Geotechnical Report
Laboratory Test Data
Wind Farm Sites III&IV
Borssele Wind Farm Zone
Dutch Sector, North Sea

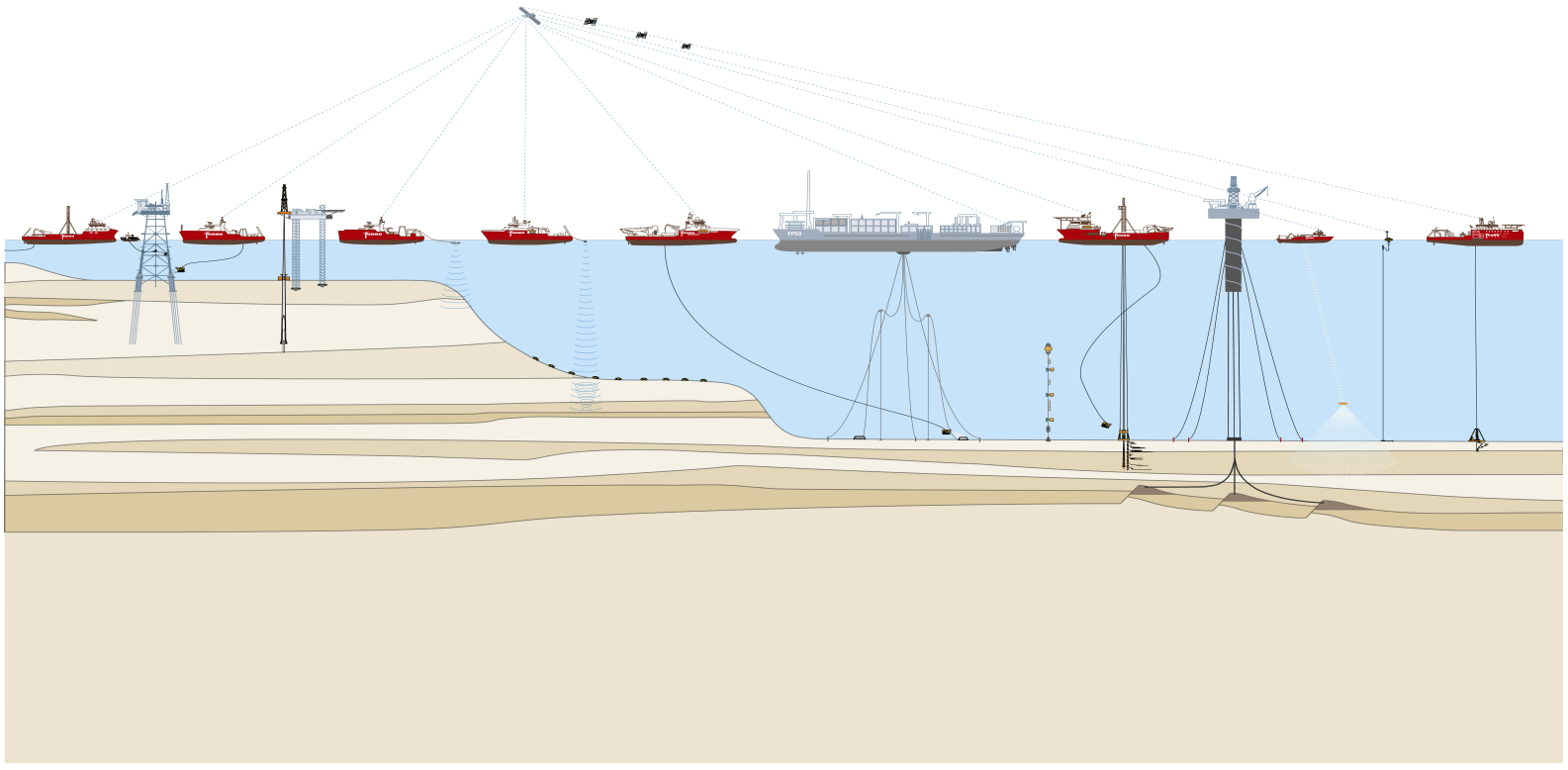
Client Reference No. WOZ1500010

Fugro Report No. N6083/07

Issue 3

Rijksdienst voor Ondernemend Nederland

Rijksdienst voor Ondernemend Nederland (RVO)



Geotechnical Report
Laboratory Test Data
Wind Farm Sites III&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.	**N6083/07 (3)**

Report Issue No.	Date	Report Status	Approved
3	01-Apr-2016	Final	MKL
2	20-Mar-2016	Interim	MKL
1	02-Feb-2016	Interim	MKL

FUGRO ENGINEERS B.V.

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: N6083/07 (3)/ESE/EMG

Nootdorp, 1 April 2016

Geotechnical Report – Laboratory Test Data
Wind Farm Sites III&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 P. Holley (Geotechnical Engineers) and undersigned. 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

CONTENTS

		Page
REPORT ISSUE CONTROL		**(i)**
QUALITY MANAGEMENT RECORD		**(ii)**
SUMMARY		**(iii)**
SAMENVATTING		**(iv)**
MAIN TEXT:		
1.	**INTRODUCTION**	**1**
1.1	Purpose of Report	1
1.2	Scope of Report	1
1.3	Project Responsibilities and Use of Report	2
1.4	Report Format	2
2.	**STUDY OVERVIEW**	**3**
2.1	Sources of Information	3
2.2	Laboratory Test Programme	3
3.	**REFERENCES**	**7**
LIST OF PLATES FOLLOWING MAIN TEXT:		Plate
Vicinity Map		1-1
Detailed Location Plan		1-2
List of Project Reports		1-3
Normalised Cyclic Shear Stress versus Number of Cycles to Failure - Cyclic Triaxial Tests (Cohesionless Specimens)		2-1
Normalised Cyclic Shear Stress versus Number of Cycles to Failure - Cyclic Direct Simple Shear Tests (Cohesionless Specimens)		2-2
Normalised Cyclic Shear Stress versus Number of Cycles to Failure - Cyclic Triaxial Tests (Cohesive Specimens)		2-3
Cyclic Triaxial Test Results – Drammen Clay Comparison (YSR=1)		2-4
Cyclic Triaxial Test Results – Drammen Clay Comparison (YSR=4)		2-5
Normalised Cyclic Shear Stress versus Number of Cycles to Failure - Cyclic Direct Simple Shear Tests (Cohesive Specimens)		2-6
Cyclic Direct Simple Shear Test Results – Drammen Clay Comparison (YSR=1)		2-7
Cyclic Direct Simple Shear Test Results – Drammen Clay Comparison (YSR=4)		2-8
SECTION A: GEOTECHNICAL LABORATORY TEST RESULTS		
SECTION B: GUIDELINES FOR USE OF REPORT		

ISSUE 75
FEBV/GEO/REP/001
© Fugro 1998-2015

REPORT ISSUE CONTROL

Section	Page No.	Plate No.	Issue No.	Revision
Main Text	All	-	3	Editorial changes and additions
Plates following Main Text	-	All	3	S-N degradation graphs and Drammen Clay model graphs revised; order of plates updated
Section A1.1	All	-	3	Editorial corrections and additions; Table A1.1 updated; PSD graphs updated with batch PSD
Section A1	-	A1-1, A1-3, A1-4, A1-5, A1-6, A1-7 and A1-9	3	Summary tables revised
Section A2-1	-	A2-2 to A2-4	3	Post-testing PSD curves added
Section A6.2	-	Various	3	Results of CTXL tests CTX11R and CTX21R added
Main Text	3 to 6	-	2	Editorial corrections and additions; Table 2.1 expanded
Plates following Main Text	-	All	2	S-N degradation graphs and Drammen Clay model graphs revised and added
Section A1	All	-	2	Editorial corrections and additions
Section A1	-	All	2	Summary tables revised and added
Section A3	-	All	2	Technical Note on microscope descriptions added
Section A5.2	-	All	2	Results of DSS tests added
Section A6.2	-	All	2	Results of CTXL tests added
Section A7.1	-	Various	2	Results of CSS tests revised or added
Section A7.2	-	All	2	Results of CSS tests 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 1 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: E. Schoute – Senior Project Engineer

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

Report Section	Prepared By	Checked By
Main Text	ESE	JLI
Plates following Main Text	JLI	ESE
A Geotechnical Laboratory Test Results		
- Laboratory Testing Overview	ESE	JLI
- Index Laboratory Tests	PH	ESE
- Microscopic Inspection	LRM	ESE
- Static Triaxial Tests	PH	ESE
- Static Direct Simple Shear Tests	PH	ESE
- Cyclic Triaxial Tests	PH	ESE
- Cyclic Direct Simple Shear Tests	PH	ESE

Person(s):
ESE: E. Schoute
JLI: J. Marçal Liça
LRM: L. McDonald
PH: P. Holley

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 Sites 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 included 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 laboratory test results for WFS III&IV and comprises the following:

- Results of geotechnical index tests;
- Results of static triaxial and direct simple shear tests;
- Results of cyclic triaxial and cyclic simple shear tests;
- Cyclic and static test results plotted on S-N degradation curves;
- Cyclic test results plotted with Drammen Clay Model as background.

This report is one in a series of reports prepared as part of this project (refer to "List of Project Reports" on Page vii). Companion reports for WFS III&IV contain results of geotechnical borehole locations and seafloor in situ test locations and describe a geological ground model for sites WFS III&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:

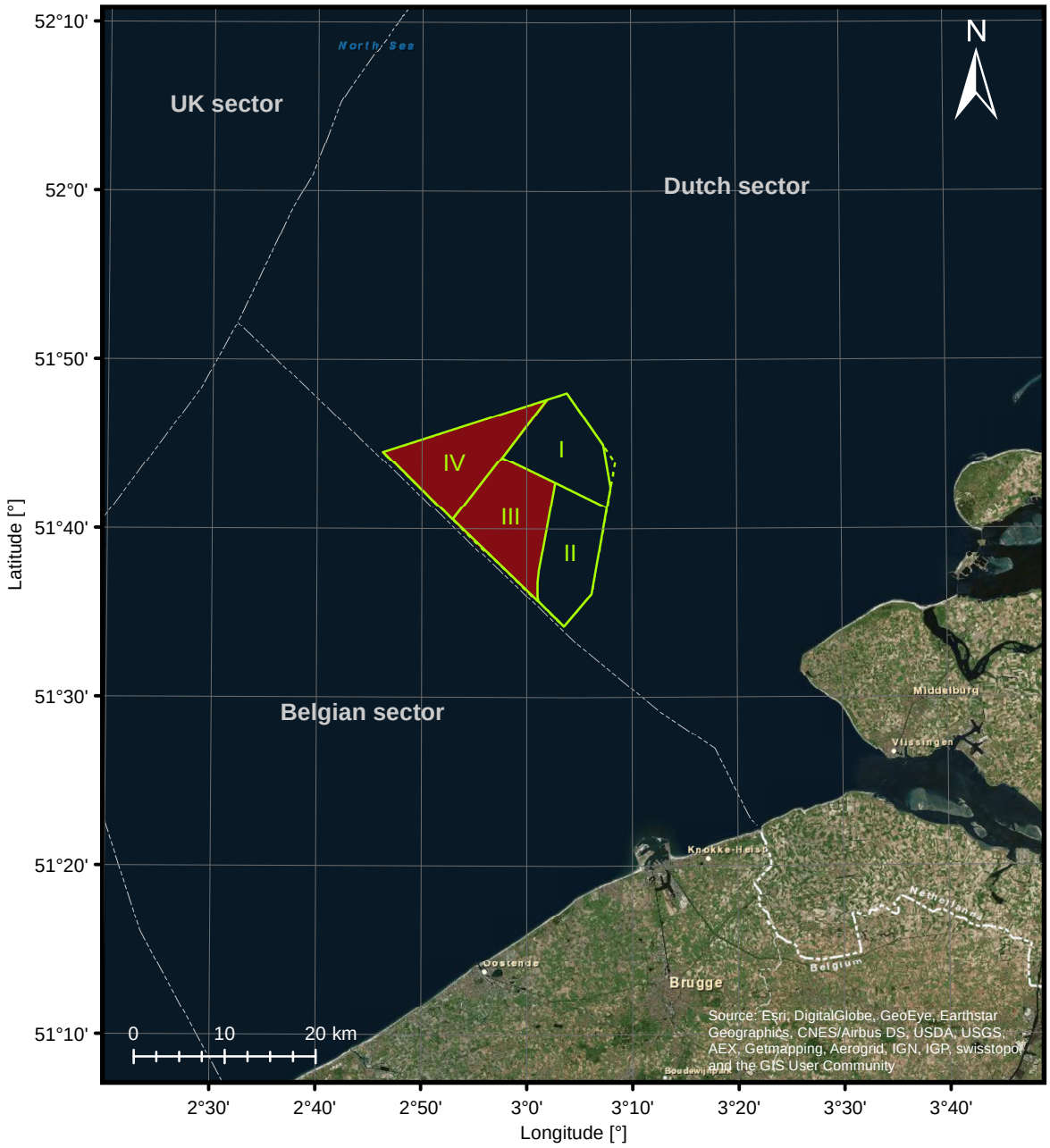
- inzicht te verkrijgen in de geologische en geotechnische omstandigheden;
- het bestaande geofysische en geologische model te verfijnen;
- een gedetailleerd geologisch grondmodel te genereren;
- de verticale en laterale variabiliteit van de grond te bepalen;
- relevante geotechnische data voor de ontwikkeling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

Het geotechnisch onderzoek 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 III&IV en omvat het volgende:

- Resultaten van geotechnische classificatie laboratoriumproeven;
- Resultaten van statische triaxiaal proeven en statische schuif proeven;
- Resultaten van cyclische triaxiaal en cyclische schuif proeven;
- Grafieken van statische en cyclische testresultaten met S-N degradatielijnen als achtergrond;
- Grafieken van cyclische testresultaten met het ‘Drammen Clay’ model als achtergrond.

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



Investigation Area III & IV (subjects of this report)

Outline of Borssele Wind Farm Zone

Outline Borssele Investigation Area (Roman numeral indicates area number)

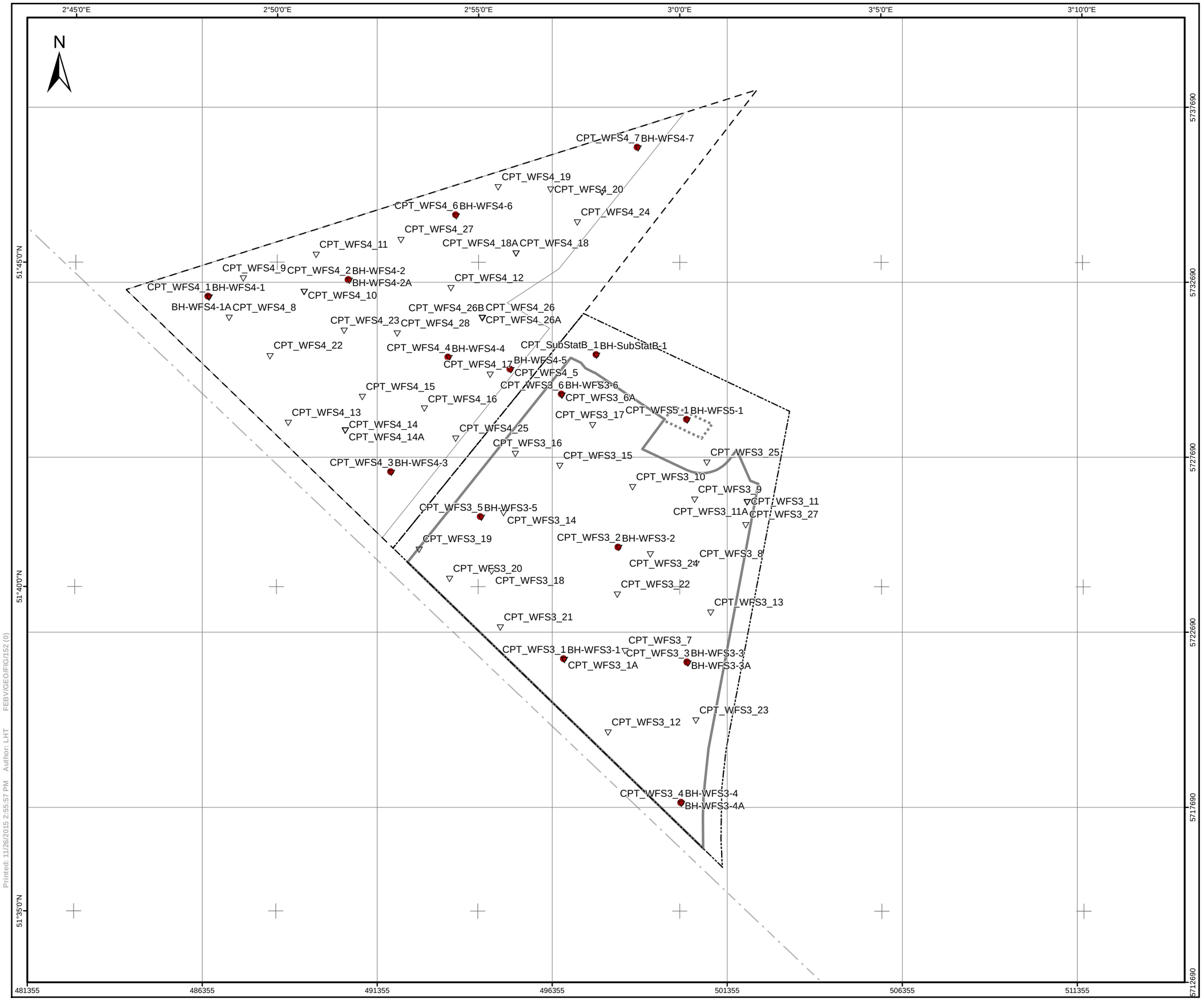
Maritime Boundary

Ellipsoid: GRS 1980
Datum: ETRS 1989

Printed: 11/26/2015 2:53:50 PM

VICINITY MAP

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



Printed: 11/26/2015 2:55:57 PM Author: LHT FERV/GEO/FIG/152 (0)

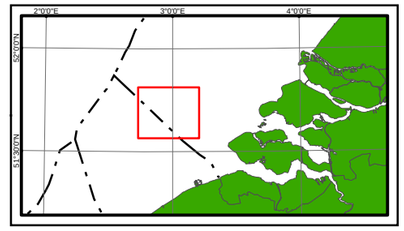
LEGEND:

- CPT location
- BH location
- Outline of WFS V
- Investigation Area III
- Investigation Area IV
- Outline of WFS 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 III & IV
DUTCH SECTOR, NORTH SEA

Scale 1:100,000
at original A3 page size

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

Fugro Report No. N6083/07	Issue 1	Page vi of vii

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
FEBV/CDE/TAB/052
© Fugro 1998-2014

LIST OF PROJECT REPORTS
BORSSELE WIND FARM ZONE, WFS III & 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 Sites 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 included 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 III and WFS IV and comprises the following:

- Results of geotechnical index tests;
- Results of static triaxial and direct simple shear tests;
- Results of cyclic triaxial and cyclic simple shear tests;
- Cyclic and static test results plotted on S-N degradation curves;
- Cyclic and static test results plotted with Drammen Clay Model as background.

Results presented in this report are for an area demarcated as Investigation Areas III and IV (Plates 1-1 and 1-2). Besides WFS III, Investigation Area III also includes the innovation site for wind turbine generator foundations, designated as 'WFS V' and the planned Substation Beta transformer

station, designated as 'SubStatB', of transmission system operator TenneT. WFS V and Substation Beta are included on Plate 1-2. The boundaries of WFS III, WFS IV and WFS V or the location of Substation Beta may be subject to change within Investigation Areas III&IV.

For practical reasons, the information obtained from locations in WFS V and at Substation Beta will be reported along with WFS III data. No further distinction or separation (other than location name) is made in this report.

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 B.

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. Companion reports for WFS III&IV contain results of geotechnical borehole locations, seafloor in situ test locations and describe a geological ground model for sites WFS III&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 Section A. 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;
- Section A provides the principal information as described in Section 1.2 "Scope of Report". This section should be read in conjunction with the Plates following Main Text, where applicable;
- Section A starts with primary information, which may consist of links to Plates following Main Text. Plate numbering starts with a section number, e.g. Plate A1-1 belongs to Section A1.

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 Borssele Wind Farm Zone (RVO, 2015a; Periplus, 2015);
- Geotechnical Scope of Work (RVO, 2015b).

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

2.2 Laboratory Test Programme

2.2.1 Test Results

Geotechnical laboratory testing comprised (where appropriate) geotechnical index, microscopic inspection, and (cyclic) strength. Static and cyclic strength tests included isotropically consolidated undrained triaxial in compression and extension (CIUc/CIUe) with bender element (BE) tests on selected samples, cyclic CIU triaxial (CTXL), direct simple shear (DSS) and cyclic DSS (CSS). Laboratory test results are provided in Section A “Geotechnical Laboratory Test Results”. Section A further presents details and includes commentary on individual test results where required.

The static and cyclic test programme covered specimens of seven distinct soil units present across WFS III&IV; microscopic inspection was performed on the coarse-grained cohesionless soil units tested in the static and cyclic test programme plus an additional seven soils units. Refer to Table 2.1 and Section A for details.

Table 2.1: Overview of Tested Soil Units

Unit	Sub-unit	Formation (Member)	Test type(s)
A	-	Southern Bight (-)	Geotechnical index, microscopic inspection and (cyclic) strength
B	-	Eem/Kreftenheye (-)	Geotechnical index, microscopic inspection and (cyclic) strength
C2	-	Westkapelle Ground (-)	Microscopic inspection
D	-	Rupel (Rupel Clay)	(Cyclic) strength
E1	-	Tongeren (Ruisbroek Sand)	Microscopic inspection
E3	-	Tongeren (Bassevelde 3 Sand)	Geotechnical index, microscopic inspection and (cyclic) strength
E4	-	Tongeren (Bassevelde 2 Sand)	Microscopic inspection
E5	E5a	Tongeren (Bassevelde 1 Sand)	Microscopic inspection
E5	E5b	Tongeren (Bassevelde 1 Sand)	Geotechnical index, microscopic inspection and (cyclic) strength
F1	F1a	Dongen (Onderdijke)	Microscopic inspection
F1	F1c	Dongen (Onderdijke)	(Cyclic) strength
F2	-	Dongen (Buisputten)	Microscopic inspection
F3	-	Dongen (Zomergem)	(Cyclic) strength and microscopic inspection

In this report, soil units will be referred to using a combination of (sub-)unit and formation name (e.g. 'Unit E5b (Tongeren)').

Of the soil units tested in the cyclic test programme, Units A (Southern Bight), B (Eem/Kreftenheye), E3 (Tongeren), and E5b (Tongeren) consist predominantly of coarse-grained cohesionless soils; Units D (Rupel), F1c (Dongen), and F3 (Dongen) consist predominantly of fine-grained cohesive soils.

The cyclic test programme is detailed in Section A1.1.

Results of CTXL and CSS tests are plotted as cyclic degradation S-N curves, refer to Plate 2-1 to Plate 2-3 and Plate 2-6. The S-N curves show normalized cyclic shear stress (Cyclic Stress Ratio, CSR) versus number of cycles (N) for tests performed with average shear stress (τ_{av}) set to zero.

Normalization of cyclic shear stresses for fine-grained cohesive samples uses a static reference undrained shear strength ($s_{u;ref}$). This reference strength was selected using mainly CIU and DSS test results from nearby samples. When these results show undrained shear strength (s_u) values that were not in line with the general shear strength profile for that location, the reference strength was chosen based on in situ test data. Normalization of the static results plotted in the S-N curves for fine-grained cohesive samples uses the same reference strength as used for the corresponding cyclic tests. Normalization of cyclic shear stresses for coarse-grained cohesionless samples uses the applied vertical consolidation stress.

The degradation curves were generated using a best-fit power regression model through data points; static test results are included in these graphs. However, to derive the regression lines for coarse-grained cohesionless material (Plates 2-1 and 2-2), static test results have been omitted from the data set. Results from test CTXL04 on Unit A (Southern Bight) (refer to Fugro (2015)) were also omitted from the data set for generation of the regression line for Unit A.

For reference purposes, results from static and cyclic tests performed as part of the testing programme for WFS I&II (Fugro, 2015) are also presented in the S-N graphs and were used to derive regression lines. Presented S-N curves should be used with care. Specific design situations require verification of suitability of the laboratory approach and presented regression lines.

Some test results presented on the plates with S-N degradation curves have (nearly) identical number of cycles to failure (N_f)/CSR combinations and therefore plot on top of each other. Details about test results are presented in the summary tables (refer to Plates A1-1 to A1-9).

Plate 2-2 also includes background degradation curves proposed by Andersen (2009) for CSS tests with symmetrical cyclic loading (τ_{av} = 0) on normally consolidated sands and silts with selected relative densities ranging from 40% to 100% and consolidation stresses ranging from 85 kPa to 710 kPa. It may be noted that specimens from Unit A (Batch 1) and Unit B (Batch 2) were consolidated at lower stresses than the tests used to derive the background degradation curves.

Regression lines for the fine-grained cohesive materials (Plates 2-3 and 2-6) are generated using all test results that show a N_f of less than 1500 and only selected test results for specimens that did not

show failure before 1500 cycles. In case of multiple tests that did not fail before 1500 cycles, the test performed applying the highest CSR was used for the regression. Even though test results with no clear failure before 1500 cycles at lower CSRs were not considered for the regression lines, the data points are still included on Plates 2-3 and 2-6.

CSS and CTXL test data from tests on fine-grained cohesive specimens are further plotted with background Drammen Clay Model contours (Andersen, 1988), refer to Plates 2-4, 2-5, 2-7 and 2-8. Results are plotted for Drammen Clay Models with a yield stress ratio (YSR) of 1 and 4. Selected $s_{u;ref}$ is the same as used for the S-N normalization. On Plate 2-7, two CSS test results for Unit F1c have identical N_f/CSR combinations and therefore plot on top of each other. Details about average shear strain, cyclic shear strain and number of cycles at failure are presented for both tests to the right of the data point. Details about test results are presented in the summary table (refer to Plate A1-7).

2.2.2 Premises and Assumptions

The laboratory test programme was performed in addition to earlier laboratory test programmes carried out as part of this project (refer to Plate 1-3).

For the coarse-grained cohesionless soil units, test specimens were reconstituted. Testing was performed on batch samples, i.e. for each soil unit a selection of samples were mixed to form a batch. For each batch, static and cyclic testing was performed on specimens with the same target densities and consolidation stresses.

Undisturbed specimens were used for static and cyclic testing of fine-grained cohesive soil units. Test conditions, i.e. vertical and radial stresses for re-compression, were selected on the basis of estimated in situ stress conditions.

Cyclic testing was performed at a frequency of 0.1 Hz, i.e. a cycle of 10 seconds. Specimens were subjected to stress-controlled cyclic loading under undrained conditions and a sinusoidal loading waveform. Specimens were tested at selected cyclic shear stresses (τ_{cy}) and with, for the majority of tests, average shear stress (τ_{av}) set to zero. Two tests (CSS05 and CSS06R) were performed including application of a τ_{av}.

Specimen failure is considered to be achieved when one of the following conditions has been met:

- The average shear strain amplitude exceeds 3.75% in coarse-grained cohesionless soils or 15% in fine-grained cohesive soils;
- The cyclic shear strain amplitude exceeds 3.75% in coarse-grained cohesionless soils or 15% in fine-grained cohesive soils;
- Excess pore water pressure exceeds 95% of the effective stress in the specimen at the start of cycling;
- The applied cyclic shear stress drops to less than 90% of the specified value.

Cyclic testing was terminated when failure of the specimen was evident or at 1500 cycles, whichever condition came first.

2.2.3 Test preparations and test conditions

Triaxial testing was performed under isotropic conditions following an assessment of expected in situ stress conditions for Units D (Rupel), F1c (Dongen), and F3 (Dongen). Consolidation history of these units was estimated using available oedometer test data and using cone penetration test (CPT) correlation.

Coefficient of earth pressure at rest (K_0) was estimated using a proposed relation between OCR, plasticity and K_0 (Brooker and Ireland, 1965) and by using Mayne and Kulhawy (1982). Both methods indicated a K_0 value of around 1 for the fine-grained cohesive soil units.

In situ stress conditions used the unit weight profiles as used in calculation of derived CPT parameters, presented in companion reports (refer to Plate 1-3). For CIU triaxial tests (static and cyclic), final consolidation stresses were chosen similar to calculated in situ vertical effective stresses. For DSS and CSS tests, specimens were first consolidated to a pressure coinciding with approximately 80% of the assessed preconsolidation pressure, after which a secondary consolidation step took place where the consolidation stresses were reduced to pressures similar to the assessed in situ vertical effective stress. This methodology was applied to better simulate in situ stress conditions.

For coarse-grained cohesionless specimens, selected consolidation and test stresses represent an approximate average of in situ stress levels within the target formation. For the Southern Bight formation, a higher than average level was selected considering the recommended lower limits of the test apparatus (which is around 10 kPa to 15 kPa). Consolidation stresses are the same for tests on coarse-grained specimens from the same formation.

For tests on coarse-grained cohesionless material, “batch” samples were prepared. Available particle size distribution data from samples from various formations were used to select a number of samples with similar grading as the predominant grading of the target formation. On selected samples, microscopic inspection was performed to confirm that angularity and sphericity were similar. The microscopic inspection confirmed that samples could be batched. Section A3 presents results of the microscopic inspection. After samples were batched, sieving analyses were done to confirm that sample grading was in line with the predominant grading of the target formation. For verification of changes in specimen grading during testing, four additional particle size distribution analyses were performed on specimens that were used for CTXL tests (one for each batch). Results of the sieving analyses on the batch samples before testing are presented on Plate A2-1. On Plate A2-2 to A2-4 results of sieving analyses before and after testing are combined per batch.

Selection of dry densities for preparation of coarse-grained cohesionless specimens was based on (a) average measured unit weights and water contents and (b) test conditions used for tests performed previously on specimens from similar soil units. Selected dry densities represent relative densities of approximately 70% (Unit A - Southern Bight), 100% (Unit B - Eem/Kreftenheye), and 60% (Units E3 and E5b - Tongeren). It may be noted that the method for determination of the maximum index unit weight is different from the method of triaxial test specimen preparation. The results of maximum index unit weight tests are typically higher and may not be fully achieved during test specimen preparation.

3. REFERENCES

Andersen, K.H. and Lauritzsen, R., 1988. Bearing Capacity for Foundations with Cyclic Loads. *Journal of Geotechnical Engineering*, Vol. 114, No.5, pp. 540-555.

Andersen, K.H., 2009. Bearing Capacity under Cyclic Loading - Offshore, along the Coast, and on Land. The 21st Bjerrum Lecture presented in Oslo, 23 November 2007. *Canadian Geotechnical Journal*, Vol. 46, No. 5, pp. 513-535.

Brooker, E.W. and Ireland, H.O., 1965. Earth Pressures at Rest Related to Stress History. *Canadian Geotechnical Journal*, Vol. 2, No. 1, pp. 1-15.

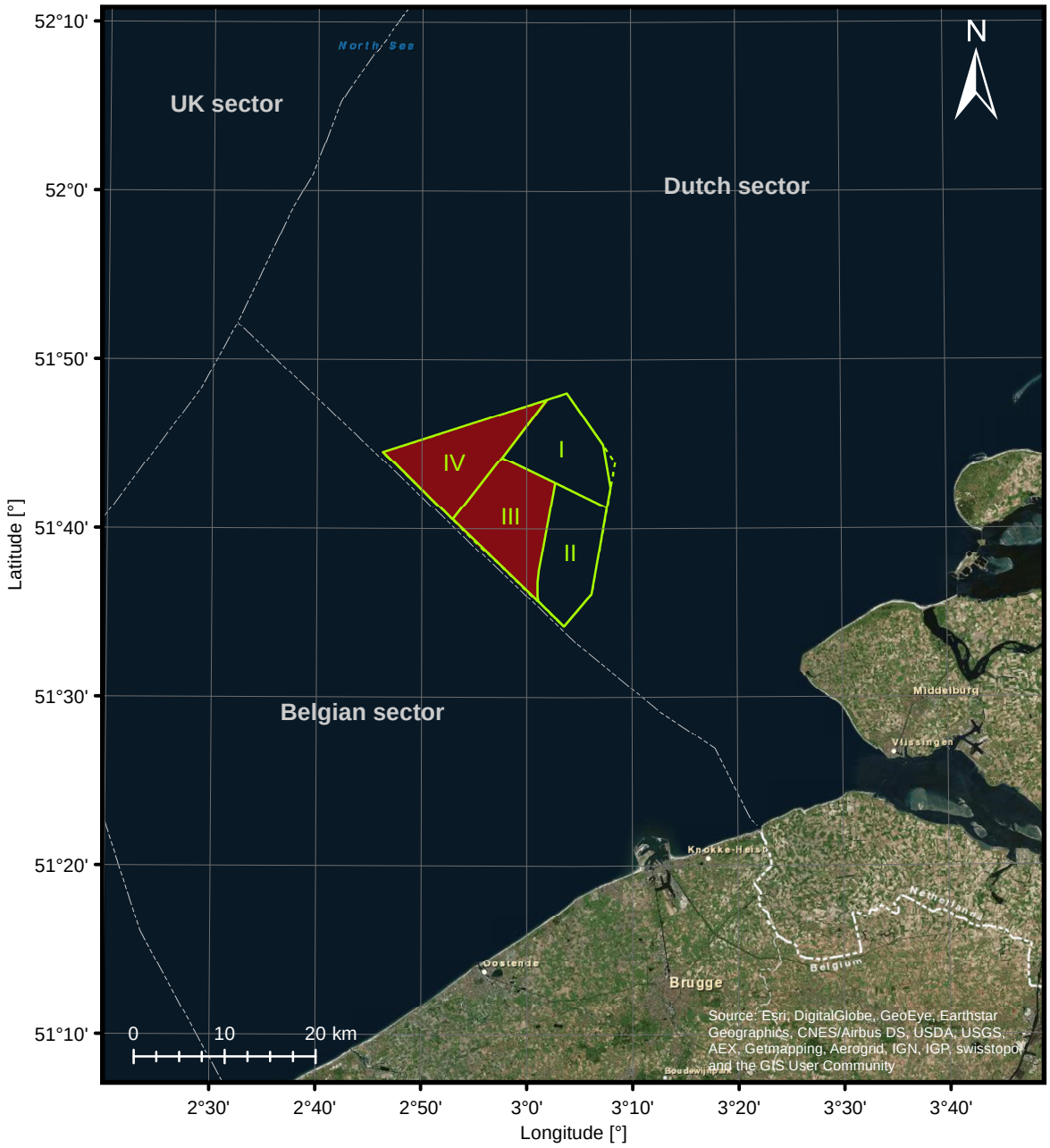
Fugro, 2015. *Geotechnical Report – Laboratory Test Data – Wind Farm Site I&II – Borssele Wind Farm Zone – Dutch Sector, North Sea*, Fugro Report No. N6016/07, Issue 3, 4 September 2015.

Mayne, P.W. and Kulhawy, F.H., 1982. K_o - OCR Relationships in Soil*. Journal of the Geotechnical Engineering Division,* Vol. 108, No. GT6, pp. 851-872.

Periplus, 2015. *20150828 Borssele Sector 5 – coordinates*, email sent to Fugro, 28 August 2015.

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 III & IV (subjects of this report)

Outline of Borssele Wind Farm Zone

Outline Borssele Investigation Area (Roman numeral indicates area number)

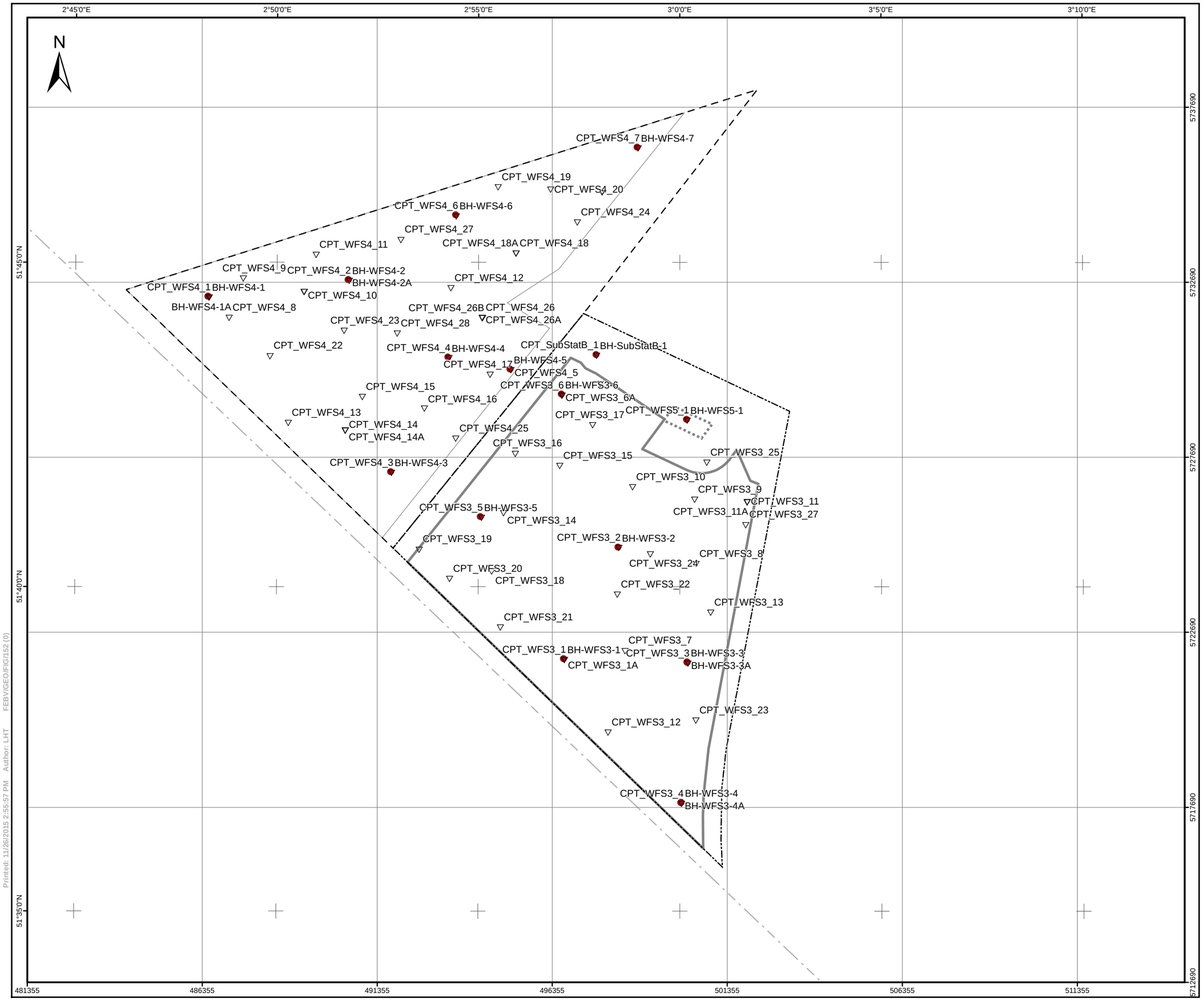
Maritime Boundary

Ellipsoid: GRS 1980
Datum: ETRS 1989

Printed: 11/26/2015 2:53:50 PM

VICINITY MAP

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



Printed: 11/26/2015 2:55:57 PM Author: LHT FERV/GEO/FIG/152 (0)

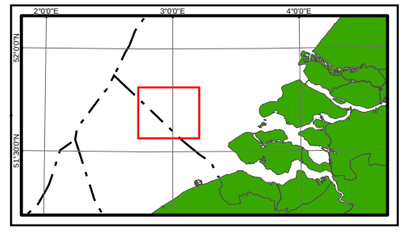
LEGEND:

- CPT location
- BH location
- Outline of WFS V
- Investigation Area III
- Investigation Area IV
- Outline of WFS 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 III & IV
DUTCH SECTOR, NORTH SEA

Scale 1:100,000
at original A3 page size

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

Fugro Report No. N6083/07	Issue 1	Plate 1-2

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.

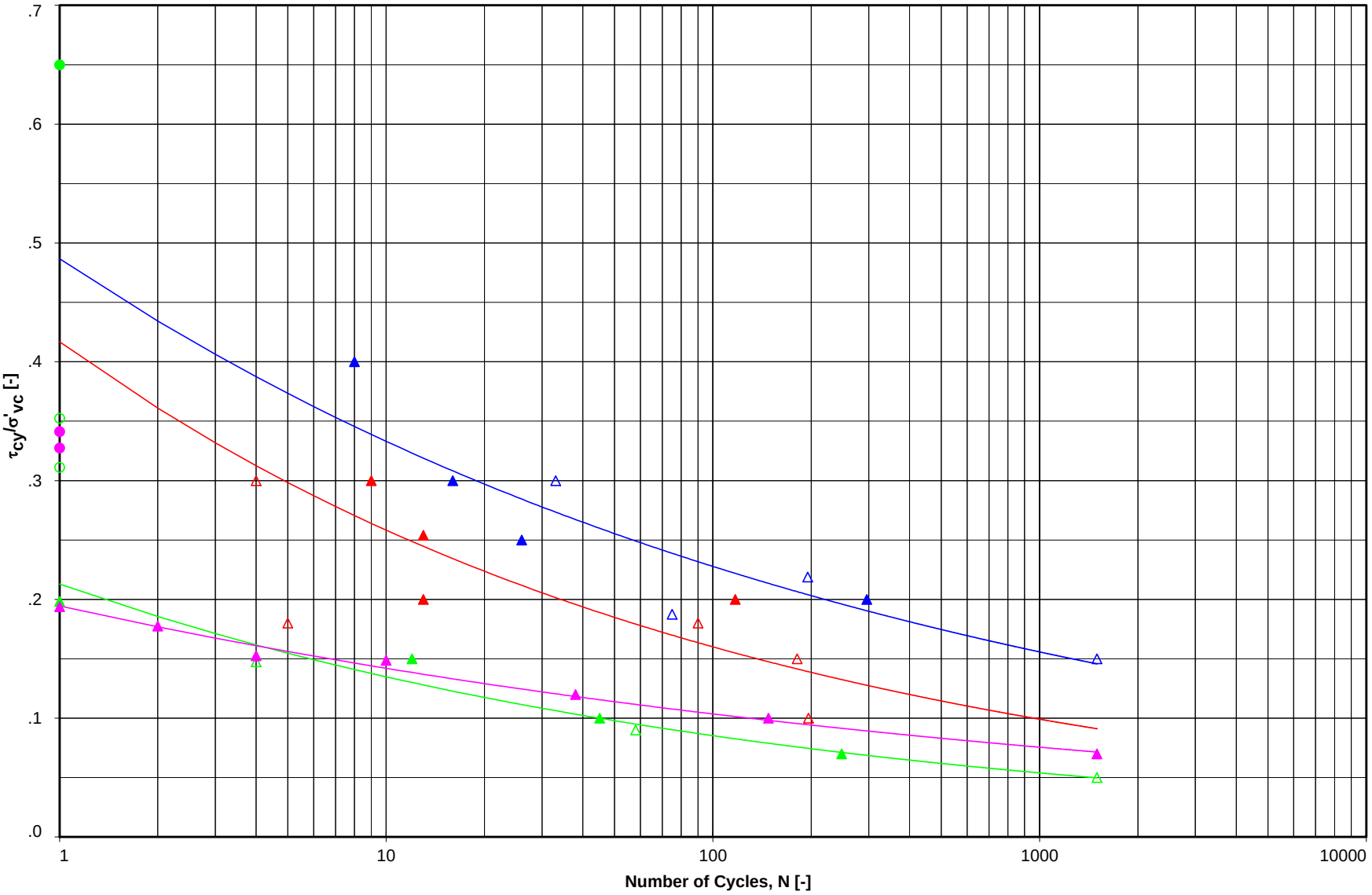
ISSUE 04
FEBV/CDE/TAB/052
© Fugro 1998-2014

LIST OF PROJECT REPORTS
BORSSELE WIND FARM ZONE, WFS III & IV – DUTCH SECTOR, NORTH SEA

PPPWIN 03.26.nl/N6083_S-N_CTXL_Cohesionless.ppp/2016-03-31 09:09:54

NORMALIZED CYCLIC SHEAR STRESS VERSUS NUMBER OF CYCLES TO FAILURE

BORSSELE WIND FARM SITE III&IV - DUTCH SECTOR, NORTH SEA



S-N Degradation curve for Unit A (Southern Bight) $\tau_{cy}/\sigma'_{vc} = 0.417*N^{-0.208}$

S-N Degradation curve for Unit B (Eem/Kreftenheye) $\tau_{cy}/\sigma'_{vc} = 0.487*N^{-0.165}$

S-N Degradation curve for Unit E3 (Tongeren) $\tau_{cy}/\sigma'_{vc} = 0.213*N^{-0.199}$

S-N Degradation curve for Unit E5b (Tongeren) $\tau_{cy}/\sigma'_{vc} = 0.195*N^{-0.137}$

Test results - Unit A (Southern Bight) at σ'_{vc} = 25 kPa

Test results - Unit B (Eem/Kreftenheye) at σ'_{vc} = 80 kPa

Test results - Unit E3 (Tongeren) at σ'_{vc} = 300 kPa

Test results - Unit E5b (Tongeren) at σ'_{vc} = 400 kPa

▲ CTXL - WFSIII&IV

△ CTXL - WFSI&II

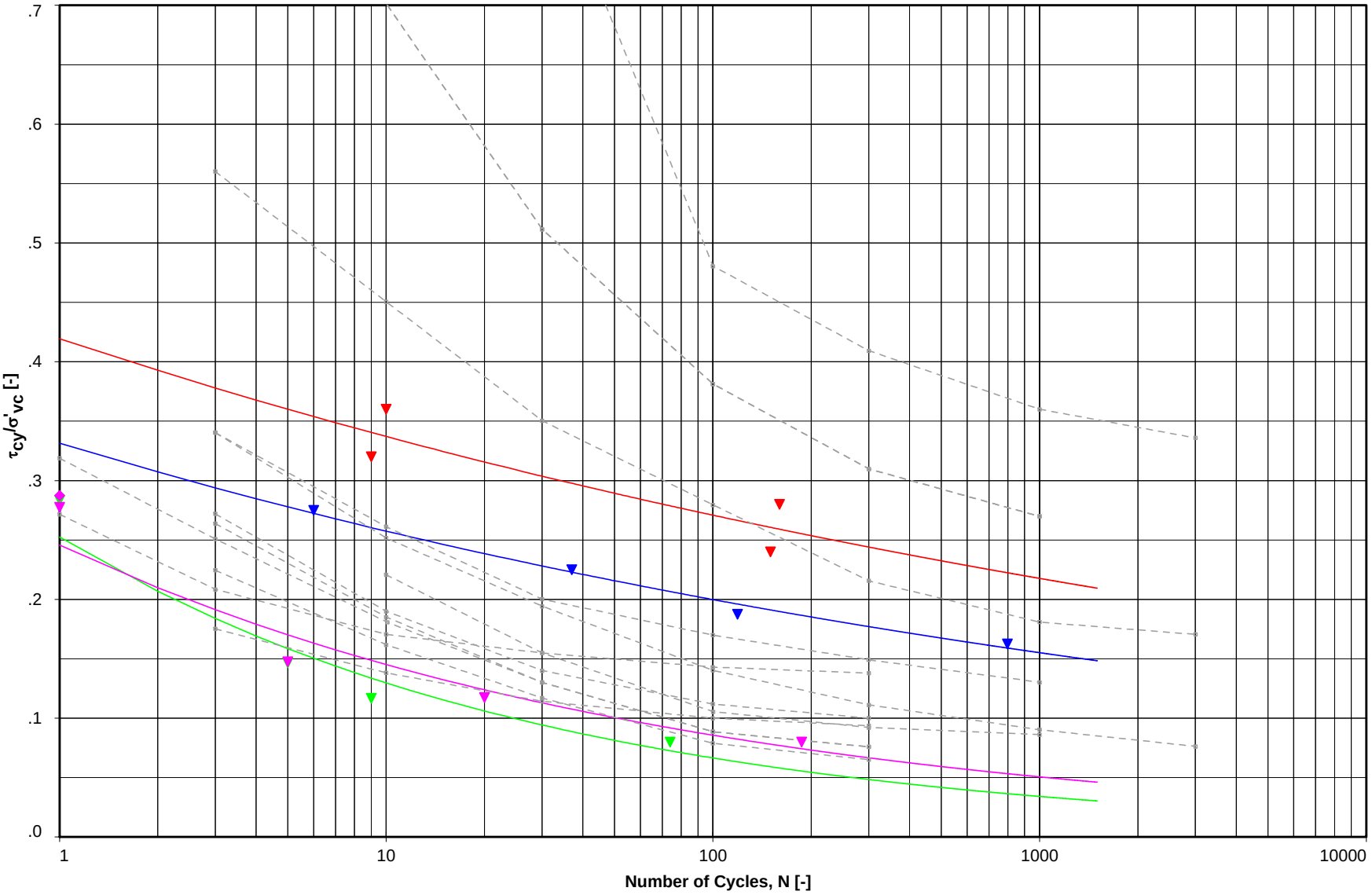
● CIU - WFSIII&IV

○ CIU - WFSI&II

PPPWIN 03.26.nl/N6083_S-N_CSS_Cohesionless.ppp/2016-03-31 15:47:48

NORMALIZED CYCLIC SHEAR STRESS VERSUS NUMBER OF CYCLES TO FAILURE

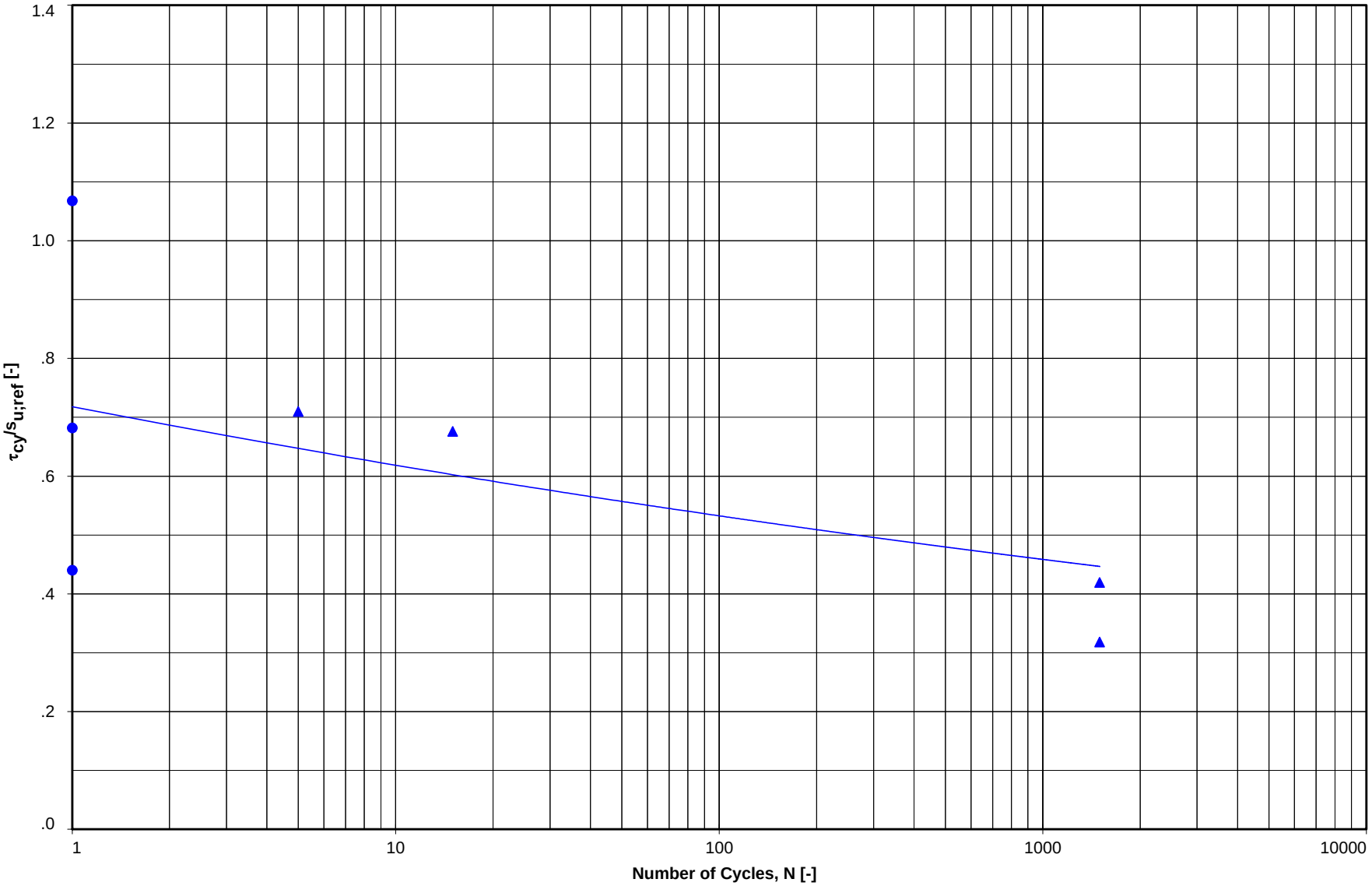
BORSSELE WIND FARM SITE III&IV - DUTCH SECTOR, NORTH SEA



PPPWIN 03.26.nl/N6083_S-N_CTXL_Cohesive.ppp/2016-03-31 15:45:49

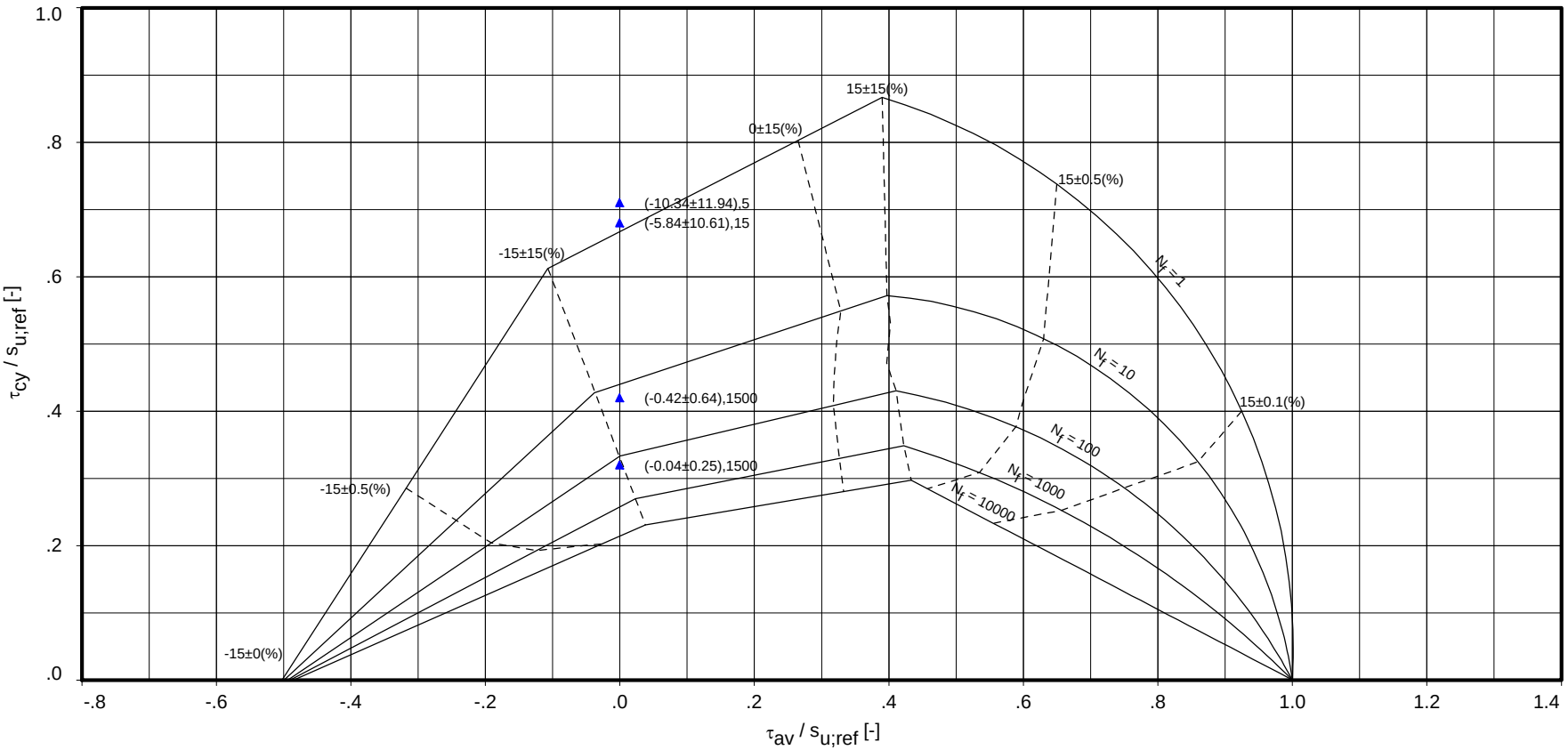
NORMALIZED CYCLIC SHEAR STRESS VERSUS NUMBER OF CYCLES TO FAILURE

BORSSELE WIND FARM SITE III&IV - DUTCH SECTOR, NORTH SEA



CYCLIC TRIAXIAL TESTS - DRAMMEN CLAY COMPARISON (YSR=1)

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



▲ CTXL test results - Unit F3 (Dongen), WFS III&IV

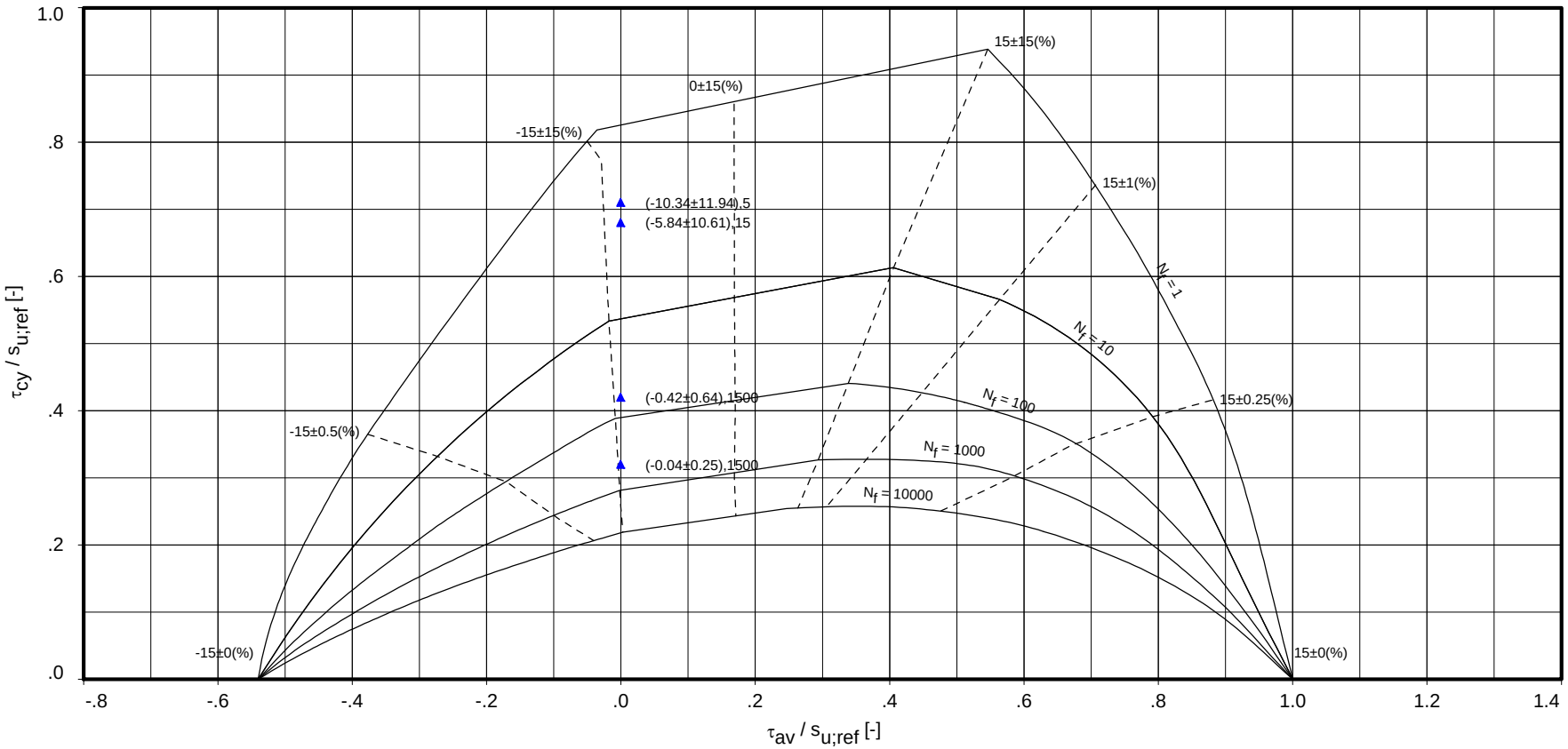
Notes:

- Comparison of cyclic triaxial test results with Drammen clay model at YSR = 1 (Andersen et al., 1988)
- $(\gamma_{av} \pm \gamma_{cy}),N_f$: Average shear strain and cyclic shear strain (%) at final number of cycles

PPPWIN 03.26.nl/N6083_Drammen_CTXL_YSR=04.ppp/2016-03-30 14:46:52

CYCLIC TRIAXIAL TESTS - DRAMMEN CLAY COMPARISON (YSR=4)

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



▲ CTXL test results - Unit F3 (Dongen), WFS III&IV

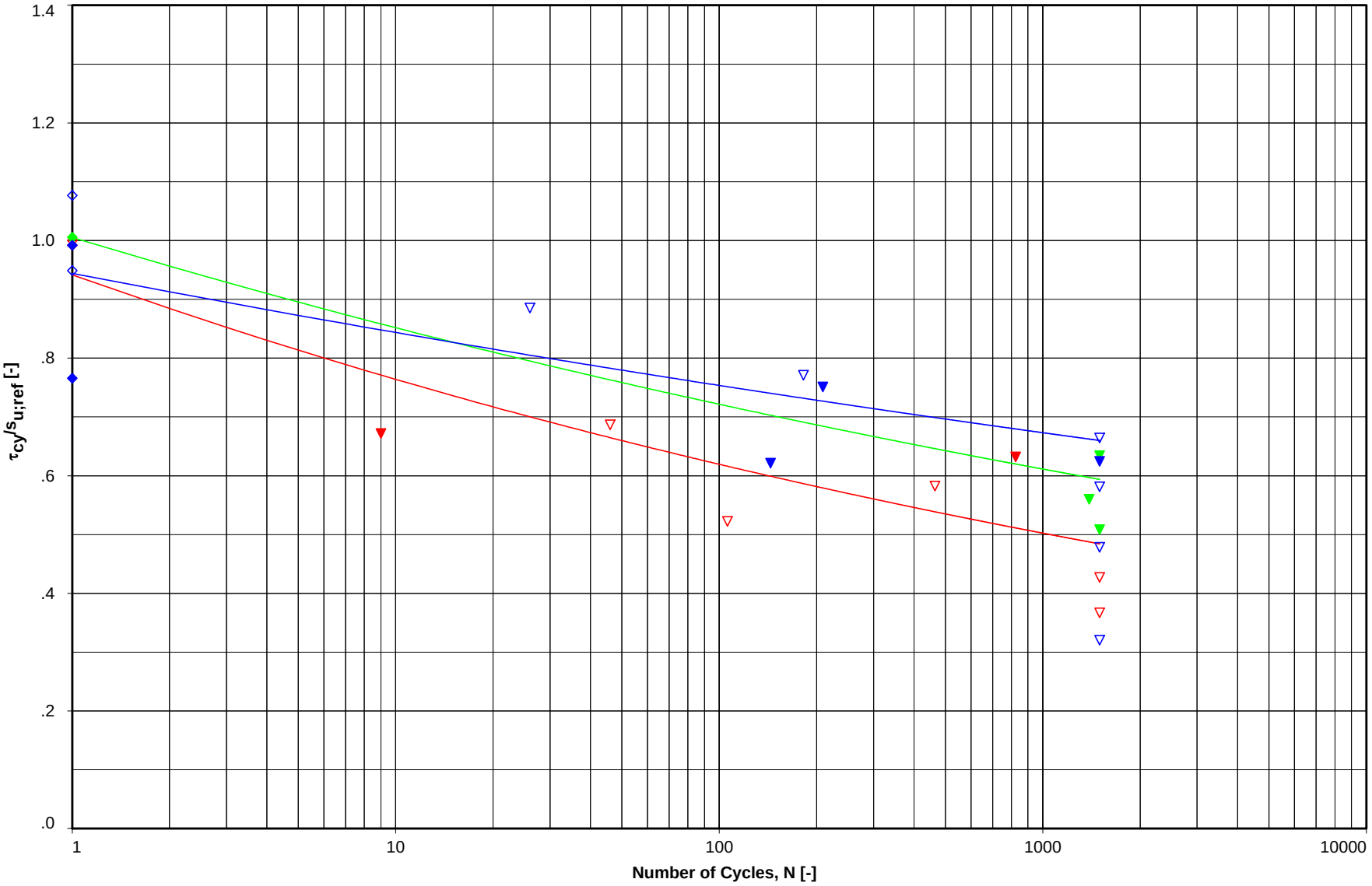
Notes:

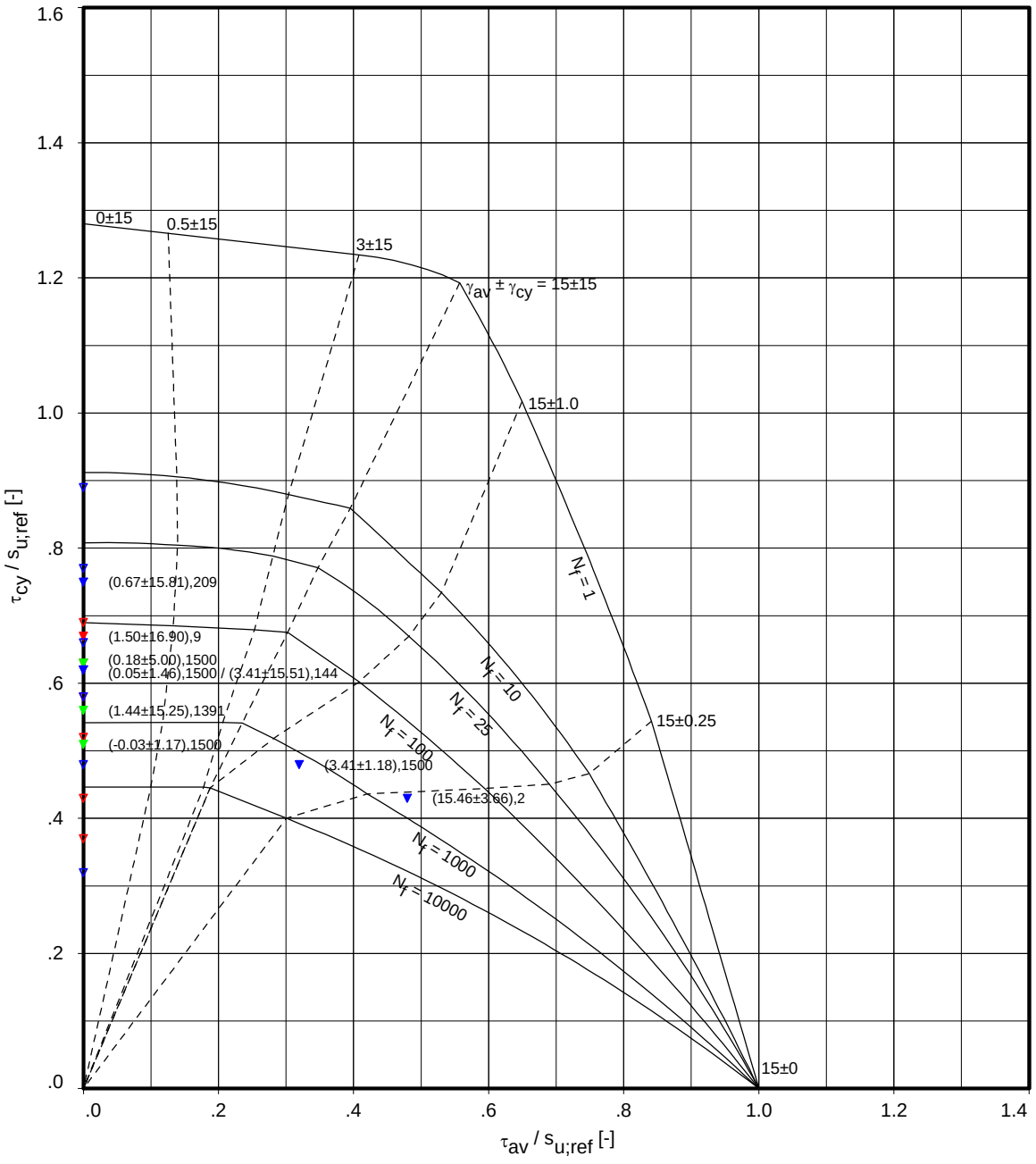
- Comparison of cyclic triaxial test results with Drammen clay model at YSR = 4 (Andersen et al., 1988)
- $(\gamma_{av} \pm \gamma_{cy}),N_f$: Average shear strain and cyclic shear strain (%) at final number of cycles

PPPWIN 03.26.nl/N6083_S-N_CSS_Cohesive.ppp/2016-03-31 15:51:13

NORMALIZED CYCLIC SHEAR STRESS VERSUS NUMBER OF CYCLES TO FAILURE

BORSSELE WIND FARM SITE III&IV - DUTCH SECTOR, NORTH SEA



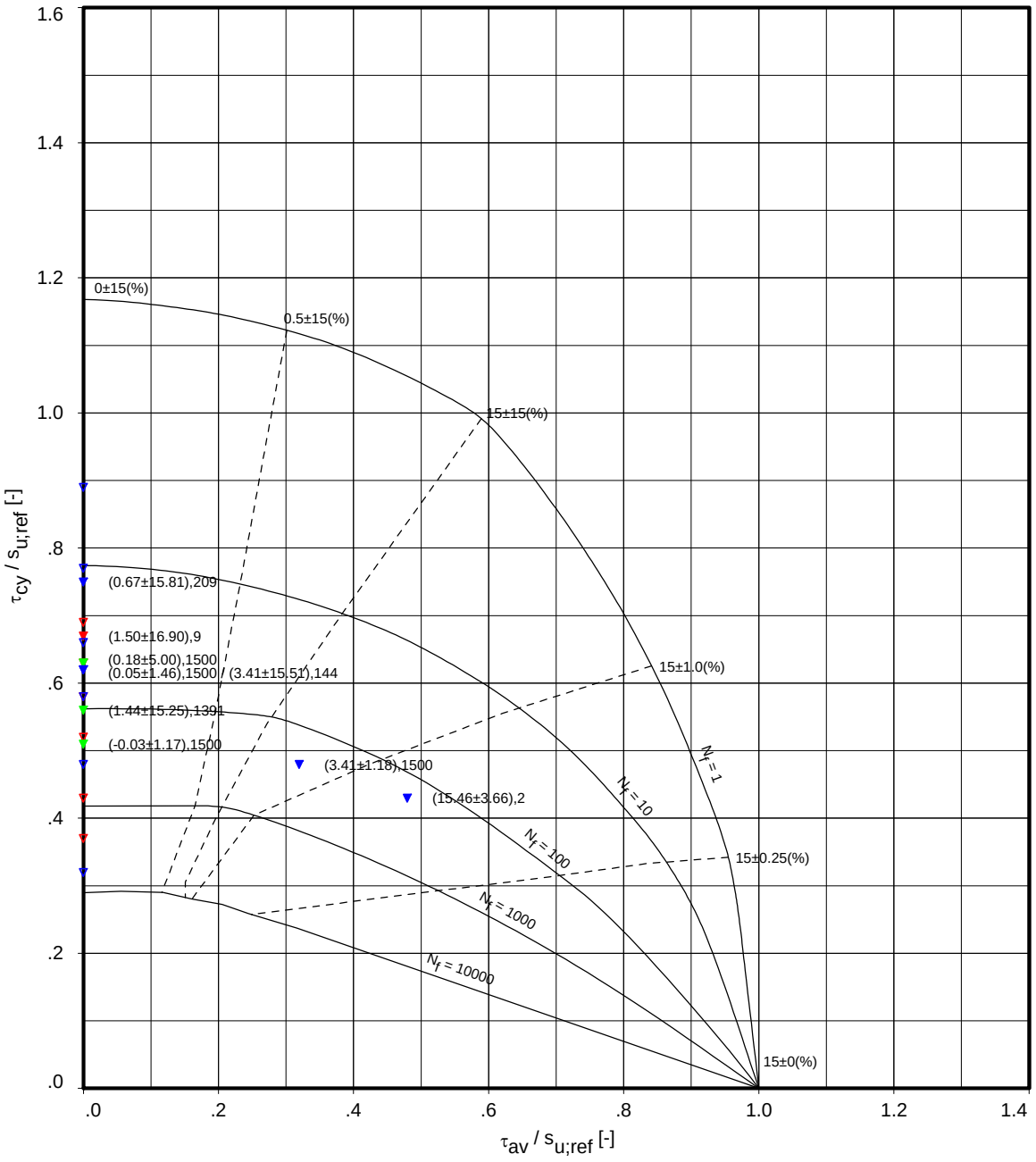


Notes:
- Comparison of cyclic direct simple shear test results with Drammen clay model at YSR = 1 (Andersen et al., 1988)
- $(\gamma_{av} \pm \gamma_{cy})$,$N_f$: Average shear strain and cyclic shear strain (%) at final number of cycles

PPPWIN 03.26.nl/N6083_Drammen_CSS_YSR=01.ppp/2016-03-30 15:07:20

CYCLIC DIRECT SIMPLE SHEAR TESTS - DRAMMEN CLAY COMPARISON (YSR=1)

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



- Test results - Unit D (Rupel)
- Test results - Unit F1c (Dongen)
- Test results - Unit F3 (Dongen)
- ▼ CSS - WFSIII&IV
- ▽ CSS - WFSI&II

Notes:
- Comparison of cyclic direct simple shear test results with Drammen clay model at YSR = 4 (Andersen et al., 1988)
- $(\gamma_{av} \pm \gamma_{cy}),N_f$: Average shear strain and cyclic shear strain (%) at final number of cycles

PPPWIN 03.26.nl/N6083_Drammen_CSS_YSR=04.ppp/2016-03-30 15:08:49

CYCLIC DIRECT SIMPLE SHEAR TESTS - DRAMMEN CLAY COMPARISON (YSR=4)

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

SECTION A: GEOTECHNICAL LABORATORY TEST RESULTS

SECTION A1: LABORATORY TESTING OVERVIEW
SECTION A2: INDEX LABORATORY TESTS
SECTION A3: MICROSCOPIC INSPECTION
SECTION A4: STATIC TRIAXIAL TESTS
SECTION A5: STATIC DIRECT SIMPLE SHEAR TESTS
SECTION A6: CYCLIC TRIAXIAL TESTS
SECTION A7: CYCLIC DIRECT SIMPLE SHEAR TESTS

SECTION A1: LABORATORY TESTING OVERVIEW

TEXT – SECTION A1: Page

A1. LABORATORY TESTING OVERVIEW

A1.1 SUMMARY OF LABORATORY TESTS A1-1 to A1-5
A1.2 QUALITY OF RESULTS A1-6
A1.3 PRACTICE FOR SAMPLE HANDLING AND LABORATORY TESTING A1-7
A1.4 INDEX LABORATORY TESTS A1-8
A1.5 MICROSCOPIC INSPECTION A1-8
A1.6 STATIC TRIAXIAL TESTS A1-8 to A1-9
A1.7 STATIC DIRECT SIMPLE SHEAR TESTS A1-9
A1.8 CYCLIC TRIAXIAL TESTS A1-9 to A1-10
A1.9 CYCLIC DIRECT SIMPLE SHEAR TESTS A1-10
A1.10 REFERENCES A1-10

LIST OF PLATES IN SECTION A1: Plate

Summary of Isotropically Consolidated Undrained Triaxial Test Results - Cohesive Specimens A1-1
Summary of Isotropically Consolidated Undrained Triaxial Test Results - Cohesionless Specimens A1-2
Summary of Cyclic Triaxial Test Results - Cohesive Specimens A1-3
Summary of Cyclic Triaxial Test Results: Consolidation Stage - Cohesionless Specimens A1-4
Summary of Cyclic Triaxial Test Results: Test Results - Cohesionless Specimens A1-5
Summary of (Cyclic) Direct Simple Shear Test Results: Consolidation Stage - Cohesive Specimens A1-6
Summary of (Cyclic) Direct Simple Shear Test Results: Test Stage - Cohesive Specimens A1-7
Summary of (Cyclic) Direct Simple Shear Test Results: Consolidation Stage - Cohesionless Specimens A1-8
Summary of (Cyclic) Direct Simple Shear Test Results: Test Stage - Cohesionless Specimens A1-9

A1. LABORATORY TESTING OVERVIEW

A1.1 SUMMARY OF LABORATORY TESTS

Main Text Section 2.2 titled “Laboratory Test Programme” presents an overview of the geotechnical laboratory tests performed including discussion of adopted strategy, premises and assumptions. Section A presents results from the performed laboratory tests. Table A1.1 presents the type and number of laboratory tests along with test references. Note that water content, unit weight and pocket penetrometer tests, which are part of selected test types are not presented in this table. Laboratory test data are presented per type per section.

Table A1.1: Overview of Laboratory Test Programme

	Unit														
	Total	A (Southern Bight)	B (Eem/Kreftenheye)	C2 (Westkapelle Ground)	D (Rupel)	E1 (Tongeren)	E3 (Tongeren)	E4 (Tongeren)	E5a (Tongeren)	E5b (Tongeren)	F1a (Dongen)	F1c (Dongen)	F2 (Dongen)	F3 (Dongen)	
Test Type	**Number of Tests**														**Test Procedure**
Geotechnical Index															
Particle Size Distribution (sieving/pipette)	4	1	1	-	-	-	1	-	-	1	-	-	-	-	BS1377:Part 2:1990 / Fugro in-house procedure
Microscopic Inspection	66	9	19	1	-	3	9	2	3	15	2	-	2	1	In general accordance with BS5930:1999+A2:2010 / Fugro in-house procedures
Strength															
Isotropically Consolidated Undrained Triaxial in compression (CIUc) (with bender elements)	10 (6)	1 (1)	1 (1)	-	-	-	1 (1)	-	-	2 (1)	-	2 (1)	-	3 (1)	BS1377:Part 8:1990 / Fugro in-house procedure L-T-023
Isotropically Consolidated Undrained Triaxial in extension (CIUe)	4	-	-	-	-	-	-	-	-	-	-	2	-	2	BS1377:Part 8:1990 / Fugro in-house procedure L-T-023
Direct Simple Shear (DSS)	11	2	2	-	1	-	2	-	-	1	-	1	-	2	Fugro in-house procedure based on ASTM D6528-07
Cyclic															
Cyclic Isotropically Consolidated Undrained Triaxial (CTXL)	23	4	4	-	-	-	4	-	-	7	-	-	-	4	BS1377:Part 8:1990 / Fugro in-house procedure L-T-023
Cyclic Direct Simple Shear (CSS)	26	4	4	-	2	-	4	-	-	4	-	3	-	5	Fugro in-house procedure based on ASTM D6528-07

Testing of coarse-grained cohesionless material was performed on batch samples. For testing on fine-grained cohesive soils, undisturbed wax samples were used. Tables A1.2 and A1.3 present summaries of the selected samples used for batch sample preparation and strength testing.

Table A1.2: Test Specimens per Coarse-grained Cohesionless Soil Unit

Soil Unit[(1)]	Location	Site	Sample	Sample Depth [m BSF]	Test Type(s)
A (Southern Bight) - Batch 1	BH-WFS3-1	WFS III	1BagB	0.35	DSS, CSS, CIU+BE, CTXL
	BH-WFS3-2	WFS III	1BagA	0.00	
	BH-WFS3-3	WFS III	1BagB	0.25	
	BH-WFS3-5	WFS III	1BagA	0.00	
	BH-WFS3-6	WFS III	2BagA	0.50	
	BH-SubStatB-1	WFS III	2BagA	0.50	
	BH-WFS4-4	WFS IV	1BagA	0.00	
	BH-WFS4-7	WFS IV	1BagB	0.35	
B (Eem/Kreftenheye) - Batch 2	BH-WFS3-1	WFS III	7BagA	5.00	DSS, CSS, CIU+BE, CTXL
	BH-WFS3-1	WFS III	18BagA	12.00	
	BH-WFS3-6	WFS III	16BagA	11.00	
	BH-WFS5-1	WFS III	5BagA	4.00	
	BH-SubStatB-1	WFS III	5BagA	3.50	
	BH-SubStatB-1	WFS III	11BagA	8.00	
	BH-WFS4-5	WFS IV	9BagA	4.50	
	BH-WFS4-5	WFS IV	15BagA	8.00	
	BH-WFS4-6	WFS IV	21BagA	12.50	
	BH-WFS4-7	WFS IV	6BagB	4.75	
E3 (Tongeren) - Batch 3	BH-WFS5-1	WFS III	16BagB	18.40	DSS, CSS, CIU+BE, CTXL
	BH-SubStatB-1	WFS III	16BagA	11.00	
	BH-SubStatB-1	WFS III	22BagA	14.50	
	BH-SubStatB-1	WFS III	23BagA	18.00	
	BH-WFS4-6	WFS IV	25BagA	17.50	
	BH-WFS4-7	WFS IV	28BagA	42.50	
	BH-WFS4-7	WFS IV	29BagA	46.50	
E5b (Tongeren) - Batch 4	BH-WFS3-3A	WFS III	13BagA	26.50	DSS, CSS, CIU(+BE), CTXL
	BH-WFS3-6	WFS III	25BagA	33.50	
	BH-WFS3-6	WFS III	26BagA	37.50	
	BH-WFS5-1	WFS III	24BagA	49.50	
	BH-WFS4-2A	WFS IV	12BagA	18.00	
	BH-WFS4-3	WFS IV	13BagB	10.80	
	BH-WFS4-3	WFS IV	18BagA	14.00	
	BH-WFS4-5	WFS IV	31BagA	26.00	
	BH-WFS4-6	WFS IV	33BagA	48.00	

Note:
[(1)] Samples for units A (Southern Bight), B (Eem/Kreftenheye), E3 (Tongeren) and E5b (Tongeren) were batched.

Table A1.3: Test Specimens per Fine-grained Cohesive Soil Unit

Soil Unit	Location	Site	Sample	Sample Depth [m BSF]	Test Type(s)
D (Rupel)	BH-WFS4-7	WFS IV	22WaxD	23.56	DSS
	BH-WFS4-7	WFS IV	22WaxD	23.64	CSS
	BH-WFS4-7	WFS IV	22WaxD	23.68	CSS
F1c (Dongen)	BH-WFS3-4A	WFS III	2WaxD	23.36	DSS
	BH-WFS3-4A	WFS III	2WaxD	23.40	CSS
	BH-WFS3-4A	WFS III	2WaxD	23.44	CSS
	BH-WFS3-4A	WFS III	2WaxD	23.48	CSS
	BH-WFS3-4A	WFS III	3WaxE	24.47	CIUe
	BH-WFS3-1	WFS III	27WaxC	32.37	CIUc+BE
	BH-WFS3-1	WFS III	28WaxB	33.05	CIUe
	BH-WFS3-5	WFS III	31WaxB	36.55	CIUc
F3 (Dongen)	BH-WFS3-4A	WFS III	6WaxD	33.39	DSS
	BH-WFS3-4A	WFS III	6WaxD	33.40	CSS
	BH-WFS3-4A	WFS III	6WaxB	33.12	CSS
	BH-WFS3-4A	WFS III	6WaxF	33.61	CSS
	BH-WFS4-1A	WFS IV	22WaxB	37.06	CIUc+BE
	BH-WFS4-1A	WFS IV	22WAXC	37.48	CTXL
	BH-WFS4-1A	WFS IV	23WaxB	38.20	DSS
	BH-WFS4-1A	WFS IV	23WaxB	38.24	CSS
	BH-WFS3-4A	WFS III	8WAXC	38.48	CTXL
	BH-WFS3-4A	WFS III	9WaxB	39.13	CIUe
	BH-WFS3-4A	WFS III	9WaxC	39.38	CIUc
	BH-WFS3-1	WFS III	30WAXC	41.58	CTXL
	BH-WFS3-1	WFS III	31WaxB	42.15	CIUc
	BH-WFS4-1A	WFS IV	24WaxB	42.18	CSS
	BH-WFS3-1	WFS III	31WaxC	43.37	CIUe
	BH-WFS4-3	WFS IV	29WAXC	45.88	CTXL

Table A1.4 presents an overview of the selected dry densities and consolidation pressures for the various batch samples. In general sample preparation achieved the specified conditions.

Table A1.4: Target Test Preparation Conditions for Batch Samples

Soil Unit	Test Types	Target Dry Density [Mg/m^3]	Isotropic Consolidation Stress [kPa]
A (Southern Bight) - Batch 1	DSS, CSS, CIU(+BE), CTXL	1.63	25
B (Eem/Kreftenheye) - Batch 2		1.70	80
E3 (Tongeren) - Batch 3		1.61	300
E5b (Tongeren) - Batch 4		1.61	400

Note:
- Actual dry densities may vary slightly compared to target dry densities

Figures 1 to 4 present summaries of the particle size distribution curves of the individual samples used for batching, as well as for the batch as a whole.

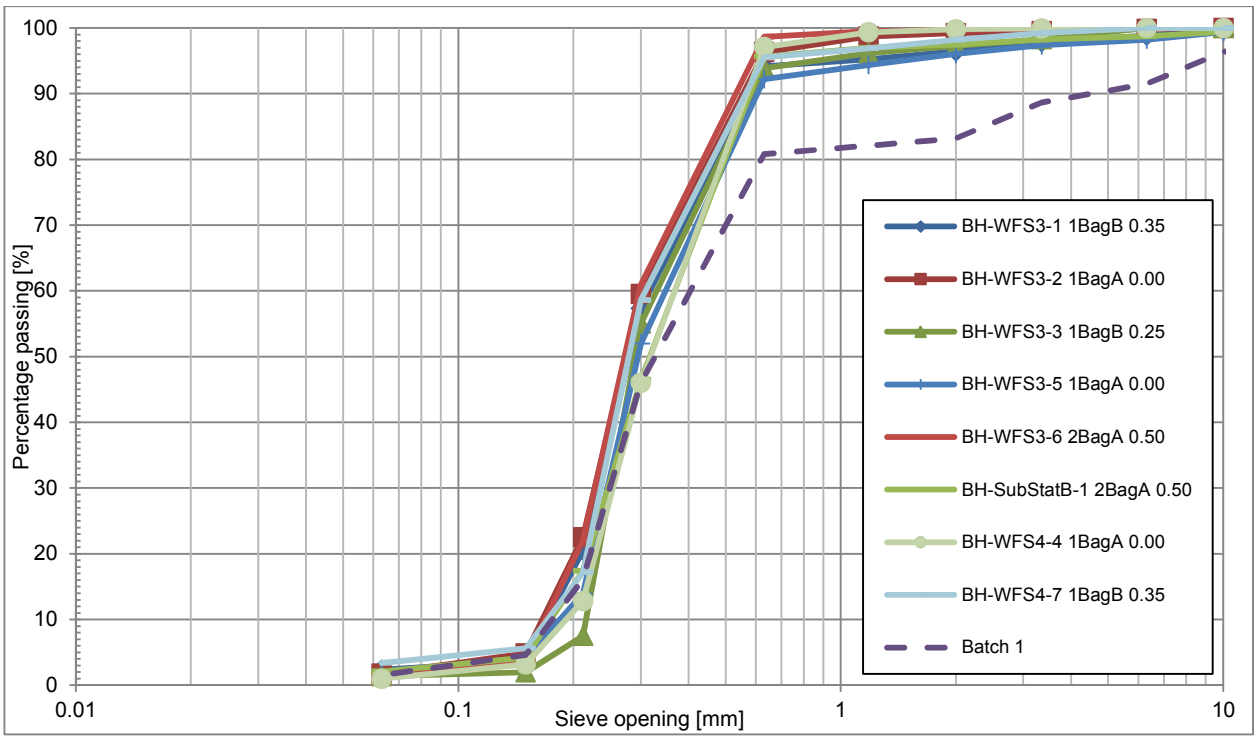


Figure 1. PSD curves of individual samples and batch sample (Batch 1 - Unit A (Southern Bight))

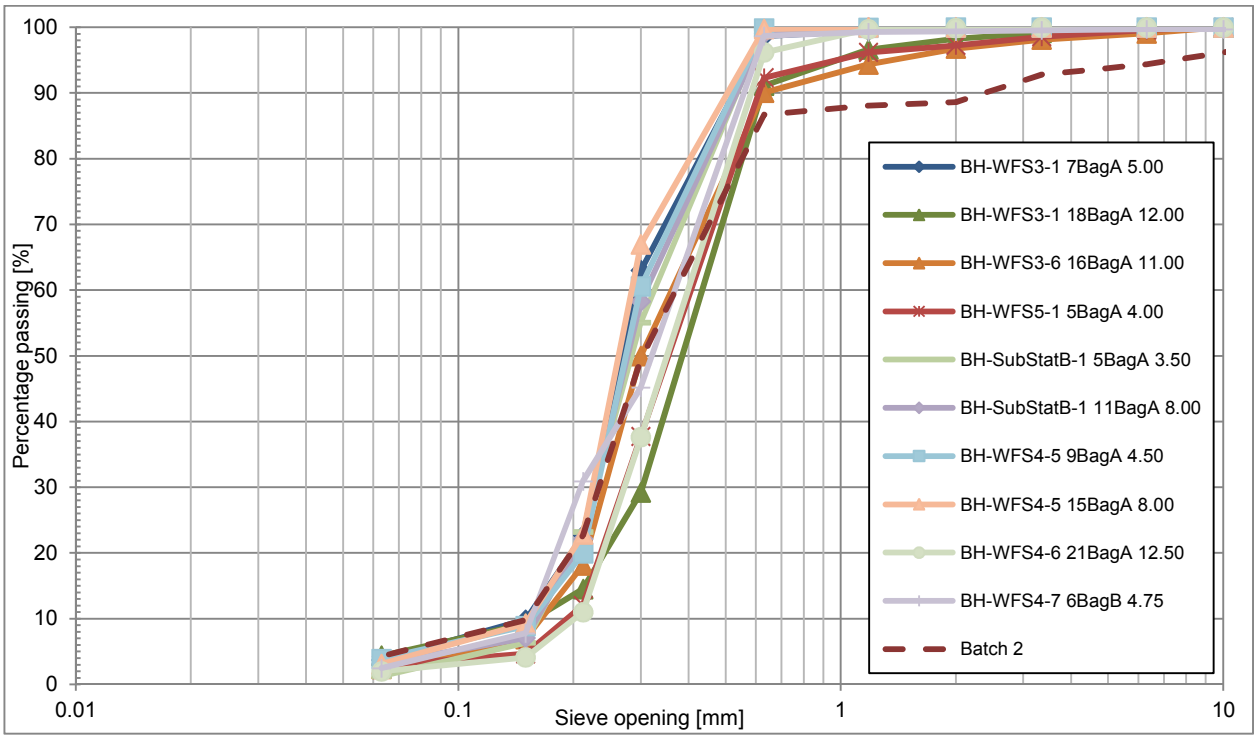


Figure 2. PSD curves of individual samples and batch sample (Batch 2 - Unit B (Eem/Kreftenheye))

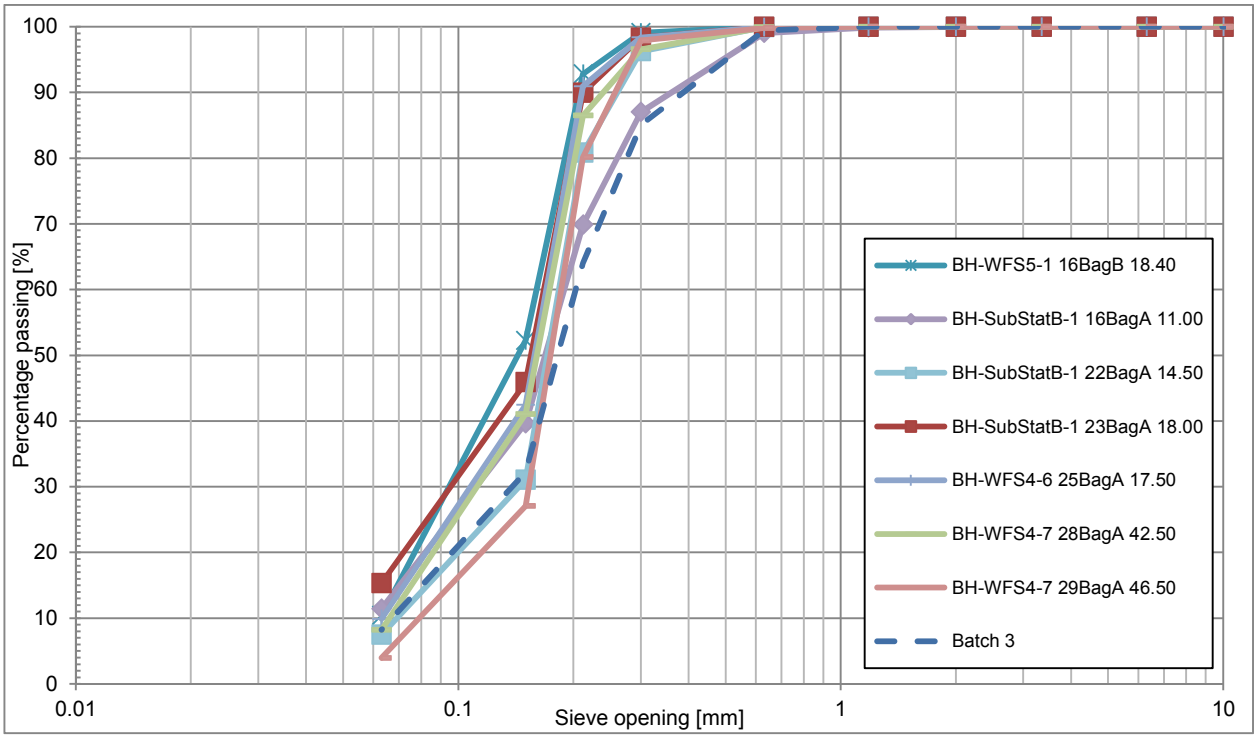


Figure 3. PSD curves of individual samples and batch sample (Batch 3 - Unit E3 (Tongeren))

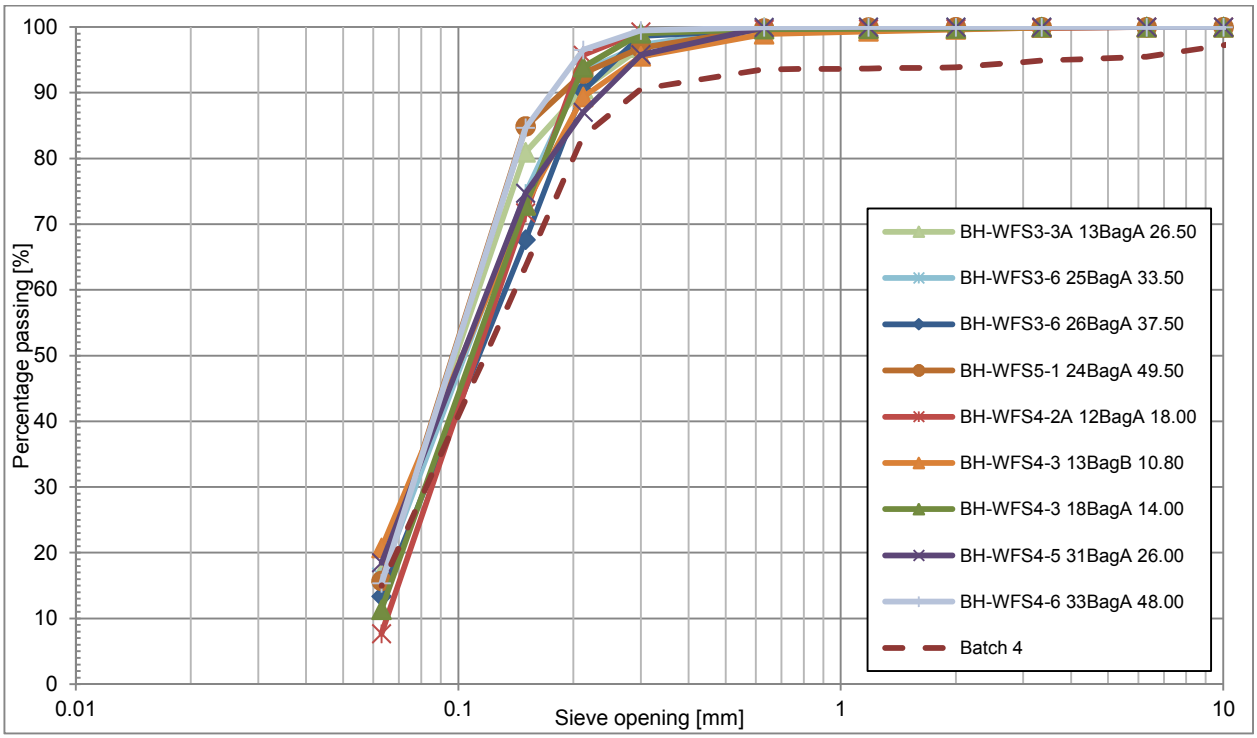


Figure 4. PSD curves of individual samples and batch sample (Batch 4 - Unit E5b (Tongeren))

A1.2 QUALITY OF RESULTS

In general, the laboratory test results are considered to be of good quality. Assessed data quality is according to expectations for used sampling practice and laboratory test methods. Laboratory tests were only performed on suitable soil samples.

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 strength tests results correlate reasonably well with the shear strength derived from in situ tests reported in companion reports (refer to Plate 1-3), although some scatter is noted. This is likely attributed to heterogeneity of the test specimens in combination with differences between the various testing techniques used.

According to ISO (2014), an indication of sample quality may be derived from laboratory consolidation tests. The method however applies to a limited range of soil conditions.

The normalized sample quality parameter ($\Delta e/e_0$) for CIUc and CIUe triaxial compression test specimens ranges between 0.000 and 0.046. ISO (2014) undisturbed sample quality indication for these specimens classifies as “very good to excellent” to “fair to good” – this indication must be used with caution for soils outside the specified range.

The normalized sample quality parameter ($\Delta e/e_0$) for DSS test specimens ranges between 0.018 and 0.110. 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.

A1.3 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 – 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
Data Format(s):	PDF for viewing and printing (this primary document)

Initial Sample Handling – refer to companion reports (refer to Plate 1-3)

Site Geotechnical Laboratory – refer to companion reports (refer to Plate 1-3)

Office Geotechnical Laboratory

Test Programme	Geotechnical index, static and cyclic strength/stiffness
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
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 testing – If applicable, selection and labelling of left-over sample sections for undisturbed preservation and/or disturbed preservation
Sample in Plastic Bags	– Geotechnical testing – If applicable, selection and labelling of left-over sample sections for disturbed preservation)

Sample Storage and Disposition

Sample Storage:	– Storage period as per contract – 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

– 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.

ISSUE 14
FEBV/GEO/SPE/020
© Fugro 1995-2015

A1.4 INDEX LABORATORY TESTS

Particle size distributions (PSD) were determined for the four batches of coarse-grained cohesionless material, before and after testing. The PSD curves are presented on Plates A2-1 to A2-5. Plate A2-1 shows the pre-testing PSD curves for the four batches, Plate A2-2 to A2-5 present a comparison between the pre-testing PSD (solid line) and post-testing PSD (dotted line) for each batch separately.

A1.5 MICROSCOPIC INSPECTION

Microscopic inspections were performed on samples selected for batching and on samples that were selected during the fieldwork phase to assess glauconite content of these samples. No microscopic inspections were done on the individual batch samples.

Results from the microscopic inspections indicated that selected samples from the individual formations were similar in composition, angularity and sphericity within these formations.

A1.6 STATIC TRIAXIAL TESTS

Results of the CIUc and CIUe triaxial tests on fine-grained cohesive specimens are in line with expectations considering stress history of the different soil units tested. Compression tests results generally show the typical behaviour expected for (overconsolidated) clays: an 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).

Extension tests show behaviour similar to the compression tests, but reversed, i.e. an initial decrease in deviator stress q, a non-linear p'/q relationship and an initial decrease of pore water pressure followed by an increase proportional to the overconsolidation ratio.

Results of the CIUc triaxial test results on coarse-grained cohesionless material were according to expectations. Specimens from Unit A (Southern Bight) and Unit B (Eem/Kreftenheye) showed typical behaviour for dense sands, i.e. a sharp increase in deviator stress due to negative shear-induced excess pore water pressures. Stress paths (p'/q) show strain-hardening behaviour. The p'/q stress paths from the tests performed on specimens from Unit E3 and Unit E5b (Tongeren) show (limited) strain softening.

Bender element tests were performed in two of the CIUc triaxial tests on fine-grained cohesive specimens (CIU01 and CIU09) and in four of the CIUc triaxial tests on coarse-grained cohesionless specimens (CIU10 to CIU13) to measure shear wave velocity (v_s) and shear modulus at small strain (G_{max}). The measured shear wave velocities for the test specimens tend to be lower than those inferred for in situ conditions. Reasons include:

- Different methods for determination of shear wave velocity: seismic downhole and/or CPT-based correlation versus bender elements;
- Approximation of specimen density versus in situ soil density has inherent uncertainties;
- Used method for specimen preparation is different than in situ soil deposition;
- In situ soil includes long-term stress history and time effects (aging).

Note that bender element tests are performed at a variety of frequencies, generally in the range of 1000 Hz to 5000 Hz in order to find the frequency with the optimum coupling from sender to receiver elements, and hence the strongest received signal. The optimum frequency can vary between tests. In the summary tables in Section 1, the range of measured or assessed v_s and G_{max} values for the applied frequencies are presented.

A1.7 STATIC DIRECT SIMPLE SHEAR TESTS

Test results are in line with expectations. Shear behaviour of fine-grained cohesive specimens shows a continuous increase in shear stress in combination with an initial decrease in pore pressure followed by an increase after approximately 6% to 18% shear strain.

Due to a communication error in the dynamic control system during the second consolidation stage of test DSS01, a small data step and data gap is visible in the consolidation graphs. The communication error did not influence the actual specimen consolidation or shearing stages.

Due to a communication error in the dynamic control system during the shearing stage of test DSS03, a dip in stress-strain curves is visible. This took place after the specimen had reached peak stress and therefore test results are deemed valid.

A1.8 CYCLIC TRIAXIAL TESTS

Fine-grained cohesive specimens as well as coarse-grained cohesionless specimens were used for CTXL testing. Coarse-grained cohesionless specimens were not pre-sheared prior to the start of the cyclic test phase. Cyclic test results for both types of specimens generally show a consistent behaviour, i.e. number of cycles to failure (N_f) increases with decreasing cyclic stress ratios (CSR).

Post-cyclic static testing was performed on most specimens. Typical stress-strain behaviour was similar to the static CIU tests. Stress paths (p'/q) show strain-hardening behaviour. No post-cyclic static testing was performed for tests CTX13, CTX16 and CTX21 as the specimen either failed in extension during cycling or more than 20% axial strain was reached during cycling.

Resistance to cyclic loading of coarse-grained cohesionless specimens increases at higher relative densities, with the two Tongeren batches (Batch 3/Unit E3 and Batch 4/Unit E5b) plotting at the lower end and Batch 1 (Unit A - Southern Bight) and Batch 2 (Unit B - Eem/Kreftenheye) plotting at high CSR levels (at similar N_f values). Note that the two Tongeren batches include approximately 8% and 14% fines. This may contribute to the lower cyclic resistance compared to the other two batches.

The cyclic test results for the coarse-grained cohesionless specimens generally show a steady increase of pore pressure at low cyclic and average strain levels up to pore pressure ratio values between 0.6 and 0.8. Thereafter, pore pressure (ratios) and cyclic and average strain levels progressively increase until failure occurs. The measured pore pressure response towards failure is consistent with expectations for medium dense to dense sand. As the effective stress within the soil approaches zero, the soil dilates in order to sustain an increasing deviator stress. The dilation ceases momentarily at the stress reversal point before unloading occurs. This is clearly seen in the temporary drop in pore pressure once the pore pressure ratios are above 0.8 to 0.9.

For test CTX20 both sample photographs are missing. This was due to operator error.

A1.9 CYCLIC DIRECT SIMPLE SHEAR TESTS

Fine-grained cohesive specimens as well as coarse-grained cohesionless specimens were used for CSS testing. Coarse-grained cohesionless specimens were not pre-sheared prior to the start of the cyclic test phase. Specimens used for CSS testing were not pre-sheared prior to the start of the cyclic test phase. Cyclic test results for both types of specimens generally show a consistent behaviour, i.e. number of cycles to failure (N_f) increases with decreasing cyclic stress ratios (CSR).

In general, test results indicate a similar behaviour as the CTXL data, i.e. the two Tongeren batches (Batch 3/Unit E3 and Batch 4/Unit E5b) showing low cyclic resistance and Batch 1 (Unit A - Southern Bight) and Batch 2 (Unit B - Eem/Kreftenheye) showing high cyclic resistance. However, CSS tests on specimens from Batch 1 (Unit A) show the highest cyclic resistance, whereas for the CTXL tests Batch 2 (Unit B) show the highest cyclic resistance. The CTXL trend in cyclic resistance is expected considering the higher consolidation stress and specimen densities. Test results per batch were consistent and test execution was evaluated and assessed as correct.

Resistance to cyclic loading of coarse-grained cohesionless specimens increases at higher relative densities, with the two Tongeren batches (Batch 3/Unit E3 and Batch 4/Unit E5b) plotting at the lower end and Batch 1 (Unit A - Southern Bight) and Batch 2 (Unit B - Eem/Kreftenheye) plotting at high CSR levels (at similar N_f values). Note that the two Tongeren batches include approximately 8% to 14% fines. This may contribute to the lower cyclic resistance compared to the other two batches.

Post-cyclic static testing was performed on almost every specimen for both specimen types. Typical stress-strain behaviour was similar to the static DSS tests. Coarse-grained cohesionless specimens show strain-hardening behaviour.

It was observed during the post-cyclic static loading phase that for most tested specimens failure took place along or close to the loading platen interface, or along a horizontal fissure or slickensided surface approximately in the middle of the specimen. Specimens containing horizontal fissures or slickensided surfaces may show reduced post-cyclic static shear strengths compared to non-fissured/slickensided specimens as these features can act as preferred planes of failure.

A1.10 REFERENCES

British Standards Institution, 2010. *BS 5930:1999+A2:2010 Code of Practice for Site Investigations*. London: BSI.

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

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS

COHESIVE SPECIMENS

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

Location	Sample No.	Depth [m]	Unit (Formation)	Test Type	Test ID	Initial Conditions			Final Consolidation Conditions							Δe/e$_o$
						w_i [%]	γ_i [kN/m³]	e_0 [-]	w_f [%]	γ_f [kN/m³]	σ'_{vc} [kPa]	σ'_{rc} [kPa]	e_{pc} [-]	$\varepsilon_{vol;pc}$ [%]	$\varepsilon_{v;pc}$ [%]	[-]
BH-WFS3-1	27WaxC	32.37	F1c (Dongen)	CIUc+BE	CIU01	33.0	19.2	0.836	32.8	19.2	325	325	0.831	0.26	0.09	0.006
BH-WFS3-1	28WaxB	33.05		CIUe	CIU02	21.9	20.5	0.575	21.8	20.5	330	330	0.570	0.30	-	0.008
BH-WFS3-4A	3WaxE	24.47		CIUe	CIU03	34.3	18.8	0.887	34.6	18.9	265	265	0.887	0.01	-	0.000
BH-WFS3-5	31WaxB	36.55		CIUc	CIU04	33.0	18.8	0.873	33.0	18.8	370	370	0.871	0.10	-	0.002
BH-WFS3-1	31WaxB	42.15	F3 (Dongen)	CIUc	CIU05	39.1	18.4	0.939	39.0	18.4	410	410	0.936	0.12	-	0.002
BH-WFS3-1	31WaxC	43.37		CIUe	CIU06	37.1	18.5	0.961	37.1	18.5	410	410	0.960	0.05	-	0.001
BH-WFS3-4A	9WaxC	39.38		CIUc	CIU07	37.0	18.2	1.001	37.0	18.2	355	355	1.000	0.02	-	0.000
BH-WFS3-4A	9WaxB	39.13		CIUe	CIU08	51.9	17.6	1.291	49.7	17.8	360	360	1.232	2.58	-	0.046
BH-WFS4-1A	22WaxB	37.06		CIUc+BE	CIU09	37.1	18.2	1.002	36.8	18.2	345	345	0.994	0.41	0.14	0.008

Location	Sample No.	Depth [m]	Unit (Formation)	Test Type	Test ID	At Peak Deviator Stress					At Maximum Stress Ratio			Post-Saturation*		Post-Consolidation*	
						s_u [kPa]	s_u/σ'_{vc} [-]	ε_a [%]	ε_{50} [%]	E_{50} [MPa]	s_u [kPa]	s_u/σ'_{vc} [-]	ε_a [%]	v_s [m/s]	G_{max} [MPa]	v_s [m/s]	G_{max} [MPa]
BH-WFS3-1	27WaxC	32.37	F1c (Dongen)	CIUc+BE	CIU01	131	0.40	3.00	0.25	52.3	130	0.40	2.50	181-202	64-80	177-203	61-81
BH-WFS3-1	28WaxB	33.05		CIUe	CIU02	-172	0.52	-8.25	-0.48	35.6	-172	0.52	-8.25	-	-	-	-
BH-WFS3-4A	3WaxE	24.47		CIUe	CIU03	-122	0.46	-7.50	-0.29	41.5	-122	0.46	-6.50	-	-	-	-
BH-WFS3-5	31WaxB	36.55		CIUc	CIU04	126	0.34	2.34	0.29	43.8	126	0.34	2.34	-	-	-	-
BH-WFS3-1	31WaxB	42.15	F3 (Dongen)	CIUc	CIU05	171	0.42	5.75	0.24	70.9	170	0.41	4.25	-	-	-	-
BH-WFS3-1	31WaxC	43.37		CIUe	CIU06	-153	0.37	-2.12	-0.25	60.8	-152	0.37	-1.87	-	-	-	-
BH-WFS3-4A	9WaxC	39.38		CIUc	CIU07	132	0.37	1.00	0.12	113.6	131	0.37	1.63	-	-	-	-
BH-WFS3-4A	9WaxB	39.13		CIUe	CIU08	-102	0.28	-5.00	-0.23	44.6	-102	0.28	-5.00	-	-	-	-
BH-WFS4-1A	22WaxB	37.06		CIUc+BE	CIU09	299	0.87	5.00	1.03	28.9	281	0.81	3.25	221-243	90-109	229-250	97-116

Notes:

- $\sigma'_{vc} = \sigma'_{vc(max)}$
- * = v_s and G_{max} values represent the range of values for the tested range of frequencies

Key:

$w_{i\,/\,f}$	=	initial / after consolidation water content	Δe	=	change of void ratio from initial conditions to estimated in-situ stress conditions
$\gamma_{i\,/\,f}$	=	initial / after consolidation unit weight	s_u	=	undrained shear strength
e_0	=	initial void ratio	ε_a	=	axial strain at peak deviator stress or maximum stress ratio
$\sigma'_{vc\,/\,rc}$	=	vertical / radial effective stress at end of consolidation	ε_{50}	=	axial strain at 50% of peak deviator stress
e_{pc}	=	void ratio at end of consolidation	E_{50}	=	Young's modulus at 50% of peak deviator stress
$\varepsilon_{vol;pc}$	=	volumetric strain at end of consolidation	v_s	=	shear wave velocity
$\varepsilon_{v;pc}$	=	vertical strain at end of consolidation	G_{max}	=	shear modulus at small strain

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS

COHESIONLESS SPECIMENS

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

Batch	Unit (Formation)	Test Type	Test ID	Initial Conditions			Final Consolidation Conditions						
				w_i [%]	γ_i [kN/m³]	e_0 [-]	w_f [%]	γ_f [kN/m³]	σ'_{vc} [kPa]	σ'_{rc} [kPa]	e_{pc} [-]	$\varepsilon_{vol;pc}$ [%]	$\varepsilon_{v;pc}$ [%]
1	A (Southern Bight)	CIUc+BE	CIU10	10.2	17.6	0.630	23.7	19.7	25	25	0.629	0.11	0.04
2	B (Eem/Kreftenheye)	CIUc+BE	CIU11	10.1	18.3	0.566	21.2	20.2	80	80	0.561	0.31	0.10
3	E3 (Tongeren)	CIUc+BE	CIU12	10.9	17.4	0.665	24.2	19.6	300	300	0.645	1.18	0.39
4	E5b (Tongeren)	CIUc+BE	CIU13	10.2	17.4	0.654	23.3	19.8	400	400	0.618	2.17	0.72
		CIUc	CIU14	10.2	17.4	0.648	23.1	19.8	400	400	0.613	2.13	-

Batch	Unit (Formation)	Test Type	Test ID	At Peak Deviator Stress					At Maximum Stress Ratio			Post-Saturation*		Post-Consolidation*	
				q [kPa]	u [kPa]	ε_a [%]	ε_{50} [%]	E_{50} [MPa]	q [kPa]	u [kPa]	ε_a [%]	v_s [m/s]	G_{max} [MPa]	v_s [m/s]	G_{max} [MPa]
1	A (Southern Bight)	CIUc+BE	CIU10	1143	-357	7.00	2.35	24.3	190	-30	0.88	116-118	27-28	225-242	102-118
2	B (Eem/Kreftenheye)	CIUc+BE	CIU11	1359	-364	5.50	1.89	36.0	424	-45	1.25	123-126	31-33	198-222	80-102
3	E3 (Tongeren)	CIUc+BE	CIU12	390	124	12.25	0.35	56.4	332	163	5.00	115-123	26-30	245-304	121-186
4	E5b (Tongeren)	CIUc+BE	CIU13	273	279	19.00	0.20	67.8	220	312	6.75	115-123	26-30	254-304	130-186
		CIUc	CIU14	262	221	0.75	0.10	137.2	226	306	9.75	-	-	-	-

Notes:

- $\sigma'_{vc} = \sigma'_{vc(max)}$
- * = v_s and G_{max} values represent the range of values for the tested range of frequencies

Key:

$w_{i\,/\,f}$	=	initial / after consolidation water content	q	=	deviator stress
$\gamma_{i\,/\,f}$	=	initial / after consolidation unit weight	u	=	excess pore pressure
e_0	=	initial void ratio	ε_a	=	axial strain at peak deviator stress or maximum stress ratio
$\sigma'_{vc\,/\,rc}$	=	vertical / radial effective stress at end of consolidation	ε_{50}	=	axial strain at 50% of peak deviator stress
e_{pc}	=	void ratio at end of consolidation	E_{50}	=	Young's modulus at 50% of peak deviator stress
$\varepsilon_{vol;pc}$	=	volumetric strain at end of consolidation	v_s	=	shear wave velocity
$\varepsilon_{v;pc}$	=	vertical strain at end of consolidation	G_{max}	=	shear modulus at small strain

SUMMARY OF CYCLIC TRIAXIAL TEST RESULTS

COHESIVE SPECIMENS

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

Location	Sample No.	Depth [m]	Unit (Formation)	Test Type	Test ID	Initial Conditions			Final Consolidation Conditions							$\Delta e/e_o$
						w_i [%]	γ_i [kN/m³]	e_0 [-]	w_f [%]	γ_f [kN/m³]	σ'_{vc} [kPa]	σ'_{rc} [kPa]	e_{pc} [-]	$\varepsilon_{vol;pc}$ [%]	$\varepsilon_{v;pc}$ [%]	[-]
BH-WFS3-4A	8WaxC	38.48	F3 (Dongen)	CTXL	CTX01	42.6	17.7	1.141	42.8	17.7	355	355	1.147	-0.26	-0.13	-0.01
BH-WFS3-1	30WaxC	41.58		CTXL	CTX02	26.8	19.1	0.703	26.3	19.2	405	405	0.690	0.77	0.19	0.02
BH-WFS4-1A	22WaxC	37.48		CTXL	CTX03	38.8	18.0	1.051	38.7	18.0	350	350	1.048	0.12	0.04	0.00
BH-WFS4-3	29WaxC	45.88		CTXL	CTX04	35.0	18.3	0.948	35.5	18.3	450	450	0.959	-0.60	-0.37	-0.01

Location	Sample No.	Depth [m]	Unit (Formation)	Test Type	Test ID	Cyclic Loading							At Peak Deviator Stress (Post-Cyclic Static)				
						$s_{u;ref}$ [kPa]	$\tau_{av}/s_{u;ref}$ [-]	$\tau_{cy}/s_{u;ref}$ [-]	N_f [-]	γ_{av} [%]	γ_{cy} [%]	u_a [kPa]	s_u [kPa]	ε_a [%]	ε_{50} [%]	E_{50} [MPa]	u_f [kPa]
BH-WFS3-4A	8WaxC	38.48	F3 (Dongen)	CTXL	CTX01	300	0.00	0.32	1500	-0.04	0.25	-7.1	300	2.29	0.51	54.8	182
BH-WFS3-1	30WaxC	41.58		CTXL	CTX02	250	0.00	0.68	15	-5.84	10.61	131.0	-101	-16.25	-14.88	14.7	101
BH-WFS4-1A	22WaxC	37.48		CTXL	CTX03	280	0.00	0.42	1500	-0.42	0.64	68.0	288	3.73	0.44	30.9	155
BH-WFS4-3	29WaxC	45.88		CTXL	CTX04	250	0.00	0.71	5	-10.34	11.94	-5.4	-118	-21.74	-20.75	49.4	-162

Notes:

- $\sigma'_{vc} = \sigma'_{vc(max)}$

Key:

$w_{i\,/\,f}$	=	initial / after consolidation water content	τ_{av}	=	average shear stress
$\gamma_{i\,/\,f}$	=	initial / after consolidation unit weight	τ_{cy}	=	cyclic shear stress
e_0	=	initial void ratio	γ_{av}	=	average shear strain at N_f
$\sigma'_{vc\,/\,rc}$	=	vertical / radial effective stress at end of consolidation	γ_{cy}	=	cyclic shear strain at N_f
e_{pc}	=	void ratio at end of consolidation	u_a	=	pore water pressure at N_f
$\varepsilon_{vol;pc}$	=	volumetric strain at end of consolidation	s_u	=	undrained shear strength
$\varepsilon_{v;pc}$	=	vertical strain at end of consolidation	ε_a	=	axial strain at peak deviator stress
Δe	=	change of void ratio from initial conditions to estimated in-situ stress conditions	ε_{50}	=	axial strain at 50% of peak deviator stress
$s_{u;ref}$	=	reference undrained shear strength	E_{50}	=	Young's modulus at 50% of peak deviator stress
N_f	=	number of cycles to failure	u_f	=	pore water pressure at failure

SUMMARY OF CYCLIC TRIAXIAL TEST RESULTS – CONSOLIDATION STAGE

COHESIONLESS SPECIMENS

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

Batch	Unit (Formation)	Test Type	Test ID	Initial Conditions			Final Consolidation Conditions						
				w_i [%]	γ_i [kN/m³]	e_0 [-]	w_f [%]	γ_f [kN/m³]	σ'_{vc} [kPa]	σ'_{rc} [kPa]	e_{pc} [-]	$\varepsilon_{vol;pc}$ [%]	$\varepsilon_{v;pc}$ [%]
1	A (Southern Bight)	CTXL	CTX05	10.3	17.6	0.633	23.9	19.7	25	25	0.634	-0.03	0.02
		CTXL	CTX06	10.4	17.6	0.632	23.9	19.7	25	25	0.633	-0.07	0.01
		CTXL	CTX07	12.7	17.6	0.672	25.4	19.5	25	25	0.674	-0.09	0.01
		CTXL	CTX08	10.6	17.6	0.637	24.1	19.7	25	25	0.638	-0.05	-0.03
2	B (Eem/Kreftenheye)	CTXL	CTX09	10.0	18.3	0.559	20.9	20.2	80	80	0.555	0.29	0.12
		CTXL	CTX10	10.5	18.3	0.564	21.0	20.2	80	80	0.558	0.41	0.11
		CTXL	CTX11R	9.9	18.3	0.559	20.7	20.2	80	80	0.550	0.62	0.11
		CTXL	CTX12	10.5	18.3	0.573	21.4	20.1	80	80	0.567	0.37	0.09
3	E3 (Tongeren)	CTXL	CTX13	9.7	17.4	0.639	22.5	19.9	300	300	0.596	2.58	0.91
		CTXL	CTX14	10.2	17.4	0.650	24.9	19.9	300	300	0.632	1.11	0.46
		CTXL	CTX15	10.0	17.4	0.647	23.2	19.8	300	300	0.615	1.93	0.60
		CTXL	CTX16	9.1	17.5	0.623	22.7	19.9	300	300	0.602	1.27	0.51
4	E5b (Tongeren)	CTXL	CTX17	9.2	17.4	0.633	22.3	20.0	400	400	0.592	2.49	0.79
		CTXL	CTX18	9.2	17.4	0.633	22.3	20.0	400	400	0.592	2.51	0.87
		CTXL	CTX19	10.3	17.4	0.651	23.2	19.8	400	400	0.614	2.20	0.82
		CTXL	CTX20	9.5	17.4	0.638	22.3	20.0	400	400	0.590	2.95	0.86
		CTXL	CTX21	10.1	17.4	0.644	22.8	19.9	400	400	0.604	2.45	0.85
		CTXL	CTX21R	10.2	17.4	0.649	23.0	19.9	400	400	0.609	2.41	0.65
		CTXL	CTX22	10.0	17.5	0.641	22.8	19.9	400	400	0.604	2.25	0.68

Notes:

- $\sigma'_{vc} = \sigma'_{vc(max)}$

Key:

$w_{i\,/\,f}$ = initial / after consolidation water content
$\gamma_{i\,/\,f}$ = initial / after consolidation unit weight
e_0 = initial void ratio
$\sigma'_{vc\,/\,rc}$ = vertical / radial effective stress at end of consolidation

e_{pc} = void ratio at end of consolidation
$\varepsilon_{vol;pc}$ = volumetric strain at end of consolidation
$\varepsilon_{v;pc}$ = vertical strain at end of consolidation

SUMMARY OF CYCLIC TRIAXIAL TEST RESULTS – TEST RESULTS

COHESIONLESS SPECIMENS

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

Batch	Unit (Formation)	Test Type	Test ID	Cyclic Loading							At Peak Deviator Stress (Post-Cyclic Static)				
				σ'_{vc} [kPa]	τ_{av}/σ'_{vc} [-]	τ_{cy}/σ'_{vc} [-]	N_f [-]	ε_{av} [%]	ε_{cy} [%]	u_a [kPa]	q_f [kPa]	ε_a [%]	ε_{50} [%]	E_{50} [MPa]	u_f [kPa]
1	A (Southern Bight)	CTXL	CTX05	25	0.00	0.30	9	-1.42	3.39	18	1891	21.38	10.76	7.7	-813
		CTXL	CTX06	25	0.00	0.20	117	0.13	0.47	20	2371	13.69	9.12	16.3	-901
		CTXL	CTX07	25	0.00	0.20	13	-1.22	2.20	17	1521	22.39	12.12	9.7	-657
		CTXL	CTX08	25	0.00	0.25	13	-1.88	3.22	11	2475	20.58	11.65	5.8	-1109
2	B (Eem/Kreftenheye)	CTXL	CTX09	80	0.00	0.40	8	-0.72	3.27	40	2261	17.46	8.57	14.0	-8.12
		CTXL	CTX10	80	0.00	0.30	16	-0.66	3.12	48	2349	10.97	7.68	11.3	-799
		CTXL	CTX11R	80	0.00	0.25	26	-1.86	4.32	47	3232	18.09	8.54	18.0	-923
		CTXL	CTX12	80	0.00	0.20	296	-1.24	3.38	59	2890	14.24	7.65	24.5	-1002
3	E3 (Tongeren)	CTXL	CTX13	300	0.00	0.20	1	-2.95	3.05	121	-	-	-	-	-
		CTXL	CTX14	300	0.00	0.15	12	-0.65	0.98	204	302	24.21	9.66	1.0	168
		CTXL	CTX15	300	0.00	0.10	45	-0.35	1.00	238	268	23.63	10.57	1.0	188
		CTXL	CTX16	300	0.00	0.07	248	-0.10	0.19	241	-	-	-	-	-
4	E5b (Tongeren)	CTXL	CTX17	400	0.01	0.19	1	-6.33	6.46	158	291	23.37	8.64	0.9	266
		CTXL	CTX18	400	0.00	0.15	10	-4.05	4.67	282	312	23.57	8.43	1.2	254
		CTXL	CTX19	400	0.00	0.10	148	-1.23	1.95	321	375	23.45	10.27	1.4	225
		CTXL	CTX20	400	0.00	0.07	1500	0.24	0.04	183	225	5.32	0.59	31.8	290
		CTXL	CTX21	400	0.00	0.15	4	-0.10	0.15	160	265	16.17	6.26	0.9	287
		CTXL	CTX21R	400	0.01	0.18	2	-8.67	8.70	182	-	-	-	-	-
		CTXL	CTX22	400	0.00	0.12	38	-1.74	1.90	305	234	20.73	14.62	0.5	316

Notes:

Key:

σ'_{vc}	=	vertical effective stress at end of consolidation
N_f	=	number of cycles to failure
τ_{av}	=	average shear stress
τ_{cy}	=	cyclic shear stress
ε_{av}	=	average axial strain at N_f
ε_{cy}	=	cyclic axial strain at N_f
u_a	=	pore water pressure at N_f
q_f	=	deviator stress at failure
ε_a	=	axial strain
ε_{50}	=	axial strain at 50% of peak deviator stress
E_{50}	=	Young's modulus at 50% of peak deviator stress
u_f	=	pore water pressure at failure

SUMMARY OF (CYCLIC) DIRECT SIMPLE SHEAR TEST RESULTS – CONSOLIDATION STAGE

COHESIVE SPECIMENS

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

Location	Sample No.	Depth	Unit (Formation)	Test Type	Test ID	Initial Conditions			Final Consolidation Conditions						$\Delta e/e_o$
						w_i	γ_i	e_0	w_f	γ_f	σ'_{vc}	$\sigma'_{vc(max)}$	e_{pc}	$\varepsilon_{v;pc}$	
		[m]				[%]	[kN/m³]	[-]	[%]	[kN/m³]	[kPa]	[kPa]	[-]	[%]	[-]
BH-WFS4-7	22WaxD	23.56	D (Rupel)	DSS	DSS04	34.1	18.6	0.905	34.2	18.6	230	548	0.909	2.69	0.057
BH-WFS4-7	22WaxD	23.68		CSS	CSS09R	34.1	19.1	0.860	33.4	19.2	230	230	0.841	0.98	0.021
BH-WFS4-7	22WaxD	23.64		CSS	CSS10	34.1	18.9	0.877	33.5	19.0	230	548	0.862	0.82	0.018
BH-WFS3-4A	2WaxD	23.36	F1c (Dongen)	DSS	DSS01	33.1	18.6	0.892	33.6	18.5	230	738	0.903	3.17	0.067
BH-WFS3-4A	2WaxD	23.40		CSS	CSS01	33.1	18.6	0.887	30.4	19.0	254	799	0.813	3.93	0.084
BH-WFS3-4A	2WaxD	23.44		CSS	CSS02	33.1	18.7	0.883	31.1	19.0	235	738	0.829	2.87	0.061
BH-WFS3-4A	2WaxD	23.48		CSS	CSS03	33.1	18.6	0.887	31.6	18.9	235	738	0.845	2.23	0.047
BH-WFS3-4A	6WaxD	33.39	F3 (Dongen)	DSS	DSS02	39.4	18.1	1.043	40.6	18.0	315	885	1.074	1.86	0.036
BH-WFS4-1A	23WaxB	38.20		DSS	DSS03	41.2	17.4	1.160	39.0	17.6	355	913	1.099	2.81	0.052
BH-WFS3-4A	6WaxD	33.40		CSS	CSS04	39.4	18.1	1.045	37.3	18.3	320	885	0.988	2.77	0.054
BH-WFS3-4A	6WaxF	33.61		CSS	CSS05	37.2	18.3	0.978	35.1	18.6	320	885	0.922	2.86	0.058
BH-WFS3-4A	6WaxB	33.12		CSS	CSS06R	39.5	18.2	1.033	37.7	18.3	320	885	0.984	2.43	0.048
BH-WFS4-1A	23WaxB	38.24		CSS	CSS07	41.2	17.6	1.132	39.0	17.8	365	913	1.074	2.73	0.051
BH-WFS4-1A	24WaxB	42.18		CSS	CSS08	32.3	17.9	0.967	28.4	18.3	365	913	0.861	5.40	0.110

Notes:

Key:

$w_{i\,/\,f}$ = initial / after consolidation water content
$\gamma_{i\,/\,f}$ = initial / after consolidation unit weight
e_0 = initial void ratio
σ'_{vc} = vertical effective stress at end of final consolidation phase
$\sigma'_{vc(max)}$ = vertical effective stress at end of initial consolidation phase
e_{pc} = void ratio at end of consolidation
$\varepsilon_{v;pc}$ = vertical strain at end of consolidation
Δe = change of void ratio from initial conditions to estimated in-situ stress conditions

SUMMARY OF (CYCLIC) DIRECT SIMPLE SHEAR TEST RESULTS – TEST STAGE

COHESIVE SPECIMENS

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

Location	Sample No.	Depth	Unit (Formation)	Test Type	Test ID		At Peak Shear Stress (Static)				Cyclic Loading							At Peak Shear Stress (Post-Cyclic Static)		
						σ'_{vc}	s_u	s_u/σ'_{vc}	γ_c	Δu	$s_{u;ref}$	$\tau_{av}/s_{u;ref}$	$\tau_{cy}/s_{u;ref}$	N_f	γ_{av}	γ_{cy}	u_a	s_u	γ_f	u_f
		[m]				[kPa]	[kPa]	[-]	[%]	[kPa]	[kPa]	[-]	[-]	[-]	[%]	[%]	[kPa]	[kPa]	[%]	[kPa]
BH-WFS4-7	22WaxD	23.56	D (Rupel)	DSS	DSS04	230	248	1.08	24.2	-135	-	-	-	-	-	-	-	-	-	-
BH-WFS4-7	22WaxD	23.68		CSS	CSS09R	230	-	-	-	-	250	-0.01	0.67	9	1.50	16.90	69	154	29.46	-88
BH-WFS4-7	22WaxD	23.64		CSS	CSS10	230	-	-	-	-	250	0.00	0.63	825	1.73	15.23	-199	164	28.09	-279
BH-WFS3-4A	2WaxD	23.36	F1c (Dongen)	DSS	DSS01	230	176	0.77	21.3	-60	-	-	-	-	-	-	-	-	-	-
BH-WFS3-4A	2WaxD	23.40		CSS	CSS01	254	-	-	-	-	175	0.00	0.51	1500	-0.03	1.17	1	188	12.59	-35
BH-WFS3-4A	2WaxD	23.44		CSS	CSS02	235	-	-	-	-	175	0.00	0.56	1391	1.44	15.25	22	104	29.05	-41
BH-WFS3-4A	2WaxD	23.48		CSS	CSS03	235	-	-	-	-	175	0.00	0.63	1500	0.18	5.00	-34	136	18.79	-101
BH-WFS3-4A	6WaxD	33.39	F3 (Dongen)	DSS	DSS02	315	180	0.57	13.9	-99	-	-	-	-	-	-	-	-	-	-
BH-WFS4-1A	23WaxB	38.20		DSS	DSS03	355	243	0.68	6.6	-108	-	-	-	-	-	-	-	-	-	-
BH-WFS3-4A	6WaxD	33.40		CSS	CSS04	320	-	-	-	-	235	0.00	0.62	144	3.41	15.51	-93	152	29.11	-52
BH-WFS3-4A	6WaxF	33.61		CSS	CSS05	320	-	-	-	-	235	0.32	0.48	1500	3.41	1.18	38	264	14.54	-113
BH-WFS3-4A	6WaxB	33.12		CSS	CSS06R	320	-	-	-	-	235	0.48	0.43	2	15.46	3.66	-101	153	27.52	-72
BH-WFS4-1A	23WaxB	38.24		CSS	CSS07	365	-	-	-	-	245	0.00	0.62	1500	0.05	1.46	3	282	7.99	-64
BH-WFS4-1A	24WaxB	42.18		CSS	CSS08	365	-	-	-	-	245	0.00	0.75	209	0.67	15.81	149	158	19.97	108

Notes:
- Static, cyclic and post-cyclic shear stages performed at constant volume

Key:

σ'_{vc}	=	vertical effective stress at end of consolidation
s_u	=	undrained shear strength
γ_c	=	shear strain at peak shear stress
Δu	=	change in inferred pore water pressure
$s_{u;ref}$	=	reference undrained shear strength
N_f	=	number of cycles to failure
τ_{av}	=	average shear stress
τ_{cy}	=	cyclic shear stress
γ_{av}	=	average shear strain at N_f
γ_{cy}	=	cyclic shear strain at N_f
u_a	=	inferred pore water pressure at N_f
γ_f	=	shear strain at failure
u_f	=	inferred pore water pressure at failure

SUMMARY OF (CYCLIC) DIRECT SIMPLE SHEAR TEST RESULTS – CONSOLIDATION STAGE

COHESIONLESS SPECIMENS

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

Batch	Unit (Formation)	Test Type	Test ID	Initial Conditions			Final Consolidation Conditions					
				w_i [%]	γ_i [kN/m³]	e_0 [-]	w_f [%]	γ_f [kN/m³]	σ'_{vc} [kPa]	σ'_{rc} [kPa]	e_{pc} [-]	$\varepsilon_{v;pc}$ [%]
1	A (Southern Bight)	DSS	DSS05	10.0	17.6	0.626	23.5	19.8	25	25	0.623	0.21
		DSS	DSS06	10.3	17.6	0.630	23.6	19.7	25	25	0.627	0.19
		CSS	CSS11	11.5	17.6	0.649	24.3	19.6	25	25	0.645	0.26
		CSS	CSS12	11.0	17.6	0.640	24.0	19.7	25	25	0.635	0.30
		CSS	CSS13	10.3	17.6	0.630	23.7	19.7	25	25	0.628	0.16
		CSS	CSS14	11.0	17.6	0.641	24.1	19.7	25	25	0.639	0.09
2	B (Eem/Kreftenheye)	DSS	DSS07	9.9	18.3	0.557	20.7	20.3	80	80	0.548	0.58
		DSS	DSS08	10.1	18.3	0.561	20.9	20.2	80	80	0.555	0.36
		CSS	CSS15	9.8	18.3	0.556	20.8	20.2	80	80	0.552	0.24
		CSS	CSS16	11.1	18.3	0.574	21.5	20.1	80	80	0.571	0.21
		CSS	CSS17	11.2	18.3	0.575	21.6	20.1	80	80	0.571	0.24
		CSS	CSS18	9.9	18.3	0.557	20.9	20.2	80	80	0.553	0.22
3	E3 (Tongeren)	DSS	DSS09	9.6	17.4	0.640	22.7	19.9	300	300	0.603	2.28
		DSS	DSS10	9.7	17.4	0.642	22.6	19.9	300	300	0.598	2.70
		CSS	CSS19	10.3	17.4	0.650	23.6	19.7	300	300	0.626	1.45
		CSS	CSS20	10.7	17.4	0.656	24.2	19.6	300	300	0.643	0.81
		CSS	CSS21	10.1	17.4	0.648	23.4	19.8	300	300	0.619	1.79
		CSS	CSS22	9.9	17.4	0.644	23.4	19.8	300	300	0.620	1.47
4	E5b (Tongeren)	DSS	DSS11	10.2	17.4	0.649	23.0	19.8	400	400	0.610	2.34
		CSS	CSS23	10.6	17.4	0.655	23.7	19.7	400	400	0.629	1.54
		CSS	CSS24	11.0	17.4	0.661	23.5	19.8	400	400	0.624	2.23
		CSS	CSS25	10.8	17.4	0.658	23.8	19.7	400	400	0.632	1.57
		CSS	CSS26	10.8	17.4	0.657	23.6	19.7	400	400	0.627	1.84

Notes:

- $\sigma'_{vc} = \sigma'_{vc(max)}$

Key:

$w_{i\,/\,f}$ = initial / after consolidation water content

$\gamma_{i\,/\,f}$ = initial / after consolidation unit weight

e_0 = initial void ratio

$\sigma'_{vc\,/\,rc}$ = vertical / radial effective stress at end of consolidation

e_{pc} = void ratio at end of consolidation

$\varepsilon_{vol;pc}$ = volumetric strain at end of consolidation

$\varepsilon_{v;pc}$ = vertical strain at end of consolidation

SUMMARY OF (CYCLIC) DIRECT SIMPLE SHEAR TEST RESULTS – TEST STAGE

COHESIONLESS SPECIMENS

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

Batch	Unit (Formation)	Test Type	Test ID	At Peak Shear Stress (Static)			Cyclic Loading							At Peak Shear Stress (Post-Cyclic Static)		
				τ [kPa]	γ_c [%]	Δu [kPa]	σ'_{vc} [kPa]	τ_{av}/σ'_{vc} [-]	τ_{cy}/σ'_{vc} [-]	N_f [-]	γ_{av} [%]	γ_{cy} [%]	u_a [kPa]	τ_f [kPa]	γ_f [%]	u_f [kPa]
1	A (Southern Bight)	DSS	DSS05	775	24.1	-1415	-	-	-	-	-	-	-	-	-	-
		DSS	DSS06	718	29.8	-1325	-	-	-	-	-	-	-	-	-	-
		CSS	CSS11	-	-	-	25	0.00	0.28	160	-2.60	3.75	19	164	28.09	-279
		CSS	CSS12	-	-	-	25	0.00	0.36	10	-0.18	3.68	13	834	28.60	-1418
		CSS	CSS13	-	-	-	25	0.00	0.32	9	0.50	3.67	19	347	29.93	-555
		CSS	CSS14	-	-	-	25	0.00	0.24	150	-1.32	3.69	25	274	30.16	-436
2	B (Eem/Kreftenheye)	DSS	DSS07	820	13.5	-1352	-	-	-	-	-	-	-	-	-	-
		DSS	DSS08	591	30.0	-964	-	-	-	-	-	-	-	-	-	-
		CSS	CSS15	-	-	-	80	0.00	0.28	6	-0.10	3.59	65	447	29.93	-690
		CSS	CSS16	-	-	-	80	0.00	0.19	119	-1.73	3.74	73	322	22.20	-464
		CSS	CSS17	-	-	-	80	0.00	0.16	797	-0.17	3.71	74	319	29.97	-467
		CSS	CSS18	-	-	-	80	0.00	0.23	37	0.07	3.73	69	848	19.49	-1354
3	E3 (Tongeren)	DSS	DSS09	256	26.1	-183	-	-	-	-	-	-	-	-	-	-
		DSS	DSS10	226	18.5	-129	-	-	-	-	-	-	-	-	-	-
		CSS	CSS19	-	-	-	300	0.00	0.28	1	-1.69	7.77	143	120	21.64	94
		CSS	CSS20	-	-	-	300	0.00	0.15	5	-0.72	2.08	246	109	28.22	128
		CSS	CSS21	-	-	-	300	0.00	0.12	9	-1.10	3.64	266	157	25.34	37
		CSS	CSS22	-	-	-	300	0.00	0.08	74	-0.66	3.77	276	99	21.72	124
4	E5b (Tongeren)	DSS	DSS11	123	23.1	185	-	-	-	-	-	-	-	-	-	-
		CSS	CSS23	-	-	-	400	0.01	0.28	1	-4.24	8.00	164	89	28.07	250
		CSS	CSS24	-	-	-	400	0.00	0.15	5	-0.39	1.47	283	103	30.66	231
		CSS	CSS25	-	-	-	400	0.00	0.08	187	-0.44	2.41	364	53	25.72	316
		CSS	CSS26	-	-	-	400	0.00	0.12	20	-0.98	3.57	344	78	30.52	283

Notes:
- Static, cyclic and post-cyclic shear stages performed at constant volume

Key:

τ	=	peak shear stress
γ_c	=	shear strain at peak shear stress
Δu	=	change in inferred pore water pressure
σ'_{vc}	=	vertical effective stress at end of consolidation
N_f	=	number of cycles to failure
τ_{av}	=	average shear stress
τ_{cy}	=	cyclic shear stress
γ_{av}	=	average shear strain at N_f
γ_{cy}	=	cyclic shear strain at N_f
u_a	=	inferred pore water pressure at N_f
τ_f	=	shear stress at failure
γ_f	=	shear strain at failure
u_f	=	inferred pore water pressure at failure

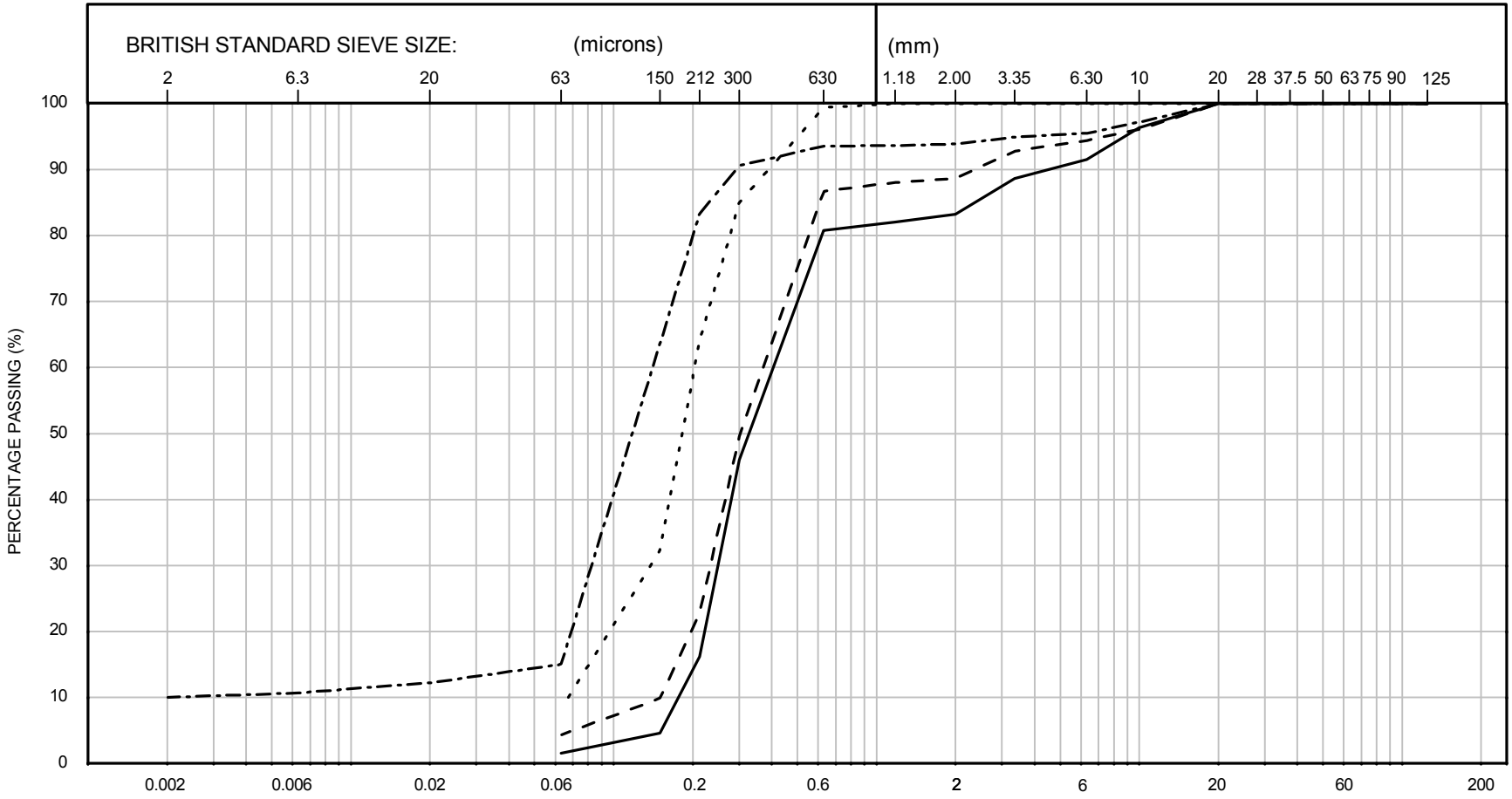
SECTION A2: INDEX LABORATORY TESTS

LIST OF PLATES IN SECTION A2: Plate

Particle Size Distribution A2-1 to A2-5

PARTICLE SIZE DISTRIBUTION TEST RESULTS

BORSSELE WIND FARM ZONE, WFS III & 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
———	BATCH 1	1-1	-	9.2	N/A	0	1	83	16	0
– – –	BATCH 2	2-1	-	9.2	N/A	0	4	85	11	0
· · · ·	BATCH 3	3-1	-	9.2	N/A	0	8	92	0	0
——·——	BATCH 4	4-1	-	9.2/9.4	N/A	10	4	80	6	0

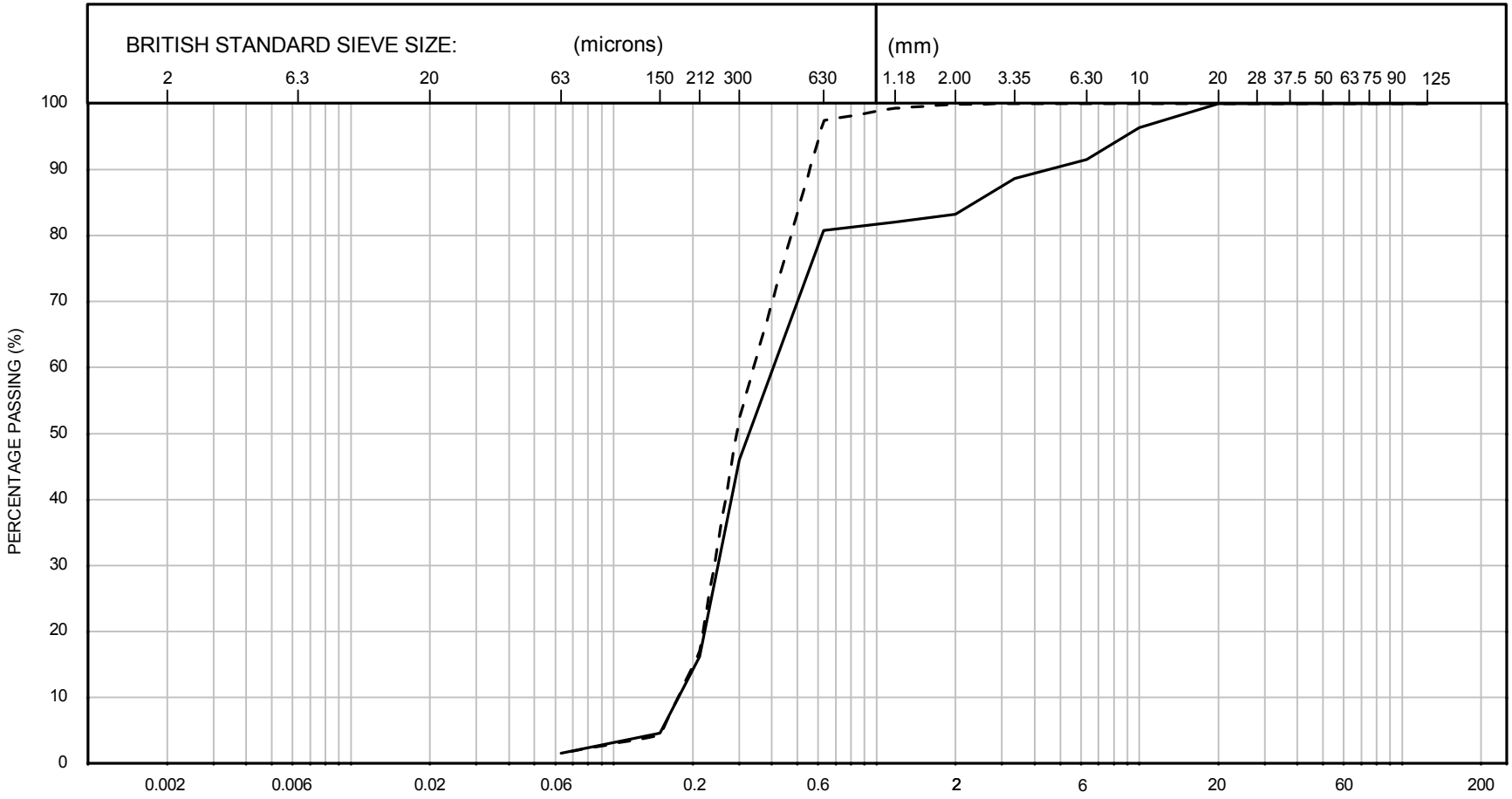
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

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 III & IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Batch	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
⊢—⊣	1	PSD_1-1	-	9.2	N/A	0	1	83	16	0
⊢ ⊣	1	PSD_1-3	-	9.2	N/A	0	1	99	0	0

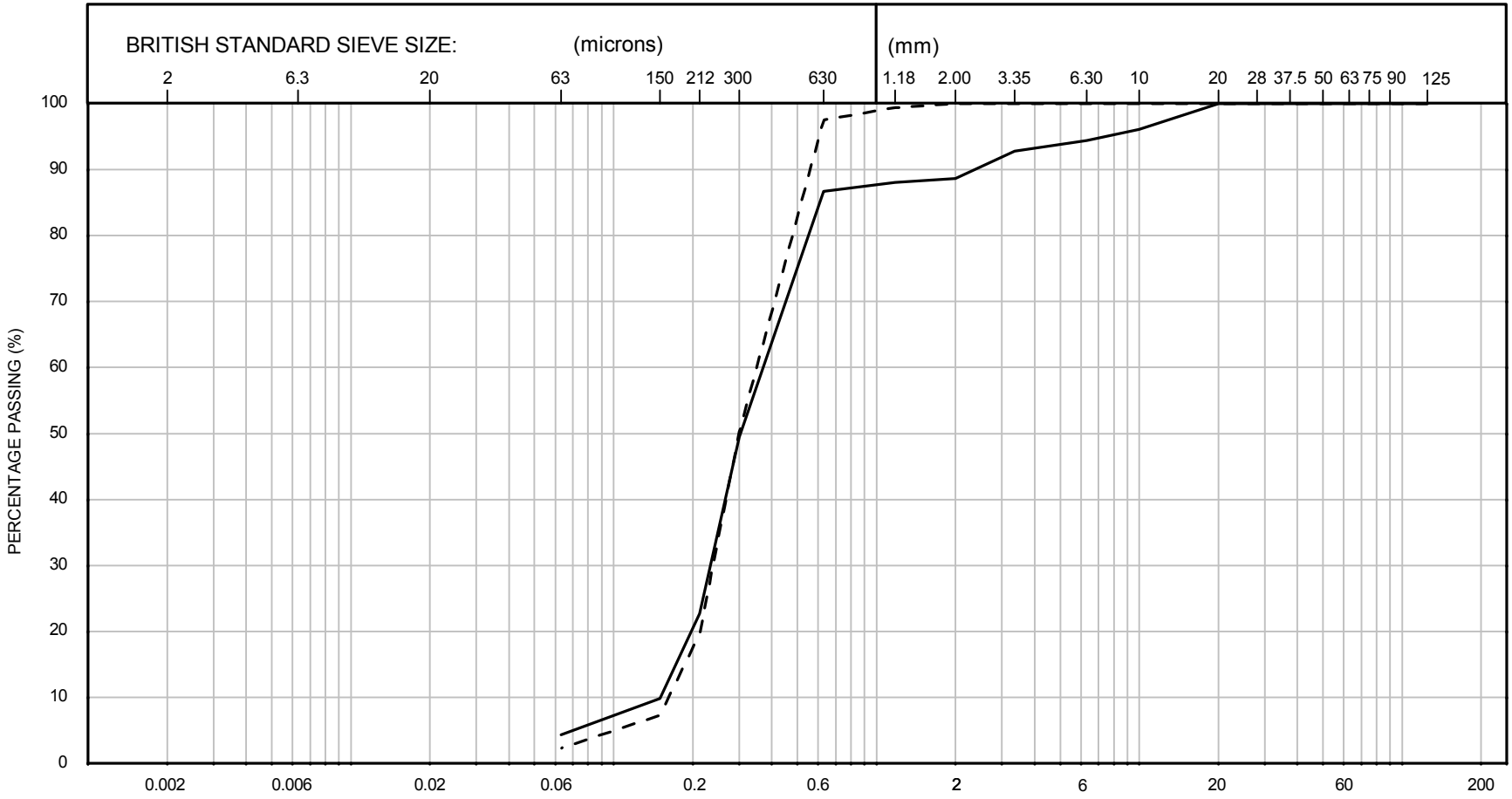
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

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 III & IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Batch	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
⊢—⊣	2	PSD_2-1	-	9.2	N/A	0	4	85	11	0
⊢ ⊣	2	PSD_2-3	-	9.2	N/A	0	2	98	0	0

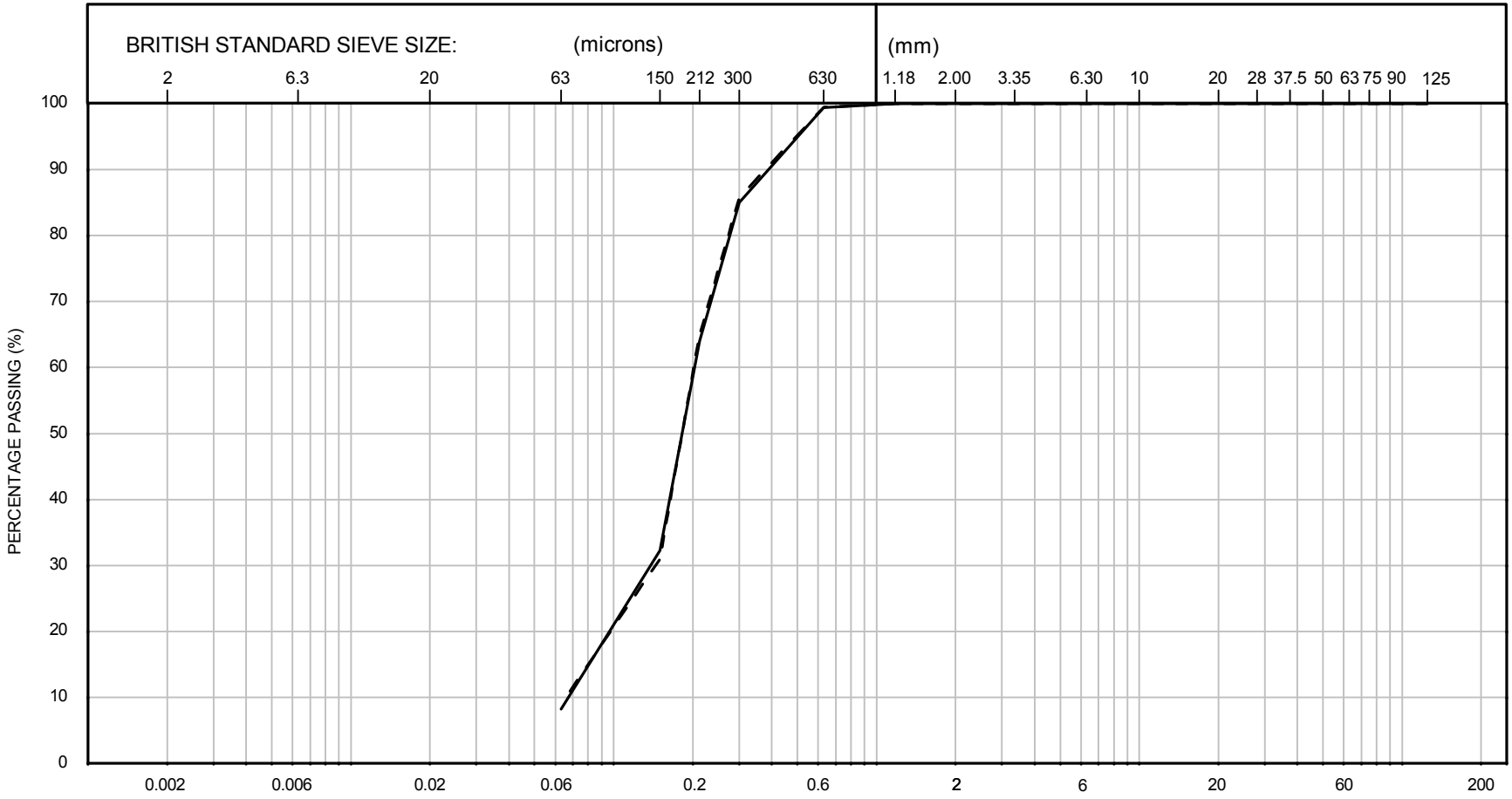
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

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 III & IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Batch	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
⊢—⊣	3	PSD_3-1	-	9.2	N/A	0	8	92	0	0
⊢ ⊣	3	PSD_3-1	-	9.2	N/A	0	8	92	0	0

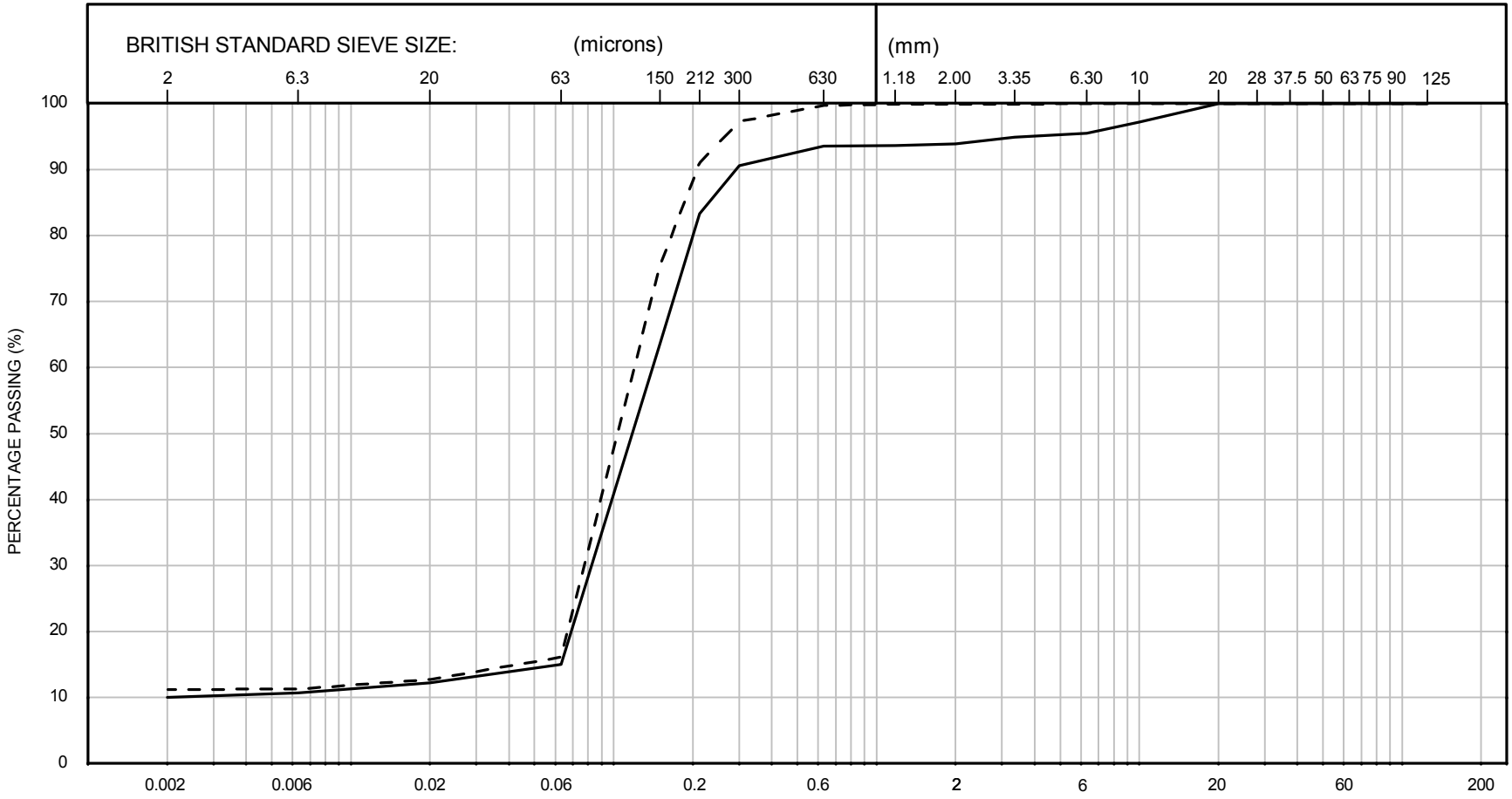
* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:

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 III & IV - DUTCH SECTOR, NORTH SEA



CLAY	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	COBBLES
	SILT			SAND			GRAVEL			

Curve	Batch	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
———	4	PSD_4-1	-	9.2/9.4	N/A	10	4	80	6	0
– – –	4	PSD_4-1	-	9.2/9.4	N/A	11	4	85	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

SECTION A3: MICROSCOPIC INSPECTION

LIST OF PLATES IN SECTION A3:

Technical Note: Microscope Descriptions, Report No. J11302-TN-001(03) 85 Pages

FUGRO GEOCONSULTING LIMITED

Technical Note: Microscope Descriptions

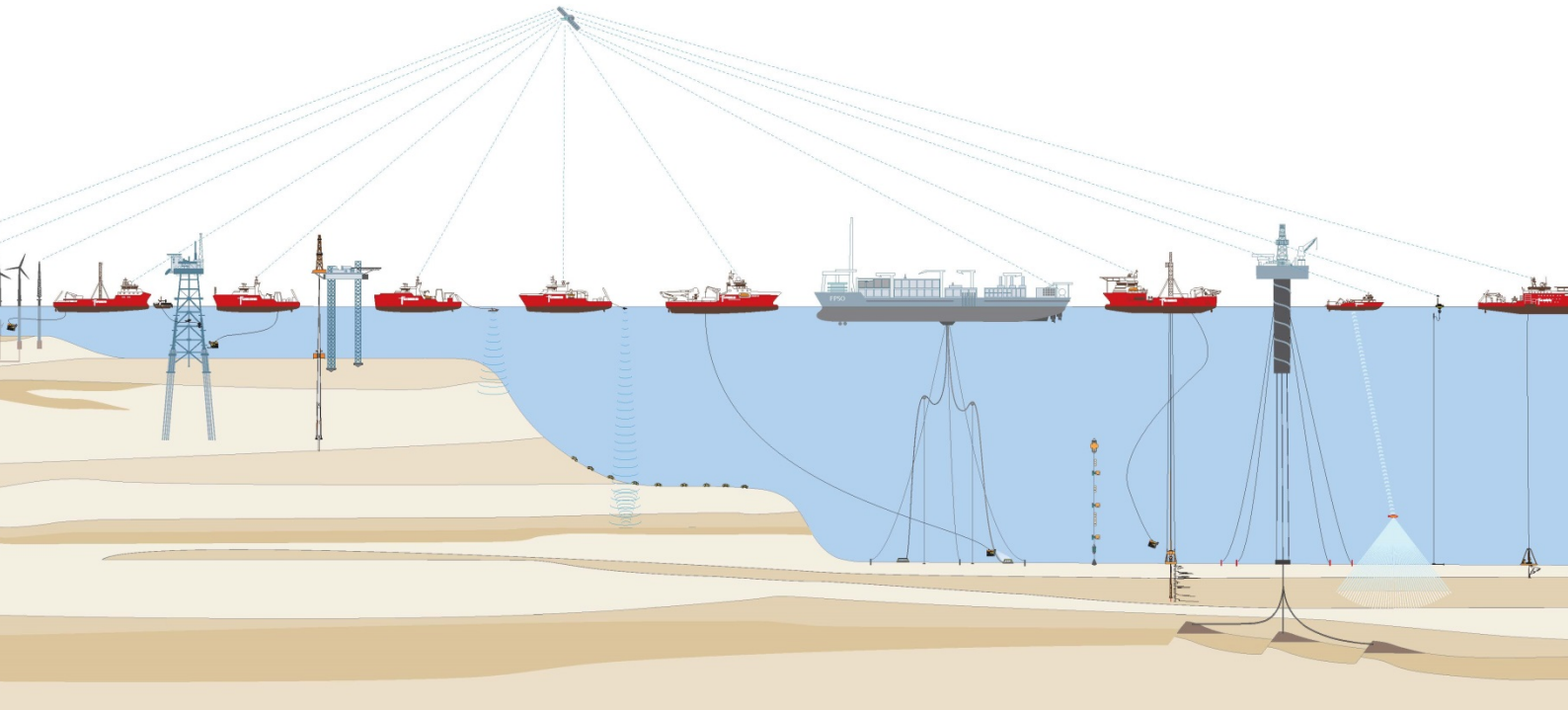
Wind Farm Sites III & IV
Borssele Wind Farm Zone
Dutch Sector, North Sea

Fugro Document No.: J11302-TN-001(03)

Rijksdienst voor Ondernemend Nederland (RVO)

Rijksdienst voor Ondernemend Nederland

Final Technical Note



Project Name:	Microscope Descriptions		
Project Number:	J11302	**Document Number:**	J11302-TN-001(03)
Subject:	Microscope Descriptions		
Issued to:	Rijksdienst voor Ondernemend Nederland (RVO) and Fugro Engineers B.V.		
Issue Date:	14 March 2016		
Prepared by:	Liam McDonald		
Checked by:	Leah Arlott	**Approved by:**	Chris A. Smith

1. INTRODUCTION

1.1 Project Overview

Reflected light microscopic analyses were carried out on 66 specimens from Wind Farm Sites (WFS) III and IV in the Borssele Wind Farm Zone (WFZ), Dutch Sector, North Sea. The analyses were performed in two phases. Phase I (32 specimens) had as main purpose an assessment of glauconite content of the sediments; Phase II (34 specimens) analyses were carried out to determine mineralogical composition of specimens, and sphericity and angularity of individual grains in order to assess sample suitability for batching. Batches of coarse-grained cohesionless material were prepared for four different soil units for use in a static and cyclic test programme.

Analysed specimens originate from various geological formations present in the Borssele WFZ. These formations can consist of various units and sub-units. In this report, soil units will be referred to using a combination of (sub-)unit and formation name (e.g. 'E5b (Tongeren)'). Units A (Southern Bight), B (Eem/Kreftenheye), C2 (Westkapelle Ground), E1 (Tongeren), E3 (Tongeren), E4 (Tongeren), E5a (Tongeren), E5b (Tongeren), and F2 (Dongen) consist predominantly of coarse-grained cohesionless soils; units F1a (Dongen) and F3 (Dongen) consist predominantly of fine-grained cohesive soils.

1.2 Guidelines on Use of Technical Note

Appendix A (Guidelines on Use of Technical Note) outlines the limitations of this technical note, in terms of a range of considerations including, but not limited to, its purpose, its scope, the data on which it is based, its use by third parties, possible future changes in design procedures and possible changes in the conditions at the site with time. It represents a clear exposition of the constraints which apply to all technical notes issued by Fugro. It should be noted that the Guidelines do not in any way supersede the terms and conditions of the contract between Fugro and Rijksdienst voor Ondernemend Nederland (RVO).

2. METHODOLOGY

2.1 General

Hand specimen descriptions and smear slide mineralogical observations were performed in accordance with BS 5930 (BSI, 2010) soil classification procedure. The hydrochloric acid test and subsequent carbonate content estimate (Section 2.4), as well as the description of the clay or silt coating (Section 2.3) around unwashed sediment, were performed using an in-house Fugro method.

All 66 samples (Table 2.1) underwent hand specimen description and smear slide analysis to determine their sedimentary and mineralogical composition. A hydrochloric acid test was also performed on the samples to determine an estimate of the carbonate content of the sediment.

Table 2.1 List of Samples for Microscopic Analysis

Testing Phase	(Sub-)unit (Formation)	Borehole ID	Sample ID	Sample Depth Below Seabed [m bsf]
I	A (Southern Bight)	BH-WFS3-6	3BagB	1.90
I	B (Eem/Kreftenheye)	BH-WFS3-1	4BagB	3.30
I	B (Eem/Kreftenheye)	BH-WFS4-4	6BagA	4.00
I	B (Eem/Kreftenheye)	BH-WFS4-7	7BagA	5.50
I	B (Eem/Kreftenheye)	BH-WFS3-1	12BagA	8.00
I	B (Eem/Kreftenheye)	BH-WFS3-6	12BagA	8.50
I	B (Eem/Kreftenheye)	BH-WFS4-6	13BagA	8.50
I	B (Eem/Kreftenheye)	BH-SubStatB-1	13BagA	9.00
I	B (Eem/Kreftenheye)	BH-WFS3-3A	2BagA	9.00
I	B (Eem/Kreftenheye)	BH-WFS4-5	24BagA	12.50
I	C2 (Westkapelle Ground)	BH-WFS4-7	16BagB	12.80
I	E1 (Tongeren)	CPT_WFS5_1	1BagA	6.50
I	E1 (Tongeren)	CPT_WFS5_1	1BagB	6.90
I	E1 (Tongeren)	BH-WFS4-7	23BagB	27.35
I	E3 (Tongeren)	BH-WFS5-1	15BagB	14.45
I	E3 (Tongeren)	BH-WFS4-6	24BagA	14.50
I	E4 (Tongeren)	BH-WFS4-6	28BagA	28.00
I	E4 (Tongeren)	BH-SubStatB-1	26BagA	30.00
I	E5a (Tongeren)	BH-WFS4-4	26BagA	14.50
I	E5a (Tongeren)	BH-WFS3-2	21BagA	14.50
I	E5a (Tongeren)	BH-WFS4-5	30BagA	22.00
I	E5b (Tongeren)	BH-WFS3-2	23BagA	22.50
I	E5b (Tongeren)	BH-WFS3-3A	14BagA	30.50
I	E5b (Tongeren)	CPT_WFS4_18A	1BagA	45.00
I	E5b (Tongeren)	CPT_WFS4_18A	1BagB	45.40
I	E5b (Tongeren)	CPT_SubStatB_1	1BagA	45.50
I	E5b (Tongeren)	CPT_SubStatB_1	1BagB	45.90
I	F1a (Dongen)	BH-WFS3-1	24BagUU	23.30
I	F1a (Dongen)	BH-SubStatB-1	35BagA	62.00
I	F2 (Dongen)	CPT_WFS3_1A	1BagA	38.50
I	F2 (Dongen)	CPT_WFS3_1A	1BagB	38.90
I	F3 (Dongen)	BH-WFS3-4A	11BagA	44.00
II	A (Southern Bight)	BH-WFS4-4	1BagA	0.00
II	A (Southern Bight)	BH-WFS3-5	1BagA	0.00
II	A (Southern Bight)	BH-WFS3-2	1BagA	0.00
II	A (Southern Bight)	BH-WFS3-3	1BagB	0.25
II	A (Southern Bight)	BH-WFS4-7	1BagB	0.35
II	A (Southern Bight)	BH-WFS3-1	1BagB	0.35
II	A (Southern Bight)	BH-SubStatB-1	2BagA	0.50
II	A (Southern Bight)	BH-WFS3-6	2BagA	0.50

Testing Phase	(Sub-)unit (Formation)	Borehole ID	Sample ID	Sample Depth Below Seabed [m bsf]
II	B (Eem/Kreftenheye)	BH-SubStatB-1	5BagA	3.50
II	B (Eem/Kreftenheye)	BH-WFS5-1	5BagA	4.00
II	B (Eem/Kreftenheye)	BH-WFS4-5	9BagA	4.50
II	B (Eem/Kreftenheye)	BH-WFS4-7	6BagB	4.75
II	B (Eem/Kreftenheye)	BH-WFS3-1	7BagA	5.00
II	B (Eem/Kreftenheye)	BH-WFS4-5	15BagA	8.00
II	B (Eem/Kreftenheye)	BH-SubStatB-1	11BagA	8.00
II	B (Eem/Kreftenheye)	BH-WFS3-6	16BagA	11.00
II	B (Eem/Kreftenheye)	BH-WFS-3-1	18BagA	12.00
II	B (Eem/Kreftenheye)	BH-WFS4-6	21BagA	12.50
II	E3 (Tongeren)	BH-SubStatB-1	16BagA	11.00
II	E3 (Tongeren)	BH-SubStatB-1	22BagA	14.50
II	E3 (Tongeren)	BH-WFS4-6	25BagA	17.50
II	E3 (Tongeren)	BH-SubStatB-1	23BagA	18.00
II	E3 (Tongeren)	BH-WFS5-1	16BagB	18.40
II	E3 (Tongeren)	BH-WFS4-7	28BagA	42.50
II	E3 (Tongeren)	BH-WFS4-7	29BagA	46.50
II	E5b (Tongeren)	BH-WFS4-3	13BagB	10.80
II	E5b (Tongeren)	BH-WFS4-3	18BagA	14.00
II	E5b (Tongeren)	BH-WFS4-2A	12BagA	18.00
II	E5b (Tongeren)	BH-WFS4-5	31BagA	26.00
II	E5b (Tongeren)	BH-WFS3-3A	13BagA	26.50
II	E5b (Tongeren)	BH-WFS3-6	25BagA	33.50
II	E5b (Tongeren)	BH-WFS3-6	26BagA	37.50
II	E5b (Tongeren)	BH-WFS4-6	33BagA	48.00
II	E5b (Tongeren)	BH-WFS5-1	24BagA	49.50

2.2 Hand Specimen

Sediment was observed under a hand lens to determine its basic characteristics. A Munsell colour chart (2009) was used to describe the colour of samples. Percentages of each mineral constituent were estimated using a point-and-count method, aided by comparison charts such as Terry and Chilingar (1955) and Folk (1951). Table 2.2 presents the Krumbein roundness comparison chart which was used to determine the estimated angularity and sphericity for each constituent mineral.

Table 2.2 Comparison of Roundness and Krumbein Number

Roundness	Krumbein Number [*r*K]
Angular	0.1 – 0.2
Subangular	0.3 – 0.4
Subrounded	0.5 – 0.6
Rounded	0.7 – 0.8
Well-rounded	0.9

2.3 Clay or Silt Coating

For samples which contained sand and coarser material, the percentage of clay or silt coating around the grains was estimated for unwashed samples. No approved standard exists for this type of estimation; therefore an arbitrary value was applied to standardise coating of grains across all samples (Table 2.3).

Table 2.3 Terminology Arbitrarily Assigned to Clay or Silt Coating around Grains

Clay or Silt Coating	Percentage [%]
Minor	0 – 25
Limited	25 – 50
Moderate	50 – 75
Extensive	75 – 100

2.4 Hydrochloric Acid Test

Approximately 1 g of sediment was removed from each sample and submerged in 10 % hydrochloric acid concentration. The duration and volatility of the reaction was observed to estimate carbonate content until all observable reactions with HCl and carbonate had ceased. Table 2.4 outlines the Fugro in-house method used to estimate carbonate content.

Table 2.4 Reaction with HCl to Estimate the Sediment Carbonate Content

Reaction with 10 % Diluted HCl		Mass Carbonate content [%]	Residue
Clay Composition	Sand Composition		
No or slow	Limited reaction	0 – 10	Nearly all soil remaining
Prolonged and foaming	Violent reaction	10 – 50	Large part of soil remaining
Violent reaction	Violent reaction	50 – 90	Only small part of soil remaining
Violent reaction	Violent reaction	90 –100	Hardly any soil remaining

2.5 Reflected-Light Binocular Microscope

Representative sediment was prepared for both washed and unwashed on smear slides. Both were prepared using the same technique, however, the washed slides were first prepared by washing a small amount of sediment in a clean tray using deionised water. Sediment was then smeared approximately one grain thick onto a glass slide, with care taken to avoid crushing or losing grains when smearing. To determine a consistent colour of the sample, soil samples were sufficiently dried before a colour code was assigned. Using the binocular microscope under reflected unpolarised light, the composition, angularity and sphericity of the main mineral constituents and sediment fabric were described.

2.6 Sediment Classification and Descriptions

Sediment classifications for this technical note are in accordance with BS 5930 (BSI, 2010).

A hand sample analysis of the prepared slides and bagged samples was performed to obtain a generalised soil description. Table 2.5 presents sediment classification name and associated particle size as described in BS 5930 (2010).

Table 2.5 Particle Size Classification Ranges in Accordance with BS 5930 (BSI, 2010)

Soil Type	Classification Name	Particle Size [mm]
Clay	-	>0.002
Silt	Fine	0.002 – 0.006
	Medium	0.006 – 0.02
	Coarse	0.02 – 0.063
Sand	Fine	0.063 – 0.2
	Medium	0.2 – 0.63
	Coarse	0.63 – 2.0
Gravel	Fine	2.0 – 6.3
	Medium	6.3 – 20
	Coarse	20 – 63

Details of sediment sorting were provided as part of the microscope description. Sediment sorting is a qualitative assessment describing the distribution of grain size in a sediment sample. Well-sorted samples contain a limited range of grain sizes: sediment grains are all of a similar size. In contrast, poorly sorted samples contain a wide range of grain sizes: sediment grains are a variety of sizes, such as silt-, sand- and gravel-sized material.

Percentages of each mineral constituent were estimated using a point-and-count method aided by comparison charts such as those of Terry and Chilingar (1955) and Folk (1951) (Figure 2.1).

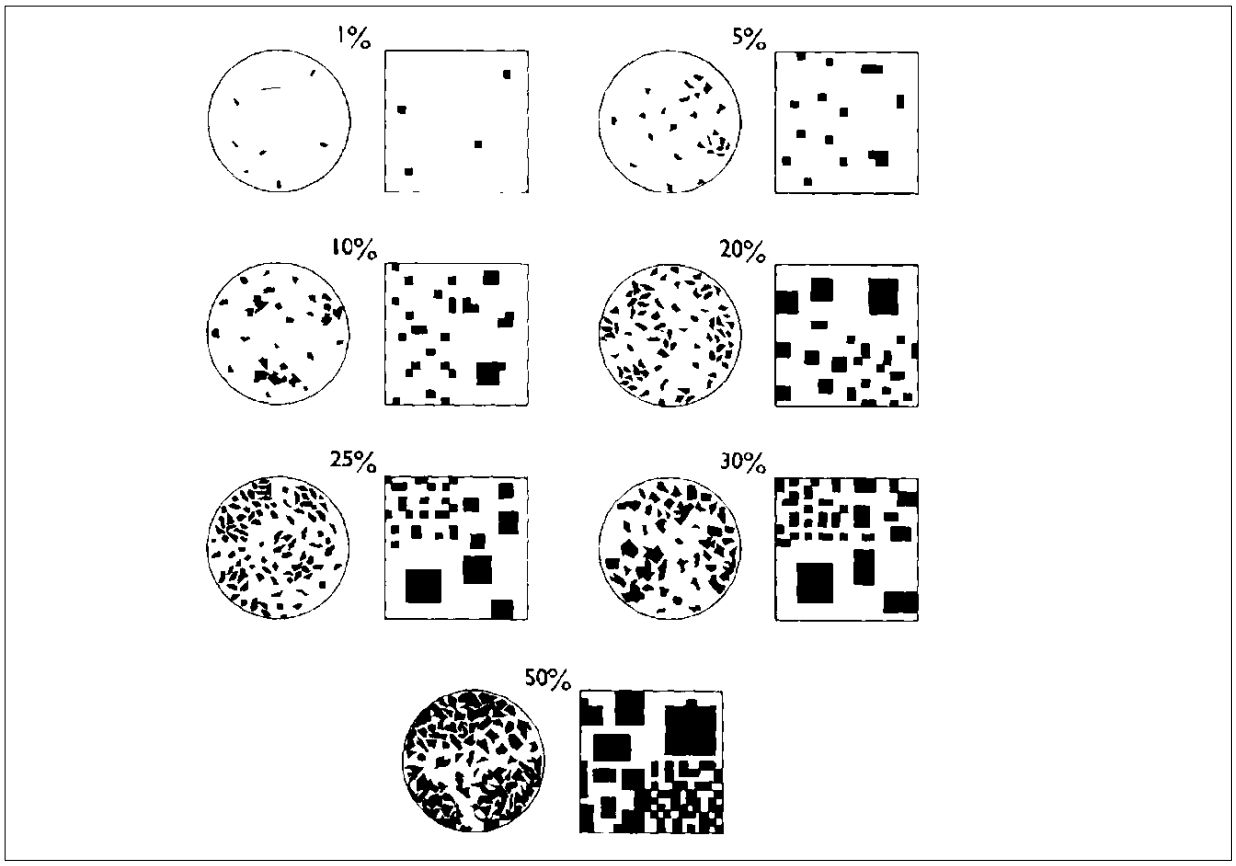


Figure 2.1 Estimation of percentages based on Folk (1951) and Terry and Chilingar (1955). Reproduced from Folk et al., (1970)

Figure 2.2 presents Krumbein's angularity chart used to estimate the angularity and sphericity of sediment grains. Krumbein roundness number ($r\mathrm{K}$) ranges were assigned based on Krumbein and Sloss (1963) presented in Table 2.2. Sizes of shells and shell fragments were described according to BS 5930 (BSI, 2010).

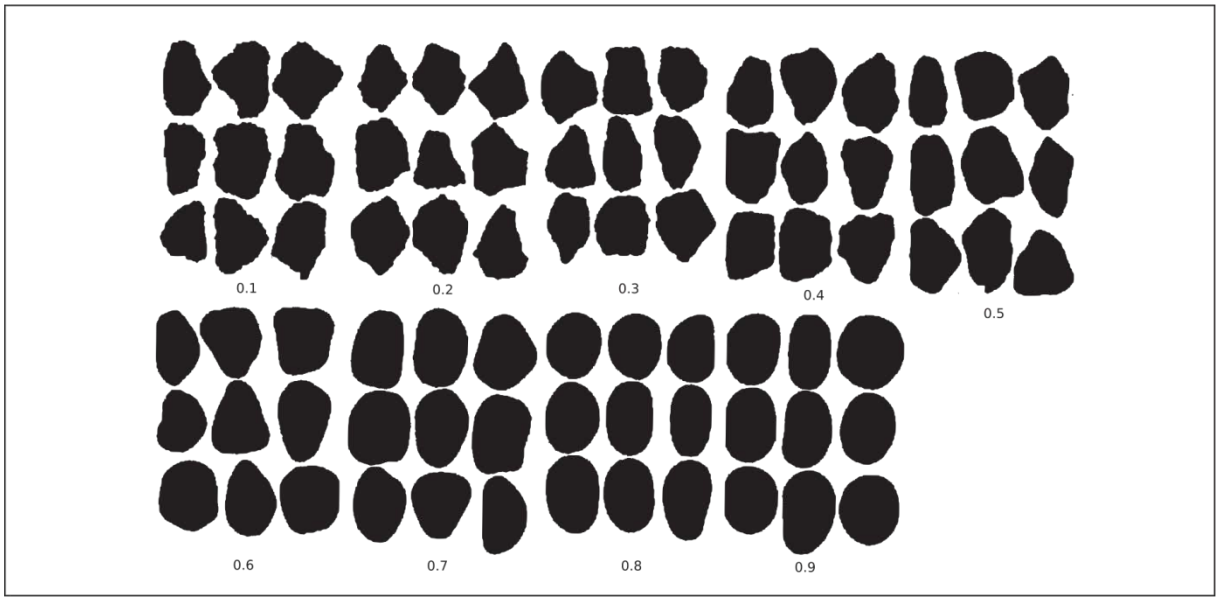


Figure 2.2: Krumbein's angularity chart (Krumbein, 1941; adapted from Roussillon et al., 2009)

2.7 Photography

Photographs were taken at multiple frame widths depending on the type of sample and the observed features. The microscope was focused prior to the taking of each image. However, where grains do not occur at one grain thickness, focusing the lens was not possible. In this case, the image was focused on a representative area of the sample.

2.8 Summary Plates

Sample summary plates (A.3 to A.68) were made in a similar format to the Borssele WFS I & II microscopy analysis (Fugro, 2015). These plates summarise hand specimen descriptions and reflected light microscope descriptions and observations.

3. RESULTS

3.1 Summary Plates

Plates A.1 and A.2 summarise the results of the microscopic descriptions and observations.

3.2 Phase I

Phase I samples are grouped into five main formations, with five sub-units within the Tongeren Formation and three in the Dongen Formation, totalling eleven sample groups. The range of glauconite within each sample group varies, with Unit A (Southern Bight) and Unit C2 (Westkapelle Ground) containing 0 %, whilst Unit E1 and Unit E4 (Tongeren) sample groups contain up to 15 %.

3.3 Phase II

Phase II samples are grouped into four main formations. Samples in Phase II were analysed to confirm suitability for batching. All samples within the laboratory testing batches are sufficiently comparable to confirm consistent sediment types within these four groups.

4. REFERENCES

BSI, 2010. *BS 5930:1999 Code of Practice for Site Investigations, Incorporating Amendment No. 2*. London: BSI.

FUGRO, 2015. *Technical Note: Microscope Descriptions, Borssele Wind Farm, The Netherlands, North Sea.* Fugro Report No. J11286-TN-007(02). Wallingford: Fugro GeoConsulting Limited

FOLK, R. L., 1951. A Comparison Chart for Visual Percentage Estimation, *Journal of Sedimentary Petrology*, **21** (1) pp 32–33.

FOLK, R. L., ANDREWS, P. B., and LEWIS, D., 1970. Detrital sedimentary rock classification and nomenclature for use in New Zealand. *New Zealand journal of geology and geophysics*, *13*(4), 937-968.

KRUMBEIN, W. C., 1941. Measurement and Geological Significance of Shape and Roundness of Sedimentary Particles, *Journal of Sedimentary Petrology* **11** (2), pp 64–72.

KRUMBEIN, W. C., and SLOSS, L. L., 1963. *Stratigraphy and Sedimentation, 2nd edition*. San Francisco: W.H Freeman.

MUNSELL COLOR, 2009. *Munsell Soil Color Charts: with Genuine Munsell Color Chips*, 2009 (Revised Ed.). Grand Rapids: Munsell Color.

ROUSSILLON, T., PIÉGAY, H., SIVIGNON, I., TOUGNE, L., and LAVIGNE, F. 2009. Automatic computation of pebble roundness using digital imagery and discrete geometry. *Computers & Geosciences*, *35* (10), 1992-2000.

TERRY, R. D and CHILINGAR, G. V., 1955. *Summary of "Concerning some additional aids in studying sedimentary formations'* In. SHESTOV, M.S., 1955. *Studying Sedimentary Formations,* Journal of Sedimentary Petrology, **25** (3), pp 229–234.

LIST OF PLATES

Title	Plate No.
Phase I Sample Summary Sheet	A.1
Phase II Sample Summary Sheet	A.2
Hand Specimen and Mineralogical Observations for BH-WFS3-6 – (3BagB)	A.3
Hand Specimen and Mineralogical Observations for BH-WFS3-1 – (4BagB)	A.4
Hand Specimen and Mineralogical Observations for BH-WFS4-4 – (6BagA)	A.5
Hand Specimen and Mineralogical Observations for BH-WFS4-7 – (7BagA)	A.6
Hand Specimen and Mineralogical Observations for BH-WFS3-1 – (12BagA)	A.7
Hand Specimen and Mineralogical Observations for BH-WFS3-6 – (12BagA)	A.8
Hand Specimen and Mineralogical Observations for BH-WFS4-6 – (13BagA)	A.9
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (13BagA)	A.10
Hand Specimen and Mineralogical Observations for BH-WFS3-3A – (2BagA)	A.11
Hand Specimen and Mineralogical Observations for BH-WFS4-5 – (24BagA)	A.12
Hand Specimen and Mineralogical Observations for BH-WFS4-7 – (16BagA)	A.13
Hand Specimen and Mineralogical Observations for CPT_WFS5_1 – (1BagA)	A.14
Hand Specimen and Mineralogical Observations for CPT_WFS5_1 – (1BagB)	A.15
Hand Specimen and Mineralogical Observations for BH-WFS4-7 – (23BagB)	A.16
Hand Specimen and Mineralogical Observations for BH-WFS5-1 – (15BagB)	A.17
Hand Specimen and Mineralogical Observations for BH-WFS4-6 – (24BagA)	A.18
Hand Specimen and Mineralogical Observations for BH-WFS4-6 – (28BagA)	A.19
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (26BagA)	A.20
Hand Specimen and Mineralogical Observations for BH-WFS4-4 – (26BagA)	A.21
Hand Specimen and Mineralogical Observations for BH-WFS3-2 – (21BagA)	A.22
Hand Specimen and Mineralogical Observations for BH-WFS4-5 – (30BagA)	A.23
Hand Specimen and Mineralogical Observations for BH-WFS3-2 – (23BagA)	A.24
Hand Specimen and Mineralogical Observations for BH-WFS3-3A – (14BagA)	A.25
Hand Specimen and Mineralogical Observations for CPT_WFS4-18A – (1BagA)	A.26
Hand Specimen and Mineralogical Observations for CPT_WFS4-18A – (1BagB)	A.27
Hand Specimen and Mineralogical Observations for CPT_SubStatB_1 – (1BagA)	A.28
Hand Specimen and Mineralogical Observations for CPT_SubStatB_1 – (1BagB)	A.29
Hand Specimen and Mineralogical Observations for BH-WFS3-1 – (24BagUU)	A.30
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (35BagA)	A.31
Hand Specimen and Mineralogical Observations for CPT_WFS3_1A – (1BagA))	A.32
Hand Specimen and Mineralogical Observations for CPT_WFS3_1A – (1BagB)	A.33
Hand Specimen and Mineralogical Observations for BH-WFS3-4A – (1BagA)	A.34
Hand Specimen and Mineralogical Observations for BH-WFS4-4 – (1BagA)	A.35
Hand Specimen and Mineralogical Observations for BH-WFS3-5 – (1BagA)	A.36
Hand Specimen and Mineralogical Observations for BH-WFS3-2 – (1BagA)	A.37
Hand Specimen and Mineralogical Observations for BH-WFS3-3 – (1BagB)	A.38
Hand Specimen and Mineralogical Observations for BH-WFS4-7 – (1BagB)	A.39
Hand Specimen and Mineralogical Observations for BH-WFS3-1 – (1BagB)	A.40
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (2BagB)	A.41
Hand Specimen and Mineralogical Observations for BH-WFS3-6 – (2BagA)	A.42

Title	Plate No.
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (5BagA)	A.43
Hand Specimen and Mineralogical Observations for BH-WFS5-1 – (5BagA)	A.44
Hand Specimen and Mineralogical Observations for BH-WFS4-5 – (9BagA)	A.45
Hand Specimen and Mineralogical Observations for BH-WFS4-7 – (6BagB)	A.46
Hand Specimen and Mineralogical Observations for BH-WFS3-1 – (7BagA)	A.47
Hand Specimen and Mineralogical Observations for BH-WFS4-5 – (15BagA)	A.48
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (11BagA)	A.49
Hand Specimen and Mineralogical Observations for BH-WFS3-6 – (16BagA)	A.50
Hand Specimen and Mineralogical Observations for BH-WFS3-1 – (18bagA)	A.51
Hand Specimen and Mineralogical Observations for BH-WFS4-6 – (21BagA)	A.52
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (16BagA)	A.53
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (22BagA)	A.54
Hand Specimen and Mineralogical Observations for BH-WFS4-6 – (25BagA)	A.55
Hand Specimen and Mineralogical Observations for BH-SubStatB-1 – (23BagA)	A.56
Hand Specimen and Mineralogical Observations for BH-WFS5-1 – (16BagB)	A.57
Hand Specimen and Mineralogical Observations for BH-WFS4-7 – (28BagA)	A.58
Hand Specimen and Mineralogical Observations for BH-WFS4-7 – (29BagA)	A.59
Hand Specimen and Mineralogical Observations for BH-WFS4-3 – (13BagB)	A.60
Hand Specimen and Mineralogical Observations for BH-WFS4-3 – (18BagA)	A.61
Hand Specimen and Mineralogical Observations for BH-WFS4-2A – (12BagA)	A.62
Hand Specimen and Mineralogical Observations for BH-WFS4-5 – (31BagA)	A.63
Hand Specimen and Mineralogical Observations for BH-WFS3-3A – (13BagA)	A.64
Hand Specimen and Mineralogical Observations for BH-WFS3-6 – (25BagA)	A.65
Hand Specimen and Mineralogical Observations for BH-WFS3-6 – (26BagA)	A.66
Hand Specimen and Mineralogical Observations for BH-WFS4-6 – (33BagA)	A.67
Hand Specimen and Mineralogical Observations for BH-WFS5-1 – (24BagA)	A.68

APPENDICES

A. GUIDELINES ON USE OF TECHNICAL NOTE

B. PHASES I AND II SAMPLE SUMMARY SHEETS

C. PHASE I SAMPLE PLATES

D. PHASE II SAMPLE PLATES

A. GUIDELINES ON USE OF TECHNICAL NOTE

This report and the assessment carried out in connection with the report (together the 'Services') were compiled and carried out by Fugro GeoConsulting Limited ('Fugro') for Rijksdienst voor Ondernemend Nederland (RVO) (the 'Client') in accordance with the terms of a contract between Fugro and the Client. The Services were performed by Fugro with the skill and care ordinarily exercised by a reasonable geotechnical specialist at the time the Services were performed. Further, and in particular, the Services were performed by Fugro taking into account the limits of the scope of works required by the Client, the time scale involved and the resources, including financial and manpower resources, agreed between Fugro and the Client.

Other than that expressly contained in paragraph one above, Fugro provides no other representation or warranty whether express or implied, in relation to the Services.

The Services were performed by Fugro exclusively for the purposes of the Client. Fugro is not aware of any interest of or reliance by any party other than the Client in or on the Services. Unless expressly provided in writing, Fugro does not authorise, consent or condone any party other than the Client relying upon the Services. Should this report or any part of this report or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and Fugro disclaims any liability to such party. Any such party would be well advised to seek independent advice from a competent geotechnical specialist and / or lawyer.

It is Fugro's understanding that this report is to be used for the purpose described in Section 1 (Introduction) of this report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, and/or should the Client's proposed development or use of the site change (including in particular any change in any design and/or specification relating to the proposed use or development of the site), this report may no longer be valid or appropriate and any further use of or reliance upon the report in those circumstances by the Client without Fugro's review and advice shall be at the Client's sole and own risk. Should Fugro be requested, and Fugro agree, to review the report after the date hereof, Fugro shall be entitled to additional payment at the then existing rates or such other terms as may be agreed between Fugro and the Client.

The passage of time may result in changes (whether man-made or otherwise) in site conditions and changes in regulatory or other legal provisions, technology, methods of analysis, or economic conditions which could render the report inaccurate or unreliable. The information, recommendations and conclusions contained in this report should not be relied upon if any such changes have taken place or after a period of two years from the date of this report or such other period as maybe expressly stated in the report, without the written agreement of Fugro. In the absence of such written agreement of Fugro, reliance on the report after any such changes have occurred or after the period of two years has expired shall be at the Client's own and sole risk. Should Fugro agree to review the report after the period of two years has expired, Fugro shall be entitled to additional payment at the then existing rates or such other terms as may be agreed between Fugro and the Client.

The observations, recommendations and conclusions in this report are based solely upon the Services which were provided pursuant to the contract between the Client and Fugro. Fugro has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the Client and Fugro. Fugro is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services.

Where the Services have involved Fugro's interpretation and/or other use of any information (including documentation or materials, analysis, recommendations and conclusions) provided by third parties (including independent testing and/or information services or laboratories) or the Client and upon which Fugro was reasonably entitled to rely or involved Fugro's observations of existing physical conditions of any site involved in the Services, then the Services clearly are limited by the accuracy of such information and the observations which were reasonably possible of the said site. Unless otherwise stated, Fugro was not authorised and did not attempt to independently verify the accuracy or completeness of such information, received from the Client or third parties during the performance of the Services. Fugro is not liable for any inaccuracies (including any incompleteness) in the said information, the discovery of which inaccuracies required the doing of any act including the gathering of any information which it was not reasonably possible for Fugro to do including the doing of any independent investigation of the information provided to Fugro save as otherwise provided in the terms of the contract between the Client and Fugro.

The soil and ground conditions information provided in the Services are based solely on evaluations of soil and ground condition samples and in situ tests at determined sample test locations and elevations. That information cannot be extrapolated to any area or elevation outside those locations and elevations unless specifically so stated in the report. In the light of the information available to Fugro, the soil and ground conditions information are considered appropriate for use in relation to the geotechnical design and installation aspects of the structures addressed in the report, but they may not be appropriate for the design of other structures.

B. PHASES I AND II SAMPLE SUMMARY SHEETS

Phase I Sample Summary Sheet

Soil Unit	Borehole ID	Sample ID	Depth [m BSF]	Microscope Descriptions								Plate No.	Batch Summary							
				Quartz [%]	Feldspar [%]	Lithic [%]	Biotite [%]	Shell [%]	Glauconite [%]	Calcite [%]	Muscovite [%]		Quartz [%]	Feldspar [%]	Lithic [%]	Biotite [%]	Shell [%]	Glauconite [%]	Calcite [%]	Muscovite [%]
A (Southern Bight)	BH-WFS3-6	3BagB	1.90	80	5	5	10	-	-	-	-	A.3	80	5	5	10	-	-	-	-
B (Eem/Kreftenheye)	BH-WFS3-1	4BagB	3.30	70	8	8	6	6	2	-	-	A.4	70-75	5-10	3-10	H-12	3-8	2-4	2-3	3
	BH-WFS4-4	6BagA	4.00	70	8	5	8	3	-	3	3	A.5								
	BH-WFS4-7	7BagA	5.50	75	10	5	7	3	-	-	-	A.6								
	BH-WFS3-1	12BagA	8.00	70	10	7	7	3	-	3	-	A.7								
	BH-WFS3-6	12BagA	8.50	75	10	8	2	5	-	-	-	A.8								
	BH-WFS4-6	13BagA	8.50	70	7	10	7	4	-	2	-	A.9								
	BH-SubStatB-1	13BagA	9.00	70	7	10	7	-	4	2	-	A.10								
	BH-WFS3-3A	2BagA	9.00	75	5	7	3	8	2	-	-	A.11								
	BH-WFS4-5	24BagA	12.50	75	8	3	12	-	2	-	-	A.12								
C2 (Westkapelle Ground)	BH-WFS4-7	16BagB	12.80	15	8	5	8	60	-	4	-	A.13	15	8	5	8	60	-	4	-
E1 (Tongeren)	CPT_WFS5_1	1BagA	6.50	60	-	-	15	-	25	-	-	A.14	60-75	3	2	10-15	-	10-25	-	5
	CPT_WFS5_1	1BagB	6.90	60	-	-	15	-	20	-	5	A.15								
	BH-WFS4-7	23BagB	27.35	75	3	2	10	-	10	-	-	A.16								
E3 (Tongeren)	BH-WFS5-1	15BagB	14.45	90	-	3	5	-	2	-	-	A.17	85-90	2	3	4-5	-	2-9	-	-
	BH-WFS4-6	24BagA	14.50	85	2	-	4	-	9	-	-	A.18								
E4 (Tongeren)	BH-WFS4-6	28BagA	28.00	75	-	-	15	-	10	-	-	A.19	75-90	-	-	6-15	-	4-10	-	-
	BH-SubStatB-1	26BagA	30.00	90	-	-	6	-	4	-	-	A.20								
E5a (Tongeren)	BH-WFS3-2	21BagA	14.50	90	2	3	5	-	-	-	-	A.21	80-90	2	2-4	4-8	-	4-6	-	-
	BH-WFS4-4	26BagA	14.50	90	-	2	4	-	4	-	-	A.22								
	BH-WFS4-5	30BagA	22.00	80	2	4	8	-	6	-	-	A.23								
E5b (Tongeren)	BH-WFS3-2	23BagA	22.50	90	-	5	3	-	2	-	-	A.24	80-90	2	2-6	3-10	-	2-4	-	2
	BH-WFS3-3A	14BagA	30.50	85	-	4	6	-	3	-	2	A.25								
	CPT_WFS4_18A	1BagA	45.00	85	-	6	7	-	-	-	2	A.26								
	CPT_WFS4_18A	1BagB	45.40	90	-	2	4	-	4	-	-	A.27								
	CPT_SubStatB_1	1BagA	45.50	80	2	6	10	-	2	-	-	A.28								
	CPT_SubStatB_1	1BagB	45.90	85	-	3	6	-	4	-	2	A.29								
F1a (Dongen)	BH-WFS3-1	24BagUU	23.30	85	3	-	5	-	-	-	7	A.30	80-85	2-3	3	5-7	-	-	-	7-8
	BH-SubStatB-1	35BagA	62.00	80	2	3	7	-	-	-	8	A.31								
F2 (Dongen)	CPT_WFS3_1A	1BagA	38.50	80	-	5	10	-	5	-	-	A.32	80-90	-	3-5	3-10	-	4-5	-	-
	CPT_WFS3_1A	1BagB	38.90	90	-	3	3	-	4	-	-	A.33								
F3 (Dongen)	BH-WFS3-4A	11BagA	44.00	90	3	-	2	5	-	-	-	A.34	90	3	-	2	5	-	-	-

J11302 - N6083 RVO Borssele
Detailed Microscope Description
Phase I Sample Summary Sheet

Plate Number: A.1

Made:	LRM	14/03/2016
Checked:	LA	14/03/2016
Approved:	CAS	14/03/2016

FUGRO

Phase II Sample Summary Sheet

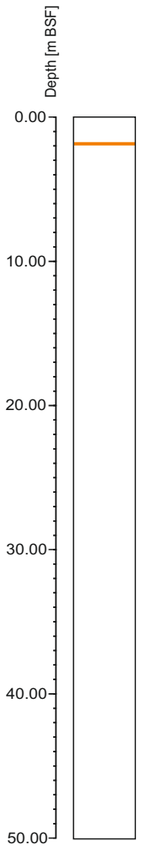
Batch I.D	Soil Unit	Borehole ID	Sample I.D	Depth [m BSF]	Microscope Descriptions								Plate No.	Batch Summary							
					Quartz [%]	Feldspar [%]	Lithic [%]	Biotite [%]	Shell [%]	Glauconite [%]	Calcite [%]	Muscovite [%]		Quartz [%]	Feldspar [%]	Lithic [%]	Biotite [%]	Shell [%]	Glauconite [%]	Calcite [%]	Muscovite [%]
1	A (Southern Bight)	BH-WFS4-4	1BagA	0.00	70	10	10	10	-	-	-	-	A.35	60-80	3-10	4-13	3-15	4-15	2	5	-
		BH-WFS3-5	1BagA	0.00	70	5	5	3	15	2	-	-	A.36								
		BH-WFS3-2	1BagA	0.00	75	7	4	10	4	-	-	-	A.37								
		BH-WFS3-3	1BagB	0.25	80	3	5	3	7	2	-	-	A.38								
		BH-WFS4-7	1BagB	0.35	75	4	7	4	10	-	-	-	A.39								
		BH-WFS3-1	1BagB	0.35	70	3	13	5	7	2	-	-	A.40								
		BH-SubStatB-1	2BagA	0.50	70	9	6	5	10	-	-	-	A.41								
		BH-WFS3-6	2BagA	0.50	60	10	5	15	5	-	5	-	A.42								
2	B (Eem/Kreftenheye)	BH-SubStatB-1	5BagA	3.50	80	3	5	7	3	2	-	-	A.43	70-90	2-10	2-5	3-15	2-5	2-3	2-5	5
		BH-WFS5-1	5BagA	4.00	75	5	3	15	-	2	-	-	A.44								
		BH-WFS4-5	9BagA	4.50	85	8	3	5		-	-	-	A.45								
		BH-WFS4-7	6BagB	4.75	85	3	2	10	-	-	-	-	A.46								
		BH-WFS3-1	7BagA	5.00	70	10	5	7	3	-	5	-	A.47								
		BH-WFS4-5	15BagA	8.00	80	2	-	10	-	3	-	5	A.48								
		BH-SubStatB-1	11BagA	8.00	80	8	5	5	-	2	-	-	A.49								
		BH-WFS3-6	16BagA	11.00	80	5	-	8	5	-	2	-	A.50								
		BH-WFS3-1	18BagA	12.00	90	5	-	3	-	2	-	-	A.51								
		BH-WFS4-6	21BagA	12.50	85	5	3	5	2	-	-	-	A.52								
3	E3 (Tongeren)	BH-SubStatB-1	16BagA	11.00	85	-	2	5	-	8	-	-	A.53	75-95	-	2-5	2-10	-	3-15	-	2
		BH-SubStatB-1	22BagA	14.50	85	-	-	10	-	5	-	-	A.54								
		BH-WFS4-6	25BagA	17.50	80	-	-	5	-	15	-	-	A.55								
		BH-SubStatB-1	23BagA	18.00	90	-	2	5	-	3	-	-	A.56								
		BH-WFS5-1	16BagB	18.40	75	-	5	8	-	10	-	2	A.57								
		BH-WFS4-7	28BagA	42.50	85	-	2	3	-	10	-	-	A.58								
		BH-WFS4-7	29BagA	46.50	95	-	-	2	-	3	-	-	A.59								
4	E5b (Tongeren)	BH-WFS4-3	13BagB	10.80	90	3	-	5	-	2	-	-	A.60	80-90	3	2-5	3-15	2	2-15	-	2-5
		BH-WFS4-3	18BagA	14.00	90	-	2	3	2	-	-	3	A.61								
		BH-WFS4-2A	12BagA	18.00	90	-	3	5	-	-	-	-	A.62								
		BH-WFS4-5	31BagA	26.00	80	-	-	15	-	5	-	-	A.63								
		BH-WFS3-3A	13BagA	26.50	85	-	2	5	-	8	-	-	A.64								
		BH-WFS3-6	25BagA	33.50	90	-	4	6	-	-	-	2	A.65								
		BH-WFS3-6	26BagA	37.50	85	3	5	4	-	3	-	-	A.66								
		BH-WFS4-6	33BagA	48.00	85	-	3	5	-	2	-	5	A.67								
		BH-WFS5-1	24BagA	49.50	80	-	-	5	-	15	-	-	A.68								

J11302 - N6083 RVO Borssele
Detailed Microscope Description
Phase II Sample Summary Sheet

Plate Number: A.2			
	Made:	LRM	14/03/2016
	Checked:	CB	14/03/2016
	Approved:	CAS	14/03/2016

C. PHASE I SAMPLE PLATES

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (5GY-4/1) oxidised yellowish brown (10YR-5/6) subangular to rounded medium to high sphericity fine to medium SAND with few fine sand-sized to fine gravel-sized angular low sphericity white shell fragments (bivalves) and with fine to medium sand-sized subangular to subrounded low to high sphericity black lithic fragments

Colour:
Unwashed: Yellowish brown (10YR-5/6)
Washed: Olive brown (2.5Y-4/3)

Sand is moderately to well sorted
Sand: Violent, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

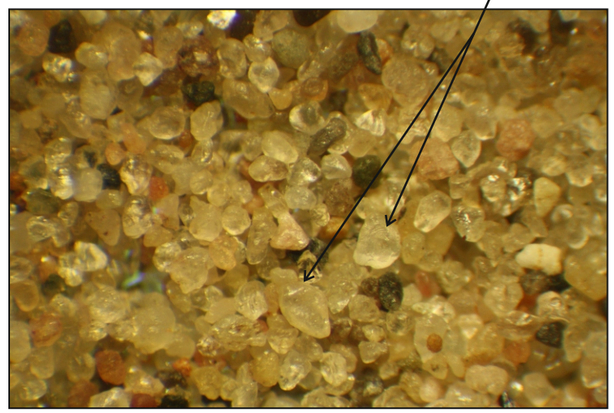
80 % - Fine to medium sand-sized subangular to rounded (*r*K = 0.4 to 0.8) low to medium sphericity (*r*K = 0.1 to 0.7) QUARTZ
- ~60 % frosted
- ~35 % glassy
- ~5 % light pink to reddish orange/red

10 % - Fine sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.1 to 0.5) black BIOTITE MICA
5 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.4 to 0.6) low sphericity (*r*K = 0.1 to 0.3) white to pinkish red FELDSPAR
5 % - Fine to medium sand-sized subangular to rounded (*r*K = 0.3 to 0.8) low to medium sphericity (*r*K = 0.3 to 0.7) brown to black LITHIC FRAGMENTS

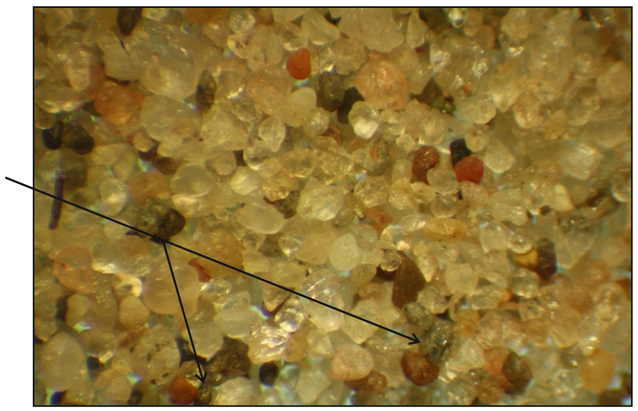
Trace: calcite, bioclastic debris, muscovite mica

Reflected Light Microphotographs

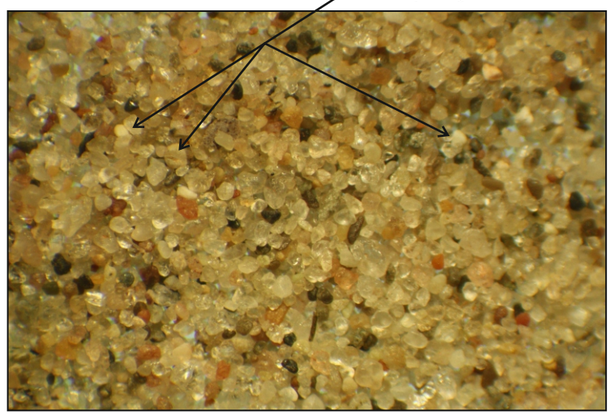
Unwashed Sample



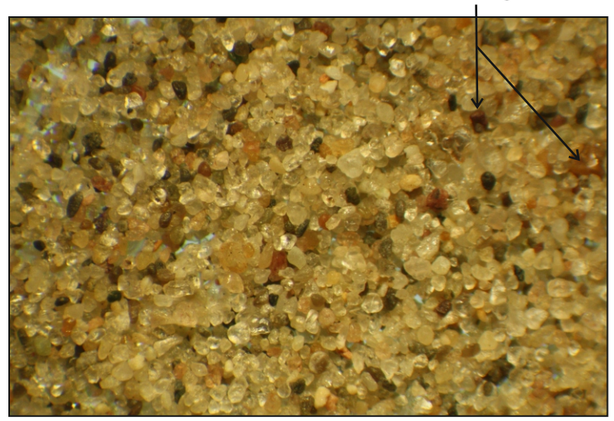
Washed Sample



Washed Sample

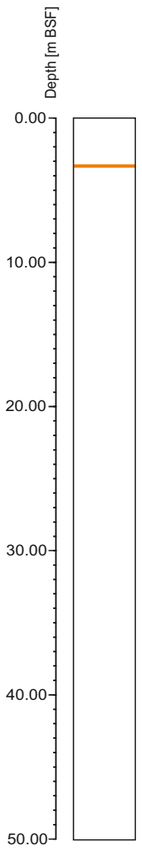


Unwashed Sample



J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS3-6 Sample Name: 3BagB**	**Depth: 1.90 m bsf Soil Unit: A (Southern Bight)**	**Plate Number: A.3**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Olive brown (2.5Y-4/3) subangular to well-rounded low to high sphericity medium to coarse SAND with coarse sand-sized to coarse gravel-sized angular low sphericity white shell fragments

Colour:
Unwashed: Olive brown (2.5Y-4/3)
Washed: Light olive brown (2.5Y-5/4)

Sand is moderately to well sorted
Sand: Violent, strong prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

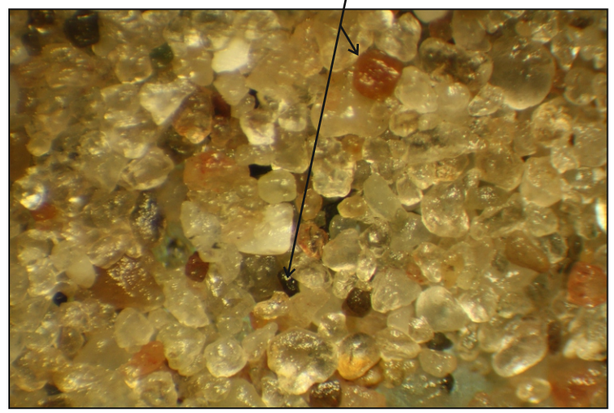
70 % - Fine to coarse sand-sized subangular to rounded (*r*K = 0.4 to 0.8) low to high sphericity (*r*K = 0.1 to 0.9) QUARTZ
~70 % frosted
~25 % glassy
~5 % light pink to reddish orange/red

8 % - Medium to coarse sand-sized angular to subrounded (*r*K = 0.1 to 0.6) low to medium sphericity (*r*K = 0.1 to 0.7) reddish pink to white FELDSPAR
8 % - Fine sand-sized to fine gravel-sized angular to subrounded (*r*K = 0.2 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) reddish brown to black LITHIC FRAGMENTS
6 % -Fine to coarse sand-sized angular to subrounded (*r*K = 0.2 to 0.5) low to high sphericity (*r*K = 0.1 to 0.9) black BIOTITE MICA
6 % - Medium sand-sized to fine gravel-sized subangular to rounded (*r*K = 0.3 to 0.8) low to medium sphericity (*r*K = 0.1 to 0.7) white BIOCLASTIC FRAGMENTS
2 % - Fine to medium sand-sized subangular to rounded (*r*K = 0.4 to 0.8) low to high sphericity (*r*K = 0.1 to 0.9) green GLAUCONITE

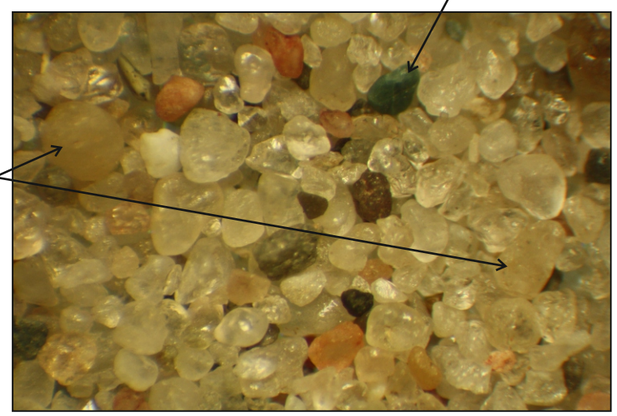
Trace: muscovite mica

Reflected Light Microphotographs

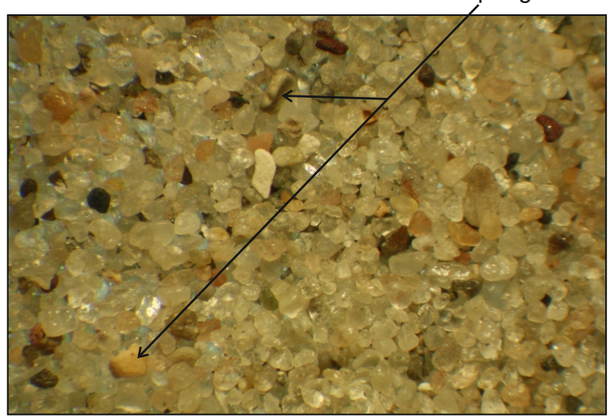
Unwashed Sample



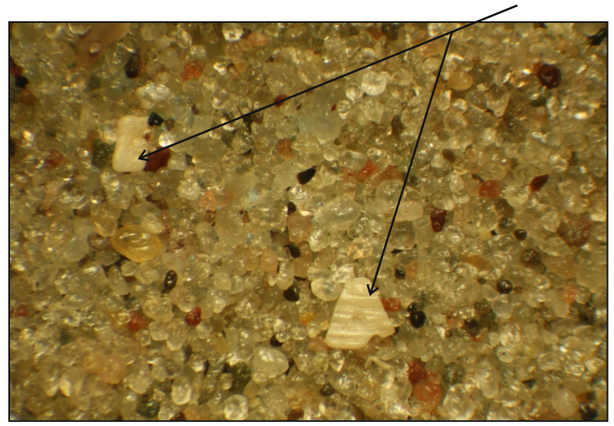
Washed Sample



Washed Sample



Unwashed Sample

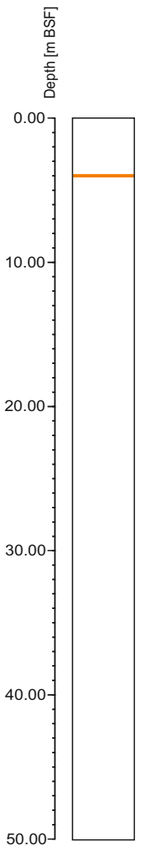


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-1** **Sample Name: 4BagB**	**Depth: 3.30 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.4**

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/4) subangular to rounded low to high sphericity coarse SAND with many fine to coarse sand-sized angular to subrounded low to high sphericity black lithic fragments and with fine sand-sized coarse gravel-sized angular low sphericity white to light greenish grey shell fragments (bivalves)

Colour:
Unwashed: Light olive brown (2.5Y-5/4)
Washed: Light grey (2.5Y-7/1)

Sand is moderately to well sorted
Sand: Strong, slow and prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

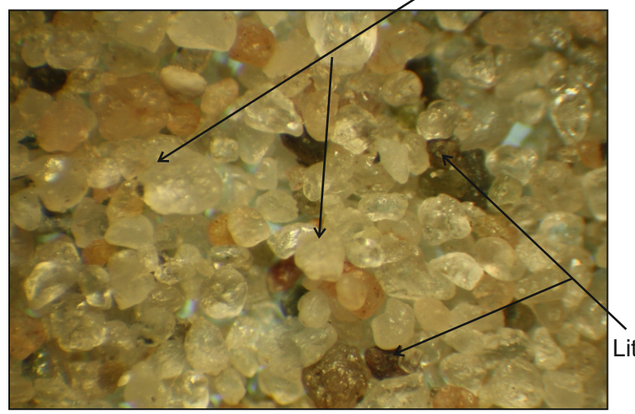
70 % - Fine to coarse sand-sized subangular to well-rounded (*r*K = 0.4 to 0.9) medium to high sphericity (*r*K = 0.5 to 0.9) QUARTZ
~80 % frosted
~20 % glassy

8 % - Medium to coarse sand-sized subangular to subrounded (*r*K = 0.4 to 0.8) low to medium sphericity (*r*K = 0.1 to 0.7) white to orange/pinkish FELDSPAR
8 % - Medium to coarse sand-sized angular to rounded (*r*K = 0.2 to 0.7) low to high sphericity (*r*K = 0.1 to 0.9) black BIOTITE MICA
5 % - Fine to coarse sand-sized subangular to rounded (*r*K = 0.4 to 0.8) low to high sphericity (*r*K = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
3 % - Medium sand-sized to fine gravel-sized angular to subangular (*r*K = 0.2 to 0.4) low sphericity (*r*K = 0.1 to 0.3) white to pinkish BIOCLASTIC FRAGMENTS
3 % - Fine to coarse sand-sized subangular to subrounded (*r*K = 0.4 to 0.6) low to medium sphericity (*r*K = 0.1 to 0.7) white CALCITE
3 % - Fine to medium sand-sized angular (*r*K = 0.1 to 0.2) low to medium sphericity (*r*K = 0.1 to 0.5) metallic lustre MUSCOVITE MICA

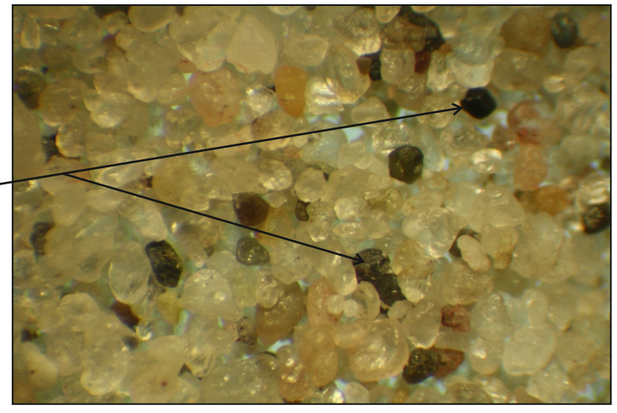
Trace: glauconite

Reflected Light Microphotographs

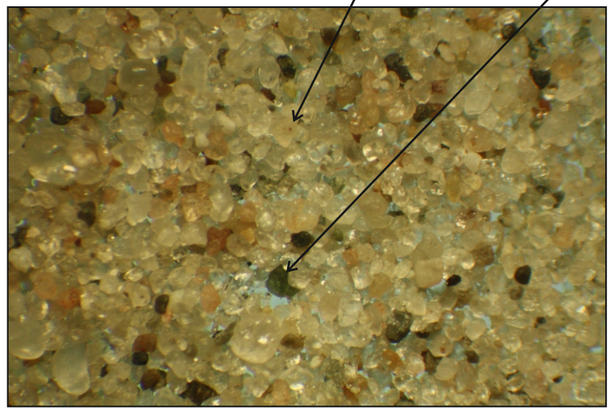
Unwashed Sample



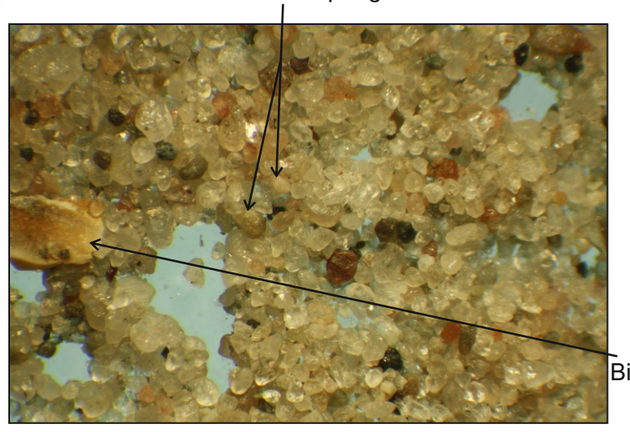
Washed Sample



Washed Sample



Unwashed Sample

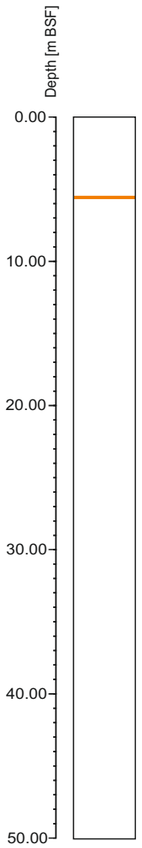


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-4** **Sample Name: 6BagA**	**Depth: 4.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.5**

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Olive grey (5Y-4/2) subrounded to rounded medium to high sphericity medium to coarse SAND with coarse sand-sized to coarse gravel-sized white (N-8/1) shell fragments (bivalves, echinoid spines)

Colour:
Unwashed: Olive grey (5Y-4/2)
Washed: Olive grey (5Y-74/2)

Sand is moderately to well sorted
Sand: Limited reaction to HCl

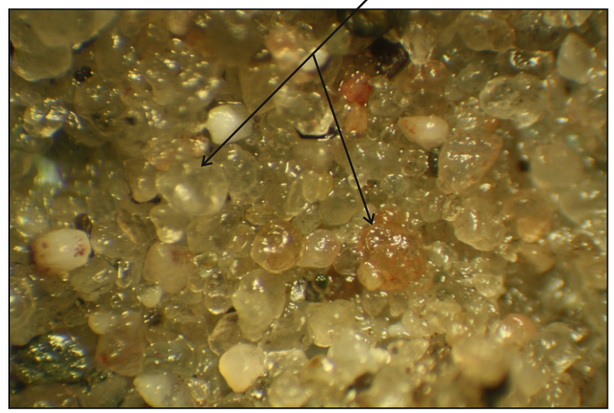
Microscope Description
Unwashed sample shows no coating of clay/silt

75 % - Medium to coarse sand-sized subrounded to well-rounded (*r*K = 0.5 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) QUARTZ
~90 % glassy
~10 % frosted

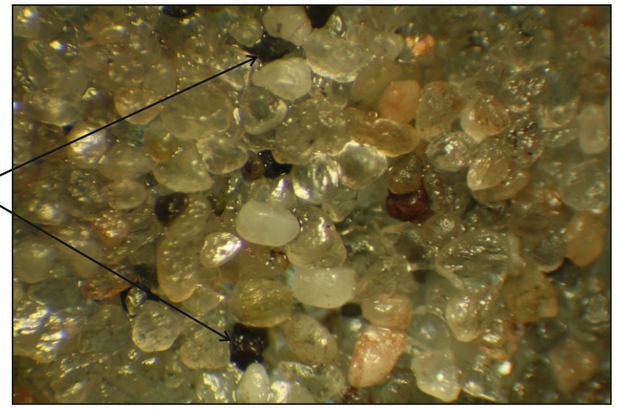
10 % - Fine to coarse sand-sized subangular to rounded (*r*K = 0.3 to 0.9) low to medium sphericity (*r*K = 0.3 to 0.7) white to pinkish/orange FELDSPAR
7 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.1 to 0.7) black BIOTITE MICA
5 % - Fine to coarse sand-sized subangular to well-rounded (*r*K = 0.3 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) black LITHIC FRAGMENTS
3 % - Fine to medium sand-sized subrounded to well-rounded (*r*K = 0.5 to 0.9) medium to high sphericity (*r*K = 0.5 to 0.9) green BIOCLASTIC FRAGMENTS
Trace: muscovite mica, glauconite

Reflected Light Microphotographs

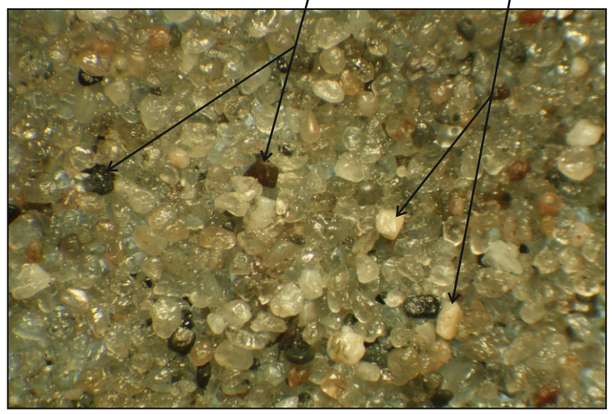
Unwashed Sample



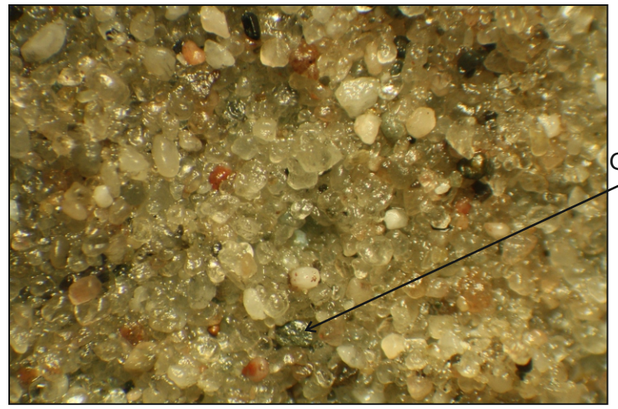
Washed Sample



Washed Sample

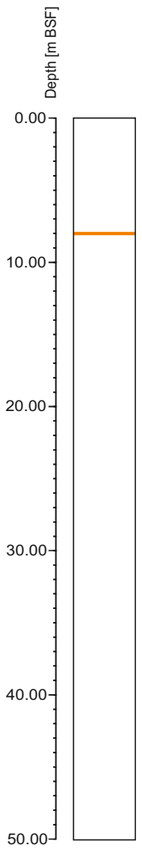


Unwashed Sample



J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS4-7 Sample Name: 7BagA**	**Depth: 5.50 m bsf Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.6**	Made:	LRM	29/01/2016	FUGRO
				Checked:	LA	15/02/2016	
				Approved:	CAS	17/02/2016	

Sample Microscope Description



Sample Description

Hand-Specimen Description
Greyish brown (2.5Y-5/2) subangular to well-rounded low to high sphericity medium to coarse SAND with fine to coarse sand-sized angular to subrounded low to medium sphericity white shell fragments

Colour:
Unwashed: Greyish brown (2.5Y-5/2)
Washed: Brownish yellow (10YR-6/6)

Sand is moderately to well sorted
Sand: Slow, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

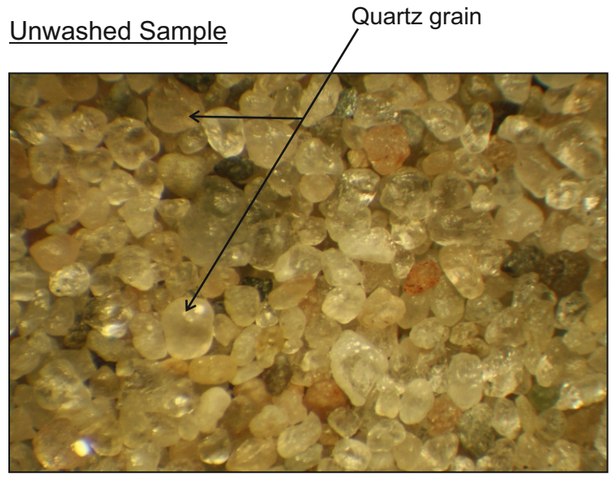
70 % - Medium to coarse sand-sized subangular to well-rounded (*r*K = 0.3 to 0.9) low to medium sphericity (*r*K = 0.3 to 0.7) QUARTZ
~85 % frosted
~10 % light pink to reddish orange/red
~5 % glassy

10 % - Fine to coarse sand-sized angular to rounded (*r*K = 0.2 to 0.8) low to medium sphericity (*r*K = 0.1 to 0.7) white FELDSPAR
7 % - Fine to medium sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to high sphericity (*r*K = 0.3 to 0.9) black BIOTITE MICA
7 % - Fine to coarse sand-sized angular to rounded (*r*K = 0.2 to 0.7) low to high sphericity (*r*K = 0.1 to 0.9) reddish brown, orange to black LITHIC FRAGMENTS
3 % - Fine to medium sand-sized angular to rounded (*r*K = 0.2 to 0.8) low to high sphericity (*r*K = 0.3 to 0.9) translucent white CALCITE
3 % - Fine to coarse sand-sized angular to rounded (*r*K = 0.2 to 0.7) low to high sphericity (*r*K = 0.3 to 0.9) white BIOCLASTIC FRAGMENTS

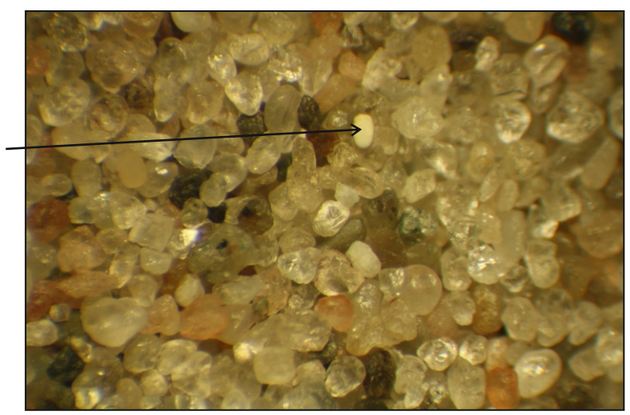
Trace: glauconite, calcite

Reflected Light Microphotographs

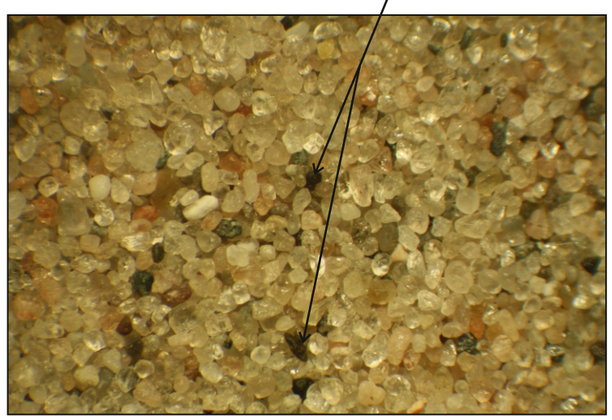
Unwashed Sample



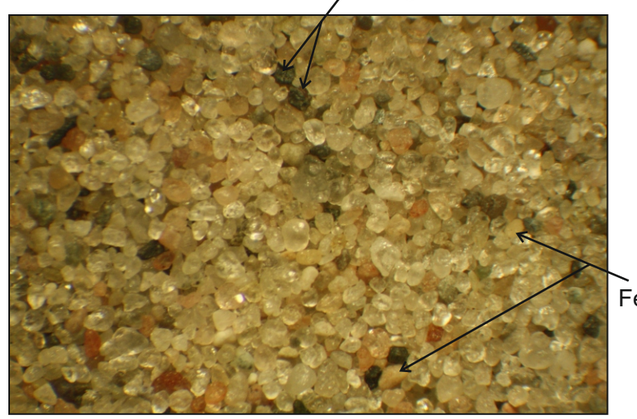
Washed Sample



Washed Sample

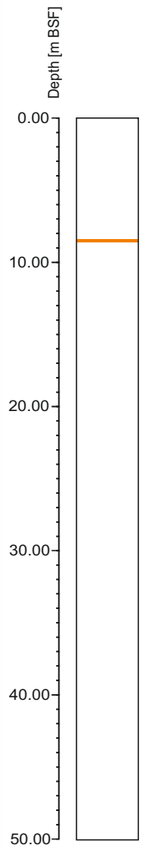


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-1** **Sample Name: 12BagA**	**Depth: 8.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.7**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Greyish brown (2.5Y-5-2) subangular to well-rounded low to high sphericity coarse SAND to fine gravel with fine to coarse sand-sized angular to subrounded low to high sphericity white shell fragments

Colour:
Unwashed: Greyish brown (2.5Y-5-2)
Washed: Light grey (2.5Y-7/1)

Sand is moderately well sorted
Sand: Strong, slow reaction to HCl

Microscope Description
Unwashed sample shows limited coating of clay/silt

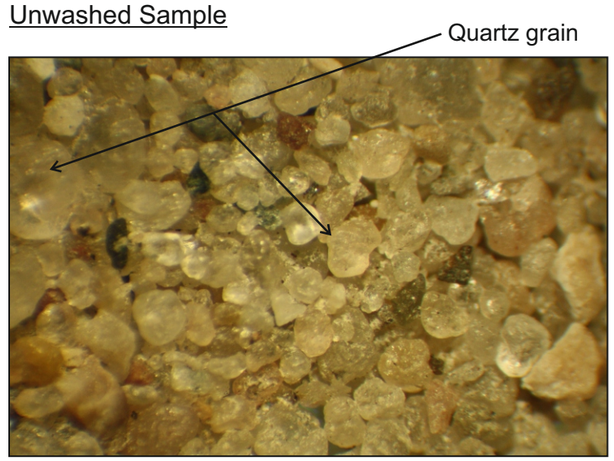
75 % - Medium to coarse sand-sized subangular to well-rounded (*r*K = 0.4 to 0.9) medium to high sphericity (*r*K = 0.5 to 0.9) QUARTZ
- ~85 % frosted
- ~10 % glassy
- ~5 % light pink to reddish orange/red

10 % - Fine to coarse sand-sized subangular to rounded (*r*K = 0.4 to 0.7) medium to high sphericity (*r*K = 0.5 to 0.9) white FELDSPAR
8 % - Fine to coarse sand-sized angular to rounded (*r*K = 0.2 to 0.8) low to high sphericity (*r*K = 0.3 to 0.9) reddish brown to black LITHIC FRAGMENTS
5 % - Medium to coarse sand-sized angular to subrounded (*r*K = 0.1 to 0.5) low to medium sphericity (*r*K = 0.1 to 0.7) white BIOCLASTIC FRAGMENTS
2 % - Fine to medium sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to high sphericity (*r*K = 0.3 to 0.9) black BIOTITE MICA

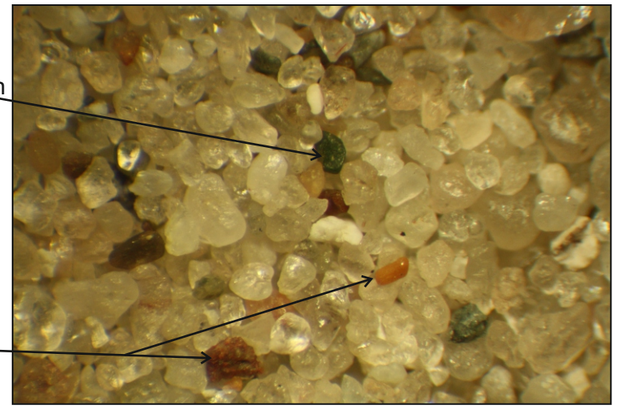
Trace: calcite, muscovite mica, glauconite, epidote

Reflected Light Microphotographs

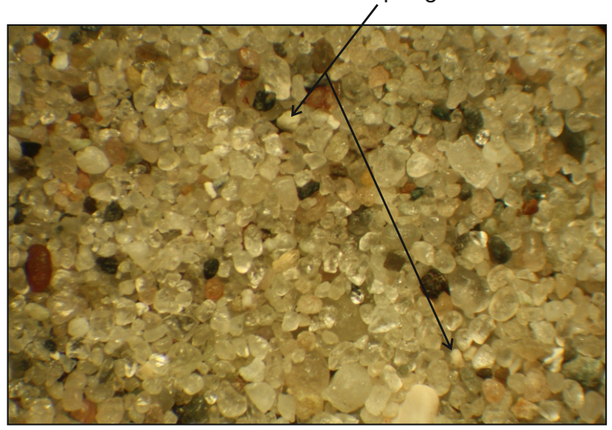
Unwashed Sample



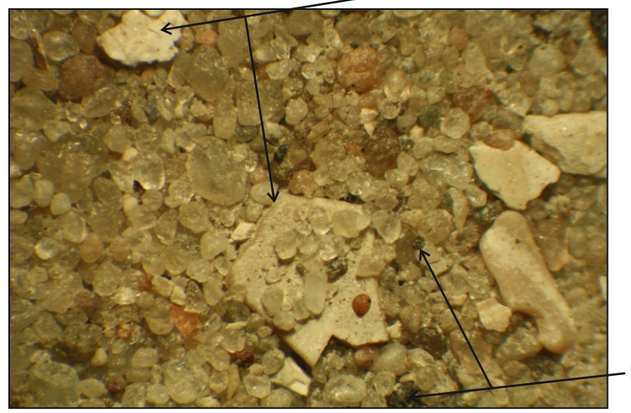
Washed Sample



Washed Sample



Unwashed Sample

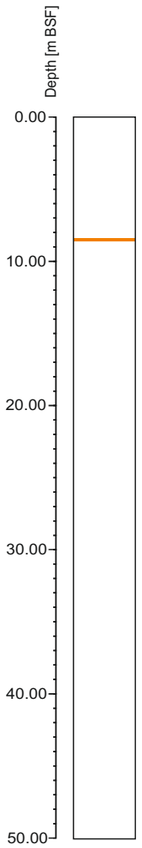


J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS3-6 Sample Name: 12BagA**	**Depth: 8.50 m bsf Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.8**

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greyish brown (2.5Y-4/2) subangular to rounded low to high sphericity medium to coarse SAND with trace medium to coarse sand-sized angular low sphericity shell fragments and with fine to coarse sand-sized angular to subrounded low to high sphericity black lithic fragments

Colour:
Unwashed: Dark greyish brown (2.5Y-4/2)
Washed: Light grey (N-7/1)

Sand is well sorted
Sand: Violent, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

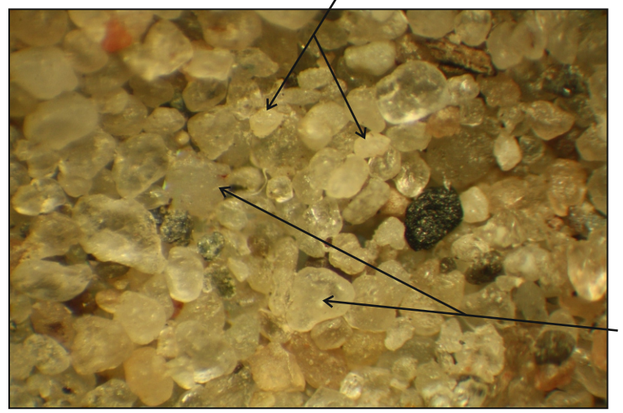
70 % - Fine to coarse sand-sized subangular to well-rounded (*r*K = 0.3 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) QUARTZ
~85 % frosted
~15 % glassy

10 % - Medium to coarse sand-sized subangular to rounded (*r*K = 0.4 to 0.7) low to high sphericity (*r*K = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
7 % - Medium to coarse sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) white to orange/pinkish FELDSPAR
7 % - Fine to coarse sand-sized angular to subrounded (*r*K = 0.2 to 0.5) low to medium sphericity (*r*K = 0.1 to 0.7) black BIOTITE MICA
4 % - Fine to medium sand-sized subangular to well-rounded (*r*K = 0.4 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) white BIOCLASTIC FRAGMENTS
2 % - Fine to coarse sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.5) white to light greenish grey CALCITE

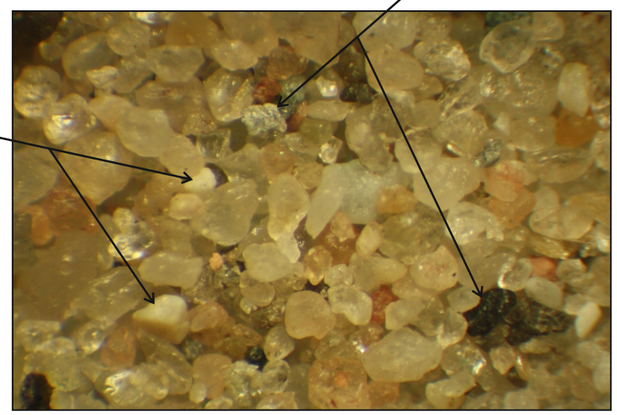
Trace: muscovite mica, glauconite

Reflected Light Microphotographs

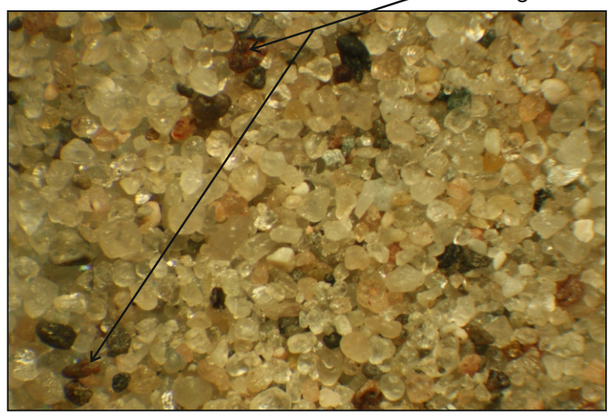
Unwashed Sample



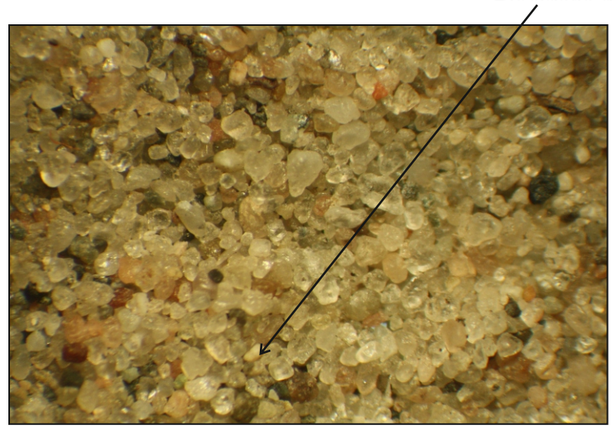
Washed Sample



Washed Sample

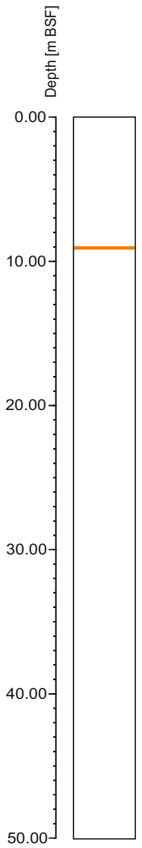


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-6** **Sample Name: 13BagA**	**Depth: 8.50 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.9**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greyish brown (2.5Y-4/2) subangular to rounded low to high sphericity medium to coarse SAND with trace medium to coarse sand-sized angular low sphericity shell fragments and with fine to coarse sand-sized angular to subrounded low to high sphericity black lithic fragments

Colour:
Unwashed: Dark greyish brown (2.5Y-4/2)
Washed: Light grey (2.5Y-7/1)

Sand is well sorted
Sand: Violent, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

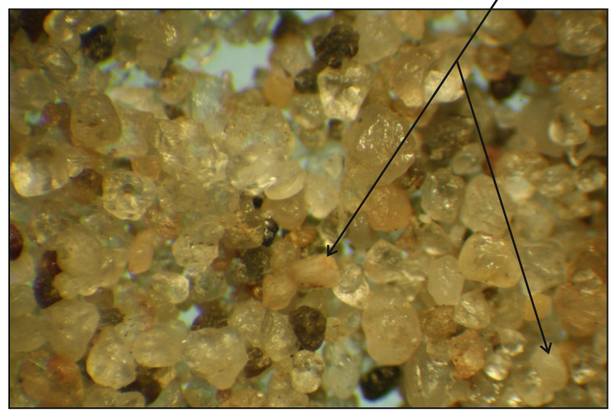
70 % - Fine to coarse sand-sized subangular to well-rounded (*r*K = 0.4 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) QUARTZ
~85 % frosted
~15 % glassy

10 % - Medium to coarse sand-sized subangular to rounded (*r*K = 0.3 to 0.7) low to high sphericity (*r*K = 0.1 to 0.9) brown to black LITHIC FRAGMENTS
7 % - Medium to coarse sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) white to orange/pinkish FELDSPAR
7 % - Fine to coarse sand-sized angular to subrounded (*r*K = 0.2 to 0.5) low to medium sphericity (*r*K = 0.1 to 0.5) black BIOTITE MICA
4 % - Fine to medium sand-sized subrounded to well-rounded (*r*K = 0.6 to 0.9) medium to high sphericity (*r*K = 0.5 to 0.9) green GLAUCONITE
2 % - Fine to coarse sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) white to light greenish grey CALCITE

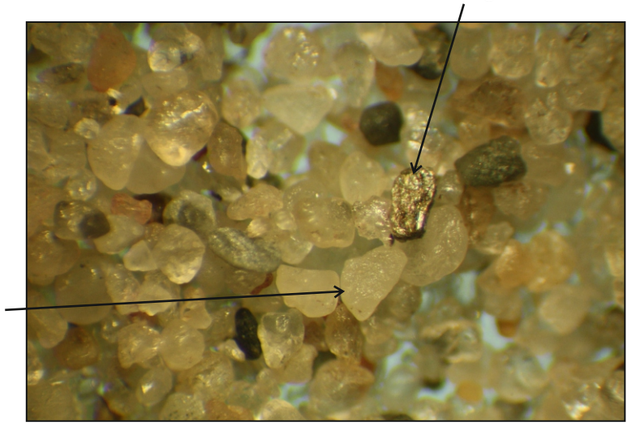
Trace: muscovite mica

Reflected Light Microphotographs

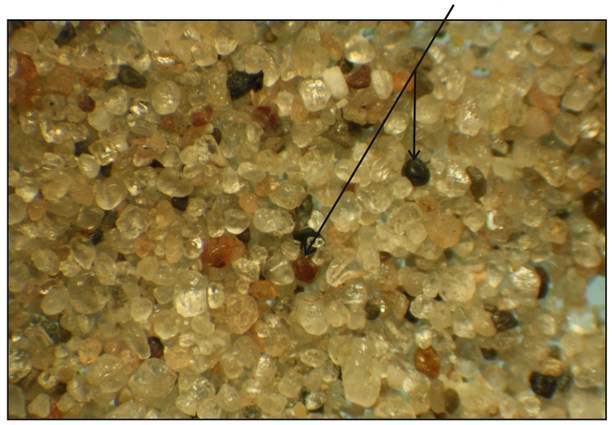
Unwashed Sample



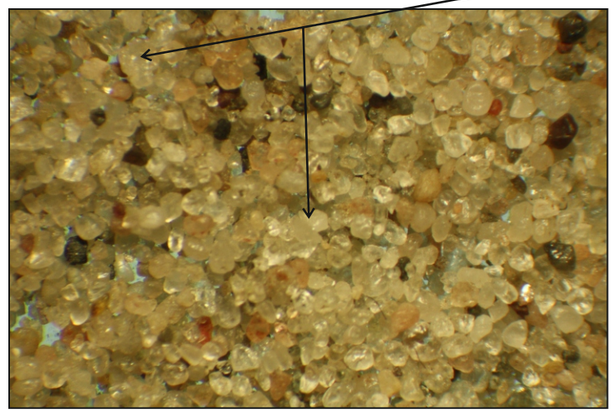
Washed Sample



Washed Sample

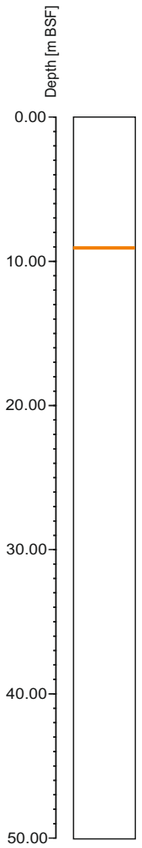


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-SubStatB-1** **Sample Name: 13BagA**	**Depth: 9.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.10**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Grey (2.5Y-6/1) angular to rounded low to high sphericity fine SAND with fine to coarse sand-sized angular to subrounded low to medium sphericity white shell fragments and with fine to coarse sand-sized angular to rounded low to high sphericity lithic fragments

Colour:
Unwashed: Grey (2.5Y-6/1)
Washed: Grey (2.5Y-6/1)

Sand is moderately to well sorted
Sand: Limited, slow prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

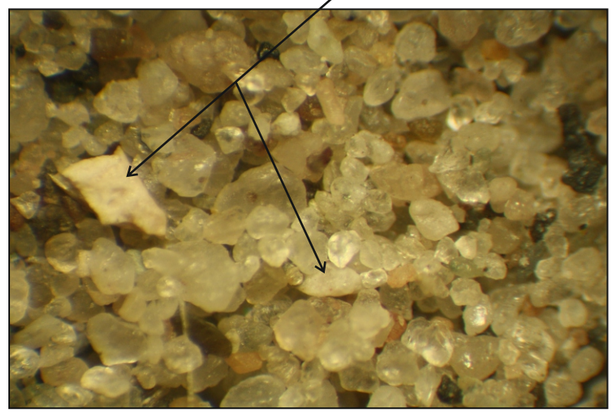
75 % - Fine to coarse sand-sized subrounded to well-rounded (*r*K = 0.5 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) QUARTZ
~80 % frosted
~15 % glassy
~5 % light pink to reddish orange/red

8 % -Medium sand –sized to coarse gravel-sized angular to rounded (*r*K = 0.2 to 0.7) low to medium sphericity (*r*K = 0.3 to 0.7) white BIOCLASTIC FRAGMENTS
7 % - Fine to coarse sand-sized subangular to well-rounded (*r*K = 0.3 to 0.9) low to high sphericity (*r*K = 0.1 to 0.9) reddish brown, orange to black LITHIC FRAGMENTS
5 % - Fine to coarse sand-sized subrounded to rounded (*r*K = 0.5 to 0.8) low to medium sphericity (*r*K = 0.3 to 0.7) white FELDSPAR
3 % - Fine to medium sand-sized subangular to rounded (*r*K = 0.3 to 0.9) low to high sphericity (*r*K = 0.1 to 0.9) black BIOTITE MICA
2 % - Fine sand-sized subrounded to well-rounded (*r*K = 0.6 to 0.9) medium to high sphericity (*r*K = 0.5 to 0.9) green GLAUCONITE

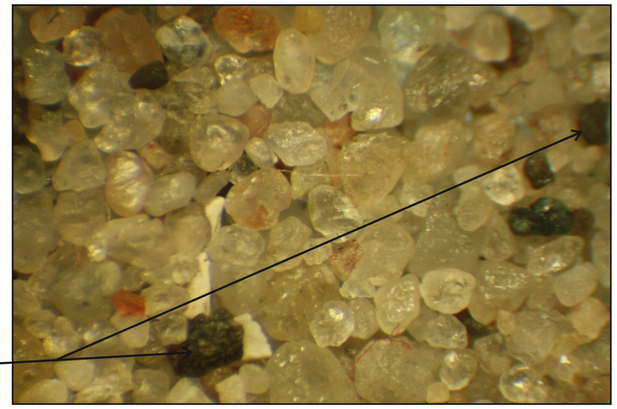
Trace: calcite, muscovite mica

Reflected Light Microphotographs

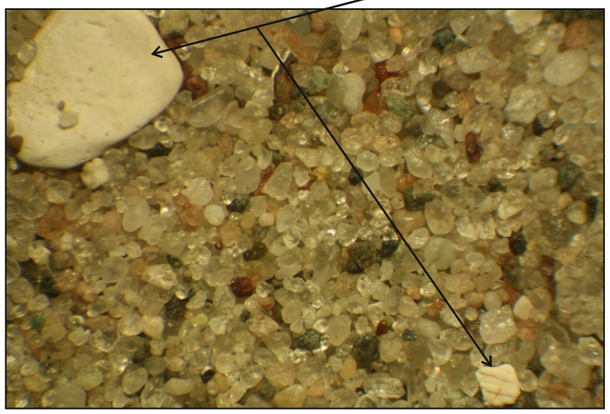
Unwashed Sample



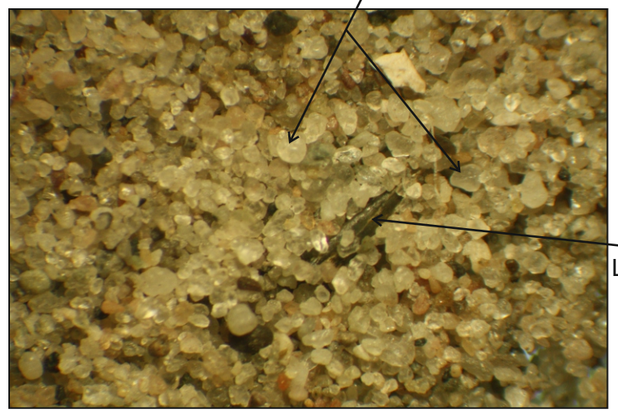
Washed Sample



Washed Sample



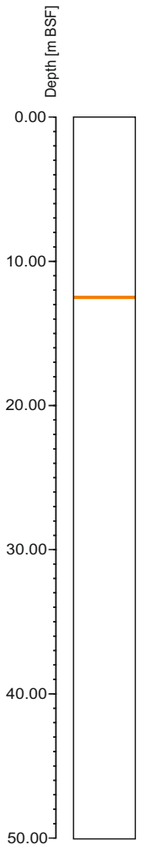
Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-3A** **Sample Name: 2BagA**	**Depth: 9.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.11**

Made:	LRM	29/01/2016	FUGRO
Checked:	LA	15/02/2016	
Approved:	CAS	17/02/2016	

Sample Microscope Description



Sample Description

Hand-Specimen Description
Grey (5Y-5/1) angular to rounded low to high sphericity fine to medium SAND with trace coarse sand-sized to coarse gravel-sized angular low sphericity light greenish grey shell fragments (bivalves)

Colour:
Unwashed: Grey (5Y-5/1)
Washed: Grey (5Y-6/1)

Sand is moderately to well sorted
Sand: Strong, prolonged reaction to HCl

Microscope Description
Unwashed sample shows minor coating of silt

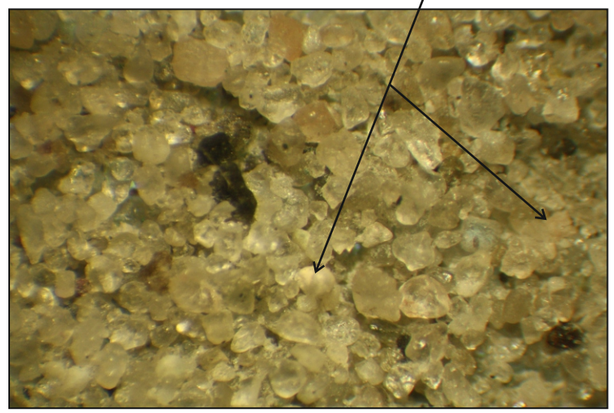
75 % - Fine to medium sand-sized angular to rounded (*r*K = 0.1 to 0.8) low to high sphericity (*r*K = 0.1 to 0.9) QUARTZ
~60 % glassy
~40 % frosted

12 % - Fine to medium sand-sized angular to subangular (*r*K = 0.2 to 0.4) low sphericity (*r*K = 0.1 to 0.3) black BIOTITE MICA
8 % - Fine to medium subangular to subrounded (*r*K = 0.4 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) white to pinkish/orange FELDSPAR
3 % - Fine sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to high sphericity (*r*K = 0.1 to 0.9) black LITHIC FRAGMENTS
2 % - Fine sand-sized subrounded to rounded (*r*K = 0.5 to 0.8) medium to high sphericity (*r*K = 0.5 to 0.9) green GLAUCONITE

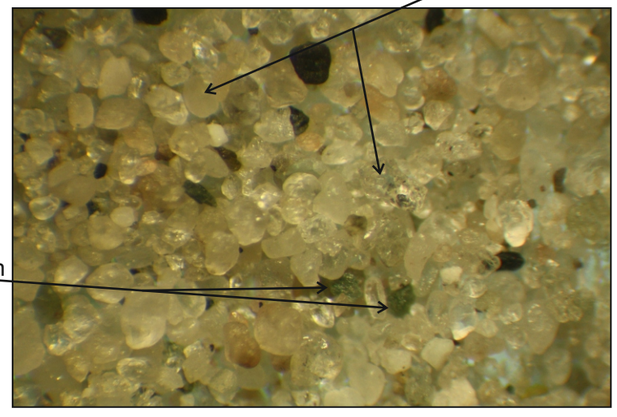
Trace: calcite, muscovite mica, pyrite

Reflected Light Microphotographs

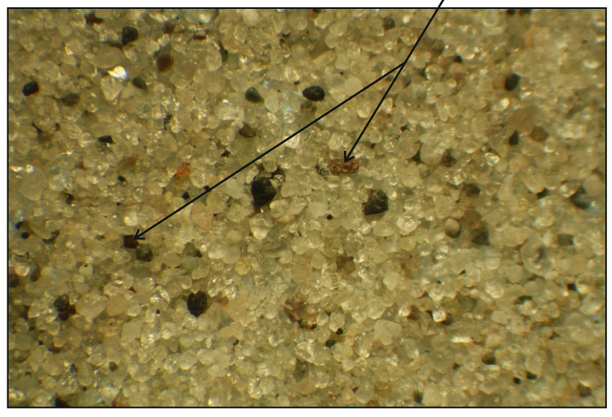
Unwashed Sample



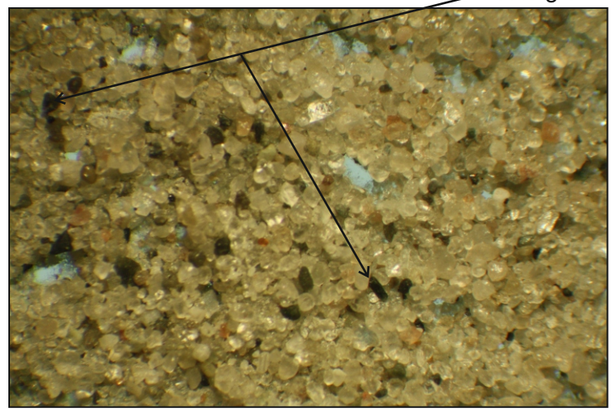
Washed Sample



Washed Sample



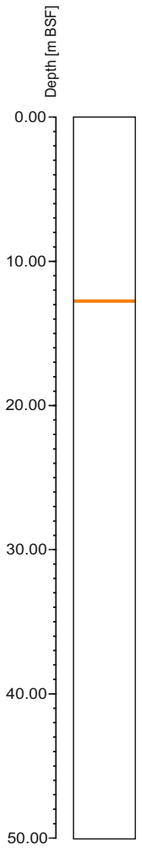
Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-5** **Sample Name: 24BagA**	**Depth: 12.50 m bsf** **Soil Unit: B (Eem/Kreftenheye)**

Plate Number: A.12			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10Y-4/1) subangular to rounded low to high sphericity clayey medium to coarse SAND with many fine sand-sized coarse gravel-sized angular low sphericity white to dark bluish green shell fragments (bivalves) and with many fine to coarse sand-sized subangular to subrounded low to medium sphericity black lithic fragments

Colour:
Unwashed: Dark greenish grey (10Y-4/1)
Washed: Olive grey (5Y-5/2)

Sand is poorly sorted
Sand: Violent, prolonged reaction to HCl

Microscope Description
Unwashed sample shows moderate coating of clay and silt

60 % - Medium sand-sized to fine gravel-sized angular to rounded (rK = 0.2 to 0.8) low to high sphericity (rK = 0.1 to 0.9) white to orange/blue BIOCLASTIC FRAGMENTS

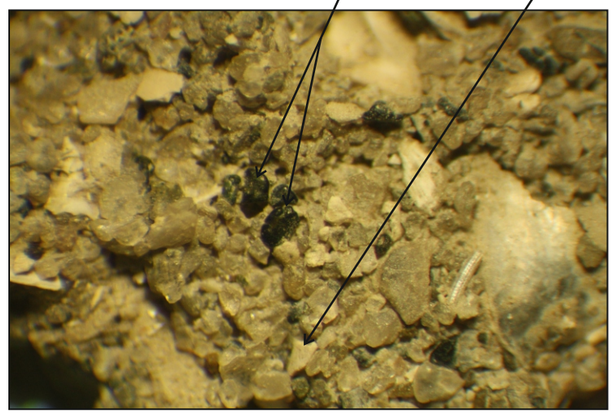
15 % - Medium sand-sized to fine gravel-sized subangular to well-rounded (rK = 0.4 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~90 % frosted
~10 % glassy

8 % - Medium to coarse sand-sized subangular to subrounded (rK = 0.4 to 0.7) low sphericity (rK = 0.1 to 0.3) white to light greenish grey FELDSPAR
8 % Fine to coarse sand-sized subangular to rounded (rK = 0.3 to 0.8) low to high sphericity (rK = 0.1 to 0.9) black BIOTITE MICA
5 % Medium to coarse sand-sized subangular to well-rounded (rK = 0.4 to 0.9) low to high sphericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
4 % Fine to coarse sand-sized subangular to subrounded (rK = 0.4 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) white to light greenish grey CALCITE

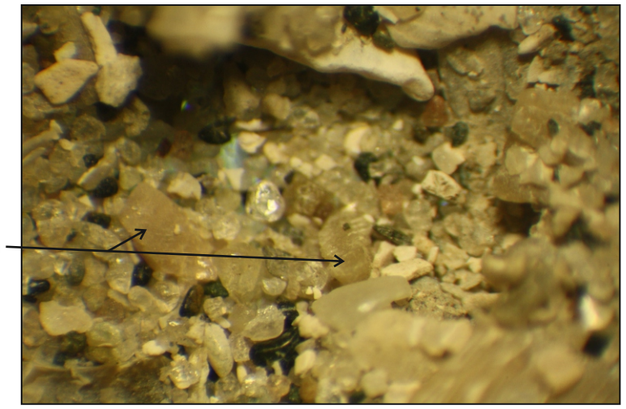
Trace: glauconite, muscovite mica

Reflected Light Microphotographs

Unwashed Sample



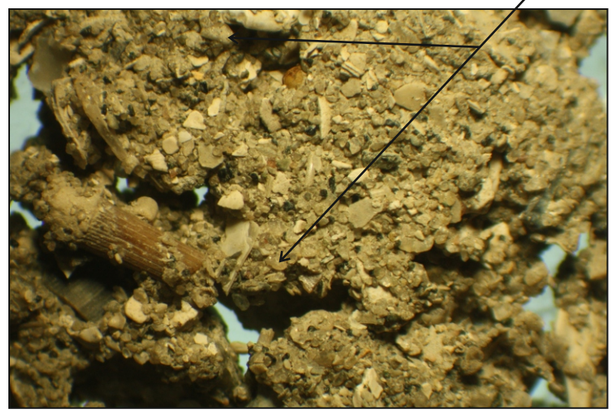
Washed Sample



Washed Sample

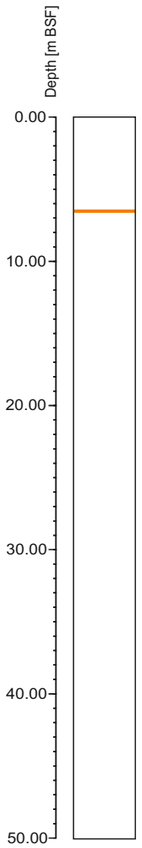


Unwashed Sample



J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS4-7 Sample Name: 16BagB**	**Depth: 12.80 m bsf Soil Unit: C2 (Westkapelle Ground)**	**Plate Number: A.13**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (10GY-3/1) angular to subangular low to medium sphericity clayey fine SAND with many fine sand-sized angular to subrounded low to high sphericity black lithic fragments

Colour:
Unwashed: Very dark greenish grey (10Y-3/1)
Washed: Dark greenish grey (10Y-4/1)

Sand is poorly to moderately well sorted
Sand: Very limited, minor reaction to HCl

Microscope Description
Unwashed sample shows moderate coating of clay

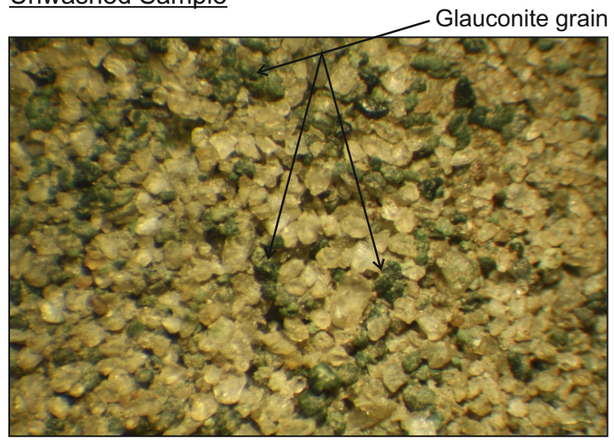
60 % Fine sand-sized angular to subrounded (*r*K = 0.1 to 0.5) low to medium sphericity (*r*K = 0.1 to 0.5) QUARTZ
~95 % glassy
~5 % frosted

25 % - Fine sand-sized subangular to well-rounded (*r*K = 0.4 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE
15 % - Fine sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to medium sphericity (*r*K = 0.1 to 0.7) black BIOTITE MICA

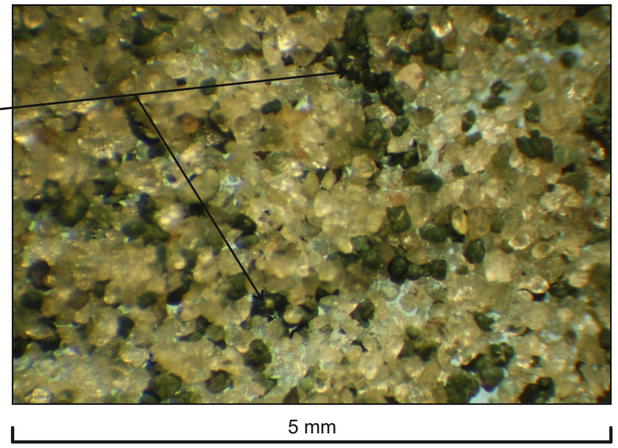
Trace: calcite, feldspar, muscovite mica

Reflected Light Microphotographs

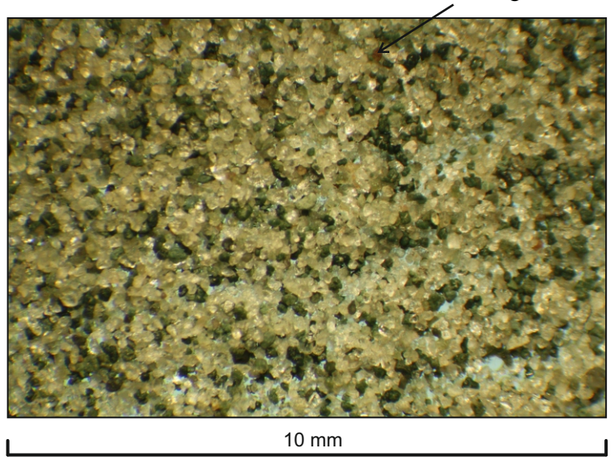
Unwashed Sample



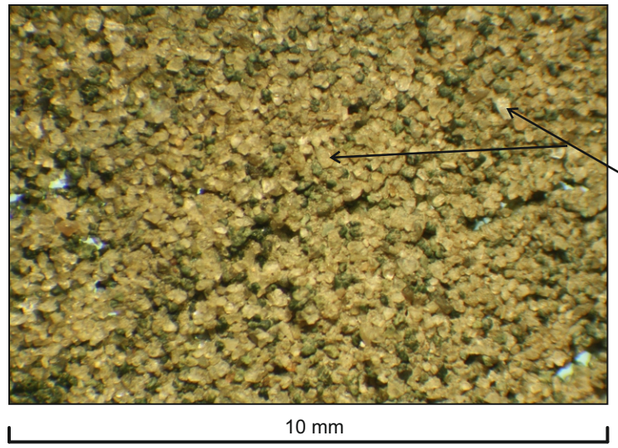
Washed Sample



Washed Sample

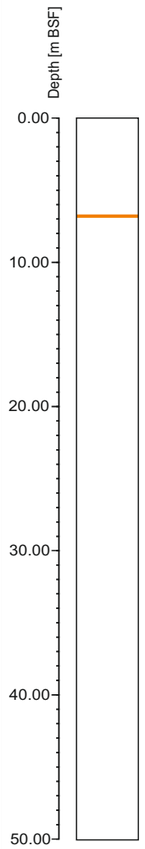


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: CPT_WFS5_1** **Sample Name: 1BagA**	**Depth: 6.50 m bsf** **Soil Unit: E1 (Tongeren)**	**Plate Number: A.14**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (10Y-3/1) angular to subrounded low to medium sphericity clayey fine SAND

Colour:
Unwashed: Very dark greenish grey (10Y-3/1)
Washed: Greenish grey (10Y-5/1)

Sand is poorly to moderately well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows moderate coating of clay

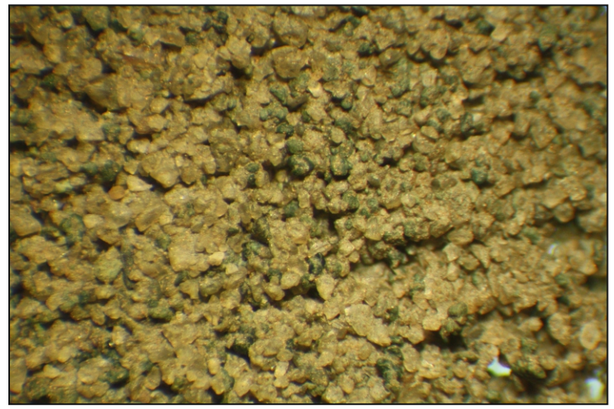
60 % - Fine sand-sized angular to subangular (*r*K = 0.1 to 0.4) low sphericity (*r*K = 0.1 to 0.3) QUARTZ
~95 % glassy
~5 % frosted

20 % - Fine sand-sized subrounded to well-rounded (*r*K = 0.5 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE
15 % - Fine sand-sized angular to subangular (*r*K = 0.1 to 0.3) low to medium sphericity (*r*K = 0.3 to 0.7) black BIOTITE MICA
5 % - Fine sand-sized angular to subangular (*r*K = 0.1 to 0.4) low sphericity (*r*K = 0.1 to 0.3) metallic lustre MUSCOVITE MICA

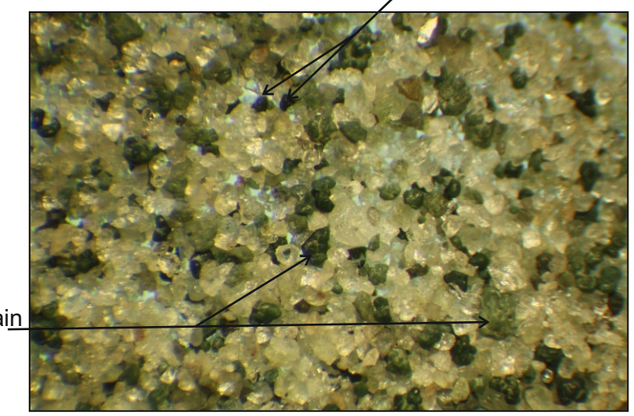
Trace: lithic fragment

Reflected Light Microphotographs

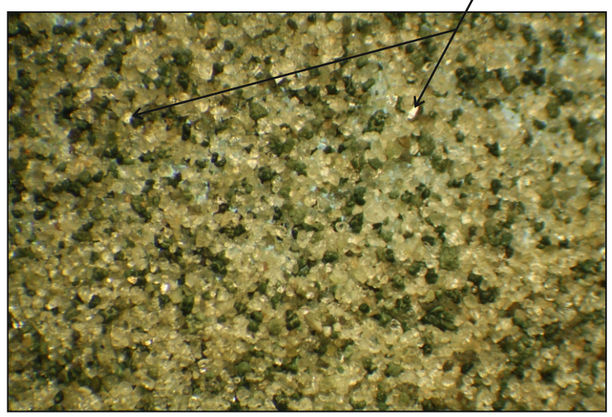
Unwashed Sample



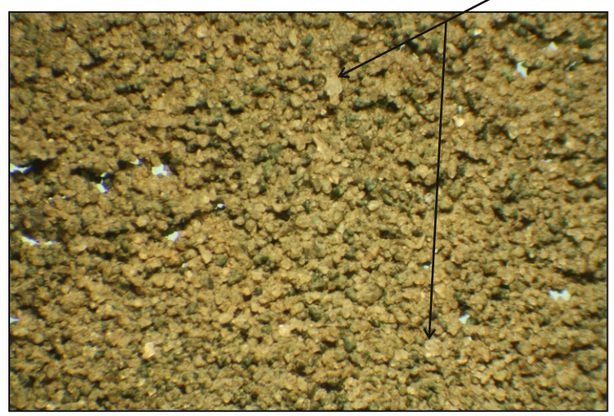
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

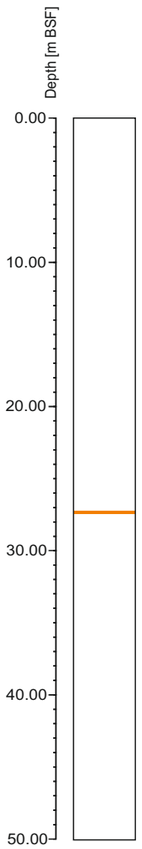
Sample Location: CPT_WFS5_1
Sample Name: 1BagB

Depth: 6.90 m bsf
Soil Unit: E1 (Tongeren)

Plate Number: A.15

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark olive grey (5Y-3/2) angular to subrounded low to high sphericity clayey fine SAND with many fine sand-sized to coarse gravel-sized subrounded low to medium sphericity dark olive grey (5Y-3/2) pockets of clay

Colour:
Unwashed: Dark olive grey (5Y-3/2)
Washed: Light olive brown (2.5Y-7/1)

Sand is moderately to well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows extensive coating of clay/silt

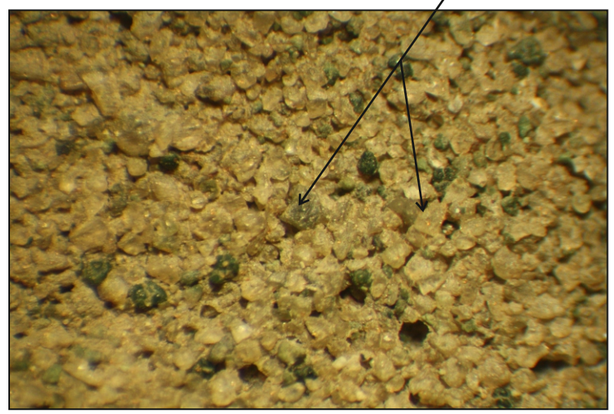
75 % - Silt-sized angular to subrounded (*r*K = 0.1 to 0.6) low to medium sphericity (*r*K = 0.1 to 0.7) QUARTZ
~80 % glassy
~20 % frosted

10 % - Silt-sized angular to rounded (*r*K = 0.2 to 0.7) low to medium sphericity (*r*K = 0.1 to 0.7) black BIOTITE MICA
10 % - Silt-sized subangular to rounded (*r*K = 0.3 to 0.8) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE
3 % - Silt-sized angular to subangular (*r*K = 0.2 to 0.4) low to high sphericity (*r*K = 0.3 to 0.9) white FELDSPAR
2 % - Silt-sized angular to subrounded (*r*K = 0.1 to 0.6) low to high sphericity (*r*K = 0.1 to 0.9) reddish brown to black LITHIC FRAGMENTS

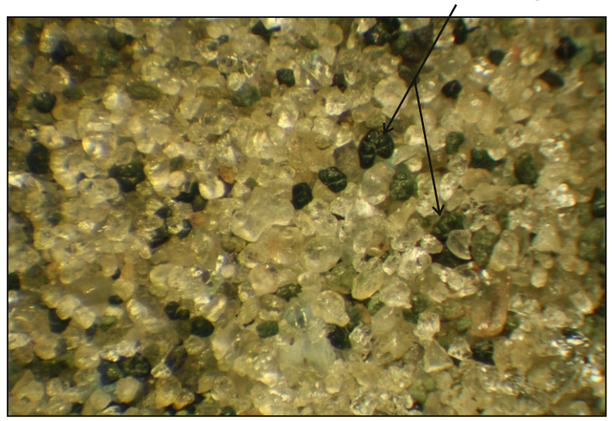
Trace: muscovite mica

Reflected Light Microphotographs

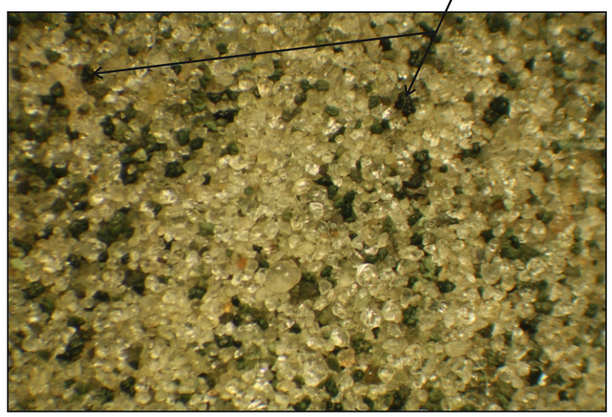
Unwashed Sample



Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS4-7
Sample Name: 23BagB

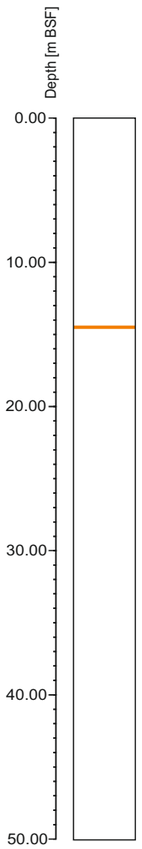
Depth: 27.35 m bsf
Soil Unit: E1 (Tongeren)

Plate Number: A.16

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark olive grey (5Y-3/2) angular to rounded medium to high sphericity fine SAND

Colour:
Unwashed: Dark olive grey (5Y-3/2)
Washed: Olive grey (2.5Y-5/4)

Sand is well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows moderate coating of clay

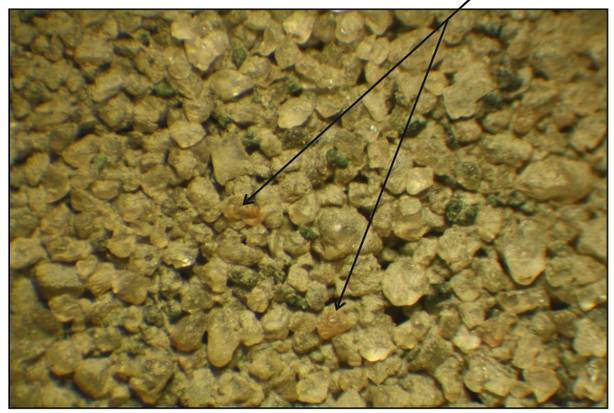
90 % - Silt to fine sand-sized subangular to well-rounded (*r*K = 0.3 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) QUARTZ
~90 % glassy
~10 % frosted

5 % - Silt to fine sand-sized angular to subangular (*r*K = 0.3 to 0.9) low to medium sphericity (*r*K = 0.3 to 0.9) black BIOTITE MICA
3 % - Silt to fine sand-sized angular to subrounded (*r*K = 0.3 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
2 % - Silt to fine sand-sized subangular to rounded (*r*K = 0.3 to 0.9) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE

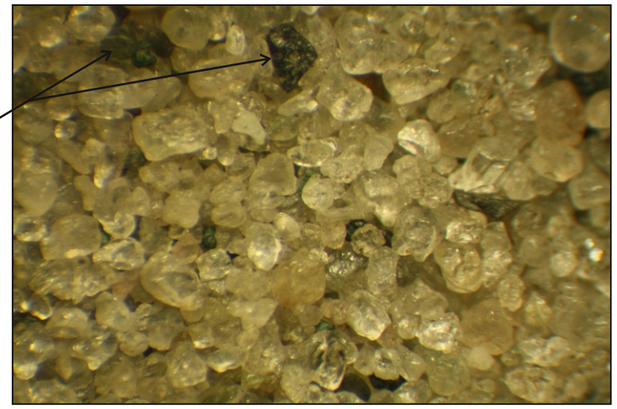
Trace: feldspar

Reflected Light Microphotographs

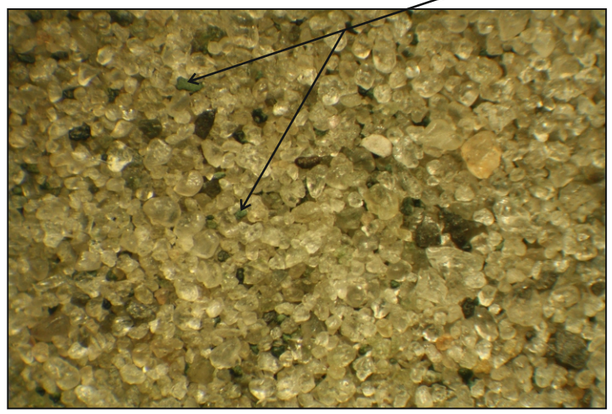
Unwashed Sample



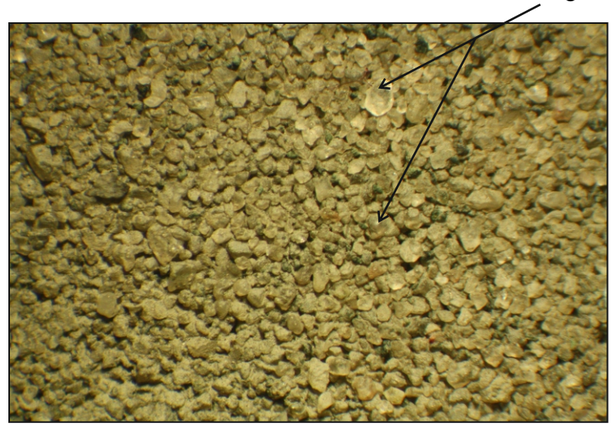
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS5-1
Sample Name: 15BagB

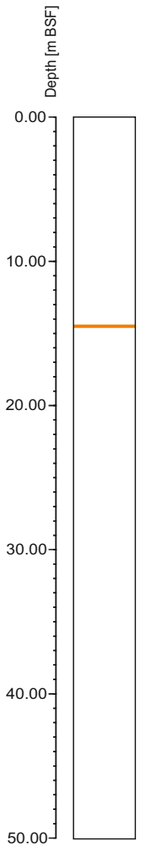
Depth: 14.45 m bsf
Soil Unit: E3 (Tongeren)

Plate Number: A.17

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark grey (5Y-3/1) angular to subangular low to high sphericity clayey fine SAND

Colour:
Unwashed: Very dark grey (5Y-3/1)
Washed: Dark grey (N-4/1)

Sand is well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows moderate coating of clay/silt

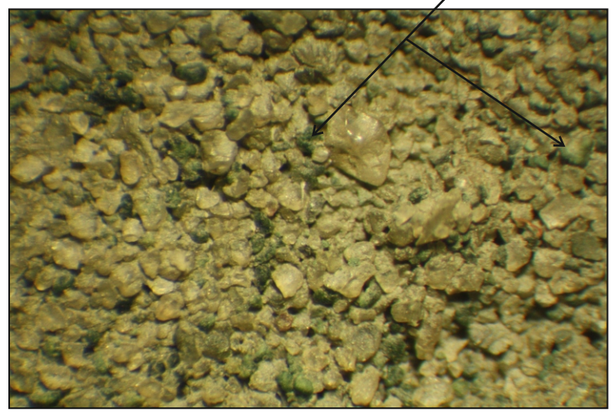
85 % - Silt-sized angular to rounded (*r*K = 0.1 to 0.8) low to medium sphericity (*r*K = 0.1 to 0.7) QUARTZ
~90 % glassy
~7 % frosted
~3 % light pink to reddish orange/red

9 % - Silt-sized subangular to rounded (*r*K = 0.3 to 0.8) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE
4 % - Silt-sized angular to rounded (*r*K = 0.3 to 0.7) low to medium sphericity (*r*K = 0.3 to 0.7) black BIOTITE MICA
2 % - Silt-sized angular to subrounded (*r*K = 0.2 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) reddish pink to white FELDPSAR

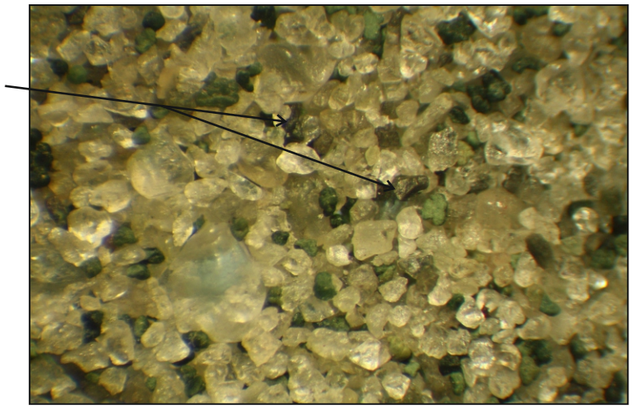
Trace: muscovite mica, calcite, lithic fragment

Reflected Light Microphotographs

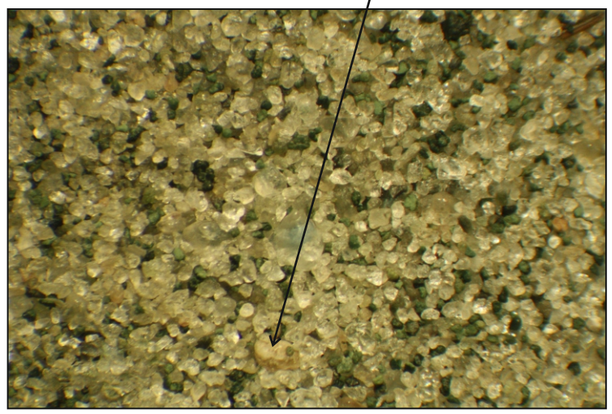
Unwashed Sample



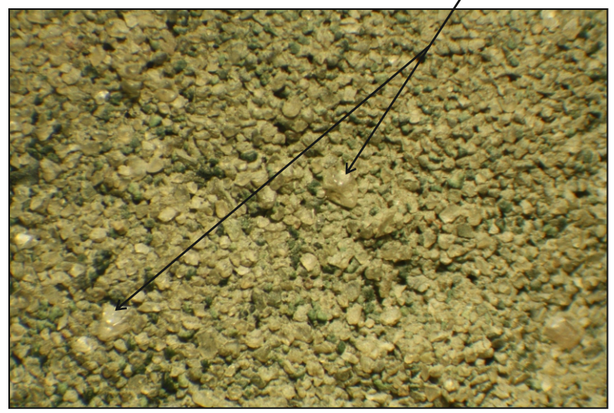
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

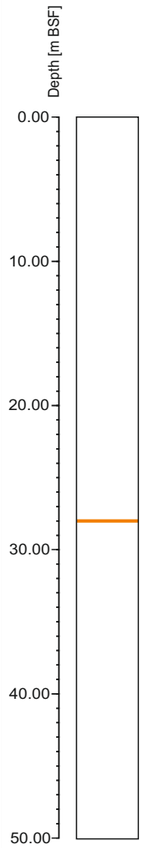
Sample Location: BH-WFS4-6
Sample Name: 24BagA

Depth: 14.50 m bsf
Soil Unit: E3 (Tongeren)

Plate Number: A.18			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Greenish black (5GY-2.5/1) angular to subrounded medium to high sphericity clayey fine SAND with many fine sand-sized angular to subrounded low to high sphericity black lithic fragments

Colour:
Unwashed: Greenish black (5GY-2.5/1)
Washed: Greenish grey (10Y-5/1)

Sand is moderately to well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

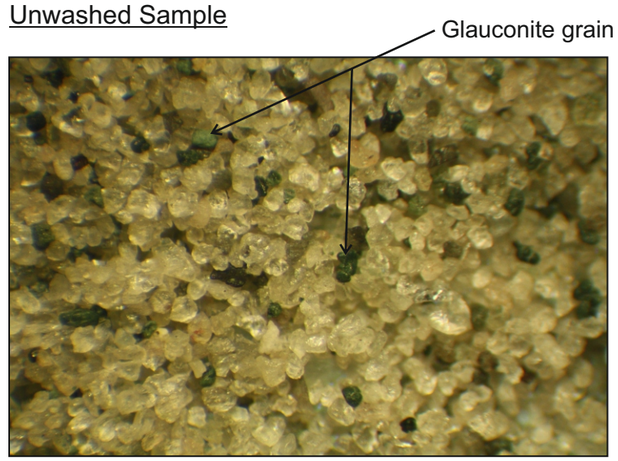
75 % - Fine sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to medium sphericity (*r*K = 0.1 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

15 % - Fine sand-sized angular to subangular (*r*K = 0.2 to 0.4) low to medium sphericity (*r*K = 0.3 to 0.7) black BIOTITE MICA
10 % - Fine sand-sized subangular to rounded (*r*K = 0.3 to 0.8) medium to high sphericity (*r*K = 0.5 to 0.9) green GLAUCONITE

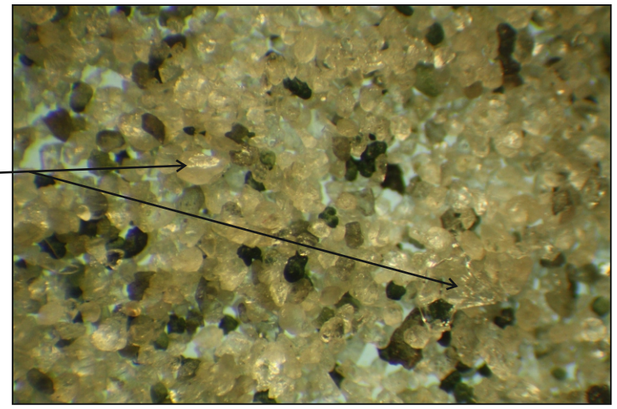
Trace: feldspar, pyrite, lithic fragments

Reflected Light Microphotographs

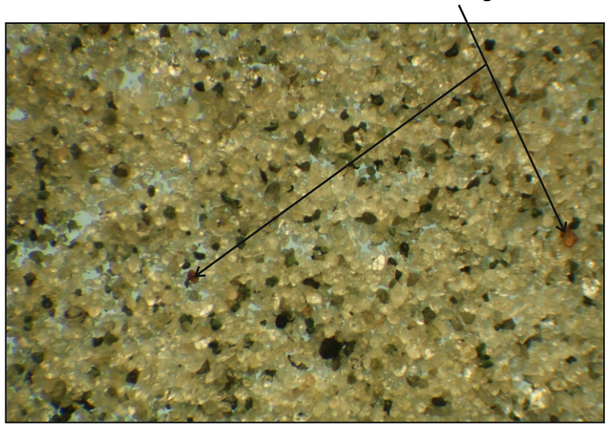
Unwashed Sample



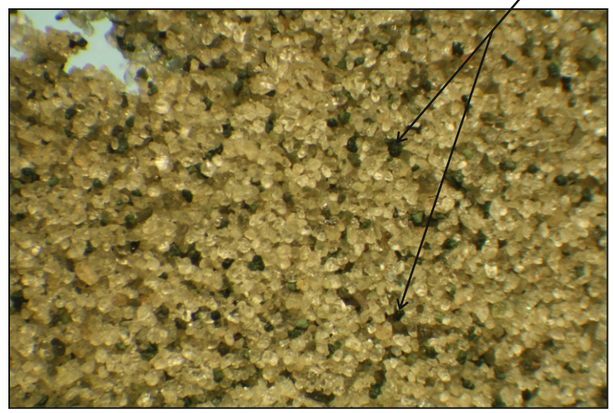
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

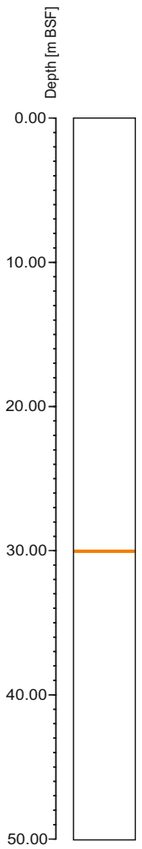
Sample Location: BH-WFS4-6
Sample Name: 28BagA

Depth: 28.00 m bsf
Soil Unit: E4 (Tongeren)

Plate Number: A.19

Made:	LRM	29/01/2016	
Checked:	LA	15/02/2016	
Approved:	CAS	17/02/2016	

Sample Microscope Description



Sample Description

Hand-Specimen Description
Grey (5Y-6/1) angular to rounded low to high sphericity fine SAND

Colour:
Unwashed: Grey (5Y-6/1)
Washed: Light grey (2.5Y-7/1)

Sand is well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows minor coating of clay

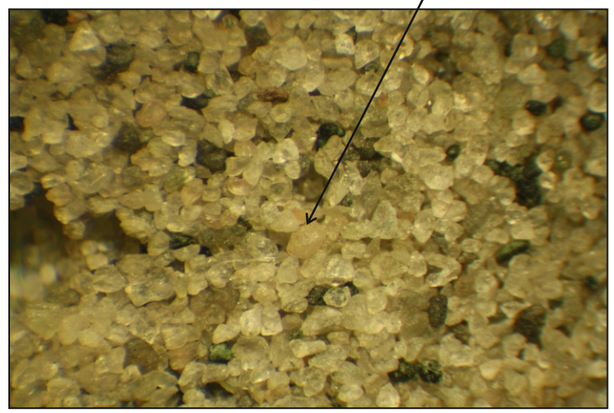
90 % - Silt-sized angular to subrounded (*r*K = 0.2 to 0.6) low to high sphericity (*r*K = 0.1 to 0.9) QUARTZ
~95 % glassy
~5 % frosted

6 % - Silt-sized angular to subrounded (*r*K = 0.2 to 0.5) low to medium sphericity (*r*K = 0.1 to 0.7) black BIOTITE MICA
4 % - Silt-sized subangular to rounded (*r*K = 0.3 to 0.8) medium to high sphericity (*r*K = 0.5 to 0.9) green GLAUCONITE

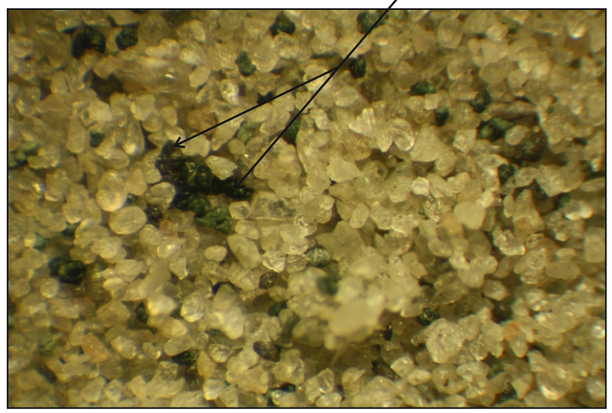
Trace: lithic fragments, feldspar

Reflected Light Microphotographs

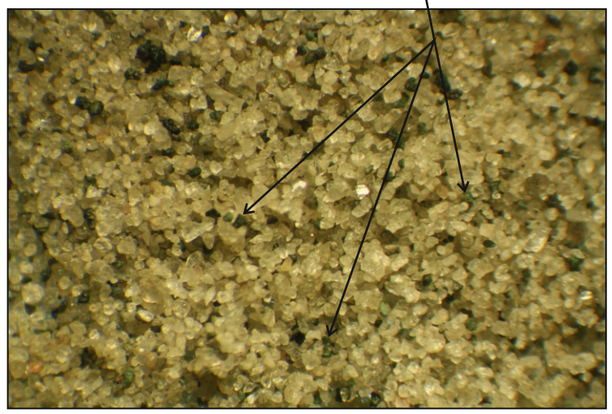
Unwashed Sample



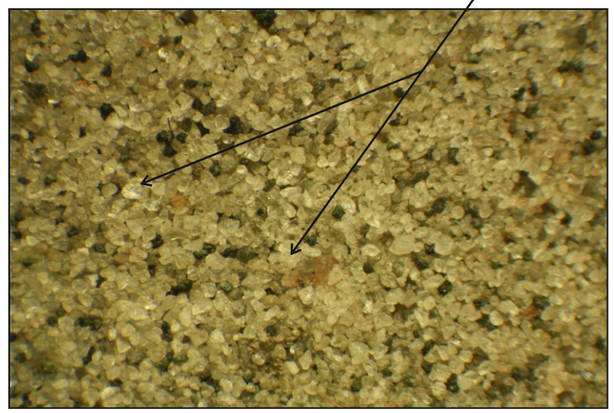
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

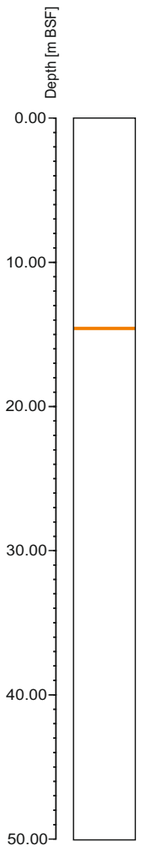
Sample Location: BH-SubStatB-1
Sample Name: 26BagA

Depth: 30.00 m bsf
Soil Unit: E4 (Tongeren)

Plate Number: A.20			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark bluish grey (5B-4/1) angular to subrounded low to high sphericity clayey fine SAND with angular to subrounded low to high sphericity black lithic fragments

Colour:
Unwashed: Dark bluish grey (5BG-4/1)
Washed: Grey (5Y-6/1)

Sand is moderately well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows limited coating of clay

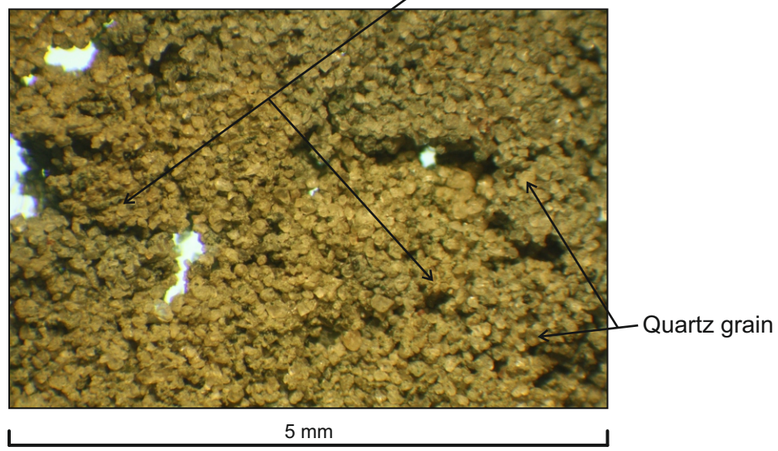
90 % Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

5 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.5) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
3 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) brown to black LITHIC FRAGMENTS
2 % - Fine sand-sized subangular to rounded (rK = 0.4 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) white FELDSPAR

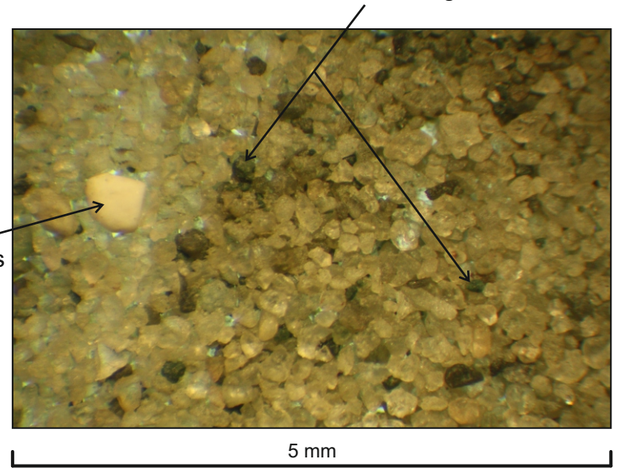
Trace: glauconite

Reflected Light Microphotographs

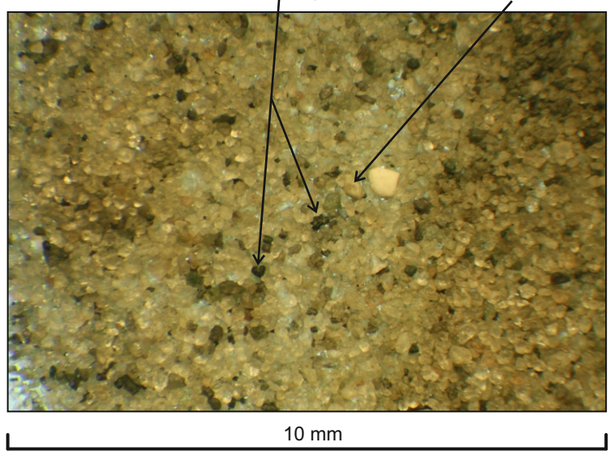
Unwashed Sample



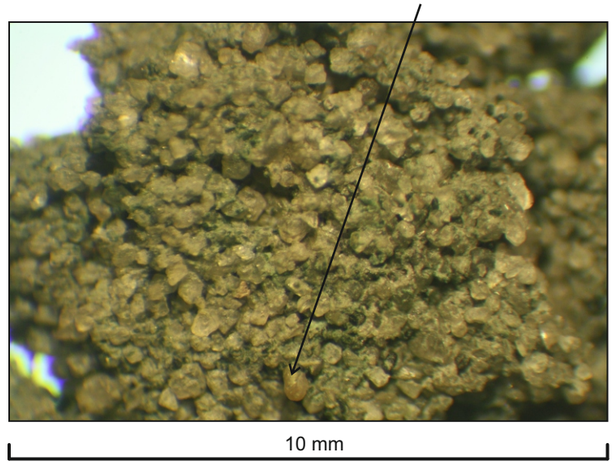
Washed Sample



Washed Sample

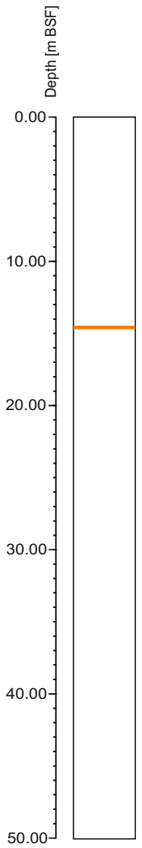


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-2** **Sample Name: 21BagA**	**Depth: 14.50 m bsf** **Soil Unit: E5a (Tongeren)**	**Plate Number: A.21**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (5GY-3/1) subangular to subrounded medium to high sphericity fine SAND

Colour:
Unwashed: Very dark greenish grey (5GY-3/1)
Washed: Light grey (2.5Y-7/1)

Sand is well sorted
Sand: No reaction to HCl

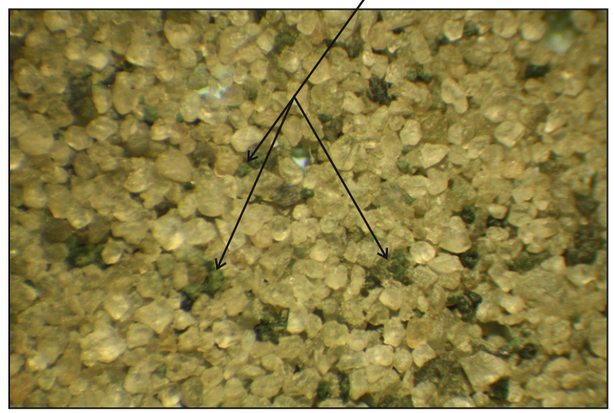
Microscope Description
Unwashed sample shows minor coating of silt

90 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.7) low to high sphericity (rK = 0.1 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

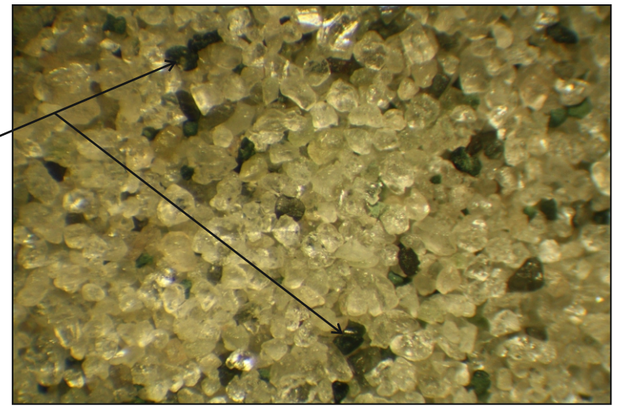
4 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.1 to 0.7) black BIOTITE MICA
4 % - Silt-sized subangular to rounded (rK = 0.4 to 0.8) medium to high sphericity(rK = 0.3 to 0.9) green GLAUCONITE
2 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.7) low to high sphericity (rK = 0.1 to 0.9) reddish brown to black LITHIC FRAGMENTS

Reflected Light Microphotographs

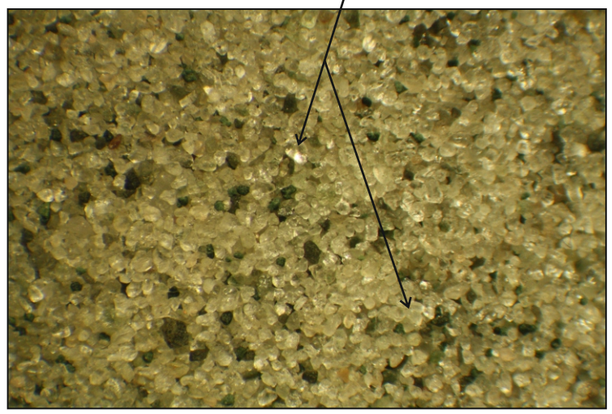
Unwashed Sample



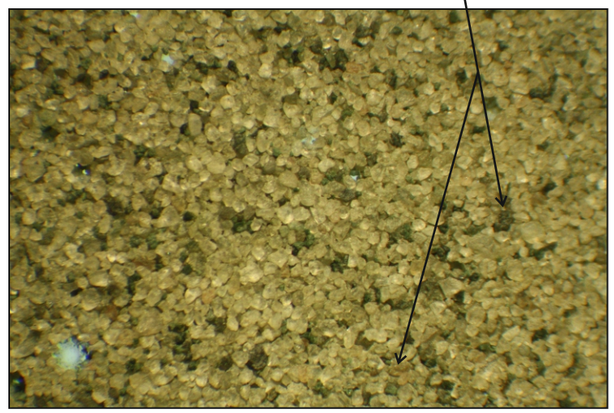
Washed Sample



Washed Sample



Unwashed Sample



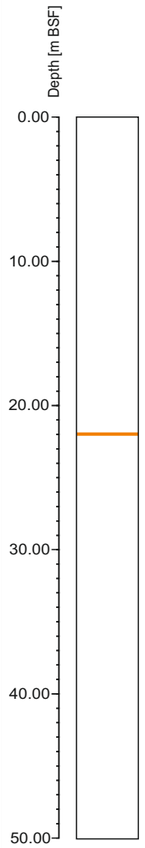
J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS4-4
Sample Name: 26BagA

Depth: 14.50 m bsf
Soil Unit: E5a (Tongeren)

Plate Number: A.22			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Olive grey (5Y-4/2) subangular to subrounded medium to high sphericity fine SAND with few fine to medium sand-sized angular low to medium sphericity white shell fragments and with trace fine to coarse gravel-sized angular low sphericity brownish black lithic fragments

Colour:
Unwashed: Olive grey (5Y-4/2)
Washed: Light grey (5Y-7/1)

Sand is well sorted
Sand: Limited, slow reaction to HCl

Microscope Description
Unwashed sample shows minor coating of clay

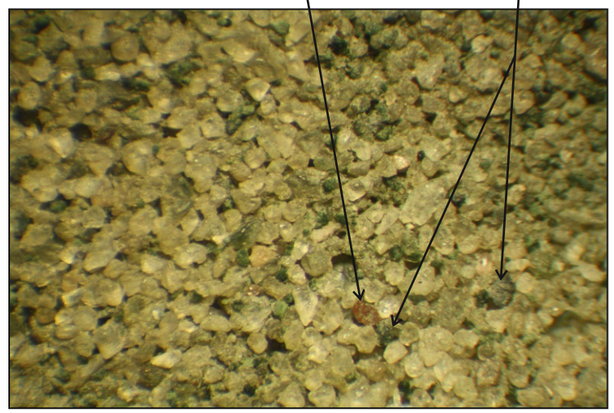
80 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~60 % frosted
~40 % glassy

8 % - Silt-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.1 to 0.5) black BIOTITE MICA
6 % - Silt-sized subangular to rounded (rK = 0.4 to 0.7) low to high sphericity (rK = 0.3 to 0.9) green GLAUCONITE
4 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
2 % - Silt-sized to fine sand-sized subangular to subrounded (rK = 0.4 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) white FELDSPAR

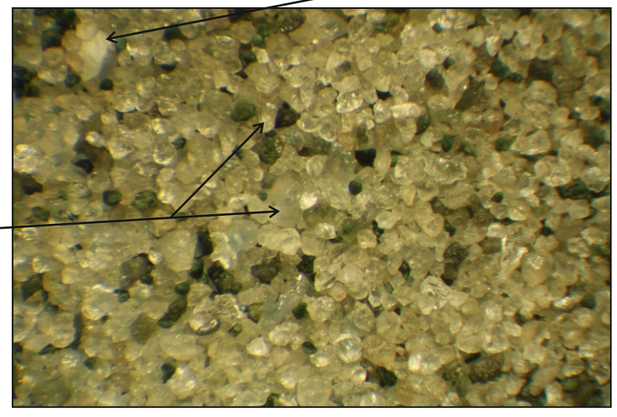
Trace: muscovite mica, bioclastic fragments, calcite

Reflected Light Microphotographs

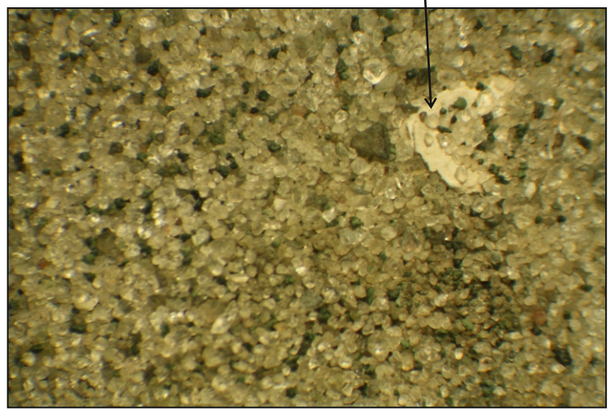
Unwashed Sample



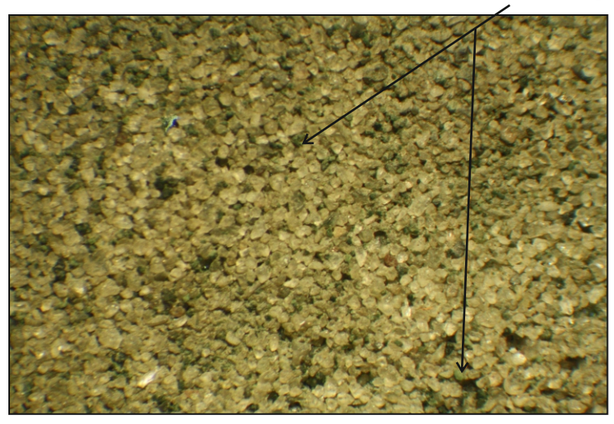
Washed Sample



Washed Sample

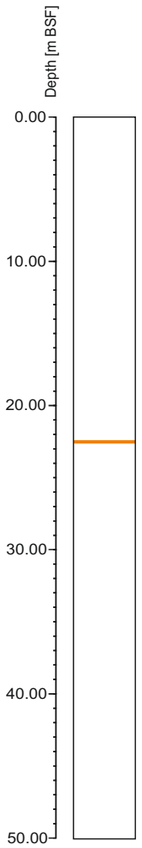


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-5** **Sample Name: 30BagA**	**Depth: 22.00 m bsf** **Soil Unit: E5a (Tongeren)**	**Plate Number: A.23**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (5G-7/1) subangular to rounded low to high sphericity clayey fine SAND

Colour:
Unwashed: Dark greenish grey (5G-7/1)
Washed: Light grey (5Y-7/2)

Sand is poorly to moderately well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows limited coating of silt

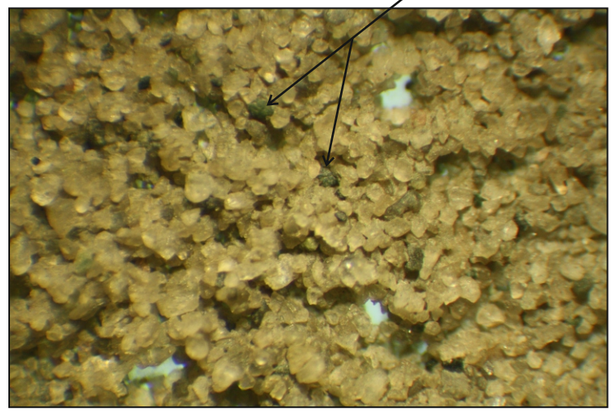
90 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.5) low to medium sphericity (rK = 0.1 to 0.7) QUARTZ
~90 % glassy
~10 % frosted

5 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.9) brown to black LITHIC FRAGMENTS
3 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.9) black BIOTITE
2 % - Fine sand-sized subrounded to rounded (rK = 0.5 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

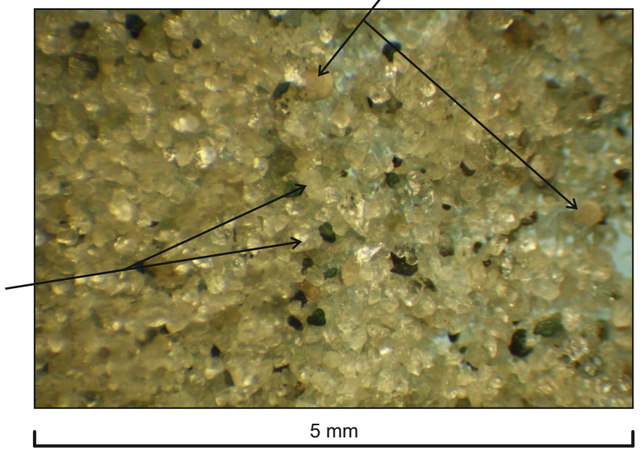
Trace: muscovite mica, bioclastic debris

Reflected Light Microphotographs

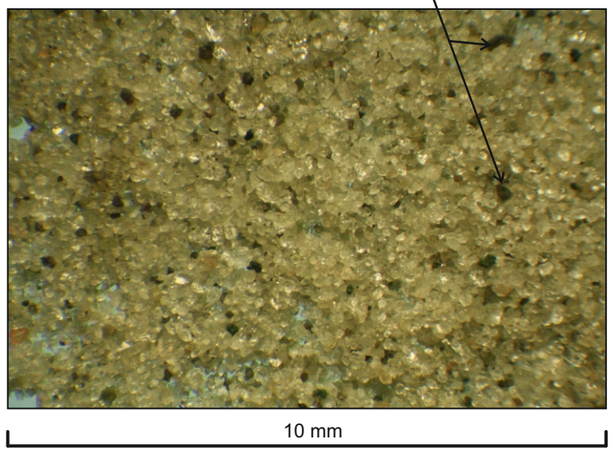
Unwashed Sample



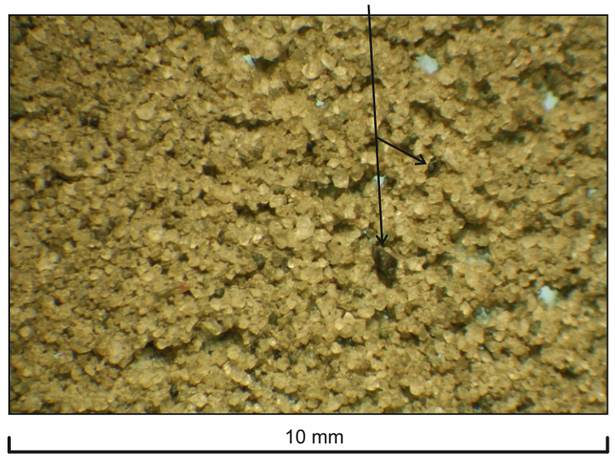
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

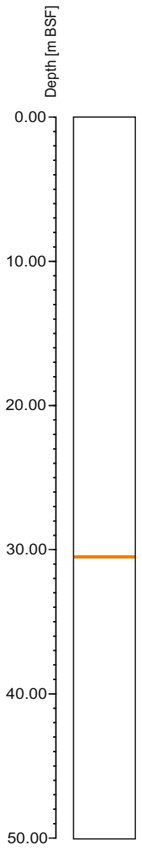
Sample Location: BH-WFS3-2
Sample Name: 23BagA

Depth: 22.50 m bsf
Soil Unit: E5b (Tongeren)

Plate Number: A.24

Made:	LRM	29/01/2016	
Checked:	LA	15/02/2016	
Approved:	CAS	17/02/2016	

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10GY-4/1) subangular to rounded medium to high sphericity fine SAND

Colour:
Unwashed: Dark greenish grey (10GY-4/1)
Washed: Light olive grey (5Y-6/2)

Sand is well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows limited coating of silt

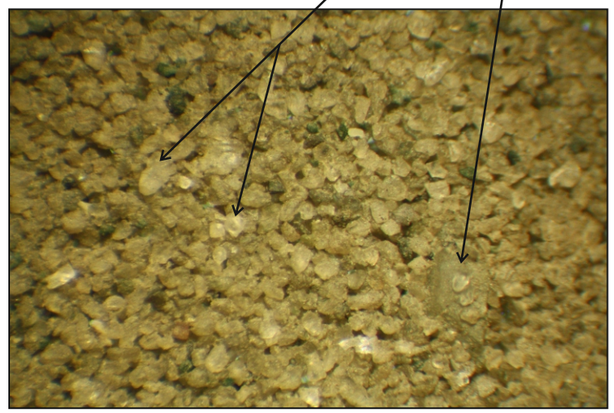
85 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.1 to 0.5) QUARTZ
~80 % glassy
~20 % frosted

6 % - Silt-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.9) black BIOTITE MICA
4 % - Silt-sized to fine sand-sized angular to rounded (rK = 0.2 to 0.8) low to high sphericity (rK = 0.3 to 0.9) reddish brown to brownish black LITHIC FRAGMENTS
3 % - Silt-sized subangular to rounded (rK = 0.4 to 0.8) low to medium sphericity (rK = 0.1 to 0.7) green GLAUCONITE
2 % - Silt-sized angular to subangular (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.1 to 0.5) green MUSCOVITE MICA

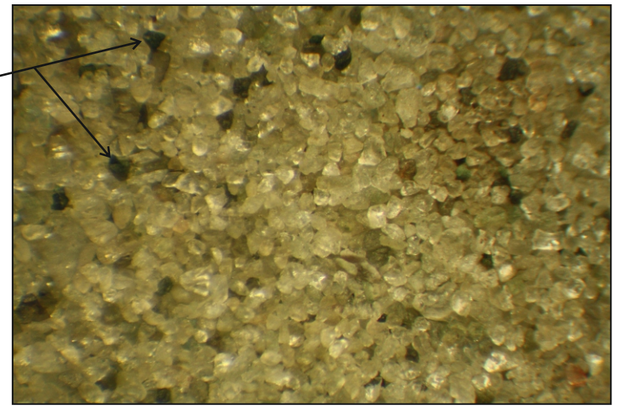
Trace: feldspar, epidote

Reflected Light Microphotographs

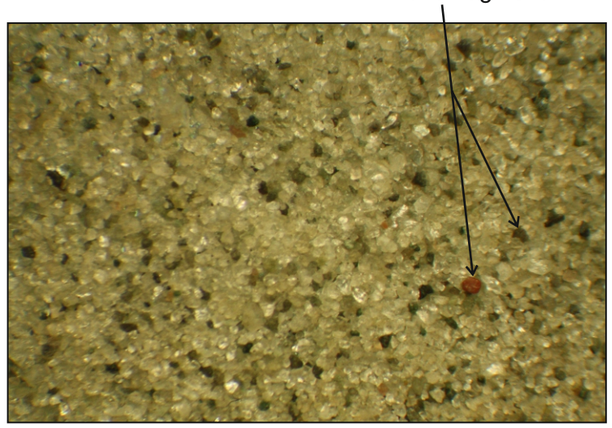
Unwashed Sample



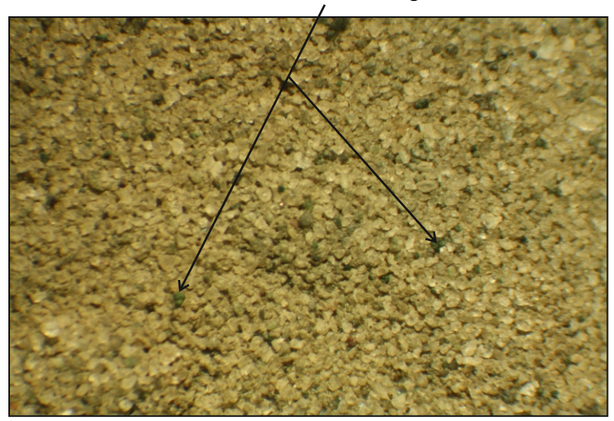
Washed Sample



Washed Sample

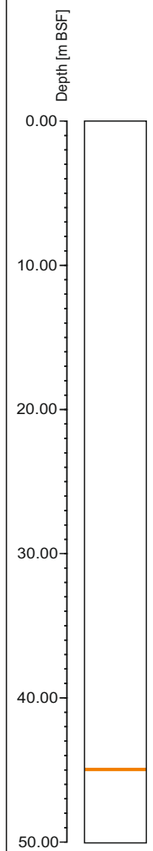


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-3A** **Sample Name: 14BagA**	**Depth: 30.50 m bsf** **Soil Unit: E5b (Tongeren)**	**Plate Number: A.25**	Made:	LRM	29/01/2016
				Checked:	LA	15/02/2016
				Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (5GY-3/1) angular to subrounded low to medium sphericity silty fine SAND with trace fine gravel-sized subangular medium sphericity black biotite nodule

Colour:
Unwashed: Very dark greenish grey (5GY-3/1)
Washed: Light olive brown (2.5Y-5/3)

Sand is well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows moderate coating of clay and silt

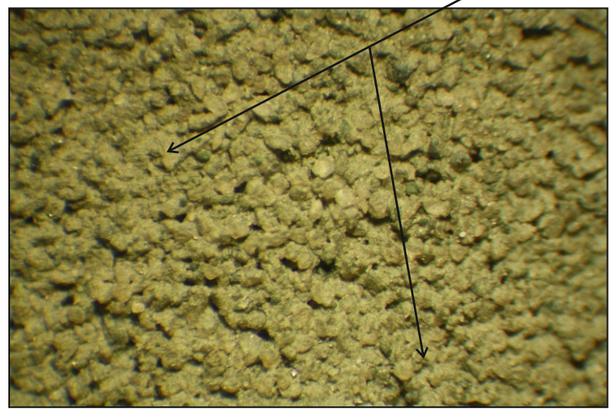
85 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.7) QUARTZ
~65 % glassy
~35 % frosted

7 % - Silt-sized to fine sand-sized angular to rounded (rK = 0.2 to 0.7) low to high sphericity (rK = 0.1 to 0.9) black BIOTITE MICA
6 % - Silt-sized angular to rounded (rK = 0.2 to 0.8) low to high sphericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
2 % - Silt-sized angular to subangular (rK = 0.2 to 0.4) low sphericity (rK = 0.1 to 0.3) metallic lustre MUSCOVITE MICA

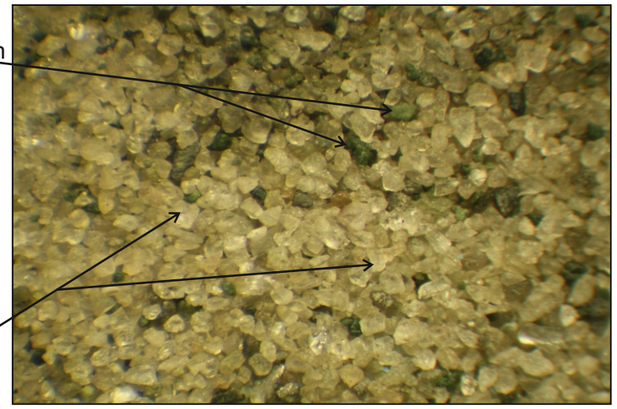
Trace: calcite, feldspar, epidote

Reflected Light Microphotographs

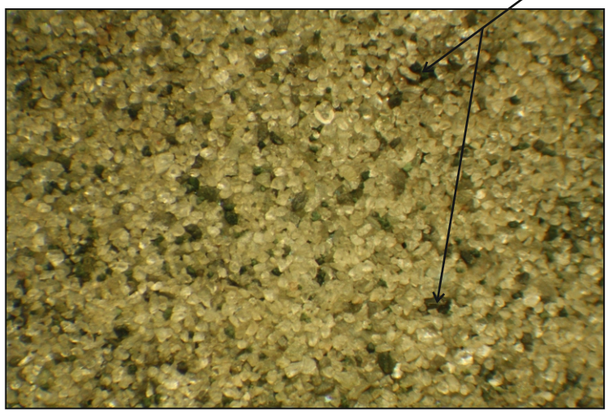
Unwashed Sample



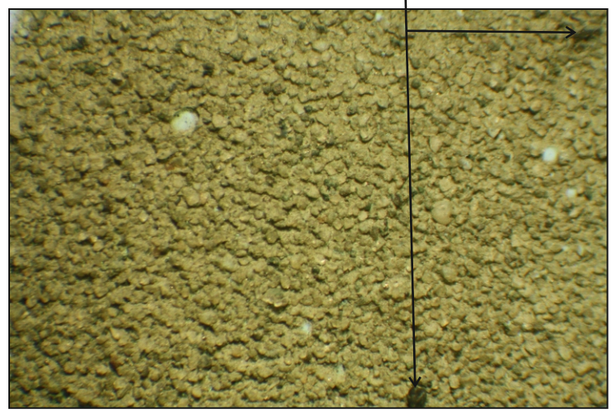
Washed Sample



Washed Sample



Unwashed Sample



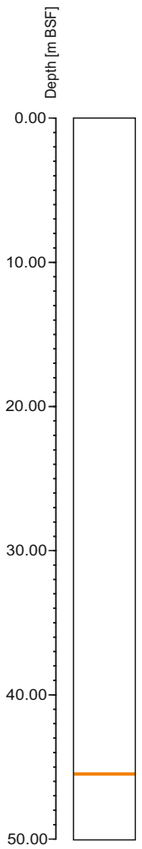
J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: CPT_WFS4_18A
Sample Name: 1BagA

Depth: 45.00 m bsf
Soil Unit: E5b (Tongeren)

Plate Number: A.26			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (5GY-3/1) angular to subrounded low to medium sphericity silty fine SAND

Colour:
Unwashed: Very dark greenish grey (5GY-3/1)
Washed: Grey (2.5Y-5/1)

Sand is well sorted
Sand: No reaction to HCl

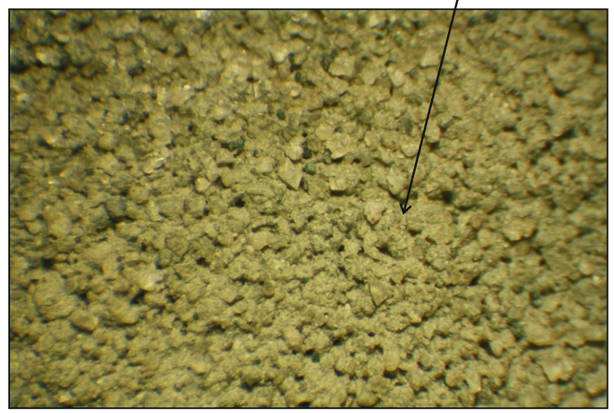
Microscope Description
Unwashed sample shows moderate coating of clay and silt

90 % - Silt-sized to fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.1 to 0.5) QUARTZ
- ~95 % glassy
- ~3 % frosted
- ~2 % light pink to reddish orange/red

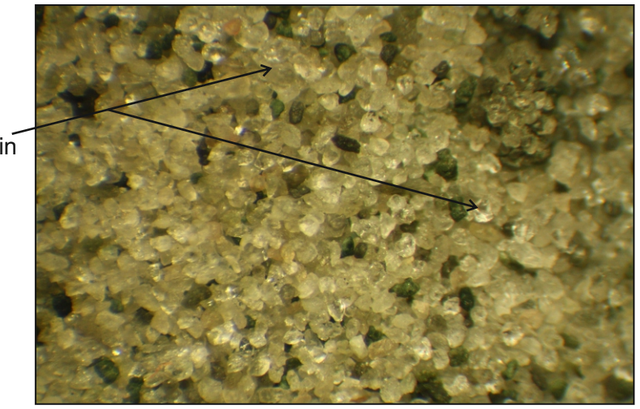
4 % - Silt-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
4 % - Silt-sized subrounded to rounded (rK = 0.6 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE
2 % - Silt to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) reddish brown to black LITHIC FRAGMENTS

Reflected Light Microphotographs

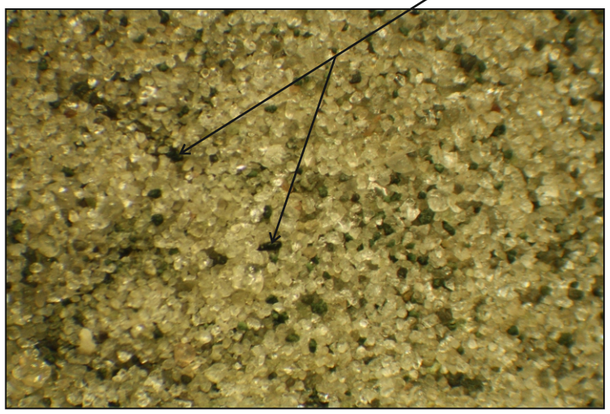
Unwashed Sample



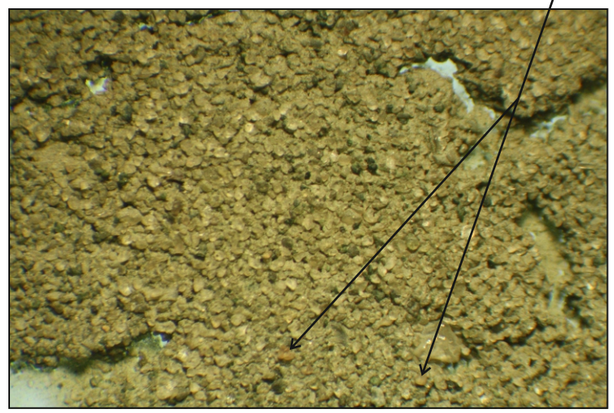
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

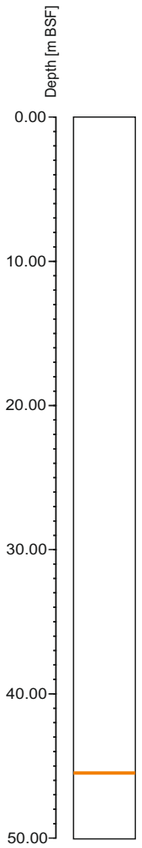
Sample Location: CPT_WFS4_18A
Sample Name: 1BagB

Depth: 45.40 m bsf
Soil Unit: E5b (Tongeren)

Plate Number: A.27

Made:	LRM	29/01/2016	
Checked:	LA	15/02/2016	
Approved:	CAS	17/02/2016	

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10BG-4/1) subangular to subrounded low to high sphericity clayey fine SAND with many silt-sized angular low sphericity muscovite

Colour:
Unwashed: Dark greenish grey (10BG-4/1)
Washed: Light grey (2.5Y-7/1)

Sand is moderately well sorted
Sand: No reaction to HCl

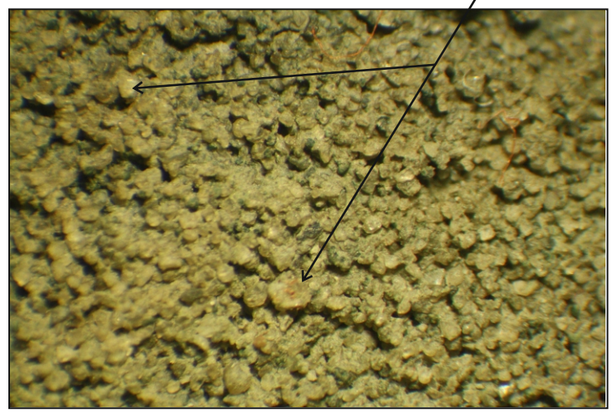
Microscope Description
Unwashed sample shows moderate coating of clay

80 % - Silt to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.9) QUARTZ
~80 % glassy
~20 % frosted

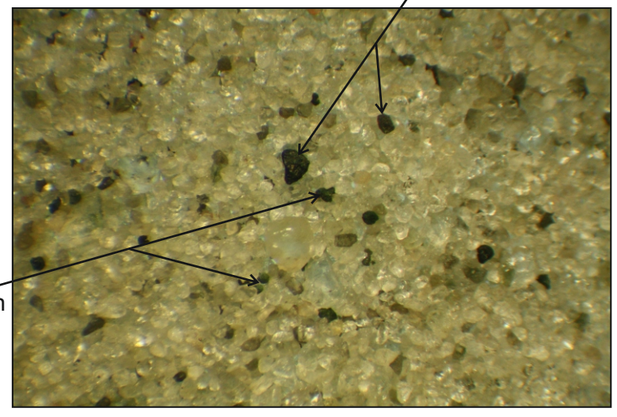
10 % - Silt to fine sand-sized angular to subangular (rK = 0.1 to 0.5) low to medium sphericity (rK = 0.1 to 0.7) black BIOTITE MICA
6 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.7) orange brown to reddish black LITHIC FRAGMENTS
2 % - Fine sand-sized subangular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.1 to 0.7) white FELDSPAR
2 % - Silt-sized subangular to subrounded (rK = 0.2 to 0.6) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

Reflected Light Microphotographs

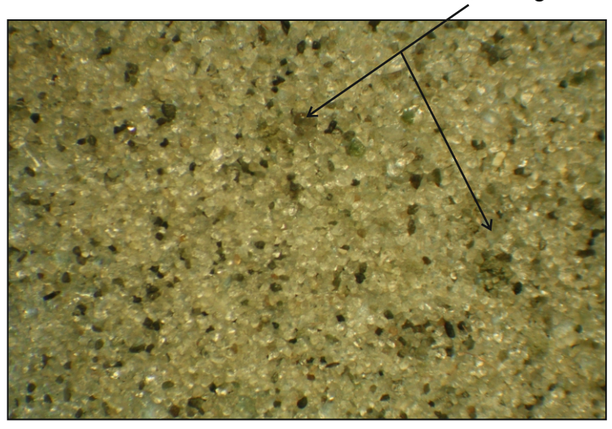
Unwashed Sample



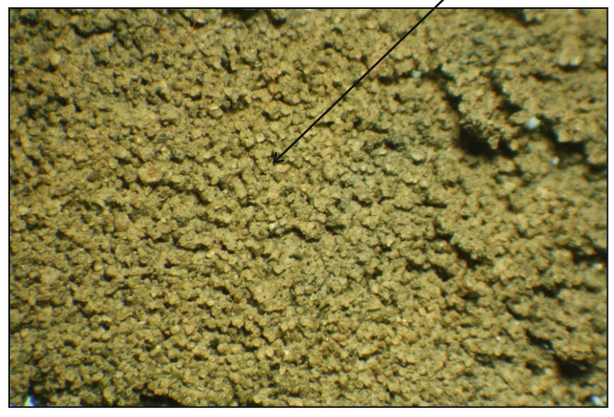
Washed Sample



Washed Sample



Unwashed Sample

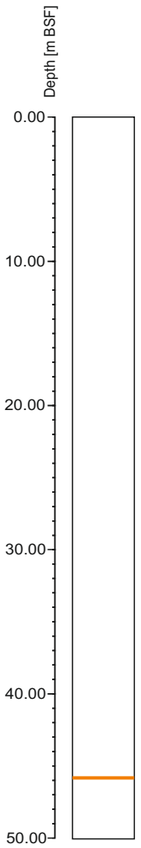


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: CPT_SubStatB_1** **Sample Name: 1BagA**	**Depth: 45.50 m bsf** **Soil Unit: E5b (Tongeren)**	**Plate Number: A.28**

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (10GY-4/1) angular to subrounded low to medium sphericity clayey fine SAND

Colour:
Unwashed: Very dark greenish grey (10GY-4/1)
Washed: Grey (5Y-5/1)

Sand is poorly sorted
Sand: Limited, slow reaction to HCL

Microscope Description
Unwashed sample shows moderate coating of clay

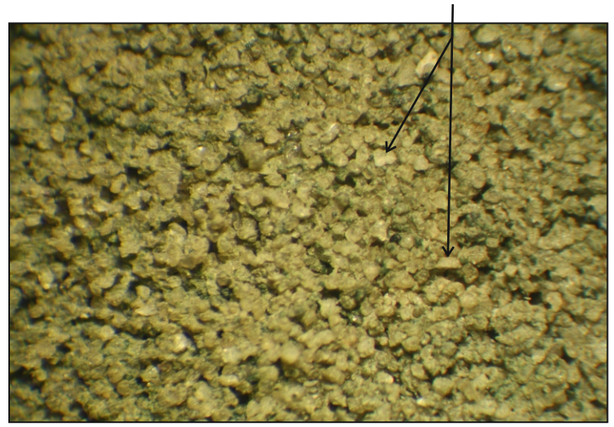
85 % - Silt to fine sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~85 % glassy
~10 % frosted
~5 % light pink to reddish orange/red

6 % - Silt-sized angular to subangular (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.1 to 0.5) black BIOTITE MICA
4 % - Silt-sized subangular to rounded (rK = 0.2 to 0.6) medium to high sphericity (rK = 0.2 to 0.6) green GLAUCONITE
3 % - Silt to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) black to brown LITHIC FRAGMENTS
2 % - Silt-sized angular to subangular (rK = 0.2 to 0.5) low to medium sphericity (rK = 0.3 to 0.9) metallic lustre MUSCOVITE MICA

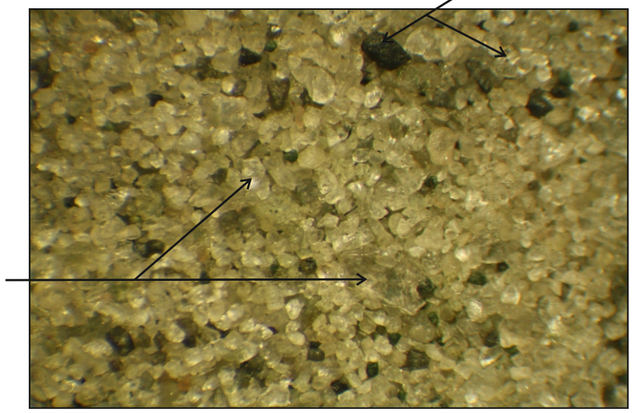
Trace: feldspar, calcite

Reflected Light Microphotographs

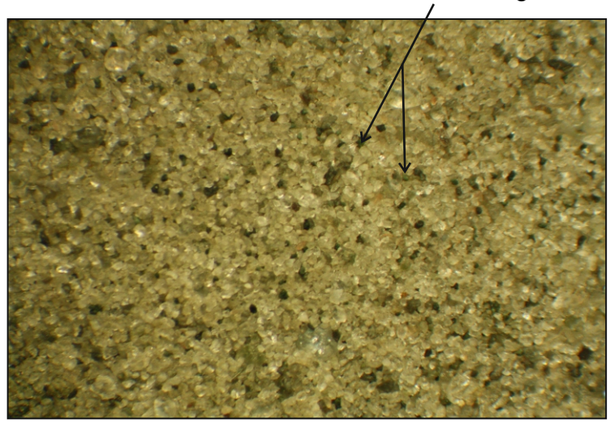
Unwashed Sample



Washed Sample



Washed Sample



Unwashed Sample



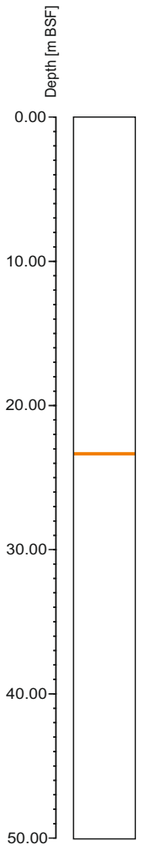
J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: CPT_SubStatB_1
Sample Name: 1BagB

Depth: 45.90 m bsf
Soil Unit: E5b (Tongeren)

Plate Number: A.29			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Olive grey (5Y-4/2) angular to subangular medium to high sphericity clayey SILT

Colour:
Unwashed: Olive grey (5Y-4/2)
Washed: Grey (5Y-6/1)

Silt is well sorted
Silt: No reaction to HCl

Microscope Description
Unwashed sample shows extensive coating of clay

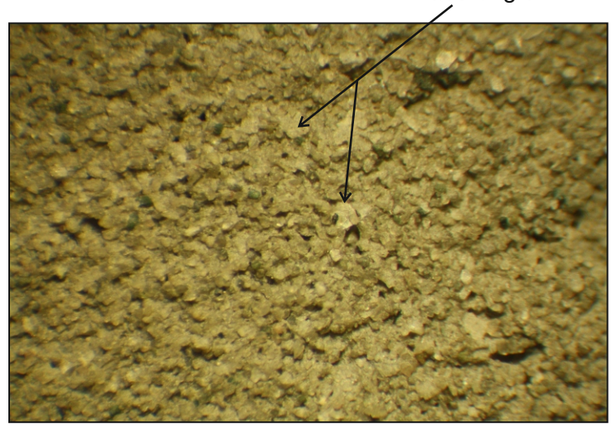
85 % - Silt-sized angular to subangular (rK = 0.2 to 0.5) low to high sphericity (rK = 0.1 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

7 % - Silt to fine sand-sized angular (rK = 0.1 to 0.2) low to medium sphericity metallic (rK = 0.1 to 0.3) lustre MUSCOVITE MICA
5 % - Silt-sized angular to subrounded (rK = 0.1 to 0.6) low to high sphericity (rK = 0.1 to 0.9) black BIOTITE MICA
3 % - Silt-sized subangular to rounded (rK = 0.2 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) white FELDSPAR

