drawn By : ER Date: 02/11/2015
Filename: J11302 \ SHEAR \ BH-WFS4-1_3BagA_R3.OPJ
Date:03/11/2015 Date:03/11/2015
Checked By : ALB Checked By : PH



INITIAL CONDITIONS

Sample Height	5 mm	Outer Radius	50 mm
Inner Radius	35 mm	Water Content	10.9 %

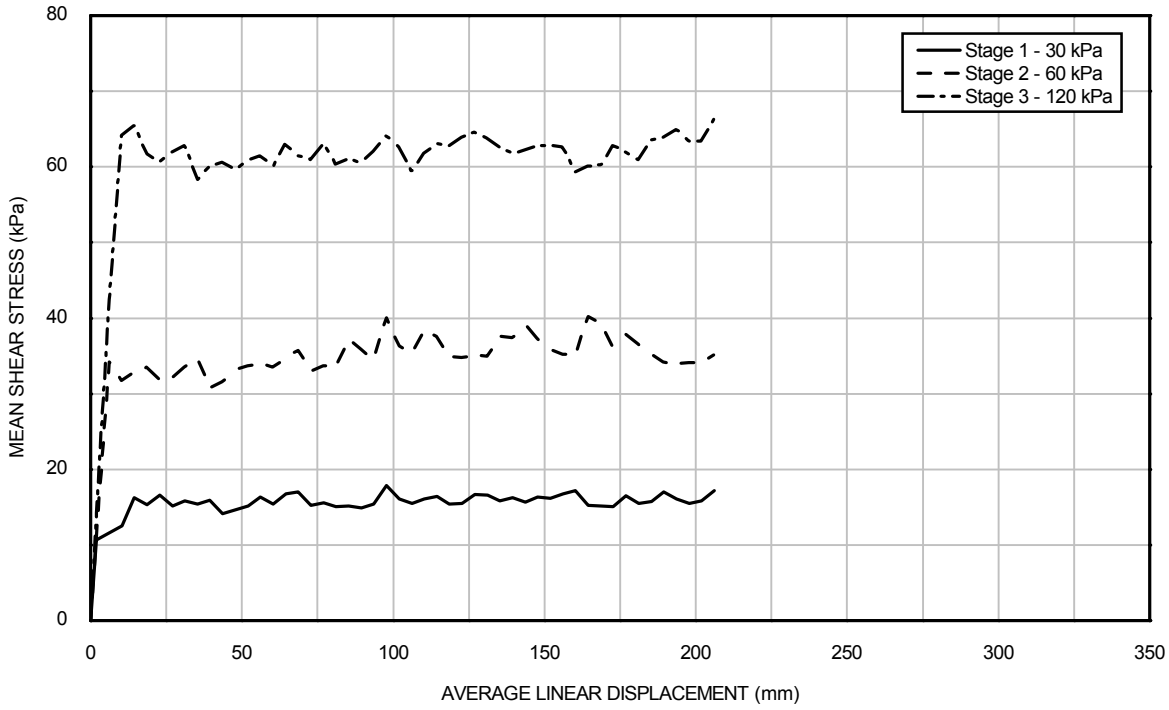
BOREHOLE	: BH-WFS4-1
SAMPLE	: 3BagA
DEPTH (m)	: 2.00

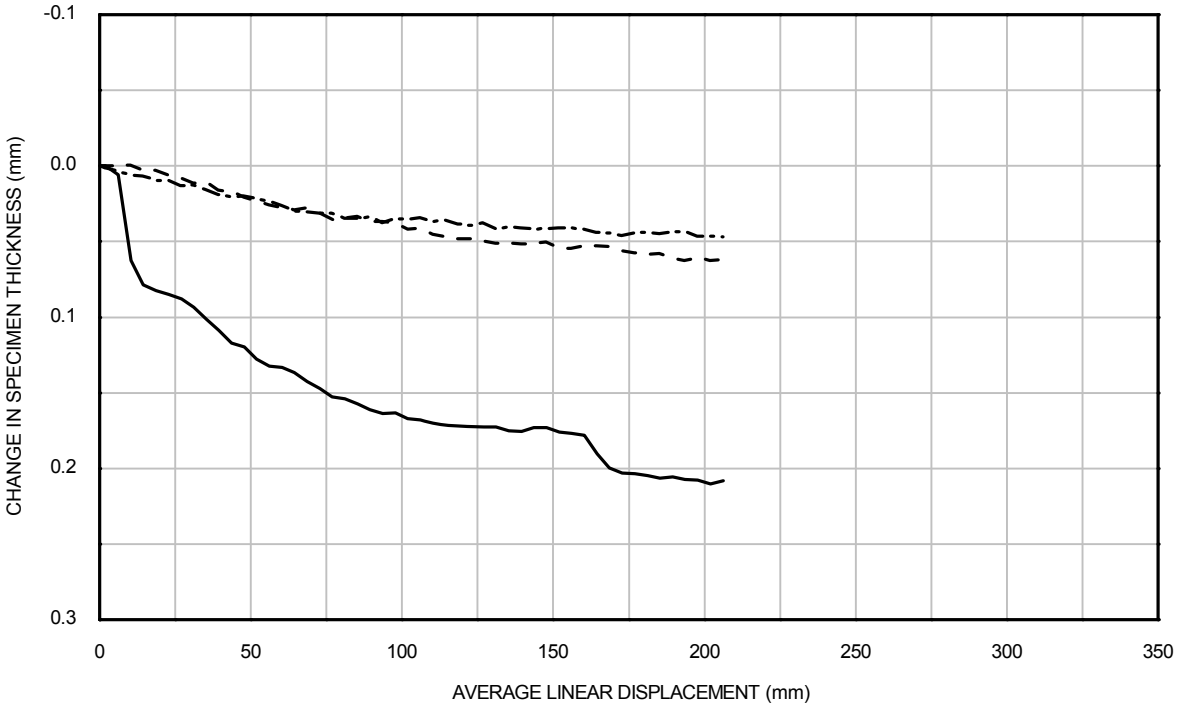
Tested in accordance with BS1377 : Part 7 : 1990 : Clause 6

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





BOREHOLE	: BH-WFS4-1
SAMPLE	: 3BagA
DEPTH (m)	: 2.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

FAST SHEARING STAGES

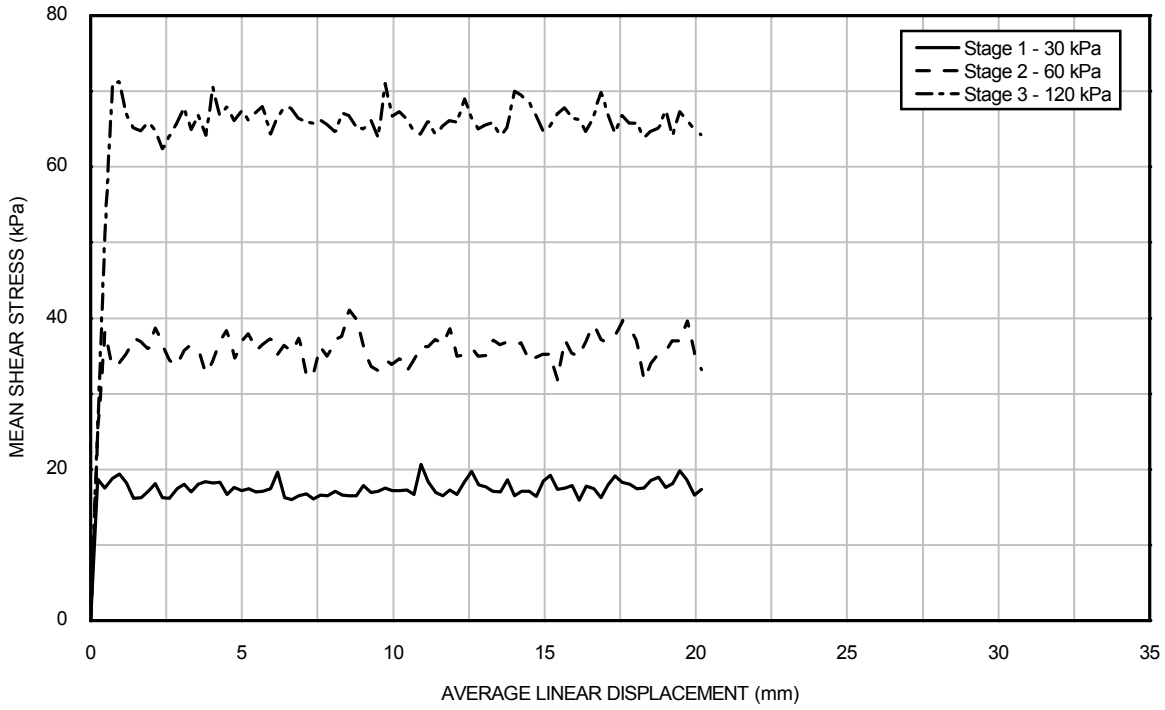
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

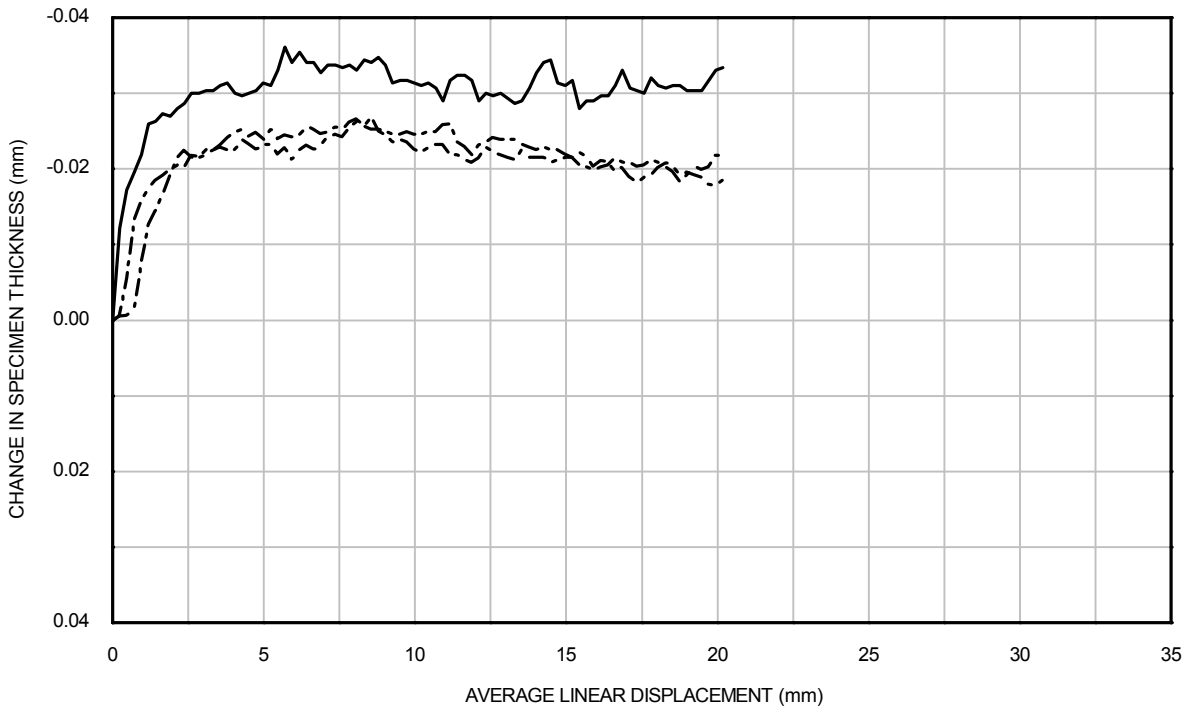
Drawn By : ER Date: 02/11/2015

Filename: J11302 \ SHEAR \ BH-WFS4-1_3BagA_R3.OPJ

Checked By : ALB Date:03/11/2015

Checked By : PH Date:03/11/2015





BOREHOLE	: BH-WFS4-1
SAMPLE	: 3BagA
DEPTH (m)	: 2.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SLOW SHEARING STAGES

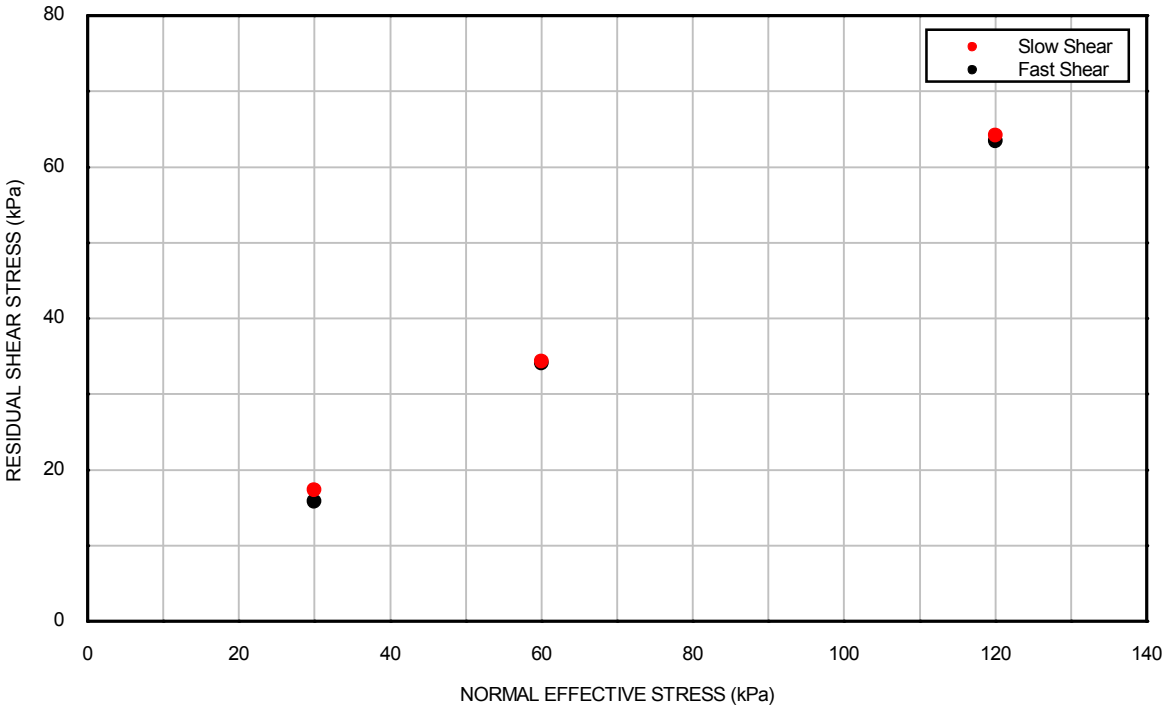
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn By : ER Date: 02/11/2015

Filename: J11302 \ SHEAR \ BH-WFS4-1_3BagA_R3.OPJ

Date:03/11/2015 Checked By : ALB

Date:03/11/2015 Checked By : PH



SHEARING	Shear Stage 1		Shear Stage 2		Shear Stage 3	
Rate of angular displacement (° / min)	0.16	674	0.16	674	0.16	674
Normal effective stress σ'_n (kPa)	30	30	60	60	120	120
Residual shear stress τ_n (kPa)	17.3	15.8	34.4	34.1	64.2	63.4
Mean linear displacement at end of shearing stage (mm)	20.2	201.9	20.4	193.6	20.2	197.7
Angle of residual shear resistance °	29.8	27.6	29.9	29.7	28.2	27.9

BOREHOLE : BH-WFS4-1

SAMPLE : 3BagA

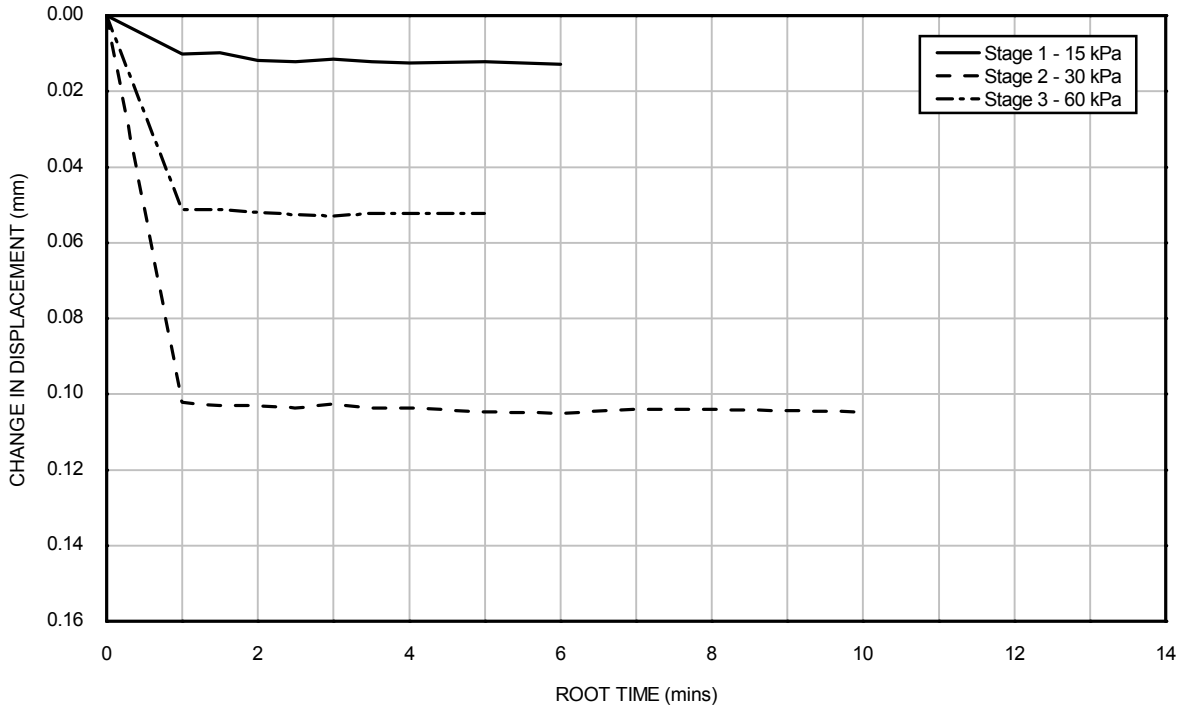
DEPTH (m) : 2.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Filename: J11302 \ SHEAR \ BH-WFS4-2_3BagA_R3.OPJ
Drawn By : ER
Date: 02/11/2015
Checked By : ALB
Date:03/11/2015
Checked By : PH
Date:03/11/2015



INITIAL CONDITIONS

Sample Height	5 mm	Outer Radius	50 mm
Inner Radius	35 mm	Water Content	8.9 %

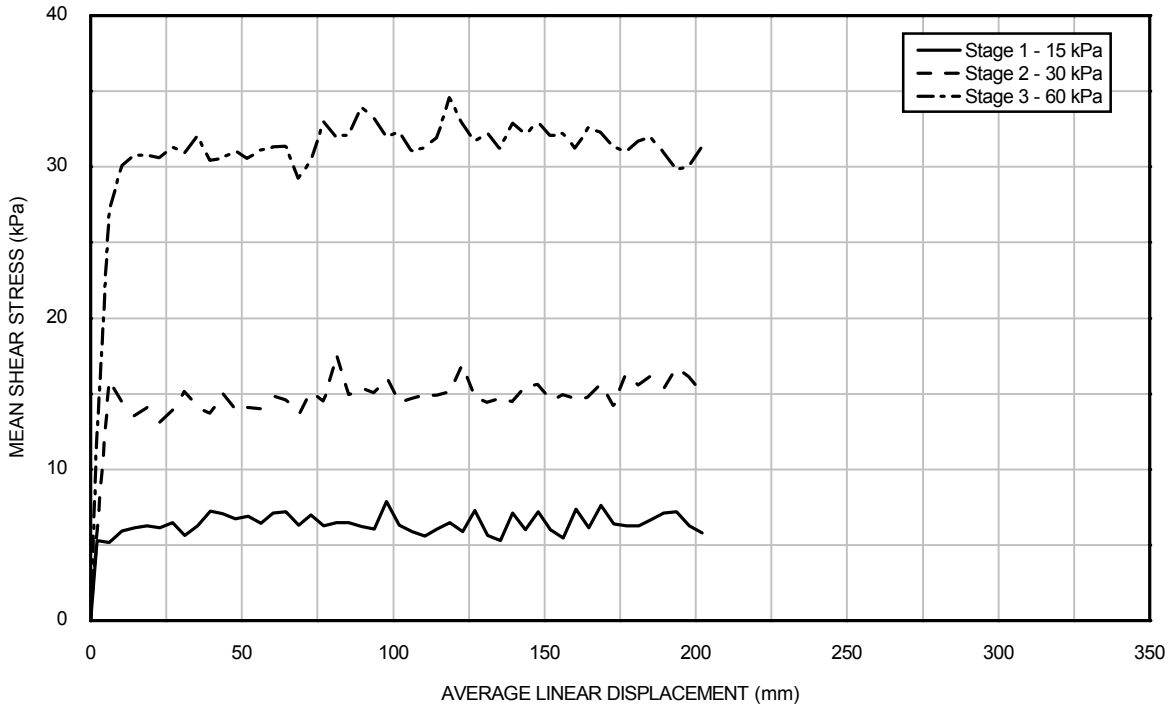
BOREHOLE	: BH-WFS4-2
SAMPLE	: 3BagA
DEPTH (m)	: 1.50

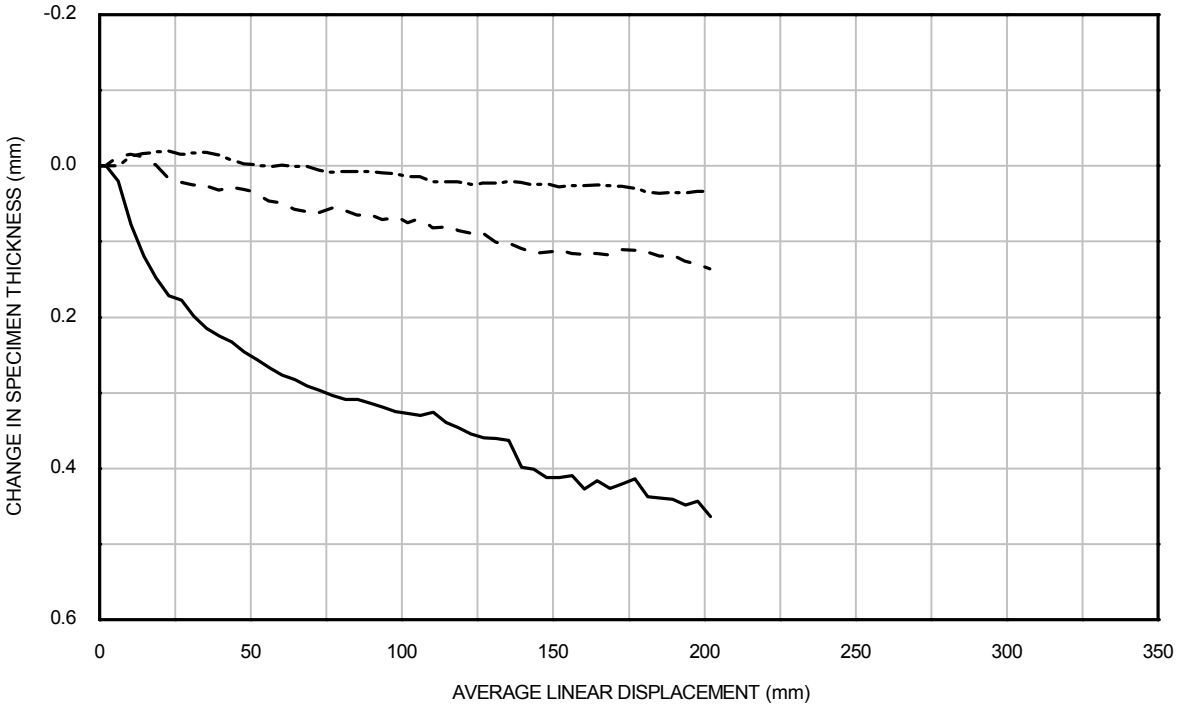
Tested in accordance with BS1377 : Part 7 : 1990 : Clause 6

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





BOREHOLE	: BH-WFS4-2
SAMPLE	: 3BagA
DEPTH (m)	: 1.50

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

FAST SHEARING STAGES

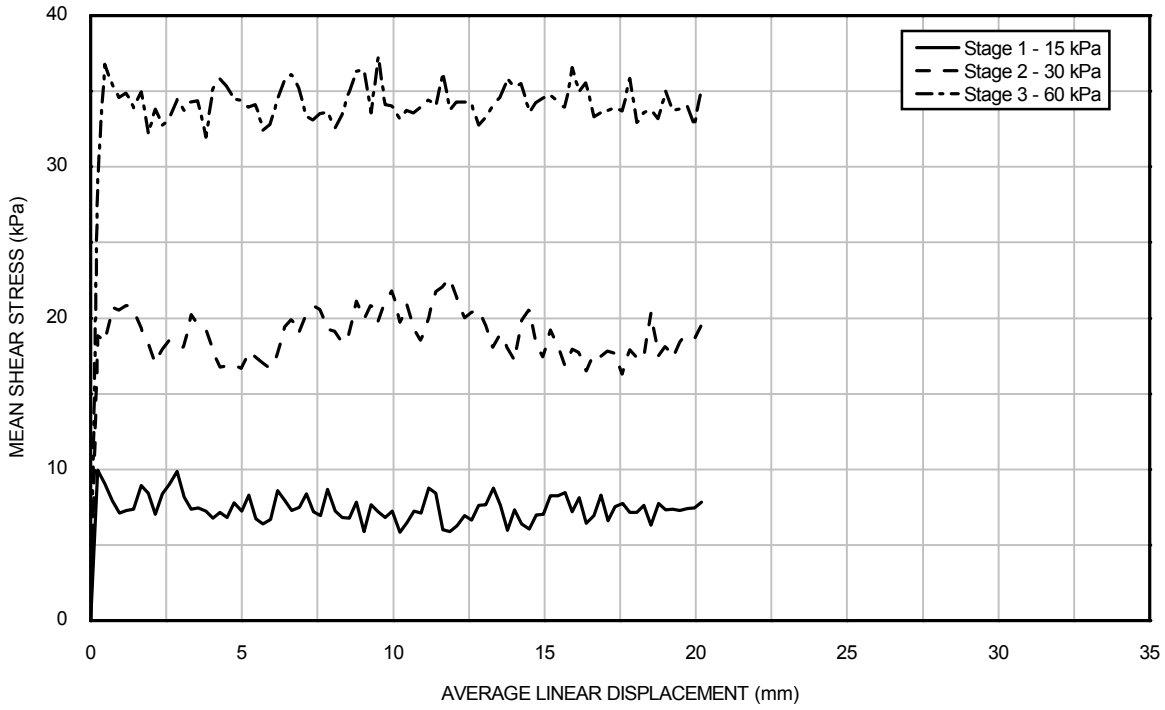
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

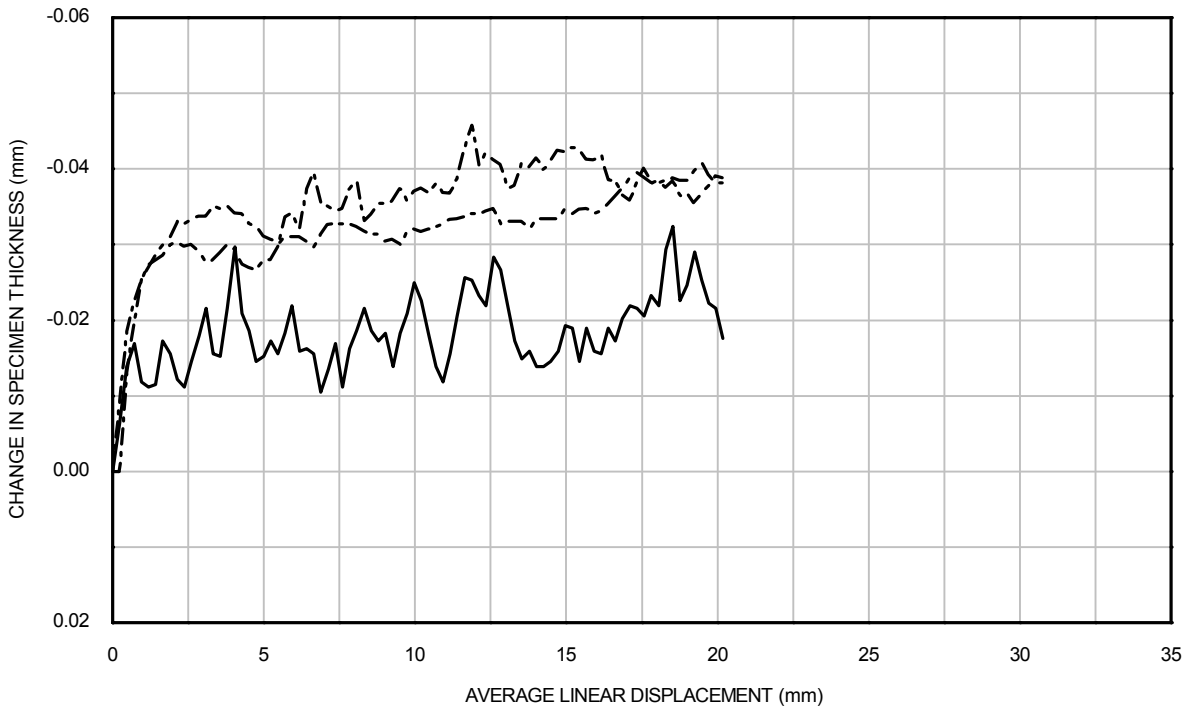
Drawn By : ER Date: 02/11/2015

Filename: J11302 \ SHEAR \ BH-WFS4-2_3BagA_R3.OPJ

Checked By : ALB Date:03/11/2015

Checked By : PH Date:03/11/2015





BOREHOLE	: BH-WFS4-2
SAMPLE	: 3BagA
DEPTH (m)	: 1.50

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SLOW SHEARING STAGES

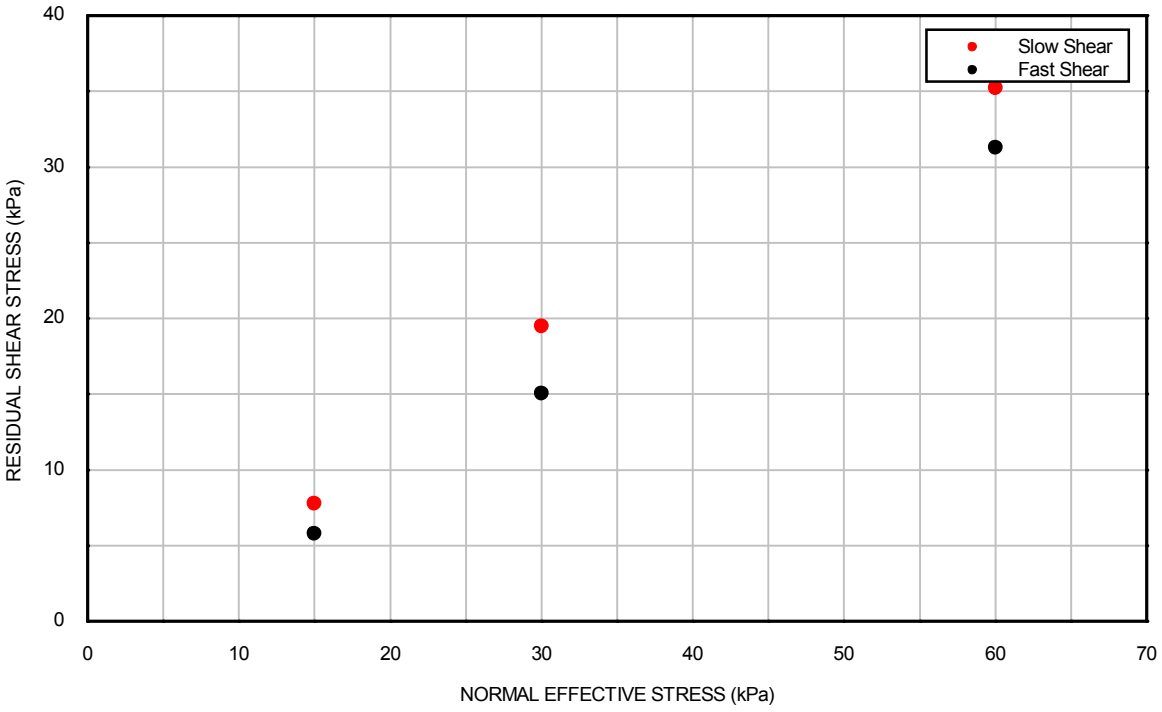
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn By : ER Date: 02/11/2015

Filename: J11302 \ SHEAR \ BH-WFS4-2_3BagA_R3.OPJ

Checked By : ALB Date:03/11/2015

Checked By : PH Date:03/11/2015



SHEARING	Shear Stage 1		Shear Stage 2		Shear Stage 3	
Rate of angular displacement (° / min)	0.16	674	0.16	674	0.16	674
Normal effective stress σ'_n (kPa)	15	15	30	30	60	60
Residual shear stress τ_n (kPa)	7.8	5.8	19.5	15.1	35.2	31.3
Mean linear displacement at end of shearing stage (mm)	20.2	202.0	20.2	202.0	20.2	201.9
Angle of residual shear resistance °	28.3	21.8	32.7	26.3	30.5	27.6

BOREHOLE : BH-WFS4-2

SAMPLE : 3BagA

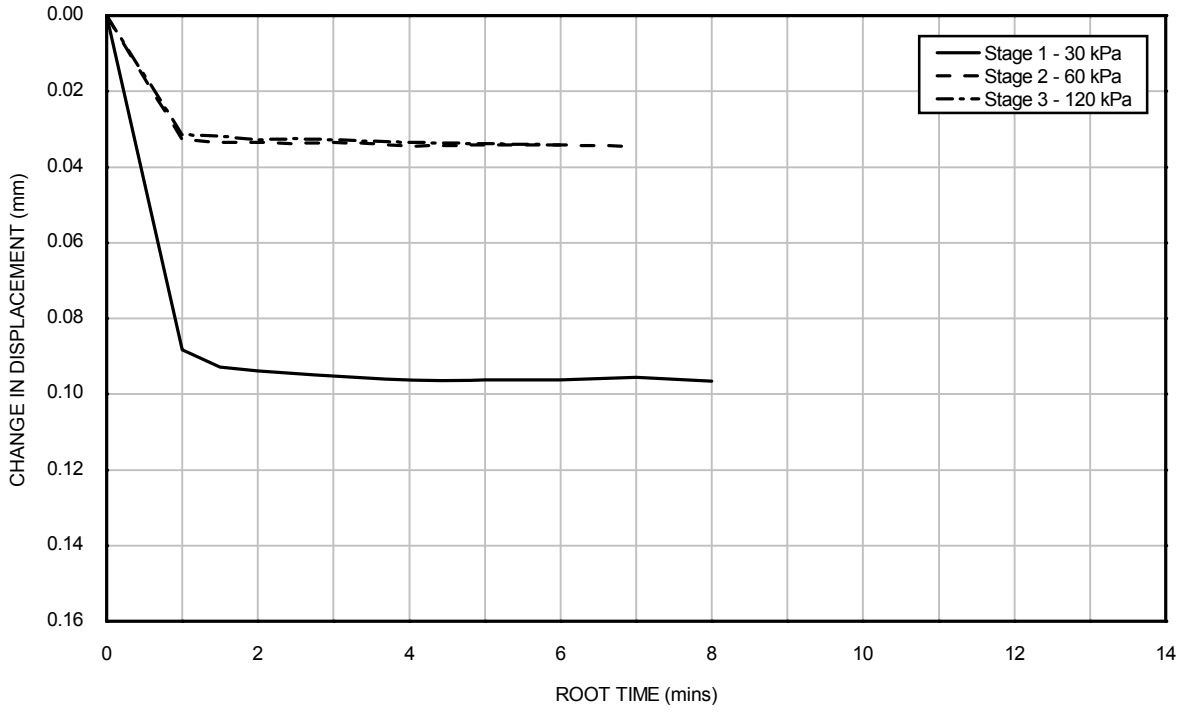
DEPTH (m) : 1.50

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-3_B_R3.OPJ
Date:28/10/2015
Checked By : ALB
Date:03/11/2015
Checked By : PH



INITIAL CONDITIONS

Sample Height	5 mm	Outer Radius	50 mm
Inner Radius	35 mm	Water Content	8.6 %

BOREHOLE	: BH-WFS4-3
SAMPLE	: 4BagA
DEPTH (m)	: 3.00

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 6

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015

Drawn By : ER

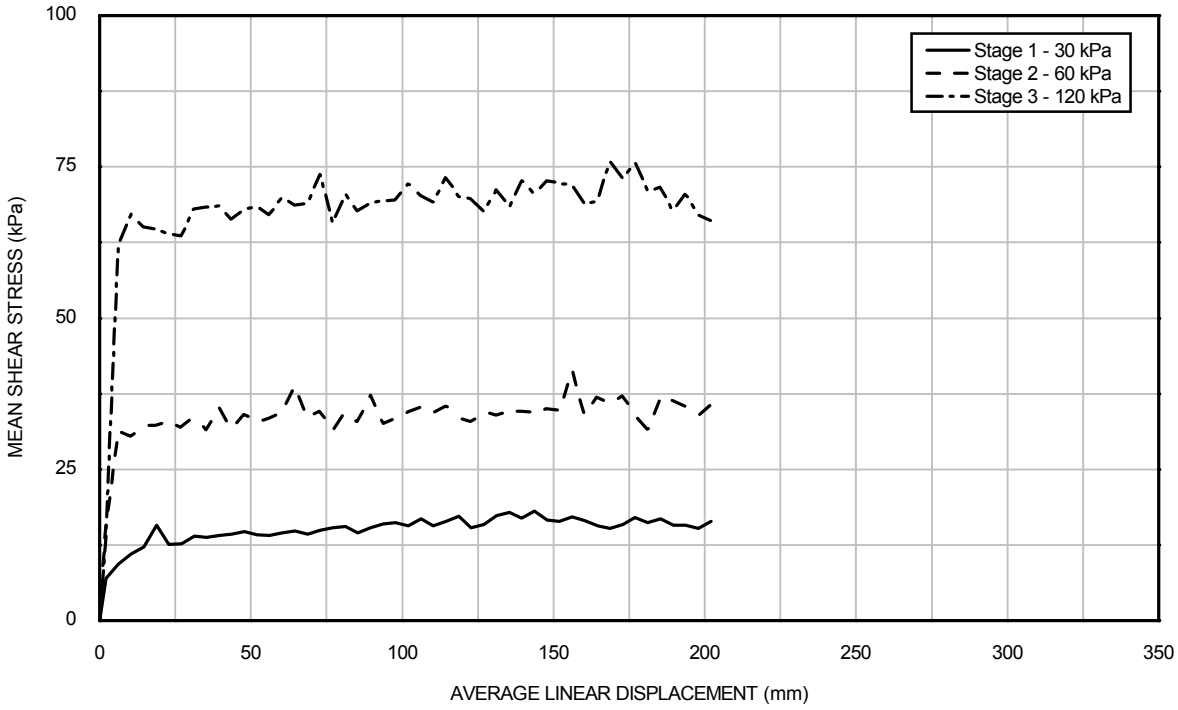
Filename: J11302 \ SHEAR \ BH-WFS4-3_B_R3.OPJ

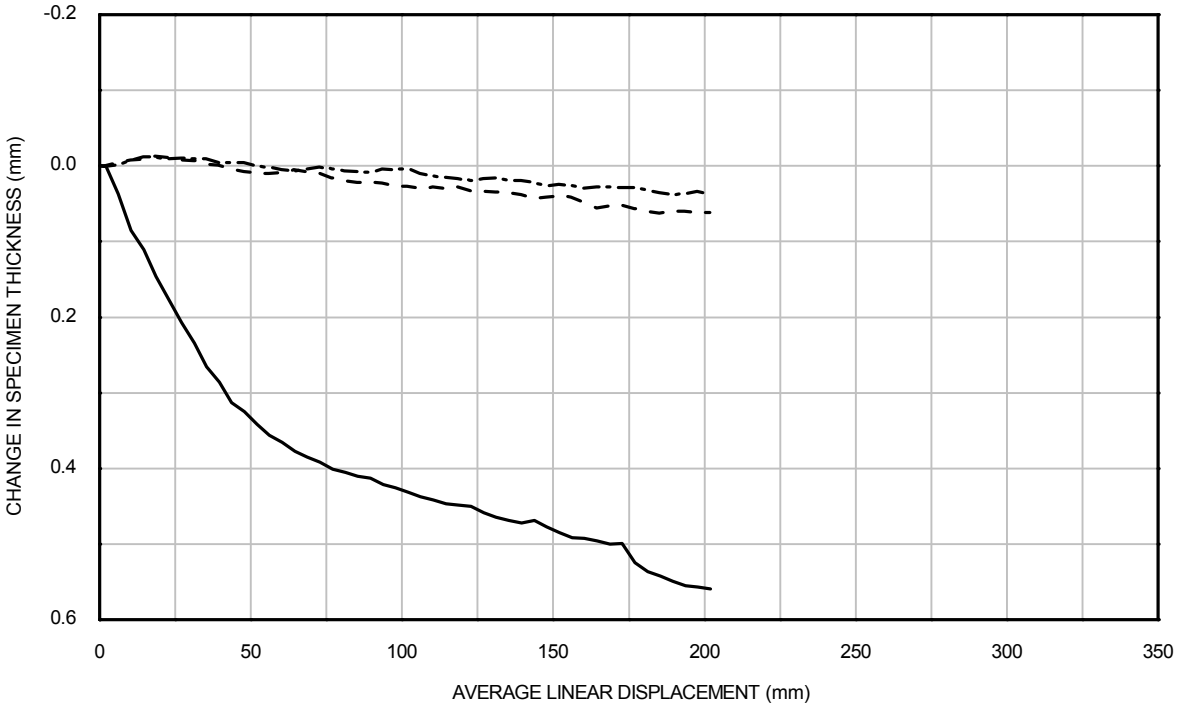
Date:28/10/2015

Checked By : ALB

Date:03/11/2015

Checked By : PH



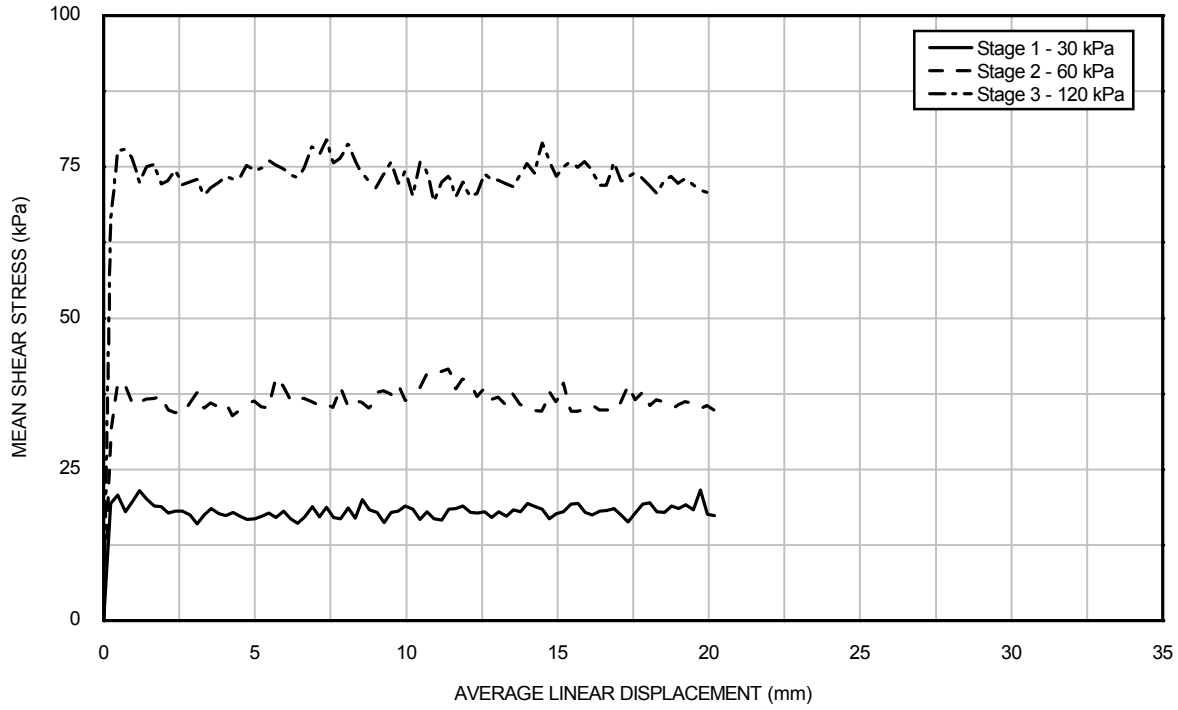


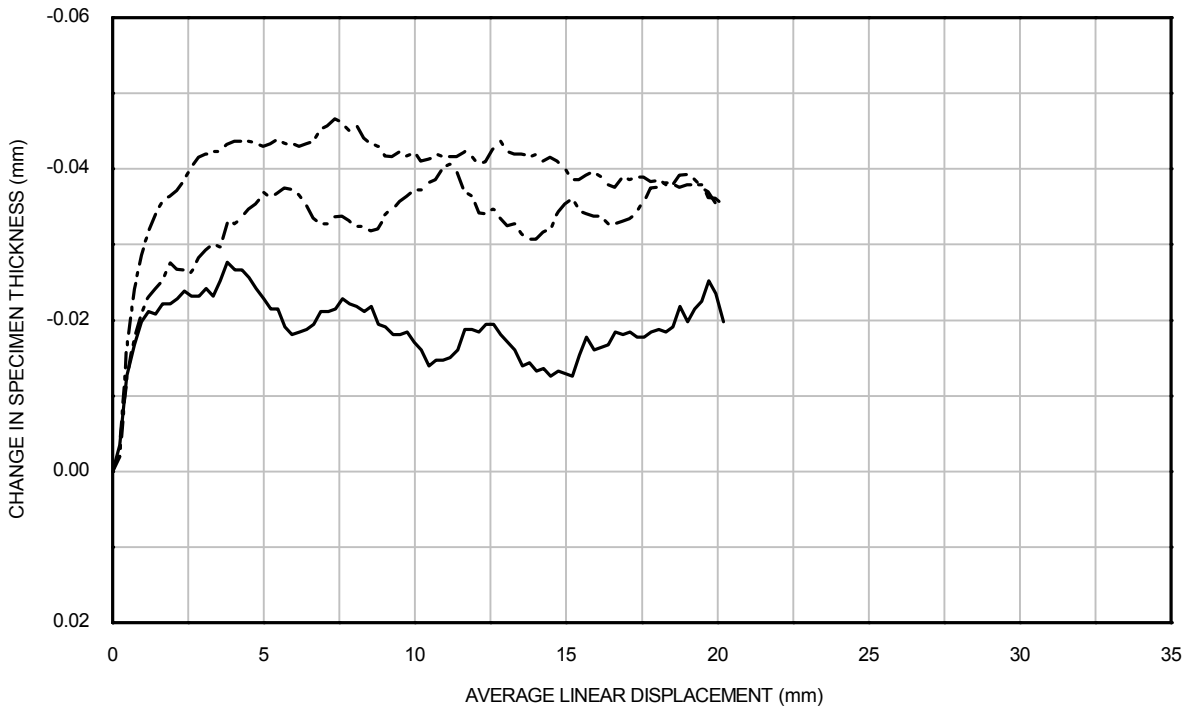
BOREHOLE	: BH-WFS4-3
SAMPLE	: 4BagA
DEPTH (m)	: 3.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

FAST SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





BOREHOLE	: BH-WFS4-3
SAMPLE	: 4BagA
DEPTH (m)	: 3.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SLOW SHEARING STAGES

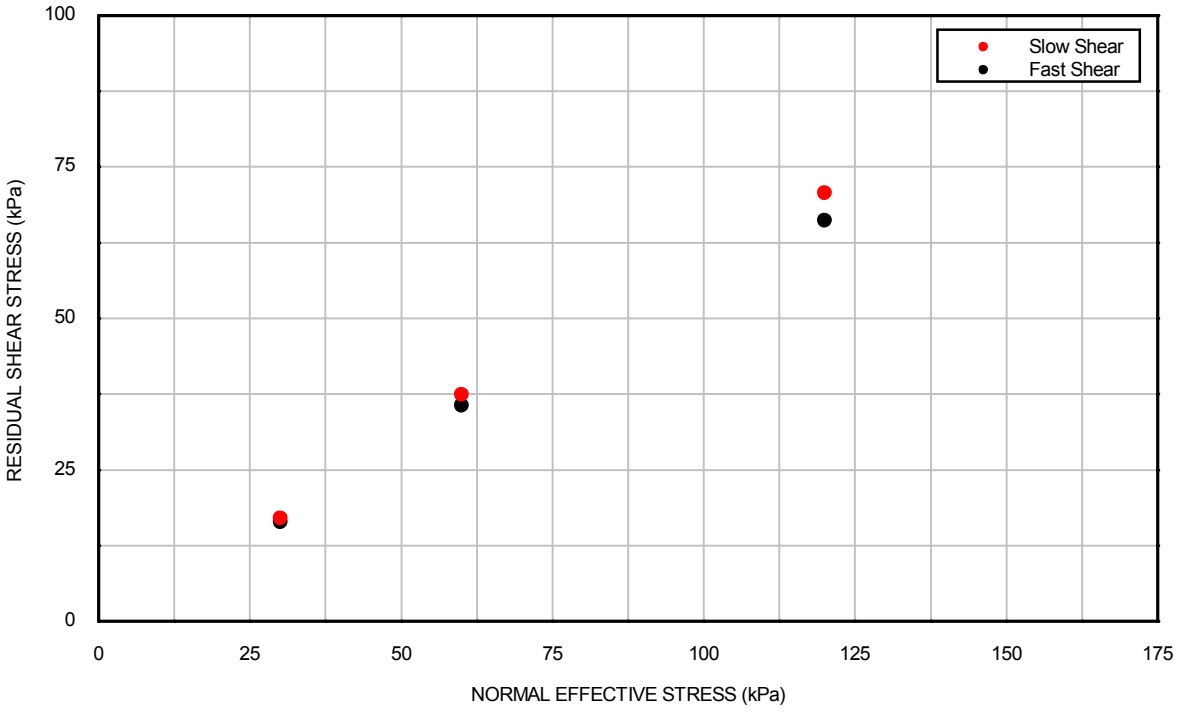
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn By : ER Date: 27/10/2015

Filename: J11302 \ SHEAR \ BH-WFS4-3_B_R3.OPJ

Date:28/10/2015 Checked By : ALB

Date:03/11/2015 Checked By : PH



SHEARING	Shear Stage 1		Shear Stage 2		Shear Stage 3	
Rate of angular displacement (° / min)	0.16	674	0.16	674	0.16	674
Normal effective stress σ'_n (kPa)	30	30	60	60	120	120
Residual shear stress τ_n (kPa)	17.0	16.4	37.4	35.7	70.7	66.1
Mean linear displacement at end of shearing stage (mm)	24.5	202.0	237.2	201.9	20.0	202.0
Angle of residual shear resistance °	29.1	28.4	32.0	30.8	30.6	28.9

BOREHOLE : BH-WFS4-3

SAMPLE : 4BagA

DEPTH (m) : 3.00

Drawn By : ER Date: 27/10/2015

Filename: J11302 \ SHEAR \ BH-WFS4-3_B_R3.OPJ

Checked By : ALB Date:28/10/2015

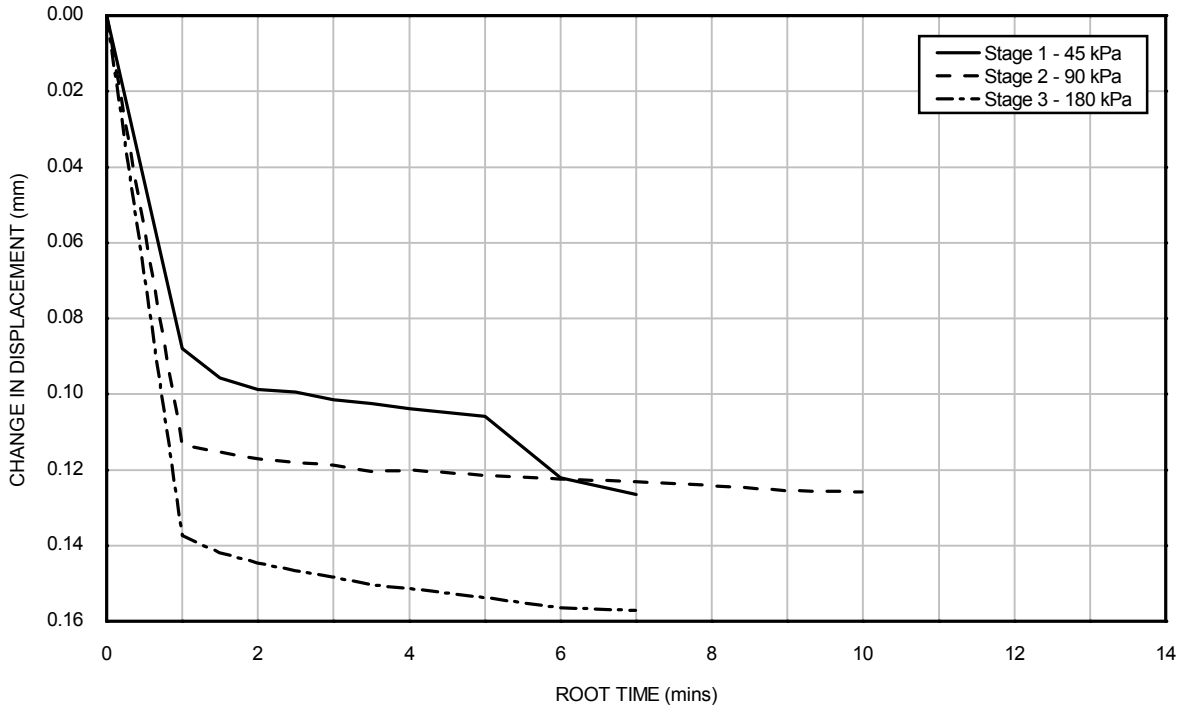
Checked By : PH Date:03/11/2015

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Filename: J11302 \ SHEAR \ BH-WFS4-4_7BagA_R3.OPJ
Drawn By : ER
Date: 29/10/2015
Date:29/10/2015
Checked By : ALB
Date:03/11/2015
Checked By : PH



INITIAL CONDITIONS

Sample Height	5 mm	Outer Radius	50 mm
Inner Radius	35 mm	Water Content	10 %

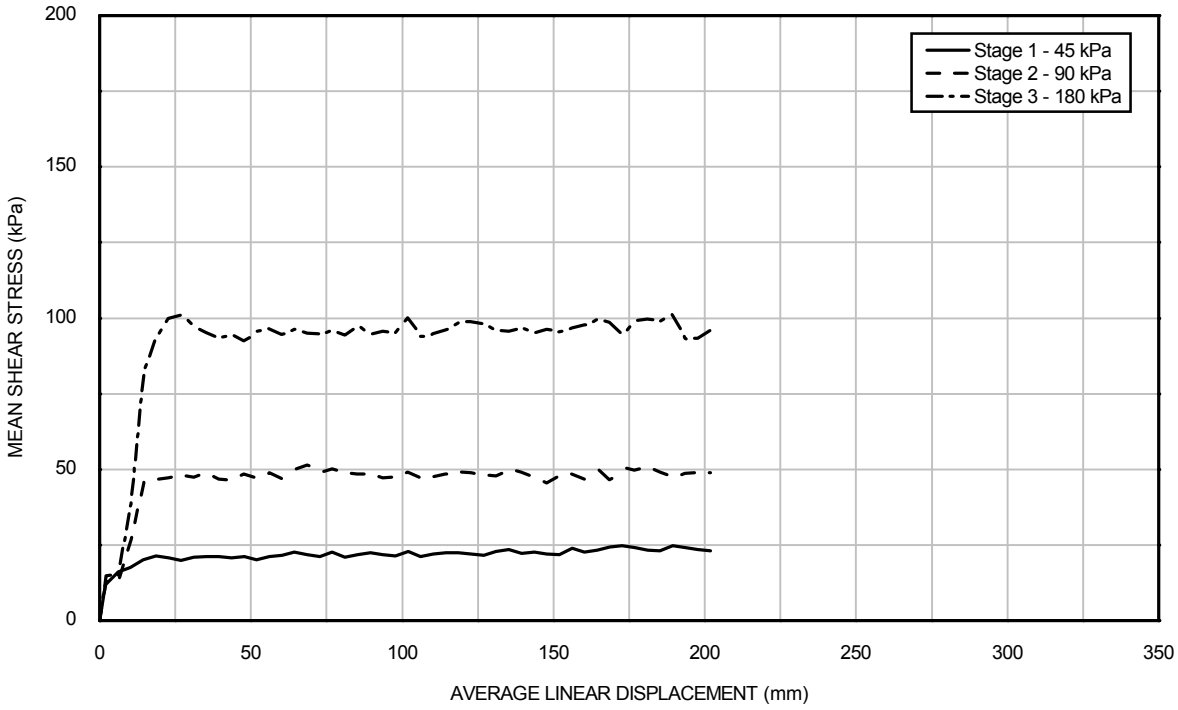
BOREHOLE	: BH-WFS4-4
SAMPLE	: 7BagA
DEPTH (m)	: 4.50

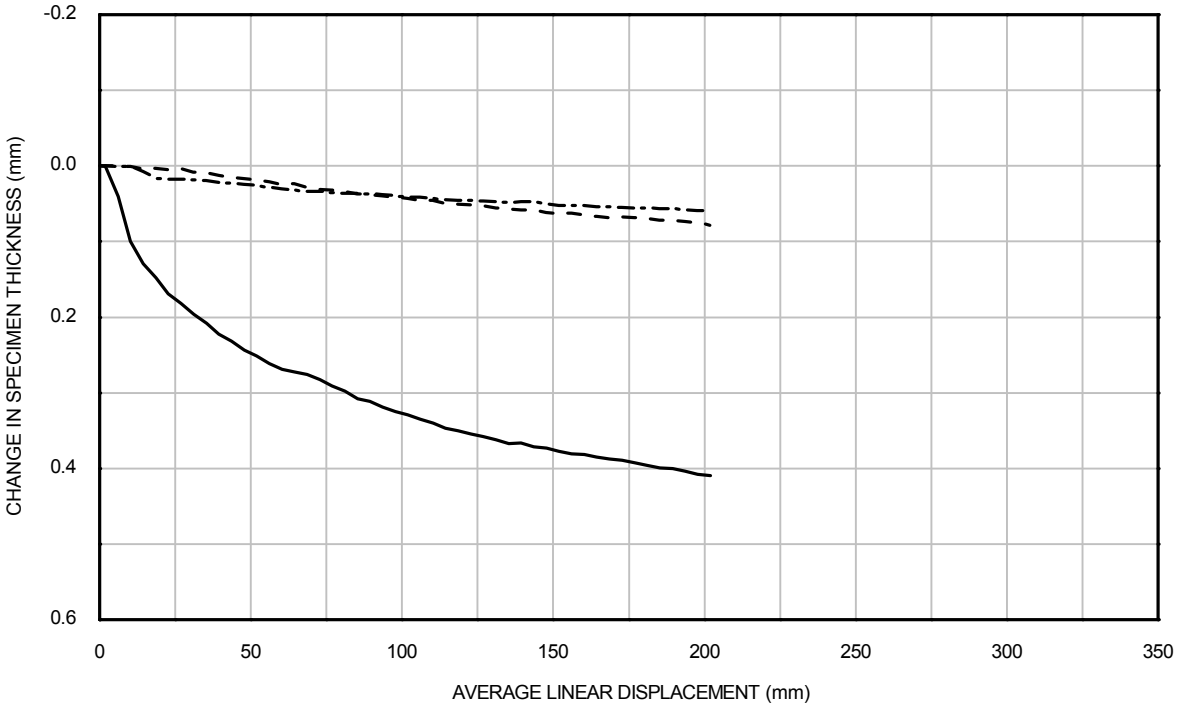
Tested in accordance with BS1377 : Part 7 : 1990 : Clause 6

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





BOREHOLE	: BH-WFS4-4
SAMPLE	: 7BagA
DEPTH (m)	: 4.50

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

FAST SHEARING STAGES

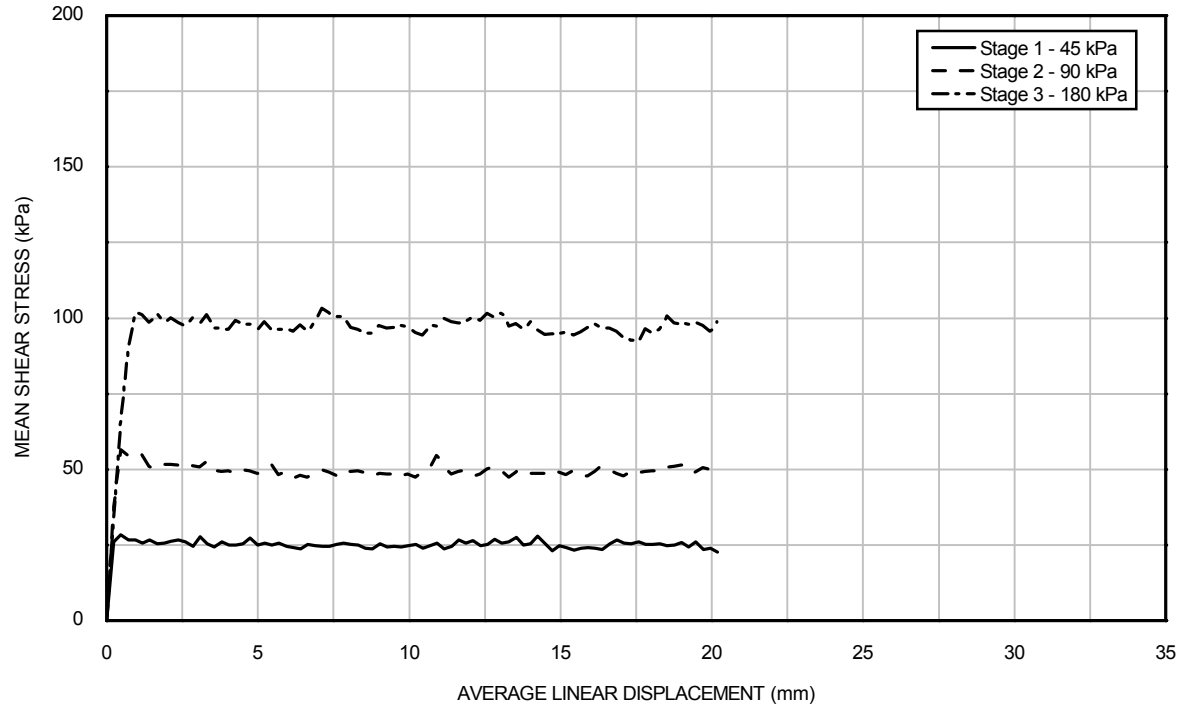
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

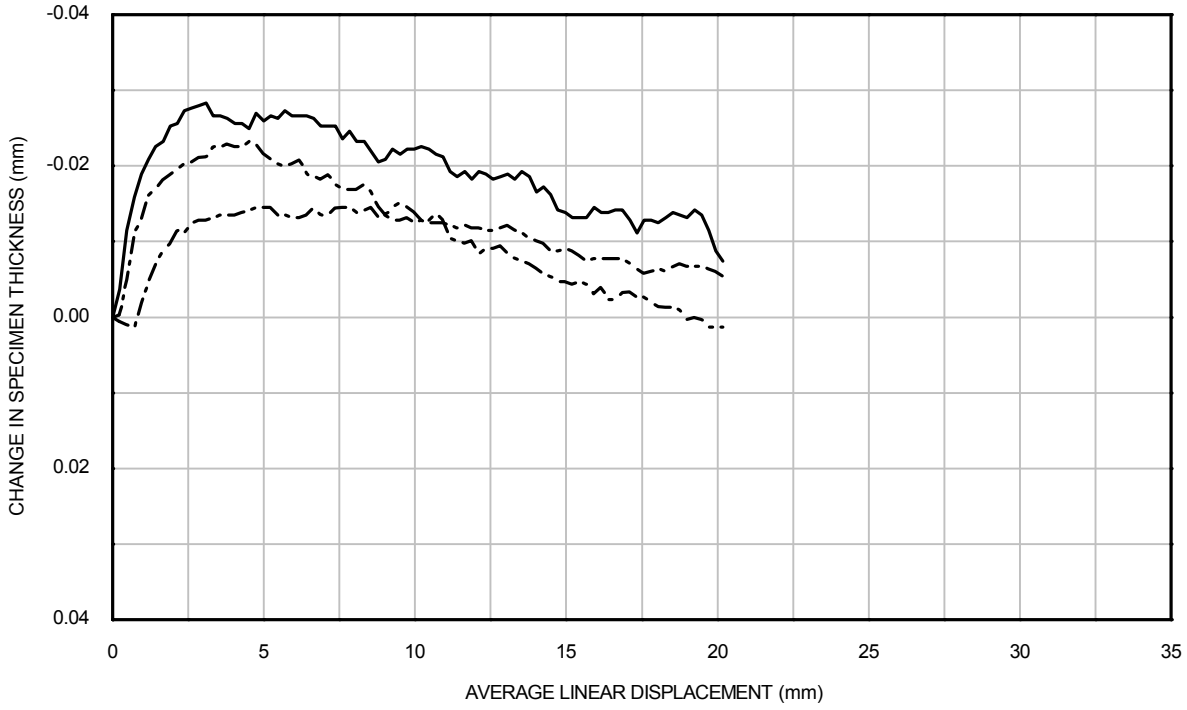
Drawn By : ER Date: 29/10/2015

Filename: J11302 \ SHEAR \ BH-WFS4-4_7BagA_R3.OPJ

Checked By : ALB Date:29/10/2015

Checked By : PH Date:03/11/2015





BOREHOLE	: BH-WFS4-4
SAMPLE	: 7BagA
DEPTH (m)	: 4.50

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SLOW SHEARING STAGES

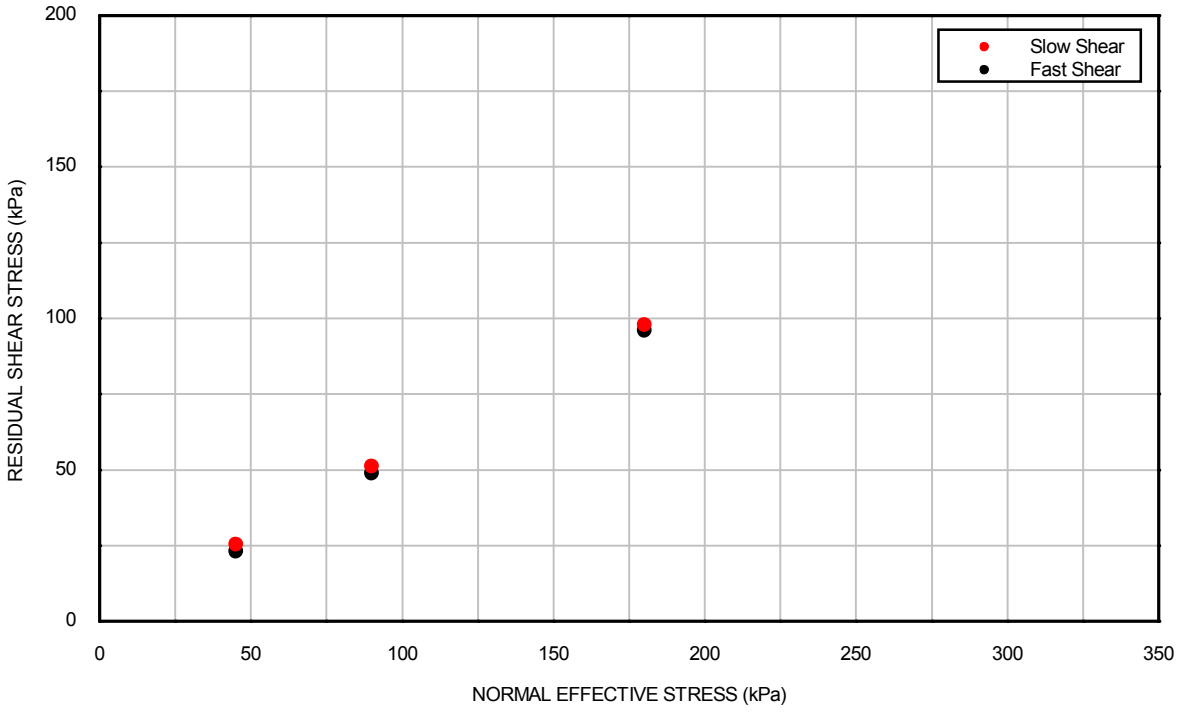
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn By : ER Date: 29/10/2015

Filename: J11302 \ SHEAR \ BH-WFS4-4_7BagA_R3.OPJ

Date:29/10/2015 Checked By : ALB

Date:03/11/2015 Checked By : PH



SHEARING	Shear Stage 1		Shear Stage 2		Shear Stage 3	
Rate of angular displacement (° / min)	0.16	674	0.16	674	0.16	674
Normal effective stress σ'_n (kPa)	45	45	90	90	180	180
Residual shear stress τ_n (kPa)	25.4	23.0	51.1	48.8	97.9	96.1
Mean linear displacement at end of shearing stage (mm)	23.3	201.9	114.2	202.0	22.1	202.0
Angle of residual shear resistance °	29.5	27.1	29.5	28.4	28.6	28.1

BOREHOLE : BH-WFS4-4

SAMPLE : 7BagA

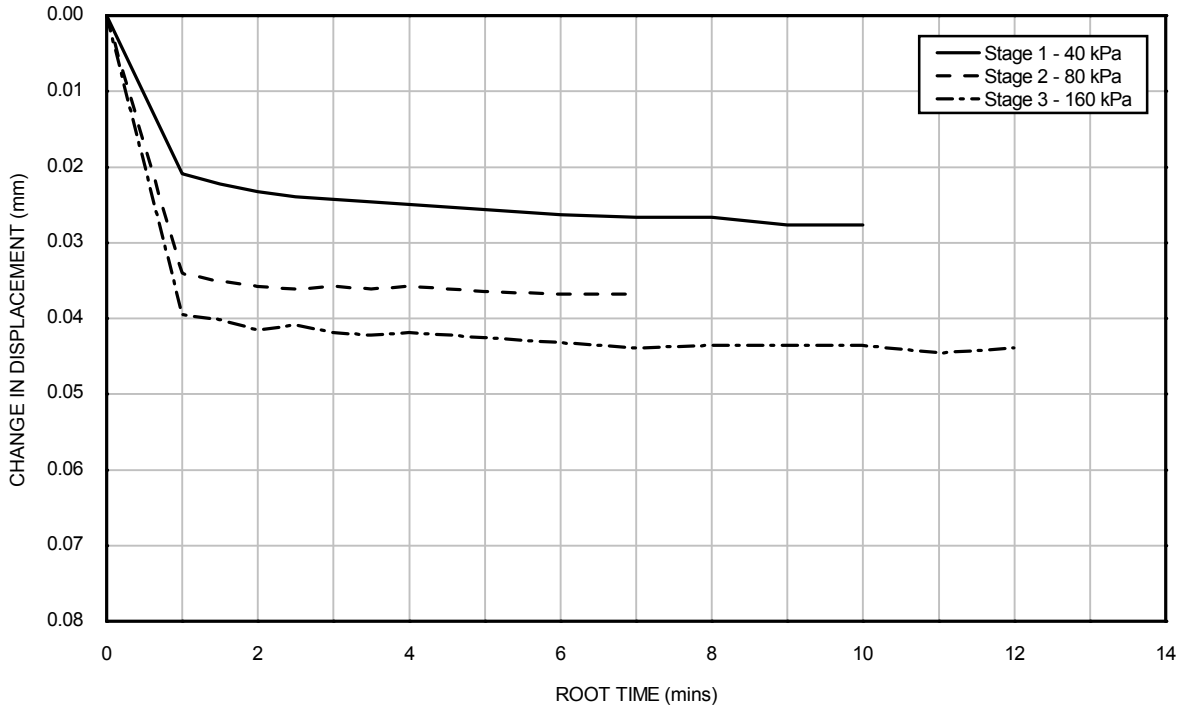
DEPTH (m) : 4.50

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-5_8BagA_R3.OPJ
Date:03/11/2015
Checked By : PH



Date:03/11/2015
Checked By : PH

INITIAL CONDITIONS

Sample Height	5 mm	Outer Radius	50 mm
Inner Radius	35 mm	Water Content	10 %

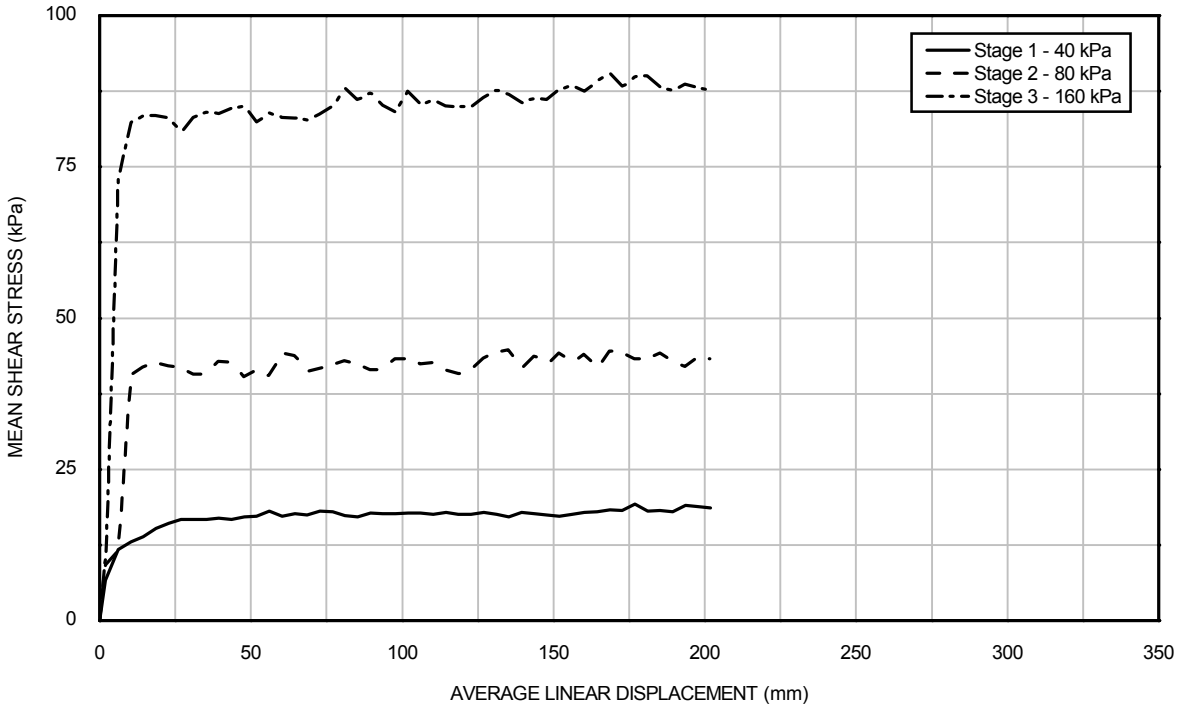
BOREHOLE	: BH-WFS4-5
SAMPLE	: 8BagA
DEPTH (m)	: 4.00

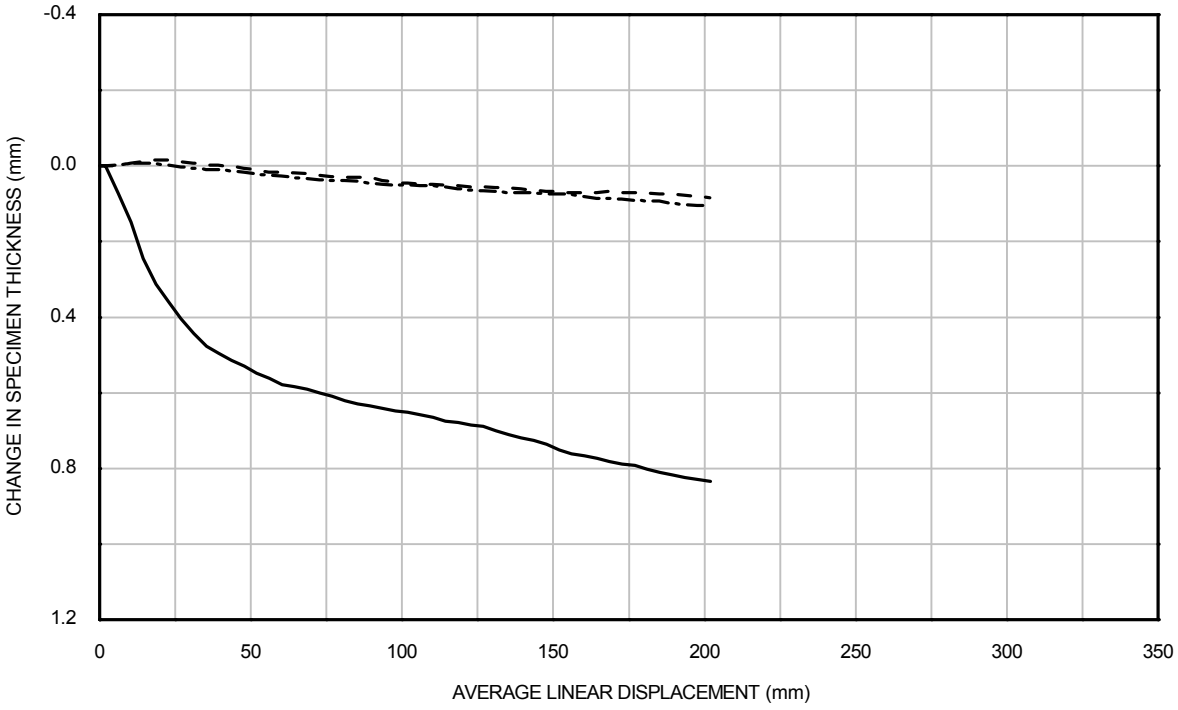
Tested in accordance with BS1377 : Part 7 : 1990 : Clause 6

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





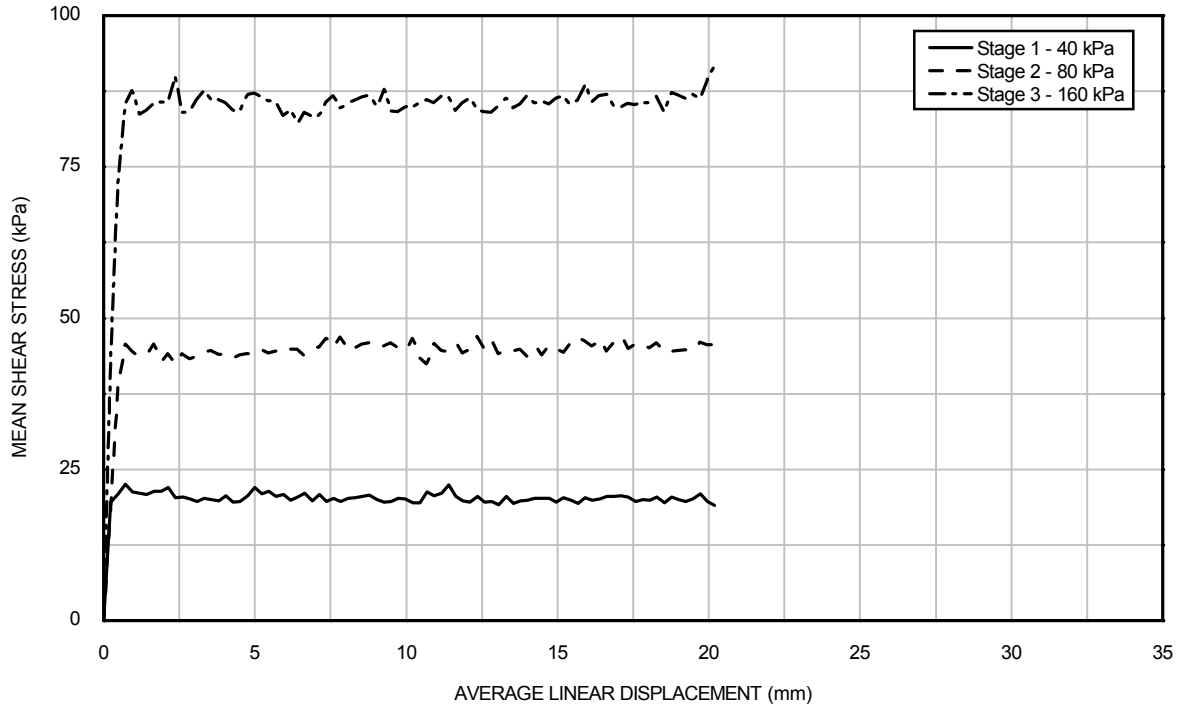
BOREHOLE	: BH-WFS4-5
SAMPLE	: 8BagA
DEPTH (m)	: 4.00

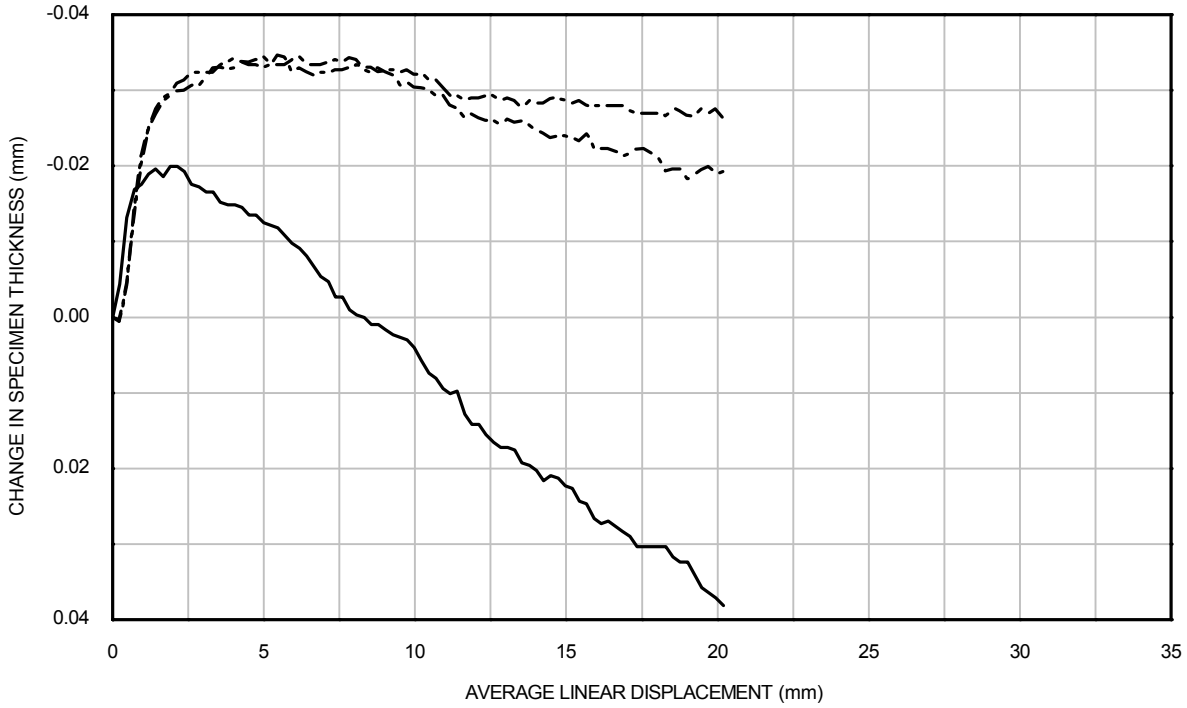
DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

FAST SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 29/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-5_8BagA_R3.OPJ
Date:03/11/2015
Checked By : PH
Date:03/11/2015
Checked By : PH





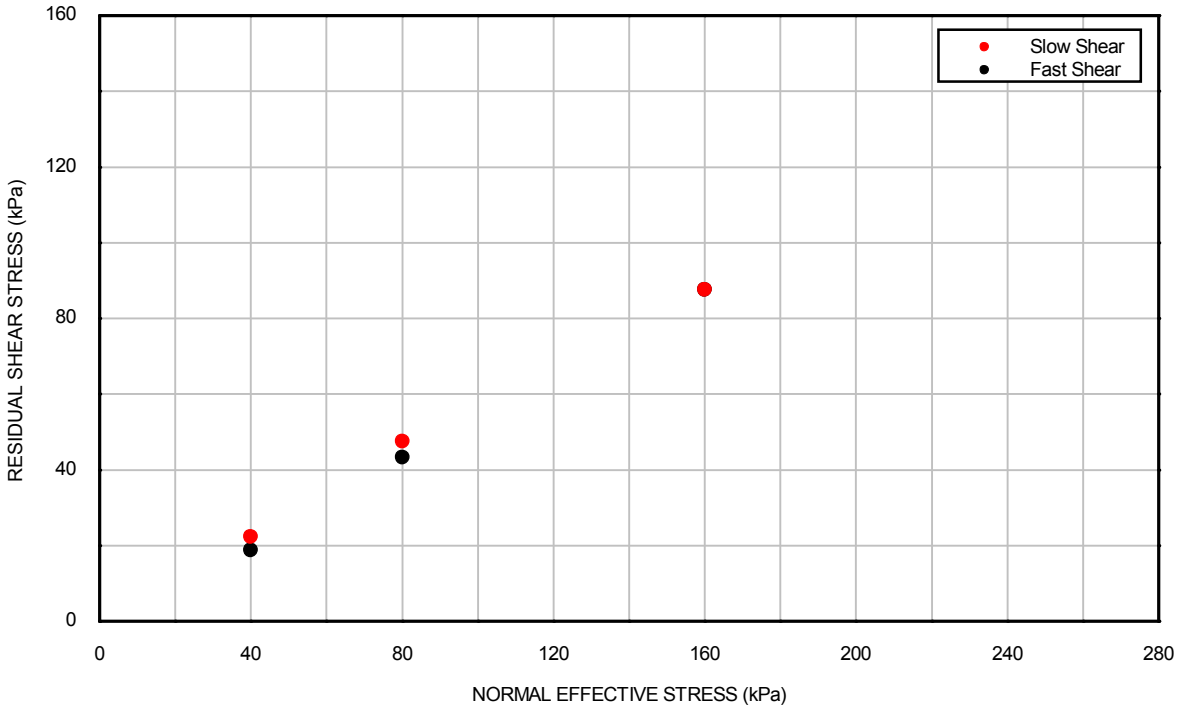
BOREHOLE	: BH-WFS4-5
SAMPLE	: 8BagA
DEPTH (m)	: 4.00

Date: 29/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-5_8BagA_R3.OPJ
Date:03/11/2015
Checked By : PH
Date:03/11/2015
Checked By : PH

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SLOW SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



SHEARING	Shear Stage 1		Shear Stage 2		Shear Stage 3	
Rate of angular displacement (° / min)	0.16	674	0.16	674	0.16	674
Normal effective stress σ'_n (kPa)	40	40	80	80	160	160
Residual shear stress τ_n (kPa)	22.4	18.7	47.6	43.3	87.5	87.7
Mean linear displacement at end of shearing stage (mm)	114.5	201.9	22.3	201.9	116.1	202.0
Angle of residual shear resistance °	29.1	24.9	30.9	28.6	28.6	28.7

BOREHOLE : BH-WFS4-5

SAMPLE : 8BagA

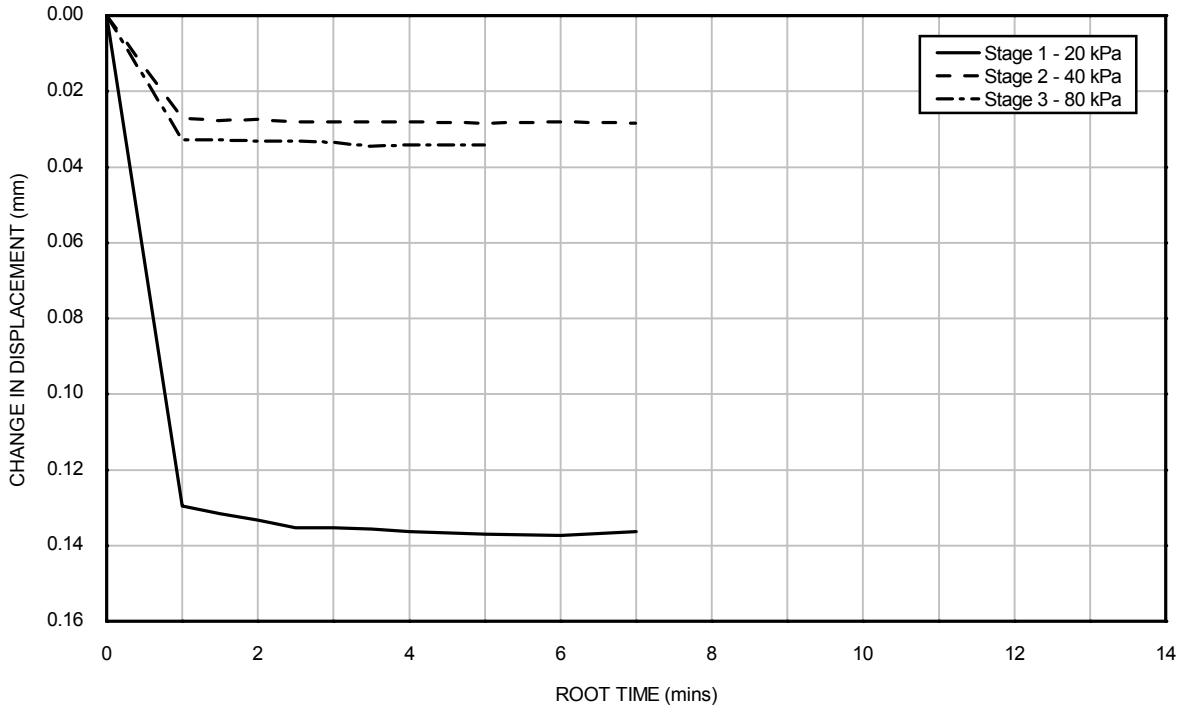
DEPTH (m) : 4.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-6_3BagA_R3.OPJ
Date:28/10/2015
Checked By : PH
Date:03/11/2015
Checked By : PH



INITIAL CONDITIONS

Sample Height	5 mm	Outer Radius	50 mm
Inner Radius	35 mm	Water Content	10.5 %

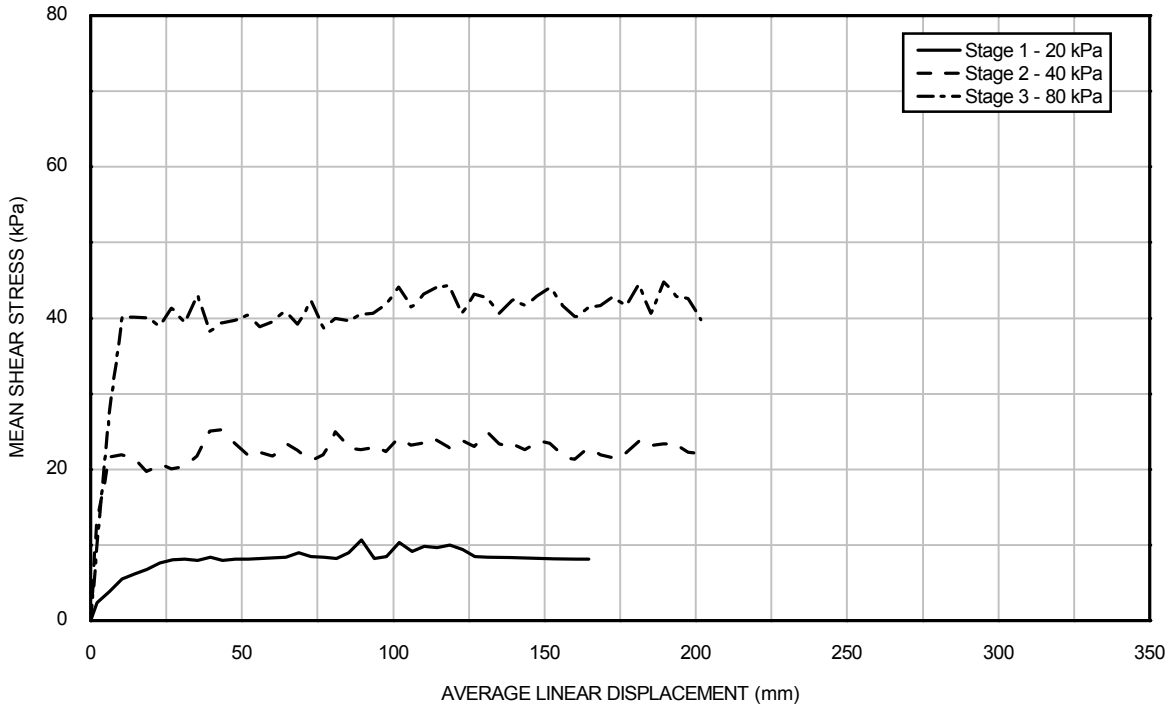
BOREHOLE	: BH-WFS4-6
SAMPLE	: 3BagA
DEPTH (m)	: 2.00

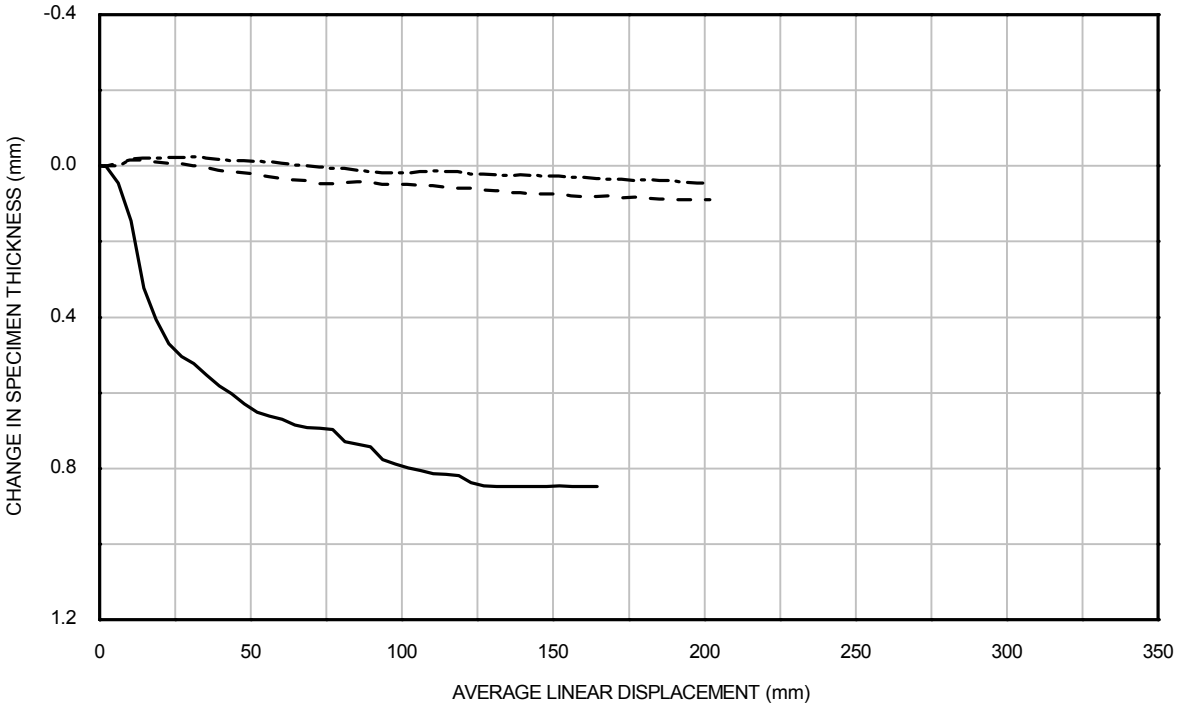
Tested in accordance with BS1377 : Part 7 : 1990 : Clause 6

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





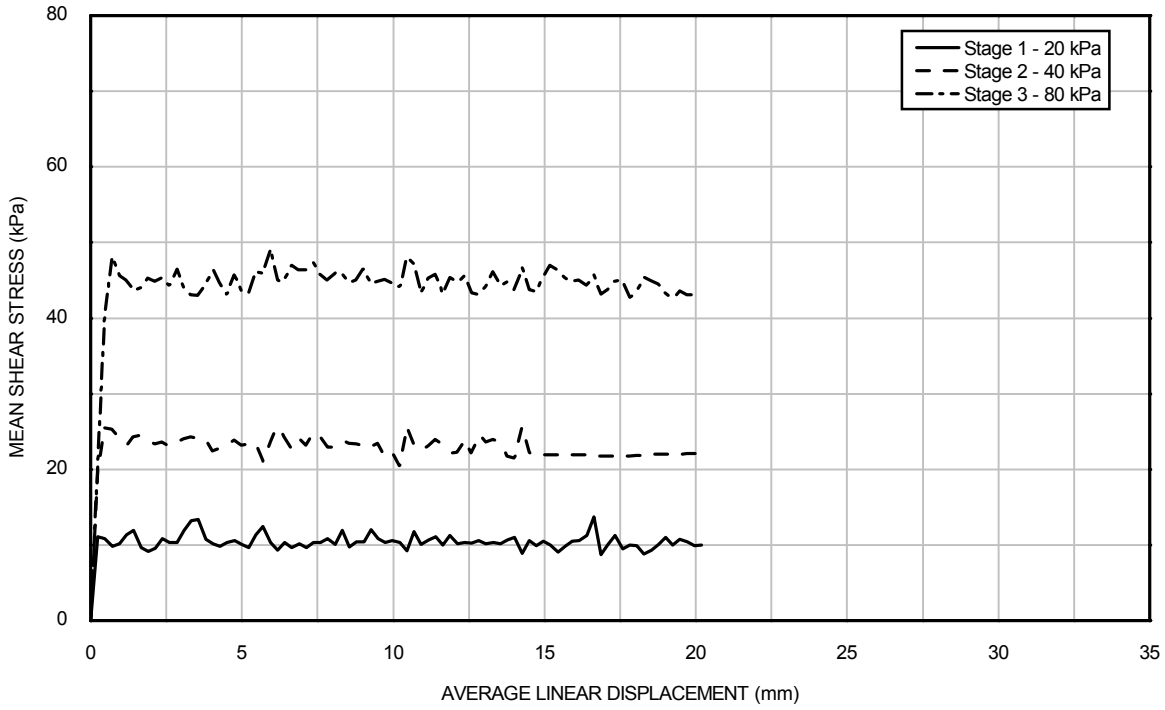
BOREHOLE	: BH-WFS4-6
SAMPLE	: 3BagA
DEPTH (m)	: 2.00