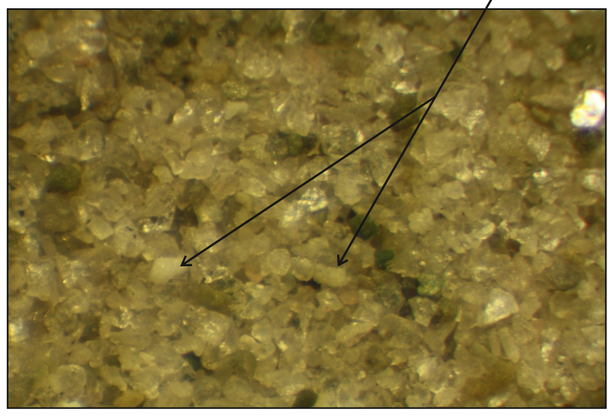
Trace: lithic fragments, glauconite

Reflected Light Microphotographs

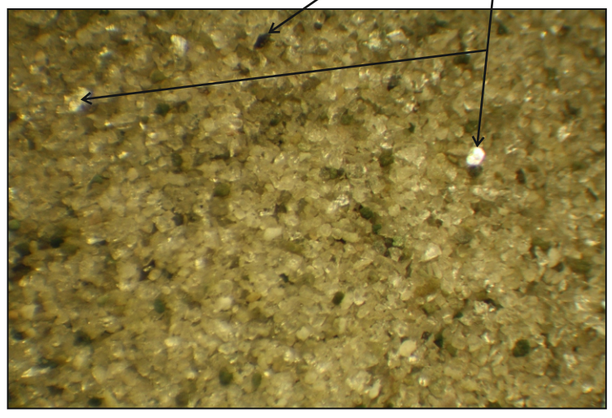
Unwashed Sample



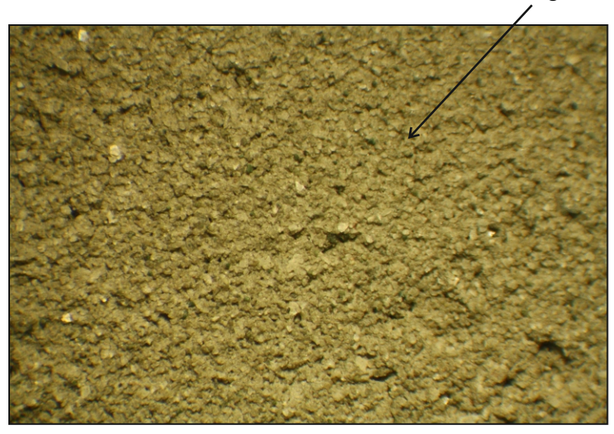
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

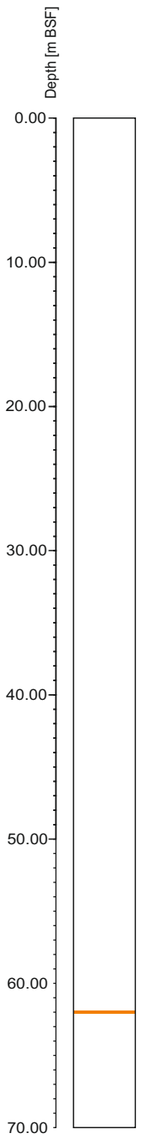
Sample Location: BH-WFS3-1
Sample Name: 24BagUU

Depth: 23.30 m bsf
Soil Unit: F1a (Dongen)

Plate Number: A.30			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10GY-4/1) silty CLAY

Colour:
Unwashed: Dark greenish grey (10GY-4/1)
Dark greenish grey (10GY-4/1)

Silt is poorly sorted
Silt: Limited, slow reaction to HCl

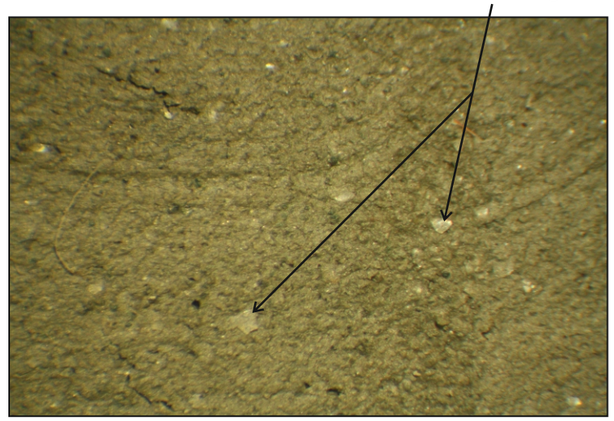
Microscope Description

80 % - Silt-sized angular to subrounded (rK = 0.1 to 0.7) low to medium sphericity (rK = 0.1 to 0.7) QUARTZ
~80 % glassy
~20 % frosted

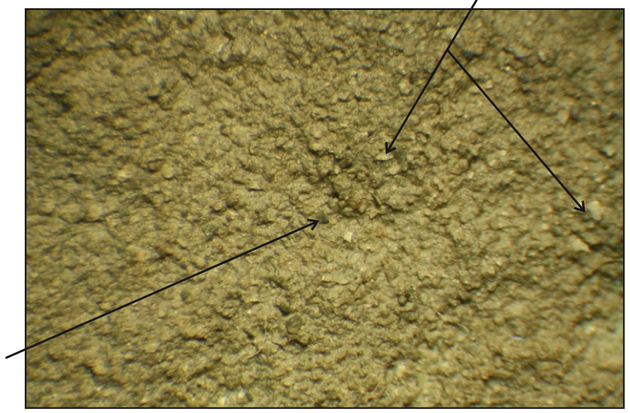
8 % - Silt-sized angular (rK = 0.1 to 0.2) low sphericity (rK = 0.1 to 0.3) metallic lustre MUSCOVITE MICA
7 % - Silt-sized angular to subangular (rK = 0.2 to 0.5) low to medium sphericity (rK = 0.1 to 0.7) black BIOTITE MICA
3 % - Silt-sized angular to subangular (rK = 0.2 to 0.6) low sphericity (rK = 0.1 to 0.3) brown/black LITHIC FRAGMENTS
2 % - Silt-sized angular to subangular (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.1 to 0.5) white FELDSPAR

Reflected Light Microphotographs

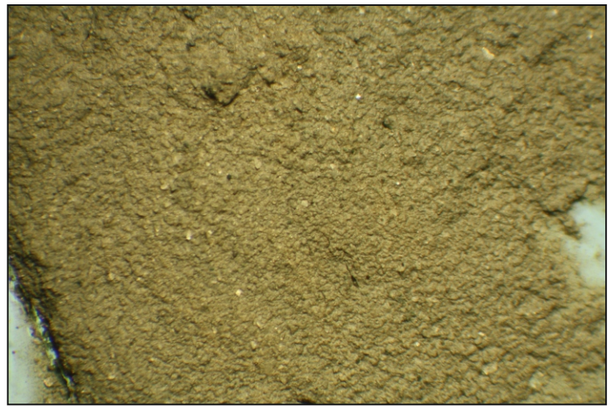
Unwashed Sample



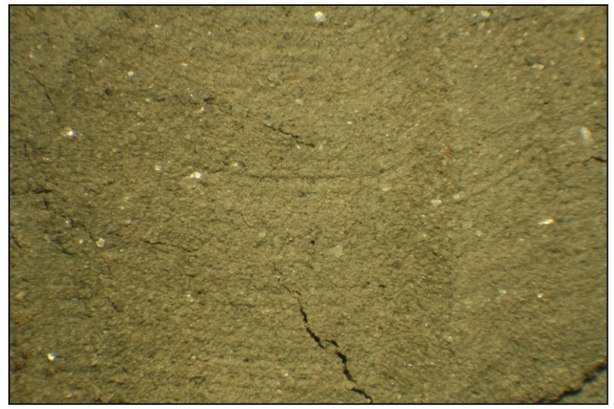
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

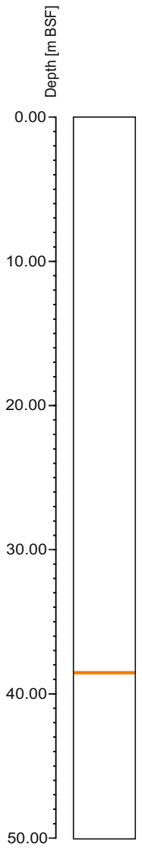
Sample Location: BH-SubStatB-1
Sample Name: 35BagA

Depth: 62.00 m bsf
Soil Unit: F1a (Dongen)

Plate Number: A.31			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (5G7/1) sandy fine SAND. sand is subangular to subrounded medium to high sphericity

Colour:
Unwashed: Dark greenish grey (5G7/1)
Washed: Light grey (5Y-7/1)

Sand is moderately to well sorted
Sand: No reaction to HCl

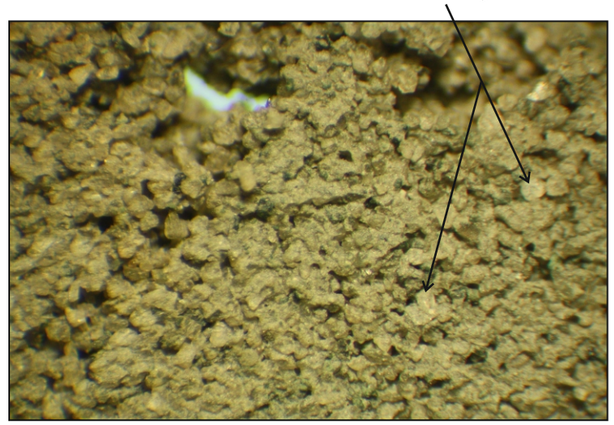
Microscope Description
Unwashed sample shows extensive coating of clay

80 % - Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.1 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

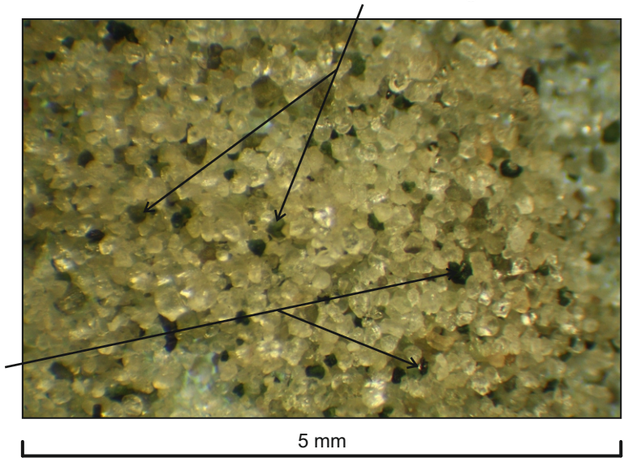
10 % - Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.1 to 0.5) black BIOTITE MICA
5 % - Fine sand-sized subangular to rounded (rK = 0.2 to 0.8) medium to high sphericity (rK = 0.5 to 09) green GLAUCONITE
5 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) brown to black LITHIC FRAGMENTS

Reflected Light Microphotographs

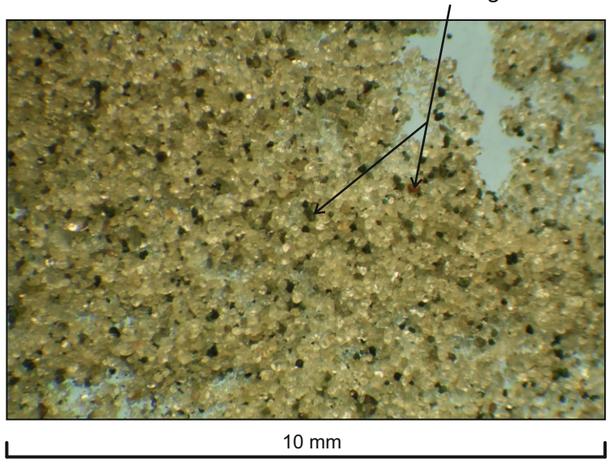
Unwashed Sample



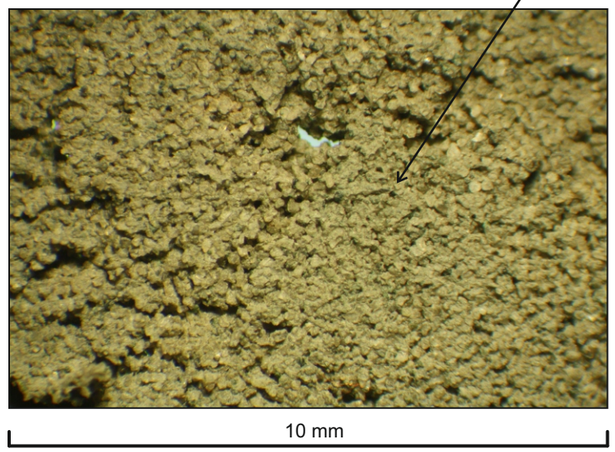
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: CPT-WFS3-1A
Sample Name: 1BagA

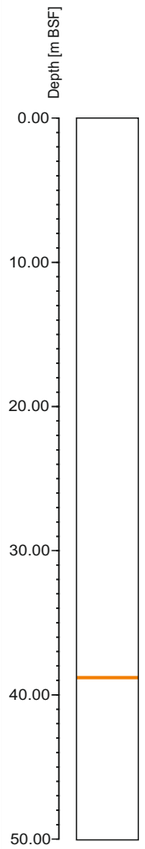
Depth: 38.50 m bsf
Soil Unit: F2 (Dongen)

Plate Number: A.32

Made:	LRM	29/01/2016
Checked:	LA	15/02/2016
Approved:	CAS	17/02/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (5GY-4/1) angular to subrounded low to high sphericity clayey fine SAND

Colour:
Unwashed: Very dark greenish grey (5GY-4/1)
Washed: Greenish grey (10Y-6/1)

Sand is moderately to well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows limited coating of clay

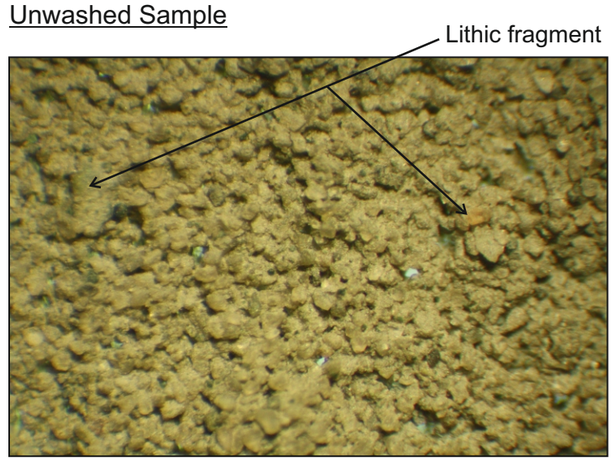
90 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.9) QUARTZ
~95 % glassy
~5 % frosted

4 % - Silt-sized subangular to subrounded (rK = 0.3 to 0.6) low to high sphericity (rK = 0.3 to 0.9) green GLAUCONITE
3 % - Silt-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.9) black BIOTITE MICA
3 % - Silt-sized to fine sand-sized angular to rounded (rK = 0.2 to 0.8) low to high sphericity (rK = 0.1 to 0.9) reddish brown to black LITHIC FRAGMENTS

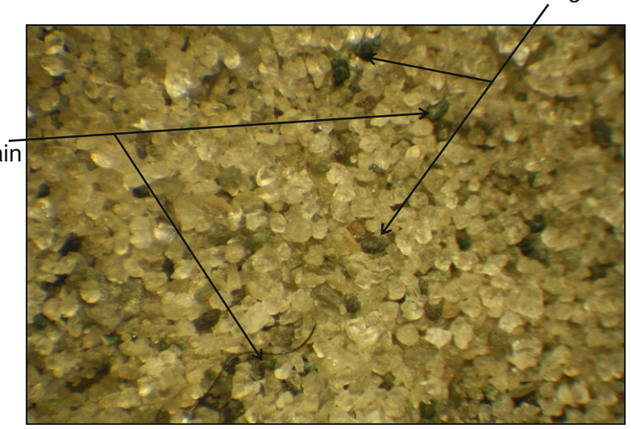
Trace: muscovite mica, feldspar

Reflected Light Microphotographs

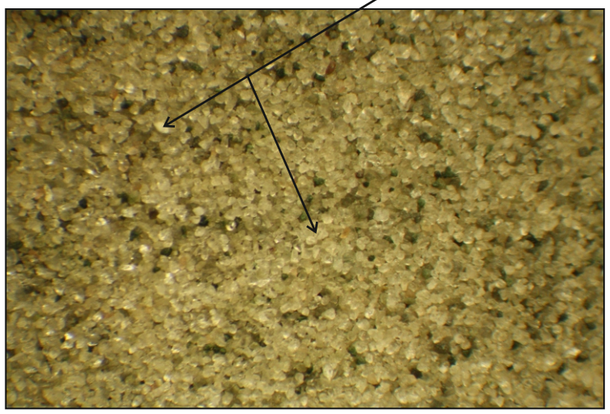
Unwashed Sample



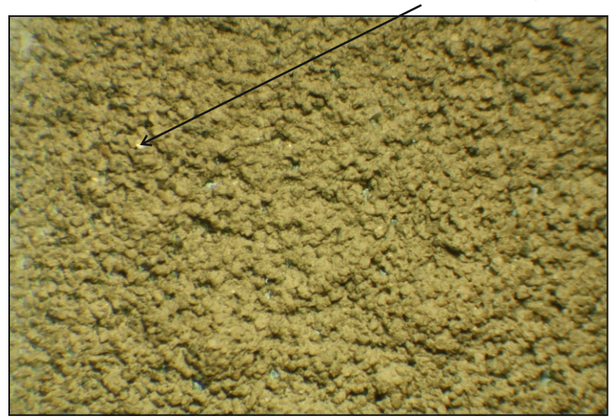
Washed Sample



Washed Sample



Unwashed Sample



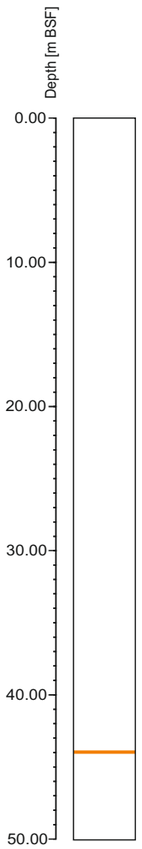
J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: CPT-WFS3-1A
Sample Name: 1BagB

Depth: 38.90 m bsf
Soil Unit: F2 (Dongen)

Plate Number: A.33			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10G-4/1) silty CLAY

Colour:
Unwashed: Dark greenish grey (10G-4/1)
Dark greenish grey (10GY-4/1)

Silt is well sorted
Silt: No reaction to HCl

Microscope Description
Unwashed sample shows extensive coating of clay

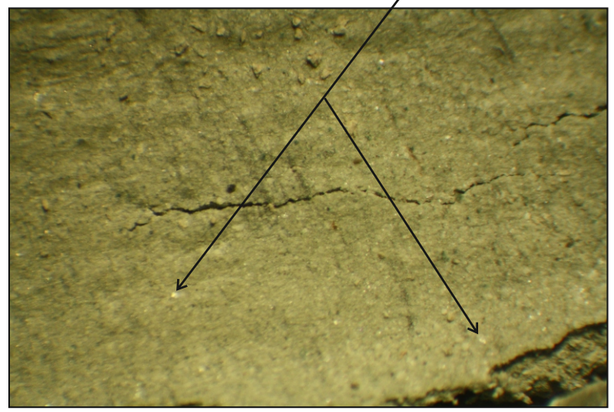
90 % - Silt-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.1 to 0.7) QUARTZ
~90 % glassy
~10 % frosted

5 % - Silt-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) white BIOCLASTIC FRAGMENTS
3 % - Silt-sized angular to subangular (rK = 0.2 to 0.5) low to high sphericity (rK = 0.3 to 0.9) white FELDSPAR
2 % - Silt-sized angular to subrounded (rK = 0.2 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA

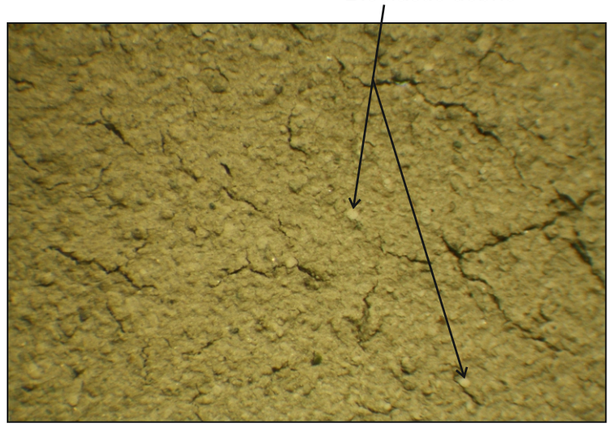
Trace: muscovite mica, lithic fragments

Reflected Light Microphotographs

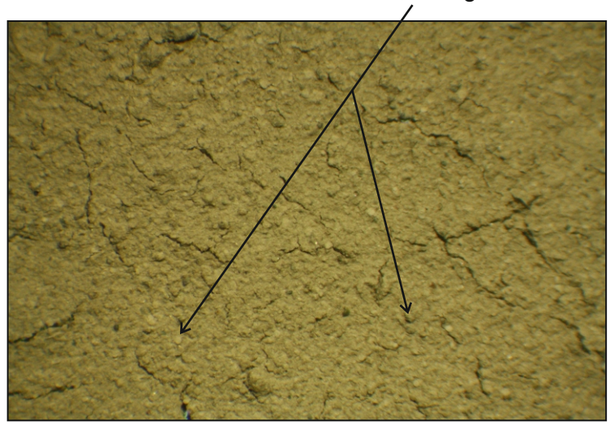
Unwashed Sample



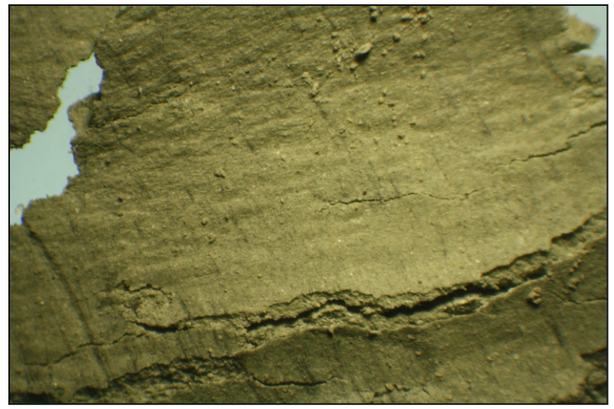
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS3-4A
Sample Name: 11BagA

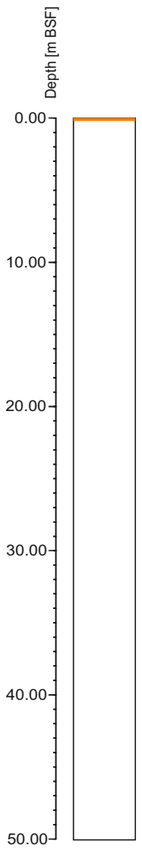
Depth: 44.00 m bsf
Soil Unit: F3 (Dongen)

Plate Number: A.34			
	Made:	LRM	29/01/2016
	Checked:	LA	15/02/2016
	Approved:	CAS	17/02/2016

FUGRO

D. PHASE II SAMPLE PLATES

Sample Microscope Description



Sample Description

Hand-Specimen Description
Olive yellow (2.5Y-6/6) subangular to rounded low to high sphericity medium to coarse SAND with medium sand-sized to fine gravel-sized few subangular to subrounded low to high sphericity white (N-8/1) shell fragments

Colour:
Unwashed: Olive yellow (2.5Y-6/6)
Washed: Brownish yellow (10YR-6/6)

Sand is moderately well sorted
Sand: limited, slow reaction to HCL

Microscope Description
Unwashed sample shows no coating of clay/silt

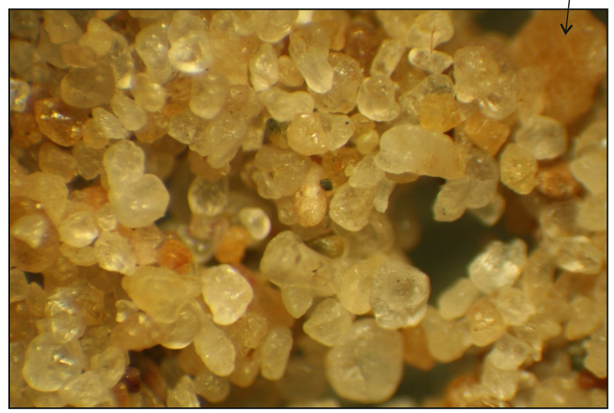
70 % - Medium to coarse sand-sized subangular to rounded (*r*K = 0.3 to 0.7) medium to high sphericity (*r*K = 0.5 to 0.9) QUARTZ
- ~ 83 % clear, frosted
- ~ 10 % clear, glassy
- ~ 7 % light pink to reddish orange/red

10 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) black BIOTITE
10 % - Medium to coarse sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to medium sphericity (*r*K = 0.3 to 0.7) white to orange FELDSPAR
10 % - Fine to medium sand-sized subangular to rounded (*r*K = 0.3 to 0.8) low to high sphericity (*r*K = 0.3 to 0.9) brown to black LITHIC FRAGMENTS

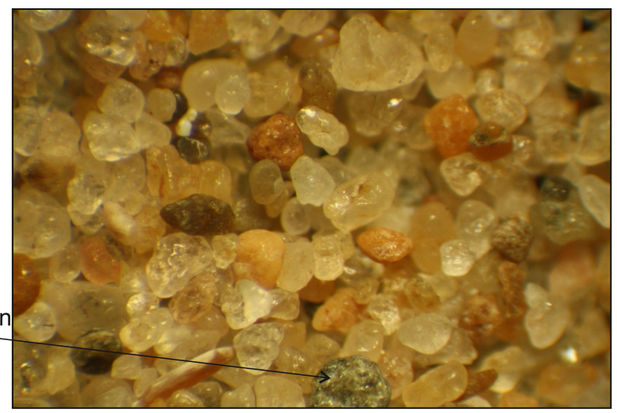
Trace: glauconite, bioclastic fragments, calcite

Reflected Light Microphotographs

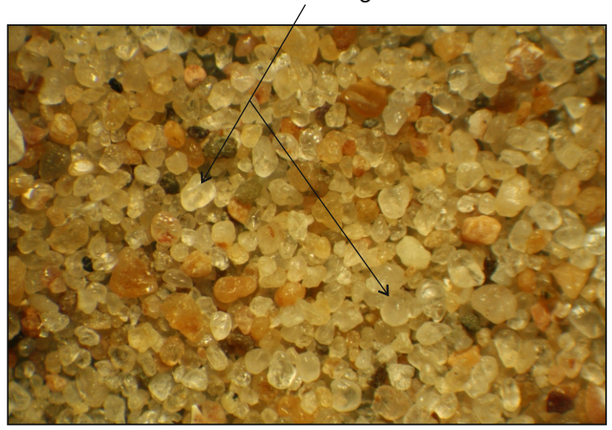
Unwashed Sample



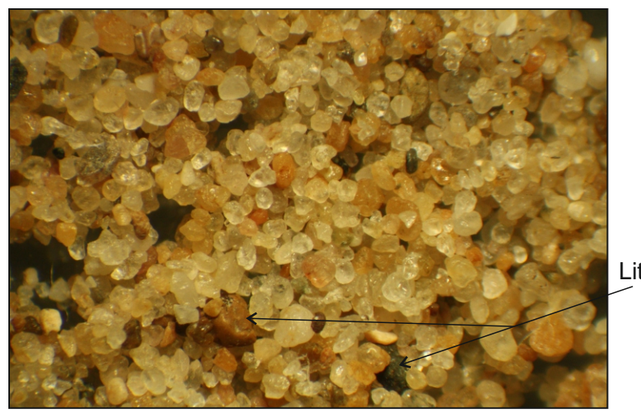
Washed Sample



Washed Sample



Unwashed Sample

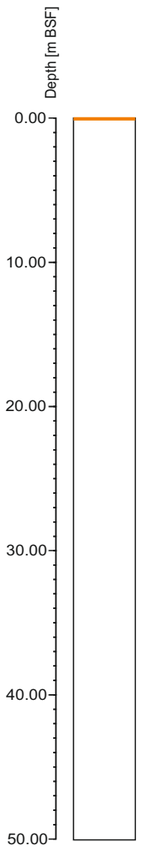


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-4** **Sample Name: 1BagA**	**Depth: 0.00 m bsf** **Soil Unit: A (Southern Bight)**	**Plate Number: A.35**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/4) subangular to rounded low to high sphericity medium to coarse SAND with many fine sand-sized to coarse gravel-sized white to orange and brown angular low sphericity shell fragments (bivalves, echinoid spines, byrozoa) and with coarse sand-sized to coarse gravel-sized shells (echinoids, bivalves, gastropods) and with trace subrounded to rounded low to medium sphericity coarse gravel

Colour:
Unwashed: Light olive brown (2.5Y-5/4)
Washed: Light yellowish brown (10YR-6/4)

Sand is poorly sorted
Sand: strong, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

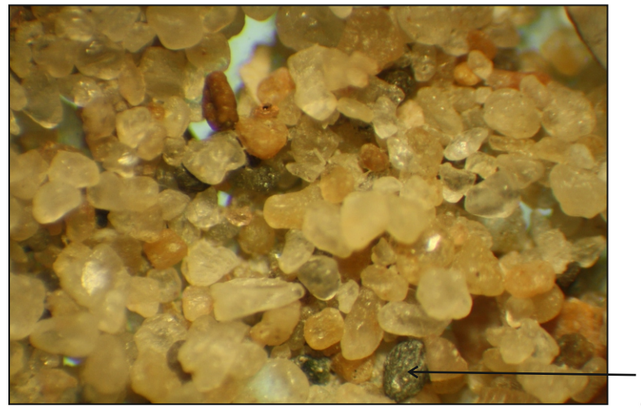
70 % - Fine to coarse sand-sized subangular to well-rounded (rK = 0.3 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~90 % frosted
~7 % glassy
~3 % light pink to reddish orange/red

15 % - Medium sand-sized to coarse gravel-sized angular to subangular (rK = 0.2 to 0.4) low sphericity (rK = 0.3 to 0.5) BIOCLASTIC DEBRIS
5 % - Medium to coarse sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to high sphericity (rK = 0.3 to 0.7) white, orange to pinkish FELDSPAR
5 % - Fine sand-sized to fine gravel-sized subangular to subrounded (rK = 0.4 to 0.6) low to high sphericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
3 % - Medium to coarse sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE
2 % - Fine to coarse sand-sized subrounded to rounded (rK = 0.5 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) Green GLAUCONITE

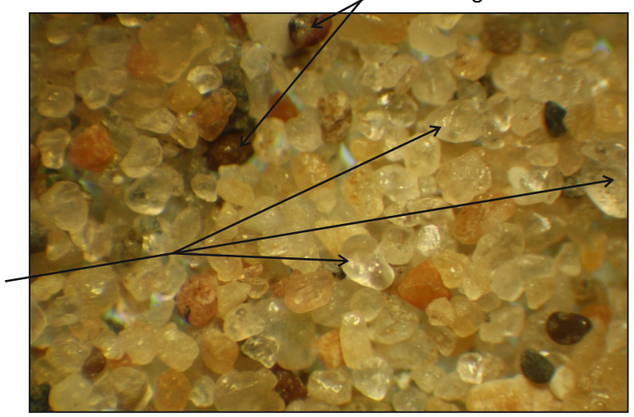
Trace: calcite, muscovite mica

Reflected Light Microphotographs

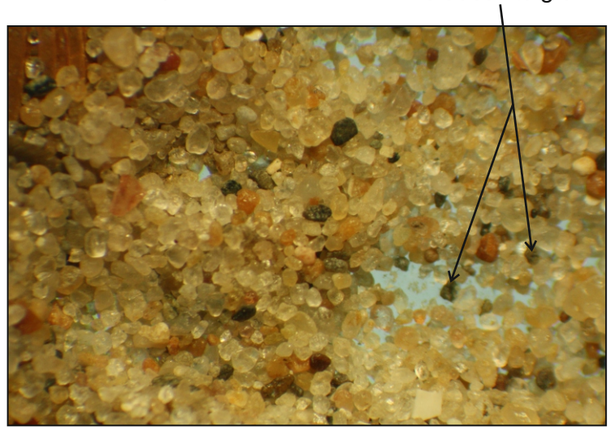
Unwashed Sample



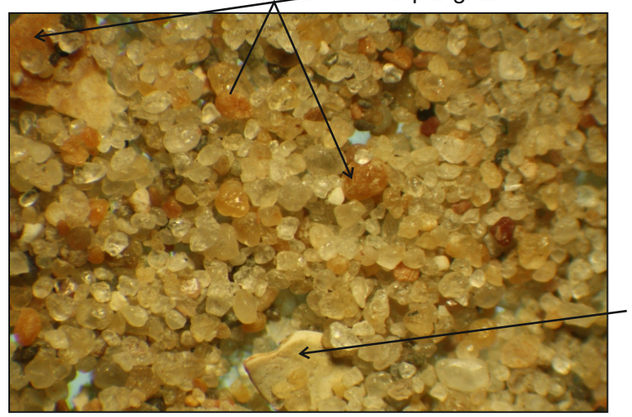
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

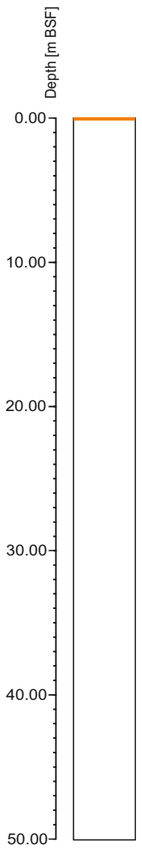
Sample Location: BH-WFS3-5
Sample Name: 1BagA

Depth: 0.00 m bsf
Soil Unit: A (Southern Bight)

Plate Number: A.36			
	Made:	LRM	08/01/2016
	Checked:	CB	12/01/2016
	Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/4) subangular to rounded low to high sphericity coarse SAND with many fine sand-sized to coarse coarse gravel-sized white to orange and brown angular low sphericity shell fragments (bivalves, echinoid spines)

Colour:
Unwashed: Light olive brown (2.5Y-5/4)
Washed: Olive yellow (2.5Y-6/6)

Sand is poorly sorted
Sand: Violent, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

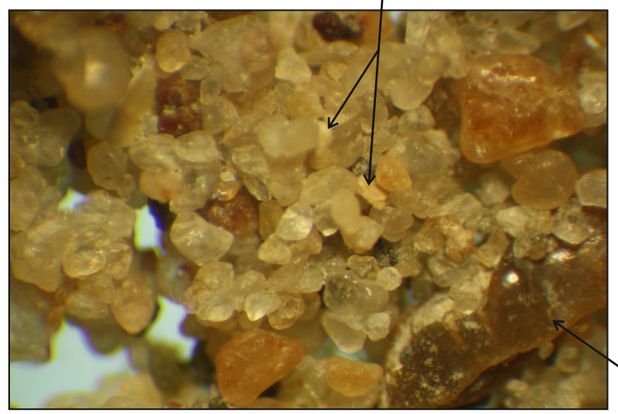
75 % - Medium to coarse sand-sized subangular to rounded (rK = 0.4 to 0.7) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~60 % frosted
~35 % glassy
~5 % light pink to reddish orange/red

10 % - Fine to coarse sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.5) black BIOTITE MICA
7 % - Medium to coarse sand-sized subangular to rounded (rK = 0.4 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) white to orange/pinkish FELDSPAR
4 % - Fine to coarse sand-sized angular to rounded (rK = 0.2 to 0.7) low to high sphericity (rK = 0.3 to 0.9) brown, black to orange LITHIC FRAGMENTS
4 % - Medium sand-sized to fine gravel-sized angular to subangular (rK = 0.1 to 0.4) low to medium sphericity (rK = 0.3 to 0.5) white BIOCLASTIC DEBRIS (bivalves, echinoid spines)

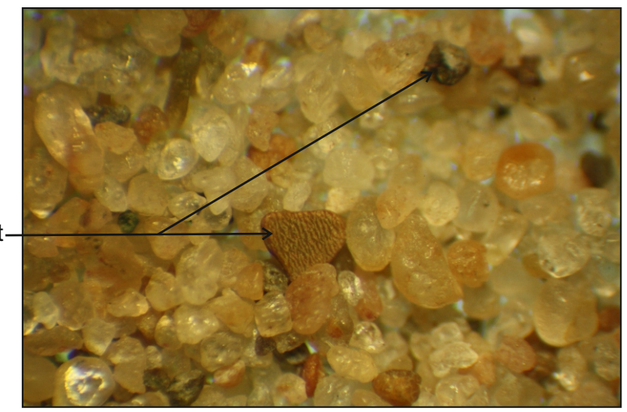
Trace: calcite, glauconite

Reflected Light Microphotographs

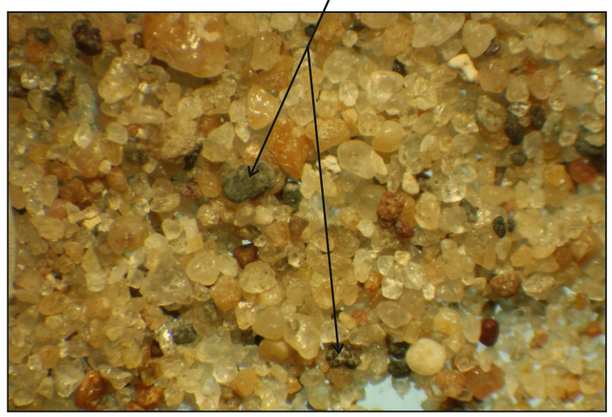
Unwashed Sample



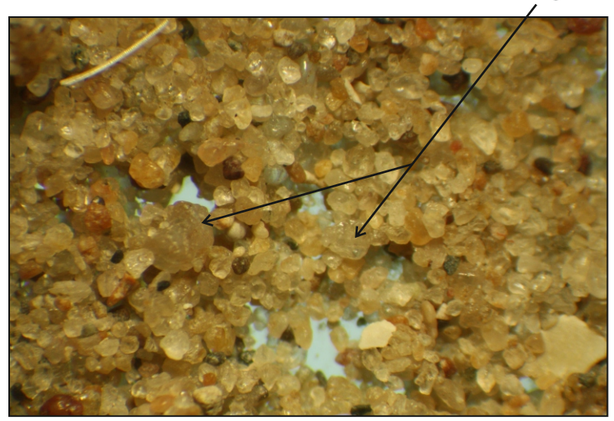
Washed Sample



Washed Sample

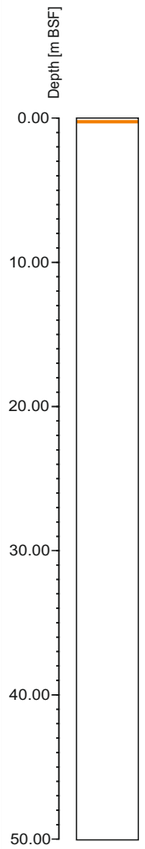


Unwashed Sample



J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS3-2 Sample Name: 1BagA**	**Depth: 0.00 m bsf Soil Unit: A (Southern Bight)**	**Plate Number: A.37**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	20/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Olive brown (2.5Y-4/4) subrounded to well-rounded medium to high sphericity medium to coarse SAND with many medium sand-sized to coarse gravel-sized white (N-8/1) shell fragments and few coarse gravel-sized white (N-8/1 and reddish brown (2.5YR-4/4) bivalves

Colour:
Unwashed: Olive brown (2.5Y-4/4)
Washed: Light yellowish brown (10YR-6/4)

Sand is poorly sorted
Sand: limited, slow reaction with HCL

Microscope Description
Unwashed sample shows no coating of clay/silt

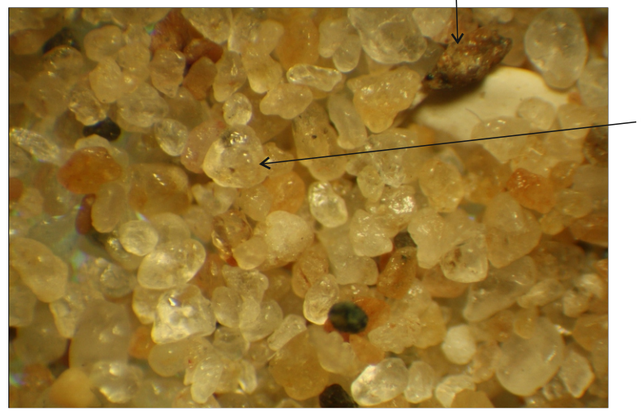
80 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) medium to high sphericity (*r*K = 0.5 to 0.9) QUARTZ
~ 70 % clear, frosted
~ 25 % clear, glassy
~ 2 % light pink to reddish orange/red

7 % - Fine sand-sized subangular to rounded (*r*K = 0.4 to 0.8) low to medium sphericity (*r*K = 0.3 to 0.7) brown to white BIOCLASTIC DEBRIS
5 % - Fine sand-sized angular to subangular (*r*K = 0.2 to 0.4) low to high sphericity (*r*K = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
3 % - Fine sand-sized subangular to rounded (*r*K = 0.3 to 0.7) low to high sphericity (*r*K = 0.3 to 0.9) black BIOTITE
3 % - Fine sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to medium sphericity (*r*K = 0.3 to 0.7) white to orange FELDSPAR
2 % - Fine sand-sized subrounded to rounded (*r*K = 0.5 to 0.7) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE

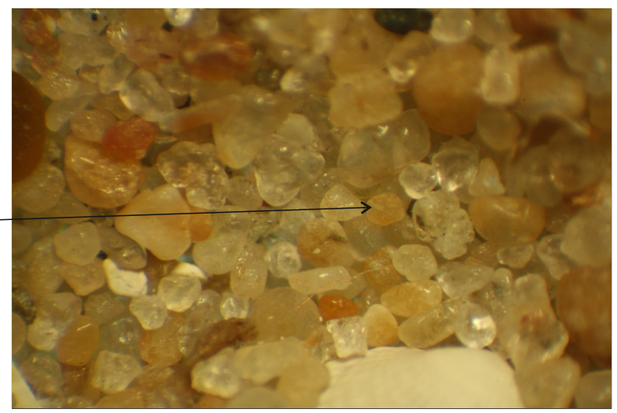
Trace: calcite

Reflected Light Microphotographs

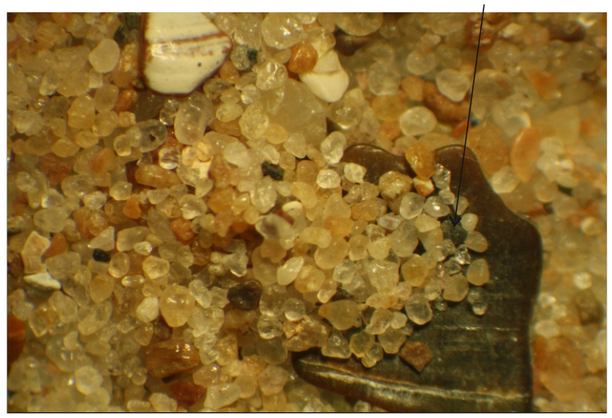
Unwashed Sample



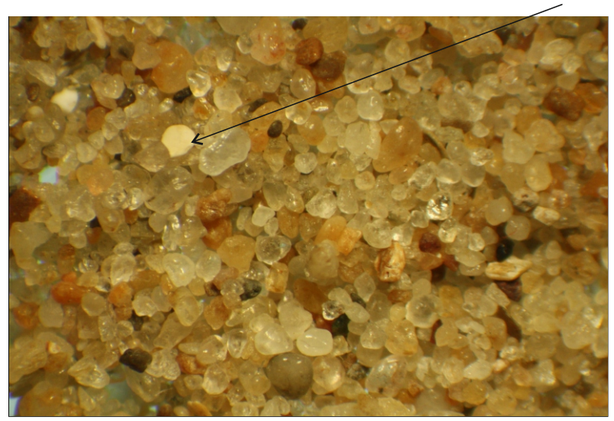
Washed Sample



Washed Sample



Unwashed Sample

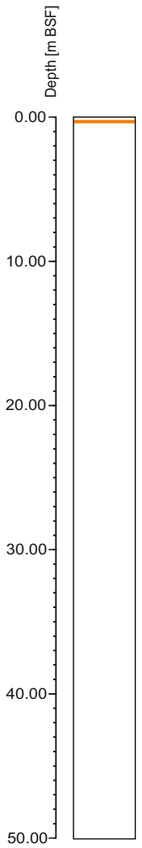


J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS3-3 Sample Name: 1BagB**	**Depth: 0.25 m bsf Soil Unit: A (Southern Bight)**	**Plate Number: A.38**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/4) subangular to well-rounded medium to high sphericity medium SAND with many fine to coarse sand-sized white shell fragments (echinoid spines, bivalves) and with few fine to coarse gravel-sized white shells (bivalves)

Colour:
Unwashed: Light olive brown (2.5Y-5/4)
Washed: Light yellowish brown (2.5Y-6/3)

Sand is poorly to moderately sorted
Sand: No reaction with HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

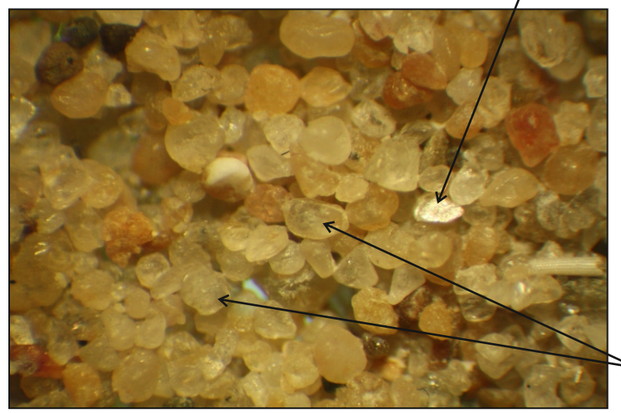
75 % - Fine to medium sand-sized subangular to well-rounded (rK = 0.4 to 0.9) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
- ~75 % frosted
- ~20 % glassy
- ~5 % light pink to reddish orange/red

10 % - Fine sand-sized to fine gravel-sized subangular to rounded (rK = 0.3 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) white BIOCLASTIC DEBRIS
7 % - Medium sand-sized to fine gravel-sized subrounded to rounded (rK = 0.5 to 0.7) low to high sphericity (rK = 0.3 to 0.9) LITHIC FRAGMENTS
4 % - Medium sand-sized subangular to rounded (rK = 0.5 to 0.8) low to high sphericity (rK = 0.3 to 0.9) white FELDSPAR
4 % - Fine to medium sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA

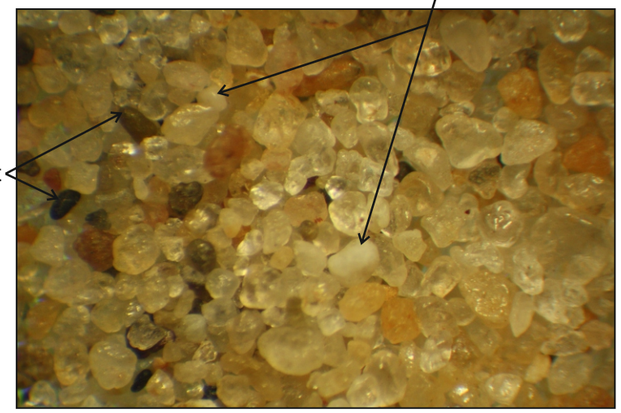
Trace: muscovite mica, glauconite, calcite

Reflected Light Microphotographs

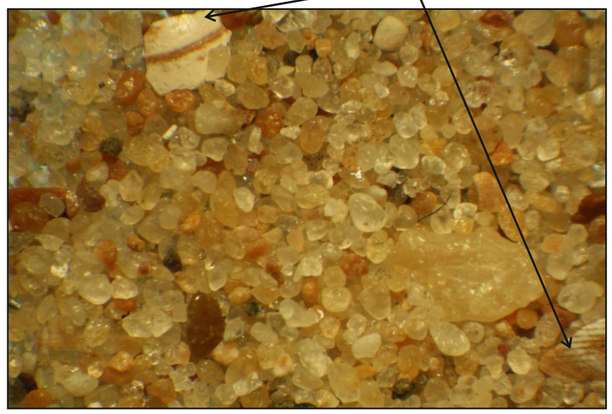
Unwashed Sample



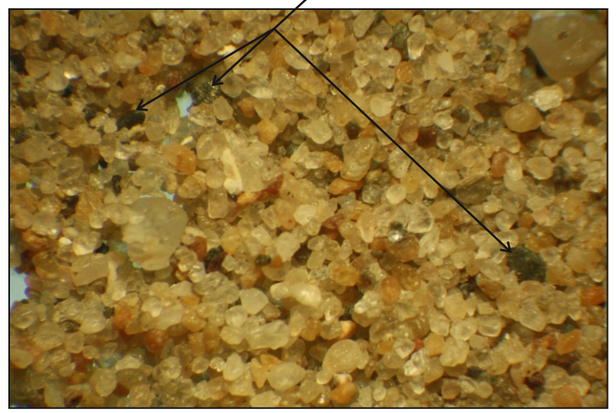
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS4-7
Sample Name: 1BagB

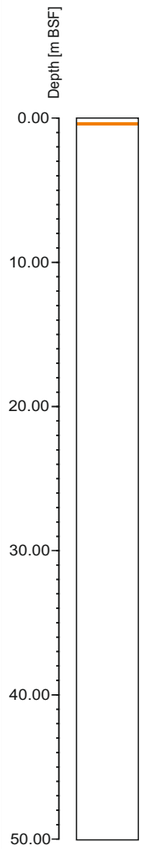
Depth: 0.35 m bsf
Soil Unit: A (Southern Bight)

Plate Number: A.39

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/3) subangular to rounded medium to high sphericity medium to coarse SAND with many coarse sand-sized to coarse gravel-sized angular to subrounded low to medium sphericity white to orange shell fragments (bivavles, echinoids, echinoid spines, coral) and with few fine to coarse gravel-sized white shells (echinoids)

Colour:
Unwashed: Light olive brown (2.5Y-5/3)
Washed: Light yellowish brown (10YR-6/4)

Sand is poorly to moderately well sorted
Sand: violent, prolonged reaction to HCL

Microscope Description
Unwashed sample shows no coating of clay/silt

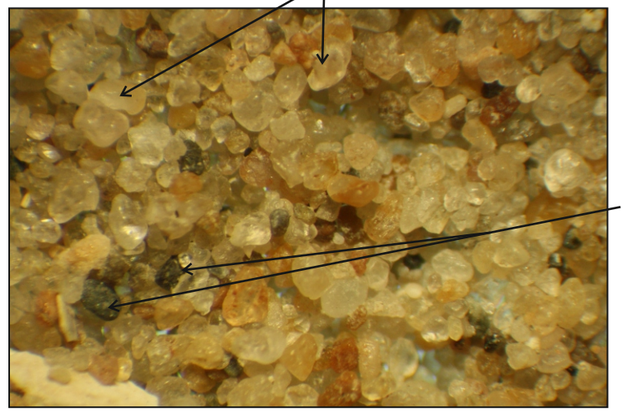
70 % - Medium to coarse sand-sized subrounded to well-rounded (rK = 0.5 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~75 % frosted
~20 % glassy
~5 % light pink to reddish orange/red

13 % - Medium sand to fine gravel-sized subrounded to rounded (rK = 0.5 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) brown to orange LITHIC FRAGMENTS
7 % - Medium sand to fine gravel-sized subrounded to well-rounded (rK = 0.5 to 0.9) low to medium sphericity (rK = 0.3 to 0.7) white BIOCLASTIC DEBRIS
5 % - Medium to coarse sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to high sphericity (rK = 0.3 to 0.9) black BIOTITE MICA
3 % - Fine to medium sand-sized subangular to rounded (rK = 0.3 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) white to orange FELDSPAR
2 % - Fine to medium sand-sized subrounded to rounded (rK = 0.5 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

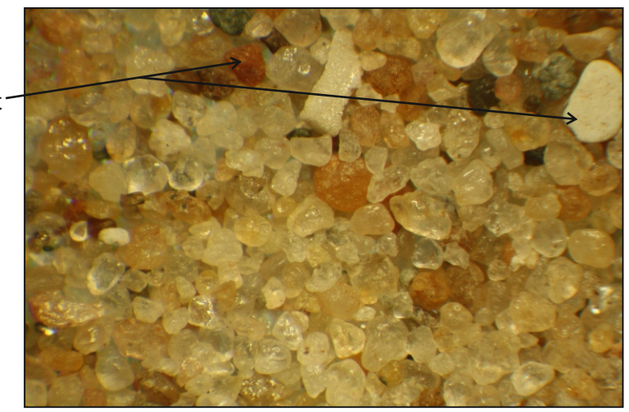
Trace: calcite

Reflected Light Microphotographs

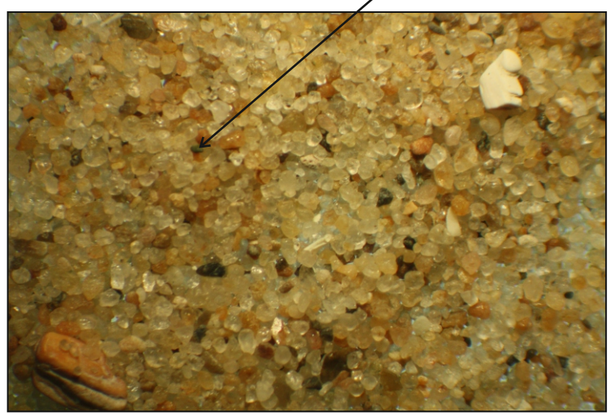
Unwashed Sample



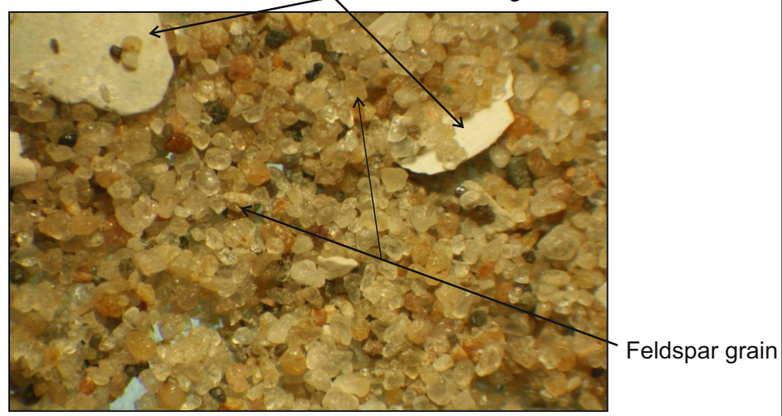
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS3-1
Sample Name: 1BagB

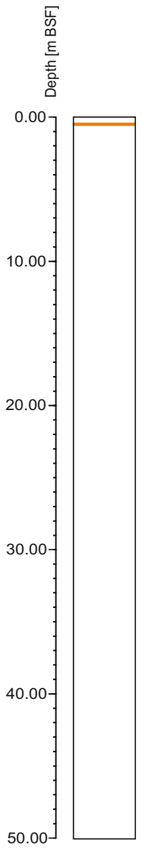
Depth: 0.35 m bsf
Soil Unit: A (Southern Bight)

Plate Number: A.40

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light yellowish brown (2.5Y-6/4) subangular to well-rounded low to high sphericity coarse SAND with many sand to coarse gravel-sized white shell fragments (bivalves, echinoid spines) and with few fine to coarse gravel-sized white shells (bivalves)

Colour:
Unwashed: Light yellowish brown (2.5Y-6/4)
Washed: Light yellowish brown (2.5Y-6/3)

Sand is poorly to moderately sorted
Sand: strong, prolonged reaction to HCL

Microscope Description
Unwashed sample shows minor coating of silt

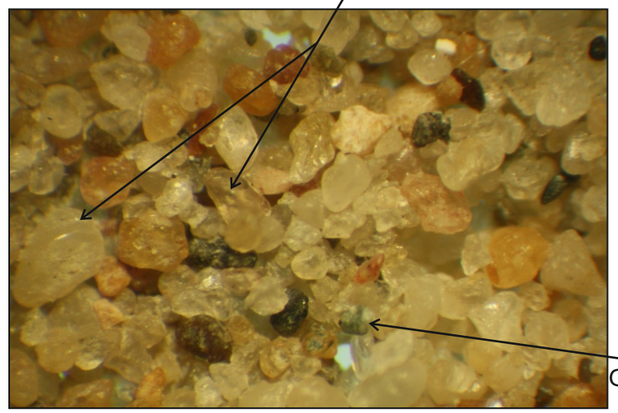
70 % - Medium to coarse sand-sized subangular to rounded (rK = 0.4 to 0.8) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~80 % frosted
~15 % light pink to reddish orange/red
~5 % glassy

10 % - Medium sand-sized to fine gravel-sized subangular to rounded (rK = 0.3 to 0.7) low to high medium sphericity (rK = 0.3 to 0.7) BIOCLASTIC DEBRIS
9 % - Fine to coarse sand-sized subangular to subrounded (rK = 0.4 to 0.7) low to high sphericity (rK = 0.3 to 0.9) white FELDSPAR
6 % - Medium to coarse sand-sized subangular to rounded (rK = 0.4 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) LITHIC FRAGMENTS
5 % - Medium to coarse sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.1 to 0.7) black BIOTITE MICA

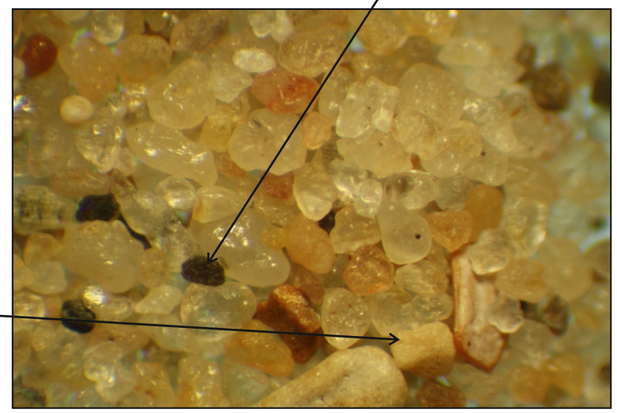
Trace: glauconite

Reflected Light Microphotographs

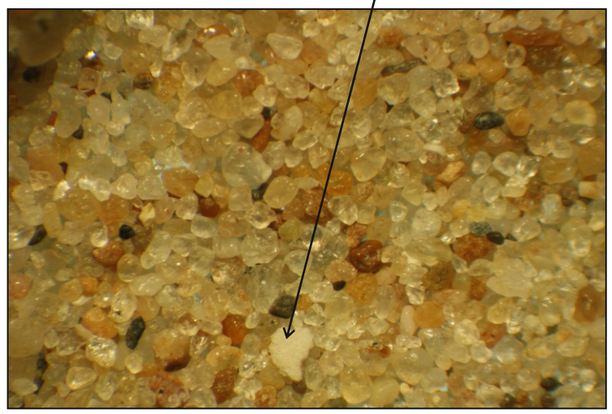
Unwashed Sample



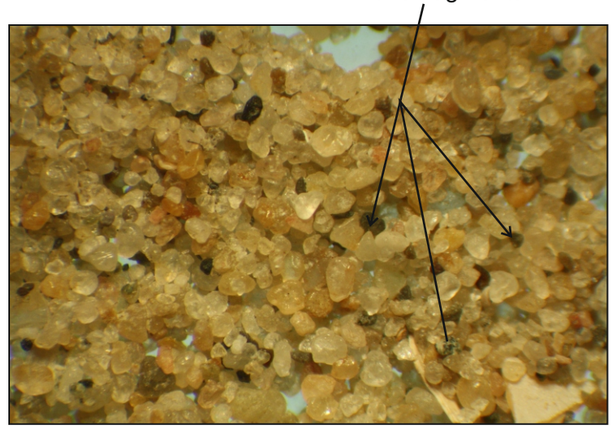
Washed Sample



Washed Sample



Unwashed Sample

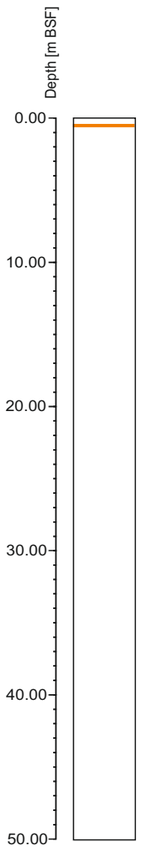


J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-SubStatB-1 Sample Name: 2BagA**	**Depth: 0.50 m bsf Soil Unit: A (Southern Bight)**	**Plate Number: A.41**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/4) subangular to rounded low to high sphericity medium to coarse SAND with many fine sand-sized to coarse coarse gravel-sized white to orange and brown angular low sphericity shell fragments (bivalves, echinoid spines, gastropods) and with coarse sand-sized to coarse gravel-sized shells (bivalves) and with trace rounded medium sphericity coarse gravel-sized lithic fragment (chalk)

Colour:
Unwashed: Light olive brown (2.5Y-5/4)
Washed: Pale brown (2.5Y-6/1)

Sand is poorly sorted
Sand: violent, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

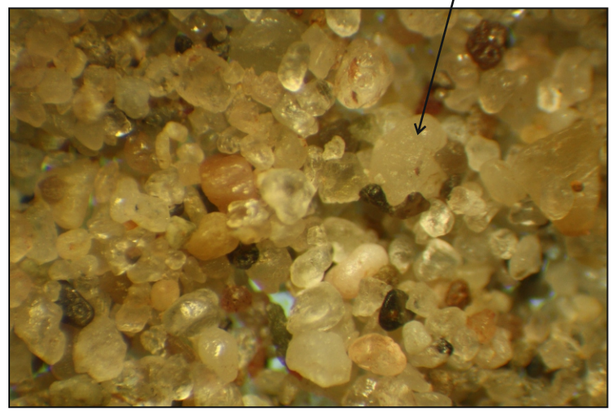
60 % - Fine to coarse sand-sized subangular to well-rounded (rK = 0.3 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~75 % frosted
~25 % glassy

15 % - Medium to coarse sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
10 % - Medium to coarse sand-sized subangular to rounded (rK = 0.3 to 0.7) low to high sphericity (rK = 0.3 to 0.9) orange, pinkish to red FELDSPAR
5 % – Medium sand-sized to fine gravel-sized angular to subrounded (rK = 0.2 to 0.5) low to medium sphericity (rK = 0.3 to 0.7) white to orange BIOCLASTIC DEBRIS
5 % Fine to coarse sand-sized subangular to rounded (rK = 0.3 to 0.7) low to high sphericity (rK = 0.3 to 0.7) black, brown to yellow LITHIC FRAGMENTS
5 % - Medium sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) clear to light greenish grey CALCITE

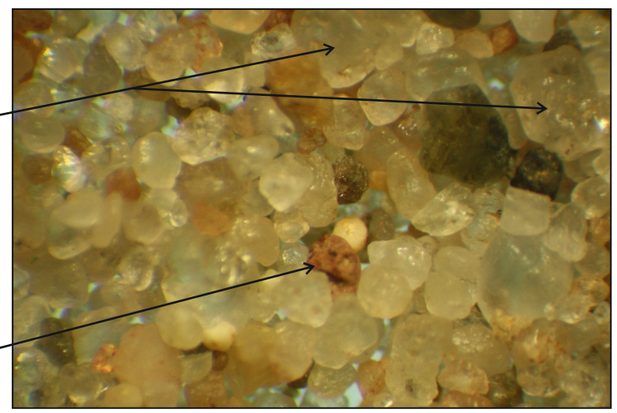
Trace: muscovite mica, pyrite

Reflected Light Microphotographs

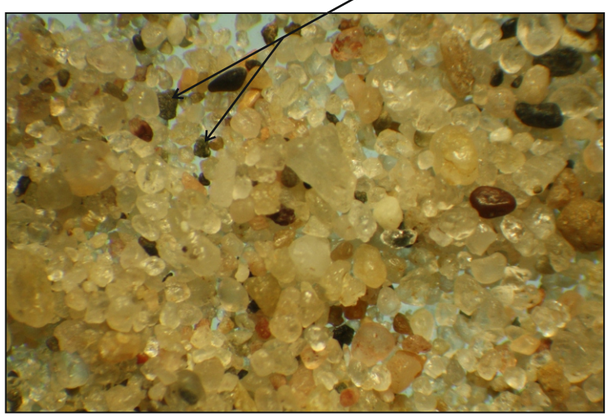
Unwashed Sample



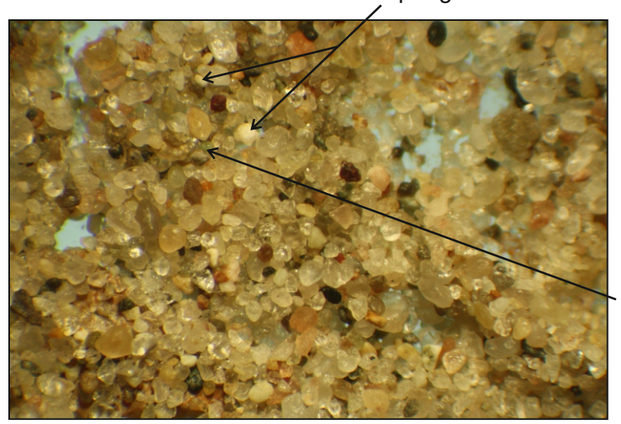
Washed Sample



Washed Sample

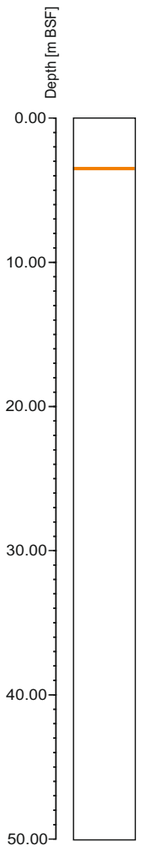


Unwashed Sample



J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS3-6 Sample Name: 2BagA**	**Depth: 0.50 m bsf Soil Unit: A (Southern Bight)**	**Plate Number: A.42**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	20/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/4) subrounded to well-rounded low to high sphericity medium SAND with few fine sand-sized to coarse gravel-sized angular to subangular low sphericity white shell fragments (bivalves)

Colour:
Unwashed: Light olive brown (2.5Y-5/3)
Washed: Light yellowish brown (2.5Y-7/2)

Sand is well sorted
Sand: strong, prolonged reaction to HCL

Microscope Description
Unwashed sample shows no coating of clay/silt

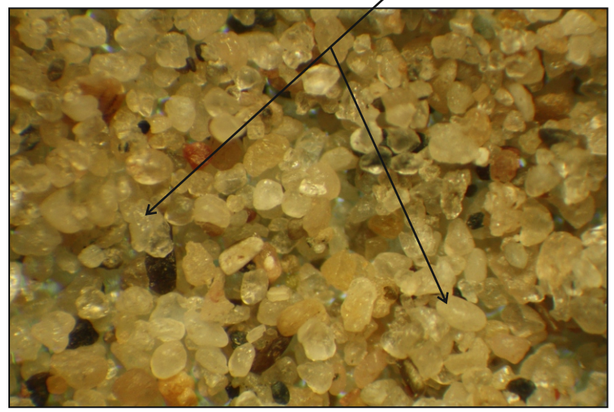
80 % - Fine to medium sand-sized subrounded to rounded (rK = 0.5 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
- ~55 % glassy
- ~42 % frosted
- ~3 % light pink to reddish orange/red

7 % - Medium sand-sized angular to subangular (rK = 0.3 to 0.5) low to medium sphericity (rK = 0.3 to 0.5) black BIOTITE MICA
5 % - Medium sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.1 to 0.7) brown/brown/orange LITHIC FRAGMENTS
3 % - Fine to medium sand-sized subangular to rounded (rK = 0.3 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) translucent white FELDSPAR
3 % - Medium to coarse sand-sized subrounded to well-rounded (rK = 0.5 to 0.9) low to medium sphericity (rK = 0.3 to 0.7) white BIOCLASTIC DEBRIS
2 % - Fine to medium sand-sized subrounded to rounded (rK = 0.5 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

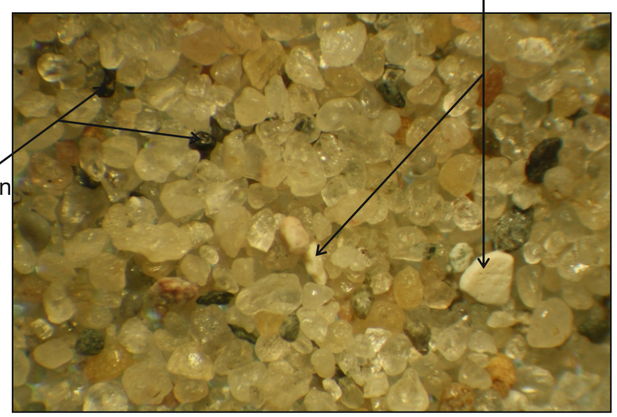
Trace: muscovite, calcite

Reflected Light Microphotographs

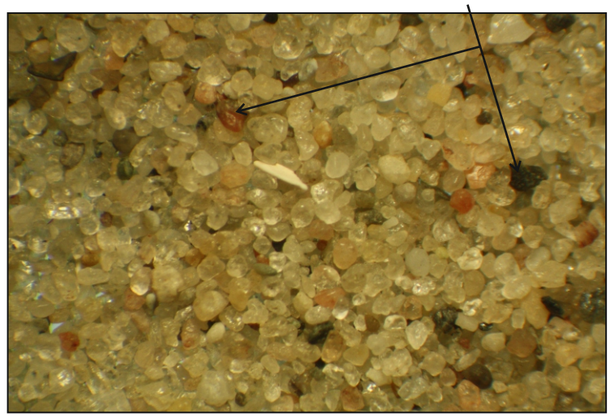
Unwashed Sample



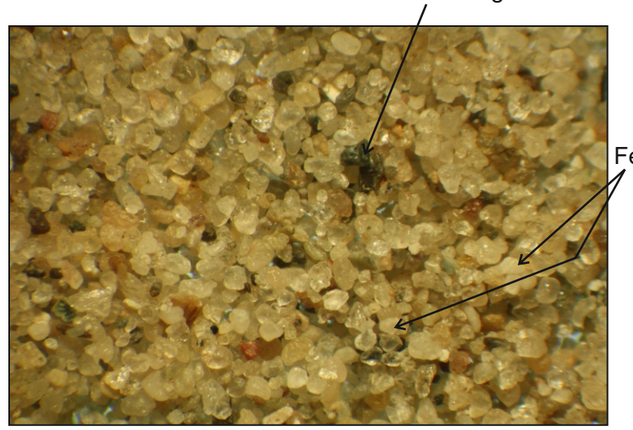
Washed Sample



Washed Sample

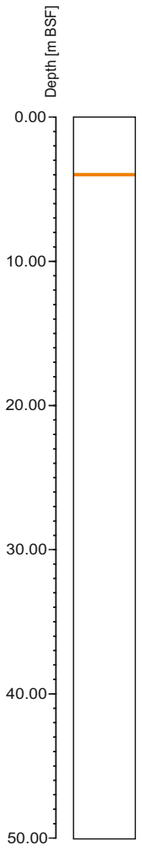


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-SubStatB-1** **Sample Name: 5BagA**	**Depth: 3.50 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.43**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	20/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Brown (10Y-5/3) subangular to rounded medium to high sphericity coarse SAND with few fine to coarse sand-sized angular to subrounded low to high sphericity black lithic fragments and with fine sand-sized to coarse gravel-sized angular low sphericity white shell fragments (bivalves)

Colour:
Unwashed: Brown (10Y-5/3)
Washed: Light grey (2.5Y-7/2)

Sand is poorly to moderately well sorted
Sand: Strong, however limited reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

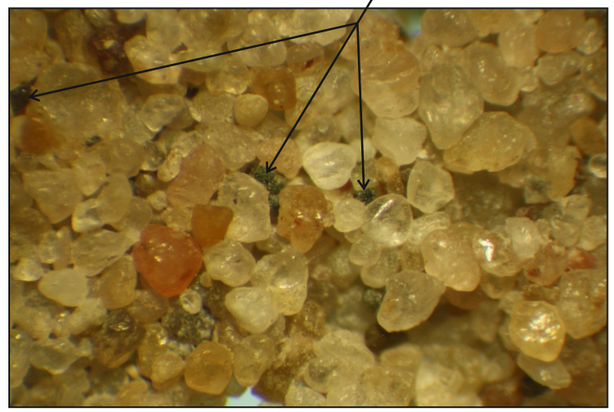
75 % - Medium sand-sized to fine gravel-sized subangular to rounded (rK = 0.3 to 0.8) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~85 % frosted
~ 10 % glassy

15 % - Fine to coarse sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) black BIOTITE MICA
5 % - Medium to coarse sand-sized subangular to subrounded (0.3 to 0.6) low to medium sphericity (0.3 to 0.7) orange to pinkish FELDSPAR
3 % - Fine to coarse sand-sized subangular to rounded (rK = 0.3 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) black LITHIC FRAGMENTS
2 % - Fine to coarse sand-sized subangular to rounded (rK = 0.3 to 0.7) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

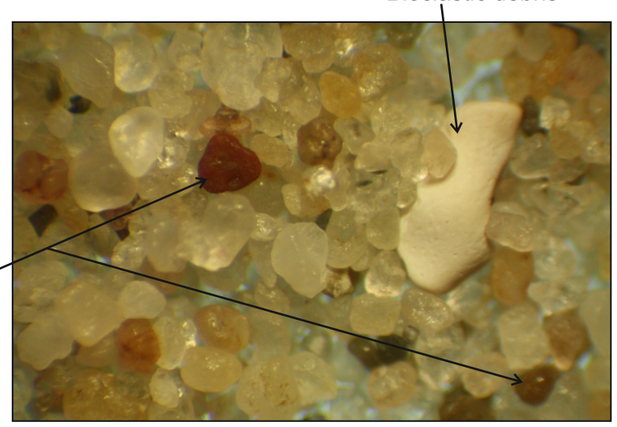
Trace: calcite

Reflected Light Microphotographs

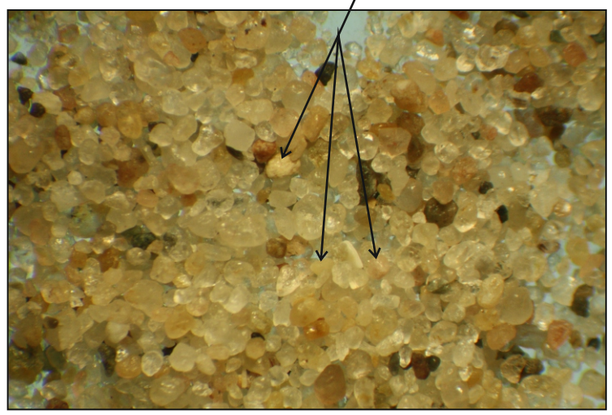
Unwashed Sample



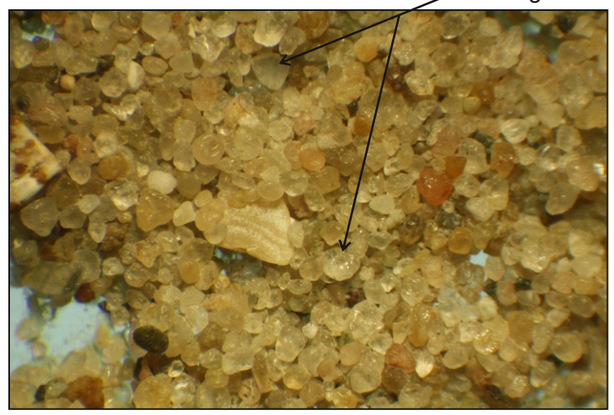
Washed Sample



Washed Sample



Unwashed Sample

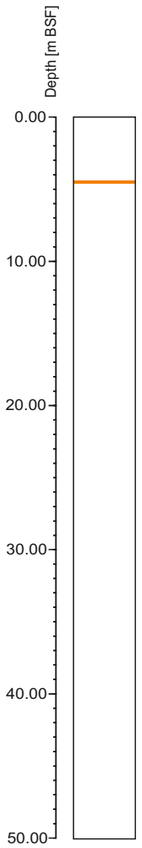


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS5-1** **Sample Name: 5BagA**	**Depth: 4.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.44**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/4) subangular to subrounded low to high sphericity medium to coarse SAND

Colour:
Unwashed: Light olive brown (2.5Y-5/4)
Washed: Light grey (2.5Y-7/2)

Sand is moderately well sorted
Sand: Slow, prolonged reaction with HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

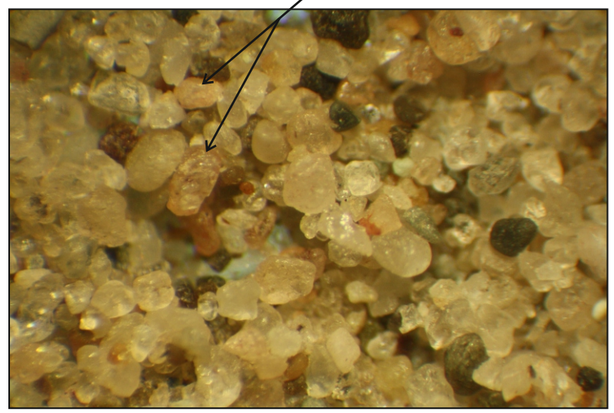
85 % - Medium to coarse sand-sized subangular to well-rounded (rK = 0.3 to 0.9) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~75 % frosted
~25 % glassy

8 % - Fine to coarse sand-sized angular to rounded (rK = 0.2 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) white FELDSPAR
4 % - Medium to coarse sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) black BIOTITE MICA
3 % - Fine to coarse sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.7) black LITHIC FRAGMENTS

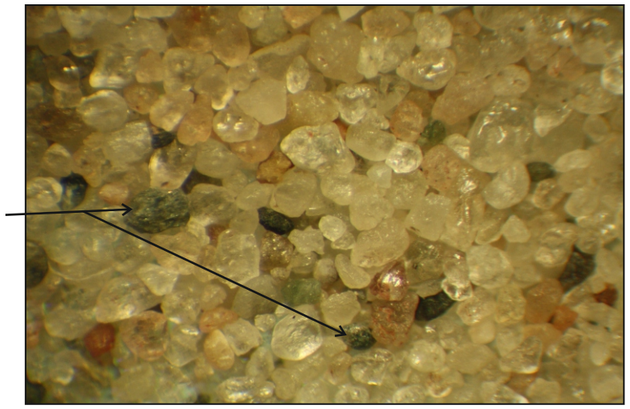
Trace: muscovite mica, glauconite

Reflected Light Microphotographs

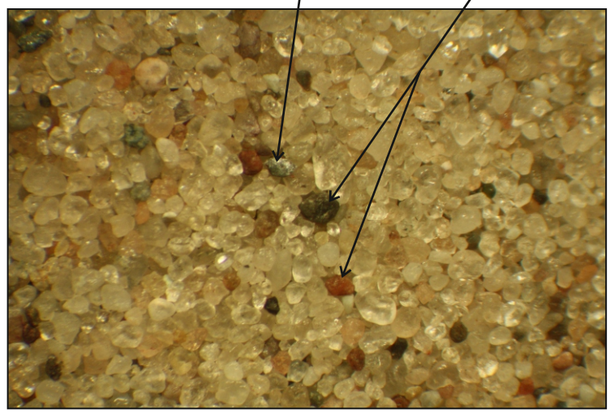
Unwashed Sample



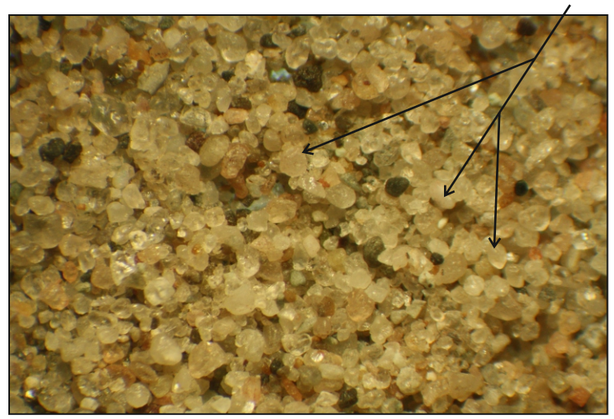
Washed Sample



Washed Sample



Unwashed Sample

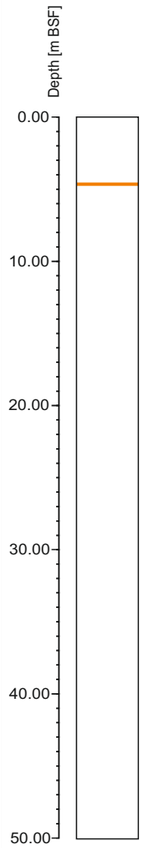


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-5** **Sample Name: 9BagA**	**Depth: 4.50 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.45**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greyish brown (2.5Y-4/2) subangular to rounded medium to high sphericity medium to coarse SAND with trace coarse gravel-sized rounded low to medium sphericity pockets of greenish grey clay and with trace coarse gravel-sized angular low sphericity white shell fragments (bivalves)

Colour:
Unwashed: Dark greyish brown (2.5Y-4/2)
Washed: Light yellowish brown (2.5Y-6/3)

Sand is moderately to well sorted
Sand: Limited, slow and prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

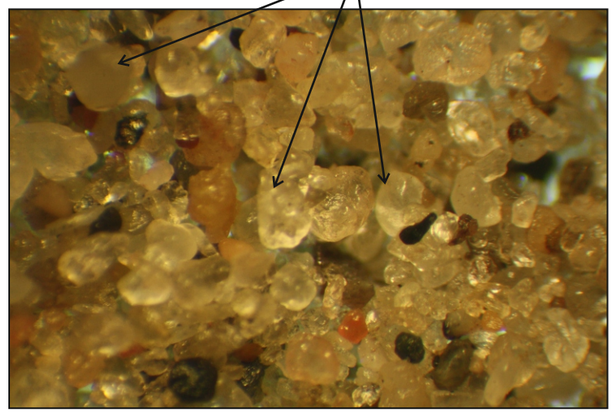
85 % - Medium to coarse sand-sized subrounded to well-rounded (rK = 0.5 to 0.9) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~70 % glassy
~30 % frosted

10 % - Fine to coarse sand-sized angular to subrounded (rK = 0.1 to 0.6) low to medium sphericity (rK = 0.3 to 0.5) black BIOTITE MICA
3 % - Fine to medium sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) white FELDSPAR
2 % - Fine to coarse sand-sized subrounded to well-rounded (rK = 0.5 to 0.9) low to high sphericity (rK = 0.3 to 0.9) LITHIC FRAGMENTS

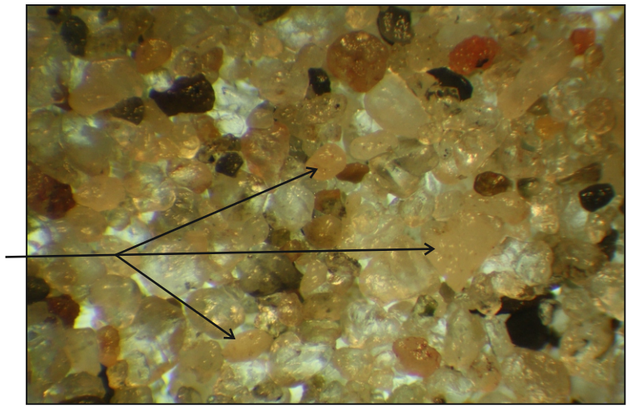
Trace: muscovite mica, bioclastic debris, calcite, glauconite

Reflected Light Microphotographs

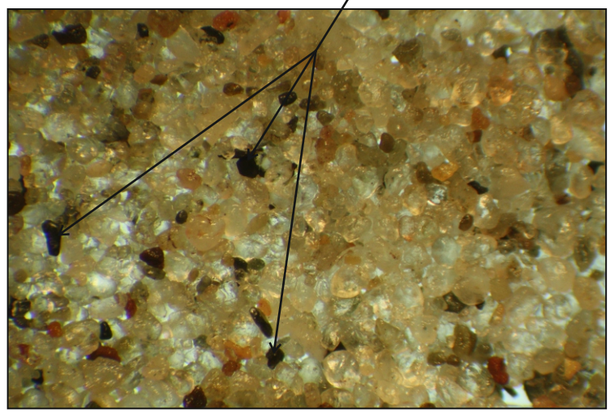
Unwashed Sample



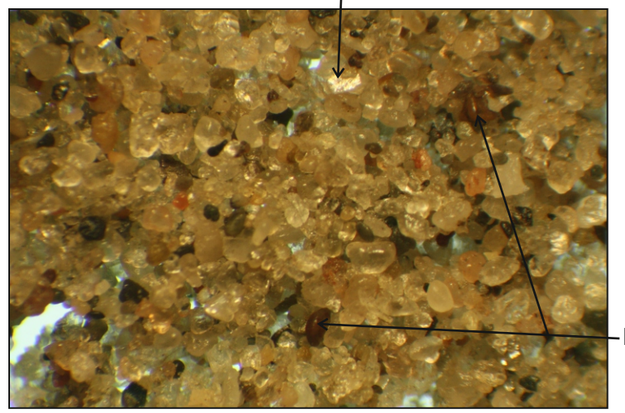
Washed Sample



Washed Sample

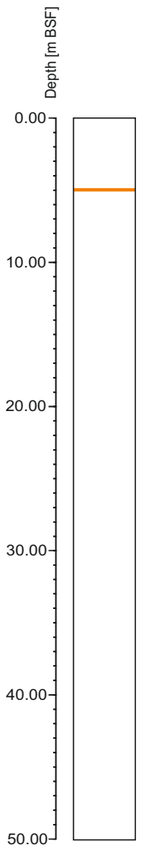


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-7** **Sample Name: 6BagB**	**Depth: 4.75 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.46**	Made:	LRM	08/01/2016	FUGRO
				Checked:	CB	12/01/2016	
				Approved:	CAS	20/01/2016	

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/3) subrounded to well-rounded medium to high sphericity coarse SAND with trace fine sand-sized coarse gravel-sized angular low sphericity white to light greenish grey shell fragments (bivalves)

Colour:
Unwashed: Light olive brown (2.5Y-5/3)
Washed: Light grey (2.5Y-7/2)

Sand is moderately to well sorted
Sand: Strong, slow and prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

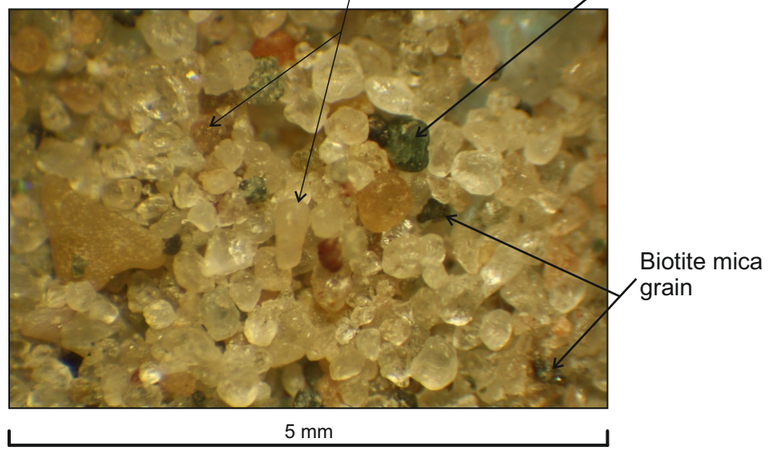
65% – Medium to coarse sand-sized subangular to well-rounded (rK = 0.3 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~75 % frosted
~25 % glassy

15 % - Medium to coarse sand-sized subangular to subrounded (rK = 0.4 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) white to light greenish grey and pinkish FELDSPAR
7 %- Fine to coarse sand-sized subangular to subrounded (rK = 0.4 to 0.6) low to high sphericity (rK = 0.3 to 0.9) black BIOTITE MICA
5 % - Medium to coarse sand-sized subangular to rounded (rK = 0.4 to 0.8) low to high sphericity (rK = 0.3 to 0.9) translucent to white CALCITE
5 % - Fine to coarse sand-sized angular to well-rounded (rK = 0.2 to 0.8) low to high sphericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
3 % - Medium sand-sized to fine gravel-sized angular to rounded (rK = 0.2 to 0.7) low sphericity (rK = 0.3 to 0.5) BIOCLASTIC DEBRIS

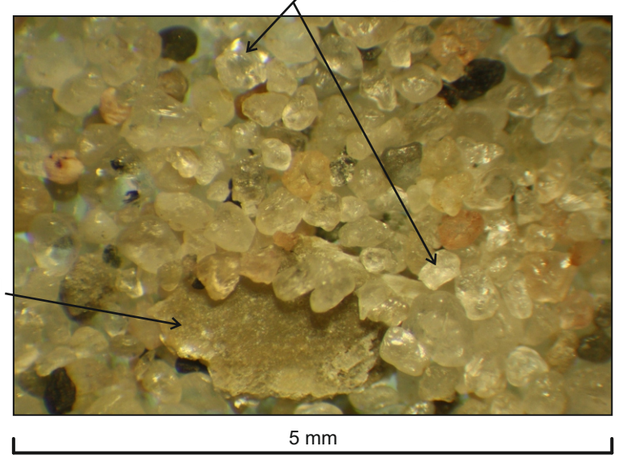
Trace: muscovite mica, glauconite, pyrite

Reflected Light Microphotographs

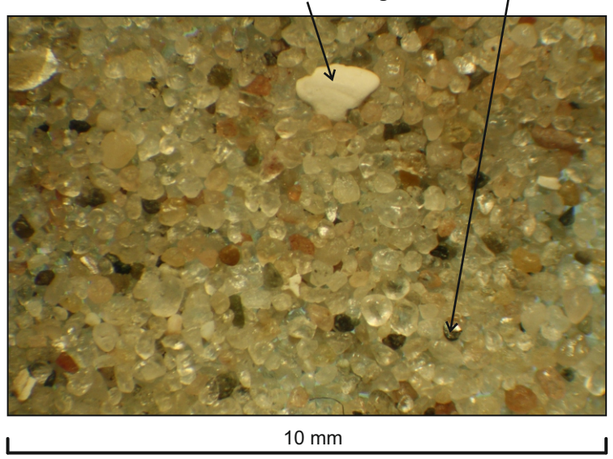
Unwashed Sample



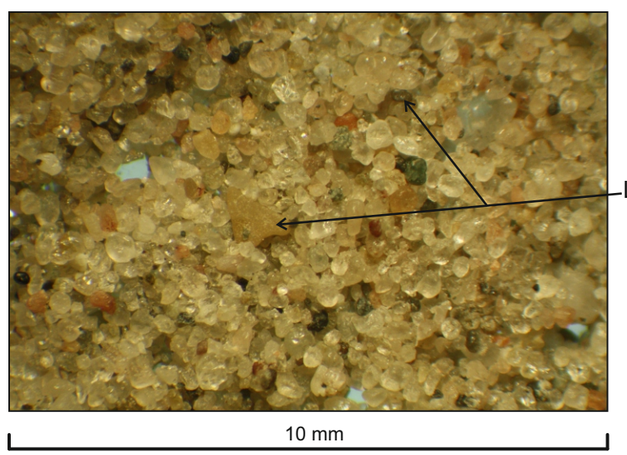
Washed Sample



Washed Sample

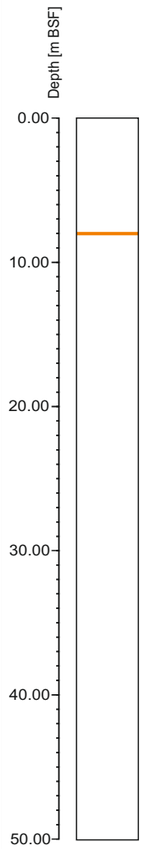


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-1** **Sample Name: 7BagA**	**Depth: 5.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.47**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	20/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Grey (2.5Y-6/1) subangular to subrounded low to high sphericity fine to medium SAND with few fine sand-sized to fine gravel-sized angular to subangular low to medium sphericity white (N-8/1) shell fragments

Colour:
Unwashed: Grey (2.5Y-6/1)
Washed: Light grey (N-7/1)

Sand is well sorted
Sand: limited, slow prolonged reaction to HCL

Microscope Description
Unwashed sample shows very minor coating of clay

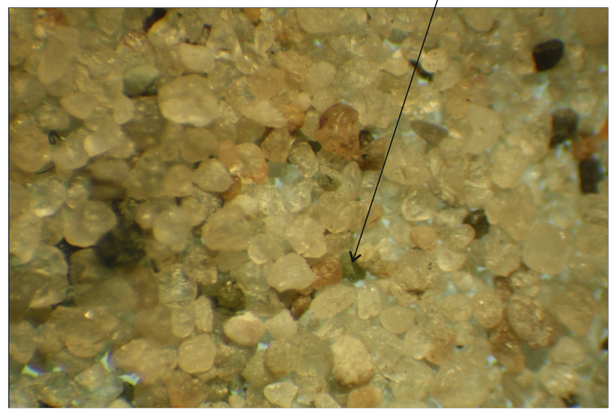
80 % - Fine to coarse sand-sized subangular to rounded (*r*K = 0.3 to 0.8) medium to high sphericity (*r*K = 0.5 to 0.9) QUARTZ
- ~ 85 % clear, frosted
- ~ 13 % clear, glassy
- ~ 2 % light pink to reddish orange/red

10 % - Fine to medium sand-sized angular to subrounded (*r*K = 0.2 to 0.6) medium to high sphericity (*r*K = 0.5 to 0.9) black BIOTITE
5 % - Fine sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to high sphericity (*r*K = 0.3 to 0.7) MUSCOVITE
3 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE
2 % - Fine sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to medium sphericity (*r*K = 0.3 to 0.7) white to orange/pinkish FELDSPAR

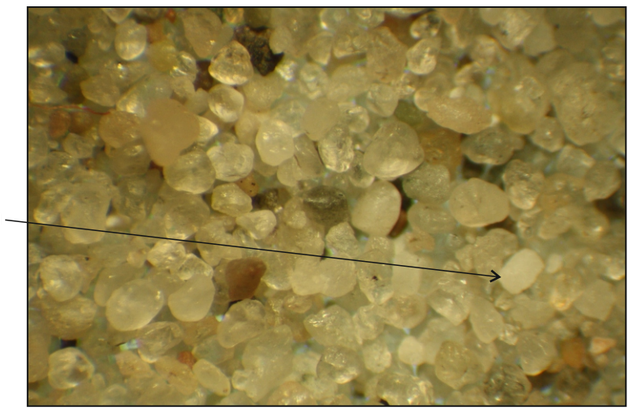
Trace: calcite, bioclastic fragments, lithic fragments

Reflected Light Microphotographs

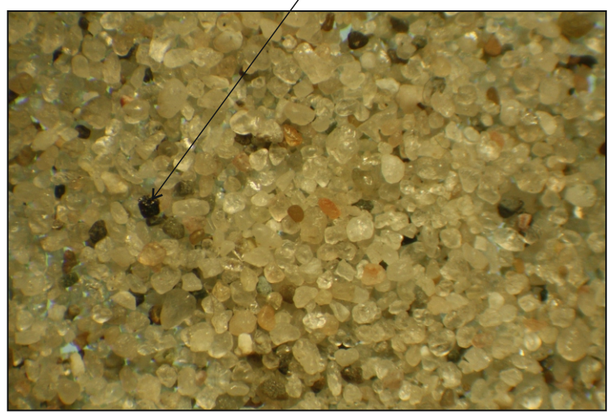
Unwashed Sample



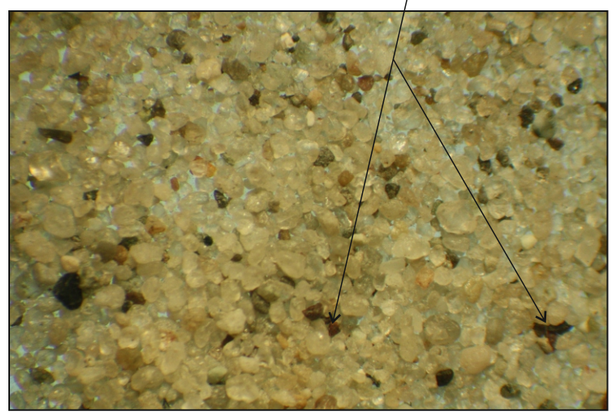
Washed Sample



Washed Sample



Unwashed Sample

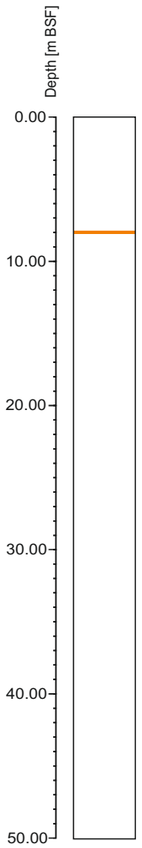


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-5** **Sample Name: 15BagA**	**Depth: 8.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.48**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Greyish brown (2.5Y-5/2) subangular to subrounded low to medium sphericity fine to medium SAND with trace medium sand-sized angular low sphericity white shell fragments

Colour:
Unwashed: Light olive brown (2.5Y-5/3)
Washed: Light grey (2.5Y-7/2)

Sand is moderately well sorted
Sand: Strong, prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

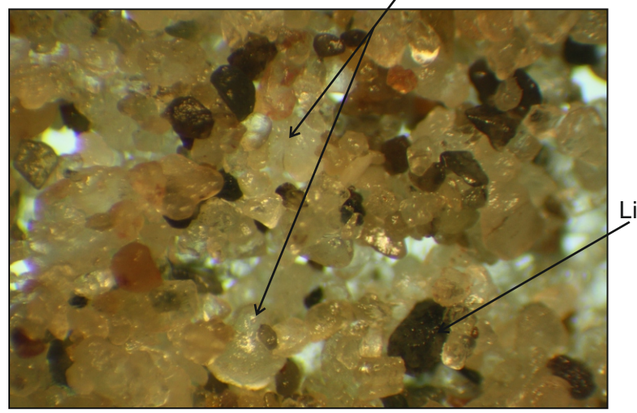
80 % - Fine to medium sand-sized subangular to rounded (rK = 0.3 to 0.7) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~60 % frosted
~40 % glassy

8 % - Fine to medium sand-sized subangular to subrounded (rK = 0.4 to 0.6) low sphericity (rK = 0.3 to 0.5) white FELDSPAR
5 % - Fine to medium sand-sized angular to rounded (rK = 0.2 to 0.7) low to high sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
5 % - Fine to medium sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to high sphericity (rK = 0.3 to 0.7) brown to black LITHIC FRAGMENTS
2 % - Fine sand-sized subrounded to rounded (rK = 0.5 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

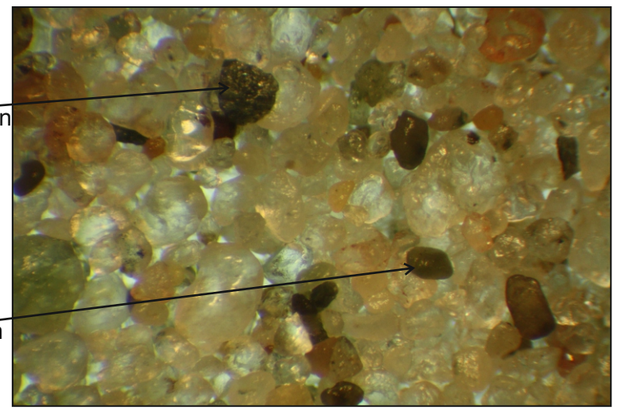
Trace: calcite, bioclastic debris, muscovite mica

Reflected Light Microphotographs

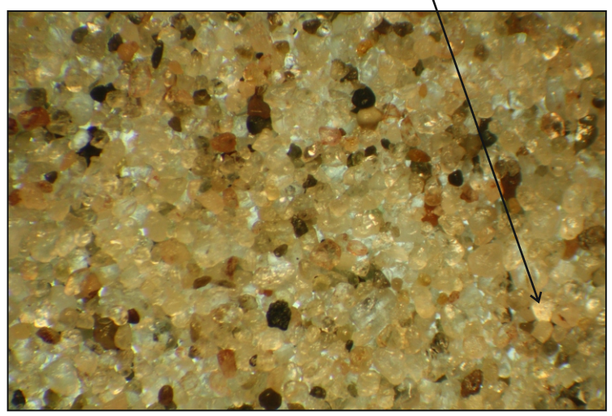
Unwashed Sample



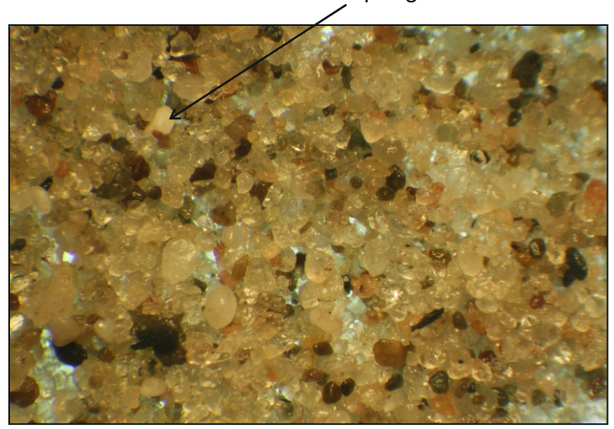
Washed Sample



Washed Sample



Unwashed Sample

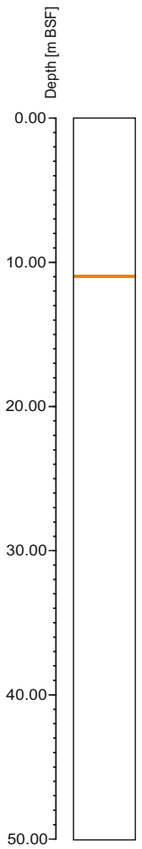


J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-SubStatB-1 Sample Name: 11BagA**	**Depth]: 8.00 m bsf Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.49**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	20/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light grey (5Y-7/1) subangular to well-rounded low to high sphericity fine to medium SAND with coarse sand-sized to fine gravel-sized angular low sphericity white shell fragments (bivalves)

Colour:
Unwashed: Light grey (5Y-7/1)
Washed: Light grey (2.5Y-7/1)

Sand is well sorted
Sand: Slow and prolonged reaction to HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

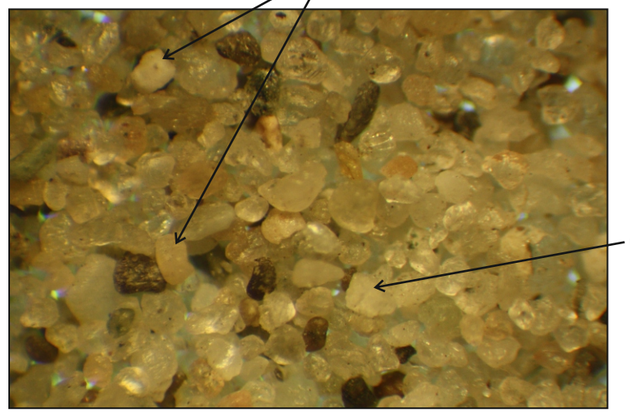
80 % - Fine to medium subangular to well-rounded (rK = 0.3 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~90 % frosted
~10 % glassy

8 % - Fine to coarse sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
5 % - Fine to coarse sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to medium sphericity (rK = 0.3 to 0.5) white FELDSPAR
5 % - Medium to coarse sand-sized subrounded to rounded (rK = 0.5 to 0.8) low to medium sphericity (rK = 0.3 to 0.7) white BIOCLASTIC DEBRIS
2 % - Fine to medium sand-sized subangular to rounded (rK = 0.3 to 0.7) medium to high sphericity (rK = 0.5 to 0.9) green CALCITE

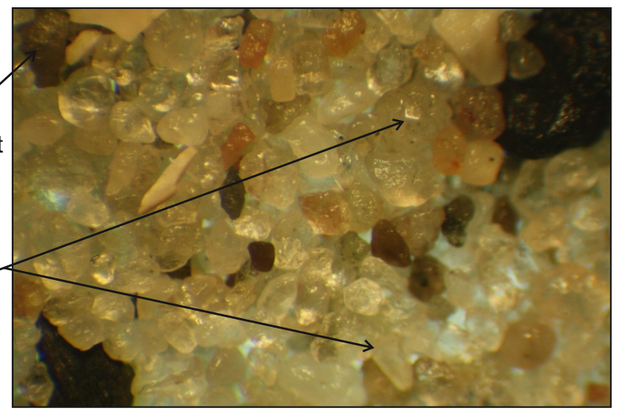
Trace: glauconite, lithic fragments

Reflected Light Microphotographs

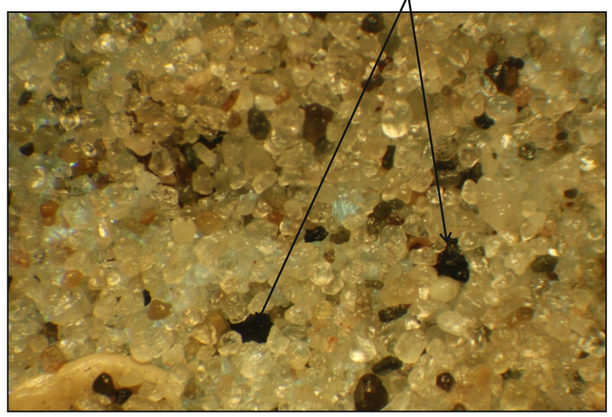
Unwashed Sample



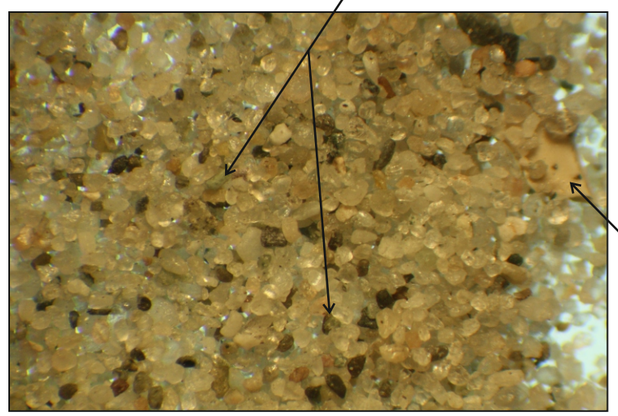
Washed Sample



Washed Sample

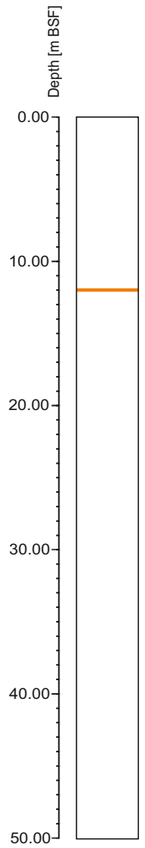


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-6** **Sample Name: 16BagA**	**Depth: 11.00 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.50**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	20/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Light olive brown (2.5Y-5/3) subangular to well rounded medium to high sphericity medium to coarse SAND with medium sand-sized to coarse gravel-sized white (N-8/1) shell fragments and with few medium to coarse subrounded medium to high sphericity black (N-2.5/1) lithic fragments

Colour:
Unwashed: Light olive brown (2.5Y-5/3)
Washed: Light grey (2.5Y-7/1)

Sand is poorly sorted
Sand: limited, slow reaction to HCL

Microscope Description
Unwashed sample shows no coating of clay/silt

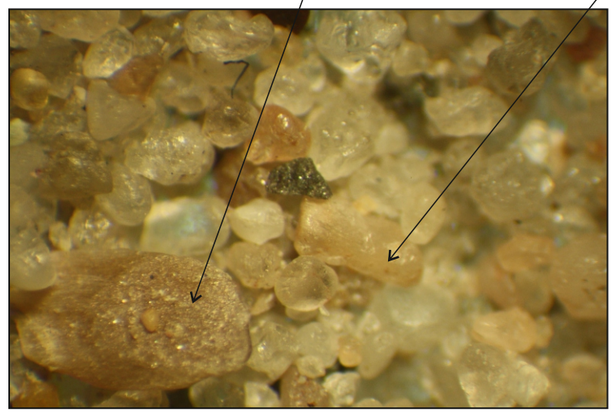
90 % - Medium to coarse sand-sized subrounded to rounded (*r*K = 0.5 to 0.7) medium to high sphericity (*r*K = 0.5 to 0.9) QUARTZ
- ~ 85 % clear, frosted
- ~ 13 % clear, glassy
- ~ 2 % light pink to reddish orange/red

5 % - Medium to coarse sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to medium sphericity (*r*K = 0.3 to 0.7) pink to orange FELDSPAR
3 % - Medium to coarse sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.5 to 0.7) black BIOTITE
2 % - Fine to medium sand-sized subangular to rounded (*r*K = 0.3 to 0.7) medium to high sphericity (*r*K = 0.5 to 0.9) green GLAUCONITE

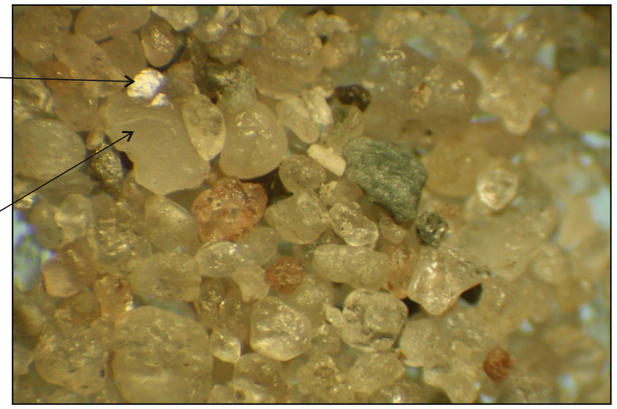
Trace: calcite, lithic fragments, bioclastic fragments

Reflected Light Microphotographs

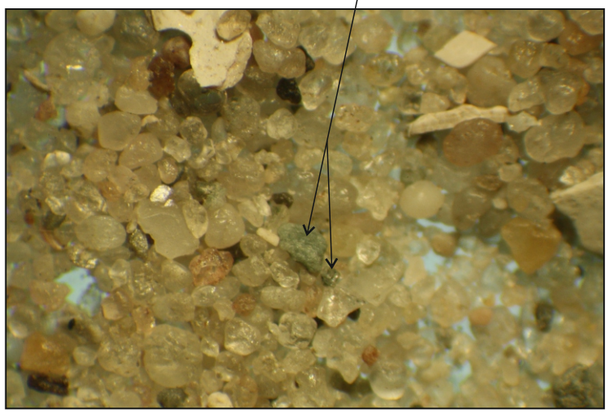
Unwashed Sample



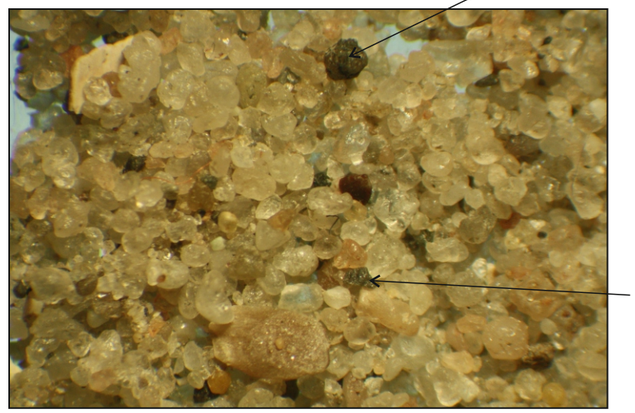
Washed Sample



Washed Sample

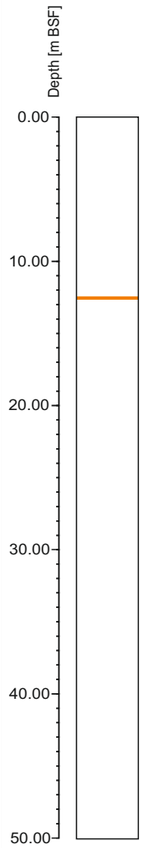


Unwashed Sample



J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS3-1 Sample Name: 18BagA**	**Depth: 12.00 m bsf Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.51**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	20/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Greyish brown (2.5Y-5/2) subangular to rounded medium to high sphericity coarse SAND with fine to coarse sand-sized angular to subrounded low to high sphericity white to orange shell fragments (bivavles, echinoid spines)

Colour:
Unwashed: Greyish brown (2.5Y-5/2)
Washed: Pale brown (2.5Y-7/3)

Sand is moderately well sorted
Sand: Violent, prolonged reaction with HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

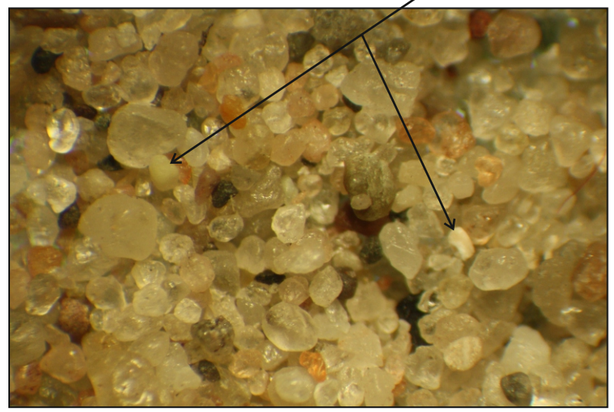
85 % - Medium to coarse sand-sized subangular to well-rounded (rK = 0.3 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) QUARTZ
~90 % frosted
~10 % glassy

5 % - Medium to coarse sand-sized subangular to subrounded (rK = 0.3 to 0.6) low to medium sphericity (rK = 0.3 to 0.5) white to orange FELDSPAR
5 % - Medium to coarse sand-sized angular to subrounded (rK = 0.2 to 0.5) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
3 % - Coarse sand-sized subangular to rounded (rK = 0.3 to 0.7) low to high spehericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS
2 % - Fine to coarse sand-sized subrounded to well-rounded (rK = 0.5 to 0.9) low to medium sphericity (rK = 0.3 to 0.9) white BIOCLASTIC DEBRIS

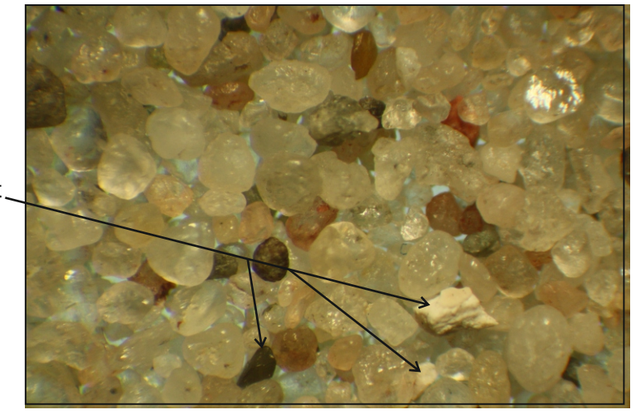
Trace: glauconite

Reflected Light Microphotographs

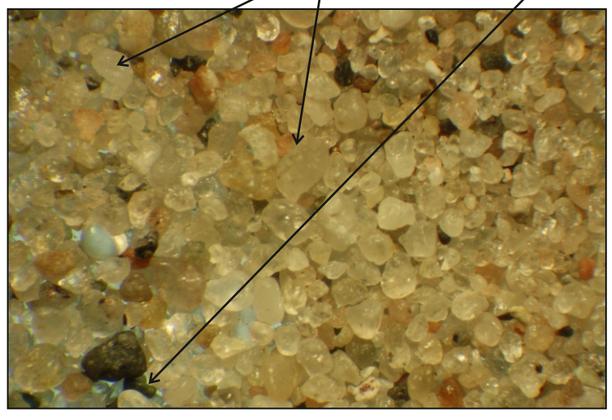
Unwashed Sample



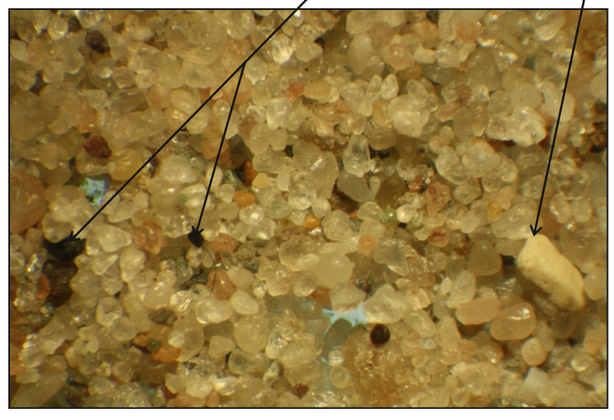
Washed Sample



Washed Sample

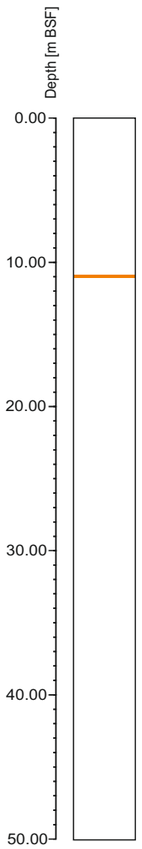


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-6** **Sample Name: 21BagA**	**Depth: 12.50 m bsf** **Soil Unit: B (Eem/Kreftenheye)**	**Plate Number: A.52**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	20/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Grey (5Y-5/1) angular to subangular low to medium sphericity slightly clayey fine SAND

Colour:
Unwashed: Grey (5Y-5/1)
Washed: Light grey (2.5Y-7/2)

Sand is well sorted
Sand: No reaction with HCl

Microscope Description
Unwashed sample shows minor coating of clay

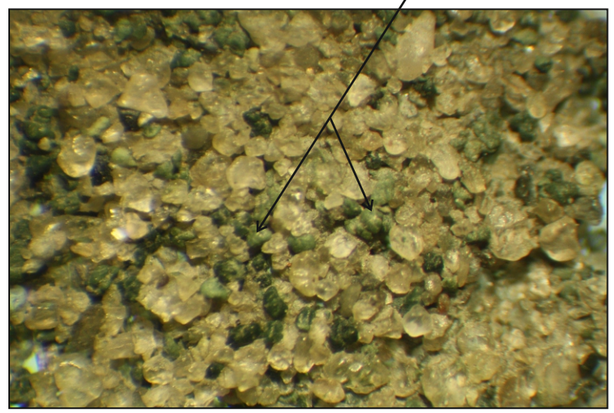
85 % - Fine sand-sized angular to rounded (rK = 0.1 to 0.7) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~95 % glassy
~5 % frosted

8 % - Fine sand-sized subrounded to well-rounded (rK = 0.5 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE
5 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.5) black BIOTITE MICA
2 % - Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to high sphericity (rK = 0.3 to 0.7) black/brown LITHIC FRAGMENTS

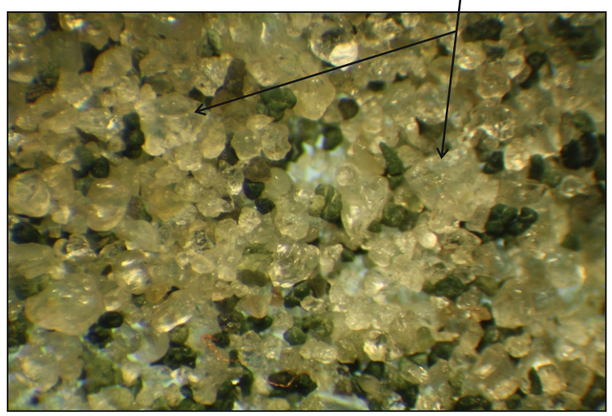
Trace: feldspar, muscovite mica

Reflected Light Microphotographs

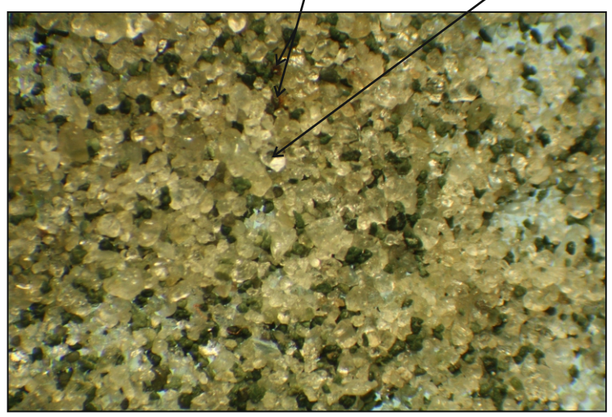
Unwashed Sample



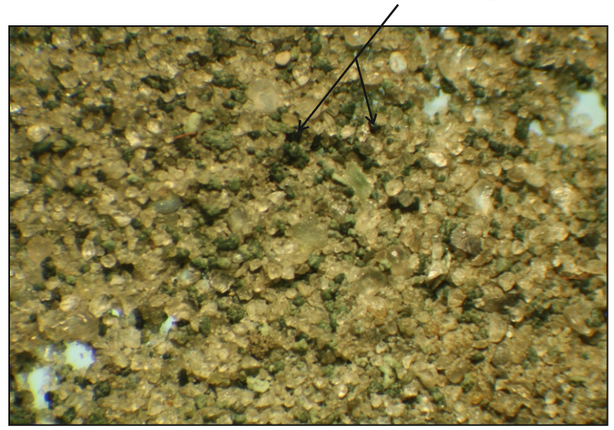
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-SubStatB-1
Sample Name: 16 Bag A

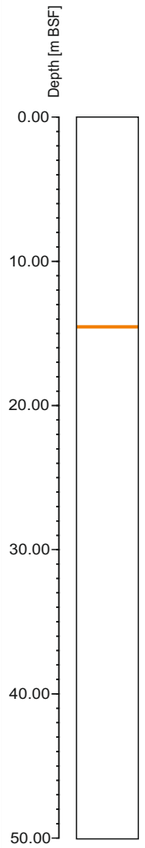
Depth: 11.00 m bsf
Soil Unit: E3 (Tongeren)

Plate Number: A.53

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10GY-4/1) subangular to rounded low to medium sphericity fine SAND with many silt to fine sand-sized angular to rounded low to high sphericity black lithic fragments and biotite mica

Colour:
Unwashed: Dark greenish grey (10GY-4/1)
Washed: Grey (2.5Y-6/1)

Sand is well sorted
Sand: No reaction with HCL

Microscope Description
Unwashed sample shows no coating of clay/silt

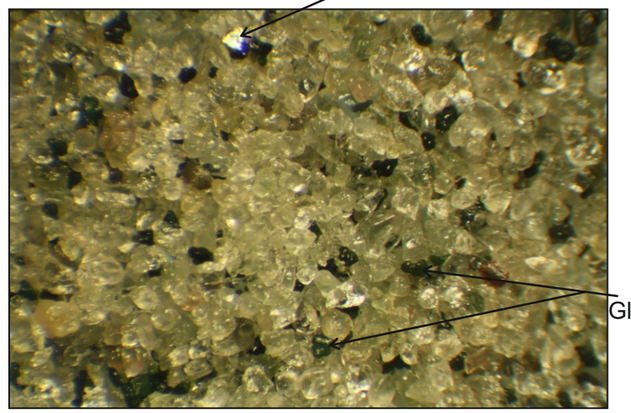
85 % - Silt to fine sand-sized subangular to rounded (rK = 0.3 to 0.7) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~95 % glassy
~5 % frosted

10 % - Silt to fine sand-sized subangular to rounded (rK = 0.3 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
5 % - Silt-sized subangular to well-rounded (rK = 0.3 to 0.9) low to medium sphericity (rK = 0.3 to 0.5) green GLAUCONITE

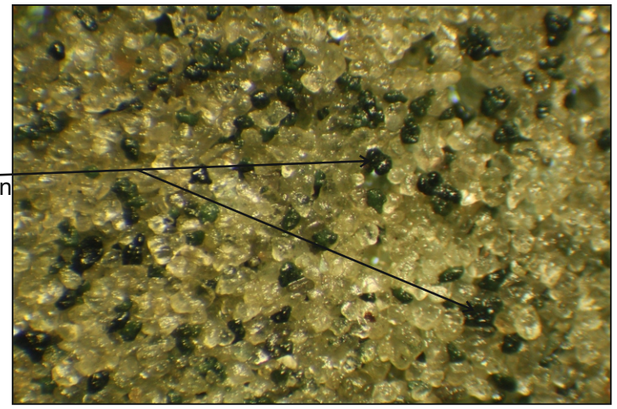
Trace: muscovite mica

Reflected Light Microphotographs

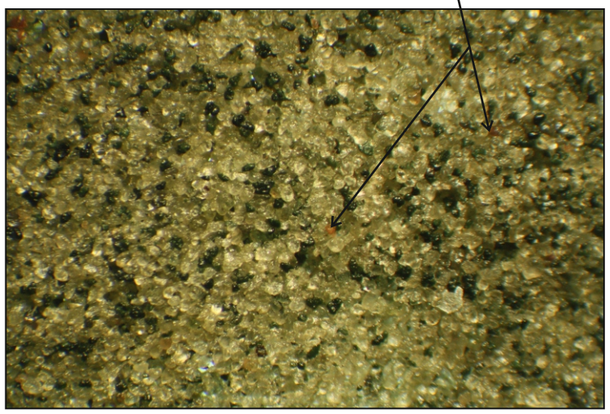
Unwashed Sample



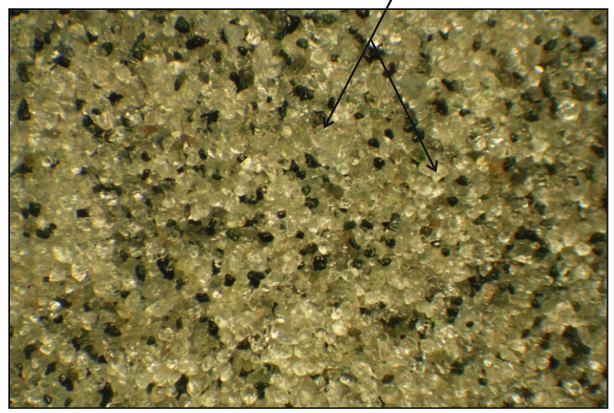
Washed Sample



Washed Sample

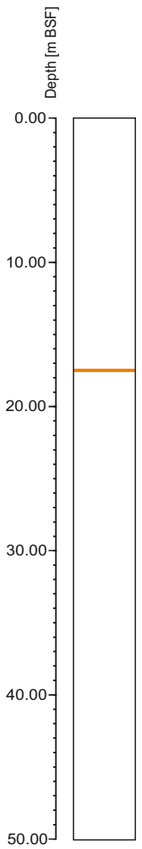


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-SubStatB-1** **Sample Name: 22 Bag A**	**Depth: 14.50 m bsf** **Soil Unit: E3 (Tongeren)**	**Plate Number: A.54**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	14/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (5GY-3/1) subangular to subrounded low to high sphericity clayey fine SAND

Colour:
Unwashed: Very dark greenish grey (5GY-3/1)
Washed: Grey (5Y-6/1)

Sand is poorly to moderately well sorted
Sand: no reaction to HCl

Microscope Description
Unwashed sample shows minor coating of clay

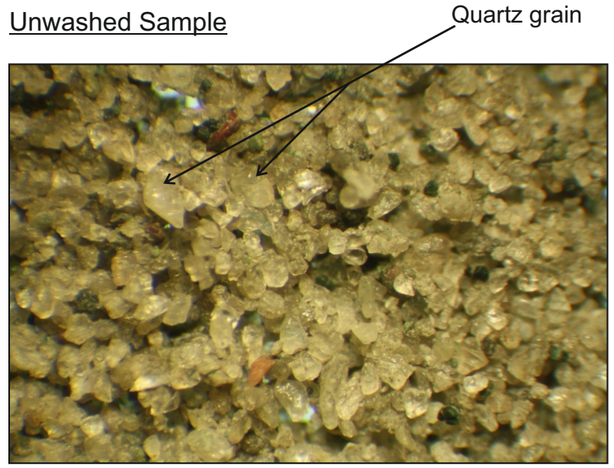
80 % - Fine sand-sized angular to subangular (rK = 0.1 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

15 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE
5 % - Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to high sphericity (rK = 0.3 to 0.9) black BIOTITE MICA

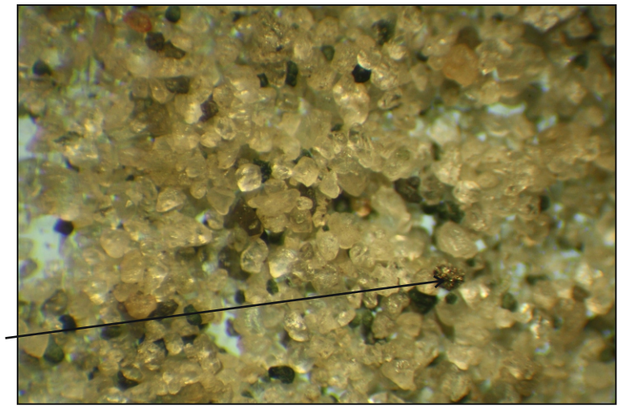
Trace: muscovite mica, lithic fragments, pyrite

Reflected Light Microphotographs

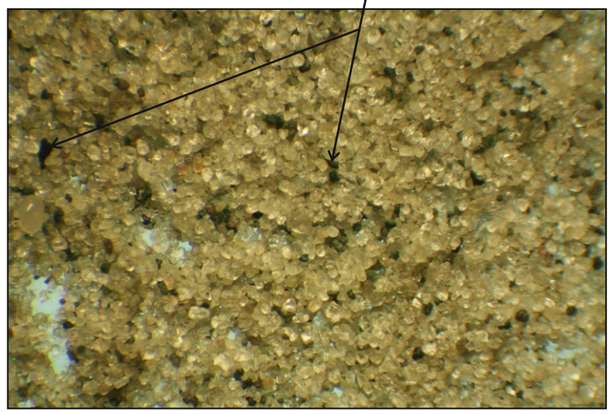
Unwashed Sample



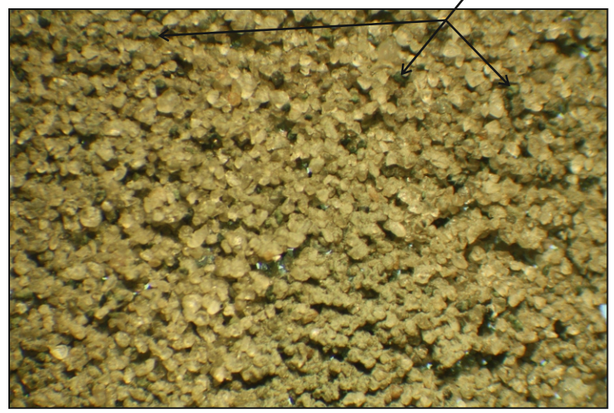
Washed Sample



Washed Sample

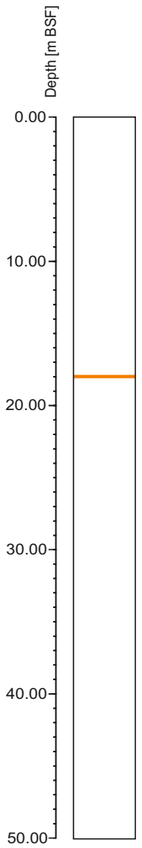


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-6** **Sample Name: 25 Bag A**	**Depth: 17.50 m bsf** **Soil Unit: E3 (Tongeren)**	**Plate Number: A.55**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	14/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (10Y-3/1) subrounded to well-rounded medium to high sphericity slightly clayey fine SAND

Colour:
Unwashed: Very dark greenish grey (10Y-3/1)
Washed: Grey (5Y-7/1)

Sand is well sorted
Sand: No reaction with HCl

Microscope Description
Unwashed sample shows minor coating of clay

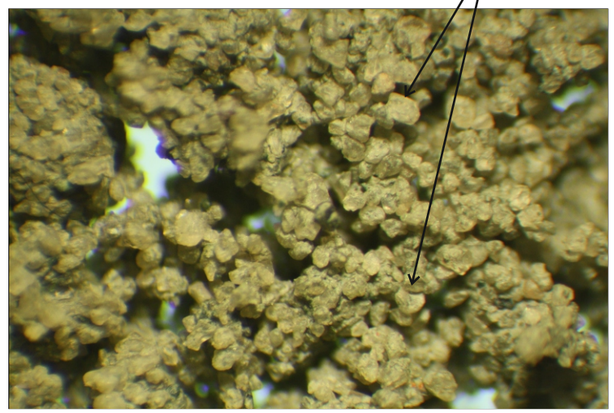
90 % - Silt-sized to fine sand-sized angular to well-rounded (rK = 0.2 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) Quartz
~90 % glassy
~10 % frosted

5 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
3 % - Silt-sized subrounded to well-rounded (rK = 0.5 to 0.9) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE
2 % - Silt-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS

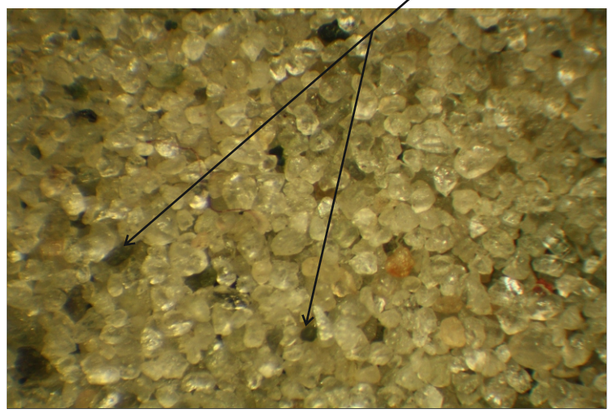
Trace: muscovite mica

Reflected Light Microphotographs

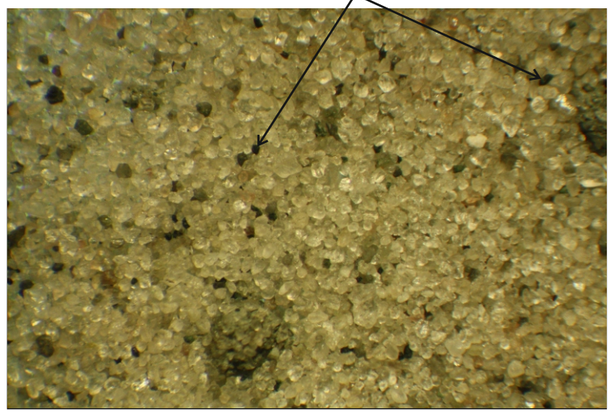
Unwashed Sample



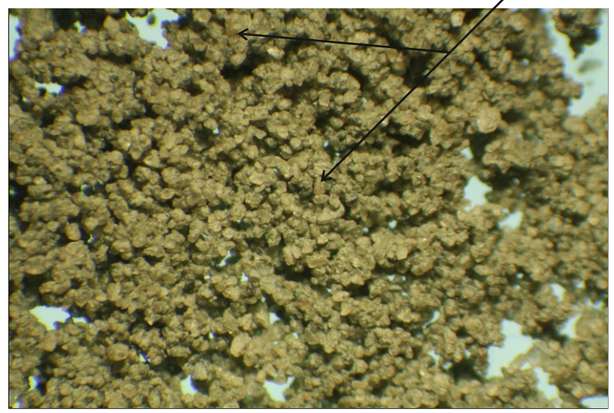
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

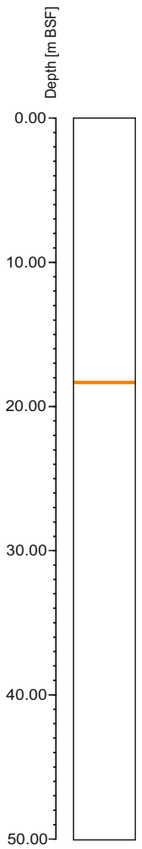
Sample Location: BH-SubStatB-1
Sample Name: 23 Bag A

Depth: 18.00 m bsf
Soil Unit: E3 (Tongeren)

Plate Number: A.56			
	Made:	LRM	08/01/2016
	Checked:	CB	12/01/2016
	Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Greenish black (10Y-2.5/1) subangular to well rounded low to high sphericity clayey fine SAND

Colour:
Unwashed: Greenish black (10Y-2.5/1)
Washed: Greenish grey (10Y-6/1)

Sand is moderately well sorted
Sand: limited, slow reaction to HCL

Microscope Description
Unwashed sample shows minor coating of clay

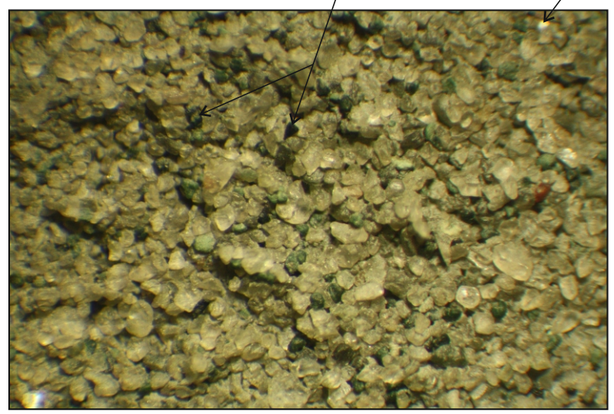
75 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to high sphericity (*r*K = 0.5 to 0.7) QUARTZ
- ~ 70 % clear, frosted
- ~ 28 % clear, glassy
- ~ 2 % beige to light orange

10 % - Fine sand-sized subrounded to well rounded (*r*K = 0.5 to 0.7) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE
8 % - Fine sand-sized angular to subangular (*r*K = 0.1 to 0.4) low to medium sphericity (*r*K = 0.3 to 0.5) black BIOTITE
5 % - Fine sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to high sphericity (*r*K = 0.5 to 0.9) brown to black LITHIC FRAGMENTS
2 % - Fine sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to high sphericity (*r*K = 0.3 to 0.9) platy high lustre MUSCOVITE

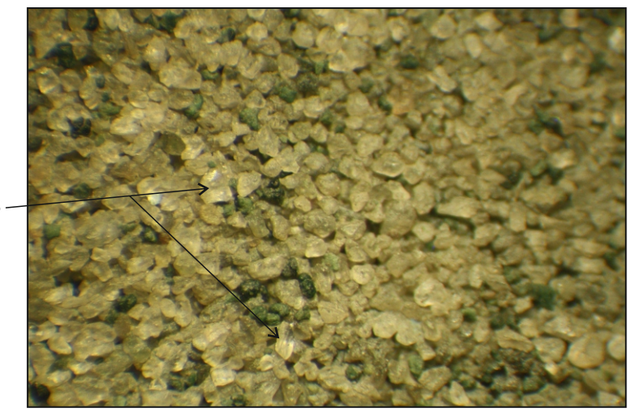
Trace: pyrite, calcite

Reflected Light Microphotographs

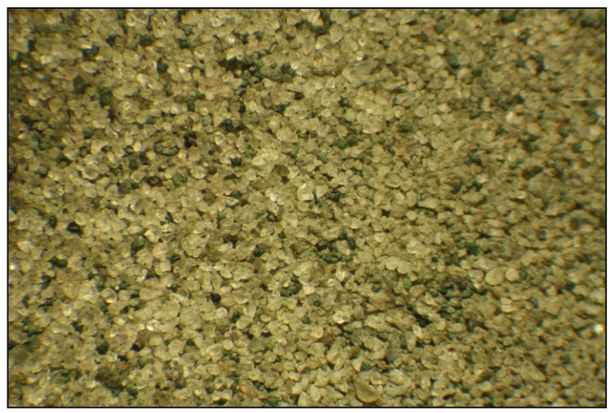
Unwashed Sample



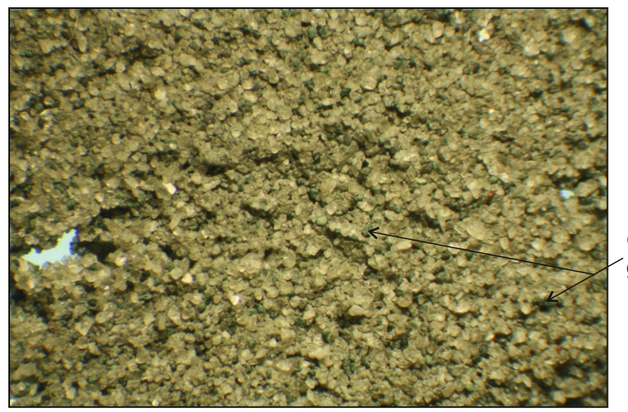
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS5-1
Sample Name: 16 Bag B

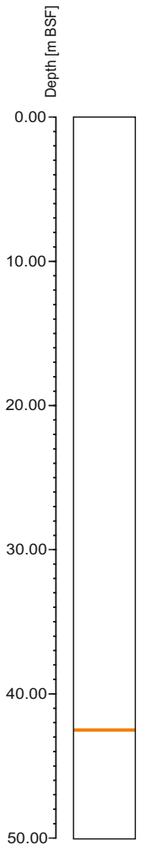
Depth: 18.40 m bsf
Soil Unit: E3 (Tongeren)

Plate Number: A.57

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark grey (5Y-4/1) subangular to subrounded low to high sphericity fine to medium SAND

Colour:
Unwashed: Dark grey (5Y-4/1)
Washed: Dark greyish brown (2.5Y-4/2)

Sand is moderately well sorted
Sand: no reaction to HCL

Microscope Description
Unwashed sample shows minor coating of clay

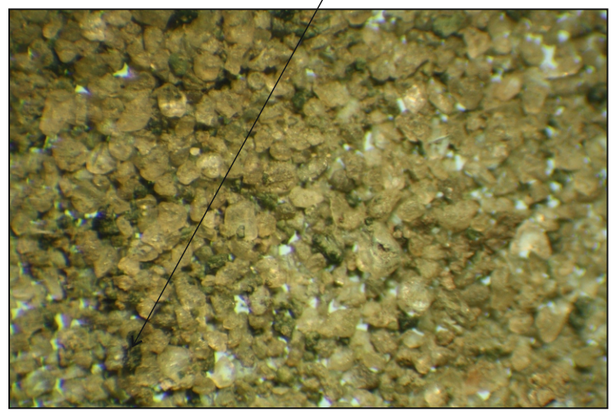
85 % - Fine to medium sand-sized angular to subrounded (*r*K = 0.2 to 0.5) low to medium sphericity (*r*K = 0.3 to 0.7) QUARTZ
~ 75 % clear, frosted
~ 20 % clear, glassy

10 % - Fine sand-sized subrounded to rounded (*r*K = 0.5 to 0.7) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE
3 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to high sphericity (*r*K = 0.3 to 0.9) black BIOTITE
2 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.3 to 0.5) low to high sphericity (*r*K = 0.3 to 0.9) brown to black LITHIC FRAGMENTS

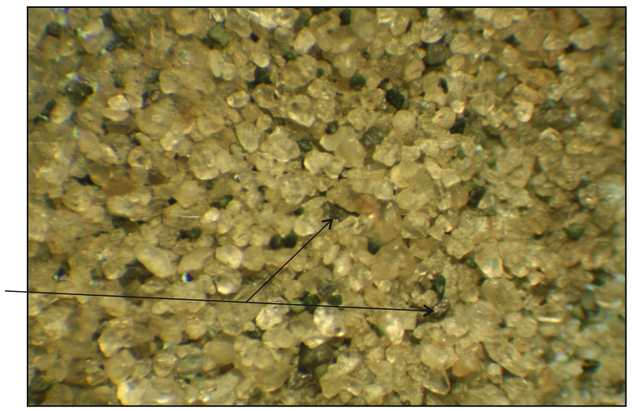
Trace: muscovite mica

Reflected Light Microphotographs

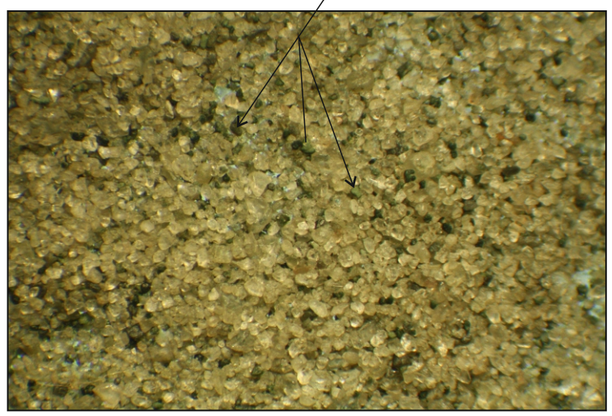
Unwashed Sample



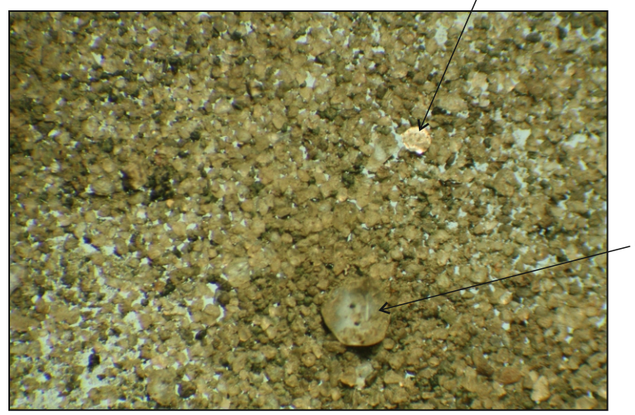
Washed Sample



Washed Sample



Unwashed Sample

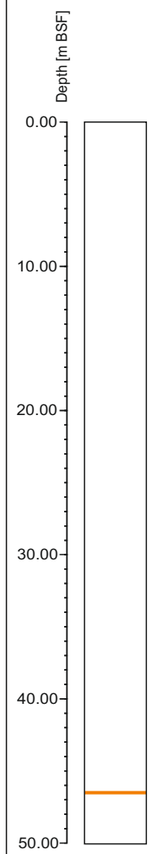


J11302 - N6083 RVO Borssele Detailed Microscope Description	**Sample Location: BH-WFS4-7 Sample Name: 28 Bag A**	**Depth: 42.50 m bsf Soil Unit: E3 (Tongeren)**	**Plate Number: A.58**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark grey (5Y-4/1) angular to subrounded low to high sphericity fine to medium SAND with many fine sand-sized subangular to rounded low to high sphericity black lithic fragments

Colour:
Unwashed: Dark grey (5Y-4/1)
Washed: Grey (2.5Y-6/1)

Sand is well sorted
Sand: No reaction with HCl

Microscope Description
Unwashed sample shows no coating of clay/silt

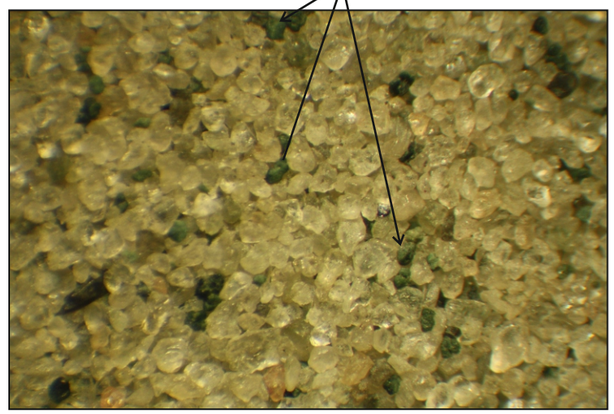
95 % - Fine to medium sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

3 % - Fine sand-sized subrounded to well-rounded (rK = 0.5 to 0.9) low to medium sphericity (rK = 0.3 to 0.7) green GLAUCONITE
2 % - Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA

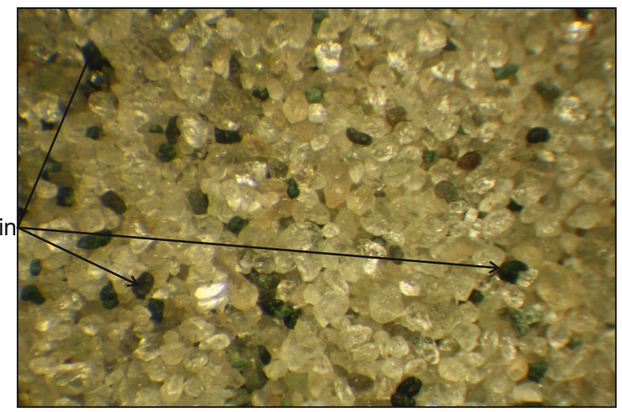
Trace: feldspar, epidote, lithic fragments

Reflected Light Microphotographs

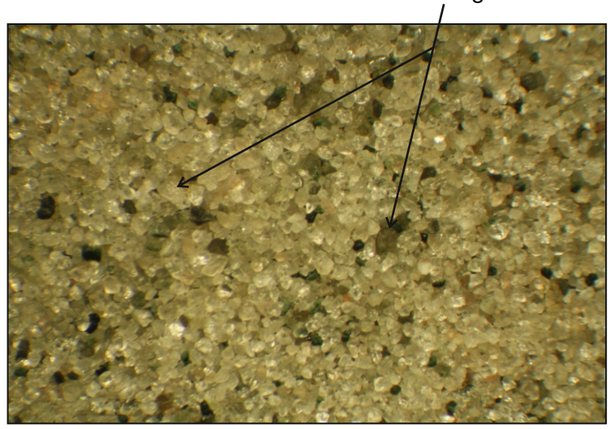
Unwashed Sample



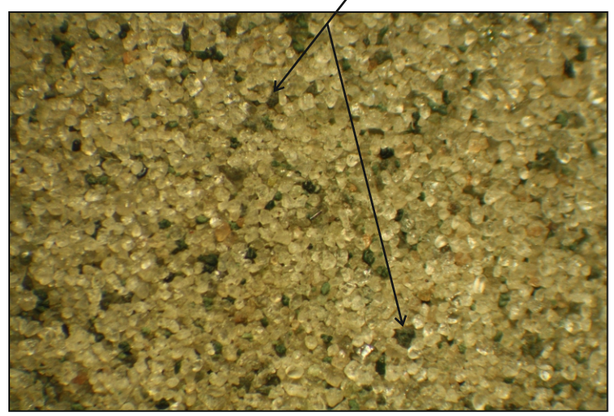
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

Sample Location: BH-WFS4-7
Sample Name: 29 Bag A

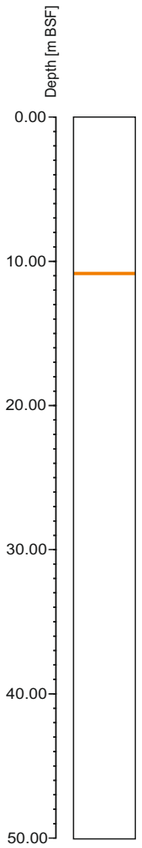
Depth: 46.50 m bsf
Soil Unit: E3 (Tongeren)

Plate Number: A.59

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (10GY-3/1) angular to subangular low to medium sphericity clayey silty fine SAND with trace medium sand-sized to fine gravel-sized angular to subangular low sphericity white to orange shell fragments

Colour:
Unwashed: Very dark greenish grey (10GY-3/1)
Washed: Grey (2.5Y-6/1)

Sand is moderately well sorted
Sand: No reaction with HCl

Microscope Description
Unwashed sample shows limited coating of silt

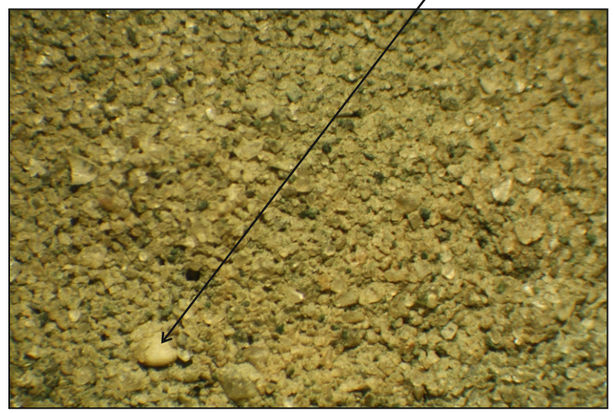
90 % - Silt to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) QUARTZ
~75 % glassy
~25 % frosted

5 % - Silt to fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) BIOTITE MICA
3 % - Silt to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) orange to pinkish FELDSPAR
2 % - Silt to fine sand-sized subrounded to rounded (rK = 0.4 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

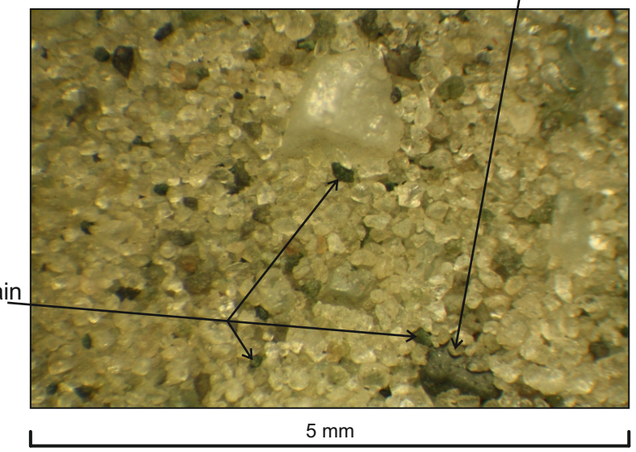
Trace: lithic fragments, bioclastic debris

Reflected Light Microphotographs

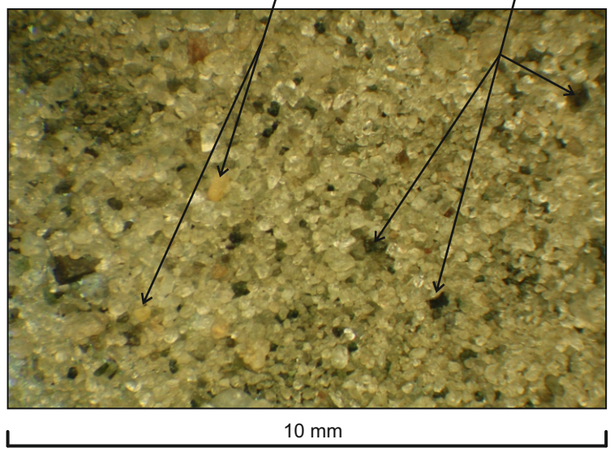
Unwashed Sample



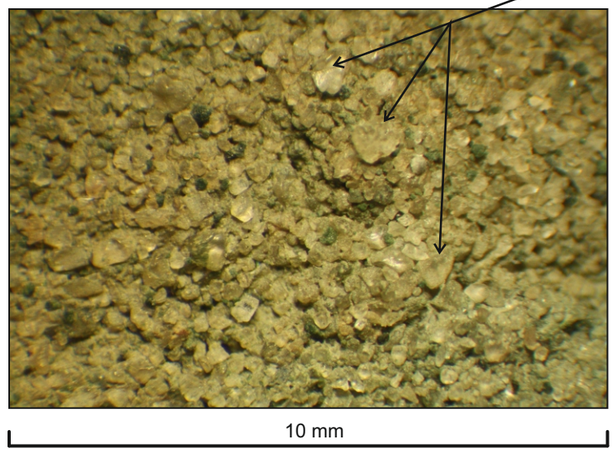
Washed Sample



Washed Sample



Unwashed Sample

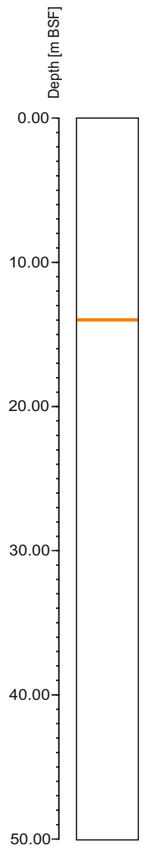


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-3** **Sample Name: 13 Bag B**	**Depth: 10.80 m bsf** **Soil Unit: E5b (Tongeren)**	**Plate Number: A.60**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Olive grey (5Y-5/2) angular to subrounded low to high sphericity fine SAND with trace fine sand-sized to fine gravel-sized white shell fragments (bivalves)

Colour:
Unwashed: Olive grey (5Y-5/2)
Washed: Light grey (2.5Y-7/1)

Sand is moderately to well sorted
Sand: limited, slow reaction to HCL

Microscope Description
Unwashed sample shows no coating of clay/silt

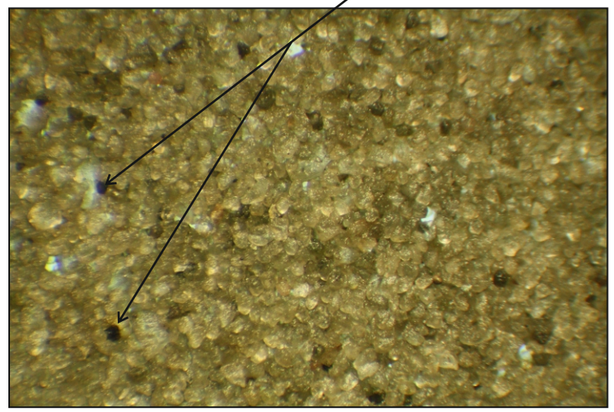
90 % - Silt to fine sand-sized subangular to rounded (rK = 0.2 to 0.8) low to high sphericity (rK 0.3 to 0.9) QUARTZ
~95 % glassy
~5 % frosted

3 % - Silt-sized subangular to rounded (rK = 0.4 to 0.7) low to medium (rK = 0.3 to 0.5) sphericity black BIOTITE MICA
3 % - Silt-sized subangular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) MUSCOVITE MICA
2 % - Silt-sized subangular to rounded (rK = 0.3 to 0.7) low to medium sphericity (rK = 0.3 to 0.7) black, red to orange LITHIC FRAGMENTS
2 % - Silt-sized to fine sand-sized subangular to subrounded (rK = 0.3 to 0.5) low to medium (rK = 0.3 to 0.7) sphericity white BIOCLASTIC DEBRIS

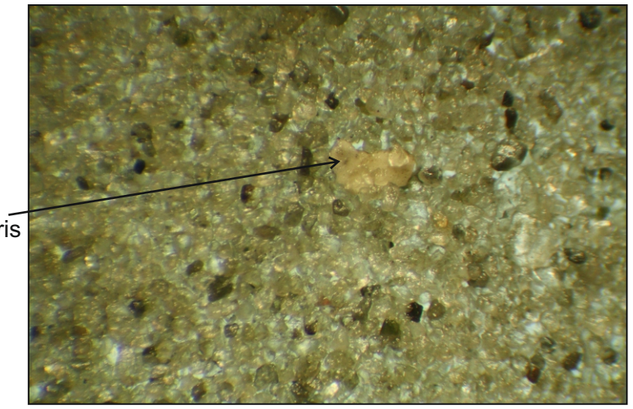
Trace: pyrite, glauoncite

Reflected Light Microphotographs

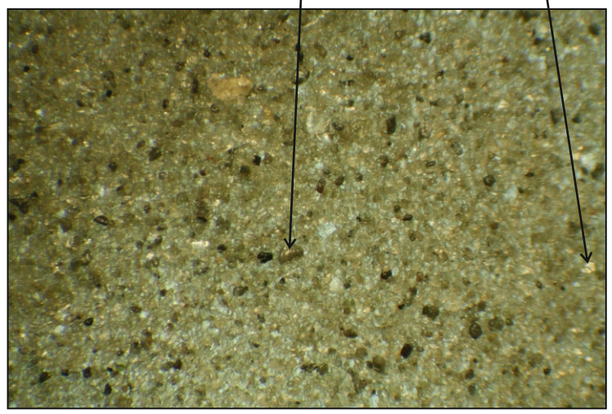
Unwashed Sample



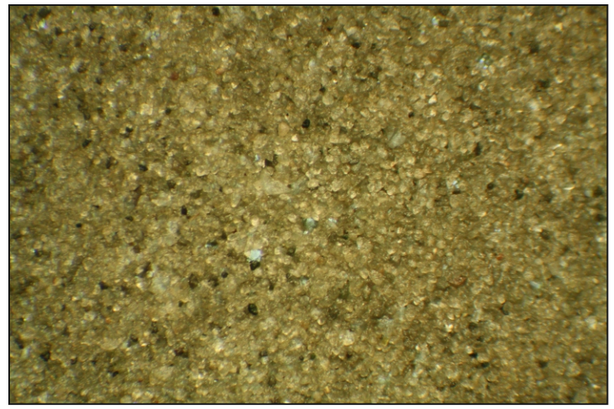
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

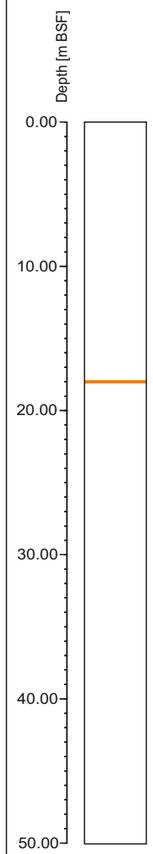
Sample Location: BH-WFS4-3
Sample Name: 18 Bag A

Depth: 14.00 m bsf
Soil Unit: E5b (Tongeren)

Plate Number: A.61			
	Made:	LRM	08/01/2016
	Checked:	CB	12/01/2016
	Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10Y-4/1) angular to subangular low sphericity clayey fine SAND

Colour:
Unwashed: Dark greenish grey (10Y-4/1)
Washed: Light grey (5Y-7/1)

Sand is well sorted
Sand: No reaction with HCl

Microscope Description
Unwashed sample shows minor coating of clay

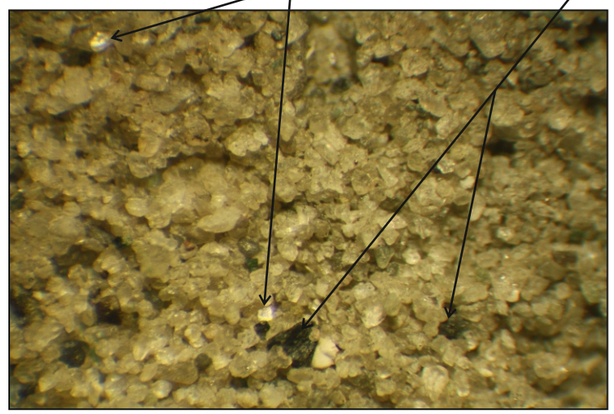
90 % - Silt-sized to fine sand-sizedangular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
~90 % glassy
~10 % frosted

5 % - Silt-sized to fine sand-sized to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) black BIOTITE MICA
3 % - Silt-sized to fine sand-sized subangular to rounded (rK = 0.3 to 0.8) low to high sphericity (rK = 0.3 to 0.7) brown to black LITHIC FRAGMENTS
2 % - Silt-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) MUSCOVITE

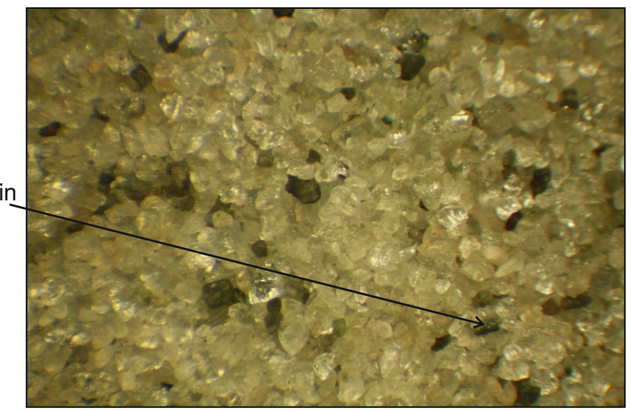
Trace: glauconite, feldspar

Reflected Light Microphotographs

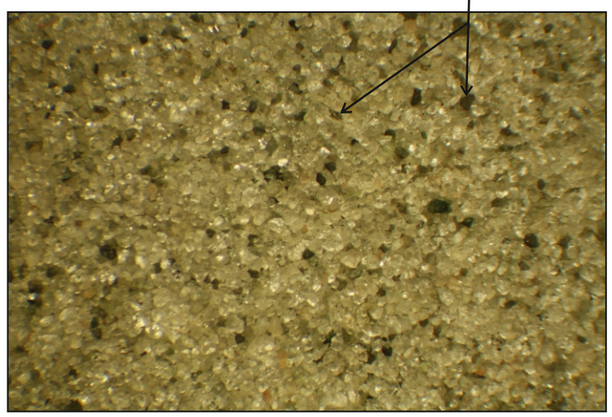
Unwashed Sample



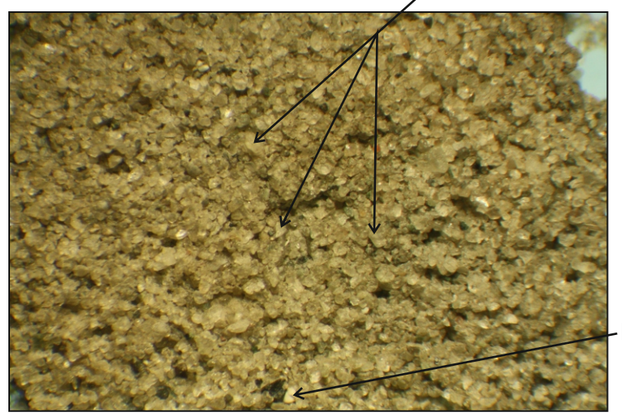
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

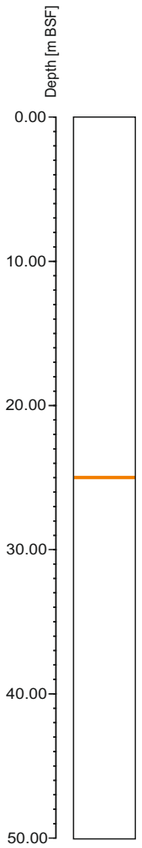
Sample Location: BH-WFS4-2A
Sample Name: 12 Bag A

Depth: 18.00 m bsf
Soil Unit: E5b (Tongeren)

Plate Number: A.62			
	Made:	LRM	08/01/2016
	Checked:	CB	12/01/2016
	Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark grey (5Y-4/1) angular to subangular low to medium sphericity clayey fine SAND

Colour:
Unwashed: Dark grey (5Y-4/1)
Washed: Olive grey (5Y-5/2)

Sand is poorly to moderately well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows minor coating of clay

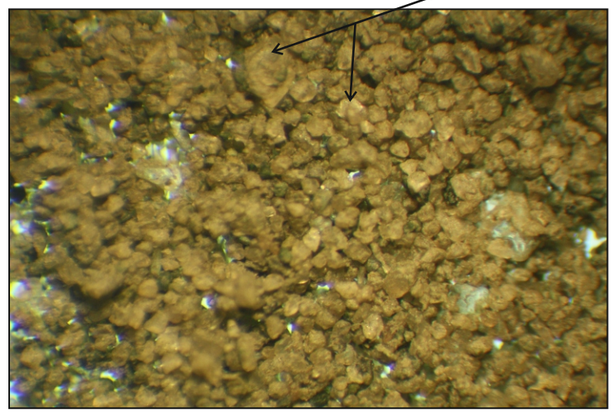
80 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
~85 % glassy
~15 % frosted

15 % - Fine to medium sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
5 % - Fine sand-sized subrounded to rounded (rK = 0.5 to 0.8) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE

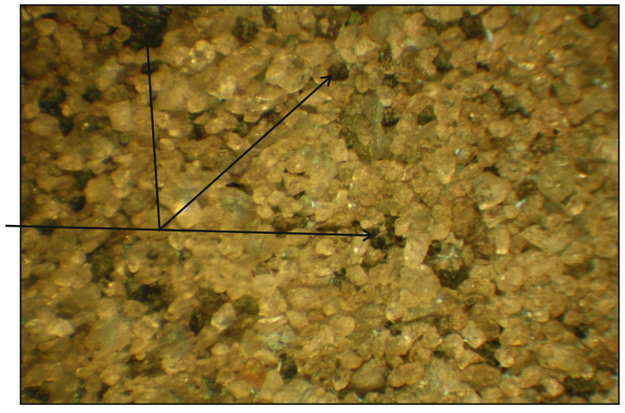
Trace: muscovite mica

Reflected Light Microphotographs

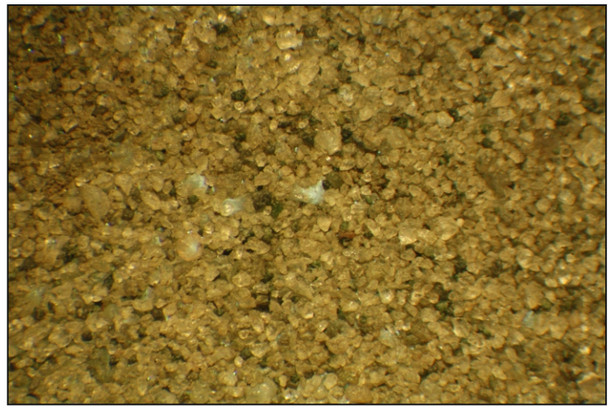
Unwashed Sample



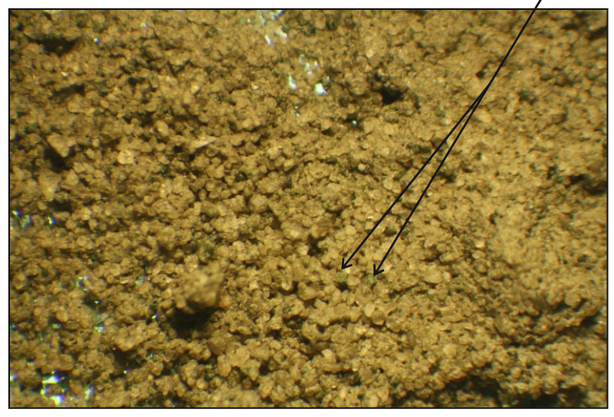
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele
Detailed Microscope Description

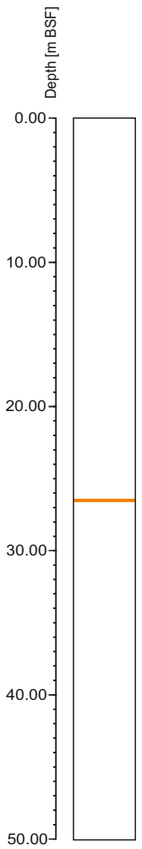
Sample Location: BH-WFS4-5
Sample Name: 31 Bag A

Depth: 26.00 m bsf
Soil Unit: E5b (Tongeren)

Plate Number: A.63

Made:	LRM	08/01/2016	FUGRO
Checked:	CB	12/01/2016	
Approved:	CAS	14/01/2016	

Sample Microscope Description



Sample Description

Hand-Specimen Description
Grey (5Y-5/1) angular to subrounded low to high sphericity clayey fine SAND

Colour:
Unwashed: Grey (5Y-5/1)
Washed: Grey (5Y-6/1)

Sand is moderately to well sorted
Sand: No reaction to HCl

Microscope Description
Unwashed sample shows extensive coating of clay

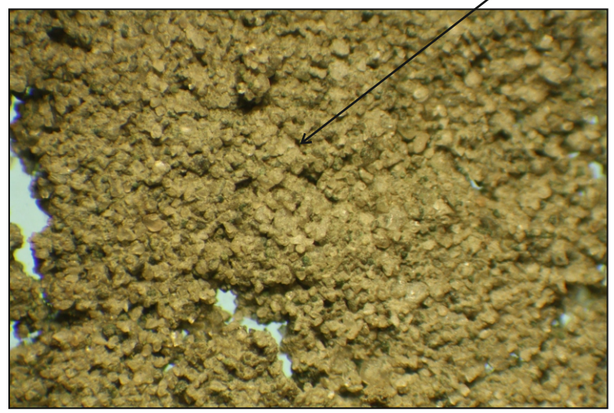
85 % - Silt to fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

8 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) green GLAUCONITE
5 % - Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.9) BIOTITE MICA
2 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) low to high sphericity (rK = 0.3 to 0.9) black LITHIC FRAGMENTS

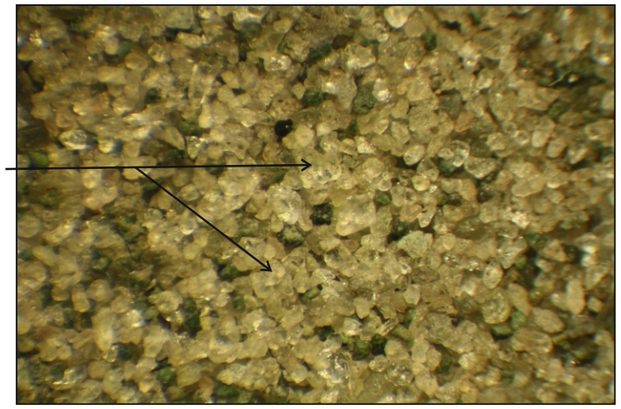
Trace: feldspar, muscovite mica

Reflected Light Microphotographs

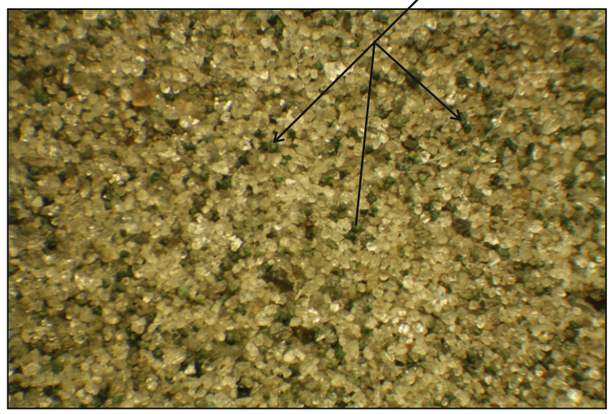
Unwashed Sample



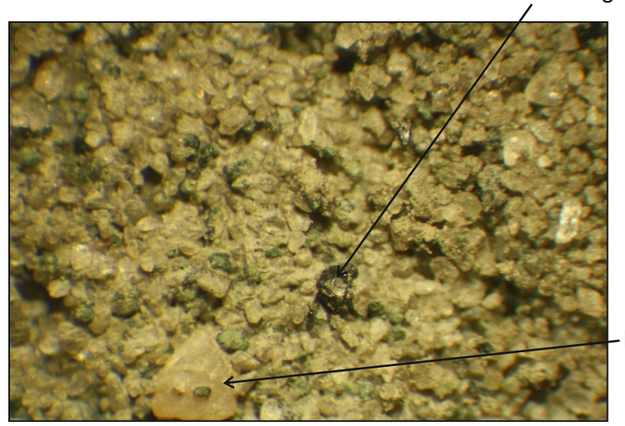
Washed Sample



Washed Sample

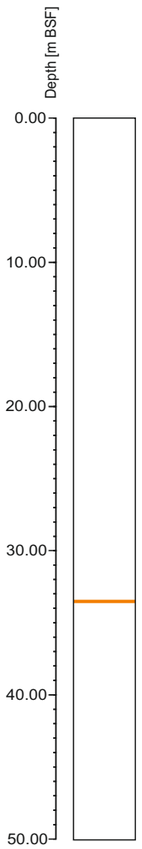


Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-3A** **Sample Name: 13 Bag A**	**Depth: 26.50 m bsf** **Soil Unit: E5b (Tongeren)**	**Plate Number: A.64**	Made:	LRM	08/01/2016
				Checked:	CB	12/01/2016
				Approved:	CAS	14/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark grey (5Y-4/1) angular to subangular low to medium sphericity clayey fine SAND

Colour:
Unwashed: Dark grey (5Y-4/1)
Washed: Grey (5Y-6/1)

Sand is moderately sorted
Sand: No reaction with HCl

Microscope Description
Unwashed sample shows limited coating of clay

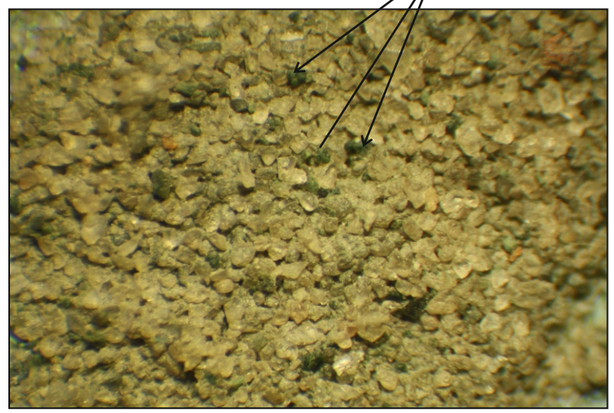
90 % - Fine sand-sized angular to subangular (rK = 0.1 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
~90 % glassy
~10 % frosted

6 % -Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to medium sphericity (rK = 0.3 to 0.7) black BIOTITE MICA
4 % - Fine sand-sized subangular to rounded (rK = 0.3 to 0.7) low to high sphericity (rK = 0.3 to 0.9) brown to black LITHIC FRAGMENTS

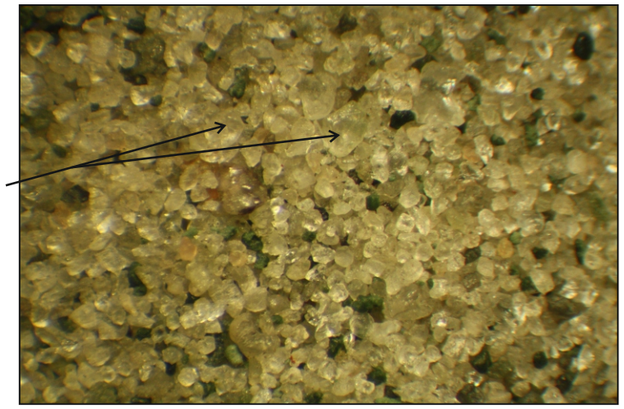
Trace: muscovite mica

Reflected Light Microphotographs

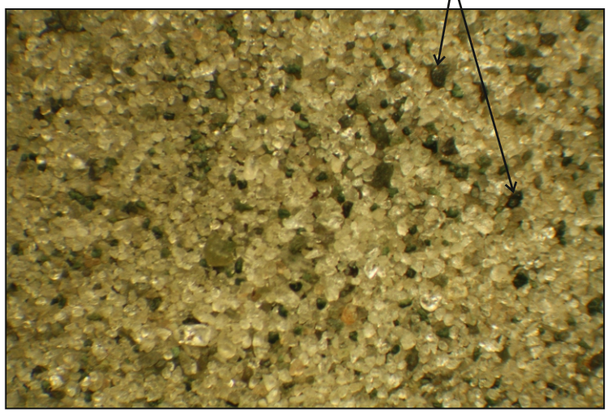
Unwashed Sample



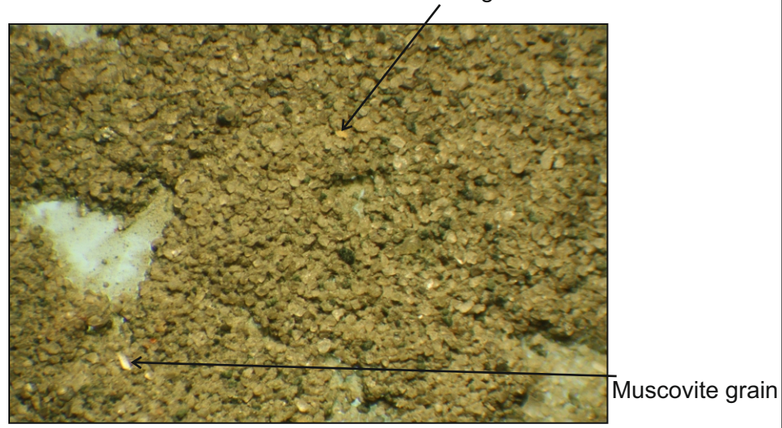
Washed Sample



Washed Sample



Unwashed Sample

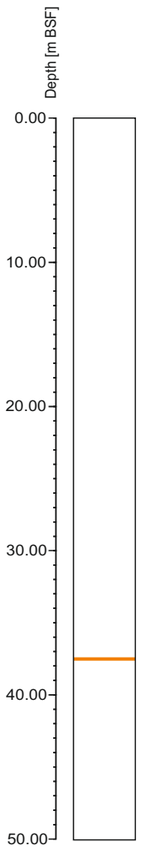


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-6** **Sample Name: 25 Bag A**	**Depth: 33.50 m bsf** **Soil Unit: E5b (Tongeren)**	**Plate Number: A.65**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Grey (2.5YR-5/1) subangular to subrounded low to high sphericity fine SAND with few fine sand-sized subangular to subrounded low to high sphericity black lithic fragments

Colour:
Unwashed: Grey (2.5YR-5/1)
Washed: Olive grey (5Y-5/2)

Sand is well sorted
Sand: no reaction to HCL

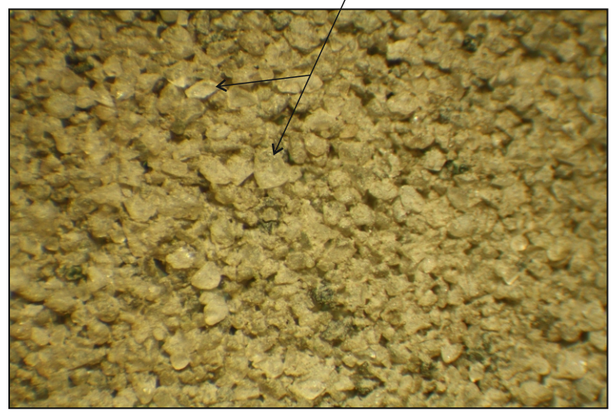
Microscope Description
Unwashed sample shows moderate coating of clay

85 % - Fine to medium sand-sized subangular to subrounded (*r*K = 0.2 to 0.5) medium to high sphericity (*r*K = 0.5 to 0.9) QUARTZ
~ 60 % clear, glassy
~ 40 % clear, frosted
5 % - Fine sand-sized angular to subangular (*r*K = 0.2 to 0.5) low to high sphericity (*r*K = 0.3 to 0.6) brown to black LITHIC FRAGMENTS
4 % - Fine sand-sized subangular to rounded (*r*K = 0.3 to 0.7) low to high sphericity (*r*K = 0.3 to 0.9) black BIOTITE
3 % - Fine sand-sized subangular to subrounded (*r*K = 0.3 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.5) white to orange FELDSPAR
3 % - Fine sand-sized subrounded to rounded (*r*K = 0.4 to 0.6) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE

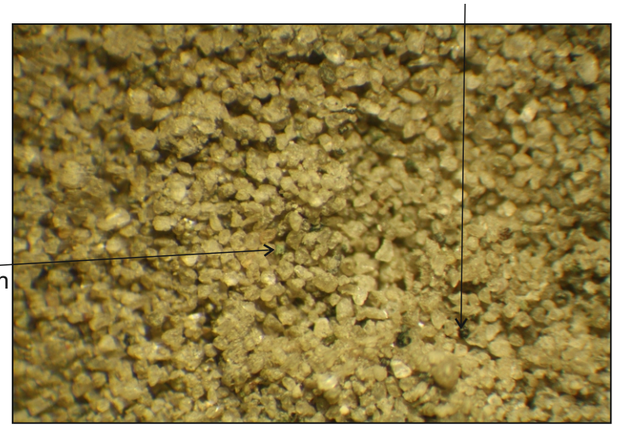
Trace: pyrite, calcite

Reflected Light Microphotographs

Unwashed Sample



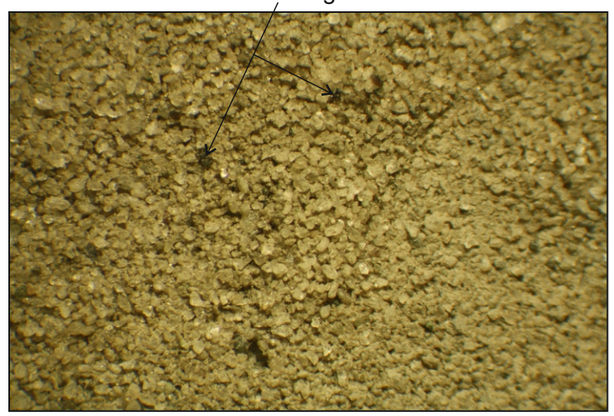
Washed Sample



Washed Sample



Unwashed Sample

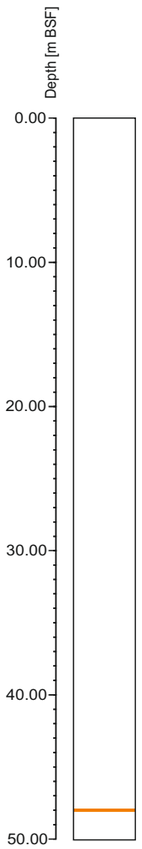


J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS3-6** **Sample Name: 26 Bag A**	**Depth: 37.50 m bsf** **Soil Unit: E5b (Tongeren)**

Plate Number: A.66			
	Made:	LRM	08/01/2016
	Checked:	CB	12/01/2016
	Approved:	CAS	14/01/2016

FUGRO

Sample Microscope Description



Sample Description

Hand-Specimen Description
Dark greenish grey (10Y-4/1) subangular to subrounded low to medium sphericity clayey silty fine SAND

Colour:
Unwashed: Dark greenish grey (10Y-4/1)
Washed: Light grey (5Y-7/1)

Sand is moderately well sorted
Sand: limited, no reaction to HCL

Microscope Description
Unwashed sample shows moderate coating of clay/silt

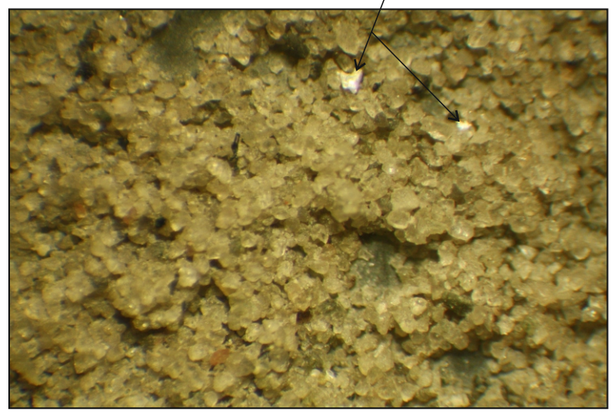
80 % - Fine sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to medium sphericity (*r*K = 0.3 to 0.7) QUARTZ
~ 85 % clear, glassy
~ 15 % clear, frosted

10 % - Fine to medium sand-sized angular to subangular (*r*K = 0.2 to 0.4) low to medium sphericity (*r*K = 0.3 to 0.7) platy MUSCOVITE
5 % - Fine to medium sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to high sphericity (*r*K = 0.3 to 0.9) black BIOTITE
3 % - Fine sand-sized angular to subrounded (*r*K = 0.2 to 0.6) low to high sphericity (*r*K = 0.3 to 0.7) brown to black LITHIC FRAGMENTS
2 % - Fine sand-sized subangular to rounded (*r*K = 0.3 to 0.8) low to high sphericity (*r*K = 0.3 to 0.9) green GLAUCONITE

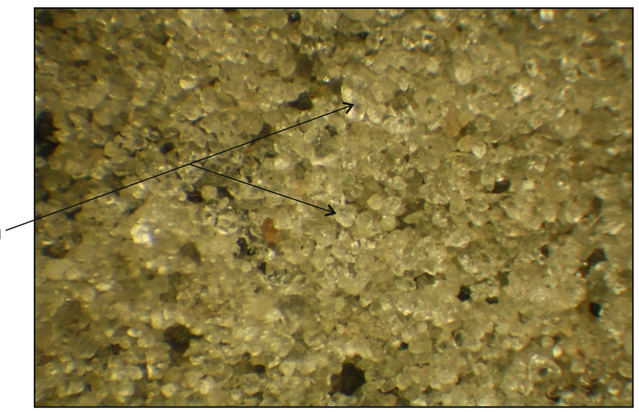
Trace: pyrite

Reflected Light Microphotographs

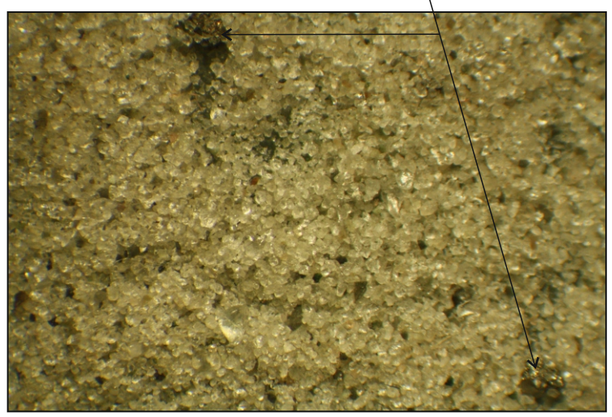
Unwashed Sample



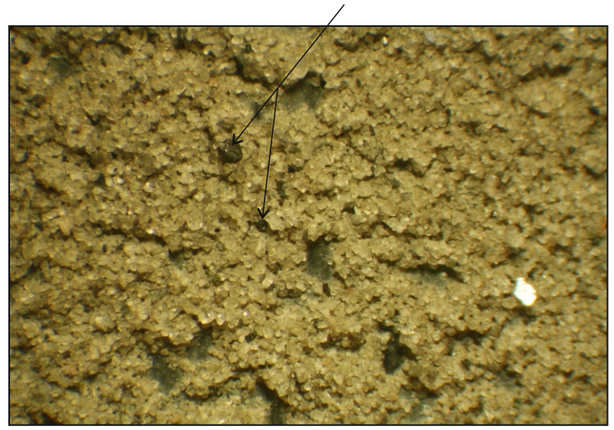
Washed Sample



Washed Sample



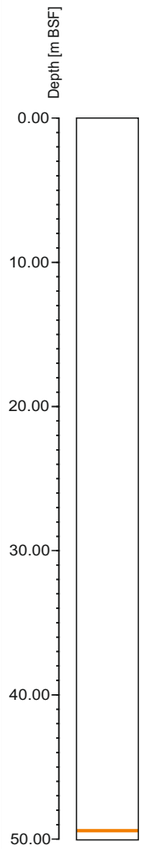
Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS4-6** **Sample Name: 33 Bag A**	**Depth: 48.00 m bsf** **Soil Unit: E5b (Tongeren)**

Plate Number: A.67			
	Made:	LRM	08/01/2016
	Checked:	CB	12/01/2016
	Approved:	CAS	14/01/2016

Sample Microscope Description



Sample Description

Hand-Specimen Description
Very dark greenish grey (5GY-3/1) subangular to subrounded low to high sphericity clayey fine SAND

Colour:
Unwashed: Very dark greenish grey (5GY-3/1)
Washed: Light grey (5Y-7/1)

Sand is poorly to moderately well sorted
Sand: No reaction to HCL

Microscope Description
Unwashed sample shows limited coating of clay

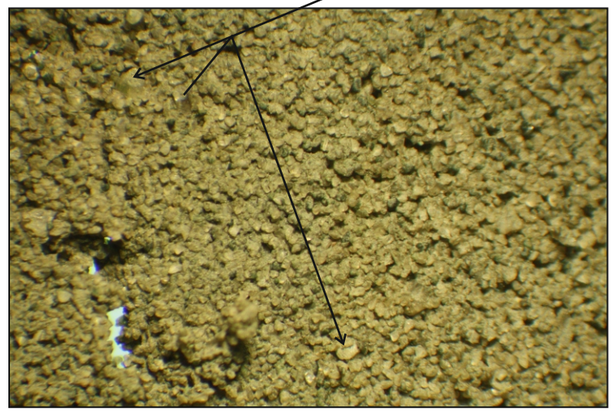
80 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.5) low to medium sphericity (rK = 0.3 to 0.7) QUARTZ
~95 % glassy
~5 % frosted

15 % - Fine sand-sized angular to subrounded (rK = 0.2 to 0.6) medium to high sphericity (rK = 0.5 to 0.9) green GLAUCONITE
5 % - Fine sand-sized angular to subangular (rK = 0.2 to 0.4) low to high sphericity (rK = 0.3 to 0.9) black BIOTITE MICA

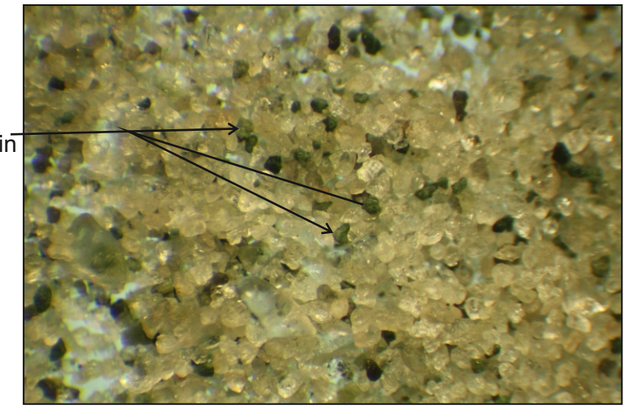
Trace: muscovite mica, lithic fragments

Reflected Light Microphotographs

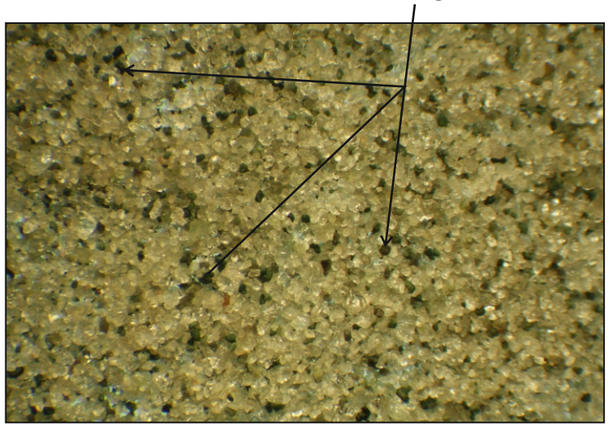
Unwashed Sample



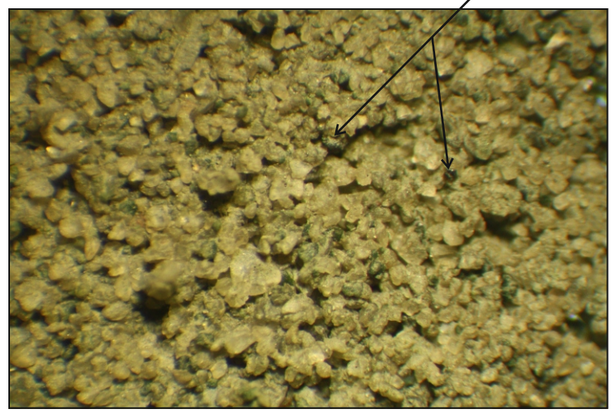
Washed Sample



Washed Sample



Unwashed Sample



J11302 - N6083 RVO Borssele **Detailed Microscope Description**	**Sample Location: BH-WFS5-1** **Sample Name: 24 Bag A**	**Depth: 49.50 m bsf** **Soil Unit: E5b (Tongeren)**	**Plate Number: A.68**

Made:	LRM	08/01/2016
Checked:	CB	12/01/2016
Approved:	CAS	14/01/2016

FUGRO

SECTION A4: STATIC TRIAXIAL TESTS

LIST OF PLATES IN SECTION A4: Plate

Isotropically Consolidated Undrained Triaxial Test - Cohesive Specimens	A4.1-1 to A4.1-60
Isotropically Consolidated Undrained Triaxial Test - Cohesionless Specimens	A4.2-1 to A4.2-37

Date: 04/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / BH-WFS3-
Date: 04/01/2016
Checked by: PH
Approved by: PH
Date: 04/01/2016

VISUAL DESCRIPTION
High strength dark greenish grey CLAY

GENERAL	
Date test started	20/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	[mm]	71.5
Length	[mm]	139.8
Moisture content	[%]	33.0
Bulk density	[Mg/m³]	1.96
Dry density	[Mg/m³]	1.47
Void ratio		0.836
Degree of saturation	[%]	100

SATURATION		
Pressure increments applied	[kPa]	100
Differential pressure used	[kPa]	N/A
Pore pressure on completion	[kPa]	538
Cell pressure on completion	[kPa]	825
B value achieved		1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.4 Fugro testing procedure L-T-023 Clause 5.3.7
Consolidation - Isotropic Consolidation - Anisotropic	BS 1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS3-1
Sample	27WaxC
Unit	F1c (Dongen)
Depth [m]	32.37
Test number	CIU01

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Drawn by: ALB Date: 04/01/2016

Template Issue: 3 Filename: J11302 / EFFECTIVE / BH-WFS3-

Checked by: PH Date: 04/01/2016

Approved by: PH Date: 04/01/2016

CONSOLIDATION : ISOTROPIC		
Cell pressure	[kPa]	825
Back pressure	[kPa]	500
Effective cell pressure	[kPa]	325
Pore pressure on completion	[kPa]	500
Pore pressure dissipation	[%]	100
Moisture content	[%]	32.8
Bulk density	[Mg/m³]	1.96
Dry density	[Mg/m³]	1.47
Void ratio		0.831
Degree of saturation	[%]	100
Volumetric strain	[%]	0.26
Axial strain	[%]	0.09

Borehole	BH-WFS3-1
Sample	27WaxC
Unit	F1c (Dongen)
Depth [m]	32.37
Test number	CIU01

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 04/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / BH-WFS3-
Date: 04/01/2016
Checked by: PH
Approved by: PH

BENDER ELEMENT DETERMINATIONS - POST SATURATION

Bulk density	[Mg/m^3]	1.96
Dry density	[Mg/m^3]	1.47
Void ratio	[-]	0.836
Distance	[mm]	136.96
Effective radial pressure	[kPa]	287
Effective axial pressure	[kPa]	287

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	0.6765	3.38	202.45	80.2
0.30	0.7005	2.33	195.52	74.8
0.40	0.7160	1.79	191.28	71.6
0.50	0.7225	1.45	189.56	70.3
0.60	0.7280	1.21	188.13	69.2
0.70	0.7355	1.05	186.21	67.8
0.80	0.7415	0.93	184.71	66.7
0.90	0.7560	0.84	181.16	64.2
1.00	0.7575	0.76	180.81	63.9

BENDER ELEMENT DETERMINATIONS - POST ISOTROPIC CONSOLIDATION

Bulk density	[Mg/m^3]	1.96
Dry density	[Mg/m^3]	1.47
Void ratio	[-]	0.831
Distance	[mm]	136.84
Effective radial pressure	[kPa]	325
Effective axial pressure	[kPa]	325

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	0.6735	3.37	203.17	80.8
0.30	0.6890	2.30	198.60	77.2
0.40	0.6970	1.74	196.32	75.5
0.50	0.7205	1.44	189.92	70.6
0.60	0.7180	1.20	190.58	71.1
0.70	0.7215	1.03	189.66	70.4
0.80	0.7410	0.93	184.67	66.8
0.90	0.7740	0.86	176.79	61.2

Borehole	BH-WFS3-1
Sample	27WaxC
Unit	F1c (Dongen)
Depth [m]	32.37
Test number	CIU01

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 04/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / BH-WFS3-
Date: 04/01/2016
Checked by: PH
Approved by: PH

SHEARING		
Initial pore pressure	[kPa]	500
Initial effective cell pressure	[kPa]	325
Rate of strain	[%/hour]	0.28
At peak deviator stress		
Corrected deviator stress	[kPa]	262
Membrane correction applied	[kPa]	0.3
Drain correction applied	[kPa]	0
Axial strain	[%]	3.00
Excess pore pressure	[kPa]	118
Major principal effective stress	[kPa]	470
Minor principal effective stress	[kPa]	207
Principal effective stress ratio		2.27
Epsilon 50 [ε 50]	[%]	0.25
Secant modulus [E50] at ε 50	[kPa]	52282
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	259
Membrane correction applied	[kPa]	0.3
Drain correction applied	[kPa]	0
Axial strain	[%]	2.50
Excess pore pressure	[kPa]	123
Major principal effective stress	[kPa]	460
Minor principal effective stress	[kPa]	202
Principal effective stress ratio		2.28
At 10% axial strain		
Corrected deviator stress	[kPa]	256
Membrane correction applied	[kPa]	0.9
Drain correction applied	[kPa]	0
Axial strain	[%]	10.00
Excess pore pressure	[kPa]	68
Major principal effective stress	[kPa]	513
Minor principal effective stress	[kPa]	257
Principal effective stress ratio		2.00

FINAL CONDITIONS		
Moisture content	[%]	32.8
Bulk density	[Mg/m³]	1.96
Dry density	[Mg/m³]	1.47

Borehole	BH-WFS3-1
Sample	27WaxC
Unit	F1c (Dongen)
Depth [m]	32.37
Test number	CIU01

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 04/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / BH-WFS3-
Checked by: PH Date: 04/01/2016
Approved by: PH Date: 04/01/2016

SPECIMEN PHOTOGRAPHS

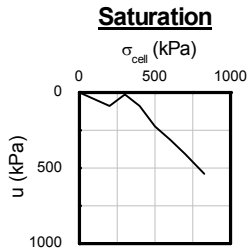


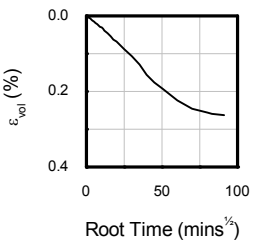
Borehole	BH-WFS3-1
Sample	27WaxC
Unit	F1c (Dongen)
Depth [m]	32.37
Test number	CIU01

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

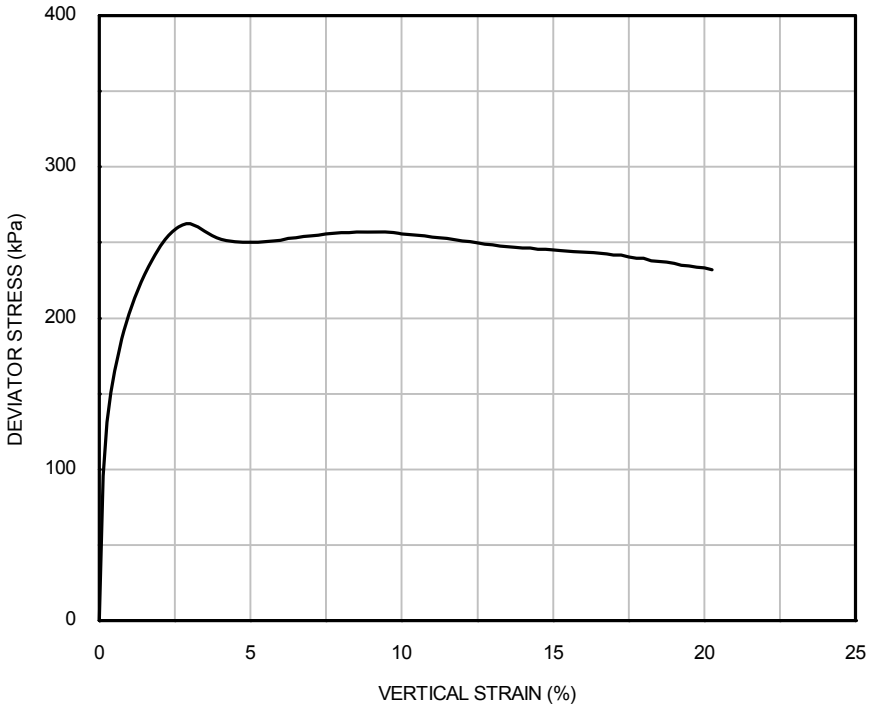
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

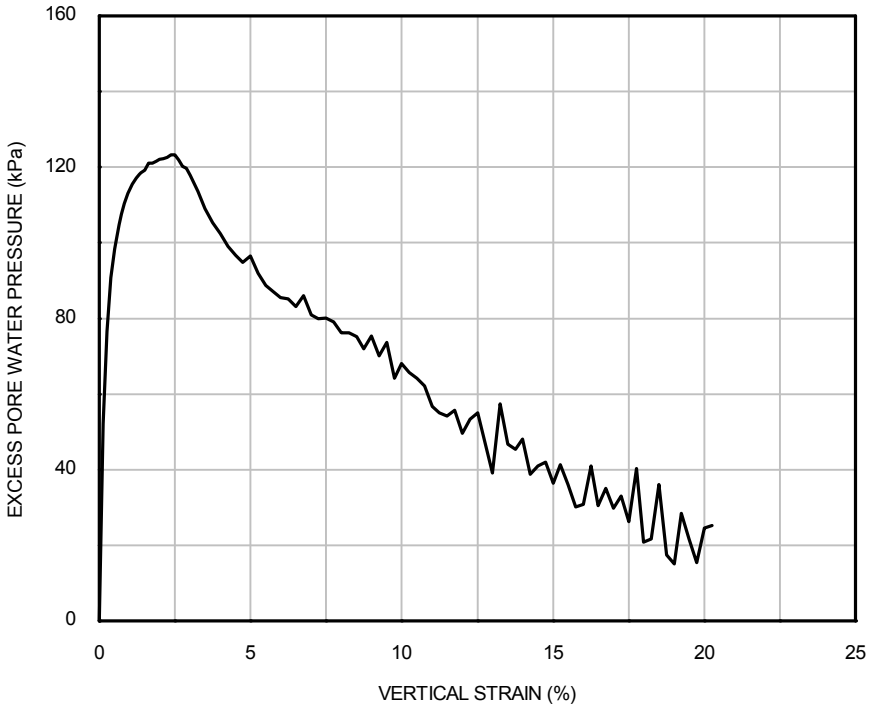
Drawn by: ALB Date: 04/01/2016
Template Issue: 4.1
Filename: J11302 \ EFFECTIV \ BH-WFS3-1_27WaxC_ca.OPJ
Date : 04/01/2016
Checked by: PH
Date : 04/01/2016
Approved by: PH





Consolidation



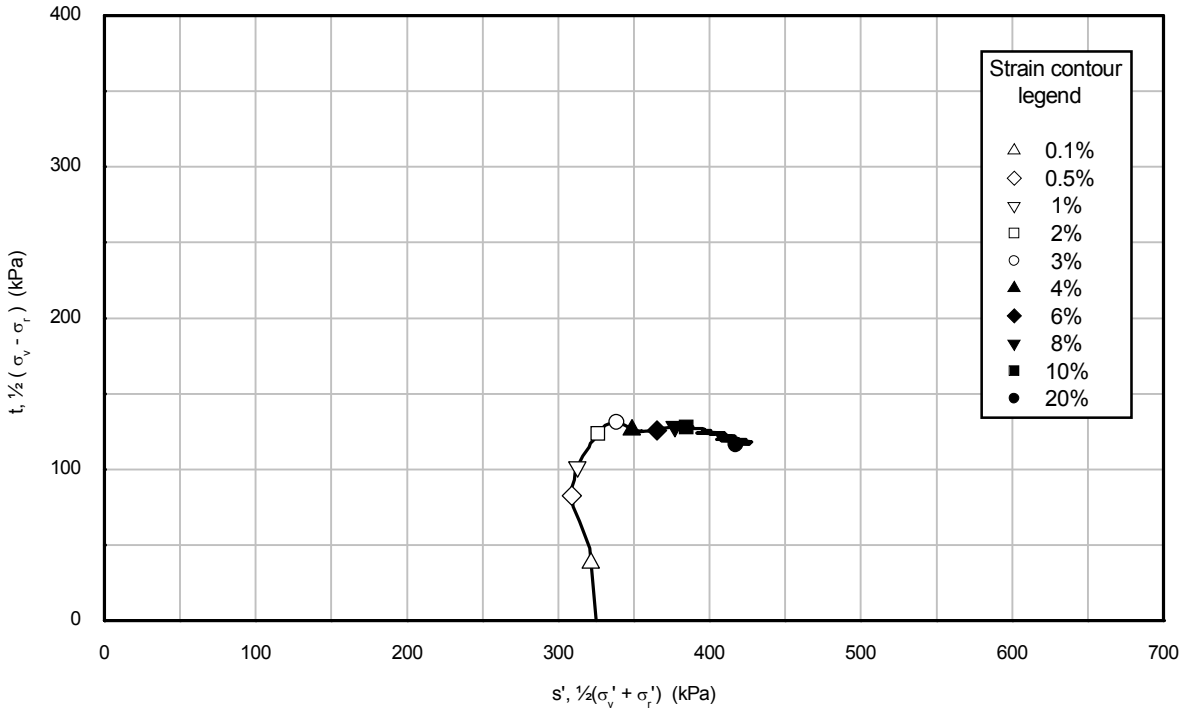


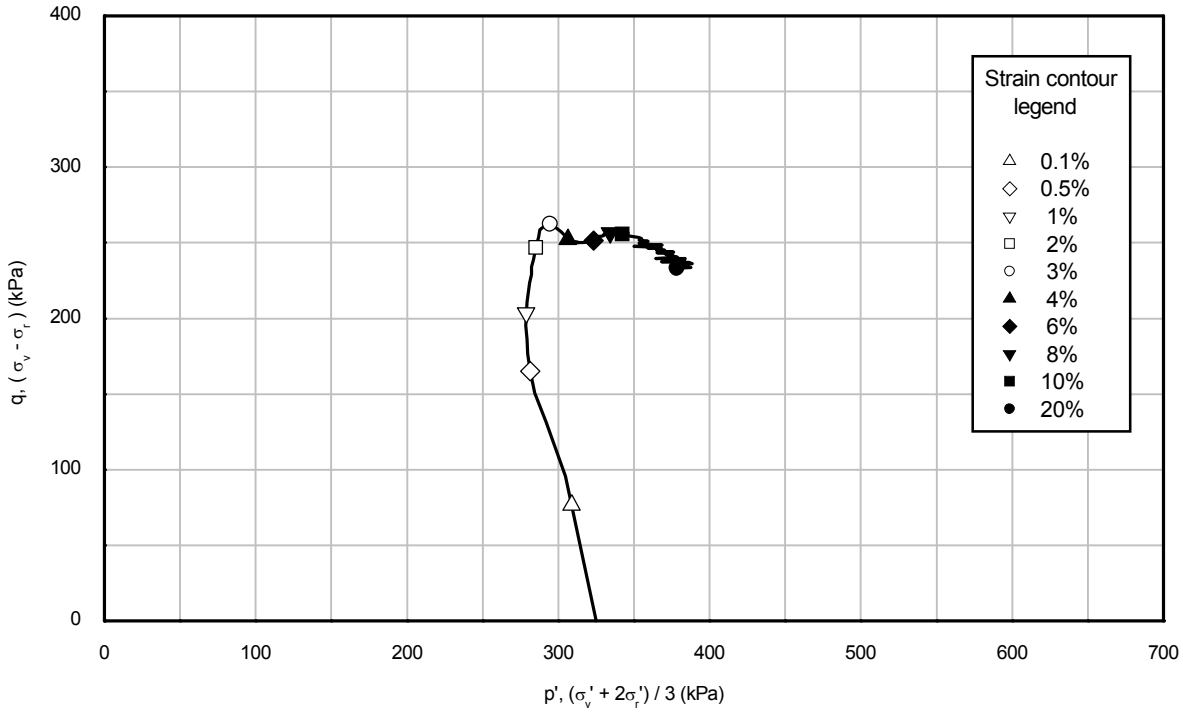
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	325	325

Borehole	: BH-WFS3-1
Sample	: 27WaxC
Unit	: F1c (Dongen)
Depth (m)	: 32.37
Test number	: CIU01

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	325	325

Borehole	: BH-WFS3-1
Sample	: 27WaxC
Unit	: F1c (Dongen)
Depth (m)	: 32.37
Test number	: CIU01

Drawn by: ALB Date: 04/01/2016

Filename: J11302 \ EFFECTIV \ BH-WFS3-1_27WaxC_ca.OPJ

Template Issue: 4.1

Date : 04/01/2016

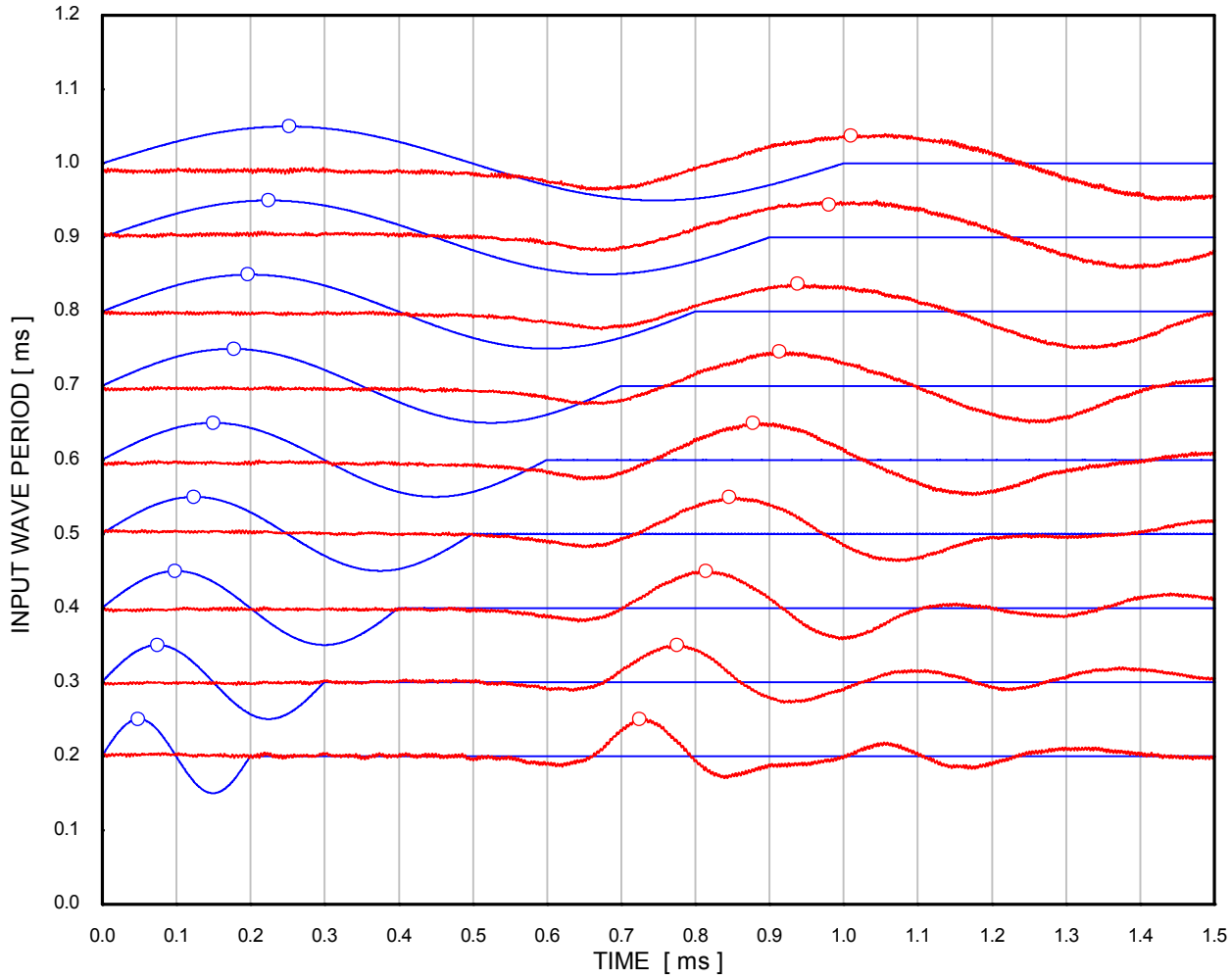
Checked by: PH

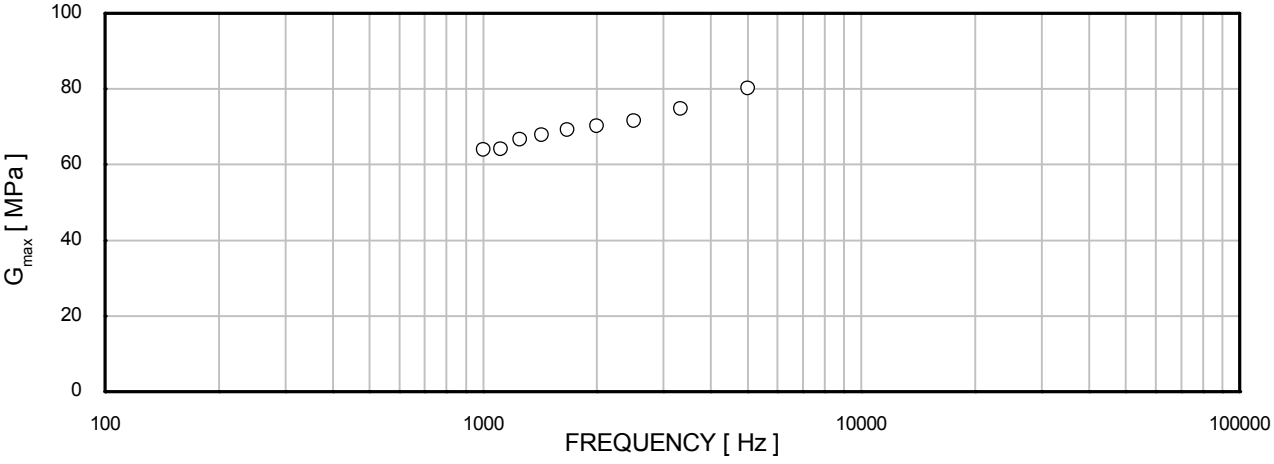
Date : 04/01/2016

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

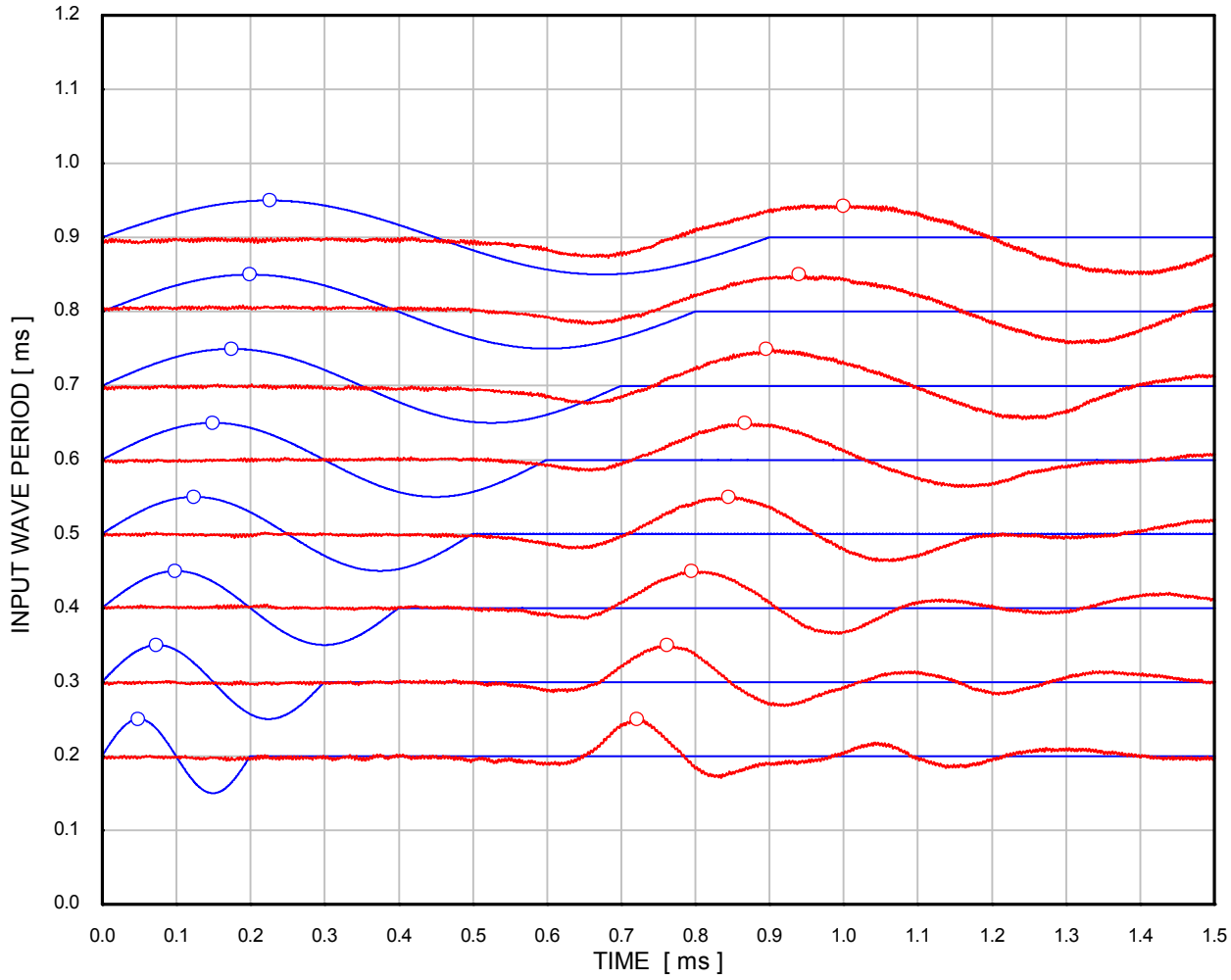


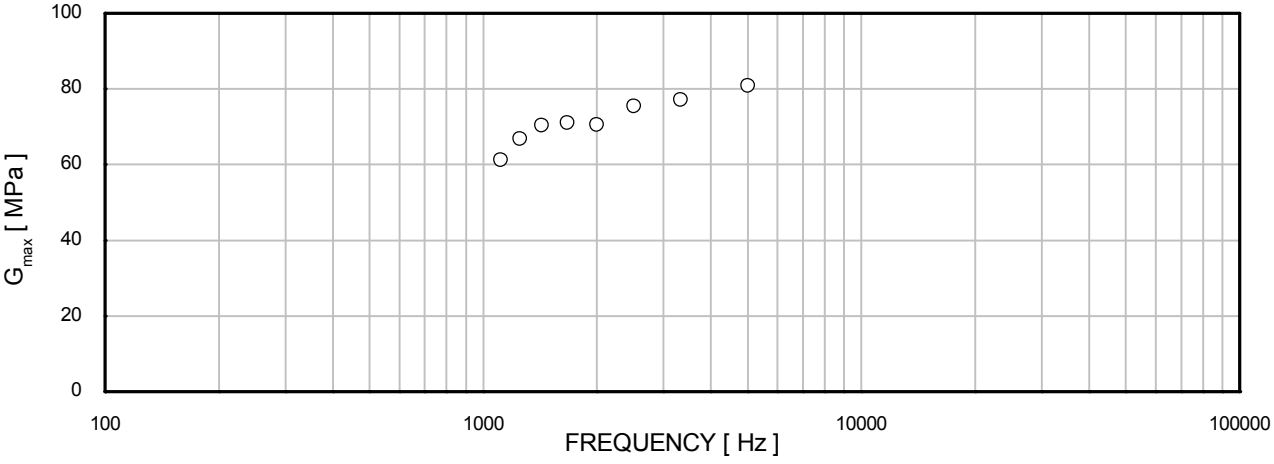


σ'rc : 287 kPa
σ'ac : 287 kPa
Source signal
Received signal
○ / ○ Selected peak values

Borehole : BH-WFS3-1
Sample : 27WaxC
Unit : F1c (Dongen)
Depth [m] : 32.37
Test number. : CIU01

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-SATURATION S_{VH} BENDER ELEMENT DETERMINATIONS





σ'_{rc}	: 325 kPa	Borehole	: BH-WFS3-1
σ'_{ac}	: 325 kPa	Sample	: 27WaxC
	Source signal	Unit	: F1c (Dongen)
	Received signal	Depth [m]	: 32.37
○ / ○	Selected peak values	Test number.	: CIU01

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-ISOTROPIC CONSOLIDATION S_{VH} BENDER ELEMENT DETERMINATIONS

Date: 23/11/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-1_28WaxB_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
Dark greenish grey sandy CLAY

GENERAL	
Date test started	13/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	72.3
Length	(mm)	125.1
Moisture content	(%)	21.9
Bulk density	(Mg/m³)	2.09
Dry density	(Mg/m³)	1.71
Void ratio		0.575
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	645
Cell pressure on completion	(kPa)	800
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 5.3
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-WFS3-1
Sample	28WaxB
Unit	F1c (Dongen)
Depth (m)	33.05
Test number	CIU02

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 23/11/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-1_28WaxB_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	930
Back pressure	(kPa)	600
Effective cell pressure	(kPa)	330
Pore pressure on completion	(kPa)	600
Pore pressure dissipation	(%)	100
Moisture content	(%)	21.8
Bulk density	(Mg/m³)	2.09
Dry density	(Mg/m³)	1.72
Void ratio		0.570
Degree of saturation	(%)	100
Volumetric strain	(%)	0.30

Mode of failure: Necking failure

Borehole	BH-WFS3-1
Sample	28WaxB
Unit	F1c (Dongen)
Depth (m)	33.05
Test number	CIU02

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 23/11/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-1_28WaxB_IE.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	600
Initial effective cell pressure	(kPa)	330
Rate of strain	(%/hour)	0.22
At peak deviator stress		
Corrected deviator stress	(kPa)	-343
Membrane correction applied	(kPa)	-1.0
Drain correction applied	(kPa)	0
Axial strain	(%)	-8.25
Excess pore pressure	(kPa)	-147
Major principal effective stress	(kPa)	135
Minor principal effective stress	(kPa)	477
Principal effective stress ratio		0.28
Epsilon 50 (ε 50)	(%)	-0.48
Secant modulus (E50) at ε 50	(kPa)	35558
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	-343
Membrane correction applied	(kPa)	-1.0
Drain correction applied	(kPa)	0
Axial strain	(%)	-8.25
Excess pore pressure	(kPa)	-147
Major principal effective stress	(kPa)	135
Minor principal effective stress	(kPa)	477
Principal effective stress ratio		0.28
At -10% axial strain		
Corrected deviator stress	(kPa)	-416
Membrane correction applied	(kPa)	-1.2
Drain correction applied	(kPa)	0
Axial strain	(%)	-10.00
Excess pore pressure	(kPa)	-179
Major principal effective stress	(kPa)	163
Minor principal effective stress	(kPa)	579
Principal effective stress ratio		0.34

FINAL CONDITIONS		
Moisture content	(%)	21.8
Bulk density	(Mg/m³)	2.09
Dry density	(Mg/m³)	1.72

Borehole	BH-WFS3-1
Sample	28WaxB
Unit	F1c (Dongen)
Depth (m)	33.05
Test number	CIU02

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Drawn by: ALB Date: 23/11/2015

Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS3-1_28WaxB_IE.XLS

Checked by: PH Date: 14/01/2016

Approved by: PH Date: 14/01/2016

SPECIMEN PHOTOGRAPHS

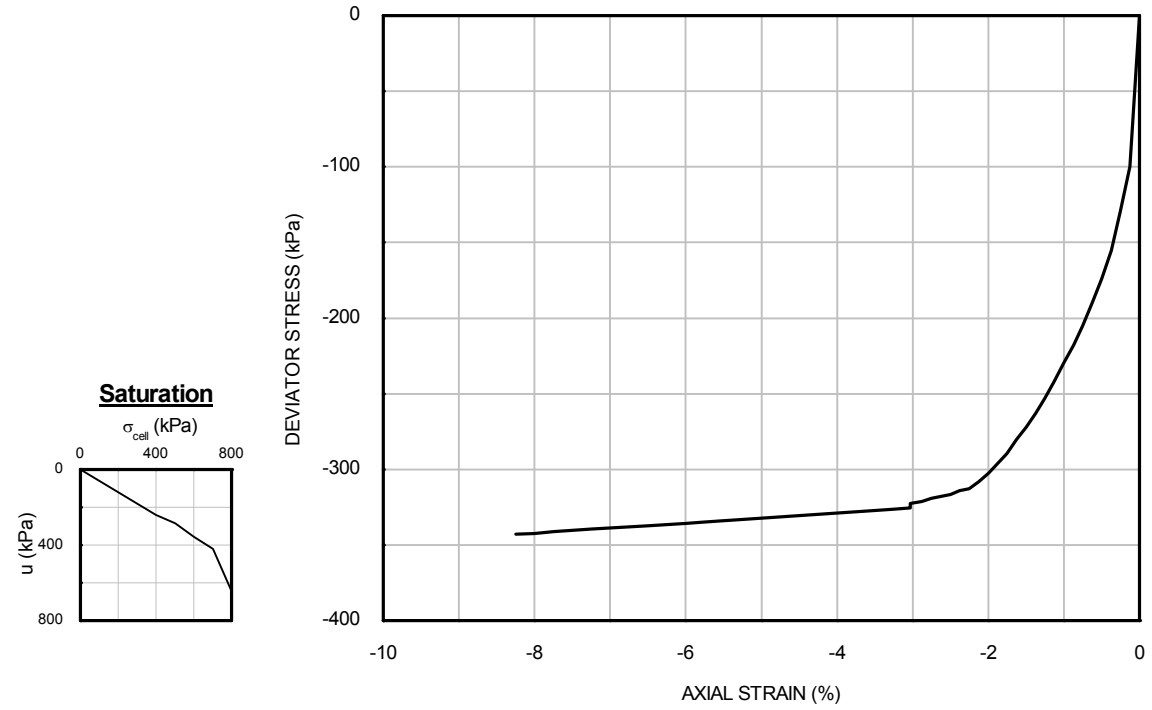


Borehole	BH-WFS3-1
Sample	28WaxB
Unit	F1c (Dongen)
Depth (m)	33.05
Test number	CIU02

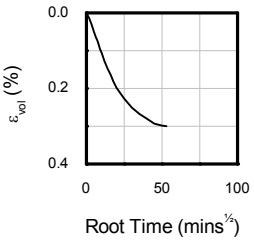
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

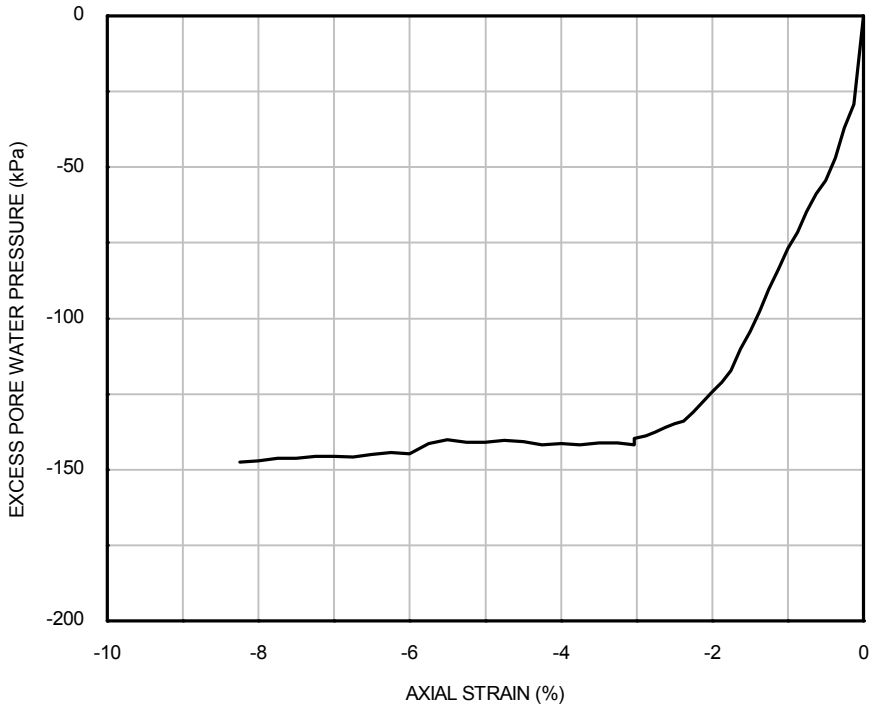
Drawn by: ALB Date: 23/11/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-1_28WaxB_IE.OPJ
Template Issue: 4.1
Date : 14/01/2016
Checked by: PH
Date : 14/01/2016
Approved by: PH



Saturation



Consolidation

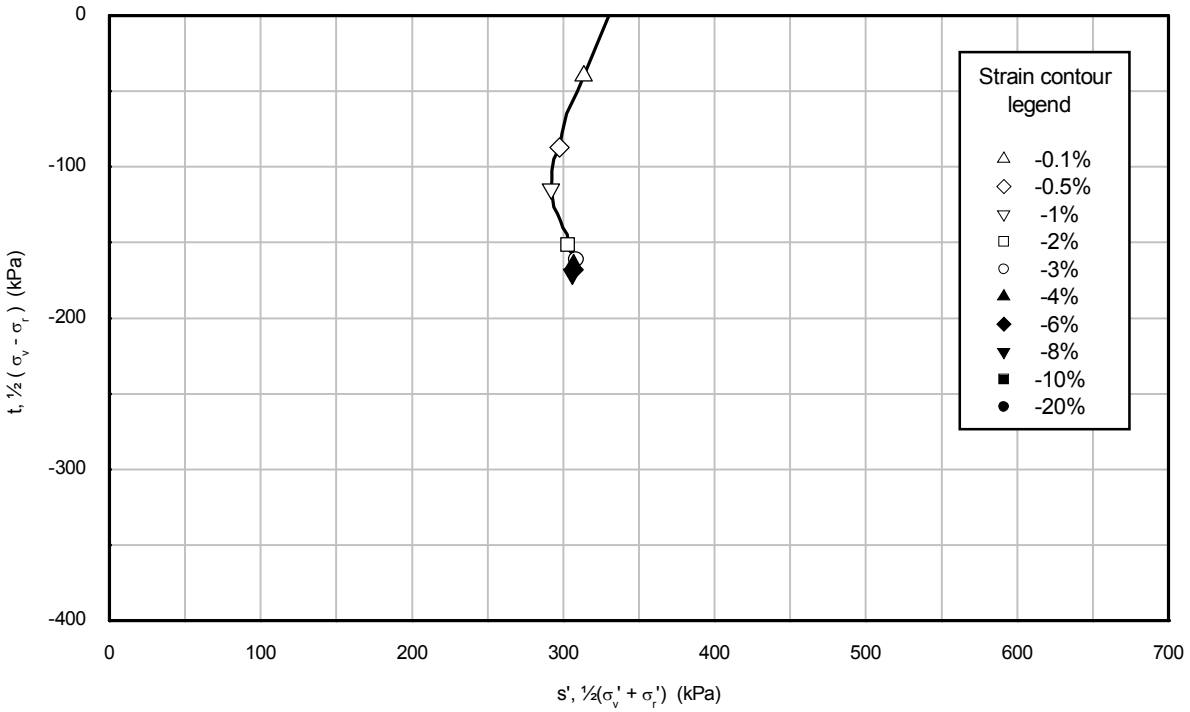


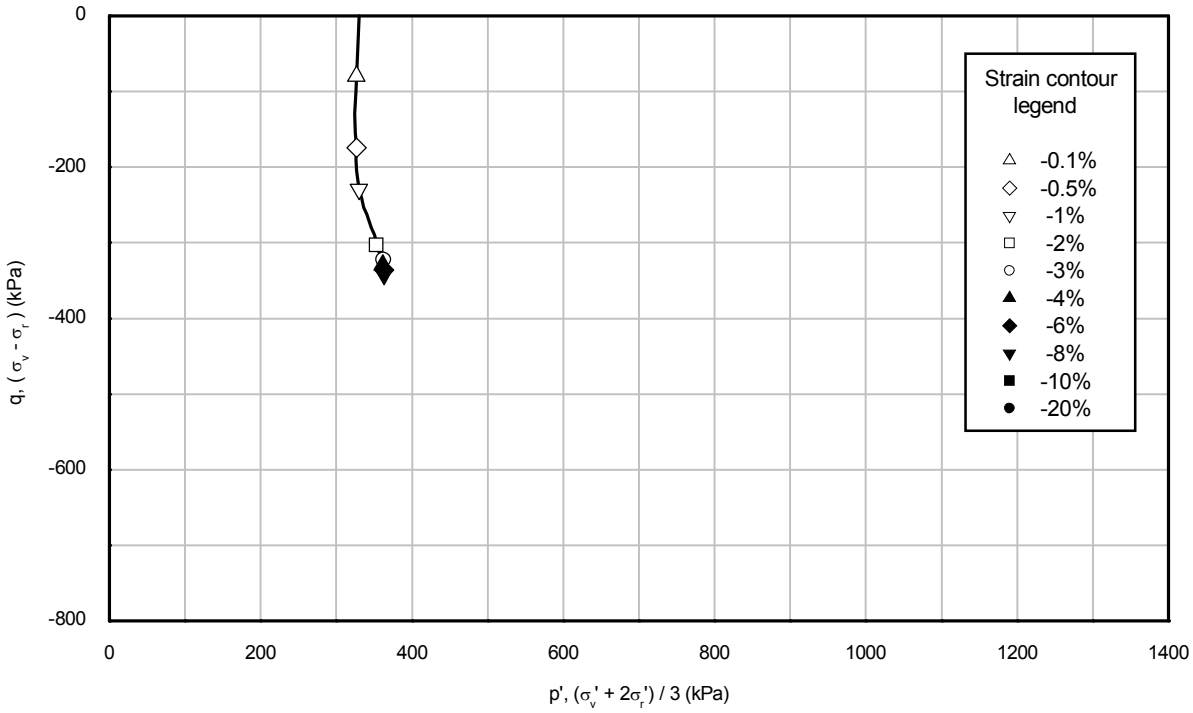
Curve	Specimen	σrc' (kPa)	σvc' (kPa)
——	1	330	330

Borehole	: BH-WFS3-1
Sample	: 28WaxB
Unit	: F1c (Dongen)
Depth (m)	: 33.05
Test number	: CIU02

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	330	330

Borehole	: BH-WFS3-1
Sample	: 28WaxB
Unit	: F1c (Dongen)
Depth (m)	: 33.05
Test number	: CIU02

Drawn by: ALB Date: 23/11/2015

Filename: J11302 \ EFFECTIV \ BH-WFS3-1_28WaxB_IE.OPJ Template Issue: 4.1

Date : 14/01/2016

Checked by: PH

Date : 14/01/2016

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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

Date: 18/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-4A_3WaxE_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
Very stiff dark greenish grey CLAY

GENERAL	
Date test started	16/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.2
Length	(mm)	126.9
Moisture content	(%)	34.3
Bulk density	(Mg/m³)	1.92
Dry density	(Mg/m³)	1.43
Void ratio		0.887
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	437
Cell pressure on completion	(kPa)	700
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 5.3
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-WFS3-4A
Sample	3WaxE
Unit	F1c (Dongen)
Depth (m)	24.47
Test number	CIU03

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 18/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-4A_3WaxE_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	700
Back pressure	(kPa)	435
Effective cell pressure	(kPa)	265
Pore pressure on completion	(kPa)	435
Pore pressure dissipation	(%)	100
Moisture content	(%)	34.6
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.43
Void ratio		0.887
Degree of saturation	(%)	100
Volumetric strain	(%)	0.01

Mode of failure: Necking failure

Borehole	BH-WFS3-4A
Sample	3WaxE
Unit	F1c (Dongen)
Depth (m)	24.47
Test number	CIU03

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 18/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-4A_3WaxE_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	435
Initial effective cell pressure	(kPa)	265
Rate of strain	(%/hour)	0.30
At peak deviator stress		
Corrected deviator stress	(kPa)	-244
Membrane correction applied	(kPa)	-1.0
Drain correction applied	(kPa)	0
Axial strain	(%)	-7.50
Excess pore pressure	(kPa)	-149
Major principal effective stress	(kPa)	170
Minor principal effective stress	(kPa)	414
Principal effective stress ratio		0.41
Epsilon 50 (ε 50)	(%)	-0.29
Secant modulus (E50) at ε 50	(kPa)	41489
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	-243
Membrane correction applied	(kPa)	-0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	-6.50
Excess pore pressure	(kPa)	-147
Major principal effective stress	(kPa)	169
Minor principal effective stress	(kPa)	412
Principal effective stress ratio		0.41
At -10% axial strain		
Corrected deviator stress	(kPa)	-223
Membrane correction applied	(kPa)	-1.4
Drain correction applied	(kPa)	0
Axial strain	(%)	-10.00
Excess pore pressure	(kPa)	-143
Major principal effective stress	(kPa)	185
Minor principal effective stress	(kPa)	408
Principal effective stress ratio		0.45

FINAL CONDITIONS		
Moisture content	(%)	34.6
Bulk density	(Mg/m³)	1.93
Dry density	(Mg/m³)	1.43

Borehole	BH-WFS3-4A
Sample	3WaxE
Unit	F1c (Dongen)
Depth (m)	24.47
Test number	CIU03

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Drawn by: ALB Date: 18/12/2015

Template Issue: 2 Filename: J11302 / EFFECTIV / BH-WFS3-4A_3WaxE_IE.XLS

Checked by: PH Date: 14/01/2016 Approved by: PH Date: 14/01/2016

SPECIMEN PHOTOGRAPHS

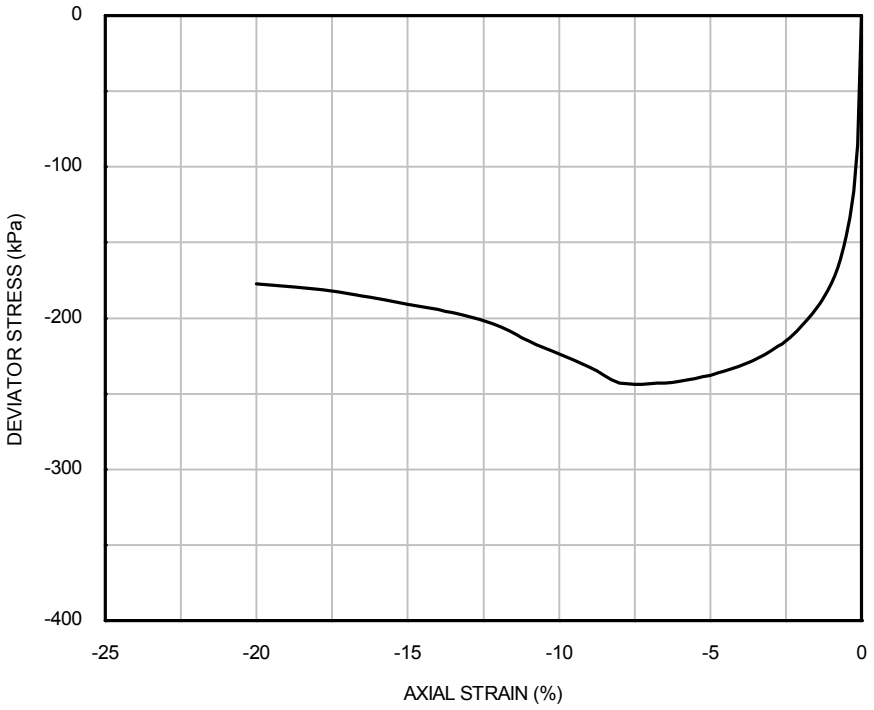


Borehole	BH-WFS3-4A
Sample	3WaxE
Unit	F1c (Dongen)
Depth (m)	24.47
Test number	CIU03

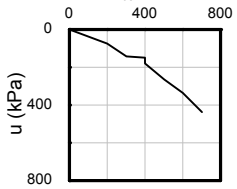
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

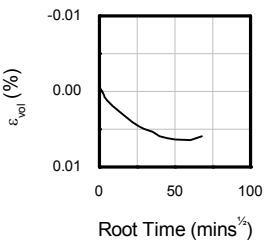
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 18/12/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-4A_3WaxE_IE.OPJ Template Issue: 4.1
Date : 14/01/2016
Date : 14/01/2016
Checked by: PH
Approved by: PH

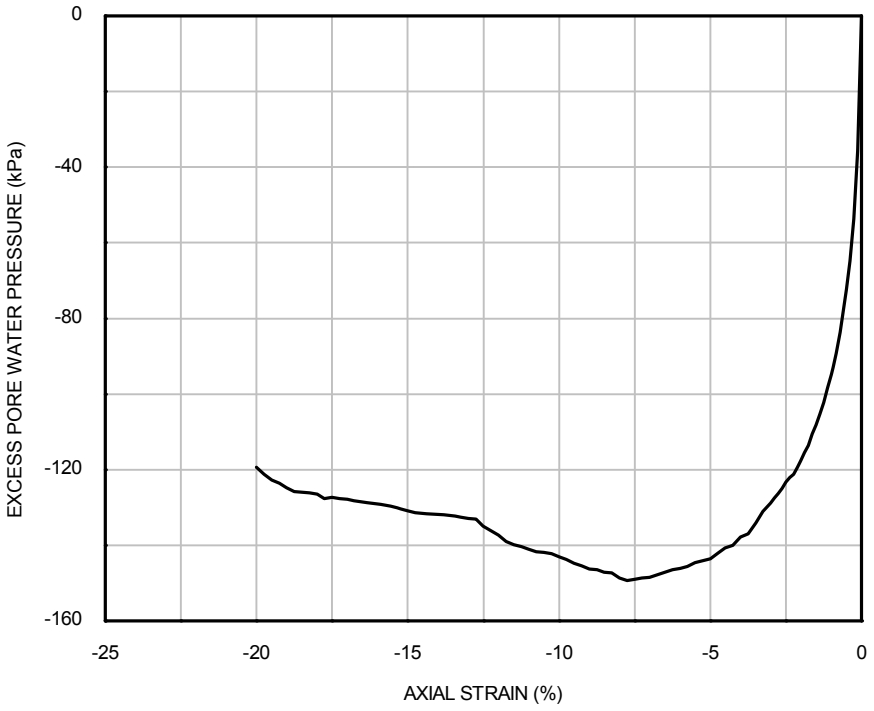


Saturation





Consolidation

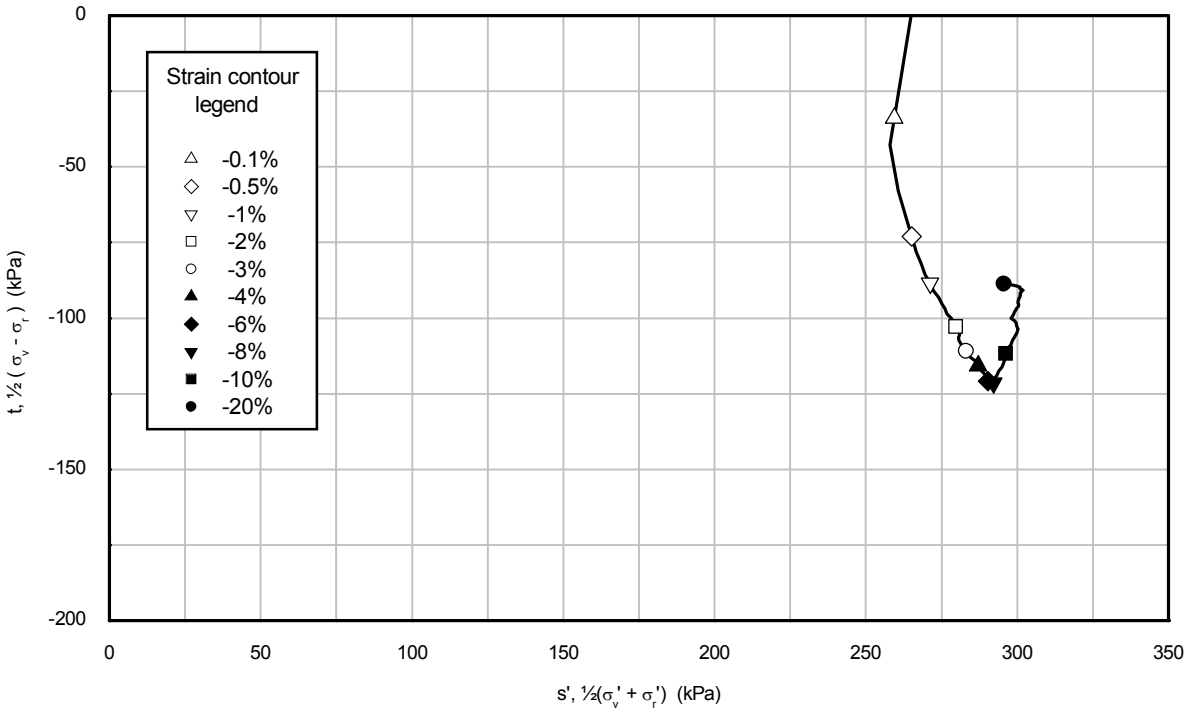


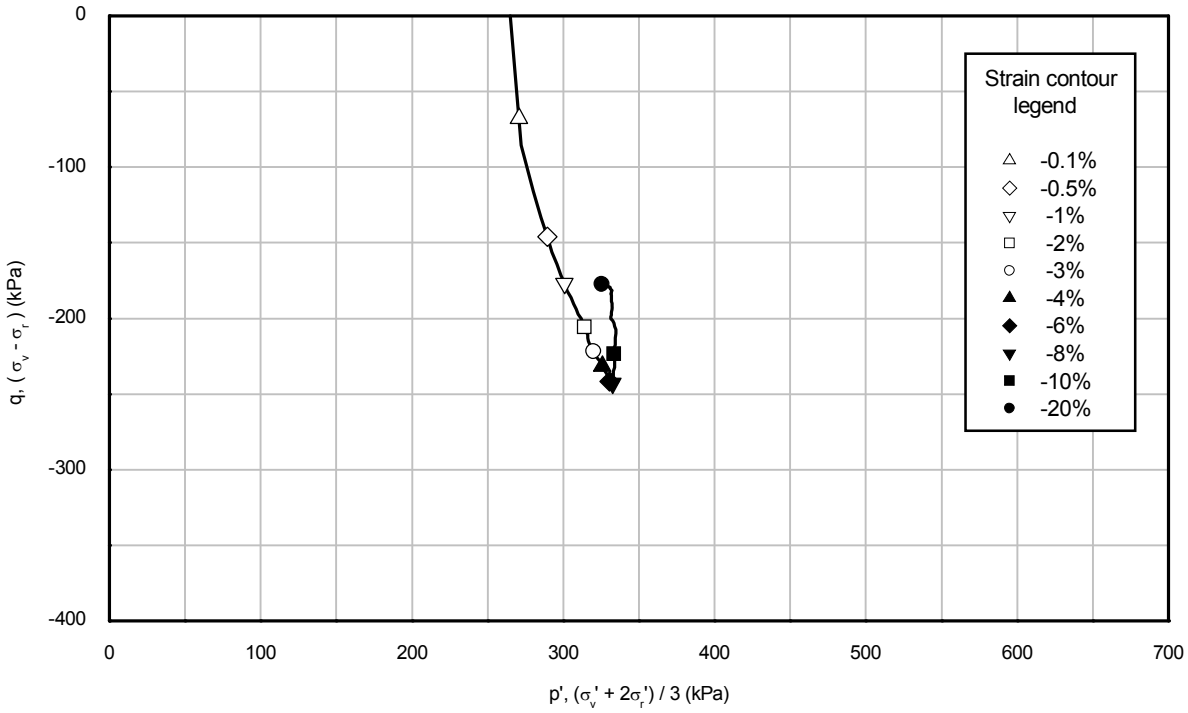
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	240	240

Borehole	: BH-WFS3-4A
Sample	: 3WaxE
Unit	: F1c (Dongen)
Depth (m)	: 24.47
Test number	: CIU03

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	240	240

Borehole	: BH-WFS3-4A
Sample	: 3WaxE
Unit	: F1c (Dongen)
Depth (m)	: 24.47
Test number	: CIU03

Drawn by: ALB Date: 18/12/2015

Filename: J11302 \ EFFECTIV \ BH-WFS3-4A_3WaxE_IE.OPJ

Template Issue: 4.1

Date : 14/01/2016

Checked by: PH

Date : 14/01/2016

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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

Date: 18/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-5_31WaxB_CU.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
High strength greenish grey slightly silty CLAY

GENERAL	
Date test started	29/11/2015
Type of sample	Remoulded
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.9
Length	(mm)	140.2
Moisture content	(%)	33.0
Bulk density	(Mg/m³)	1.92
Dry density	(Mg/m³)	1.44
Void ratio		0.873
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	402
Cell pressure on completion	(kPa)	770
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-WFS3-5
Sample	31WaxB
Unit	F1c (Dongen)
Depth (m)	36.55
Test number	CIU04

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 18/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-5_31WaxB_CU.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
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	(%)	33.0
Bulk density	(Mg/m³)	1.92
Dry density	(Mg/m³)	1.44
Void ratio		0.871
Degree of saturation	(%)	100
Volumetric strain	(%)	0.10

Mode of failure: Brittle failure

Borehole	BH-WFS3-5
Sample	31WaxB
Unit	F1c (Dongen)
Depth (m)	36.55
Test number	CIU04

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 18/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-5_31WaxB_CU.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	370
Rate of strain	(%/hour)	0.42
At peak deviator stress		
Corrected deviator stress	(kPa)	252
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	2.34
Excess pore pressure	(kPa)	121
Major principal effective stress	(kPa)	501
Minor principal effective stress	(kPa)	249
Principal effective stress ratio		2.01
Epsilon 50 (ε 50)	(%)	0.29
Secant modulus (E50) at ε 50	(kPa)	43771
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	252
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	2.34
Excess pore pressure	(kPa)	121
Major principal effective stress	(kPa)	501
Minor principal effective stress	(kPa)	249
Principal effective stress ratio		2.01
At 10% axial strain		
Corrected deviator stress	(kPa)	201
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	65
Major principal effective stress	(kPa)	506
Minor principal effective stress	(kPa)	305
Principal effective stress ratio		1.66

FINAL CONDITIONS		
Moisture content	(%)	33.0
Bulk density	(Mg/m³)	1.92
Dry density	(Mg/m³)	1.44

Borehole	BH-WFS3-5
Sample	31WaxB
Unit	F1c (Dongen)
Depth (m)	36.55
Test number	CIU04

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Drawn by: ALB Date: 18/12/2015

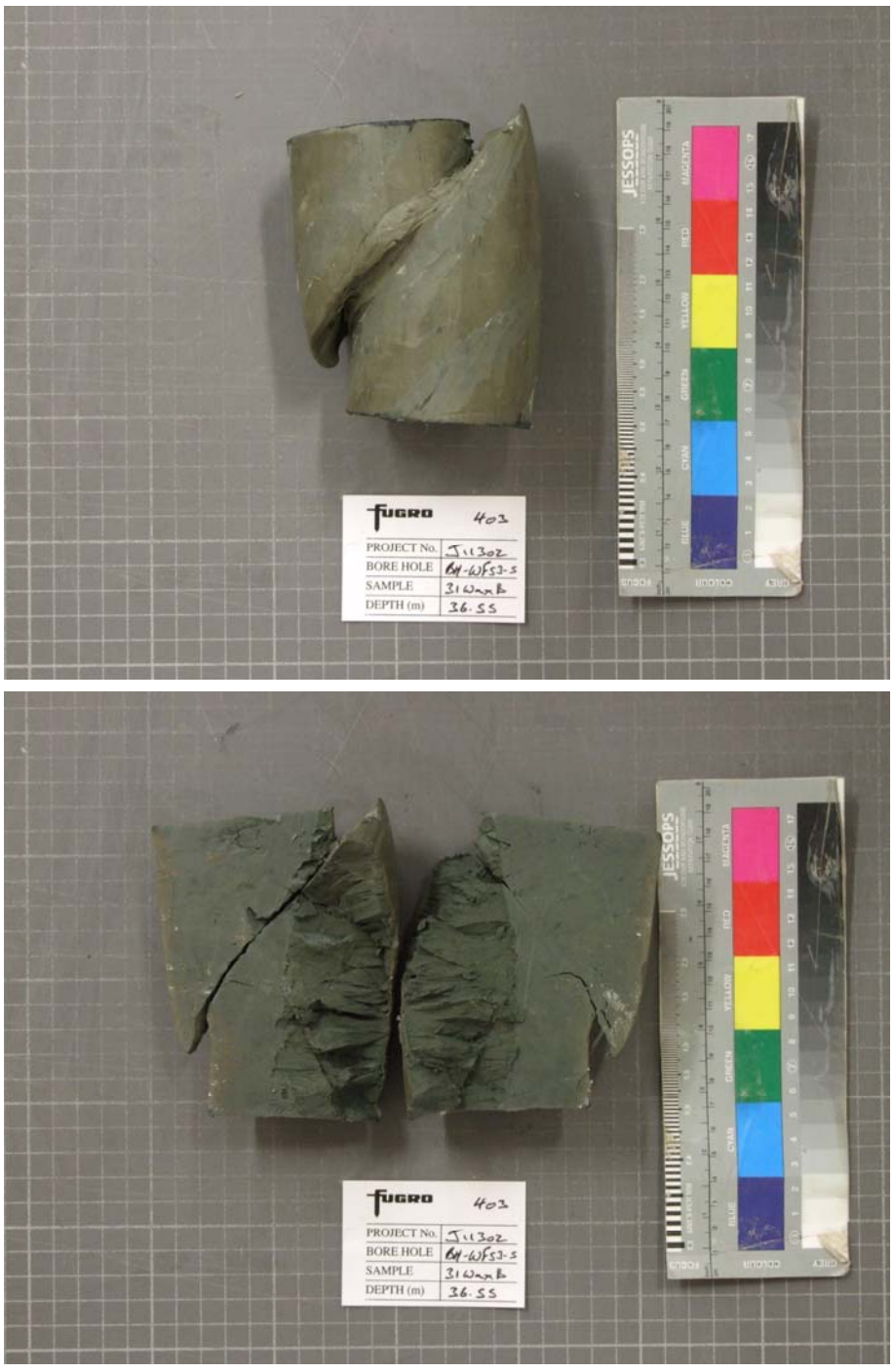
Template Issue: 2

Filename: J11302 / EFFECTIV / BH-WFS3-5_31WaxB_CU.XLS

Checked by: PH Date: 14/01/2016

Approved by: PH Date: 14/01/2016

SPECIMEN PHOTOGRAPHS

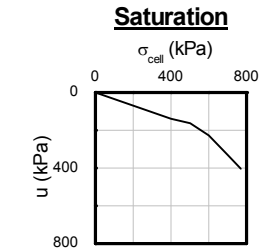


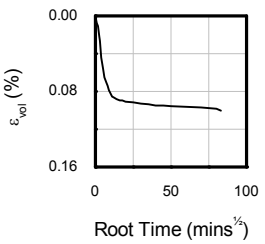
Borehole	BH-WFS3-5
Sample	31WaxB
Unit	F1c (Dongen)
Depth (m)	36.55
Test number	CIU04

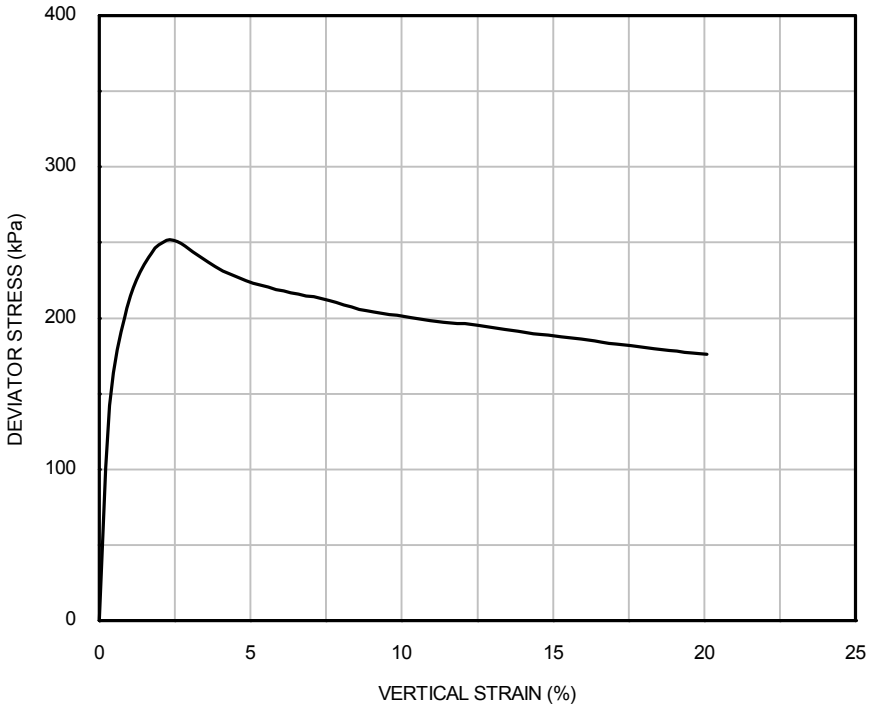
SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

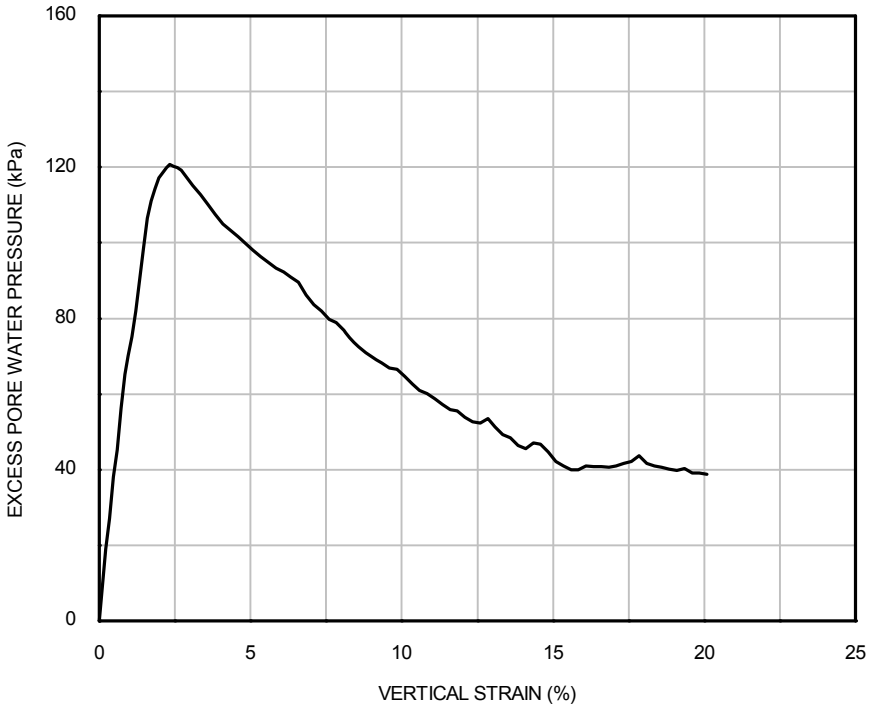
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 18/12/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-5_31WaxB_CU.OPJ
Template Issue: 4.1
Date : 14/01/2016
Checked by: PH
Date : 14/01/2016
Approved by: PH







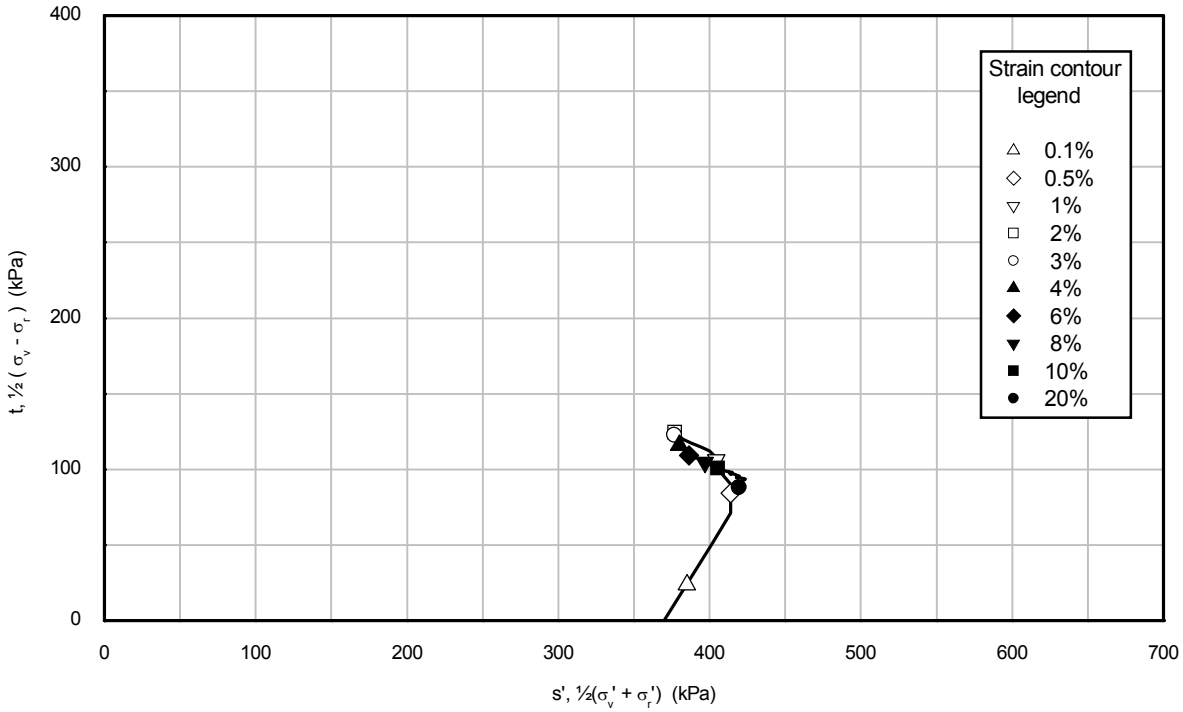


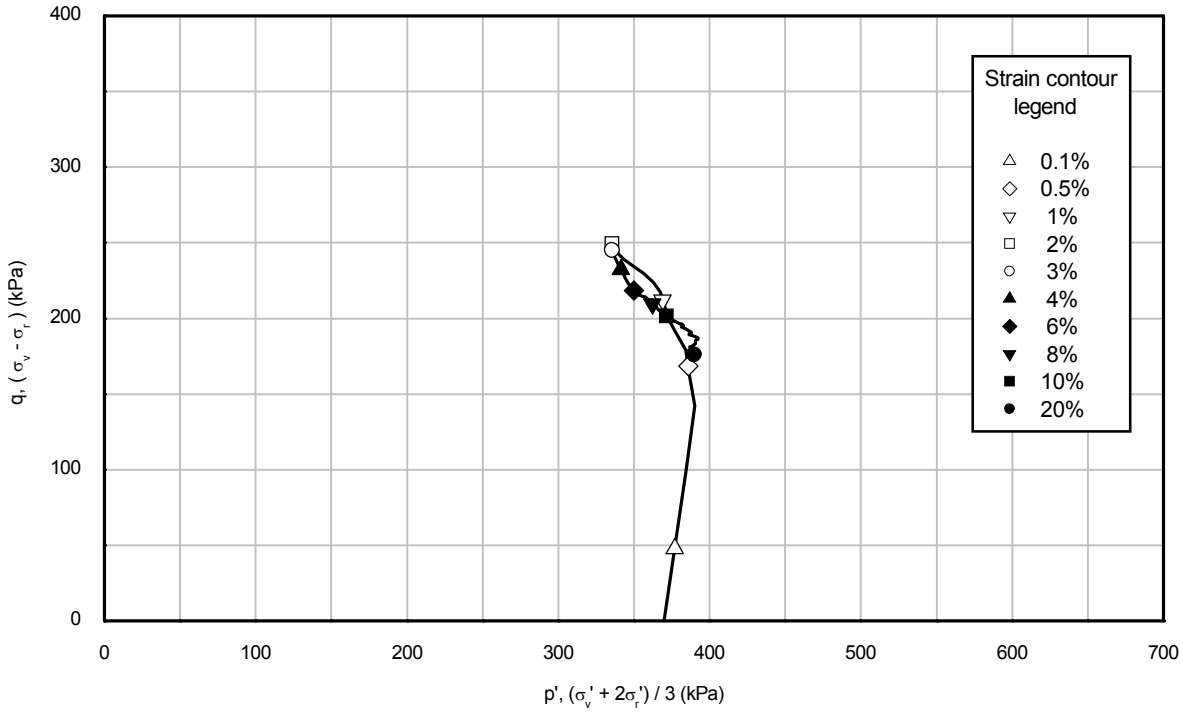
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	370	370

Borehole	: BH-WFS3-5
Sample	: 31WaxB
Unit	: F1c (Dongen)
Depth (m)	: 36.55
Test number	: CIU04

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	370	370

Borehole	: BH-WFS3-5
Sample	: 31WaxB
Unit	: F1c (Dongen)
Depth (m)	: 36.55
Test number	: CIU04

Drawn by: ALB Date: 18/12/2015

Filename: J11302 \ EFFECTIV \ BH-WFS3-5_31WaxB_CU.OPJ

Template Issue: 4.1

Date : 14/01/2016

Checked by: PH

Date : 14/01/2016

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxB_CU.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
Very high strength dark grey slightly silty CLAY

GENERAL	
Date test started	13/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	72.6
Length	(mm)	139.4
Moisture content	(%)	39.1
Bulk density	(Mg/m³)	1.88
Dry density	(Mg/m³)	1.35
Void ratio		0.939
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	426
Cell pressure on completion	(kPa)	810
B value achieved		0.97

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-WFS3-1
Sample	31WaxB
Unit	F3 (Dongen)
Depth (m)	42.15
Test number	CIU05

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxB_CU.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

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	(%)	39.0
Bulk density	(Mg/m³)	1.88
Dry density	(Mg/m³)	1.35
Void ratio		0.936
Degree of saturation	(%)	100
Volumetric strain	(%)	0.12

Mode of failure: Brittle failure

Borehole	BH-WFS3-1
Sample	31WaxB
Unit	F3 (Dongen)
Depth (m)	42.15
Test number	CIU05

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxB_CU.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	410
Rate of strain	(%/hour)	0.31
At peak deviator stress		
Corrected deviator stress	(kPa)	341
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	5.75
Excess pore pressure	(kPa)	167
Major principal effective stress	(kPa)	584
Minor principal effective stress	(kPa)	243
Principal effective stress ratio		2.40
Epsilon 50 (ε 50)	(%)	0.24
Secant modulus (E50) at ε 50	(kPa)	70877
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	339
Membrane correction applied	(kPa)	0.4
Drain correction applied	(kPa)	0
Axial strain	(%)	4.25
Excess pore pressure	(kPa)	175
Major principal effective stress	(kPa)	574
Minor principal effective stress	(kPa)	235
Principal effective stress ratio		2.44
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)	136
Major principal effective stress	(kPa)	590
Minor principal effective stress	(kPa)	274
Principal effective stress ratio		2.16

FINAL CONDITIONS		
Moisture content	(%)	39.0
Bulk density	(Mg/m³)	1.88
Dry density	(Mg/m³)	1.35

Borehole	BH-WFS3-1
Sample	31WaxB
Unit	F3 (Dongen)
Depth (m)	42.15
Test number	CIU05

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxB_CU.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SPECIMEN PHOTOGRAPHS



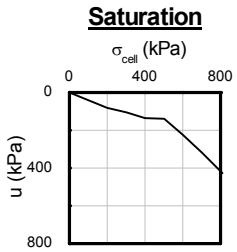


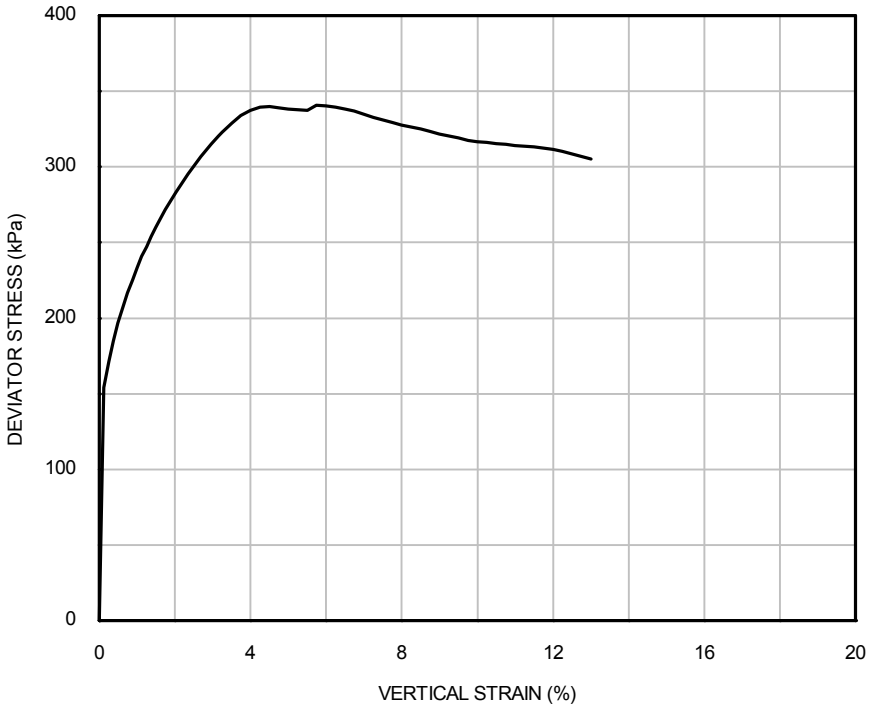
Borehole	BH-WFS3-1
Sample	31WaxB
Unit	F3 (Dongen)
Depth (m)	42.15
Test number	CIU05

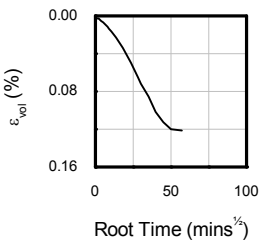
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

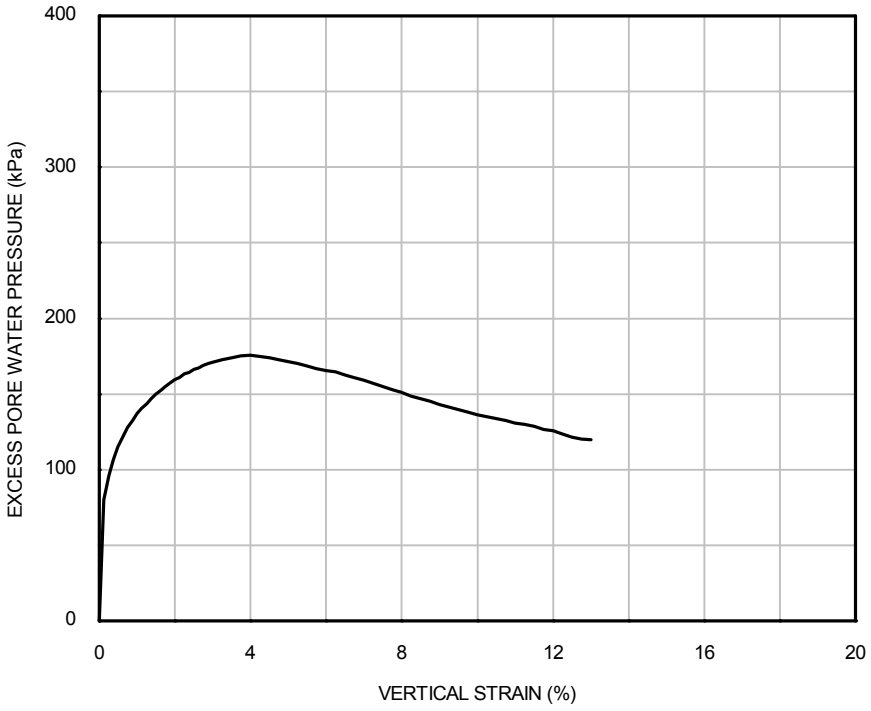
Drawn by: ALB Date: 07/12/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-1_31WaxB_CU.OPJ
Template Issue: 4.1
Date : 14/01/2016
Checked by: PH
Date : 14/01/2016
Approved by: PH







Consolidation

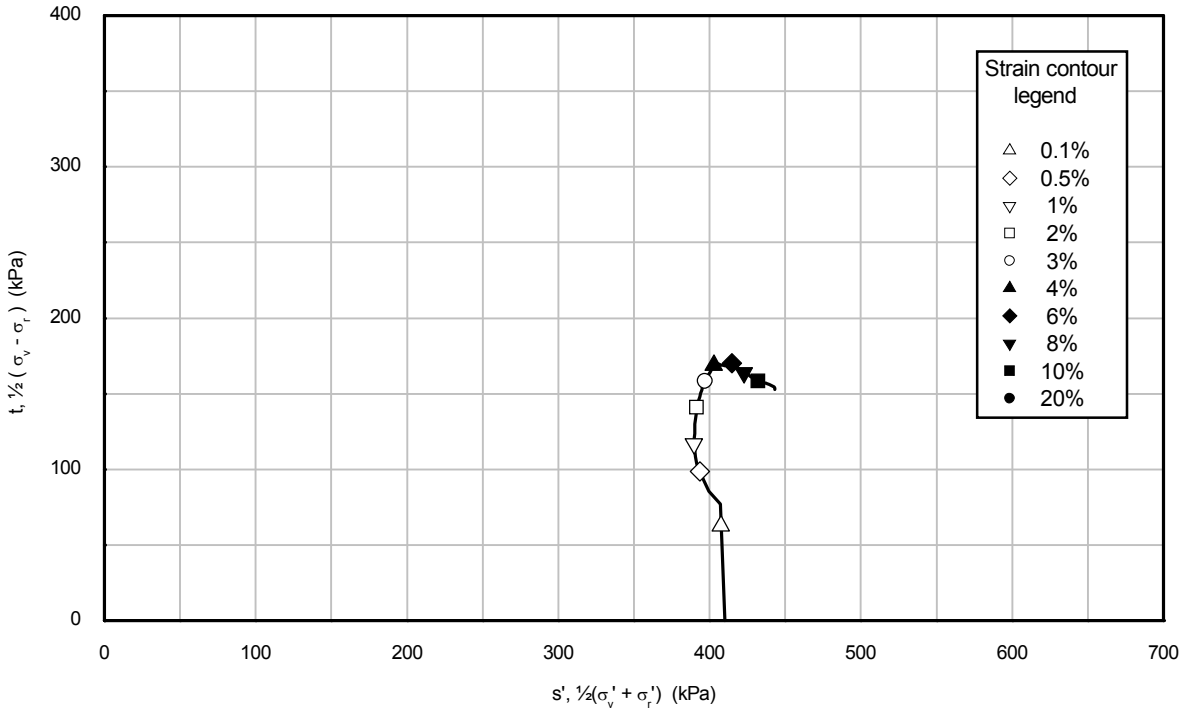


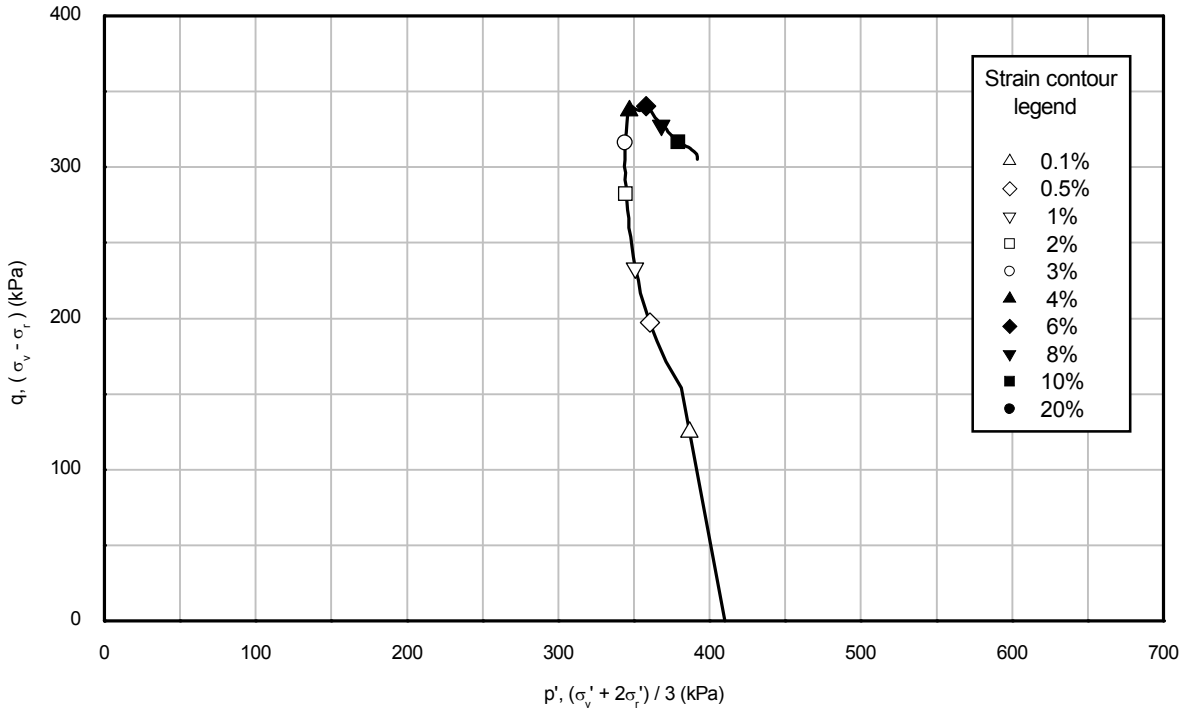
Curve	Specimen	σrc' (kPa)	σvc' (kPa)
——	1	410	410

Borehole	: BH-WFS3-1
Sample	: 31WaxB
Unit	: F3 (Dongen)
Depth (m)	: 42.15
Test number	: CIU05

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	410	410

Borehole	: BH-WFS3-1
Sample	: 31WaxB
Unit	: F3 (Dongen)
Depth (m)	: 42.15
Test number	: CIU05

Drawn by: ALB Date: 07/12/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-1_31WaxB_CU.OPJ
Template Issue: 4.1
Date : 14/01/2016
Checked by: PH
Date : 14/01/2016
Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxC_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
Very high strength dark greenish grey CLAY

GENERAL	
Date test started	16/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	70.9
Length	(mm)	126.8
Moisture content	(%)	37.1
Bulk density	(Mg/m³)	1.89
Dry density	(Mg/m³)	1.38
Void ratio		0.961
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	412
Cell pressure on completion	(kPa)	810
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 5.3
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-WFS3-1
Sample	31WaxC
Unit	F3 (Dongen)
Depth (m)	43.37
Test number	CIU06

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxC_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

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	(%)	37.1
Bulk density	(Mg/m³)	1.89
Dry density	(Mg/m³)	1.38
Void ratio		0.960
Degree of saturation	(%)	100
Volumetric strain	(%)	0.05

Mode of failure: Necking failure

Borehole	BH-WFS3-1
Sample	31WaxC
Unit	F3 (Dongen)
Depth (m)	43.37
Test number	CIU06

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxC_IE.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	410
Rate of strain	(%/hour)	0.50
At peak deviator stress		
Corrected deviator stress	(kPa)	-305
Membrane correction applied	(kPa)	-0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	-2.12
Excess pore pressure	(kPa)	-154
Major principal effective stress	(kPa)	260
Minor principal effective stress	(kPa)	564
Principal effective stress ratio		0.46
Epsilon 50 (ε 50)	(%)	-0.25
Secant modulus (E50) at ε 50	(kPa)	60792
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	-304
Membrane correction applied	(kPa)	-0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	-1.87
Excess pore pressure	(kPa)	-150
Major principal effective stress	(kPa)	256
Minor principal effective stress	(kPa)	560
Principal effective stress ratio		0.46
At -10% axial strain		
Corrected deviator stress	(kPa)	-217
Membrane correction applied	(kPa)	-1.2
Drain correction applied	(kPa)	0
Axial strain	(%)	-10.00
Excess pore pressure	(kPa)	-152
Major principal effective stress	(kPa)	345
Minor principal effective stress	(kPa)	562
Principal effective stress ratio		0.61

FINAL CONDITIONS		
Moisture content	(%)	37.1
Bulk density	(Mg/m³)	1.89
Dry density	(Mg/m³)	1.38

Borehole	BH-WFS3-1
Sample	31WaxC
Unit	F3 (Dongen)
Depth (m)	43.37
Test number	CIU06

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-1_31WaxC_IE.XLS
Checked by: PH Date: 14/01/2016
Approved by: PH Date: 14/01/2016

SPECIMEN PHOTOGRAPHS



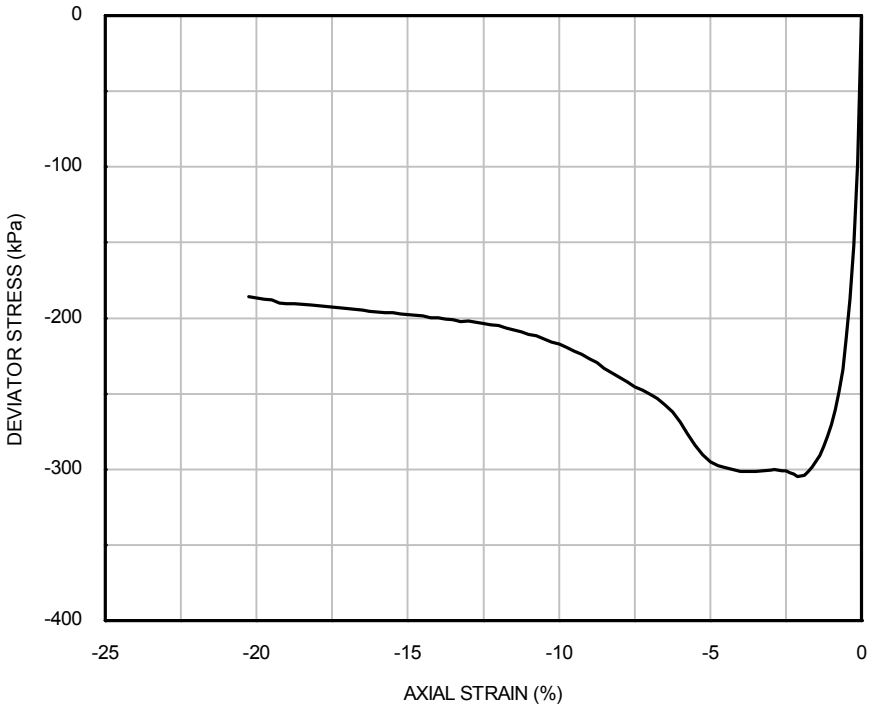


Borehole	BH-WFS3-1
Sample	31WaxC
Unit	F3 (Dongen)
Depth (m)	43.37
Test number	CIU06

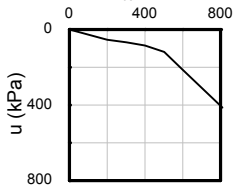
SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

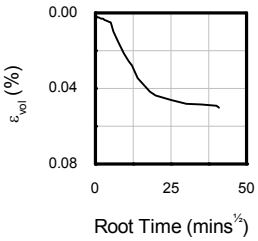
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 07/12/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-1_31WaxC_IE.OPJ
Template Issue: 4.1
Date : 14/01/2016
Checked by: PH
Date : 14/01/2016
Approved by: PH

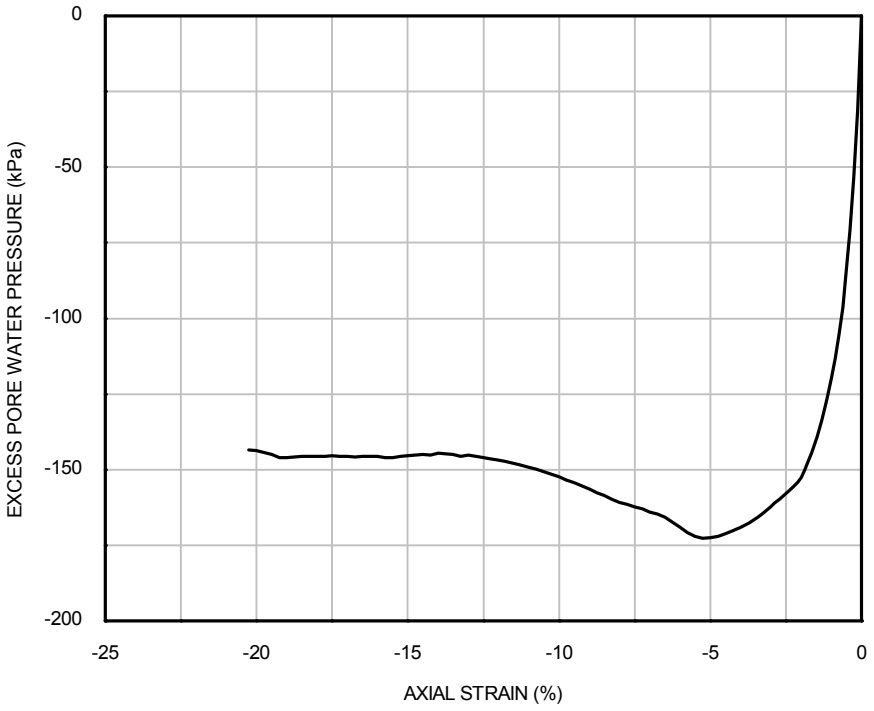


Saturation





Consolidation

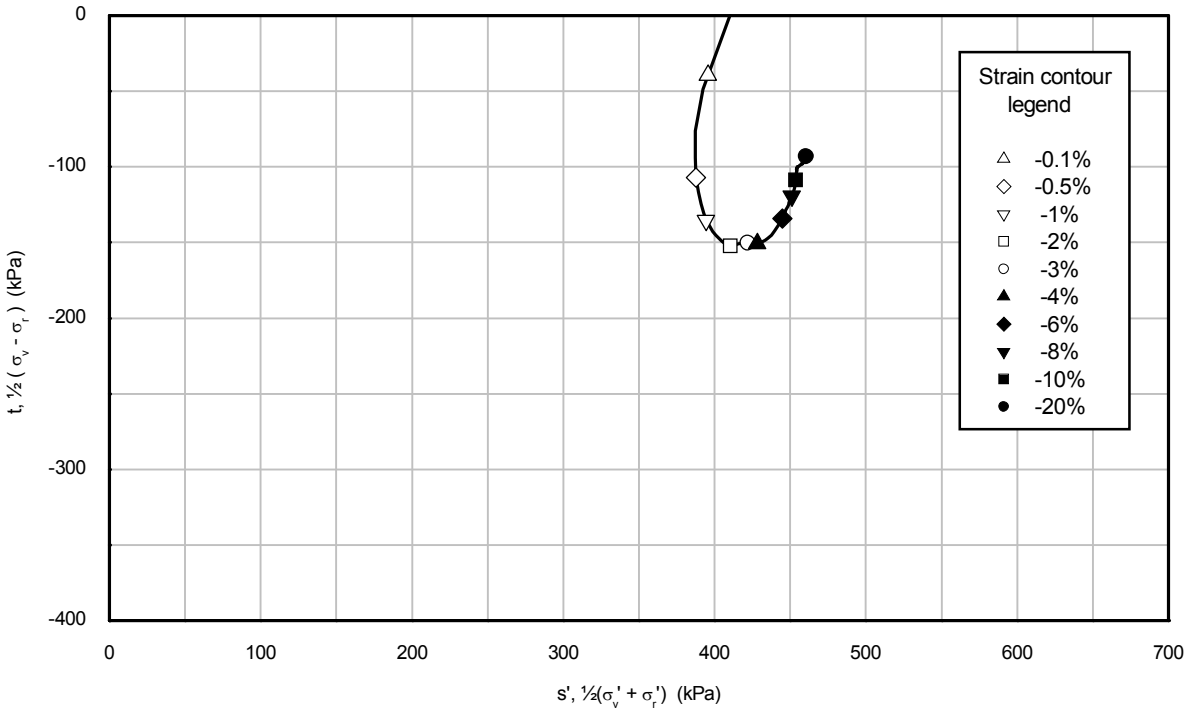


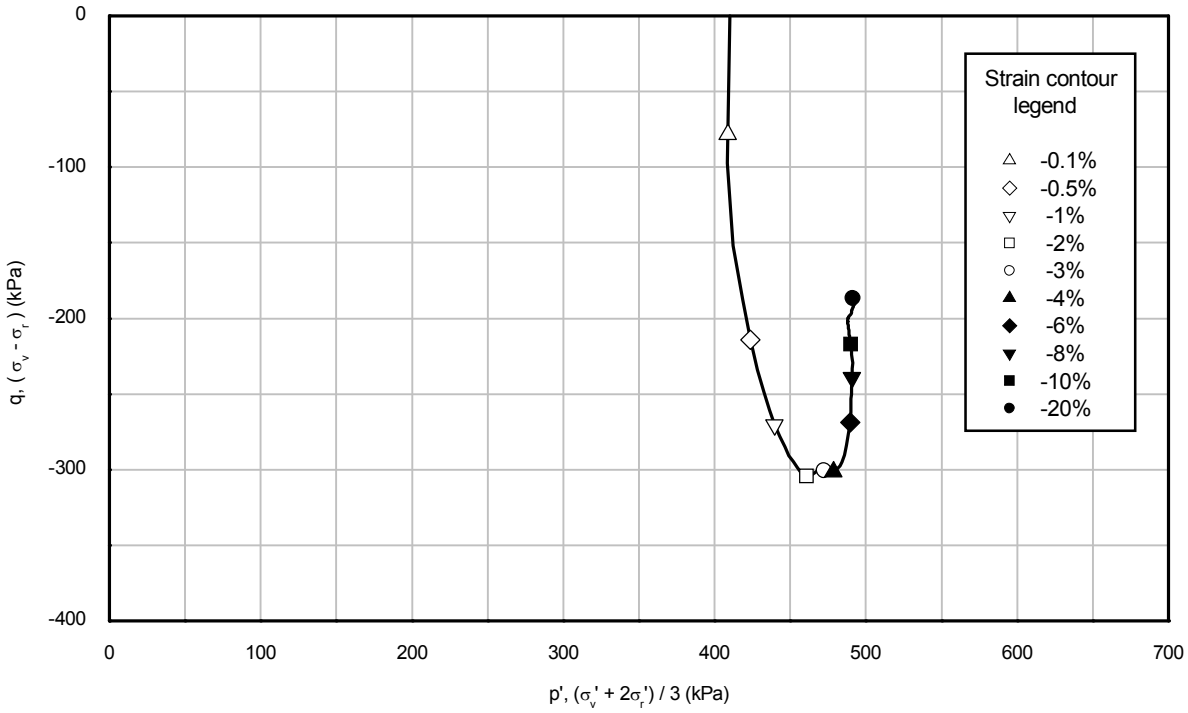
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	410	410

Borehole	: BH-WFS3-1
Sample	: 31WaxC
Unit	: F3 (Dongen)
Depth (m)	: 43.37
Test number	: CIU06

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	410	410

Borehole	: BH-WFS3-1
Sample	: 31WaxC
Unit	: F3 (Dongen)
Depth (m)	: 43.37
Test number	: CIU06

Drawn by: ALB Date: 07/12/2015

Filename: J11302 \ EFFECTIV \ BH-WFS3-1_31WaxC_IE.OPJ

Template Issue: 4.1

Date : 14/01/2016

Checked by: PH

Date : 14/01/2016

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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

Date: 04/01/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxC_CU.XLS
Template Issue: 2
Date: 13/01/2016
Checked by: PJS
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
High strength dark greenish grey CLAY

GENERAL	
Date test started	02/12/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.7
Length	(mm)	139.8
Moisture content	(%)	37.0
Bulk density	(Mg/m³)	1.85
Dry density	(Mg/m³)	1.35
Void ratio		1.001
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	350
Pore pressure on completion	(kPa)	510
Cell pressure on completion	(kPa)	855
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-WFS3-4A
Sample	9WaxC
Unit	F3 (Dongen)
Depth (m)	39.38
Test number	CIU07

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 04/01/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxC_CU.XLS
Date: 13/01/2016
Checked by: PJS
Date: 14/01/2016
Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	855
Back pressure	(kPa)	500
Effective cell pressure	(kPa)	355
Pore pressure on completion	(kPa)	500
Pore pressure dissipation	(%)	100
Moisture content	(%)	37.0
Bulk density	(Mg/m³)	1.85
Dry density	(Mg/m³)	1.35
Void ratio		1.000
Degree of saturation	(%)	100
Volumetric strain	(%)	0.02

Mode of failure: Brittle failure

Borehole	BH-WFS3-4A
Sample	9WaxC
Unit	F3 (Dongen)
Depth (m)	39.38
Test number	CIU07

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 04/01/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxC_CU.XLS
Date: 13/01/2016
Checked by: PJS
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	500
Initial effective cell pressure	(kPa)	355
Rate of strain	(%/hour)	0.23
At peak deviator stress		
Corrected deviator stress	(kPa)	263
Membrane correction applied	(kPa)	0.1
Drain correction applied	(kPa)	0
Axial strain	(%)	1.00
Excess pore pressure	(kPa)	120
Major principal effective stress	(kPa)	498
Minor principal effective stress	(kPa)	235
Principal effective stress ratio		2.12
Epsilon 50 (ε 50)	(%)	0.12
Secant modulus (E50) at ε 50	(kPa)	113605
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	261
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	1.63
Excess pore pressure	(kPa)	126
Major principal effective stress	(kPa)	490
Minor principal effective stress	(kPa)	229
Principal effective stress ratio		2.14
At 10% axial strain		
Corrected deviator stress	(kPa)	246
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	64
Major principal effective stress	(kPa)	537
Minor principal effective stress	(kPa)	291
Principal effective stress ratio		1.84

FINAL CONDITIONS		
Moisture content	(%)	37.0
Bulk density	(Mg/m³)	1.85
Dry density	(Mg/m³)	1.35

Borehole	BH-WFS3-4A
Sample	9WaxC
Unit	F3 (Dongen)
Depth (m)	39.38
Test number	CIU07

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Checked by: PJS Date: 13/01/2016 Template Issue: 2 Drawn by: ALB Date: 04/01/2015

Approved by: PH Date: 14/01/2016 Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxC_CU.XLS

SPECIMEN PHOTOGRAPHS

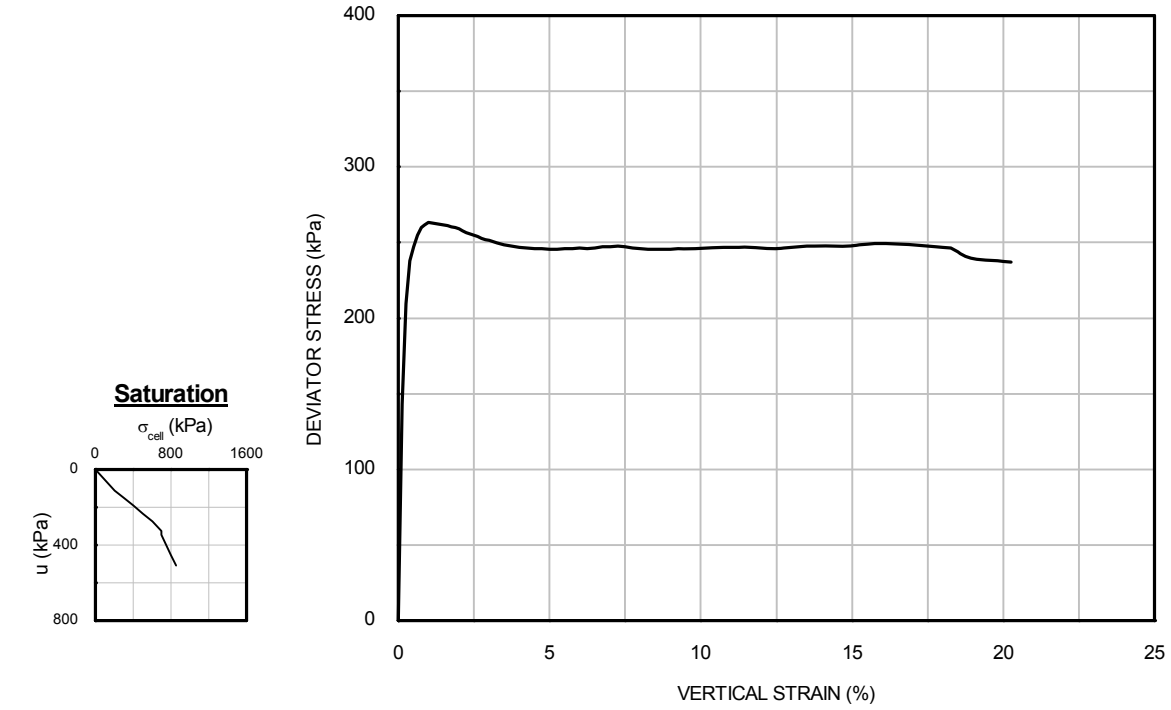


Borehole	BH-WFS3-4A
Sample	9WaxC
Unit	F3 (Dongen)
Depth (m)	39.38
Test number	CIU07

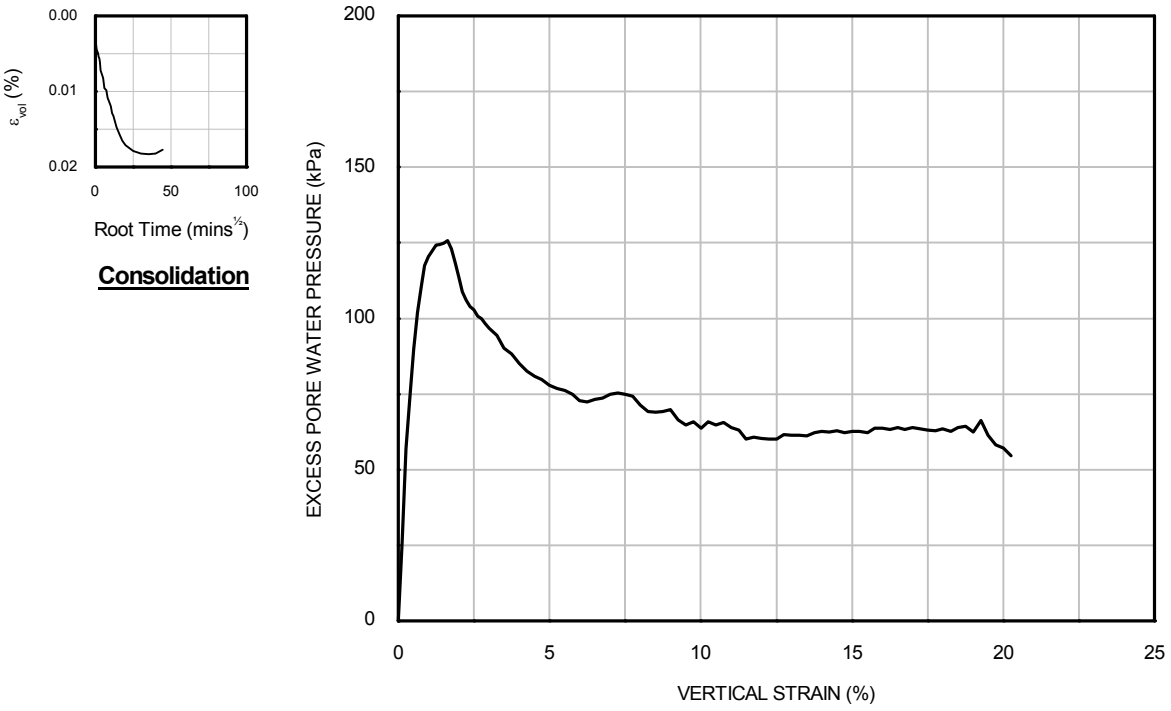
SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Drawn by: ALB Date: 04/01/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-4A_9WaxC_CU.OPJ
Template Issue: 4.1
Date : 14/01/2016
Checked by: PH
Date : 14/01/2016
Approved by: PH



Saturation



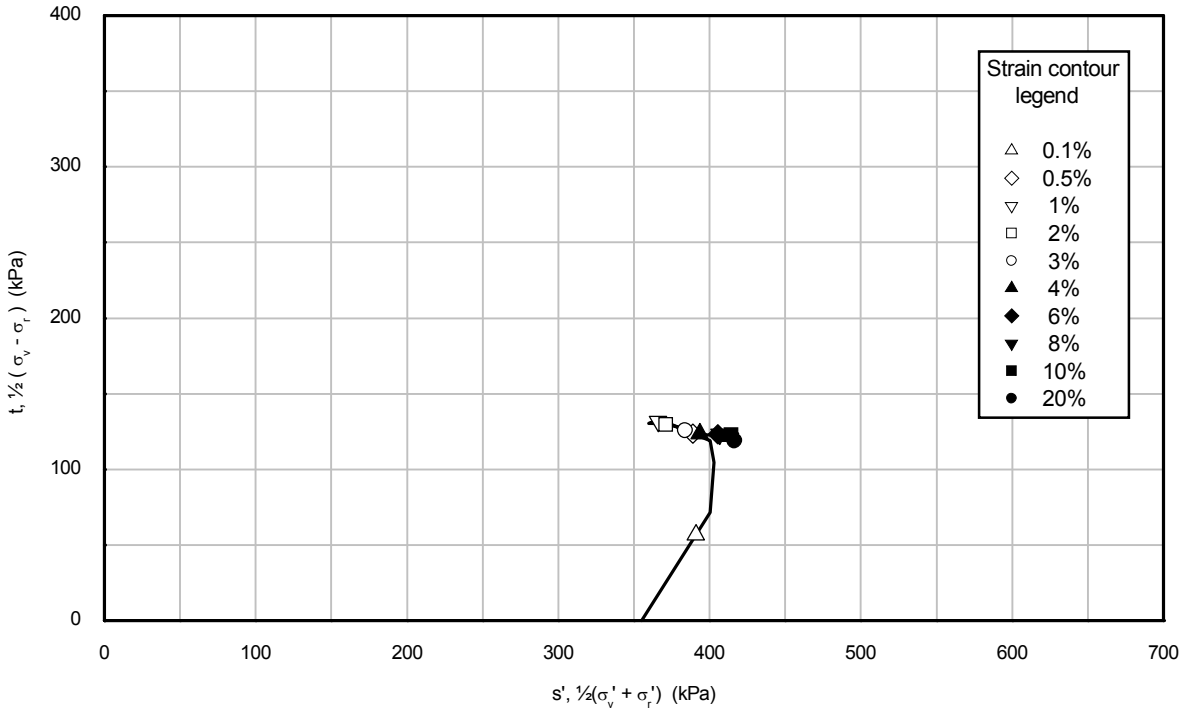
Consolidation

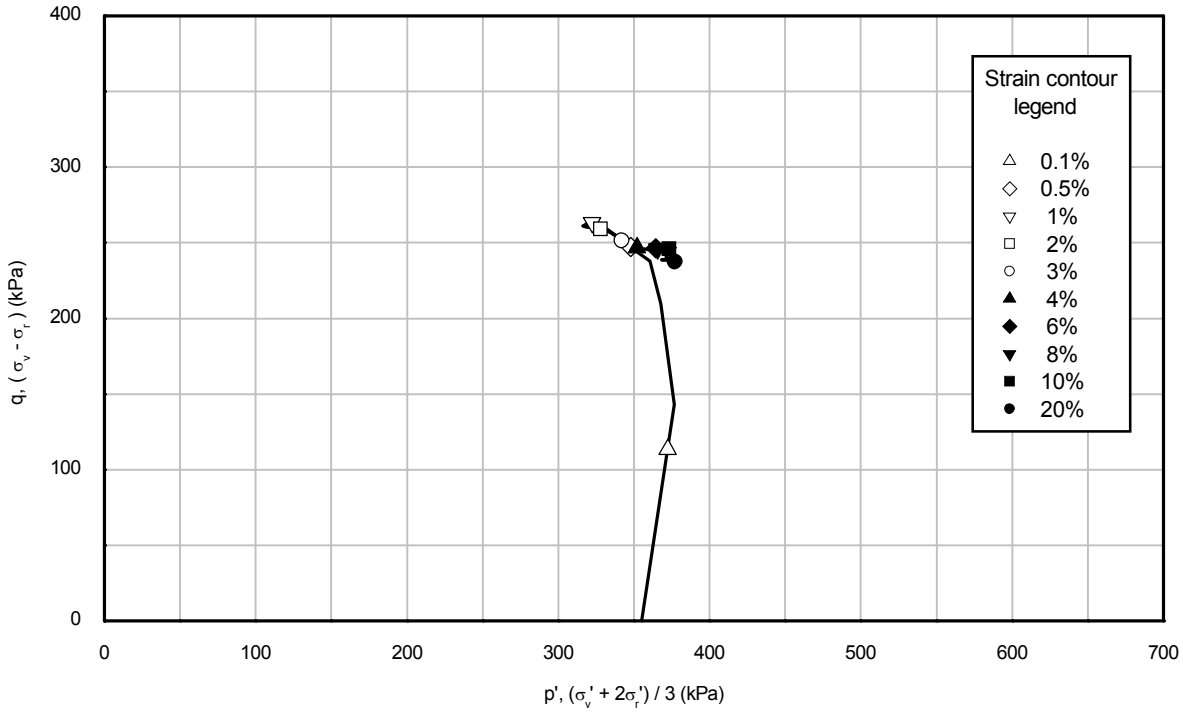
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	355	355

Borehole	: BH-WFS3-4A
Sample	: 9WaxC
Unit	: F3 (Dongen)
Depth (m)	: 39.38
Test number	: CIU07

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	355	355

Borehole	: BH-WFS3-4A
Sample	: 9WaxC
Unit	: F3 (Dongen)
Depth (m)	: 39.38
Test number	: CIU07

Drawn by: ALB Date: 04/01/2015

Filename: J11302 \ EFFECTIV \ BH-WFS3-4A_9WaxC_CU.OPJ

Template Issue: 4.1

Date : 14/01/2016

Checked by: PH

Date : 14/01/2016

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxB_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
High strength dark greenish grey CLAY

GENERAL	
Date test started	16/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	72.1
Length	(mm)	126.8
Moisture content	(%)	51.9
Bulk density	(Mg/m³)	1.79
Dry density	(Mg/m³)	1.18
Void ratio		1.291
Degree of saturation	(%)	100

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	635
Cell pressure on completion	(kPa)	810
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 5.3
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-WFS3-4A
Sample	9WaxB
Unit	F3 (Dongen)
Depth (m)	39.13
Test number	CIU08

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxB_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

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	(%)	49.7
Bulk density	(Mg/m³)	1.81
Dry density	(Mg/m³)	1.21
Void ratio		1.232
Degree of saturation	(%)	100
Volumetric strain	(%)	2.58

Mode of failure: Necking failure

Borehole	BH-WFS3-4A
Sample	9WaxB
Unit	F3 (Dongen)
Depth (m)	39.13
Test number	CIU08

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxB_IE.XLS
Template Issue: 2
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	450
Initial effective cell pressure	(kPa)	360
Rate of strain	(%/hour)	1.33
At peak deviator stress		
Corrected deviator stress	(kPa)	-204
Membrane correction applied	(kPa)	-0.4
Drain correction applied	(kPa)	0
Axial strain	(%)	-5.00
Excess pore pressure	(kPa)	-40
Major principal effective stress	(kPa)	196
Minor principal effective stress	(kPa)	400
Principal effective stress ratio		0.49
Epsilon 50 (ε 50)	(%)	-0.23
Secant modulus (E50) at ε 50	(kPa)	44595
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	-204
Membrane correction applied	(kPa)	-0.4
Drain correction applied	(kPa)	0
Axial strain	(%)	-5.00
Excess pore pressure	(kPa)	-40
Major principal effective stress	(kPa)	196
Minor principal effective stress	(kPa)	400
Principal effective stress ratio		0.49
At -10% axial strain		
Corrected deviator stress	(kPa)	-178
Membrane correction applied	(kPa)	-0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	-10.00
Excess pore pressure	(kPa)	-32
Major principal effective stress	(kPa)	214
Minor principal effective stress	(kPa)	392
Principal effective stress ratio		0.55

FINAL CONDITIONS		
Moisture content	(%)	49.7
Bulk density	(Mg/m³)	1.81
Dry density	(Mg/m³)	1.21

Borehole	BH-WFS3-4A
Sample	9WaxB
Unit	F3 (Dongen)
Depth (m)	39.13
Test number	CIU08

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL EXTENSION TEST : SINGLE SPECIMEN

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

Date: 07/12/2015
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / BH-WFS3-4A_9WaxB_IE.XLS
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SPECIMEN PHOTOGRAPHS



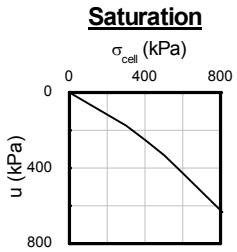


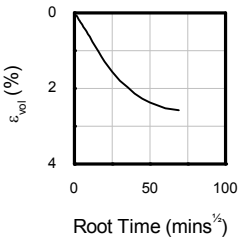
Borehole	BH-WFS3-4A
Sample	9WaxB
Unit	F3 (Dongen)
Depth (m)	39.13
Test number	CIU08

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

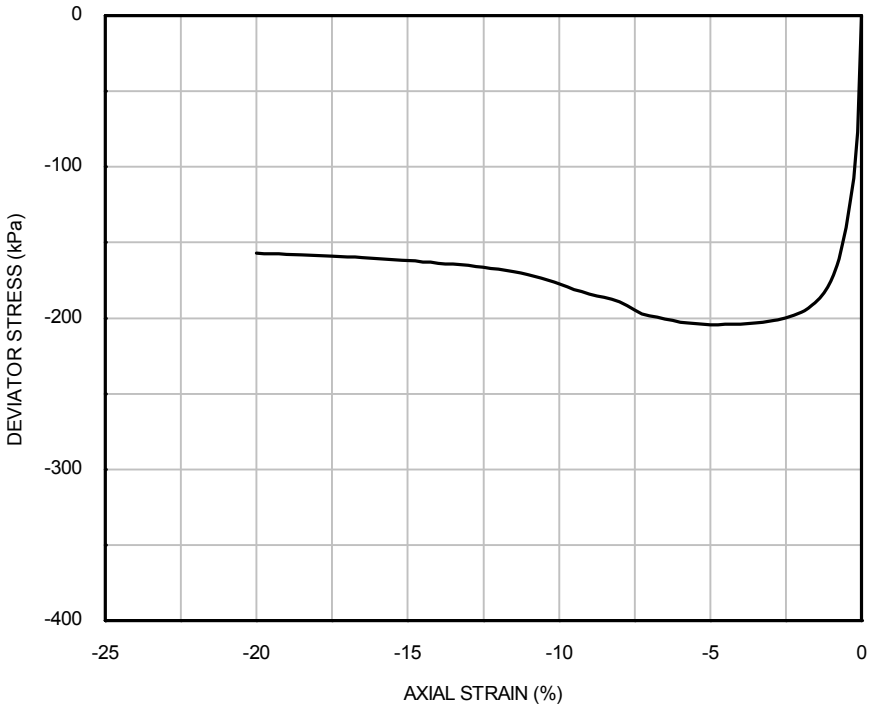
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

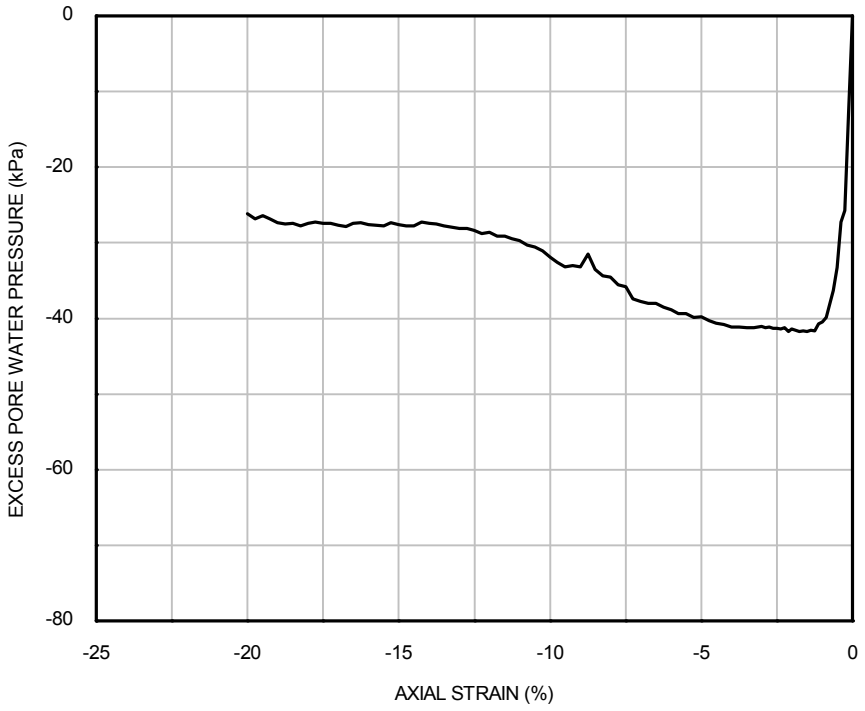
Drawn by: ALB Date: 07/12/2015
Filename: J11302 \ EFFECTIV \ BH-WFS3-4A_9WaxB_IE.OPJ
Template Issue: 4.1
Date : 14/01/2016
Checked by: PH
Date : 14/01/2016
Approved by: PH





Consolidation



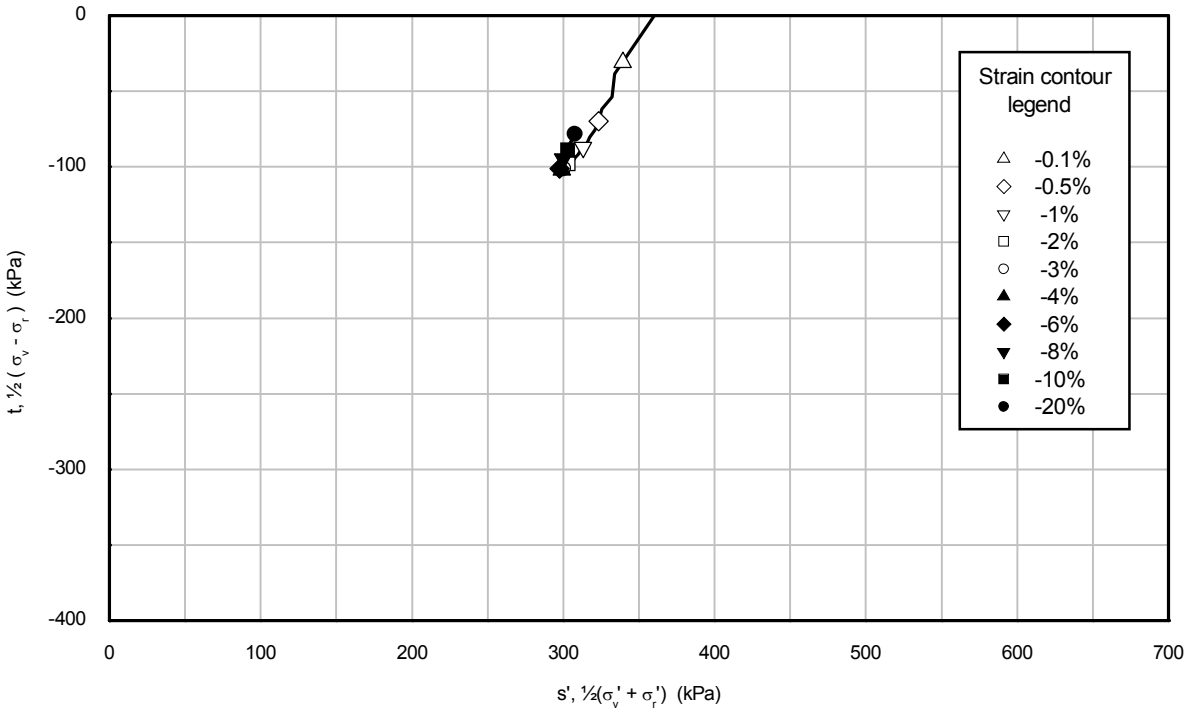


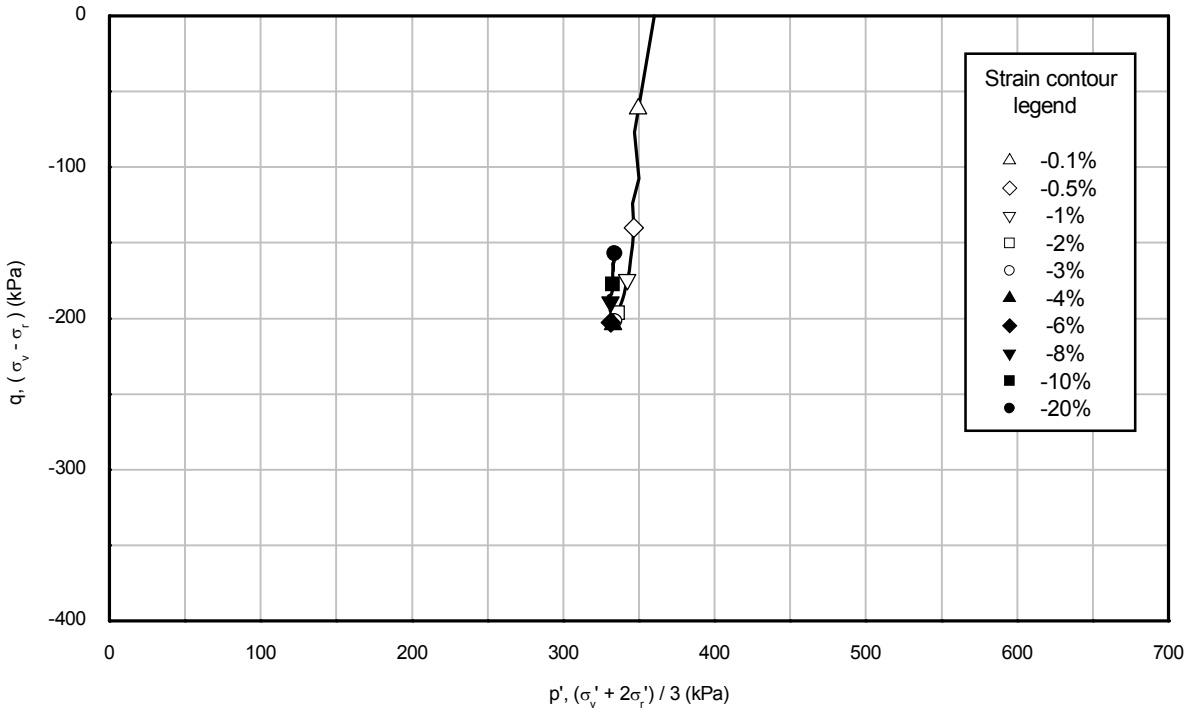
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	360	360

Borehole	: BH-WFS3-4A
Sample	: 9WaxB
Unit	: F3 (Dongen)
Depth (m)	: 39.13
Test number	: CIU08

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	360	360

Borehole	: BH-WFS3-4A
Sample	: 9WaxB
Unit	: F3 (Dongen)
Depth (m)	: 39.13
Test number	: CIU08

Drawn by: ALB Date: 07/12/2015

Filename: J11302 \ EFFECTIV \ BH-WFS3-4A_9WaxB_IE.OPJ

Template Issue: 4.1

Date : 14/01/2016

Checked by: PH

Date : 14/01/2016

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL EXTENSION TEST: SINGLE SPECIMEN

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

Date: 13/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / BH-WFS4-
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

VISUAL DESCRIPTION
High strength dark greenish grey CLAY

GENERAL	
Date test started	20/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	[mm]	71.4
Length	[mm]	139.7
Moisture content	[%]	37.1
Bulk density	[Mg/m³]	1.85
Dry density	[Mg/m³]	1.35
Void ratio		1.002
Degree of saturation	[%]	100

SATURATION		
Pressure increments applied	[kPa]	100
Differential pressure used	[kPa]	N/A
Pore pressure on completion	[kPa]	567
Cell pressure on completion	[kPa]	845
B value achieved		1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.4 Fugro testing procedure L-T-023 Clause 5.3.7
Consolidation - Isotropic Consolidation - Anisotropic	BS 1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH-WFS4-1A
Sample	22WaxB
Unit	F3 (Dongen)
Depth [m]	37.06
Test number	CIU09

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

CONSOLIDATION : ISOTROPIC		
Cell pressure	[kPa]	845
Back pressure	[kPa]	500
Effective cell pressure	[kPa]	345
Pore pressure on completion	[kPa]	500
Pore pressure dissipation	[%]	100
Moisture content	[%]	36.8
Bulk density	[Mg/m³]	1.85
Dry density	[Mg/m³]	1.35
Void ratio		0.994
Degree of saturation	[%]	100
Volumetric strain	[%]	0.41
Axial strain	[%]	0.14

Drawn by: ALB Date: 13/01/2016

Template Issue: 3 Filename: J11302 / EFFECTIVE / BH-WFS4-

Checked by: PH Date: 14/01/2016

Approved by: PH Date: 14/01/2016

Borehole	BH-WFS4-1A
Sample	22WaxB
Unit	F3 (Dongen)
Depth [m]	37.06
Test number	CIU09

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 13/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / BH-WFS4-
Date: 14/01/2016
Date: 14/01/2016
Checked by: PH
Approved by: PH

BENDER ELEMENT DETERMINATIONS - POST SATURATION		
Bulk density	[Mg/m^3]	1.85
Dry density	[Mg/m^3]	1.35
Void ratio	[-]	1.002
Distance	[mm]	136.80
Effective radial pressure	[kPa]	278
Effective axial pressure	[kPa]	278

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	0.5670	2.84	241.27	107.6
0.30	0.5870	1.96	233.05	100.4
0.40	0.6110	1.53	223.90	92.6
0.50	0.5810	1.16	235.46	102.5
0.60	0.5635	0.94	242.77	108.9
0.70	0.5715	0.82	239.37	105.9
0.80	0.6185	0.77	221.18	90.4
0.90	0.5830	0.65	234.65	101.8

BENDER ELEMENT DETERMINATIONS - POST ISOTROPIC CONSOLIDATION		
Bulk density	[Mg/m^3]	1.85
Dry density	[Mg/m^3]	1.35
Void ratio	[-]	0.994
Distance	[mm]	136.61
Effective radial pressure	[kPa]	345
Effective axial pressure	[kPa]	345

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	0.5465	2.73	249.97	115.7
0.30	0.5820	1.94	234.72	102.0
0.40	0.5755	1.44	237.38	104.3
0.50	0.5730	1.15	238.41	105.2
0.60	0.5915	0.99	230.95	98.8
0.70	0.5860	0.84	233.12	100.6
0.80	0.5860	0.73	233.12	100.6
0.90	0.5960	0.66	229.21	97.3

Borehole	BH-WFS4-1A
Sample	22WaxB
Unit	F3 (Dongen)
Depth [m]	37.06
Test number	CIU09

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 13/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / BH-WFS4-
Date: 14/01/2016
Checked by: PH
Date: 14/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	[kPa]	500
Initial effective cell pressure	[kPa]	345
Rate of strain	[%/hour]	0.28
At peak deviator stress		
Corrected deviator stress	[kPa]	598
Membrane correction applied	[kPa]	0.5
Drain correction applied	[kPa]	0
Axial strain	[%]	5.00
Excess pore pressure	[kPa]	171
Major principal effective stress	[kPa]	771
Minor principal effective stress	[kPa]	174
Principal effective stress ratio		4.44
Epsilon 50 [ε 50]	[%]	1.03
Secant modulus [E50] at ε 50	[kPa]	28927
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	561
Membrane correction applied	[kPa]	0.4
Drain correction applied	[kPa]	0
Axial strain	[%]	3.25
Excess pore pressure	[kPa]	198
Major principal effective stress	[kPa]	708
Minor principal effective stress	[kPa]	147
Principal effective stress ratio		4.82
At 10% axial strain		
Corrected deviator stress	[kPa]	481
Membrane correction applied	[kPa]	1.0
Drain correction applied	[kPa]	0
Axial strain	[%]	10.00
Excess pore pressure	[kPa]	121
Major principal effective stress	[kPa]	704
Minor principal effective stress	[kPa]	224
Principal effective stress ratio		3.15

FINAL CONDITIONS		
Moisture content	[%]	36.8
Bulk density	[Mg/m³]	1.85
Dry density	[Mg/m³]	1.35

Borehole	BH-WFS4-1A
Sample	22WaxB
Unit	F3 (Dongen)
Depth [m]	37.06
Test number	CIU09

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Drawn by: ALB Date: 13/01/2016

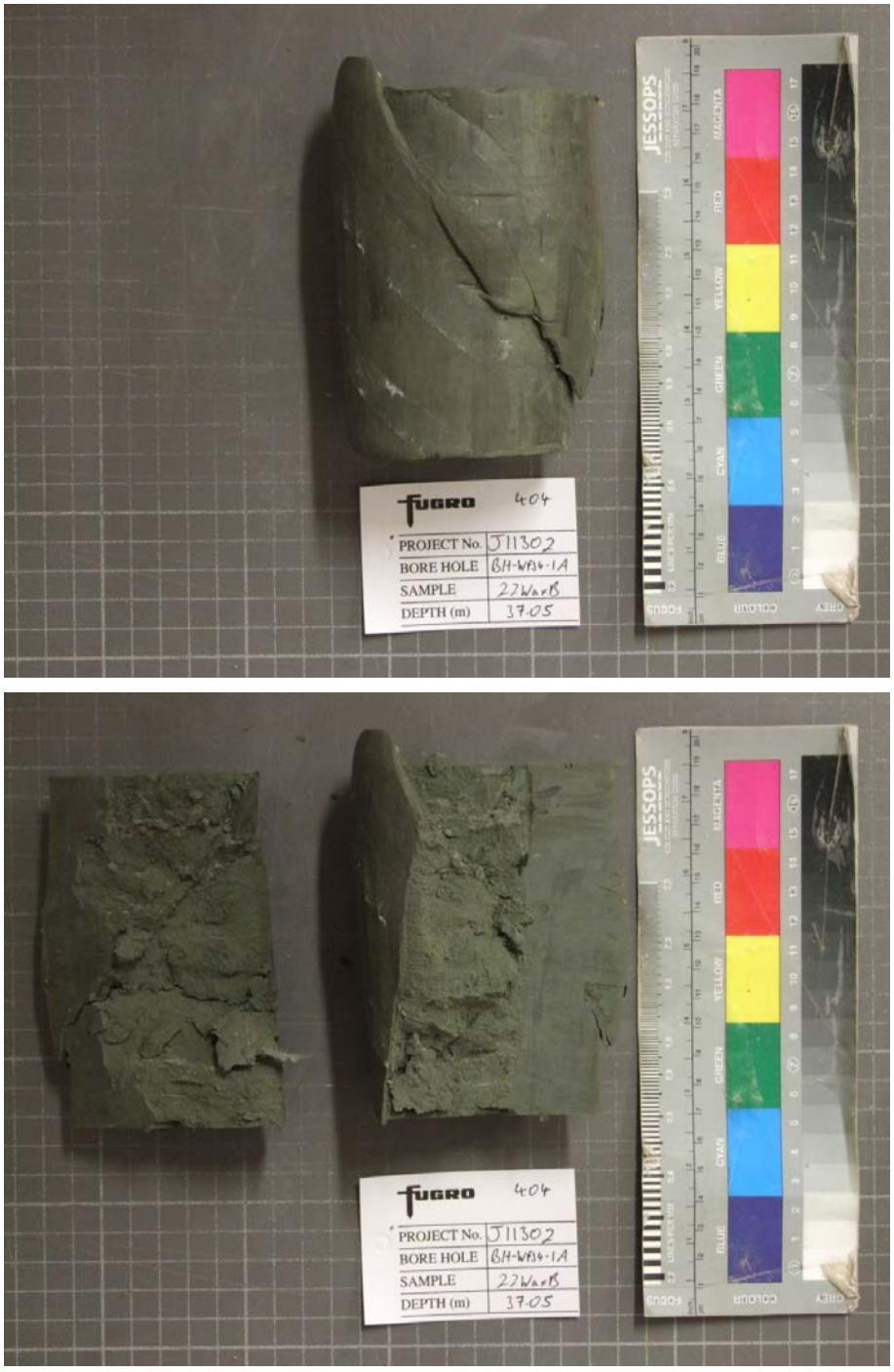
Template Issue: 3

Filename: J11302 / EFFECTIVE / BH-WFS4-

Checked by: PH Date: 14/01/2016

Approved by: PH Date: 14/01/2016

SPECIMEN PHOTOGRAPHS

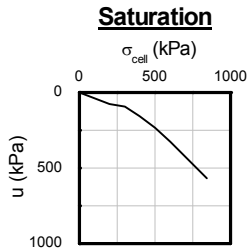


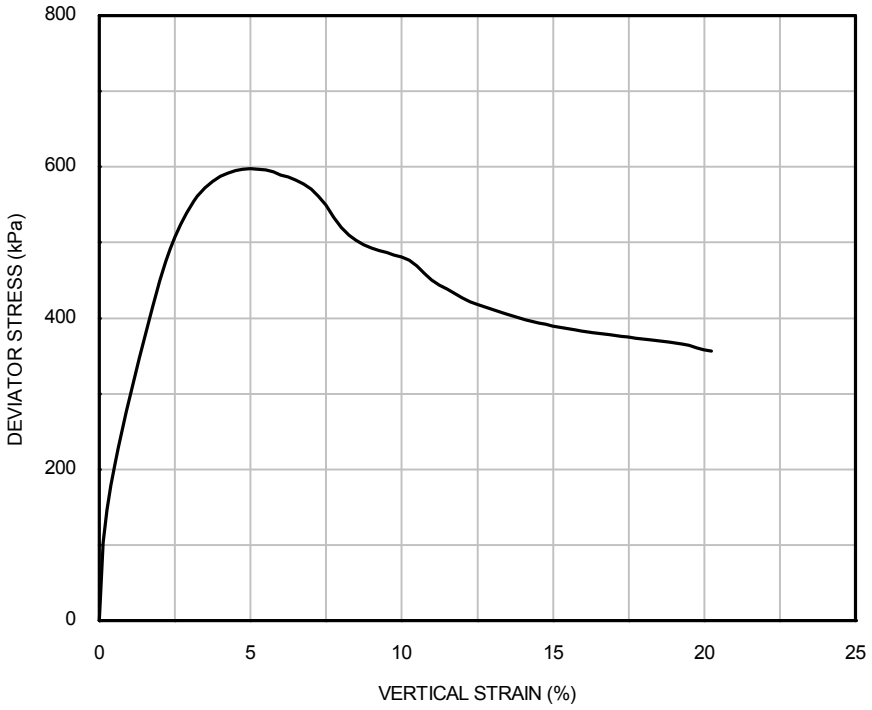
Borehole	BH-WFS4-1A
Sample	22WaxB
Unit	F3 (Dongen)
Depth [m]	37.06
Test number	CIU09

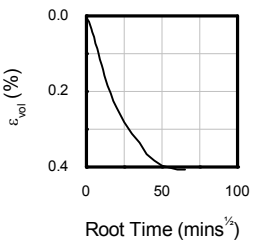
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

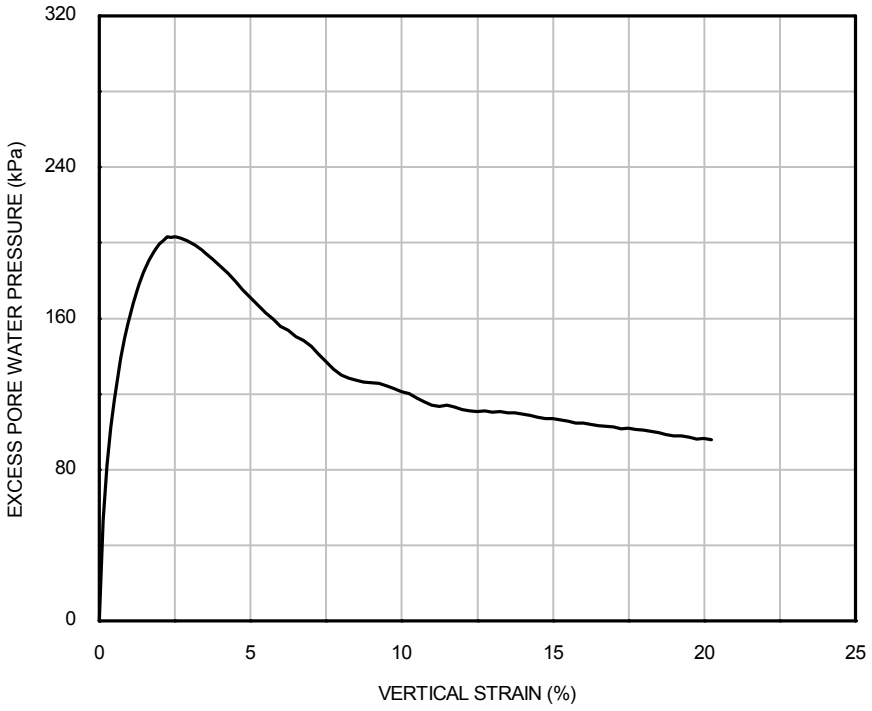
Drawn by: ALB Date: 13/01/2016
Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_22WaxB_ca.OPJ Template Issue: 4.1
Date : 04/01/2016
Date : 04/01/2016
Checked by: PH
Approved by: PH







Consolidation

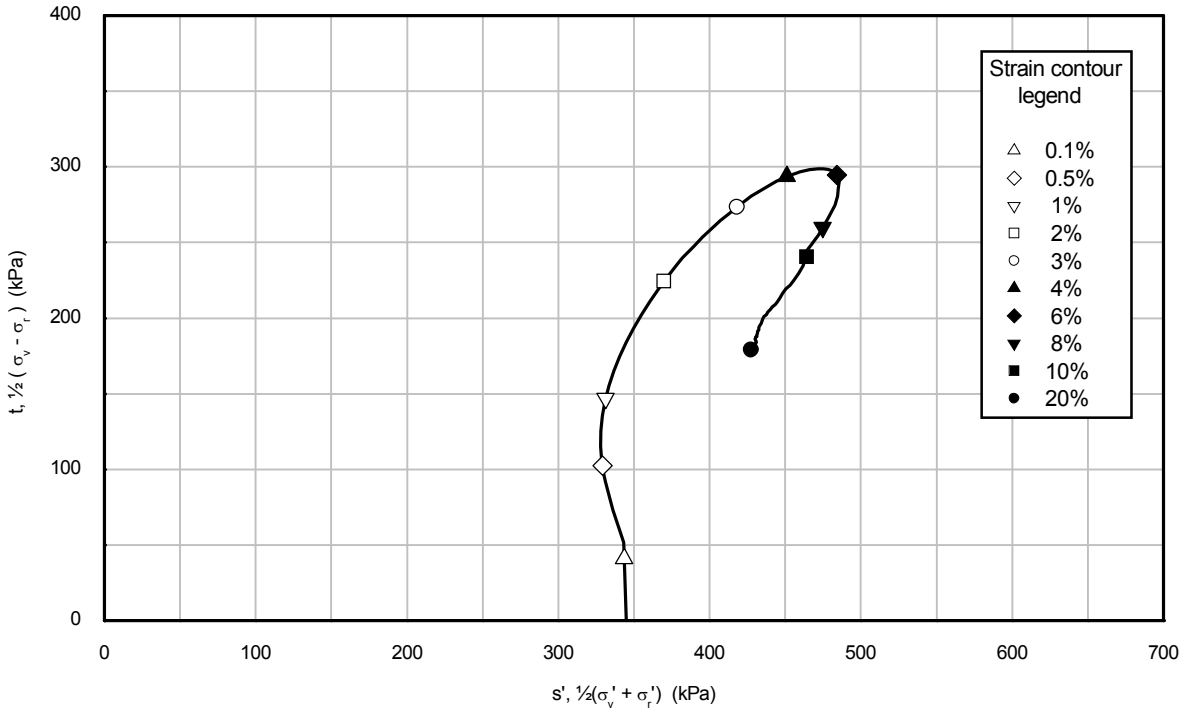


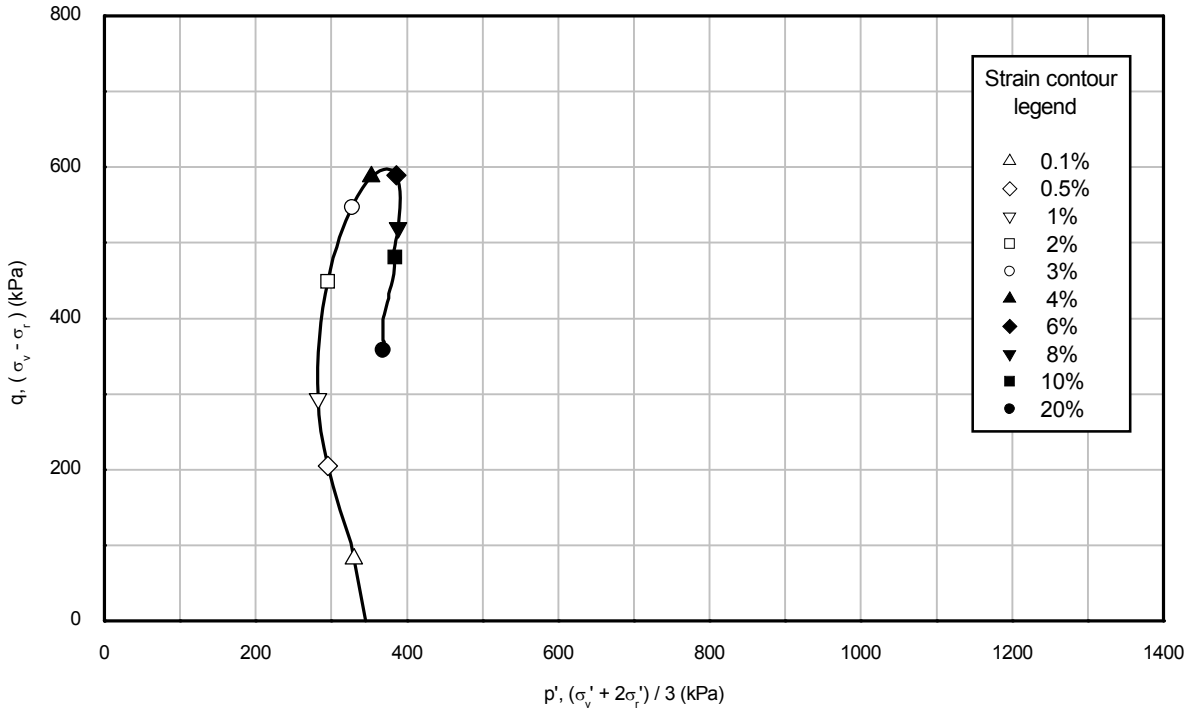
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	345	345

Borehole	: BH-WFS4-1A
Sample	: 22WaxB
Unit	: F3 (Dongen)
Depth (m)	: 37.06
Test number	: CIU09

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	345	345

Borehole	: BH-WFS4-1A
Sample	: 22WaxB
Unit	: F3 (Dongen)
Depth (m)	: 37.06
Test number	: CIU09

Drawn by: ALB Date: 13/01/2016

Filename: J11302 \ EFFECTIV \ BH-WFS4-1A_22WaxB_ca.OPJ

Template Issue: 4.1

Date : 04/01/2016

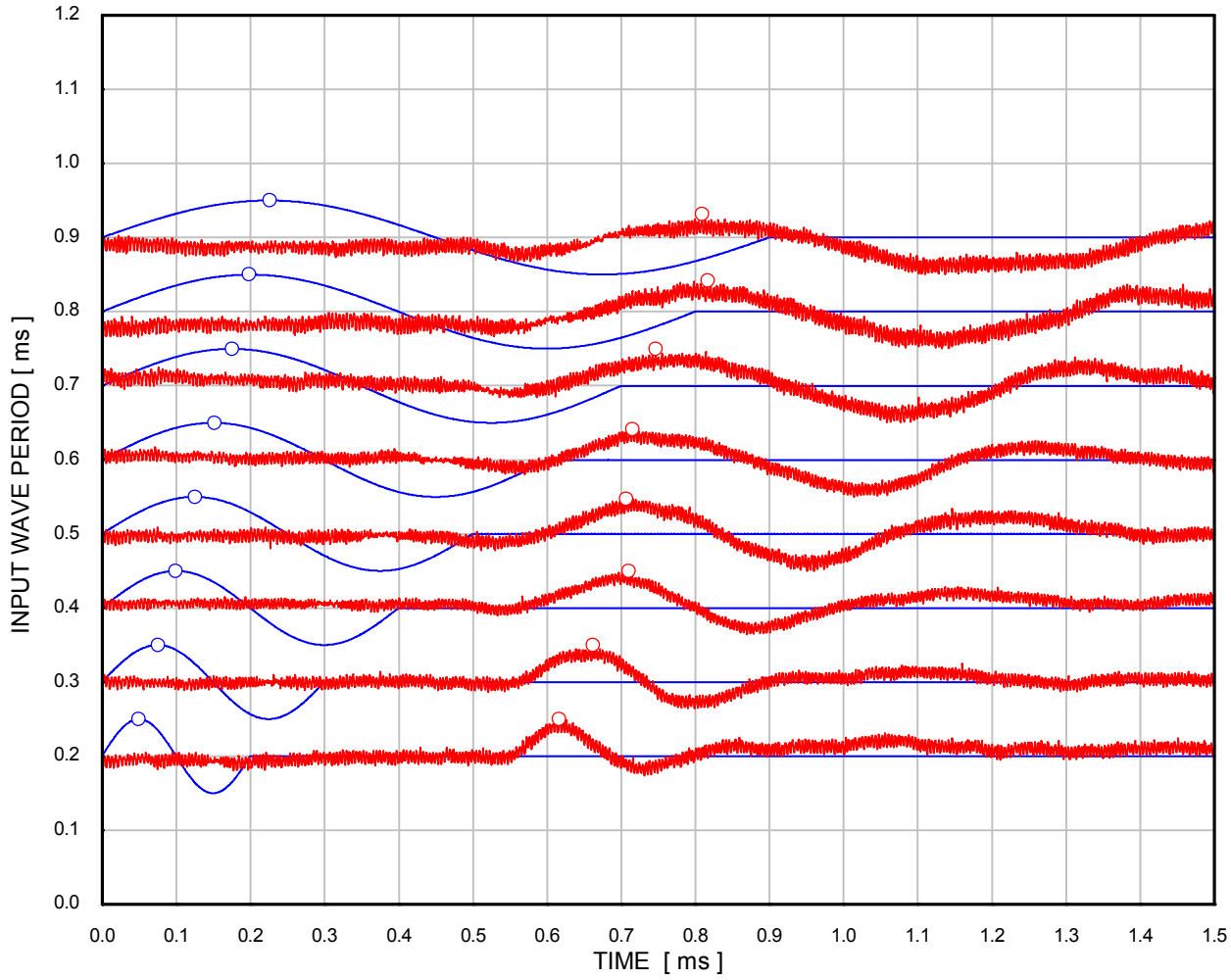
Date : 04/01/2016

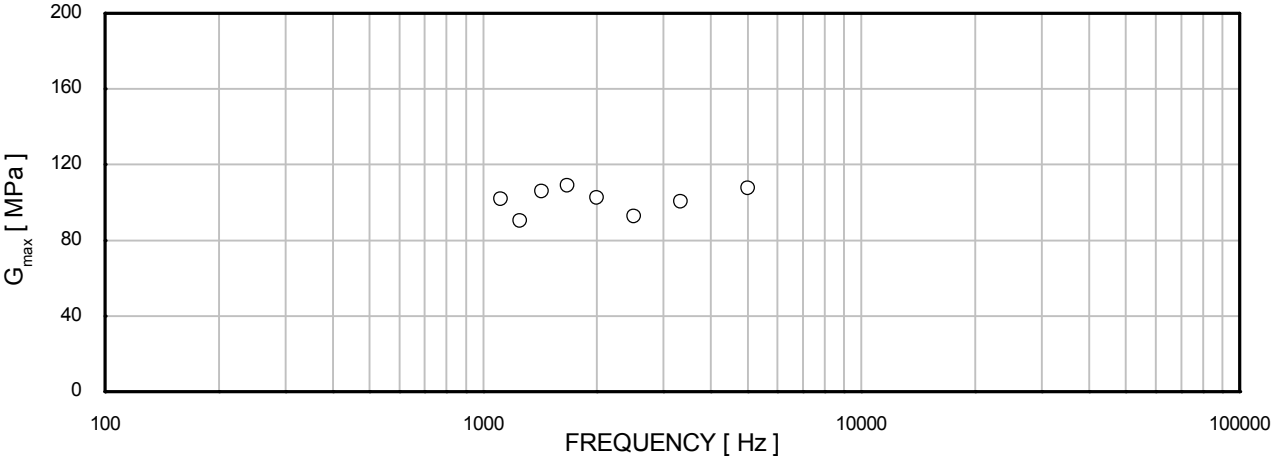
Checked by: PH

Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

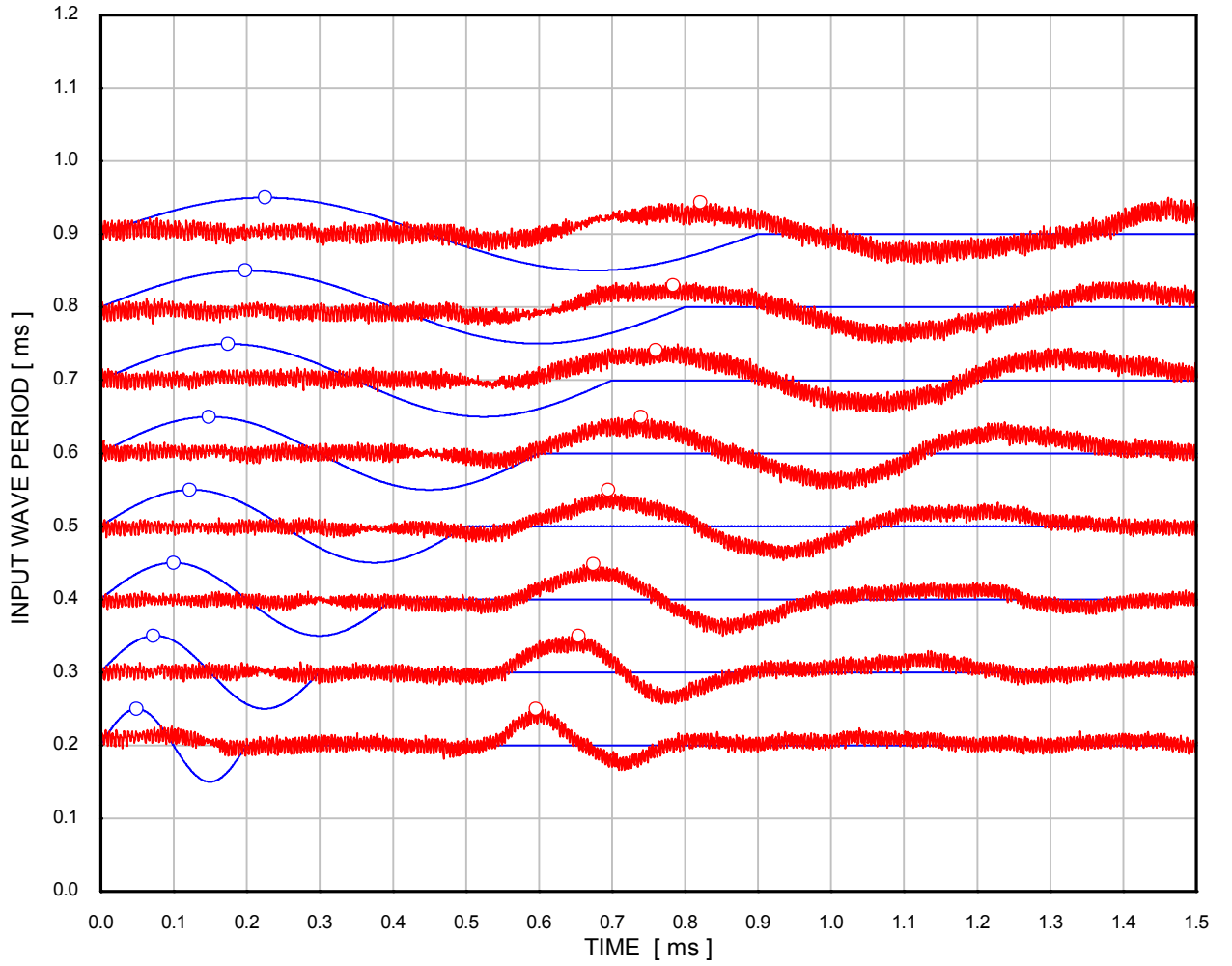
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

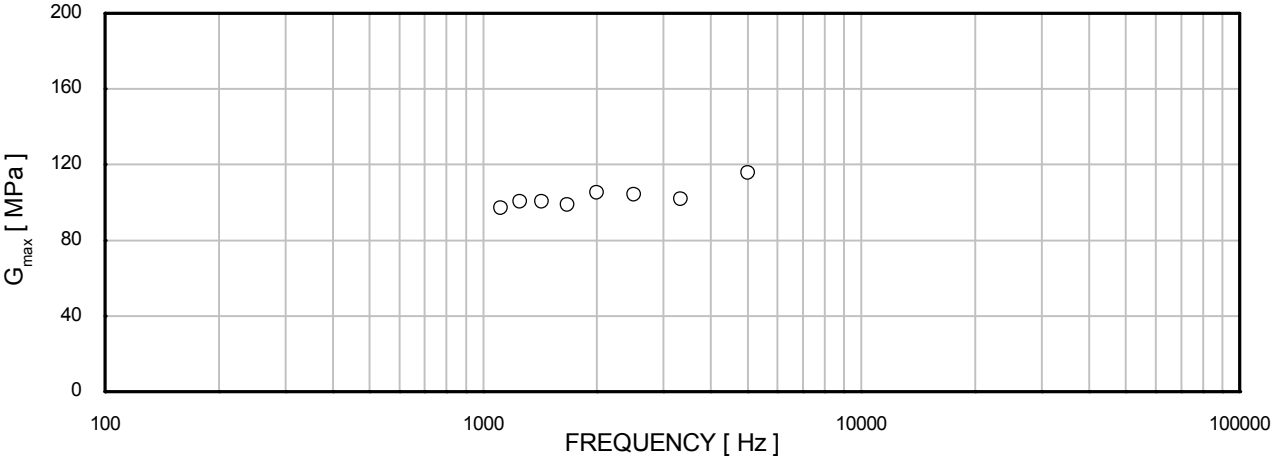




σ'_{rc}	: 278 kPa	Borehole	: BH-WFS4-1A
σ'_{ac}	: 278 kPa	Sample	: 22WaxB
	Source signal	Unit	: F3 (Dongen)
	Received signal	Depth [m]	: 37.06
○ / ○	Selected peak values	Test number.	: CIU09

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-SATURATION S_{VH} BENDER ELEMENT DETERMINATIONS





σ'_{rc}	: 345 kPa	Borehole	: BH-WFS4-1A
σ'_{ac}	: 345 kPa	Sample	: 22WaxB
	Source signal	Unit	: F3 (Dongen)
	Received signal	Depth [m]	: 37.06
○ / ○	Selected peak values	Test number.	: CIU09

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-ISOTROPIC CONSOLIDATION S_{VH} BENDER ELEMENT DETERMINATIONS

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 1_CIU_1-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Approved by: PH
Date: 18/01/2016

VISUAL DESCRIPTION
Brown fine to coarse SAND

GENERAL	
Date test started	12/01/2016
Type of sample	Recompacted
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL		
Diameter	[mm]	71.7
Length	[mm]	135.0
Moisture content	[%]	10.2
Bulk density	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.63
Void ratio		0.630
Degree of saturation	[%]	43

SATURATION		
Pressure increments applied	[kPa]	50
Differential pressure used	[kPa]	10
Pore pressure on completion	[kPa]	415
Cell pressure on completion	[kPa]	425
B value achieved		1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.3 Fugro testing procedure L-T-023 Clause 5.3.7
Consolidation - Isotropic Consolidation - Anisotropic	BS 1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Batch	1
Sample	CIU_1-1
Unit	A (Southern Bight)
Test number	CIU10

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

CONSOLIDATION : ISOTROPIC		
Cell pressure	[kPa]	425
Back pressure	[kPa]	400
Effective cell pressure	[kPa]	25
Pore pressure on completion	[kPa]	400
Pore pressure dissipation	[%]	100
Moisture content	[%]	23.7
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.63
Void ratio		0.629
Degree of saturation	[%]	100
Volumetric strain	[%]	0.11
Axial strain	[%]	0.04

Drawn by: ALB Date: 18/01/2016

Template Issue: 3 Filename: J11302 / EFFECTIVE / 1_CIU_1-1_ca.XLS

Checked by: PH Date: 18/01/2016

Approved by: PH Date: 18/01/2016

Batch	1
Sample	CIU_1-1
Unit	A (Southern Bight)
Test number	CIU10

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 1_CIU_1-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Date: 18/01/2016
Approved by: PH

BENDER ELEMENT DETERMINATIONS - POST SATURATION		
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.630
Distance	[mm]	132.14
Effective radial pressure	[kPa]	10
Effective axial pressure	[kPa]	10

Input Wave Period [ms]	Peak-to-Peak Arrival Time [ms]	Wavelength Ratio [-]	Velocity [m/s]	G_{max} [MPa]
0.20	1.1325	5.66	116.68	27.4
0.30	1.1375	3.79	116.17	27.2
0.40	1.1315	2.83	116.78	27.4
0.50	1.1240	2.25	117.56	27.8
0.60	1.1195	1.87	118.03	28.0
0.70	1.1185	1.60	118.14	28.1
0.80	1.1285	1.41	117.09	27.6
0.90	1.1205	1.24	117.93	28.0

BENDER ELEMENT DETERMINATIONS - POST ISOTROPIC CONSOLIDATION		
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.629
Distance	[mm]	132.09
Effective radial pressure	[kPa]	25
Effective axial pressure	[kPa]	25

Input Wave Period [ms]	Peak-to-Peak Arrival Time [ms]	Wavelength Ratio [-]	Velocity [m/s]	G_{max} [MPa]
0.20	0.5465	2.73	241.71	117.6
0.30	0.5680	1.89	232.56	108.9
0.40	0.5755	1.44	229.53	106.1
0.50	0.5730	1.15	230.53	107.0
0.60	0.5725	0.95	230.73	107.2
0.70	0.5860	0.84	225.41	102.3
0.80	0.5770	0.72	228.93	105.5
0.90	0.5560	0.62	237.58	113.6

Batch	1
Sample	CIU_1-1
Unit	A (Southern Bight)
Test number	CIU10

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 1_CIU_1-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Date: 18/01/2016
Approved by: PH

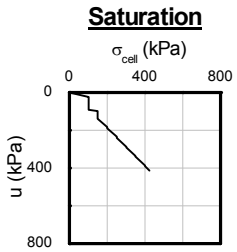
SHEARING		
Initial pore pressure	[kPa]	400
Initial effective cell pressure	[kPa]	25
Rate of strain	[%/hour]	1.33
At peak deviator stress		
Corrected deviator stress	[kPa]	1143
Membrane correction applied	[kPa]	0.7
Drain correction applied	[kPa]	0
Axial strain	[%]	7.00
Excess pore pressure	[kPa]	-357
Major principal effective stress	[kPa]	1525
Minor principal effective stress	[kPa]	382
Principal effective stress ratio		3.99
Epsilon 50 [ε 50]	[%]	2.35
Secant modulus [E50] at ε 50	[kPa]	24287
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	190
Membrane correction applied	[kPa]	0.1
Drain correction applied	[kPa]	0
Axial strain	[%]	0.88
Excess pore pressure	[kPa]	-30
Major principal effective stress	[kPa]	245
Minor principal effective stress	[kPa]	55
Principal effective stress ratio		4.48
At 10% axial strain		
Corrected deviator stress	[kPa]	1059
Membrane correction applied	[kPa]	1.0
Drain correction applied	[kPa]	0
Axial strain	[%]	10.00
Excess pore pressure	[kPa]	-382
Major principal effective stress	[kPa]	1465
Minor principal effective stress	[kPa]	407
Principal effective stress ratio		3.60

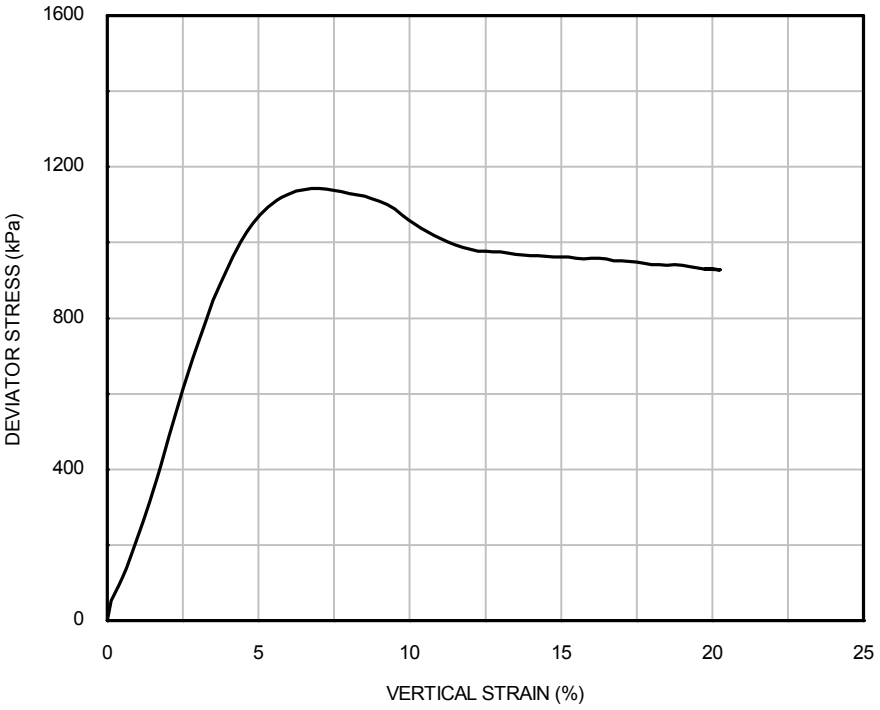
FINAL CONDITIONS		
Moisture content	[%]	23.7
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.63

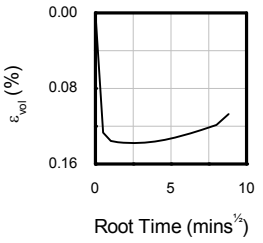
Batch	1
Sample	CIU_1-1
Unit	A (Southern Bight)
Test number	CIU10

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

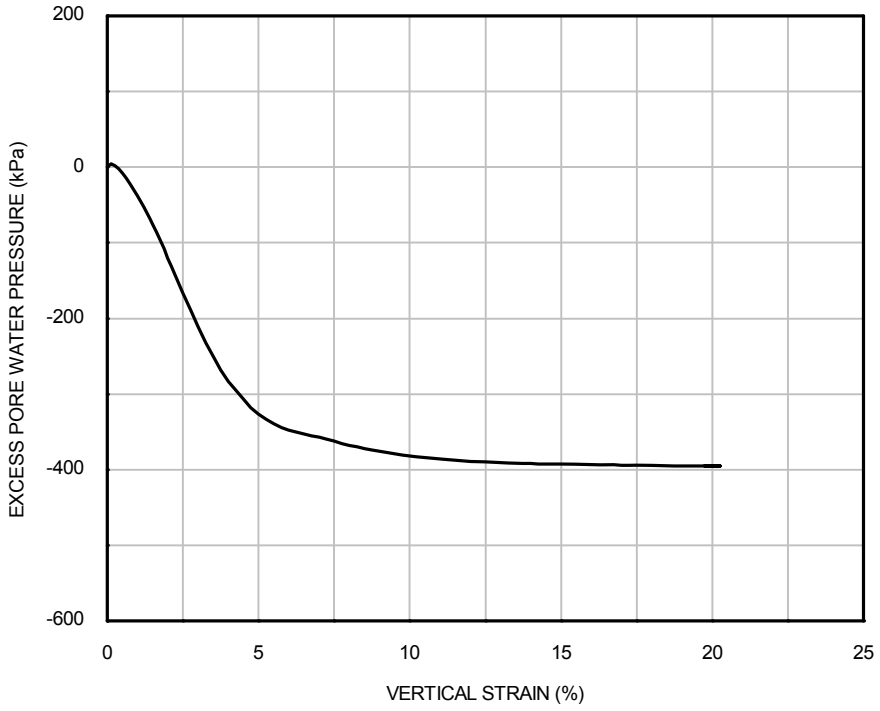
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA







Consolidation

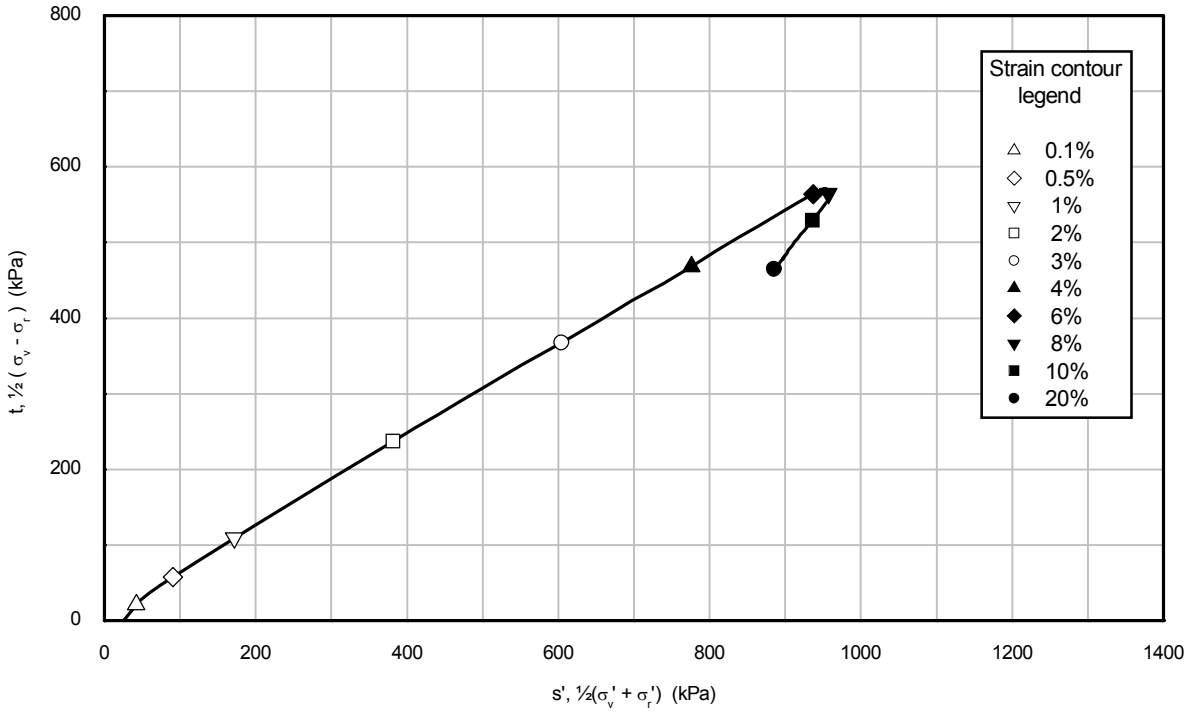


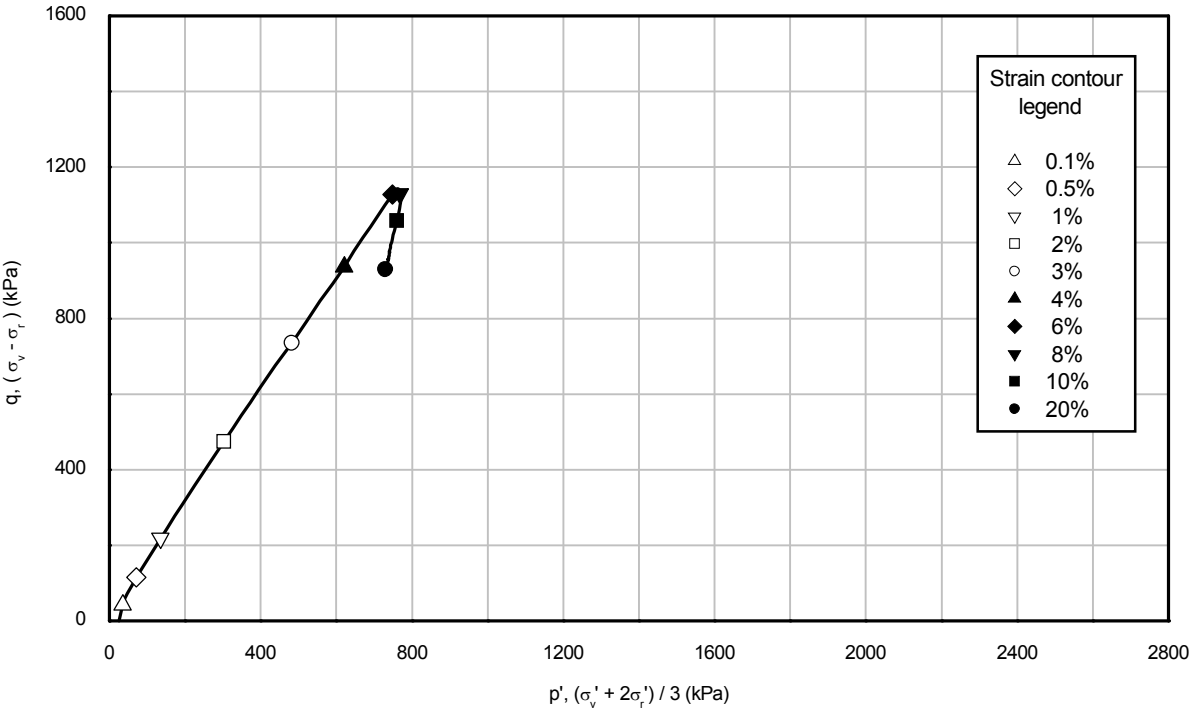
Curve	Specimen	σrc' (kPa)	σvc' (kPa)
——	1	25	25

Batch	: 1
Sample	: CIU_1-1
Unit	: A (Southern Bight)
Test number	: CIU10

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





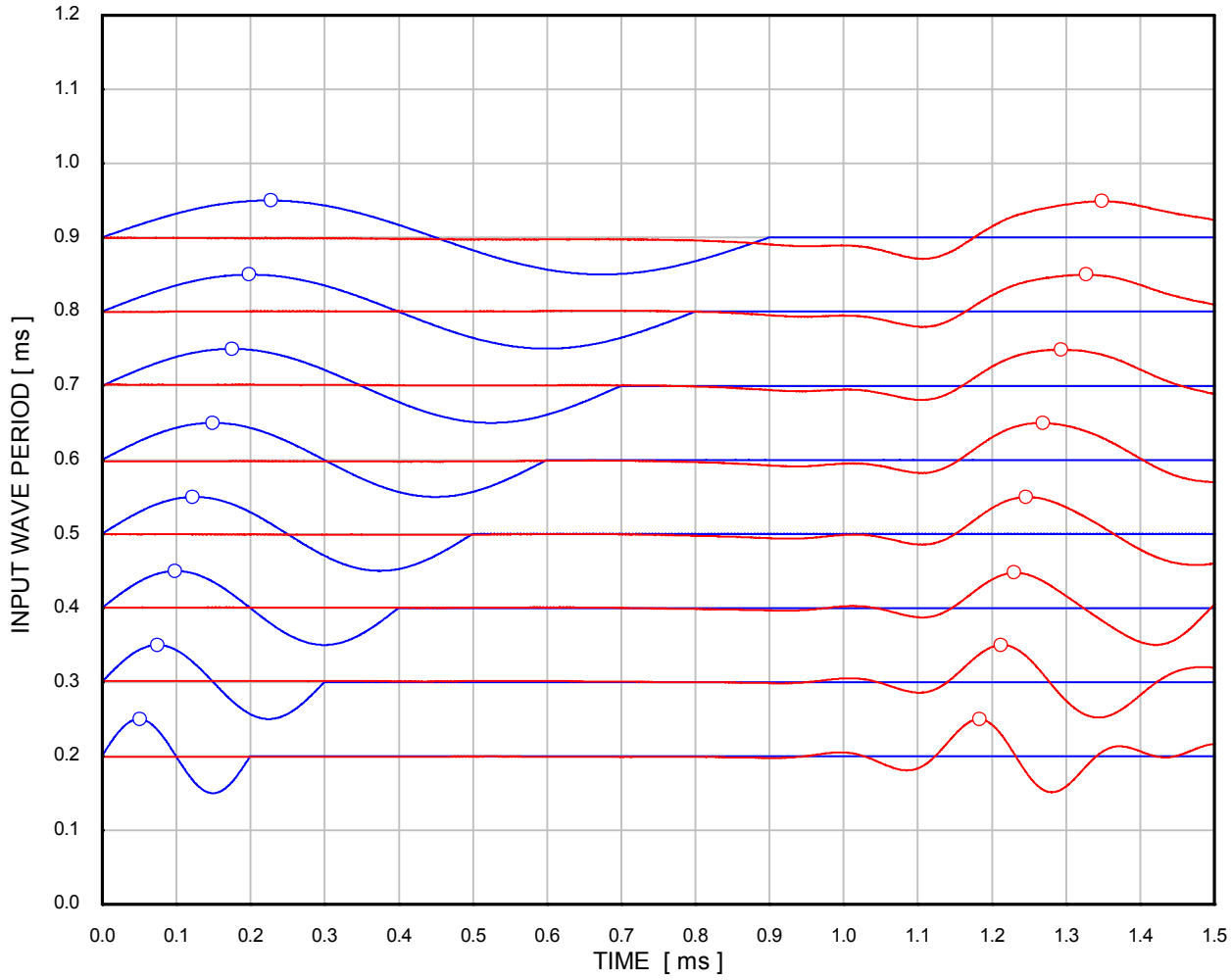
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	25	25

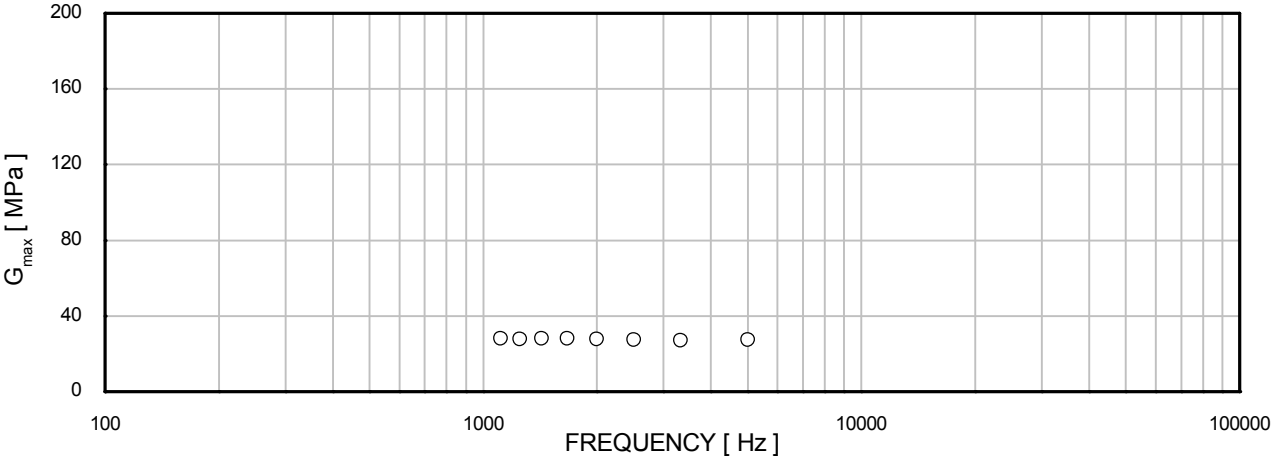
Batch	: 1
Sample	: CIU_1-1
Unit	: A (Southern Bight)
Test number	: CIU10

Drawn by: ALB Date: 18/01/2016
Template Issue: 4.1
Filename: J11302 \ EFFECTIV \ Batch 1_CIU_1-1_ca.OPJ
Date : 18/01/2016
Checked by: PH
Date : 18/01/2016
Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

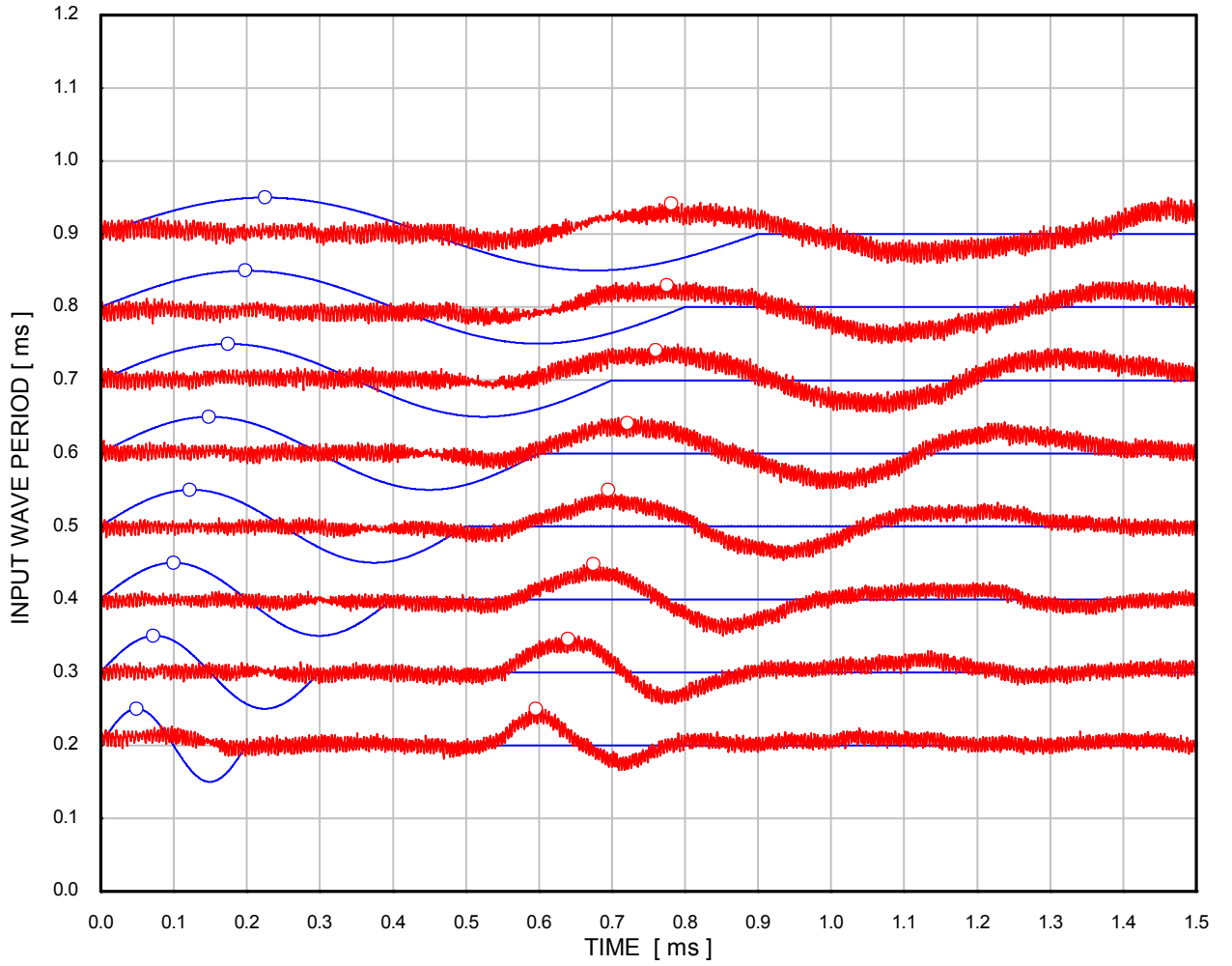


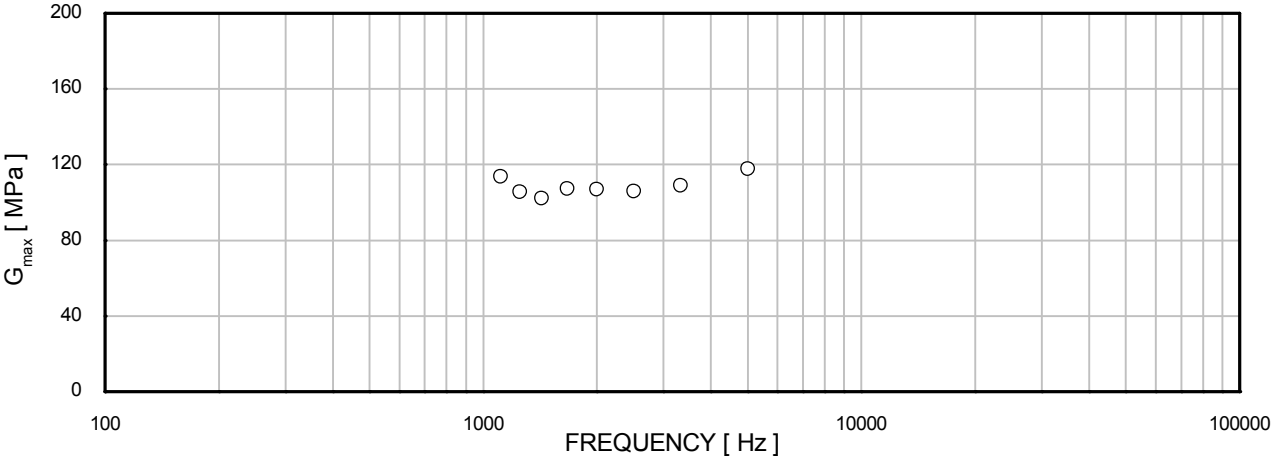


σ'_{rc}	: 10 kPa	Batch	: 1
σ'_{ac}	: 10 kPa	Sample	: CIU_1-1
	Source signal	Unit	: A (Southern Bight)
	Received signal	Test number.	: CIU10
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-SATURATION S_{VH} BENDER ELEMENT DETERMINATIONS

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





σ'_{rc}	: 25 kPa	Batch	: 1
σ'_{ac}	: 25 kPa	Sample	: CIU_1-1
	Source signal	Unit	: A (Southern Bight)
	Received signal	Test number.	: CIU10
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-ISOTROPIC CONSOLIDATION S_{VH} BENDER ELEMENT DETERMINATIONS

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 2_CIU_2-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Approved by: PH
Date: 18/01/2016

VISUAL DESCRIPTION
Brownish grey fine to coarse SAND

GENERAL	
Date test started	12/01/2016
Type of sample	Recompacted
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL		
Diameter	[mm]	71.7
Length	[mm]	135.0
Moisture content	[%]	10.1
Bulk density	[Mg/m³]	1.86
Dry density	[Mg/m³]	1.69
Void ratio		0.566
Degree of saturation	[%]	47

SATURATION		
Pressure increments applied	[kPa]	50
Differential pressure used	[kPa]	10
Pore pressure on completion	[kPa]	468
Cell pressure on completion	[kPa]	480
B value achieved		0.98

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.3 Fugro testing procedure L-T-023 Clause 5.3.7
Consolidation - Isotropic Consolidation - Anisotropic	BS 1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Batch	2
Sample	CIU_2-1
Unit	B (Eem / Kreftenheye)
Test number	CIU11

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Drawn by: ALB Date: 18/01/2016

Template Issue: 3 Filename: J11302 / EFFECTIVE / 2_CIU_2-1_ca.XLS

Checked by: PH Date: 18/01/2016

Approved by: PH Date: 18/01/2016

CONSOLIDATION : ISOTROPIC		
Cell pressure	[kPa]	480
Back pressure	[kPa]	400
Effective cell pressure	[kPa]	80
Pore pressure on completion	[kPa]	400
Pore pressure dissipation	[%]	100
Moisture content	[%]	21.2
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70
Void ratio		0.561
Degree of saturation	[%]	100
Volumetric strain	[%]	0.31
Axial strain	[%]	0.10

Batch	2
Sample	CIU_2-1
Unit	B (Eem / Kreftenheye)
Test number	CIU11

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 2_CIU_2-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Date: 18/01/2016
Approved by: PH

BENDER ELEMENT DETERMINATIONS - POST SATURATION		
Bulk density	[Mg/m^3]	2.05
Dry density	[Mg/m^3]	1.69
Void ratio	[-]	0.566
Distance	[mm]	132.05
Effective radial pressure	[kPa]	12
Effective axial pressure	[kPa]	12

Input Wave Period [ms]	Peak-to-Peak Arrival Time [ms]	Wavelength Ratio [-]	Velocity [m/s]	G_{max} [MPa]
0.20	1.0450	5.23	126.36	32.8
0.30	1.0670	3.56	123.76	31.5
0.40	1.0675	2.67	123.70	31.4
0.50	1.0680	2.14	123.64	31.4
0.60	1.0720	1.79	123.18	31.2
0.70	1.0585	1.51	124.75	32.0
0.80	1.0630	1.33	124.22	31.7
0.90	1.0635	1.18	124.17	31.7

BENDER ELEMENT DETERMINATIONS - POST ISOTROPIC CONSOLIDATION		
Bulk density	[Mg/m^3]	2.06
Dry density	[Mg/m^3]	1.70
Void ratio	[-]	0.561
Distance	[mm]	131.91
Effective radial pressure	[kPa]	80
Effective axial pressure	[kPa]	80

Input Wave Period [ms]	Peak-to-Peak Arrival Time [ms]	Wavelength Ratio [-]	Velocity [m/s]	G_{max} [MPa]
0.20	0.5935	2.97	222.26	101.6
0.30	0.6420	2.14	205.47	86.8
0.40	0.6280	1.57	210.05	90.7
0.50	0.6670	1.33	197.77	80.4
0.60	0.6620	1.10	199.26	81.7
0.70	0.6400	0.91	206.11	87.4
0.80	0.6235	0.78	211.56	92.1
0.90	0.6035	0.67	218.57	98.3

Batch	2
Sample	CIU_2-1
Unit	B (Eem / Kreftenheye)
Test number	CIU11

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 2_CIU_2-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Approved by: PH
Date: 18/01/2016

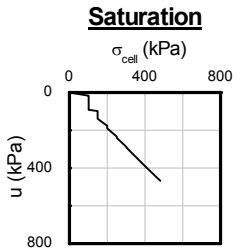
SHEARING		
Initial pore pressure	[kPa]	400
Initial effective cell pressure	[kPa]	80
Rate of strain	[%/hour]	1.33
At peak deviator stress		
Corrected deviator stress	[kPa]	1359
Membrane correction applied	[kPa]	0.7
Drain correction applied	[kPa]	0
Axial strain	[%]	5.50
Excess pore pressure	[kPa]	-364
Major principal effective stress	[kPa]	1804
Minor principal effective stress	[kPa]	444
Principal effective stress ratio		4.06
Epsilon 50 [ε 50]	[%]	1.89
Secant modulus [E50] at ε 50	[kPa]	35967
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	424
Membrane correction applied	[kPa]	0.2
Drain correction applied	[kPa]	0
Axial strain	[%]	1.25
Excess pore pressure	[kPa]	-45
Major principal effective stress	[kPa]	549
Minor principal effective stress	[kPa]	125
Principal effective stress ratio		4.39
At 10% axial strain		
Corrected deviator stress	[kPa]	1169
Membrane correction applied	[kPa]	1.1
Drain correction applied	[kPa]	0
Axial strain	[%]	10.00
Excess pore pressure	[kPa]	-386
Major principal effective stress	[kPa]	1635
Minor principal effective stress	[kPa]	466
Principal effective stress ratio		3.51

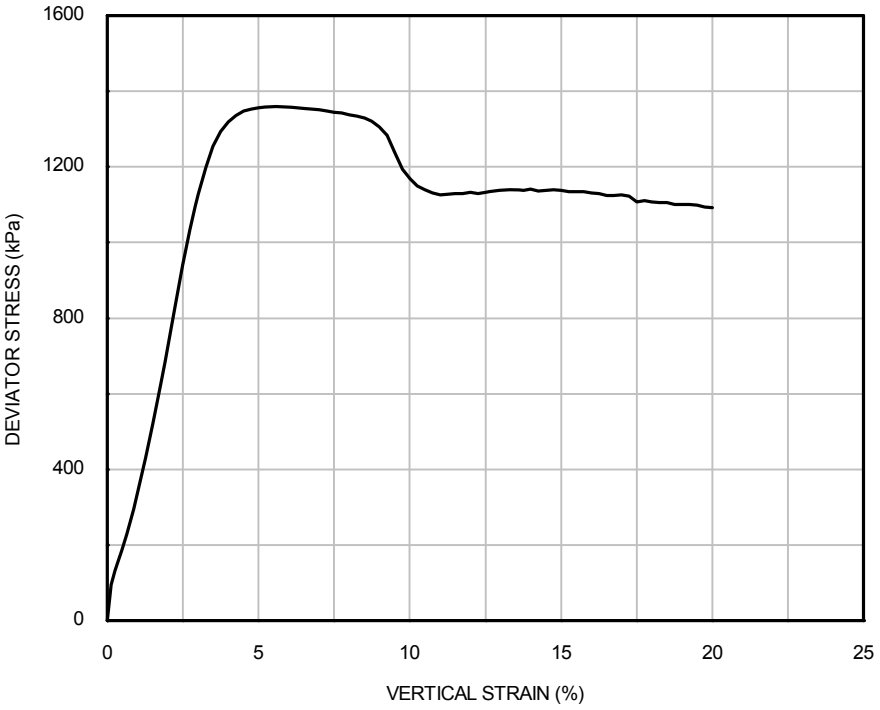
FINAL CONDITIONS		
Moisture content	[%]	21.2
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70

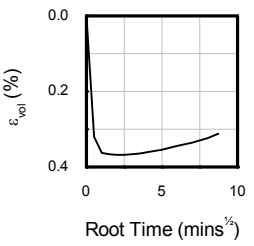
Batch	2
Sample	CIU_2-1
Unit	B (Eem / Kreftenheye)
Test number	CIU11

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

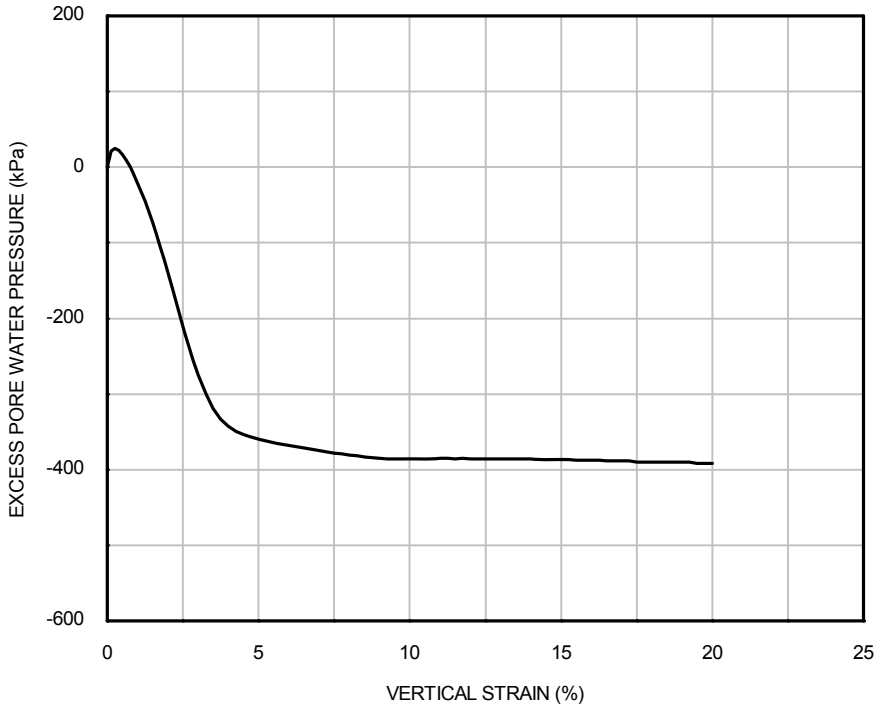
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA







Consolidation

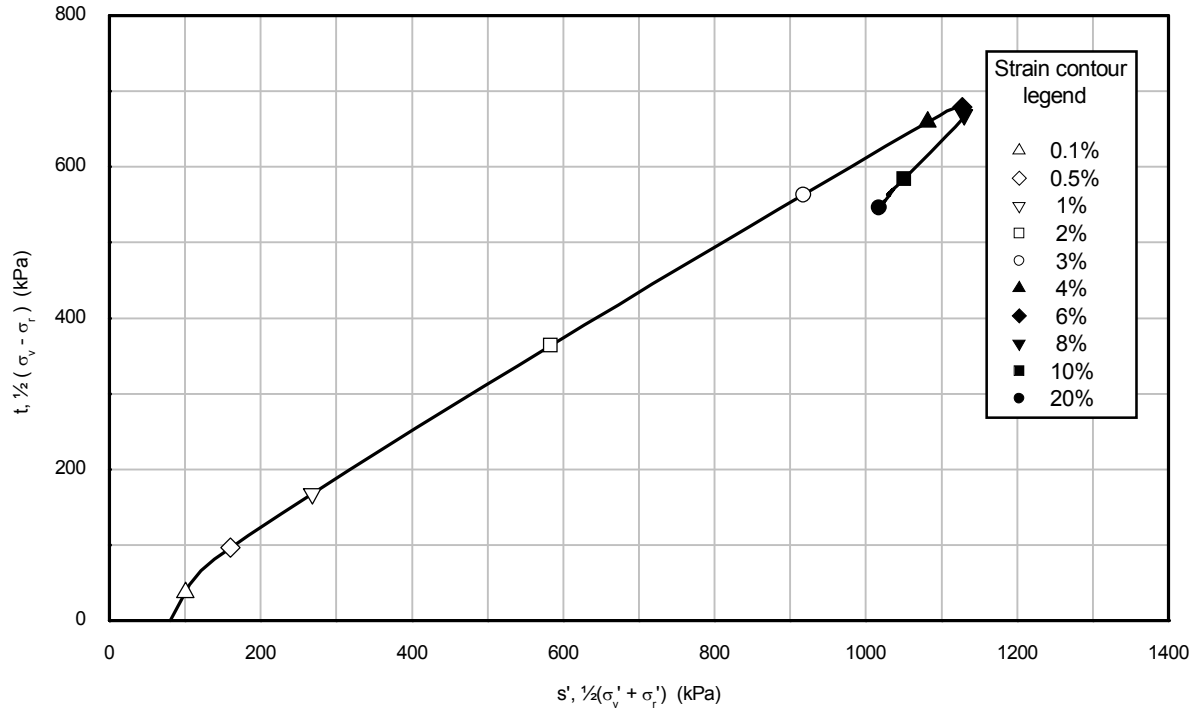


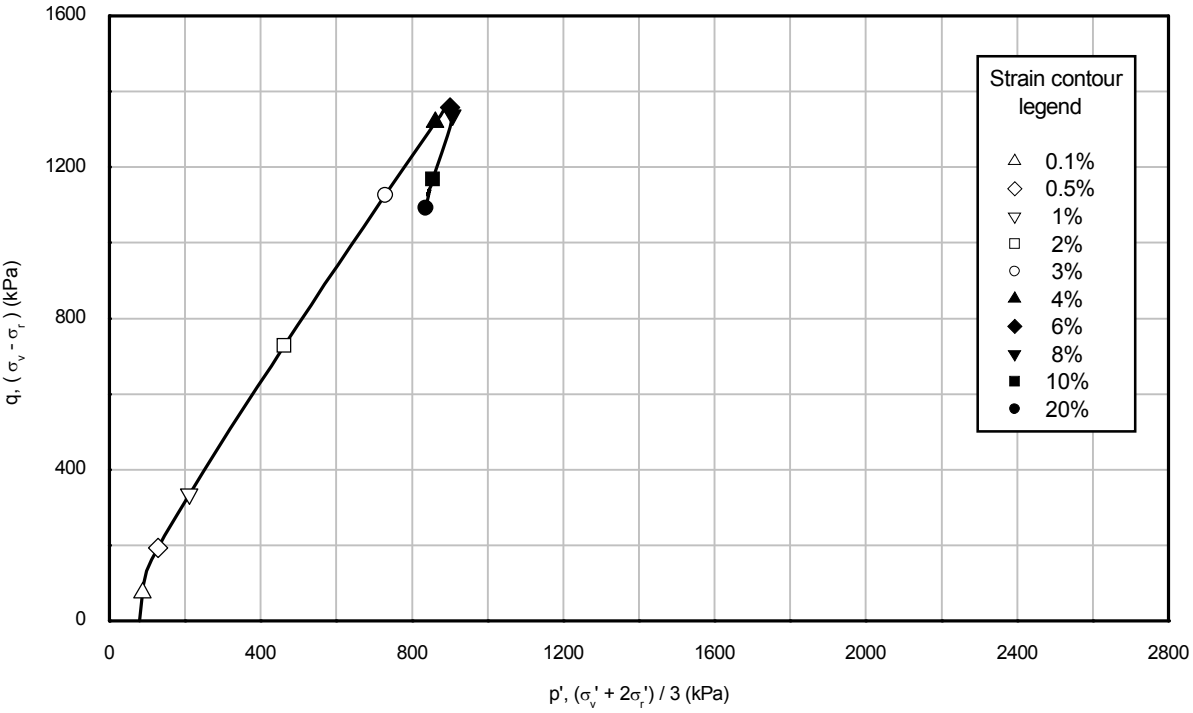
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	80	80

Batch : 2
Sample : CIU_2-1
Unit : B (Eem / Kreftenheye)
Test number : CIU11

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





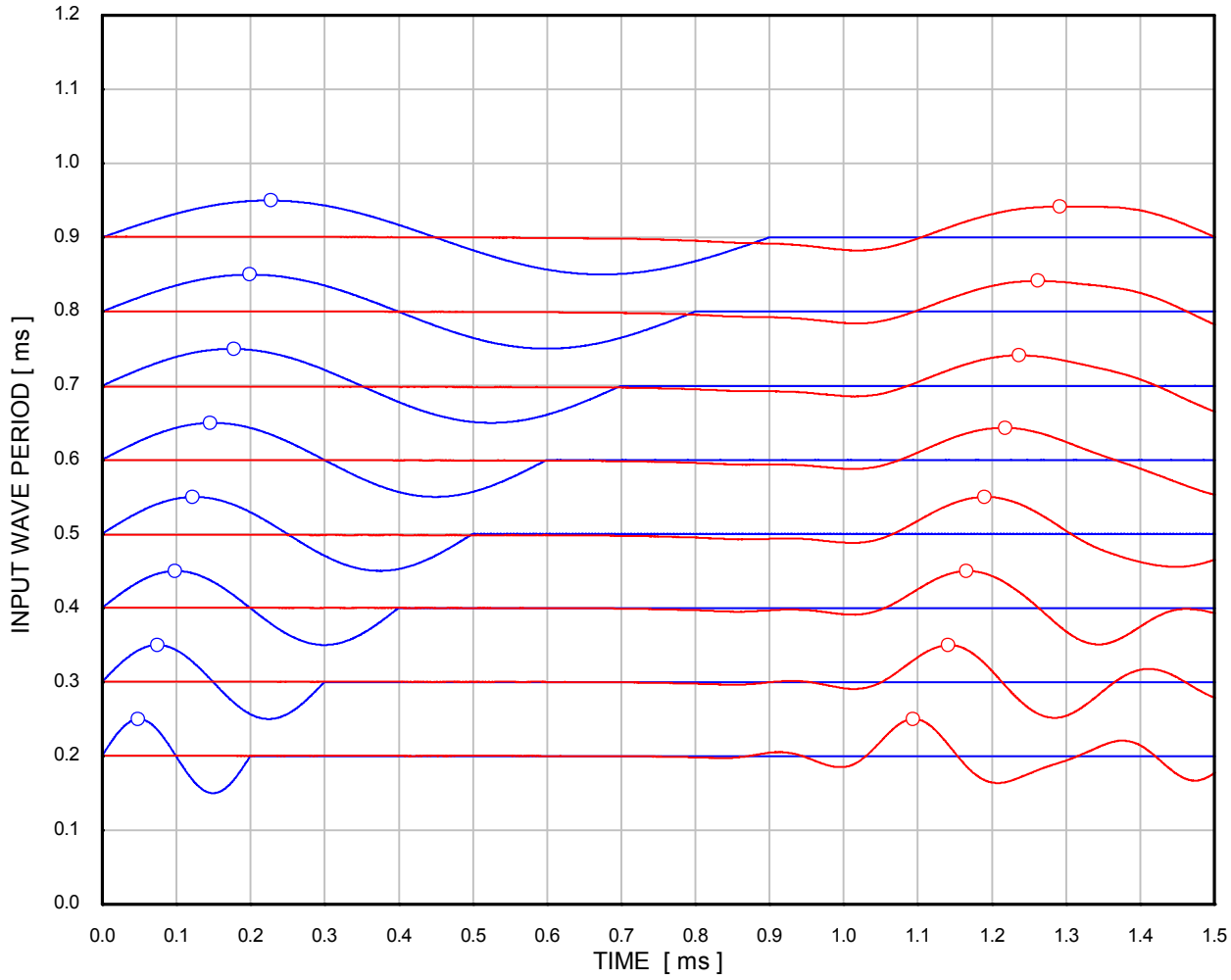
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	80	80

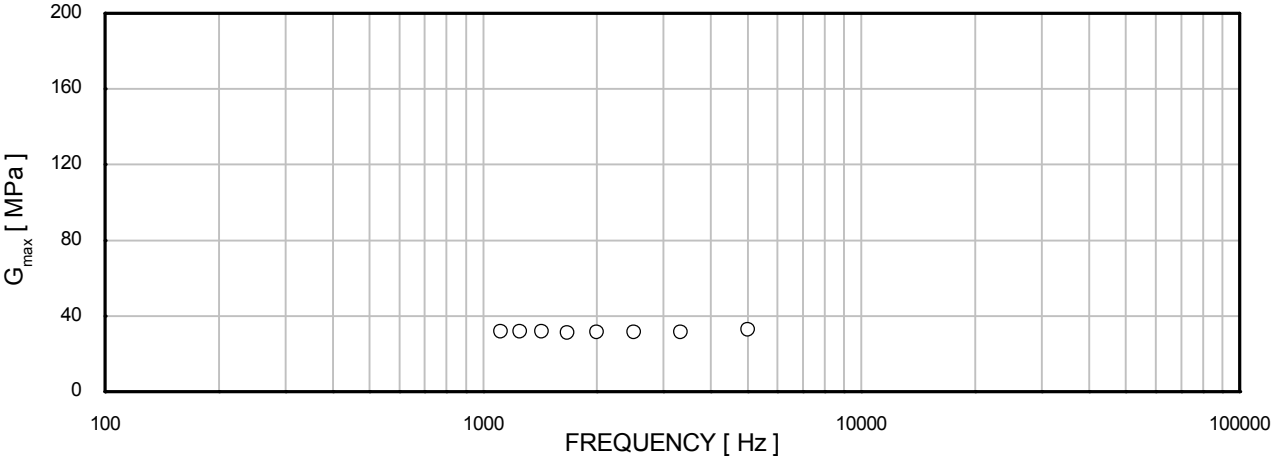
Batch : 2
Sample : CIU_2-1
Unit : B (Eem / Kreftenheye)
Test number : CIU11

Template Issue: 4.1
Filename: J11302 \ EFFECTIV \ Batch 2_CIU_2-1_ca.OPJ
Drawn by: ALB Date: 18/01/2016
Date : 18/01/2016
Checked by: PH
Date : 18/01/2016
Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

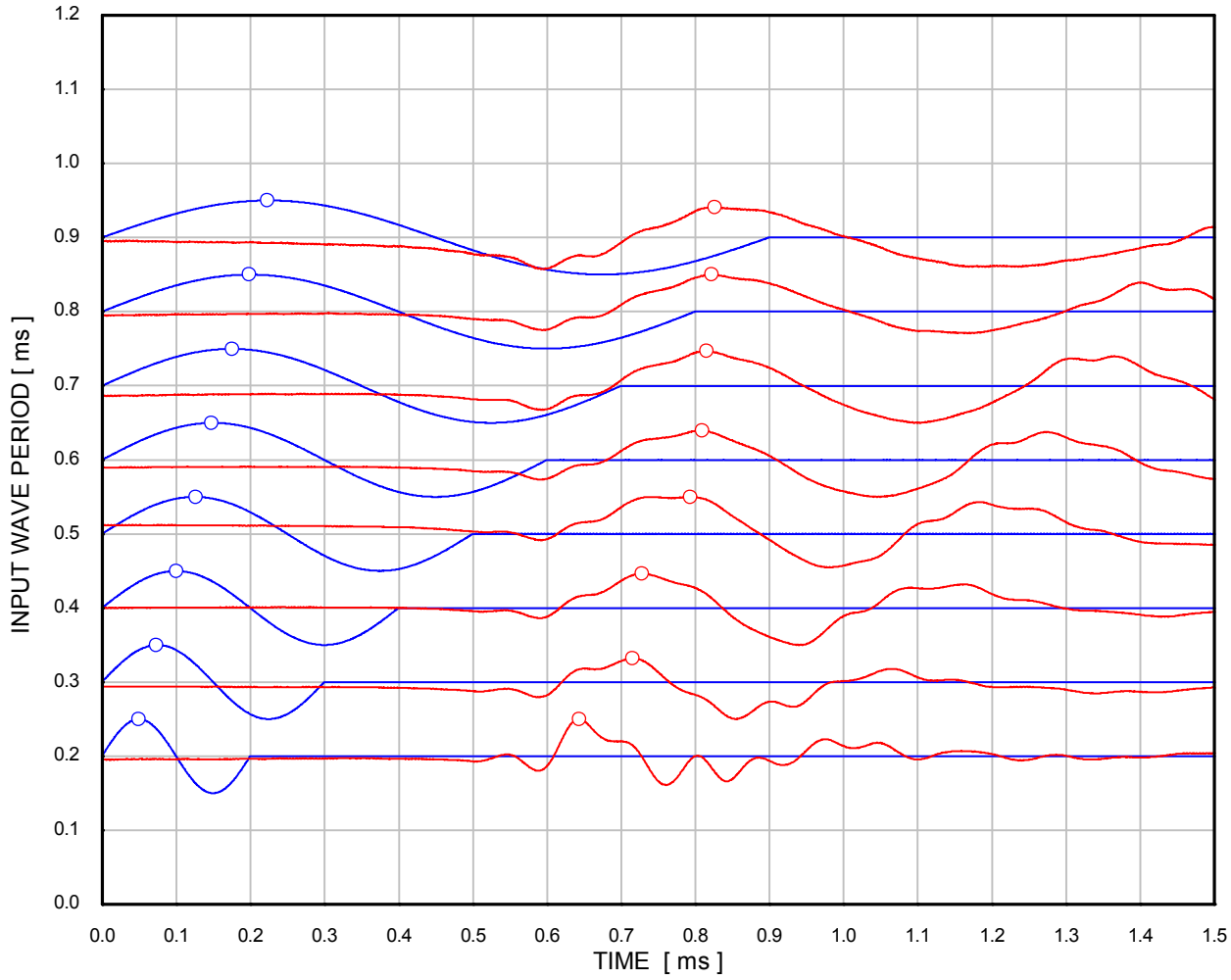


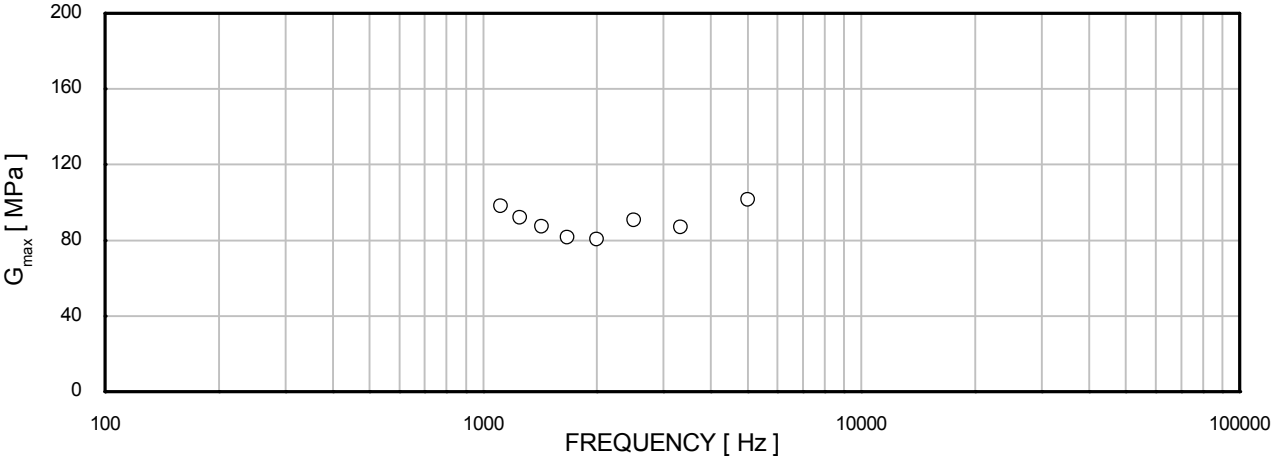


σ'_{rc}	: 12 kPa	Batch	: 2
σ'_{ac}	: 12 kPa	Sample	: CIU_2-1
	Source signal	Unit	: B (Eem / Kreftenheye)
	Received signal	Test number.	: CIU11
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-SATURATION S_{VH} BENDER ELEMENT DETERMINATIONS

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





σ'_{rc}	: 80 kPa	Batch	: 2
σ'_{ac}	: 80 kPa	Sample	: CIU_2-1
	Source signal	Unit	: B (Eem / Kreftenheye)
	Received signal	Test number.	: CIU11
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-ISOTROPIC CONSOLIDATION S_{VH} BENDER ELEMENT DETERMINATIONS

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 3_CIU_3-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Approved by: PH
Date: 18/01/2016

VISUAL DESCRIPTION
Very dark grey fine to medium SAND

GENERAL	
Date test started	13/01/2016
Type of sample	Recompacted
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL		
Diameter	[mm]	71.7
Length	[mm]	135.0
Moisture content	[%]	10.9
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.59
Void ratio		0.665
Degree of saturation	[%]	44

SATURATION		
Pressure increments applied	[kPa]	50
Differential pressure used	[kPa]	10
Pore pressure on completion	[kPa]	680
Cell pressure on completion	[kPa]	700
B value achieved		0.97

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.3 Fugro testing procedure L-T-023 Clause 5.3.7
Consolidation - Isotropic Consolidation - Anisotropic	BS 1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Batch	3
Sample	CIU_3-1
Unit	E3 (Tongeren)
Test number	CIU12

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Drawn by: ALB Date: 18/01/2016

Template Issue: 3 Filename: J11302 / EFFECTIVE / 3_CIU_3-1_ca.XLS

Checked by: PH Date: 18/01/2016

Approved by: PH Date: 18/01/2016

CONSOLIDATION : ISOTROPIC		
Cell pressure	[kPa]	700
Back pressure	[kPa]	400
Effective cell pressure	[kPa]	300
Pore pressure on completion	[kPa]	400
Pore pressure dissipation	[%]	100
Moisture content	[%]	24.4
Bulk density	[Mg/m³]	2.00
Dry density	[Mg/m³]	1.61
Void ratio		0.645
Degree of saturation	[%]	100
Volumetric strain	[%]	1.18
Axial strain	[%]	0.39

Batch	3
Sample	CIU_3-1
Unit	E3 (Tongeren)
Test number	CIU12

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 3_CIU_3-1_ca.XLS
Date: 18/01/2016
Date: 18/01/2016
Checked by: PH
Approved by: PH

BENDER ELEMENT DETERMINATIONS - POST SATURATION		
Bulk density	[Mg/m^3]	1.99
Dry density	[Mg/m^3]	1.59
Void ratio	[-]	0.665
Distance	[mm]	132.05
Effective radial pressure	[kPa]	20
Effective axial pressure	[kPa]	20

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	1.0885	5.44	121.31	29.3
0.30	1.0880	3.63	121.37	29.3
0.40	1.0790	2.70	122.38	29.8
0.50	1.0775	2.16	122.55	29.9
0.60	1.0735	1.79	123.01	30.1
0.70	1.0835	1.55	121.87	29.6
0.80	1.0835	1.35	121.87	29.6
0.90	1.1060	1.23	119.39	28.4
1.00	1.1510	1.15	114.73	26.2

BENDER ELEMENT DETERMINATIONS - POST ISOTROPIC CONSOLIDATION		
Bulk density	[Mg/m^3]	2.00
Dry density	[Mg/m^3]	1.61
Void ratio	[-]	0.645
Distance	[mm]	131.51
Effective radial pressure	[kPa]	300
Effective axial pressure	[kPa]	300

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	0.5090	2.55	258.38	133.7
0.30	0.4925	1.64	267.03	142.8
0.40	0.5360	1.34	245.36	120.6
0.50	0.5235	1.05	251.22	126.4
0.60	0.5010	0.84	262.50	138.0
0.70	0.4835	0.69	272.00	148.2
0.80	0.4560	0.57	288.41	166.6
0.90	0.4345	0.48	302.68	183.5
1.00	0.4320	0.43	304.43	185.6

Batch	3
Sample	CIU_3-1
Unit	E3 (Tongeren)
Test number	CIU12

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 3_CIU_3-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Date: 18/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	[kPa]	400
Initial effective cell pressure	[kPa]	300
Rate of strain	[%/hour]	1.33
At peak deviator stress		
Corrected deviator stress	[kPa]	390
Membrane correction applied	[kPa]	1.2
Drain correction applied	[kPa]	0
Axial strain	[%]	12.25
Excess pore pressure	[kPa]	124
Major principal effective stress	[kPa]	565
Minor principal effective stress	[kPa]	176
Principal effective stress ratio		3.22
Epsilon 50 [ε 50]	[%]	0.35
Secant modulus [E50] at ε 50	[kPa]	56350
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	332
Membrane correction applied	[kPa]	0.6
Drain correction applied	[kPa]	0
Axial strain	[%]	5.00
Excess pore pressure	[kPa]	163
Major principal effective stress	[kPa]	469
Minor principal effective stress	[kPa]	137
Principal effective stress ratio		3.42
At 10% axial strain		
Corrected deviator stress	[kPa]	385
Membrane correction applied	[kPa]	1.0
Drain correction applied	[kPa]	0
Axial strain	[%]	10.00
Excess pore pressure	[kPa]	134
Major principal effective stress	[kPa]	551
Minor principal effective stress	[kPa]	166
Principal effective stress ratio		3.32

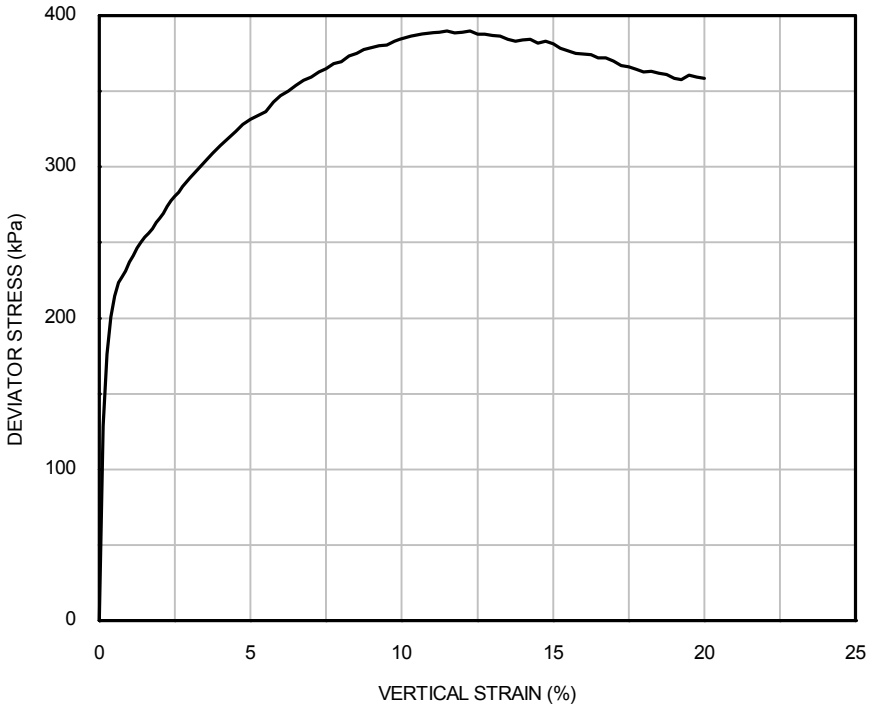
FINAL CONDITIONS		
Moisture content	[%]	24.4
Bulk density	[Mg/m³]	2.00
Dry density	[Mg/m³]	1.61

Batch	3
Sample	CIU_3-1
Unit	E3 (Tongeren)
Test number	CIU12

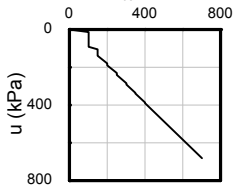
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

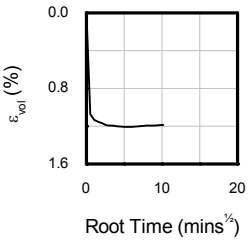
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 18/01/2016
Template Issue: 4.1
Filename: J11302 \ EFFECTIV \ Batch 3_CIU_3-1_ca.OPJ
Date : 18/01/2016
Checked by: PH
Date : 18/01/2016
Approved by: PH

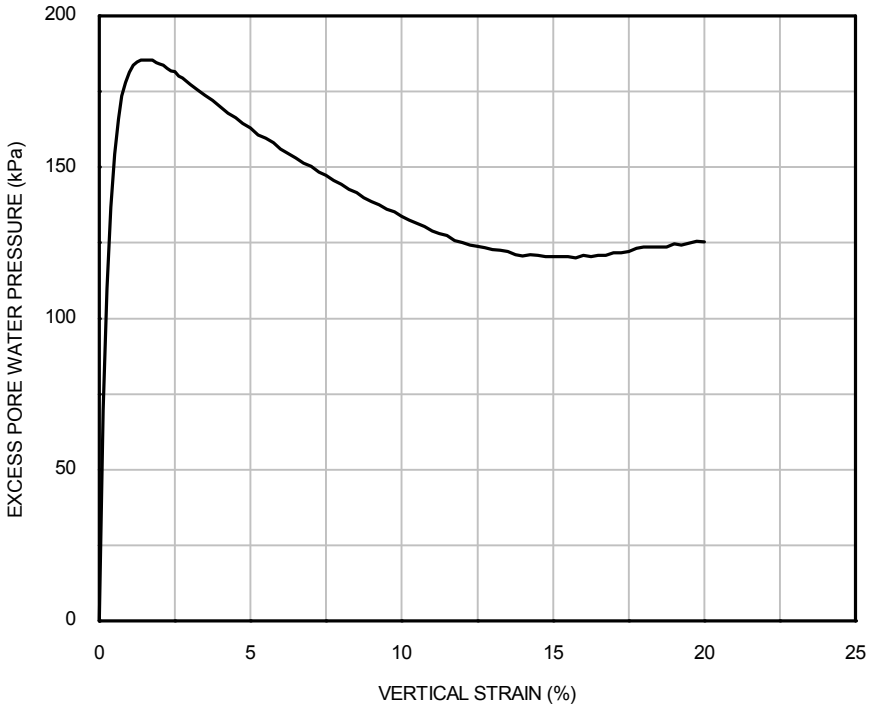


Saturation





Consolidation

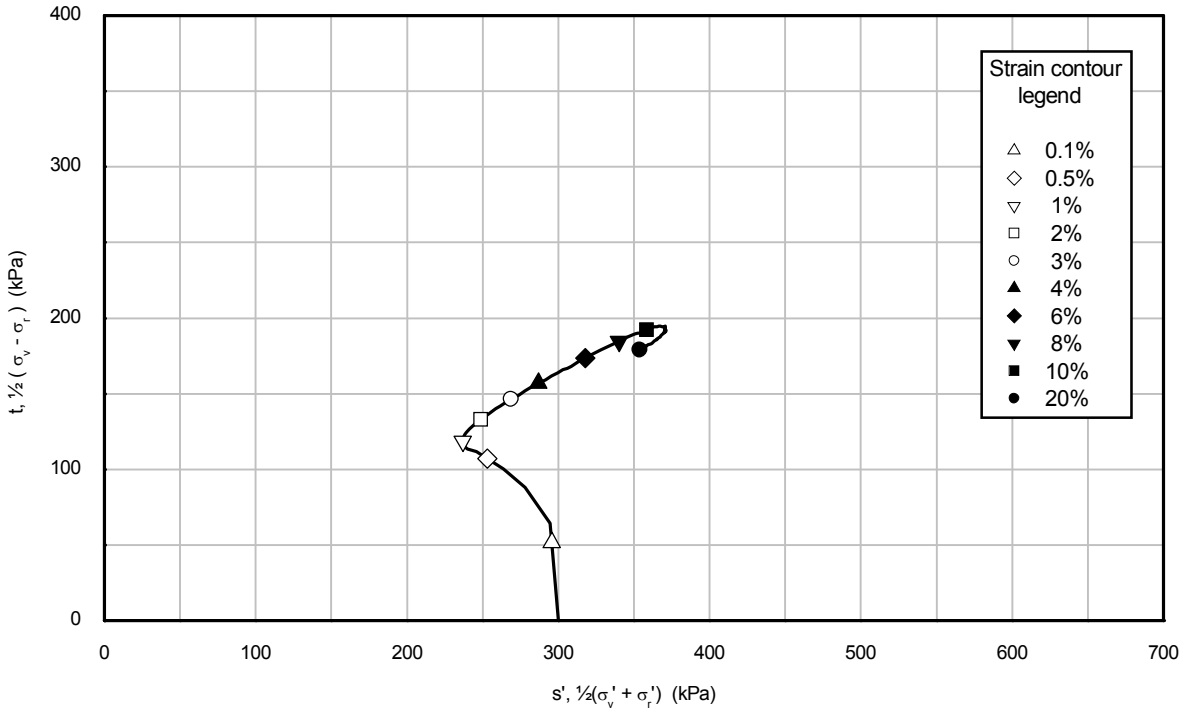


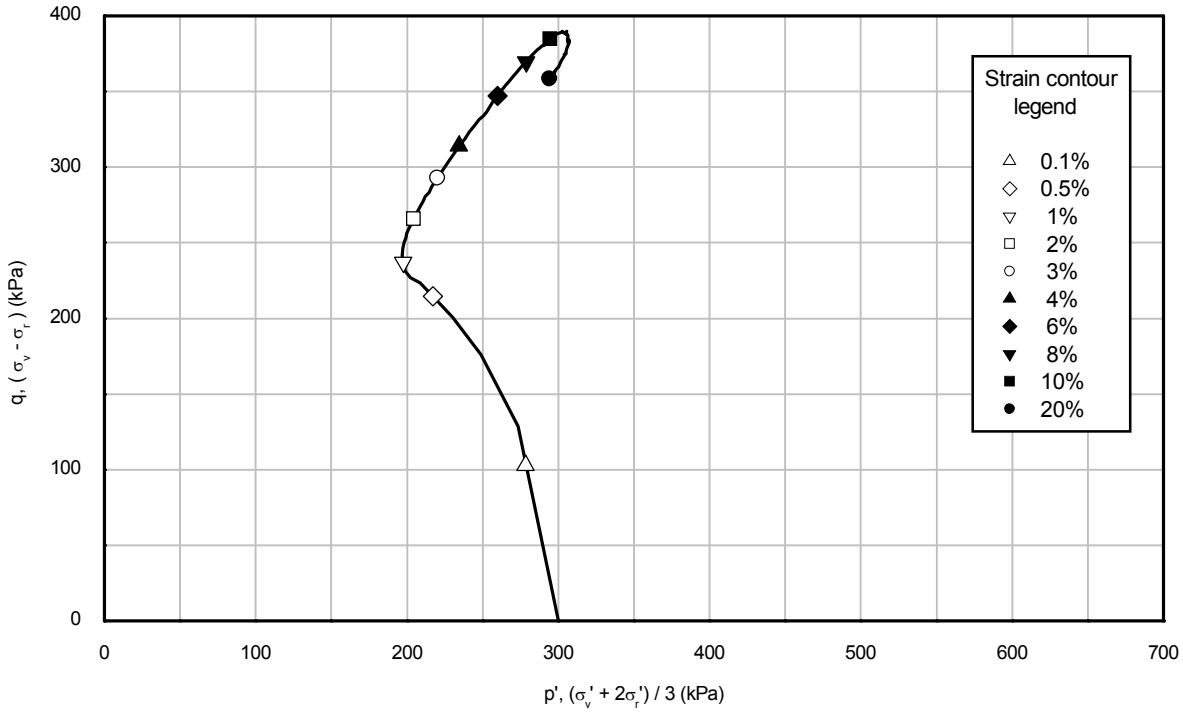
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	300	300

Batch : 3
Sample : CIU_3-1
Unit : E3 (Tongeren)
Test number : CIU12

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





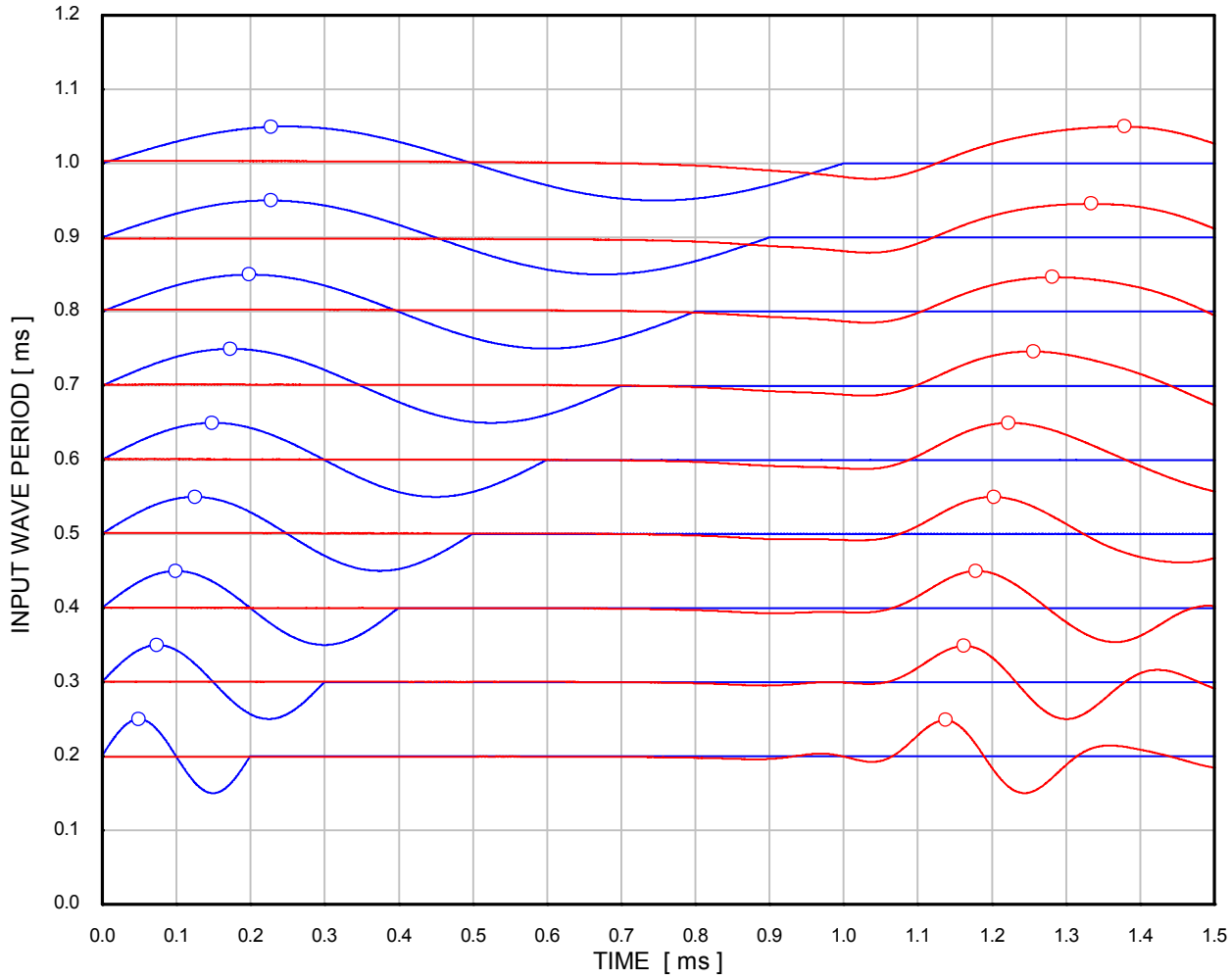
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	300	300

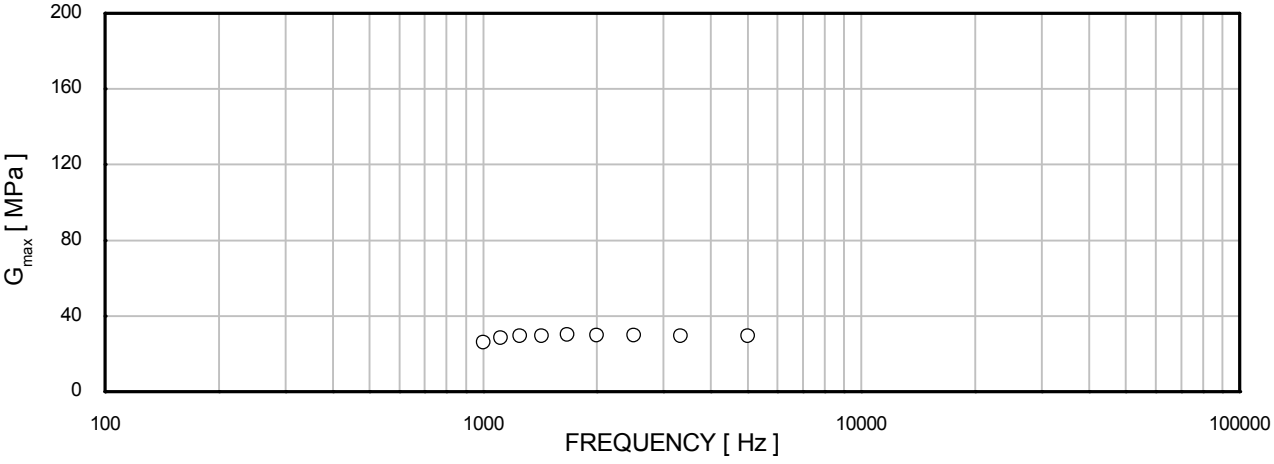
Batch : 3
Sample : CIU_3-1
Unit : E3 (Tongeren)
Test number : CIU12

Drawn by: ALB Date: 18/01/2016
Filename: J11302 \ EFFECTIV \ Batch 3_CIU_3-1_ca.OPJ
Template Issue: 4.1
Date : 18/01/2016
Checked by: PH
Date : 18/01/2016
Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

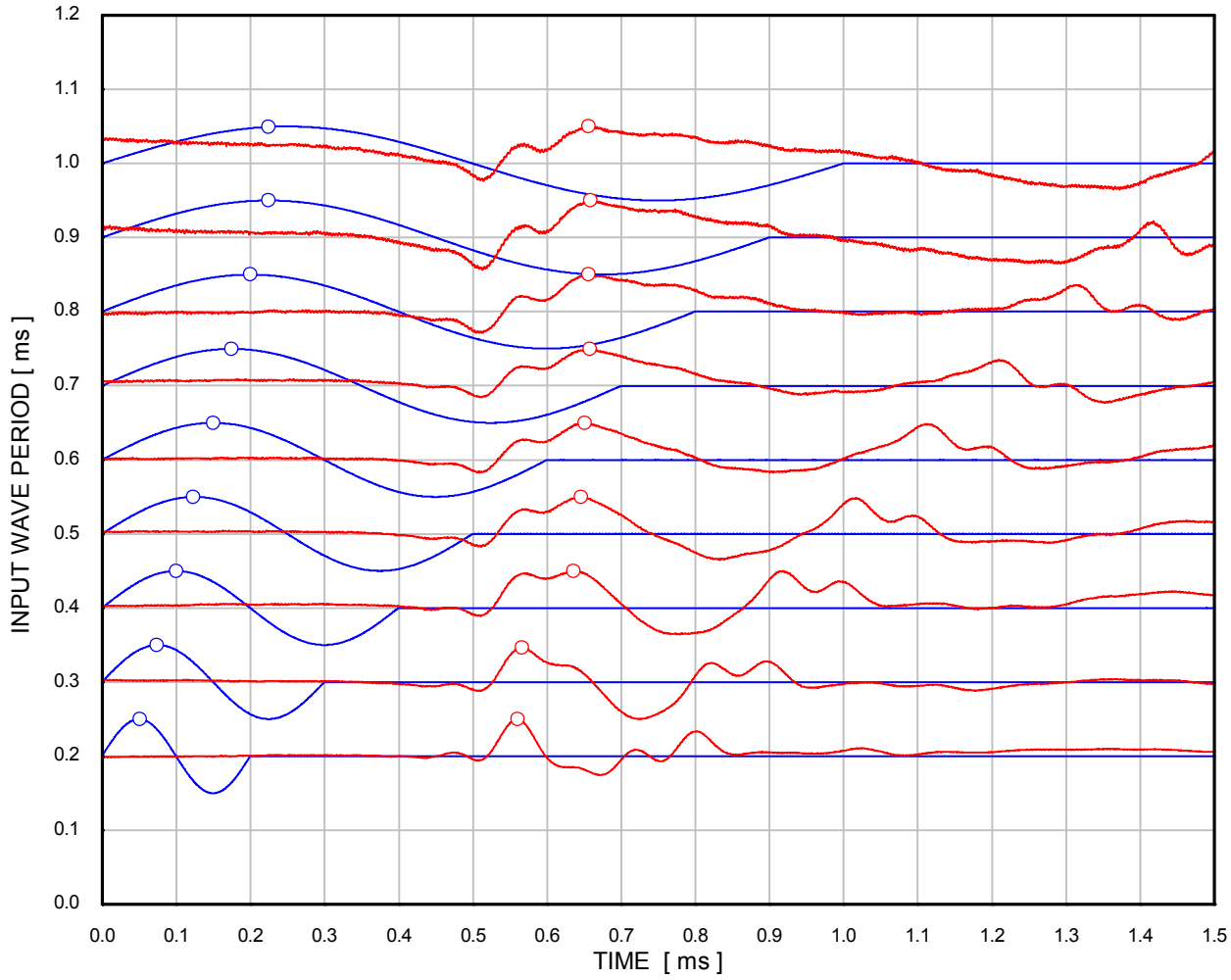


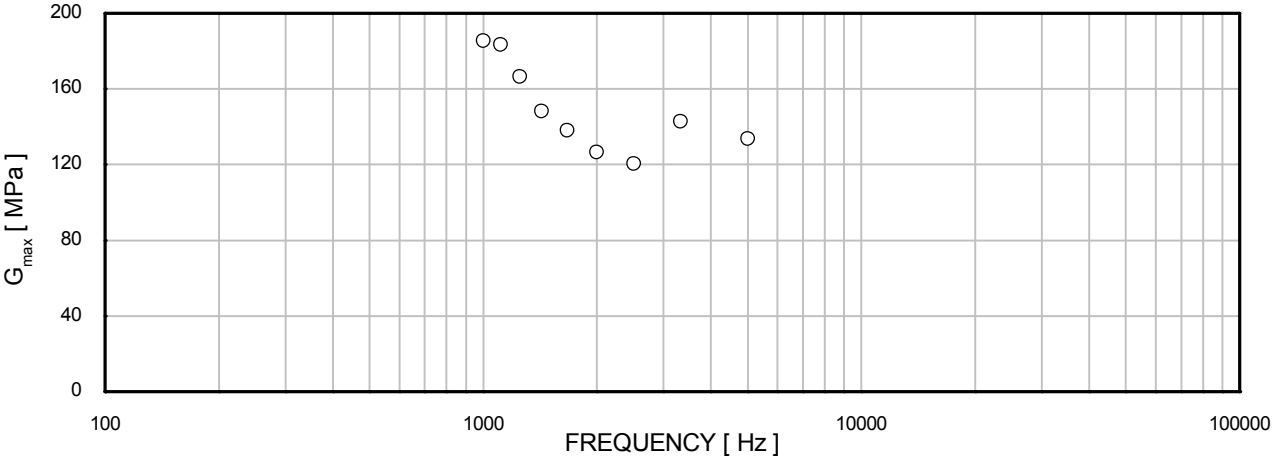


σ'_{rc}	: 20 kPa	Batch	: 3
σ'_{ac}	: 20 kPa	Sample	: CIU_3-1
	Source signal	Unit	: E3 (Tongeren)
	Received signal	Test number.	: CIU12
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-SATURATION S_{VH} BENDER ELEMENT DETERMINATIONS

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





σ'_{rc}	: 300 kPa	Batch	: 3
σ'_{ac}	: 300 kPa	Sample	: CIU_3-1
	Source signal	Unit	: E3 (Tongeren)
	Received signal	Test number.	: CIU12
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-ISOTROPIC CONSOLIDATION S_{VH} BENDER ELEMENT DETERMINATIONS

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 4_CIU_4-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Approved by: PH
Date: 18/01/2016

VISUAL DESCRIPTION
Very dark grey fine to medium SAND

GENERAL	
Date test started	13/01/2016
Type of sample	Recompacted
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL		
Diameter	[mm]	71.7
Length	[mm]	135.0
Moisture content	[%]	10.2
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.60
Void ratio		0.654
Degree of saturation	[%]	41

SATURATION		
Pressure increments applied	[kPa]	50
Differential pressure used	[kPa]	10
Pore pressure on completion	[kPa]	785
Cell pressure on completion	[kPa]	800
B value achieved		0.99

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.3 Fugro testing procedure L-T-023 Clause 5.3.7
Consolidation - Isotropic Consolidation - Anisotropic	BS 1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Batch	4
Sample	CIU_4-1
Unit	E5b (Tongeren)
Test number	CIU13

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Drawn by: ALB Date: 18/01/2016

Template Issue: 3 Filename: J11302 / EFFECTIVE / 4_CIU_4-1_ca.XLS

Checked by: PH Date: 18/01/2016

Approved by: PH Date: 18/01/2016

CONSOLIDATION : ISOTROPIC		
Cell pressure	[kPa]	800
Back pressure	[kPa]	400
Effective cell pressure	[kPa]	400
Pore pressure on completion	[kPa]	400
Pore pressure dissipation	[%]	100
Moisture content	[%]	23.3
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64
Void ratio		0.618
Degree of saturation	[%]	100
Volumetric strain	[%]	2.17
Axial strain	[%]	0.72

Batch	4
Sample	CIU_4-1
Unit	E5b (Tongeren)
Test number	CIU13

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 4_CIU_4-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Date: 18/01/2016
Approved by: PH

BENDER ELEMENT DETERMINATIONS - POST SATURATION		
Bulk density	[Mg/m^3]	2.00
Dry density	[Mg/m^3]	1.60
Void ratio	[-]	0.654
Distance	[mm]	132.14
Effective radial pressure	[kPa]	15
Effective axial pressure	[kPa]	15

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	1.0885	5.44	121.40	29.4
0.30	1.0880	3.63	121.45	29.5
0.40	1.0790	2.70	122.47	30.0
0.50	1.0775	2.16	122.64	30.0
0.60	1.0735	1.79	123.09	30.3
0.70	1.0835	1.55	121.96	29.7
0.80	1.0835	1.35	121.96	29.7
0.90	1.1060	1.23	119.48	28.5
1.00	1.1510	1.15	114.80	26.3

BENDER ELEMENT DETERMINATIONS - POST ISOTROPIC CONSOLIDATION		
Bulk density	[Mg/m^3]	2.02
Dry density	[Mg/m^3]	1.64
Void ratio	[-]	0.618
Distance	[mm]	131.15
Effective radial pressure	[kPa]	400
Effective axial pressure	[kPa]	400

Input Wave Period	Peak-to-Peak Arrival Time	Wavelength Ratio	Velocity	G_{max}
[ms]	[ms]	[-]	[m/s]	[MPa]
0.20	0.5100	2.55	257.15	133.6
0.30	0.5025	1.67	260.99	137.6
0.40	0.4975	1.24	263.61	140.4
0.50	0.5170	1.03	253.67	130.0
0.60	0.4990	0.83	262.82	139.5
0.70	0.4695	0.67	279.33	157.6
0.80	0.4660	0.58	281.43	160.0
0.90	0.4320	0.48	303.58	186.2
1.00	0.4475	0.45	293.07	173.5

Batch	4
Sample	CIU_4-1
Unit	E5b (Tongeren)
Test number	CIU13

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

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

Date: 18/01/2016
Drawn by: ALB
Template Issue: 3
Filename: J11302 / EFFECTIVE / 4_CIU_4-1_ca.XLS
Date: 18/01/2016
Checked by: PH
Date: 18/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	[kPa]	400
Initial effective cell pressure	[kPa]	400
Rate of strain	[%/hour]	1.33
At peak deviator stress		
Corrected deviator stress	[kPa]	273
Membrane correction applied	[kPa]	1.6
Drain correction applied	[kPa]	0
Axial strain	[%]	19.00
Excess pore pressure	[kPa]	279
Major principal effective stress	[kPa]	394
Minor principal effective stress	[kPa]	121
Principal effective stress ratio		3.25
Epsilon 50 [ε 50]	[%]	0.20
Secant modulus [E50] at ε 50	[kPa]	67777
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	220
Membrane correction applied	[kPa]	0.7
Drain correction applied	[kPa]	0
Axial strain	[%]	6.75
Excess pore pressure	[kPa]	312
Major principal effective stress	[kPa]	307
Minor principal effective stress	[kPa]	88
Principal effective stress ratio		3.51
At 10% axial strain		
Corrected deviator stress	[kPa]	239
Membrane correction applied	[kPa]	1.0
Drain correction applied	[kPa]	0
Axial strain	[%]	10.00
Excess pore pressure	[kPa]	304
Major principal effective stress	[kPa]	335
Minor principal effective stress	[kPa]	96
Principal effective stress ratio		3.48

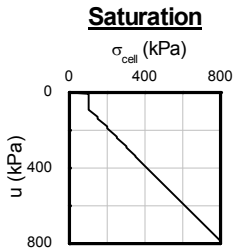
FINAL CONDITIONS		
Moisture content	[%]	23.3
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64

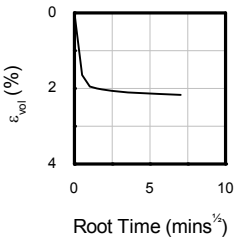
Batch	4
Sample	CIU_4-1
Unit	E5b (Tongeren)
Test number	CIU13

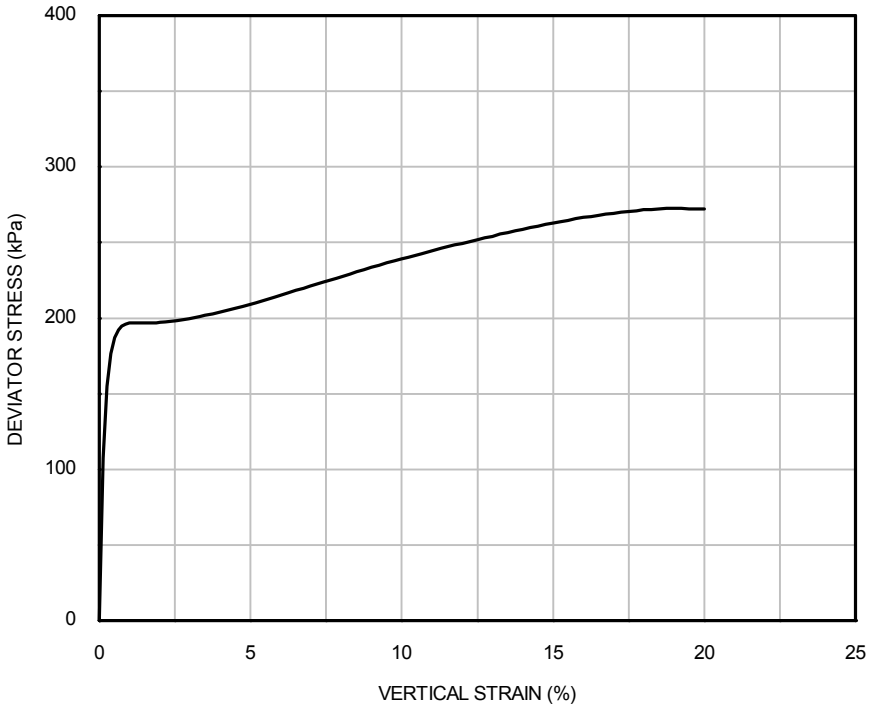
SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN WITH BENDER ELEMENT ADDITION

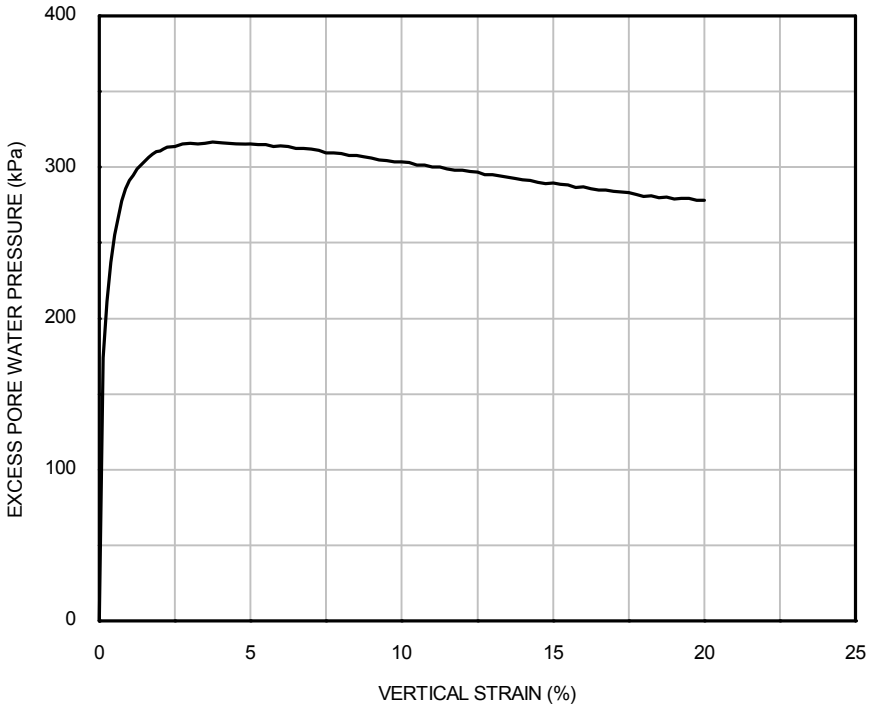
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 18/01/2016
Template Issue: 4.1
Filename: J11302 \ EFFECTIV \ Batch 4_CIU_4-1_ca.OPJ
Date : 18/01/2016
Checked by: PH
Date : 18/01/2016
Approved by: PH







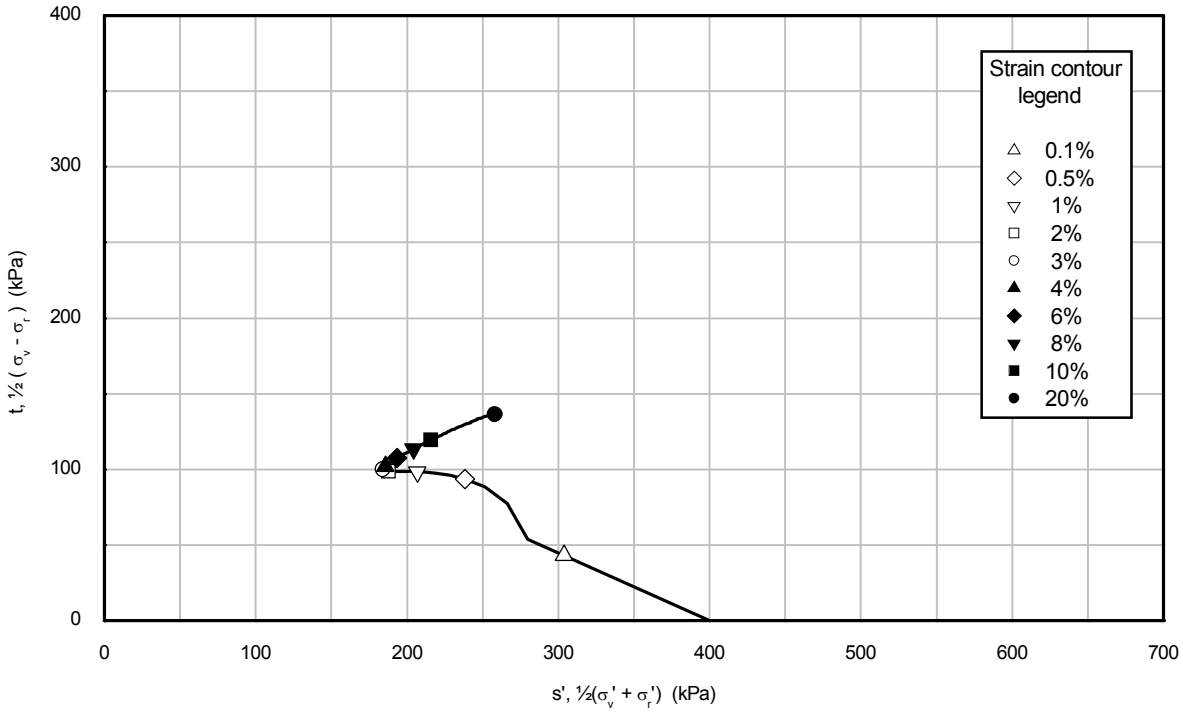


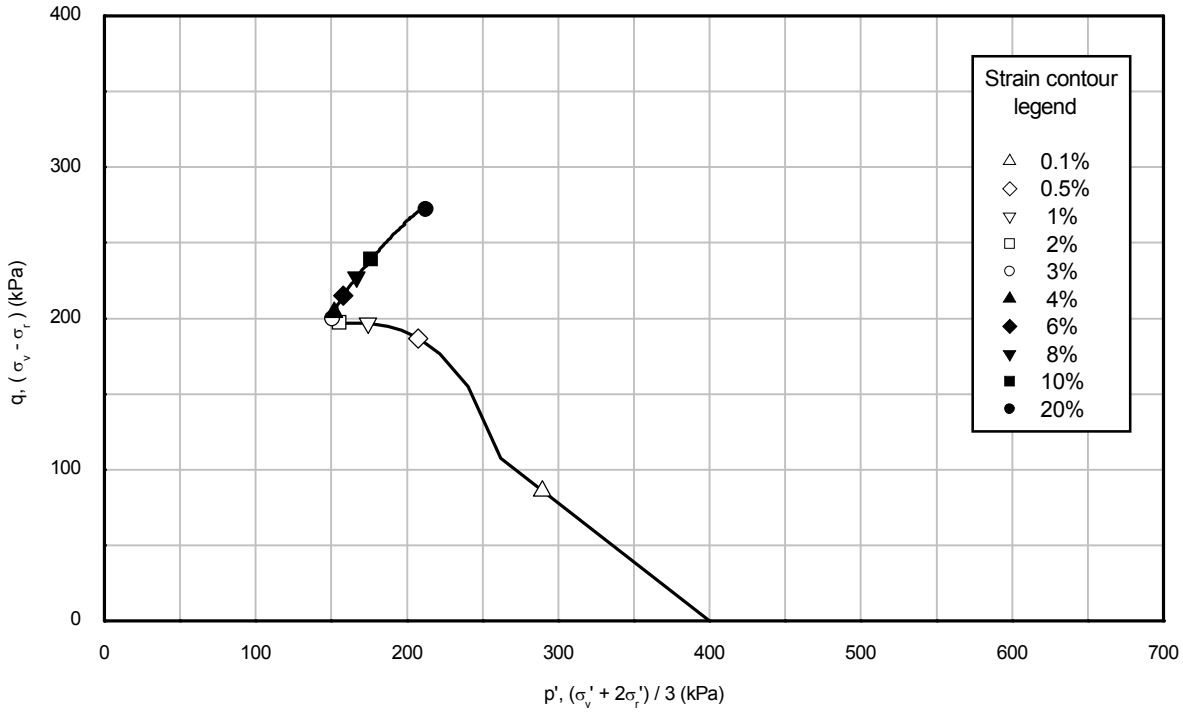
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	400	400

Batch : 4
Sample : CIU_4-1
Unit : E5b (Tongeren)
Test number : CIU13

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





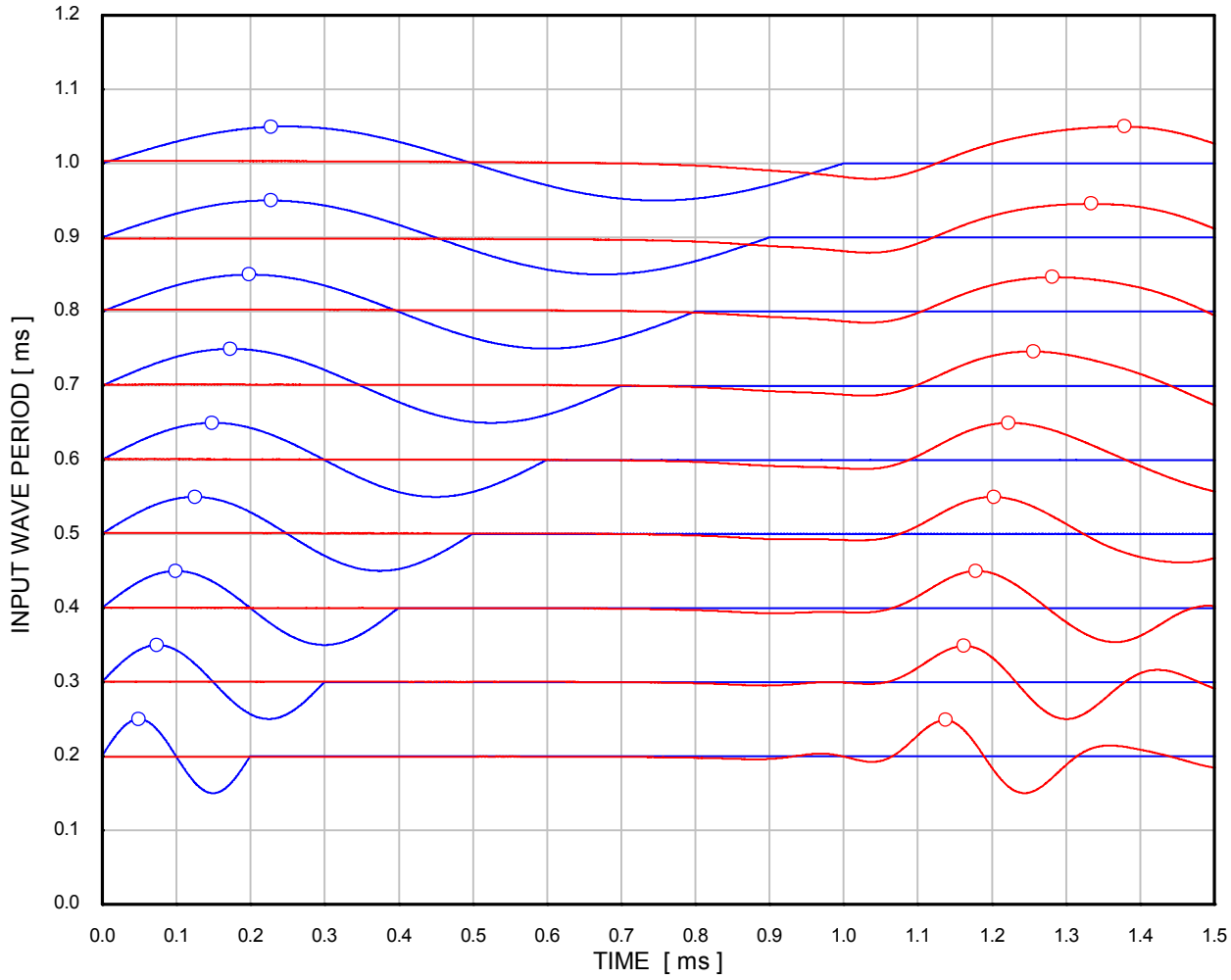
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	400	400

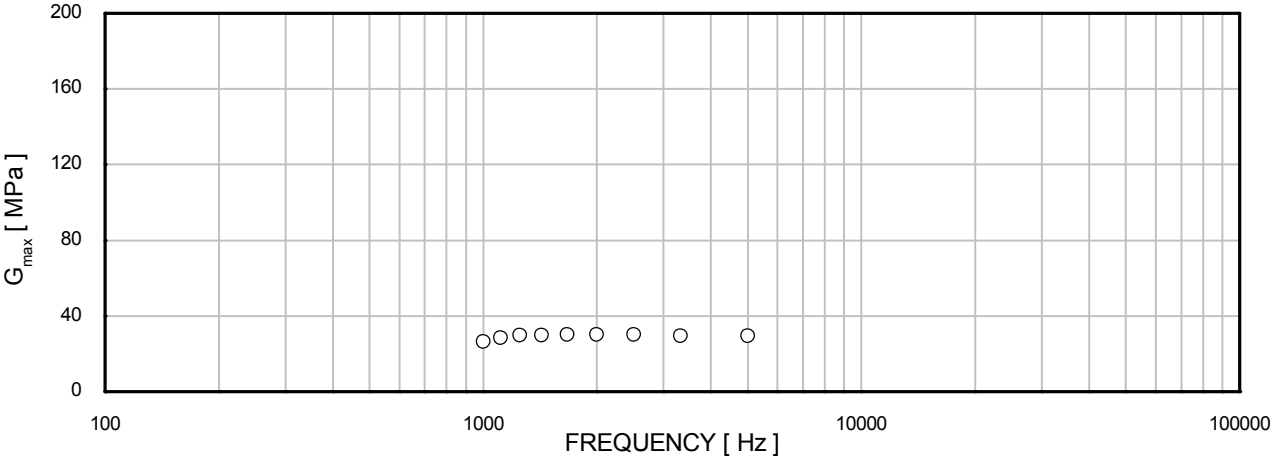
Batch : 4
Sample : CIU_4-1
Unit : E5b (Tongeren)
Test number : CIU13

Drawn by: ALB Date: 18/01/2016
Template Issue: 4.1
Filename: J11302 \ EFFECTIV \ Batch 4_CIU_4-1_ca.OPJ
Date : 18/01/2016
Checked by: PH
Date : 18/01/2016
Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

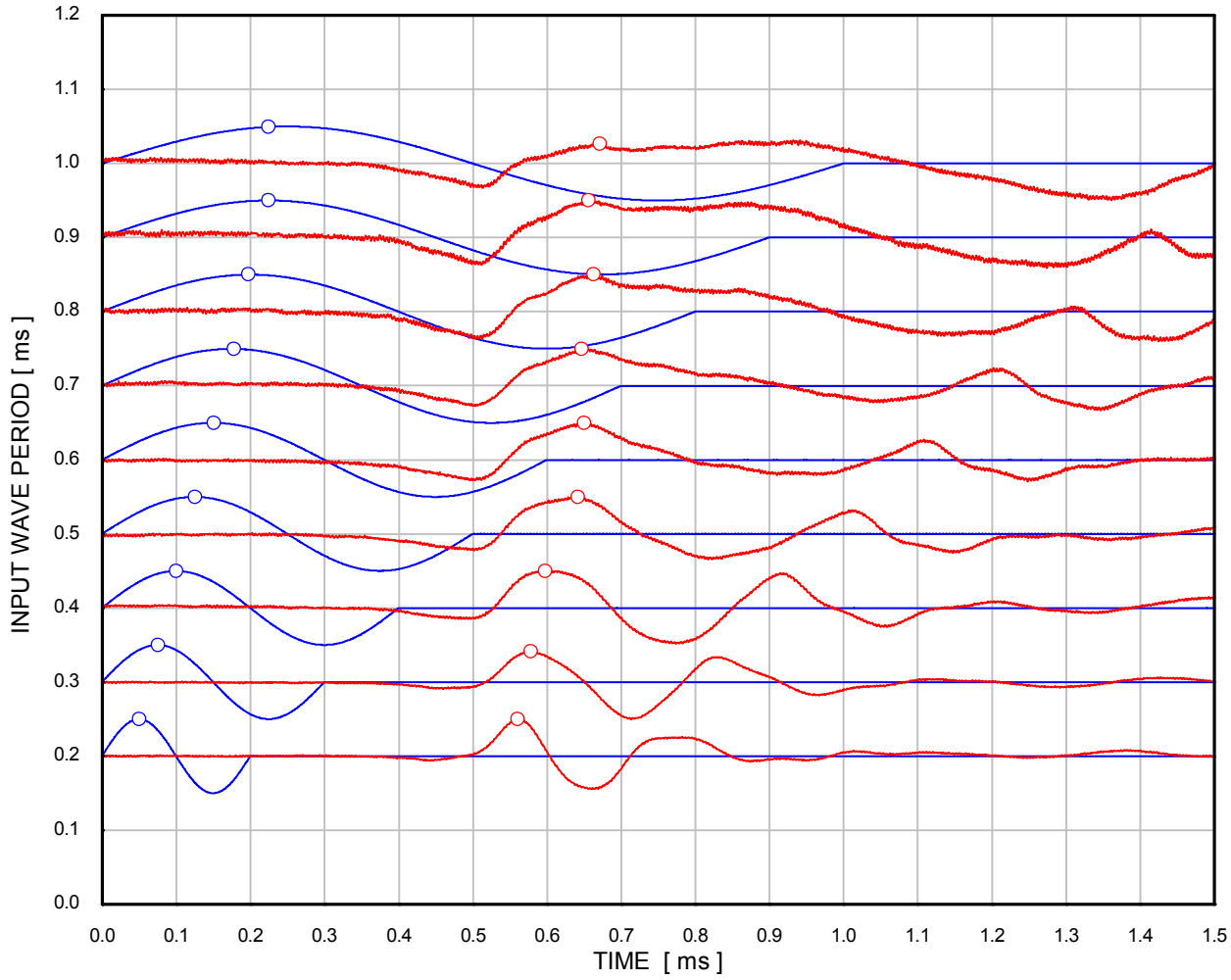


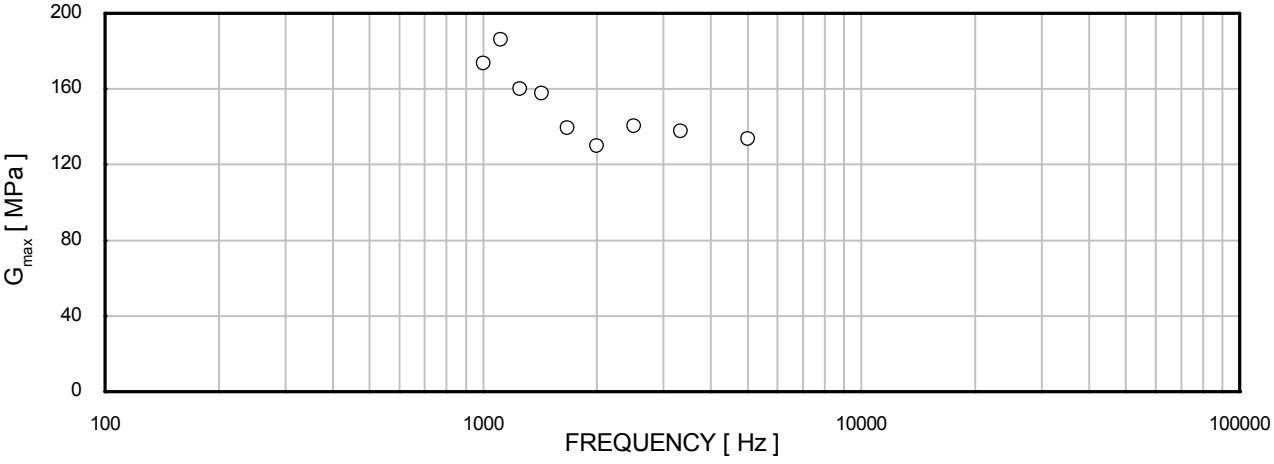


σ'_{rc}	: 15 kPa	Batch	: 4
σ'_{ac}	: 15 kPa	Sample	: CIU_4-1
	Source signal	Unit	: E5b (Tongeren)
	Received signal	Test number.	: CIU13
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-SATURATION S_{VH} BENDER ELEMENT DETERMINATIONS

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





σ'_{rc}	: 400 kPa	Batch	: 4
σ'_{ac}	: 400 kPa	Sample	: CIU_4-1
	Source signal	Unit	: E5b (Tongeren)
	Received signal	Test number.	: CIU13
○ / ○	Selected peak values		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
POST-ISOTROPIC CONSOLIDATION S_{VH} BENDER ELEMENT DETERMINATIONS

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

Date: 15/01/2016
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / 4_CIU_4-2_CU.XLS
Date: 18/01/2016
Checked by: PJS
Date: 19/01/2016
Approved by: PH

VISUAL DESCRIPTION
Dark grey fine to medium SAND

GENERAL	
Date test started	12/01/2016
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	71.7
Length	(mm)	135.0
Moisture content	(%)	10.2
Bulk density	(Mg/m³)	1.77
Dry density	(Mg/m³)	1.61
Void ratio		0.648
Degree of saturation	(%)	42

SATURATION		
Pressure increments applied	(kPa)	50
Differential pressure used	(kPa)	10
Pore pressure on completion	(kPa)	776
Cell pressure on completion	(kPa)	800
B value achieved		0.97

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	

Batch	4
Sample	CIU_4-2
Unit	E5b (Tongeren)
Test number	CIU14

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Drawn by: ALB Date: 15/01/2016

Template Issue: 2 Filename: J11302 / EFFECTIV / 4_CIU_4-2_CU.XLS

Checked by: PJS Date: 18/01/2016

Approved by: PH Date: 19/01/2016

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	800
Back pressure	(kPa)	400
Effective cell pressure	(kPa)	400
Pore pressure on completion	(kPa)	400
Pore pressure dissipation	(%)	100
Moisture content	(%)	23.1
Bulk density	(Mg/m³)	2.02
Dry density	(Mg/m³)	1.64
Void ratio		0.613
Degree of saturation	(%)	100
Volumetric strain	(%)	2.13

Mode of failure: Compound failure

Batch	4
Sample	CIU_4-2
Unit	E5b (Tongeren)
Test number	CIU14

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

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

Date: 15/01/2016
Drawn by: ALB
Template Issue: 2
Filename: J11302 / EFFECTIV / 4_CIU_4-2_CU.XLS
Date: 18/01/2016
Checked by: PJS
Date: 19/01/2016
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	400
Rate of strain	(%/hour)	1.33
At peak deviator stress		
Corrected deviator stress	(kPa)	262
Membrane correction applied	(kPa)	0.1
Drain correction applied	(kPa)	0
Axial strain	(%)	0.75
Excess pore pressure	(kPa)	221
Major principal effective stress	(kPa)	441
Minor principal effective stress	(kPa)	179
Principal effective stress ratio		2.47
Epsilon 50 (ε 50)	(%)	0.10
Secant modulus (E50) at ε 50	(kPa)	137208
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	226
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	9.75
Excess pore pressure	(kPa)	306
Major principal effective stress	(kPa)	320
Minor principal effective stress	(kPa)	94
Principal effective stress ratio		3.41
At 10% axial strain		
Corrected deviator stress	(kPa)	227
Membrane correction applied	(kPa)	0.9
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	305
Major principal effective stress	(kPa)	322
Minor principal effective stress	(kPa)	95
Principal effective stress ratio		3.38

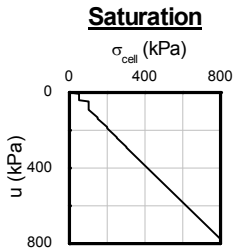
FINAL CONDITIONS		
Moisture content	(%)	23.1
Bulk density	(Mg/m³)	2.02
Dry density	(Mg/m³)	1.64

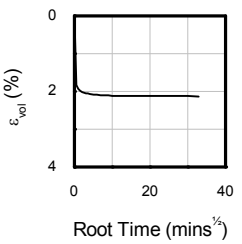
Batch	4
Sample	CIU_4-2
Unit	E5b (Tongeren)
Test number	CIU14

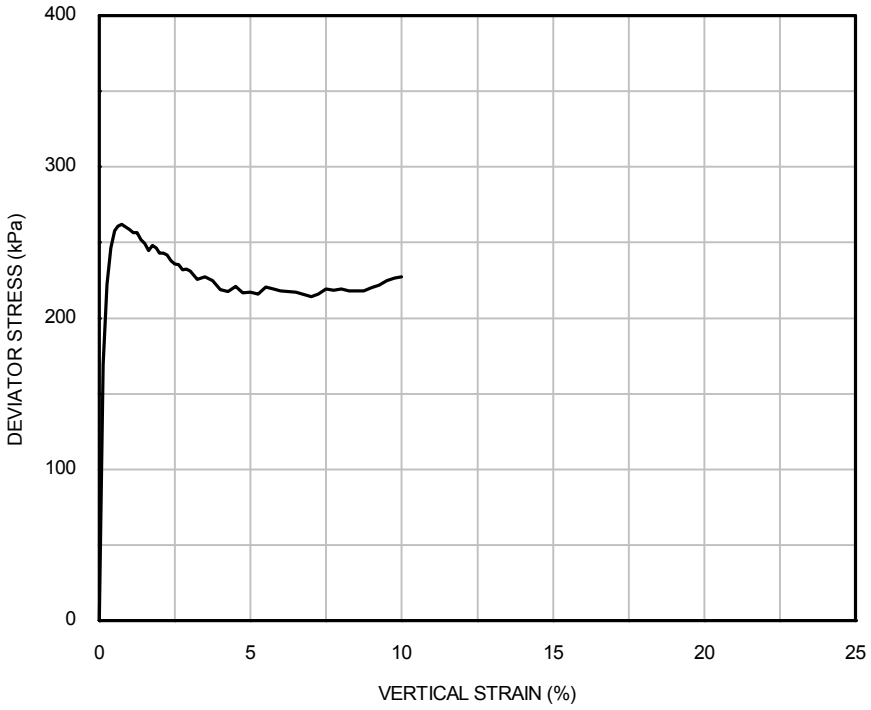
SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

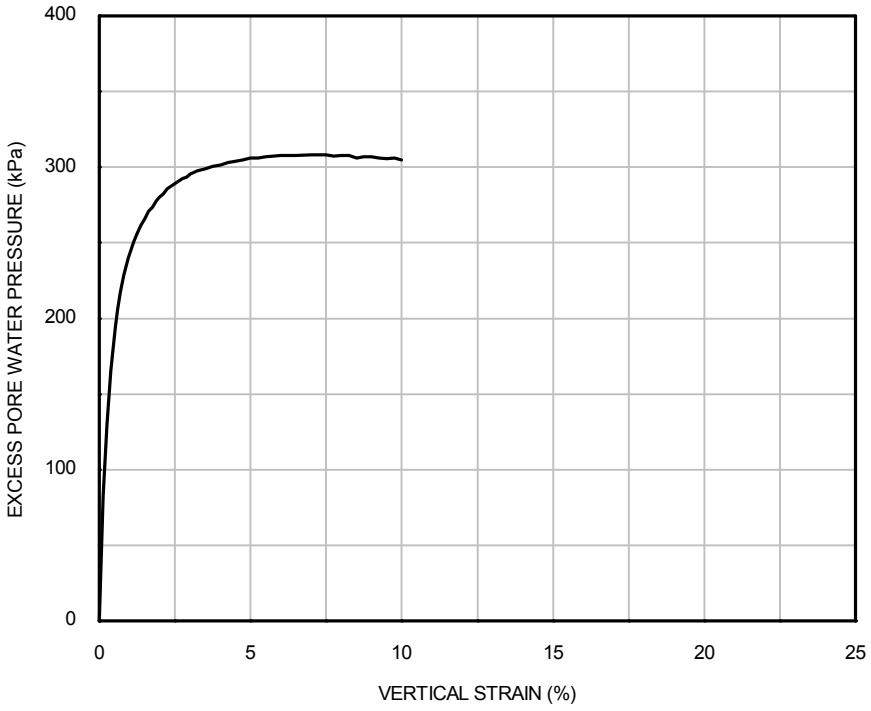
BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

Drawn by: ALB Date: 15/01/2016
Filename: J11302 \ EFFECTIV \ BATCH 4_4-2_CU.OPJ
Template Issue: 4.1
Date : 18/01/2016
Checked by: PJS
Date : 19/01/2016
Approved by: PH







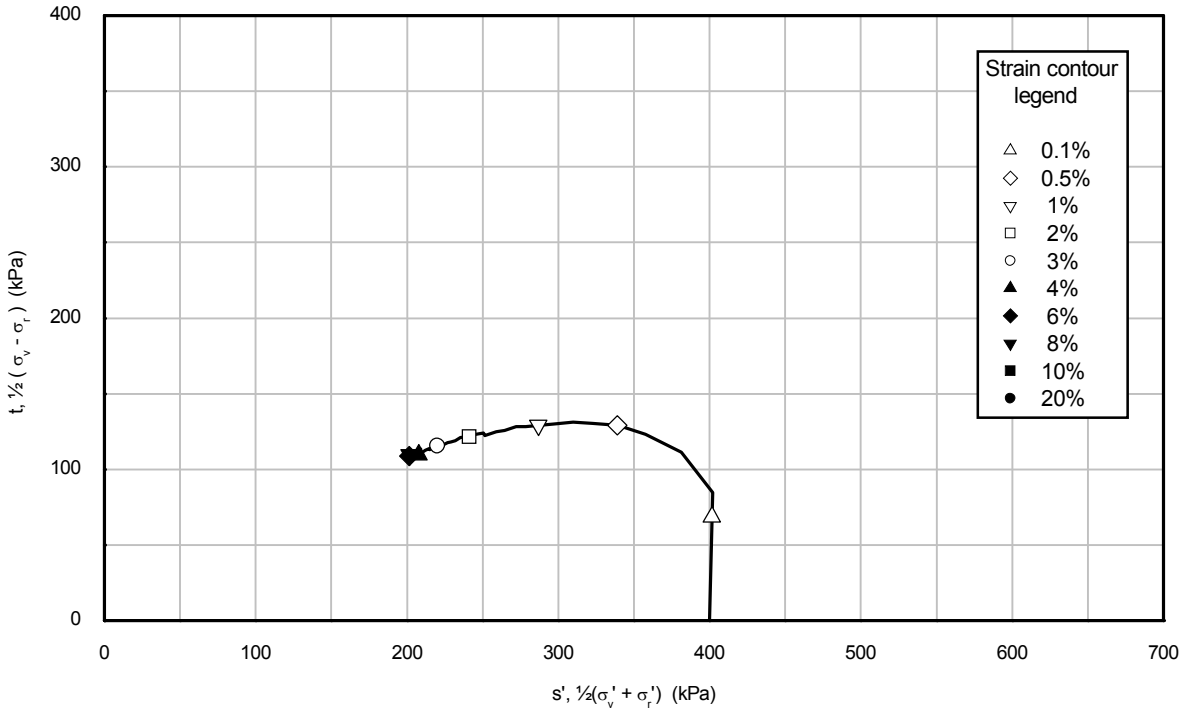


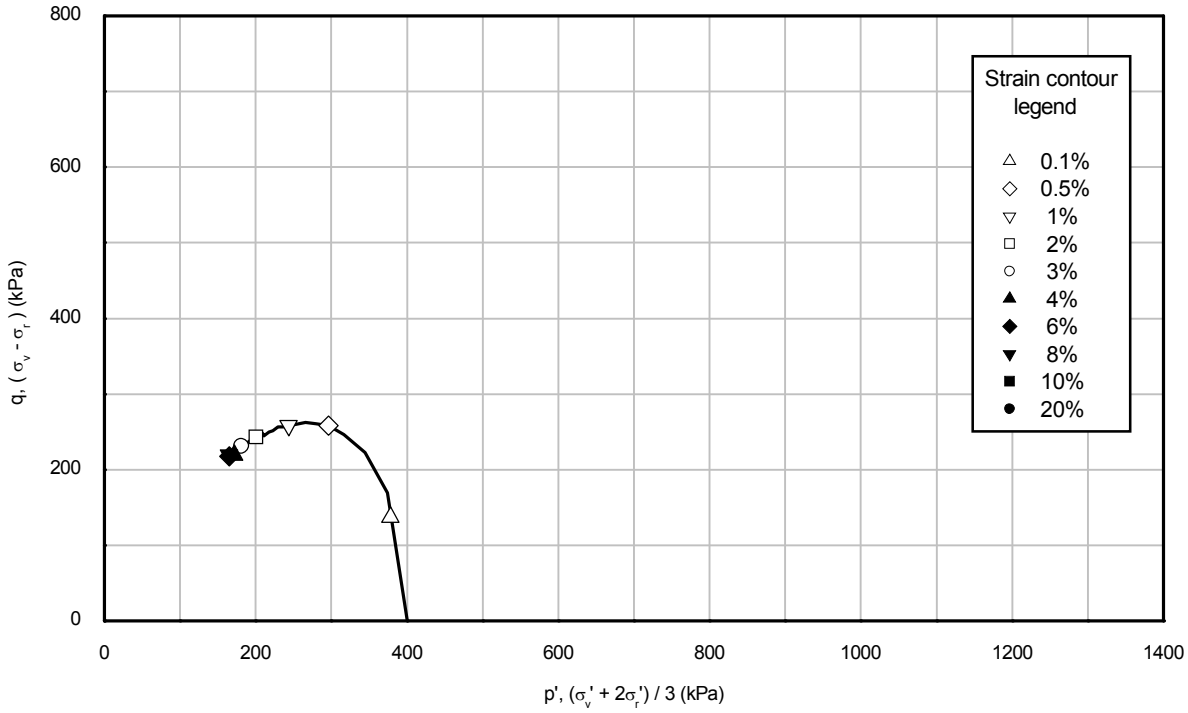
Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	400	400

Batch	: 4
Sample	: CIU_4-2
Unit	: E5b (Tongeren)
Test number	: CIU14

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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





Curve	Specimen	σ_{rc}' (kPa)	σ_{vc}' (kPa)
——	1	400	400

Batch	: 4
Sample	: CIU_4-2
Unit	: E5b (Tongeren)
Test number	: CIU14

Drawn by: ALB Date: 15/01/2016

Filename: J11302 \ EFFECTIV \ BATCH 4_4-2_CU.OPJ Date : 19/01/2016

Template Issue: 4.1 Date : 18/01/2016

Checked by: PJS Approved by: PH

ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

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

SECTION A5: STATIC DIRECT SIMPLE SHEAR TESTS

LIST OF PLATES IN SECTION A5: Plate

Direct Simple Shear Test - Cohesive Specimens	A5.1-1 to A5.1-32
Direct Simple Shear Test - Cohesionless Specimens	A5.2-1 to A5.1-56

VISUAL DESCRIPTION
Very dark grey fissured CLAY

GENERAL	
Date test started	18/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	30.0
Moisture content	[%]	33.1
Bulk density	[Mg/m³]	1.90
Dry density	[Mg/m³]	1.43
Void ratio	[-]	0.892
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	163
Pocket penetrometer	[kPa]	233
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure based on ASTM D6528-07
Consolidation	Fugro in house procedure based on ASTM D6528-07
Shearing	Fugro in house procedure based on ASTM D6528-07
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_2WaxD_DSS01
Template issue	1.3
Processed by	RN
Date	25/11/2015
Checked by	HJ
Date	09/12/2015
Approved by	PH
Date	13/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.36
Test number	DSS01

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ'_{vc}	[kPa]	738
Vertical strain	[%]	3.39
Bulk density	[Mg/m^3]	1.93
Dry density	[Mg/m^3]	1.48
Void ratio	[-]	0.828
Moisture content	[%]	30.8

CONSOLIDATION		
σ'_{vc}	[kPa]	230
Vertical strain	[%]	3.17
Bulk density	[Mg/m^3]	1.89
Dry density	[Mg/m^3]	1.42
Void ratio	[-]	0.903
Moisture content	[%]	33.6

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	176
Shear strain	[%]	21.33
Shear induced -$\Delta\sigma'_v$	[kPa]	-60
Vertical stress	[kPa]	290
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.97
At 15 % shear strain		
Shear stress	[kPa]	172
Shear induced -$\Delta\sigma'_v$	[kPa]	-65
Vertical stress	[kPa]	295
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.36
Test number	DSS01

SUMMARY OF CONSOLIDATED DSS TEST

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

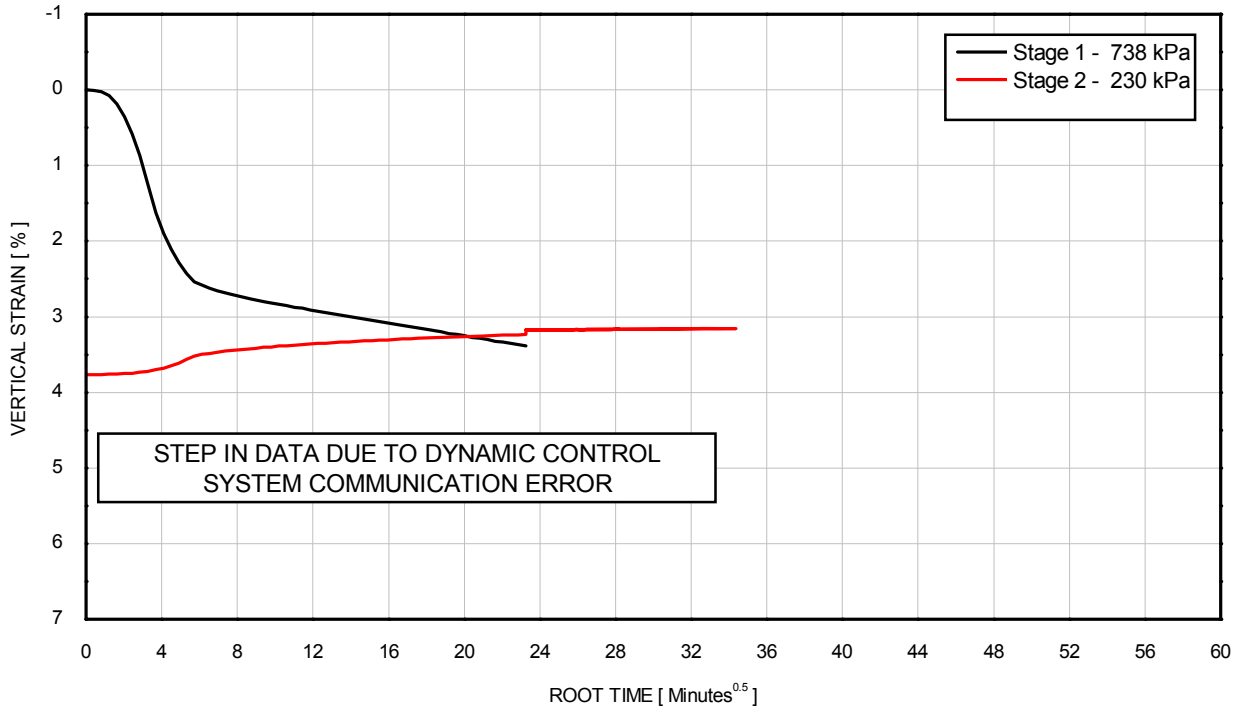
SPECIMEN PHOTOGRAPH

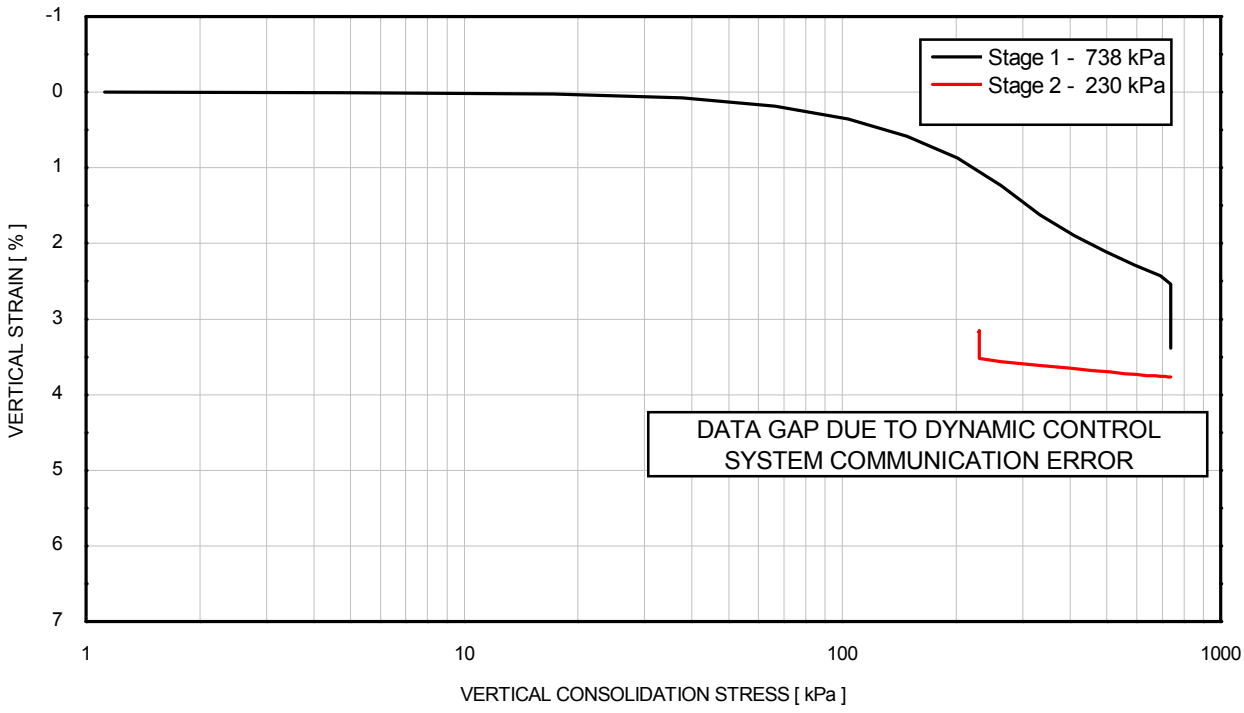


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.36
Test number	DSS01

SUMMARY OF CONSOLIDATED DSS TEST

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

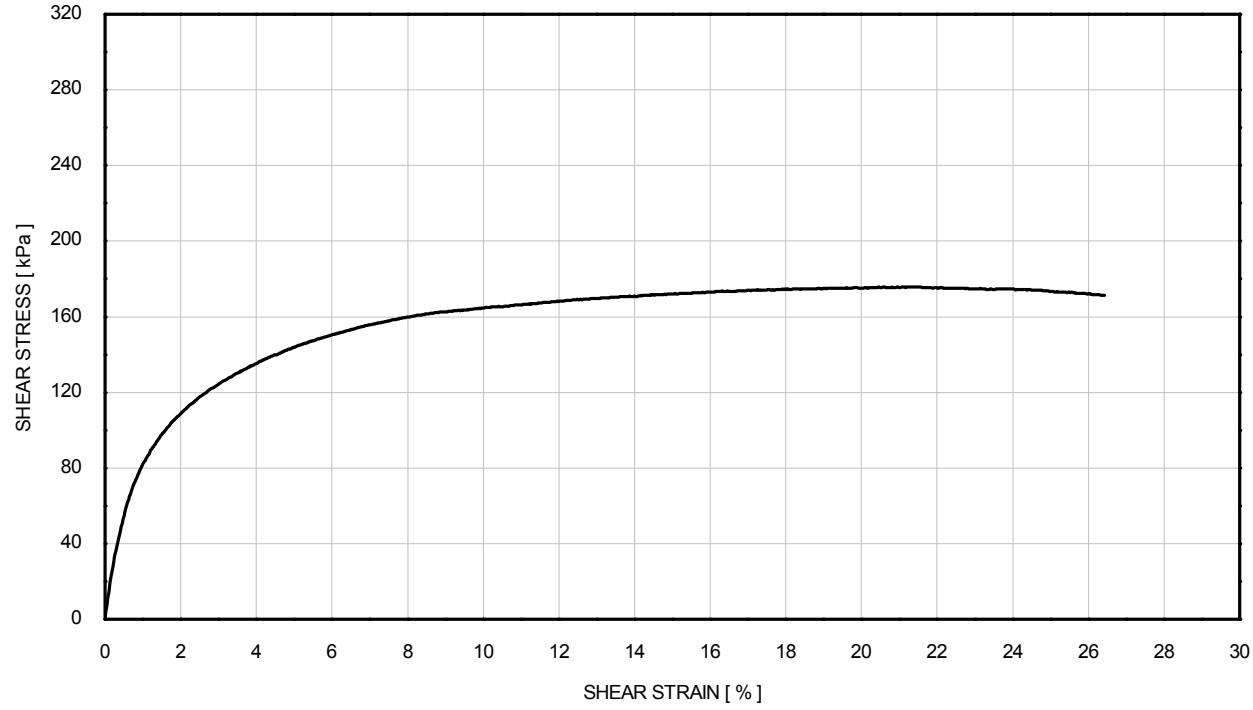


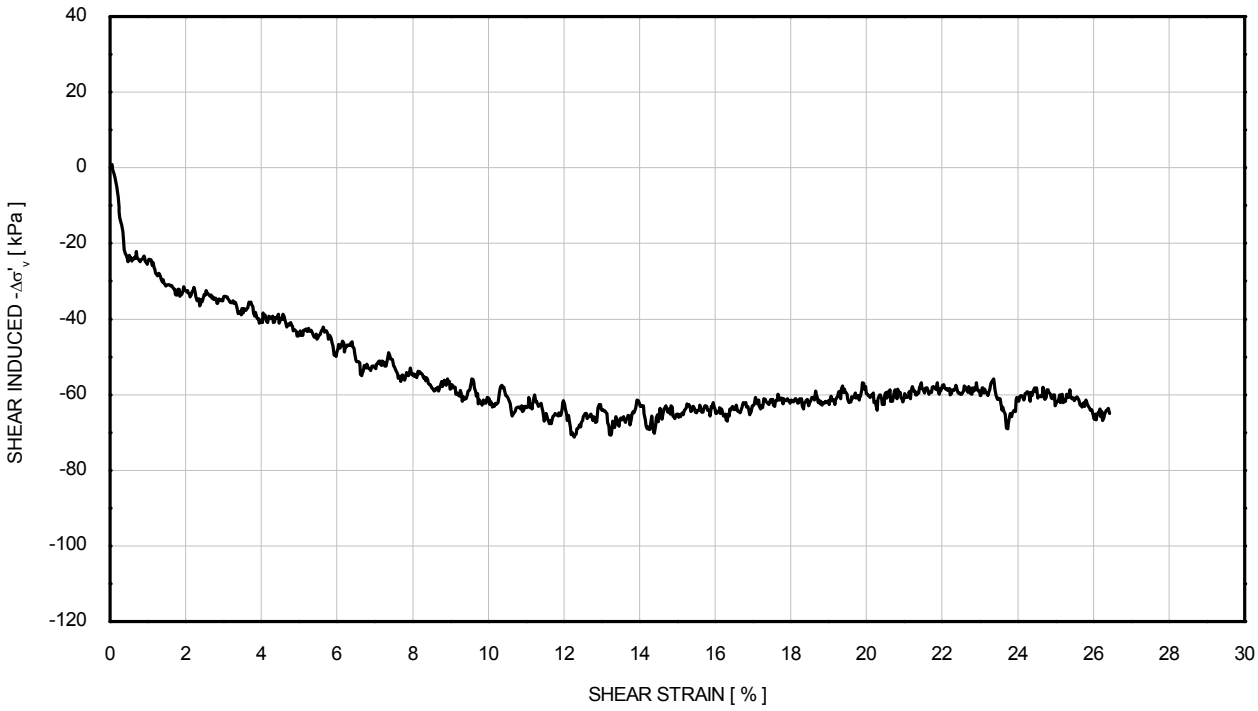


σ'_{vc}	: 230 kPa	Borehole	: BH-WFS3-4A
		Sample	: 2WaxD
		Unit	: F1c (Dongen)
		Depth [m]	: 23.36
		Test No.	: DSS01

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

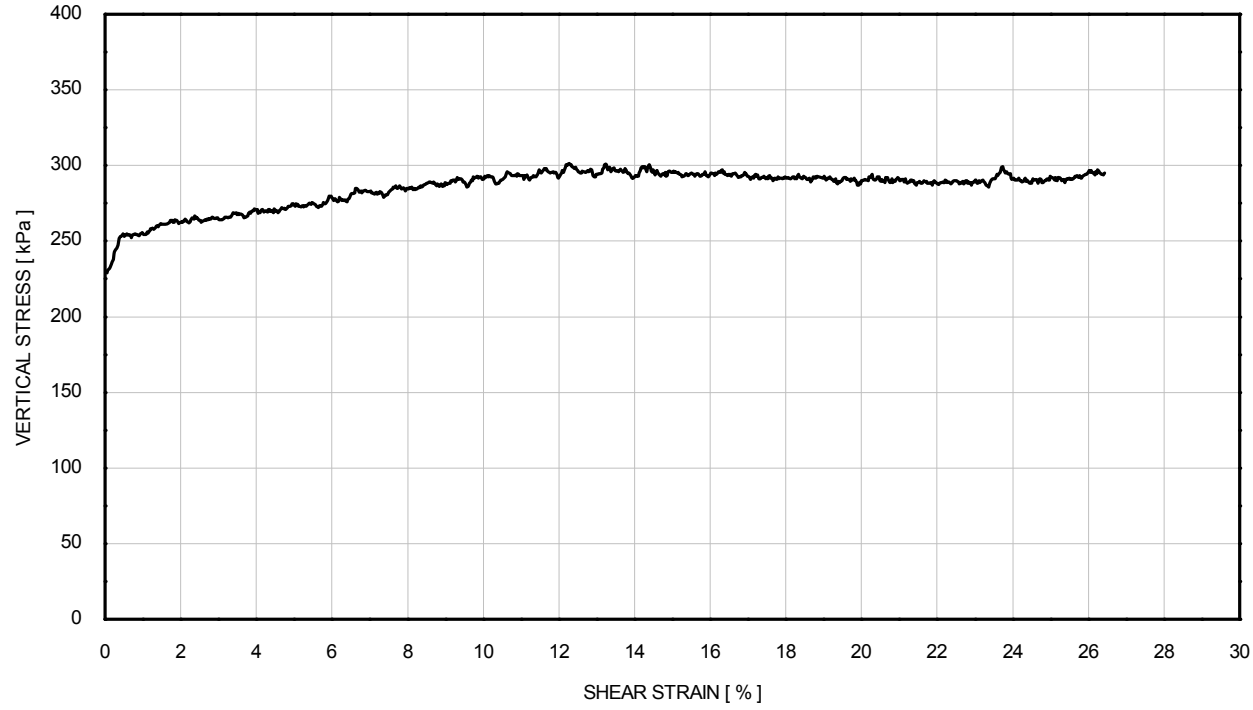


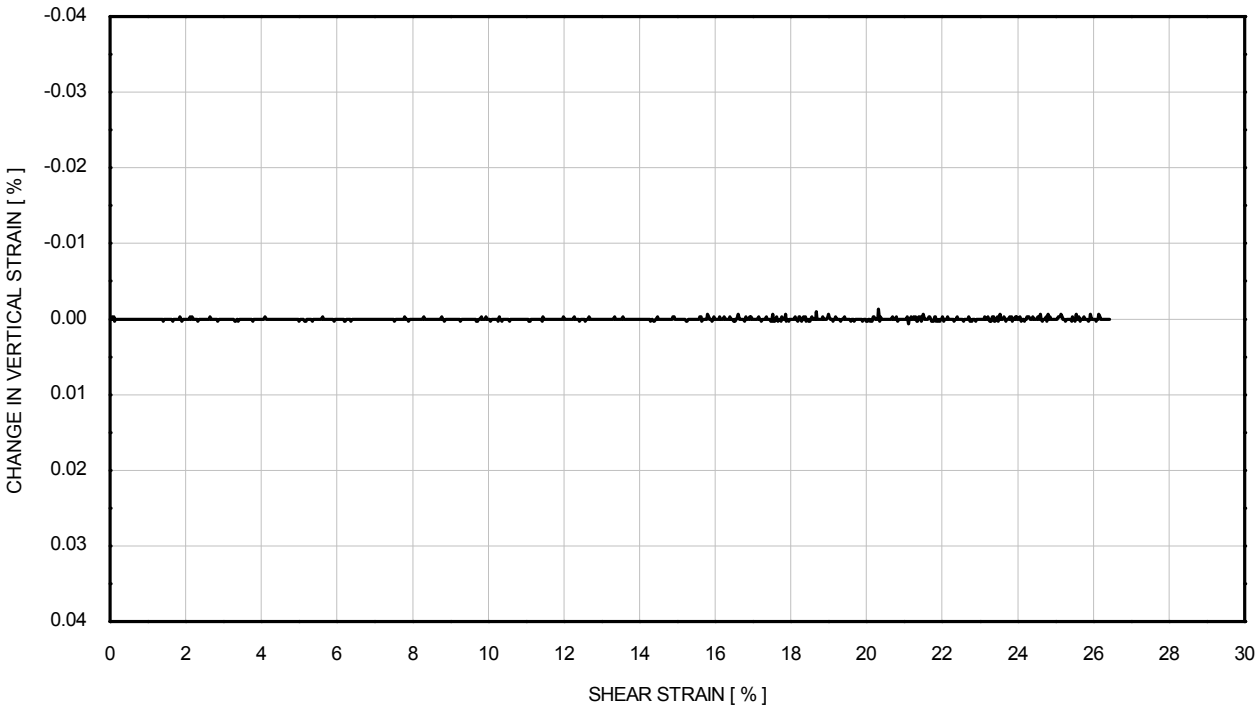


σ'_{vc}	: 230 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 176 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 21.33 %	Unit	: F1c (Dongen)
Rate of strain	: 2.97 %/hour	Depth [m]	: 23.36
		Test No.	: DSS01

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

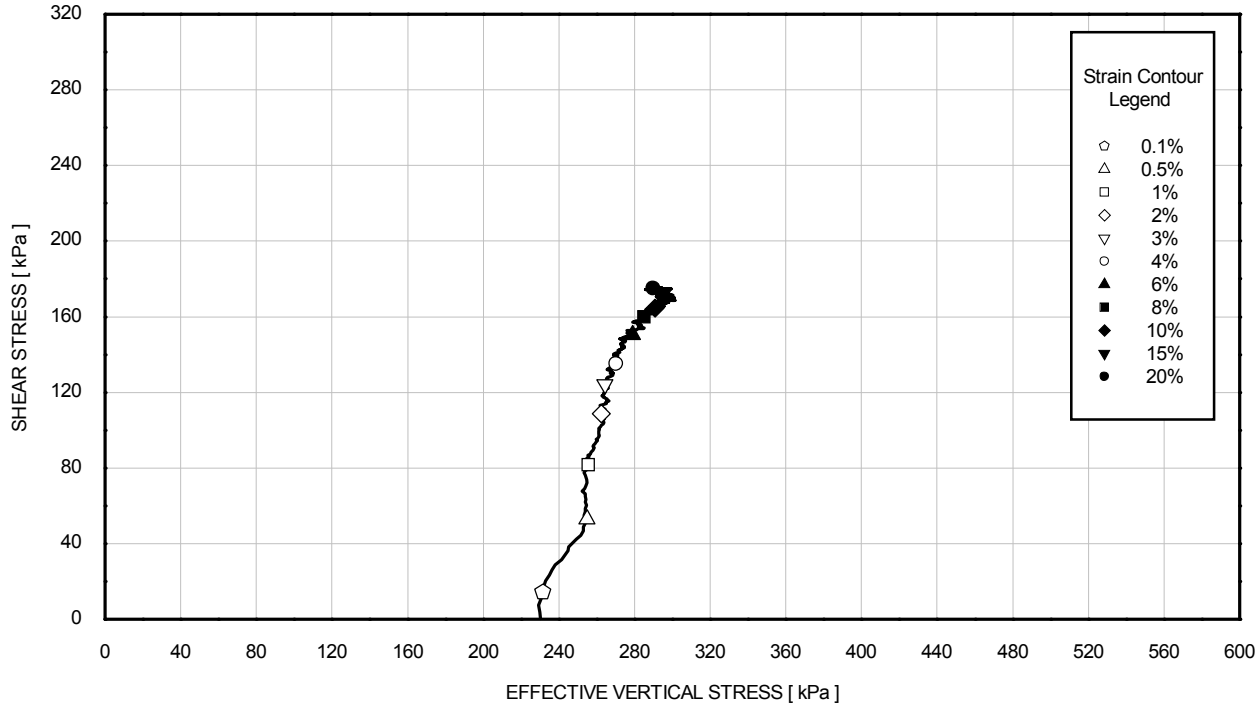


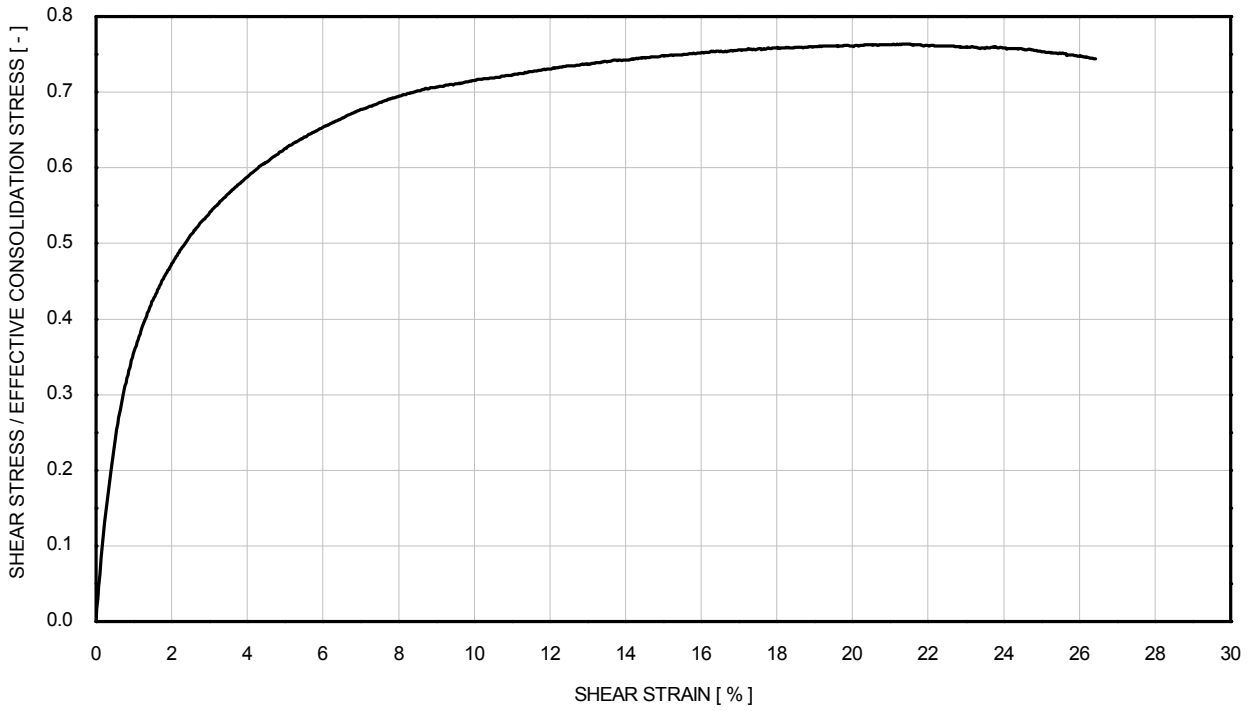


σ'_{vc}	: 230 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 176 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 21.33 %	Unit	: F1c (Dongen)
Rate of strain	: 2.97 %/hour	Depth [m]	: 23.36
		Test No.	: DSS01

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

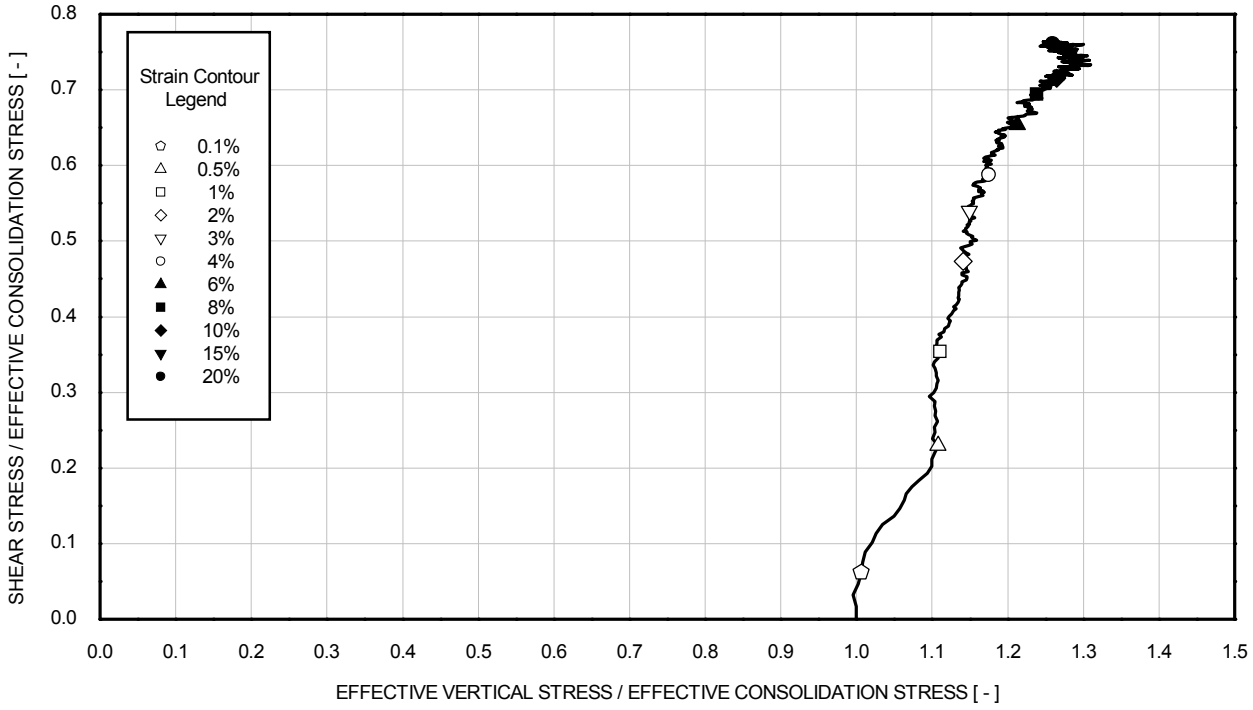


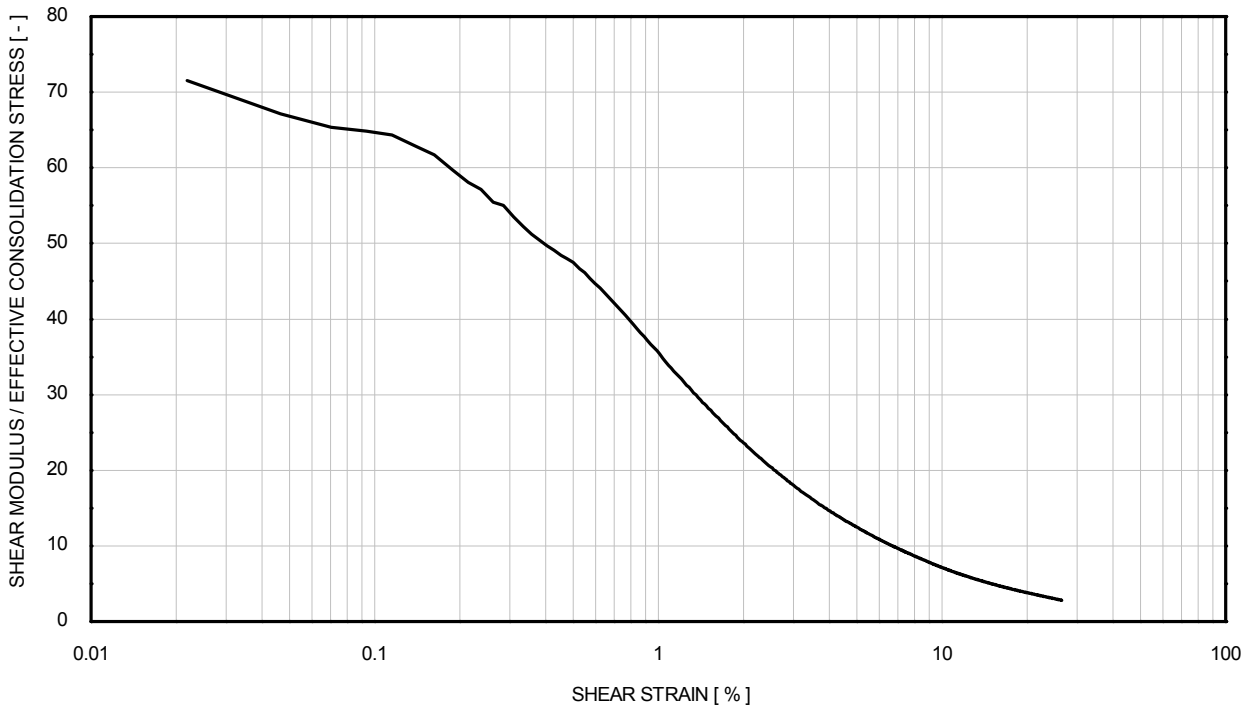


σ'_{vc}	:	230 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	176 kPa	Sample	:	2WaxD
γ at τ_{peak}	:	21.33 %	Unit	:	F1c (Dongen)
Rate of strain	:	2.97 %/hour	Depth [m]	:	23.36
			Test No.	:	DSS01

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ'_{vc}	:	230 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	176 kPa	Sample	:	2WaxD
γ at τ_{peak}	:	21.33 %	Unit	:	F1c (Dongen)
Rate of strain	:	2.97 %/hour	Depth [m]	:	23.36
			Test No.	:	DSS01

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark greenish grey fissured and slickensided CLAY

GENERAL	
Date test started	18/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.9
Length	[mm]	29.9
Moisture content	[%]	39.4
Bulk density	[Mg/m³]	1.84
Dry density	[Mg/m³]	1.32
Void ratio	[-]	1.043
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	242
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure based on ASTM D6528-07
Consolidation	Fugro in house procedure based on ASTM D6528-07
Shearing	Fugro in house procedure based on ASTM D6528-07
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_6WaxD_DSS02
Template issue	1.3
Processed by	HJ
Date	23/11/2015
Checked by	RN
Date	04/12/2015
Approved by	PH
Date	13/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxD
Unit	F3 (Dongen)
Depth [m]	33.39
Test number	DSS02

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ'_{vc}	[kPa]	885
Vertical strain	[%]	3.45
Bulk density	[Mg/m^3]	1.87
Dry density	[Mg/m^3]	1.37
Void ratio	[-]	0.973
Moisture content	[%]	36.8

CONSOLIDATION		
σ'_{vc}	[kPa]	315
Vertical strain	[%]	1.86
Bulk density	[Mg/m^3]	1.83
Dry density	[Mg/m^3]	1.30
Void ratio	[-]	1.074
Moisture content	[%]	40.6

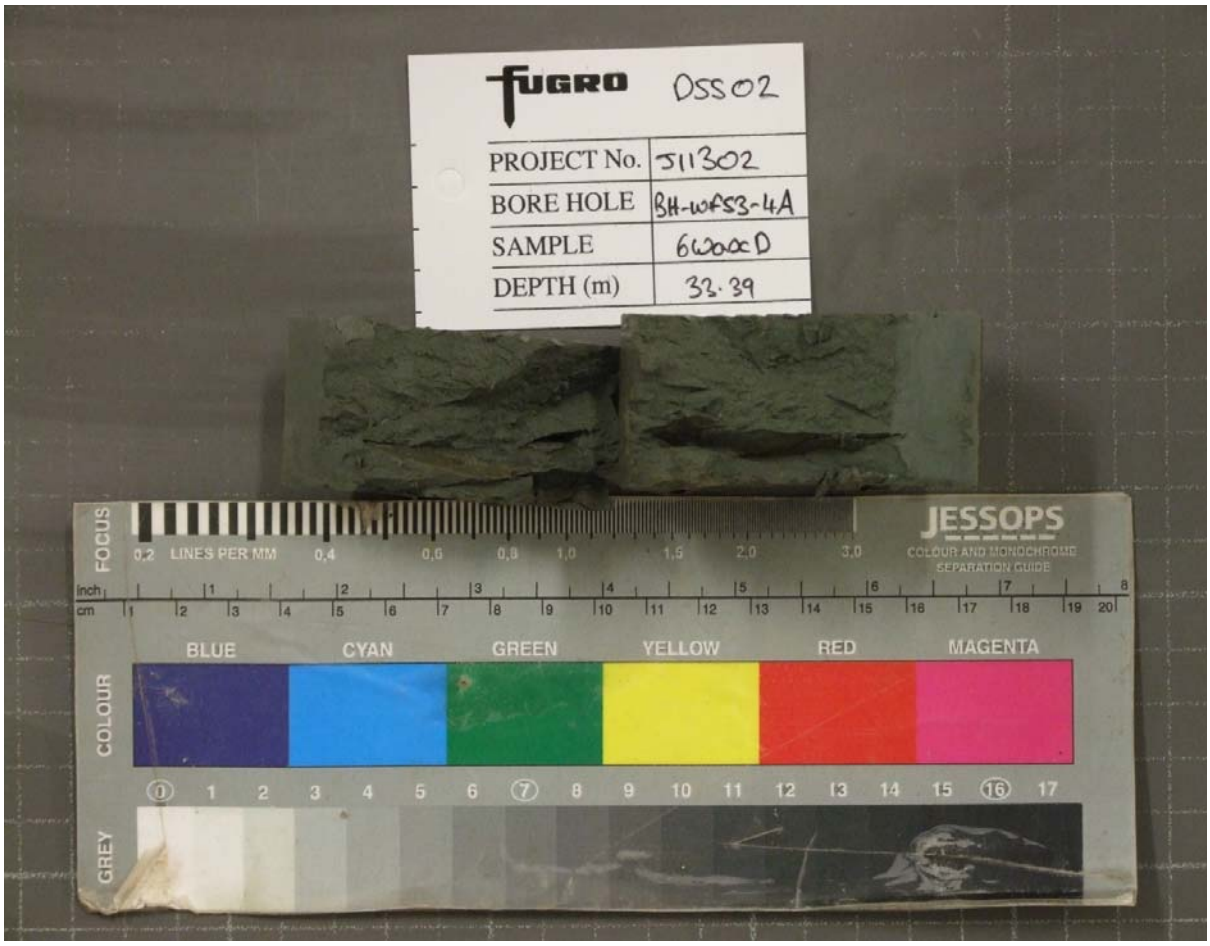
SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	180
Shear strain	[%]	13.93
Shear induced -$\Delta\sigma'_v$	[kPa]	-99
Vertical stress	[kPa]	415
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.99
At 15 % shear strain		
Shear stress	[kPa]	179
Shear induced -$\Delta\sigma'_v$	[kPa]	-112
Vertical stress	[kPa]	428
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxD
Unit	F3 (Dongen)
Depth [m]	33.39
Test number	DSS02

SUMMARY OF CONSOLIDATED DSS TEST

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

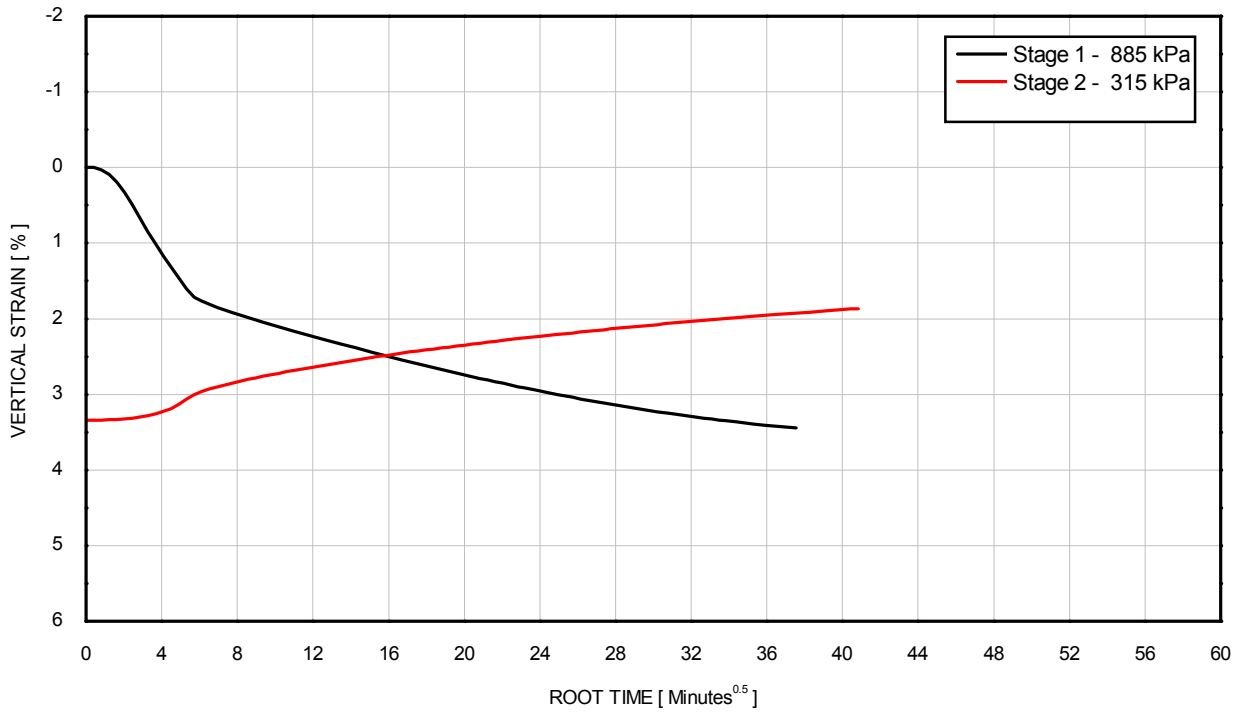
SPECIMEN PHOTOGRAPH

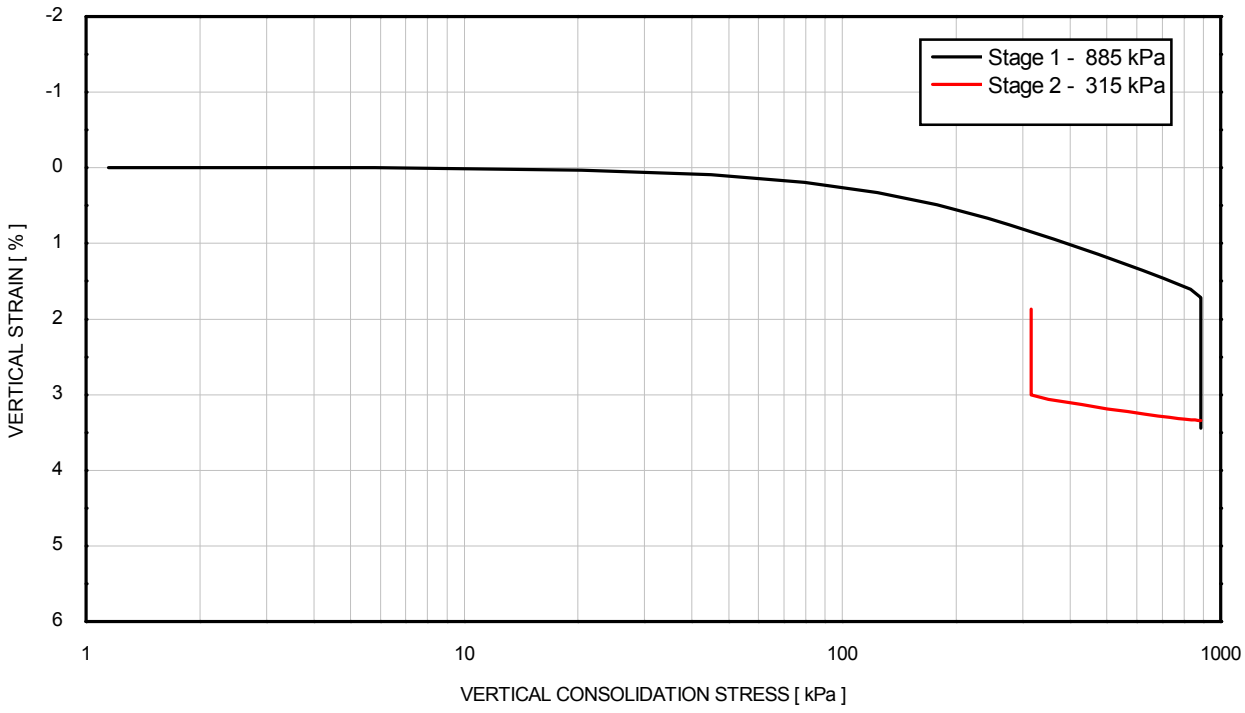


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxD
Unit	F3 (Dongen)
Depth [m]	33.39
Test number	DSS02

SUMMARY OF CONSOLIDATED DSS TEST

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

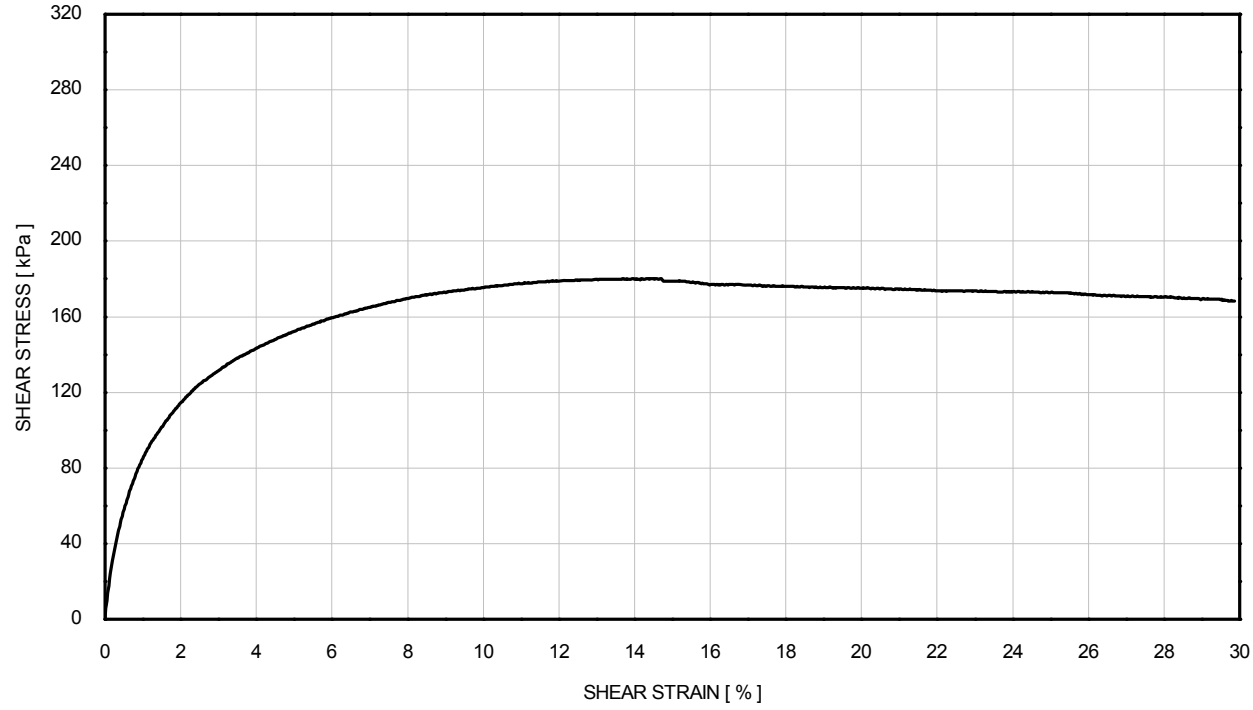


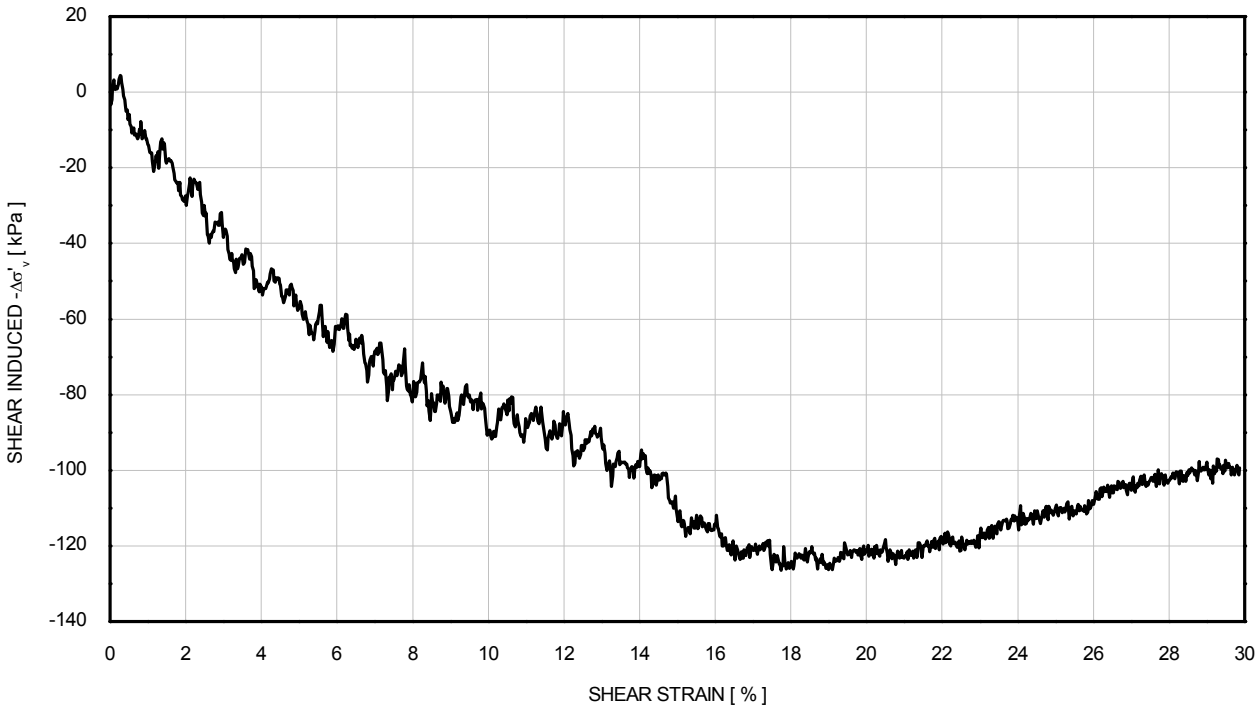


σ'_{vc}	: 315 kPa	Borehole	: BH-WFS3-4A
		Sample	: 6WaxD
		Unit	: F3 (Dongen)
		Depth [m]	: 33.39
		Test No.	: DSS02

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

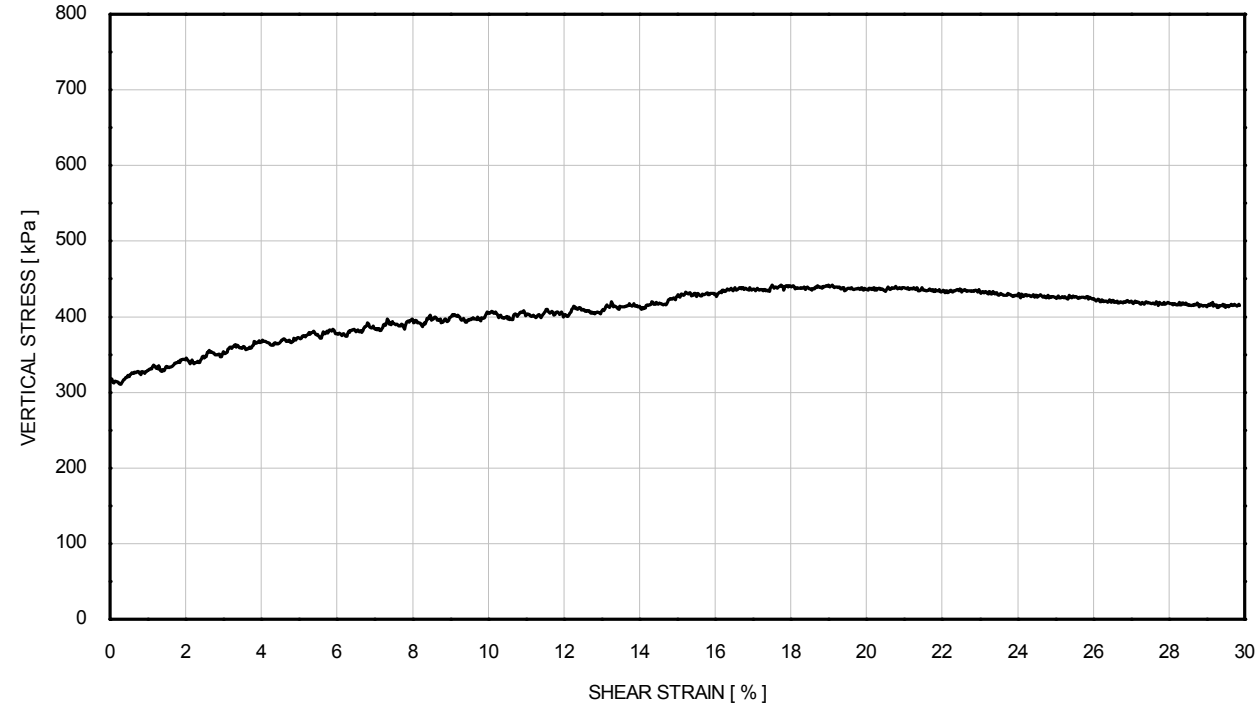


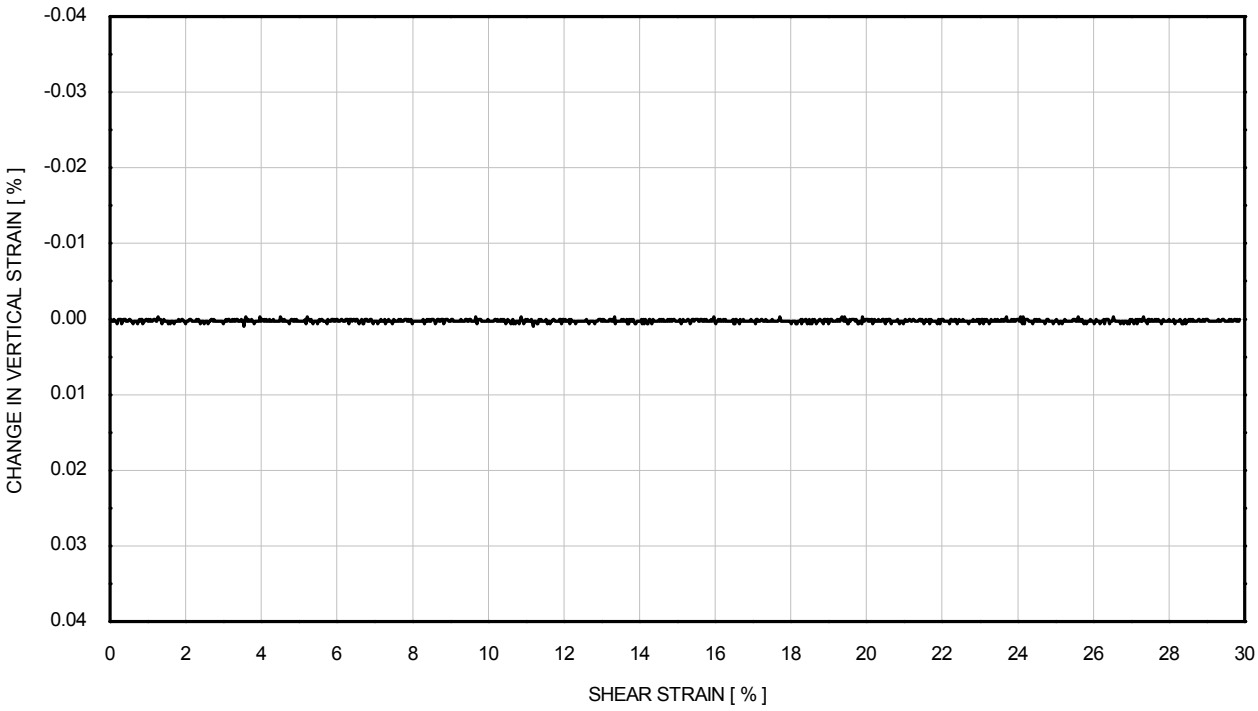


σ'_{vc}	: 315 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 180 kPa	Sample	: 6WaxD
γ at τ_{peak}	: 13.93 %	Unit	: F3 (Dongen)
Rate of strain	: 2.99 %/hour	Depth [m]	: 33.39
		Test No.	: DSS02

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

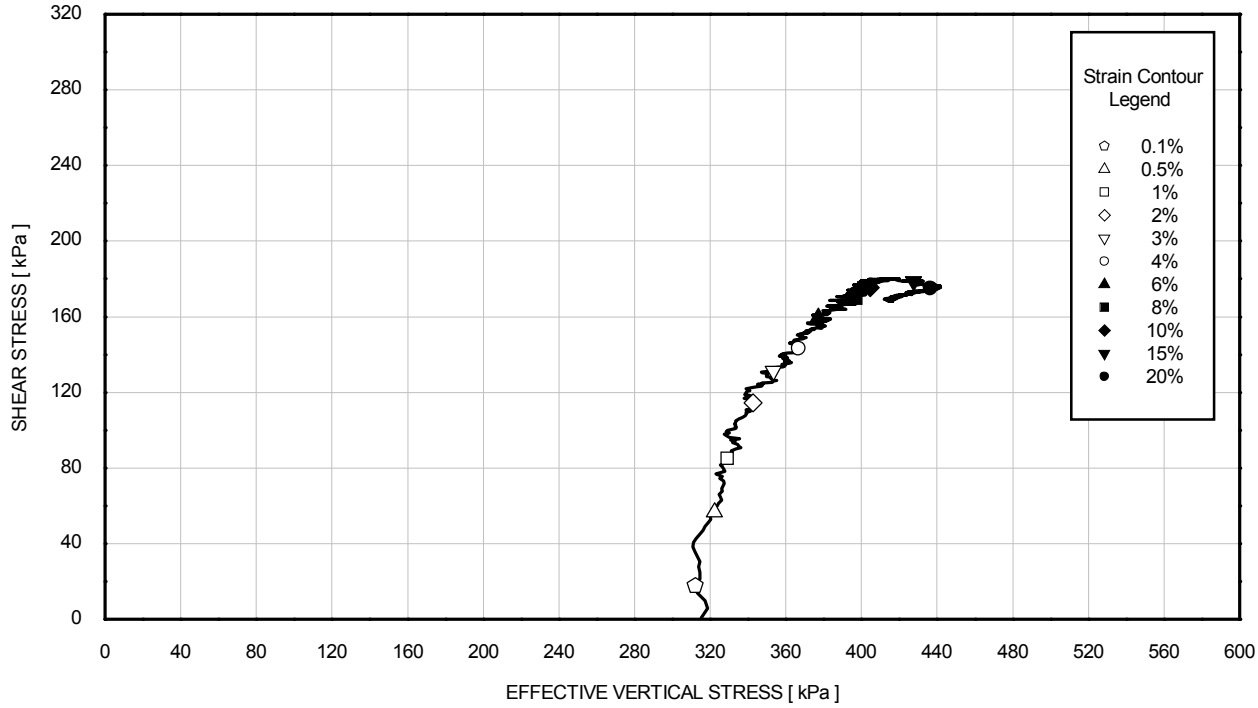


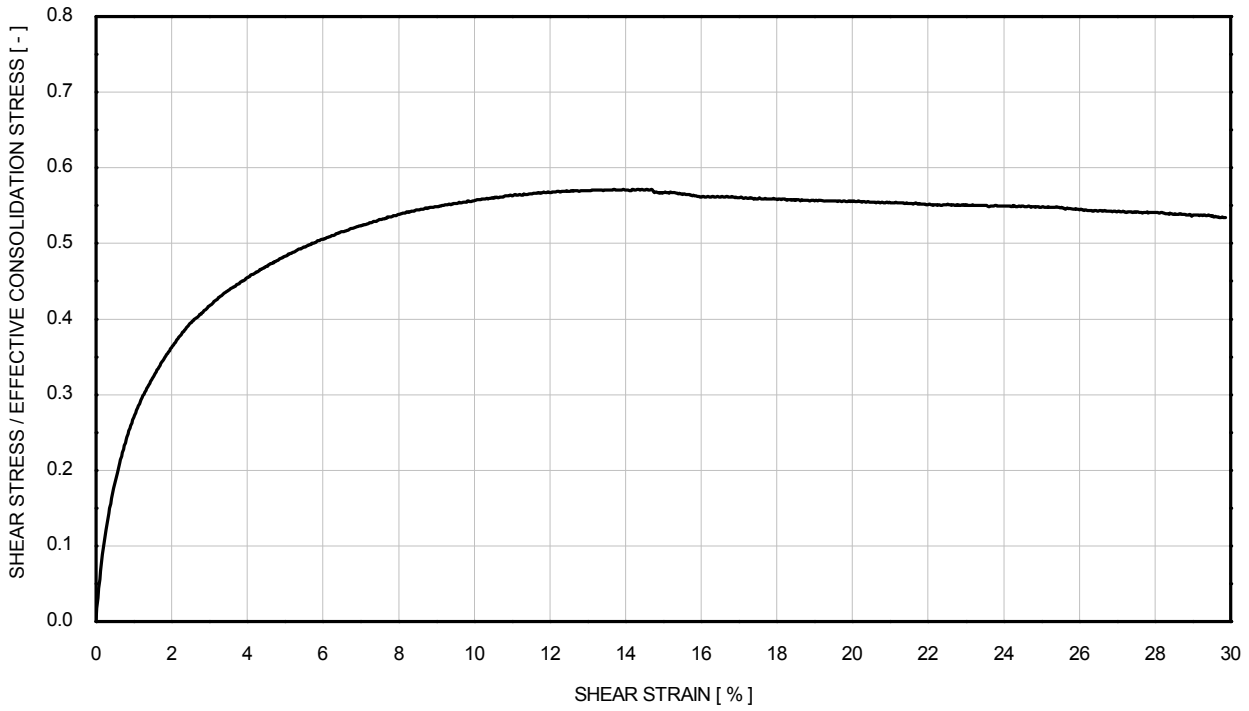


σ'_{vc}	:	315 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	180 kPa	Sample	:	6WaxD
γ at τ_{peak}	:	13.93 %	Unit	:	F3 (Dongen)
Rate of strain	:	2.99 %/hour	Depth [m]	:	33.39
			Test No.	:	DSS02

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

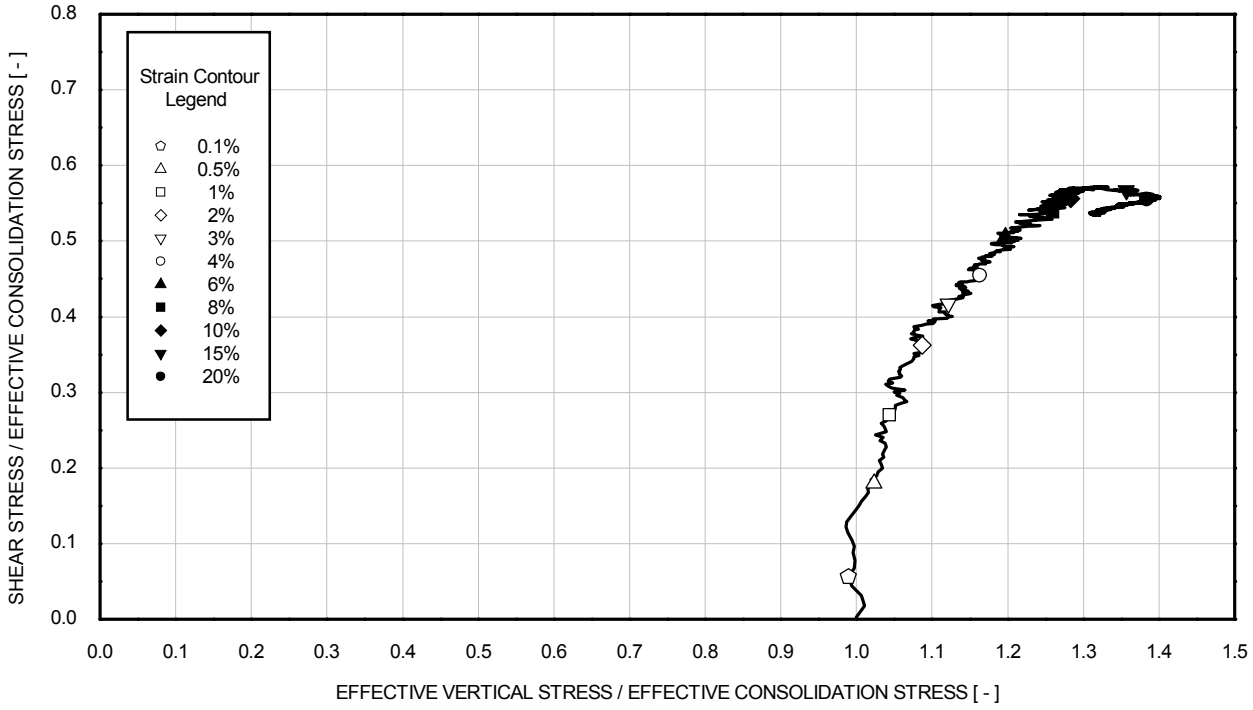


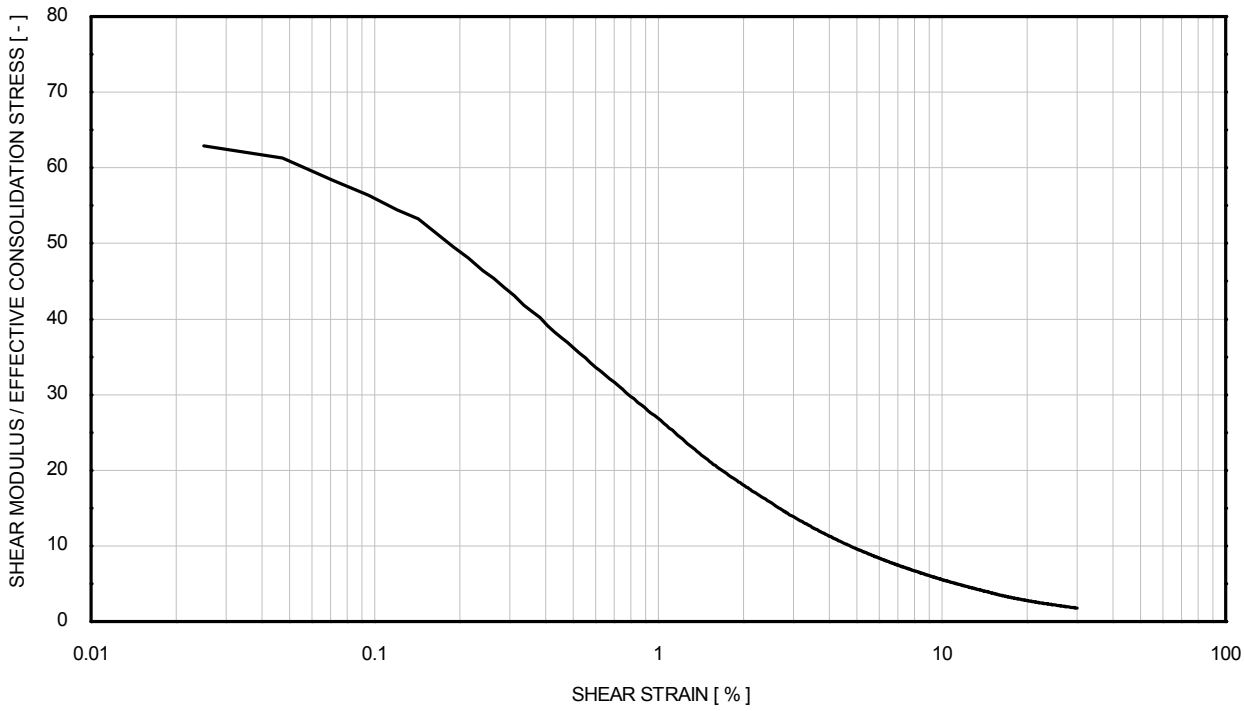


σ'_{vc}	:	315 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	180 kPa	Sample	:	6WaxD
γ at τ_{peak}	:	13.93 %	Unit	:	F3 (Dongen)
Rate of strain	:	2.99 %/hour	Depth [m]	:	33.39
			Test No.	:	DSS02

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ'_{vc}	:	315 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	180 kPa	Sample	:	6WaxD
γ at τ_{peak}	:	13.93 %	Unit	:	F3 (Dongen)
Rate of strain	:	2.99 %/hour	Depth [m]	:	33.39
			Test No.	:	DSS02

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark greenish grey silty CLAY with few coarse sand-sized pockets of black silt and burrows infilled with light grey silt

GENERAL	
Date test started	18/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.9
Length	[mm]	29.9
Moisture content	[%]	41.2
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.25
Void ratio	[-]	1.160
Degree of saturation	[%]	96
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	125
Pocket penetrometer	[kPa]	283
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure based on ASTM D6528-07
Consolidation	Fugro in house procedure based on ASTM D6528-07
Shearing	Fugro in house procedure based on ASTM D6528-07
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-1A_23WaxB_DSS03
Template issue	1.3
Processed by	HJ
Date	18/11/2015
Checked by	RN
Date	04/12/2015
Approved by	PH
Date	13/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	23WaxB
Unit	F3 (Dongen)
Depth [m]	38.20
Test number	DSS03

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ'_{vc}	[kPa]	913
Vertical strain	[%]	3.90
Bulk density	[Mg/m^3]	1.80
Dry density	[Mg/m^3]	1.30
Void ratio	[-]	1.076
Moisture content	[%]	38.1

CONSOLIDATION		
σ'_{vc}	[kPa]	355
Vertical strain	[%]	2.81
Bulk density	[Mg/m^3]	1.79
Dry density	[Mg/m^3]	1.29
Void ratio	[-]	1.099
Moisture content	[%]	39.0

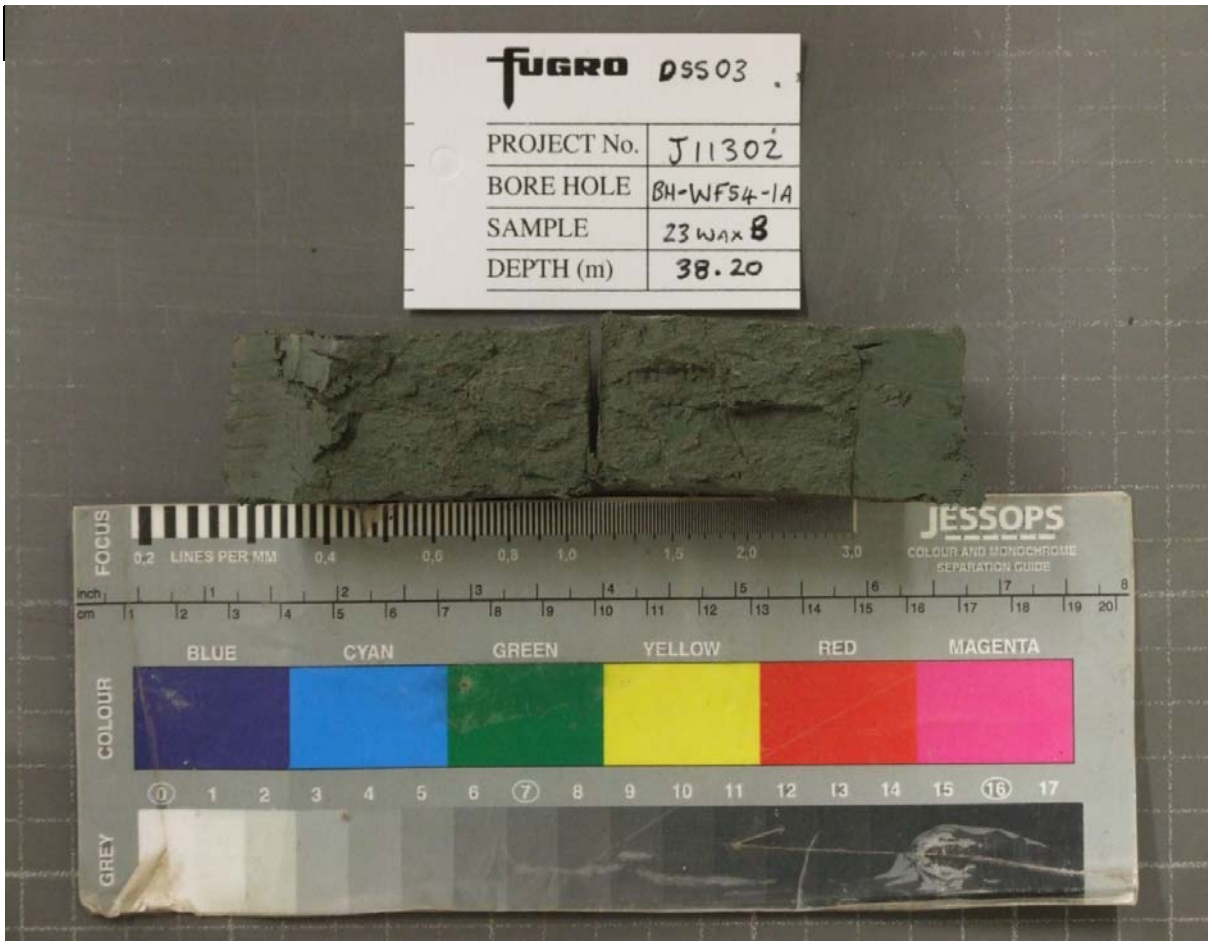
SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	243
Shear strain	[%]	6.56
Shear induced $-\Delta\sigma'_v$	[kPa]	-108
Vertical stress	[kPa]	463
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	3.00
At 15 % shear strain		
Shear stress	[kPa]	233
Shear induced $-\Delta\sigma'_v$	[kPa]	-84
Vertical stress	[kPa]	438
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	23WaxB
Unit	F3 (Dongen)
Depth [m]	38.20
Test number	DSS03

SUMMARY OF CONSOLIDATED DSS TEST

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

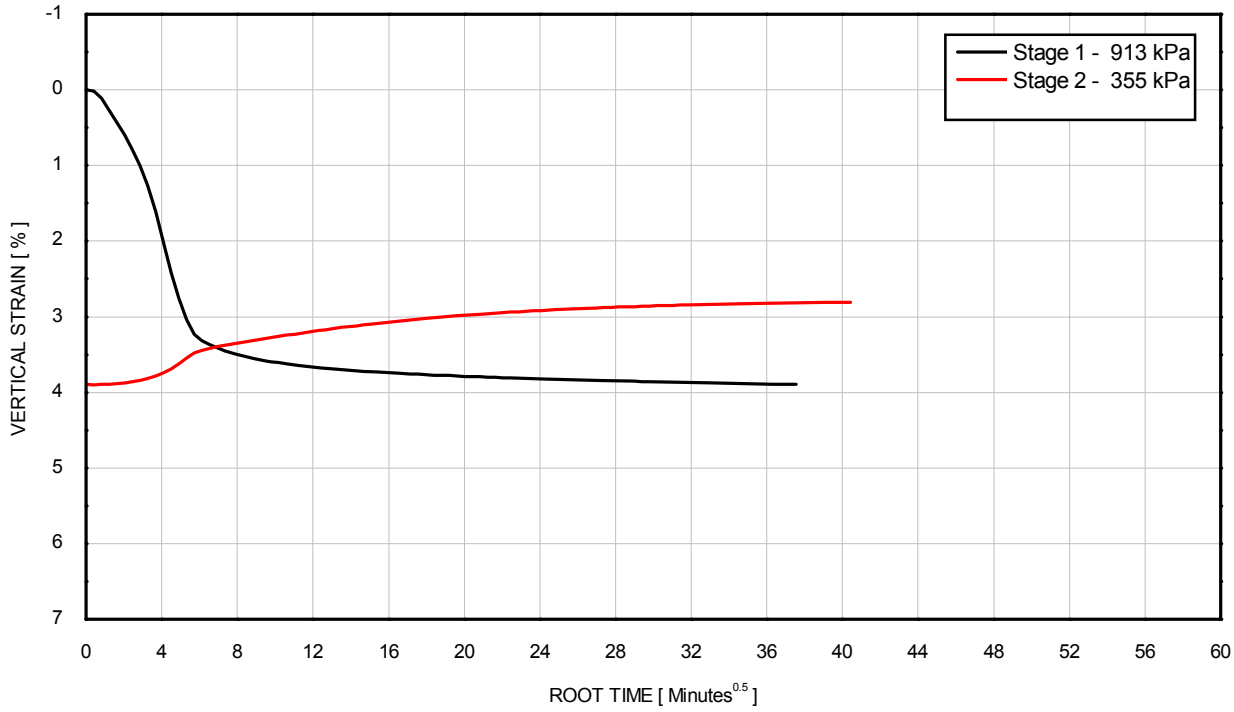
SPECIMEN PHOTOGRAPH

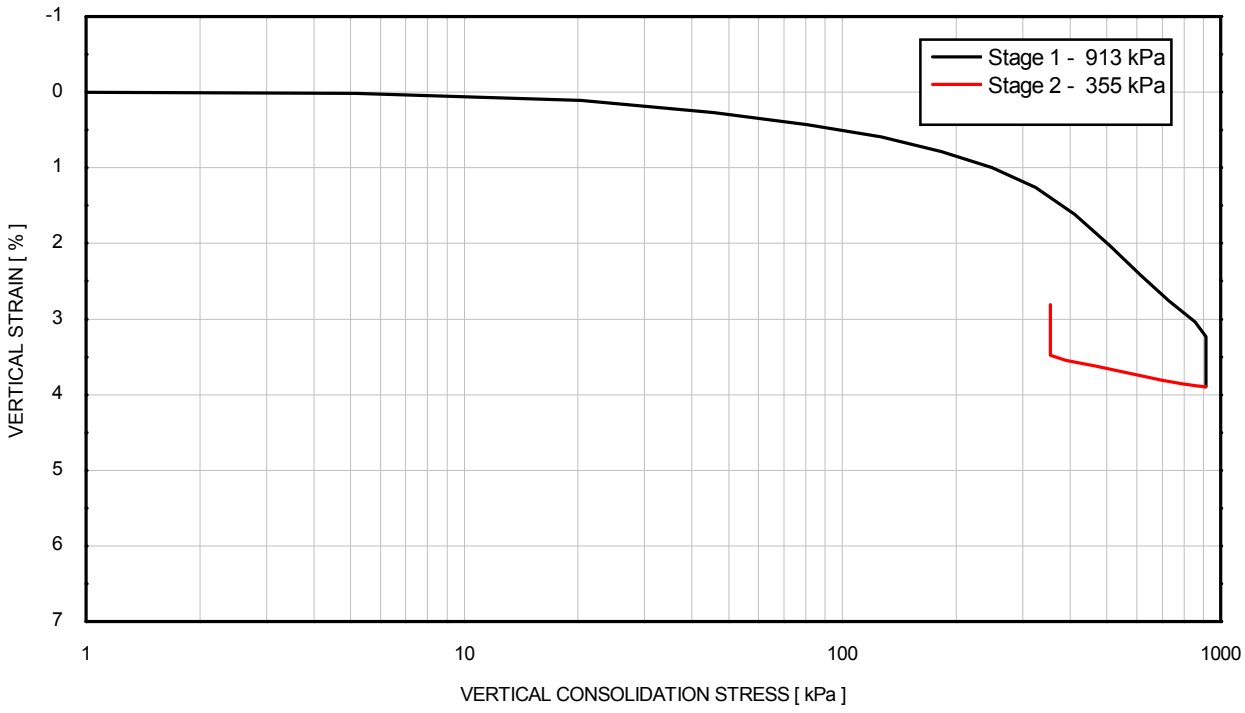


TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	23WaxB
Unit	F3 (Dongen)
Depth [m]	38.20
Test number	DSS03

SUMMARY OF CONSOLIDATED DSS TEST

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

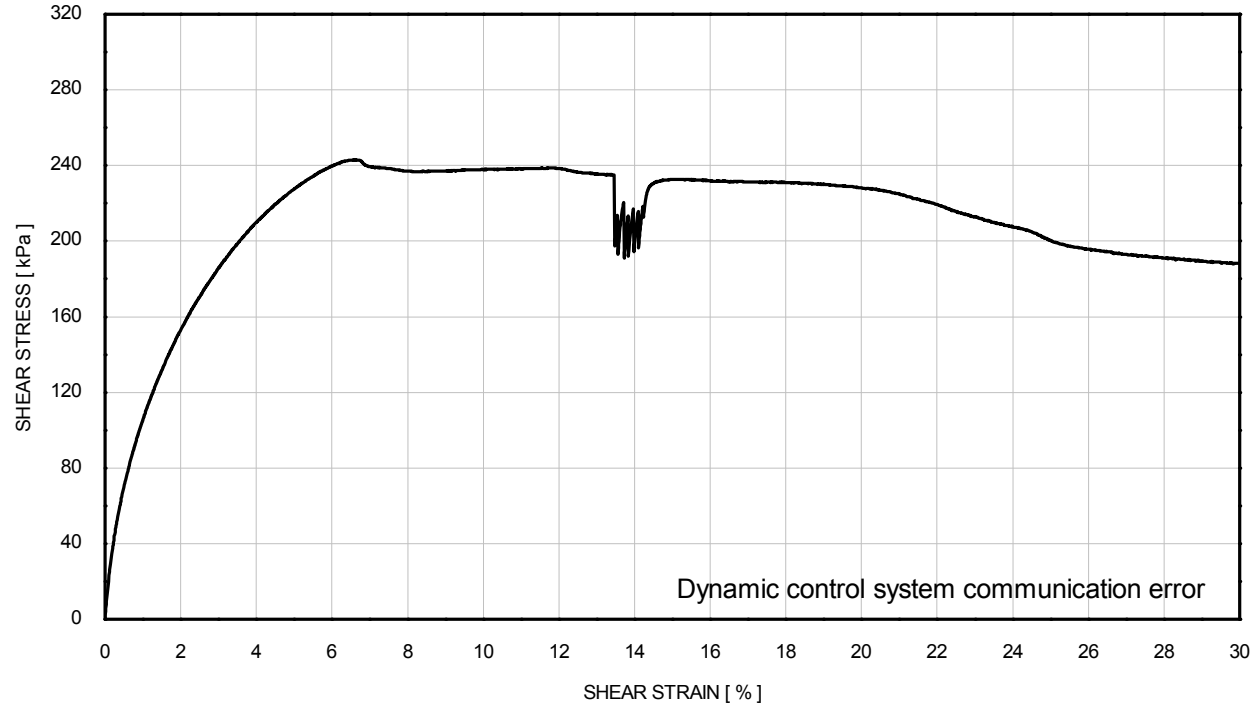


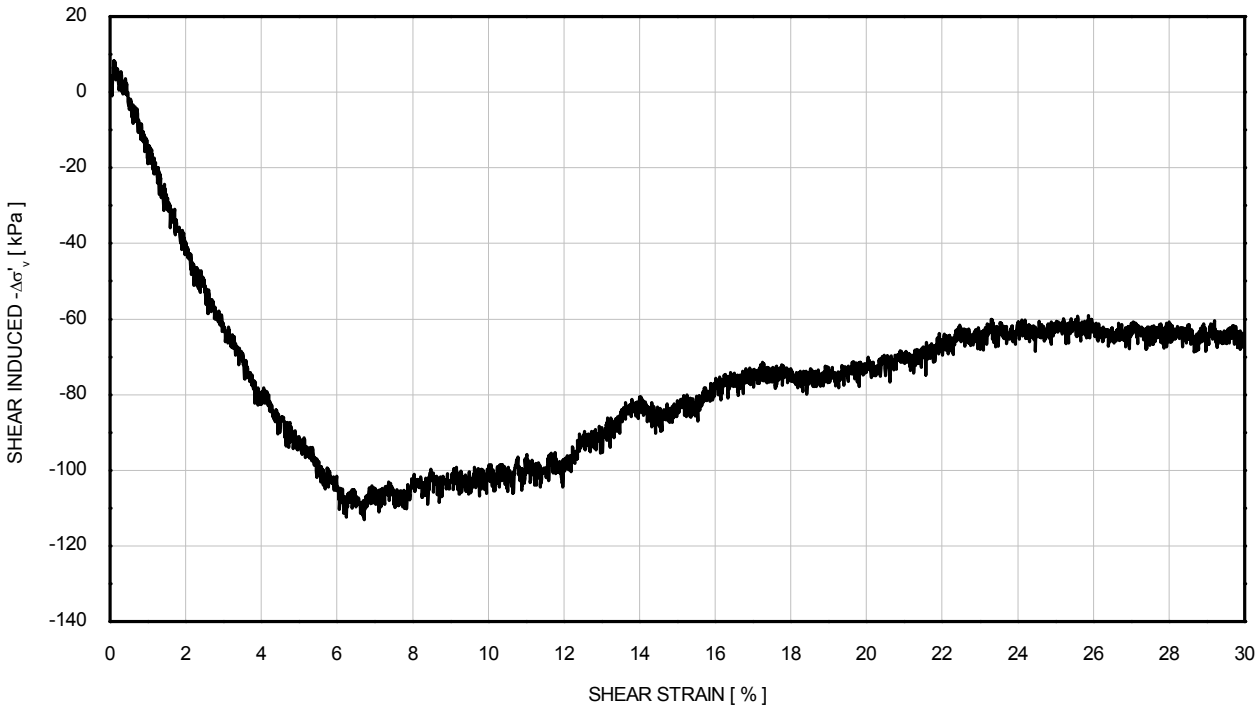


σ'_{vc}	: 355 kPa	Borehole	: BH-WFS4-1A
		Sample	: 23WaxB
		Unit	: F3 (Dongen)
		Depth [m]	: 38.20
		Test No.	: DSS03

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

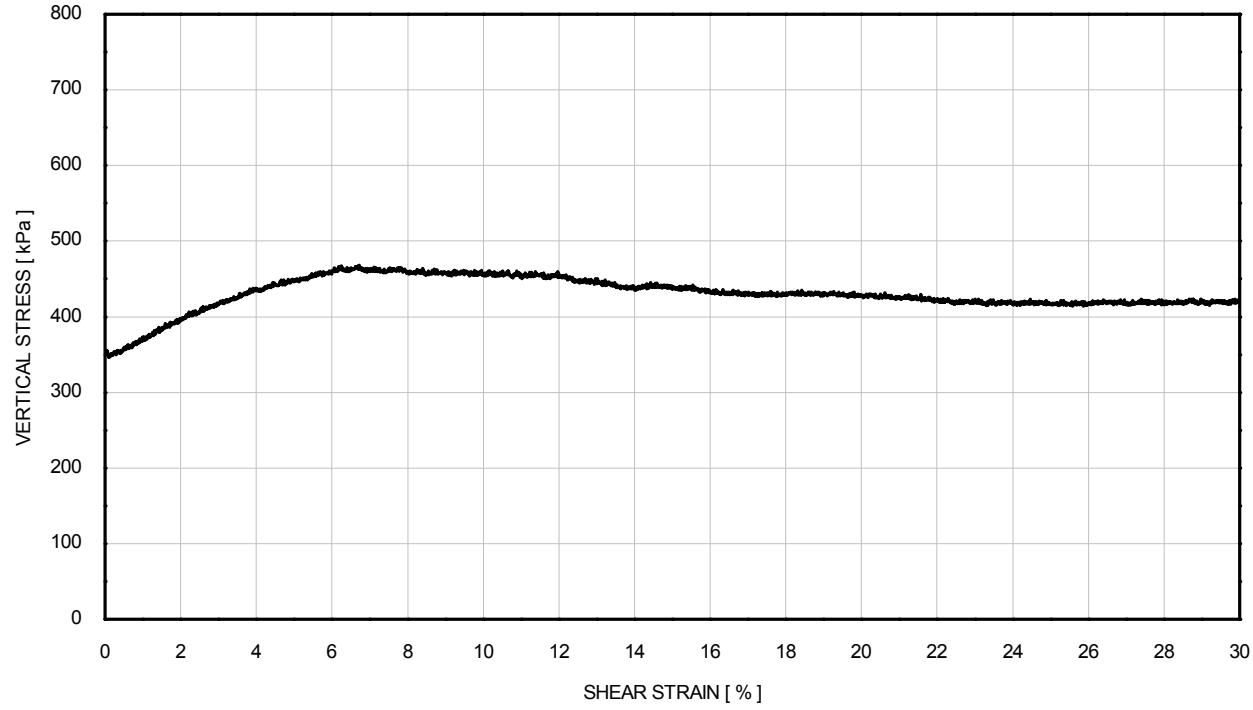


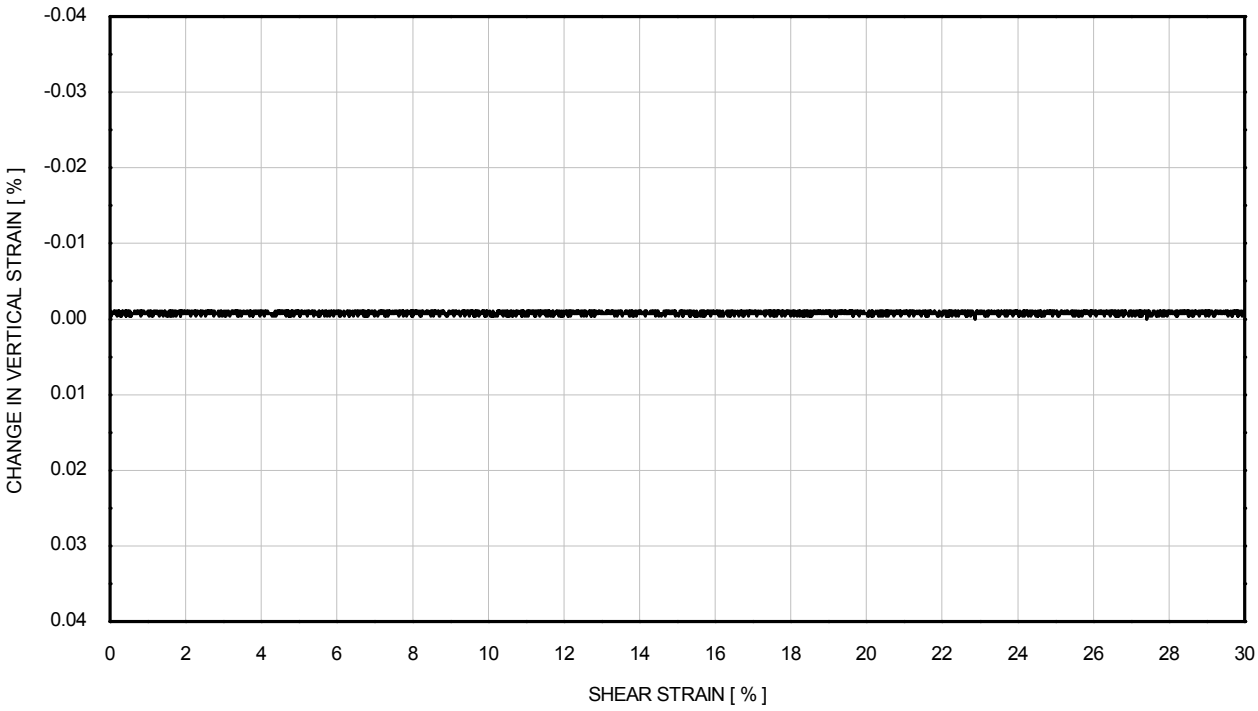


σ'_{vc}	:	355 kPa	Borehole	:	BH-WFS4-1A
τ_{peak}	:	243 kPa	Sample	:	23WaxB
γ at τ_{peak}	:	6.56 %	Unit	:	F3 (Dongen)
Rate of strain	:	3.00 %/hour	Depth [m]	:	38.20
			Test No.	:	DSS03

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

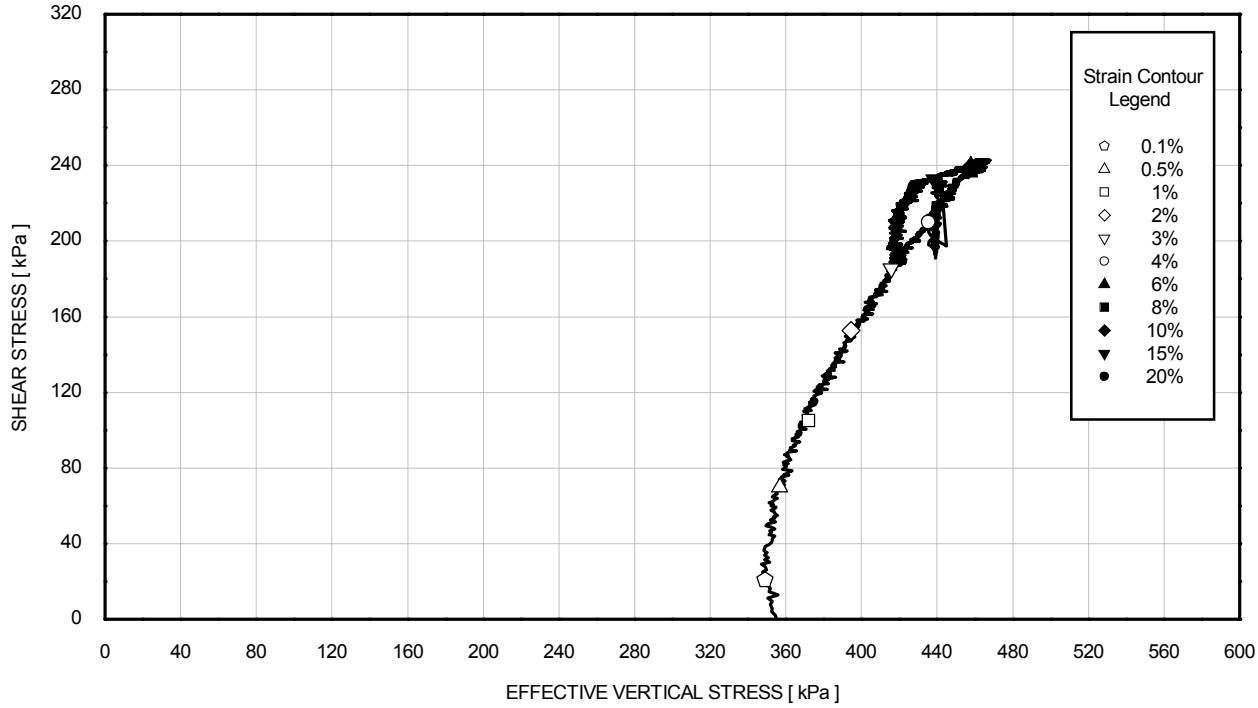


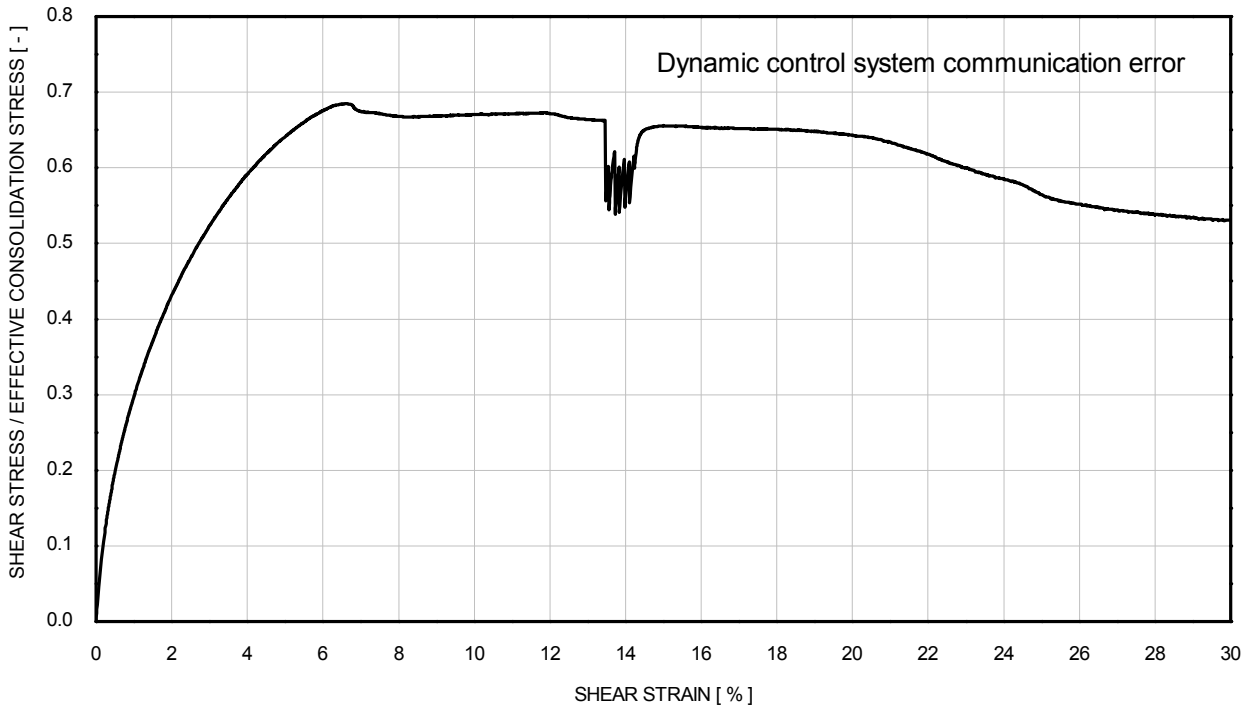


σ'_{vc}	:	355 kPa	Borehole	:	BH-WFS4-1A
τ_{peak}	:	243 kPa	Sample	:	23WaxB
γ at τ_{peak}	:	6.56 %	Unit	:	F3 (Dongen)
Rate of strain	:	3.00 %/hour	Depth [m]	:	38.20
			Test No.	:	DSS03

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

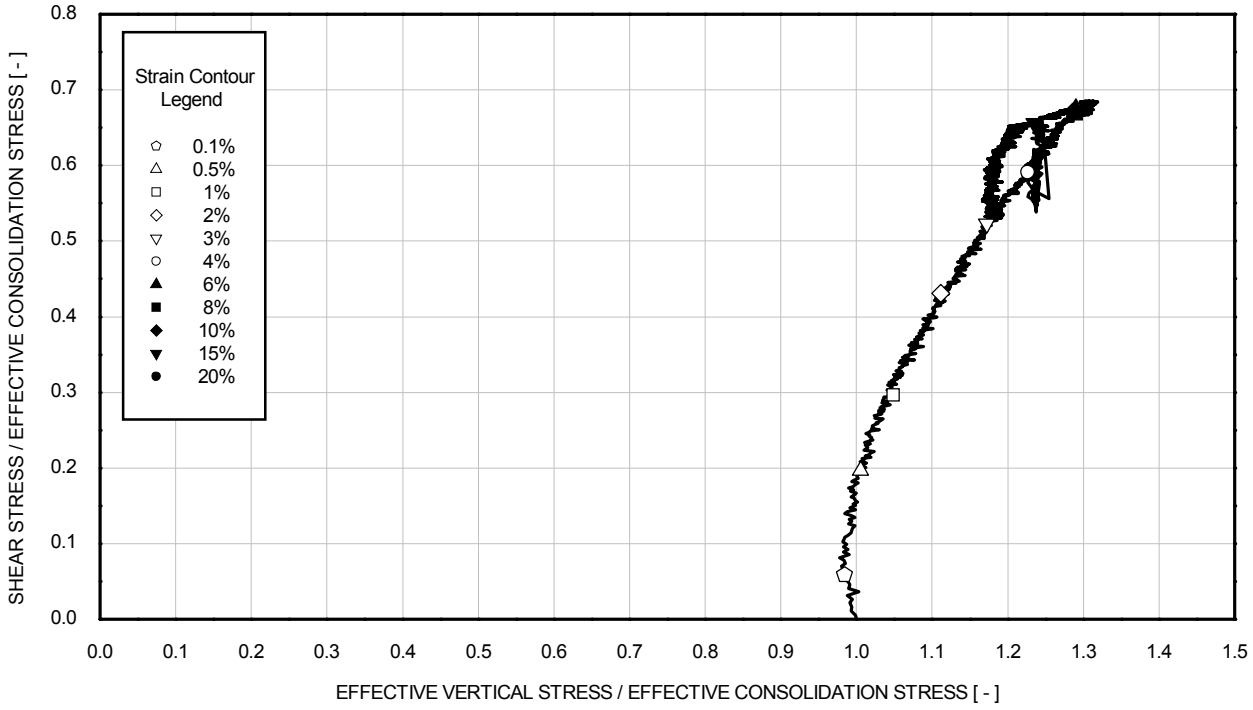


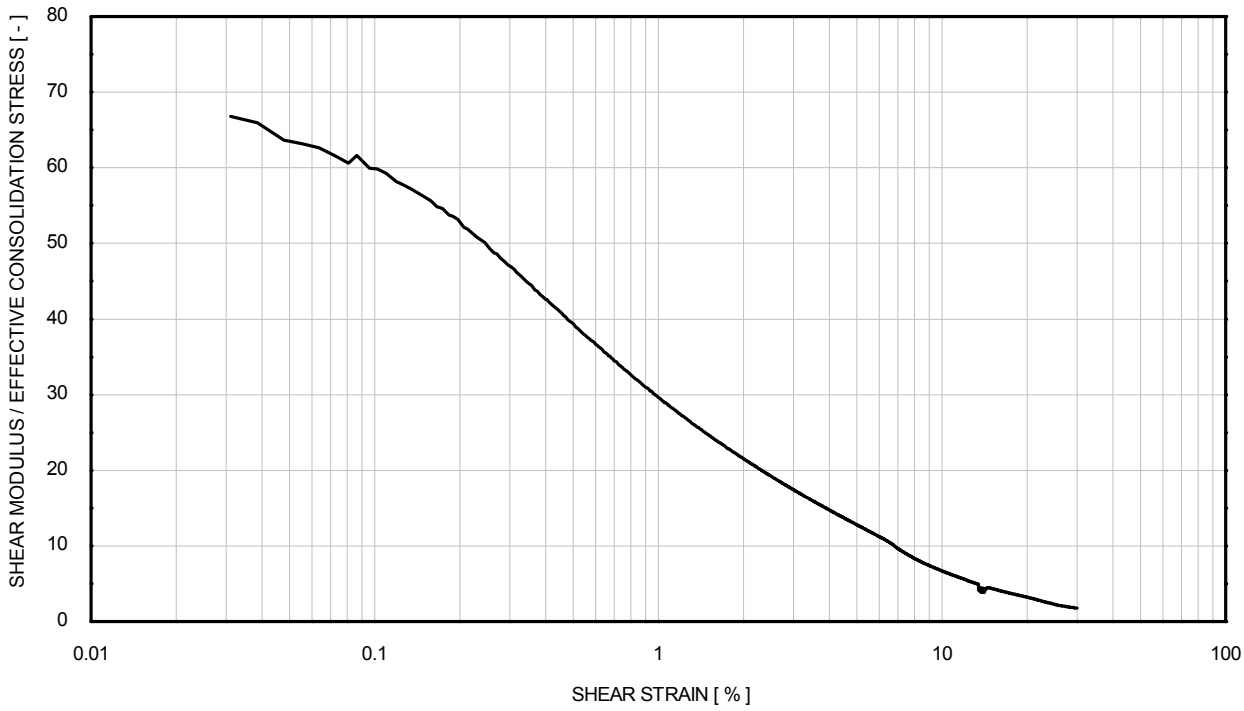


σ'_{vc}	:	355 kPa	Borehole	:	BH-WFS4-1A
τ_{peak}	:	243 kPa	Sample	:	23WaxB
γ at τ_{peak}	:	6.56 %	Unit	:	F3 (Dongen)
Rate of strain	:	3.00 %/hour	Depth [m]	:	38.20
			Test No.	:	DSS03

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ'_{vc}	:	355 kPa	Borehole	:	BH-WFS4-1A
τ_{peak}	:	243 kPa	Sample	:	23WaxB
γ at τ_{peak}	:	6.56 %	Unit	:	F3 (Dongen)
Rate of strain	:	3.00 %/hour	Depth [m]	:	38.20
			Test No.	:	DSS03

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark greenish grey CLAY with traces of fine gravel-sized pockets of black pyritic fine sand

GENERAL	
Date test started	18/11/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	29.9
Moisture content	[%]	34.1
Bulk density	[Mg/m³]	1.90
Dry density	[Mg/m³]	1.42
Void ratio	[-]	0.905
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	175
Pocket penetrometer	[kPa]	267
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure based on ASTM D6528-07
Consolidation	Fugro in house procedure based on ASTM D6528-07
Shearing	Fugro in house procedure based on ASTM D6528-07
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-7_22WaxD_DSS04
Template issue	1.3
Processed by	HJ
Date	23/11/2015
Checked by	RN
Date	09/12/2015
Approved by	PH
Date	13/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.56
Test number	DSS04

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ'_{vc}	[kPa]	548
Vertical strain	[%]	2.96
Bulk density	[Mg/m^3]	1.93
Dry density	[Mg/m^3]	1.46
Void ratio	[-]	0.849
Moisture content	[%]	32.0

CONSOLIDATION		
σ'_{vc}	[kPa]	230
Vertical strain	[%]	2.69
Bulk density	[Mg/m^3]	1.90
Dry density	[Mg/m^3]	1.41
Void ratio	[-]	0.909
Moisture content	[%]	34.2

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	248
Shear strain	[%]	24.15
Shear induced $-\Delta\sigma'_v$	[kPa]	-135
Vertical stress	[kPa]	365
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.98
At 15 % shear strain		
Shear stress	[kPa]	231
Shear induced $-\Delta\sigma'_v$	[kPa]	-106
Vertical stress	[kPa]	337
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.56
Test number	DSS04

SUMMARY OF CONSOLIDATED DSS TEST

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

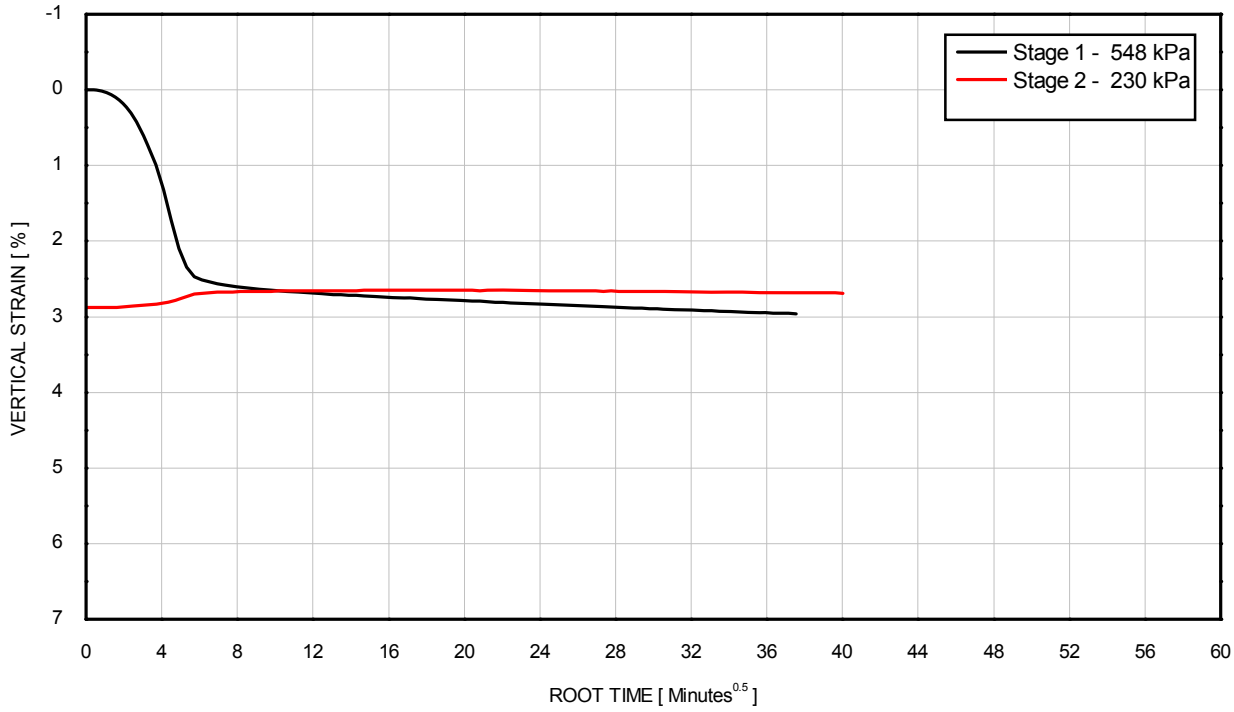
SPECIMEN PHOTOGRAPH

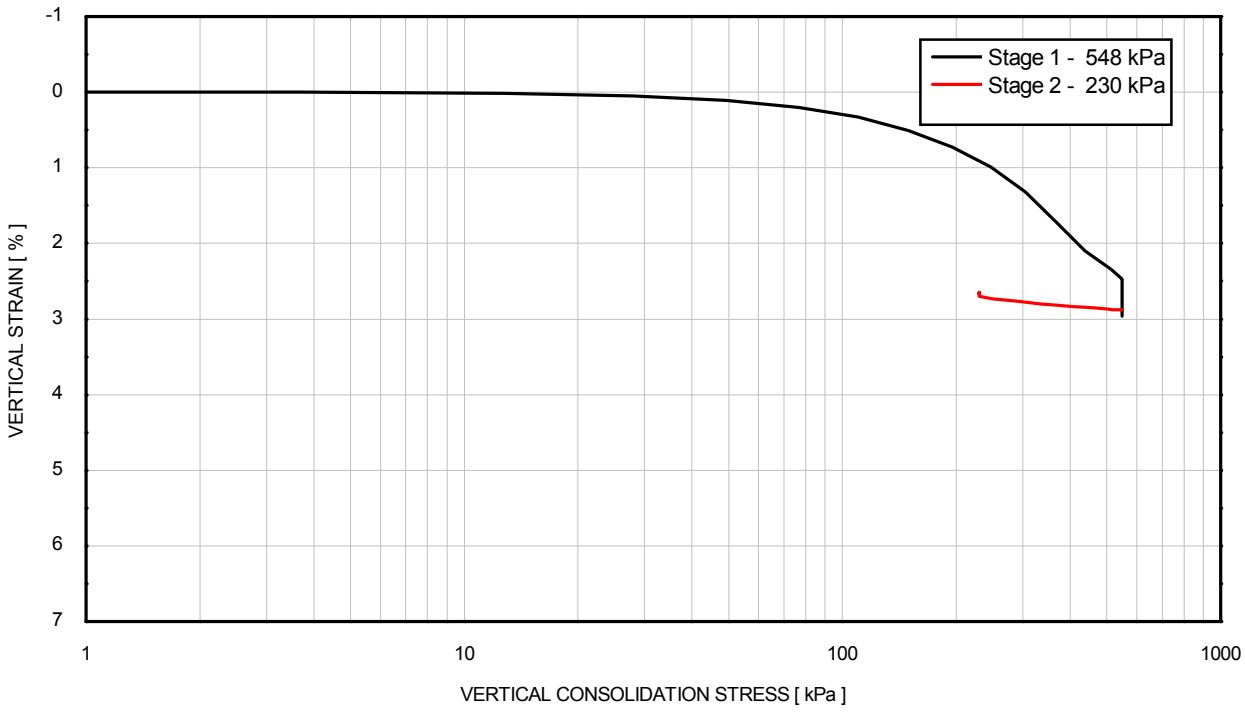


TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.56
Test number	DSS04

SUMMARY OF CONSOLIDATED DSS TEST

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

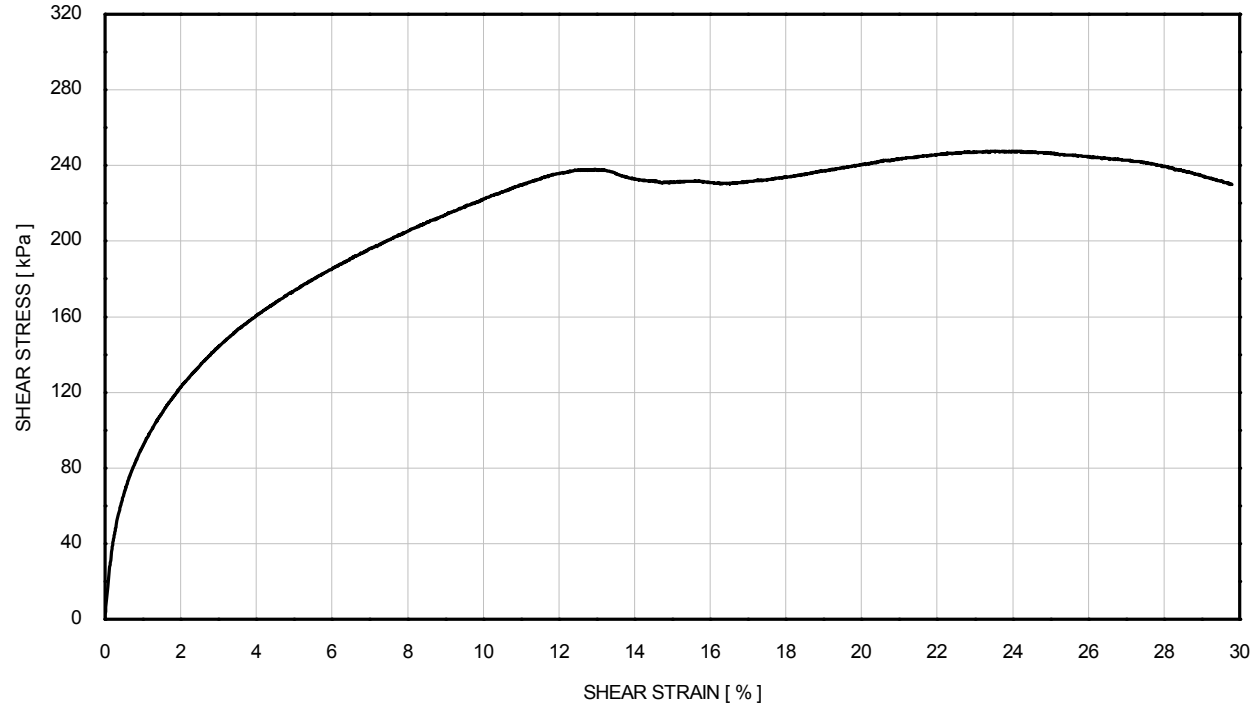


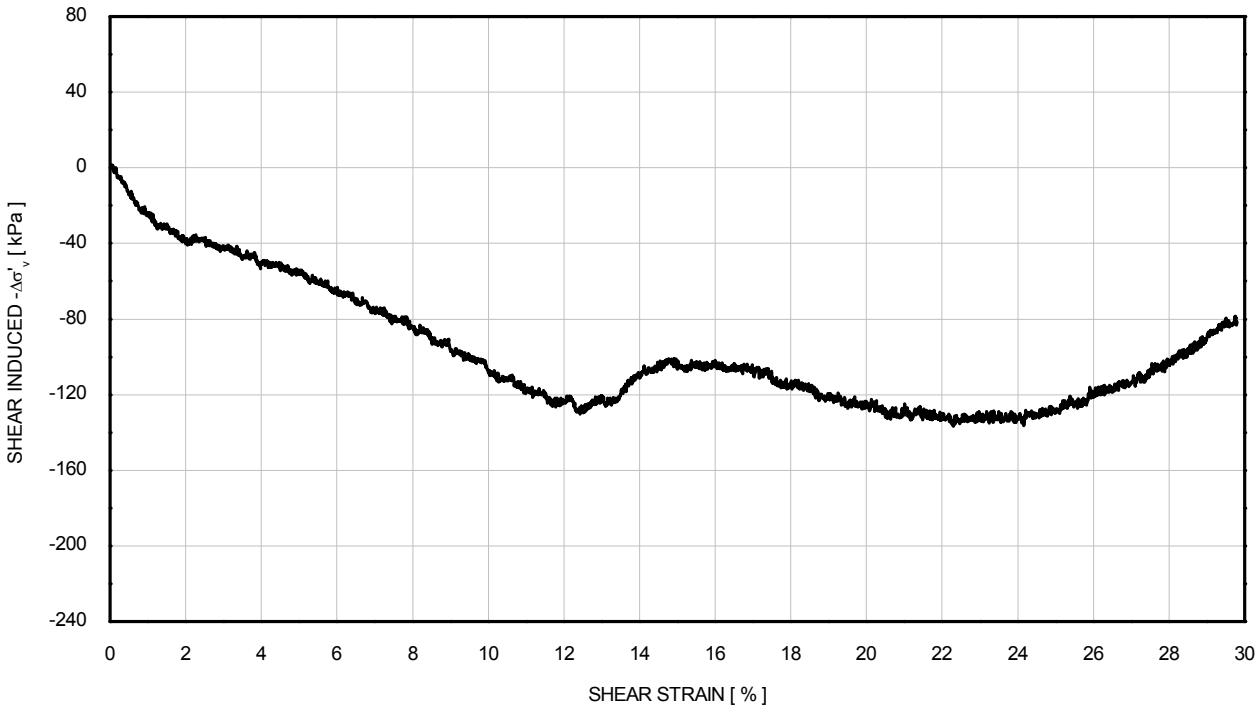


σ'_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
		Sample	: 22WaxD
		Unit	: D (Rupel)
		Depth [m]	: 23.56
		Test No.	: DSS04

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

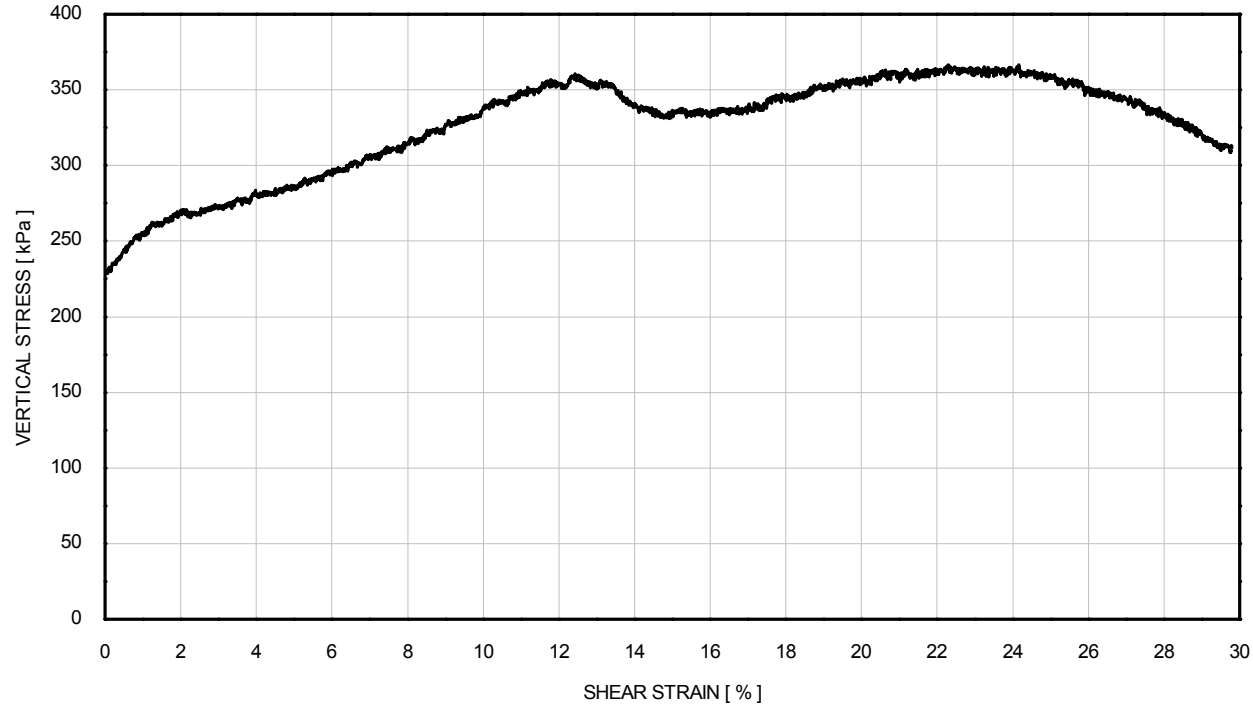


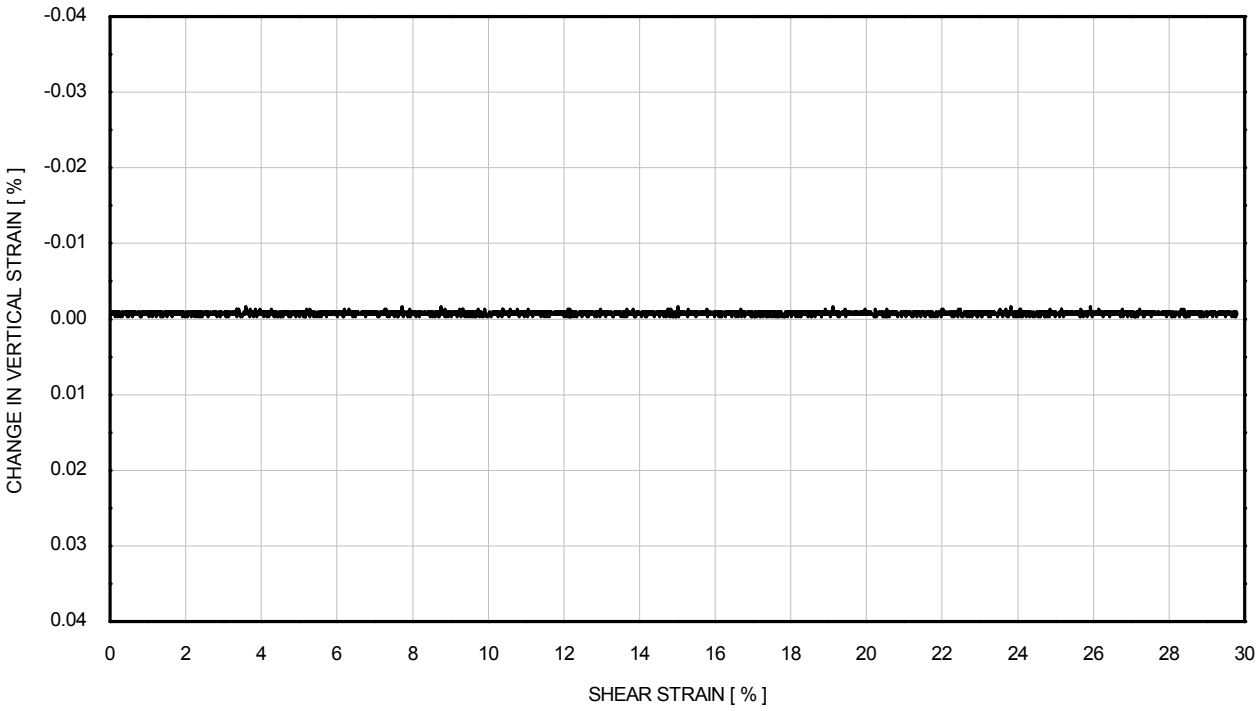


σ'_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 248 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 24.15 %	Unit	: D (Rupel)
Rate of strain	: 2.98 %/hour	Depth [m]	: 23.56
		Test No.	: DSS04

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

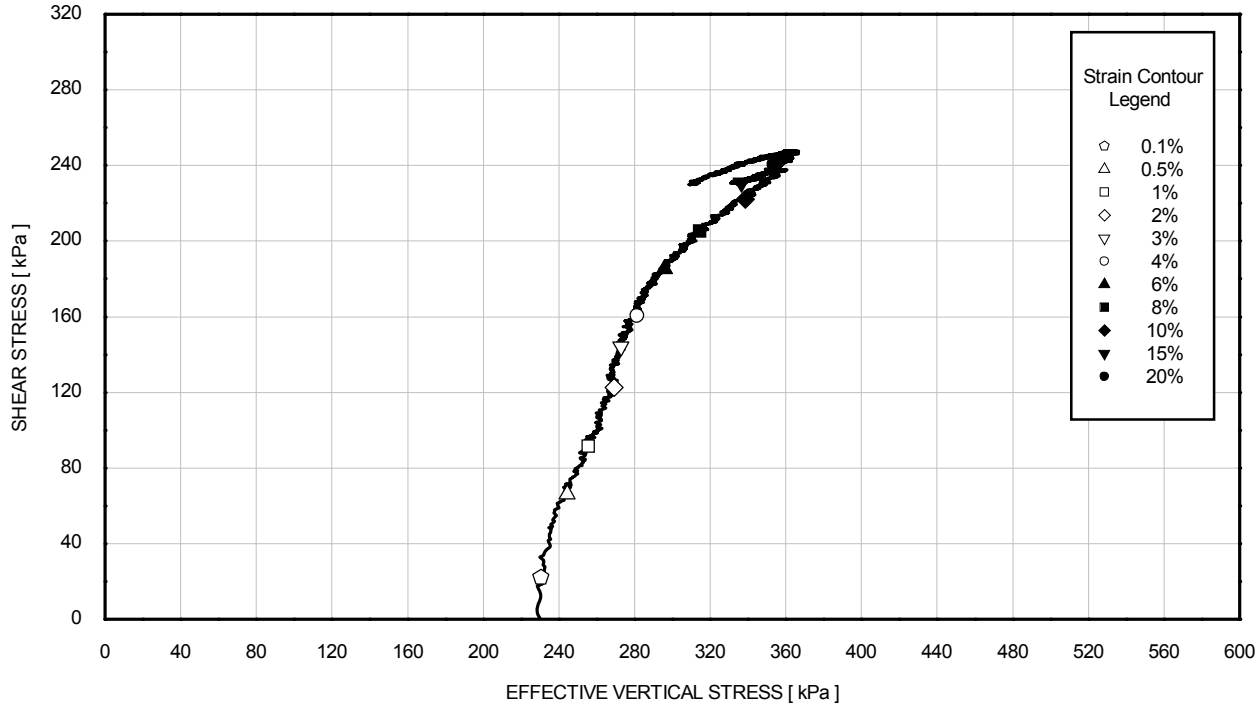


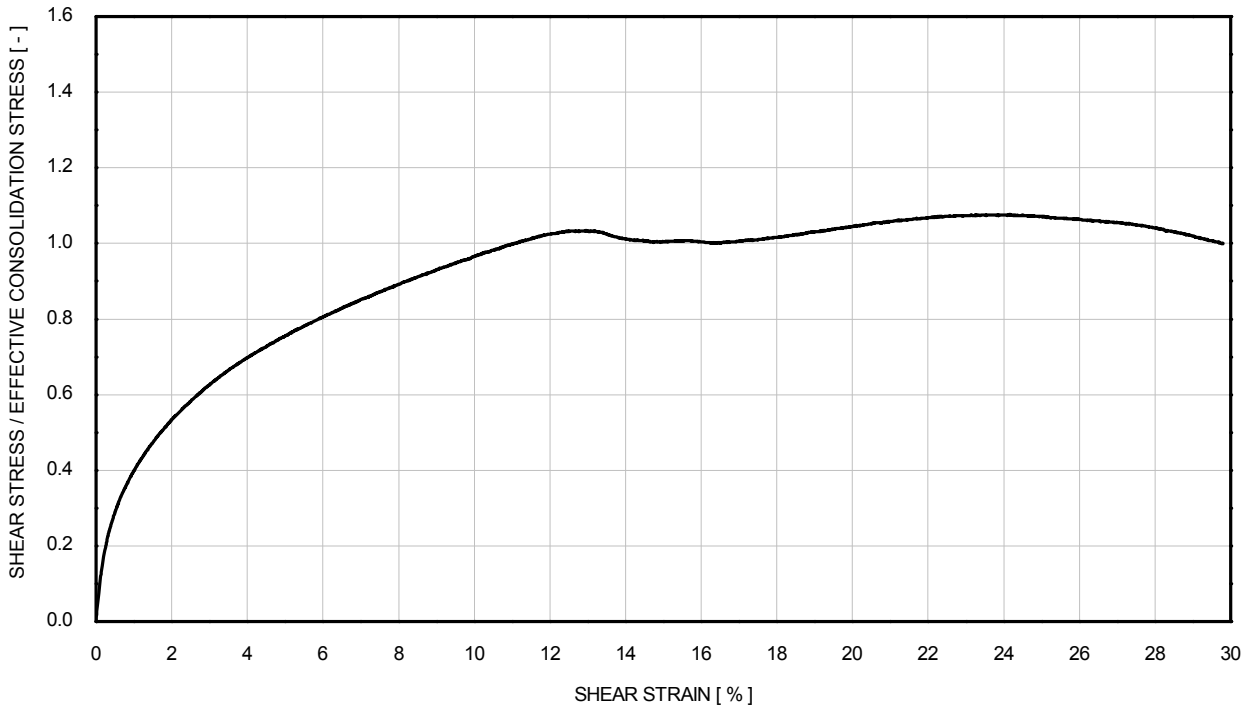


σ'_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
τ_{peak}	:	248 kPa	Sample	:	22WaxD
γ at τ_{peak}	:	24.15 %	Unit	:	D (Rupel)
Rate of strain	:	2.98 %/hour	Depth [m]	:	23.56
			Test No.	:	DSS04

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

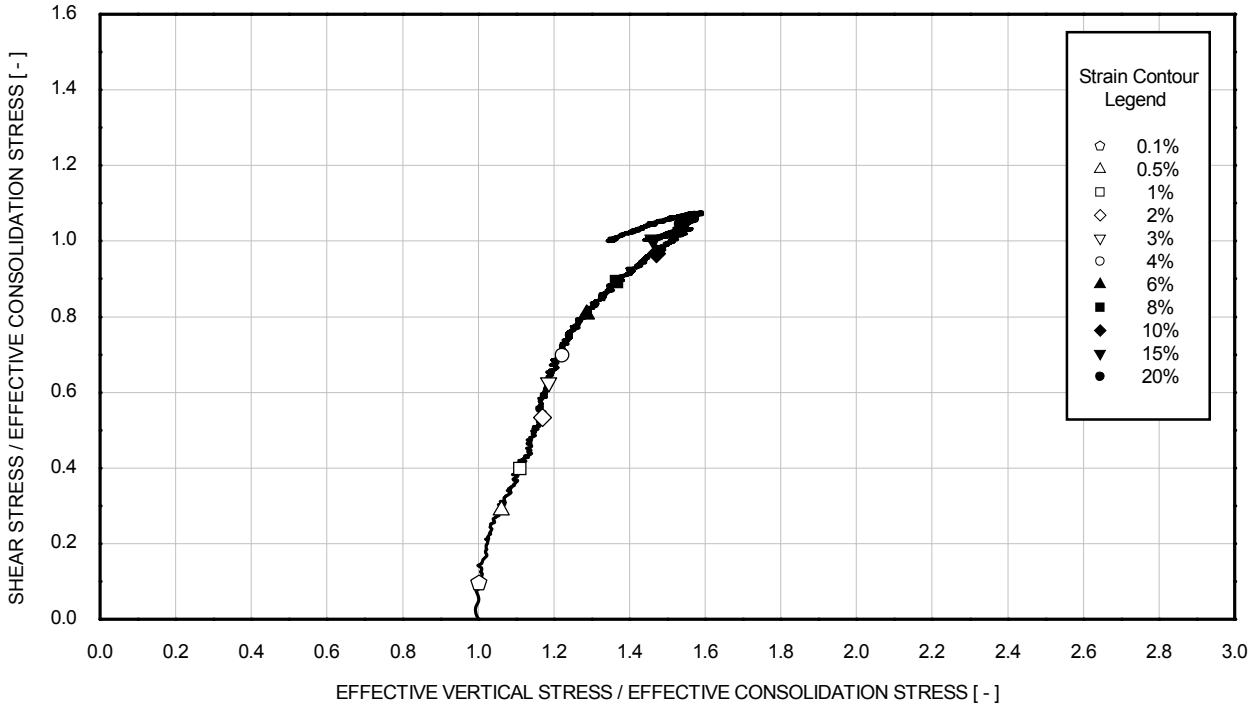


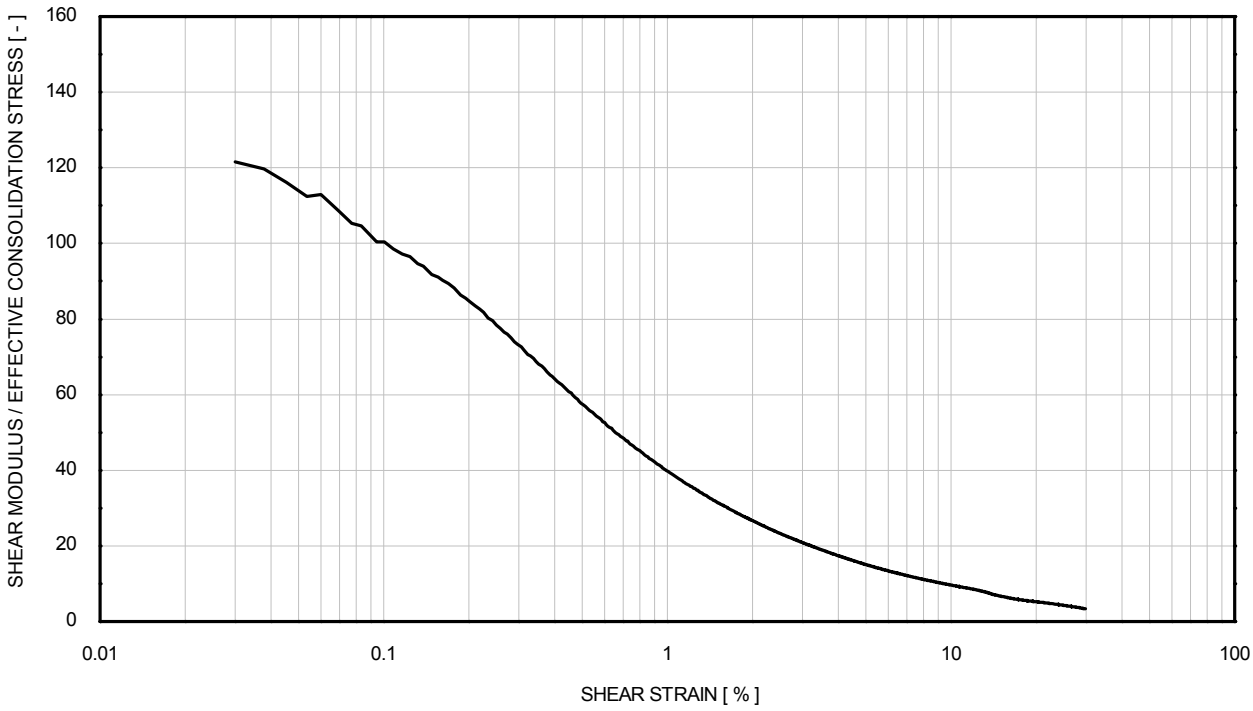


σ'_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
τ_{peak}	:	248 kPa	Sample	:	22WaxD
γ at τ_{peak}	:	24.15 %	Unit	:	D (Rupel)
Rate of strain	:	2.98 %/hour	Depth [m]	:	23.56
			Test No.	:	DSS04

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ'_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
τ_{peak}	:	248 kPa	Sample	:	22WaxD
γ at τ_{peak}	:	24.15 %	Unit	:	D (Rupel)
Rate of strain	:	2.98 %/hour	Depth [m]	:	23.56
			Test No.	:	DSS04

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	15/01/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.4
Length	[mm]	30.0
Moisture content after compaction	[%]	10.0
Bulk density after compaction	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.63
Void ratio	[-]	0.626
Degree of saturation after compaction	[%]	42
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	23.6
Bulk density at start of test	[Mg/m³]	2.01
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BATCH1_DSS_1_1_DSS05
Template issue	1.3
Processed by	GG
Date	01/02/2016
Checked by	PH
Date	03/02/2016
Approved by	PH
Date	03/02/2016

TEST IDENTIFICATION	
Batch	1
Sample	DSS_1-1
Unit	A (Southern Bight)
Test number	DSS05

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	25
Vertical strain	[%]	0.21
Bulk density	[Mg/m^3]	2.02
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.623
Moisture content	[%]	23.5

SHEARING – CONSTANT VOLUME		
At peak shear stress*		
Shear stress	[kPa]	775
Shear strain	[%]	24.12
Shear induced -$\Delta\sigma_v$	[kPa]	-1415
Vertical stress	[kPa]	1440
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.97
At 15 % shear strain		
Shear stress	[kPa]	522
Shear induced -$\Delta\sigma_v$	[kPa]	-930
Vertical stress	[kPa]	955
Vertical strain	[%]	0.00

* Please note that the maximum axial load tranducer limit was reached prior to 30% shear strain being achieved.

TEST IDENTIFICATION	
Batch	1
Sample	DSS_1-1
Unit	A (Southern Bight)
Test number	DSS05

SUMMARY OF CONSOLIDATED DSS TEST

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

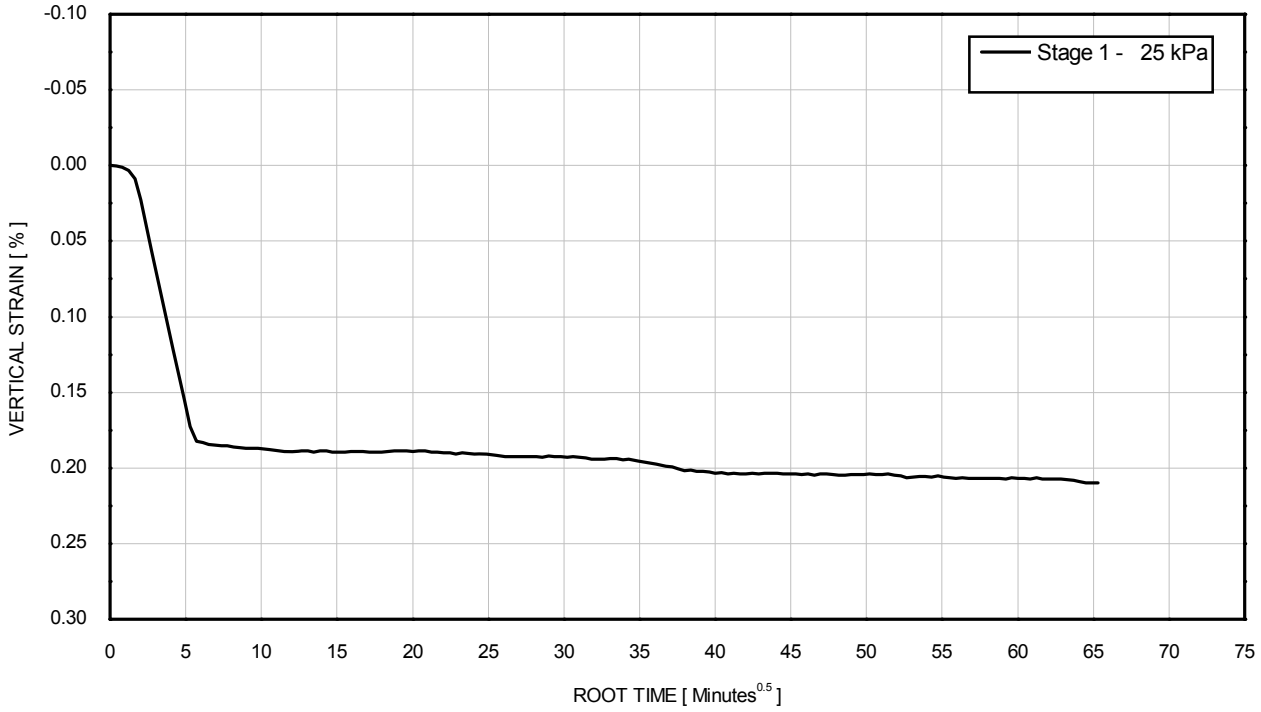
SPECIMEN PHOTOGRAPH

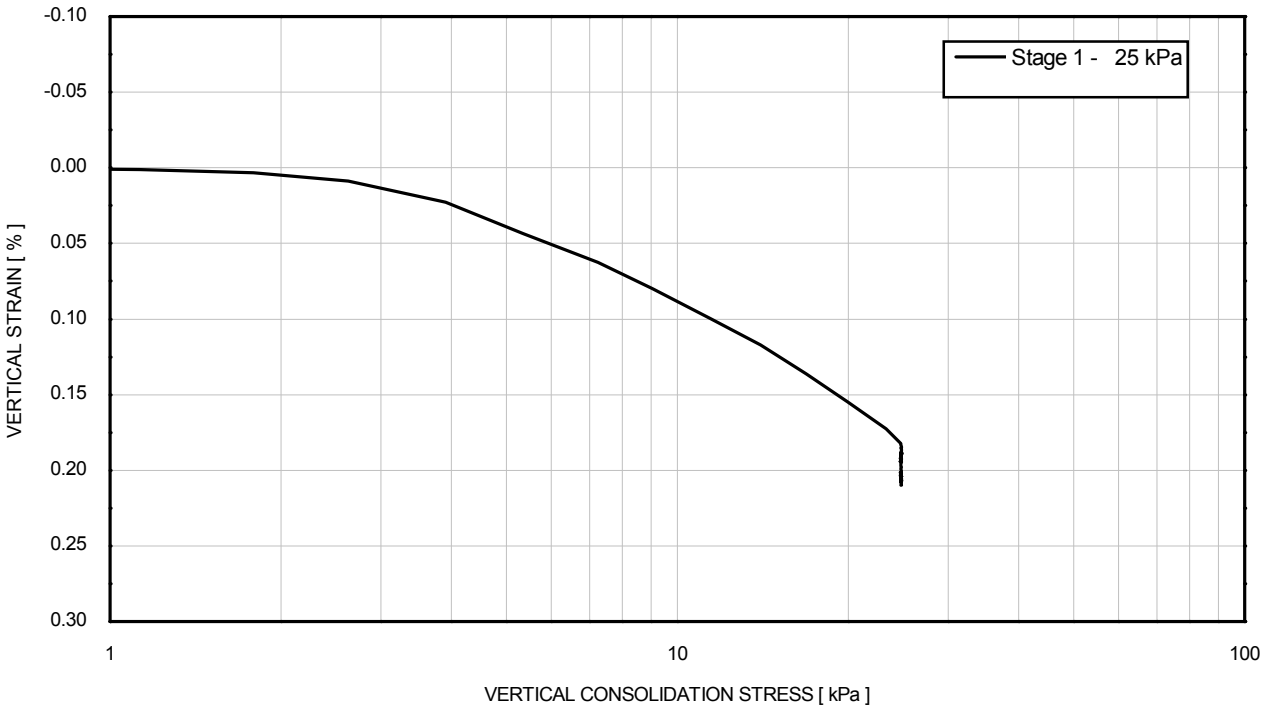


TEST IDENTIFICATION	
Batch	1
Sample	DSS_1-1
Unit	A (Southern Bight)
Test number	DSS05

SUMMARY OF CONSOLIDATED DSS TEST

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

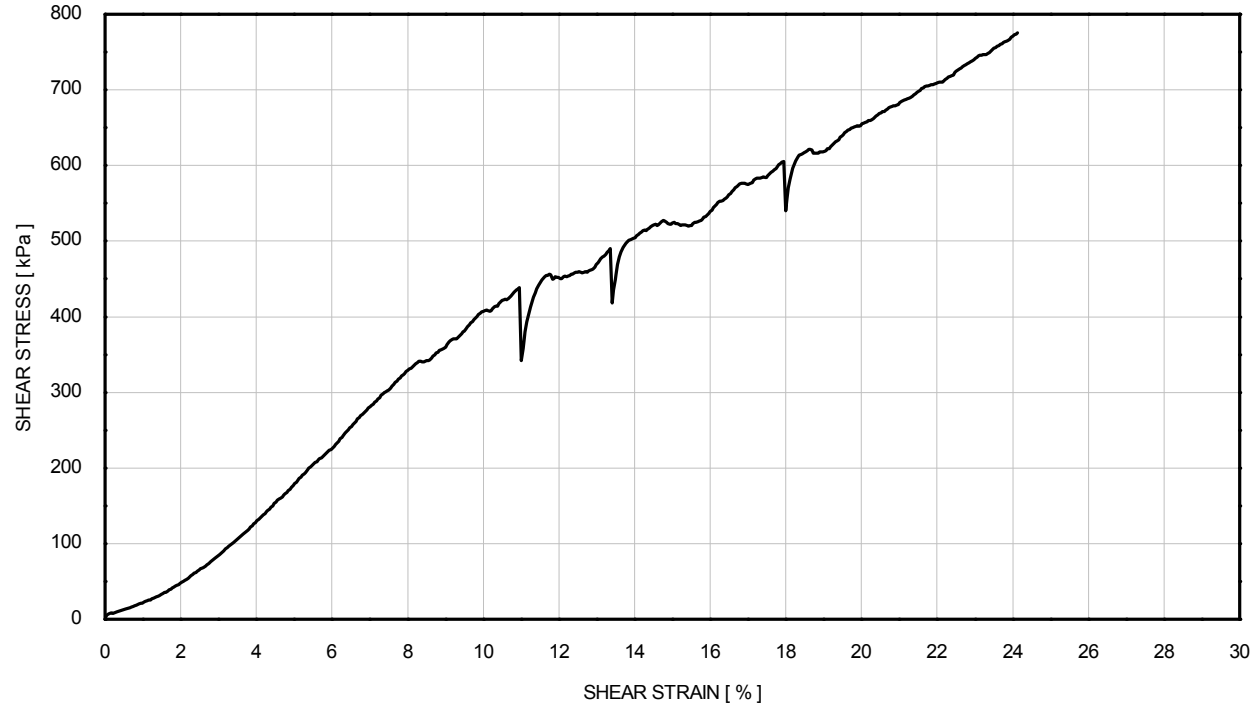


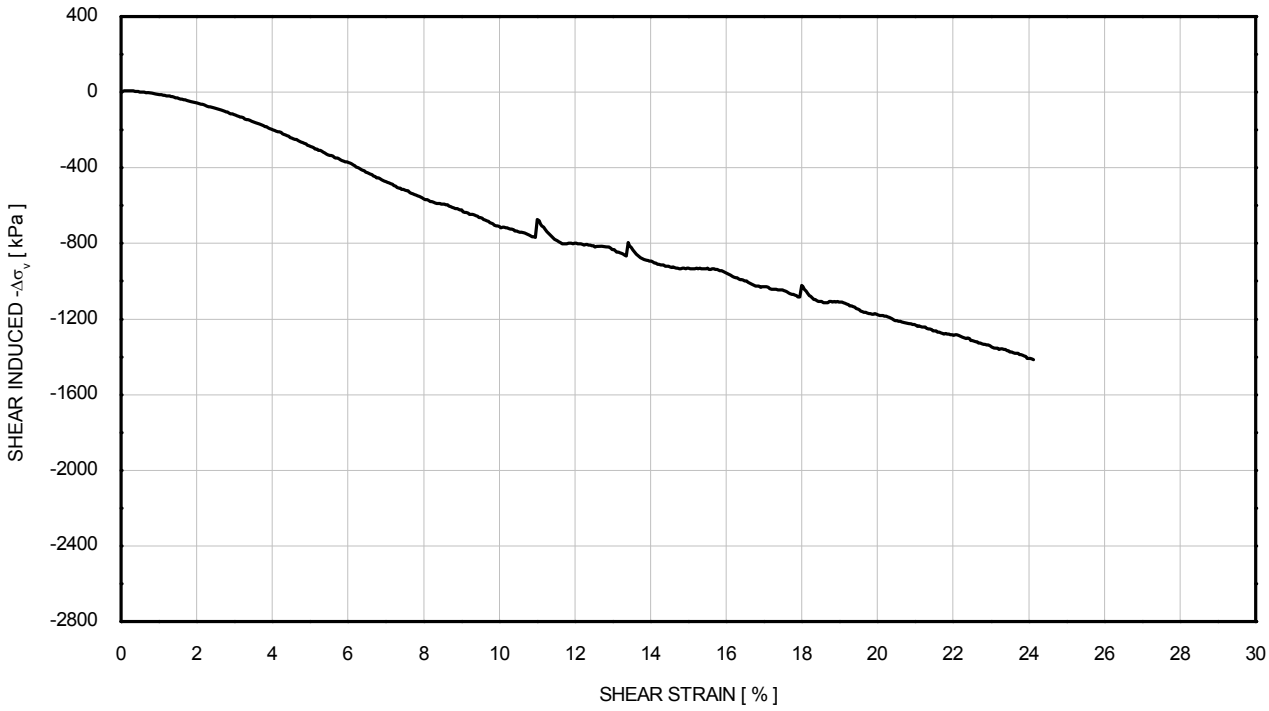


σ_{vc}	: 25 kPa	Batch	: 1
		Sample	: DSS_1-1
		Unit	: A (Southern Bight)
		Test No.	: DSS05

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

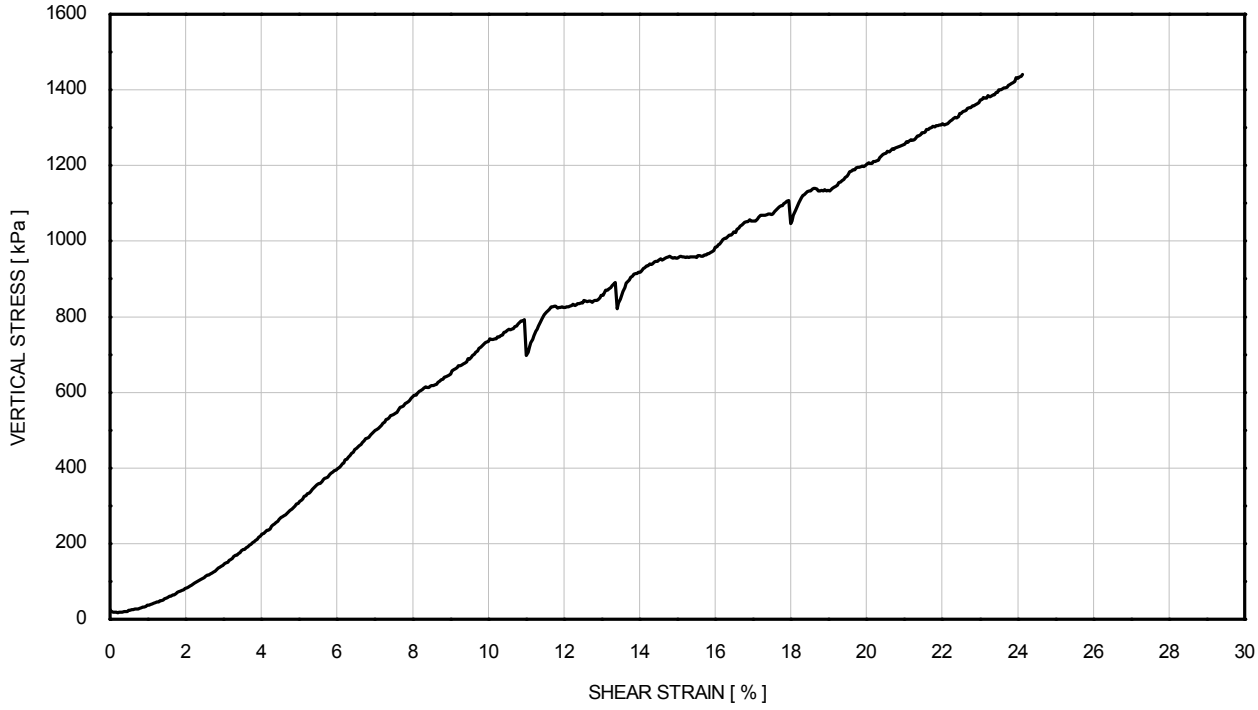


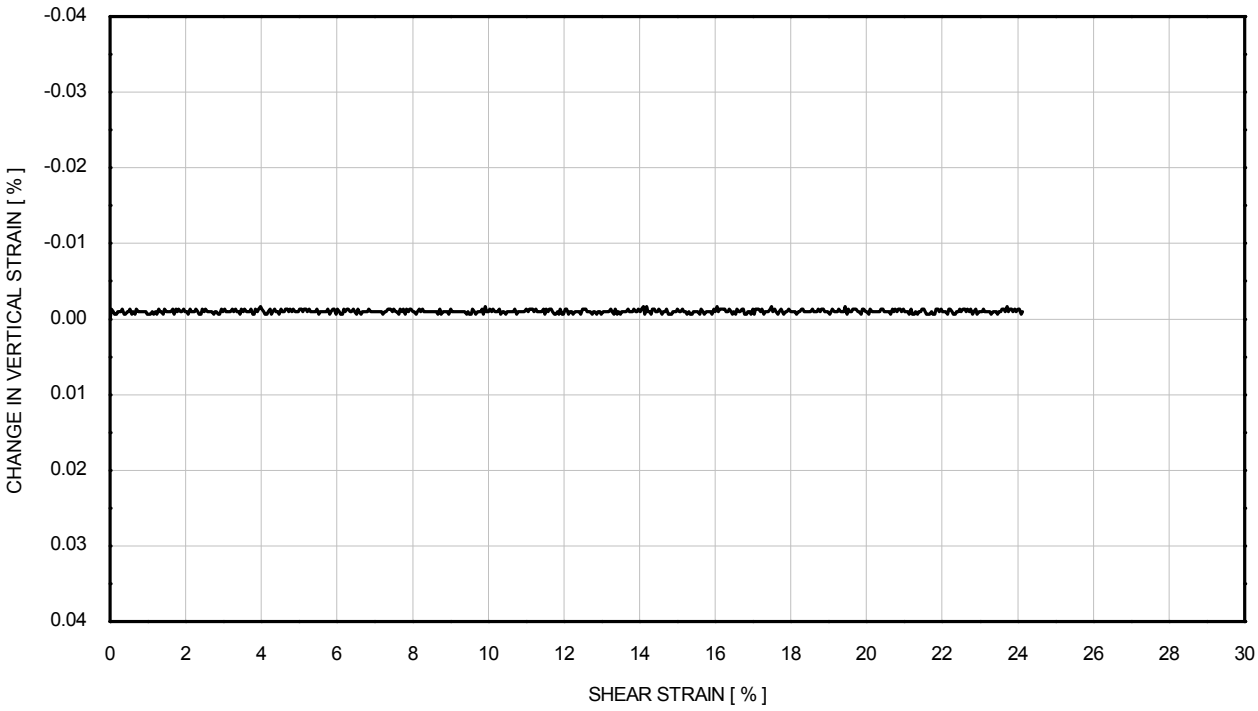


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 775 kPa	Sample	: DSS_1-1
γ at τ_{peak}	: 24.12 %	Unit	: A (Southern Bight)
Rate of strain	: 4.97 %/hour	Test No.	: DSS05

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

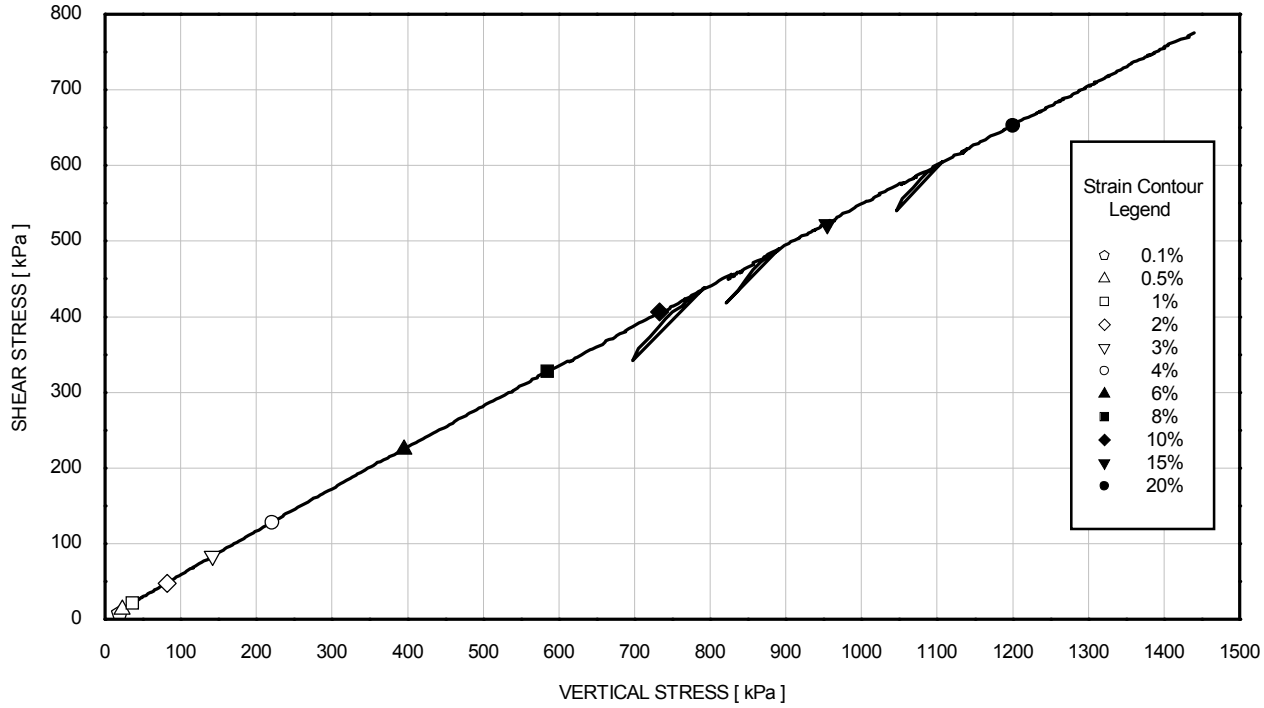


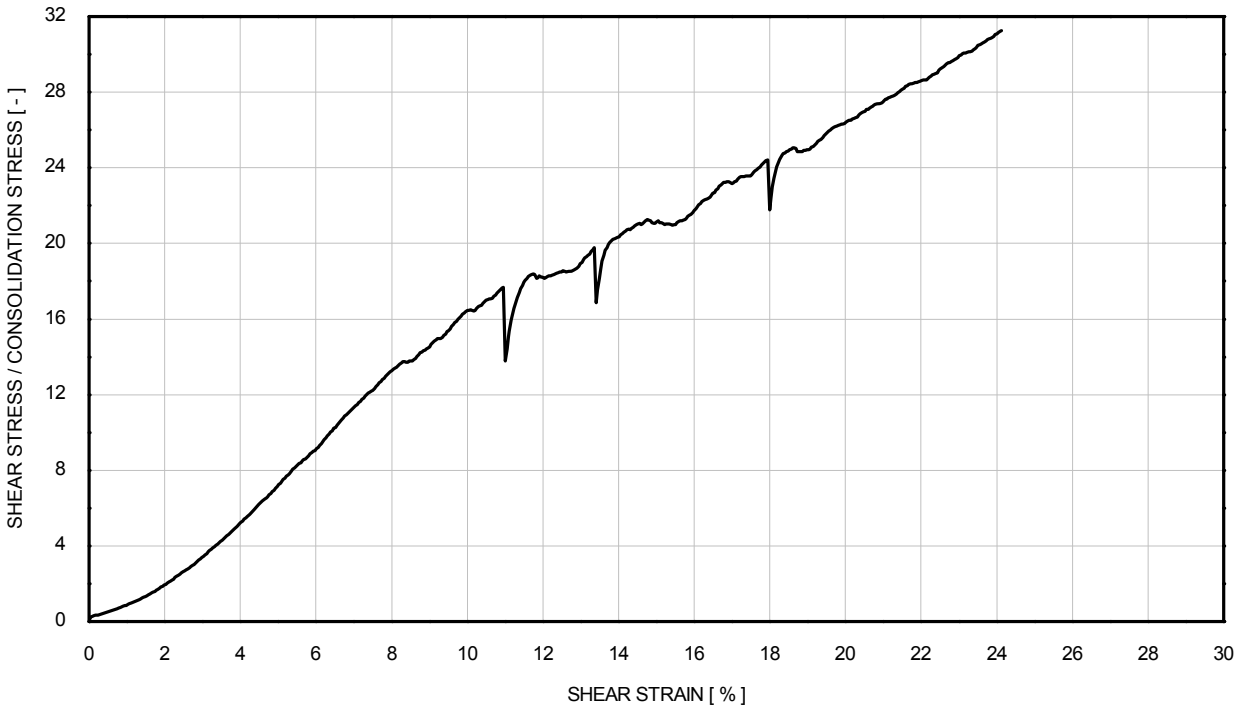


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 775 kPa	Sample	: DSS_1-1
γ at τ_{peak}	: 24.12 %	Unit	: A (Southern Bight)
Rate of strain	: 4.97 %/hour	Test No.	: DSS05

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

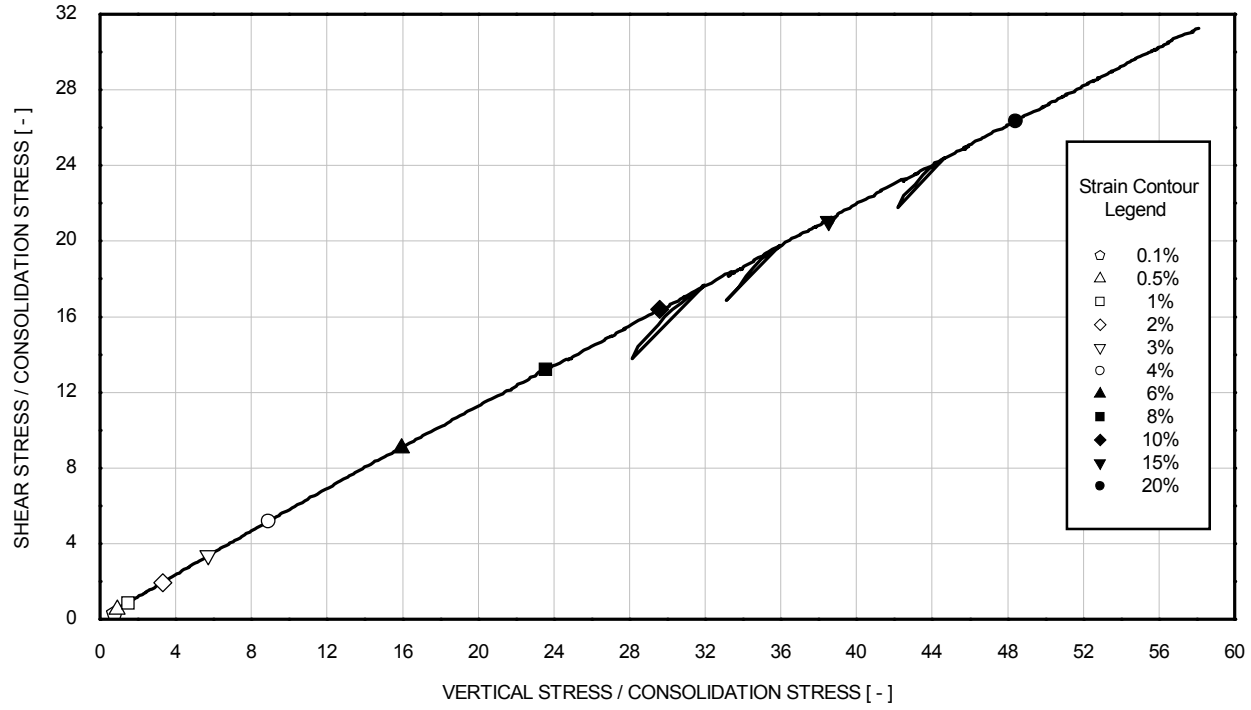


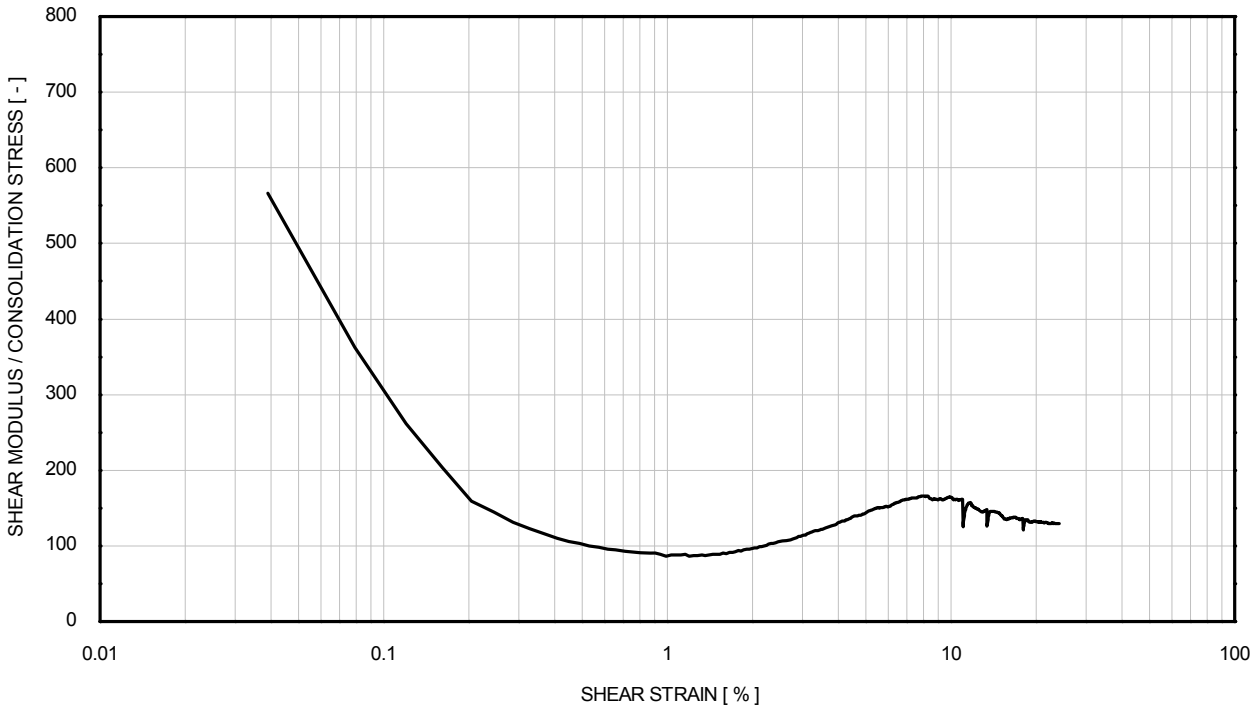


σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	775 kPa	Sample	:	DSS_1-1
γ at τ_{peak}	:	24.12 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.97 %/hour	Test No.	:	DSS05

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	775 kPa	Sample	:	DSS_1-1
γ at τ_{peak}	:	24.12 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.97 %/hour	Test No.	:	DSS05

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	20/01/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.2
Length	[mm]	30.0
Moisture content after compaction	[%]	10.3
Bulk density after compaction	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.63
Void ratio	[-]	0.630
Degree of saturation after compaction	[%]	43
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	23.8
Bulk density at start of test	[Mg/m³]	2.01
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BATCH1_DSS_1_2_DSS06
Template issue	1.3
Processed by	GG
Date	01/02/2016
Checked by	PH
Date	03/02/2016
Approved by	PH
Date	03/02/2016

TEST IDENTIFICATION	
Batch	1
Sample	DSS_1-2
Unit	A (Southern Bight)
Test number	DSS06

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	25
Vertical strain	[%]	0.19
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.627
Moisture content	[%]	23.6

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	718
Shear strain	[%]	29.80
Shear induced -$\Delta\sigma_v$	[kPa]	-1325
Vertical stress	[kPa]	1350
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.98
At 15 % shear strain		
Shear stress	[kPa]	395
Shear induced -$\Delta\sigma_v$	[kPa]	-675
Vertical stress	[kPa]	700
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	1
Sample	DSS_1-2
Unit	A (Southern Bight)
Test number	DSS06

SUMMARY OF CONSOLIDATED DSS TEST

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

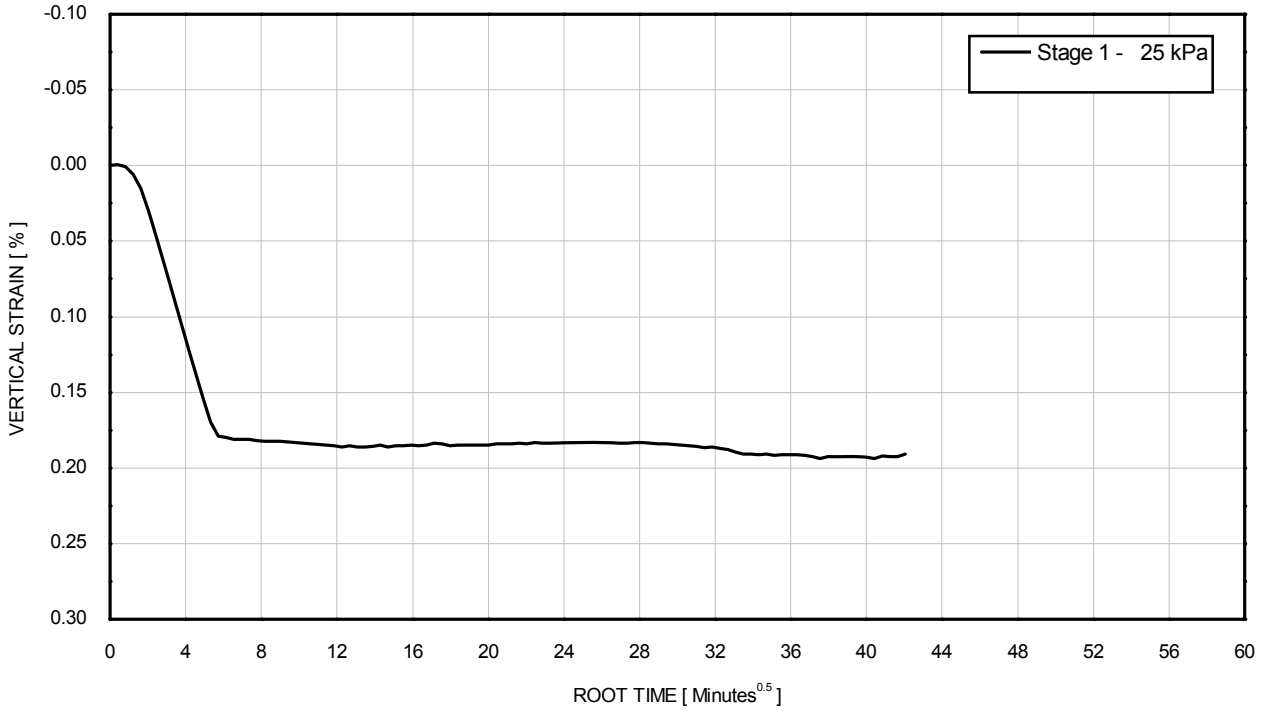
SPECIMEN PHOTOGRAPH

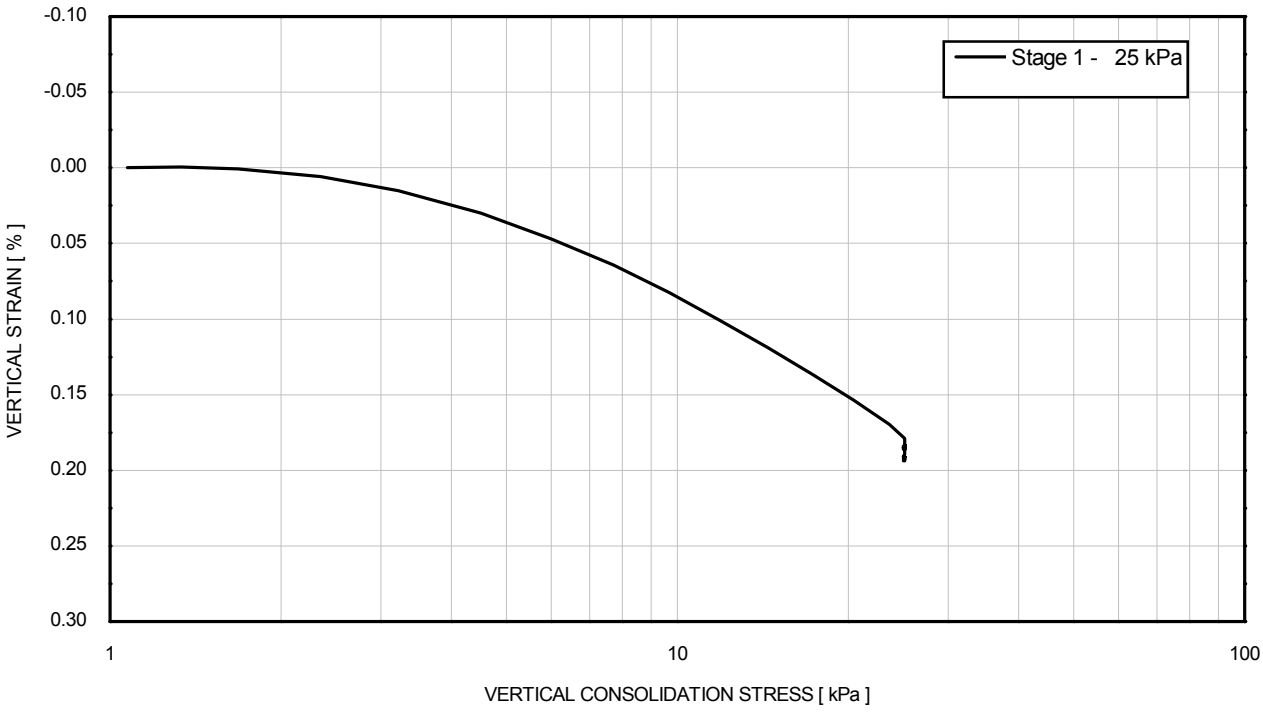


TEST IDENTIFICATION	
Batch	1
Sample	DSS_1-2
Unit	A (Southern Bight)
Test number	DSS06

SUMMARY OF CONSOLIDATED DSS TEST

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

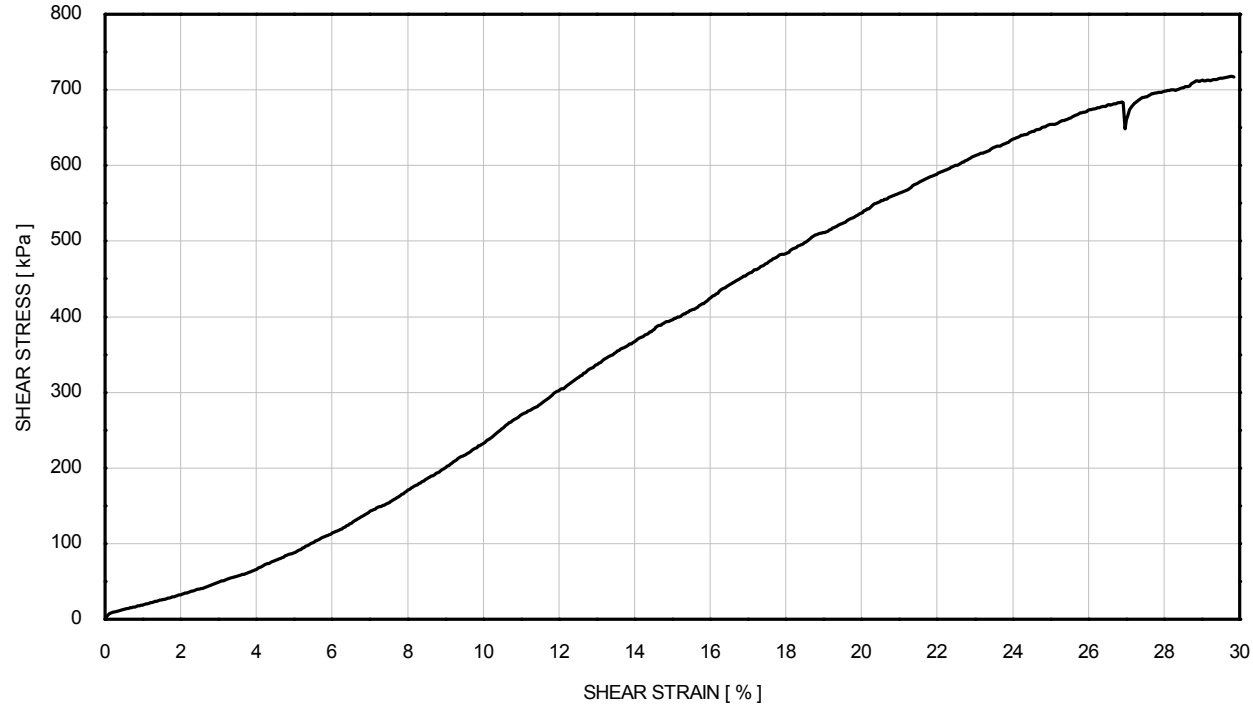


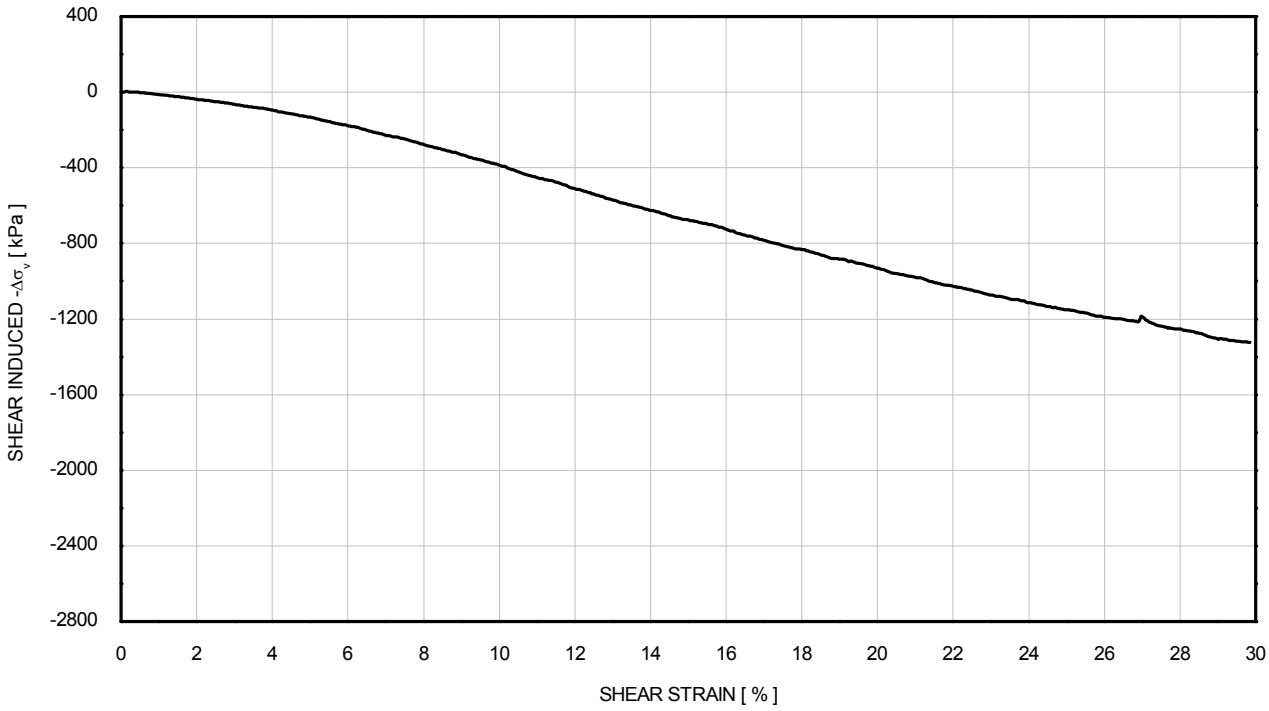


σ_{vc}	: 25 kPa	Batch	: 1
		Sample	: DSS_1-2
		Unit	: A (Southern Bight)
		Test No.	: DSS06

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

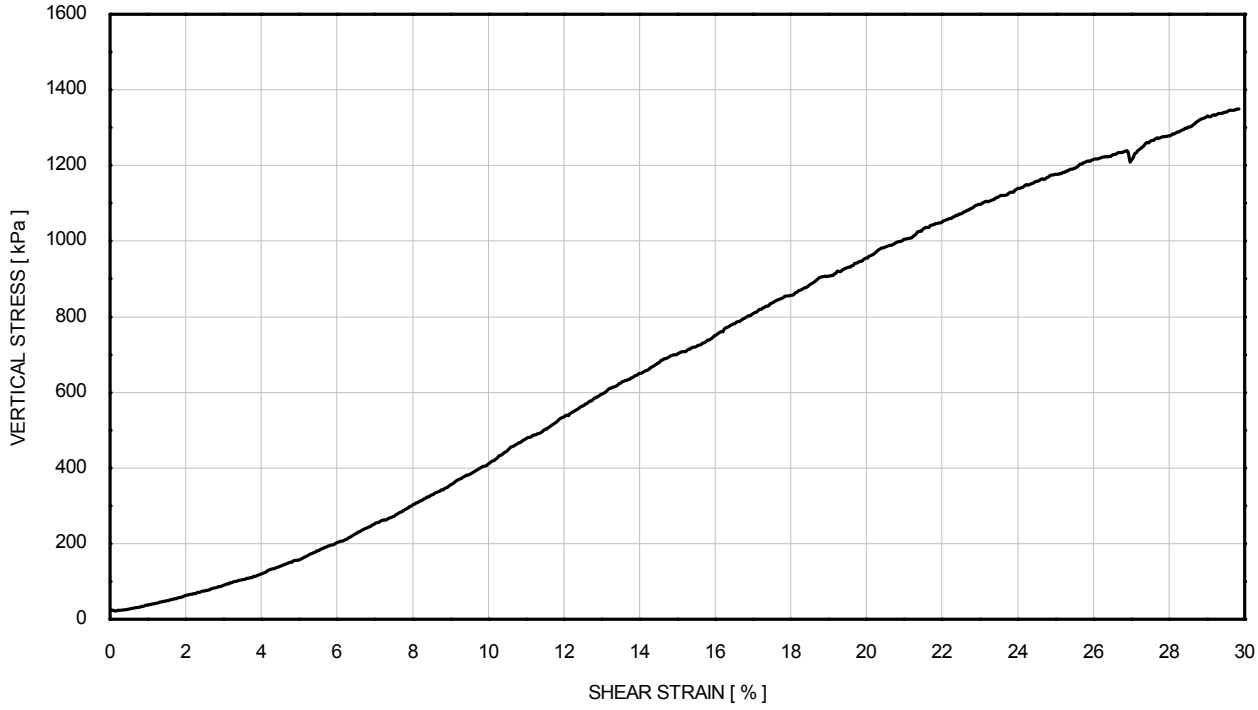


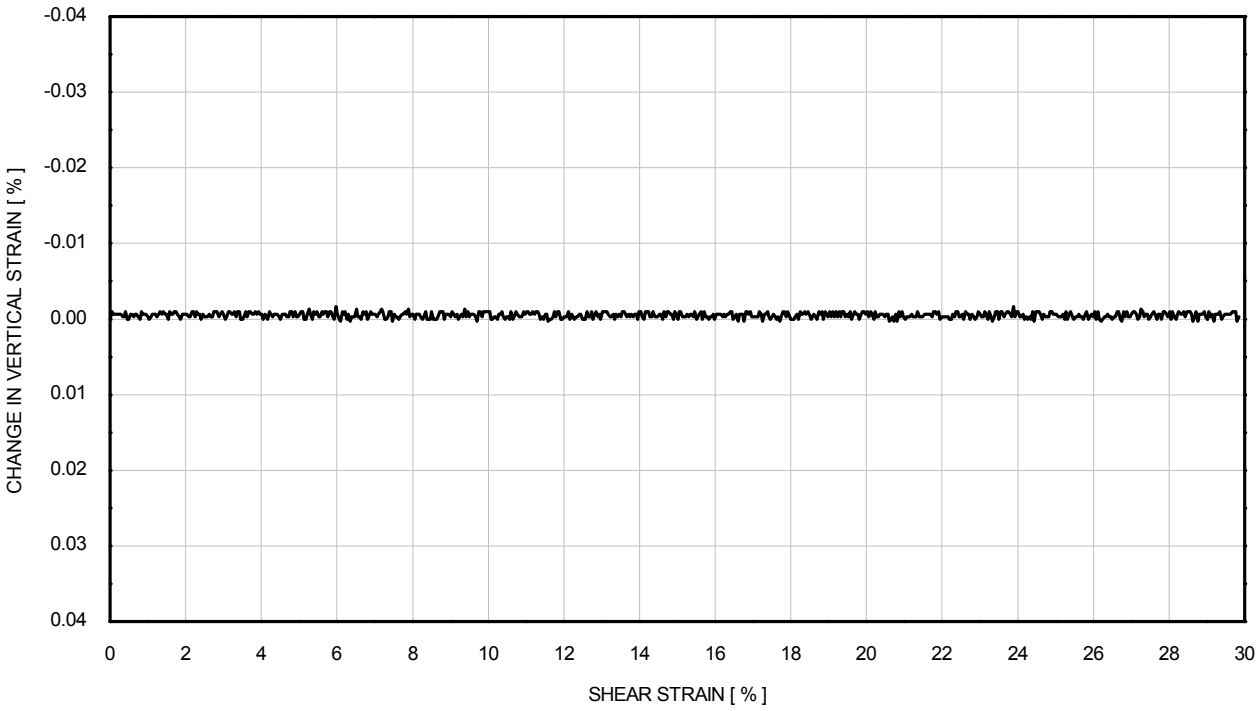


σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	718 kPa	Sample	:	DSS_1-2
γ at τ_{peak}	:	29.80 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.98 %/hour	Test No.	:	DSS06

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

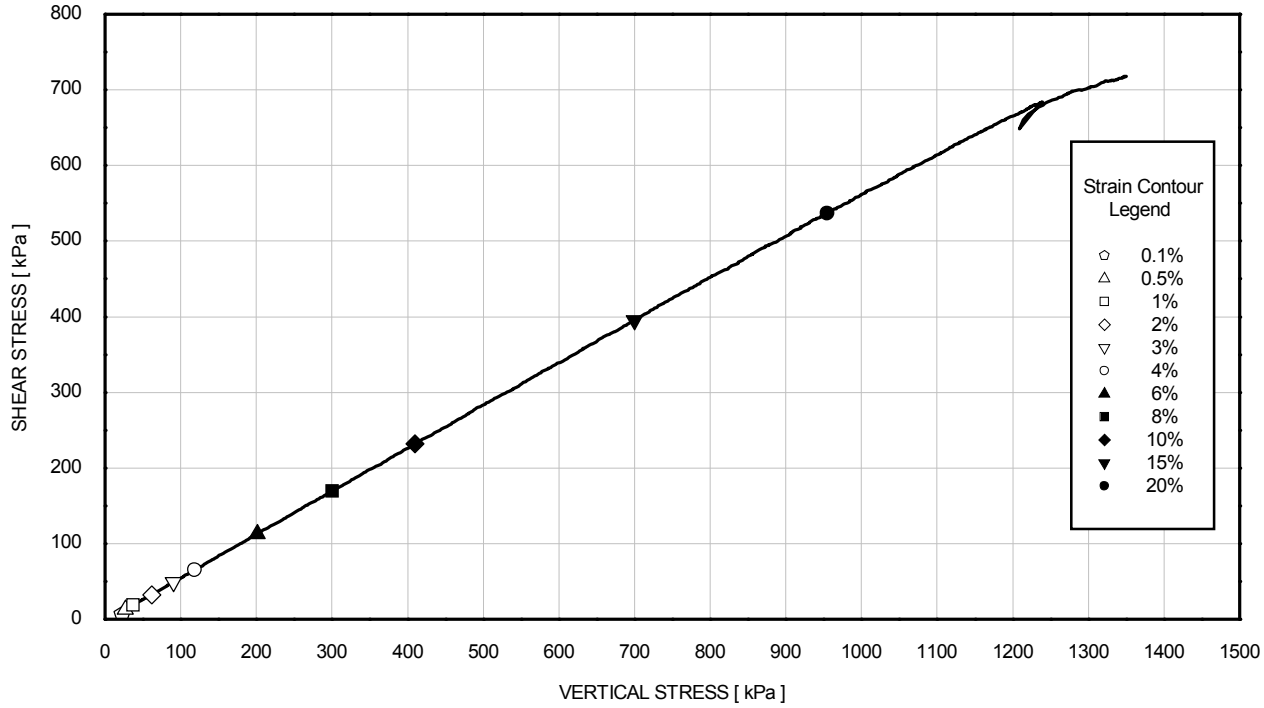


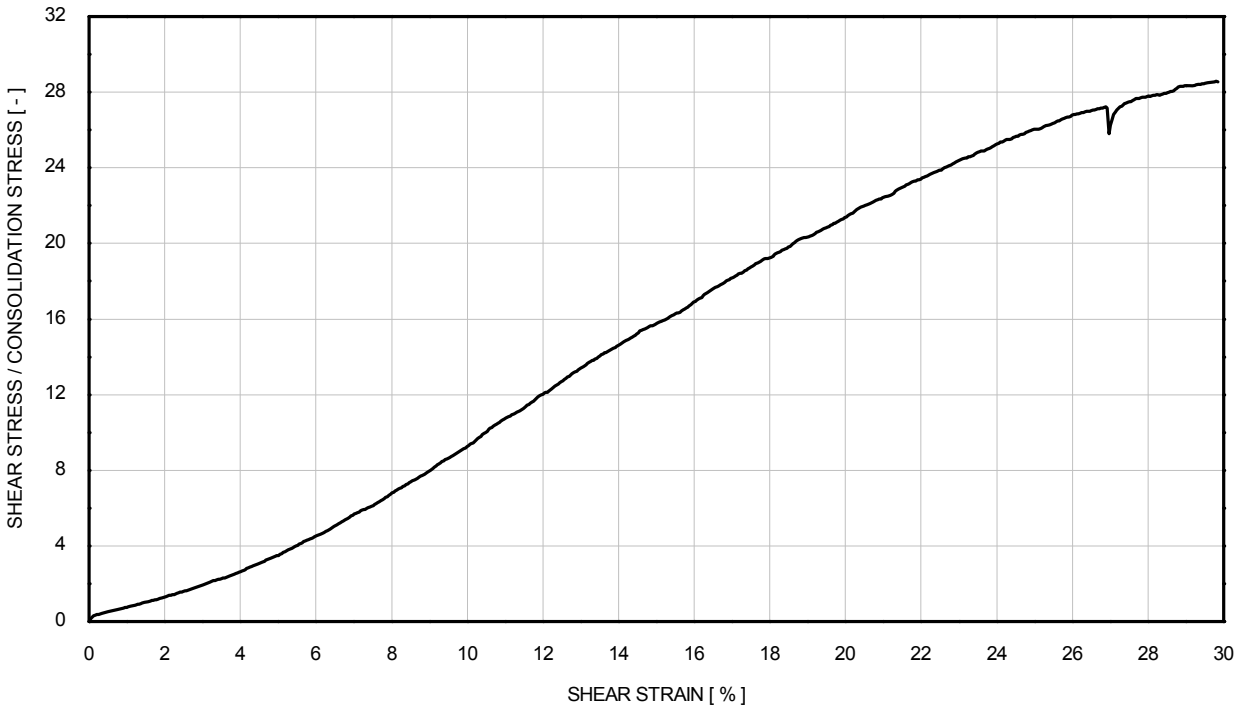


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 718 kPa	Sample	: DSS_1-2
γ at τ_{peak}	: 29.80 %	Unit	: A (Southern Bight)
Rate of strain	: 4.98 %/hour	Test No.	: DSS06

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

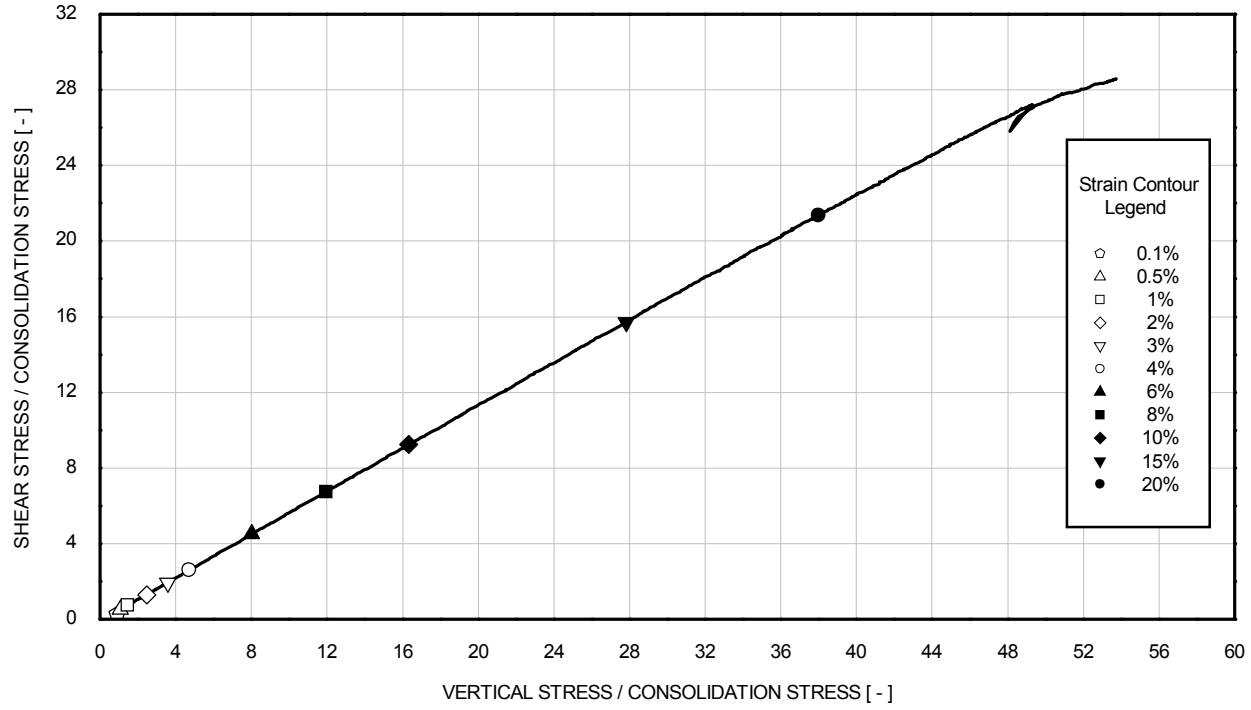


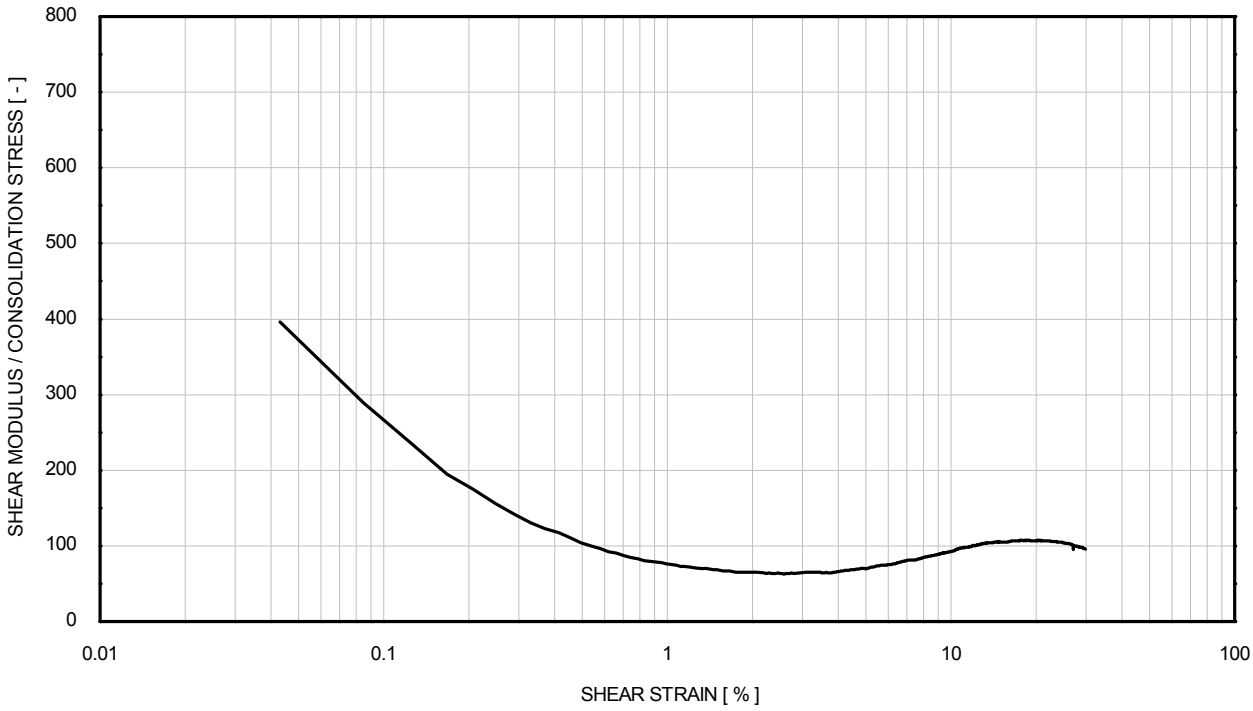


σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	718 kPa	Sample	:	DSS_1-2
γ at τ_{peak}	:	29.80 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.98 %/hour	Test No.	:	DSS06

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	718 kPa	Sample	:	DSS_1-2
γ at τ_{peak}	:	29.80 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.98 %/hour	Test No.	:	DSS06

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	14/01/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.5
Length	[mm]	30.0
Moisture content after compaction	[%]	9.9
Bulk density after compaction	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.557
Degree of saturation after compaction	[%]	47
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	21.0
Bulk density at start of test	[Mg/m³]	2.06
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BATCH2_DSS_2_1_DSS07
Template issue	1.3
Processed by	GG
Date	01/02/2016
Checked by	PH
Date	04/02/2016
Approved by	PH
Date	04/02/2016

TEST IDENTIFICATION	
Batch	2
Sample	DSS_2-1
Unit	B (Eem/Kreftenheye)
Test number	DSS07

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	80
Vertical strain	[%]	0.58
Bulk density	[Mg/m^3]	2.07
Dry density	[Mg/m^3]	1.71
Void ratio	[-]	0.548
Moisture content	[%]	20.7

SHEARING – CONSTANT VOLUME*		
At peak shear stress		
Shear stress	[kPa]	820
Shear strain	[%]	13.46
Shear induced -$\Delta\sigma_v$	[kPa]	-1352
Vertical stress	[kPa]	1432
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.97
At 15 % shear strain		
Shear stress	[kPa]	820
Shear induced -$\Delta\sigma_v$	[kPa]	-1352
Vertical stress	[kPa]	1432
Vertical strain	[%]	0.00

* Please note that the maximum axial load tranducer limit was reached prior to 15% shear strain being achieved.