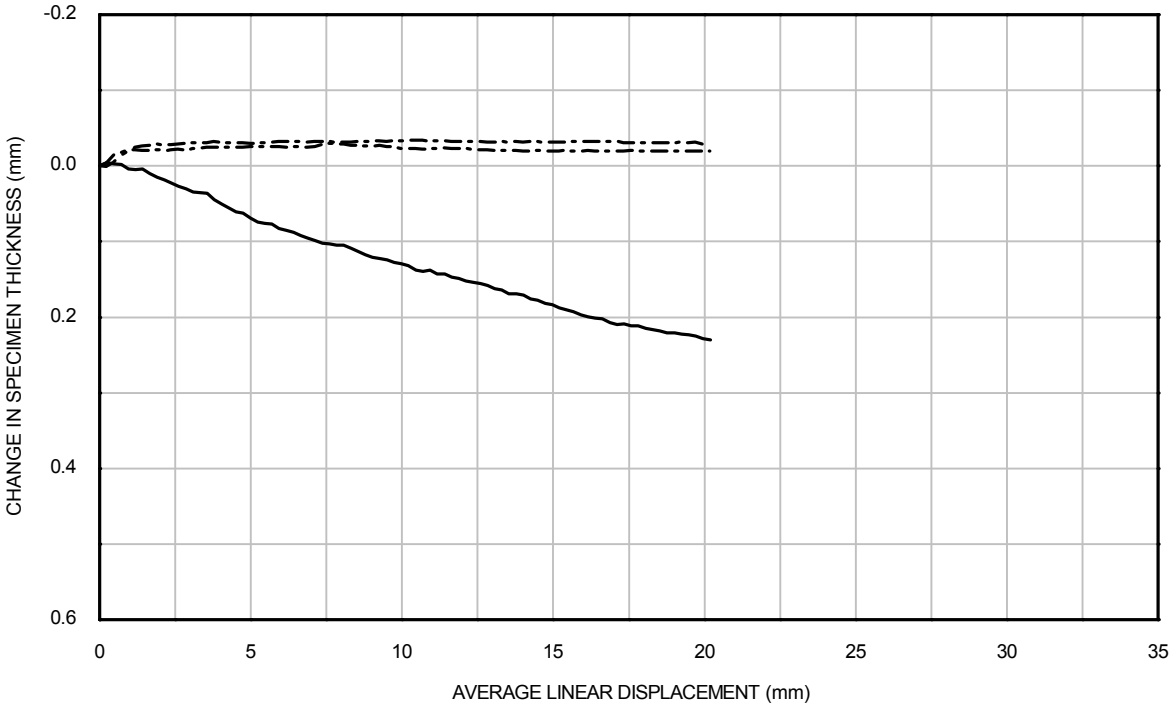
DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

FAST SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-6_3BagA_R3.OPJ
Date:28/10/2015
Checked By : PH
Date:03/11/2015
Checked By : PH





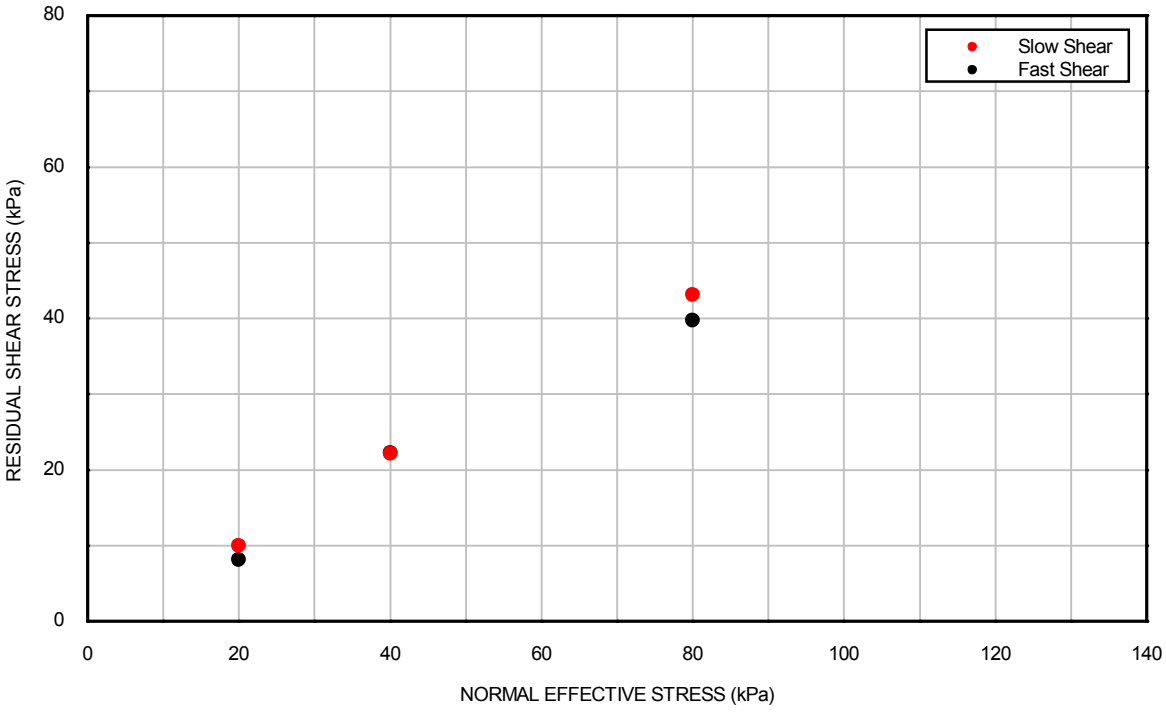
BOREHOLE	: BH-WFS4-6
SAMPLE	: 3BagA
DEPTH (m)	: 2.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SLOW SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-6_3BagA_R3.OPJ
Date:28/10/2015
Checked By : PH
Date:03/11/2015
Checked By : PH



SHEARING	Shear Stage 1		Shear Stage 2		Shear Stage 3	
Rate of angular displacement (° / min)	0.16	674	0.16	674	0.16	674
Normal effective stress σ'_n (kPa)	20	20	40	40	80	80
Residual shear stress τ_n (kPa)	10.0	8.1	22.2	22.2	43.1	39.7
Mean linear displacement at end of shearing stage (mm)	237.2	164.5	20.2	197.7	20.0	201.9
Angle of residual shear resistance °	27.3	22.8	28.8	28.9	28.5	26.6

BOREHOLE : BH-WFS4-6

SAMPLE : 3BagA

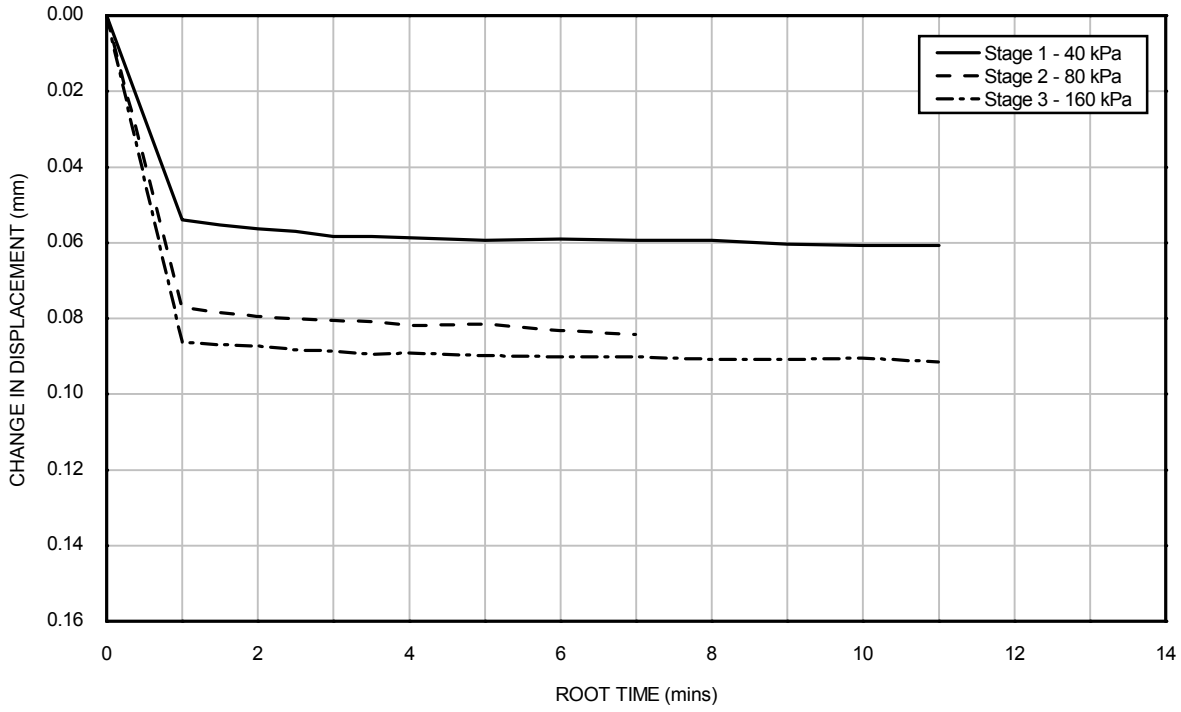
DEPTH (m) : 2.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Filename: J11302 \ SHEAR \ BH-WFS4-7_5BagA_R3.OPJ
Drawn By : ER
Date: 04/11/2015
Checked By : PH
Date:05/11/2015
Checked By : PH
Date:05/11/2015



INITIAL CONDITIONS

Sample Height	5 mm	Outer Radius	50 mm
Inner Radius	35 mm	Water Content	10.1 %

BOREHOLE	: BH-WFS4-7
SAMPLE	: 5BagA
DEPTH (m)	: 4.00

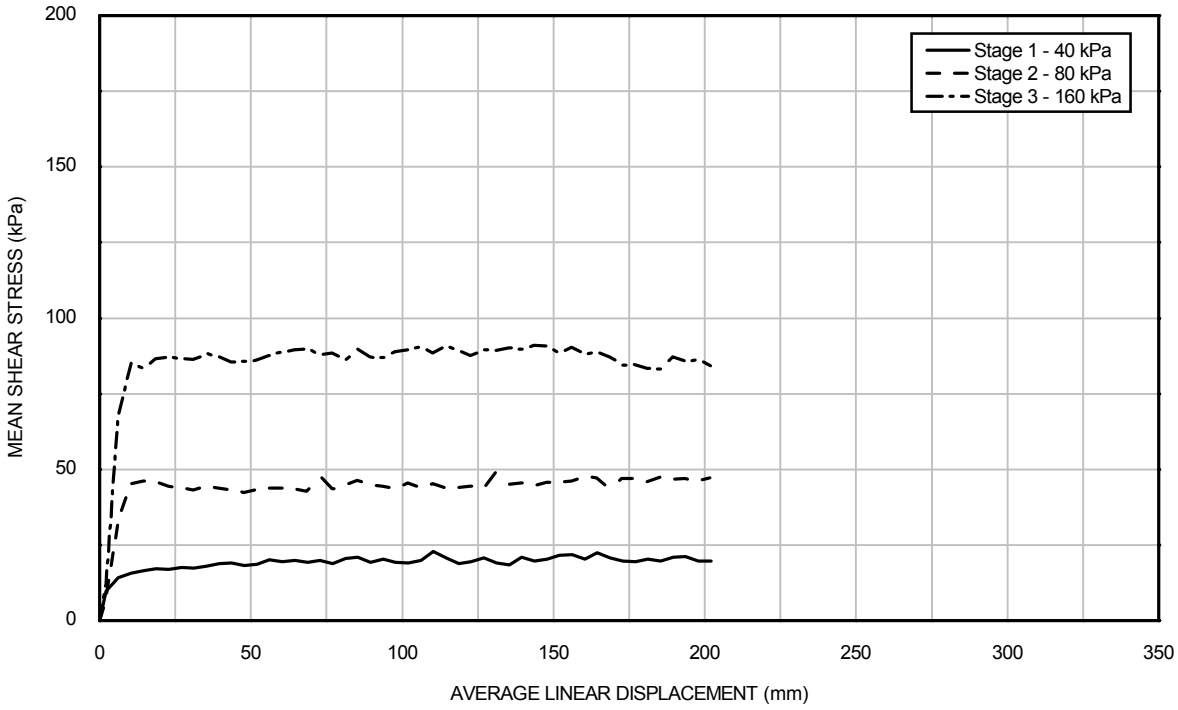
Tested in accordance with BS1377 : Part 7 : 1990 : Clause 6

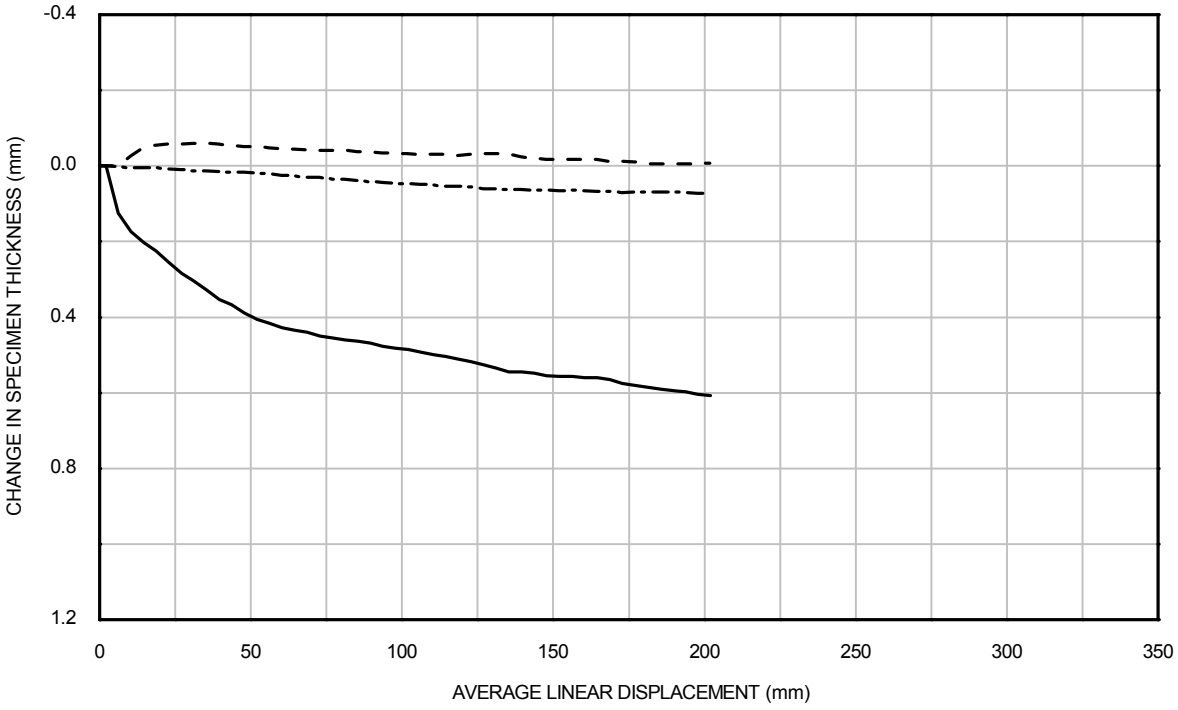
DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 04/11/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-7_5BagA_R3.OPJ
Date:05/11/2015
Checked By : PH
Date:05/11/2015
Checked By : PH





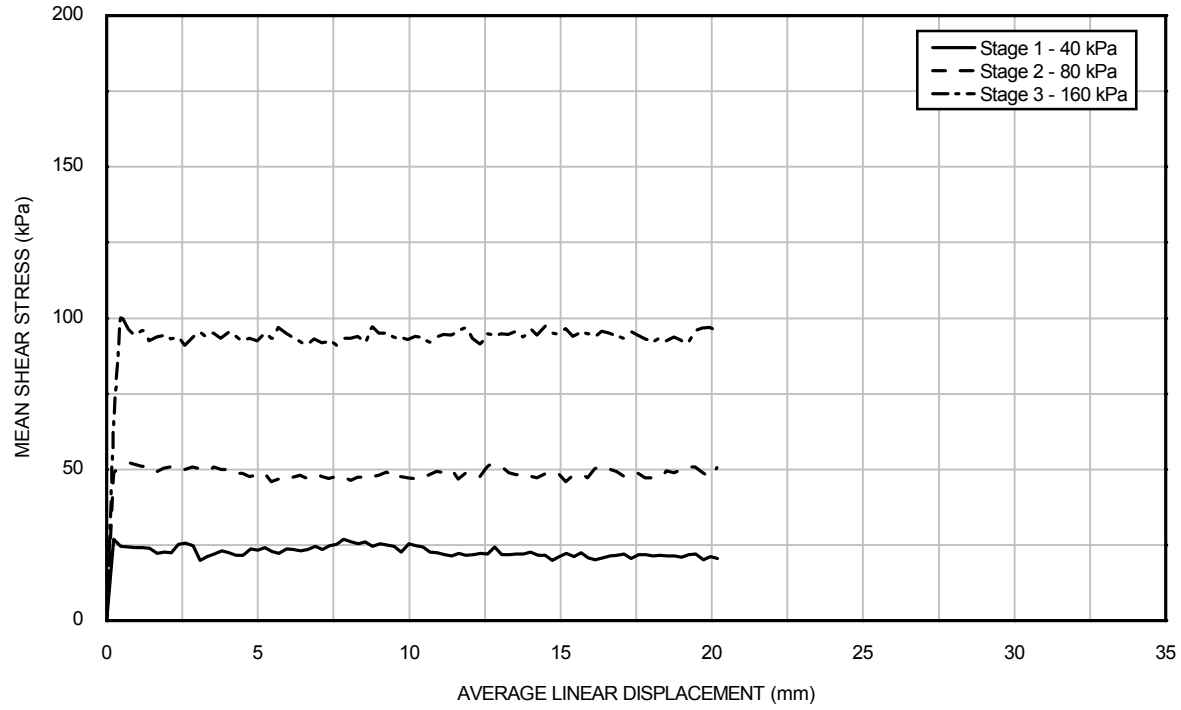
BOREHOLE	: BH-WFS4-7
SAMPLE	: 5BagA
DEPTH (m)	: 4.00

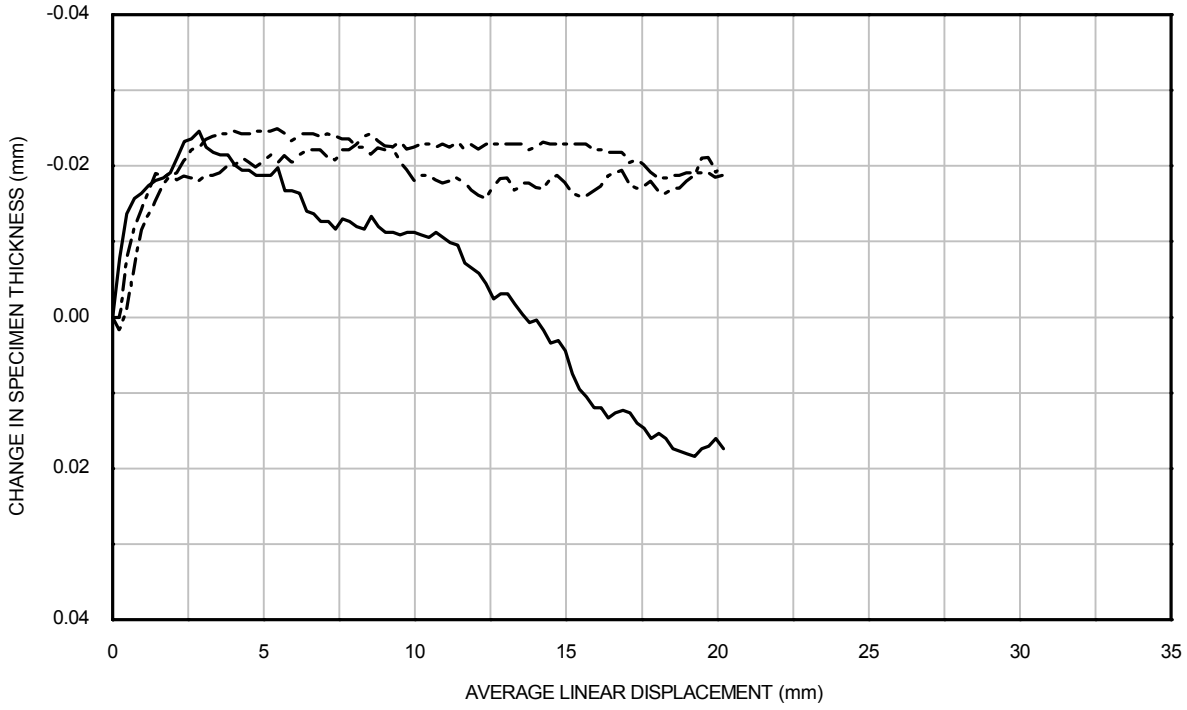
DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

FAST SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 04/11/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-7_5BagA_R3.OPJ
Date:05/11/2015
Checked By : PH
Date:05/11/2015
Checked By : PH



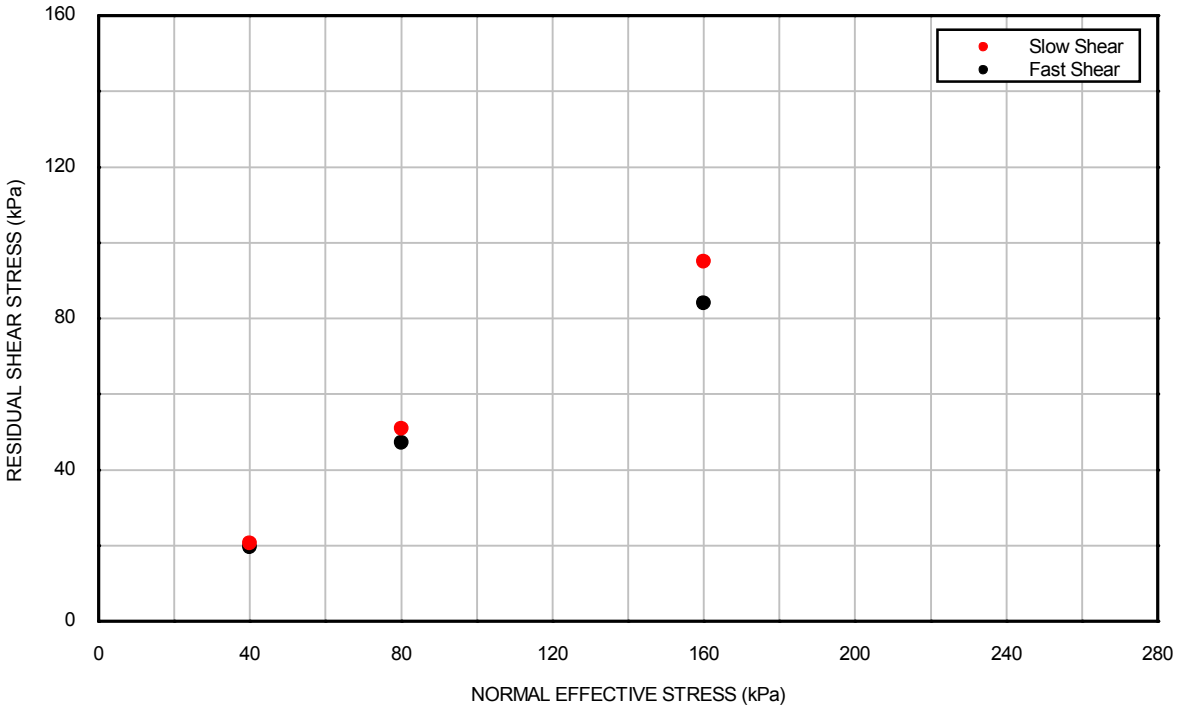


BOREHOLE	: BH-WFS4-7
SAMPLE	: 5BagA
DEPTH (m)	: 4.00

DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SLOW SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



SHEARING	Shear Stage 1		Shear Stage 2		Shear Stage 3	
Rate of angular displacement (° / min)	0.16	674	0.16	674	0.16	674
Normal effective stress σ'_n (kPa)	40	40	80	80	160	160
Residual shear stress τ_n (kPa)	20.6	19.6	50.9	47.1	95.1	84.0
Mean linear displacement at end of shearing stage (mm)	20.2	202.0	20.2	201.9	20.2	202.0
Angle of residual shear resistance °	27.1	26.0	32.6	30.7	30.7	27.7

BOREHOLE : BH-WFS4-7

SAMPLE : 5BagA

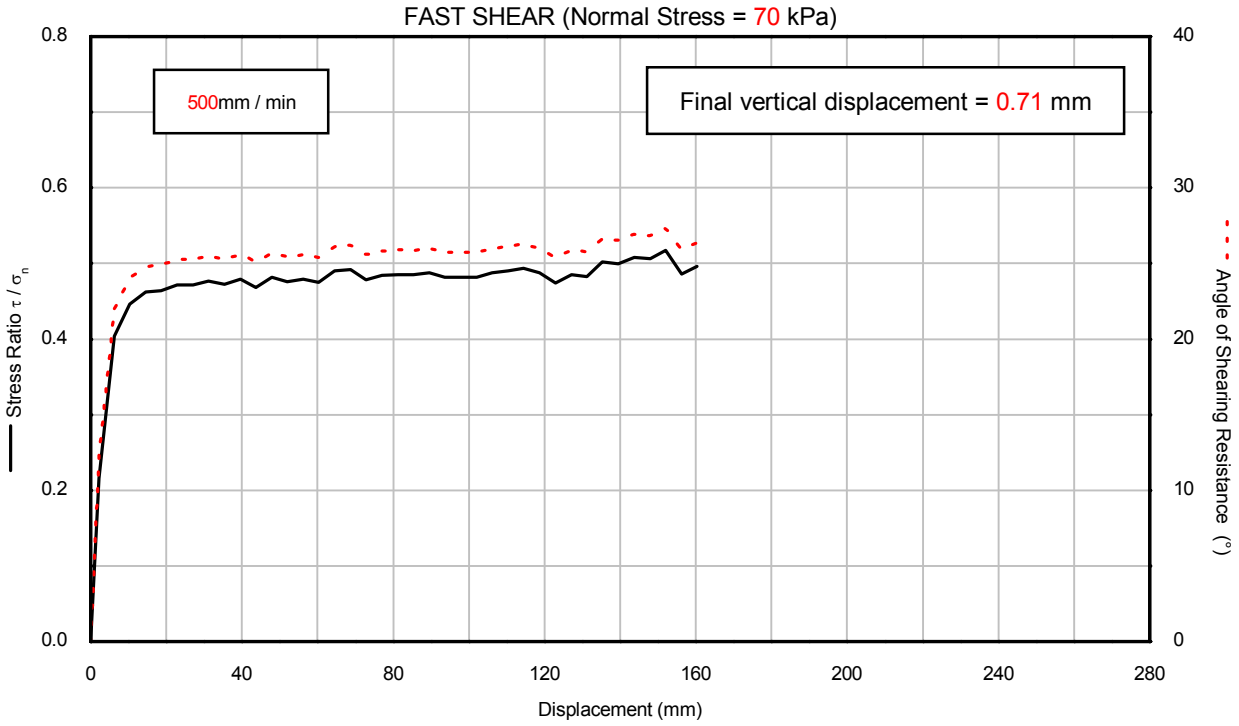
DEPTH (m) : 4.00

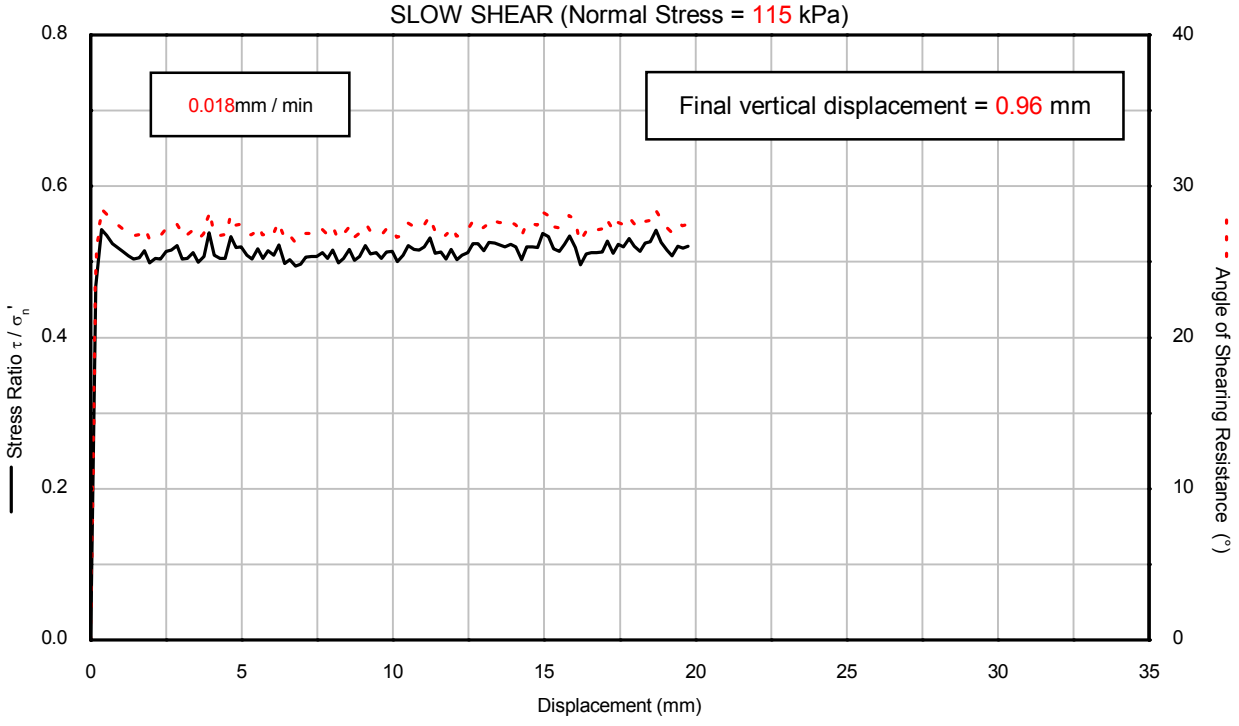
DETERMINATION OF RESIDUAL STRENGTH USING THE SMALL RING SHEAR TEST - SOIL - SOIL

SHEARING STAGES

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ALB
Template Issue: 2
Date: 30/10/2015
Filename: J11302 \ SHEAR \ BH-WFS4-1A_3BagB_RS.OPJ
Date: 30/10/2015
Checked By : PH
Approved By : PH



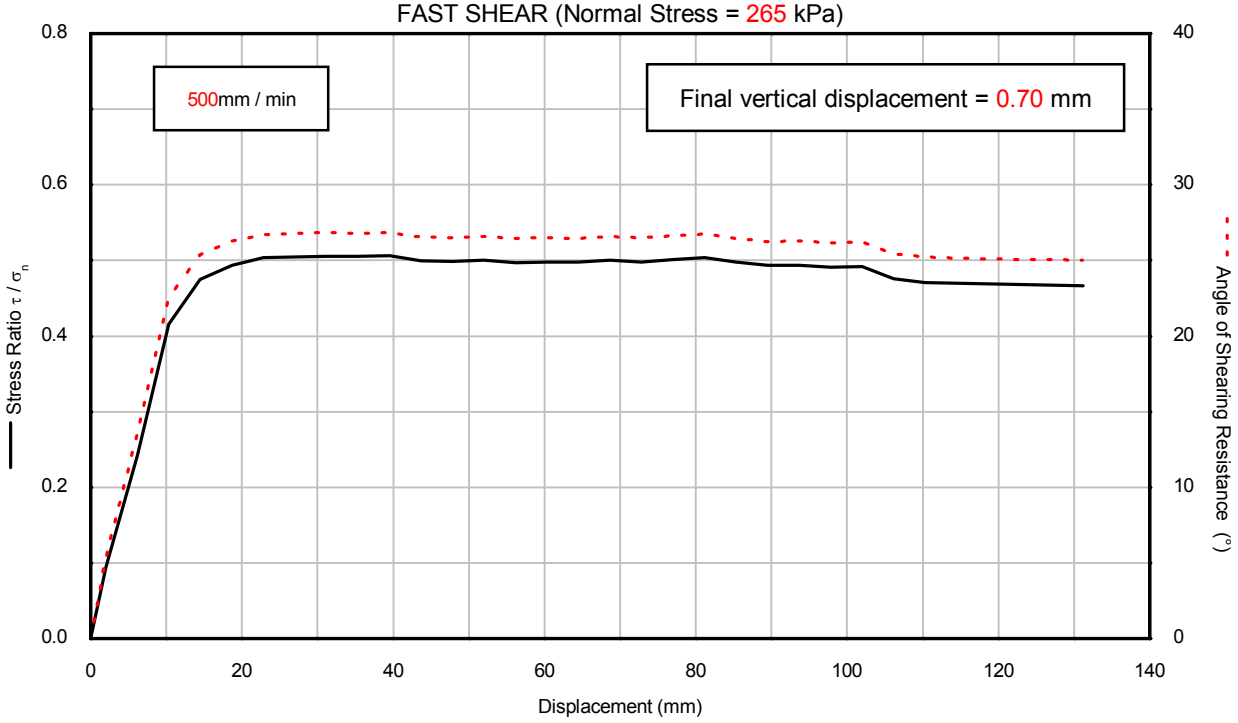


Interface Roughness (μm) : 8.06	Borehole	: BH-WFS4-1A
	Sample	: 3BagB
	Depth (m)	: 6.55

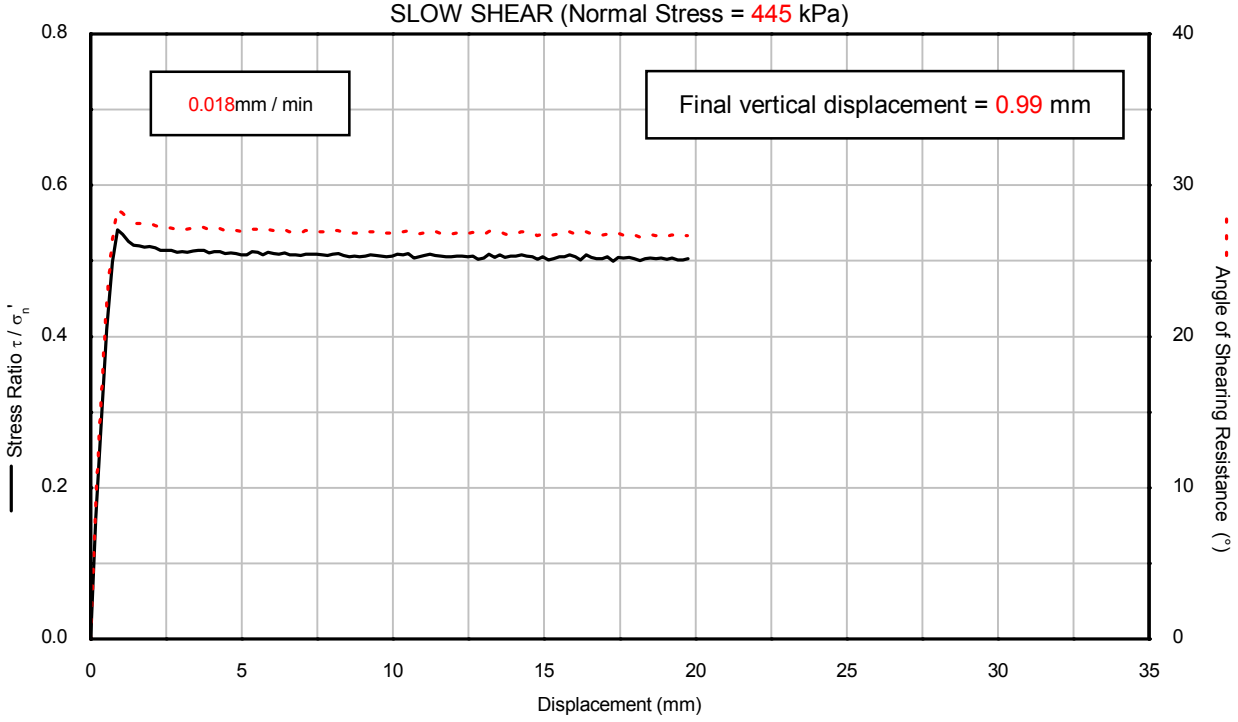
RING SHEAR TEST
SOIL / STEEL INTERFACE
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ALB
Template Issue: 2
Filename: J11302 \ SHEAR \ BH-WFS4-1A_18BagA_RS.OPJ
Date: 03/11/2015
Date: 03/11/2015
Checked By : PH
Approved By : PH

FAST SHEAR (Normal Stress = 265 kPa)



SLOW SHEAR (Normal Stress = 445 kPa)

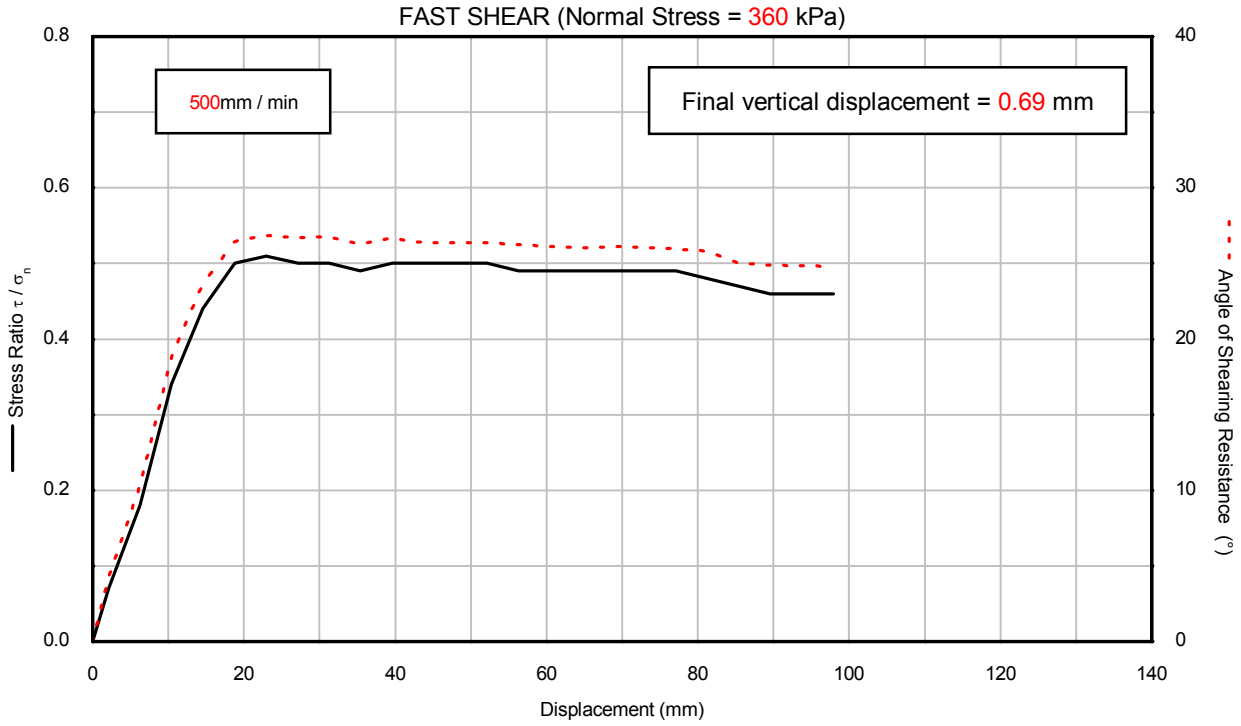


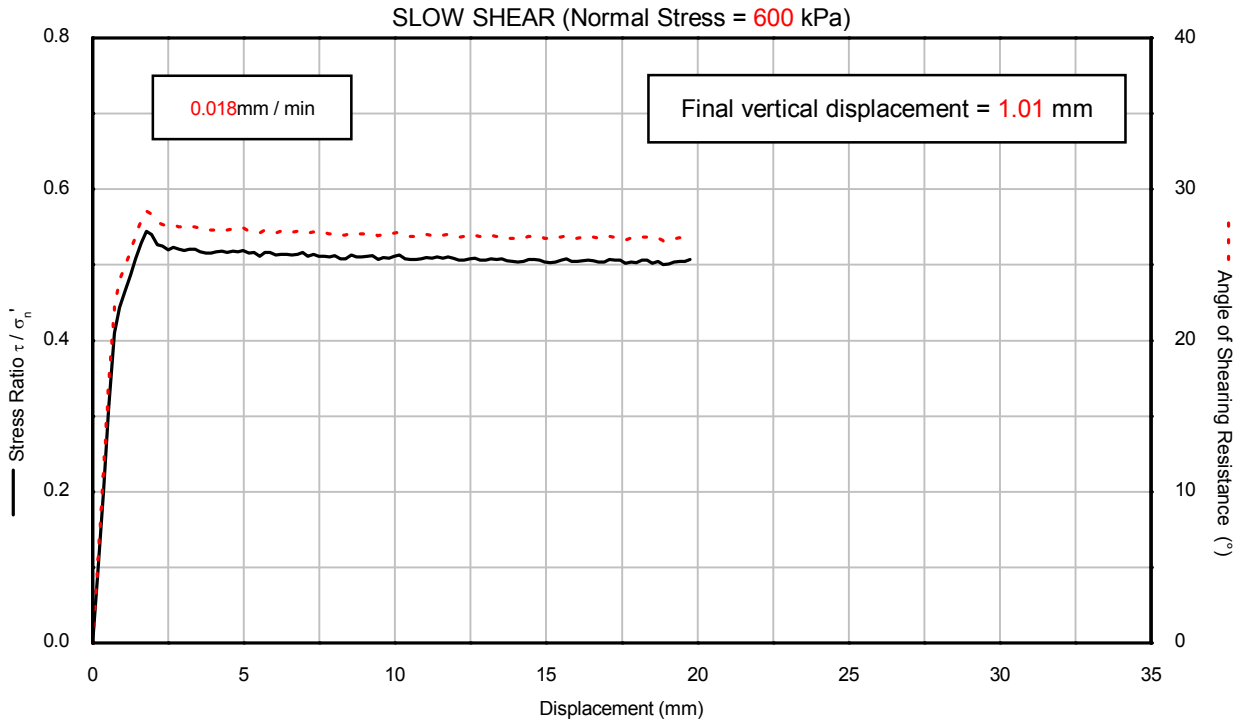
Interface Roughness (μm) : 8.81	Borehole	: BH-WFS4-1A
	Sample	: 18BagA
	Depth (m)	: 27.00

RING SHEAR TEST
SOIL / STEEL INTERFACE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

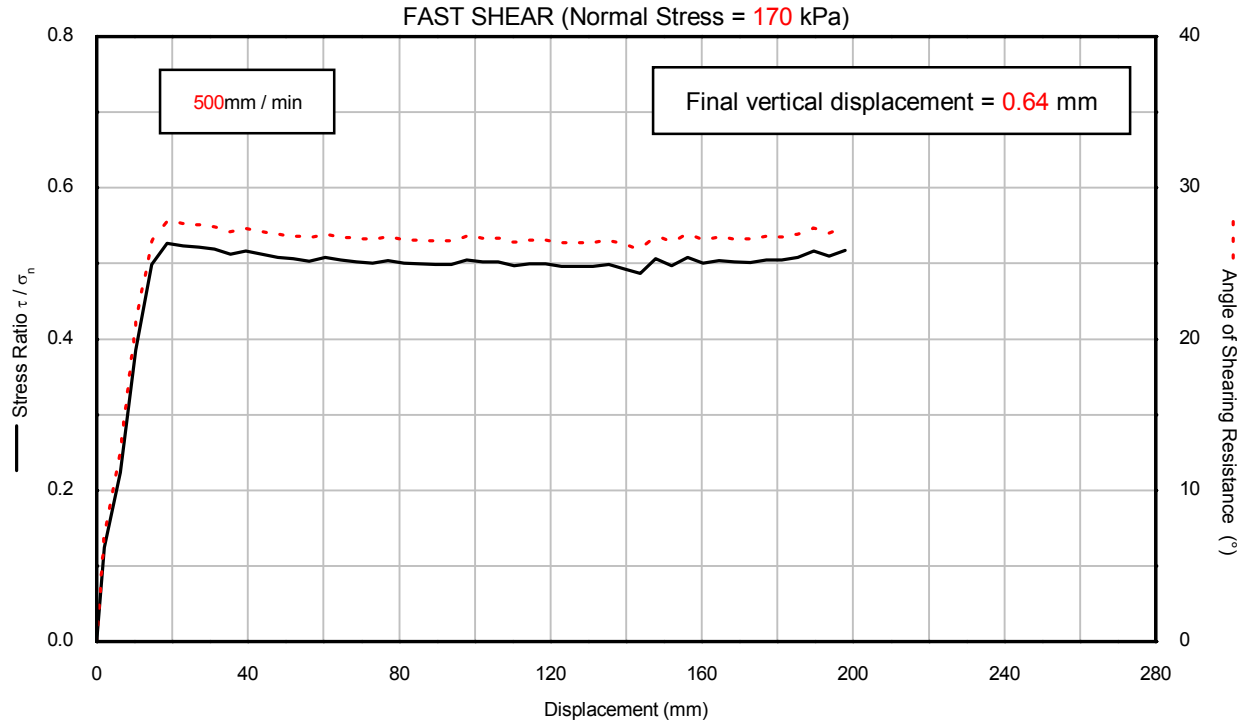
Date: 27/10/2015
Drawn By : ALB
Template Issue: 2
Filename: J11302 \ SHEAR \ BH-WFS4-3_25BagA_RS.OPJ
Date: 03/11/2015
Date: 03/11/2015
Checked By : PH
Approved By : PH

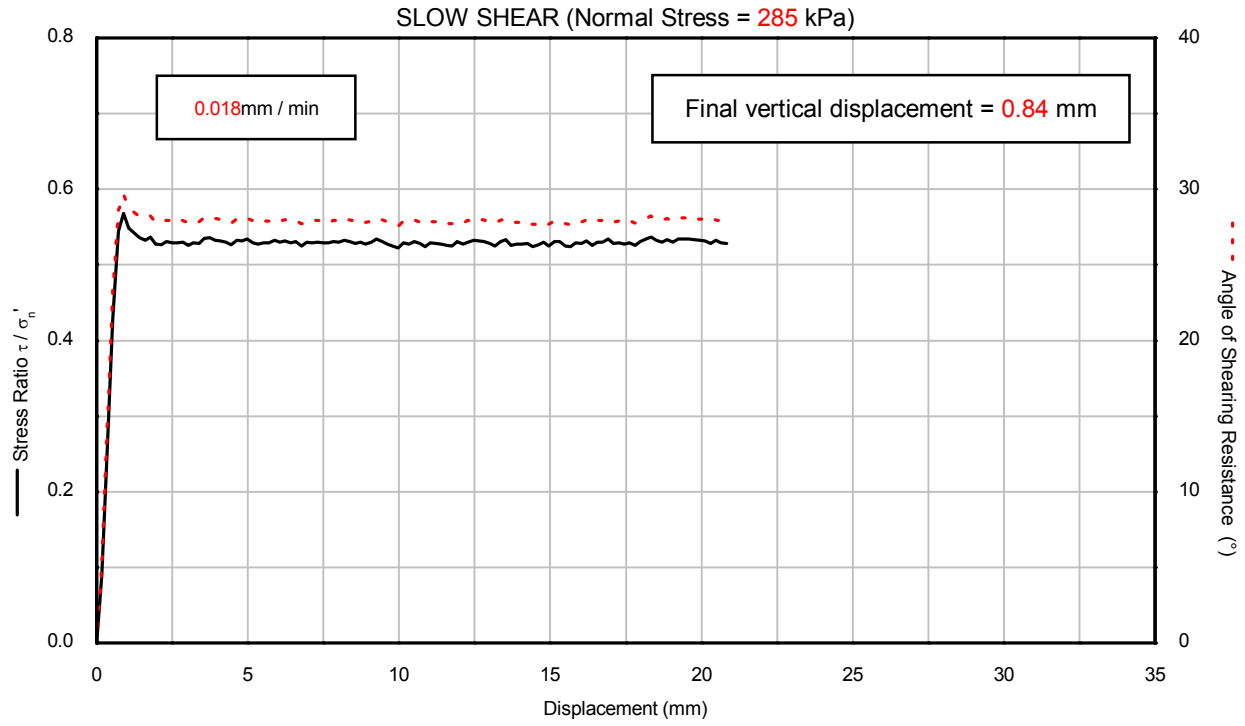




Interface Roughness (μm) : 10.40	Borehole	: BH-WFS4-3
	Sample	: 25BagA
	Depth (m)	: 36.00

RING SHEAR TEST
SOIL / STEEL INTERFACE
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Interface Roughness (μm) : 9.46

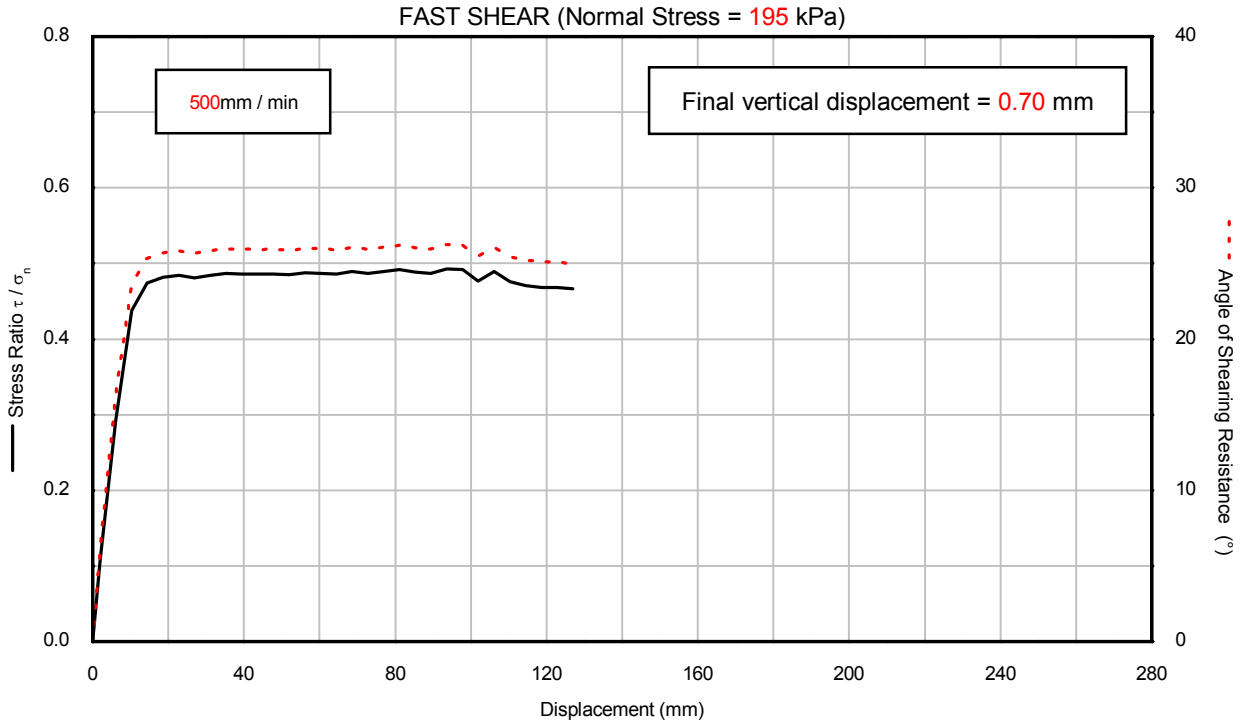
Borehole	:	BH-WFS4-4
Sample	:	24BagA
Depth (m)	:	13.50

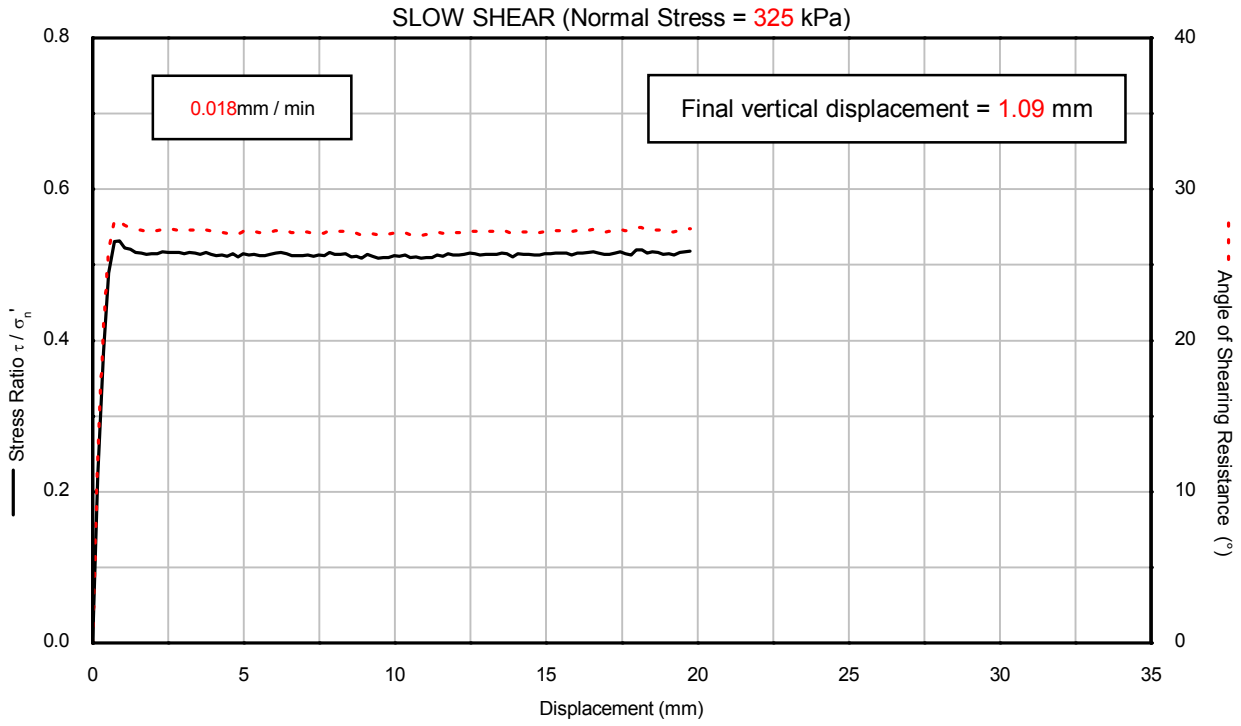
RING SHEAR TEST
SOIL / STEEL INTERFACE

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ER
Filename: J11302 \ SHEAR \ BH-WFS4-4_24BagA_RS.OPJ
Template Issue: 2
Date: 28/10/2015
Date: 29/10/2015
Checked By : ALB
Approved By : PH

Date: 27/10/2015
Drawn By : ER
Template Issue: 2
Date: 25/10/2015
Checked By : ALB
Filename: J11302 \ SHEAR \ BH-WFS4-6_25BagA_RS.OPJ
Date: 29/10/2015
Approved By : PH

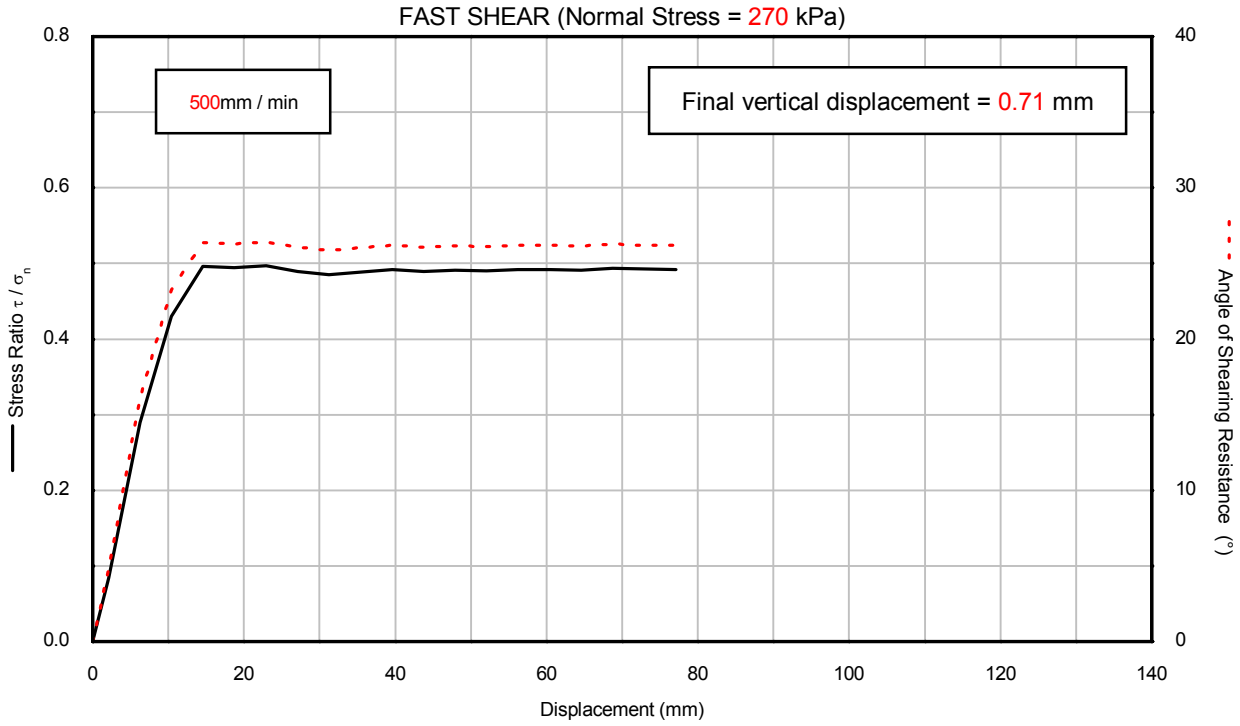


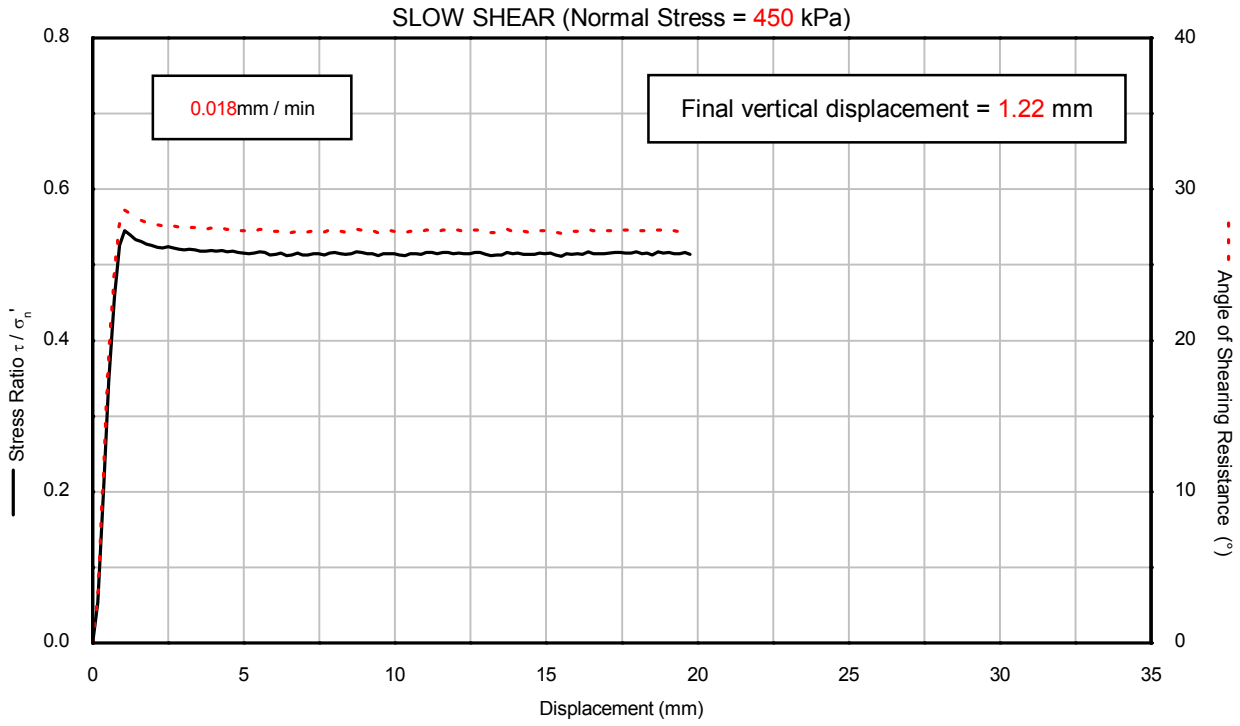


Interface Roughness (μm) : 9.26	Borehole	: BH-WFS4-6
	Sample	: 25BagA
	Depth (m)	: 17.50

RING SHEAR TEST
SOIL / STEEL INTERFACE
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ALB
Template Issue: 2
Date: 30/10/2015
Filename: J11302 \ SHEAR \ BH-WFS4-6_28BagA_RS.OPJ
Date: 30/10/2015
Checked By : PH
Approved By : PH

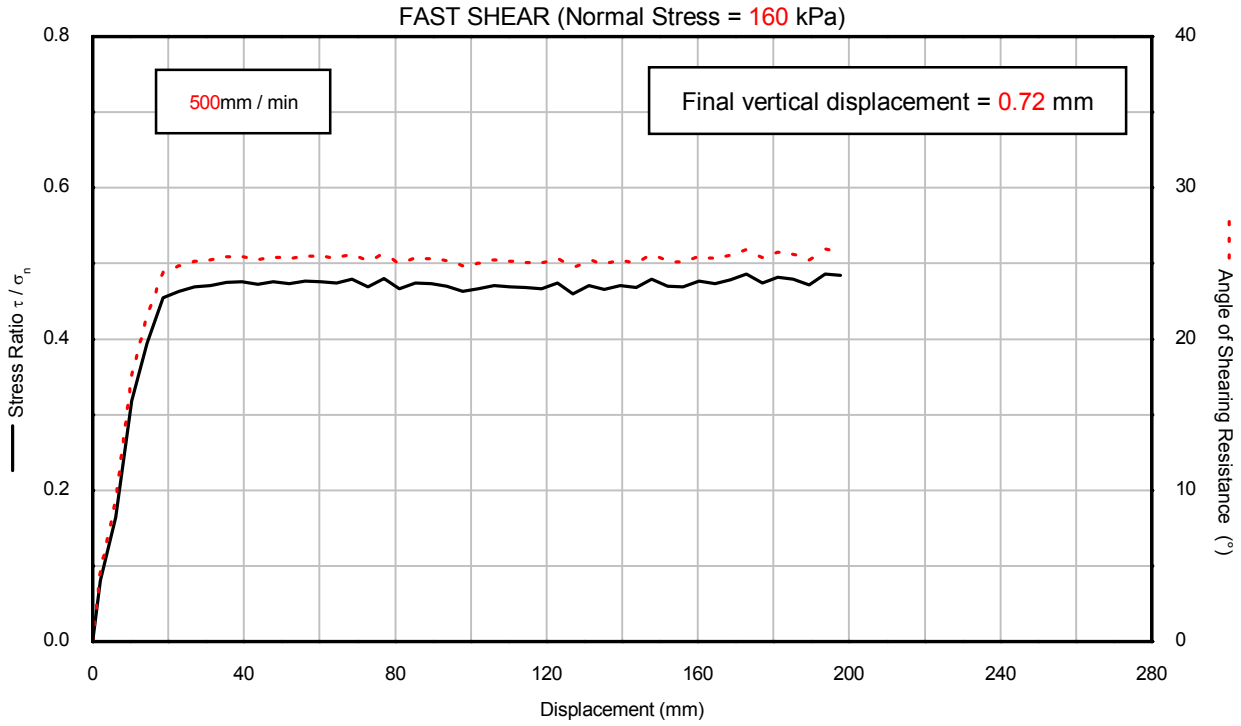


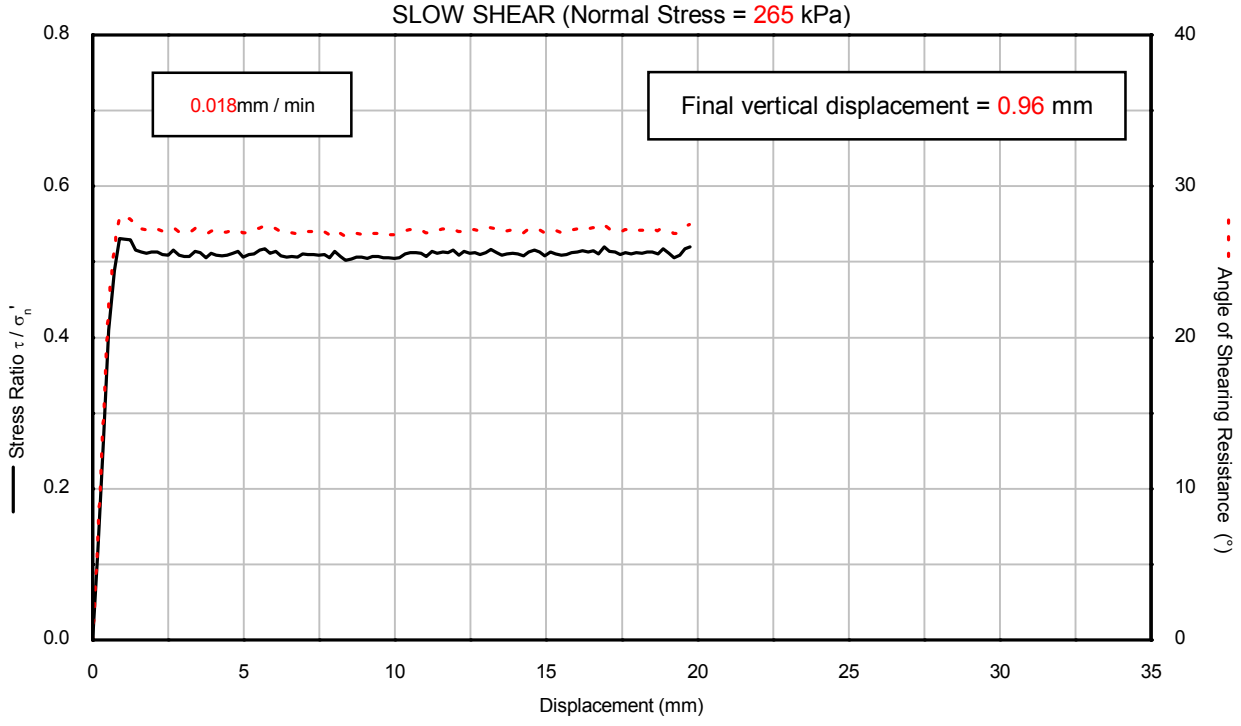


Interface Roughness (μm) : 9.22	Borehole	: BH-WFS4-6
	Sample	: 28BagA
	Depth (m)	: 28.00

RING SHEAR TEST
SOIL / STEEL INTERFACE
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Date: 27/10/2015
Drawn By : ALB
Template Issue: 2
Date: 30/10/2015
Filename: J11302 \ SHEAR \ BH-WFS4-7_16BagB_RS.OPJ
Date: 30/10/2015
Checked By : PH
Approved By : PH





Interface Roughness (μm) : 8.04	Borehole	: BH-WFS4-7
	Sample	: 16BagB
	Depth (m)	: 12.80

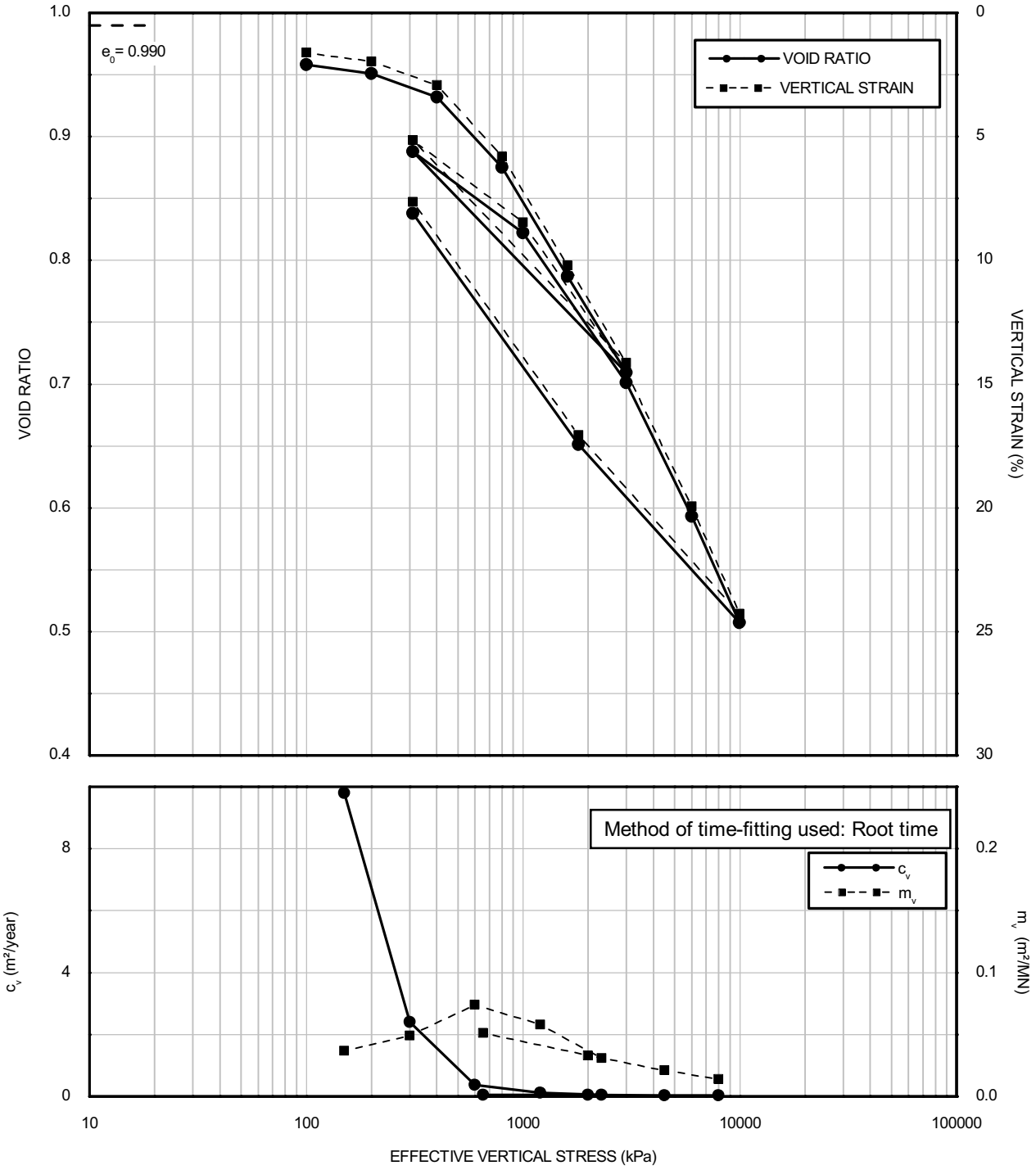
RING SHEAR TEST
SOIL / STEEL INTERFACE
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SECTION C6: OEDOMETER TESTS

LIST OF PLATES IN SECTION C6: Plate

Incremental Loading (IL) Oedometer Test	C6.1-1 to C6.1-4
Constant Rate of Strain (CRS) Oedometer Test	C6.2-1 to C6.2-45

Drawn by: ER Date: 09/11/2015
Filename: J11302 \ Labdata \ Compress \ BH-WFS4-1A_20WaxB_od.OPJ
Template Issue: 3
Date : 10/11/2015
Date : 11/11/2015
Checked by: ALB
Approved by: PH



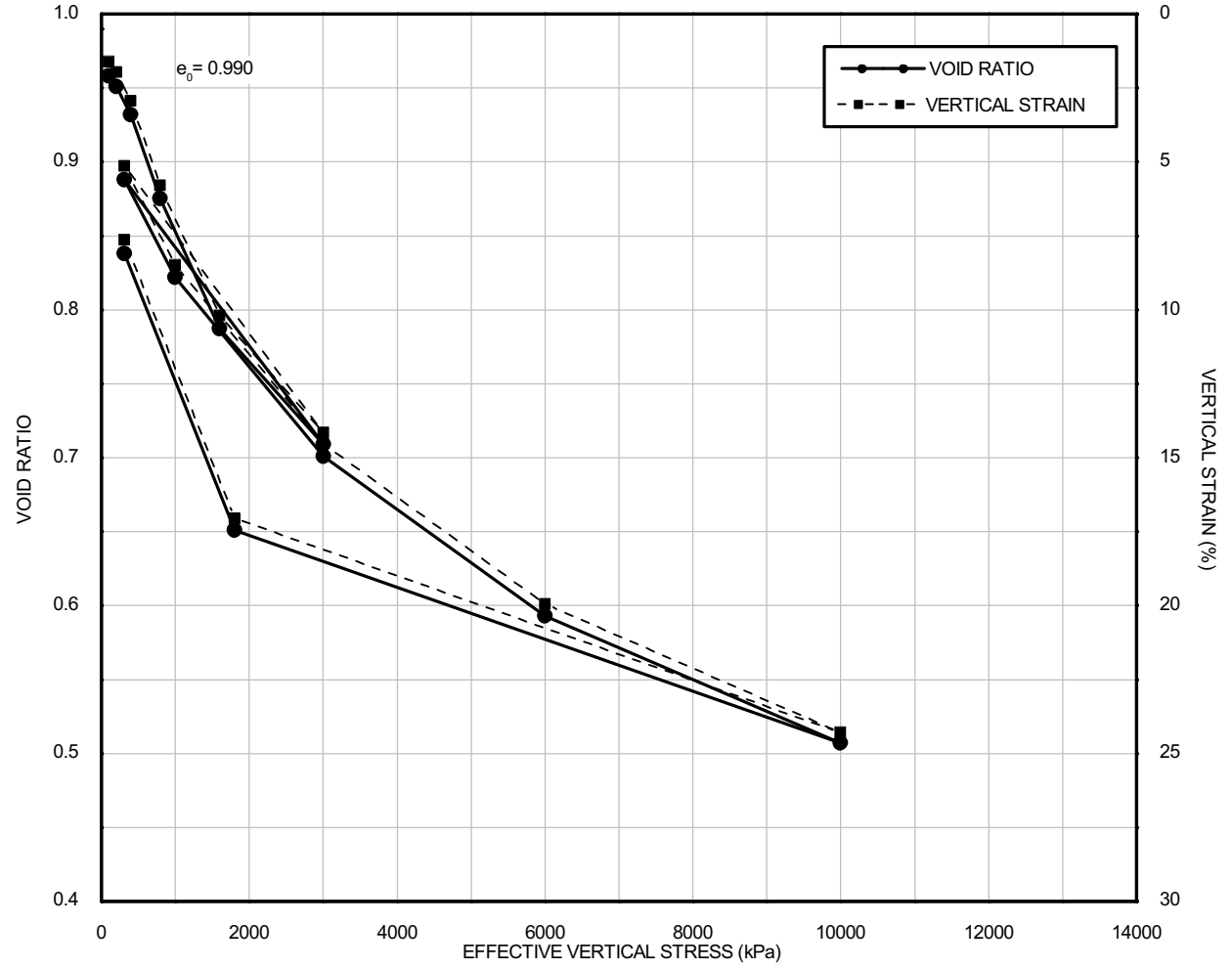
Initial Conditions					
Specimen height	: 19.3 mm	Bulk density	: 1.86 Mg/m^3	Borehole	:BH-WFS4 -1A
Specimen diameter	: 50.1 mm	Dry density	: 1.37 Mg/m^3	Sample	:20WaxB
Degree of saturation	: 100 %	Moisture content	: 36.3 %		
Particle density	: 2.72 Mg/m^3 (Measured)	Lab. temperature	: 20 °C	Depth (m)	:32.15
Specimen condition	: Undisturbed	Swelling pressure	: NA kPa		
Method of time fitting	: Root Time Method				

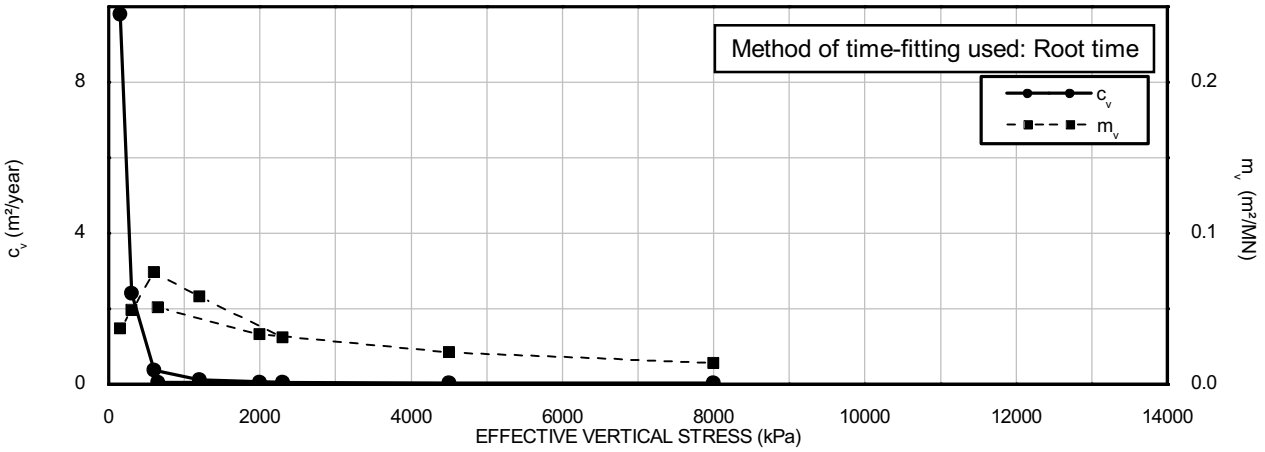
Tested in accordance with BS1377: Part 5: 1990: Clause 3

ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ER Date: 09/11/2015
Filename: J11302 \ Labdata \ Compress \ BH-WFS4-1A_20WaxB_od.OPJ
Template Issue: 3
Date : 10/11/2015
Date : 11/11/2015
Checked by: ALB
Approved by: PH



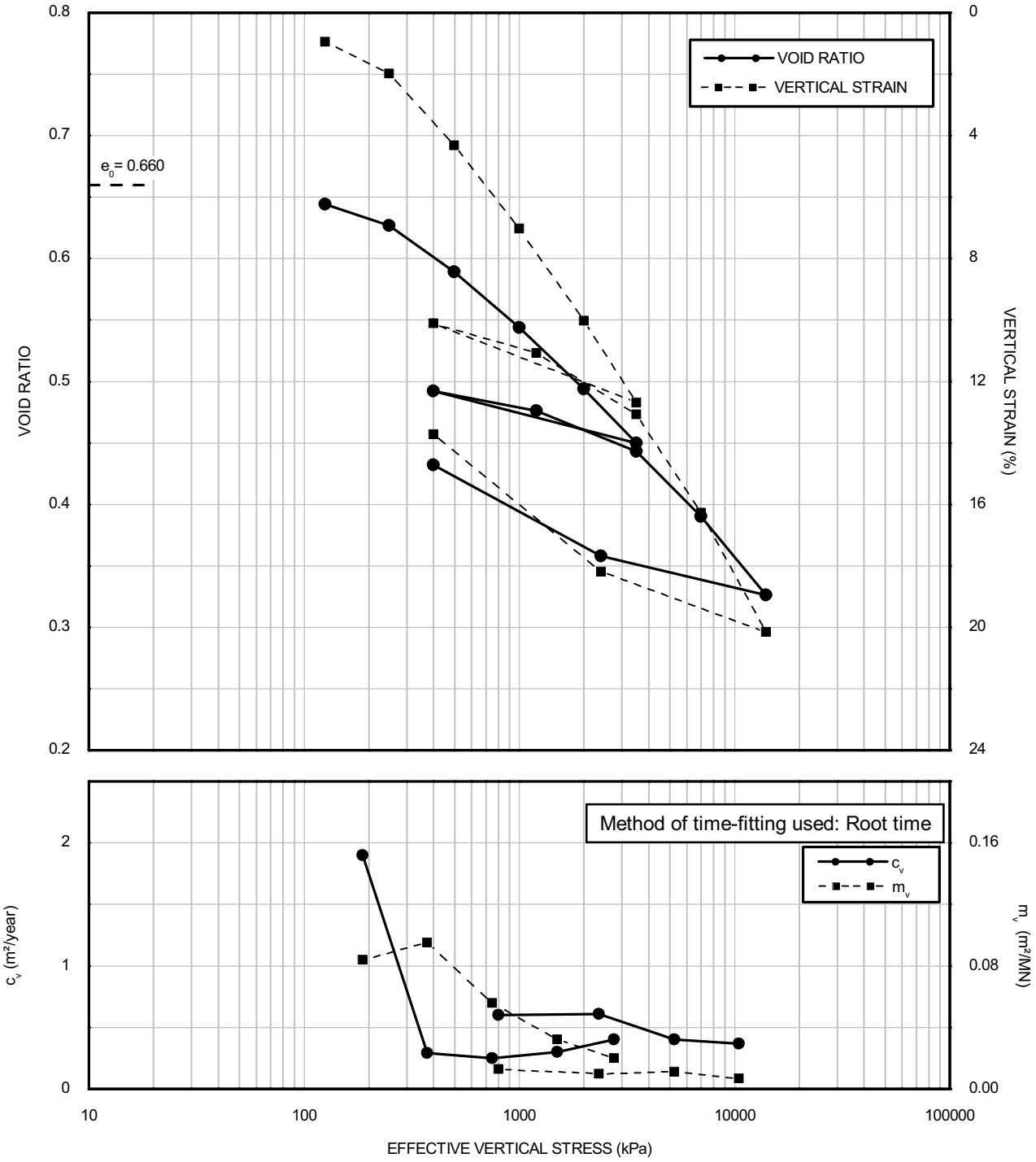


Initial Conditions					
Specimen height	: 19.3 mm	Bulk density	: 1.86 Mg/m^3	Borehole	:BH-WFS4 -1A
Specimen diameter	: 50.1 mm	Dry density	: 1.37 Mg/m^3	Sample	:20WaxB
Degree of saturation	: 100 %	Moisture content	: 36.3 %		
Particle density	: 2.72 Mg/m^3 (Measured)	Lab. temperature	: 20 °C	Depth (m)	:32.15
Specimen condition	: Undisturbed	Swelling pressure	: NA kPa		
Method of time fitting	: Root Time Method				

Tested in accordance with BS1377: Part 5: 1990: Clause 3

ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



Initial Conditions					
Specimen height	: 18.5 mm	Bulk density	: 2.00 Mg/m^3	Borehole	:BH-WFS4-4
Specimen diameter	: 50.0 mm	Dry density	: 1.63 Mg/m^3		
Degree of saturation	: 95 %	Moisture content	: 23.2 %	Sample	:34WaxB
Particle density	: 2.70 Mg/m^3 (Assumed)	Lab. temperature	: 20 °C	Depth (m)	:38.60
Specimen condition	: Undisturbed	Swelling pressure	: NA kPa		
Method of time fitting	: Root Time Method				

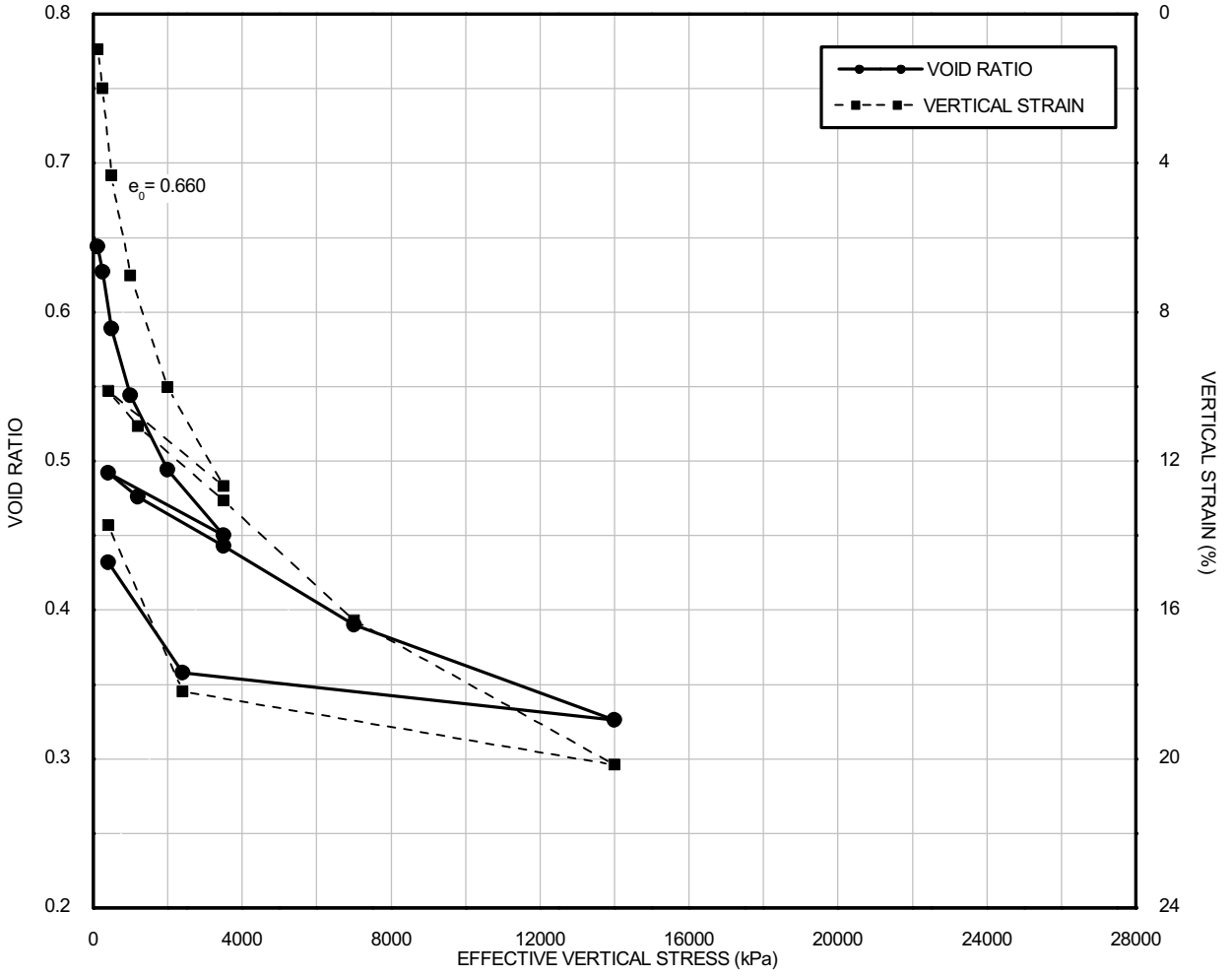
Tested in accordance with BS1377: Part 5: 1990: Clause 3

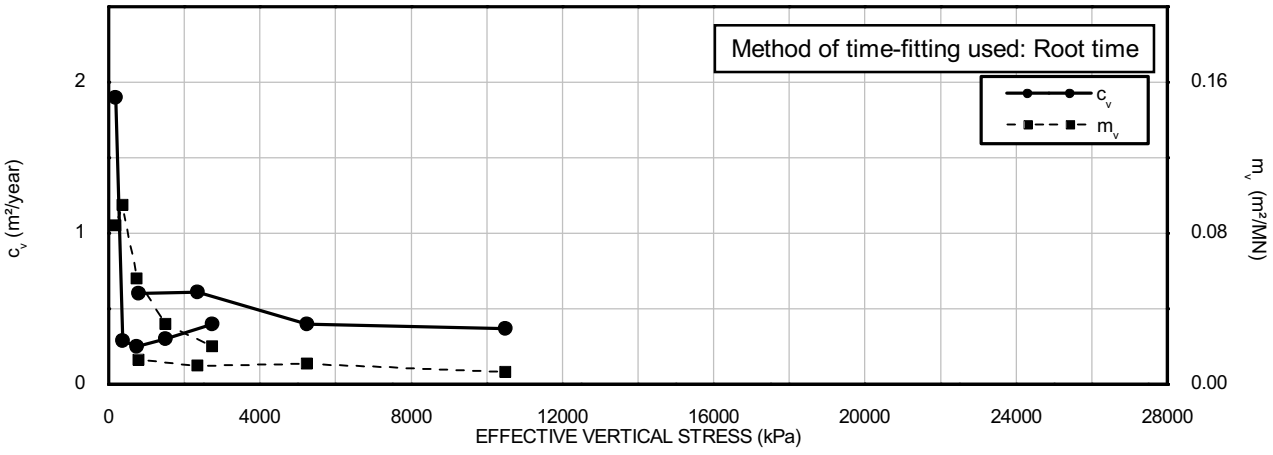
ONE - DIMENSIONAL
CONSOLIDATION TEST (OEDOMETER)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 06/11/2015
Filename: J11302 \ Labdata \ Compress \ BH-WFS4-4_34WaxB_od.OPJ
Template Issue: 3
Date : 11/11/2015
Date : 11/11/2015
Checked by: PH
Approved by: PH

Drawn by: ALB Date: 06/11/2015
Filename: J11302 \ Labdata \ Compress \ BH-WFS4-4_34WaxB_od.OPJ
Template Issue: 3
Date : 11/11/2015
Date : 11/11/2015
Checked by: PH
Approved by: PH





Initial Conditions					
Specimen height	: 18.5 mm	Bulk density	: 2.00 Mg/m^3	Borehole	:BH-WFS4-4
Specimen diameter	: 50.0 mm	Dry density	: 1.63 Mg/m^3		
Degree of saturation	: 95 %	Moisture content	: 23.2 %	Sample	:34WaxB
Particle density	: 2.70 Mg/m^3 (Assumed)	Lab. temperature	: 20 °C	Depth (m)	:38.60
Specimen condition	: Undisturbed	Swelling pressure	: NA kPa		
Method of time fitting	: Root Time Method				

Tested in accordance with BS1377: Part 5: 1990: Clause 3

ONE - DIMENSIONAL
CONSOLIDATION TEST (OEDOMETER)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Hard dark greenish grey CLAY.