TEST IDENTIFICATION	
Batch	2
Sample	DSS_2-1
Unit	B (Eem/Kreftenheye)
Test number	DSS07

SUMMARY OF CONSOLIDATED DSS TEST

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

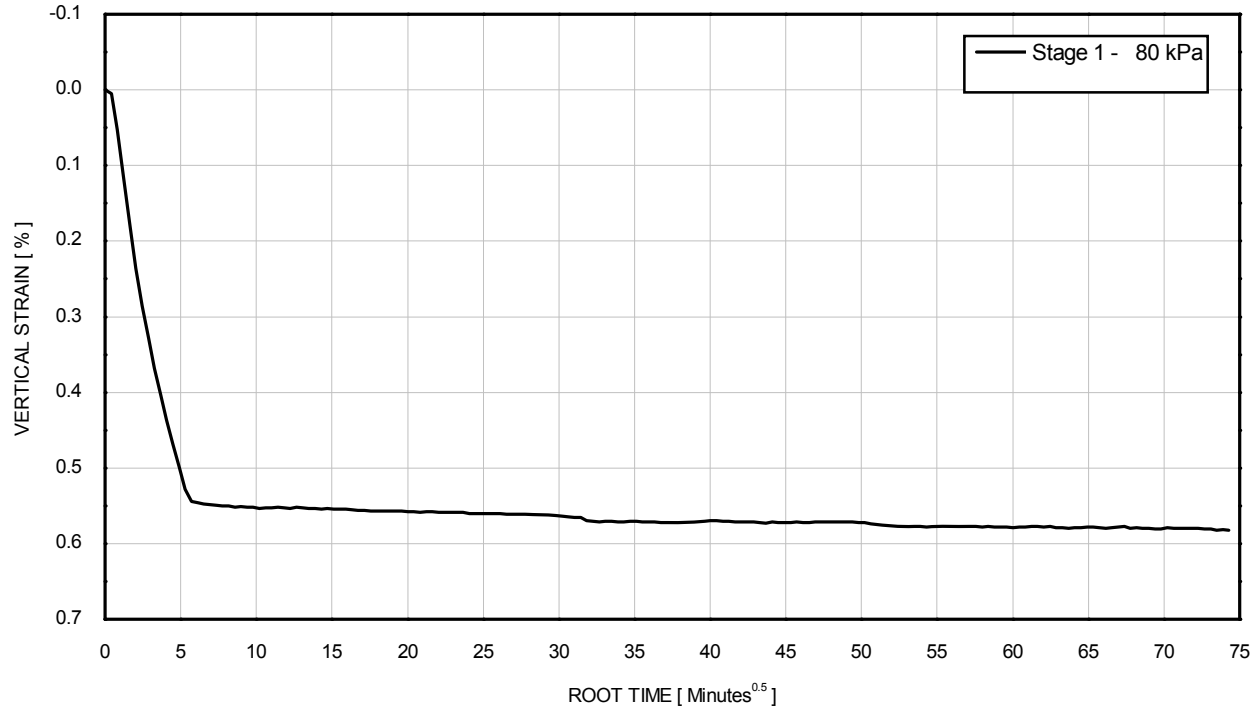
SPECIMEN PHOTOGRAPH

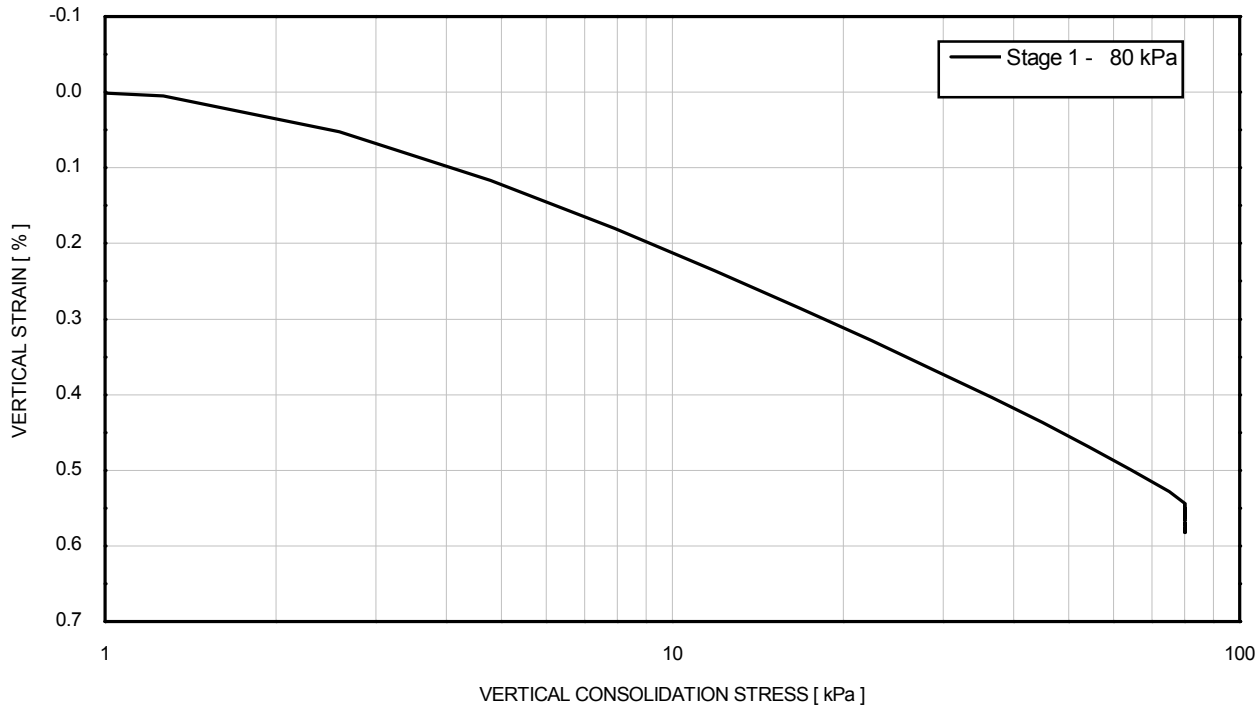


TEST IDENTIFICATION	
Batch	2
Sample	DSS_2-1
Unit	B (Eem/Kreftenheye)
Test number	DSS07

SUMMARY OF CONSOLIDATED DSS TEST

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

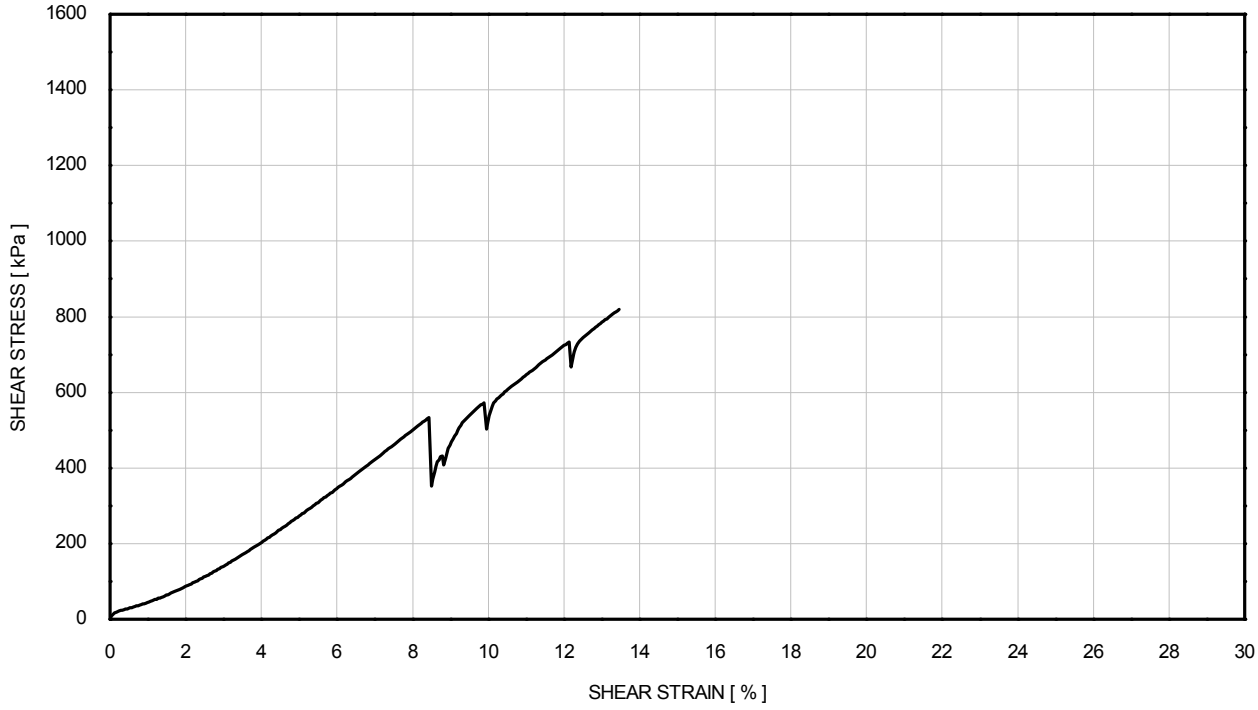


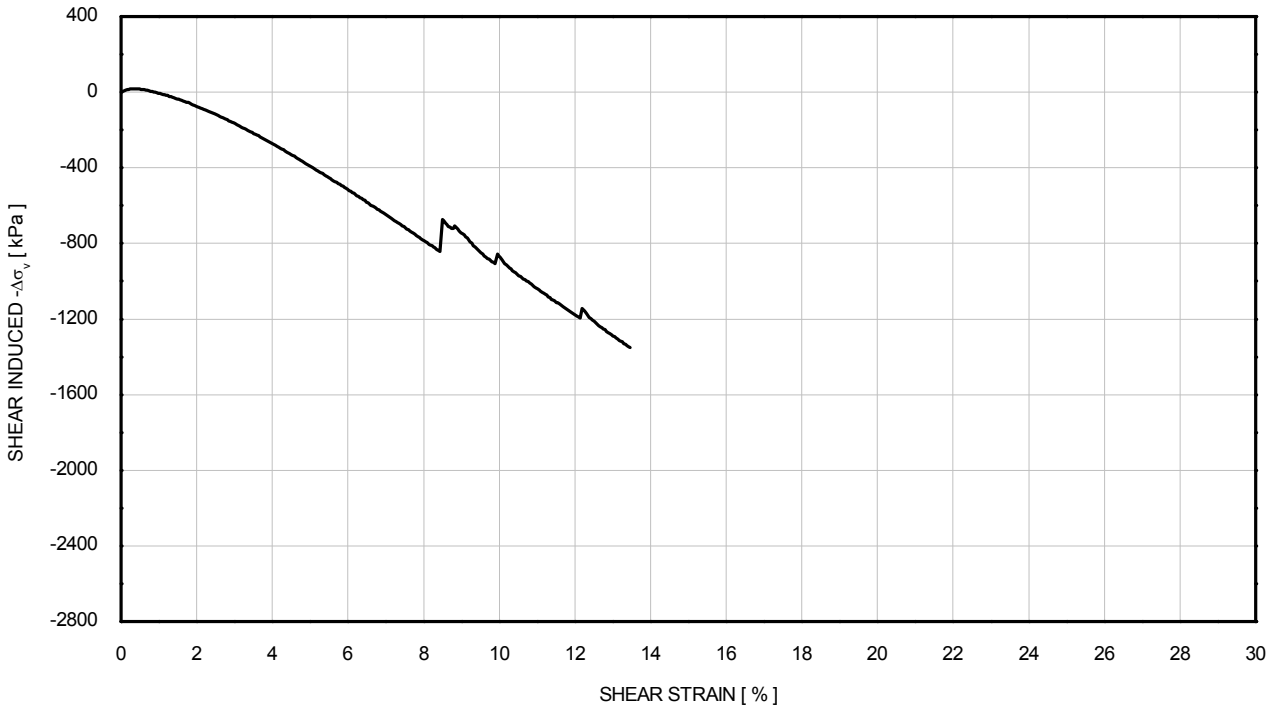


σ_{vc}	: 80 kPa	Batch	: 2
		Sample	: DSS_2-1
		Unit	: B (Eem/Kreftenheye)
		Test No.	: DSS07

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

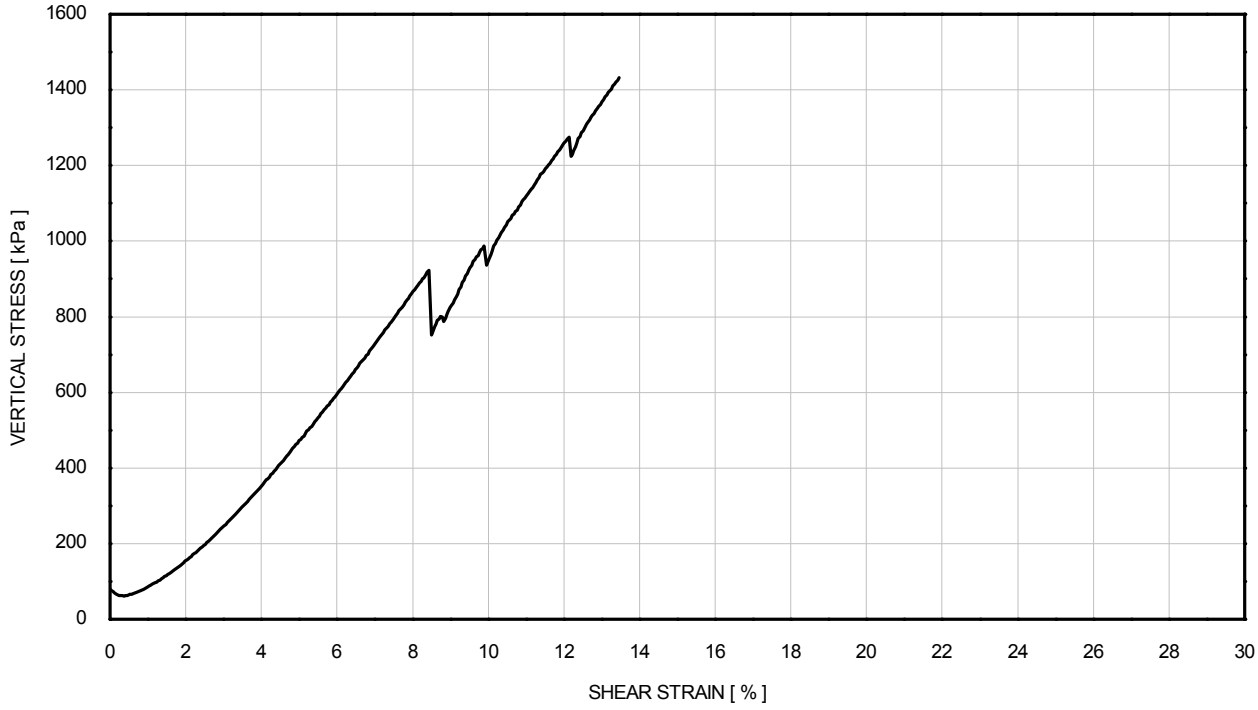


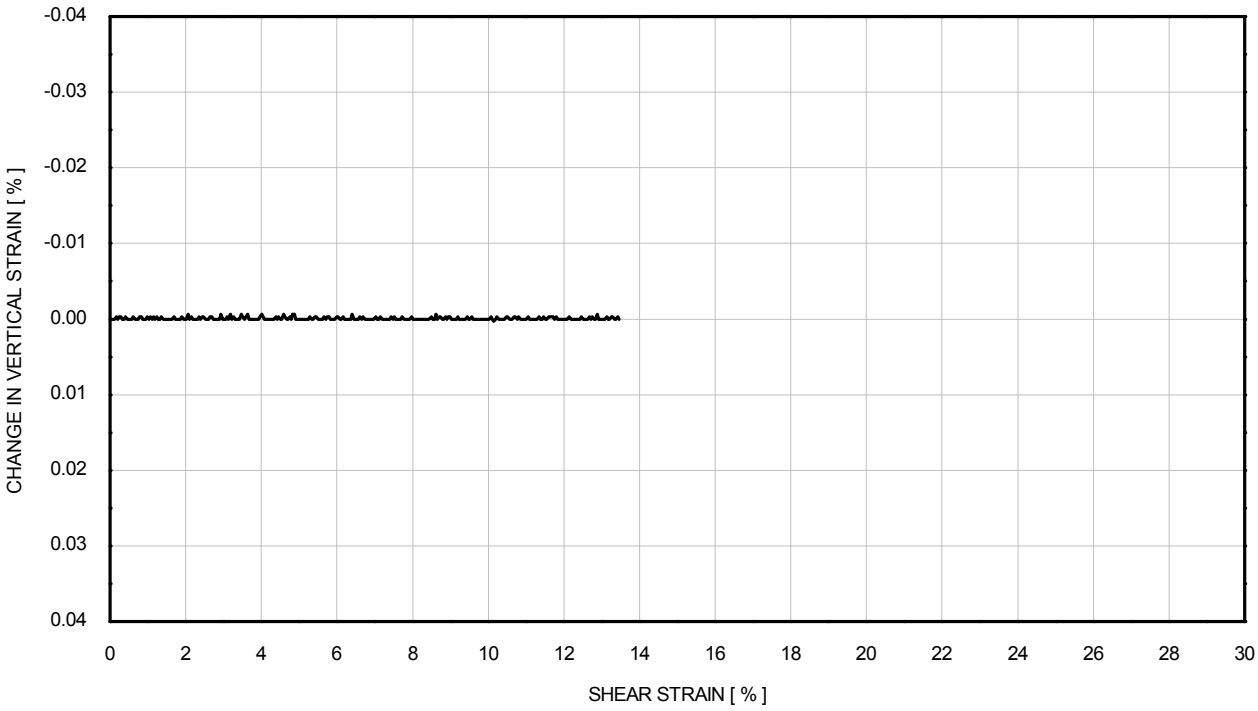


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 820 kPa	Sample	: DSS_2-1
γ at τ_{peak}	: 13.46 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.97 %/hour	Test No.	: DSS07

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

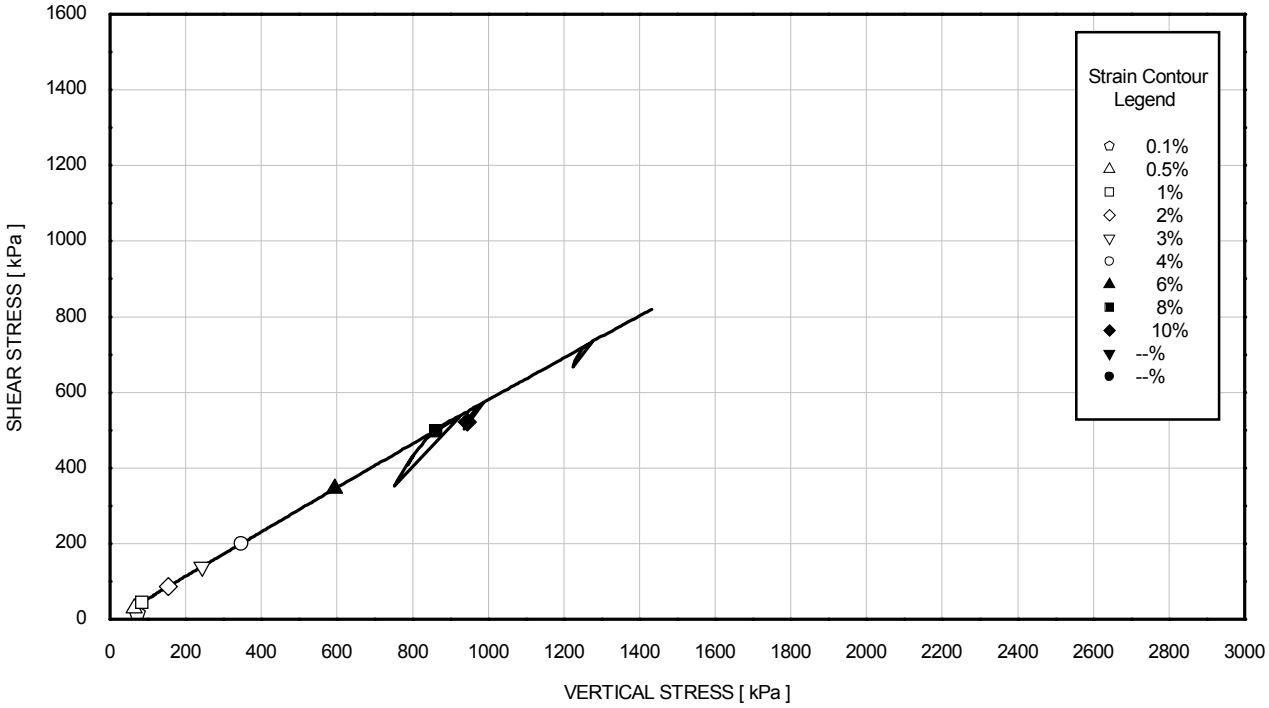


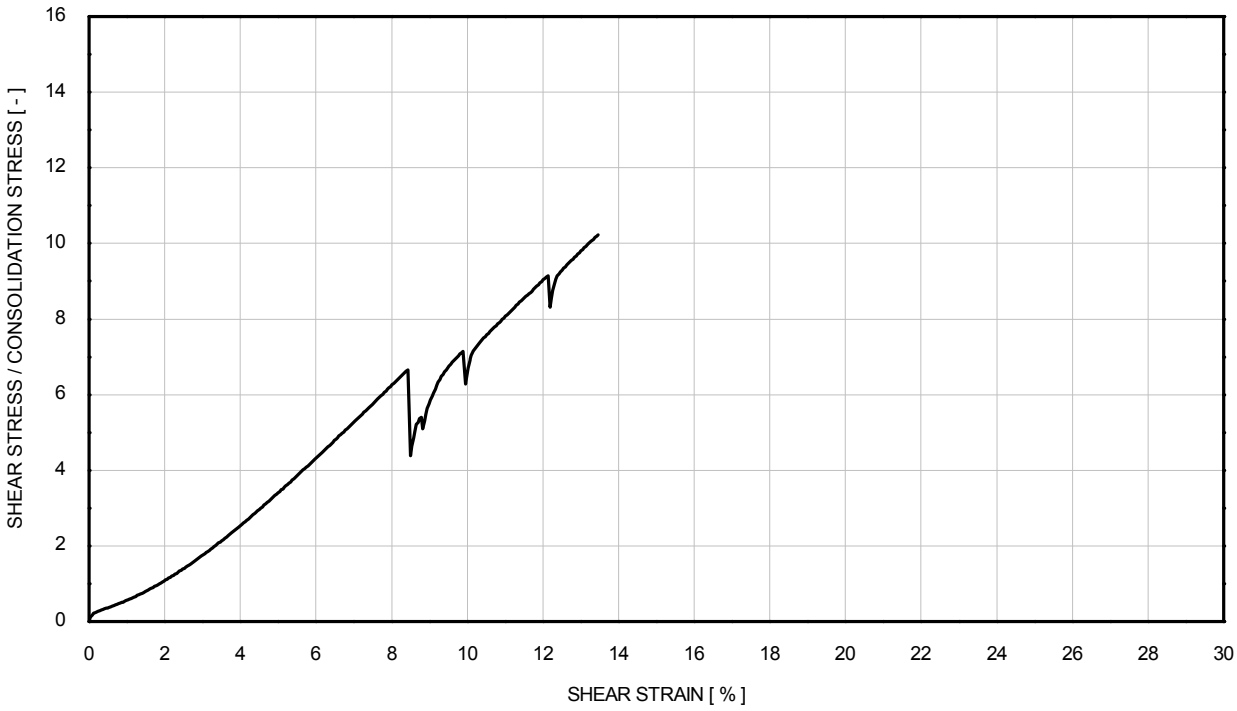


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 820 kPa	Sample	: DSS_2-1
γ at τ_{peak}	: 13.46 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.97 %/hour	Test No.	: DSS07

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

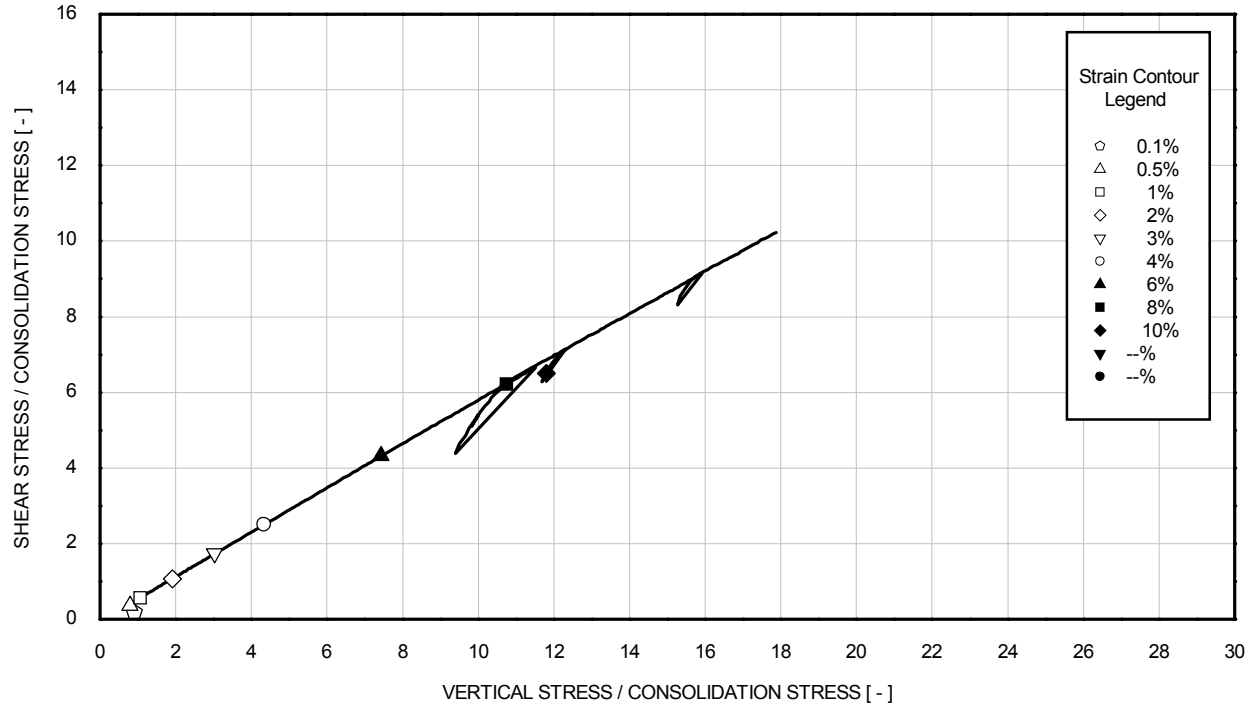


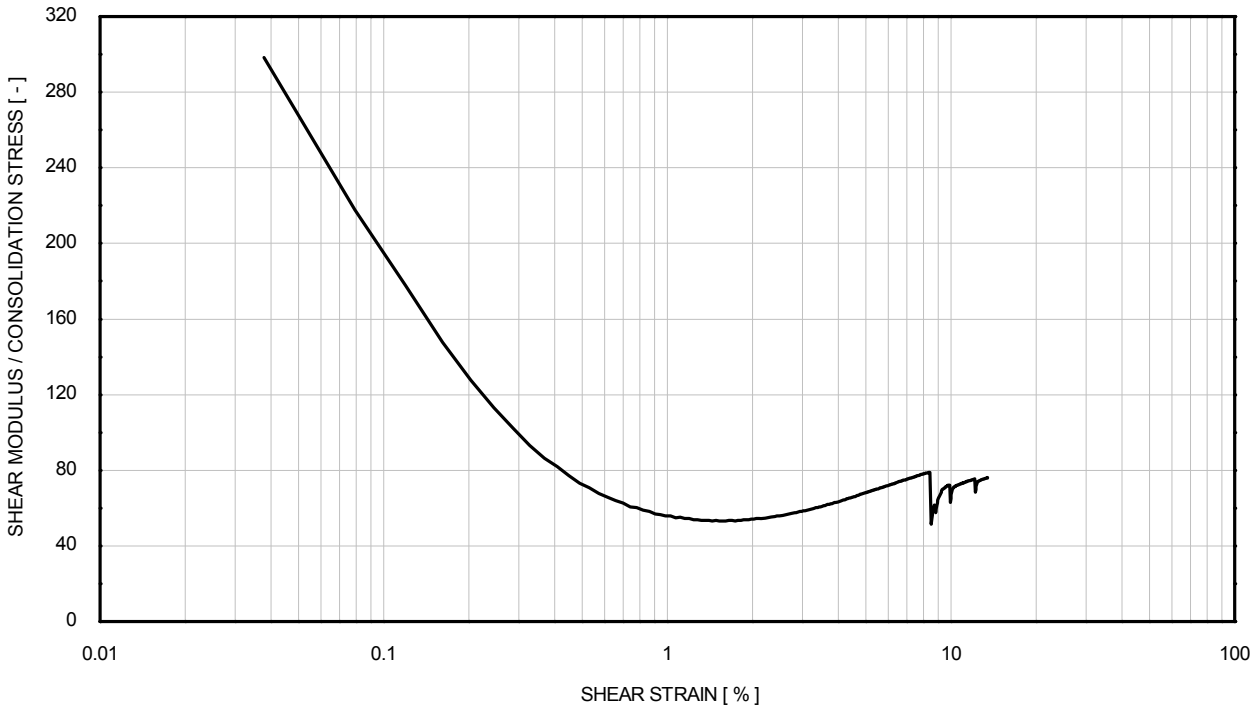


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 820 kPa	Sample	: DSS_2-1
γ at τ_{peak}	: 13.46 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.97 %/hour	Test No.	: DSS07

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	80 kPa	Batch	:	2
τ_{peak}	:	820 kPa	Sample	:	DSS_2-1
γ at τ_{peak}	:	13.46 %	Unit	:	B (Eem/Kreftenheye)
Rate of strain	:	4.97 %/hour	Test No.	:	DSS07

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few medium to coarse sand-sized shell fragments

GENERAL	
Date test started	26/01/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.2
Length	[mm]	30.0
Moisture content after compaction	[%]	10.1
Bulk density after compaction	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.561
Degree of saturation after compaction	[%]	48
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	21.2
Bulk density at start of test	[Mg/m³]	2.06
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BATCH2_DSS_2_2_DSS08
Template issue	1.3
Processed by	GG
Date	01/02/2016
Checked by	PH
Date	04/02/2016
Approved by	PH
Date	04/02/2016

TEST IDENTIFICATION	
Batch	2
Sample	DSS_2-2
Unit	B (Eem/Kreftenheye)
Test number	DSS08

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	80
Vertical strain	[%]	0.36
Bulk density	[Mg/m^3]	2.06
Dry density	[Mg/m^3]	1.70
Void ratio	[-]	0.555
Moisture content	[%]	20.9

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	591
Shear strain	[%]	29.98
Shear induced -$\Delta\sigma_v$	[kPa]	-964
Vertical stress	[kPa]	1044
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.99
At 15 % shear strain		
Shear stress	[kPa]	335
Shear induced -$\Delta\sigma_v$	[kPa]	-506
Vertical stress	[kPa]	586
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	2
Sample	DSS_2-2
Unit	B (Eem/Kreftenheye)
Test number	DSS08

SUMMARY OF CONSOLIDATED DSS TEST

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

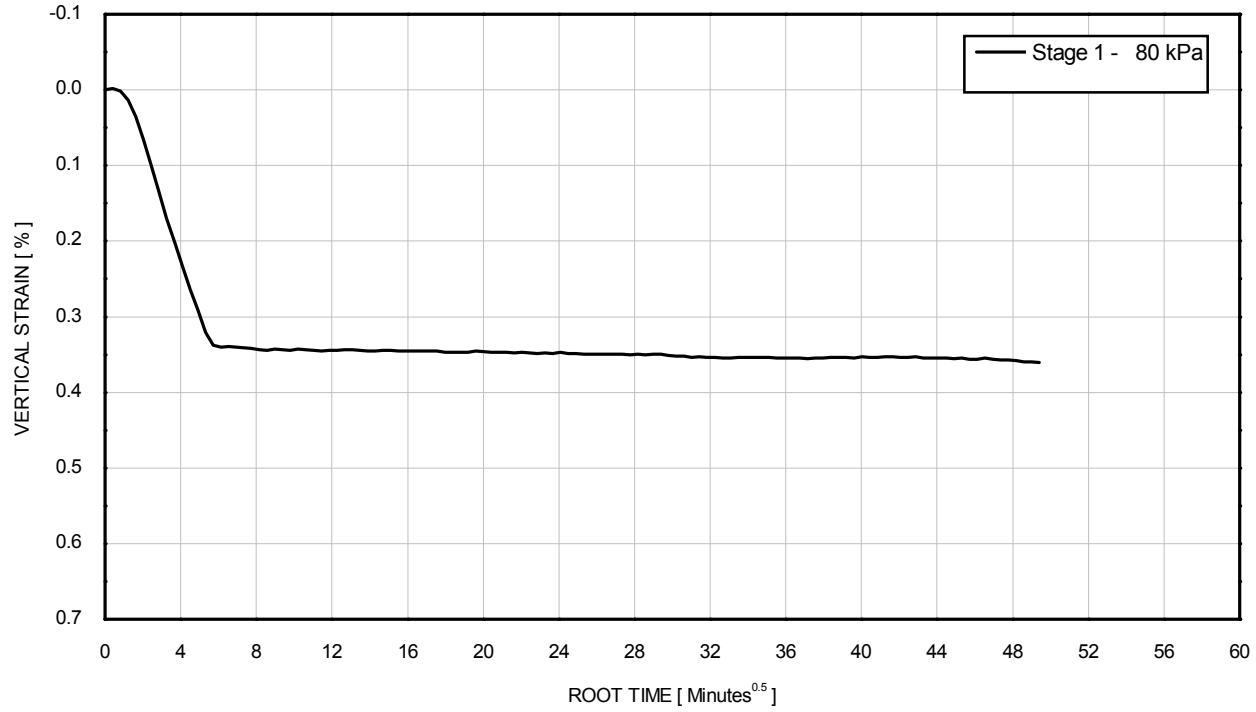
SPECIMEN PHOTOGRAPH

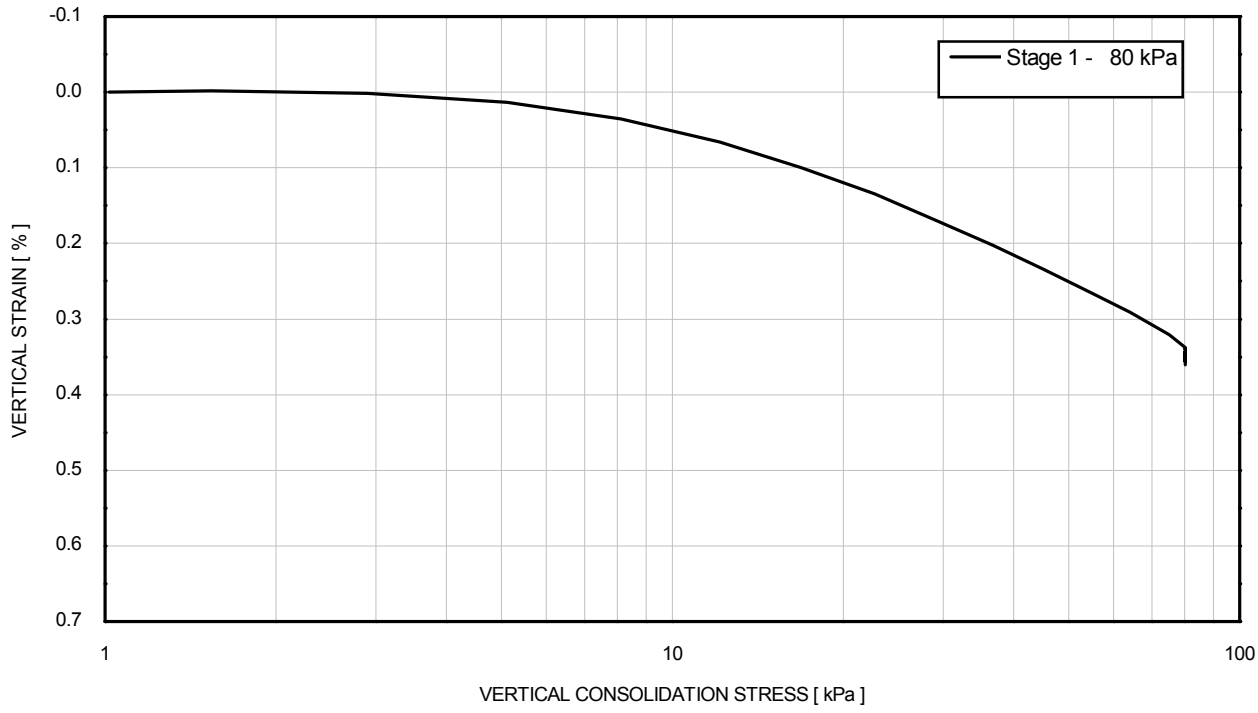


TEST IDENTIFICATION	
Batch	2
Sample	DSS_2-2
Unit	B (Eem/Kreftenheye)
Test number	DSS08

SUMMARY OF CONSOLIDATED DSS TEST

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

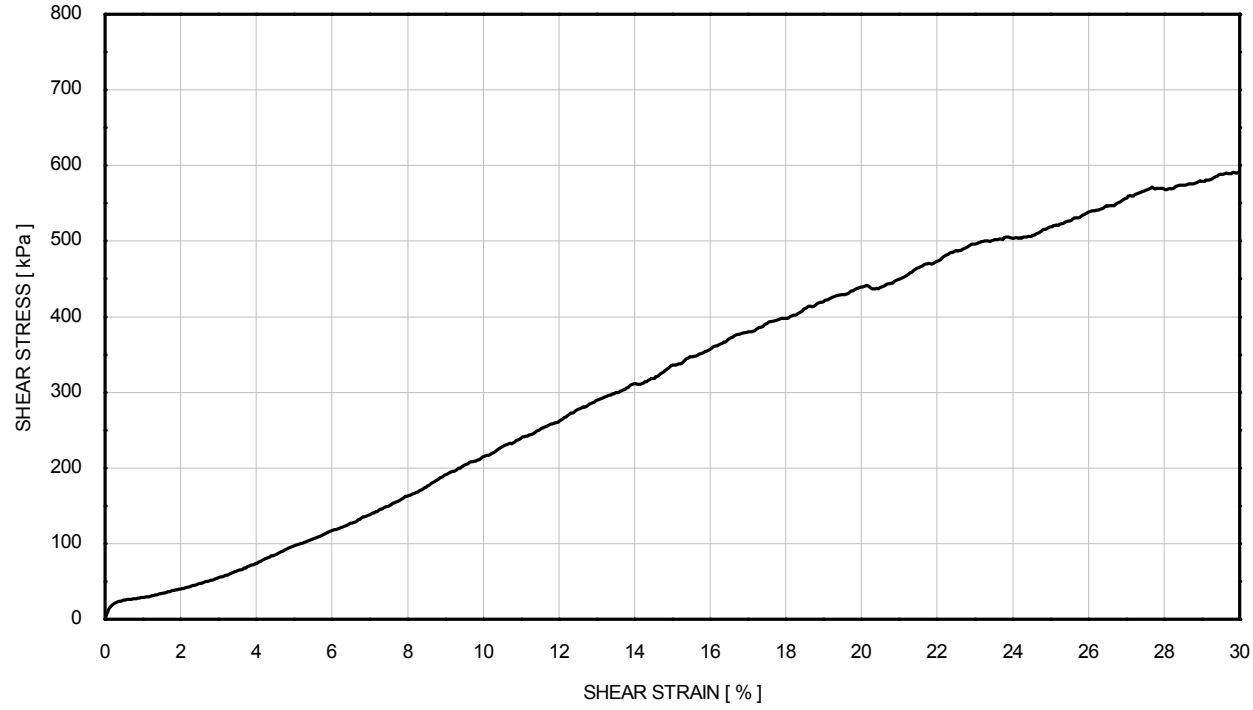


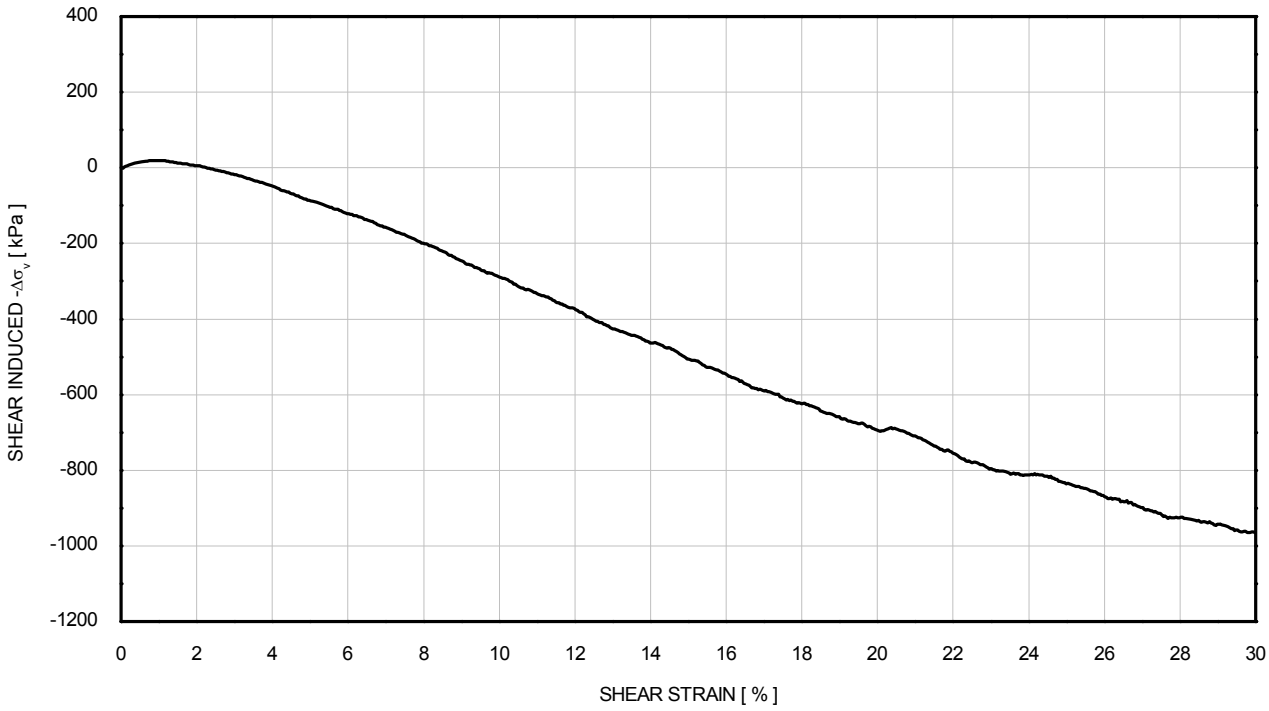


σ_{vc}	: 80 kPa	Batch	: 2
		Sample	: DSS_2-2
		Unit	: B (Eem/Kreftenheye)
		Test No.	: DSS08

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

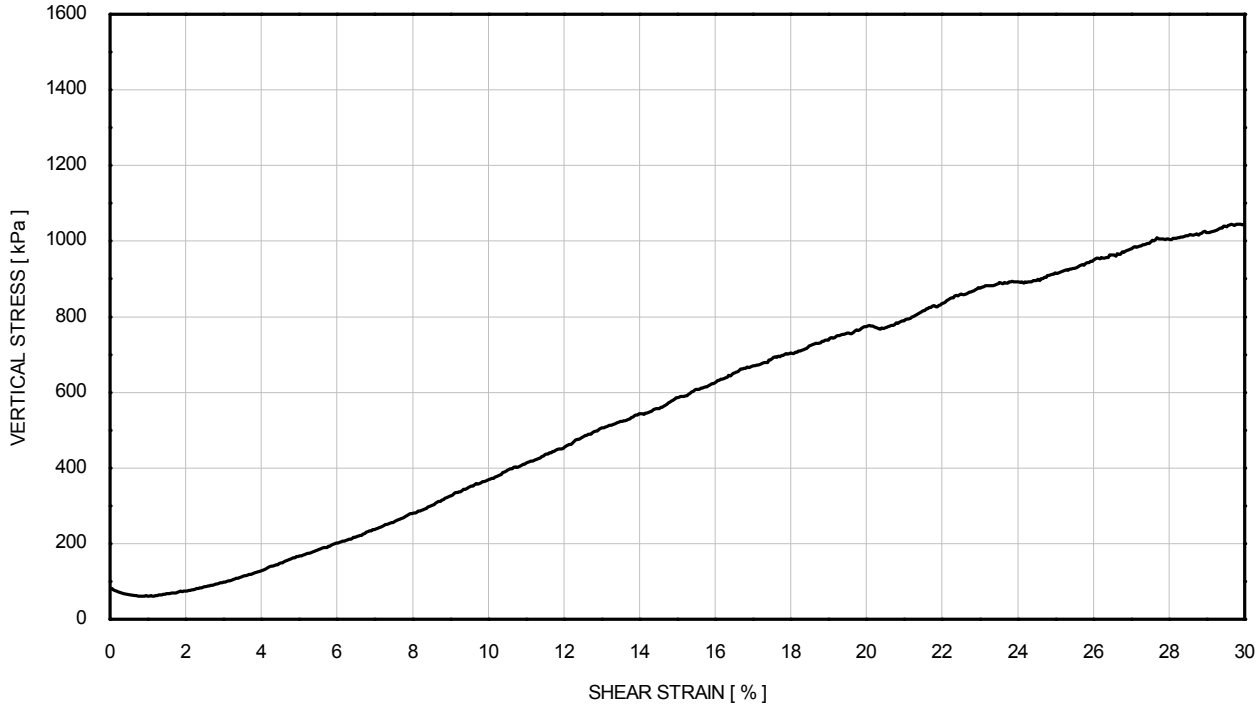


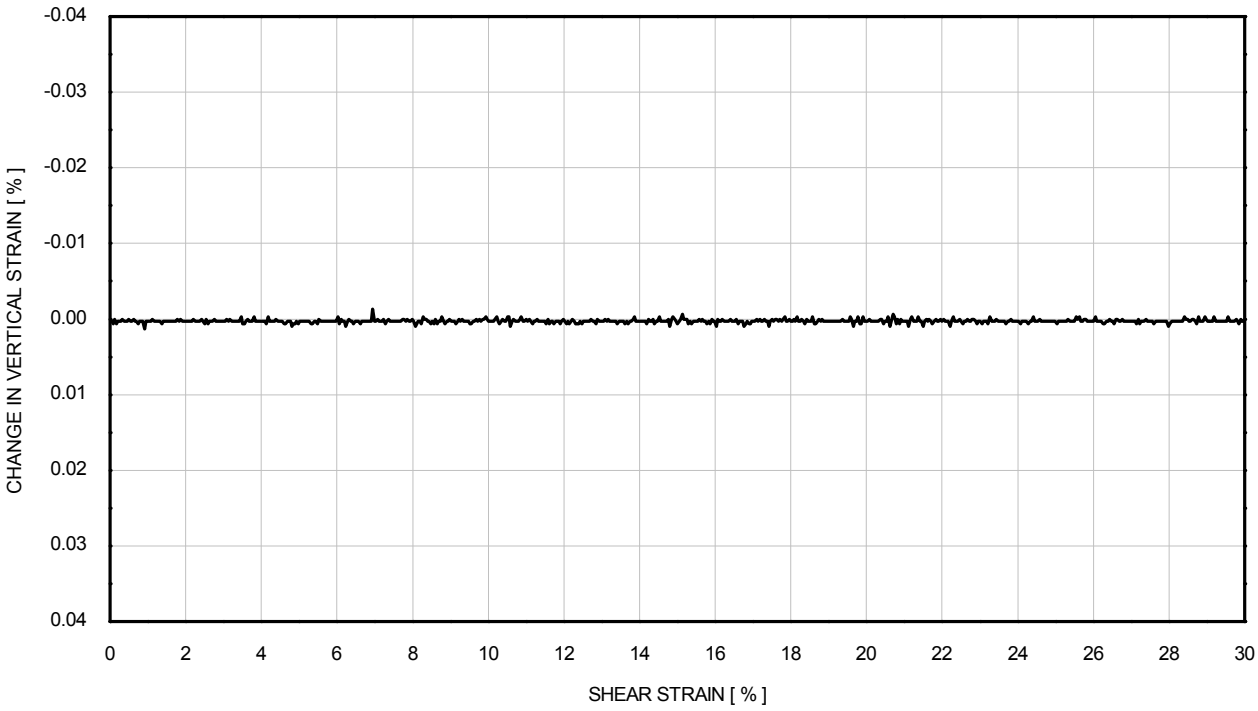


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 591 kPa	Sample	: DSS_2-2
γ at τ_{peak}	: 29.98 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: DSS08

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

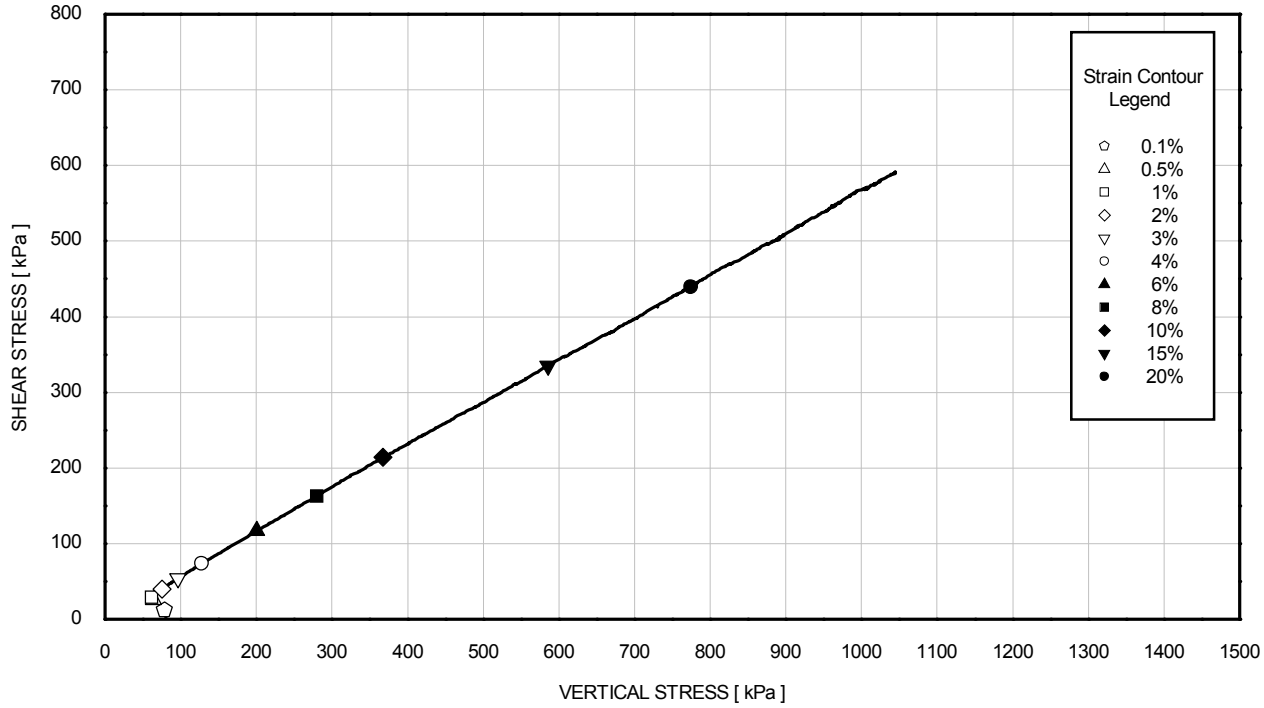


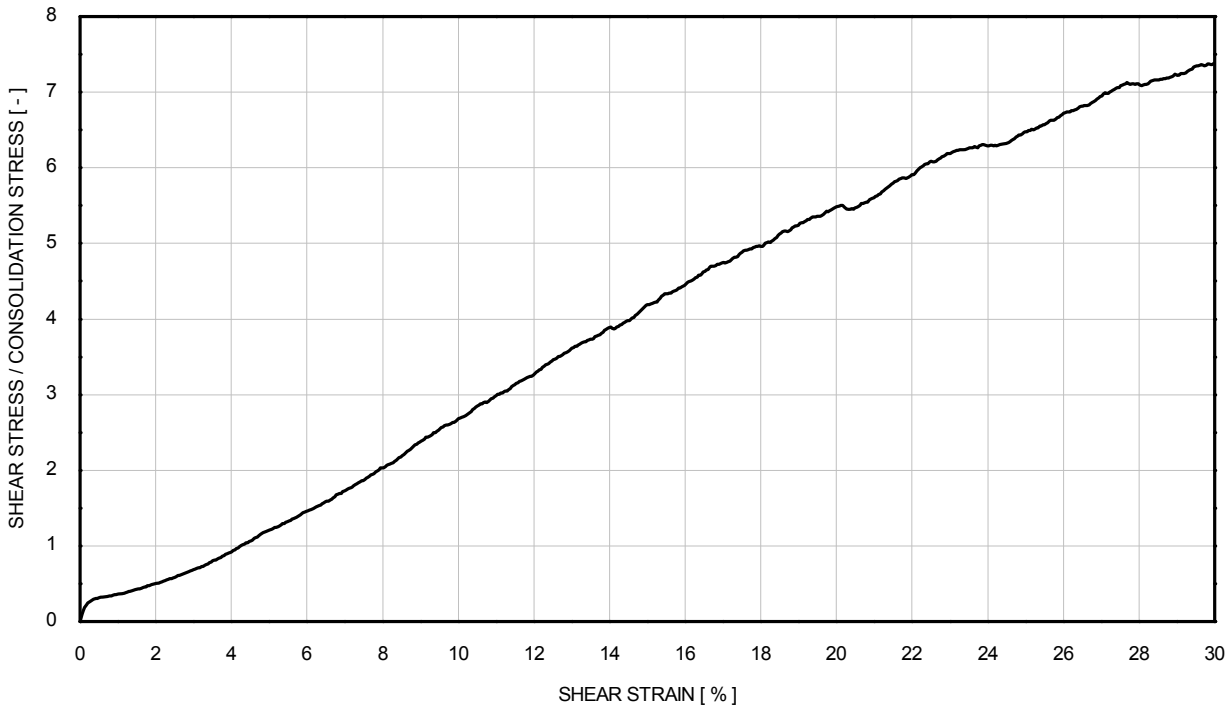


σ_{vc}	:	80 kPa	Batch	:	2
τ_{peak}	:	591 kPa	Sample	:	DSS_2-2
γ at τ_{peak}	:	29.98 %	Unit	:	B (Eem/Kreftenheye)
Rate of strain	:	4.99 %/hour	Test No.	:	DSS08

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

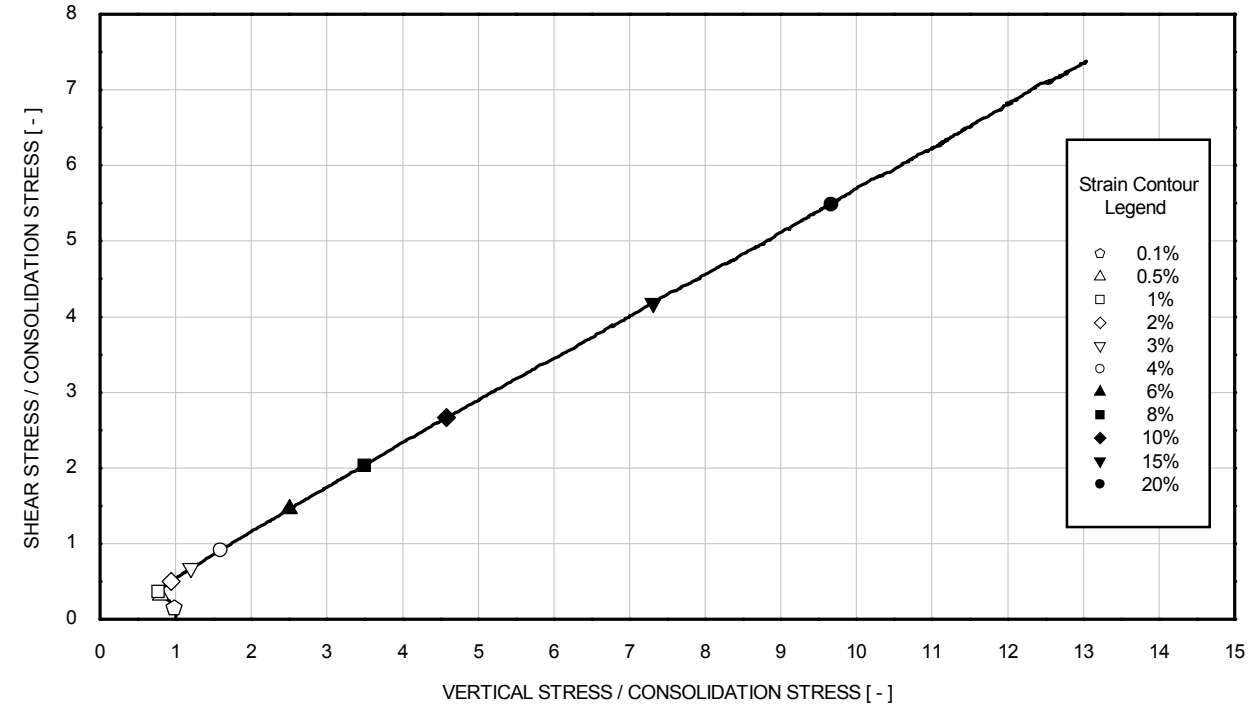


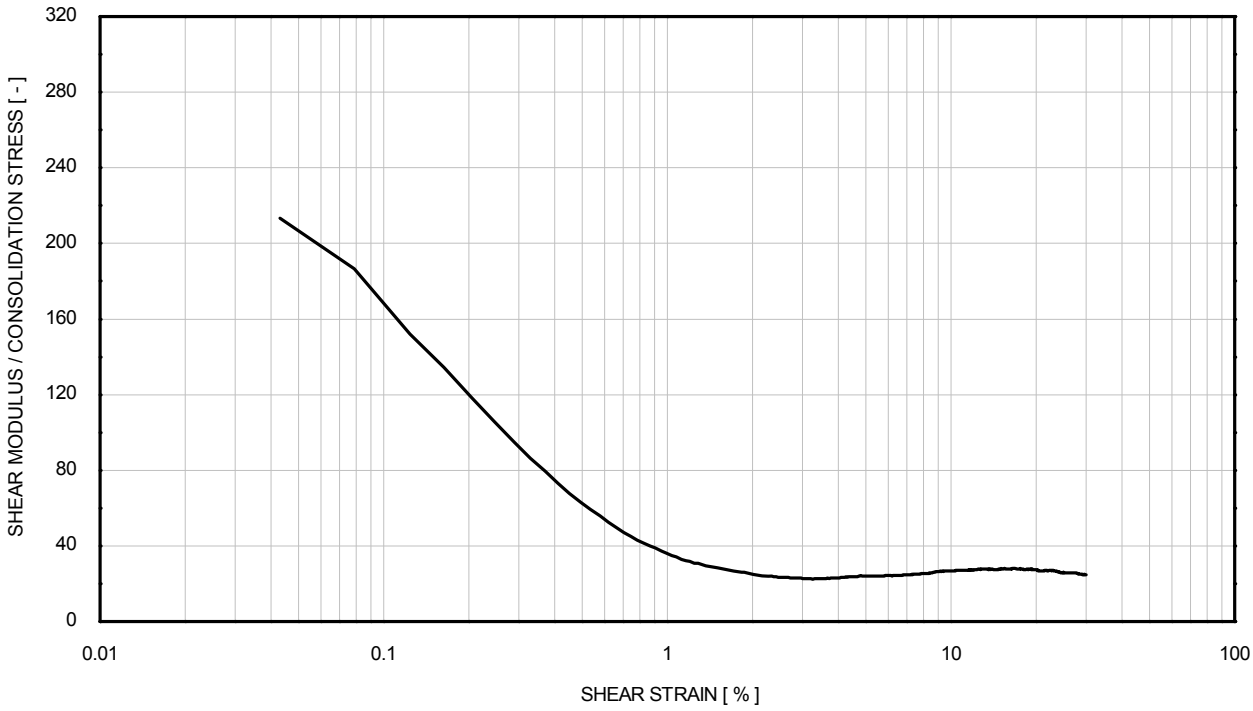


σ_{vc}	:	80 kPa	Batch	:	2
τ_{peak}	:	591 kPa	Sample	:	DSS_2-2
γ at τ_{peak}	:	29.98 %	Unit	:	B (Eem/Kreftenheye)
Rate of strain	:	4.99 %/hour	Test No.	:	DSS08

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	80 kPa	Batch	:	2
τ_{peak}	:	591 kPa	Sample	:	DSS_2-2
γ at τ_{peak}	:	29.98 %	Unit	:	B (Eem/Kreftenheye)
Rate of strain	:	4.99 %/hour	Test No.	:	DSS08

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	20/01/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.2
Length	[mm]	30.0
Moisture content after compaction	[%]	9.6
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.640
Degree of saturation after compaction	[%]	40
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.2
Bulk density at start of test	[Mg/m³]	2.01
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BATCH3_DSS_3_1_DSS09
Template issue	1.3
Processed by	GG
Date	01/02/2016
Checked by	PH
Date	04/02/2016
Approved by	PH
Date	04/02/2016

TEST IDENTIFICATION	
Batch	3
Sample	DSS_3-1
Unit	E3 (Tongeren)
Test number	DSS09

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	300
Vertical strain	[%]	2.28
Bulk density	[Mg/m^3]	2.03
Dry density	[Mg/m^3]	1.65
Void ratio	[-]	0.603
Moisture content	[%]	22.7

SHEARING – CONSTANT VOLUME		
At peak shear stress*		
Shear stress	[kPa]	256
Shear strain	[%]	26.10
Shear induced -$\Delta\sigma_v$	[kPa]	-183
Vertical stress	[kPa]	482
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.10
At 15 % shear strain		
Shear stress	[kPa]	220
Shear induced -$\Delta\sigma_v$	[kPa]	-108
Vertical stress	[kPa]	407
Vertical strain	[%]	0.00

* Please note that specimen failure was observed to occur close to the loading platen interface.

TEST IDENTIFICATION	
Batch	3
Sample	DSS_3-1
Unit	E3 (Tongeren)
Test number	DSS09

SUMMARY OF CONSOLIDATED DSS TEST

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

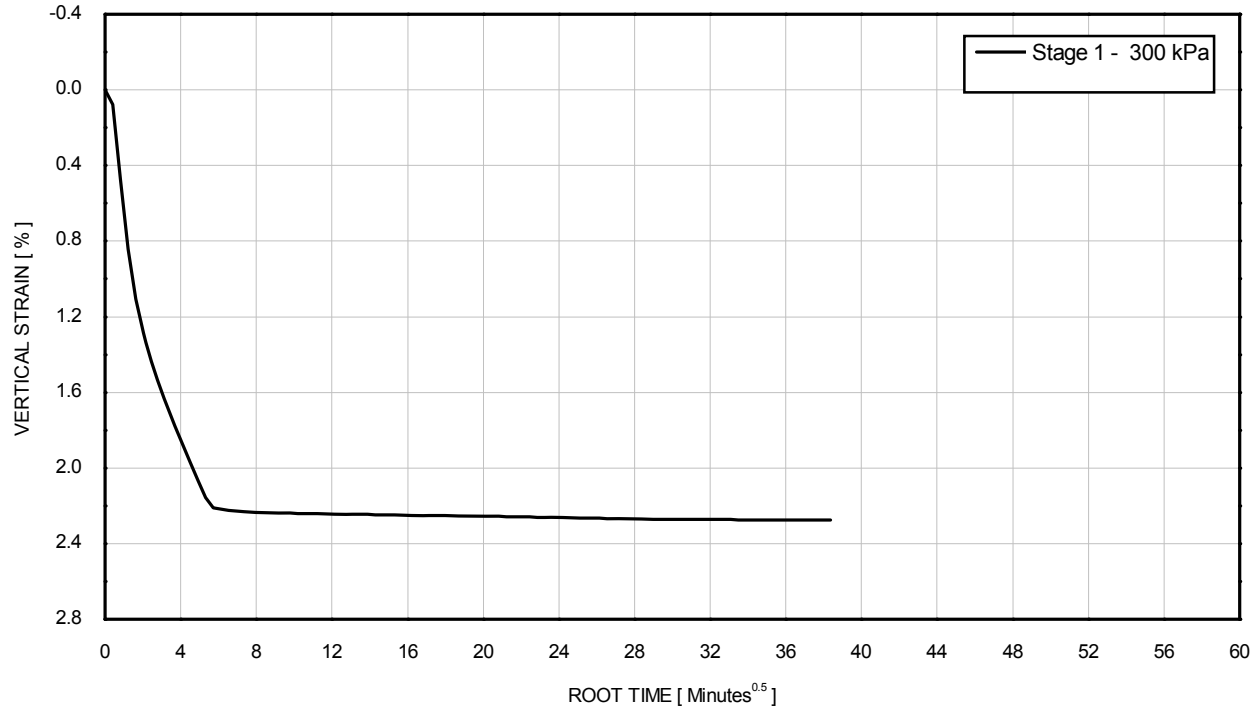
SPECIMEN PHOTOGRAPH

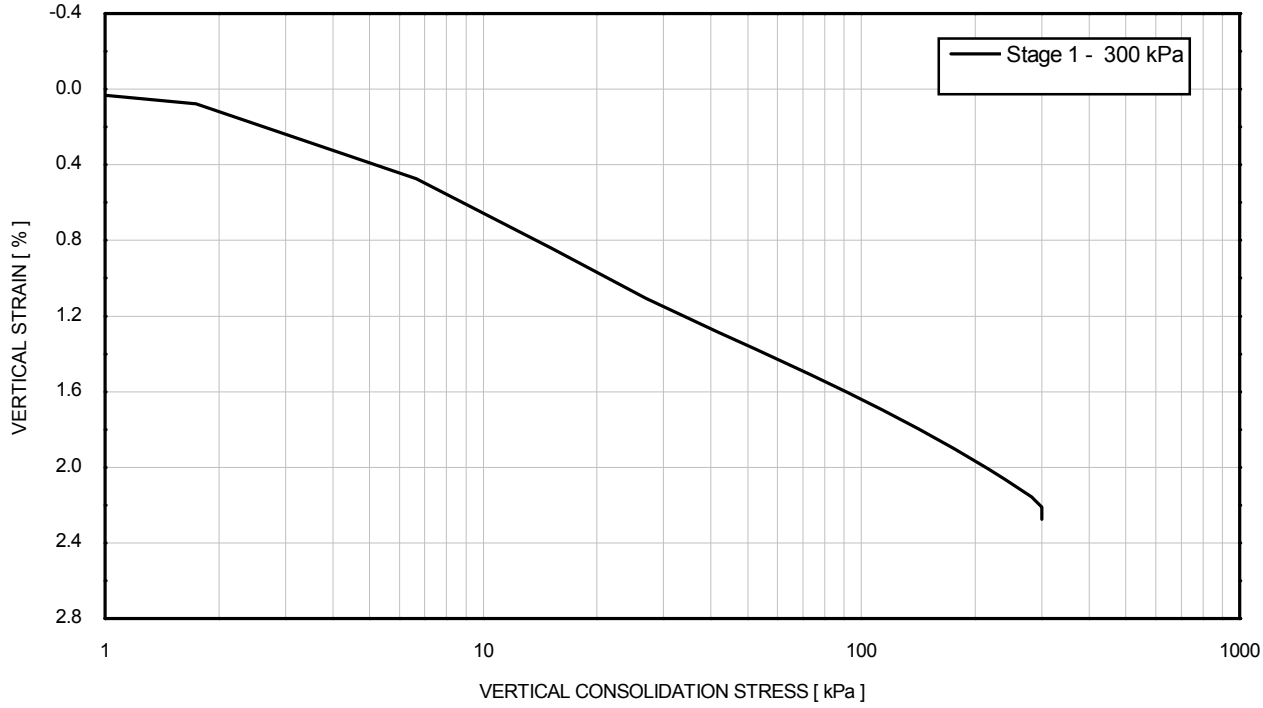


TEST IDENTIFICATION	
Batch	3
Sample	DSS_3-1
Unit	E3 (Tongeren)
Test number	DSS09

SUMMARY OF CONSOLIDATED DSS TEST

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

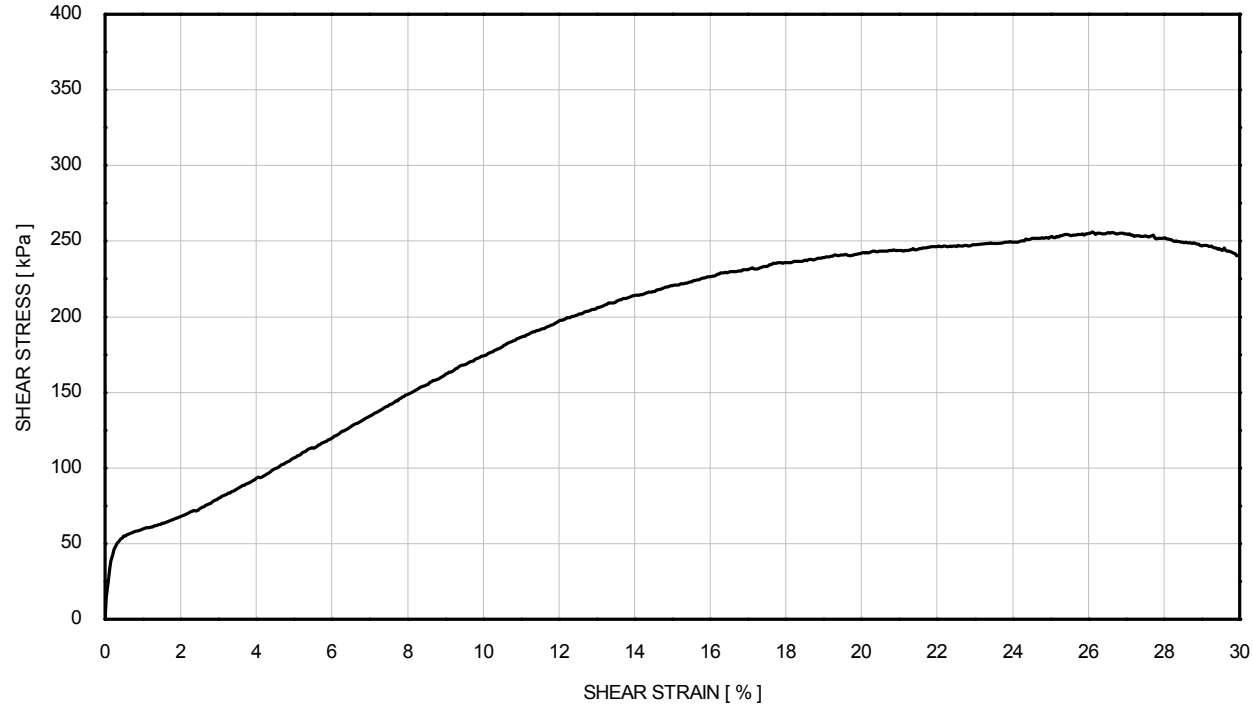


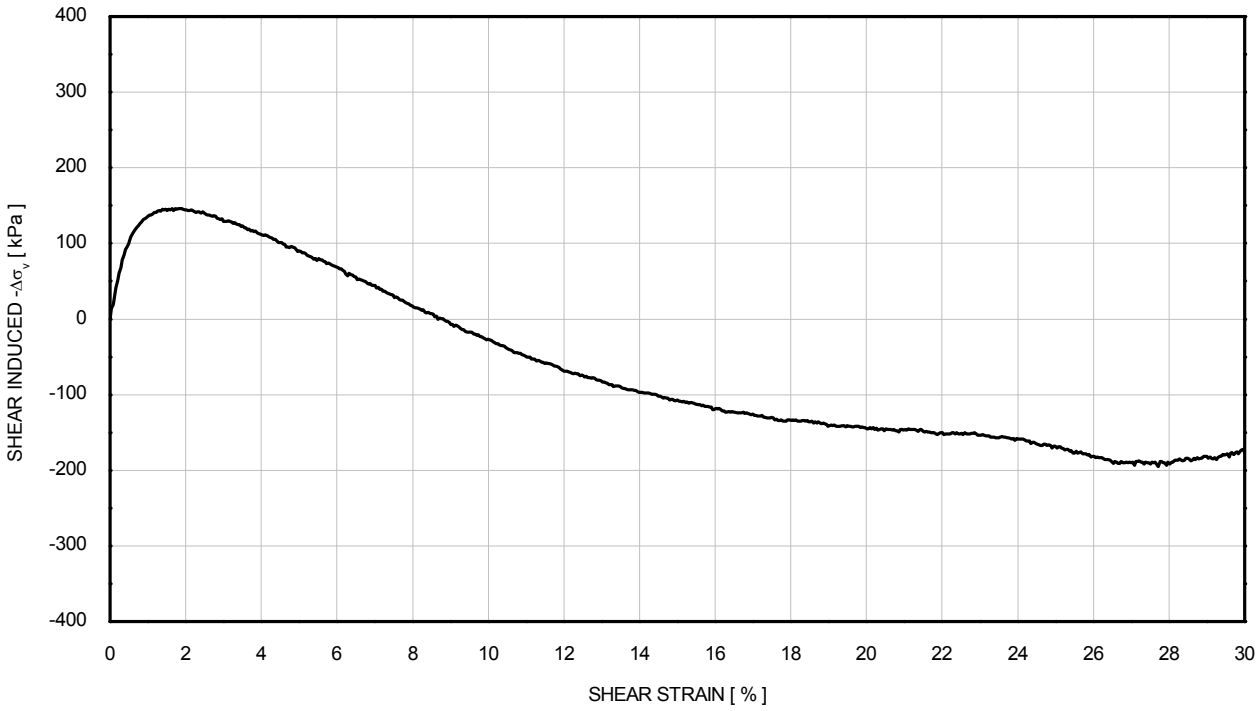


σ_{vc}	: 300 kPa	Batch	: 3
		Sample	: DSS_3-1
		Unit	: E3 (Tongeren)
		Test No.	: DSS09

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

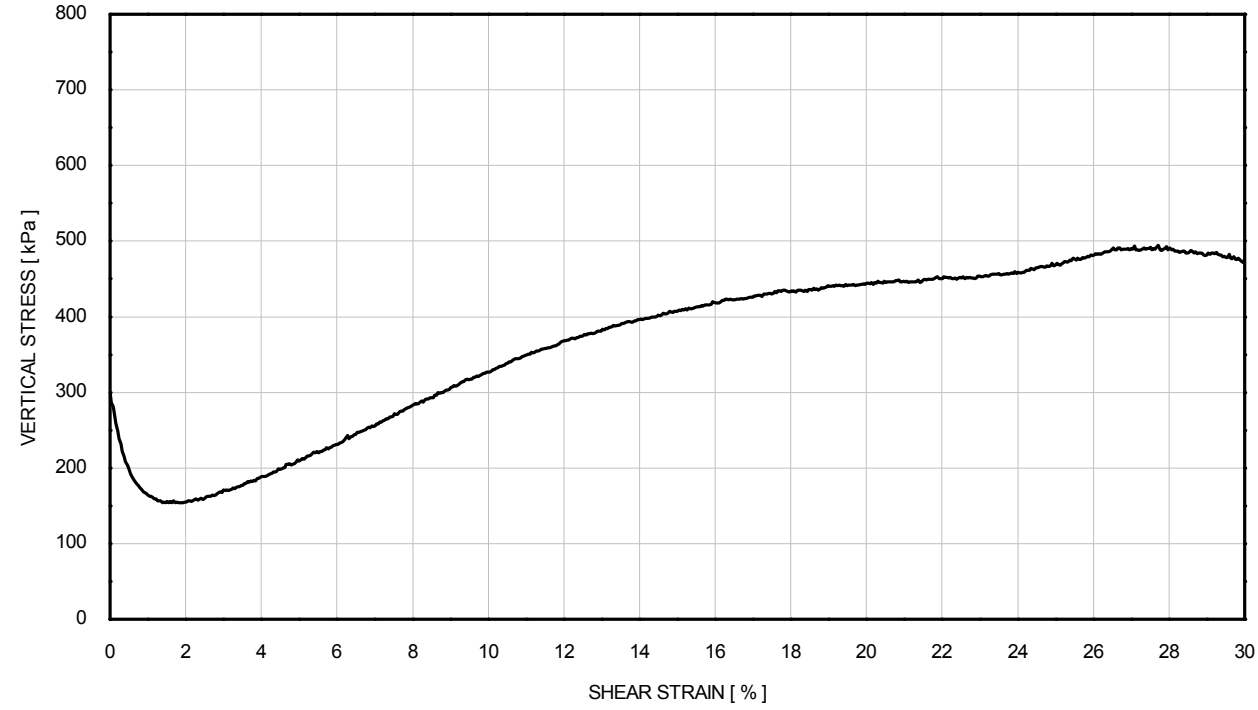


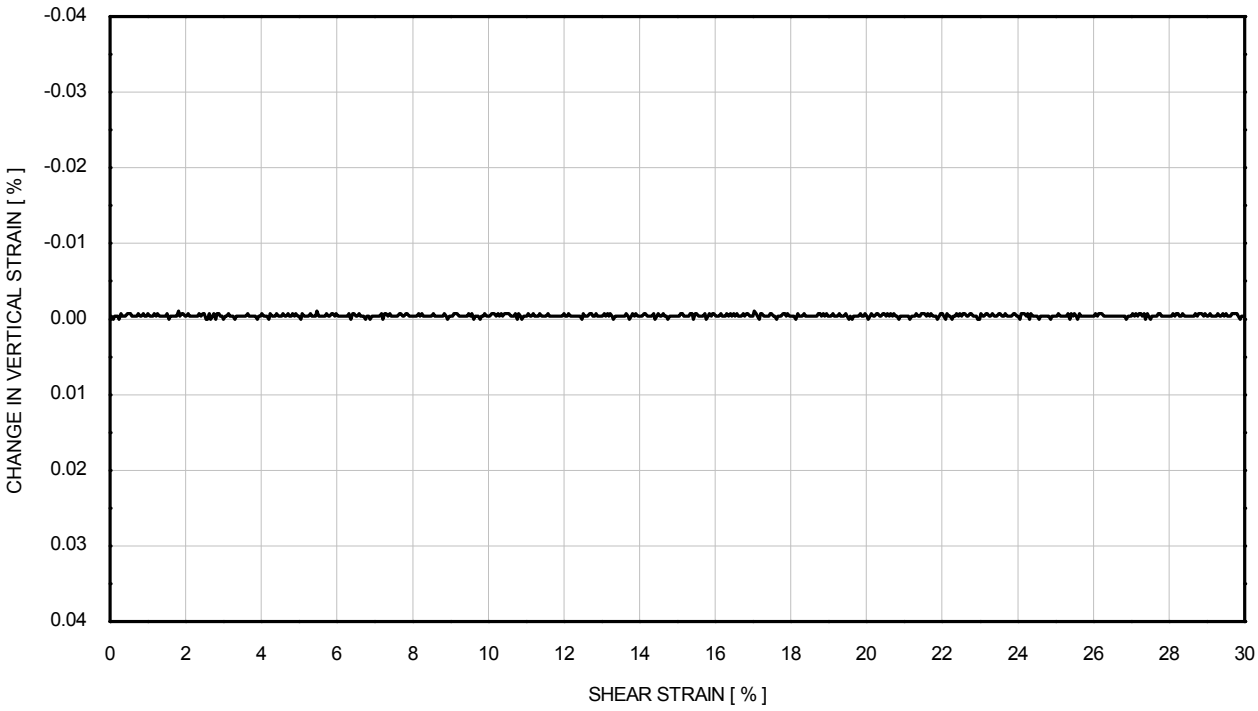


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 256 kPa	Sample	: DSS_3-1
γ at τ_{peak}	: 26.10 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: DSS09

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

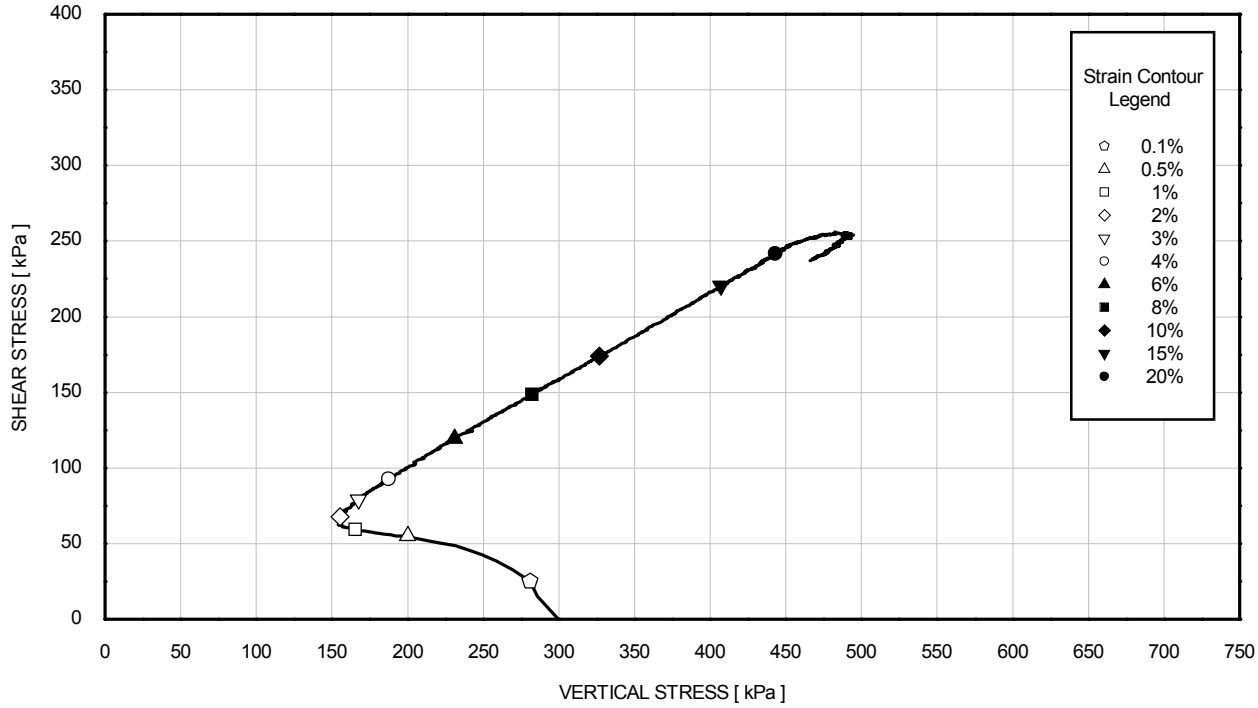


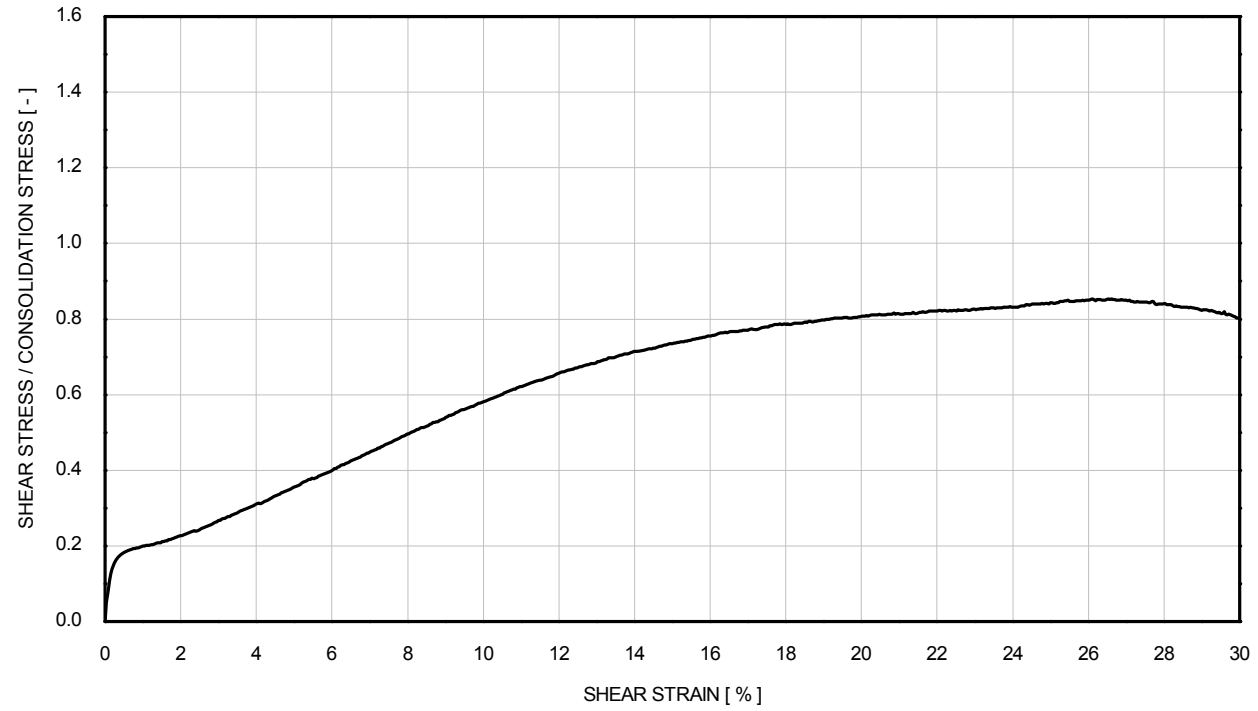


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 256 kPa	Sample	: DSS_3-1
γ at τ_{peak}	: 26.10 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: DSS09

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

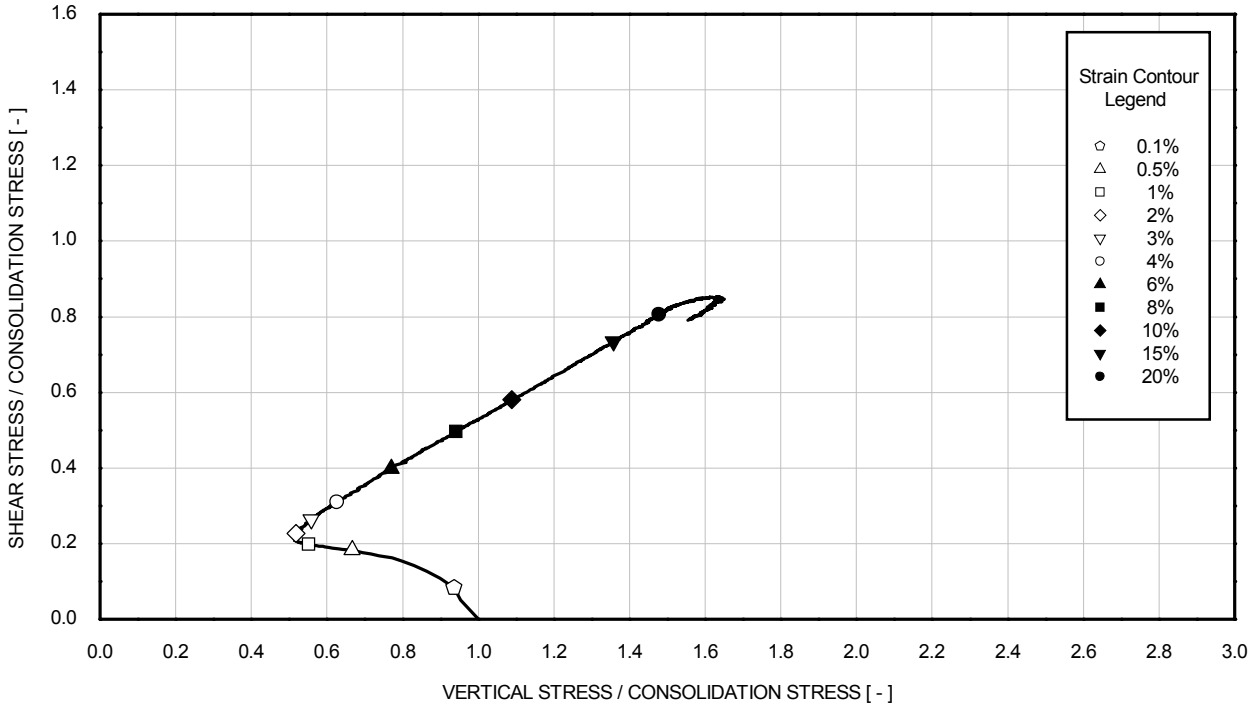


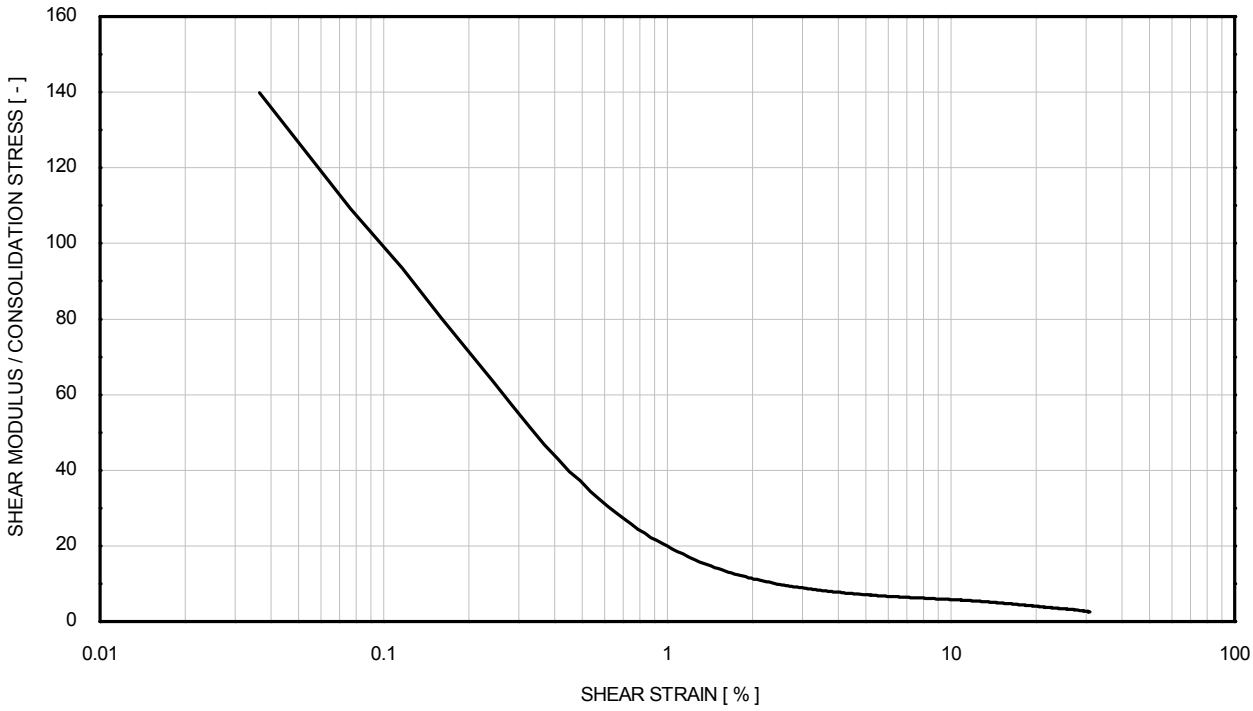


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 256 kPa	Sample	: DSS_3-1
γ at τ_{peak}	: 26.10 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: DSS09

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 256 kPa	Sample	: DSS_3-1
γ at τ_{peak}	: 26.10 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: DSS09

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	26/01/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.4
Length	[mm]	30.0
Moisture content after compaction	[%]	9.7
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.642
Degree of saturation after compaction	[%]	40
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.2
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BATCH3_DSS_3_2_DSS10
Template issue	1.3
Processed by	GG
Date	01/02/2016
Checked by	PH
Date	04/02/2016
Approved by	PH
Date	04/02/2016

TEST IDENTIFICATION	
Batch	3
Sample	DSS_3-2
Unit	E3 (Tongeren)
Test number	DSS10

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	300
Vertical strain	[%]	2.70
Bulk density	[Mg/m^3]	2.03
Dry density	[Mg/m^3]	1.66
Void ratio	[-]	0.598
Moisture content	[%]	22.6

SHEARING – CONSTANT VOLUME		
At peak shear stress*		
Shear stress	[kPa]	226
Shear strain	[%]	18.49
Shear induced -$\Delta\sigma_v$	[kPa]	-129
Vertical stress	[kPa]	429
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.15
At 15 % shear strain		
Shear stress	[kPa]	214
Shear induced -$\Delta\sigma_v$	[kPa]	-103
Vertical stress	[kPa]	403
Vertical strain	[%]	0.00

* Please note that specimen failure was observed to occur close to the loading platen interface.

TEST IDENTIFICATION	
Borehole	3
Sample	DSS_3-2
Unit	E3 (Tongeren)
Test number	DSS10

SUMMARY OF CONSOLIDATED DSS TEST

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

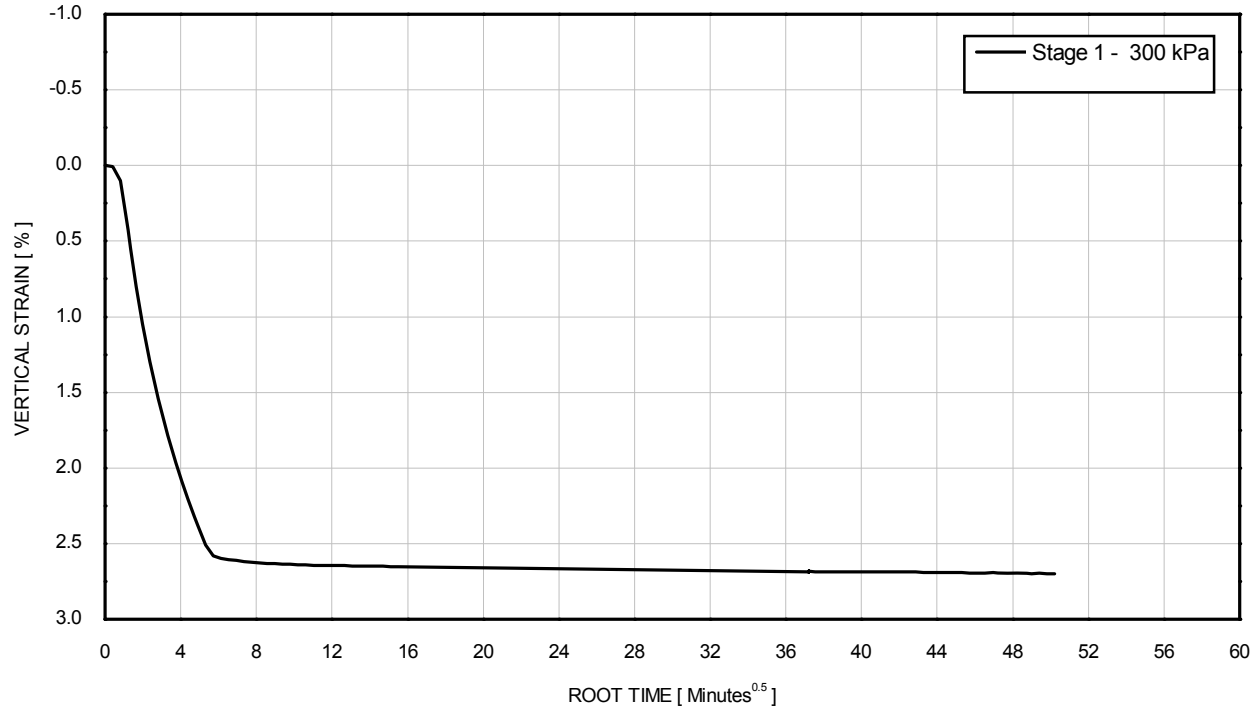
SPECIMEN PHOTOGRAPH

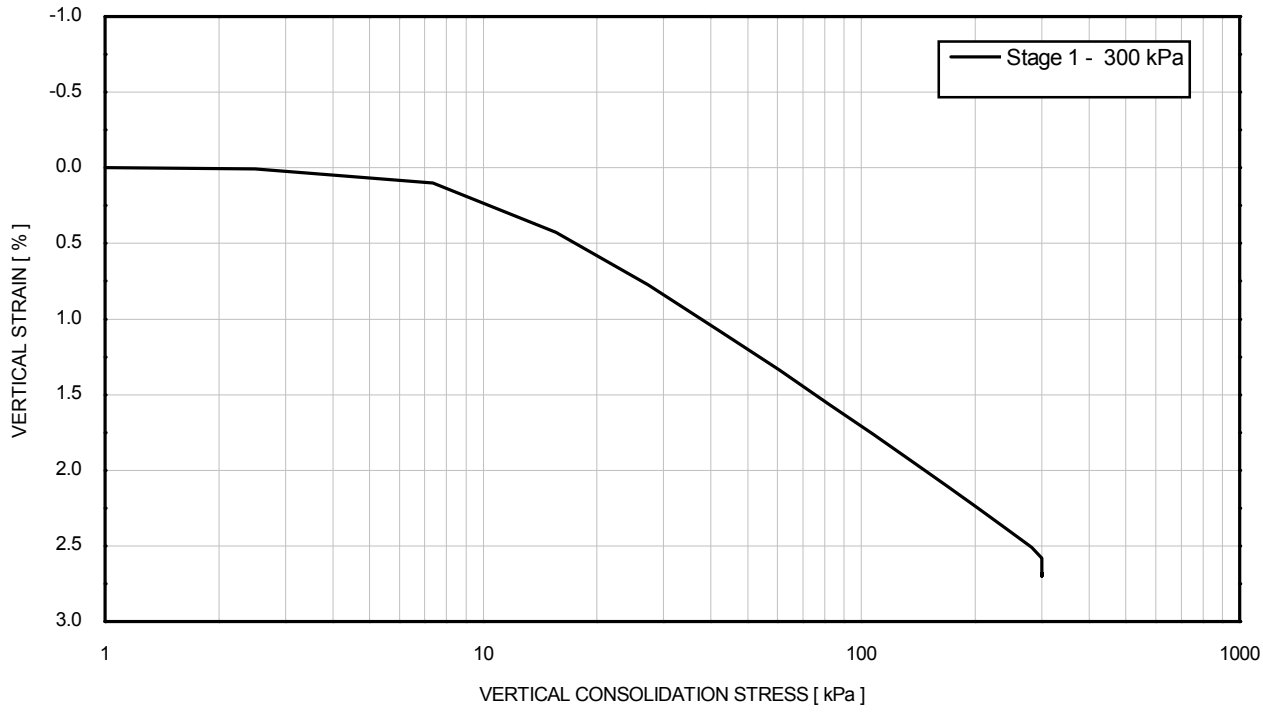


TEST IDENTIFICATION	
Borehole	3
Sample	DSS_3-2
Unit	E3 (Tongeren)
Test number	DSS10

SUMMARY OF CONSOLIDATED DSS TEST

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

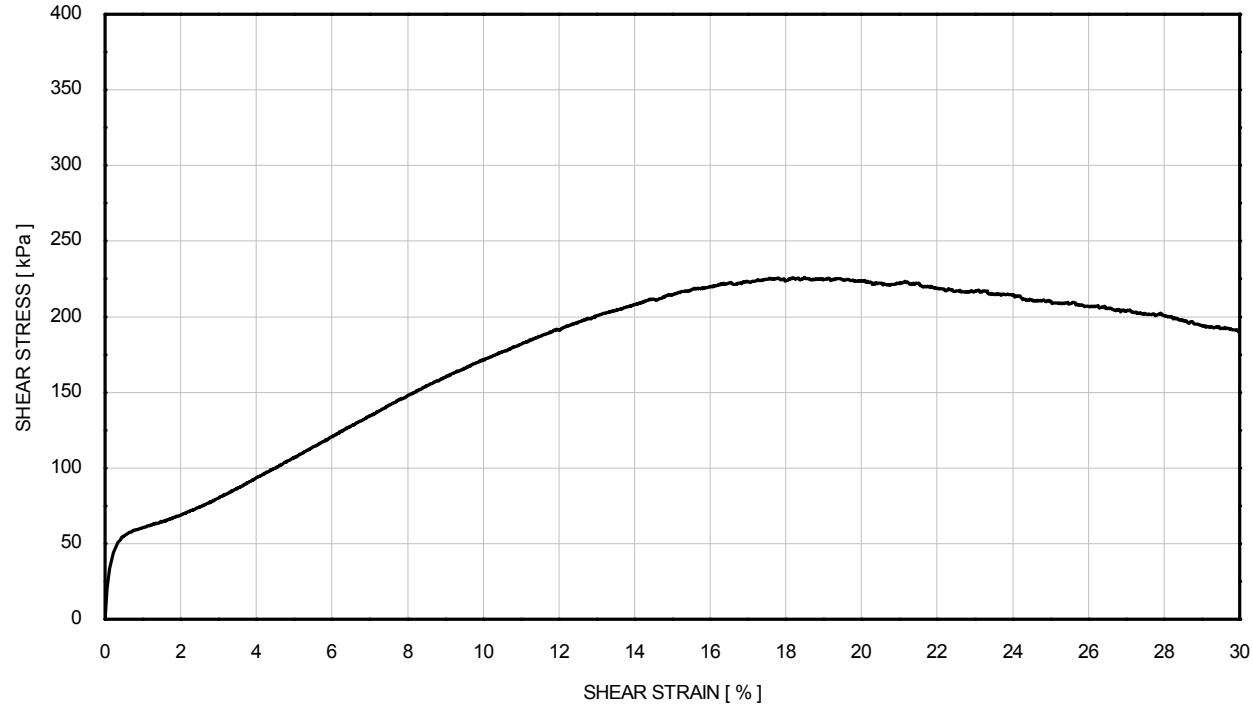


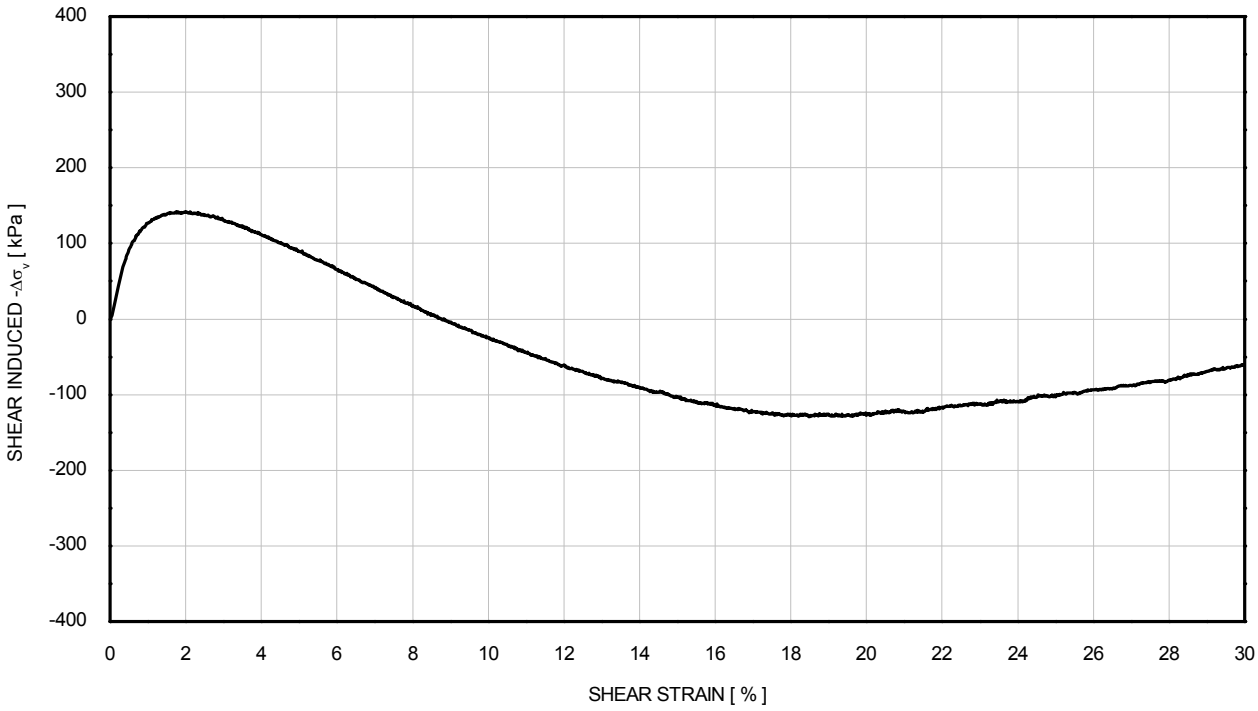


σ_{vc}	: 300 kPa	Batch	: 3
		Sample	: DSS_3-2
		Unit	: E3 (Tongeren)
		Test No.	: DSS10

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

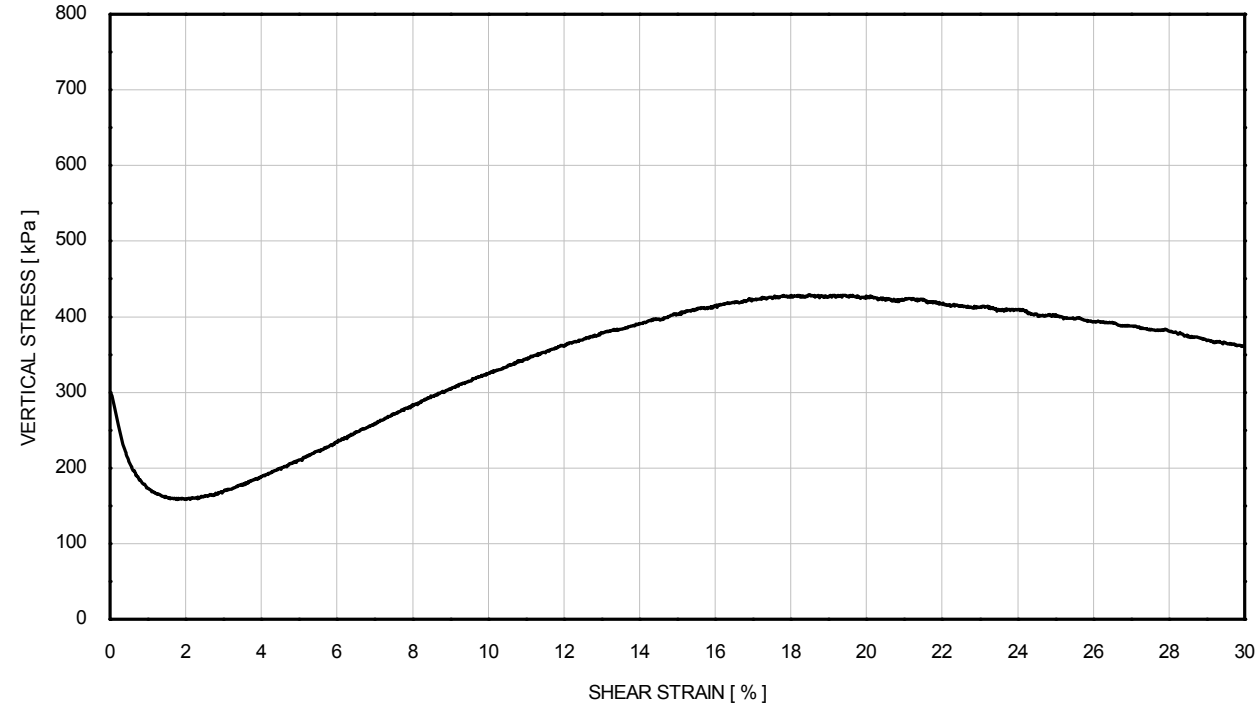


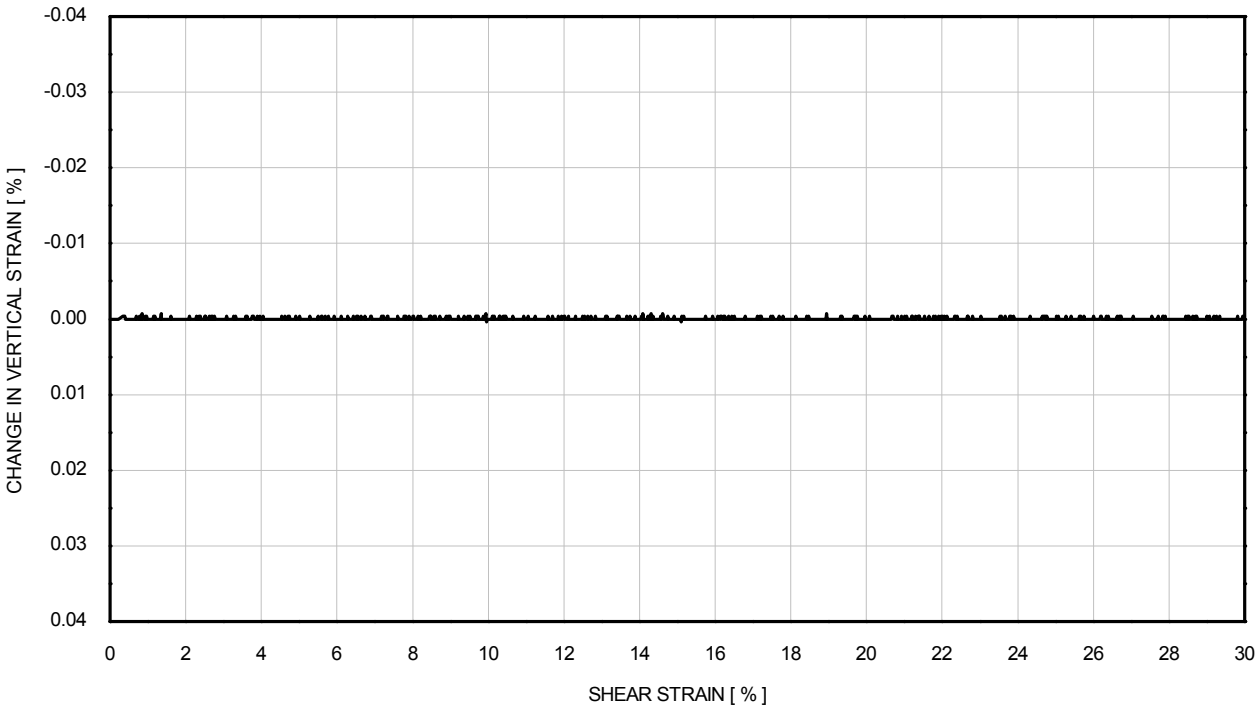


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 226 kPa	Sample	: DSS_3-2
γ at τ_{peak}	: 18.49 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.15 %/hour	Test No.	: DSS10

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

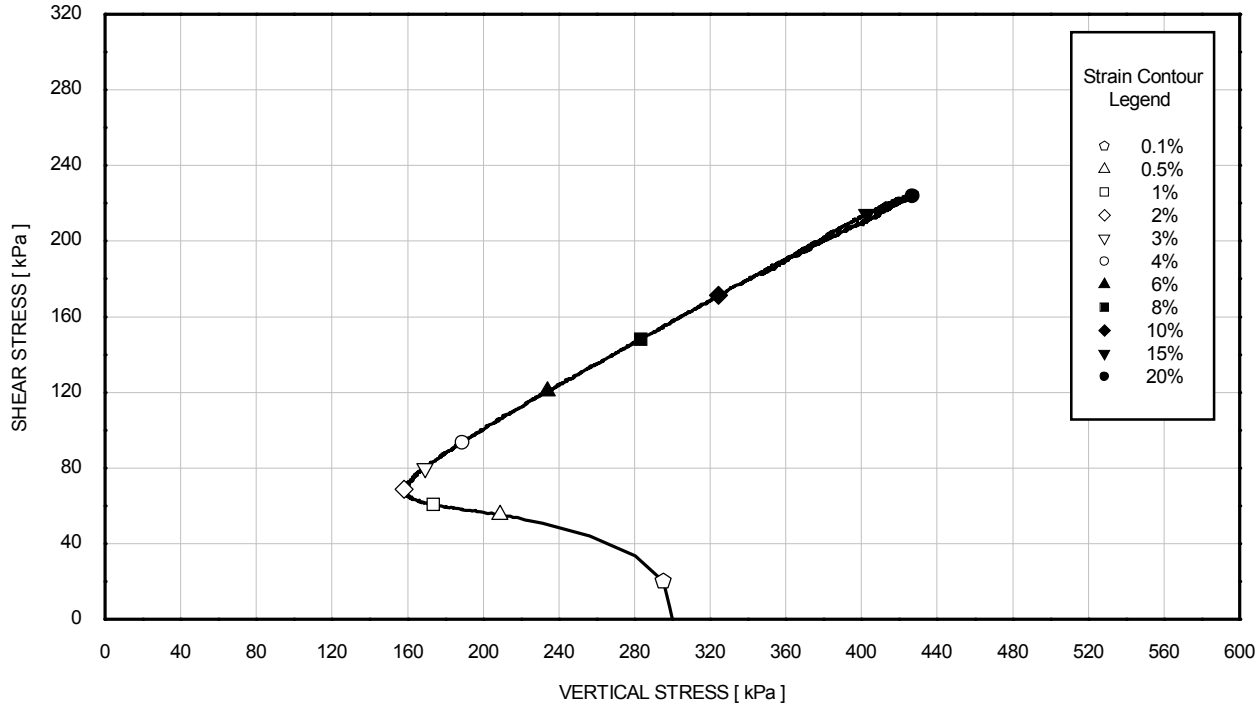


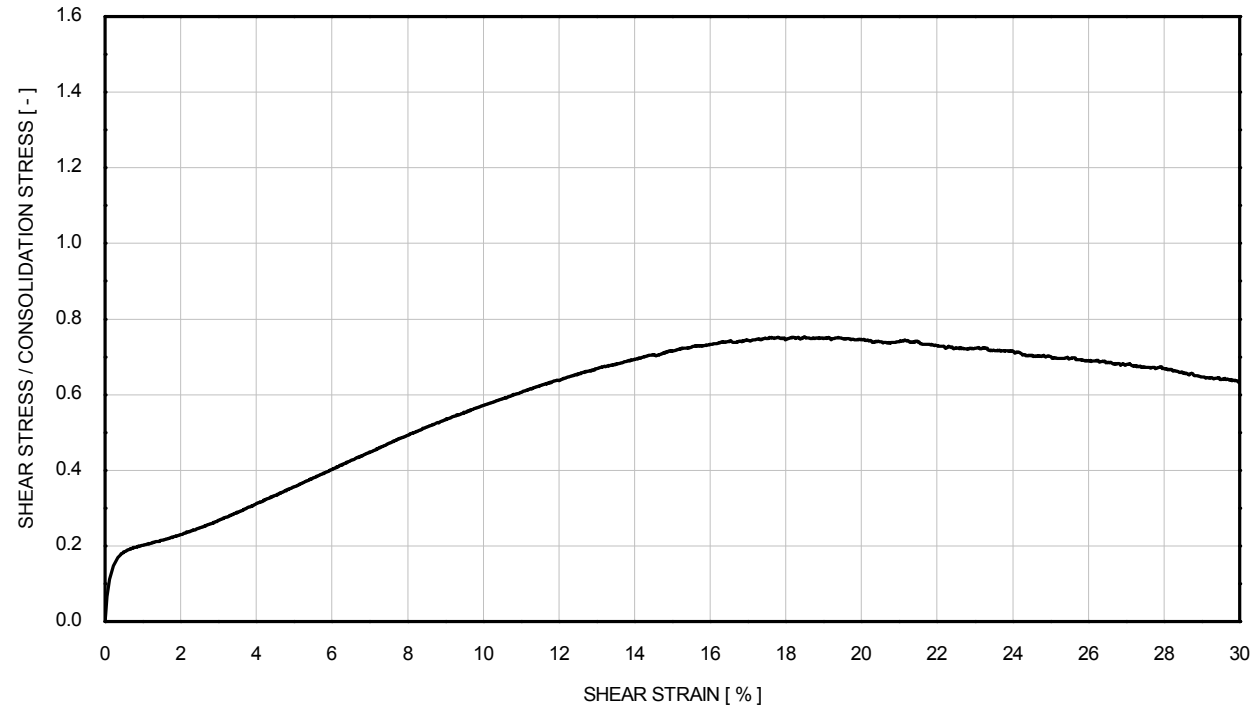


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 226 kPa	Sample	: DSS_3-2
γ at τ_{peak}	: 18.49 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.15 %/hour	Test No.	: DSS10

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

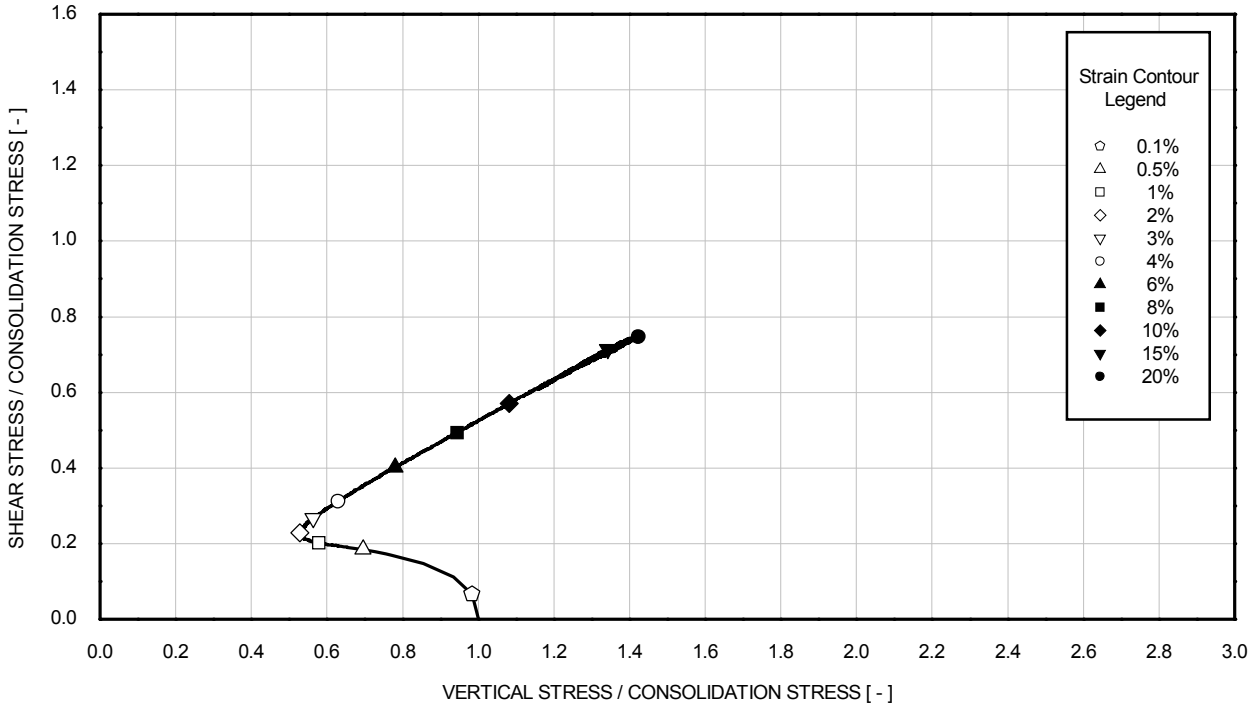


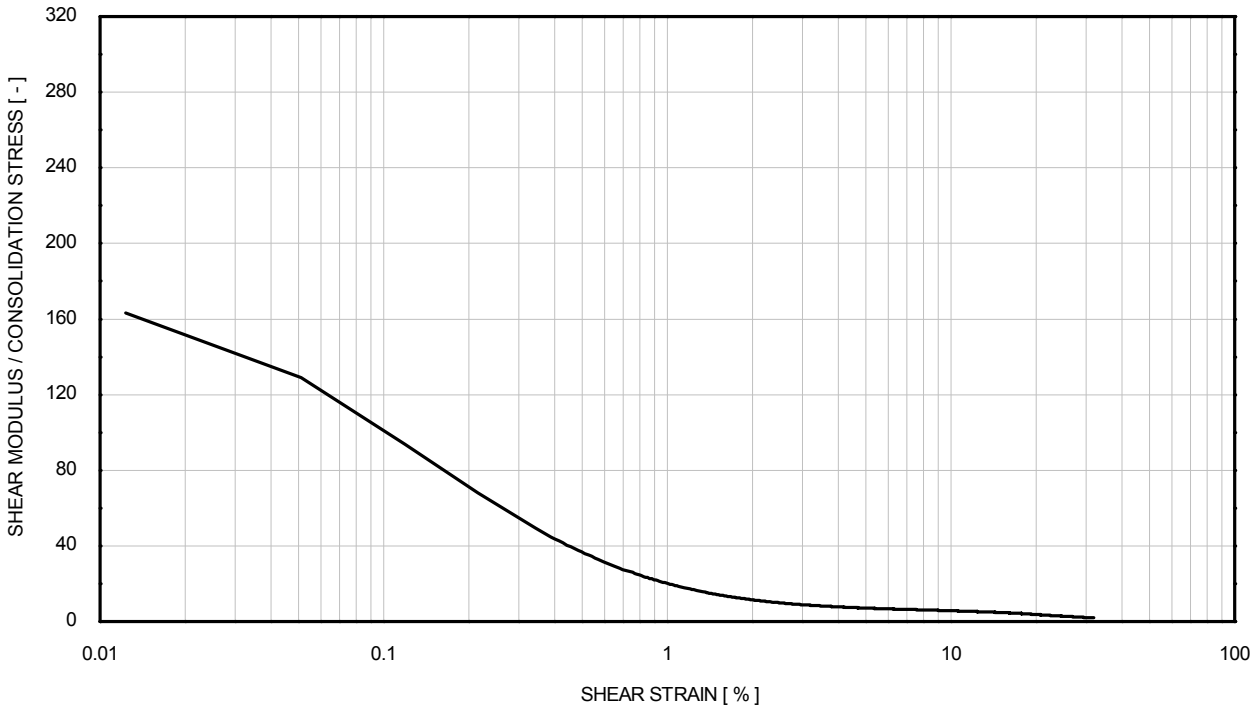


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 226 kPa	Sample	: DSS_3-2
γ at τ_{peak}	: 18.49 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.15 %/hour	Test No.	: DSS10

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 226 kPa	Sample	: DSS_3-2
γ at τ_{peak}	: 18.49 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.15 %/hour	Test No.	: DSS10

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	15/01/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.0
Length	[mm]	30.0
Moisture content after compaction	[%]	10.2
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.649
Degree of saturation after compaction	[%]	42
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.5
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BATCH4_DSS_4_1_DSS11
Template issue	1.3
Processed by	GG
Date	01/02/2016
Checked by	PH
Date	04/02/2016
Approved by	PH
Date	04/02/2016

TEST IDENTIFICATION	
Batch	4
Sample	DSS_4-1
Unit	E5b (Tongeren)
Test number	DSS11

SUMMARY OF CONSOLIDATED DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	400
Vertical strain	[%]	2.34
Bulk density	[Mg/m^3]	2.02
Dry density	[Mg/m^3]	1.65
Void ratio	[-]	0.610
Moisture content	[%]	23.0

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	123
Shear strain	[%]	23.12
Shear induced -$\Delta\sigma_v$	[kPa]	185
Vertical stress	[kPa]	216
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.12
At 15 % shear strain		
Shear stress	[kPa]	115
Shear induced -$\Delta\sigma_v$	[kPa]	193
Vertical stress	[kPa]	207
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	4
Sample	DSS_4-1
Unit	E5b (Tongeren)
Test number	DSS11

SUMMARY OF CONSOLIDATED DSS TEST

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

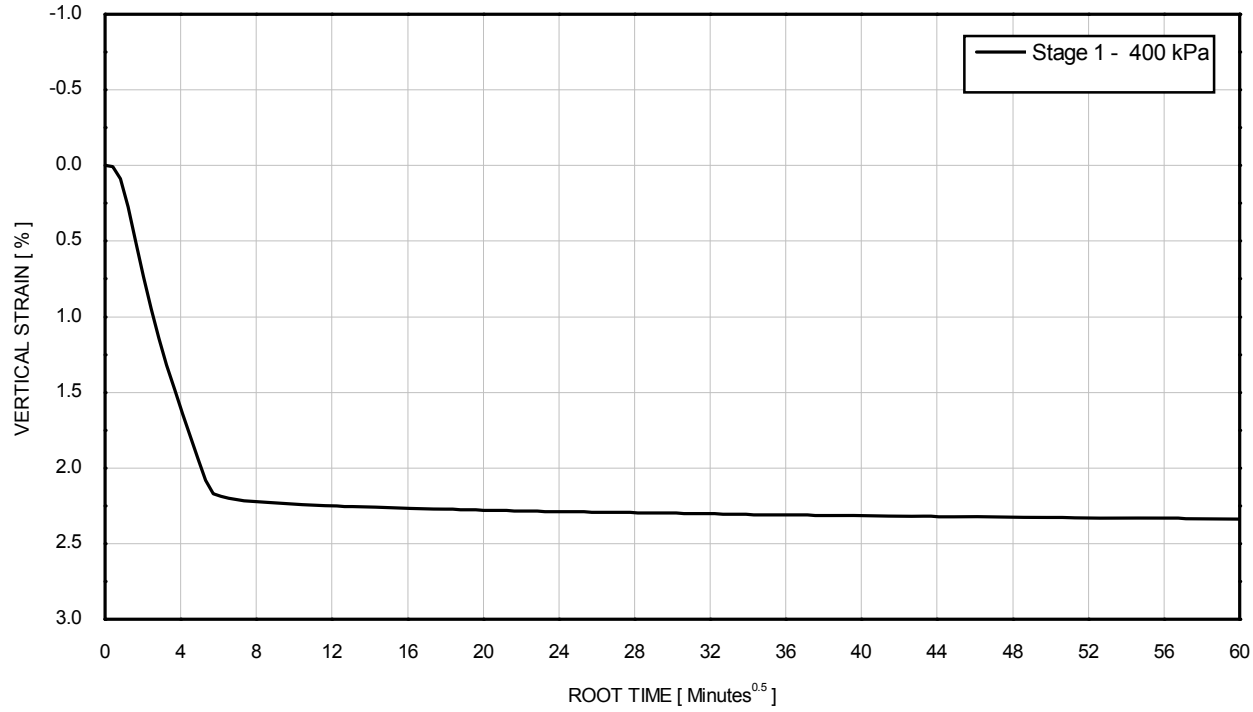
SPECIMEN PHOTOGRAPH

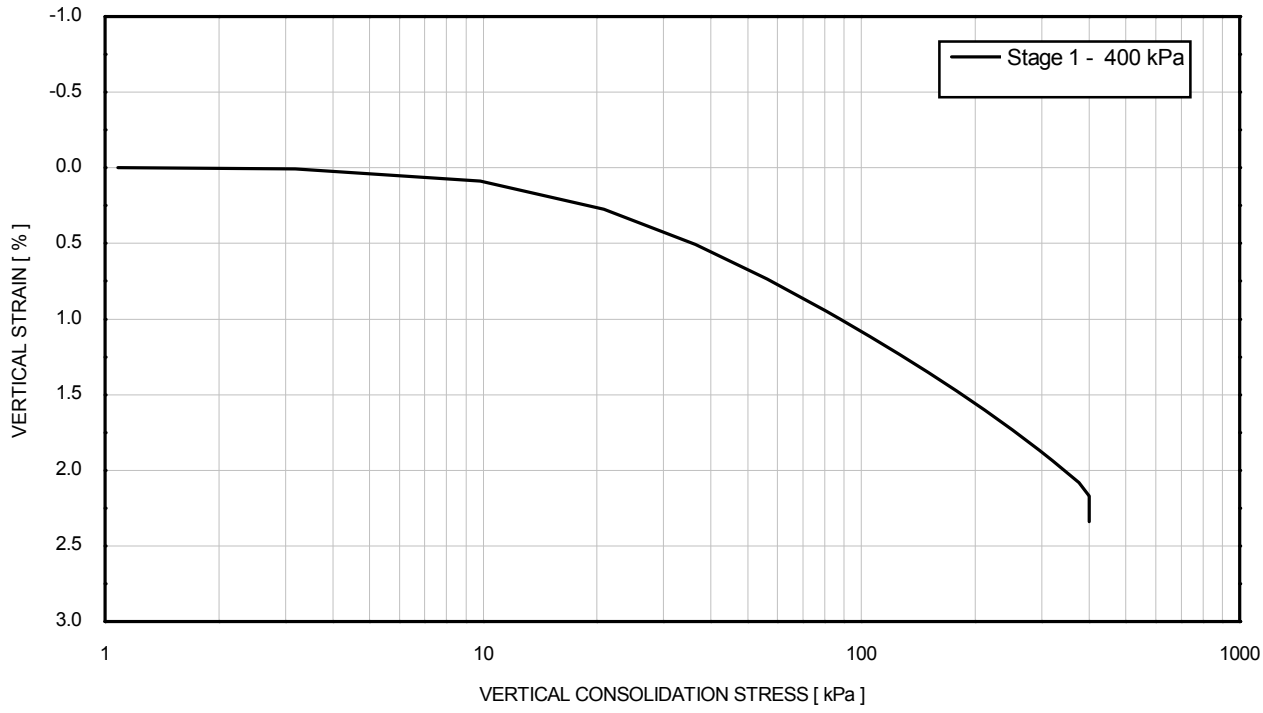


TEST IDENTIFICATION	
Batch	4
Sample	DSS_4-1
Unit	E5b (Tongeren)
Test number	DSS11

SUMMARY OF CONSOLIDATED DSS TEST

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

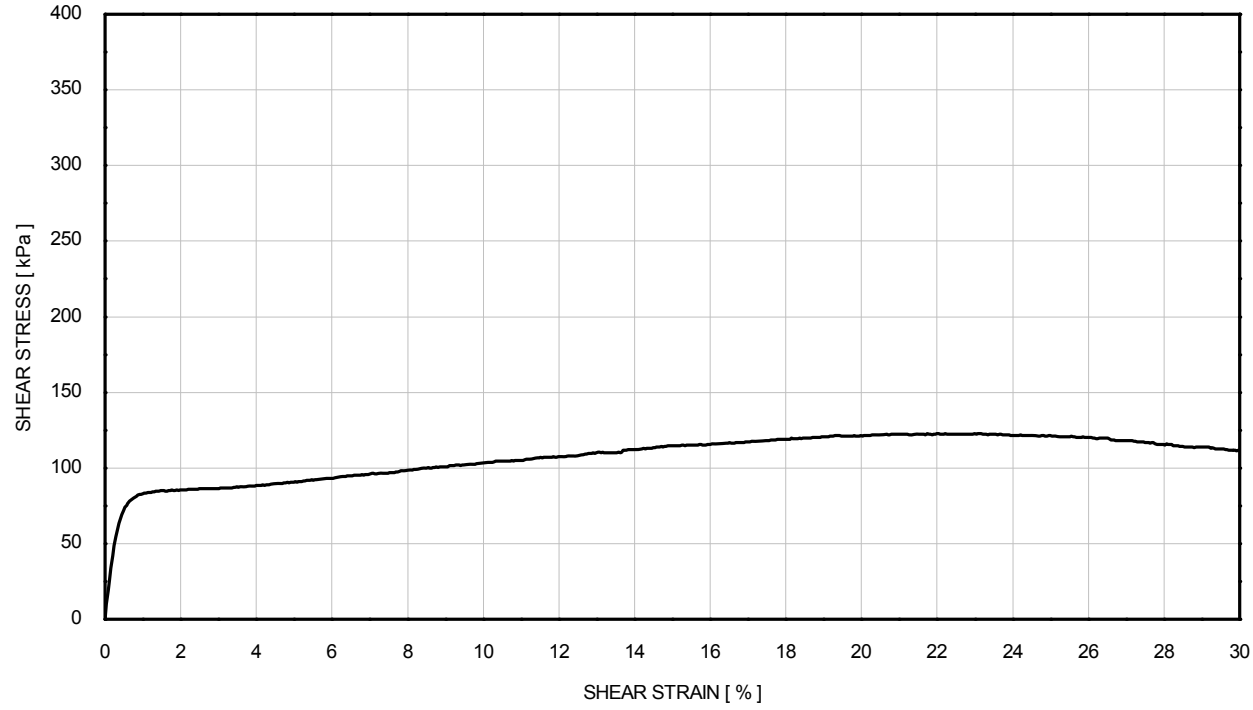


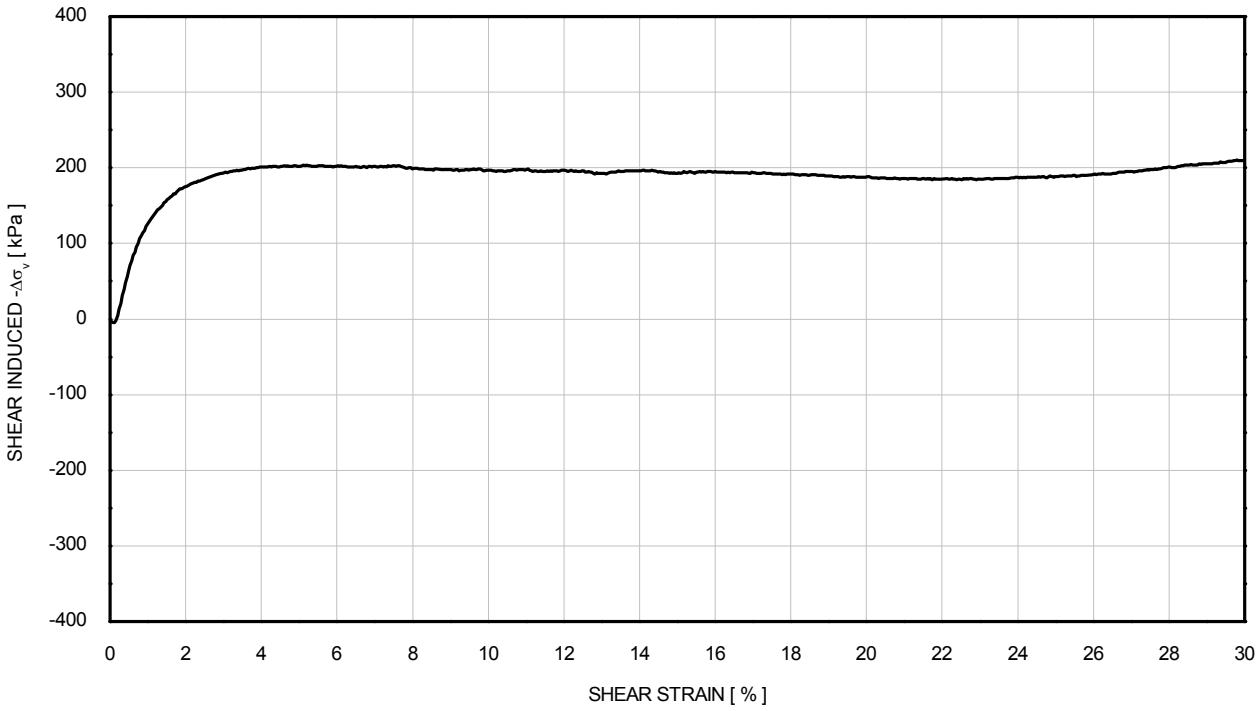


σ_{vc}	: 400 kPa	Batch	: 4
		Sample	: DSS_4-1
		Unit	: E5b (Tongeren)
		Test No.	: DSS11

CONSOLIDATED DSS TEST
CONSOLIDATION STAGE

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

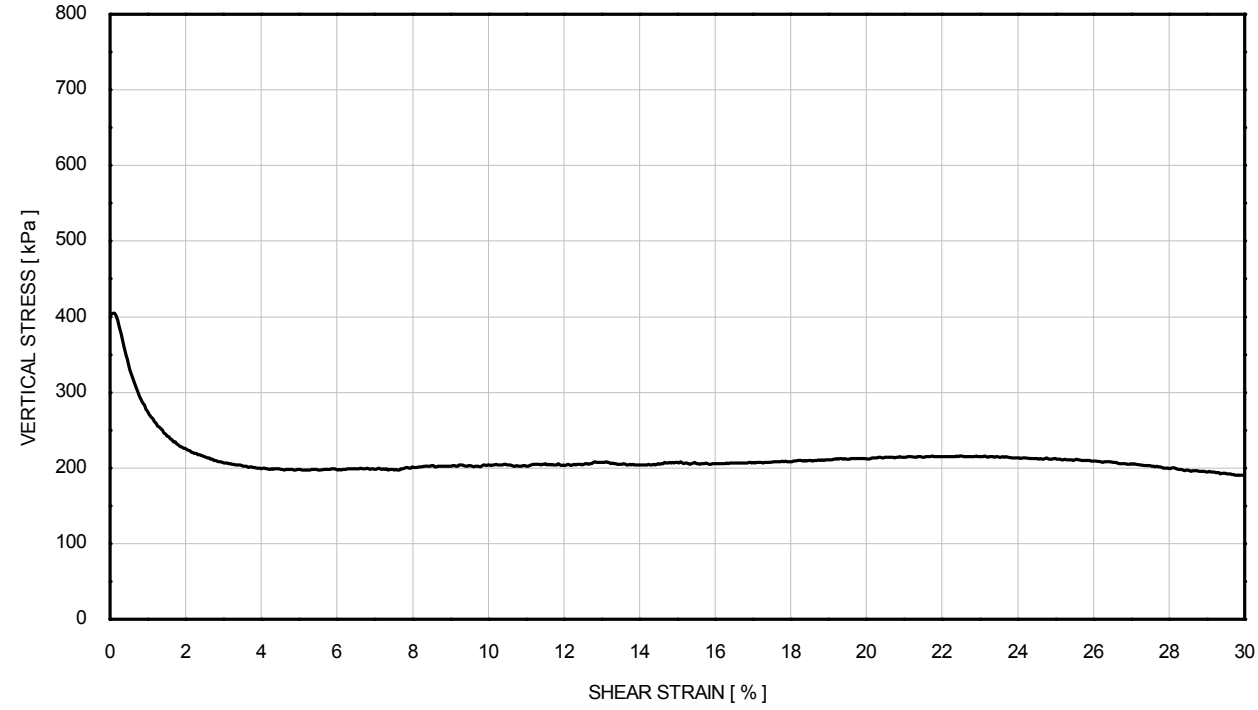


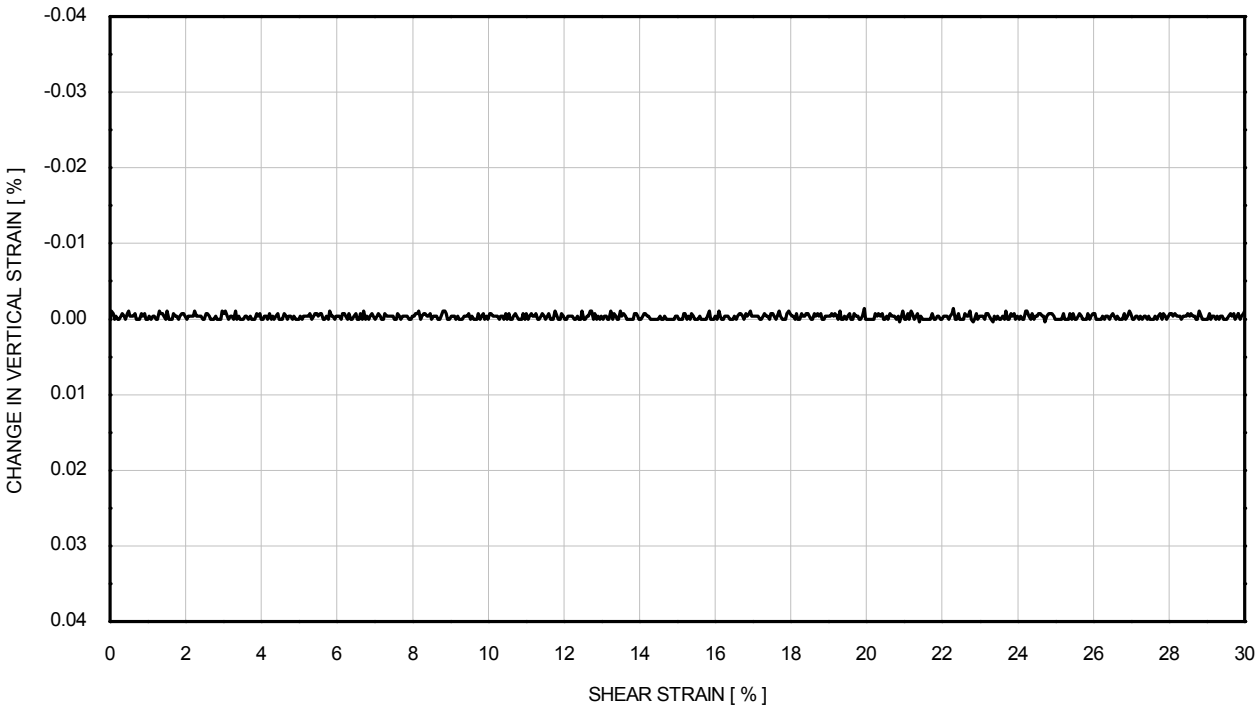


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 123 kPa	Sample	: DSS_4-1
γ at τ_{peak}	: 23.12 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.12 %/hour	Test No.	: DSS11

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

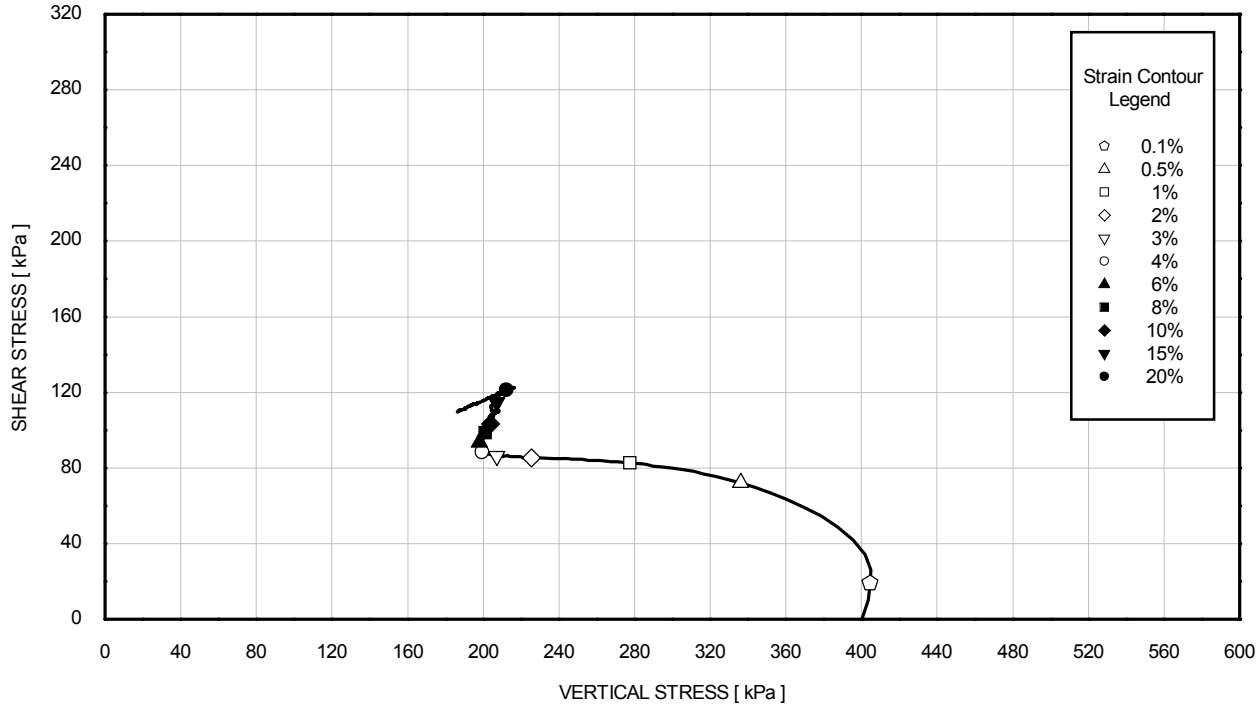


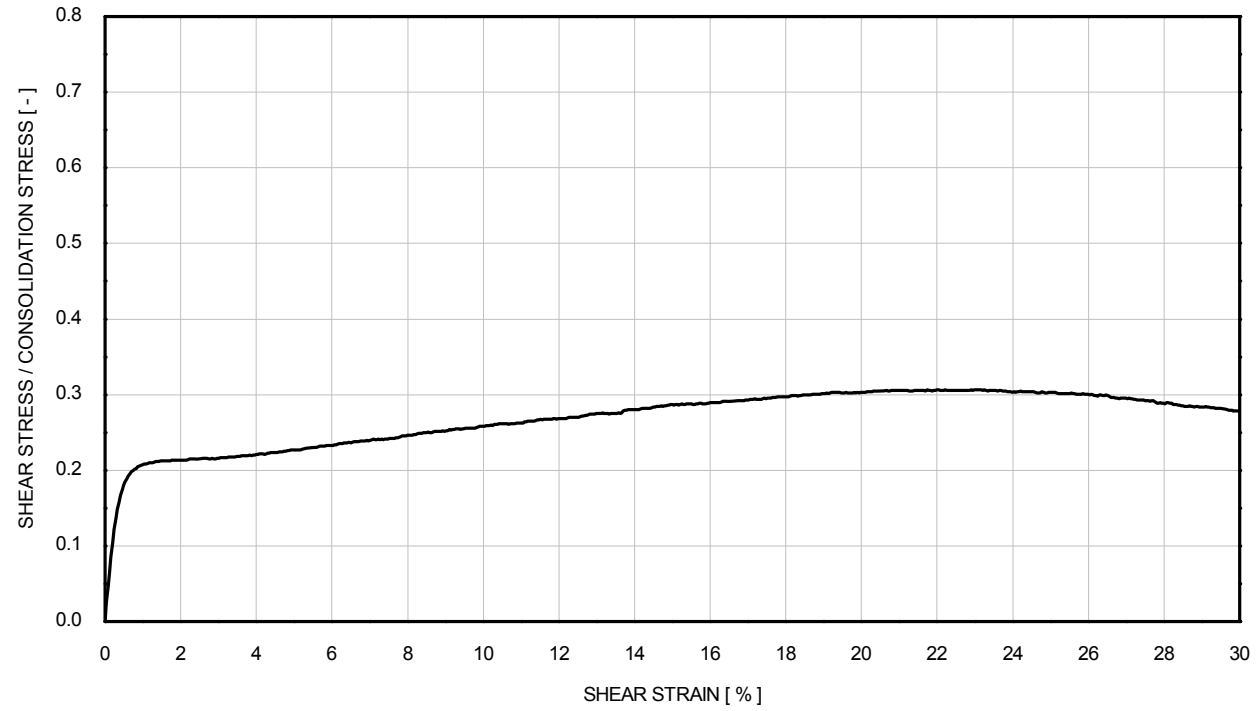


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 123 kPa	Sample	: DSS_4-1
γ at τ_{peak}	: 23.12 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.12 %/hour	Test No.	: DSS11

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

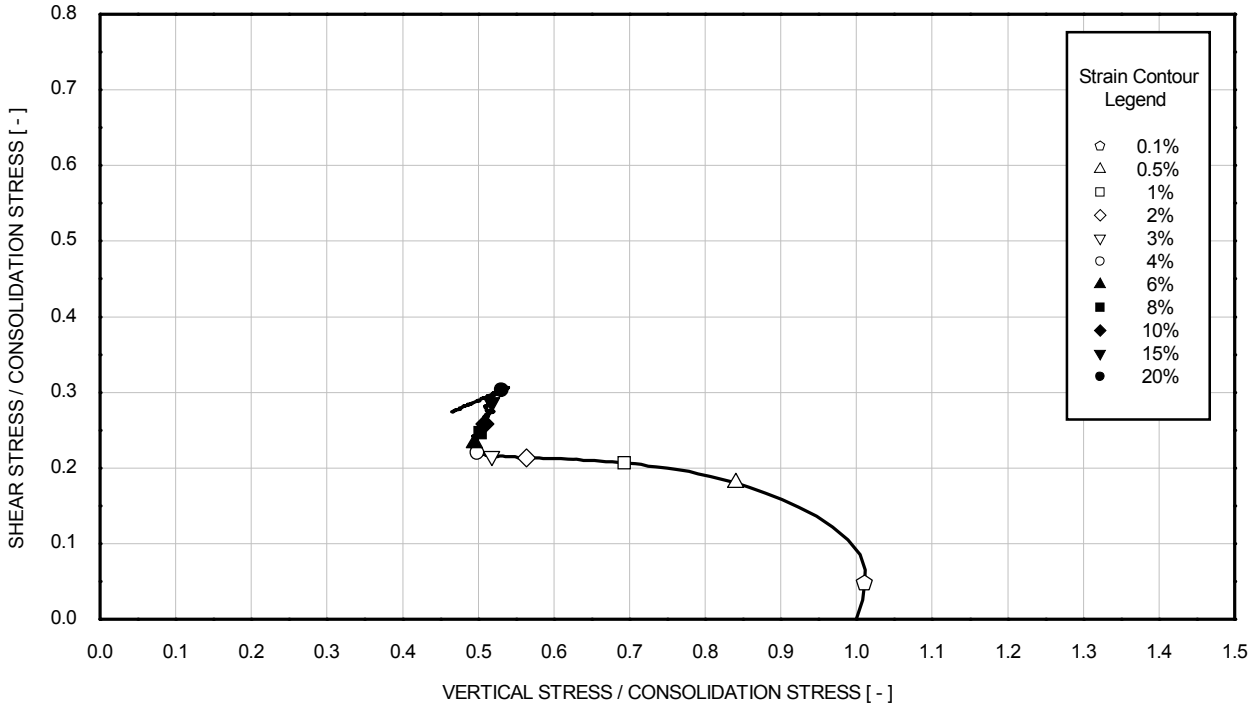


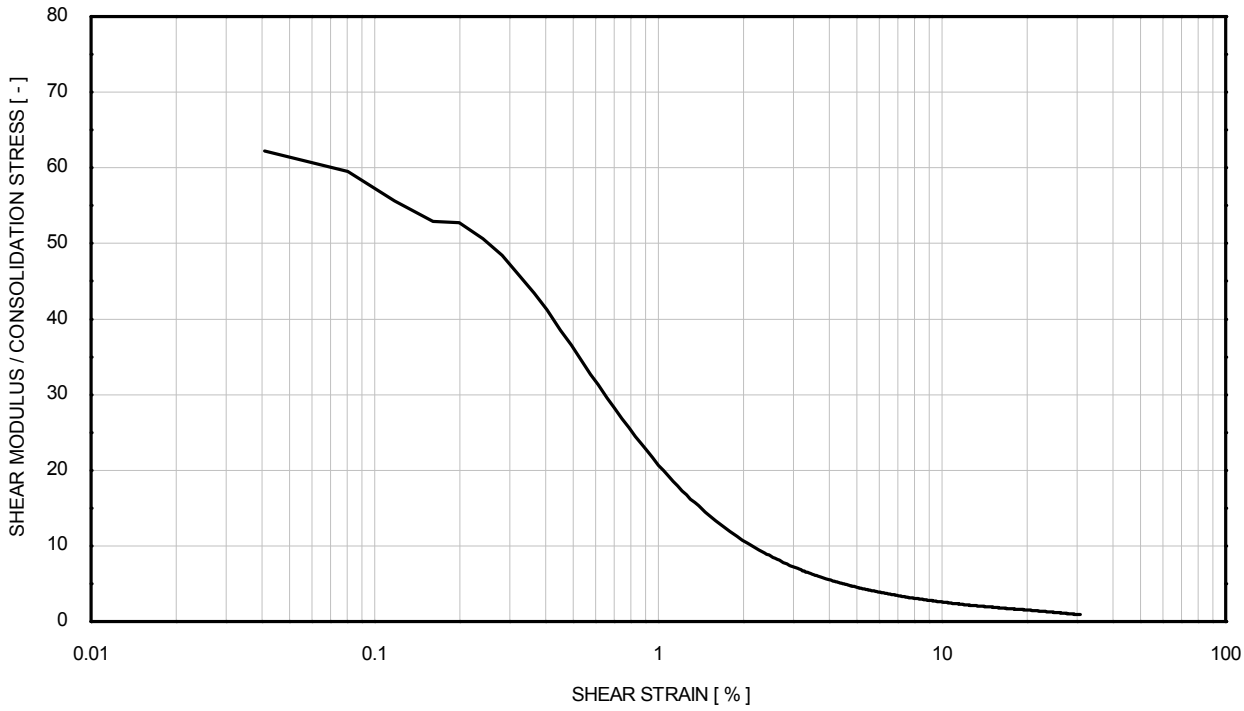


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 123 kPa	Sample	: DSS_4-1
γ at τ_{peak}	: 23.12 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.12 %/hour	Test No.	: DSS11

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 123 kPa	Sample	: DSS_4-1
γ at τ_{peak}	: 23.12 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.12 %/hour	Test No.	: DSS11

CONSOLIDATED DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

SECTION A6: CYCLIC TRIAXIAL TESTS

LIST OF PLATES IN SECTION A6: Plate

Cyclic Triaxial Test - Cohesive Specimens	A6.1-1 to A6.1-68
Cyclic Triaxial Test - Cohesionless Specimens	A6.2-1 to A6.2-311

VISUAL DESCRIPTION
Olive grey CLAY

GENERAL	
Date test started	30/11/2015
Type of sample	Undisturbed
Type of drains fitted	Radial (spiral) & one end only

INITIAL		
Diameter	[mm]	69.4
Length	[mm]	144.9
Moisture content	[%]	42.6
Bulk density	[Mg/m³]	1.80
Dry density	[Mg/m³]	1.26
Void ratio	[-]	1.141
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	290

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic	BS1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ BH-WFS3-4A_08C_CTX01
Processed by	PR
Date	04/12/2015
Checked by	LJ
Date	15/12/2015
Approved by	PH
Date	15/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	8WaxC
Unit	F3 (Dongen)
Depth [m]	38.48
Test number	CTX01

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Undrained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	N/A
Cell pressure	[kPa]	1355
Base PWP	[kPa]	933
Mid height PWP	[kPa]	-
B value achieved	[-]	0.97

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1355
Back pressure	[kPa]	1000
Base PWP	[kPa]	1000
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	355
Effective axial pressure	[kPa]	355
Deviator stress	[kPa]	0
Volumetric strain	[%]	-0.26
External axial strain	[%]	-0.13
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	42.8
Bulk density	[Mg/m³]	1.80
Dry density	[Mg/m³]	1.26
Void ratio	[-]	1.147
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	8WaxC
Unit	F3 (Dongen)
Depth [m]	38.48
Test number	CTX01

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	600
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	191
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1500
External ε_{av} at N_f	[%]	-0.04
External ε_{cy} at N_f	[%]	0.25
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	-7.1
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	42.8
Bulk density	[Mg/m³]	1.80
Dry density	[Mg/m³]	1.26
Void ratio	[-]	1.147
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-0.02	0.18	107.33	-	6.38	-
2	-0.02	0.18	103.78	-	6.33	-
5	-0.02	0.19	100.10	-	6.47	-
10	-0.02	0.20	96.71	-	6.69	-
20	-0.02	0.20	94.38	-	6.68	-
30	-0.02	0.21	92.75	-	6.68	-
40	-0.02	0.21	91.61	-	6.78	-
50	-0.03	0.21	90.29	-	6.83	-
100	-0.03	0.22	87.59	-	6.97	-
500	-0.04	0.24	80.87	-	7.23	-
1000	-0.04	0.24	78.18	-	7.32	-
1500	-0.04	0.25	76.82	-	7.34	-

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	8WaxC
Unit	F3 (Dongen)
Depth [m]	38.48
Test number	CTX01

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

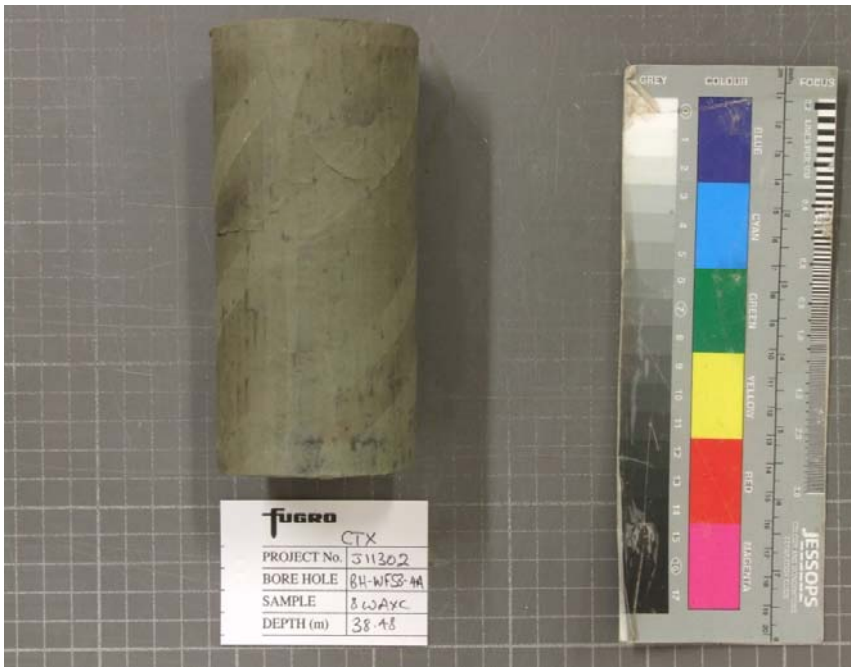
SHEARING STAGE		
Initial effective radial pressure	[kPa]	358
Initial effective axial pressure	[kPa]	358
Rate of strain	[%/hour]	0.20
At peak deviator stress		
Corrected deviator stress	[kPa]	599
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	2.29
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	182
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	173
Effective axial pressure	[kPa]	773
Principal effective stress ratio	[-]	4.46
ε_{50}	[%]	0.51
Secant modulus (E_{50}) at ε_{50}	[kPa]	54814
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	593
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	1.99
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	189
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	166
Effective axial pressure	[kPa]	759
Principal effective stress ratio	[-]	4.58
At 1% external axial strain		
Corrected deviator stress	[kPa]	435
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	1.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	163
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	192
Effective axial pressure	[kPa]	627
Principal effective stress ratio	[-]	3.26

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	8WaxC
Unit	F3 (Dongen)
Depth [m]	38.48
Test number	CTX01

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS





FINAL CONDITIONS

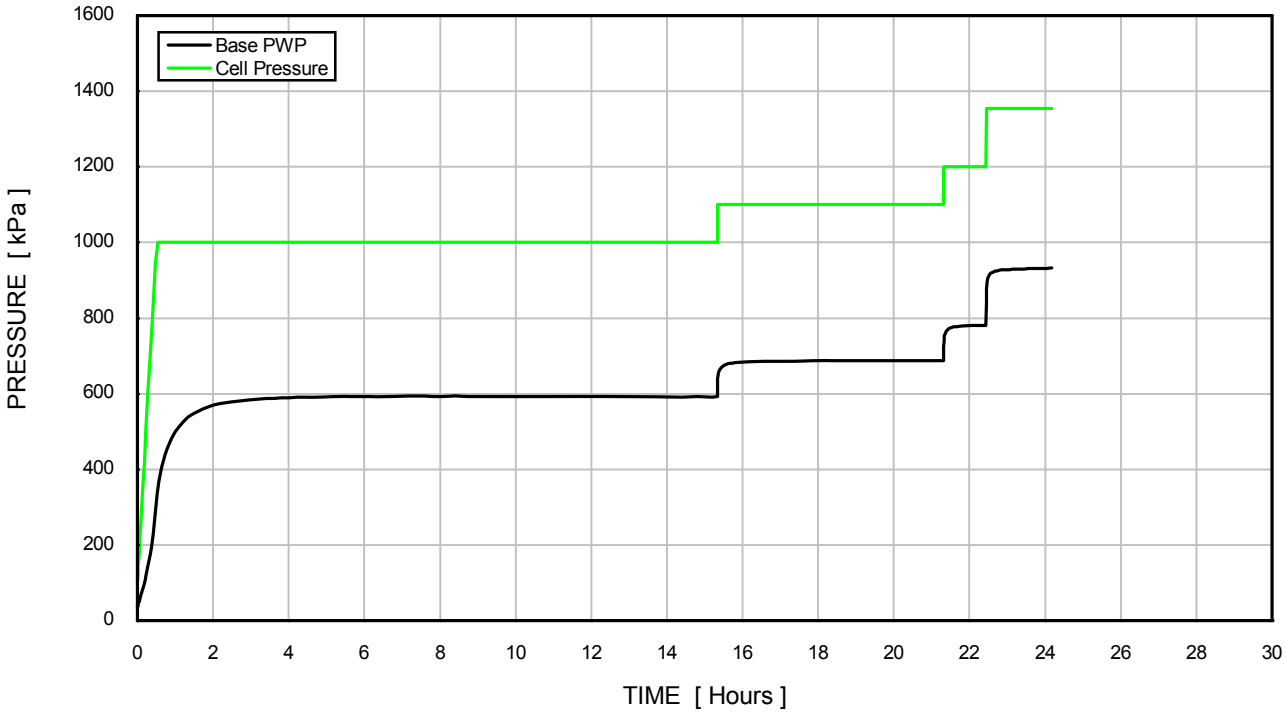
Moisture content	[%]	42.8
Bulk density	[Mg/m³]	1.80
Dry density	[Mg/m³]	1.26

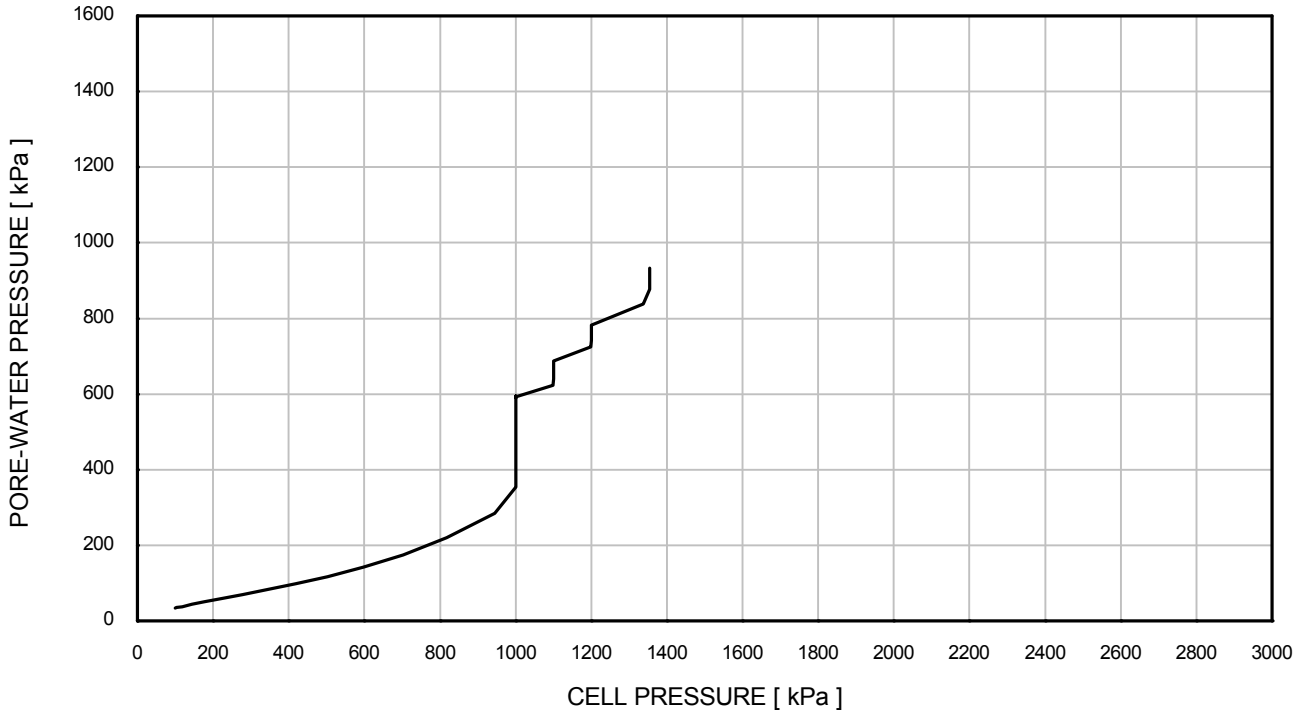
TEST IDENTIFICATION

Borehole	BH-WFS3-4A
Sample	8WaxC
Unit	F3 (Dongen)
Depth [m]	38.48
Test number	CTX01

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

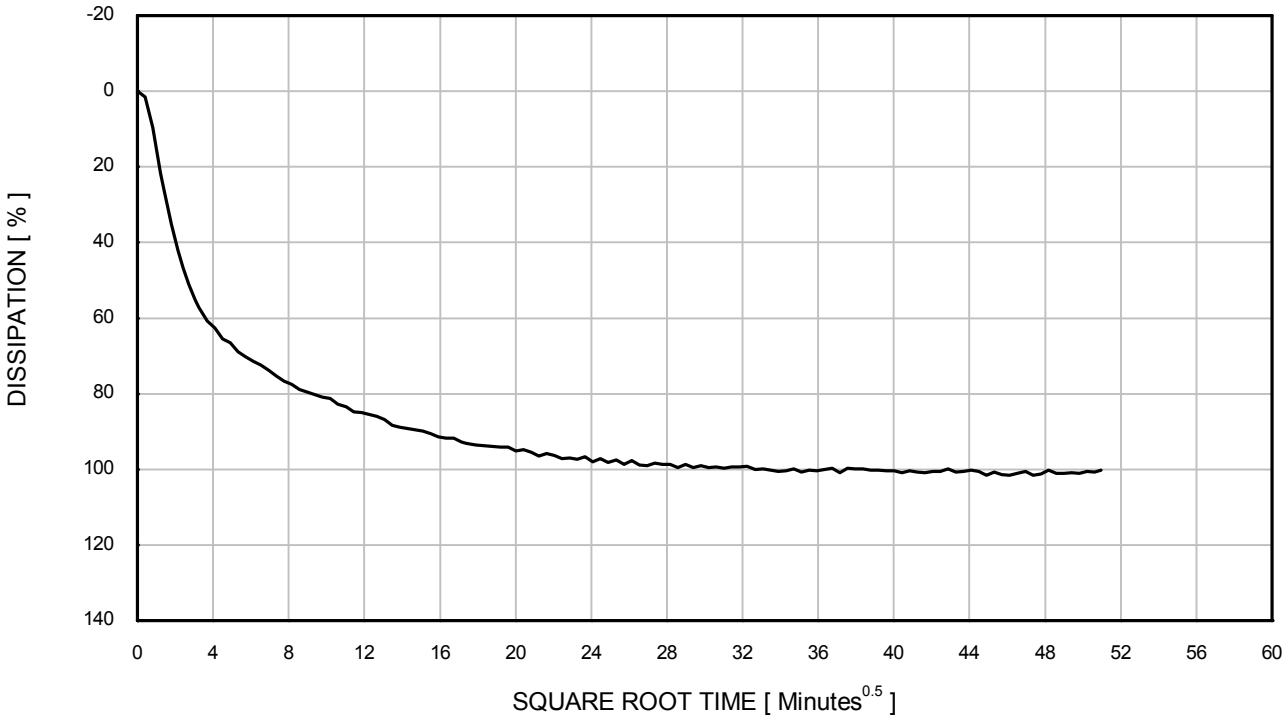


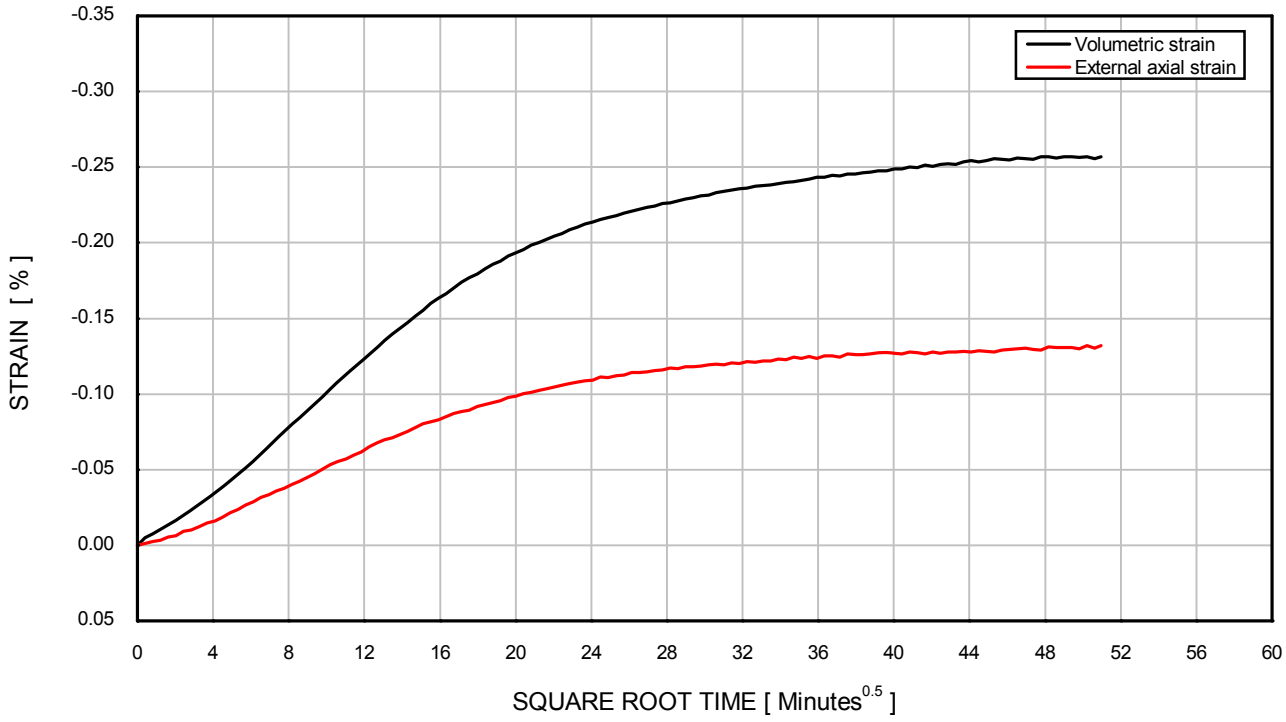


B value	:	0.97	Borehole	:	BH-WFS3-4A
Initial σ'_r	:	66 kPa	Sample	:	8WaxC
Initial σ'_a	:	66 kPa	Unit	:	F3 (Dongen)
Final σ'_r	:	422 kPa	Depth [m]	:	38.48
Final σ'_a	:	422 kPa	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - UNDRAINED

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

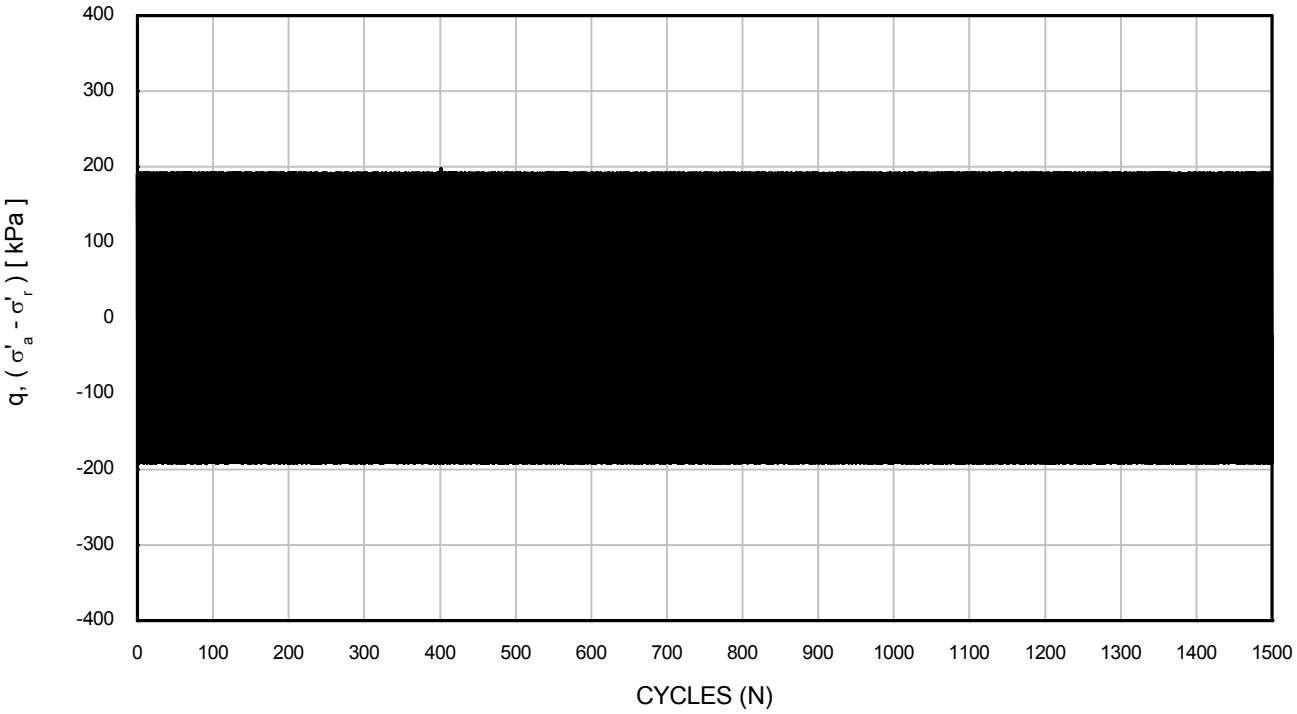


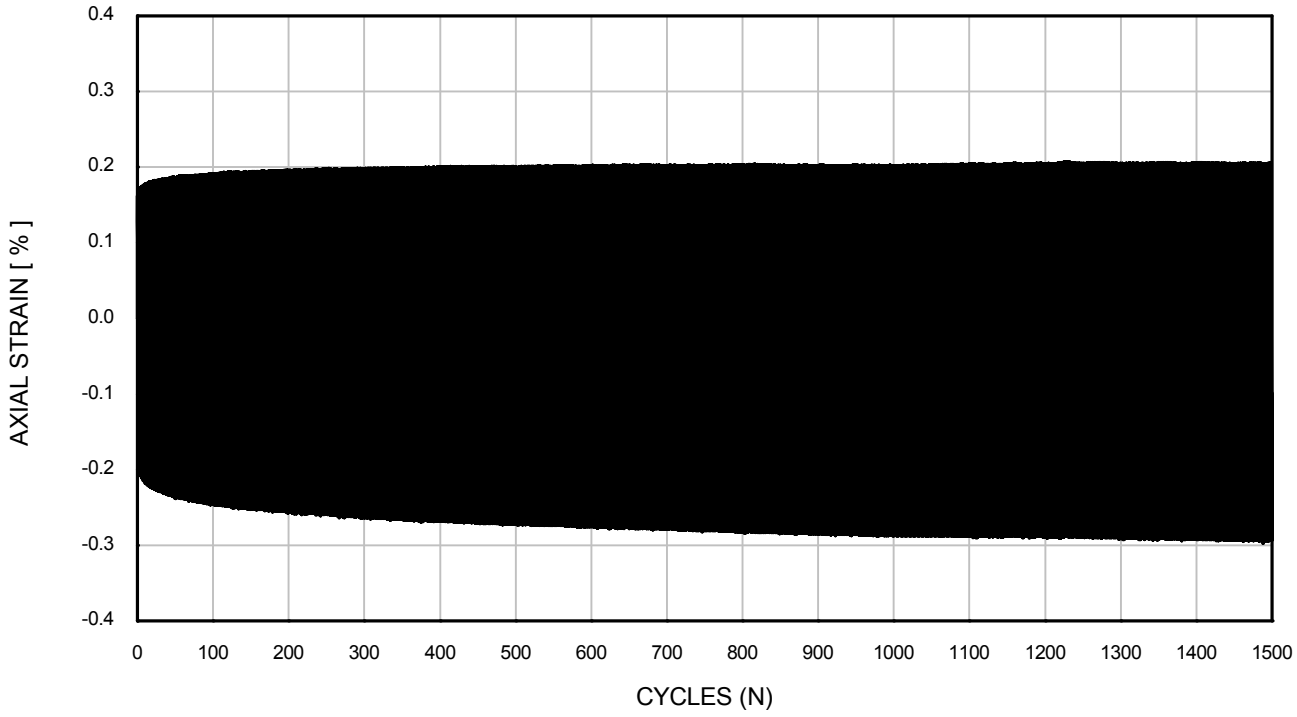


σ'_{rc}	: 355 kPa	Borehole	: BH-WFS3-4A
σ'_{ac}	: 355 kPa	Sample	: 8WaxC
		Unit	: F3 (Dongen)
		Depth [m]	: 38.48
		Test No.	: CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

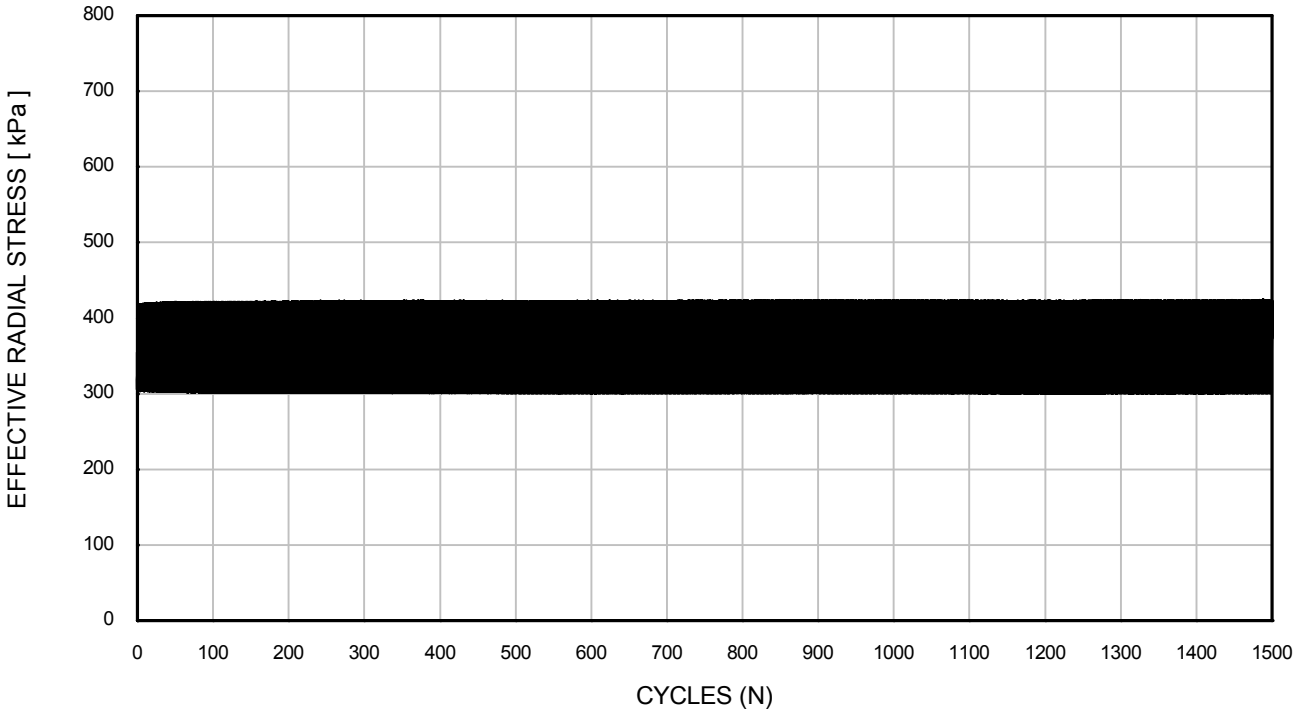


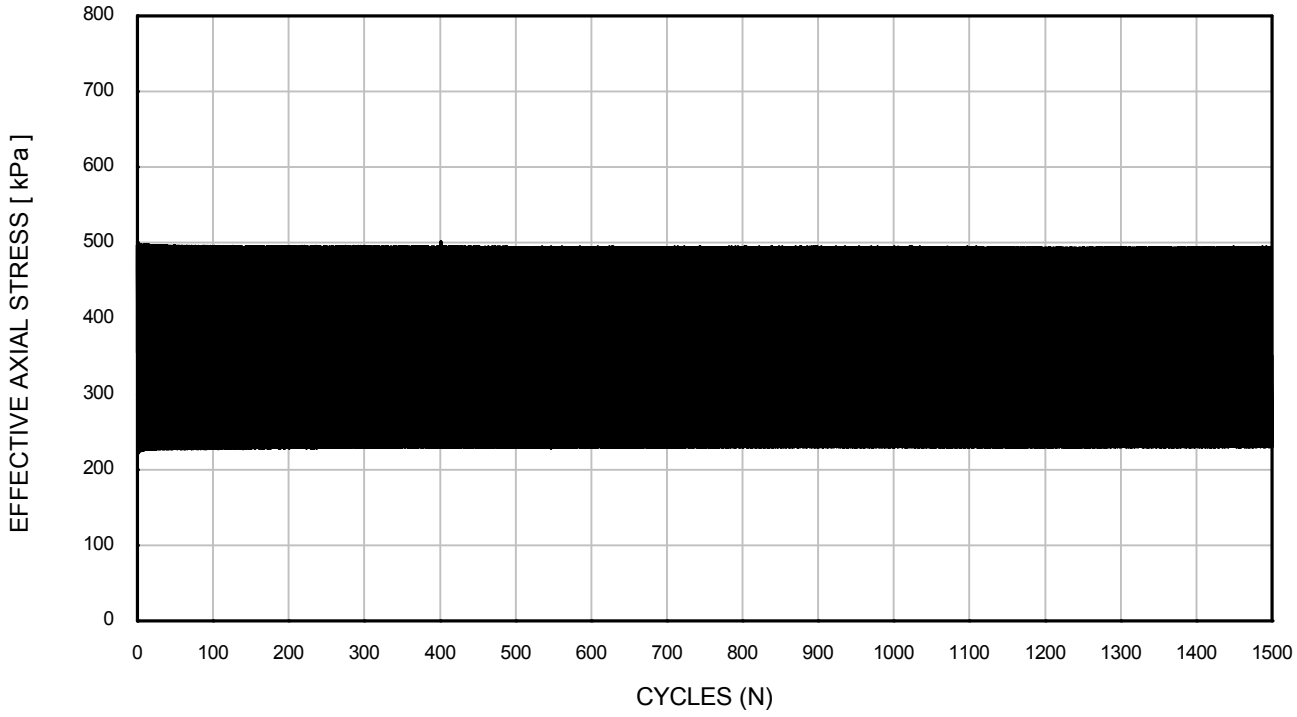


Initial σ'_r	:	355 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	355 kPa	Sample	:	8WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	191 kPa	Depth [m]	:	38.48
Frequency	:	0.10 Hz	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

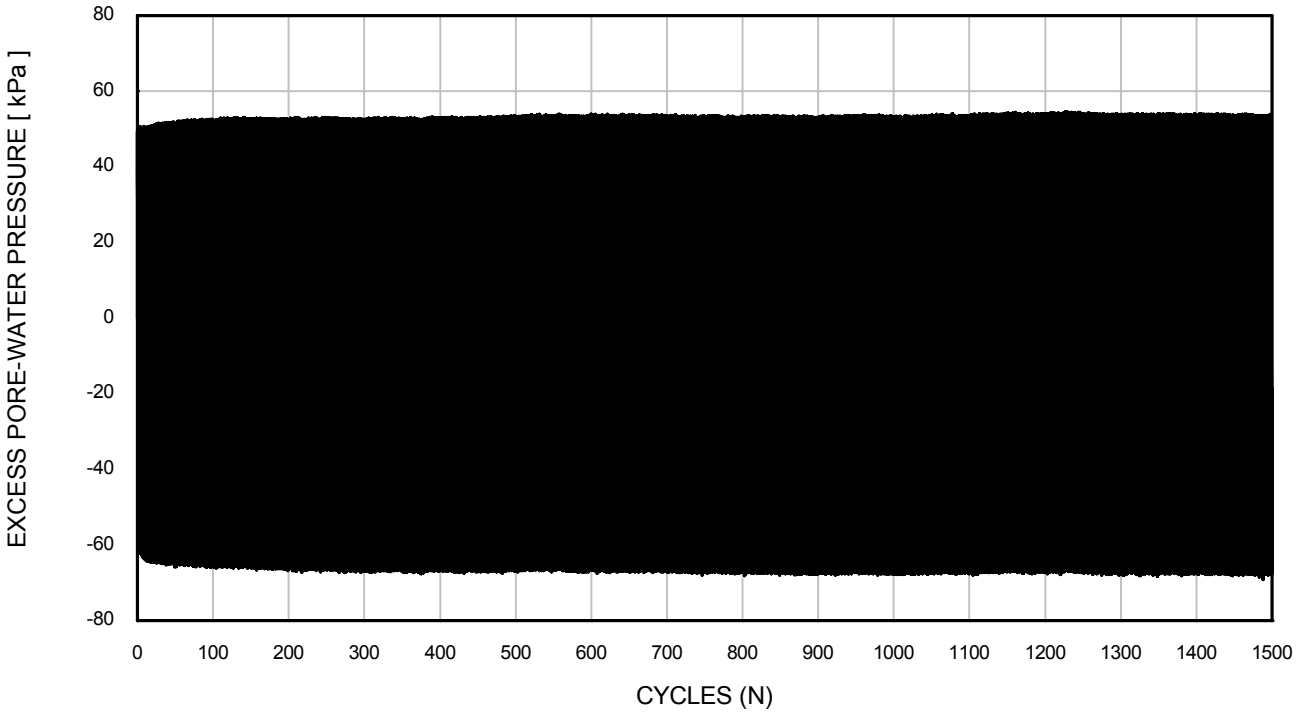


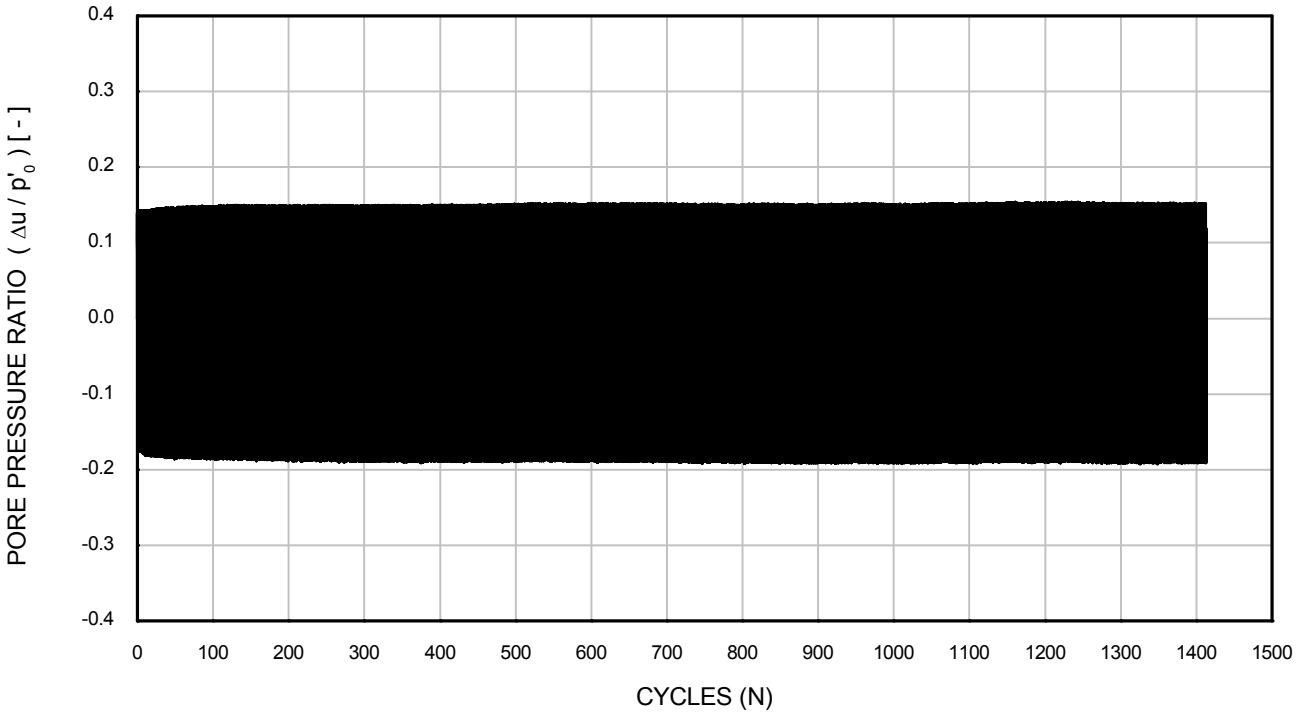


Initial σ'_r	:	355 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	355 kPa	Sample	:	8WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	191 kPa	Depth [m]	:	38.48
Frequency	:	0.10 Hz	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

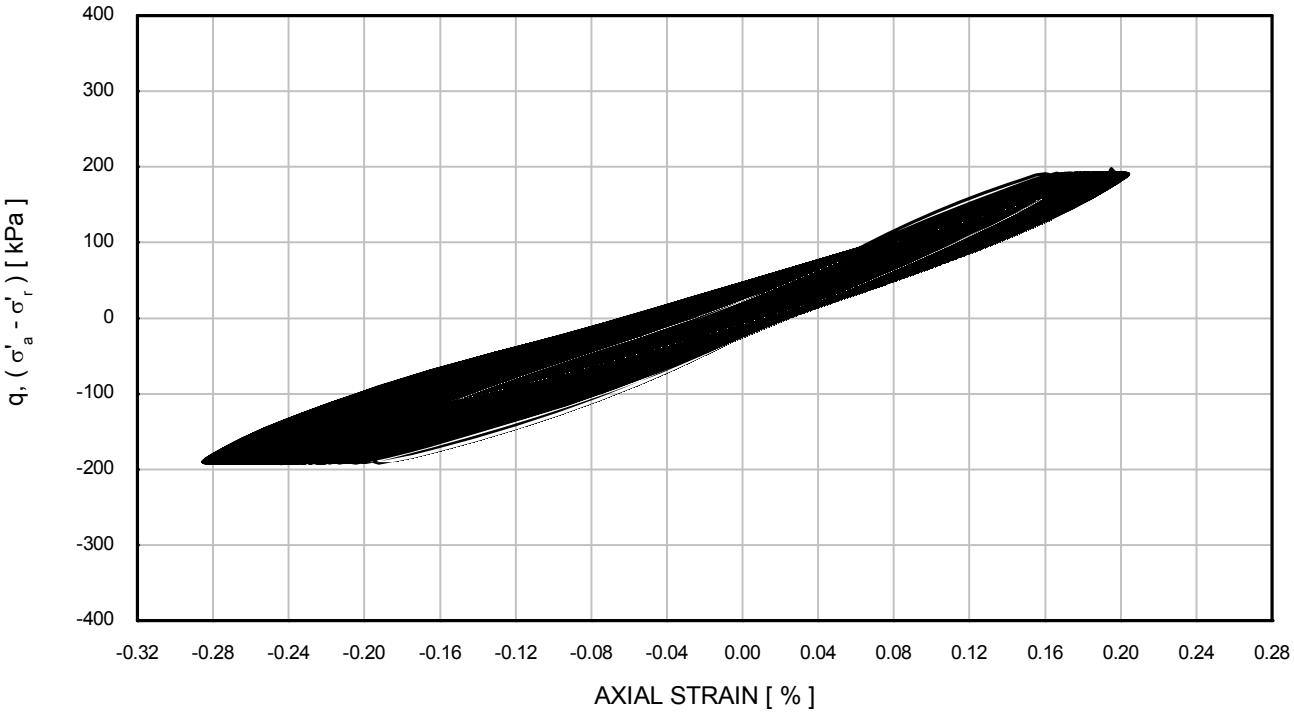


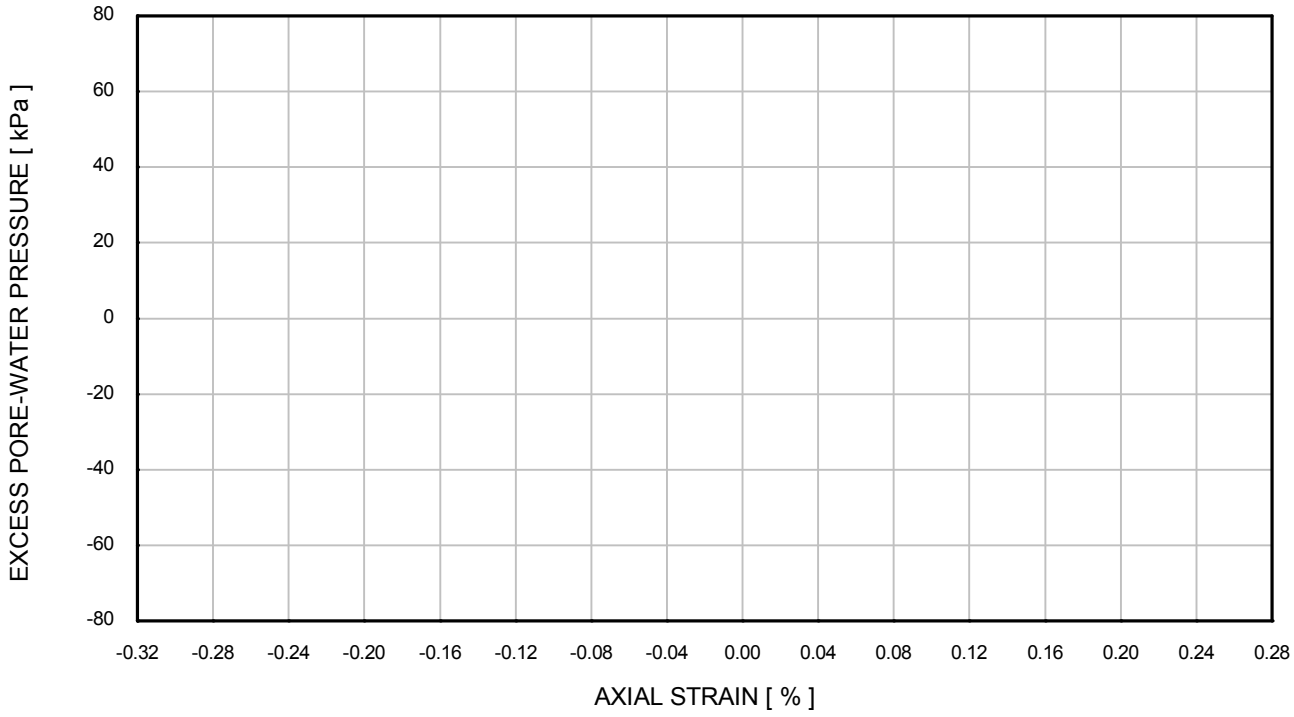


Initial σ'_r	:	355 kPa	Borehole	: BH-WFS3-4A
Initial σ'_a	:	355 kPa	Sample	: 8WaxC
q_{av}	:	0 kPa	Unit	: F3 (Dongen)
q_{cy}	:	191 kPa	Depth [m]	: 38.48
Frequency	:	0.10 Hz	Test No.	: CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

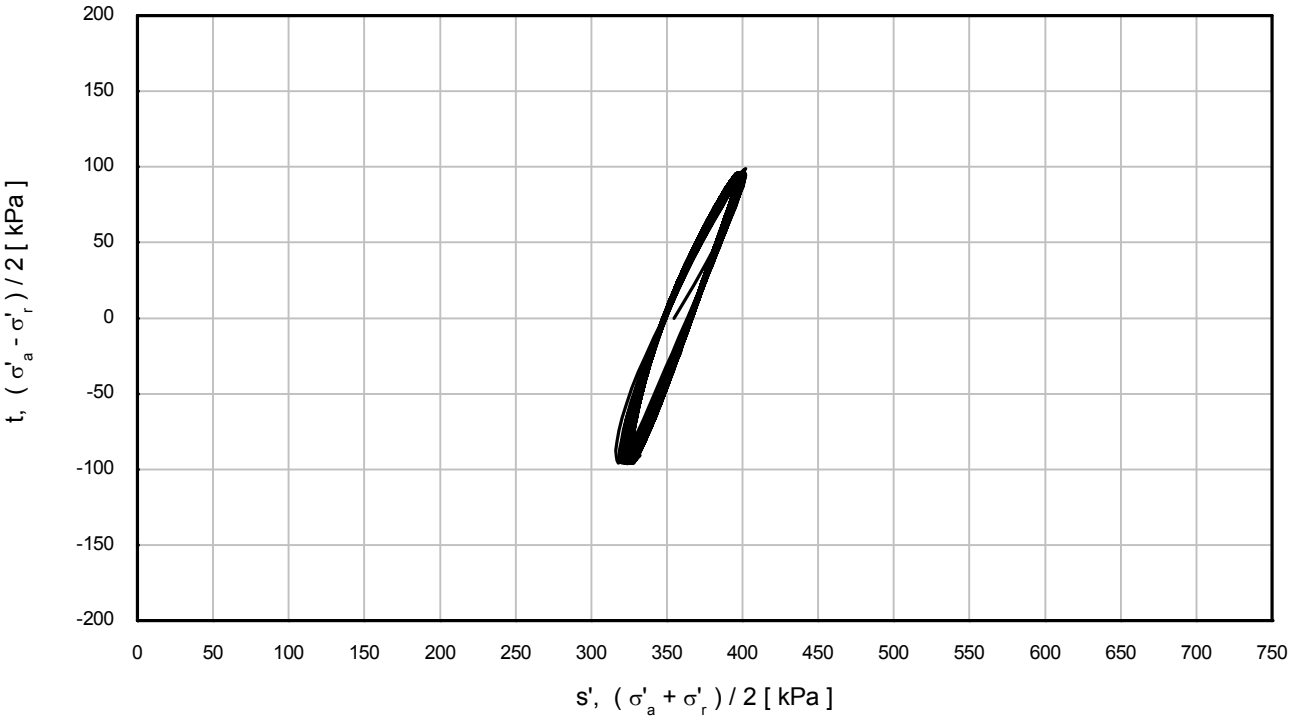


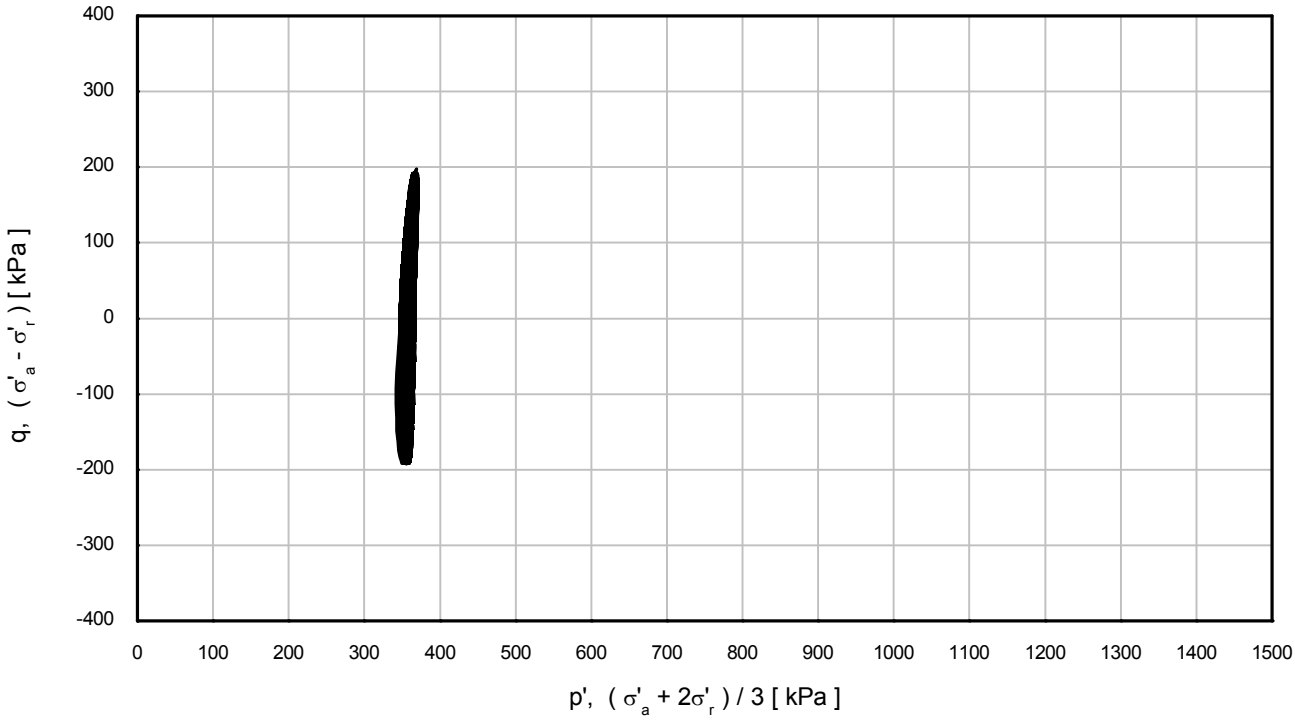


Initial σ'_r	:	355 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	355 kPa	Sample	:	8WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	191 kPa	Depth [m]	:	38.48
Frequency	:	0.10 Hz	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

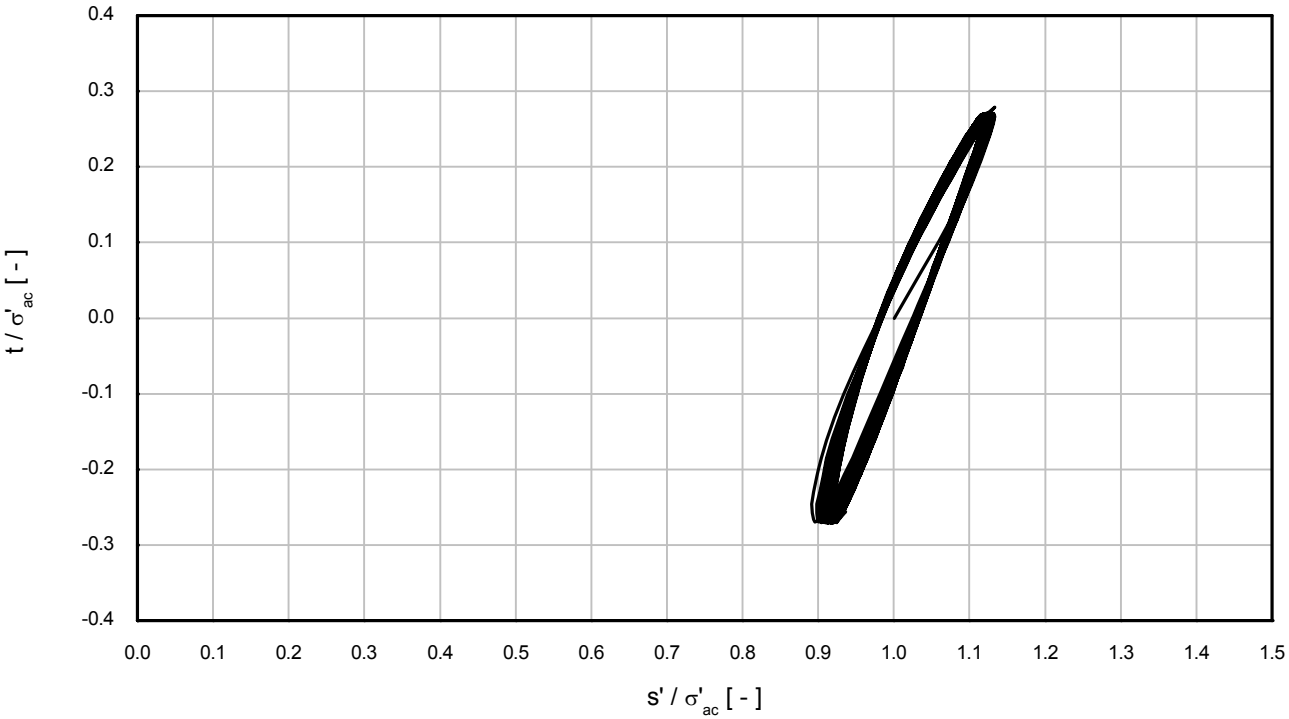


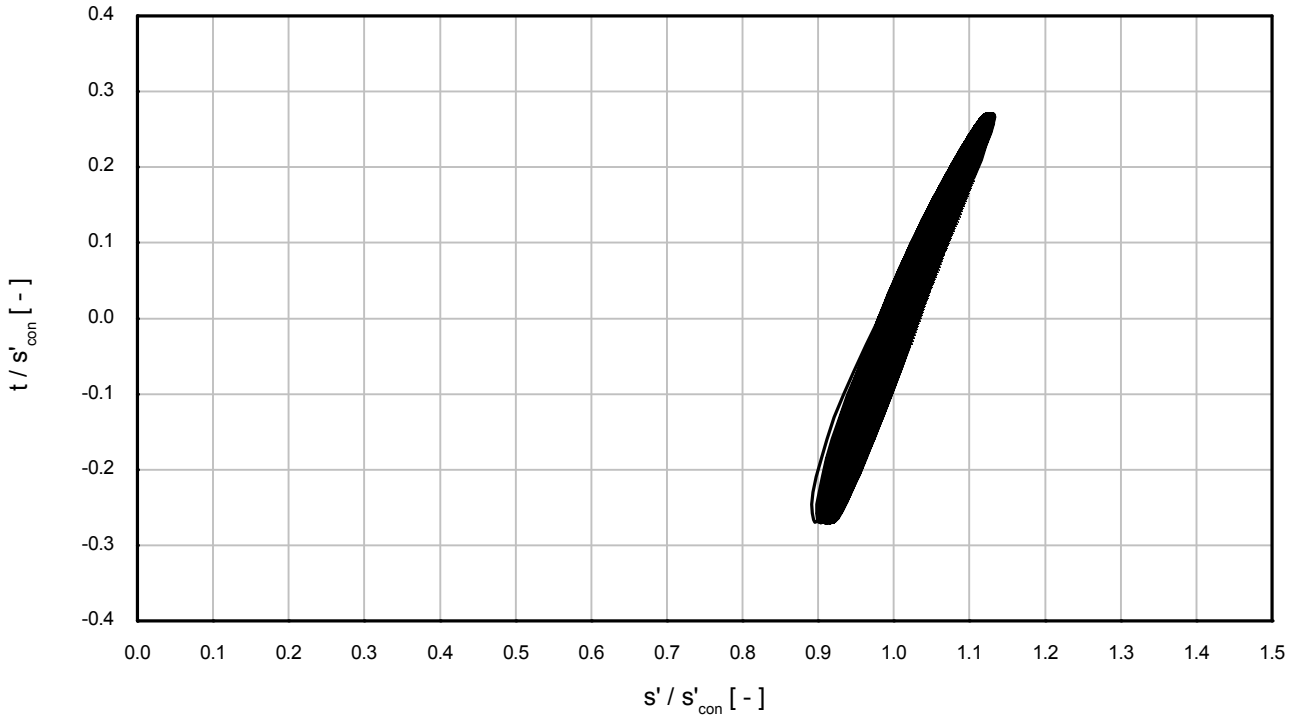


Initial σ'_r	:	355 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	355 kPa	Sample	:	8WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	191 kPa	Depth [m]	:	38.48
Frequency	:	0.10 Hz	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

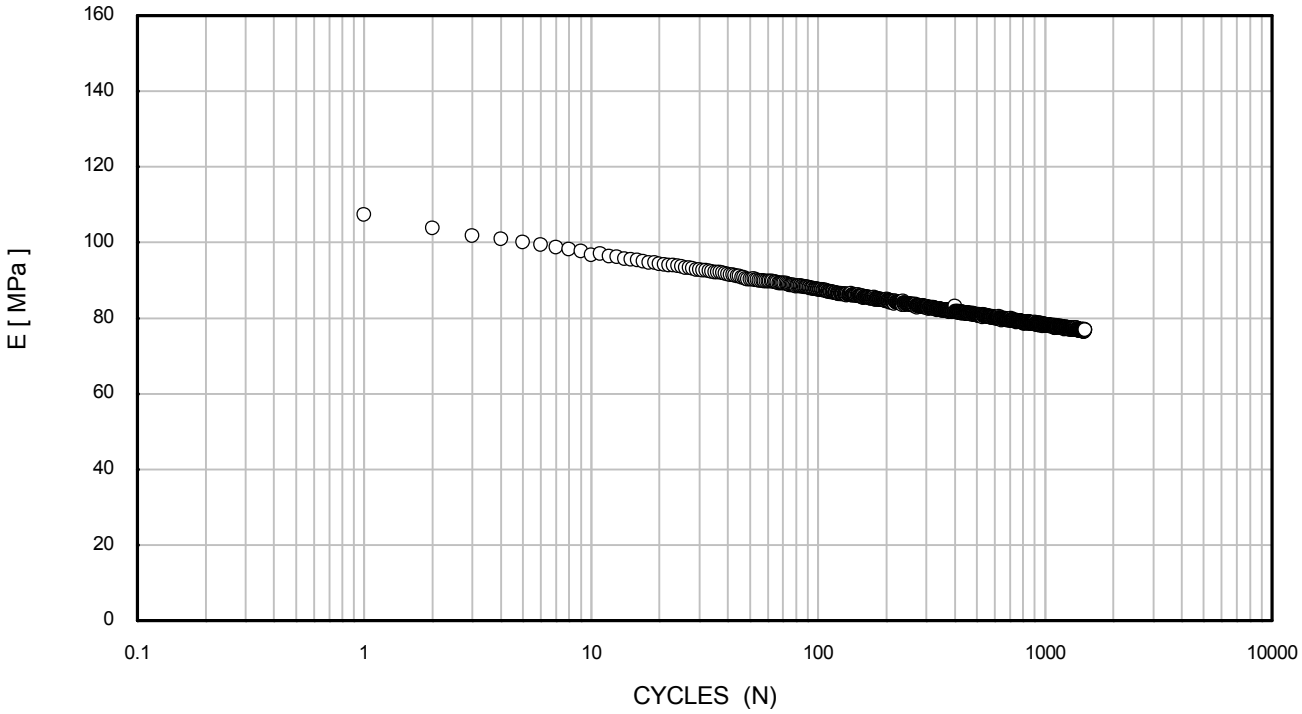


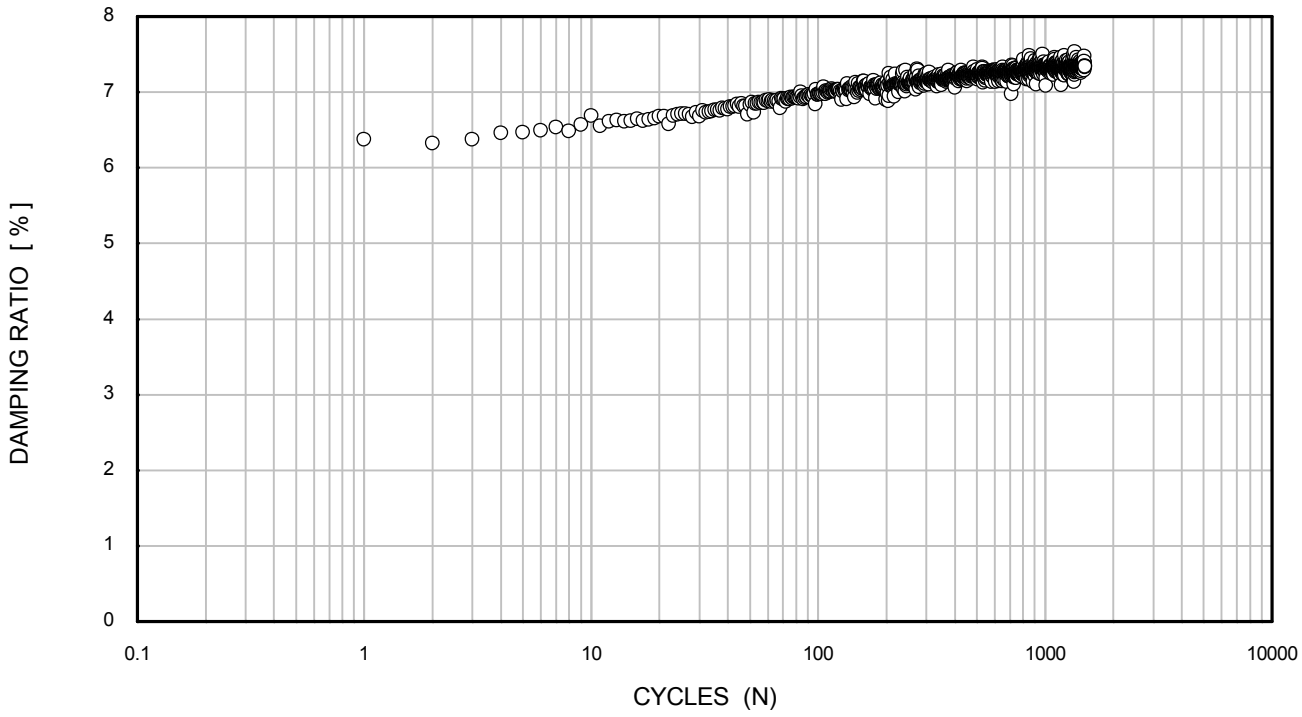


Initial σ'_r	:	355 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	355 kPa	Sample	:	8WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	191 kPa	Depth [m]	:	38.48
Frequency	:	0.10 Hz	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

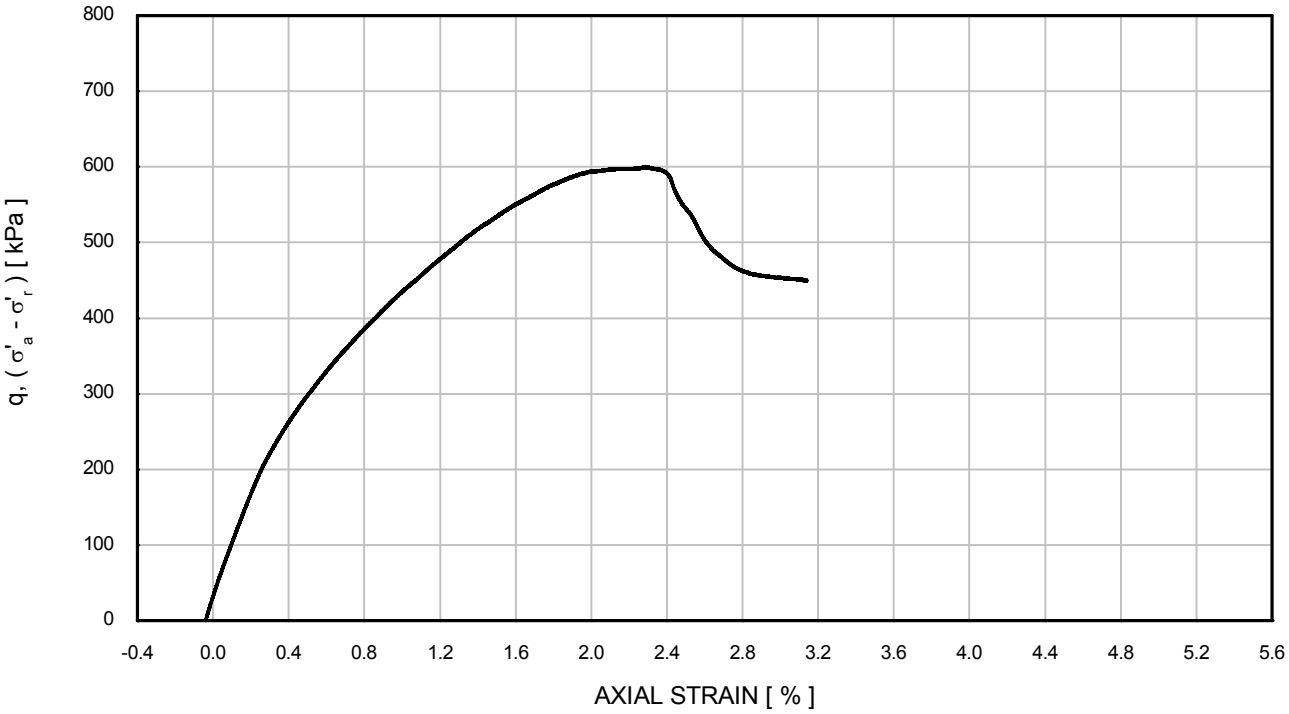


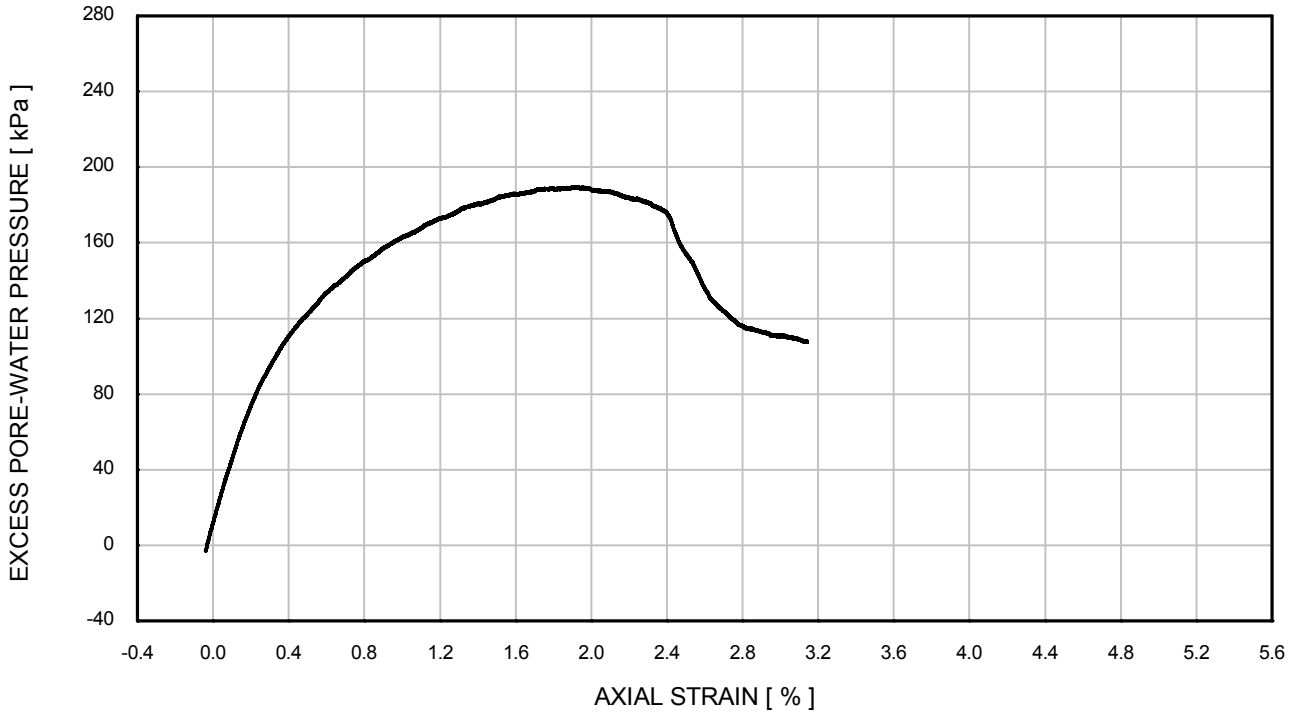


Initial σ'_r	:	355 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	355 kPa	Sample	:	8WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	191 kPa	Depth [m]	:	38.48
Frequency	:	0.10 Hz	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

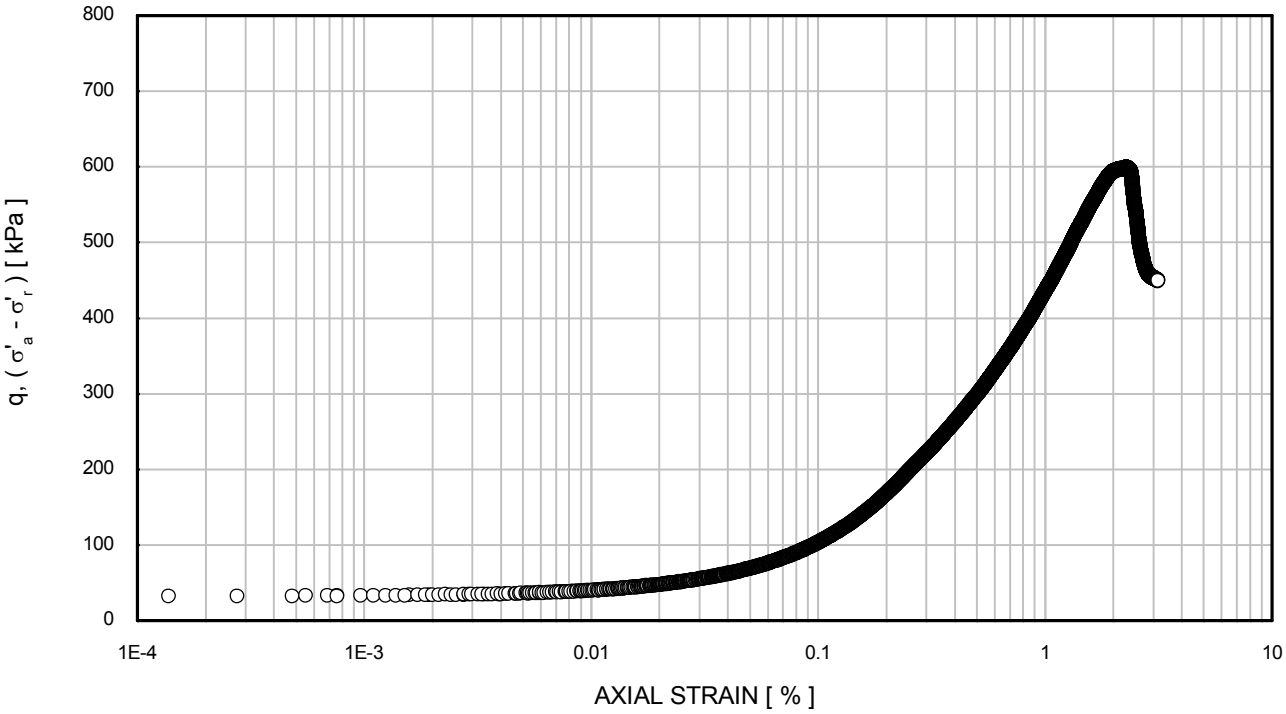


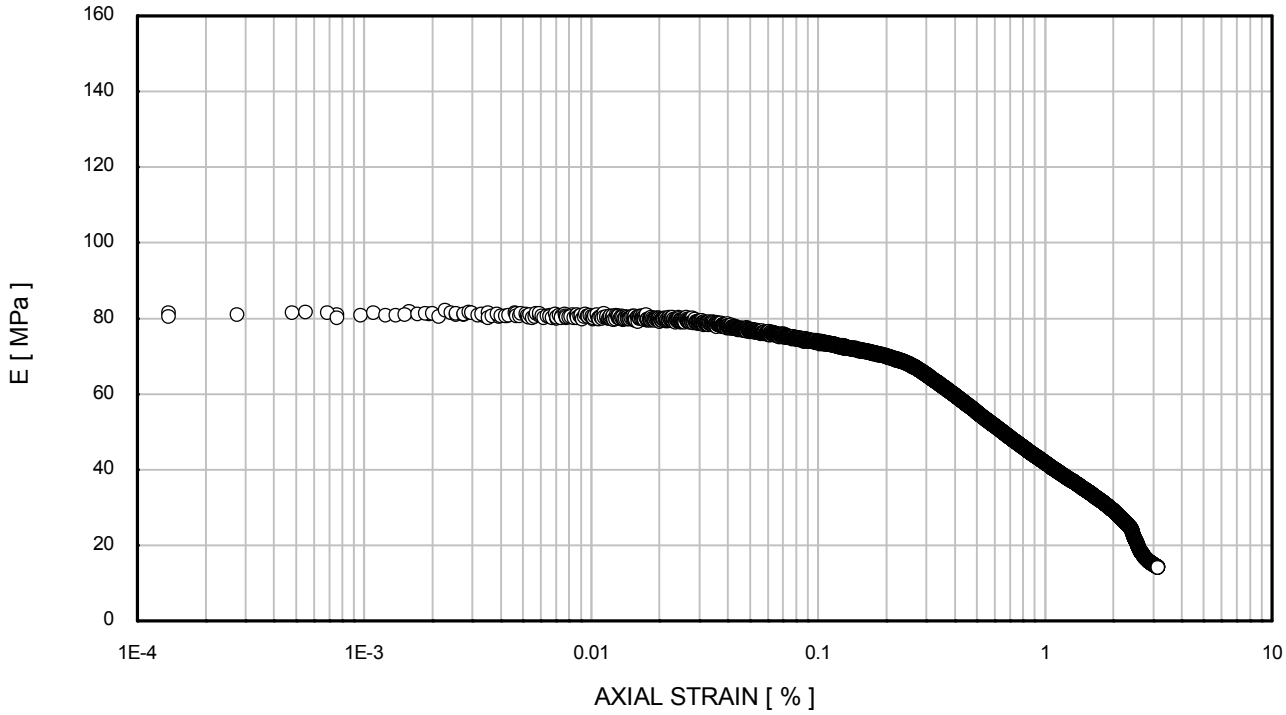


Initial σ'_r	:	358 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	358 kPa	Sample	:	8WaxC
q_{peak}	:	599 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	2.29 %	Depth [m]	:	38.48
Rate of strain	:	0.20 %/hour	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

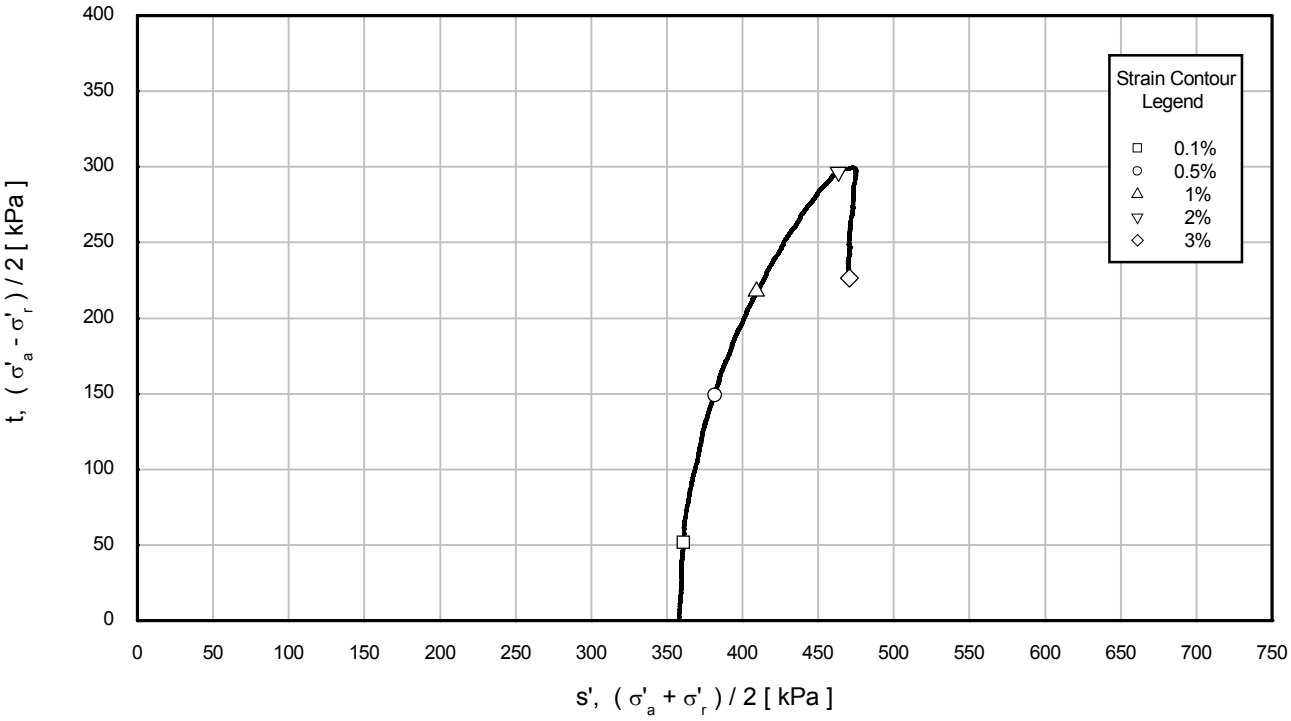


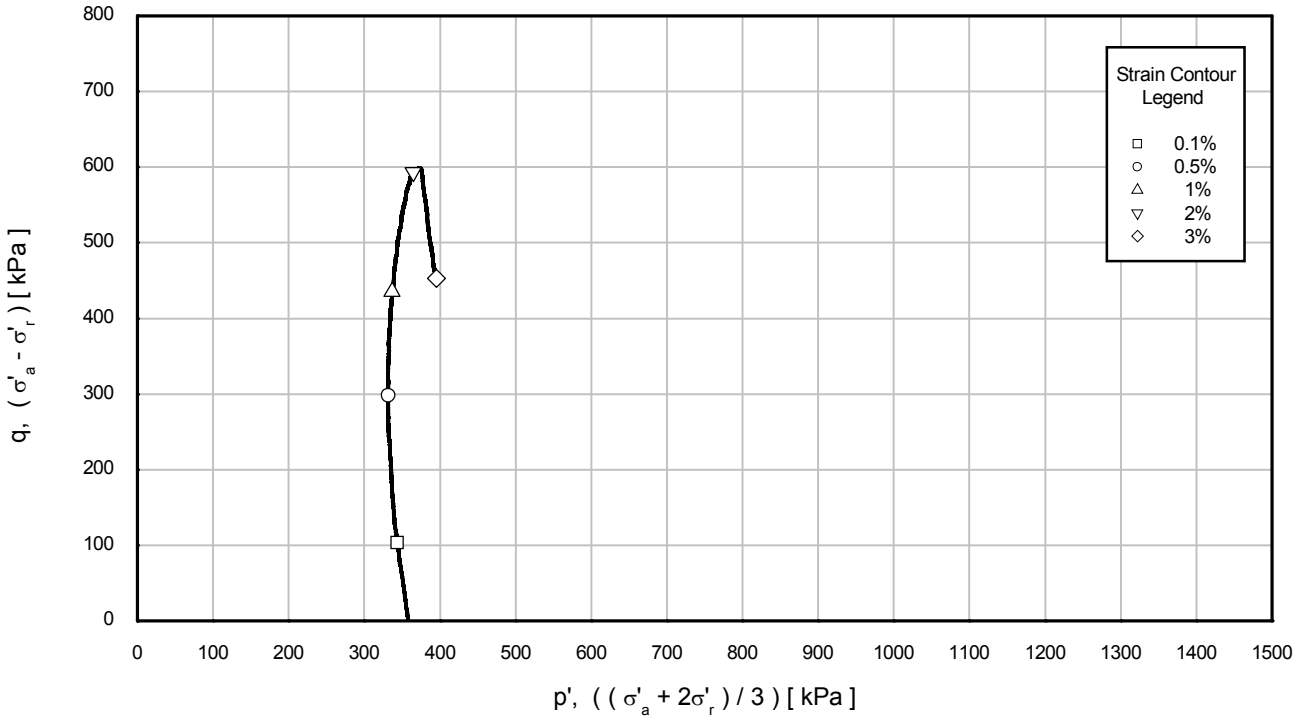


Initial σ'_r	:	358 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	358 kPa	Sample	:	8WaxC
q_{peak}	:	599 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	2.29 %	Depth [m]	:	38.48
Rate of strain	:	0.20 %/hour	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	358 kPa	Borehole	:	BH-WFS3-4A
Initial σ'_a	:	358 kPa	Sample	:	8WaxC
q_{peak}	:	599 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	2.29 %	Depth [m]	:	38.48
Rate of strain	:	0.20 %/hour	Test No.	:	CTX01

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Olive very sandy CLAY with pockets of light grey silty fine sand

GENERAL	
Date test started	04/12/2015
Type of sample	Undisturbed
Type of drains fitted	Radial (spiral) & one end only

INITIAL		
Diameter	[mm]	69.7
Length	[mm]	144.9
Moisture content	[%]	26.8
Bulk density	[Mg/m³]	1.95
Dry density	[Mg/m³]	1.54
Void ratio	[-]	0.703
Degree of saturation	[%]	100
Measured particle density	[Mg/m³]	2.62
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic	BS1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ BH-WFS3-1_30C_CTX1
Processed by	PR
Date	06/12/2015
Checked by	LJ
Date	15/12/2015
Approved by	PH
Date	15/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-1
Sample	30WaxC
Unit	F3 (Dongen)
Depth [m]	41.58
Test number	CTX02

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Undrained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	N/A
Cell pressure	[kPa]	1405
Base PWP	[kPa]	1151
Mid height PWP	[kPa]	-
B value achieved	[-]	0.96

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1405
Back pressure	[kPa]	1000
Base PWP	[kPa]	1000
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	405
Effective axial pressure	[kPa]	405
Deviator stress	[kPa]	0
Volumetric strain	[%]	0.77
External axial strain	[%]	0.19
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	26.3
Bulk density	[Mg/m³]	1.96
Dry density	[Mg/m³]	1.55
Void ratio	[-]	0.690
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Borehole	BH-WFS3-1
Sample	30WaxC
Unit	F3 (Dongen)
Depth [m]	41.58
Test number	CTX02

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	500
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	338
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	15
External ε_{av} at N_f	[%]	-5.84
External ε_{cy} at N_f	[%]	10.61
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	131
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	26.3
Bulk density	[Mg/m³]	1.96
Dry density	[Mg/m³]	1.55
Void ratio	[-]	0.690
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-1.01	1.50	22.52	-	21.34	-
2	-1.38	1.94	17.45	-	20.37	-
3	-1.64	2.37	14.30	-	18.76	-
4	-1.87	2.80	12.08	-	17.84	-
5	-2.09	3.26	10.39	-	17.36	-
6	-2.32	3.75	9.02	-	17.08	-
7	-2.55	4.29	7.89	-	17.00	-
8	-2.80	4.87	6.94	-	17.06	-
9	-3.06	5.51	6.15	-	17.23	-
10	-3.37	6.19	5.45	-	17.61	-
12	-4.10	7.73	4.34	-	18.48	-
15	-5.84	10.61	3.18	-	19.81	-

TEST IDENTIFICATION	
Borehole	BH-WFS3-1
Sample	30WaxC
Unit	F3 (Dongen)
Depth [m]	41.58
Test number	CTX02

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	77
Initial effective axial pressure	[kPa]	77
Rate of strain	[%/hour]	0.99
At peak deviator stress		
Corrected deviator stress	[kPa]	-202
Membrane correction applied	[kPa]	-3
Drain correction applied	[kPa]	0
External axial strain	[%]	-16.25
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	101
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	304
Effective axial pressure	[kPa]	102
Principal effective stress ratio	[-]	2.98
ε_{50}	[%]	-14.88
Secant modulus (E_{50}) at ε_{50}	[kPa]	14687
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	-183
Membrane correction applied	[kPa]	-3
Drain correction applied	[kPa]	0
External axial strain	[%]	-15.73
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	141
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	264
Effective axial pressure	[kPa]	81
Principal effective stress ratio	[-]	3.26
At -15% external axial strain		
Corrected deviator stress	[kPa]	-113
Membrane correction applied	[kPa]	-3
Drain correction applied	[kPa]	0
External axial strain	[%]	-15.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	229
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	176
Effective axial pressure	[kPa]	63
Principal effective stress ratio	[-]	2.79

TEST IDENTIFICATION	
Borehole	BH-WFS3-1
Sample	30WaxC
Unit	F3 (Dongen)
Depth [m]	41.58
Test number	CTX02

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS





FINAL CONDITIONS

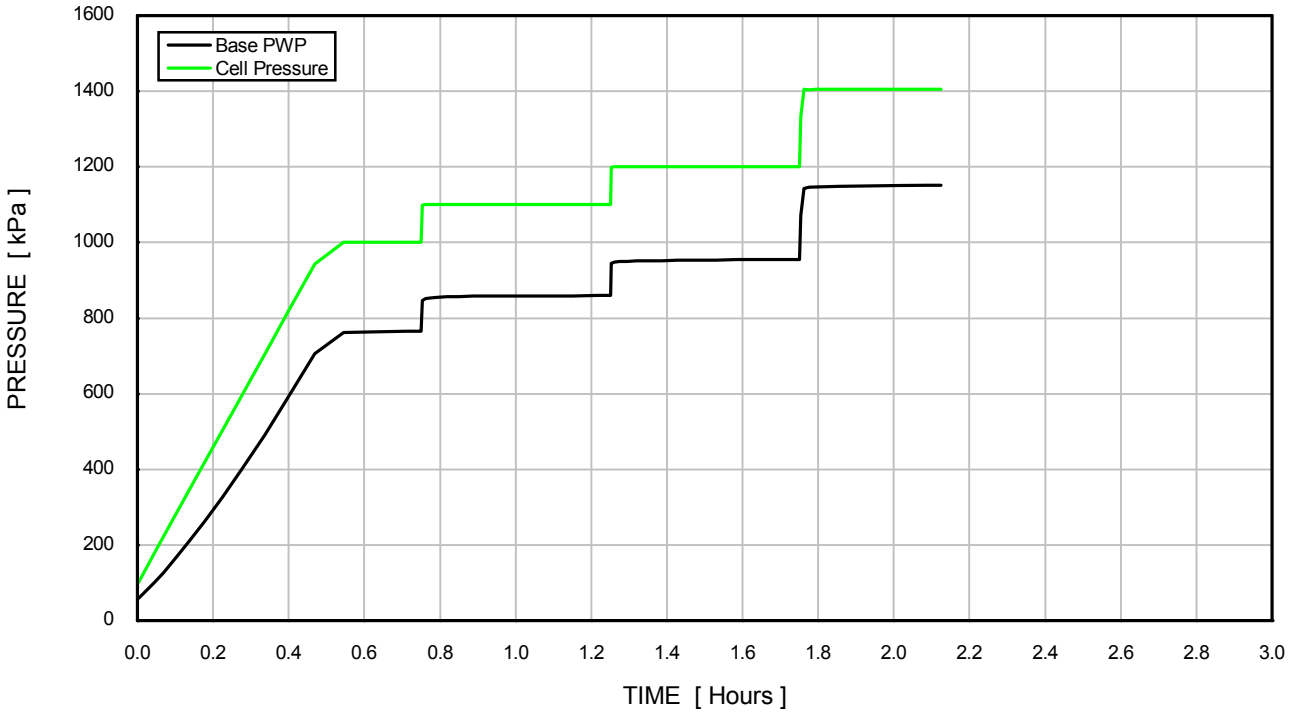
Moisture content	[%]	26.3
Bulk density	[Mg/m³]	1.96
Dry density	[Mg/m³]	1.55

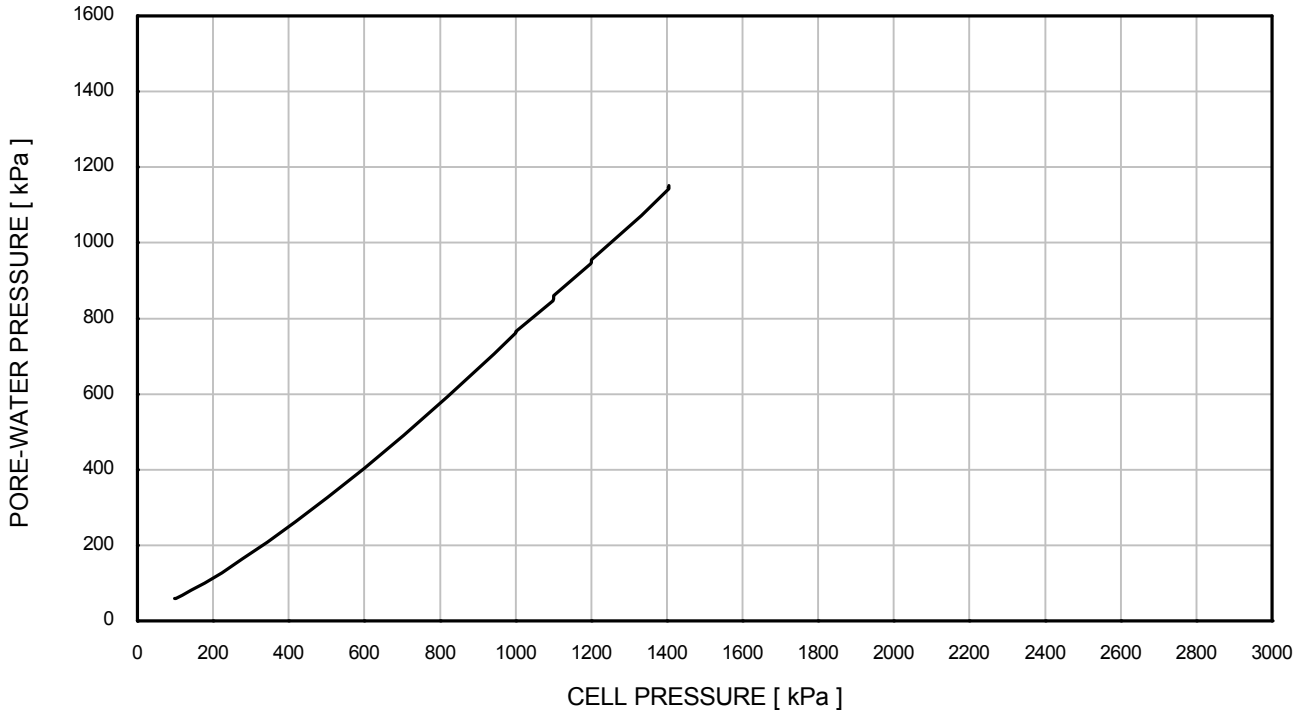
TEST IDENTIFICATION

Borehole	BH-WFS3-1
Sample	30WaxC
Unit	F3 (Dongen)
Depth [m]	41.58
Test number	CTX02

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

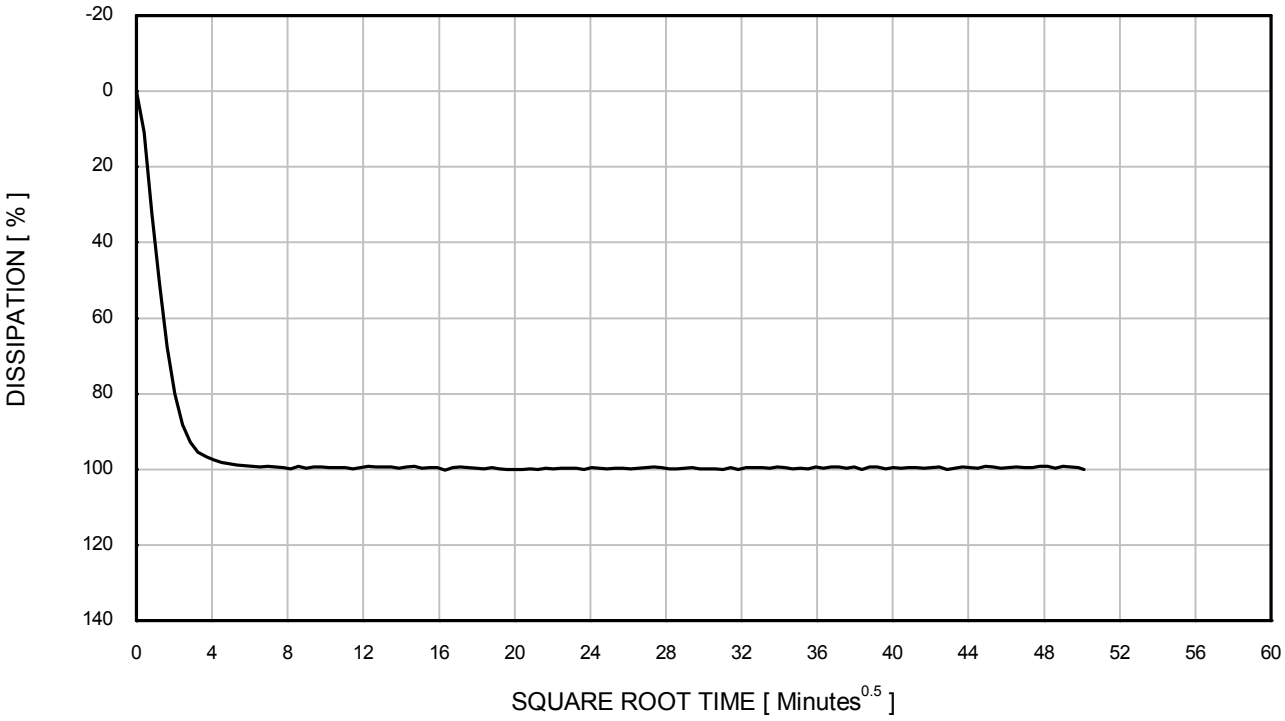


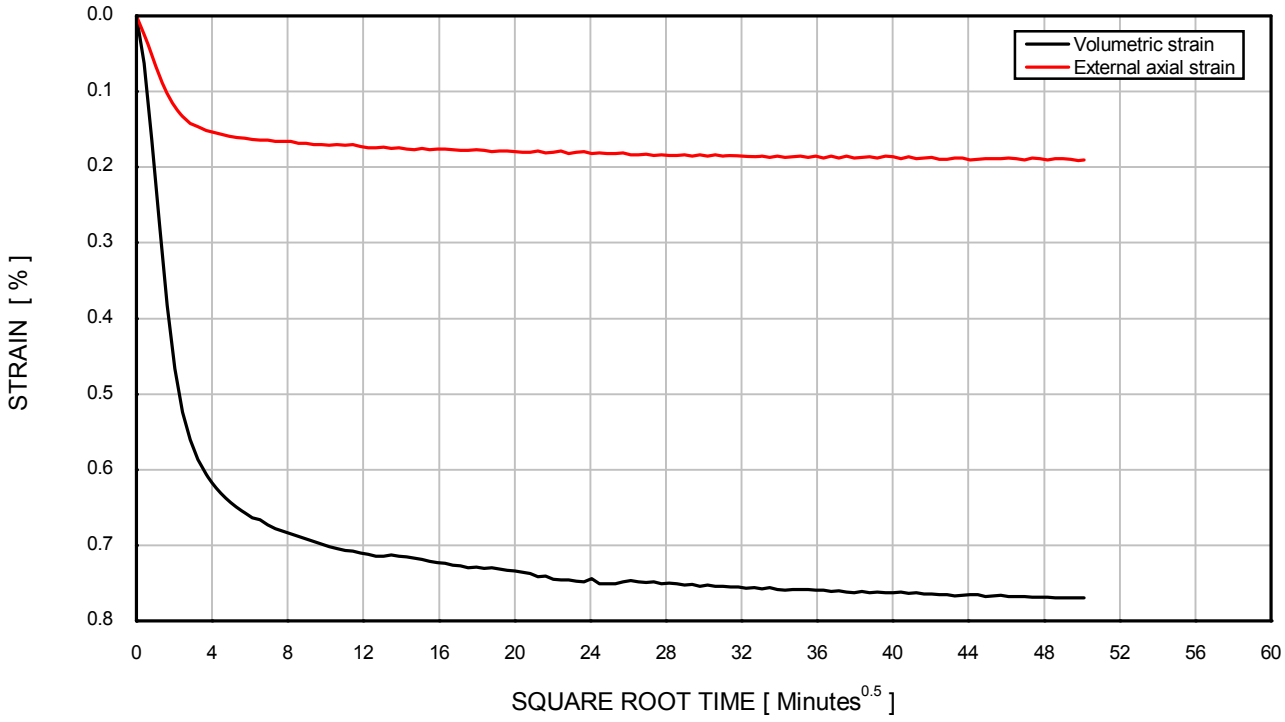


B value	:	0.96	Borehole	:	BH-WFS3-1
Initial σ'_r	:	40 kPa	Sample	:	30WaxC
Initial σ'_a	:	40 kPa	Unit	:	F3 (Dongen)
Final σ'_r	:	254 kPa	Depth [m]	:	41.58
Final σ'_a	:	254 kPa	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - UNDRAINED

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

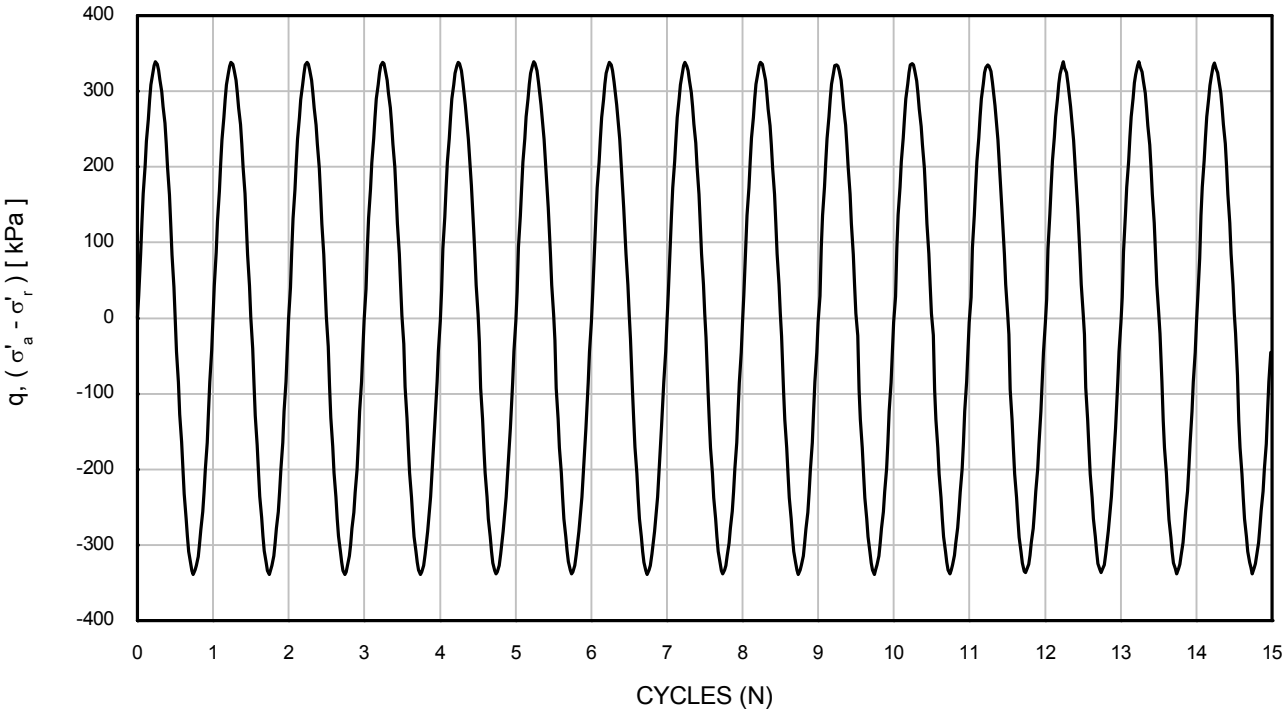


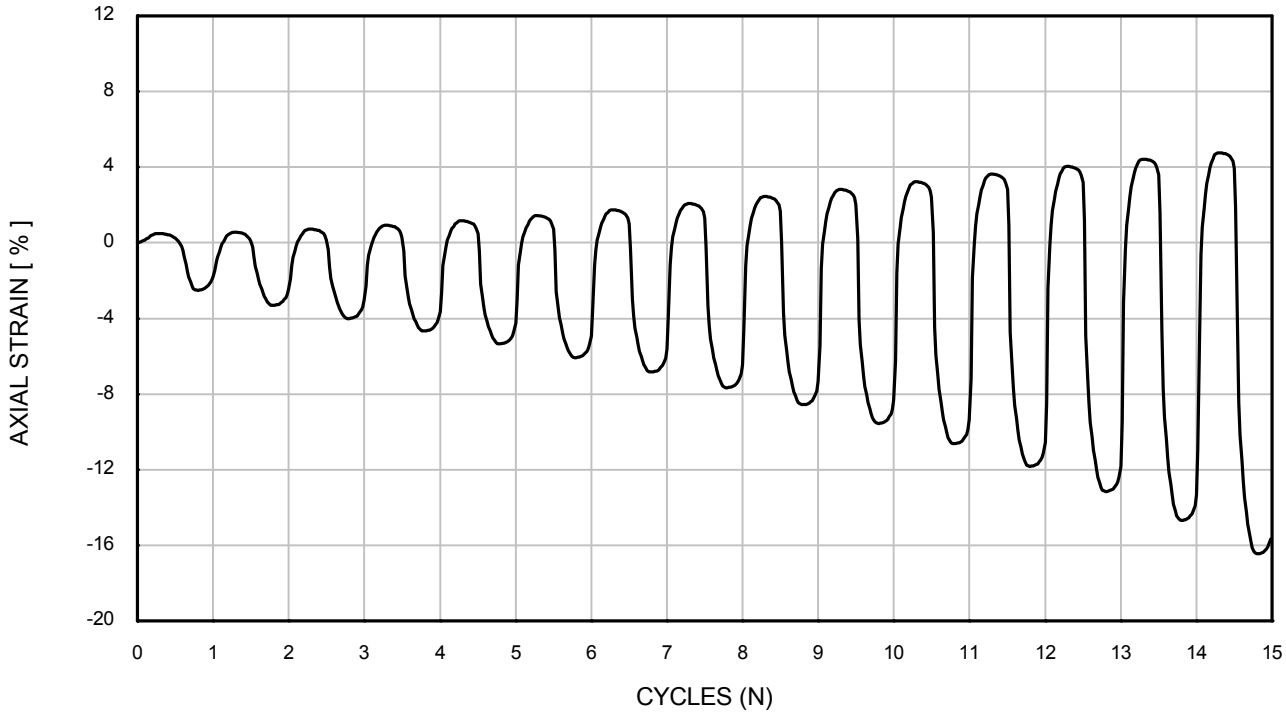


σ'_{rc}	: 405 kPa	Borehole	: BH-WFS3-1
σ'_{ac}	: 405 kPa	Sample	: 30WaxC
		Unit	: F3 (Dongen)
		Depth [m]	: 41.58
		Test No.	: CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

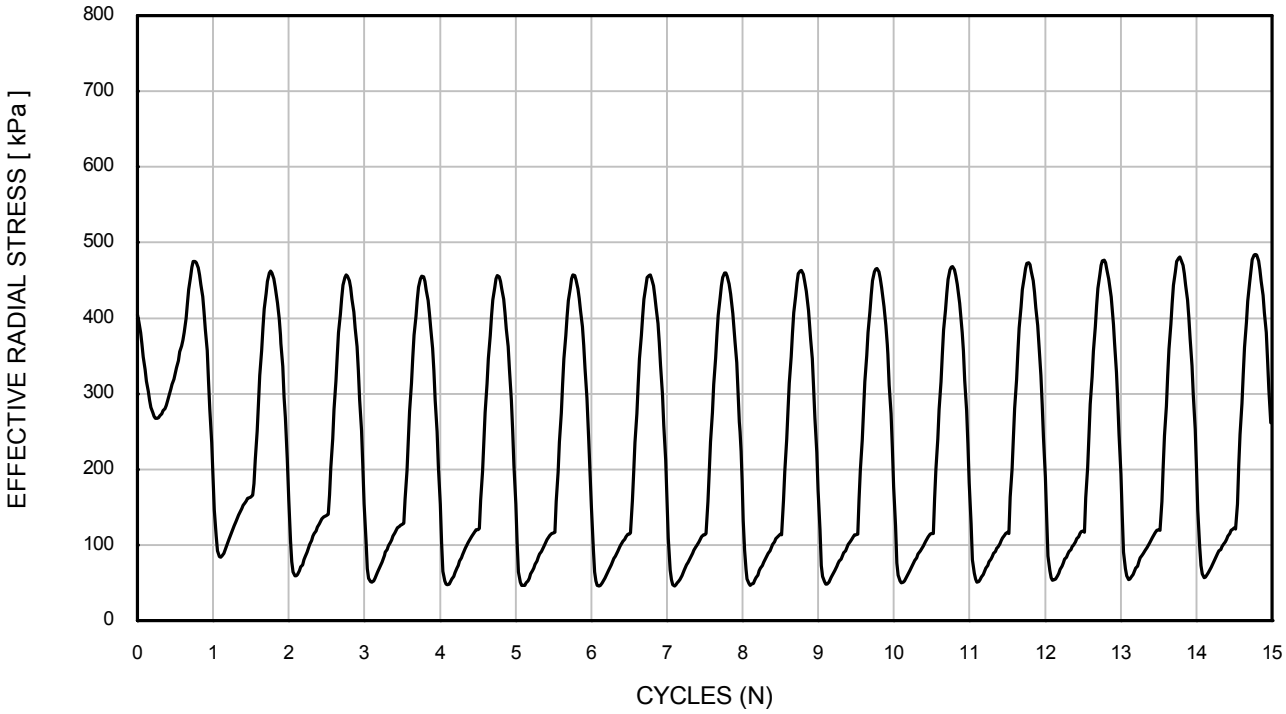


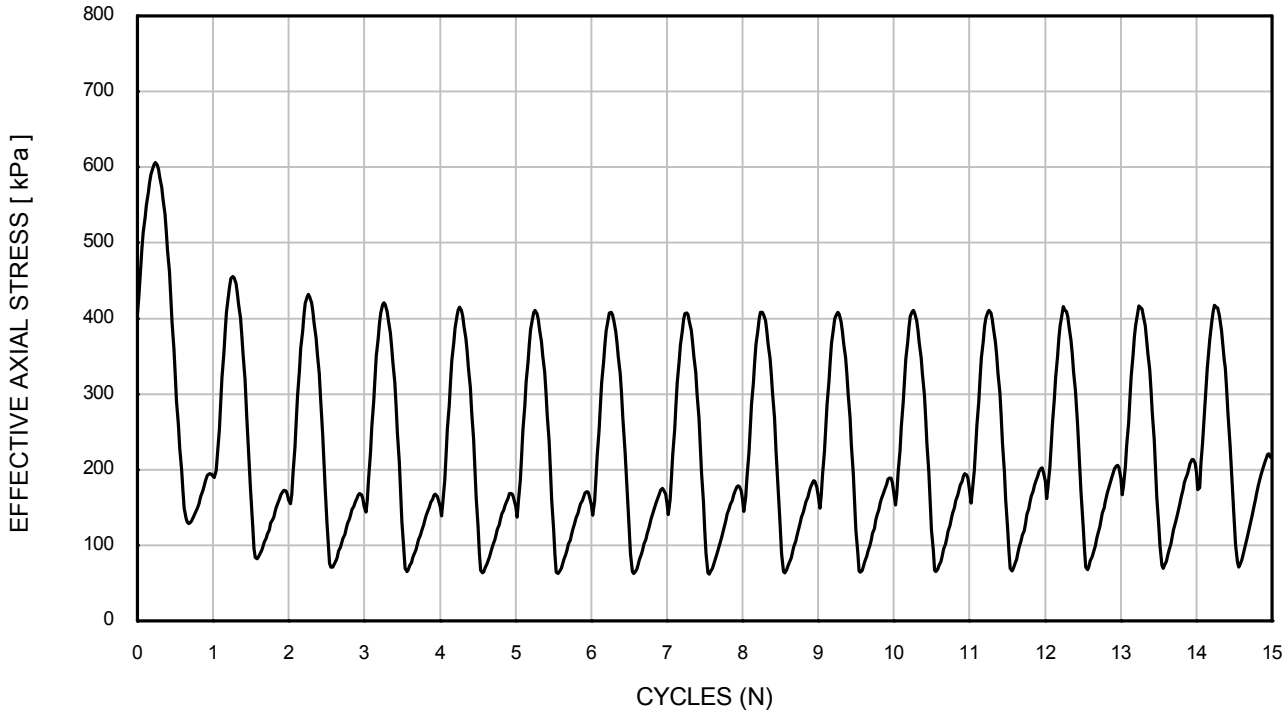


Initial σ'_r	:	405 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	405 kPa	Sample	:	30WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	338 kPa	Depth [m]	:	41.58
Frequency	:	0.10 Hz	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

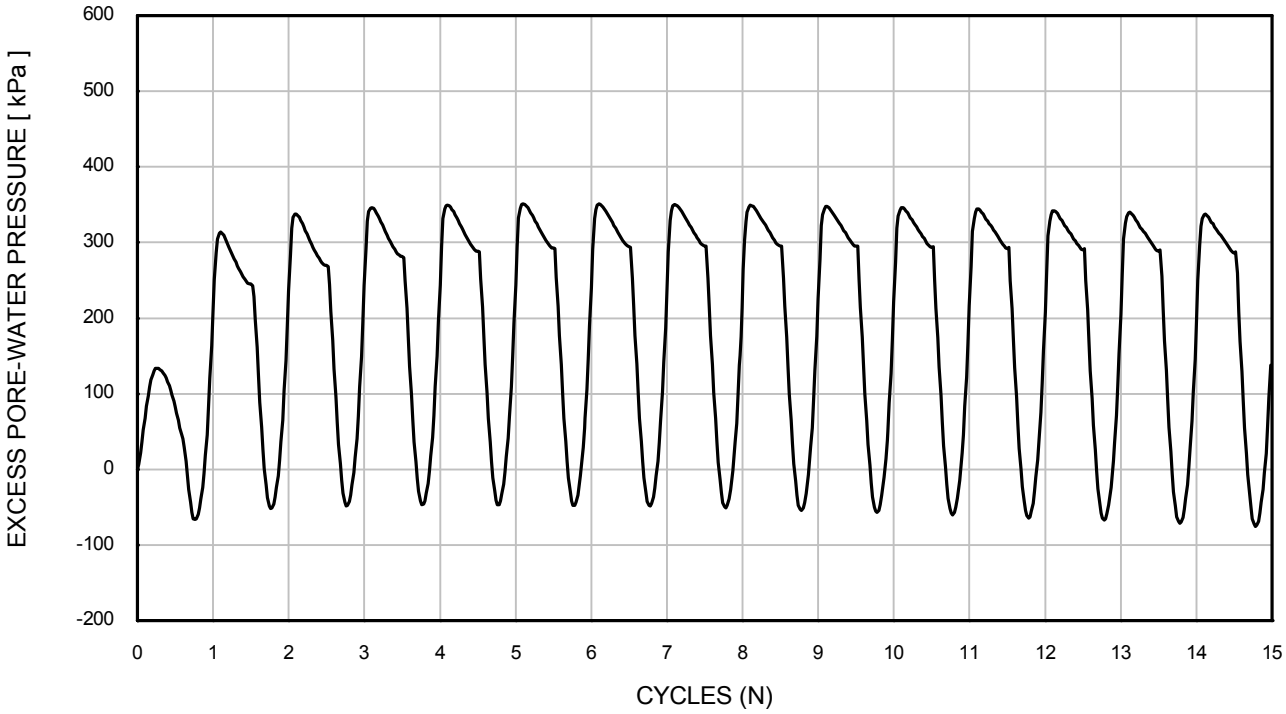


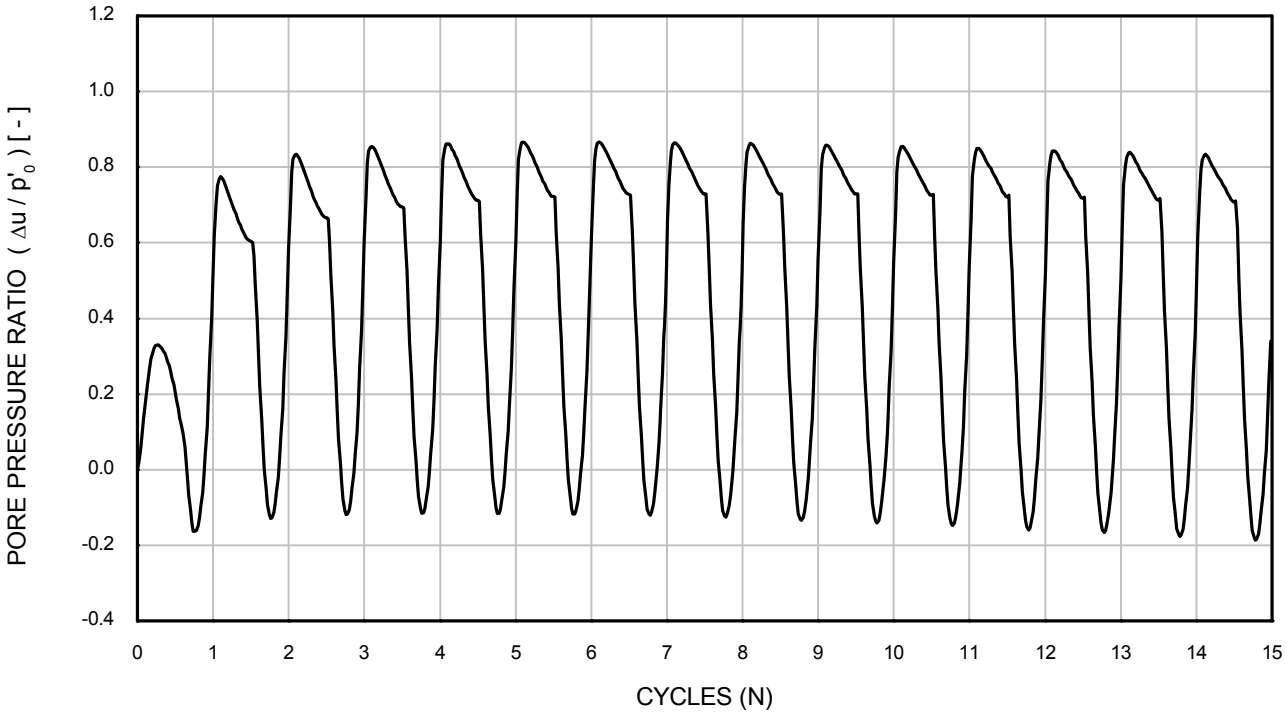


Initial σ'_r	:	405 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	405 kPa	Sample	:	30WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	338 kPa	Depth [m]	:	41.58
Frequency	:	0.10 Hz	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

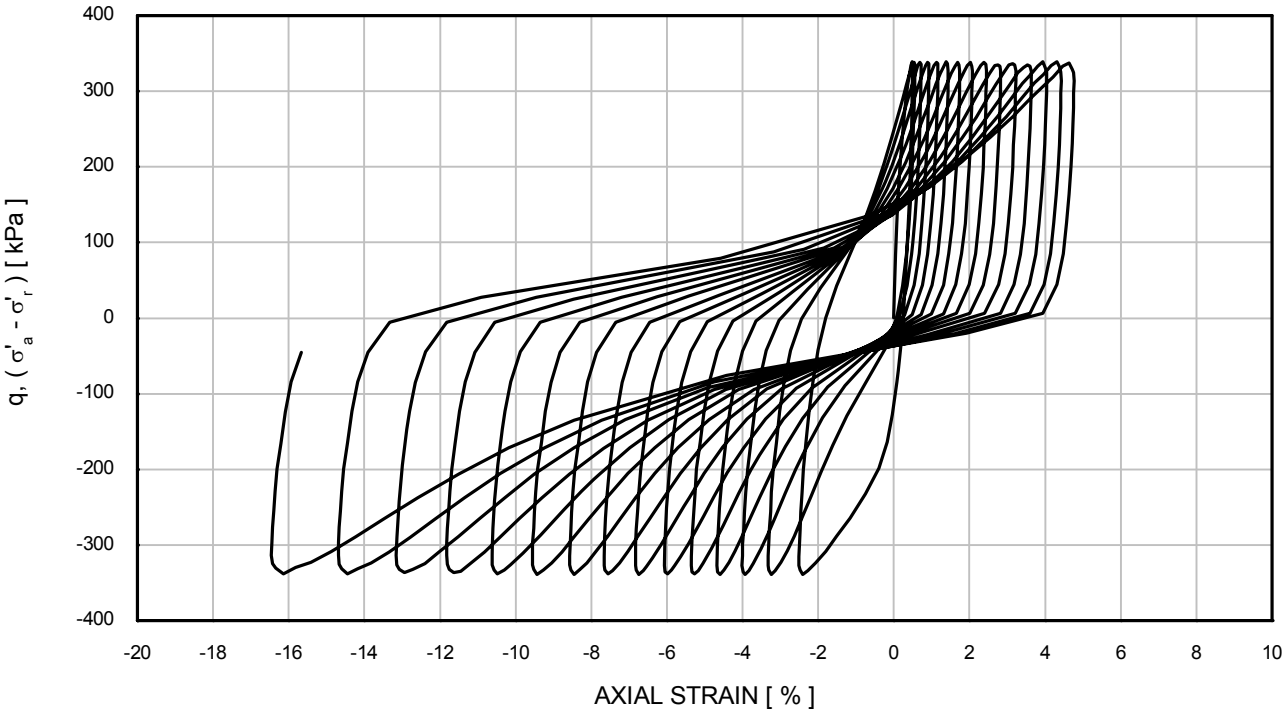


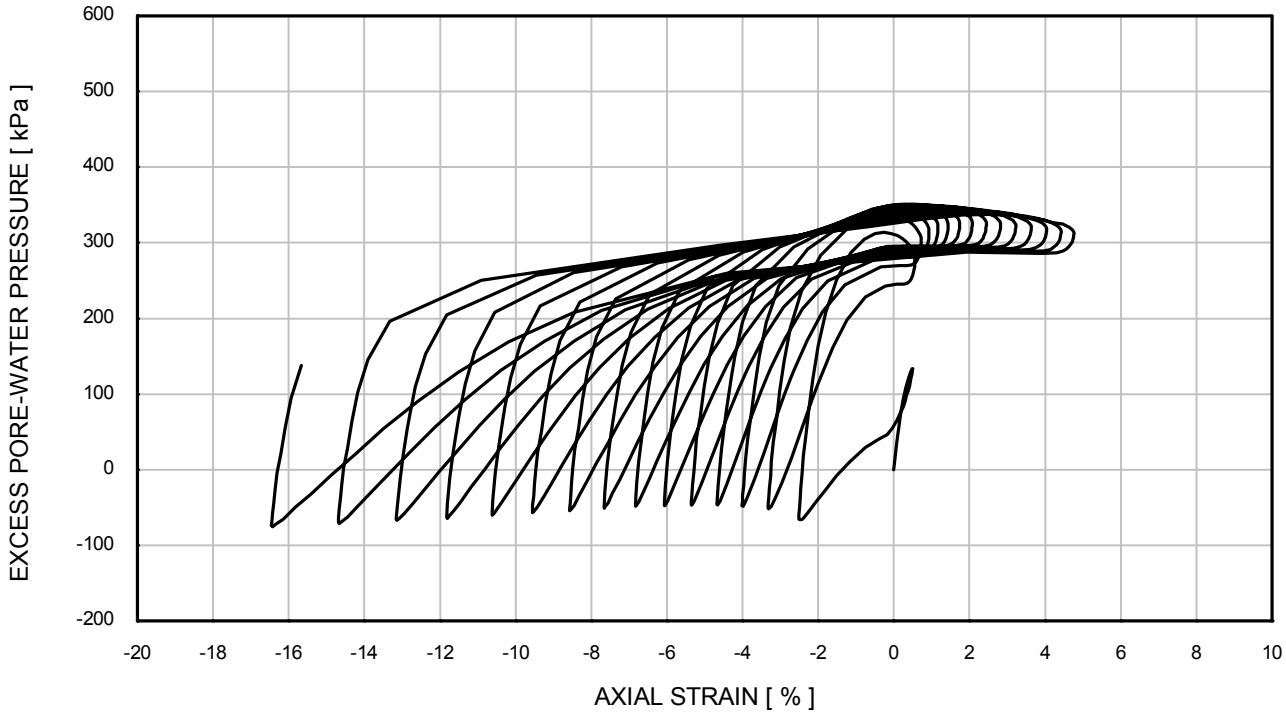


Initial σ'_r	:	405 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	405 kPa	Sample	:	30WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	338 kPa	Depth [m]	:	41.58
Frequency	:	0.10 Hz	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

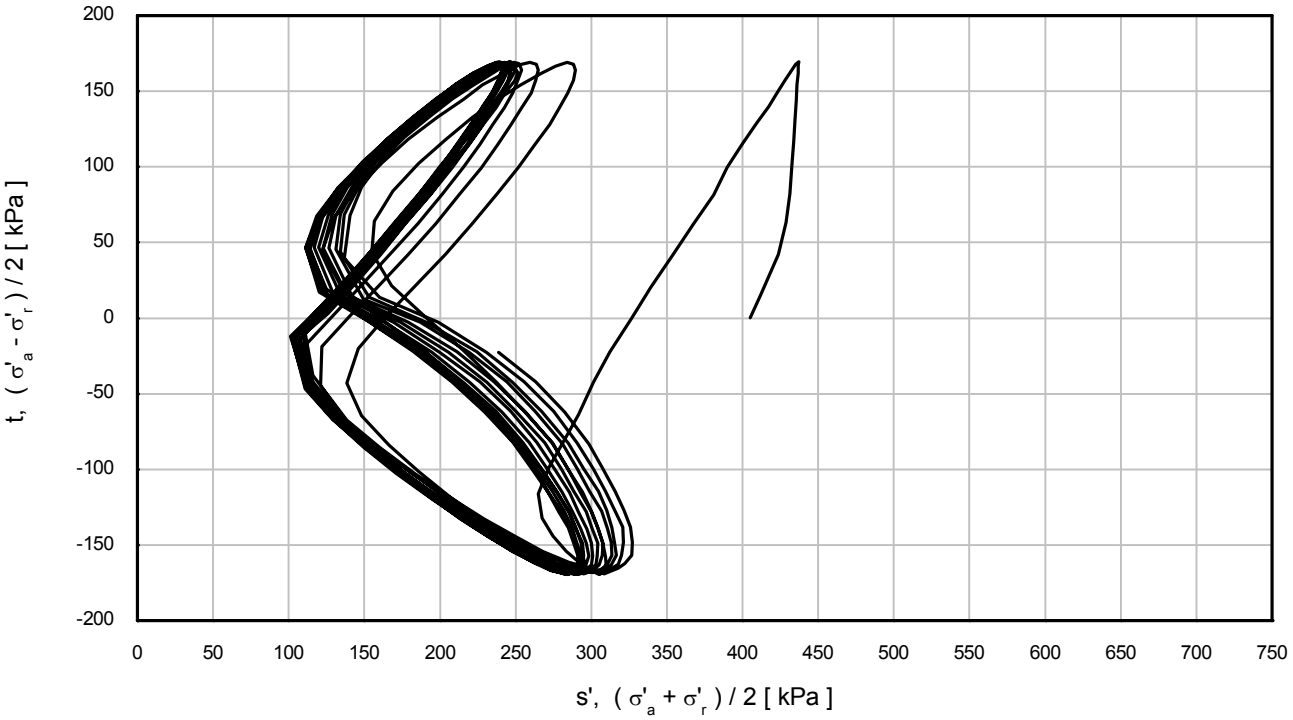


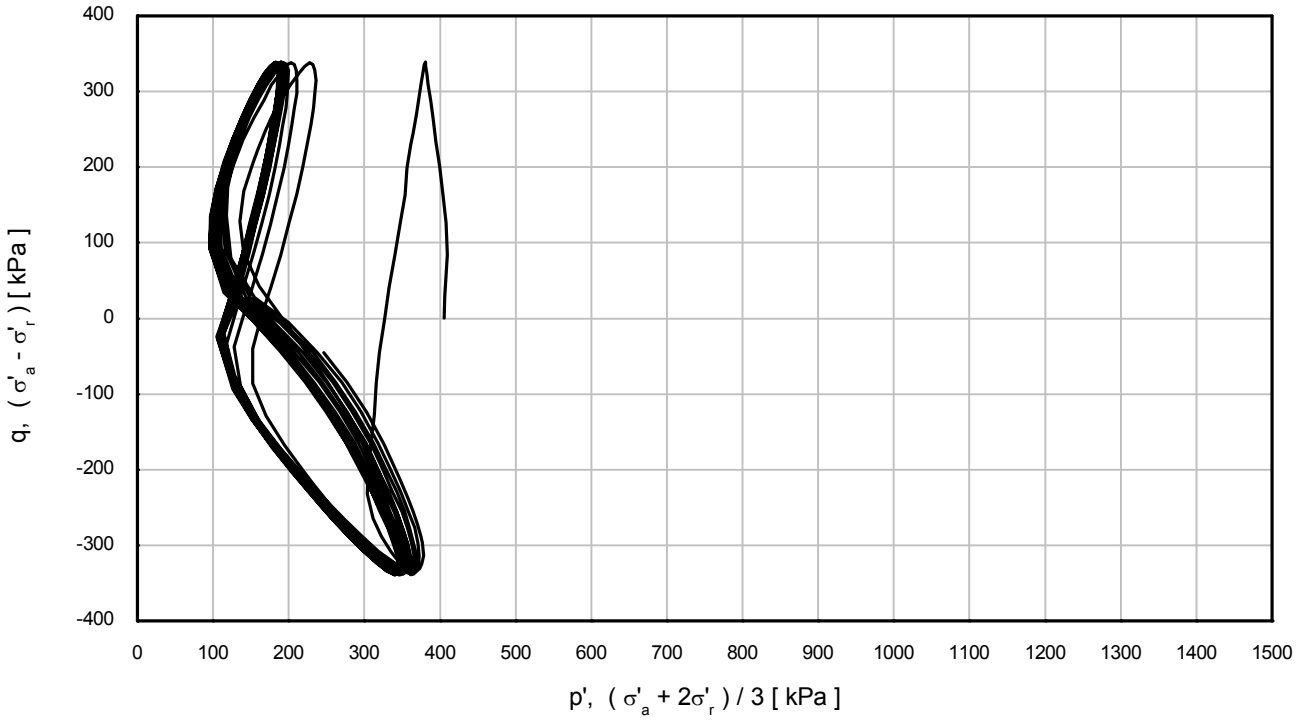


Initial σ'_r	:	405 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	405 kPa	Sample	:	30WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	338 kPa	Depth [m]	:	41.58
Frequency	:	0.10 Hz	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

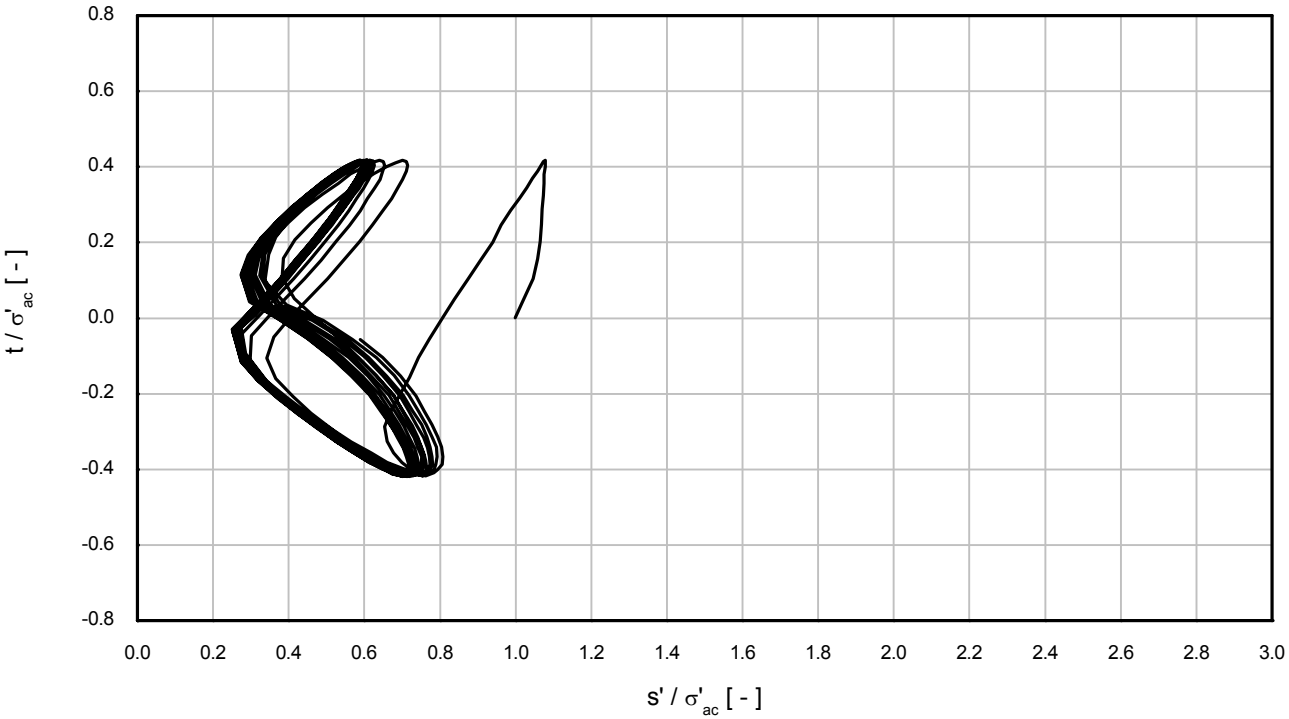


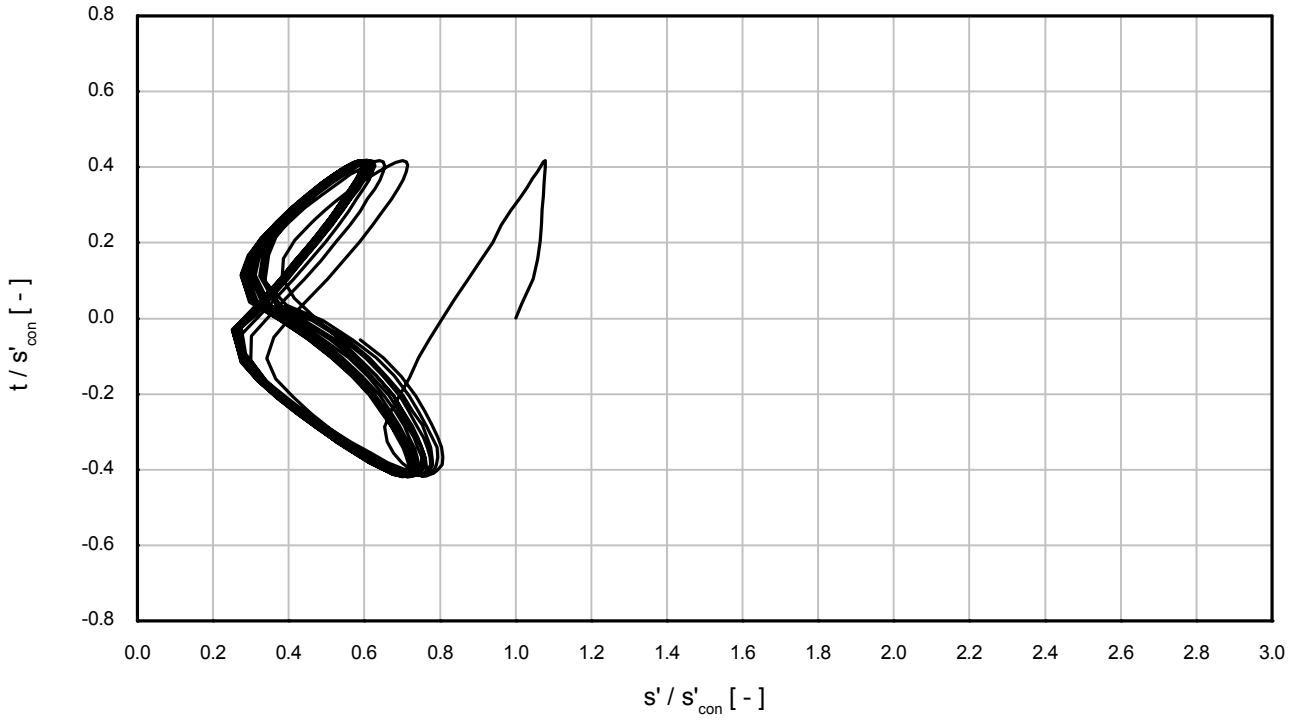


Initial σ'_r	:	405 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	405 kPa	Sample	:	30WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	338 kPa	Depth [m]	:	41.58
Frequency	:	0.10 Hz	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

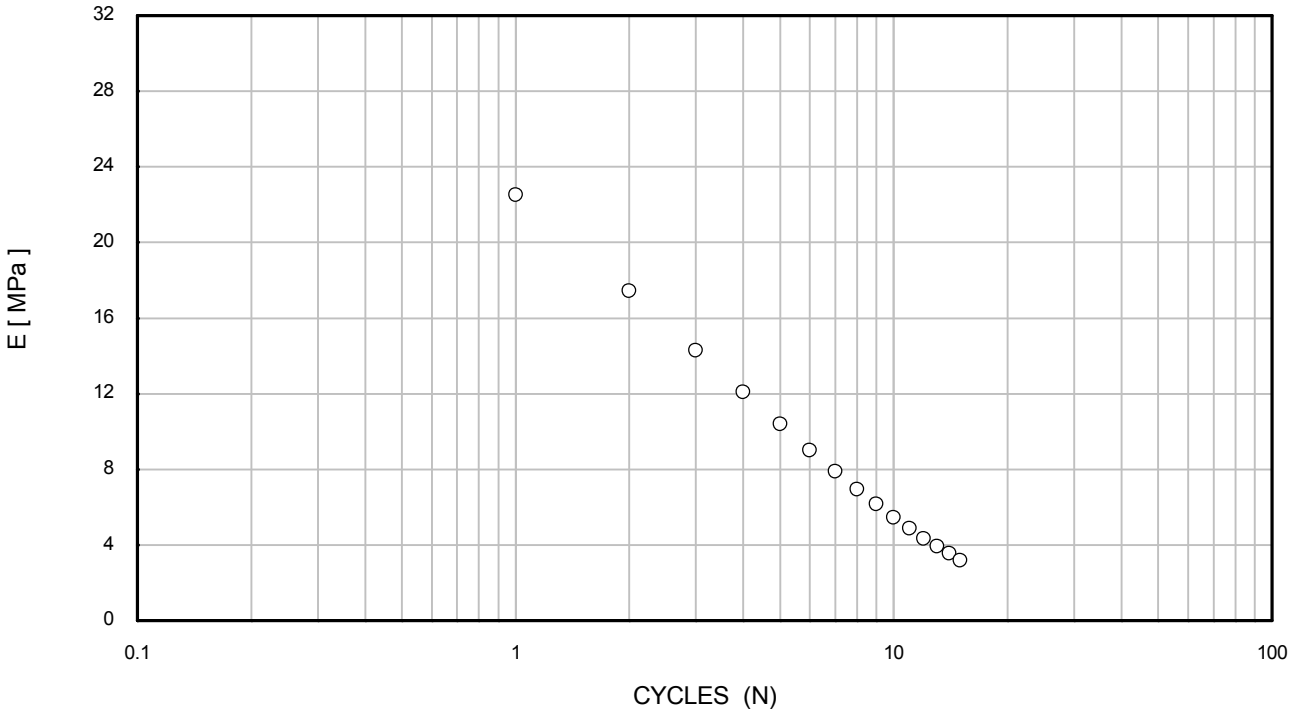


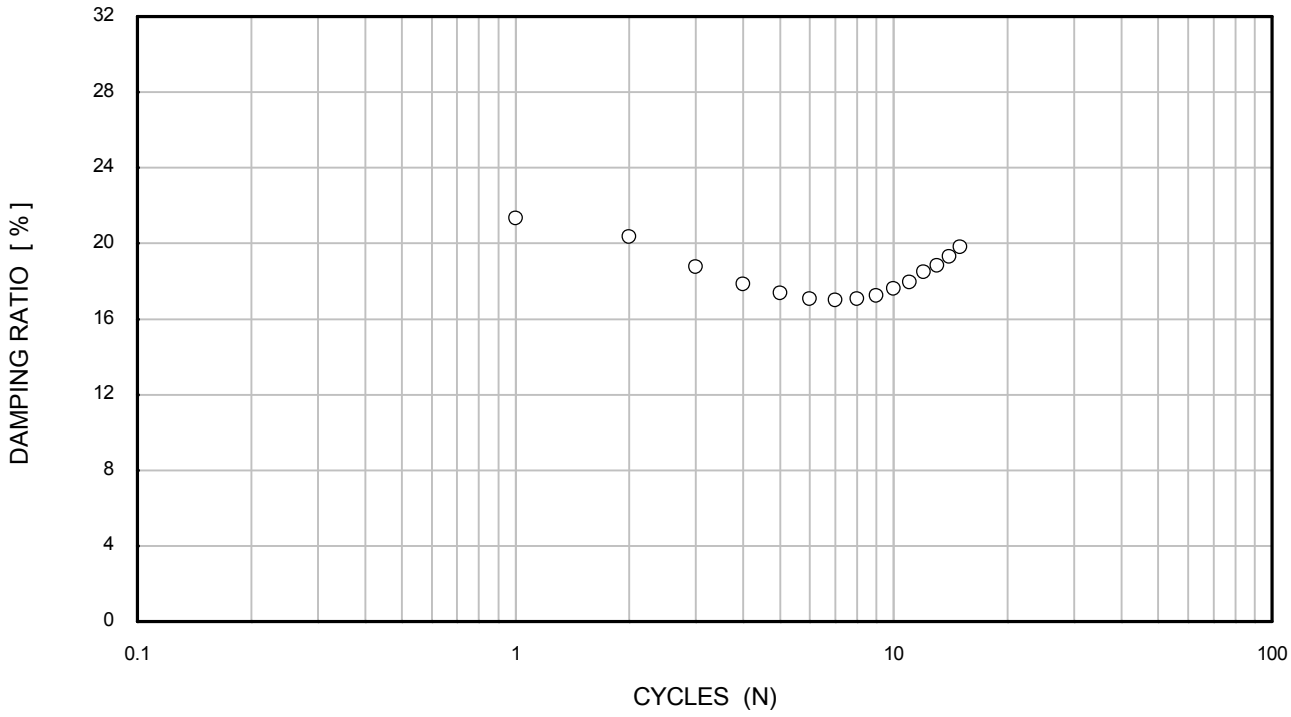


Initial σ'_r	:	405 kPa	Borehole	: BH-WFS3-1
Initial σ'_a	:	405 kPa	Sample	: 30WaxC
q_{av}	:	0 kPa	Unit	: F3 (Dongen)
q_{cy}	:	338 kPa	Depth [m]	: 41.58
Frequency	:	0.10 Hz	Test No.	: CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

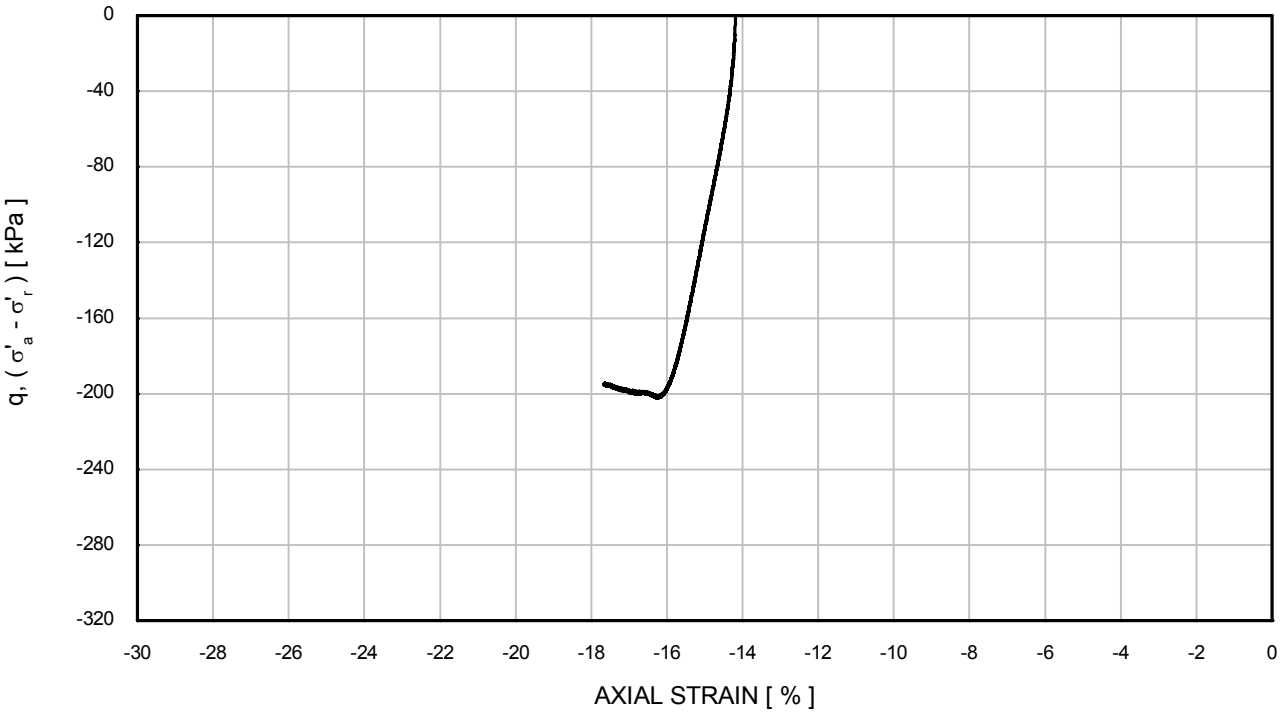


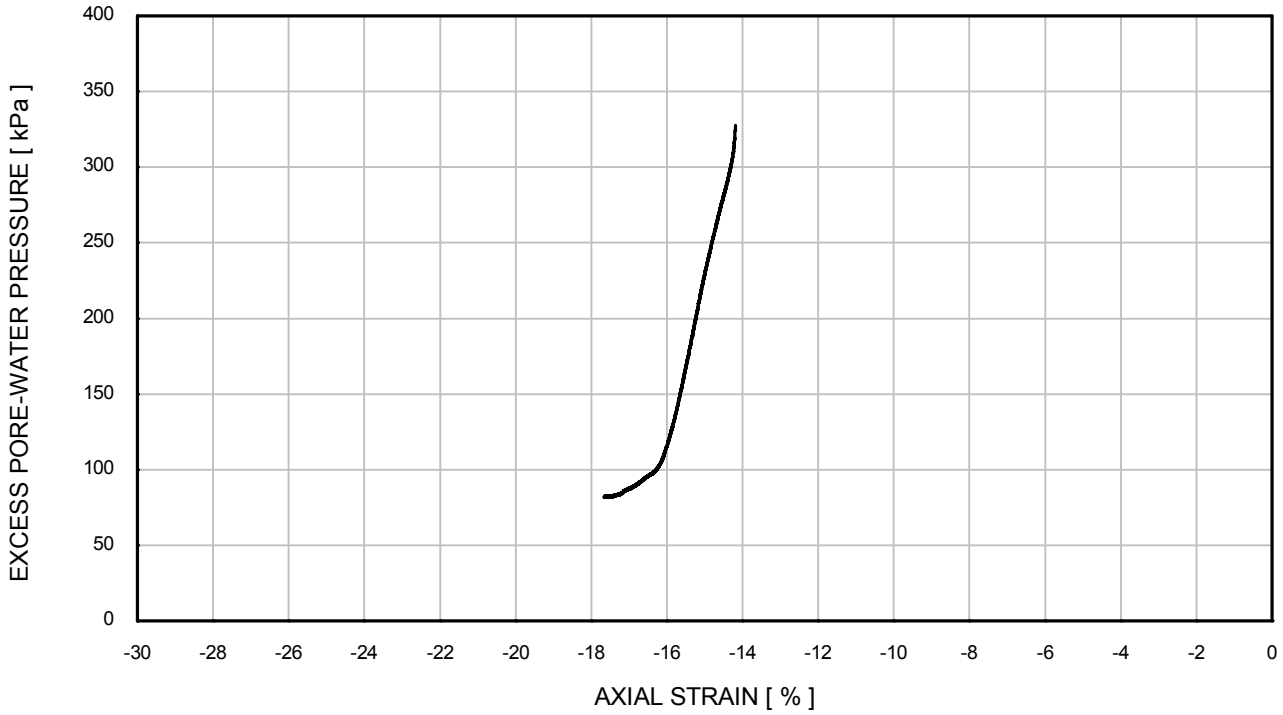


Initial σ'_r	:	405 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	405 kPa	Sample	:	30WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	338 kPa	Depth [m]	:	41.58
Frequency	:	0.10 Hz	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

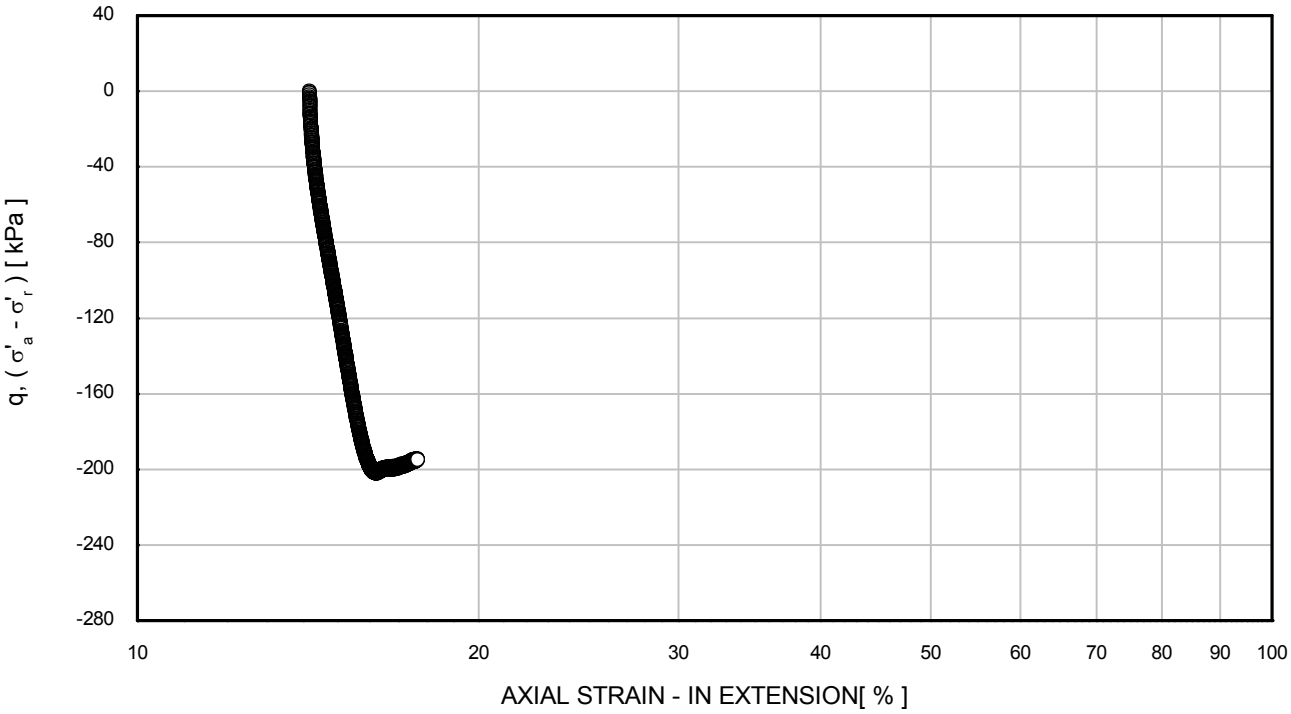


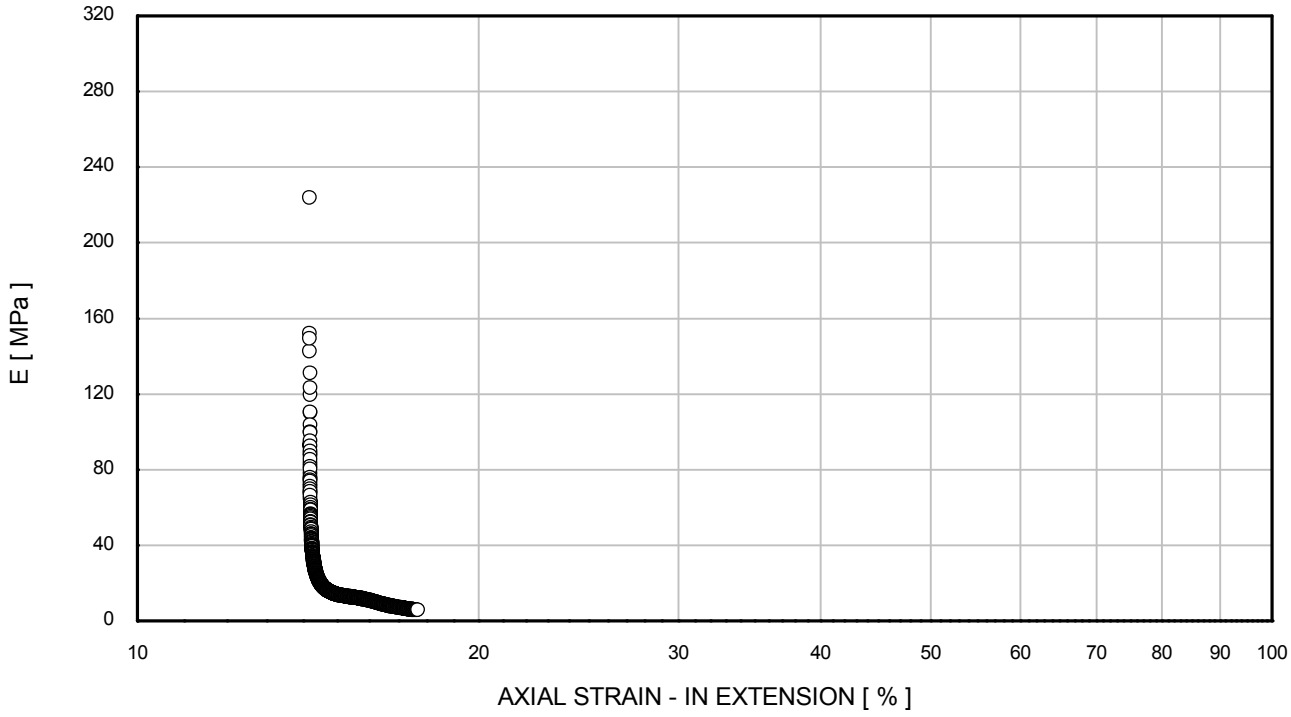


Initial σ'_r	:	77 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	77 kPa	Sample	:	30WaxC
q_{peak}	:	-202 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	-16.25 %	Depth [m]	:	41.58
Rate of strain	:	0.99 %/hour	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

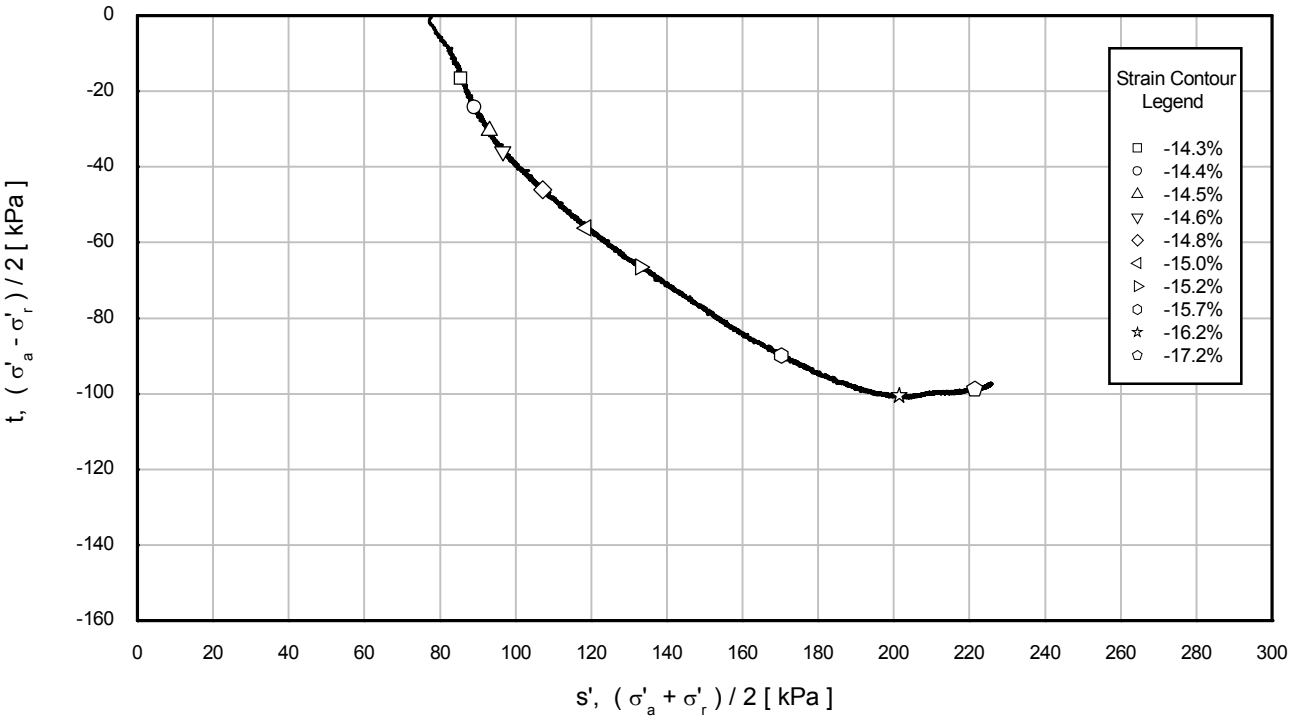


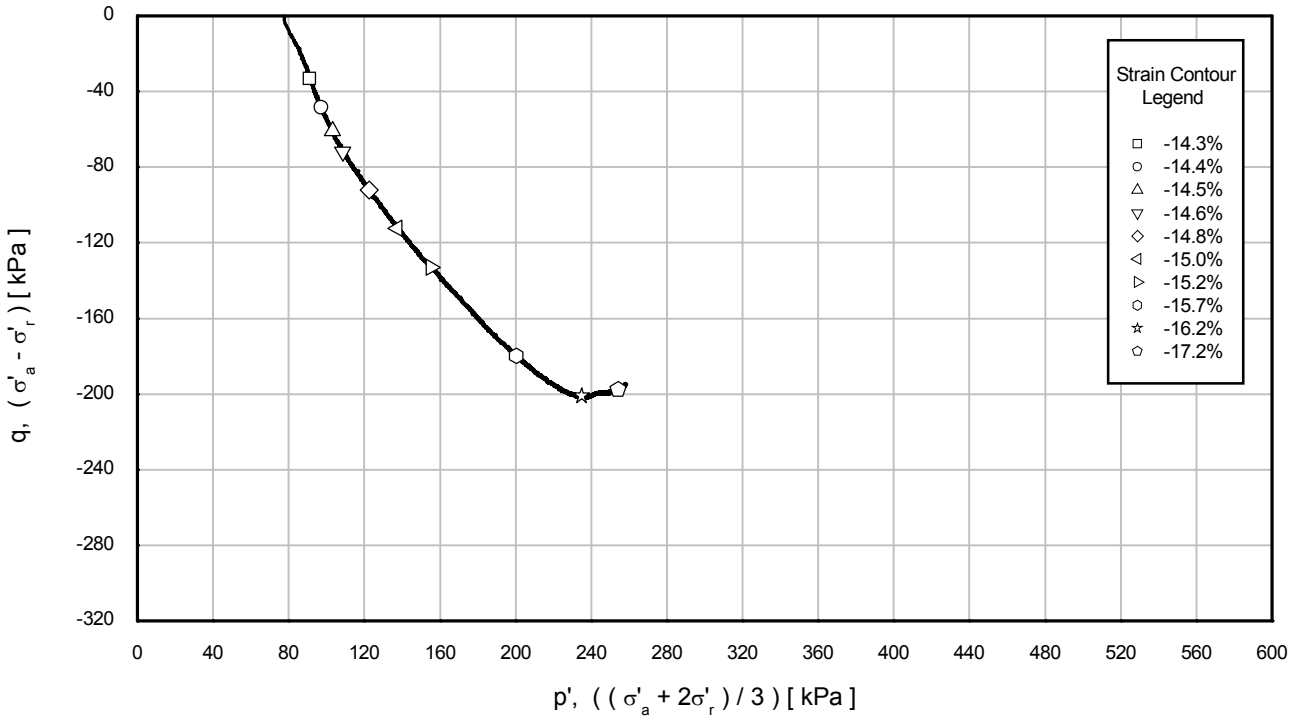


Initial σ'_r	:	77 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	77 kPa	Sample	:	30WaxC
q_{peak}	:	-202 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	-16.25 %	Depth [m]	:	41.58
Rate of strain	:	0.99 %/hour	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	77 kPa	Borehole	:	BH-WFS3-1
Initial σ'_a	:	77 kPa	Sample	:	30WaxC
q_{peak}	:	-202 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	-16.25 %	Depth [m]	:	41.58
Rate of strain	:	0.99 %/hour	Test No.	:	CTX02

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark greenish grey CLAY with black staining and with pockets of light grey silty fine sand

GENERAL	
Date test started	06/12/2015
Type of sample	Undisturbed
Type of drains fitted	Radial (spiral) & one end only

INITIAL		
Diameter	[mm]	71.3
Length	[mm]	145.6
Moisture content	[%]	38.8
Bulk density	[Mg/m³]	1.83
Dry density	[Mg/m³]	1.32
Void ratio	[-]	1.051
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic	BS1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ BH-WFS4-1A_22C_CTX03
Processed by	PR
Date	10/12/2015
Checked by	LJ
Date	15/12/2015
Approved by	PH
Date	15/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	22WaxC
Unit	F3 (Dongen)
Depth [m]	37.48
Test number	CTX03

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Undrained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	N/A
Cell pressure	[kPa]	1350
Base PWP	[kPa]	1017
Mid height PWP	[kPa]	-
B value achieved	[-]	0.97

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1350
Back pressure	[kPa]	1000
Base PWP	[kPa]	1000
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	350
Effective axial pressure	[kPa]	350
Deviator stress	[kPa]	0
Volumetric strain	[%]	0.12
External axial strain	[%]	0.04
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	38.7
Bulk density	[Mg/m³]	1.83
Dry density	[Mg/m³]	1.32
Void ratio	[-]	1.048
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	22WaxC
Unit	F3 (Dongen)
Depth [m]	37.48
Test number	CTX03

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	560
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	235
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1500
External ε_{av} at N_f	[%]	-0.42
External ε_{cy} at N_f	[%]	0.64
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	68
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	38.7
Bulk density	[Mg/m³]	1.83
Dry density	[Mg/m³]	1.32
Void ratio	[-]	1.048
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-0.08	0.37	64.03	-	12.11	-
2	-0.10	0.39	60.51	-	12.34	-
5	-0.13	0.41	56.96	-	12.11	-
10	-0.15	0.43	54.60	-	11.90	-
20	-0.18	0.45	52.11	-	11.69	-
30	-0.20	0.46	50.68	-	11.62	-
40	-0.21	0.47	49.65	-	11.53	-
50	-0.22	0.48	48.95	-	11.49	-
100	-0.25	0.51	46.38	-	11.22	-
500	-0.35	0.58	40.66	-	10.53	-
1000	-0.39	0.62	38.10	-	10.24	-
1500	-0.42	0.64	36.59	-	10.12	-

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	22WaxC
Unit	F3 (Dongen)
Depth [m]	37.48
Test number	CTX03

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	266
Initial effective axial pressure	[kPa]	265
Rate of strain	[%/hour]	0.20
At peak deviator stress		
Corrected deviator stress	[kPa]	576
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	3.73
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	155
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	195
Effective axial pressure	[kPa]	771
Principal effective stress ratio	[-]	3.96
ε_{50}	[%]	0.44
Secant modulus (E_{50}) at ε_{50}	[kPa]	30850
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	541
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	2.40
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	185
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	165
Effective axial pressure	[kPa]	706
Principal effective stress ratio	[-]	4.28
At 5% external axial strain		
Corrected deviator stress	[kPa]	564
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	5.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	132
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	218
Effective axial pressure	[kPa]	782
Principal effective stress ratio	[-]	3.59

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	22WaxC
Unit	F3 (Dongen)
Depth [m]	37.48
Test number	CTX03

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS





FINAL CONDITIONS

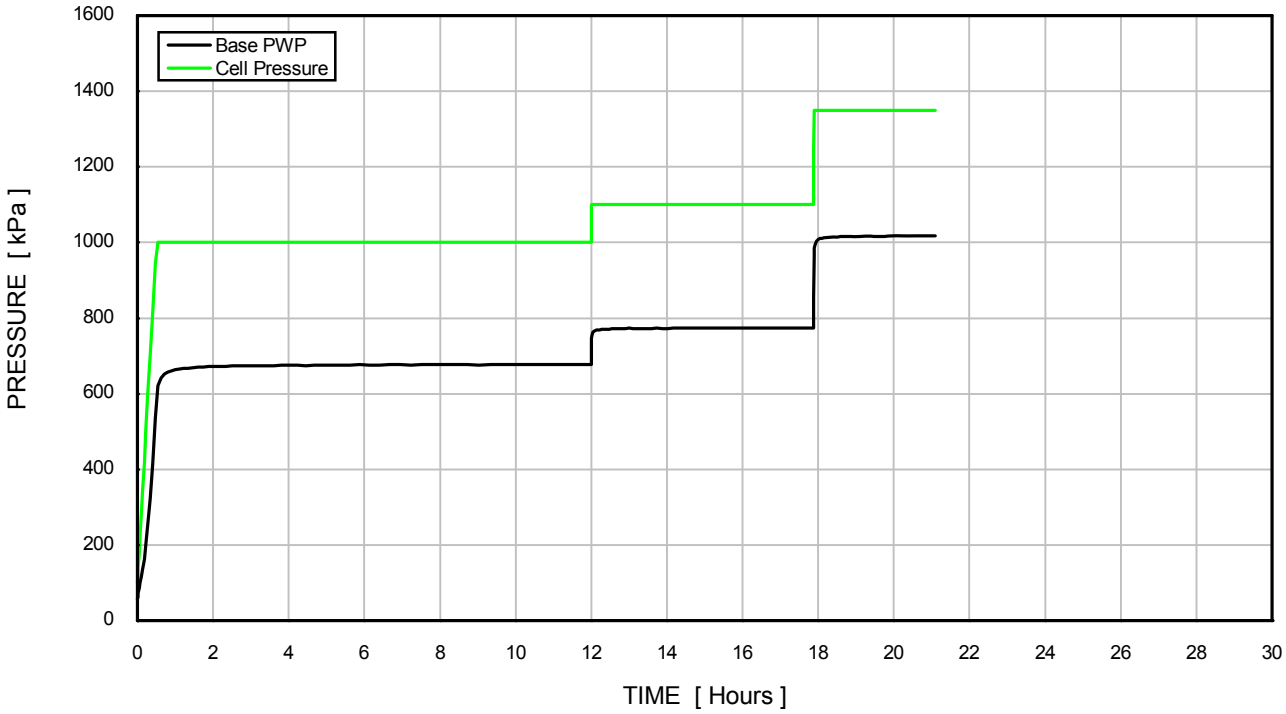
Moisture content	[%]	38.7
Bulk density	[Mg/m³]	1.83
Dry density	[Mg/m³]	1.32

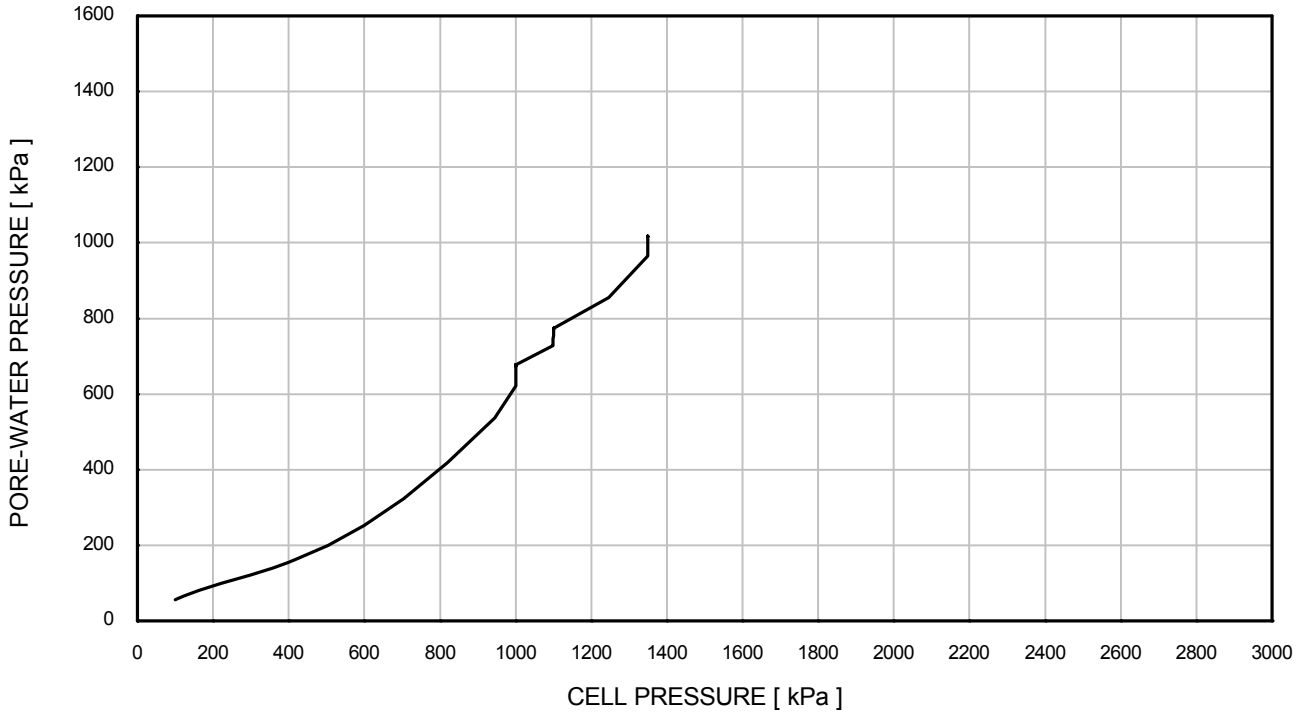
TEST IDENTIFICATION

Borehole	BH-WFS4-1A
Sample	22WaxC
Unit	F3 (Dongen)
Depth [m]	37.48
Test number	CTX03

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

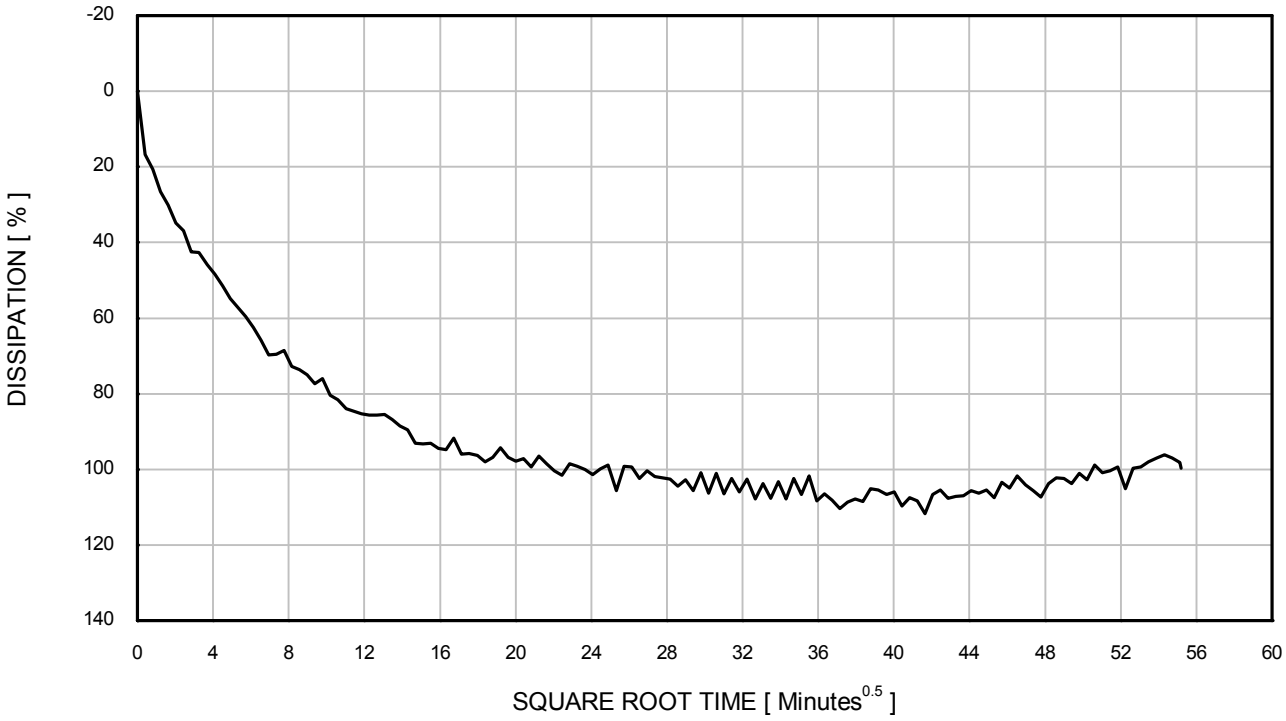


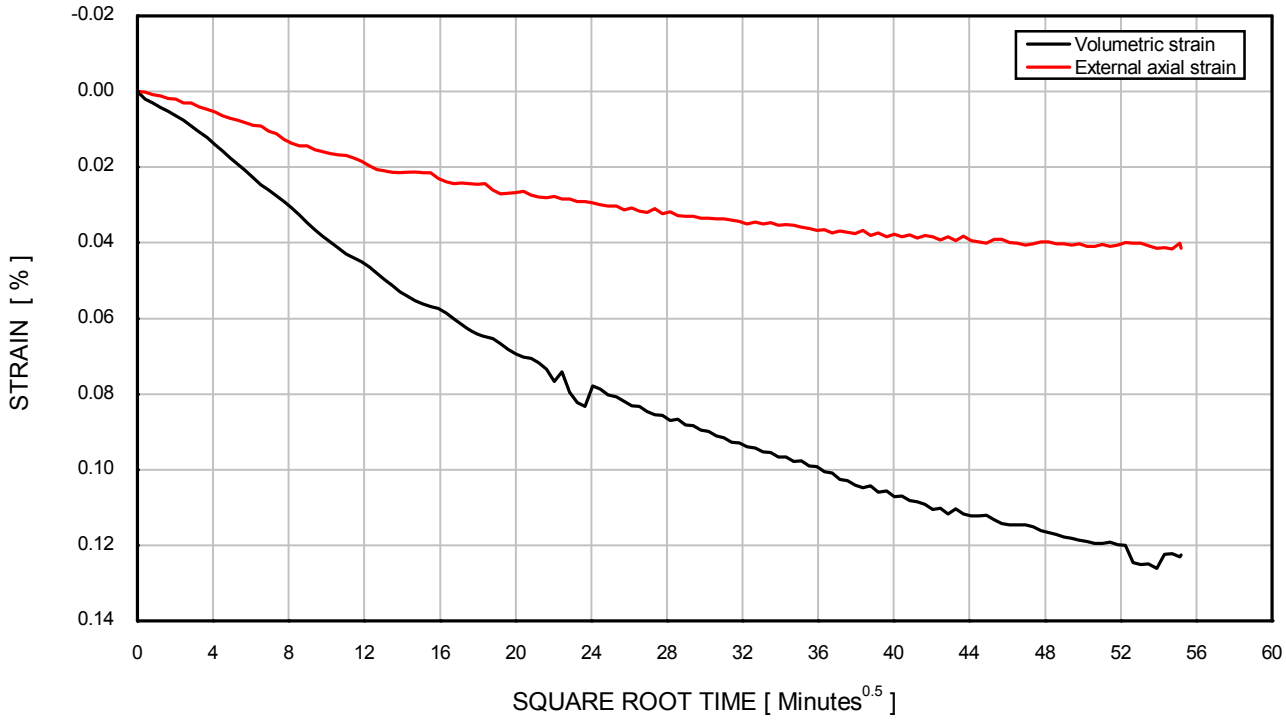


B value	:	0.97	Borehole	:	BH-WFS4-1A
Initial σ'_r	:	44 kPa	Sample	:	22WaxC
Initial σ'_a	:	44 kPa	Unit	:	F3 (Dongen)
Final σ'_r	:	333 kPa	Depth [m]	:	37.48
Final σ'_a	:	333 kPa	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - UNDRAINED

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

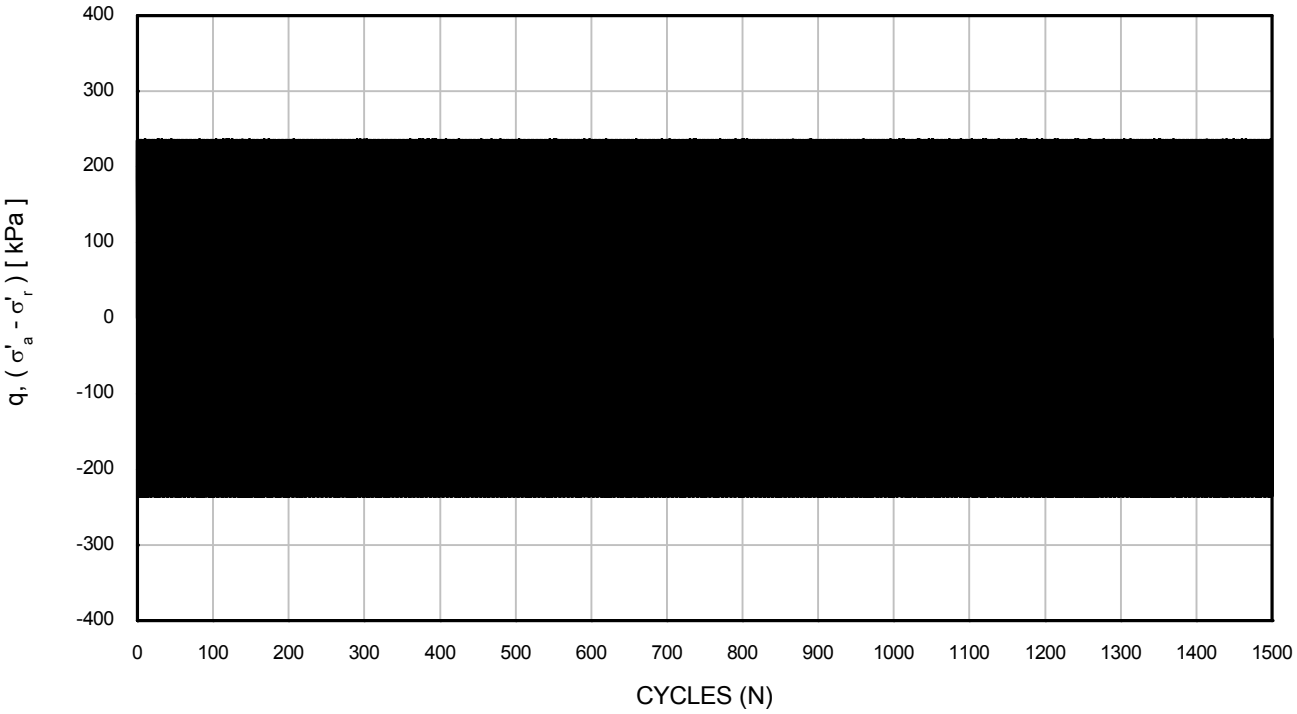


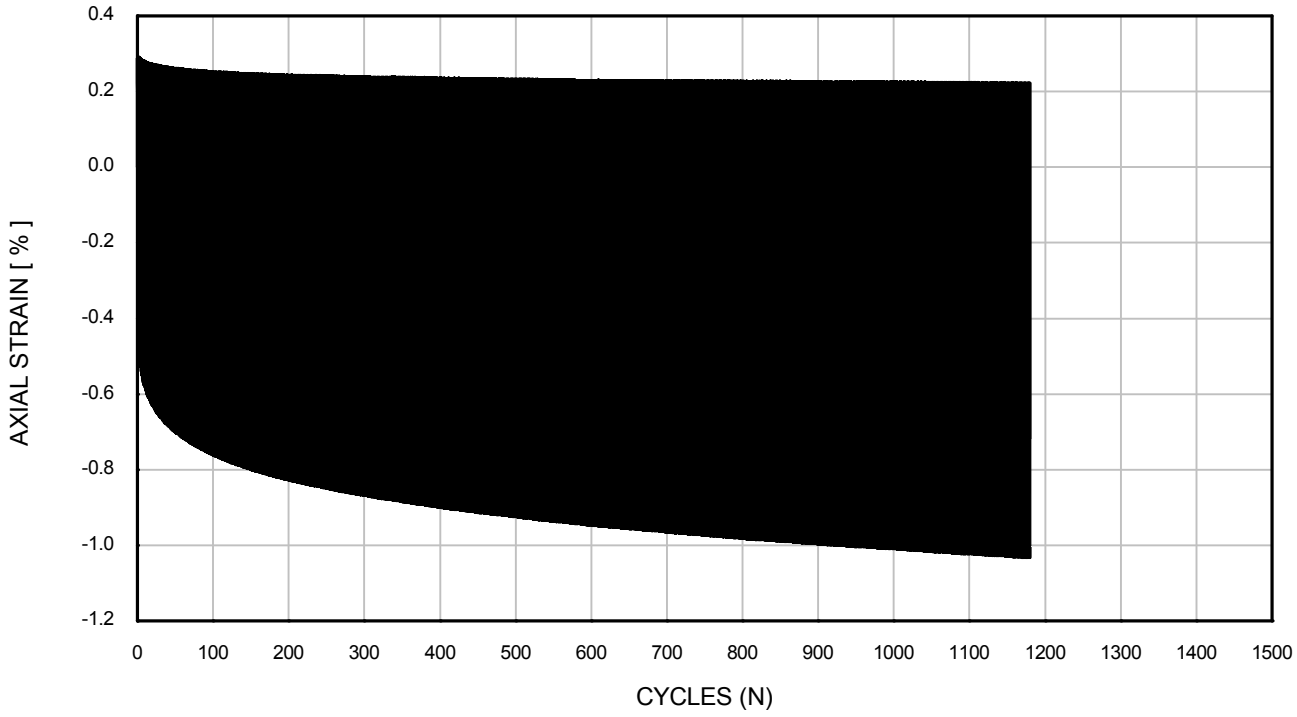


σ'_{rc}	: 350 kPa	Borehole	: BH-WFS4-1A
σ'_{ac}	: 350 kPa	Sample	: 22WaxC
		Unit	: F3 (Dongen)
		Depth [m]	: 37.48
		Test No.	: CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

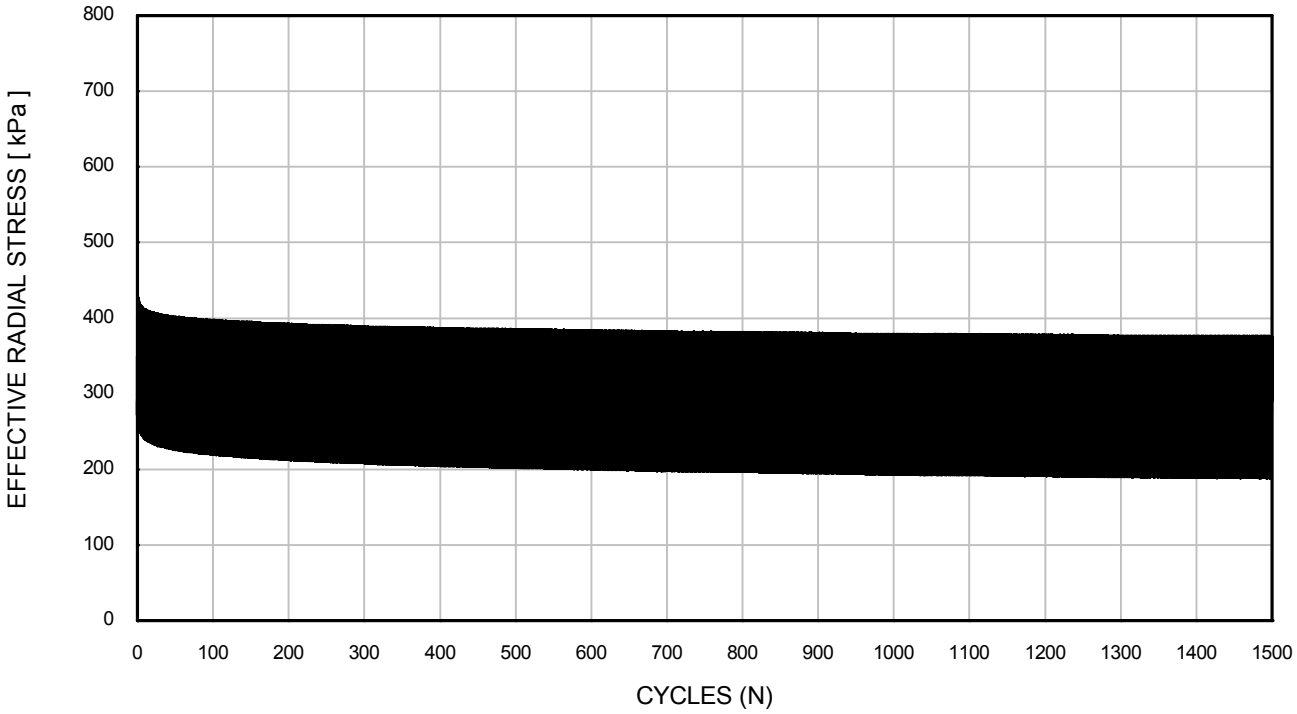


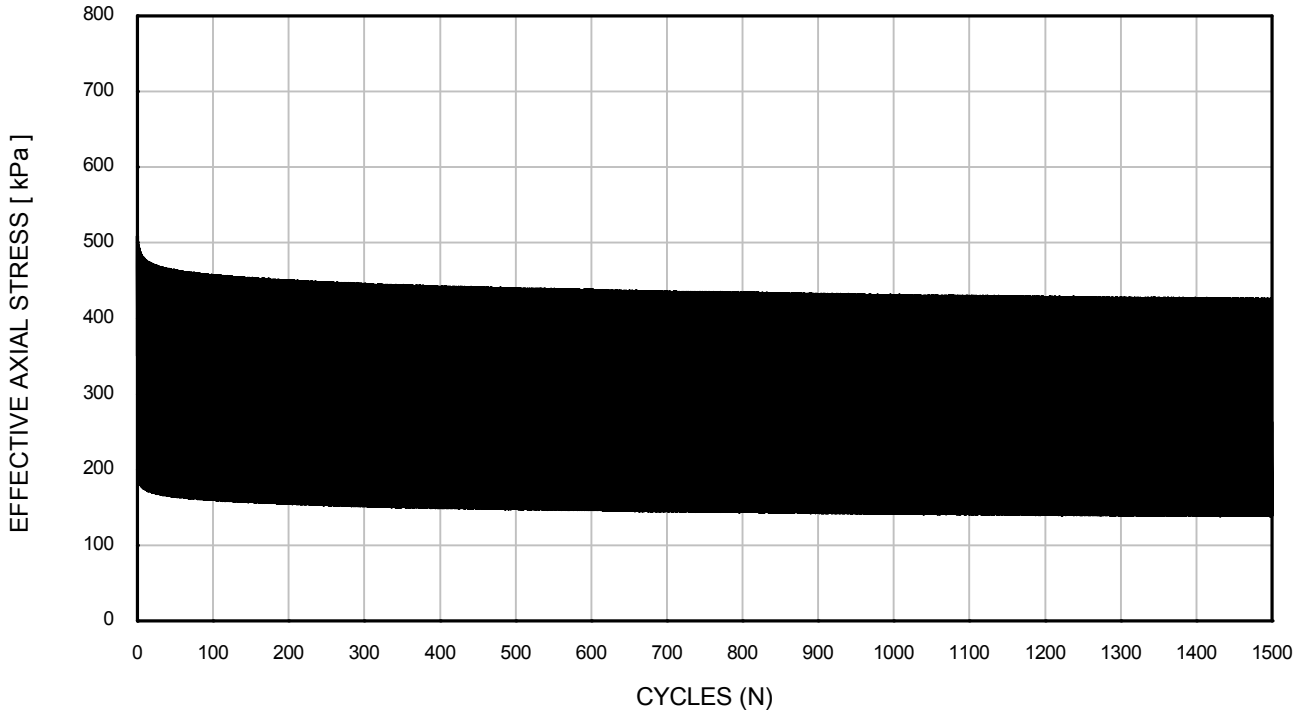


Initial σ'_r	:	350 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	350 kPa	Sample	:	22WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	235 kPa	Depth [m]	:	37.48
Frequency	:	0.10 Hz	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

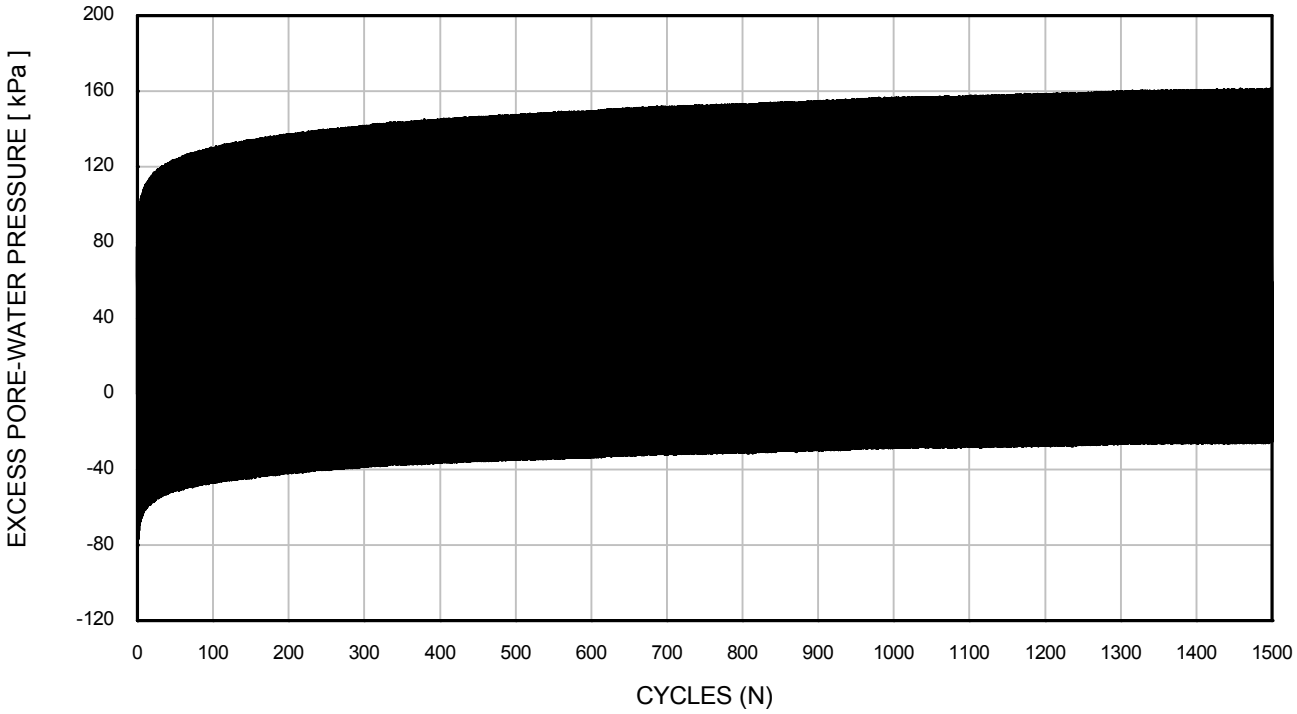


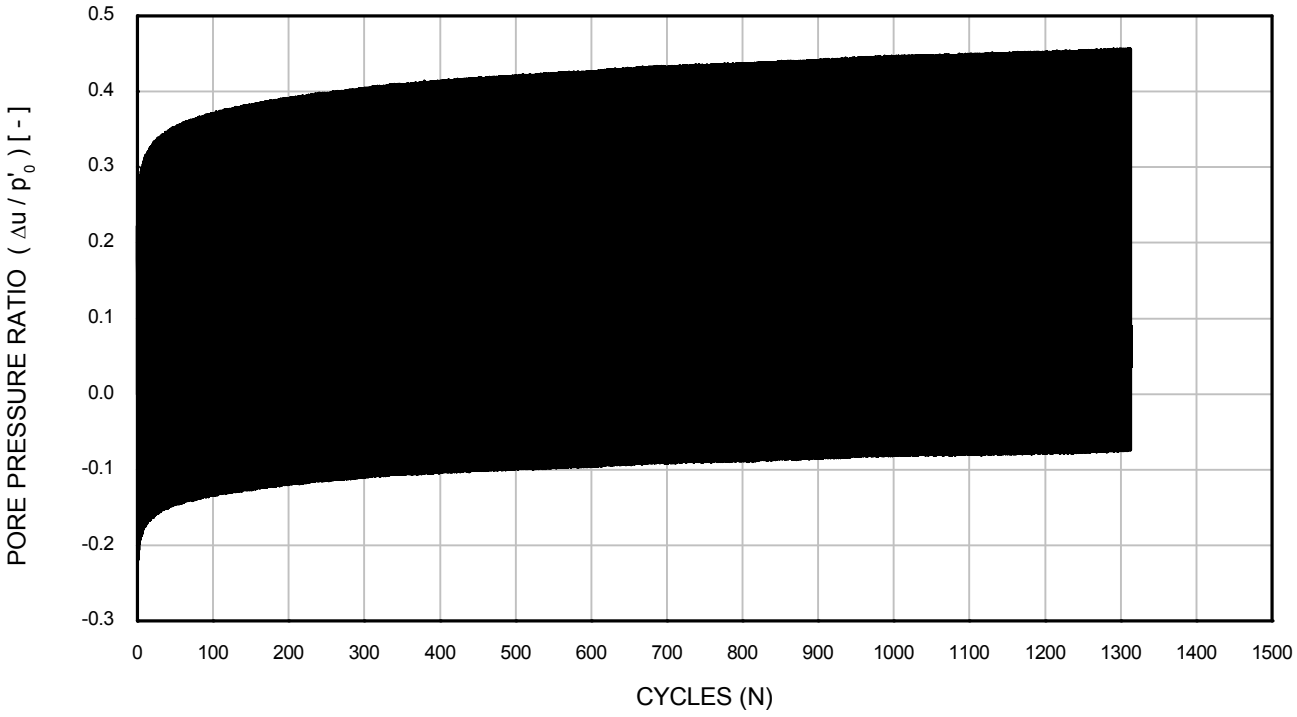


Initial σ'_r	:	350 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	350 kPa	Sample	:	22WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	235 kPa	Depth [m]	:	37.48
Frequency	:	0.10 Hz	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

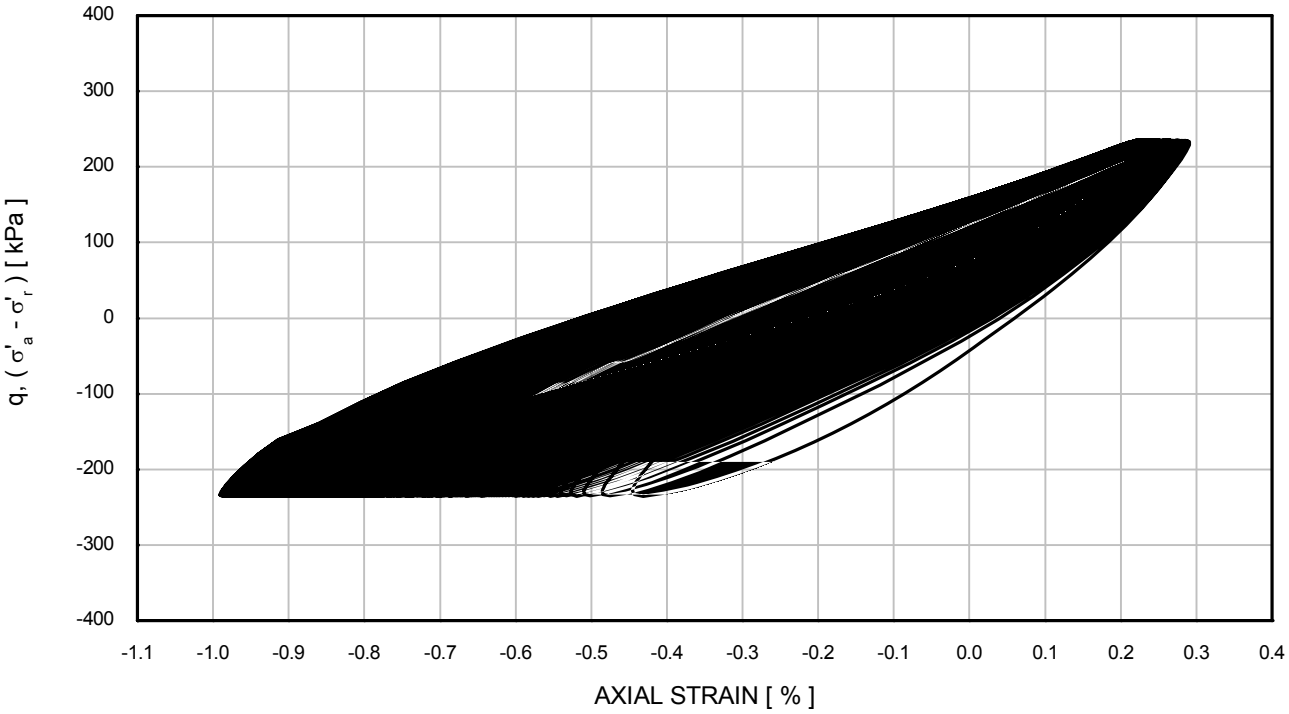


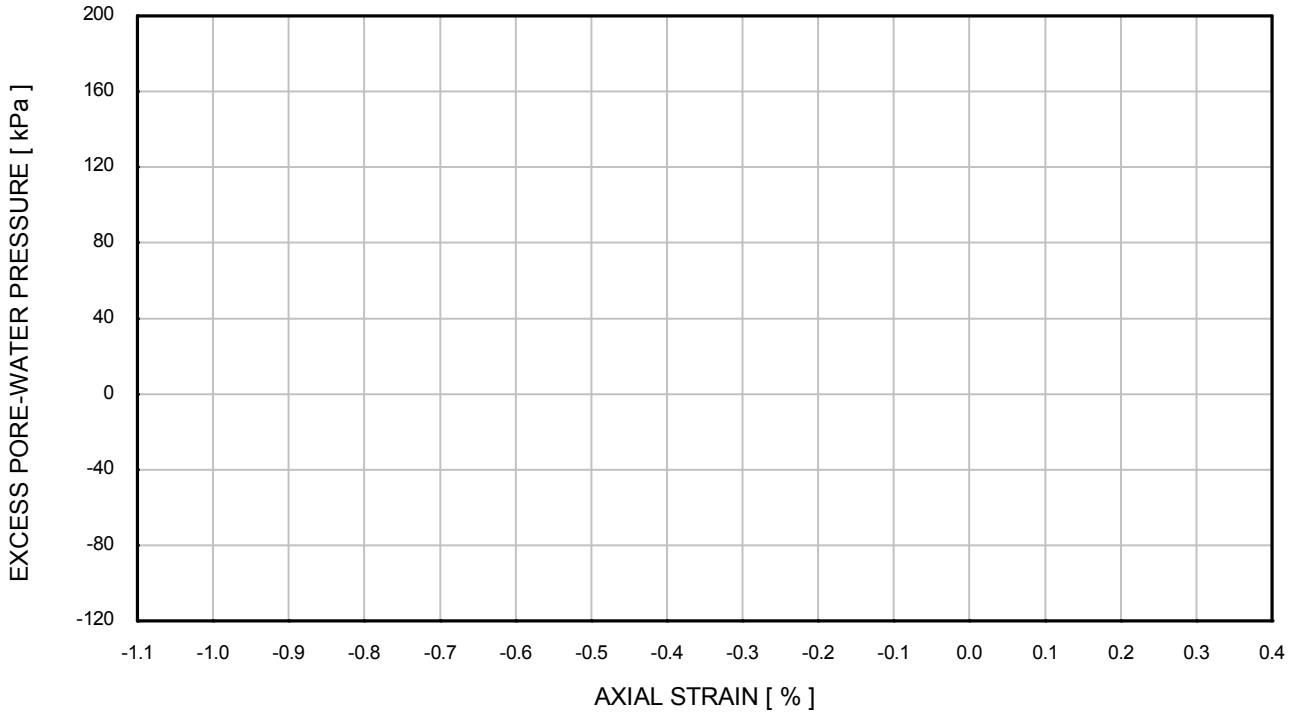


Initial σ'_r	: 350	kPa	Borehole	: BH-WFS4-1A
Initial σ'_a	: 350	kPa	Sample	: 22WaxC
q_{av}	: 0	kPa	Unit	: F3 (Dongen)
q_{cy}	: 235	kPa	Depth [m]	: 37.48
Frequency	: 0.10	Hz	Test No.	: CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

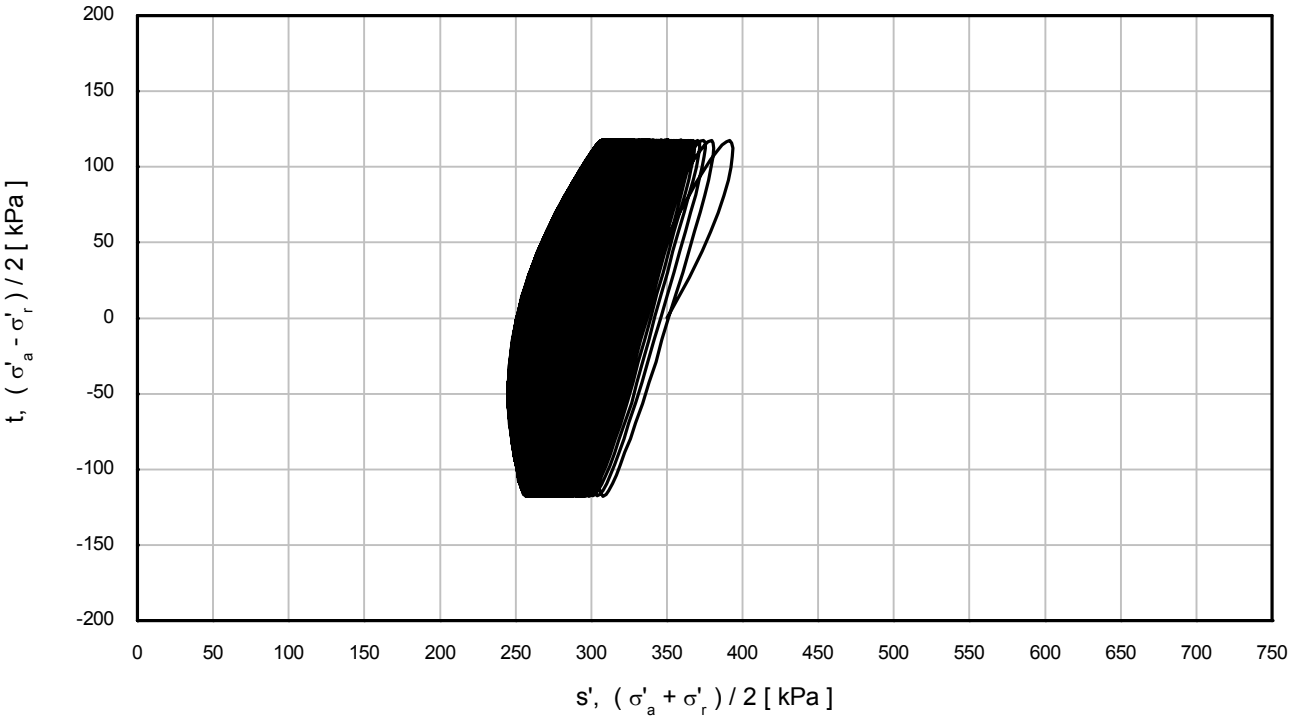


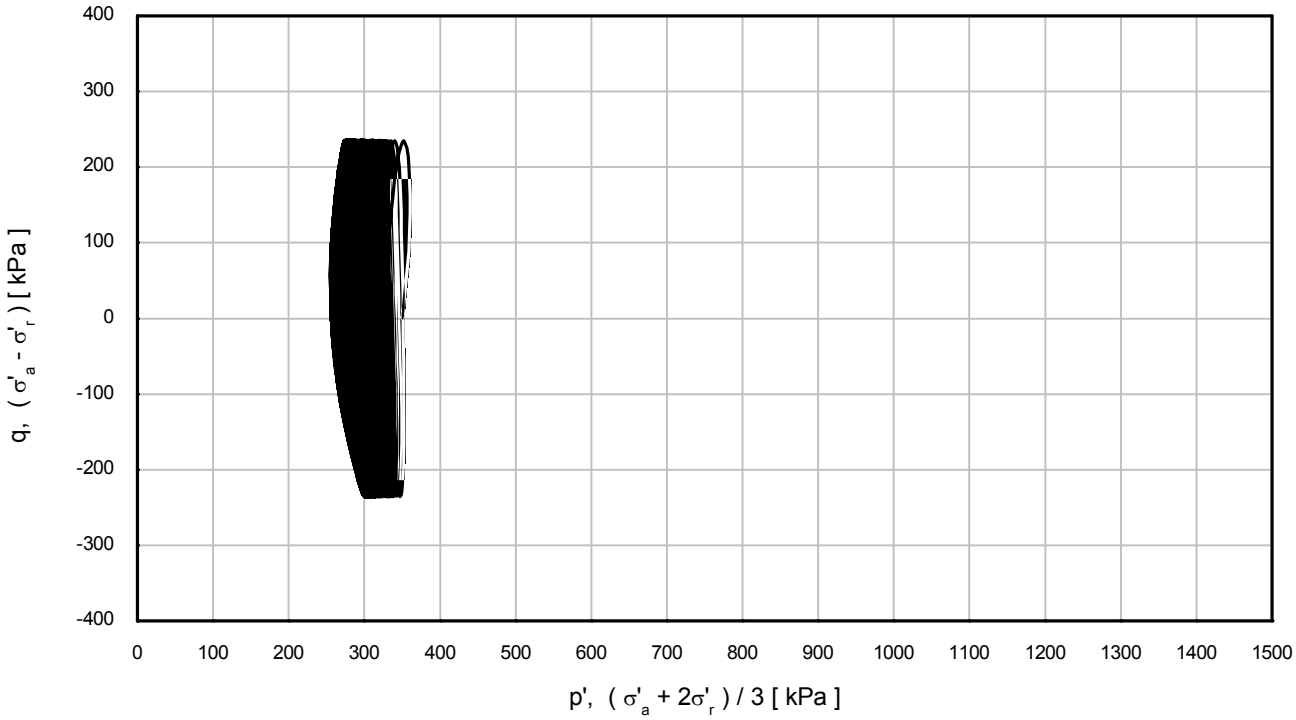


Initial σ'_r	:	350 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	350 kPa	Sample	:	22WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	235 kPa	Depth [m]	:	37.48
Frequency	:	0.10 Hz	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

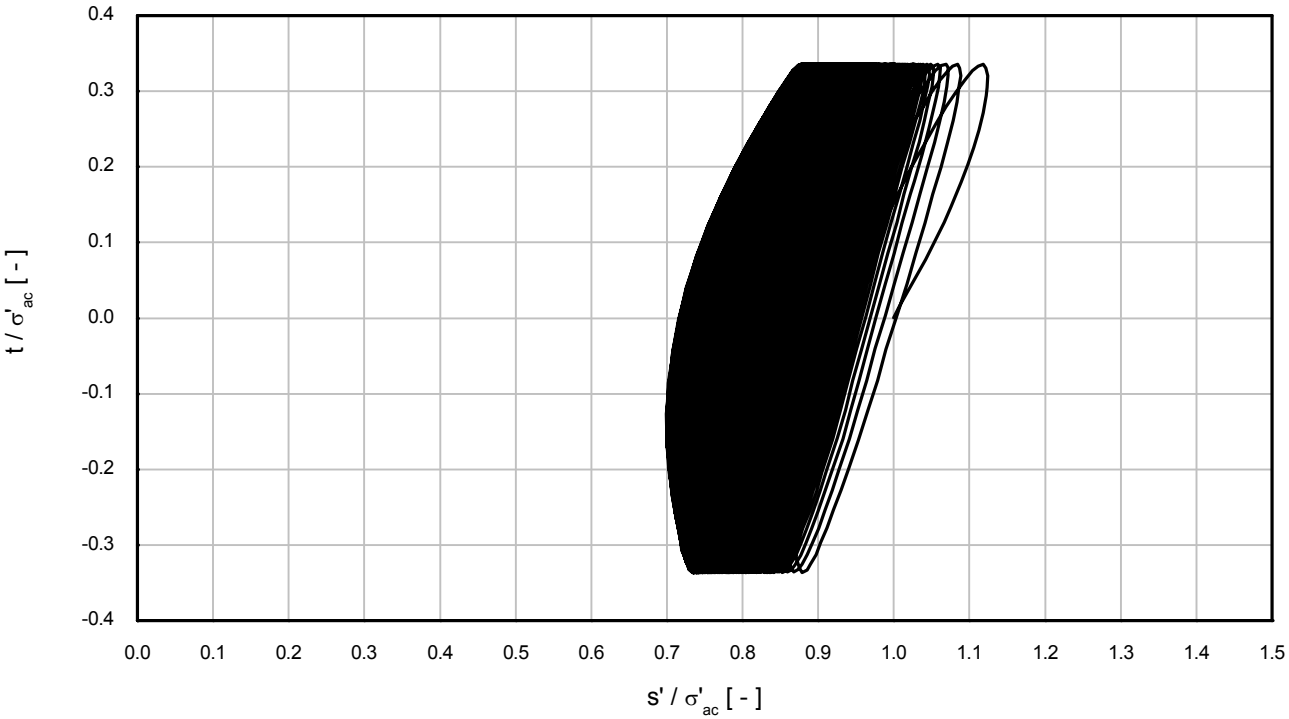


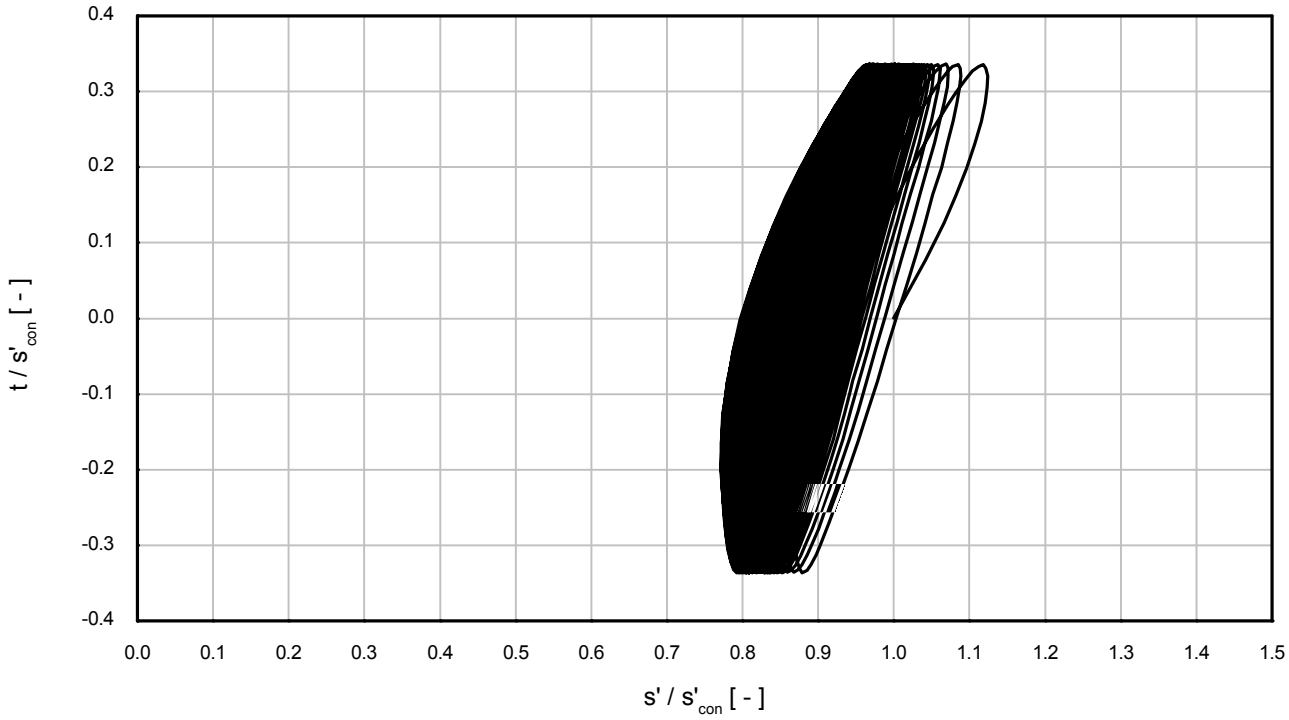


Initial σ'_r	:	350 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	350 kPa	Sample	:	22WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	235 kPa	Depth [m]	:	37.48
Frequency	:	0.10 Hz	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

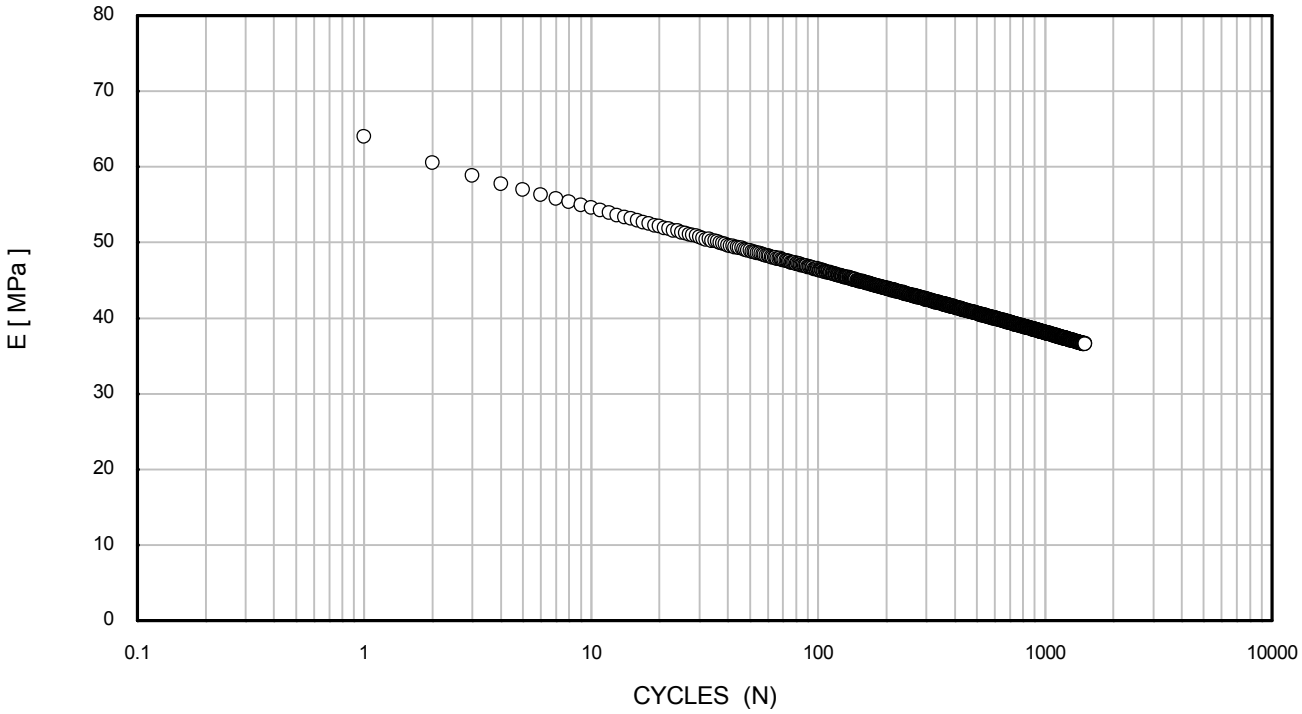


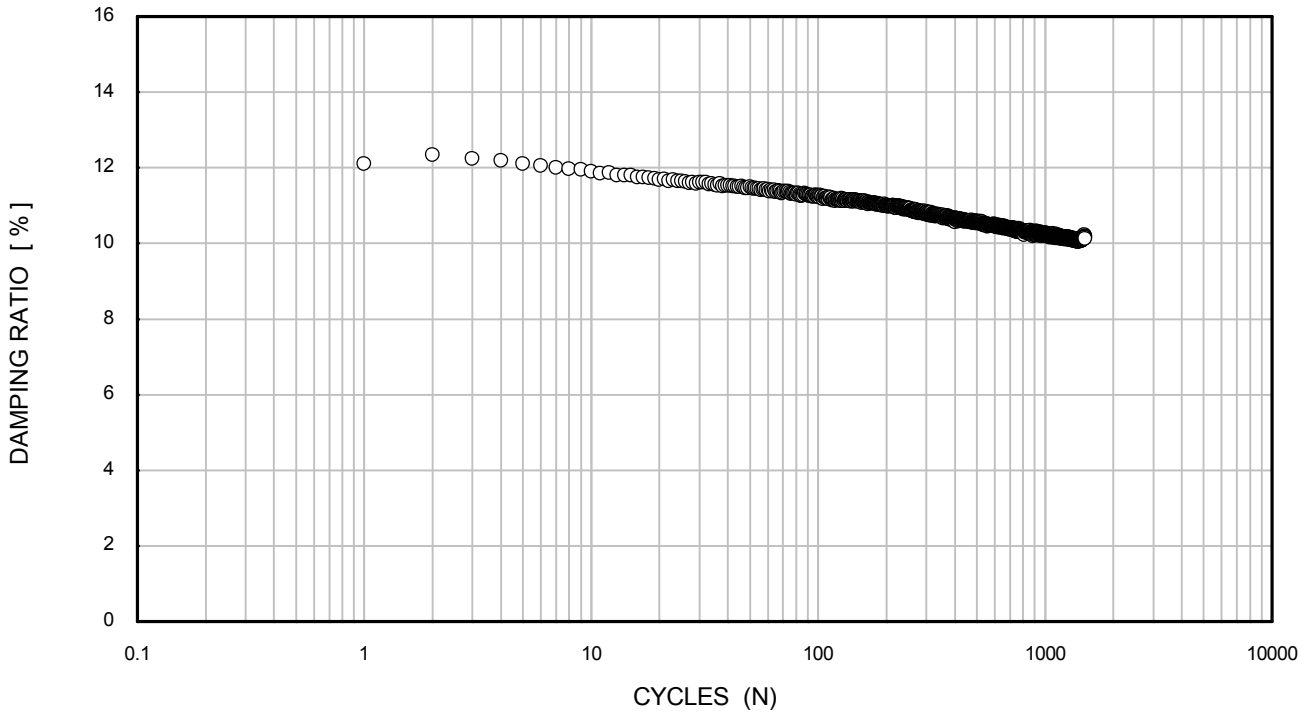


Initial σ'_r	:	350 kPa	Borehole	: BH-WFS4-1A
Initial σ'_a	:	350 kPa	Sample	: 22WaxC
q_{av}	:	0 kPa	Unit	: F3 (Dongen)
q_{cy}	:	235 kPa	Depth [m]	: 37.48
Frequency	:	0.10 Hz	Test No.	: CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

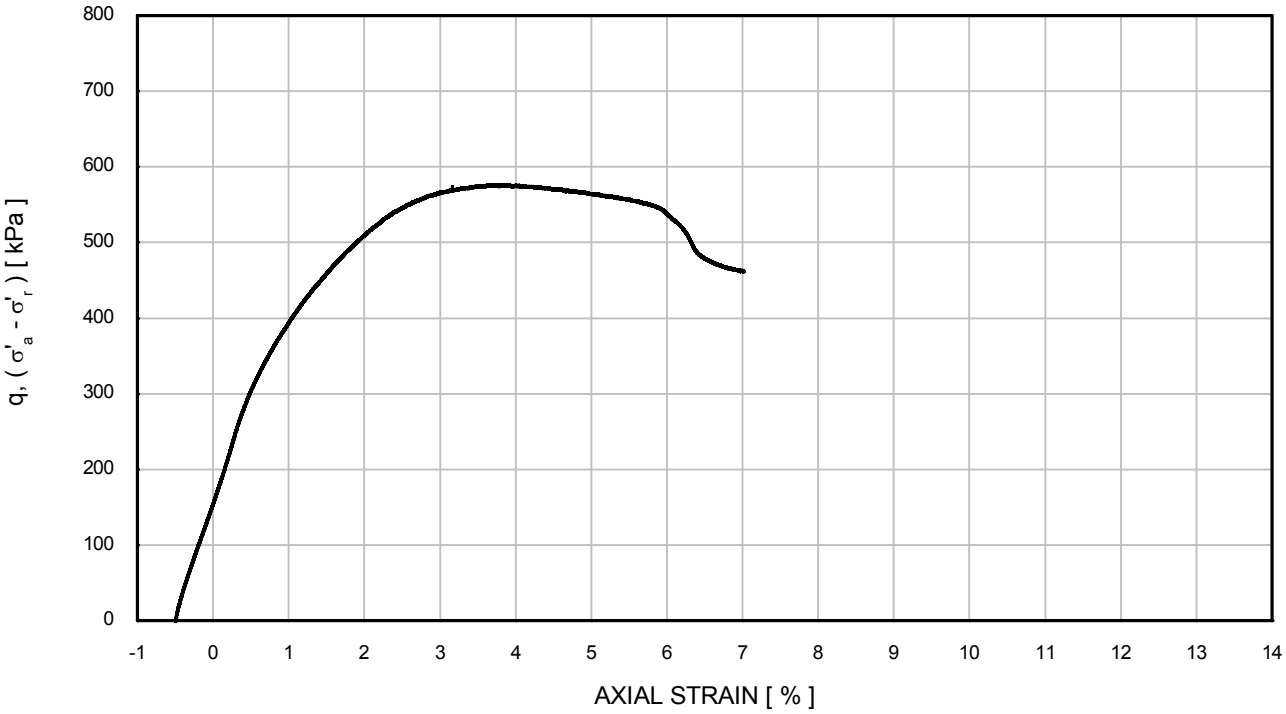


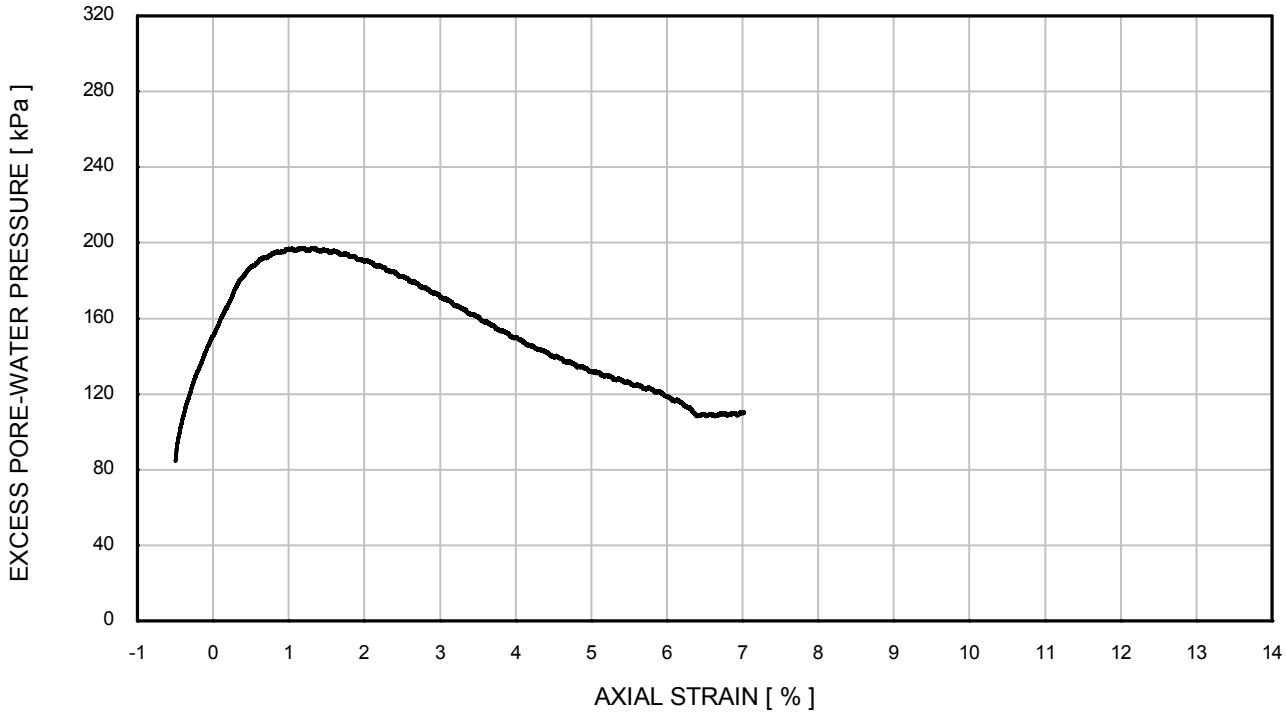


Initial σ'_r	:	350 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	350 kPa	Sample	:	22WaxC
q_{av}	:	0 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	235 kPa	Depth [m]	:	37.48
Frequency	:	0.10 Hz	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

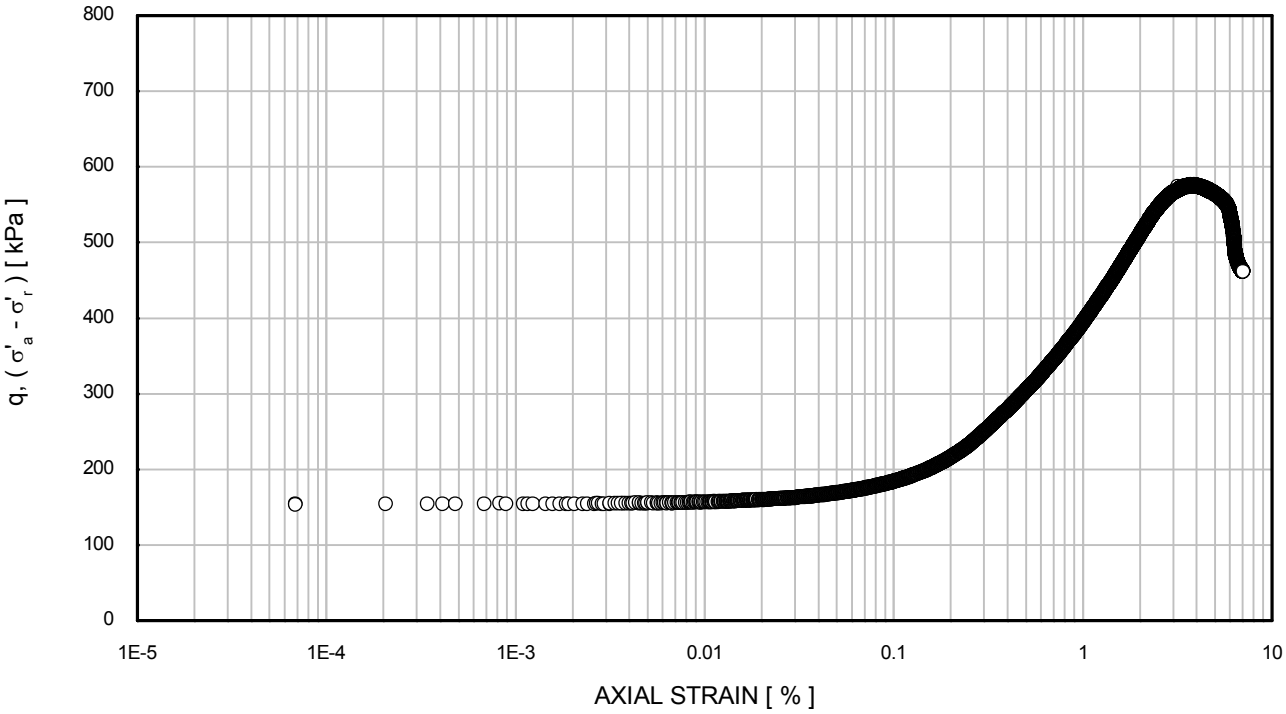


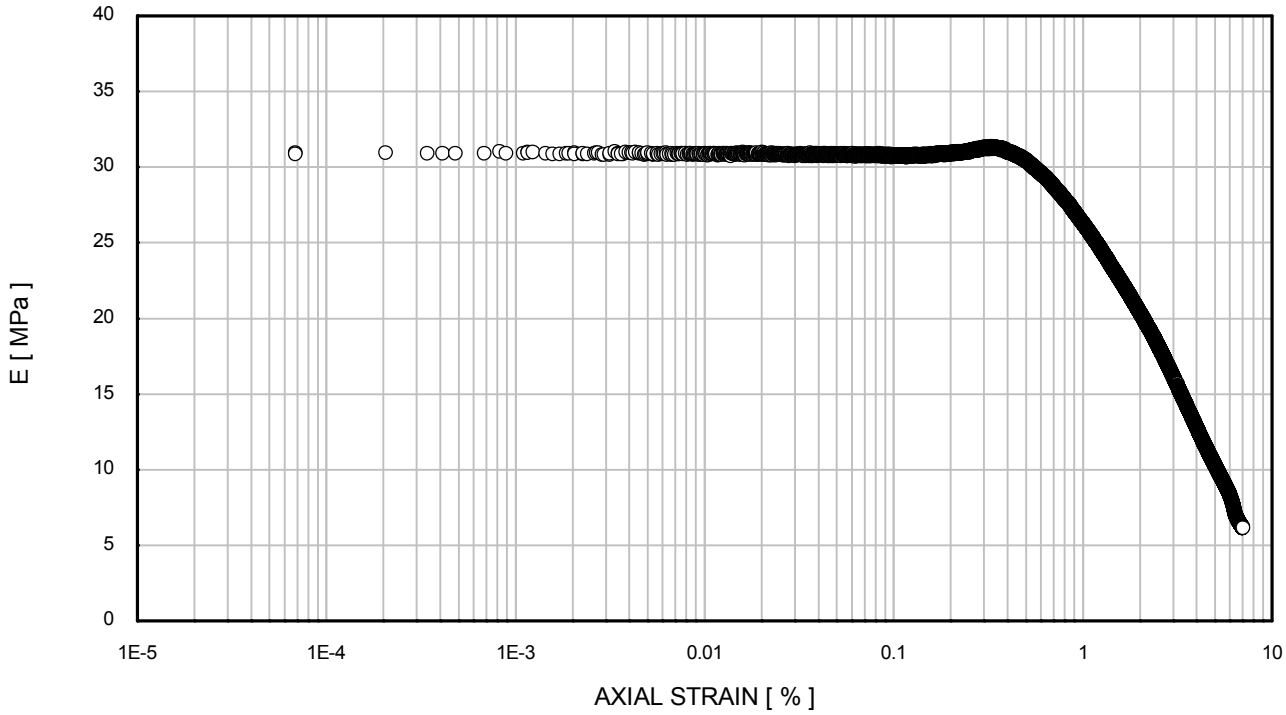


Initial σ'_r	:	266 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	265 kPa	Sample	:	22WaxC
q_{peak}	:	576 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	3.73 %	Depth [m]	:	37.48
Rate of strain	:	0.20 %/hour	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

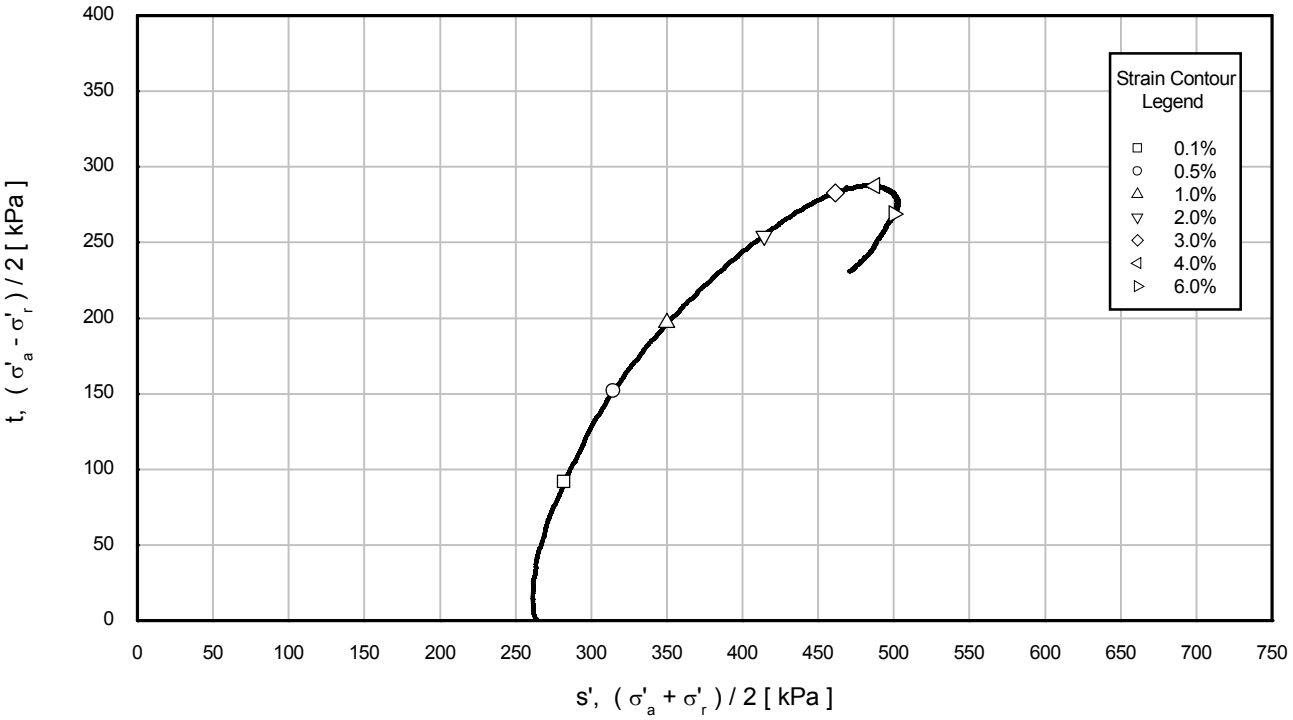


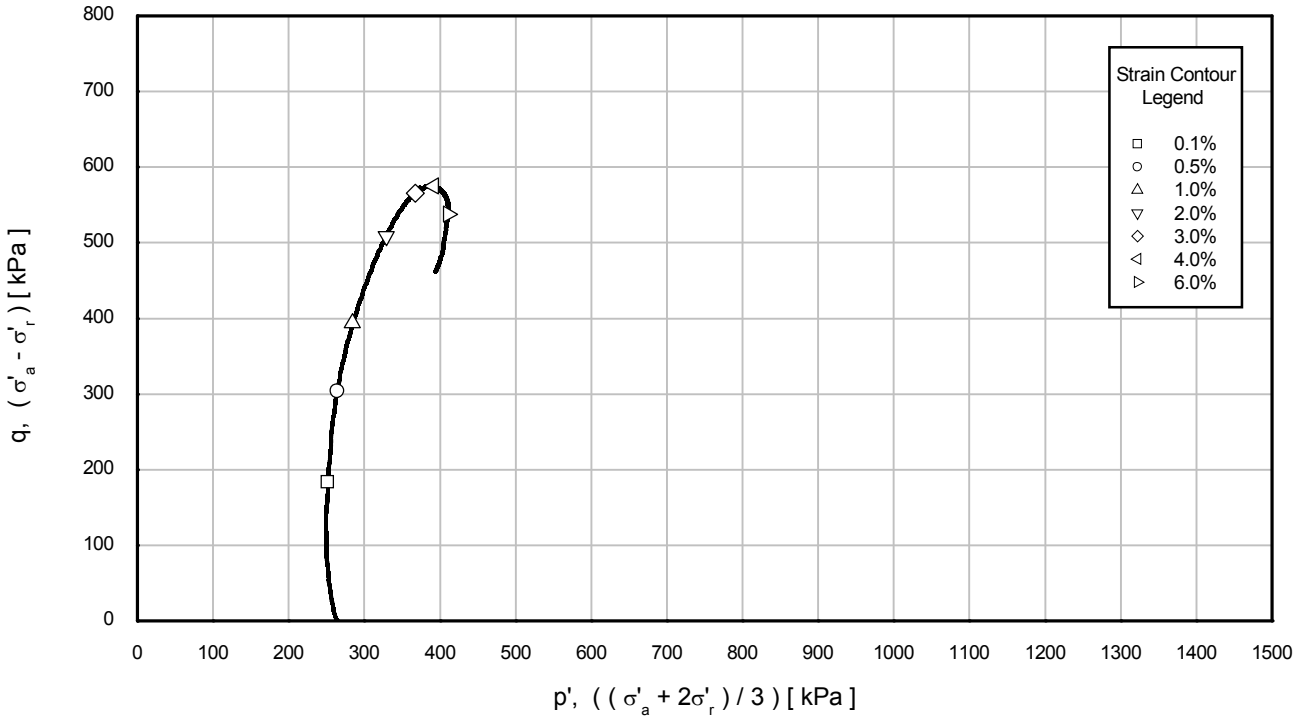


Initial σ'_r	:	266 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	265 kPa	Sample	:	22WaxC
q_{peak}	:	576 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	3.73 %	Depth [m]	:	37.48
Rate of strain	:	0.20 %/hour	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	266 kPa	Borehole	:	BH-WFS4-1A
Initial σ'_a	:	265 kPa	Sample	:	22WaxC
q_{peak}	:	576 kPa	Unit	:	F3 (Dongen)
Ext. ε at q_{peak}	:	3.73 %	Depth [m]	:	37.48
Rate of strain	:	0.20 %/hour	Test No.	:	CTX03

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark greenish grey fissured CLAY

GENERAL	
Date test started	11/12/2015
Type of sample	Undisturbed
Type of drains fitted	Radial (spiral) & one end only

INITIAL		
Diameter	[mm]	71.6
Length	[mm]	144.6
Moisture content	[%]	35.0
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.39
Void ratio	[-]	0.948
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic	BS1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ BH-WFS4-3_29C_CTX04
Processed by	PR
Date	16/12/2015
Checked by	LJ
Date	17/12/2015
Approved by	PH
Date	15/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	29WaxC
Unit	F3 (Dongen)
Depth [m]	45.88
Test number	CTX04

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Undrained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	N/A
Cell pressure	[kPa]	1850
Base PWP	[kPa]	1288
Mid height PWP	[kPa]	-
B value achieved	[-]	0.96

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1850
Back pressure	[kPa]	1400
Base PWP	[kPa]	1400
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	450
Effective axial pressure	[kPa]	450
Deviator stress	[kPa]	0
Volumetric strain	[%]	-0.60
External axial strain	[%]	-0.37
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	35.5
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.38
Void ratio	[-]	0.959
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	29WaxC
Unit	F3 (Dongen)
Depth [m]	45.88
Test number	CTX04

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	500
Mean q_{av}	[kPa]	2
Mean q_{cy}	[kPa]	355
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	5
External ε_{av} at N_f	[%]	-10.34
External ε_{cy} at N_f	[%]	11.94
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	-5.4
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	35.5
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.38
Void ratio	[-]	0.959
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-1.17	2.37	14.98	-	26.87	-
2	-2.73	4.59	7.72	-	34.46	-
3	-4.86	7.02	5.09	-	38.31	-
4	-7.06	8.80	4.06	-	42.30	-
5	-10.34	11.94	2.96	-	42.69	-

TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	29WaxC
Unit	F3 (Dongen)
Depth [m]	45.88
Test number	CTX04

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	415
Initial effective axial pressure	[kPa]	418
Rate of strain	[%/hour]	0.41
At peak deviator stress		
Corrected deviator stress	[kPa]	-235
Membrane correction applied	[kPa]	-5
Drain correction applied	[kPa]	0
External axial strain	[%]	-21.74
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-162
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	612
Effective axial pressure	[kPa]	377
Principal effective stress ratio	[-]	1.62
ε_{50}	[%]	-20.75
Secant modulus (E_{50}) at ε_{50}	[kPa]	49444
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	-234
Membrane correction applied	[kPa]	-5
Drain correction applied	[kPa]	0
External axial strain	[%]	-21.58
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-157
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	607
Effective axial pressure	[kPa]	373
Principal effective stress ratio	[-]	1.63
At -21% external axial strain		
Corrected deviator stress	[kPa]	-177
Membrane correction applied	[kPa]	-5
Drain correction applied	[kPa]	0
External axial strain	[%]	-21.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-109
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	559
Effective axial pressure	[kPa]	382
Principal effective stress ratio	[-]	1.46

TEST IDENTIFICATION	
Borehole	BH-WFS4-3
Sample	29WaxC
Unit	F3 (Dongen)
Depth [m]	45.88
Test number	CTX04

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS





FINAL CONDITIONS

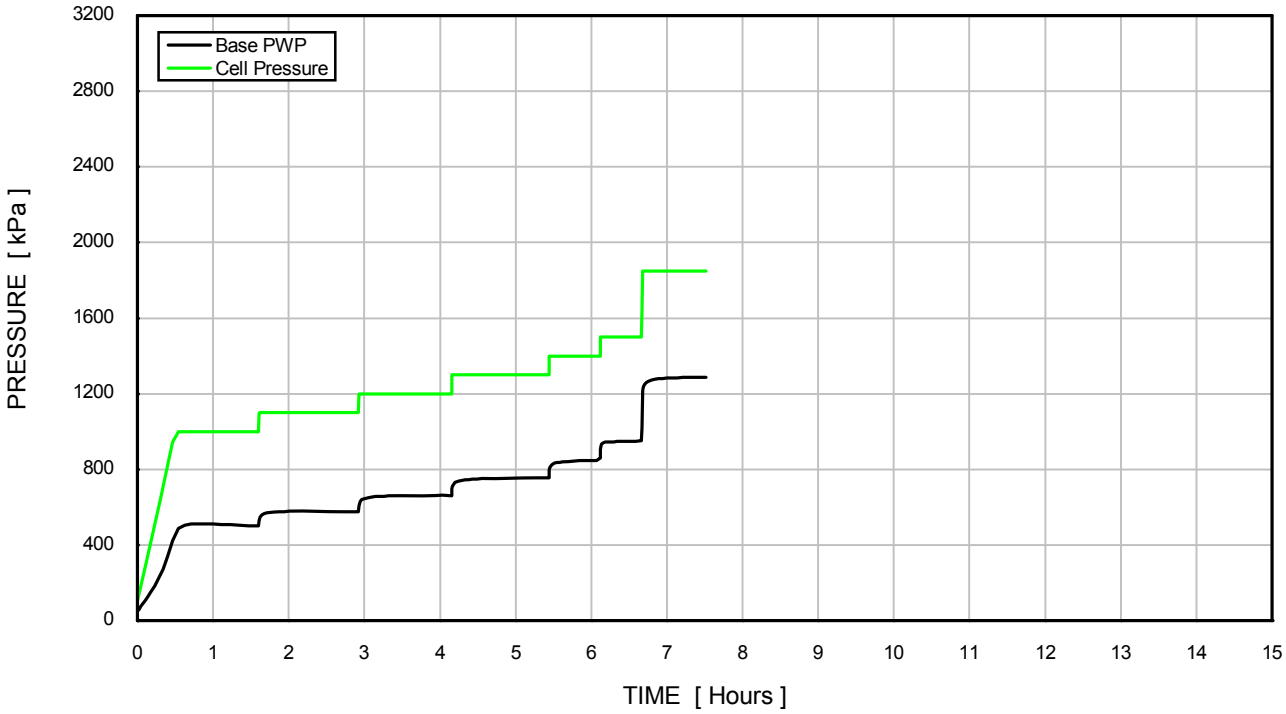
Moisture content	[%]	35.5
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.38

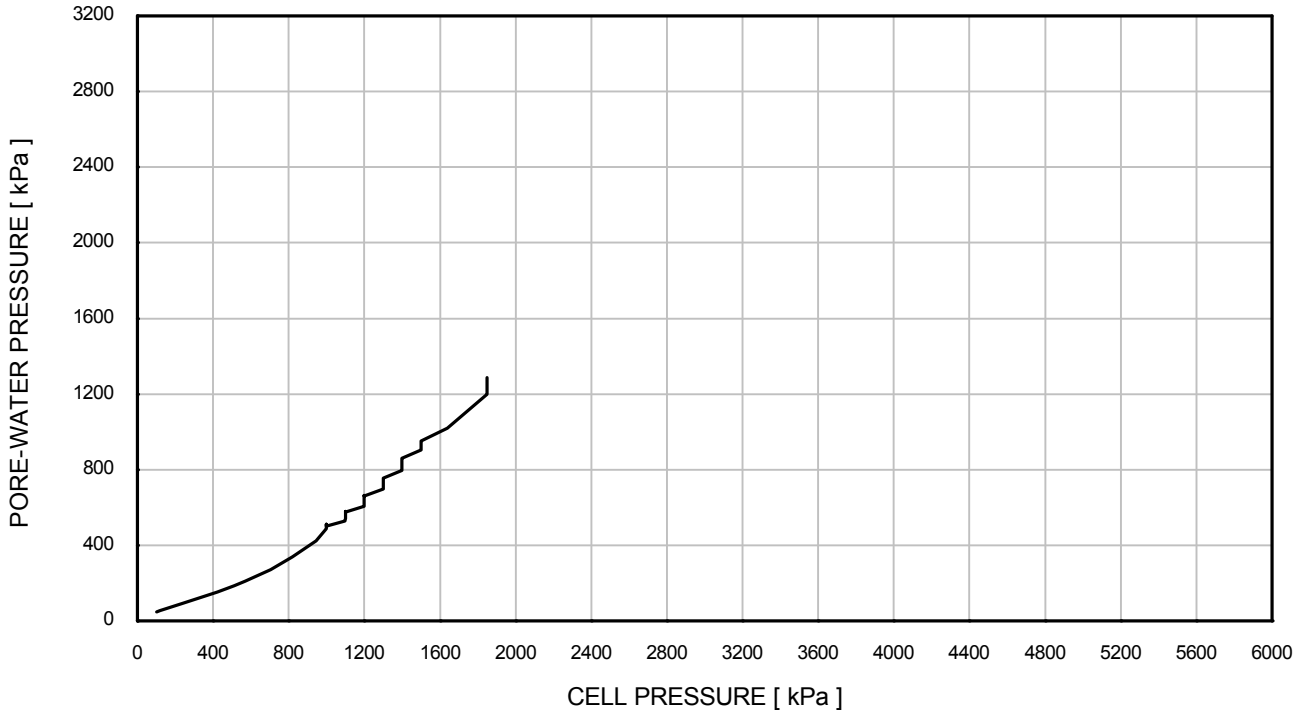
TEST IDENTIFICATION

Borehole	BH-WFS4-3
Sample	29WaxC
Unit	F3 (Dongen)
Depth [m]	45.88
Test number	CTX04

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

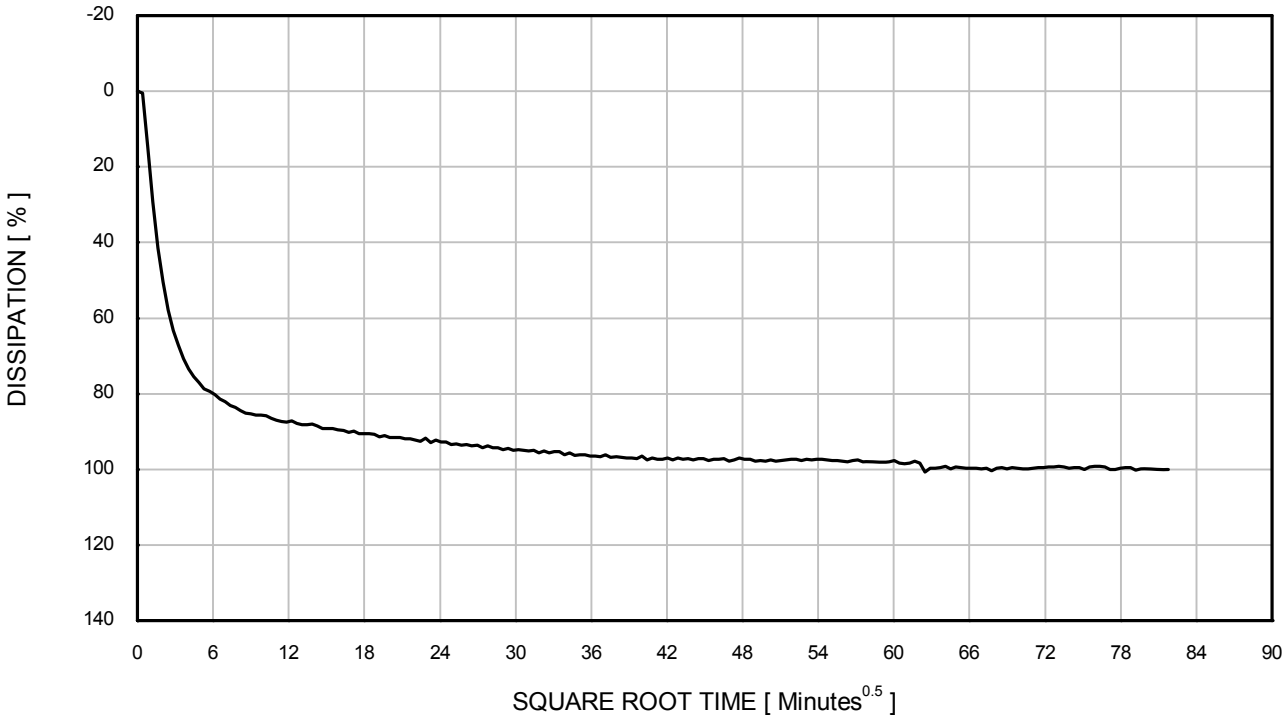


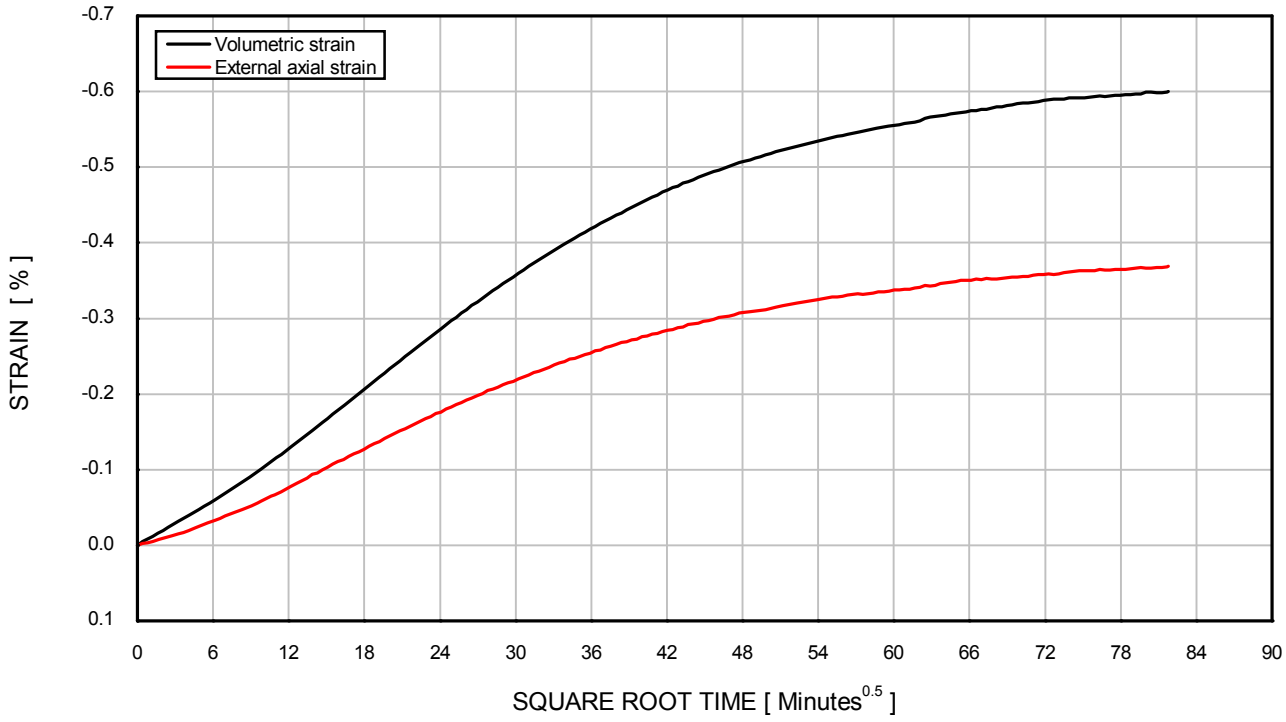


B value	: 0.96	Borehole	: BH-WFS4-3
Initial σ'_r	: 53 kPa	Sample	: 29WaxC
Initial σ'_a	: 53 kPa	Unit	: F3 (Dongen)
Final σ'_r	: 562 kPa	Depth [m]	: 45.88
Final σ'_a	: 563 kPa	Test No.	: CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - UNDRAINED

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

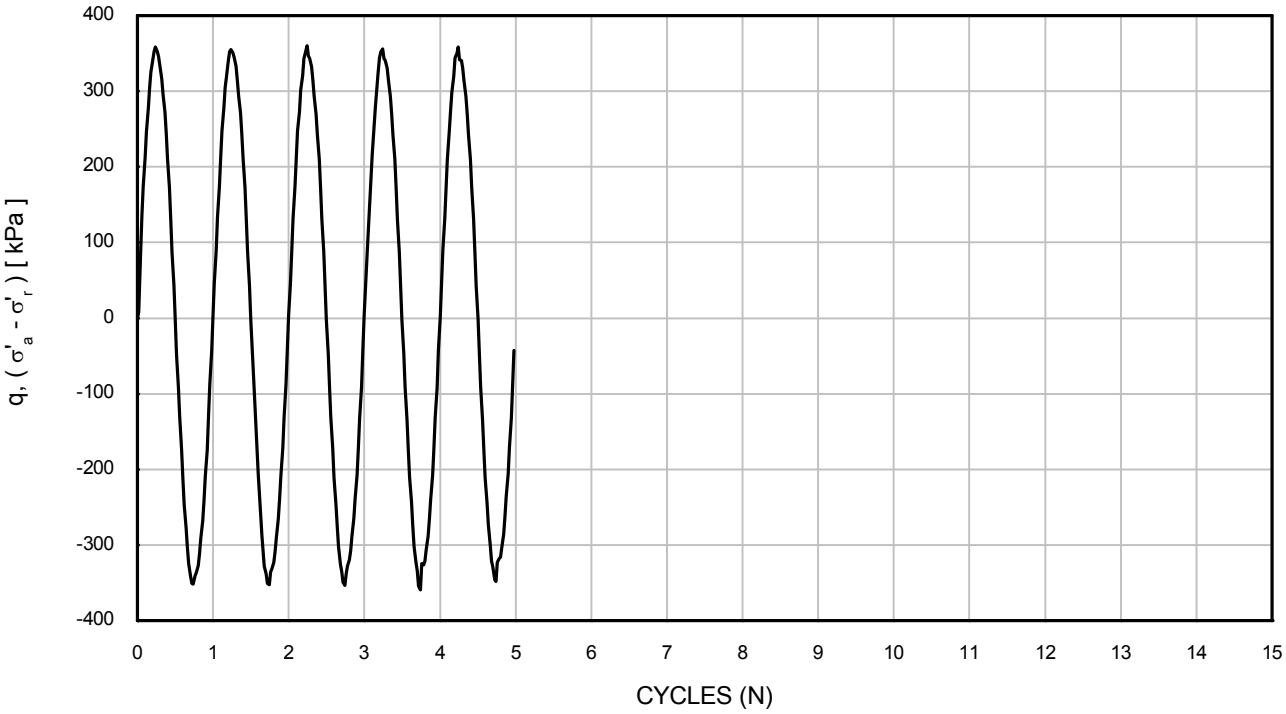


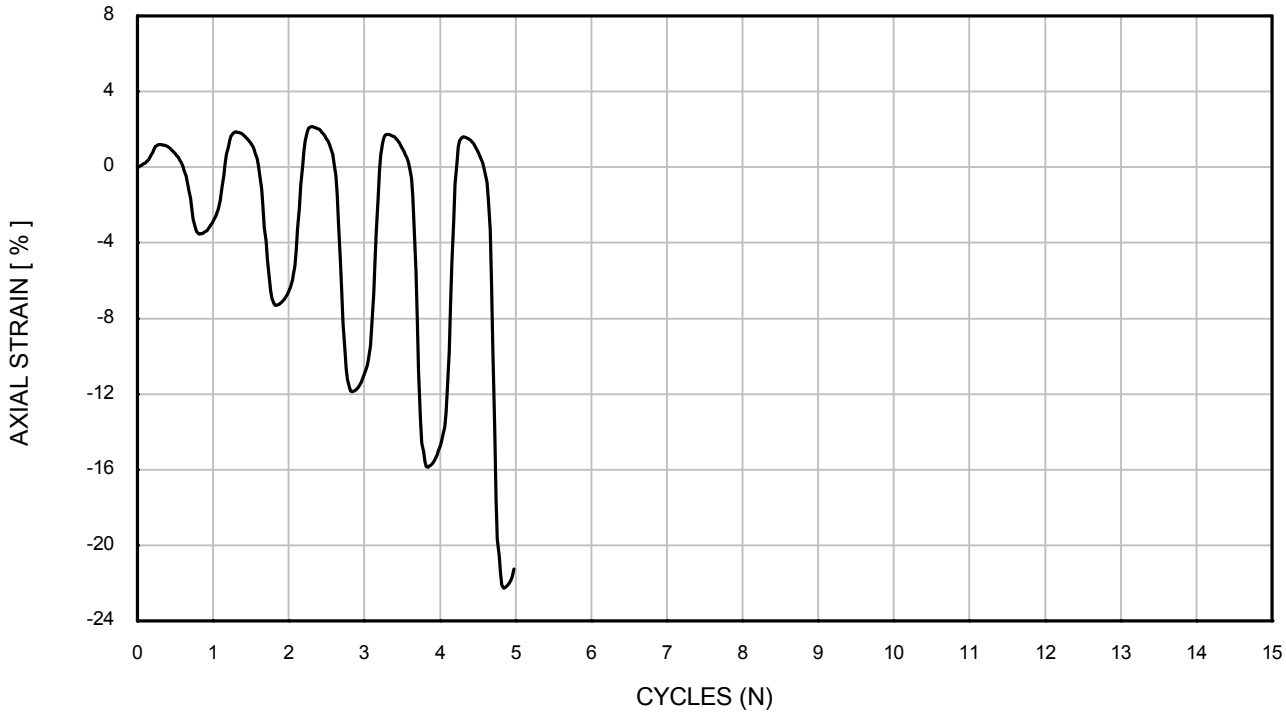


σ'_{rc}	: 450 kPa	Borehole	: BH-WFS4-3
σ'_{ac}	: 450 kPa	Sample	: 29WaxC
		Unit	: F3 (Dongen)
		Depth [m]	: 45.88
		Test No.	: CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

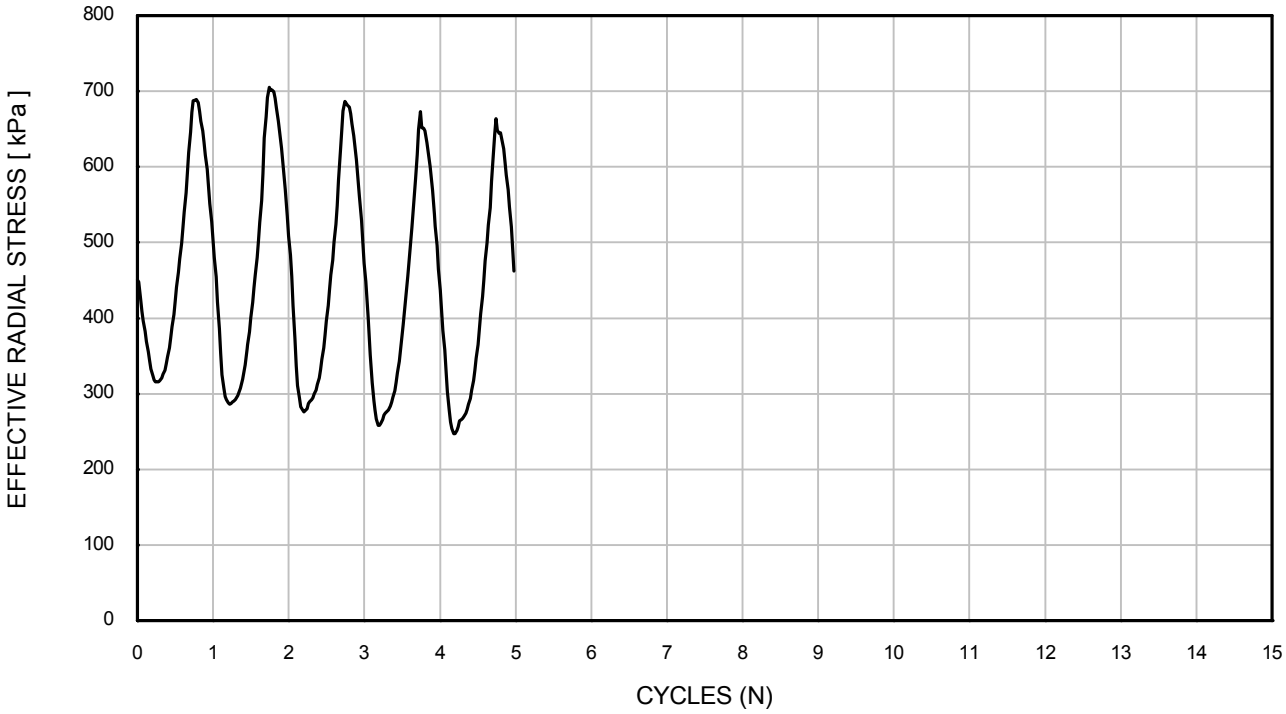


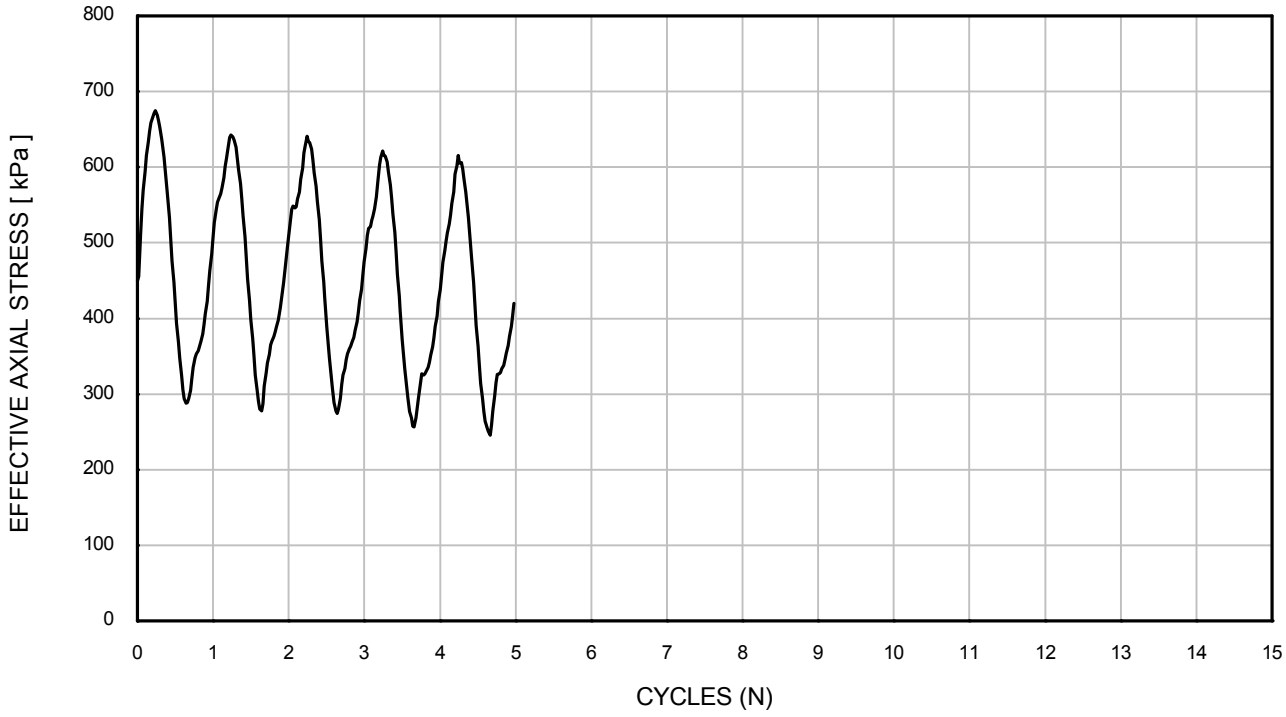


Initial σ'_r	:	450 kPa	Borehole	:	BH-WFS4-3
Initial σ'_a	:	450 kPa	Sample	:	29WaxC
q_{av}	:	2 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	355 kPa	Depth [m]	:	45.88
Frequency	:	0.10 Hz	Test No.	:	CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

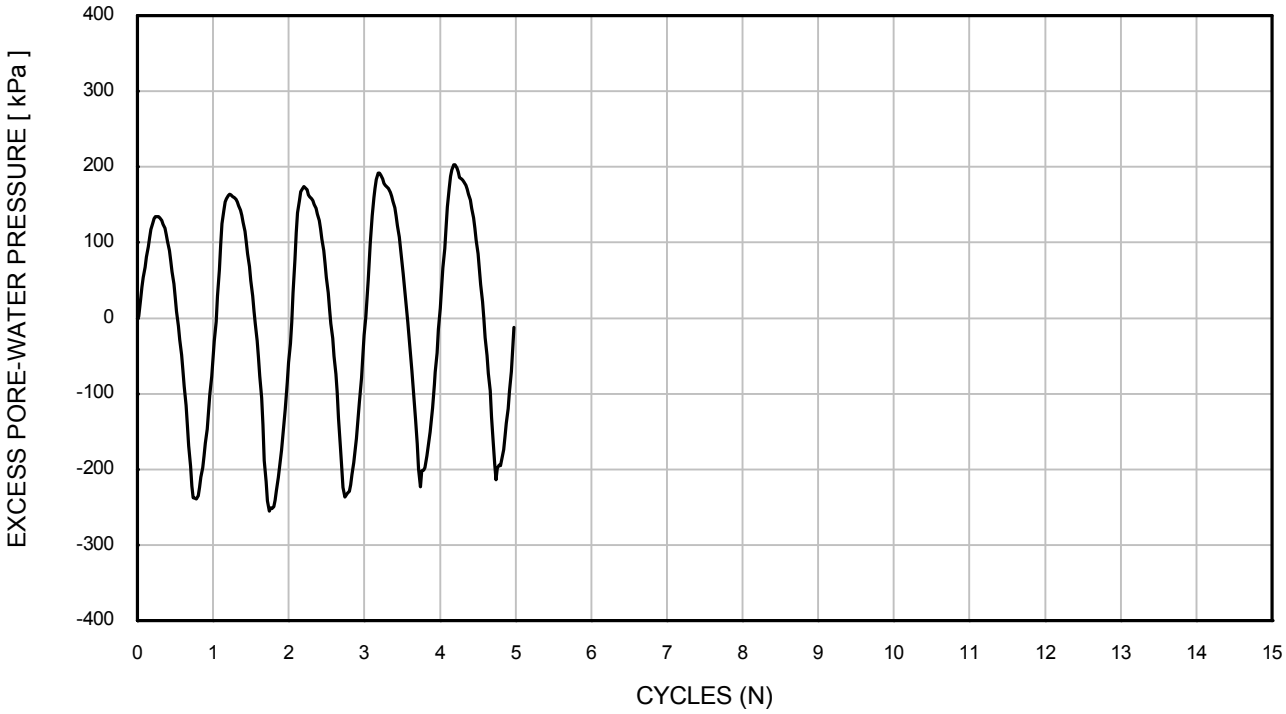


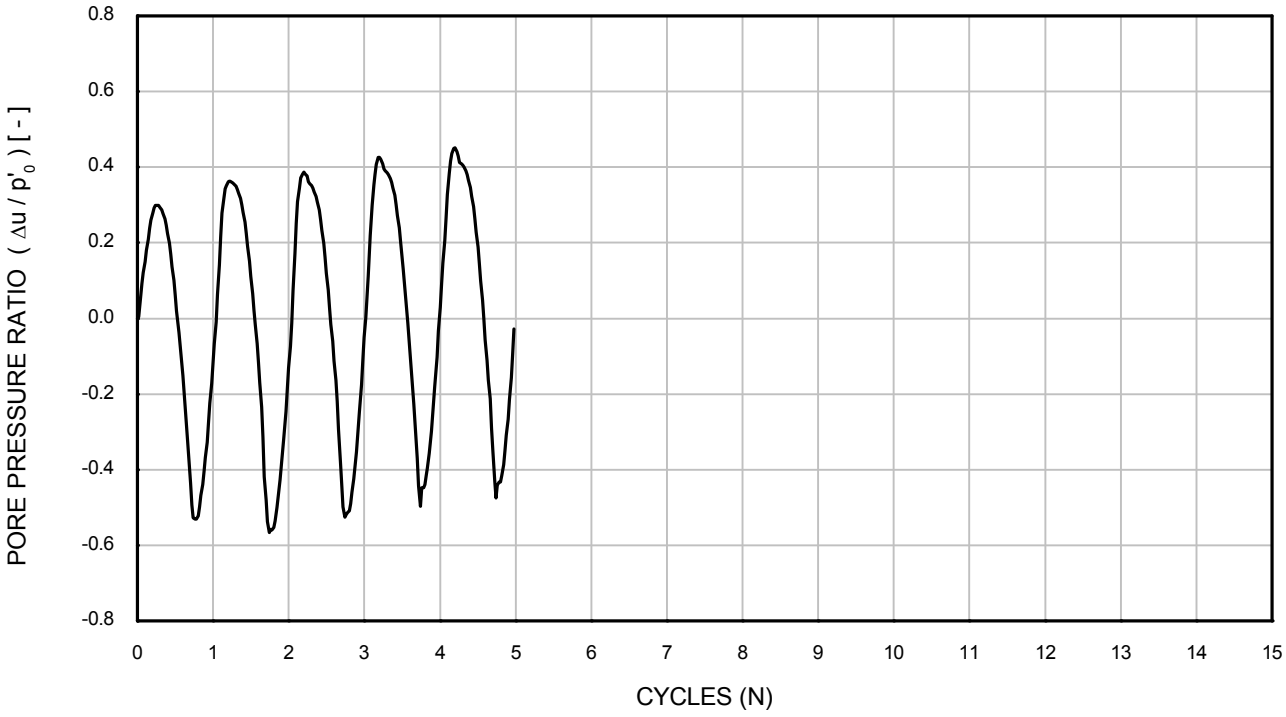


Initial σ'_r	:	450 kPa	Borehole	:	BH-WFS4-3
Initial σ'_a	:	450 kPa	Sample	:	29WaxC
q_{av}	:	2 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	355 kPa	Depth [m]	:	45.88
Frequency	:	0.10 Hz	Test No.	:	CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

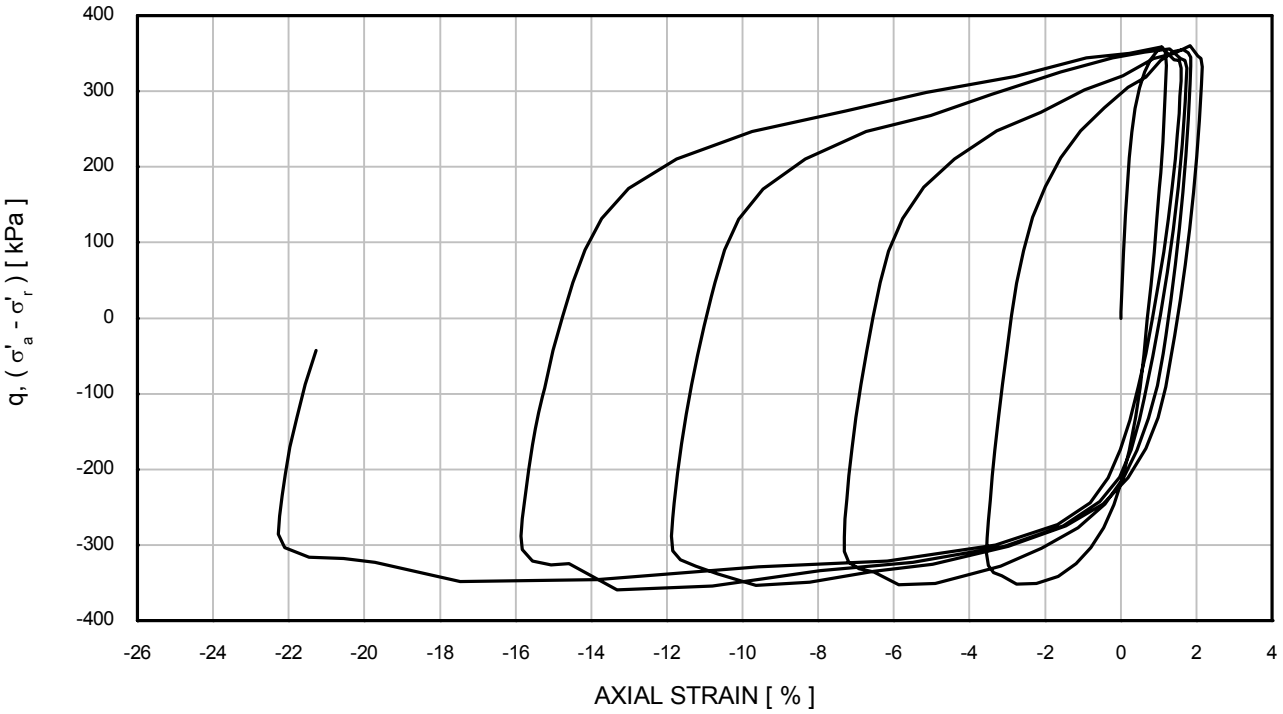


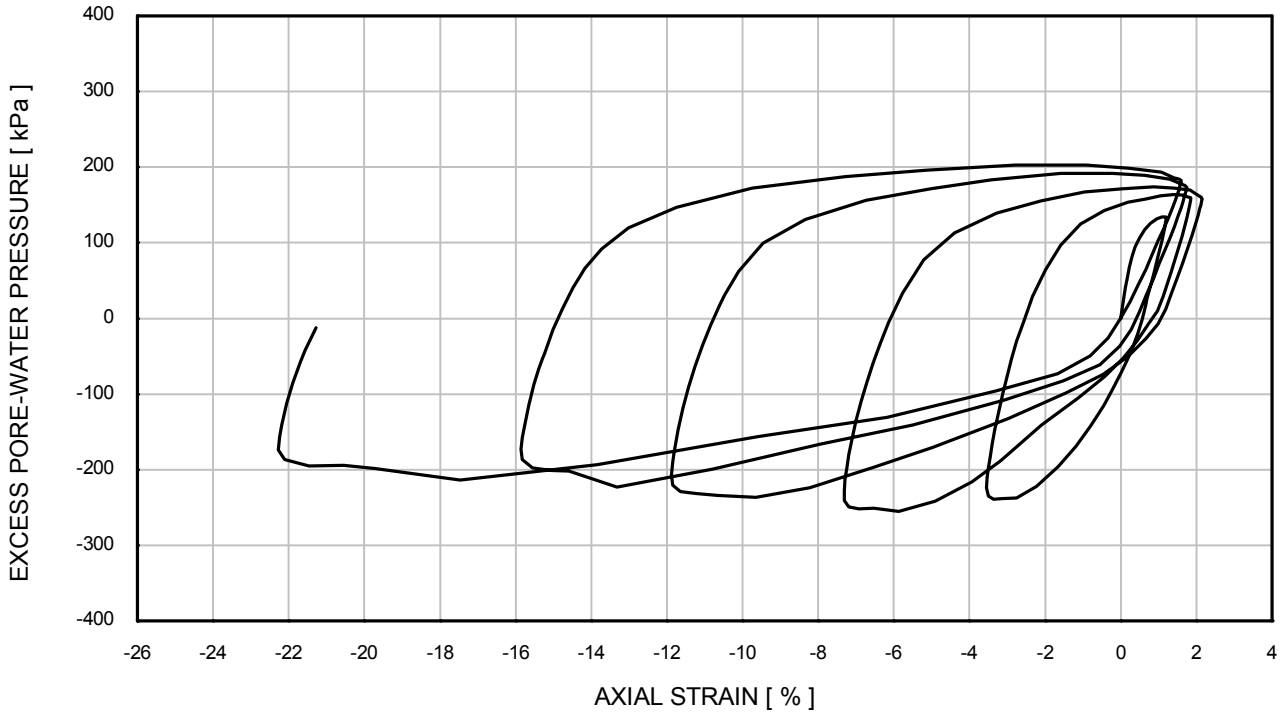


Initial σ'_r	:	450 kPa	Borehole	:	BH-WFS4-3
Initial σ'_a	:	450 kPa	Sample	:	29WaxC
q_{av}	:	2 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	355 kPa	Depth [m]	:	45.88
Frequency	:	0.10 Hz	Test No.	:	CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

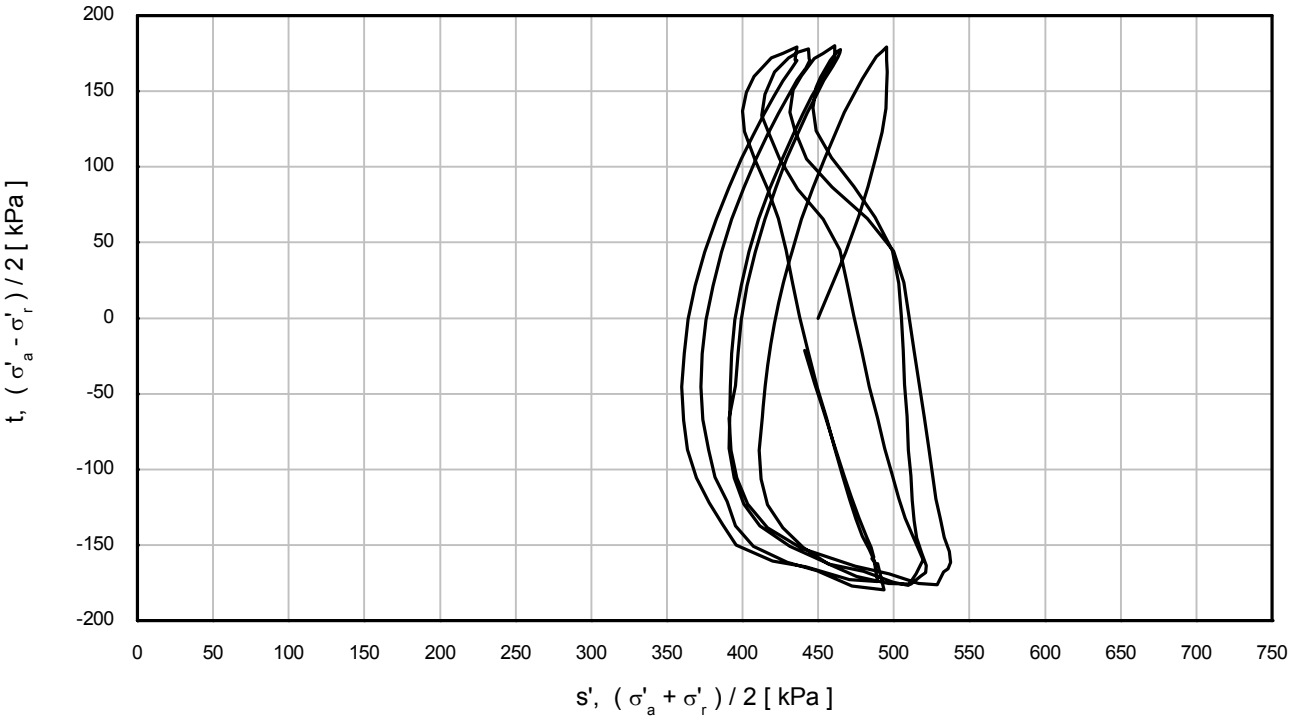


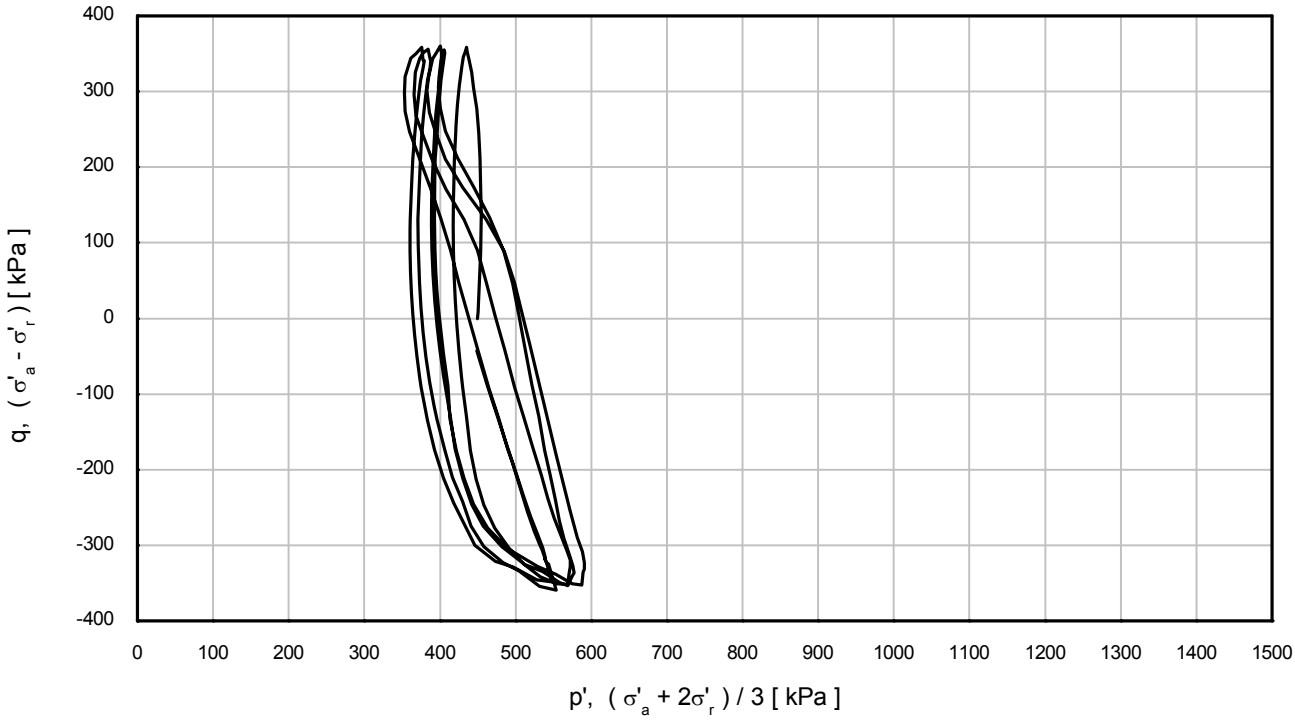


Initial σ'_r	:	450 kPa	Borehole	:	BH-WFS4-3
Initial σ'_a	:	450 kPa	Sample	:	29WaxC
q_{av}	:	2 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	355 kPa	Depth [m]	:	45.88
Frequency	:	0.10 Hz	Test No.	:	CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

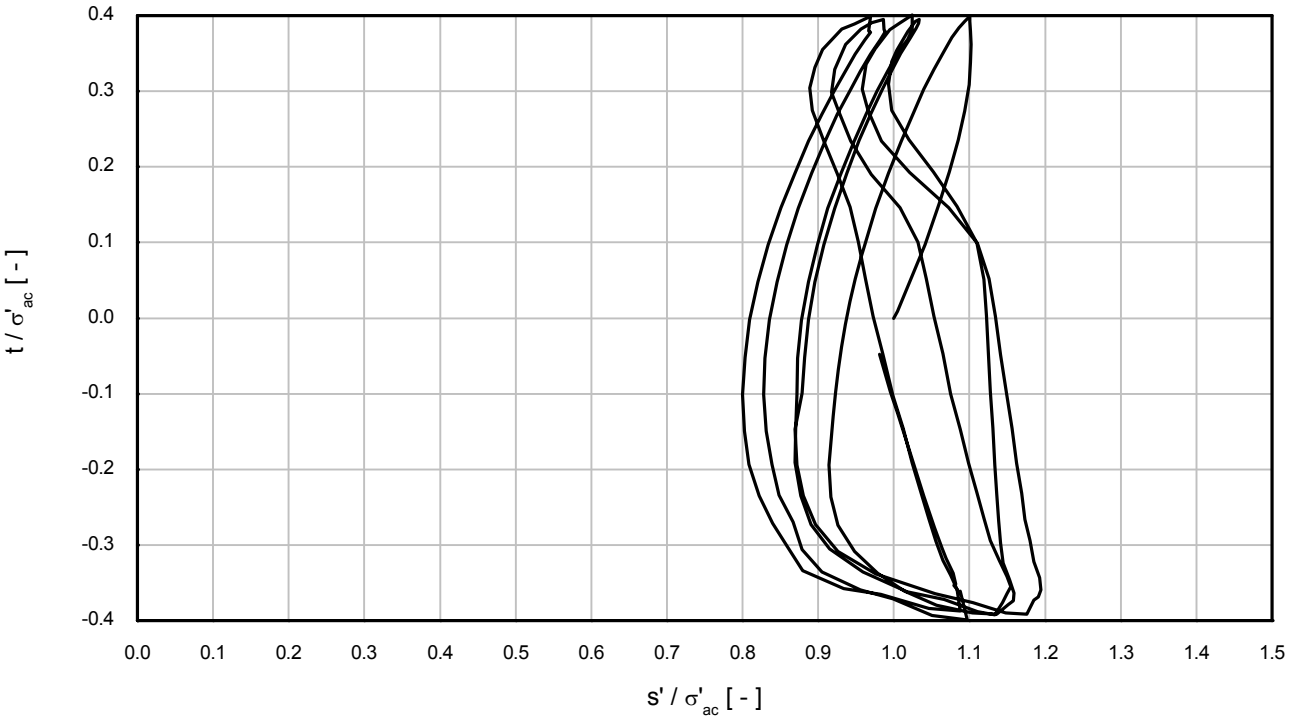


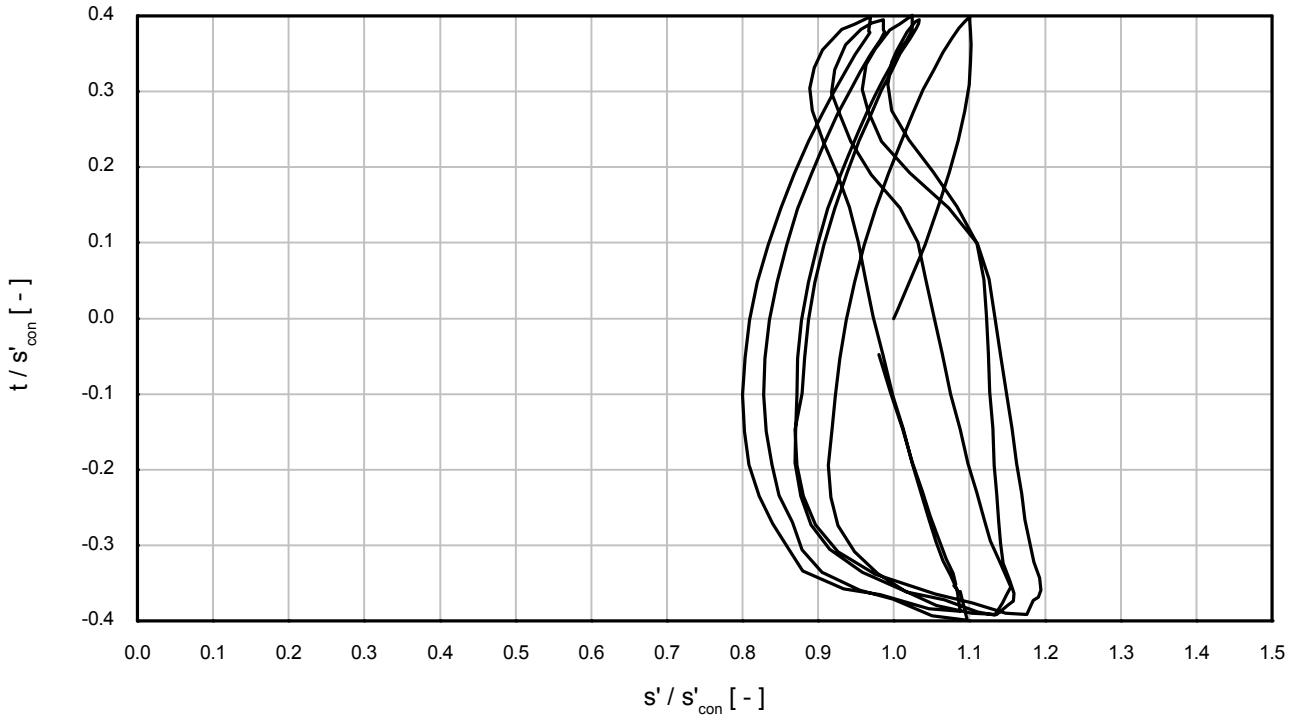


Initial σ'_r	:	450	kPa	Borehole	: BH-WFS4-3
Initial σ'_a	:	450	kPa	Sample	: 29WaxC
q_{av}	:	2	kPa	Unit	: F3 (Dongen)
q_{cy}	:	355	kPa	Depth [m]	: 45.88
Frequency	:	0.10	Hz	Test No.	: CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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



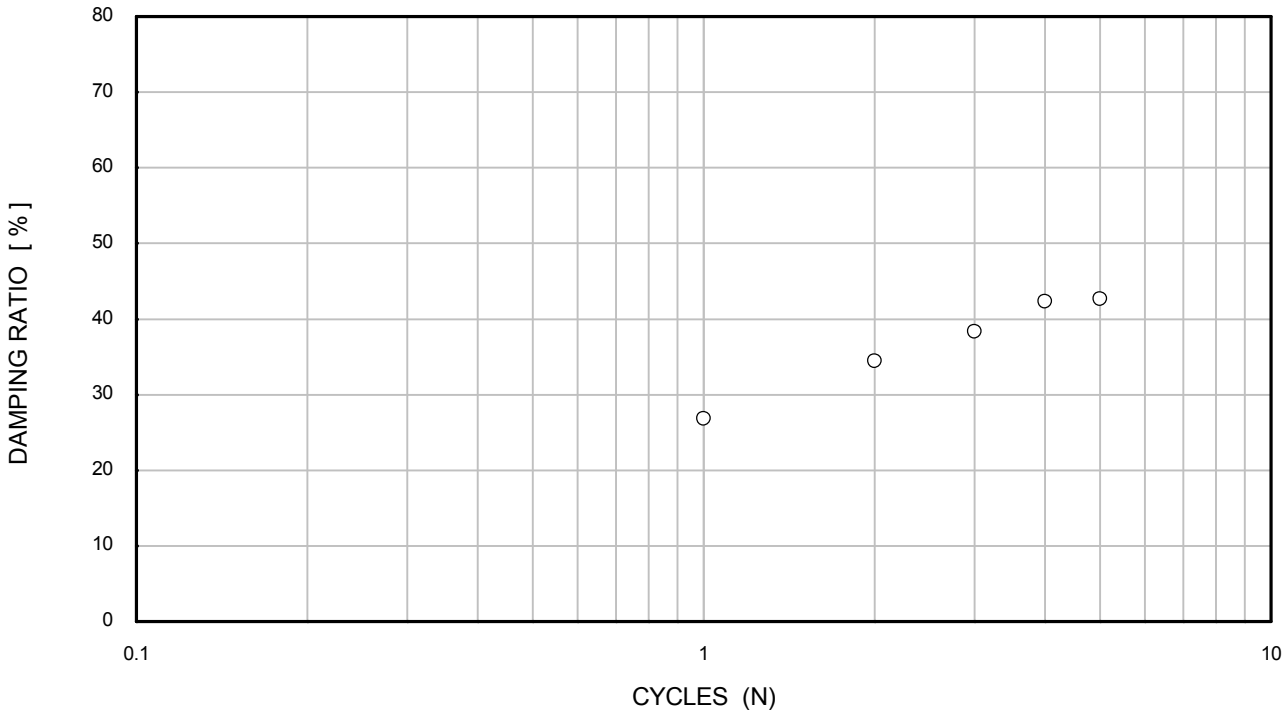


Initial σ'_r	:	450 kPa	Borehole	:	BH-WFS4-3
Initial σ'_a	:	450 kPa	Sample	:	29WaxC
q_{av}	:	2 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	355 kPa	Depth [m]	:	45.88
Frequency	:	0.10 Hz	Test No.	:	CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

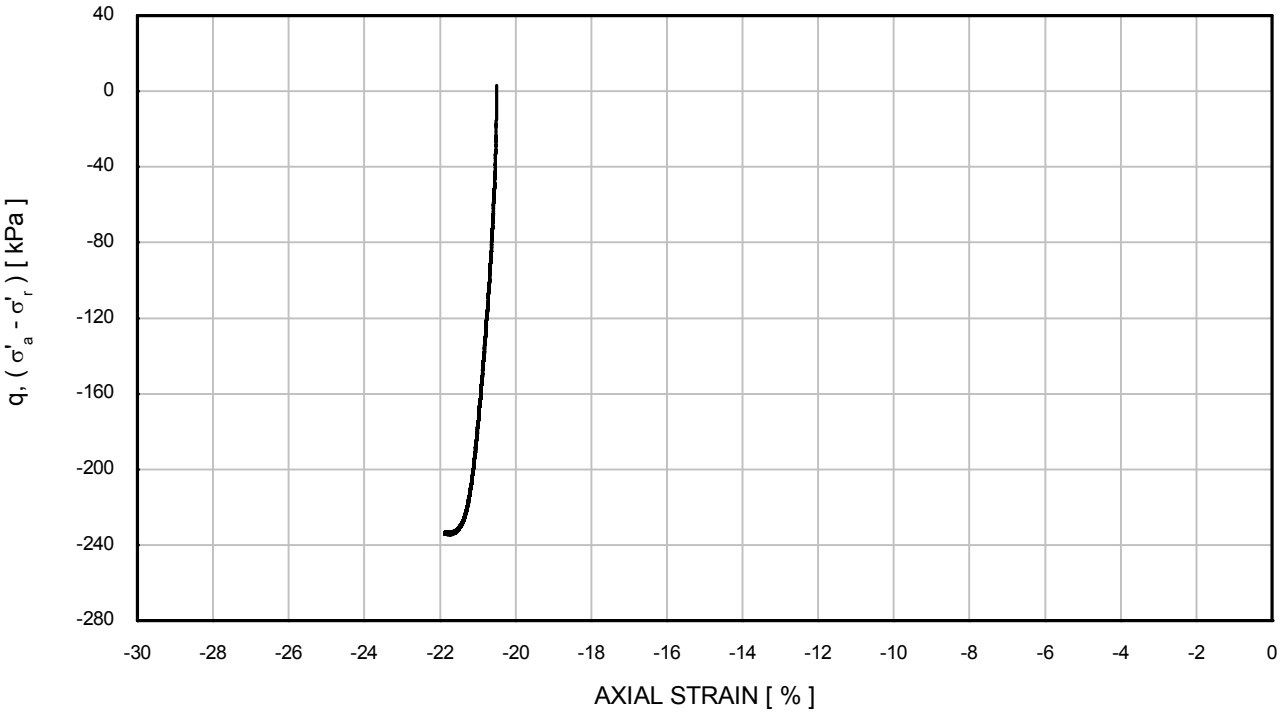


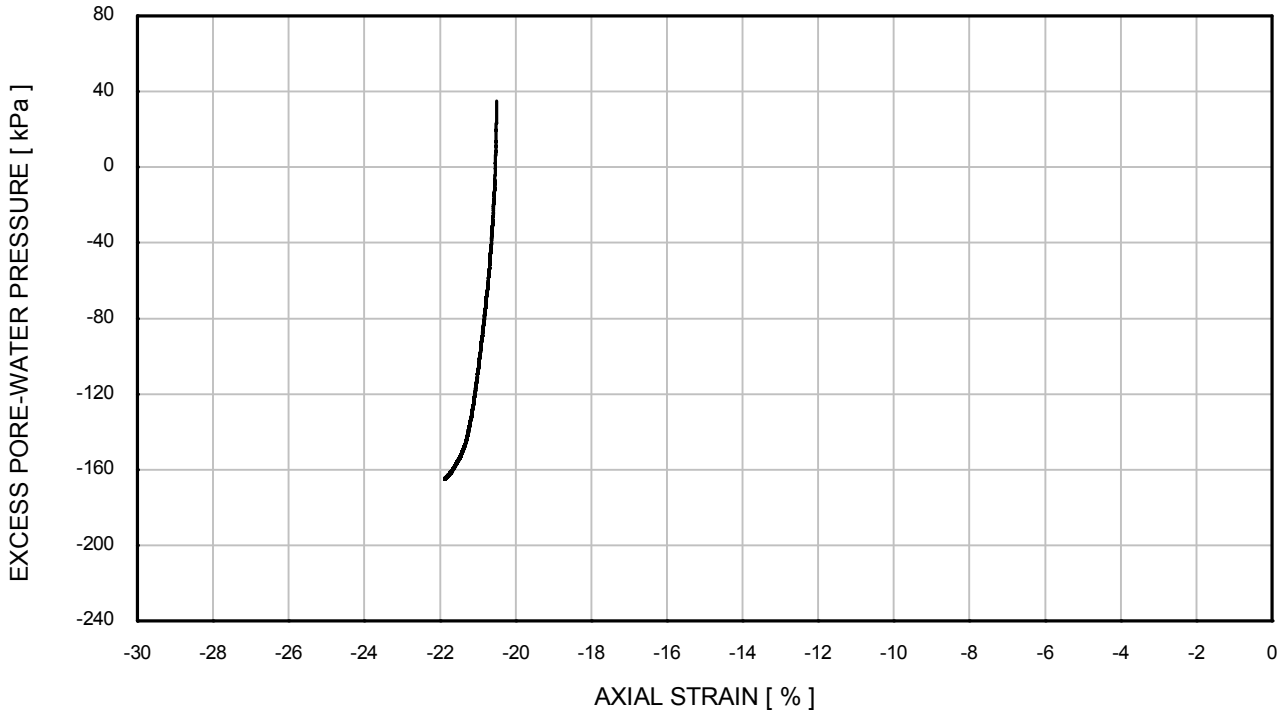


Initial σ'_r	:	450 kPa	Borehole	:	BH-WFS4-3
Initial σ'_a	:	450 kPa	Sample	:	29WaxC
q_{av}	:	2 kPa	Unit	:	F3 (Dongen)
q_{cy}	:	355 kPa	Depth [m]	:	45.88
Frequency	:	0.10 Hz	Test No.	:	CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

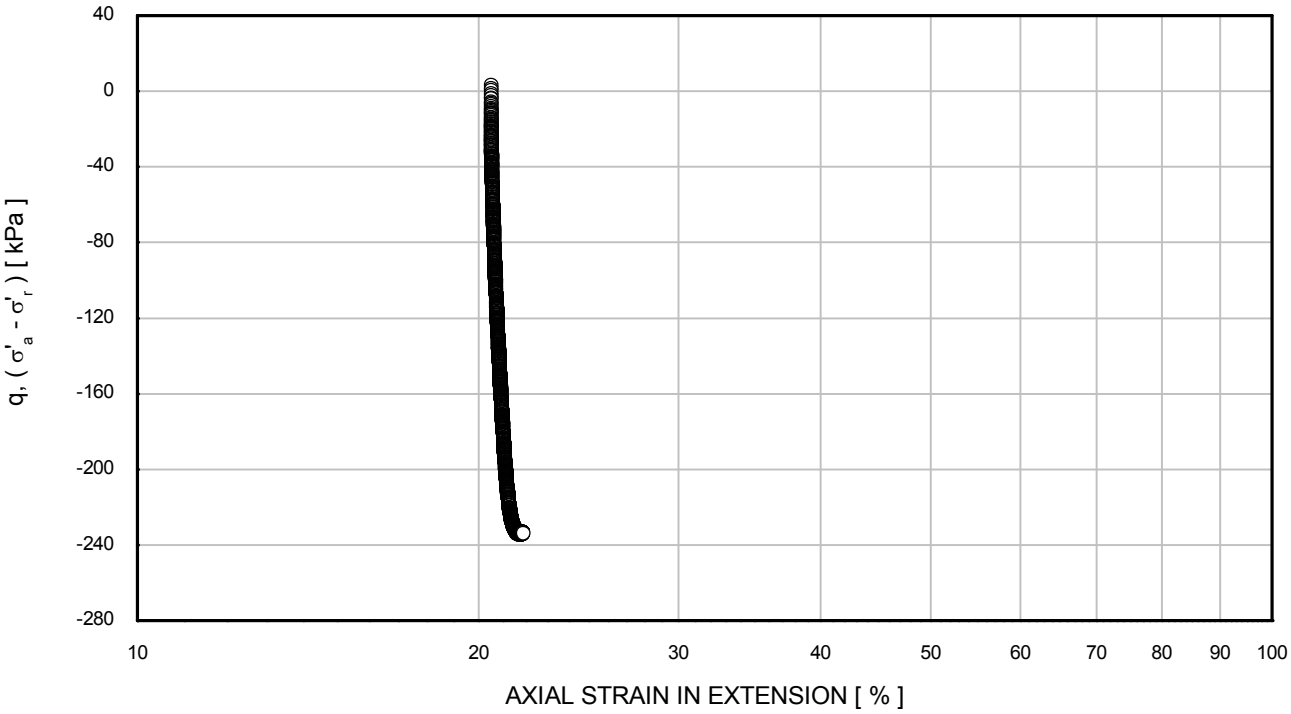


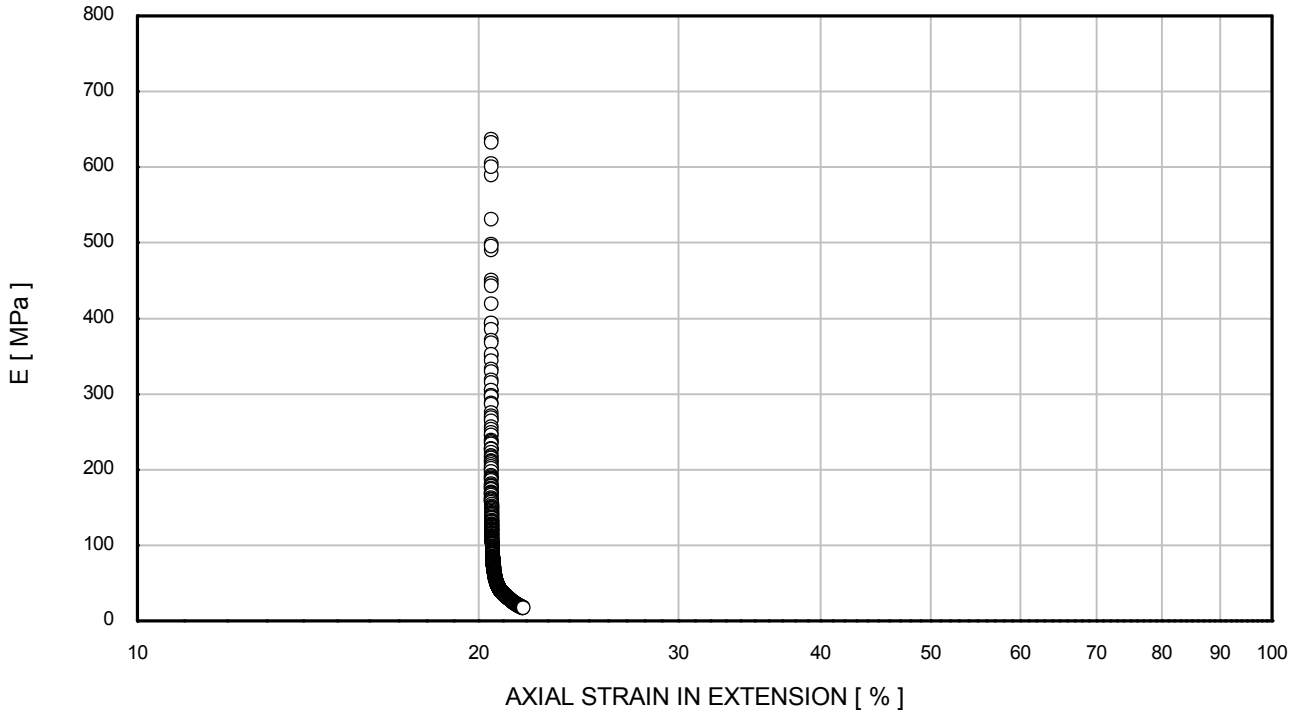


Initial σ'_r	: 415 kPa	Borehole	: BH-WFS4-3
Initial σ'_a	: 418 kPa	Sample	: 29WaxC
q_{peak}	: -235 kPa	Unit	: F3 (Dongen)
Ext. ε at q_{peak}	: -21.74 %	Depth [m]	: 45.88
Rate of strain	: 0.41 %/hour	Test No.	: CTX04

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

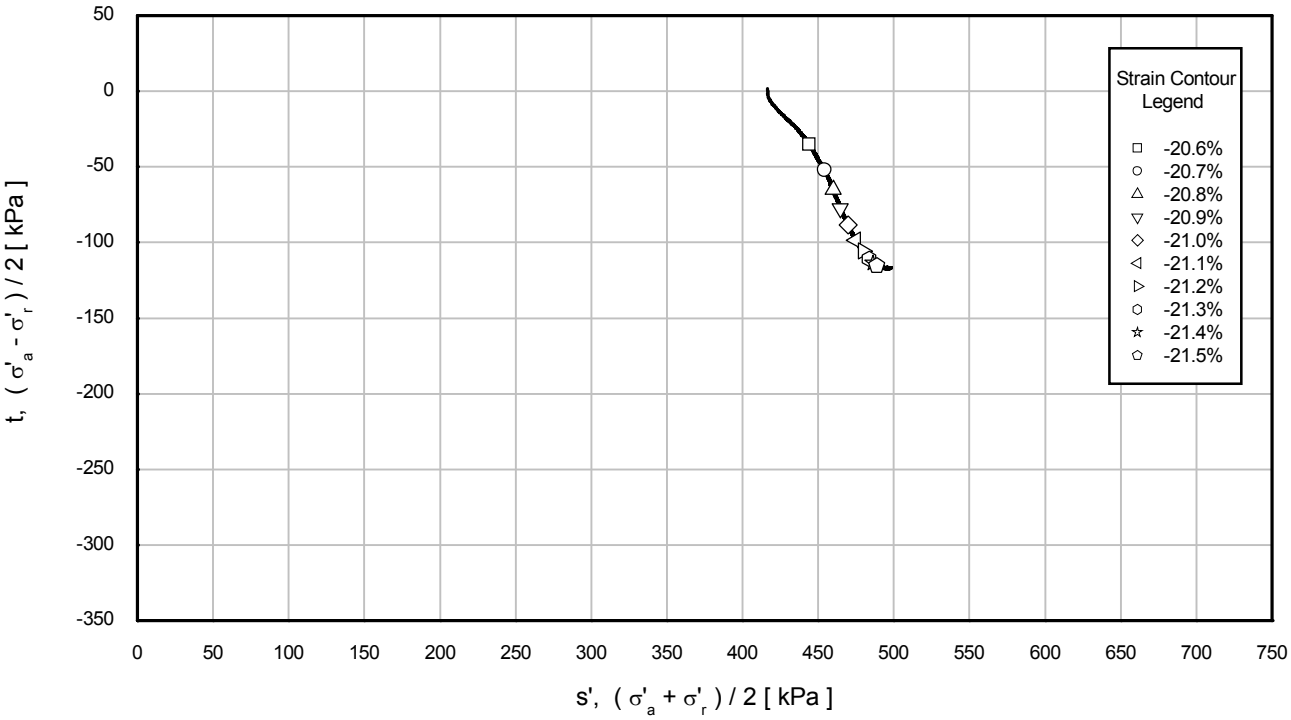


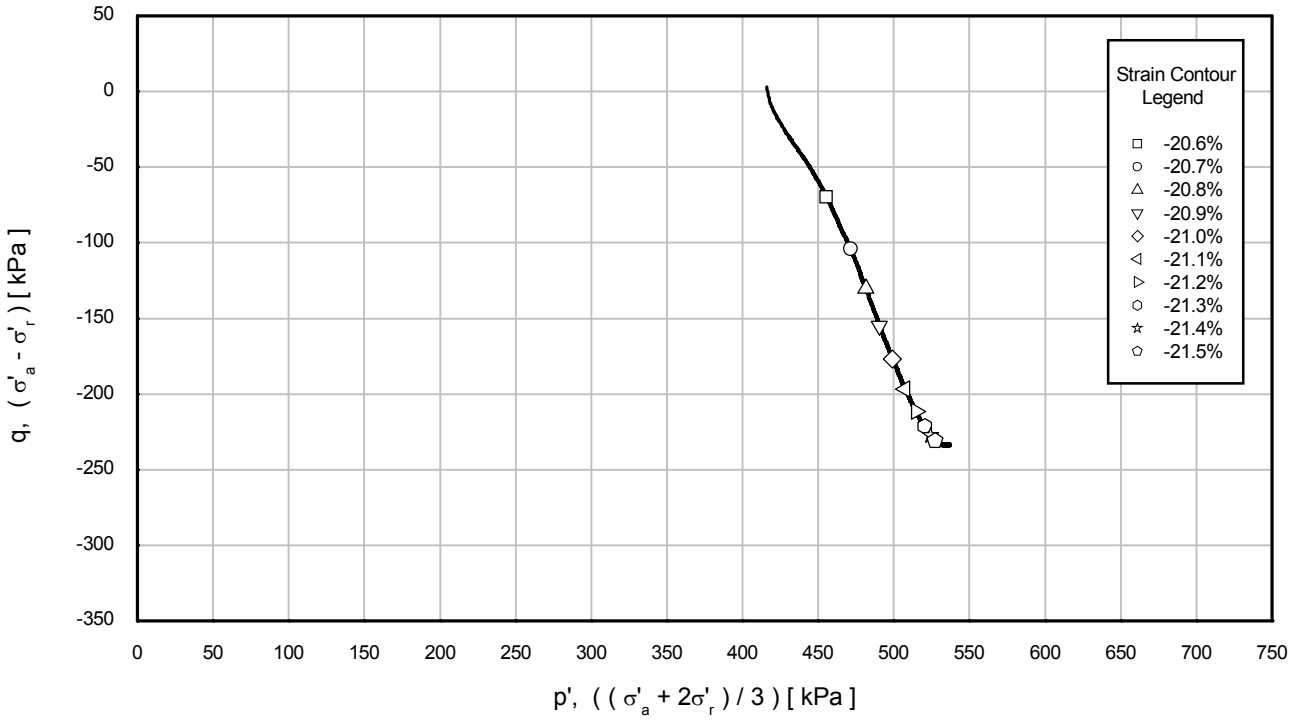


Initial σ'_r	: 415 kPa	Borehole	: BH-WFS4-3
Initial σ'_a	: 418 kPa	Sample	: 29WaxC
q_{peak}	: -235 kPa	Unit	: F3 (Dongen)
Ext. ε at q_{peak}	: -21.74 %	Depth [m]	: 45.88
Rate of strain	: 0.41 %/hour	Test No.	: CTX04

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	: 415 kPa	Borehole	: BH-WFS4-3
Initial σ'_a	: 418 kPa	Sample	: 29WaxC
q_{peak}	: -235 kPa	Unit	: F3 (Dongen)
Ext. ε at q_{peak}	: -21.74 %	Depth [m]	: 45.88
Rate of strain	: 0.41 %/hour	Test No.	: CTX04

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	21/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.3
Bulk density	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.633
Degree of saturation	[%]	43
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 1_CTX-1-1_CTX05
Processed by Date	PR 26/01/2016
Checked by Date	PH 08/02/2016
Approved by Date	PH 08/02/2016

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-1
Unit	A (Southern Bight)
Test number	CTX05

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1080
Mid height PWP	[kPa]	-
B value achieved	[-]	0.98

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1105
Back pressure	[kPa]	1080
Base PWP	[kPa]	1080
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	25
Effective axial pressure	[kPa]	25
Deviator stress	[kPa]	0
Volumetric strain	[%]	-0.03
External axial strain	[%]	0.02
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	23.9
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.634
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-1
Unit	A (Southern Bight)
Test number	CTX05

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	50
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	15
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	9
External ε_{av} at N_f	[%]	-1.42
External ε_{cy} at N_f	[%]	3.39
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	18
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	23.9
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.634
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.04	33.95	-	14.85	-
2	0.01	0.05	29.76	-	16.09	-
3	0.00	0.06	24.66	-	17.09	-
4	0.00	0.08	19.00	-	18.77	-
5	-0.03	0.12	13.01	-	20.60	-
6	-0.09	0.20	7.43	-	21.92	-
7	-0.27	0.46	3.29	-	20.74	-
8	-0.79	1.38	1.10	-	13.42	-
9	-1.42	3.39	0.44	-	9.20	-
10	-1.80	5.48	0.27	-	5.87	-

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-1
Unit	A (Southern Bight)
Test number	CTX05

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	-2
Initial effective axial pressure	[kPa]	-2
Rate of strain	[%/hour]	4.75
At peak deviator stress		
Corrected deviator stress	[kPa]	1891
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	21.38
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-813
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	838
Effective axial pressure	[kPa]	2729
Principal effective stress ratio	[-]	3.26
ε_{50}	[%]	10.76
Secant modulus (E_{50}) at ε_{50}	[kPa]	7656
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	9
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	4.85
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	25
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	0
Effective axial pressure	[kPa]	9
Principal effective stress ratio	[-]	460.01
At 10% external axial strain		
Corrected deviator stress	[kPa]	775
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-246
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	271
Effective axial pressure	[kPa]	1046
Principal effective stress ratio	[-]	3.85

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-1
Unit	A (Southern Bight)
Test number	CTX05

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



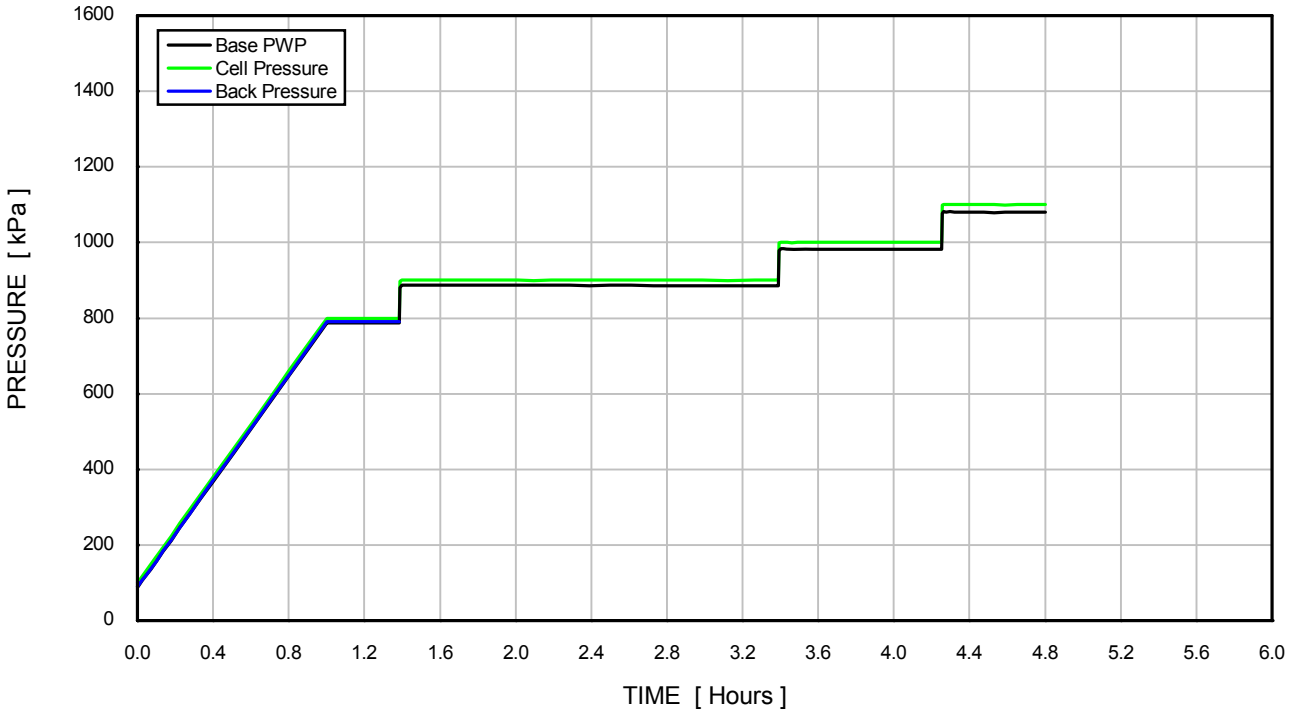


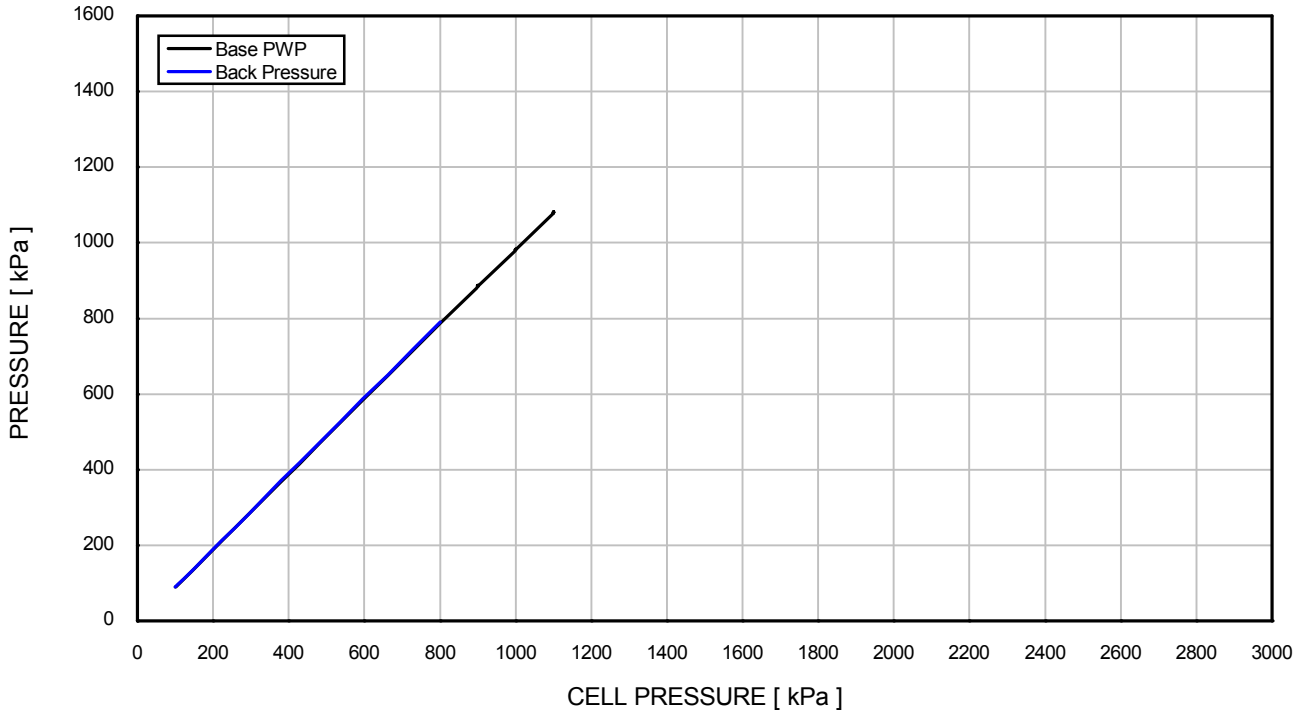
FINAL CONDITIONS		
Moisture content	[%]	23.9
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-1
Unit	A (Southern Bight)
Test number	CTX05

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

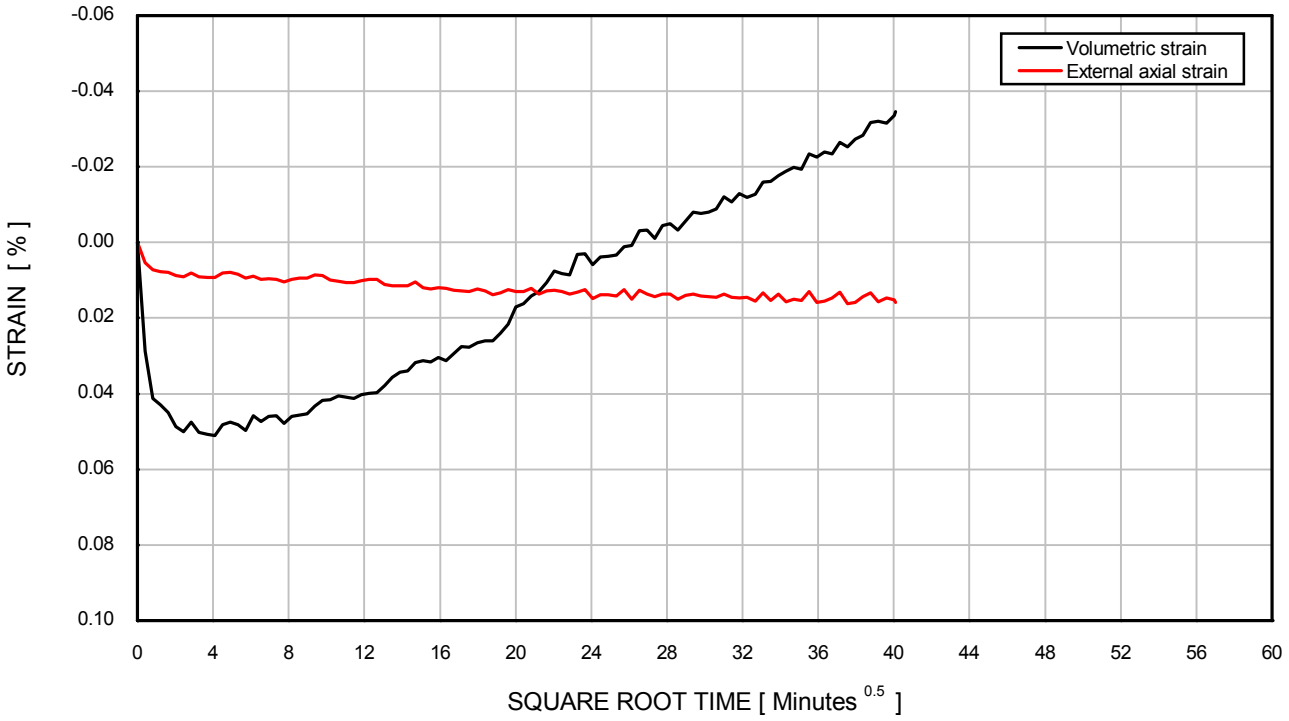


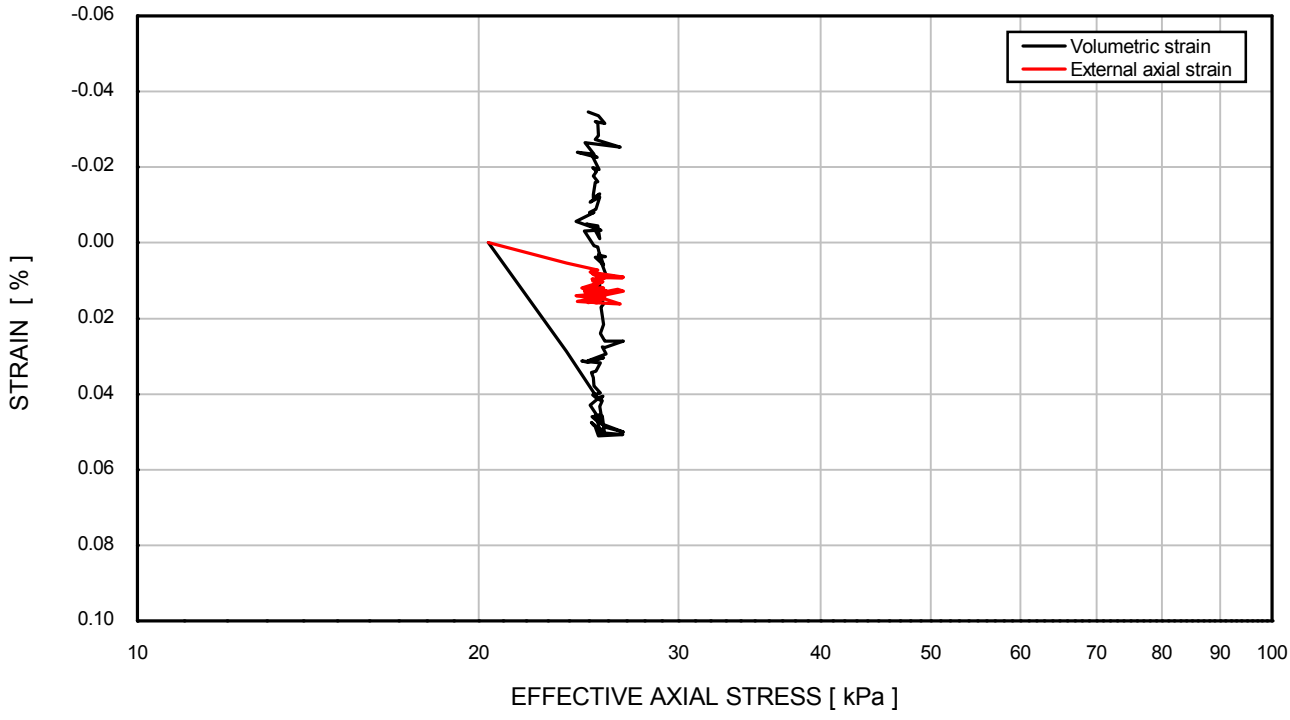


B value	:	0.98			
Initial σ'_r	:	11	kPa	Batch	: 1
Initial σ'_a	:	11	kPa	Sample	: CTX_1-1
Final σ'_r	:	20	kPa	Unit	: A (Southern Bight)
Final σ'_a	:	20	kPa	Test No.	: CTX05

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

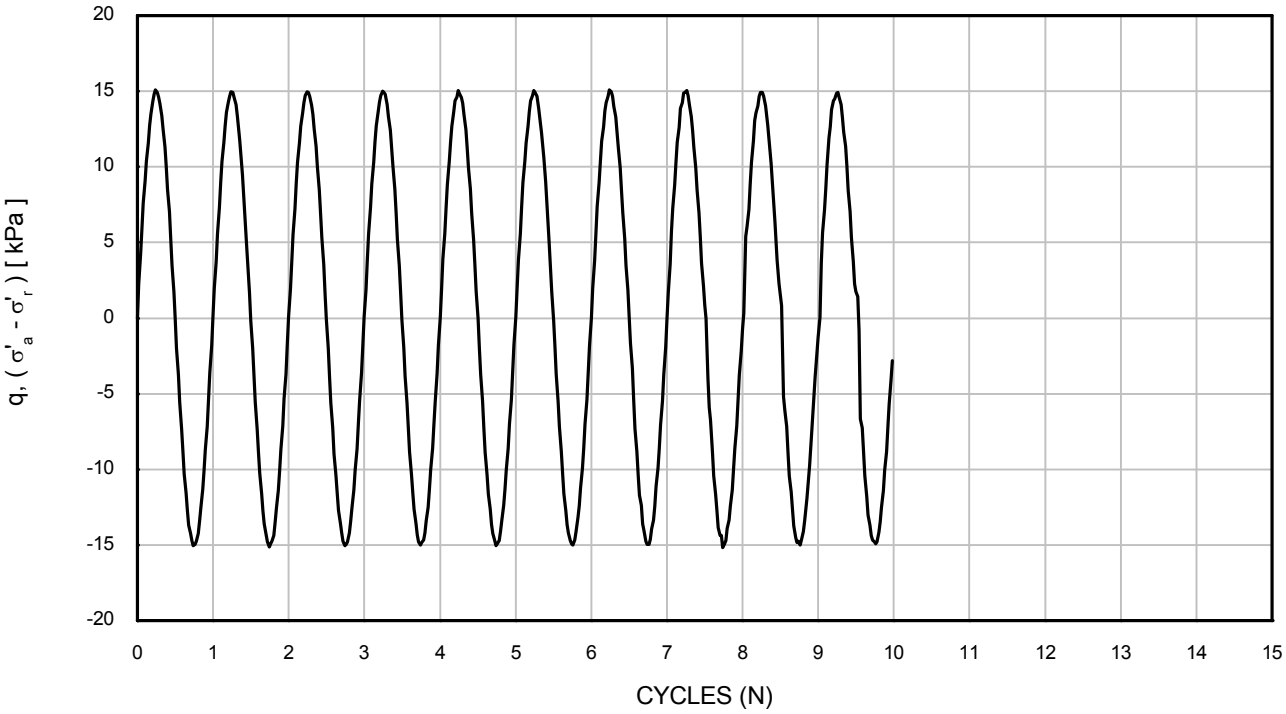


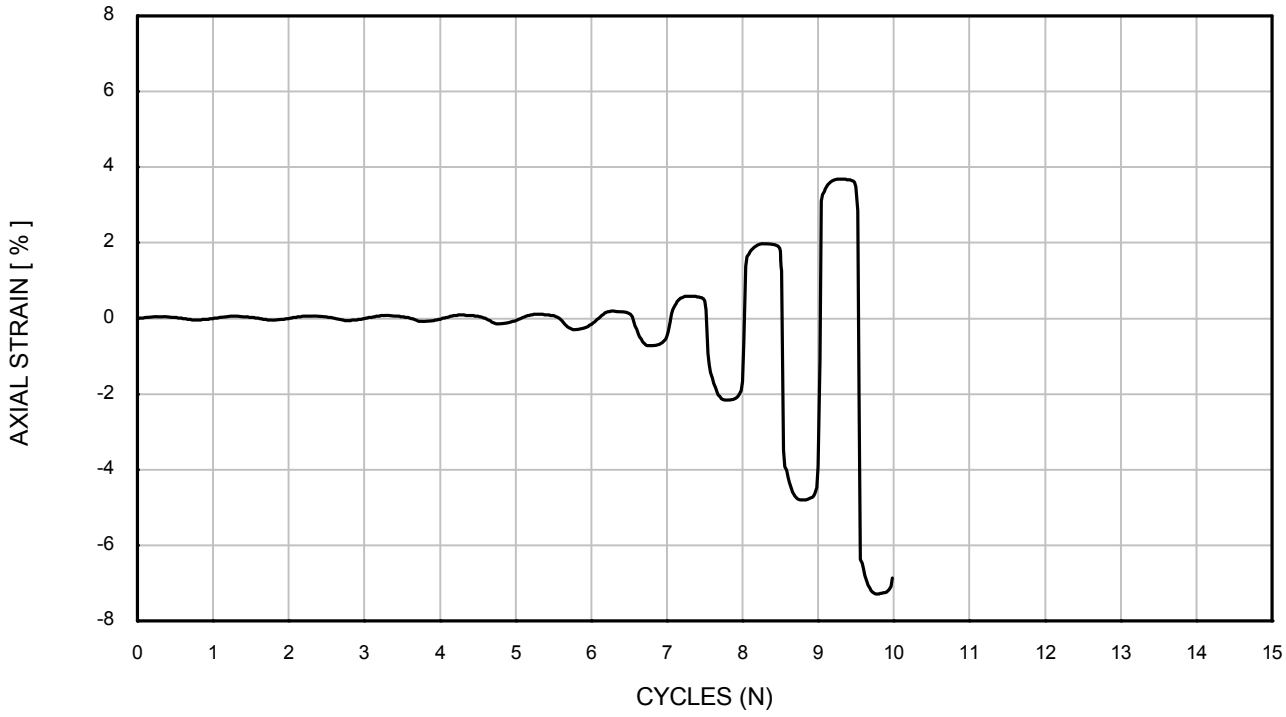


σ'_{rc}	:	25 kPa	Batch	: 1
σ'_{ac}	:	25 kPa	Sample	: CTX_1-1
			Unit	: A (Southern Bight)
			Test No.	: CTX05

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

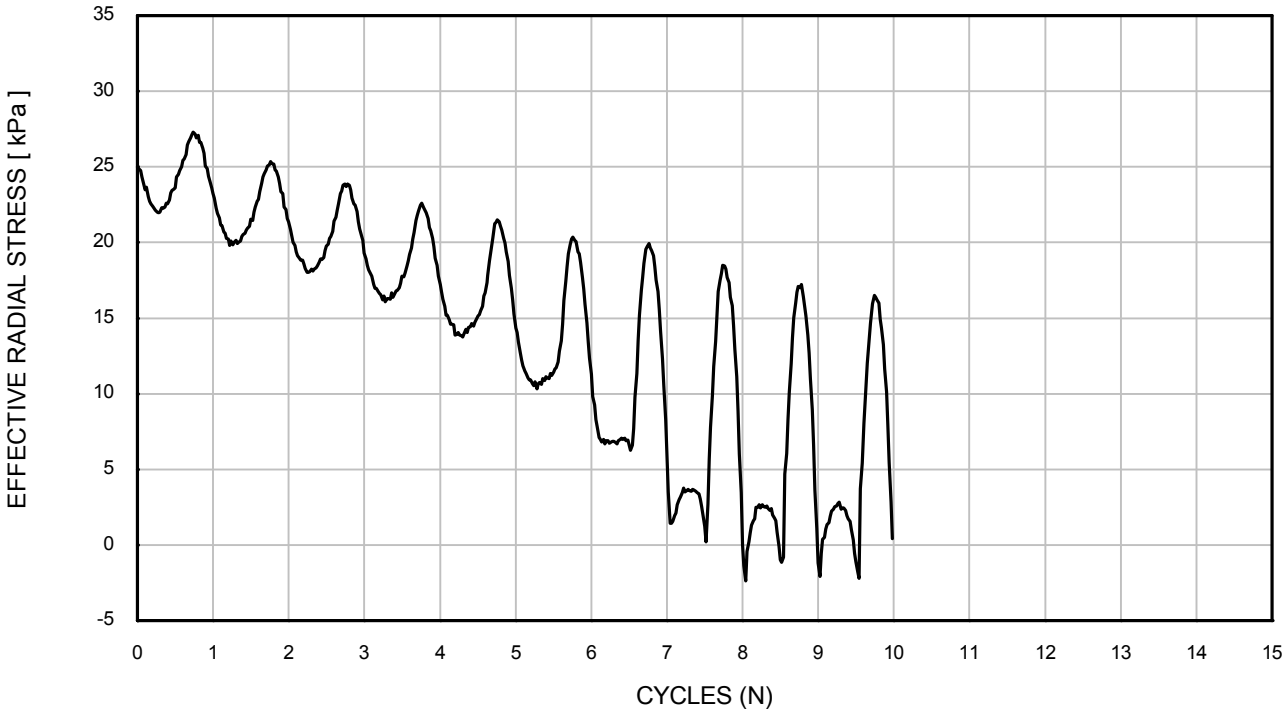


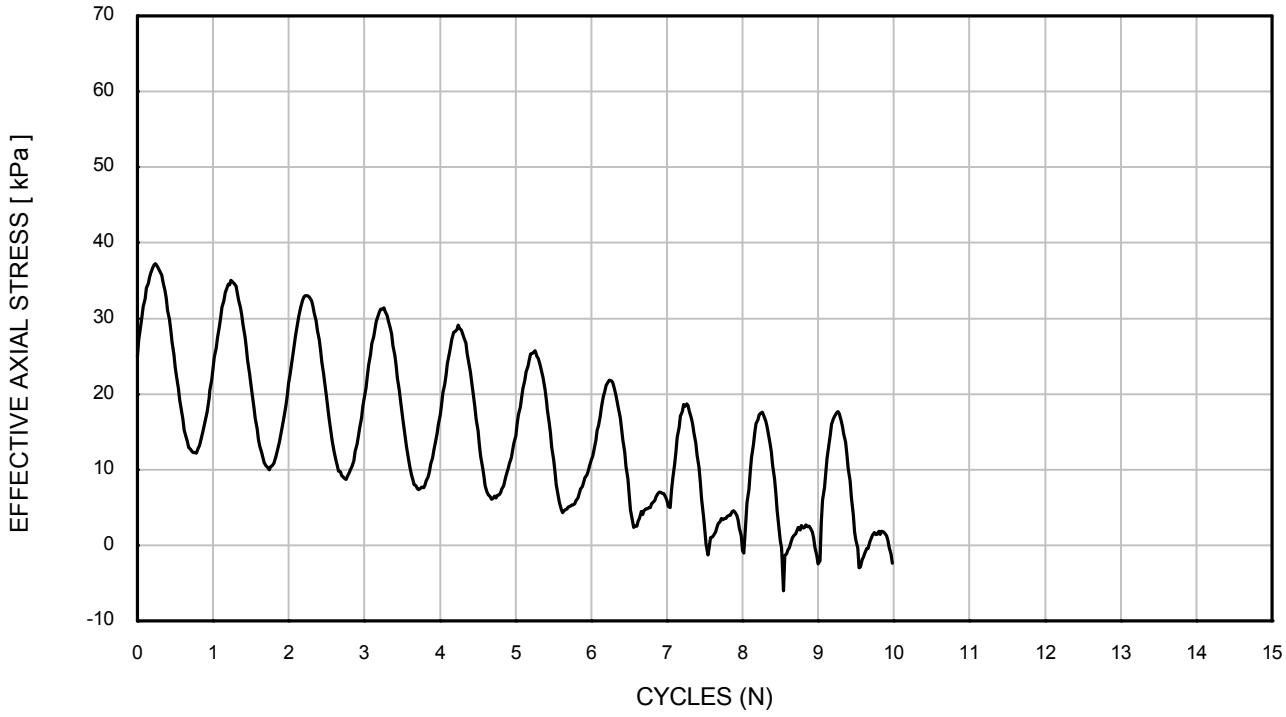


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-1
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	15	kPa	Test No.	: CTX05
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

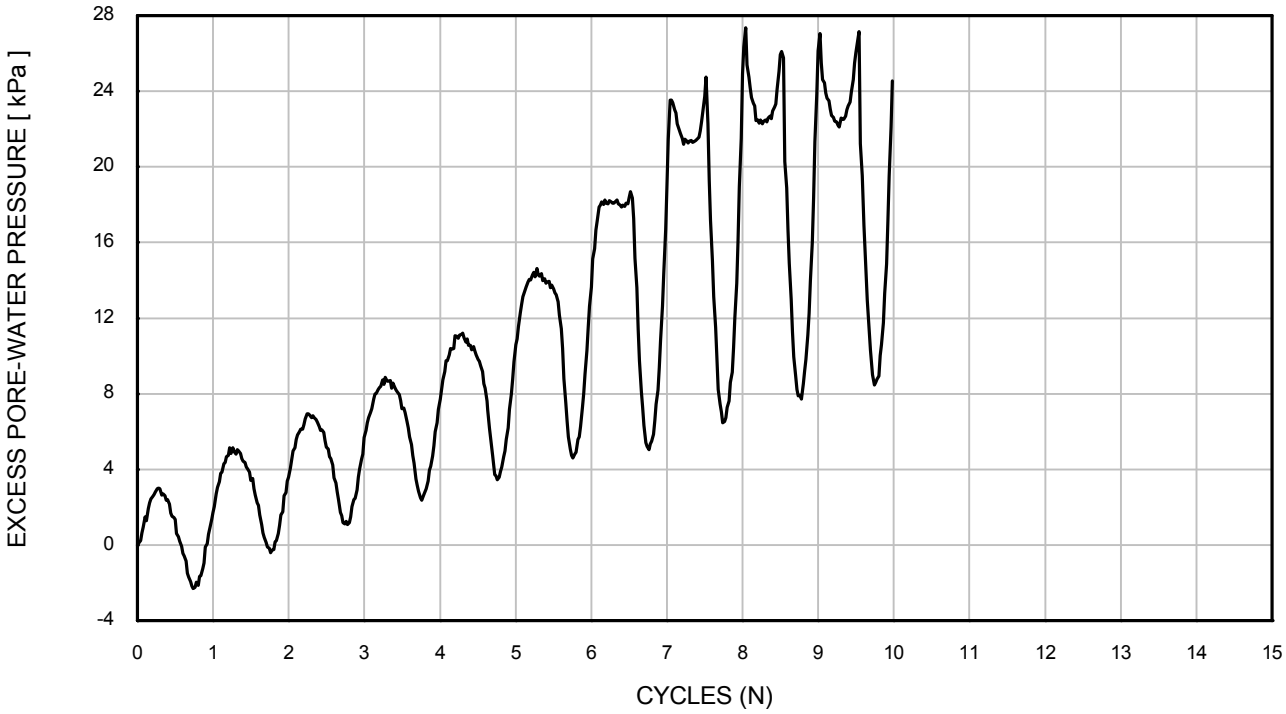


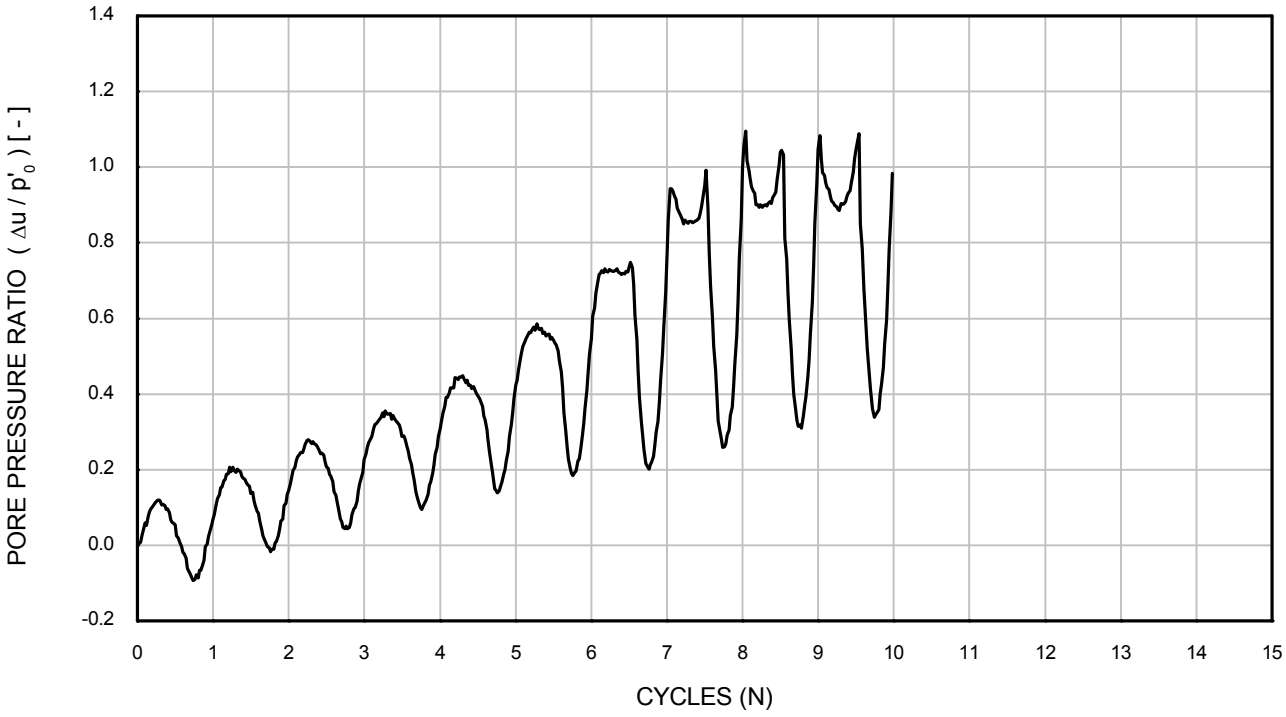


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-1
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	15	kPa	Test No.	: CTX05
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

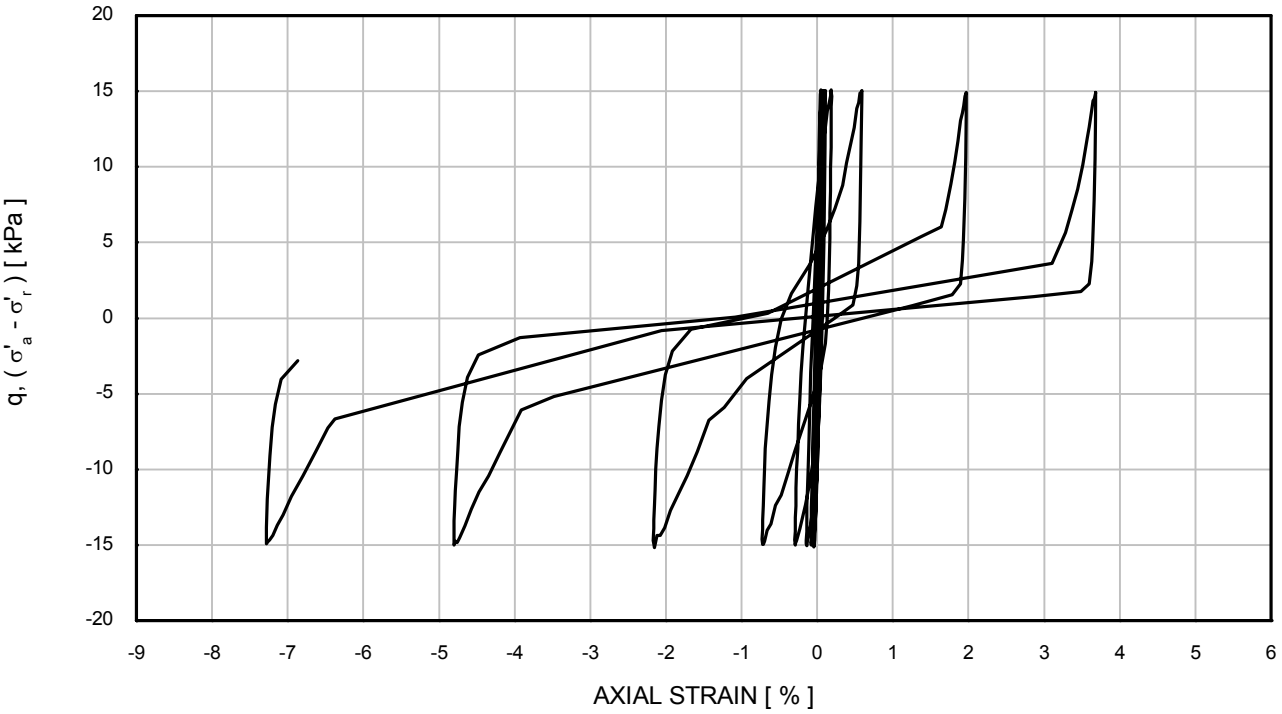


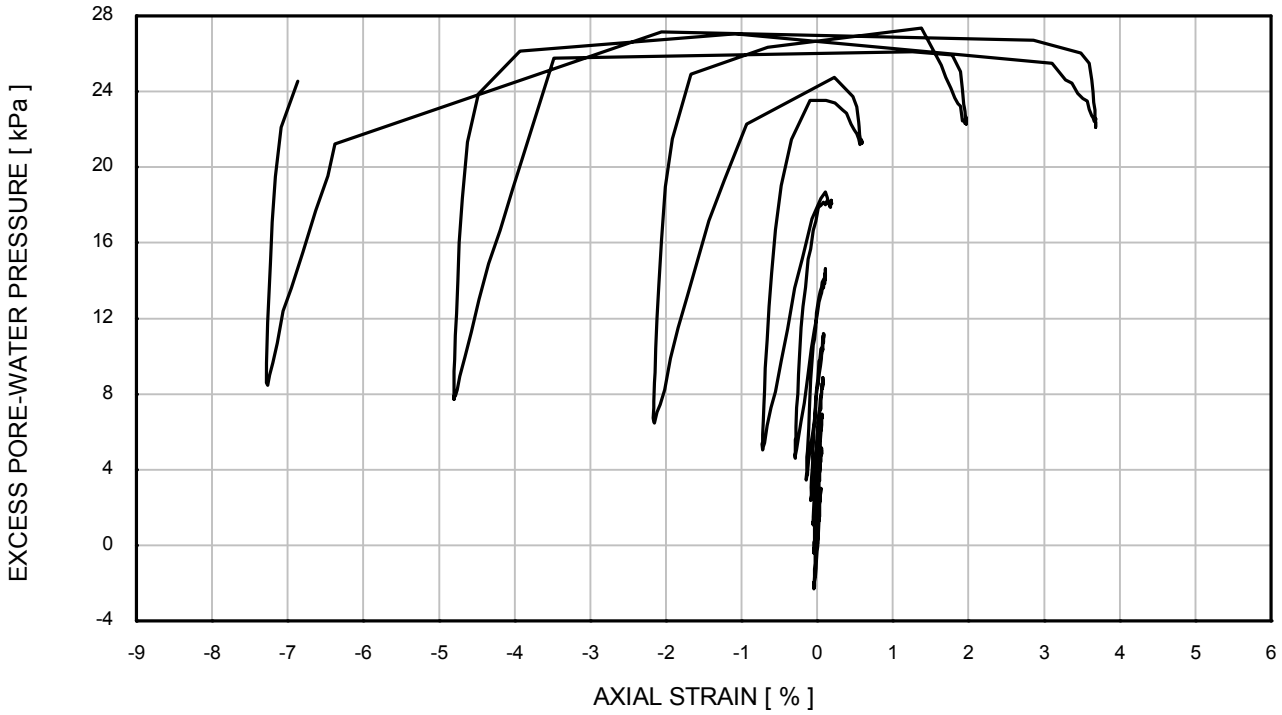


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-1
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	15	kPa	Test No.	: CTX05
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

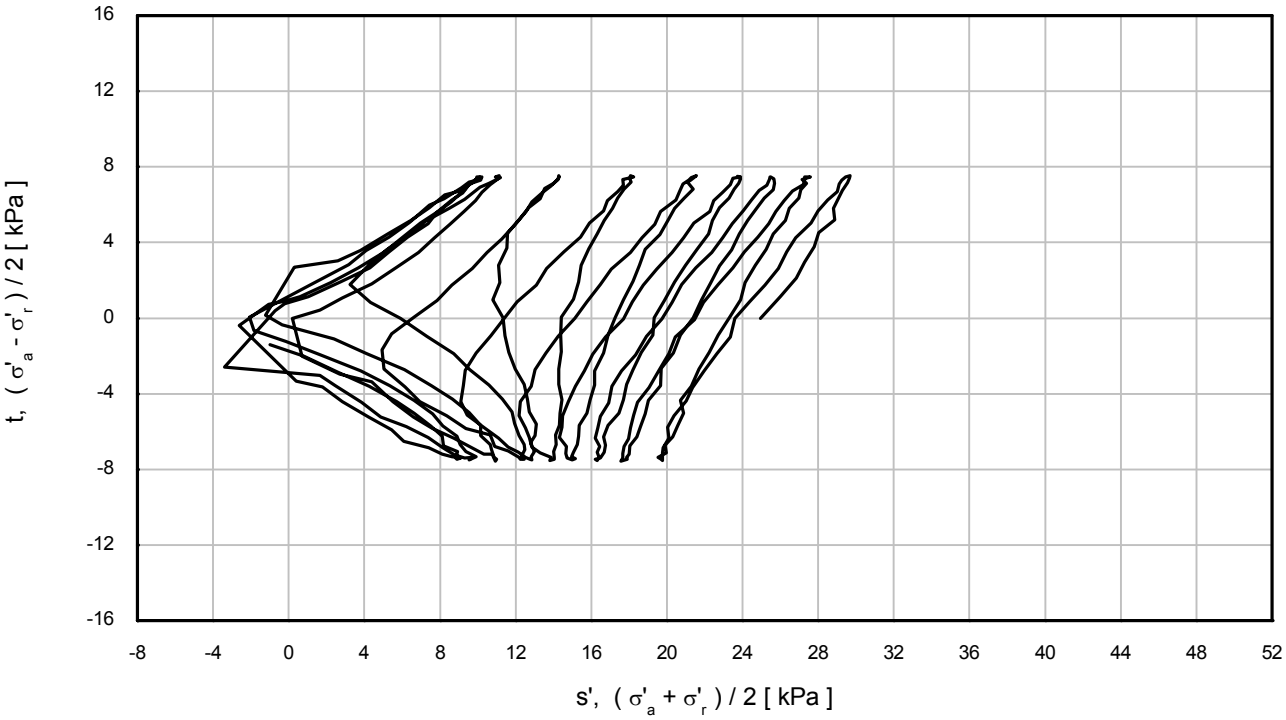


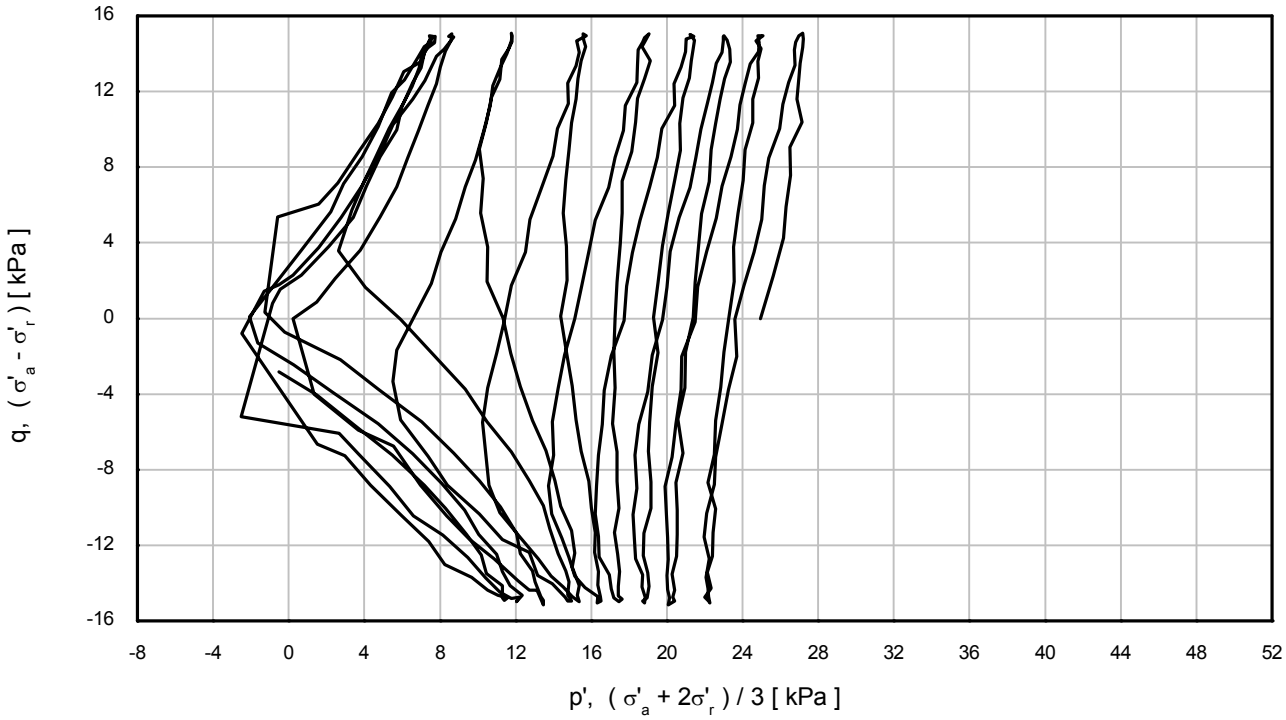


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-1
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	15 kPa	Test No.	:	CTX05
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

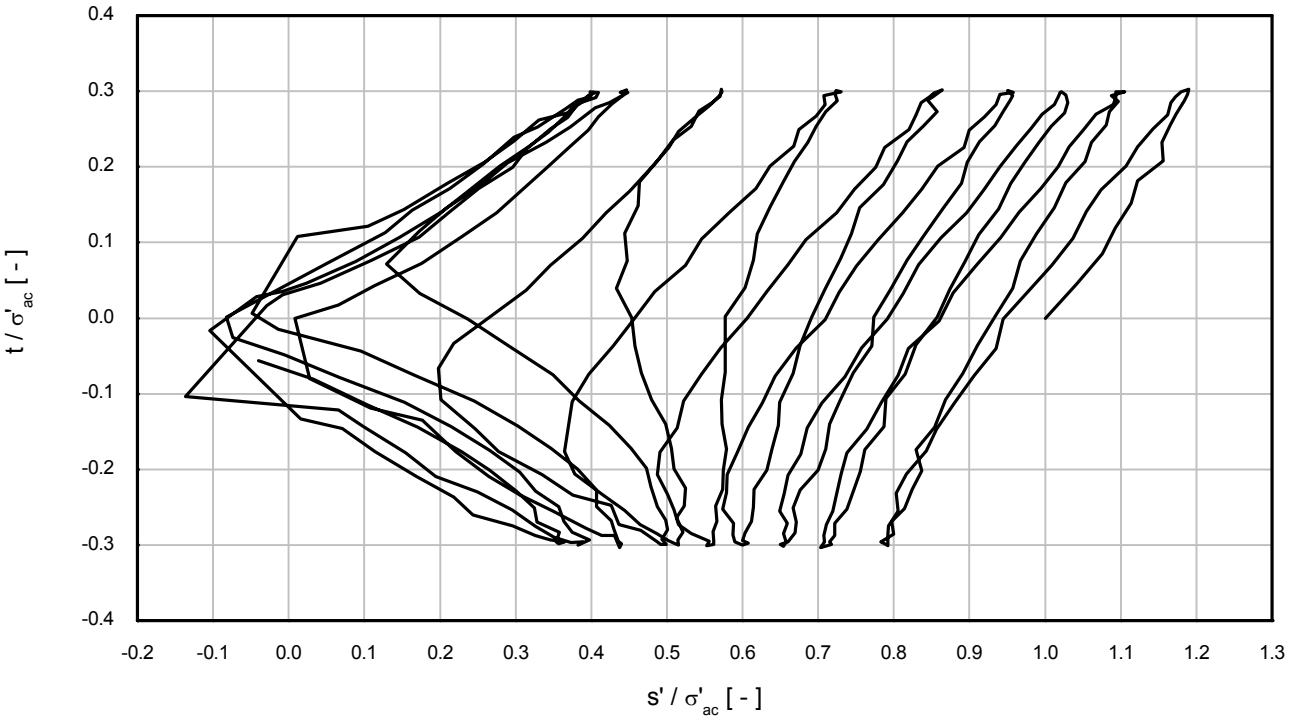


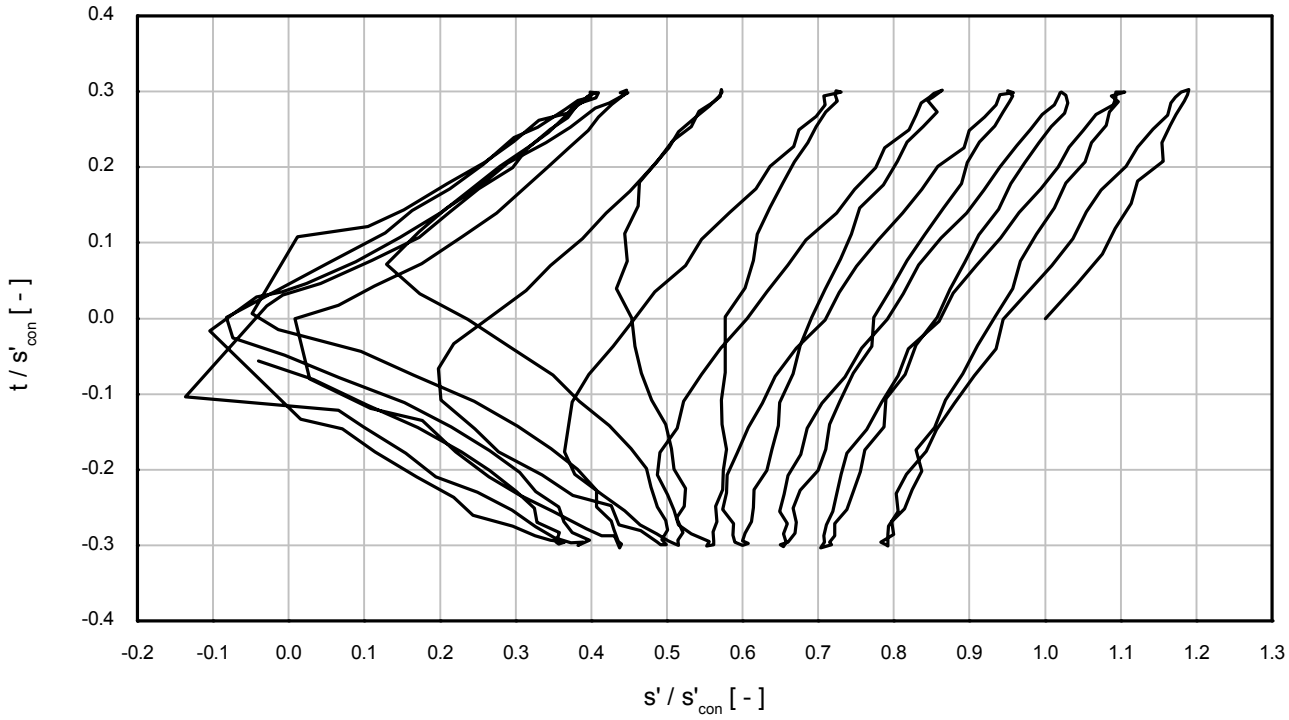


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-1
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	15	kPa	Test No.	: CTX05
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

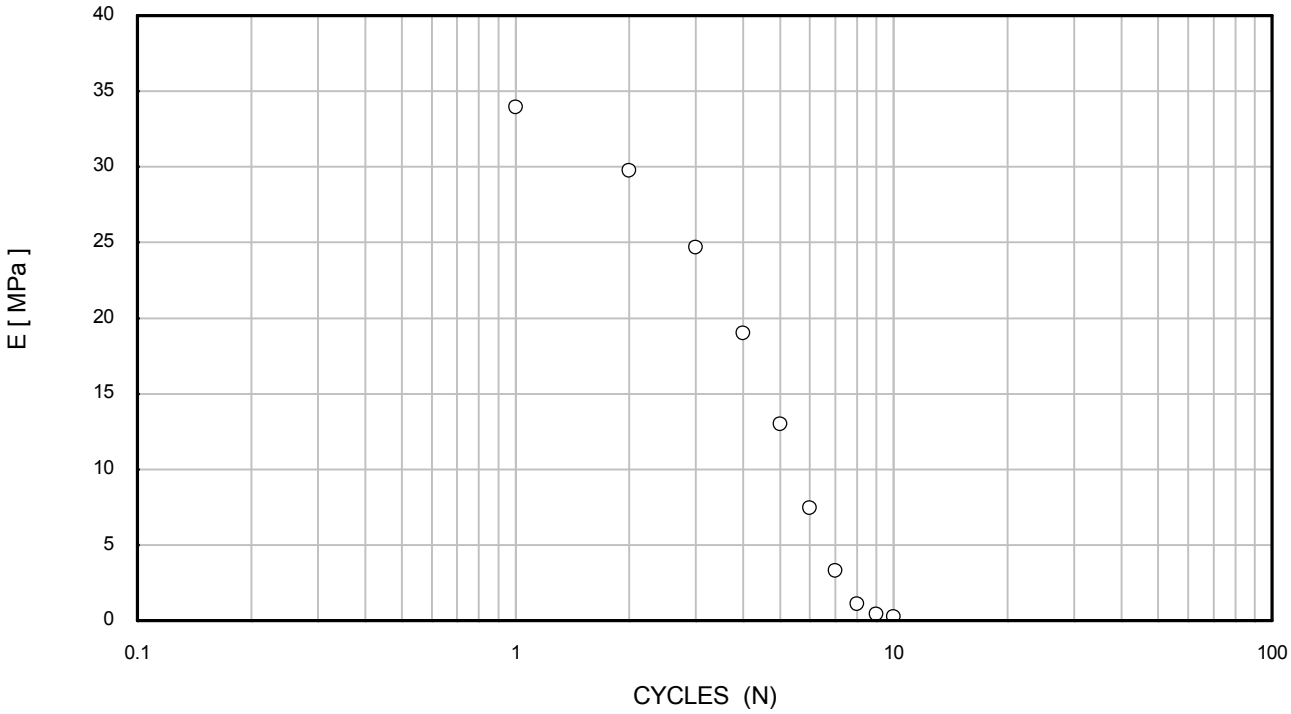


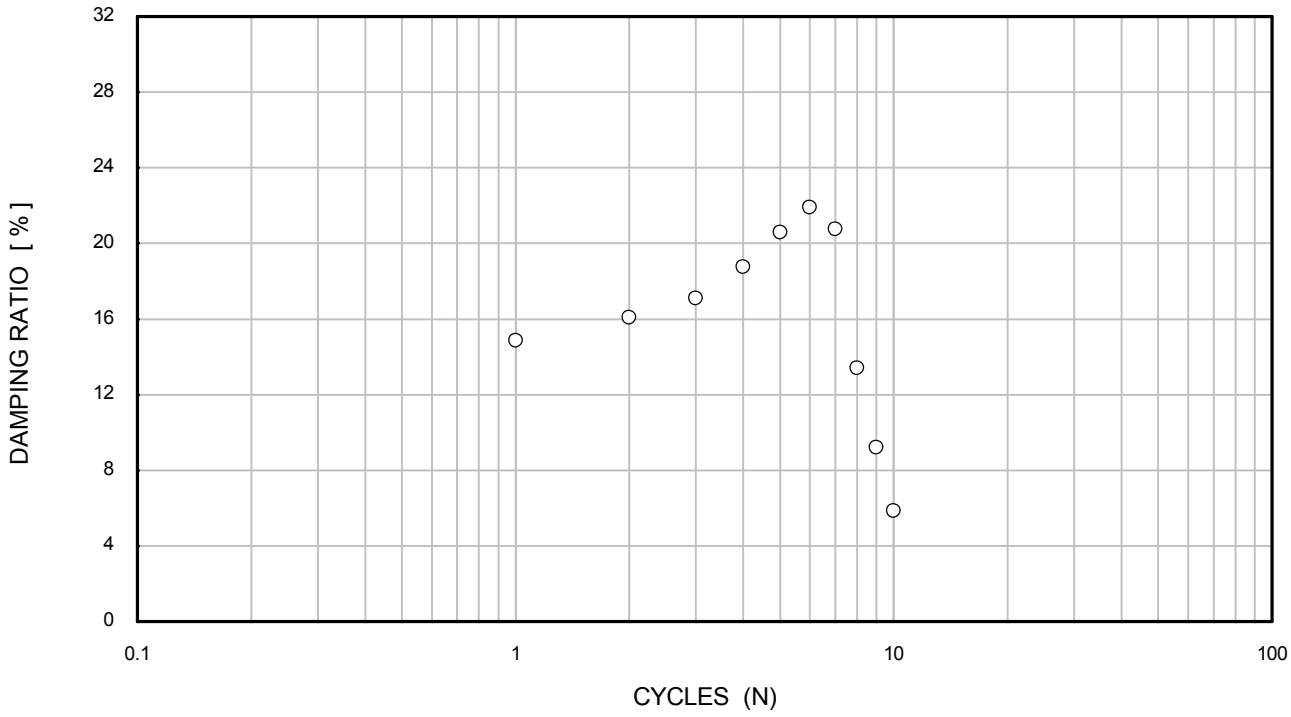


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-1
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	15 kPa	Test No.	:	CTX05
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

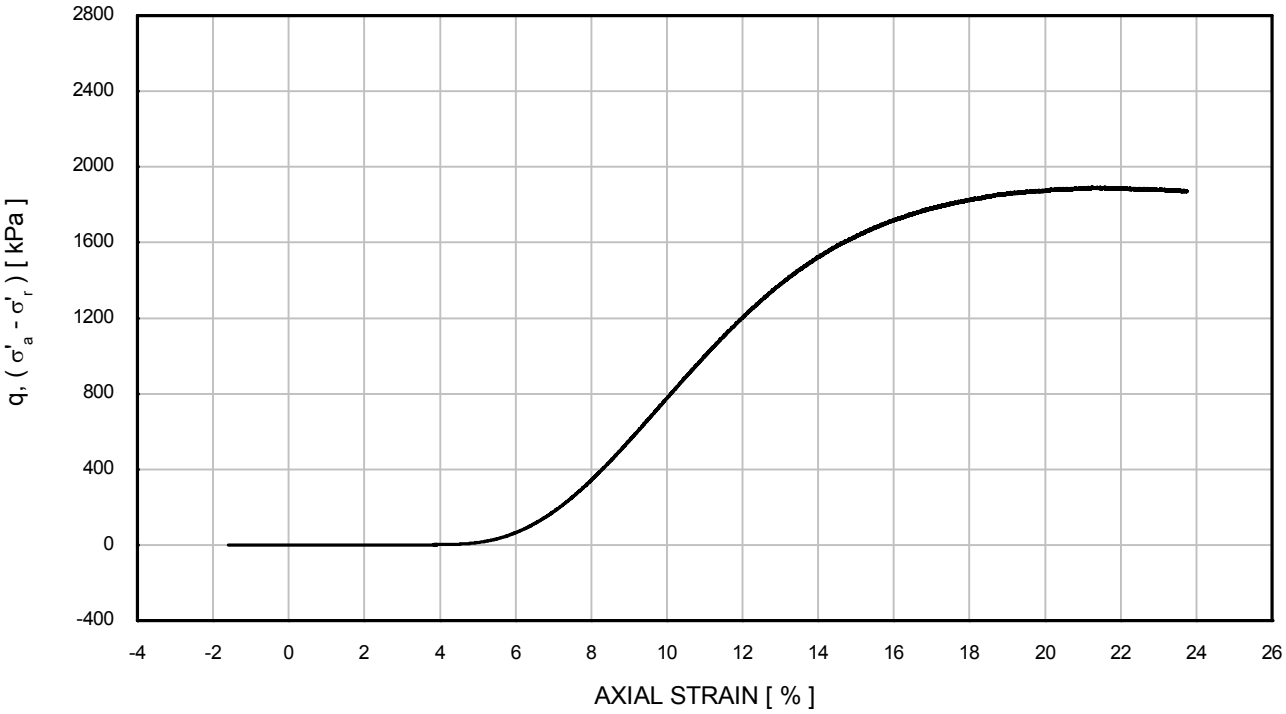


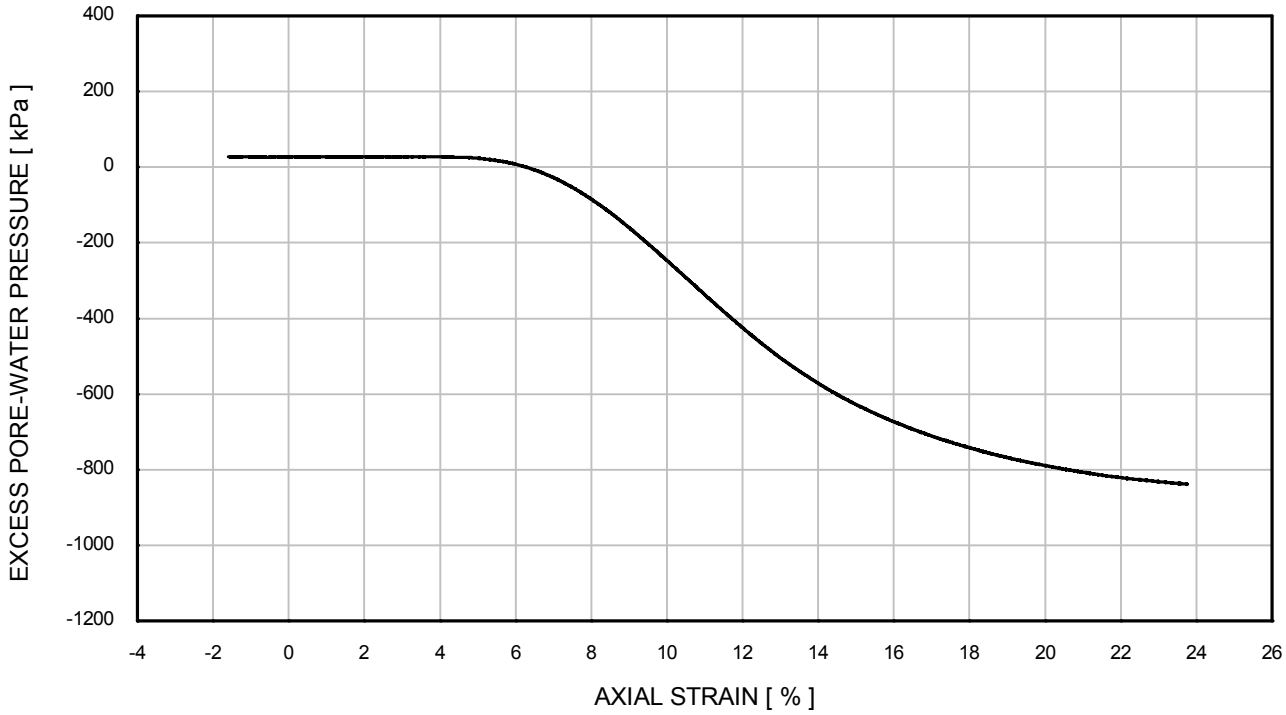


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-1
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	15 kPa	Test No.	:	CTX05
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

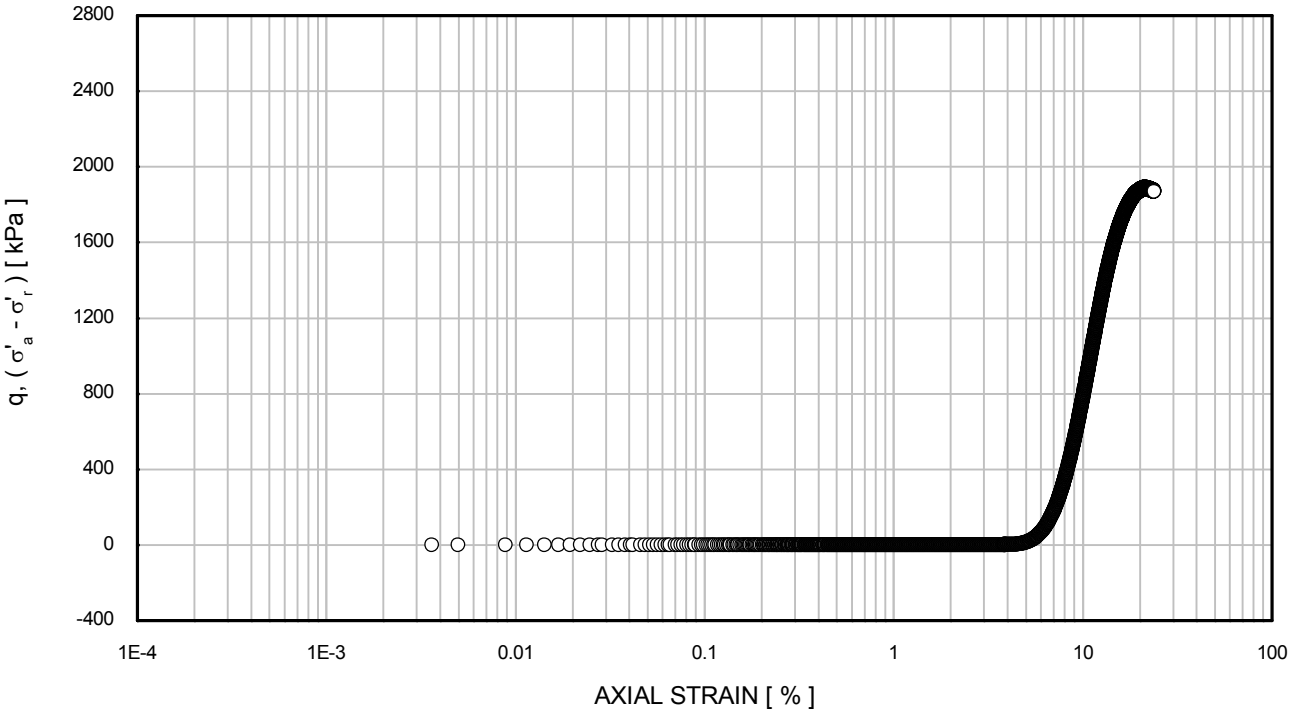


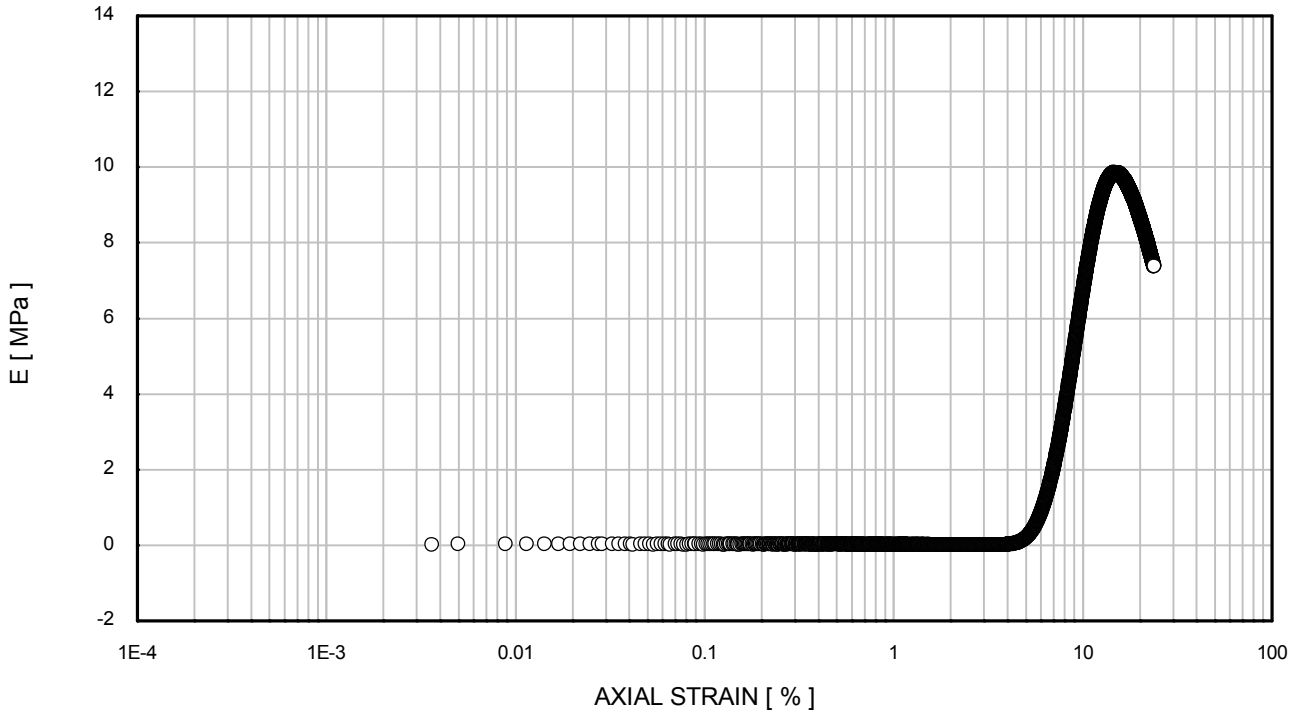


Initial σ'_r	:	-2 kPa	Batch	:	1
Initial σ'_a	:	-2 kPa	Sample	:	CTX_1-1
q_{peak}	:	1891 kPa	Unit	:	A (Southern Bight)
Ext. ε at q_{peak}	:	21.38 %	Test No.	:	CTX05
Rate of strain	:	4.75 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

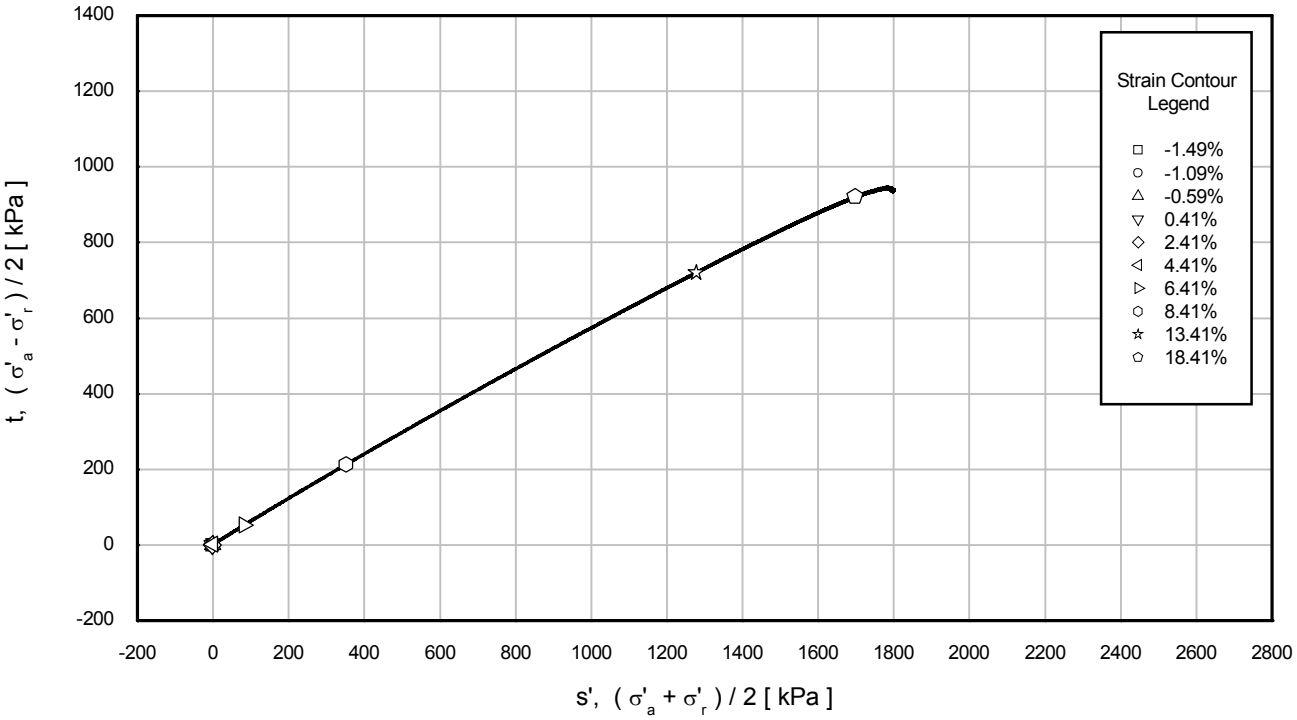


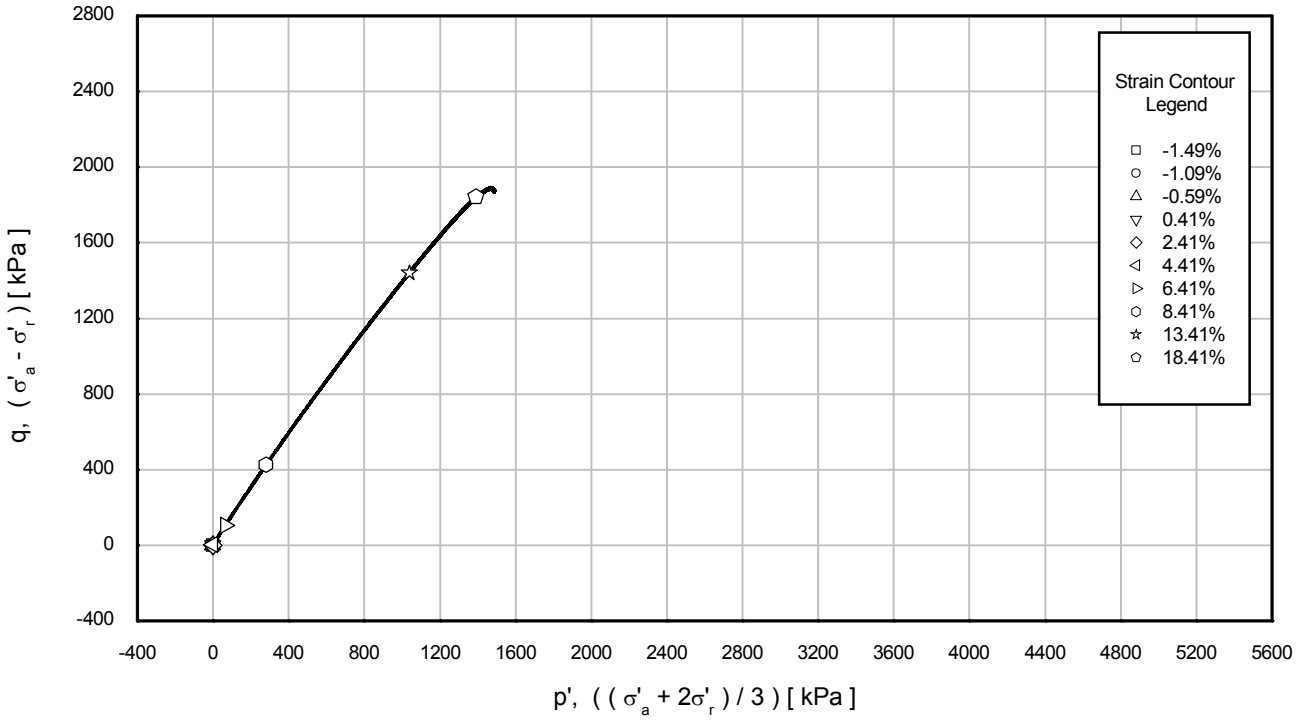


Initial σ'_r	:	-2 kPa	Batch	:	1
Initial σ'_a	:	-2 kPa	Sample	:	CTX_1-1
q_{peak}	:	1891 kPa	Unit	:	A (Southern Bight)
Ext. ε at q_{peak}	:	21.38 %	Test No.	:	CTX05
Rate of strain	:	4.75 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	-2 kPa	Batch	:	1
Initial σ'_a	:	-2 kPa	Sample	:	CTX_1-1
q_{peak}	:	1891 kPa	Unit	:	A (Southern Bight)
Ext. ε at q_{peak}	:	21.38 %	Test No.	:	CTX05
Rate of strain	:	4.75 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	29/01/2015
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.4
Bulk density	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.632
Degree of saturation	[%]	44
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 1_CTX-1-2_CTX6
Processed by Date	PH 04/02/2016
Checked by Date	DT 03/03/2016
Approved by Date	PH 04/03/2016

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-2
Unit	A (Southern Bight)
Test number	CTX06

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1079
Mid height PWP	[kPa]	-
B value achieved	[-]	0.97

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1104
Back pressure	[kPa]	1079
Base PWP	[kPa]	1079
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	25
Effective axial pressure	[kPa]	25
Deviator stress	[kPa]	0
Volumetric strain	[%]	-0.07
External axial strain	[%]	0.01
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	23.9
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.633
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-2
Unit	A (Southern Bight)
Test number	CTX06

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	50
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	10
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	117
External ε_{av} at N_f	[%]	0.13
External ε_{cy} at N_f	[%]	0.47
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	20
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	23.9
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.633
Degree of saturation	[%]	100

Cycle* (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.01	0.02	46.76	-	9.61	-
2	0.01	0.02	47.12	-	6.33	-
5	0.02	0.02	45.85	-	5.00	-
10	0.03	0.02	44.88	-	4.54	-
20	0.04	0.02	42.88	-	4.57	-
30	0.05	0.02	40.89	-	4.76	-
40	0.06	0.03	38.98	-	5.15	-
50	0.07	0.03	37.31	-	5.55	-
100	0.13	0.04	22.79	-	12.03	-
117	0.13	0.47	2.14	-	16.71	-

* 100% pwp ratio criteria reached on 117th cycle

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-2
Unit	A (Southern Bight)
Test number	CTX06

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	-2
Initial effective axial pressure	[kPa]	-2
Rate of strain	[%/hour]	4.72
At peak deviator stress		
Corrected deviator stress	[kPa]	2371
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	13.69
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-901
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	926
Effective axial pressure	[kPa]	3297
Principal effective stress ratio	[-]	3.56
ε_{50}	[%]	9.12
Secant modulus (E_{50}) at ε_{50}	[kPa]	16268
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	8
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	3.79
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	25
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	0
Effective axial pressure	[kPa]	8
Principal effective stress ratio	[-]	760.96
At 10% external axial strain		
Corrected deviator stress	[kPa]	1474
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-502
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	527
Effective axial pressure	[kPa]	2001
Principal effective stress ratio	[-]	3.79

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-2
Unit	A (Southern Bight)
Test number	CTX06

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



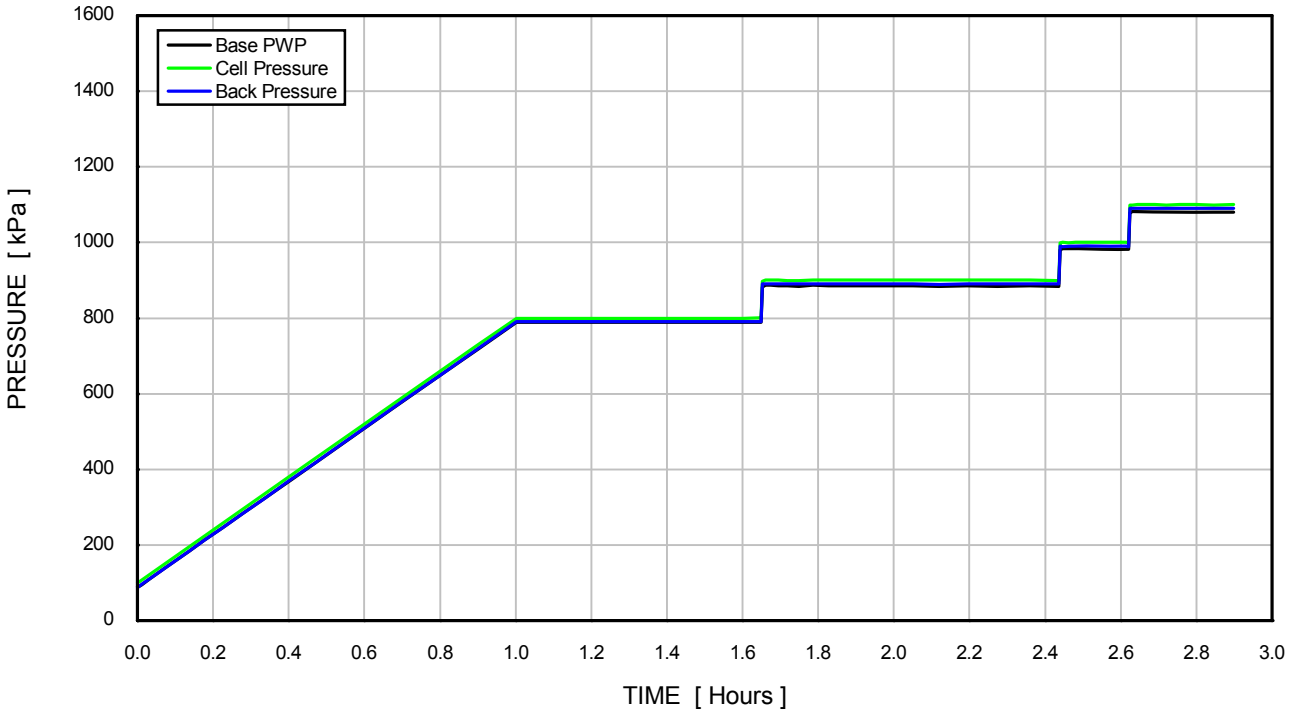


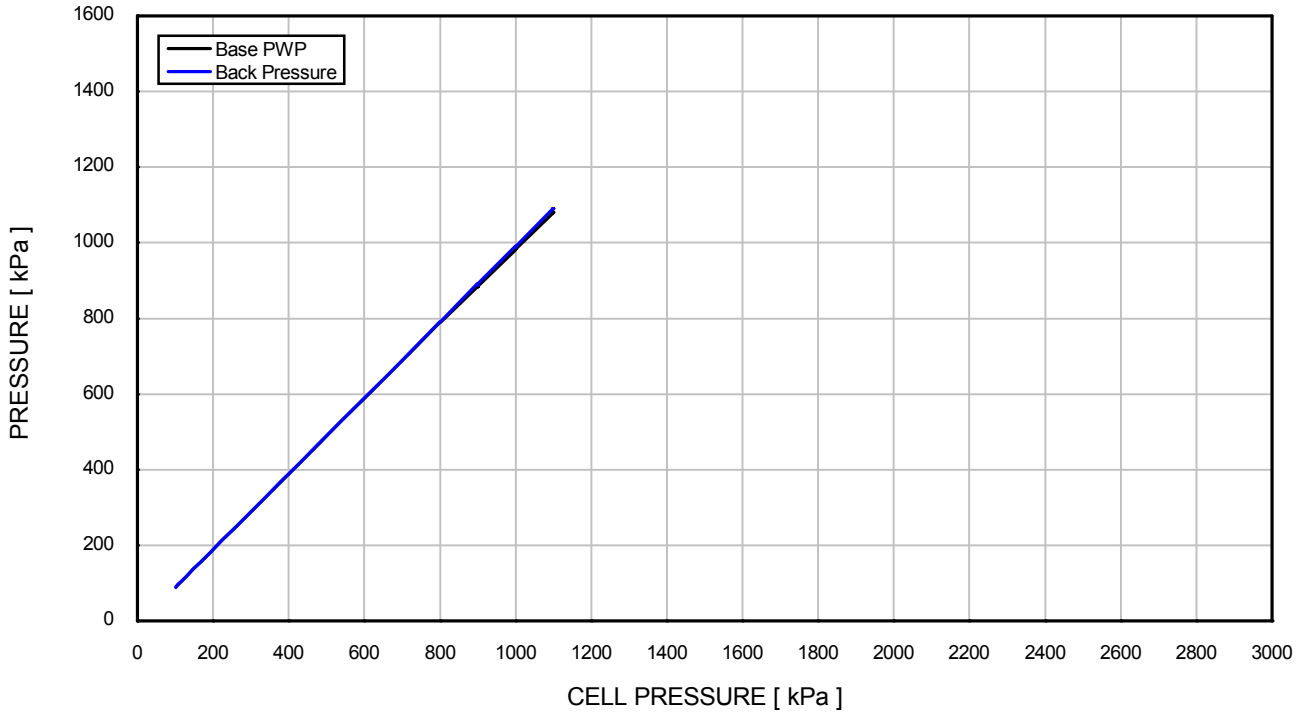
FINAL CONDITIONS		
Moisture content	[%]	23.9
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-2
Unit	A (Southern Bight)
Test number	CTX06

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

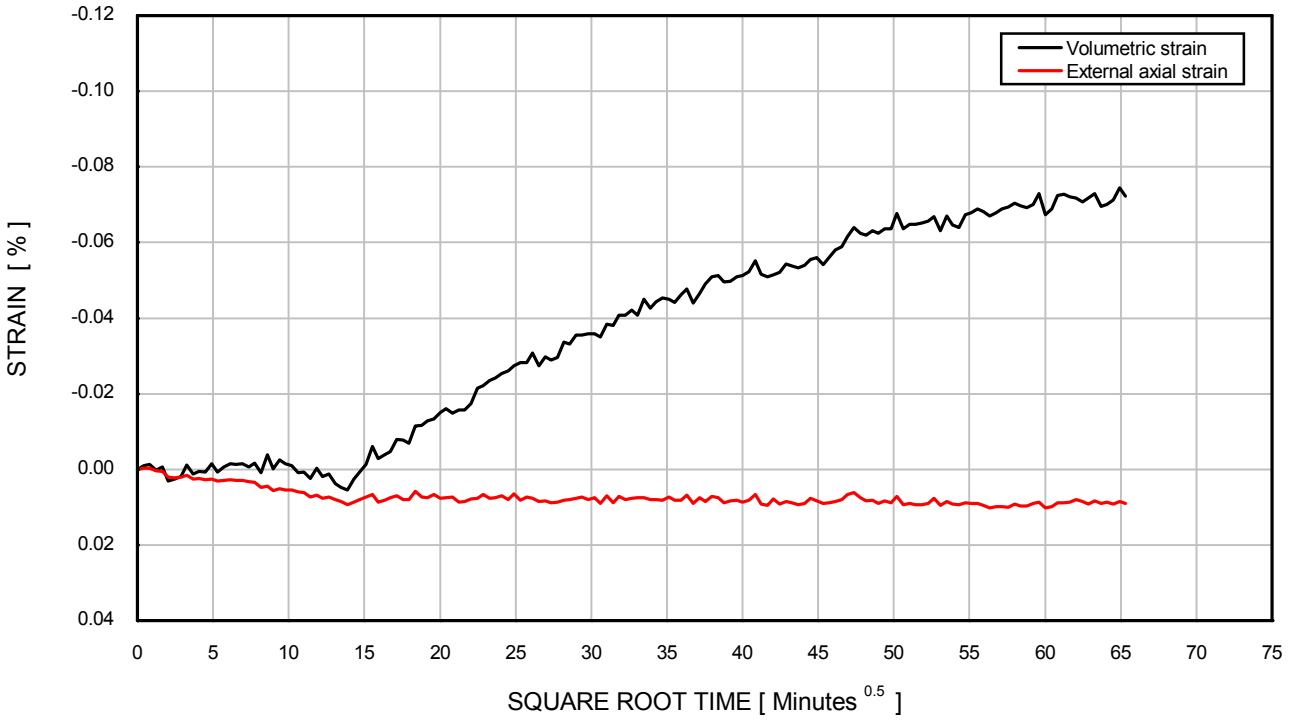


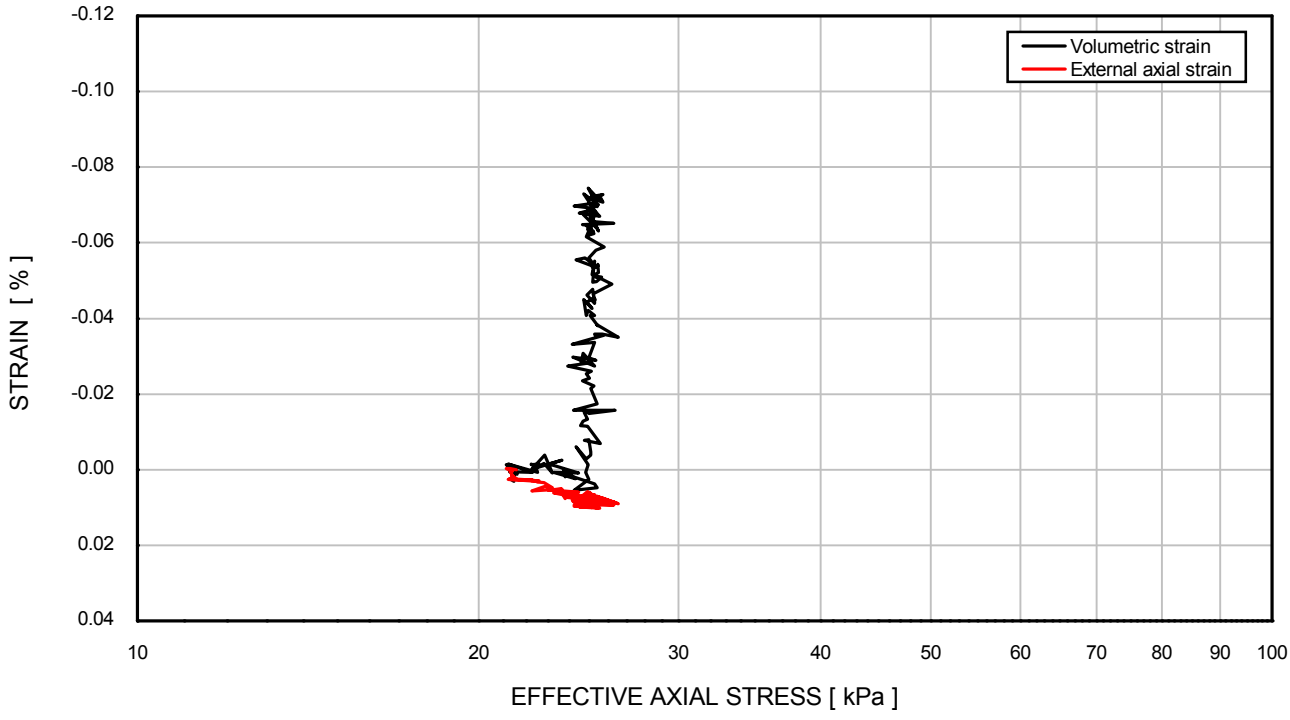


B value	:	0.97			
Initial σ'_r	:	12	kPa	Batch	: 1
Initial σ'_a	:	12	kPa	Sample	: CTX_1-2
Final σ'_r	:	21	kPa	Unit	: A (Southern Bight)
Final σ'_a	:	21	kPa	Test No.	: CTX06

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

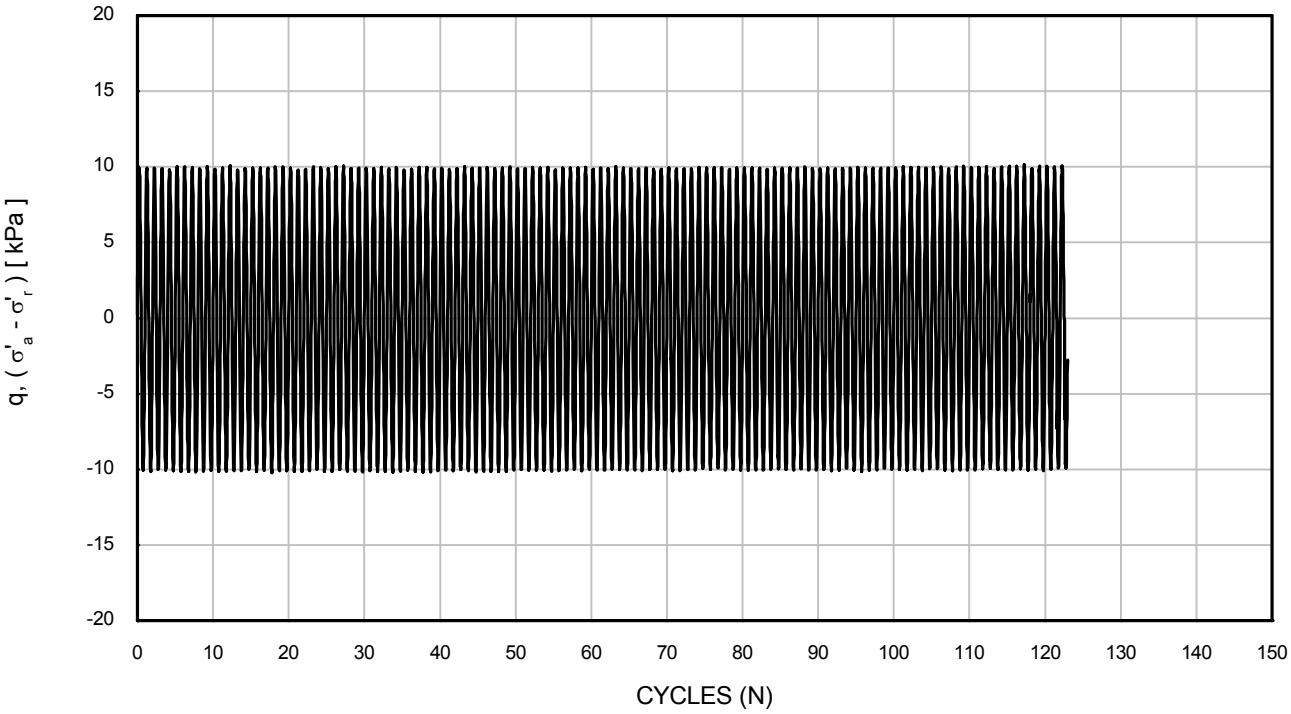


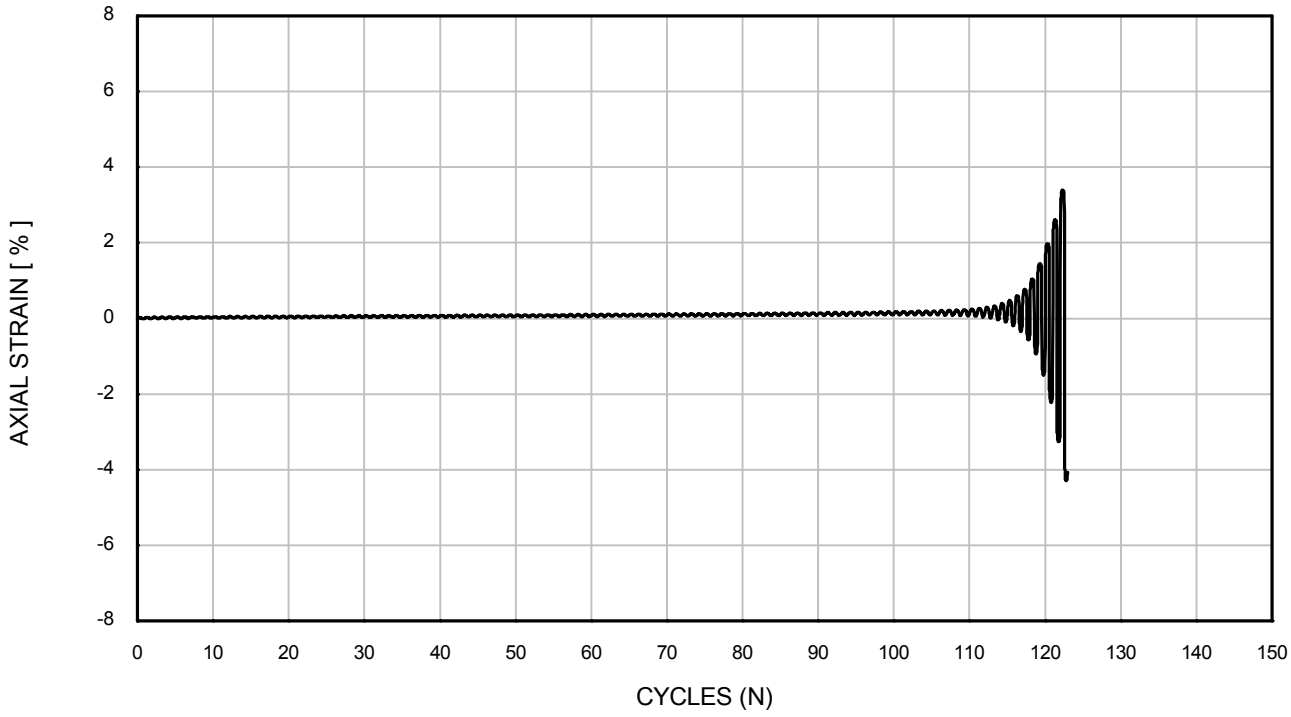


σ'_{rc}	:	25 kPa	Batch	:	1
σ'_{ac}	:	25 kPa	Sample	:	CTX_1-2
			Unit	:	A (Southern Bight)
			Test No.	:	CTX06

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

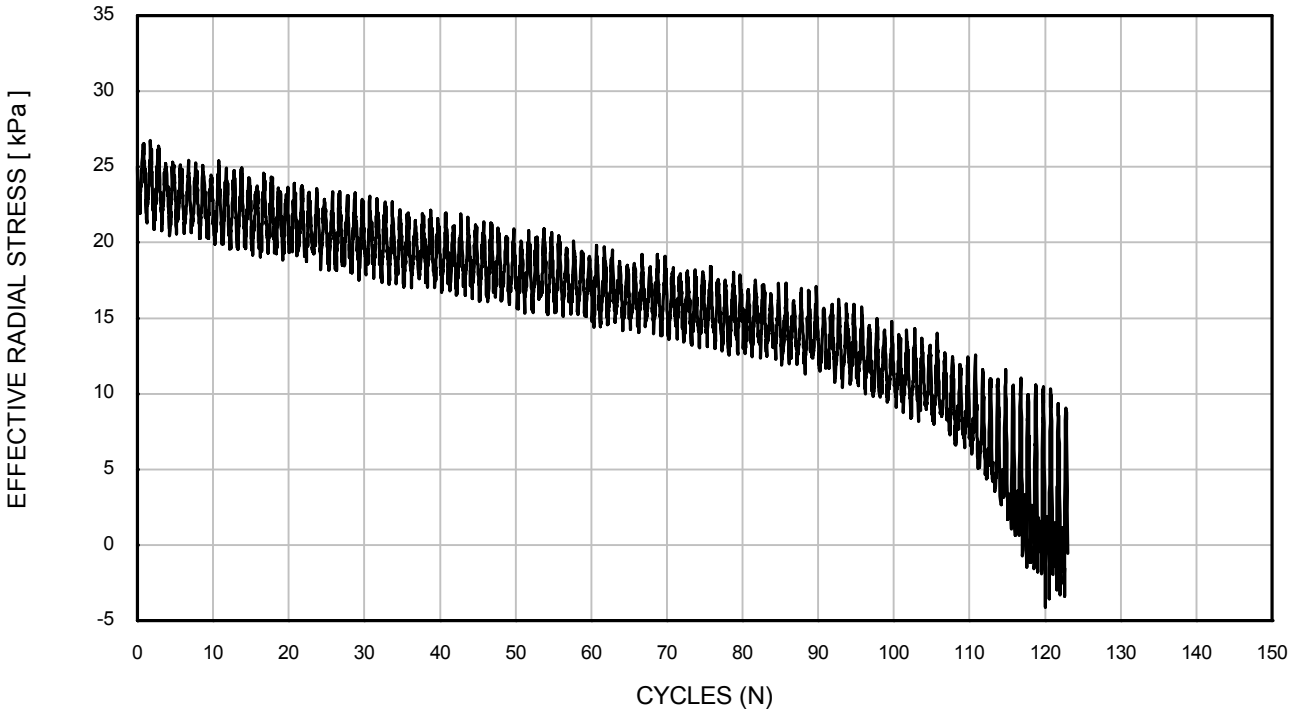


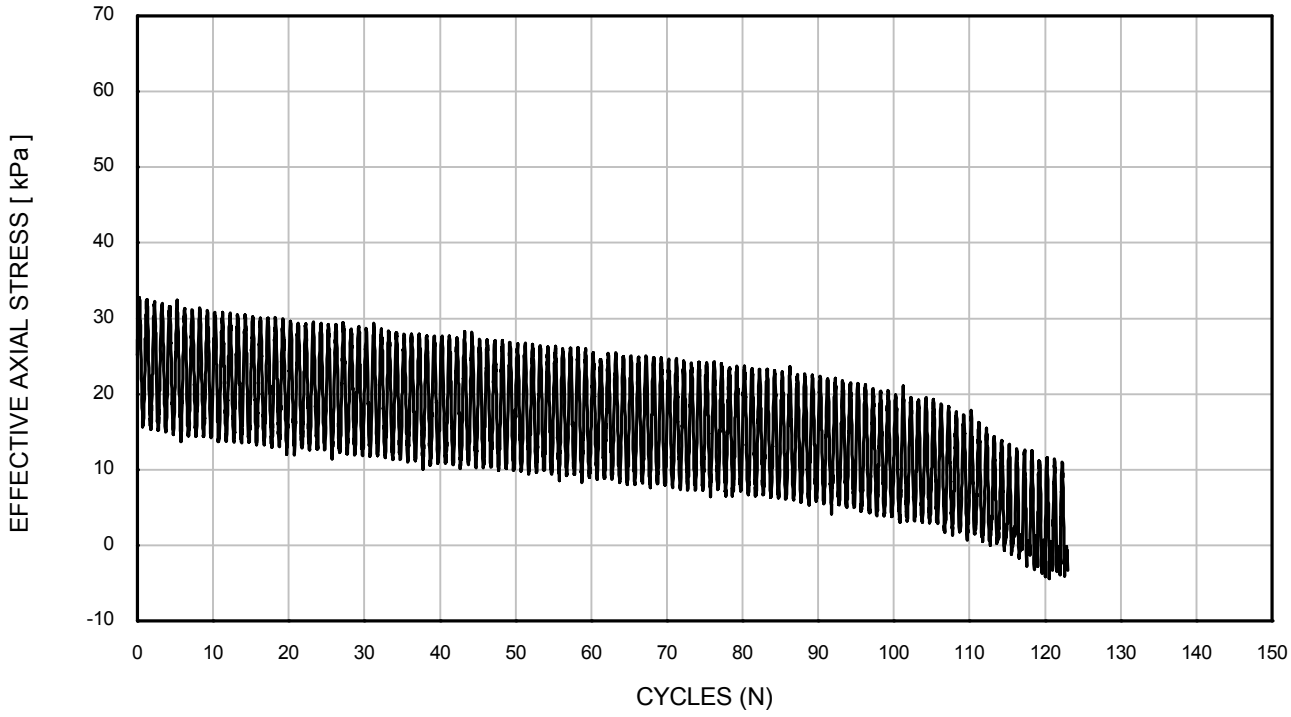


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-2
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX06
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

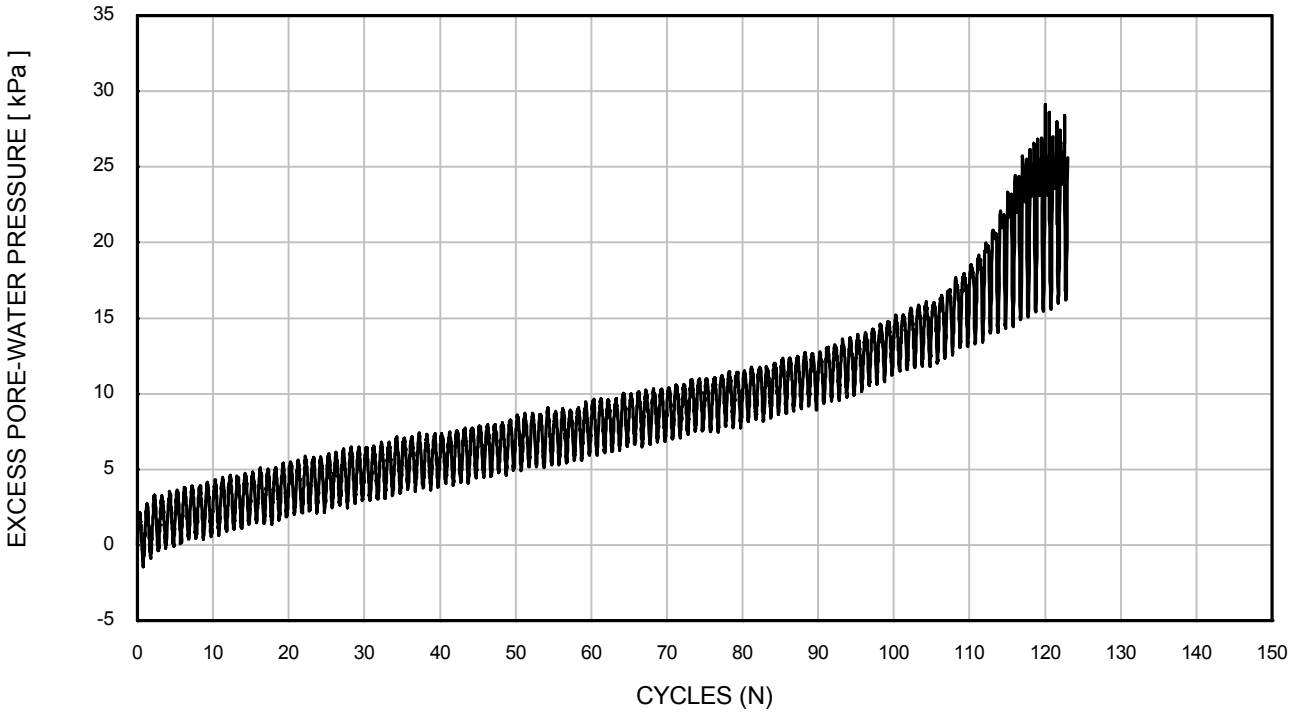


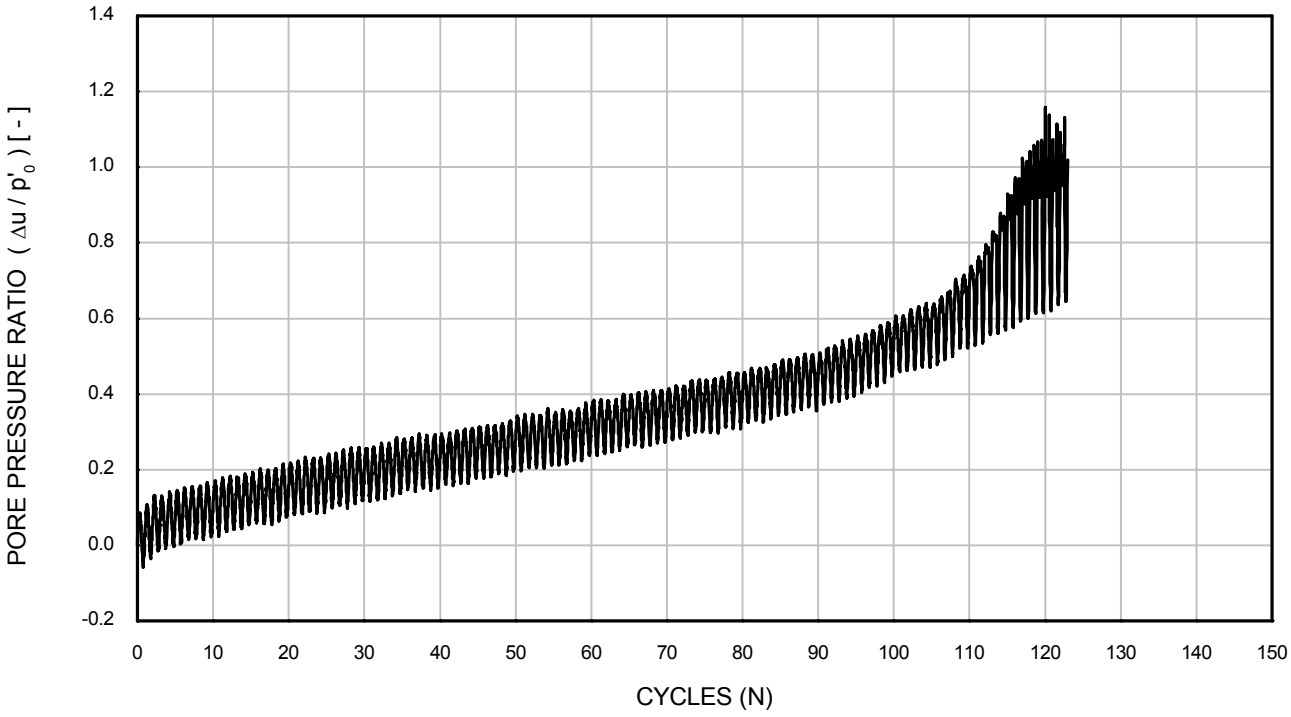


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-2
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX06
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

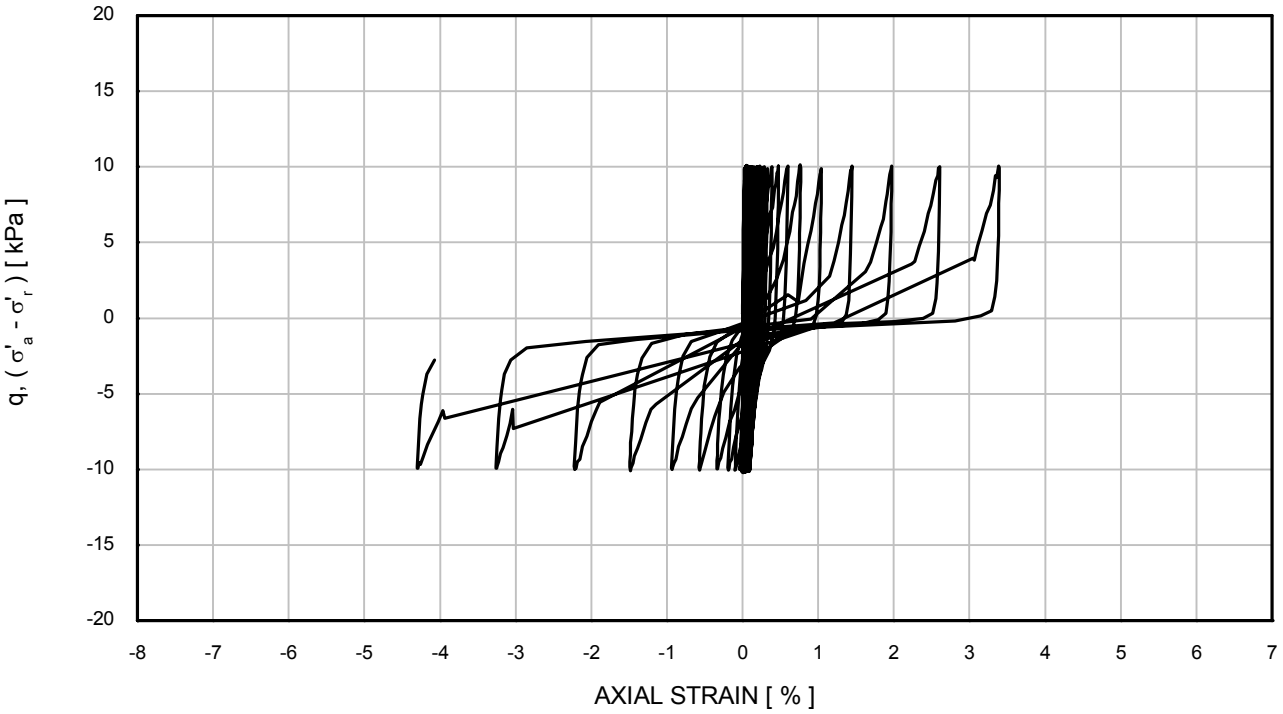


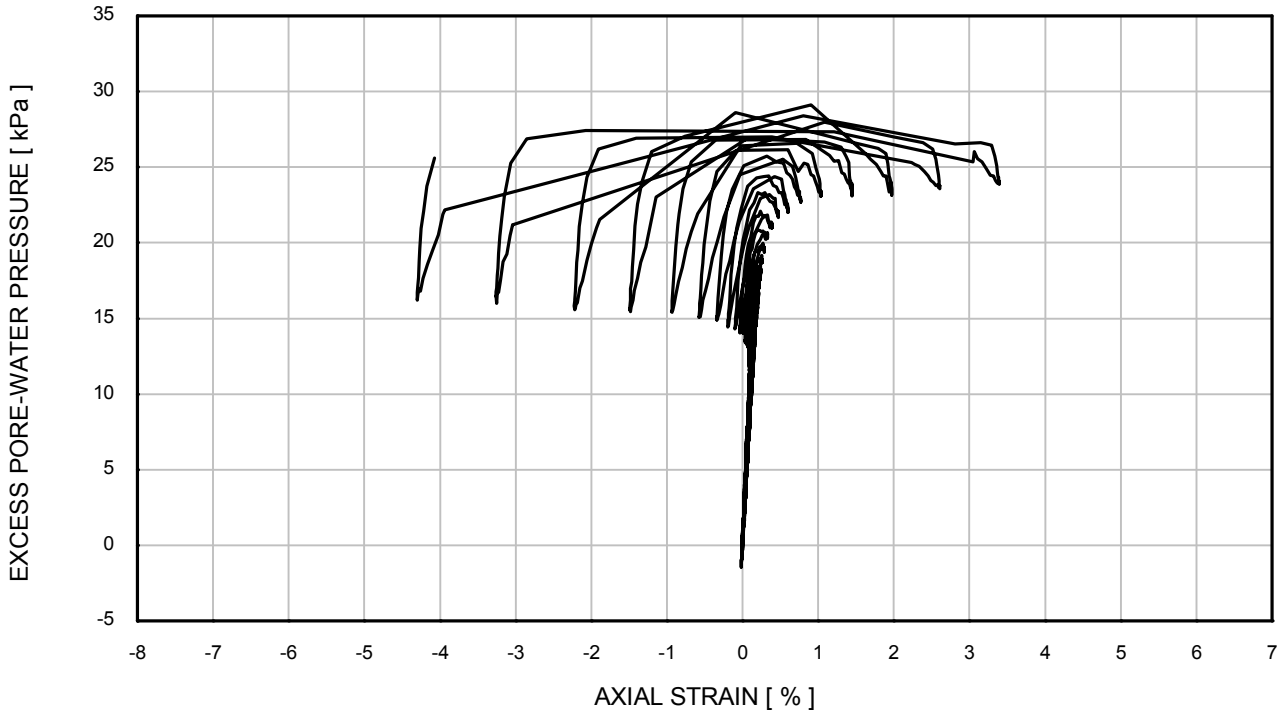


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-2
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX06
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

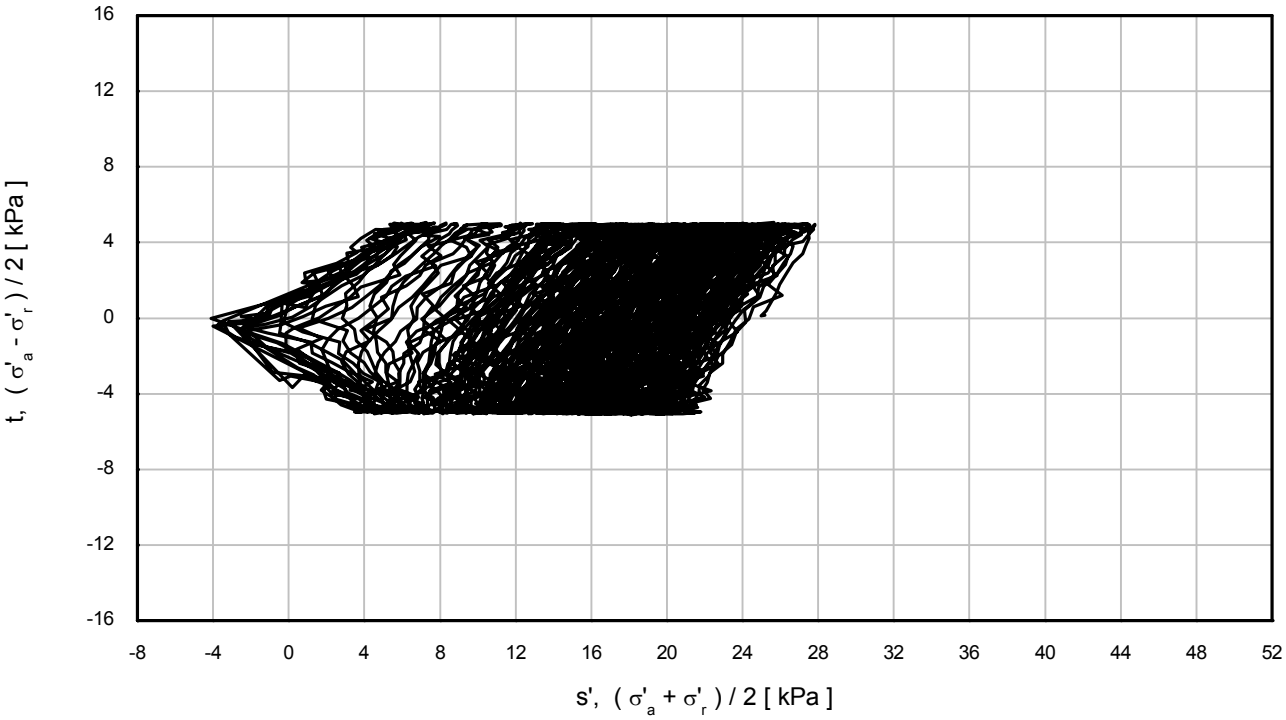


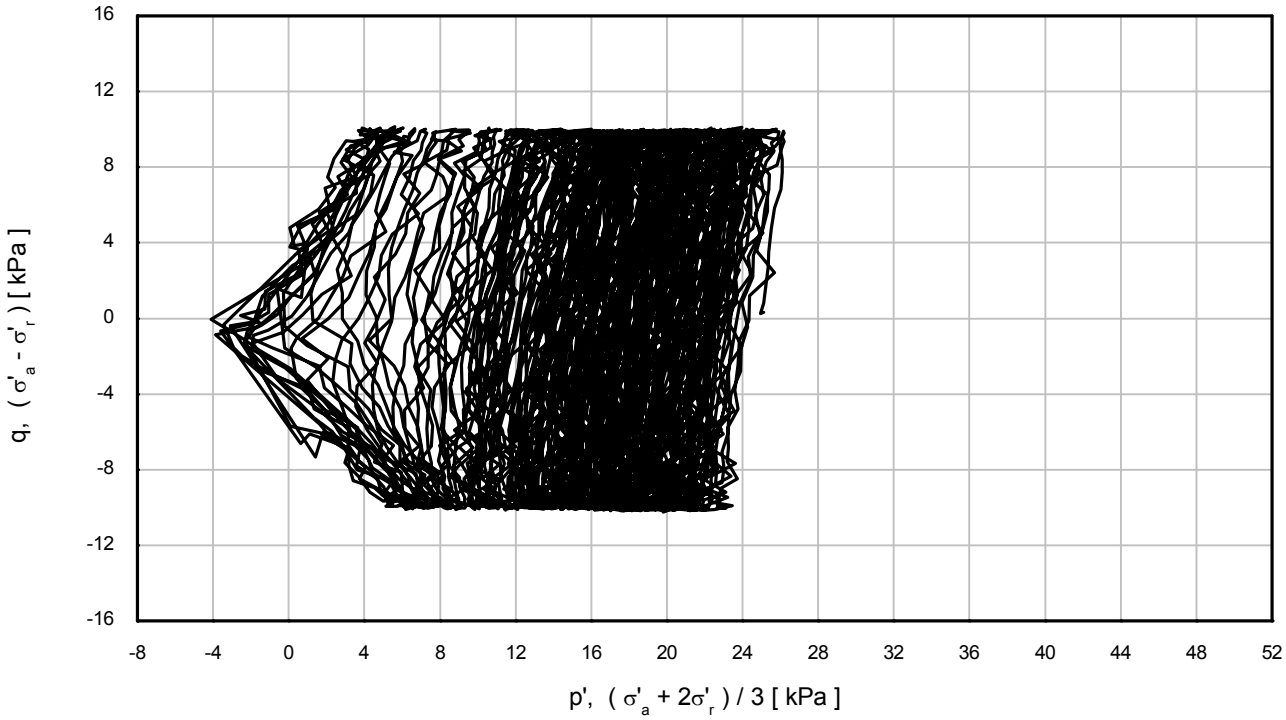


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-2
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX06
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

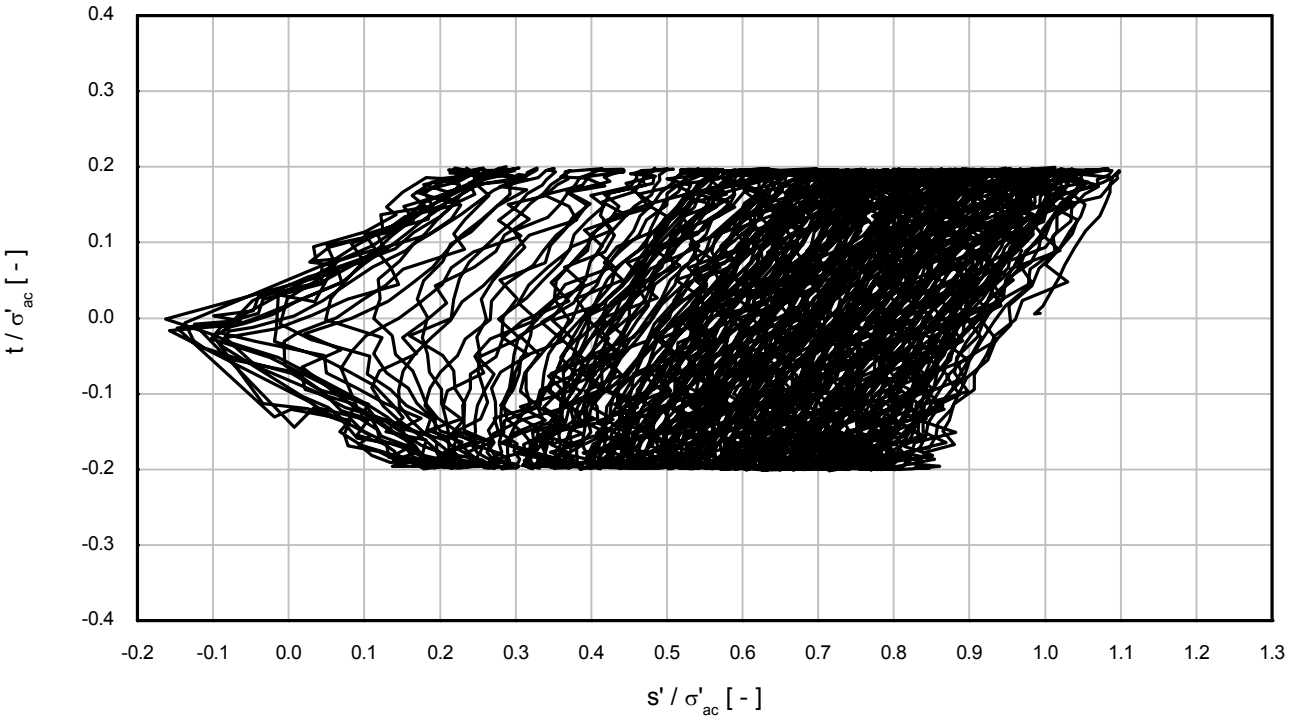


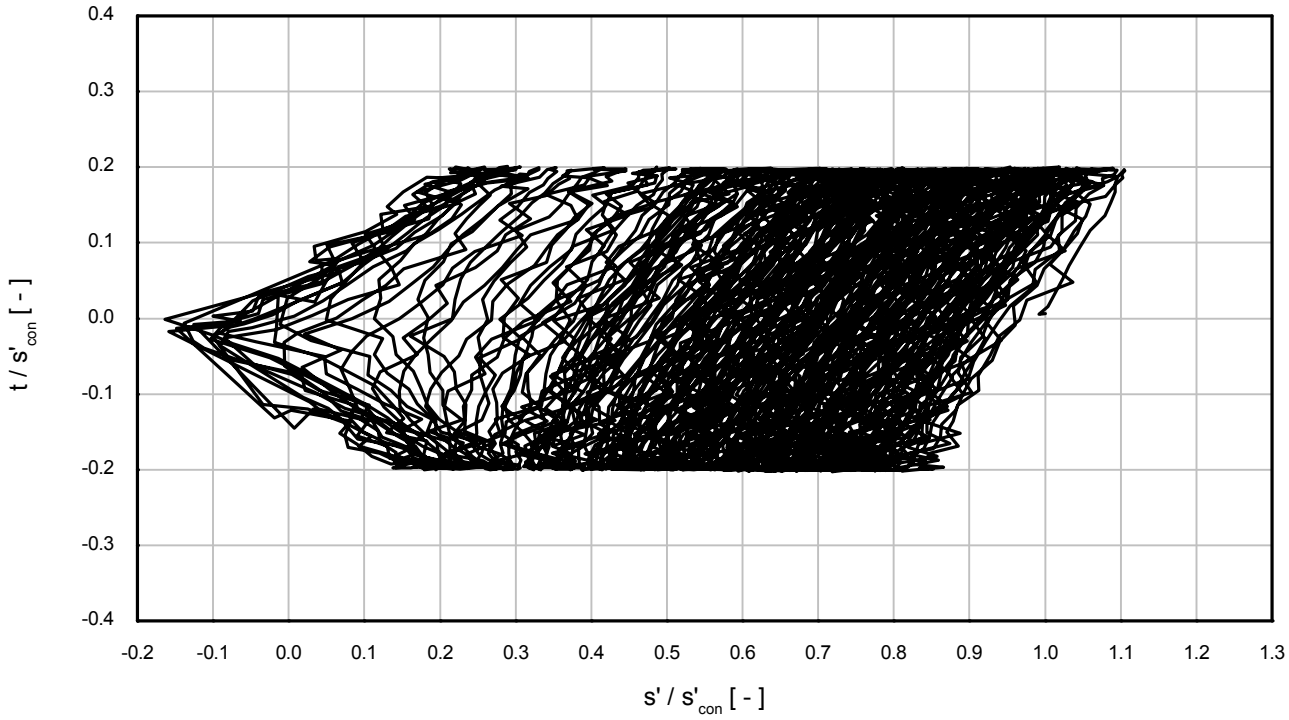


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-2
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	10	kPa	Test No.	: CTX06
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

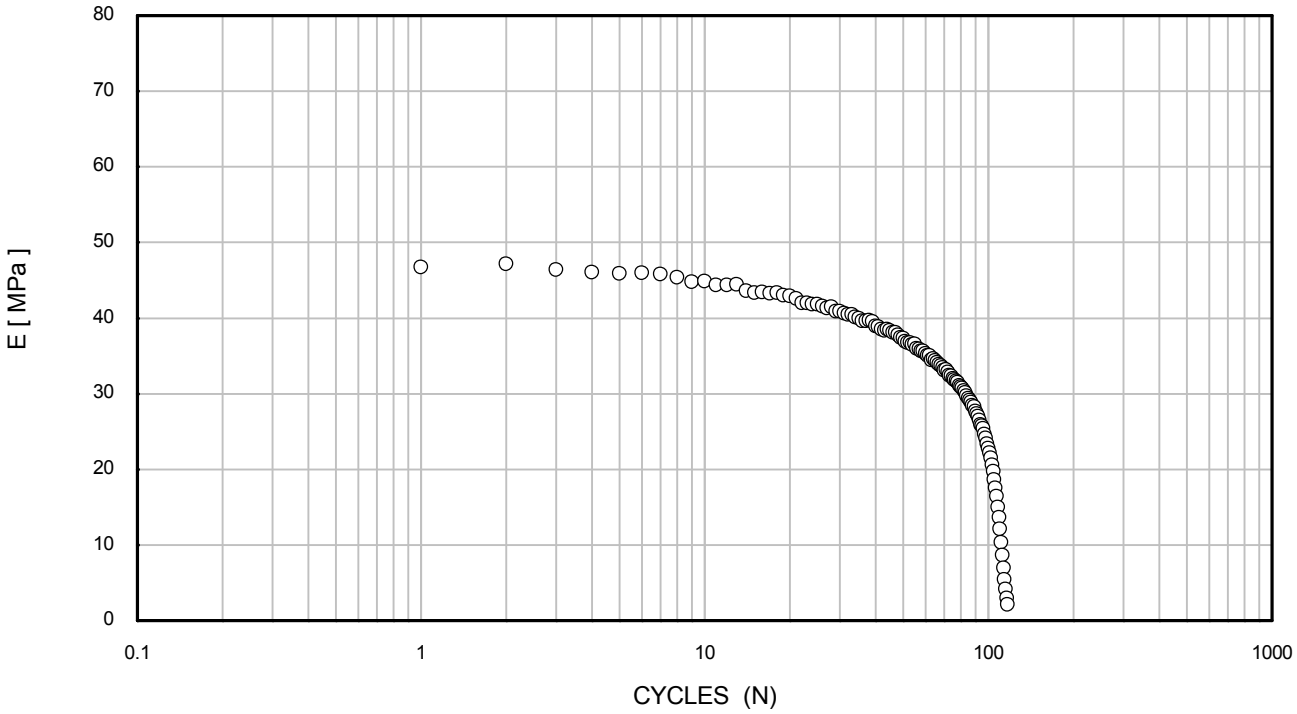


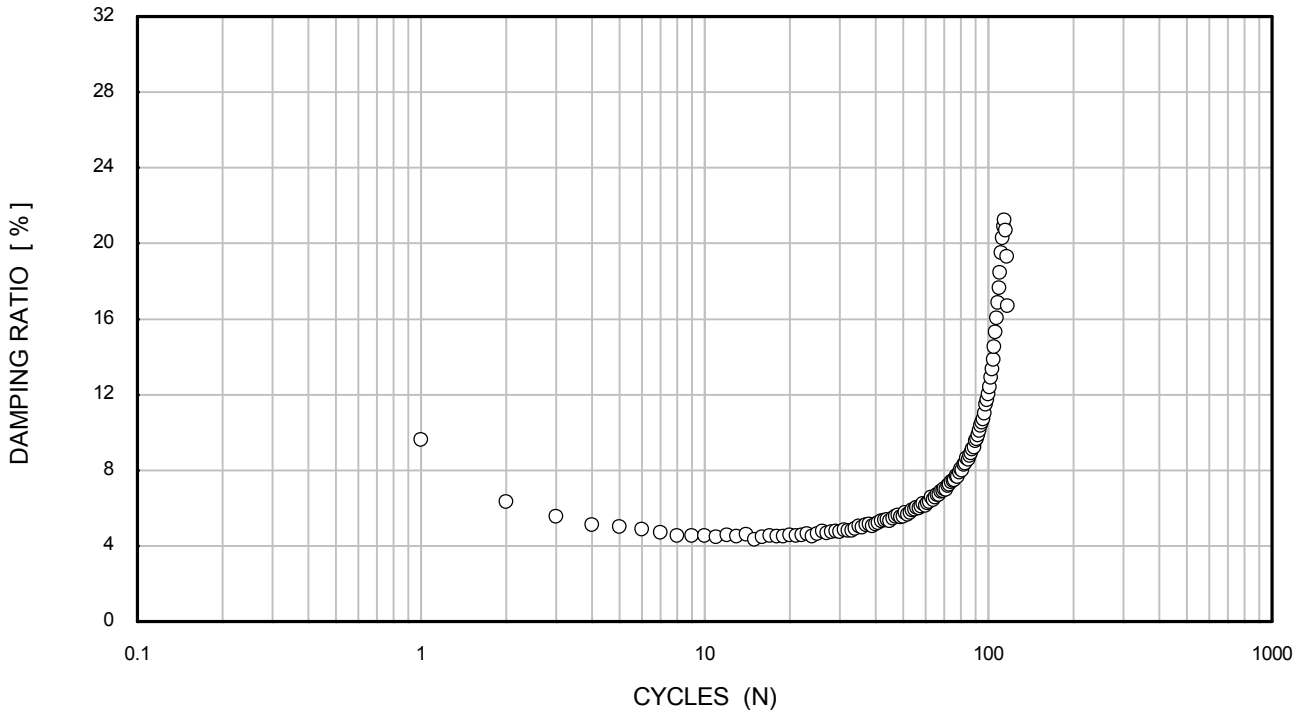


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-2
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX06
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

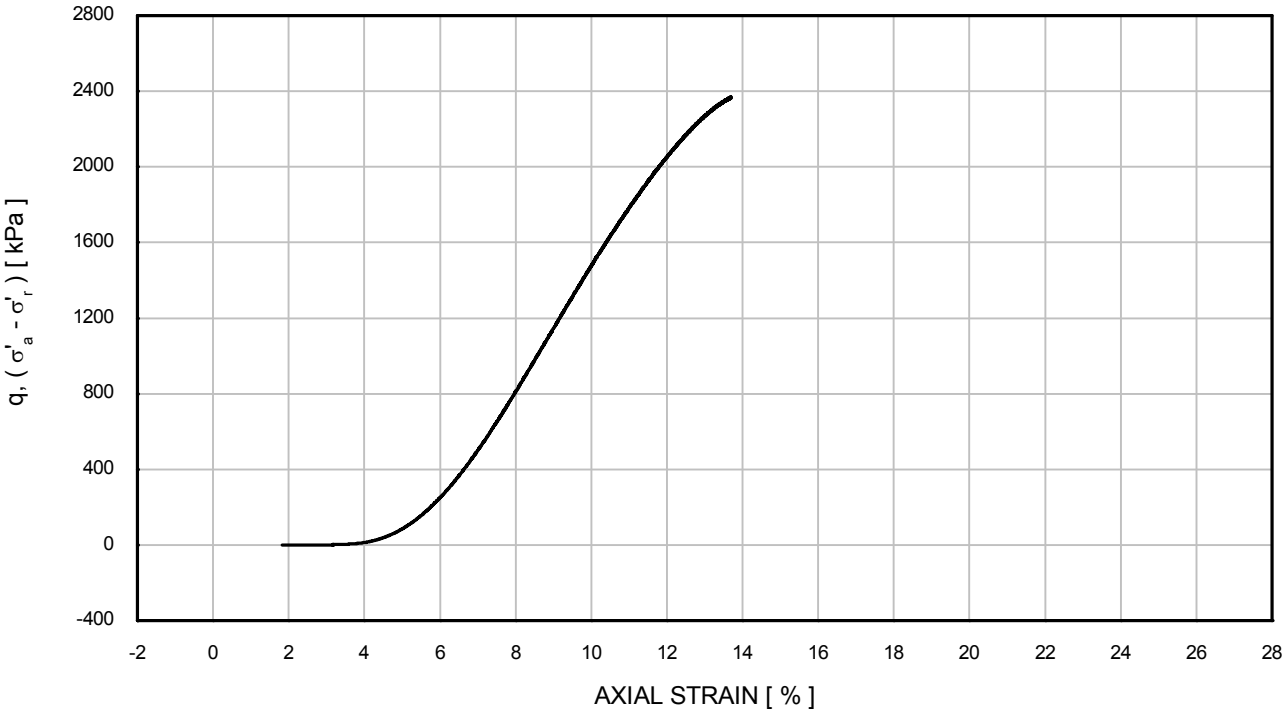


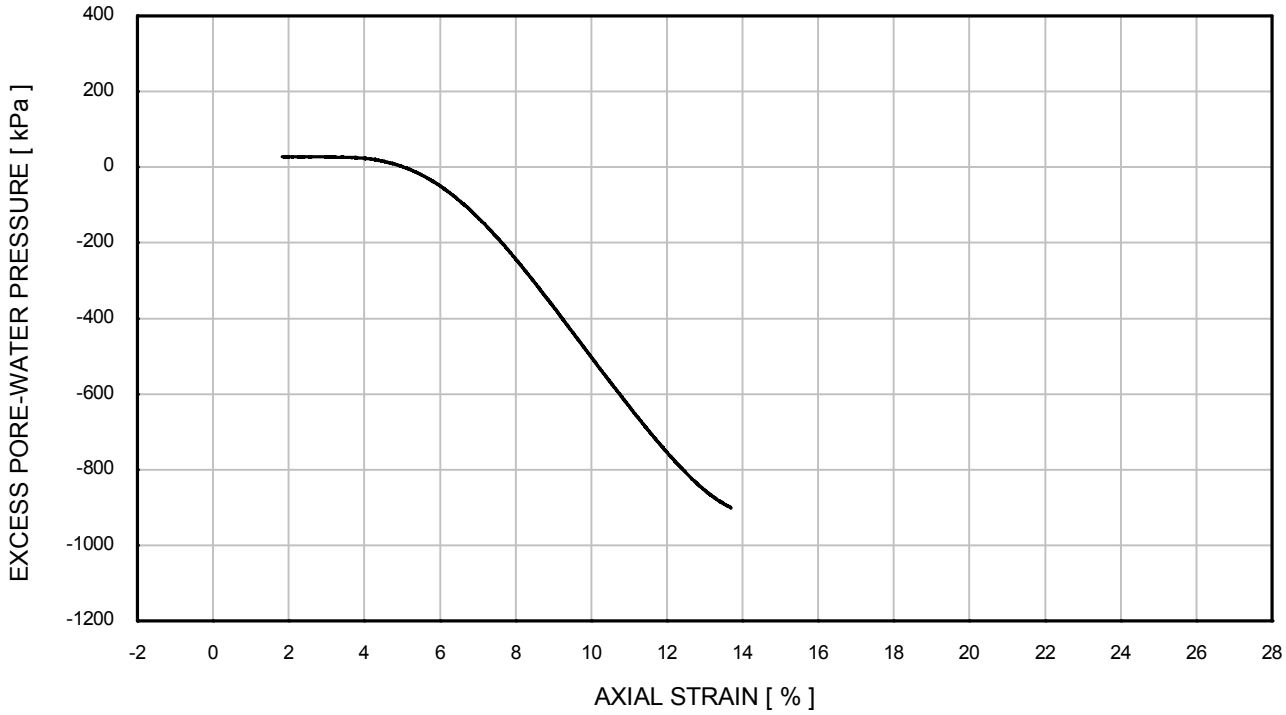


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-2
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX06
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

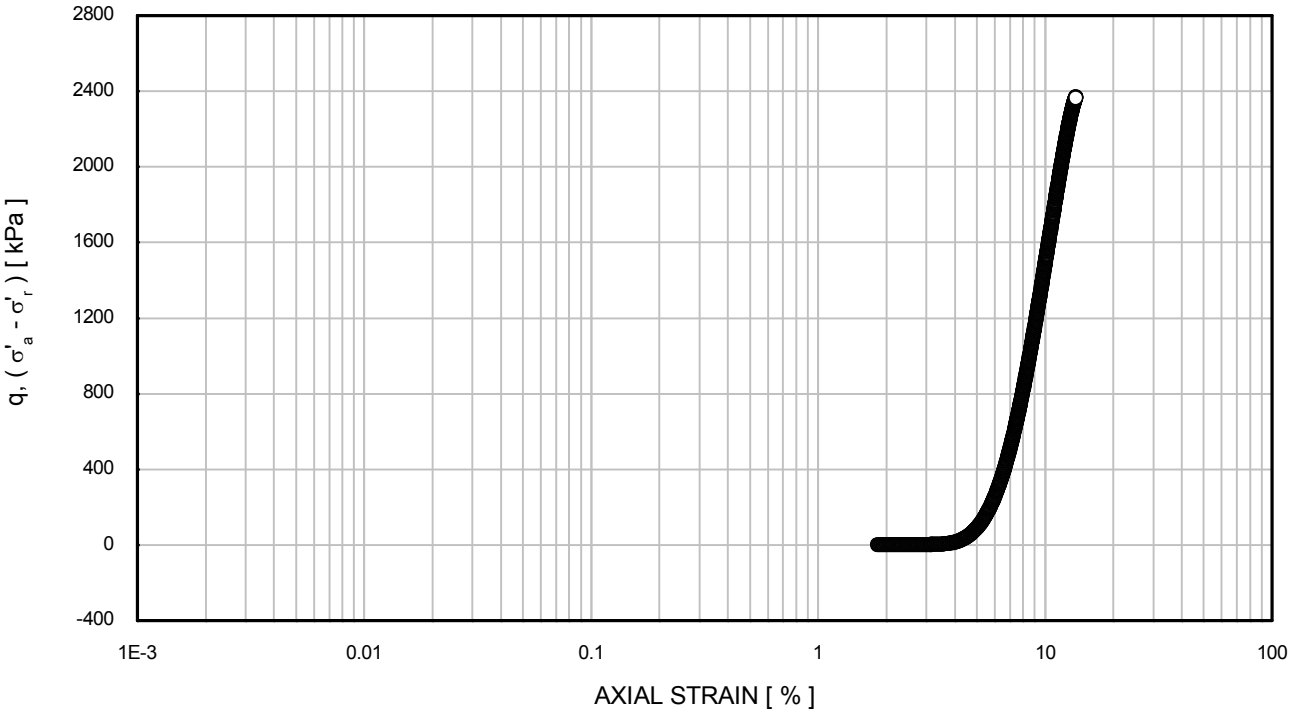


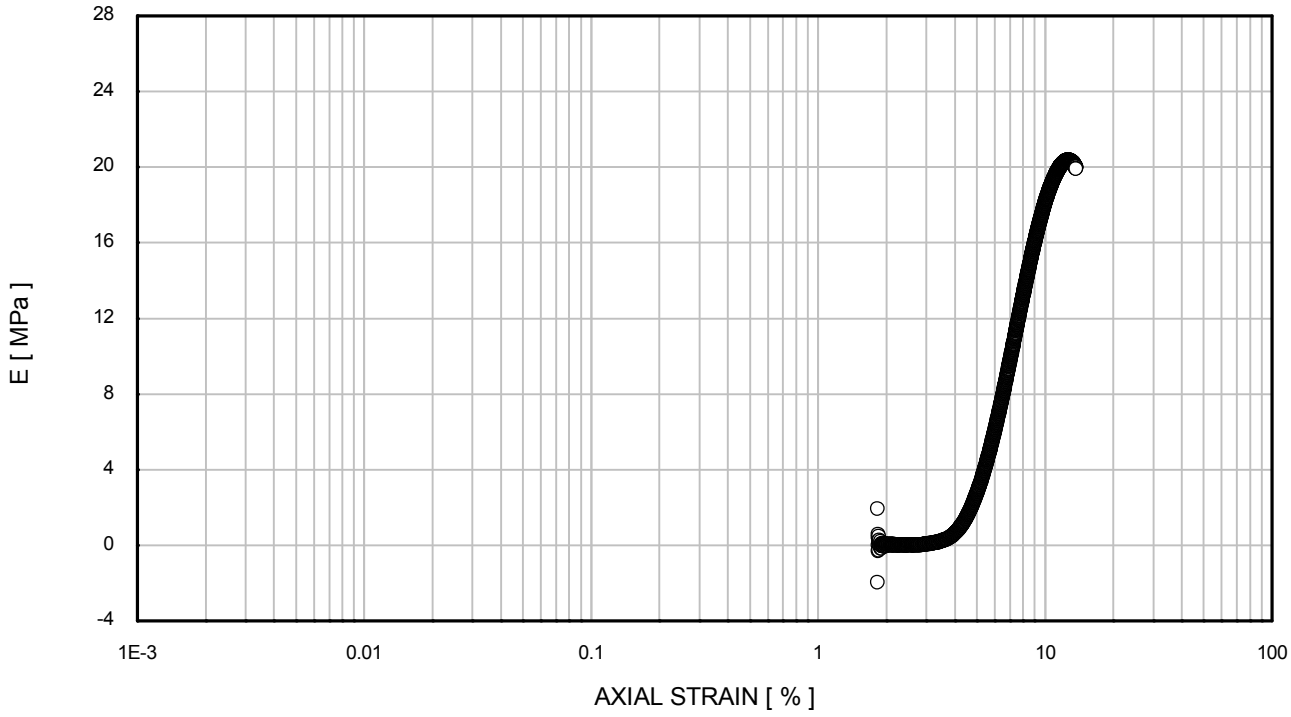


Initial σ'_r	:	-2 kPa	Batch	:	1
Initial σ'_a	:	-2 kPa	Sample	:	CTX_1-2
q_{peak}	:	2371 kPa	Unit	:	A (Southern Bight)
Ext. ε at q_{peak}	:	13.69 %	Test No.	:	CTX06
Rate of strain	:	4.72 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

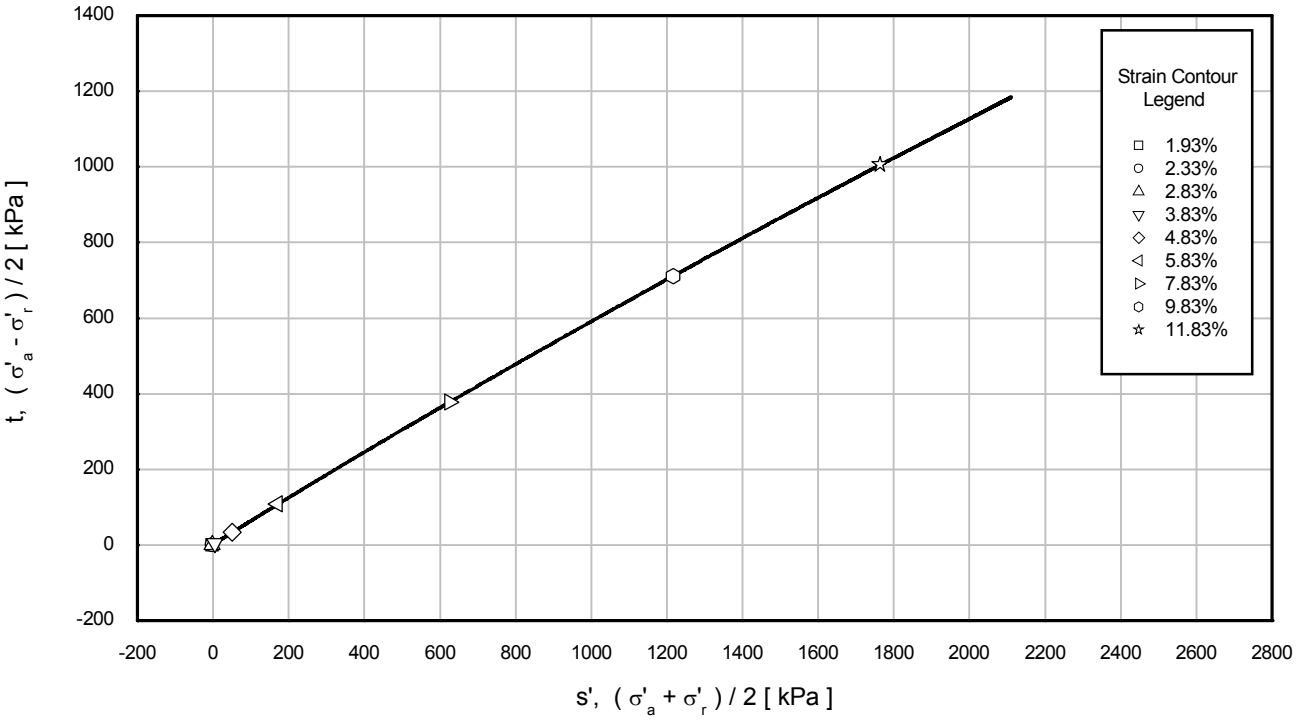


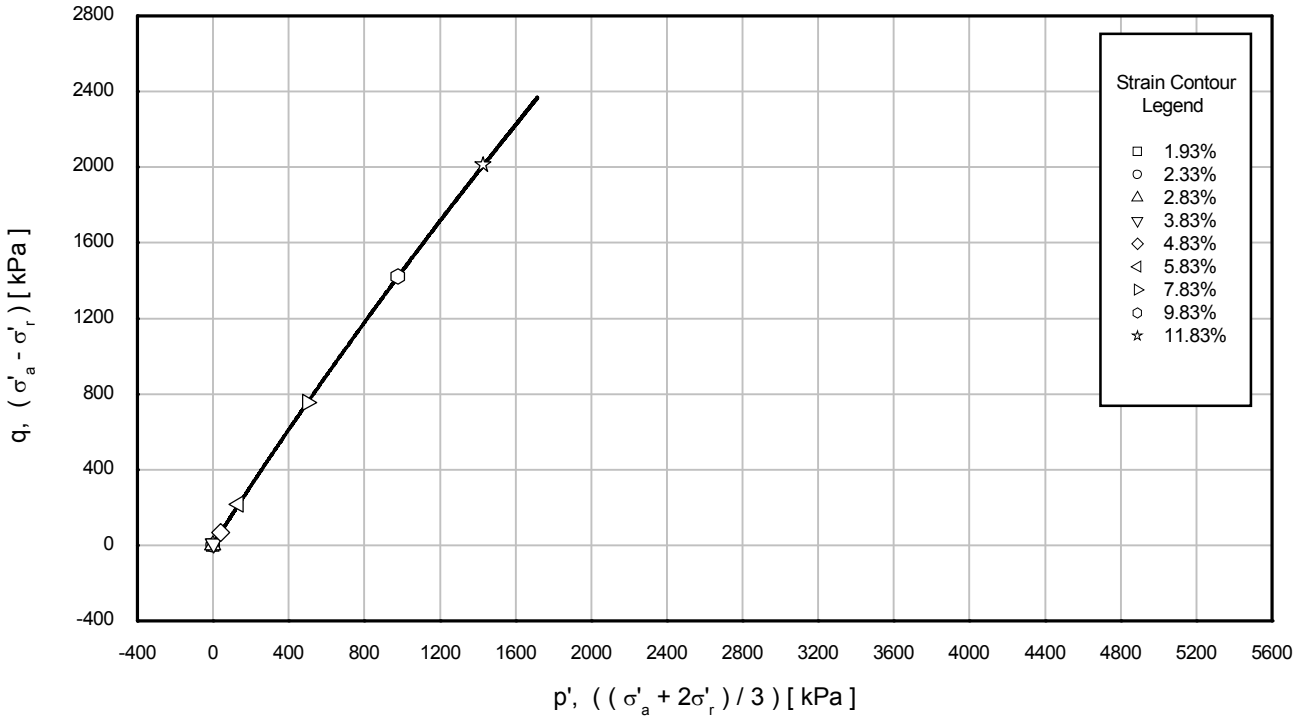


Initial σ'_r	:	-2 kPa	Batch	:	1
Initial σ'_a	:	-2 kPa	Sample	:	CTX_1-2
q_{peak}	:	2371 kPa	Unit	:	A (Southern Bight)
Ext. ε at q_{peak}	:	13.69 %	Test No.	:	CTX06
Rate of strain	:	4.72 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	-2	kPa	Batch	: 1
Initial σ'_a	:	-2	kPa	Sample	: CTX_1-2
q_{peak}	:	2371	kPa	Unit	: A (Southern Bight)
Ext. ε at q_{peak}	:	13.69	%	Test No.	: CTX06
Rate of strain	:	4.72	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	11/02/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	12.7
Bulk density	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.58
Void ratio	[-]	0.672
Degree of saturation	[%]	50
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 1_CTX-1-3_CTX07
Processed by Date	HJ 19/02/2016
Checked by Date	PH 04/03/2016
Approved by Date	PH 04/03/2016

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-3
Unit	A (Southern Bight)
Test number	CTX07

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1074
Mid height PWP	[kPa]	-
B value achieved	[-]	0.96

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1100
Back pressure	[kPa]	1075
Base PWP	[kPa]	1075
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	25
Effective axial pressure	[kPa]	25
Deviator stress	[kPa]	0
Volumetric strain	[%]	-0.09
External axial strain	[%]	0.01
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	25.4
Bulk density	[Mg/m³]	1.99
Dry density	[Mg/m³]	1.58
Void ratio	[-]	0.674
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-3
Unit	A (Southern Bight)
Test number	CTX07

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	50
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	10
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	13
External ε_{av} at N_f	[%]	-1.22
External ε_{cy} at N_f	[%]	2.20
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	17
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	25.4
Bulk density	[Mg/m³]	1.99
Dry density	[Mg/m³]	1.58
Void ratio	[-]	0.674
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.03	35.15	-	14.90	-
2	0.00	0.03	34.53	-	13.32	-
3	0.00	0.03	32.42	-	12.52	-
4	0.00	0.03	30.19	-	13.10	-
5	0.00	0.04	28.19	-	13.12	-
6	0.00	0.04	25.35	-	15.11	-
7	0.00	0.04	22.71	-	15.25	-
8	0.00	0.05	18.11	-	17.89	-
9	-0.02	0.08	13.01	-	19.60	-
10	-0.06	0.13	7.59	-	22.25	-
13	-1.22	2.20	0.49	-	8.74	-

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-3
Unit	A (Southern Bight)
Test number	CTX07

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	4
Initial effective axial pressure	[kPa]	2
Rate of strain	[%/hour]	0.45
At peak deviator stress		
Corrected deviator stress	[kPa]	1521
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	22.39
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-657
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	682
Effective axial pressure	[kPa]	2202
Principal effective stress ratio	[-]	3.23
ε_{50}	[%]	12.12
Secant modulus (E_{50}) at ε_{50}	[kPa]	9656
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	210
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	8.54
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-48
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	73
Effective axial pressure	[kPa]	283
Principal effective stress ratio	[-]	3.88
At 10% external axial strain		
Corrected deviator stress	[kPa]	419
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-124
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	149
Effective axial pressure	[kPa]	568
Principal effective stress ratio	[-]	3.81

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-3
Unit	A (Southern Bight)
Test number	CTX07

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



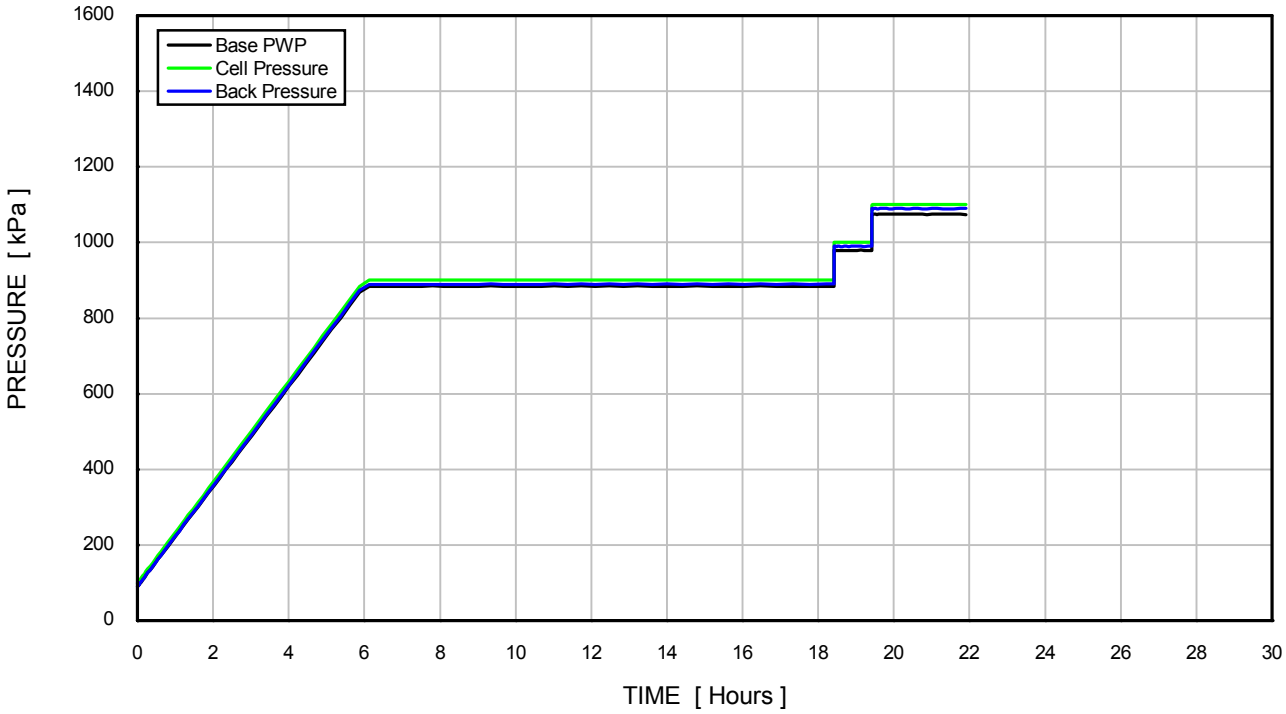


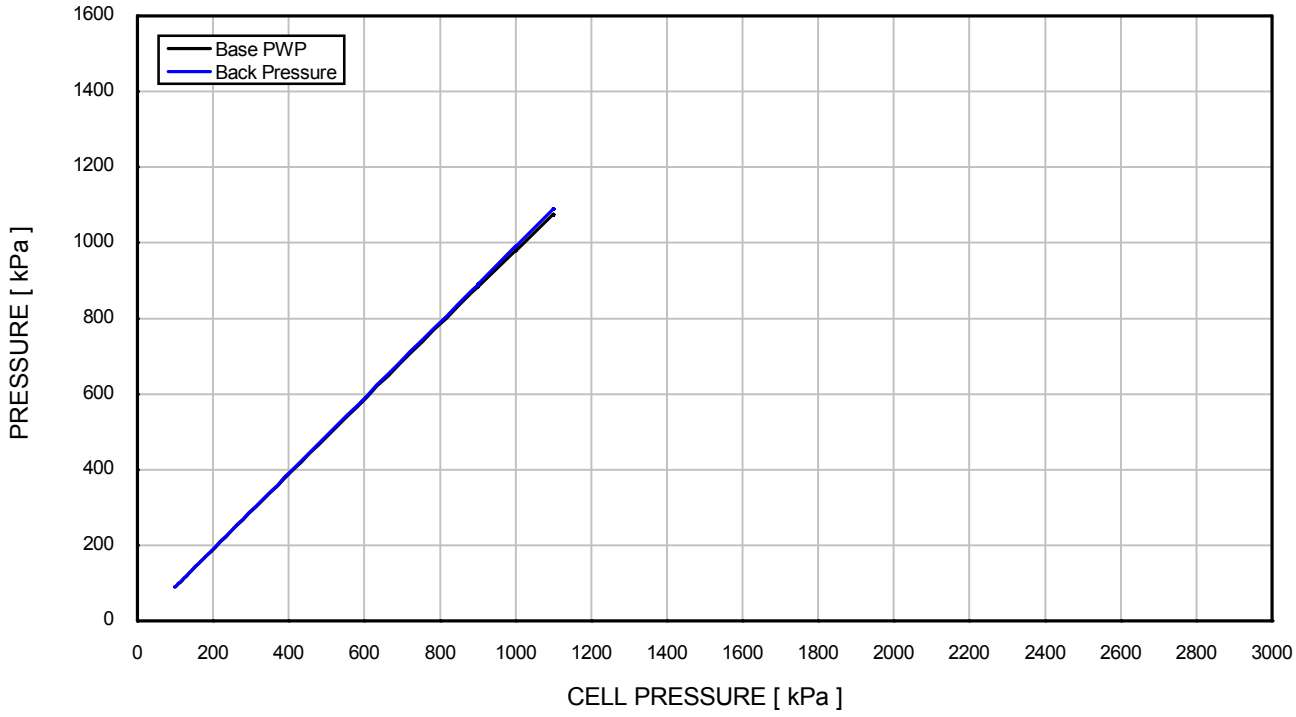
FINAL CONDITIONS		
Moisture content	[%]	25.4
Bulk density	[Mg/m³]	1.99
Dry density	[Mg/m³]	1.58

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-3
Unit	A (Southern Bight)
Test number	CTX07

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

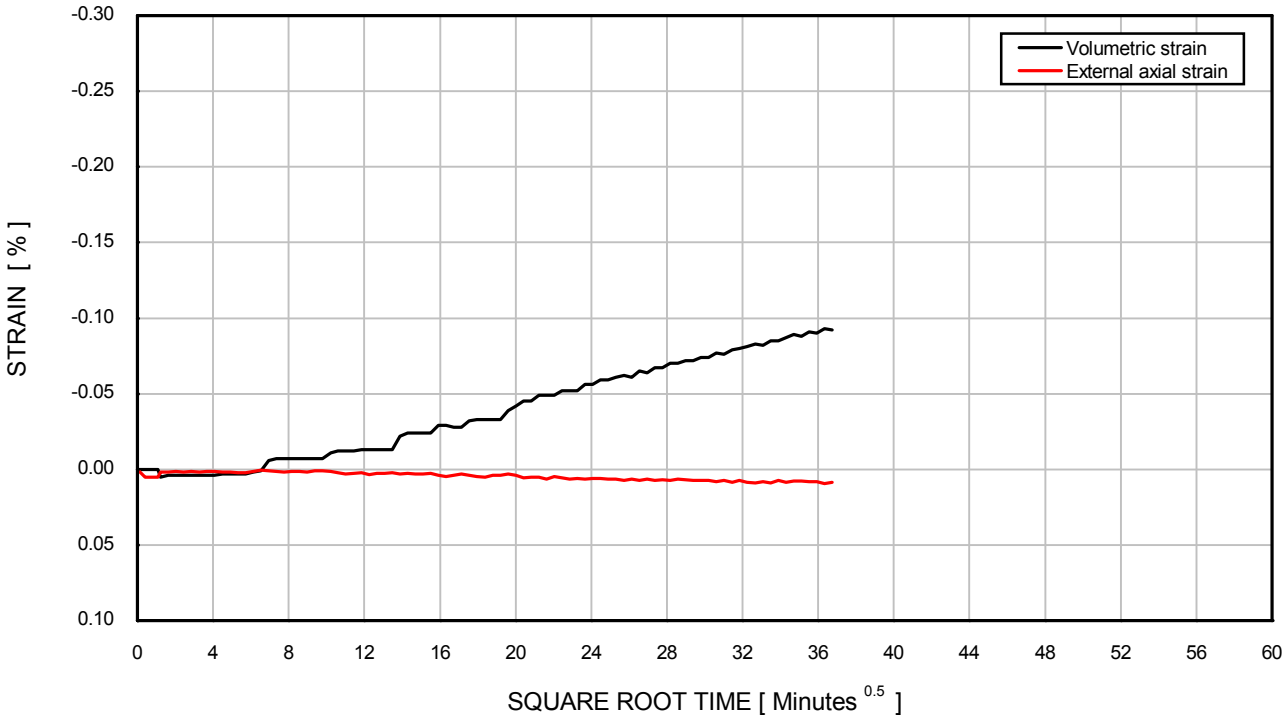


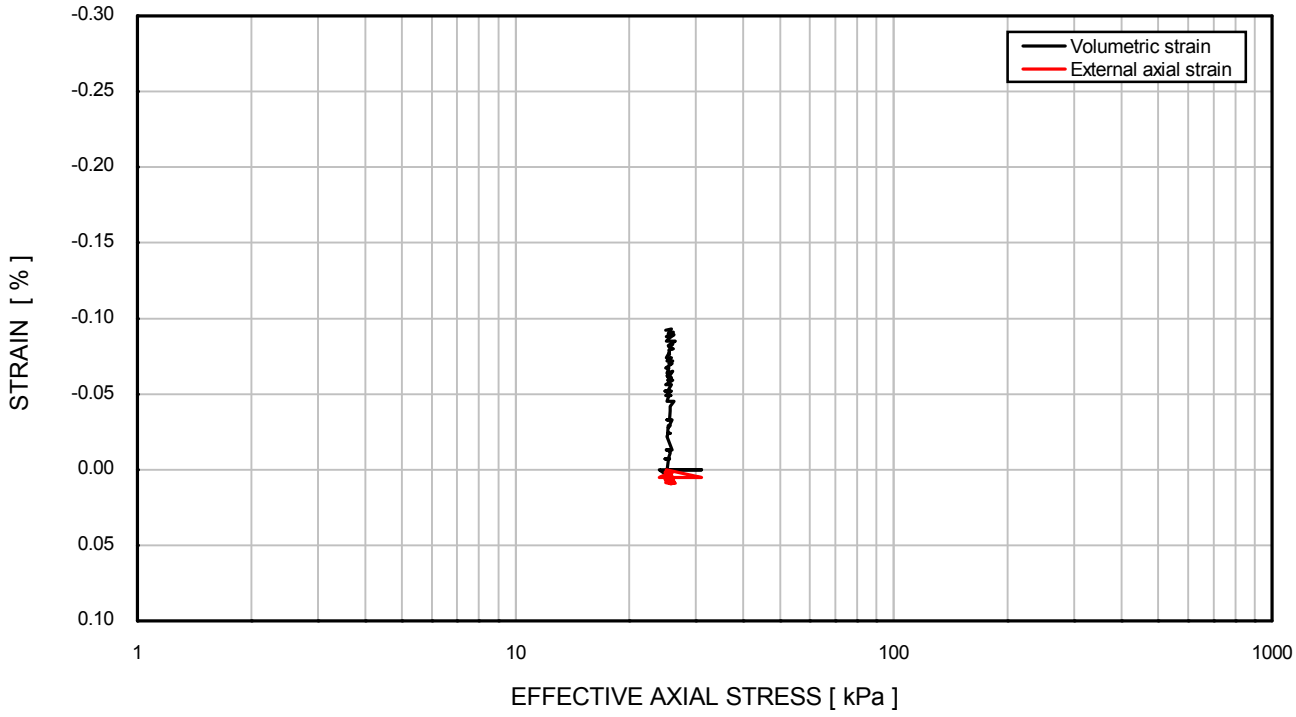


B value	:	0.96			
Initial σ'_r	:	9	kPa	Batch	: 1
Initial σ'_a	:	9	kPa	Sample	: CTX_1-3
Final σ'_r	:	26	kPa	Unit	: A (Southern Bight)
Final σ'_a	:	26	kPa	Test No.	: CTX07

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

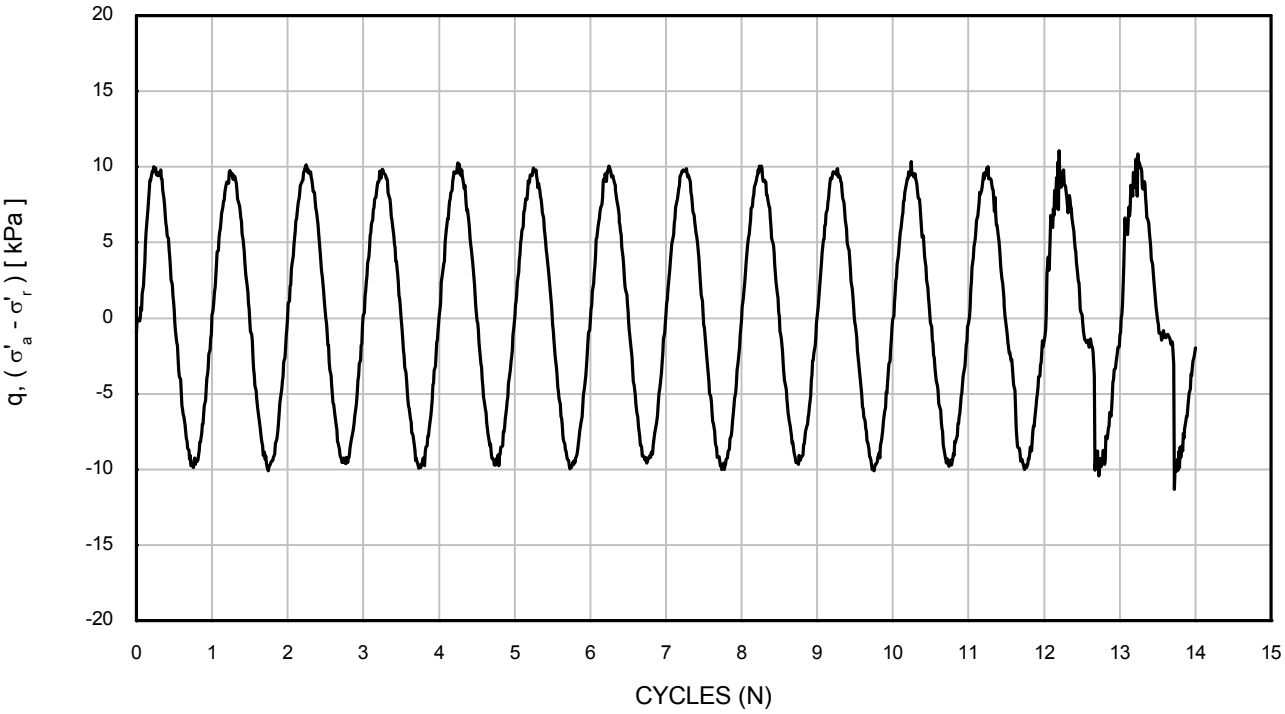


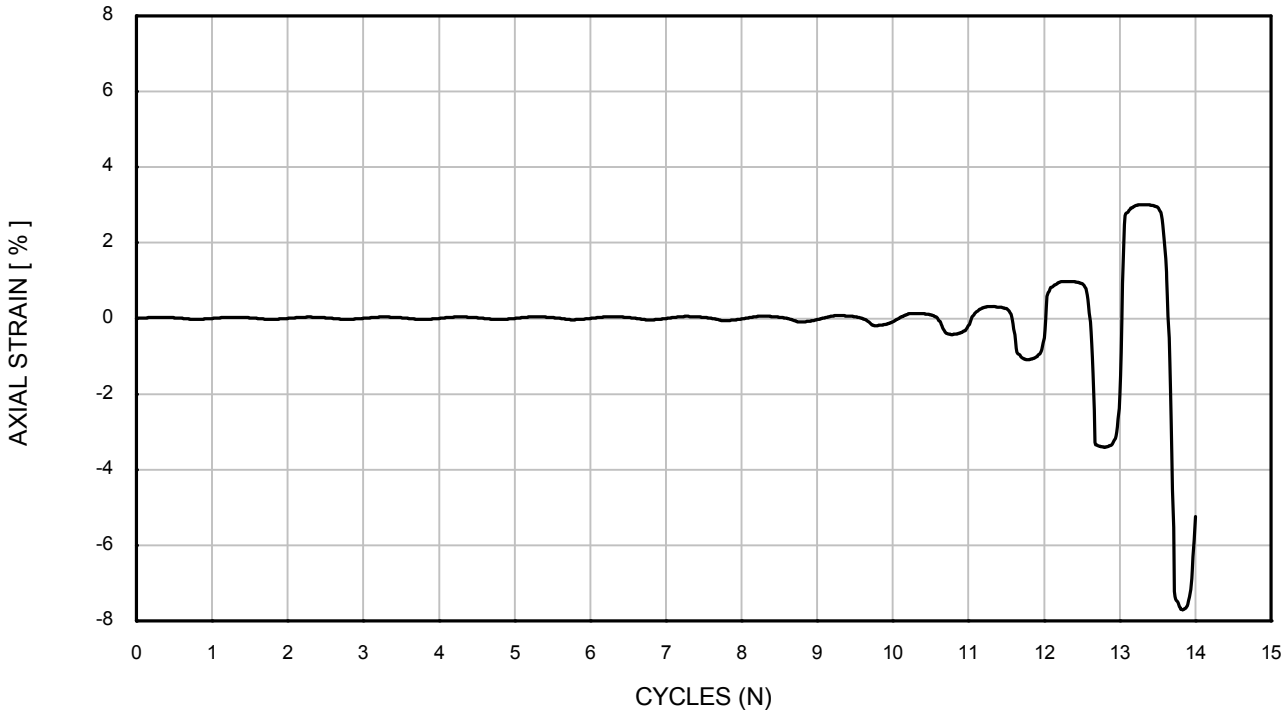


σ'_{rc}	:	25 kPa	Batch	:	1
σ'_{ac}	:	25 kPa	Sample	:	CTX_1-3
			Unit	:	A (Southern Bight)
			Test No.	:	CTX07

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

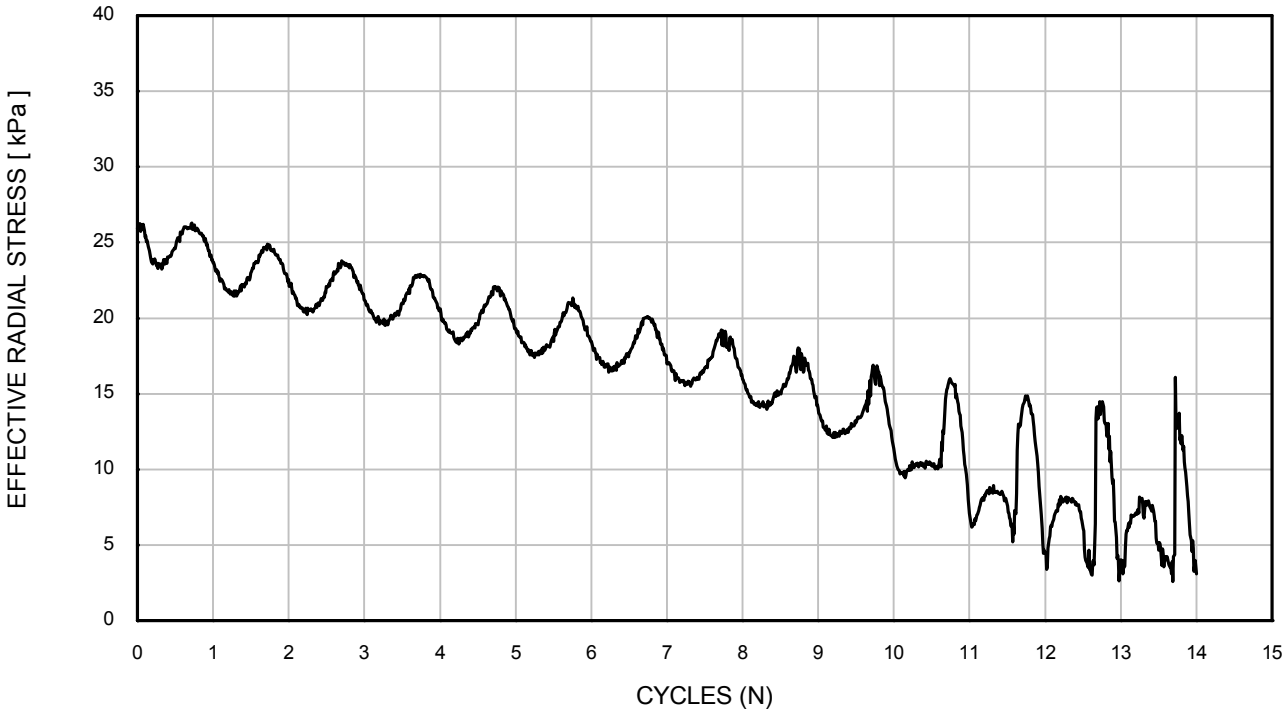


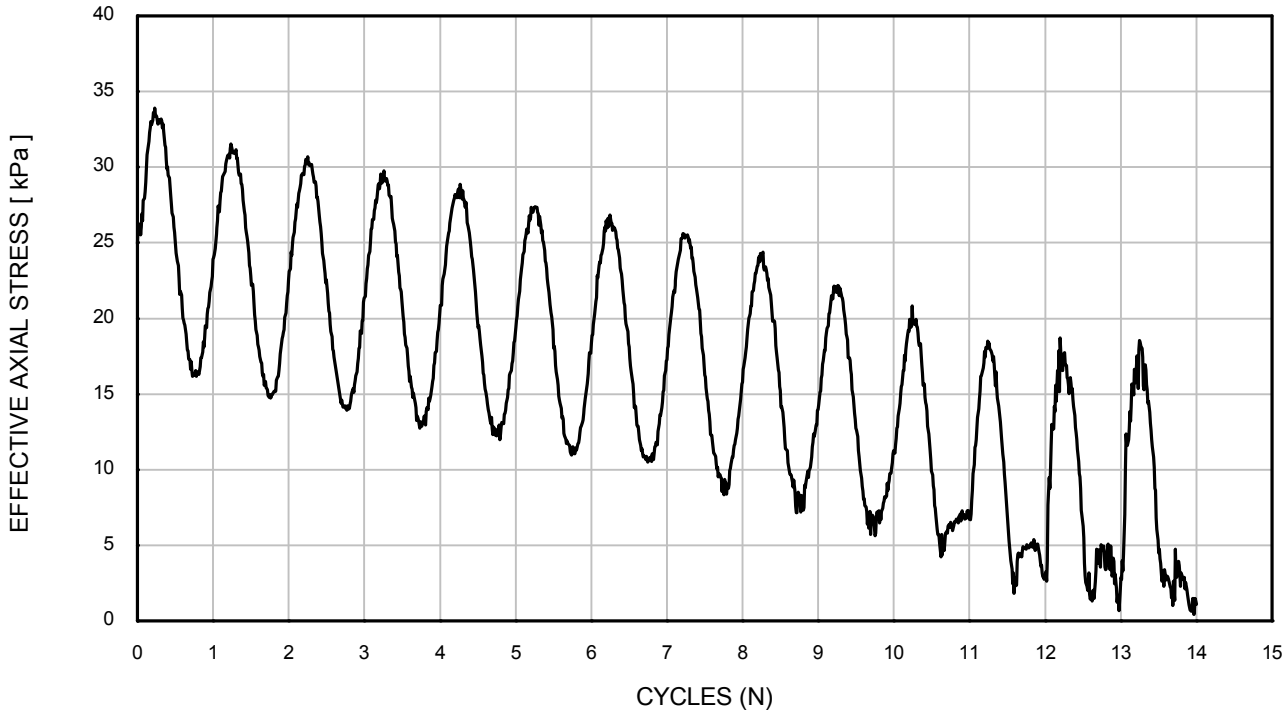


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-3
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX07
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

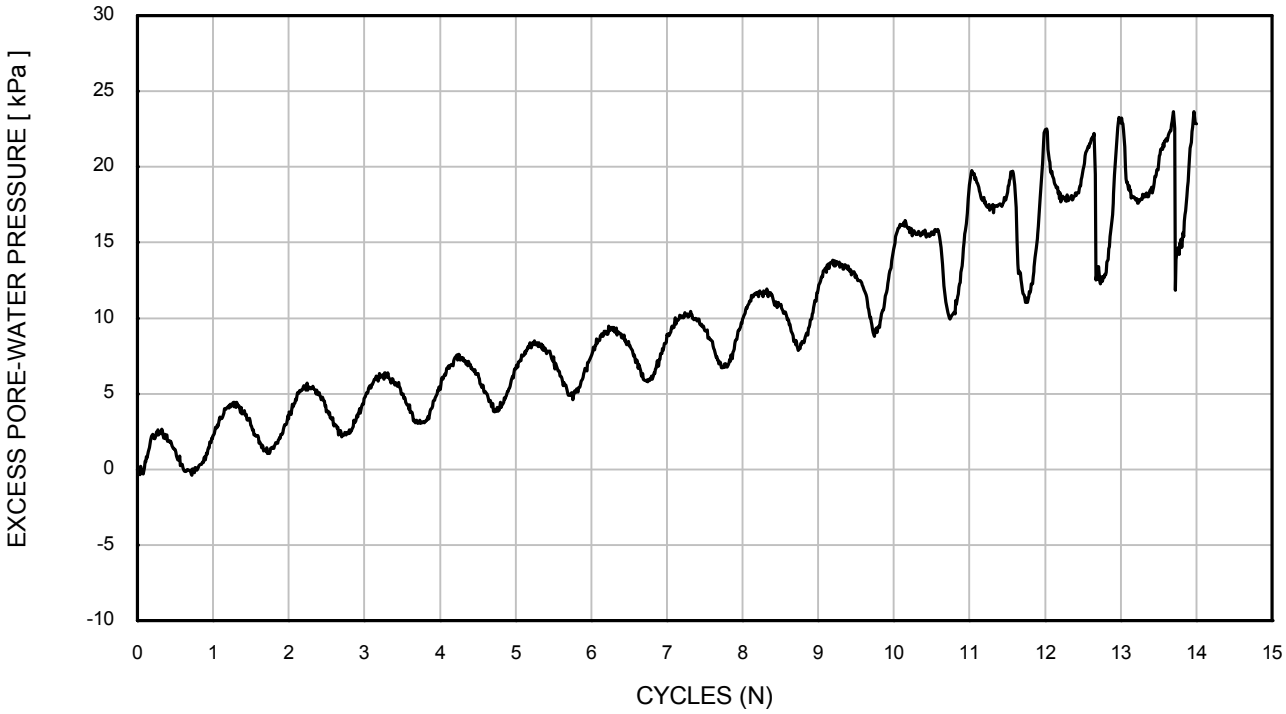


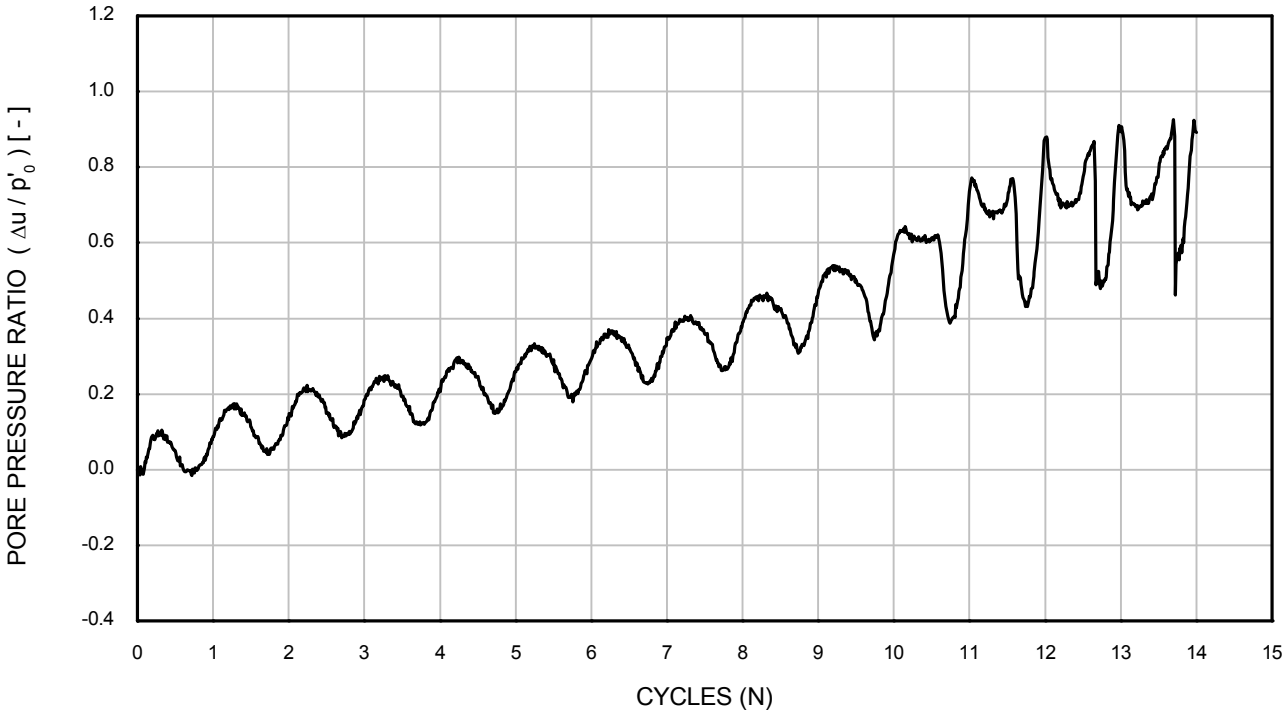


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-3
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX07
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

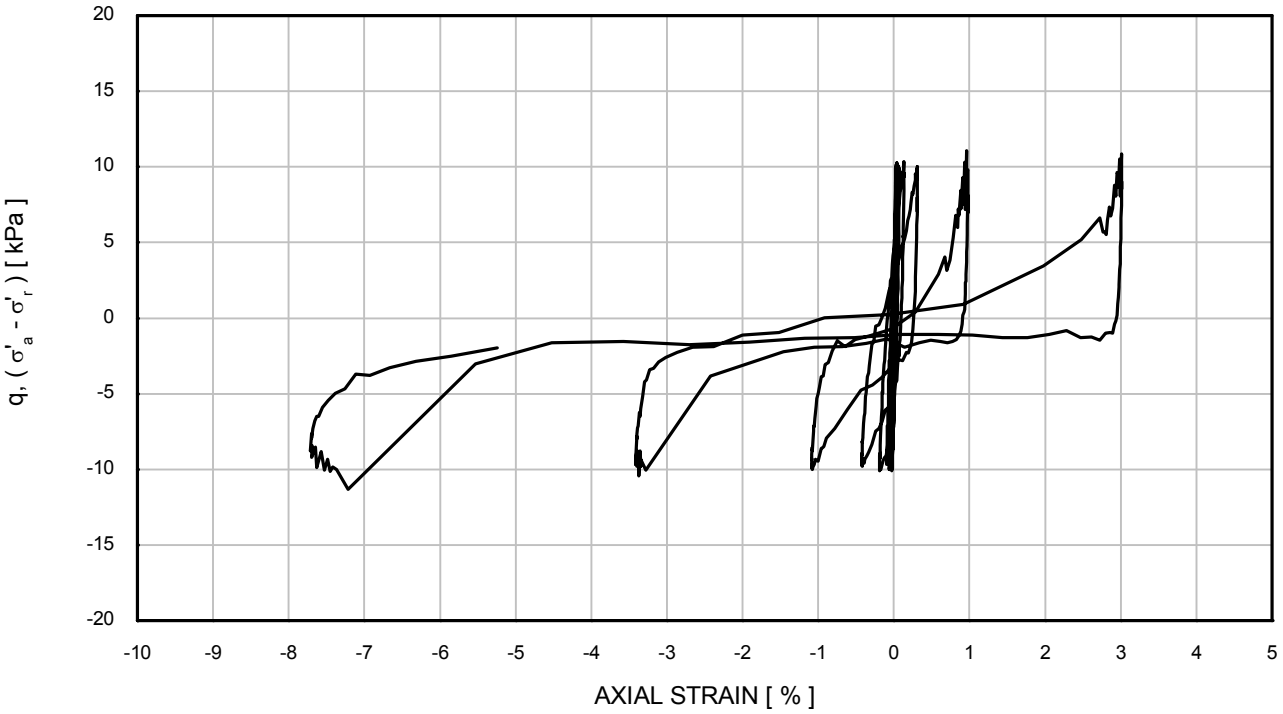


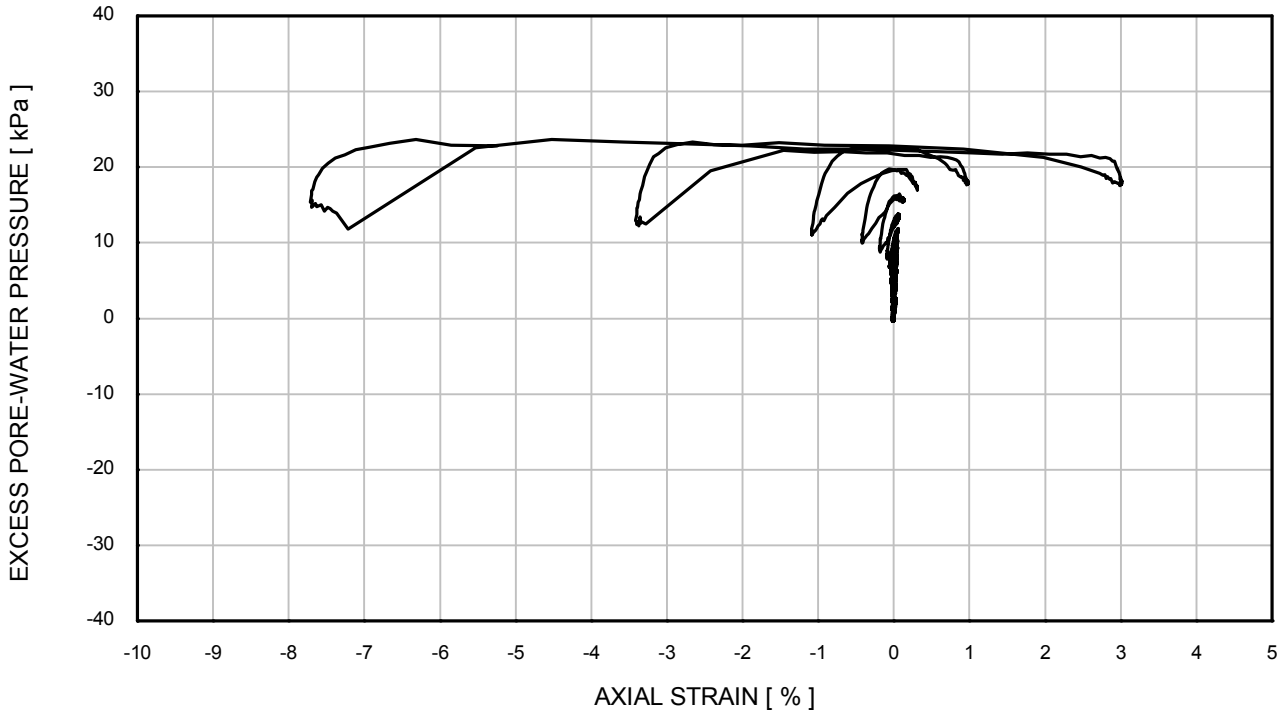


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-3
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	10	kPa	Test No.	: CTX07
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

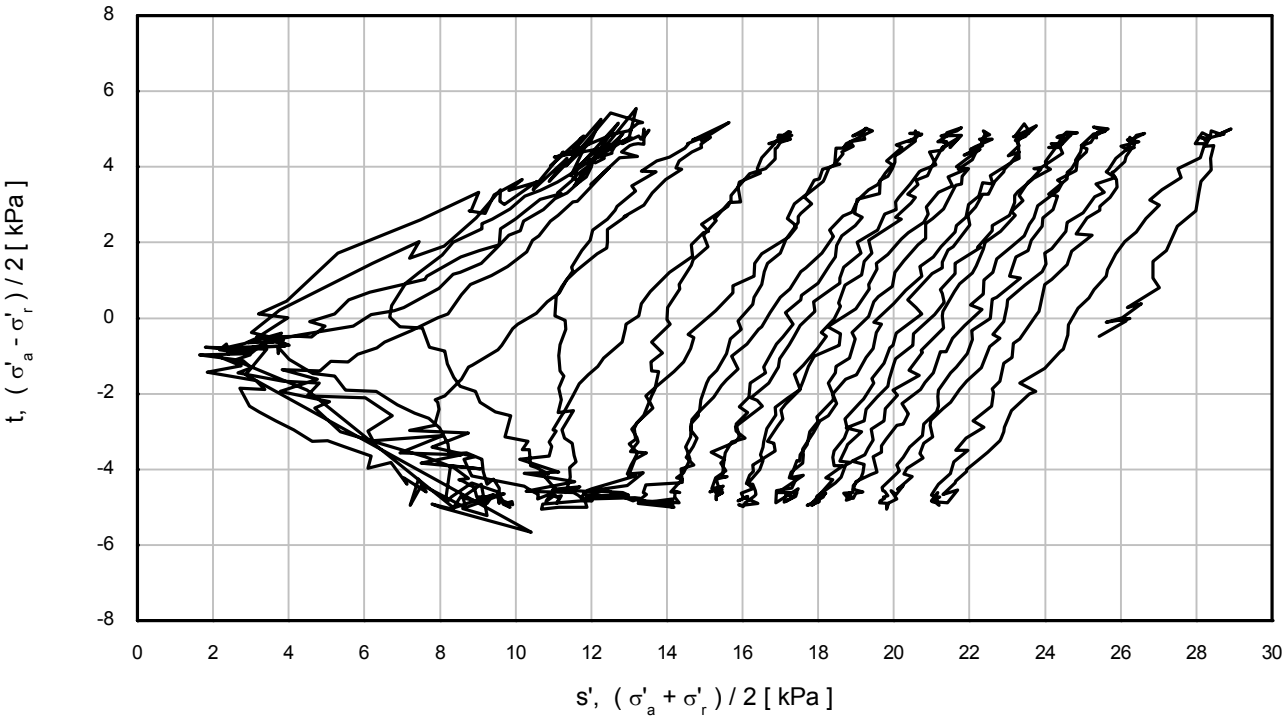


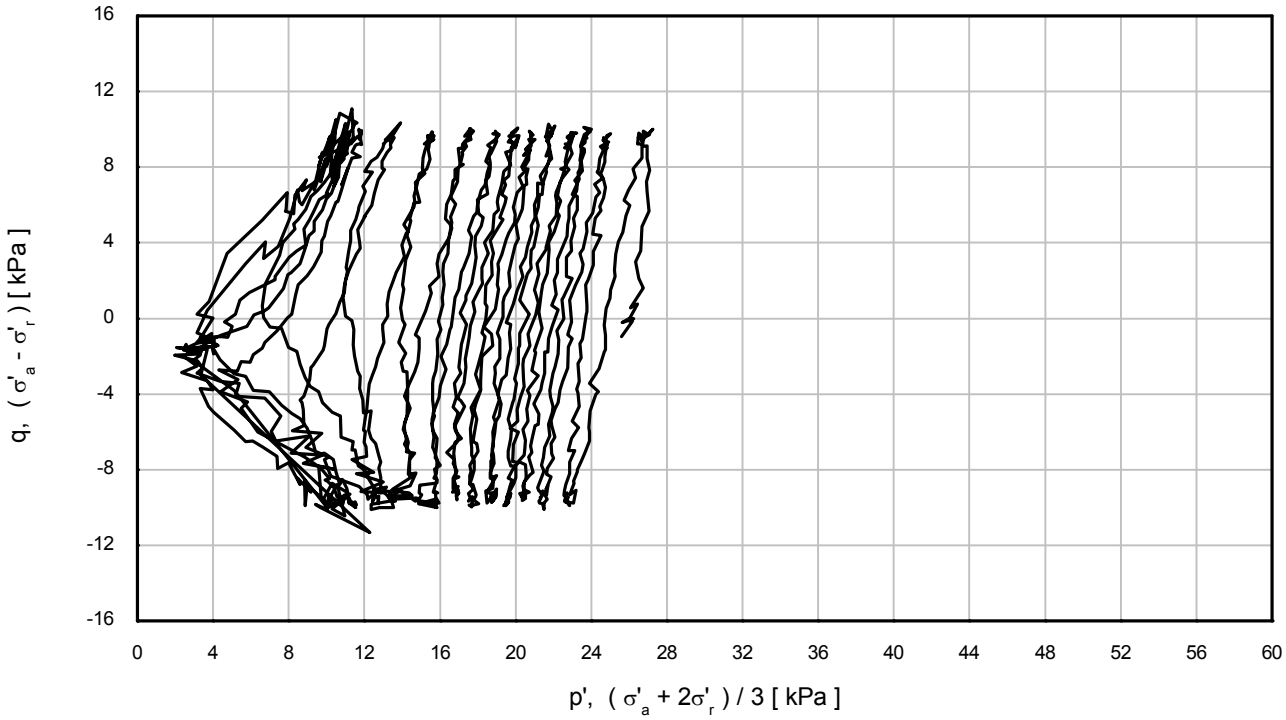


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-3
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX07
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

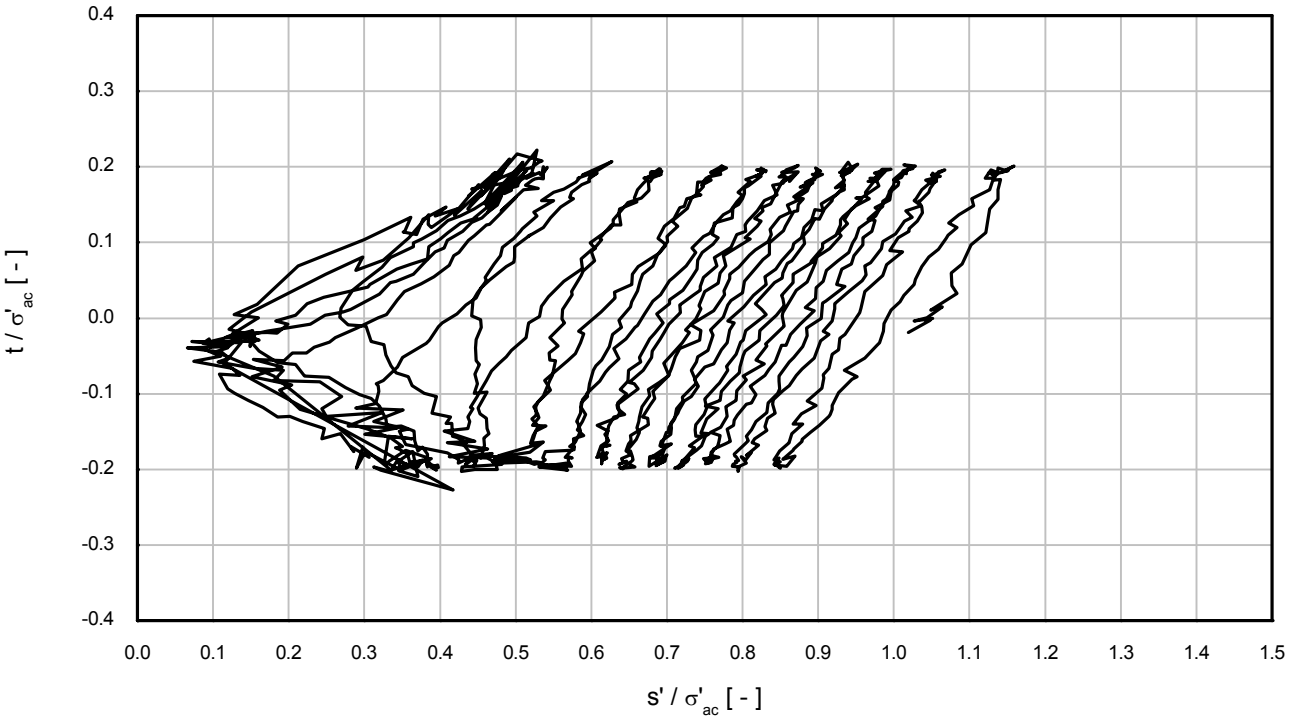


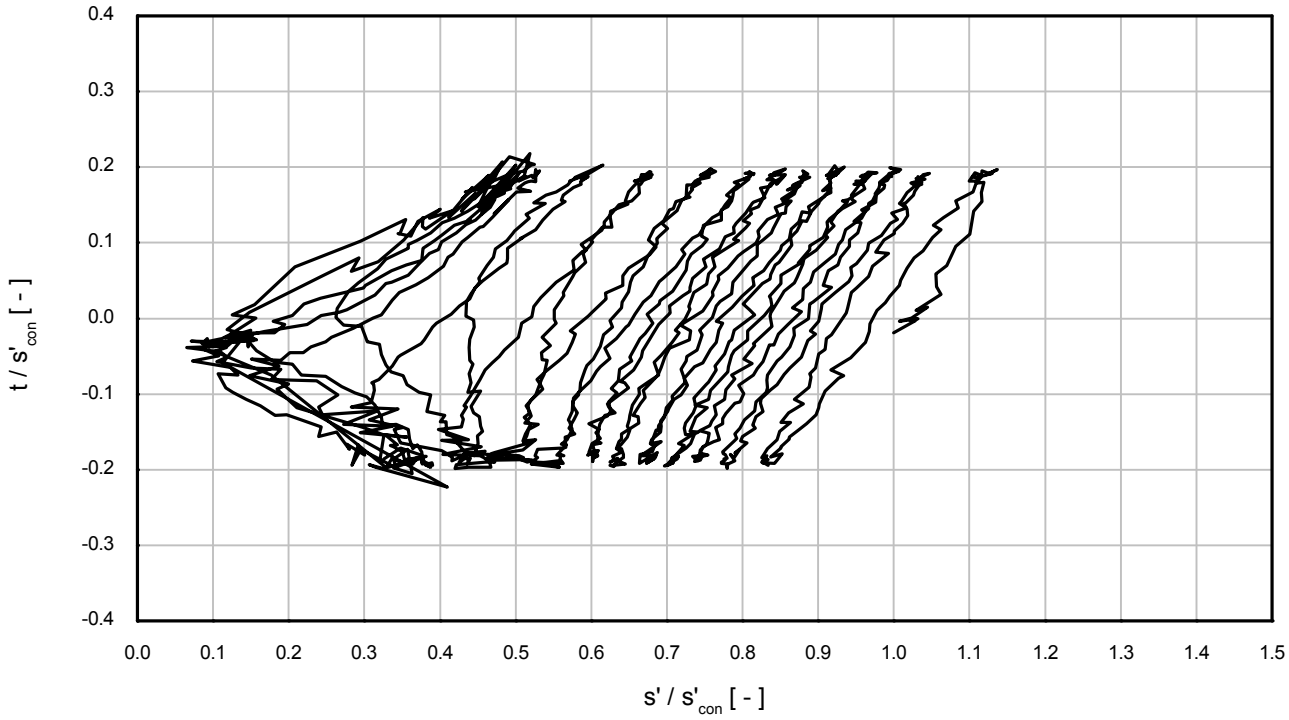


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-3
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	10	kPa	Test No.	: CTX07
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

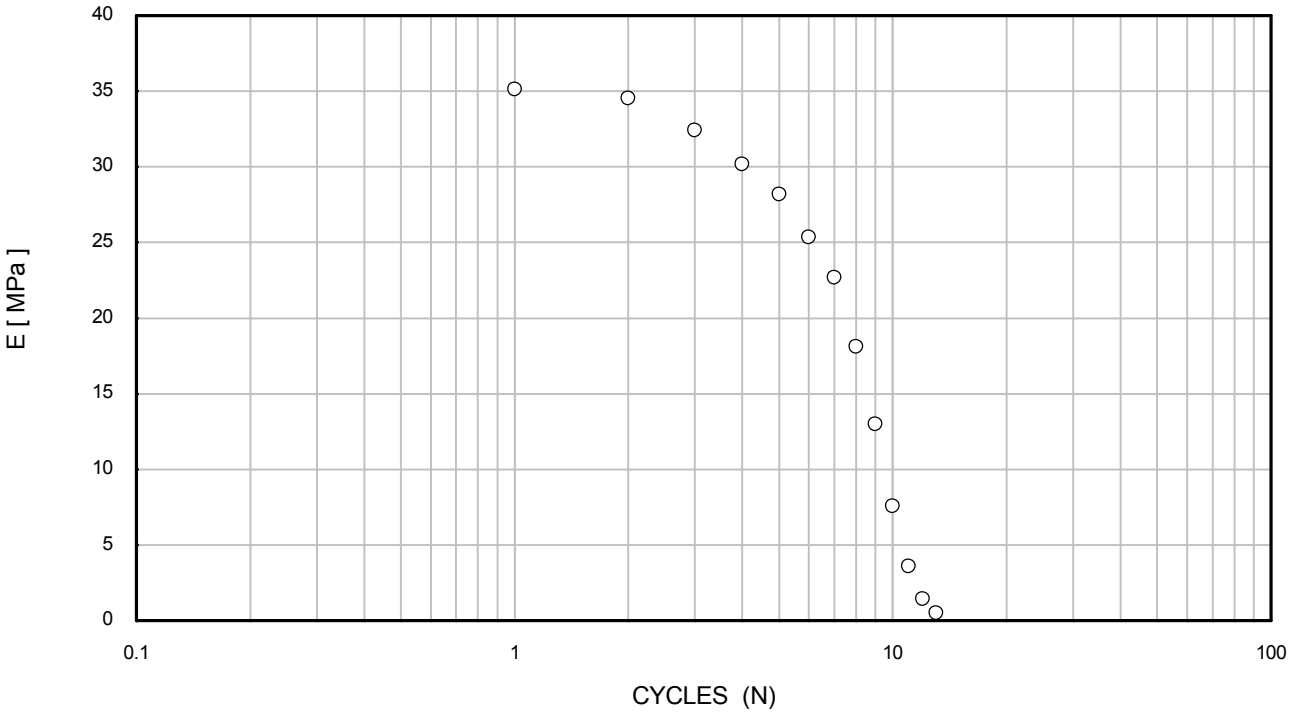


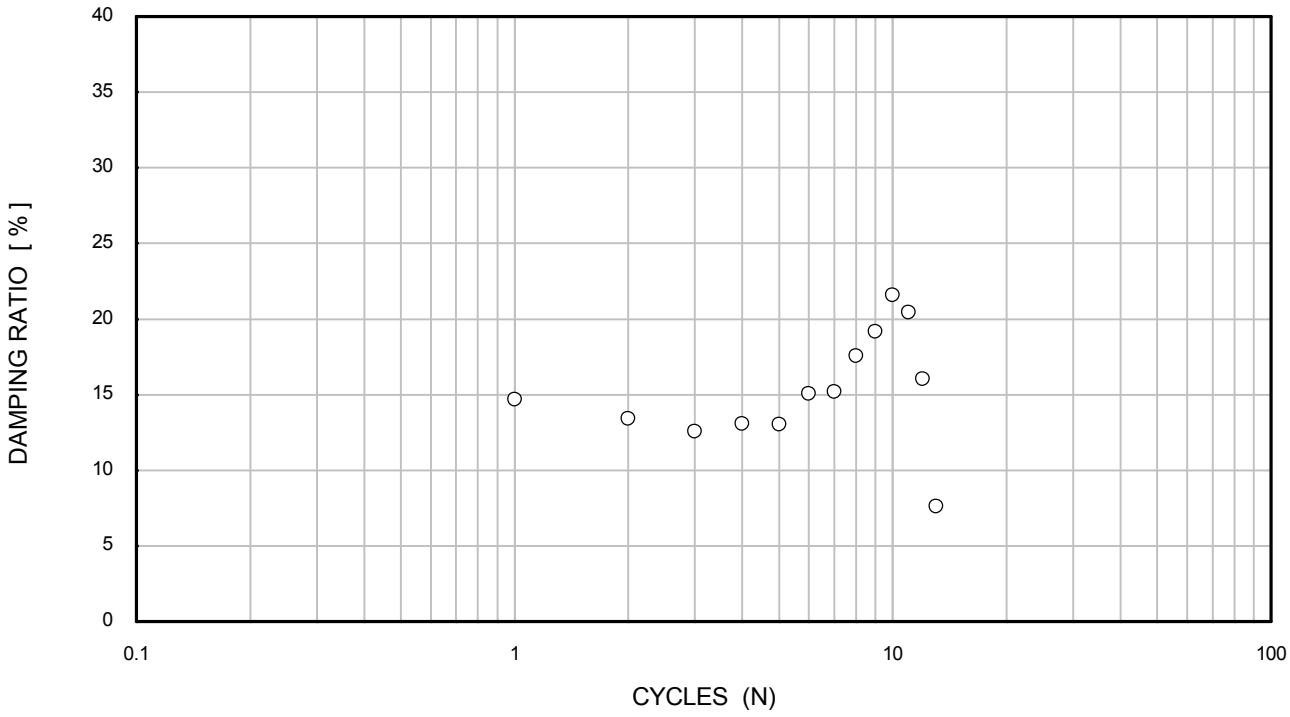


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-3
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX07
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

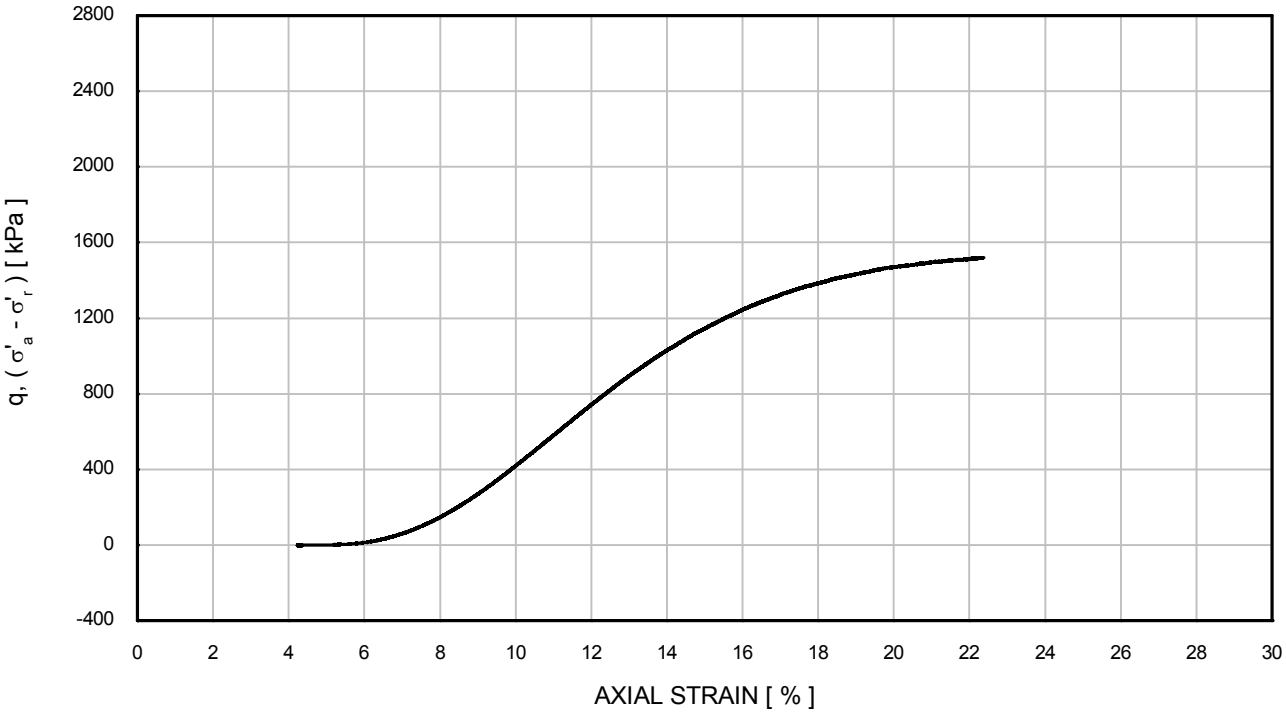


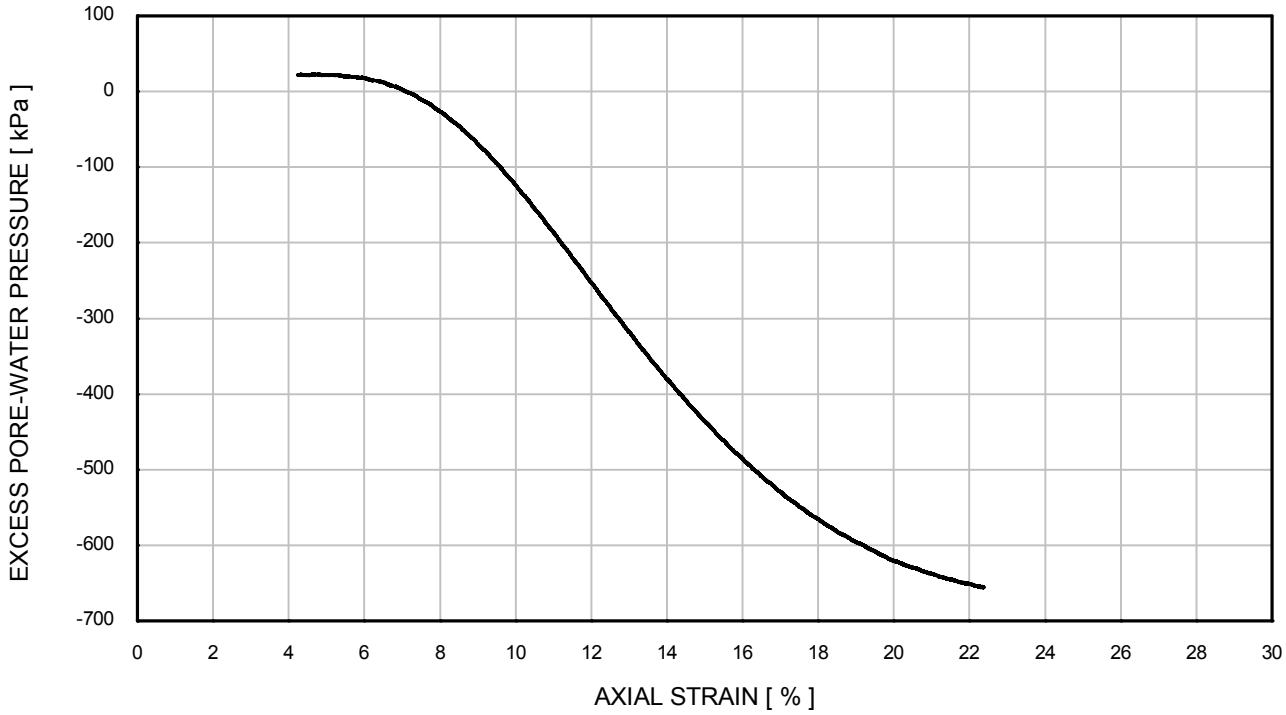


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-3
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	10 kPa	Test No.	:	CTX07
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

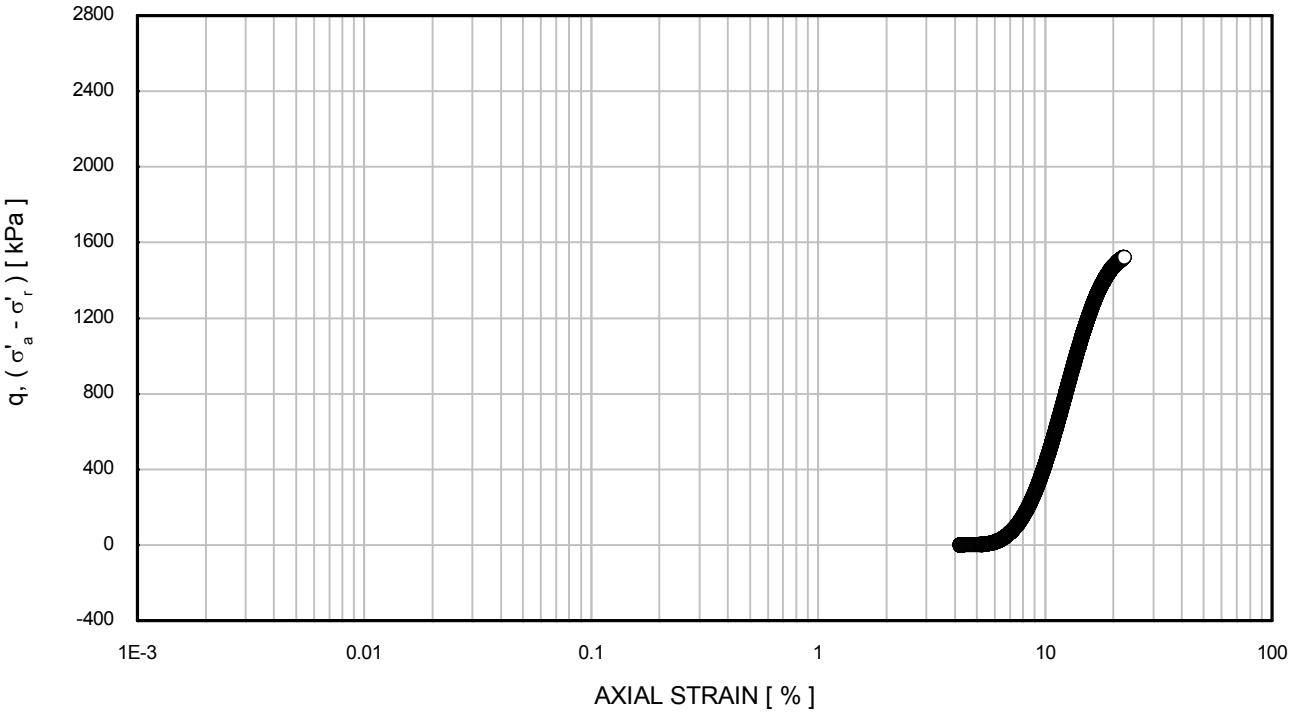


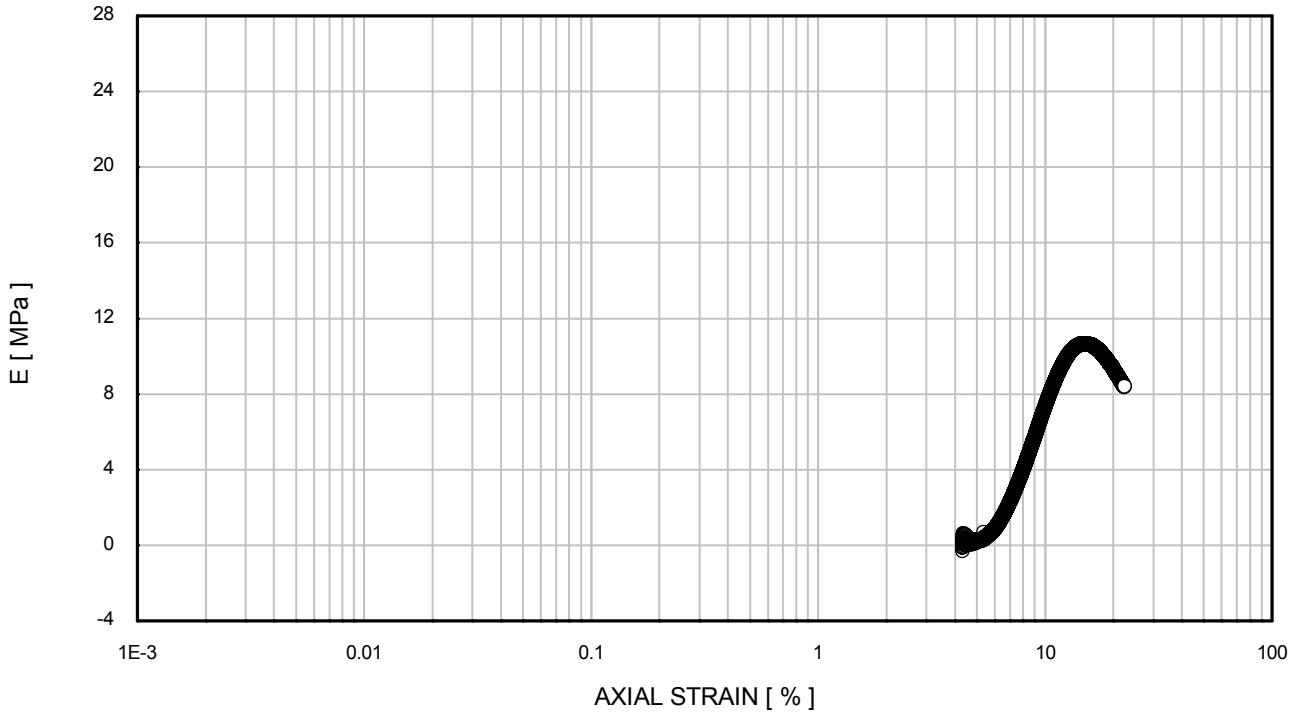


Initial σ'_r	:	4	kPa	Batch	: 1
Initial σ'_a	:	2	kPa	Sample	: CTX_1-3
q_{peak}	:	1521	kPa	Unit	: A (Southern Bight)
Ext. ε at q_{peak}	:	22.39	%	Test No.	: CTX07
Rate of strain	:	0.45	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

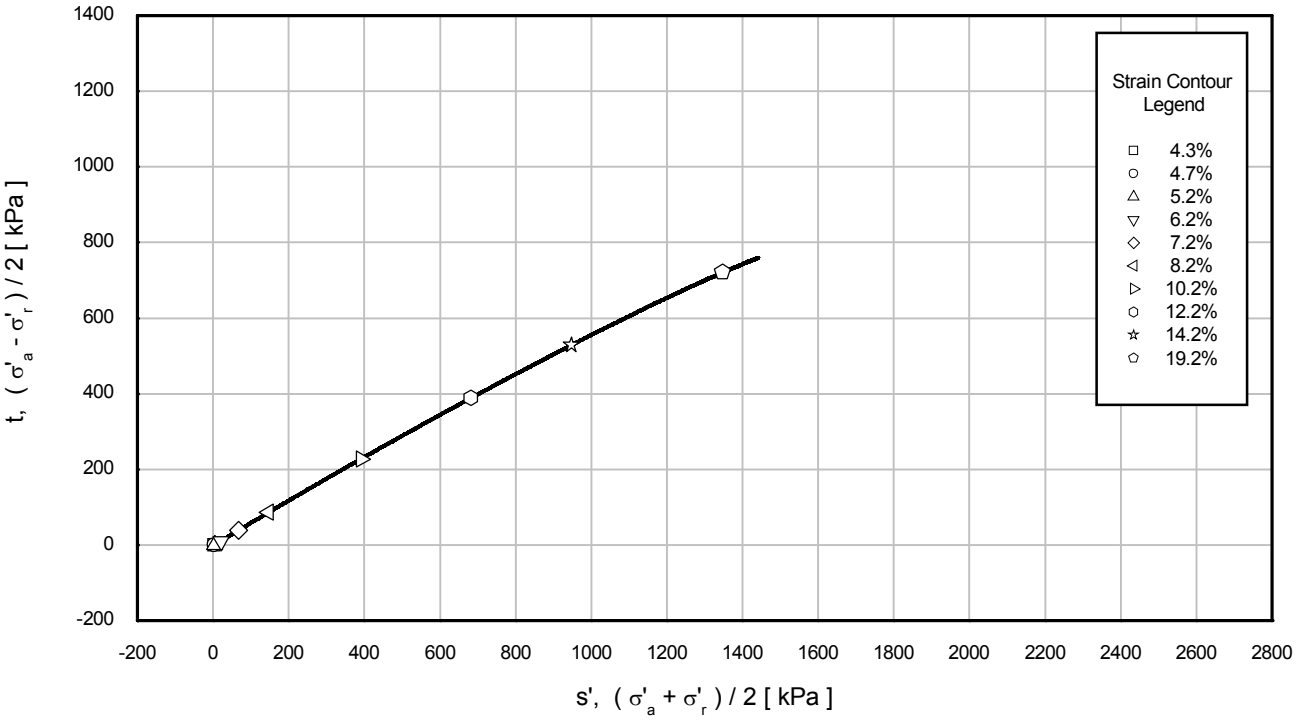


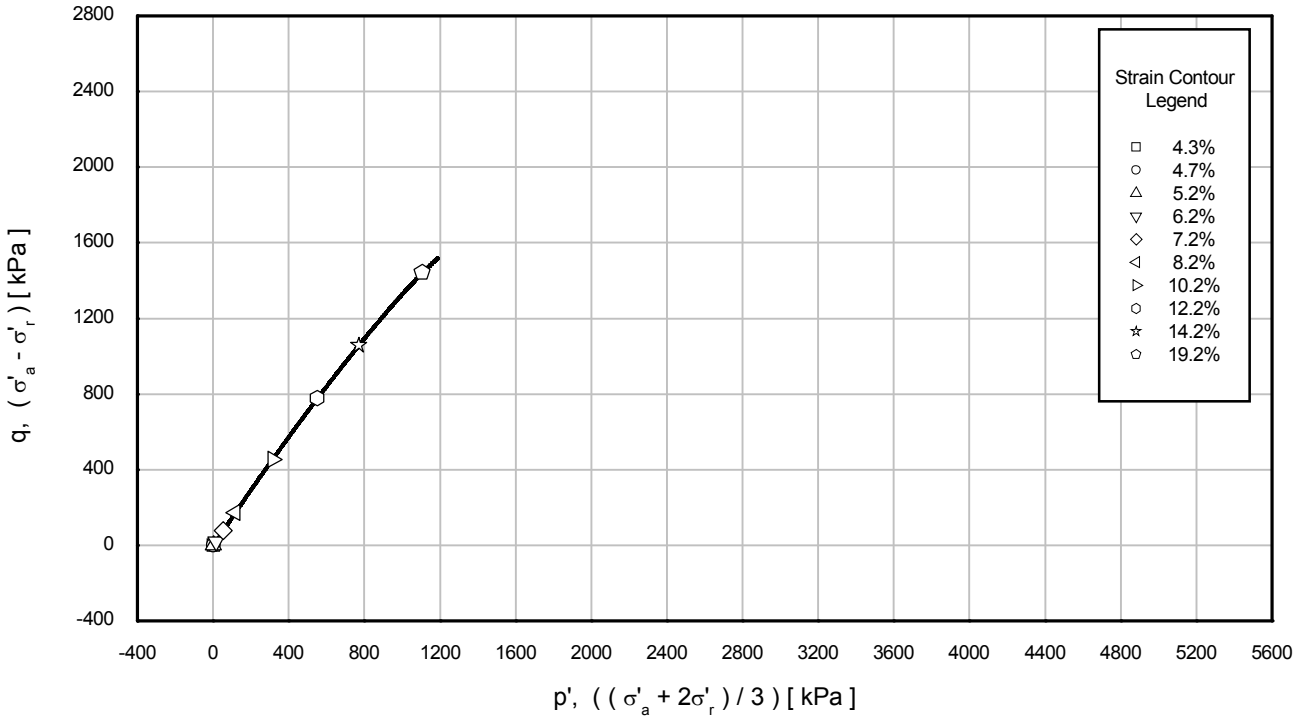


Initial σ'_r	:	4 kPa	Batch	:	1
Initial σ'_a	:	2 kPa	Sample	:	CTX_1-3
q_{peak}	:	1521 kPa	Unit	:	A (Southern Bight)
Ext. ε at q_{peak}	:	22.39 %	Test No.	:	CTX07
Rate of strain	:	0.45 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	4	kPa	Batch	: 1
Initial σ'_a	:	2	kPa	Sample	: CTX_1-3
q_{peak}	:	1521	kPa	Unit	: A (Southern Bight)
Ext. ε at q_{peak}	:	22.39	%	Test No.	: CTX07
Rate of strain	:	0.45	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	15/02/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.6
Bulk density	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.637
Degree of saturation	[%]	44
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 1_CTX-1-4_CTX08
Processed by Date	HJ 03/03/2016
Checked by Date	PH 04/03/2016
Approved by Date	PH 04/03/2016

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-4
Unit	A (Southern Bight)
Test number	CTX08

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1200
Base PWP	[kPa]	1171
Mid height PWP	[kPa]	-
B value achieved	[-]	0.96

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1187
Back pressure	[kPa]	1162
Base PWP	[kPa]	1162
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	25
Effective axial pressure	[kPa]	25
Deviator stress	[kPa]	0
Volumetric strain	[%]	-0.05
External axial strain	[%]	-0.03
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	24.1
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.638
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-4
Unit	A (Southern Bight)
Test number	CTX08

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	50
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	12.7
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	13
External ε_{av} at N_f	[%]	-1.88
External ε_{cy} at N_f	[%]	3.22
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	11
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	24.1
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.638
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-0.03	0.06	20.56	-	15.32	-
2	-0.06	0.06	21.16	-	17.17	-
4	-0.13	0.09	13.31	-	19.60	-
6	-0.24	0.17	7.23	-	20.30	-
8	-0.45	0.38	3.38	-	18.06	-
10	-0.83	0.96	1.34	-	10.94	-
11	-1.12	1.51	0.83	-	7.78	-
12	-1.50	2.29	0.56	-	6.75	-
13	-1.88	3.22	0.41	-	5.82	-

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-4
Unit	A (Southern Bight)
Test number	CTX08

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

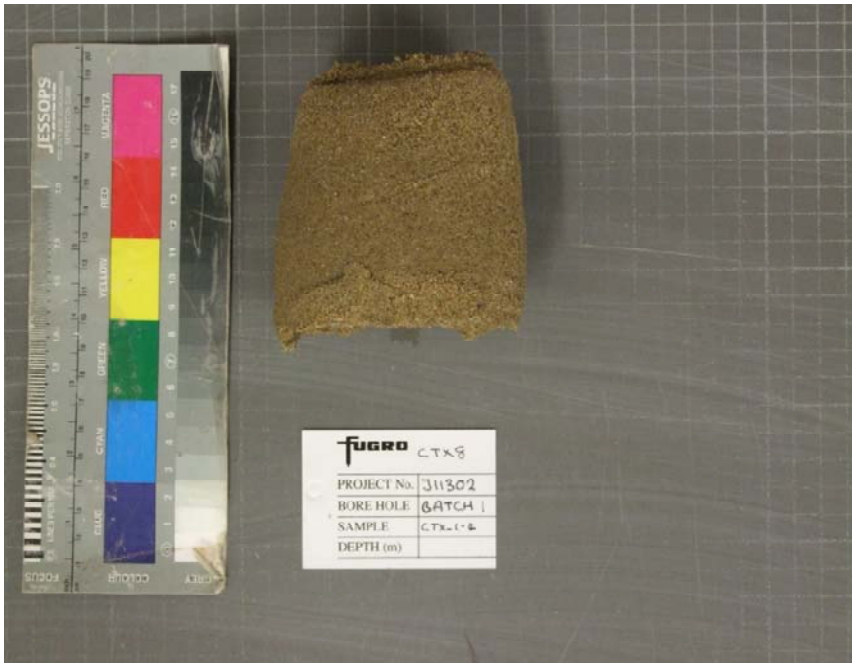
SHEARING STAGE		
Initial effective radial pressure	[kPa]	7
Initial effective axial pressure	[kPa]	8
Rate of strain	[%/hour]	4.83
At peak deviator stress		
Corrected deviator stress	[kPa]	2475
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	20.58
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-1109
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	1134
Effective axial pressure	[kPa]	3609
Principal effective stress ratio	[-]	3.18
ε_{50}	[%]	11.65
Secant modulus (E_{50}) at ε_{50}	[kPa]	5812
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	284
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	7.85
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-73
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	99
Effective axial pressure	[kPa]	383
Principal effective stress ratio	[-]	3.89
At 10% external axial strain		
Corrected deviator stress	[kPa]	789
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	9.99
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-262
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	287
Effective axial pressure	[kPa]	1076
Principal effective stress ratio	[-]	3.75

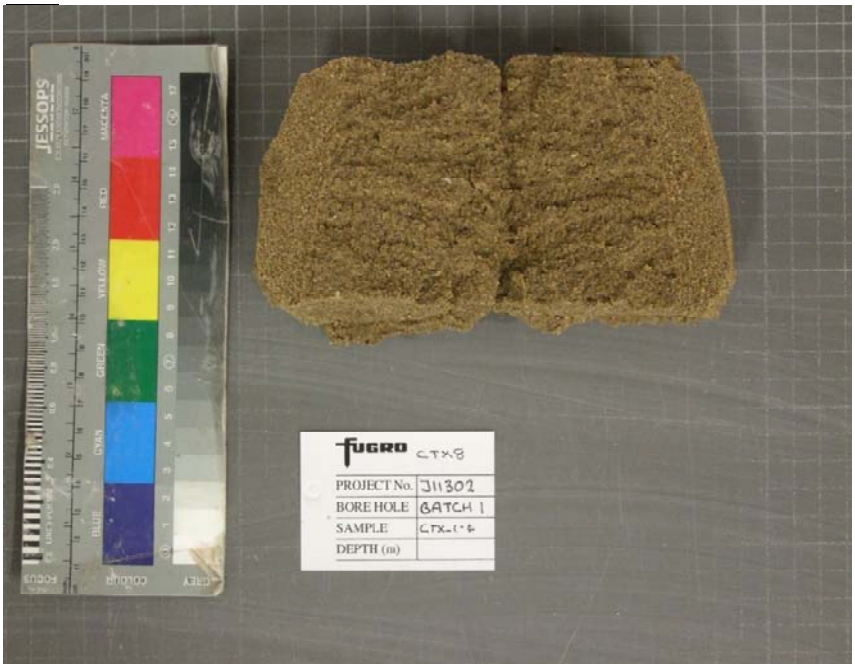
TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-4
Unit	A (Southern Bight)
Test number	CTX08

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



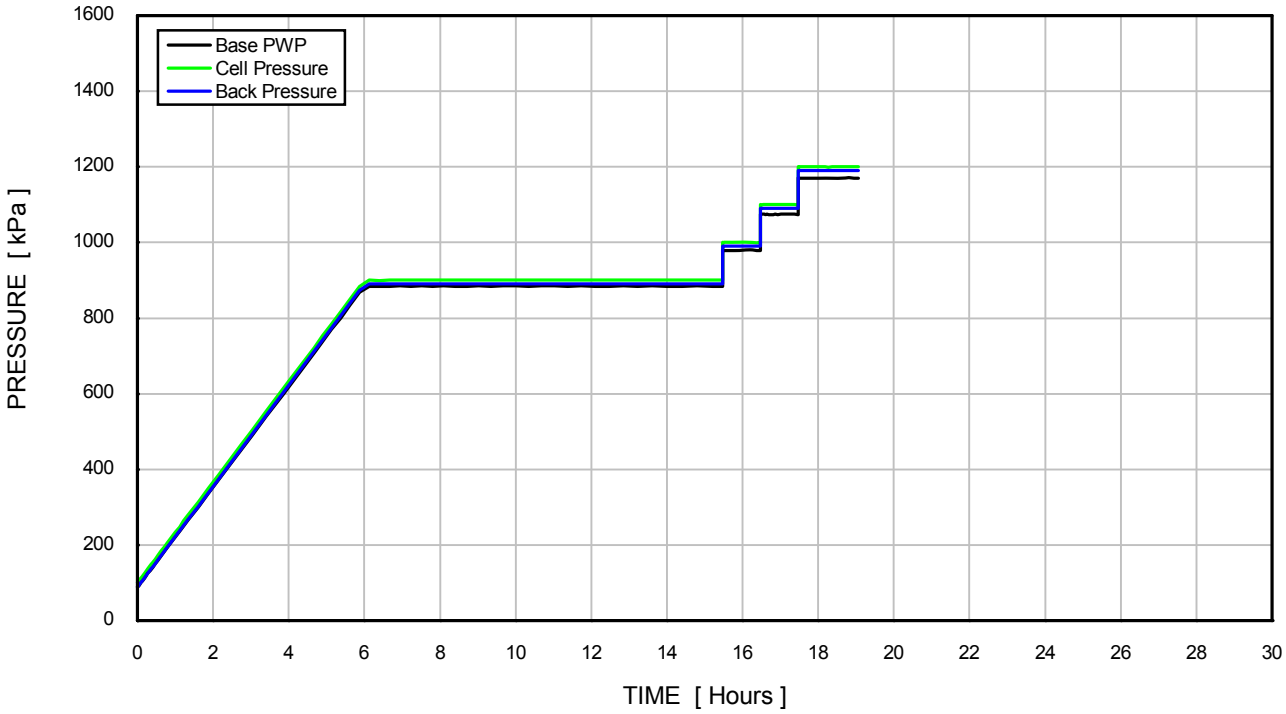


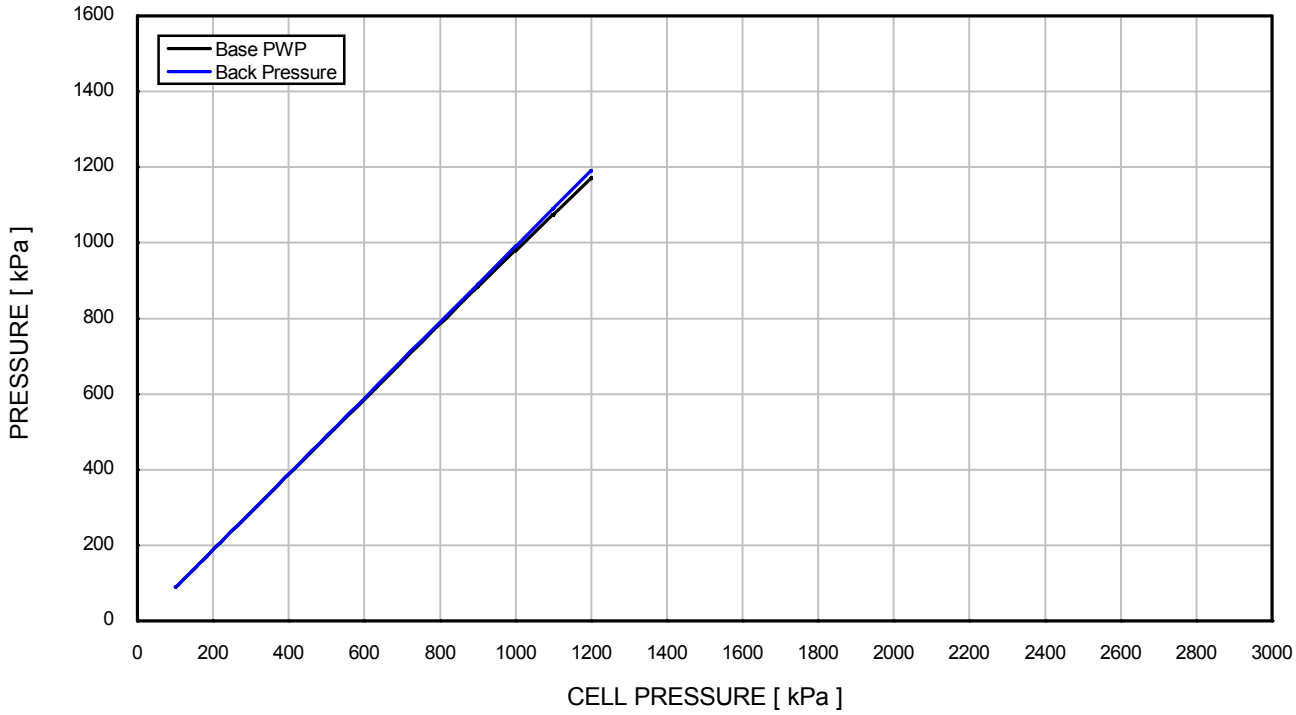
FINAL CONDITIONS		
Moisture content	[%]	24.1
Bulk density	[Mg/m³]	2.01
Dry density	[Mg/m³]	1.62

TEST IDENTIFICATION	
Batch	1
Sample	CTX_1-4
Unit	A (Southern Bight)
Test number	CTX08

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

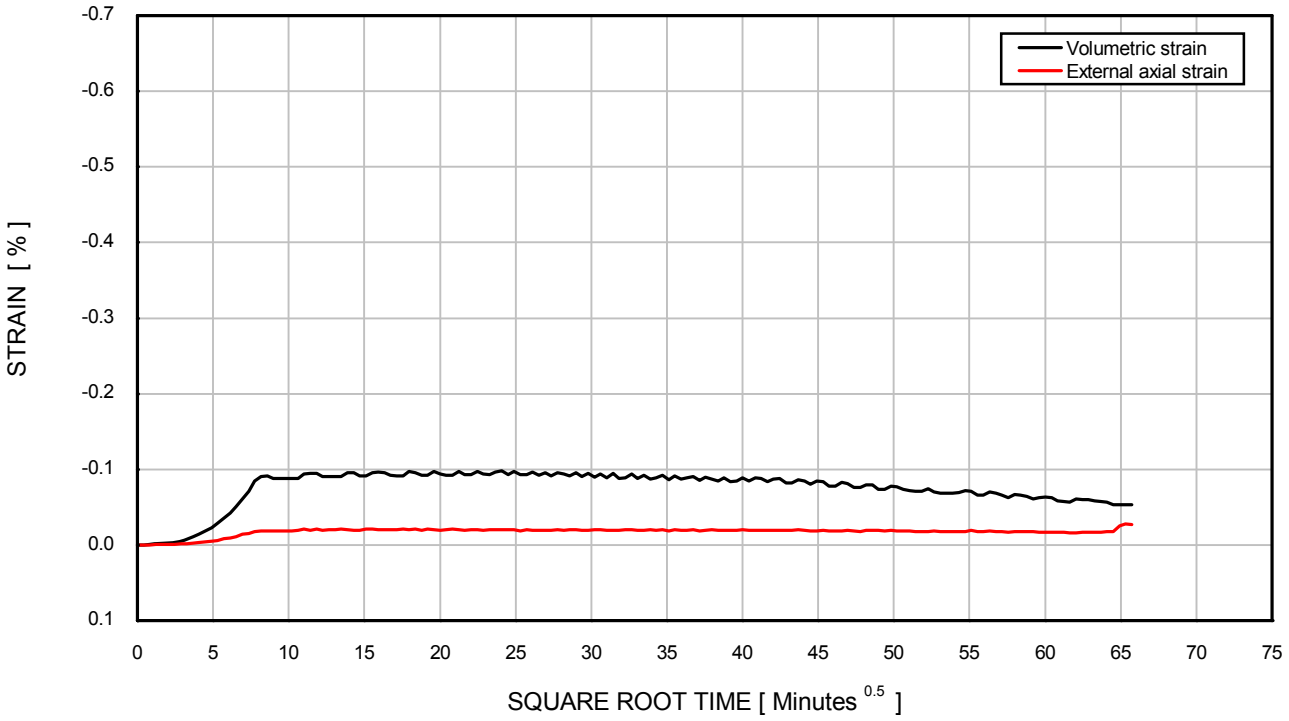


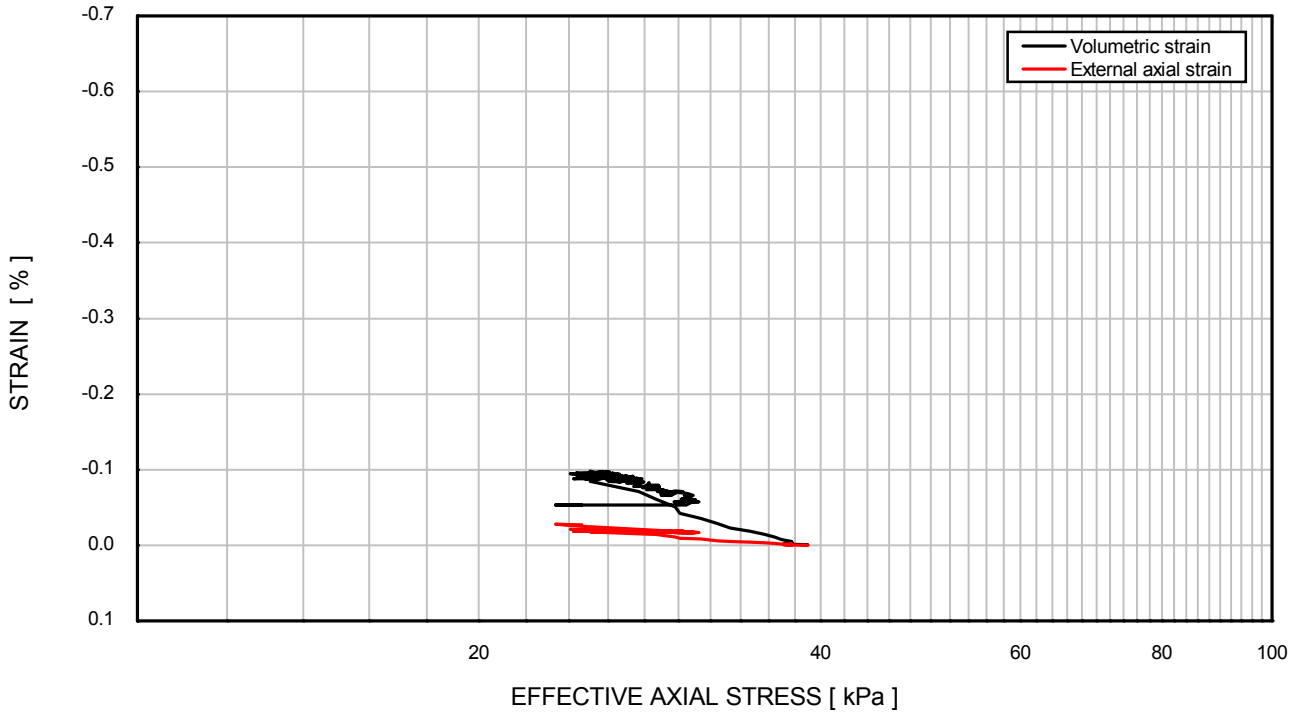


B value	:	0.96			
Initial σ'_r	:	11	kPa	Batch	: 1
Initial σ'_a	:	11	kPa	Sample	: CTX_1-4
Final σ'_r	:	29	kPa	Unit	: A (Southern Bight)
Final σ'_a	:	29	kPa	Test No.	: CTX08

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

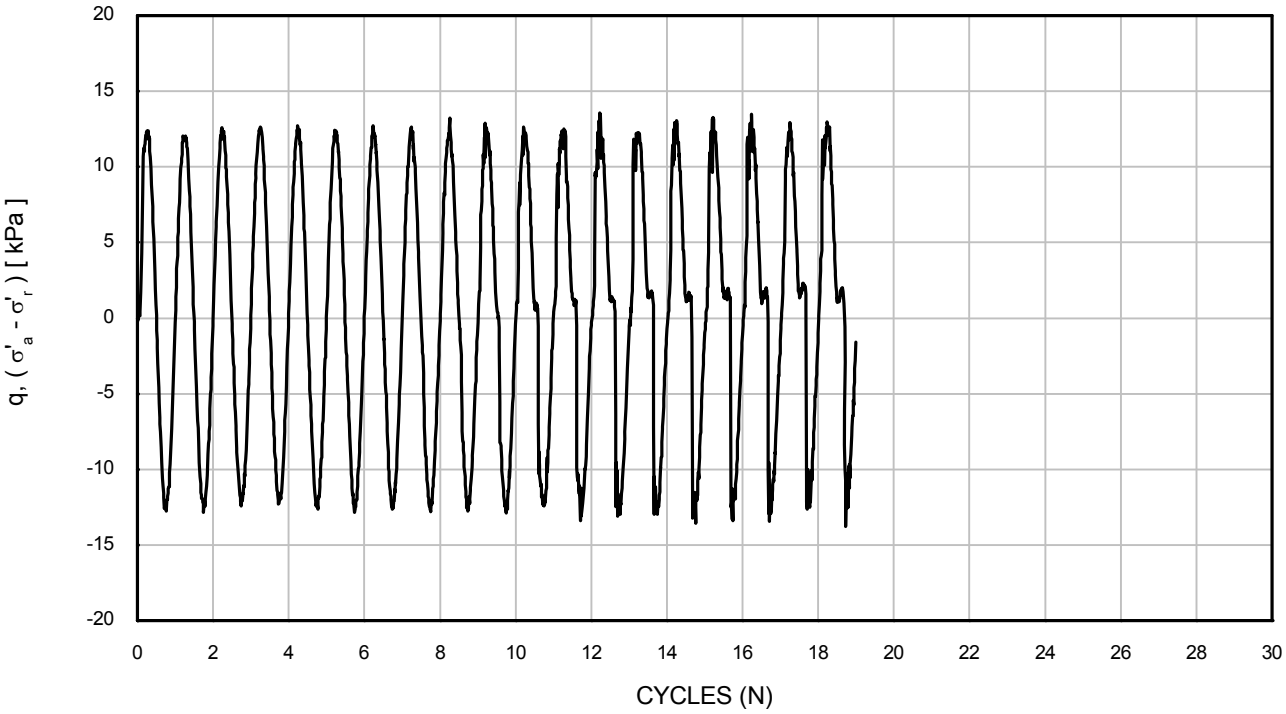


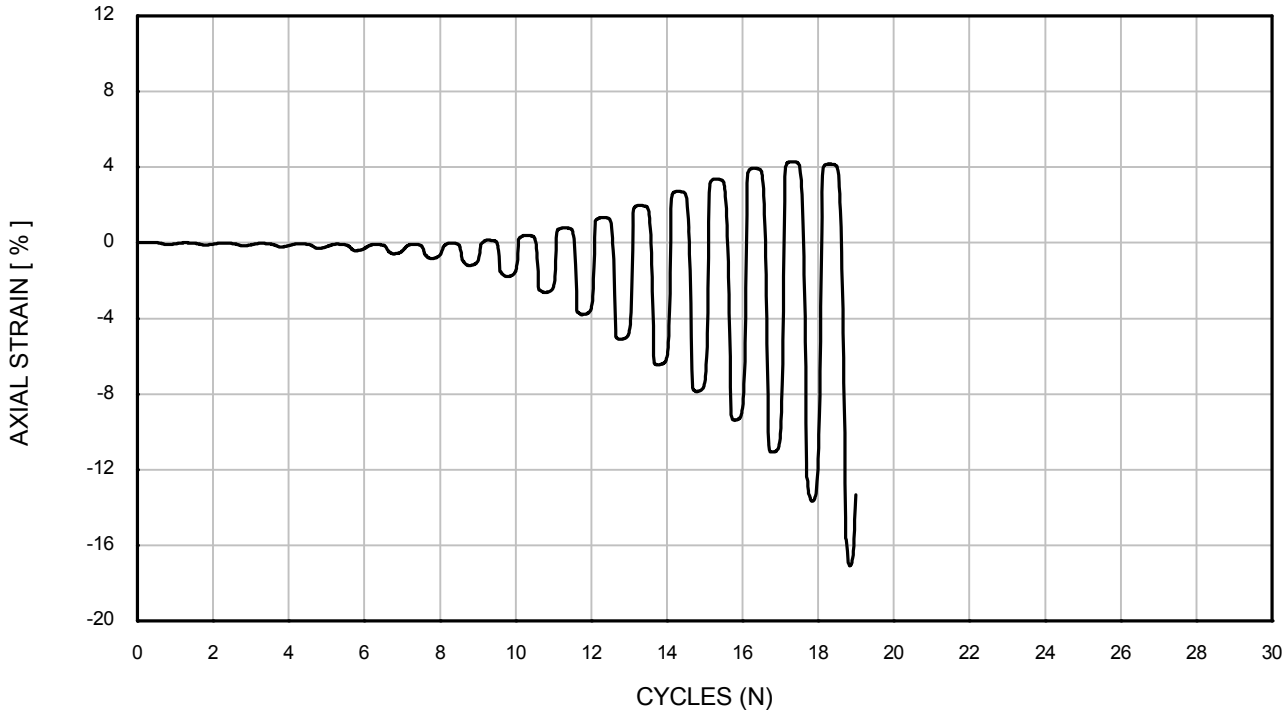


σ'_{rc}	:	25 kPa	Batch	:	1
σ'_{ac}	:	25 kPa	Sample	:	CTX_1-4
			Unit	:	A (Southern Bight)
			Test No.	:	CTX08