GENERAL	
Date test started	02/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.0
Length	[mm]	20.7
Moisture content	[%]	36.5
Bulk density	[Mg/m³]	1.82
Dry density	[Mg/m³]	1.33
Void ratio	[-]	1.045
Degree of saturation	[%]	95
Measured particle density	[Mg/m³]	2.72
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-1A_20WaxB_crs
Template issue	9.0
Processed by	ALB
Date	18/11/2015
Checked by	PH
Date	19/11/2015
Approved by	PH
Date	19/11/2015

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	20WaxB
Depth [m]	32.15
Test Number	314

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

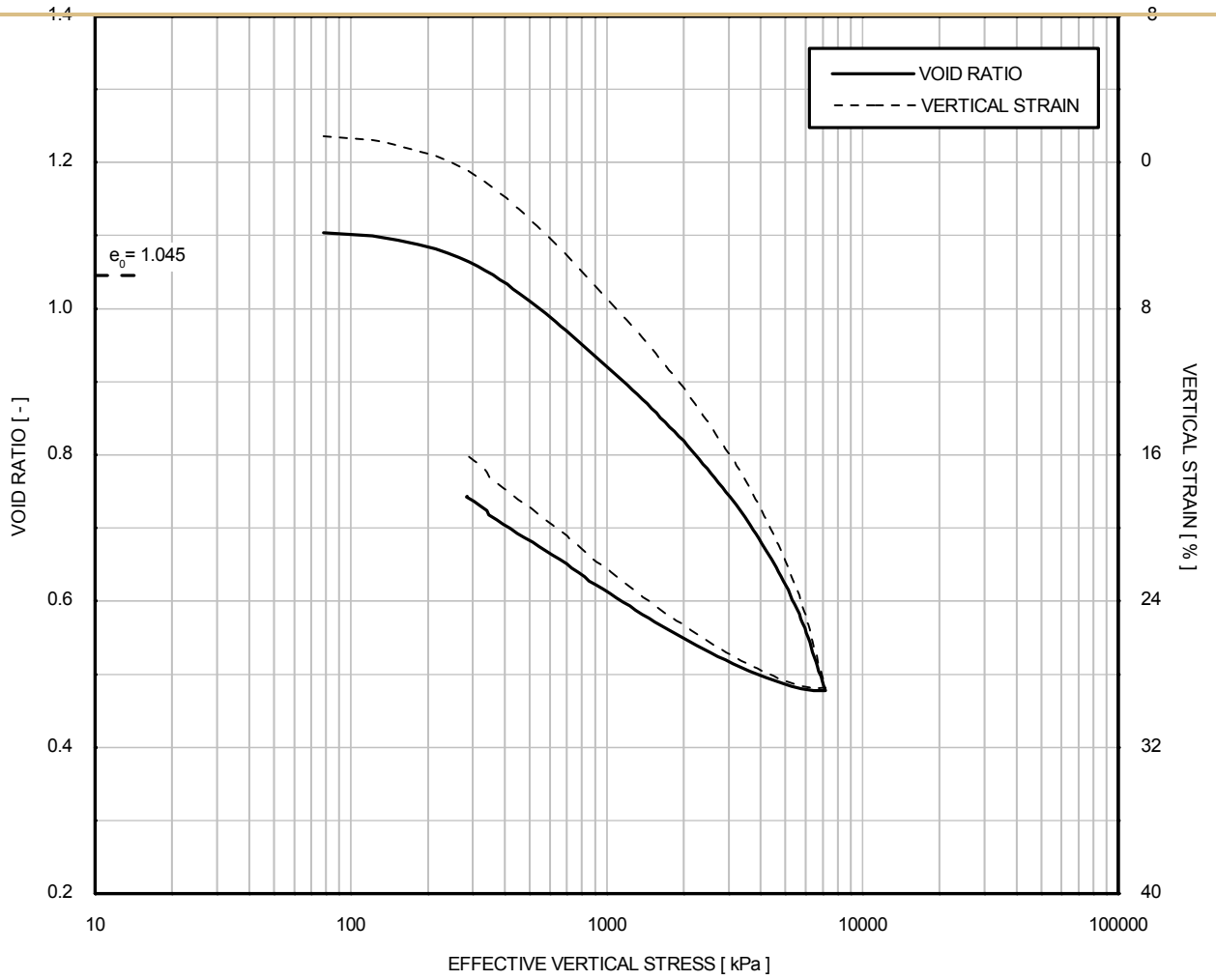
SPECIMEN PHOTOGRAPH

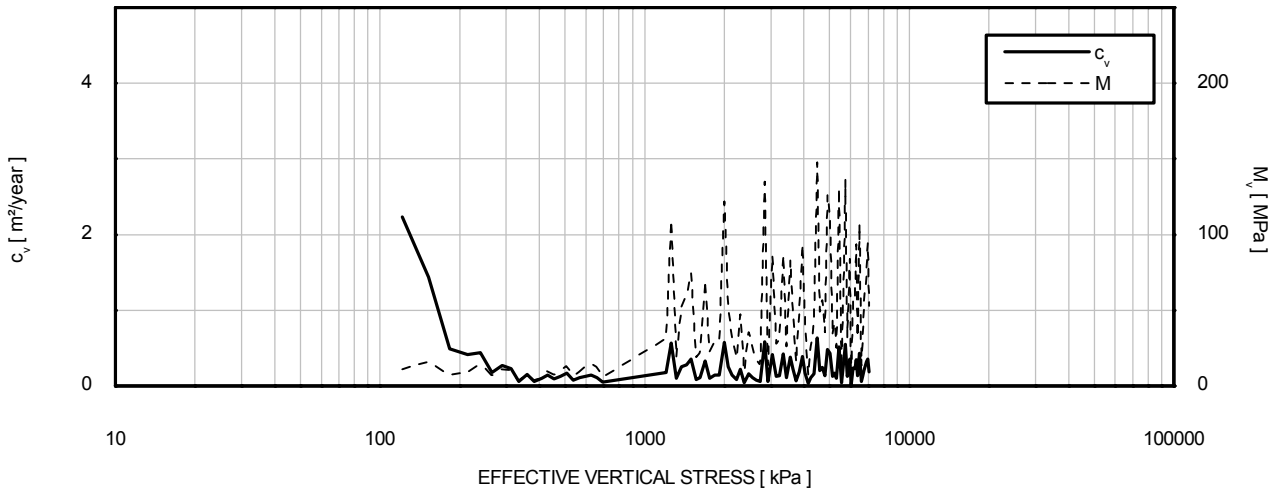


TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	20WaxB
Depth [m]	32.15
Test Number	314

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



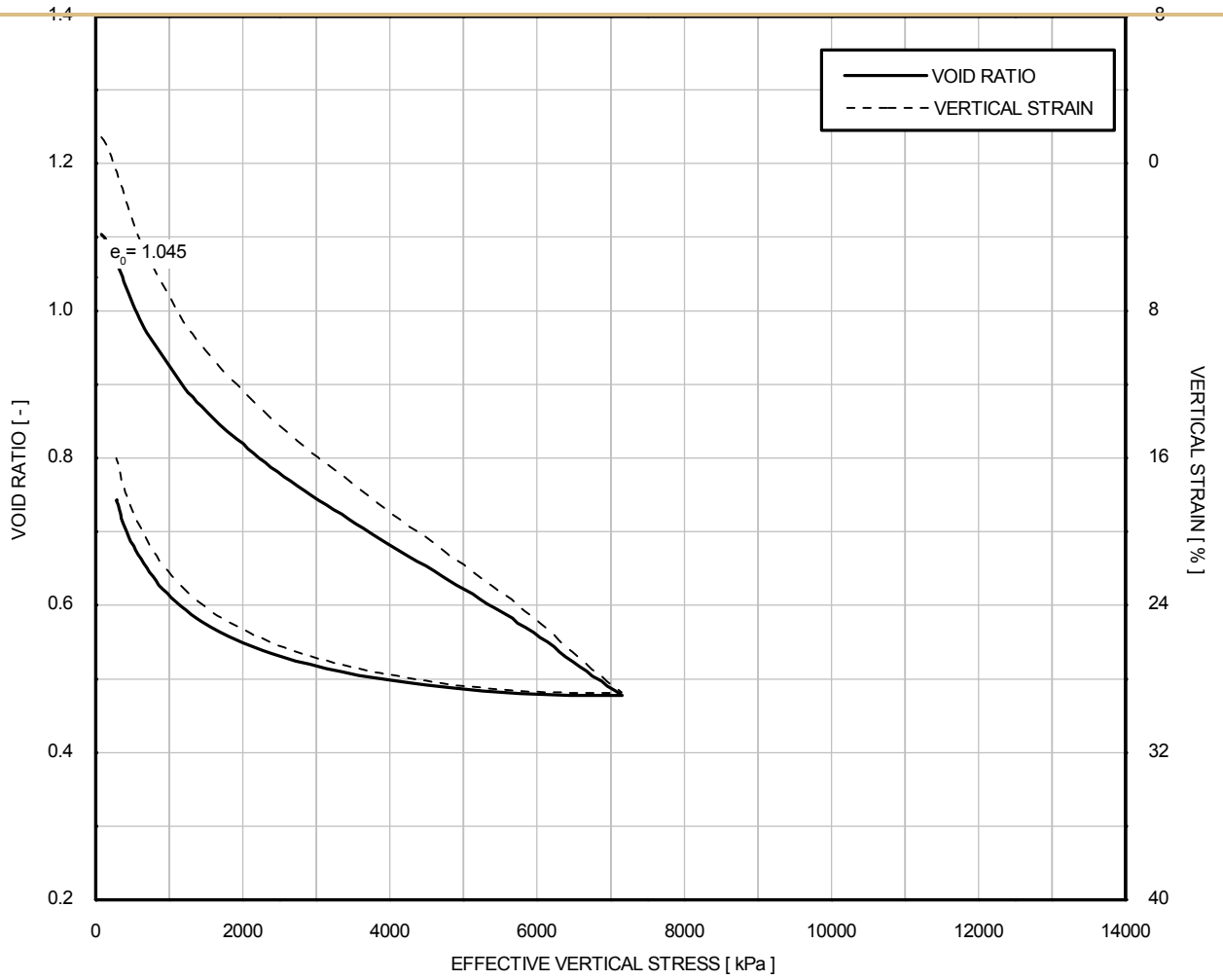


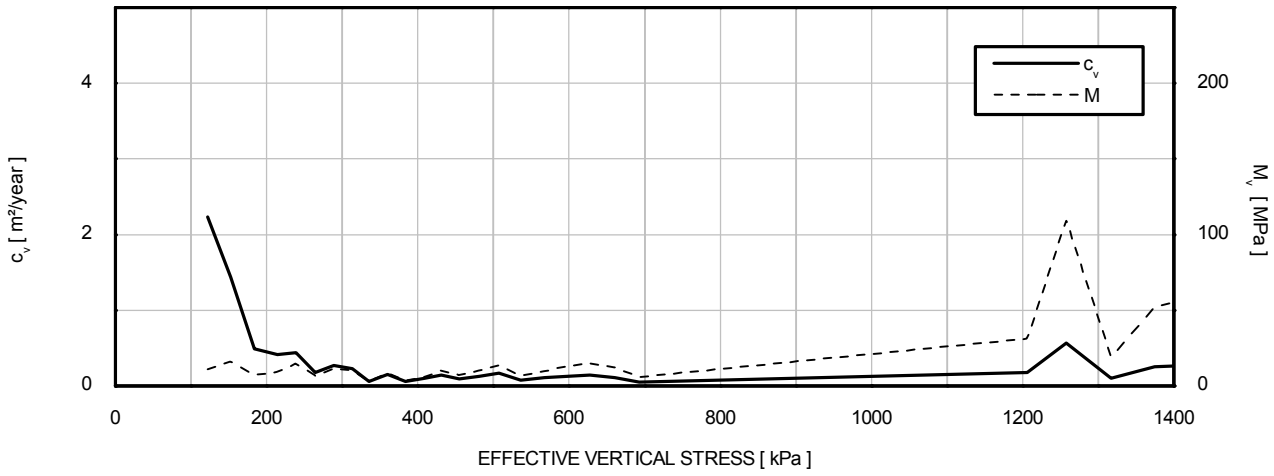
Borehole	Sample	Depth [m]
BH-WFS4-1A	20WaxB	32.15

Initial void ratio	: 1.045
Particle Density	: 2.72 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



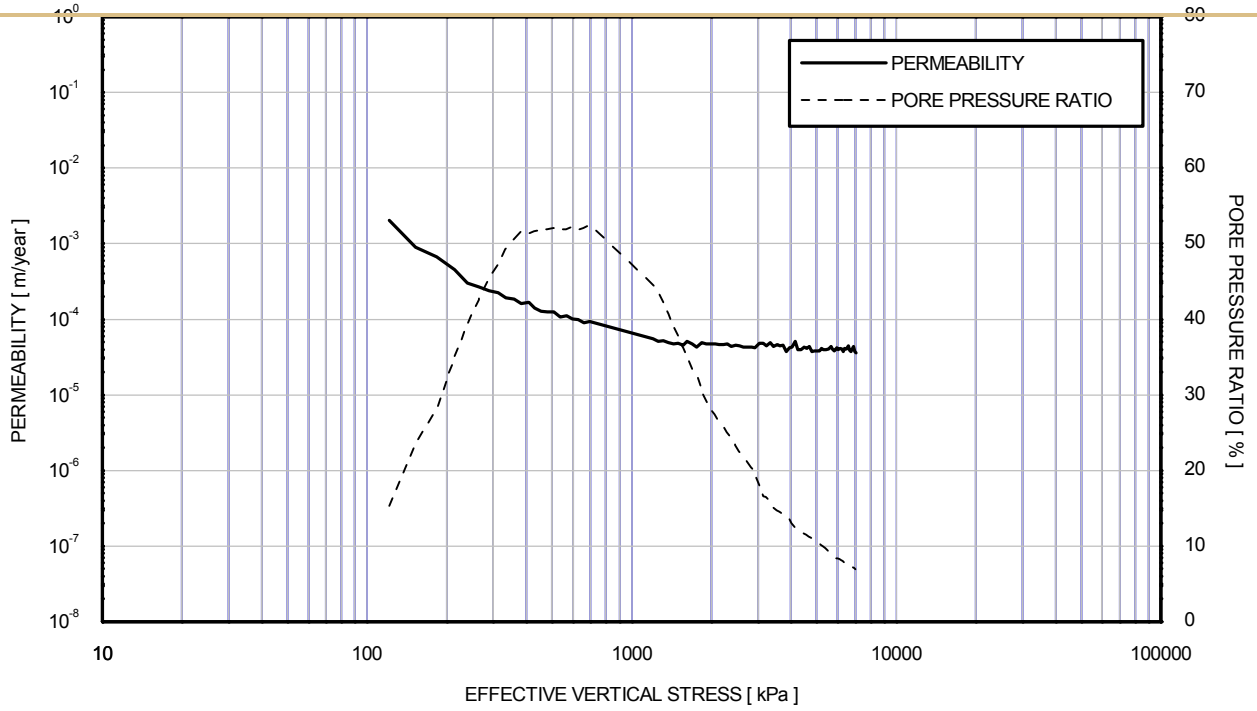


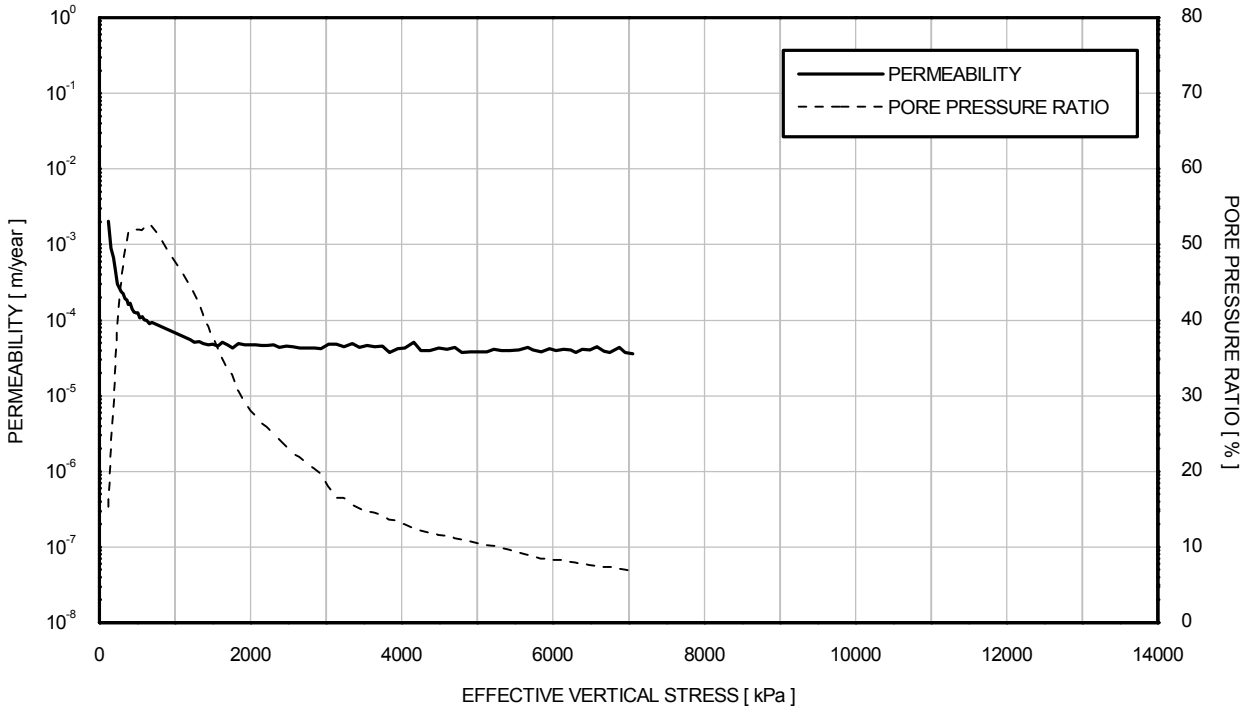
Borehole	Sample	Depth [m]
BH-WFS4-1A	20WaxB	32.15

Initial void ratio	: 1.045
Particle Density	: 2.72 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-1A	20WaxB	32.15

Initial void ratio	: 1.045
Particle Density	: 2.72 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Very stiff dark greenish grey CLAY

GENERAL	
Date test started	06/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.0
Length	[mm]	20.7
Moisture content	[%]	32.2
Bulk density	[Mg/m³]	1.95
Dry density	[Mg/m³]	1.47
Void ratio	[-]	0.806
Degree of saturation	[%]	100
Measured particle density	[Mg/m³]	2.66
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ LPS J11302m
Template issue	9.0
Processed by	ALB
Date	27/11/2015
Checked by	PH
Date	30/11/2015
Approved by	PH
Date	30/11/2015

TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	22WaxD
Depth [m]	30.85
Test Number	315R

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

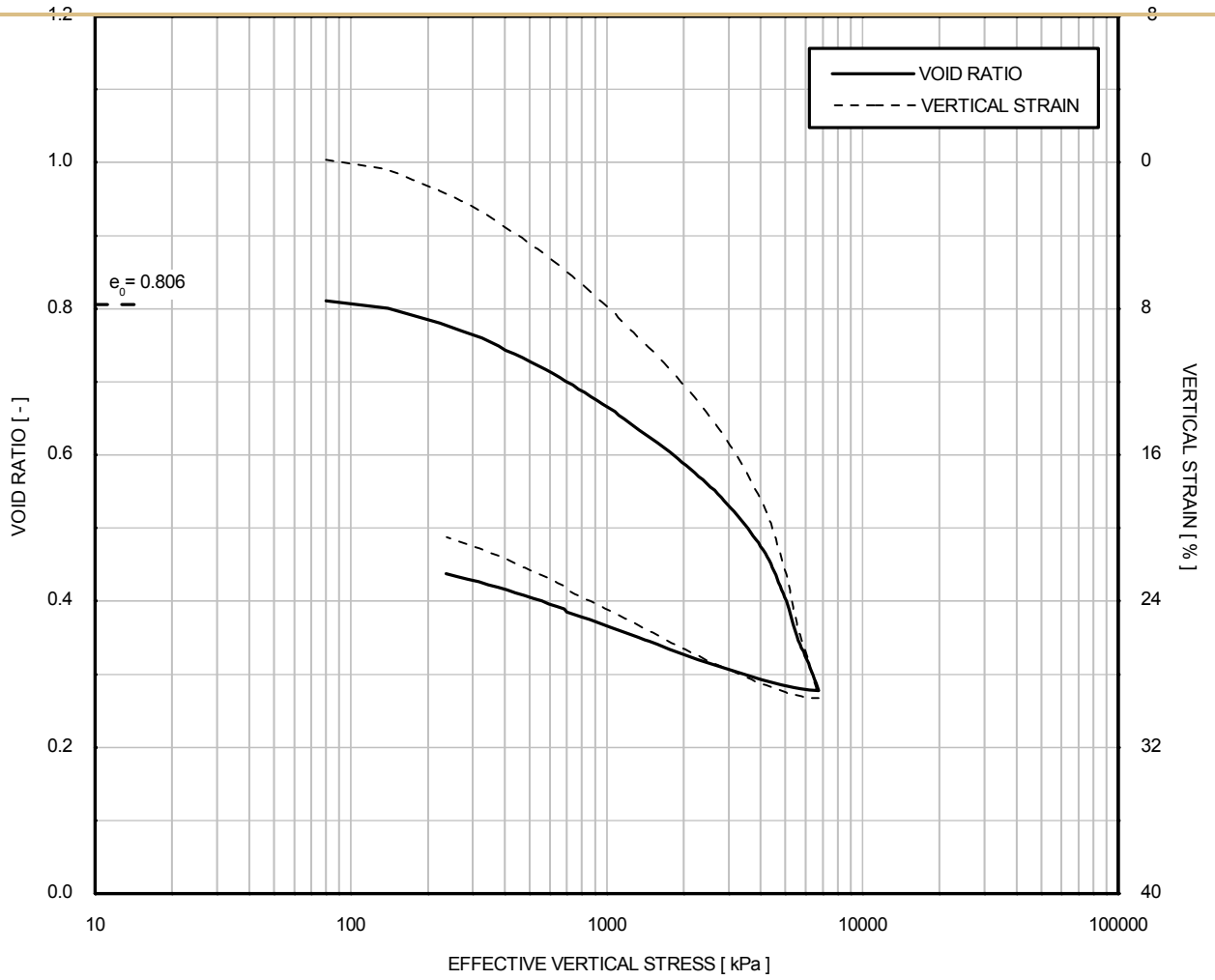
SPECIMEN PHOTOGRAPH

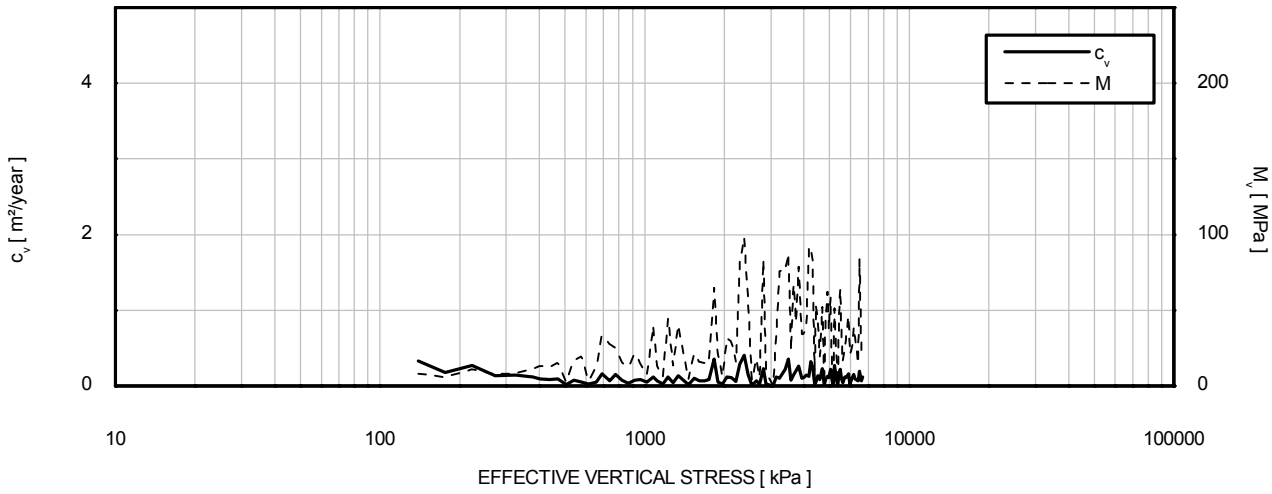


TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	22WaxD
Depth [m]	30.85
Test Number	315R

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



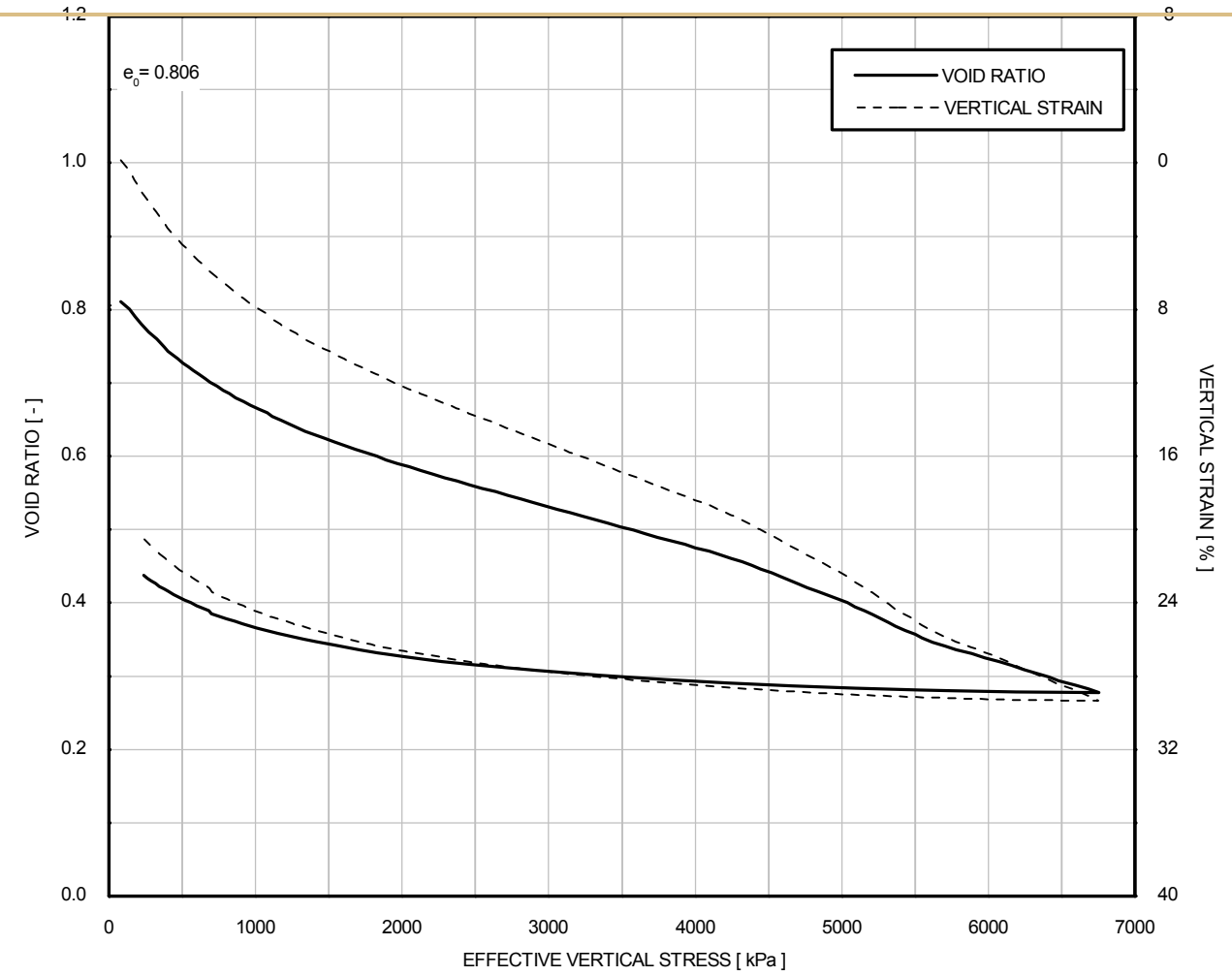


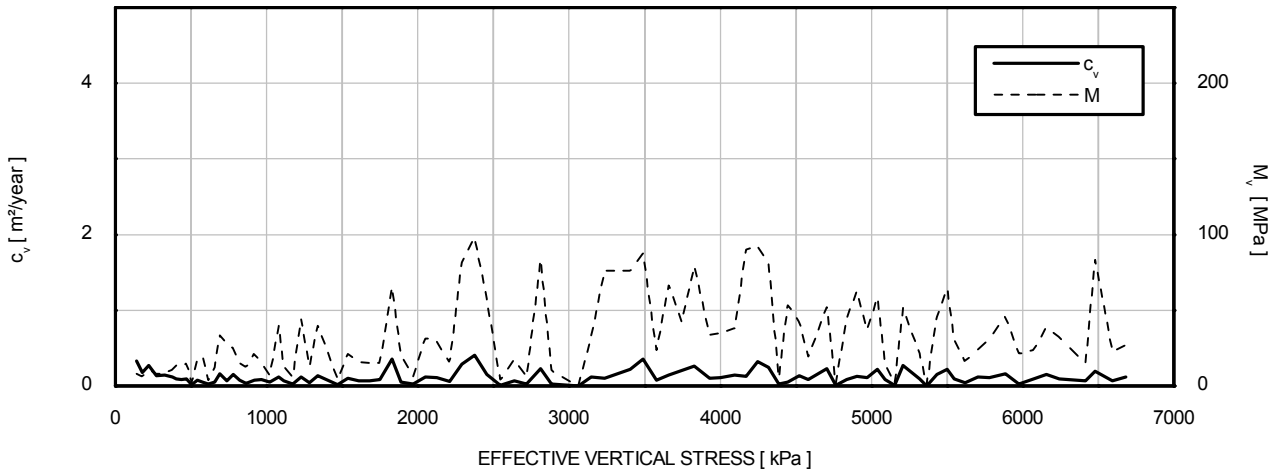
Borehole	Sample	Depth [m]
BH-WFS4-3	22WaxD	30.85

Initial void ratio	: 0.806
Particle Density	: 2.66 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



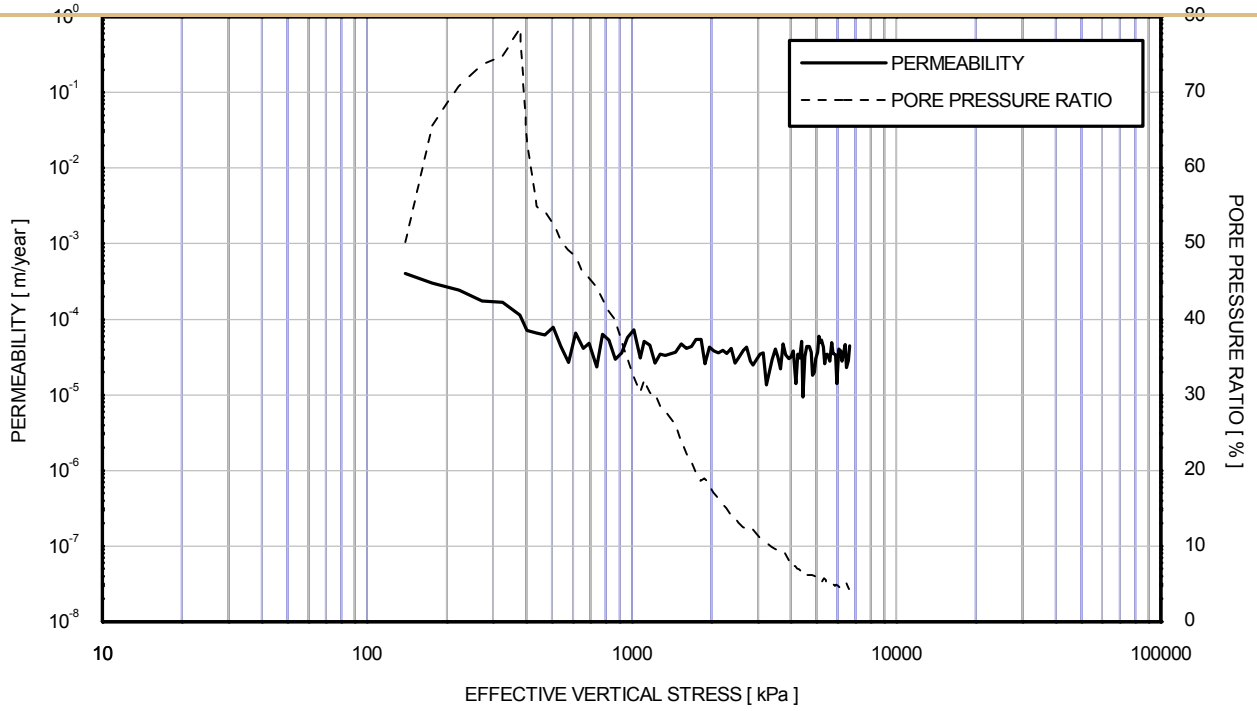


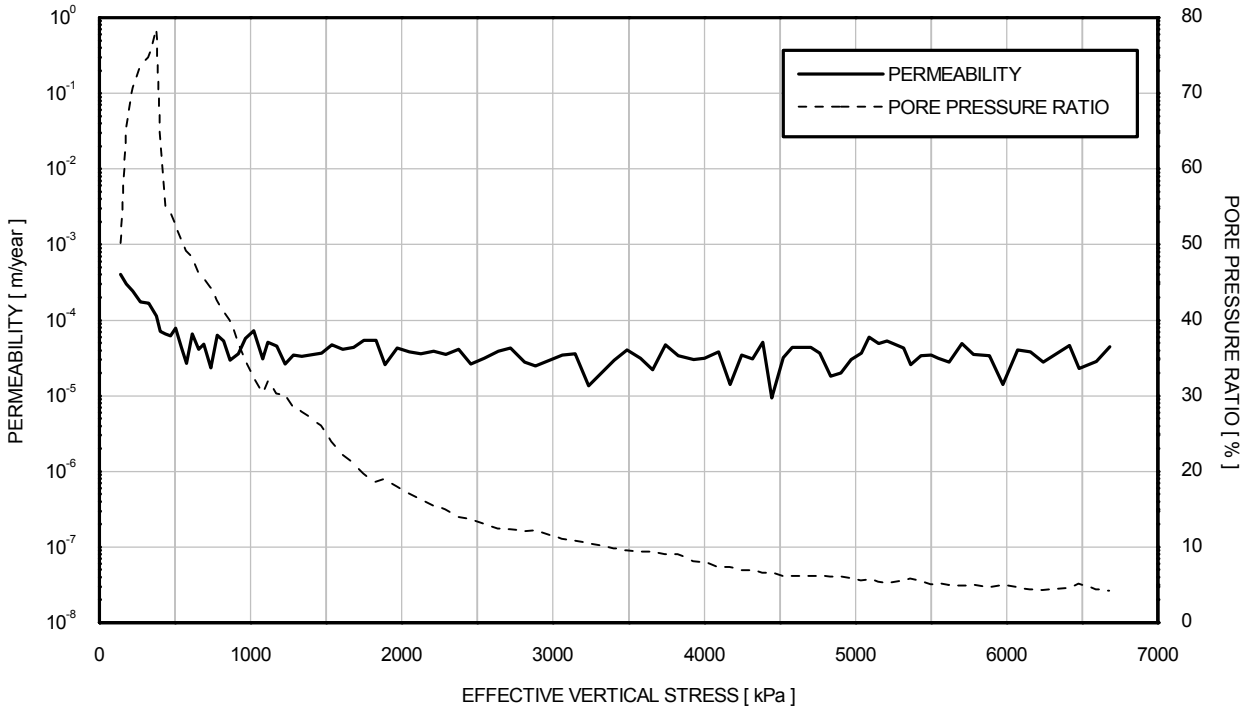
Borehole	Sample	Depth [m]
BH-WFS4-3	22WaxD	30.85

Initial void ratio	: 0.806
Particle Density	: 2.66 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-3	22WaxD	30.85

Initial void ratio	: 0.806
Particle Density	: 2.66 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark greenish grey CLAY.

GENERAL	
Date test started	03/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.1
Length	[mm]	20.8
Moisture content	[%]	41.2
Bulk density	[Mg/m³]	1.83
Dry density	[Mg/m³]	1.30
Void ratio	[-]	1.082
Degree of saturation	[%]	100
Measured particle density	[Mg/m³]	2.70
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-3_28WaxB_crs
Template issue	9.0
Processed by	ALB
Date	18/11/2015
Checked by	PH
Date	19/11/2015
Approved by	
Date	

TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	28WaxB
Depth [m]	44.56
Test Number	316

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

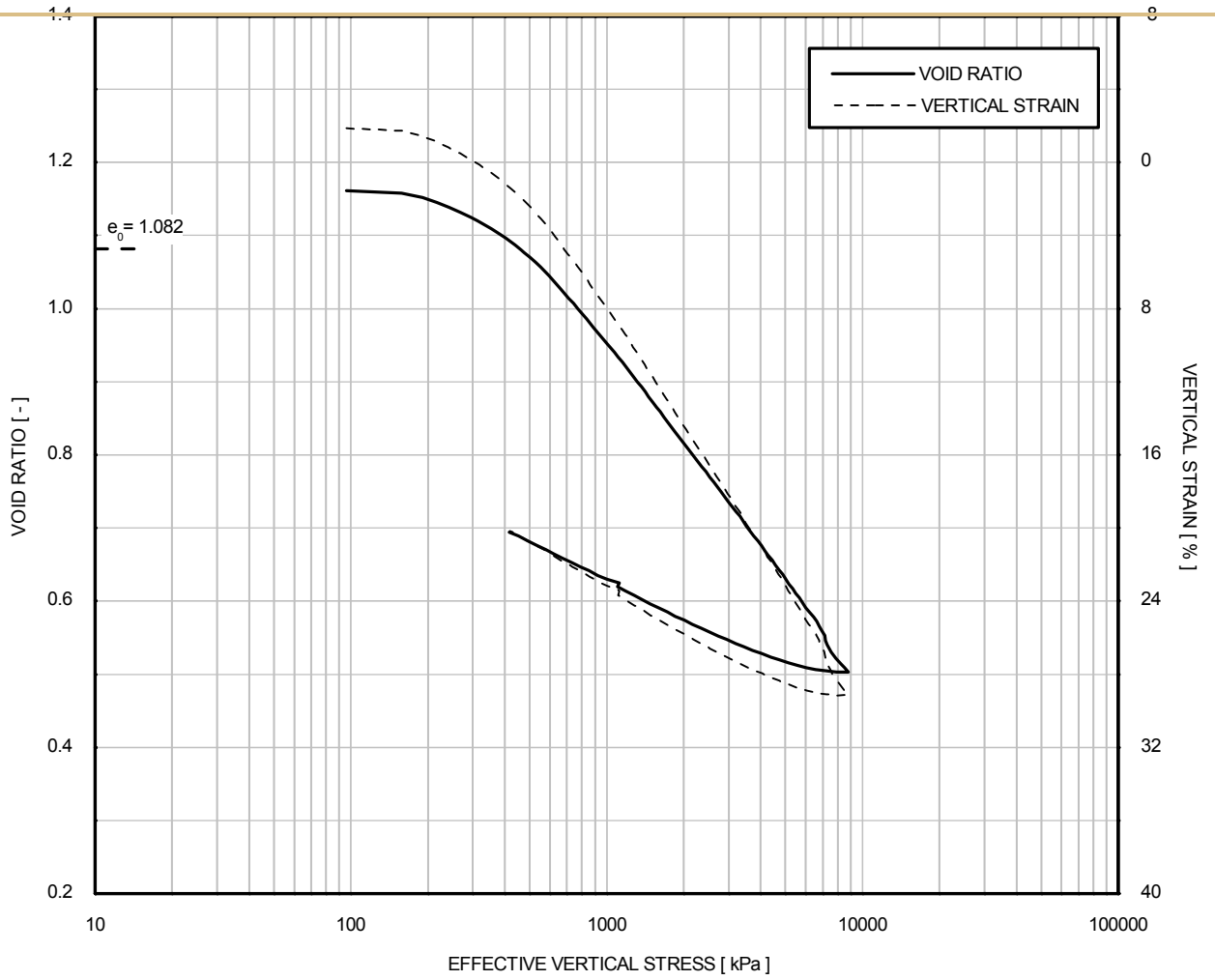
SPECIMEN PHOTOGRAPH

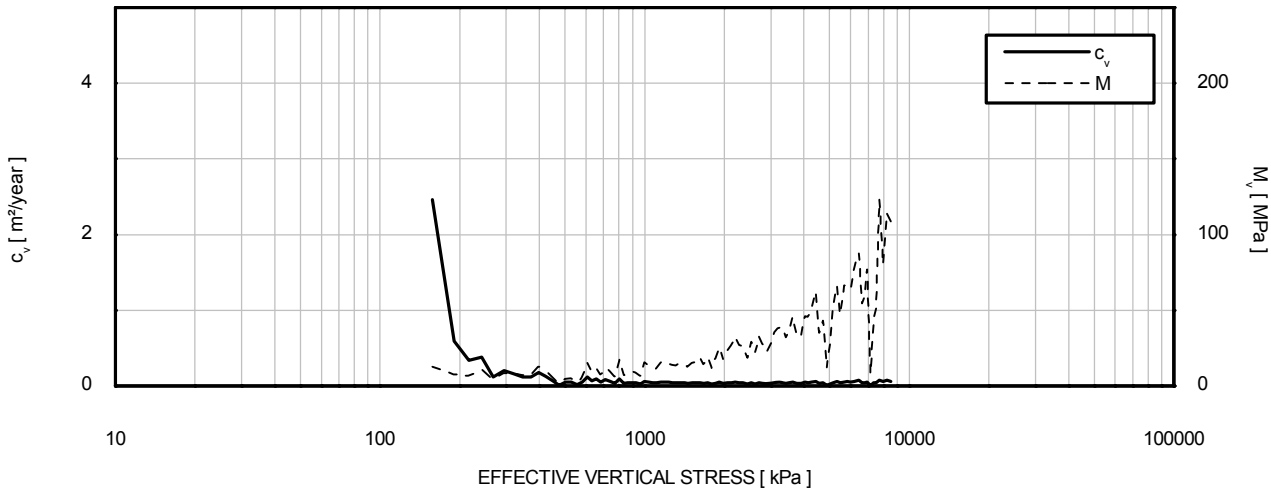


TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	28WaxB
Depth [m]	44.56
Test Number	316

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



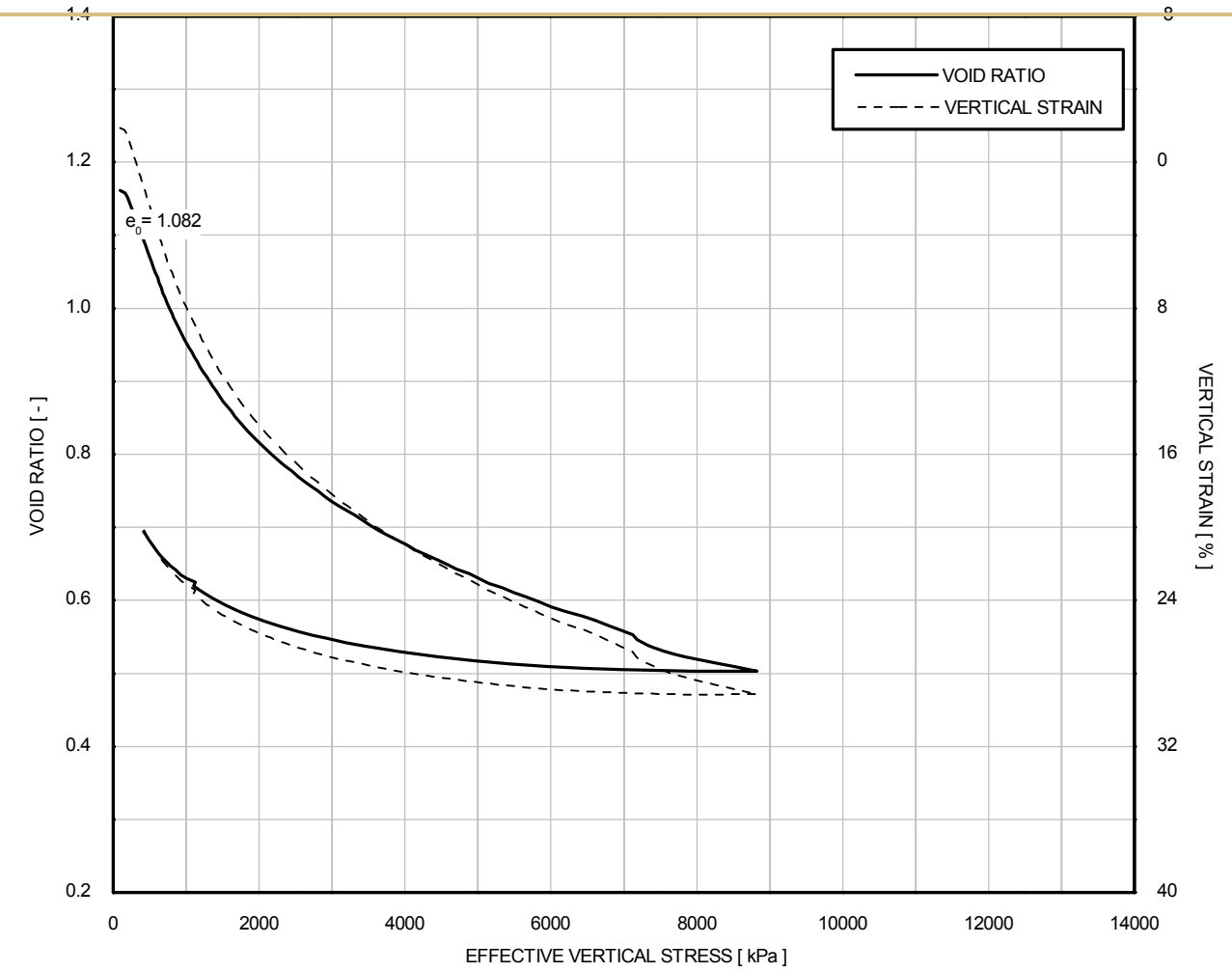


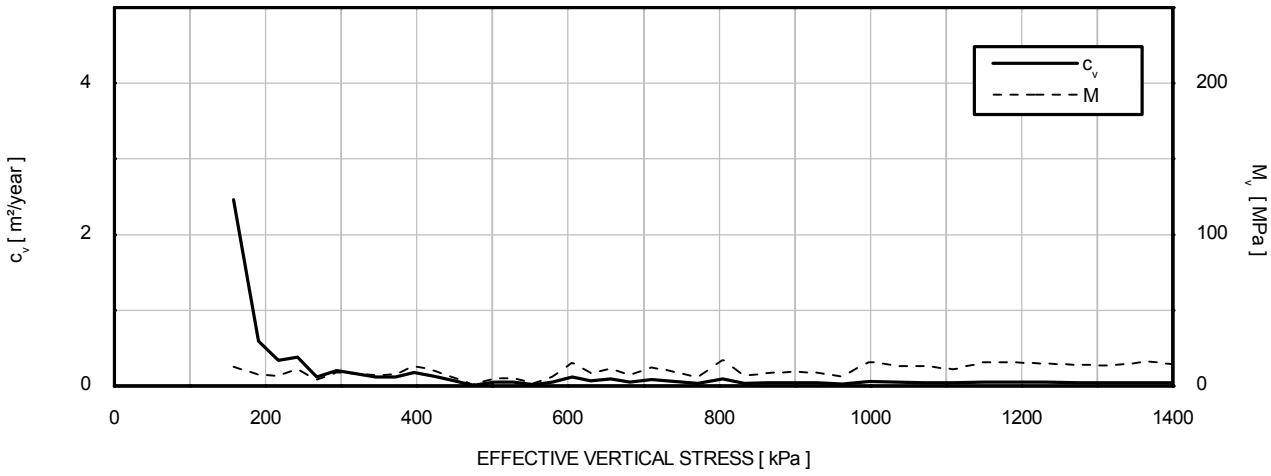
Borehole	Sample	Depth [m]
BH-WFS4-3	28WaxB	44.55

Initial void ratio	: 1.082
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



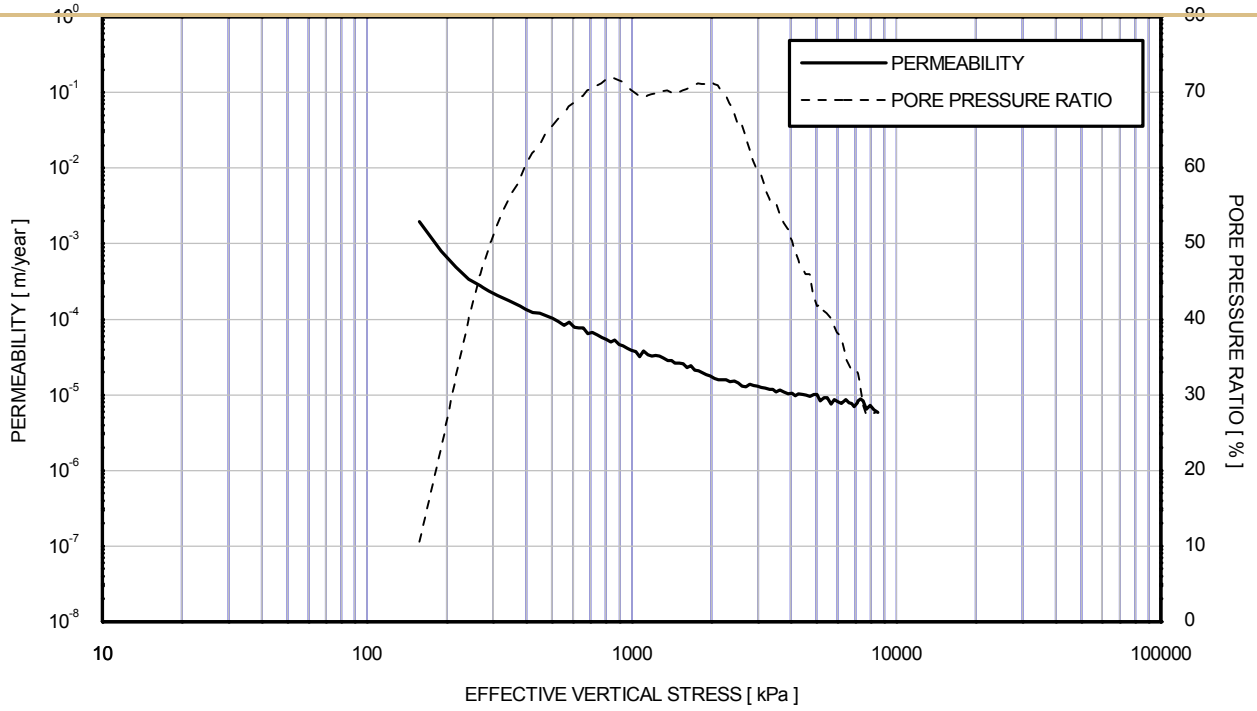


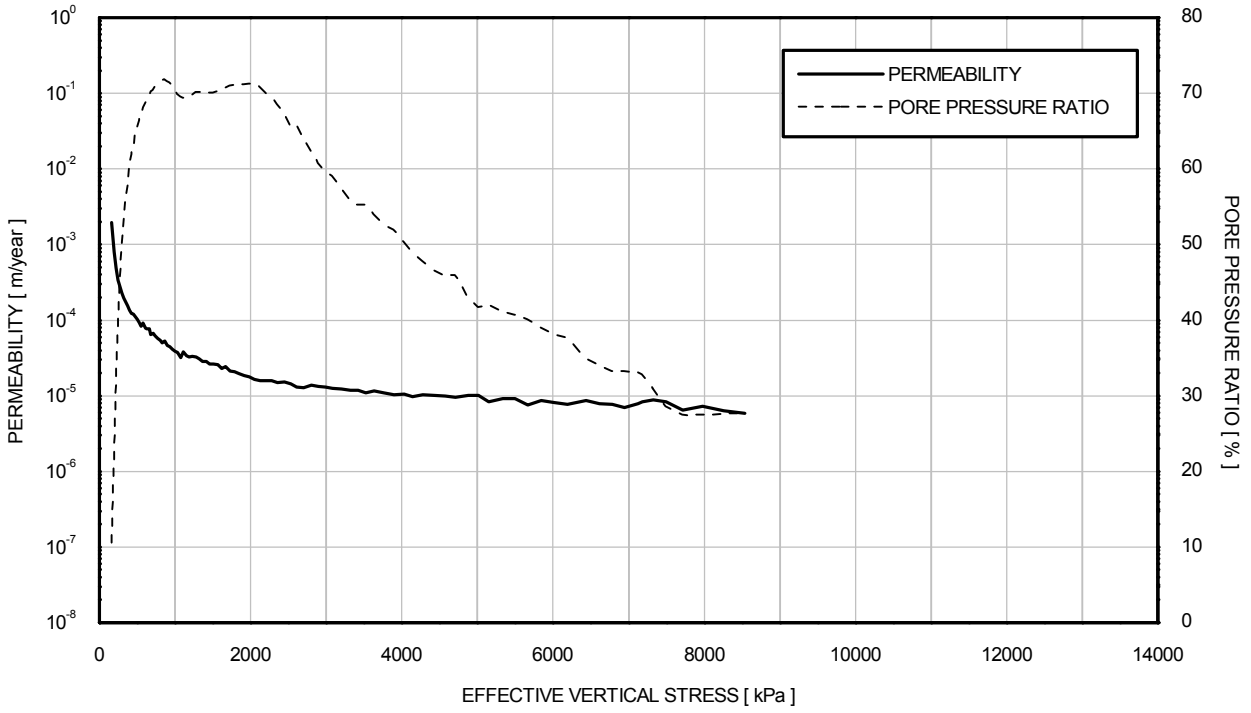
Borehole	Sample	Depth [m]
BH-WFS4-3	28WaxB	44.55

Initial void ratio	: 1.082
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-3	28WaxB	44.55

Initial void ratio	: 1.082
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey fine sandy CLAY.

GENERAL	
Date test started	16/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.1
Length	[mm]	20.8
Moisture content	[%]	22.5
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.64
Void ratio	[-]	0.647
Degree of saturation	[%]	94
Assumed particle density	[Mg/m³]	2.70
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-4_34WaxB_crs
Template issue	9.0
Processed by	ER
Date	29/10/2015
Checked by	ALB
Date	29/10/2015
Approved by	PH
Date	30/10/2015

TEST IDENTIFICATION	
Borehole	BH-WFS4-4
Sample	34WaxB
Depth [m]	38.64
Test Number	311

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

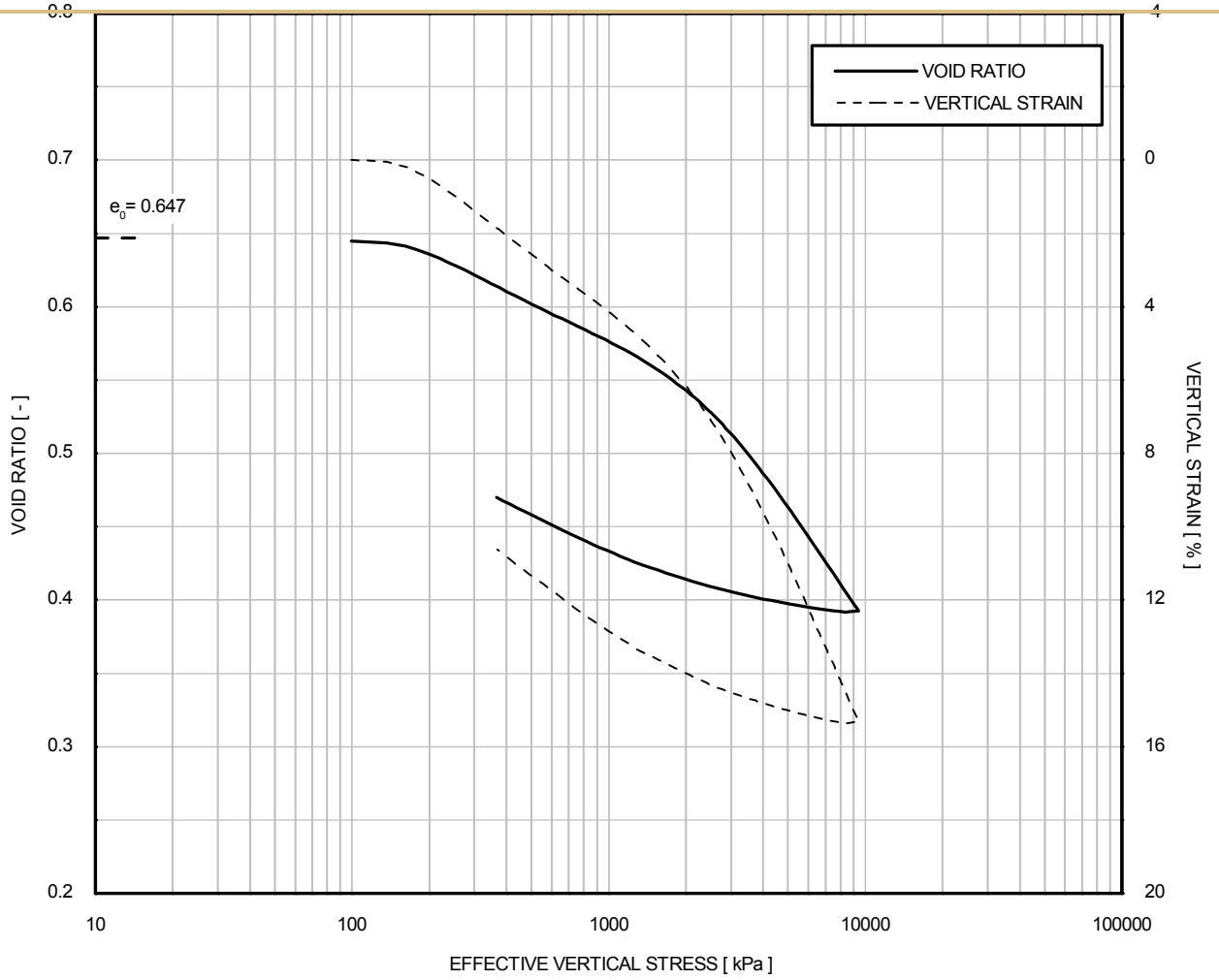
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

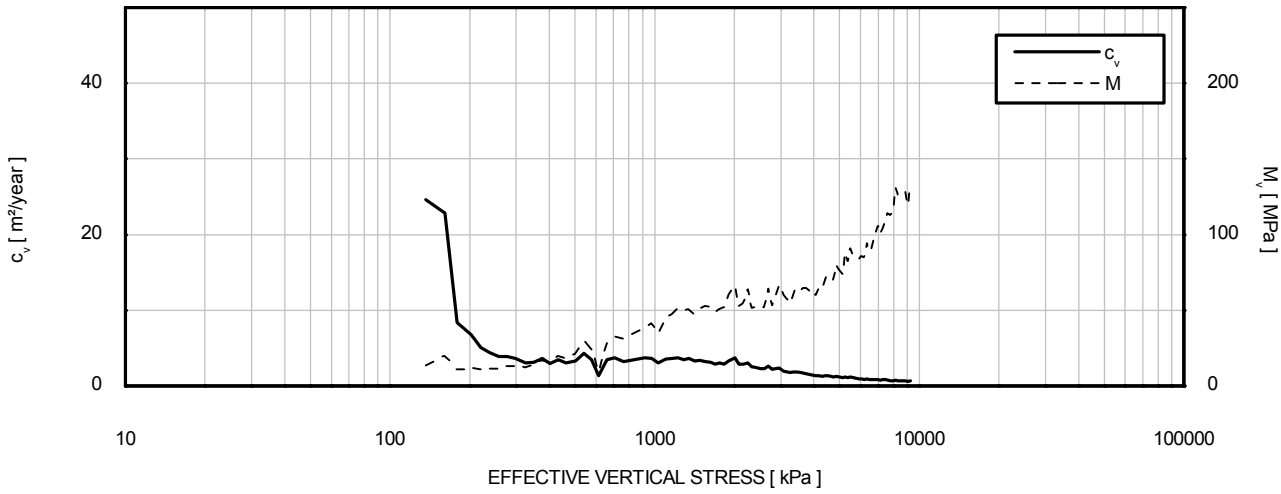
SPECIMEN PHOTOGRAPH



TEST IDENTIFICATION	
Borehole	BH-WFS4-4
Sample	34WaxB
Depth [m]	38.64
Test Number	311

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)
BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



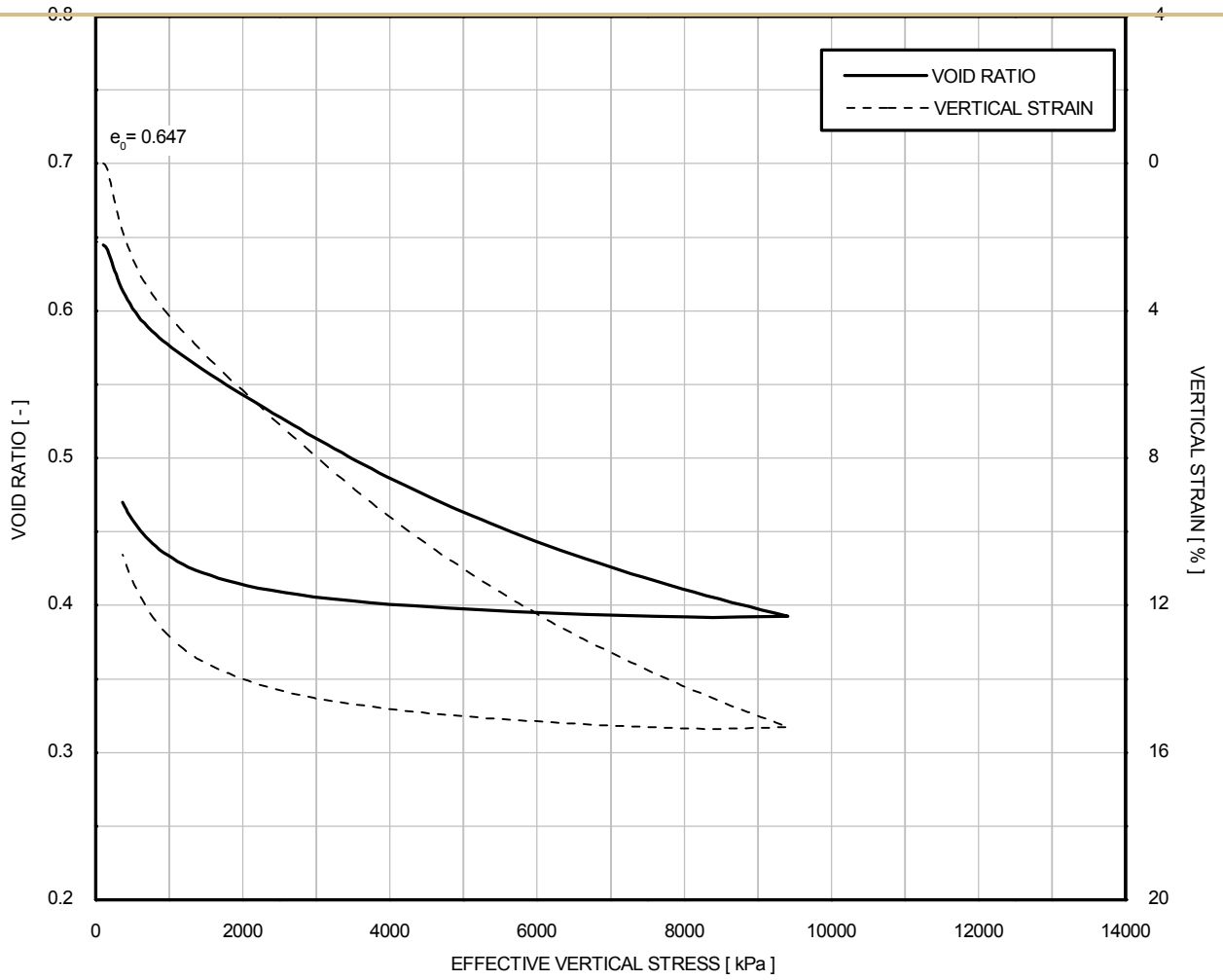


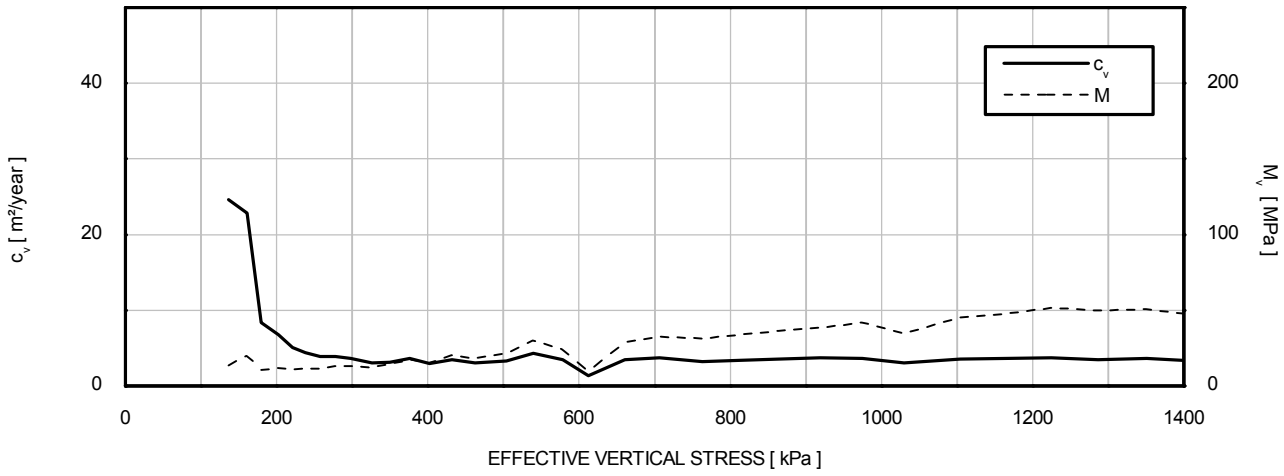
Borehole	Sample	Depth [m]
BH-WFS4-4	34WaxB	38.64

Initial void ratio	: 0.647
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.60 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



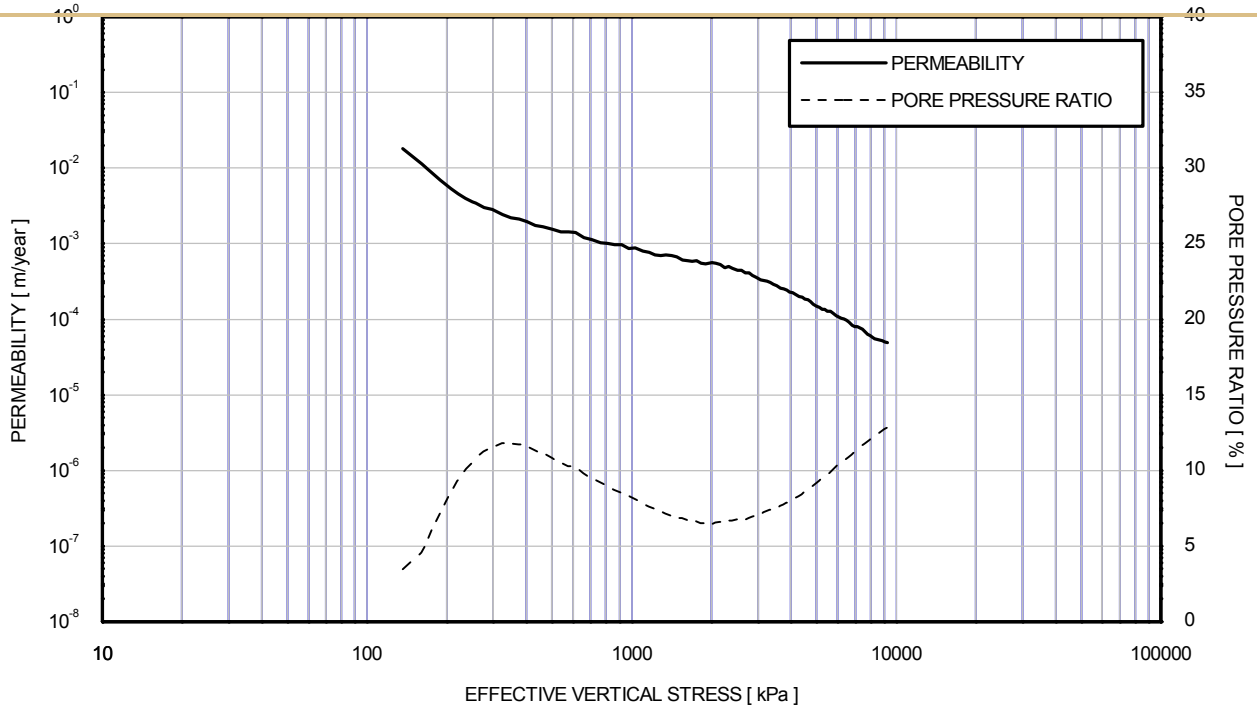


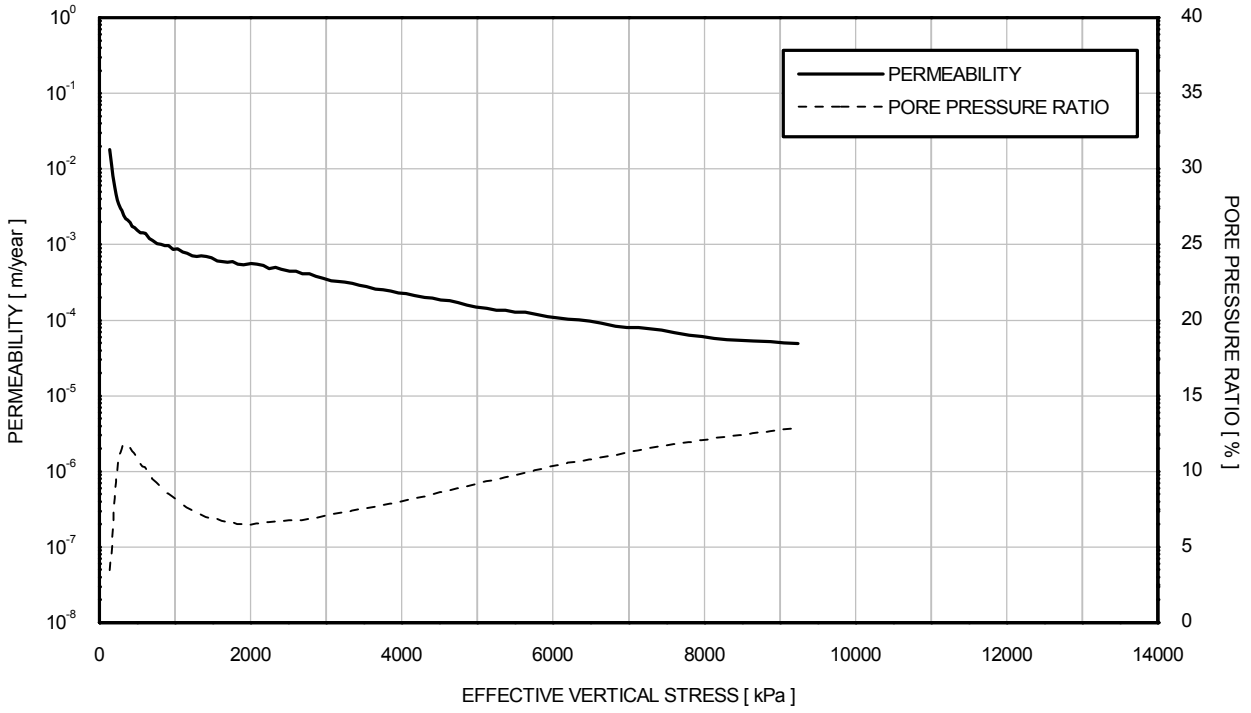
Borehole	Sample	Depth [m]
BH-WFS4-4	34WaxB	38.64

Initial void ratio	: 0.647
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.60 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-4	34WaxB	38.64

Initial void ratio	: 0.647
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.60 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark greenish grey CLAY

GENERAL	
Date test started	06/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.1
Length	[mm]	20.7
Moisture content	[%]	32.9
Bulk density	[Mg/m³]	1.91
Dry density	[Mg/m³]	1.44
Void ratio	[-]	0.880
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J112302 \ BH-WFS4-4_36WaxD_crs
Template issue	9.0
Processed by	ALB
Date	18/11/2015
Checked by	PH
Date	19/11/2015
Approved by	
Date	

TEST IDENTIFICATION	
Borehole	BH-WFS4-4
Sample	36WaxD
Depth [m]	43.89
Test Number	312R

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

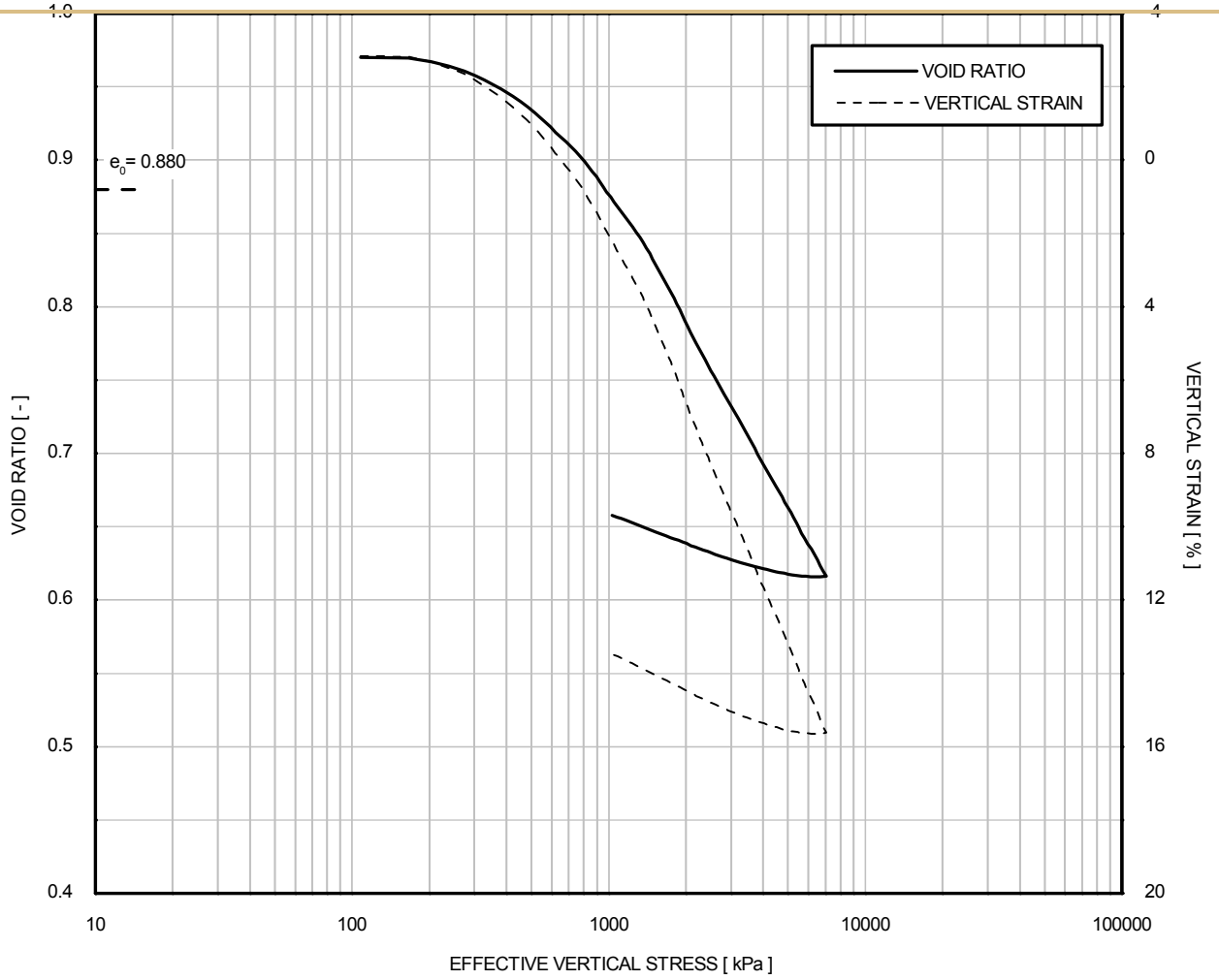
SPECIMEN PHOTOGRAPH

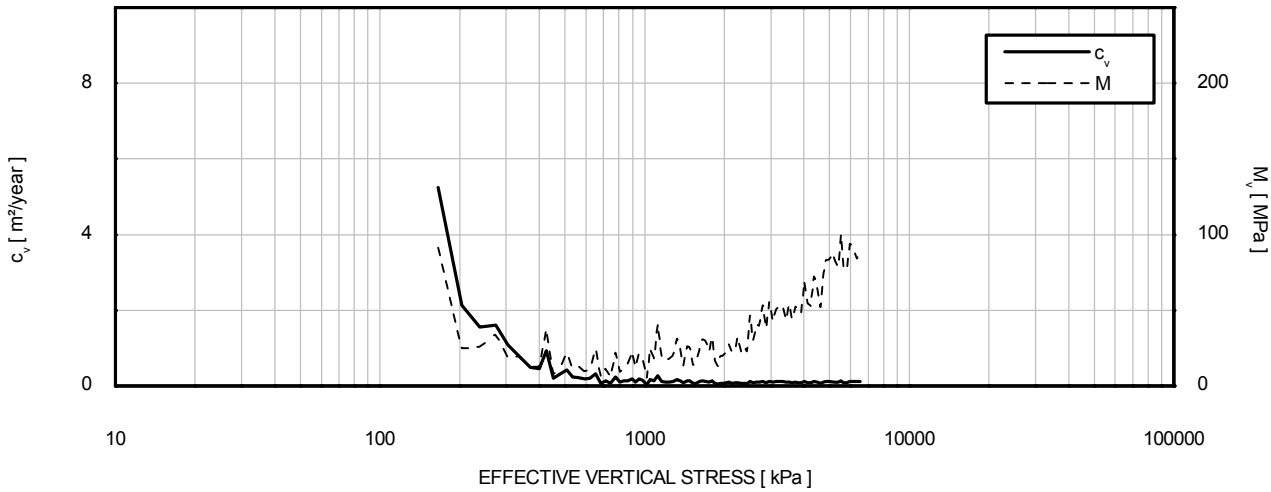


TEST IDENTIFICATION	
Borehole	BH-WFS4-4
Sample	36WaxD
Depth [m]	43.89
Test Number	312R

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



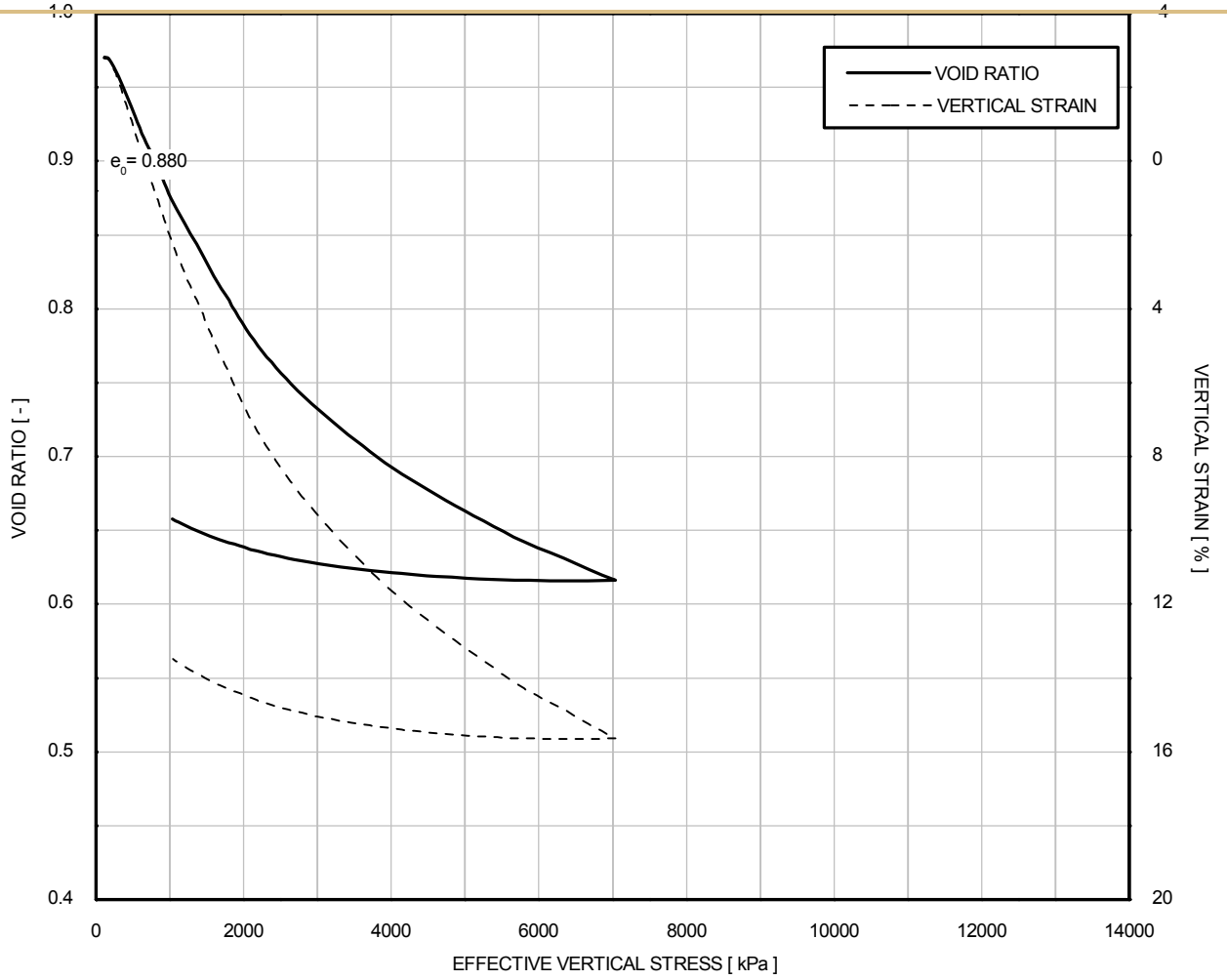


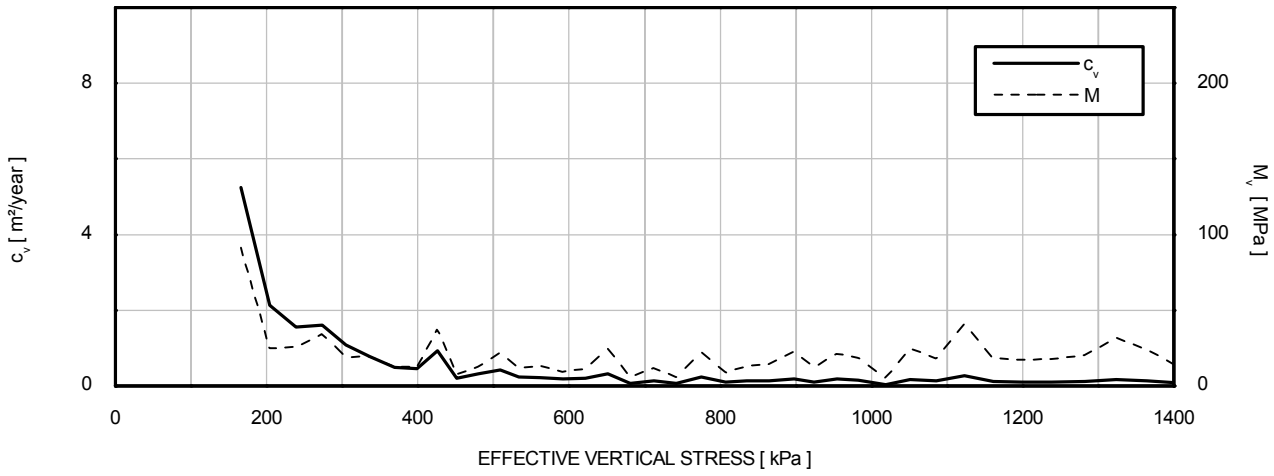
Borehole	Sample	Depth [m]
BH-WFS4-4	36WaxD	43.89

Initial void ratio	: 0.880
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



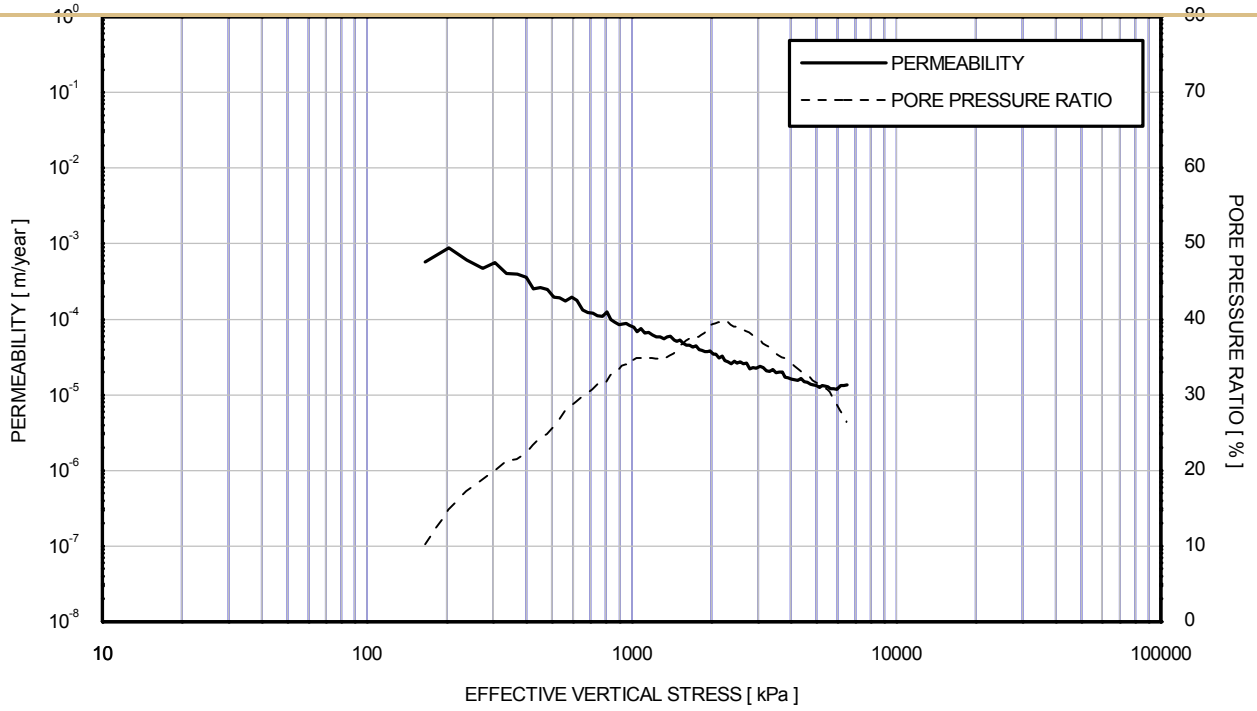


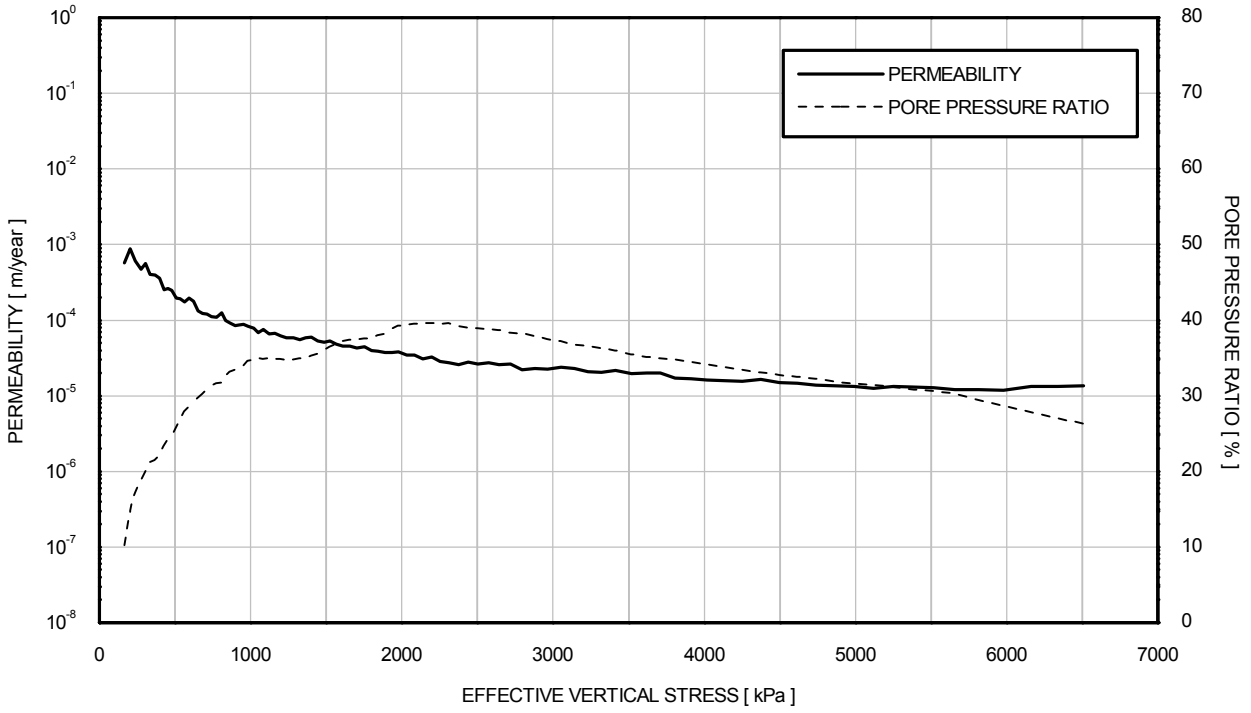
Borehole	Sample	Depth [m]
BH-WFS4-4	36WaxD	43.89

Initial void ratio	: 0.880
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-4	36WaxD	43.89

Initial void ratio	: 0.880
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.20 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark grey silty fine sandy CLAY

GENERAL	
Date test started	28/10/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.1
Length	[mm]	20.6
Moisture content	[%]	22.7
Bulk density	[Mg/m³]	2.00
Dry density	[Mg/m³]	1.63
Void ratio	[-]	0.655
Degree of saturation	[%]	94
Assumed particle density	[Mg/m³]	2.70
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ J11302_pd.XLS
Template issue	9.0
Processed by	ALB
Date	03/11/2015
Checked by	PH
Date	04/11/2015
Approved by	PH
Date	04/11/2015

TEST IDENTIFICATION	
Borehole	BH-WFS4-5
Sample	36WaxB
Depth [m]	43.06
Test Number	313

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

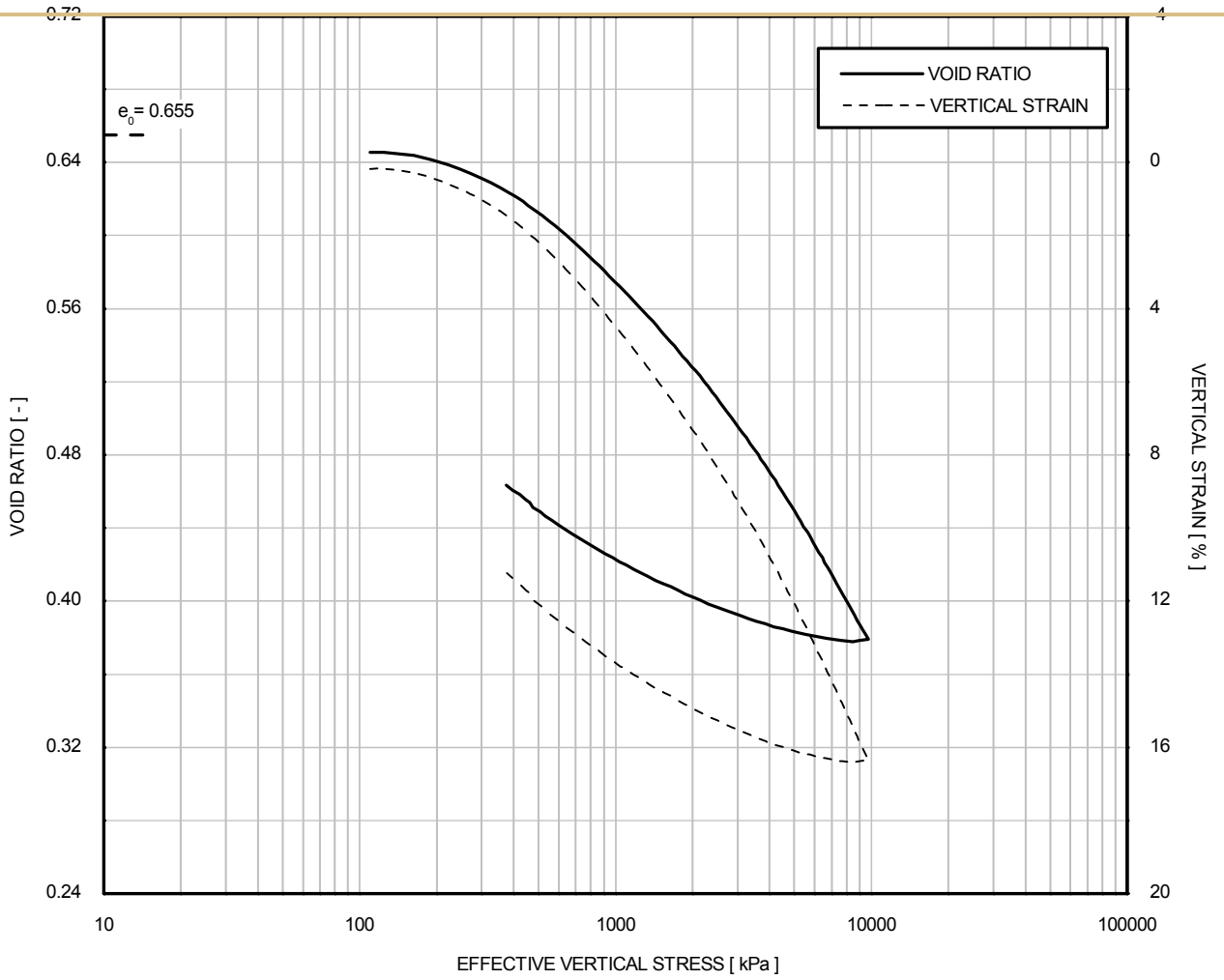
SPECIMEN PHOTOGRAPH

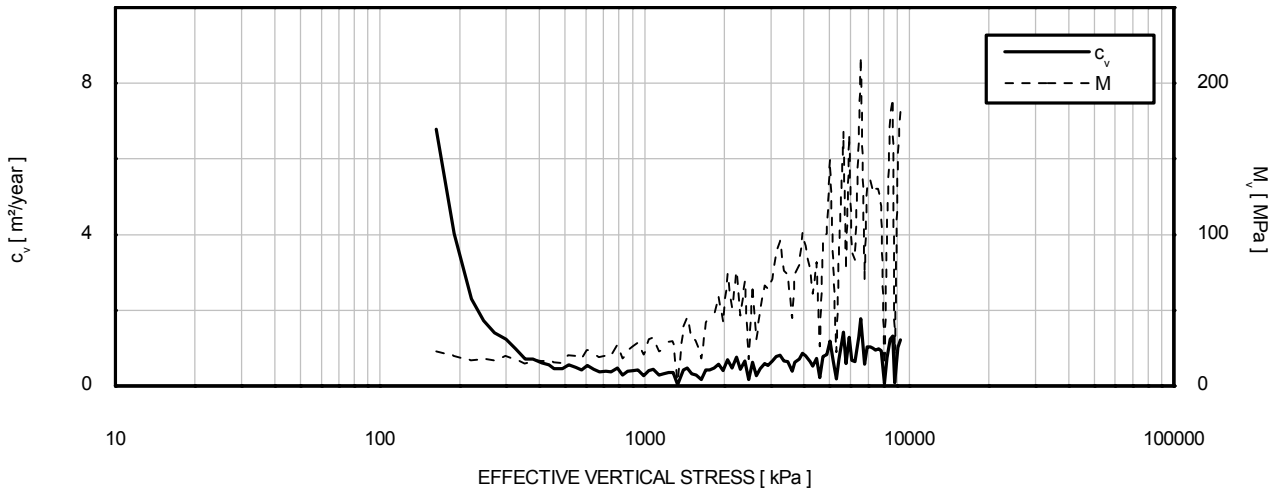


TEST IDENTIFICATION	
Borehole	BH-WFS4-5
Sample	36WaxB
Depth [m]	43.06
Test Number	313

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



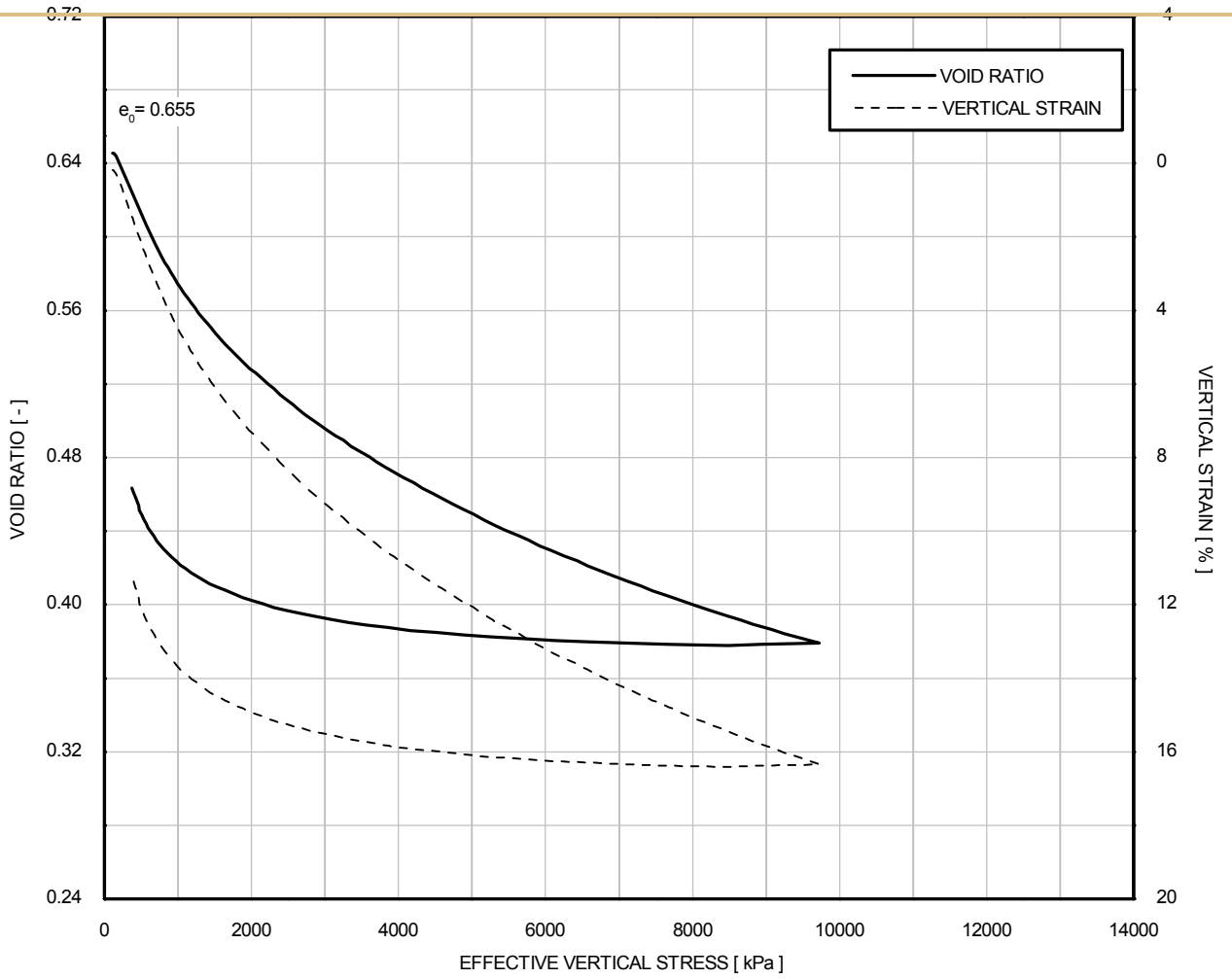


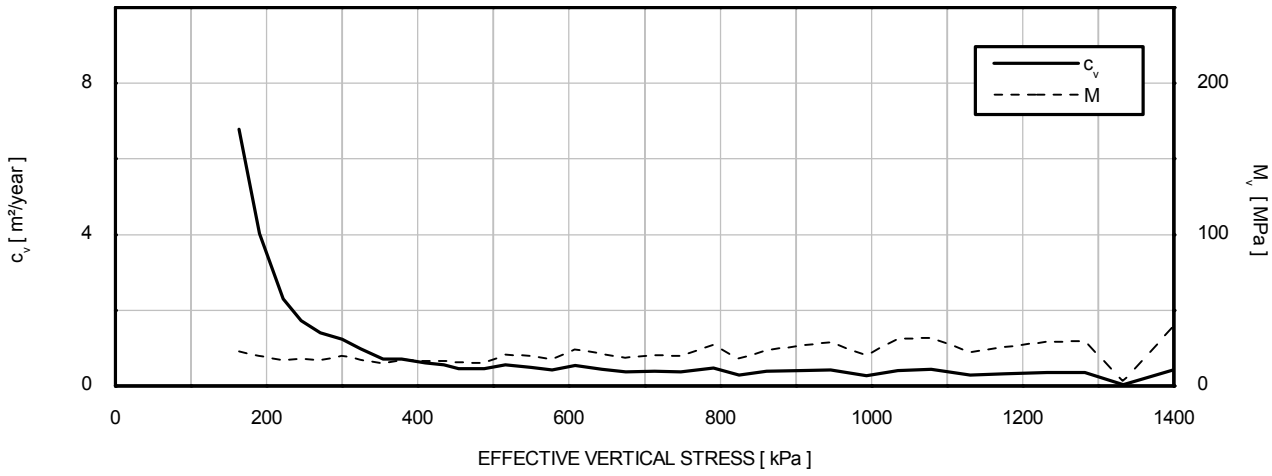
Borehole	Sample	Depth [m]
BH-WFS4-5	36WaxB	43.06

Initial void ratio	: 0.655
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.50 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



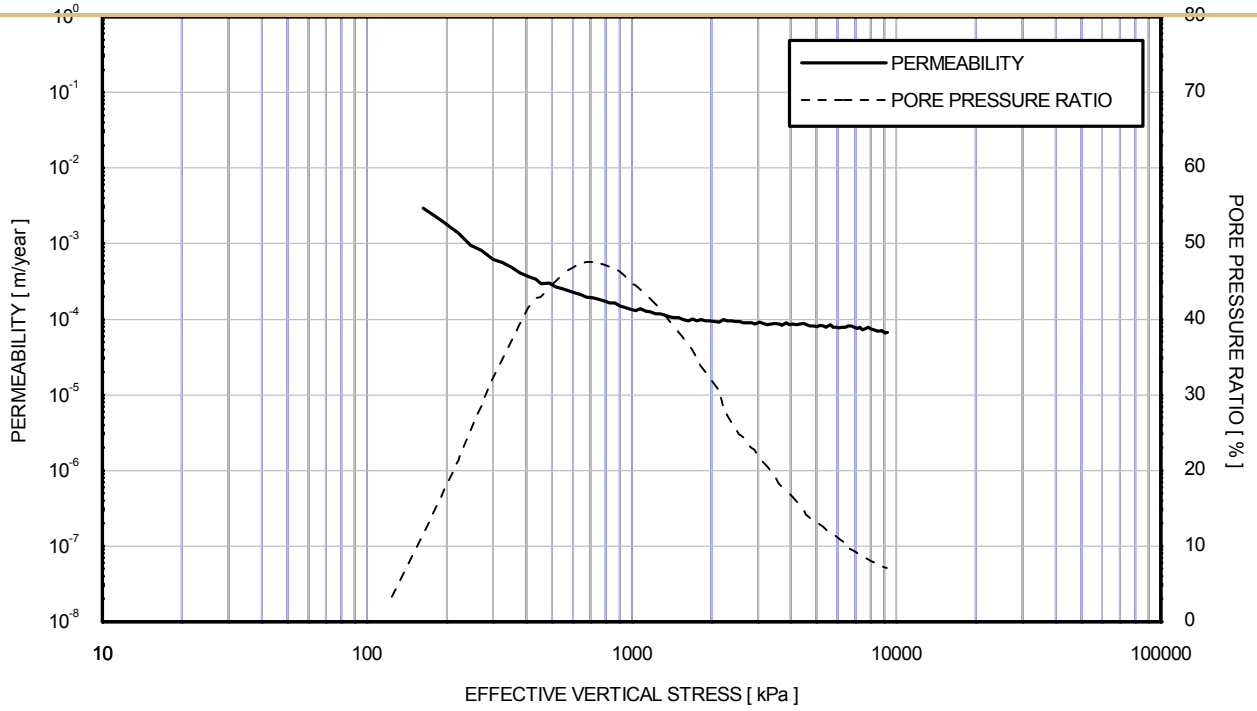


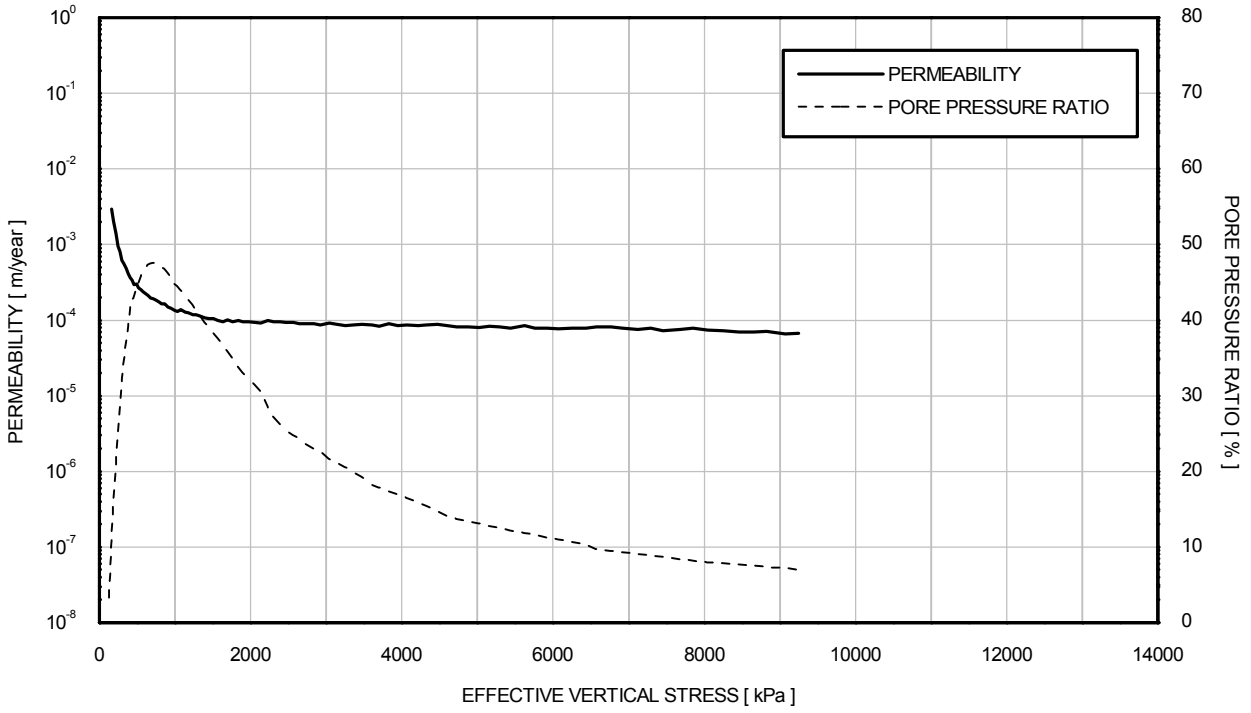
Borehole	Sample	Depth [m]
BH-WFS4-5	36WaxB	43.06

Initial void ratio	: 0.655
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.50 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-5	36WaxB	43.06

Initial void ratio	: 0.655
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.50 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark brown CLAY with fine to medium sand.