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

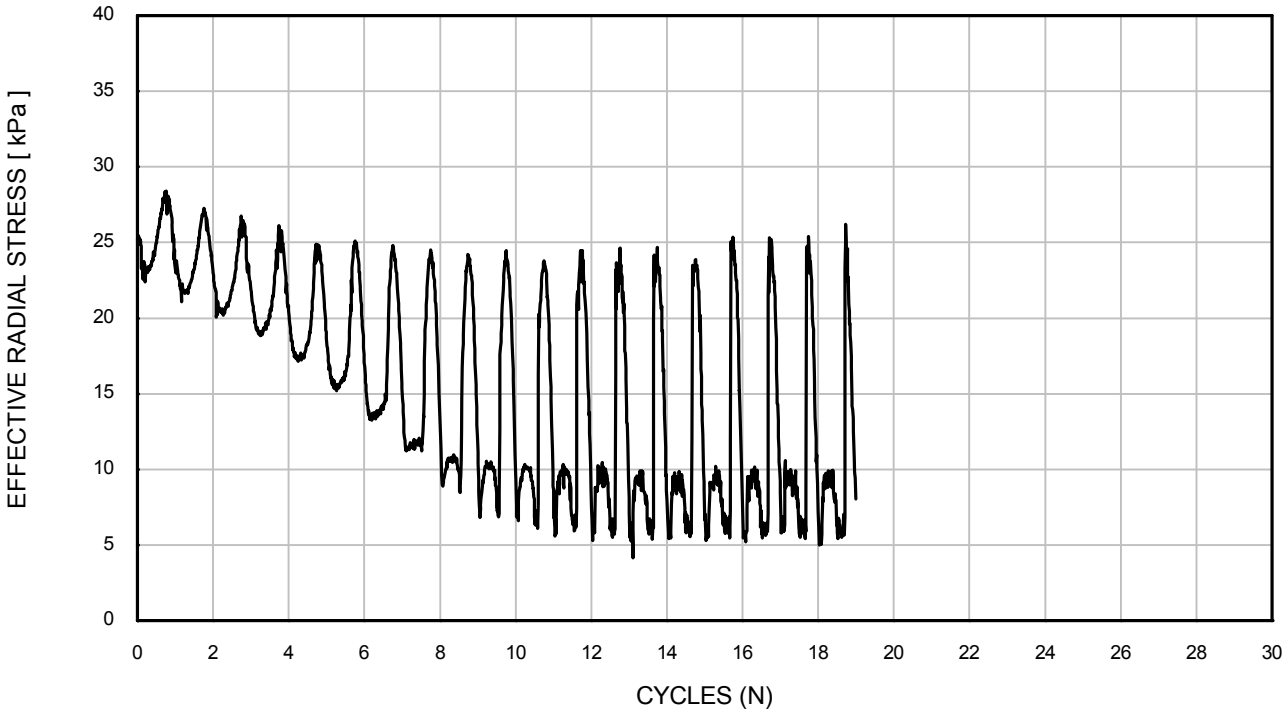


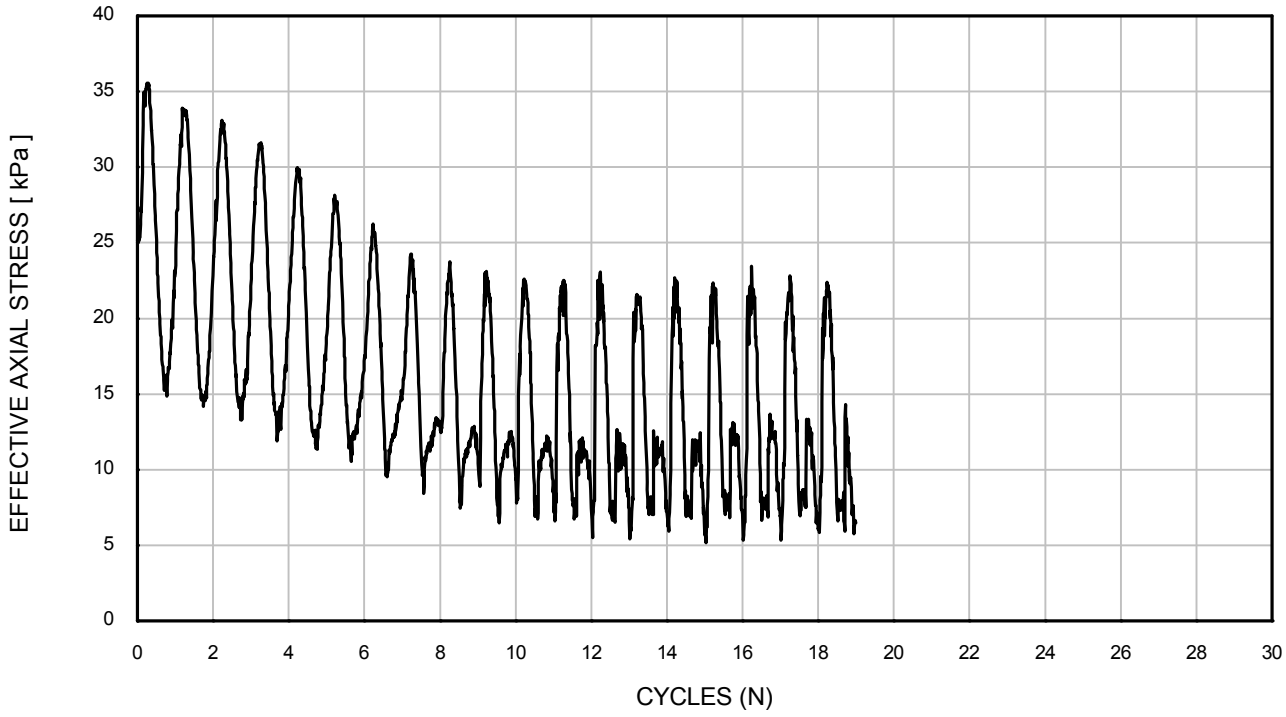


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-4
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	13	kPa	Test No.	: CTX08
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

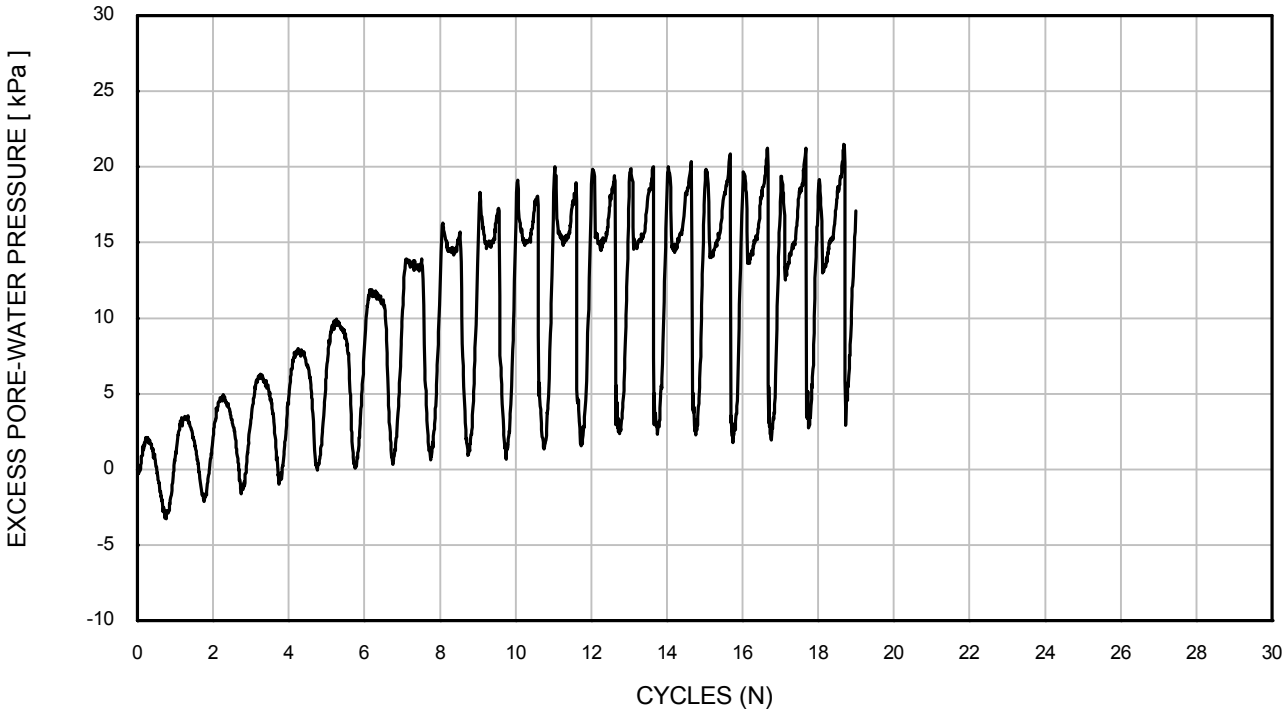


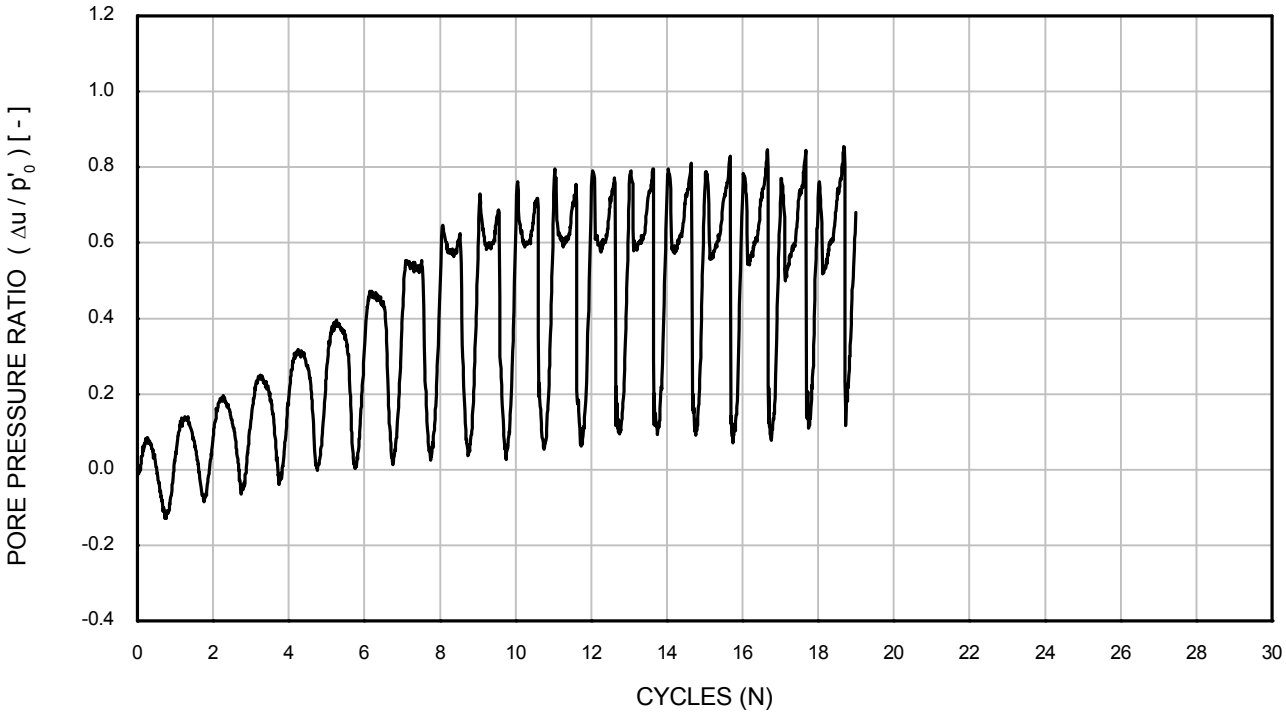


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-4
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	13 kPa	Test No.	:	CTX08
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

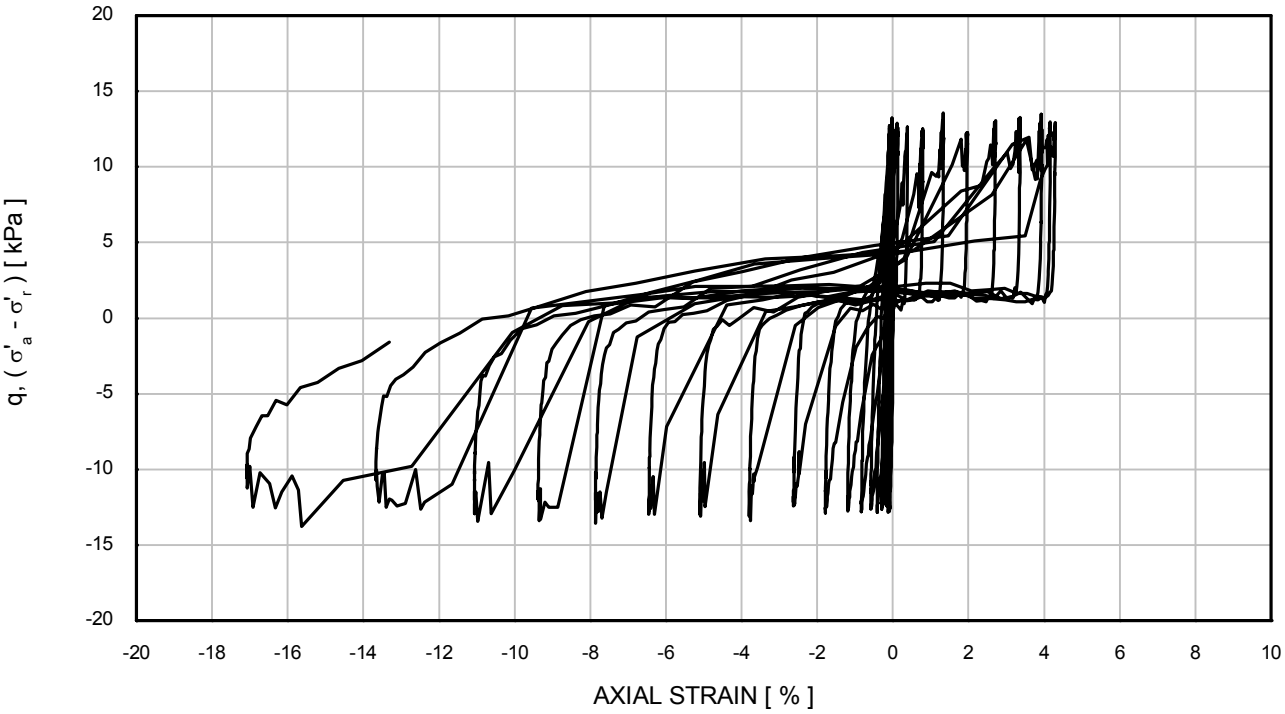


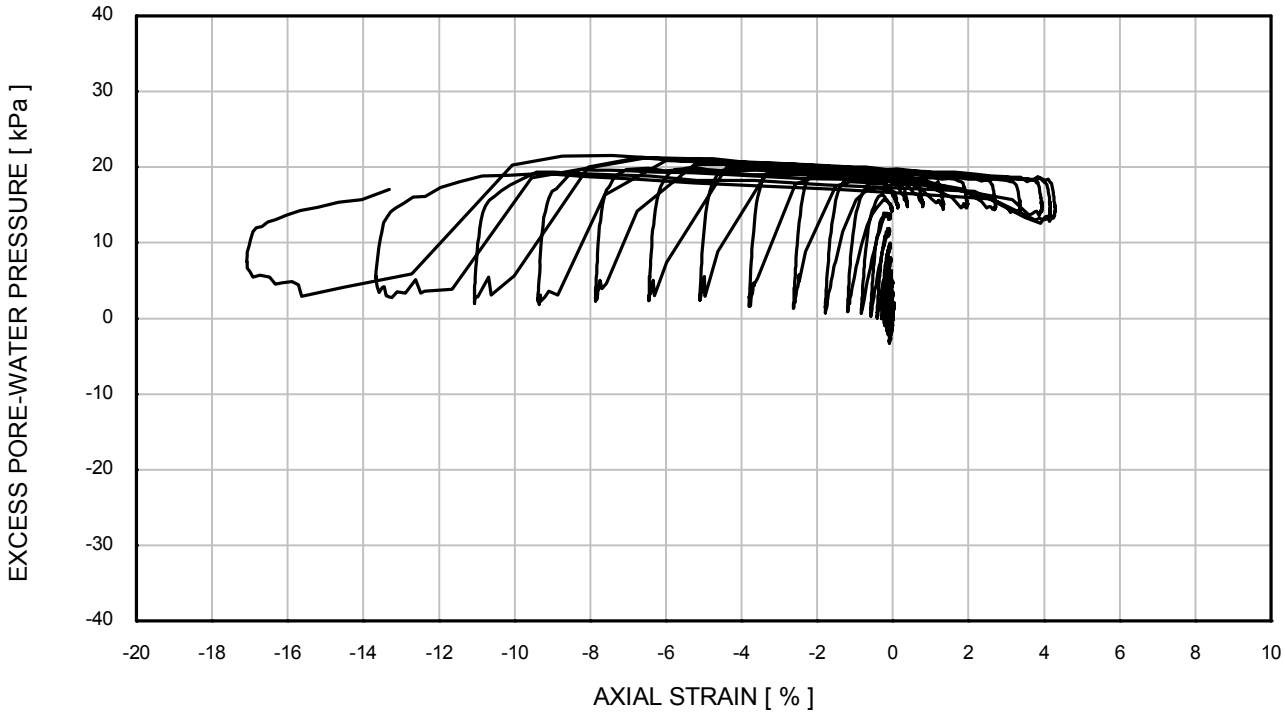


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-4
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	13 kPa	Test No.	:	CTX08
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

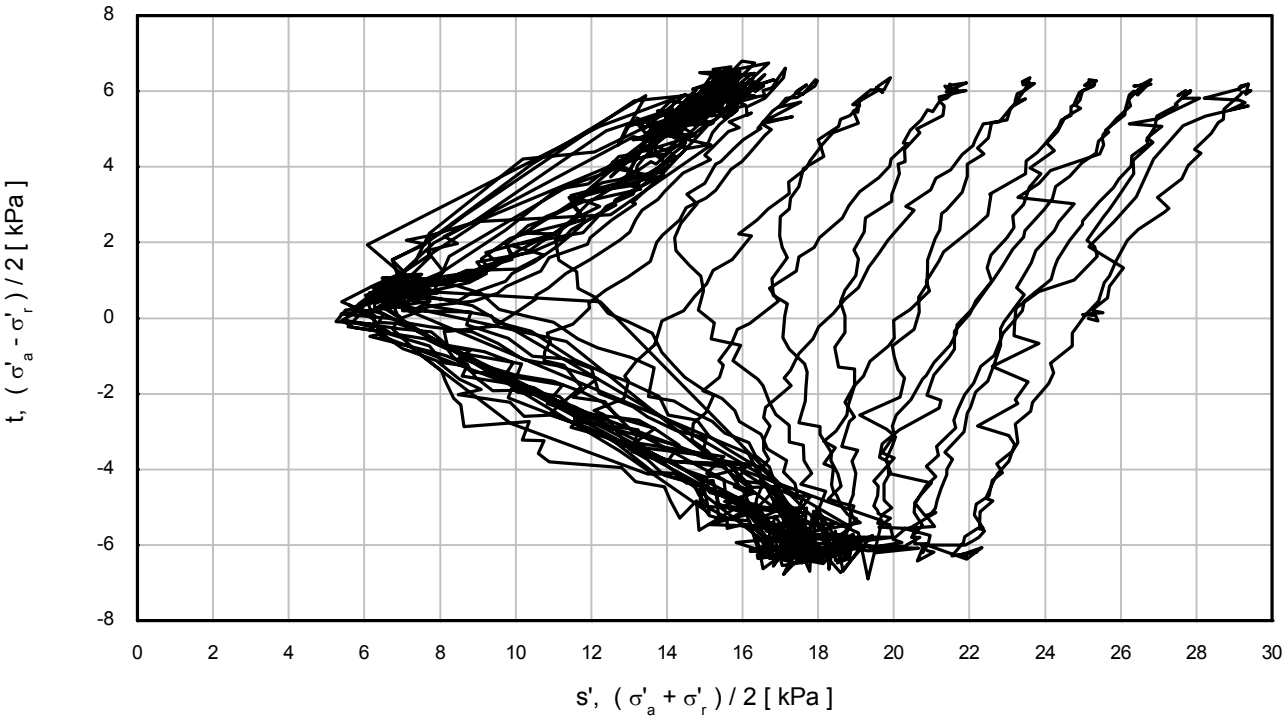


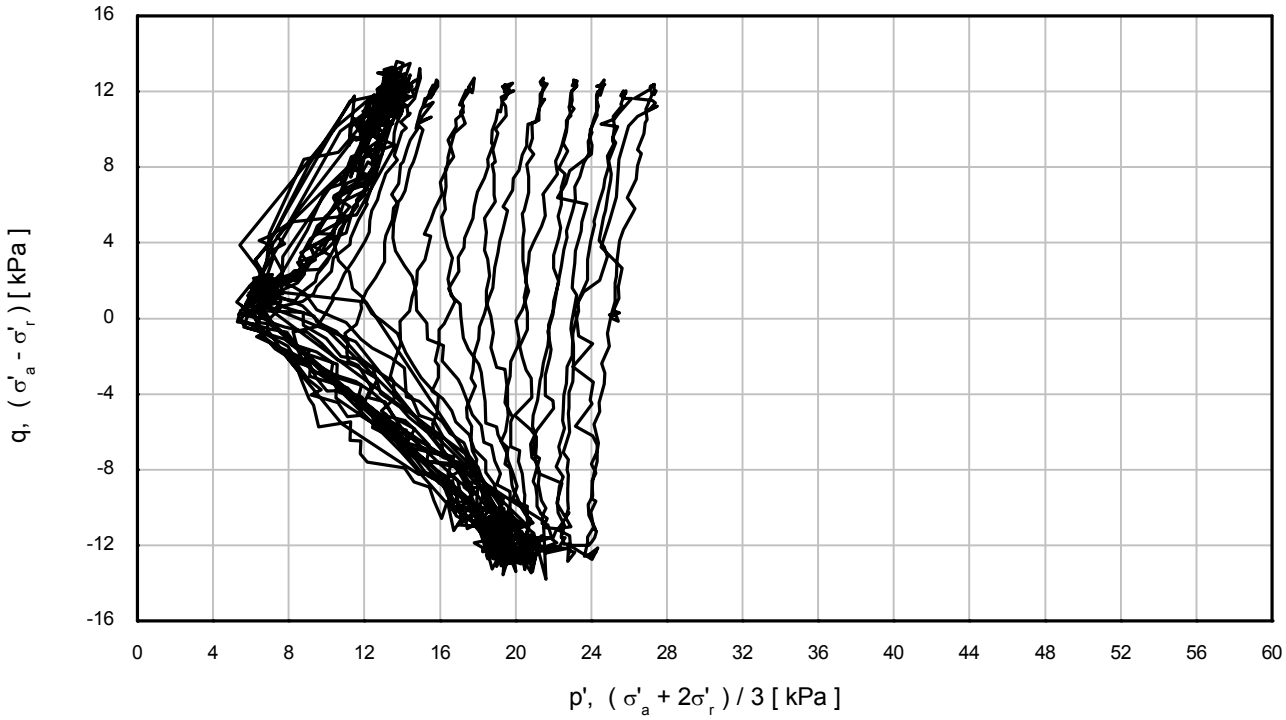


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-4
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	13 kPa	Test No.	:	CTX08
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

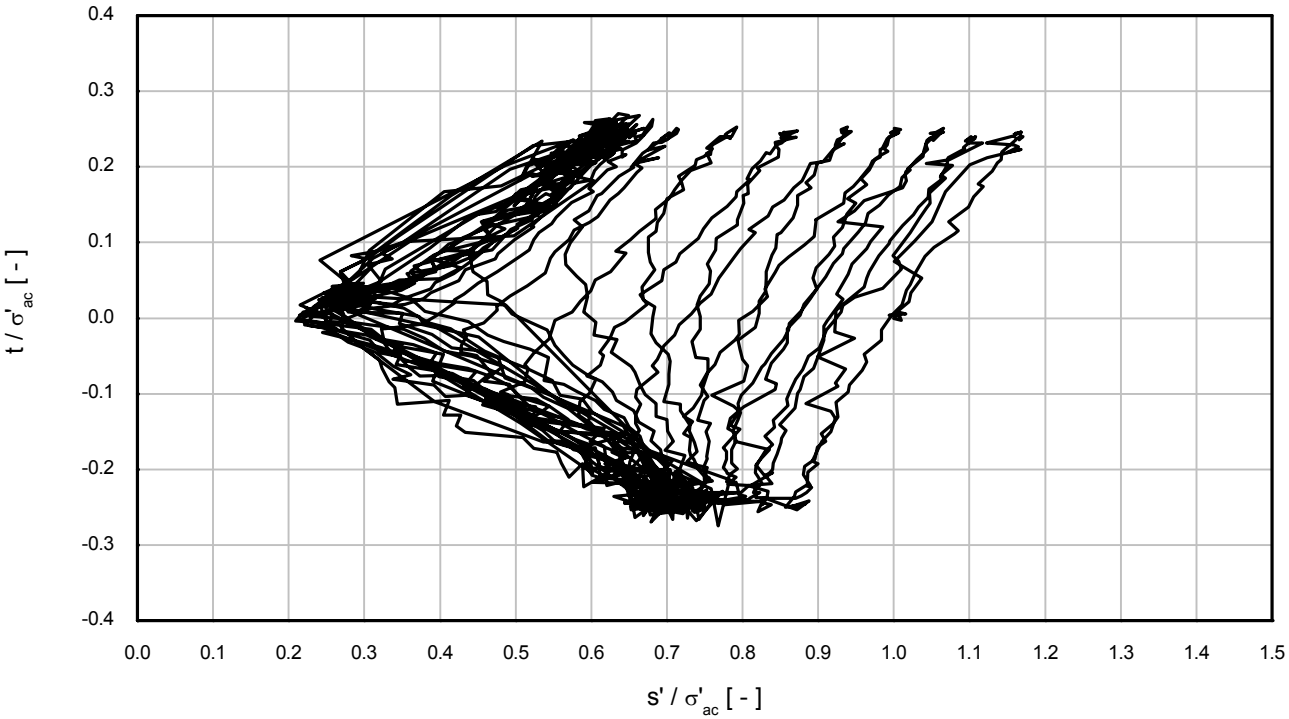


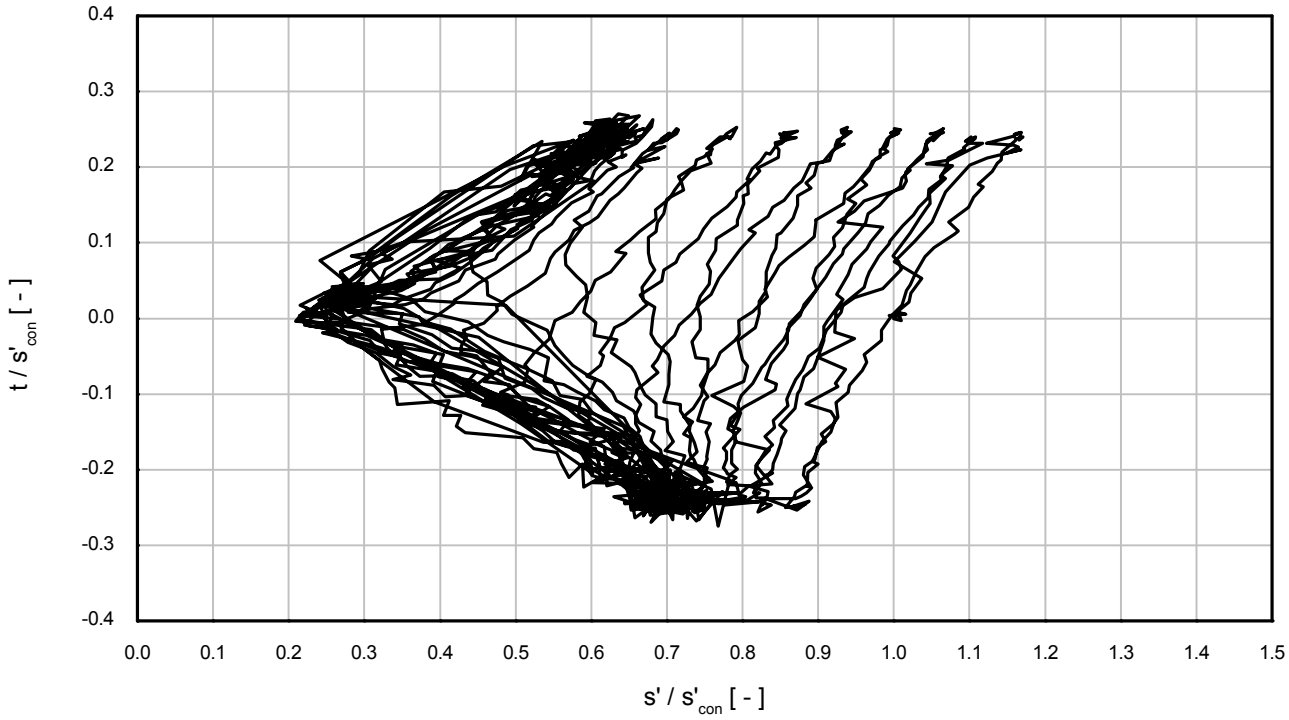


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-4
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	13	kPa	Test No.	: CTX08
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

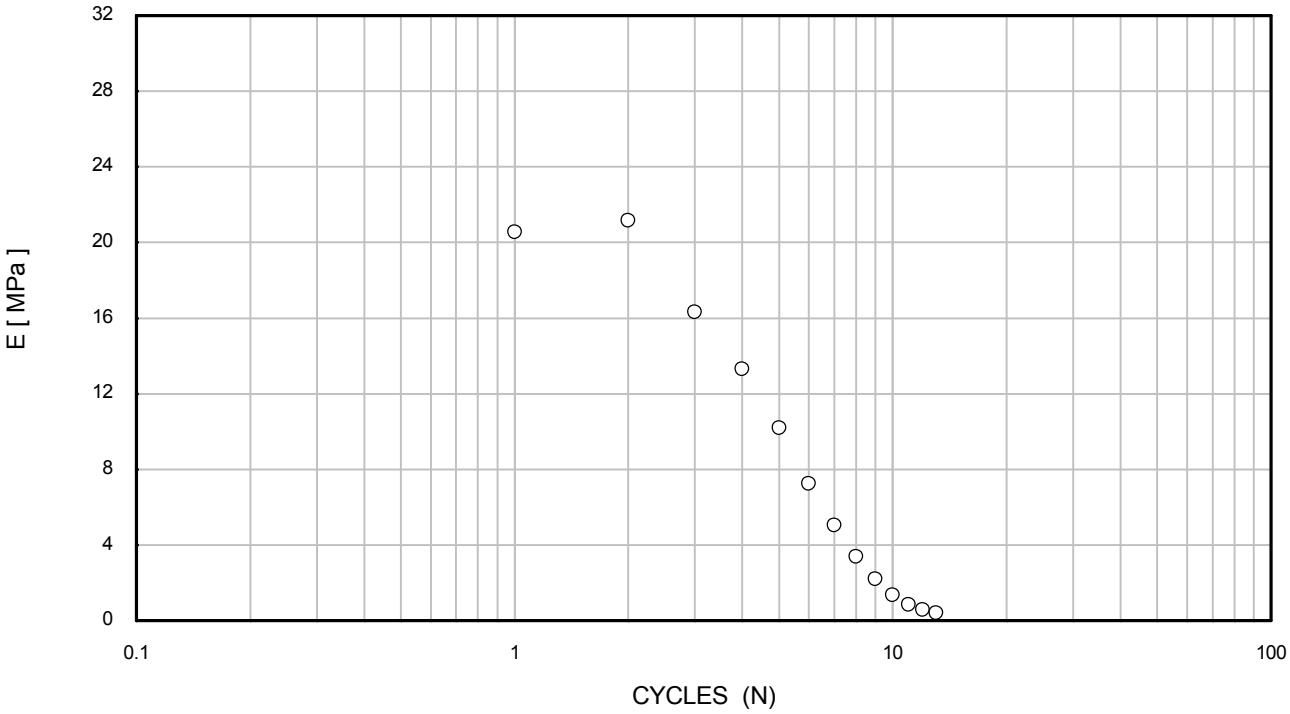


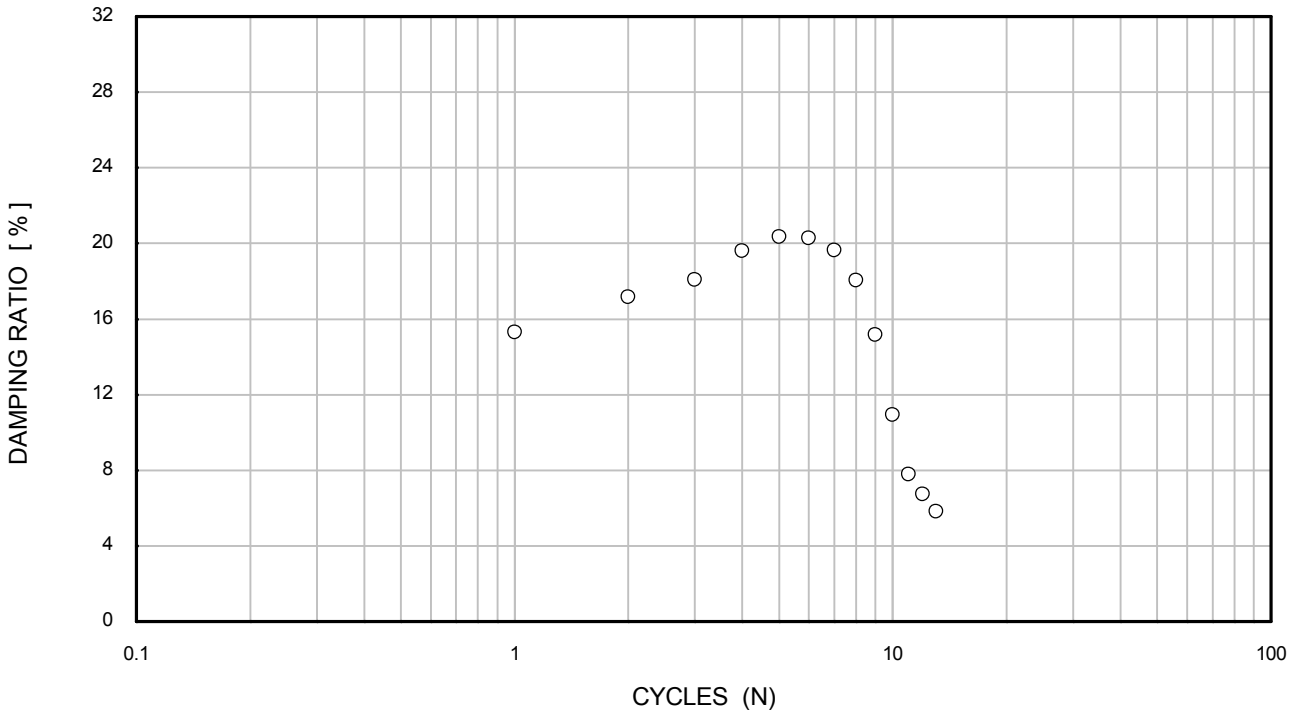


Initial σ'_r	:	25 kPa	Batch	:	1
Initial σ'_a	:	25 kPa	Sample	:	CTX_1-4
q_{av}	:	0 kPa	Unit	:	A (Southern Bight)
q_{cy}	:	13 kPa	Test No.	:	CTX08
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

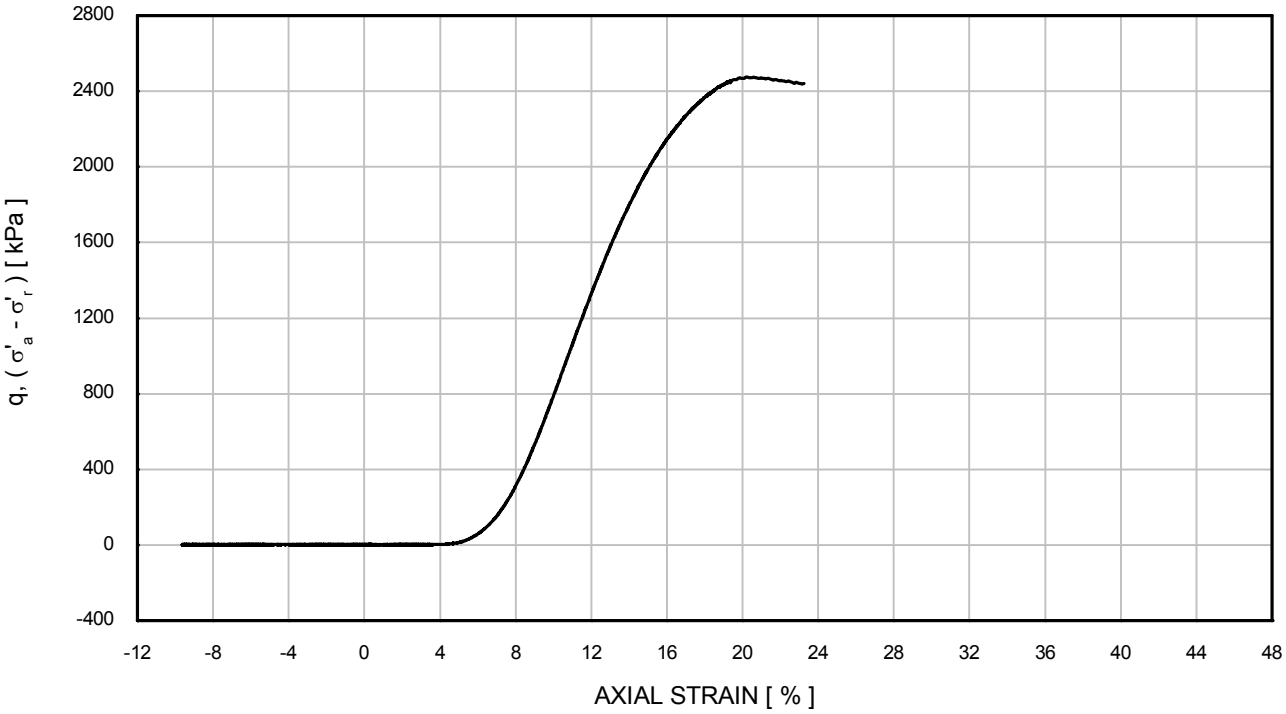


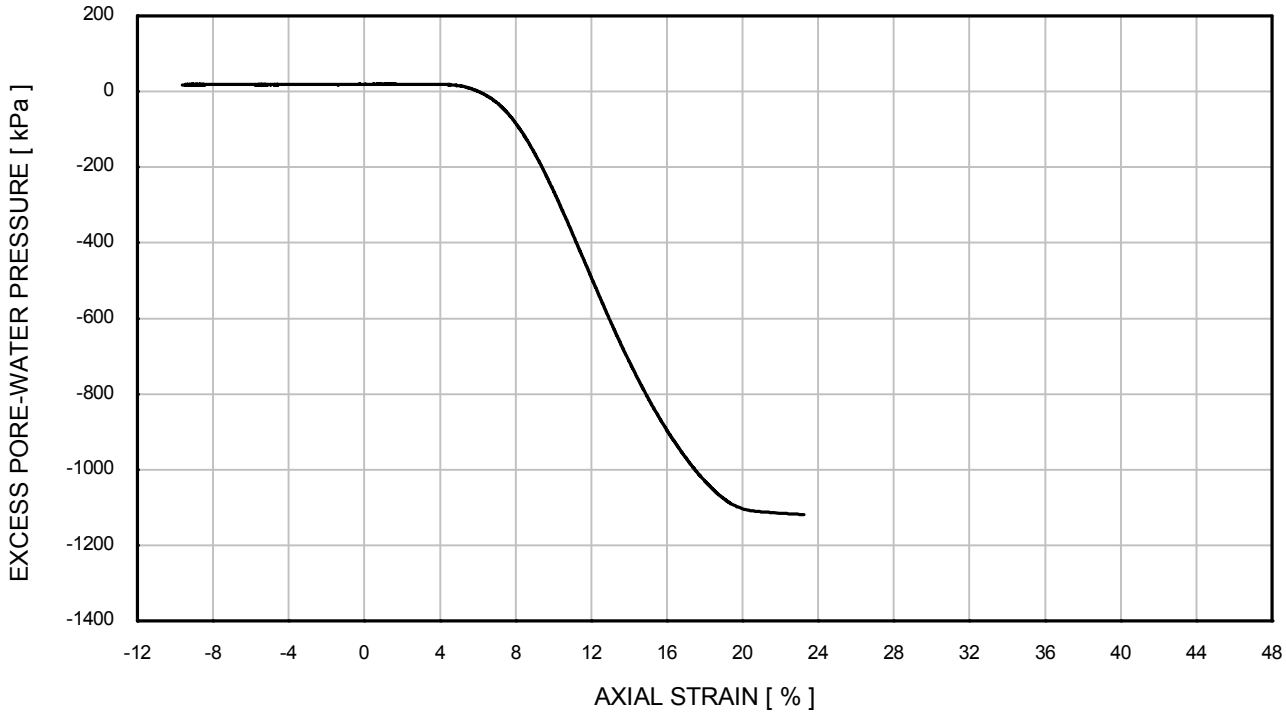


Initial σ'_r	:	25	kPa	Batch	: 1
Initial σ'_a	:	25	kPa	Sample	: CTX_1-4
q_{av}	:	0	kPa	Unit	: A (Southern Bight)
q_{cy}	:	13	kPa	Test No.	: CTX08
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

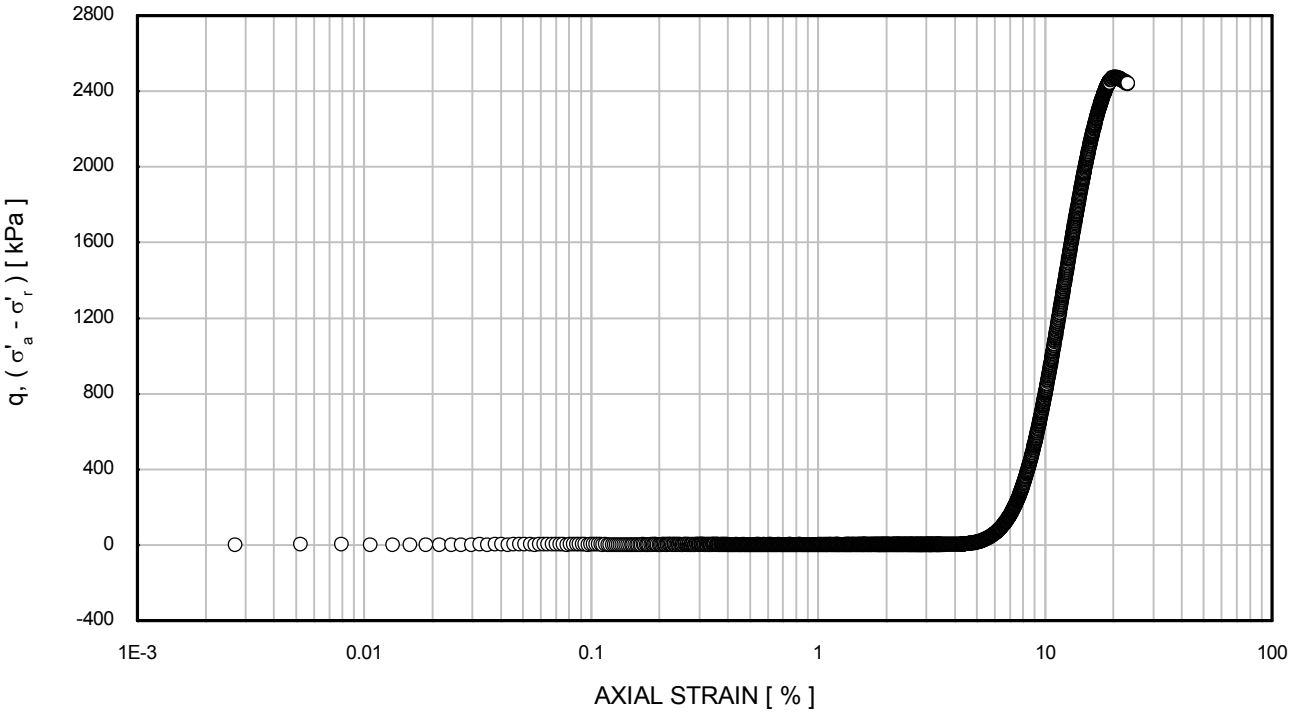


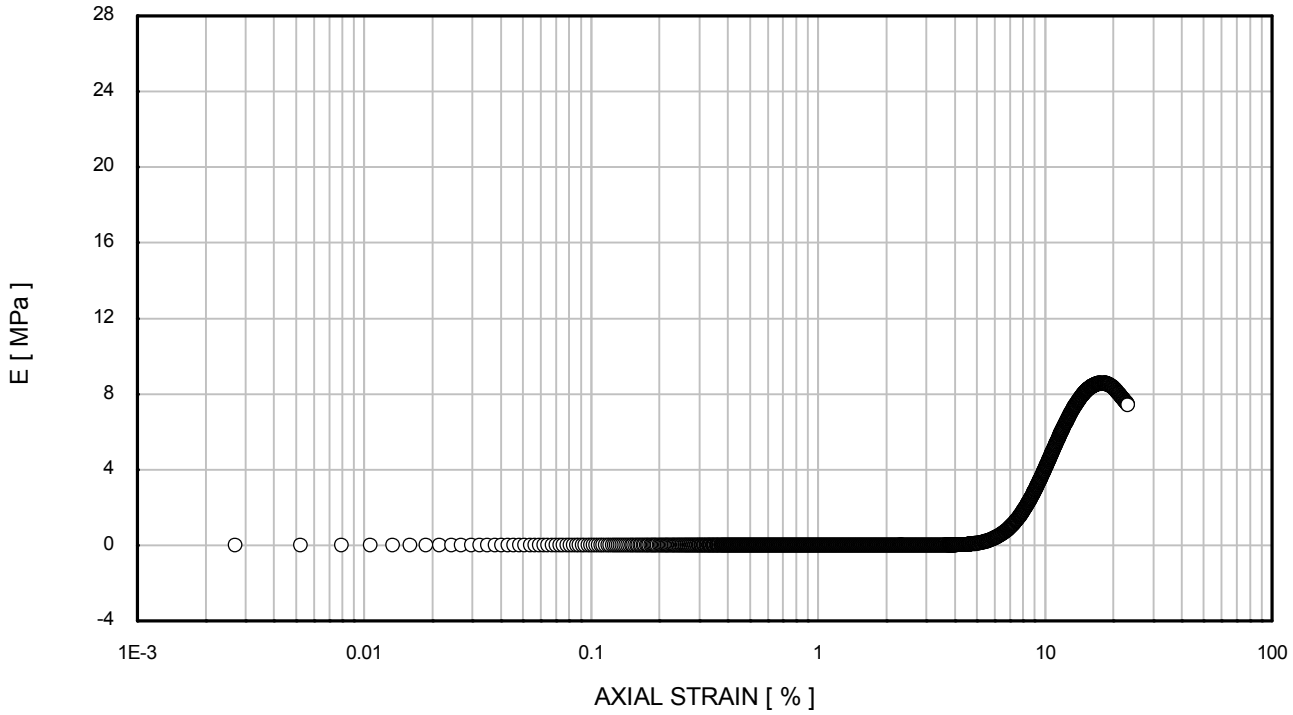


Initial σ'_r	:	7	kPa	Batch	: 1
Initial σ'_a	:	8	kPa	Sample	: CTX_1-4
q_{peak}	:	2475	kPa	Unit	: A (Southern Bight)
Ext. ε at q_{peak}	:	20.58	%	Test No.	: CTX08
Rate of strain	:	4.83	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

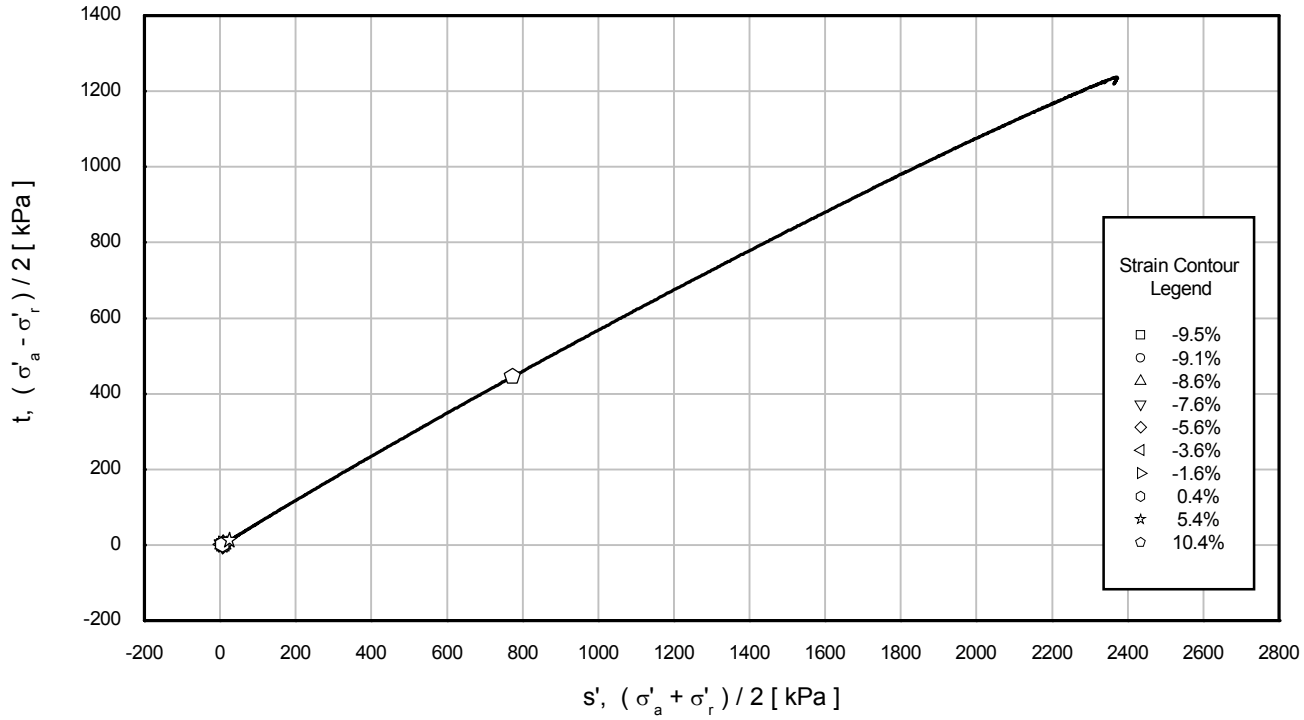


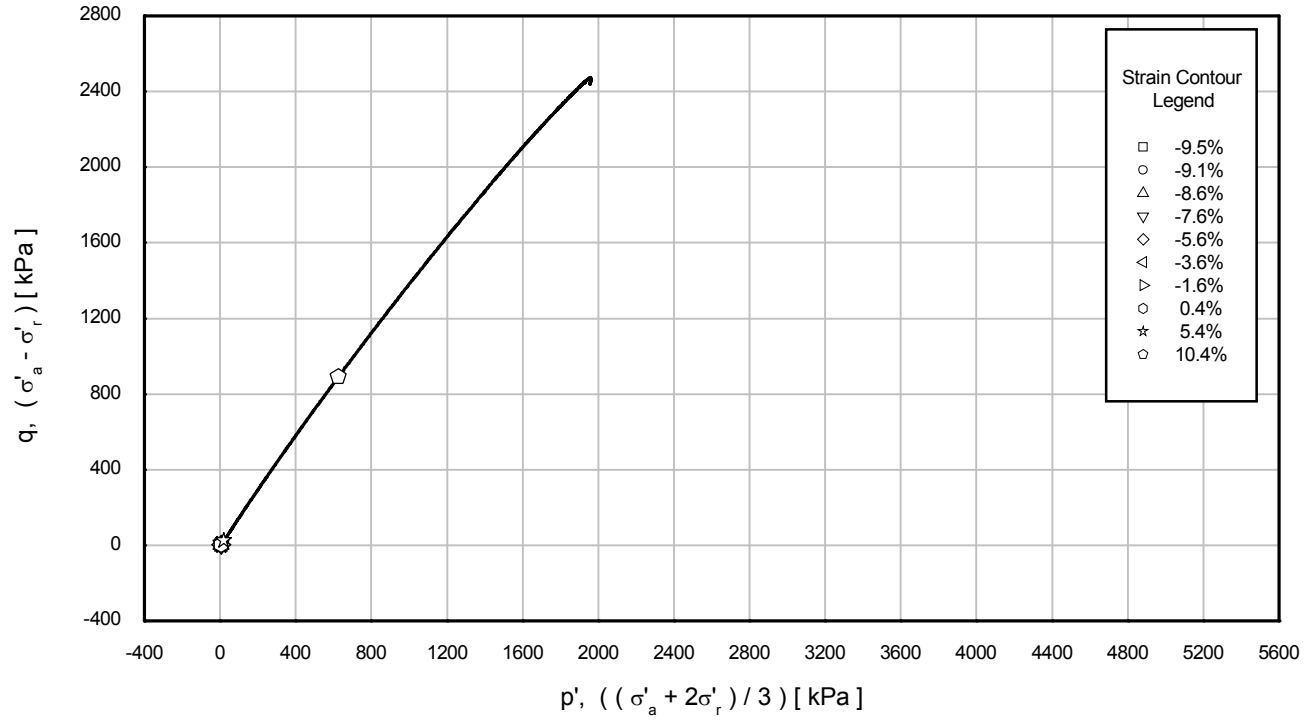


Initial σ'_r	:	7 kPa	Batch	:	1
Initial σ'_a	:	8 kPa	Sample	:	CTX_1-4
q_{peak}	:	2475 kPa	Unit	:	A (Southern Bight)
Ext. ε at q_{peak}	:	20.58 %	Test No.	:	CTX08
Rate of strain	:	4.83 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	7	kPa	Batch	: 1
Initial σ'_a	:	8	kPa	Sample	: CTX_1-4
q_{peak}	:	2475	kPa	Unit	: A (Southern Bight)
Ext. ε at q_{peak}	:	20.58	%	Test No.	: CTX08
Rate of strain	:	4.83	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Light brown fine to medium SAND

GENERAL	
Date test started	13/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.0
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.559
Degree of saturation	[%]	47
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic	BS1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ BATCH2_CTX_2-1_CTX9
Processed by	LJ
Date	22/01/2016
Checked by	PH
Date	08/02/2016
Approved by	PH
Date	08/02/2016

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-1
Unit	B (Eem/Kreftenheye)
Test number	CTX09

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1076
Mid height PWP	[kPa]	-
B value achieved	[-]	0.95

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1160
Back pressure	[kPa]	1080
Base PWP	[kPa]	1080
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	80
Effective axial pressure	[kPa]	80
Deviator stress	[kPa]	0
Volumetric strain	[%]	0.29
External axial strain	[%]	0.12
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	20.9
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.555
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-1
Unit	B (Eem/Kreftenheye)
Test number	CTX09

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	160
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	64
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	8
External ε_{av} at N_f	[%]	-0.72
External ε_{cy} at N_f	[%]	3.27
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	40
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	20.9
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.555
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.17	0.35	18.18	-	30.04	-
2	0.16	0.56	11.42	-	22.94	-
3	0.10	0.79	8.10	-	19.28	-
4	0.00	1.06	6.01	-	16.43	-
5	-0.13	1.40	4.57	-	13.39	-
6	-0.30	1.84	3.46	-	11.38	-
7	-0.53	2.50	2.54	-	14.83	-
8	-0.72	3.27	1.95	-	13.62	-

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-1
Unit	B (Eem/Kreftenheye)
Test number	CTX09

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	0
Initial effective axial pressure	[kPa]	0
Rate of strain	[%/hour]	4.74
At peak deviator stress		
Corrected deviator stress	[kPa]	2261
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	17.46
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-812
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	893
Effective axial pressure	[kPa]	3154
Principal effective stress ratio	[-]	3.53
ε_{50}	[%]	8.57
Secant modulus (E_{50}) at ε_{50}	[kPa]	13991
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	2
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	1.76
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	80
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	0
Effective axial pressure	[kPa]	2
Principal effective stress ratio	[-]	166.51
At 10% external axial strain		
Corrected deviator stress	[kPa]	1509
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-447
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	527
Effective axial pressure	[kPa]	2036
Principal effective stress ratio	[-]	3.86

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-1
Unit	B (Eem/Kreftenheye)
Test number	CTX09

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



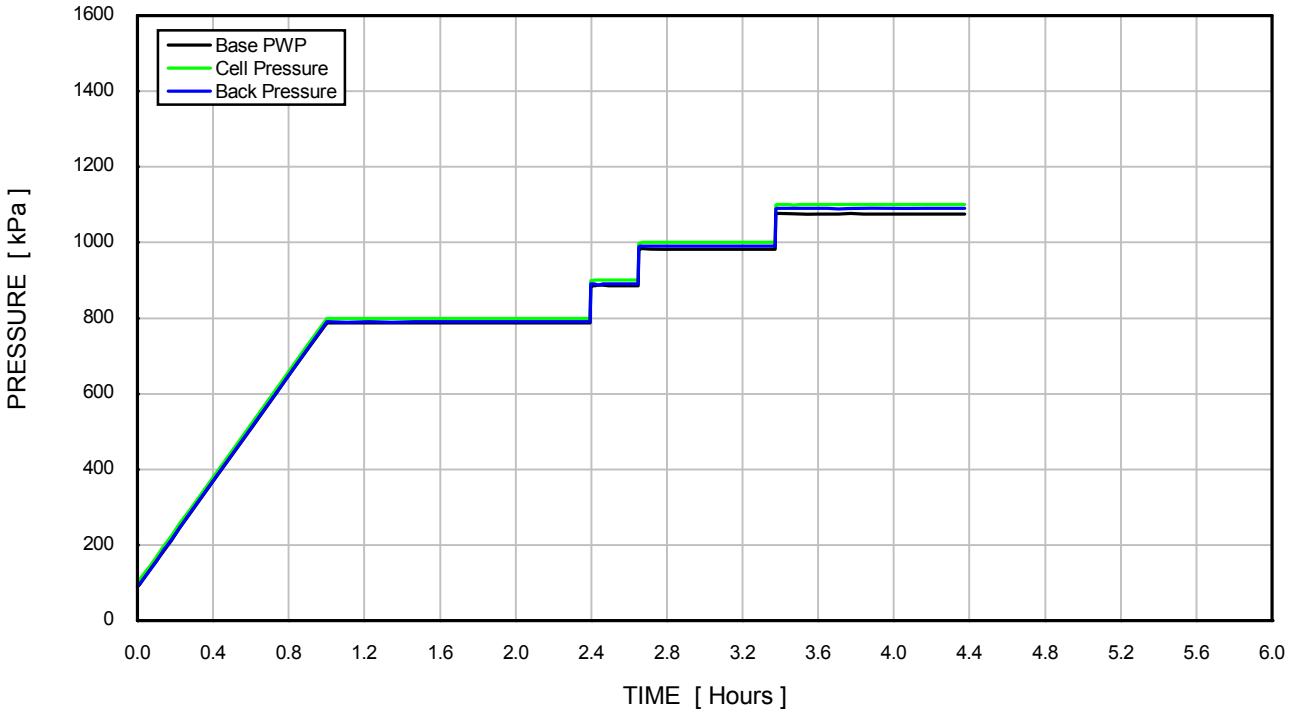


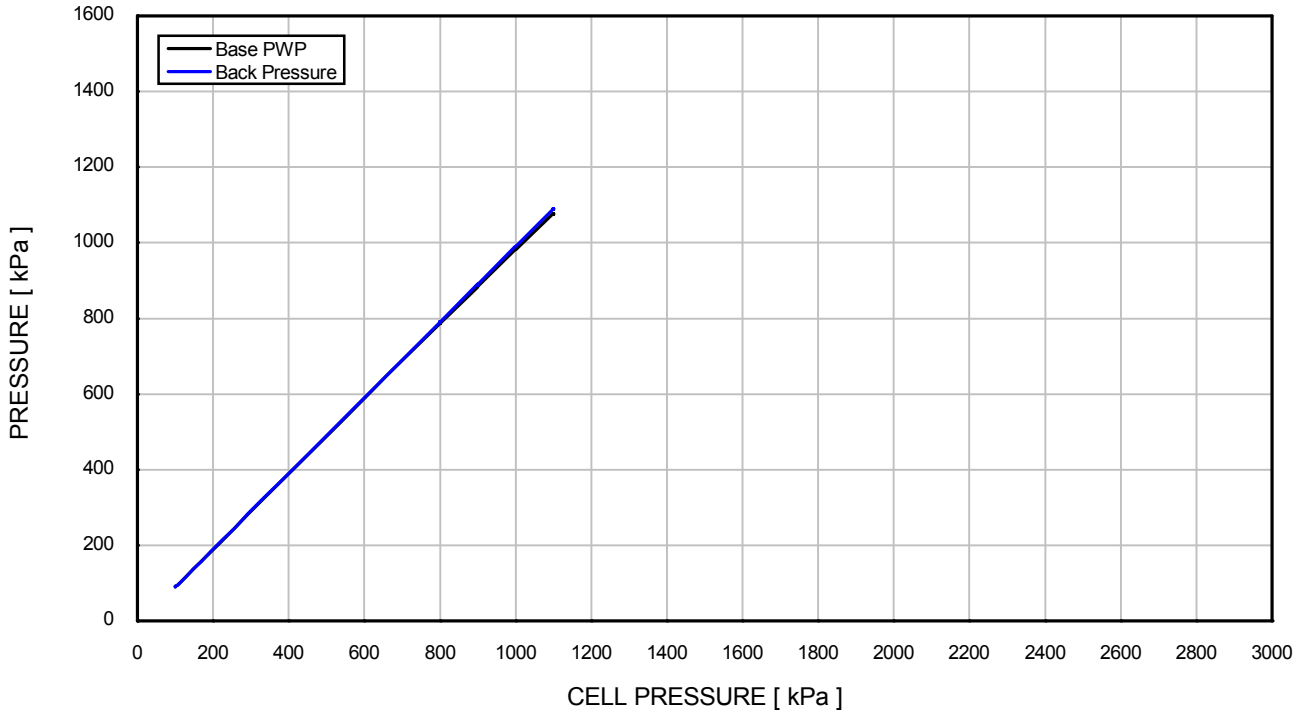
FINAL CONDITIONS		
Moisture content	[%]	20.9
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-1
Unit	B (Eem/Kreftenheye)
Test number	CTX09

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

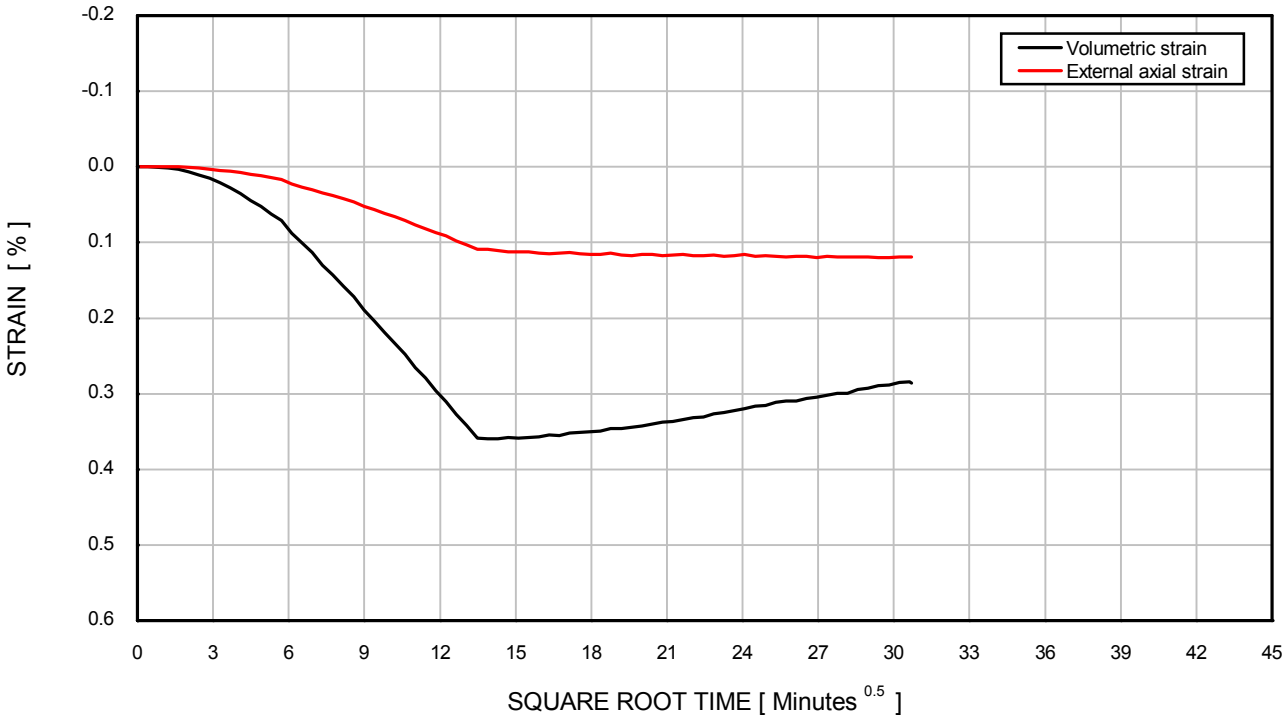


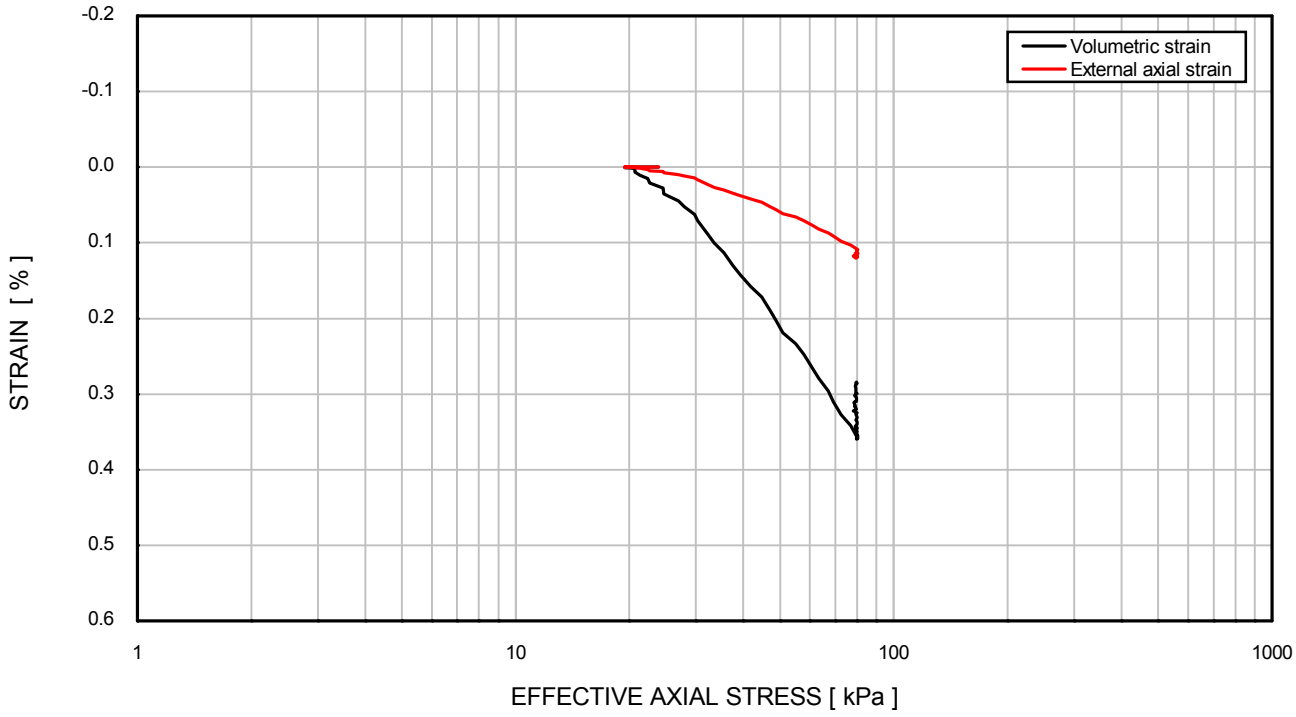


B value	:	0.95			
Initial σ'_r	:	10	kPa	Batch	: 2
Initial σ'_a	:	10	kPa	Sample	: CTX_2-1
Final σ'_r	:	24	kPa	Unit	: B (Eem/Kreftenheye)
Final σ'_a	:	24	kPa	Test No.	: CTX09

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

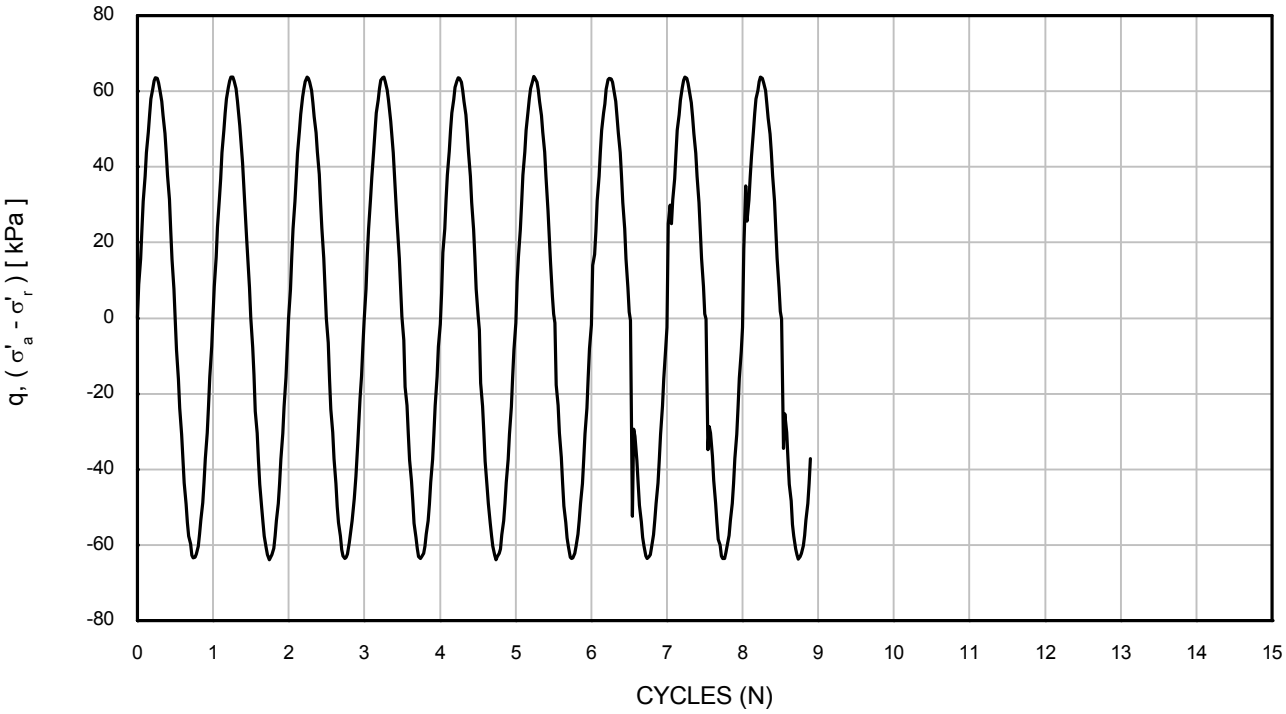


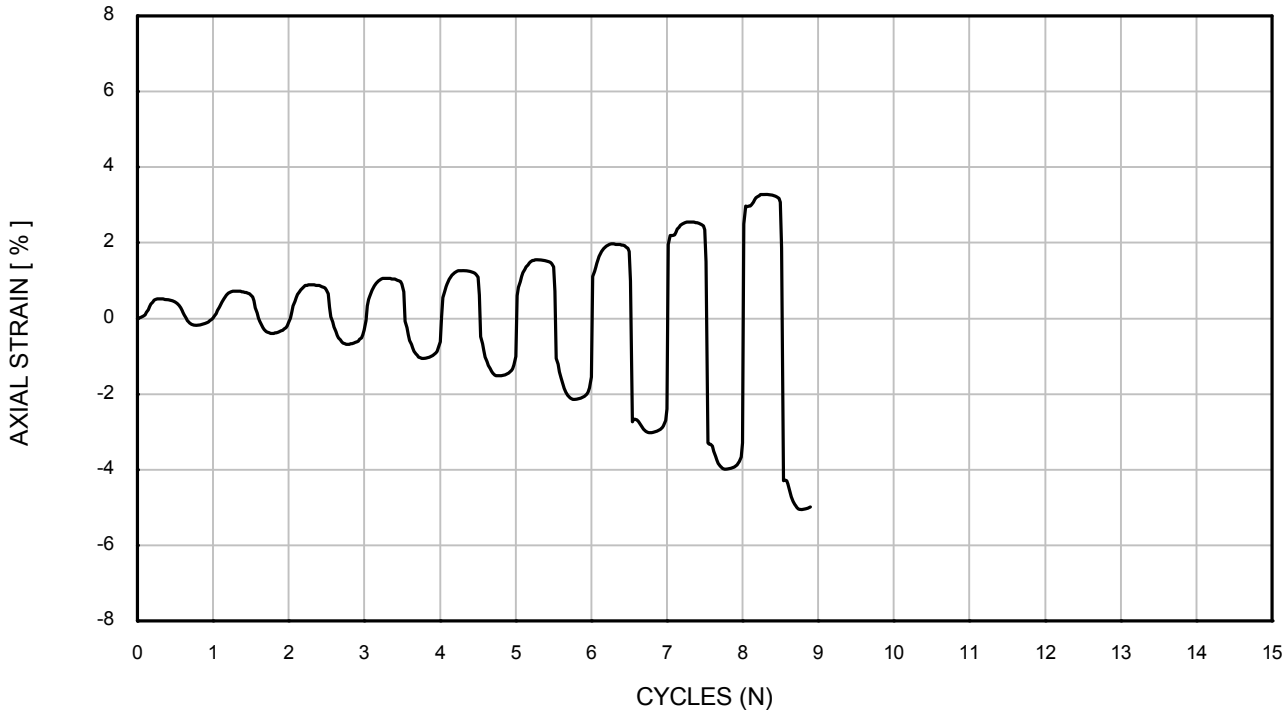


σ'_{rc}	:	80 kPa	Batch	:	2
σ'_{ac}	:	80 kPa	Sample	:	CTX_2-1
			Unit	:	B (Eem/Kreftenheye)
			Test No.	:	CTX09

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

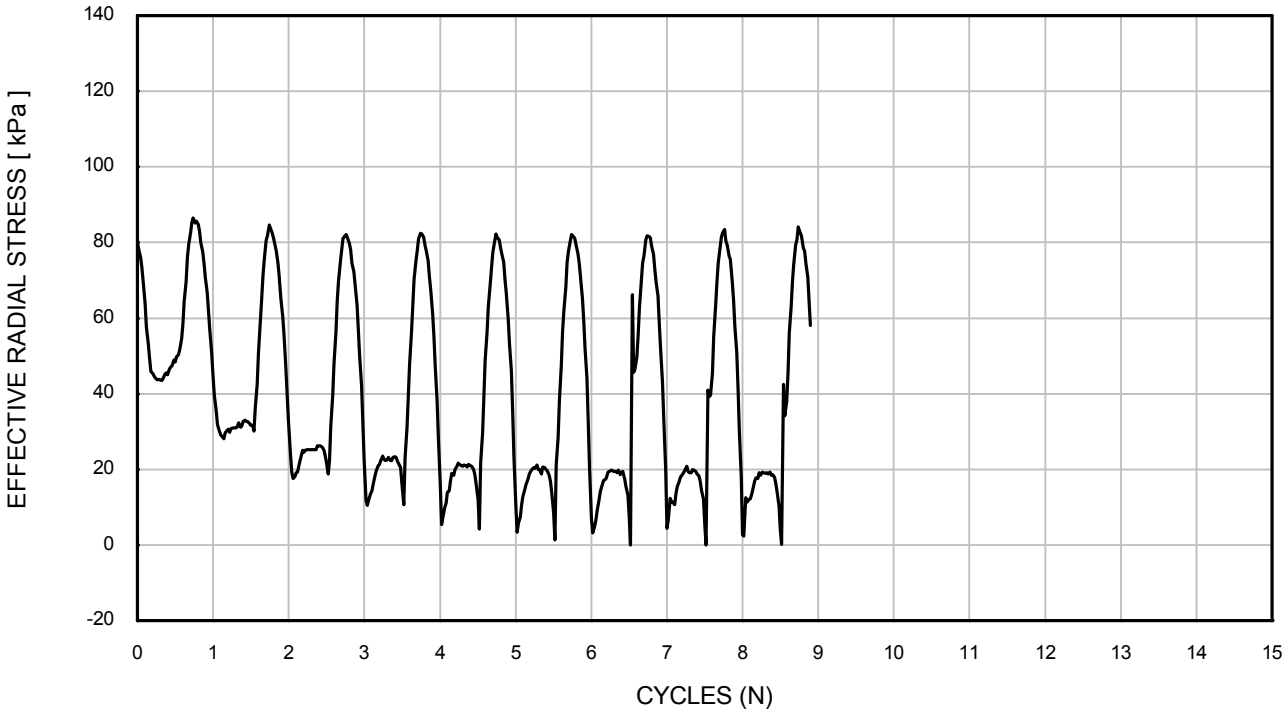


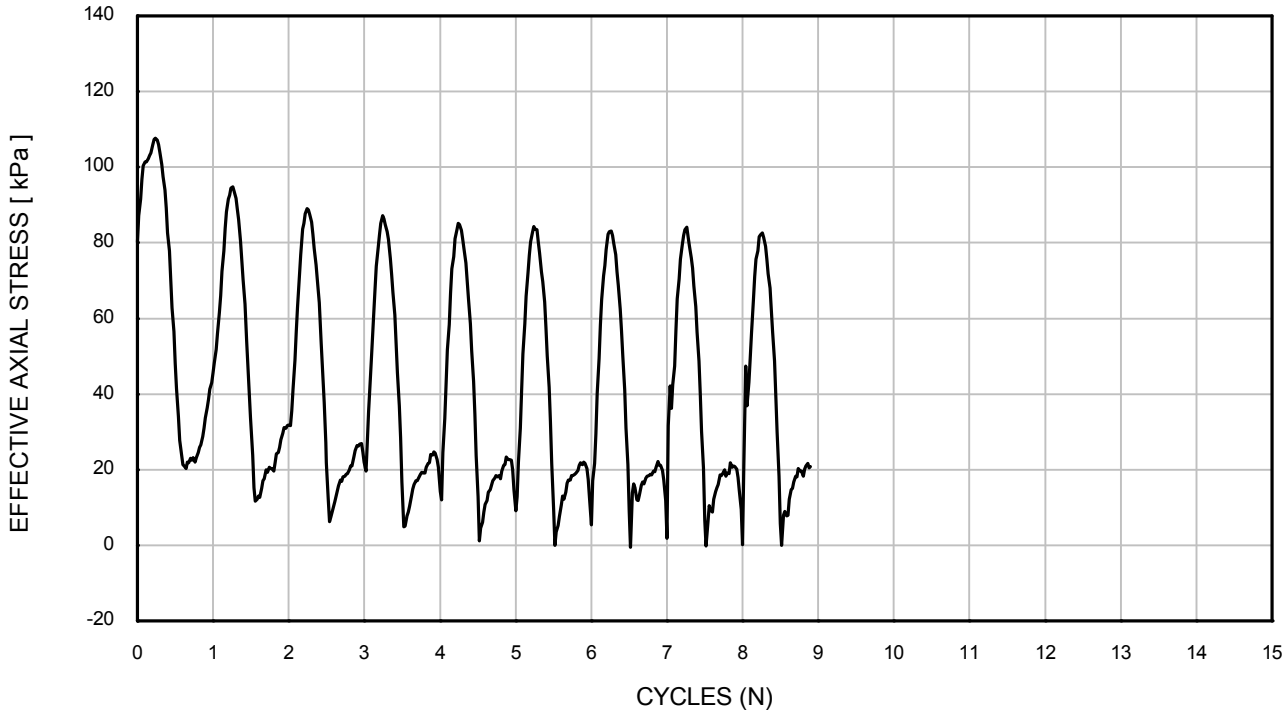


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-1
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	64 kPa	Test No.	:	CTX09
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

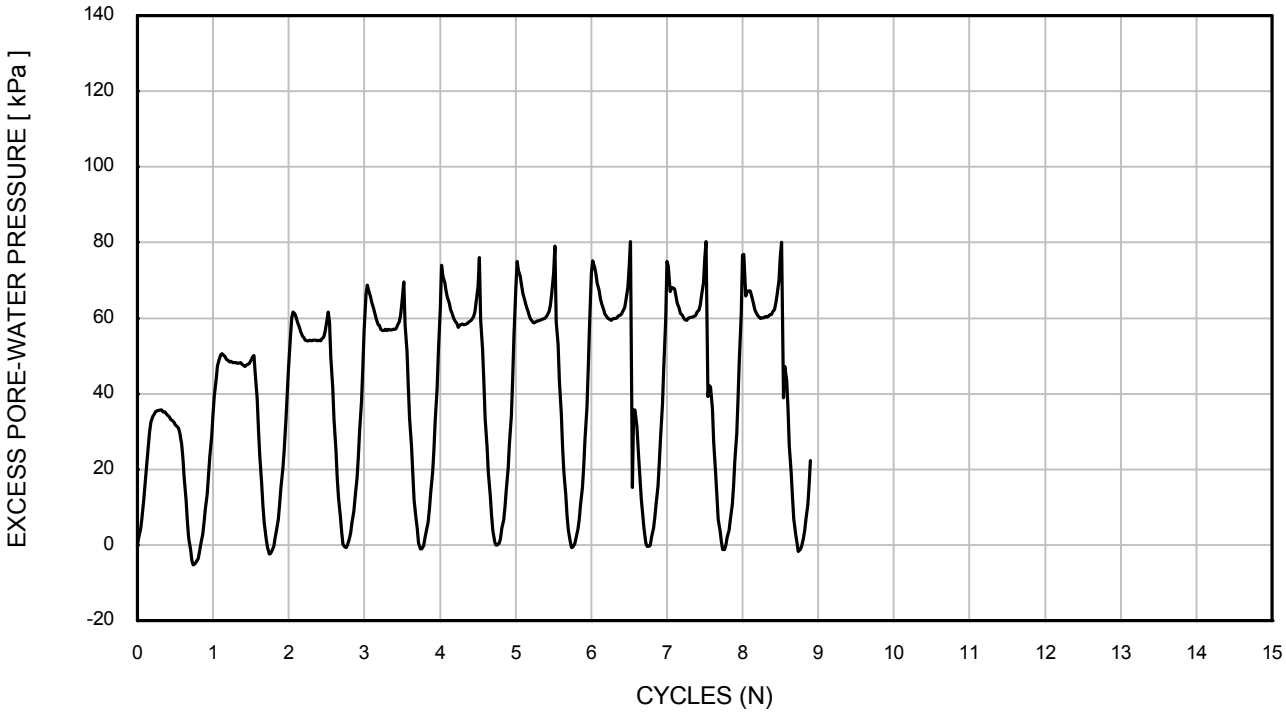


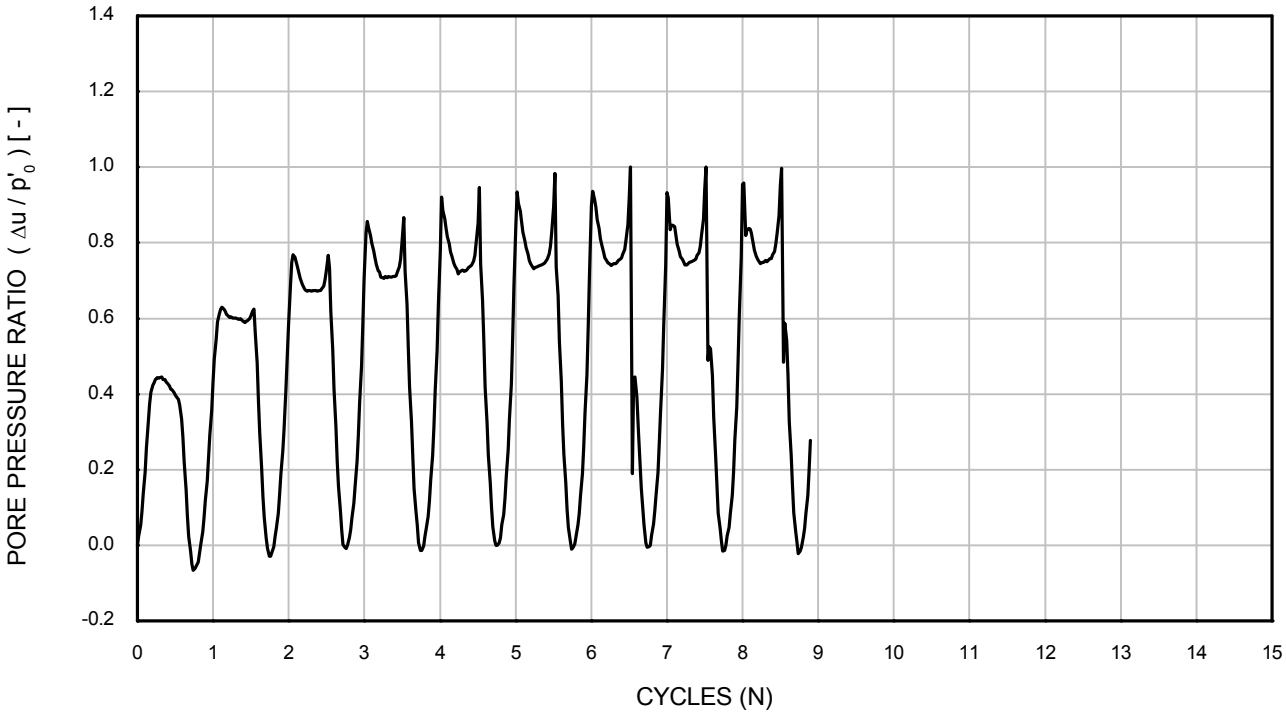


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-1
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	64	kPa	Test No.	: CTX09
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

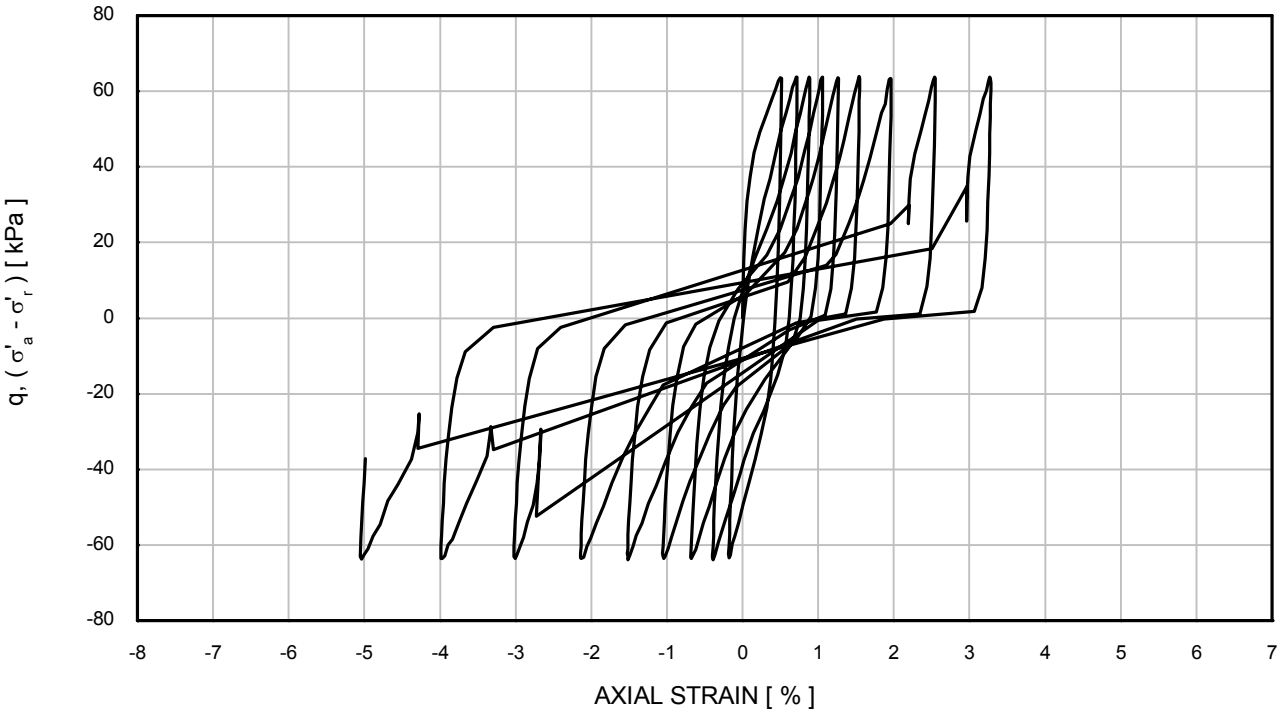


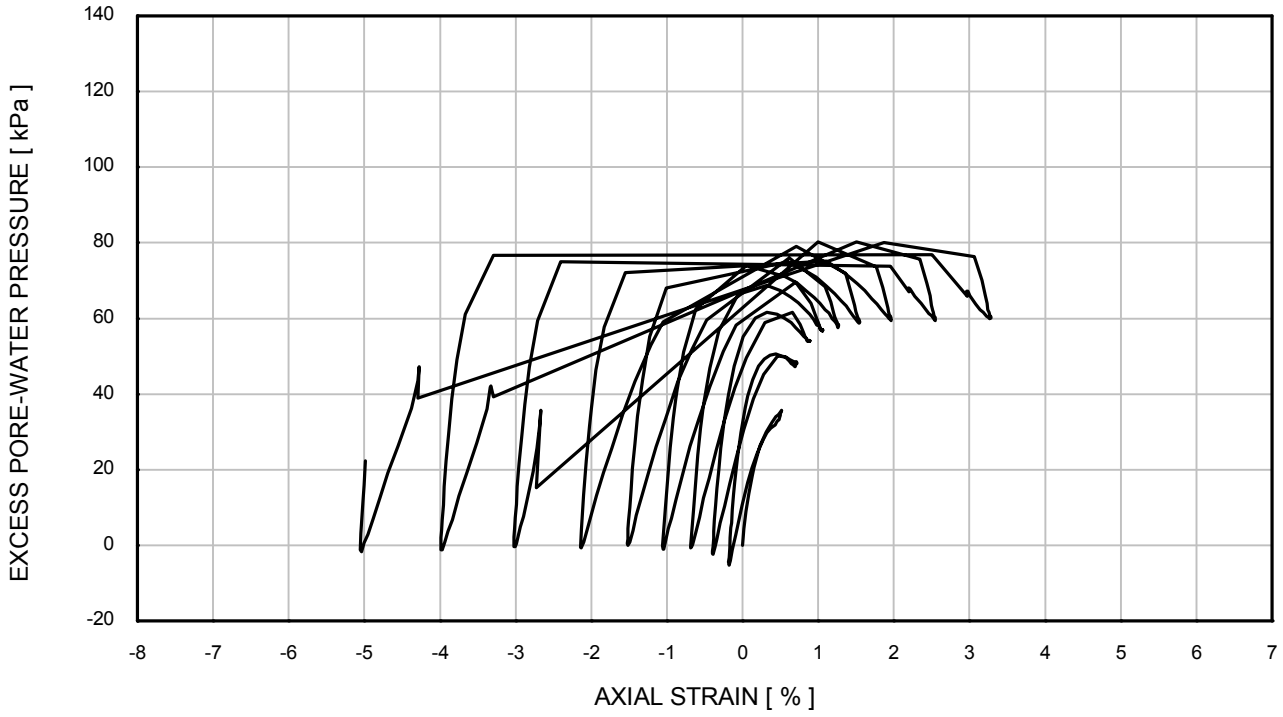


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-1
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	64	kPa	Test No.	: CTX09
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

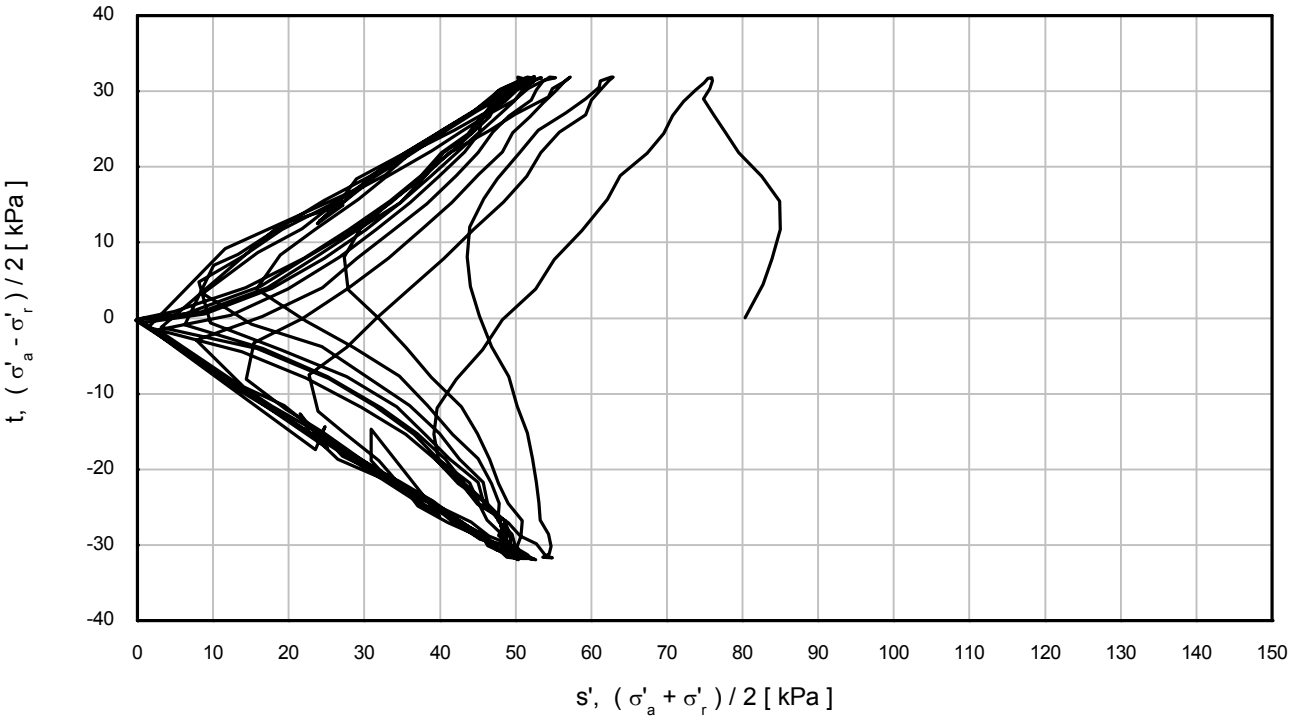


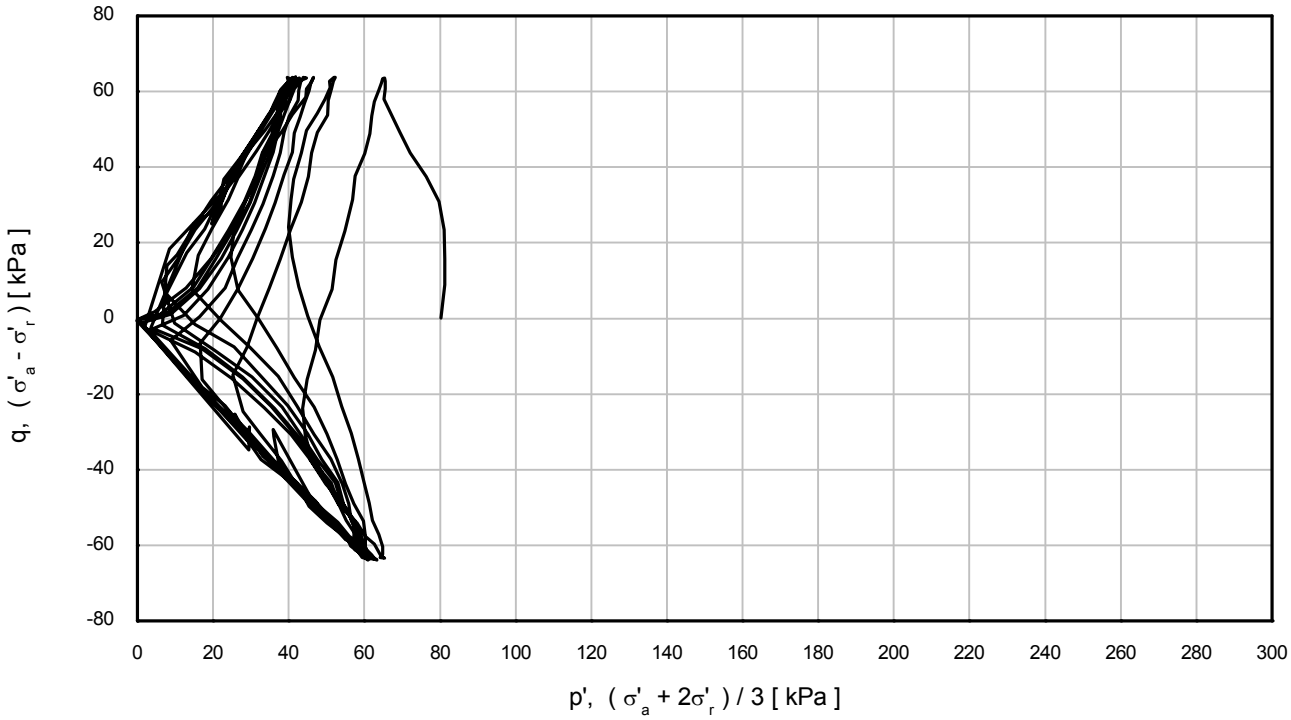


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-1
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	64 kPa	Test No.	:	CTX09
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

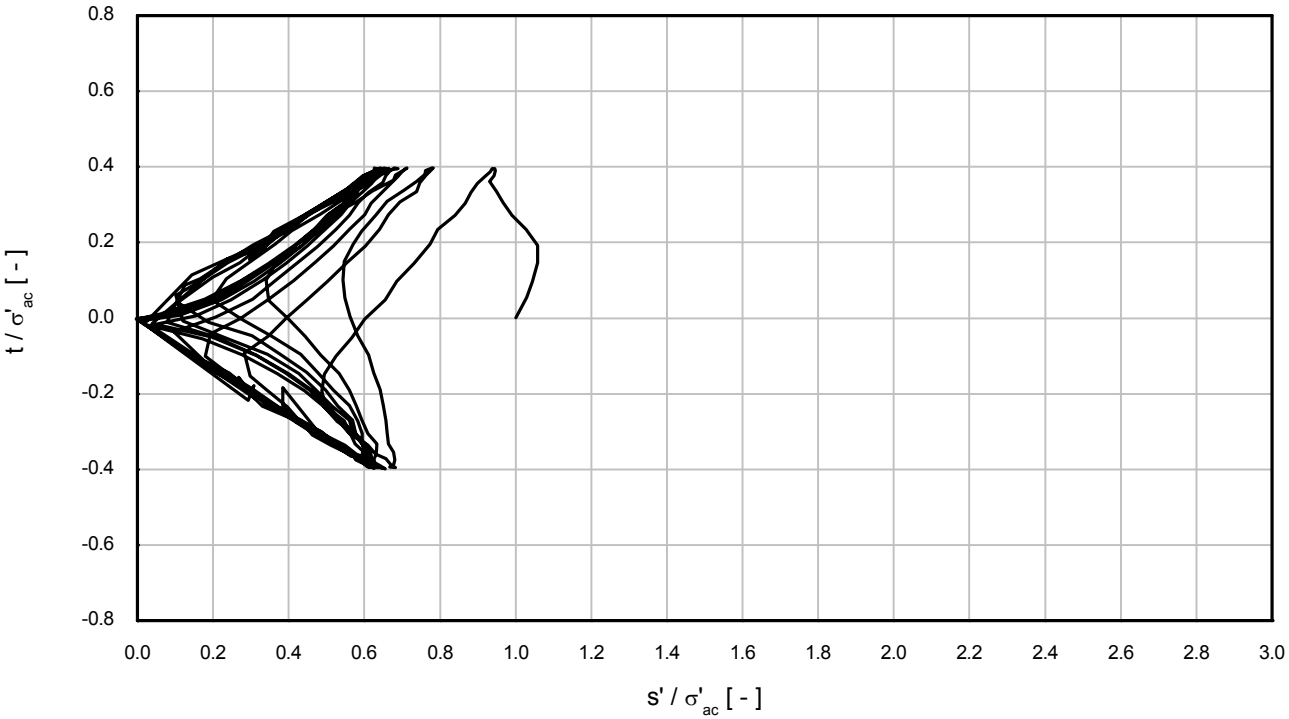


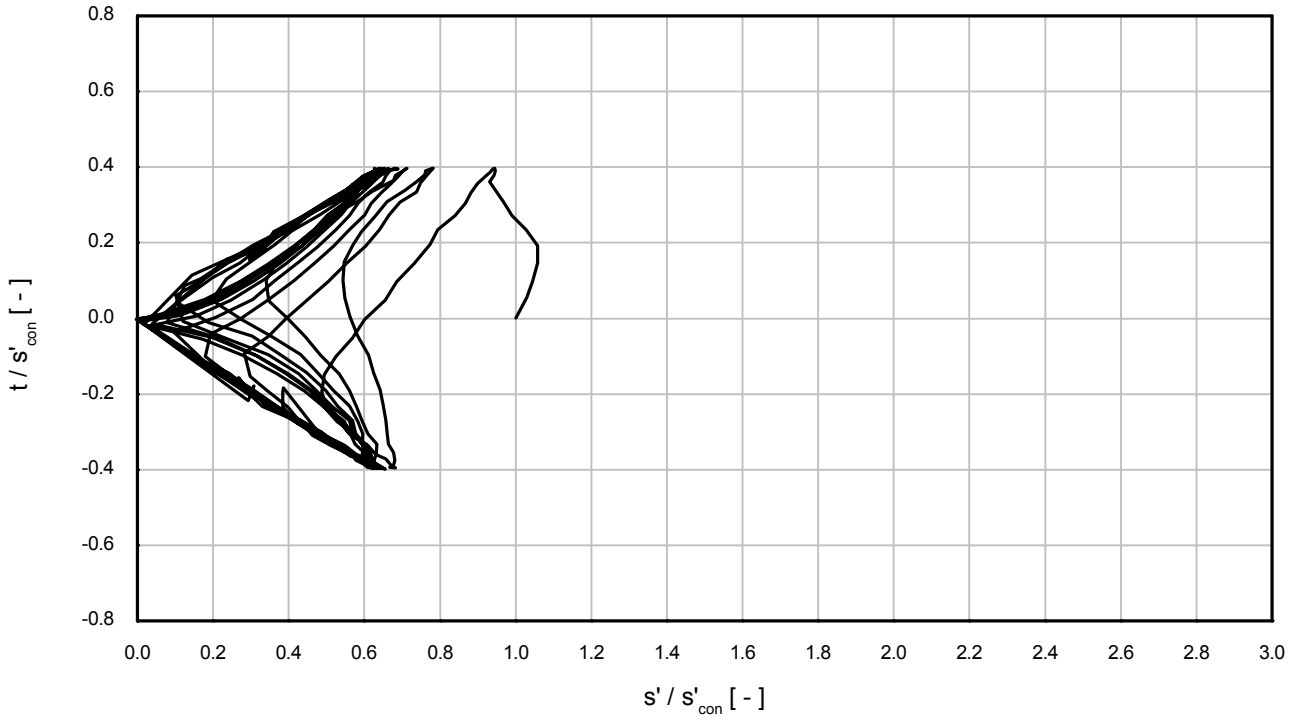


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-1
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	64	kPa	Test No.	: CTX09
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

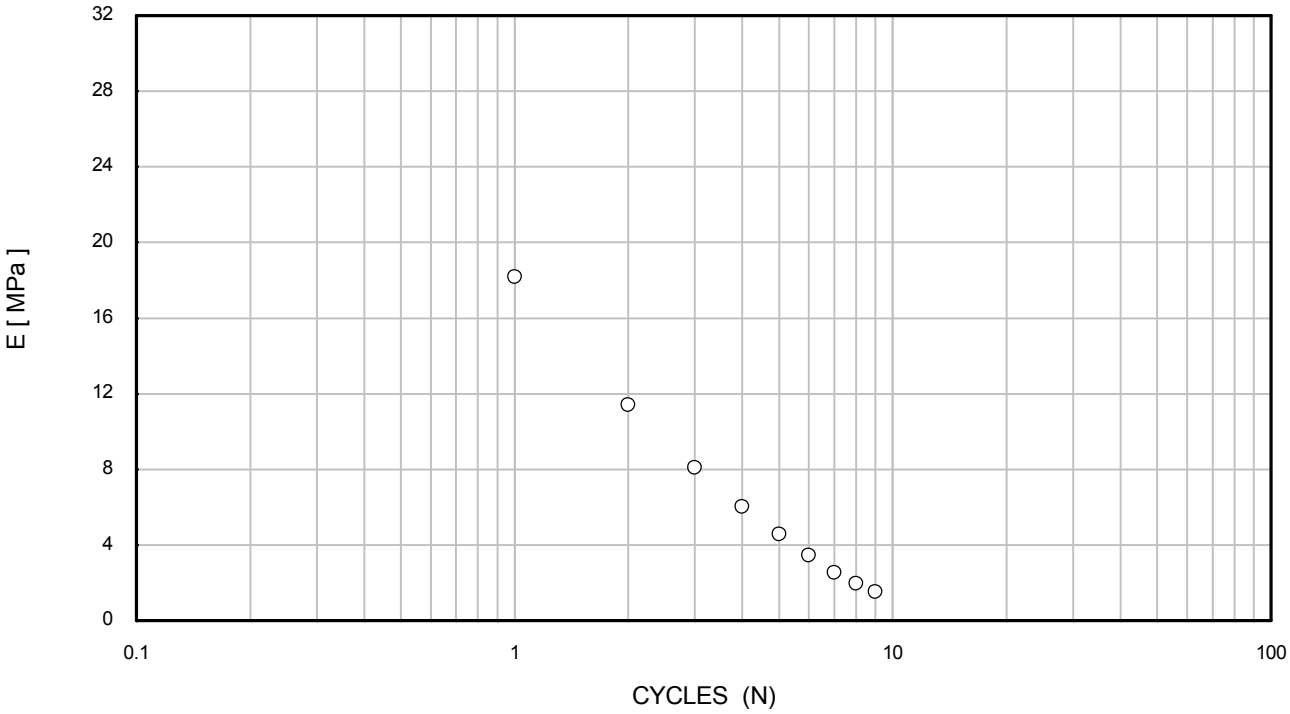


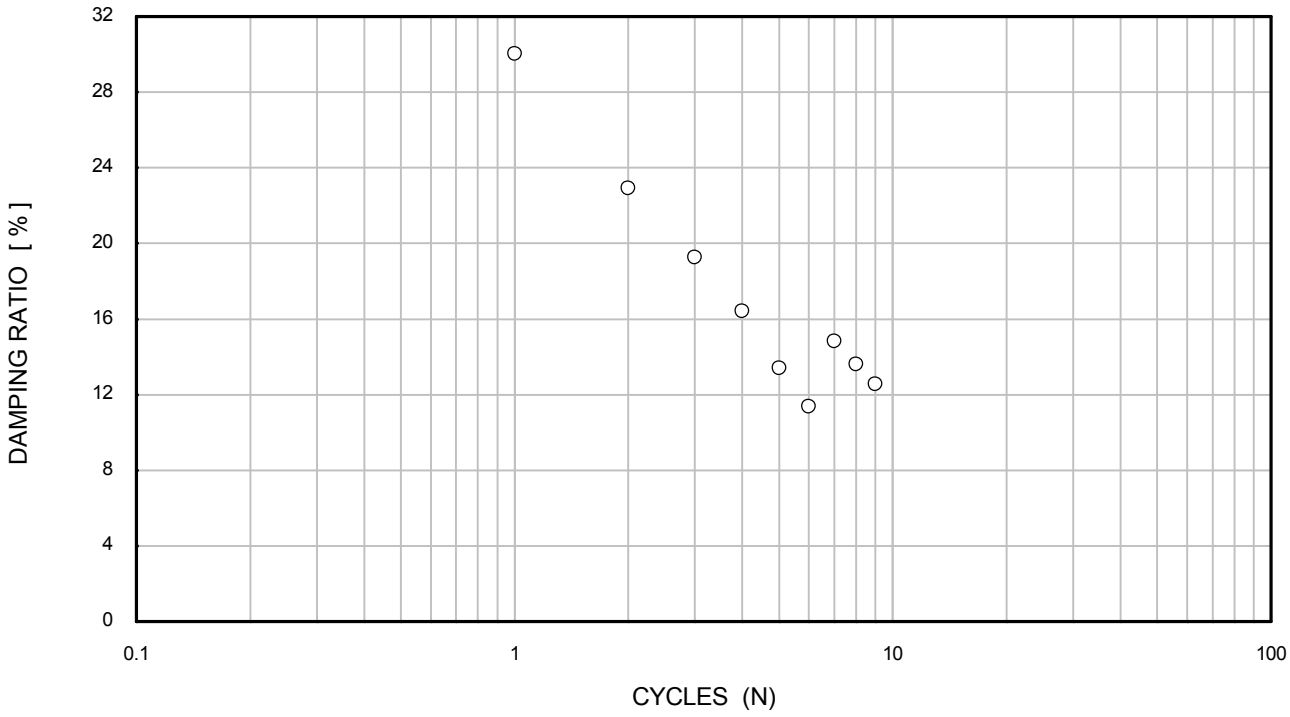


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-1
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	64	kPa	Test No.	: CTX09
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

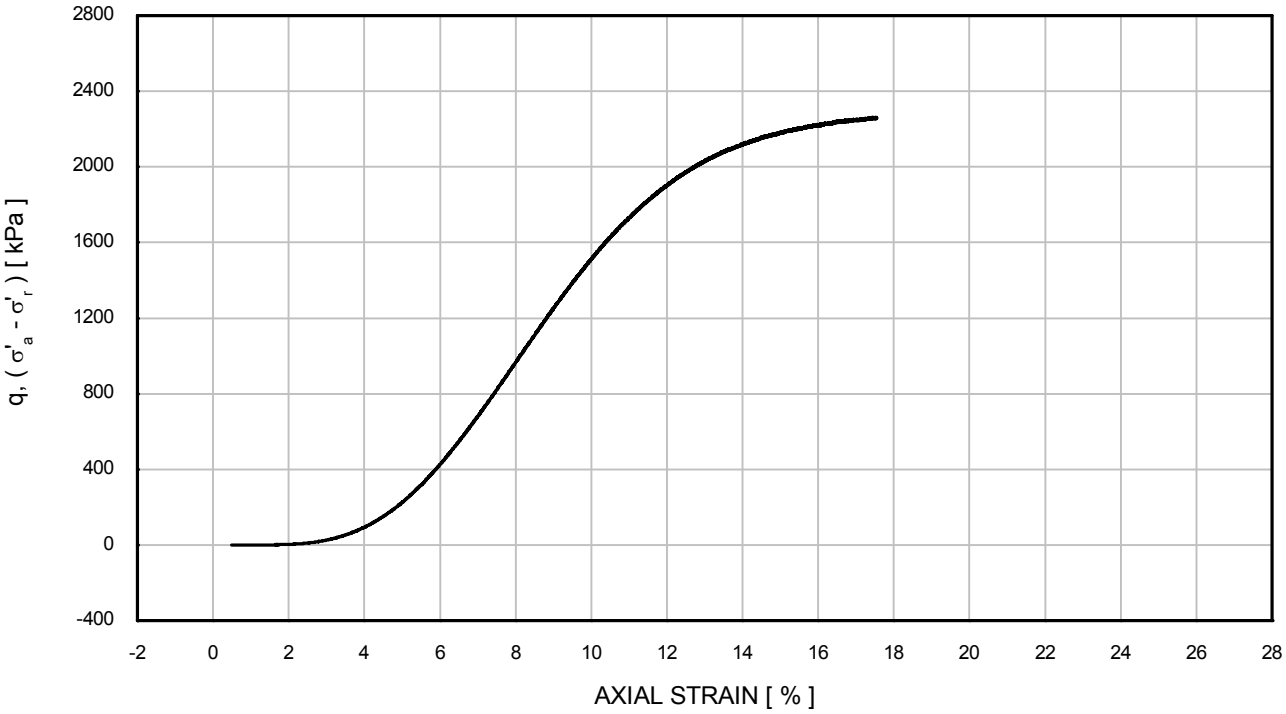


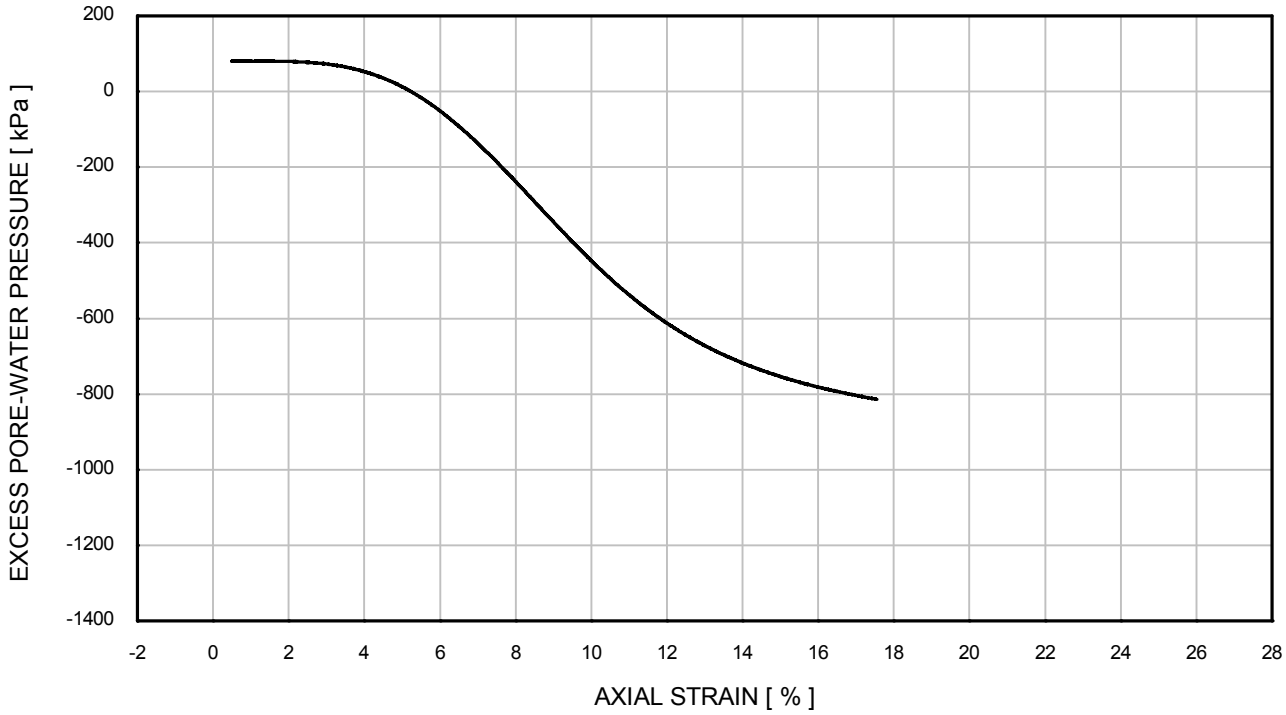


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-1
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	64 kPa	Test No.	:	CTX09
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

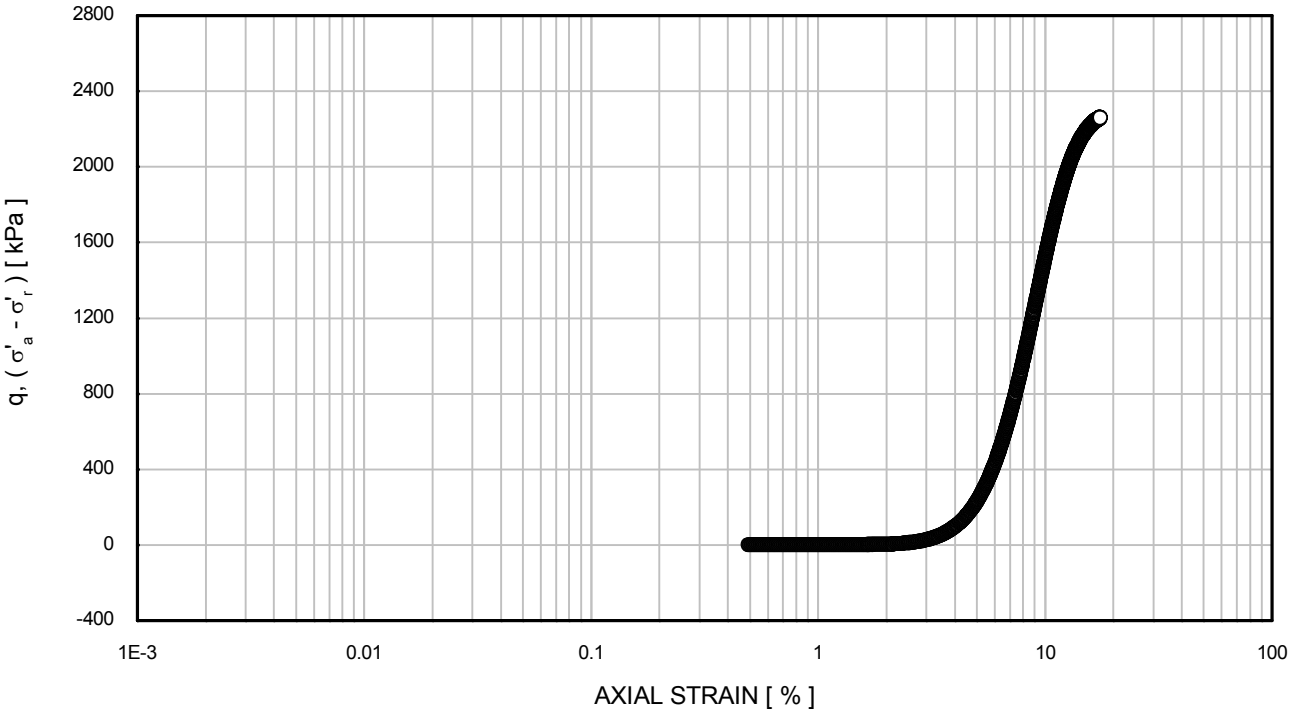


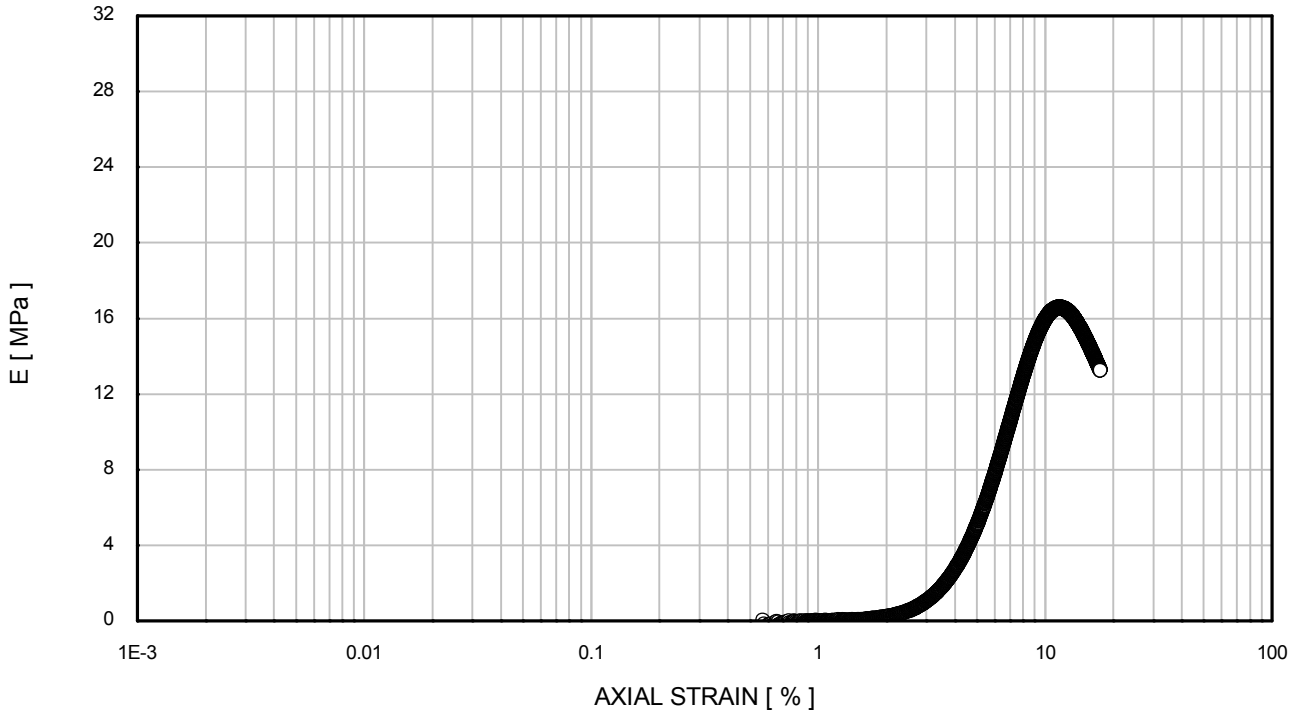


Initial σ'_r	:	-0	kPa	Batch	: 2
Initial σ'_a	:	0	kPa	Sample	: CTX_2-1
q_{peak}	:	2261	kPa	Unit	: B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	17.46	%	Test No.	: CTX09
Rate of strain	:	4.74	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

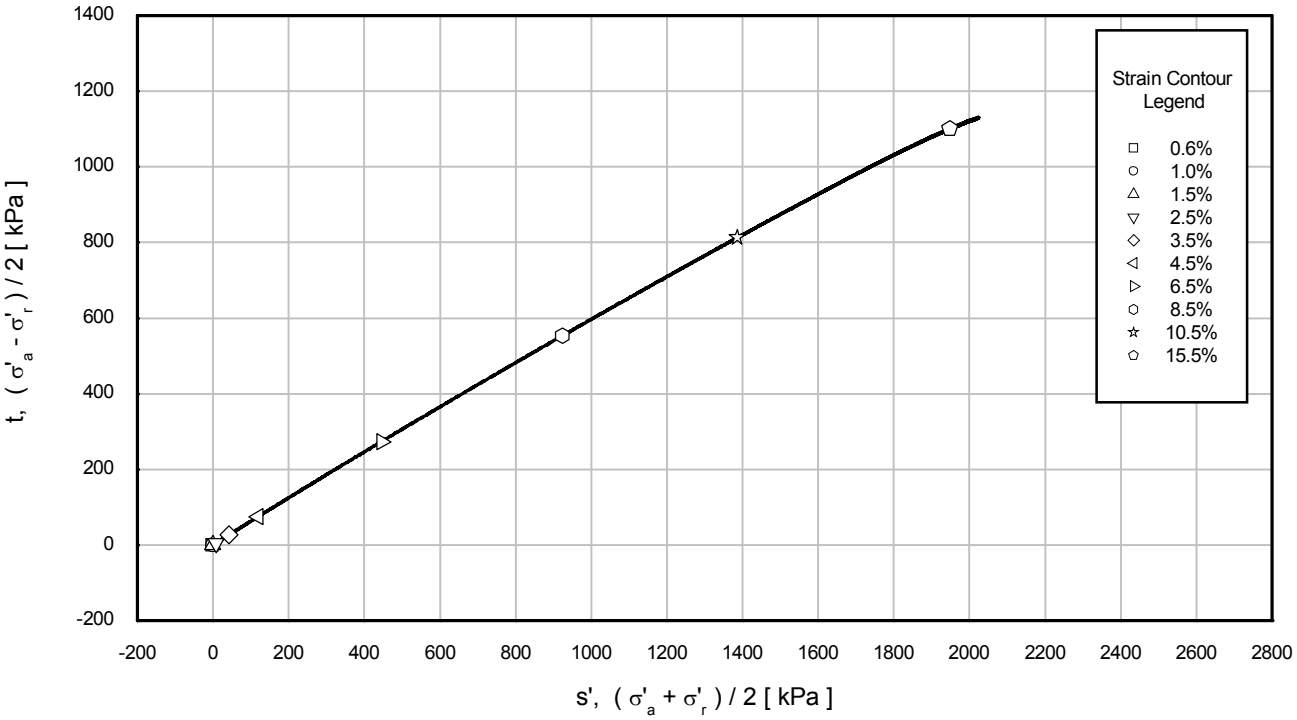


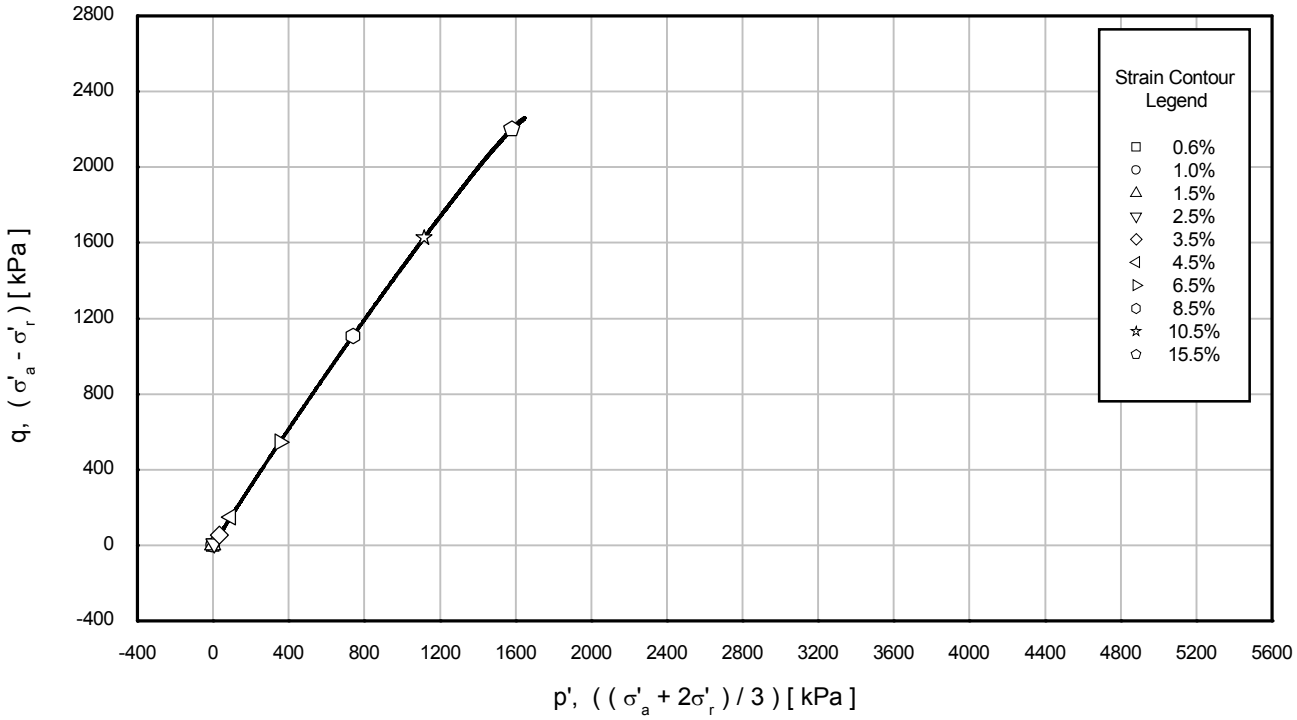


Initial σ'_r	:	-0 kPa	Batch	:	2
Initial σ'_a	:	0 kPa	Sample	:	CTX_2-1
q_{peak}	:	2261 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	17.46 %	Test No.	:	CTX09
Rate of strain	:	4.74 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	-0	kPa	Batch	: 2
Initial σ'_a	:	0	kPa	Sample	: CTX_2-1
q_{peak}	:	2261	kPa	Unit	: B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	17.46	%	Test No.	: CTX09
Rate of strain	:	4.74	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Light brown fine to medium SAND

GENERAL	
Date test started	21/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.5
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.69
Void ratio	[-]	0.564
Degree of saturation	[%]	49
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 2_CTX-2-2_CTX10
Processed by Date	PR 26/01/2016
Checked by Date	PH 08/02/2016
Approved by Date	PH 08/02/2016

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-2
Unit	B (Eem/Kreftenheye)
Test number	CTX10

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
B value achieved	[-]	1.00

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1162
Back pressure	[kPa]	1082
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	80
Effective axial pressure	[kPa]	80
Deviator stress	[kPa]	0
Volumetric strain	[%]	0.41
External axial strain	[%]	0.11
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	21.0
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.558
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-2
Unit	B (Eem/Kreftenheye)
Test number	CTX10

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	160
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	48
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	16
External ε_{av} at N_f	[%]	-0.66
External ε_{cy} at N_f	[%]	3.12
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	48
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	21.0
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.558
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.13	0.14	35.00	-	34.14	-
2	0.17	0.19	24.60	-	25.93	-
3	0.18	0.26	18.74	-	24.22	-
4	0.18	0.33	14.59	-	23.09	-
5	0.16	0.41	11.74	-	21.76	-
6	0.14	0.50	9.61	-	20.36	-
7	0.10	0.60	7.99	-	18.64	-
8	0.05	0.72	6.68	-	17.32	-
9	-0.01	0.85	5.60	-	15.46	-
10	-0.08	1.01	4.72	-	13.80	-
15	-0.56	2.58	1.85	-	13.95	-
16	-0.66	3.12	1.53	-	17.25	-

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-2
Unit	B (Eem/Kreftenheye)
Test number	CTX10

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	1
Initial effective axial pressure	[kPa]	1
Rate of strain	[%/hour]	4.93
At peak deviator stress		
Corrected deviator stress	[kPa]	2349
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	10.97
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-799
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	879
Effective axial pressure	[kPa]	3228
Principal effective stress ratio	[-]	3.67
ε_{50}	[%]	7.68
Secant modulus (E_{50}) at ε_{50}	[kPa]	11262
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	1
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	-0.63
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	80
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	0
Effective axial pressure	[kPa]	1
Principal effective stress ratio	[-]	112.75
At 10% external axial strain		
Corrected deviator stress	[kPa]	2073
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-680
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	760
Effective axial pressure	[kPa]	2833
Principal effective stress ratio	[-]	3.73

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-2
Unit	B (Eem/Kreftenheye)
Test number	CTX10

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



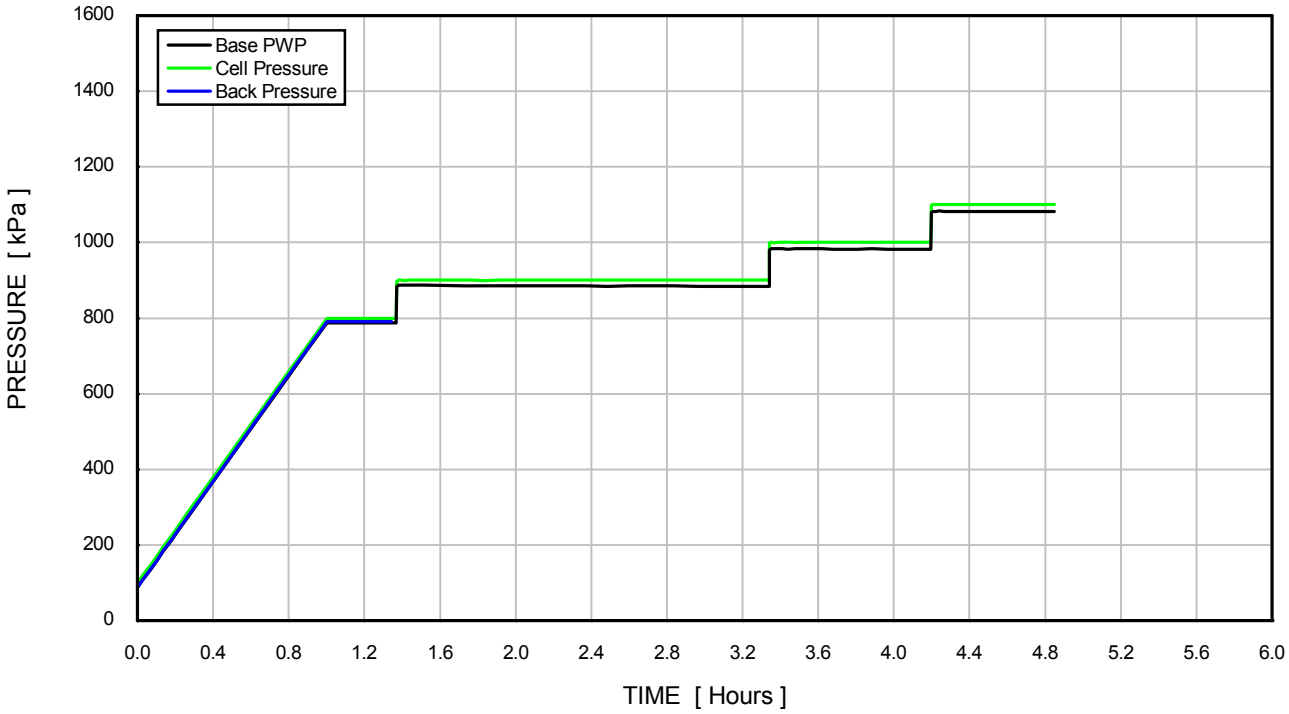


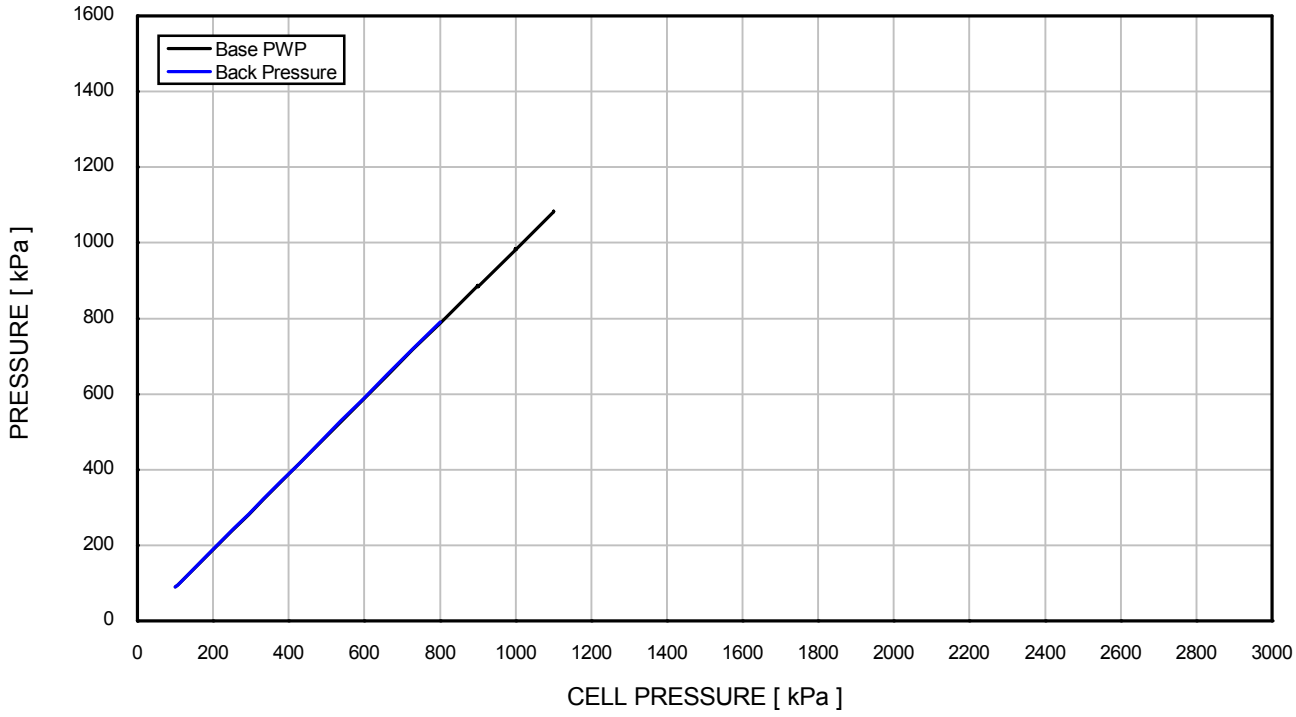
FINAL CONDITIONS		
Moisture content	[%]	21.0
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.70

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-2
Unit	B (Eem/Kreftenheye)
Test number	CTX10

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

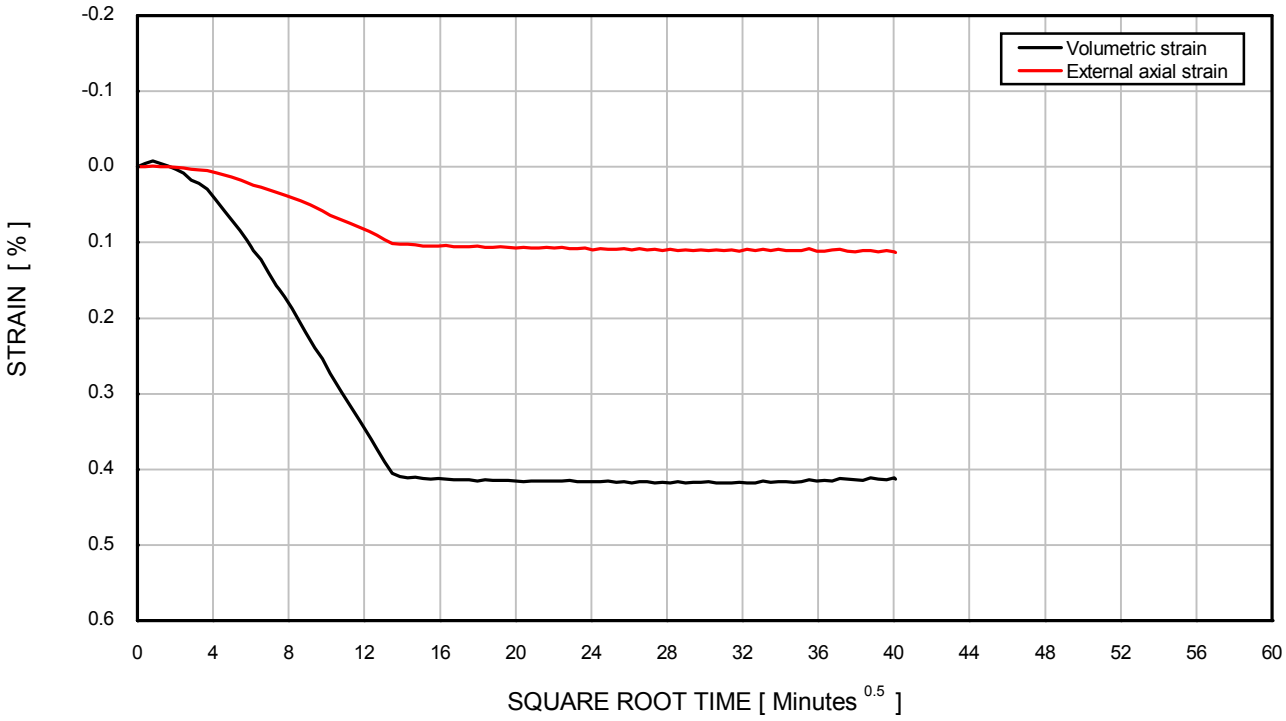


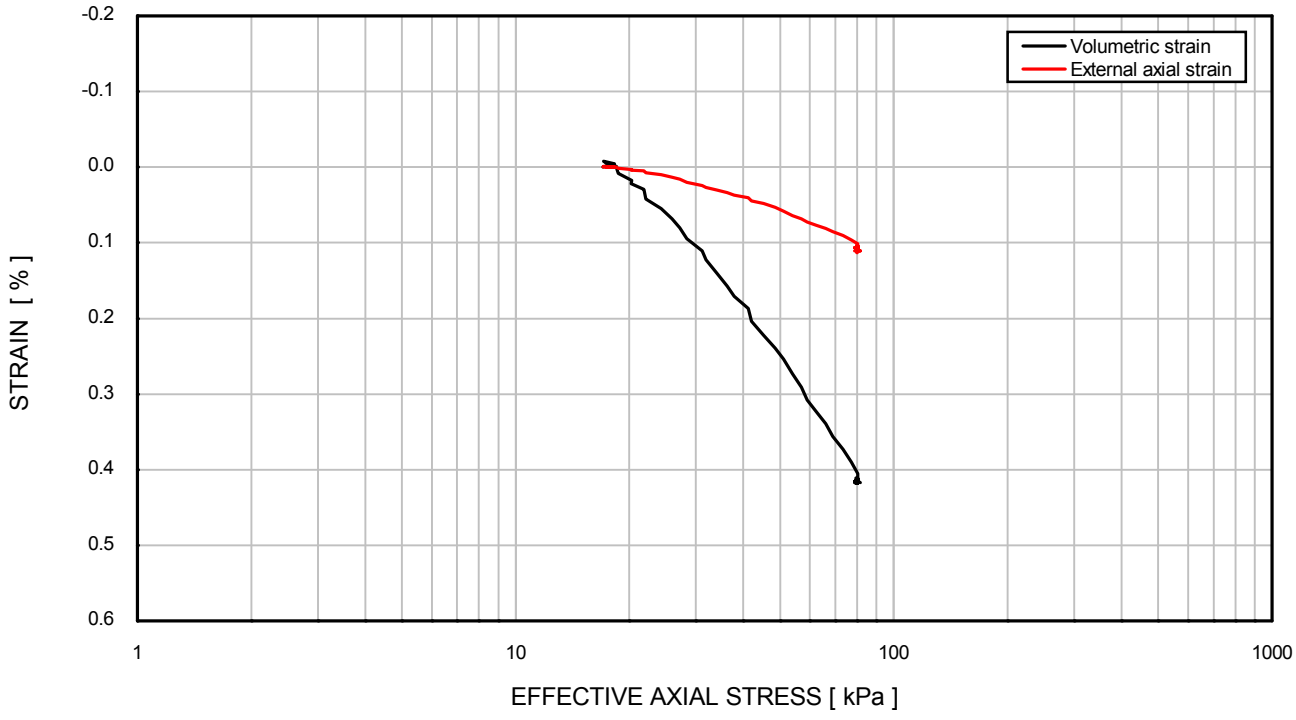


B value	:	1.00			
Initial σ'_r	:	10	kPa	Batch	: 2
Initial σ'_a	:	10	kPa	Sample	: CTX_2-2
Final σ'_r	:	18	kPa	Unit	: B (Eem/Kreftenheye)
Final σ'_a	:	18	kPa	Test No.	: CTX10

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

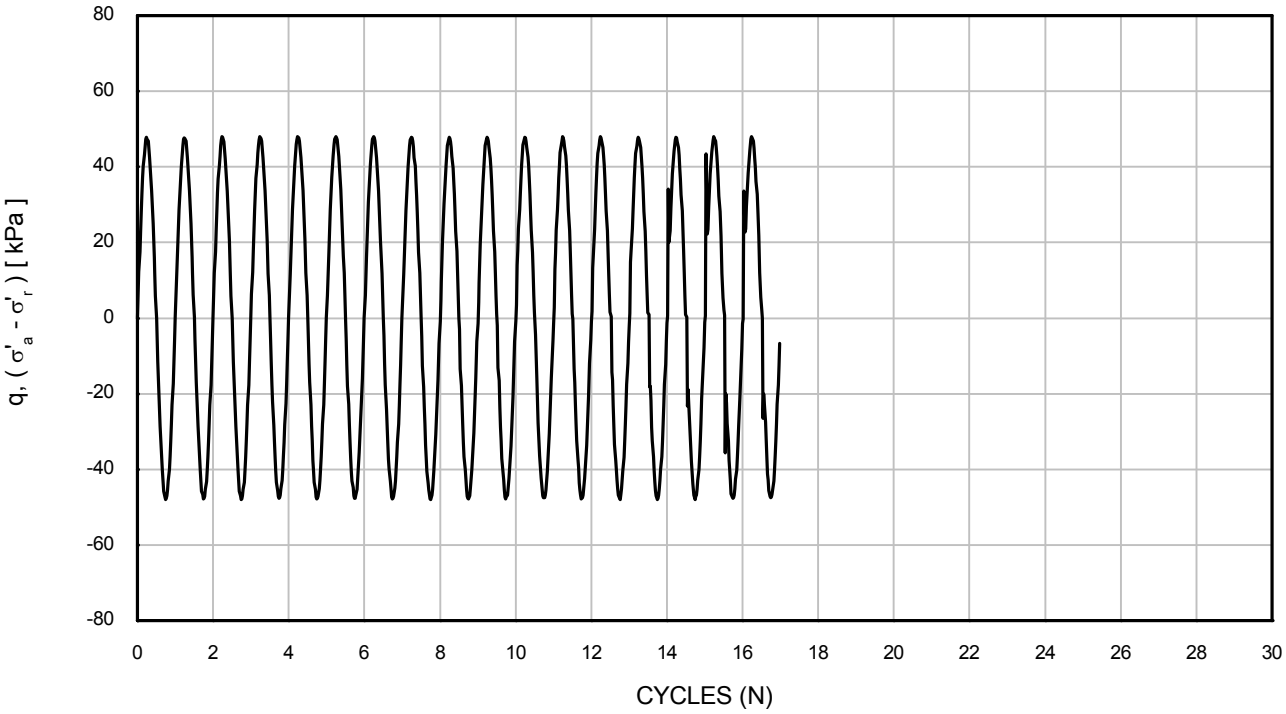


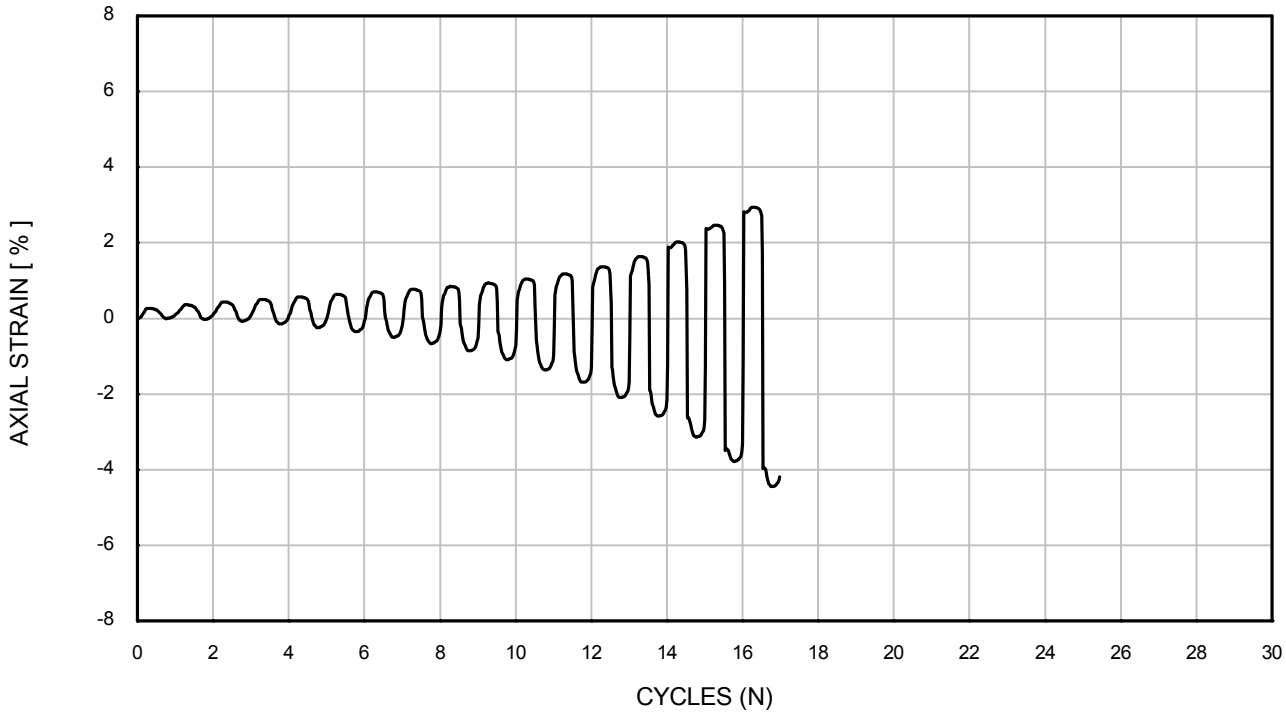


σ'_{rc}	:	80 kPa	Batch	: 2
σ'_{ac}	:	80 kPa	Sample	: CTX_2-2
			Unit	: B (Eem/Kreftenheye)
			Test No.	: CTX10

ISOTROPICALLY CONSOLIDATED CYCLE TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

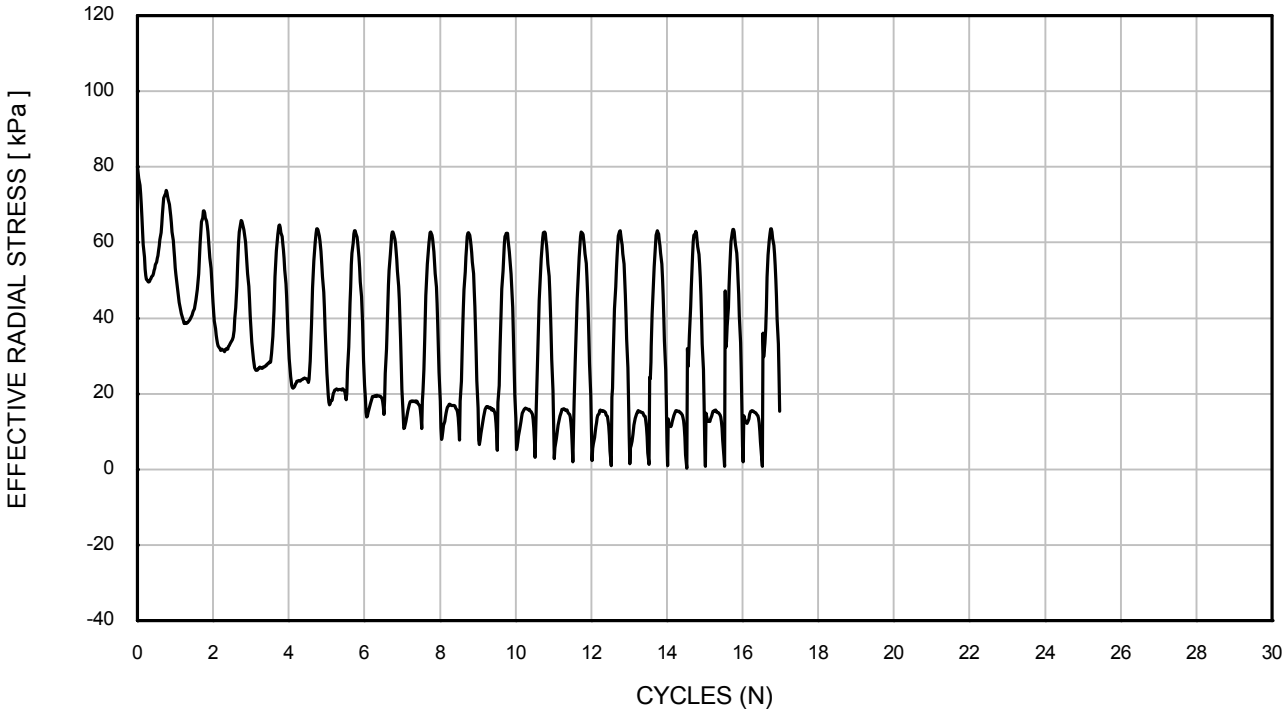


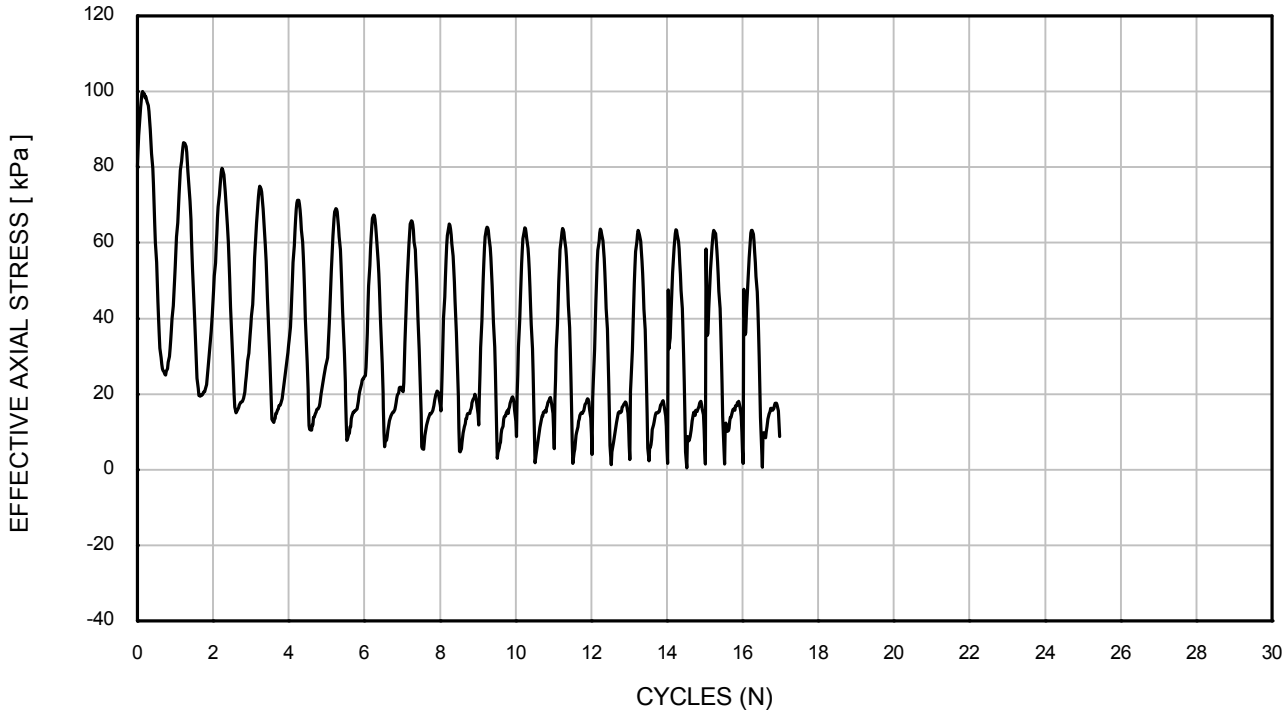


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-2
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	48	kPa	Test No.	: CTX10
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

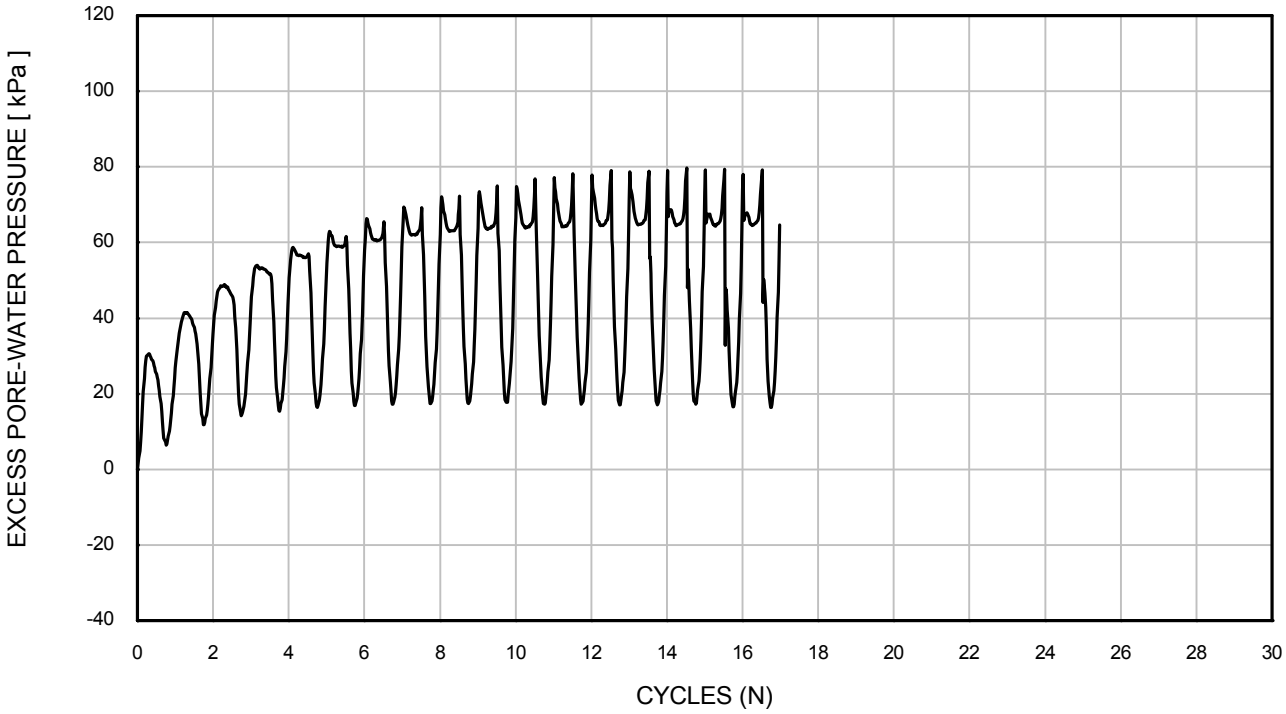


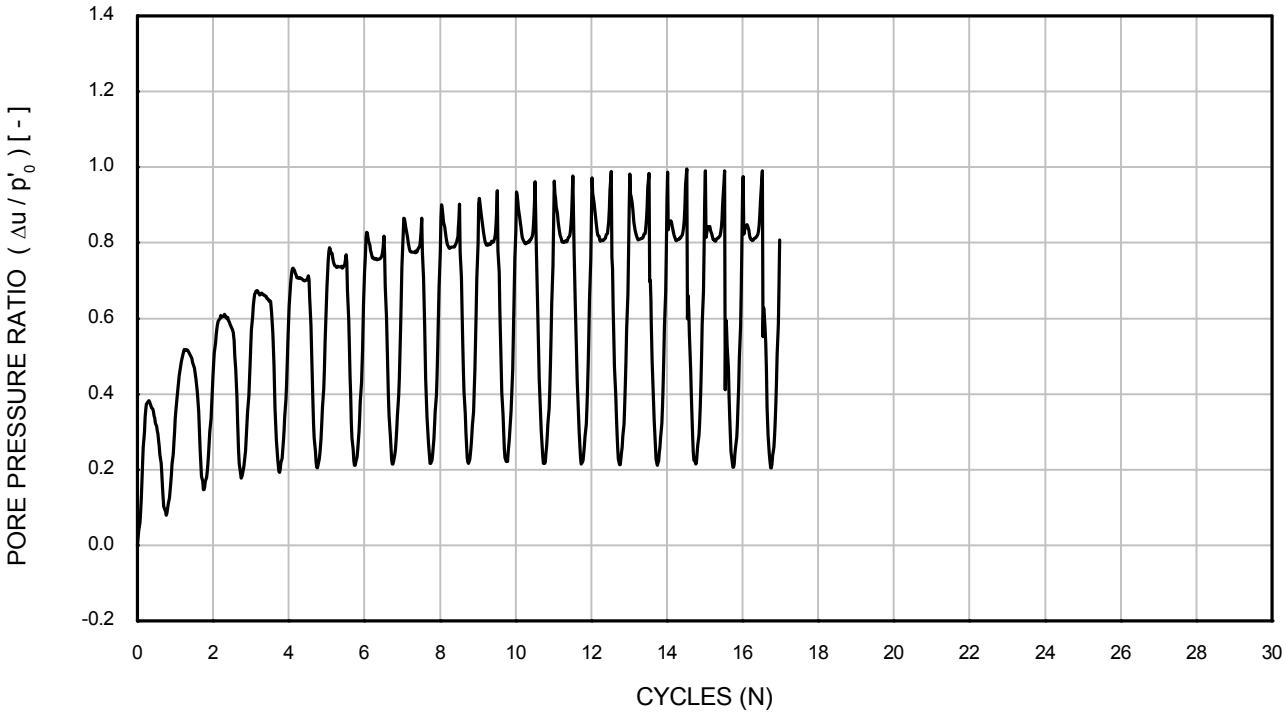


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-2
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	48 kPa	Test No.	:	CTX10
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

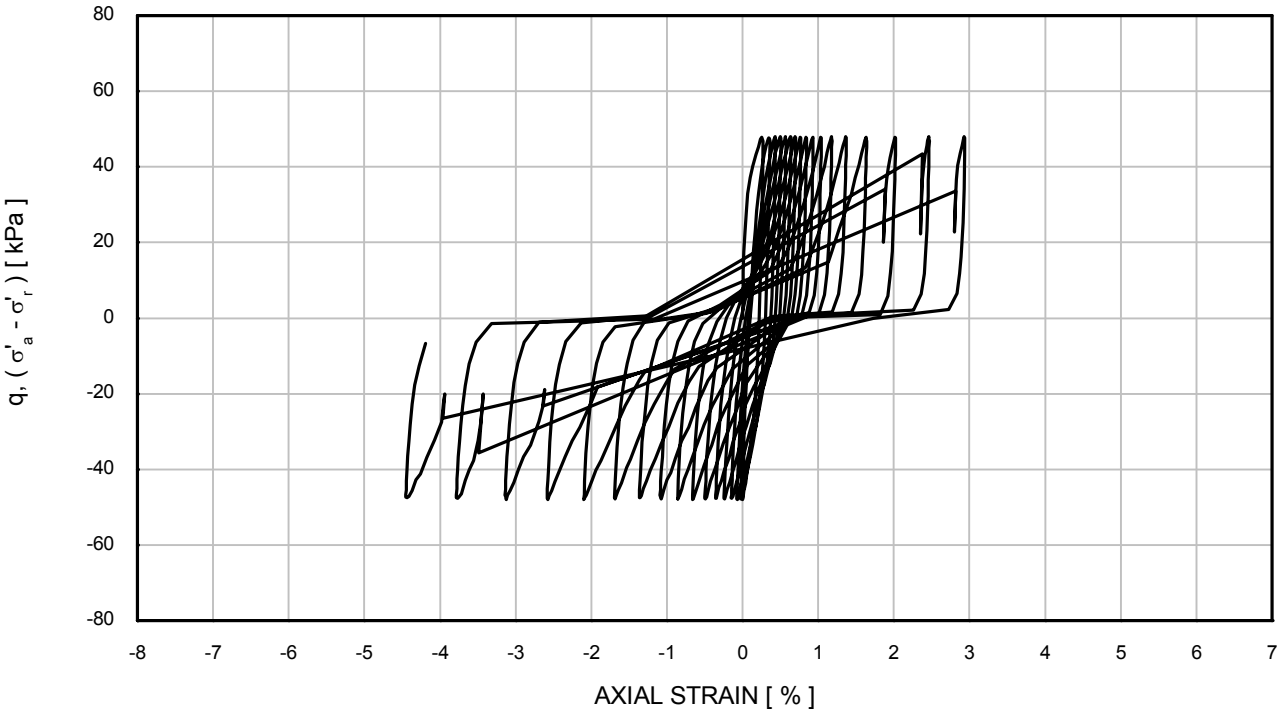


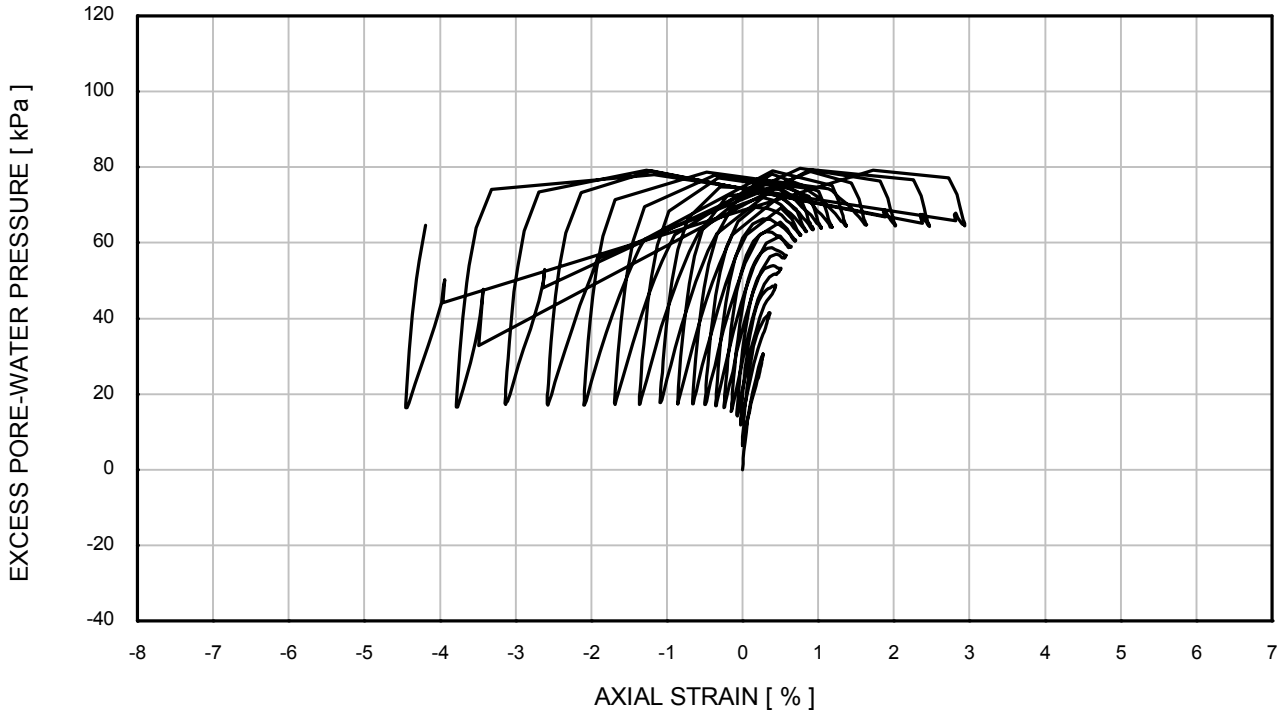


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-2
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	48	kPa	Test No.	: CTX10
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

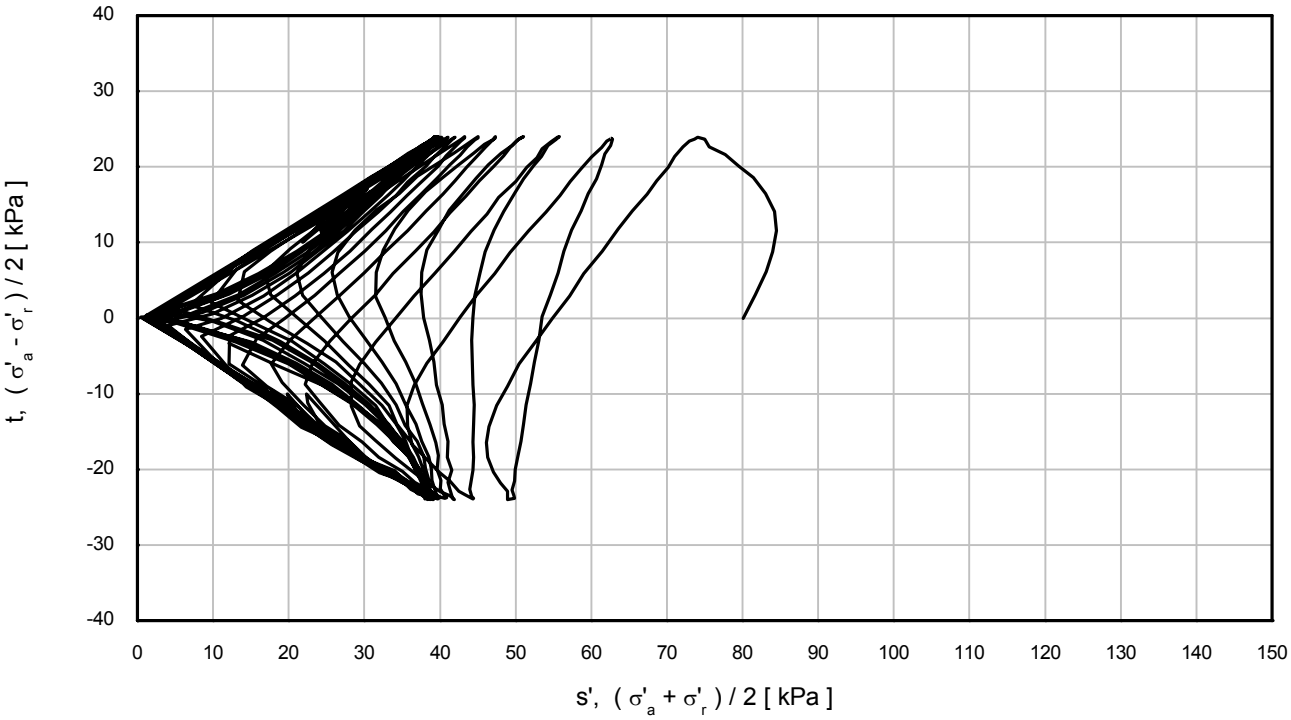


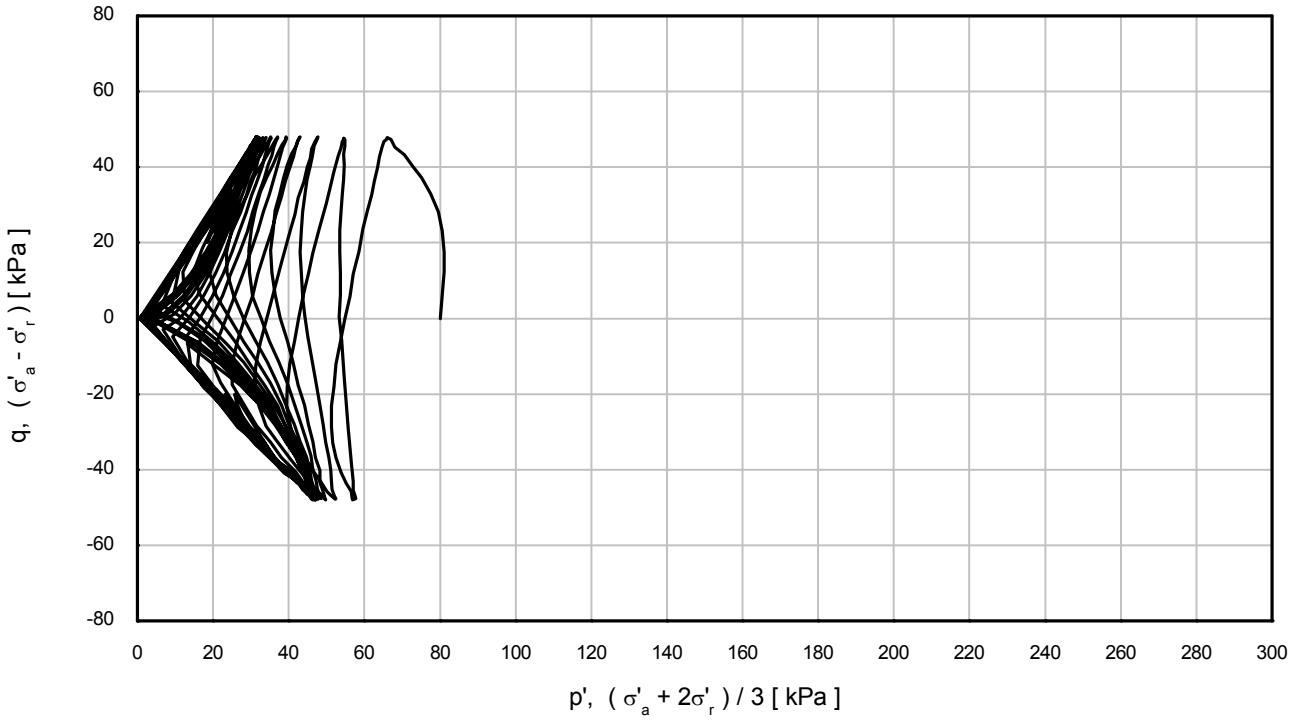


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-2
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	48 kPa	Test No.	:	CTX10
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

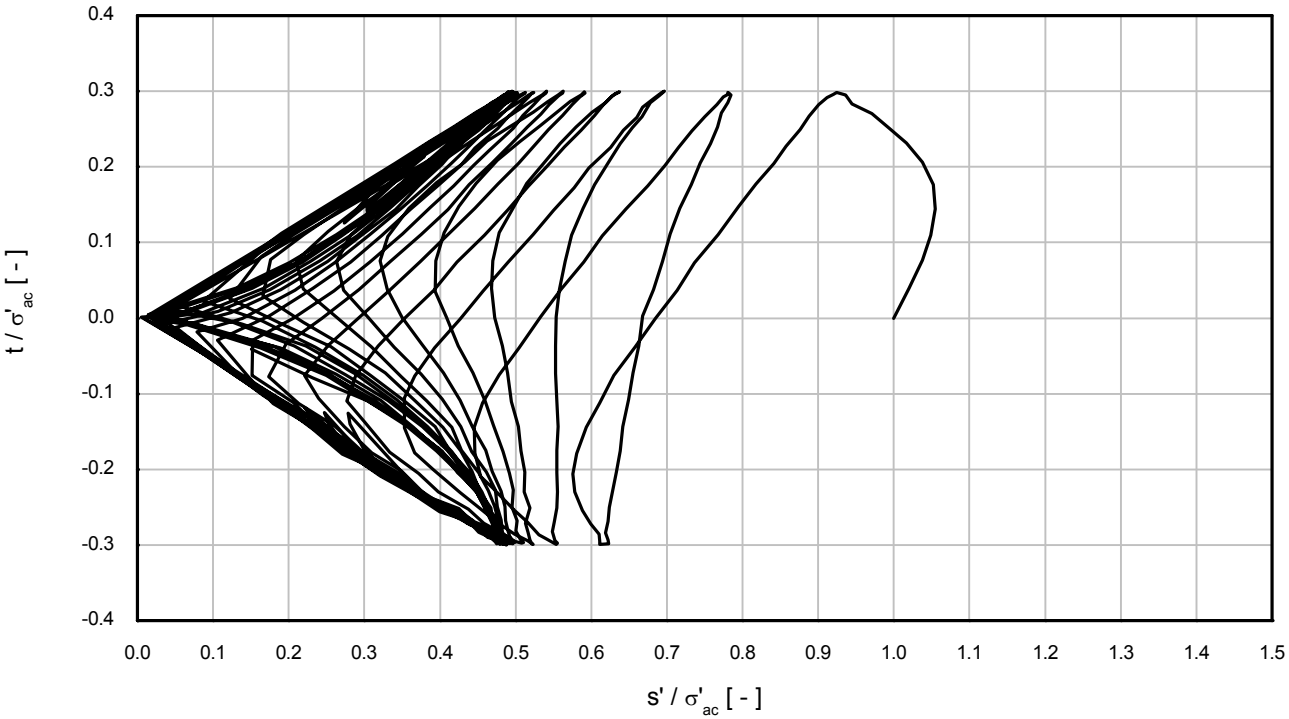


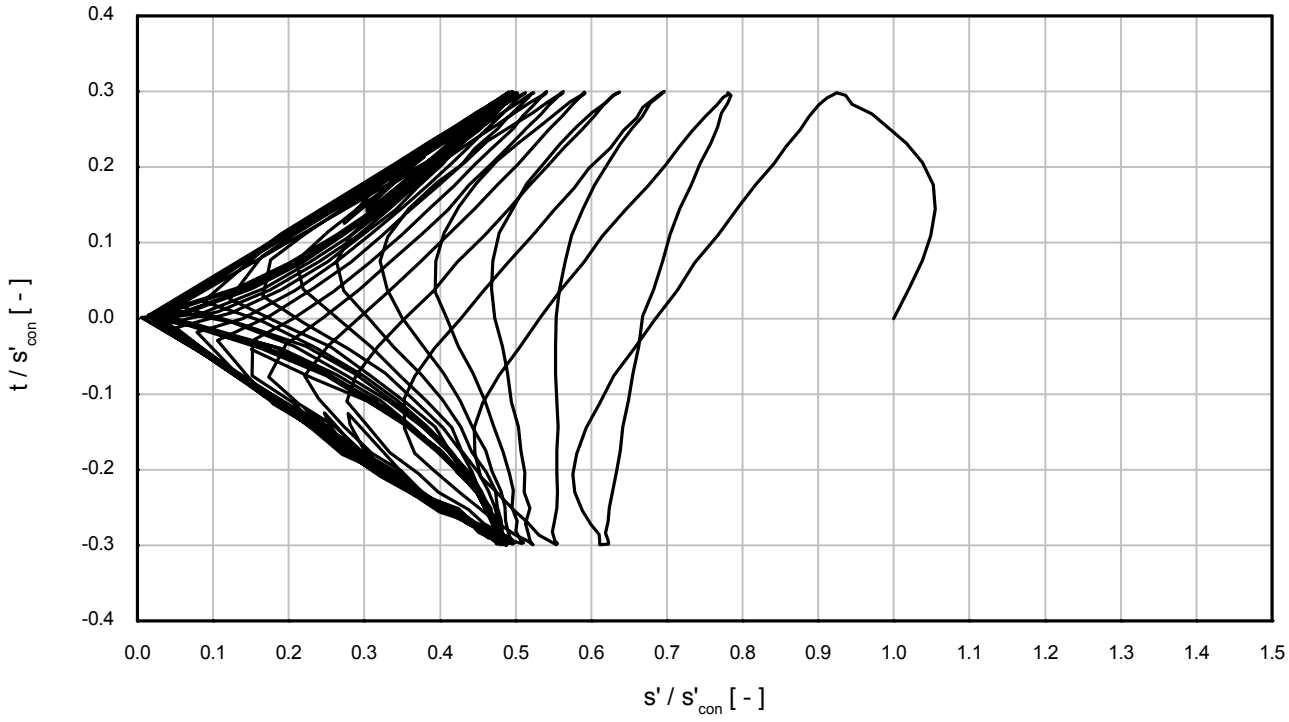


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-2
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	48	kPa	Test No.	: CTX10
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

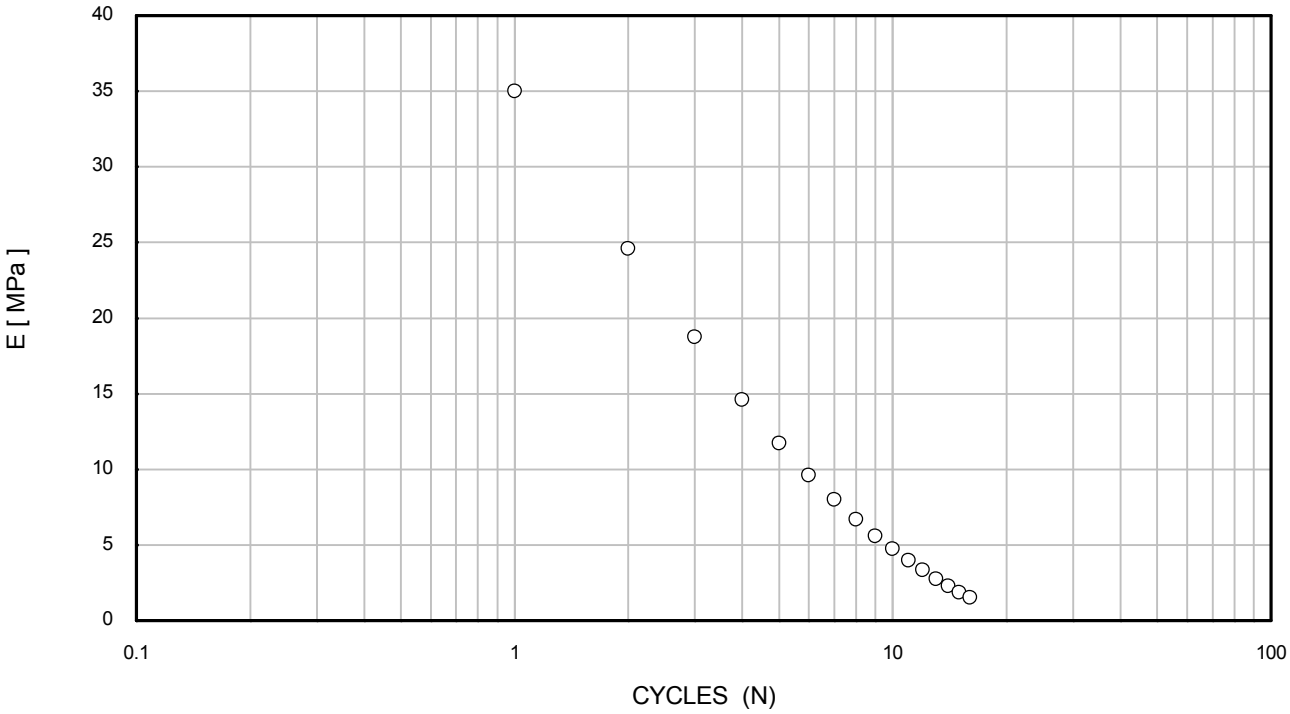


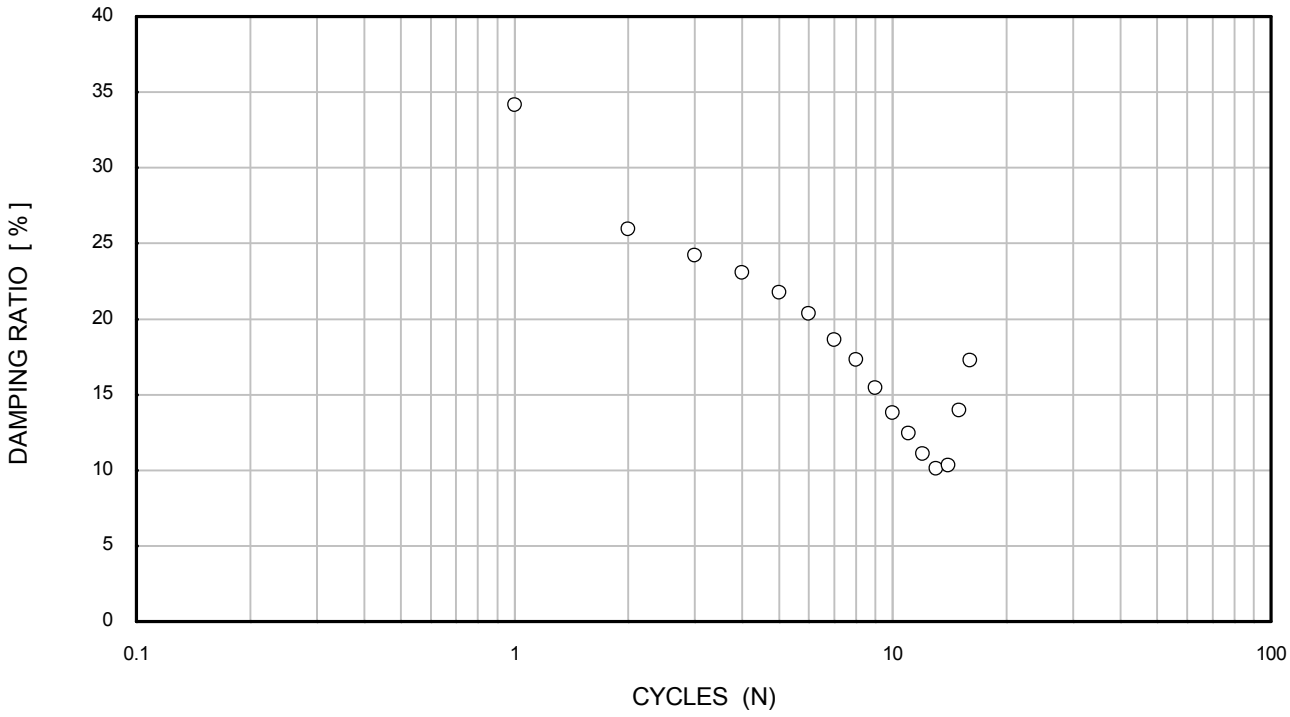


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-2
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	48	kPa	Test No.	: CTX10
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

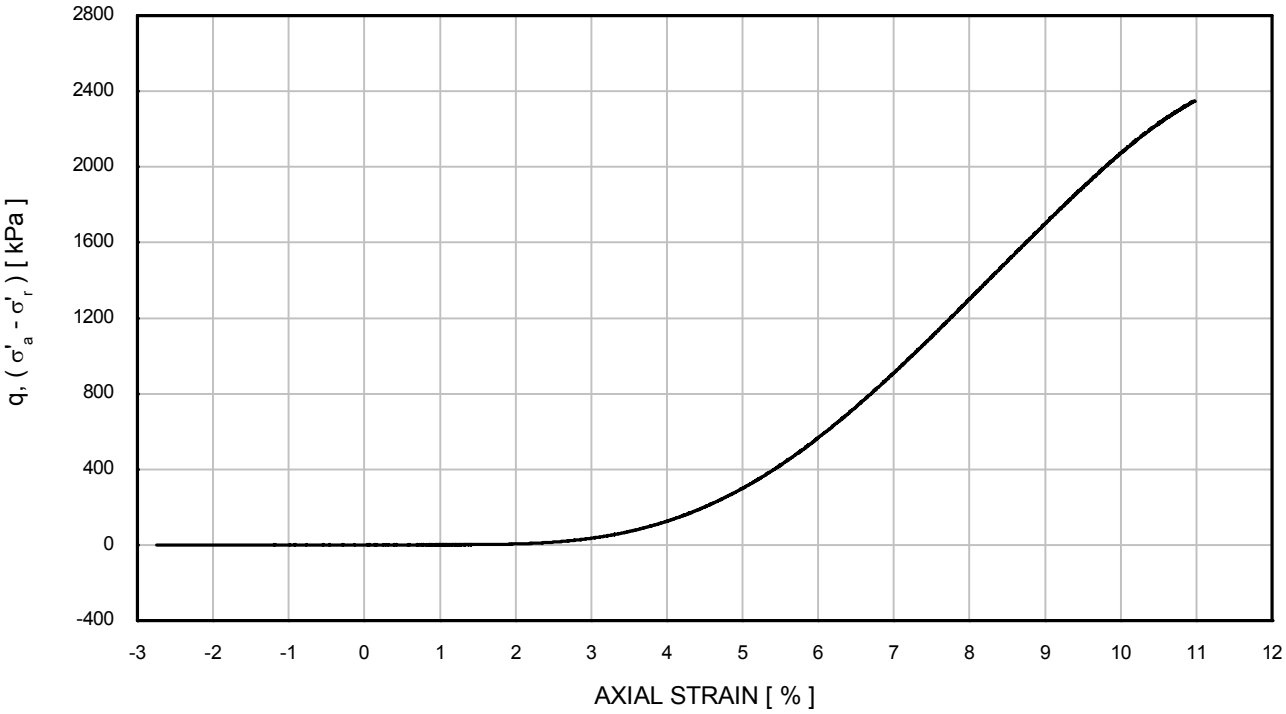


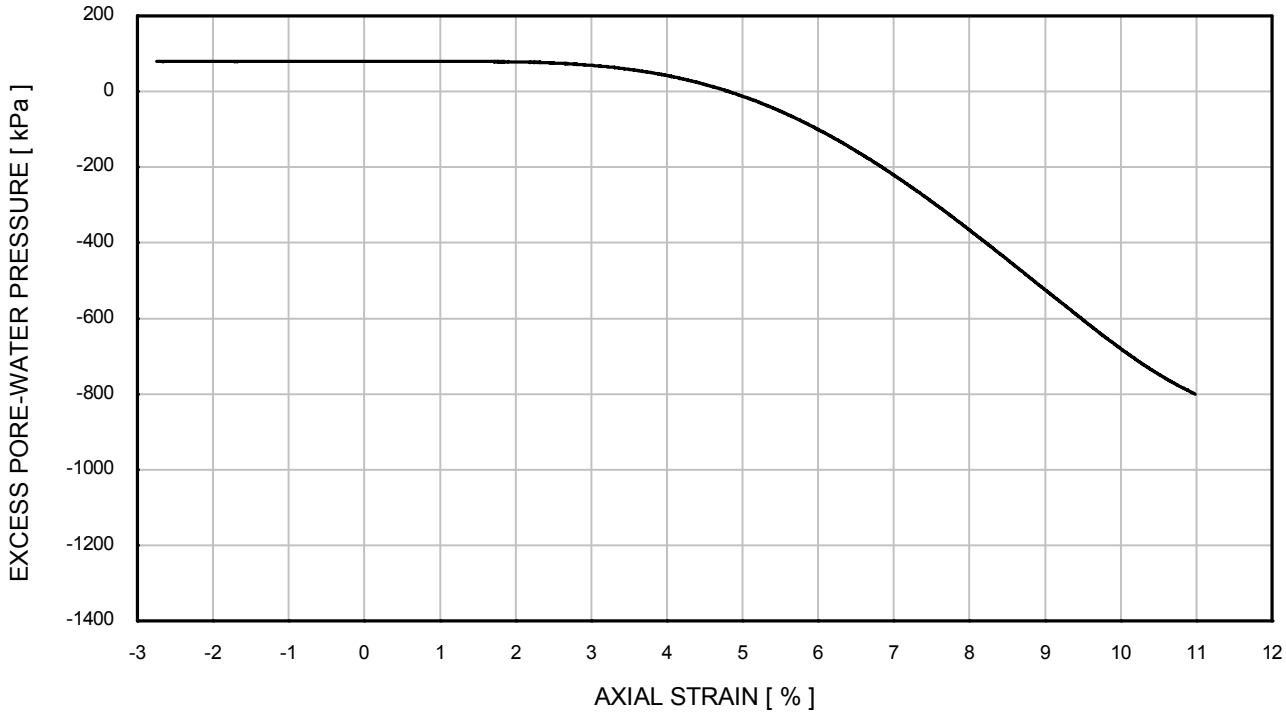


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-2
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	48 kPa	Test No.	:	CTX10
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

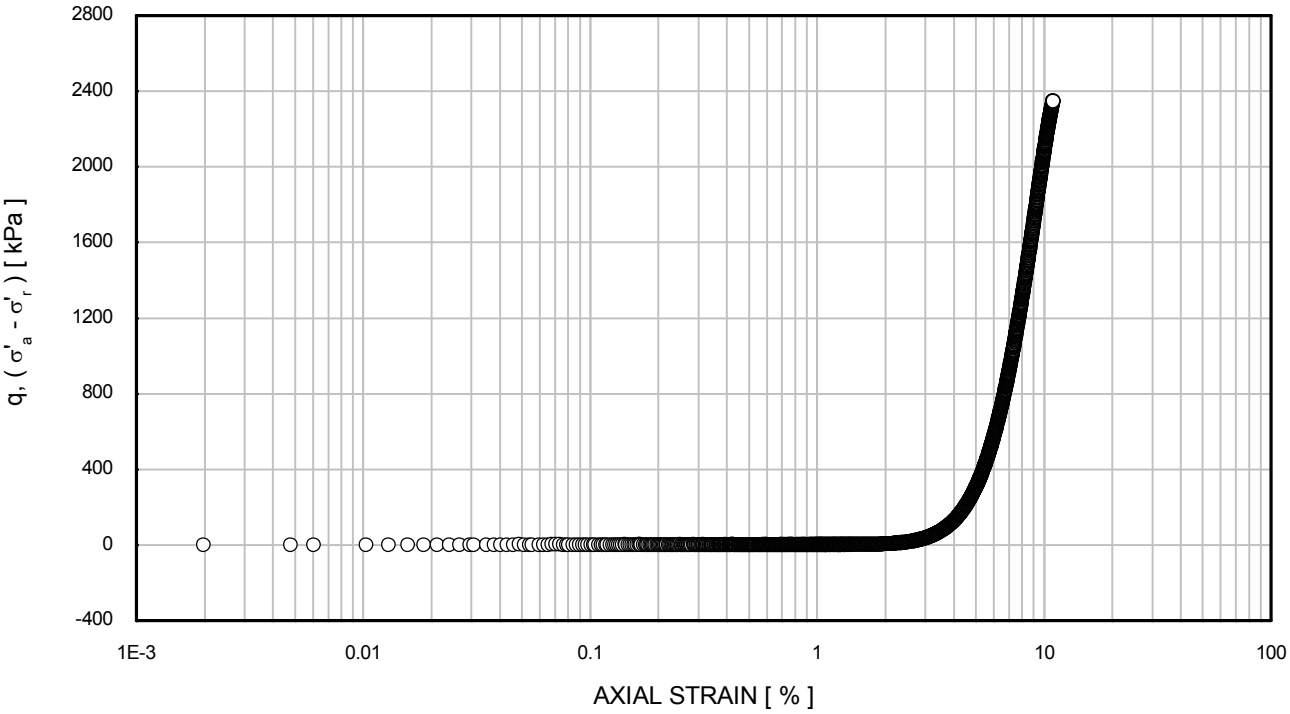


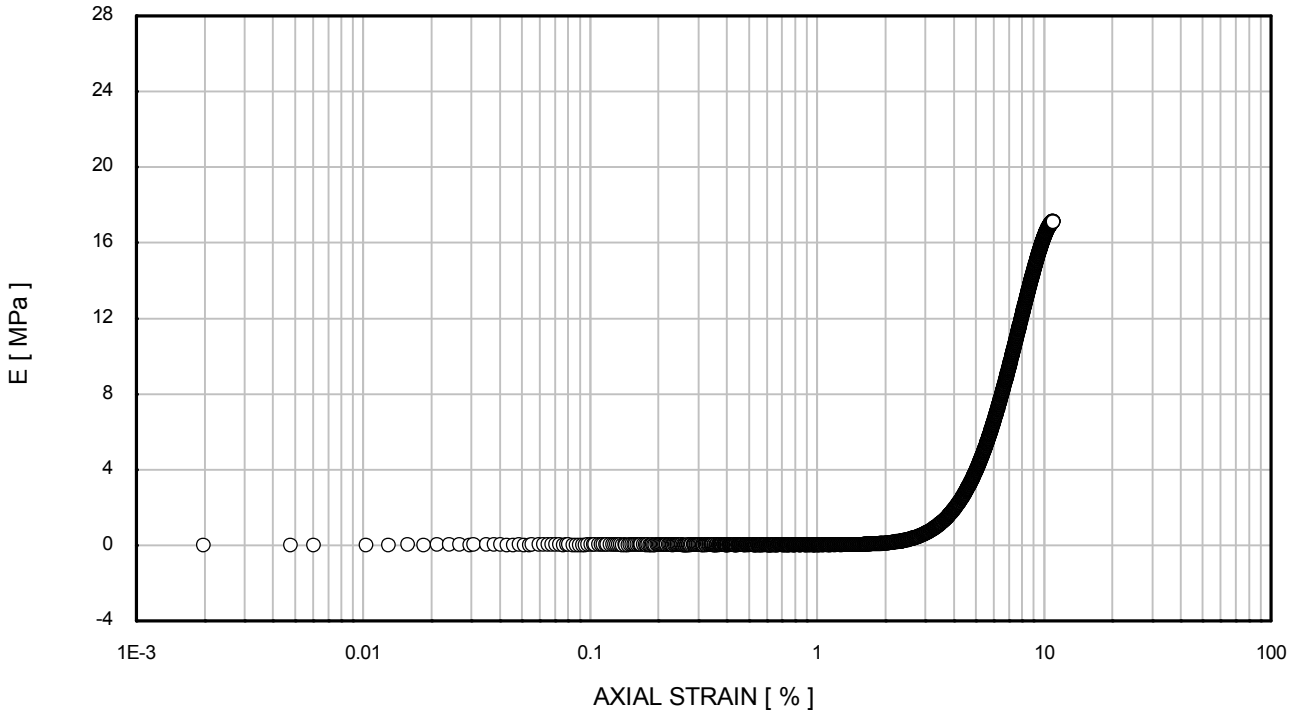


Initial σ'_r	:	1 kPa	Batch	:	2
Initial σ'_a	:	1 kPa	Sample	:	CTX_2-2
q_{peak}	:	2349 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	10.97 %	Test No.	:	CTX10
Rate of strain	:	4.93 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

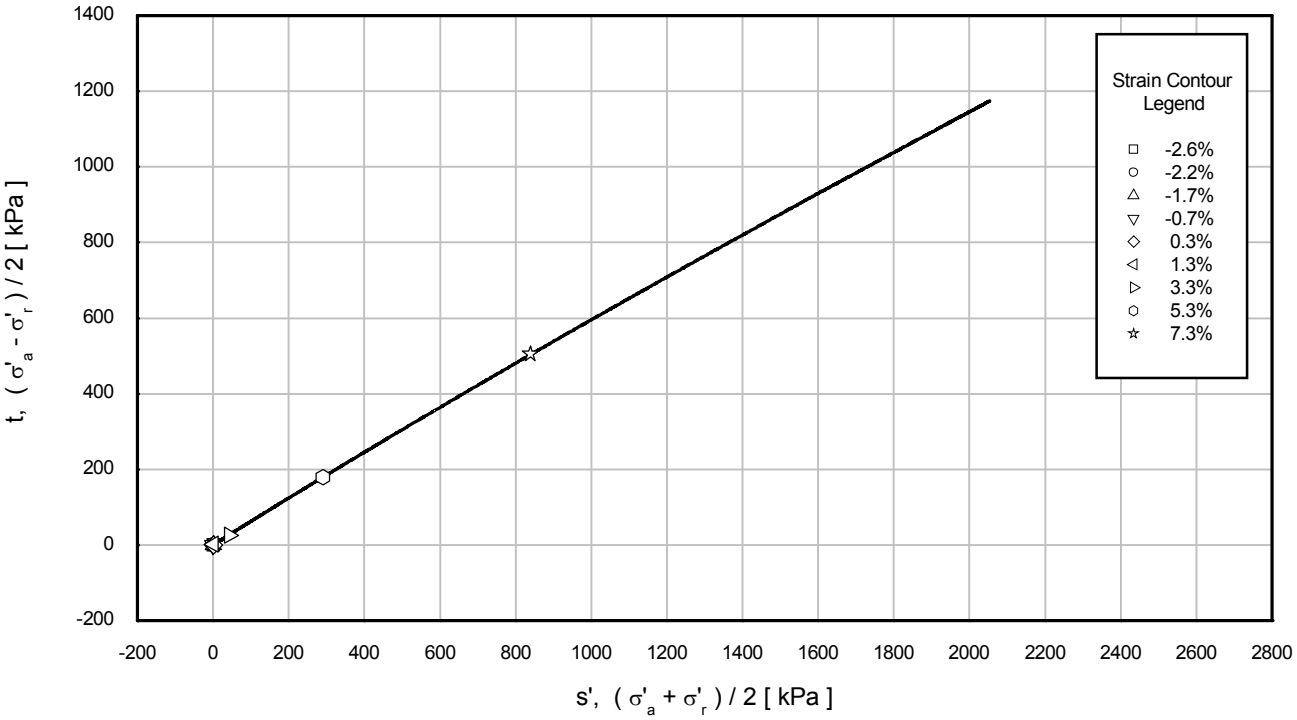


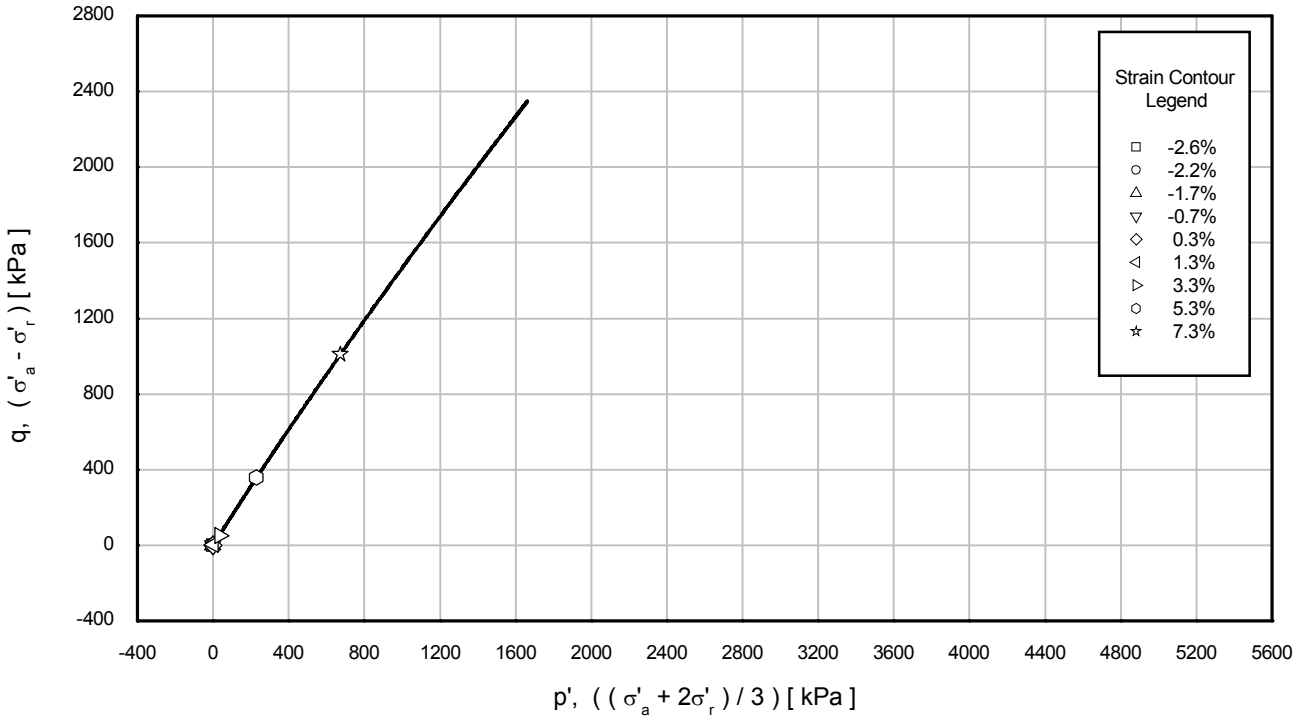


Initial σ'_r	:	1 kPa	Batch	:	2
Initial σ'_a	:	1 kPa	Sample	:	CTX_2-2
q_{peak}	:	2349 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	10.97 %	Test No.	:	CTX10
Rate of strain	:	4.93 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	1 kPa	Batch	:	2
Initial σ'_a	:	1 kPa	Sample	:	CTX_2-2
q_{peak}	:	2349 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	10.97 %	Test No.	:	CTX10
Rate of strain	:	4.93 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Light brown fine to medium SAND

GENERAL	
Date test started	16/03/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	9.9
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.559
Degree of saturation	[%]	47
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 2_CTX-2-3_CTX11R
Processed by Date	HJ 30/03/2016
Checked by Date	DT 30/03/2016
Approved by Date	DT 30/03/2016

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-3
Unit	B (Eem/Kreftenheye)
Test number	CTX11R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Undrained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	N/A
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1080
Mid height PWP	[kPa]	-
B value achieved	[-]	0.99

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1160
Back pressure	[kPa]	1080
Base PWP	[kPa]	1080
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	80
Effective axial pressure	[kPa]	80
Deviator stress	[kPa]	0
Volumetric strain	[%]	0.62
External axial strain	[%]	0.11
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	20.7
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.71
Void ratio	[-]	0.550
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-3
Unit	B (Eem/Kreftenheye)
Test number	CTX11R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	160
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	40
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	26
External ε_{av} at N_f	[%]	-1.86
External ε_{cy} at N_f	[%]	4.32
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	47
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	20.7
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.71
Void ratio	[-]	0.550
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.05	75	-	11.38	-
2	0.00	0.06	72	-	9.58	-
5	0.00	0.06	65	-	9.91	-
10	-0.02	0.08	49	-	12.35	-
20	-0.53	0.79	5	-	16.38	-
26	-1.86	4.32	1	-	8.33	-

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-3
Unit	B (Eem/Kreftenheye)
Test number	CTX11R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	10
Initial effective axial pressure	[kPa]	7
Rate of strain	[%/hour]	4.76
At peak deviator stress		
Corrected deviator stress	[kPa]	3232
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	18.09
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-923
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	1325
Effective axial pressure	[kPa]	4557
Principal effective stress ratio	[-]	3.44
ε_{50}	[%]	8.54
Secant modulus (E_{50}) at ε_{50}	[kPa]	18027
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	554
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	5.79
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	224
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	179
Effective axial pressure	[kPa]	732
Principal effective stress ratio	[-]	4.10
At 1% external axial strain		
Corrected deviator stress	[kPa]	-3
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	1.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	392
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	11
Effective axial pressure	[kPa]	8
Principal effective stress ratio	[-]	1.30

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-3
Unit	B (Eem/Kreftenheye)
Test number	CTX11R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



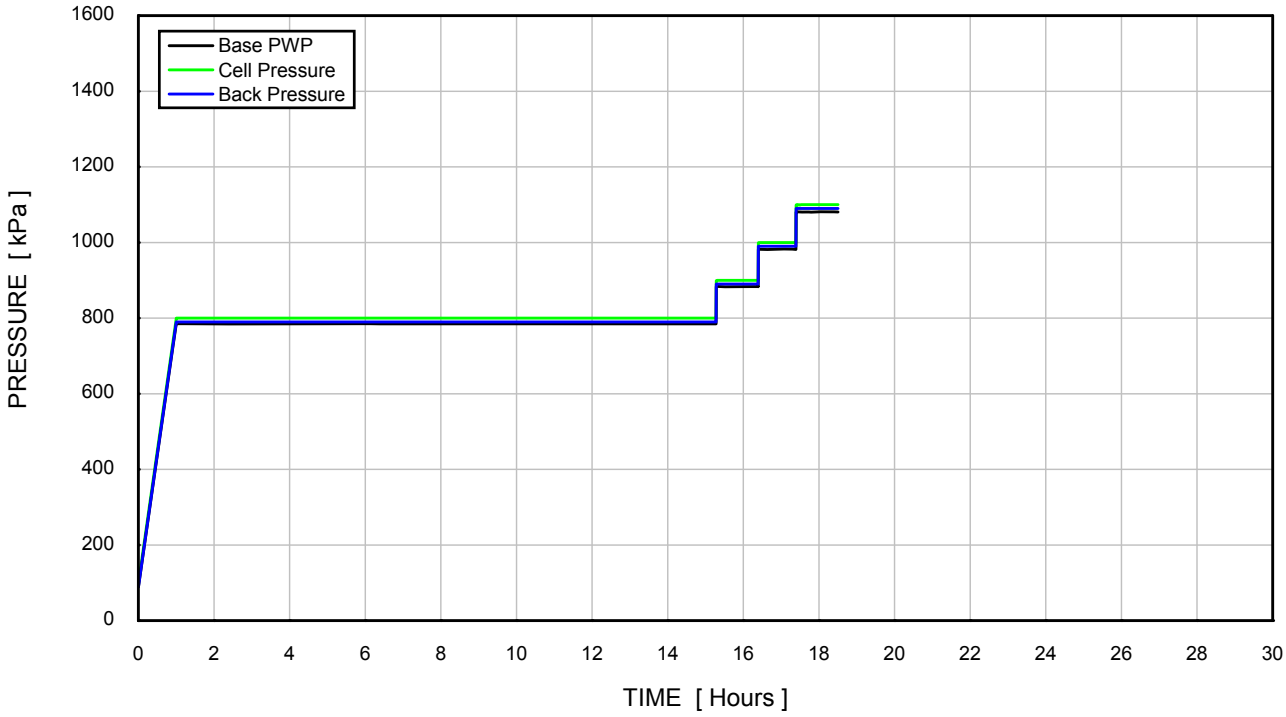


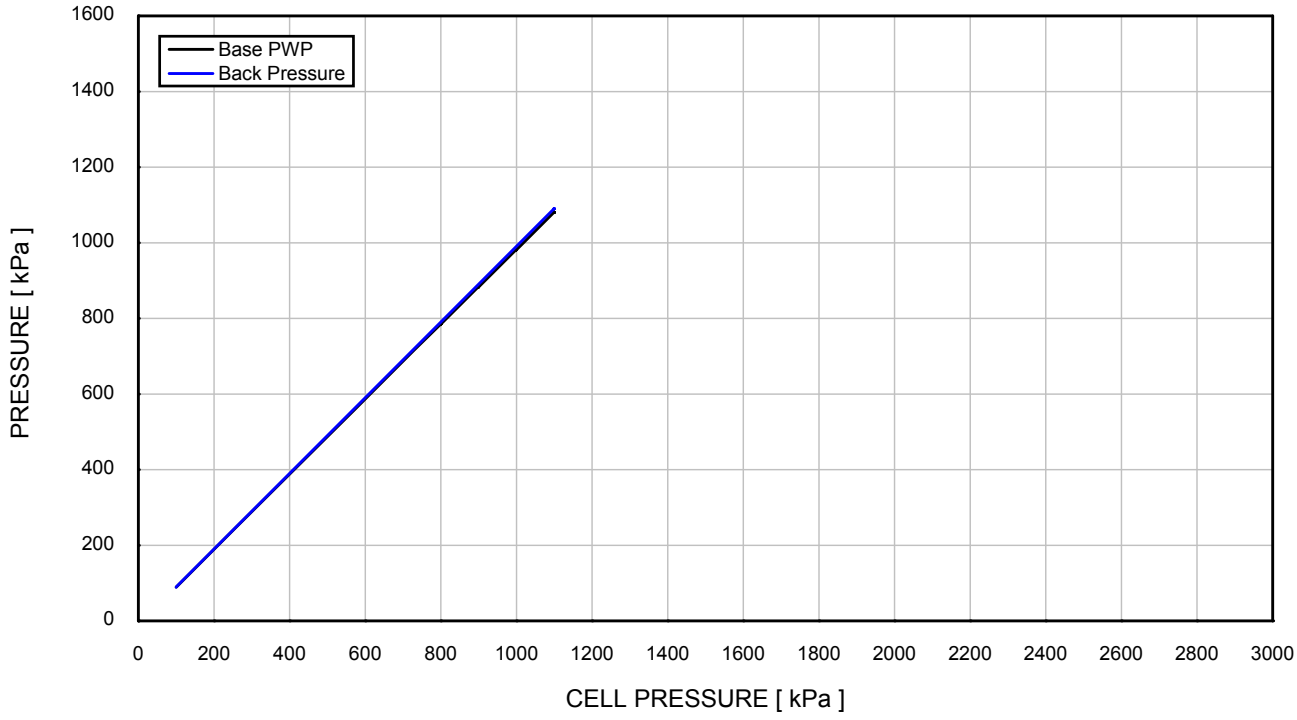
FINAL CONDITIONS		
Moisture content	[%]	20.7
Bulk density	[Mg/m³]	2.06
Dry density	[Mg/m³]	1.71

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-3
Unit	B (Eem/Kreftenheye)
Test number	CTX11R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

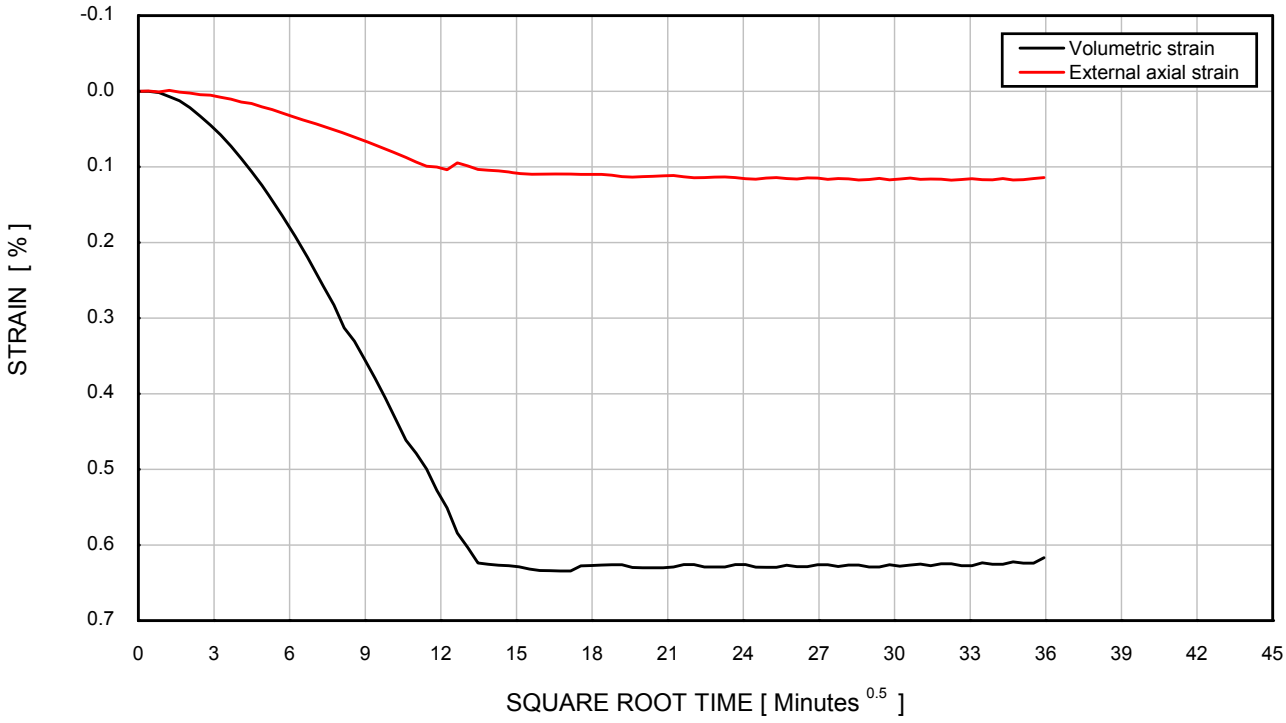


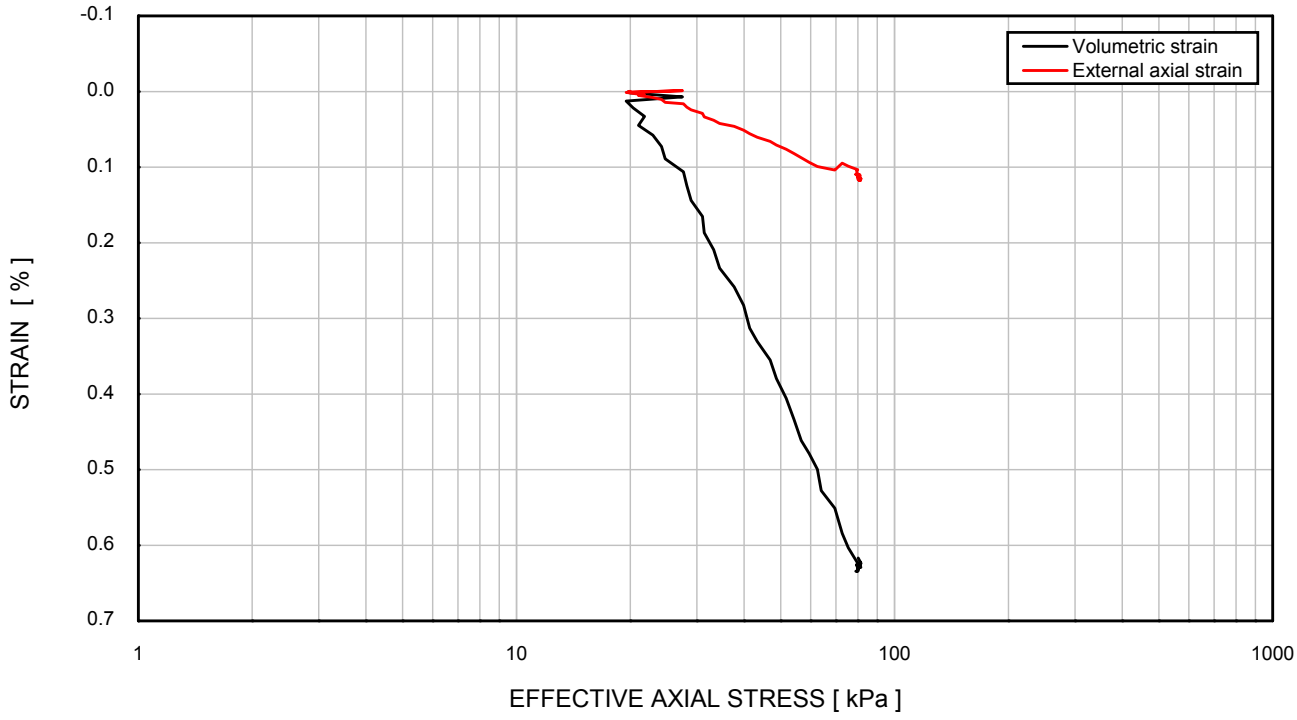


B value	:	0.99			
Initial σ'_r	:	11	kPa	Batch	: 2
Initial σ'_a	:	11	kPa	Sample	: CTX2-3
Final σ'_r	:	20	kPa	Unit	: B (Eem/Kreftenheye)
Final σ'_a	:	20	kPa	Test No.	: CTX11R

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

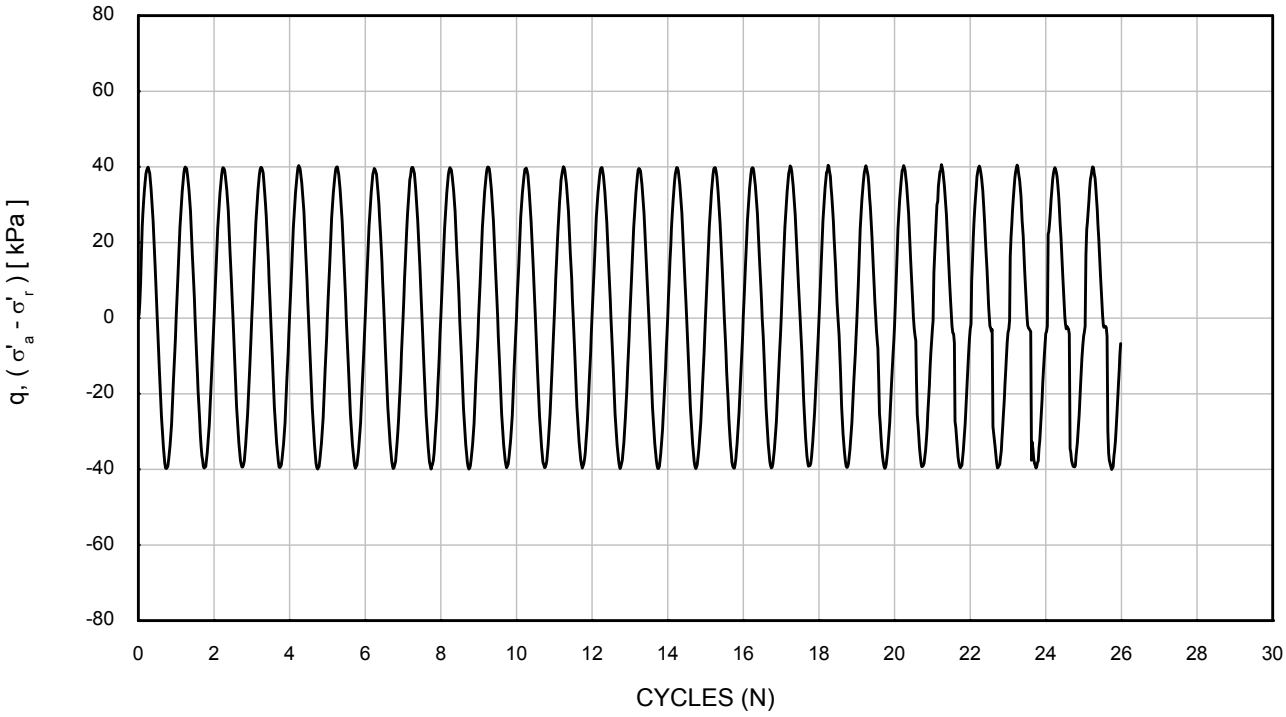


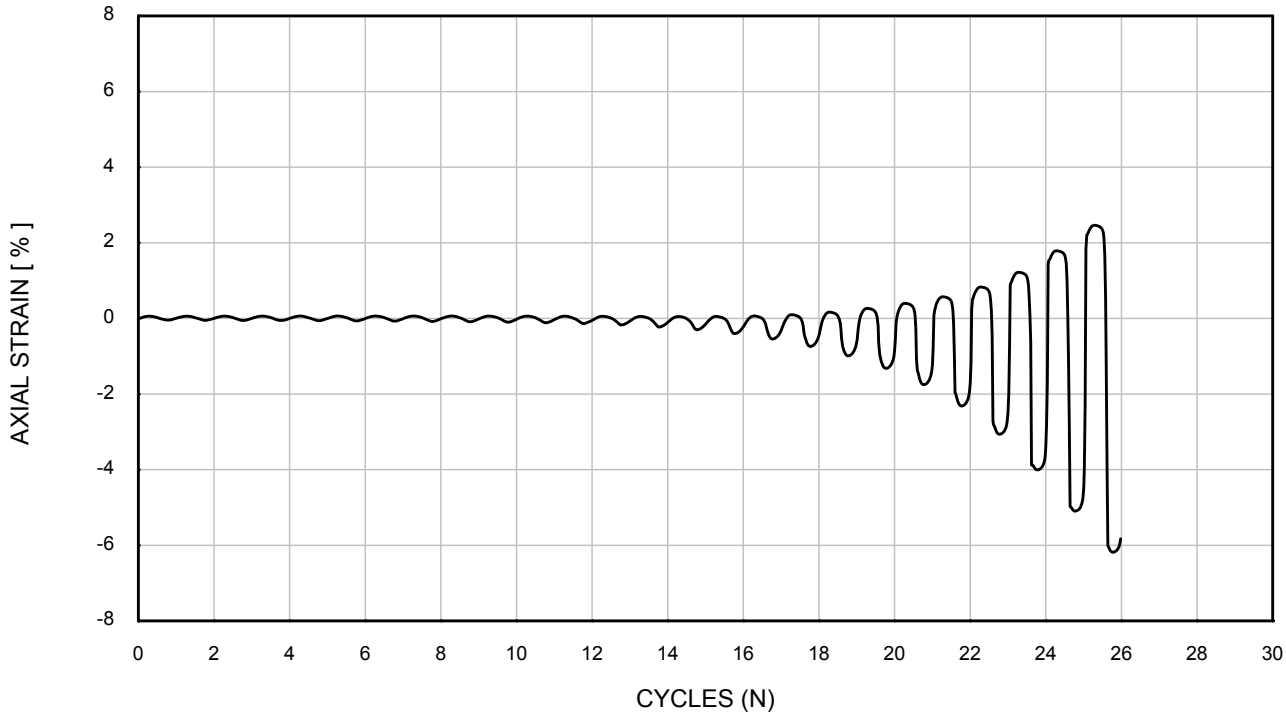


σ'_{rc}	:	80 kPa	Batch	:	2
σ'_{ac}	:	80 kPa	Sample	:	CTX_2-3
			Unit	:	B (Eem/Krefenheye)
			Test No.	:	CTX11R

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

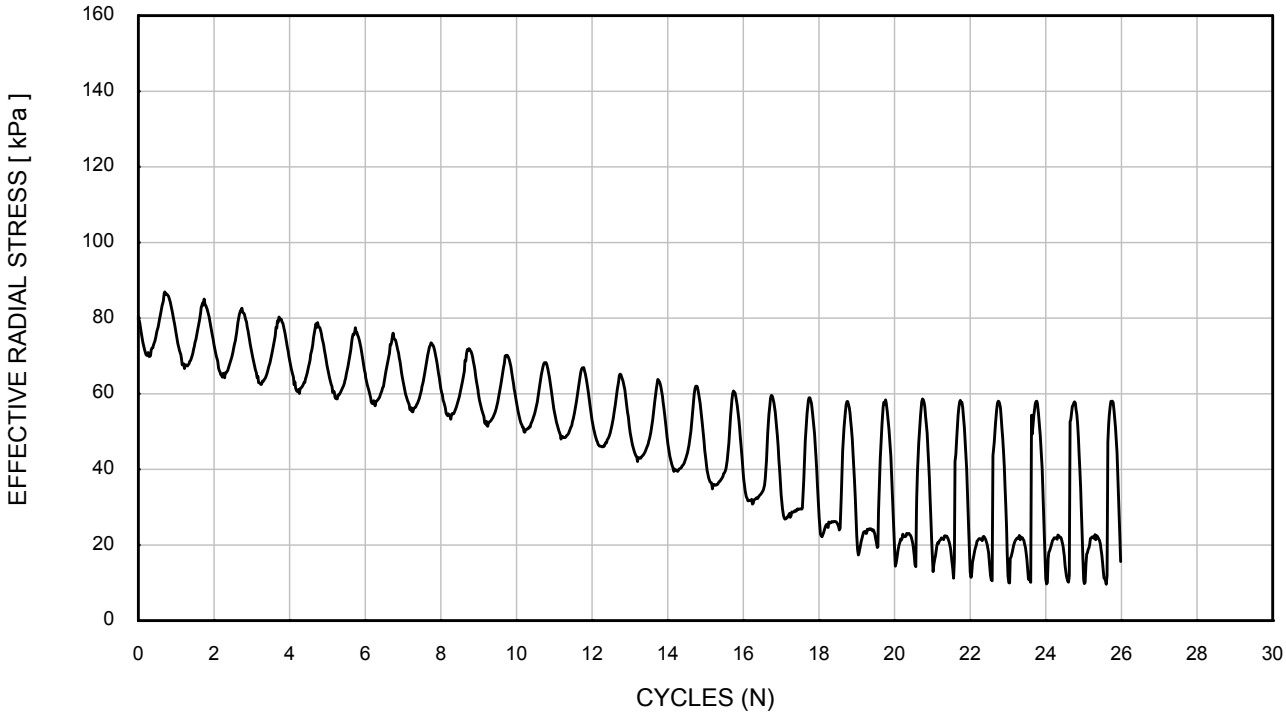


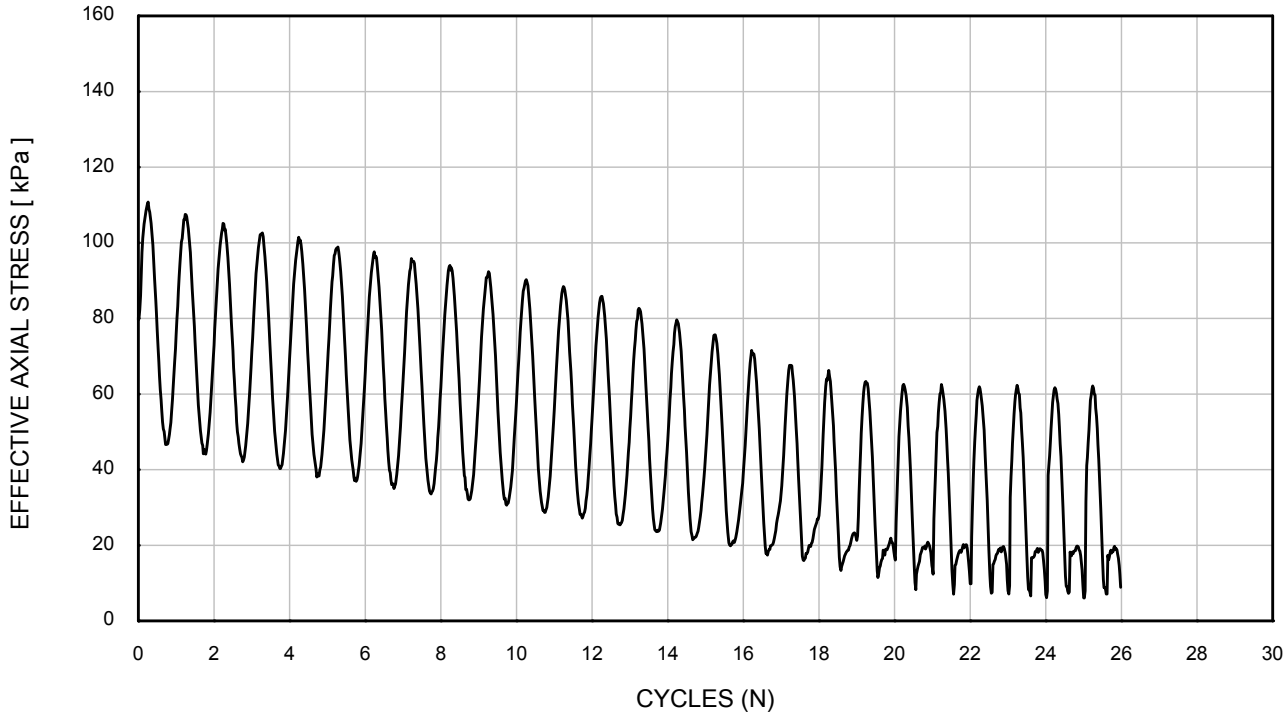


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX2-3
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	40 kPa	Test No.	:	CTX11R
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

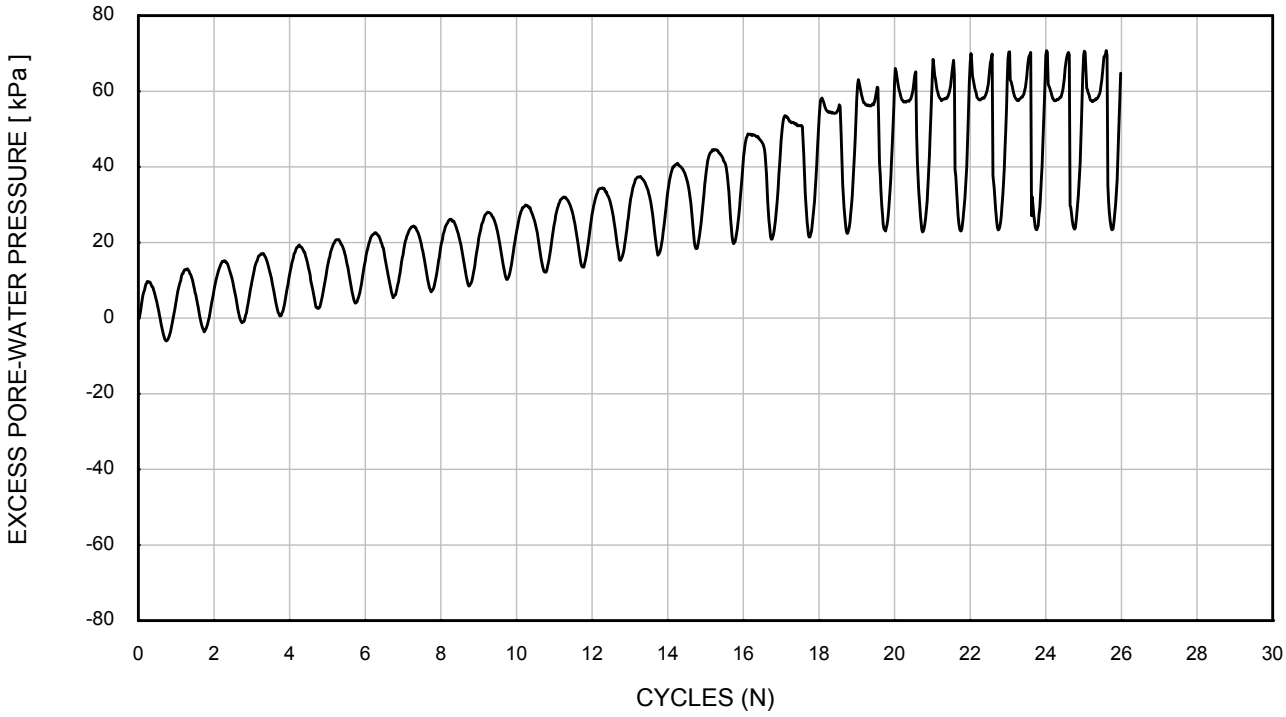


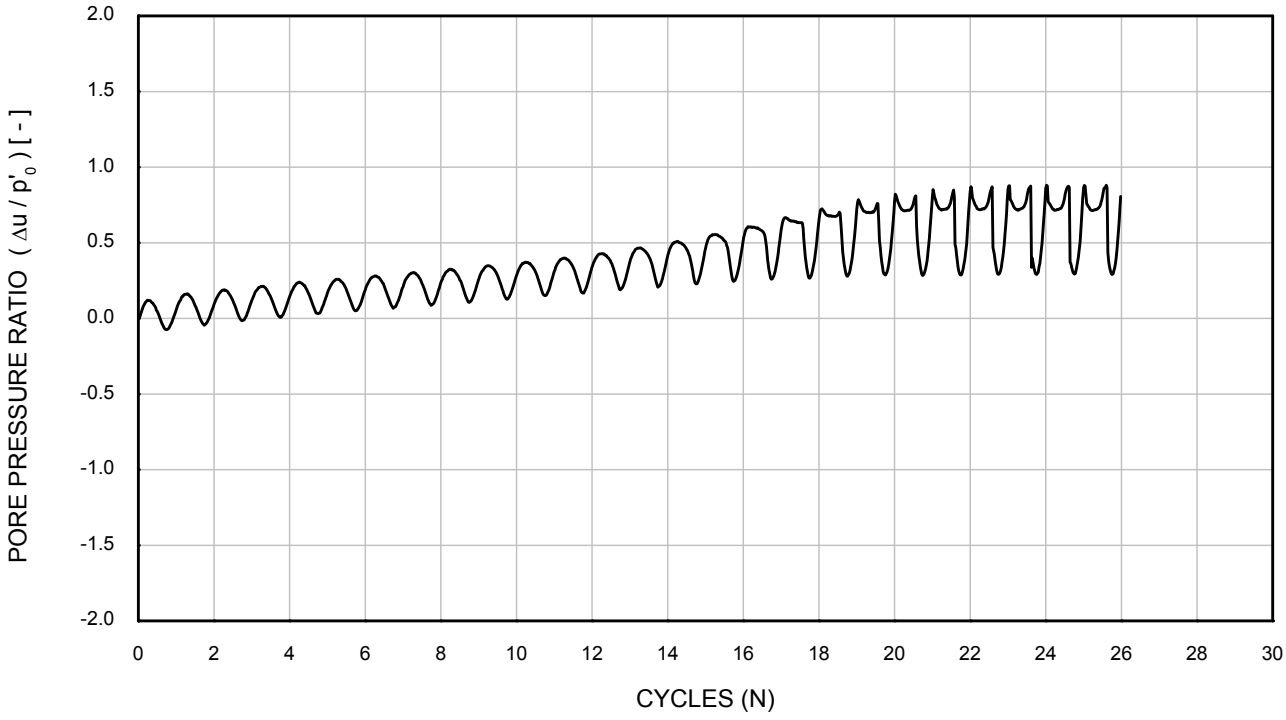


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	40	kPa	Test No.	: CTX11R
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

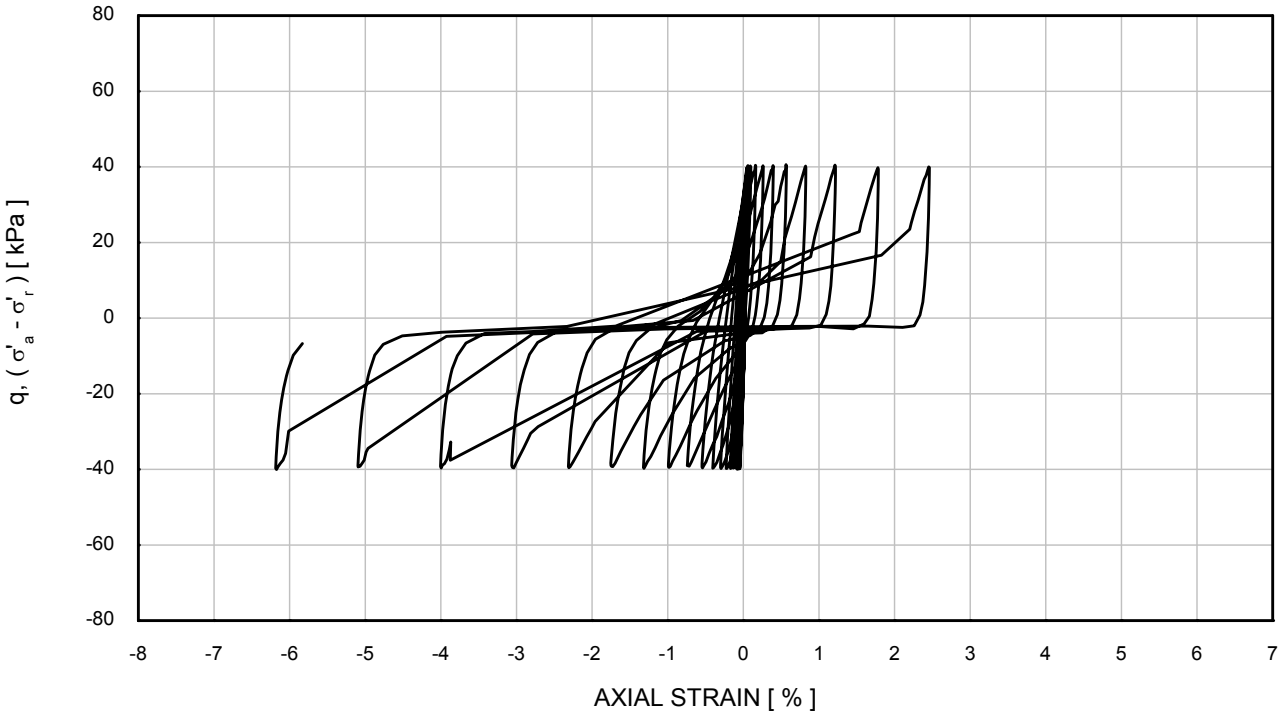


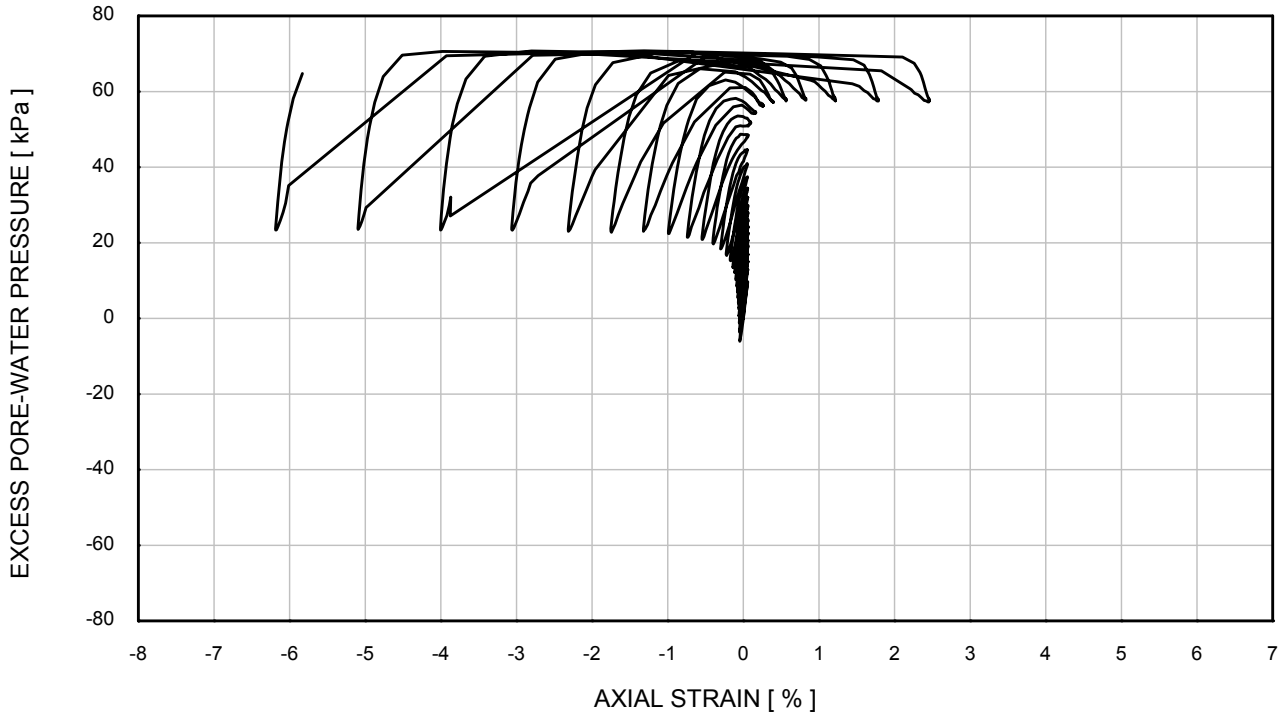


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	40	kPa	Test No.	: CTX11R
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

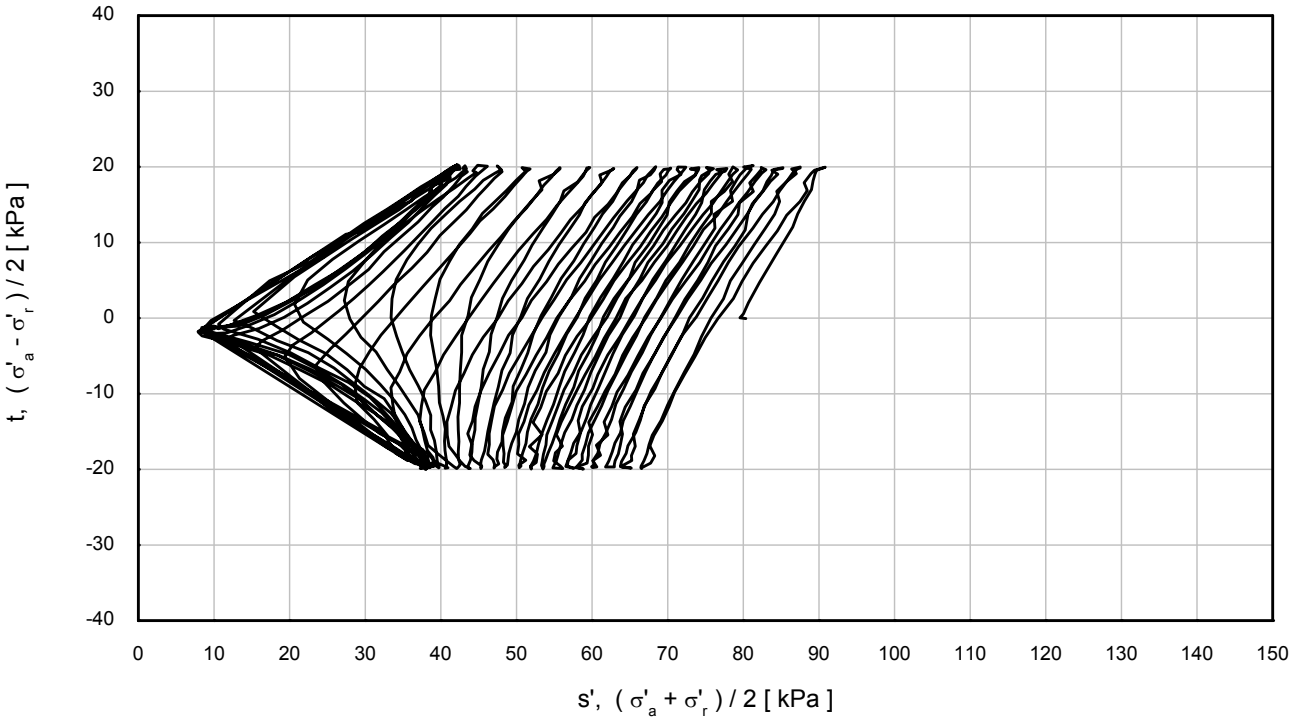


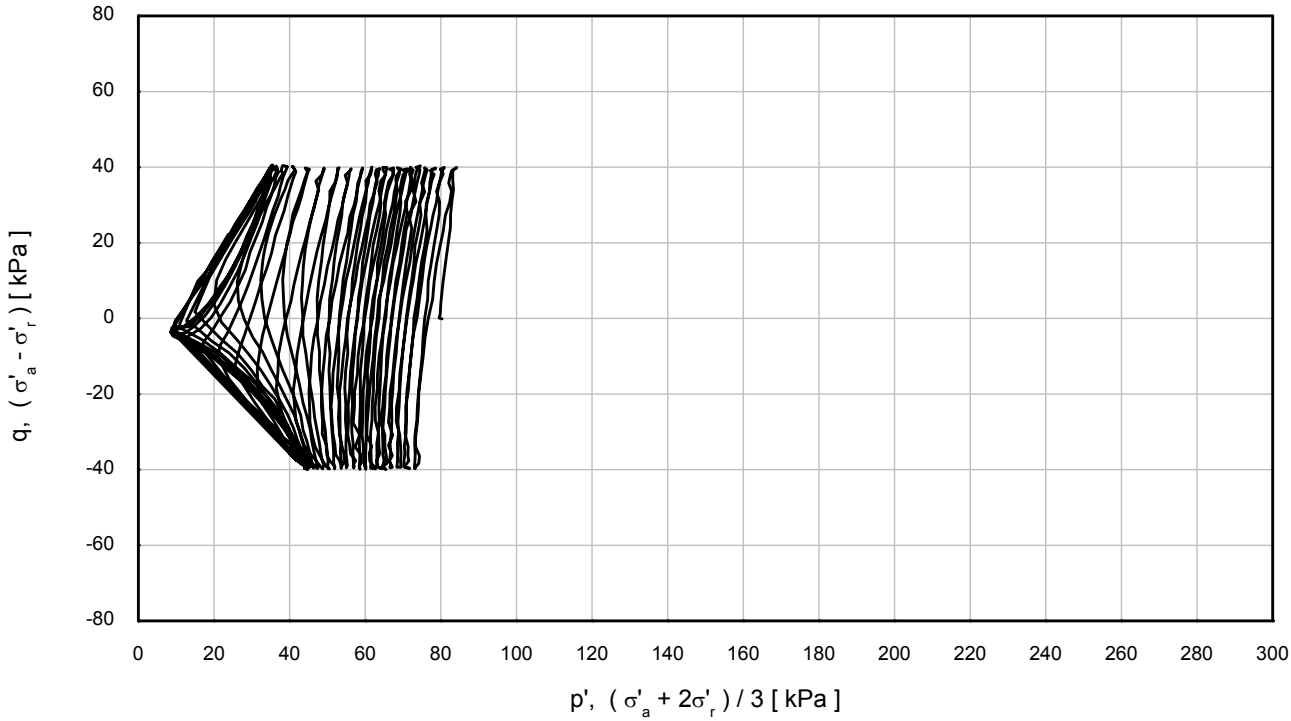


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	40	kPa	Test No.	: CTX11R
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

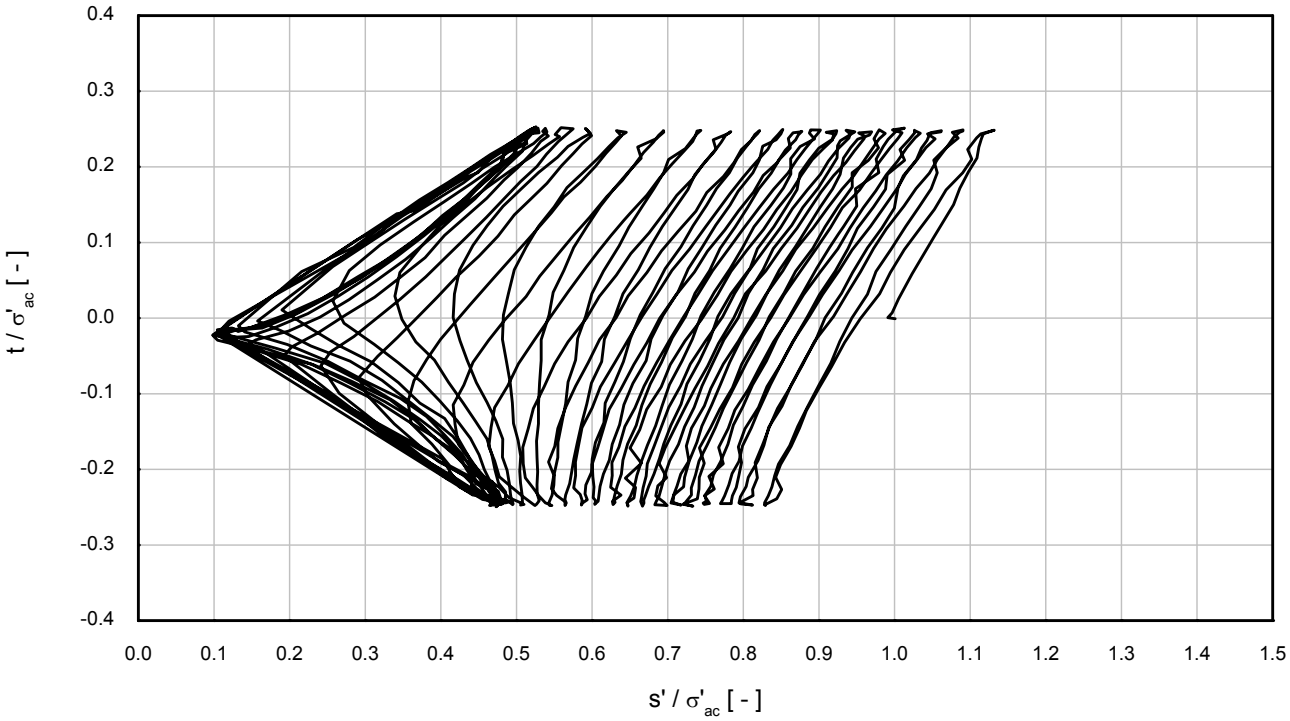


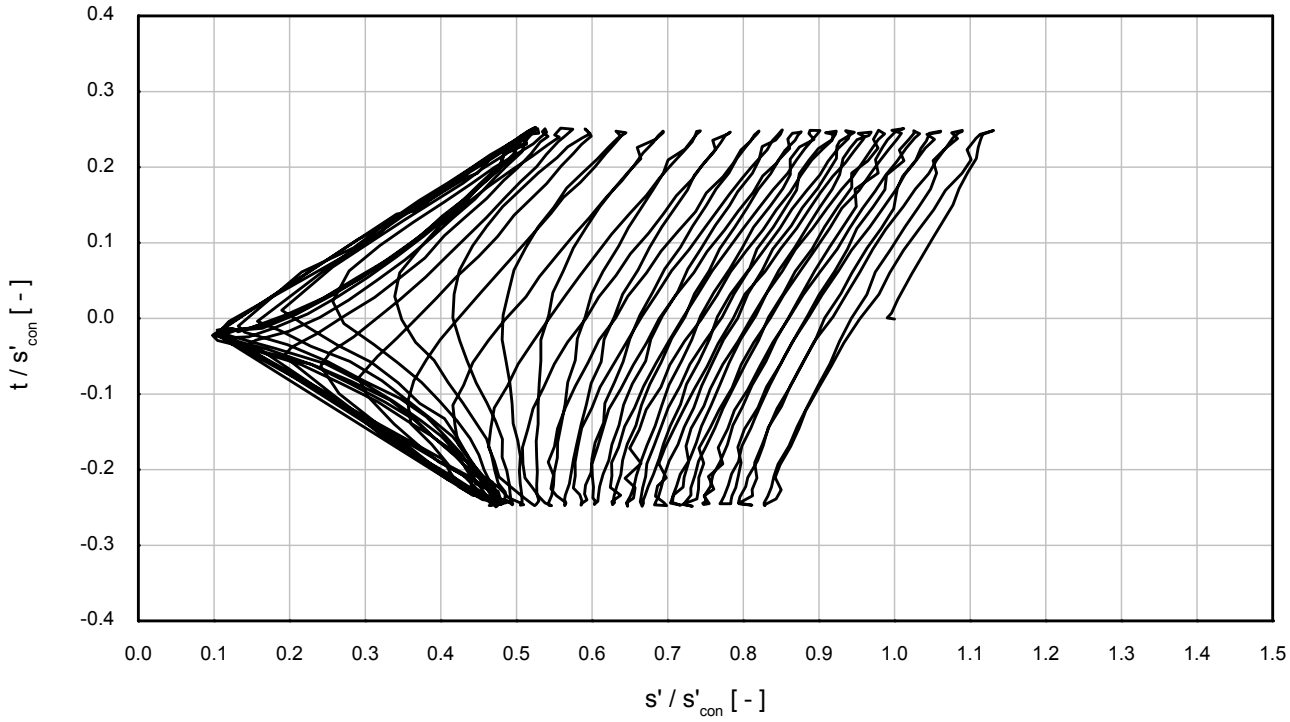


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	40	kPa	Test No.	: CTX11R
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

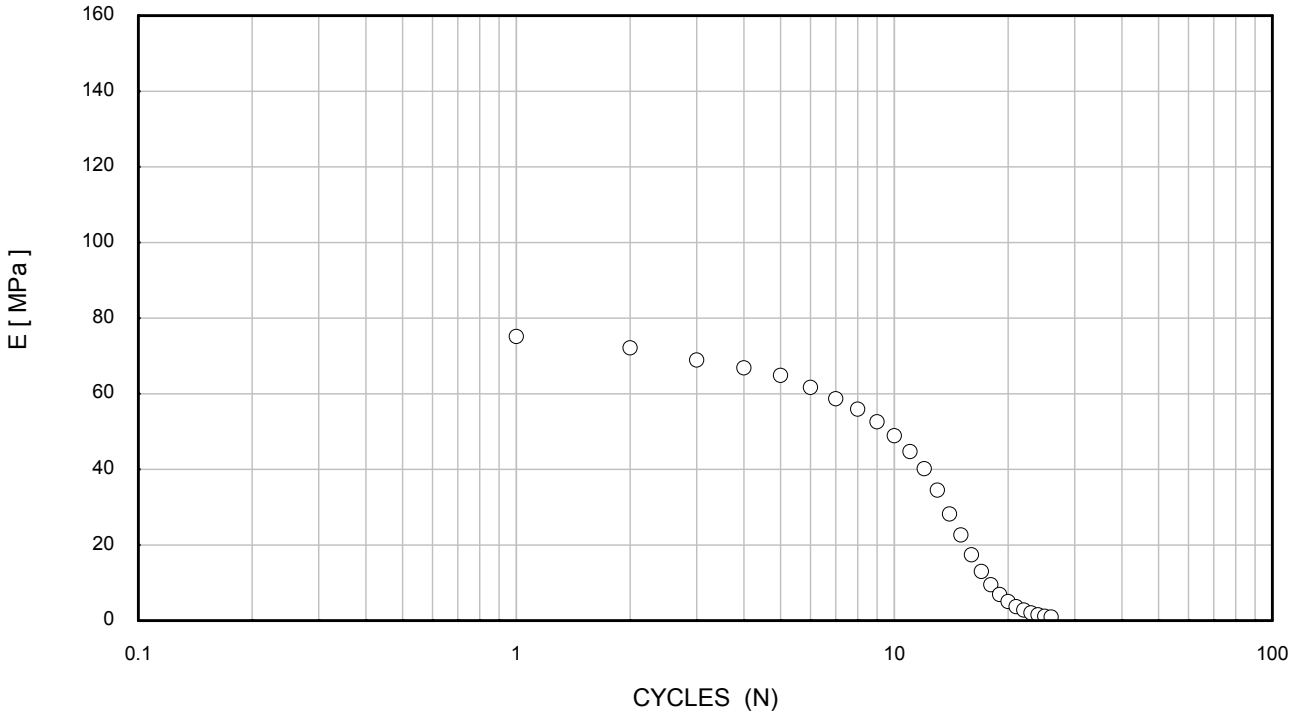


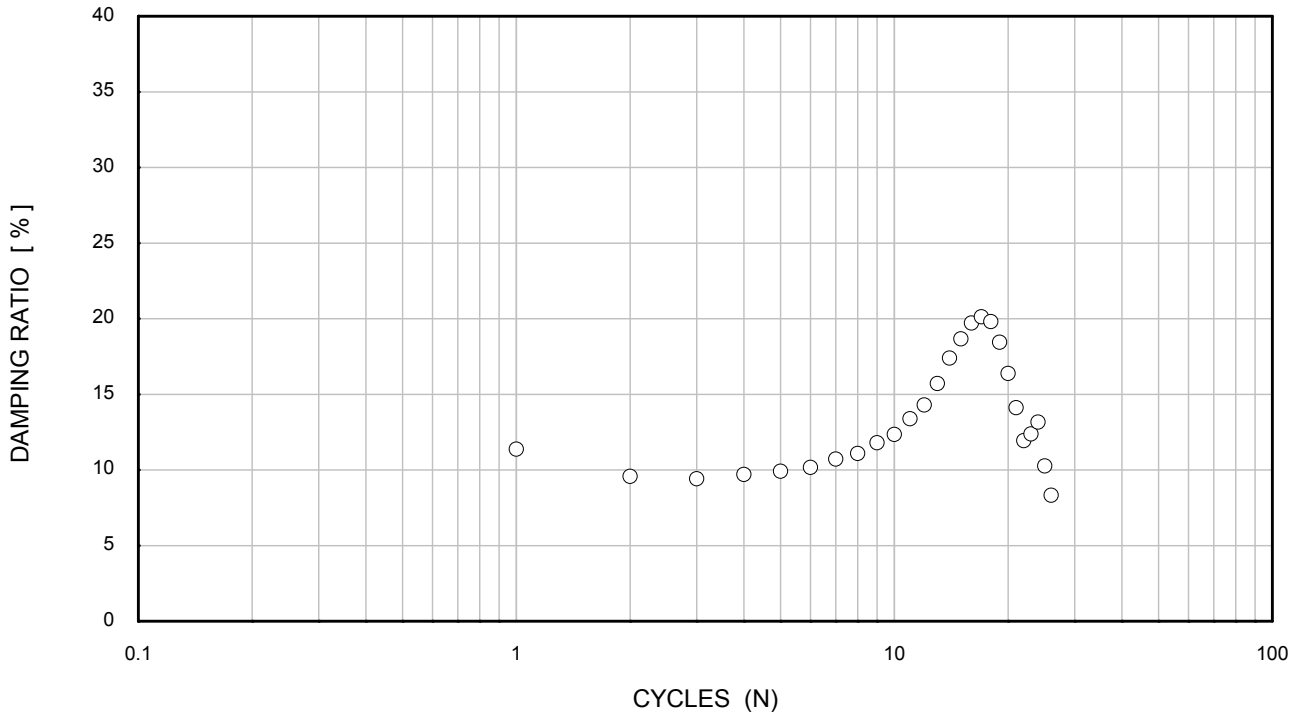


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	40	kPa	Test No.	: CTX11R
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

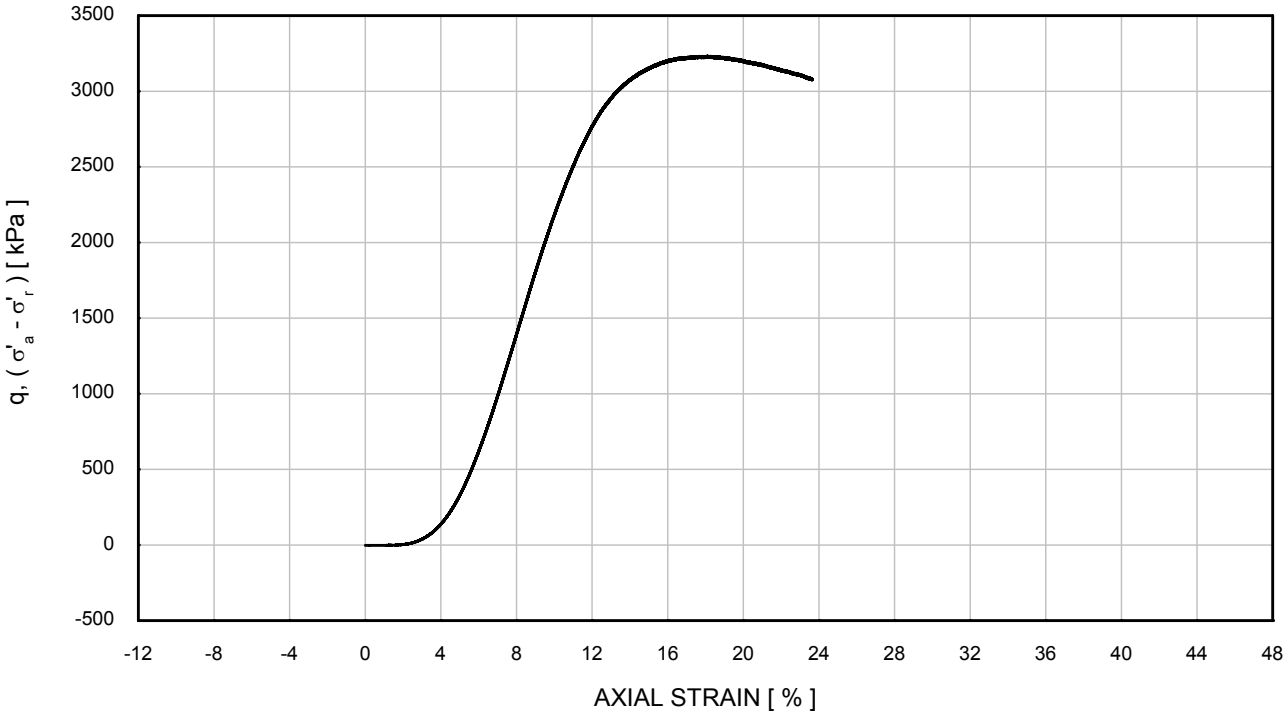


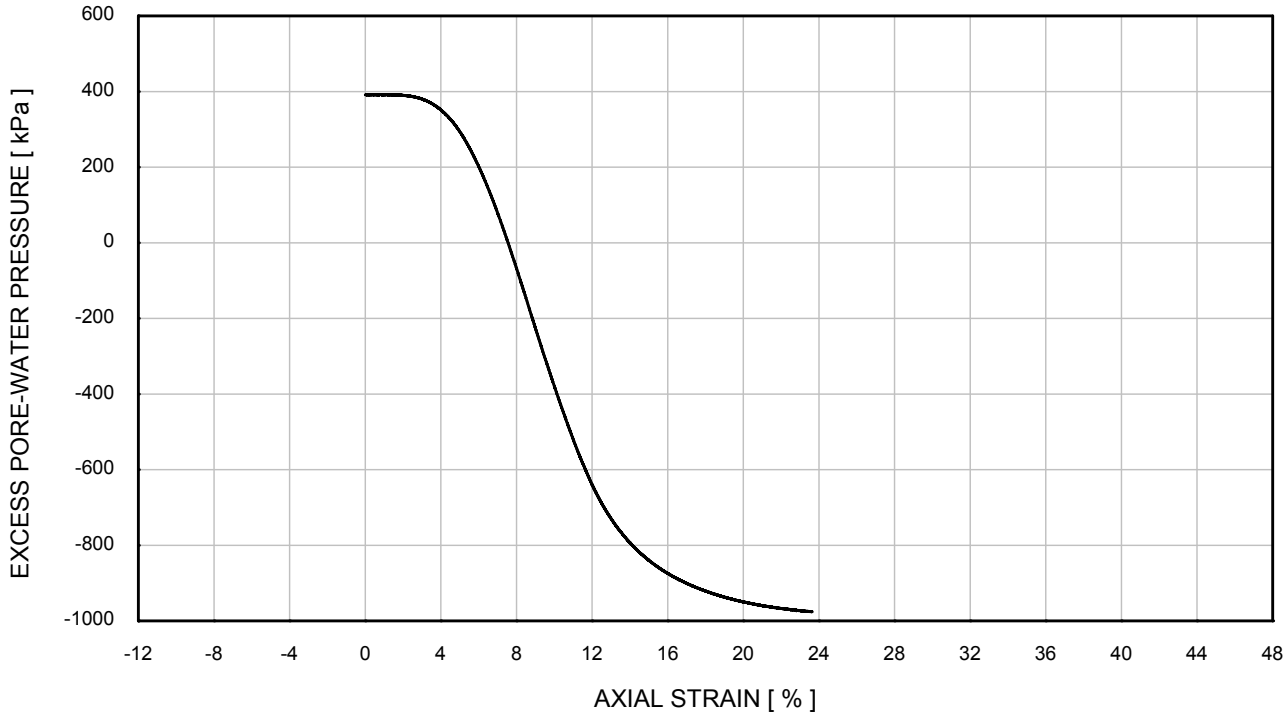


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	40	kPa	Test No.	: CTX11R
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

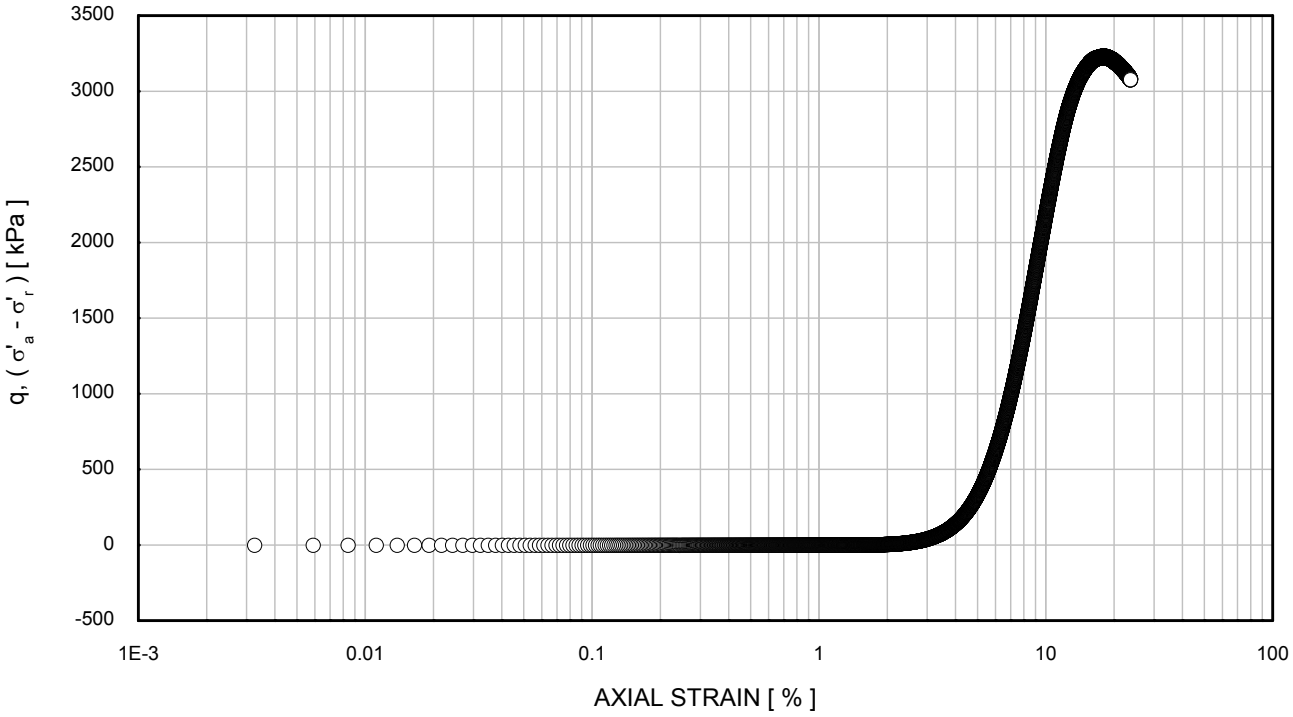


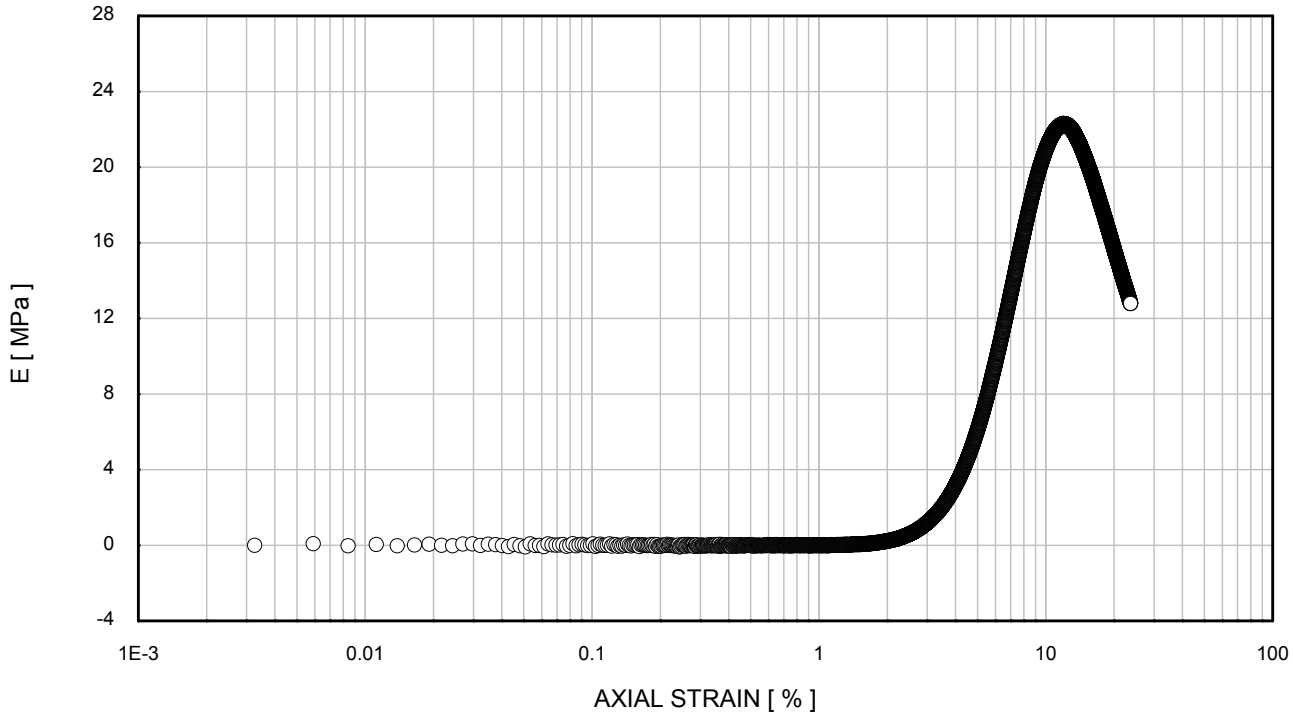


Initial σ'_r	:	10	kPa	Batch	: 2
Initial σ'_a	:	7	kPa	Sample	: CTX_2-3
q_{peak}	:	3232	kPa	Unit	: B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	18.09	%	Test No.	: CTX11R
Rate of strain	:	4.76	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

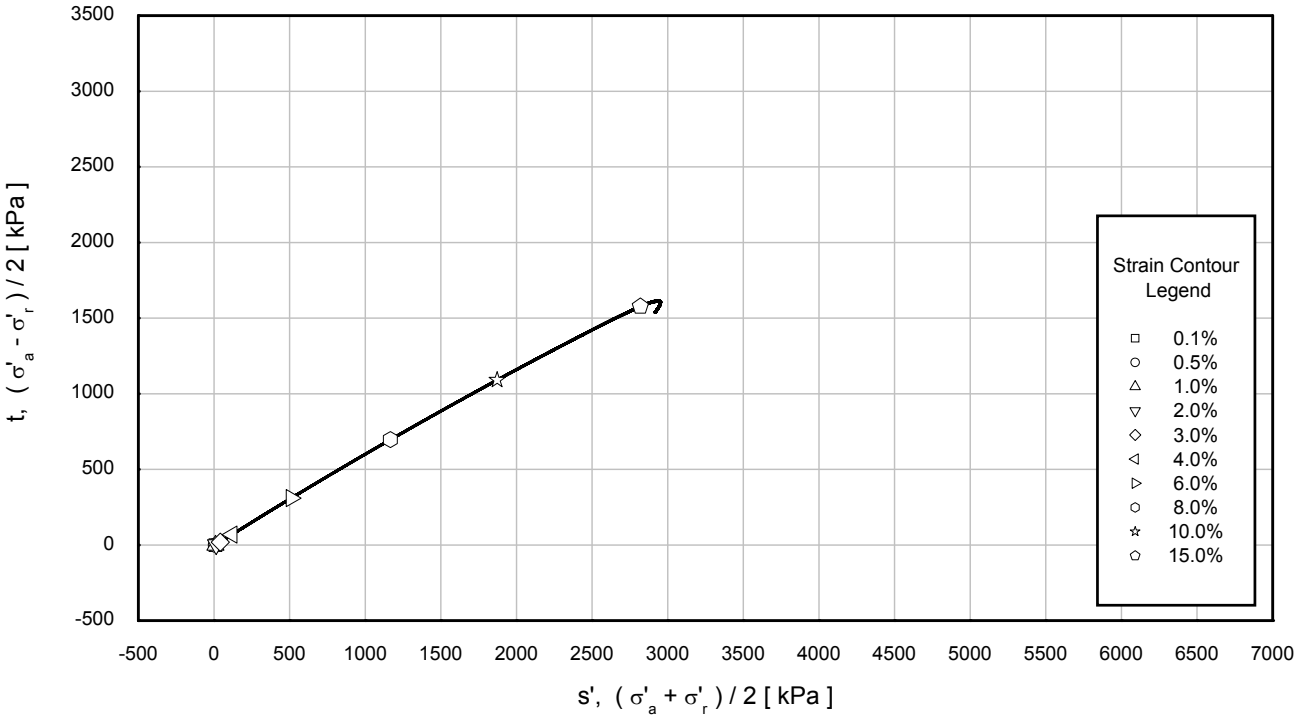


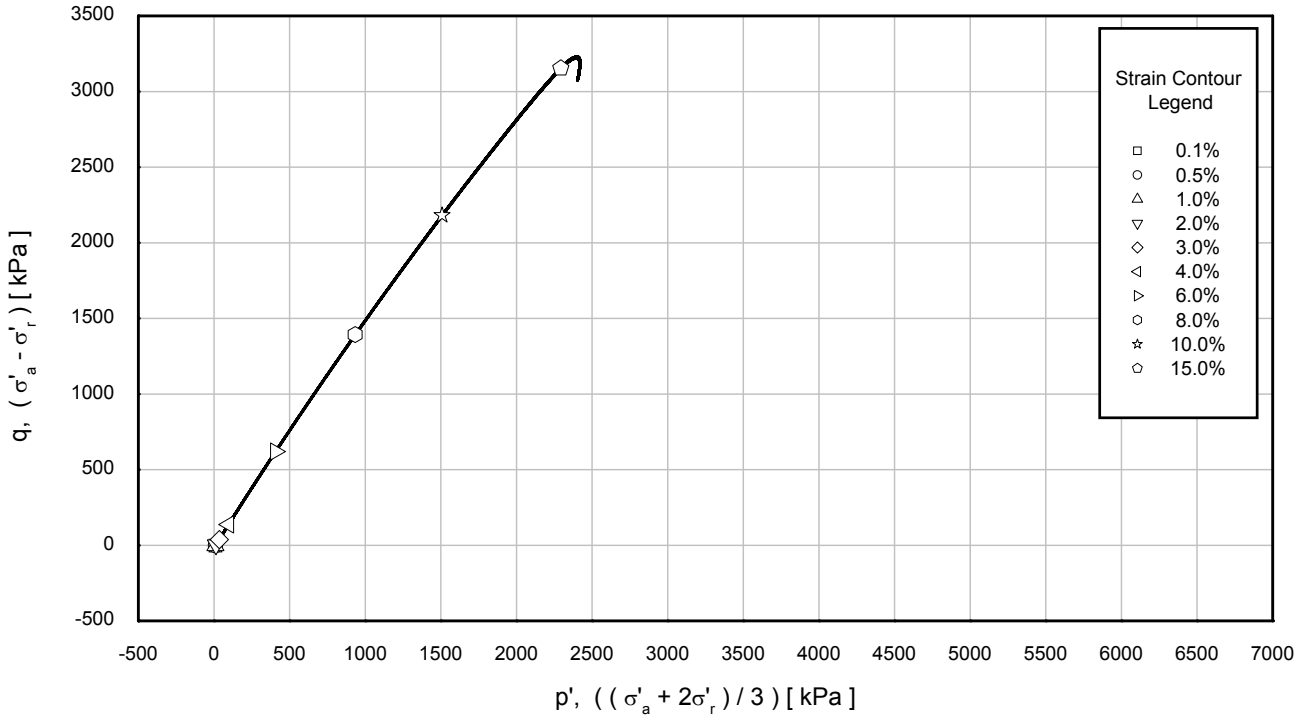


Initial σ'_r	:	10 kPa	Batch	:	2
Initial σ'_a	:	7 kPa	Sample	:	CTX_2-3
q_{peak}	:	3232 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	18.09 %	Test No.	:	CTX11R
Rate of strain	:	4.76 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	10 kPa	Batch	:	2
Initial σ'_a	:	7 kPa	Sample	:	CTX_2-3
q_{peak}	:	3232 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	18.09 %	Test No.	:	CTX11R
Rate of strain	:	4.76 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Light brown fine to medium SAND

GENERAL	
Date test started	24/02/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	69.9
Length	[mm]	140.0
Moisture content	[%]	10.5
Bulk density	[Mg/m³]	1.86
Dry density	[Mg/m³]	1.68
Void ratio	[-]	0.573
Degree of saturation	[%]	48
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 2_CTX-2-4_CTX12
Processed by Date	HJ 03/03/2016
Checked by Date	PH 04/03/2016
Approved by Date	DT 11/03/2016

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-4
Unit	B (Eem/Kreftenheye)
Test number	CTX12

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1070
Mid height PWP	[kPa]	-
B value achieved	[-]	1.00

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1150
Back pressure	[kPa]	1070
Base PWP	[kPa]	1070
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	80
Effective axial pressure	[kPa]	80
Deviator stress	[kPa]	0
Volumetric strain	[%]	0.37
External axial strain	[%]	0.09
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	21.4
Bulk density	[Mg/m³]	2.05
Dry density	[Mg/m³]	1.69
Void ratio	[-]	0.567
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-4
Unit	B (Eem/Kreftenheye)
Test number	CTX12

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	160
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	32
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	296
External ε_{av} at N_f	[%]	-1.24
External ε_{cy} at N_f	[%]	3.38
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	59
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	21.4
Bulk density	[Mg/m³]	2.05
Dry density	[Mg/m³]	1.69
Void ratio	[-]	0.567
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.03	95.59	-	8.55	-
2	0.00	0.03	101.45	-	6.24	-
5	0.00	0.03	101.07	-	4.99	-
10	0.00	0.03	97.80	-	4.42	-
20	0.00	0.03	94.87	-	4.41	-
30	0.00	0.03	91.49	-	4.32	-
40	-0.01	0.04	89.69	-	4.36	-
50	-0.01	0.04	87.29	-	4.47	-
100	-0.01	0.04	79.01	-	4.65	-
200	-0.03	0.05	62.00	-	6.78	-
296	-1.24	3.38	0.94	-	10.79	-

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-4
Unit	B (Eem/Kreftenheye)
Test number	CTX12

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	5
Initial effective axial pressure	[kPa]	5
Rate of strain	[%/hour]	0.94
At peak deviator stress		
Corrected deviator stress	[kPa]	2890
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	14.24
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-1002
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	1082
Effective axial pressure	[kPa]	3972
Principal effective stress ratio	[-]	-0.02
ε_{50}	[%]	7.65
Secant modulus (E_{50}) at ε_{50}	[kPa]	24526
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	2869
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	13.06
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-972
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	1052
Effective axial pressure	[kPa]	3921
Principal effective stress ratio	[-]	139.50
At 10% external axial strain		
Corrected deviator stress	[kPa]	2429
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	-766
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	846
Effective axial pressure	[kPa]	3275
Principal effective stress ratio	[-]	-0.71

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-4
Unit	B (Eem/Kreftenheye)
Test number	CTX12

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



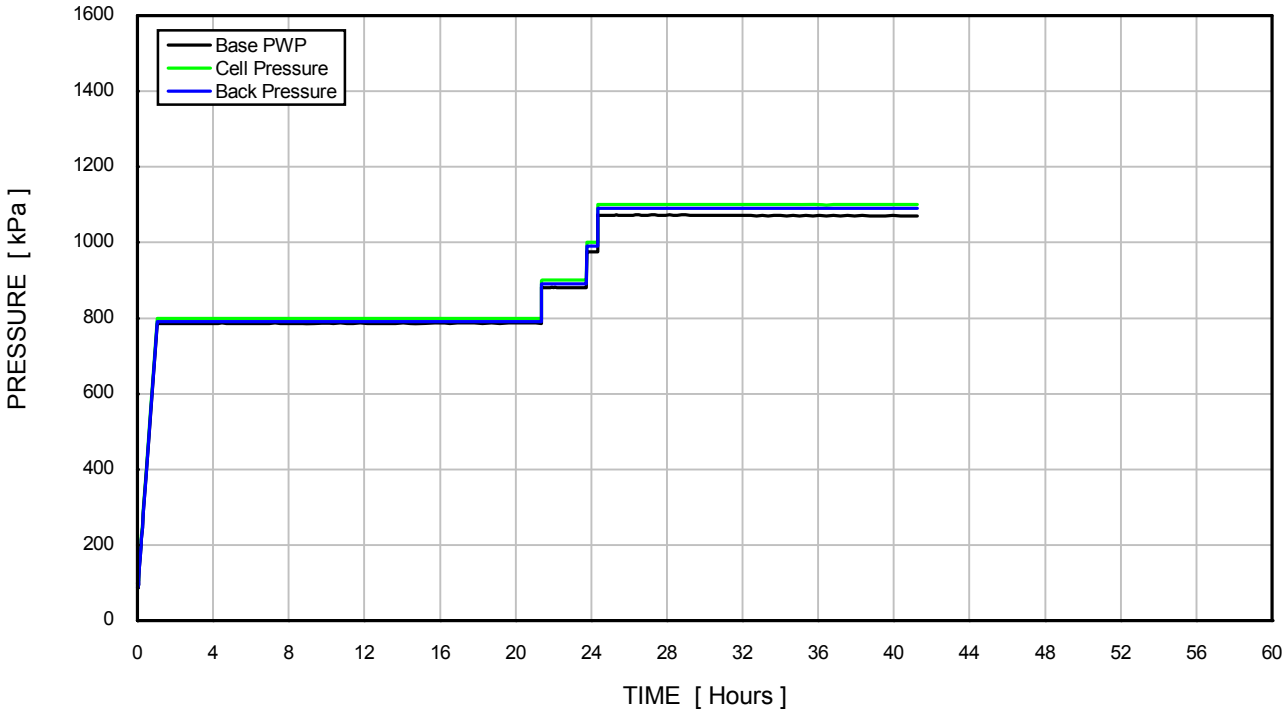


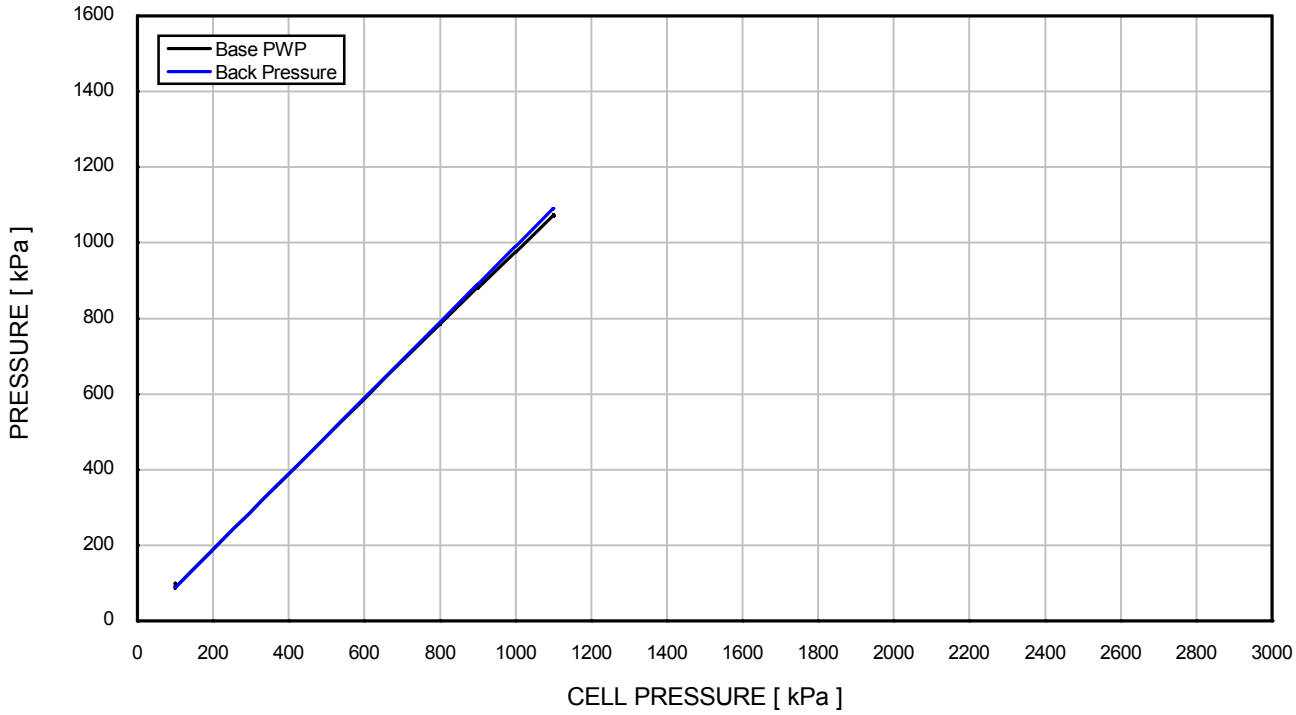
FINAL CONDITIONS		
Moisture content	[%]	21.4
Bulk density	[Mg/m³]	2.05
Dry density	[Mg/m³]	1.69

TEST IDENTIFICATION	
Batch	2
Sample	CTX_2-4
Unit	B (Eem/Kreftenheye)
Test number	CTX12

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

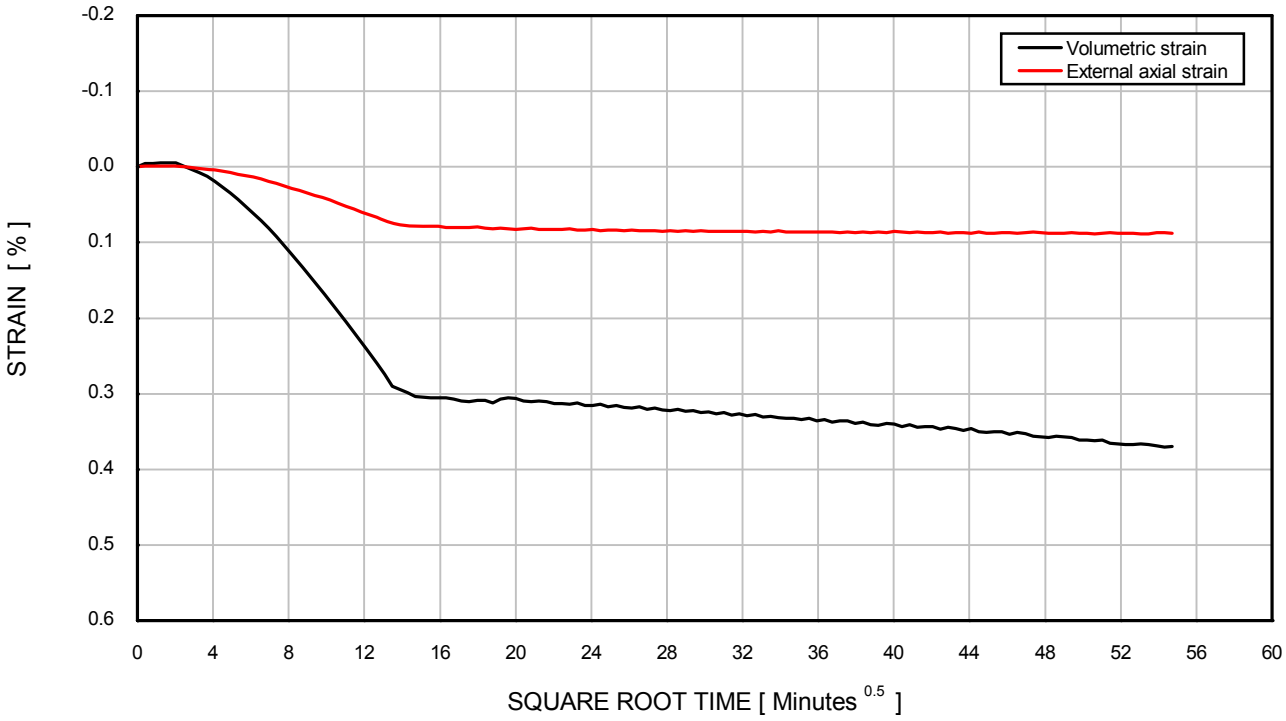


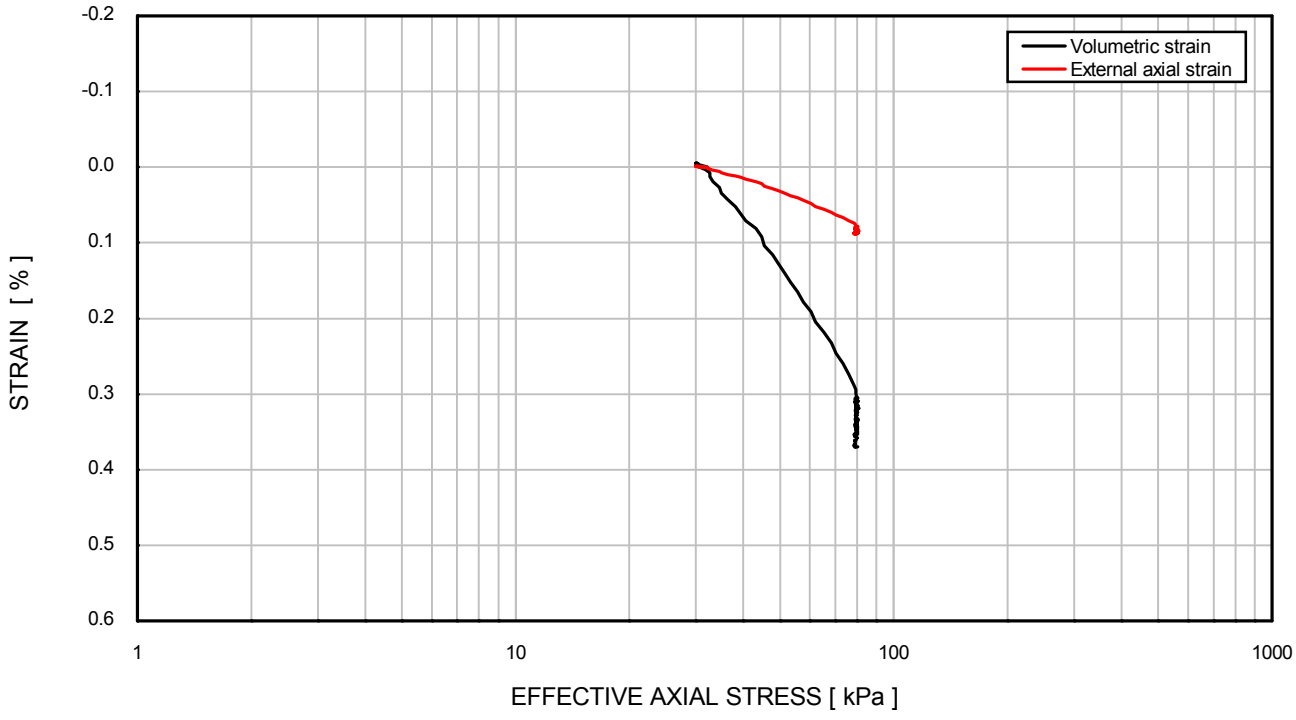


B value	:	0.95			
Initial σ'_r	:	2	kPa	Batch	: 2
Initial σ'_a	:	2	kPa	Sample	: CTX_2-3
Final σ'_r	:	29	kPa	Unit	: B (Eem/Kreftenheye)
Final σ'_a	:	29	kPa	Test No.	: CTX12

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

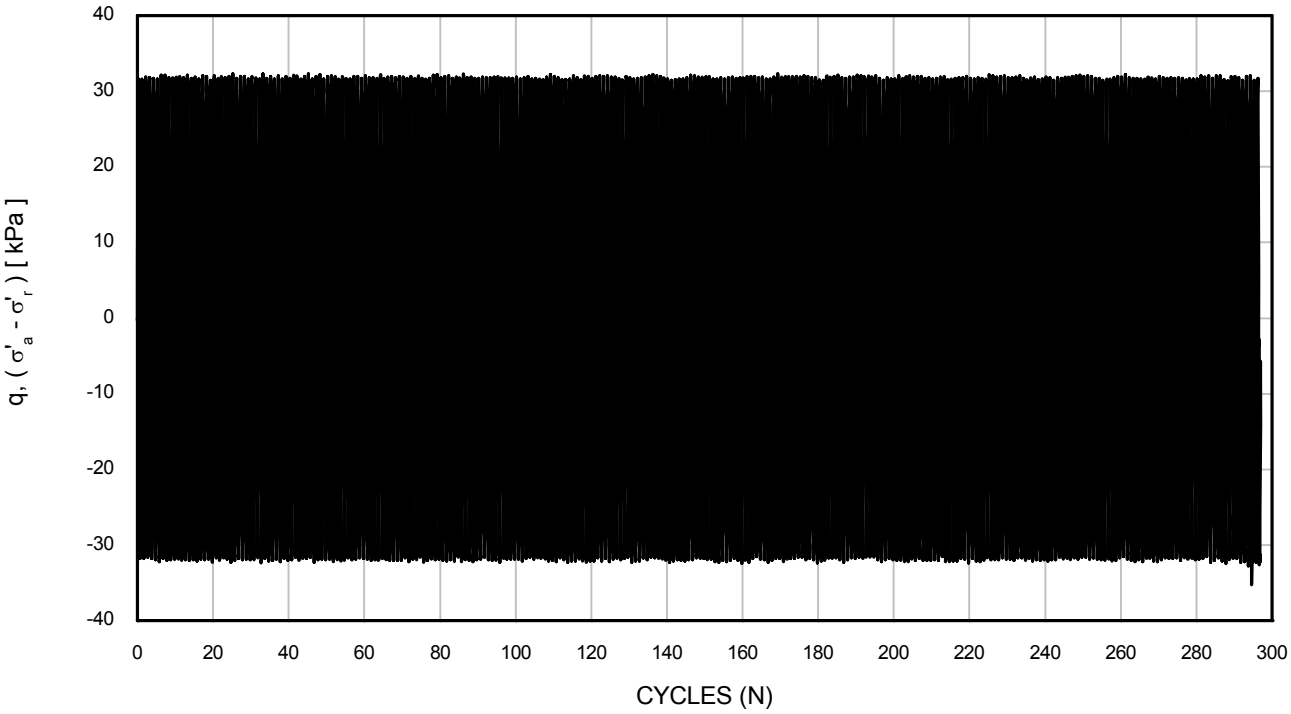


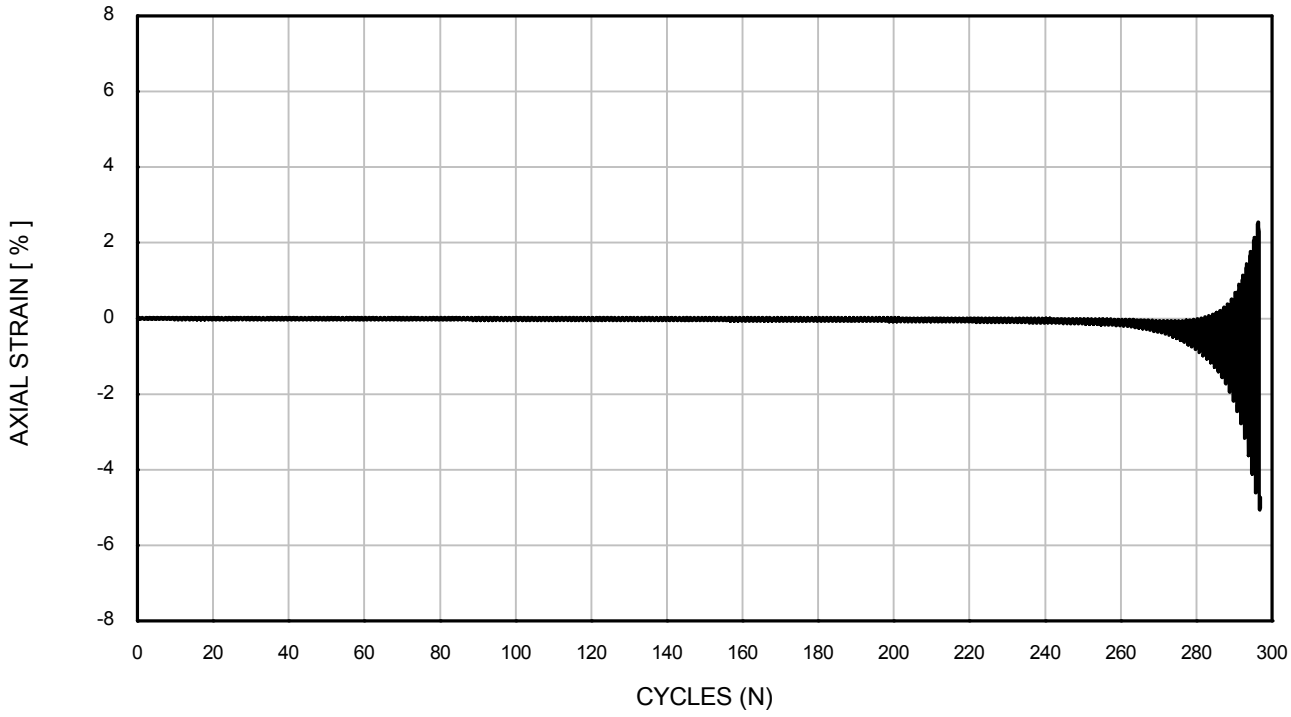


σ'_{rc}	:	80 kPa	Batch	:	2
σ'_{ac}	:	80 kPa	Sample	:	CTX_2-3
			Unit	:	B (Eem/Kreftenheye)
			Test No.	:	CTX12

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

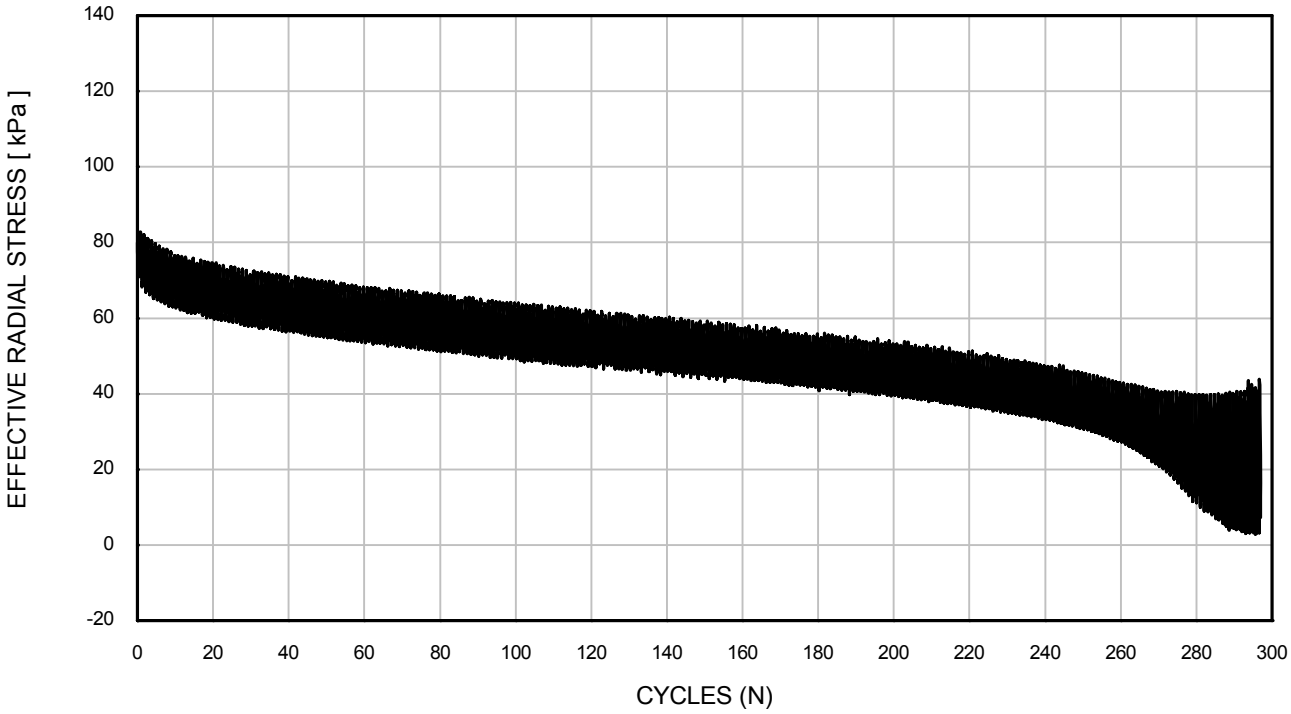


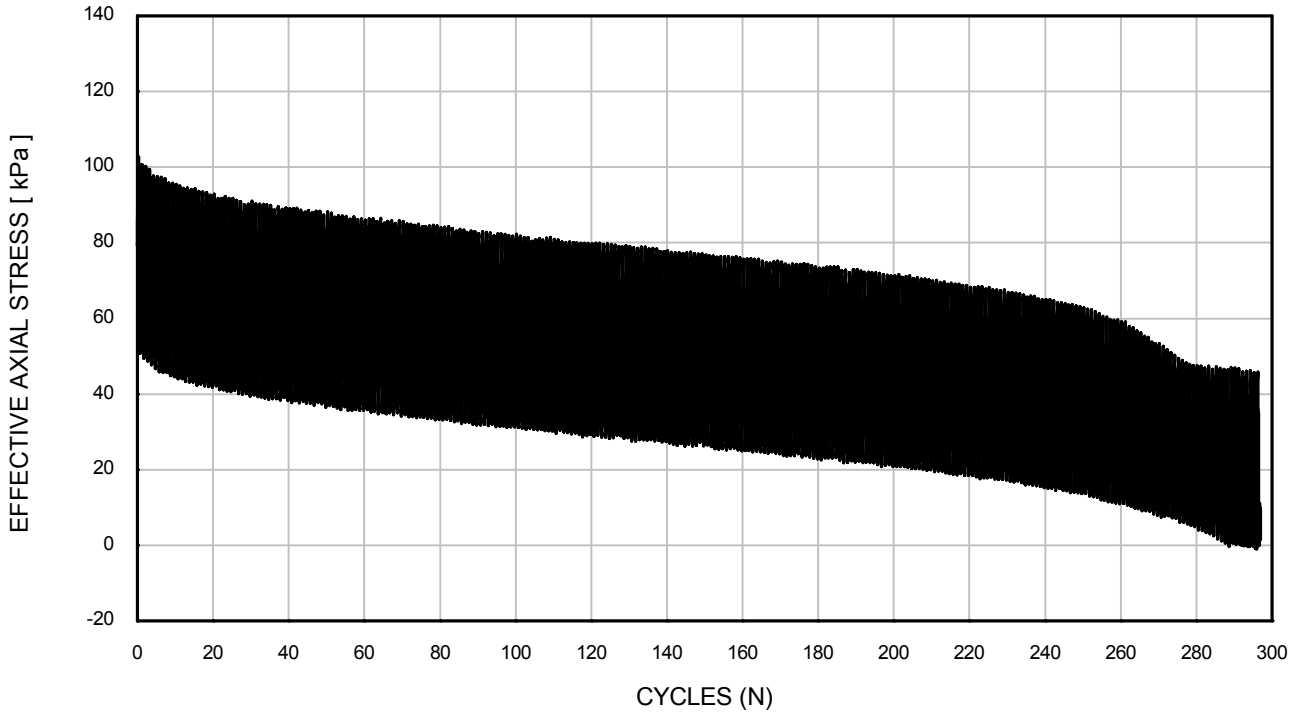


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-3
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	32 kPa	Test No.	:	CTX12
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

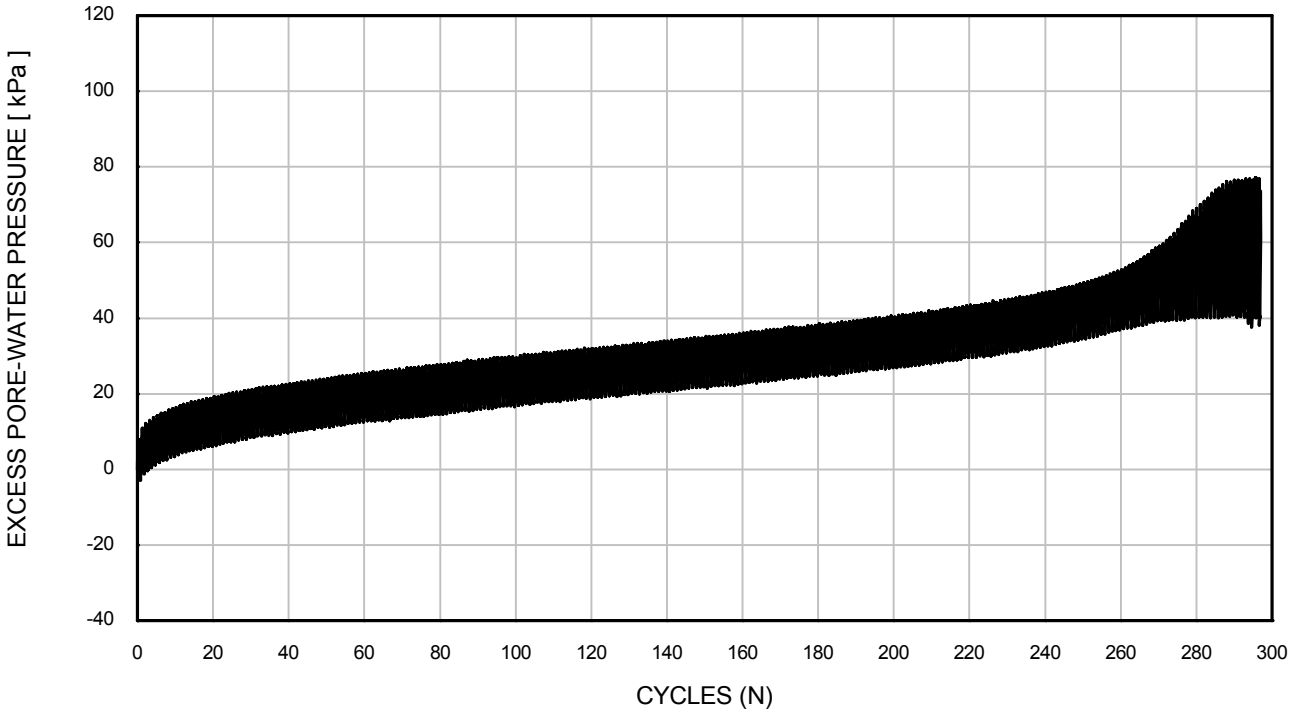


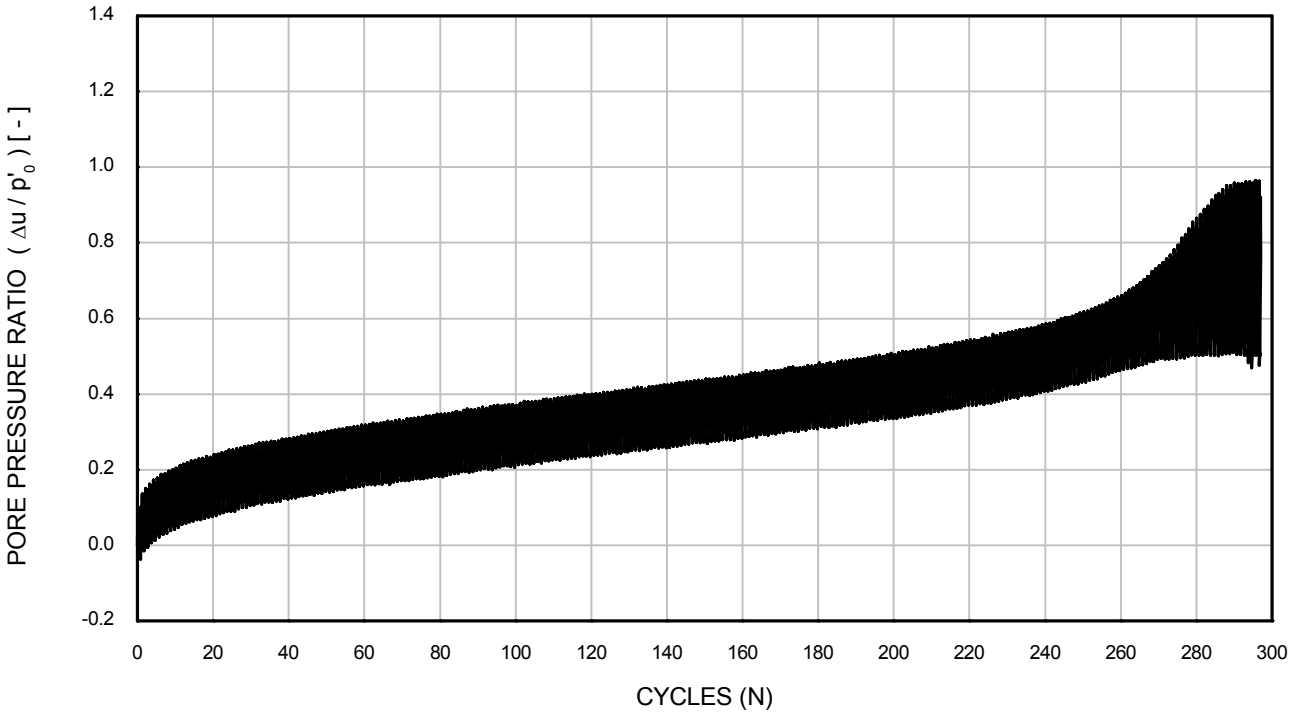


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-3
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	32 kPa	Test No.	:	CTX12
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

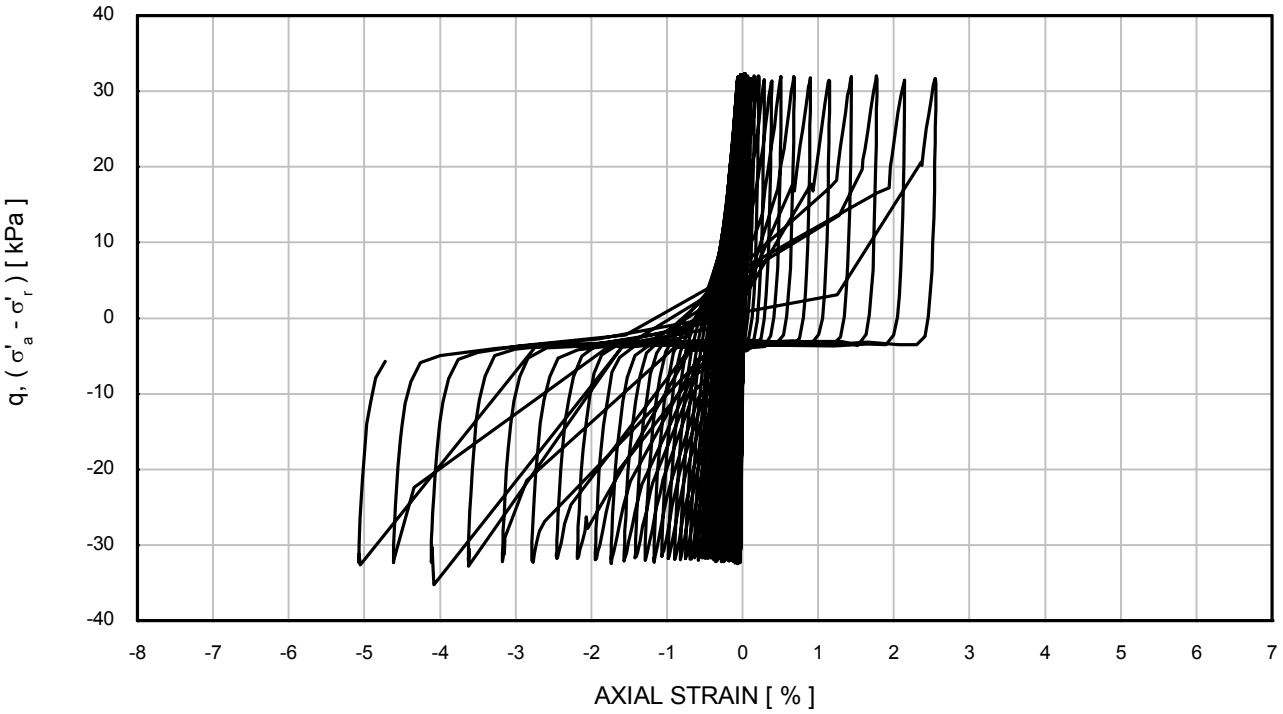


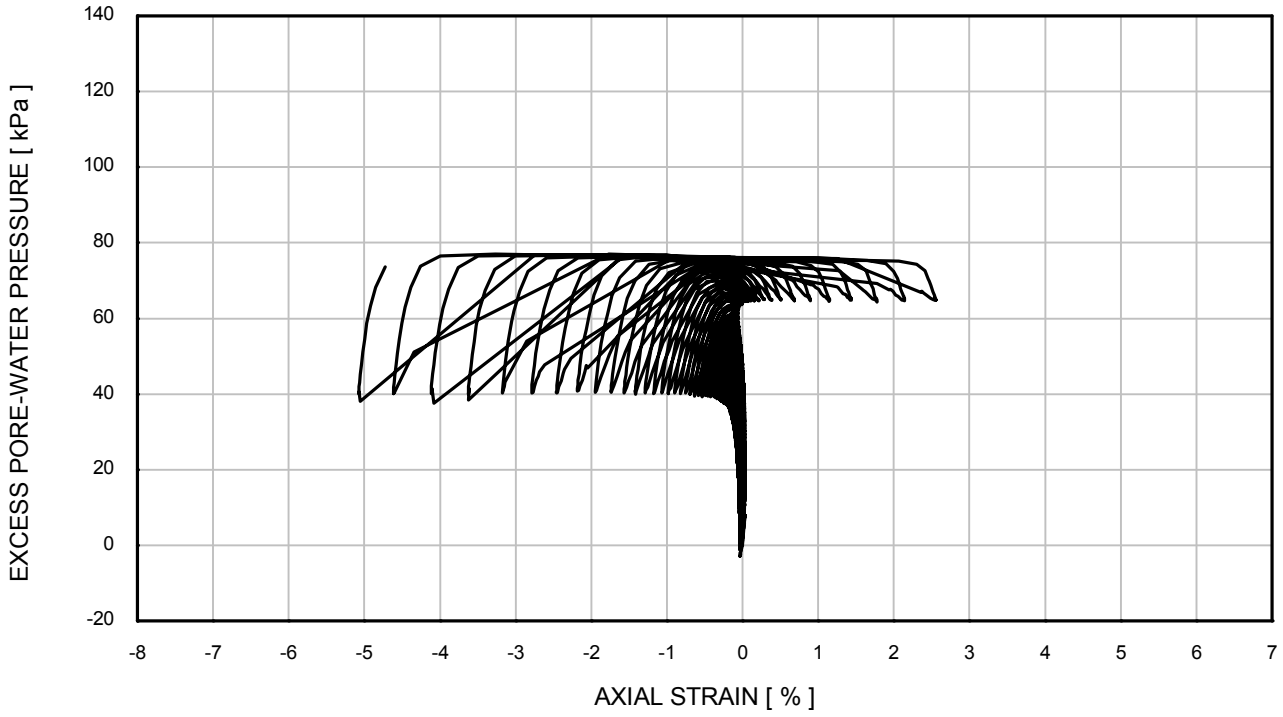


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	32	kPa	Test No.	: CTX12
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

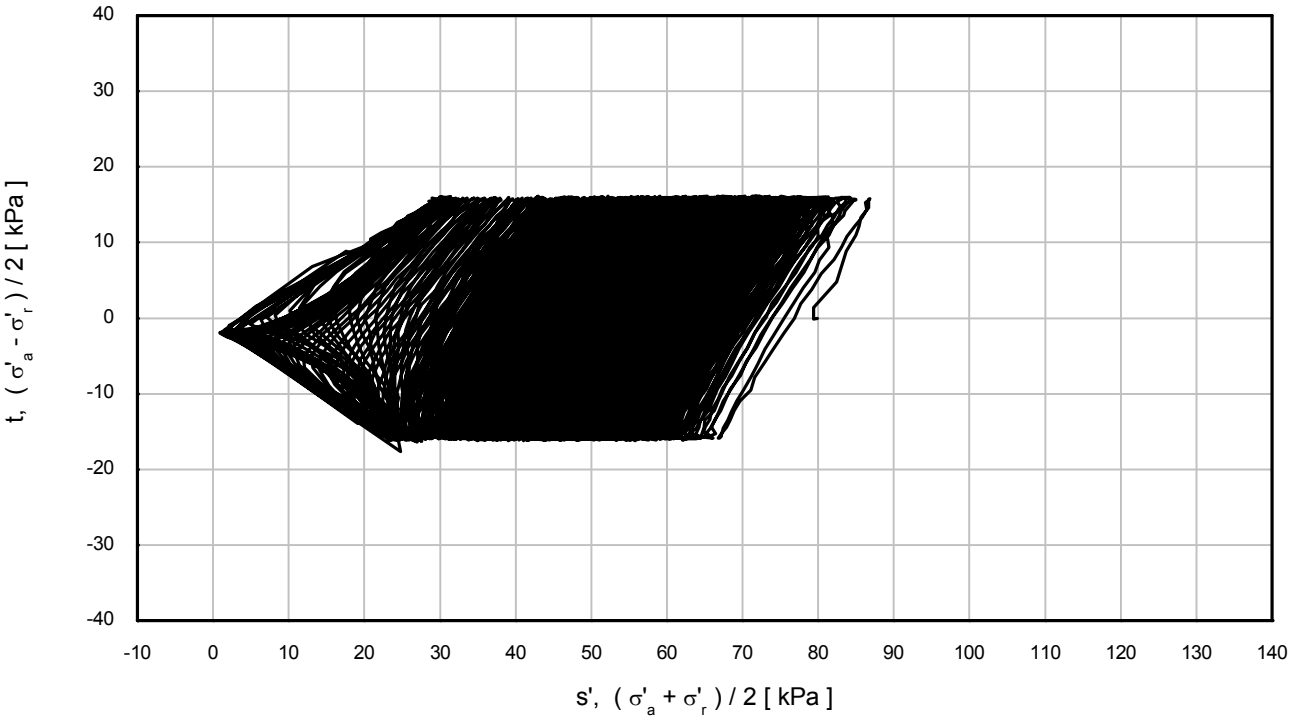


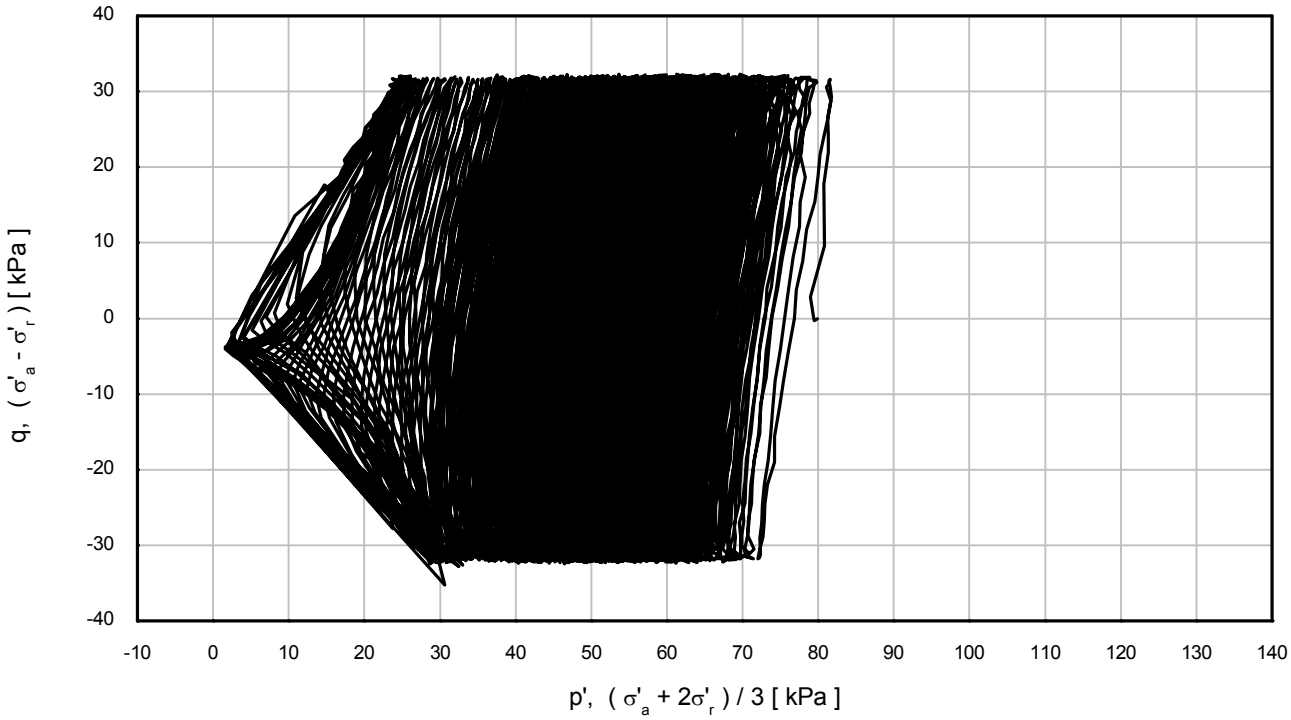


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-3
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	32 kPa	Test No.	:	CTX12
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

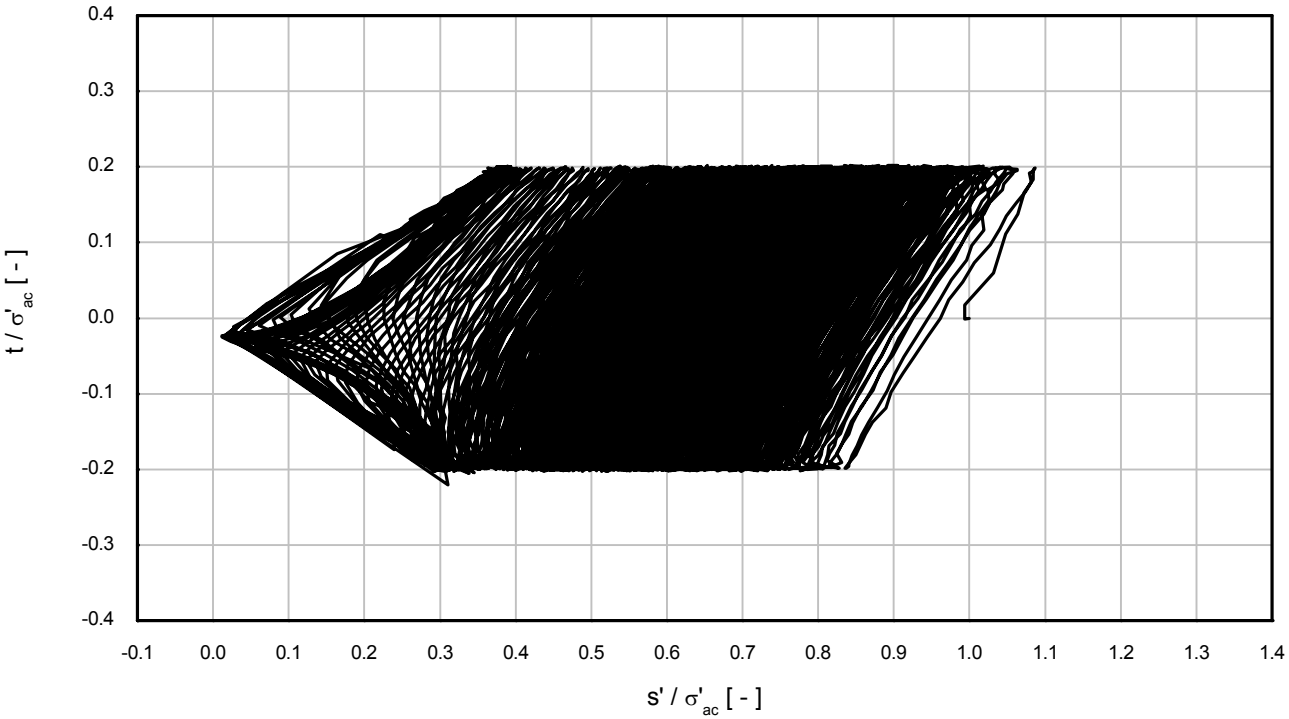


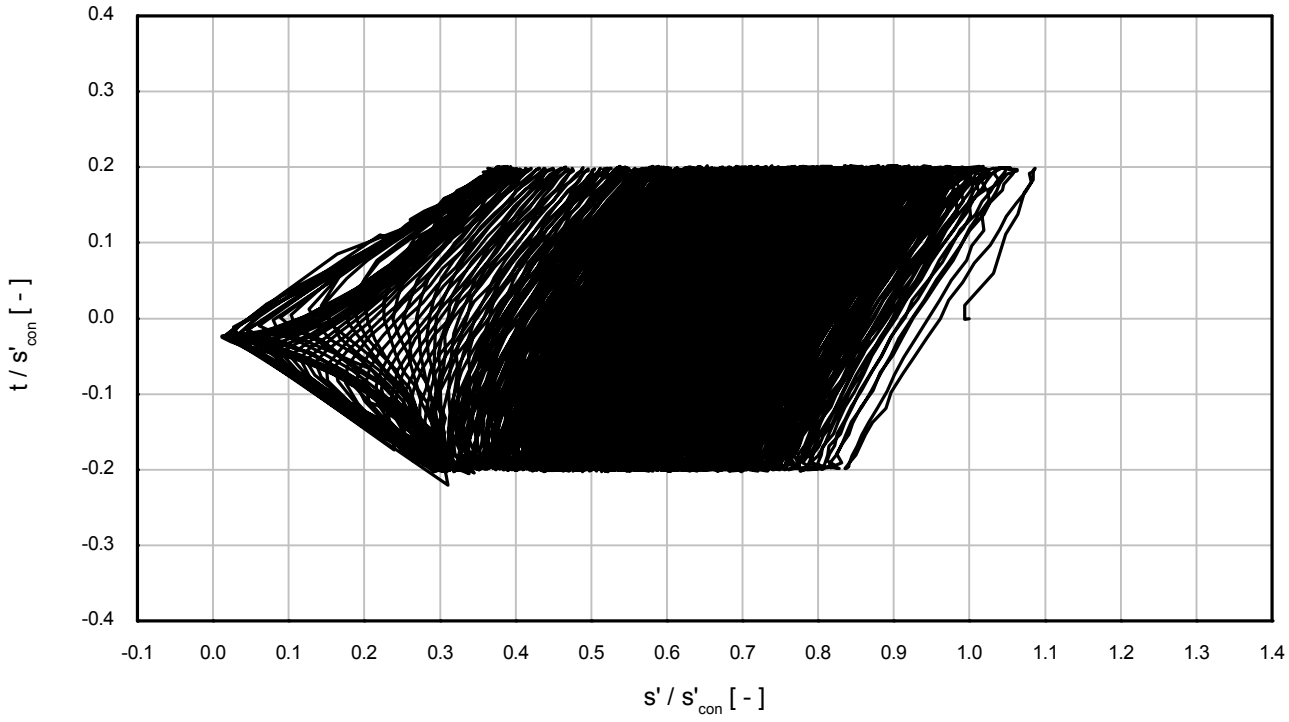


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	32	kPa	Test No.	: CTX12
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

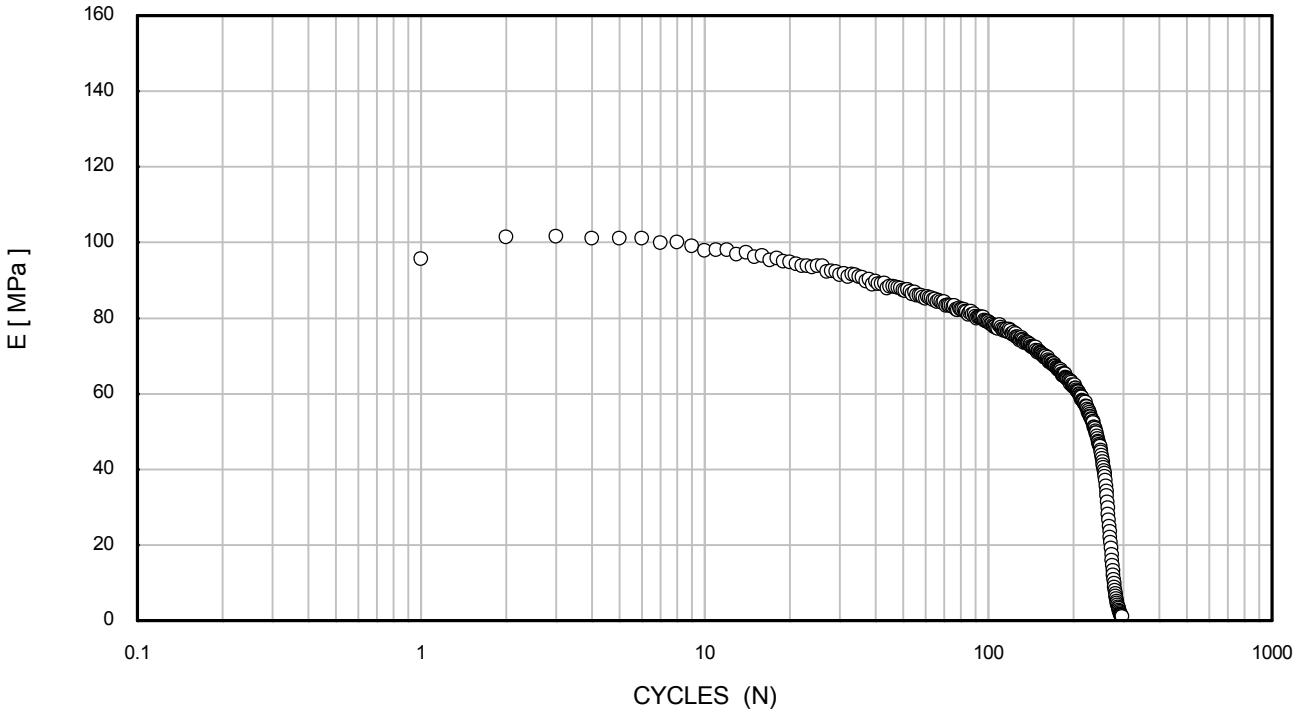


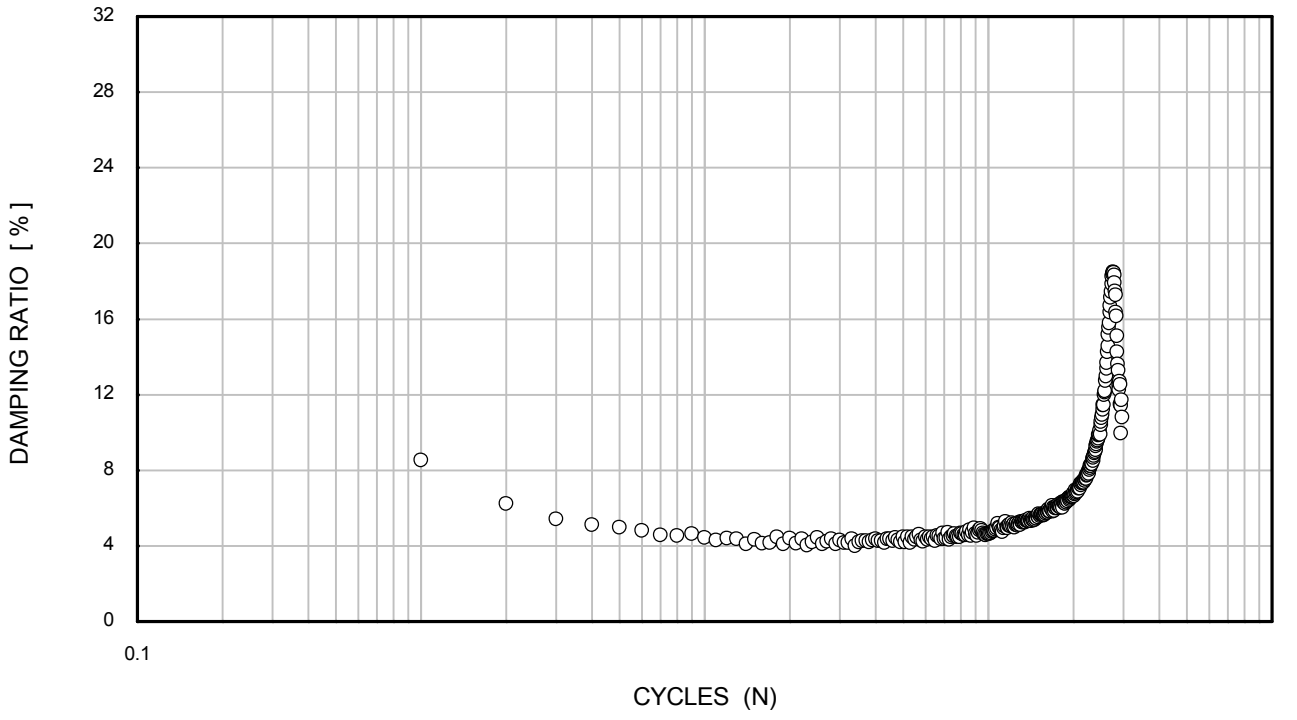


Initial σ'_r	:	80	kPa	Batch	: 2
Initial σ'_a	:	80	kPa	Sample	: CTX_2-3
q_{av}	:	0	kPa	Unit	: B (Eem/Kreftenheye)
q_{cy}	:	32	kPa	Test No.	: CTX12
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

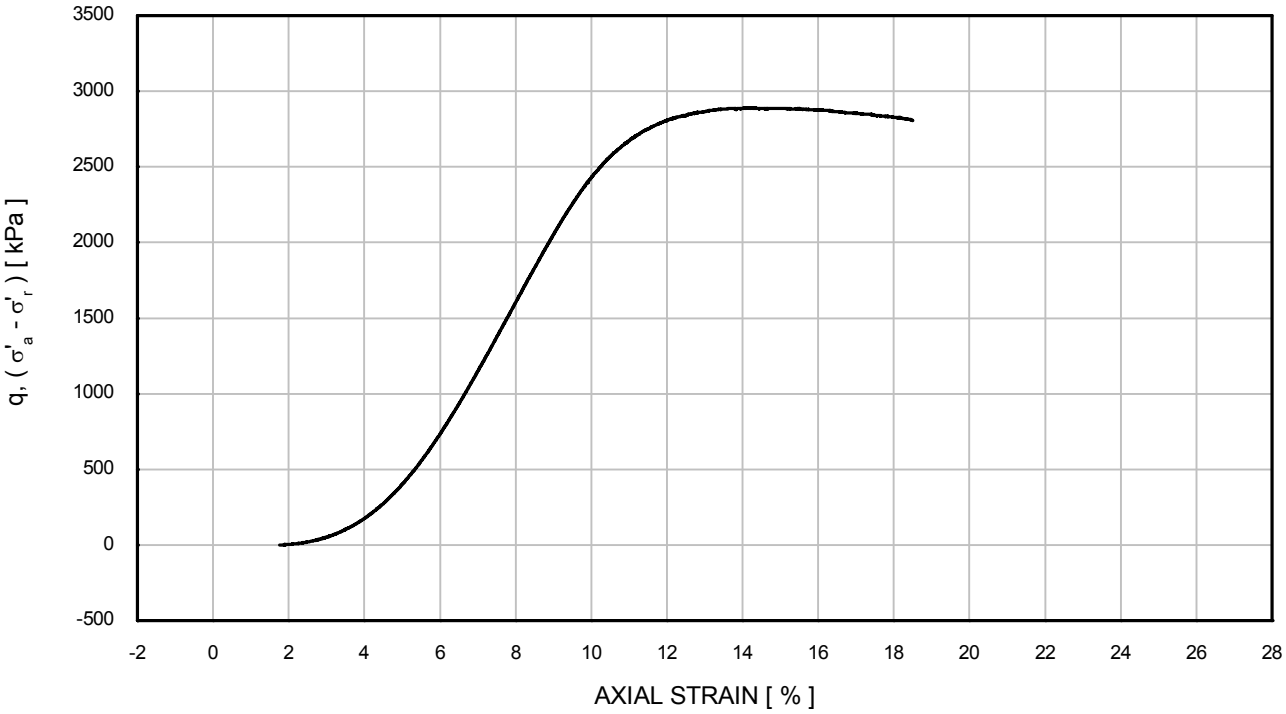


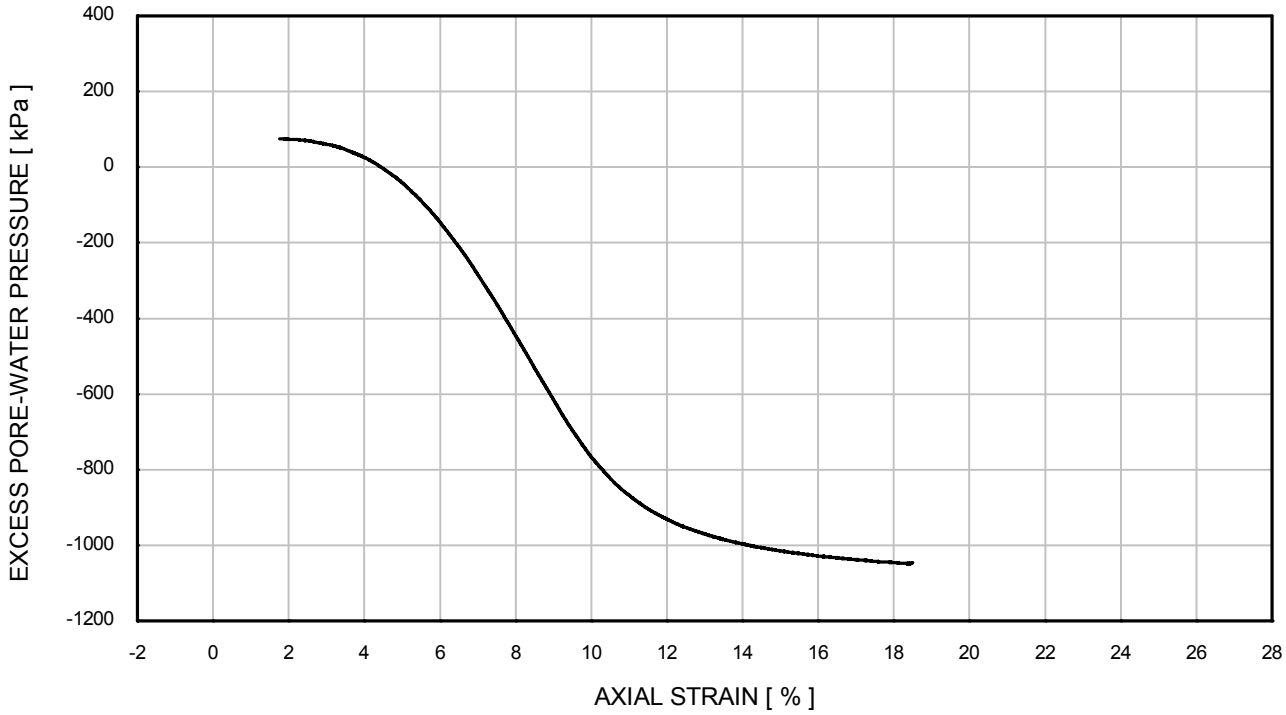


Initial σ'_r	:	80 kPa	Batch	:	2
Initial σ'_a	:	80 kPa	Sample	:	CTX_2-3
q_{av}	:	0 kPa	Unit	:	B (Eem/Kreftenheye)
q_{cy}	:	32 kPa	Test No.	:	CTX12
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

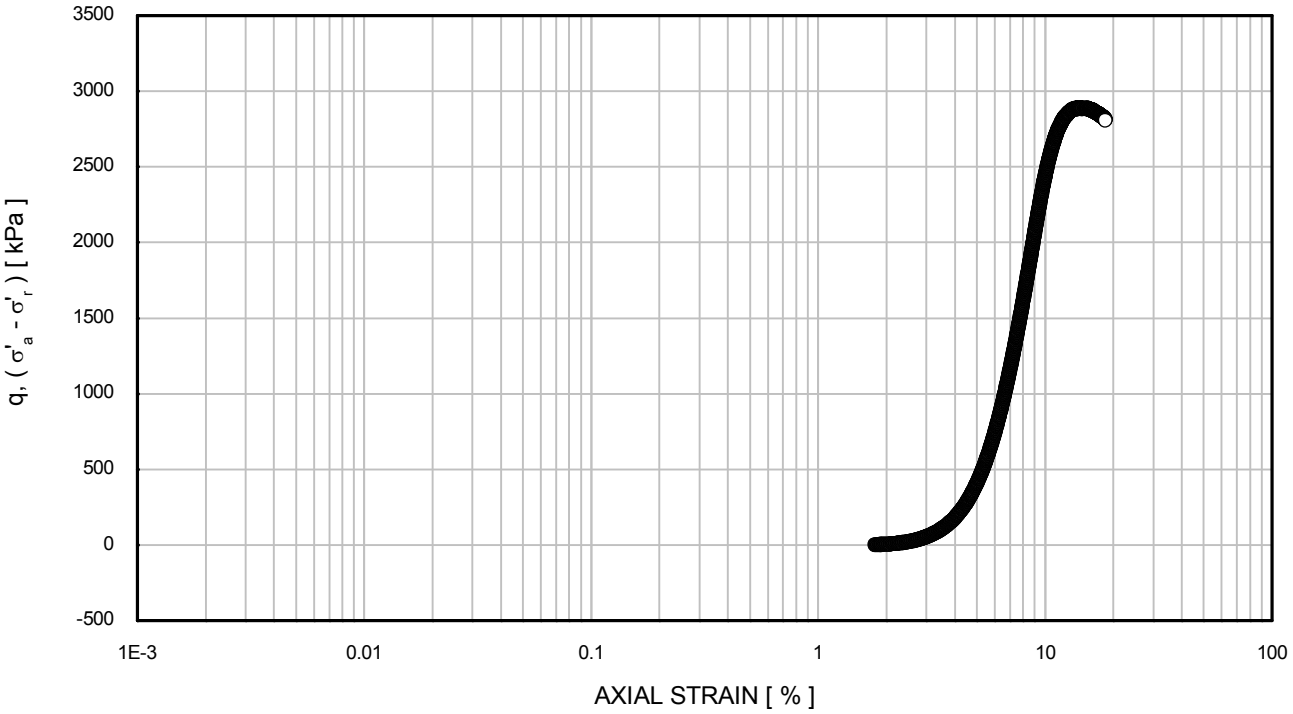


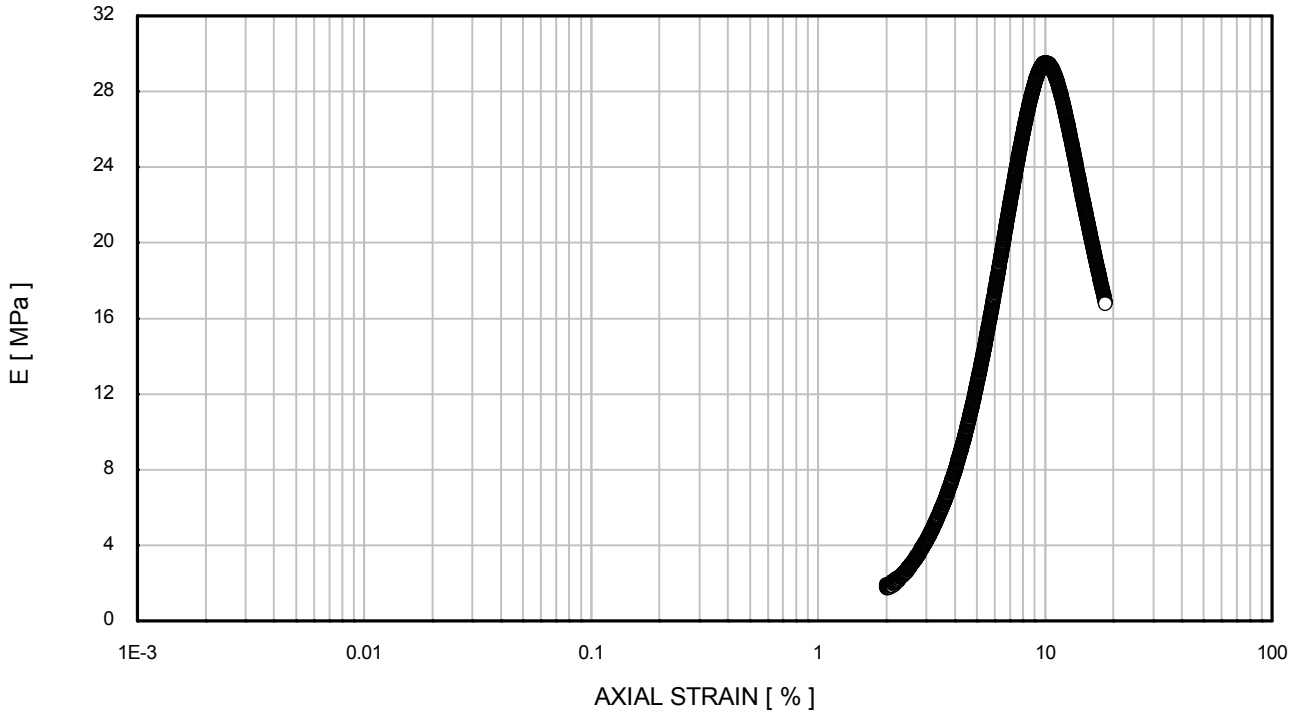


Initial σ'_r	:	5 kPa	Batch	:	2
Initial σ'_a	:	5 kPa	Sample	:	CTX_2-3
q_{peak}	:	2890 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	14.24 %	Test No.	:	CTX12
Rate of strain	:	0.94 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