GENERAL	
Date test started	04/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.0
Length	[mm]	20.9
Moisture content	[%]	16.4
Bulk density	[Mg/m³]	2.11
Dry density	[Mg/m³]	1.82
Void ratio	[-]	0.487
Degree of saturation	[%]	91
Assumed particle density	[Mg/m³]	2.70
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-7_13WaxC_crs
Template issue	9.0
Processed by	ER
Date	09/11/2015
Checked by	ALB
Date	10/11/2015
Approved by	PH
Date	11/11/2015

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	13WaxC
Depth [m]	10.75
Test Number	317

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

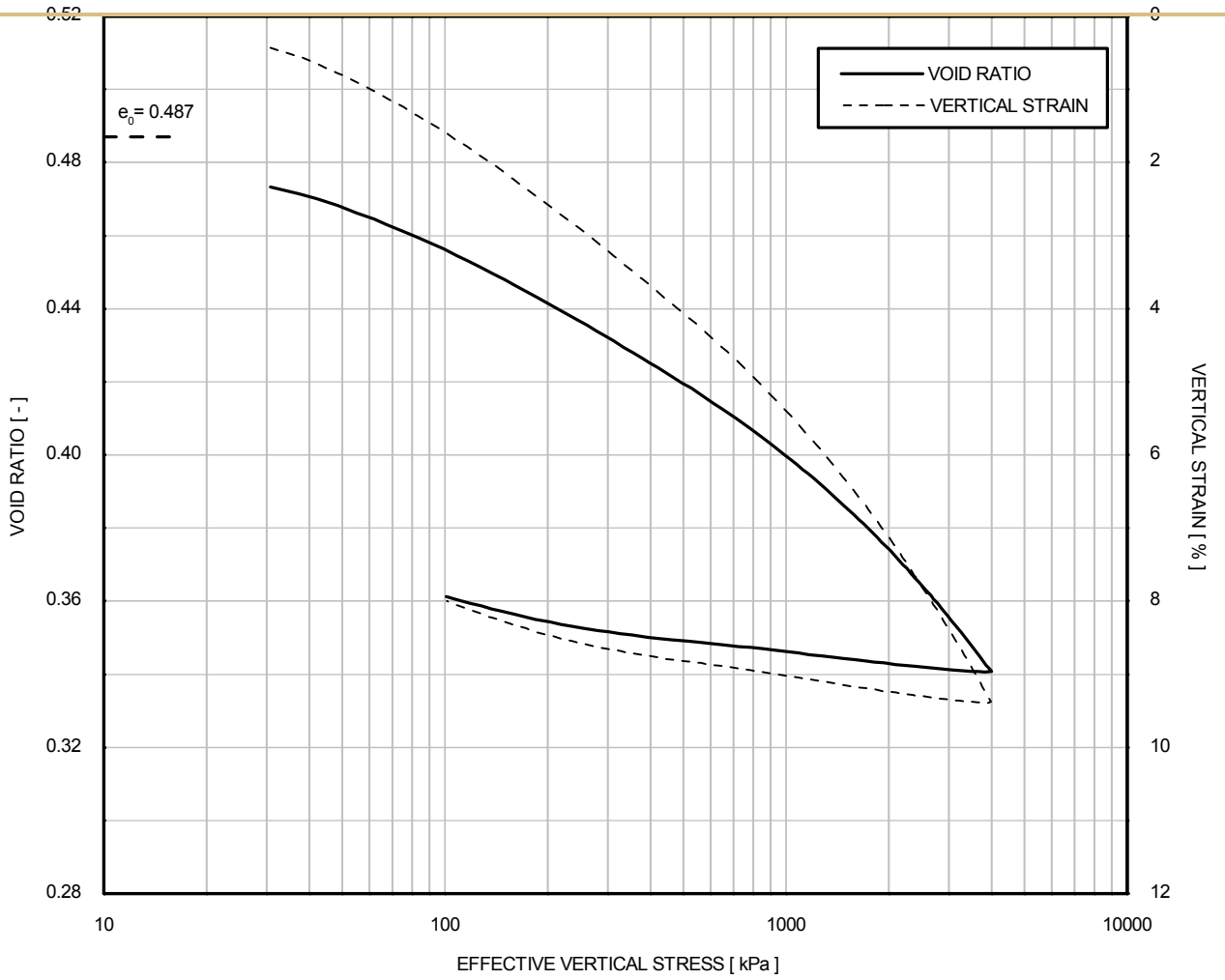
SPECIMEN PHOTOGRAPH

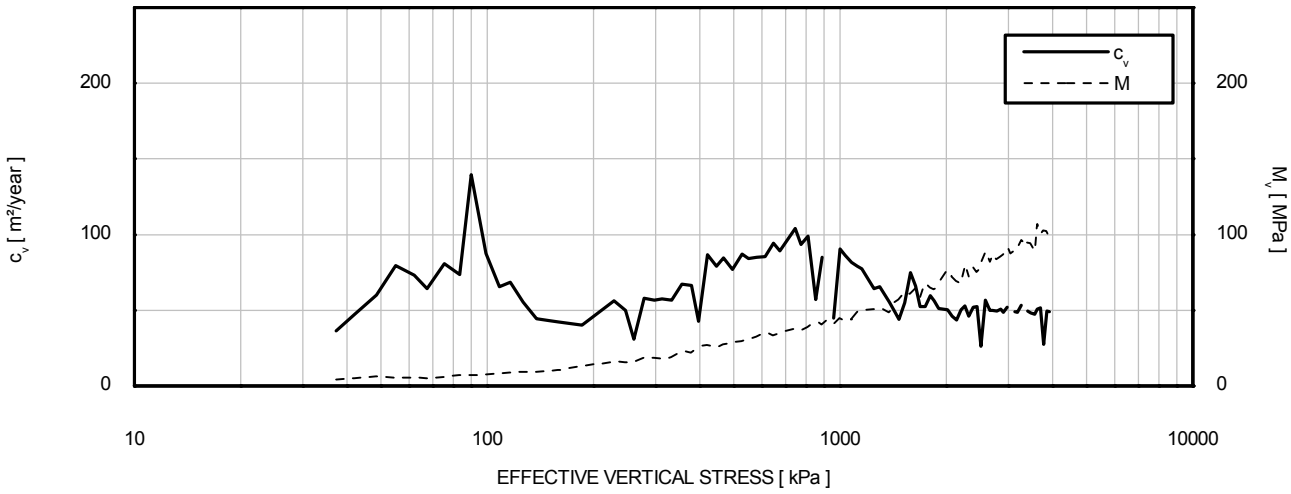


TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	13WaxC
Depth [m]	10.75
Test Number	317

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



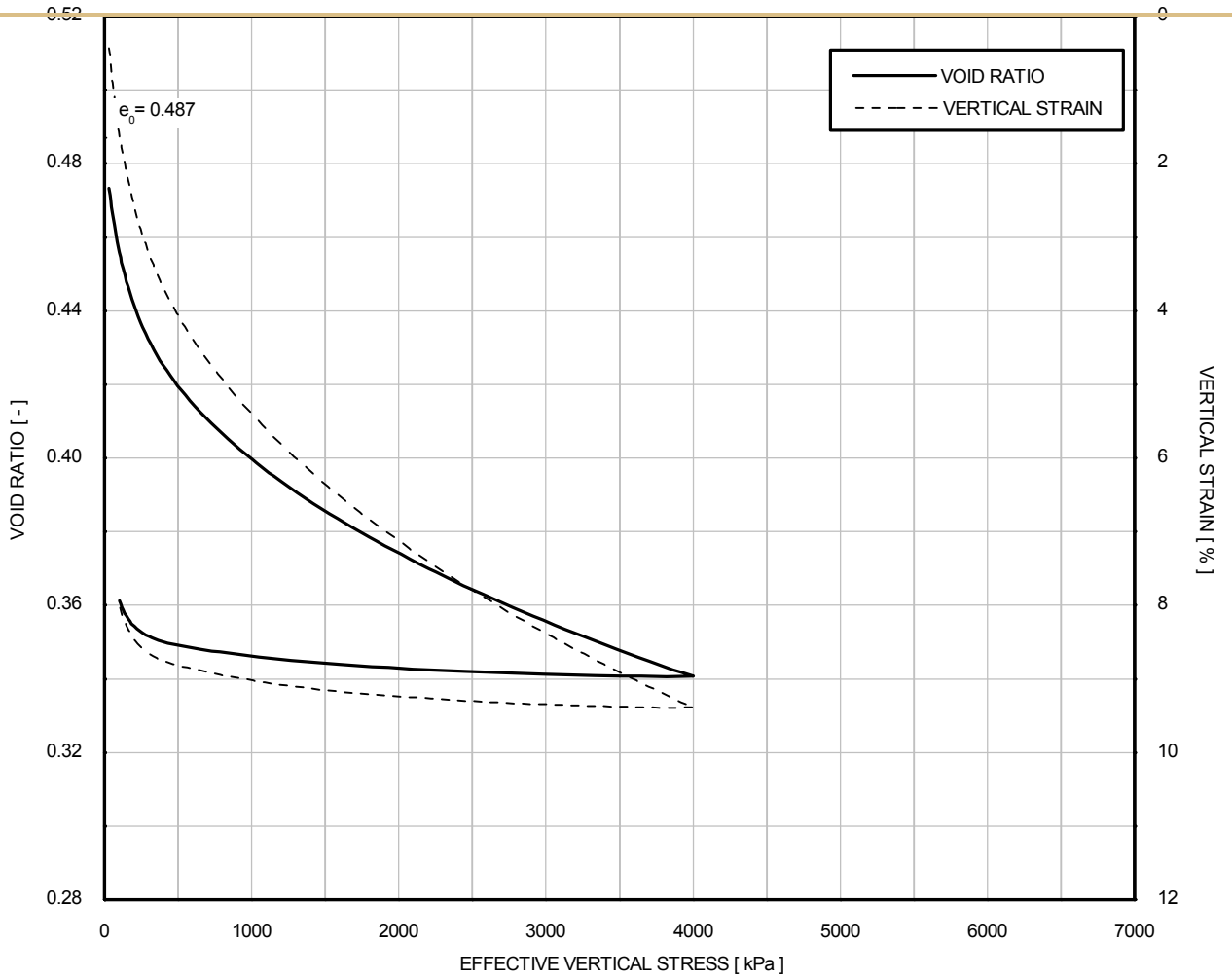


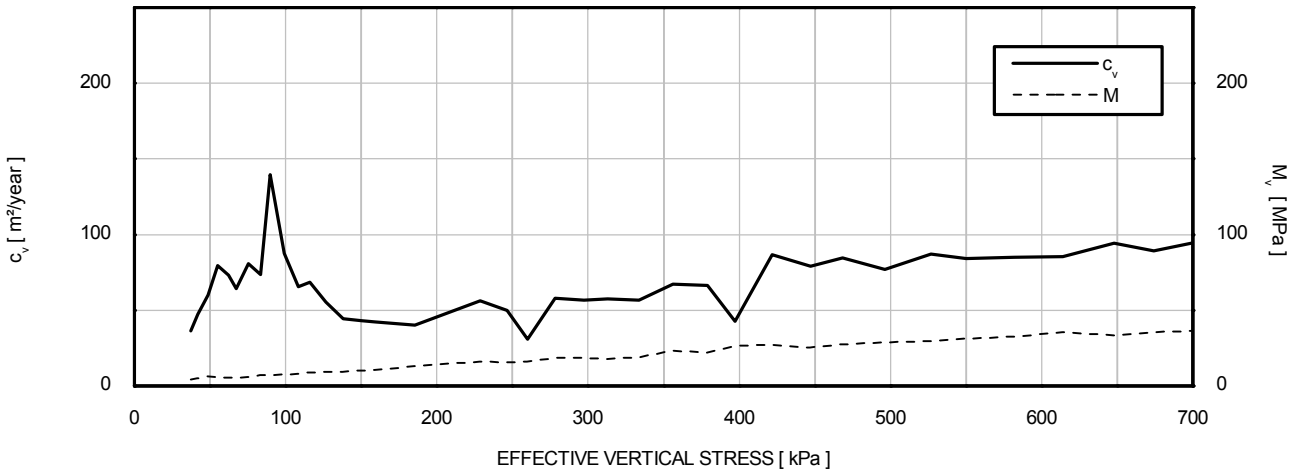
Borehole	Sample	Depth [m]
BH-WFS4-7	13WaxC	10.75

Initial void ratio	: 0.487
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.40 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



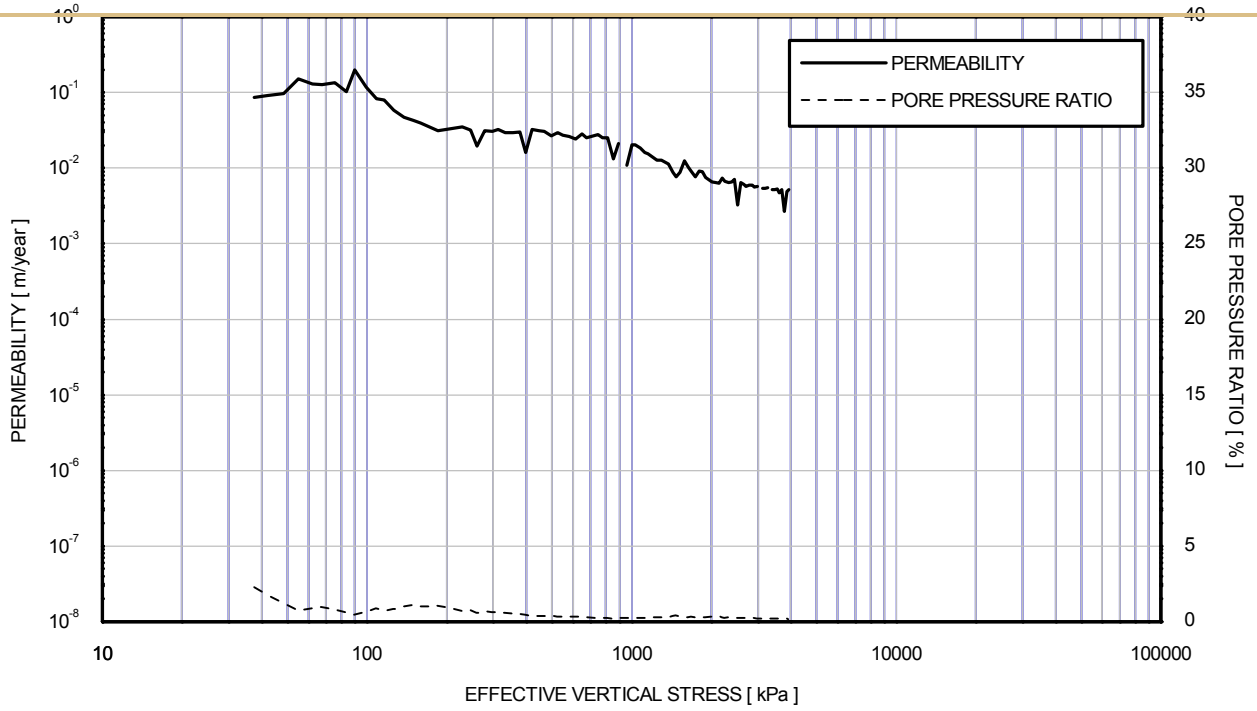


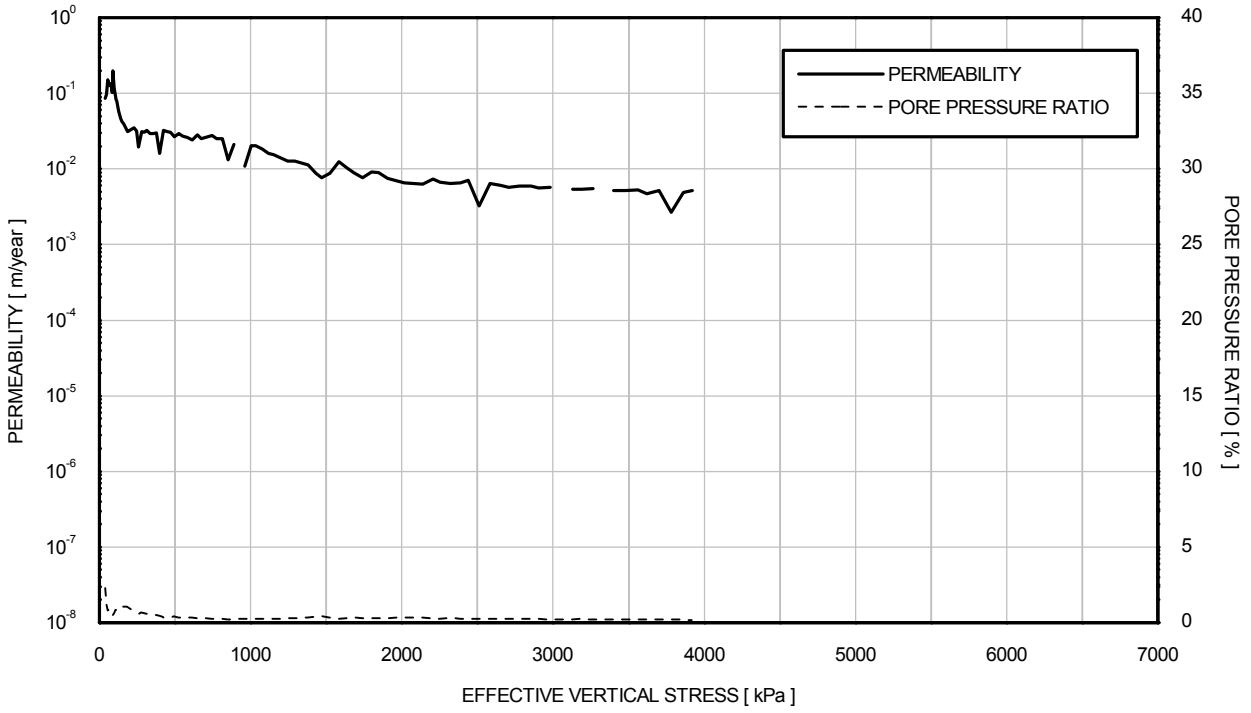
Borehole	Sample	Depth [m]
BH-WFS4-7	13WaxC	10.75

Initial void ratio	: 0.487
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.40 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-7	13WaxC	10.75

Initial void ratio	: 0.487
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.40 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark brown CLAY.

GENERAL	
Date test started	03/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.0
Length	[mm]	20.7
Moisture content	[%]	28.8
Bulk density	[Mg/m³]	1.95
Dry density	[Mg/m³]	1.51
Void ratio	[-]	0.785
Degree of saturation	[%]	99
Measured particle density	[Mg/m³]	2.70
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

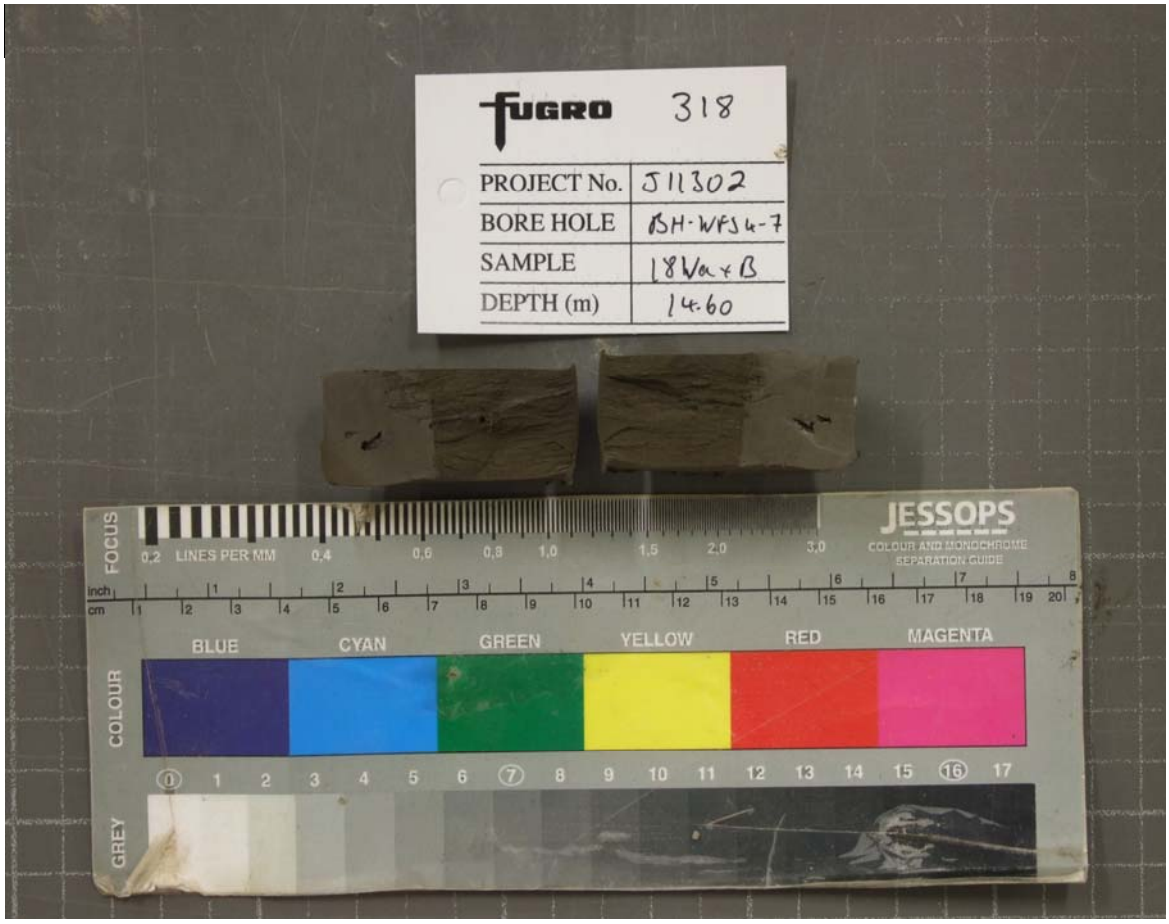
QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-7_18WaxB_crs
Template issue	9.0
Processed by	ALB
Date	18/11/2015
Checked by	PH
Date	19/11/2015
Approved by	
Date	

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	18WaxB
Depth [m]	14.70
Test Number	318

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

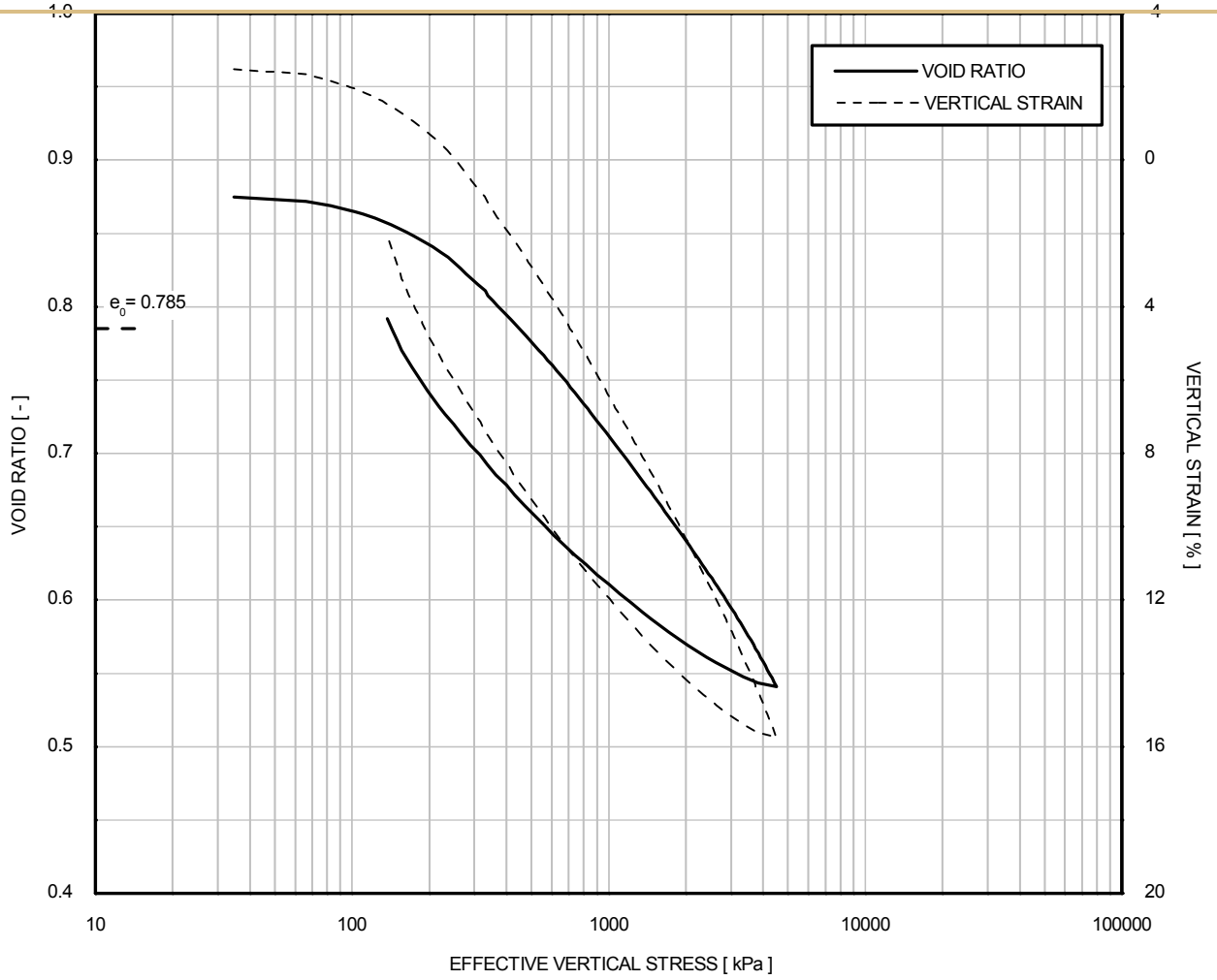
SPECIMEN PHOTOGRAPH

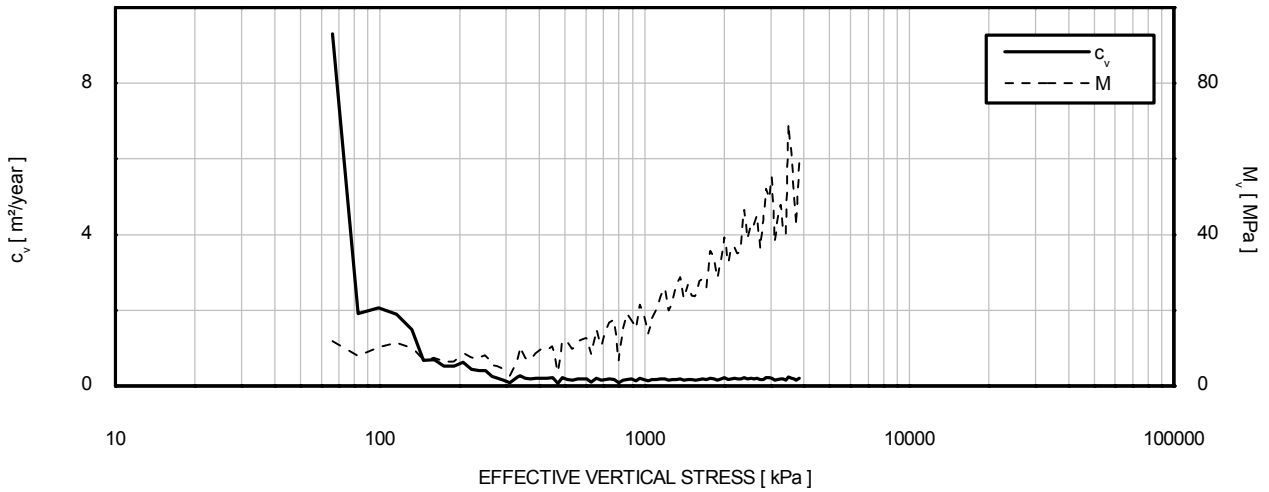


TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	18WaxB
Depth [m]	14.70
Test Number	318

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



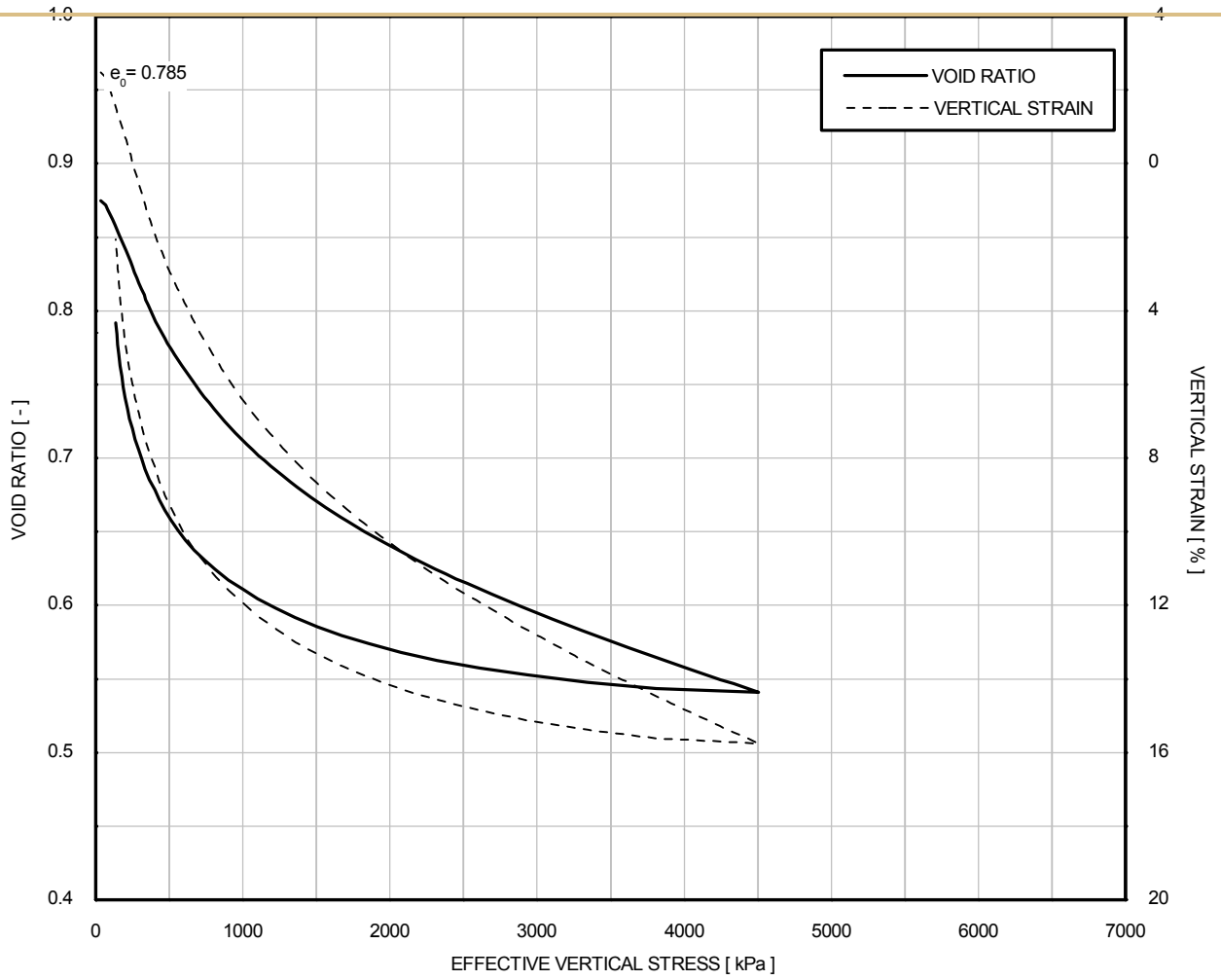


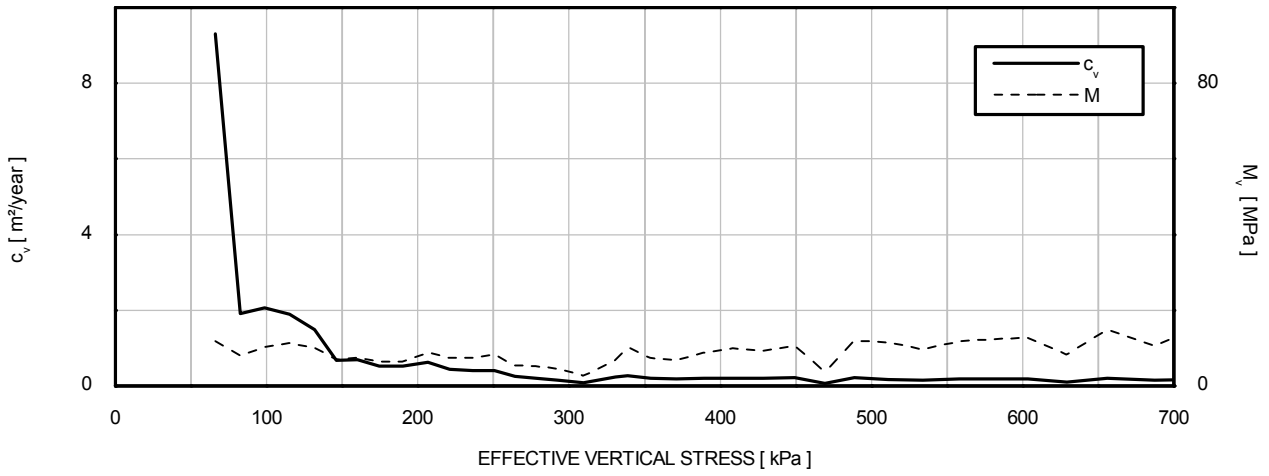
Borehole	Sample	Depth [m]
BH-WFS4-7	18WaxB	14.70

Initial void ratio	: 0.785
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.40 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



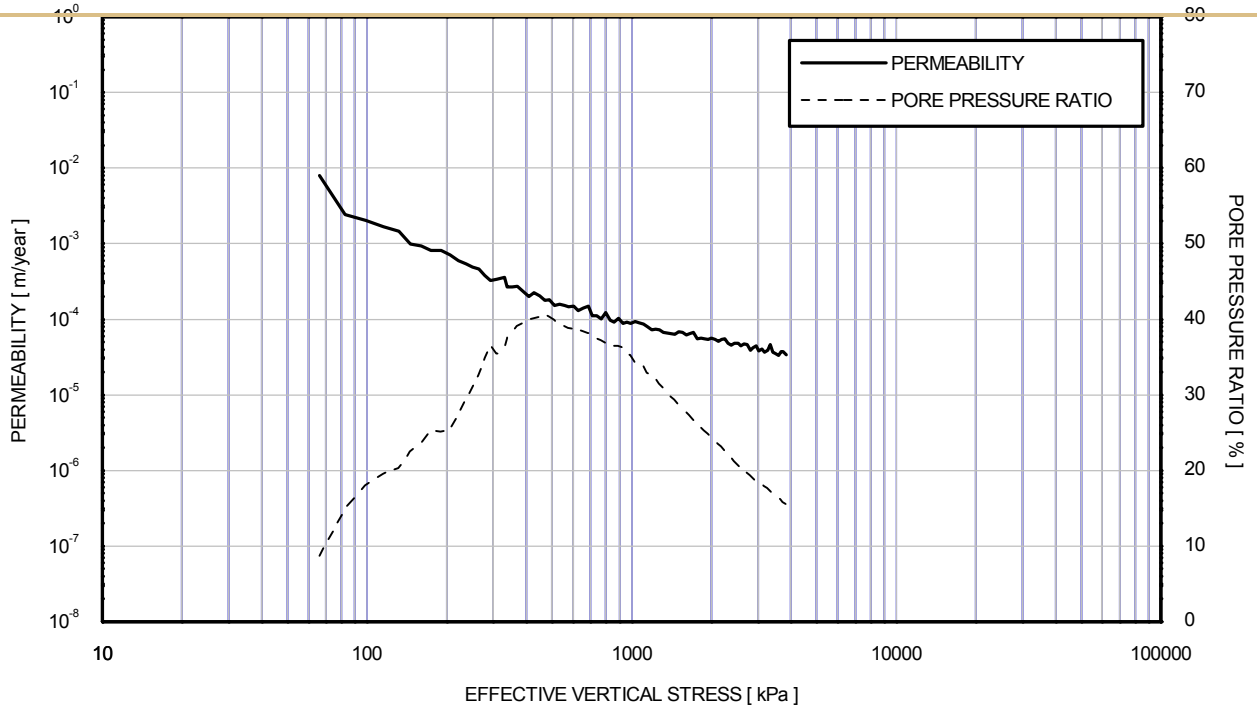


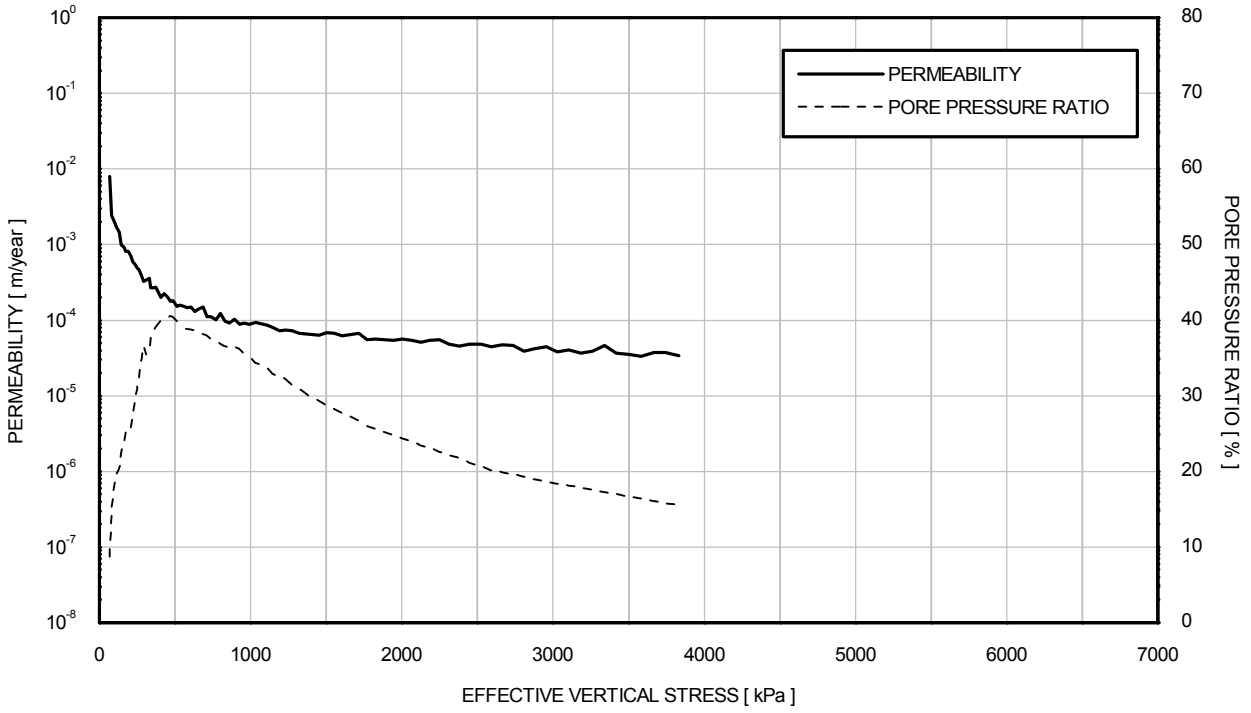
Borehole	Sample	Depth [m]
BH-WFS4-7	18WaxB	14.70

Initial void ratio	: 0.785
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.40 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
BH-WFS4-7	18WaxB	14.70

Initial void ratio	: 0.785
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.40 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey CLAY

GENERAL	
Date test started	04/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	50.1
Length	[mm]	20.8
Moisture content	[%]	33.1
Bulk density	[Mg/m³]	1.91
Dry density	[Mg/m³]	1.44
Void ratio	[-]	0.877
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Laboratory Temperature	[°C]	20

TESTING PROCEDURES USED	
Specimen set-up	Fugro procedure L-T-027 based on ASTM D4186-12.
Compression	Fugro procedure L-T-027 based on ASTM D4186-12.
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-7_22WaxB_crs
Template issue	9.0
Processed by	ALB
Date	24/11/2015
Checked by	PH
Date	26/11/2015
Approved by	
Date	

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxB
Depth [m]	23.12
Test Number	18

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

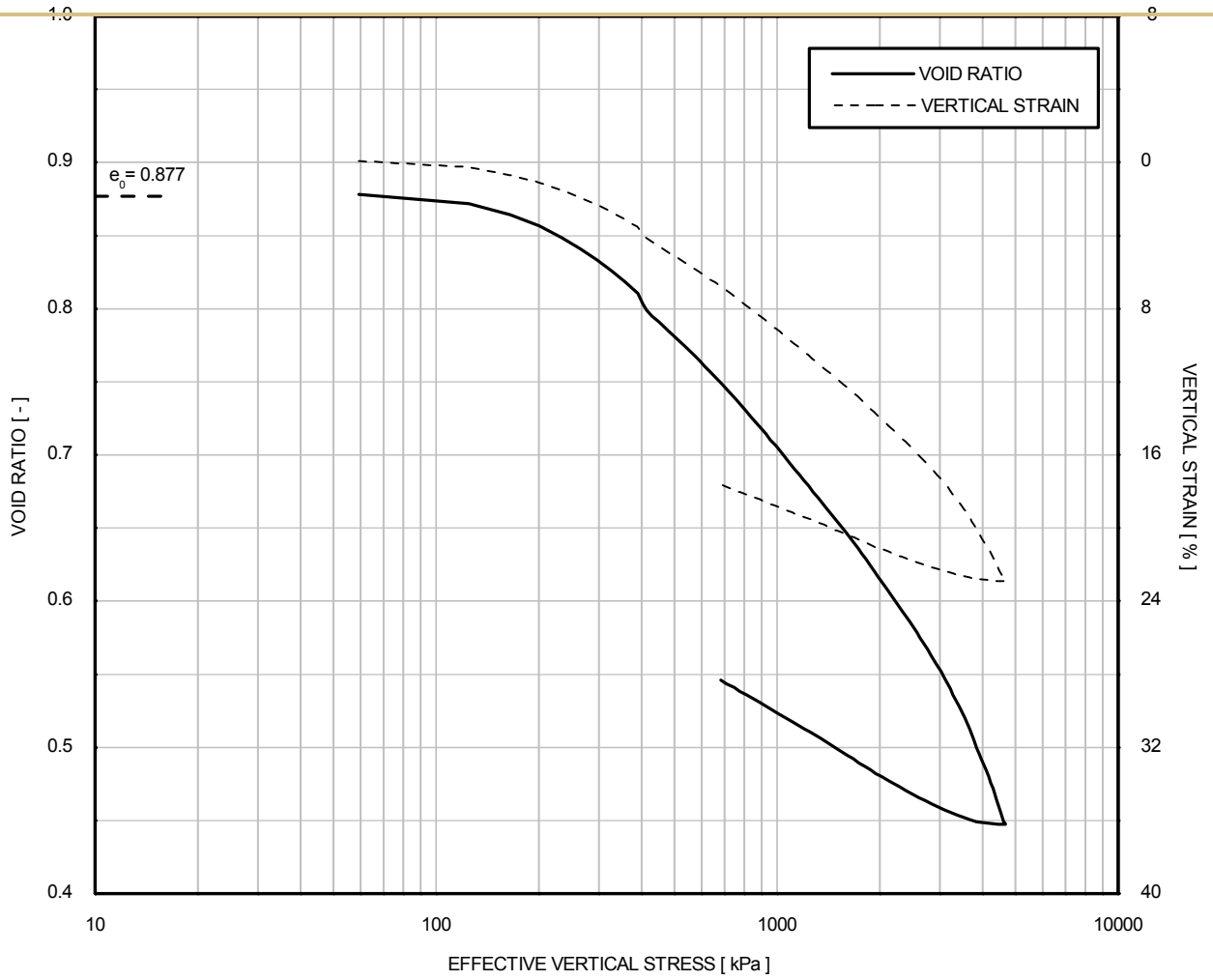
SPECIMEN PHOTOGRAPH

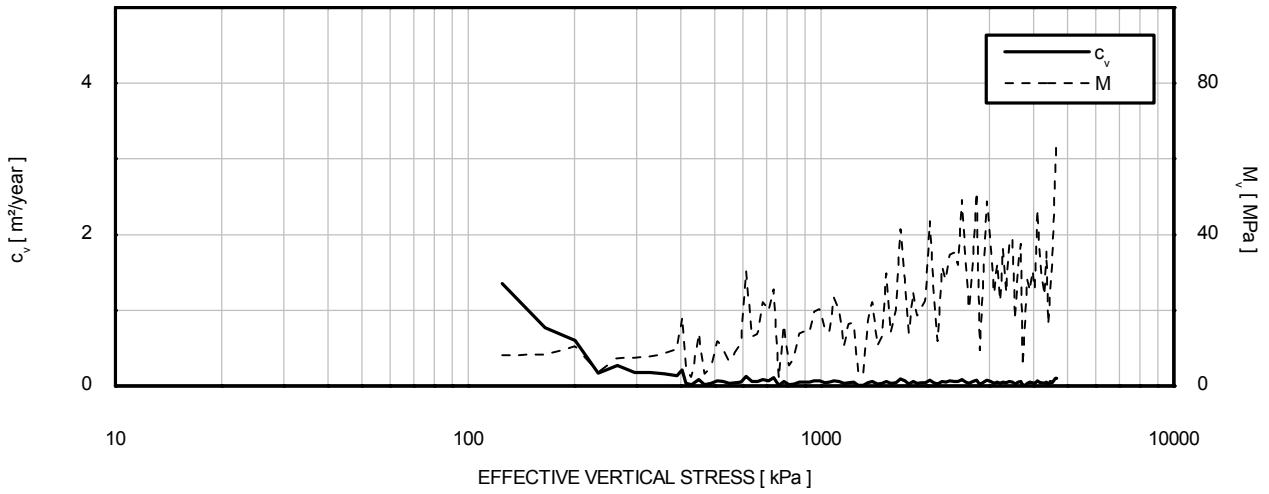


TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxB
Depth [m]	23.12
Test Number	18

ONE DIMENSIONAL - VERTICAL
CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



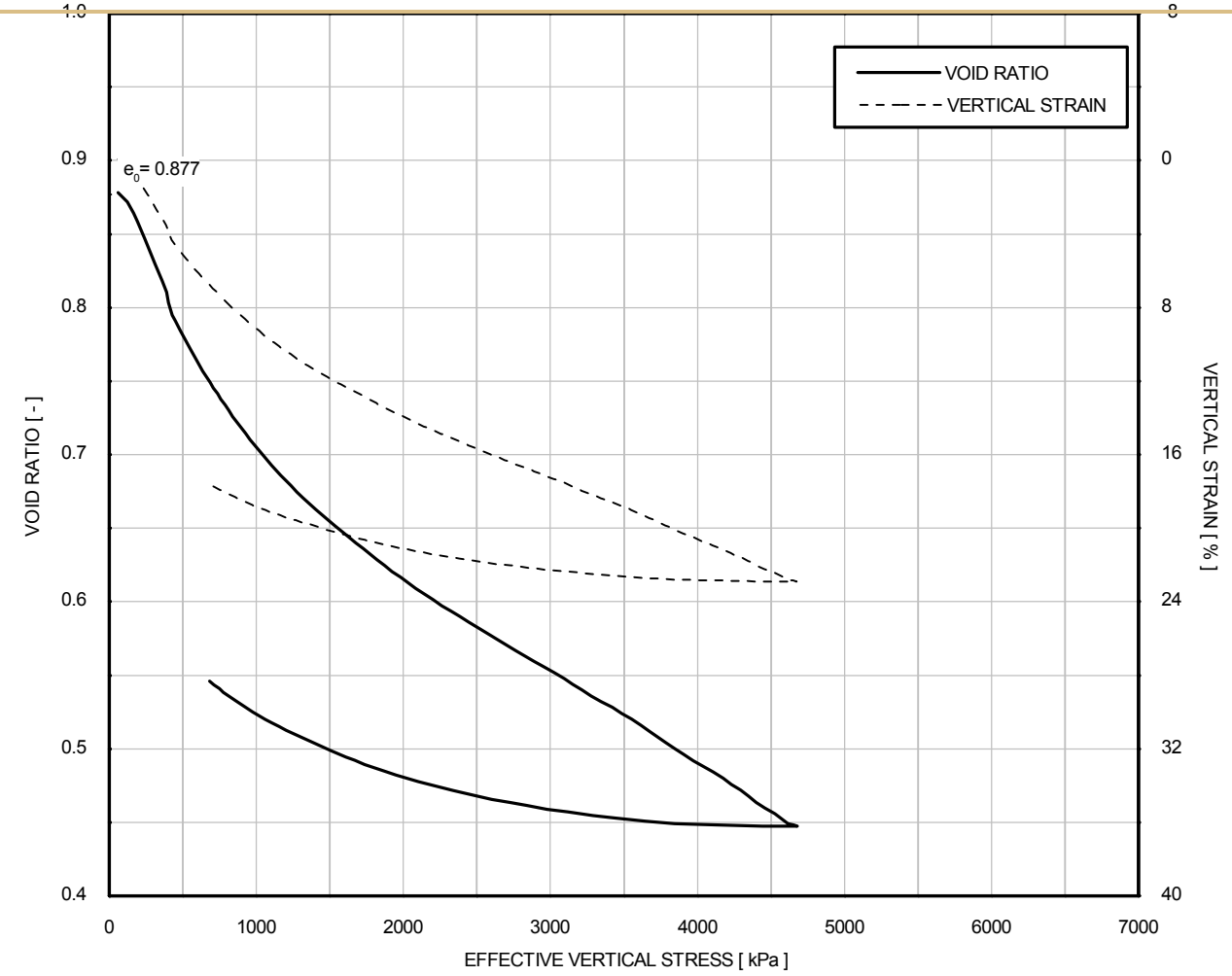


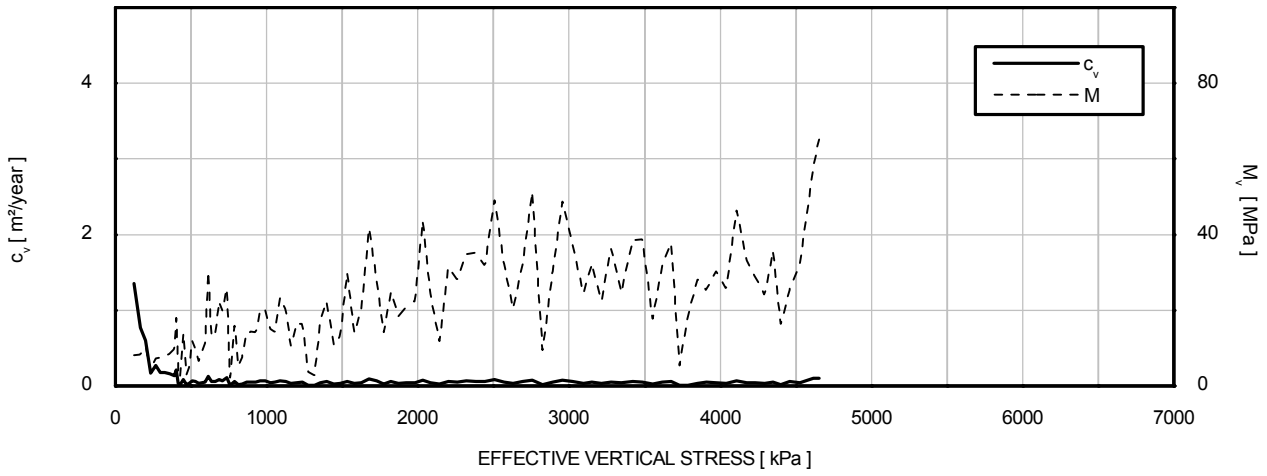
Borehole	Sample	Depth [m]
BH-WFS4-7	22WaxB	23.12

Initial void ratio	: 0.877
Particle Density	: 2.70 Mg/m^3
Strain rate (constant)	: 0.40 %/hour

ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA



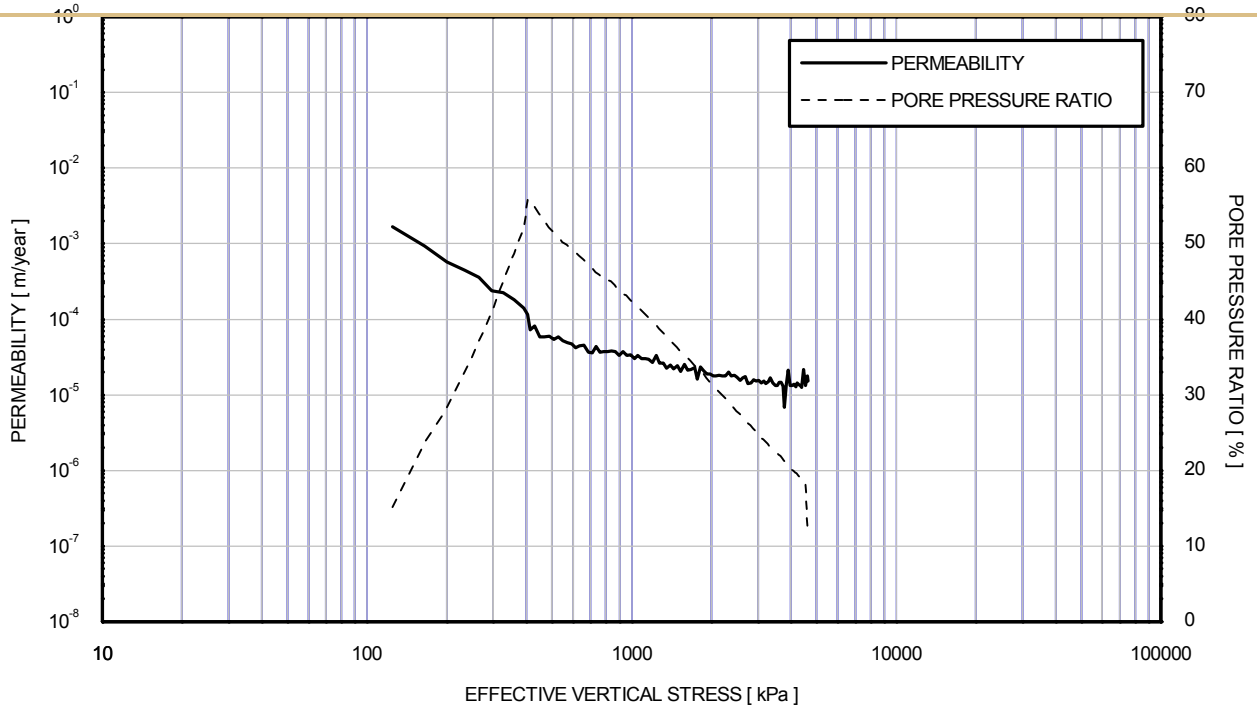


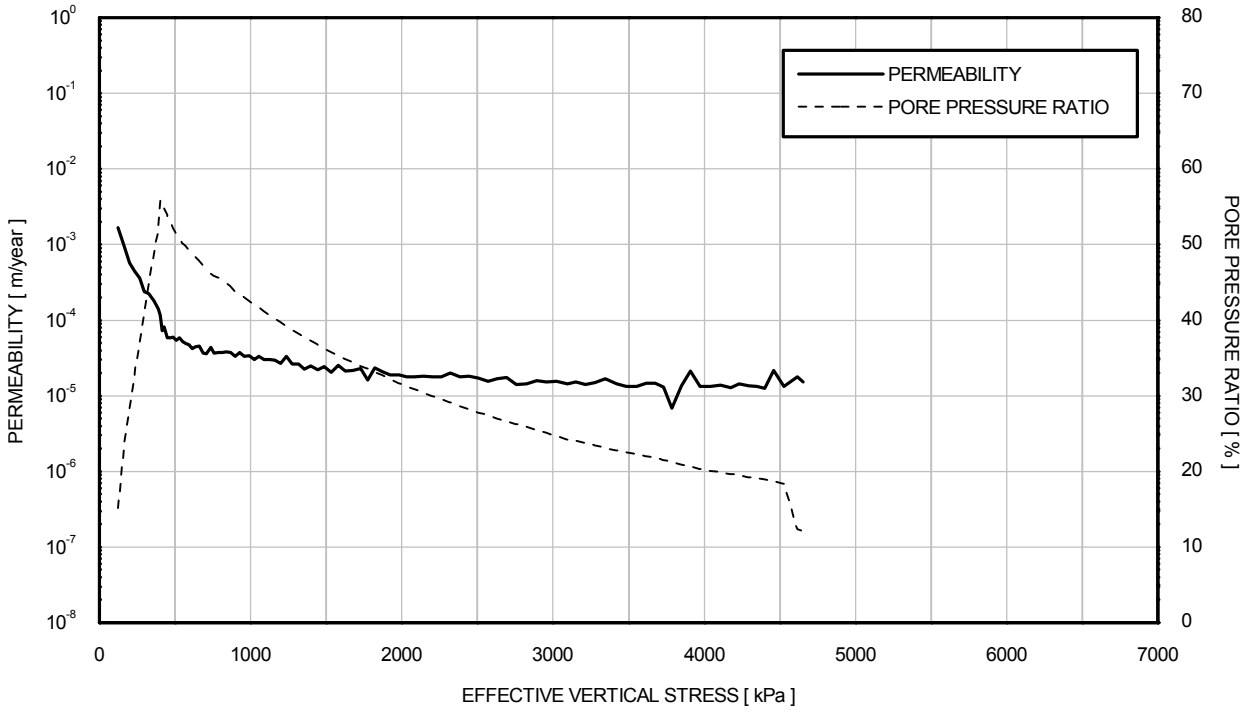
Borehole	Sample	Depth [m]
BH-WFS4-7	22WaxB	23.12

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ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA





Borehole	Sample	Depth [m]
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ONE DIMENSIONAL - VERTICAL CONTINUOUS LOADING OEDOMETER TEST (CRS)

BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA

SECTION D: GUIDELINES FOR USE OF REPORT

CONTENTS Reference

Guide for Use of Report FEBV/GEO/APP/077

INTRODUCTION

This document provides guidelines, recommendations and limitations regarding the use of information in this report.

The cost of geotechnical data acquisition, interpretation and monitoring is a small portion of the total cost of a construction project. By contrast, the costs of correcting a wrongly designed programme or mobilising alternative construction methods are often far greater than the cost of the original investigation. Attention and adherence to the guidelines and recommendations presented in this guide and in the geotechnical report can reduce delays and cost overruns related to geotechnical factors.

This guide applies equally to the use of geotechnical and multi-disciplinary project information and advice.

REQUIREMENTS FOR QUALITY GEOTECHNICAL INFORMATION

Fugro follows ISO 9001 quality principles for project management and ISO 2394 for general principles on reliability for structures. Project activities usually comprise part of specific phases of a construction project. The quality plan for the entire construction project should incorporate geotechnical input in every phase - from the feasibility planning stages to project completion. The parties involved should do the following:

- Provide complete and accurate information necessary to plan an appropriate geotechnical site investigation.
- Describe the purpose(s), type(s) and construction methods of planned structures in detail.
- Provide the time, financial, personnel and other resources necessary for the planning, execution and follow-up of a site investigation programme.
- Understand the limitations and degree of accuracy inherent in the geotechnical data and engineering advice based upon these data.
- During all design and construction activities, be aware of the limitations of geotechnical data and geotechnical engineering analyses/advice, and use appropriate preventative measures.
- Incorporate all geotechnical input in the design, planning, construction and other activities involving the site and structures. Provide the entire geotechnical report to parties involved in design and construction.
- Use the geotechnical data and engineering advice for only the structures, site and activities which were described to Fugro prior to and for the purpose of planning the geotechnical site investigation or geotechnical engineering analysis programme.

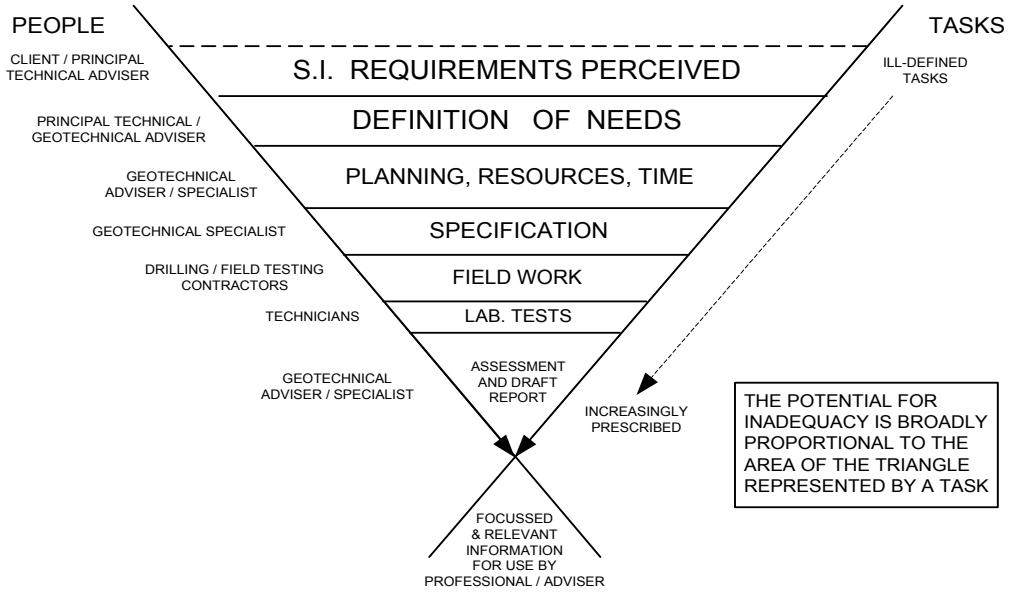
AUTHORITY, TIME AND RESOURCES NECESSARY FOR GEOTECHNICAL INVESTIGATIONS

Adequate designation of authority and accountability for geotechnical aspects of construction projects is necessary. This way, an appropriate investigation can be performed, and the use of the results by project design and construction professionals can be optimised.

Figure 1 illustrates the importance of the initial project phases for gathering adequate geotechnical information for a project. The initial phases, when site investigation requirements are defined and resources are allocated, are represented by more than 50% of the Quality Triangle (Figure 1). Decisions and actions made during these phases have a large impact of the outcome and thus the potential of the investigation to meet project requirements.

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Figure 1: Quality of Geotechnical Site Investigation (adapted from SISG[1]).



DATA ACQUISITION AND MONITORING PROGRAMMES

Geotechnical investigations are operations of discovery. Investigation should proceed in logical stages. Planning should allow operational adjustments deemed necessary by newly available information. This observational approach permits the development of a sound engineering strategy and reduces the risk of discovering unexpected hazards during or after construction.

GEOTECHNICAL INFORMATION – DATA TYPES AND LIMITATIONS

1. RELIABILITY OF SUPPLIED INFORMATION

Geotechnical engineering can involve the use of information and physical material that is publicly available or supplied by the Client. Examples are geodetic data, geological maps, geophysical records, earthquake data, earlier geotechnical logs and soil samples. Fugro endeavours to identify potential anomalies, but does not independently verify the accuracy or completeness of public or Client-supplied information unless indicated otherwise. This information, therefore, can limit the accuracy of the report.

2. COMPLEXITY OF GROUND CONDITIONS

There are hazards associated with the ground. An adequate understanding of these hazards can help to minimize risks to a project and the site. The ground is a vital element of all structures which rest on or in the ground. Information about ground behaviour is necessary to achieve a safe and economical structure. Often less is known about the ground than for any other element of a structure.

3. GEOTECHNICAL INVESTIGATION - SPATIAL COVERAGE LIMITATIONS

Geotechnical investigations collect data at specific test locations. Interpretation of ground conditions away from test locations is a matter of extrapolation and judgement based on geotechnical knowledge and experience, but actual conditions in untested areas may differ from predictions. For example, the interface between ground materials may be far more gradual or abrupt than a report indicates. It is not realistic to expect a geotechnical investigation to reveal or anticipate every detail of ground conditions. Nevertheless, an investigation can reduce the residual risk associated with unforeseen conditions to a tolerable level. If ground problems do arise, it is important to have geotechnical expertise available to help reduce and mitigate safety and financial risks.

1 Site Investigation Steering Group SISG (1993), “Site Investigation in Construction 2: Planning, Procurement and Quality Management”, Thomas Telford, London.

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4. ROLE OF JUDGEMENT AND OPINION IN GEOTECHNICAL ENGINEERING

Geotechnical engineering is less exact than most other design disciplines, and requires extensive judgement and opinion. Therefore, a geotechnical report may contain definitive statements that identify where the responsibility of Fugro begins and ends. These are not exculpatory clauses designed to transfer liabilities to another party, but they are statements that can help all parties involved to recognise their individual responsibilities and take appropriate actions.

COMPLETE GEOTECHNICAL REPORT SHOULD BE AVAILABILE TO ALL PARTIES INVOLVED

To prevent costly construction problems, construction contractors should have access to the best available information. They should have access to the complete original report to prevent or minimize any misinterpretation of site conditions and engineering advice. To prevent errors or omissions that could lead to misinterpretation, geotechnical logs and illustrations should not be redrawn, and users of geotechnical engineering information and advice should confer with the authors when applying the report information and/or recommendations.

GEOTECHNICAL INFORMATION IS PROJECT-SPECIFIC

Fugro's investigative programmes and engineering assessments are designed and conducted specifically for the Client described project and conditions. Thus this report presents data and/or recommendations for a unique construction project. Project-specific factors for a structure include but are not limited to:

- location
- size and configuration of structure
- type and purpose or use of structure
- other facilities or structures in the area.

Any factor that changes subsequent to the preparation of this report may affect its applicability. A specialised review of the impact of changes would be necessary. Fugro is not responsible for conditions which develop after any factor in site investigation programming or report development changes.

For purposes or parties other than the original project or Client, the report may not be adequate and should not be used.

CHANGES IN SUBSURFACE CONDITIONS AFFECT THE ACCURACY / SUITABILITY OF THE DATA

Ground is complex and can be changed by natural phenomena such as earthquakes, floods, seabed scour and groundwater fluctuations. Construction operations at or near the site can also change ground conditions. This report considers conditions at the time of investigation. Construction decisions should consider any changes in site conditions, regulatory provisions, technology or economic conditions subsequent to the investigation. In general, two years after the report date, the information may be considered inaccurate or unreliable. A specialist should be consulted regarding the adequacy of this geotechnical report for use after any passage of time.

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APPENDIX 1: DESCRIPTIONS OF METHODS AND PRACTICES

CONTENTS Reference

Geotechnical Borehole	FEBV/GEO/APP/002
Soil Description	FEBV/GEO/APP/005
Geotechnical Laboratory Tests	FEBV/GEO/APP/007
Cone Penetration Test	FEBV/GEO/APP/001
Cone Penetration Test Interpretation	FEBV/GEO/APP/012
Seismic Downhole Test	FEBV/GEO/APP/032
In Situ Pore Pressure Dissipation Test	FEBV/GEO/APP/033
Metrological Confirmation System for In Situ Test	FEBV/GEN/APP/001
Symbols and Units	FEBV/GEO/APP/017

This appendix presents method statements and terminology that are generally familiar to expert users of the information

INTRODUCTION

This document describes borehole activities for a geotechnical project. The activities comprise borehole drilling and, optionally (1) in situ testing in borehole and/or (2) sampling and sample handling.

The common drilling techniques for onshore and nearshore projects are:
- Open-hole drilling: a drilling method whereby all material within the diameter of the borehole is cut, such as open-hole rotary drilling, cable percussion drilling and auger drilling.
- Open-hole rotary drilling: an open-hole drilling method whereby ground at the bottom of the borehole is cut by a drill bit rotated on the bottom of a borehole, and drill fluid is pumped down to the drill bit through the hollow drill pipe.
- Cable percussion drilling: an open-hole drilling method whereby ground at the bottom of the borehole is broken up by percussive action of a bailer, clay cutter or chisel, and brought to the surface by the bailer or clay cutter.
- Auger drilling: an open-hole drilling method whereby ground at the bottom of the borehole is cut and brought to the surface by auger flights.
- Core drilling: a rotary drilling method that cuts out cylindrical ground samples.

The common drilling techniques for an offshore project are open-hole rotary drilling and core drilling. Offshore core drilling is by either piggyback or by downhole system. Piggyback core drilling uses drilling techniques whereby the drill pipe for open-hole rotary drilling acts as drill casing and as support for the drill rig. Downhole core drilling uses a core barrel that latches in a bottomhole assembly for open-hole rotary drilling.

A wide range of in situ tests is available for boreholes. Examples are the Pore Pressure Dissipation Test (PPDT), Vane Shear Test (VST), Thermal Conductivity Test (TCT) and Cone Penetration Test (CPT). This document describes such tests as an integral part of borehole activities, but gives no test details. Separate descriptions apply, if appropriate.

The common sampling techniques are drive sampling and/or push sampling of an open-tube sampler, and push sampling in case of a piston sampler. Sampling of cuttings from drilling may be feasible for some types of drilling techniques.

Borehole activities are based on ISO, CEN, BSI and ASTM standards.

DRILLING APPARATUS

GENERAL

Descriptions of common borehole drilling apparatus are as follows:
- Drilling Equipment: any equipment that provides a suitably clean open hole before insertion of downhole sampling and/or testing apparatus and ensures that sampling and/or testing is performed in undisturbed ground.
- Drill Rig: machine capable of providing:
  - rotation, feed and retraction to drill pipe, casing and/or auger,
  - drill fluid pumping capacity, as required,
  - sampler or test apparatus insertion.
- Drill Casing: cylindrical pipe with one or more of the following purposes:
  - to support the sides of a borehole,
  - to support drill pipe above ground surface in case of over-water drilling,
  - to promote return of drilling fluid.
- Drill Pipe: cylindrical pipe connecting drill rig and drill bit.
- Drill Collar: thick-walled drill pipe providing self-weight thrust for the drill bit.
- Drill Bit: device attached to drill pipe and used as a cutting tool to drill into the ground.
- Core Bit: device attached to a rotary core sampler and used as a cutting tool to drill into the ground.
- Core Catcher: device that assists retention of core in the core barrel.
- Core Box: box with longitudinal separators for the protection and storage of (core) sample.
- Bottom Hole Assembly: lower section of offshore drill pipe and drill bit, shaped to permit latching of downhole in situ testing and sampling apparatus.

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An optional activity for rotary drilling is analogue or digital recording of MWD (Measure-While-Drilling) parameters, such as penetration rate, torque and drill fluid pressure.

CORING

Core drilling is a ground investigation technique comprising simultaneous drilling and sampling. Descriptions of apparatus are as follows:

- Single Tube Core Barrel: hollow steel tube with a head at the upper end threaded for drill pipe, and a threaded connection for the core bit at the lower end.
- Double Tube Core Barrel: assembly of two concentric steel tubes joined at the upper end by means of a swivel arranged to permit rotation of the outer tube without causing rotation of the inner tube; the upper end of the outer tube is threaded for drill pipe and the lower end is threaded for the core bit.
- Double Tube Core Barrel with Retrievable Inner Tube: double tube core barrel that permits retrieval of the core-laden inner tube assembly to the surface through matching drill pipe without the need for withdrawal of the drill pipe.
-

OFFSHORE OPERATIONS

Offshore drilling can require additional apparatus, in particular when drilling from a vessel:

- Seabed Reaction Frame: seafloor-based apparatus capable of providing one or more of the following:
  - improved horizontal and vertical control of the drill pipe
  - re-entry of a borehole by drill pipe after earlier retraction
  - vertical reaction for the drill pipe during downhole testing and sampling
  - vertical reaction for hard-tie rigging.
- Heave Compensator: apparatus to compensate the drill pipe for vertical motion of a drill rig mounted on a vessel.
- Hard-tie Rigging: special rigging system incorporating a seabed reaction frame and a heave compensator, for heave-compensated drilling with low drill bit load and/or increased depth control of the drill bit.

SAMPLING APPARATUS

DRIVE SAMPLING

- Drive-Weight Assembly: Device consisting of hammer, hammer fall guide, anvil and hammer drop system.
- Hammer: impact mass, which is successively lifted and dropped to provide the energy that accomplishes sampler penetration.
- Hammer Fall Guide: guide arrangement for the fall of the hammer.
- Anvil: drive-head which the hammer strikes and through which the hammer energy passes into the sampling rods.
- Hammer Drop System: pick-up and release mechanism by which lifting and dropping of the hammer is accomplished.
- Cathead: rotating drum in a rope-cathead hammer drop system around which a rope is wrapped to lift and drop the hammer by successively tightening and loosening the rope turns around the drum.
- Self-Tripping Release: hammer drop system that ensures a free fall of the hammer after lifting by a cable or rope.
- Free-Fall Winch: hammer drop system that permits a free release of the rotating drum of the winch around which a cable is wrapped to lift and drop the hammer.
- Hydraulic Percussion: hammer drop system that provides rapid impact hammer blows by fluid flow.
- Sampling Rods: rods that connect the drive-weight assembly to the sampler head.

PUSH SAMPLING APPARATUS

- Sampler Insertion Equipment: apparatus providing relatively rapid continuous penetration force.
- Reaction Equipment: reaction for the sampler insertion equipment.
- Sampling Rods: rods that connect the sampler insertion equipment to the sampler head.

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SAMPLER

- Open-Tube Sampler: sampler with tube that is open at one end and fitted to the sampler head at the other end.
- Piston Sampler: sampler with close-fitting sliding piston that is held stationary during penetration of a sample tube into the ground.
- Rotary Core Sampler:
  - Single Tube Core Barrel: hollow steel tube with a head at the upper end threaded for drill pipe, and a threaded connection for the core bit at the lower end.
  - Double Tube Core Barrel: assembly of two concentric steel tubes joined at the upper end by means of a swivel arranged to permit rotation of the outer tube without causing rotation of the inner tube; the upper end of the outer tube is threaded for drill pipe and the lower end is threaded for the core bit.
  - Double Tube Core Barrel with Retrievable Inner Tube: double tube core barrel that permits retrieval of the core-laden inner tube assembly to the surface through matching drill pipe without the need for withdrawal of the drill pipe.
- Sampler Head: coupling between sampling rods and sample tube, and containing a non-return valve to allow free exit of water and air above sample.
- Sample Tube: cylindrical tube with cutting edge or cylindrical tube fitted with separate cutting shoe.
- Liner: cylindrical plastic tube inserted in a sampler to preserve sample and reduce friction.
- Thin-Walled Sample Tube: sample tube with area ratio of less than 15% and inside clearance ratio of less than 1%.
- Thick-Walled Sample Tube: sample tube not meeting the requirements of a thin-walled sample tube.
- Core Catcher: device that assists retention of the sample in the sampler.
- Cutting Shoe: replaceable tapered cutting edge of sample tube to allow use of core catcher and the selection of inside clearance ratio and/or area ratio.
- Stroke length: maximum achievable sample length.

Table 1 shows dimensions of common samplers.

TABLE 1 - DIMENSIONS OF SAMPLERS

Sampler type	Inside diameter D_1 [mm]	Outside diameter D_2 [mm]	Inside diameter D_3 [mm]	Wall thickness [mm]	Area ratio A_r [%]	Inside clearance ratio C_r [%]	Stroke length [mm]
Thin-walled 3 inch tube	72.0	76.0	72.0	2.0	10.2	0.0	950
Thin-walled 5^o – 10^o tube	72.0	76.0	72.0	2.0	10.2	0.0	950
Thick-walled 3 inch tube	72.0	80.0	72.0	4.0	19.0	0.0	950
Thin-walled 2 inch tube	54.0	57.0	54.0	1.5	10.2	0.0	950 and 570
Thick-walled 2 inch tube	53.0	60.3	53.1	3.6	22.7	0.2	570
Piston Sampler(1)	72.0	76.0	72.0	2.0	10.2	0.0	845
3 meter EP Piston Sampler(1)	66.0	80.0	67.0	2.6	31.3	1.5	3000
Hammer Sampler 2 inch splitspoon	40.0	51.0	41.0	5.0	38.5	2.5	600
Rotary Core Sampler(7)	62.5	85.0	63.6	4.1	44.0	1.8	3000

Notes
1. Tool can be assembled with liners and a range of cutting shoes; D_1, D_2, D_3, A_r and C_r can be varied.
2. D_1 = inside diameter of cutting shoe.
3. D_2 = outside diameter of sample tube and/or cutting shoe.
4. D_3 = inside diameter of the flush portion of the sampler or liner.
5. "Length" dimension considers manufactured length. Re-use of a sampler may lead to shortening, for example to reshape cutting edge.
6. Thin walled 5^o - 10^o tube is equivalent to conventional thin-walled 3 inch tube except for specially machined cutting edge with 5^o and 10^o taper to reduce sampling disturbance.
7. Fugro Marine Core Barrel

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The definitions of area ratio and inside clearance ratio are as follows:

Area Ratio: Indication of volume of ground displaced by the sample tube, calculated as follows:

$$A_r = [(D_2^2-D_1^2)/D_2^2] \times 100$$

where:
A_r = area ratio expressed as percentage
D_2 = outside diameter of the sample tube and/or cutting shoe
D_1 = inside diameter of the cutting shoe.

Inside Clearance Ratio: Indication of clearance of sample inside the sample tube, calculated as follows:

$$C_r = [(D_3-D_1)/D_1] \times 100$$

where:
C_r = inside clearance ratio expressed as percentage
D_3 = inside diameter of the flush portion of the sample tube or liner
D_1 = inside diameter of the cutting shoe.
The worst case of manufacturing tolerances applies for calculation of C_r.

PROCEDURE

Figure 1 summarises the procedure for boreholes. The procedure includes several stages, as follows:

BOREHOLE SET-UP STAGE

- assignment of borehole details such as location, target borehole depth, types of apparatus, sequence of sampling
- positioning of drill rig at assigned location
- selection of drilling, sampling or in situ testing stage.

The subsequent stage is one of the following:

DRILLING STAGE

- open-hole or core drilling
- borehole logging, such as drill bits and drill fluids used, borehole size and depth, drilling observations
- borehole water level, where practicable
- selection of subsequent drilling, sampling or in situ testing stage.

- selection of subsequent drilling, sampling or in situ testing stage.

IN SITU TESTING STAGE

- in situ test
- logging, such as test depth and test parameters
- selection of subsequent drilling stage.

SAMPLING STAGE

- sampling
- logging, such as sample depth and sample inspection at the time of sampling
- sample handling
- selection of subsequent drilling stage.

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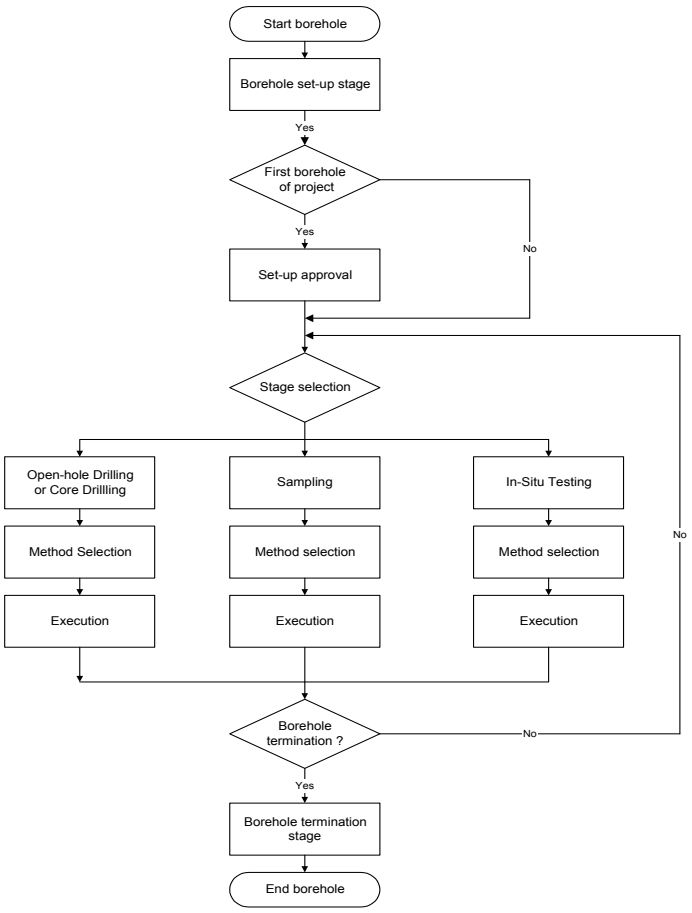


Figure 1 - Flow chart

BOREHOLE TERMINATION STAGE

- termination of borehole
- backfilling of borehole, if appropriate
- data processing.

Set-up requires a reasonably flat, accessible, ground surface with a slope of 5^{o} or less. In other cases, set-up is at discretion of equipment operator, considering risks such as damage to apparatus or safety of personnel. Most onshore drilling systems have levelling facilities allowing a vertical start of drilling. Seabed reaction frames used for offshore drilling activities typically have no levelling facilities. Drill pipe passage through a seabed reaction frame must be (near-)vertical.

The sampling stage may result in no-recovery or partial recovery of a sample due to unfavourable conditions for the deployment of a particular sampler. A subsequent sampling event at the same depth or immediately below the initial sampling depth is a separate sampling activity, unless specifically agreed otherwise or unless no specific evidence shows departure from the agreed procedure for the earlier activity.

Criteria for borehole termination are as follows, unless specifically agreed otherwise:

- as instructed by Client
- reaching target penetration
- drilling progress rate of less than 1m/hour based on half-hourly observation
- circumstances at discretion of system operator, such as risk of damage to apparatus or safety of personnel

whichever occurs first and as applicable.

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RESULTS

GEOTECHNICAL LOG

The geotechnical log or borehole log contains the geotechnical descriptions of the encountered strata, and the borehole water level measurements, if applicable. In addition, it may include the principal details of the borehole operational activities.

The penetration depth of a (vertical) borehole is defined as the deepest point reached by drilling, sampling or in situ testing. The recovery depth of a borehole is the deepest point for which sample or test data are presented.

Unless indicated otherwise, recovery of a tube sample or a core sample is assumed to be continuous from the starting depth of sampling. In other words, the geotechnical log ignores possible plugging, flow-in and/or wash-out.

MWD PARAMETERS

Optional presentation of MWD parameters for rotary drilling is usually in graphical format. Interpretation of MWD parameters can help characterisation of ground conditions such as cemented strata, weak rock and formations with cavities.

GEOTECHNICAL DESCRIPTION

The geotechnical description, including the strata boundaries, is an interpretation of the processed data available at the time of the preparation of the geotechnical log. Subsequent processing and integration of supplementary ground investigation data may require adjustment of the log. Supplementary information can include:

- geological information
- geophysical data
- results of nearby boreholes and in situ tests
- laboratory test results
- analysis of drilling parameters such as torque, feed, drill fluid pressure and drilling time.

Level of detail and accuracy in geotechnical description depend on factors such as sample size, quality, coverage of samples and test data, availability of supplementary information, and project requirements. For example, geotechnical descriptions prepared for the purpose of a pile foundation may differ from those prepared for a pipeline.

Any graphical presentation of test results considers values within the scale limits only. No automatic scaling applies, unless indicated otherwise.

WATER LEVEL

Water level measurements taken in boreholes can be valuable. Interpretation of water levels requires due caution. They may or may not be representative of the ground water levels. In any case, water levels apply to the time and date of the measurements only. They will vary due to seasonal and other environmental influences, including construction activities.

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SAMPLE QUALITY

Additional documentation of borehole operational activities can include further details on drilling, sampling and in situ testing. In particular, details of sampling techniques and samplers can be important for the evaluation of the results of laboratory tests.

An example is the open-tube sampler fitted with a thin-walled sample tube of 50 mm to 100 mm diameter. The sample quality (BSI, 1999) is typically undisturbed, Class 2, for very soft fine-grained soil and Class 1 for firm to very stiff fine-grained soil. The sample quality for coarse-grained soils is typically disturbed, Class 3. For a thick-walled sample tube, the sample quality for fine-grained soil is typically one class worse than for a thin-walled tube. A piston sampler with a thin-walled sample tube allows Class 1 sample quality for very soft fine-grained soil.

The classification system for sample quality recognises 5 classes on the basis of feasibility of specific geotechnical identification and laboratory tests. A summary of these classes is as follows:
Class 1: undisturbed: strength, stiffness and consolidation
Class 2: undisturbed: layering, permeability, unit weight
Class 3: disturbed: water content
Class 4: disturbed: particle size analysis, Atterberg limits, soil type
Class 5: disturbed: stratigraphy
The higher class includes the laboratory tests of the lower classes.

Comments on Class 1 and Class 2 fine-grained soil samples are as follows:

- Some sample disturbance is inevitable because of the required sampling process and subsequent on-site and laboratory sample handling.
- Silt soil is more sensitive to disturbance than clay soil.
- Sample disturbance typically increases with increasing total stress conditions applicable to the in situ soil. Negative pore pressures develop after sampling, upon reduction of total stresses. The resulting effective stresses within the sample cause sample disturbance. Sample disturbance may thus increase with sampling depth or with increasing water depth for offshore boreholes.
- Reduction in water pressure occurring after sampling causes a change in equilibrium between dissolved gasses, gas bubbles and gas hydrates, where present. The amount of gas release increases with water pressure. This may result in increased sample disturbance, in particular for deep-water sites.

ASTM International (2008) provides descriptions for rock core quality as follows:
TCR Total Core Recovery: the total core length divided by the core run length
SCR Solid Core Recovery: the total length of the pieces of solid core that have a complete circumference divided by the core run length
RQD Rock Quality Designation: the total length of the pieces of sound core over 100 mm long along the centreline divided by the core run lengths per stratum or core run; sound core includes core with obvious drilling breaks
I_F Fracture Index: spacing of natural discontinuities.

Table 2 shows a classification of rock quality according to ASTM International (2002b).

TABLE 2 CLASSIFICATION OF ROCK QUALITY

RQD	Classification of Rock Quality
0 to 25%	Very poor
25 to 50%	Poor
50 to 75%	Fair
75 to 90%	Good
90 to 100%	Excellent

Sample quality may change with time and storage conditions. The type of soil or rock will influence the degree of change. For example, exposure to air may initiate chemical processes, such as rapid oxidisation of organic soil.

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SYMBOLS

The geotechnical log contains a graphic log of the ground conditions. Figures 2 through 4 present details for soils, cementation degrees and rocks. In addition, the geotechnical log may show specific symbols for sampling and in situ testing. Figure 5 presents details.

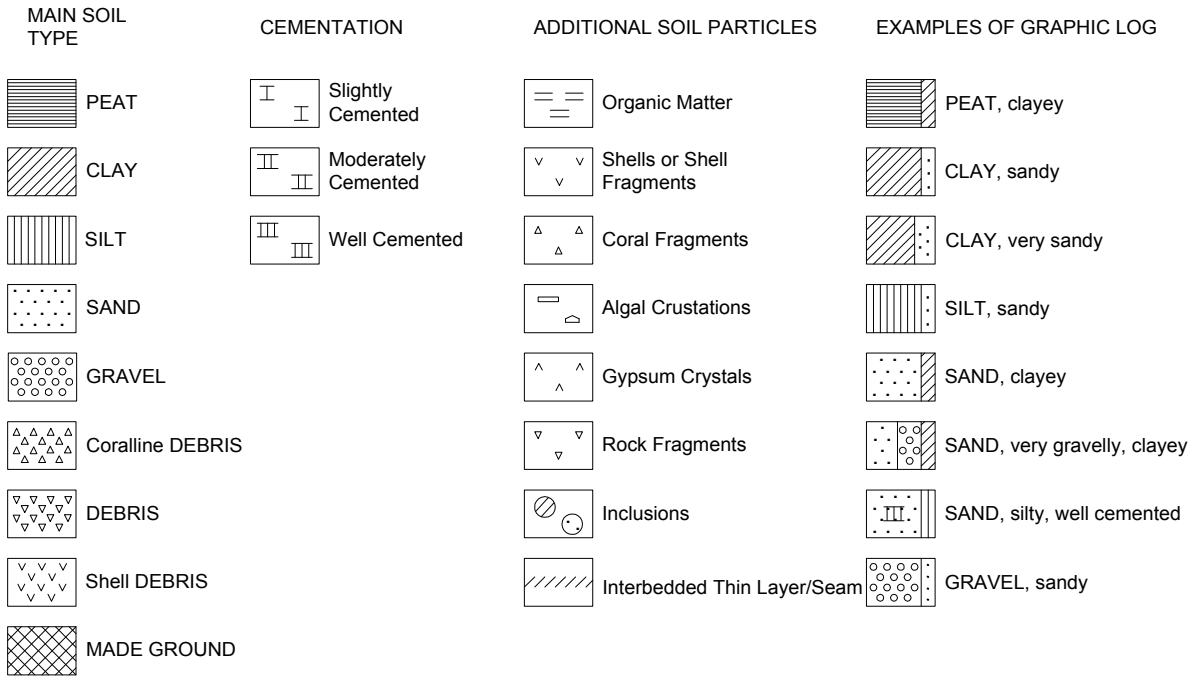


Figure 2 - Symbols for soils

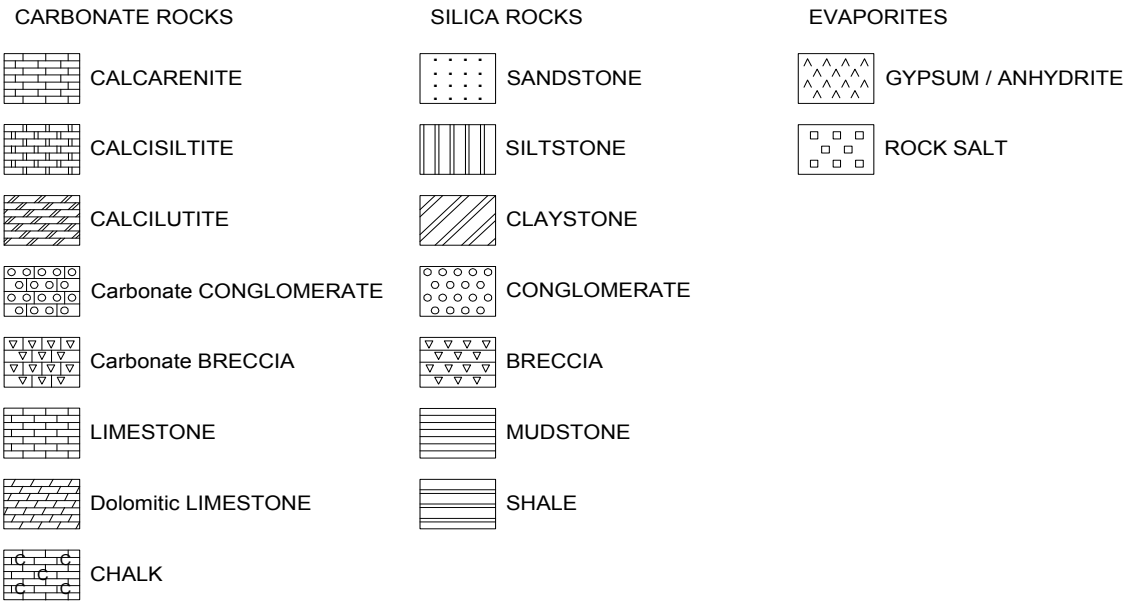


Figure 3 - Symbols for sedimentary rocks

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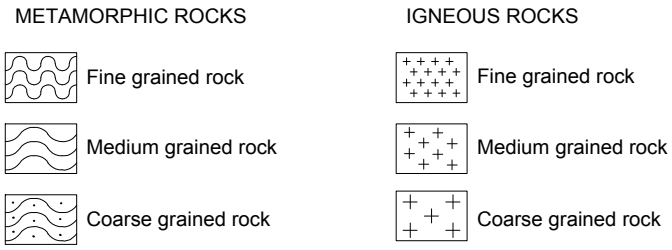


Figure 4 - Symbols for metamorphic and igneous rocks

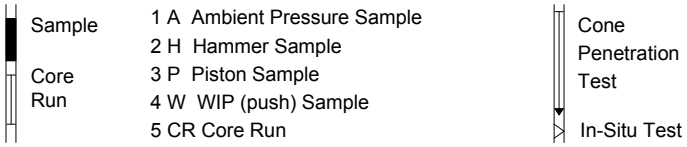


Figure 5 - Symbols for identification of samples and in situ tests

REFERENCES

ASTM International (2014), “Standard Practices for Preserving and Transporting Soil Samples", ASTM D4220 / D4220M-14.

ASTM International (2011), "Standard Test Method for Standard Penetration Test (SPT) and Split Barrel Sampling of Soils", ASTM D1586-11.

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ASTM International (2013), “Standard Practices for Handling, Storing and Preparing Soft Undisturbed Marine Soil", ASTM D3213-13.

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BSI British Standards Institution (1999), "Code of Practice for Site Investigations", British Standard BS 5930:1999+A2:2010

CEN European Committee for Standardization (2007), “Eurocode 7 - Geotechnical Design – Part 2: Ground Investigation and Testing”, European Standard EN 1997-2:2007.

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INTRODUCTION

Fugro employs a range of industry-standard systems for soil description, with additional refinements. The more important systems are:

- British Standard 5930 (BS, specifically Section 6 Paragraphs 41 to 43 on Description of soils) published in 1999.
- American Society for Testing and Materials (ASTM) Standards D 2487-11 (Classification of soils for Engineering Purposes) and D 2488-09a (Description and Identification of Soils – Visual-Manual Procedure).
- International Standard ISO 14688-1:2002 (Geotechnical Investigation and Testing - Identification and Classification of Soil: Identification and Description) and International Standard ISO 14688-2:2004 (Principles for a Classification).
- International Standard ISO 19901-8:2014 (Marine Soil Investigations).

The standards are similar, as they are (1) based on the Unified Classification System (Casagrande, 1948), (2) rely on a range of relatively simple visual and manual observations and (3) classify soils according to particle-size distribution and plasticity. Laboratory particle-size distribution and Atterberg limits tests are used to confirm the observations. In addition, the standards include organic soils characterization under soil particle type description.

Significant differences between the standards include the particle-size boundaries and the degree to which plasticity is used as a basis for description. Other differences include the format and order of the soil description.

This document describes a convention that is consistent with either the BS or ASTM standard, and that produces soil descriptions, which can be converted to the other standard. In addition, to describe calcareous soils, Fugro has integrated the carbonate classification system outlined by Clark and Walker (1977) with both British Standard and ASTM systems (Landva et al., 2007). No further information is given about the ISO standards.

British Standard and ASTM systems apply primarily to common terrestrial soils in temperate climates. However, construction activities in coastal areas and offshore can also encounter major carbonate soil deposits. The engineering characteristics of carbonate soil deposits can differ substantially from those of silica-based soil deposits, primarily because of cementation and differences in void ratios.

Appropriate description is necessary. A commonly accepted procedure for calcareous soil deposits is the Clark and walker system, originally developed for the Middle East. This considers particle size, carbonate content and material strength. The particle size classification fits both BS and ASTM system. The carbonate content is an additional feature and the material strength classification relates to common post-depositional alteration of calcareous soil.

This document does not include rock description or specific engineering geological classification systems, such as those for the detailed identification of peat, chalk or micaceous sand.

The main steps of the soil description system are:

1. Measure or estimate particle type as silica-based, organic, or calcareous.
2. For soils that are predominantly silica-based and organic, select BS 5930:1999 or ASTM D 2487 based on local geotechnical practice or project requirements, and follow the appropriate descriptive procedure. For calcareous soils, use the process described by Peuchen et al. (1999).
3. Measure or estimate the particle-size distribution and Atterberg limits (plasticity) for use in defining the principal and secondary soil fractions.
4. Measure or estimate soil strength according to one of the following: (1) relative density of coarse-grained soil, (2) consistency of fine-grained soil, (3) cementation of cemented soil, or (4) lithification of soil undergoing diagenesis.
5. Complete the description using the additional terms for the soil mass characteristics and other features such as bedding, colour, and particle shape.

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CALCAREOUS SOIL DESCRIPTION

The procedure considers particle size, carbonate content and material strength. The particle-size classification follows the Unified Soil Classification System. The carbonate content is an additional feature and the material strength classification relates to common post-depositional alteration of calcareous soil.

PARTICLE TYPE

The first determinant for soil description is particle type using Table 1. It mainly differentiates between silica and carbonate soil compositions with organic content of less than 1% of the dry weight. Organic soils are further described in the soil description procedures for BS and ASTM (Table 4).

TABLE 1 - PARTICLE TYPE

Clay soil	Other Soils	Carbonate Content (by dry weight)	Reaction with HCl (10%)
--	Silica	< 10 %	In clays: no bubbles, or slowly forming bubbles. In sands: reaction often limited to some individual particles, or particle surface Residue - Nearly all soil remaining
Calcareous	Calcareous silica	10 to 50	In clays: clearly visible, prolonged reaction and foaming. In sand: violent reaction Residue - Large part of soil remaining
Carbonate	Siliceous carbonate	50 to 90	Violent reaction Residue - Only small part of soil remaining
Carbonate	Carbonate	> 90	Violent reaction Residue - Hardly any soil remaining

The description method does not distinguish between types of carbonate material, and assumes that non-carbonate particles are siliceous.

CEMENTATION AND LITHIFICATION

Cementation is the process by which a binding material precipitates in the voids between the grains or minerals. Lithification is the process by which a soil is hardened due to pressure solution and transformation or new grain or mineral growth. Both processes contribute to the formation of rock.

The descriptions for cementation follow rock strength classification (Table 2) expressed as uniaxial compressive strength σ_c:

TABLE 2 – CEMENTATION

Cementation	σ_c [MPa]
Slightly cemented	0.3 to 1.25
Moderately cemented	1.25 to 5.0
Well cemented	5.0 to 12.5

The term "well cemented" in Table 2 applies to soil, which also shows sublayers with little or no cementation. In case of further lithification, the soil description becomes a rock description using Table 3. The rock strength is only indicative.

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TABLE 3 - LITHIFICATION

Carbonate content [%]	Dominant fraction: Clay	Silt	Sand	Gravel	Cobbles	Boulders	σ_c [MPa]
incomplete lithification							
< 10	CLAYSTONE	SILTSTONE	SANDSTONE	CONGLOMERATE	CONGLOMERATE or BRECCIA		0.3 to 12.5
10 to 50	Calcareous CLAYSTONE	Calcareous SILTSTONE	Calcareous SANDSTONE	Calcareous CONGLOMERATE			
50 to 90	Clayey CALCILUTITE	Siliceous CALCISILTITE	Siliceous CALCARENITE	Conglomeratic CALCIRUDITE			
> 90	CALCILUTITE	CALCISILTITE	CALCARENITE	CALCIRUDITE			
complete lithification							
< 50	CLAYSTONE	SILTSTONE	SANDSTONE	GRAVEL CONGLOMERATE	CONGLOMERATE or BRECCIA		>12.5
> 50	Fine-grained Argillaceous LIMESTONE	Fine-grained Siliceous LIMESTONE	Medium grained LIMESTONE	Conglomeratic LIMESTONE			

The Clark and Walker system does not include reef limestone (biolithite). **Reef limestone** represents an in situ accumulation of biological origin (e.g. coral reef) and consists largely of carbonate skeletal material of colonising organisms. The carbonate content normally exceeds 90%. Classification of strength follows rock description procedures.

SOIL DESCRIPTION USING BS 5930:1999

In the following sections, each of the main characteristics is described in the order most commonly used for soil identification, with some portions of the text quoted (shown within quotation marks) or paraphrased from the BS 5930.

SOIL GROUP (BS)

The soil group subdivides the soils into very coarse, coarse, fine, and organic soils.

Very coarse soils consist of cobbles and boulders, with particles larger than 60 mm in diameter. These soil particles are rarely sampled using standard soil sampling techniques. They are described separately, and not included when determining the proportions of the other soil components.

The initial classification of silica soils as coarse or fine is based on the percentage of fine particles after the very coarse particles are removed. In BS 5930, the boundary between coarse (i.e. sands and gravels) and fines (i.e. silts and clays) is 0.060 mm (60 µm). When the soil contains approximately 35% or more fines, it is described as a fine soil; further classification of the fine soil as a clay or silt depends on the plasticity of the soil. When the soil contains less than about 35% fine material, it is usually described as a coarse soil. “The boundary between fine and coarse soils is approximate, as it depends on the plasticity of the fine fraction and the grading of the coarse fraction.”

Organic soils contain usually small quantities of dispersed organic matter that can have a significant effect on soil plasticity. Organic soil descriptions in BS 5930 are based on an organic content by weight determined by loss on ignition. Where organic matter is present as a secondary constituent, the following terms are used:

TABLE 4 - ORGANIC SOIL DESCRIPTIONS

Term	Organic content [% by weight]	Typical colour
Slightly organic clay or silt	2 to 5	Grey
Slightly organic sand	1 to 3	Same as mineral
Organic clay or silt	5 to 10	Dark grey
Organic sand	3 to 5	Dark grey
Very organic clay or silt	> 10	Black
Very organic sand	> 5	Black

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Soils with organic contents up to approximately 30% by weight and water contents up to about 250% behave as mineral soils and are described using the terms given in the lower portion of Table 4.

Peat consists predominantly of plant remains, is usually dark brown or black, and has a distinctive smell. It is generally classified according to the degree of decomposition (fibrous, pseudo-fibrous, or amorphous) and strength (firm, spongy, or plastic). When encountered, reference can also be made to the classification given in ASTM Standard Procedure D 4427.

PRINCIPAL SOIL TYPE AND PARTICLE SIZE (BS)

Coarse-Grained Soils

The principal soil type in coarse-grained soils is sand if the dry weight of the sand fraction (0.06 mm to 2 mm particle sizes) exceeds that of the gravel fraction (2 mm to 60 mm particle sizes), and vice versa for gravel.

As an addition to the BS 5930 classification, coarse-grained soils are described as well-graded or poorly-graded based on the grain-size distribution curve, using the coefficient of uniformity (C_U) and, to a lesser extent, the coefficient of curvature (C_C), as follows:
- Sands with ≤12% fines are well-graded when $C_U \geq 6$ and C_C is between 1 and 3.
- Sands are poorly-graded for other values of C_U and C_C.
- Gravels with ≤12% fines are well-graded when $C_U \geq 4$ and C_C is between 1 and 3.
- Gravels are poorly-graded for other values of C_U and C_C.

For coarse-grained soils with fines contents > 12%, these terms are not used.

Sands and gravels are sub-divided into coarse, medium, and fine, as defined in Table 5.

TABLE 5 - SIZE FRACTION DESCRIPTIONS FOR COARSE-GRAINED SOILS

Soil	Particle diameter range [mm]		
	Coarse	Medium	Fine
Gravel	60 to 20	20 to 6	6 to 2
Sand	2 to 0.6	0.6 to 0.2	0.2 to 0.06

Fine-Grained Soils

Fine-grained soils are classified as clay or silt according to the results of Atterberg limits tests. A fine-grained soil is classified as clay if:

$$I_P \geq 6 \text{ and } I_P \geq 0.73\ (w_L\text{-}20)$$

where:
I_P = plasticity index [%]
w_L = liquid limit [%]

Otherwise the dominant soil fraction is silt. The equation $I_P = 0.73\ (w_L\text{-}20)$ represents the "A-line" in a plasticity chart. The plasticity chart may also show a “U-line” defined as $I_P = 0.9\ (w_L\text{-}8)$ and $w_L \geq 16$, according to Casagrande (1948). The U-line represents an approximate upper limit of correlation between plasticity index and liquid limit for natural soils.

The following additional descriptors (as used in the ASTM soil description procedure) are added:
- Clays with liquid limits of 50% or higher are described as “fat.”
- Clays with liquid limits below 50% are described as “lean.”
- Silts with liquid limits of 50% or higher are termed “elastic silt.”
- Silts with liquid limits below 50% are simply “silts.”

The term “silty clay” is not used, since BS 5930 explicitly states that silt and clay “are to be mutually exclusive.”

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Particle Shape

The description of particle shape includes terms for form, angularity, and surface texture. These terms are the same for BS 5930 as for ASTM D 2488. Reference should be made to the corresponding ASTM section of this document.

COMPOSITE (SECONDARY) SOIL TYPES (BS)

BS 5930 defines procedures for assigning secondary soil fractions to coarse-grained soils that are identical for sand and gravel, except that the secondary soil type is sandy when the principal soil type is gravel and vice versa. For fine-grained soils (silt and clay) there is a single procedure for assigning secondary soil fractions. The ranges for the percentages of the secondary constituents are similar to, though different from, those defined by ASTM.

If the principal soil type is sand, secondary soil fractions may be gravelly and silty or clayey (e.g. silty sand). Similarly, if the principal soil type is clay, secondary soil fractions may be sandy or gravelly. Table 6 (from BS 5930) gives the terms to be used for ranges of secondary constituents.

TABLE 6 - DESCRIPTIVE TERMS AND RANGES FOR SECONDARY CONSTITUENTS

Term	Principal soil type	Approximate proportion of secondary constituent	
		Coarse soil	Fine soil
Slightly clayey or silty	SAND and/or GRAVEL		< 5%
Clayey or silty			5% to 20%
Very clayey or silty			> 20% (1)
Slightly sandy or gravelly		< 5%	
Sandy or gravelly		5% to 20%	
Very sandy or gravelly		> 20%	
Slightly sandy and/or gravelly	SILT or CLAY	< 35%	
Sandy and/or gravelly		35% to 65%	
Very sandy and/or gravelly		> 65% (2)	

Notes: (1) or can be described as fine soil depending on engineering behaviour
(2) or can be described as coarse soil depending on engineering behaviour.

COLOUR (BS)

Soil colours are described using the Munsell Soil Colour Charts (Gretag-Macbeth, 2000).

The Munsell colour is arranged according to three variables known as Hue, Value and Chroma. The Hue notation of a colour indicates its relation to red, yellow, green, blue and purple. The Value notation indicates the relative lightness. The Chroma notation indicates the intensity of the colour.

BEDDING/STRATIGRAPHY (BS)

Layers of different soil types within a stratum are called bedding units, and are described in terms of the unit thickness. In an otherwise homogeneous soil, these can be identified as bedding planes or as colour changes, and not necessarily as discontinuities.

Table 7 (from BS 5930) gives terms for bedding/stratigraphy.

TABLE 7 - DESCRIPTIVE TERMS FOR BEDDING/STRATIGRAPHY

Stratified	Bedding	Interbedded	Thickness [mm]
Very thick beds	Very thick bedded	Very thickly interbedded	>2000
Thick beds	Thickly bedded	Thickly interbedded	600 to 2000
Medium beds	Medium bedded	Medium interbedded	200 to 600
Thin beds	Thinly bedded	Thinly interbedded	60 to 200
Very thin beds	Very thinly bedded	Very thinly interbedded	20 to 60
Thick laminae	Thickly laminated	Thickly interlaminated	6 to 20
Thin laminae	Thinly laminated	Thinly interlaminated	<6

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Strata with alternating or different beds or laminations can be described as interbedded or interlaminated. Where the soil types are approximately equal, both terms can be used (e.g. thinly interlaminated SAND and CLAY).

Partings are bedding surfaces that separate easily, and typically are laminae of no appreciable thickness. The spacing between partings is described in the same terms as for spacing of discontinuities (Table 8).

DISCONTINUITIES/STRUCTURE (BS)

Discontinuities include fissures and shear planes, and the descriptor refers to the mean spacing between such discontinuities in a soil mass. A soil is “fissured” when it breaks into blocks along unpolished discontinuities, and “sheared” when it breaks into blocks along polished discontinuities (which is equivalent to a slickensided soil). The spacing description ranges from extremely closely spaced (less than 20 mm) to very widely spaced (over 2000 mm). No other descriptive terms are used. An example would be: Firm grey very closely fissured fine sandy calcareous CLAY with many silt partings.

The spacing terms are also used for distances between partings, isolated beds or laminae, desiccation cracks, rootlets, etc.

TABLE 8 - SPACING OF DISCONTINUITIES

Term	Mean spacing range [mm]
Very widely	Over 2000
Widely	600 to 2000
Medium	200 to 600
Closely	60 to 200
Very closely	20 to 60
Extremely closely	Under 20

DENSITY/COMPACTNESS OF GRANULAR SOILS (BS)

Usually, soil description offers little evidence about the density condition of coarse-grained cohesionless (granular) soil samples. The reason for this is the substantial sampling disturbance incurred during conventional sampling operations such as push sampling, percussion sampling, and vibrocoring. Complementary investigation techniques, such as Cone Penetration Tests (CPT), are usually necessary. The strength of a cohesionless soil is normally measured as a function of its relative density (also termed compactness or density index). Relative density is the ratio of the difference between the void ratios of a cohesionless soil in its loosest state and existing natural state to the difference between its void ratio in the loosest and densest states.

Relative density (compactness) is referred to in BS 5930:1999 only in terms of N-values obtained by the Standard Penetration Test (which is not conducted in offshore site investigations). Rather than using SPT-based values, it is common practice to interpret relative density on the basis of CPT results. Ranges of relative density are given in Table 9. These ranges are in common use in the industry. They were originally given in Lambe and Whitman (1979) and in the API RP 2A guidelines generally used for offshore pile design. These terms also apply to cohesionless fine-grained soils.

TABLE 9- RANGE OF RELATIVE DENSITY OF GRANULAR SOILS

Term	Range of relative density [%]
Very loose	Less than 15
Loose	15 to 35
Medium dense	35 to 65
Dense	65 to 85
Very dense	Greater than 85

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STRENGTH OF COHESIVE SOILS (BS)

The strength of cohesive soils is given in terms of undrained shear strength, using the terms and ranges given in Table 10, with an additional level to cover “very hard” soils.

TABLE 10 - UNDRAINED SHEAR STRENGTH SCALE FOR COHESIVE SOILS (BS 5930:1999)

Term	Undrained shear strength	
	[kPa]	[ksf] (1)
Very soft	Less than 20	Less than 0.4
Soft	20 to 40	0.4 to 0.8
Firm	40 to 75	0.8 to 1.5
Stiff	75 to 150	1.5 to 3.0
Very stiff	150 to 300	3.0 to 6.0
Hard	300 to 600	6.0 to 12.0
Very hard (2)	Greater than 600	Greater than 12.0

Notes: (1) Unit conversion added to table
(2) Added for global practice.

MINOR CONSTITUENTS (BS)

Percentages of minor constituents within the soil, such as shell or wood fragments, or small soil inclusions (such as partings or pockets), can be quantified using the terms “with trace”, “with few”, “with” and “with many” (in increasing order). These terms are usually added at the end of the main soil description (e.g. with many shell fragments, with silt pockets, etc.); exceptions are terms such as “shelly”, which are more appropriate before the soil group name. For beds of material within a soil matrix, the terminology for spacing and thickness of beds is used. For individual particles of soil or material within a soil matrix, the terms “partings” and “pockets” are used.

SOIL ODOUR (BS)

Describing the odour from soil samples as they are retrieved or extruded on board ship can be useful. Terms used to describe the odour are H_2S, “musty”, “putrid” and “chemical”. It must be emphasised that soil odour descriptions are unlikely to be fully consistent, because of factors such as variations in sample handling, ambient conditions at time of sample description, and strong dependence on a person’s ability to detect and identify odour.

SOIL DESCRIPTION USING ASTM D 2487 AND D 2488

The identification and description of silica soils in the ASTM system consists primarily of a group name and symbol, which are based on the particle-size distribution and the Atterberg limits test results, and the results of other laboratory classification tests.

The main standard for soil description, D 2487 Classification of Soils for Engineering Purposes, is applicable to naturally-occurring soils passing a 3-in. (75-mm) sieve, and identifies three major soil types: coarse-grained, fine-grained, and highly organic soils. The major soil types are further subdivided into 15 specific basic soil groups.

An accompanying Standard, D 2488, outlines the Description and Identification of Soils using a Visual-Manual Procedure. This standard is used primarily in the field, where full particle-size distribution curves and Atterberg limits values are not available. It gives guidance for detailed descriptions of soil particles and soil conditions (e.g. colour, structure, strength, cementation, etc.), which are not included in D 2487.

Soil types with particles larger than 75 mm (i.e. cobbles and boulders) are not included in the Standards, but are identified.

SOIL TYPES (ASTM)

The initial classification of silica soils as coarse-grained or fine-grained is based on the percentage fines, expressed as the percentage of dry weight of the total sample after the very coarse particles are removed, as with BS 5930. However, ASTM has defined the coarse-fine boundary as 0.075 mm (75 µm).

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The soil is coarse-grained (sand or gravel) if the percentage fines is 50% or less. Otherwise, the soil is fine-grained (silt or clay) – the classification is not based on plasticity.

Coarse-grained soils are classified further as either sand or gravel using the results of particle-size distribution tests.

Fine-grained soils are classified further as silt or clay on the basis of the liquid limit and plasticity index (from Atterberg limits tests).

The soil is an organic soil if it contains sufficient quantities of dispersed organic matter that it has an influence on the liquid limits of the fines component after oven-drying, as outlined in the BS Section. The definition of peat is similar to that in BS 5930 and it is generally classified according to the degree of decomposition and strength. When encountered, reference should be made to the classification given in ASTM D 4427.

SOIL GROUP NAME AND SYMBOL (ASTM)

Coarse-Grained Soils

For coarse-grained soils, the dominant soil fraction is sand if the dry weight of the sand fraction, i.e. particle sizes from 0.075 mm to 4.75 mm, exceeds that of the gravel fraction, i.e. particles ranging from 4.75 mm to 75 mm, and vice versa for gravel.

Coarse-grained soils with ≤12% fines are also described as well-graded or poorly-graded based on the particle-size distribution curve, using the coefficient of uniformity (C_U) and, to a lesser extent, the coefficient of curvature (C_C) as follows:
- Sands are well-graded when $C_U \geq 6$ and C_C is between 1 and 3.
- Sands are poorly-graded for other values of C_U and C_C.
- Gravels are well-graded when $C_U \geq 4$ and C_C is between 1 and 3.
- Gravels are poorly-graded for other values of C_U and C_C.

For coarse-grained soils with fines contents >12%, these terms are not used.

Sands and gravels are also sub-divided into coarse, medium, and fine, as defined in Table 11.

TABLE 11 - SIZE FRACTION DESCRIPTIONS FOR COARSE-GRAINED SOILS

Soil	Particle diameter range [mm]		
	Coarse	Medium	Fine
Gravel	75 to 19	-	19 to 4.75
Sand	4.75 to 2.0	2.0 to 0.425	0.425 to 0.075

The predominant size fractions present are identified, and the absence of size range descriptors means that fine, medium, and coarse fractions are all present in roughly equal proportions.

Fine-Grained Soils

Fine-grained soils are classified as clay or silt according to the results of Atterberg limits tests. A soil is inorganic clay if: $I_P \geq 6$ and $I_P \geq 0.73(w_L\text{-}20)$

where:
I_P = plasticity index [%]
w_L = liquid limit [%]

The A-line and U-line in a plasticity chart are as described in the BS section.

Clays with liquid limit $w_L < 50$ and plasticity index $I_P > 7$ are further classified as lean clay, and given the group symbol “CL”. Clays with liquid limits $w_L \geq 50$ are further classified as fat clay, and are given the group symbol “CH”.

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A soil is classified as a silt when it plots below the A-line or the plasticity index I_P < 4. Silts with liquid limit w_L < 50 are given the group symbol “ML”. Silts with liquid limits w_L ≥ 50 are further classified as elastic silt, and are given the group symbol “MH”.

Soils are classified as silty clay where the liquid limit versus plasticity index plots on or above the A-line but where the plasticity index falls within the range 4 ≤ I_P ≤ 7, i.e. the hatched zone in the lower left-hand corner of the plasticity chart. Silty clays are given the Group Symbol “CL-ML”.

Organic Soils

For both clay and silt, or the fines component of a coarse-grained soil, the additional term organic applies if the ratio of the liquid limit of a sample (or the fines portion of the sample) after oven drying at 105° C to the liquid limit without oven drying is less than 0.75.

Organic soils are classified in a manner similar to that for inorganic soils for plots of the liquid limit (not oven dried) versus plasticity index with respect to the A-line. Organic clays and silts with liquid limit w_L < 50 are given the same group symbol “OL”. Organic clays and silts with liquid limits w_L ≥ 50 are given the group symbol “OH”.

Coarse-grained soils containing fine organic material are described using the term “with organic fines”.

SECONDARY SOIL TYPE (ASTM)

Secondary soil type descriptions follow the ranges given in Table 12. No other terms are used, though combinations of these terms are.

TABLE 12 - DESCRIPTIVE TERMS AND RANGES FOR SECONDARY CONSTITUENTS

Term	Principal soil type	Term	Approximate proportion of secondary constituent	
			Coarse soil	Fine soil
	SAND and/or GRAVEL[(1)]			< 5%
	SAND and/or GRAVEL[(1)]	with clay or silt		5% to 12%
Clayey or Silty	SAND and/or GRAVEL[(1)]			> 12%
	SAND and/or GRAVEL[(1)]		<15% gravel or sand	
	SAND and/or GRAVEL[(1)]	with gravel or sand	≥15% gravel or sand	
	SILT or CLAY		< 15%	
	SILT or CLAY	with sand or gravel[(1)]	15% to 29%	
Sandy and/or gravelly[(1)]	SILT or CLAY		≥30%	

Note: (1) choice depends on which has higher percentage.

PARTICLE SHAPE (ASTM)

The description of particle shape includes references to form, angularity, and surface texture. These terms are normally used only for gravels, cobbles, and boulders, though in some cases for coarse sands.

The form (or shape) of coarse particles is described as flat, elongated, or both.

Flat: Width/Thickness > 3
Elongated: Length/Width > 3
Flat and elongated meets both criteria. These terms are not used if the criteria are not strictly met.

Angularity terms are usually only applied to particles gravel-size and larger (Table 13, from ASTM D 2488).

TABLE 13 - ANGULARITY OF COARSE-GRAINED PARTICLES

Term	Criteria
Angular	Particles have sharp edges and relatively plane sides with unpolished surfaces
Subangular	Particles are similar to angular description but have rounded edges
Subrounded	Particles have nearly plane sides but have well-rounded corners and edges
Rounded	Particles have smoothly curved sides and no edges

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The surface texture of coarse particles are described as rough or smooth.

COLOUR (ASTM)

As noted for BS 5930 (BS section), soil colours are described using the Munsell Soil Colour Charts (Gretag-Macbeth, 2000).

SOIL ODOUR (ASTM)

The same descriptive terms suggested for BS 5930 (BS Section) are used with the ASTM Standards. It must be emphasised that soil odour descriptions are unlikely to be fully consistent, because of factors such as variations in sample handling, ambient conditions at time of sample description, and strong dependence on a person's ability to detect and identify odour.

STRENGTH OF COHESIVE SOILS (ASTM)

Descriptions of cohesive soil strength are not part of the ASTM classification system; however soil strength is incorporated whenever available from laboratory or in situ test results and interpretation. The boundaries for undrained shear strength ranges in current use in North American practice are given in Table 14. These boundaries are lower than those used with BS 5930.

TABLE 14 - UNDRAINED SHEAR STRENGTH SCALE FOR COHESIVE SOILS (1)

Term	Undrained shear strength	
	[kPa]	[ksf] (2)
Very soft	Less than 12.5	Less than 0.25
Soft	12.5 to 25	0.25 to 0.50
Firm	25 to 50	0.50 to 1.0
Stiff	50 to 100	1.0 to 2.0
Very stiff	100 to 200	2.0 to 4.0
Hard	200 to 400	4.0 to 8.0
Very hard (3)	Greater than 400	Greater than 8.0

Notes: 1) from Terzaghi and Peck (1967)
2) ksf used primarily for US projects
3) the upper boundary for "Hard", and the "Very hard" range have been added

DENSITY/COMPACTNESS OF GRANULAR SOILS (ASTM)

Tables of recommended values and descriptors for relative density are not provided in the ASTM Standards, but in practice relative density is often interpreted on the basis of cone penetration test results. The same ranges of relative density (compactness) as those recommended for use with BS 5930 (see BS Section) are used.

DISCONTINUITIES/STRUCTURE (ASTM)

Criteria for describing soil structure are provided in ASTM D 2488, and in Table 15 along with additional terms in use in the geotechnical industry.

TABLE 15 - DESCRIPTIVE TERMS FOR SOIL STRUCTURE

Term	Description
Slickensided	Fracture or shear planes (or planes of weakness) that appears slick and glossy.
Fissured	Cohesive soil that breaks into blocks along unpolished planes (discontinuities), often filled with a different material. The fill material is noted.
Blocky	Cohesive soil that breaks into small angular lumps along polished planes (discontinuities) which resist further breakdown.
Gassy	Soil has a porous nature and there is evidence of gas, such as blisters.
Expansive	Visibly expands after sampling. Degree of expansion is estimated and noted.
Platy	A stratified appearance when the soil can be broken into thin horizontal plates.
Cemented	Material grains bound together forming an intact mass.

The distance between the fissures, shear planes and expansion cracks is noted using the terms in Table 8.

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BEDDING/STRATIGRAPHY (ASTM)

The terminology for bedding thickness and stratigraphic description used in North American offshore practice is more detailed than outlined in ASTM D 2488, and is different from BS 5930. In Table 16, the descriptive terms have been further defined and integrated with BS 5930 terminology.

TABLE 16 - DESCRIPTIVE TERMS FOR BEDDING THICKNESS AND INCLUSIONS

Term	Bedding thickness	
	[mm]	[inch]
Pocket	Inclusion of material of different texture that is smaller than the diameter of the sample	
Parting	< 3	1/8
Lamina	3 to < 6	1/8 to < 0.25
Laminated(1)	Alternating partings or laminae of different soil types in equal proportion	
Lens	6 to < 20	0.25 to < 0.75
Seam	20 to < 76	0.75 to < 3
Layer	Greater than 76	Greater than 3
Stratified(2)	Alternating lenses, seams or layers of different soil types in equal proportion	
Intermixed	Soil sample composed of pockets of different soil types, and laminated or stratified structure is not evident	

Notes: (1) Equivalent to “Interlaminated” term used in BS 5930:1999
(2) Equivalent to “Interbedded” term used in BS 5930:1999.

MINOR CONSTITUENTS (ASTM)

Minor constituents within a soil, such as shell or wood fragments, or small quantities of soil particles (not secondary soil types), are typically more relevant to the site geology or to laboratory testing procedures than to soil behaviour. Since the terms and percentages are not defined in either BS 5930 or ASTM D 2487/8, the terms “with trace”, “with few”, “with”, “with many” are used as a guide.

WRITTEN SOIL DESCRIPTIONS

Although soils are classified in the order of the characteristics described in the preceding sections, written descriptions are given in a different order in both Standards. To bring as much consistency as possible to the soil descriptions, Fugro selected a single preferred order of terms, which most closely resembled the majority of the descriptions used in Fugro offices around the world.

In this description, the principal soil type is given last as the soil name, with most other terms written as adjectives. The principal soil type is given in upper-case.

The preferred order of terms for a soil description are:
1. Density/compactness/strength.
2. Discontinuities.
3. Bedding.
4. Colour.
5. Secondary (composite) soil types.
6. Particle shape.
7. Particle size.
8. PRINCIPAL SOIL TYPE.

with:
9. Minor constituents (can be inserted in front of the principal soil type, such as “shelly”).
10. Soil odour.

For example: Firm closely-fissured dark olive grey sandy calcareous CLAY with few silt pockets. Where used, the Group Symbol is part of the soil description, e.g. loose poorly-graded fine to medium SAND with silt (SP-SM).

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PARTICULATE DEPOSITS

The geological origin of a single particle type allows the following descriptions (optional):

Clastic: sediment transported and deposited as grains of inorganic origin. Typical clastic particles are:
- quartz grains: clear or milky white and ranging from very angular to very rounded; commonly a frosted surface for wind-blown grains
- feldspar grains: varying in colour from milky white to light yellowish brown
- mica flakes: varying in colour from gold-coloured to dark brown
- dark mineral grains: usually of igneous or metamorphic origin with undetermined mineralogy
- silicate grains: undetermined mineralogy
- rock fragments: including fragments of carbonate rock
- debris: deposit of rock fragments of a variety of particle sizes which may include sand and finer fractions; typical examples are rock debris and coral debris.

Organic: remains of plants and animals that consists mainly of carbon compounds

Bioclastic: sediment transported and deposited as grains of organic origin. Examples of bioclastic particles are:
- Calcareous algae: crustal or nodular growths or erect and branching forms produced by lime-secreting algae; microstructures include layered, rectangular structures and internal fine tube-like structures.
- Foraminifera: hard sediment test (external skeleton) consisting of calcite or aragonite and produced by unicellular organisms; commonly less than 1 mm in diameter, multi-chambered and intact.
- Sponge spicules: spicules of siliceous sponges in a variety of rayed shapes; dimensions ranging from less than 1 mm to over 1 cm in length but usually less than 1 mm in width.
- Corals: commonly consisting of small fibres set perpendicular to the walls and septal surfaces; mainly aragonite composition for relatively recent forms; conversion of aragonite to calcite for earlier corals, usually with consequent loss of original structural details.
- Echinoids: hard part of echinoids consisting of a plate or skeletal element forming a single crystal of calcite; five-rayed internal symmetry for spines of echinoids; typical widths ranging from several mm to a few cm.
- Bryozoans: chambered cell-like structures that are considerably coarser than those of calcareous algae; either aragonite or calcite composition; possible cell in-fill consisting of clear calcite and/or micrite.
- Bivalves and Gastropods: Mollusk shells, chiefly of aragonite composition; inner layer of aragonite protected by an outer layer of calcite for some bivalve shells and gastropods.

Oolitic: sediment consisting of solid, round or oval, highly polished and smooth coated grains, which may or may not have a nucleus. The coating consists of chemically precipitated aragonite, possibly converted to calcite. Ooliths have concentric structures and may also have radial structures. The grains are generally less than 2 mm diameter.

Pelletal: sediment consisting of well-rounded grains of ellipsoidal shape and no specific internal structure. The composition is clay to silt-sized carbonate material, which is probably the excretion product of sediment eating organisms. Pellets may have an oolitic crust. The grains are generally less than 2 mm diameter.

STRUCTURE OF NON PARTICULATE DEPOSITS

Reef: soil or rock formed by in situ accumulation or build-up of carbonate material by colonial organisms such as polyps (coral), algae (algal mats or balls) and sponges.

Orthochemical: orthochemical components precipitated during or after deposition. These components can include: (1) pyrite spherulites and grains, (2) crystal euhedra of anhydride or gypsum, (3) replacement patches and nodular masses of anhydrite and gypsum. Single grains are rare.

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GEOLOGICAL INFORMATION

Specific geological terms can assist the geotechnical soil description by providing information on stratigraphy, origin (genesis) or regional significance (optional). Examples are:

- time stratigraphy, such as Eemian and Pleistocene
- lithostratigraphy, such as Yarmouth Roads Formation
- depositional environment, such as Marine, Glacio-lacustrine and Residual Soil
- regional significance, such as Chalk and Mud.

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TESTING PRACTICE

GENERAL

This document summarises geotechnical laboratory test methods for soil.

Fugro strives to arrange testing in registered laboratories with formal accreditation. This document summarises test methods used by Fugro geotechnical laboratories in the Netherlands. Test methods used by on-site laboratories and other office laboratories are often identical or generally equivalent.

Laboratory tests are carried out in general accordance with standards published by ASTM International (ASTM), British Standards Institution (BSI) and International Organization for Standardization (ISO). Note that ISO (2014) refers mainly to test procedures published in other documents, with some additional recommendations. In-house test procedures adopted for some tests are generally based on published recommendations for which no standards are available. Detailed work instructions and calibration details are available for inspection at the laboratory.

Some of the laboratory tests allow various optional procedures. These procedures are not applicable, unless specifically agreed.

Soil parameter values can vary with temperature. Tests are generally conducted at laboratory temperatures of around 20°C. Any tests conducted at specific temperatures and any corrections for temperature are explicitly reported.

SAMPLE REQUIREMENTS

The feasibility of a particular laboratory test relates to the sampling practice and sample handling for a particular soil and depends on factors such as soil type, available amount of sample material and sample quality. Usually, a reasonable estimate of test feasibility is possible at the time of sampling. A further refinement is possible in the laboratory prior to testing and, in some cases, only after testing. The limitations of feasibility estimates may lead to rejection of samples for testing upon inspection in the laboratory or may result in appropriate comments on test results after completion of testing.

The adopted classification system for sample quality is according to BSI (2010) and ISO (2006, 2014). The classification system recognises 5 classes on the basis of feasibility of specific geotechnical identification and laboratory tests. A summary of these classes is as follows:

Class 1: undisturbed: strength, stiffness and consolidation
Class 2: undisturbed: permeability, unit weight, boundaries of strata - fine
Class 3: disturbed: water content
Class 4: disturbed: particle size analysis, Atterberg limits, boundaries of strata - broad
Class 5: disturbed: sequence of layers

The higher class includes the laboratory tests of the lower class.

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An indication of intact (undisturbed) sample quality may be obtained from re-compression of a test specimen, for example in an oedometer or triaxial cell. Table 1 presents a method recommended by ISO (2014) based on $\Delta e/e_0$. Here, Δe represents the change in void ratio Δe from an initial laboratory value (e_0) at atmospheric conditions to the specimen void ratio upon re-compression to in situ stress conditions.

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TABLE 1 - INTACT SAMPLE QUALITY - $\Delta e/e_0$

Overconsolidation Ratio	**$\Delta e/e_0$**			
	1 (very good to excellent)	**2** (good to fair)	**3** (poor)	**4** (very poor)
1 to 2	< 0.04	0.04 to 0.07	0.07 to 0.14	> 0.14
2 to 4	< 0.03	0.03 to 0.05	0.05 to 0.10	> 0.10

The presented criteria are based on tests on marine clays in the depth range 4 m to 25 m, with plasticity index in the range 6% to 43%, water content 20% to 67% and overconsolidation ratios of 1 to 4. The criteria must be used with caution for soils outside this range.

Table 2 presents an alternative indication of intact (undisturbed) sample quality according to Terzaghi et al. (1996). Here, volumetric strain is derived from an initial laboratory specimen volume and the specimen volume upon re-compression to in situ stress conditions. The criteria apply to clays with an overconsolidation ratio of less than about 3 to 5. Parameters such as effective preconsolidation pressure σ'_p and undrained shear strength c_u preferably require laboratory specimen with SQD equal to B or better (DeGroot et al., 2005).

TABLE 2 – INTACT SAMPLE QUALITY - SDQ

Volumetric Strain ε_v [%]	SDQ
< 1	A
1 to 2	B
2 to 4	C
4 to 8	D
> 8	E
Note: SDQ: Sample Quality Designation	

The $\Delta e/e_0$ and ε_v criteria represent a simplification, as they ignore important soil changes during the process of sampling and sample handling up to specimen preparation in a geotechnical laboratory. This simplification avoids interpretation anomalies related to uncertainties in laboratory values for soil unit weights, water contents and density of solid particles.

The $\Delta e/e_0$ and ε_v criteria assume no-gas within the pore water. Gas can cause an increase in void ratio when recovering samples to surface. The result is a correspondingly larger change in void ratio when returning a specimen back to the estimated effective stress conditions in situ. In such case, it is likely that the undrained shear strength would be less affected than soil stiffness, as the void ratio in situ has been partially restored. Changes in soil fabric remain.

Values for $\Delta e/e_0$ and ε_v should exclude secondary consolidation. In practice, no correction for secondary consolidation will be applied. This practice underestimates undisturbed sample quality, particularly for incremental loading oedometer tests with 24 hour load increments and longer.

GEOTECHNICAL INDEX TESTING

WATER CONTENT

The water content is determined by drying selected moist/wet soil material for at least 18 hours to a constant mass in a 110°C drying oven. The difference in mass before and after drying is used as the mass of the water in the test material. The mass of material remaining after drying is used as the mass of the solid particles. The ratio of the mass of water to the measured mass of solid particles is the water content of the material. This ratio can exceed 1 (or 100%).

Test references: ASTM D2216-10, BS 1377: Part 2: 1990, ISO/TS 17892-1:2004, ISO 19901-8:2014

UNIT WEIGHT – VOLUME-MASS CALCULATION

Measurement of volume and mass of a soil sample allows calculation of unit weight. For fine-grained (cohesive) soils, a soil specimen is generally obtained from a standard steel cylinder with cutting edge, which is pushed manually into the extruded soil sample. Preference is given to a 100 ml cylinder (area ratio of 12%), but a volume of 33.3 ml (area ratio of 21%) may be used when insufficient homogeneous sample is available. If possible, a specimen of coarse-grained (non-cohesive) soil is obtained by selecting a part of a cylindrical soil sample, trimming the end surfaces, and measuring height and diameter. This method also applies to fine-grained specimens selected for strength and/or stiffness (e.g. triaxial and oedometer) tests.

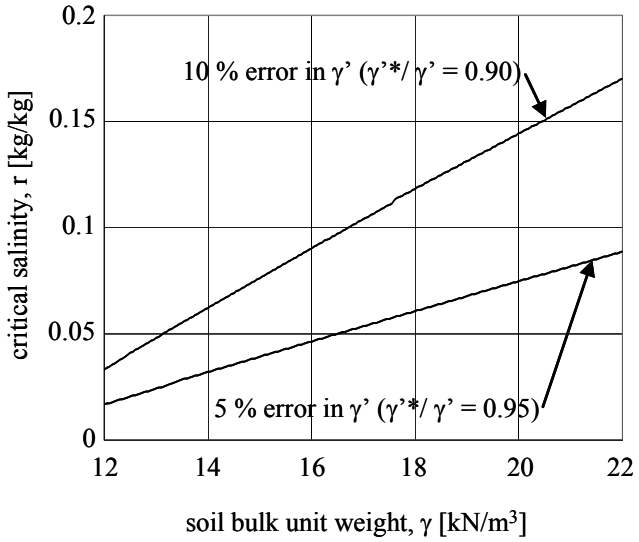
Unit weight γ (kN/m^3) refers to unit weight of the soil specimen at the water content at the time of test.

The method excludes correction for pore water salinity r (contains dissolved solids), in situ pressure and temperature. The diagram below provides an indication of error in calculated submerged unit weight γ' versus

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submerged unit weight corrected for salinity, γ'^* (Kay et al., 2005). Typical seawater salinity is 35 g salt per kg seawater (r = 0.035). Correction for salinity is optional.

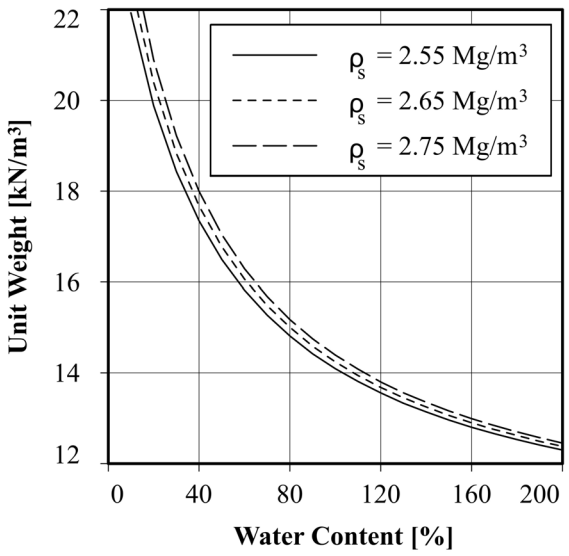


Optionally, dry unit weight γ_d, is calculated from the mass of oven-dried soil and the initial specimen volume.

Test references: BS 1377: Part 2: 1990, ASTM D7263-09, ISO 19901-8:2014

UNIT WEIGHT – DERIVED FROM WATER CONTENT

Water content (w) measurement allows estimation of soil unit weight (γ) on fully saturated samples. This practice requires input on density of solid particles (ρ_s) and presumes saturation of non-saline pore water.



Correction for (high) pore water salinity (contains dissolved solids) is optional.

Test reference: In-house

DENSITY OF SOLID PARTICLES – CONVENTIONAL PYCNOMETER

The density of the solid particles of an oven-dried soil sample is determined by means of a stoppered-bottle pycnometer, using distilled water. The method is considered applicable to solid particles that are not soluble in water. For soils with a high organic content, a different liquid may be selected. Soils with high pore water salinity (contain dissolved solids) require use of a gas pycnometer. This is optional.

Test references: BS 1377: Part 2: 1990, ASTM D854-10, ISO 19901-8:2014

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GRAIN SHAPE

Grain shape is determined by microscopic comparison of both grain roundness and sphericity with standard grain shapes. The standard shapes are presented together with the test results.

Test reference: In-house

PARTICLE SIZE ANALYSIS

Particle size analysis can be performed by means of sieving and/or hydrometer readings. Sieving is carried out for particles that would be retained on a 0.063 mm (ISO and BS) or 0.075 mm (ASTM) sieve, while additional hydrometer readings may be carried out when a significant fraction of the material passes a 0.063 mm (0.075 mm) sieve.

In a sieve analysis, the mass of soil retained on each sieve is determined, and expressed as a percentage of the total mass of the sample. Prior to sieving, samples are treated with a dispersing agent (sodium hexameta-phosphate), rinsed on a 0.063 mm (0.075 mm) sieve and dried.

The hydrometer method allows measurement of the density of a suspension consisting of fine-grained soil particles and distilled water, to which a dispersion agent is added. This suspension is mixed using a high speed stirrer. Testing is performed in a thermostatically controlled water bath (25° ± 0.5°). The particle size is calculated according to Stokes' Law for a single sphere, on the basis that particles of a particular diameter were at the surface of the suspension at the beginning of sedimentation and had settled to the level at which the hydrometer is measuring the density of the suspension. These calculations require a value for the density of solid particles. Generally, a value of 2.65 t/m^3 is assumed. When other values are used, this is included in the laboratory report. The hydrometer results for selected particle sizes are presented as a percentage of the total mass of the soil sample.

Particle size is presented on a logarithmic scale so that two soils having the same degree of uniformity are represented by curves of the same shape regardless of their positions on the particle size distribution plot. The general slope of the distribution curve may be described by the coefficient of uniformity C_u, where $C_u = D_{60}/D_{10}$, and the coefficient of curvature C_c, where $C_c = (D_{30})^2/D_{10} \times D_{60}$. D_{60}, D_{30}, and D_{10} are effective particle sizes indicating that 60%, 30%, and 10% respectively of the particles (by weight) are smaller than the given effective size.

Combined presentation of results from hydrometer readings and sieving normally requires data harmonising in the area of overlap, i.e. near the 0.06 mm particle size.

Test references: ISO/TS 17892-4:2004, BS 1377: Part 2: 1990, ASTM D422-63 (2007), ISO 19901-8:2014

PERCENTAGE FINES

The Percentage Fines test identifies the proportions of fine grained (< 0.06 mm for BS/ISO and < 0.075 mm for ASTM) and coarse-grained (> 0.06 mm) particle sizes of a soil sample by wet sieving through a 0.063 mm (0.075 mm) sieve. Prior to sieving, the sample is treated with a dispersing agent. The Percentage Fines is defined as the ratio of dry mass of soil passing the 0.063 mm (0.075 mm) sieve to the dry mass of the total soil sample, expressed as a percentage.

Test references: ISO/TS 17892-4:2004, BS 1377: Part 2: 1990, ASTM D422-63 (2007), ISO 19901-8:2014

ATTERBERG LIMITS

Atterberg limits are determined on soil specimens with a particle size of less than 0.425 mm. If necessary, coarser material is removed by dry sieving. The Atterberg limits refer to arbitrarily defined boundaries between the liquid and plastic states (Liquid Limit, w_L), and between the plastic and brittle states (Plastic Limit, w_P) of fine grained soils. They are expressed as water content, in percent.

The liquid limit is defined as the water content at which a part of soil is placed in a standard cup and cut by a groove of standard dimensions will flow together at the base of the groove, when the cup is subjected to 25 standard shocks. The one-point liquid limit test is usually carried out. Distilled water may be added during soil mixing to achieve the required consistency.

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The plastic limit is defined as the water content at which a soil can no longer be deformed by rolling into 3 mm diameter threads without crumbling.

The range of water contents over which a soil behaves plastically is the Plasticity Index, I_P. This is the difference between the liquid limit and the plastic limit (w_L-w_P).

Test references: BS 1377: Part 2: 1990, ASTM D4318-10, ISO 19901-8:2014

MINIMUM INDEX UNIT WEIGHT

The minimum index unit weight (γ_{dmin}) of cohesionless soil is determined from the mass of oven-dry material that is deposited by slowly withdrawing a soil-filled funnel from a standard mould of either 70 ml or 550 ml volume.

Test reference: In-house

MAXIMUM INDEX UNIT WEIGHT - IMPACT COMPACTION

The maximum index unit weight (γ_{dmax}) of cohesionless soil is determined from the mass of oven-dry, compacted soil in a standard mould. The soil is compacted in 5 layers, with each layer being subjected to respectively 5, 10, 20, 40 and 80 blows from a standard, hand-held hammer.

Equipment dimensions are as follows. Preference is given to the large mould, but application depends on size of sample.

		70.5 ml mould	**554 ml mould**
Hammer mass	[g]	185	750
Drop height	[mm]	300	390
Cross-sectional area	[mm^2]	1006	38,500

Reference: In-house, DGI Product Sheet #000 96-07-02

MAXIMUM INDEX UNIT WEIGHT – VIBRATING HAMMER

The maximum index unit weight (γ'_{dmax}) is obtained by compacting soil that has been passed through a 4 mm sieve into a mould at a range of water contents. The first sample is thoroughly mixed with water, to produce a soil with a 4% water content, and then compacted in three equal layers using a vibrating hammer for a period of 10 seconds per layer. The top section of the mould is removed and the sample levelled in the bottom section of the mould. The unit weight of the sample is calculated and a representative portion of soil is removed for water content determination.

The test is repeated at four further water contents. By determining the dry unit weight achieved at each water content, a maximum dry unit weight may be estimated. There is evidence of breakdown of crushable particles during a test.

Equipment dimensions are as follows:

- Volume of mould: 96.4 ml
- Hammer: Milwaukee heavy duty 545S
  - 1300 W nominal / 650 W release
  - rotation/min: 300
  - hammer force: 8.5 J
  - mass: 6.7 kg

Test reference: In-house

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GEOCHEMICAL TESTING

ORGANIC MATTER CONTENT – DICHROMATE OXIDATION METHOD

An oven-dried (50°C) soil sample is mixed with potassium dichromate solution and left for 30 min to allow the oxidation of organic matter to proceed. The solution is titrated with a ferrous sulphate solution (to determine the amount of excess potassium dichromate). The organic matter content is defined as the ratio of the total volume of potassium dichromate solution used to oxidize the organic matter in the soil sample to the mass of the initial dried soil sample (Walkley and Black's method). It is expressed as a percentage.

Note: soils containing sulphides or chlorides have been found to yield inaccurate (too high) organic matter content measurements using this procedure.

Test references: BS 1377: Part 3: 1990:3

ORGANIC MATTER CONTENT – LOSS ON IGNITION

An oven-dried (105°C) soil sample is heated to 550°C for 2 hours. The mass is measured before and after heating. The organic matter content is defined as the ratio of the mass loss due to heating to the original mass of the dried soil sample, and is expressed as a percentage.

Note: the mass loss on ignition test is reliable for (1) sandy soils that contain little or no clay and no carbonate and (2) peats and organic clays containing more than 10% organic matter.

Test references: BS 1377: Part 3: 1990:4, ASTM D2974-07a, NEN 5754, ISO 19901-8:2014

CARBONATE CONTENT – GAS VOLUME

The carbonate content is determined by drying selected soil material to a constant mass in a 110°C drying oven, and measuring the volume of dissipated carbon dioxide (CO_2) upon reaction of the soil with hydrochloric acid (HCl). The carbonate content is calculated from calibration values, and expressed as a percentage of dry mass of the original soil.

Test reference: ISO 10693:2004, ISO 19901-8:2014

CARBONATE CONTENT - GAS PRESSURE

The carbonate content is determined by using a dried or a natural soil specimen and measuring the pressure of dissipated carbon dioxide (CO_2) upon reaction of the soil with hydrochloric acid (HCl). The carbonate content is calculated from the mass of the specimen and the pressure increase after reaction by comparison with calibration values. For a natural soil, a correction factor is applied to correct for water content. Carbonate content is expressed as a percentage of dry mass of the original soil.

Test reference: ASTM D4373-14, ISO 19901-8:2014

WATER-SOLUBLE SULPHATE CONTENT – GRAVIMETRIC METHOD

The water-soluble sulphate content of a soil sample is determined on a test portion that has been sieved and crushed through a 2 mm sieve and oven dried to 110°C. The test portion is mixed with distilled water to prepare a 2:1 water:soil extract.

In the gravimetric method, barium chloride solution is added to the water:soil extract and the precipitated barium sulphate is collected, dried and weighted. The sulphate content is then calculated from the mass of the material used in the analysis and the mass of the barium sulphate precipitated. BS presents the results in SO_3 [g/l] and AASTHO in SO_4 [mg/kg].

If a 2:1 water:soil extract is prepared, one can convert sulphites (SO_3) into sulphates (SO_4) by multiplying SO_3 by a factor 1.2. For extractions other than a 2:1 the multiplying factor is different.

Test reference: BS 1377: Part 3:1990, AASHTO T290-95-UL (2007)

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WATER-SOLUBLE CHLORIDE CONTENT – MOHR'S METHOD

The water-soluble chloride content of a soil sample is determined on a test portion that has been sieved and crushed through a 2 mm sieve and oven dried to 110°C. The test portion is mixed with distilled water to prepare a 2:1 water:soil extract.

In the Mohr's method chloride ion will precipitate with silver nitrate. The chloride reacts with the silver ion before any silver chromate forms, due to the lower solubility of silver nitrate. The potassium chromate indicator reacts with excess silver ion to form a red silver chromate precipitate. The end point is the appearance of the first permanent orange colour. The chloride content is expressed as a percentage by mass of dry soil.

This test method is suitable for analysing solutions with a pH between 6.0 and 8.5.

Test reference: BS 1377: Part 3: 1990, AASHTO T291-94-UL (2008)

PERMEABILITY TESTING

CONSTANT HEAD PERMEABILITY: TRIAXIAL CELL

The effect of stress level on the coefficient of permeability may be estimated from constant head tests in a triaxial cell – flexible wall permeameter. The specimen is compacted in a split mould by tamping of thin layers of moist soil to the required initial density, and subsequently mounted in the triaxial cell. Filter screens or porous disks are placed at both ends of the specimen. The required stress level is applied and saturation is achieved by flushing with CO_2 gas followed by controlled flow of de-aired water and the application of backpressure. The degree of saturation is checked by the pore water pressure response to small variations in cell pressure. A hydraulic gradient is applied and the rate of flow is recorded for various time steps. The permeability is calculated in accordance with Darcy's equation for laminar flow.

References: BS 1377: Part 6: 1990, ASTM D5084-10, ISO 19901-8:2014

COMPRESSIBILITY TESTING

OEDOMETER - INCREMENTAL LOADING

The oedometer test covers determination of the rate and magnitude of consolidation of a laterally restrained soil specimen, which is axially loaded in increments of constant stress until the excess pore water pressures have dissipated for each increment. Normally, each load increment is maintained for 24 hours.

The test is generally carried out on undisturbed (intact) cohesive specimens using a consolidometer (oedometer) apparatus, which is placed in a thermostatically controlled room (10°C). Selection of mounting method depends on soil characteristics. Soils that show a tendency to swell, such as peat or overconsolidated clays, are mounted dry. Moist sponges are placed in the oedometer cell to retain sample moisture conditions. Other samples are usually mounted using the wet mounting method. Distilled water is added to the cell when loads are applied to the loading arm. When required, the initial load is increased to prevent swell.

Key parameters that can be obtained from this test are the preconsolidation pressure σ'_p and the coefficient of consolidation c_v. The preconsolidation pressure is estimated using the graphical Casagrande construction. The root time method or the log time method is used for determination of c_v. Other parameters that may be derived from this test are the compression index C_c, the coefficient of volume compressibility m_v and the vertical permeability k_v.

Test references: ASTM D2435/D2435M -11, BS 1377: Part 5: 1990, ISO 19901-8:2014

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OEDOMETER - CONSTANT RATE OF STRAIN

The Constant Rate of Strain (CRS) oedometer test covers determination of the rate and magnitude of consolidation of a laterally restrained soil specimen when it is drained axially and subjected to controlled deformation loading. The rate of deformation is selected so that excess pore water pressures are between 3% and 20% of the applied axial stress. Drainage of pore water is permitted from the top of the specimen and pore water pressures are measured at the bottom of the specimen. The test is generally carried out on undisturbed (intact) cohesive specimens using a consolidometer, in a thermostatically controlled room (20°C).

Key parameters that can be obtained from this test are the preconsolidation pressure σ'_p and the coefficient of consolidation c_v as a function of axial stress. The preconsolidation pressure is estimated using the graphical Casagrande procedure, while the coefficient of consolidation is determined analytically from the measurements of axial stress, strain and excess pore water pressure. Other parameters that may be derived from this test are the compression index C_c, the coefficient of volume compressibility m_v and the coefficient of vertical permeability k_v.

Test reference: ASTM D4186/D4186M-12, ISO 19901-8:2014

STRENGTH INDEX TESTING

TORVANE AND POCKET PENETROMETER

The torvane and pocket penetrometer are small hand-held instruments for rapid strength index testing of fine grained (cohesive) soils. The torvane test is carried out by pressing a standard vane into the soil and measuring the minimum torque required to rotate the vane. The vane size can be selected to suit the expected torque up to an equivalent undrained shear strength of the soil of 250 kPa. The undrained shear strength is correlated to the measured torque by vane size and torvane spring constant.

The pocket penetrometer test consists of pressing a small solid cylinder into the soil, to a specified penetration. The maximum force required for penetration is correlated to the undrained shear strength. The size of the cylinder can be selected so that undrained shear strength readings of up to 900 kPa can be taken.

Test reference: ISO 22475-1:2006, ISO 19901-8:2014

FALL CONE

The fall cone is a rapid index test for determining undrained shear strength of undisturbed or remoulded specimens of cohesive soil. The test consists of suspending a standard cone of a specified mass and apex angle vertically over and just touching the surface of the specimen. Subsequently, the cone is released and penetrates into the sample under its self-weight. The depth of penetration for the selected cone is correlated to the undrained shear strength of the soil. Several correlations exist. The cone size and shape can be selected to suit the expected undrained shear strength of the specimen.

Reference: ISO/TS 17892-6, ISO 19901-8:2014

HAND VANE

The hand vane allows index testing for undrained shear strength of cohesive soil. The tool is similar to the laboratory miniature vane except for reduced control: manual penetration and rotation of the vane.

Several different measurements of undrained shear strength are possible:

a) Intact: undisturbed undrained shear strength as measured on an intact specimen.
b) Intact–residual: measured post-peak during initial shearing of an intact specimen.
c) Intact–vane-remoulded: measured after multiple rotations of the hand vane after completion of the intact test.
d) Hand-remoulded: steady state (post-peak if exists) resistance of a hand-remoulded test specimen.
e) Hand-remoulded–cane-remoulded: steady state resistance of a hand-remoulded specimen measured after applying multiple vane rotations.

Different values of the remoulded shear strength are often obtained from the different measurement methods.

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A specimen may be tested in the sample tube in which it was taken, in a block sample or in a mould after removal from a sampler. The test apparatus consists of a rectangular vane with a short push rod for penetration into the soil. The vane is then slowly rotated by hand and the maximum torsional moment is recorded. Various vane sizes can be selected depending on the consistency of the specimen. Calculation of undrained shear strength is based on a cylindrical failure surface for which uniform stress distributions are assumed. The equation for undrained shear strength is as follows:

$$c_U = \frac{T_{max}}{\pi D^2 \left(\frac{1}{2} H + \frac{1}{6} D \right)}$$

where:

c_u	= peak undrained shear strength	[kPa]
T_{max}	= maximum torsional moment	[kNm]
D	= vane diameter	[m]
H	= vane height	[m]

Test reference: in-house

LABORATORY MINIATURE VANE

The laboratory miniature vane test allows determination of undrained shear strength of cohesive soil. CEN (2007) classifies the laboratory miniature vane as a strength index test.

Several different measurements of undrained shear strength are possible:

a) Intact: undisturbed undrained shear strength as measured on an intact specimen.
b) Intact–residual: measured post-peak during initial shearing of an intact specimen.
c) Intact–vane-remoulded: measured after multiple rotations of the vane after completion of the intact test.
d) Hand-remoulded: steady state (post-peak if exists) resistance of a hand-remoulded test specimen.
e) Hand-remoulded–vane-remoulded: steady state resistance of a hand-remoulded specimen measured after applying multiple vane rotations.

Different values of the remoulded shear strength are often obtained from the different measurement methods.

A specimen may be tested in the sample tube in which it was taken or in a mould after extrusion from the sample tube. The sample tube or mould is mounted in the test apparatus and a rectangular vane is lowered into the soil. The vane is then rotated at 10°/min (BS 1377) or at 60°/min to 90°/min (ASTM D4648) and the maximum torsional moment is recorded. A continuous record of rotation versus torsional moment can also be made if required (optional). Various vane sizes can be selected depending on the consistency of the specimen. Calculation of undrained shear strength is based on a cylindrical failure surface for which uniform stress distributions are assumed. The equation for undrained shear strength is as follows:

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$$c_U = \frac{T_{max}}{\pi D^2 \left(\frac{1}{2} H + \frac{1}{6} D \right)}$$

where:

c_u	= peak undrained shear strength	[kPa]
T_{max}	= maximum torsional moment	[kNm]
D	= vane diameter	[m]
H	= vane height	[m]

Test references: BS 1377: Part 7: 1990, ASTM D4648-10, ISO 19901-8:2014

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UNCONSOLIDATED UNDRAINED TRIAXIAL (UU)

This type of test is usually performed on undisturbed (intact) samples of cohesive soils. Depending on the consistency of the cohesive material, the test specimen is prepared by trimming the sample or by pushing a mould into the sample. A latex membrane with a thickness of approximately 0.2 mm is placed around the specimen. A lateral confining pressure of 600 kPa to 1000 kPa is maintained during axial compression loading of the specimen. Some test procedures consider lateral confining pressures that are equivalent to

total in situ vertical stress. Consolidation and drainage of pore water during testing is not allowed. The test is deformation controlled (strain rate of 60%/h), single stage, and stopped when an axial strain of 15% or 20% is achieved. The deviator stress is calculated from the measured load assuming that the specimen deforms as a right cylinder.

The presentation of test results includes a plot of deviator stress versus axial strain. The undrained shear strength, c_u, is taken as half the maximum deviator stress. The stress at 15% or 20% strain is used to calculate undrained shear strength if a maximum stress has not been reached earlier.

To determine strength sensitivity, the test may be repeated on remoulded (compacted) specimens. When possible, the tested undisturbed specimen is kneaded in the membrane, and then reshaped in a mould prior to testing. Stiff to hard specimens are cut into pieces, and reconstituted (compacted) by tamping the pieces in layers into a mould, until the original specimen dimensions are obtained. The sensitivity is the ratio of shear strength of undisturbed soil to shear strength of remoulded soil, $c_u/c_{u;r}$.

Test references: ASTM D2850-03a (2007), BS 1377: Part 7: 1990 (Clause 8), ISO 19901-8:2014

STRENGTH TESTING

RING SHEAR - SOIL/STEEL INTERFACE

Ring shear interface tests are performed on remoulded or reconstituted (compacted) soils to infer the residual friction angle, also called the constant volume friction angle (δ_{cv}), on a soil-steel interface.

The ring shear apparatus enables an annular specimen of soil, 5 mm thick with internal and external diameters of 70 mm and 100 mm, respectively, to be subjected to rotational shear.

First, the sample is consolidated to selected stress conditions. Then, it is sheared at a rate of 500 mm/min (fast shear), followed by 50 mm/min, up to a relative displacement of at least one metre. The sample is then resting for a period of 24h and after that is again consolidated to its selected stress conditions. Finally, the sample is sheared at a slower rate of 0.018 mm/min under drained conditions.

The presentation of the test results includes a plot of stress ratio and angle of shearing resistance versus displacement, both for fast and slow shear.

Test reference: BS 1377: Part 7: 1990, Jardine et al. (2005) (Appendix A), ISO 19901-8:2014

DIRECT SIMPLE SHEAR (DSS)

Simple shear tests provide a simulation of the plane strain mode of shearing for undisturbed (intact), remoulded or reconstituted (compacted) specimens. Key features of the DSS test are essentially constant horizontal dimensions of the specimen in the direction of shear, and a constant volume during shear to simulate undrained behaviour for a saturated test specimen. A constant volume is achieved by maintaining a constant specimen height. A constant specimen height is achieved by varying the normal load applied to the specimen or by fixing the vertical loading ram in place.

The direct simple shear test is carried out on a cylindrical specimen of 66 mm diameter and 16 mm to 19 mm height depending on the test apparatus. Lateral confinement of the specimen is provided by a membrane in combination with a stack of brass shearing washers, or by a reinforced membrane. There are no facilities for applying back pressure and control of drainage.

The stress state within a test specimen is insufficiently uniform to allow fundamental processing of test results. Nevertheless, data are commonly presented by shear stresses and strains for the horizontal plane and by equivalent pore pressures.

The peak horizontal shear stress is inferred as the undrained shear strength.

Test reference: ASTM D6528-07, ISO 19901-8:2014

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DIRECT SHEAR – SOIL/SOIL INTERFACE

Direct shear testing (or shear box testing) is a method for determining drained soil resistance (angle of internal friction, φ') for cohesionless and cohesive soils.

The soil to be tested is placed in a split mould, with internal dimensions of 60 mm by 60 mm. A porous stone and loading plate are placed on top of the specimen and a normal load is applied to the specimen. The sample is then sheared, by displacing the top half of the split mould relative to the bottom half, at a rate of displacement preventing significant excess pore water pressures to be generated. During the test, horizontal displacement, load and vertical displacement are recorded.

On completion of the first stage, the specimen is removed from the mould and the unit weight and water content are determined. Two further tests may then be performed, at the same unit weight, but with increased normal loads.

The test results are presented in the form of graphs of horizontal displacement versus shear stress and normal stress versus maximum shear stress.

Test reference: BS1377: Part 7: 1990, ISO 19901-8:2014

CONSOLIDATED UNDRAINED TRIAXIAL (CIU AND CAU)

The consolidated undrained triaxial test offers the opportunity to derive both undrained and drained strength parameters for undisturbed (intact) or remoulded (compacted) specimens. Specimens are generally prepared by trimming cohesive samples to the required dimensions. The wet mounting method is used, which includes use of wet porous disks and a water-filled drainage system.

Test procedures include specimen saturation, consolidation and compression loading. For cohesive soils, filter paper strips are attached to the specimen circumference to promote drainage during consolidation. Saturation is obtained by incrementing cell pressure and back pressure. The degree of saturation is checked by the pore water pressure response to small variations in cell pressure.

In case of isotropic consolidation (CIU) the specimen is usually consolidated to a stress level equivalent to the mean in situ stress estimated for the appropriate sample depth. For anisotropic consolidation (CAU), the specimen is consolidated to the estimated vertical and horizontal effective stresses. Various consolidation stages may be adopted to simulate the consolidation history and the effects of the expected loading sequence.

Specimen shearing is carried out under conditions of constant axial strain rate, while monitoring axial load and pore water pressure. A strain rate of 4%/h is generally applied, except when consolidation was slow, in which case a smaller strain rate is applied. The deviator stress is calculated from the measured load assuming the specimen deforms as a right cylinder. The shearing stage is terminated on the basis of effective principal stress ratio (ratio of effective axial stress to effective lateral stress σ'_1/σ'_3), or when an axial strain of 15% or 20% is reached. The CIU test may consist of three consolidation and shearing stages of increasing stress level. These stages may be performed on a single specimen or on three separate specimens.

The presentation of test results includes stress-strain data, effective stress paths, pore water pressures and shear strength parameters. Stress paths may be presented in terms of a mean effective stress (p' or s') and the principal stress difference or deviator stress (q or t) as follows:

- Cambridge p'-q space and ASTM p'-q space, with p' defined as $(\sigma'_1+2\sigma'_3)/3$ and q as $\sigma_1-\sigma_3$;
- BSI (1990) s'-t space, with s' defined as $(\sigma'_1+\sigma'_3)/2$ and t as $(\sigma_1-\sigma_3)/2$.

The undrained shear strength is defined as half the deviator stress at failure, $c_u = q/2$ and is reported for the following failure criteria:

1) maximum deviator stress
2) maximum stress ratio q/p'.

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The stress at 15% or 20% strain is used to calculate undrained shear strength when a maximum stress has not been reached. A secant angle of internal friction, φ', is determined from $q = Mp'$ where $M = (6\sin\varphi')/(3-\sin\varphi')$ or $\sin\varphi' = 3M/(6+M)$ for compression conditions. This definition assumes a zero effective cohesion intercept and may be applied to M_{max} but also to other values of M and corresponding values of q and p'. Similarly, $\sin\varphi' = t/s'$. For tests with three shearing stages, angles of internal friction may be determined for each stage separately, and from a straight line approximation of the failure points of the three stages. The latter method also provides a value for effective cohesion intercept c'.

Test references: NEN 5117, ASTM D4767-11 (2011), BS 1377: Part 8: 1990 (Clause 4, 5, 6, 7), ISO 19901-8:2014

CONSOLIDATED DRAINED TRIAXIAL (CID AND CAD)

Consolidated drained triaxial compression tests are generally performed on samples of cohesionless soils. The specimen of dry soil is prepared in the rubber membrane on the base of the triaxial cell, without the use of side drains. Soil particles larger than 20% of the diameter of the specimen are removed. Specimens are prepared by tamping thin layers of soil to a density approximating the estimated in situ dry density. To saturate the specimen, CO_2 gas is used to expel the air and subsequently de-aired water is used to expel the CO_2 gas. The specimen is further saturated by incrementing cell pressure and back pressure, until the pore pressure response to a cell pressure increment (B-factor) indicates saturation is complete. The specimen is then isotropically or anisotropically consolidated (CID and CAD respectively).

After consolidation the sample is sheared by applying axial load at a sufficiently slow rate to permit drainage (usually 6%/h). The lateral confining pressure is kept constant during each loading stage. Pore pressure measurements are made at the bottom to check if the test is fully drained. The deviator stress is calculated from the measured load assuming the specimen deforms as a right cylinder. The CID test may have three consolidation and loading stages of increasing pressure performed on either a single specimen or on three separate specimens. The CAD test is limited to a single shearing stage. A shearing stage is terminated on the basis of effective stress ratio (ratio of effective axial stress to effective lateral stress, σ'_1/σ'_3), or when an axial strain of 15% or 20% is reached.

Results include stress-strain data, stress paths, and volumetric/shear strain of each loading stage. Stress paths may be presented in terms of a mean effective stress (p' or s') and the principal stress difference or deviator stress (q or t) as follows:

- Cambridge p'-q space and ASTM p'-q space, with p' defined as $(\sigma'_1+2\sigma'_3)/3$ and q as $\sigma_1-\sigma_3$;
- BSI (1990) s'-t space, with s' defined as $(\sigma'_1+\sigma'_3)/2$ and t as $(\sigma_1-\sigma_3)/2$.

A secant angle of internal friction, φ', is determined from $q = Mp'$ where $M = (6\sin\varphi')/(3-\sin\varphi')$ or $\sin\varphi' = 3M/(6+M)$ for compression conditions. This definition assumes zero effective cohesion intercept and may be applied to M_{max} but also to other values of M and corresponding values of q and p'. Similarly, $\sin\varphi' = t/s'$. For tests with three shearing stages, angles of internal friction may be determined for each stage separately, and from a straight line approximation of the failure points of the three stages. The latter method also provides a value for effective cohesion intercept c'.

Test reference: ASTM D7181-11; BS 1377: Part 8: 1990 (Clause 4, 5, 6, 8), ISO 19901-8:2014

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INTRODUCTION

The Cone Penetration Test (CPT) involves the measurement of the resistance of ground to steady and continuous penetration of a cone penetrometer equipped with internal sensors. The measurements comprise penetration depth, cone resistance, sleeve friction and, optionally, pore pressure and inclination from vertical. These measurements permit interpretation of ground conditions.

CPT apparatus and procedures adopted by Fugro are in general accordance ISSMGE (1999), ASTM (2012), ISO (2012) and ISO (2014). BS 5930 (BSI, 1999) and NORSOK Standard G-CR-001 (NORSOK, 2004) refer to ISSMGE (1999). General agreement also applies to Eurocode 7 (CEN, 2007).

Fugro offers CPT systems operated from (1) ground surface and seafloor (non-drilling deployment mode) and (2) downhole in a borehole (drilling deployment mode).

CPT APPARATUS

GENERAL

CPT apparatus includes various parts as described below:
- Thrust machine: apparatus providing thrust to the push rods so that the required constant rate of penetration is controlled.
- Reaction equipment: reaction for the thrust machine.
- Push rod: thick-walled cylindrical tube used for advancing the penetrometer to the required test depth. Push rods may also consist of drill pipe.
- Friction-cone penetrometer (CPT): cylindrical terminal body mounted on the lower end of the push rods, including a cone, a friction sleeve and internal sensing devices for the measurement of cone resistance, sleeve friction and, optionally, inclination.
- Piezo-cone penetrometer (CPTU or PCPT): cylindrical terminal body mounted on the lower end of the push rods, including a cone, a friction sleeve, a filter and internal sensing devices for the measurement of cone resistance, sleeve friction, pressure and, optionally, inclination.
- Measuring system: apparatus and software, including sensors, data transmission apparatus, recording apparatus and data processing apparatus.

DEPLOYMENT FROM GROUND SURFACE OR SEAFLOOR

Specific additional apparatus for CPT deployment from ground surface and seafloor can include:
- Push rod casing: guide for the part of the push rods protruding above the soil, and for the push rod length exposed in water or soil, in order to prevent buckling when the required penetration pressure increases beyond the safe limit for the exposed upstanding length of push rods.
- Friction reducer: ring or special projections fixed on the outside of the push rods, with an outside diameter larger than the base of the cone, to reduce soil friction acting on the push rods.

DOWNHOLE BOREHOLE DEPLOYMENT

Downhole CPT systems latch into a bottom hole assembly at the lower end of a drill pipe. System options are:
1. Operation of a downhole thrust machine by applying mud pressure in the borehole.
2. Remote control of a downhole thrust machine by hydraulic pressure transmitted through an umbilical cable connected to a surface-based pump unit, together with.
3. Application of thrust to drill rods where CPT apparatus and a short push rod are latched in the bottom hole assembly; the thrust machine is at ground surface or seafloor.

Data recording can be surface-based and/or downhole.

Downhole CPTs require drilling apparatus for advancing the borehole. The maximum CPT stroke is generally 1.5 m or 3 m.

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CONE PENETROMETER

Typical features of Fugro penetrometers (Figure 1) include:
- Cone base areas of 500 mm^2, 1000 mm^2 or 1500 mm^2; other sizes are also in use, e.g. 3300 mm^2
- Cone and friction sleeve sensors placed in series, i.e. subtraction-type penetrometers.
- Pore pressure measurements either at the face of the cone (u_1) or at the cylindrical extension of the cone (u_2). Multiple-sensor penetrometers (u_1, u_2 and u_3) are also available. The u_3 location is immediately above the friction sleeve.
- Inclinometer.
- Storage of signals from the penetrometer in digital form for subsequent computer-based processing and presentation.

PROCEDURE

Figure 2 summarises the test procedure. The procedure includes several stages. The stage of Additional Measurements is optional.

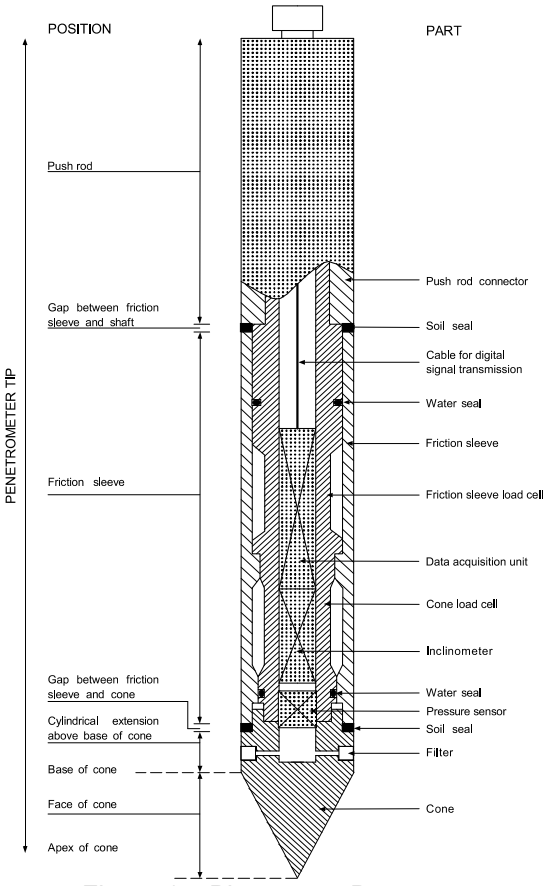


Figure 1 – Piezo-cone Penetrometer

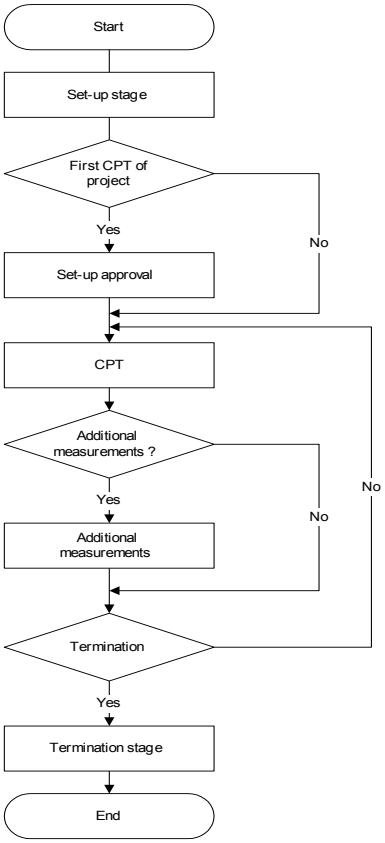


Figure 2 - Flow chart

Set-up requires a reasonably flat, accessible, ground surface with a slope of 5° or less. In other cases, set-up is at discretion of the equipment operator, considering risks such as damage to apparatus or safety of personnel. Most onshore thrust machines have levelling facilities allowing a vertical start of penetration. Seabed frames used for offshore CPT activities have no levelling facilities, i.e. start of penetration may not be vertical.

The set-up stage includes selection of equipment and procedures according to project-specific agreements, such as a required accuracy class or application class, penetration, type of cone penetrometer and data processing/ submission. Table 1 presents ISSMGE accuracy classes and Tables 2 and 3 summarise ISO application classes. The allowable minimum accuracy of a measured parameter is the larger value of the two quoted. A percentage value applies to the measured value and not to the measuring range. The

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concept of application classes considers intended soil conditions for selection of an application class. For example, Application Class 1 of ISO (2014) can be selected for “very soft to soft soil deposits”, which is approximately equivalent to $q_c < 0.5$ to $q_c < 1$ MPa. In other words, Application Class 1 should not apply to “mixed bedded soil profiles with weak to strong layers”.

The accuracy values apply to ground surface or seafloor as reference. They are uncoupled from uncertainty of spatial position below ground surface or seafloor.

TABLE 1 ACCURACY CLASSES (ISSMGE, 1999)

Accuracy Class	Measured Parameter	Allowable Minimum Accuracy	Maximum Length between Measurements
1	Cone resistance, q_c Sleeve friction, f_s Pore pressure, u Inclination, i Penetration depth, z	50 kPa or 3% 10 kPa or 10% 5 kPa or 2% 2° 0.1 m or 1%	20 mm
2	Cone resistance, q_c Sleeve friction, f_s Pore pressure, u Inclination, i Penetration depth, z	200 kPa or 3% 25 kPa or 15% 25 kPa or 3% 2° 0.2 m or 2%	20 mm
3	Cone resistance, q_c Sleeve friction, f_s Pore pressure, u Inclination, i Penetration depth, z	400 kPa or 5% 50 kPa or 15% 50 kPa or 5% 5° 0.2 m or 2%	50 mm
4	Cone resistance, q_c Sleeve friction, f_s Penetration length, l	500 kPa or 5% 50 kPa or 20% 0.1 m or 1%	50 mm

TABLE 2 APPLICATION CLASSES (ISO, 2012)

Appl. Class	Measured Parameter	Allowable Minimum Accuracy	Maximum Length between Measurements
1	Cone resistance, q_c Sleeve friction, f_s Pore pressure, u Inclination, i Penetration length, l	35 kPa or 5% 5 kPa or 10% 10 kPa or 2% 2° 0.1 m or 1%	20 mm
2	Cone resistance, q_c Sleeve friction, f_s Pore pressure, u Inclination, i Penetration length, l	100 kPa or 5% 15 kPa or 15% 10 kPa or 3% 2° 0.1 m or 1%	20 mm
3	Cone resistance, q_c Sleeve friction, f_s Pore pressure, u Inclination, i Penetration length, l	200 kPa or 5% 25 kPa or 15% 50 kPa or 5% 5° 0.2 m or 2%	50 mm
4	Cone resistance, q_c Sleeve friction, f_s Penetration length, l	500 kPa or 5% 50 kPa or 20% 0.2 m or 2%	50 mm

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TABLE 3 APPLICATION CLASSES (ISO, 2014)

Application Class	Measured Parameter	Allowable Minimum Accuracy
1	Cone Resistance	35 kPa or 5%
	Sleeve friction	5 kPa or 10%
	Pore pressure	25 kPa or 5%
2	Cone resistance	100 kPa or 5%
	Sleeve friction	15 kPa or 15%
	Pore pressure	50 kPa or 5%
3	Cone Resistance	200 kPa or 5%
	Sleeve friction	25 kPa or 15%
	Pore pressure	100 kPa or 5 %

The set-up stage or the termination stage includes the location survey, i.e. the determination of the co-ordinates and the ground surface elevation (or the water depth).

The set-up stage and the termination stage for a downhole CPT include lowering of the CPT apparatus into the borehole and lifting respectively. Most projects require multiple downhole tests in a single borehole.

For piezo-cone testing, the set-up stage also includes the following steps:
- Office-based or site-based: de-airing of the filter in glycerine by application of 24-hour vacuum and storage in a glycerine-filled container.
- On-site: glycerine filling of hollow space in the cone penetrometer and subsequent mounting of the filter.
- On-site: application of a flexible membrane around the filter to prevent loss of saturating fluid prior to the start of a test.

Land-based tests may include specific measures to help retention of filter saturation during penetration of partially saturated zones. Relaxation of requirements typically applies to offshore tests where water pressures will force entrapped air into solution.

Criteria for test termination are as follows, unless specifically agreed otherwise:
- as instructed by Client
- reaching target penetration
- reaching maximum capacity of the thrust machine, reaction equipment, push rods and/or measuring sensors
- penetrometer inclination of greater than 15^{o}
- sudden increase in penetrometer inclination
- circumstances at discretion of equipment operator, such as risk of damage to apparatus or safety of personnel,

whichever occurs first and as applicable.

A CPTU pore pressure measuring system is intended for use in water-saturated uncemented fine-grained soil. Results obtained for ground conditions such as partially saturated soils, very dense sands and cemented soils may not be reliable and/or repeatable. For example, stiffness differences between the steel components of the cone penetrometer and the piezo-cone filter can affect results for very dense sands. Also, loss of saturation of the pore pressure measuring system may occur during a test (Lunne et al. 1997; Peuchen and Terwindt 2014). Reasons can include:
- penetration of partially saturated ground, for example ground containing significant amounts of gas
- measurement of negative pore pressures such that cavitation occurs. For example, this is not uncommon for a piezo-cone filter located at the cylindrical extension above the base of the cone (u_2 location). Particularly, this may occur at the time of penetration of dense sand or overconsolidated clay layers. Loss of saturation usually causes a sluggish pore pressure response during penetration of ground below the zone causing desaturation of the pore pressure measuring system.

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Special apparatus and procedures may apply to:
- specific additional measurements (for example shear wave velocity)
- specific applications (for example deepwater tests or measurements for application (accuracy) classes 1 and 2).

RESULTS

CPT PARAMETERS

Presentation of results from cone penetration tests typically includes:
- CPT parameters q_c, f_s and R_f versus depth below ground surface or versus elevation
- additional CPTU parameters u_1 or u_2 and, optionally, q_t, q_n, B_q, Q_t, Q_{tn}, F_r and I_c for tests with pore pressure measurements
- optionally, inclination i for tests with inclination measurements
- standard graphical format and optional ASCII and AGS formats.

Most standards specify scales for graphical presentation as follows:
- axis for penetration depth z: 1 scale unit = 1 m
- axis for cone resistance q_c, corrected cone resistance q_t and net cone resistance q_n: 1 scale unit = 2 MPa or 0.5 MPa
- axis for sleeve friction f_s: 1 scale unit = 50 kPa
- axis for friction ratio R_f: 1 scale unit = 2%
- axis for pore pressure u: 1 scale unit = 0.2 MPa or 0.02 MPa
- axis for pore pressure ratio B_q: 1 scale unit = 0.5.

Graphical presentation aims for these scale units and scale ratios, where suitable and practicable.

This reference level of a test is (1) the ground surface for onshore tests, (2) the seafloor for nearshore and offshore tests. Historically, the bottom of the borehole was used as the reference level of downhole tests. Data processing presumes a hydrostatic pore pressure profile relative to seafloor, unless specifically indicated otherwise. The definition of CPT parameters is as follows:

z = penetration depth relative to ground surface or seafloor, corrected for inclination from vertical (i) where a test includes inclination measurements, as follows:

$$z = \int_0^l \cos i \, . \, dl$$

where:
- z = penetration depth for the conical base of the cone penetrometer
- l = recorded penetration length
- i = recorded inclination from vertical

q_c = cone resistance relative to the reference level of the test.

f_s = sleeve friction relative to the reference level of the test. A calculated depth correction applies so that the presented sleeve friction corresponds with the cone depth.

f_t = corrected sleeve friction relative to the reference level of the test. Sleeve friction is corrected for pore pressures acting on the end areas of the friction sleeve

$$f_t = f_s - \frac{(u_2 * A_{sb} - u_3 * A_{st})}{A_s}$$

or simplified to:

$$f_t = f_s - u_2 \frac{(A_{sb} - A_{st})}{A_s} \quad \text{or}$$

$$f_t = f_s - (u_2 * a_{fs})$$

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where:
A_{sb} = cross sectional area in the gap between the friction sleeve and the cone
A_{st} = cross sectional area in the gap above the friction sleeve
A_s = surface area of the friction sleeve
a_{fs} = net area ratio of the friction sleeve $(A_{sb} – A_{st})/A_s$

R_f = ratio of sleeve friction to cone resistance (f_s/q_c). This calculated ratio is for the cone depth.

R_{ft} = corrected friction ratio (f_s/q_t). The ratio f_t/q_t applies if f_t is known.

I_{SBT} = non-normalized soil behaviour type index (Robertson, 2010)

$$I_{SBT} = [(3.47 – \log(q_c/P_a))^2 + (\log R_f + 1.22)^2]^{0.5}$$

where:
P_a = atmospheric pressure

u_1 = pore pressure at the face of the cone, relative to the reference level of the test.

u_2 = pore pressure at the cylindrical extension above the base of the cone or in the gap between the friction sleeve and the cone, relative to the reference level of the test.

u_3 = pore pressure immediately above the friction sleeve or in the gap above the friction sleeve, relative to the reference level of the test.

q_t = corrected cone resistance (also called total cone resistance). This includes corrections for hydrostatic and transient pore pressures, and cone construction. The corrected cone resistance is relative to ground surface or seafloor:

Ground surface / seafloor:
$q_t = q_c+(1-a)u_2$ or
$q_t = q_c+(1-a)\{K(u_1-u_o)+u_o\}$

Downhole (historic):
$q_t = q_c+(1-a)u_2+u_{oi}$ or
$q_t = q_c+(1-a)\{K(u_1+u_{oi}-u_o)+u_o\}+au_{oi}$

where:

a = net area ratio of the cross-sectional steel area at the gap between cone and friction sleeve to the cone base area. This ratio is penetrometer-type dependent. The a-factor indicates the effect of pore pressure on unequal cross-sectional areas of the cone.

u_o = hydrostatic pore pressure at the cone, relative to the phreatic surface or the seafloor. This is a calculated value.

u_{oi} = hydrostatic pore pressure at the bottom of the borehole, relative to seafloor. This is a calculated value.

K = adjustment factor for the ratio of pore pressure at the cylindrical extension above the base of the cone to pore pressure on the cone face.

Ground surface / seafloor:
$K = (u_2-u_o)/(u_1-u_o)$

Downhole (historic):
$K = (u_2+u_{oi}-u_o)/(u_1+u_{oi}-u_o)$

The term u_2-u_o or $u_2+u_{oi}-u_o$ refers to excess pore pressure (with respect to hydrostatic pore pressure). Common symbols for excess pore pressure are du_2 or Δu_2. Similarly, du_1 or Δu_1 may represent the term u_1-u_o or $u_1+u_{oi}-u_o$.

The K-factor is only of interest for processing of CPTU results with pore pressure measurement at the cone face (u_1). The factor depends on soil characteristics as fabric, overconsolidation ratio, compressibility and crushability. The K-factor is estimated from:

$$K = 0.91e^{-0.09Q_t^{0.47}}\left(\frac{1}{1+F_r(0.17+0.061(Q_t-21.6)^{1/3})}-e^{-2F_r}\right)$$ (Peuchen et al., 2010)

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q_n = q_t-σ_{vo} = net cone resistance. This includes corrections for hydrostatic and transient pore pressures, in situ stress, and cone construction. The symbol for q_n may also be q_{net}.

where:
σ_{vo} = total in situ vertical stress at the cone base, relative to ground surface or seafloor. This is a calculated value.

Q_t = q_n/σ'_{vo} = normalized cone resistance

where:
σ'_{vo} = effective in situ vertical stress at the cone base, relative to ground surface or seafloor. This is a calculated value.

Q_{tn} = normalized cone resistance with variable stress exponent n, where:

$$Q_{tn} = [(q_t - \sigma_{vo})/P_a] (P_a/\sigma'_{vo})^n$$

$$n = 0.381 (I_c) + 0.05 (\sigma'_{vo} / P_a) - 0.15 \text{ and } n \leq 1$$ (Zhang et al., 2002)

I_c = soil behaviour type index (Robertson and Wride,1998)

$$I_c = [(3.47 - \log Q_{tn})^2 + (\log F_r + 1.22)^2]^{0.5}$$

F_r = f_t/q_n = normalized friction ratio.

B_q = pore pressure ratio.

Ground surface / seafloor:
B_q = $K(u_1-u_o)/q_n$ or
B_q = $(u_2-u_o)/q_n$

Downhole (historic):
B_q = $K(u_1+u_{oi}-u_o)/q_n$ or
B_q = $(u_2+u_{oi}-u_o)/q_n$

Note that pore pressure measurements (u) are commonly assumed to represent pore water pressures. This assumption is reasonable for soils saturated under in situ stress conditions and remaining saturated during penetration of the cone penetrometer. Furthermore, pressure u_2 at the cylindrical extension is commonly assumed equal to u_{2g} in the gap. This assumption is reasonable for saturated low-permeability soils (clays) that are normally consolidated or lightly overconsolidated and where the gap can become saturated by adequate supply of water and/or water pressure. A similar comment applies to u_3.

Presented values for u_2, q_t, q_n and B_q may be denoted by u_2*, q_t*, q_n*, B_q*, Q_t* and F_r* if u_2 is derived rather than measured, for example if derived by applying a K-factor.

Some deployment systems allow monitoring of CPT parameters in reverse mode, i.e. upon retraction of the cone penetrometer. This optional feature presents additional information that can improve interpretation of ground behaviour, for example strength sensitivity of fine-grained soil.

ACCURACY OF MEASUREMENTS

Accuracy Classes and Application Classes

Cone penetration test standards can follow a “prescriptive” approach, whereby specific detailed measures provided a “deemed to comply” practice. ASTM (2012) is an example of this approach. ISSMGE (1999) and ISO (2012, 2014) specify “performance” criteria for cone penetration test measurements. The ISO standard on metrological confirmation (ISO, 2003) provides the general framework for assessment of performance compliance. Peuchen and Terwindt (2014, 2015) provide guidance on uncertainty estimation for cone penetration test results.

The following comments apply:
- Accuracy is the “closeness of a measurement to the true value of the quantity being measured”. It is the accuracy as a whole that is ultimately important not the individual parts. Precision is the “closeness of each set of measurements to each other”. The resolution of a measuring system is the “minimum

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size of the change in the value of a quantity that it can detect". It will influence the accuracy and precision of a measurement.
- Accuracy Class 3 and Application Class 3 typically represents industry practice. They are approximately equivalent to the more implicit requirements of ASTM International. Class 3 applies, unless specifically agreed otherwise.

So-called "zero drift" of a measured parameter is an approximate performance indicator for the measuring system. Zero drift is the absolute difference of the zero readings, reference readings or zero reference reading of a measuring system between the start and completion of the cone penetration test. The reference readings can be taken at (1) atmospheric pressure at ground surface or above water level or (2) under hydrostatic water pressure close to seafloor. The zero drift of the measured parameters should be within the allowable minimum accuracy according to the selected accuracy class. Correction of measured parameters for zero drift can be adopted if appropriate. Peuchen and Terwindt (2014) provide comments on interpretation of zero drift values.

Accuracy considerations for strongly layered soils should allow for heat flux phenomena. Heat flux gives an apparent shift in cone resistance (Post and Nebbeling, 1995). For example, friction in dense sand causes a cone to heat by about 1^{o}C/MPa cone resistance. Resulting heat flux decreases cone resistance by an apparent shift in the order of 100 kPa to 200 kPa for a penetrating probe going from dense sand into clay. This is a temporary decrease lasting about 5 minutes. Ambient temperature compensation systems cannot avoid heat flux effects. Penetration interruption can serve as mitigation measure.

Shallow Penetration

Use of reaction equipment will affect stress conditions for shallow penetration. Particularly, offshore conditions may include extremely soft ground at seafloor. Soil disturbance, pore pressure build-up and consolidation of near-surface soft soil may take place. This will affect the measurements.

Downhole borehole deployment implies a typical limiting CPT stroke of 1.5 m or 3 m. It is common to perform multiple semi-continuous tests. Graphics for such tests typically show a build-up of CPT values for the initial 0.1 m to 0.5 m penetration. This penetration zone is immediately below the required borehole and represents complex ground stress conditions and/or borehole-induced ground disturbance that cannot be avoided.

Penetration Interruption

A penetration interruption may be unavoidable, for example to add a push rod or to perform a pore pressure dissipation test. This will affect test results.

Consolidation of low-permeability soil around a cone tip is of particular interest. A stationary cone penetrometer can apply local stresses that approach failure conditions, i.e. about 9 times the undrained shear strength or about 2 times the in situ mean effective stress. Pore pressure re-distribution and dissipation occur, resulting in a local increase in undrained shear strength and hence cone (bearing) resistance. A doubling of cone resistance may not be unreasonable for 100% consolidation. Supplementary considerations include:
- Small downward movement of a penetrometer (order of millimetres) during a test can contribute to maintaining local stresses approaching failure conditions.
- Soil consolidation around a cone penetrometer may lead to soil/penetrometer adhesion that is sufficient to give an increase in "cone" diameter. Resumption of penetration will lead to loss of adhered soil, usually within an equivalent distance of a few times the cone diameter.
- A low B_q value may imply partially drained penetration conditions. It is likely that any steady-state penetration conditions will not apply instantaneously upon resumption of penetration.
- Measuring sensors in a probe generate heat, but this is probably not significant for any stationary measurement. Fugro's strain-gauge load sensors are compensated for ambient temperature fluctuations.

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Depth Measurement for Offshore Conditions

Offshore definition of the seafloor (ground surface) is difficult for extremely soft ground at seafloor. Penetration of the reaction equipment into a near-fluid zone of the seabed may take place unnoticed. Such settlement affects the start of penetration depth z. Also, settlement may continue at the time of testing.

Downhole CPT systems rely on depth control applicable to borehole drilling. Depth control according to Z2 of Table 4 is feasible for drilling systems deployed from a fixed platform, for example a jack-up. This value excludes uncertainty associated with determination of seafloor level. Drilling control from floating equipment, for example a geotechnical survey vessel, may be subject to the additional influence of waves and tides. Z2 is typically feasible for favourable conditions. Z3 or Z4 may apply for adverse conditions.

TABLE 4 DEPTH ACCURACY CLASSES ACCORDING TO ISO (2014)

Depth Accuracy Class	Maximum Data Point Depth Uncertainty [m]
Z1	0.1
Z2	0.5
Z3	1.0
Z4	2.0
Z5	> 2.0

Zero-Correction for Offshore Conditions

Water pressures generate significant values of cone resistance and pore pressure. The standardised practice is to correct these reference readings to zero at seafloor. CPT systems for non-drilling mode and for seafloor drilling mode allow zero-correction to hydrostatic conditions prior to the start of a test, typically with a zero-correction uncertainty approaching the resolution of the CPT system. Downhole borehole CPT systems latch into the lower end of a drill pipe. The pressure conditions in the drill pipe may not be in full equilibrium with the surrounding ground water pressure and zero-correction will be subject to increased uncertainty, i.e. uncertainty for pore pressure in the order of 100 kPa for deepwater tests (Peuchen, 2000). This uncertainty depends on factors such as the free-flow and viscosity of drill fluid between the drill bit and the seafloor. The uncertainty typically decreases with decreasing depth of the drill bit below sea level and below seafloor. Uncertainty for the zero-correction of cone resistance is approximately equivalent, but by a factor representing the net area ratio effect.

Deepwater Tests

A deepwater environment presents some favourable conditions for cone penetration tests, notably temperature. Ambient temperature conditions are practically constant and the measuring system has ample time to adjust to these temperatures. In addition, transient heat flow phenomenain a cone penetrometer are usually not applicable due to the generally very soft soil consistency and the absence of crust layers formed by desiccation of clay or silt in geological history.

Deepwater (piezo-cone) pore pressure measurements are essentially similar to shallow-water measurements, with the exception of an increased measuring range for pore pressure leading to some reduction in sensor accuracy. Saturation of a pore pressure measuring system is excellent for a deepwater environment, as the high pressures will force any gas bubbles into solution.

Currently available evidence indicates that a high-quality subtraction-type cone penetrometer is adequate for very soft soil characterisation to a water depth of 3000 metres and probably beyond.

ADDITIONAL MEASUREMENTS

Friction-cone and piezo-cone penetrometers allow specific additional measurements, such as friction set-up tests, pore pressure dissipation tests and measurements of ground water pressure. These additional measurements require a penetration interruption or may be feasible at the end of a test. It is also common

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to add other in situ test devices to a cone penetrometer. Table 5 presents the more common types.