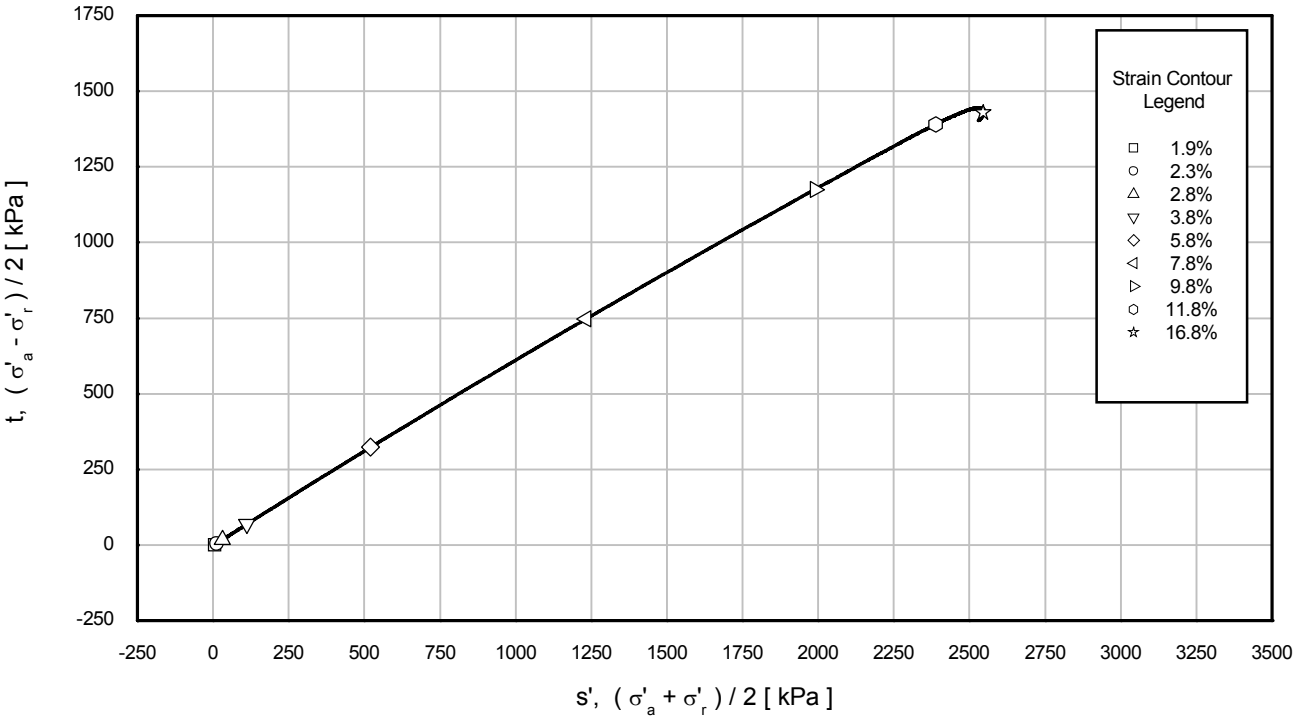


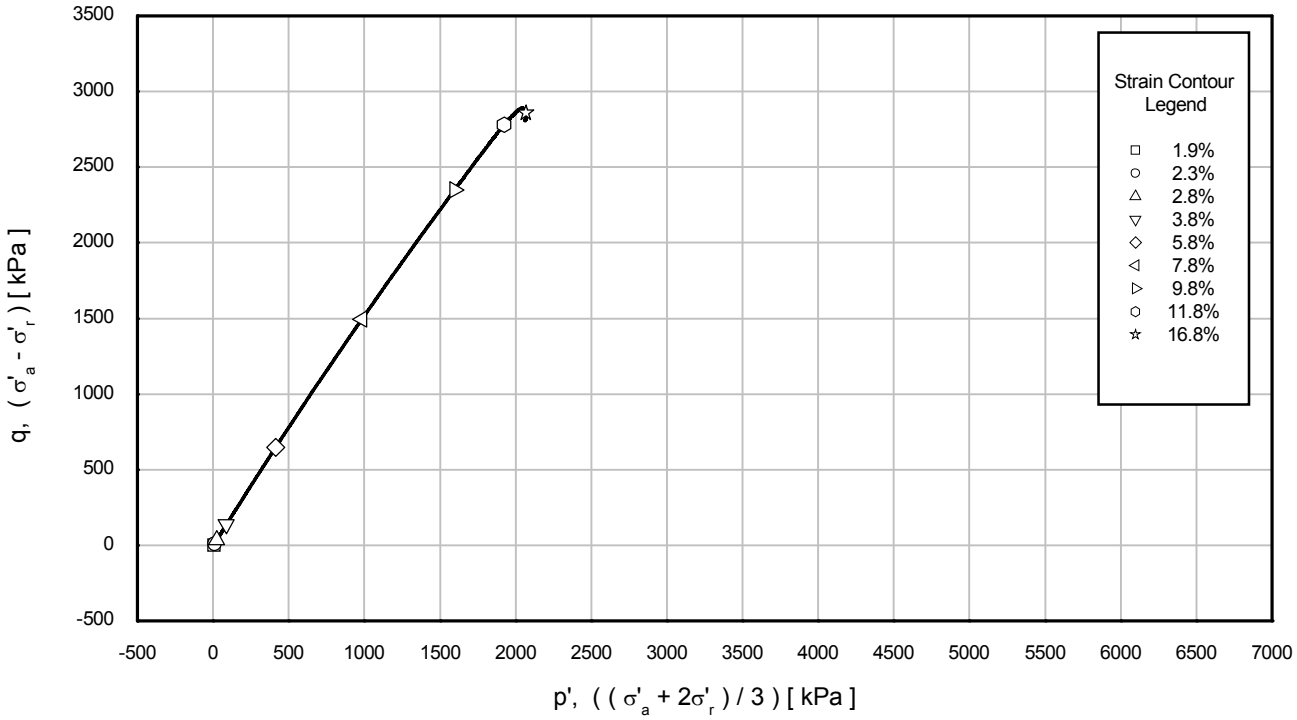


Initial σ'_r	:	5 kPa	Batch	:	2
Initial σ'_a	:	5 kPa	Sample	:	CTX_2-3
q_{peak}	:	2890 kPa	Unit	:	B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	14.24 %	Test No.	:	CTX12
Rate of strain	:	0.94 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	5	kPa	Batch	: 2
Initial σ'_a	:	5	kPa	Sample	: CTX_2-3
q_{peak}	:	2890	kPa	Unit	: B (Eem/Kreftenheye)
Ext. ε at q_{peak}	:	14.24	%	Test No.	: CTX12
Rate of strain	:	0.94	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Very dark grey slightly silty fine SAND

GENERAL	
Date test started	13/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	9.7
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.639
Degree of saturation	[%]	40
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic	BS1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ BATCH3_CTX_3-1_CTX13
Processed by Date	LJ 22/01/2016
Checked by Date	PH 08/02/2016
Approved by Date	PH 08/02/2016

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-1
Unit	E3 (Tongeren)
Test number	CTX13

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1090
Mid height PWP	[kPa]	-
B value achieved	[-]	1.00

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1390
Back pressure	[kPa]	1090
Base PWP	[kPa]	1090
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	300
Effective axial pressure	[kPa]	300
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.58
External axial strain	[%]	0.91
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	22.5
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.66
Void ratio	[-]	0.596
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-1
Unit	E3 (Tongeren)
Test number	CTX13

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deivator)	[kPa]	600
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	119
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1
External ε_{av} at N_f	[%]	-2.95
External ε_{cy} at N_f	[%]	3.05
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	121
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	22.5
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.66
Void ratio	[-]	0.596
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-2.95	3.05	3.91	-	28.84	-

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-1
Unit	E3 (Tongeren)
Test number	CTX13

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



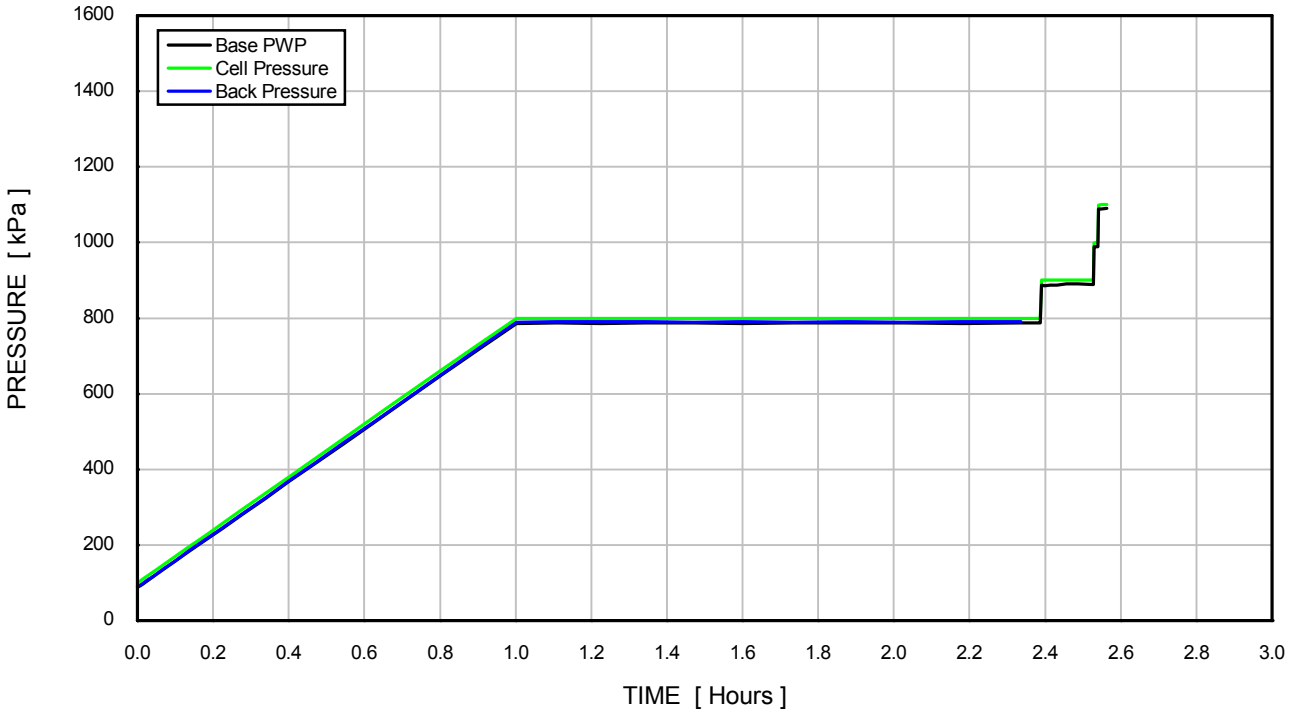


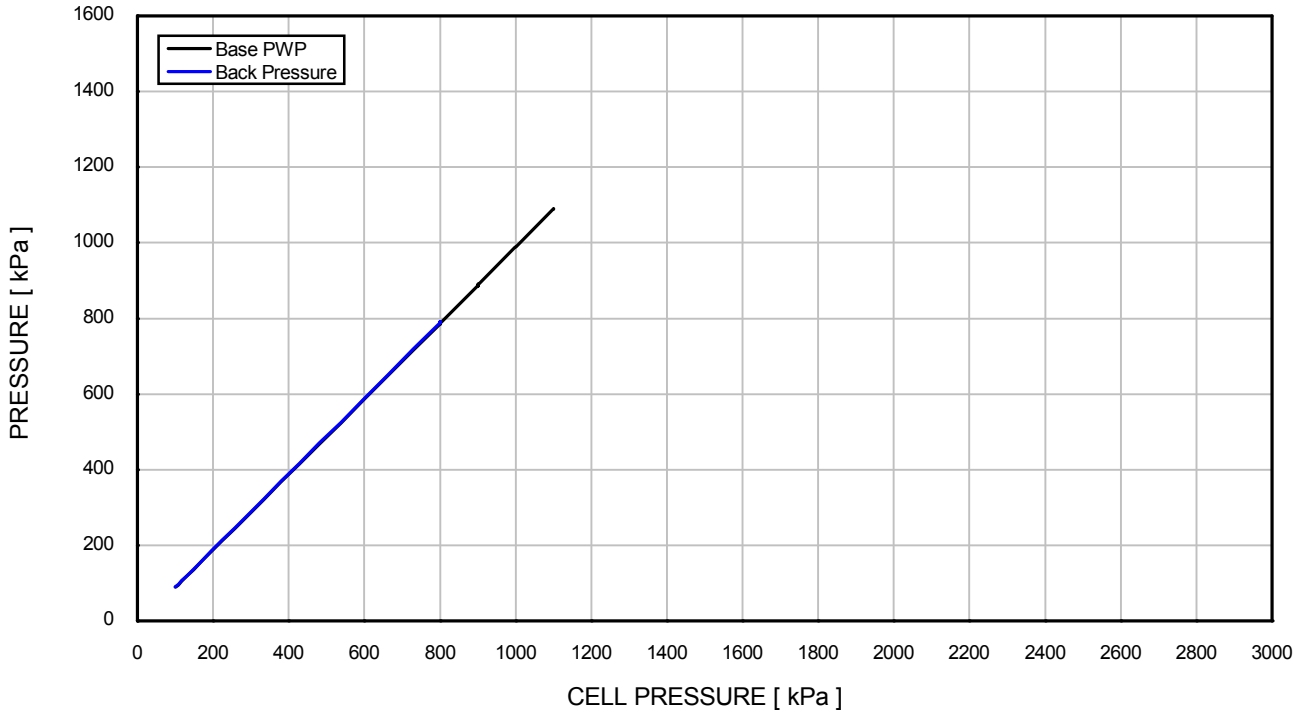
FINAL CONDITIONS		
Moisture content	[%]	22.5
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.66

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-1
Unit	E3 (Tongeren)
Test number	CTX13

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

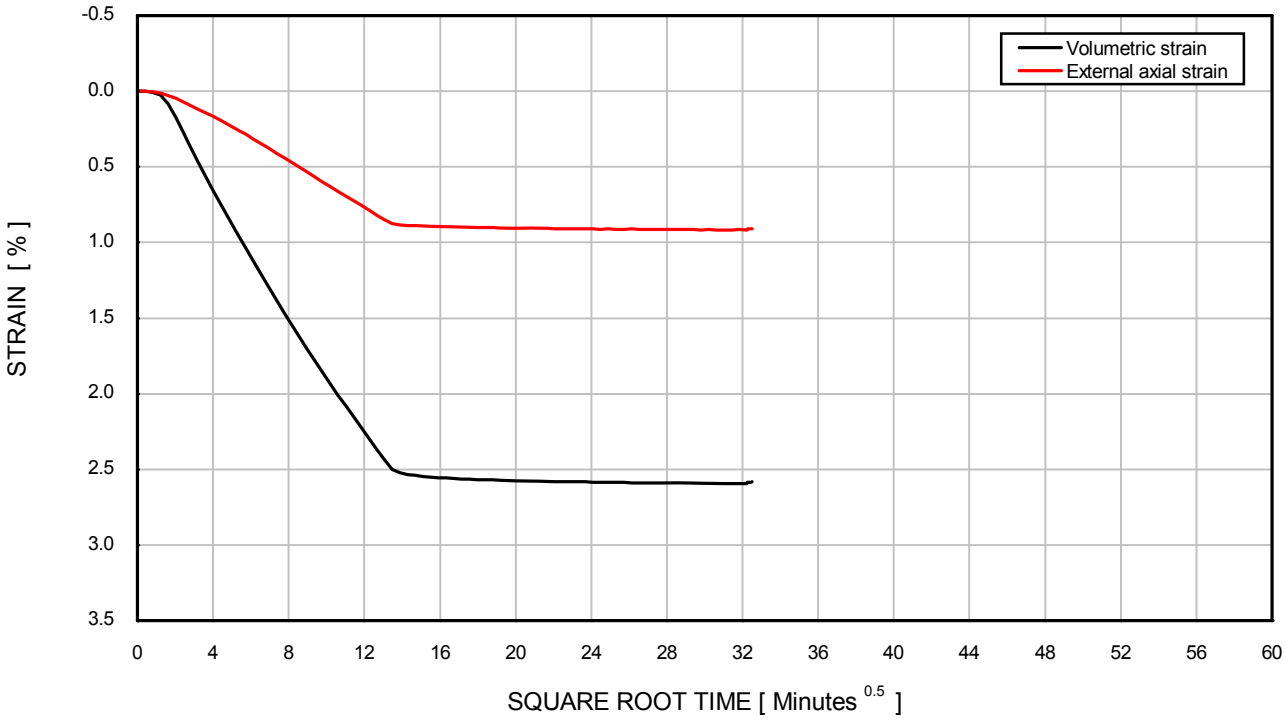


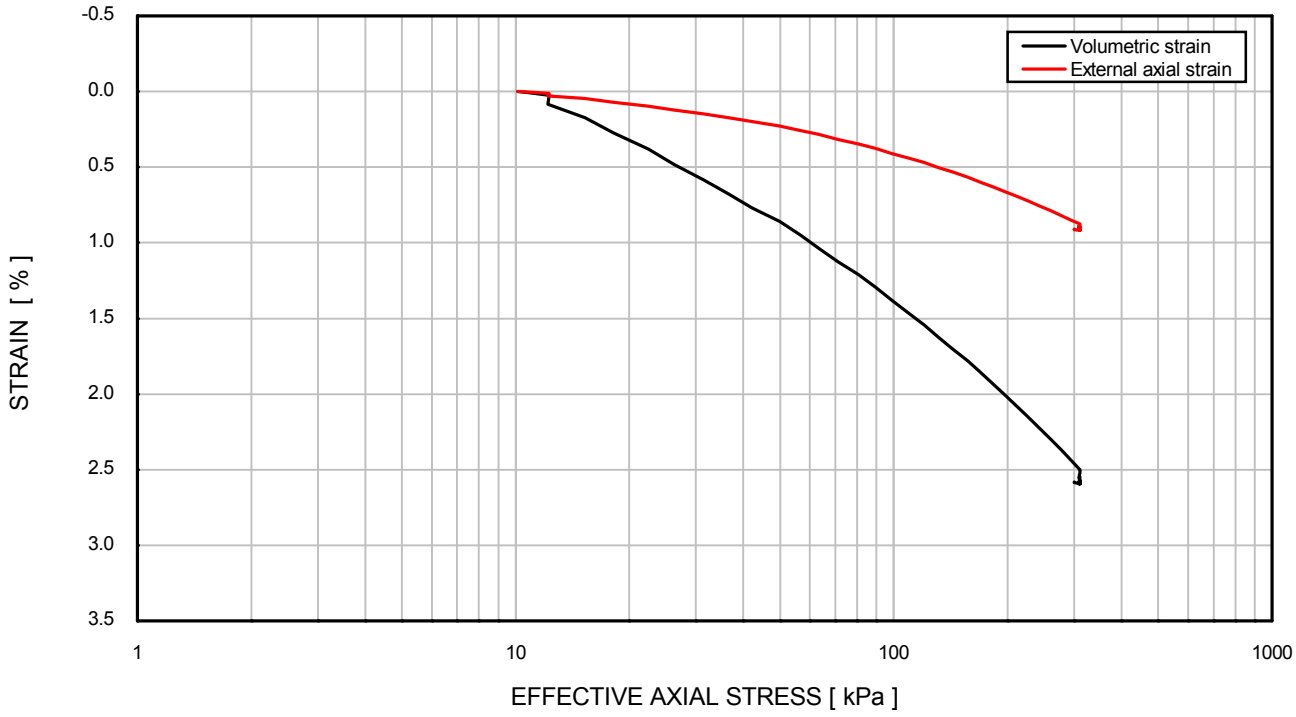


B value	:	1.00			
Initial σ'_r	:	11	kPa	Batch	: 3
Initial σ'_a	:	11	kPa	Sample	: CTX_3-1
Final σ'_r	:	10	kPa	Unit	: E3 (Tongeren)
Final σ'_a	:	10	kPa	Test No.	: CTX13

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

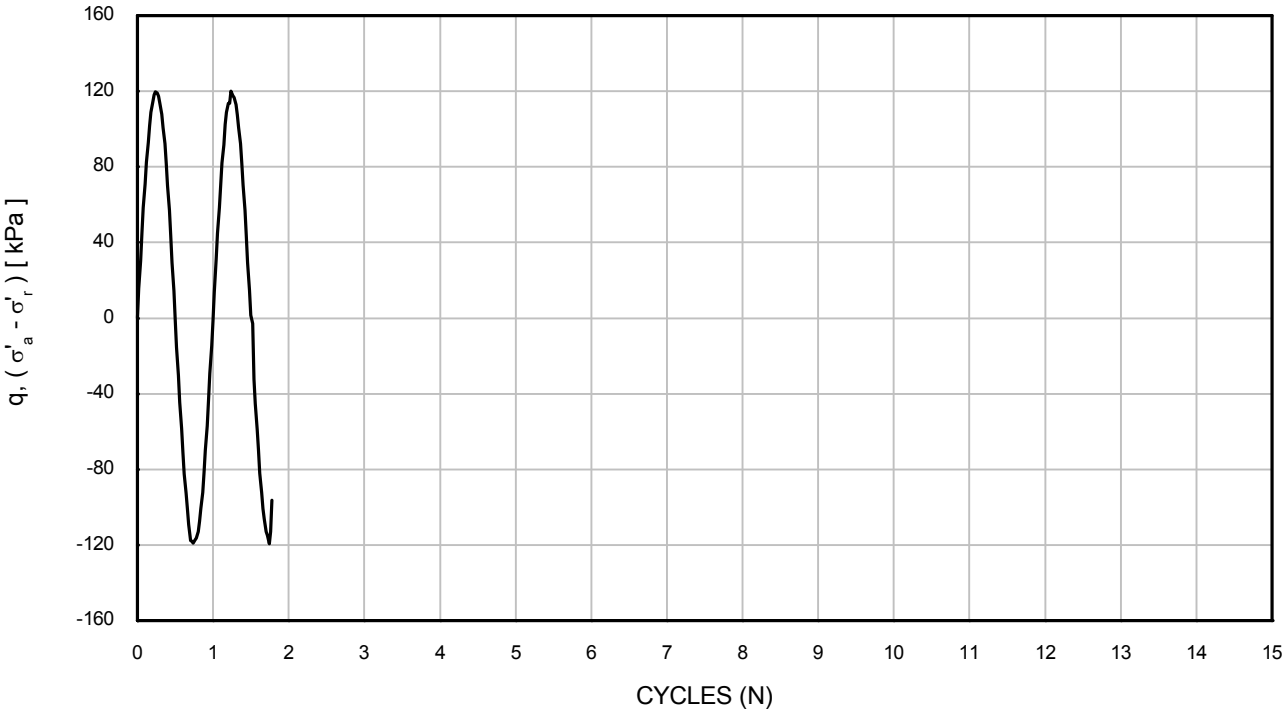


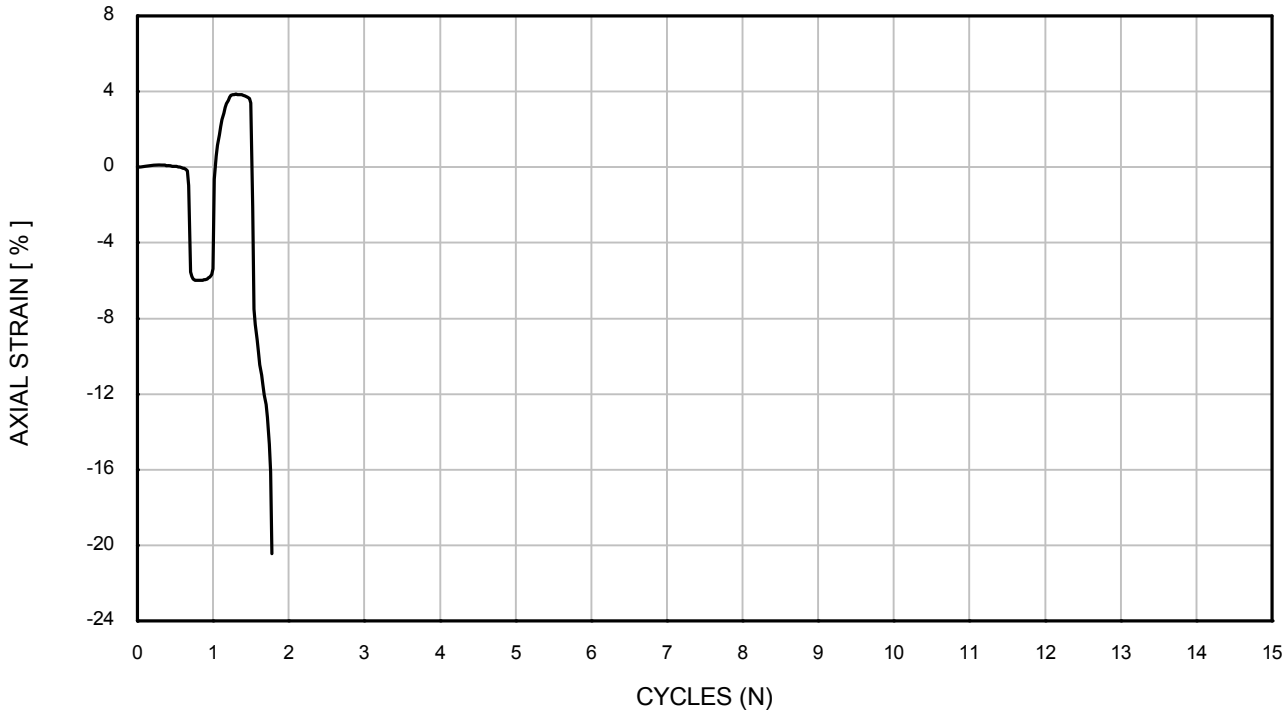


σ'_{rc}	: 300 kPa	Batch	: 3
σ'_{ac}	: 300 kPa	Sample	: CTX_3-1
		Unit	: E3 (Tongeren)
		Test No.	: CTX13

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

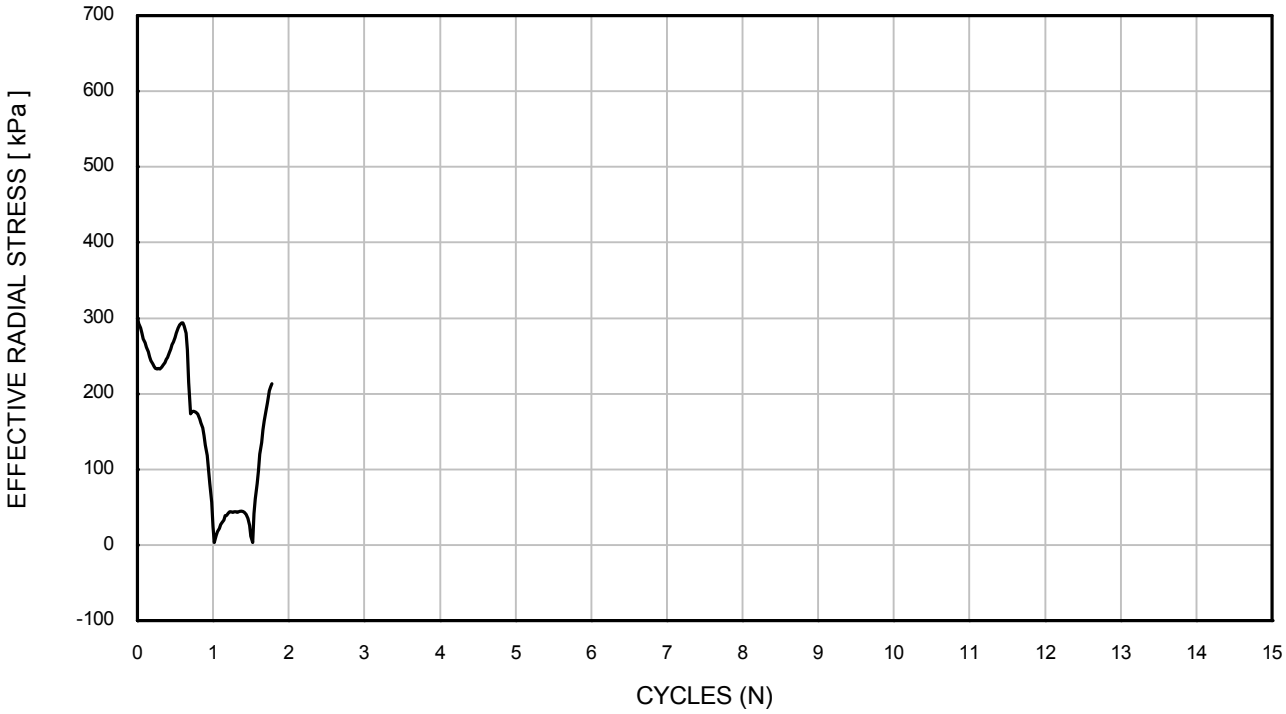


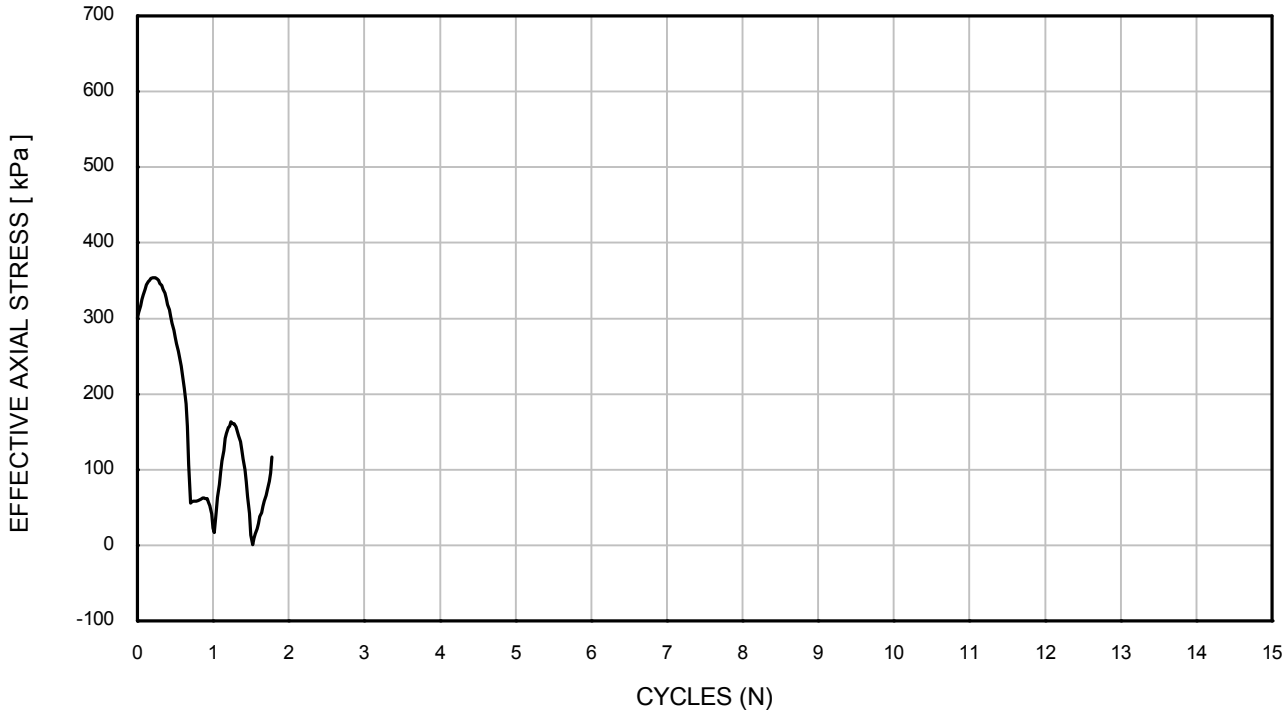


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-1
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	120 kPa	Test No.	:	CTX13
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

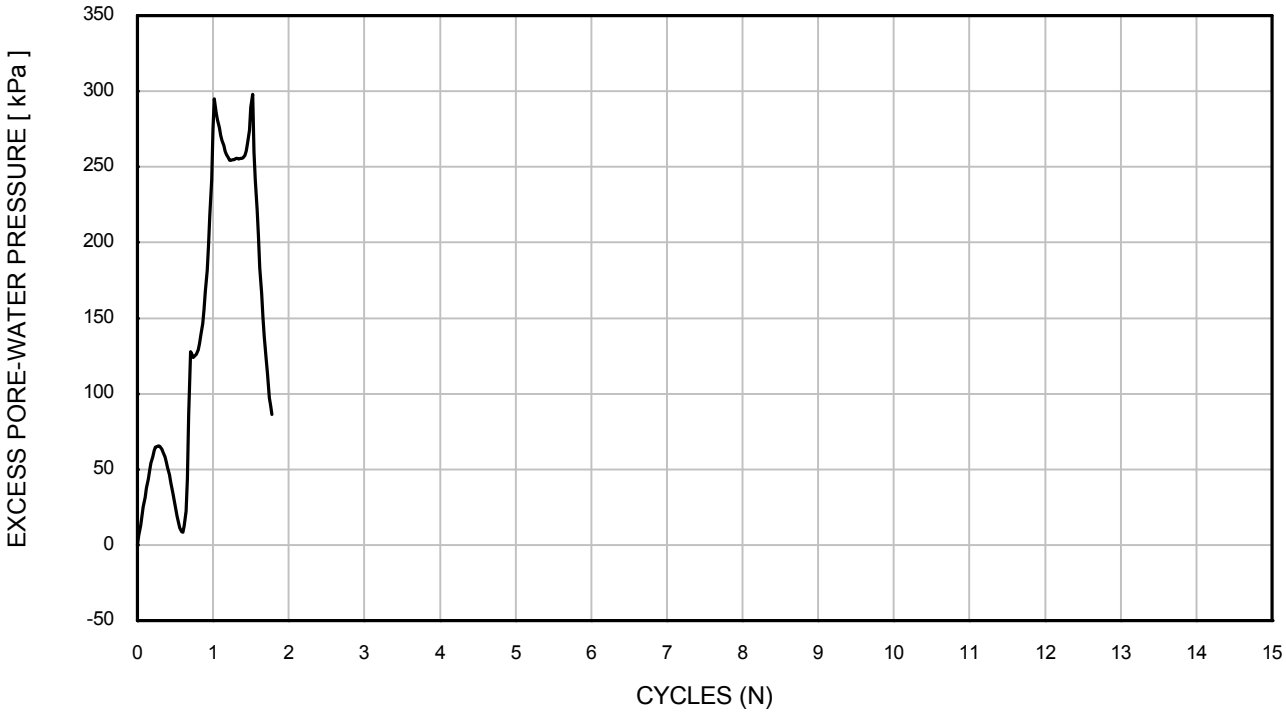


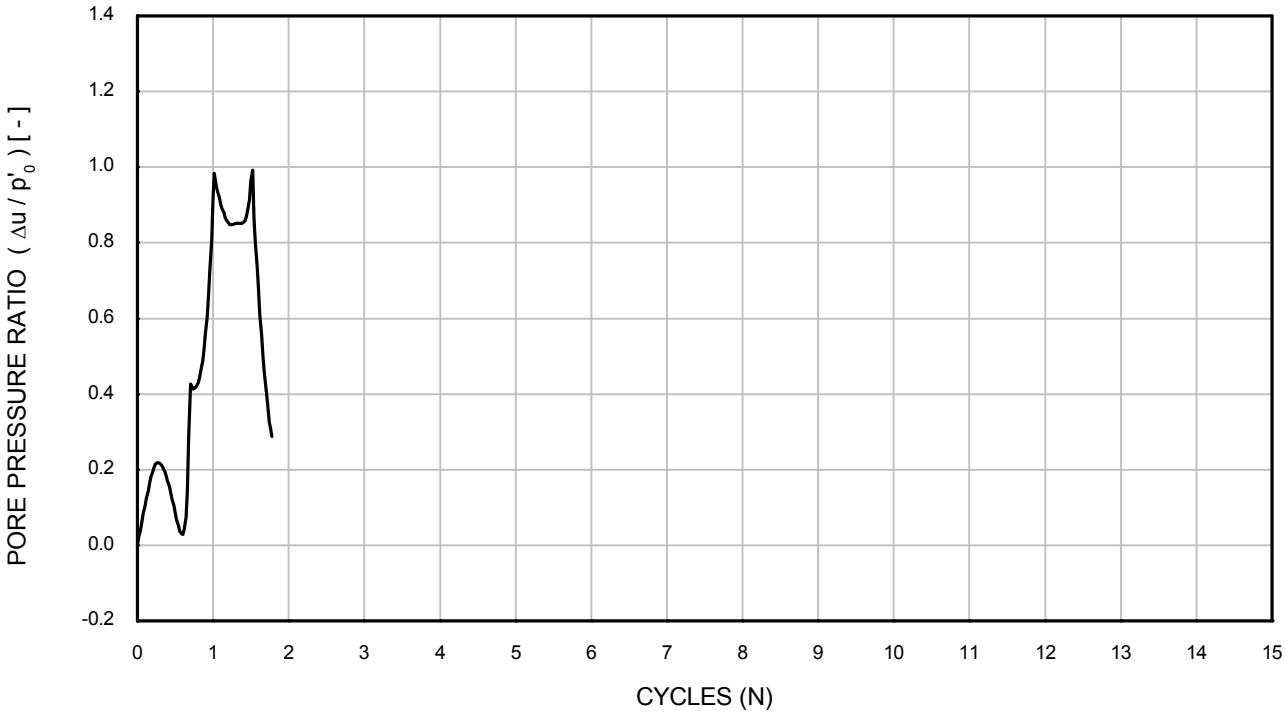


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-1
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	120 kPa	Test No.	:	CTX13
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

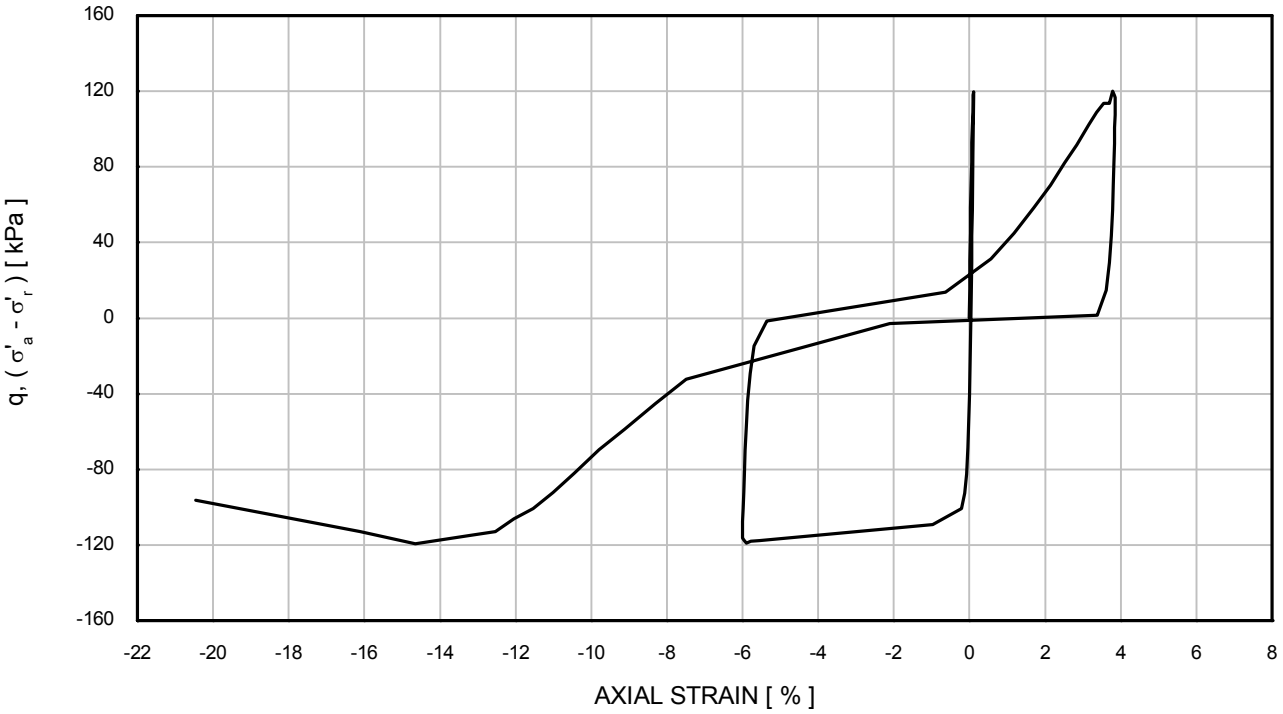


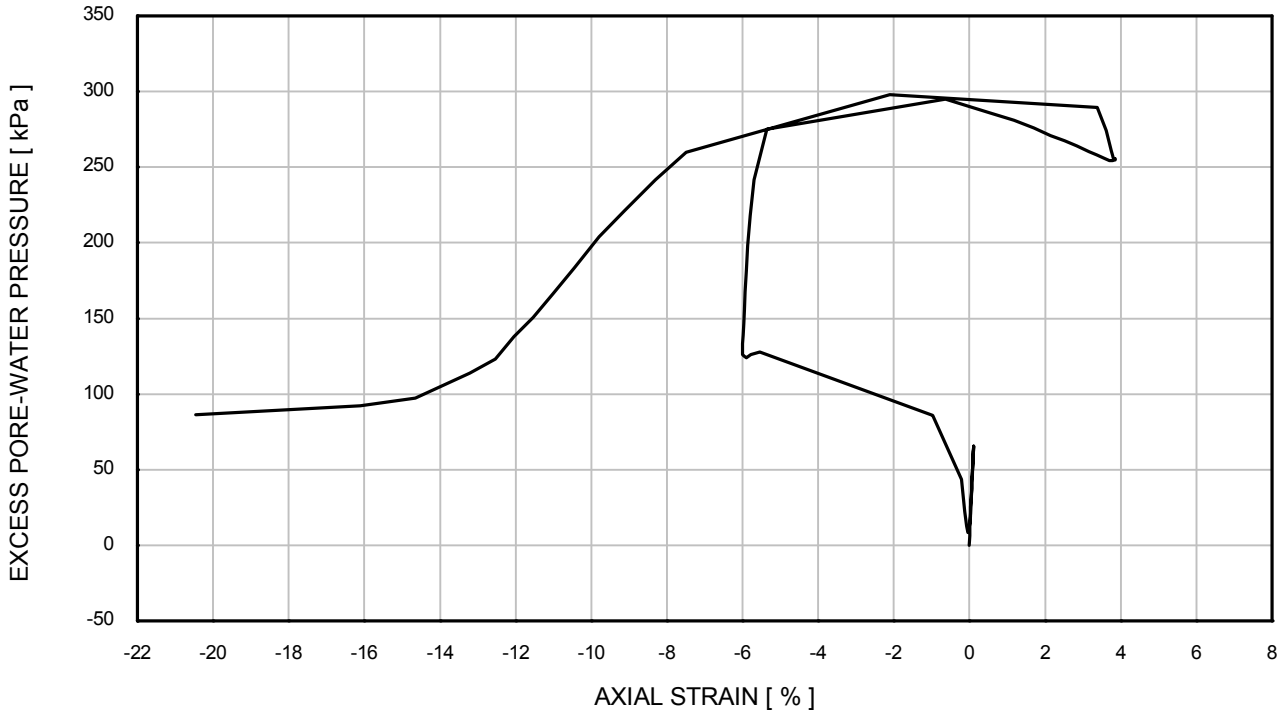


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-1
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	120 kPa	Test No.	:	CTX13
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

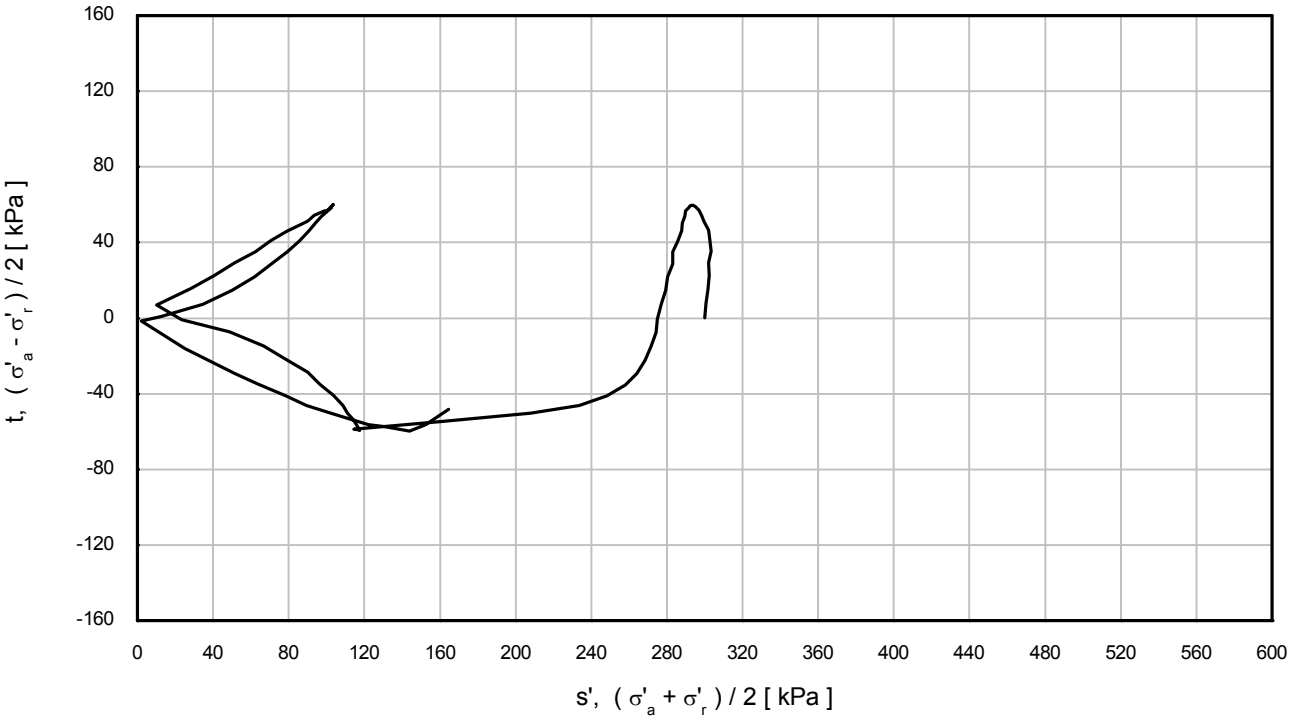


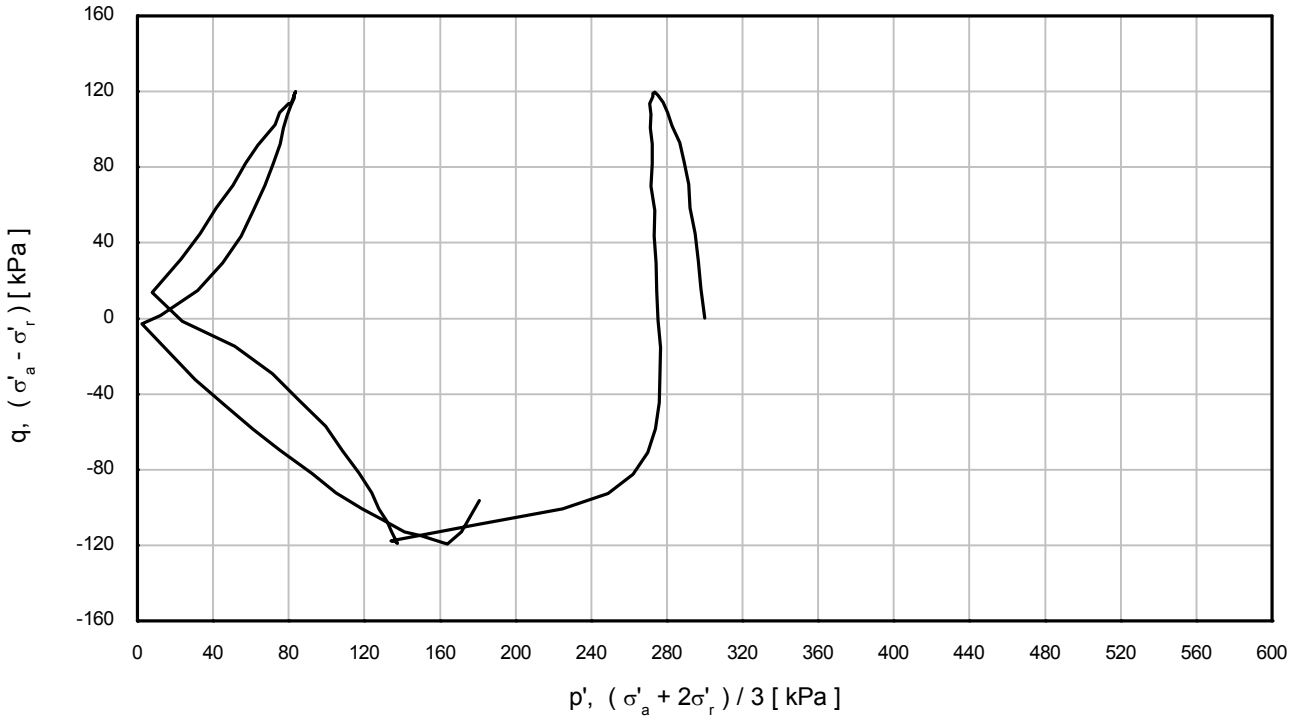


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-1
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	120 kPa	Test No.	:	CTX13
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

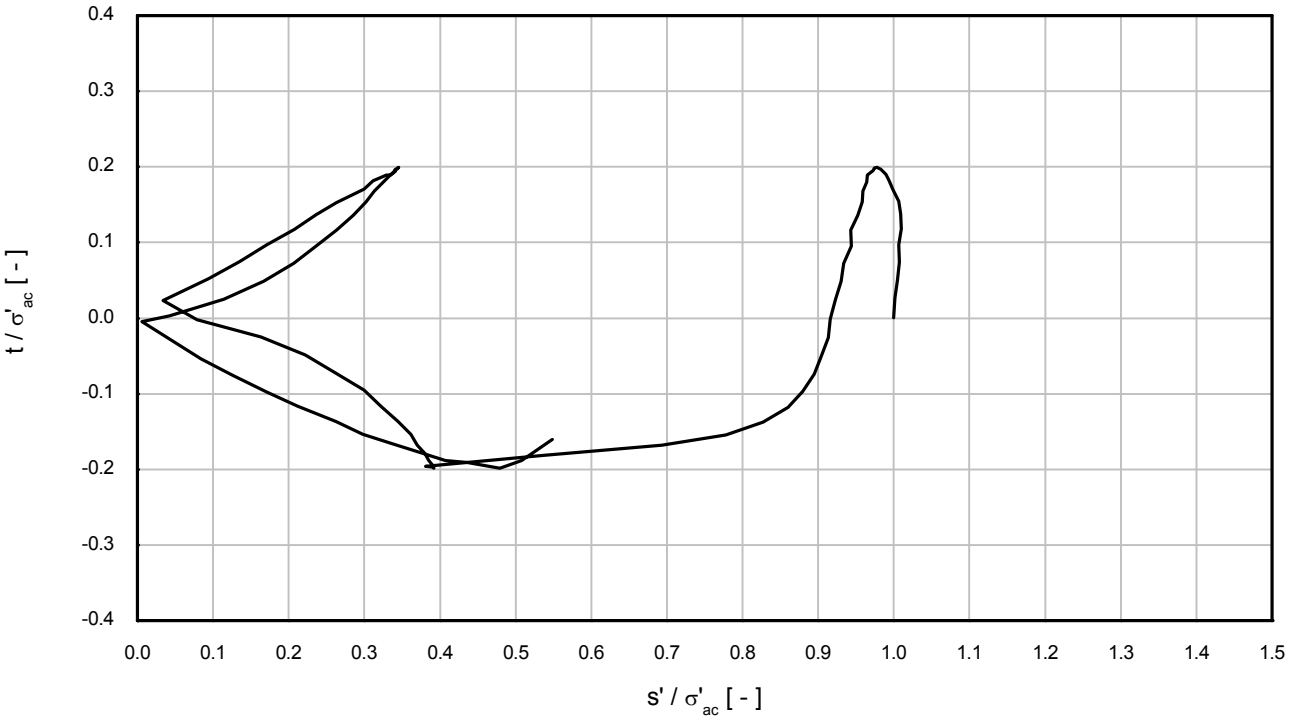


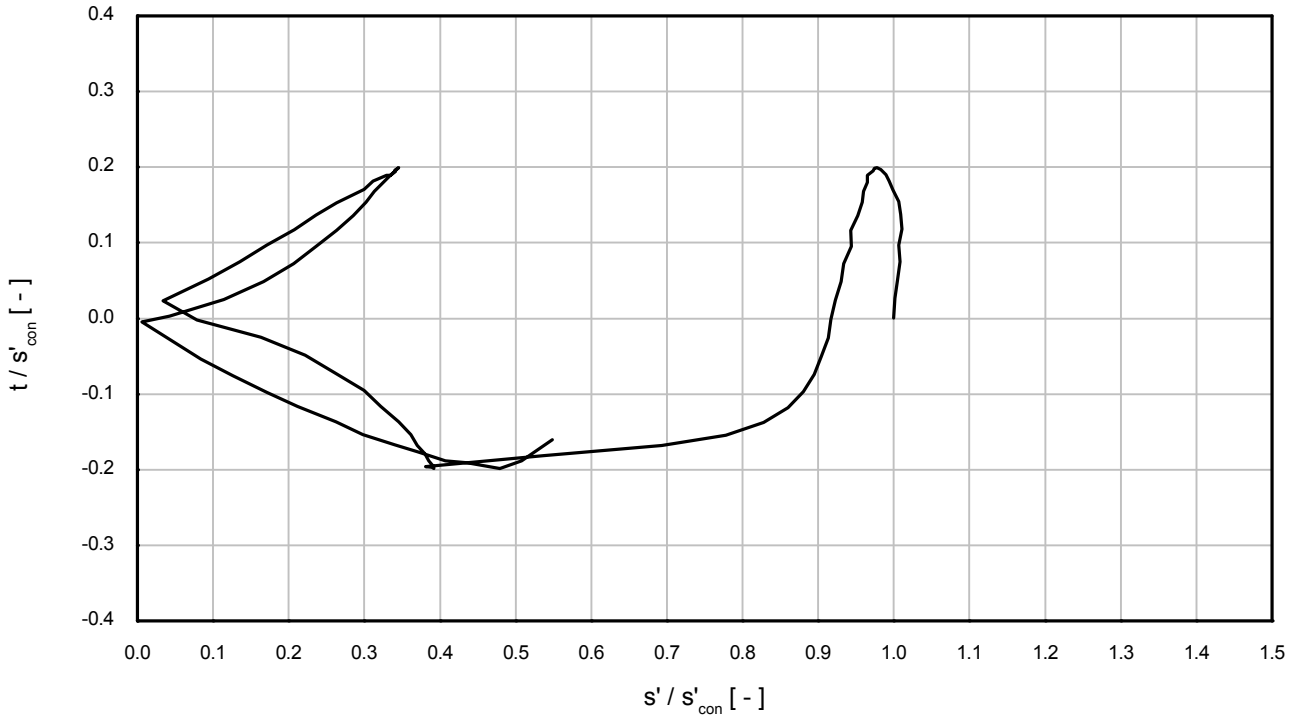


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-1
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	120 kPa	Test No.	:	CTX13
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

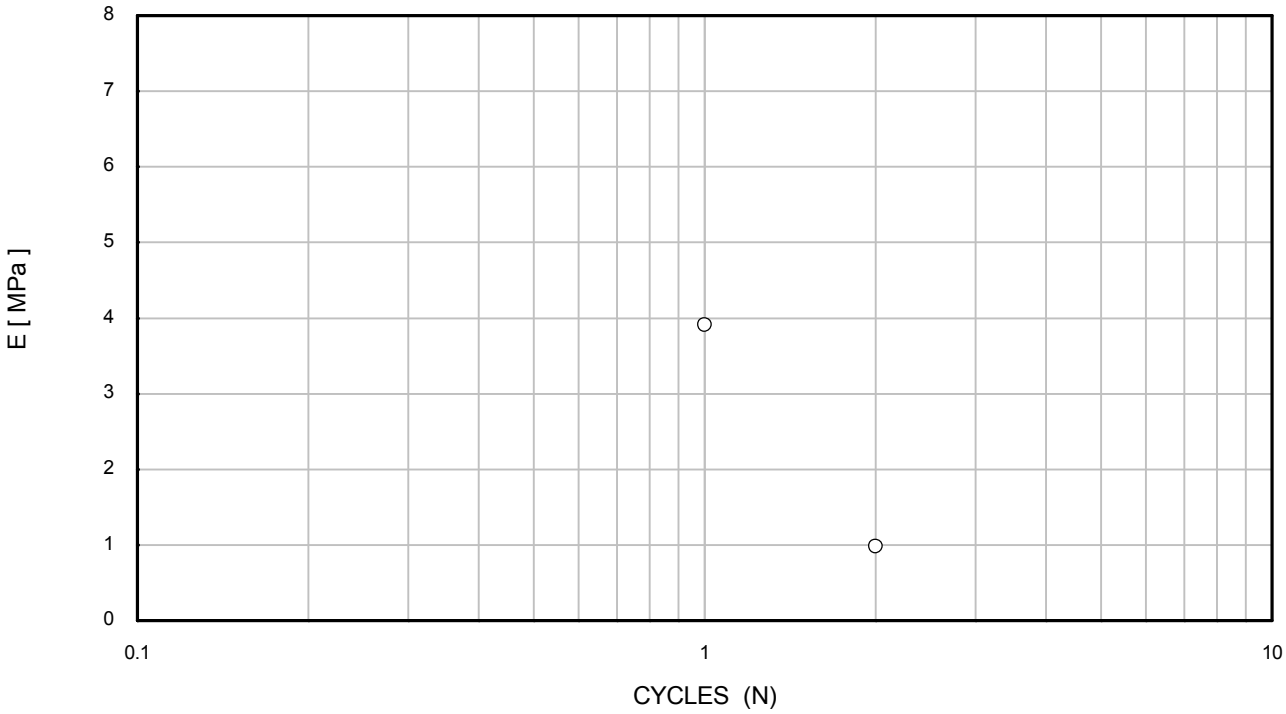


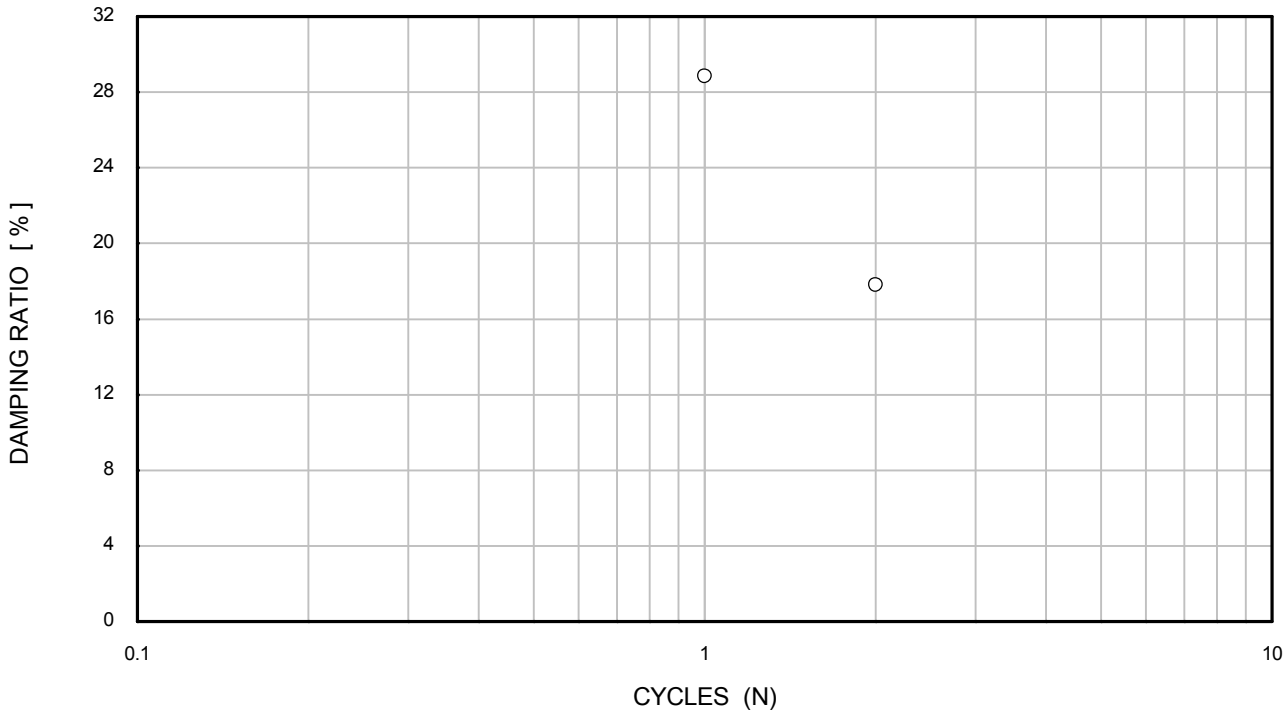


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-1
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	120 kPa	Test No.	:	CTX13
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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





Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-1
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	120 kPa	Test No.	:	CTX13
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Very dark grey slightly silty SAND

GENERAL	
Date test started	21/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.2
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.650
Degree of saturation	[%]	42
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 3_CTX-3-2_CTX14
Processed by Date	PR 26/01/2016
Checked by Date	PH 09/02/2016
Approved by Date	PH 09/02/2016

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-2
Unit	E3 (Tongeren)
Test number	CTX14

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
B value achieved	[-]	0.99

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1382
Back pressure	[kPa]	1082
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	300
Effective axial pressure	[kPa]	300
Deviator stress	[kPa]	0
Volumetric strain	[%]	1.11
External axial strain	[%]	0.46
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	24.9
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.632
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-2
Unit	E3 (Tongeren)
Test number	CTX14

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	600
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	90
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	12
External ε_{av} at N_f	[%]	-0.65
External ε_{cy} at N_f	[%]	0.98
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	204
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	24.9
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.632
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.02	0.06	151.04	-	14.18	-
2	0.02	0.06	149.02	-	11.70	-
4	0.03	0.07	133.84	-	11.48	-
6	0.03	0.08	116.59	-	12.60	-
8	0.03	0.09	94.97	-	14.78	-
10	0.00	0.15	61.39	-	19.10	-
11	-0.08	0.26	34.62	-	23.00	-
12	-0.65	0.98	9.10	-	25.85	-

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-2
Unit	E3 (Tongeren)
Test number	CTX14

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	2
Initial effective axial pressure	[kPa]	3
Rate of strain	[%/hour]	4.91
At peak deviator stress		
Corrected deviator stress	[kPa]	302
Membrane correction applied	[kPa]	3
Drain correction applied	[kPa]	0
External axial strain	[%]	24.21
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	168
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	132
Effective axial pressure	[kPa]	435
Principal effective stress ratio	[-]	3.28
ε_{50}	[%]	9.66
Secant modulus (E_{50}) at ε_{50}	[kPa]	1014
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	4
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	-0.48
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	300
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	0
Effective axial pressure	[kPa]	4
Principal effective stress ratio	[-]	399.74
At 10% external axial strain		
Corrected deviator stress	[kPa]	158
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	239
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	61
Effective axial pressure	[kPa]	219
Principal effective stress ratio	[-]	3.59

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-2
Unit	E3 (Tongeren)
Test number	CTX14

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



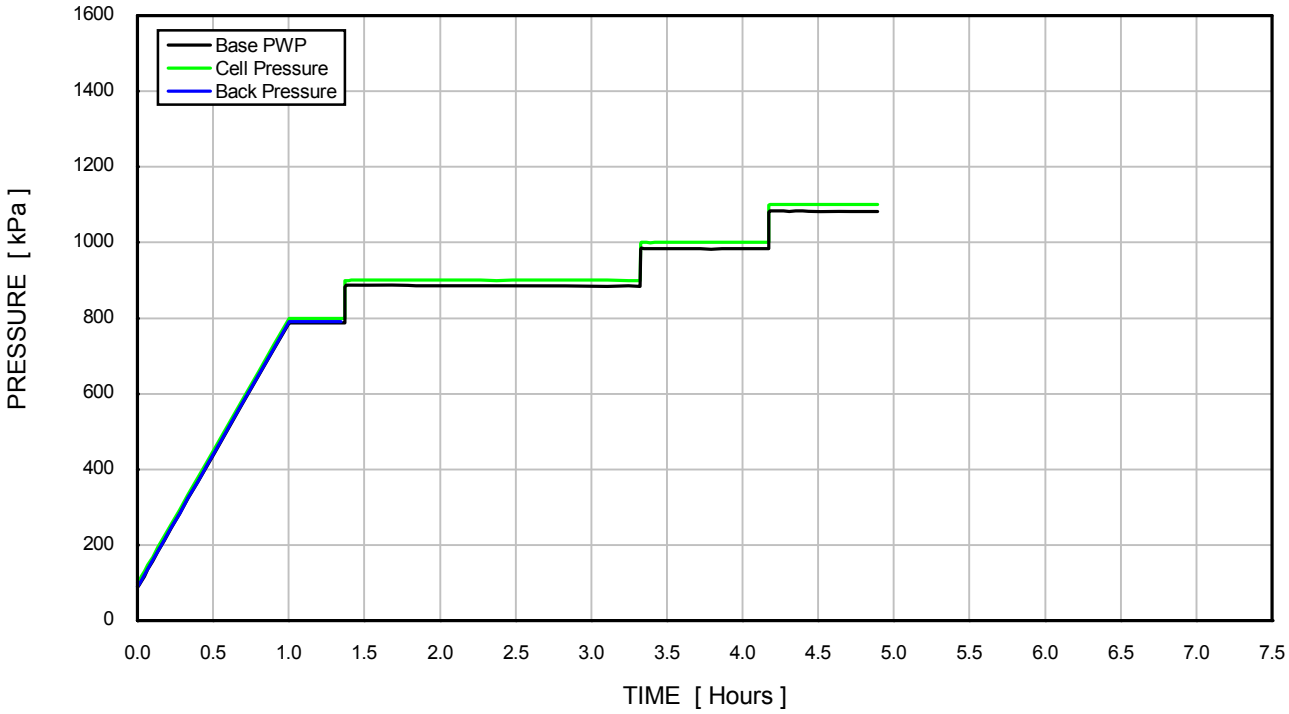


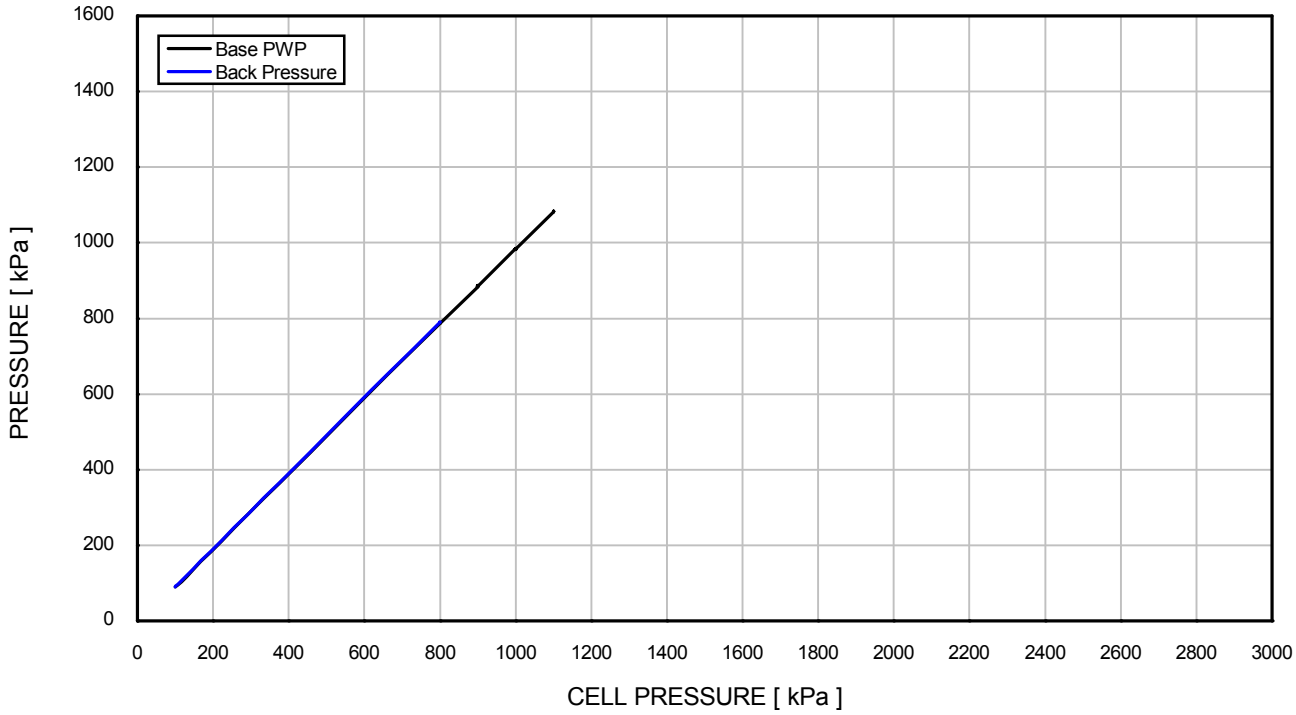
FINAL CONDITIONS		
Moisture content	[%]	24.9
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.62

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-2
Unit	E3 (Tongeren)
Test number	CTX14

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

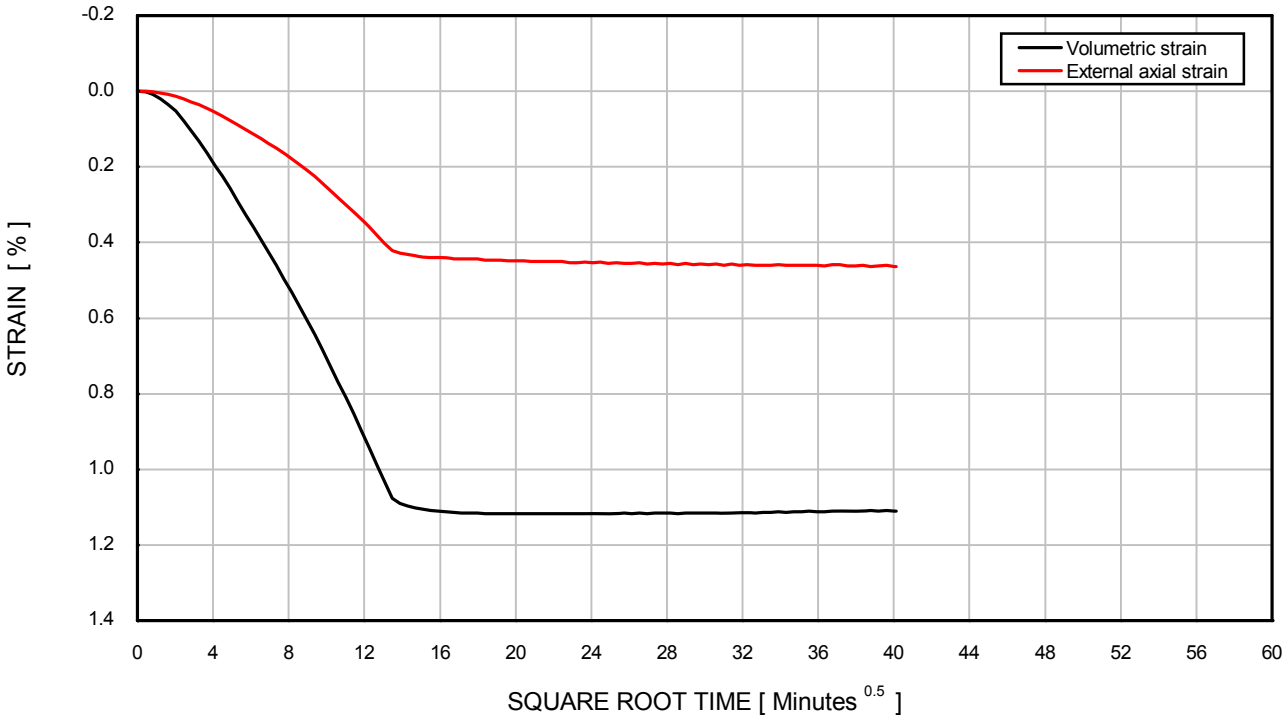


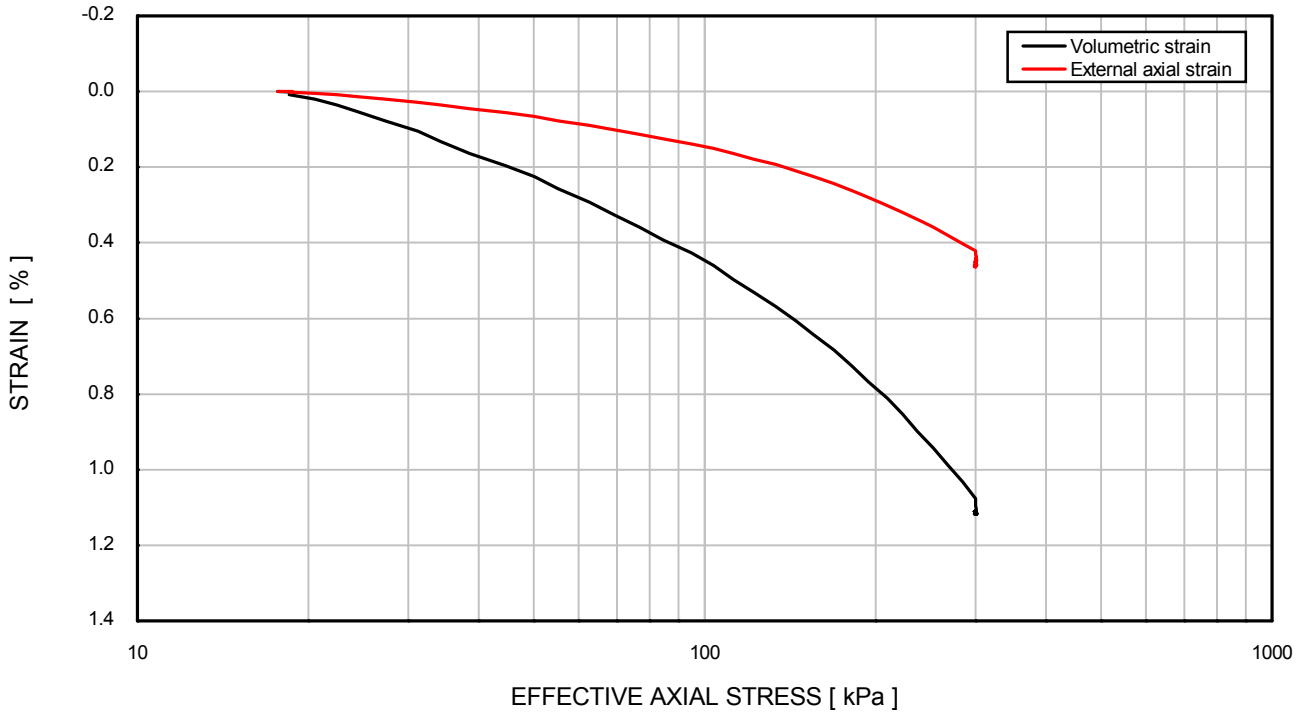


B value	:	0.99			
Initial σ'_r	:	10	kPa	Batch	: 3
Initial σ'_a	:	10	kPa	Sample	: CTX_3-2
Final σ'_r	:	18	kPa	Unit	: E3 (Tongeren)
Final σ'_a	:	18	kPa	Test No.	: CTX14

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

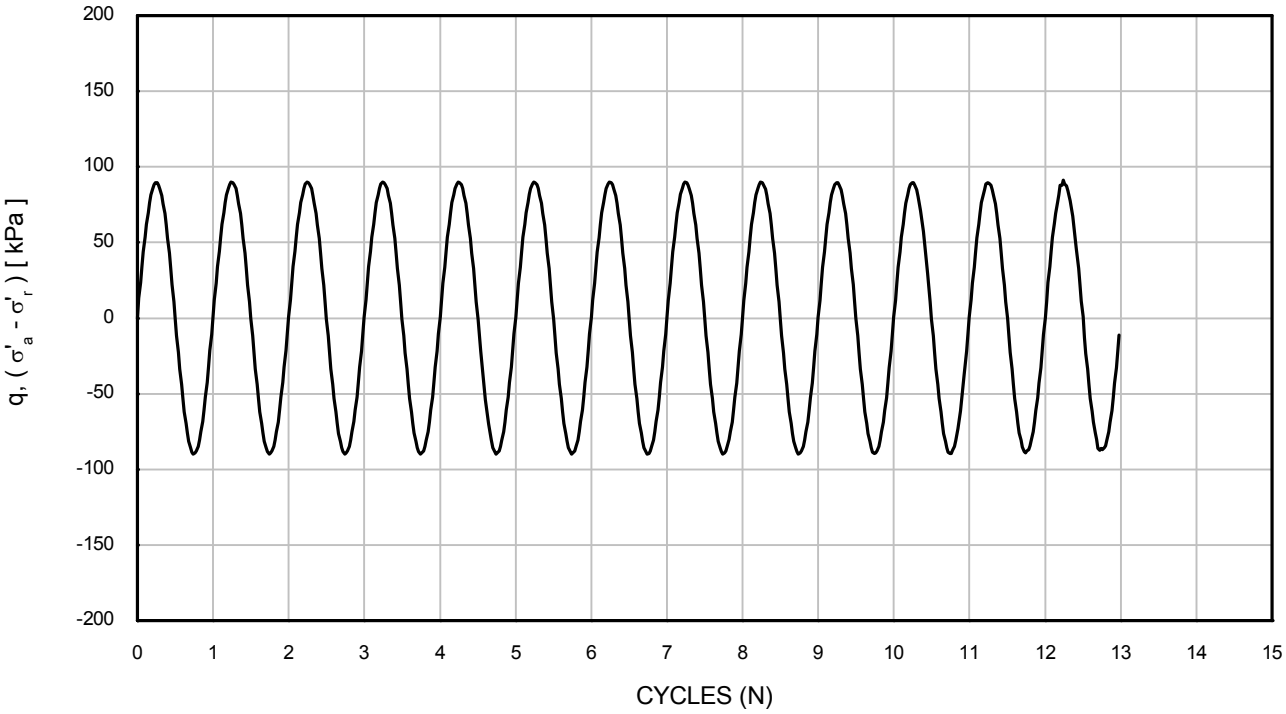


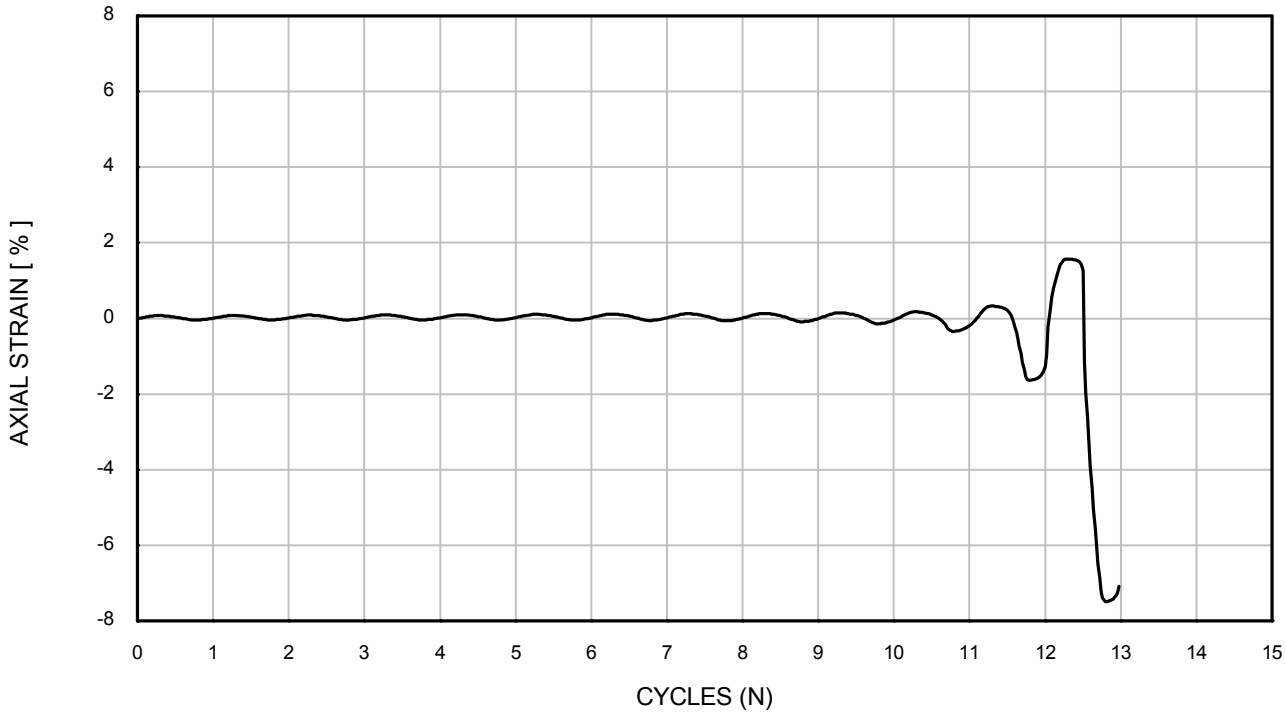


σ'_{rc}	: 300 kPa	Batch	: 3
σ'_{ac}	: 300 kPa	Sample	: CTX_3-2
		Unit	: E3 (Tongeren)
		Test No.	: CTX14

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

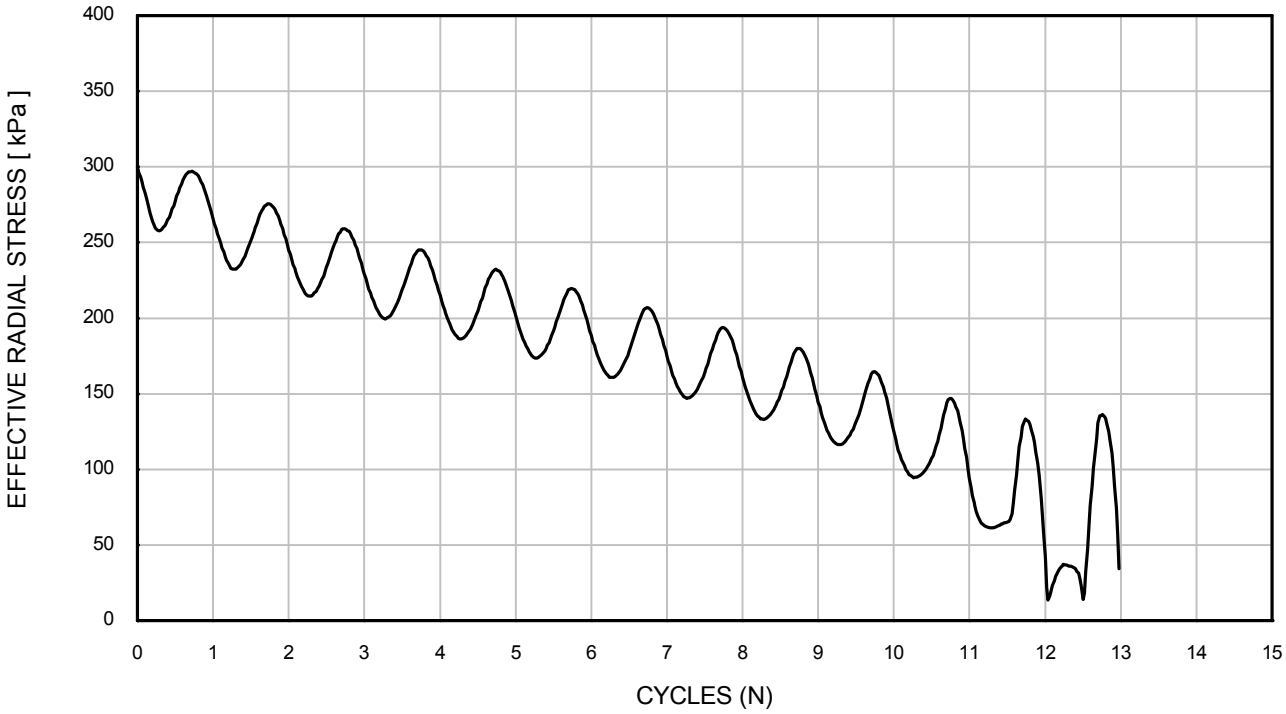


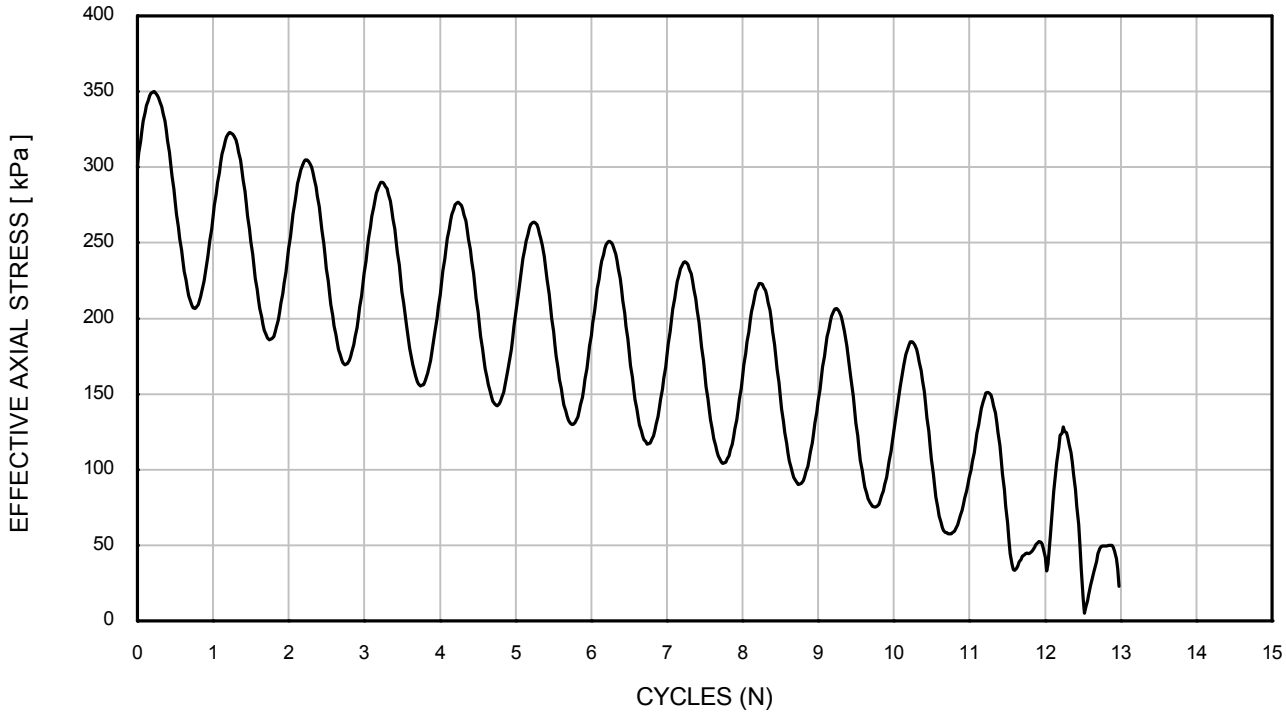


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-2
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	90 kPa	Test No.	:	CTX14
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

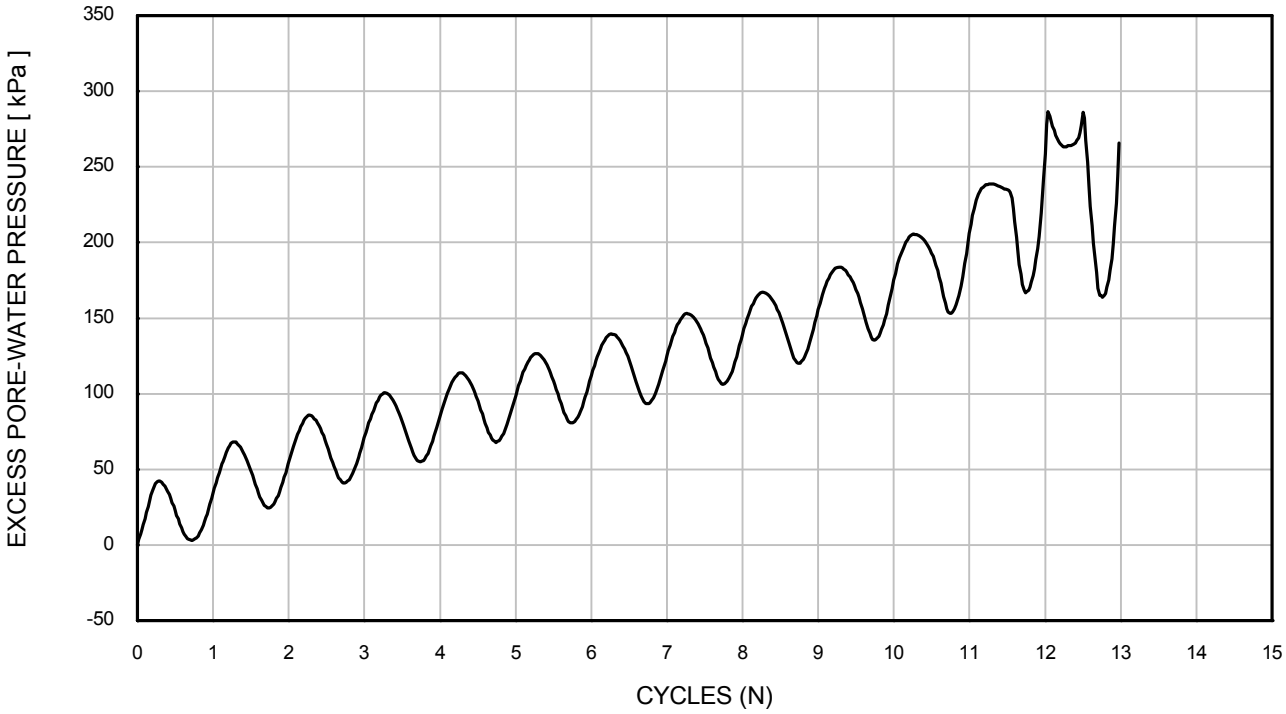


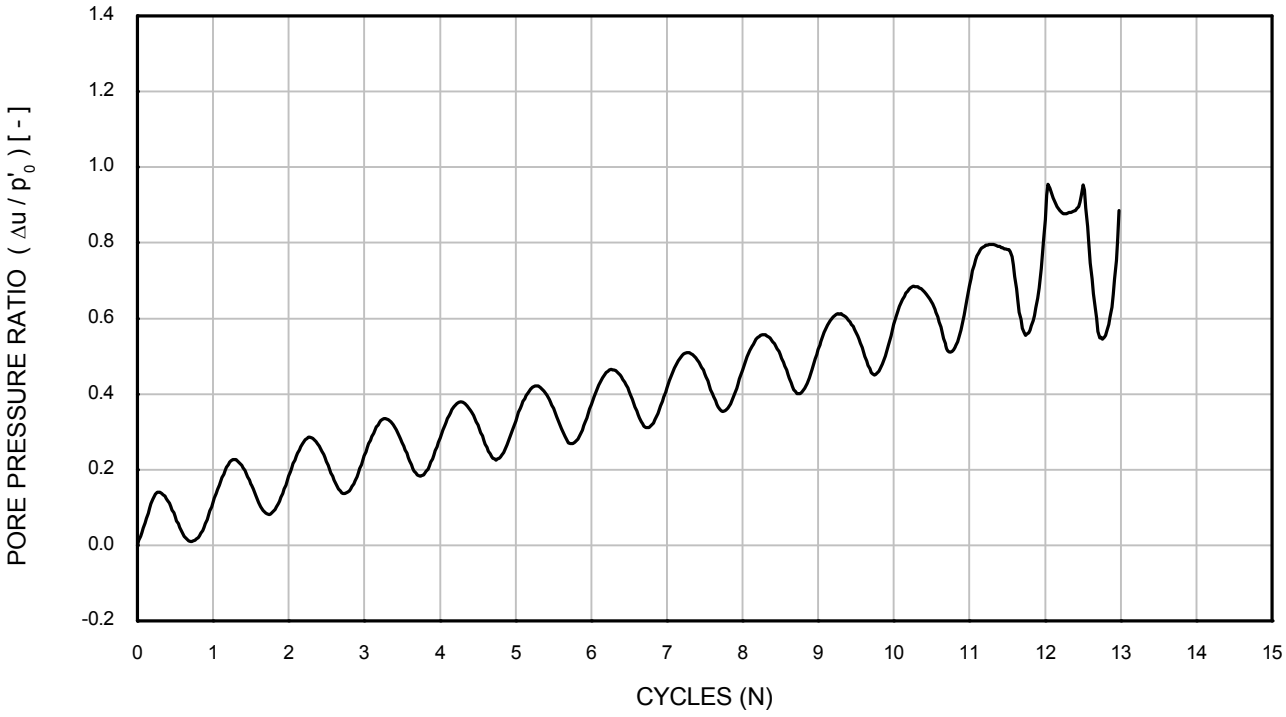


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-2
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	90 kPa	Test No.	:	CTX14
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

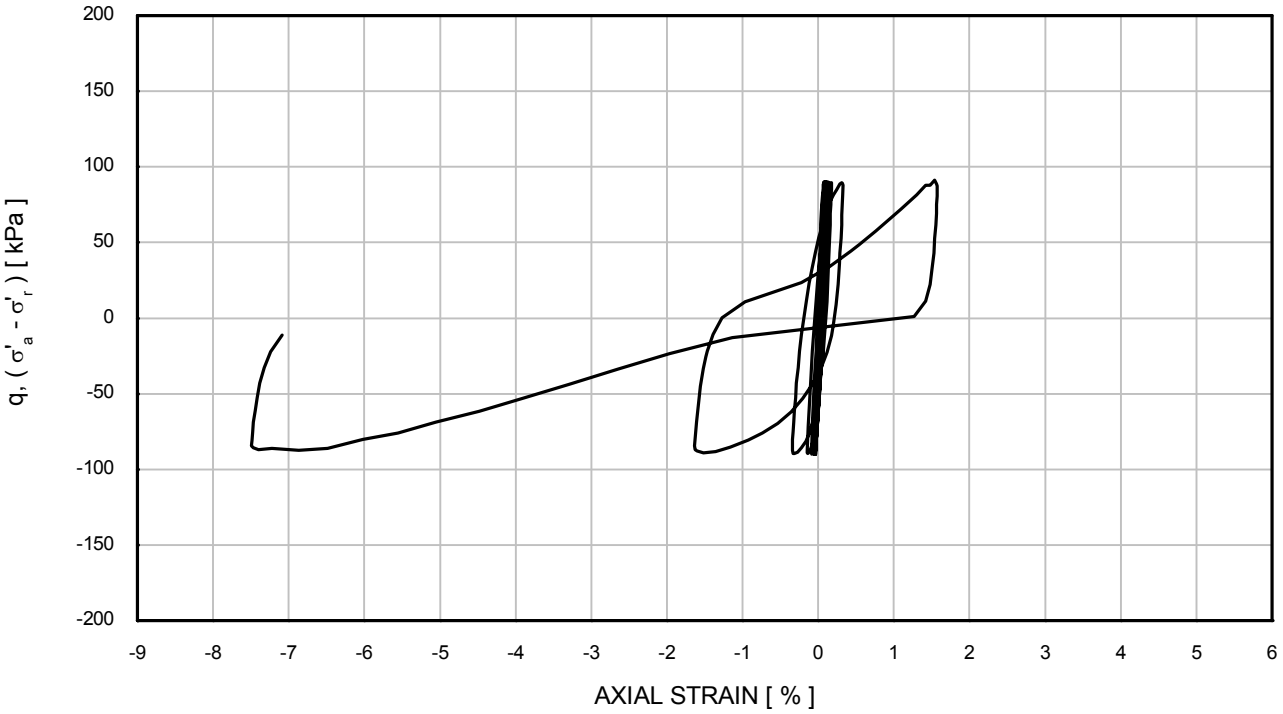


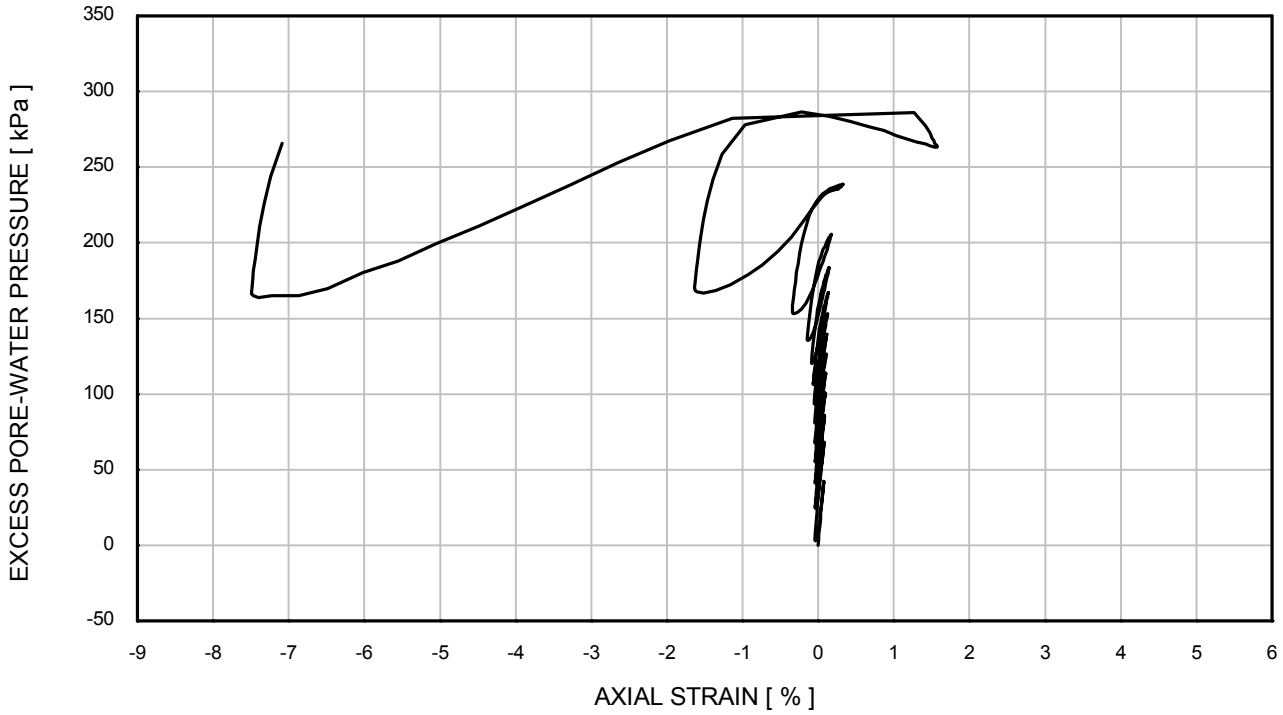


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-2
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	90 kPa	Test No.	:	CTX14
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

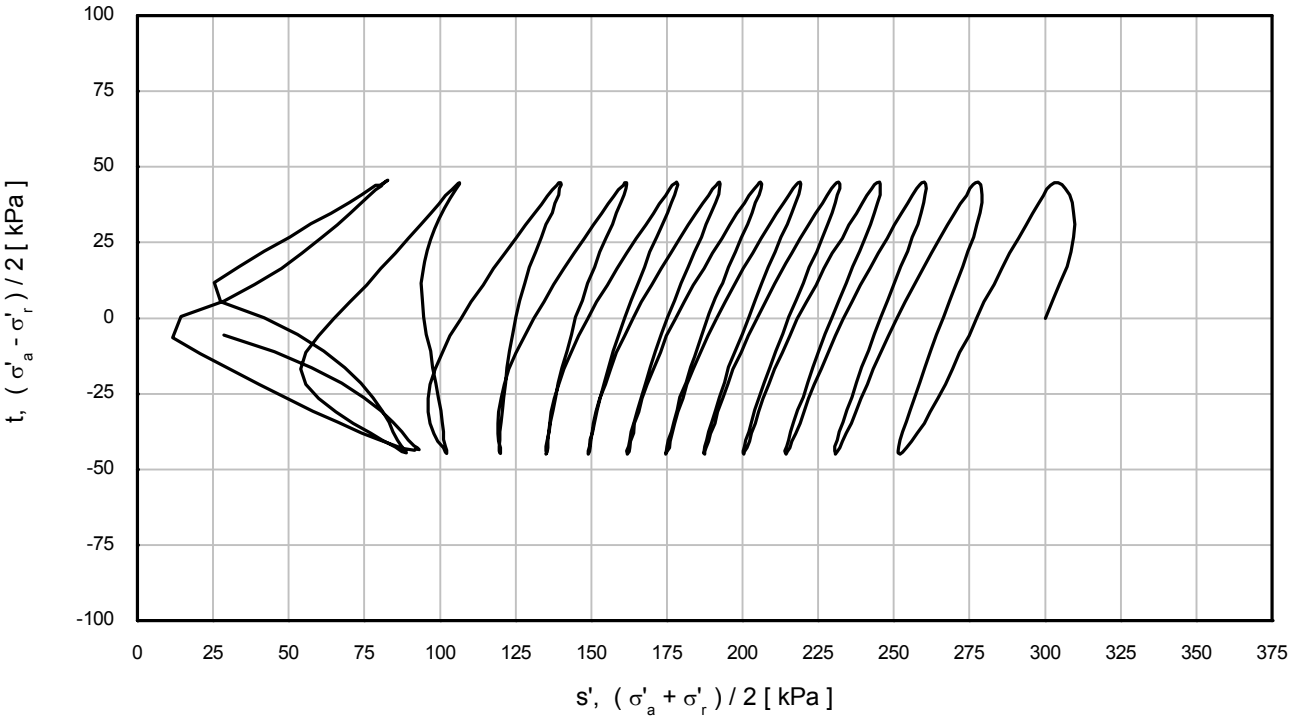


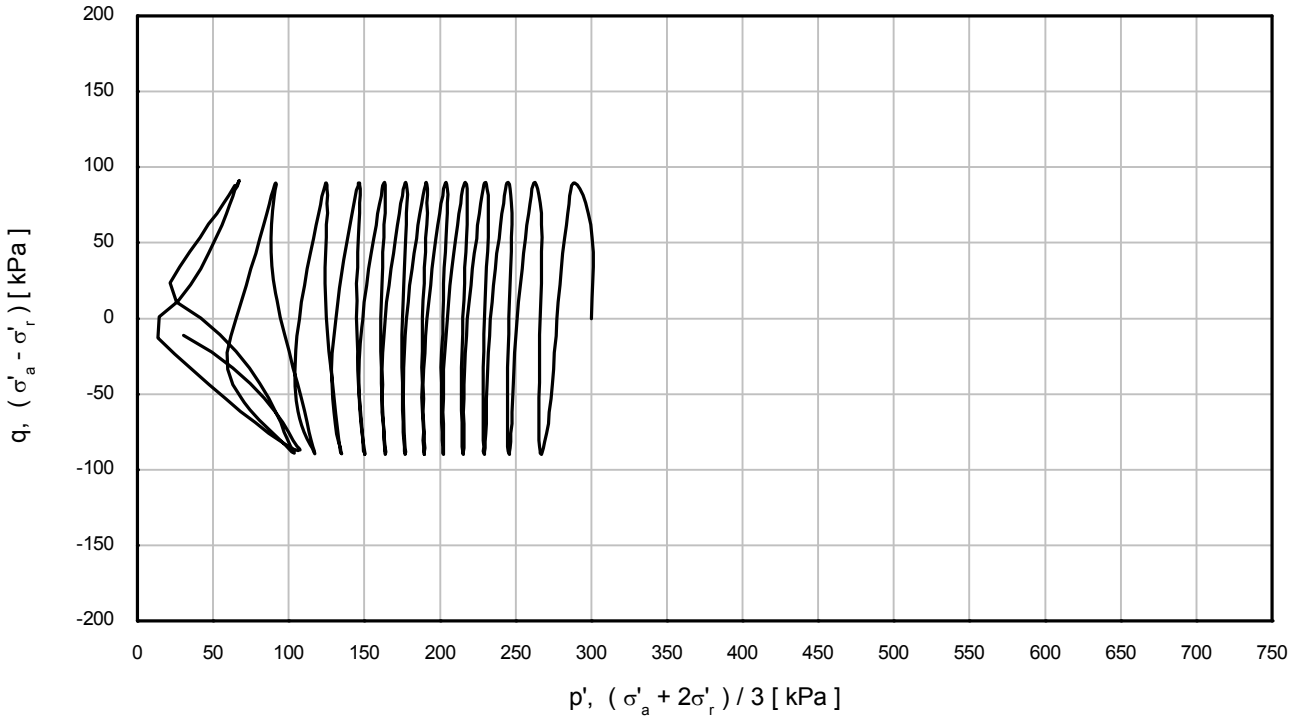


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-2
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	90 kPa	Test No.	:	CTX14
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

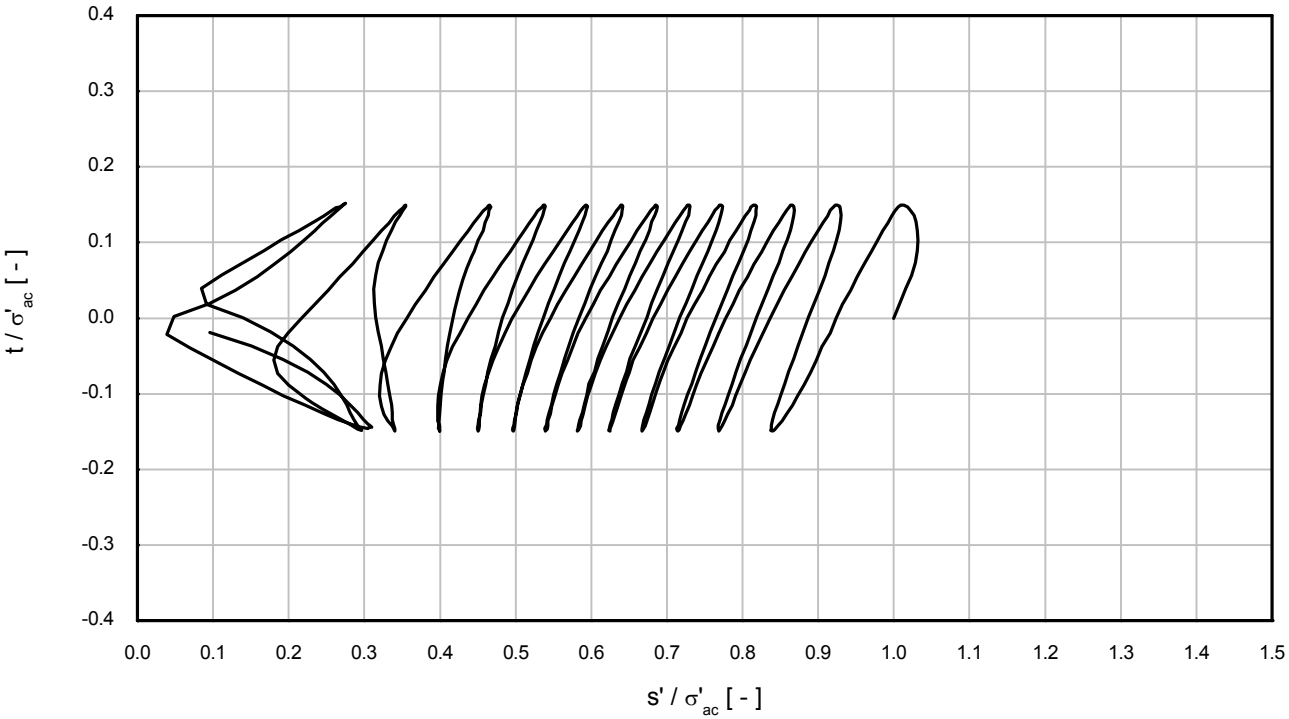


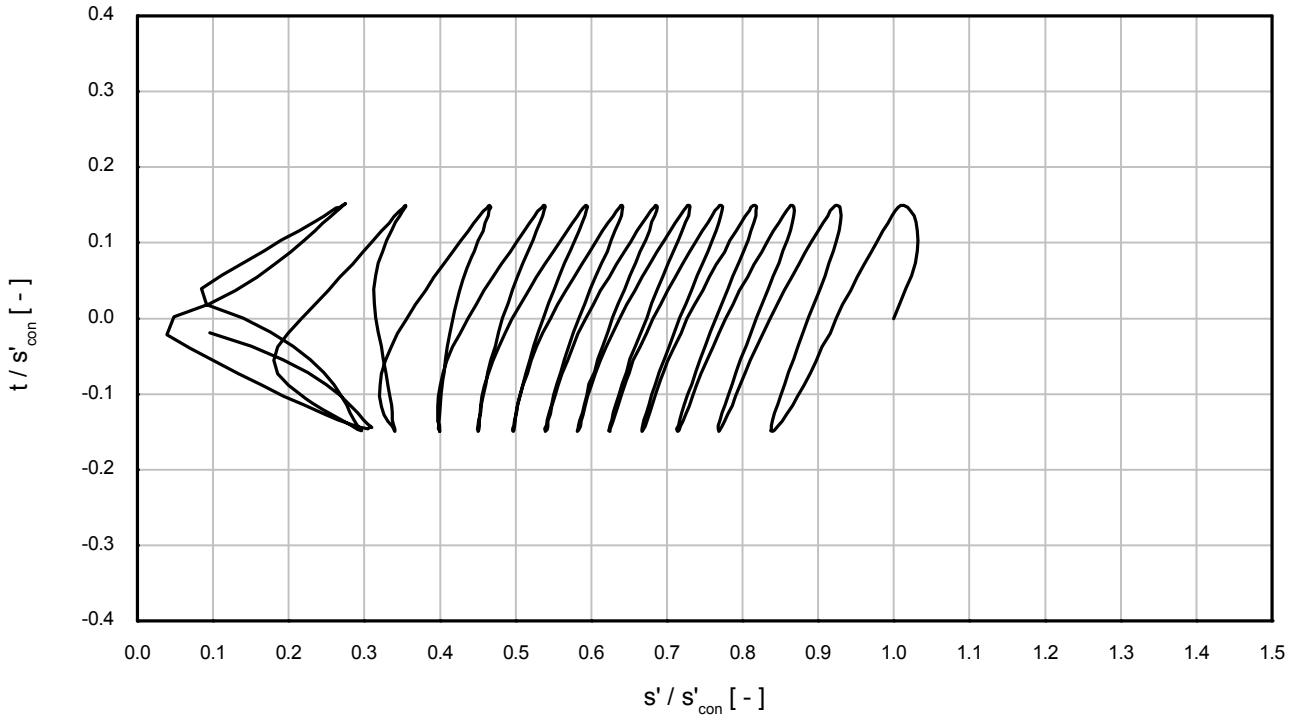


Initial σ'_r	:	300	kPa	Batch	: 3
Initial σ'_a	:	300	kPa	Sample	: CTX_3-2
q_{av}	:	0	kPa	Unit	: E3 (Tongeren)
q_{cy}	:	90	kPa	Test No.	: CTX14
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

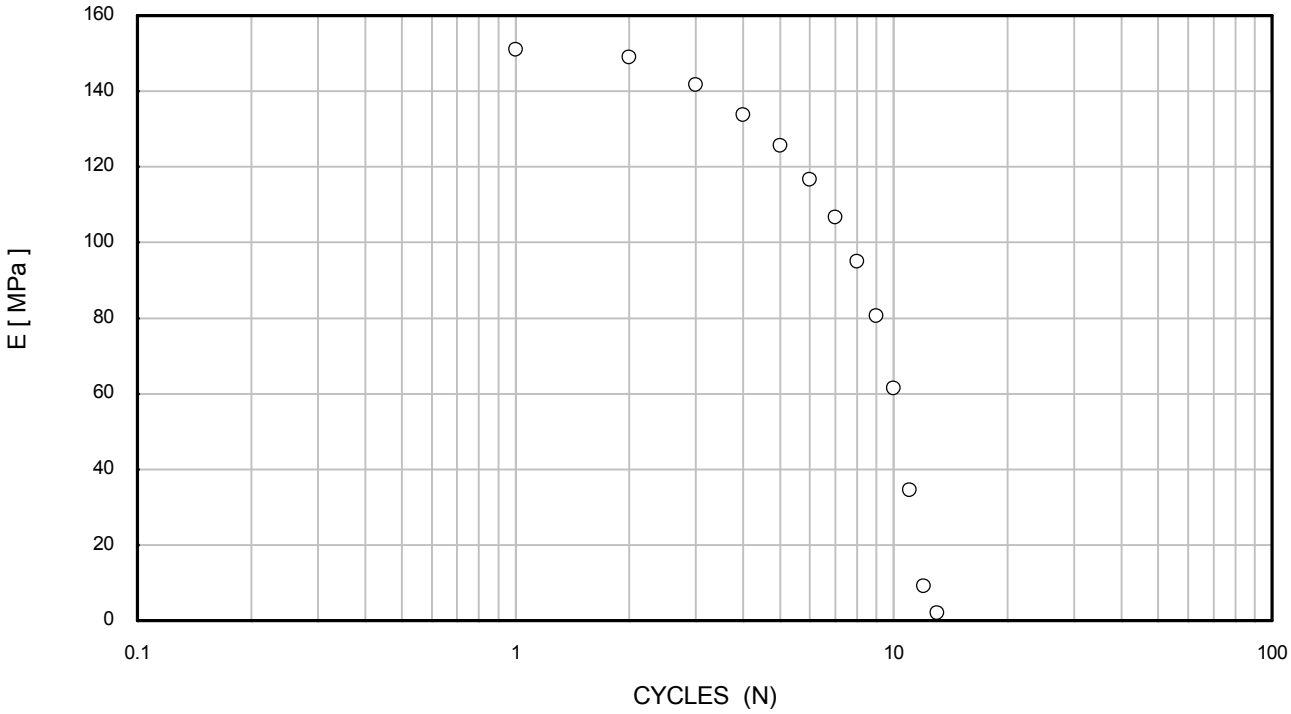


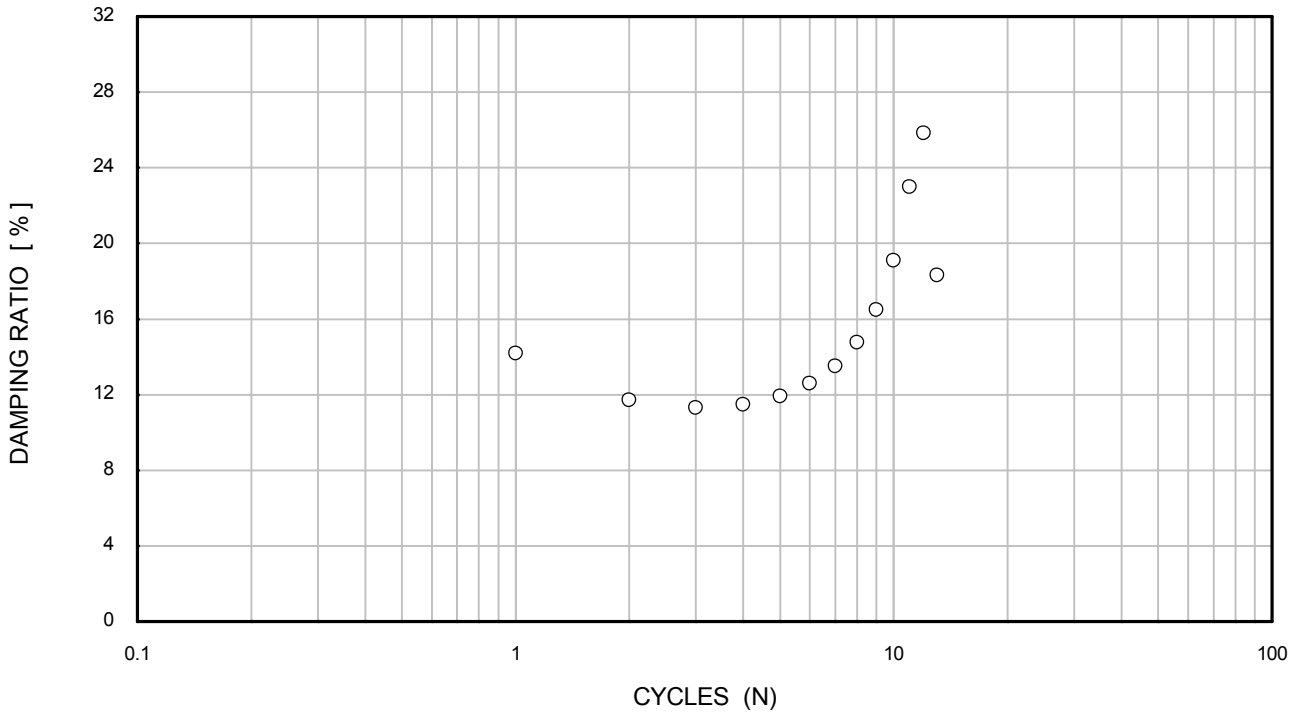


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-2
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	90 kPa	Test No.	:	CTX14
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

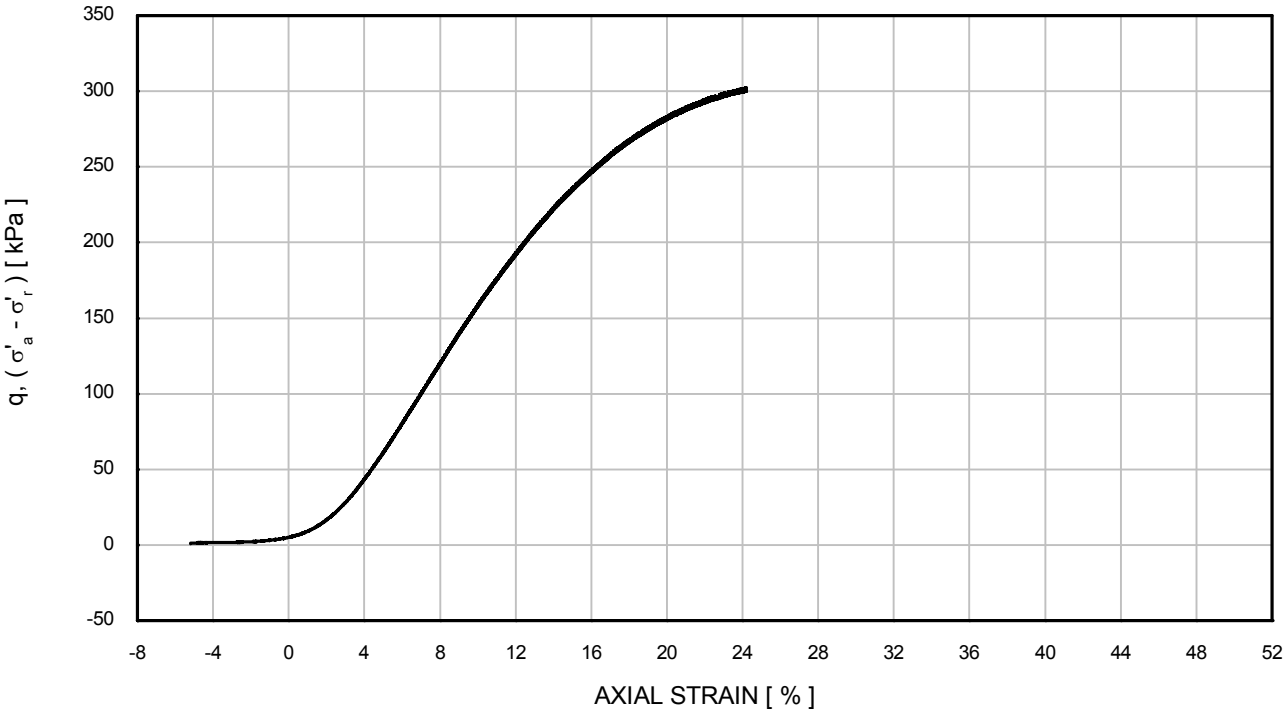


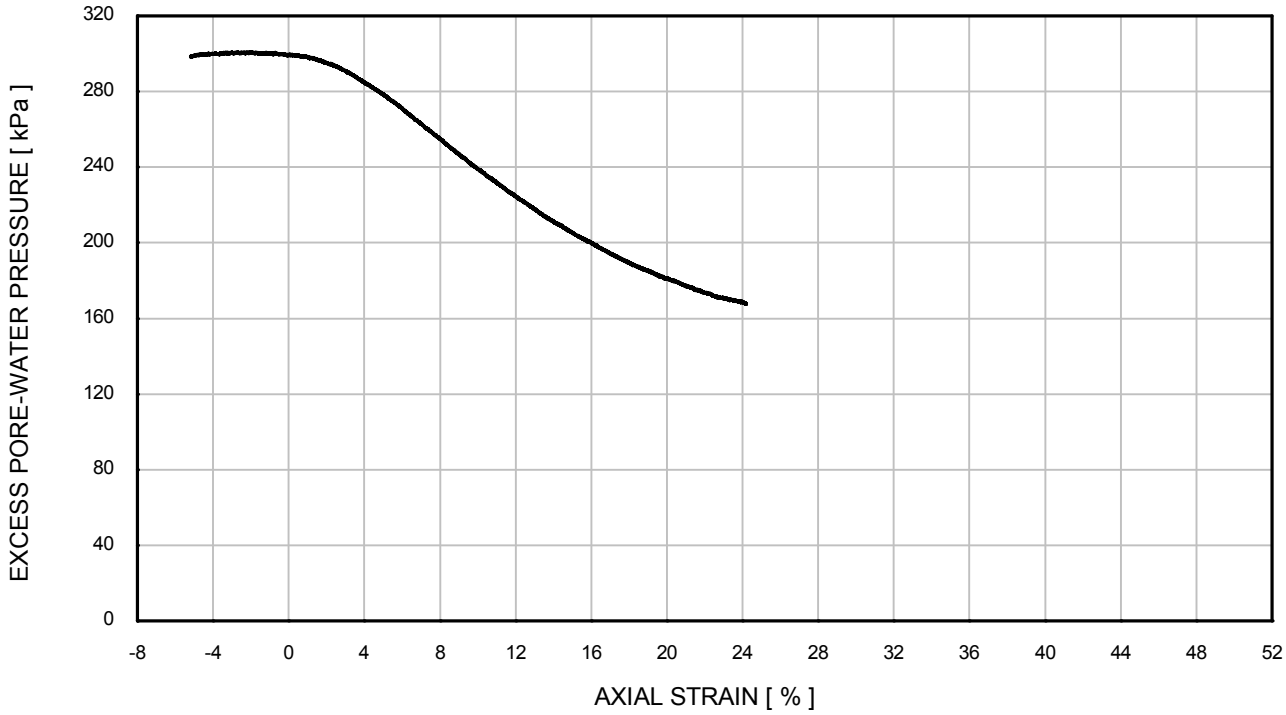


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-2
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	90 kPa	Test No.	:	CTX14
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

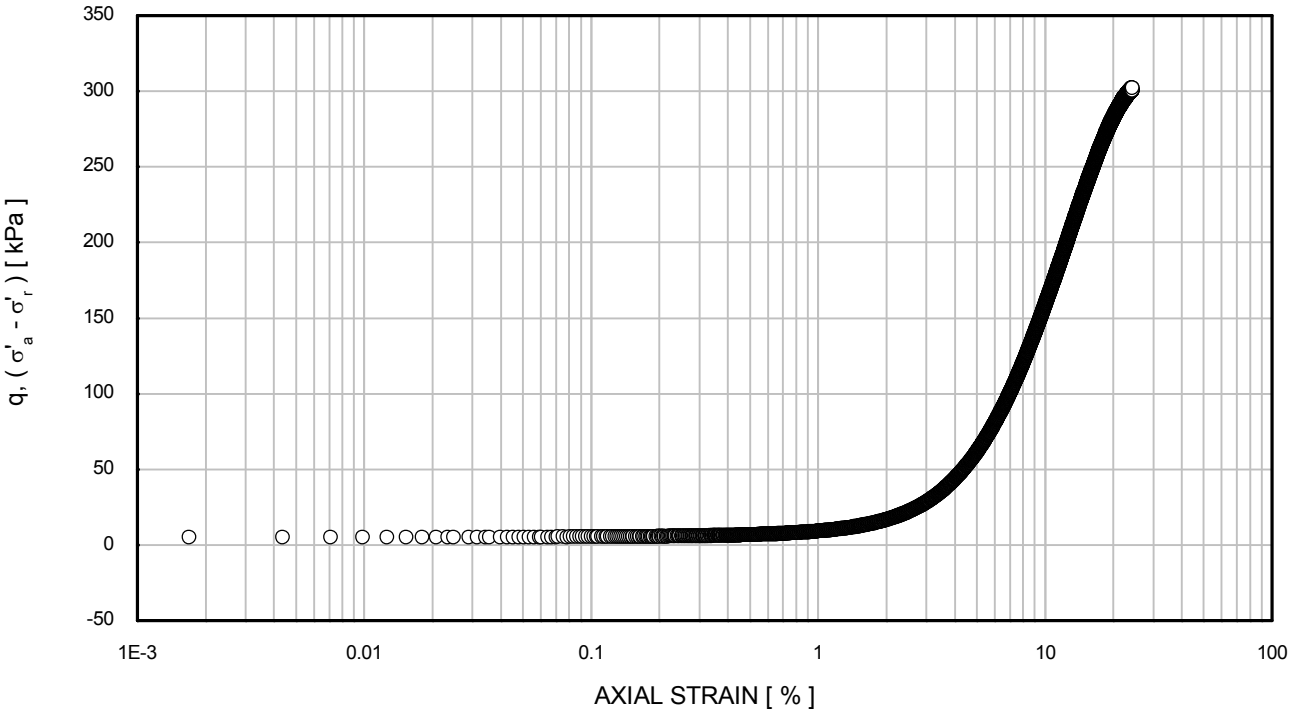


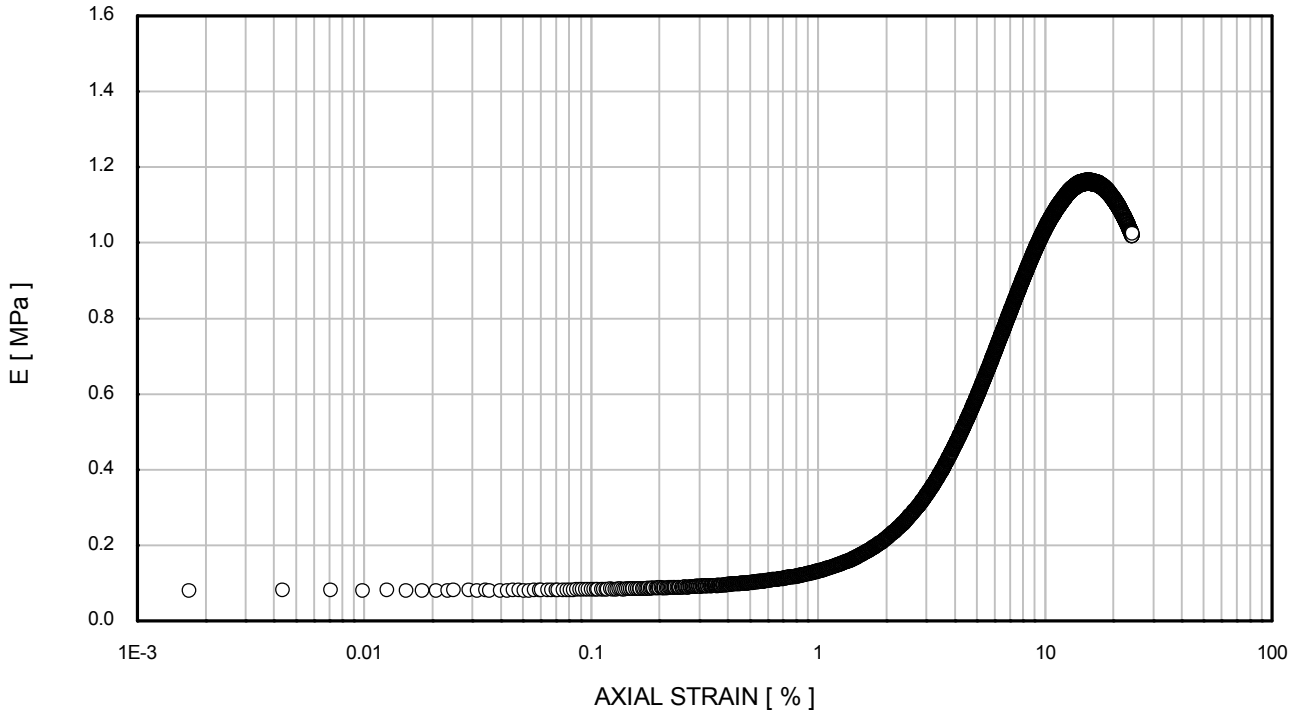


Initial σ'_r	:	2 kPa	Batch	:	3
Initial σ'_a	:	3 kPa	Sample	:	CTX_3-2
q_{peak}	:	302 kPa	Unit	:	E3 (Tongeren)
Ext. ε at q_{peak}	:	24.21 %	Test No.	:	CTX14
Rate of strain	:	4.91 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

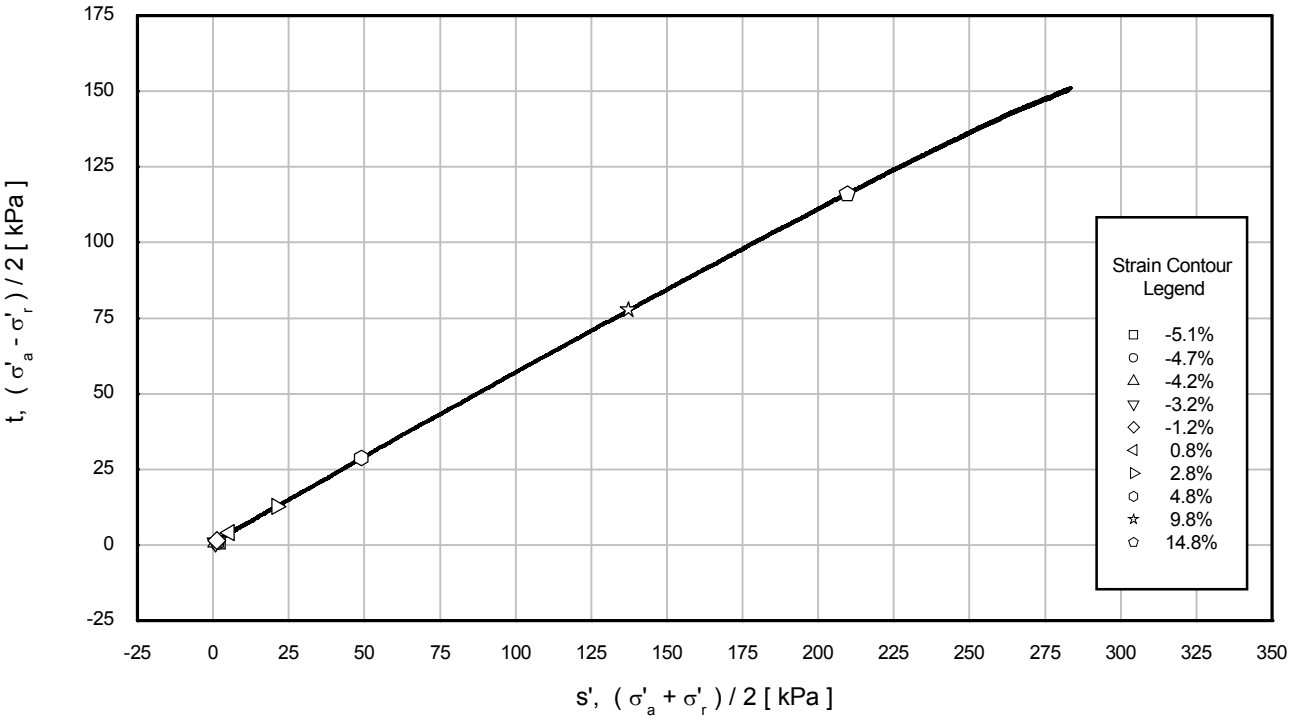


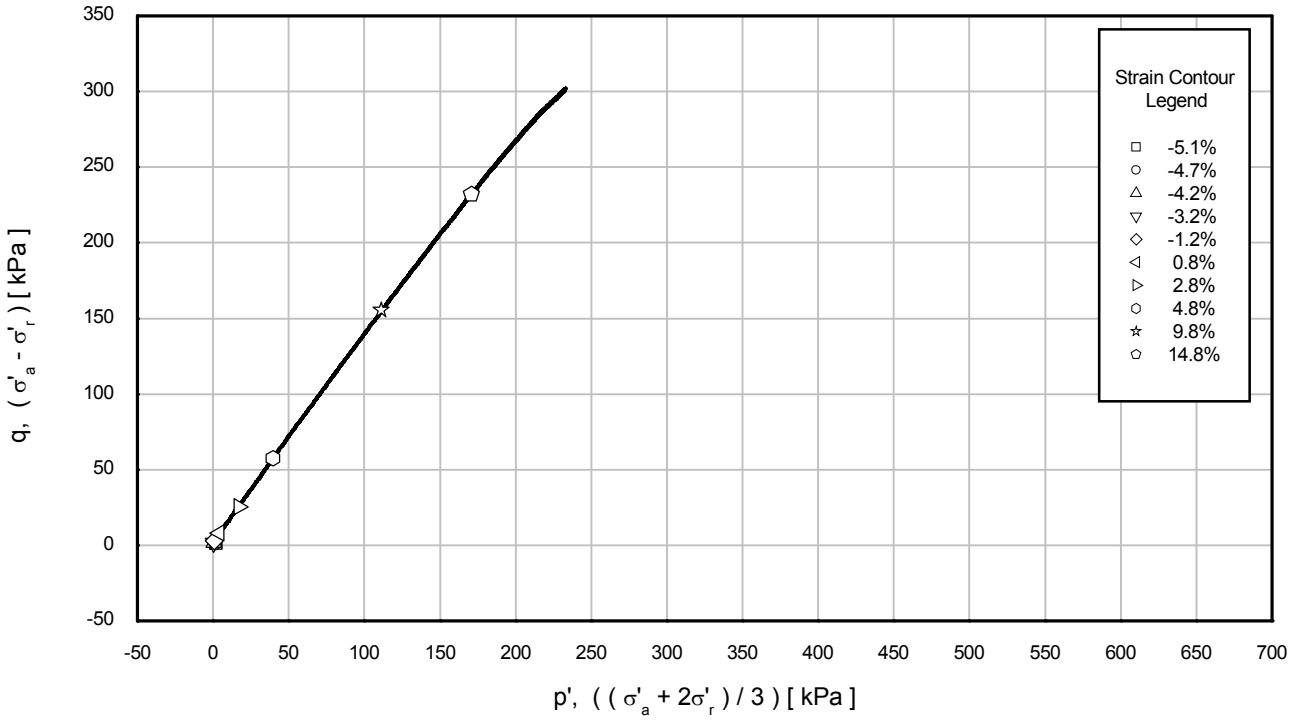


Initial σ'_r	:	2 kPa	Batch	:	3
Initial σ'_a	:	3 kPa	Sample	:	CTX_3-2
q_{peak}	:	302 kPa	Unit	:	E3 (Tongeren)
Ext. ε at q_{peak}	:	24.21 %	Test No.	:	CTX14
Rate of strain	:	4.91 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	2	kPa	Batch	: 3
Initial σ'_a	:	3	kPa	Sample	: CTX_3-2
q_{peak}	:	302	kPa	Unit	: E3 (Tongeren)
Ext. ε at q_{peak}	:	24.21	%	Test No.	: CTX14
Rate of strain	:	4.91	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	29/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.0
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.647
Degree of saturation	[%]	41
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 3_CTX-3-3_CTX15
Processed by Date	HJ 05/02/2016
Checked by Date	PH 15/03/2016
Approved by Date	PH 15/03/2016

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-3
Unit	E3 (Tongeren)
Test number	CTX15

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
B value achieved	[-]	0.96

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1382
Back pressure	[kPa]	1082
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	300
Effective axial pressure	[kPa]	300
Deviator stress	[kPa]	0
Volumetric strain	[%]	1.93
External axial strain	[%]	0.60
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	23.2
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64
Void ratio	[-]	0.615
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-3
Unit	E3 (Tongeren)
Test number	CTX15

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	600
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	60
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	45
External ε_{av} at N_f	[%]	-0.35
External ε_{cy} at N_f	[%]	1.00
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	238
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	23.2
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64
Void ratio	[-]	0.615
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.01	0.03	178.55	-	10.12	-
2	0.01	0.03	179.28	-	7.63	-
5	0.02	0.03	171.30	-	6.46	-
10	0.03	0.04	159.17	-	6.30	-
20	0.05	0.04	138.08	-	7.10	-
30	0.07	0.05	114.80	-	8.98	-
40	0.10	0.08	74.57	-	14.57	-
45	-0.35	1.00	5.97	-	25.16	-

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-3
Unit	E3 (Tongeren)
Test number	CTX15

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	1
Initial effective axial pressure	[kPa]	1
Rate of strain	[%/hour]	4.82
At peak deviator stress		
Corrected deviator stress	[kPa]	268
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	23.63
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	188
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	114
Effective axial pressure	[kPa]	381
Principal effective stress ratio	[-]	3.35
ε_{50}	[%]	10.57
Secant modulus (E_{50}) at ε_{50}	[kPa]	991
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	5
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	1.48
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	301
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	0
Effective axial pressure	[kPa]	5
Principal effective stress ratio	[-]	155.27
At 10% external axial strain		
Corrected deviator stress	[kPa]	124
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	254
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	47
Effective axial pressure	[kPa]	171
Principal effective stress ratio	[-]	3.62

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-3
Unit	E3 (Tongeren)
Test number	CTX15

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS

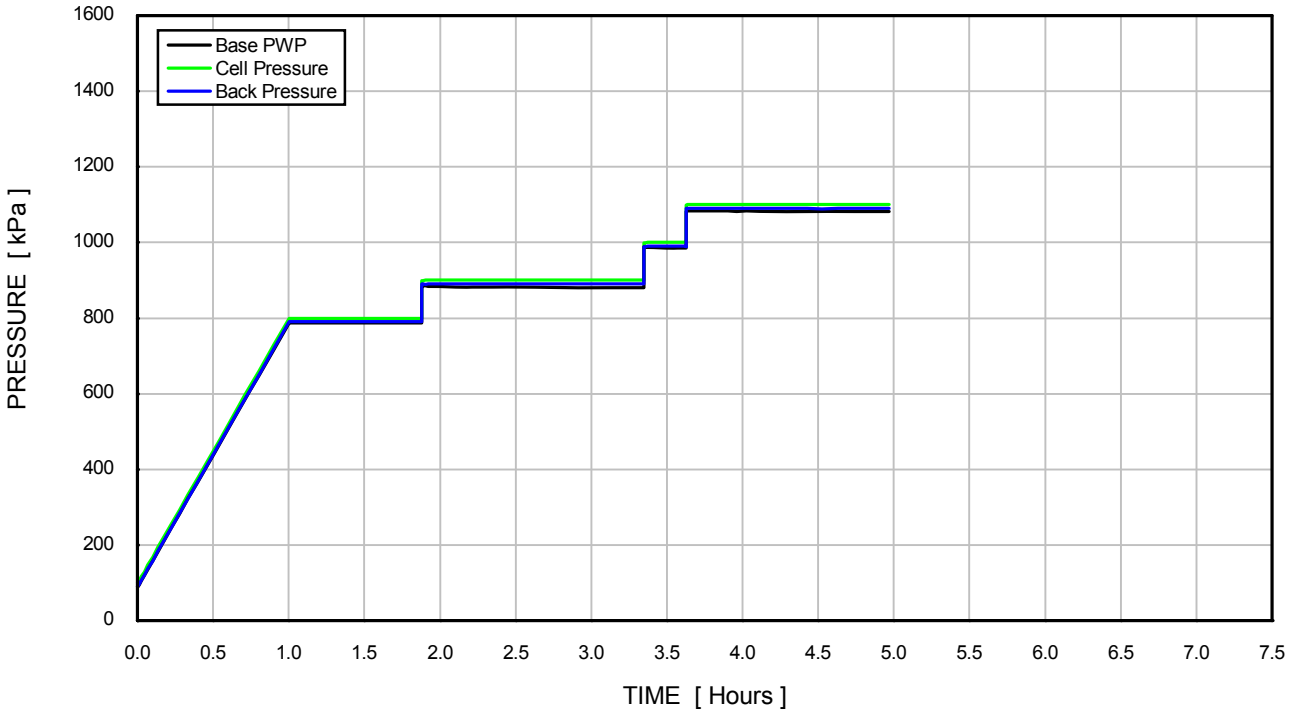


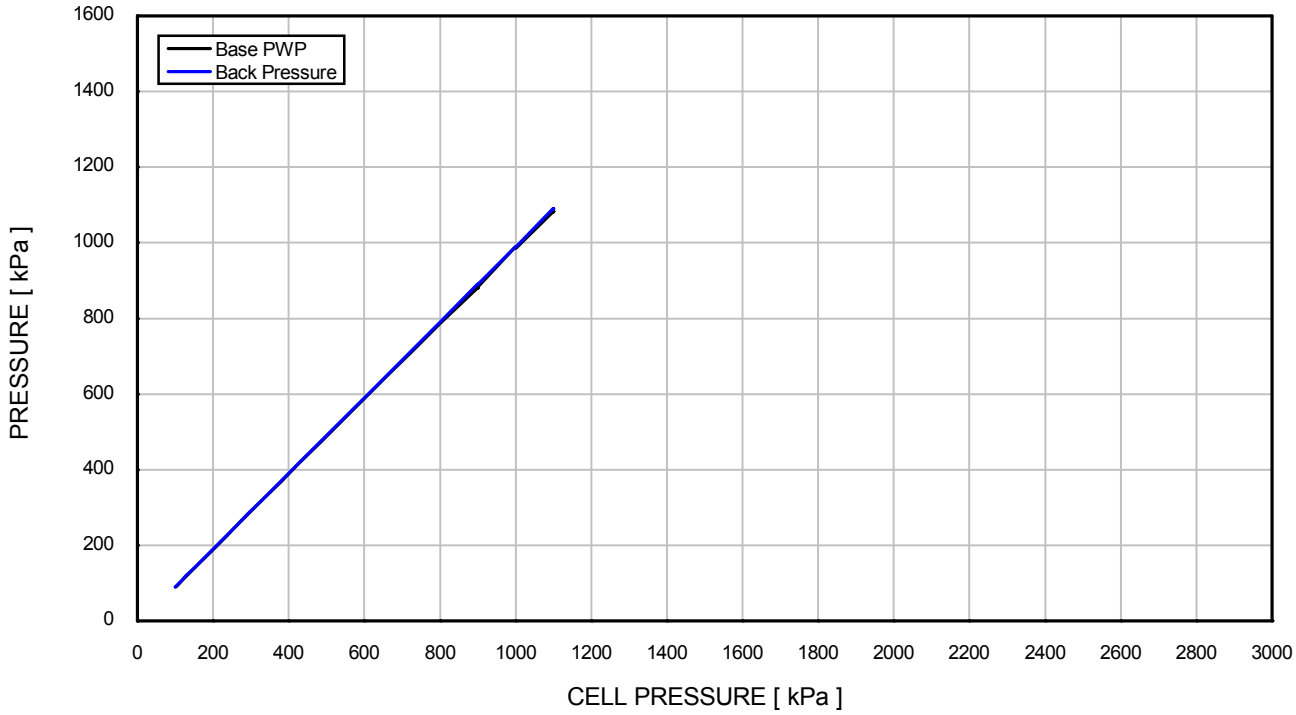
FINAL CONDITIONS		
Moisture content	[%]	23.2
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-3
Unit	E3 (Tongeren)
Test number	CTX15

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

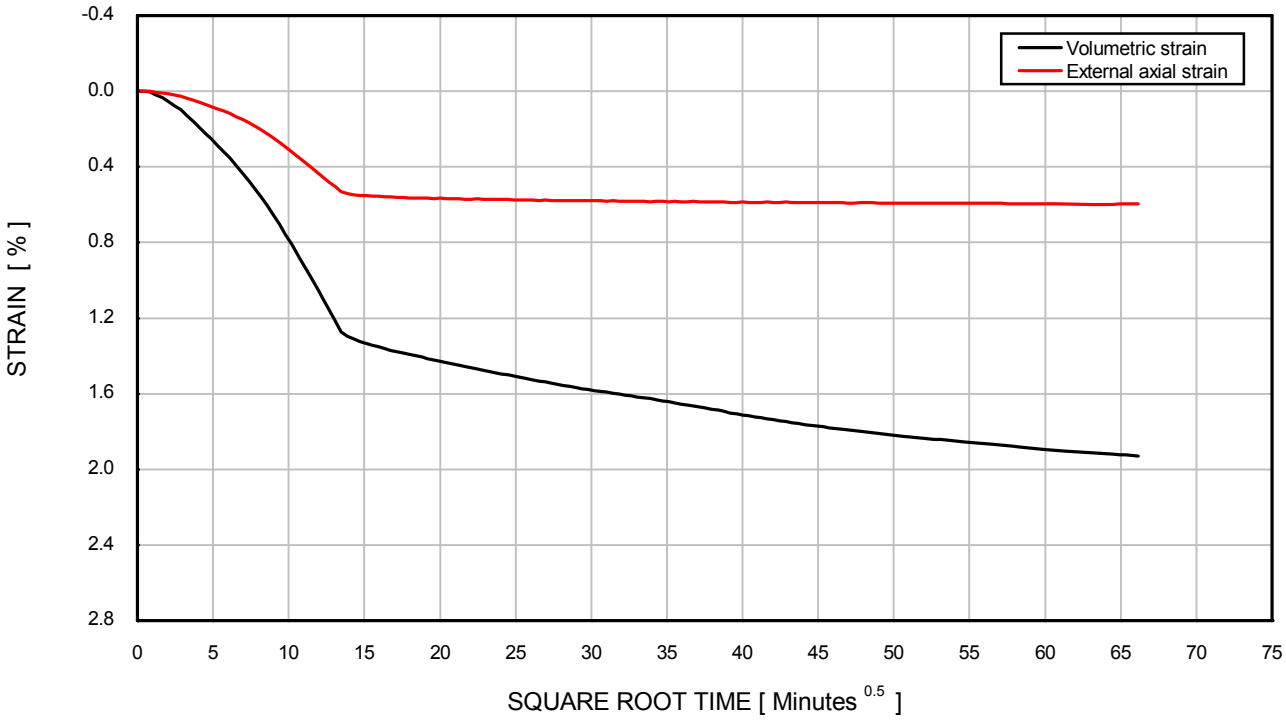


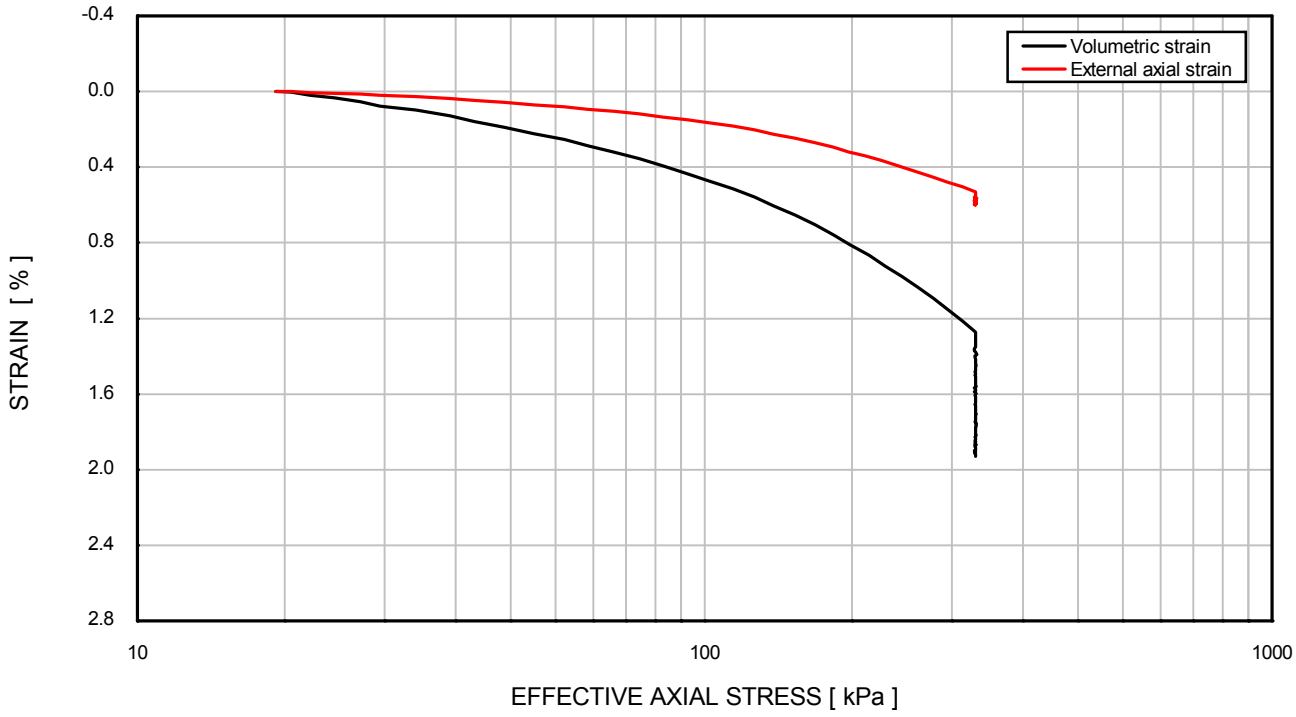


B value	:	0.96			
Initial σ'_r	:	10	kPa	Batch	: 3
Initial σ'_a	:	10	kPa	Sample	: CTX_3-3
Final σ'_r	:	18	kPa	Unit	: E3 (Tongeren)
Final σ'_a	:	18	kPa	Test No.	: CTX15

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

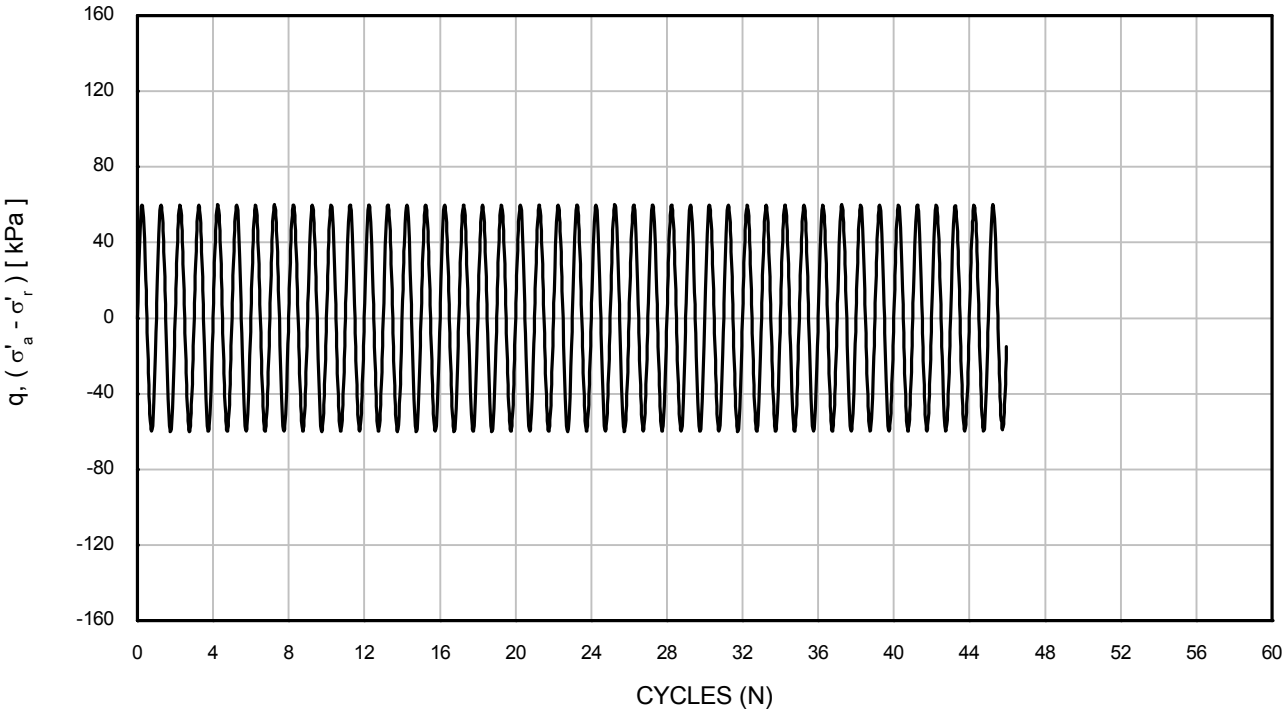


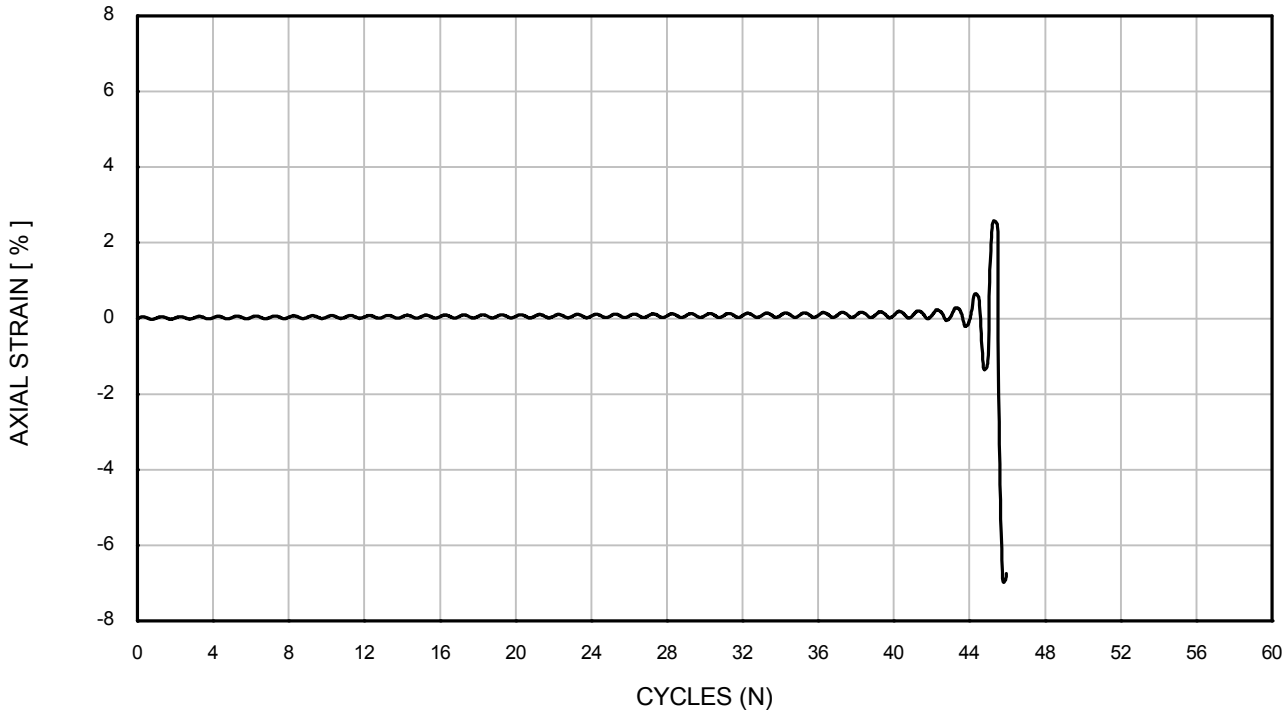


σ'_{rc}	: 300 kPa	Batch	: 3
σ'_{ac}	: 300 kPa	Sample	: CTX_3-3
		Unit	: E3 (Tongeren)
		Test No.	: CTX15

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

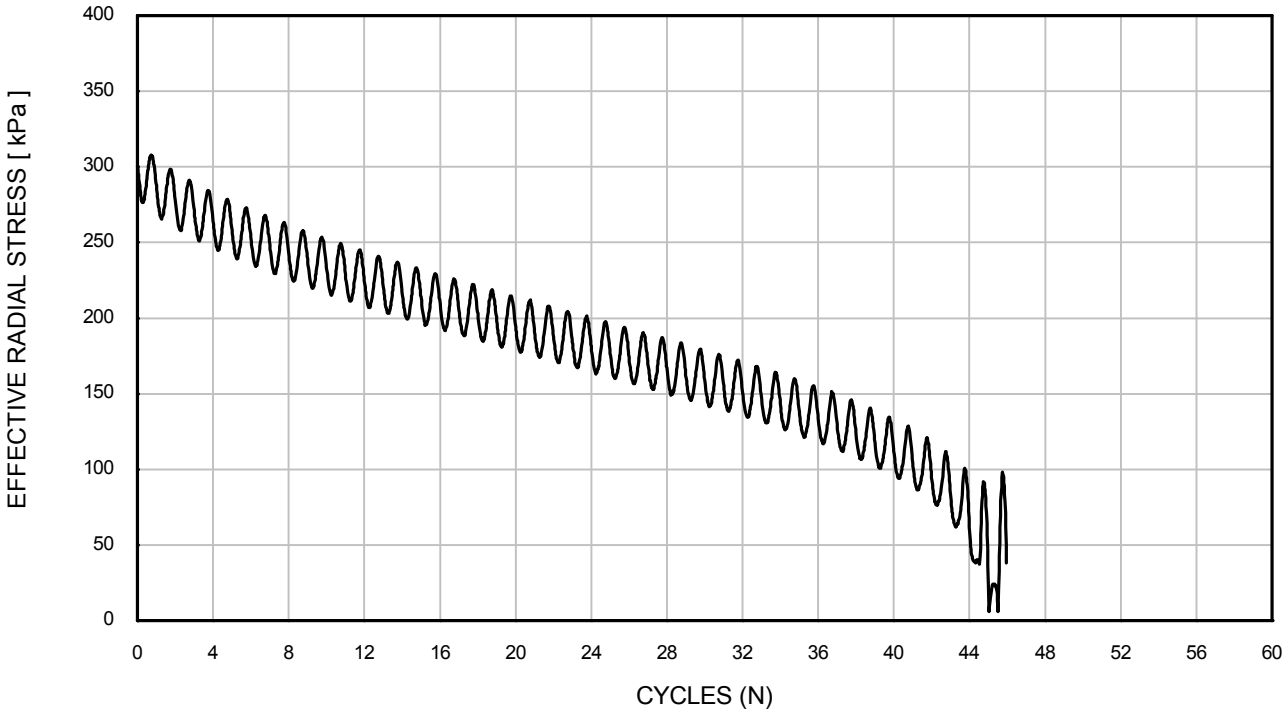


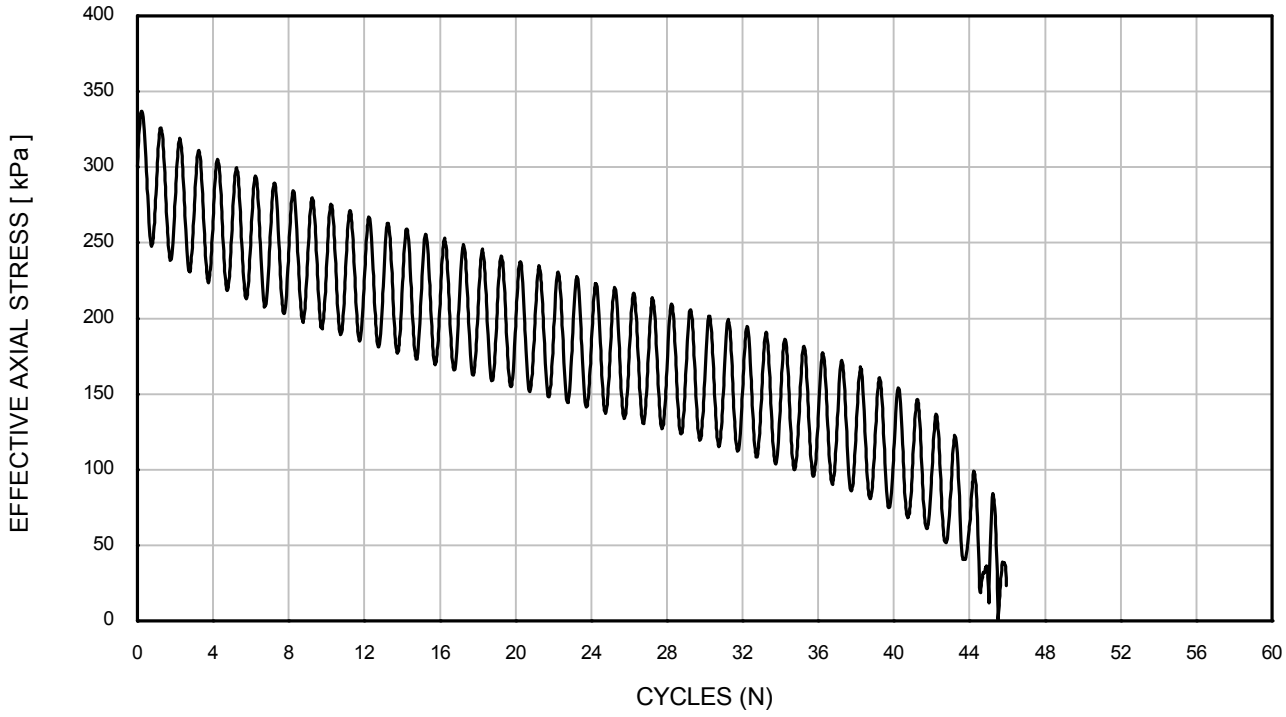


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-3
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	60 kPa	Test No.	:	CTX15
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

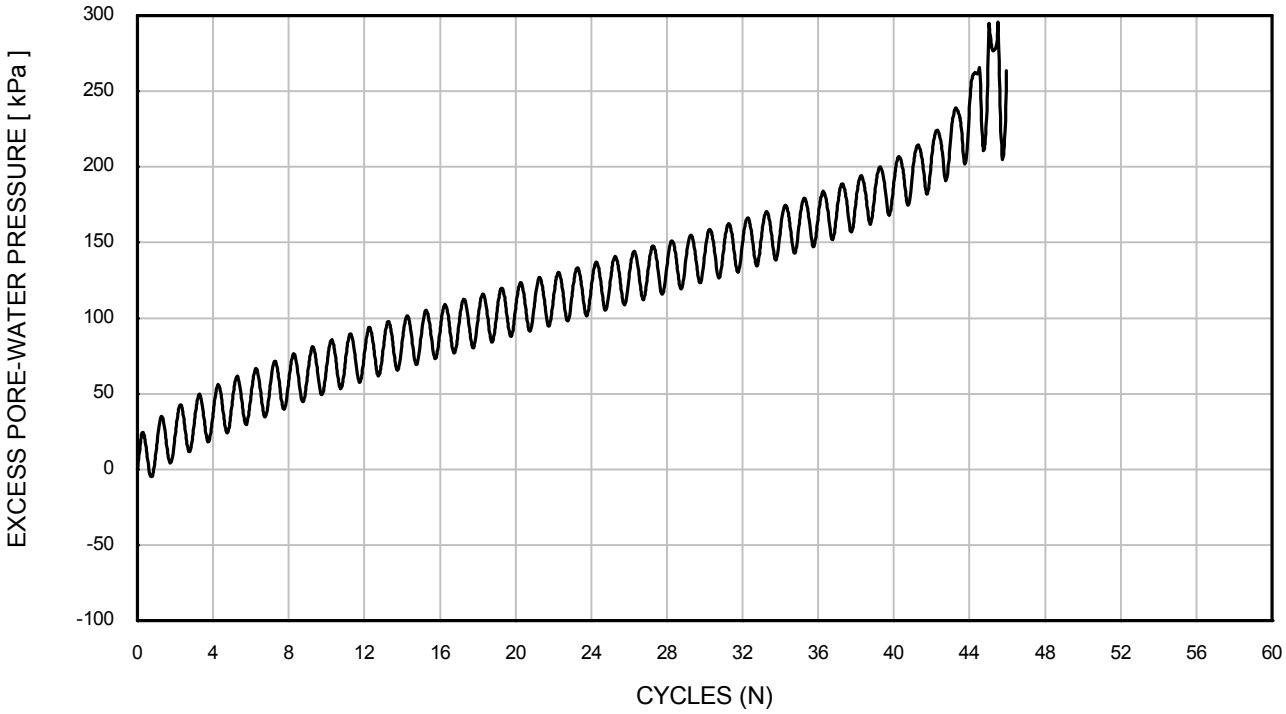


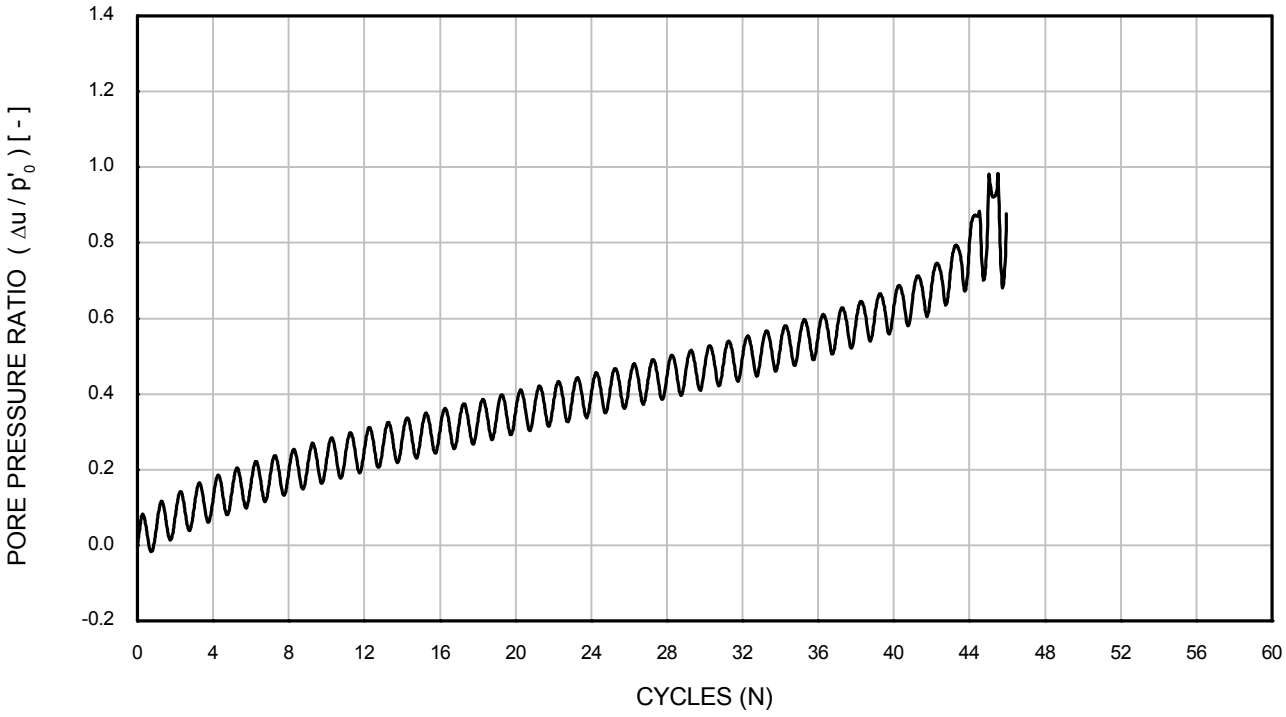


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-3
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	60 kPa	Test No.	:	CTX15
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

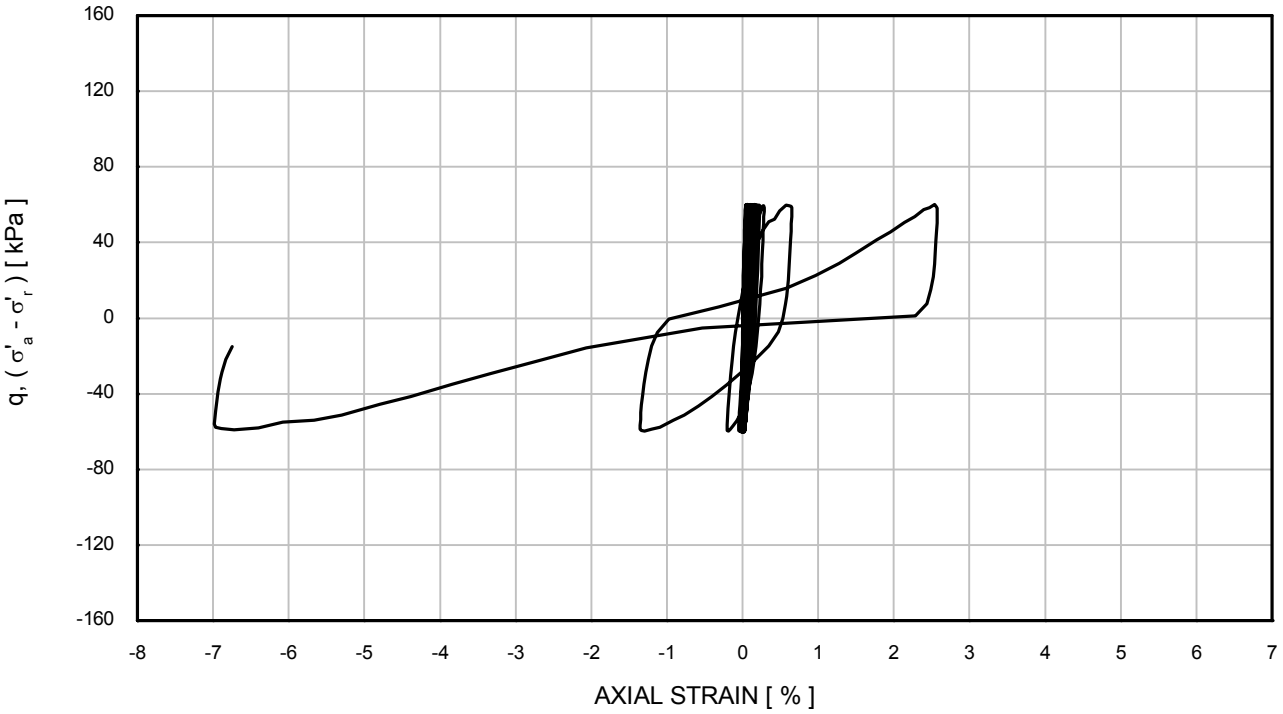


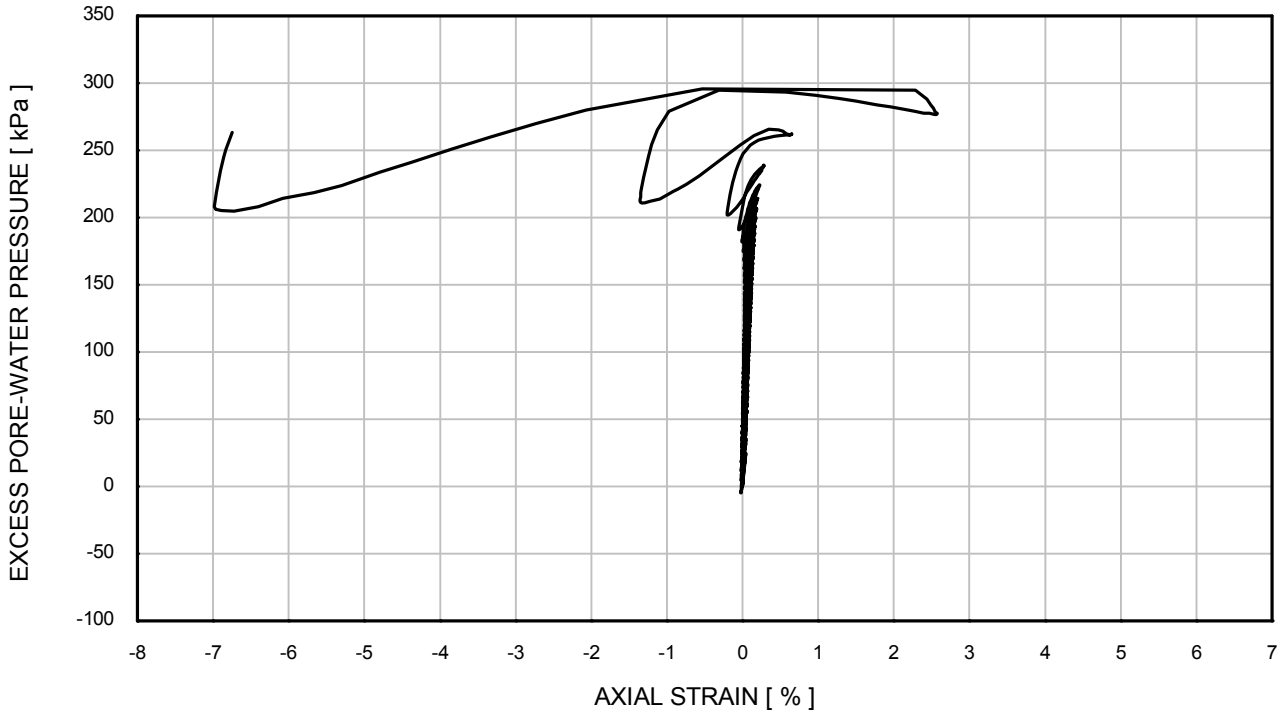


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-3
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	60 kPa	Test No.	:	CTX15
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

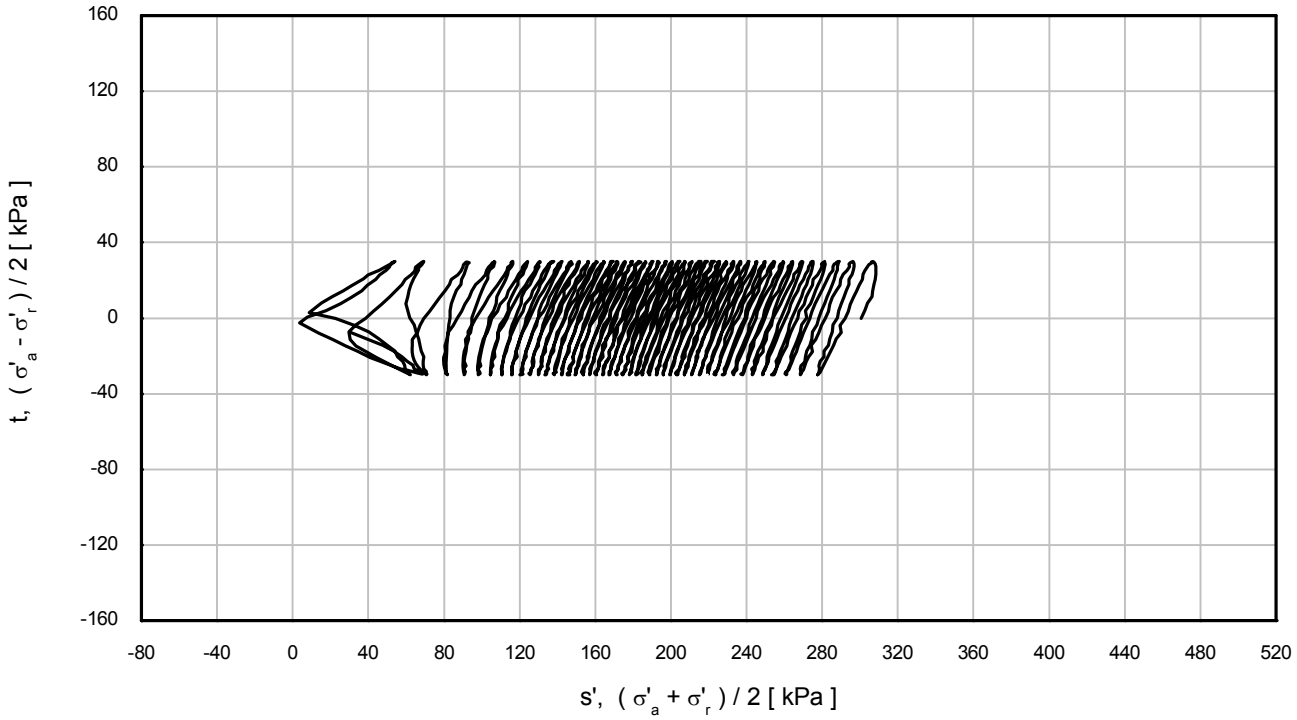


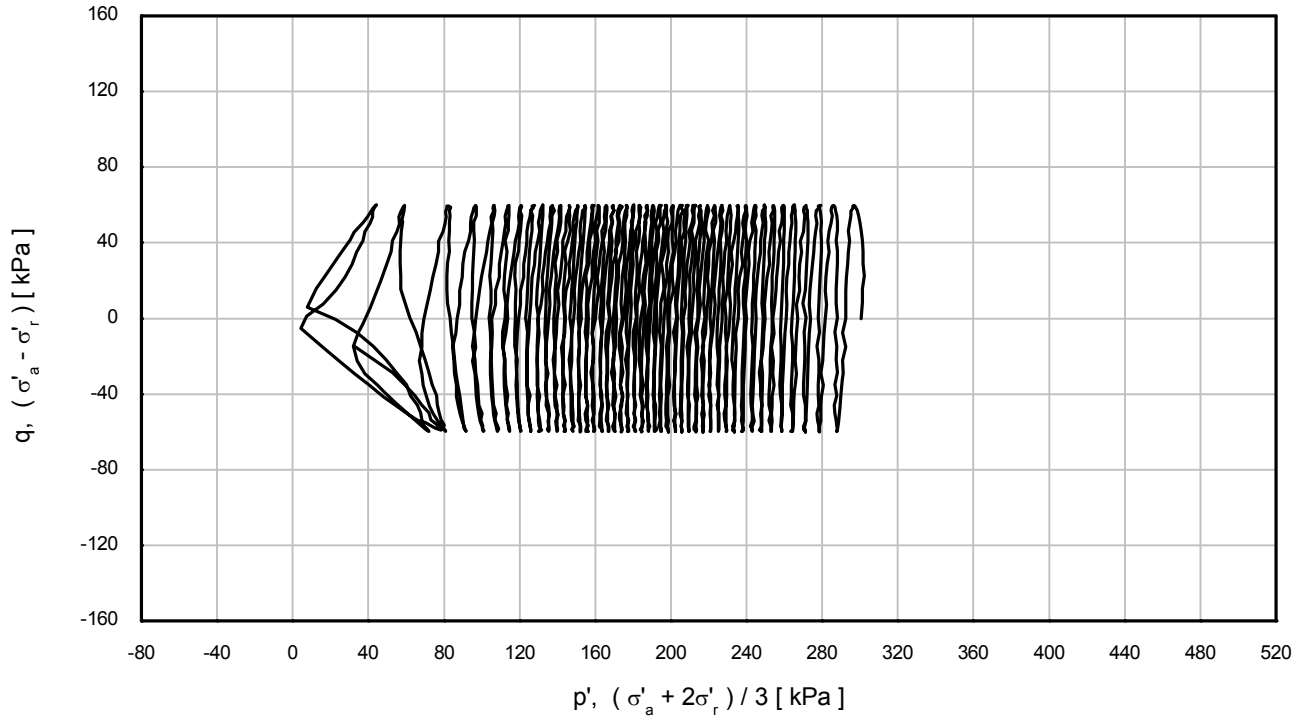


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-3
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	60 kPa	Test No.	:	CTX15
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

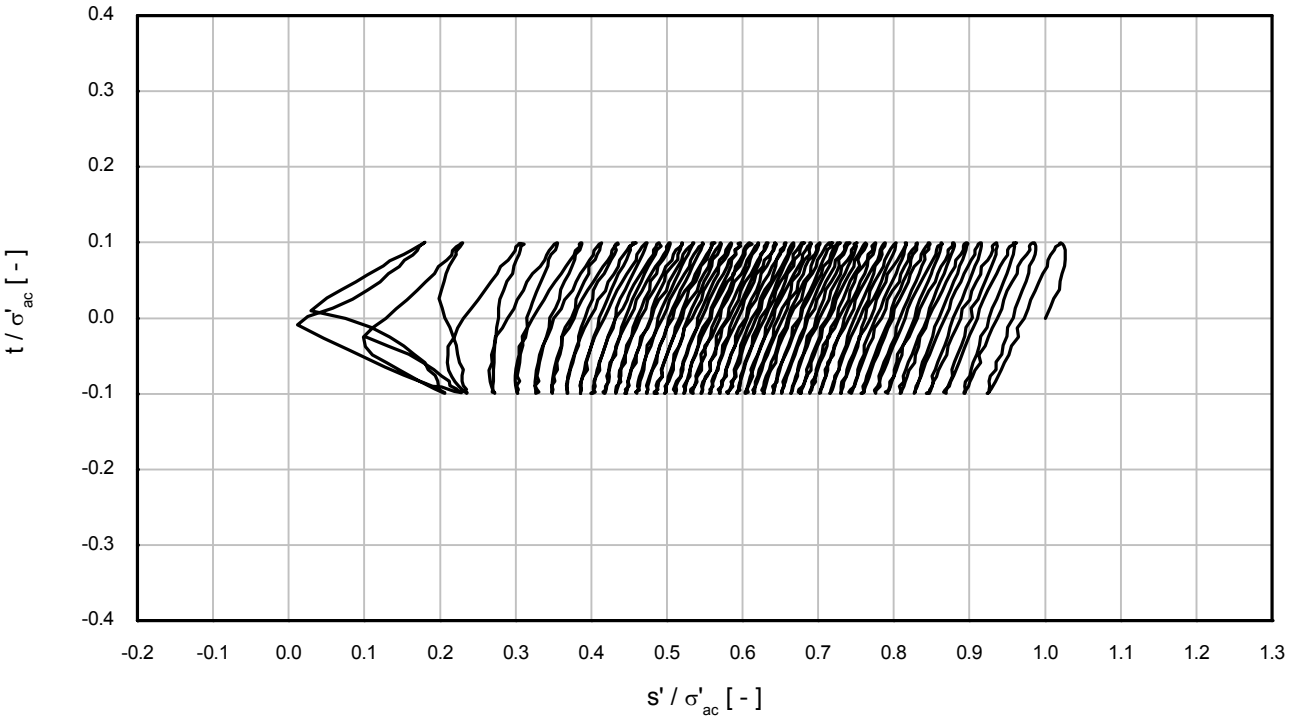


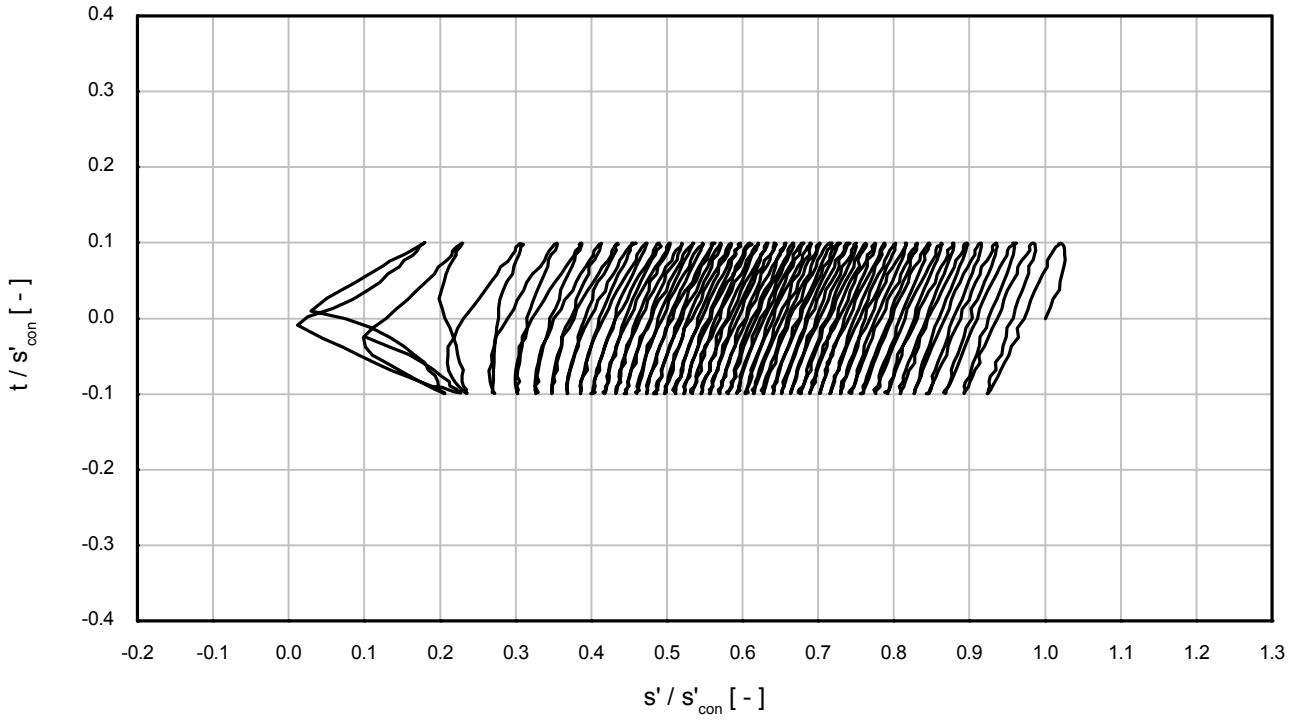


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-3
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	60 kPa	Test No.	:	CTX15
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

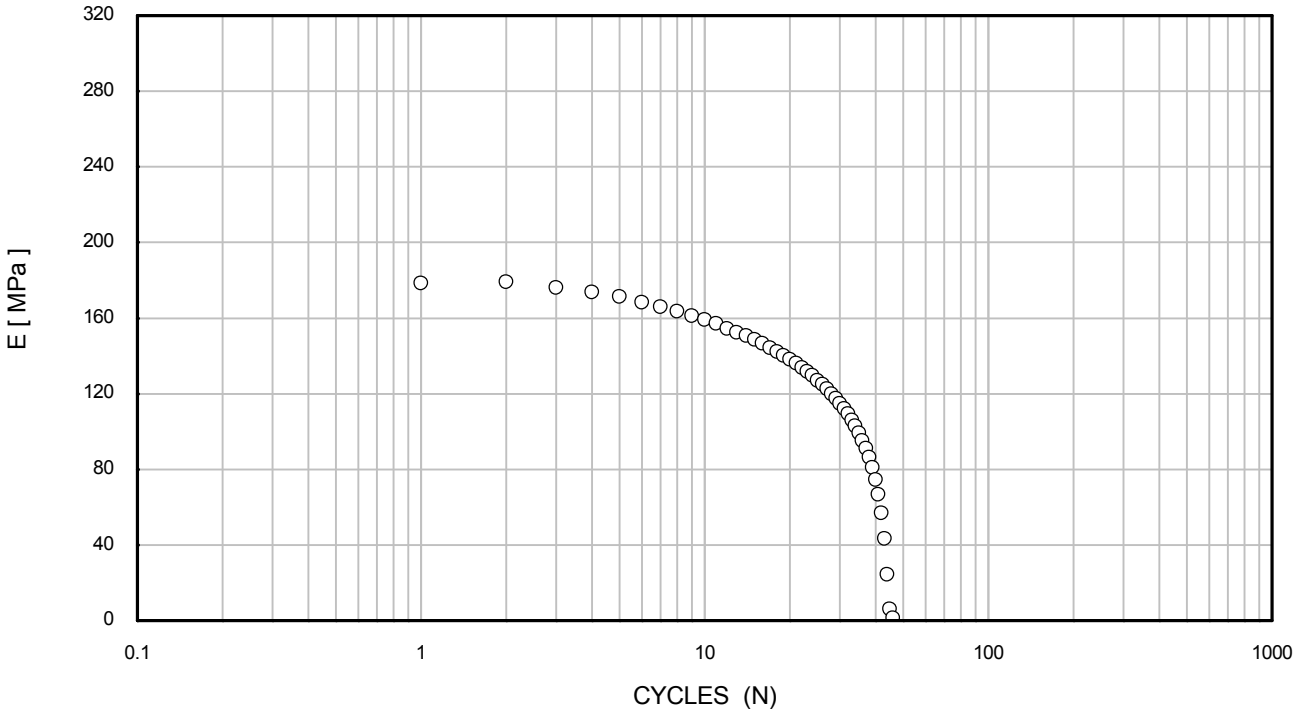


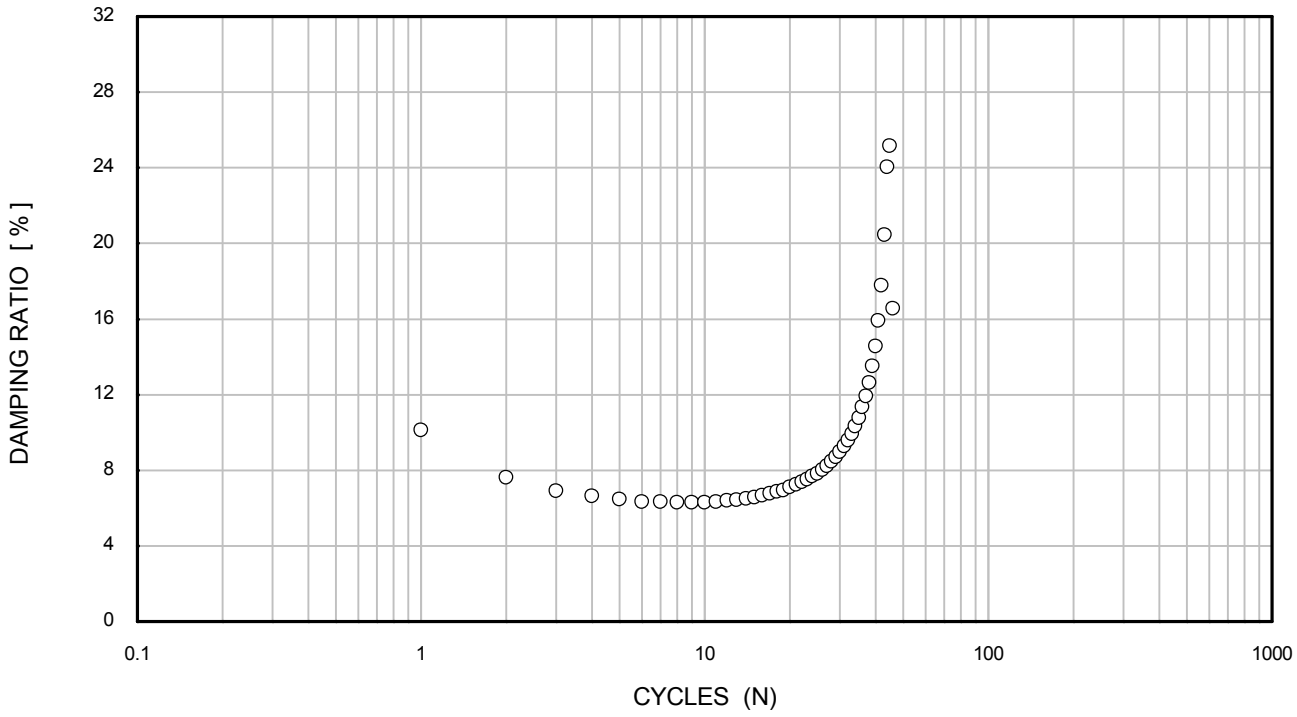


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-3
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	60 kPa	Test No.	:	CTX15
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

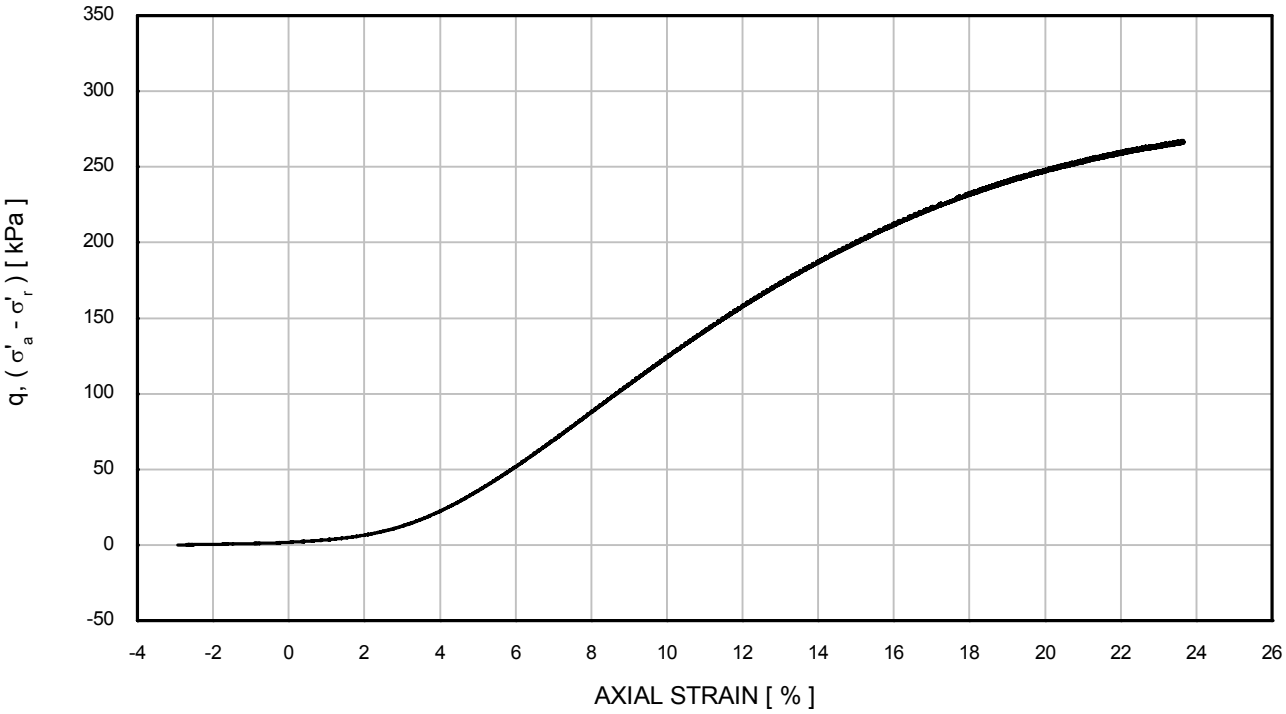


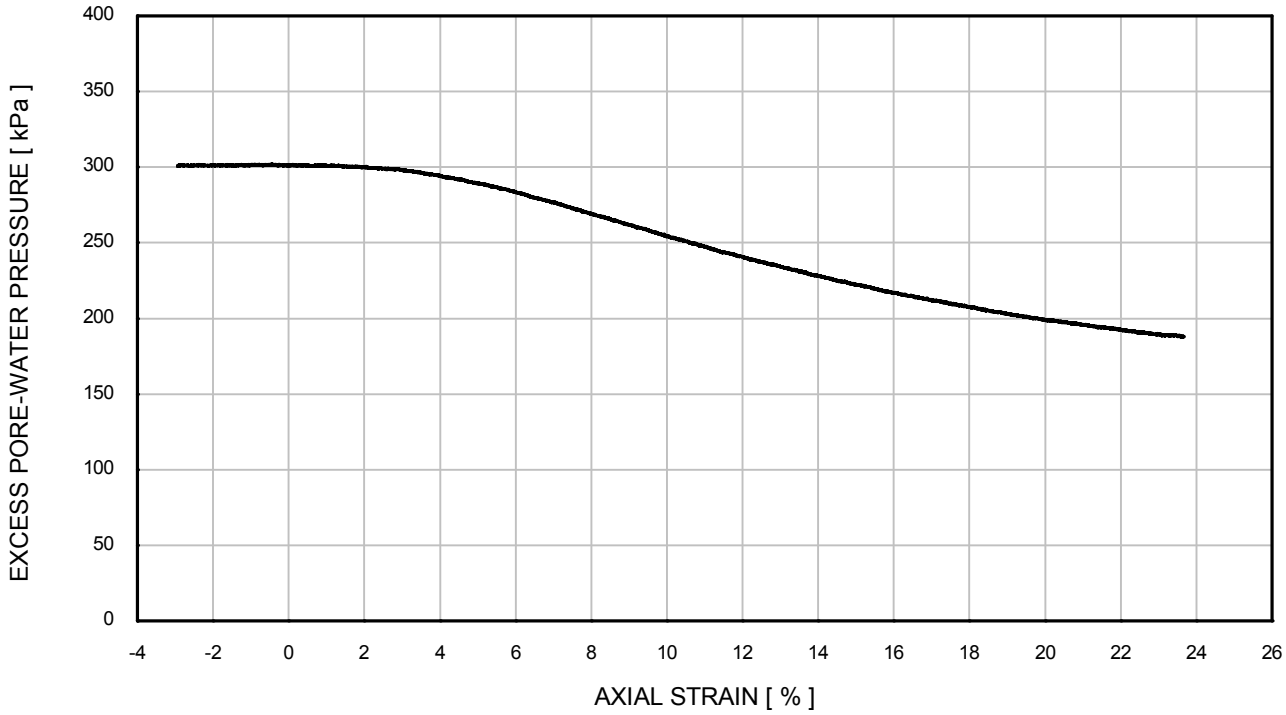


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-3
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	60 kPa	Test No.	:	CTX15
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

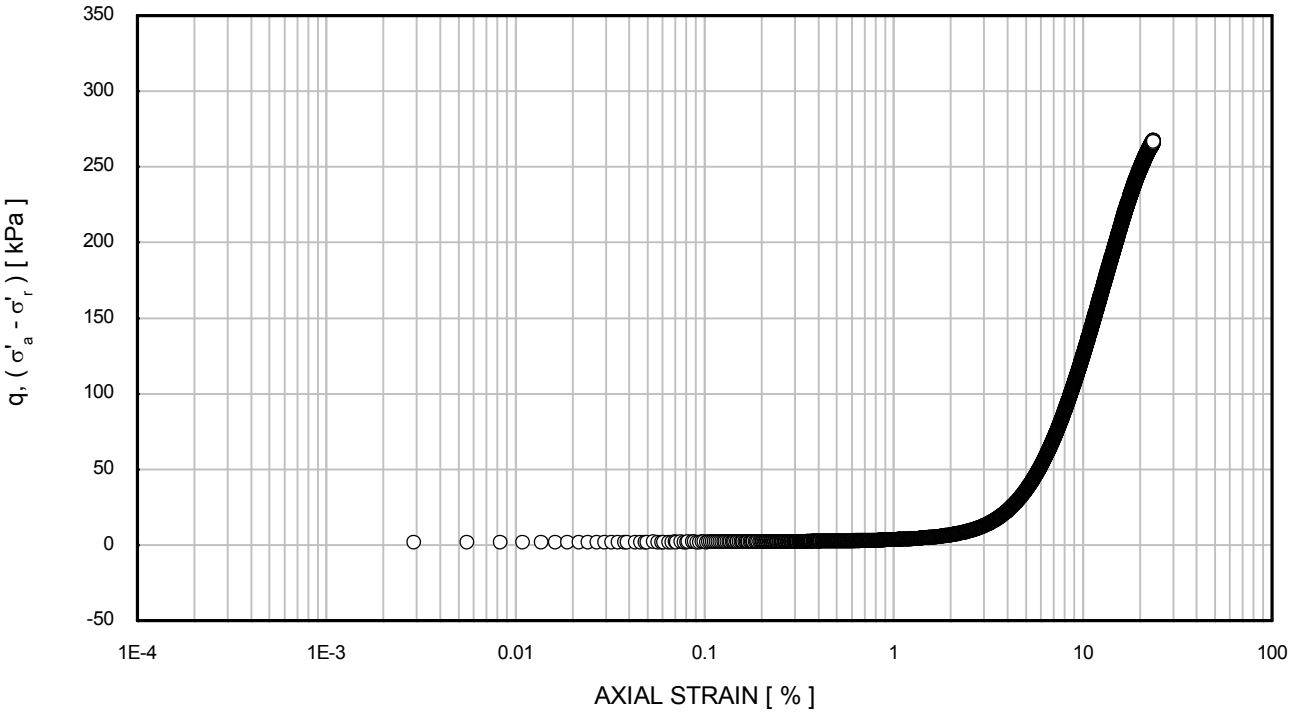


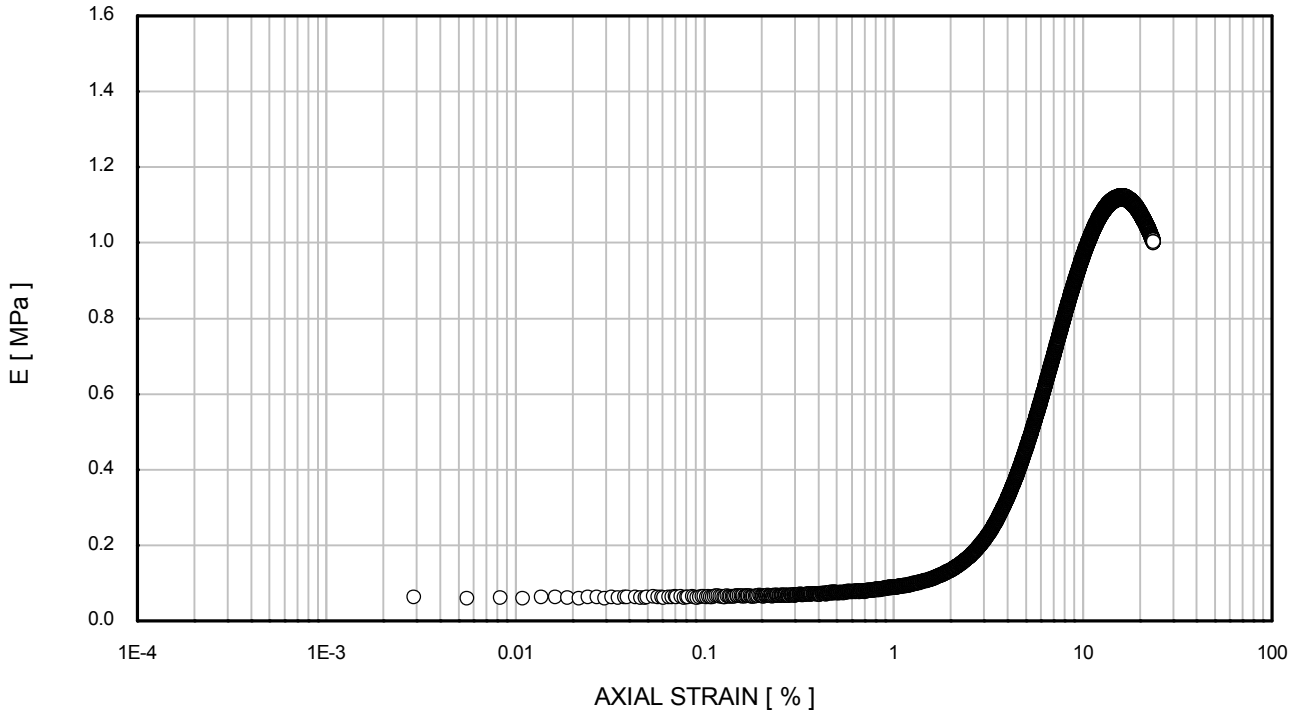


Initial σ'_r	:	1 kPa	Batch	:	3
Initial σ'_a	:	1 kPa	Sample	:	CTX_3-3
q_{peak}	:	268 kPa	Unit	:	E3 (Tongeren)
Ext. ε at q_{peak}	:	23.63 %	Test No.	:	CTX15
Rate of strain	:	4.82 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

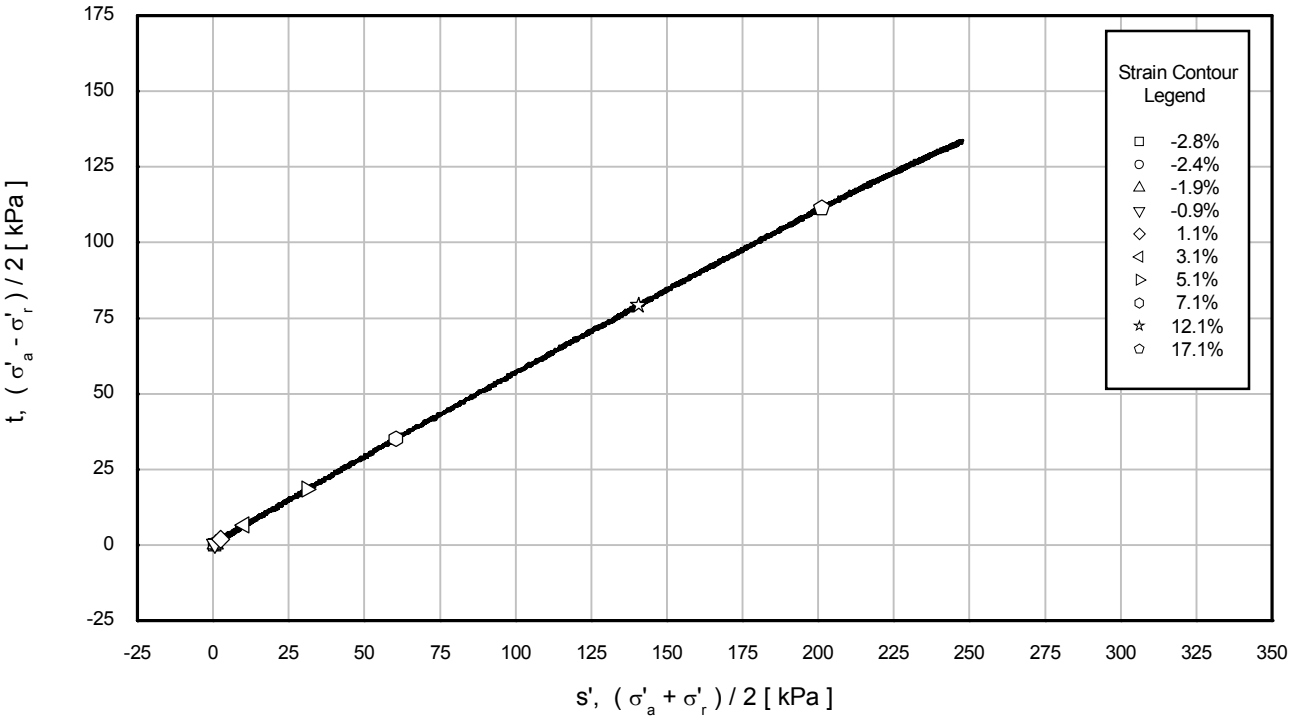


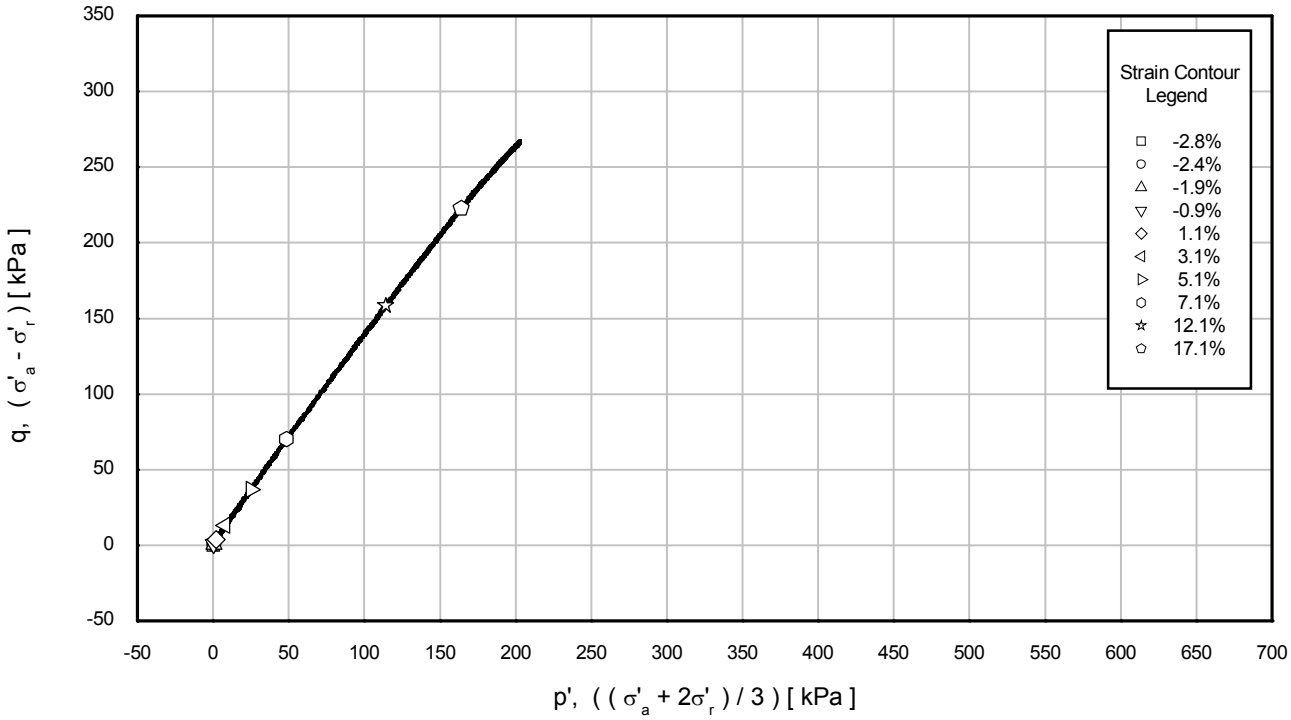


Initial σ'_r	:	1	kPa	Batch	: 3
Initial σ'_a	:	1	kPa	Sample	: CTX_3-3
q_{peak}	:	268	kPa	Unit	: E3 (Tongeren)
Ext. ε at q_{peak}	:	23.63	%	Test No.	: CTX15
Rate of strain	:	4.82	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	1	kPa	Batch	: 3
Initial σ'_a	:	1	kPa	Sample	: CTX_3-3
q_{peak}	:	268	kPa	Unit	: E3 (Tongeren)
Ext. ε at q_{peak}	:	23.63	%	Test No.	: CTX15
Rate of strain	:	4.82	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	05/02/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	9.1
Bulk density	[Mg/m³]	1.78
Dry density	[Mg/m³]	1.63
Void ratio	[-]	0.623
Degree of saturation	[%]	39
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 3_CTX-3-4_CTX16
Processed by Date	HJ 11/02/2016
Checked by Date	PH 16/02/2016
Approved by Date	PH 16/02/2016

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-4
Unit	E3 (Tongeren)
Test number	CTX16

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1074
Mid height PWP	[kPa]	-
B value achieved	[-]	0.99

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1374
Back pressure	[kPa]	1074
Base PWP	[kPa]	1074
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	300
Effective axial pressure	[kPa]	300
Deviator stress	[kPa]	0
Volumetric strain	[%]	1.27
External axial strain	[%]	0.51
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	22.7
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.602
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-4
Unit	E3 (Tongeren)
Test number	CTX16

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	600
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	42
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	248
External ε_{av} at N_f	[%]	-0.10
External ε_{cy} at N_f	[%]	0.19
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	241
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	22.7
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.602
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.02	207.64	-	3.33	-
2	0.00	0.02	211.32	-	1.89	-
5	0.00	0.02	208.38	-	1.23	-
10	0.00	0.02	204.77	-	1.06	-
20	0.00	0.02	198.23	-	1.02	-
30	0.00	0.02	192.88	-	1.04	-
40	0.00	0.02	188.48	-	1.13	-
50	0.01	0.02	183.88	-	1.17	-
100	0.01	0.03	165.44	-	1.77	-
248	-0.10	0.19	22.12	-	22.96	-

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-4
Unit	E3 (Tongeren)
Test number	CTX16

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



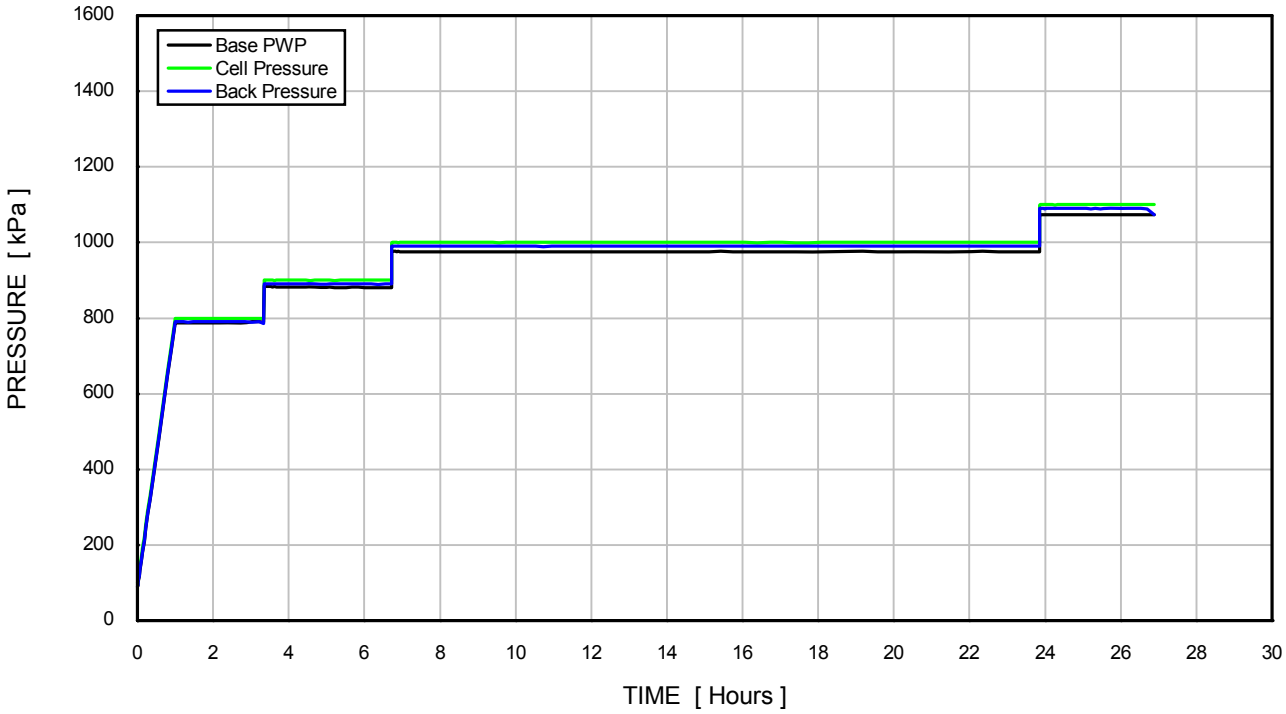


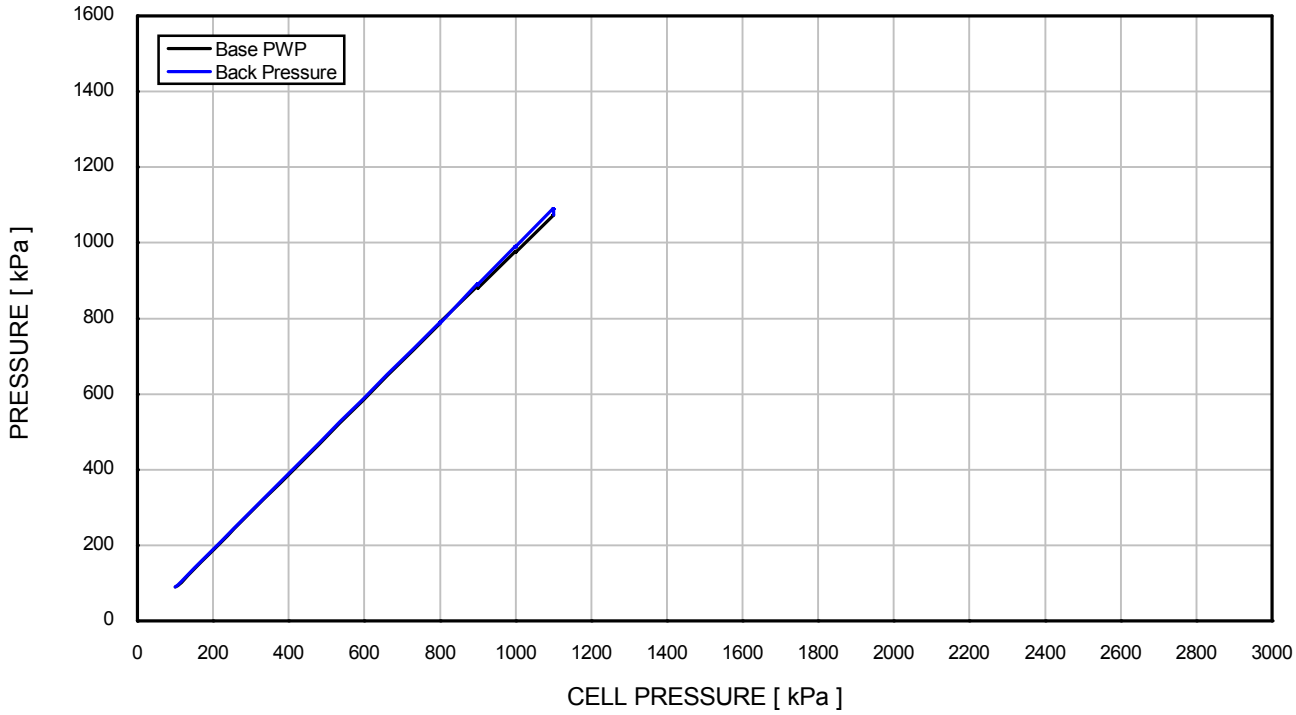
FINAL CONDITIONS		
Moisture content	[%]	22.7
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65

TEST IDENTIFICATION	
Batch	3
Sample	CTX_3-4
Unit	E3 (Tongeren)
Test number	CTX16

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

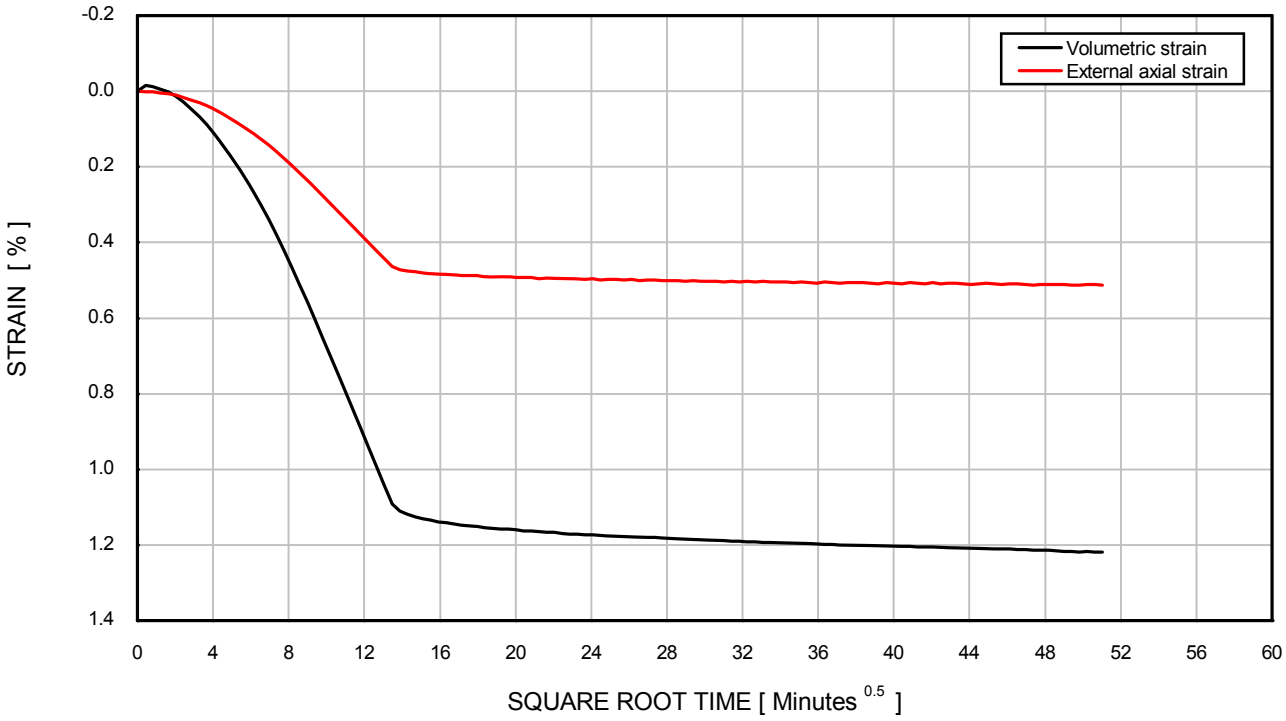


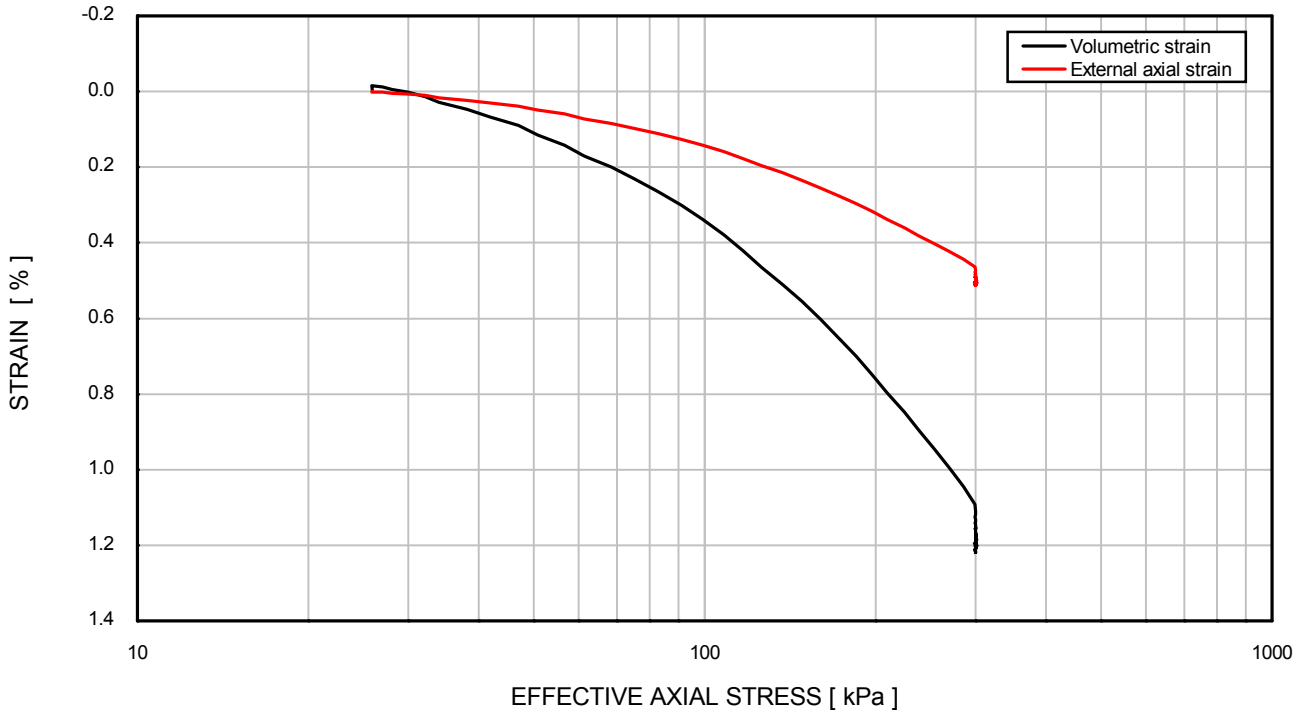


B value	:	0.99			
Initial σ'_r	:	10	kPa	Batch	: 3
Initial σ'_a	:	10	kPa	Sample	: CTX_3-4
Final σ'_r	:	26	kPa	Unit	: E3 (Tongeren)
Final σ'_a	:	26	kPa	Test No.	: CTX16

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

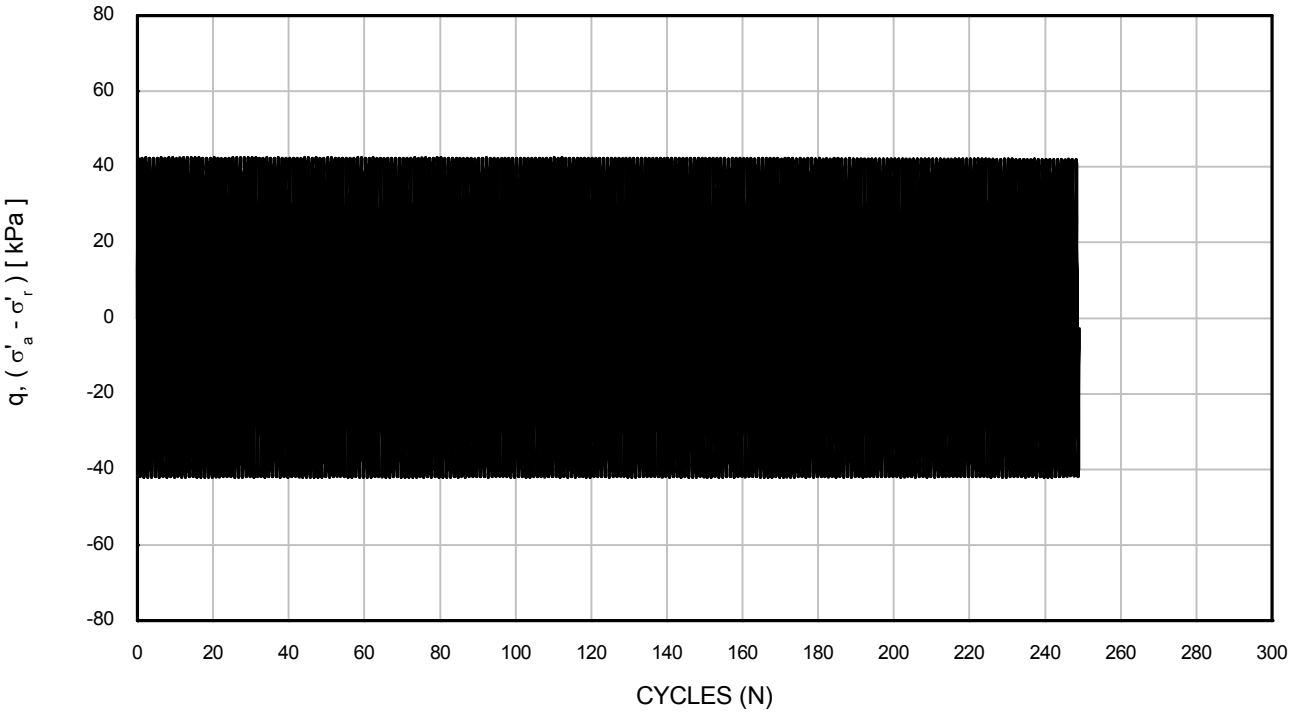


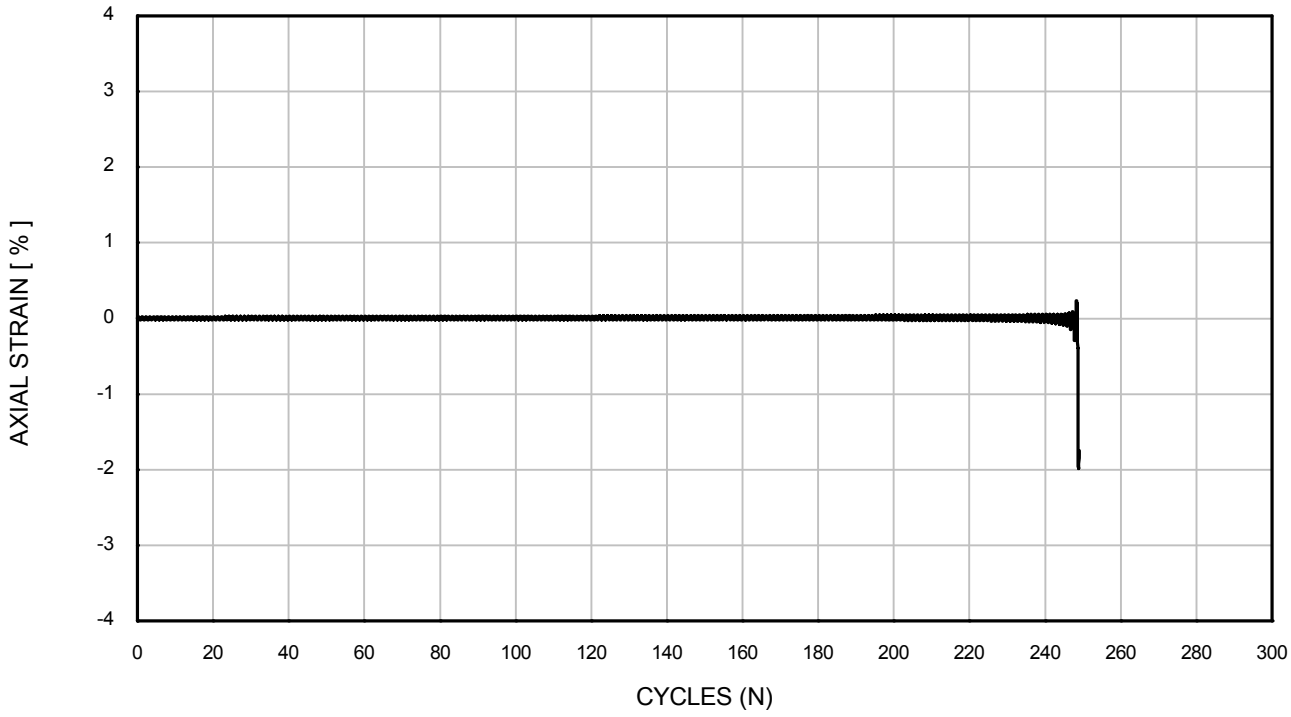


σ'_{rc}	: 300 kPa	Batch	: 3
σ'_{ac}	: 300 kPa	Sample	: CTX_3-4
		Unit	: E3 (Tongeren)
		Test No.	: CTX16

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

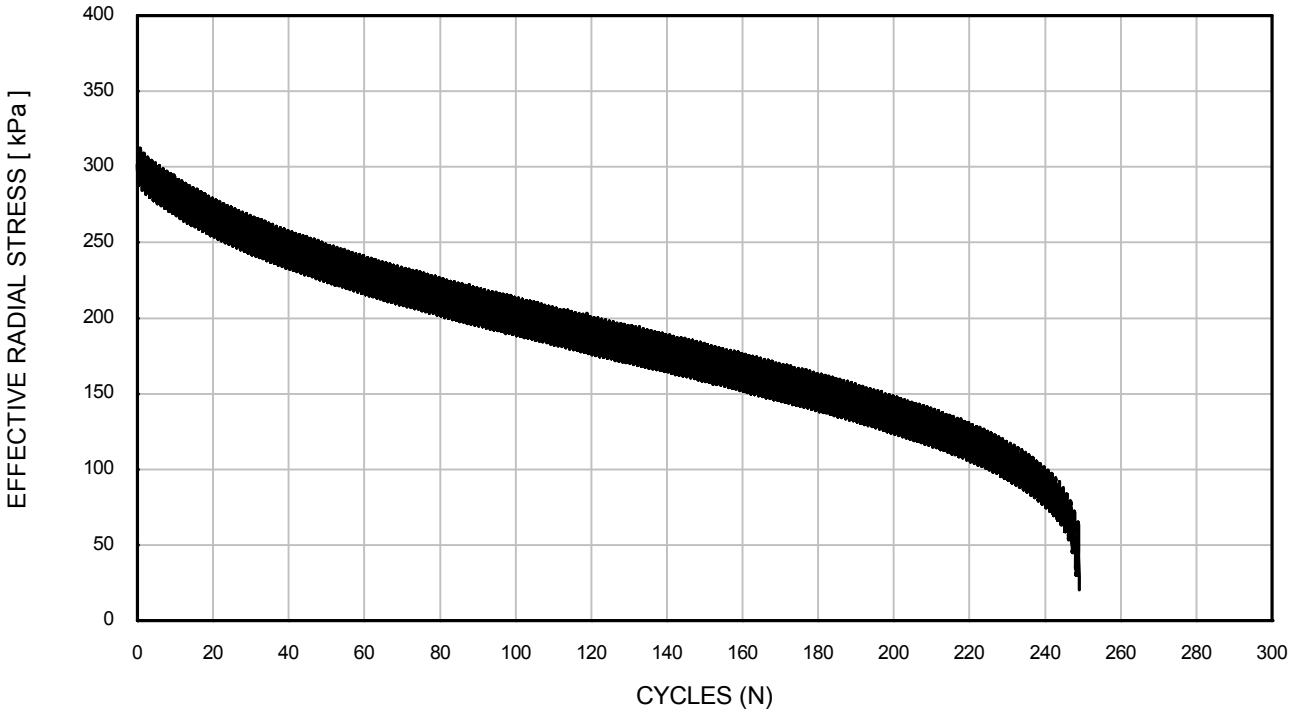


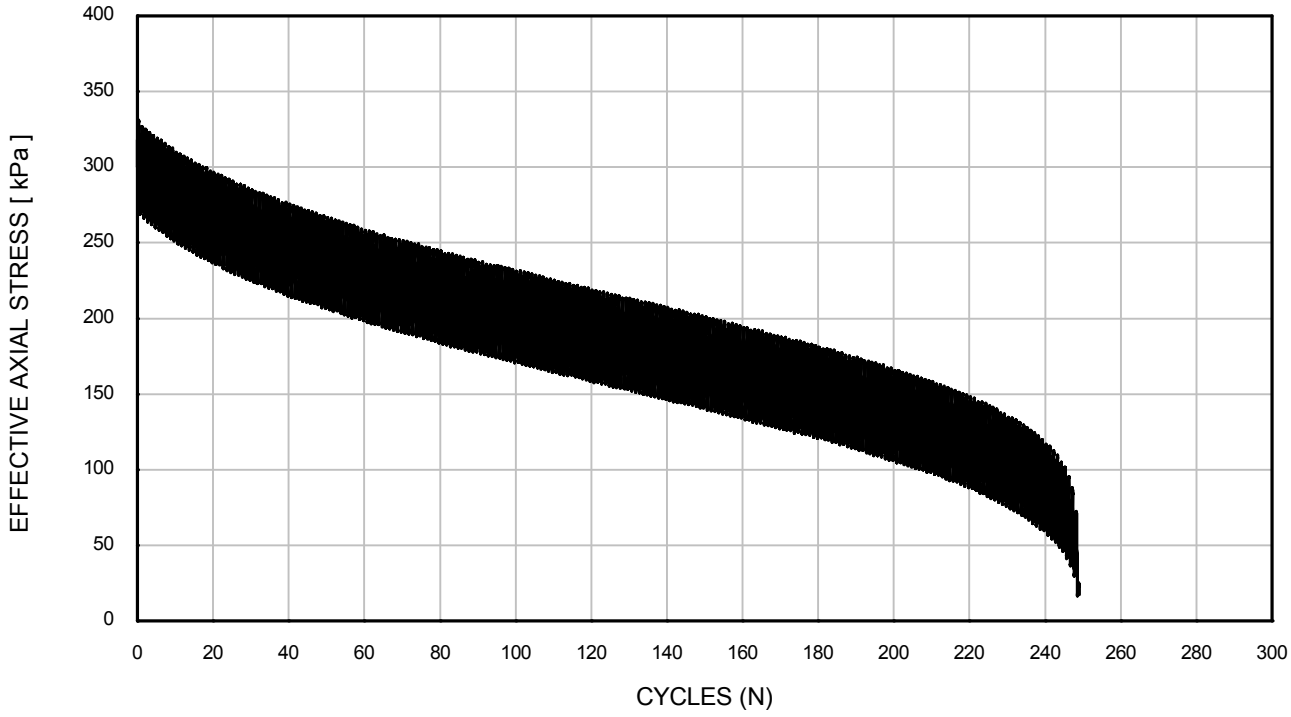


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-4
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	42 kPa	Test No.	:	CTX16
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

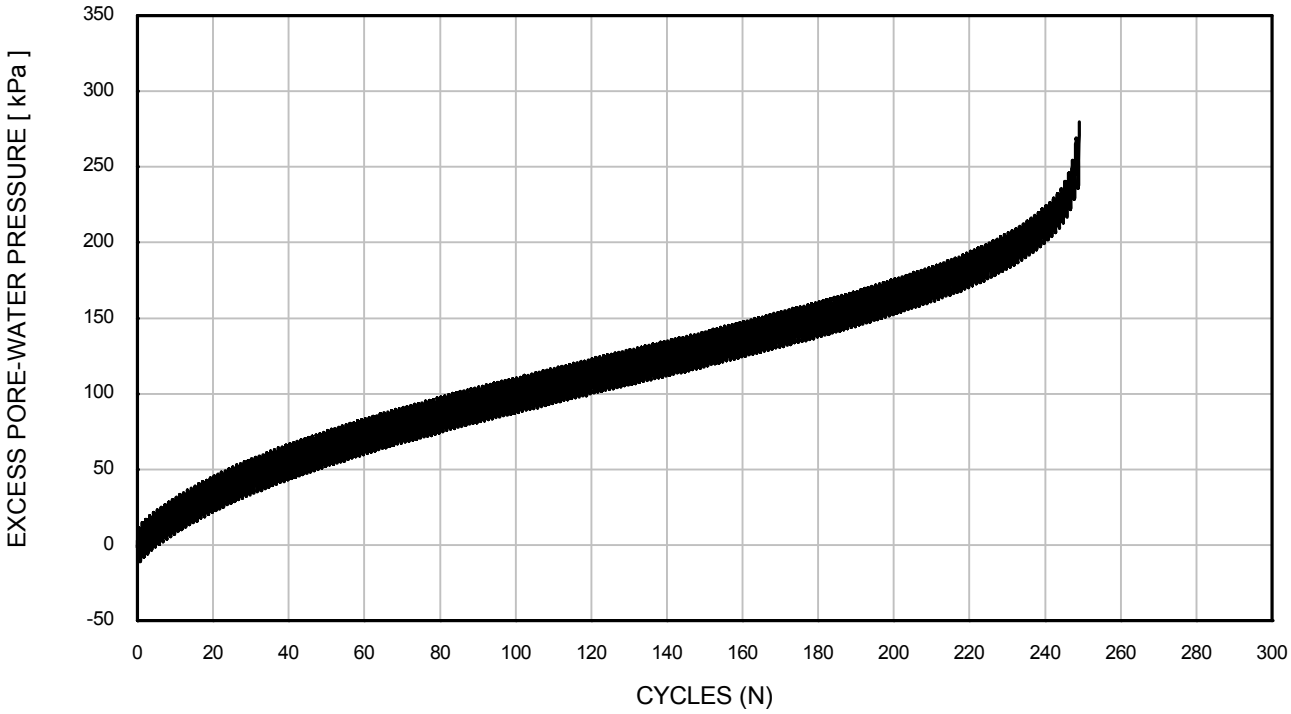


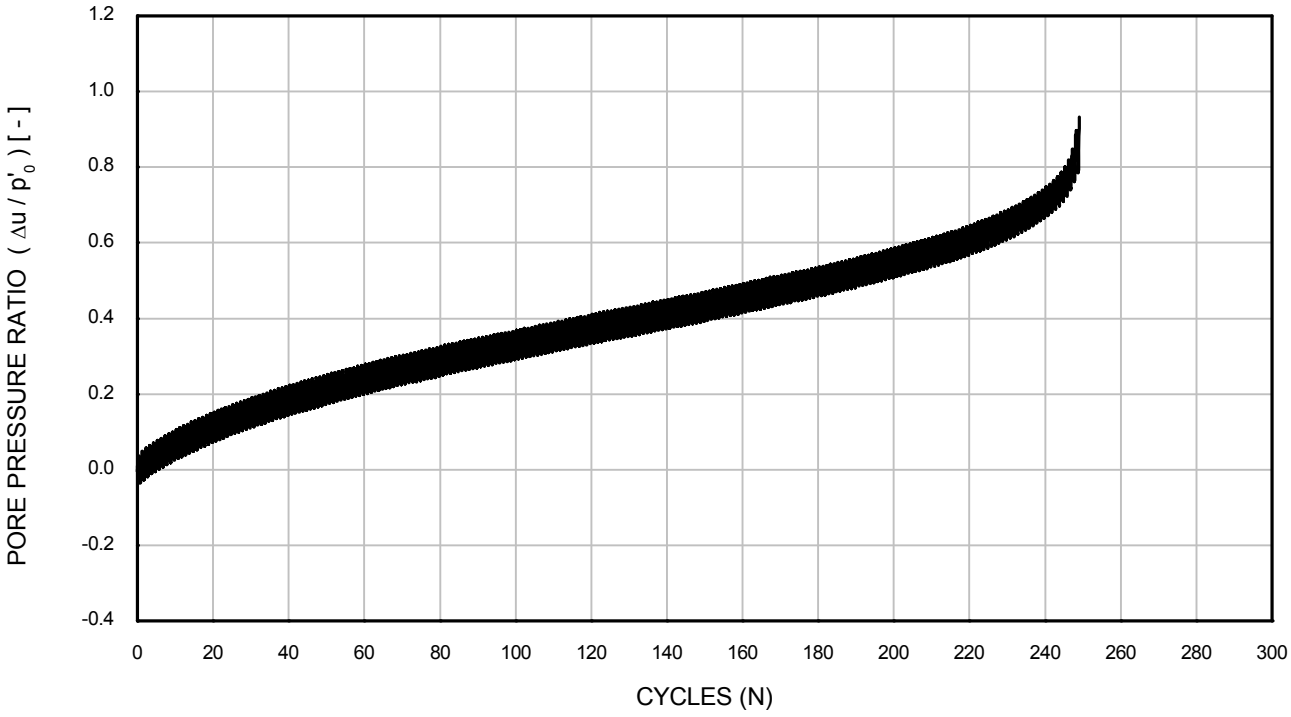


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-4
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	42 kPa	Test No.	:	CTX16
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

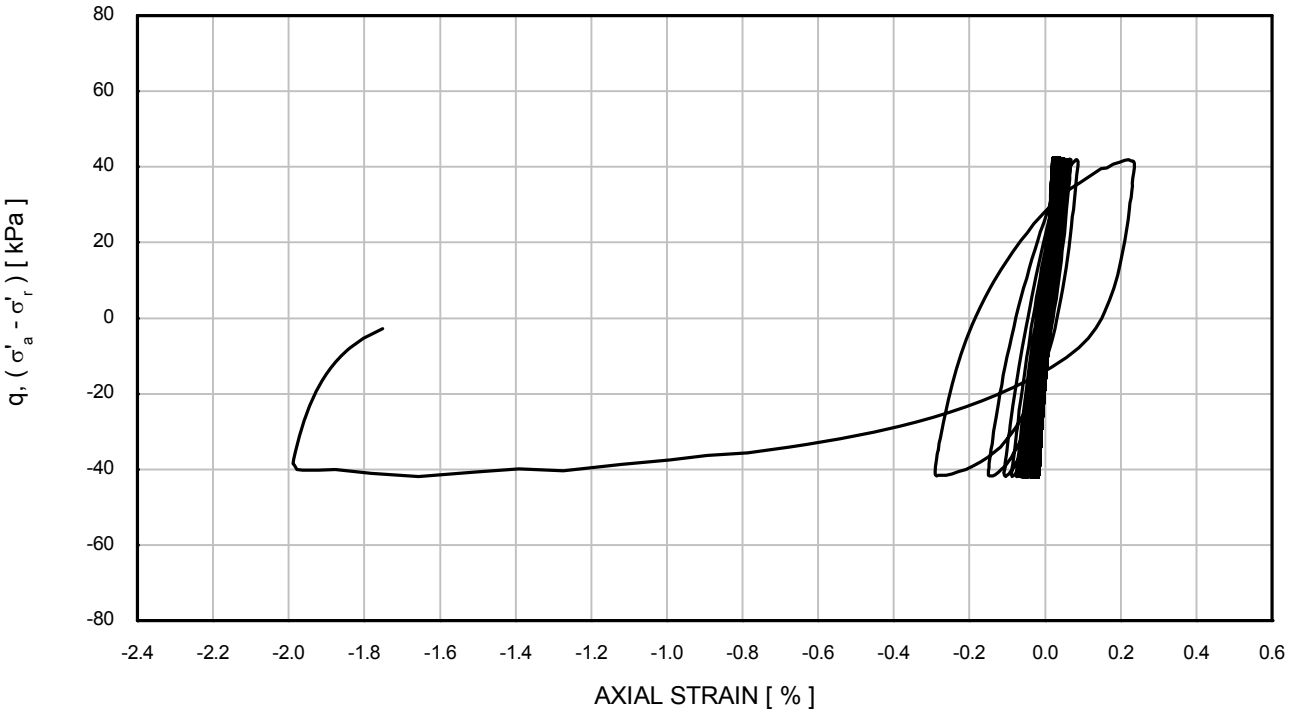


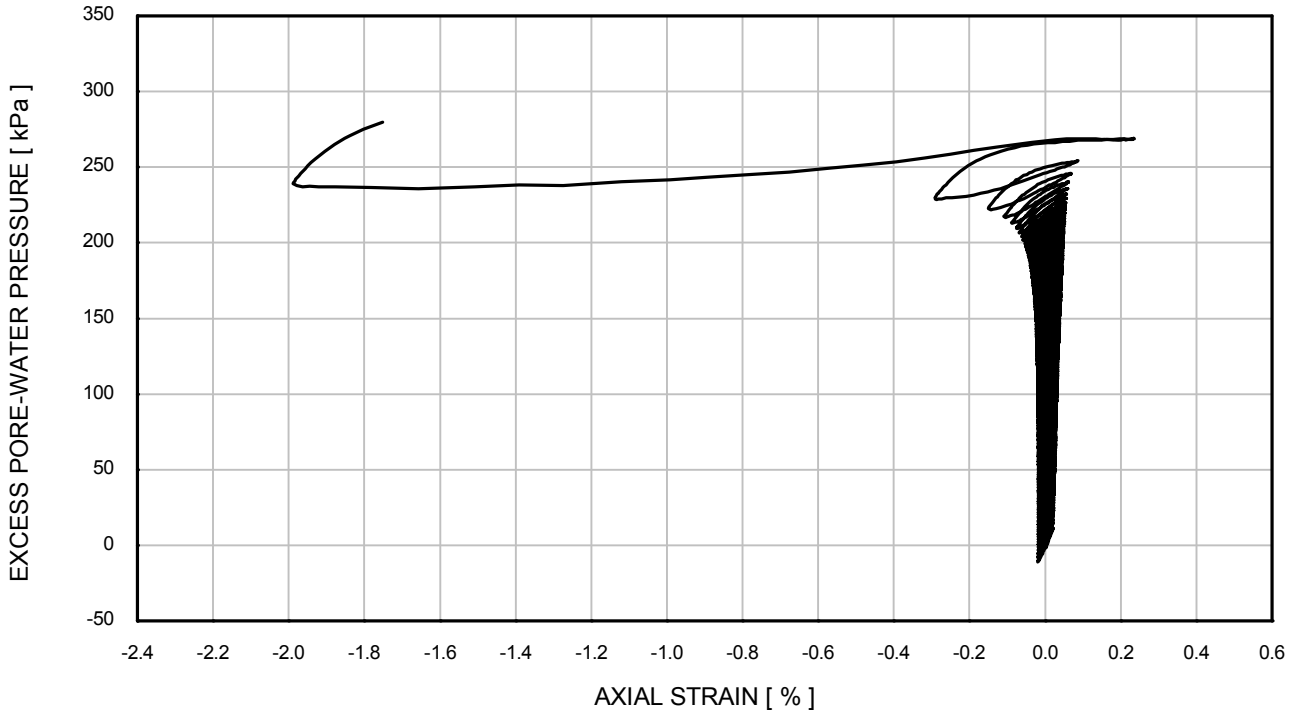


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-4
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	42 kPa	Test No.	:	CTX16
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

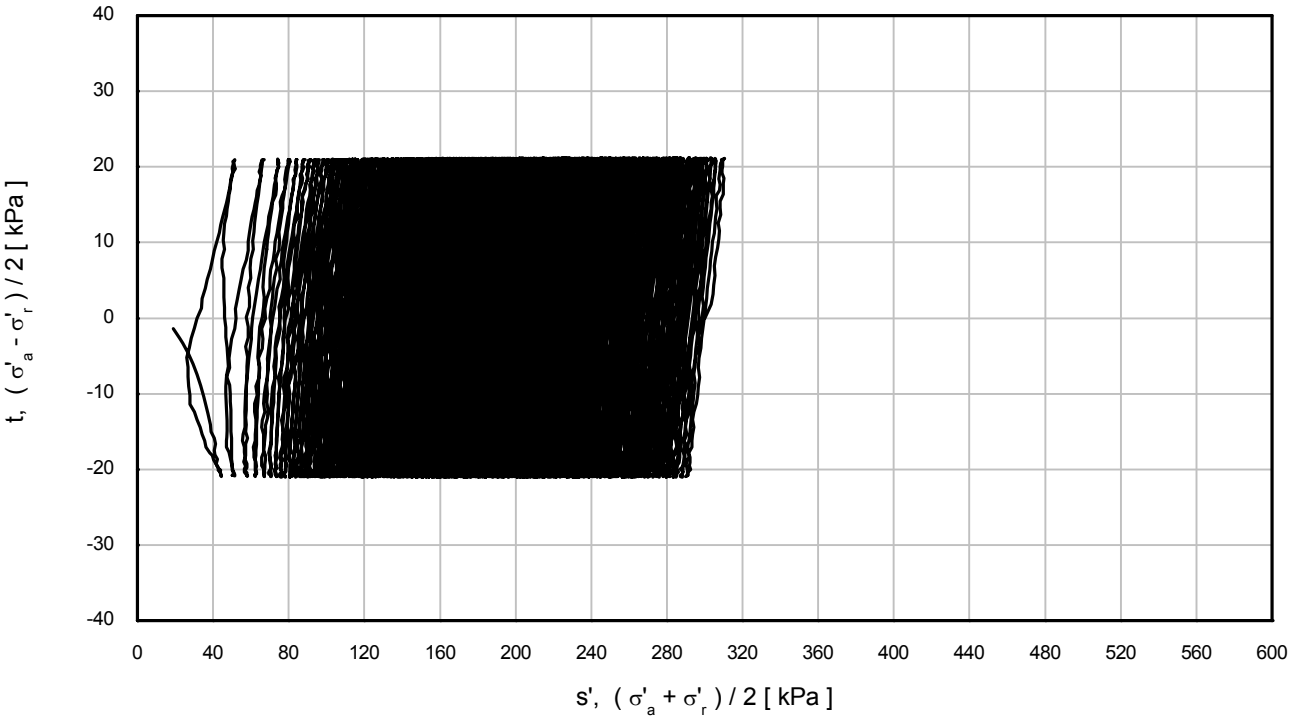


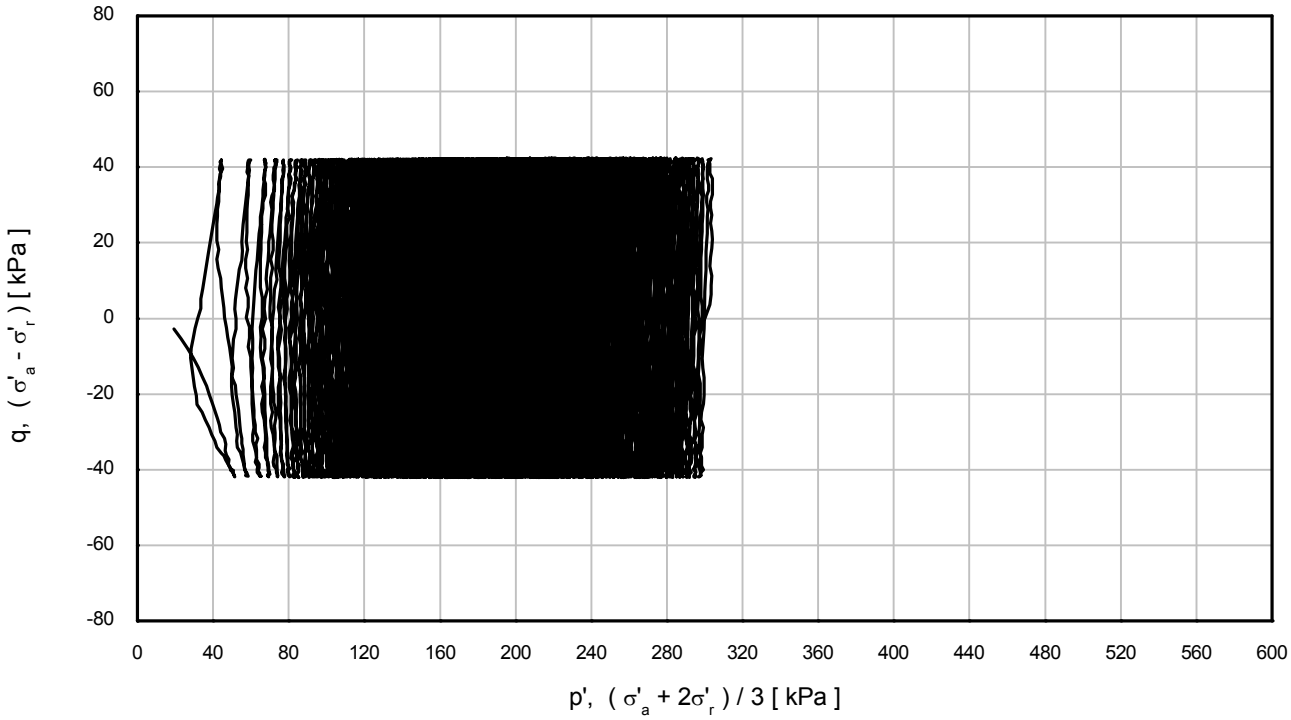


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-4
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	42 kPa	Test No.	:	CTX16
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

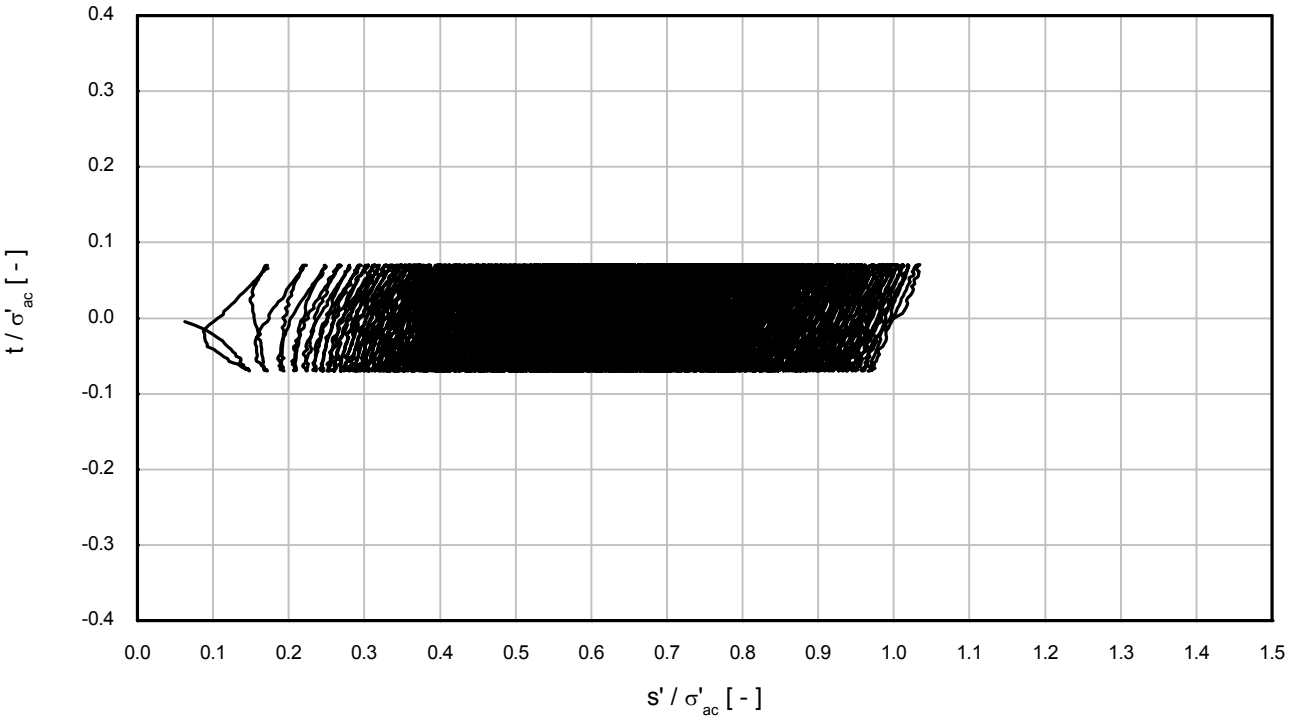


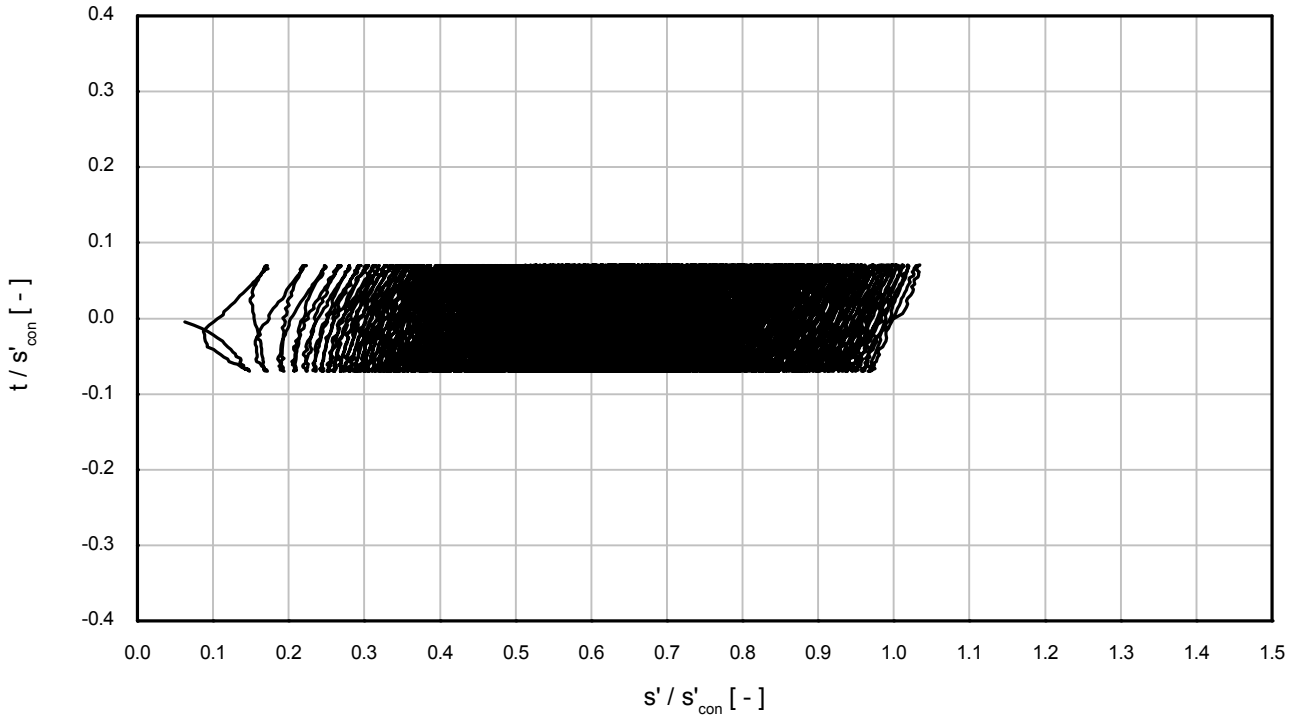


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-4
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	42 kPa	Test No.	:	CTX16
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

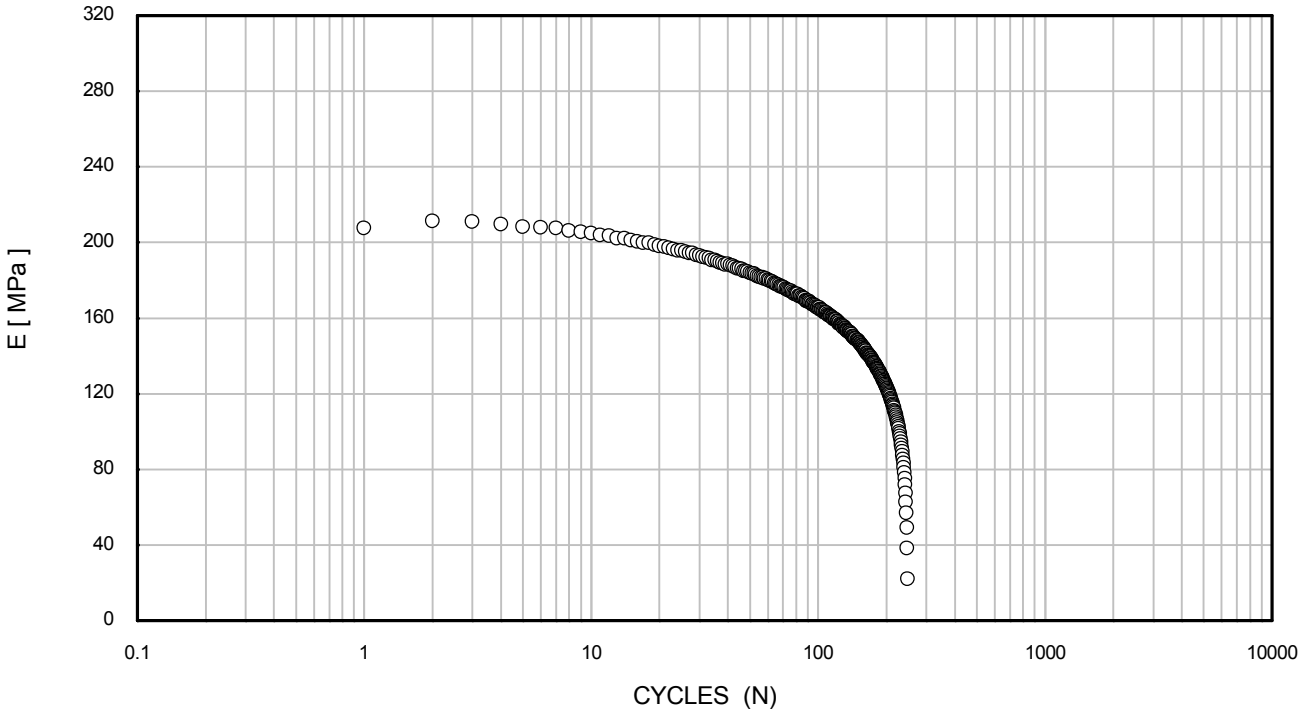


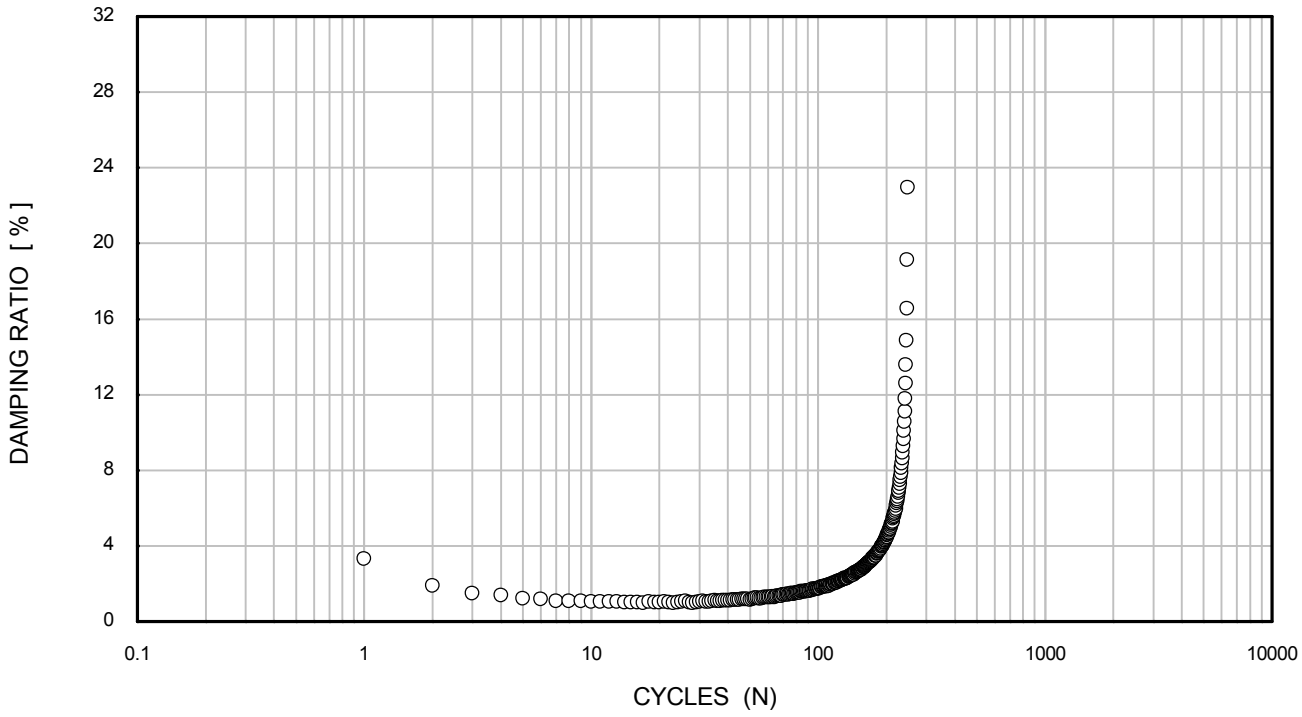


Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-4
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	42 kPa	Test No.	:	CTX16
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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





Initial σ'_r	:	300 kPa	Batch	:	3
Initial σ'_a	:	300 kPa	Sample	:	CTX_3-4
q_{av}	:	0 kPa	Unit	:	E3 (Tongeren)
q_{cy}	:	42 kPa	Test No.	:	CTX16
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey slightly silty fine SAND

GENERAL	
Date test started	14/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	9.2
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.633
Degree of saturation	[%]	38
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic	BS1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ BATCH4_CTX_4-1_CTX17
Processed by Date	LJ 25/01/2016
Checked by Date	PH 09/02/2016
Approved by Date	PH 09/02/2016

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-1
Unit	E5b (Tongeren)
Test number	CTX17

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1077
Mid height PWP	[kPa]	-
B value achieved	[-]	0.97

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1478
Back pressure	[kPa]	1078
Base PWP	[kPa]	1078
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	400
Effective axial pressure	[kPa]	400
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.49
External axial strain	[%]	0.79
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.66
Void ratio	[-]	0.592
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-1
Unit	E5b (Tongeren)
Test number	CTX17

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	800
Mean q_{av}	[kPa]	4
Mean q_{cy}	[kPa]	155
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1
External ε_{av} at N_f	[%]	-6.33
External ε_{cy} at N_f	[%]	6.46
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	158
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.66
Void ratio	[-]	0.592
Degree of saturation	[%]	100

Cycle	ε_{av}	ε_{cy}	E_{ext}	E_{loc}	λ_{ext}	λ_{loc}
(N)	[%]	[%]	[MPa]	[MPa]	[%]	[%]
1	-6.33	6.46	2.40	-	25.96	-

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-1
Unit	E5b (Tongeren)
Test number	CTX17

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	16
Initial effective axial pressure	[kPa]	17
Rate of strain	[%/hour]	4.81
At peak deviator stress		
Corrected deviator stress	[kPa]	291
Membrane correction applied	[kPa]	3
Drain correction applied	[kPa]	0
External axial strain	[%]	23.37
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	266
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	133
Effective axial pressure	[kPa]	425
Principal effective stress ratio	[-]	3.19
ε_{50}	[%]	8.64
Secant modulus (E_{50}) at ε_{50}	[kPa]	867
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	221
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	14.79
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	302
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	96
Effective axial pressure	[kPa]	317
Principal effective stress ratio	[-]	3.29
At 10% external axial strain		
Corrected deviator stress	[kPa]	165
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	326
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	74
Effective axial pressure	[kPa]	239
Principal effective stress ratio	[-]	3.24

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-1
Unit	E5b (Tongeren)
Test number	CTX17

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS





FINAL CONDITIONS

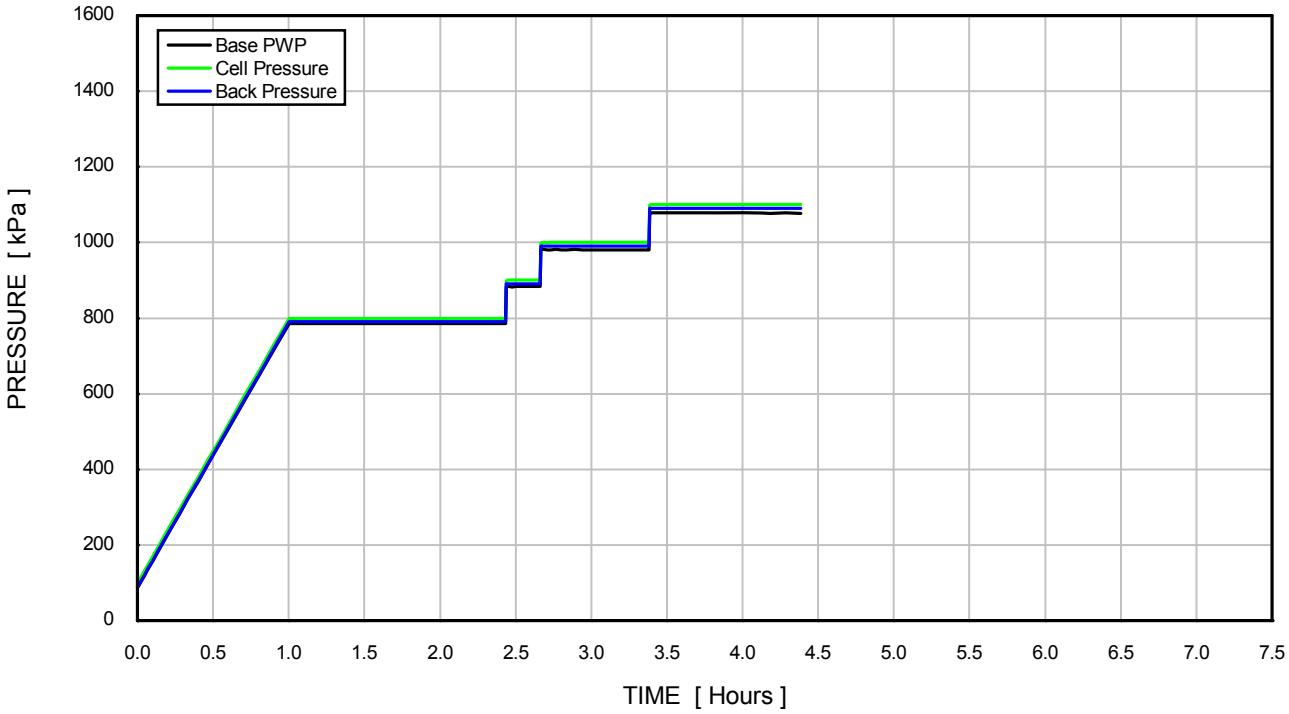
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.66

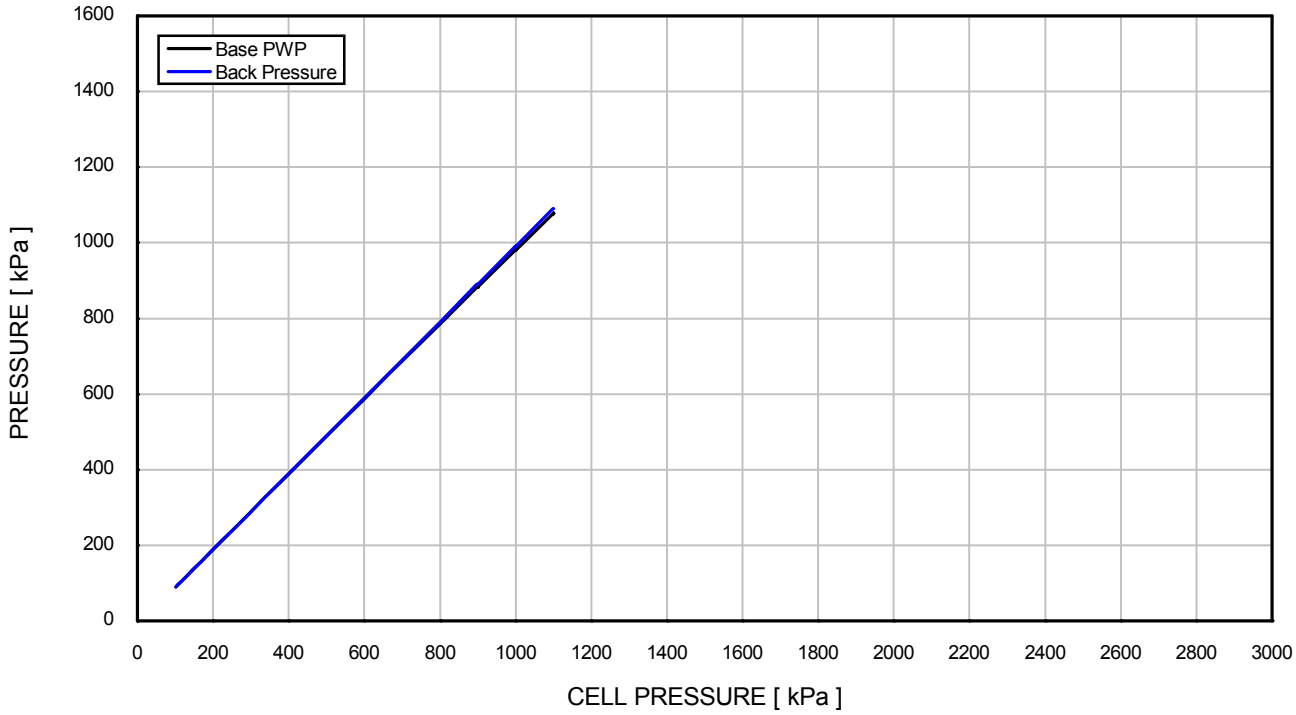
TEST IDENTIFICATION

Batch	4
Sample	CTX_4-1
Unit	E5b (Tongeren)
Test number	CTX17

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

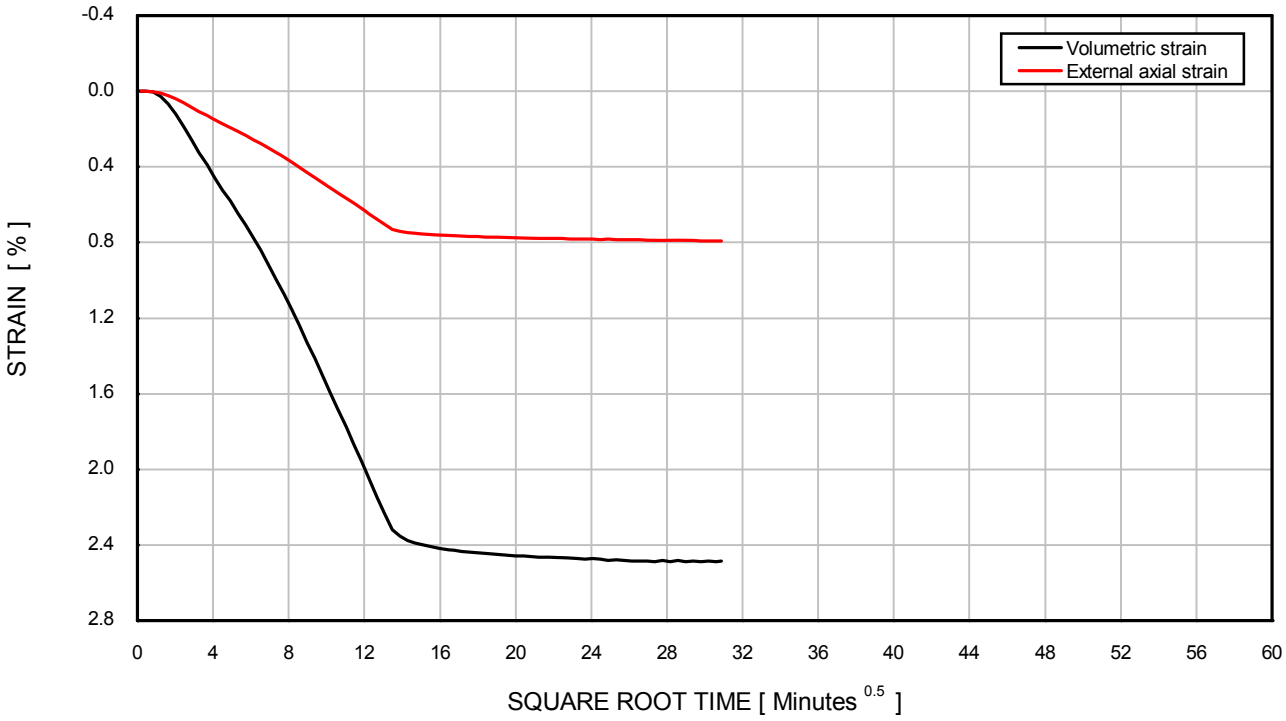


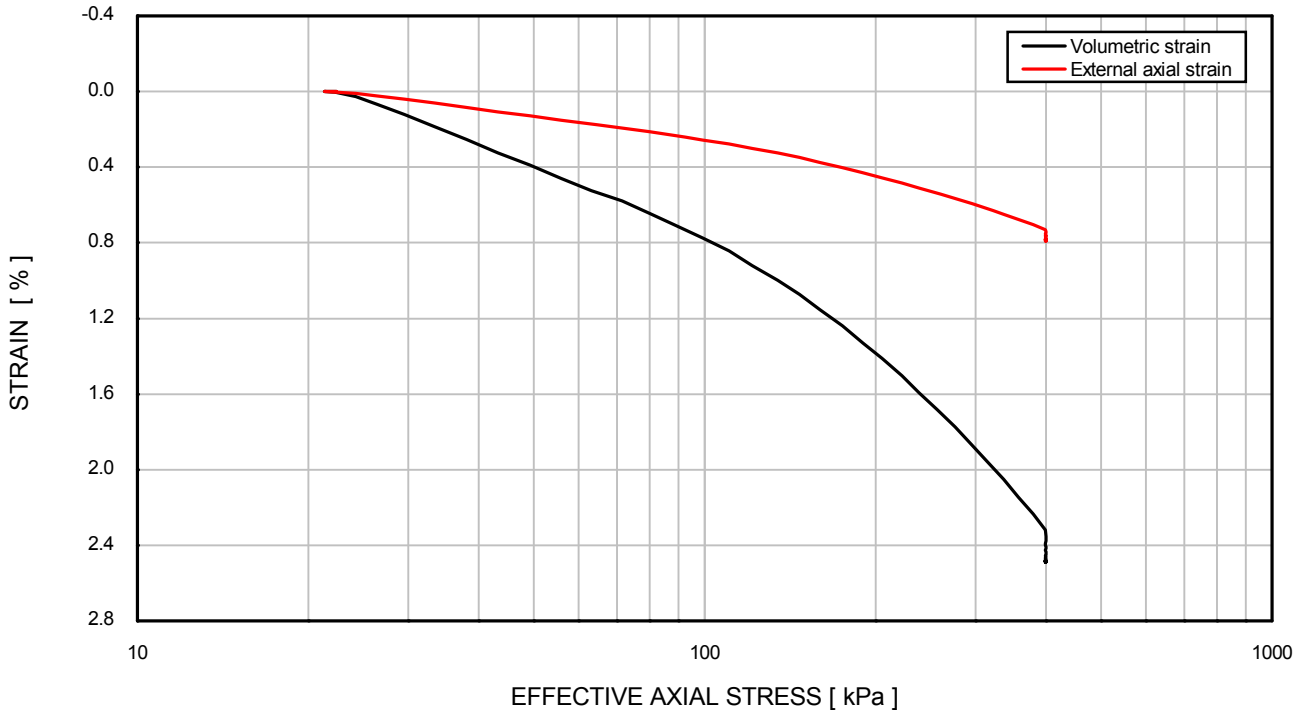


B value	:	0.97			
Initial σ'_r	:	11	kPa	Batch	: 4
Initial σ'_a	:	11	kPa	Sample	: CTX_4-1
Final σ'_r	:	23	kPa	Unit	: E5b (Tongeren)
Final σ'_a	:	23	kPa	Test No.	: CTX17

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

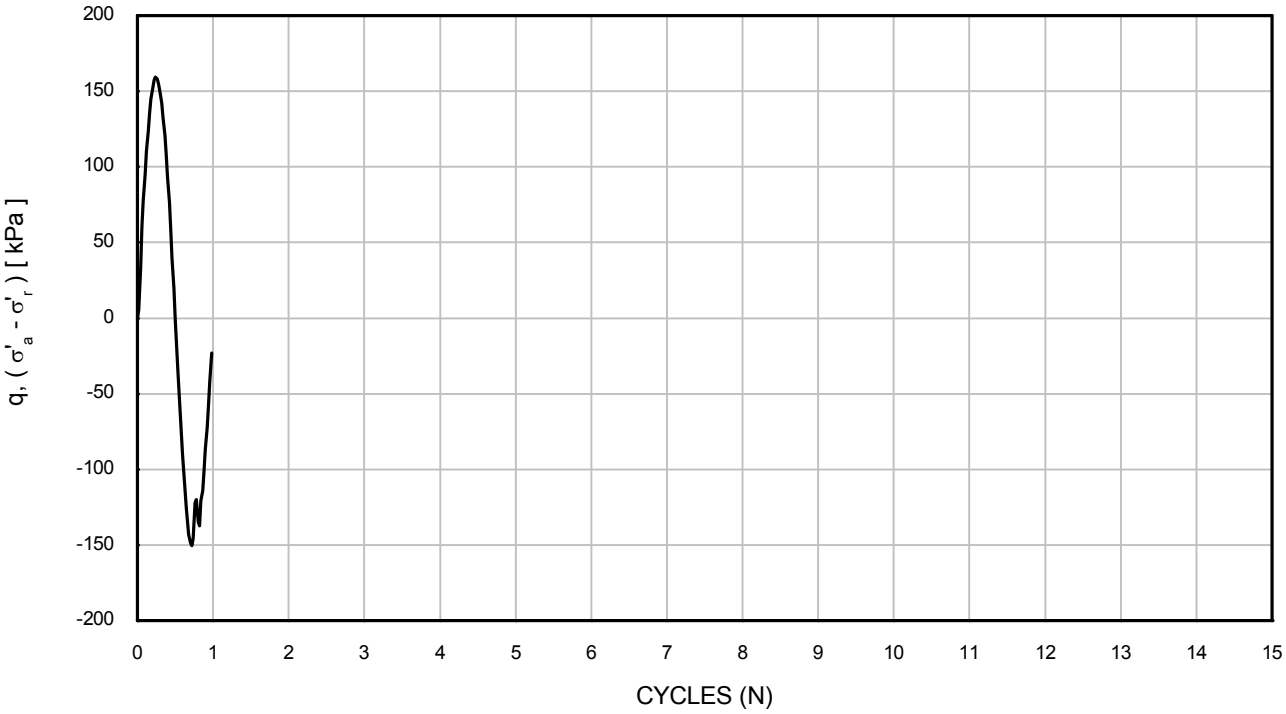


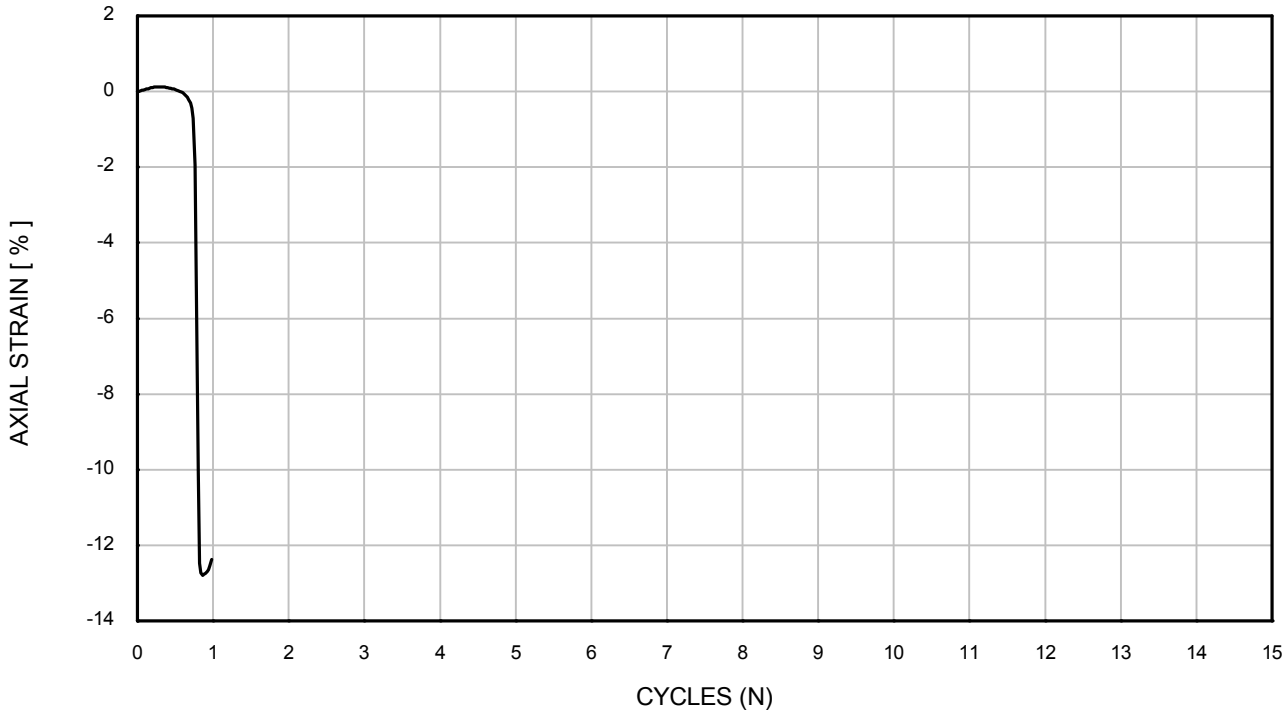


σ'_{rc}	: 400 kPa	Batch	: 4
σ'_{ac}	: 400 kPa	Sample	: CTX_4-1
		Unit	: E5b (Tongeren)
		Test No.	: CTX17

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

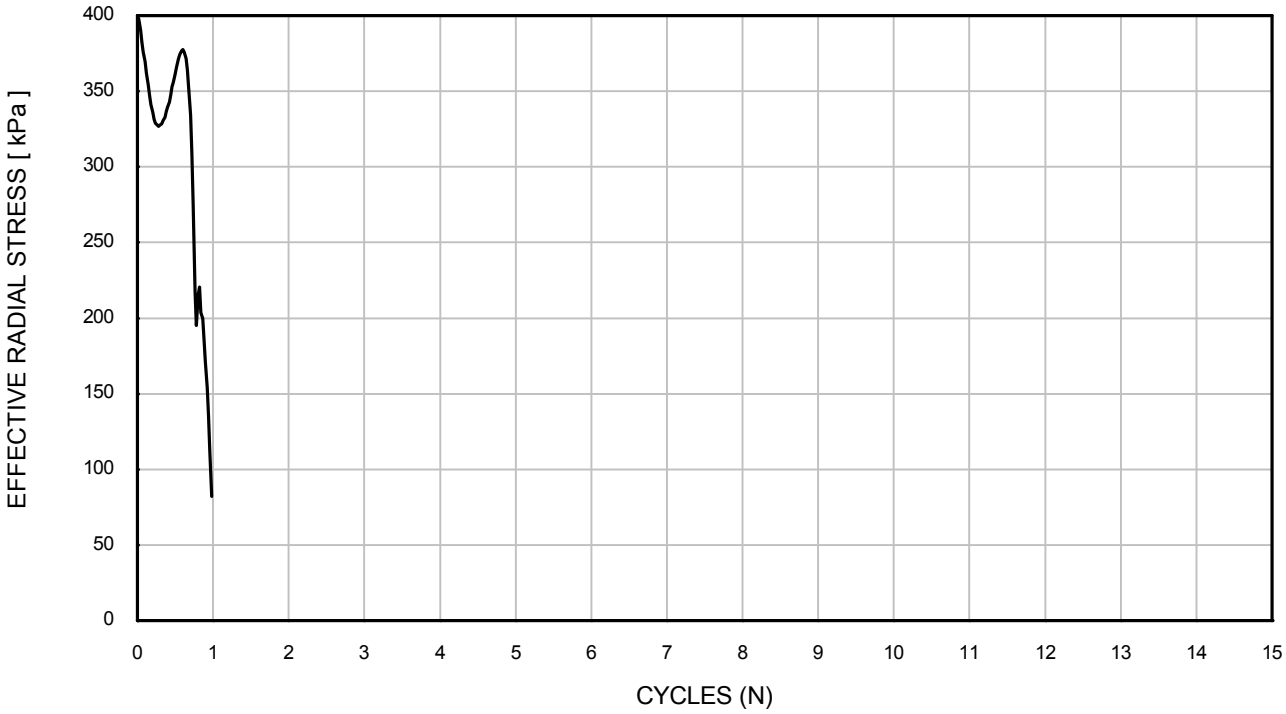


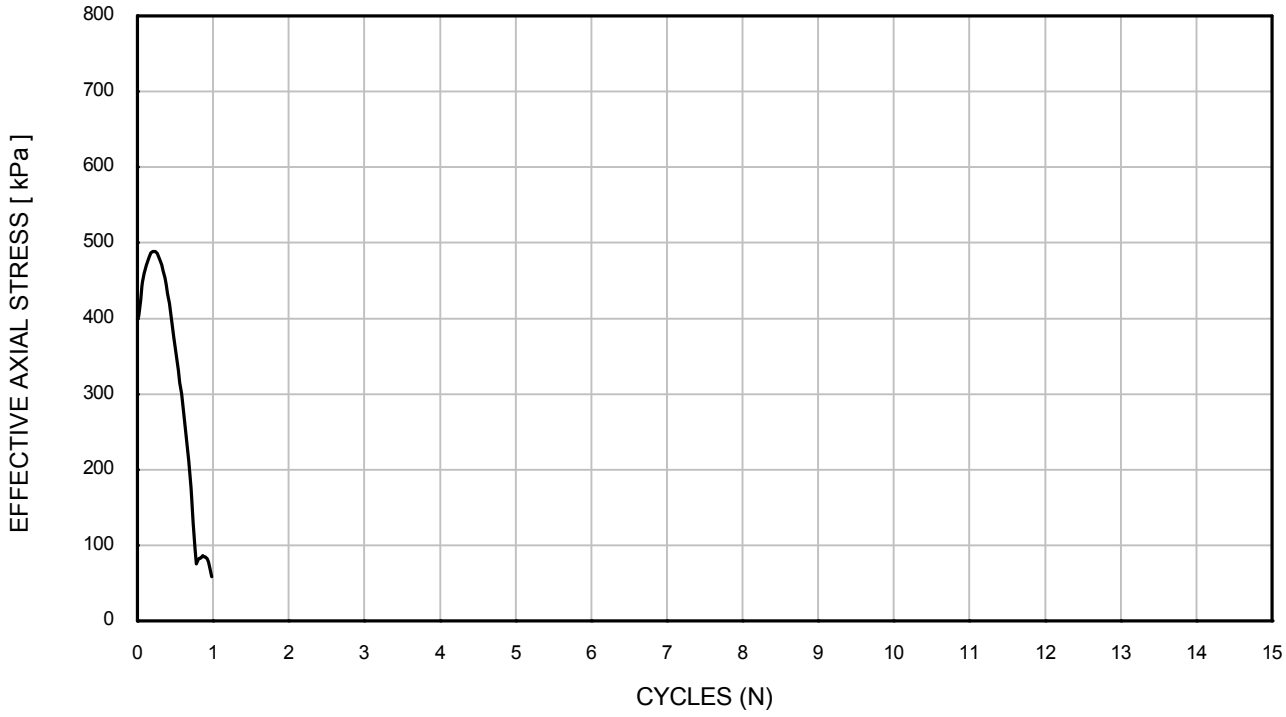


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-1
q_{av}	:	4 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	155 kPa	Test No.	:	CTX17
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

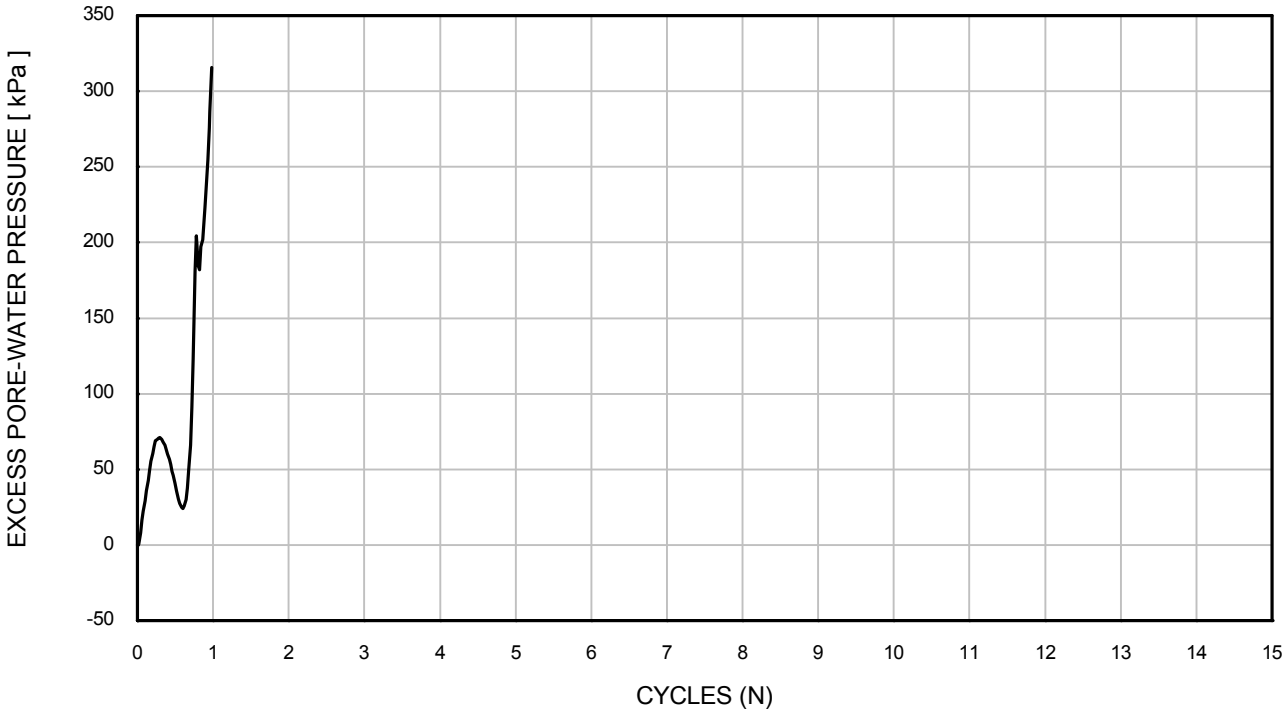


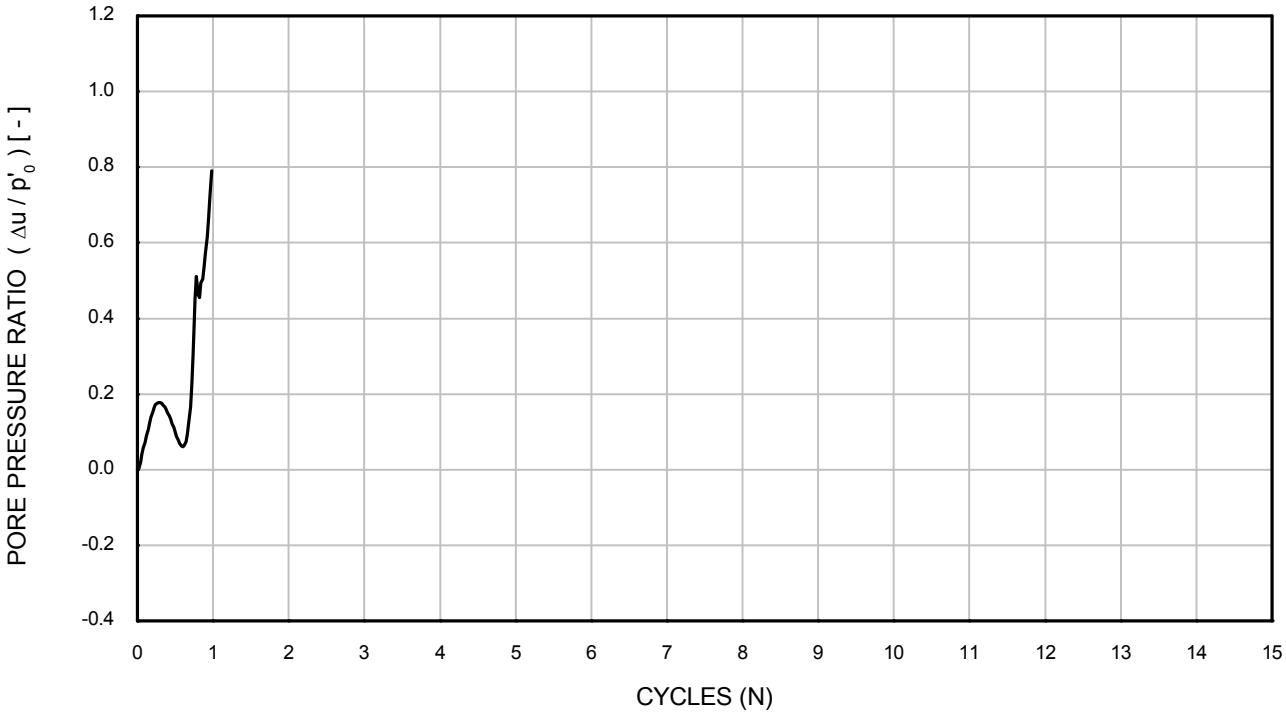


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-1
q_{av}	:	4 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	155 kPa	Test No.	:	CTX17
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

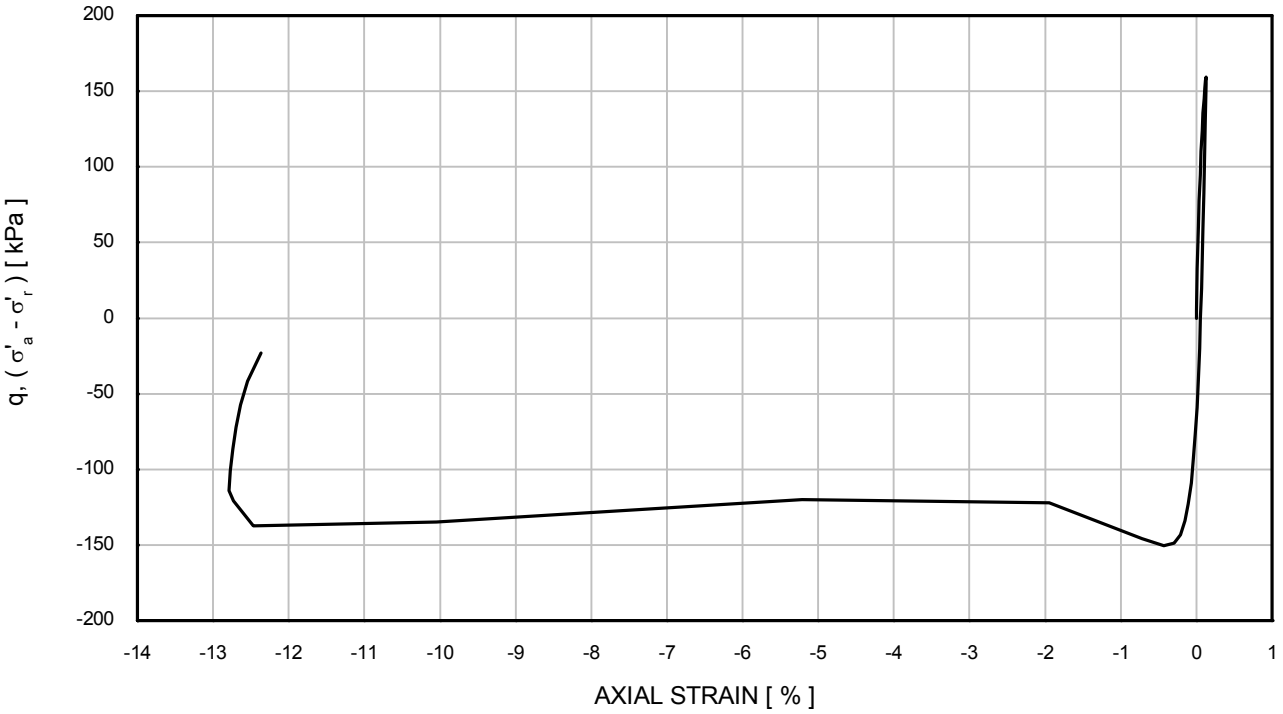


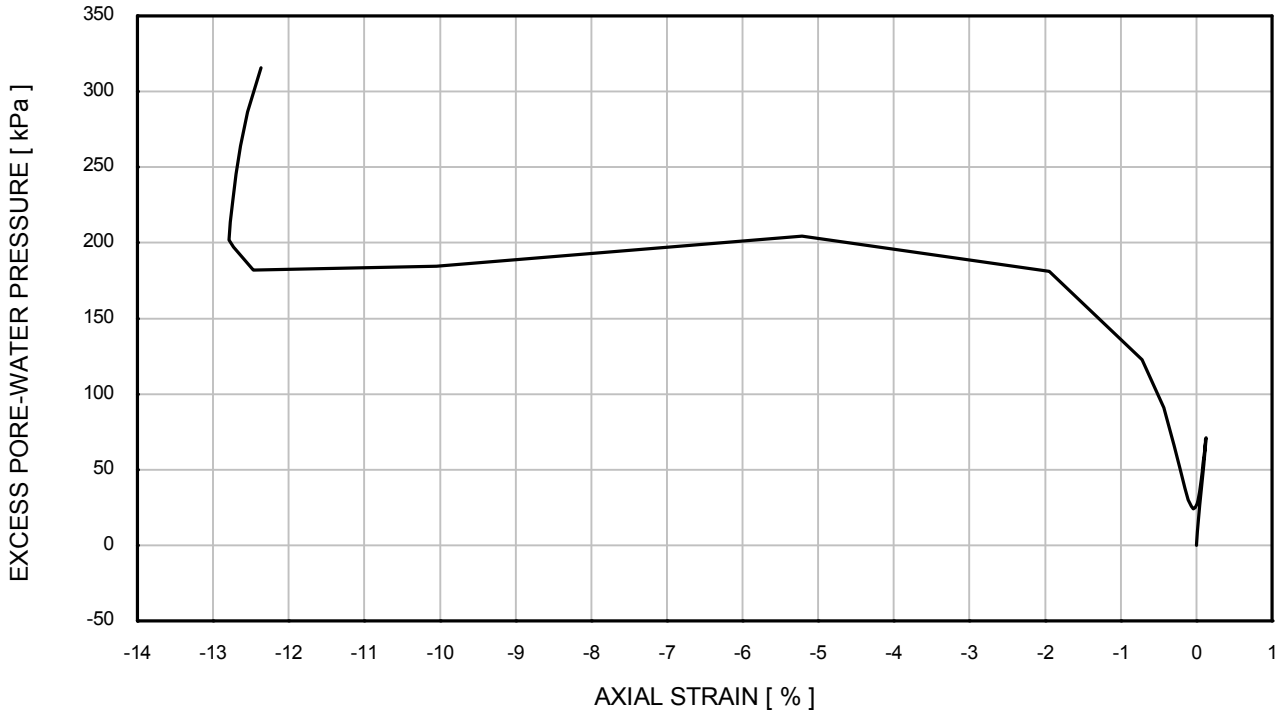


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-1
q_{av}	:	4 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	155 kPa	Test No.	:	CTX17
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

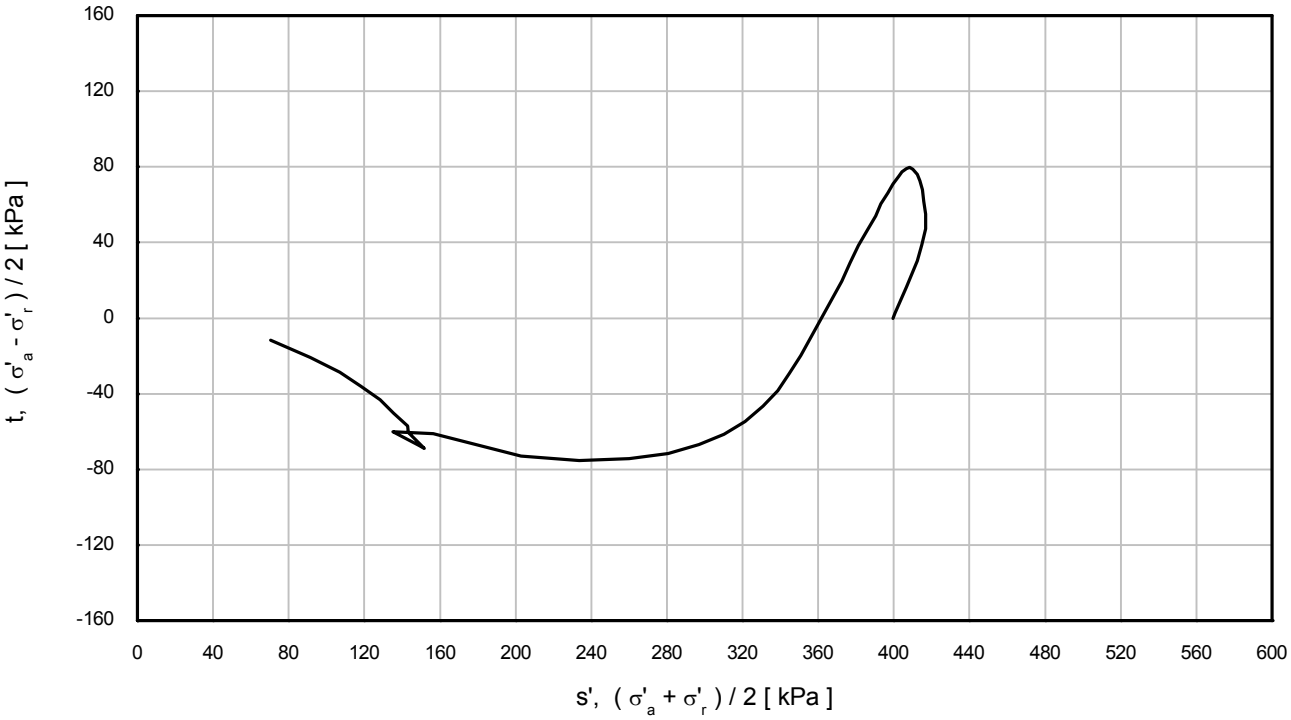


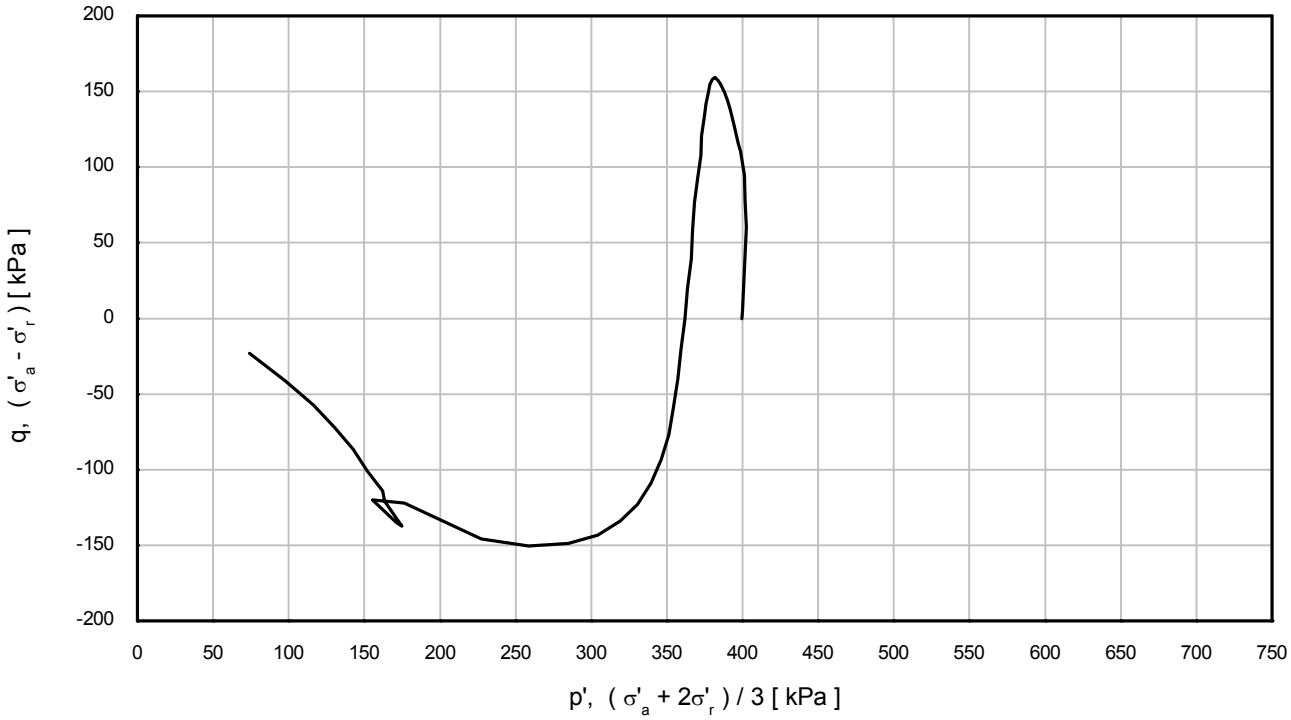


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-1
q_{av}	:	4 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	155 kPa	Test No.	:	CTX17
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

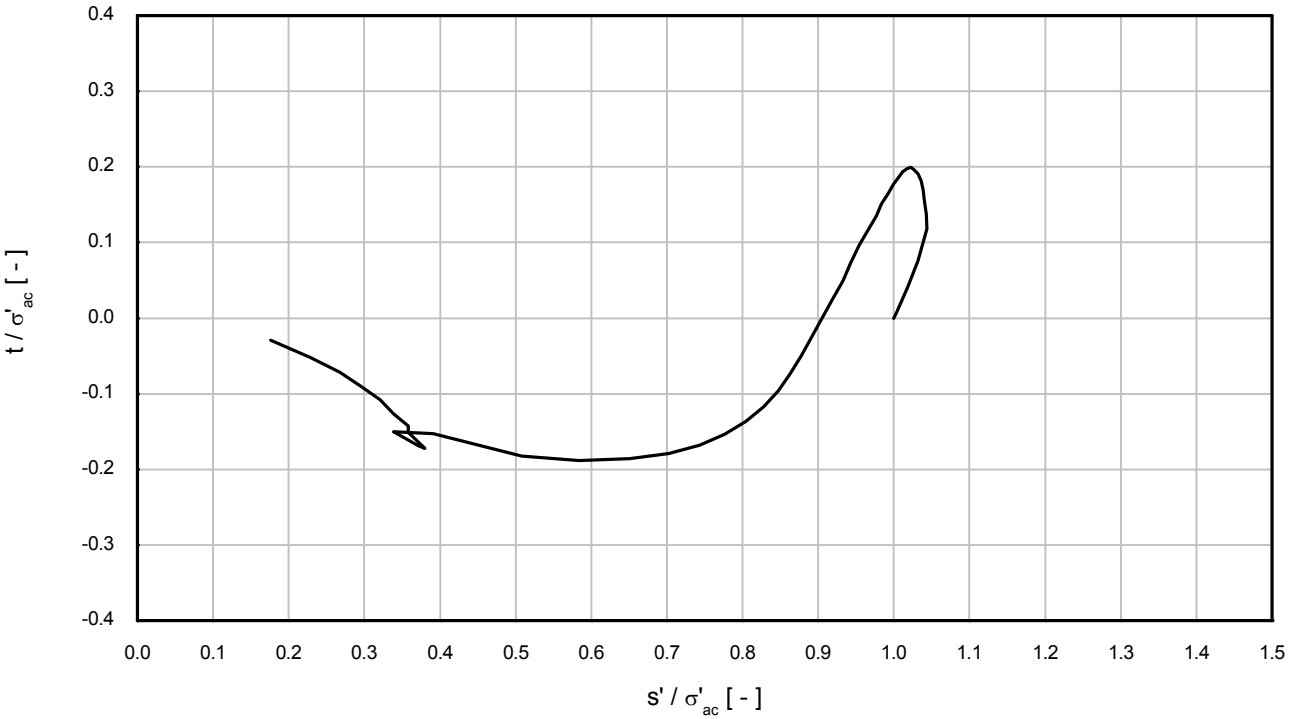


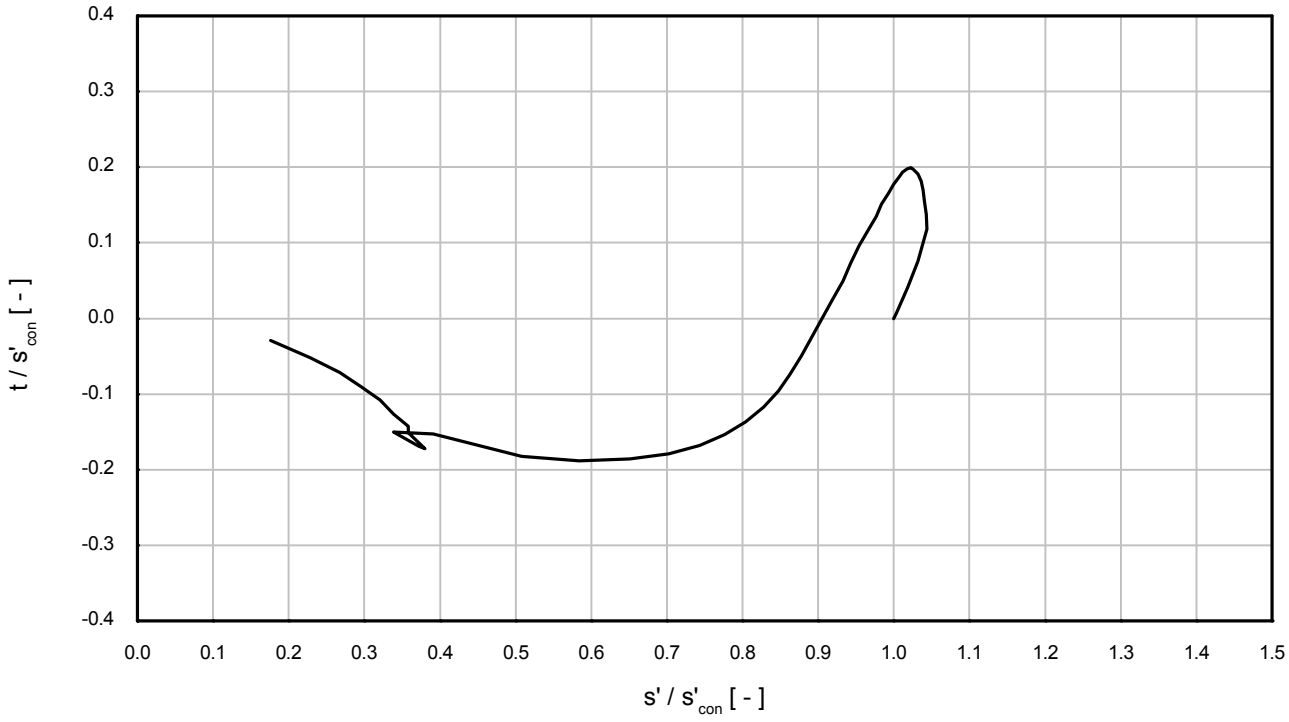


Initial σ'_r	:	400	kPa	Batch	: 4
Initial σ'_a	:	400	kPa	Sample	: CTX_4-1
q_{av}	:	4	kPa	Unit	: E5b (Tongeren)
q_{cy}	:	155	kPa	Test No.	: CTX17
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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



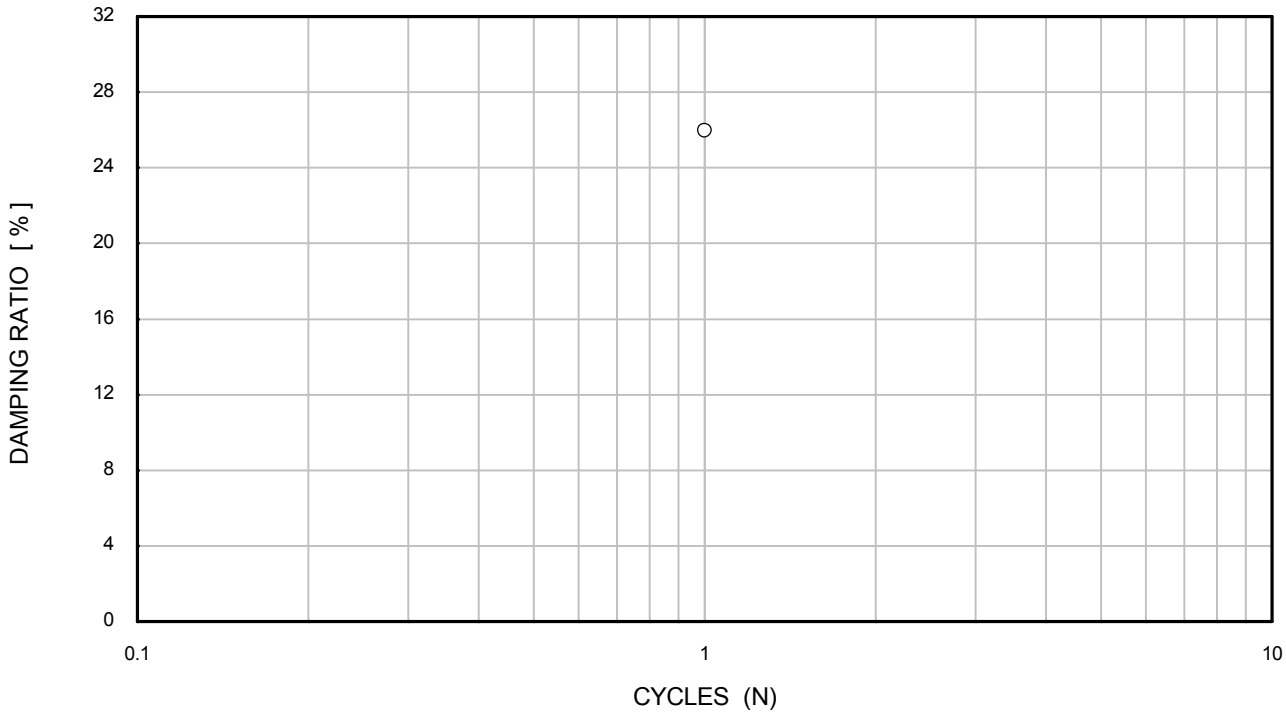


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-1
q_{av}	:	4 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	155 kPa	Test No.	:	CTX17
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

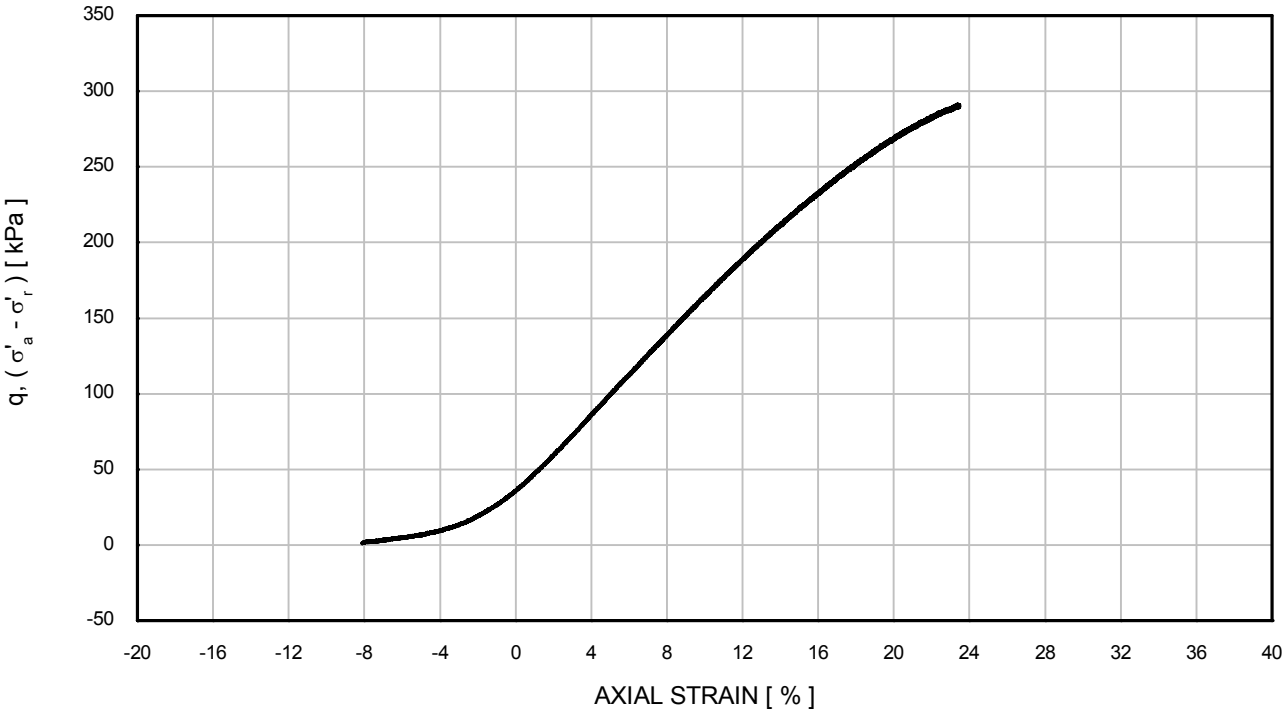


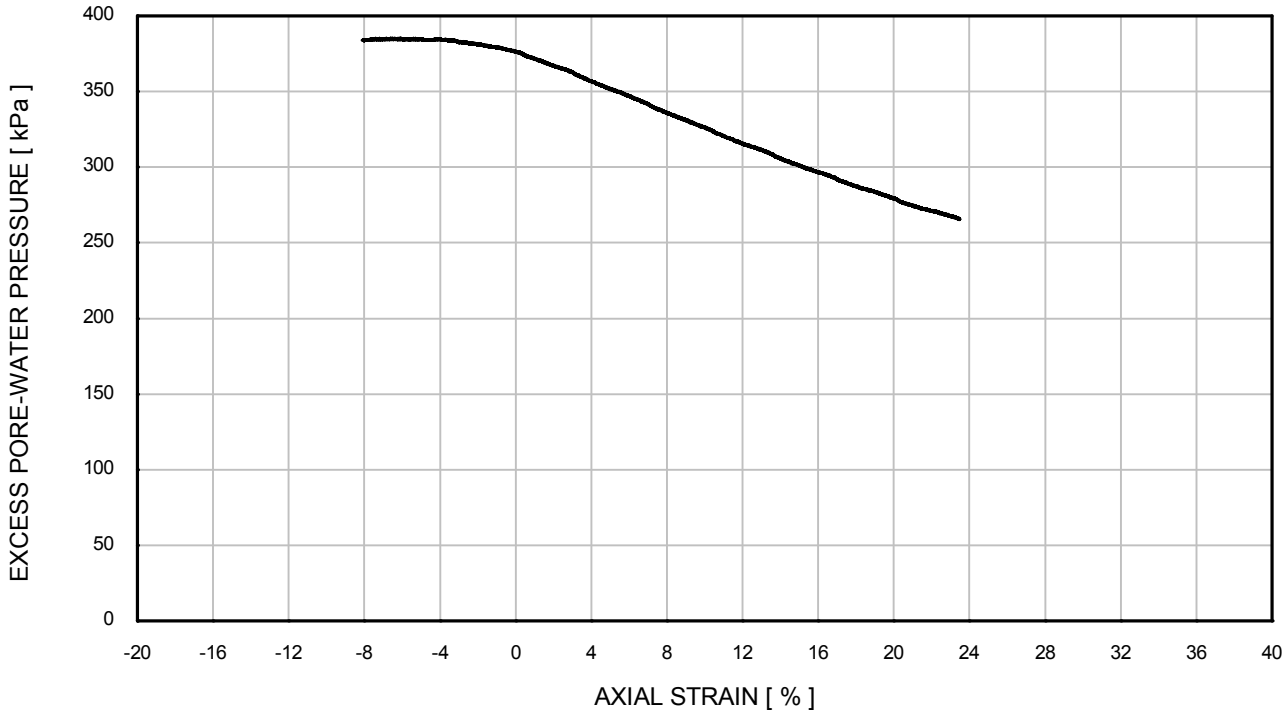


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-1
q_{av}	:	4 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	155 kPa	Test No.	:	CTX17
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

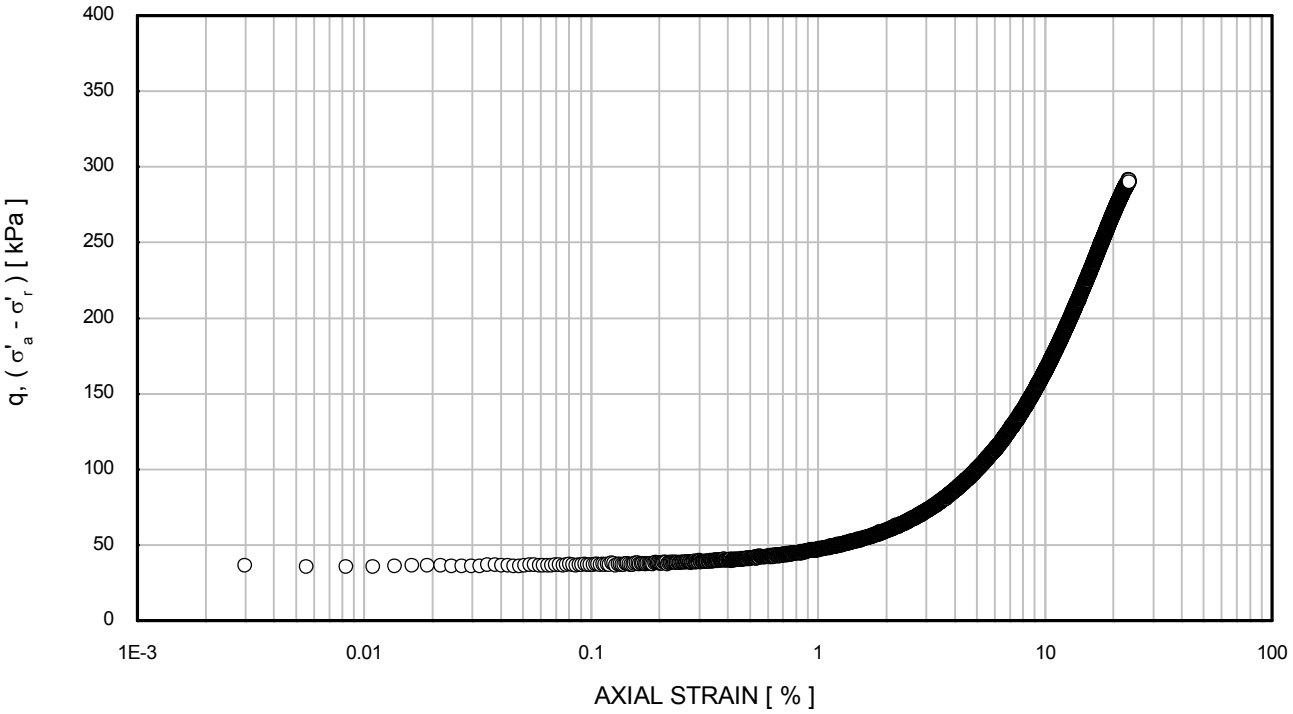


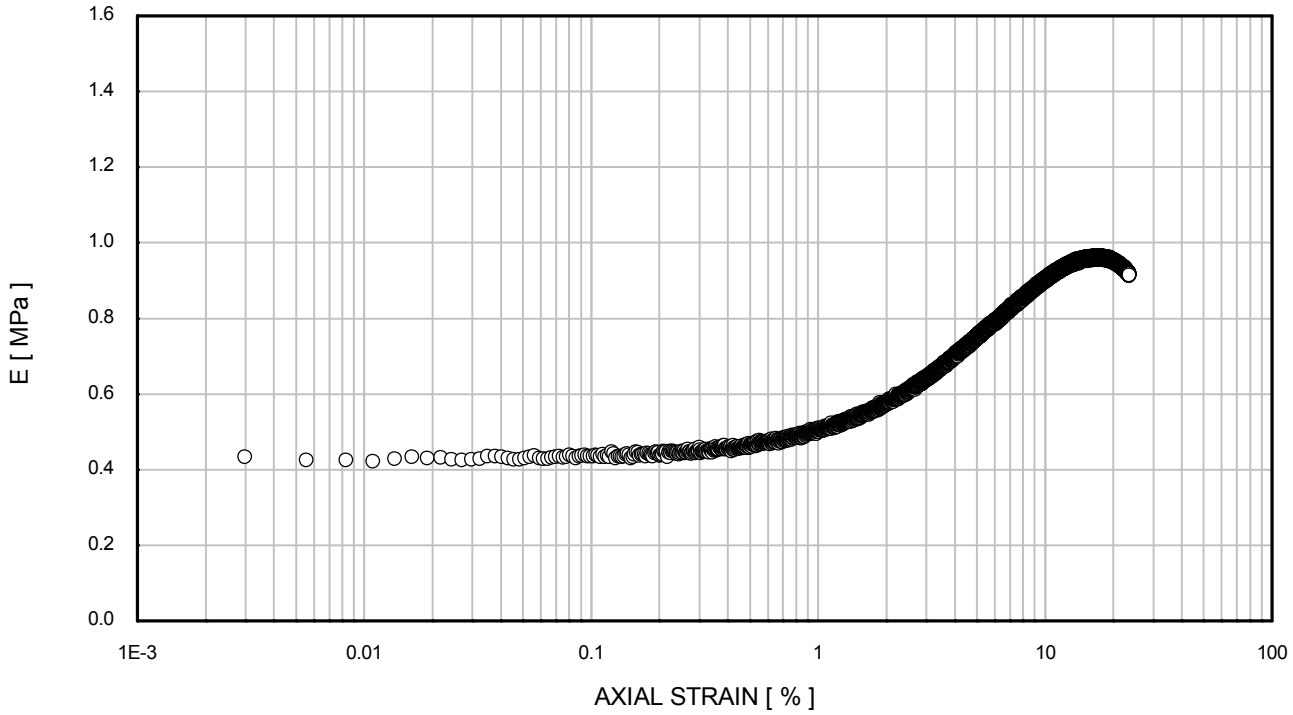


Initial σ'_r	:	16 kPa	Batch	:	4
Initial σ'_a	:	17 kPa	Sample	:	CTX_4-1
q_{peak}	:	291 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	23.37 %	Test No.	:	CTX17
Rate of strain	:	4.81 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

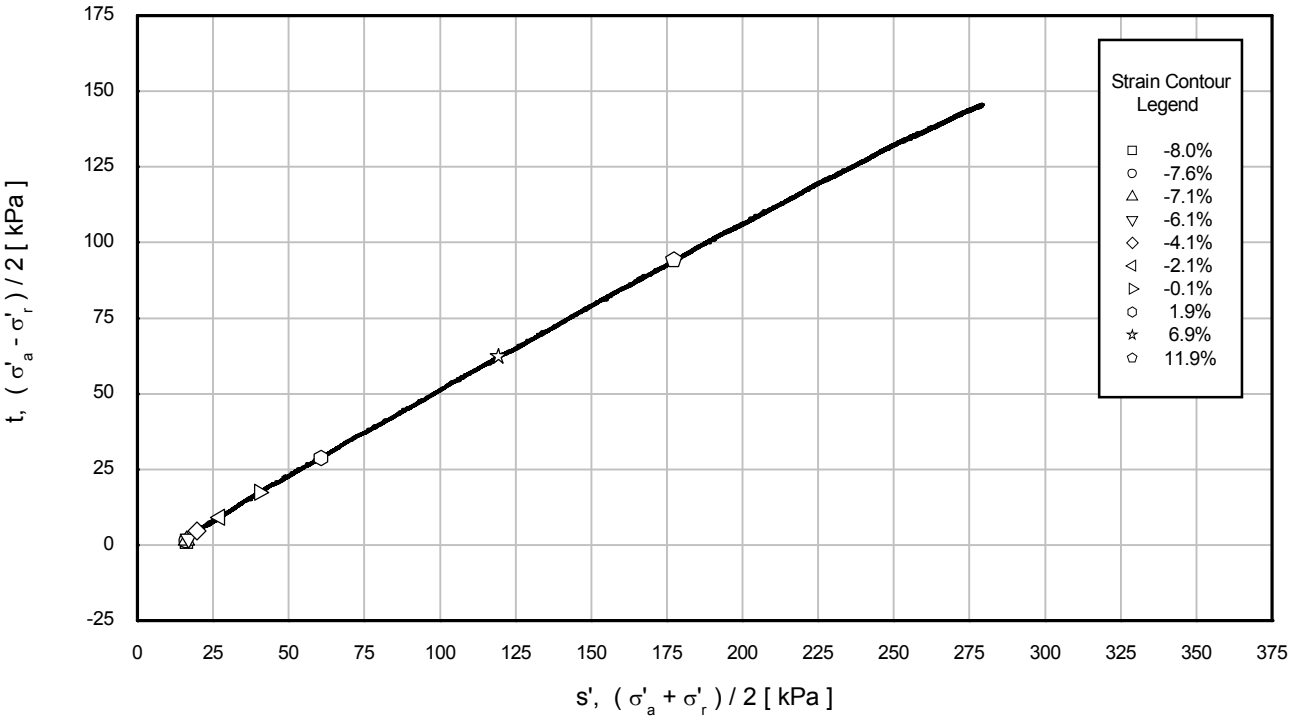


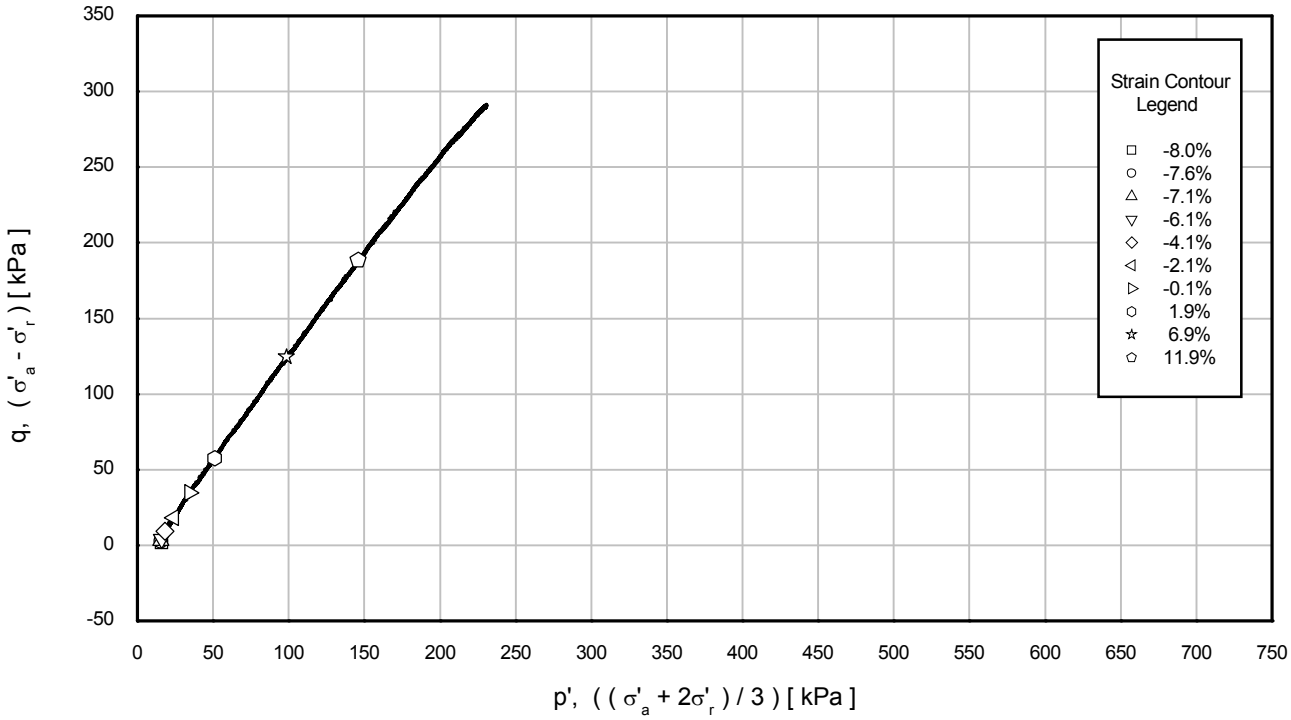


Initial σ'_r	:	16 kPa	Batch	:	4
Initial σ'_a	:	17 kPa	Sample	:	CTX_4-1
q_{peak}	:	291 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	23.37 %	Test No.	:	CTX17
Rate of strain	:	4.81 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	16	kPa	Batch	: 4
Initial σ'_a	:	17	kPa	Sample	: CTX_4-1
q_{peak}	:	291	kPa	Unit	: E5b (Tongeren)
Ext. ε at q_{peak}	:	23.37	%	Test No.	: CTX17
Rate of strain	:	4.81	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey slightly silty fine SAND

GENERAL	
Date test started	21/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	9.2
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.633
Degree of saturation	[%]	39
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 4_CTX-4-2_CTX18
Processed by Date	PR 29/01/2016
Checked by Date	PH 09/02/2016
Approved by Date	PH 09/02/2016

TEST IDENTIFICATION	
Borehole	4
Sample	CTX_4-2
Unit	E5b (Tongeren)
Test number	CTX18

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
B value achieved	[-]	1.00

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1482
Back pressure	[kPa]	1082
Base PWP	[kPa]	1082
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	400
Effective axial pressure	[kPa]	400
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.51
External axial strain	[%]	0.87
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.66
Void ratio	[-]	0.592
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Borehole	4
Sample	CTX_4-2
Unit	E5b (Tongeren)
Test number	CTX18

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	800
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	119
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	10
External ε_{av} at N_f	[%]	-4.05
External ε_{cy} at N_f	[%]	4.67
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	282
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.66
Void ratio	[-]	0.592
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-0.02	0.10	123.57	-	13.36	-
2	-0.03	0.09	129.33	-	11.89	-
3	-0.04	0.10	123.63	-	11.66	-
4	-0.05	0.10	115.50	-	12.02	-
5	-0.06	0.11	106.25	-	12.61	-
6	-0.07	0.13	95.77	-	13.67	-
7	-0.09	0.15	81.82	-	15.22	-
8	-0.14	0.19	61.31	-	18.11	-
9	-0.52	0.59	20.03	-	25.41	-
10	-4.05	4.67	2.56	-	24.51	-

TEST IDENTIFICATION	
Borehole	4
Sample	CTX_4-2
Unit	E5b (Tongeren)
Test number	CTX18

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	15
Initial effective axial pressure	[kPa]	15
Rate of strain	[%/hour]	4.84
At peak deviator stress		
Corrected deviator stress	[kPa]	312
Membrane correction applied	[kPa]	3
Drain correction applied	[kPa]	0
External axial strain	[%]	23.57
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	254
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	146
Effective axial pressure	[kPa]	458
Principal effective stress ratio	[-]	3.13
ε_{50}	[%]	8.43
Secant modulus (E_{50}) at ε_{50}	[kPa]	1165
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	185
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.10
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	319
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	81
Effective axial pressure	[kPa]	266
Principal effective stress ratio	[-]	3.28
At 10% external axial strain		
Corrected deviator stress	[kPa]	182
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	319
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	81
Effective axial pressure	[kPa]	262
Principal effective stress ratio	[-]	3.25

TEST IDENTIFICATION	
Borehole	4
Sample	CTX_4-2
Unit	E5b (Tongeren)
Test number	CTX18

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



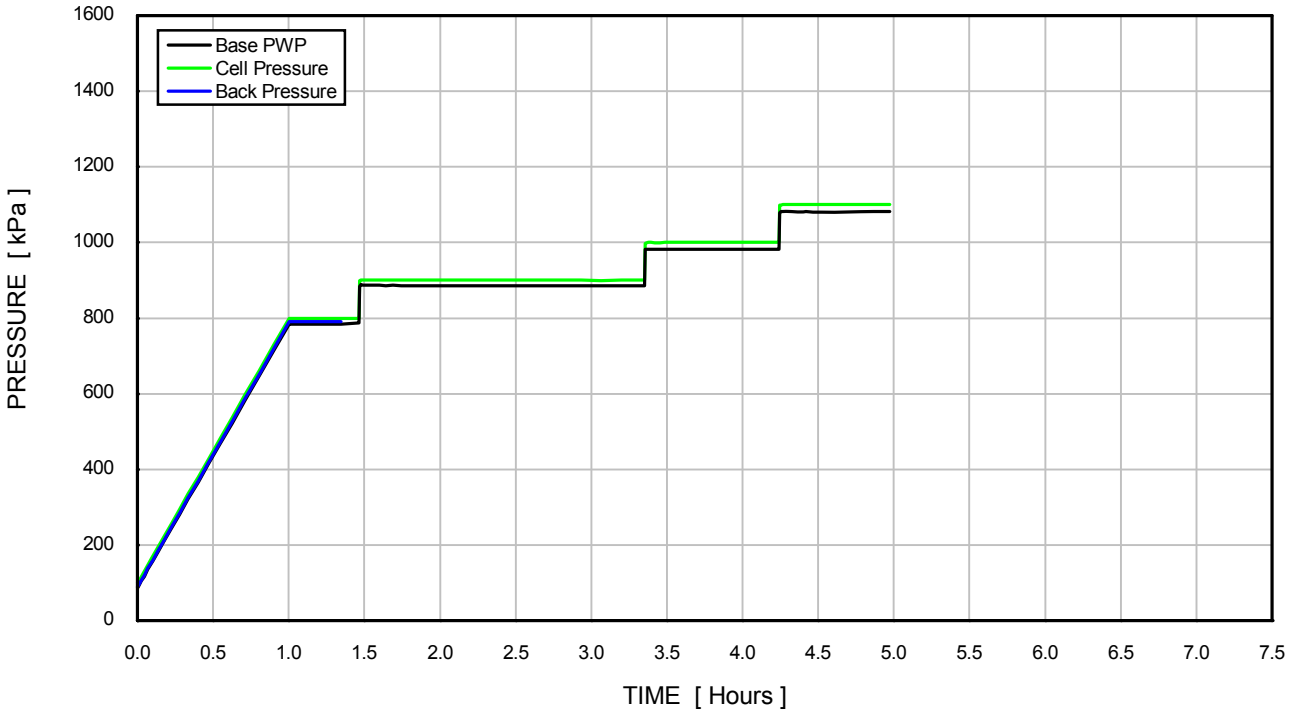


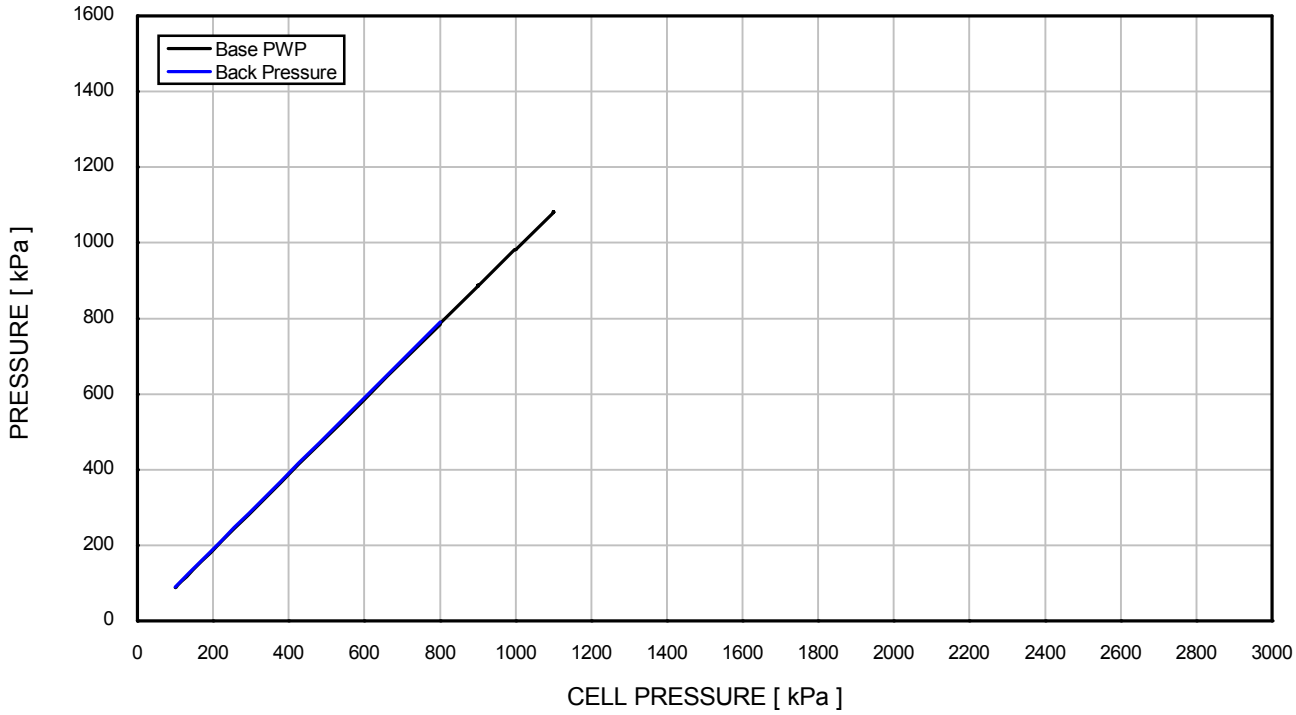
FINAL CONDITIONS		
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.66