TABLE 5 PROBES FOR ADDITIONAL IN SITU TESTS

Type of Probe	Properties	Units
Electrical Conductivity Penetrometer (ECPT)	Electrical conductivity, K	S/m
Temperature Cone Penetrometer (TCPT)	Temperature, T	°C
Seismic Cone Penetrometer (SCPT)	Shear wave velocity, v_s	m/s
Cone Pressuremeter (CPMT)	Shear stress-strain-time response, σ, ε, t	MPa, -, s
Natural Gamma Penetrometer (GCPT)	Natural gamma ray, γ	CPS
Cone Magnetometer (CMMT)	Magnetic flux density B, magnetic field horizontal angle θ and vertical angle ϕ	μT, °, °
Hydraulic Profiling Tool (HPT)	Permeability, k	m/s
S = Siemens m = metre s = second	Pa = Pascal CPS = counts per second T = Tesla	

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INTRODUCTION

This document presents a summary of interpretation methods for Cone Penetration Test (CPT) results. The project-specific selection of methods depends on the agreed project requirements. Some of the methods suit computer-based interpretation of CPT data records.

Interpretation of Cone Penetration Test results helps provide parameters for geotechnical models. Conventional models are typically based on plasticity theory for ultimate limit states, and on elasticity theory and consolidation theory for serviceability limit states. Features of these geotechnical models are:

- analysis of either drained (sand model) behaviour or undrained (clay model) behaviour for plasticity models
- analysis for the ultimate limit state differs from that for the serviceability limit state.

CPT interpretation methods are mostly based on empirical correlations with limited theoretical backing. Data integration with other, complementary investigation techniques (such as drilling, sampling and laboratory testing) improves confidence levels.

The interpretation techniques discussed below are subject to limitations such as:

- The majority of interpretation methods apply to "conventional" sands and clays. Conventional methods may not be appropriate for silts, sand/clay/gravel mixtures, varved or layered soils, gassy soils, underconsolidated soils, peats, carbonate soils, cemented soils and residual soils. These non-conventional soils warrant a more specific approach.
- Empirical correlations use reference parameters such as the undrained shear strength determined from a laboratory single-stage Isotropically Consolidated Undrained triaxial test (CIU) on an undisturbed specimen obtained by means of push sampling techniques (Van der Wal et al., 2010). The reference parameter may not be appropriate for the selected geotechnical model, and adjustment may be necessary. Also, adjustment for test conditions may be necessary, for example in situ temperature versus laboratory temperature.
- The cone penetration test offers limited direct information on serviceability limit states (deformation), as the penetration process imposes large strains in the surrounding soil. In comparison to ultimate limit states, better complementary data will usually be required.
- CPT interpretation techniques are often indirect. Usually, interpretation requires estimates of various other parameters. This is consistent with an integrated geotechnical investigation approach. Inevitably, this approach also includes some redundancy of data.
- Drained or undrained behaviour for the geotechnical analysis at hand may or may not coincide with respectively drained or undrained behaviour during fixed-rate penetration testing. This interpretation difficulty remains largely unresolved at this time.
- The interpretations apply to conditions as encountered at the time of the geotechnical investigation. Geological, environmental and construction/operational factors may alter as-found conditions.

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PENETRATION BEHAVIOUR

Soil behaviour during cone penetration testing shows large displacements in the immediate vicinity of the penetrometer, and small elastic displacements further away from the penetrometer. Density/structure, stiffness and in situ stress conditions significantly affect the measured parameters.

The measured cone resistance (q_c) includes hydrostatic water pressures as well as stress-induced pore pressures. The pore pressures are usually negligible for clean sand because the ratio of effective stress to pore pressure is high. This ratio is, however, low for penetration into clay. Knowledge of pore pressures around the penetrometer can thus be important. CPT parameters that take account of pore pressure effects include total cone resistance (q_t), net cone resistance (q_n) and pore pressure ratio (B_q). These parameters can be calculated if Piezo-cone Penetration Test (PCPT or CPTU) data are available. The influence of pore pressures on sleeve friction f_s is relatively small. It is common to ignore this influence. Calculation of friction ratio R_f (defined as f_s/q_c) includes no allowance for pore pressure effects.

The penetration rate with respect to soil permeability determines whether soil behaviour is primarily undrained, drained or partially drained. In general, soil behaviour during cone penetration testing is drained in clean sand (no measurable pore pressures as a consequence of soil displacements) and undrained in clay (significant pore pressure changes). Partially drained behaviour occurs in soils with intermediate permeability, such as sandy silt. The following sections mostly consider interpretation of drained soil behaviour (sand) and undrained soil behaviour (clay).

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SOIL BEHAVIOUR IDENTIFICATION

Identification of soil stratigraphy in terms of general soil behaviour (and to a lesser degree soil type) is a more important feature of CPT than other investigation technique.

Figures 1 to 3 show soil behaviour identification according to procedures given by Robertson (2009) and Ramsey (2002). Robertson (2009) represents an update of Robertson (1990), by exchange of Q_t with Q_{tn}. The procedures consider a normalised soil behaviour classification that provides general guidance on likely soil type (silty sand for example) and a preliminary indication of parameters such as angle of internal friction φ', overconsolidation ratio (OCR) and clay sensitivity (S_t). The procedures require piezo-cone test data:

$$Q_{tn} = [(q_t - \sigma_{vo})/P_a]\,(P_a/\sigma'_{vo})^n \qquad Q_t = \frac{q_t - \sigma_{vo}}{\sigma'_{vo}} \qquad F_r \text{ or } nR_f = \frac{f_s}{q_t - \sigma_{vo}} 100\% \qquad B_q = \frac{u - u_0}{q_t - \sigma_{vo}}$$

where:

Q_{tn} = normalised cone resistance with variable stress exponent
Q_t = normalised cone resistance
q_t = corrected cone resistance
σ_{vo} = total in situ vertical stress
σ'_{vo} = effective in situ vertical stress
P_a = atmospheric pressure
n = stress exponent
f_s = measured sleeve friction
u = measured pore pressure
u_0 = theoretical hydrostatic pore pressure.

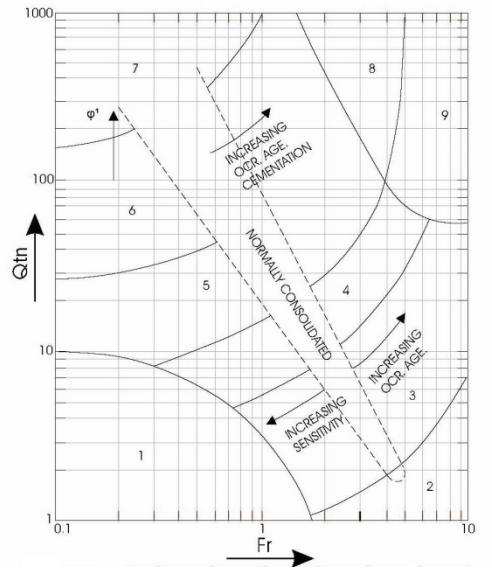
Zhang et al. (2002) defined stress exponent n as follows:

$$n = 0.381\,(I_c) + 0.05\,(\sigma'_{vo} / P_a) - 0.15 \text{ where } n \le 1$$

Robertson and Wride (1998) defined soil behaviour type index I_c (Figure 3) as follows:

$$I_c = [(3.47 - \log Q_{tn})^2 + (\log F_r + 1.22)^2\,]^{0.5}$$

Soils with $I_c < 2.5$ are generally cohesionless, coarse grained, where cone penetration is generally drained and soils with $I_c > 2.7$ are generally cohesive, fine grained, where cone penetration is generally undrained (Robertson, 1990). Cone penetration in soils with $2.5 < I_c < 2.7$ is often partially drained.



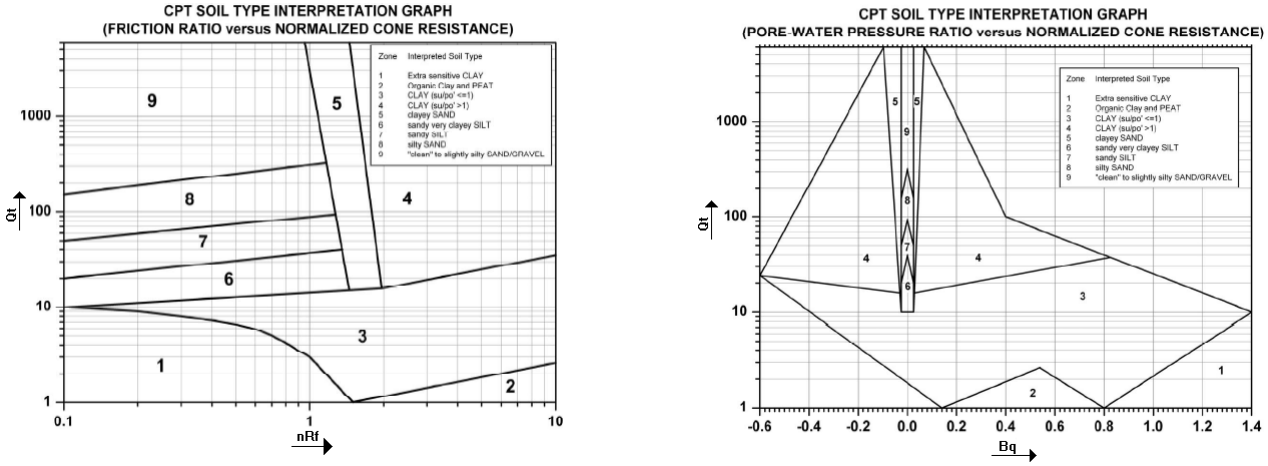
1. Sensitive, fine grained
2. Organic soils - peats
3. Clays- clay to silty clay
4. Silt mixtures – clayey silt to silty clay
5. Sand mixtures – silty sand to sandy silt
6. Sands – clean sand to silty sand
7. Gravelly sand to sand
8. Very stiff sand to clayey sand*
9. Very stiff, fine grained*

(*) Heavily overconsolidated or cemented

Figure 1, Classification chart Robertson (2009)

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1. Extra sensitive clay
2. Organic clay and peat
3. Clay (s_u/σ'_{vo} <= 1)
4. Clay (s_u/σ'_{vo} > 1)
5. Clayey sand
6. Sandy very clayey silt
7. Sandy silt
8. Silty sand
9. “Clean” sand/gravel

Figure 2, Classification charts Ramsey (2002)

Classification is only possible for certain combinations of Q_{tn}, Q_t , F_r, nR_f and B_q, as shown below.

Classification Limits	
Robertson	**Ramsey**
$1 \le Q_{tn} \le 1000$ $0.1 \le F_r \le 10$ $-0.2 \le B_q \le 1.4$	$1 \le Q_t \le 6000$ $0.1 \le nR_f \le 10$ $-0.6 \le B_q \le 1.4$

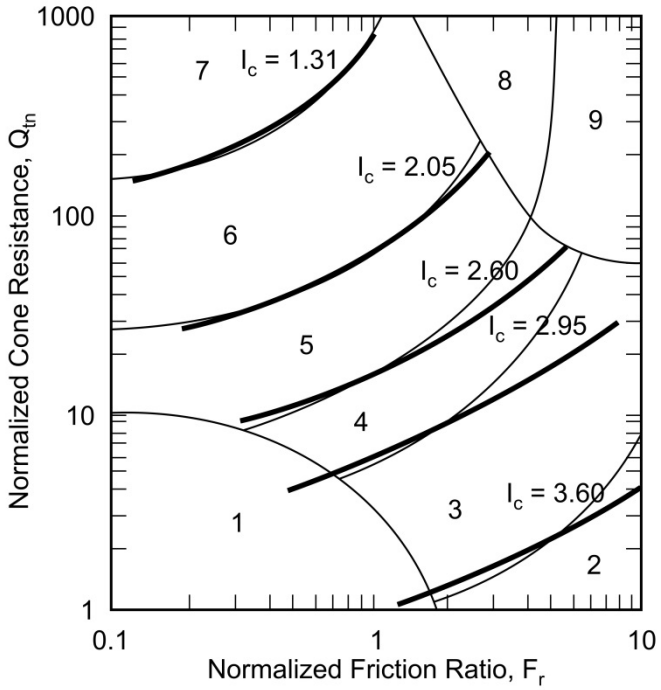


Figure 3, Soil behaviour type index I_c superimposed on Robertson (2009) classification chart

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Figure 4 presents a classification chart for friction cone data according to Robertson (2010). This procedure requires no pore pressure input. A non-normalised soil behaviour type index, I_{SBT} applies:

$$I_{SBT} = [(3.47 - \log(q_c/P_a))^2 + (\log R_f + 1.22)^2]^{0.5}$$

I_{SBT} is similar to I_c. Values for I_{SBT} and I_c are typically comparable for effective in situ vertical stress between 50 kPa and 150 kPa.

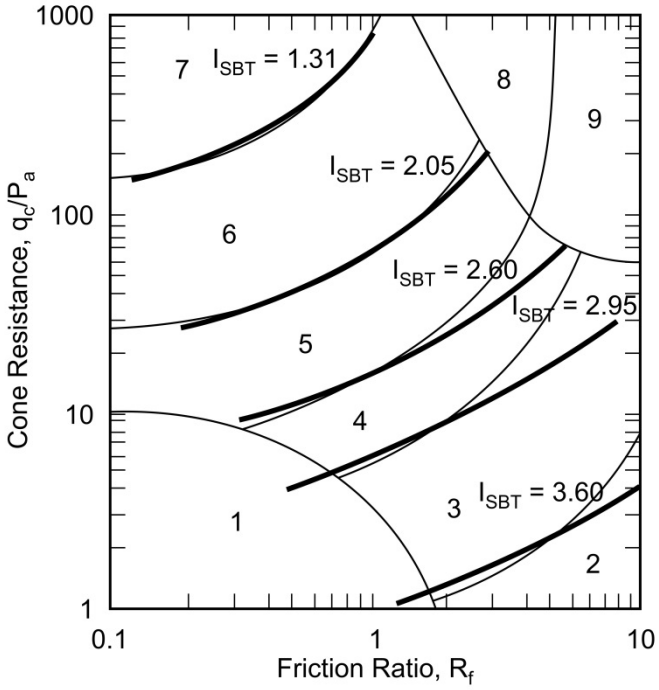


Figure 4, Robertson (2010) classification chart including I_{SBT}

SAND MODEL

Unit Weight – Sand

Unit weight of uncemented (silica) sand, silt and clay soils may be derived according to Mayne et al. (2010):

$$\gamma = 1.95\,\gamma_w \left(\frac{\sigma'_{vo}}{P_a}\right)^{0.06} \left(\frac{f_t}{P_a}\right)^{0.06}$$

where total unit weight γ and unit weight of water γ_w are in kN/m^3 and effective in situ vertical stress σ'_{vo} is in kPa. The symbol f_t refers to sleeve friction corrected for pore pressures acting on the end areas of the friction sleeve, with units in kPa. Atmospheric pressure P_a is in kPa.

In Situ Stress Conditions - Sand

A knowledge of in situ stress conditions is required for estimation of parameters such as relative density D_r and angle of internal friction of a sand deposit φ'. The effective in situ vertical stress σ'_{vo} may be calculated with a reasonable degree of accuracy but the effective in situ horizontal stress $\sigma'_{ho} = K_o\sigma'_{vo}$ is generally unknown. Usually, it is necessary to consider a range of conditions for K_o (coefficient of earth pressure at rest). The range considers overconsolidation as inferred from a geological assessment, pre-consolidation pressures of intermediate clay layers and/or theoretical limits of K_o.

Geological factors concerning overconsolidation include ice loading, soil loading and groundwater fluctuations. Possible subdivisions for these factors are mechanical, cyclic and ageing consolidation.

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K_o may be directly correlated to Overconsolidation Ratio (OCR), as follows:

$$K_o = 0.4 \sqrt{(OCR)}$$

Mayne and Kulhawy (1982) investigated mechanical overconsolidation of reconstituted laboratory specimens for over 170 different soils. A K_0 OCR correlation requiring effective angle of internal friction as input was found to provide a reasonable match. It can be shown that the $K_o = 0.4 \sqrt{(OCR)}$ equation provides similar statistics to the Mayne and Kulhawy correlation.

No laboratory study can fully capture in situ behaviour. Particularly, K_o may be underestimated if effects such as ageing and cyclic loading are relevant.

In general, in situ K_o values are limited to the range $K_o = 0.5$ to $K_o = 1.5$. For many situations, K_o values are believed to be relatively low at greater depths (say $K_o < 1$ for depths exceeding 50 m). Jamiolkowski et al. (2003) recommend using a limiting value $K_o = 1$ in practice.

Relative Density - Sand

Procedures for estimation of in situ density condition (loose, dense, etc.) consist of:
(a) Estimation of in situ stress conditions σ'_{vo} and σ'_{ho}
(b) Empirical correlation of relative density D_r (or density condition) with q_c, σ'_{vo} and σ'_{ho}.

Estimation of stress conditions has been discussed above.

Common relationships between q_c and D_r are based on Cone Penetration Tests carried out in sand samples reconstituted in laboratory calibration chamber tests. Such tests are carried out as part of general geotechnical research projects and are subject to a number of limitations, such as:
- soil type dependence
- inaccuracies in determination of laboratory D_r
- limited range of stress levels and K_o values
- sample preparation and soil stress history simplifications.

Jamiolkowski et al. (2003) proposes the following relationship between q_c and D_r for normally and overconsolidated silica (dry) sands:

$$D_{r(dry)} = \frac{1}{2.96} \ln \left[\frac{\frac{q_c}{P_a}}{24.94 \left(\frac{\sigma'_{vo}\left(\frac{1+2K_o}{3}\right)}{P_a} \right)^{0.46}} \right]$$

and for saturated sands:

$$D_{r(sat)} = \left(\frac{-1.87 + 2.32 \ln \frac{q_c}{(P_a * \sigma'_{v0})^{0.5}}}{100} + 1 \right) \frac{D_r(dry)}{100}$$

where relative density D_r is a fraction. The correlation for saturated sands results in relative densities that can be up to about 10% higher compared to the correlation for dry sands.

Determination of laboratory minimum and maximum index dry unit weights (γ_{dmin} and γ_{dmax}) forms the basis for the relative density concept (loose, dense sand, etc.). As yet, there is no internationally agreed procedure. Hence, laboratory test procedure dependence applies. Also, it is unlikely that any of the procedures consistently provide the "lowest" γ_{dmin} or the "highest" γ_{dmax}. In situ soil unit weights may therefore fall outside laboratory ranges. The relative density concept is necessary to provide a link between field investigations and laboratory testing on reconstituted specimens, as undisturbed sampling of sands is expensive.

Calibration chamber test results apply to a limited range of stress conditions only; typically:

50 kPa	<	σ'_{vo}	<	400 kPa
0.4	<	K_o	<	1.5

Sample preparation for laboratory chamber tests is usually by means of dry pluviation. Soil stress history application is by mechanical overconsolidation.

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Angle of Internal Friction - Sand

The effective shear strength parameter φ' is not a true constant. It depends on factors such as density, stress level, shearing mode and mineralogy. There is evidence that overconsolidation ratio, method of deposition and in situ stress anisotropy is less important.

Correlation of angle of internal friction φ' to cone resistance q_c may be done at various levels of sophistication. Simple procedures rely on a conservative assessment of soil behaviour classification. A more sophisticated empirical correlation consists of:

(a) Estimation of in situ stress conditions σ'_{vo} and σ'_{ho}
(b) Estimation of relative density D_r
(c) Empirical correlation of angle of internal friction φ' with D_r, σ'_{vo} and σ'_{ho}.

Estimation of stress conditions and relative density has been discussed above.

The empirical procedure proposed by Bolton (1986 and 1987) is used for estimation of φ'. This correlation applies to clean sands and considers peak secant angle of internal friction in Isotropically Consolidated Drained triaxial compression (CID) of reconstituted sand. This procedure requires estimation of the dilatancy index and the critical state angle of internal friction.

Kulhawy and Mayne (1990) determined an equation based upon 20 data sets obtained from calibration chamber tests. This equation is almost identical to the empirical formula determined earlier by Trofimenkov (1974) which was based on mechanical cone data. Mayne (2007) validated the use of total cone resistance q_t instead of cone resistance q_c used in the equation from Kulhawy and Mayne (1990).

$$\varphi' = 17.6 + 11.0 \log\left(\left(\frac{q_t}{P_a}\right) / \left(\frac{\sigma'_{vo}}{P_a}\right)^{0.5}\right) \qquad \text{(Mayne, 2007)}$$

Undrained Shear Strength - Sand

Undrained shear strength of cohesionless soil can be important for assessment of cyclic mobility and liquefaction potential. Geotechnical procedures other than the conventional limit state models are employed.

Compressibility - Sand

Correlations between CPT data and compressibility parameters are indicative only. Further developments in interpretation techniques may offer improvement in the future.

Elasticity theory is commonly employed for analysis of drained soil deformation behaviour. Secant moduli are adopted. A common guideline is an empirical correlation given by Baldi et al. (1989). The correlation is for silica-based sand and considers cone resistance q_c, in situ stress conditions and secant Young's modulus for drained stress change E'. The ratio of E'/q_c typically ranges from about 3 to 5 for recently deposited normally consolidated sands up to about E'/q_c = 6 to 25 for overconsolidated sands. The correlation has been inferred from laboratory conditions; including CPT tests in a calibration chamber and conventional triaxial compression tests on reconstituted sand samples. It takes account of the degree of deformation and overconsolidation. In this regard, it is noted that secant deformation moduli are strongly dependent on strain level: the elastic modulus increases with decreasing strain to an upper limit at about 10^{-4}% strain.

For estimation of initial (small strain) or dynamic shear moduli, ratios of G_{max}/q_c of between about 4 and 20 are considered, in accordance with Baldi et al. (1989).The basis for this correlation is similar to that of secant Young's modulus, except that laboratory resonant column tests serve as reference instead of triaxial compression tests. Results of limited in situ seismic cross-hole and downhole tests provide an approximate check of this correlation.

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Constrained Modulus M - Sand

Kulhawy and Mayne (1990) derived two formulas for the determination of the constrained modulus for both normally consolidated and overconsolidated sands by indicating that the modulus is a function of relative density. The determination of relative density can be done with, for example, the methods indicated previously.

$$M = q_c * 10^{1.09-0.0075D_r}$$ (Normally consolidated sands, Kulhawy and Mayne, 1990)

$$M = q_c * 10^{1.78-0.0122D_r}$$ (Overconsolidated sands, Kulhawy and Mayne, 1990)

where D_r is in %, and q_c and M in kPa respectively.

Shear Wave Velocity v_s – Sand

If no in situ measurements of shear wave velocities (v_s) are available, then empirical correlation with CPT parameters may be considered. Hegazy and Mayne (2006) published a statistical correlation derived from 73 sites worldwide representing a range of soil types including sands, clays, soil mixtures and mine tailings (Figure 5). The correlation considers a normalized cone resistance (q_{c1N_hm}) and a soil behaviour type index (I_{c_hm}) as follows:

$$v_s = 0.0831 q_{c1N_hm} (\sigma'_{vo}/P_a)^{0.25} e^{(1.786\, I_{c_hm})}$$ (Hegazy and Mayne, 2006)

where shear wave velocity v_s is in m/s and q_{c1N_hm} and I_{c_hm} are dimensionless. Calculations for q_{c1N_hm} and I_{c_hm} require iteration, and consider measured cone resistance q_c or corrected cone resistance q_t, measured sleeve friction f_s, total in situ vertical stress σ_{vo}, effective in situ vertical stress σ'_{vo} and atmospheric pressure P_a.

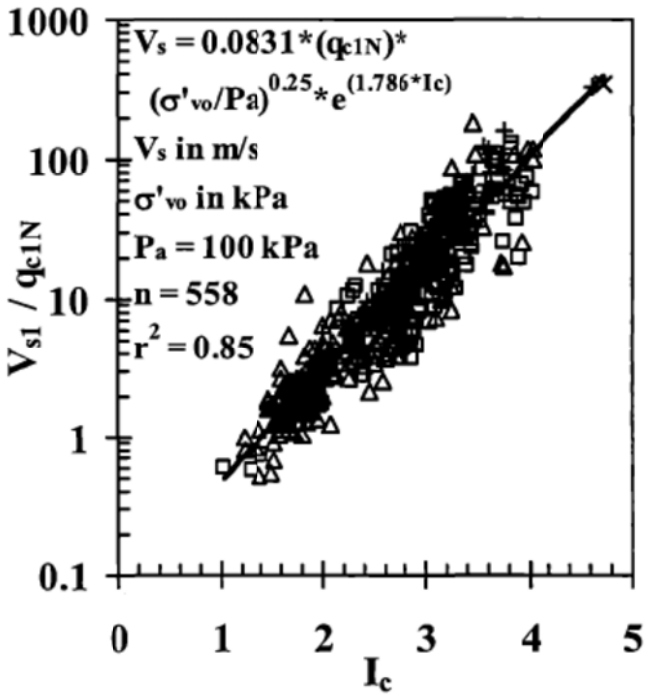


Figure 5, v_s – q_c correlation according to Hegazy and Mayne (2006)

Robertson and Cabal (2010) present a v_s correlation incorporating net cone resistance q_n (= q_t – σ_{vo}) and soil behaviour type index (I_c) as defined by Robertson and Wride (1998):

$$v_s = [\alpha_{vs}(q_t - \sigma_{v0})/P_a]^{0.5} \text{ where } \alpha_{vs} = 10^{(0.55\, I_c + 1.68)}$$ (Robertson and Cabal, 2010)

where shear wave velocity v_s is in m/s and total cone resistance q_t, total in situ vertical stress σ_{vo} and atmospheric pressure P_a are in kPa. The method can be applied to a wide range of soil behaviour types, notably uncemented Holocene to Pleistocene age soils. Older deposits could have a higher shear wave velocity. Exceptions are Zones 1, 8 and 9 of Robertson (1990 and 2009).

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Baldi et al. (1989) derived a correlation between shear wave velocity v_s and cone resistance q_c for uncemented silica sands. This correlation is based on data from CPT, cross-hole and Seismic Cone Penetration Tests (SCPT) performed in quaternary deposits of the predominantly silica Po river sand and Gioia Tauro sand with gravel.

$$v_s = 277 q_c^{0.13} \sigma'^{0.27}_{vo} \qquad \text{(Baldi et al., 1989)}$$

where shear wave velocity v_s is in m/s and cone resistance q_c and effective in situ vertical stress σ'_{vo} are in MPa.

Shear wave velocity may be normalised according to Robertson and Cabal (2010):

$$v_{s1} = v_s \cdot (P_a / \sigma'_{vo})^{0.25} \qquad \text{(Robertson and Cabal, 2010)}$$

Shear Modulus G_{max} - Sand

Interpretation of low-strain shear modulus can be considered by using the modified correlation proposed by Rix and Stokoe (1991) in which data from calibration test measurements is compared to the correlation obtained between G_{max} and q_c by Baldi et al. (1989).

$$G_{max} = 1634 (q_c)^{0.25} (\sigma'_{vo})^{0.375} \qquad \text{(Rix and Stokoe, 1991)}$$

where $G_{max,}$ q_c and σ'_{vo} are in kPa.

CLAY MODEL

Unit Weight – Clay

Empirical correlation between unit weight of clay and CPT parameters is as described in “Unit Weight – Sand” above.

In Situ Stress Conditions - Clay

Similar to sand, a knowledge of in situ stress conditions is generally necessary for estimation of other parameters such as consistency (soft, stiff, etc.) of a clay deposit and compressibility.

Calculation of the effective in situ vertical stress σ'_{vo} is reasonably accurate. A more approximate estimate applies to the effective in situ horizontal stress σ'_{ho}, or, more particular, K_o as $\sigma'_{ho} = K_o \sigma'_{vo}$.

Direct correlations for interpretation of the coefficient of earth pressure at rest K_o are uncommon.

For normally consolidated clays and silts, K_{onc} may be correlated with angle of internal friction, in accordance with Jaky (1944), or more simply in accordance with Mayne and Kulhawy (1982). The reference angle of internal friction is that obtained from a straight-line approximation of the Mohr-Coulomb failure envelope determined from Consolidated Undrained (CU) triaxial compression tests on undisturbed specimens.

For overconsolidated clays, K_{ooc} may be correlated with angle of internal friction and overconsolidation ratio, in accordance with Mayne and Kulhawy (1982). The plasticity index together with OCR may also be used for preliminary estimates of K_{ooc} as indicated by Brooker and Ireland (1965).

$$K_o = (1 - \sin\varphi')OCR^{\sin\varphi'} \qquad \text{(Mayne and Kulhawy, 1982)}$$

Overconsolidation Ratio - Clay

Overconsolidation ratio is defined as: $OCR = \sigma'_p / \sigma'_{vo}$ where σ'_p is the pre-consolidation pressure considered to correspond with the maximum vertical effective stress to which the soil has been subjected, and σ'_{vo} is the current effective in situ vertical stress. The pre-consolidation pressure approximates a stress level where relatively small strains are separated from relatively large strains occurring on the virgin compression stress range. The reference OCR is usually based on laboratory oedometer tests carried out on undisturbed samples, and may thus be influenced by factors such as sample disturbance, strain rate effects and interpretation procedure.

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Various analytical and semi-empirical models for interpretation of pre-consolidation pressure from piezo-cone test data are available. Sandven (1990) presents a summary. The procedures are mostly "experimental" and as yet uncommon in practice. Chen and Mayne (1996) presented a direct correlation between net cone resistance and overconsolidation ratio for 205 clay sites around the world, as follows:

$$OCR = 0.317\ Q_t \qquad \text{(Chen and Mayne, 1996)}$$

The overconsolidation ratio may also be inferred from a geological assessment and from undrained strength ratios.

Geological factors concerning overconsolidation have been discussed under "in situ stress conditions - sand". An empirical procedure for estimation of OCR based on undrained strength ratio s_u/σ'_{vo} is given by Wroth (1984). The procedure uses the strength rebound parameter Λ. Guidance for selection of Λ and normally consolidated undrained strength ratio is given by Mayne (1988). Historically, much use has also been made of the Skempton (1957) relationship between normally consolidated undrained strength ratio and plasticity index I_p. This equation is useful for preliminary estimates, considering that I_p probably relates to φ' in some complex manner.

Undrained Shear Strength - Clay

No single undrained shear strength exists. The in situ undrained shear strength s_u depends on factors such as mode of failure, stress history, anisotropy, strain rate and temperature.

Various theoretical and empirical procedures are available to correlate q_c with s_u. Theoretical approaches use bearing capacity, cavity expansion or steady penetration solutions, all of which require a number of simplifying assumptions. Empirical approaches are more common in engineering practice because of difficulties in realistic soil modelling. An empirical correlation for soft to stiff, intact and relatively homogeneous clays is given by Battaglio et al. (1986) as follows:

$$s_u = (q_c - \sigma_{vo})/N_c$$

where s_u, σ_{vo} and q_c are in kPa. N_c is an empirical factor that ranges between 10 and 25, with the higher N_c factors applying to clays with a relatively low plasticity index, and vice versa. The reference undrained shear strength is that determined from in situ vane test results. The term σ_{vo} (total in situ vertical stress) becomes insignificant for stiff clays at shallow depth so that the equation reduces to $s_u = q_c/N_c$.

For specific design situations, a different s_u reference strength should be used. For example, offshore axial pile capacity predictions in accordance with API (2011) recommend s_u to be based on undrained triaxial compression tests, which are likely to yield lower s_u values than in situ vane tests. A site-specific or regional approach should generally be preferred. For example, N_c factors of 15 to 20 have been commonly used for firm to hard North Sea clays. They give reasonable strength estimates for s_u values determined from pocket penetrometer, torvane and Unconsolidated Undrained triaxial tests (UU) on Shelby tube samples obtained by hammer sampling and push sampling techniques. Lower N_c factors are generally appropriate for soft clays and higher factors for heavily overconsolidated clays.

If piezo-cone test data are available, then improved correlations are feasible because of the pore pressure information. Empirical correlations of piezo-cone test results with laboratory undrained shear strengths are typically obtained from:

$$s_u = q_n/N_k$$

N_k ranges typically between 8 and 30 with the higher N_k factors applying to heavily overconsolidated clays.

Mayne et al. (2015) recommend $N_k = 12$ with a standard deviation of 2.8 for correlation with laboratory triaxial compressive strength. A mean value of 13.5 (Low et al., 2010) can be considered for correlation with average undrained shear strength defined as the average of laboratory triaxial compression, simple shear and triaxial extension. These recommendations apply to normally consolidated to slightly overconsolidated clays with q_n values between 0.1 MPa and 8 MPa.

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Clay Sensitivity

The sensitivity of a clay (S_t) is the ratio of undisturbed undrained shear strength to remoulded undrained shear strength. Sensitivity may be assessed from the CPT friction ratio R_f, in accordance with Schmertmann (1978):

$$S_t = N_s/R_f$$

where N_s is a correlation factor typically ranging between 5 and 10. The correlation is expected to be inaccurate for sensitive clays where uncertainty in very low values for sleeve friction may dominate results.

The reference S_t value is often taken to be that determined from undisturbed and remoulded laboratory unconsolidated undrained triaxial tests. This reference S_t value may differ from that determined from other tests, for example laboratory miniature vane tests. This is partly related to the definition of sensitivity. For vane tests, several measurements of undrained shear strength are possible:

- Intact (I) = undisturbed undrained shear strength as measured on an intact/undisturbed specimen.
- Intact-Residual (I-R) = measured post peak during initial shearing of the intact specimen.
- Intact-Vane Remoulded (I-VR) = measured after multiple-quick rotations of the vane after completion of the intact test.
- Hand Remoulded (HR) = steady state (post-peak if exists) resistance of hand remoulded test specimen.
- Hand Remoulded – Vane Remoulded (HR-VR) = steady state resistance of hand remoulded specimen measured after applying multiple-quick vane rotations.

Skempton and Northey (1952) present a correlation of sensitivity and laboratory liquidity index I_L. This correlation may allow a check on CPT-based interpretation of sensitivity.

Effective Shear Strength Parameters - Clay

Measurement of pore water pressures during penetration testing has led to development of interpretation procedures for estimation of effective stress parameters of cohesive soils. Background information may be found in Sandven (1990). Currently available procedures are evaluated to be "experimental" and are as yet not commonly adopted.

In general, CPT interpretation of effective shear strength parameters for clay and silt relies on soil behaviour-type classification.

It is noted that significant silt and sand fractions in a clay deposit will increase φ', while a significant clay fraction in silt will decrease φ'.

Masood and Mitchell (1993) provide an equation for the determination of φ' by combining sleeve friction with the Rankine earth-pressure theory. The equation is based on the following assumptions:

- Unit adhesion between soil and sleeve is negligible.
- Friction angle between soil and sleeve = $\varphi'/3$.
- Lateral earth pressure coefficient during penetration is equal to the Rankine coefficient of lateral earth pressure under passive conditions.

$$\frac{f_s}{\sigma'_{vo}} = \tan^2(45° + \frac{\varphi'}{2})\tan(\frac{\varphi'}{3}) \qquad \text{(Masood and Mitchell, 1993)}$$

Mayne (2001) proposed an approximation of the Masood and Mitchell equation, as follows:

$$\varphi' = 30.8\left[\log(\frac{f_s}{\sigma'_{vo}}) + 1.26\right] \qquad \text{(Mayne, 2001)}$$

Mayne (2001) also proposed the following approximation of friction angle φ' based on pore pressure ratio B_q and the cone resistance number N_m (Senneset, Sandven and Janbu, 1989):

$$\varphi' = 29.5B_q^{0.121}(0.256 + 0.336B_q + \log N_m) \qquad \text{(Mayne, 2001)}$$

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where

$$N_m = \frac{q_t - \sigma_{vo}}{\sigma'_{vo} + a}$$

where the cone resistance number N_m is dimensionless, total cone resistance q_t, total in situ vertical stress σ_{v0} and effective in situ vertical stress σ'_{v0} are in kPa.

Senneset et al. (1989) use the attraction value [a] as a function of soil type. In general the attraction value ranges from 5 to > 50 for both sands and clays and may be estimated directly from CPT results. The correlation is valid if the angle of plastification β is zero. In general a plastification angle of zero applies to medium sands and silts, sensitive clays and highly compressible clays.

Compressibility – Clay

Correlations between CPT data and compressibility parameters are viewed as indicative only, as discussed for sand compressibility.

The use of elasticity theory is common for analysis of undrained soil deformation behaviour. The adopted procedure is as follows:

(a) Estimation of undrained shear strength s_u from CPT data, as outlined above.
(b) Estimation of secant Young's moduli for undrained stress change E_u in general accordance with correlations based on s_u, as presented by Ladd et al. (1977).

Laboratory undrained triaxial tests carried out on undisturbed clay specimen form the basis for the E_u versus s_u correlations. Typical E_u/s_u ratios at a shear stress ratio of 0.3 range between about 300 and 900 for normally consolidated clays and E_u/s_u = 100 to 300 for heavily overconsolidated clay. Higher E_u/s_u ratios would apply to lower shear stress ratios, and vice versa.

Mitchell and Gardner (1976) present an approximate correlation of cone resistance with constrained modulus M (or coefficient of volume compressibility m_v, where $M = 1/m_v$). Typical ratios of M/q_c range between 1 and 8 for silts and clays. Refinements include q_c ranges and soil type (silt, clay, low plasticity, high plasticity, etc.). The correlation relies on the results of conventional laboratory oedometer tests carried out on undisturbed clay and silt samples. The constrained modulus can also be related (approximately) to secant Young's modulus E' and shear modulus G'.

It is noted that laboratory soil stiffness may differ from in situ stiffness because of inevitable sampling disturbance (in particular soil structure disturbance). In general, this implies that laboratory stiffness will usually be less than in situ stiffness.

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Constrained Modulus M

Kulhawy and Mayne (1990) correlated constrained modulus M in clays with net cone resistance data. This relationship is based on data from 12 different test sites, with constrained moduli up to 60 MPa. The published standard deviation is 6.7 MPa.

$$M = 8.25\ q_n \qquad \text{(Kulhawy and Mayne, 1990)}$$

Shear Wave Velocity v_s – Clay

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Hegazy and Mayne (2006) and Roberson and Cabal (2010) present empirical correlations between shear wave velocity and CPT parameters for a wide range of soils including clays, as described in “Shear Wave Velocity v_s – Sand” above. The Hegazy and Mayne correlation is sensitive to use of q_c or q_t. It should be used with caution for soils showing undrained or partially drained CPT response.

Mayne and Rix (1995) derived a correlation between shear wave velocity v_s and cone resistance q_c for intact and fissured clays. A database from Mayne and Rix (1993) was used including 31 different clay sites.

$$v_s = 1.75 q_c^{0.627} \qquad \text{(Mayne and Rix, 1995)}$$

where shear wave velocity v_s is in m/s and cone resistance q_c is in kPa.

Shear Modulus G_{max}

Mayne and Rix (1993) determined a relationship between G_{max} and q_c by studying 481 data sets from 31 sites all over the world. G_{max} ranged between about 0.7 MPa and 800 MPa.

$$G_{max} = 2.78\ q_c^{1.335}$$ (Mayne and Rix, 1993)

where G_{max} and q_c are in kPa.

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INTRODUCTION

The downhole method of seismic wave testing relies on measuring the travel time interval of body waves travelling between a wave source on the ground surface and an array of geophones at a selected depth below ground surface. The body waves comprise shear waves (S-wave) and compression or primary pressure waves (P-wave). Wave velocities can give an indication of ground characteristics, such as low-strain modulus. This document discusses shear wave measurements only.

The common methods for geophone placement are:
1. Push technology, such as the Seismic Cone Penetration Test (SCPT) consisting of a Cone Penetration Test (CPT) and seismic downhole tests performed during penetration interruptions;
2. Borehole method, with geophones clamped inside a casing pipe.

The principal deployment modes for push technology are from “ground surface or seabed” and “downhole”. A downhole system latches into the lower end of a drill pipe.

Apparatus and procedures adopted by Fugro are in general accordance with ISO 19901-8 (2014), ASTM D7400 (2014) and BS 5930 (2010).

APPARATUS

Test apparatus includes the following:
- push apparatus, as appropriate for push technology,
- borehole drilling, casing pipe installation and grouting equipment, as appropriate for the borehole method,
- seismic wave source, for generating the seismic waves,
- trigger, for the start of recording of the seismograph upon activation of the seismic wave source,
- geophones for receiving the seismic waves,
- seismograph, for recording the signals from the geophones.

A seismic cone penetrometer can incorporate a single or dual array of geophones. The dual array version incorporates two sets of geophones at a fixed spacing.

PROCEDURE

The SCPT procedure includes a repeated sequence of the following steps:
- interrupting the CPT at the seismic downhole test level,
- activating the seismic wave source and recording of the geophone signals, if necessary with re-activating cycles to permit stacking,
- resuming CPT, repeating the test sequence as required.

The borehole test procedure includes the following steps:
- drilling of a borehole to below the maximum test depth,
- grouting of a casing pipe in the borehole to prevent borehole collapse, if required,
- installation and clamping of the geophones within the borehole at the designated test depth,
- activating the seismic wave source and recording of the geophone signals, if necessary with re-activating cycles to permit stacking,
- installation and clamping of the geophones at the next designated test depth, repeating the test sequence as required.

Seismic downhole testing is subject to limitations, as follows:
- Wave interference effects can prevent the interpretation of results applicable to tests close to the ground surface. Common interferences for S-waves are P-waves and surface waves. For some ground conditions, interference can also result from S-wave refraction and reflection. For example, refraction can occur along an interface between a low-velocity top layer and a high-velocity lower layer. Typically, reliable test interpretation applies below about 5 m depth. However, test interpretation is often feasible for a geophone depth of about 1 m.
- The use of a downhole push system requires consideration of wave interference through the drill pipe. The penetration of the geophones below the bottom of a borehole should not be less than about 0.5 m, but preferably at least 1 m.

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- The selected seismic wave source affects the maximum depth of detection. Eventually, spherical divergence of the shear waves leads to an unacceptable signal-to-noise ratio, typically a ratio of less than about 2. The detection depth is typically in the order of 100 m for common seismic sources and favourable ground conditions. Unfavourable conditions include ground with strong absorption characteristics such as peat. Adverse wave reflection effects between high velocity and low velocity layers can also lead to a reduction in detection depth. For example, soft clay overlying dense sands or calcarenite rock interbedded with calcareous soil can prevent acceptable measurements at greater depths.

Common test termination criteria for a single test depth are:
- acceptable data quality with a maximum stack count of 20,
- unacceptable interference effects,
- inadequate signal-to-noise ratio.

Termination is at the discretion of the operator.

The criteria for termination of a test sequence are commonly:
- target depth,
- the termination criteria for conventional cone penetration testing (push technology) or for conventional borehole and casing pipe installation (borehole method),
- inadequate signal-to-noise ratio, with no expected improvement with depth.

TEST RESULTS

Primary test results consist of seismic wave traces for, usually multiple, test depths. The use of data filtering techniques is common for removing unwanted signals. Further data processing includes calculation of seismic wave velocities between individual test depths. This leads to a profile of average (apparent) seismic wave velocities for specific, usually contiguous, depth intervals.

Data processing considers a radially propagating wave train and is based on the assumption of laterally homogeneous ground, where wave train trajectories are according to Snell's law of refraction.

A single test with a dual-array system provides three velocities, one average velocity from source to upper seismic receiver, one average velocity from source to lower seismic receiver and an average velocity for the zone between the two receivers. The accuracy for the average velocity is largely unaffected by depth uncertainty and travel path. Other shear wave velocities will have lower accuracies, which can be calculated from an estimate of the uncertainties in travel path distance, either from source to receiver or from the relative distance between two test depths in a single profile. A single test with a single-array system provides one velocity only. Two tests with a single-array system in a single profile provide the opportunity for determination of three velocities, one from source to upper test depth, one from source to lower test depth and a differential velocity for the zone between the two test depths. Three or more tests provide additional opportunities for separating zones of interest.

The measurement of test depth spacing is particularly important for seismic systems using a single array of geophones. An example of unfavourable depth measurement conditions is downhole deployment of an SCPT system operated from a heaving vessel. A possible mitigation measure for spacing inaccuracy consists of decreasing the test spacing and averaging of results.

If required, test results can include low-strain (dynamic) elastic parameters, using measured or estimated densities. The following basic equations apply to the wave velocities of the S- and P-waves:

$$v_s = \sqrt{\frac{1}{2(1+\nu)} * \frac{E}{\rho}} \qquad = \sqrt{\frac{G}{\rho}}$$

$$v_p = \sqrt{\frac{1-\nu}{(1+\nu)(1-2\nu)} * \frac{E}{\rho}} = \sqrt{(K + \frac{4}{3}G) / \rho}$$

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where:

v_p	=	P-wave velocity	[m/s]	E	=	low-strain Young's modulus	[kPa]
v_s	=	S-wave velocity	[m/s]	G	=	low-strain shear modulus	[kPa]
ρ	=	density of ground	[t/m^3]	K	=	low-strain bulk modulus	[kPa]
ν	=	low-strain Poisson's ratio	[-]				

The following explicit relations are used to estimate the low-strain ground parameters:

$$G = \rho * v_s^2$$

$$K = \rho(v_p^2 - \frac{4}{3} v_s^2)$$

$$\nu = \frac{0.5 * (v_p / v_s)^2 - 1}{(v_p / v_s)^2 - 1}$$

$$E = \rho * v_s^2 * [2(1+\nu)]$$

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INTRODUCTION

A push-in probe equipped with a pore pressure sensor allows the in situ measurement of pore water pressure dissipation during a penetration interruption (ASTM, 2012; ISO, 2012; ISO, 2014). The variation of pore water pressure with time can give an indication of the consolidation and permeability characteristics of the soil. Measurement of equilibrium in situ pore water pressure is also possible if a sufficiently long dissipation period is maintained. The required period depends on factors such as geometry/size of the probe and soil coefficient of consolidation.

Common push-in probes for dissipation testing are as follows (Figure 1):
1. Piezo-cone penetrometer.
2. Piezoprobe.

The feasibility of test interpretation for consolidation or permeability depends primarily on the drainage characteristics of the soil and the location of the pore pressure filter in the probe. In low-permeability soil, the probe generates:
- excess (positive) pore pressures as a result of normal stresses due to plastic soil failure
- positive or negative pore pressures as a result of shear-induced stresses.

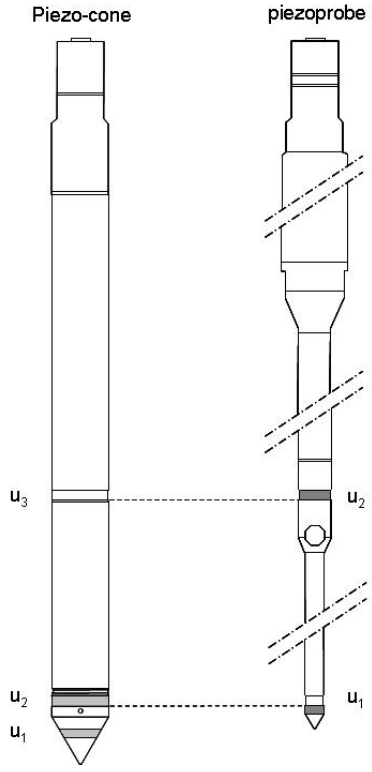


Figure 1, designations for pore pressure filter positions

These transient pore pressures are generally high at the face (designated as u_1 for a piezo-cone penetration test PCPT or CPTU) of the probe where the normal and shear components are positive. Lower or negative pore pressures apply to locations above the base of the cone (designated as u_2 and u_3 for the CPTU), where the shear-induced pore pressures may be negative (Figure 1). In particular, negative pore pressures above the base of the probe may apply to overconsolidated low-permeability soil.

APPARATUS

Pore pressure dissipation testing requires a push-in probe equipped with a water pressure sensor, separated by a filter from the surrounding soil. Generally, CPT thrust equipment is used for penetration of the probe into the soil.

PROCEDURE

The test procedure includes the following steps or a repeated sequence of these steps:
- interrupting the push-in penetration of the probe at the test level for pore pressure dissipation
- measurement of pore pressure versus time until the required termination criterion
- resuming penetration, where applicable.

Test termination criteria for analysis of equilibrium in situ pore pressure are as follows, unless agreed otherwise:
- reaching >90% dissipation of excess pore pressure (relative to equilibrium in situ pore pressure)
- dissipation period of 6 hours
- unfavourable test conditions
- circumstances at discretion of test operator, such as risk of damage to apparatus or safety of personnel
- whichever is earlier.

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Test termination criteria for consolidation analysis are comparable, with >90% dissipation changed to >50% dissipation and a dissipation period of 6 hours changed to a dissipation period of 1000 seconds. Extension of a dissipation period to beyond 1000 s may be necessary for some geotechnical applications. This is optional.

Reasons for unfavourable test conditions can include the presence of gas in the soil, significant soil layering or absence of significant excess pore pressure at the location of the filter.

TEST RESULTS

Data processing results in a diagram showing pore pressure, u, and the logarithm of time. The presented pore pressure is relative to the reference level of a test. For analysis of equilibrium in situ pore pressure, this reference level is taken as atmospheric pressure. For consolidation analysis, the reference level is (1) the ground surface for onshore tests, (2) the seafloor for nearshore and offshore tests in seabed mode, or (3) the bottom of the borehole for downhole tests. Data processing for consolidation analysis presumes a hydrostatic in situ pore pressure profile, unless specifically indicated otherwise.

Data processing for cone penetration tests also includes a diagram showing cone resistance, q_c, and the logarithm of time.

The initial pore pressure variations in low-permeability soils warrant further attention:
- Interruption of penetration of the probe results in an inevitable and abrupt reduction of the push-in resistance and, hence, stress change. Thus, the excess pore pressure shows an abrupt decrease, which can be significant for measurements taken at the face of the probe, and, to a lesser extent, for measurements above the base of a cylindrical probe.
- Penetration of the probe into the soil results in the development of radial and axial pore pressure gradients. The magnitudes of the gradients depend primarily on the soil characteristics, such as soil type and stress history. Also, a non-uniform longitudinal shape of the probe will affect pore pressure distribution. Spatial pore pressure redistribution takes place shortly after penetration interruption. For example, at the CPT u_2 filter location this can include an initial negative pore pressure, followed by a rise to positive excess pore pressure and, finally dissipation to equilibrium in situ conditions.
- Dissipation of pore pressure also takes place during penetration of the probe into the soil. This effect is generally negligible near the base of the probe, where undrained conditions are likely to dominate for low-permeability soil. However, partially drained conditions may apply to a filter positions in the shaft of a cylindrical probe, for example the CPT u_3 location above the friction sleeve.
- Soil inhomogeneities can lead to a non-uniform development of pore pressures around the probe. This may affect both the initial and the subsequent pore pressure variations.

INTERPRETATION

Indication of permeability

If required, the test results can include qualitative interpretation of soil permeability, for example by comparing the initial excess pore pressure with the excess pore pressure after 5 or 10 minutes of dissipation.

Coefficient of consolidation

Interpretation can include an estimate of the coefficient of radial consolidation, c_r, which represents radial flow of pore water under vertical compression. This coefficient is the product of the compression modulus and the permeability of the soil. These parameters vary during consolidation. Common interpretation models for c_r are according to Baligh and Levadoux (1986) and Teh and Houlsby (1991).

The Baligh and Levadoux procedure includes a comparison of a curve of normalised excess pore pressure ratio (du/du_o) against time with a theoretical curve derived from cavity expansion theory. General consolidation theory applies in case of reasonable similarity of the curves up to 50% pore pressure dissipation. Limitations include:
- cavity expansion theory does not take account of actual stress-strain behaviour of the soil and rate effects
- the shape of the theoretical expanding cavity differs from the actual shape
- displacement and remoulding of the soil applies in the immediate vicinity of the probe.

The basis for the Teh and Houlsby method is also cavity expansion theory and consolidation theory. The method requires an estimate of the rigidity index, I_r, defined as G/c_u, where G is the shear modulus of the soil and c_u is the undrained shear strength.

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Kurup et al. (1995) provide recommendations on the selection of the initial excess pore pressure. This procedure considers the initial dissipation values and not the excess pore pressure immediately before the penetration interruption. The root-time method offers the opportunity for extrapolation of dissipation records that are not sufficiently long to reach 50% dissipation of excess pore pressure (Teh and Houlsby, 1991; Sully and Campanella, 1994).

Improvement on the interpreted consolidation coefficients is possible by site-specific integration of in situ and laboratory consolidation parameters, including those made using non-standard (large diameter) Rowe hydraulic oedometer.

Equilibrium in situ pore water pressure

Equilibrium in situ pore water pressure can be estimated if dissipation of excess pore pressure is between 90% and 100% (Peuchen and Klein, 2011). The selected method uses inverse time (1/t), which is in general accordance with ASTM (2012). This method implies geometric data fitting as shown in Figures 2 and 3.

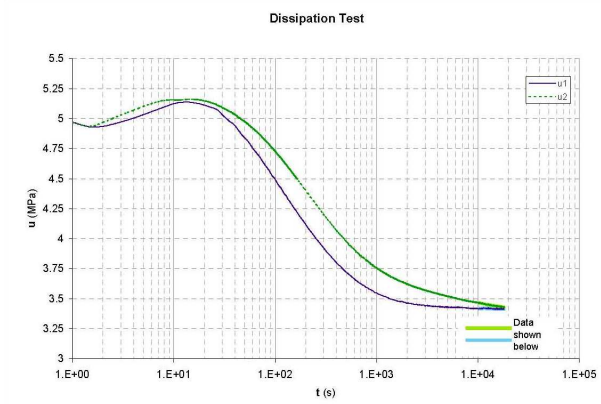


Figure 2, piezoprobe dissipation test results

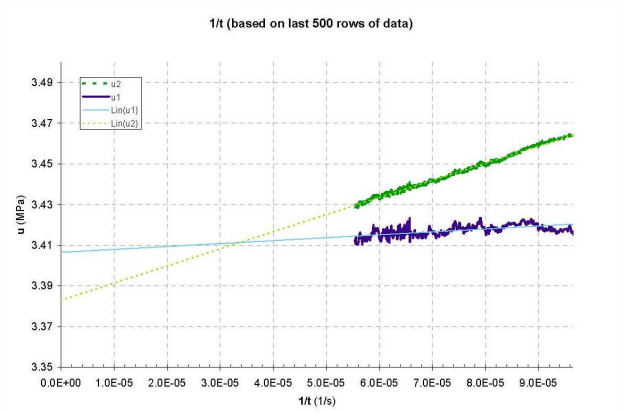


Figure 3, geometric data fitting of piezoprobe test data

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INTRODUCTION

This document is a summary of metrological confirmation systems adopted by Fugro for electric in situ test measuring equipment for geotechnical projects. Metrological confirmation compromises calibration and verification of measuring equipment. A confirmation system demonstrates compliance with reference standards by documenting the metrological characteristics of the measuring equipment, calibration and verification. The metrological confirmation described in ISO 10012:2003 is the basis for Fugro confirmation systems.

Fugro performs a wide range of geotechnical in situ tests with electrical measuring equipment, including the Pressuremeter Test (PMT), in situ Vane Test (VST), T-Bar Test (TBT), hydraulic fracturing test, electrical conductivity test and in situ temperature test. The Cone Penetration Test (CPT) is the most common in situ test.

In situ tests are not performed under controlled conditions, thus metrological confirmation processes are used to ensure confidence in the results. The mode of Fugro field control depends on the type of the in situ test system and the mode of deployment.

This document primarily illustrates the confirmation system for CPT measuring equipment, including the piezo-cone penetrometer (CPTU or PCPT). The principles also apply to in situ test measuring equipment with other types of probes.

MEASURAND

A measurand is the quantity to be measured. In most cases, this is not equivalent to the inferred value. For example, the principal measurand for a vane test is the torque required for rotation of the vane blade. The inferred value is undrained shear strength. Determination of the undrained shear strength from torque measurement requires a model for failure zone geometry and assumptions about soil behaviour during the test.

The principles for the Cone Penetration Test are similar, but more complex. For example, one of the measurands is cone resistance. This is a quantity calculated from (1) axial force measurement, (2) allowance for internal friction of penetrometer components and (3) geometry.

MEASURING EQUIPMENT

Measuring equipment includes the measuring instruments and the data acquisition system that are necessary to acquire a measurement.

Examples of in situ test measuring instruments are the vane blade and torque sensor for the VST and the pressuremeter module for the PMT. The measuring instruments for the CPT are the cone penetrometer and the penetration sensor.

The data acquisition system links the electrical output signals from the measuring instrument to the digitally recorded data. This system includes the transmission cable, the connectors, the analogue/digital converter and the data recording software.

METROLOGICAL CHARACTERISTICS OF MEASURING EQUIPMENT

Metrological characteristics of measuring equipment are the factors that contribute to measurement uncertainty. Examples include: range, bias, repeatability, stability, hysteresis, drift, effects of influencing quantities, resolution, threshold, error, and dead band.

CALIBRATION AND CONFIRMATION

The calibration of the measuring instruments takes place in a Fugro calibration laboratory. The calibration facilities use references that are traceable to (inter)national measurement standards. For example, force calibration for a cone penetrometer is traceable to Dutch NMi (Nederlands Meet-instituut) that is certified by the Dutch RvA (Raad voor Accreditatie), which is a member of the International Laboratory Accreditation Cooperation (ILAC). The confirmation interval for a calibration laboratory is 12 months.

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For example, calibration and confirmation of a piezo-cone penetrometer considers four components: (1) the load sensors used for determination of cone resistance (q_c) and sleeve friction (f_s), (2) the pressure sensor for determination of water pressure (u), (3) the inclinometer for determination of the inclination of the cone penetrometer from vertical, and (4) the geometry. Practice details are as follows:

1) Load sensors are calibrated by a special test loading facility. The test loading facility provides the calibration factors for the specified measuring range and the zero-load offsets.
2) The pressure sensor is calibrated in a special pressure vessel for cone penetrometers.
3) A special test frame provides calibration data for the inclinometer.
4) Compliance of the geometry of the cone penetrometer to (inter)national standards is verified with vernier calliper length measurements.

INTERVALS BETWEEN METROLOGICAL CONFIRMATION

Metrological confirmation of measuring equipment is generally performed as follows:

(1) Laboratory calibration of the in situ test probe at given calendar and in-use time intervals.
(2) In-service testing of the penetration (depth) sensor to ensure it conforms to a set standard.
(3) In-service testing of the data acquisition system.

Confirmation intervals are reviewed and adjusted when necessary to ensure continuous compliance with the specified metrological requirements. Each time nonconforming measuring equipment is repaired, adjusted or modified, the interval for its metrological confirmation is reviewed. Table 1 presents a summary of typical confirmation intervals.

TABLE 1 CALIBRATION/CONFIRMATION INTERVALS

Measuring Equipment Component	Calibration/Confirmation Interval (at earliest occurrence)	Records
Measuring Instrument	- 6 months - single project or campaign of projects - in-service testing - suspected non-conformance	- calibration data certificate available on-site and in Fugro calibration laboratory - in-service testing data in project file - monitoring and control data in project file
Data Acquisition System	- in-service testing - suspected non-conformance	- calibration data certificate available on-site and in Fugro calibration laboratory - in-service testing data in project file - monitoring and control data in project file

RECORDS OF METROLOGICAL CONFIRMATION PROCESS

Dated records of the metrological confirmation process are approved by an authorized person to attest to the correctness of the results, as appropriate. These records and corresponding procedures are available to staff and to Clients upon request.

Records of the metrological confirmation process are examined to confirm that each item of measuring equipment satisfies the metrological requirements specified.

The records include the following, as applicable:

1) The description and unique identification of the in situ test equipment manufacturer, type, serial number.
2) The date on which the metrological confirmation was completed.
3) The assigned interval for metrological confirmation.
4) General review of the in situ test results for given ground conditions.
5) Visual inspection of the geometry of the measuring instrument and push rods upon retraction.
6) Visual inspection of the transmission cables and connectors.
7) Checks on and monitoring the zero-load offsets before and after each test. These provide an indication of the uncertainty of the test results.
8) Checks on and monitoring the responses of the load and pressure sensors to water depth. Responses provide an indication of the sensor performance.
9) Monitoring the pressure in the hydraulic thrust machine. This permits the calculation of the total force required for penetration.

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10) Time checks. The real time on the clock of the recording apparatus provides the basis for recording of some measurands (for example q_c, f_s, u and z). Together, time and penetration measurements permit checks on the standardised penetration rate.

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Symbol	Unit	Quantity
I - GENERAL		
L	m	Length
B	m	Width
D	m	Diameter
d	m	Depth
h	m	Height or thickness
z	m	Penetration or depth below reference level (usually ground surface)
A	m^2	Area
V	m^3	Volume
W	kN	Weight
t	s	Time
v	m/s	Velocity
a	m/s^2	Acceleration
g	m/s^2	Acceleration due to gravity (g = 9.81 m/s^2)
m	kg	Mass
ρ	kg/m^3	Density
π	-	Mathematical constant (= 3.14159)
e	-	Base of natural logarithm (= 2.71828)
ln	-	Natural logarithm
log	-	Logarithm base 10
II - STRESS AND STRAIN		
P_a	kPa	Atmospheric pressure
u	MPa	Pore water pressure
u_o	MPa	Hydrostatic pore pressure relative to seafloor or phreatic surface
σ	kPa	Total stress
σ'	kPa	Effective stress
τ	kPa	Shear stress
t	kPa	Shear stress in s'-t space [= $(\sigma'_1 - \sigma'_3)/2$] or [= $(\sigma_1 - \sigma_3)/2$]
$\sigma_1,\sigma_2,\sigma_3$	kPa	Principal stresses
σ'_{ho}	kPa	Effective in situ horizontal stress
σ_{vo}	kPa	Total in situ vertical stress relative to ground surface or phreatic surface
σ'_{vo}	kPa	Effective in situ vertical stress (or p'_o)
σ'_h	kPa	Effective horizontal stress
σ'_v	kPa	Effective vertical stress
r_u	-	Pore pressure ratio [= u/σ_{vo}]
p'	kPa	Mean effective stress [= $(\sigma'_1 + \sigma'_2 + \sigma'_3)/3$]
q	kPa	Principal deviator stress [= $\sigma'_1 - \sigma'_3$] or [= $\sigma_1 - \sigma_3$]
s'	kPa	Mean effective stress in s'-t space [= $(\sigma'_1 + \sigma'_3)/2$]
ε	-	Linear strain
$\varepsilon_1,\varepsilon_2,\varepsilon_3$	-	Principal strains
ε_v	-	Volumetric strain
γ	-	Shear strain
ν	-	Poisson's ratio
ν_u	-	Poisson's ratio for undrained stress change
ν_d	-	Poisson's ratio for drained stress change
E	MPa	Modulus of linear deformation (Young's modulus)
E_u	MPa	Modulus of linear deformation (Young's modulus for undrained stress change)
E_d	MPa	Modulus of linear deformation (Young's modulus for drained stress change)
G	MPa	Modulus of shear deformation (shear modulus)
G_{max}	MPa	Shear modulus at small strain
I_r	-	Rigidity index [= G/τ_{max} or G/s_u]
K	MPa	Modulus of compressibility (bulk modulus)
M	MPa	Constrained modulus [= $1/m_v$]
μ	-	Coefficient of friction
η	kPa.s	Coefficient of viscosity

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Symbol	Unit	Quantity

III - PHYSICAL CHARACTERISTICS OF GROUND

(a) Density and Unit weights

γ	kN/m^3	Unit weight of ground (or bulk unit weight or total unit weight)
γ_d	kN/m^3	Unit weight of dry ground
γ_s	kN/m^3	Unit weight of solid particles
γ_w	kN/m^3	Unit weight of water
γ_{pf}	kN/m^3	Unit weight of pore fluid
γ_{dmin}	kN/m^3	Minimum index (dry) unit weight
γ_{dmax}	kN/m^3	Maximum index (dry) unit weight
γ' or γ_{sub}	kN/m^3	Unit weight of submerged ground
ρ	Mg/m^3 [= t/m^3]	Density of ground
ρ_d	Mg/m^3 [= t/m^3]	Density of dry ground
ρ_s	Mg/m^3 [= t/m^3]	Density of solid particles
ρ_w	Mg/m^3 [= t/m^3]	Density of water
D_r	-, %	Relative density [= $I_D = \gamma_{dmax}(\gamma_d-\gamma_{dmin})/\gamma_d(\gamma_{dmax}-\gamma_{dmin}) = (e_{max}-e)/(e_{max}-e_{min})$]
v	-	Specific volume [= 1+e]
e	-	Void ratio
e_o	-	Initial void ratio
e_{max}	-	Maximum index void ratio
e_{min}	-	Minimum index void ratio
I_D	-, %	Density index [= D_r]
R_D	-, %	Dry density ratio [= γ_d/γ_{dmax}]
n	-, %	Porosity
w	%	Water content
S_r	%	Degree of saturation
r	-, g/kg	Salinity of pore fluid [= ratio of mass of salt to mass of pore fluid]
R	g/l	Salinity of fluid [= ratio of mass of salt to volume of distilled water]
s	g/l	Salinity of fluid [= ratio of mass of salt to volume of fluid]
S	g/kg	Salinity of seawater [= ratio of mass of salt to mass of seawater]

(b) Consistency

w_L	%	Liquid limit
w_P	%	Plastic limit
I_P	%	Plasticity index [= $w_L - w_P$]
I_L	%	Liquidity index [= $(w - w_P)/(w_L - w_P)$]
I_C	%	Consistency index [= $(w_L - w)/(w_L - w_P)$]
A	-, %	Activity [= ratio of plasticity index to percentage by weight of clay-size particles]

(c) Particle size

D	mm	Particle diameter
D_n	mm	n percent diameter [n% < D]
C_u	-	Uniformity coefficient [= D_{60}/D_{10}]
C_c	-	Curvature coefficient [= $(D_{30})^2/D_{10}D_{60}$]

(d) Dynamic Properties

v_p	m/s	P-wave velocity (compression wave velocity)
v_s	m/s	S-wave velocity (shear wave velocity)
v_{s1}	m/s	S-wave velocity normalised to 100 kPa in situ vertical stress
D	-, %	Damping ratio of ground

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Symbol	Unit	Quantity
(e) Hydraulic properties		
k	m/s	Coefficient of permeability
k_v	m/s	Coefficient of vertical permeability
k_h	m/s	Coefficient of horizontal permeability
i	-	Hydraulic gradient
(f) Thermal and Electrical properties		
T	°C	Temperature
k	W/(m·K)	Thermal conductivity
a_L	1/°C	Thermal expansion coefficient (linear)
α	m^2/s	Thermal diffusion coefficient
ρ	Ω.m	Electrical resistivity
K	S/m	Electrical conductivity
(g) Magnetic properties		
B	T	Magnetic flux density (or magnetic induction)
(h) Radioactive properties		
γ	CPS	Natural gamma ray
IV - MECHANICAL CHARACTERISTICS OF GROUND		
(a) Cone Penetration Test (CPT)		
q_c	MPa	Cone resistance
q_{c1}	MPa	Cone resistance normalised to 100 kPa effective in situ vertical stress
f_s	MPa	Sleeve friction
f_t	MPa	Sleeve friction corrected for pore pressures acting on the end areas of the friction sleeve
R_f	%	Ratio of sleeve friction to cone resistance
R_{ft}	%	Ratio of sleeve friction to corrected cone resistance (f_s/q_t or f_t/q_t)
u_1	MPa	Pore pressure at the face of the cone
u_2	MPa	Pore pressure at the cylindrical extension above the base of the cone or in the gap between the friction sleeve and the cone
u_2*	MPa	Pore pressure u_2, but derived rather than measured
u_3	MPa	Pore pressure immediately above the friction sleeve or in the gap above the friction sleeve
K	-	Adjustment factor for ratio of pore pressure at u_1 to u_2 location
q_n	MPa	Net cone resistance
q_t	MPa	Corrected cone resistance (or total cone resistance)
B_q	-	Pore pressure ratio
Q_t	-	Normalized cone resistance [= q_n/σ'_{vo}]
Q_{tn}	-	Normalized cone resistance with variable stress exponent
F_r	%	Normalized friction ratio [= f_t/q_n]
N_c	-	Cone factor between q_c and s_u
N_k	-	Cone factor between q_n and s_u
I_c	-	Soil behaviour type index index (for Q_{tn} and F_r)
I_{SBT}	-	Soil behaviour type index (for q_c and R_f)
(b) Standard Penetration Test (SPT)		
N	Blows/0.3 m	SPT blowcount
N_{60}	Blows/0.3 m	SPT blowcount normalised to 60% energy
$N_{1,60}$	Blows/0.3 m	SPT blowcount normalised to 60% energy and to 100 kPa effective in situ vertical stress

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Symbol	Unit	Quantity
(c) Strength of soil		
s_u	kPa	Undrained shear strength (or c_u)
s_u/σ'_{vo}	-	Undrained strength ratio
κ	kPa/m	Rate of increase of undrained shear strength with depth (linear)
c'	kPa	Effective cohesion intercept
φ'	°(deg)	Effective angle of internal friction
φ'_{cv}	°(deg)	Effective angle of internal friction at large strain
ε_{50}	%	Strain at 50% of peak deviator stress (or ε_c)
E_{50}	MPa	Young's modulus at 50% of peak deviator stress
$s_{u;r}$	kPa	Undrained shear strength of remoulded soil
$s_{u;ar}$	kPa	Undrained shear strength of aged remoulded soil
s_R	kPa	Undrained residual shear strength
S_t	-	Sensitivity [= $s_u/s_{u;r}$ or s_u/s_R]
T_x	-	Thixotropy strength ratio [$T_x(t) = s_{u;ar}(t)/s_{u;r}$]
σ'_c	kPa	Effective consolidation pressure
M	-	Gradient of critical state line when projected onto a constant volume plane
A	-	Pore pressure coefficient for anisotropic pressure increment
B	-	Pore pressure coefficient for isotropic pressure increment
(d) Strength of rock		
$I_{s(50)}$	MPa	Point load strength index
σ_c	MPa	Uni-axial compressive strength
(e) Consolidation (one dimensional)		
σ'_p	kPa	Effective preconsolidation pressure (or effective vertical yield stress in situ)
σ^*_{ve}	kPa	Effective vertical stress on ICL at e_0
σ'_{vy}	kPa	Effective vertical yield stress in situ (or effective preconsolidation pressure)
C_c	-	Compression index
C^*_c	-	Intrinsic compression index [= $e^*_{100} - e^*_{1000}$]
C_s	-	Swelling index (or re-compression)
CR	-	Primary compression ratio [= $C_c/(1+e_0)$]
RR	-	Recompression ratio [= $C_s/(1+e_0)$]
e_0	-	Void ratio at σ'_{vo}
e_L	-	Void ratio at liquid limit w_L
e^*_{100}	-	Void ratio at σ'_v = 100 kPa during one-dimensional intrinsic compression
e^*_{1000}	-	Void ratio at σ'_v = 1000 kPa during one-dimensional intrinsic compression
C_α	-	Coefficient of secondary compression (primary compression)
$C_{\alpha s}$	-	Coefficient of secondary compression (swelling/re-compression)
c_v	m^2/s	Coefficient of consolidation
H	m	Drainage path length
ICL	-	Intrinsic compression line (Burland 1990)
I_v	-	Void index [= $(e_0 - e^*_{100})/C^*_c$]
m_v	m^2/MN	Coefficient of volume compressibility
M	MPa	Constrained modulus [= $1/m_v$]
p	kPa	Vertical pressure
OCR	-	Overconsolidation ratio [= σ'_p/σ'_{vo}]
SCC	-	Sedimentation compression curve
SCL	-	Sedimentation compression line (Burland 1990)
S_σ	-	Stress sensitivity [= $\sigma'_{vy}/\sigma^*_{ve}$]
YSR	-	Yield stress ratio [= $\sigma'_{vy}/\sigma'_{vo}$]

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V - GEOTECHNICAL DESIGN

(a) Partial factors

γ_d	-	Factor related to model uncertainty or other circumstances
γ_f	-	Partial action factor (load factor)
γ_m	-	Partial material factor (partial safety factor)
γ_R	-	Partial resistance factor (partial safety factor)

(b) Seismicity

a_g	m/s^2	Effective peak ground acceleration (design ground acceleration)
d_g	m	Peak ground displacement
α	-	Acceleration ratio [= a_g/g]
τ_c	kPa	Seismic shear stress

(c) Compaction

ρ_{dmax}	Mg/m^3 [= t/m^3]	Maximum dry density
ρ_{max}	Mg/m^3 [= t/m^3]	Maximum density
w_{opt}	%	Optimum moisture content

(d) Earth pressure

δ	°(deg)	Angle of interface friction (between ground and foundation)
K	-	Coefficient of lateral earth pressure
K_a	-	Coefficient of active earth pressure
K_{ac}	-	Coefficient of active earth pressure for total stress analysis
K_p	-	Coefficient of passive earth pressure
K_{pc}	-	Coefficient of passive earth pressure for total stress analysis
K_o	-	Coefficient of earth pressure at rest
K_{onc}	-	K_o for normally consolidated soil
K_{ooc}	-	K_o for overconsolidated soil

(e) Foundations

A	m^2	Total foundation area
A’	m^2	Effective foundation area
B’	m	Effective width of foundation
E_s	MN/m^3	Modulus of subgrade reaction
k	MPa/m	Rate of change of modulus of subgrade reaction E_s with depth z
L’	m	Effective length of foundation
H	MN	Horizontal external force or action
V	MN	Vertical external force or action
M	MN.m	External moment
T	MN.m	External torsion moment
Q	MN	Total vertical resistance of a foundation/pile
Q_p	MN	End-bearing of pile
Q_s	MN	Shaft resistance of pile
q_p	MPa	Unit end-bearing
q_{lim}	MPa	Limit unit end-bearing
f	kPa	Unit skin friction (or q_s)
f_{lim}	kPa	Limit unit skin friction
p	MN/m	Lateral resistance per unit length of pile
p_{lim}	MN/m	Limit lateral resistance per unit length of pile
s	m	Settlement
t	MN/m	Skin friction per unit length of pile
y	mm	Lateral pile deflection
z	mm	Axial pile displacement
α	-	Adhesion factor between ground and foundation (= f/s_u)
β	-	Adhesion factor between ground and foundation (= f/σ'_v or f/σ'_{vo})

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Symbol	Unit	Quantity
δ	°(deg)	Angle of interface friction (between ground and foundation)
δ_{cv}	°(deg)	Constant volume or critical-state angle of interface friction (between ground and foundation)
N_c,N_q,N_γ	-	Bearing capacity factors
K_c,K_q,K_γ	-	Bearing capacity correction factors for inclined forces or actions, foundation shape and depth of embedment
i_c,i_q,i_γ	-	Bearing capacity correction factors for external force inclined from vertical shape
s_c,s_q,s_γ	-	Bearing capacity correction factors for foundation shape
d_c,d_q,d_γ	-	Bearing capacity correction factors for foundation embedment

Signs:
- A "prime" applies to effective stress.
- A "bar" above a symbol relates to average properties.
- A "dot" above a symbol denotes derivative with respect to time.
- The prefix "Δ" denotes an increment or a change.
- A “star” after a symbol denotes value corrected for pore fluid salinity.

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APPENDIX 2: POSITIONING REPORT

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Fugro Survey B.V. (FSBV) Report “Positioning Data for MV Gargano” (Rev A) PH398-GEOT-01

POSITIONING DATA FOR
MV GARGANO
GEOTECHNICAL INVESTIGATION
BORSSELE WIND FARM ZONE III & IV
DUTCH SECTOR, NORTH SEA

Survey Period: September - October 2015
Report Number: PH398-GEOT-01



Prepared for: Fugro Engineers B.V.
Prismastraat 4
2631 RT Nootdorp
The Netherlands

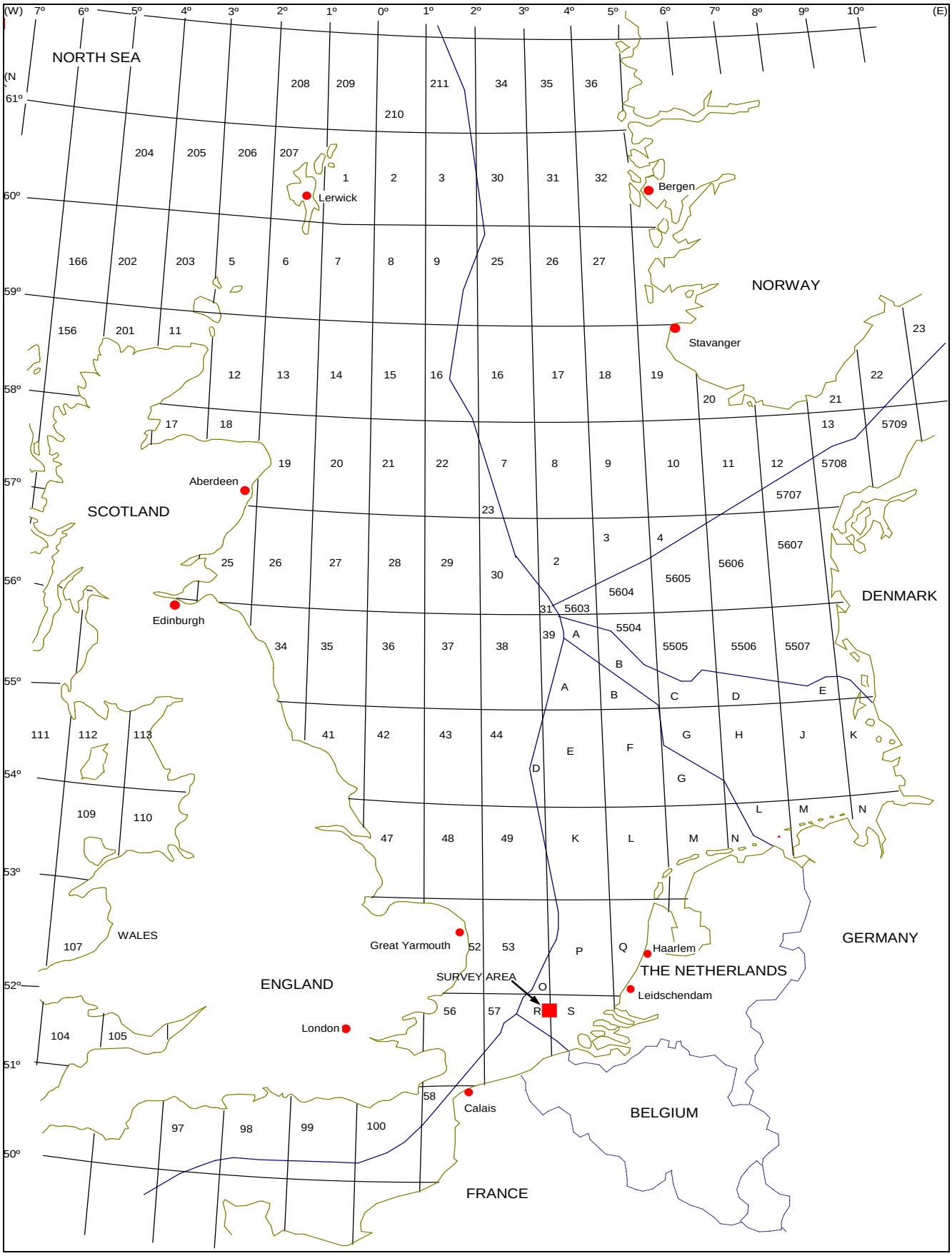
Client Reference: N6083

Rev	Description	Prepared	Checked	Approved	Date
A	Revised Report	G. Lock	Y. Wang	A. King	7 December 2015
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2	Issue for Approval	G. Lock	N. Obieti	A. King	27 October 2015
1	Field Report	G. Lock	A. Laloe		11 October 2015

12 Veurse Achterweg, P.O. Box 128, 2260 AC Leidschendam, The Netherlands
Phone 31-70-3111800, Fax 31-70-3111838, E-mail: FSBVinfo@fugro.com
Trade Register Nr: 34070322 / VAT Nr: 005621409B11

REPORT AMENDMENT SHEET

Rev No.	Report Section	Page No.	Table No.	Figure No.	Description
2	Entire				Office QC
A					EPSG code corrected



LOCATION OF BORSSELE WIND FARM ZONE, DUTCH SECTOR, NORTH SEA

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1. INTRODUCTION

Fugro Survey B.V. (FSBV) was contracted by Fugro Engineers B.V. to supply navigation and positioning services for the geotechnical drill vessel MV Gargano at 31 sampling and/or in situ testing locations at Borssele Wind Farm Zone III & IV.

The positions and depths reported here were checked and quality controlled by the FSBV office staff onshore and supersedes the values in the preliminary field report.

The sampling and/or in situ testing was carried out between 13 September 2015 and 11 October 2015. The positioning results are given in Table 2.1, Table 2.2 and Table 2.3.

System positioning performance parameters are outlined in Section 5.3.

2. RESULTS

2.1 Field Locations

Table 2.1: Actual Coordinates and Water Depths

Datum: ETRS89, UTM Zone 31N, EPSG codes: 25831 and 6258					Water Depth (LAT) [1)]		
Location	Easting [m]	Northing [m]	Latitude [North]	Longitude [East]	Pressure Sensor [m]	Echo Sounder [m]	Drill String [m]
BH-SubStatB-1	497605.50	5730626.39	51° 43' 35.6054"	002° 57' 55.1926"	31.6	31.6	31.7
BH-WFS3-1	496674.76	5721935.14	51° 38' 54.2598"	002° 57' 06.9783"	26.5	26.4	26.7
BH-WFS3-2	498233.58	5725127.56	51° 40' 37.6217"	002° 58' 28.0300"	36.9	36.6	37.4
BH-WFS3-3	500204.13	5721841.09	51° 38' 51.2507"	003° 00' 10.6213"	28.2	28.6	28.0
BH-WFS3-3A	500211.31	5721833.72	51° 38' 51.0122"	003° 00' 10.9948"	28.6	28.6	27.9
BH-WFS3-4	500033.94	5717834.38	51° 36' 41.5557"	003° 00' 01.7646"	30.3	30.9	30.2
BH-WFS3-4A	500027.63	5717826.90	51° 36' 41.3135"	003° 00' 01.4365"	29.5	30.1	30.0
BH-WFS3-5	494300.00	5725992.50	51° 41' 05.5249"	002° 55' 03.1746"	29.6	29.4	29.5
BH-WFS3-6	496613.65	5729495.56	51° 42' 58.9832"	002° 57' 03.5345"	33.5	33.4	33.8
BH-WFS4-1	486524.53	5732292.25	51° 44' 28.9626"	002° 48' 17.3945"	29.7	29.8	29.9
BH-WFS4-1A	486522.80	5732290.33	51° 44' 28.9003"	002° 48' 17.3045"	29.7	29.8	29.6
BH-WFS4-2	490527.30	5732766.63	51° 44' 44.6128"	002° 51' 46.0500"	35.3	35.3	35.5
BH-WFS4-2A	490525.59	5732763.48	51° 44' 44.5107"	002° 51' 45.9611"	35.6	35.1	35.4
BH-WFS4-3	491740.31	5727278.50	51° 41' 47.0370"	002° 52' 49.7703"	28.4	28.3	28.5
BH-WFS4-4	493370.96	5730552.63	51° 43' 33.0952"	002° 54' 14.4830"	33.0	32.7	32.8
BH-WFS4-5	495144.96	5730212.60	51° 43' 22.1542"	002° 55' 46.9639"	35.7	35.8	35.8
BH-WFS4-6	493592.65	5734620.86	51° 45' 44.7883"	002° 54' 25.7681"	30.2	29.8	30.0
BH-WFS4-7	498778.80	5736550.73	51° 46' 47.3829"	002° 58' 56.2731"	34.5	34.7	35.1
BH-WFS5-1	500191.13	5728773.91	51° 42' 35.6608"	003° 00' 09.9585"	33.9	34.7	34.7
CPT-WFS3_4	500021.09	5717829.54	51° 36' 41.3990"	003° 00' 01.0965"	29.7	30.0	30.2
CPT-WFS4_7	498784.51	5736557.44	51° 46' 47.6002"	002° 58' 56.5709"	35.0	34.8	35.0
CPT-SubStatB-1	497596.93	5730635.36	51° 43' 35.8956"	002° 57' 54.7457"	32.0	32.1	32.7
CPT-WFS3-1	496680.61	5721944.23	51° 38' 54.5542"	002° 57' 07.2824"	25.7	25.8	26.1
CPT-WFS3-1A	496678.55	5721941.57	51° 38' 54.4680"	002° 57' 07.1753"	25.9	25.8	26.5
CPT-WFS4-1	486529.73	5732297.73	51° 44' 29.1404"	002° 48' 17.6648"	29.5	29.5	30.0
CPT-WFS4-1A	486532.48	5732302.24	51° 44' 29.2866"	002° 48' 17.8076"	28.9	29.5	29.0
CPT-WFS4-18	495297.43	5733553.34	51° 45' 10.2949"	002° 55' 54.7478"	34.9	34.4	35.1
CPT-WFS4-18A	495295.13	5733549.31	51° 45' 10.1644"	002° 55' 54.6281"	34.6	34.4	35.1
CPT-WFS4-21	497759.78	5735306.32	51° 46' 07.0916"	002° 58' 03.1255"	32.1	31.7	32.8
CPT-WFS4-21A	497756.71	5735302.93	51° 46' 06.9819"	002° 58' 02.9655"	31.8	31.7	32.1
CPT-WFS5-1	500186.77	5728777.73	51° 42' 35.7844"	003° 00' 09.7314"	34.4	34.2	34.9

Notes:
1. Refer to Section 5, Methodology for details on the different water depth measurements

Table 2.2: Actual Coordinates in WGS 84

Datum: WGS 84, EPSG code: 6326		
Location	**Latitude [North]**	**Longitude [East]**
BH-SubStatB-1	51° 43' 35.6215"	002° 57' 55.2149"
BH-WFS3-1	51° 38' 54.2759"	002° 57' 07.0005"
BH-WFS3-2	51° 40' 37.6378"	002° 58' 28.0523"
BH-WFS3-3	51° 38' 51.2668"	003° 00' 10.6435"
BH-WFS3-3A	51° 38' 51.0283"	003° 00' 11.0171"
BH-WFS3-4	51° 36' 41.5718"	003° 00' 01.7868"
BH-WFS3-4A	51° 36' 41.3296"	003° 00' 01.4588"
BH-WFS3-5	51° 41' 05.5410"	002° 55' 03.1968"
BH-WFS3-6	51° 42' 58.9993"	002° 57' 03.5568"
BH-WFS4-1	51° 44' 28.9787"	002° 48' 17.4167"
BH-WFS4-1A	51° 44' 28.9164"	002° 48' 17.3267"
BH-WFS4-2	51° 44' 44.6289"	002° 51' 46.0722"
BH-WFS4-2A	51° 44' 44.5268"	002° 51' 45.9833"
BH-WFS4-3	51° 41' 47.0531"	002° 52' 49.7925"
BH-WFS4-4	51° 43' 33.1113"	002° 54' 14.5052"
BH-WFS4-5	51° 43' 22.1703"	002° 55' 46.9862"
BH-WFS4-6	51° 45' 44.8044"	002° 54' 25.7903"
BH-WFS4-7	51° 46' 47.3990"	002° 58' 56.2953"
BH-WFS5-1	51° 42' 35.6769"	003° 00' 09.9808"
CPT-WFS3_4	51° 36' 41.4151"	003° 00' 01.1187"
CPT-WFS4_7	51° 46' 47.6163"	002° 58' 56.5932"
CPT-SubStatB-1	51° 43' 35.9118"	002° 57' 54.7680"
CPT-WFS3-1	51° 38' 54.5703"	002° 57' 07.3046"
CPT-WFS3-1A	51° 38' 54.4841"	002° 57' 07.1975"
CPT-WFS4-1	51° 44' 29.1565"	002° 48' 17.6870"
CPT-WFS4-1A	51° 44' 29.3028"	002° 48' 17.8298"
CPT-WFS4-18	51° 45' 10.3110"	002° 55' 54.7701"
CPT-WFS4-18A	51° 45' 10.1805"	002° 55' 54.6503"
CPT-WFS4-21	51° 46' 07.1078"	002° 58' 03.1478"
CPT-WFS4-21A	51° 46' 06.9980"	002° 58' 02.9877"
CPT-WFS5-1	51° 42' 35.8005"	003° 00' 09.7536"

Table 2.3: Actual Locations Details

Datum: ETRS89, UTM Zone 31N EPSG code: 25831				Standard Deviation		Proposed to Actual	
Location	Easting [m]	Northing [m]	No. of Fixes	X [m]	Y [m]	Distance [m]	Bearing [°G]
BH-SubStatB-1	497605.50	5730626.39	100	0.06	0.07	0.09	215.54
BH-WFS3-1	496674.76	5721935.14	100	0.08	0.13	1.16	094.93
BH-WFS3-2	498233.58	5725127.56	100	0.06	0.11	0.26	136.55
BH-WFS3-3	500204.13	5721841.09	100	0.10	0.09	0.48	333.97
BH-WFS3-3A	500211.31	5721833.72	100	0.10	0.12	0.30	289.40
BH-WFS3-4	500033.94	5717834.38	100	0.09	0.09	0.12	014.04
BH-WFS3-4A	500027.63	5717826.90	100	0.10	0.14	0.20	300.47
BH-WFS3-5	494300.00	5725992.50	100	0.08	0.11	1.35	041.99
BH-WFS3-6	496613.65	5729495.56	100	0.09	0.08	0.28	169.88
BH-WFS4-1	486524.53	5732292.25	100	0.11	0.14	0.11	195.26
BH-WFS4-1A	486522.80	5732290.33	100	0.22	0.28	0.13	249.29
BH-WFS4-2	490527.30	5732766.63	100	0.13	0.31	0.87	343.24
BH-WFS4-2A	490525.59	5732763.48	100	0.11	0.22	0.07	278.13
BH-WFS4-3	491740.31	5727278.50	100	0.08	0.18	0.16	158.20
BH-WFS4-4	493370.96	5730552.63	100	0.08	0.19	1.43	017.55
BH-WFS4-5	495144.96	5730212.60	100	0.09	0.10	0.33	242.65
BH-WFS4-6	493592.65	5734620.86	100	0.08	0.11	0.31	213.18
BH-WFS4-7	498778.80	5736550.73	100	0.26	0.20	0.31	050.19
BH-WFS5-1	500191.13	5728773.91	100	0.08	0.15	0.25	031.76
CPT-WFS3_4	500021.09	5717829.54	100	0.11	0.07	0.26	229.64
CPT-WFS4_7	498784.51	5736557.44	100	0.09	0.12	0.35	045.00
CPT-SubStatB-1	497596.93	5730635.36	100	0.08	0.10	5.11	318.89
CPT-WFS3-1	496680.61	5721944.23	100	0.10	0.14	0.55	216.87
CPT-WFS3-1A	496678.55	5721941.57	100	0.14	0.12	1.10	039.31
CPT-WFS4-1	486529.73	5732297.73	100	0.07	0.13	0.65	147.53
CPT-WFS4-1A	486532.48	5732302.24	100	0.12	0.15	0.10	324.46
CPT-WFS4-18	495297.43	5733553.34	100	0.08	0.08	0.43	006.63
CPT-WFS4-18A	495295.13	5733549.31	100	0.22	0.18	0.72	094.76
CPT-WFS4-21	497759.78	5735306.32	100	0.15	0.19	0.95	239.66
CPT-WFS4-21A	497756.71	5735302.93	100	0.12	0.14	0.61	344.47
CPT-WFS5-1	500186.77	5728777.73	100	0.09	0.20	0.49	334.49

3. OPERATIONS

3.1 Scope of Work

FSBV was contracted to provide positioning support for navigation between the sampling and/or in situ testing locations and determination of the drill string position at each location. Sampling and/or in situ testing was carried out at 31 locations.

Table 3.1: Proposed Locations Provided by the Client

Datum: ETRS89, UTM, Zone 31N, EPSG codes: 25831 and 6258				
Location	**Easting [m]**	**Northing [m]**	**Latitude [North]**	**Longitude [East]**
BH-SubStatB-1	497605.55	5730626.46	51° 43' 35.6077"	002° 57' 55.1952"
BH-WFS3-1	496673.60	5721935.24	51° 38' 54.2630"	002° 57' 06.9179"
BH-WFS3-2	498233.40	5725127.75	51° 40' 37.6278"	002° 58' 28.0207"
BH-WFS3-3	500204.34	5721840.66	51° 38' 51.2368"	003° 00' 10.6322"
BH-WFS3-3A	500211.59	5721833.62	51° 38' 51.0089"	003° 00' 11.0094"
BH-WFS3-4	500033.91	5717834.26	51° 36' 41.5518"	003° 00' 01.7630"
BH-WFS3-4A	500027.80	5717826.80	51° 36' 41.3103"	003° 00' 01.4453"
BH-WFS3-5	494299.10	5725991.50	51° 41' 05.4925"	002° 55' 03.1278"
BH-WFS3-6	496613.60	5729495.84	51° 42' 58.9923"	002° 57' 03.5319"
BH-WFS4-1	486524.56	5732292.36	51° 44' 28.9662"	002° 48' 17.3960"
BH-WFS4-1A	486522.92	5732290.38	51° 44' 28.9019"	002° 48' 17.3108"
BH-WFS4-2	490527.55	5732765.80	51° 44' 44.5859"	002° 51' 46.0631"
BH-WFS4-2A	490525.66	5732763.47	51° 44' 44.5104"	002° 51' 45.9648"
BH-WFS4-3	491740.25	5727278.65	51° 41' 47.0419"	002° 52' 49.7672"
BH-WFS4-4	493370.53	5730551.27	51° 43' 33.0512"	002° 54' 14.4607"
BH-WFS4-5	495145.25	5730212.75	51° 43' 22.1591"	002° 55' 46.9790"
BH-WFS4-6	493592.82	5734621.12	51° 45' 44.7967"	002° 54' 25.7769"
BH-WFS4-7	498778.56	5736550.53	51° 46' 47.3764"	002° 58' 56.2605"
BH-WFS5-1	500191.00	5728773.70	51° 42' 35.6540"	003° 00' 09.9517"
CPT-WFS3_4	500021.29	5717829.71	51° 36' 41.4045"	003° 00' 01.1069"
CPT-WFS4_7	498784.30	5736557.20	51° 46' 47.5924"	002° 58' 56.5600"
CPT-SubStatB-1	497600.29	5730631.51	51° 43' 35.7711"	002° 57' 54.9209"
CPT-WFS3-1	496680.94	5721944.67	51° 38' 54.5684"	002° 57' 07.2995"
CPT-WFS3-1A	496677.85	5721940.72	51° 38' 54.4405"	002° 57' 07.1389"
CPT-WFS4-1	486529.38	5732298.28	51° 44' 29.1582"	002° 48' 17.6465"
CPT-WFS4-1A	486532.54	5732302.16	51° 44' 29.2841"	002° 48' 17.8107"
CPT-WFS4-18	495297.38	5733552.91	51° 45' 10.2810"	002° 55' 54.7453"
CPT-WFS4-18A	495294.41	5733549.37	51° 45' 10.1663"	002° 55' 54.5905"
CPT-WFS4-21	497760.60	5735306.80	51° 46' 07.1072"	002° 58' 03.1683"
CPT-WFS4-21A	497756.87	5735302.34	51° 46' 06.9628"	002° 58' 02.9738"
CPT-WFS5-1	500186.98	5728777.29	51° 42' 35.7702"	003° 00' 09.7423"

Table 3.2: Proposed Locations in WGS 84

Datum: WGS 84, EPSG code: 6326		
Location	**Latitude [North]**	**Longitude [East]**
BH-SubStatB-1	51° 43' 35.6238"	002° 57' 55.2175"
BH-WFS3-1	51° 38' 54.2791"	002° 57' 06.9402"
BH-WFS3-2	51° 40' 37.6439"	002° 58' 28.0429"
BH-WFS3-3	51° 38' 51.2529"	003° 00' 10.6545"
BH-WFS3-3A	51° 38' 51.0250"	003° 00' 11.0317"
BH-WFS3-4	51° 36' 41.5679"	003° 00' 01.7853"
BH-WFS3-4A	51° 36' 41.3264"	003° 00' 01.4676"
BH-WFS3-5	51° 41' 05.5086"	002° 55' 03.1500"
BH-WFS3-6	51° 42' 59.0084"	002° 57' 03.5541"
BH-WFS4-1	51° 44' 28.9823"	002° 48' 17.4182"
BH-WFS4-1A	51° 44' 28.9180"	002° 48' 17.3330"
BH-WFS4-2	51° 44' 44.6020"	002° 51' 46.0853"
BH-WFS4-2A	51° 44' 44.5265"	002° 51' 45.9870"
BH-WFS4-3	51° 41' 47.0580"	002° 52' 49.7894"
BH-WFS4-4	51° 43' 33.0673"	002° 54' 14.4829"
BH-WFS4-5	51° 43' 22.1752"	002° 55' 47.0013"
BH-WFS4-6	51° 45' 44.8129"	002° 54' 25.7992"
BH-WFS4-7	51° 46' 47.3926"	002° 58' 56.2828"
BH-WFS5-1	51° 42' 35.6701"	003° 00' 09.9740"
CPT-WFS3_4	51° 36' 41.4206"	003° 00' 01.1291"
CPT-WFS4_7	51° 46' 47.6085"	002° 58' 56.5822"
CPT-SubStatB-1	51° 43' 35.7872"	002° 57' 54.9432"
CPT-WFS3-1	51° 38' 54.5845"	002° 57' 07.3218"
CPT-WFS3-1A	51° 38' 54.4566"	002° 57' 07.1611"
CPT-WFS4-1	51° 44' 29.1743"	002° 48' 17.6687"
CPT-WFS4-1A	51° 44' 29.3002"	002° 48' 17.8329"
CPT-WFS4-18	51° 45' 10.2971"	002° 55' 54.7675"
CPT-WFS4-18A	51° 45' 10.1824"	002° 55' 54.6128"
CPT-WFS4-21	51° 46' 07.1233"	002° 58' 03.1906"
CPT-WFS4-21A	51° 46' 06.9789"	002° 58' 02.9961"
CPT-WFS5-1	51° 42' 35.7863"	003° 00' 09.7646"

3.2 Resources

Only equipment used is listed below; refer to Section 5 (Methodology) for procedural explanations.

Personnel	Name	From	To
Party Chief	G. McCallum	13 September 2015	30 September 2015
Party Chief	A. Laloe	30 September t 2015	11 October 2015
Surveyor	K. Vertelman	13 September 2015	30 September 2015
Engineer	G. Lock	30 September 2015	11 October 2015

Positioning Equipment

Navigation software	Starfix.NG 8.2
Primary positioning	GNSS with Starfix.G2 corrections (delivered via ESAT)
Secondary positioning	GNSS with Starfix.HP corrections (delivered via AOR-E)
Tertiary positioning	GNSS with Starfix.G2 corrections (delivered via AOR-E)
Quaternary positioning	GNSS with Starfix.HP corrections (delivered via ESAT)
Quinary positioning	GNSS with Starfix XP (corrections via ESAT)
Senary positioning	GNSS with Starfix XP (corrections via AOR-E)
Acoustic positioning	Kongsberg HiPAP 500 controlled via APOS software
Primary heading system	Meridian Surveyor
Secondary heading system	Meridian Surveyor
Tertiary heading system	StarPack Protrack Hdg 1 (from SP-1)
Quaternary heading system	StarPack Protrack Hdg 2 (from SP-2)
Reference stations	Leidschendam, Rogaland, Aberdeen, Jacou, Vienna, Torshavn, Galway

Bathymetry

Primary System	Simrad Hydrographic Echo sounder EA 400
Secondary System	Sensordata SD204 Pressure Sensor
Tertiary System	Drill string
Vertical Motion Compensator	Seatex MRU5
Data Recording	Starfix.NG 8.2

3.3 Offsets

3.3.1 MV Gargano Vessel Offsets

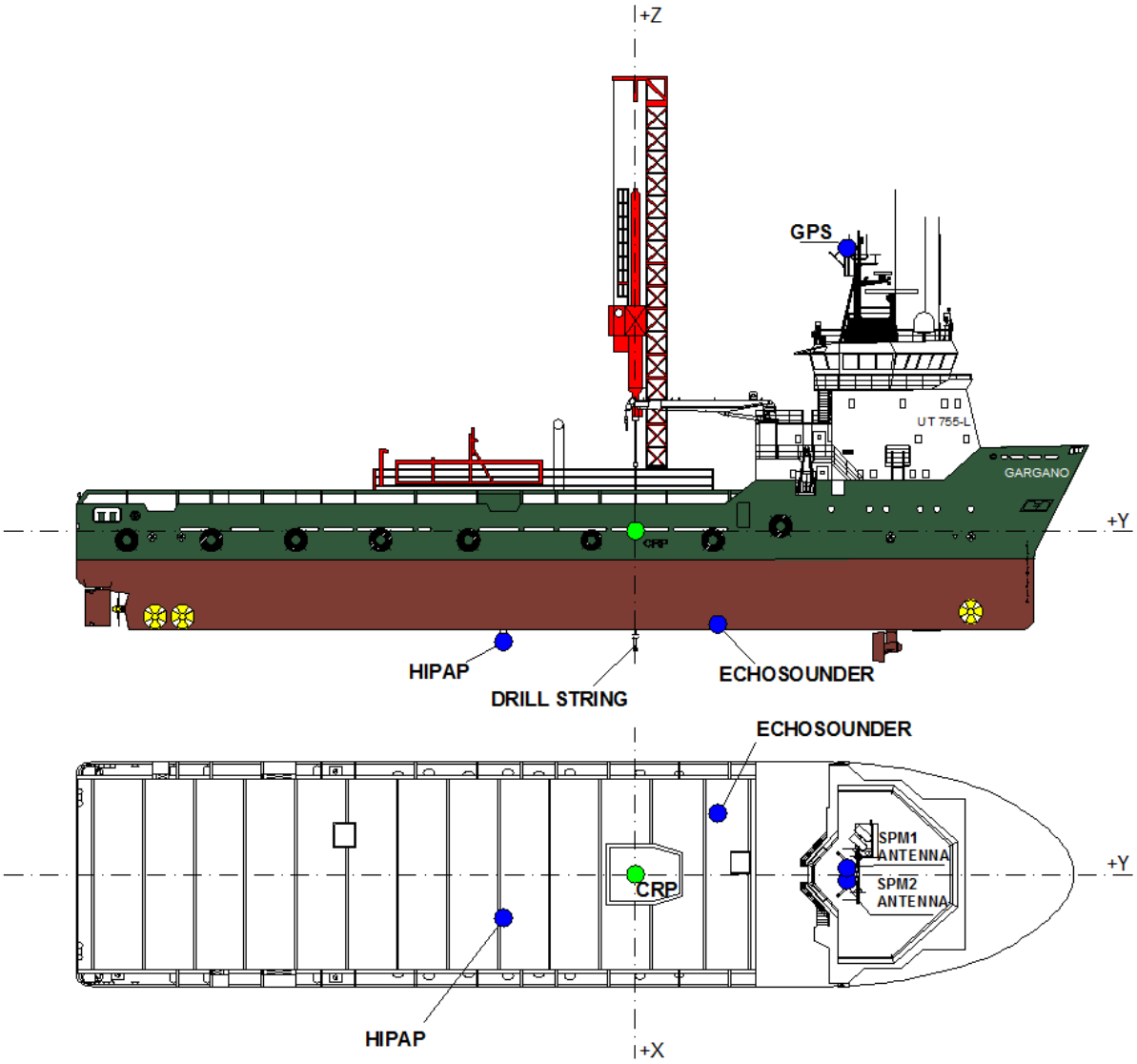


Figure 3.1: MV Gargano Vessel Diagram

Table 3.3: MV Gargano Vessel Offsets

Offsets	Athwart (X) [m]	Along (Y) [m]	Height (Z) [m]
CRP (Drill String)	0.00	0.00	0.00
SPM 1 Antenna	-0.40	15.11	20.15
SPM 2 Antenna	0.48	15.08	20.12
Echo Sounder EA400	-4.01	5.80	-6.64
HiPAP USBL	3.12	-9.55	-10.10

3.3.2 Seabed Frame Offsets

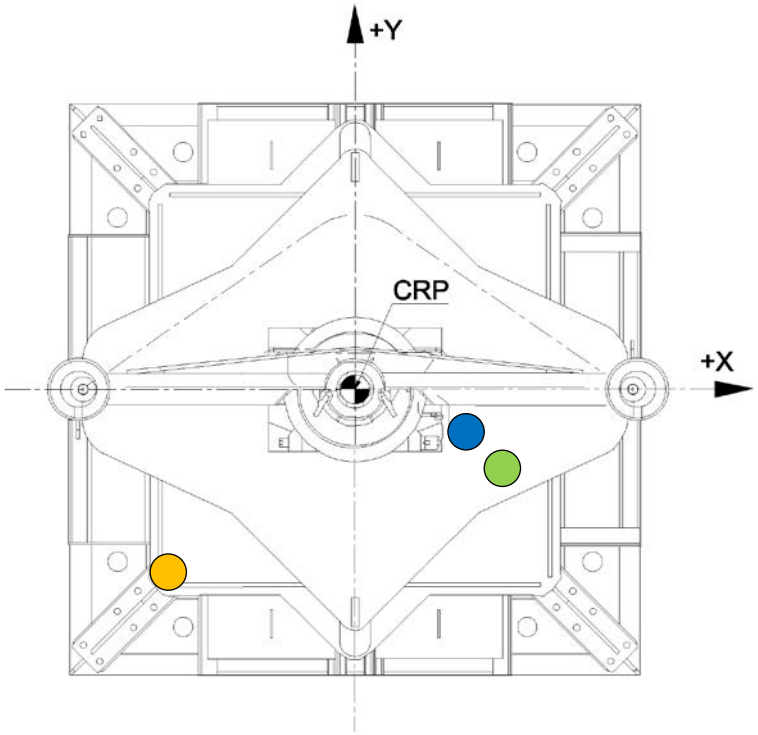


Figure 3.2: Seabed Frame Plan View

Table 3.4: Seabed Frame Offsets

Offsets	Athwart (X) [m]	Along (Y) [m]	Height (Z) [m]
CRP (Drill string centre)	0.00	0.00	0.00
HiPAP Beacon (B34)	1.23	-0.64	1.86
CTD Probe	1.06	-0.22	1.45
Sector Scan	-1.65	-0.96	-2.00

3.4 Calibration Results

This section details the results of the system calibrations that were carried out prior to positioning operations. Refer to Section 5 (Methodology), for a detailed description of the calibration procedures. Detailed results of the calibrations are available on request.

3.4.1 Positioning Systems

A positioning system verification was carried out on 13 September 2015 in Vlissingen, the Netherlands, by means of total station measurements from known points on the quay. The results of the verifications are presented in Table 3.5.

Table 3.5: Positioning System Verification

Date	Location	Method	ΔE [m]	SD [m]	ΔN [m]	SD [m]
13 September 2015	Vlissingen	Total Station	-0.09	0.02	-0.02	0.02

To check the integrity of the positioning systems a positioning system comparison was performed on 13 September 2015, in Vlissingen, the Netherlands. The differences between the positioning systems were within the expected system accuracy. The results of the comparisons are presented in Table 3.6.

Table 3.6: Positioning System Comparison

Date	Location	Positioning system	ΔE [m]	SD [m]	ΔN [m]	SD [m]
13 September 2015	Vlissingen	PORT G2 - STBD G2	0.03	0.02	0.00	0.02
13 September 2015	Vlissingen	PORT G2 - PORT HP	0.07	0.02	-0.02	0.03
13 September 2015	Vlissingen	PORT G2 - STBD HP	0.03	0.04	-0.01	0.04
13 September 2015	Vlissingen	STBD G2 - PORT HP	0.04	0.03	-0.02	0.04
13 September 2015	Vlissingen	STBD G2 - STBD HP	0.00	0.04	-0.01	0.03
13 September 2015	Vlissingen	PORT HP -STBD HP	-0.04	0.03	0.01	0.03

3.4.2 Heading Systems Alignment

The heading systems' alignments were checked using Sun azimuth observations in Vlissingen, the Netherlands, on 13 September 2015. After completion of the checks the corrections were entered into the online navigation software. The results of the alignment checks are presented in Table 3.7.

Table 3.7: Heading Systems Alignment Check

Date	Location	Heading system	Method	Computed [°T]	Observed [°T]	C-O [°]
13 September 2015	Vlissingen	Gyro 1 HDT	Sun azimuth obs.	239.3	240.52	-1.22
13 September 2015	Vlissingen	Gyro HiPAP	Sun azimuth obs.	239.3	239.85	-0.55
13 September 2015	Vlissingen	Protrack	Sun azimuth obs.	239.3	240.91	-1.61

3.4.3 Speed of Sound and Water Density Measurements

Before the start of project data acquisition and at regular intervals during the project; conductivity, temperature and pressure measurements were taken to establish the local speed of sound profile and average water density. The speed of sound profile was entered into the vessel's Simrad EA400 echo sounder and HiPAP Ultra Short Baseline (USBL) system. The average water density was used for depth determination in conjunction with the pressure sensor. The results of these measurements are presented in Table 3.8.

Table 3.8: Speed of Sound and Water Density Measurements

Date	Location	Mean [m/s]	Transducer [m/s]	Seabed [m/s]	Density [kg/m³]
13 September 2015	CPT-WFS4-7	1512.54	1512.32	1512.82	1023.73
16 September 2015	CPT-WFS3-4	1512.80	1512.58	1513.06	1024.62
20 September 2015	BH-SubStatB-1	1512.57	1512.38	1512.86	1025.11
27 September 2015	BH-WFS3-6	1511.52	1511.26	1511.84	1025.26
2 October 2015	BH-WFS4-1	1510.67	1510.71	1510.94	1025.62
5 October 2015	BH-WFS4-7	1510.48	1510.23	1510.81	1025.70
9 October 2015	CPT-WFS4-1	1510.07	1509.88	1510.33	1025.64
10 October 2015	CPT-WFS5-1	1509.24	1508.91	1509.63	1025.41

3.4.4 Simrad HiPAP USBL

The Simrad HiPAP USBL system, installed on board the MV Gargano, was interfaced to the Starfix Suite as the sub-sea positioning system. A USBL Calibration was performed on 1 December 2014. The calibration was undertaken in CABGOC CRX area in Democratic Republic of Congo at a water depth of 215 m. The results of the calibration and the settings in the APOS, Starfix.USBL and Starfix NG are presented in Table 3.9.

Table 3.9: USBL Settings

Measurement	Date	X Offset [m]	Y Offset [m]	Z Offset [m]	Orientation [°]	Scale	Pitch [°]	Roll [°]
APOS	4 Nov 2012	3.10	-3.08	-7.84	270.23	1.000	-0.20	0.15
Starfix.USBL	1 Dec 2014	0.00	0.00	0.00	-0.42	1.000	0.05	-0.29
Starfix.NG	4 Sept 2015	0.00	0.00	0.00	-0.42	1.000	-0.05	0.29

4. DATUM AND TOLERANCES

4.1 Geodetic and Projection Parameters

Table 4.1: Project Geodetic and Projection Parameters

Global Positioning System Geodetic Parameters [1)]						
Datum:	World Geodetic System 1984 (WGS 84)					
Spheroid:	World Geodetic System 1984					
Semi major axis:	a = 6 378 137 m					
Inverse Flattening:	1/f = 298.257 223 563					
EPSG Code:	6326					
Local Datum Geodetic Parameters [2)]						
Datum:	European Terrestrial Reference System 1989 (ETRS89)					
Spheroid:	GRS80					
Semi major axis:	a = 6 378 137 m					
Inverse Flattening:	1/f = 298.257 222 101					
EPSG Code:	6258					
Datum Transformation Parameters [3)] from WGS 84 to ETRS89 for Epoch 2015.742465753 (28 September 2015)						
Shift dX:	+0.05367 m	Rotation rX:	-0.002166	arcsec	Scale Factor:	0.002599 ppm
Shift dY:	+0.05087 m	Rotation rY:	-0.013104	arcsec	EPSG Code:	Not available
Shift dZ:	-0.08684 m	Rotation rZ:	+0.021180	arcsec		
Project Projection Parameters						
Grid Projection:	Universal Transverse Mercator					
Projection Name	UTM Zone 31 North (UTM 31N)					
Central Meridian:	003° 00’ 00” East					
Latitude of Origin:	00° 00’ 00” North					
False Easting:	500 000 m					
False Northing:	0 m					
Scale factor on Central Meridian:	0.9996					
Units:	Metre					
EPSG Code:	25831					

Notes:

1. Source: Starfix.NG. Starfix.NG determines the transformation parameters according to the Memo of C. Boucher and Z. Altamimi, dated 18 May 2011.
2. This is the right-handed coordinate frame rotation convention used by the Fugro Starfix navigation software
3. The coordinate transformation parameters are the combined result of the 14 parameter transformation from ITRF2008 to ETRS89 and do take into account the yearly changes on the mentioned epoch. The use of the year average values result in a maximum difference of <10 mm from the individual daily values
4. The WGS 84 realisation is nearly equal to the ITRF2008 on the above mentioned epoch. WGS84 is maintained by the US Department of Defence to be nearly identical to ITRF2008.

4.2 Vertical Control

Chart Datum	LAT
Tidal Data	Predicted utilising the standard port of Zeebrugge And the secondary port of Noordwinning, comprising of four tidal zones over the site
Time shift	Centre: -0h 08 min/ -0h 42min South: -0h 06 min/ -0h 40min West: 12h 15min/ 11h 41min North: -0h 05min/ -0h 39min
Range factor	Centre: 0.67/1.69 South: 0.69/1.76 West: 0.63/1.61 North: 0.61/1.54
Barometric pressure variation	Factored in pressure to depth calculation
Effect of wind	Not considered
Shallow water corrections	Considered
Seasonal changes in mean level	Considered
Seasonal changes in harmonic constants	Considered

4.3 System Performance Parameters

Surface positioning	± 0.5 m
USBL positioning	1% slant range
Bathymetry (absolute)	± 0.5 m absolute using predicted tides
Bathymetry (relative)	Quartz pressure sensor CTD ± 0.01% of range Echo sounder ± 1.0% of depth Drill string - variable
GNSS 3D mode	5 satellites minimum, PDOP<6, Elevation > 10°
GNSS 2D mode	4 satellites minimum, HDOP<4, Elevation > 10°
Heading system	1°

5. METHODOLOGY

5.1 Introduction

Sections 5.2 to 5.4, inclusive, describe the procedures for determining the coordinates and water depths of geotechnical sample and/or in situ testing locations. Section 5.6 describes the calibration procedures carried out for the heading system, surface and sub-surface positioning systems, and the echo sounder. The use of sub-surface positioning systems, primarily USBL and sector scan sonar, depends on the type of geotechnical sampling and/or in situ testing methods used, hence some descriptions in the sections below may not be applicable to this report.

5.2 Position Determination

The actual location may be determined by surface positioning alone or with additional use of USBL. The USBL determines the position of the centre of the seabed frame on the seafloor. Particularly in deeper water, use of USBL provides a more accurate position of the sample and/or in situ testing location since the seabed frame may be offset from the surface position of the drill string due to currents.

The position is determined as soon as the seabed frame makes contact with the seafloor. A minimum of 100 position fixes are logged at 5 second intervals. Data outliers are then discarded in accordance with standard statistical procedures. To determine the final seabed position of a sample and/or in situ testing location the following general sequence applies:

- From the global navigation satellite system (GNSS) receiver, the antenna's latitude and longitude in WGS84 are transmitted to the navigation computer and converted to Easting and Northing on the local projection by the navigation software;
- The grid heading and X and Y offsets from the antenna to the common reference point (CRP) are applied to the antenna Easting and Northing in order to compute the position of the CRP on the local projection. If the USBL system is not used then this corresponds to the sample and/or in situ testing location since the CRP has been defined as the centre of the drill string;
- The grid heading and X and Y offsets from the CRP to the USBL transducer, mounted on the vessel's hull, are applied to the CRP Easting and Northing to determine the transducer position on the local projection;
- The USBL system measures the slant range and relative bearing (measured clockwise from the vessel centreline) from the USBL transducer to the beacon, mounted on the seabed frame, and also the depth of the beacon relative to the transducer. These values are converted to ΔX, ΔY in the horizontal plane and ΔZ in the vertical plane by the USBL processor;
- The ΔX, ΔY, and ΔZ values are transmitted to the navigation computer where the Z offset of the USBL transducer is applied;
- The position of the beacon is computed in the local projection Easting and Northing and the beacon depth is computed relative to the water surface. The centre of the seabed frame, which corresponds to the seabed sample and/or in situ testing position, is derived from the USBL beacon position by applying the USBL beacons horizontal offsets. The heading of the frame is assumed to be the same as the vessel heading. When heading changes are implemented to the vessel after

the location of the frame on the seafloor, the frame will be locked in its original heading by the use of a manual heading, derived from the position fix, in which heading information was logged.

5.3 System Configuration

5.3.1 DP Position System

The MV Gargano is configured according to the classification “Offshore Supply DP Support Vessel, DP Class II” (official classification ✠ 1A1 SF E0 DYNPOS-AUTR DK(+) HL(2.5)). According to the specifications valid for this classification, the vessel’s dynamic positioning (DP) system is fed with one independent GNSS position.

The system consists of a Kongsberg Seatex Differential Positioning Sensor DPS 102 with an inbuilt dual channel GNSS receiver. This receiver allows real-time compensation of errors introduced by high ionospheric activity. Access to data from dual-frequency reference stations will remove nearly all the influence of ionospheric effects. The receiver specifications are as follows:

- Sixteen channels GNSS, L1 and L2;
- Compensation of ionospheric delay in DGPS mode;
- Multiple reference stations;
- Multipath mitigation.

The GPS receiver can handle multiple correction stations and works as a Virtual Base Station. For this purpose, this GPS receiver was connected to a Fugro SeaStar 3510LR differential corrections receiver, receiving dual frequency corrections from the Fugro Starfix Corrections system. The selection of reference stations was made in the Fugro receiver by manual selection of the available stations within the area of operations. These corrections also incorporate ionospheric information and this information was fed into the GPS receiver resulting in a dual frequency differentially corrected multi-reference solution with an accuracy level of approximately 1 m (95% confidence level).

For safety reasons, changes to the DP positioning solution were restricted to changing the selection of the corrections satellite (i.e. Atlantic Ocean Region-East (AOR-E), Éireann Satellite (ESAT)) and shore reference stations when entering a new work area. The system was under the full control and responsibility of the DP Operator. Position details from the DP system were not sent to the survey software. Quality control (QC) checks cannot be performed for this system and its performance was fully outside FSBV’s responsibility.

5.3.2 Survey Position and Navigation Systems

The survey team used two StarPack GNSS Precise Point Positioning (PPP) receivers for the surface positioning during the project. The three single modus calculation position solutions (Starfix.G2, Starfix.XP, Starfix.HP) from the two StarPack receivers were interfaced to the survey computer by means of a galvanic isolated network connection and were made available for comparison and QC. Differential correction signal redundancy was achieved by cross-linking the two StarPack receivers to provide corrections from different satellite transmissions, if required. Both Starfix.G2 solutions were fed

into Starfix.Seis by means of a serial connection. All six position solutions, three per receiver, were fed into StarPack QC suite for QC purposes.

All positions and peripheral (heading system, USBL, etc.) data were sent to the navigation computer where all data transformations, offset and survey calculations, and data integration and logging were performed. All data can be graphically and numerically presented on the navigation computer or any other computer connected to the survey network. An off-line computer was available for the survey crew to do post-processing and reporting of survey data.

The geodetic and the datum transformation parameters used are presented in Section 4.1.

5.3.2.1 Primary Positioning System

The primary survey positioning service used by the survey team was Starfix.G2 solution generated from StarPack Receiver 1. Positions were calculated by using clock and orbit corrections from the Fugro G2 network for both GPS and the Russian Global Navigation Satellite System (GLONASS) space vehicles. These corrections were received by the StarPack via ESAT transmissions and positions were output to the Starfix.Seis software package.

5.3.2.2 Secondary Positioning System

The secondary survey positioning service used by the survey team was Starfix.HP solution generated from StarPack Receiver 2. Positions were calculated using carrier phase corrections from the Fugro Starfix network. The corrections were received by the StarPack via AOR-E satellite transmissions and positions were output to the Starfix.Seis software package.

5.3.2.3 Tertiary Positioning System

The tertiary survey positioning service used by the survey team was Starfix.G2 solution generated from StarPack Receiver 2. Positions were calculated by using clock and orbit corrections from the Fugro G2 network for both GPS and GLONASS space vehicles. These corrections were received by the StarPack via AOR-E satellite transmissions and positions were output to the Starfix.Seis software package.

5.3.2.4 Quaternary Positioning System

The quaternary positioning service used by the survey team was Starfix.HP solution generated from StarPack Receiver 1. Positions were calculated by using differential corrections from the Starfix.HP differential stations network. The corrections were received by the StarPack via ESAT satellite transmissions and positions were output to the Starfix.Seis software package.

5.3.2.5 Quinary and Senary Positioning Systems

The quinary and senary survey positioning service used by the survey team was Starfix.XP solution generated from StarPack Receiver 1. Positions were calculated by using clock and orbit corrections from GPS space vehicles only. These corrections were received by the StarPack via ESAT satellite transmissions. The senary positioning system was the same as the quinary positioning system, but used StarPack Receiver 2 with the corrections received via AOR-E satellite transmissions. Both position solutions were output to the Starfix.Seis software package.

5.3.3 Quality Control

The DGNSS and GNSS PPP data was quality controlled using Starfix.QCPlot software. The quality of DGNSS and GNSS PPP derived position fixing data was monitored whilst logging position data for individual locations and also throughout the entire project period. An assessment of quality was made based on the following factors:

- Root mean square error: the error of the position resulting from the least squares adjustment;
- Standard deviation of individual station solutions and the resultant error ellipses derived from the station standard deviation (graphical display only);
- Range residuals of satellite observations;
- External reliability figure for individual and composite station solutions.

Within the area of operations the accuracy and repeatability of the Starfix.G2 system was designed to be 0.1 m in the horizontal plane and 0.2 m in the vertical plane with 95% confidence level.

5.4 Depth Determination

The depth at each location was measured using a combination of the following techniques:

- Echo sounder;
- Conductivity, Temperature, and Depth (CTD) probe;
- Drill string reading;
- USBL reading.

5.4.1 Echo Sounder

An echo sounder determines water depth by measuring the two-way travel time of a sound wave travelling from the transducer to the seabed and back again. This value is divided by two and the resultant multiplied by the speed of sound through the water column.

The speed of sound values, entered into the echo sounder were determined by the use of CTD probe using the Chen and Millero (1977) formula, which is a function of temperature, pressure and salinity.

Depth values obtained by the echo sounder are corrected for the transducer's draft. The transducer's draft is directly entered into the echo sounder. Depth values derived from the echo sounder are obtained while the vessel's echo sounder transducer is positioned over the sample and/or in situ testing location. A minimum of 100 measurements are used in the analysis, with any outliers being discarded, in accordance with standard statistical procedures.

5.4.2 Depth Measurement

A CTD probe or pressure sensor is secured to the seabed frame to measure water pressure using a Digiquartz sensor. The output from this unit is absolute pressure, i.e. atmospheric pressure plus water pressure. The atmospheric pressure is recorded on deployment and not updated until the probe returns to the surface. Adjustments are therefore necessary to take into account the actual atmospheric pressure changes that occur during the measurement cycle. Barometric pressure is recorded manually at four hourly intervals using the vessel's barometer. An UNESCO-recognised formula is then used to convert the raw pressure values to depth values.

5.4.3 Drill String Reading

This is a physical measurement made by the drilling personnel and is the total length of pipe used to reach the seabed. The measurement is corrected for the distance between the drill floor and the water surface (air gap), and corrected for local tidal variations. When operating in deep water, errors due to the effects of current may be induced in the drill string depth measurement.

5.4.4 USBL Reading

This is a measurement made by taking the HiPAP-derived USBL beacon Z-values (depth) and applying the vertical offset of the frame-mounted beacon above the seabed frame base.

5.5 System Calibration Procedures

Calibrations of all position and depth measuring equipment are carried out prior to sampling and/or in situ testing. This checks that all equipment is operating within acceptable limits and that the accuracy of the logged data is not compromised. Most equipment is permanently installed on the geotechnical drilling vessel and therefore not all calibrations are performed before the start of every sampling and/or in situ testing programme. The most recent calibrations of the equipment are assessed and new calibrations are carried out if deemed necessary.

5.5.1 Offset Measurements

At the start of the mobilisation, offsets from the vessel's datum (normally the centre of the drill string) to the various DGNSS antennas and other relevant offset points are measured. These measurements are compared with measurements taken from a scaled vessel plan or a previous vessel offset diagram. Seabed frame offsets from the frame's CRP to its transponder and the Z offset for the CTD probe are also measured. Offsets are entered into the navigation software. The USBL transducer offset is already corrected to the vessel's CRP by the vessel's Simrad APOS programme.

5.5.2 Heading System Alignment Check

Three methods are possible when performing a heading system alignment check alongside. The resulting differences between computed and observed headings are entered into the navigation software as the heading system's computed minus observed (C-O) correction.

5.5.2.1 Total Station

These methods of performing a heading system alignment check use land survey techniques. Reflectors are placed at or near the bow and stern of the vessel on the centreline and their positions fixed at regular intervals. Simultaneous heading system readings and heading observations are taken. The true bearing between the reflectors is calculated and compared to the observed heading system reading.

5.5.2.2 Sun Azimuth

Sun azimuth observations are performed with a total station and a sun filter, when the sun is at a maximum elevation of approximately 30º. The vessel's heading is determined by measuring the angle between the vessel's centreline and the sun azimuth and applying this angle to the computed sun azimuth. The logged heading subtracted from the heading derived from the azimuth of the sun will give the heading system's C-O correction.

5.5.2.3 Taped Offsets

This method requires the known heading of the quay and two measurements are taken simultaneously from the quay to the vessel's centreline. The distance between the two measurements provides a baseline for calculating the angle of the vessel's centreline relative to the quay, which is then applied to the quay heading to derive the computed grid vessel heading. The convergence is applied to the computed grid heading to obtain the true heading which is compared with the observed heading system's reading in order to obtain the C-O correction.

5.5.3 Positioning System

In order to determine the integrity and reliability of the surface positioning systems, two main procedures are followed:

5.5.3.1 Positioning Verification

The position of the primary DGNSS antenna, in local projection coordinates, and computed from the navigation system, is compared to the position derived by land survey techniques. The total station measures directly to the DGNSS antenna from a known point on the quay. The DGPS antenna position and the position derived from land survey methods are logged simultaneously and should agree to better than 1 m. This process also verifies the geodetic parameters entered into the online survey software.

5.5.3.2 System Comparison

Once the position verification results are acceptable, a position comparison against all position computations is conducted. The antenna positions for all systems are logged and using the heading system and the measured antenna offsets are reduced to the vessel's CRP. The difference in the positions should agree to within 1 m and they are represented as Delta Easting (ΔE) and Delta Northing (ΔN).

5.5.4 Ultra Short Baseline System

A USBL allows the measurement of range and bearing from a vessel-based transceiver to one or more subsea transponders. It generally operates through the phase discrimination of an acoustic signal recorded by three orthogonal transducers combined in one head. A USBL calibration is executed whenever work is carried out on the transducer and at least once a year. Calibrations are carried out in water depths slightly deeper than those in which the operations will occur.

5.5.4.1 Preparation

During the USBL calibration sequence, the vessel must be free to manoeuvre around a stationary transponder. Before starting the actual USBL calibration, it is assumed that:

- The vessel's positioning system has been verified;
- The vessel's heading system alignment has been checked;
- All relevant offsets, including the height of the transponder's transducer above the seabed, have been measured.

The actual water depth, measured by the echo sounder, and not corrected for tide, should also be known at the calibration site. A speed of sound profile, determined at the calibration site, is entered into the USBL system before calibration data is collected.

For the USBL calibration a transponder, equipped with a remote-controlled release mechanism or a surface buoy is deployed, clear of all structures and pipelines, in an area with an approximate water depth slightly deeper than the proposed survey area. The surface positioning system is used to navigate the vessel during the calibration.

5.5.4.2 Offset (Spin) Test

The first part of the calibration is carried out to verify the offsets between the USBL system and the navigation system. This is normally done by manoeuvring the vessel directly over a beacon deployed

on the seabed and then rotating the vessel through 360° while logging the surface and USBL position. Any offset errors are displayed as a 'snail trail' showing the beacon position describing a circle around the intended beacon position. Alternatively, the vessel is positioned directly over the beacon, and an equal number of fixes are logged while the vessel is heading in each of the four cardinal directions.

The Z-offset is checked by comparing the Z component of the USBL observation and the value from the echo sounder, allowing for beacon height above the seafloor. As the vessel is directly over the seafloor beacon, this minimise any errors due to Range Scale and USBL transducer misalignment.

5.5.4.3 Range Scale, Orientation, Pitch and Roll

This phase of the calibration is carried out with the vessel positioned on the circumference of a circle of radius 1.5 to 2 times the water depth, centred on the beacon. The following describes a calibration with the vessel lying to the north, east, south, and west of the beacon with the vessel maintaining the same north heading. In the case of bad weather, this pattern may be rotated so that the vessel is heading into the current. The surface position of the vessel and the USBL position of the beacon are logged at each cardinal point. Generally a minimum of 100 fixes, at 5 second intervals, are logged at each cardinal point.

When the vessel is due north or south of the beacon and heading due north, roll errors are minimised and pitch errors are observed. Transducer alignment errors will plot the beacon offset to the east or west of its actual position. Range scaling errors will plot the beacon to the north or south of the actual position.

When the vessel moves to a position due east or west of the beacon, while still maintaining a heading of due north, roll errors are observed and pitch errors are minimised. Transducer alignment error will plot the beacon offset from its actual position. Range scaling errors will plot the beacon to the east or west of the actual position.

Any resultant errors will show the beacon plotted in four quadrants. If there are no errors, the beacon position will be shown as a circular scatter plot around the actual position.

The range error consists of a fixed error and the scalar multiplier. Overall it accounts for errors in ray path and speed of sound. The Starfix.USBL module derives a range error value that contains and accounts for the range fixed error.

Starfix.USBL computes the errors and displays the results as four parameters:

- Pitch error;
- Roll error;
- Transceiver misalignment;
- Range error.

5.5.4.4 Verification of Results

The calibration results are checked using one of two methods:

1) Two lines are run at right angles and in opposite directions over the top of the beacon.
2) By conducting a spin test, where the vessel rotates through 360° at a distance of approximately two times the water depth.

In both cases the beacon's position is continuously logged and should not deviate, within operational parameters, from its calibrated position. A reasonably tight, circular scatter plot a few metres across, depending on the navigation system performance, the USBL system performance, and the depth of water, is an indication of a good calibration result.

5.6 Glossary of Terms

Accuracy	The accuracy of a measurement is its degree of closeness to its actual (true) value. Accuracy is the combination of the precision and reliability of an observation.
APOS	Acoustic Positioning Operating System. Kongsberg's in-house operating system for DP computers.
Augmentation Data	Additional information e.g. from a reference or tracking station, applied at a user receiver to improve the positioning solution. See also differential GNSS.
Azimuth	A horizontal angle measured from the spheroidal meridian clockwise from north through 360°. See also bearing and heading.
Bearing	Refers to a direction from one point to another on a chart right rotated from grid north (bearing = azimuth + convergence + arc to chord correction). See also azimuth and heading.
C-O Correction	Calculated minus observed correction. The difference found in a calibration procedure between a fixed value and an observation. The C-O correction must always be added to the observation.
Chart Datum	Vertical Datum used in charting. Chart data e.g. Mean Sea Level (MSL), Lowest Astronomical Tide (LAT), Lowest Low Water Springs (LLWS), Normaal Amsterdams Peil (Amsterdam Ordnance Datum) (NAP), Normal Null (NN). See also Vertical Datum.

CM	Central meridian, the meridian that defines the central line of longitude of the chart projection. It is a zone constant used in chart projections.
Convergence	Clockwise angle in a point between true north and grid north.
CRP	Common Reference Point is the origin of all vessel coordinates. It is also referred to as the vessel datum. It often corresponds to the drill string on drilling vessels.
Datum (Geodetic)	A mathematical model designed to best-fit part or all of the geoid. It is defined by an ellipsoid and the relationship between the ellipsoid and a point on the topographic surface established as the origin of datum. This relationship can be defined by six quantities, generally (but not necessarily) the geodetic latitude, longitude and the height of the origin, the two components of the deflection of the vertical at the origin, and the geodetic azimuth of a line, from the origin to some other point.
Datum Rotation (Geodetic)	Defined as the anti-clockwise rotation around the X-axis, Y-axis and Z-axis (Rx, Ry, and Rz) in the origin of two spheroids in terms of the Cartesian or geocentric coordinates. See also datum shift and scale.
Datum Shift (Geodetic)	Defined as the difference (ΔX, ΔY, ΔZ) in the origin of two spheroids in terms of the Cartesian or geocentric coordinates. See also datum rotation and scale.
Datum (Vessel)	The vessel datum is the origin of all vessel coordinates. It is referred to as the common reference point or CRP.
DGNSS	Augmentation technique requiring a GNSS receiver(s) to be placed at one or multiple known points from which GNSS observable (pseudo-range) corrections can be deduced. These corrections can then be applied to the offshore mobile receiver.
DP	Dynamic positioning, mainly referring to a system keeping the vessel in one position compensating for current, wind and other natural influences, using a variety of positioning systems as reference.
Differential Positioning	Determination of relative coordinates between two or more satellite receivers that are simultaneously tracking the same satellite signal.

Ellipsoid / Spheroid	In geodesy, unless otherwise specified, a mathematical figure formed by revolving an ellipse about its minor axis. It is often used interchangeably with spheroid. Two quantities define an ellipsoid: these are usually given as the length of the semi-major axis, a, and the inverse flattening, 1/f = a / (a-b), where b is the length of the semi-minor axis. Prolate and triaxial ellipsoids are invariably described as such.
False Easting / False Northing	Defined projection coordinate offsets to the origin point of the projection.
Geoid	The particular equipotential surface which coincides with mean sea level, and which may be imagined to extend through the continents. This surface is perpendicular to the force of gravity everywhere.
GLONASS	Russian global navigation satellite system.
GPS	Global positioning system.
GNSS	Global navigation satellite system. A combination solution of GPS and GLONASS with provision for the future European Galileo space system.
HDOP	Horizontal dilution of precision. A measure of the magnitude of DOP errors in latitude and longitude.
Heading	Course of a vessel measured with a heading system, i.e. a gyrocompass, or a GPS vector heading system. If the heading is magnetic this will be stated. See also azimuth and bearing.
HiPAP	High precision acoustic positioning. A USBL system developed by Simrad - Kongsberg. See USBL definition.
HPR	Hydro acoustic positioning reference. See USBL definition.
Line Scale Factor	The ratio of a distance from point A to point B on the grid to the corresponding distance on the spheroid. K = plane distance/spheroidal distance 1/k=1/6(1/kA + 4/kM +1/kB). (kA, kB, kM being point scale factors at A, B, M. See also point scale factor)

Multifix	Multi reference differential global positioning system based on simultaneous calculated single DGPS positions for each reference station which solutions are then applied to a least squares calculation by which a new solution is created by weighting the single solutions on distance of the used reference station used in the single computations.
Offset	A station offset from the main survey station. Must be defined by an azimuth and distance or ΔX, ΔY, ΔZ, or starboard/port, forward/aft, above/below.
PDOP	Position dilution of precision. A unit-less figure of merit expressing the relationship between the error in user position and the error in satellite position.
PPP	Precise Point Positioning. A global GNSS augmentation technique that corrects for GNSS satellite clock and orbit errors, and employs additional modelling techniques to further correct and improve the point positioning accuracy.
Precision	A measure of the random errors in observations and estimated parameters.
Reference Station	A GNSS receiver located at a precisely known location and used to determine the differential corrections employed for DGNSS augmentation techniques.
Satellite Configuration	State of the satellite configuration at a specific time, relative to a specific user or set of users.
Satellite Constellation	The arrangement in space of the complete set of satellites of a system such as GPS.
Scale	Reduction/expansion used in datum-datum transformations. Unit: ppm (parts per million). See also datum shift and datum rotation.
Scale Factor (Point)	Ratio of an infinitesimal distance at a point on the grid to the corresponding distance on the spheroid. K = Δ (plane distance) / Δ (spheroidal distance).
S/CTD (probe)	Salinity or conductivity, temperature and depth probe. Used to determine speed of sound through the water column. Pressure to depth conversions may be applied to provide true depth values.

SD	Standard deviation. Measure of the dispersion of random errors about the mean value. If a large number of measurements or observations of the same quantity are made, the standard deviation is the square root of the sum of the squares of deviations from the mean value divided by the number of observations less one.
Starfix.G2	A decimetre accuracy integrated GNSS service which utilises Fugro's own global network of reference stations to measure carrier phase observations. This data is then processed, producing a corrections solution for each navigation satellite. These corrections are applied to the satellite time reference clock and ephemeris ("orbit") information, hence "clock and orbit corrections". This service utilises both GPS and GLONASS L1 and L2 frequencies, thereby providing an accurate measurement of variations in Ionospheric thickness. This enables signal delay to be calculated more precisely, resulting in a more accurate satellite to antenna range, and hence a more accurate position solution. Starfix.G2 provides a high availability, high integrity, global solution to an accuracy of 10 cm (95% confidence level) both horizontally and vertically.
Starfix.HP	This service utilises the Fugro international network of approximately 100 land-based reference stations. Unlike standard L1, which uses code based measurements, Starfix.HP is based upon carrier phase measurements which provide a much higher resolution. This service utilises the GPS L1 and L2 frequencies, thereby providing an accurate measurement of Ionospheric thickness. This results in a more accurate satellite to antenna range, and hence a more accurate position solution. At a distance of 1000 km from the nearest reference station Starfix.HP accuracies are typically 10 cm and 15 cm (95% confidence level) in the horizontal and vertical planes respectively.
Starfix.XP	This service utilises a third party global network of reference stations to measure carrier phase observations. This data is then processed, producing a corrections solution for each navigation satellite. These corrections are applied to the satellite time reference clock and ephemeris ("orbit") information, hence "clock and orbit corrections". This service utilises the GPS L1 and L2 frequencies, thereby providing an accurate measurement of variations in Ionospheric thickness. This enables signal delay to be calculated more precisely, resulting in a more accurate satellite to antenna range, and hence a more accurate position solution. Starfix.XP provides a high performance global solution to an accuracy of 10 cm and 20 cm (95% confidence level) in the horizontal and vertical planes respectively.

Starfix.L1	This service is a GPS positioning correction system using single frequency code correction data from the Fugro network of reference stations, delivered via both Inmarsat and SpotBeam satellites. These corrections, combined with a single frequency GPS receiver, can provide a positional accuracy of better than 1.5 m (95%) horizontally at a distance of 500 km from the closest reference station.
Starfix.NG	Fugro's in-house advanced vessel and ROV positioning software system.
StarPack	A StarPack unit consists of a survey grade GNSS receiver and powerful processor, running Linux multi-tasking operating system. The receiver is capable of tracking all current (GPS, GLONASS) and future (Galileo) systems. A StarPack can be extended with a second receiver (in the same unit), to provide accurate, GNSS derived heading.
Transceiver	A device that can transmit and receive signals.
Transducer	A device that converts electrical energy to acoustic energy and vice-versa.
Transponder	A device that can detect a signal on a particular frequency and in response transmits signal on another frequency.
UTM	Universal Transverse Mercator. A special case of the transverse Mercator projection whereby the projection parameters are specified by worldwide agreement, abbreviated as the UTM grid. It consists of 60 north south zones, each 6 degrees of longitude wide with a unique central meridian.
USBL	Ultra Short Base Line acoustic positioning method involving the measurement of range and bearing from a vessel-based transceiver to subsea transponders. It generally operates through phase discrimination of an acoustic signal as it passes over three transducers placed at right angles to each other within the Transducer head. Using this method, a three dimensional position of the beacon(s) can be determined.
Vertical Datum	An arbitrarily assumed value for a particular benchmark or a measured value at sea level at a tide station, or a fixed adjustment of many such measurements in a common adjustment. See also chart datum.

WGS 84	World Geodetic System 1984. A rotational ellipsoid having the following dimensions: semi-major axis 6378137.000 m, semi-minor axis (derived) 6356752.314 m, flattening (derived) 1/298.257224. This ellipsoid reference model / datum is the surface from which GPS coordinates are computed.

APPENDIX 3: RECOVERY LISTS

LIST OF PLATES IN APPENDIX 3: Plate

Signed Recovery Lists (Downhole Mode) 23 Plates

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-1 Date: 3/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	0.00	96	55	3" thin wall with core catcher
W	2	1.00	96	60	3" thin wall with core catcher
W	3	2.00	96	55	3" thin wall with core catcher
W	4	3.00	86	35	3" thin wall with core catcher, drill one meter to clear hole at client's request
W	5	4.00	85	60	3" thin wall with core catcher
W	6	5.00	20	5	3" thin wall with core catcher
W	7	5.50	12	0	3" thin wall with core catcher
W	8	6.00	10	0	chisel & 3" thin wall with core catcher
W	9	7.00	10	0	3" thin wall with core catcher. Borehole terminated at 7.0 m bsf due to adverse soil conditions. (see remarks section below)

Borehole Summary: Total meters drilled: 7.0 [m] Total Number of samples: 9 Total Sample Recovery: 270 [cm]
Total Number of CPT: Total CPT Recovery: [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled = 7.00 m.
Between 4 m and 5 m bsf drilling and sampling was complicated due to encountered cobbles, which damaged the cutting shoes.
At 5 m bsf, an attempt was made to remove a cobble, probably in diameter bigger than the drill bit, by hitting it with a heavy chisel.
As it did not help, the decision was made to bump over and restart the borehole at 5 m depth.

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

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RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-1A
Date: 03/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	5.00	25	20	3" thin wall with core catcher
W	2	6.00	51	40	3" thin wall with core catcher
W	3	6.50	81	55	2" thick wall with core catcher
W	4	7.50	83	55	2" thick wall with core catcher
W	5	8.50	67	45	2" thick wall with core catcher
W	6	9.00	73	45	2" thick wall with core catcher
W	7	9.50	72	45	2" thick wall with core catcher
W	8	10.00	56	40	2" thick wall with core catcher
W	9	10.50	62	45	2" thick wall with core catcher
W	10	11.00	63	45	2" thick wall with core catcher
W	11	11.50	49	40	2" thick wall with core catcher
W	12	12.00	60	40	2" thick wall with core catcher
W	13	12.50	98	45	2" thick wall with core catcher
W	14	13.00	93	80	3" thin wall
W	15	14.00	90	75	3" thin wall
CPT	1	15.00	300	300	F5 1706-1269
W	16	18.00	83	70	3" thin wall
CPT	2	19.00	36	21	F5 1706-1269
CPT	3	19.50	47	31	F5 1706-1269
CPT	4	20.00	53	31	F8 1721-1713
CPT	5	21.00	150	139	F8 1721-1713
W	17	22.50	84	70	2" thick wall with core catcher
CPT	6	23.50	50	35	F5 1706-1269
CPT	7	24.00	150	138	F8 1721-1713
CPT	8	25.50	150	136	F8 1721-1713
W	18	27.00	99	85	2" thick wall with core catcher
W	19	28.00	70	60	3" thin wall
CPT	9	29.00	300	294	F5 1706-1269
W	20	32.00	94	45	3" thin wall

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 27 Total Sample Recovery: 1565 [cm]
Total Number of CPT: 13 Total CPT Recovery: 2284 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last CPT recovery = 51.90 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

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RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-1A
Date: 03/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	21	33.00	99	80	3" thick wall
CPT	10	34.00	300	288	F5 1706-1269
W	22	37.00	99	70	3" thin wall
W	23	38.00	99	75	3" thin wall
CPT	11	39.00	300	292	F5 1706-1269
W	24	42.00	99	70	3" thin wall
W	25	43.00	99	75	3" thck wall
CPT	12	44.00	300	289	F5 1706-1269
W	26	47.00	99	75	3" thck wall
W	27	48.00	98	75	3" thck wall
CPT	13	49.00	300	290	F5 1706-1269. E.O.B. Final recovery depth 51.90 m bsf.

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 27 Total Sample Recovery: 1565 [cm]
Total Number of CPT: 13 Total CPT Recovery: 2284 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last CPT recovery = 51.90 m

Client Representative:	Fugro Representative:
Name: P. Watson/W. Zuijderduijn	Name: H. Roth

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RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: CPT_WFS4_1
Date: 9/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
SCPT	1	0.00	253	253	F5 1706-1831
SCPT	2	2.50	300	260	F5 1706-1831
SCPT	3	5.50	300	286	F5 1706-1831
SCPT	4	8.50	300	286	F5 1706-2364
CPT	5	11.50	105	90	F5 1706-2364
SCPT	6	12.50	300	289	F5 1706-2364
SCPT	7	15.50	300	300	F5 1706-2364
CPT	8	18.50	150	150	F8 1706-0002
CPT	9	20.00	150	137	F8 1706-0002
SCPT	10	21.50	225	220	F5 1706-2364
CPT	11	24.50	150	128	F8 1706-0002
SCPT	12	26.00	300	290	F5 1706-2364
CPT	13	29.00	300	290	F5 1706-2185
SCPT	14	32.00	300	294	F5 1706-2364
CPT	15	35.00	300	290	F5 1706-2185
CPT	16	38.00	300	291	F5 1706-2185. E.O.B Final recovery depth 40.91 m bsf.

Borehole Summary:
Total Number of CPT: 7
Total meters drilled: 38.0 [m]
Total CPT Recovery: 1376 [cm]
Total Number of samples:
Total Number of SCPT: 9
Total Number of PPDT :
Total Sample Recovery: [cm]
Total SCPT Recovery: 2478 [cm]

Remarks: Final depth is meters drilled + last CPT recovery = 40.91 m.
Borehole terminated due to technical dificulties.

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

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RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: CPT_WFS4_1A

Date: 10/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
CPT	1	40.00	300	296	F5 - 1706-2185
CPT	2	43.00	300	285	F5 - 1706-2185
CPT	3	46.00	300	298	F5 - 1706-2185
CPT	4	49.00	300	288	F5 - 1706-2185, E.O.B. Final recovery depth 51.88 m bsf.

Borehole Summary:
Total Number of CPT: 4
Total meters drilled: 49.0 [m]
Total CPT Recovery: 1167 [cm]
Total Number of samples:
Total Number of SCPT:
Total Number of PPDT :
Total Sample Recovery: [cm]
Total SCPT Recovery: [cm]

Remarks: Final depth is meters drilled + last CPT recovery = 51.88 m.

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

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GeODin/Recovery List Downhole Mode SCPT.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-2 Date:

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	0.00	50	45	3" thin wall with core catcher
W	2	0.50	96	55	3" thin wall with core catcher
W	3	1.50	95	55	3" thin wall with core catcher
W	4	2.50	87	60	3" thin wall with core catcher
W	5	3.50	50	50	2" thick wall with core catcher
W	6	4.00	50	45	2" thick wall with core catcher
W	7	4.50	50	25	2" thick wall with core catcher
W	8	5.00	50	40	2" thick wall with core catcher
W	9	5.50	50	40	2" thick wall with core catcher
W	10	6.00	50	40	2" thick wall with core catcher
W	11	6.50	50	45	2" thick wall with core catcher
W	12	7.00	50	30	2" thick wall with core catcher
W	13	7.50	50	35	2" thick wall with core catcher
W	14	8.00	50	35	2" thick wall with core catcher. E.O.B. Final recovery depth 8.35 m bsf.

Borehole Summary: Total meters drilled: 8.0 [m] Total Number of samples: 14 Total Sample Recovery: 600 [cm]
Total Number of CPT: Total CPT Recovery: [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 8.35 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: P. Mrozowicz

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-2A
Date: 4/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	7.50	22	10	3" thin walled with core catcher
W	2	8.00	61	40	2" thick walled with core catcher
W	3	8.50	70	50	2" thick walled with core catcher
W	4	9.00	56	35	2" thick walled with core catcher
W	5	9.50	71	45	2" thick walled with core catcher
W	6	10.00	99	50	2" thick walled with core catcher
W	7	11.00	99	70	2" thick walled with core catcher, drill out 1m to not sample only disturbed ground
W	8	12.00	99	80	3" thin walled with core catcher
W	9	13.00	55	50	3" thin walled
W	10	13.50	67	35	3" thick walled
W	11	14.00	70	55	3" thick walled
CPT	1	15.00	299	290	F5 - 1706-2185
W	12	18.00	53	35	3" thick walled
CPT	2	19.00	299	288	F5 - 1706-2185
W	13	22.00	50	30	3" thick walled
CPT	3	23.00	299	290	F5 - 1706-2185
W	14	26.00	92	80	3" thick walled
CPT	4	27.00	299	290	F5 - 1706-2185
W	15	30.00	96	80	3" thick walled
CPT	5	31.00	299	294	F5 - 1706-2185
W	16	34.00	80	60	3" thick walled
CPT	6	35.00	299	291	F5 - 1706-2185
W	17	38.00	77	65	3" thin walled
W	18	39.00	33	30	3" thin walled
CPT	7	40.00	20	14	F5 - 1706-2185
CPT	8	41.00	50	43	F5 - 1706-2185
CPT	9	42.00	150	141	F8 - 1721-1713
W	19	43.50	68	65	3" thick walled

Borehole Summary: Total meters drilled: 51.5 [m] Total Number of samples: 21 Total Sample Recovery: 1075 [cm]
Total Number of CPT: 11 Total CPT Recovery: 2529 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 52.20 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

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RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-2A

Date: 4/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
CPT	10	44.50	299	288	F5 - 1706-2185
W	20	47.50	53	40	3" thick walled
CPT	11	48.50	300	300	F5 - 1706-2185
W	21	51.50	98	70	3" thick walled, E.O.B. Final recovery depth 52.20 m bsf.

Borehole Summary: Total meters drilled: 51.5 [m] Total Number of samples: 21 Total Sample Recovery: 1075 [cm]
Total Number of CPT: 11 Total CPT Recovery: 2529 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 52.20 m

Client Representative:

Name: P. Watson/W. Zuijderduijn

Fugro Representative:

Name: H. Roth

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GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-3
Date: 2/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	0.00	96	56	3" thin wall with core catcher
W	2	1.00	96	75	3" thin wall with core catcher
W	3	2.00	96	75	3" thin wall with core catcher
W	4	3.00	96	75	3" thin wall with core catcher
W	5	4.00	96	70	3" thin wall with core catcher
W	6	5.00	96	65	3" thin wall with core catcher
W	7	6.00	96	65	3" thin wall with core catcher
W	8	7.00	96	55	3" thin wall with core catcher
W	9	8.00	69	60	3" thin wall with core catcher
W	10	9.00	40	25	3" thin wall with core catcher
W	11	9.50	60	40	2" thick wall with core catcher, top 10 cm disturbed
W	12	10.00	73	45	2" thick wall with core catcher
W	13	10.50	96	65	2" thick wall with core catcher, top 23 cm disturbed
W	14	11.50	78	70	3" thin wall
W	15	12.50	50	50	3" thin wall
W	16	13.00	50	50	3" thin wall
W	17	13.50	50	50	3" thin wall
W	18	14.00	50	45	2" thick wall
CPT	1	15.00	0	0	Operational limitation during clamping. No recovery.
CPT	2	15.50	299	288	F5 1706-1269
W	19	18.50	96	90	2" thick wall with core catcher
CPT	3	19.50	299	290	F5 1706-1269
W	20	22.50	75	65	3" thin wall
CPT	4	23.50	299	297	F5 1706-1269
W	21	26.50	85	70	3" thin wall
CPT	5	27.50	299	295	F5 1706-1269
W	22	30.50	99	65	3" thin wall

Borehole Summary: Total meters drilled: 59.5 [m] Total Number of samples: 34 Total Sample Recovery: 1971 [cm]
Total Number of CPT: 11 Total CPT Recovery: 2896 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 59.95 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-3
Date: 2/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	23	31.50	98	40	3" thin wall
CPT	6	32.50	288	270	F5 1706-1269
W	24	35.50	24	15	3" thick wall
W	25	36.00	33	25	2" thick wall with core catcher
CPT	7	36.50	300	291	F5 1706-1269
W	26	39.50	42	35	3" thick wall
W	27	40.50	66	50	3" thick wall
CPT	8	41.50	300	290	F5 1706-1269
W	28	44.50	99	65	3" thick wall
W	29	45.50	99	60	3" thick wall
CPT	9	46.50	300	293	F5 1706-1269
W	30	49.50	99	80	3" thick wall
W	31	50.50	99	75	3" thick wall
CPT	10	51.50	300	289	F5 1706-1269
W	32	54.50	99	75	3" thick wall
W	33	55.50	99	80	3" thick wall
CPT	11	56.50	300	293	F5 1706-1269
W	34	59.50	99	45	3" thick wall. E.O.B. Final recovery depth 59.95 m bsf.

Borehole Summary: Total meters drilled: 59.5 [m] Total Number of samples: 34 Total Sample Recovery: 1971 [cm]
Total Number of CPT: 11 Total CPT Recovery: 2896 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 59.95 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01

GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-4 Date:

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	0.00	96	60	3" thin wall with core catcher
W	2	1.00	96	65	3" thin wall with core catcher
W	3	2.00	46	30	3" thin wall with core catcher. Cutting shoe damaged due to gravels
W	4	2.50	88	55	2" thick wall with core catcher
W	5	3.50	76	45	2" thick wall with core catcher
W	6	4.00	76	35	2" thick wall with core catcher
W	7	4.50	60	35	2" thick wall
W	8	5.00	58	25	2" thick wall
W	9	5.50	54	20	2" thick wall
W	10	6.00	47	25	2" thick wall
W	11	6.50	47	25	2" thick wall
W	12	7.00	50	20	2" thick wall
W	13	7.50	56	25	2" thick wall
W	14	8.00	56	30	2" thick wall
W	15	8.50	60	25	2" thick wall
W	16	9.00	46	20	2" thick wall
W	17	9.50	57	25	2" thick wall
W	18	10.00	42	20	2" thick wall
W	19	10.50	45	20	2" thick wall
W	20	11.00	66	30	2" thick wall
W	21	11.50	87	30	2" thick wall. Drill out 1.0 m client request
W	22	12.50	63	30	2" thick wall
W	23	13.00	59	25	2" thick wall
W	24	13.50	51	30	2" thick wall
W	25	14.00	37	20	2" thick wall
W	26	14.50	41	25	2" thick wall
CPT	1	15.00	300	277	F5 1706-2196
W	27	18.00	62	25	2" thick wall

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 40 Total Sample Recovery: 1423 [cm]
Total Number of CPT: 9 Total CPT Recovery: 2290 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last CPT recovery = 50.39 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: P. Mrozewicz

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-4 Date:

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	28	18.50	51	25	2" thick wall. Additional sample at client's request
CPT	2	19.00	300	283	F5 1706-2196
W	29	22.00	92	60	2" thick wall
CPT	3	23.00	300	282	F5 1706-2196
W	30	26.00	48	35	2" thick wall
W	31	26.50	94	65	2" thick wall. Additional sample at client's request
CPT	4	27.50	300	280	F5 1706-2196
W	32	30.50	95	65	2" thick wall
CPT	5	31.50	300	285	F5 1706-2196
W	33	34.50	94	25	3" thick wall
CPT	6	35.50	300	281	F5 1706-2196
W	34	38.50	95	85	3" thick wall
W	35	39.50	50	40	3" thick wall
CPT	7	40.50	300	281	F5 1706-2196
W	36	43.50	96	75	3" thick wall
W	37	44.50	95	80	3" thick wall
CPT	8	45.50	199	182	F5 1706-2196
W	38	47.50	18	8	3" thick wall
W	39	48.00	28	20	3" thick wall
W	40	48.50	38	20	3" thick wall. Additional sample at client's request
CPT	9	49.00	150	139	F8 1709-0001. E.O.B. Final recovery depth 50.39 m bsf.

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 40 Total Sample Recovery: 1423 [cm]
Total Number of CPT: 9 Total CPT Recovery: 2290 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last CPT recovery = 50.39 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: P. Mrozowicz

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-5
Date: 28/9/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	0.00	96	25	3" thin wall with core catcher
W	2	0.50	96	45	3" thin wall with core catcher
W	3	1.00	96	45	3" thin wall with core catcher
W	4	1.50	96	50	3" thin wall with core catcher
W	5	2.00	96	45	3" thin wall with core catcher
W	6	2.50	83	40	3" thin wall with core catcher. Drill out 1 m client request
W	7	3.50	82	45	3" thin wall with core catcher
W	8	4.00	94	40	2" thick wall with core catcher
W	9	4.50	77	40	2" thick wall with core catcher
W	10	5.00	75	40	2" thick wall with core catcher
W	11	5.50	94	50	2" thick wall with core catcher
W	12	6.00	69	40	2" thick wall with core catcher
W	13	6.50	66	40	2" thick wall with core catcher
W	14	7.00	81	40	2" thick wall with core catcher. Drill out 1 m client request
W	15	8.00	71	40	2" thick wall with core catcher
W	16	8.50	73	40	2" thick wall with core catcher
W	17	9.00	72	30	2" thick wall with core catcher
W	18	9.50	63	30	2" thick wall with core catcher
W	19	10.00	68	35	2" thick wall with core catcher
W	20	10.50	57	30	2" thick wall with core catcher
W	21	11.00	70	30	2" thick wall with core catcher
W	22	11.50	64	25	2" thick wall with core catcher
W	23	12.00	56	25	2" thick wall with core catcher
W	24	12.50	72	30	2" thick wall with core catcher
W	25	13.00	67	35	2" thick wall with core catcher
W	26	13.50	61	25	2" thick wall with core catcher
W	27	14.00	62	30	2" thick wall with core catcher
W	28	14.50	61	35	2" thick wall with core catcher

Borehole Summary: Total meters drilled: 52.0 [m] Total Number of samples: 40 Total Sample Recovery: 1565 [cm]
Total Number of CPT: 9 Total CPT Recovery: 2397 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 52.15 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: P. Mrozowicz

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-5
Date: 28/9/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
CPT	1	15.00	300	270	F5 1706-2196
W	29	18.00	61	30	2" thick wall
CPT	2	19.00	300	284	F5 1706-2196
W	30	22.00	51	20	2" thick wall
CPT	3	23.00	300	283	F5 1706-2196
W	31	26.00	56	30	2" thick wall
CPT	4	27.00	300	275	F5 1706-2196
W	32	30.00	40	20	2" thick wall
CPT	5	31.00	300	276	F5 1706-2196
W	33	34.00	44	20	2" thick wall
CPT	6	35.00	300	279	F5 1706-2196
W	34	38.00	75	70	3" thick wall
W	35	39.00	95	75	3" thick wall
CPT	7	40.00	300	286	F5 1706-2196
W	36	43.00	95	80	3" thick wall
W	37	44.00	66	50	3" thick wall
CPT	8	45.00	300	280	F5 1706-2196
W	38	48.00	95	55	3" thick wall
W	39	49.00	94	75	3" thick wall
CPT	9	50.00	174	164	F5 1706-2196
W	40	52.00	34	15	2" thick wall. E.O.B. Final recovery depth 52.15 m bsf.

Borehole Summary: Total meters drilled: 52.0 [m] Total Number of samples: 40 Total Sample Recovery: 1565 [cm]
Total Number of CPT: 9 Total CPT Recovery: 2397 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 52.15 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: P. Mrozowicz

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-6
Date: 5/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	0.00	97	60	3" thin wall with core catcher
W	2	1.00	99	60	3" thin wall with core catcher
W	3	2.00	90	60	3" thin wall with core catcher
W	4	3.00	50	50	2" thick wall with core catcher
W	5	3.50	50	45	2" thick wall with core catcher
W	6	4.00	99	60	2" thick wall with core catcher
W	7	5.00	50	50	2" thick wall with core catcher
W	8	5.50	50	45	2" thick wall with core catcher
W	9	6.00	50	35	2" thick wall with core catcher
W	10	6.50	98	60	2" thick wall with core catcher
W	11	7.50	50	45	2" thick wall with core catcher
W	12	8.00	50	35	2" thick wall with core catcher
W	13	8.50	50	45	2" thick wall with core catcher
W	14	9.00	50	30	2" thick wall with core catcher
W	15	9.50	50	30	2" thick wall with core catcher
W	16	10.00	50	25	2" thick wall with core catcher
W	17	10.50	50	35	2" thick wall with core catcher
W	18	11.00	50	35	2" thick wall with core catcher
W	19	11.50	50	35	2" thick wall with core catcher
W	20	12.00	50	30	2" thick wall with core catcher
W	21	12.50	50	30	2" thick wall with core catcher
W	22	13.00	50	35	2" thick wall with core catcher
W	23	13.50	99	80	2" thick wall with core catcher
W	24	14.50	64	35	3" thick wall
CPT	1	15.30	63	58	F5 1706-2185
CPT	2	16.00	150	136	F8 1721-1713
W	25	17.50	96	65	2" thick wall with core catcher
CPT	3	18.50	200	194	F5 1706-2185
W	26	20.50	37	20	2" thick wall with core catcher

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 33 Total Sample Recovery: 1500 [cm]
Total Number of CPT: 15 Total CPT Recovery: 2363 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 50.43 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-6

Date: 5/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
CPT	4	21.50	34	18	F5 1706-2185
CPT	5	22.00	69	53	F8 1721-1713
CPT	6	23.00	67	51	F8 1721-1713
W	27	24.00	94	55	2" thick wall with core catcher
CPT	7	25.00	150	135	F8 1721-1713
CPT	8	26.50	150	137	F8 1721-1713
W	28	28.00	76	50	2" thick wall with core catcher
CPT	9	29.00	150	138	F8 1721-1713
CPT	10	30.50	150	137	F8 1721-1713
W	29	32.00	56	40	2" thick wall with core catcher
CPT	11	33.00	300	284	F5 1706-2185
W	30	36.00	99	80	2" thick wall with core catcher
CPT	12	37.00	300	289	F5 1706-2185
W	31	40.00	99	90	2" thick wall with core catcher
CPT	13	41.00	300	292	F5 1706-2185
W	32	44.00	33	20	3" thick wall
CPT	14	45.00	299	298	F5 1706-2185
W	33	48.00	50	30	2" thick wall with core catcher
CPT	15	49.00	150	143	F8 1721-1713, E.O.B. Final recovery depth 50.43 m bsf.

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 33 Total Sample Recovery: 1500 [cm]
Total Number of CPT: 15 Total CPT Recovery: 2363 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 50.43 m

Client Representative:

Name: P. Watson/W. Zuijderduijn

Fugro Representative:

Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01

GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-7
Date: 6/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	1	0.00	97	70	3" thin wall with core catcher and bag
W	2	1.00	98	55	3" thin wall with core catcher and bag
W	3	2.00	99	55	3" thick wall with core catcher
W	4	3.00	98	50	3" thick wall with core catcher, full push, full drill out to sample undisturbed ground
W	5	4.00	81	50	3" thick wall with core catcher
W	6	4.50	84	55	3" thick wall with core catcher
W	7	5.50	50	35	3" thick wall with core catcher
W	8	6.00	99	80	2" thick wall with core catcher
W	9	7.00	50	50	2" thick wall with core catcher
CPT	1	7.50	150	139	F5 1706-2185
W	10	7.50	99	85	2" thick wall with core catcher. Oversample
W	11	8.50	99	90	2" thick wall with core catcher. Oversample
PPDT	1	8.89	0	0	Dissipation Test at 8.89 m bsf. Dissipation time 15 minutes.
W	12	9.50	99	70	3" thick wall
W	13	10.50	50	50	3" thick wall
W	14	11.00	50	40	2" thick wall with core catcher
W	15	11.50	99	75	2" thick wall with core catcher
W	16	12.50	99	80	2" thick wall with core catcher
W	17	13.50	99	85	2" thick wall with core catcher
W	18	14.50	99	55	3" thick wall
CPT	2	15.50	300	291	F5 1706-2185
CPT	3	18.90	110	109	F5 1706-2185. Dissipation Test at 20 m aborted after 81 min due to unlatching of the tool.
CPT	4	20.50	150	131	F5 1706-2185
W	19	20.50	99	75	3" thick wall. Oversample
W	20	21.50	50	50	3" thick wall. Oversample
PPDT	2	21.81	0	0	Dissipation Test at 21.81 m bsf. Dissipation time 120 min.

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 29 Total Sample Recovery: 1845 [cm]
Total Number of CPT: 14 Total CPT Recovery: 2381 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests : 2
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 51.85 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: BH-WFS4-7

Date: 6/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
W	21	22.00	99	50	3" thick wall
W	22	23.00	99	80	3" thick wall
CPT	5	24.00	300	289	F5 1706-2185
W	23	27.00	98	65	2" thick wall with core catcher
CPT	6	28.00	300	284	F5 1706-2185
W	24	31.00	99	75	2" thick wall with core catcher
CPT	7	32.00	150	143	F8 1721-1713. F8 cone used to not push too far into the upcoming clay layer.
W	25	33.50	86	65	3" thin wall
W	26	34.50	68	50	3" thin wall
CPT	8	35.50	300	291	F5 1706-2185
W	27	38.50	99	90	2" thick wall with core catcher
CPT	9	39.50	220	212	F5 1706-2185
W	28	42.50	99	90	2" thick wall with core catcher
CPT	10	43.50	33	19	F5 1706-2185
CPT	11	44.50	23	18	F8 1721-1713
CPT	12	45.50	45	33	F8 1721-1713
W	29	46.50	33	25	2" thick wall with core catcher
CPT	13	47.50	150	137	F8 1721-1713
CPT	14	49.00	300	285	F5 1706-2185. E.O.B. Final recovery depth 51.85 m bsf.

Borehole Summary: Total meters drilled: 49.0 [m] Total Number of samples: 29 Total Sample Recovery: 1845 [cm]
Total Number of CPT: 14 Total CPT Recovery: 2381 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests : 2
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 51.85 m

Client Representative:

Name: P. Watson/W. Zuijderduijn

Fugro Representative:

Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01

GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: CPT_WFS4_7

Date: 14/9/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
CPT	1	0.00	300	283	F5 1706-2185
CPT	2	3.00	300	283	F5 1706-2185
CPT	3	6.00	300	289	F5 1706-2185
CPT	4	9.00	300	290	F5 1706-2185
CPT	5	12.00	300	287	F5 1706-2185
CPT	6	15.00	299	290	F5 1706-2185
CPT	7	18.00	300	290	F5 1706-2185
CPT	8	21.00	300	288	F5 1706-2185
CPT	9	24.00	300	265	F5 1706-2185
CPT	10	27.00	300	290	F5 1706-2185
CPT	11	30.00	300	288	F5 1706-2185
CPT	12	33.00	300	294	F5 1706-2185
CPT	13	36.00	300	284	F5 1706-2185
CPT	14	39.00	300	288	F5 1706-2185
CPT	15	42.00	237	225	F5 1706-2185
CPT	16	44.50	49	40	F5 1706-2185
CPT	17	45.00	38	28	F5 1706-2185
CPT	18	46.00	149	141	F8 1721-1889
CPT	19	47.50	56	51	F8 1721-1889
CPT	20	48.50	150	144	F8 1721-1889. E.O.B. Final recovery depth 49.94 m bsf.

Borehole Summary: Total meters drilled: 48.5 [m] Total Number of samples: Total Sample Recovery: [cm]
Total Number of CPT: 20 Total CPT Recovery: 4638 [cm]

Remarks: Final depth is total meters drilled + last CPT = 49.94m

Client Representative:

Name: P. Watson / W. Zuijderduijn

Fugro Representative:

Name: Piotr Mrozowicz

FEBV/GEN/FOR/011 ISSUE GeODin01

GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: CPT_WFS4_18
Date: 6/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
CPT	1	0.00	186	182	F5 1706-2185
CPT	2	2.00	300	295	F5 1706-2185
CPT	3	5.00	300	283	F5 1706-2185
CPT	4	8.00	300	287	F5 1706-2185. E.O.B. Final recovery depth 10.87 m bsf.

Borehole Summary: Total meters drilled: 8.0 [m] Total Number of samples: Total Sample Recovery: [cm]
Total Number of CPT: 4 Total CPT Recovery: 1047 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last CPT recovery = 10.87 m.
Borehole terminated due to technical dificulties.

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: CPT_WFS4_18A
Date: 8/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
CPT	1	10.00	300	294	F5 1706-2185
CPT	2	13.00	88	77	F5 1706-2185
CPT	3	14.00	38	23	F5 1706-2185
CPT	4	14.50	150	141	F8 1709-0002
CPT	5	16.00	150	141	F8 1709-0002
CPT	6	17.50	95	84	F5 1706-2185
CPT	7	18.50	150	138	F8 1709-0002
CPT	8	20.00	150	141	F8 1709-0002
CPT	9	21.50	231	225	F5 1706-2185
CPT	10	24.50	30	13	F5 1706-2185
CPT	11	25.50	150	136	F8 1709-0002
CPT	12	27.00	62	46	F8 1709-0002
CPT	13	28.00	150	136	F8 1709-0002
CPT	14	29.50	76	64	F5 1706-2185
CPT	15	30.50	150	136	F8 1709-0002
CPT	16	32.00	150	139	F8 1709-0002
CPT	17	33.50	150	140	F8 1709-0002
CPT	18	35.00	300	290	F5 1706-2185
CPT	19	38.00	300	291	F5 1706-2185
CPT	20	41.00	300	289	F5 1706-2185
CPT	21	44.00	300	280	F5 1706-2185
W	1	45.00	98	85	2" thick wall with core catcher
CPT	22	47.00	300	287	F5 1706-2185
CPT	23	50.00	177	161	F5 1706-2185, E.O.B. Final recovery depth 51.61 m bsf.

Borehole Summary: Total meters drilled: 50.0 [m] Total Number of samples: 1 Total Sample Recovery: 85 [cm]
Total Number of CPT: 23 Total CPT Recovery: 3672 [cm] Total Number of SPT: Total SPT Recovery: [cm]
Total Number of In-situ Shear Vane Tests: Total Number of Pore Pressure Dissipation Tests :
Total Number of Seismic Velocity Tests:

Remarks: Final depth is meters drilled + last sample recovery = 51.61 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode.GLO

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: CPT_WFS4_21

Date: 8/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
SCPT	1	0.00	200	199	F5 1706-1831. E.O.B Final recovery depth 1.99 m bsf.

Borehole Summary:
Total Number of CPT:
Total meters drilled: 0.0 [m]
Total CPT Recovery: [cm]
Total Number of samples:
Total Number of SCPT: 1
Total Number of PPDT :
Total Sample Recovery: [cm]
Total SCPT Recovery: 199 [cm]

Remarks: Final depth is meters drilled + last CPT recovery = 1.99 m.
Borehole terminated due to technical difficulties.

Client Representative:

Name: P. Watson/W. Zuijderduijn

Fugro Representative:

Name: H. Roth

GeODin/Recovery List Downhole Mode SCPT.GLO FEBV/GEN/FOR/011 ISSUE GeODin01

RECOVERY LIST (DOWNHOLE MODE)

Project Title: BORSSELE WIND FARM ZONE, WFS IV - DUTCH SECTOR, NORTH SEA
Project No. N6083
Client: Rijksdienst voor Ondernemend Nederland
Location: CPT_WFS4_21A
Date: 8/10/15

Type	Number	Depth [m]	Penetration [cm]	Recovery [cm]	Remarks
SCPT	1	2.00	246	231	F5 1706-1831
SCPT	2	4.50	248	231	F5 1706-1831
SCPT	3	7.00	250	235	F5 1706-1831
SCPT	4	9.50	250	243	F5 1706-1831
SCPT	5	12.00	250	241	F5 1706-1831
SCPT	6	14.50	244	223	F5 1706-1831
SCPT	7	17.00	300	293	F5 1706-1831
SCPT	8	20.00	300	291	F5 1706-1831
CPT	9	23.00	300	294	F5 1706-2185
SCPT	10	26.00	300	296	F5 1706-1831
CPT	11	29.00	300	295	F5 1706-2185
SCPT	12	32.00	300	292	F5 1706-1831
CPT	13	35.00	183	172	F5 1706-2185
CPT	14	37.00	65	54	F5 1706-2185
CPT	15	38.00	43	32	F5 1706-2185
CPT	16	39.00	150	135	F8 1709-0002
CPT	17	40.50	150	142	F8 1709-0002
CPT	18	42.00	289	276	F5 1706-2185
CPT	19	45.00	29	14	F5 1706-2185
CPT	20	46.00	38	23	F8 1709-0002
CPT	21	47.00	30	20	F8 1709-0002
CPT	22	48.00	30	16	F8 1709-0002
CPT	23	49.00	29	15	F8 1709-0002
CPT	24	50.00	120	110	F8 1709-0002. E.O.B. Final recovery depth 51.10 m bsf.

Borehole Summary:
Total Number of CPT: 14
Total meters drilled: 50.0 [m]
Total CPT Recovery: 1598 [cm]
Total Number of samples:
Total Number of SCPT: 10
Total Number of PPDT :
Total Sample Recovery: [cm]
Total SCPT Recovery: 2576 [cm]

Remarks: Final depth is meters drilled + last CPT recovery = 51.10 m

Client Representative:
Name: P. Watson/W. Zuijderduijn

Fugro Representative:
Name: H. Roth

FEBV/GEN/FOR/011 ISSUE GeODin01
GeODin/Recovery List Downhole Mode SCPT.GLO

APPENDIX 4: CONE CALIBRATION CERTIFICATES

LIST OF PLATES IN APPENDIX 4: Plate

Cone Calibration Certificates 32 Plates

SYMBOLS, DEFINITIONS AND REFERENCES

Certificate Number
FCN15004585

Symbols and Definitions (general)

af	Cone net area ratio, defined as the factor between the applied pressure to the instrument and the indicated cone resistance.
af,x	Measured cone net area ratio at measurement x.
b	Repeatability error, defined as the maximum difference between the measurements of the instrument at the applied value.
bf	Friction sleeve net area ratio, defined as the factor between the applied pressure to the instrument and the indicated sleeve friction.
bf,x	The measured friction sleeve net area ratio at measurement x.
Noise RMS	Signal noise, defined as the quadratic mean when the sensor is not subjected to load.
q	Accuracy error, defined as the difference between the average indicated value by the instrument and the applied value.
Resolution	Smallest change in a quantity being measured that causes a perceptible change in the corresponding indication.
Tip-Sleeve Interaction	Effect of cone tip measurements on derived friction measurements, due to coupling of the cone tip and friction sleeve element. Expressed in terms of friction and as a percentage of the full scale output of the cone tip.
v	Reversibility error, defined as the difference between the average indicated value by the instrument at a certain applied value when it was increased and when it was decreased.

Symbols and Definitions (quantity specific: Q may be substituted for F or P, as appropriate)

Q0	Zero load offset, instrument output where the specified measured quantity value is zero.
Qa	Average indicated quantity value by the instrument.
Qa,x	Quantity value indicated by the instrument as measurement x.
Qc0	Zero load error, defined as the difference between the average indicated value by the instrument before and after the load cycle has been applied.
Qw	Applied reference quantity value.

Quantities

F	Force
P	Pressure

References

European Co-operation For Accreditation (2013), "Evaluation of the uncertainty of measurement in calibration", European Co-operation For Accreditation, 75 p. (Publication ; EA-4/02 M:2013)

ISO International Organization for Standardization (1999), "General requirements for the competence of testing and calibration laboratories", International Standard ISO 17025:2005

ISO International Organization for Standardization (2003), "Measurement management systems - requirements for measurement processes and measuring equipment", International Standard ISO 10012:2003

International Organization for Standardization (ISO) (2000), "Quality management systems - Requirements", International Standard ISO 9001

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CALIBRATION CERTIFICATE

Applicant	**Fugro Engineers B.V.**
	Prismastraat 4
	2631 RT, Nootdorp
	The Netherlands

Certificate Number
FCN15004585

Instrument	**Cone Penetrometer**
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-1269

Calibration method The instrument was calibrated according to Fugro procedures using a comparison technique against a reference standard.

Environmental Conditions

Temperature during calibration	20.5 ± 3 °C
Atmospheric pressure during calibration	1000 ± 100 mbar

Result The result is shown on the next page(s).

Uncertainty The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, which provides a confidence level of approximately 95%. The standard uncertainty has been determined in accordance with EA 4/02.

Traceability Fugro reference standards are periodically recertified and are traceable to the International System of Units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2008, ISO 10012:2003 and ISO/IEC 17025:2005.

Calibration date 11-Aug-2015

Calibrate before 11-Aug-2016

Calibrated Sensor	Manufacturer / Type	Calibrated Range	Maximum Rating	Procedure
Cone [Force]	Fugro Loadcell	0 to 50 kN	0 to 100 kN	FEBV.CAL.PRO.003
Cone+Fric. [Force]	Fugro Loadcell	0 to 50 kN	0 to 100 kN	FEBV.CAL.PRO.003
Pore 2 [Pressure]	Keller PA-8/100bar (8467.8)	0 to 10 MPa	0 to 15 MPa	FEBV.CAL.PRO.004

Member of the Fugro group of companies with offices throughout the world
FUGRO ENGINEERS B.V.
The Netherlands
VAT No: NL005621409B07
Trade Register No: 27114149

Nootdorp, 11-Aug-2015

This certificate is issued provided that Fugro assumes no liability.

Gerry Sinjorgo
Manager Transducer Workshop

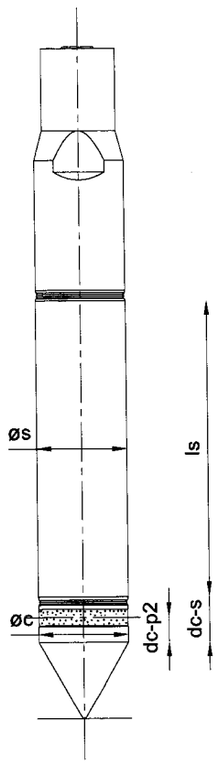
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Fugro Calibration Laboratory, P.O. Box 130, 2630 AC Nootdorp, The Netherlands, Phone +31-70-3111444, www.fugro.com

TYPICAL DIMENSIONS

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-1269

Certificate Number
FCN15004585



Typical Dimensions		
Ac	Cross-sectional projected area of the cone	0.001 m²
As	Surface area of the friction sleeve	0.015 m²
af	Cone net area ratio	0.75
scf	Friction sleeve net area ratio	0
øc	Diameter of the cylindrical part of the cone	35.8 mm
øs	Diameter of the friction sleeve	36.1 mm
ls	Length of the friction sleeve	132.7 mm
dc-s	Cone - friction sleeve distance	13.5 mm
dc-p2	Cone - pore 2 distance	5 mm

Diagram is not to scale

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PORE 2 CALIBRATION RESULT [PRESSURE]

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-1269
Electronics	3526
Node Type	7001
Hardware Version	3.00
Software Version	4.01

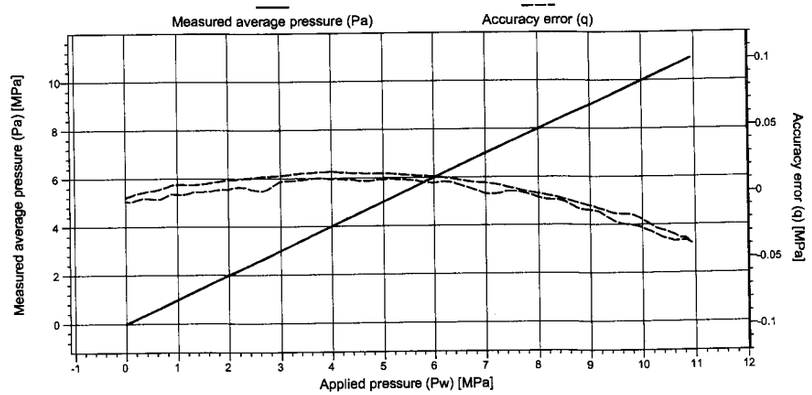
Sensor	
Channel	Pore 2 [Pressure]
Manufacturer / Type	Keller PA-8/100bar (8467.8)
Calibrated Range	0 to 10 MPa
Maximum Rating	0 to 15 MPa

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00143•Pw+0.0019 [MPa]

Calibration Details	
Calibration Date	11 Aug 2015 10:47:35
Procedure	FEBV.CAL.PRO.004
Software Version	1.16.0.15348

Certificate Number
FCN15004585

Characteristics	Unit	Value
Accuracy error (q)	[MPa]	0.021
Repeatability error (b)	[MPa]	0.010
Reversibility error (v)	[MPa]	0.007
Zero load error (Pc0)	[MPa]	0.003
Zero load offset (P0)	[MPa]	-0.005
Resolution	[MPa]	1.64E-06
Noise RMS	[MPa]	0.000



Applied pressure (Pw) [MPa]	Measured pressure 1 (Pa,1) [MPa]	Measured pressure 2 (Pa,2) [MPa]	Measured pressure 3 (Pa,3) [MPa]	Measured average pressure (Pa) [MPa]	Accuracy error (q) [MPa]	Repeatability error (b) [MPa]	Reversibility error (v) [MPa]
0.000	-0.002	-0.004	-0.002	-0.003	-0.003	0.002	
2.000	2.008	2.012	2.011	2.010	0.010	0.004	-0.007
4.000	4.014	4.019	4.016	4.016	0.016	0.005	-0.005
6.000	6.009	6.014	6.013	6.012	0.012	0.005	-0.005
8.000	7.996	8.001	7.999	7.999	-0.001	0.004	-0.003
10.000	9.974	9.984	9.977	9.979	-0.021	0.010	
8.000	7.995	7.998	7.994	7.996	-0.004	0.003	
6.000	6.012	6.005	6.006	6.007	0.007	0.007	
4.000	4.014	4.012	4.007	4.011	0.011	0.008	
2.000	2.006	1.998	2.007	2.003	0.003	0.008	
0.000	-0.006	-0.006	-0.005	-0.006	-0.006	0.001	

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CONE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-1269
Electronics	3526
Node Type	7001
Hardware Version	3.00
Software Version	4.01

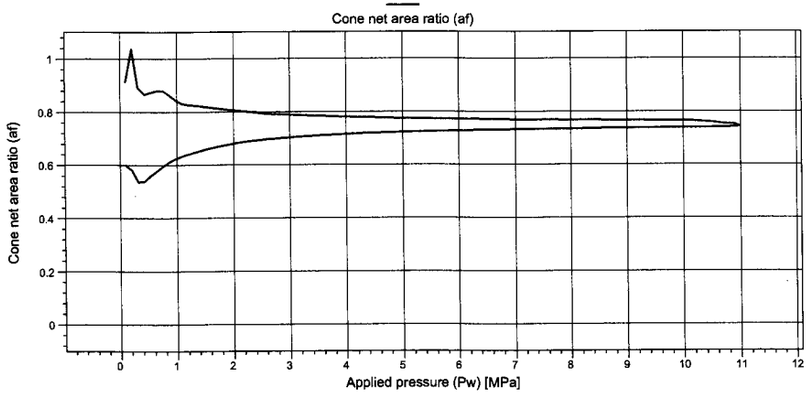
Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00143•Pw+0.0019 [MPa]

Calibration Details	
Calibration Date	11 Aug 2015 10:47:35
Procedure	FEBV.CAL.PRO.003
Software Version	1.16.0.15348

Certificate Number
FCN15004585

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.74

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
2.000	0.679	0.681	0.680	0.680
4.000	0.715	0.716	0.716	0.716
6.000	0.728	0.728	0.728	0.728
8.000	0.734	0.735	0.735	0.735
10.000	0.738	0.739	0.739	0.739
8.000	0.767	0.768	0.768	0.768
6.000	0.773	0.772	0.772	0.772
4.000	0.781	0.781	0.780	0.780
2.000	0.806	0.804	0.807	0.805

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CONE+FRIC. CALIBRATION RESULT [FORCE]

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-1269
Electronics	3526
Node Type	7001
Hardware Version	3.00
Software Version	4.01

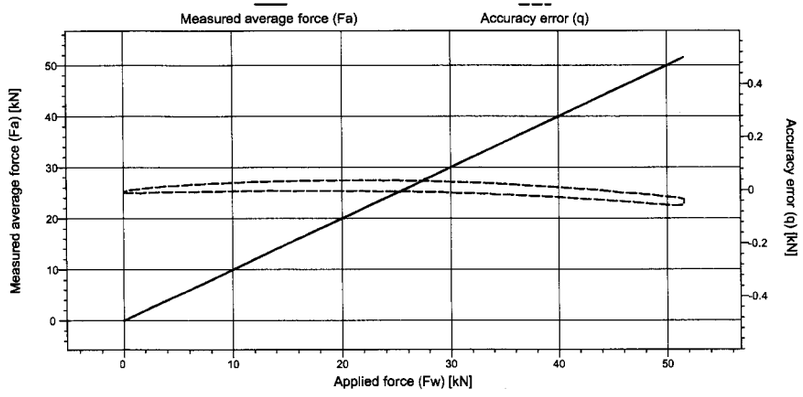
Sensor	
Channel	Cone+Fric. [Force]
Manufacturer / Type	Fugro Loadcell
Calibrated Range	0 to 50 kN
Maximum Rating	0 to 100 kN

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]

Calibration Details	
Calibration Date	11 Aug 2015 08:58:22
Procedure	FEBV.CAL.PRO.003
Software Version	1.16.0.15348

Certificate Number
FCN15004585

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.054
Repeatability error (b)	[kN]	0.016
Reversibility error (v)	[kN]	0.040
Zero load error (Fc0)	[kN]	0.001
Zero load offset (F0)	[kN]	-0.006
Resolution	[kN]	1.91E-05
Noise RMS	[kN]	0.001
Tip-Sleeve Interaction	[kPa]	1.6
Tip-Sleeve Interaction %	[%]	0.33



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.005	-0.006	-0.008	-0.006	-0.006	0.004	
10.000	10.002	10.000	9.995	9.999	-0.001	0.007	0.032
20.000	20.005	19.999	19.996	20.000	0.000	0.009	0.039
30.000	29.997	29.992	29.989	29.993	-0.007	0.008	0.040
40.000	39.980	39.975	39.972	39.975	-0.025	0.008	0.038
50.000	49.951	49.945	49.942	49.946	-0.054	0.010	
40.000	40.021	40.013	40.005	40.013	0.013	0.015	
30.000	30.041	30.031	30.028	30.033	0.033	0.013	
20.000	20.048	20.037	20.032	20.039	0.039	0.016	
10.000	10.035	10.030	10.027	10.031	0.031	0.008	
0.000	-0.002	-0.006	-0.006	-0.005	-0.005	0.004	

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FRICTION SLEEVE NET AREA RATIO RESULT

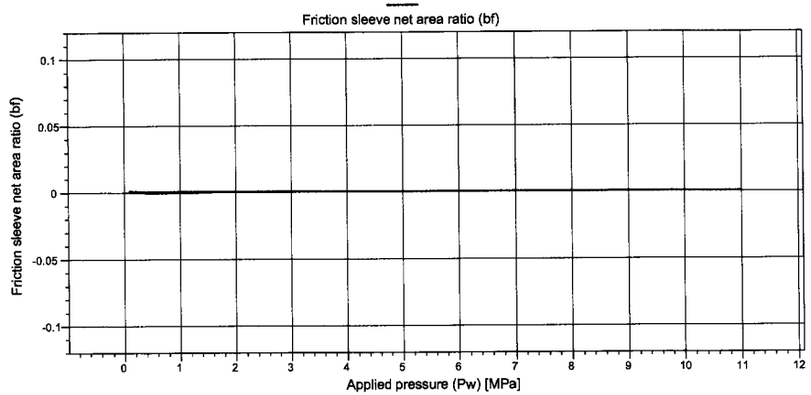
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-1269
Electronics	3526
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00143•Pw+0.0019 [MPa]
Calibration Details	
Calibration Date	11 Aug 2015 10:47:35
Procedure	FEBV.CAL.PRO.003
Software Version	1.16.0.15348

Certificate Number
FCN15004585

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	0.00038

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
2.000	0.000	0.000	0.000	0.000
4.000	0.000	0.000	0.000	0.000
6.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
10.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
6.000	0.000	0.000	0.000	0.000
4.000	0.000	0.000	0.000	0.000
2.000	0.001	0.001	0.001	0.001

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CONE CALIBRATION RESULT [FORCE]

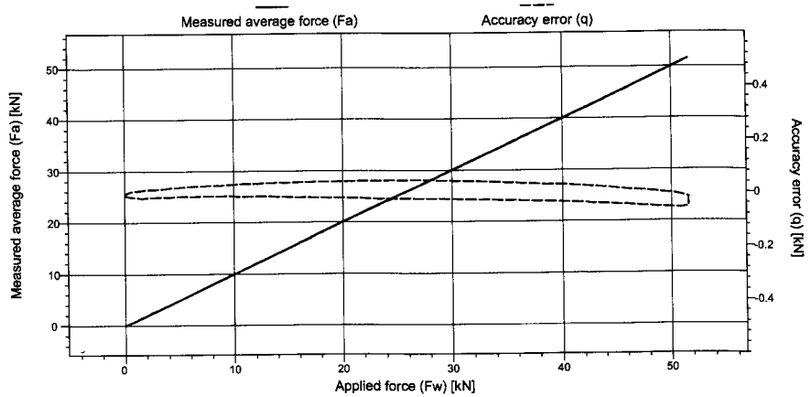
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-1269
Electronics	3526
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]
Calibration Details	
Calibration Date	11 Aug 2015 08:58:22
Procedure	FEBV.CAL.PRO.003
Software Version	1.16.0.15348

Sensor	
Channel	Cone [Force]
Manufacturer / Type	Fugro Loadcell
Calibrated Range	0 to 50 kN
Maximum Rating	0 to 100 kN

Certificate Number
FCN15004585

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.058
Repeatability error (b)	[kN]	0.008
Reversibility error (v)	[kN]	0.069
Zero load error (Fc0)	[kN]	0.006
Zero load offset (F0)	[kN]	-0.010
Resolution	[kN]	1.92E-05
Noise RMS	[kN]	0.001



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.008	-0.005	-0.005	-0.006	-0.006	0.003	
10.000	9.989	9.991	9.989	9.990	-0.010	0.002	0.044
20.000	19.985	19.982	19.982	19.983	-0.017	0.003	0.062
30.000	29.979	29.976	29.975	29.977	-0.023	0.005	0.069
40.000	39.966	39.964	39.963	39.965	-0.035	0.003	0.065
50.000	49.945	49.942	49.940	49.942	-0.058	0.005	
40.000	40.033	40.030	40.026	40.030	0.030	0.008	
30.000	30.050	30.043	30.043	30.045	0.045	0.007	
20.000	20.049	20.043	20.042	20.045	0.045	0.007	
10.000	10.036	10.034	10.032	10.034	0.034	0.005	
0.000	0.001	0.000	0.000	0.000	0.000	0.001	

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TECHNICAL SPECIFICATIONS
Fugro Engineers BV

CALIBRATION CERTIFICATE

Applicant	**FUGRO ENGINEERS B.V.**	Certificate nr.	FCN14002700
Manufacturer	Fugro Engineers B.V.	Identification	1706-2185
Instrument	**A Cone Penetrometer**		

Calibration method:
The device was calibrated according to Fugro Engineers procedures using a comparison technique against a Fugro reference standard. Fugro reference standards are periodically recertified and traceable to the National Standards and Technology (NIST) (RVA). It is derived from accepted values of natural physical constants according to the International System of units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2000 and ISO/IEC 17025:2005.

Cone and Friction Sleeve Calibration Reference

Equipment Serial Number	6034-0003
Equipment Manufacturer	ZWICK GMBH & CO
Equipment Calibration Valid till	22/09/2015
Equipment Certificate	14202947.1000.1EN/R1
Procedure used : in-house	FEBV.CAL.PRO.003

Cone and Friction Sleeve Sensor

Manufacturer	Fugro Engineers BV
Force Application Mode	Compression
Calibrated Range	0 – 50 kN
Max Load	0 – 100 kN

Pressure Calibration Reference

Equipment Serial Number	3257-0002
Equipment Manufacturer	KELLER MEETTECH
Equipment Calibration Valid till	13/11/2014
Equipment Certificate	FCLREF140027
Procedure used : in-house	FEBV.CAL.PRO.004

Pressure Sensor

Manufacturer	Keller
Pressure Application Mode	Compression and tension
Calibrated Range	Nominal Range
Nominal Range	0 –20.0 MPa

Inclinometer Calibration Reference

Equipment Serial Number	2109-0003
Equipment Manufacturer	FEBV
Equipment Calibration Valid till	14/05/2015
Procedure used : in-house	FEBV.CAL.PRO.005

Inclinometer

Manufacturer	FEBV	ADXL
Calibrated Range	0° – 15°	-10° - 10°
Max Output	0° – 30°	-15° - 15°

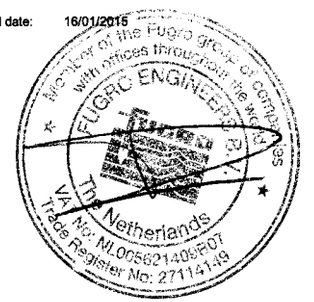
Environmental Conditions

Temperature during calibration	21 ± 3 °C
Pressure during calibration	1000 ± 100 mbar

Remarks.
The values given in this calibration certificate only relate to the submitted device, and to the values measured at the time of the test. Any uncertainty defined here does not include allowances for environmental changes, variation and shock during transportation, or the capability of other laboratories to repeat the measurement.

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Calibration technician	Tempelaar, Rolf	Approved by :	Sinjorgo, Gerry
Calibration date:	15/01/2015	Approval date:	16/01/2015
Calibrate before:	15/01/2016		



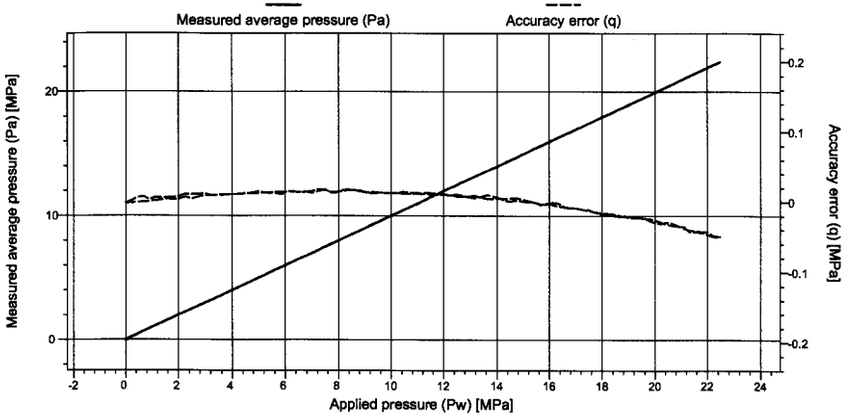
PORE 2 CALIBRATION RESULT [PRESSURE]

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M6-V1
Serial Number	1706-2185
Electronics	2837
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.001787 [MPa]
Calibration Details	
Calibration Date	15 jan 2015 14:15:03
Procedure	FEBV.CAL.PRO.004
Software Version	1.12.0.13400

Certificate Number FCN14002700

Characteristics	Unit	Value
Accuracy error (q)	[MPa]	0.030
Repeatability error (b)	[MPa]	0.006
Reversibility error (v)	[MPa]	0.001
Zero load error (Pc0)	[MPa]	-0.001
Zero load offset (P0)	[MPa]	-0.002
Resolution	[MPa]	6.78E-06
Noise RMS	[MPa]	0.000



Applied pressure (Pw) [MPa]	Measured pressure 1 (Pa,1) [MPa]	Measured pressure 2 (Pa,2) [MPa]	Measured pressure 3 (Pa,3) [MPa]	Measured average pressure (Pa) [MPa]	Accuracy error (q) [MPa]	Repeatability error (b) [MPa]	Reversibility error (v) [MPa]
0.000	-0.002	-0.002	-0.002	-0.002	-0.002	0.000	0.001
4.000	4.011	4.012	4.010	4.011	0.011	0.002	0.000
8.000	8.016	8.014	8.014	8.015	0.015	0.002	0.001
12.000	12.013	12.010	12.009	12.011	0.011	0.004	0.001
16.000	15.999	15.995	15.996	15.997	-0.003	0.004	0.001
20.000	19.969	19.971	19.970	19.970	-0.030	0.002	
16.000	15.995	15.998	15.999	15.997	-0.003	0.004	
12.000	12.006	12.012	12.012	12.010	0.010	0.006	
8.000	8.014	8.015	8.012	8.014	0.014	0.003	
4.000	4.010	4.009	4.013	4.011	0.011	0.003	
0.000	-0.002	-0.002	-0.002	-0.002	-0.002	0.000	

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CONE NET AREA RATIO RESULT

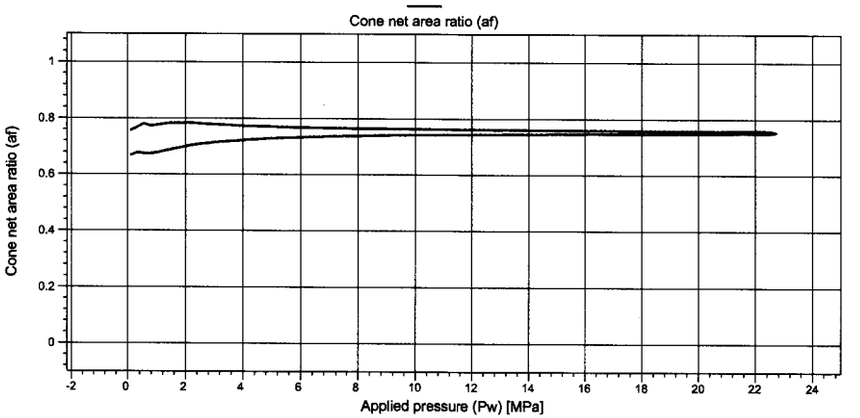
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M6-V1
Serial Number	1706-2185
Electronics	2837
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.001787 [MPa]
Calibration Details	
Calibration Date	15 jan 2015 14:15:03
Procedure	FEBV.CAL.PRO.003
Software Version	1.12.0.13400

Certificate Number FCN14002700

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.75

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
4.000	0.724	0.724	0.724	0.724
8.000	0.741	0.740	0.740	0.740
12.000	0.746	0.746	0.746	0.746
16.000	0.749	0.749	0.749	0.749
20.000	0.751	0.750	0.750	0.750
16.000	0.762	0.762	0.762	0.762
12.000	0.763	0.764	0.764	0.764
8.000	0.766	0.767	0.767	0.767
4.000	0.775	0.775	0.776	0.775

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CONE+FRIC. CALIBRATION RESULT [FORCE]

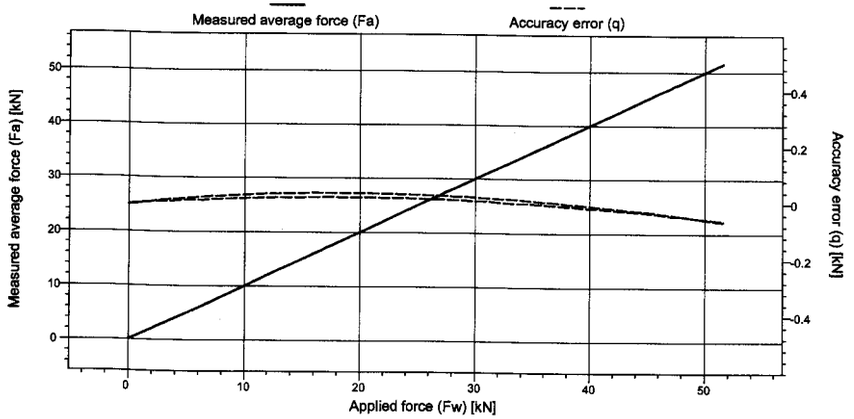
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M6-V1
Serial Number	1706-2185
Electronics	2837
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]

Calibration Details	
Calibration Date	22 dec 2014 12:22:59
Procedure	FEBV.CAL.PRO.003
Software Version	1.12.0.13400

Certificate Number
FCN14002700

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.052
Repeatability error (b)	[kN]	0.009
Reversibility error (v)	[kN]	0.015
Zero load error (Fc0)	[kN]	0.011
Zero load offset (F0)	[kN]	-0.003
Resolution	[kN]	1.91E-05
Noise RMS	[kN]	0.001
Tip-Sleeve Interaction	[kPa]	1.2
Tip-Sleeve Interaction %	[%]	0.24



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.010	-0.008	-0.007	-0.008	-0.008	0.003	0.001
10.000	10.016	10.016	10.015	10.016	0.016	0.001	0.012
20.000	20.022	20.019	20.019	20.020	0.020	0.003	0.015
30.000	30.013	30.007	30.009	30.010	0.010	0.006	0.013
40.000	39.991	39.983	39.986	39.987	-0.013	0.008	0.007
50.000	49.953	49.945	49.946	49.948	-0.052	0.008	
40.000	40.000	39.991	39.991	39.994	-0.006	0.009	
30.000	30.026	30.018	30.024	30.023	0.023	0.008	
20.000	20.040	20.033	20.033	20.035	0.035	0.007	
10.000	10.028	10.025	10.028	10.027	0.027	0.003	
0.000	-0.008	-0.008	-0.010	-0.009	-0.009	0.002	

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FRICTION SLEEVE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M6-V1
Serial Number	1706-2185
Electronics	2837
Node Type	7001
Hardware Version	3.00
Software Version	4.01

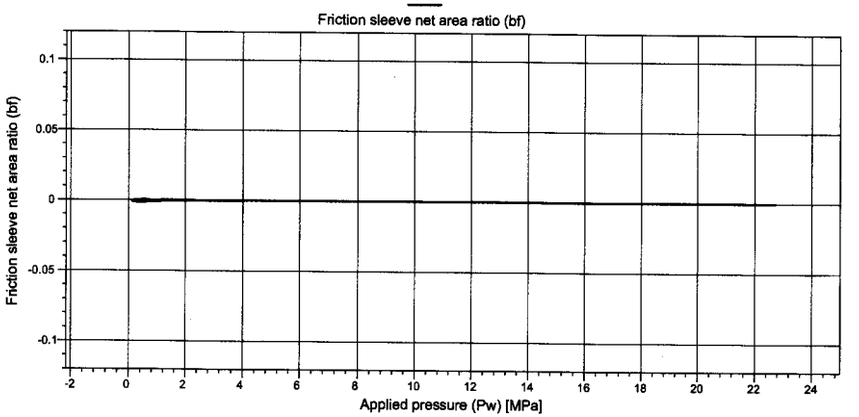
Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.001787 [MPa]

Calibration Details	
Calibration Date	15 jan 2015 14:15:03
Procedure	FEBV.CAL.PRO.003
Software Version	1.12.0.13400

Certificate Number
FCN14002700

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	-0.00001

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
4.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
12.000	0.000	0.000	0.000	0.000
16.000	0.000	0.000	0.000	0.000
20.000	0.000	0.000	0.000	0.000
16.000	0.000	0.000	0.000	0.000
12.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
4.000	0.000	0.000	0.000	0.000

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CONE CALIBRATION RESULT [FORCE]

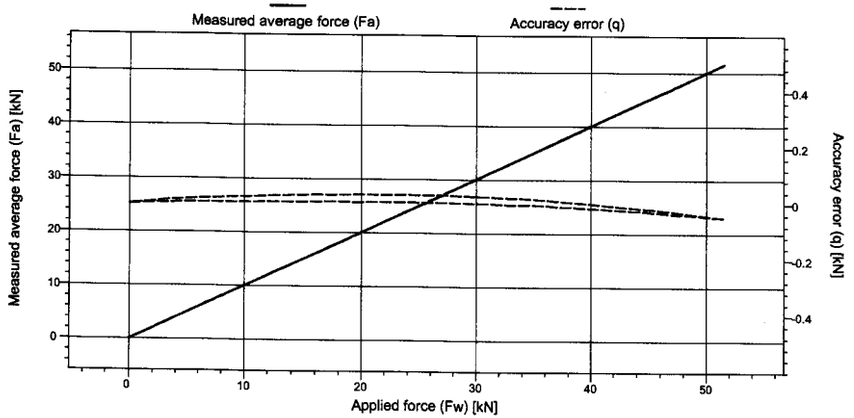
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M6-V1
Serial Number	1706-2185
Electronics	2837
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]

Calibration Details	
Calibration Date	22 dec 2014 12:22:59
Procedure	FEBV.CAL.PRO.003
Software Version	1.12.0.13400

Certificate Number
FCN14002700

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.043
Repeatability error (b)	[kN]	0.005
Reversibility error (v)	[kN]	0.027
Zero load error (Fc0)	[kN]	0.012
Zero load offset (F0)	[kN]	-0.001
Resolution	[kN]	1.91E-05
Noise RMS	[kN]	0.001



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.006	-0.005	-0.005	-0.005	-0.005	0.001	0.001
10.000	10.004	10.003	10.004	10.004	0.004	0.001	0.019
20.000	20.004	20.005	20.004	20.004	0.004	0.002	0.027
30.000	30.002	30.001	30.004	30.002	0.002	0.003	0.025
40.000	39.986	39.985	39.988	39.987	-0.013	0.003	0.015
50.000	49.957	49.957	49.957	49.957	-0.043	0.001	
40.000	40.003	40.001	40.001	40.002	0.002	0.002	
30.000	30.026	30.025	30.029	30.027	0.027	0.005	
20.000	20.033	20.030	20.031	20.031	0.031	0.003	
10.000	10.023	10.021	10.024	10.022	0.022	0.003	
0.000	-0.004	-0.004	-0.006	-0.005	-0.005	0.002	

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TECHNICAL SPECIFICATIONS
Fugro Engineers BV

CALIBRATION CERTIFICATE

Applicant	**FUGRO ENGINEERS B.V. (NOOTDORP)**	Certificate nr.	FCN15004177
Manufacturer	Fugro Engineers B.V.	Identification	1706-2196
Instrument	**A Cone Penetrometer**		

Calibration method:
The device was calibrated according to Fugro Engineers procedures using a comparison technique against a Fugro reference standard. Fugro reference standards are periodically recertified and traceable to the National Standards and Technology (NIST) (RVA). It is derived from accepted values of natural physical constants according to the International System of units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2000 and ISO/IEC 17025:2005.

Cone and Friction Sleeve Calibration Reference

Equipment Serial Number	6034-0003
Equipment Manufacturer	ZWICK GMBH & CO
Equipment Calibration Valid till	22/09/2015
Equipment Certificate	14202947.1000.1EN/R1
Procedure used : in-house	FEBV.CAL.PRO.003

Cone and Friction Sleeve Sensor

Manufacturer	Fugro Engineers BV
Force Application Mode	Compression
Calibrated Range	0 – 50 kN
Max Load	0 – 100 kN

Pressure Calibration Reference

Equipment Serial Number	3257-0002
Equipment Manufacturer	KELLER MEETTECH
Equipment Calibration Valid till	28/09/2015
Equipment Certificate	FCNREF150116
Procedure used : in-house	FEBV.CAL.PRO.004

Pressure Sensor

Manufacturer	Keller
Pressure Application Mode	Compression and tension
Calibrated Range	Nominal Range
Nominal Range	0 –10.0 MPa

Inclinometer Calibration Reference

Equipment Serial Number	2109-0006
Equipment Manufacturer	FEBV
Equipment Calibration Valid till	22/07/2016
Procedure used : in-house	FEBV.CAL.PRO.005

Inclinometer

Manufacturer	FEBV	ADXL
Calibrated Range	0° – 15°	-10° - 10°
Max Output	0° – 30°	-15° - 15°

Environmental Conditions

Temperature during calibration	21 ± 3 °C
Pressure during calibration	1000 ± 100 mbar

Remarks.
The values given in this calibration certificate only relate to the submitted device, and to the values measured at the time of the test. Any uncertainty defined here does not include allowances for environmental changes, variation and shock during transportation, or the capability of other laboratories to repeat the measurement.

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Calibration technician	Tempelaar, Rolf	Approved by :	Sinjorgo, Gerry
Calibration date:	16/06/2015	Approval date:	16/06/2015
Calibrate before:	16/06/2016		



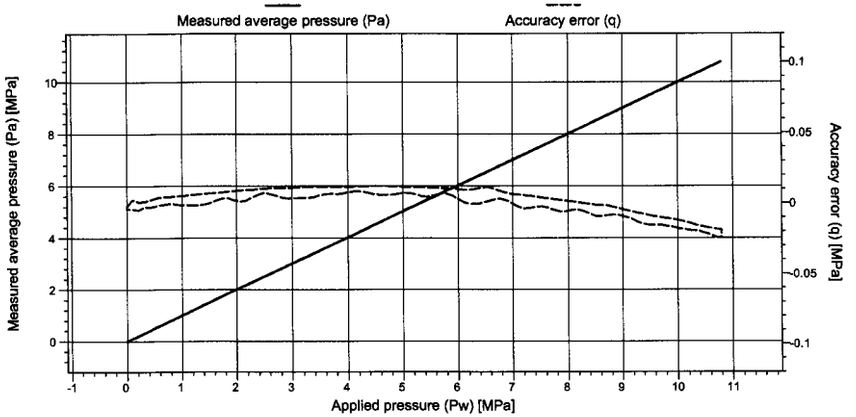
PORE 2 CALIBRATION RESULT [PRESSURE]

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-2196
Electronics	2833
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00143•Pw+0.0019 [MPa]
Calibration Details	
Calibration Date	16 Jun 2015 09:04:02
Procedure	FEBV.CAL.PRO.004
Software Version	1.15.0.14651

Certificate Number
FCN15004177

Characteristics	Unit	Value
Accuracy error (q)	[MPa]	0.012
Repeatability error (b)	[MPa]	0.007
Reversibility error (v)	[MPa]	0.007
Zero load error (Pc0)	[MPa]	-0.004
Zero load offset (P0)	[MPa]	-0.004
Resolution	[MPa]	2.21E-06
Noise RMS	[MPa]	0.000



Applied pressure (Pw) [MPa]	Measured pressure 1 (Pa,1) [MPa]	Measured pressure 2 (Pa,2) [MPa]	Measured pressure 3 (Pa,3) [MPa]	Measured average pressure (Pa) [MPa]	Accuracy error (q) [MPa]	Repeatability error (b) [MPa]	Reversibility error (v) [MPa]
0.000	-0.002	-0.004	-0.003	-0.003	-0.003	0.001	0.001
2.000	2.009	2.008	2.008	2.008	0.008	0.002	0.007
4.000	4.012	4.011	4.011	4.011	0.011	0.002	0.004
6.000	6.011	6.010	6.008	6.010	0.010	0.003	0.007
8.000	8.002	8.001	8.000	8.001	0.001	0.003	0.007
10.000	9.990	9.987	9.986	9.988	-0.012	0.004	
8.000	7.996	7.995	7.991	7.994	-0.006	0.005	
6.000	6.005	5.999	6.003	6.003	0.003	0.006	
4.000	4.004	4.009	4.009	4.007	0.007	0.005	
2.000	2.004	1.997	2.002	2.001	0.001	0.007	
0.000	-0.004	-0.004	-0.005	-0.004	-0.004	0.000	

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CONE NET AREA RATIO RESULT

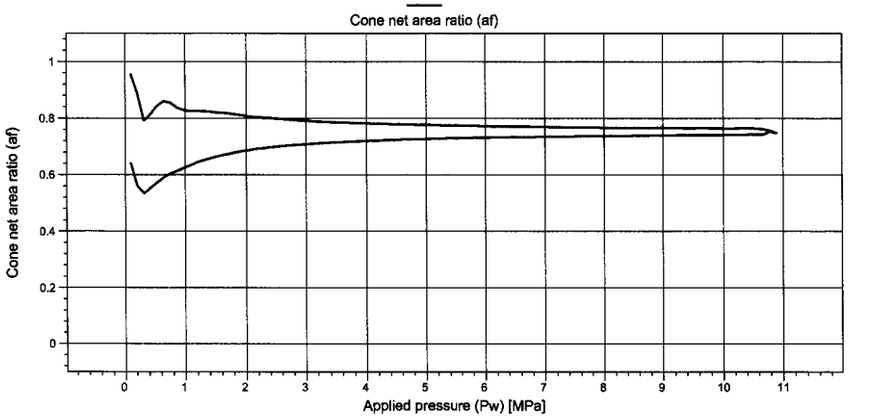
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-2196
Electronics	2833
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00143•Pw+0.0019 [MPa]
Calibration Details	
Calibration Date	16 Jun 2015 09:04:02
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15004177

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.75

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
2.000	0.686	0.686	0.686	0.686
4.000	0.720	0.720	0.720	0.720
6.000	0.732	0.732	0.732	0.732
8.000	0.738	0.738	0.738	0.738
10.000	0.742	0.742	0.742	0.742
8.000	0.768	0.768	0.768	0.768
6.000	0.773	0.773	0.773	0.773
4.000	0.782	0.783	0.783	0.783
2.000	0.808	0.807	0.809	0.808

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CONE+FRIC. CALIBRATION RESULT [FORCE]

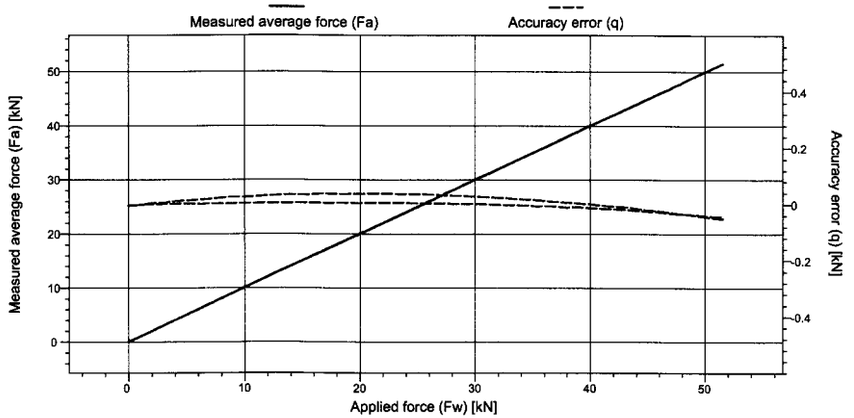
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-2196
Electronics	2833
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]

Calibration Details	
Calibration Date	16 Jun 2015 08:01:35
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15004177

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.041
Repeatability error (b)	[kN]	0.007
Reversibility error (v)	[kN]	0.034
Zero load error (Fc0)	[kN]	0.007
Zero load offset (F0)	[kN]	-0.008
Resolution	[kN]	1.89E-05
Noise RMS	[kN]	0.001
Tip-Sleeve Interaction	[kPa]	0.6
Tip-Sleeve Interaction %	[%]	0.13



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.009	-0.003	-0.004	-0.005	-0.005	0.006	0.001
10.000	10.002	10.003	10.004	10.003	0.003	0.002	0.023
20.000	20.003	20.005	20.003	20.004	0.004	0.002	0.034
30.000	30.000	30.003	30.002	30.002	0.002	0.003	0.026
40.000	39.986	39.987	39.988	39.987	-0.013	0.002	0.013
50.000	49.959	49.960	49.959	49.959	-0.041	0.001	
40.000	40.002	39.999	40.000	40.000	0.000	0.003	
30.000	30.031	30.024	30.029	30.028	0.028	0.007	
20.000	20.038	20.036	20.038	20.037	0.037	0.003	
10.000	10.026	10.025	10.026	10.026	0.026	0.001	
0.000	-0.004	-0.004	-0.004	-0.004	-0.004	0.001	

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FRICTION SLEEVE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-2196
Electronics	2833
Node Type	7001
Hardware Version	3.00
Software Version	4.01

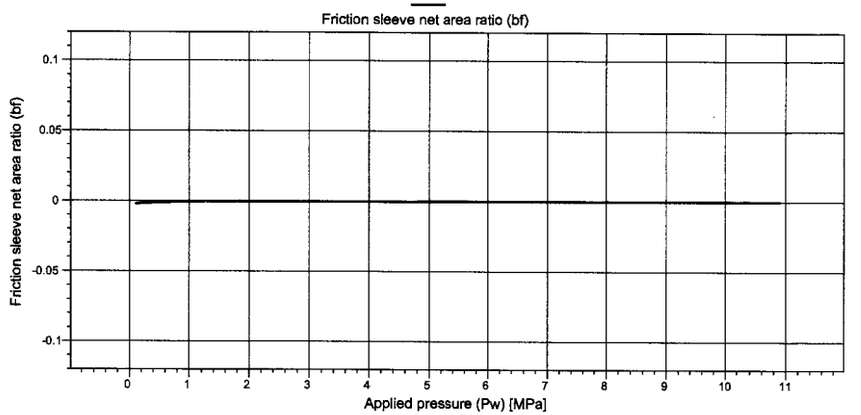
Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00143•Pw+0.0019 [MPa]

Calibration Details	
Calibration Date	16 Jun 2015 09:04:02
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15004177

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	-0.00001

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
2.000	0.000	0.000	0.000	0.000
4.000	0.000	0.000	0.000	0.000
6.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
10.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
6.000	0.000	0.000	0.000	0.000
4.000	0.000	0.000	0.000	0.000
2.000	0.000	-0.001	0.000	0.000

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CONE CALIBRATION RESULT [FORCE]

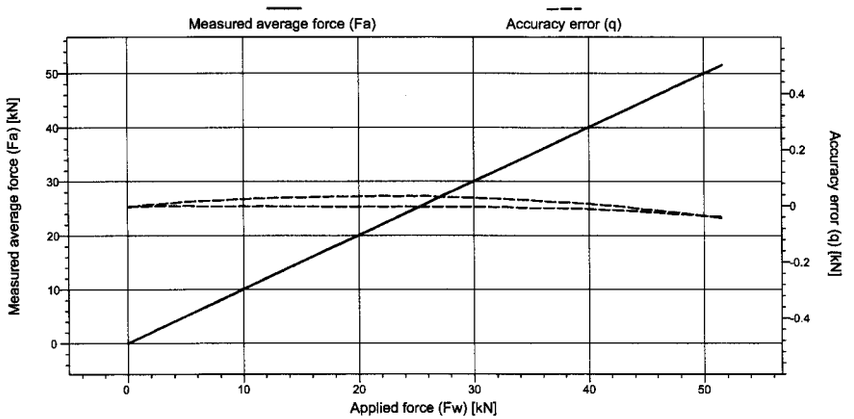
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10-P1E1M1-V1
Serial Number	1706-2196
Electronics	2833
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]

Calibration Details	
Calibration Date	16 Jun 2015 08:01:35
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15004177

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.036
Repeatability error (b)	[kN]	0.007
Reversibility error (v)	[kN]	0.038
Zero load error (Fc0)	[kN]	0.005
Zero load offset (F0)	[kN]	-0.006
Resolution	[kN]	1.89E-05
Noise RMS	[kN]	0.001



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.009	-0.003	-0.003	-0.005	-0.005	0.006	0.002
10.000	9.997	9.999	9.999	9.998	-0.002	0.003	0.025
20.000	19.994	19.997	19.996	19.998	-0.004	0.003	0.038
30.000	29.994	29.998	29.997	29.996	-0.004	0.004	0.032
40.000	39.989	39.987	39.988	39.988	-0.012	0.002	0.019
50.000	49.964	49.965	49.963	49.964	-0.036	0.002	
40.000	40.008	40.005	40.006	40.006	0.006	0.003	
30.000	30.032	30.025	30.029	30.029	0.029	0.007	
20.000	20.034	20.032	20.035	20.034	0.034	0.002	
10.000	10.023	10.023	10.023	10.023	0.023	0.000	
0.000	-0.003	-0.003	-0.003	-0.003	-0.003	0.000	

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CALIBRATION CERTIFICATE

Applicant	**Fugro Engineers B.V.** Prismastraat 4 2631 RT, Nootdorp The Netherlands	**Certificate Number** **FCN15004690**
Instrument	**Cone Penetrometer**	Page 1 of 7
Manufacturer	Fugro	
Type	CP5-CF80-P1E1M2-V1	
Serial Number	1709-0002	

Calibration method The instrument was calibrated according to Fugro procedures using a comparison technique against a reference standard.

Environmental Conditions

Temperature during calibration	20.5 ± 3 °C
Atmospheric pressure during calibration	1000 ± 100 mbar

Result The result is shown on the next page(s).

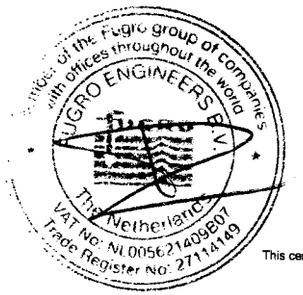
Uncertainty The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, which provides a confidence level of approximately 95%. The standard uncertainty has been determined in accordance with EA-4/02.

Traceability Fugro reference standards are periodically recertified and are traceable to the International System of Units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2008, ISO 10012:2003 and ISO/IEC 17025:2005.

Calibration period 28-Aug-2015 through 31-Aug-2015

Calibrate before 28-Aug-2016

Calibrated Sensor	Manufacturer / Type	Calibrated Range	Maximum Rating	Procedure
Cone [Force]	Fugro Loadcell	0 to 80 kN	0 to 80 kN	FEBV.CAL.PRO.003
Cone+Fric. [Force]	Fugro Loadcell	0 to 80 kN	0 to 80 kN	FEBV.CAL.PRO.003



Nootdorp, 31-Aug-2015

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Gerry Sinjorgo
Manager Transducer Workshop

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FRICTION SLEEVE NET AREA RATIO RESULT

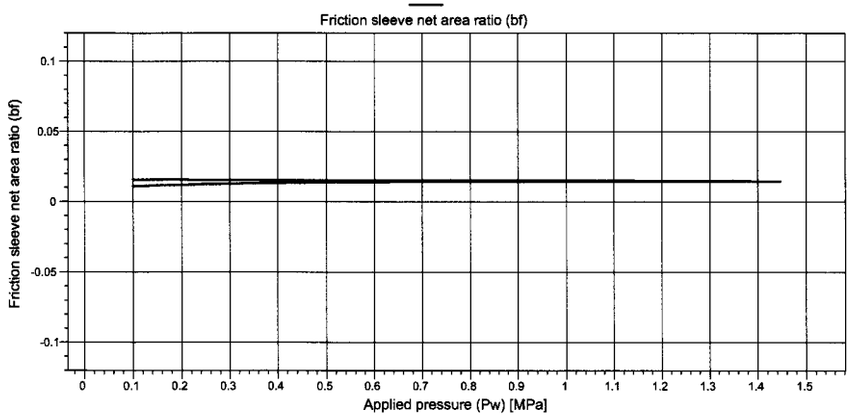
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1709-0002
Electronics	5289
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Keller PA-33X
Serial Number	3257-0004
Uncertainty	0.0013•Pw+0.0016 [MPa]
Calibration Details	
Calibration Date	28 Aug 2015 15:55:42
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Certificate Number
FCN15004690

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	0.01442

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
0.240	0.015	0.015	0.016	0.015
0.480	0.015	0.015	0.015	0.015
0.720	0.015	0.015	0.015	0.015
0.960	0.015	0.015	0.015	0.015
1.200	0.015	0.015	0.015	0.015
0.960	0.014	0.014	0.014	0.014
0.720	0.014	0.014	0.014	0.014
0.480	0.013	0.014	0.014	0.014
0.240	0.012	0.012	0.013	0.012

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CONE CALIBRATION RESULT [FORCE]

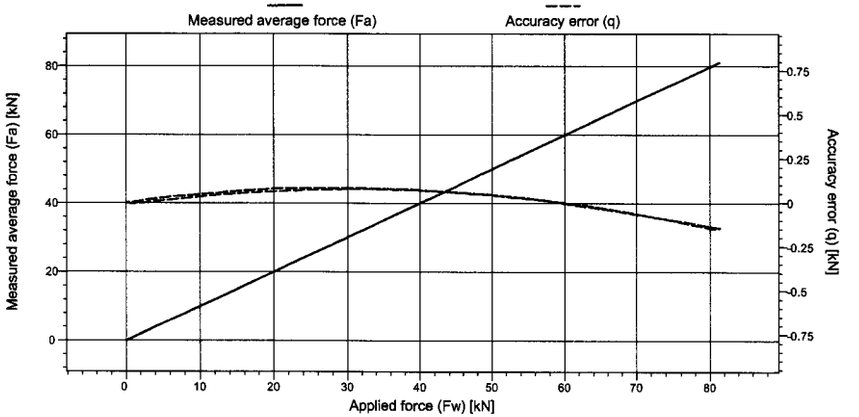
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1709-0002
Electronics	5289
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0002
Uncertainty	0.00270•Fw+0.00689 [kN]
Calibration Details	
Calibration Date	28 Aug 2015 15:46:25
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Certificate Number
FCN15004690

Sensor	
Channel	Cone [Force]
Manufacturer / Type	Fugro Loadcell
Calibrated Range	0 to 80 kN
Maximum Rating	0 to 80 kN

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.144
Repeatability error (b)	[kN]	0.004
Reversibility error (v)	[kN]	0.013
Zero load error (Fc0)	[kN]	0.002
Zero load offset (F0)	[kN]	-0.018
Resolution	[kN]	4.87E-05
Noise RMS	[kN]	0.001



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.002	0.000	0.002	0.000	0.000	0.003	
16.000	16.053	16.053	16.054	16.053	0.053	0.001	0.013
32.000	32.076	32.076	32.078	32.077	0.077	0.002	0.006
48.000	48.049	48.052	48.052	48.051	0.051	0.003	-0.003
64.000	63.976	63.980	63.978	63.978	-0.022	0.004	-0.007
80.000	79.854	79.856	79.858	79.856	-0.144	0.004	
64.000	63.969	63.972	63.971	63.971	-0.029	0.003	
48.000	48.048	48.048	48.049	48.048	0.048	0.001	
32.000	32.081	32.083	32.085	32.083	0.083	0.004	
16.000	16.065	16.066	16.068	16.066	0.066	0.003	
0.000	-0.002	-0.002	-0.002	-0.002	-0.002	0.000	

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CONE NET AREA RATIO RESULT

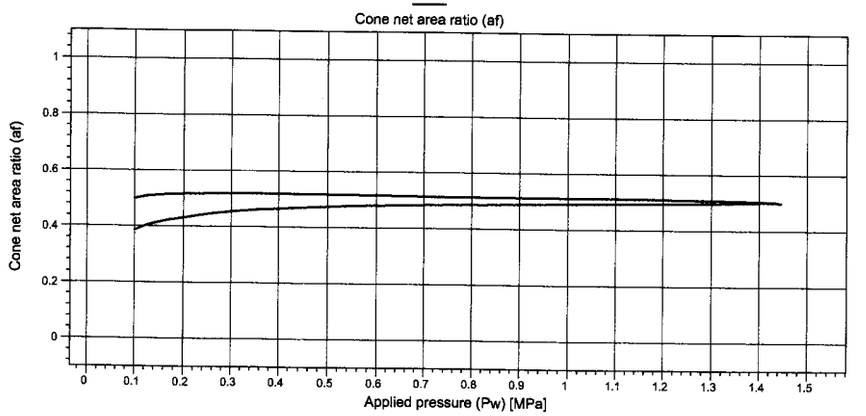
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1709-0002
Electronics	5289
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Keller PA-33X
Serial Number	3257-0004
Uncertainty	0.0013•Pw+0.0016 [MPa]
Calibration Details	
Calibration Date	28 Aug 2015 15:55:42
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Certificate Number
FCN15004690

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.50

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
0.240	0.496	0.520	0.535	0.517
0.480	0.506	0.523	0.526	0.518
0.720	0.505	0.520	0.516	0.514
0.960	0.507	0.519	0.513	0.513
1.200	0.507	0.515	0.509	0.510
0.960	0.486	0.490	0.495	0.490
0.720	0.476	0.485	0.493	0.484
0.480	0.457	0.473	0.487	0.472
0.240	0.415	0.447	0.464	0.442

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CONE+FRIC. CALIBRATION RESULT [FORCE]

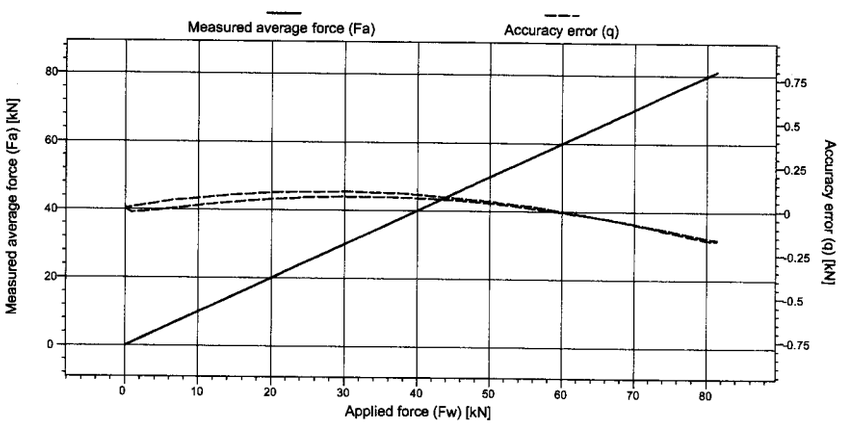
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1709-0002
Electronics	5289
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Sensor	
Channel	Cone+Fric. [Force]
Manufacturer / Type	Fugro Loadcell
Calibrated Range	0 to 80 kN
Maximum Rating	0 to 80 kN

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0002
Uncertainty	0.00270•Fw+0.00689 [kN]
Calibration Details	
Calibration Date	28 Aug 2015 15:46:25
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Certificate Number
FCN15004690

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.166
Repeatability error (b)	[kN]	0.012
Reversibility error (v)	[kN]	0.039
Zero load error (Fc0)	[kN]	0.003
Zero load offset (F0)	[kN]	-0.021
Resolution	[kN]	5.01E-05
Noise RMS	[kN]	0.000
Tip-Sleeve Interaction	[kPa]	3.3
Tip-Sleeve Interaction %	[%]	0.66



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.007	0.002	0.005	0.000	0.000	0.012	
16.000	16.046	16.043	16.043	16.044	0.044	0.003	0.039
32.000	32.073	32.073	32.073	32.073	0.073	0.000	0.026
48.000	48.046	48.048	48.049	48.048	0.048	0.003	0.011
64.000	63.966	63.969	63.967	63.967	-0.033	0.003	0.002
80.000	79.831	79.835	79.837	79.834	-0.166	0.006	
64.000	63.965	63.971	63.971	63.969	-0.031	0.006	
48.000	48.057	48.059	48.061	48.059	0.059	0.004	
32.000	32.097	32.100	32.101	32.099	0.099	0.004	
16.000	16.081	16.083	16.086	16.083	0.083	0.006	
0.000	0.001	0.003	0.003	0.003	0.003	0.002	

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TYPICAL DIMENSIONS

Instrument

Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1709-0002

Certificate Number
FCN15004690

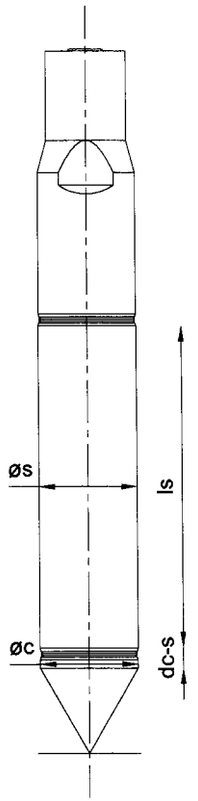


Diagram is not to scale

Typical Dimensions

Ac	Cross-sectional projected area of the cone	0.0005 m²
As	Surface area of the friction sleeve	0.0075 m²
af	Cone net area ratio	0.5
scf	Friction sleeve net area ratio	0.01669
øc	Diameter of the cylindrical part of the cone	25.3 mm
øs	Diameter of the friction sleeve	25.6 mm
ls	Length of the friction sleeve	93.6 mm
dc-s	Cone - friction sleeve distance	9 mm

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SYMBOLS, DEFINITIONS AND REFERENCES

Certificate Number
FCN15004690

Symbols and Definitions (general)

af	Cone net area ratio, defined as the factor between the applied pressure to the instrument and the indicated cone resistance.
af,x	Measured cone net area ratio at measurement x.
b	Repeatability error, defined as the maximum difference between the measurements of the instrument at the applied value.
bf	Friction sleeve net area ratio, defined as the factor between the applied pressure to the instrument and the indicated sleeve friction.
bf,x	The measured friction sleeve net area ratio at measurement x.
Noise RMS	Signal noise, defined as the quadratic mean when the sensor is not subjected to load.
q	Accuracy error, defined as the difference between the average indicated value by the instrument and the applied value.
Resolution	Smallest change in a quantity being measured that causes a perceptible change in the corresponding indication.
Tip-Sleeve Interaction	Effect of cone tip measurements on derived friction measurements, due to coupling of the cone tip and friction sleeve element. Expressed in terms of friction and as a percentage of the full scale output of the cone tip.
v	Reversibility error, defined as the difference between the average indicated value by the instrument at a certain applied value when it was increased and when it was decreased.

Symbols and Definitions (quantity specific: Q may be substituted for F or P, as appropriate)

Q0	Zero load offset, instrument output where the specified measured quantity value is zero.
Qa	Average indicated quantity value by the instrument.
Qa,x	Quantity value indicated by the instrument at measurement x.
Qc0	Zero load error, defined as the difference between the average indicated value by the instrument before and after the load cycle has been applied.
Qw	Applied reference quantity value.

Quantities

F	Force
P	Pressure

References

European Co-operation For Accreditation (2013), "Evaluation of the uncertainty of measurement in calibration", European Co-operation For Accreditation, 75 p. (Publication ; EA-4/02 M:2013)

ISO International Organization for Standardization (1999), "General requirements for the competence of testing and calibration laboratories", International Standard ISO 17025:2005

ISO International Organization for Standardization (2003), "Measurement management systems - requirements for measurement processes and measuring equipment", International Standard ISO 10012:2003

International Organization for Standardization (ISO) (2000), "Quality management systems - Requirements", International Standard ISO 9001

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Fugro Calibration Laboratory, P.O. Box 130, 2630 AC Nootdorp, The Netherlands, Phone +31-70-3111444, www.fugro.com

CALIBRATION CERTIFICATE

Applicant	Fugro Engineers B.V.
	Prismastraat 4
	2631 RT, Nootdorp
	The Netherlands

Certificate Number
FCN15004670

Instrument	Cone Penetrometer
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1713

Calibration method The instrument was calibrated according to Fugro procedures using a comparison technique against a reference standard.

Environmental Conditions	
Temperature during calibration	20.5 ± 3 °C
Atmospheric pressure during calibration	1000 ± 100 mbar

Result The result is shown on the next page(s).

Uncertainty The reported uncertainty is based on a standard uncertainty multiplied by a coverage factor k = 2, which provides a confidence level of approximately 95%. The standard uncertainty has been determined in accordance with EA-4/02.

Traceability Fugro reference standards are periodically recertified and are traceable to the International System of Units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2008, ISO 10012:2003 and ISO/IEC 17025:2005.

Calibration date 26-Aug-2015

Calibrate before 26-Aug-2016

Calibrated Sensor	Manufacturer / Type	Calibrated Range	Maximum Rating	Procedure
Cone [Force]	Fugro Loadcell	0 to 80 kN	0 to 80 kN	FEBV.CAL.PRO.003
Cone+Fric. [Force]	Fugro Loadcell	0 to 80 kN	0 to 80 kN	FEBV.CAL.PRO.003



Nootdorp, 26-Aug-2015

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Gerry Sinjorgo
Manager Transducer Workshop

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FRICTION SLEEVE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1713
Electronics	2449
Node Type	7001
Hardware Version	3.00
Software Version	4.01

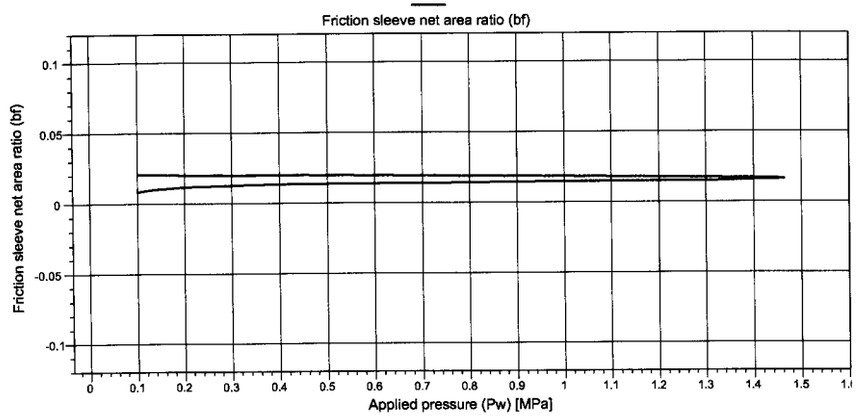
Reference	
Manufacturer	Keller PA-33X
Serial Number	3257-0004
Uncertainty	0.0012•Pw+0.0017 [MPa]

Calibration Details	
Calibration Date	26 Aug 2015 12:55:04
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Certificate Number FCN15004670

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	0.01606

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
0.240	0.012	0.013	0.011	0.012
0.480	0.013	0.014	0.014	0.014
0.720	0.014	0.014	0.014	0.014
0.960	0.014	0.014	0.015	0.014
1.200	0.015	0.015	0.015	0.015
0.960	0.018	0.018	0.018	0.018
0.720	0.019	0.019	0.019	0.019
0.480	0.019	0.020	0.019	0.020
0.240	0.020	0.020	0.020	0.020

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CONE CALIBRATION RESULT [FORCE]

Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1713
Electronics	2449
Node Type	7001
Hardware Version	3.00
Software Version	4.01

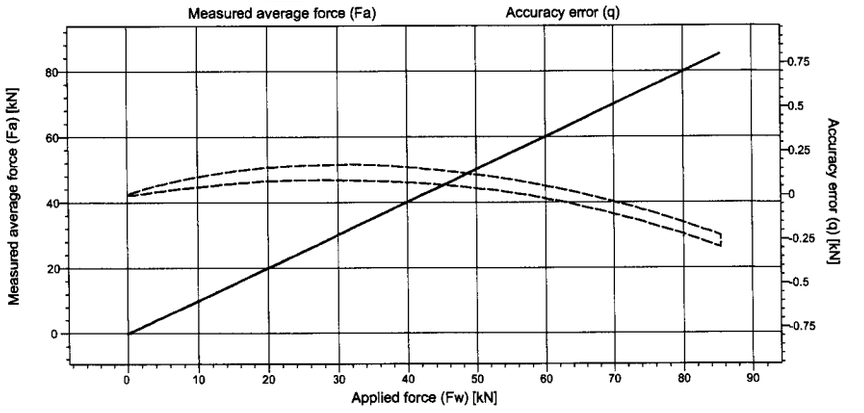
Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0002
Uncertainty	0.00272•Fw+0.01672 [kN]

Calibration Details	
Calibration Date	26 Aug 2015 12:48:52
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Sensor	
Channel	Cone [Force]
Manufacturer / Type	Fugro Loadcell
Calibrated Range	0 to 80 kN
Maximum Rating	0 to 80 kN

Certificate Number FCN15004670

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.223
Repeatability error (b)	[kN]	0.010
Reversibility error (v)	[kN]	0.091
Zero load error (Fc0)	[kN]	0.002
Zero load offset (F0)	[kN]	-0.024
Resolution	[kN]	3.29E-05
Noise RMS	[kN]	0.001



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	0.004	-0.002	-0.003	0.000	0.000	0.007	
16.000	16.071	16.067	16.065	16.068	0.068	0.006	0.071
32.000	32.086	32.082	32.079	32.082	0.082	0.008	0.091
48.000	48.050	48.044	48.043	48.046	0.046	0.007	0.079
64.000	63.947	63.945	63.947	63.946	-0.054	0.002	0.071
80.000	79.778	79.777	79.777	79.777	-0.223	0.001	
64.000	64.023	64.014	64.014	64.017	0.017	0.009	
48.000	48.131	48.122	48.121	48.125	0.125	0.010	
32.000	32.177	32.173	32.170	32.173	0.173	0.007	
16.000	16.142	16.136	16.138	16.139	0.139	0.006	
0.000	0.002	0.001	0.001	0.002	0.002	0.001	

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CONE NET AREA RATIO RESULT

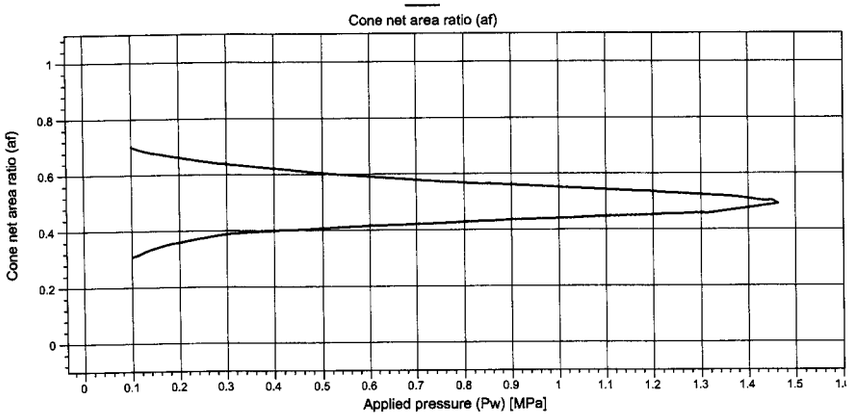
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1713
Electronics	2449
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Keller PA-33X
Serial Number	3257-0004
Uncertainty	0.0012•Pw+0.0017 [MPa]
Calibration Details	
Calibration Date	26 Aug 2015 12:55:04
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Certificate Number
FCN15004670

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.49

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
0.240	0.365	0.414	0.335	0.371
0.480	0.408	0.420	0.389	0.406
0.720	0.423	0.426	0.417	0.422
0.960	0.437	0.437	0.440	0.438
1.200	0.454	0.451	0.453	0.453
0.960	0.551	0.553	0.560	0.555
0.720	0.573	0.573	0.584	0.577
0.480	0.605	0.603	0.613	0.607
0.240	0.656	0.645	0.653	0.651

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CONE+FRIC. CALIBRATION RESULT [FORCE]

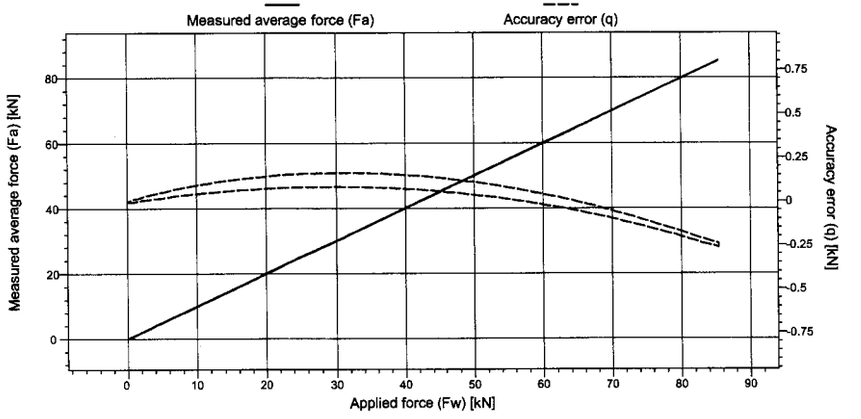
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1713
Electronics	2449
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0002
Uncertainty	0.00272•Fw+0.01672 [kN]
Calibration Details	
Calibration Date	26 Aug 2015 12:48:53
Procedure	FEBV.CAL.PRO.003
Software Version	1.17.0.15726

Certificate Number
FCN15004670

Sensor	
Channel	Cone+Fric. [Force]
Manufacturer / Type	Fugro Loadcell
Calibrated Range	0 to 80 kN
Maximum Rating	0 to 80 kN

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.201
Repeatability error (b)	[kN]	0.007
Reversibility error (v)	[kN]	0.082
Zero load error (Fc0)	[kN]	0.001
Zero load offset (F0)	[kN]	-0.025
Resolution	[kN]	3.42E-05
Noise RMS	[kN]	0.001
Tip-Sleeve Interaction	[kPa]	5.4
Tip-Sleeve Interaction %	[%]	1.07



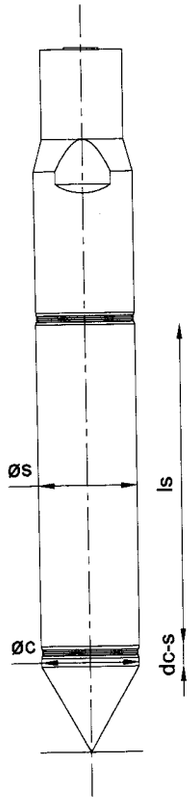
Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	0.005	-0.002	-0.003	0.000	0.000	0.007	
16.000	16.067	16.063	16.062	16.064	0.064	0.005	0.062
32.000	32.085	32.082	32.079	32.082	0.082	0.007	0.082
48.000	48.051	48.044	48.044	48.046	0.046	0.006	0.074
64.000	63.956	63.949	63.951	63.952	-0.048	0.006	0.054
80.000	79.803	79.798	79.798	79.799	-0.201	0.006	
64.000	64.010	64.004	64.005	64.006	0.006	0.006	
48.000	48.123	48.119	48.119	48.120	0.120	0.005	
32.000	32.165	32.164	32.163	32.164	0.164	0.003	
16.000	16.130	16.124	16.126	16.127	0.127	0.006	
0.000	0.002	0.000	0.000	0.001	0.001	0.002	

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TYPICAL DIMENSIONS

Certificate Number
FCN15004670

Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1713



Typical Dimensions		
Ac	Cross-sectional projected area of the cone	0.0005 m²
As	Surface area of the friction sleeve	0.0075 m²
af	Cone net area ratio	0.5
scf	Friction sleeve net area ratio	0.01669
øc	Diameter of the cylindrical part of the cone	25.3 mm
øs	Diameter of the friction sleeve	25.6 mm
ls	Length of the friction sleeve	93.6 mm
dc-s	Cone - friction sleeve distance	9 mm

Diagram is not to scale

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SYMBOLS, DEFINITIONS AND REFERENCES

Certificate Number
FCN15004670

Symbols and Definitions (general)

af	Cone net area ratio, defined as the factor between the applied pressure to the instrument and the indicated cone resistance.
af,x	Measured cone net area ratio at measurement x.
b	Repeatability error, defined as the maximum difference between the measurements of the instrument at the applied value.
bf	Friction sleeve net area ratio, defined as the factor between the applied pressure to the instrument and the indicated sleeve friction.
bf,x	The measured friction sleeve net area ratio at measurement x.
Noise RMS	Signal noise, defined as the quadratic mean when the sensor is not subjected to load.
q	Accuracy error, defined as the difference between the average indicated value by the instrument and the applied value.
Resolution	Smallest change in a quantity being measured that causes a perceptible change in the corresponding indication.
Tip-Sleeve Interaction	Effect of cone tip measurements on derived friction measurements, due to coupling of the cone tip and friction sleeve element. Expressed in terms of friction and as a percentage of the full scale output of the cone tip.
v	Reversibility error, defined as the difference between the average indicated value by the instrument at a certain applied value when it was increased and when it was decreased.

Symbols and Definitions (quantity specific: Q may be substituted for F or P, as appropriate)

Q0	Zero load offset, instrument output where the specified measured quantity value is zero.
Qa	Average indicated quantity value by the instrument.
Qa,x	Quantity value indicated by the instrument at measurement x.
Qc0	Zero load error, defined as the difference between the average indicated value by the instrument before and after the load cycle has been applied.
Qw	Applied reference quantity value.

Quantities

F	Force
P	Pressure

References

European Co-operation For Accreditation (2013), "Evaluation of the uncertainty of measurement in calibration", European Co-operation For Accreditation, 75 p. (Publication ; EA-4/02 M:2013)

ISO International Organization for Standardization (1999), "General requirements for the competence of testing and calibration laboratories", International Standard ISO 17025:2005

ISO International Organization for Standardization (2003), "Measurement management systems - requirements for measurement processes and measuring equipment", International Standard ISO 10012:2003

International Organization for Standardization (ISO) (2000), "Quality management systems - Requirements", International Standard ISO 9001

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Fugro Calibration Laboratory, P.O. Box 130, 2630 AC Nootdorp, The Netherlands, Phone +31-70-3111444, www.fugro.com

CALIBRATION CERTIFICATE

Applicant	**FUGRO ENGINEERS B.V. (NOOTDORP)**	Certificate nr.	FCN15003607
Manufacturer	Fugro Engineers B.V.	Identification	1721-1889
Instrument	**A Cone Penetrometer**		

Calibration method:
The device was calibrated according to Fugro Engineers procedures using a comparison technique against a Fugro reference standard. Fugro reference standards are periodically recertified and traceable to the National Standards and Technology (NIST) (RVA). It is derived from accepted values of natural physical constants according to the International System of units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2000 and ISO/IEC 17025:2005.

Cone and Friction Sleeve Calibration Reference

Equipment Serial Number	6034-0003
Equipment Manufacturer	ZWICK GMBH & CO
Equipment Calibration Valid till	22/09/2015
Equipment Certificate	14202947.1000.1EN/R1
Procedure used : in-house	FEBV.CAL.PRO.003

Cone and Friction Sleeve Sensor

Manufacturer	Fugro Engineers BV
Force Application Mode	Compression
Calibrated Range	0 – 80 kN
Max Load	0 – 80 kN

Pressure Calibration Reference

Equipment Serial Number	3257-0001
Equipment Manufacturer	
Equipment Calibration Valid till	28/09/2015
Equipment Certificate	FCNREF150123/24
Procedure used : in-house	FEBV.CAL.PRO.004

Environmental Conditions

Temperature during calibration	21 ± 3 °C
Pressure during calibration	1000 ± 100 mbar

Remarks.
The values given in this calibration certificate only relate to the submitted device, and to the values measured at the time of the test. Any uncertainty defined here does not include allowances for environmental changes, variation and shock during transportation, or the capability of other laboratories to repeat the measurement.

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Calibration technician	Tempelaar, Rolf	Approved by :	Sinjorgo, Gerry
Calibration date:	02/04/2015	Approval date:	02/04/2015
Calibrate before:	02/04/2016		



CONE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1889
Electronics	3559
Node Type	7001
Hardware Version	3.00
Software Version	4.01

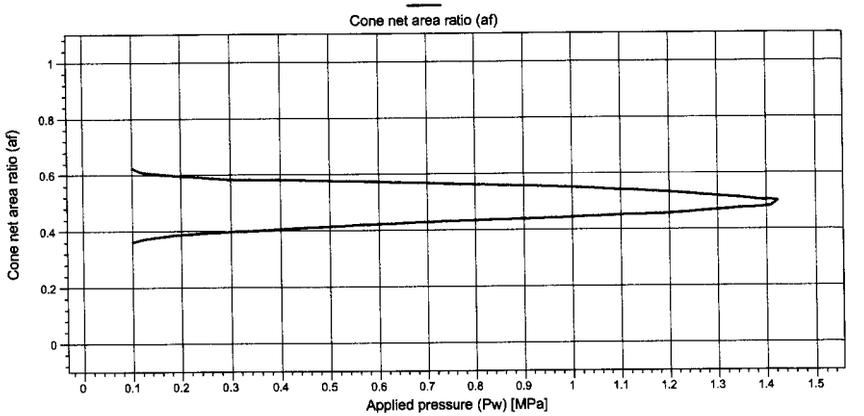
Reference	
Manufacturer	Stratham
Serial Number	3257-0001
Uncertainty	0.00329•Pw+0.00166 [MPa]

Calibration Details	
Calibration Date	02 Apr 2015 12:02:37
Procedure	FEBV.CAL.PRO.003
Software Version	1.14.0.14195

Certificate Number
FCN15003607

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.50

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
0.240	0.410	0.389	0.386	0.395
0.480	0.426	0.408	0.410	0.415
0.720	0.445	0.429	0.424	0.433
0.960	0.451	0.442	0.439	0.444
1.200	0.466	0.458	0.456	0.460
0.960	0.557	0.555	0.554	0.555
0.720	0.569	0.567	0.570	0.569
0.480	0.585	0.578	0.577	0.580
0.240	0.598	0.595	0.587	0.593

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CONE+FRIC. CALIBRATION RESULT [FORCE]

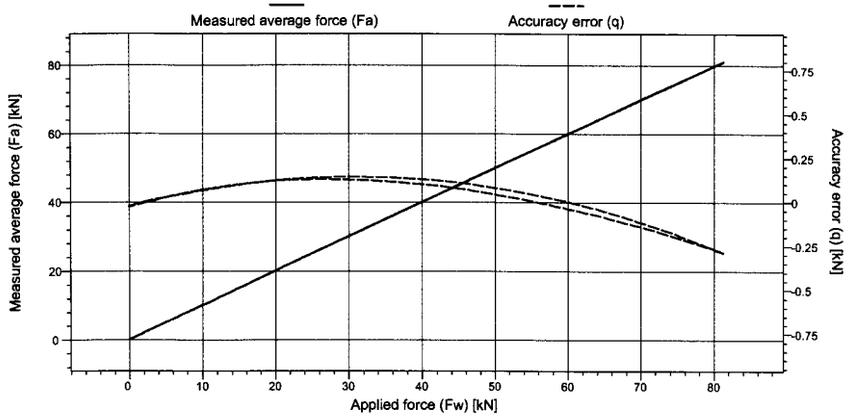
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1889
Electronics	3559
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]

Calibration Details	
Calibration Date	02 Apr 2015 11:02:54
Procedure	FEBV.CAL.PRO.003
Software Version	1.14.0.14195

Certificate Number
FCN15003607

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.267
Repeatability error (b)	[kN]	0.010
Reversibility error (v)	[kN]	0.036
Zero load error (Fc0)	[kN]	-0.004
Zero load offset (F0)	[kN]	-0.025
Resolution	[kN]	3.45E-05
Noise RMS	[kN]	0.001
Tip-Sleeve Interaction	[kPa]	6.2
Tip-Sleeve Interaction %	[%]	1.23



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.023	-0.023	-0.026	-0.024	-0.024	0.002	0.003
16.000	16.108	16.105	16.104	16.106	0.106	0.004	0.001
32.000	32.147	32.144	32.141	32.144	0.144	0.005	0.018
48.000	48.096	48.092	48.090	48.093	0.093	0.005	0.036
64.000	63.961	63.960	63.961	63.960	-0.040	0.002	0.035
80.000	79.729	79.735	79.734	79.733	-0.267	0.005	
64.000	63.931	63.926	63.921	63.926	-0.074	0.010	
48.000	48.060	48.056	48.055	48.057	0.057	0.006	
32.000	32.127	32.126	32.124	32.126	0.126	0.002	
16.000	16.104	16.104	16.106	16.105	0.105	0.002	
0.000	-0.022	-0.029	-0.030	-0.027	-0.027	0.008	

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FRICTION SLEEVE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1889
Electronics	3559
Node Type	7001
Hardware Version	3.00
Software Version	4.01

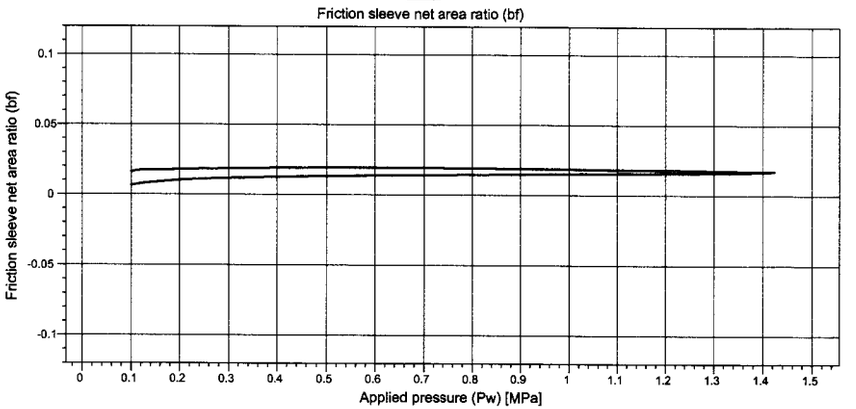
Reference	
Manufacturer	Stratham
Serial Number	3257-0001
Uncertainty	0.00329•Pw+0.00166 [MPa]

Calibration Details	
Calibration Date	02 Apr 2015 12:02:37
Procedure	FEBV.CAL.PRO.003
Software Version	1.14.0.14195

Certificate Number
FCN15003607

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	0.01711

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
0.240	0.010	0.011	0.011	0.011
0.480	0.013	0.013	0.014	0.013
0.720	0.014	0.014	0.014	0.014
0.960	0.015	0.015	0.015	0.015
1.200	0.016	0.016	0.016	0.016
0.960	0.018	0.019	0.019	0.019
0.720	0.019	0.019	0.020	0.019
0.480	0.019	0.019	0.020	0.019
0.240	0.017	0.018	0.019	0.018

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CONE CALIBRATION RESULT [FORCE]

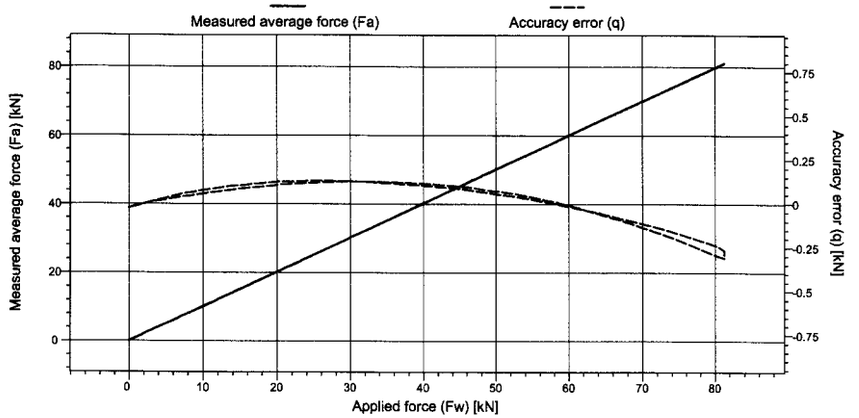
Instrument	
Manufacturer	Fugro
Type	CP5-CF80-P1E1M2-V1
Serial Number	1721-1889
Electronics	3559
Node Type	7001
Hardware Version	3.00
Software Version	4.01

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0026•Fw+0.011 [kN]

Calibration Details	
Calibration Date	02 Apr 2015 11:02:53
Procedure	FEBV.CAL.PRO.003
Software Version	1.14.0.14195

Certificate Number
FCN15003607

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.291
Repeatability error (b)	[kN]	0.018
Reversibility error (v)	[kN]	0.018
Zero load error (Fc0)	[kN]	-0.001
Zero load offset (F0)	[kN]	-0.027
Resolution	[kN]	3.38E-05
Noise RMS	[kN]	0.001



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.028	-0.026	-0.026	-0.026	-0.026	0.002	0.001
16.000	16.095	16.086	16.085	16.089	0.089	0.010	0.018
32.000	32.133	32.124	32.124	32.127	0.127	0.009	0.002
48.000	48.089	48.080	48.079	48.083	0.083	0.010	0.015
64.000	63.943	63.943	63.947	63.944	-0.056	0.005	0.004
80.000	79.704	79.710	79.712	79.709	-0.291	0.008	
64.000	63.959	63.946	63.940	63.948	-0.052	0.018	
48.000	48.077	48.064	48.060	48.067	0.067	0.017	
32.000	32.129	32.123	32.122	32.125	0.125	0.007	
16.000	16.108	16.105	16.105	16.106	0.106	0.003	
0.000	-0.024	-0.029	-0.029	-0.027	-0.027	0.005	

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TECHNICAL SPECIFICATIONS
Fugro Engineers BV

CALIBRATION CERTIFICATE

Applicant	**FUGRO ENGINEERS B.V. (NOOTDORP)**	Certificate nr.	FCN15003999
Manufacturer	Fugro Engineers B.V.	Identification	1733-0014
Instrument	**A Cone Penetrometer**		

Calibration method:
The device was calibrated according to Fugro Engineers procedures using a comparison technique against a Fugro reference standard. Fugro reference standards are periodically recertified and traceable to the National Standards and Technology (NIST) (RVA). It is derived from accepted values of natural physical constants according to the International System of units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2000 and ISO/IEC 17025:2005.

Cone and Friction Sleeve Calibration Reference

Equipment Serial Number	6034-0003
Equipment Manufacturer	ZWICK GMBH & CO
Equipment Calibration Valid till	22/09/2015
Equipment Certificate	14202947.1000.1EN/R1
Procedure used : in-house	FEBV.CAL.PRO.003

Cone and Friction Sleeve Sensor

Manufacturer	Fugro Engineers BV
Force Application Mode	Compression
Calibrated Range	0 – 50 kN
Max Load	0 – 100 kN

Pressure Calibration Reference

Equipment Serial Number	3257-0002
Equipment Manufacturer	KELLER MEETTECH
Equipment Calibration Valid till	28/09/2015
Equipment Certificate	FCNREF150116
Procedure used : in-house	FEBV.CAL.PRO.004

Pressure Sensor

Manufacturer	Keller
Pressure Application Mode	Compression and tension
Calibrated Range	Nominal Range
Nominal Range	0 –20.0 MPa

Environmental Conditions

Temperature during calibration	21 ± 3 °C
Pressure during calibration	1000 ± 100 mbar

Remarks.
The values given in this calibration certificate only relate to the submitted device, and to the values measured at the time of the test. Any uncertainty defined here does not include allowances for environmental changes, variation and shock during transportation, or the capability of other laboratories to repeat the measurement.

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Calibration technician	Tempelaar, Rolf	Approved by :	Sinjorgo, Gerry
Calibration date:	26/05/2015	Approval date:	26/05/2015
Calibrate before:	26/05/2016		



CONE CALIBRATION RESULT [FORCE]

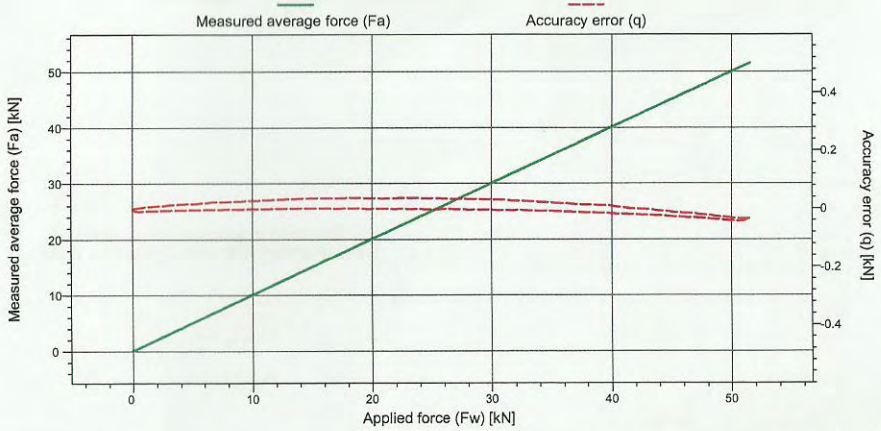
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M1-V1
Serial Number	1706-1831
Electronics	5284
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0027•Fw+0.008 [kN]

Calibration Details	
Calibration Date	26 May 2015 12:24:39
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003999

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.043
Repeatability error (b)	[kN]	0.005
Reversibility error (v)	[kN]	0.037
Zero load error (Fc0)	[kN]	0.010
Zero load offset (F0)	[kN]	-0.011
Resolution	[kN]	3.72E-05
Noise RMS	[kN]	0.001



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.009	-0.004	-0.005	-0.006	-0.006	0.005	0.005
10.000	9.997	10.000	10.000	9.999	-0.001	0.003	0.028
20.000	19.996	20.000	19.999	19.998	-0.002	0.004	0.037
30.000	29.994	29.995	29.996	29.995	-0.005	0.002	0.035
40.000	39.982	39.983	39.983	39.983	-0.017	0.002	0.025
50.000	49.956	49.959	49.957	49.957	-0.043	0.003	
40.000	40.007	40.008	40.009	40.008	0.008	0.003	
30.000	30.030	30.028	30.031	30.030	0.030	0.003	
20.000	20.032	20.035	20.037	20.035	0.035	0.005	
10.000	10.027	10.028	10.027	10.027	0.027	0.001	
0.000	-0.002	-0.001	-0.001	-0.001	-0.001	0.001	

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CONE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M1-V1
Serial Number	1706-1831
Electronics	5284
Node Type	7001
Hardware Version	4.00
Software Version	7.08

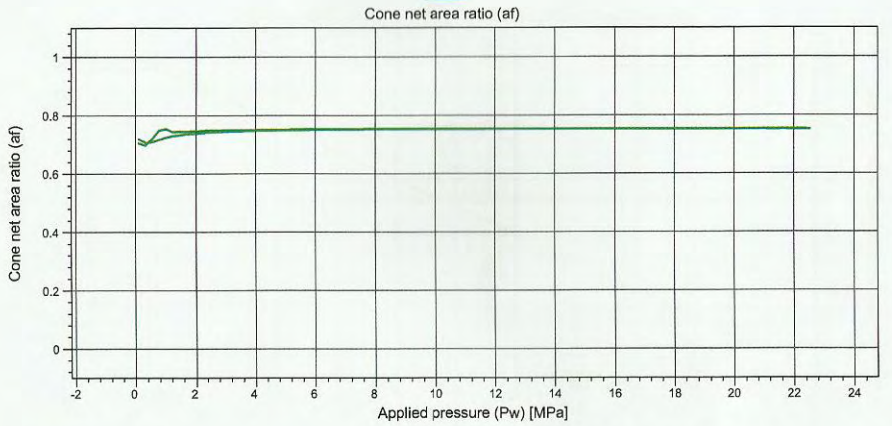
Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.00222 [MPa]

Calibration Details	
Calibration Date	26 May 2015 14:09:36
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003999

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.75

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
4.000	0.748	0.749	0.749	0.749
8.000	0.752	0.753	0.753	0.753
12.000	0.754	0.754	0.754	0.754
16.000	0.754	0.754	0.754	0.754
20.000	0.754	0.754	0.754	0.754
16.000	0.755	0.755	0.755	0.755
12.000	0.755	0.755	0.755	0.755
8.000	0.754	0.754	0.754	0.754
4.000	0.751	0.751	0.752	0.751

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CONE+FRIC. CALIBRATION RESULT [FORCE]

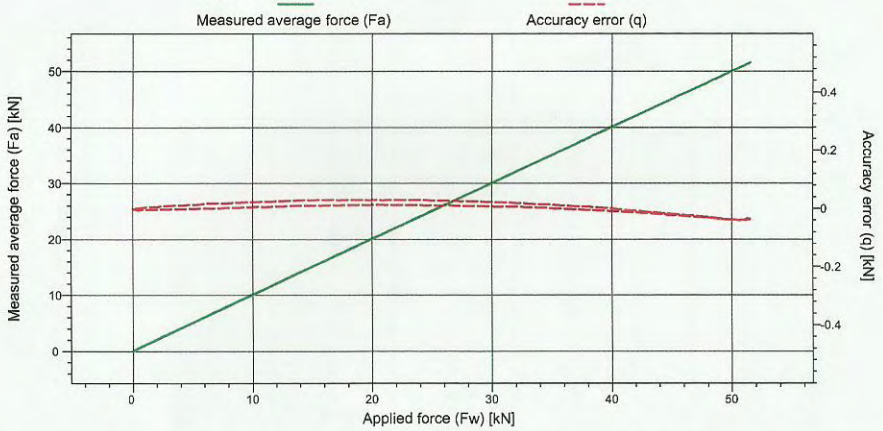
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M1-V1
Serial Number	1706-1831
Electronics	5284
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0027•Fw+0.008 [kN]

Calibration Details	
Calibration Date	26 May 2015 12:24:40
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003999

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.040
Repeatability error (b)	[kN]	0.004
Reversibility error (v)	[kN]	0.017
Zero load error (Fc0)	[kN]	0.005
Zero load offset (F0)	[kN]	-0.006
Resolution	[kN]	3.73E-05
Noise RMS	[kN]	0.000
Tip-Sleeve Interaction	[kPa]	0.9
Tip-Sleeve Interaction %	[%]	0.19



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.004	-0.002	-0.002	-0.003	-0.003	0.002	0.003
10.000	10.004	10.005	10.005	10.004	0.004	0.001	0.017
20.000	20.010	20.012	20.011	20.011	0.011	0.003	0.017
30.000	30.006	30.006	30.006	30.006	0.006	0.000	0.015
40.000	39.991	39.990	39.990	39.990	-0.010	0.001	0.009
50.000	49.960	49.960	49.959	49.960	-0.040	0.001	
40.000	39.999	39.998	40.000	39.999	-0.001	0.002	
30.000	30.021	30.020	30.022	30.021	0.021	0.002	
20.000	20.025	20.029	20.030	20.028	0.028	0.004	
10.000	10.021	10.022	10.023	10.022	0.022	0.002	
0.000	-0.001	0.000	0.000	0.000	0.000	0.001	

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FRICTION SLEEVE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M1-V1
Serial Number	1706-1831
Electronics	5284
Node Type	7001
Hardware Version	4.00
Software Version	7.08

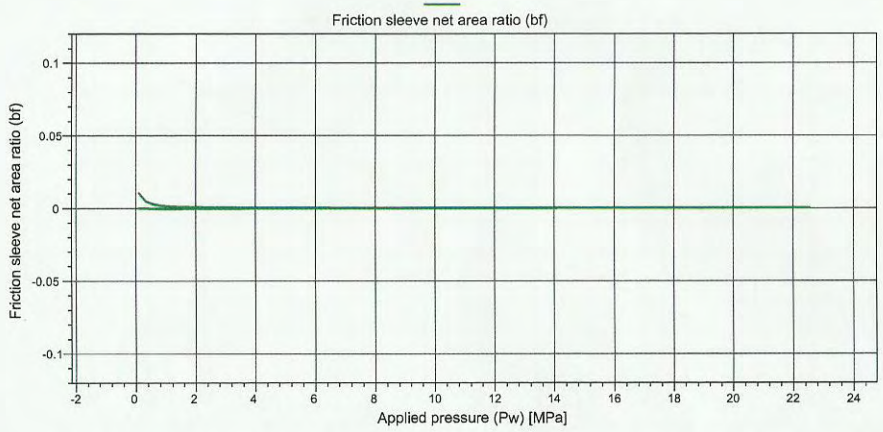
Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.00222 [MPa]

Calibration Details	
Calibration Date	26 May 2015 14:09:36
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003999

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	0.00013

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
4.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
12.000	0.000	0.000	0.000	0.000
16.000	0.000	0.000	0.000	0.000
20.000	0.000	0.000	0.000	0.000
16.000	0.000	0.000	0.000	0.000
12.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
4.000	0.000	0.000	0.000	0.000

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PORE 2 CALIBRATION RESULT [PRESSURE]

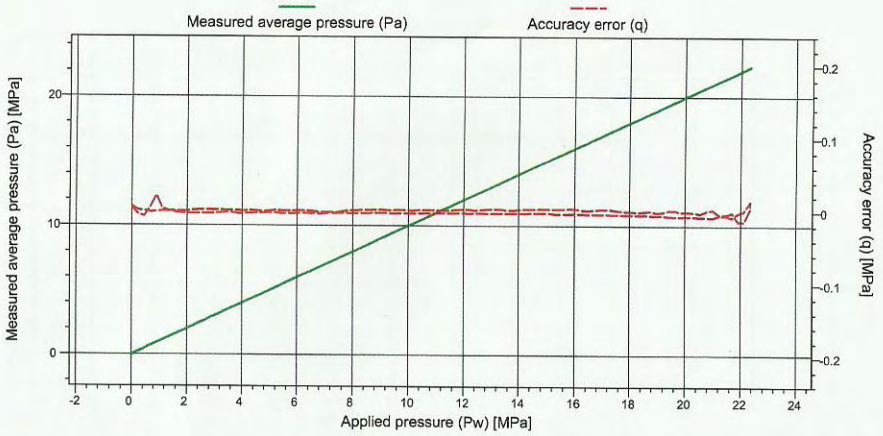
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB20-P1E1M1-V1
Serial Number	1706-1831
Electronics	5284
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.00222 [MPa]

Calibration Details	
Calibration Date	26 May 2015 14:09:36
Procedure	FEBV.CAL.PRO.004
Software Version	1.15.0.14651

Certificate Number
FCN15003999

Characteristics	Unit	Value
Accuracy error (q)	[MPa]	0.006
Repeatability error (b)	[MPa]	0.003
Reversibility error (v)	[MPa]	0.007
Zero load error (Pc0)	[MPa]	-0.002
Zero load offset (P0)	[MPa]	0.010
Resolution	[MPa]	8.06E-06
Noise RMS	[MPa]	0.000



Applied pressure (Pw) [MPa]	Measured pressure 1 (Pa,1) [MPa]	Measured pressure 2 (Pa,2) [MPa]	Measured pressure 3 (Pa,3) [MPa]	Measured average pressure (Pa) [MPa]	Accuracy error (q) [MPa]	Repeatability error (b) [MPa]	Reversibility error (v) [MPa]
0.000	0.006	0.006	0.006	0.006	0.006	0.000	0.001
4.000	3.997	3.998	3.997	3.997	-0.003	0.000	0.004
8.000	7.998	7.998	7.998	7.998	-0.002	0.000	0.004
12.000	11.999	11.998	11.998	11.998	-0.002	0.001	0.005
16.000	15.997	15.997	15.998	15.997	-0.003	0.001	0.007
20.000	19.994	19.994	19.993	19.994	-0.006	0.001	
16.000	16.003	16.003	16.006	16.004	0.004	0.003	
12.000	12.002	12.004	12.005	12.003	0.003	0.003	
8.000	8.001	8.002	8.002	8.002	0.002	0.001	
4.000	4.000	4.001	4.001	4.001	0.001	0.001	
0.000	0.005	0.005	0.005	0.005	0.005	0.000	

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TECHNICAL SPECIFICATIONS
Fugro Engineers BV

CALIBRATION CERTIFICATE

Applicant	**FUGRO ENGINEERS B.V. (NOOTDORP)**	Certificate nr.	FCN15004001
Manufacturer	Fugro Engineers B.V.	Identification	1733-0017
Instrument	**A Cone Penetrometer**		

Calibration method:
The device was calibrated according to Fugro Engineers procedures using a comparison technique against a Fugro reference standard. Fugro reference standards are periodically recertified and traceable to the National Standards and Technology (NIST) (RVA). It is derived from accepted values of natural physical constants according to the International System of units (SI). Fugro's calibration system meets or exceeds the requirements of ISO 9001:2000 and ISO/IEC 17025:2005.

This specific assembly consists of a Dual Seismic probe and a Lead Cone.
The Dual Seismic Probe governs this assembly and the Certificate nr stated on this page is of the Seismic Probe.
The Certificate nr shown on following pages is the Calibration nr of the Lead Cone.

Cone and Friction Sleeve Calibration Reference

Equipment Serial Number	6034-0003
Equipment Manufacturer	ZWICK GMBH & CO
Equipment Calibration Valid til	22/09/2015
Equipment Certificate	14202947.1000.1EN/R1
Procedure used : in-house	FEBV.CAL.PRO.003

Cone and Friction Sleeve Sensor

Manufacturer	Fugro Engineers BV
Force Application Mode	Compression
Calibrated Range	0 – 50 kN
Max Load	0 – 100 kN

Pressure Calibration Reference

Equipment Serial Number	3257-0002
Equipment Manufacturer	KELLER MEETTECH
Equipment Calibration Valid til	28/09/2015
Equipment Certificate	FCNREF150116
Procedure used : in-house	FEBV.CAL.PRO.004

Pressure Sensor

Manufacturer	Keller
Pressure Application Mode	Compression and tension
Calibrated Range	Nominal Range
Nominal Range	0 – 10 MPa

Inclinometer Calibration Reference

Equipment Serial Number	2109-0006
Equipment Manufacturer	FEBV
Equipment Calibration Validtil	22/07/2016
Procedure used : in-house	FEBV.CAL.PRO.005

Inclinometer

Manufacturer	FEBV	ADXL
Calibrated Range	0° – 15°	-10° - 10°
Max output	0° – 30°	-15° - 15°

Environmental Conditions

Temperature during calibration	21 ± 3 °C
Pressure during calibration	1000 ± 100 mbar

Remarks.
The values given in this calibration certificate only relate to the submitted device, and to the values measured at the time of the test. Any uncertainty defined here does not include allowances for environmental changes, variation and shock during transportation, or the capability of other laboratories to repeat the measurement.

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Calibration technician	Tempelaar, Rolf	Approved by:	Sinjorgo, Gerry
Calibration date:	26/05/2015	Approval date:	26/05/2015
Calibrate before:	26/05/2016		



CONE CALIBRATION RESULT [FORCE]

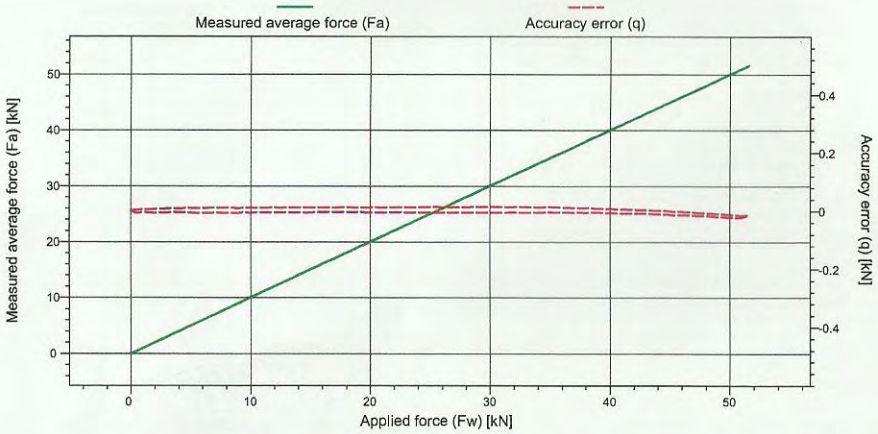
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10SN2-P1E1M1-V1
Serial Number	1706-2364
Electronics	5316
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0027•Fw+0.008 [kN]

Calibration Details	
Calibration Date	26 May 2015 10:41:08
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003996

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.021
Repeatability error (b)	[kN]	0.006
Reversibility error (v)	[kN]	0.019
Zero load error (Fc0)	[kN]	0.019
Zero load offset (F0)	[kN]	-0.008
Resolution	[kN]	3.68E-05
Noise RMS	[kN]	0.000



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.004	-0.002	0.002	-0.001	-0.001	0.006	0.002
10.000	9.994	9.993	9.994	9.994	-0.006	0.001	0.016
20.000	19.995	19.997	19.995	19.995	-0.005	0.002	0.017
30.000	29.996	29.995	29.995	29.995	-0.005	0.001	0.019
40.000	39.994	39.993	39.991	39.993	-0.007	0.003	0.014
50.000	49.980	49.981	49.976	49.979	-0.021	0.004	
40.000	40.008	40.008	40.005	40.007	0.007	0.003	
30.000	30.015	30.015	30.014	30.015	0.015	0.001	
20.000	20.012	20.013	20.013	20.013	0.013	0.001	
10.000	10.011	10.010	10.010	10.010	0.010	0.001	
0.000	0.001	0.002	0.002	0.001	0.001	0.001	

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CONE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10SN2-P1E1M1-V1
Serial Number	1706-2364
Electronics	5316
Node Type	7001
Hardware Version	4.00
Software Version	7.08

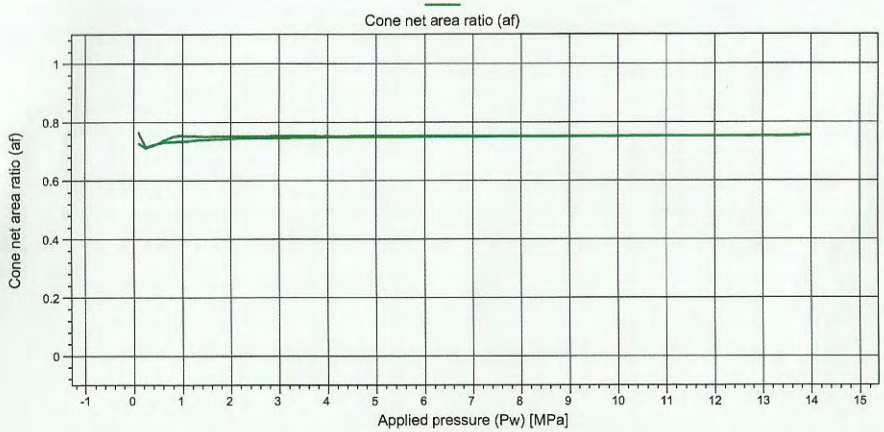
Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.00222 [MPa]

Calibration Details	
Calibration Date	26 May 2015 14:29:16
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003996

Characteristics	Unit	Value
Cone net area ratio (af)	[-]	0.75

The cone net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured cone net area ratio 1 (af,1)	Measured cone net area ratio 2 (af,2)	Measured cone net area ratio 3 (af,3)	Measured average cone net area ratio (af)
2.000	0.743	0.743	0.743	0.743
4.000	0.748	0.748	0.749	0.748
6.000	0.750	0.751	0.751	0.751
8.000	0.752	0.752	0.752	0.752
10.000	0.752	0.752	0.752	0.752
8.000	0.753	0.753	0.753	0.753
6.000	0.753	0.753	0.753	0.753
4.000	0.752	0.753	0.753	0.753
2.000	0.751	0.752	0.753	0.752

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CONE+FRIC. CALIBRATION RESULT [FORCE]

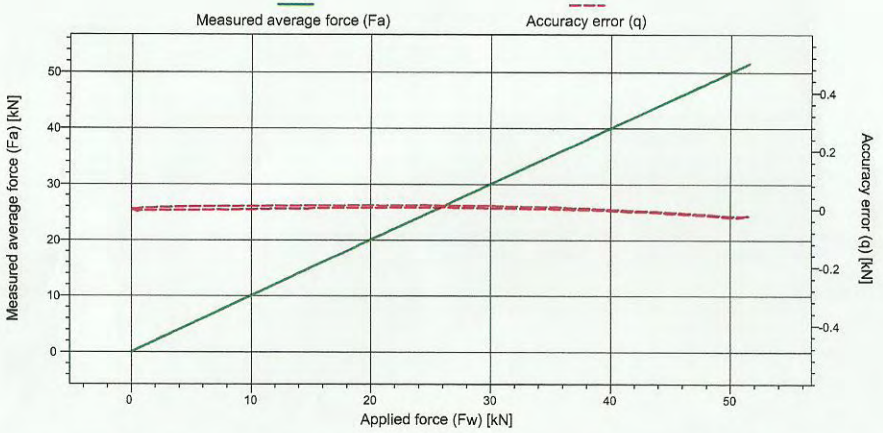
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10SN2-P1E1M1-V1
Serial Number	1706-2364
Electronics	5316
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Zwick/Roell
Serial Number	6034-0003
Uncertainty	0.0027•Fw+0.008 [kN]

Calibration Details	
Calibration Date	26 May 2015 10:41:09
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003996

Characteristics	Unit	Value
Accuracy error (q)	[kN]	0.027
Repeatability error (b)	[kN]	0.005
Reversibility error (v)	[kN]	0.011
Zero load error (Fc0)	[kN]	0.022
Zero load offset (F0)	[kN]	-0.011
Resolution	[kN]	3.68E-05
Noise RMS	[kN]	0.000
Tip-Sleeve Interaction	[kPa]	0.8
Tip-Sleeve Interaction %	[%]	0.16



Applied force (Fw) [kN]	Measured force 1 (Fa,1) [kN]	Measured force 2 (Fa,2) [kN]	Measured force 3 (Fa,3) [kN]	Measured average force (Fa) [kN]	Accuracy error (q) [kN]	Repeatability error (b) [kN]	Reversibility error (v) [kN]
0.000	-0.003	-0.002	0.002	-0.001	-0.001	0.005	0.001
10.000	10.000	9.999	10.000	10.000	0.000	0.001	0.011
20.000	20.005	20.006	20.004	20.005	0.005	0.002	0.009
30.000	30.006	30.004	30.003	30.005	0.005	0.003	0.009
40.000	39.997	39.995	39.993	39.995	-0.005	0.004	0.004
50.000	49.974	49.974	49.972	49.973	-0.027	0.002	
40.000	40.000	40.000	39.997	39.999	-0.001	0.003	
30.000	30.013	30.014	30.012	30.013	0.013	0.002	
20.000	20.013	20.014	20.015	20.014	0.014	0.002	
10.000	10.011	10.011	10.011	10.011	0.011	0.000	
0.000	0.000	0.001	0.001	0.001	0.001	0.000	

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FRICTION SLEEVE NET AREA RATIO RESULT

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10SN2-P1E1M1-V1
Serial Number	1706-2364
Electronics	5316
Node Type	7001
Hardware Version	4.00
Software Version	7.08

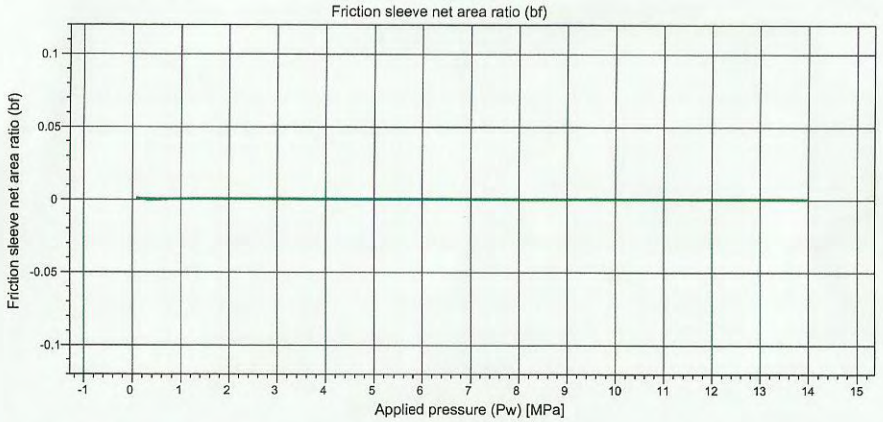
Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.00222 [MPa]

Calibration Details	
Calibration Date	26 May 2015 14:29:16
Procedure	FEBV.CAL.PRO.003
Software Version	1.15.0.14651

Certificate Number
FCN15003996

Characteristics	Unit	Value
Friction sleeve net area ratio (bf)	[-]	0.00024

The friction sleeve net area ratio presented above is determined at the maximum applied pressure during the measurement.



Applied pressure (Pw) [MPa]	Measured friction sleeve net area ratio 1 (bf,1)	Measured friction sleeve net area ratio 2 (bf,2)	Measured friction sleeve net area ratio 3 (bf,3)	Measured average friction sleeve net area ratio (bf)
2.000	0.001	0.001	0.001	0.001
4.000	0.000	0.000	0.000	0.000
6.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
10.000	0.000	0.000	0.000	0.000
8.000	0.000	0.000	0.000	0.000
6.000	0.000	0.000	0.000	0.000
4.000	0.000	0.000	0.000	0.000
2.000	0.000	0.000	0.000	0.000

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PORE 2 CALIBRATION RESULT [PRESSURE]

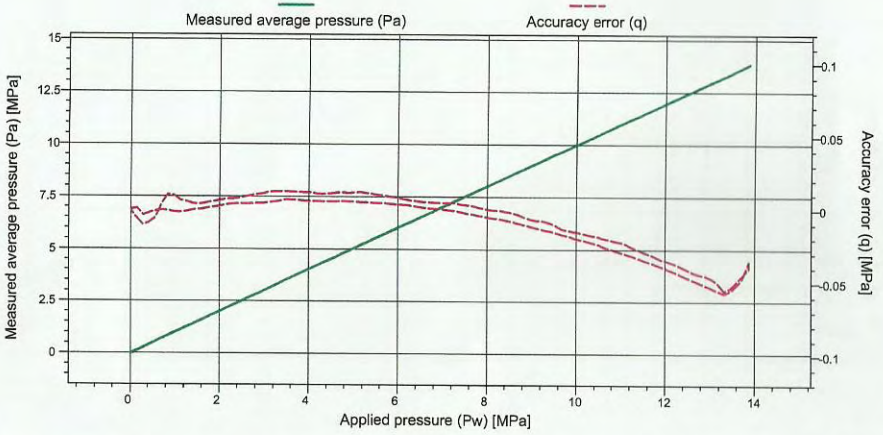
Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10SN2-P1E1M1-V1
Serial Number	1706-2364
Electronics	5316
Node Type	7001
Hardware Version	4.00
Software Version	7.08

Reference	
Manufacturer	Keller PA33X
Serial Number	3257-0002
Uncertainty	0.00142•Pw+0.00222 [MPa]

Calibration Details	
Calibration Date	26 May 2015 14:29:15
Procedure	FEBV.CAL.PRO.004
Software Version	1.15.0.14651

Certificate Number
FCN15003996

Characteristics	Unit	Value
Accuracy error (q)	[MPa]	0.020
Repeatability error (b)	[MPa]	0.004
Reversibility error (v)	[MPa]	0.006
Zero load error (Pc0)	[MPa]	0.000
Zero load offset (P0)	[MPa]	0.000
Resolution	[MPa]	2.24E-06
Noise RMS	[MPa]	0.000



Applied pressure (Pw) [MPa]	Measured pressure 1 (Pa,1) [MPa]	Measured pressure 2 (Pa,2) [MPa]	Measured pressure 3 (Pa,3) [MPa]	Measured average pressure (Pa) [MPa]	Accuracy error (q) [MPa]	Repeatability error (b) [MPa]	Reversibility error (v) [MPa]
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001
2.000	2.002	2.002	2.002	2.002	0.002	0.000	0.004
4.000	4.007	4.005	4.006	4.006	0.006	0.002	0.006
6.000	6.004	6.003	6.004	6.004	0.004	0.001	0.004
8.000	7.995	7.995	7.995	7.995	-0.005	0.001	0.005
10.000	9.981	9.980	9.981	9.980	-0.020	0.001	
8.000	7.998	8.002	8.001	8.000	0.000	0.004	
6.000	6.009	6.008	6.006	6.008	0.008	0.003	
4.000	4.010	4.014	4.011	4.012	0.012	0.004	
2.000	2.006	2.006	2.007	2.006	0.006	0.001	
0.000	-0.001	-0.001	-0.002	-0.001	-0.001	0.001	

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SLOPE CALIBRATION RESULT [INCLINATION]

Instrument	
Manufacturer	Fugro
Type	CP10-CF50PB10SN2-P1E1M1-V1
Serial Number	1706-2364
Electronics	5316
Node Type	7001
Hardware Version	4.00
Software Version	7.08

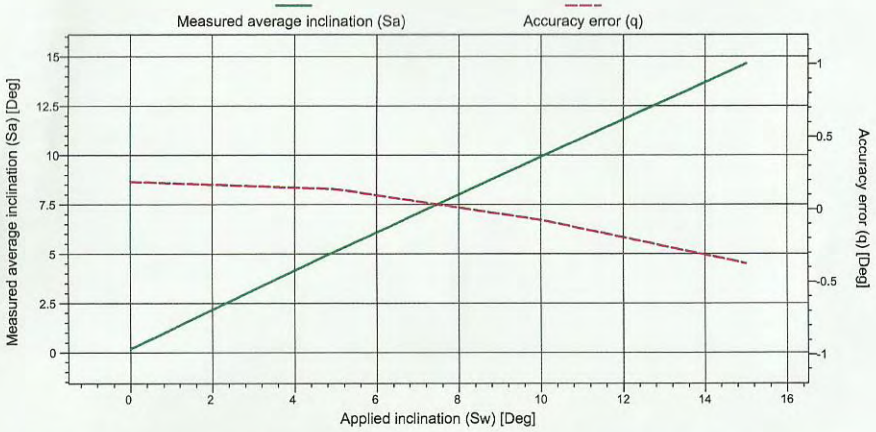
Reference	
Manufacturer	Hoek-O-Mat
Serial Number	2109-0006
Uncertainty	0.3 [Deg]

Calibration Details	
Calibration Date	26 May 2015 10:47:09
Procedure	FEBV.CAL.PRO.005
Software Version	1.15.0.14651

Certificate Number
FCN15003996

Characteristics	Unit	Value
Accuracy error (q)	[Deg]	0.374
Repeatability error (b)	[Deg]	0.281
Zero load error (Sc0)	[Deg]	0.239
Zero load offset (S0)	[Deg]	0.213
Resolution	[Deg]	1.23E-05
Noise RMS	[Deg]	0.016

Inclination is defined as the angular deviation of the cone penetrometer from the vertical.



Applied inclination (Sw) [Deg]	Measured inclination 1 (Sa,1) [Deg]	Measured inclination 2 (Sa,2) [Deg]	Measured inclination 3 (Sa,3) [Deg]	Measured average inclination (Sa) [Deg]	Accuracy error (q) [Deg]	Repeatability error (b) [Deg]
0.000	0.074	0.137	0.355	0.188	0.188	0.281
5.000	5.144	5.076	5.192	5.137	0.137	0.116
10.000	9.923	9.909	9.941	9.924	-0.076	0.032
15.000	14.734	14.610	14.532	14.626	-0.374	0.202

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Contacts
Netherlands Enterprise Agency (RVO.nl)
Croeselaan 15 | 3521 BJ | Utrecht
P.O. Box 8242 | 3503 RE | Utrecht
www.rvo.nl / http://english.rvo.nl

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