TEST IDENTIFICATION	
Borehole	4
Sample	CTX_4-2
Unit	E5b (Tongeren)
Test number	CTX18

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

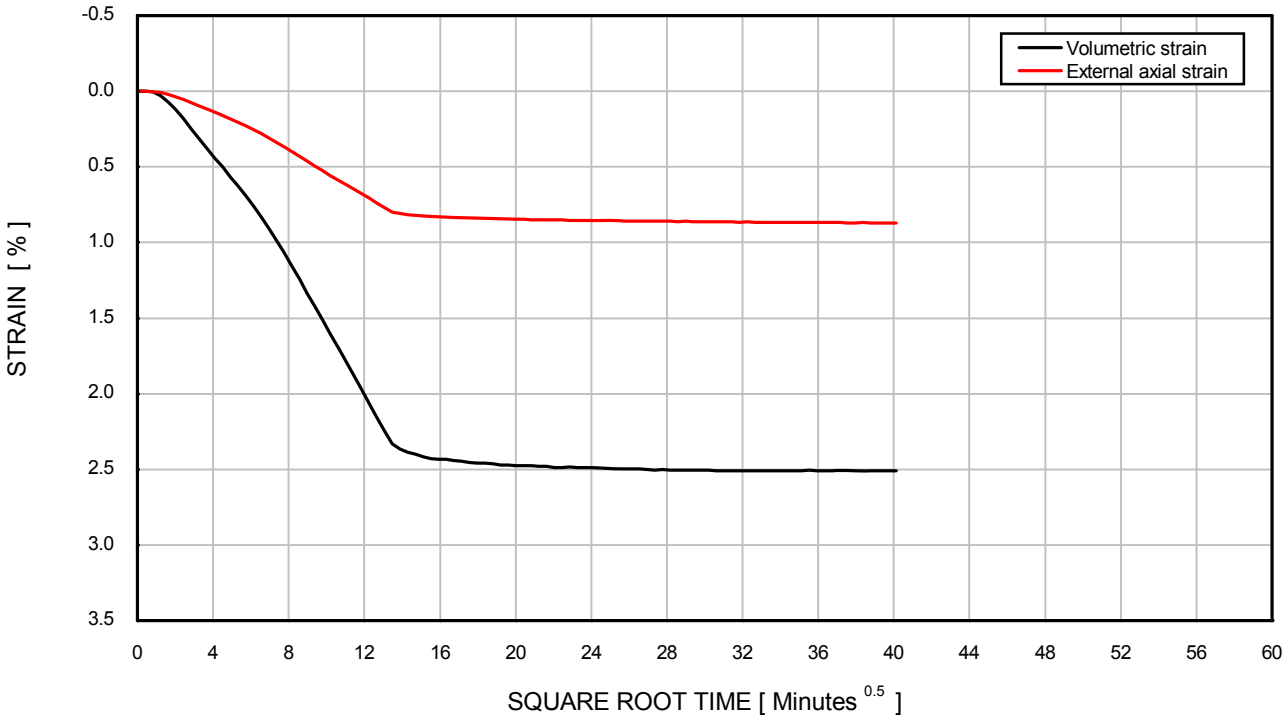


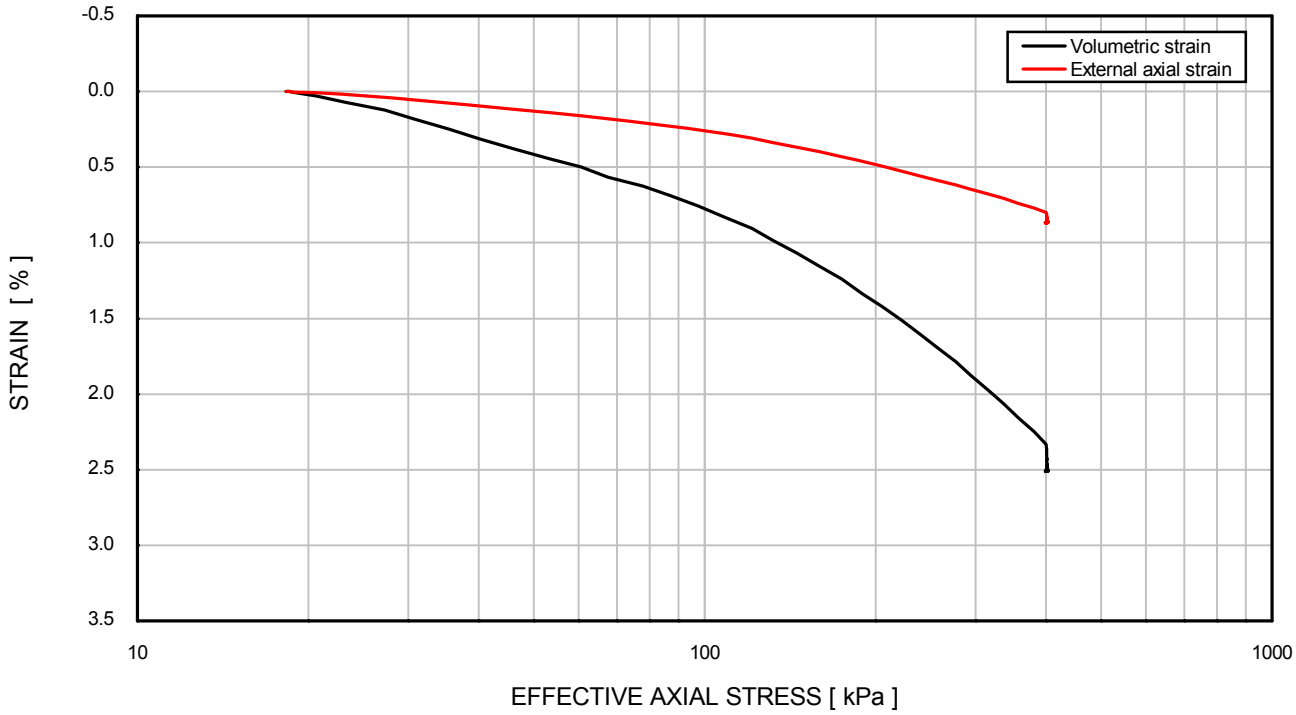


B value	:	1.00			
Initial σ'_r	:	12	kPa	Batch	: 4
Initial σ'_a	:	12	kPa	Sample	: CTX_4-2
Final σ'_r	:	18	kPa	Unit	: E5b (Tongeren)
Final σ'_a	:	18	kPa	Test No.	: CTX18

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

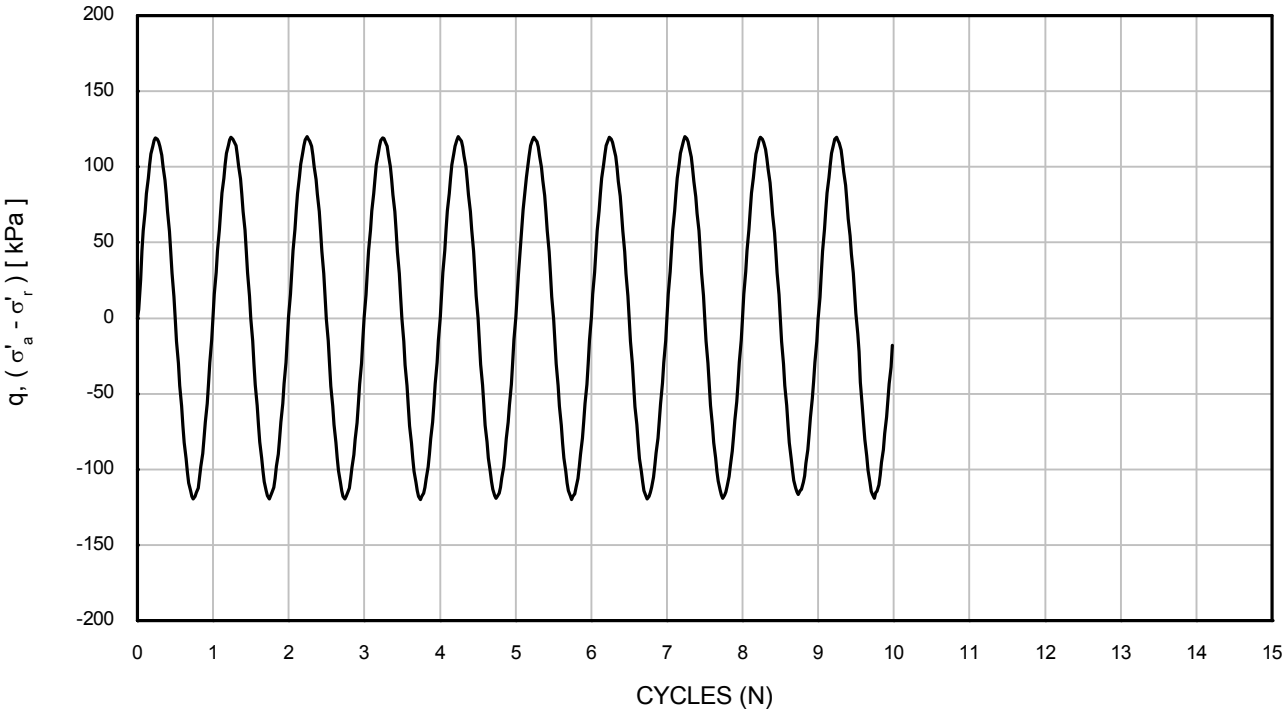


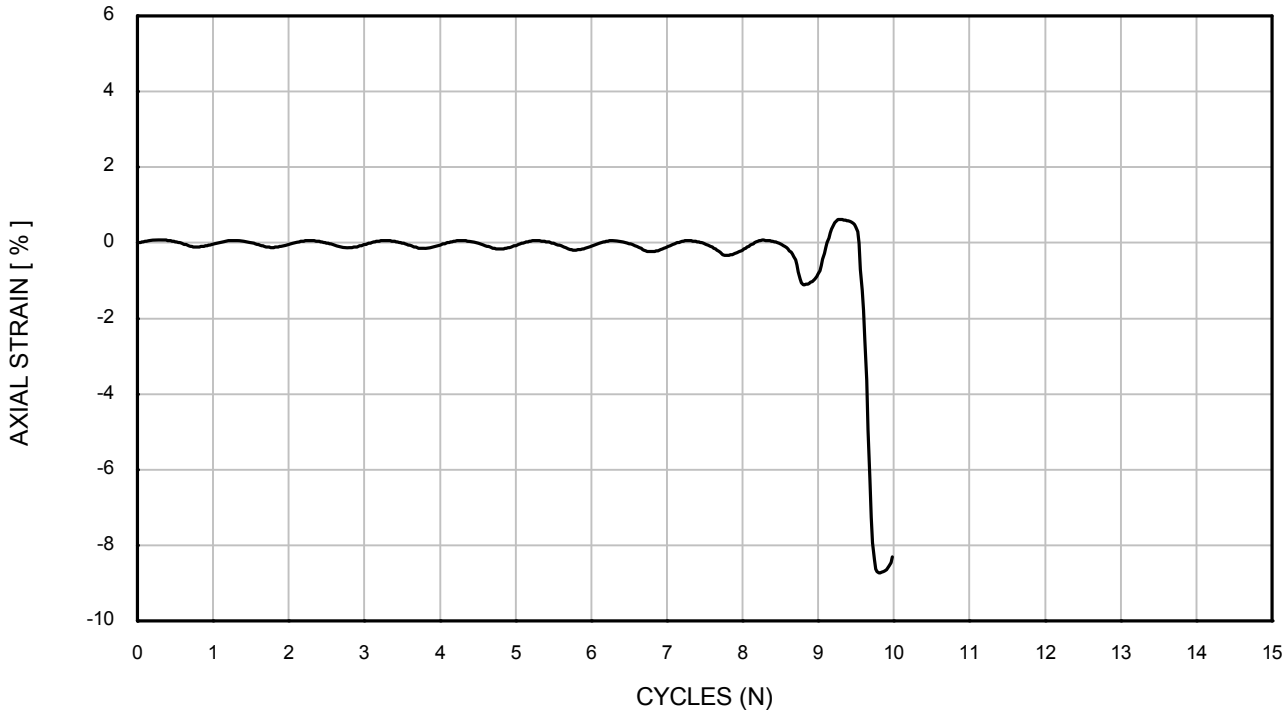


σ'_{rc}	: 400 kPa	Batch	: 4
σ'_{ac}	: 400 kPa	Sample	: CTX_4-2
		Unit	: E5b (Tongeren)
		Test No.	: CTX18

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

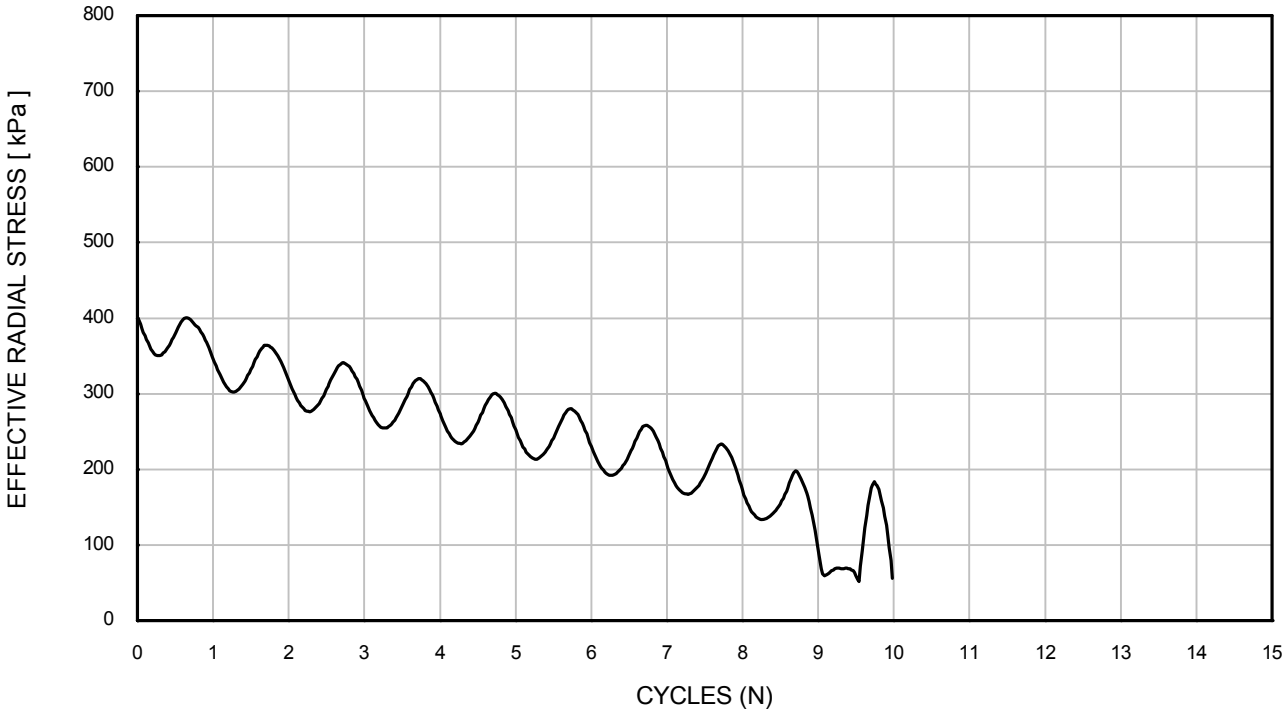


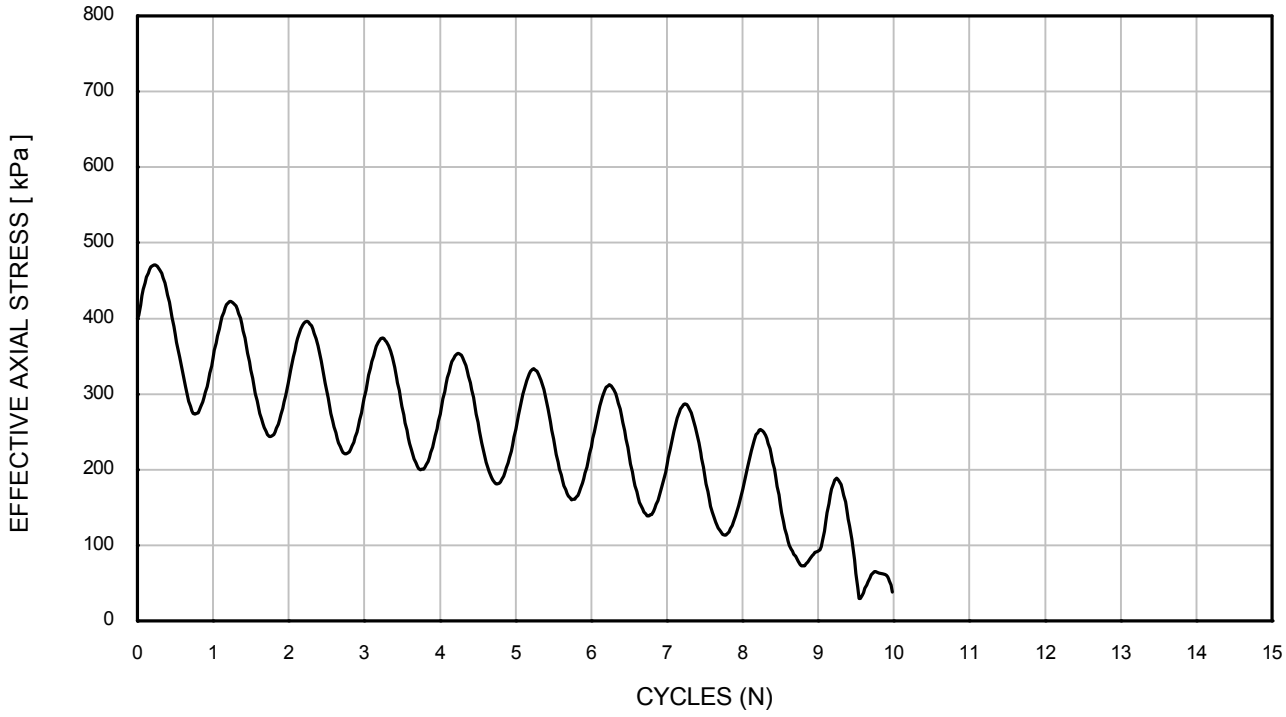


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-2
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	119 kPa	Test No.	:	CTX18
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

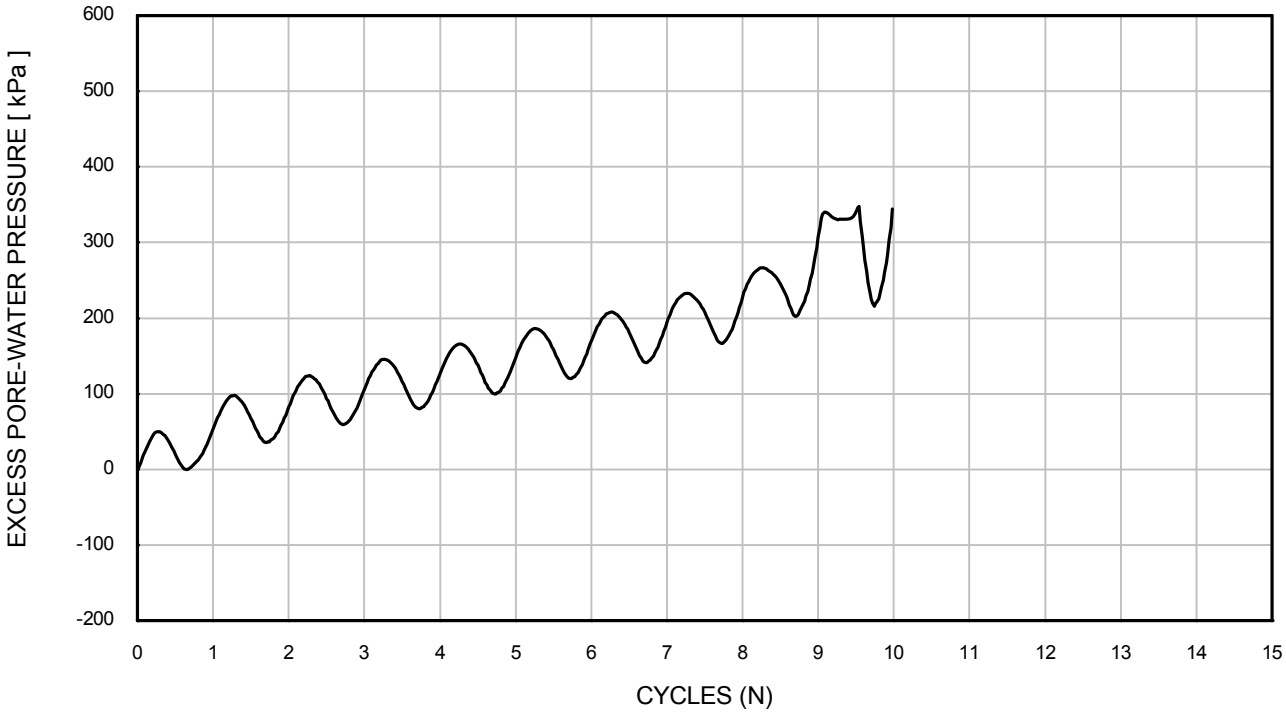


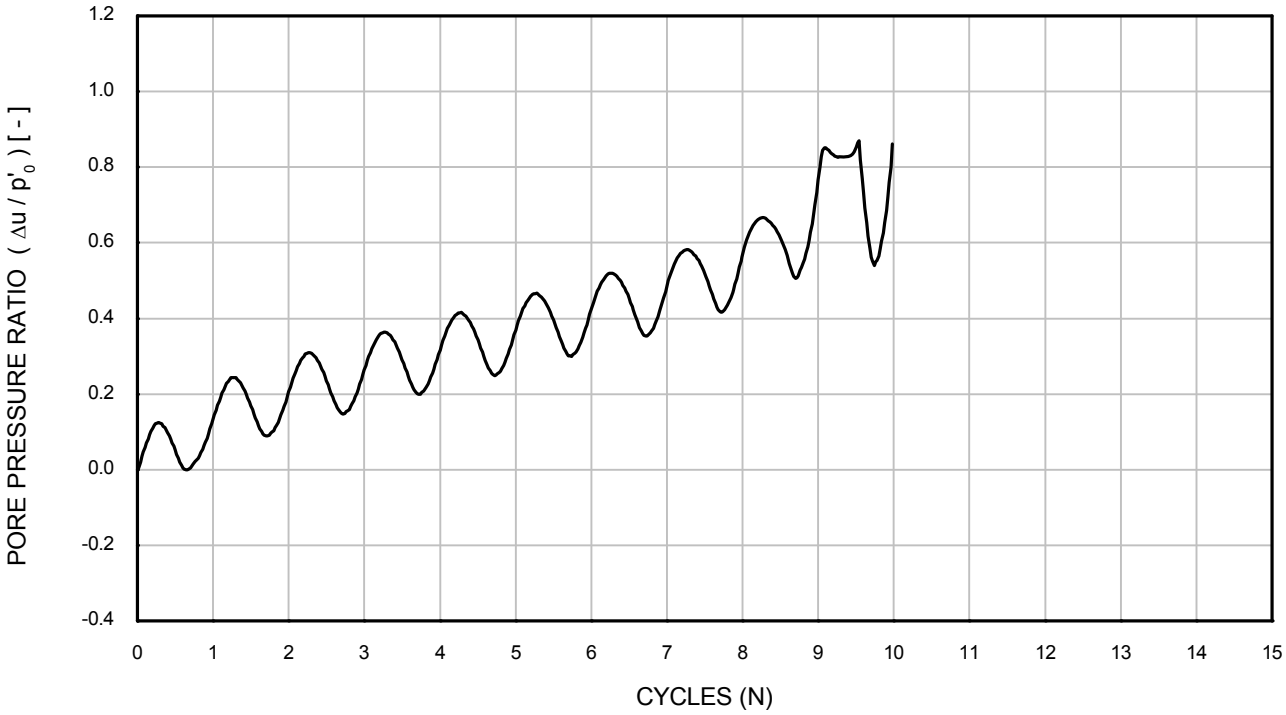


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-2
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	119 kPa	Test No.	:	CTX18
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

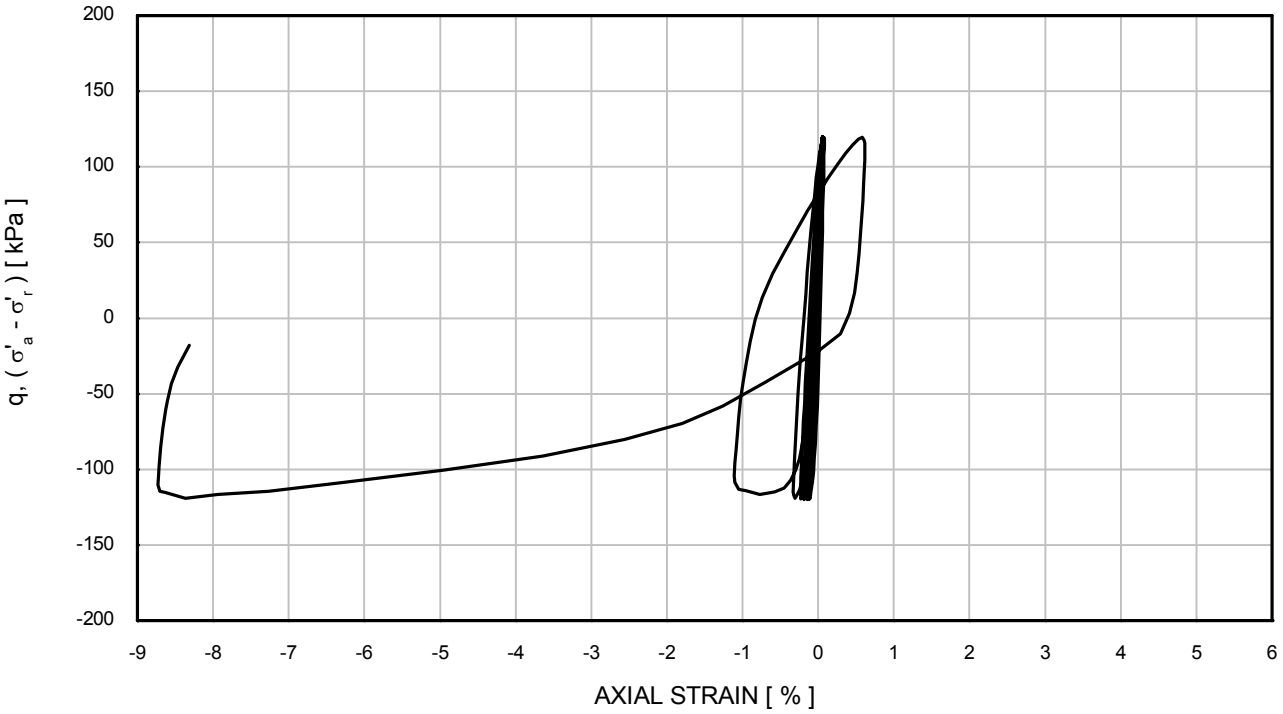


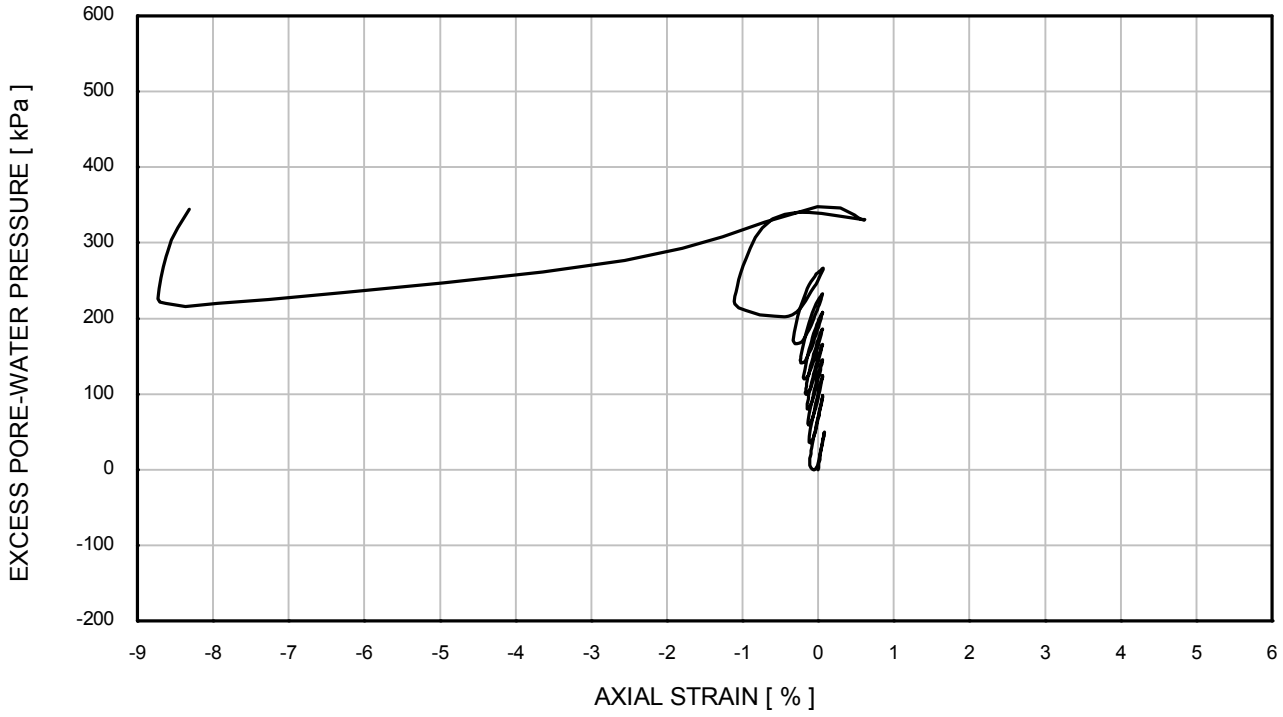


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-2
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	119 kPa	Test No.	:	CTX18
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

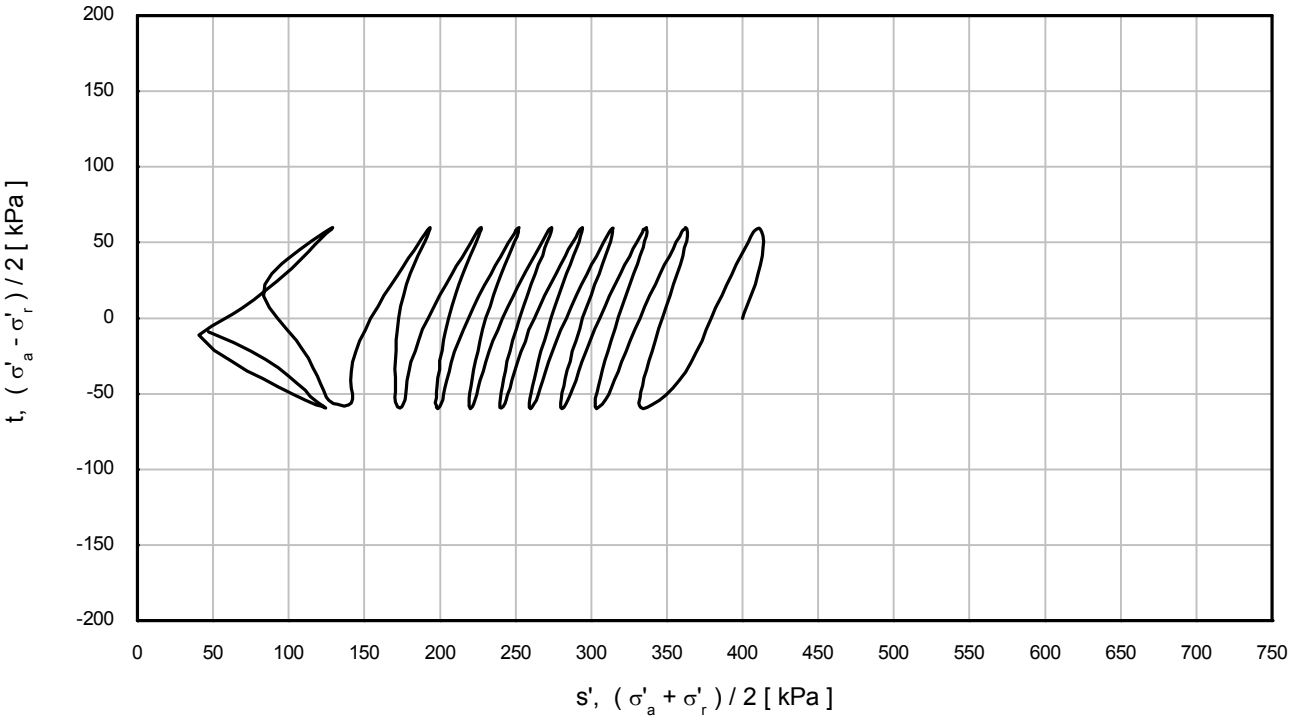


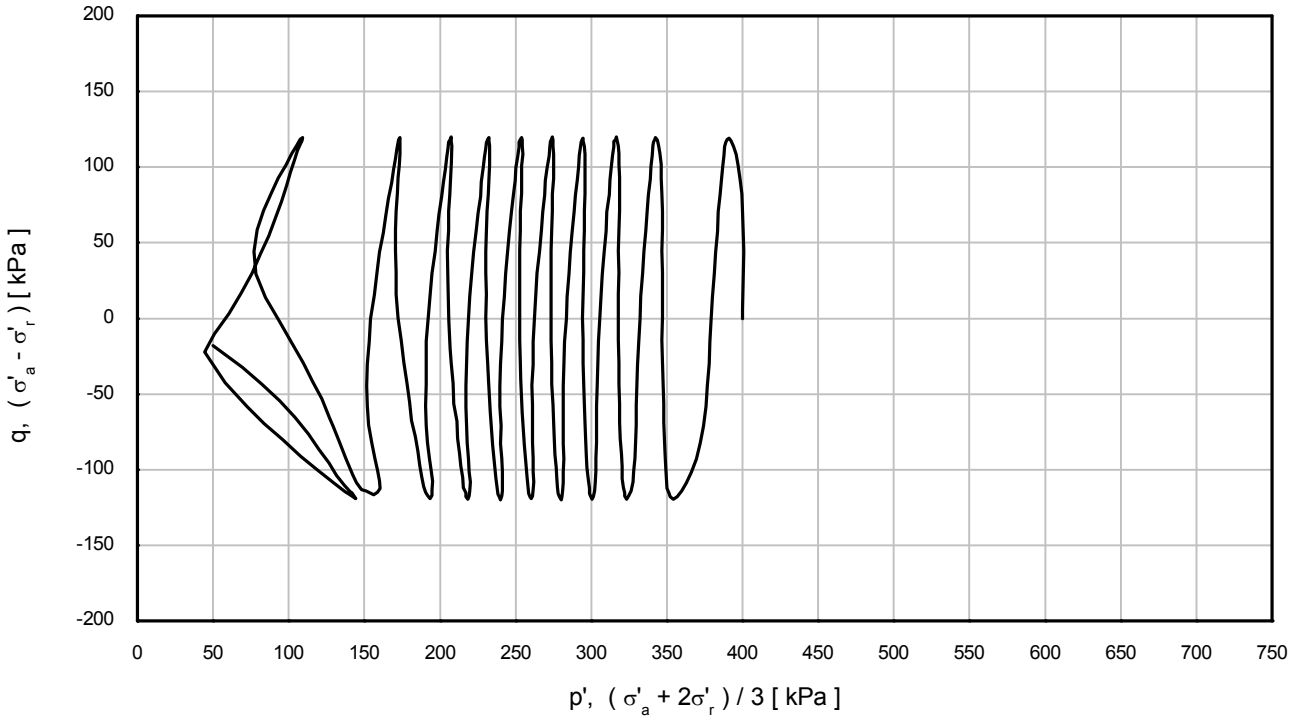


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-2
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	119 kPa	Test No.	:	CTX18
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

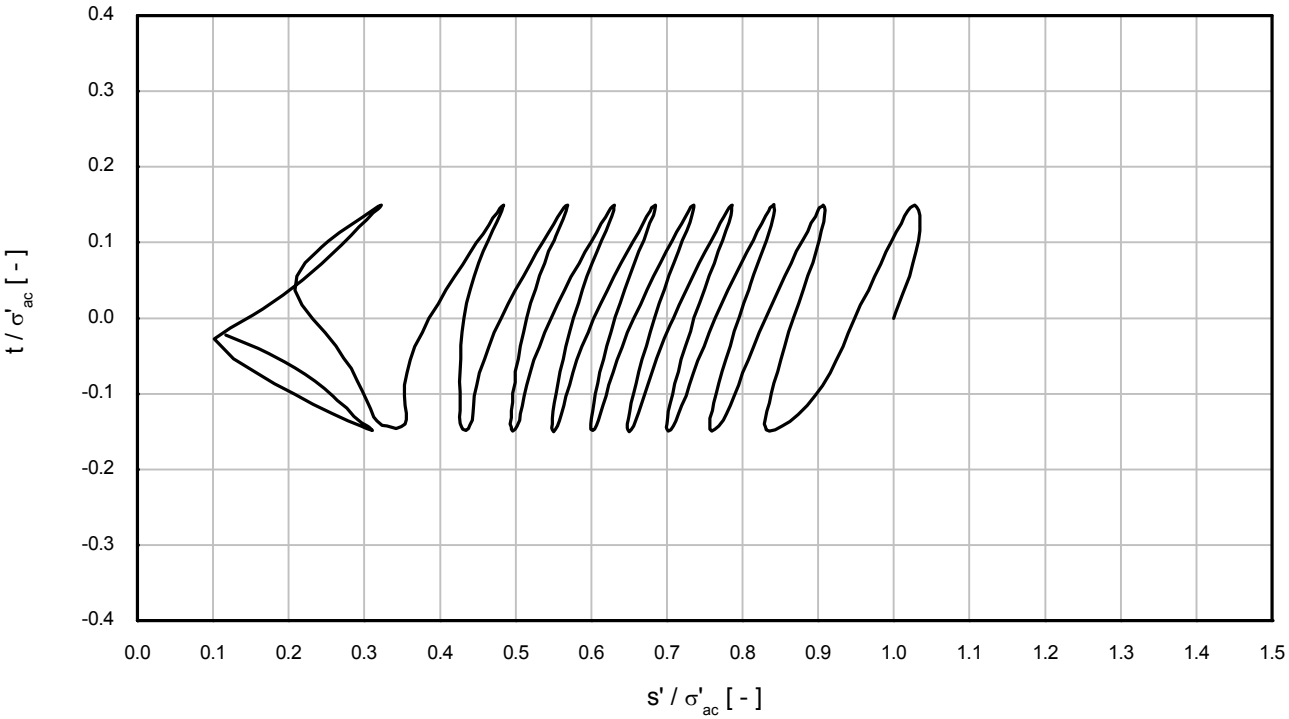


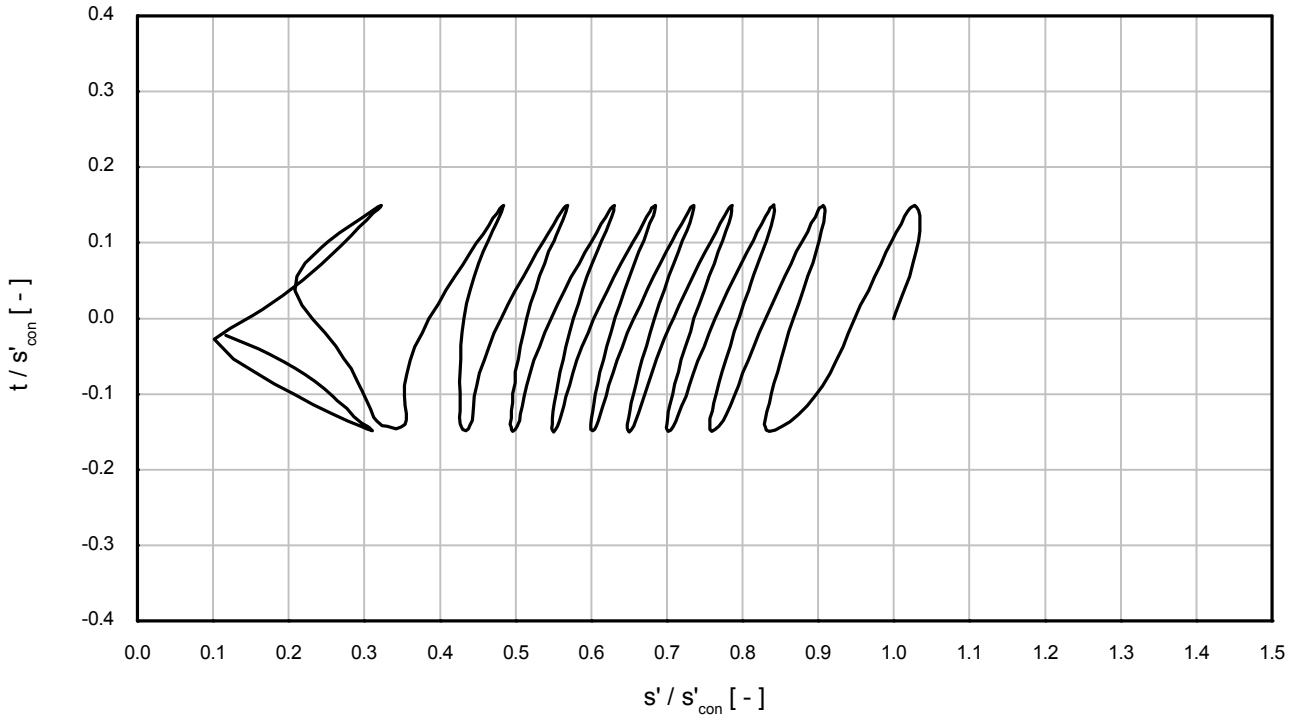


Initial σ'_r	:	400	kPa	Batch	: 4
Initial σ'_a	:	400	kPa	Sample	: CTX_4-2
q_{av}	:	0	kPa	Unit	: E5b (Tongeren)
q_{cy}	:	119	kPa	Test No.	: CTX18
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

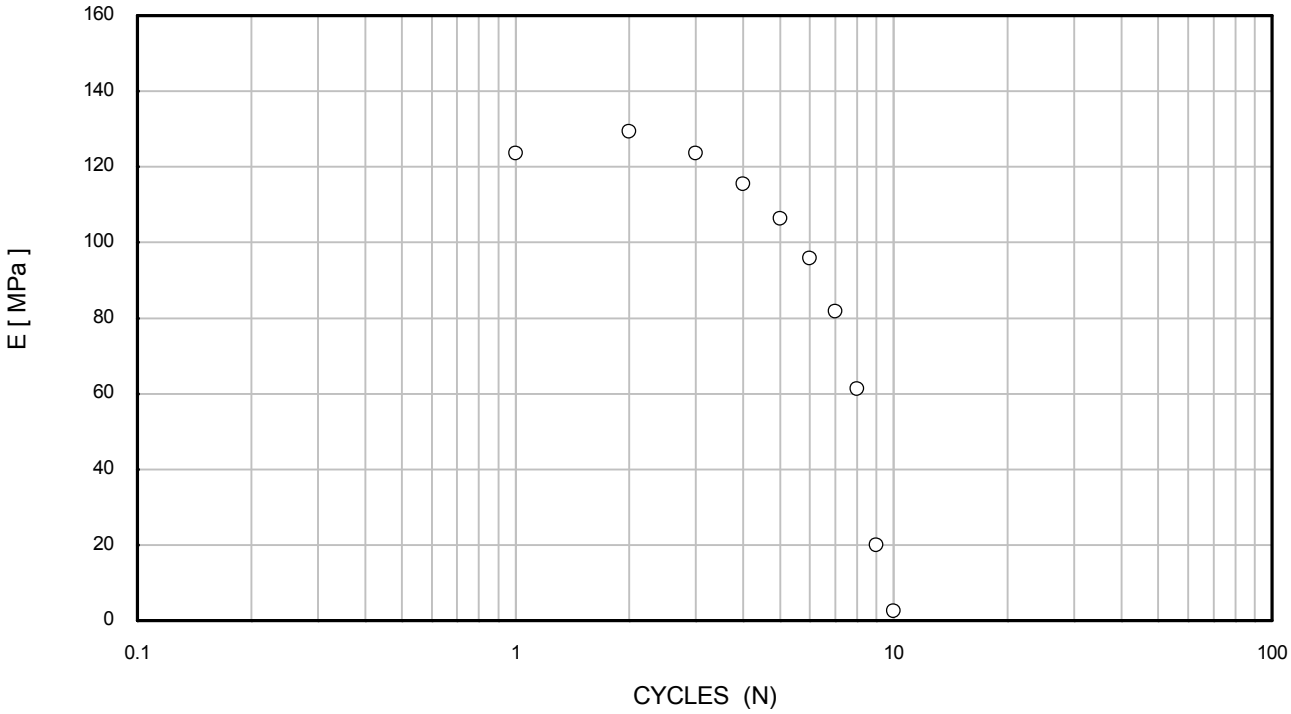


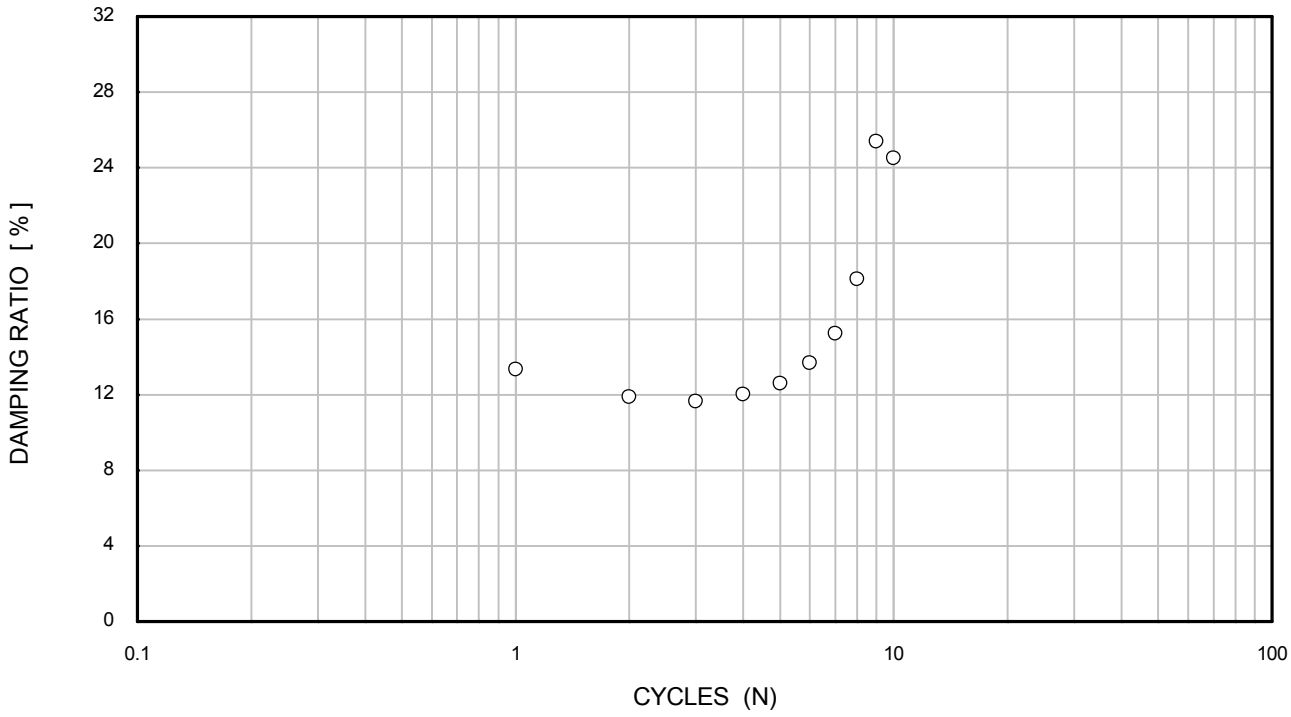


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-2
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	119 kPa	Test No.	:	CTX18
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

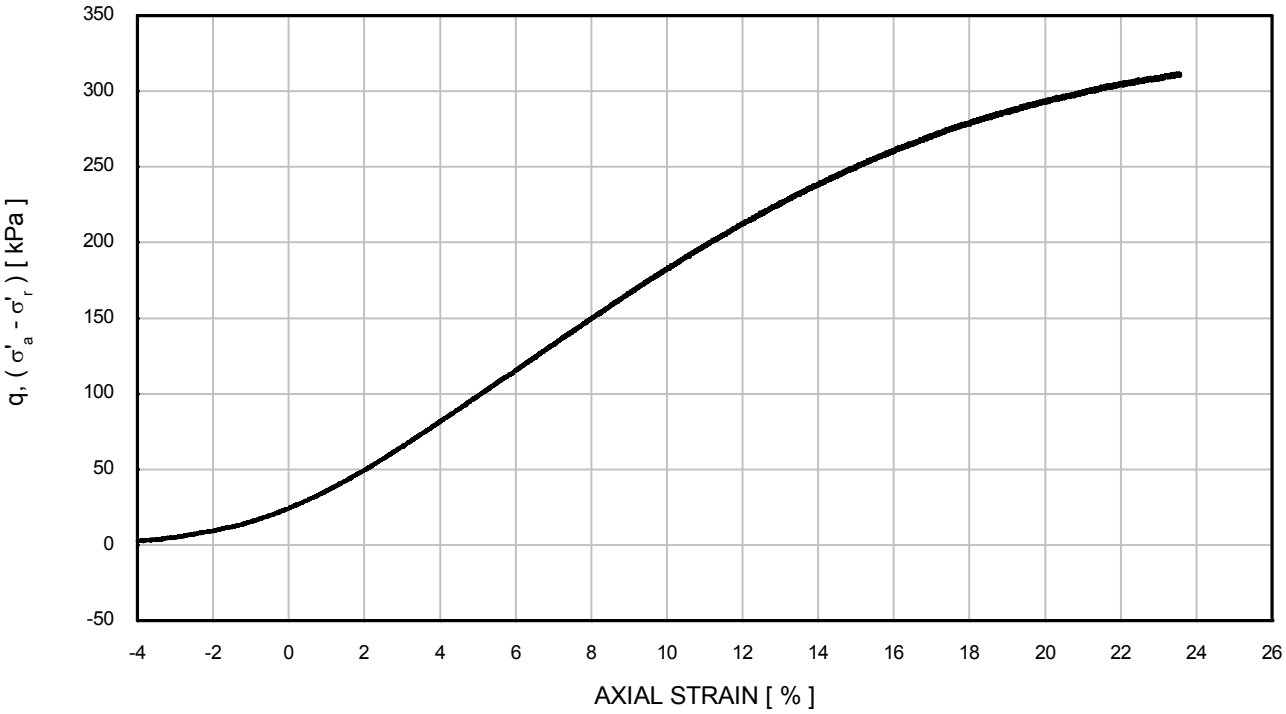


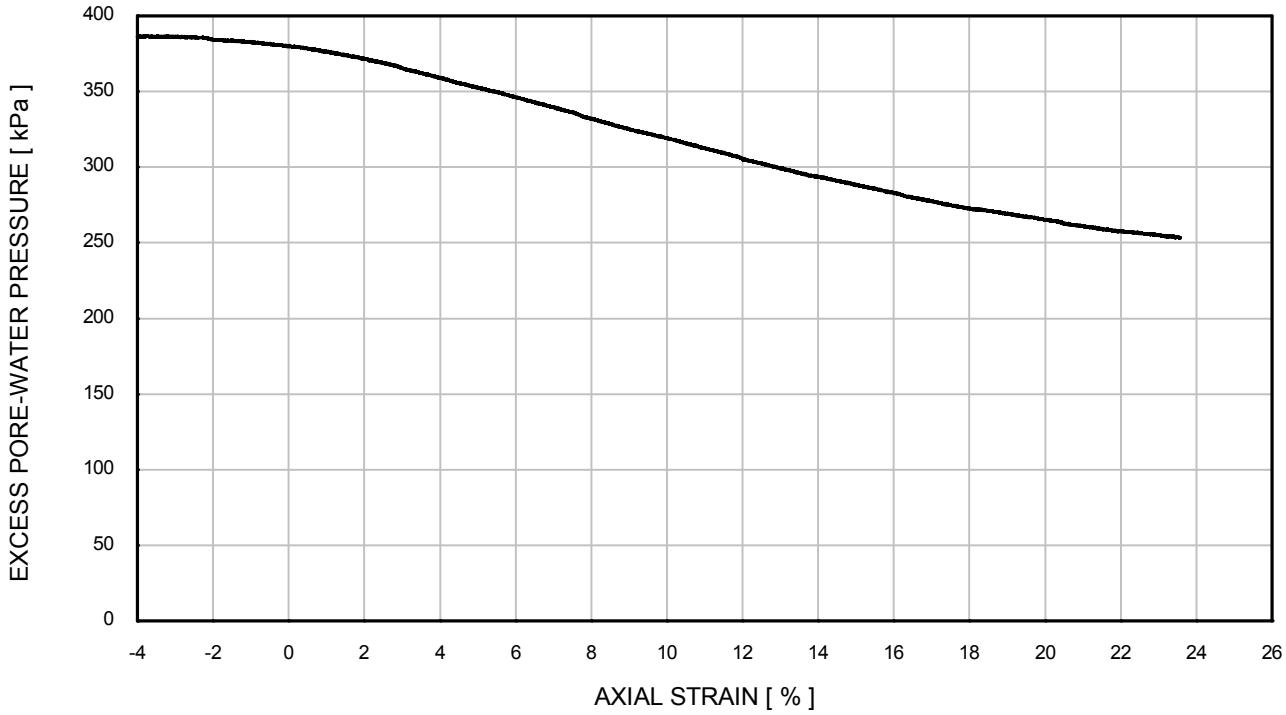


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-2
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	119 kPa	Test No.	:	CTX18
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

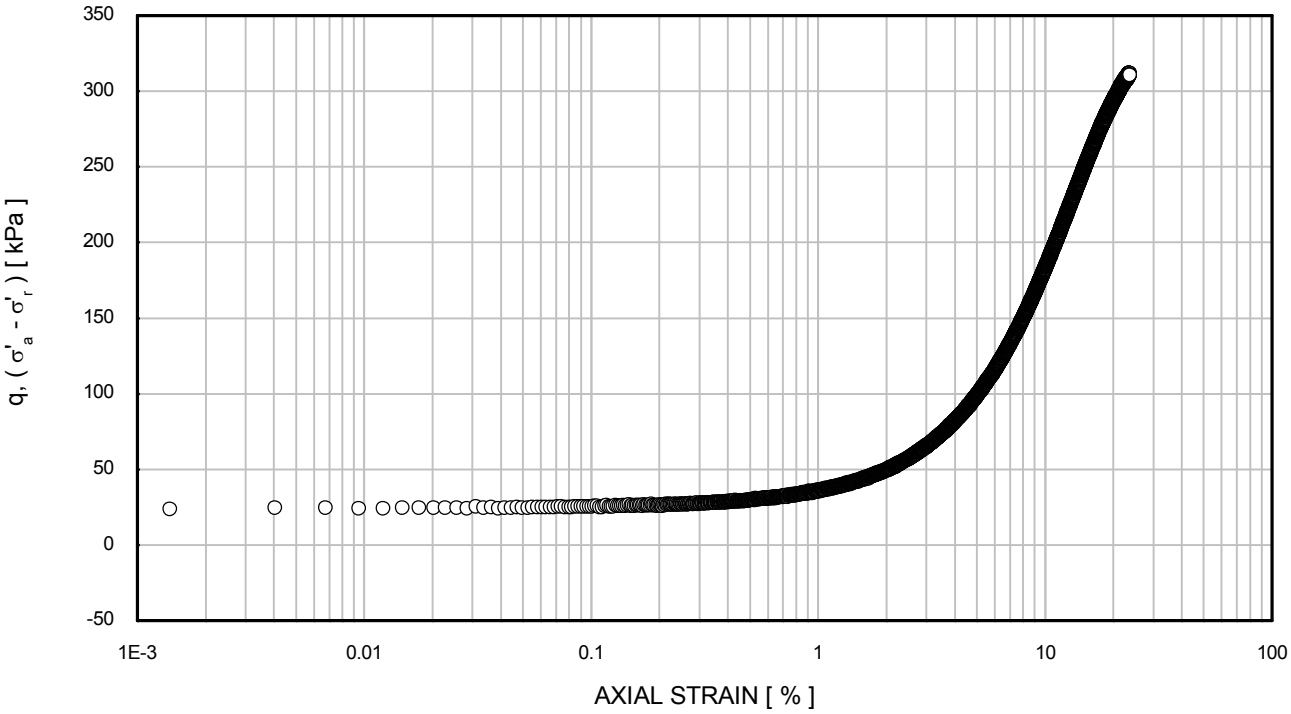


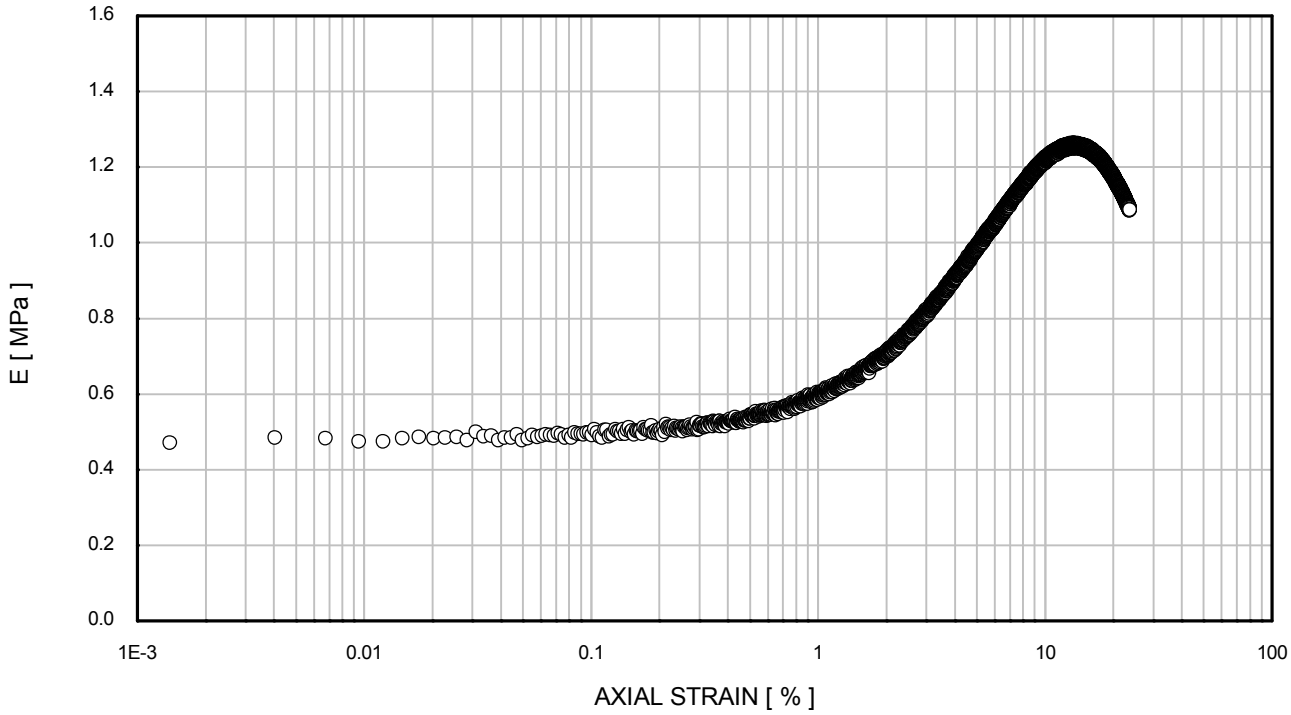


Initial σ'_r	:	15 kPa	Batch	:	4
Initial σ'_a	:	15 kPa	Sample	:	CTX_4-2
q_{peak}	:	312 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	23.57 %	Test No.	:	CTX18
Rate of strain	:	4.84 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

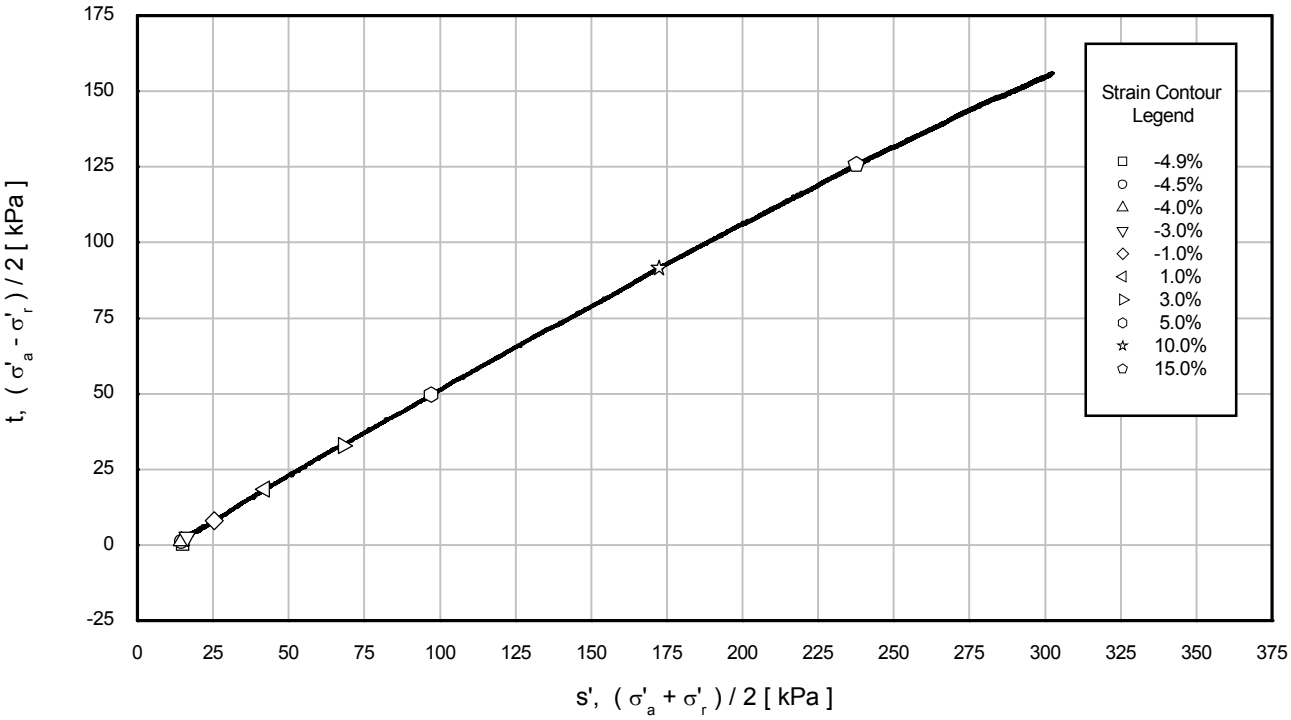


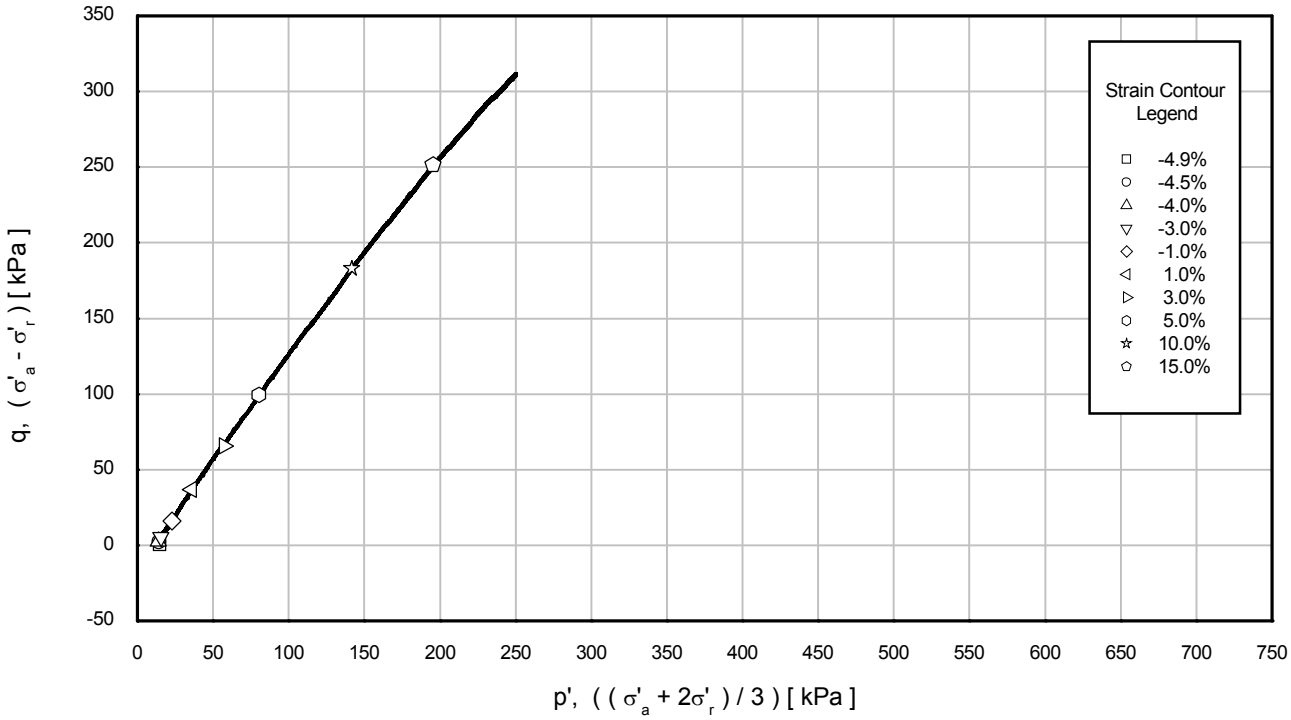


Initial σ'_r	:	15 kPa	Batch	:	4
Initial σ'_a	:	15 kPa	Sample	:	CTX_4-2
q_{peak}	:	312 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	23.57 %	Test No.	:	CTX18
Rate of strain	:	4.84 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	15 kPa	Batch	:	4
Initial σ'_a	:	15 kPa	Sample	:	CTX_4-2
q_{peak}	:	312 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	23.57 %	Test No.	:	CTX18
Rate of strain	:	4.84 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	29/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.3
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.651
Degree of saturation	[%]	42
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 4_CTX-4-3_CTX19
Processed by Date	HJ 08/02/2016
Checked by Date	PH 15/03/2016
Approved by Date	PH 15/03/2016

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-3
Unit	E5b (Tongeren)
Test number	CTX19

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1079
Mid height PWP	[kPa]	-
B value achieved	[-]	0.99

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1479
Back pressure	[kPa]	1079
Base PWP	[kPa]	1079
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	400
Effective axial pressure	[kPa]	400
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.20
External axial strain	[%]	0.82
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	23.2
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64
Void ratio	[-]	0.614
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-3
Unit	E5b (Tongeren)
Test number	CTX19

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	800
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	80
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	148
External ε_{av} at N_f	[%]	-1.23
External ε_{cy} at N_f	[%]	1.95
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	321
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	23.2
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64
Void ratio	[-]	0.614
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.04	192.86	-	9.57	-
2	0.00	0.04	200.87	-	7.36	-
5	0.00	0.04	197.98	-	6.31	-
10	0.00	0.04	191.62	-	5.81	-
20	0.00	0.04	183.08	-	5.56	-
30	0.00	0.05	175.65	-	5.68	-
40	0.00	0.05	168.33	-	5.62	-
50	0.00	0.05	162.28	-	5.84	-
100	0.00	0.06	129.51	-	7.25	-
145	-0.13	0.24	33.75	-	20.03	-
148	-1.23	1.95	4.05	-	21.85	-

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-3
Unit	E5b (Tongeren)
Test number	CTX19

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	14
Initial effective axial pressure	[kPa]	14
Rate of strain	[%/hour]	4.80
At peak deviator stress		
Corrected deviator stress	[kPa]	375
Membrane correction applied	[kPa]	3
Drain correction applied	[kPa]	0
External axial strain	[%]	23.45
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	225
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	175
Effective axial pressure	[kPa]	550
Principal effective stress ratio	[-]	3.15
ε_{50}	[%]	10.27
Secant modulus (E_{50}) at ε_{50}	[kPa]	1389
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	232
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	12.38
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	298
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	101
Effective axial pressure	[kPa]	334
Principal effective stress ratio	[-]	3.29
At 10% external axial strain		
Corrected deviator stress	[kPa]	181
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	319
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	81
Effective axial pressure	[kPa]	262
Principal effective stress ratio	[-]	3.24

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-3
Unit	E5b (Tongeren)
Test number	CTX19

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



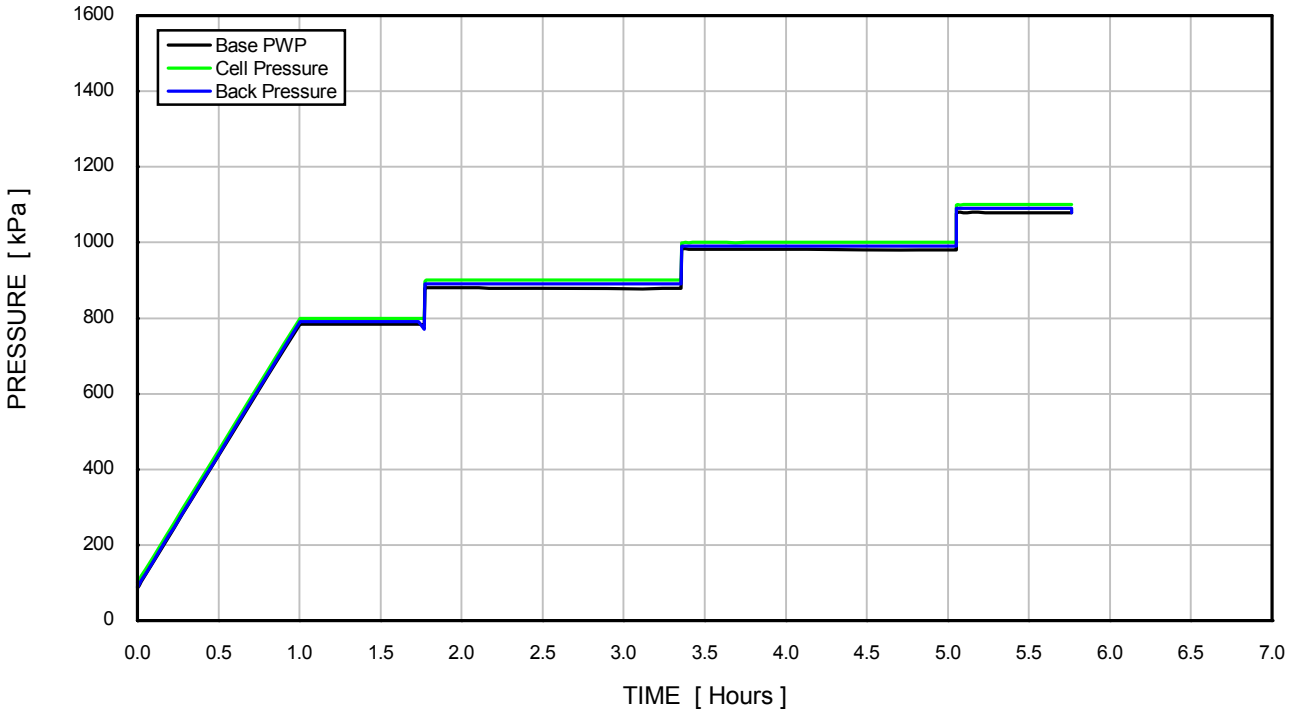


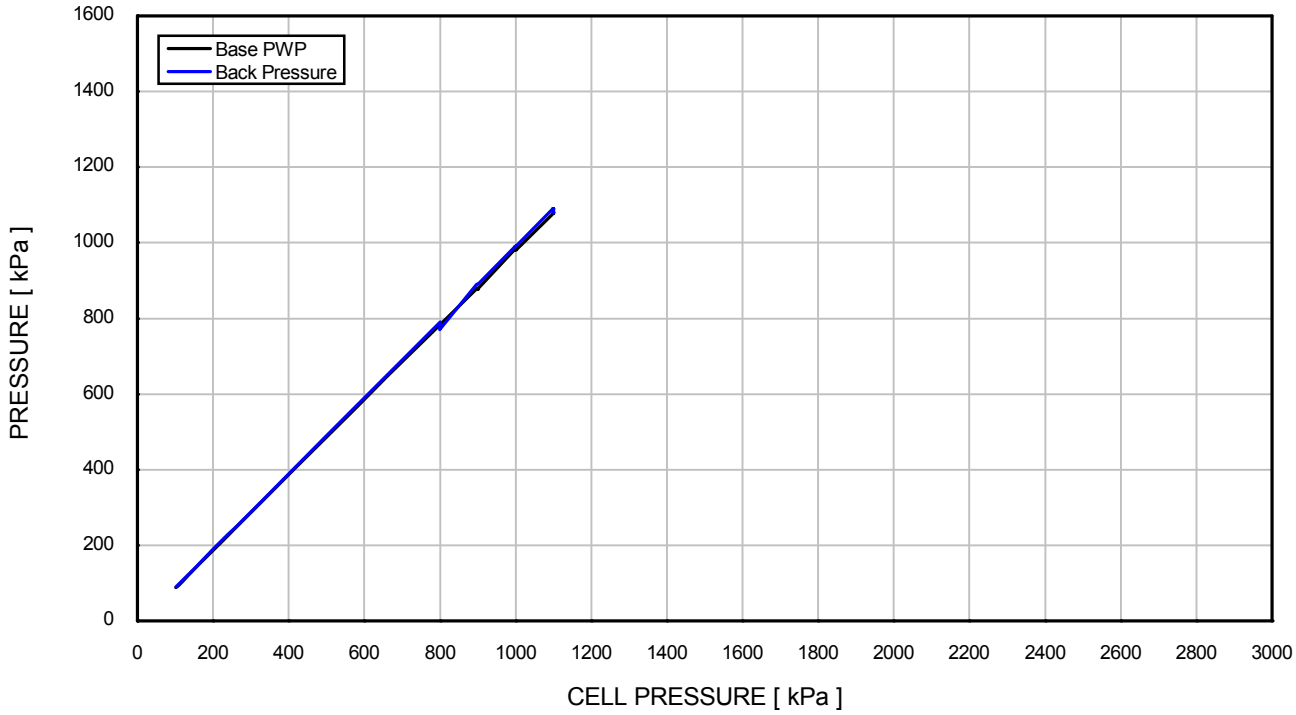
FINAL CONDITIONS		
Moisture content	[%]	23.2
Bulk density	[Mg/m³]	2.02
Dry density	[Mg/m³]	1.64

TEST IDENTIFICATION	
Borehole	4
Sample	CTX_4-3
Unit	E5b (Tongeren)
Test number	CTX19

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

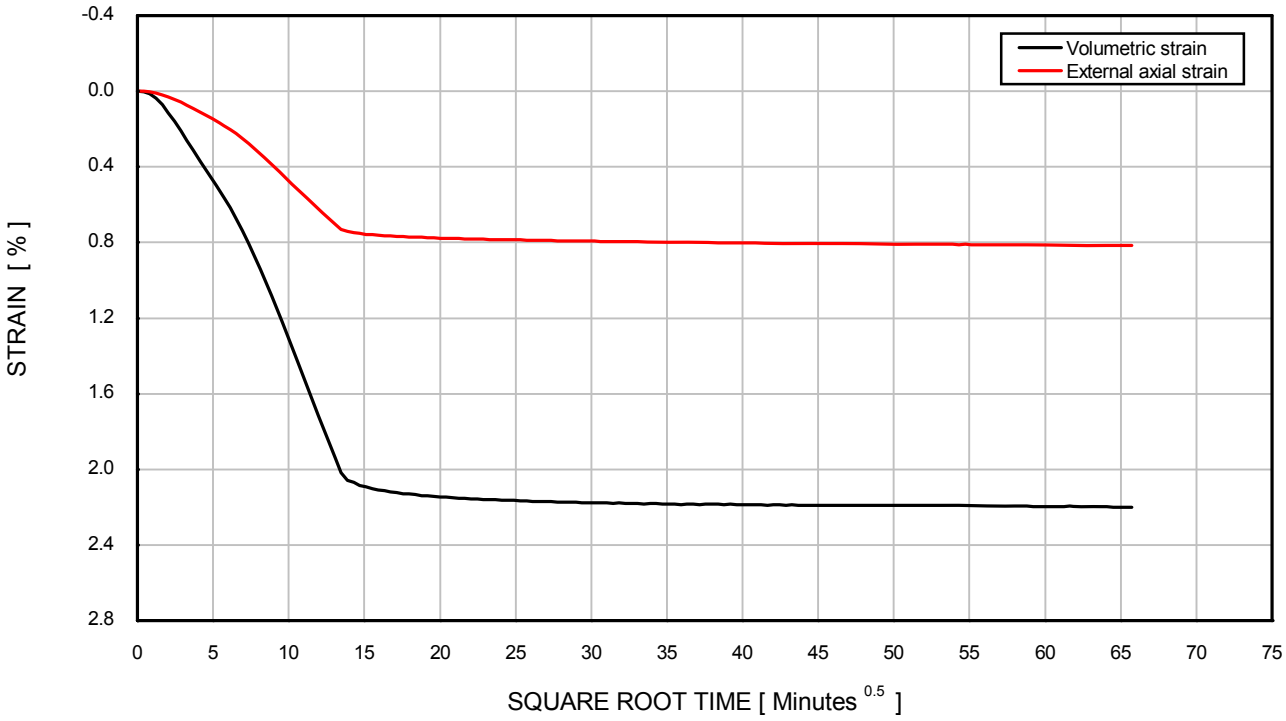


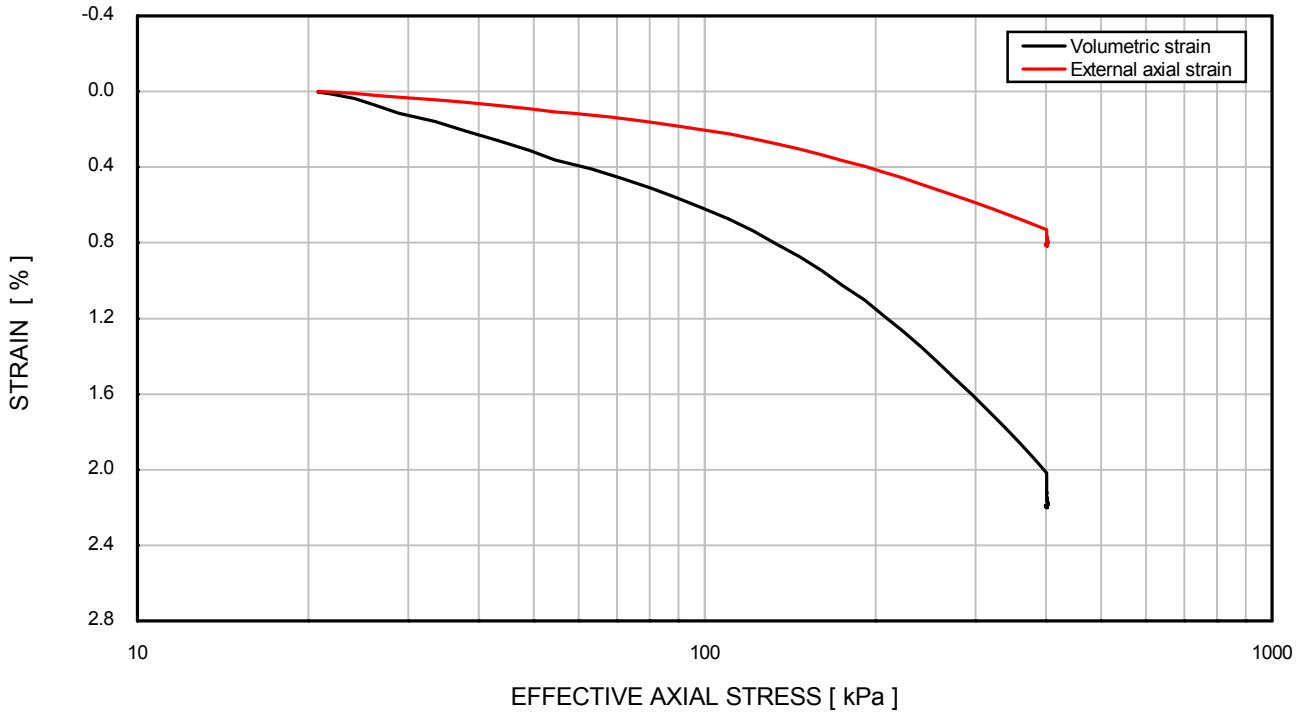


B value	:	0.99			
Initial σ'_r	:	14	kPa	Batch	: 4
Initial σ'_a	:	14	kPa	Sample	: CTX_4-3
Final σ'_r	:	21	kPa	Unit	: E5b (Tongeren)
Final σ'_a	:	21	kPa	Test No.	: CTX19

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

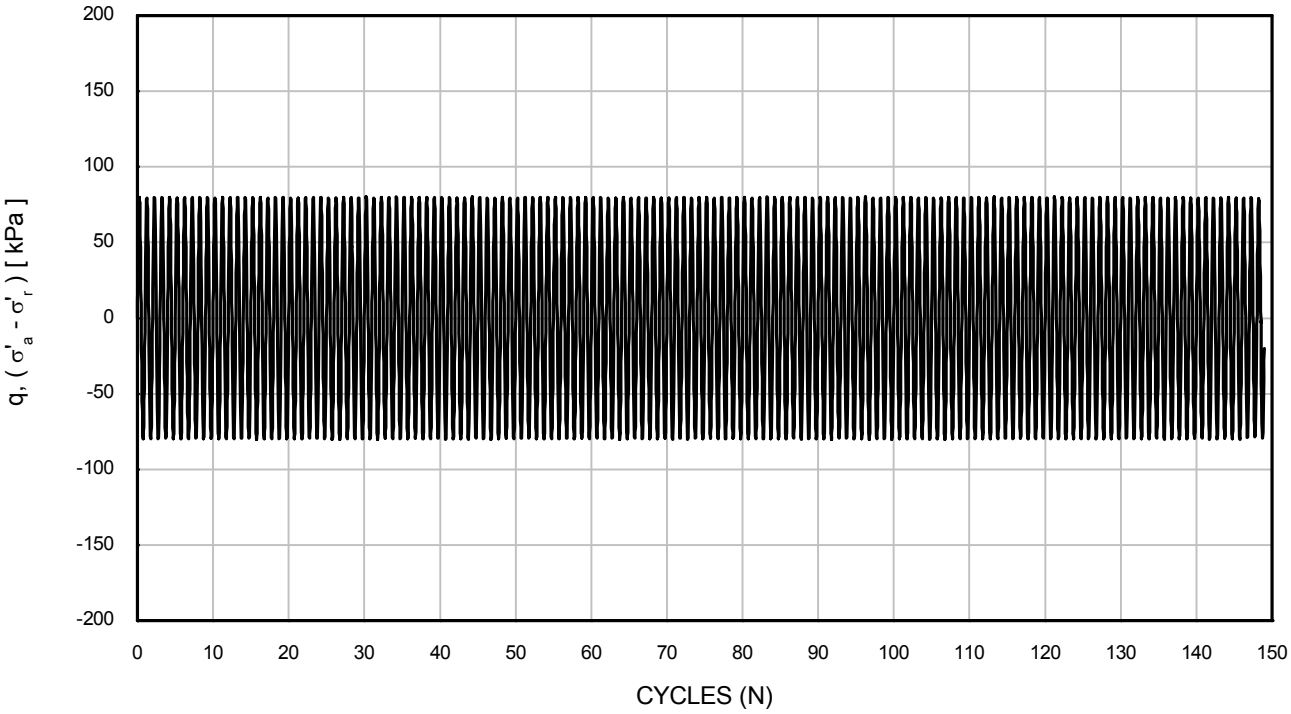


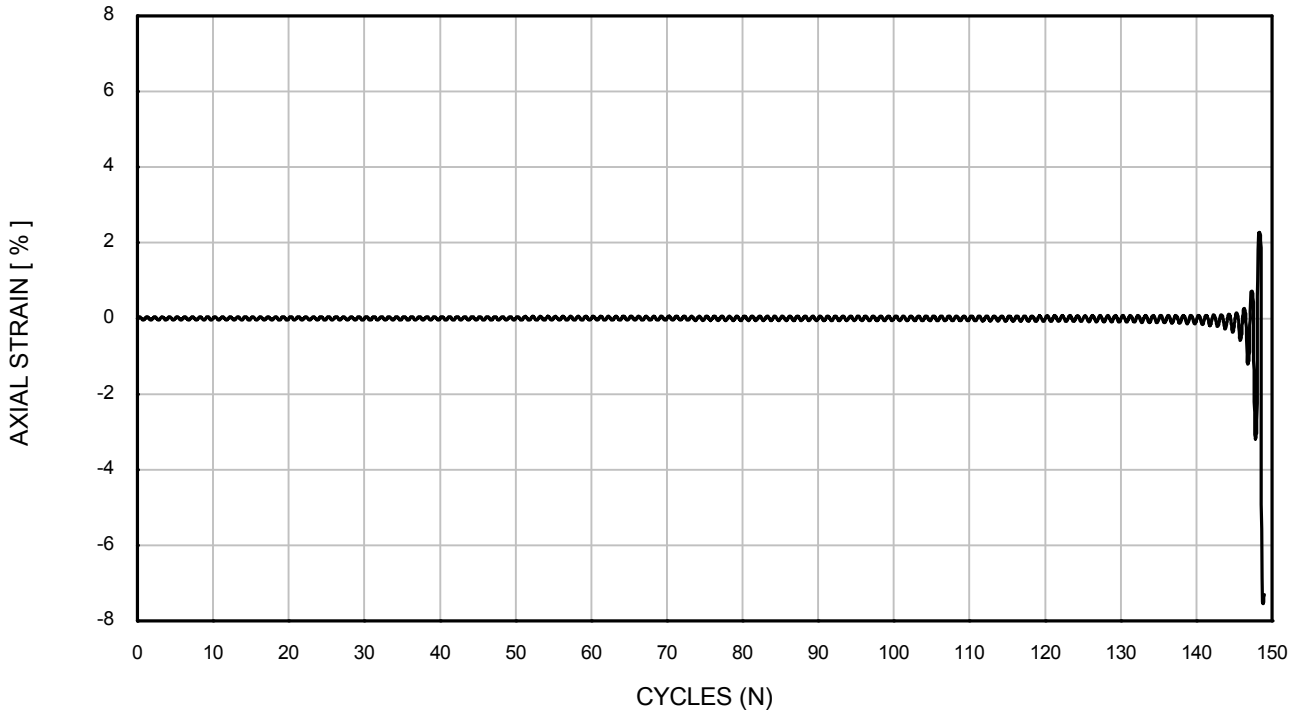


σ'_{rc}	: 400 kPa	Batch	: 4
σ'_{ac}	: 400 kPa	Sample	: CTX_4-3
		Unit	: E5b (Tongeren)
		Test No.	: CTX19

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

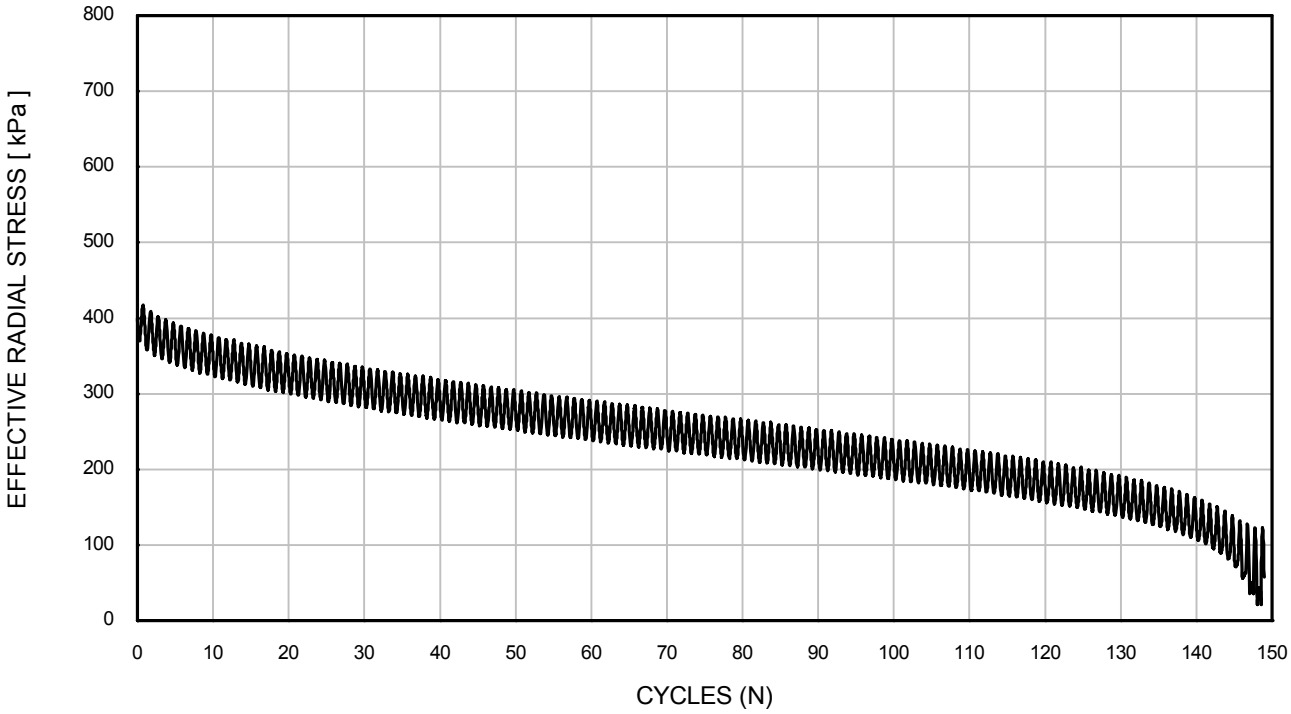


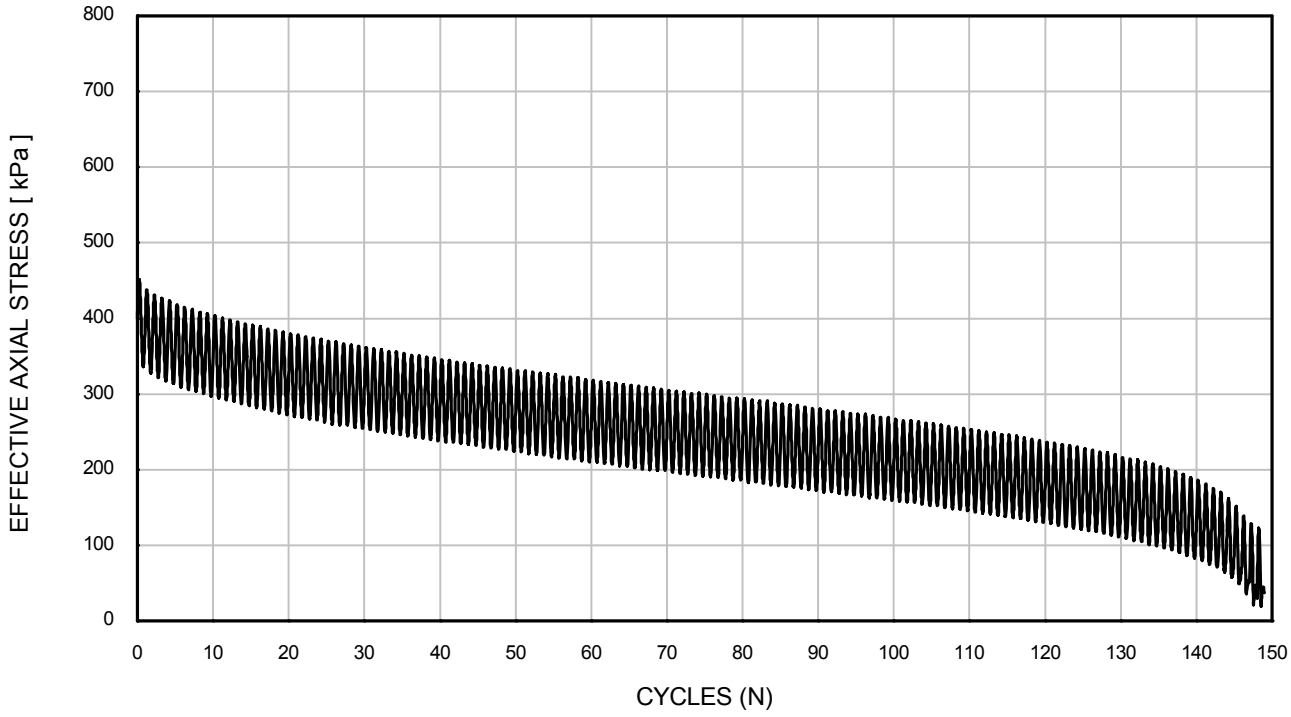


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-3
q_{av}	:	-0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	80 kPa	Test No.	:	CTX19
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

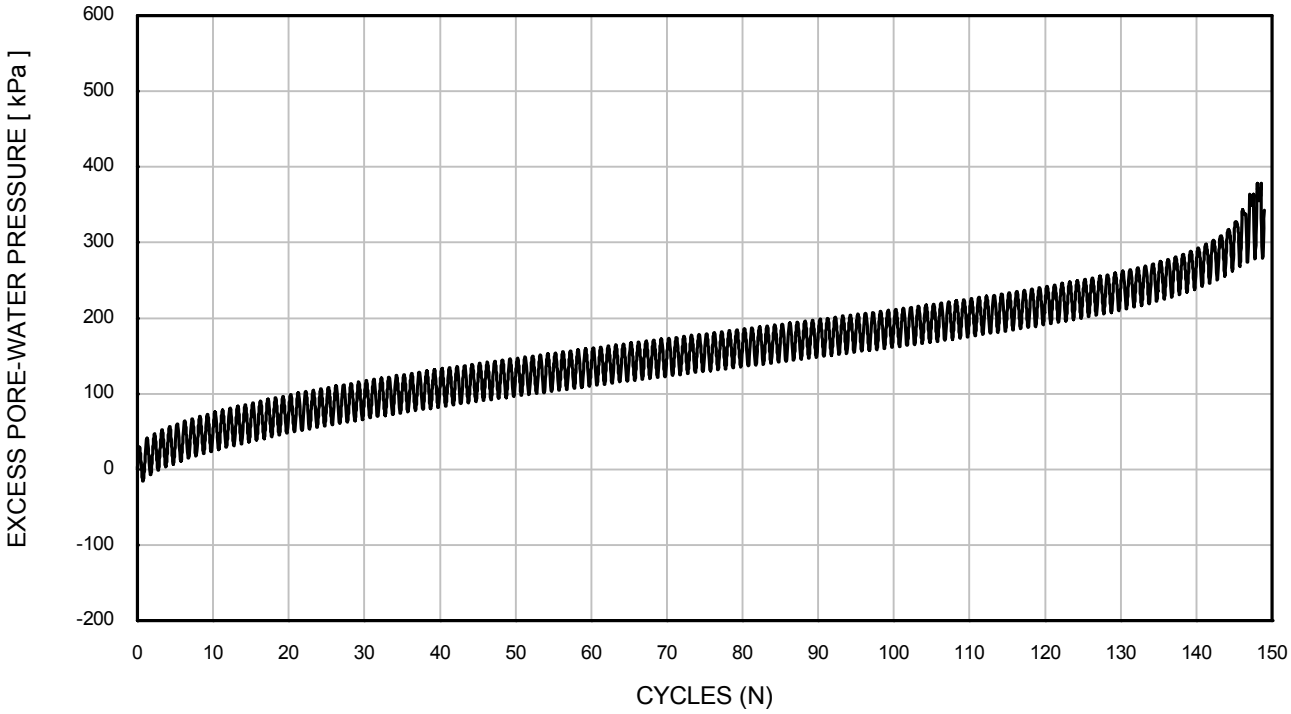


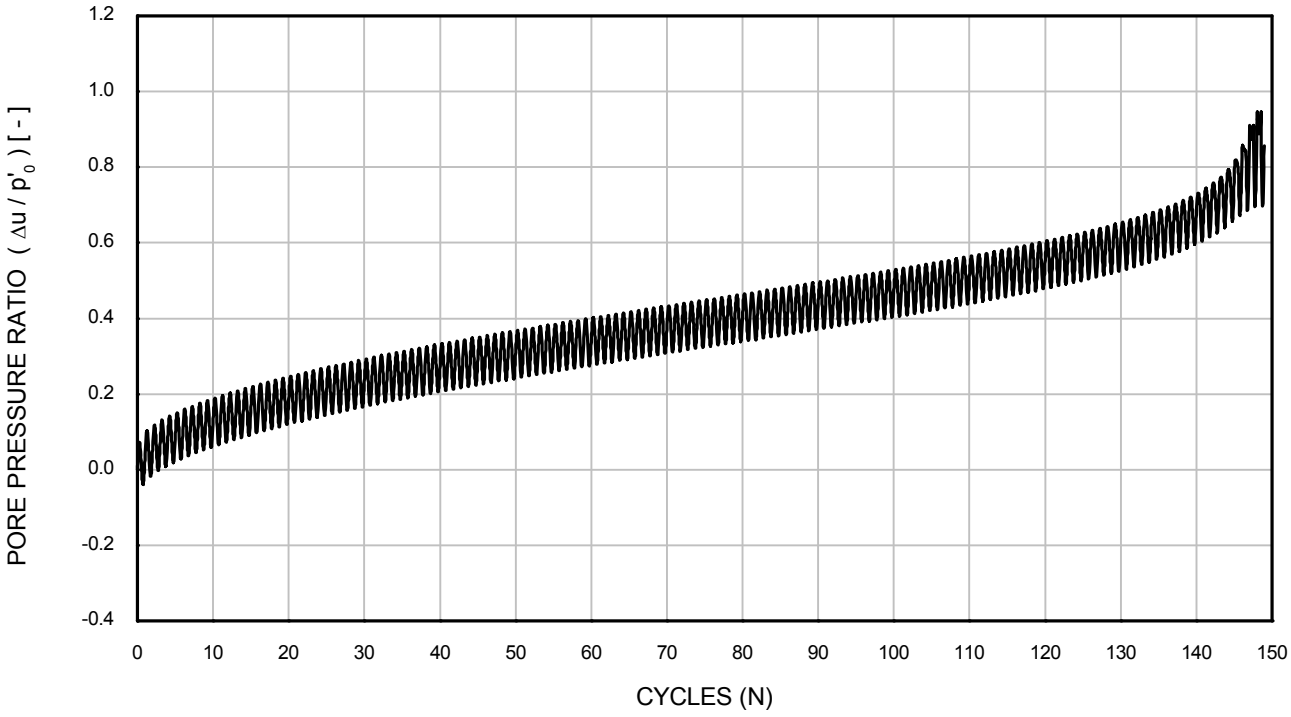


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-3
q_{av}	:	-0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	80 kPa	Test No.	:	CTX19
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

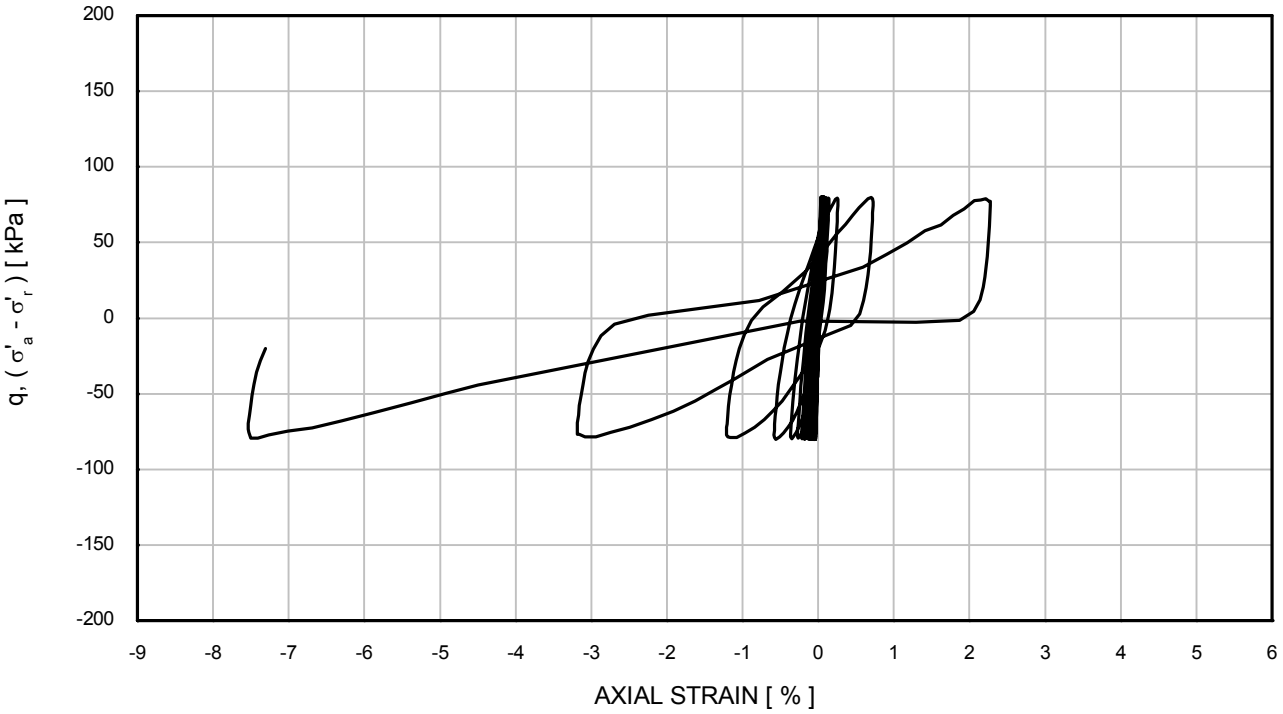


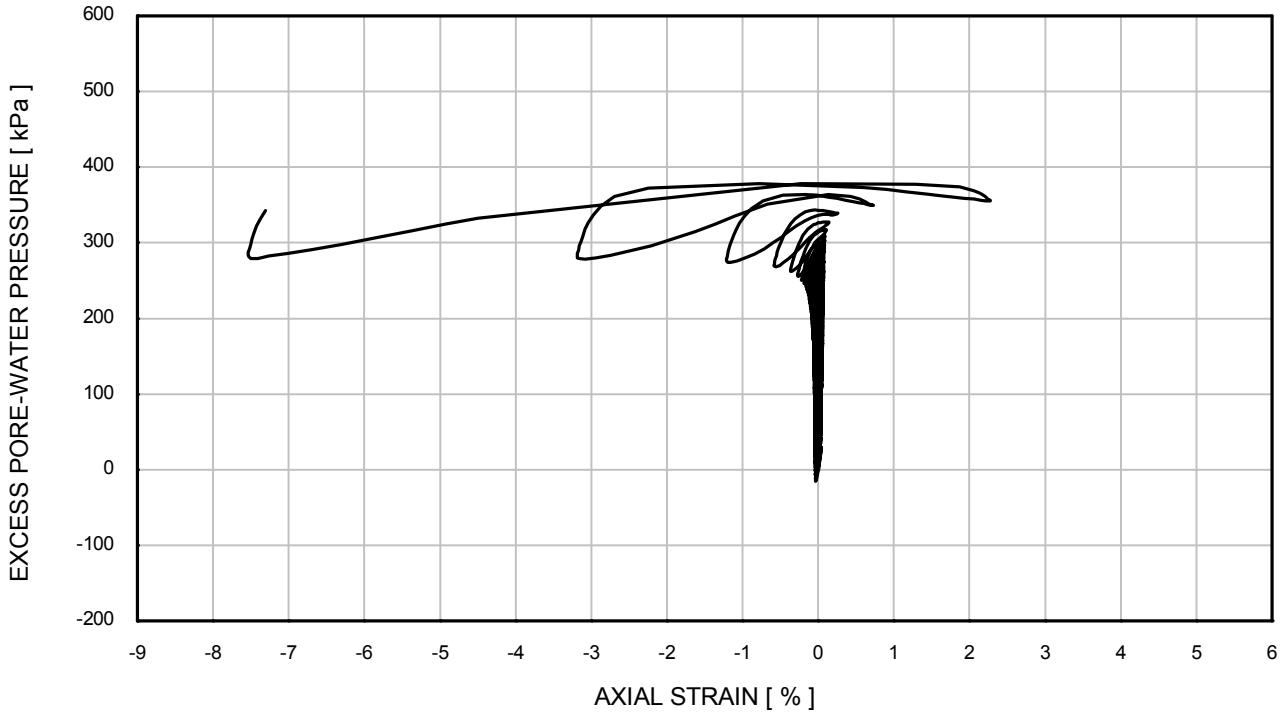


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-3
q_{av}	:	-0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	80 kPa	Test No.	:	CTX19
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

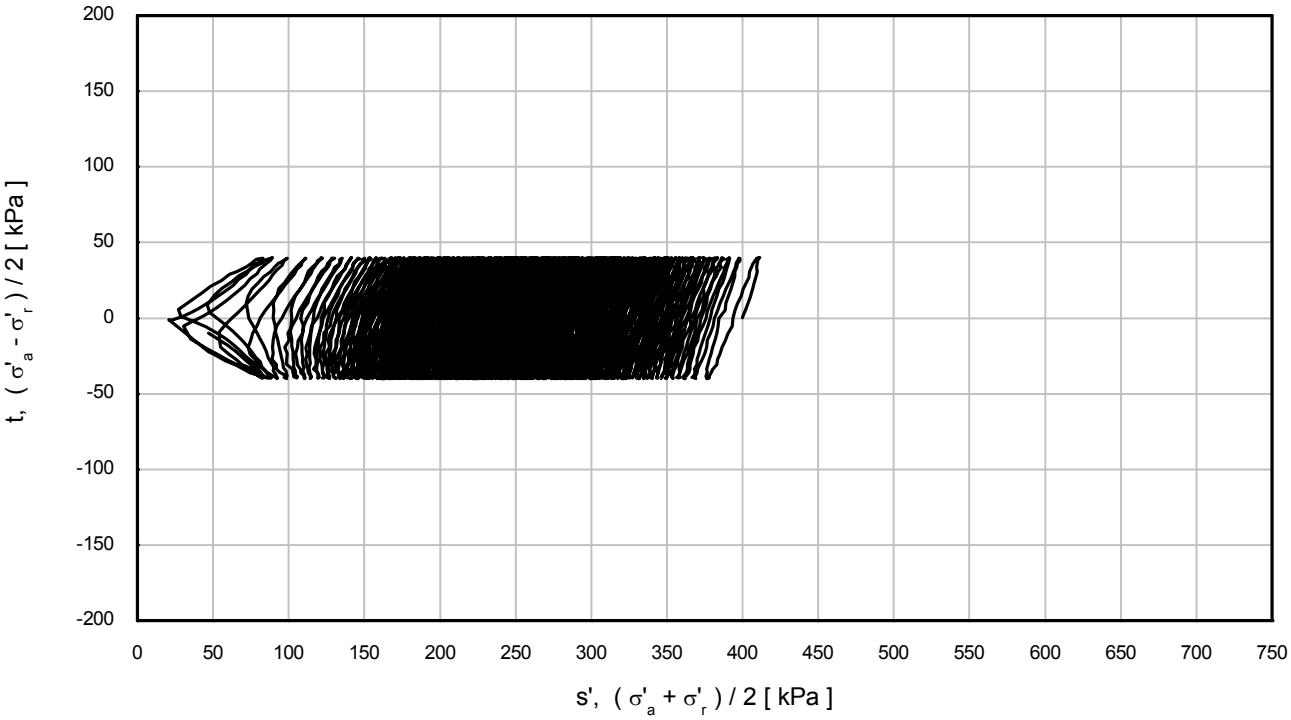


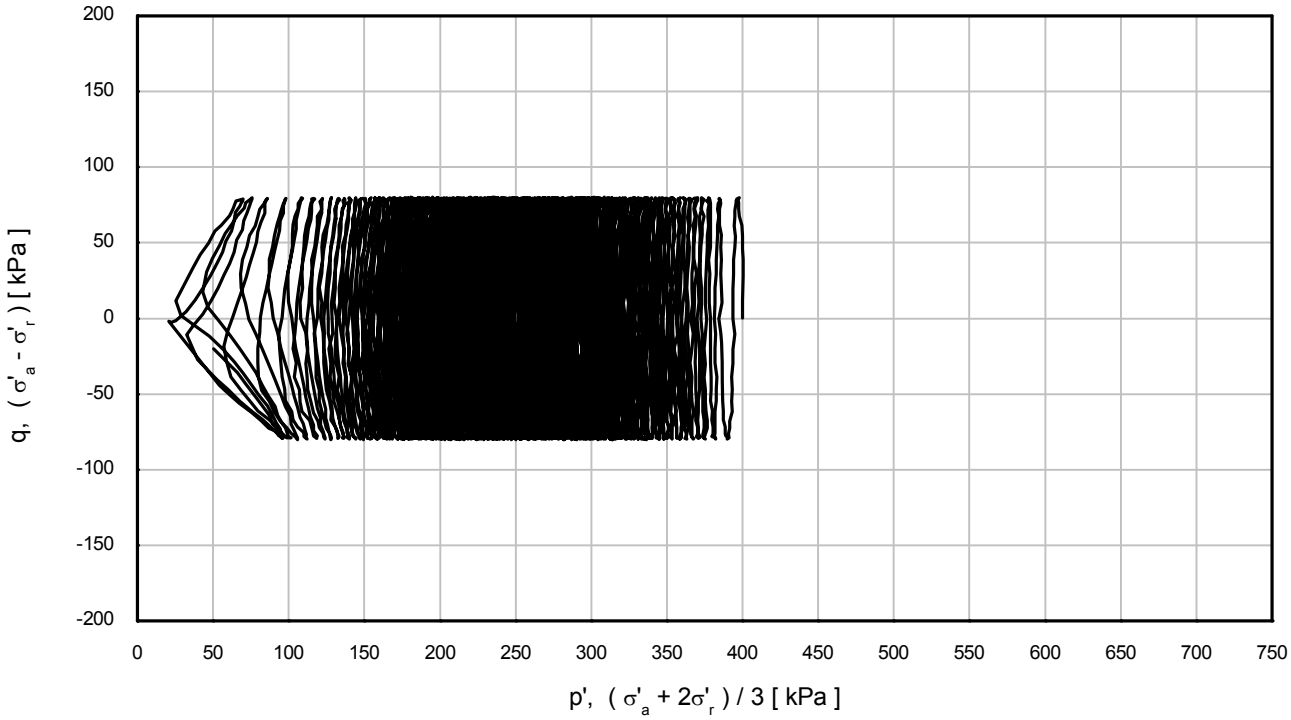


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-3
q_{av}	:	-0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	80 kPa	Test No.	:	CTX19
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

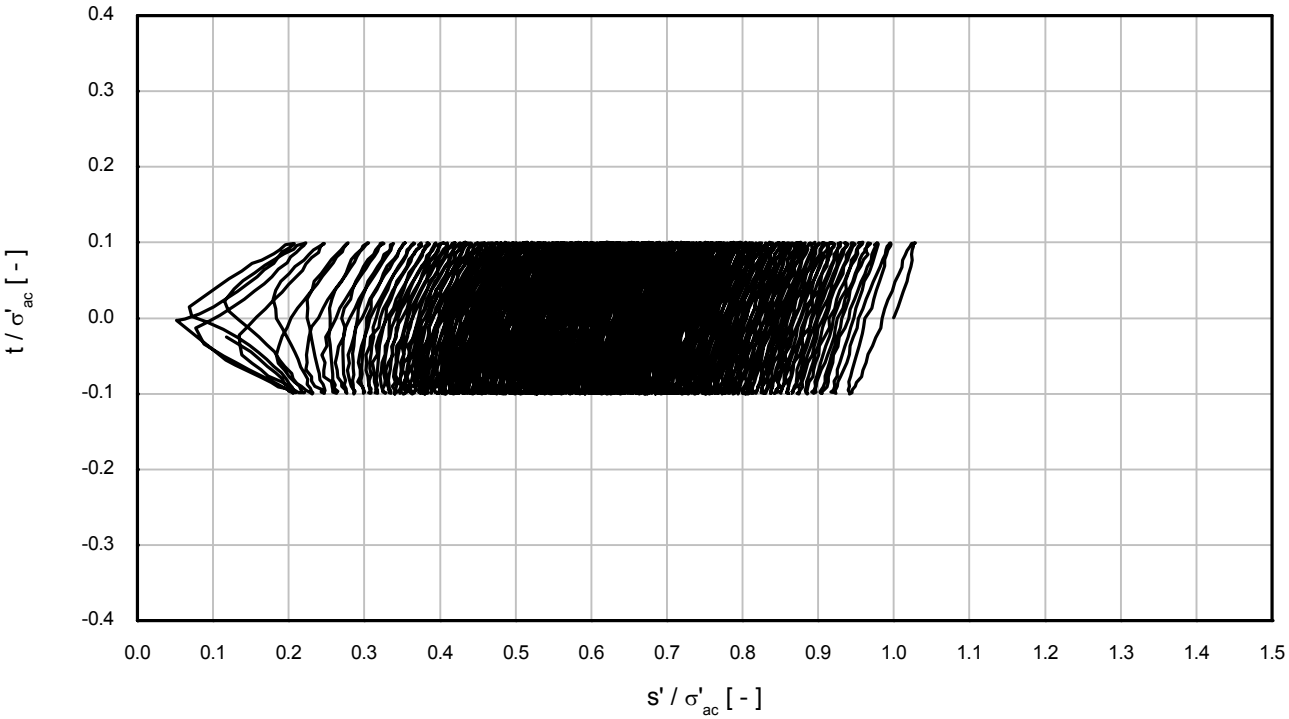


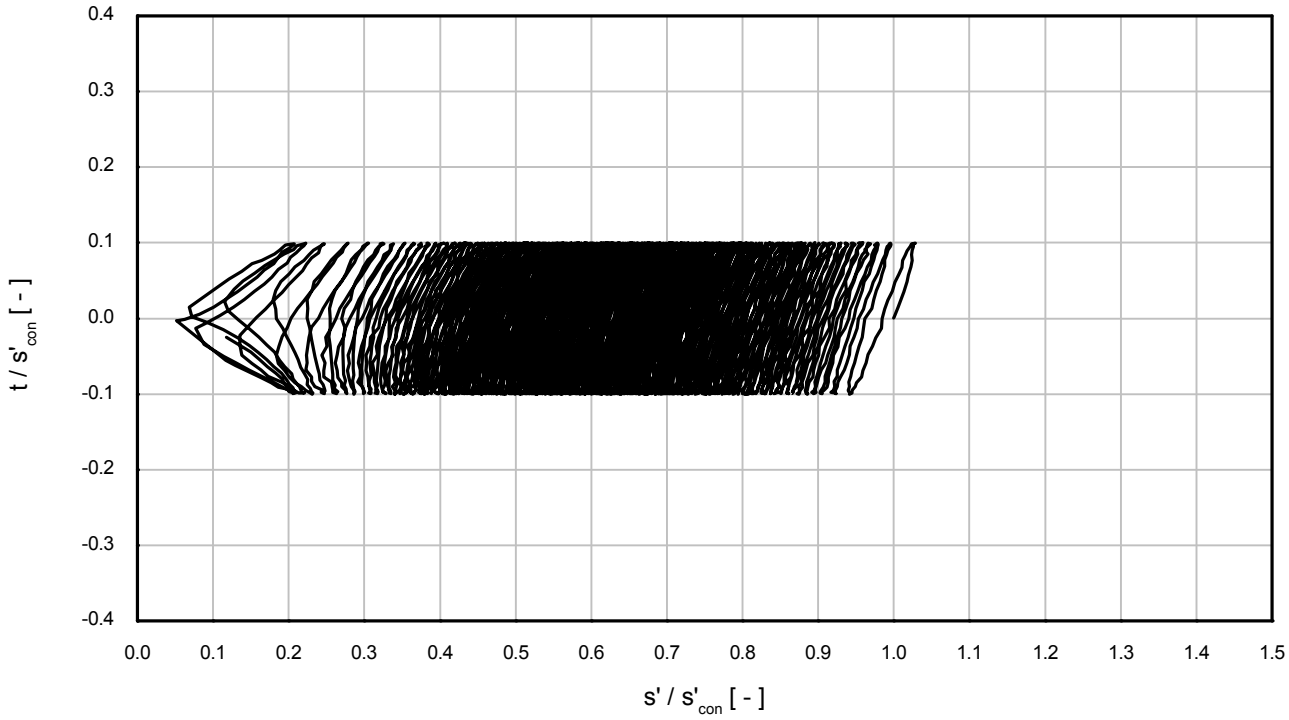


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-3
q_{av}	:	-0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	80 kPa	Test No.	:	CTX19
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

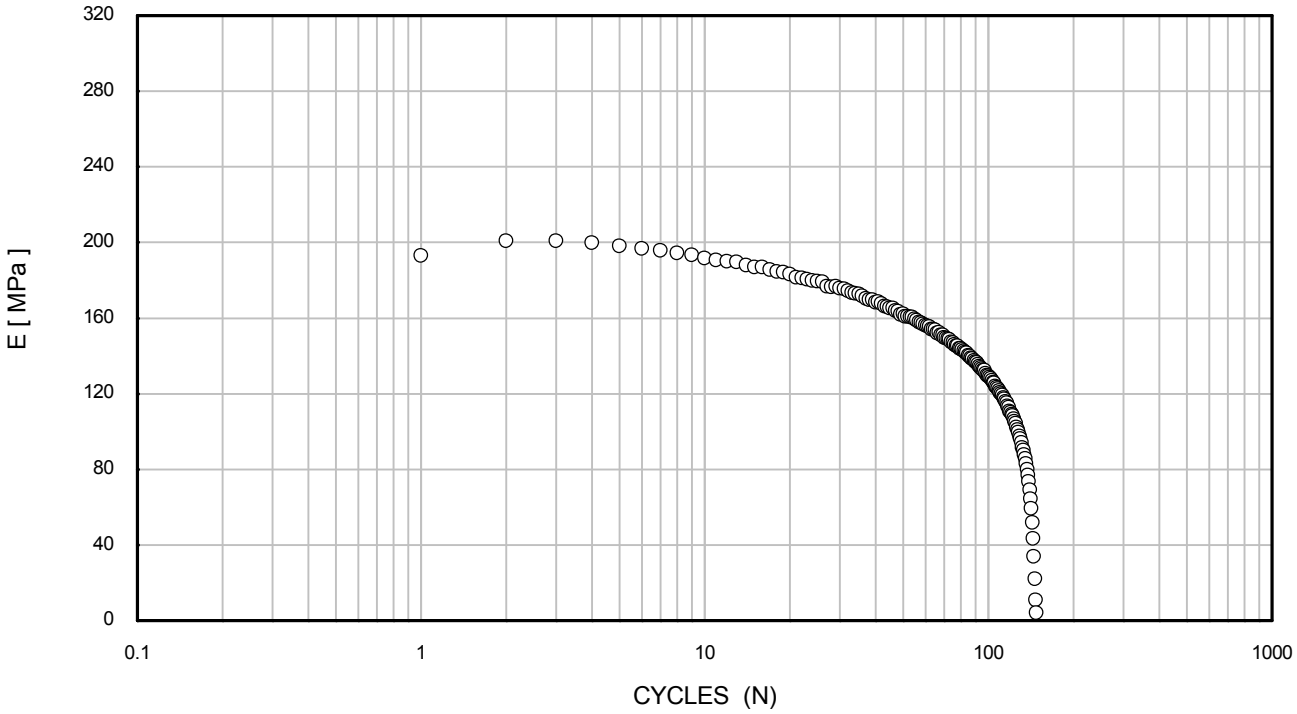


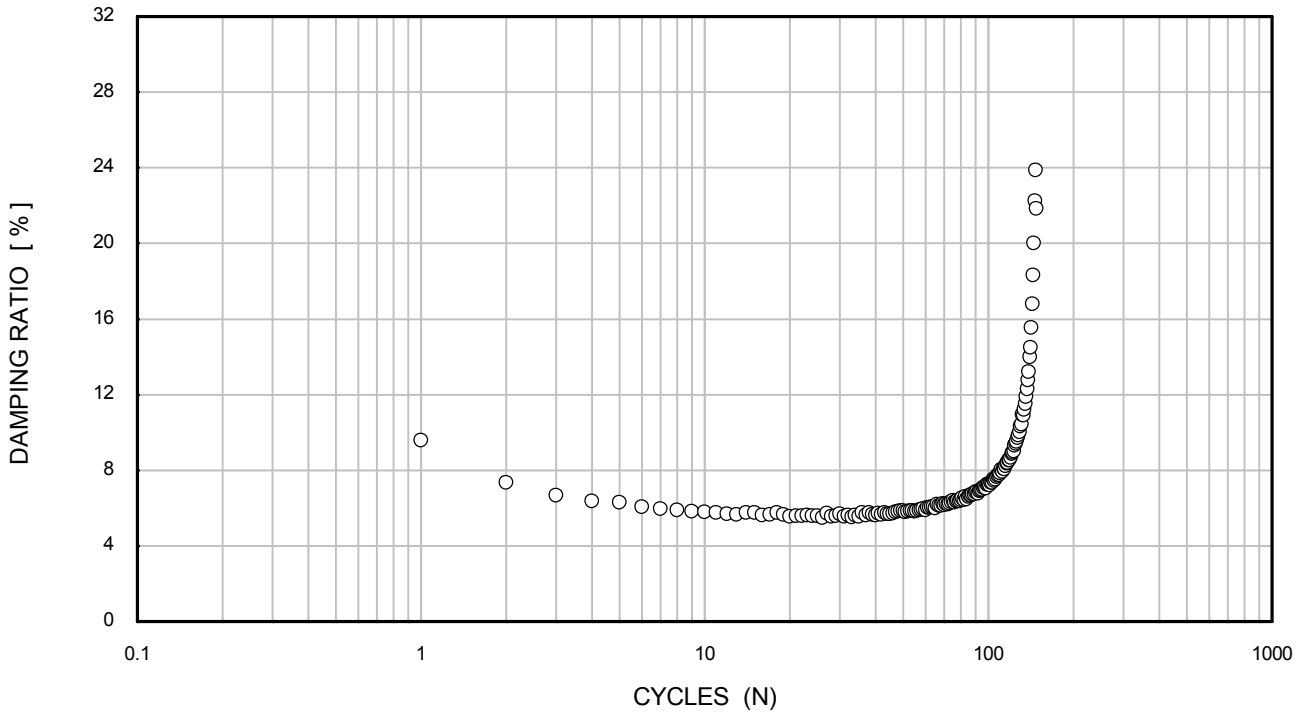


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-3
q_{av}	:	-0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	80 kPa	Test No.	:	CTX19
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

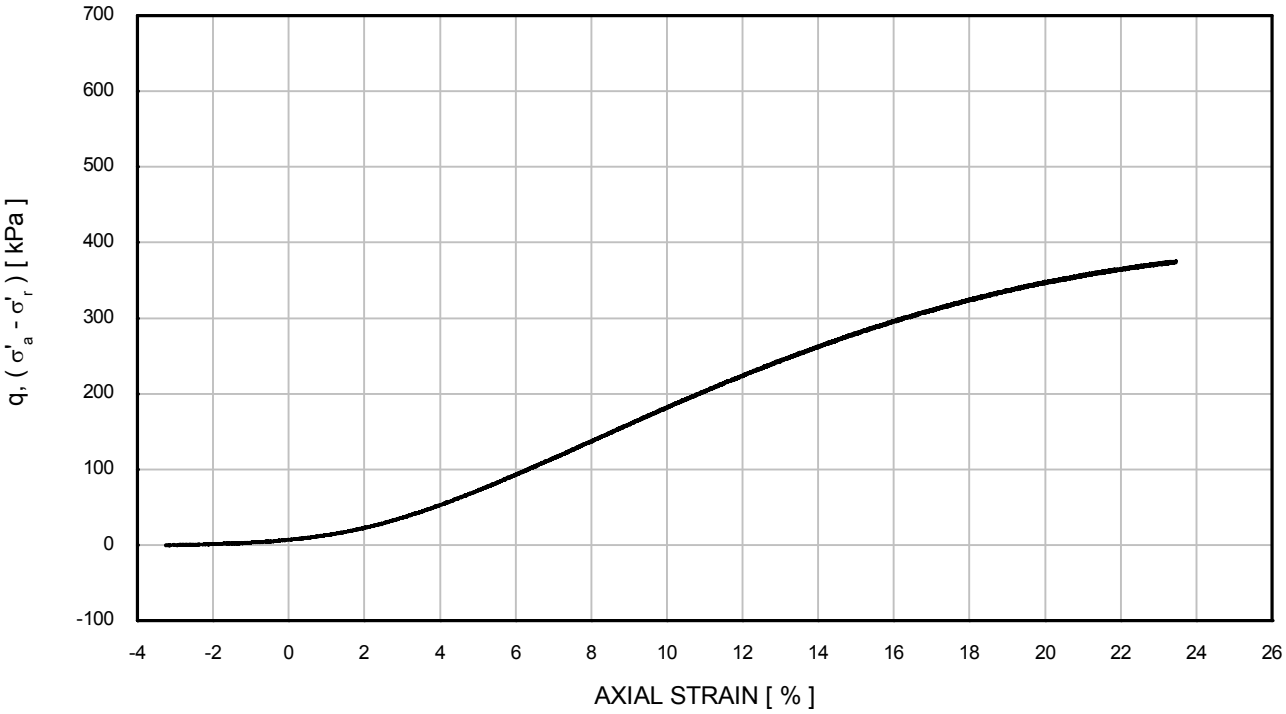


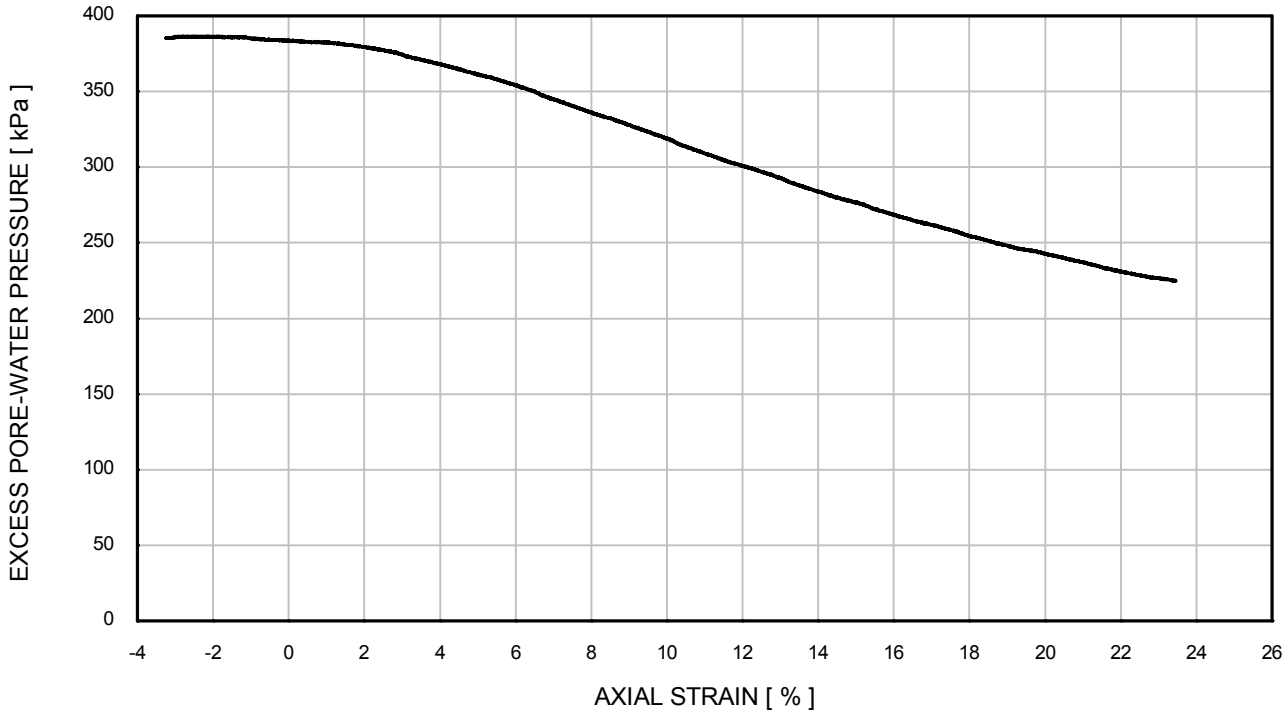


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-3
q_{av}	:	-0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	80 kPa	Test No.	:	CTX19
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

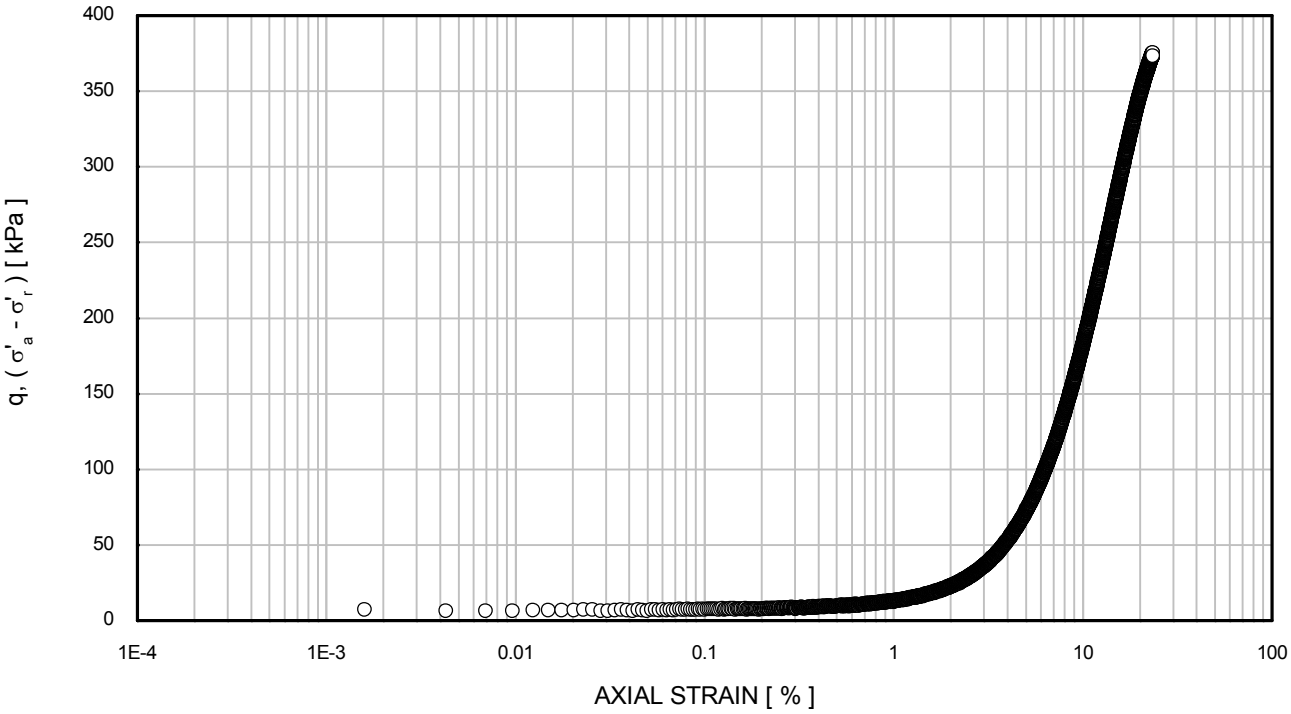


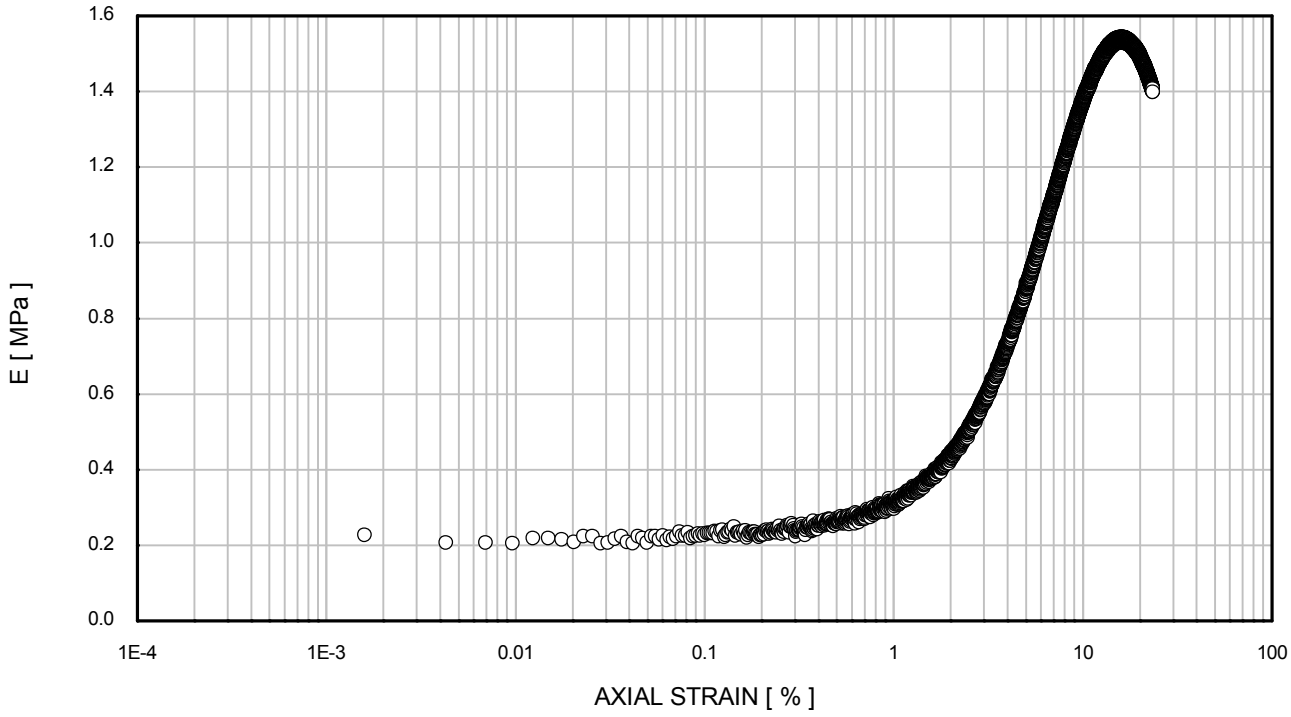


Initial σ'_r	:	14 kPa	Batch	:	4
Initial σ'_a	:	14 kPa	Sample	:	CTX_4-3
q_{peak}	:	375 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	23.45 %	Test No.	:	CTX19
Rate of strain	:	4.80 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

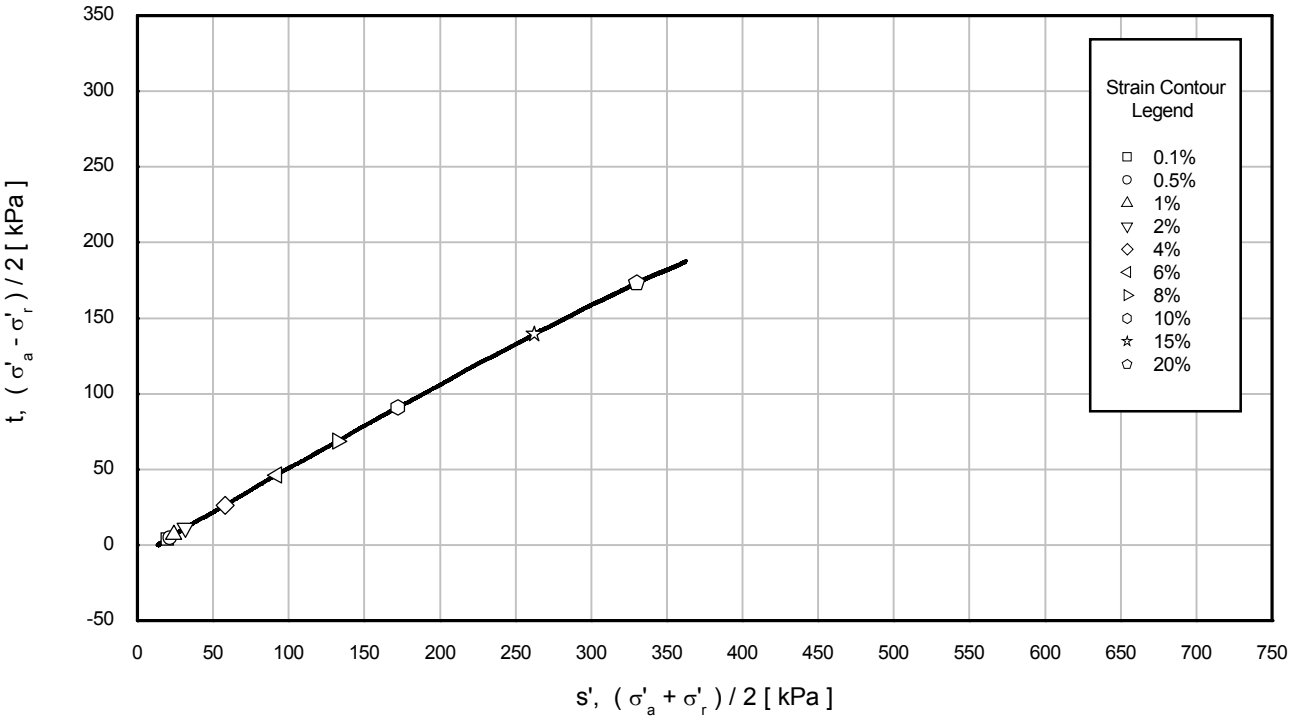


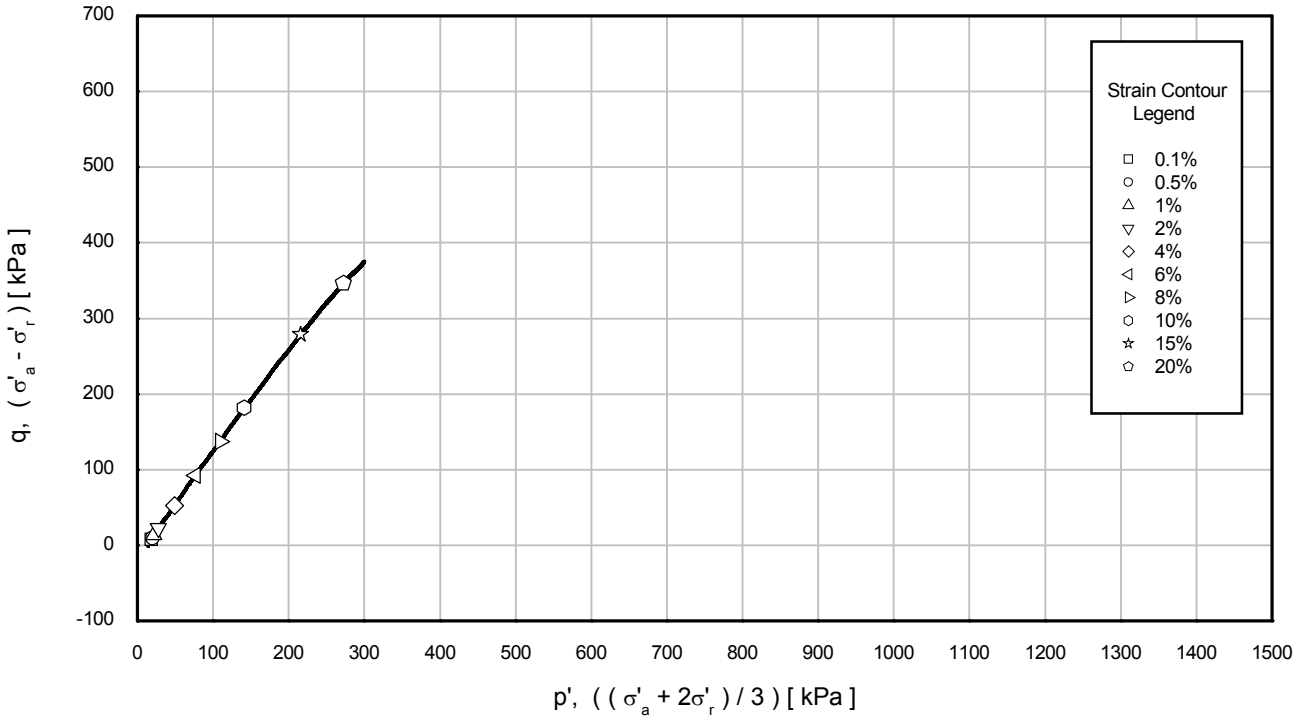


Initial σ'_r	:	14 kPa	Batch	:	4
Initial σ'_a	:	14 kPa	Sample	:	CTX_4-3
q_{peak}	:	375 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	23.45 %	Test No.	:	CTX19
Rate of strain	:	4.80 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	14	kPa	Batch	: 4
Initial σ'_a	:	14	kPa	Sample	: CTX_4-3
q_{peak}	:	375	kPa	Unit	: E5b (Tongeren)
Ext. ε at q_{peak}	:	23.45	%	Test No.	: CTX19
Rate of strain	:	4.80	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	05/02/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	9.5
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.638
Degree of saturation	[%]	39
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 4_CTX-4-4_CTX20
Processed by Date	RN 09/02/2016
Checked by Date	PH 16/02/2016
Approved by Date	PH 16/02/2016

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-4
Unit	E5b (Tongeren)
Test number	CTX20

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1086
Mid height PWP	[kPa]	-
B value achieved	[-]	0.99

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1486
Back pressure	[kPa]	1086
Base PWP	[kPa]	1086
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	400
Effective axial pressure	[kPa]	400
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.95
External axial strain	[%]	0.86
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.67
Void ratio	[-]	0.590
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-4
Unit	E5b (Tongeren)
Test number	CTX20

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	800
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	56
Frequency	[Hz]	0.10
Number of cycles applied (N)	[-]	1500
External ε_{av} at N	[%]	0.24
External ε_{cy} at N	[%]	0.04
Local ε_{av} at N	[%]	-
Local ε_{cy} at N	[%]	-
Δ base PWP at N	[kPa]	183
Δ mid height PWP at N	[kPa]	-
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.67
Void ratio	[-]	0.590
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.03	178.02	-	11.33	-
2	0.00	0.03	184.55	-	10.83	-
5	0.00	0.03	180.51	-	10.99	-
10	0.01	0.03	176.64	-	11.64	-
20	0.02	0.03	169.47	-	13.41	-
30	0.03	0.03	164.72	-	14.69	-
40	0.04	0.03	162.18	-	15.63	-
50	0.05	0.03	159.06	-	16.29	-
100	0.09	0.04	152.61	-	17.42	-
500	0.17	0.04	137.78	-	18.15	-
1000	0.21	0.04	130.91	-	15.79	-
1500	0.24	0.04	125.27	-	13.25	-

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-4
Unit	E5b (Tongeren)
Test number	CTX20

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	215
Initial effective axial pressure	[kPa]	215
Rate of strain	[%/hour]	0.50
At peak deviator stress		
Corrected deviator stress	[kPa]	225
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	5.32
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	290
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	111
Effective axial pressure	[kPa]	336
Principal effective stress ratio	[-]	3.04
ε_{50}	[%]	0.59
Secant modulus (E_{50}) at ε_{50}	[kPa]	31794
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	224
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	5.31
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	290
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	109
Effective axial pressure	[kPa]	334
Principal effective stress ratio	[-]	3.05

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-4
Unit	E5b (Tongeren)
Test number	CTX20

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS

Photograph unavailable

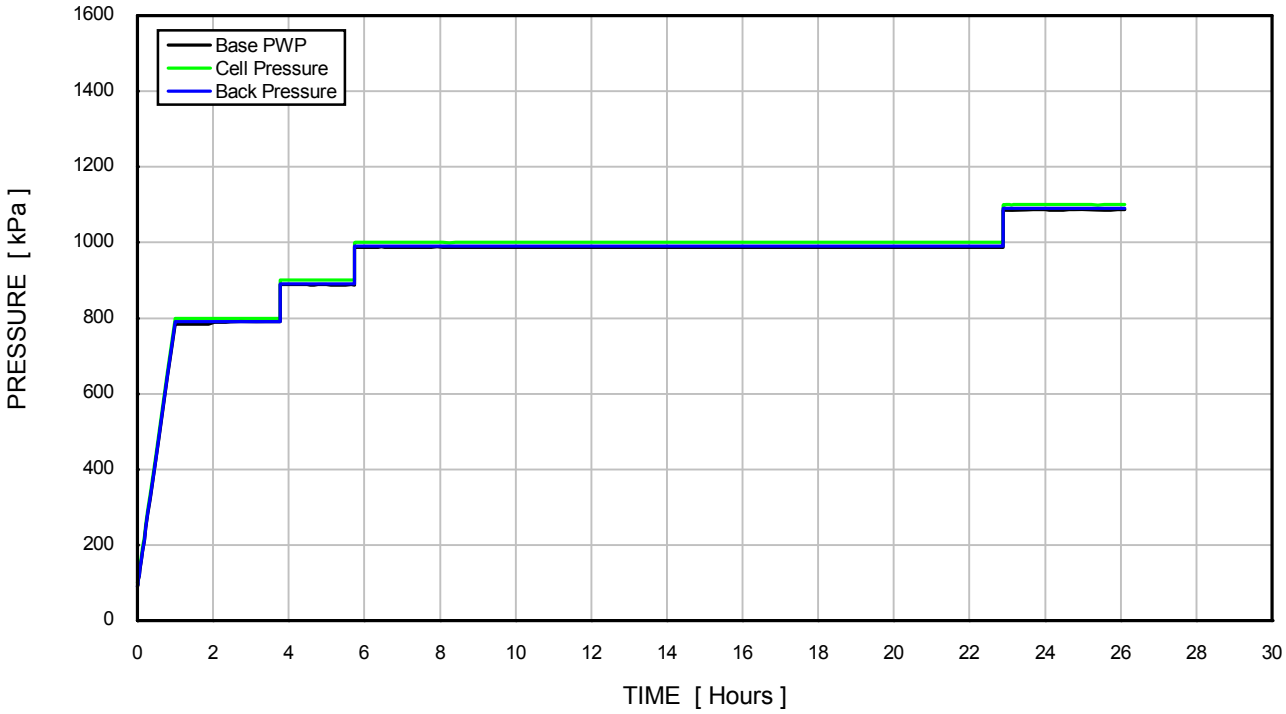
Photograph unavailable

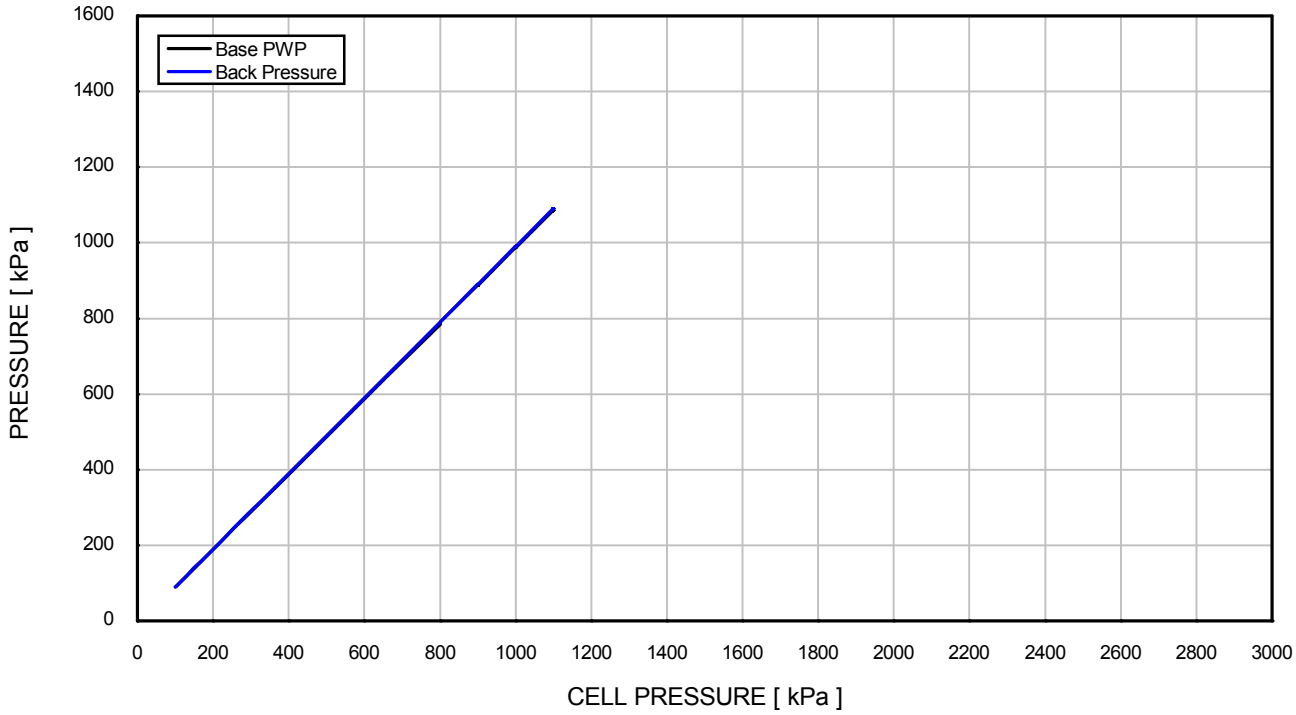
FINAL CONDITIONS		
Moisture content	[%]	22.3
Bulk density	[Mg/m³]	2.04
Dry density	[Mg/m³]	1.67

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-4
Unit	E5b (Tongeren)
Test number	CTX20

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

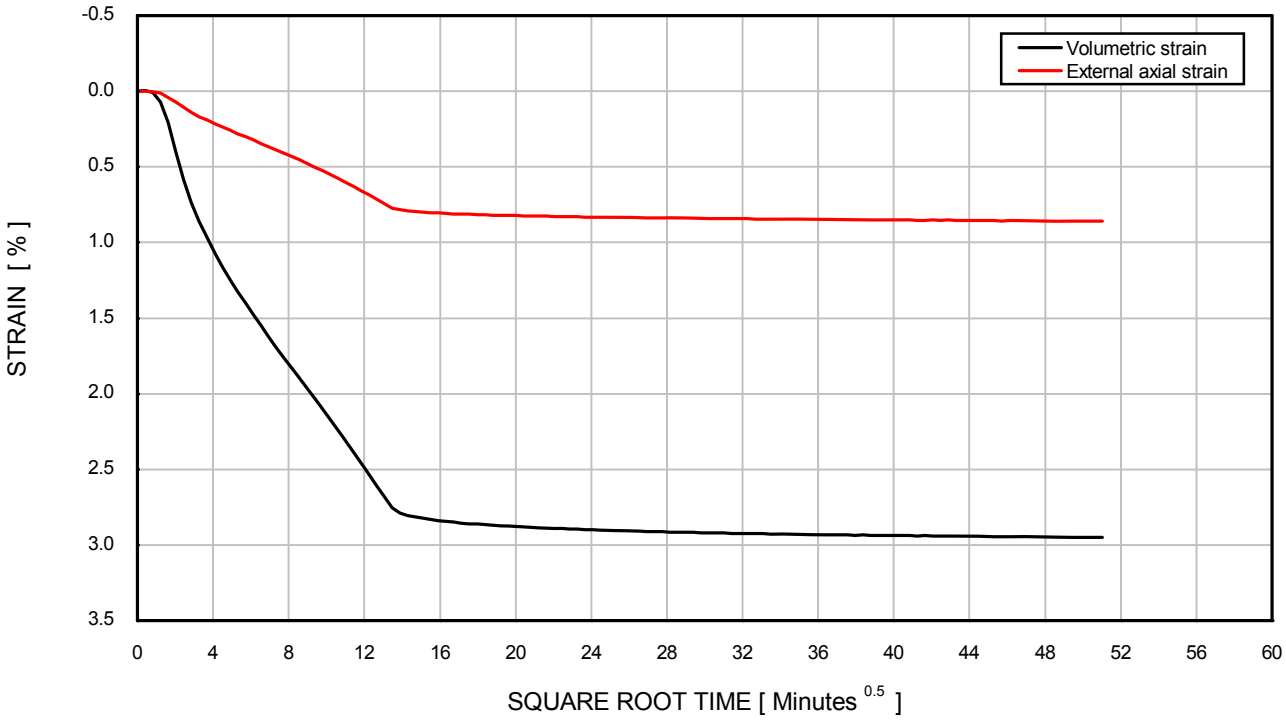


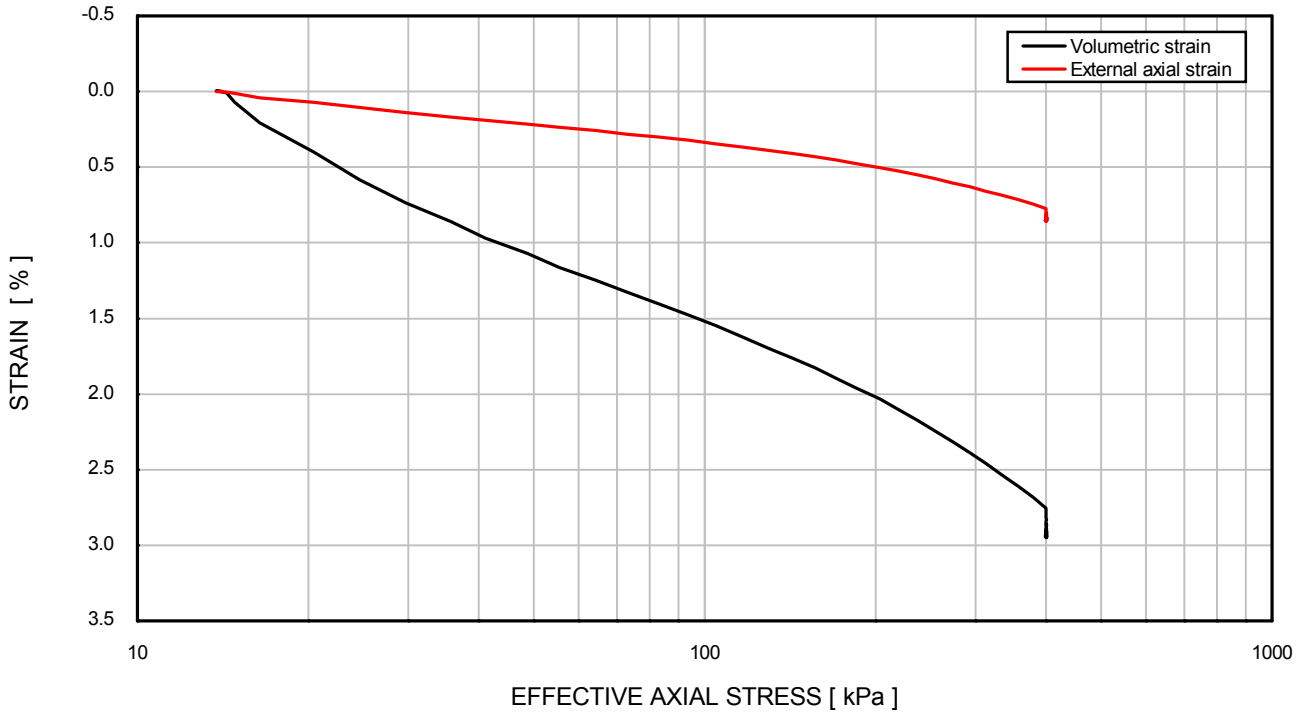


B value	:	0.99			
Initial σ'_r	:	10	kPa	Batch	: 4
Initial σ'_a	:	10	kPa	Sample	: CTX_4-4
Final σ'_r	:	14	kPa	Unit	: E5b (Tongeren)
Final σ'_a	:	14	kPa	Test No.	: CTX20

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

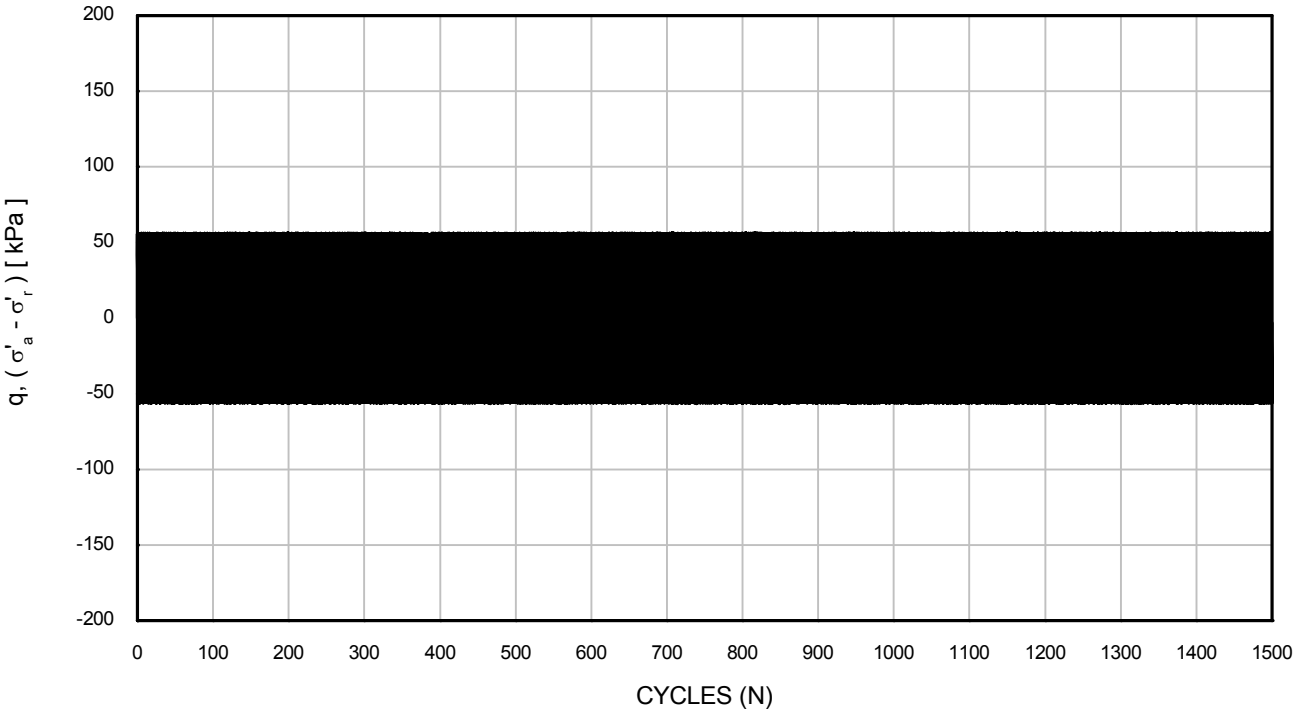


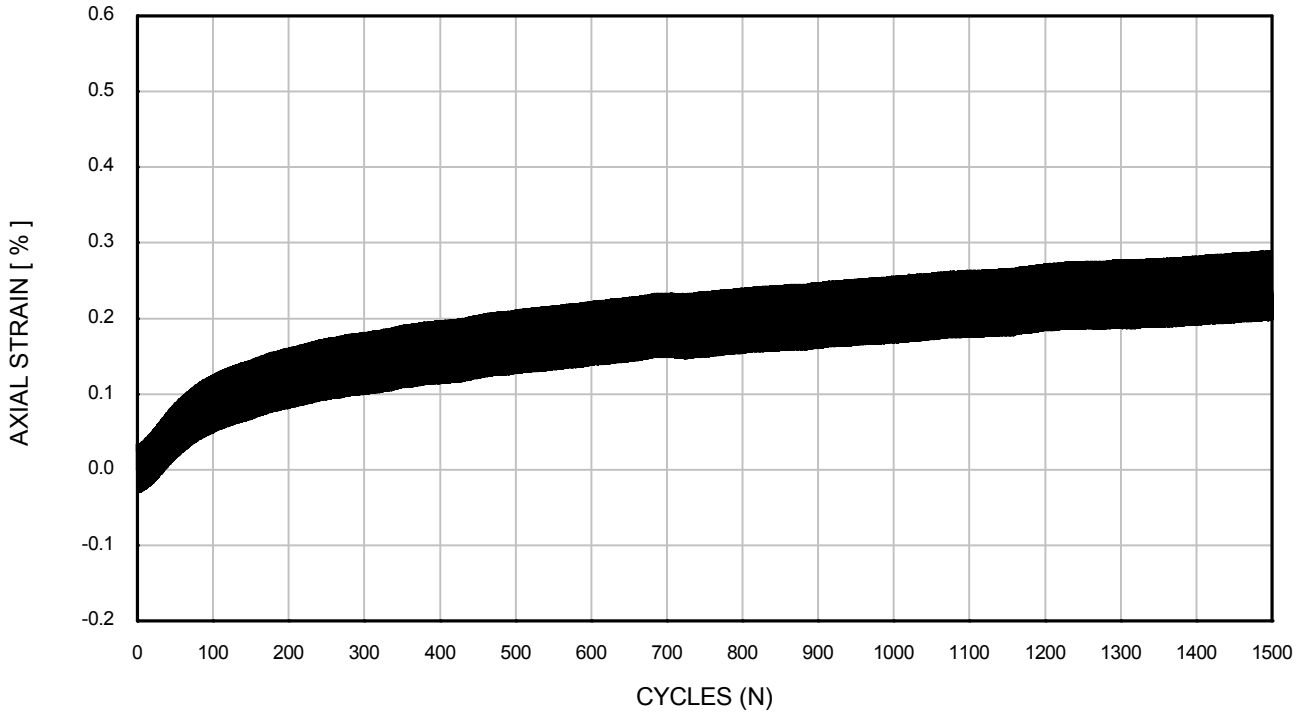


σ'_{rc}	: 400 kPa	Batch	: 4
σ'_{ac}	: 400 kPa	Sample	: CTX_4-4
		Unit	: E5b (Tongeren)
		Test No.	: CTX20

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

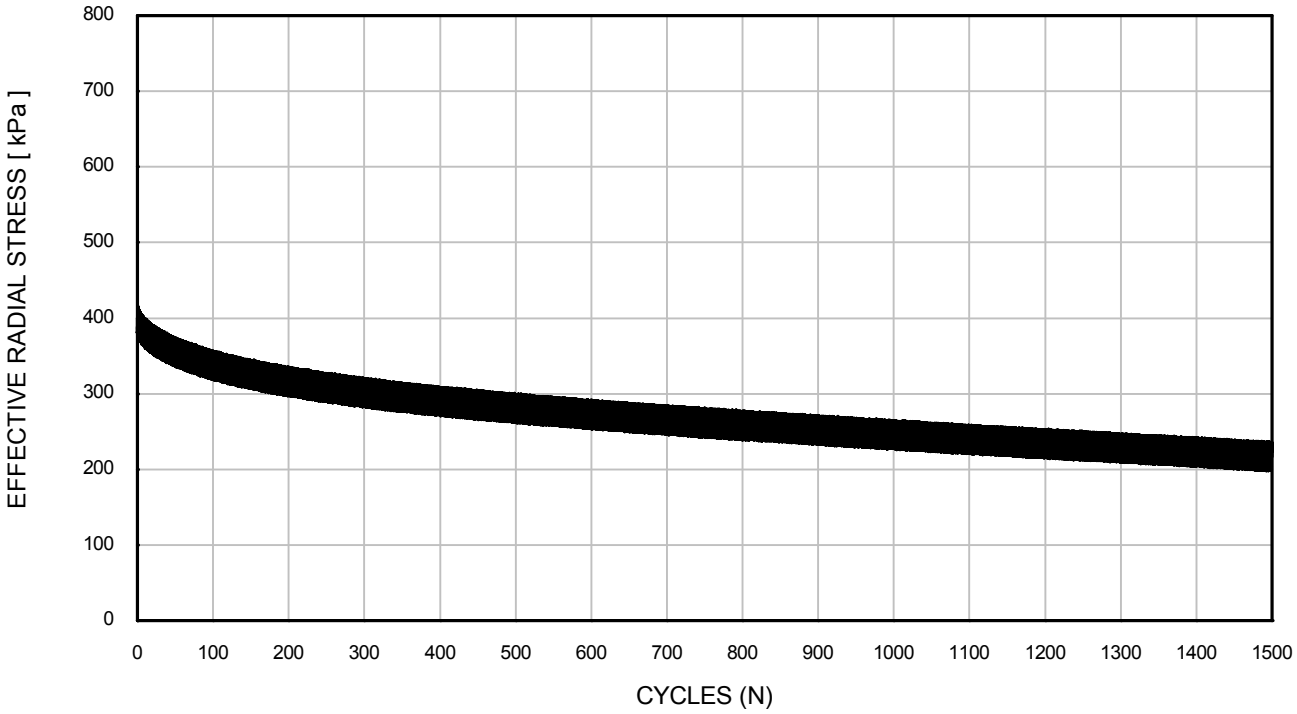


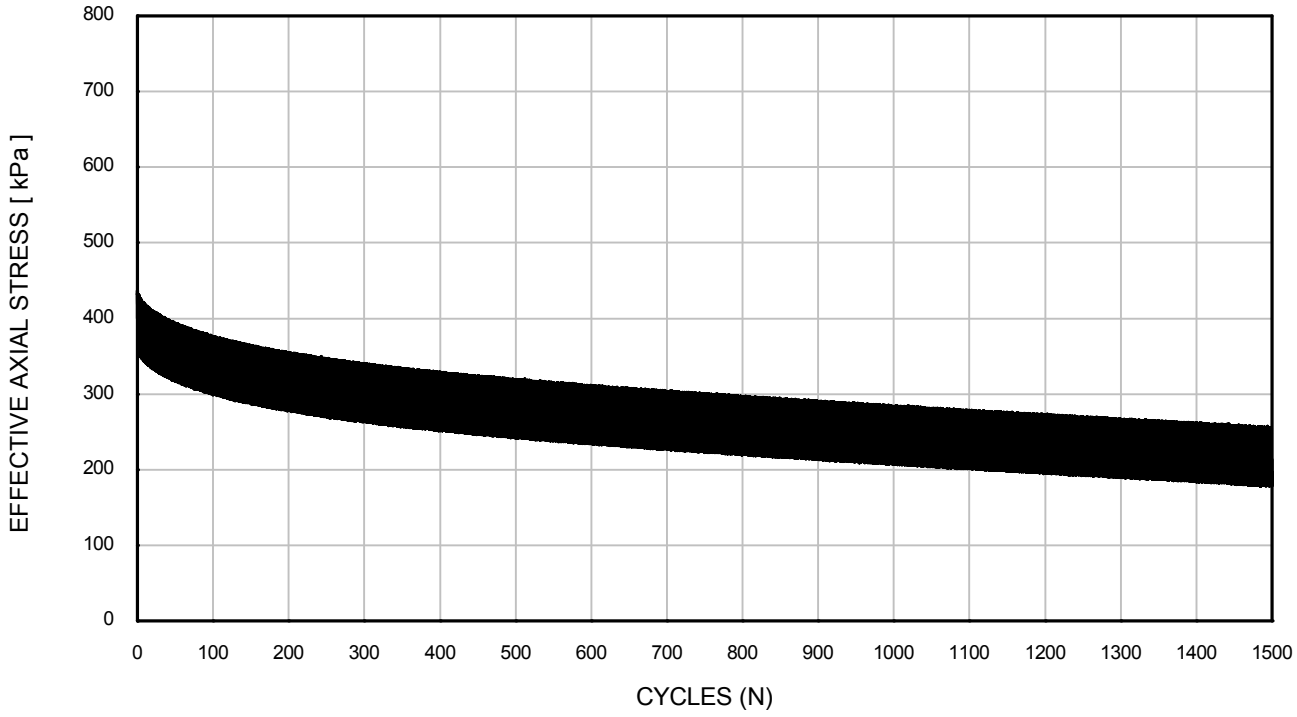


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-4
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	56 kPa	Test No.	:	CTX20
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

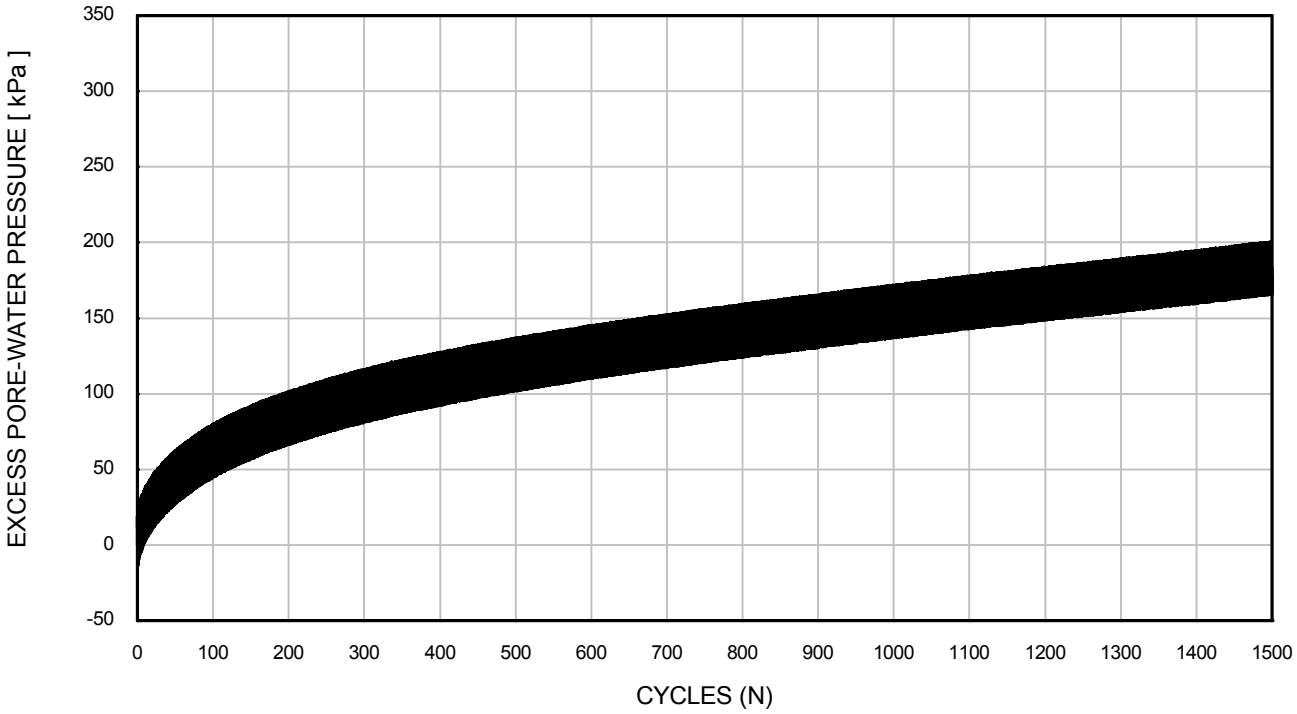


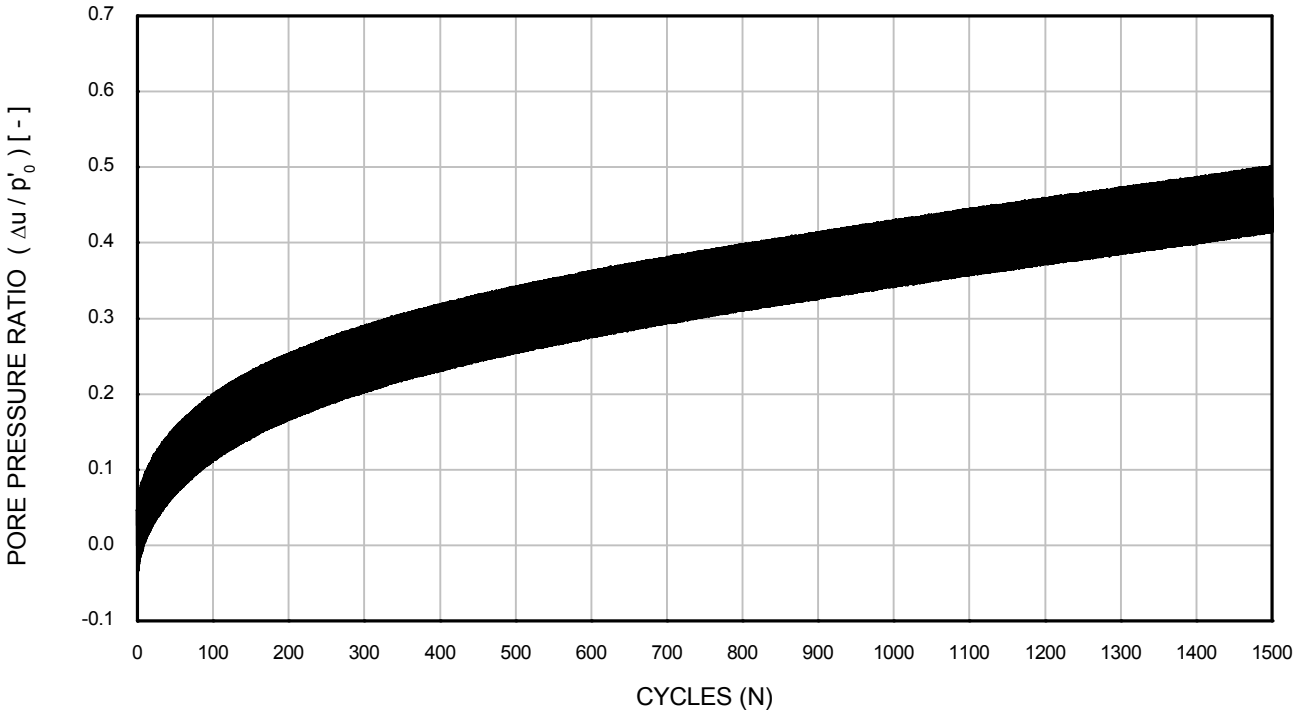


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-4
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	56 kPa	Test No.	:	CTX20
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

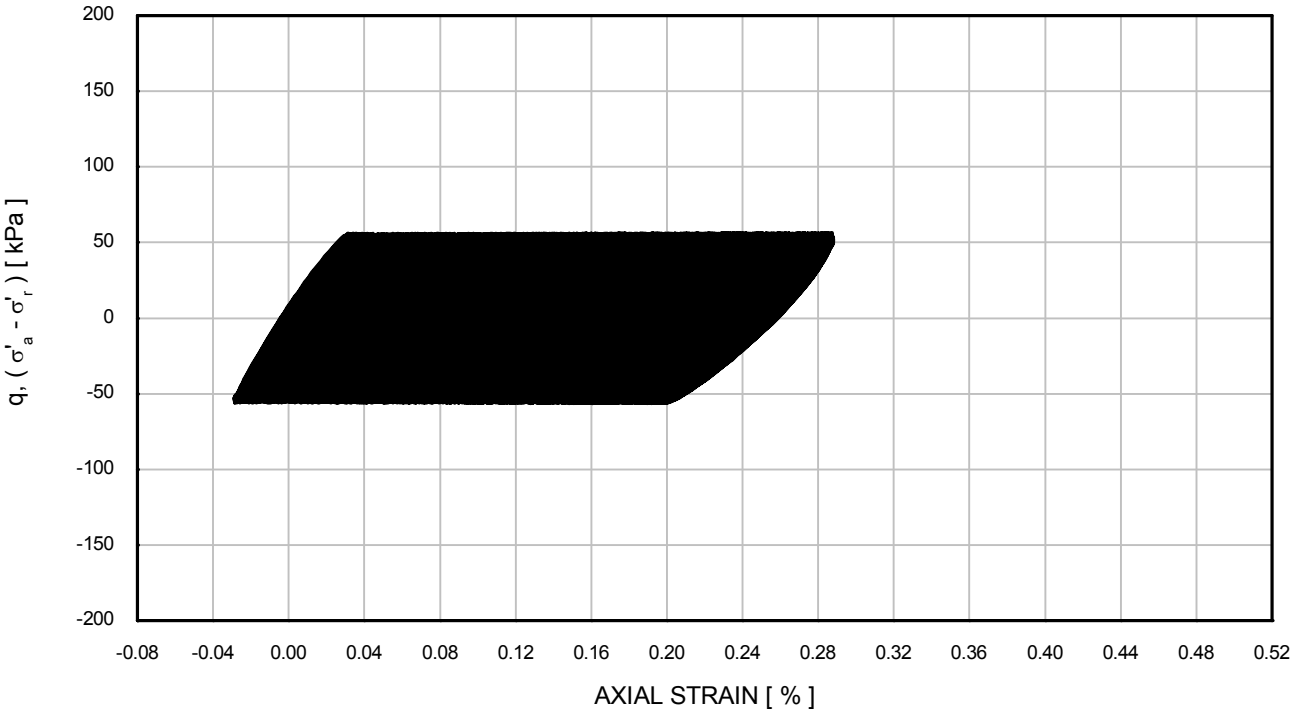


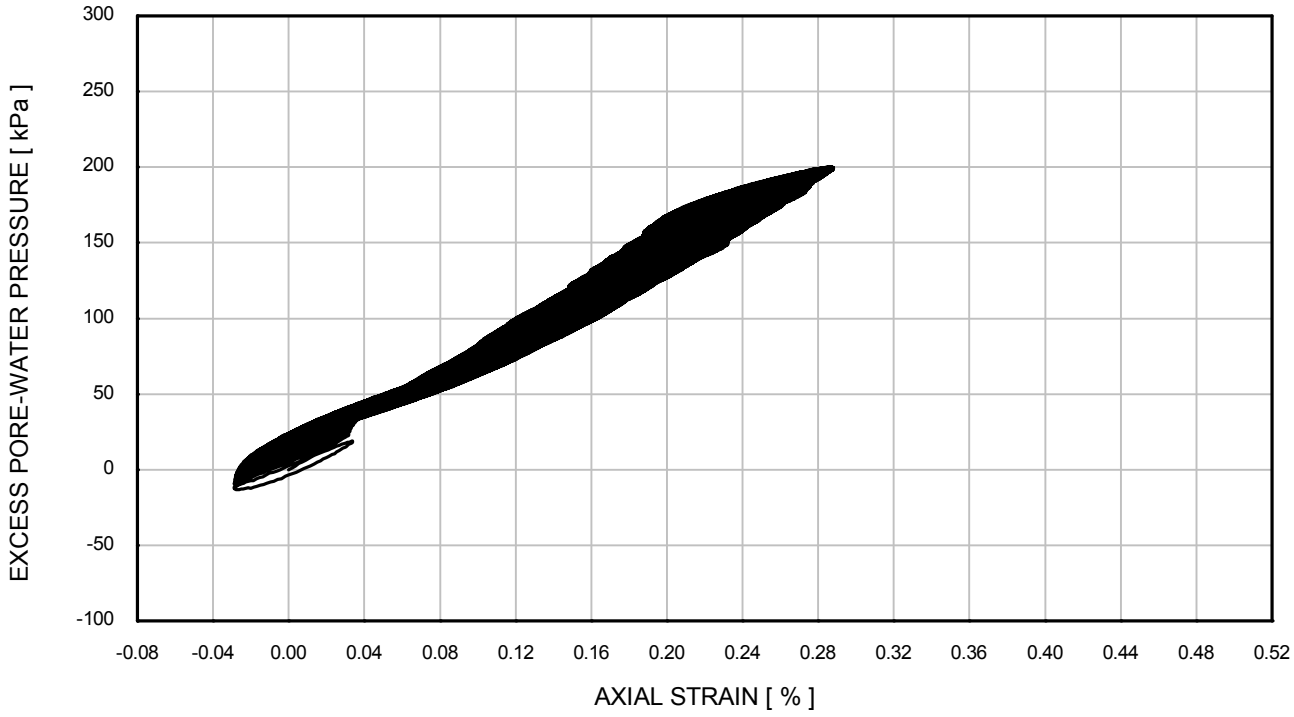


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-4
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	56 kPa	Test No.	:	CTX20
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

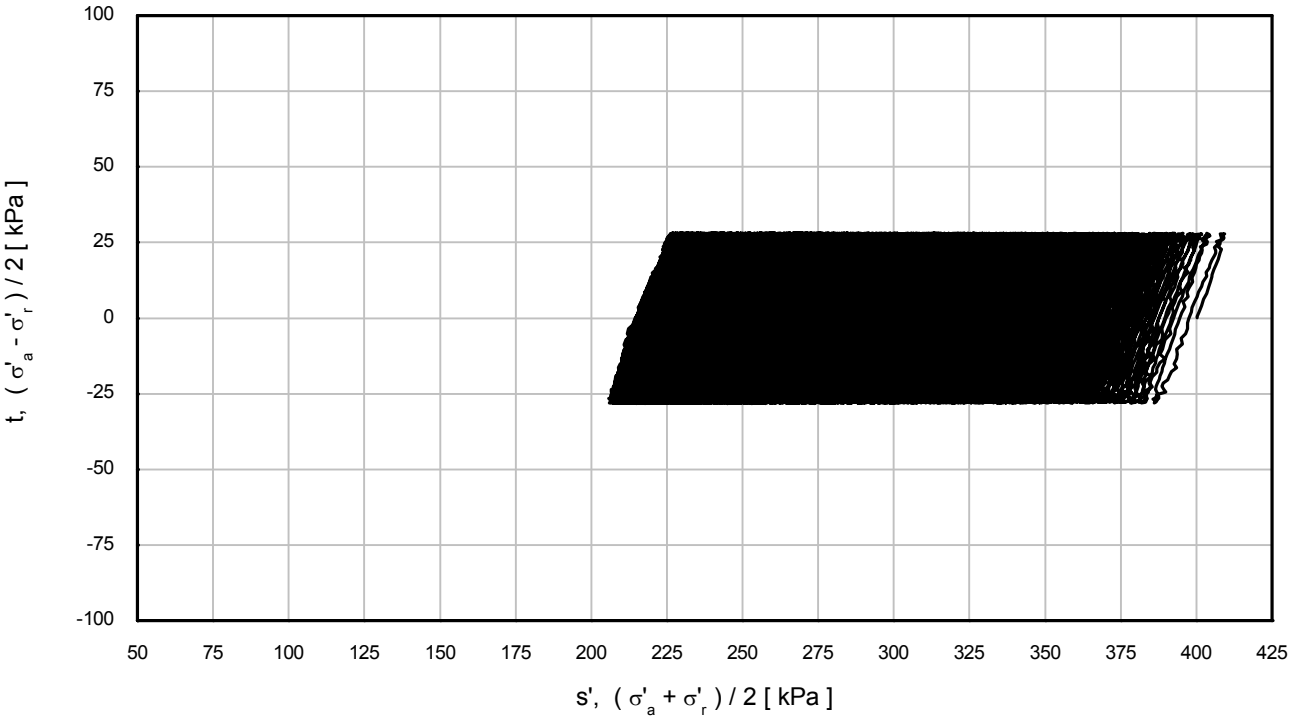


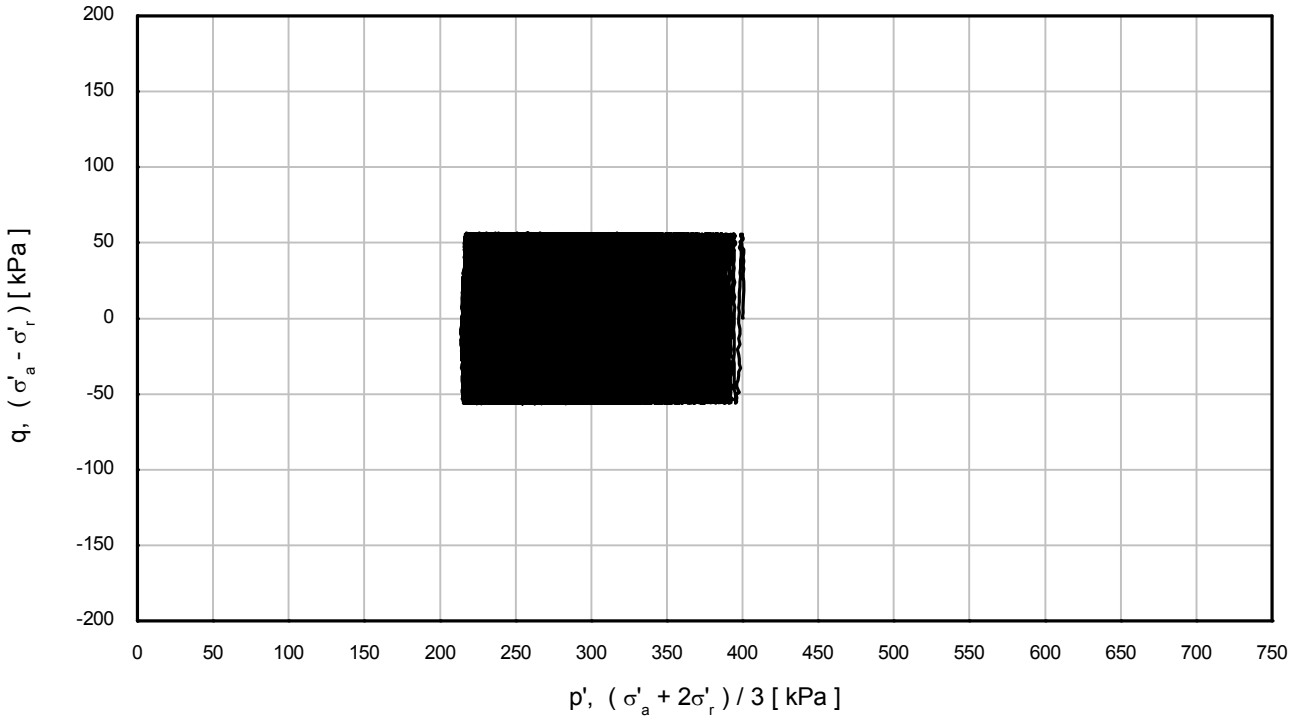


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-4
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	56 kPa	Test No.	:	CTX20
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

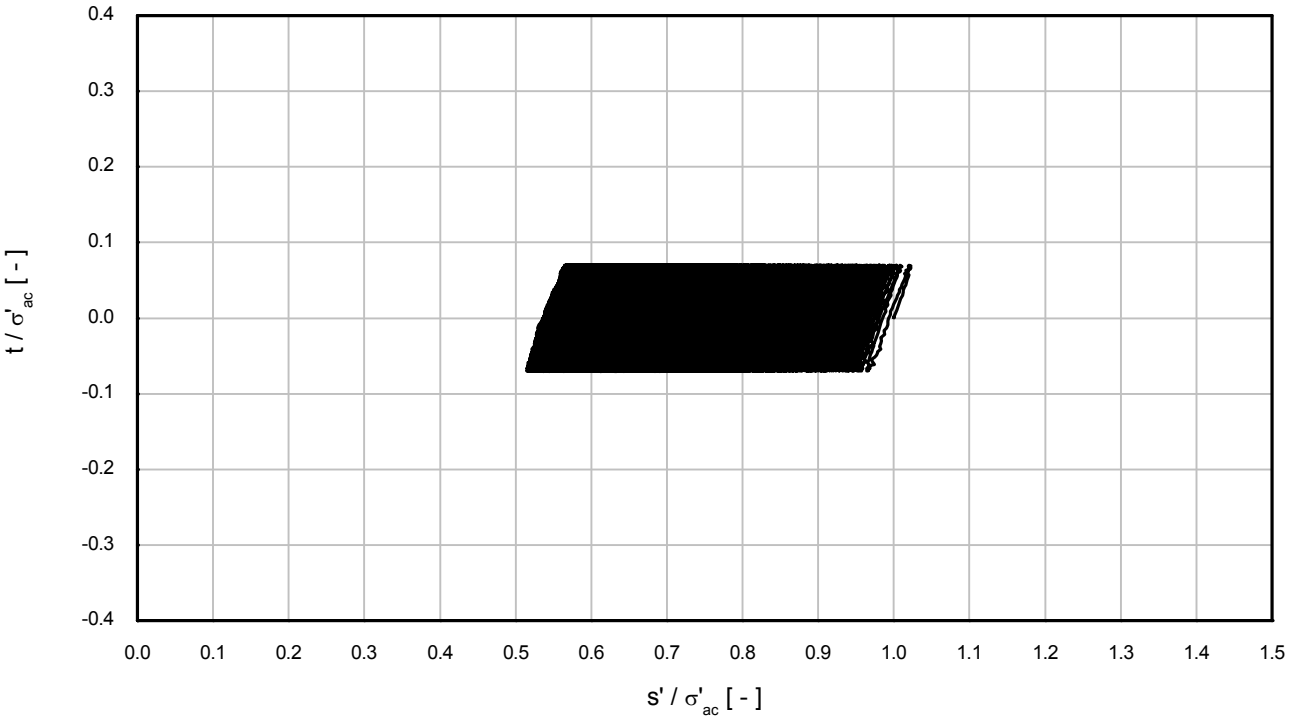


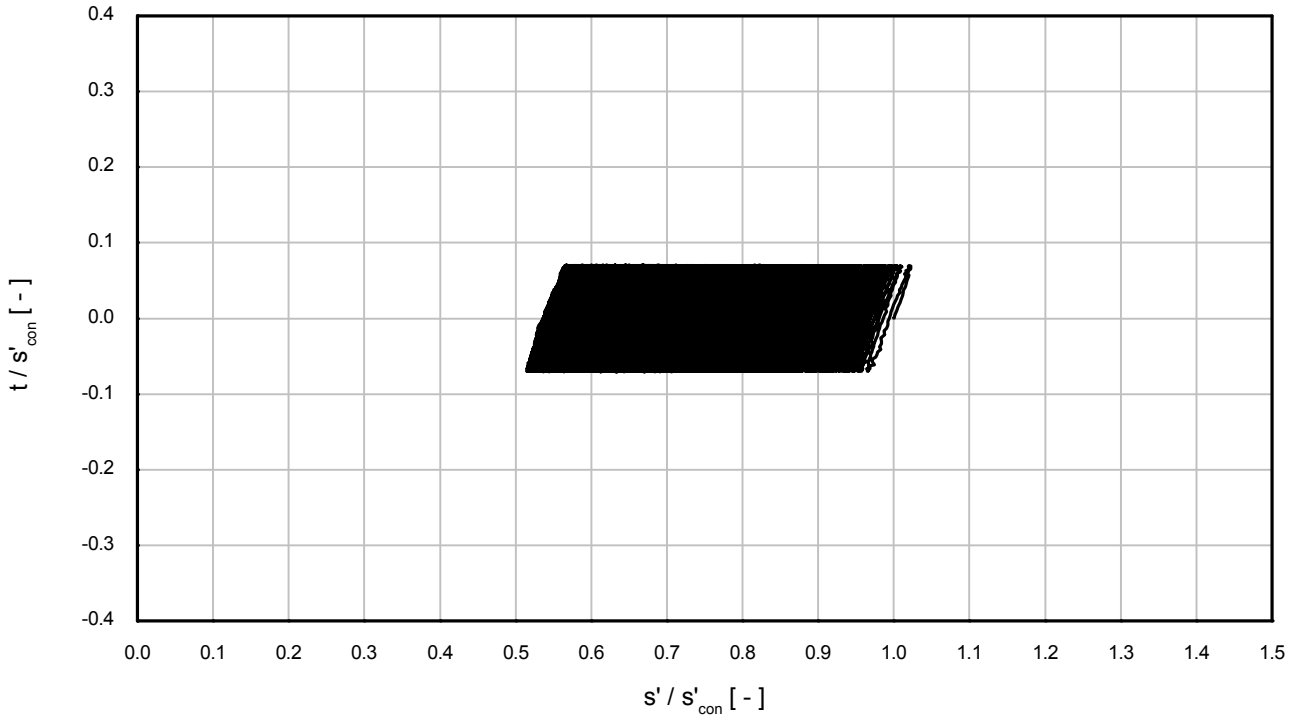


Initial σ'_r	:	400	kPa	Batch	: 4
Initial σ'_a	:	400	kPa	Sample	: CTX_4-4
q_{av}	:	0	kPa	Unit	: E5b (Tongeren)
q_{cy}	:	56	kPa	Test No.	: CTX20
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

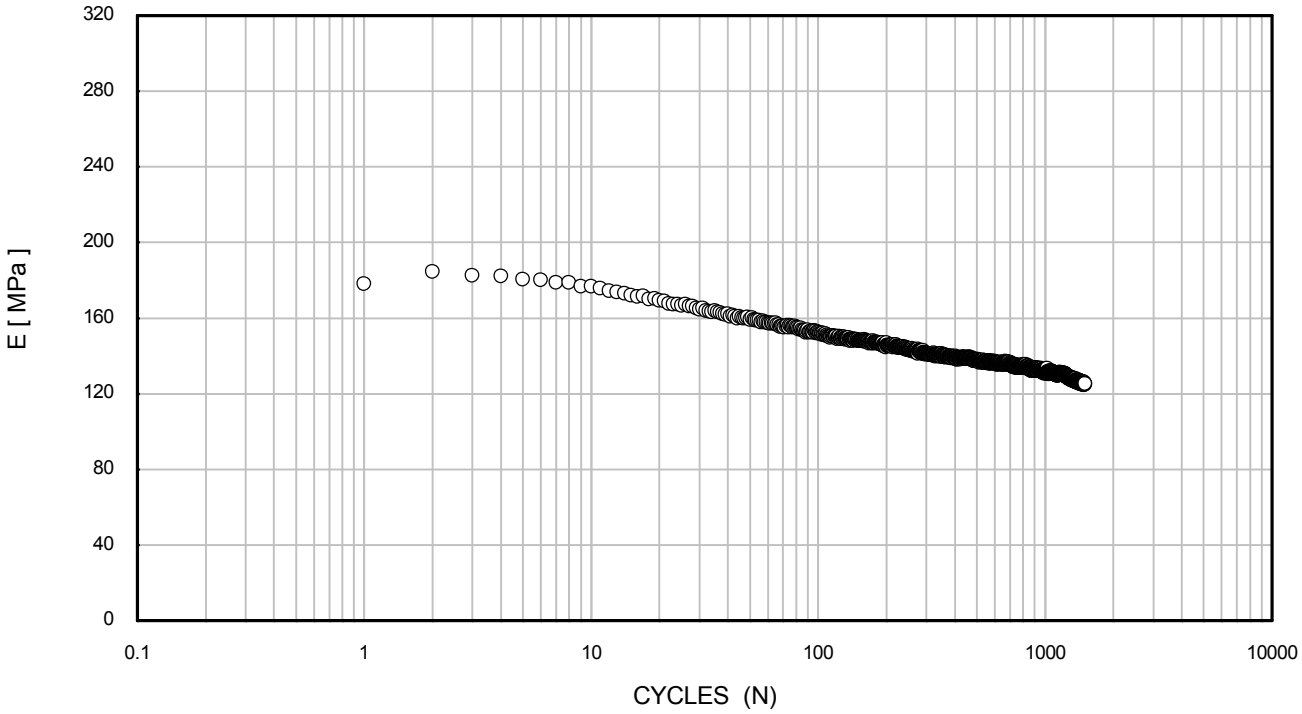


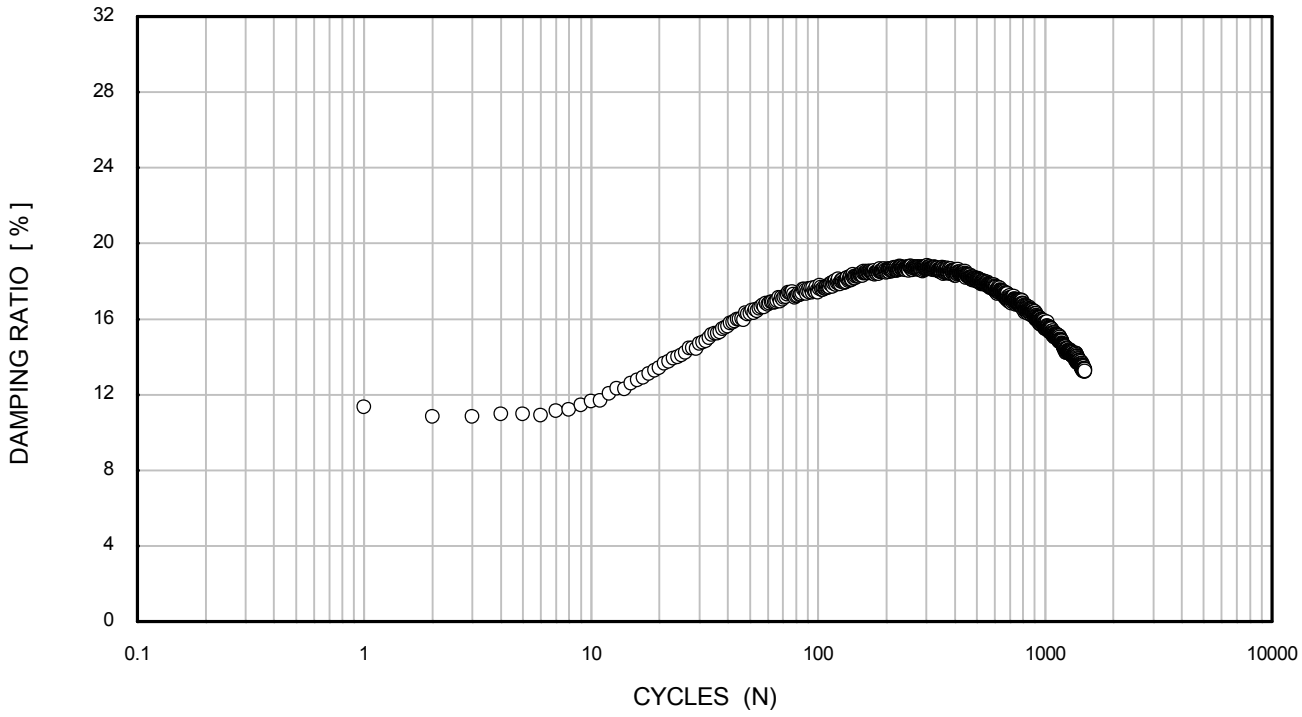


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-4
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	56 kPa	Test No.	:	CTX20
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

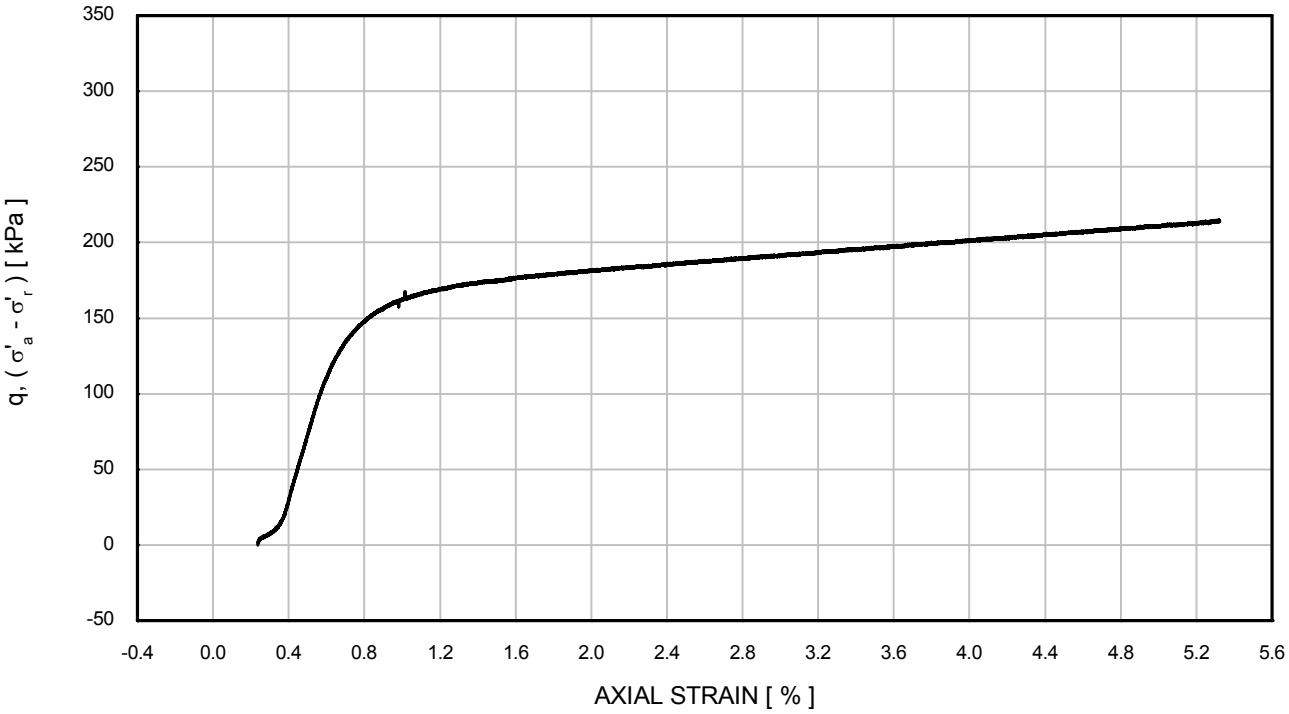


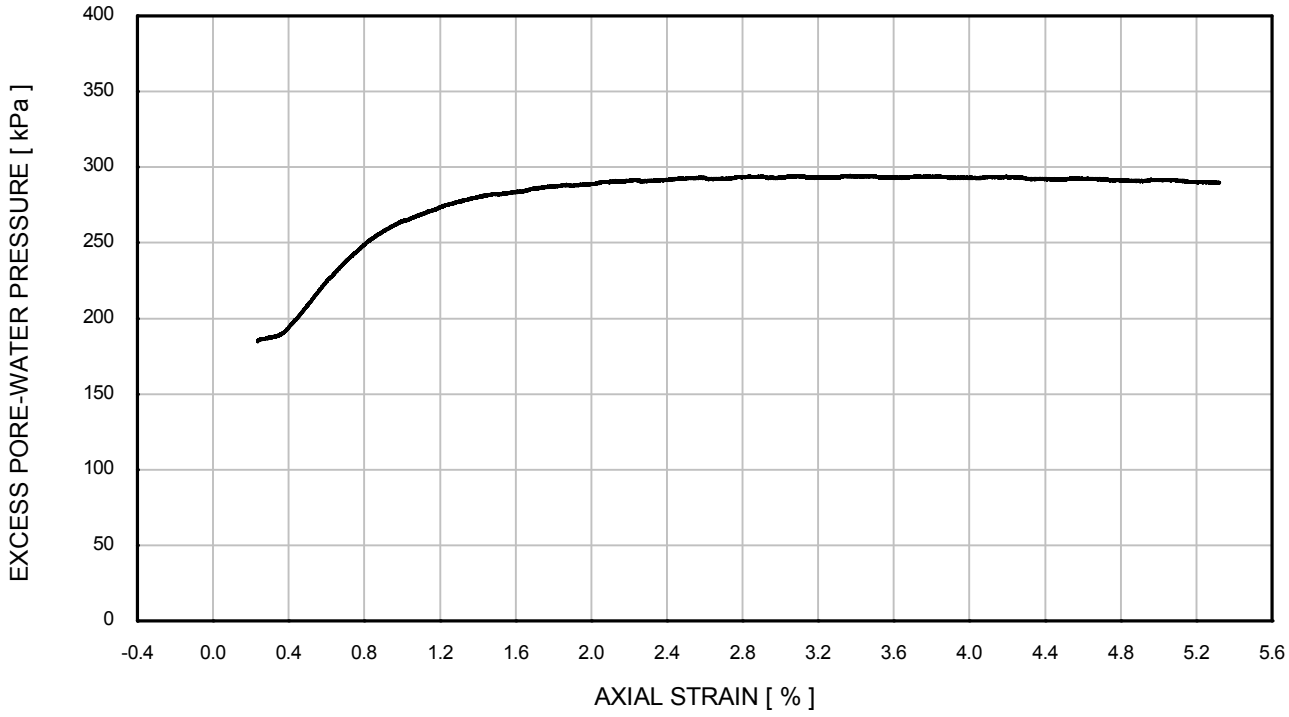


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-4
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	56 kPa	Test No.	:	CTX20
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

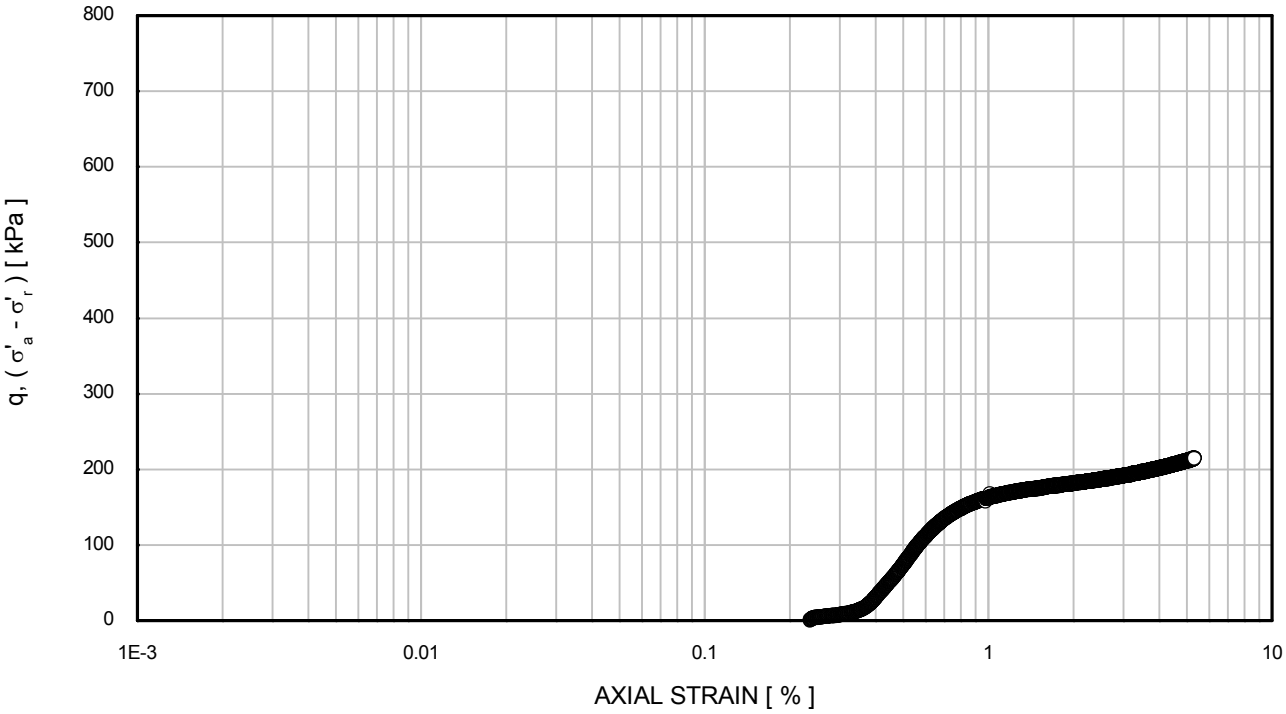


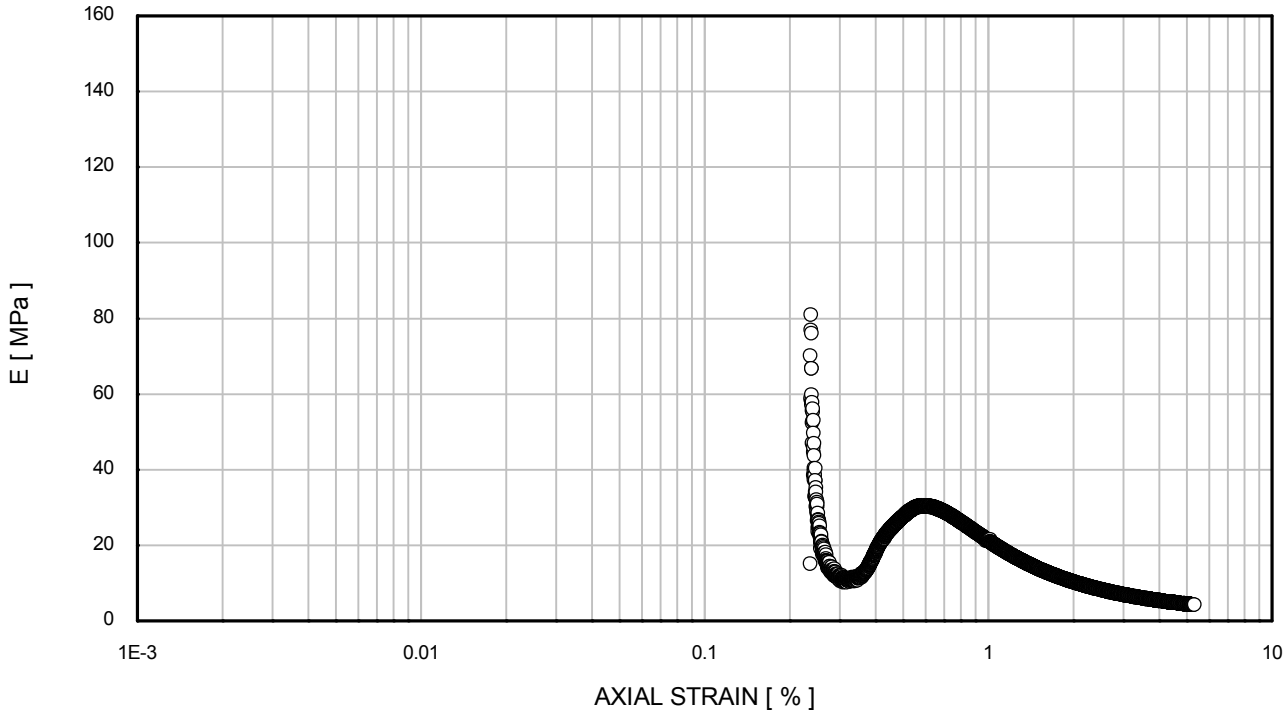


Initial σ'_r	:	215 kPa	Batch	:	4
Initial σ'_a	:	215 kPa	Sample	:	CTX_4-4
q_{peak}	:	215 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	5.32 %	Test No.	:	CTX20
Rate of strain	:	0.50 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

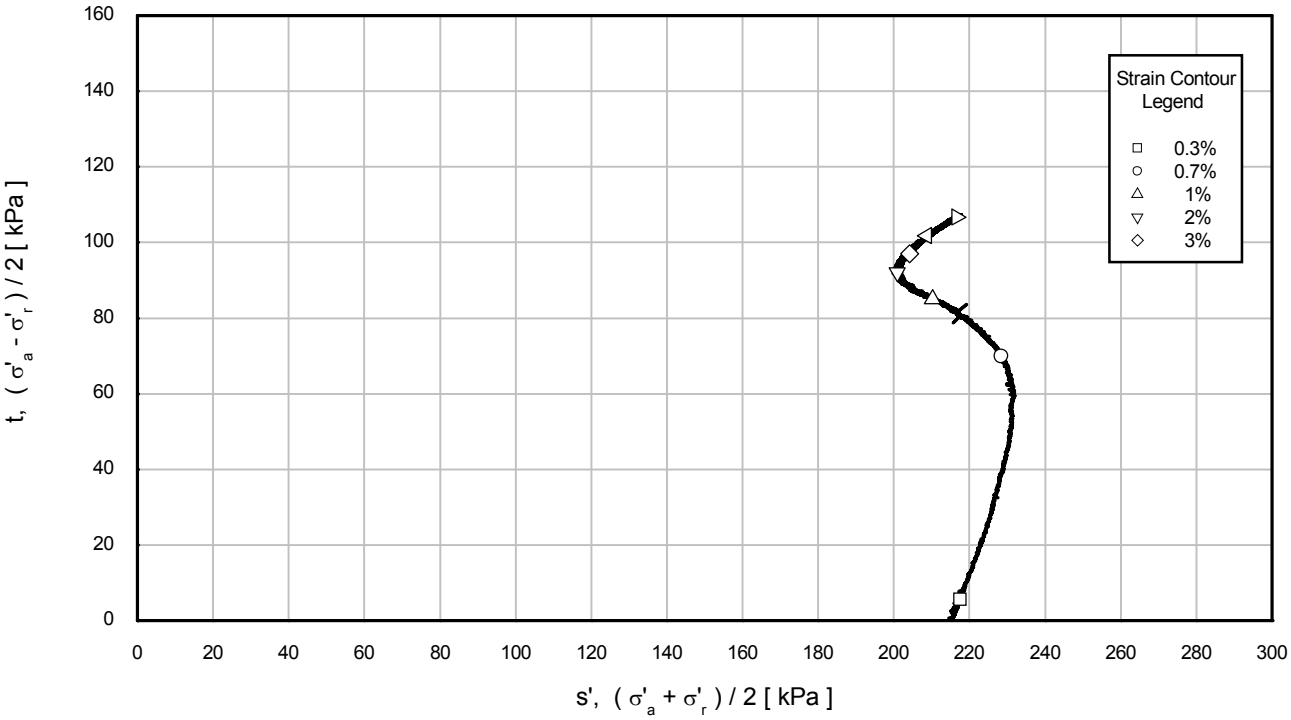


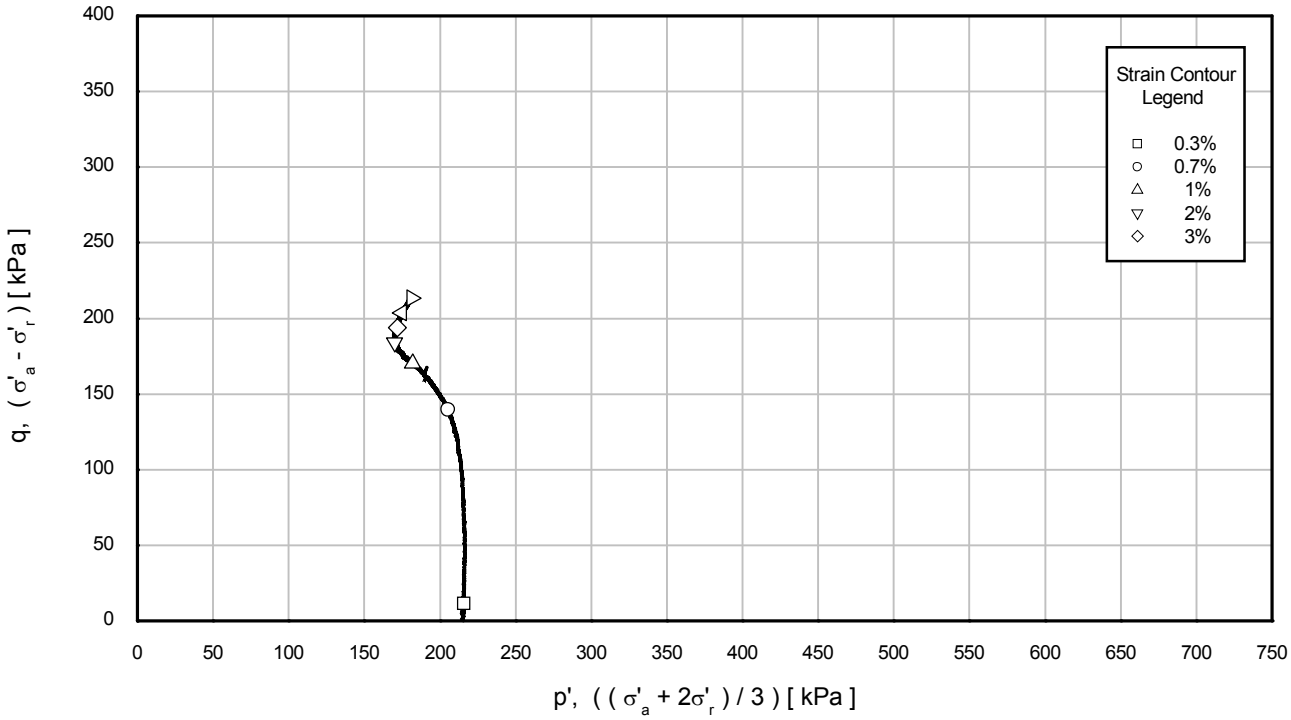


Initial σ'_r	:	215 kPa	Batch	:	4
Initial σ'_a	:	215 kPa	Sample	:	CTX_4-4
q_{peak}	:	215 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	5.32 %	Test No.	:	CTX20
Rate of strain	:	0.50 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	215 kPa	Batch	:	4
Initial σ'_a	:	215 kPa	Sample	:	CTX_4-4
q_{peak}	:	215 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	5.32 %	Test No.	:	CTX20
Rate of strain	:	0.50 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	11/02/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.1
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.644
Degree of saturation	[%]	42
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 4_CTX-4-5_CTX21
Processed by Date	HJ 22/02/2016
Checked by Date	PH 15/03/2016
Approved by Date	PH 15/03/2016

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1079
Mid height PWP	[kPa]	-
B value achieved	[-]	0.96

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1479
Back pressure	[kPa]	1079
Base PWP	[kPa]	1079
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	400
Effective axial pressure	[kPa]	400
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.45
External axial strain	[%]	0.85
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	22.8
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.604
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (Deviator)	[kPa]	800
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	122
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	4
External ε_{av} at N_f	[%]	-0.10
External ε_{cy} at N_f	[%]	0.15
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	160
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	22.8
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.604
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-0.02	0.10	127.74	-	15.30	-
2	-0.04	0.09	128.52	-	14.65	-
3	-0.06	0.11	110.87	-	15.73	-
4	-0.10	0.15	82.60	-	18.44	-

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	12
Initial effective axial pressure	[kPa]	13
Rate of strain	[%/hour]	0.49
At peak deviator stress		
Corrected deviator stress	[kPa]	265
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	16.17
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	287
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	113
Effective axial pressure	[kPa]	378
Principal effective stress ratio	[-]	3.34
ε_{50}	[%]	6.26
Secant modulus (E_{50}) at ε_{50}	[kPa]	929
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	14
Membrane correction applied	[kPa]	-1
Drain correction applied	[kPa]	0
External axial strain	[%]	-3.37
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	396
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	3
Effective axial pressure	[kPa]	16
Principal effective stress ratio	[-]	6.26
At 10% external axial strain		
Corrected deviator stress	[kPa]	187
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	10.00
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	325
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	74
Effective axial pressure	[kPa]	261
Principal effective stress ratio	[-]	3.53

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



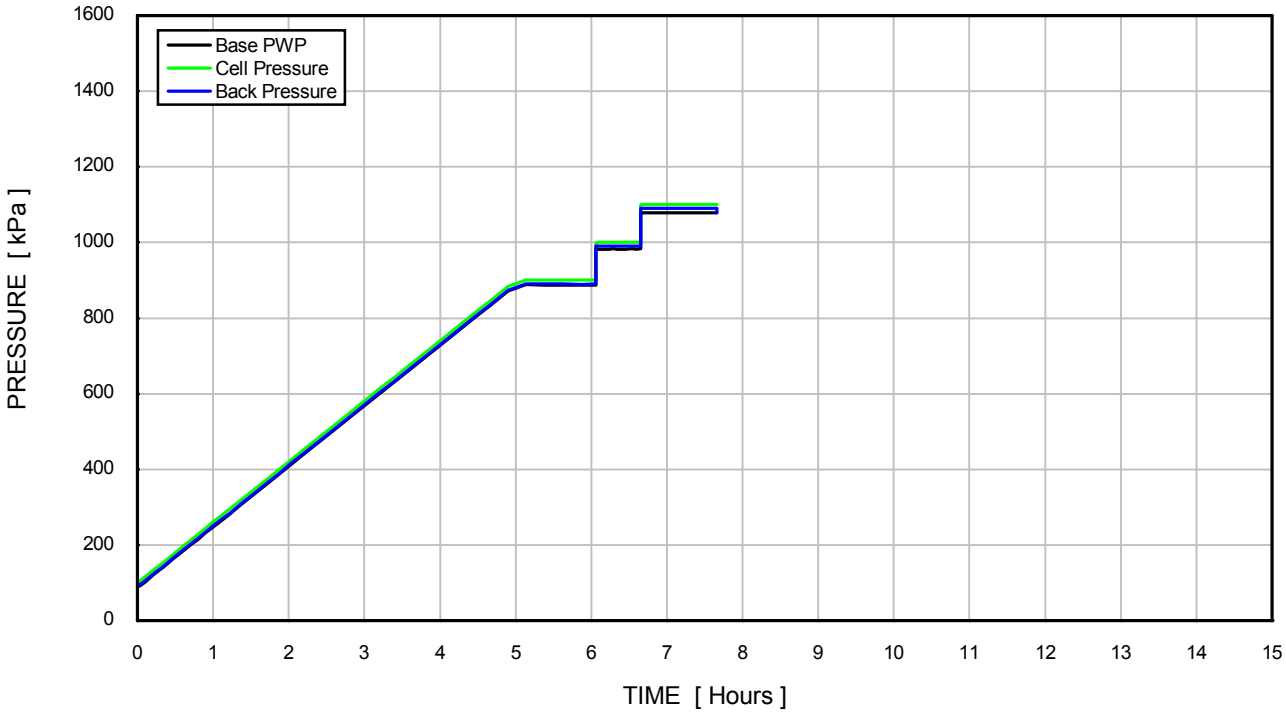


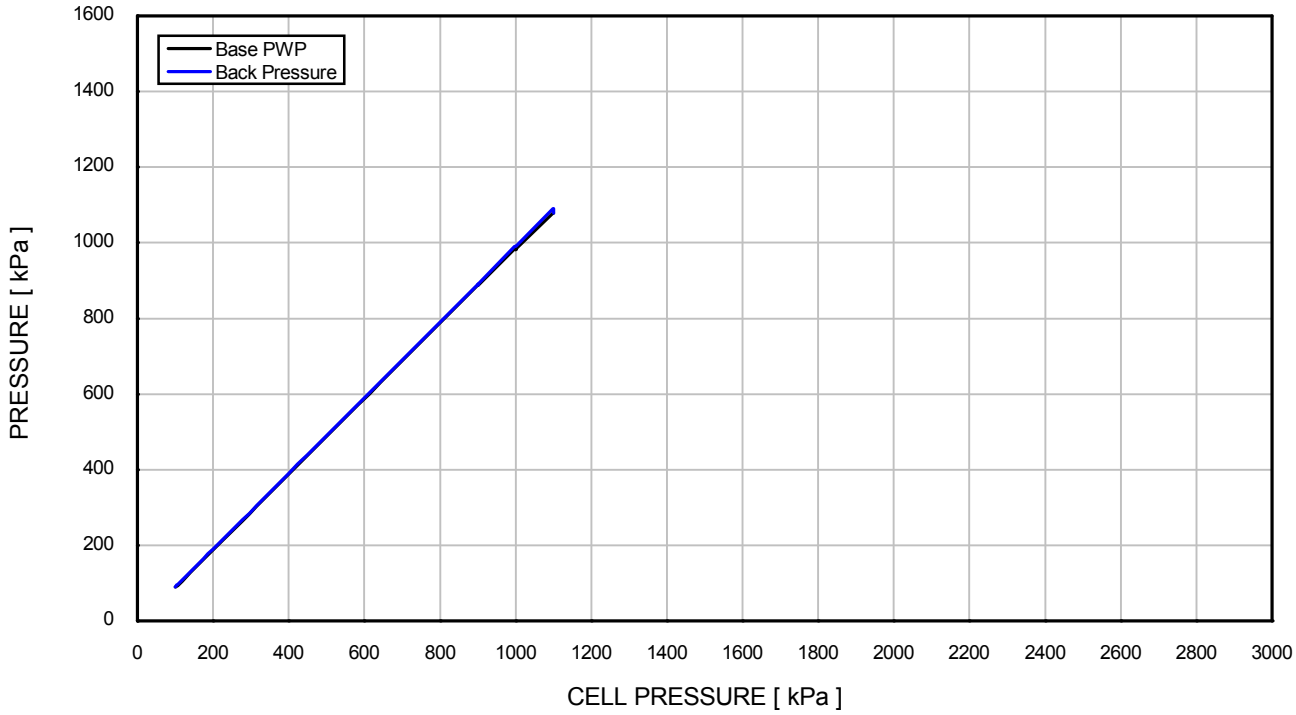
FINAL CONDITIONS		
Moisture content	[%]	22.8
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

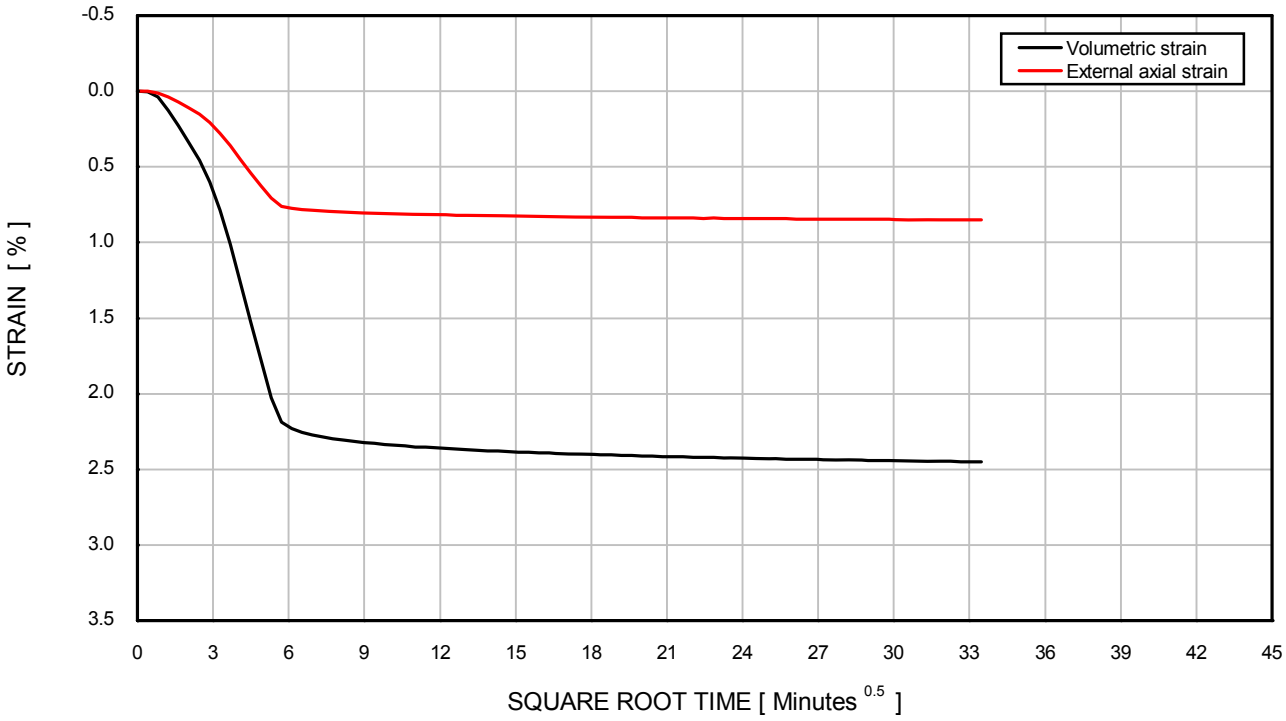


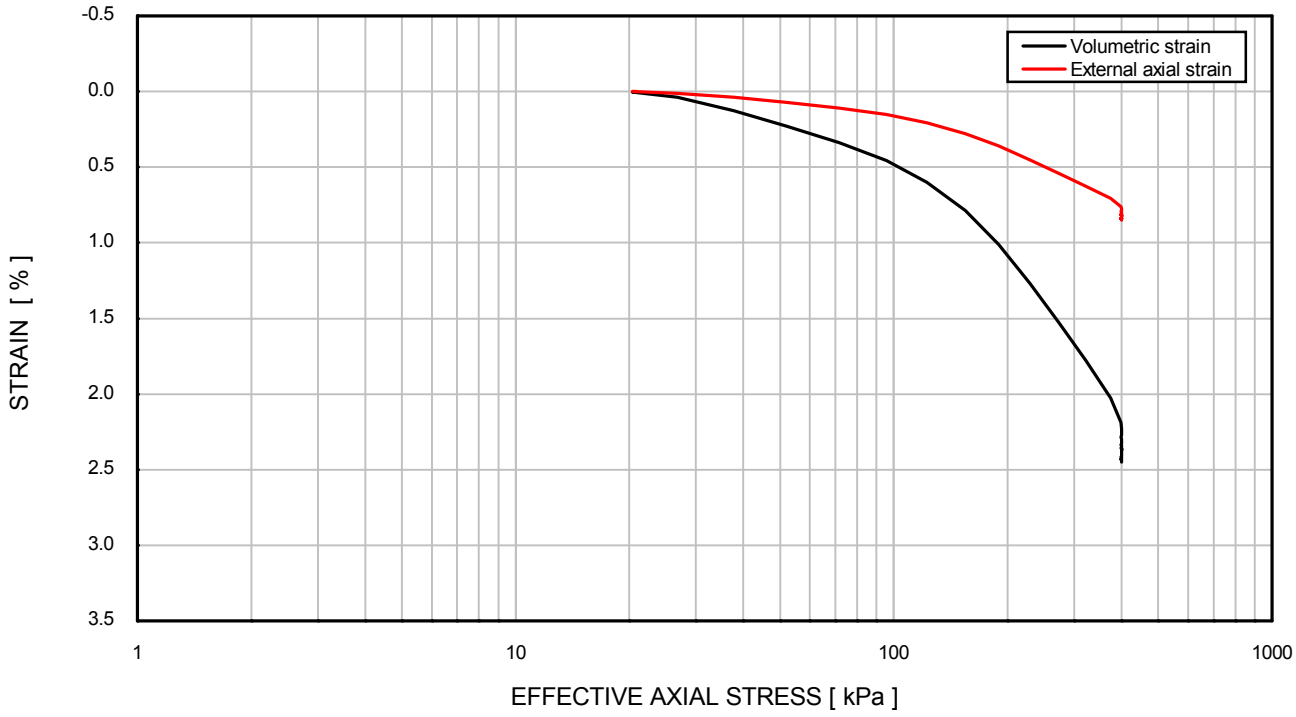


B value	:	0.96			
Initial σ'_r	:	10	kPa	Batch	: 4
Initial σ'_a	:	10	kPa	Sample	: CTX_4-5
Final σ'_r	:	21	kPa	Unit	: E5b (Tongeren)
Final σ'_a	:	21	kPa	Test No.	: CTX21

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

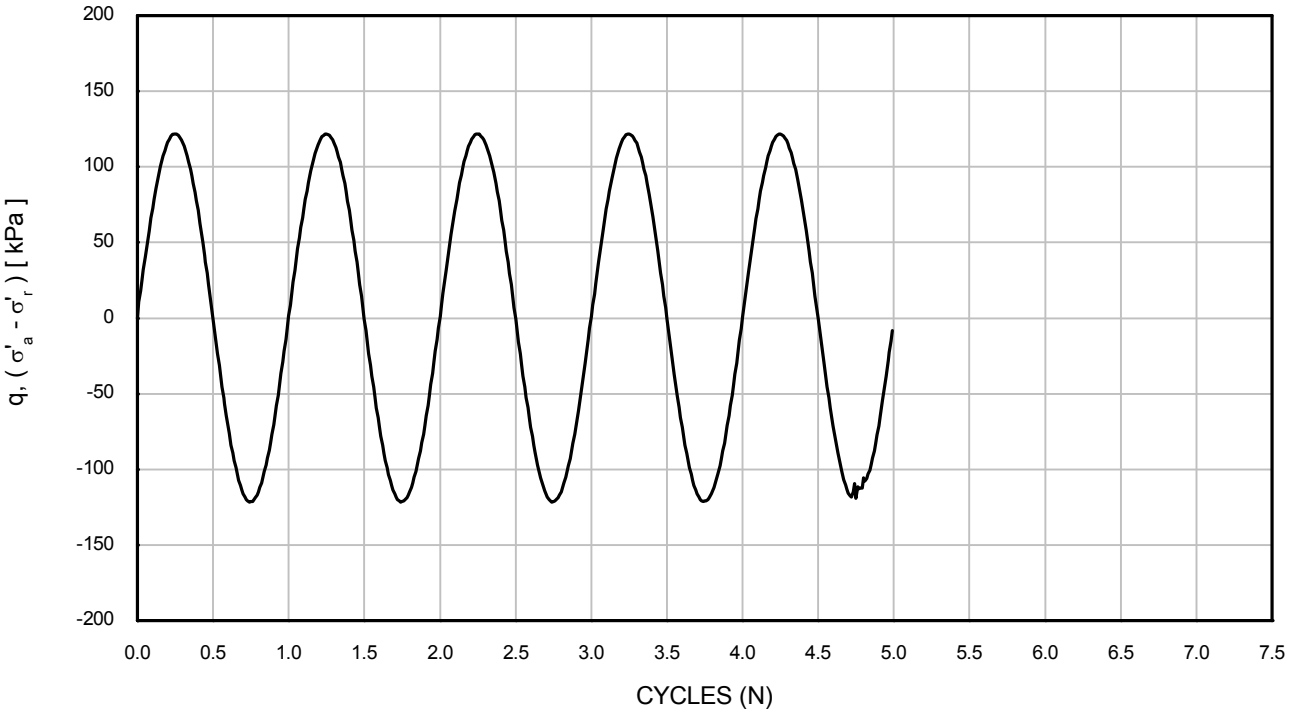


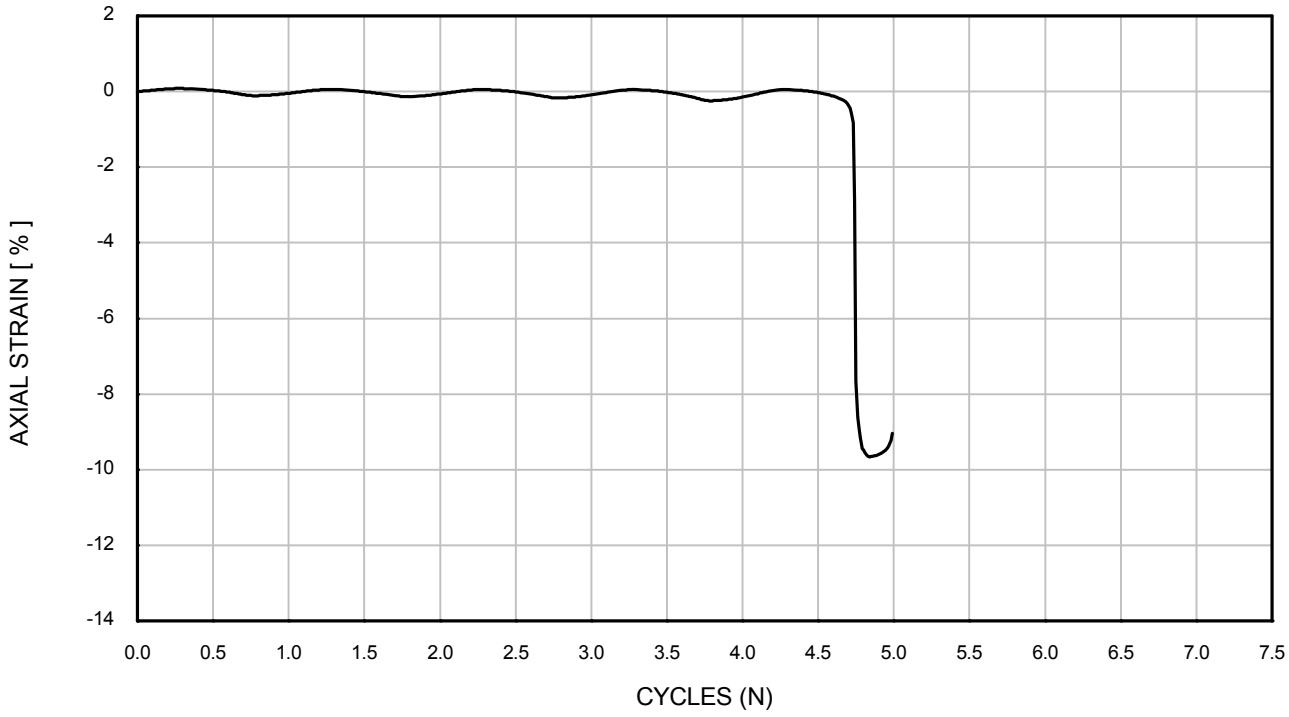


σ'_{rc}	: 400 kPa	Batch	: 4
σ'_{ac}	: 400 kPa	Sample	: CTX_4-5
		Unit	: E5b (Tongeren)
		Test No.	: CTX21

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

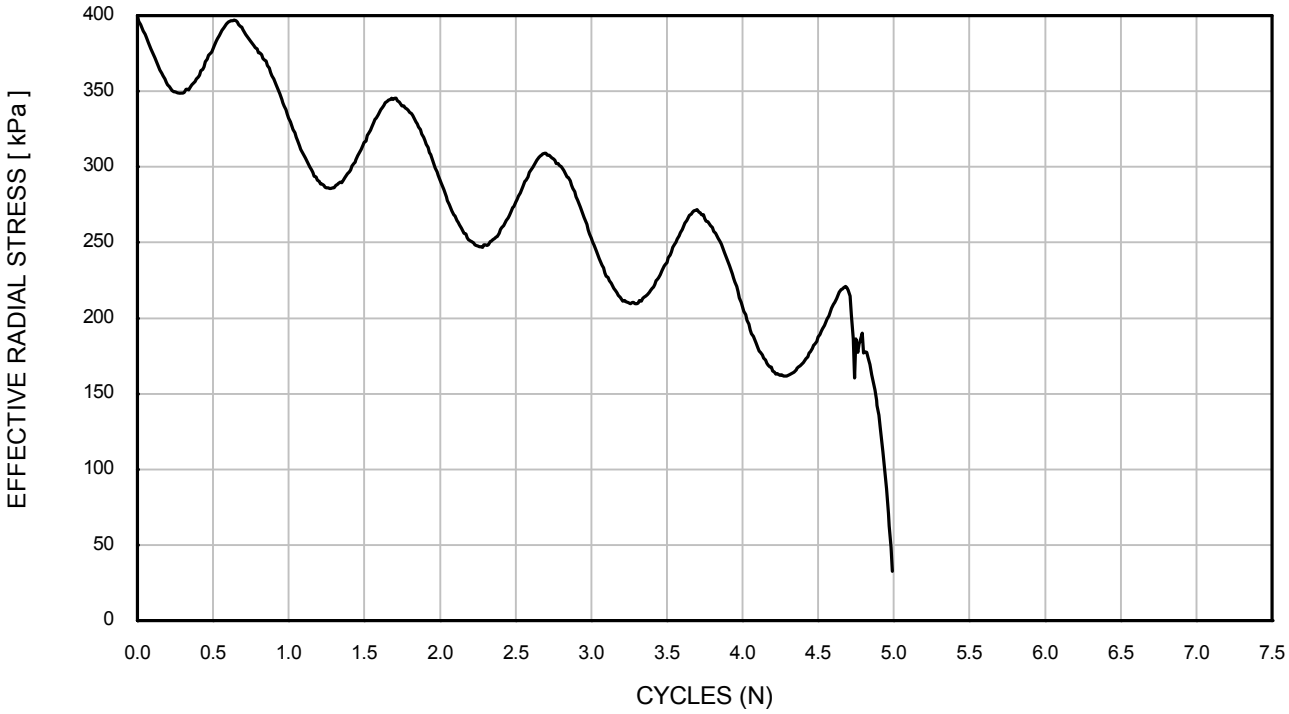


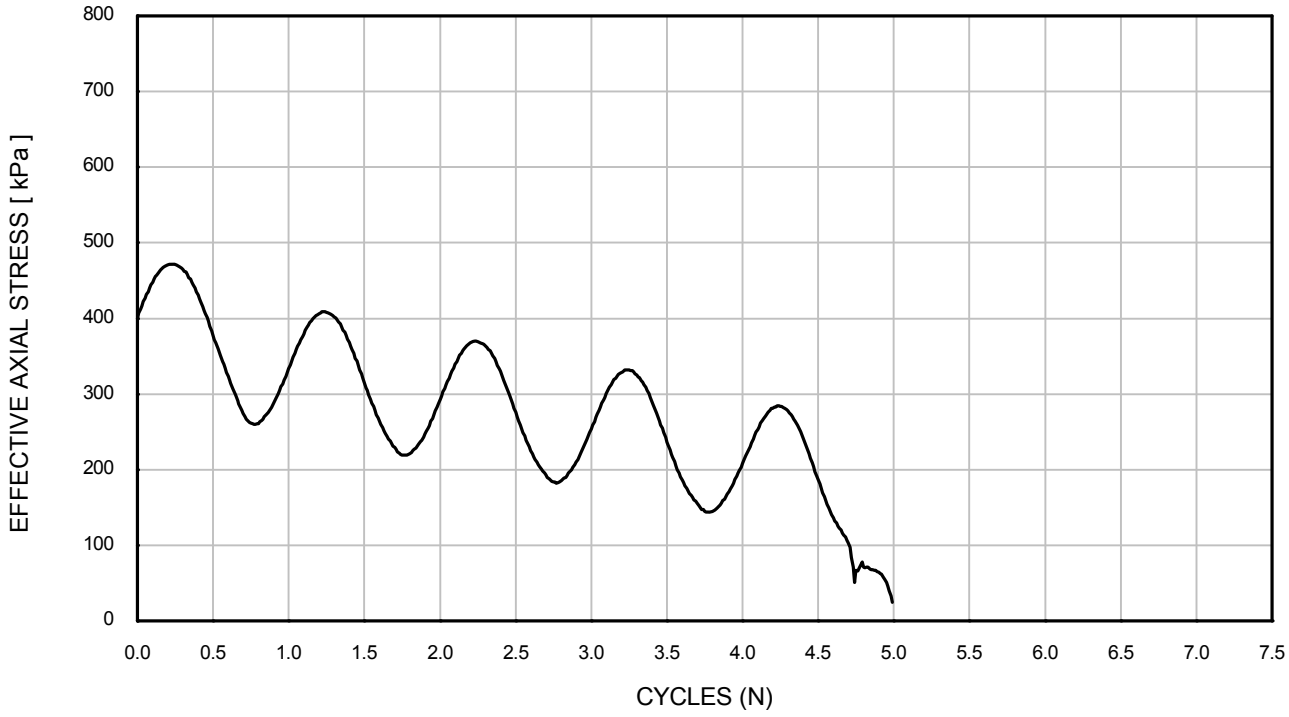


Initial σ'_r	:	400 kPa	Batch	: 4
Initial σ'_a	:	400 kPa	Sample	: CTX_4-5
q_{av}	:	0 kPa	Unit	: E5b (Tongeren)
q_{cy}	:	122 kPa	Test No.	: CTX21
Frequency	:	0.10 Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

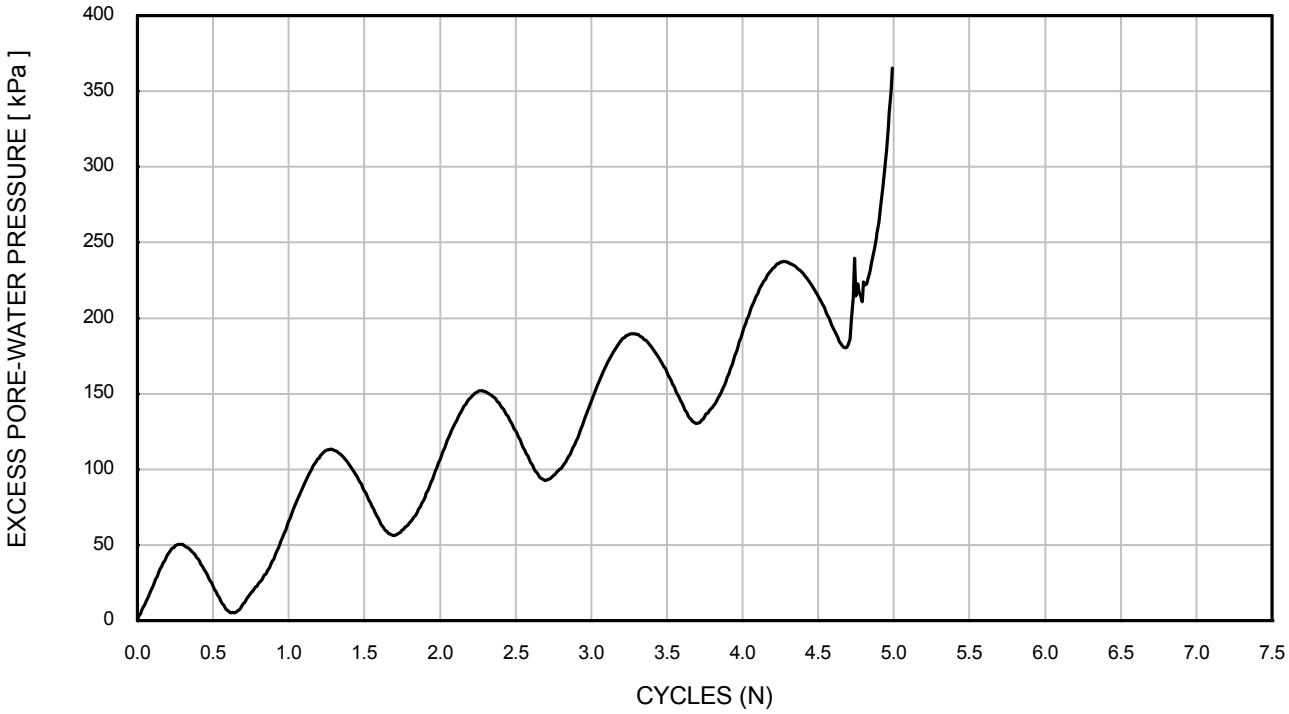


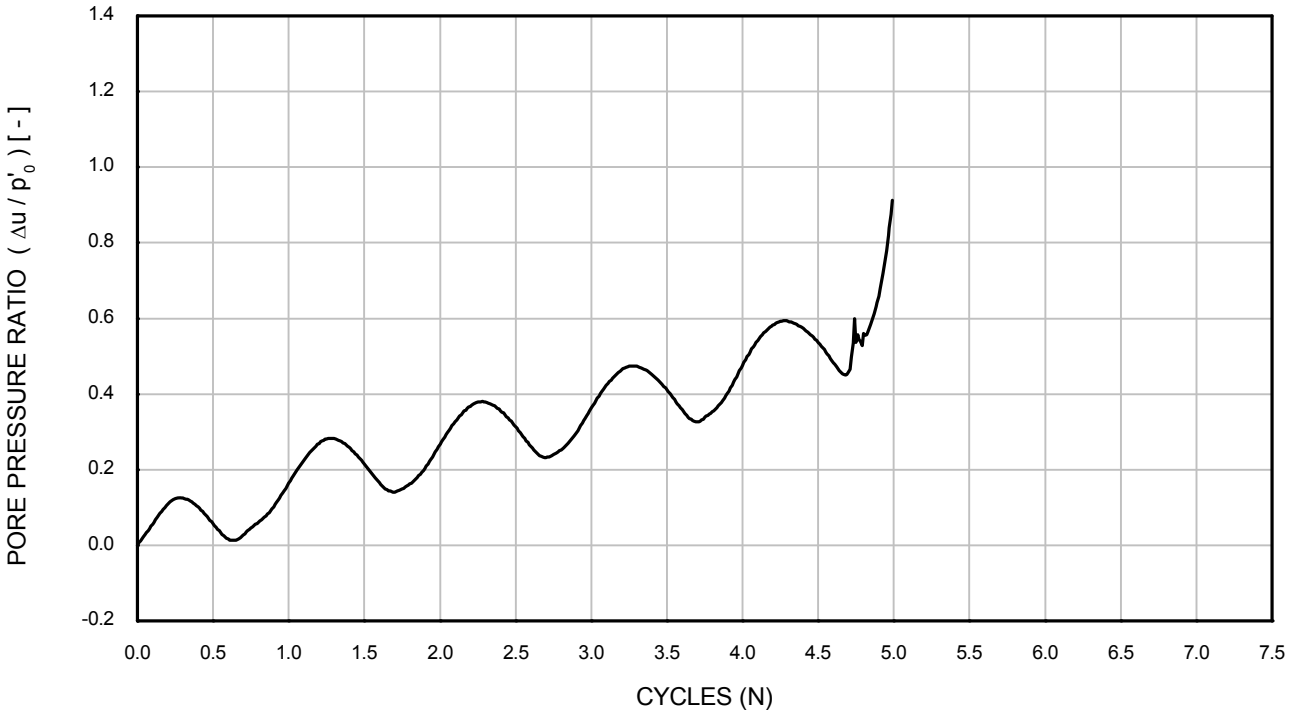


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	122 kPa	Test No.	:	CTX21
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

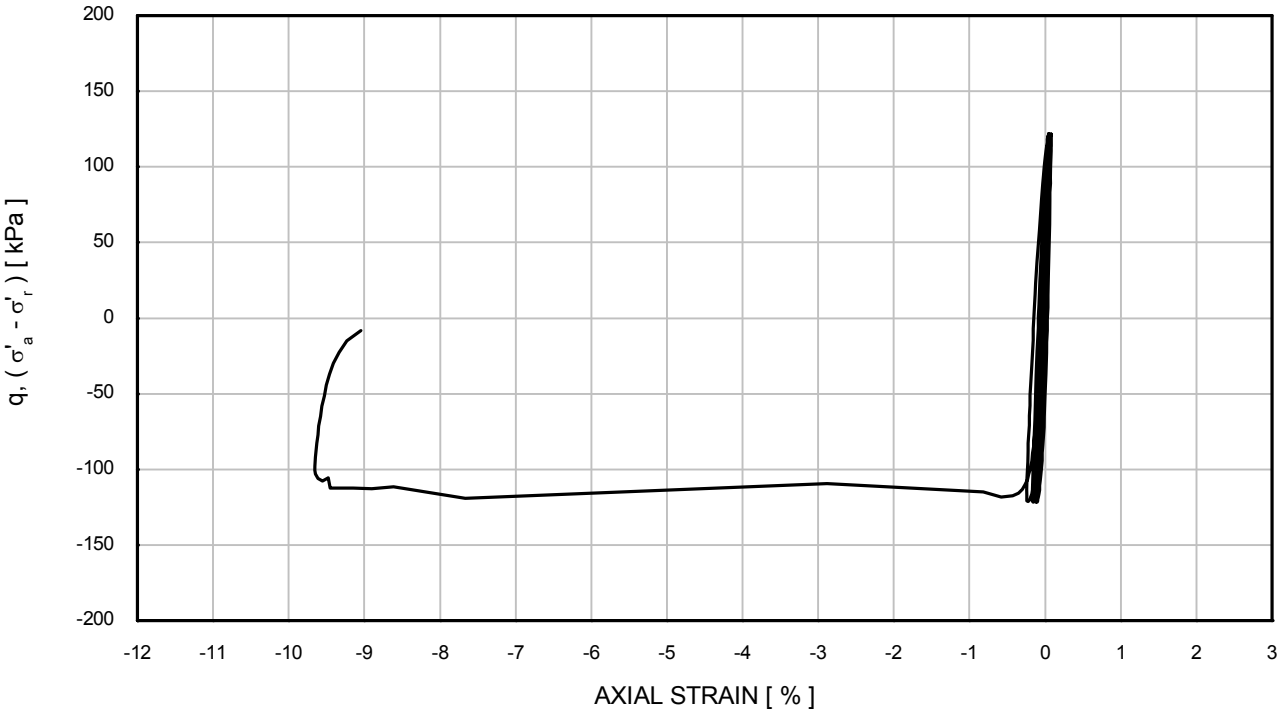


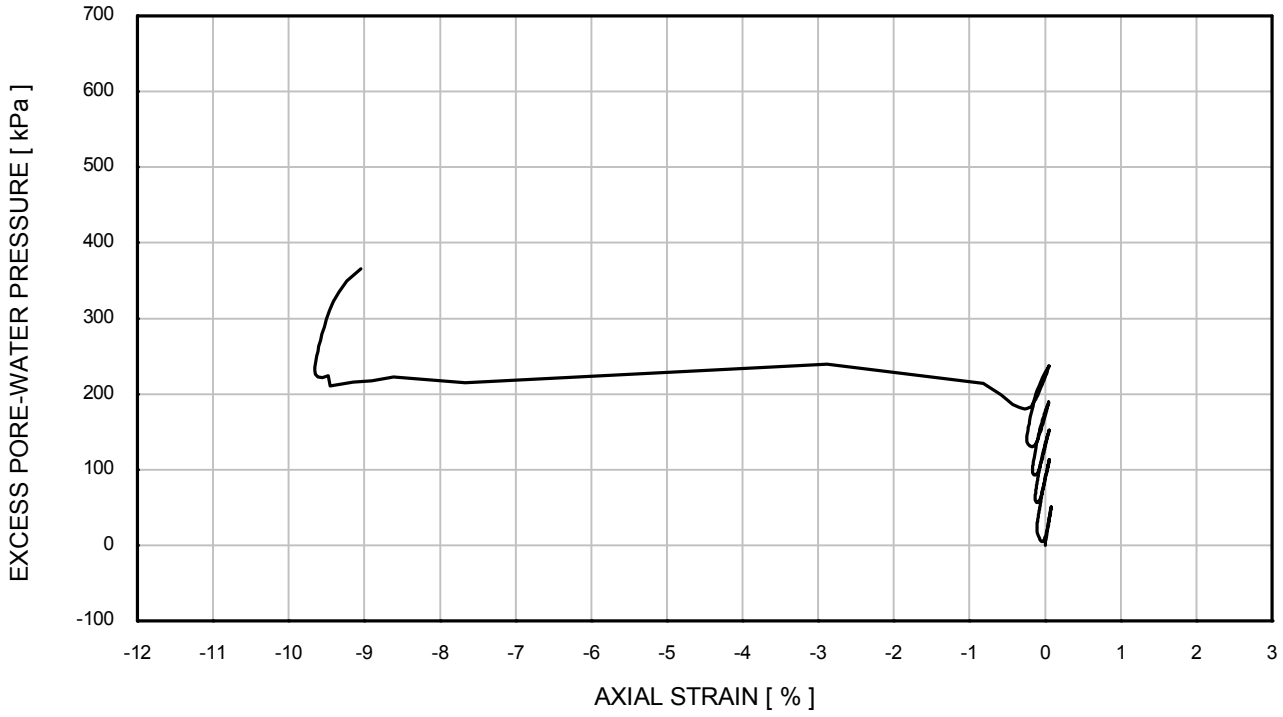


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	122 kPa	Test No.	:	CTX21
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

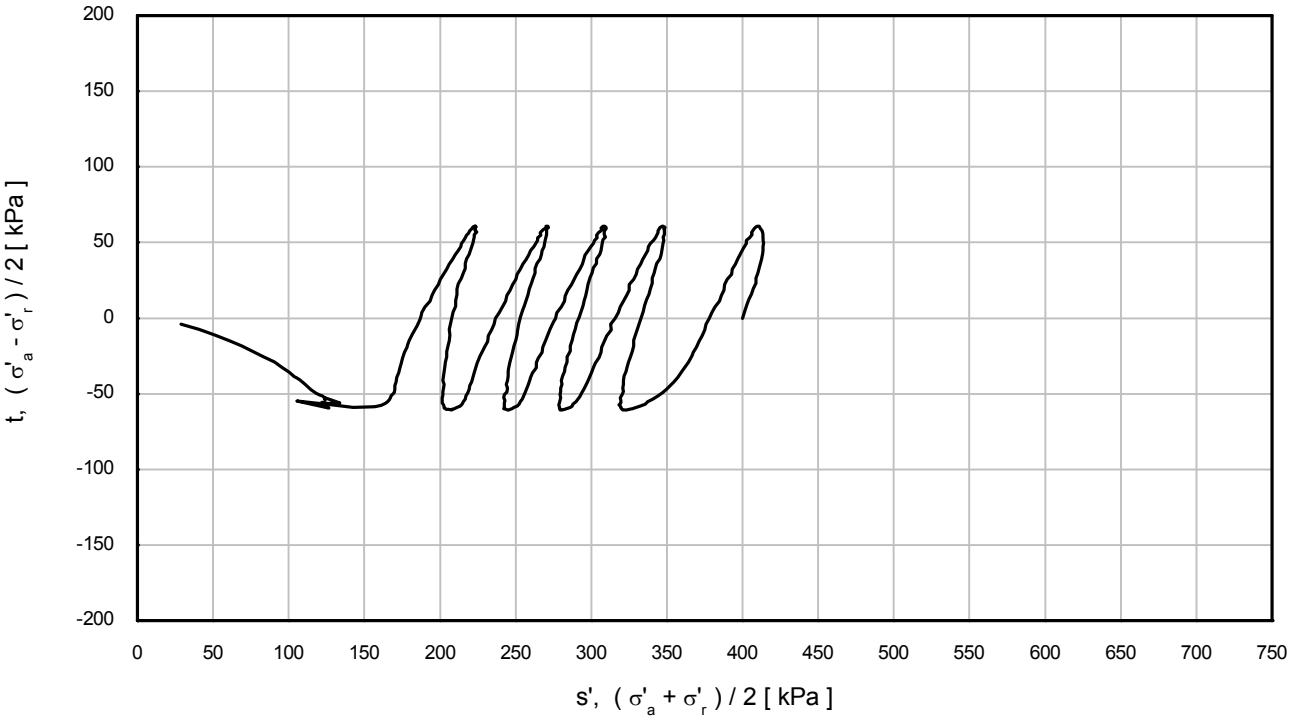


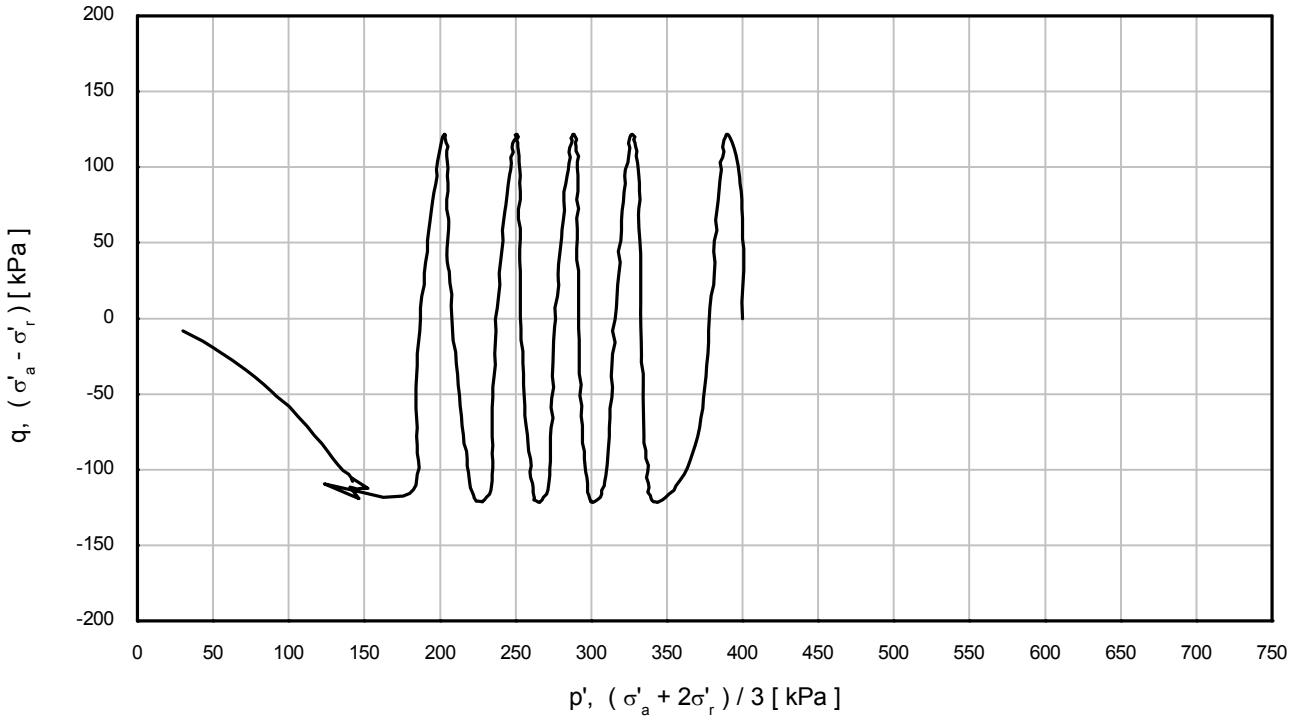


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	122 kPa	Test No.	:	CTX21
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

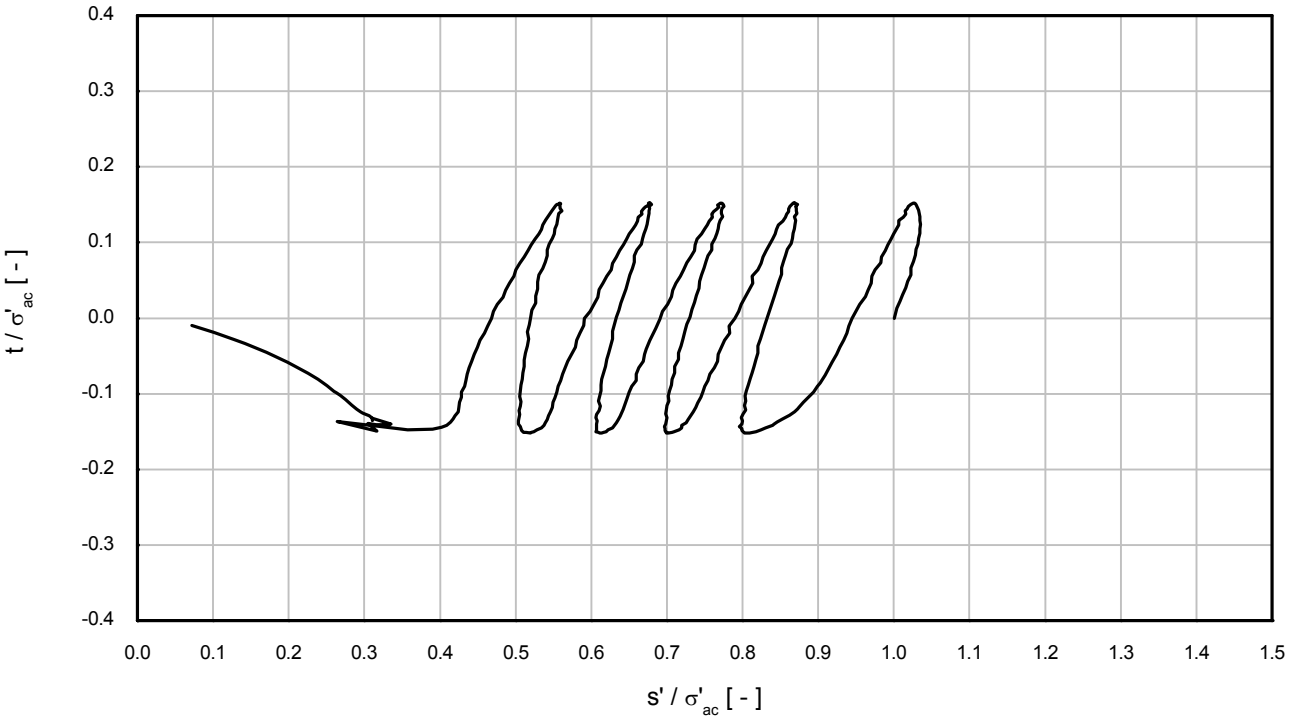


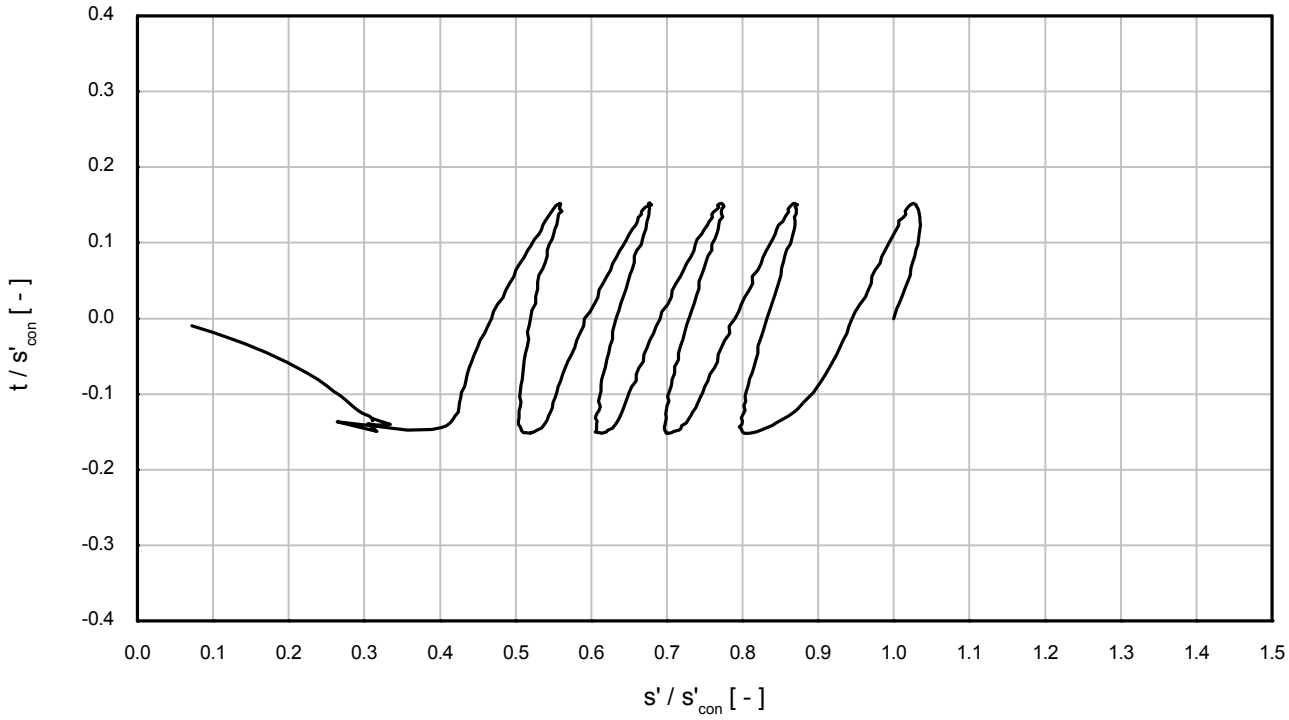


Initial σ'_r	:	400	kPa	Batch	: 4
Initial σ'_a	:	400	kPa	Sample	: CTX_4-5
q_{av}	:	0	kPa	Unit	: E5b (Tongeren)
q_{cy}	:	122	kPa	Test No.	: CTX21
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

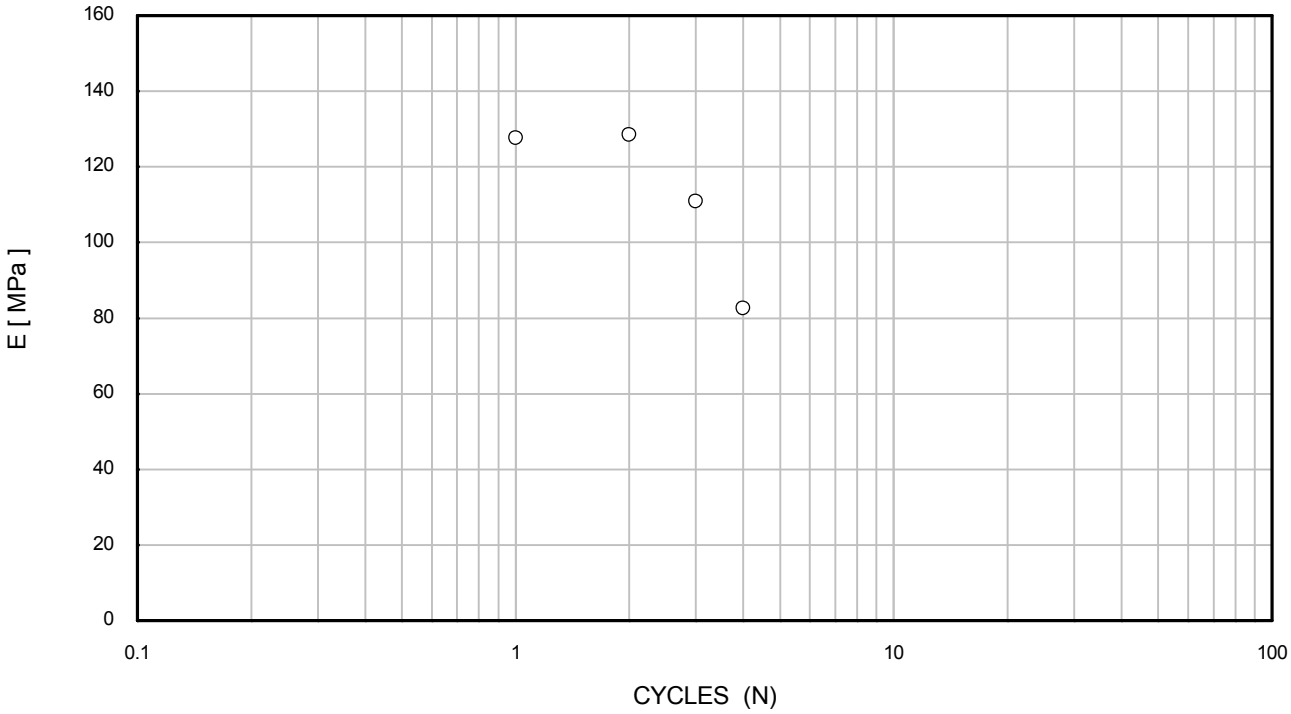


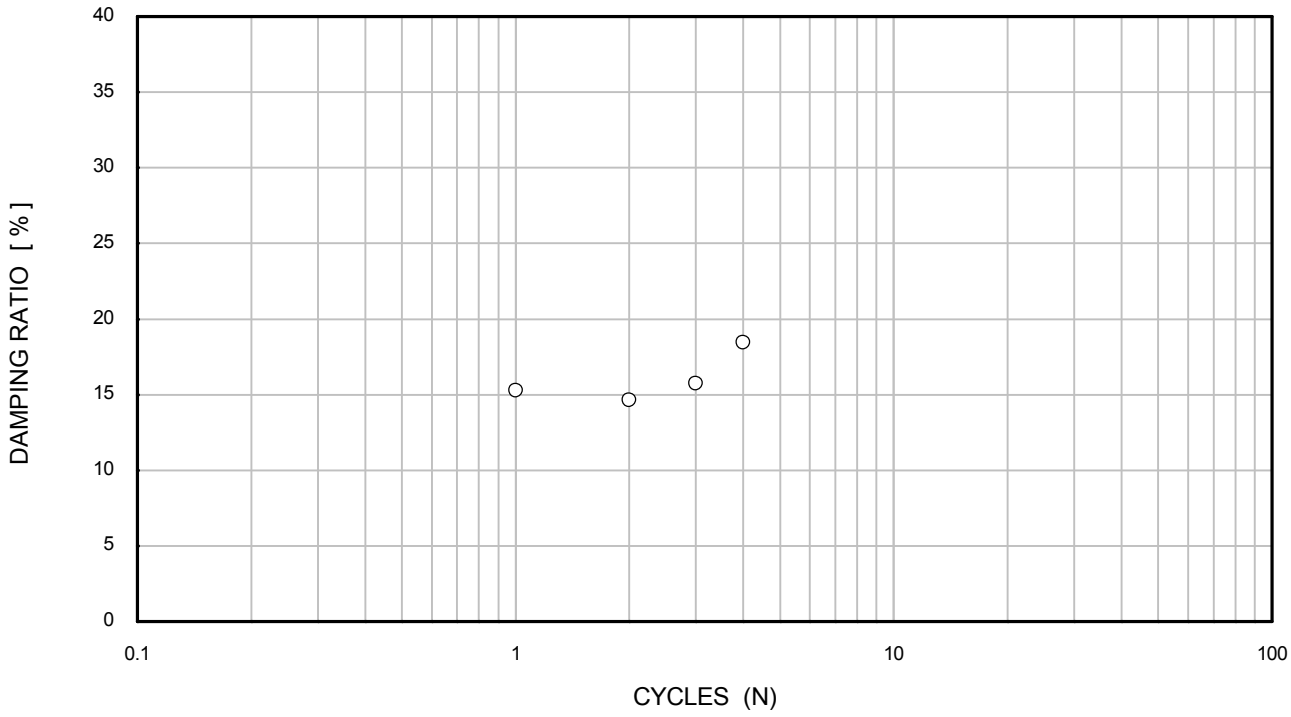


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	122 kPa	Test No.	:	CTX21
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

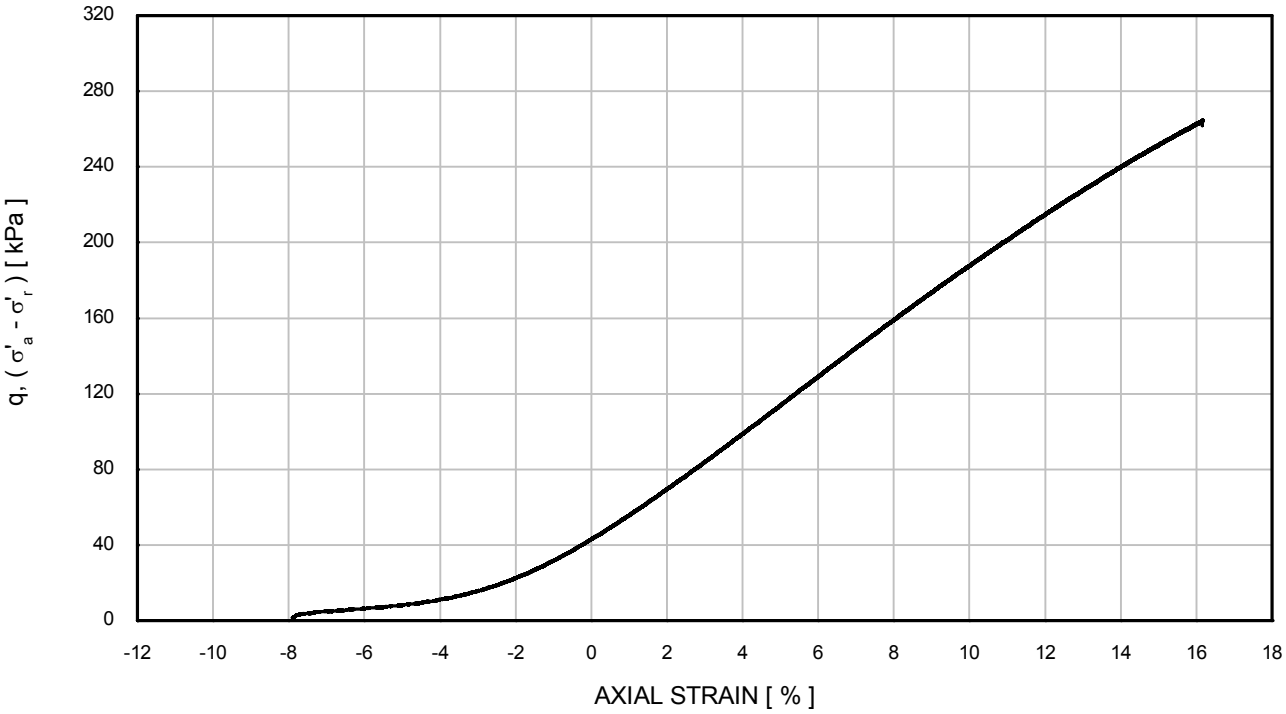


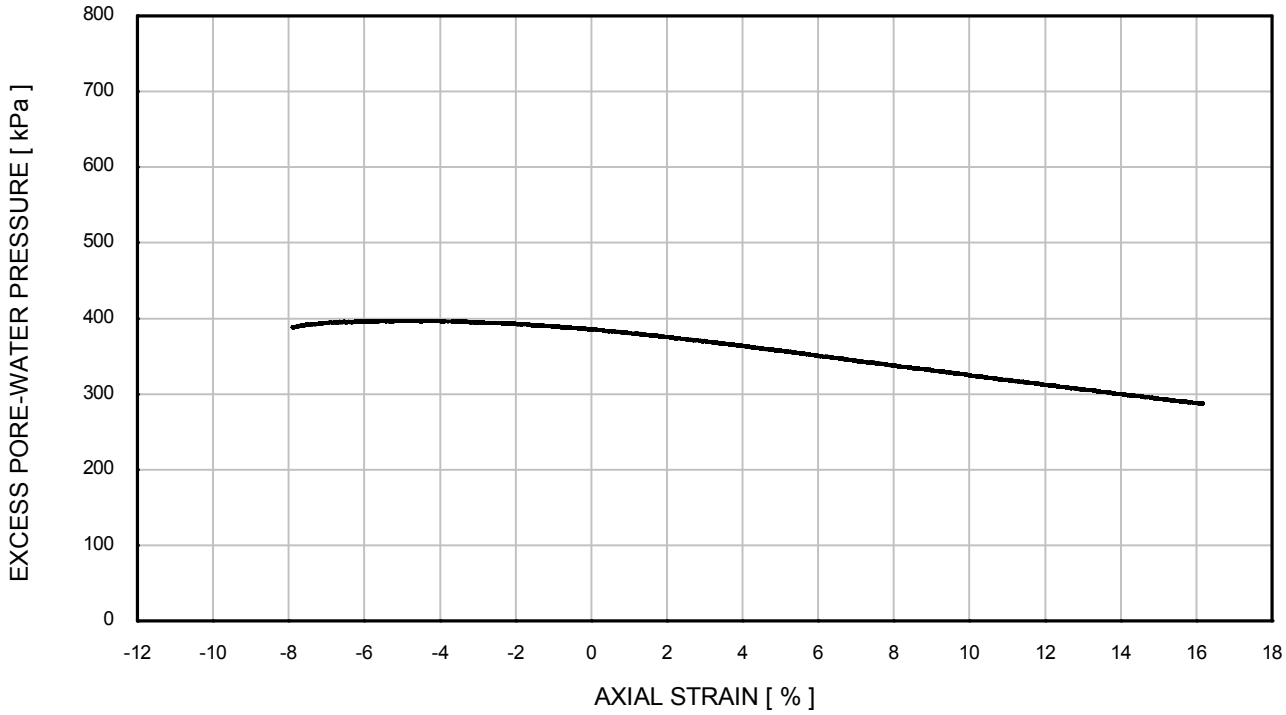


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	122 kPa	Test No.	:	CTX21
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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





Initial σ'_r	:	12 kPa	Batch	:	4
Initial σ'_a	:	13 kPa	Sample	:	CTX_4-5
q_{peak}	:	265 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	16.17 %	Test No.	:	CTX21
Rate of strain	:	0.49 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey slightly silty fine SAND

GENERAL	
Date test started	16/03/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.2
Bulk density	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.649
Degree of saturation	[%]	42
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 4_CTX-4-5_CTX21R
Processed by Date	HJ 30/03/2016
Checked by Date	DT 30/03/2016
Approved by Date	DT 30/03/2016

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Undrained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	N/A
Cell pressure	[kPa]	1100
Base PWP	[kPa]	1074
Mid height PWP	[kPa]	-
B value achieved	[-]	0.98

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1474
Back pressure	[kPa]	1073
Base PWP	[kPa]	1073
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	401
Effective axial pressure	[kPa]	401
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.41
External axial strain	[%]	0.65
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	23.0
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.609
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	800
Mean q_{av}	[kPa]	2
Mean q_{cy}	[kPa]	142
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	2
External ε_{av} at N_f	[%]	-8.67
External ε_{cy} at N_f	[%]	8.70
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	182
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	23.0
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.609
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	-0.11	0.21	69	-	20.70	-
2	-8.67	8.70	2	-	27.41	-

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



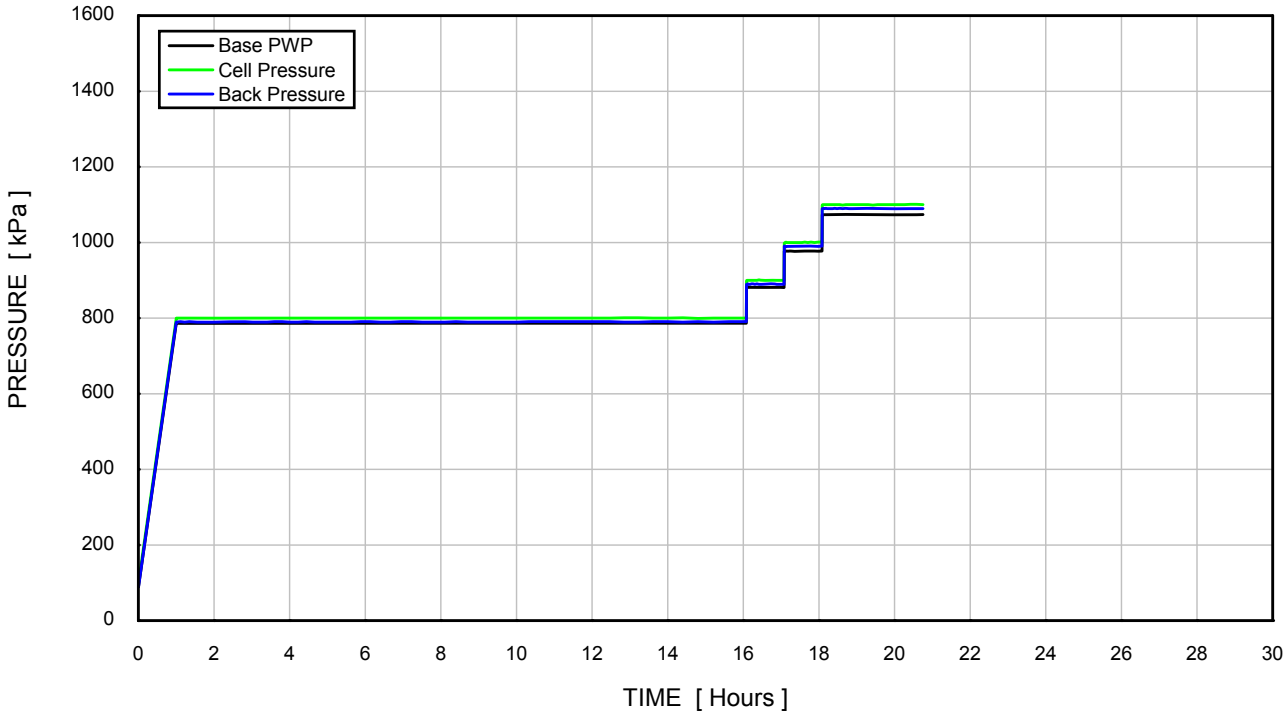


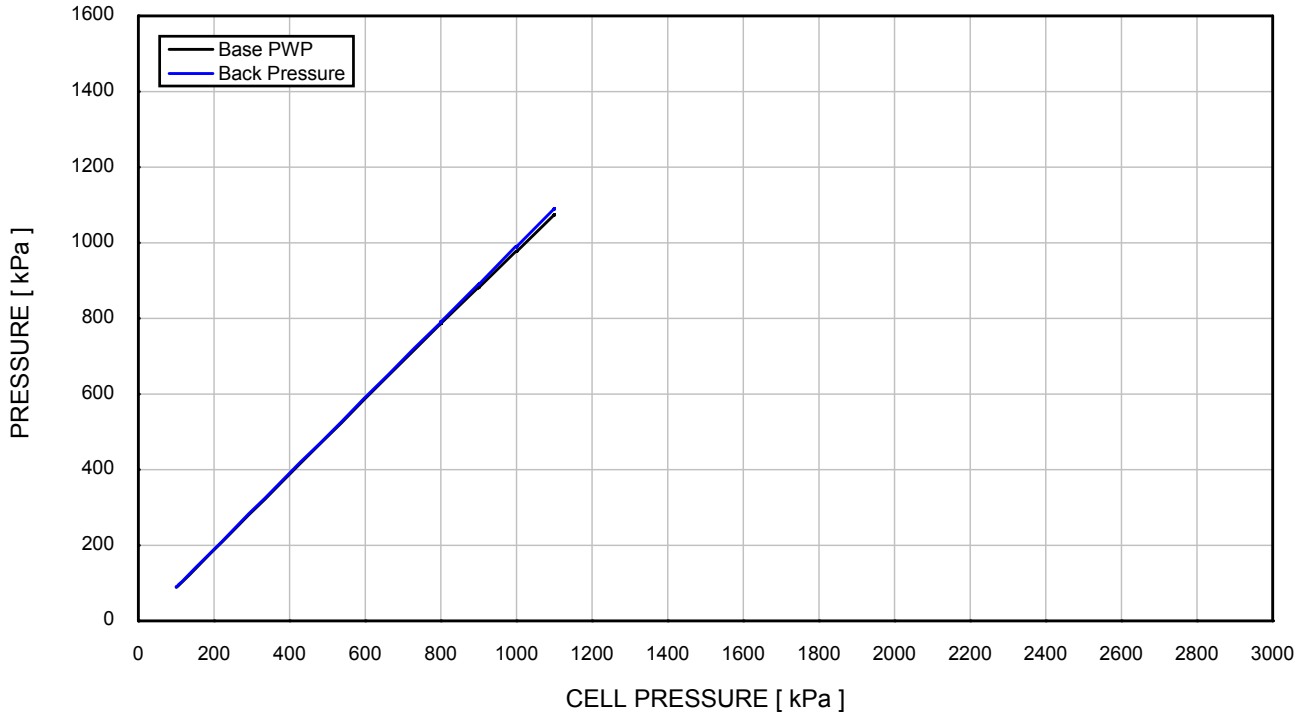
FINAL CONDITIONS		
Moisture content	[%]	
Bulk density	[Mg/m³]	
Dry density	[Mg/m³]	

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-5
Unit	E5b (Tongeren)
Test number	CTX21R

SUMMARY OF ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST

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

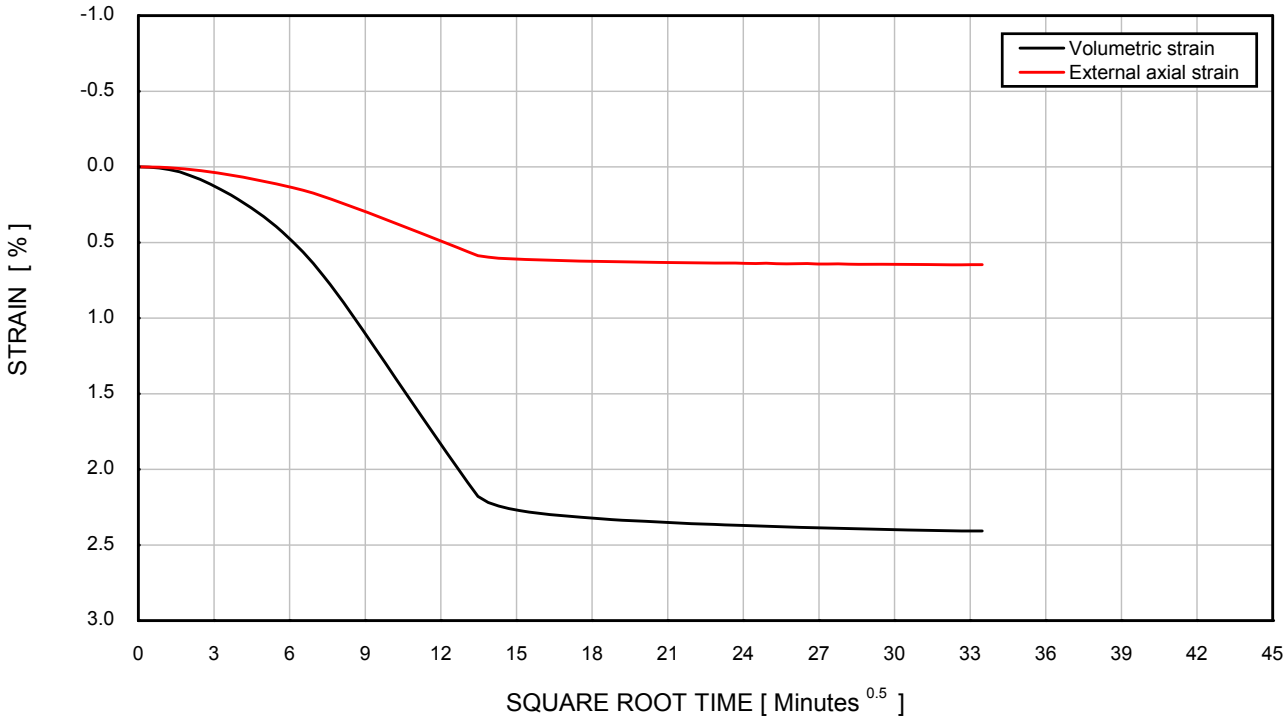


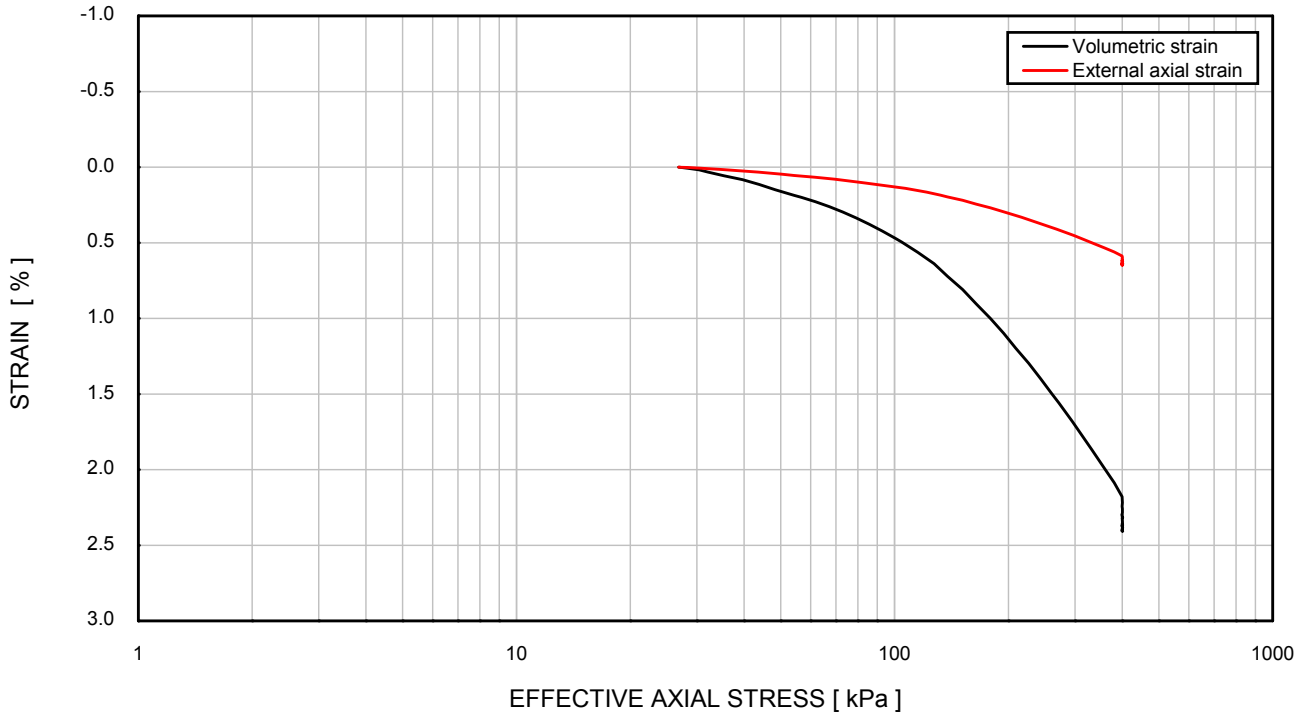


B value	: 0.98		Batch	: 4
Initial σ'_r	: 11	kPa	Sample	: CTX_4-5
Initial σ'_a	: 11	kPa	Unit	: E5b (Tongeren)
Final σ'_r	: 26	kPa	Test No.	: CTX21R
Final σ'_a	: 26	kPa		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

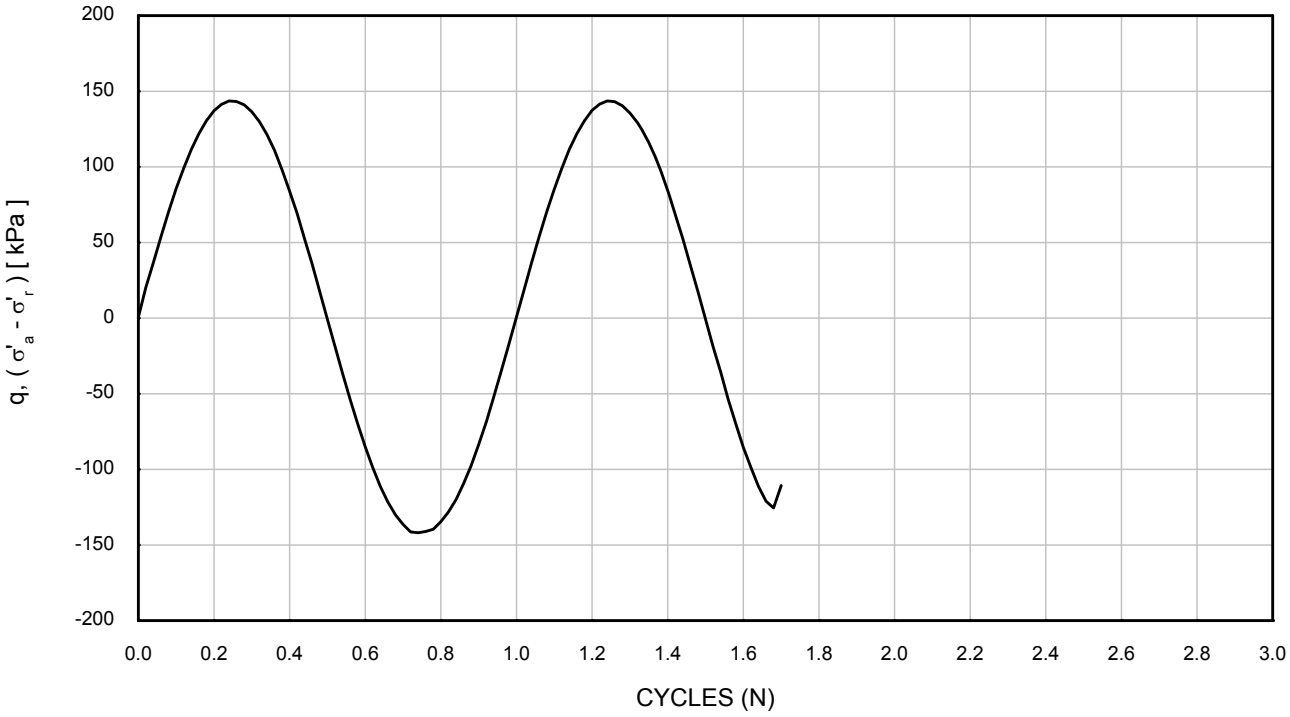


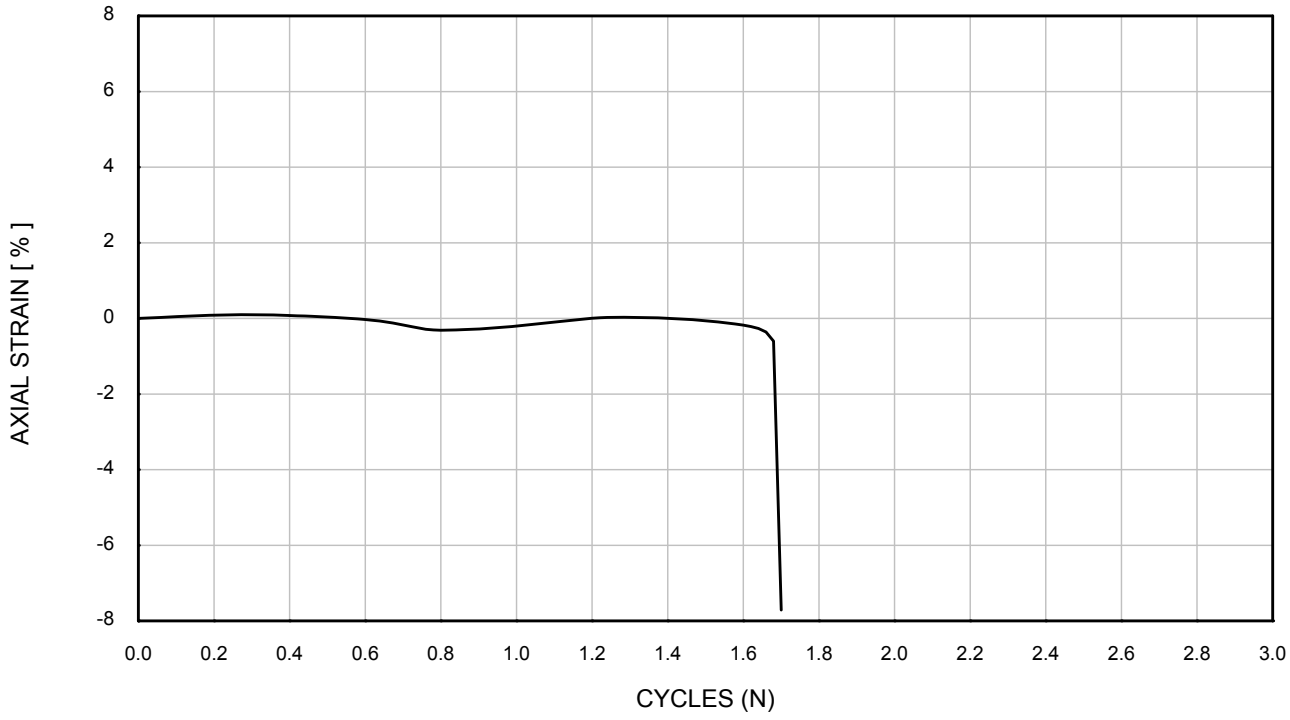


σ'_{rc}	: 401 kPa	Batch	: 4
σ'_{ac}	: 401 kPa	Sample	: CTX_4-5
		Unit	: E5b (Tongeren)
		Test No.	: CTX21R

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

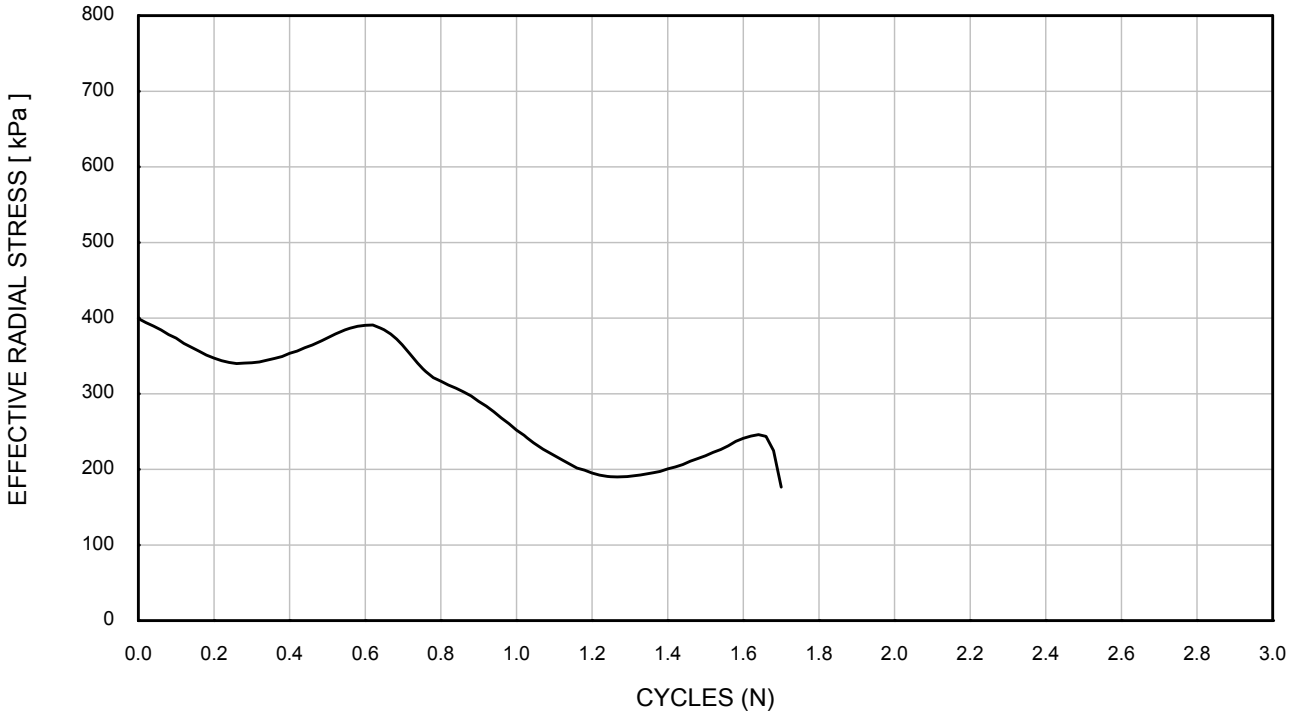


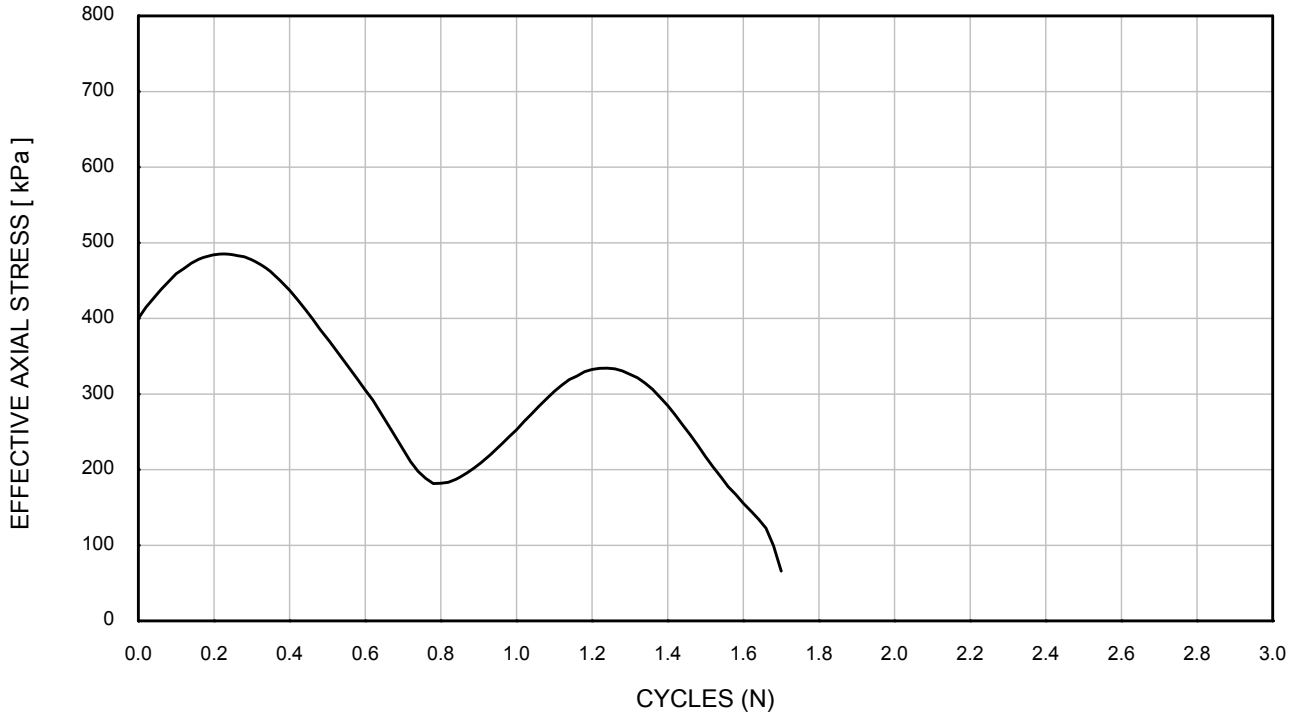


Initial σ'_r	:	401 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	2 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	142 kPa	Test No.	:	CTX21R
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

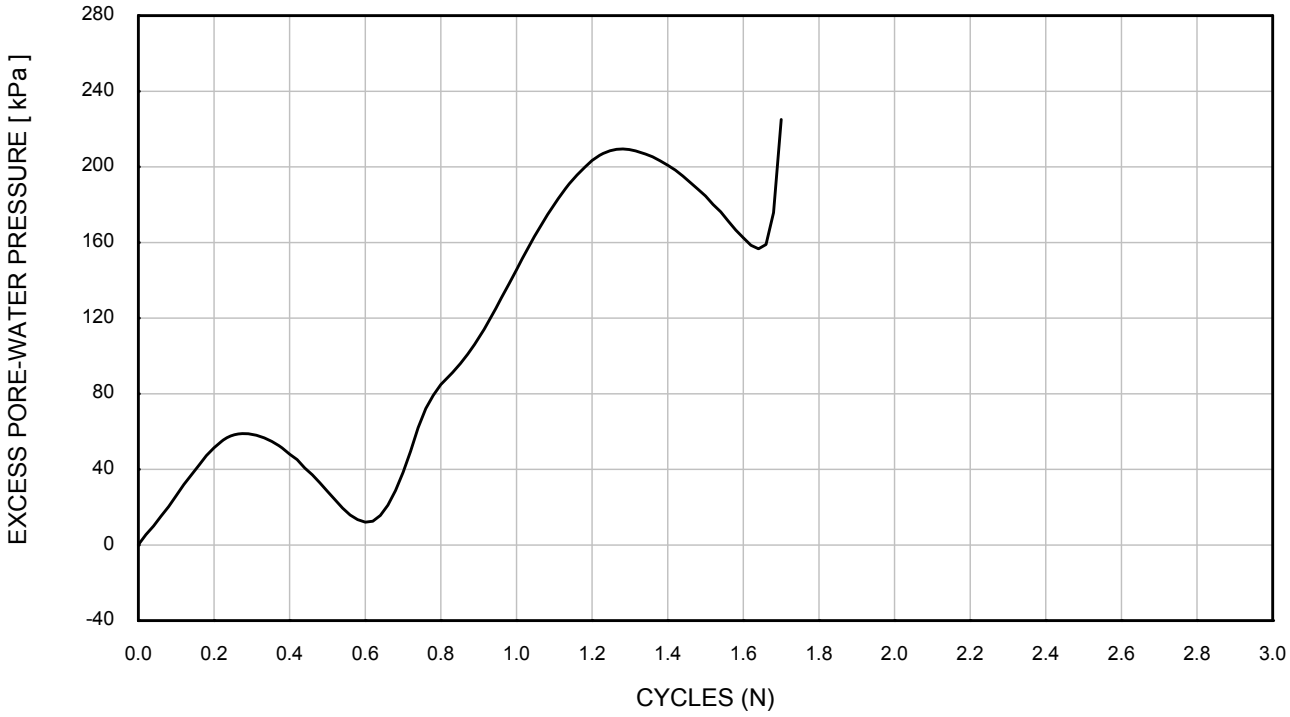


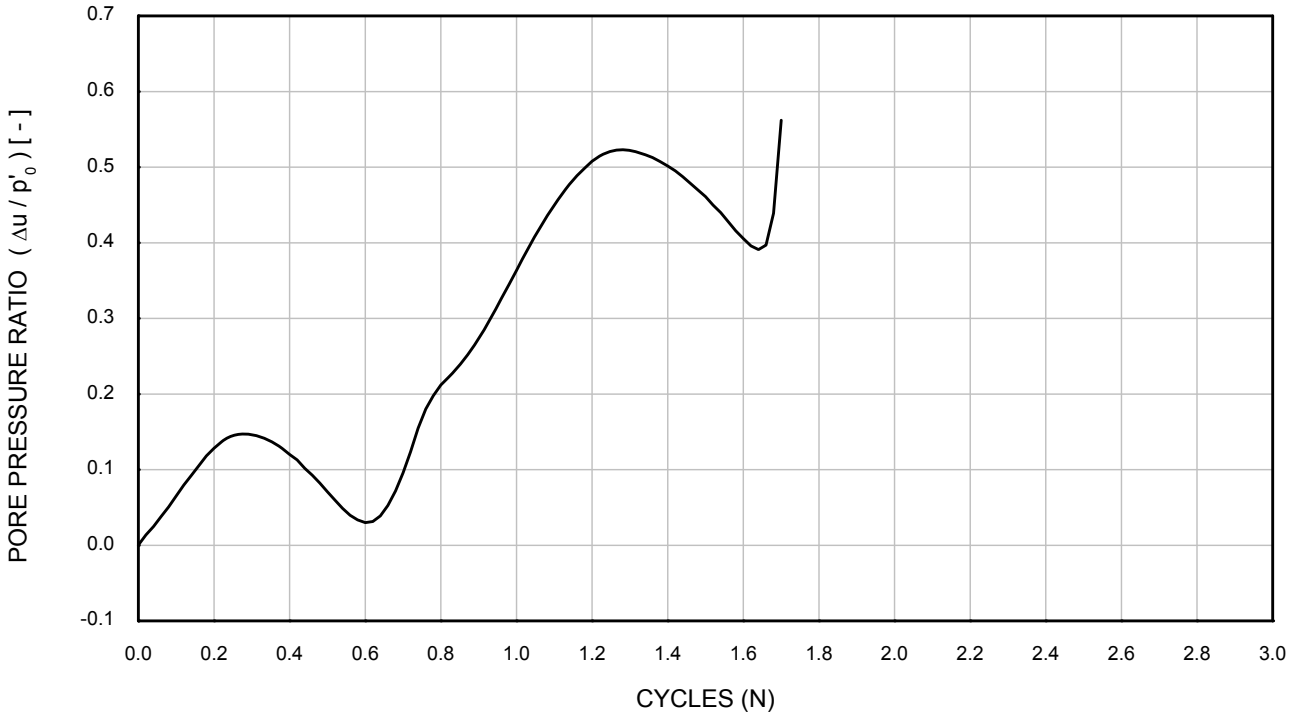


Initial σ'_r	:	401 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	2 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	142 kPa	Test No.	:	CTX21R
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

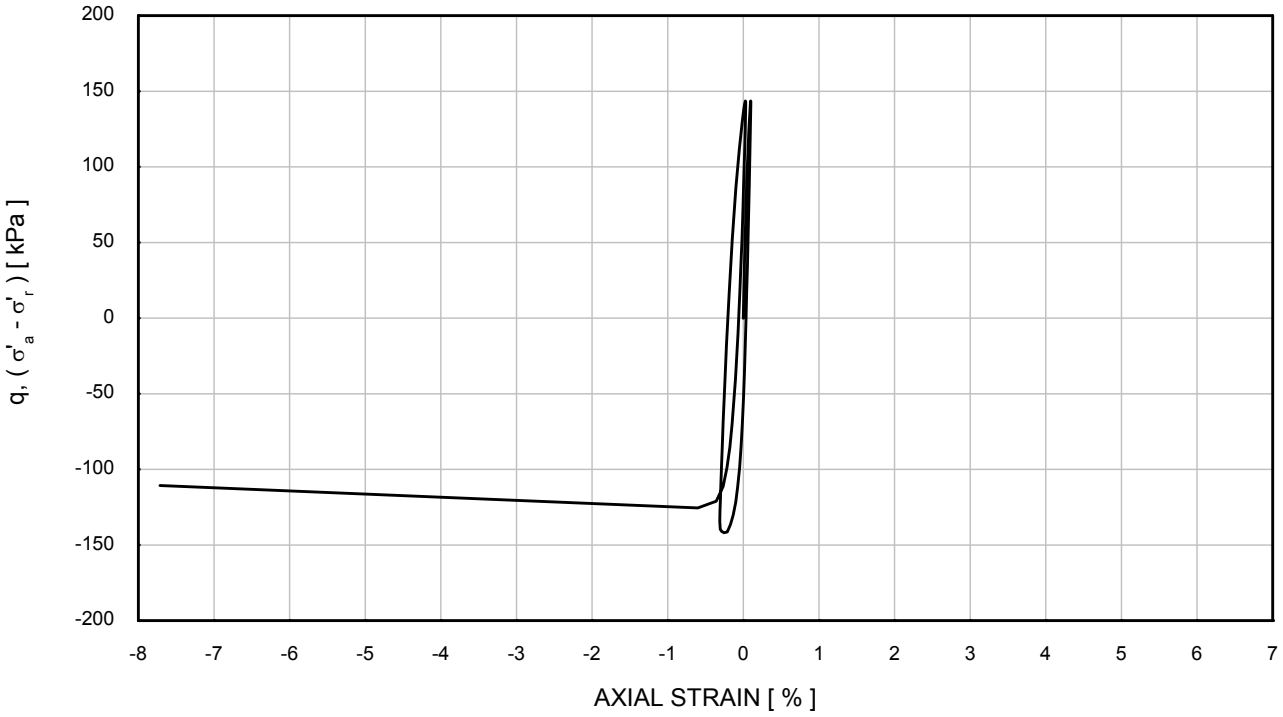


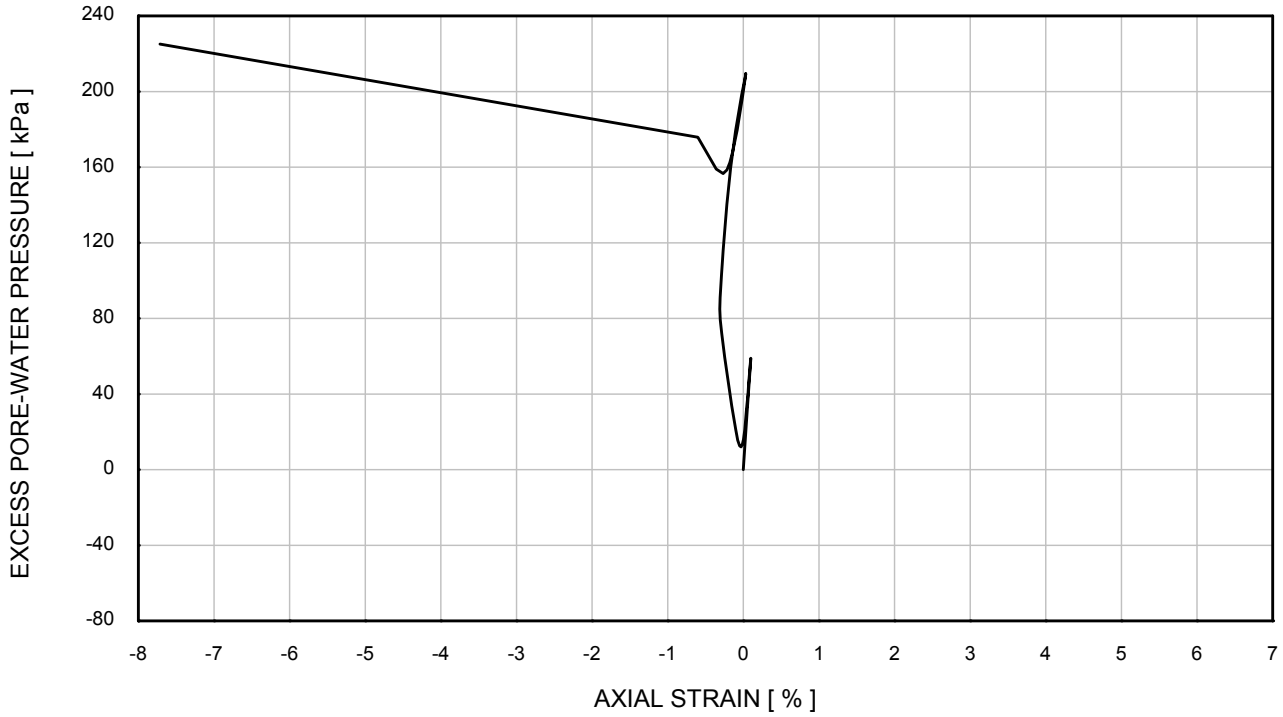


Initial σ'_r	:	401 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	2 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	142 kPa	Test No.	:	CTX21R
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

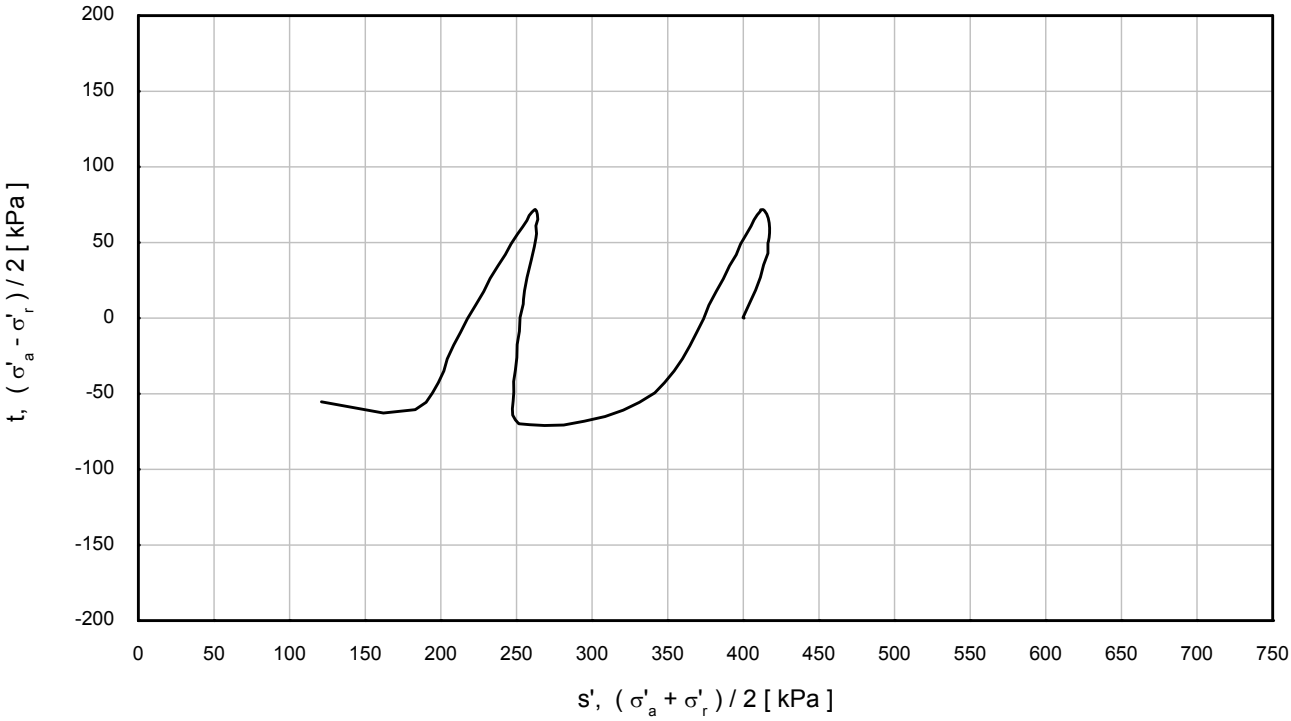


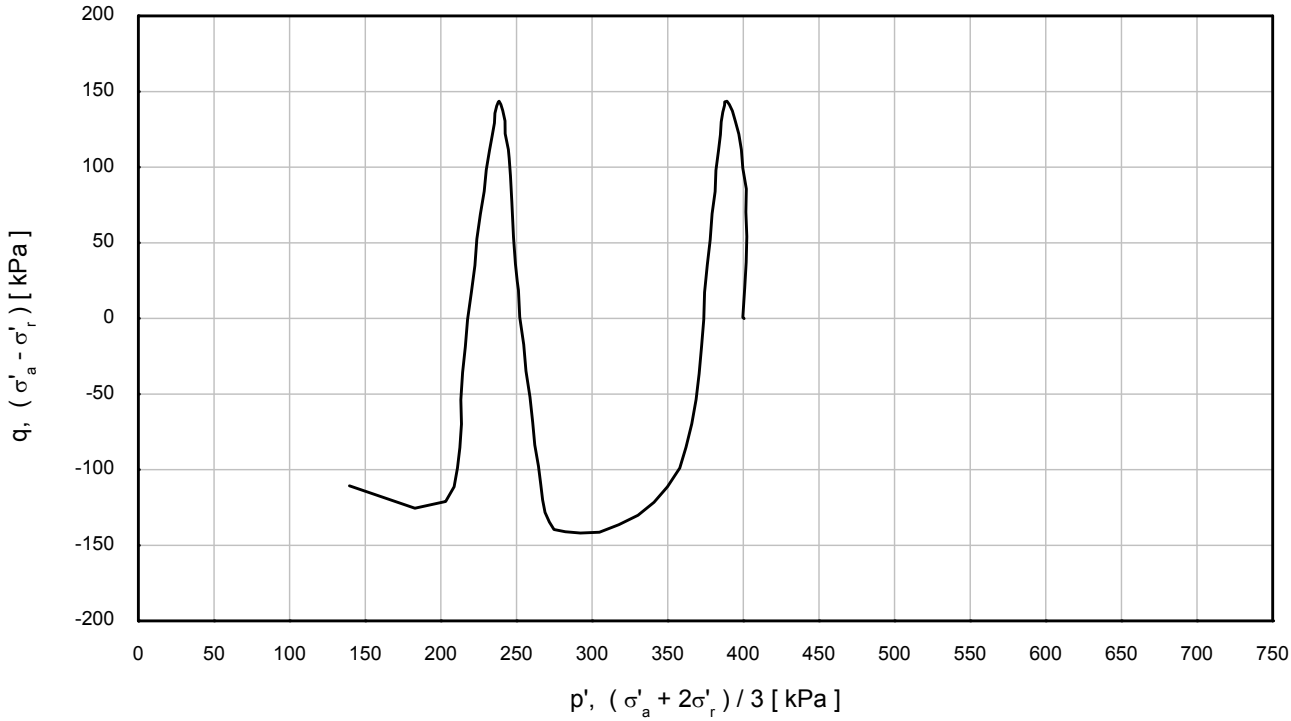


Initial σ'_r	:	401 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	2 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	142 kPa	Test No.	:	CTX21R
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

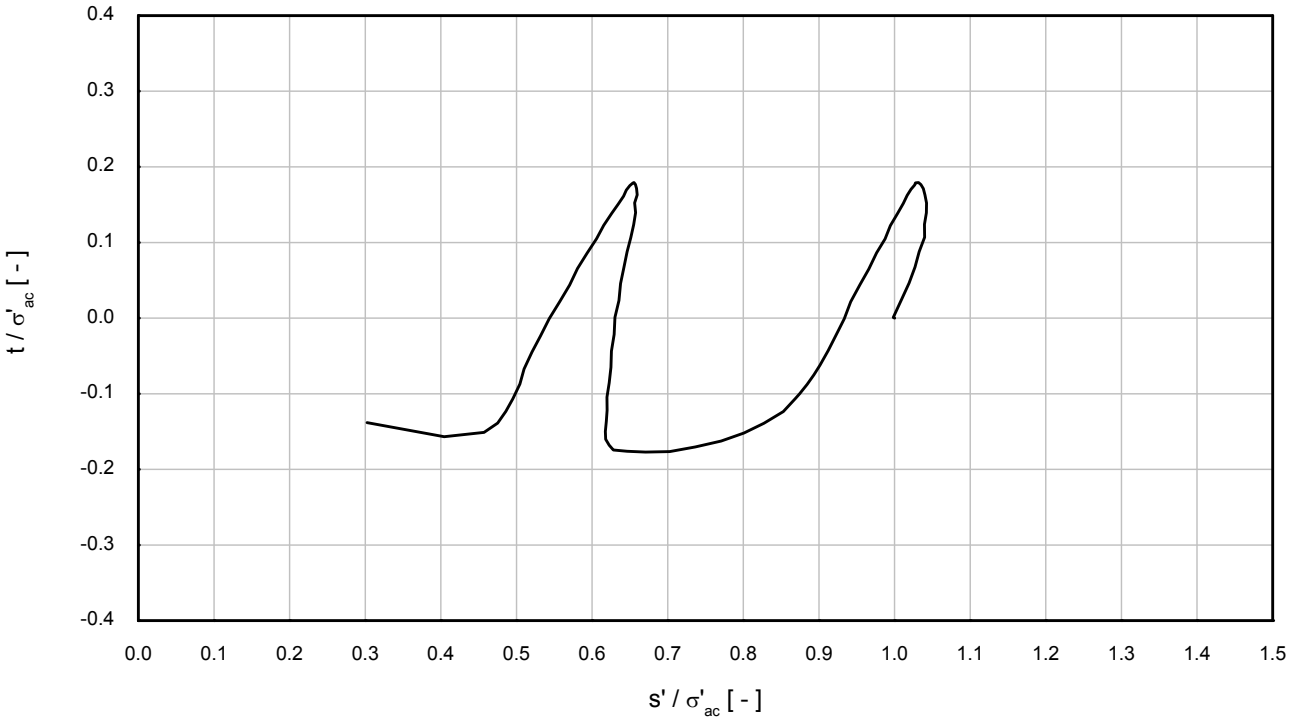


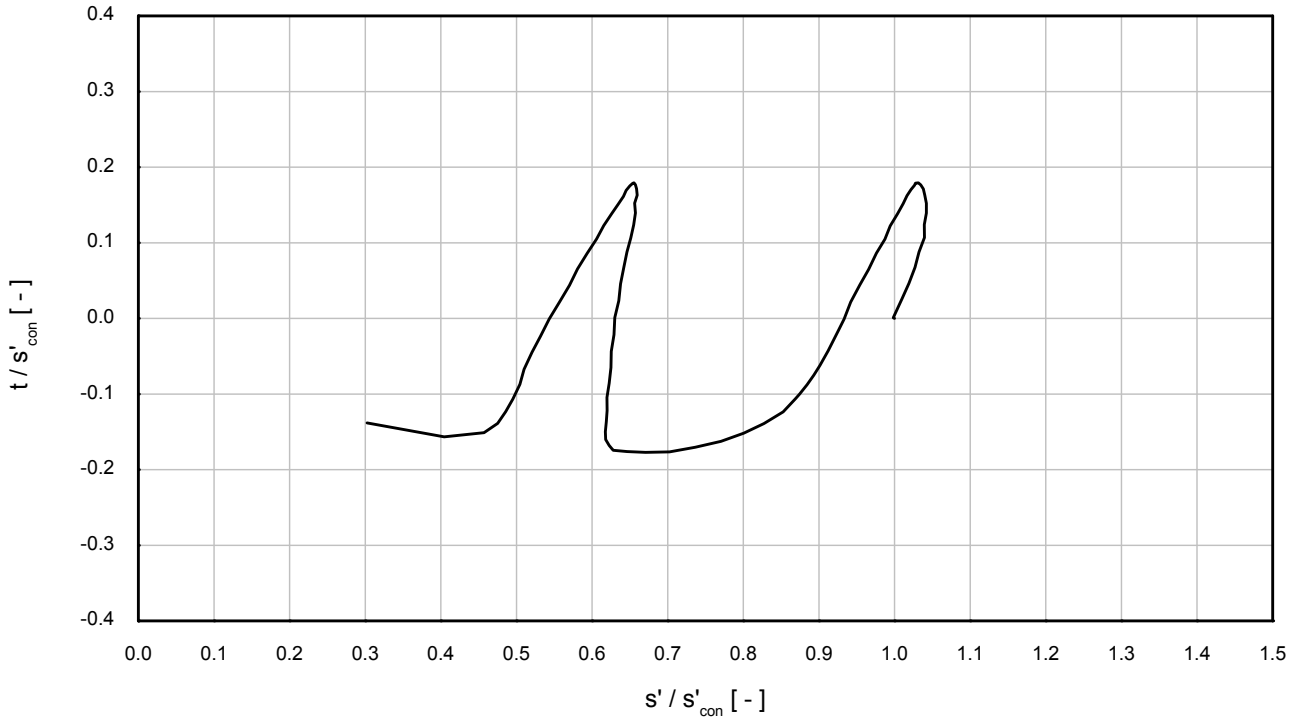


Initial σ'_r	:	401	kPa	Batch	: 4
Initial σ'_a	:	400	kPa	Sample	: CTX_4-5
q_{av}	:	2	kPa	Unit	: E5b (Tongeren)
q_{cy}	:	142	kPa	Test No.	: CTX21R
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

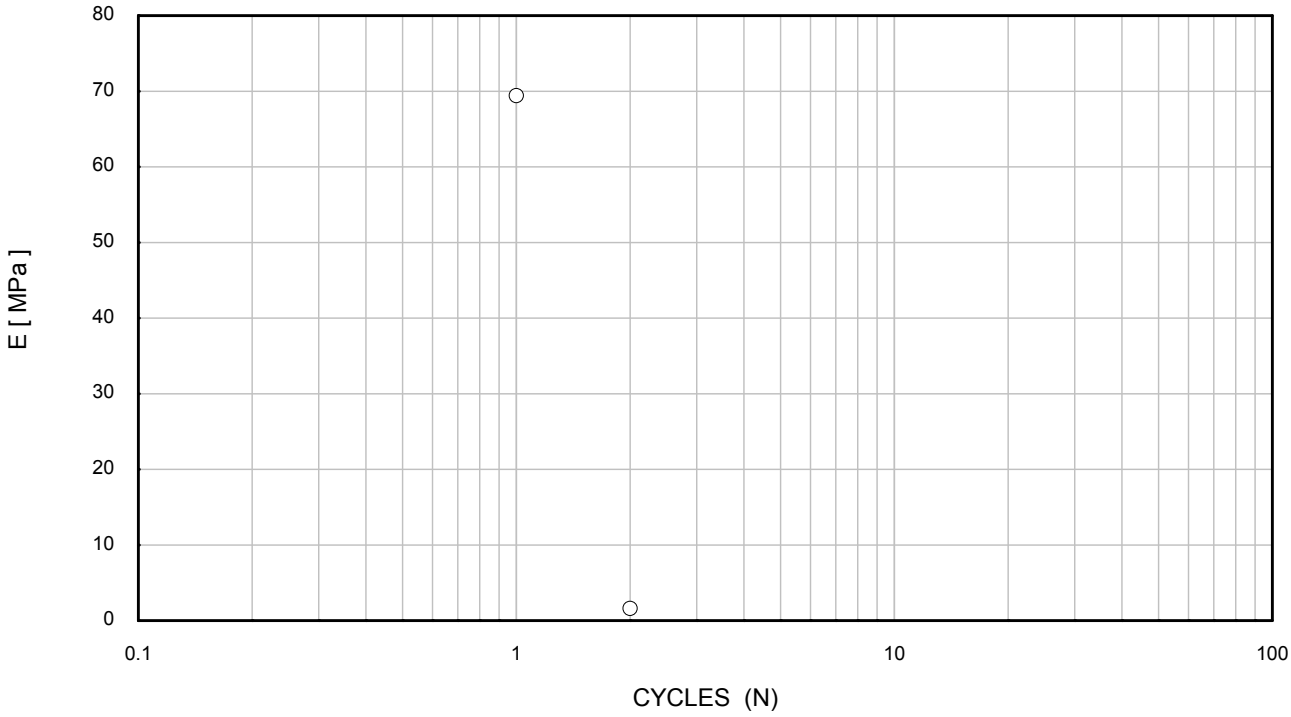


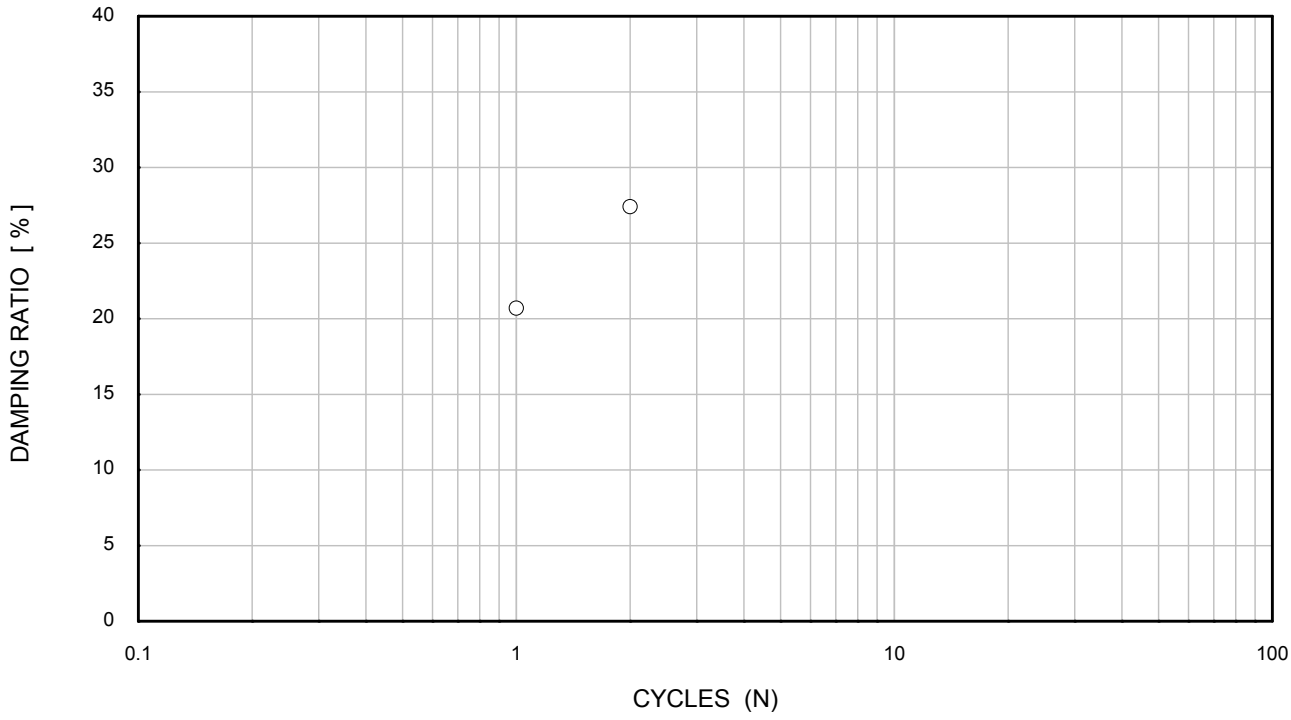


Initial σ'_r	:	401 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-5
q_{av}	:	2 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	142 kPa	Test No.	:	CTX21R
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

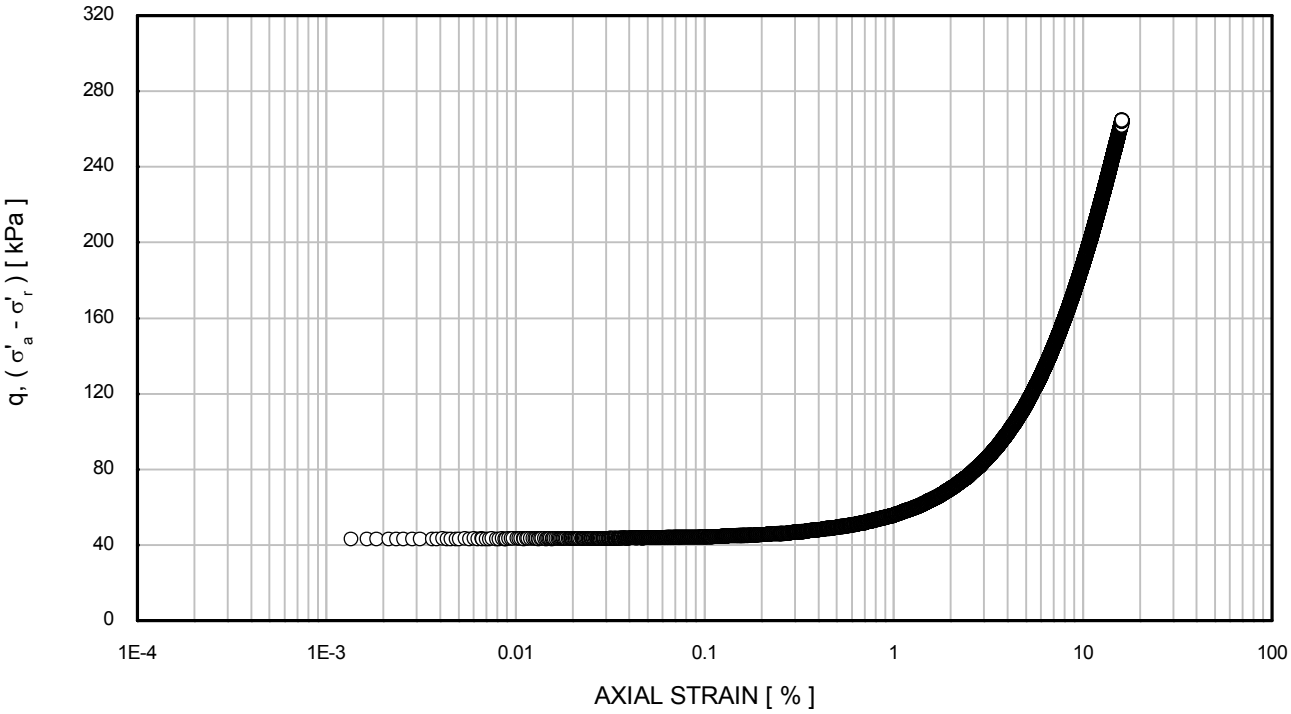


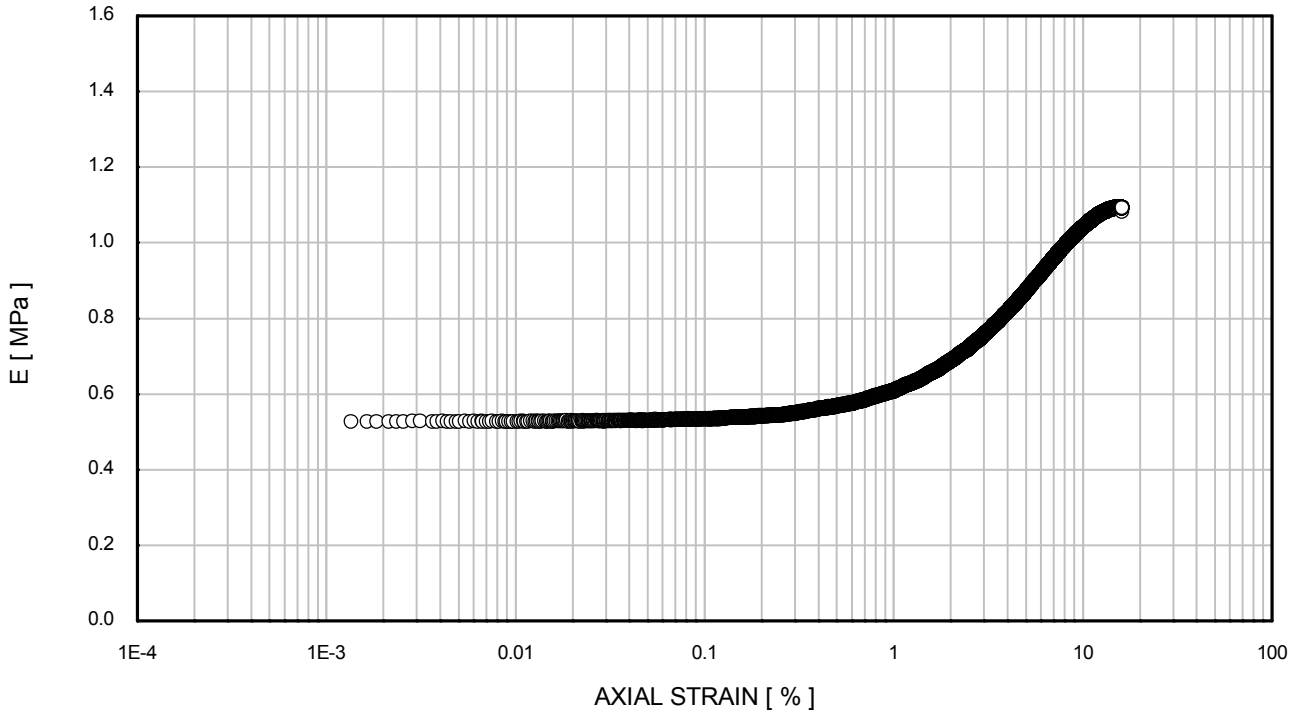


Initial σ'_r	: 401 kPa	Batch	: 4
Initial σ'_a	: 400 kPa	Sample	: CTX_4-5
q_{av}	: 2 kPa	Unit	: E5b (Tongeren)
q_{cy}	: 142 kPa	Test No.	: CTX21R
Frequency	: 0.10 Hz		

ISOTROPICALLY CONSOLIDATED TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

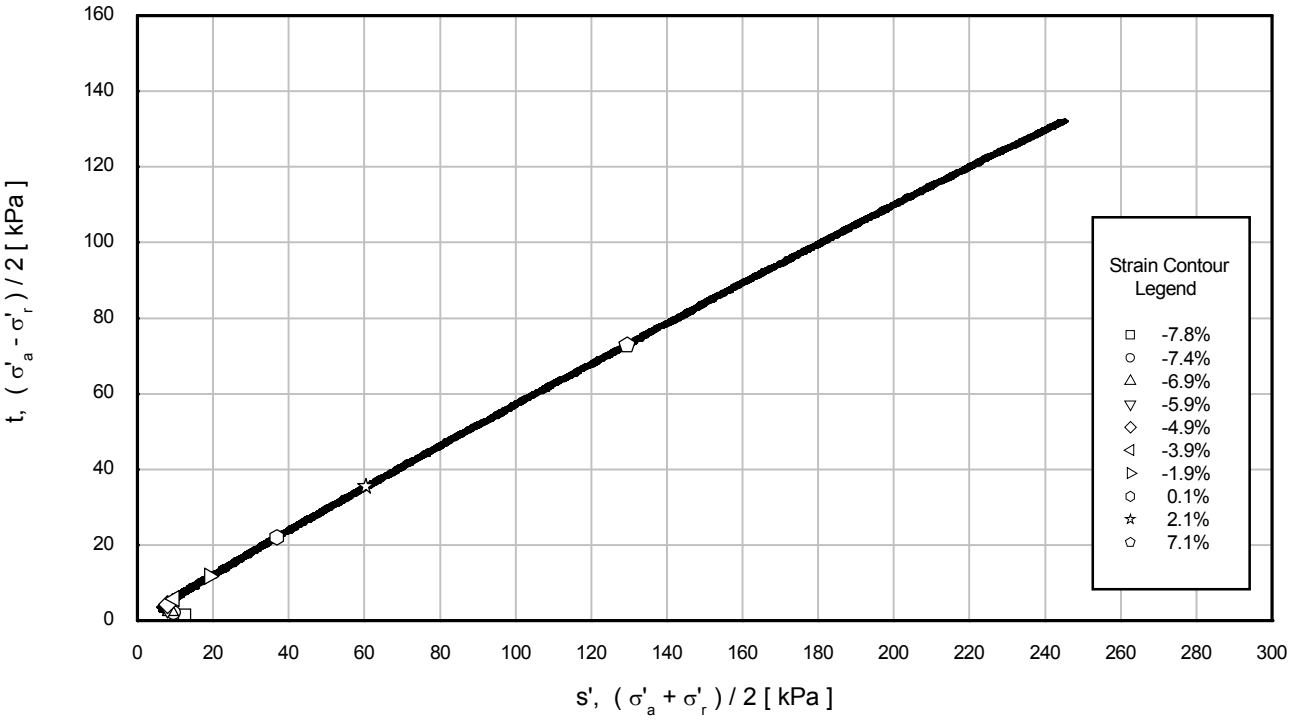


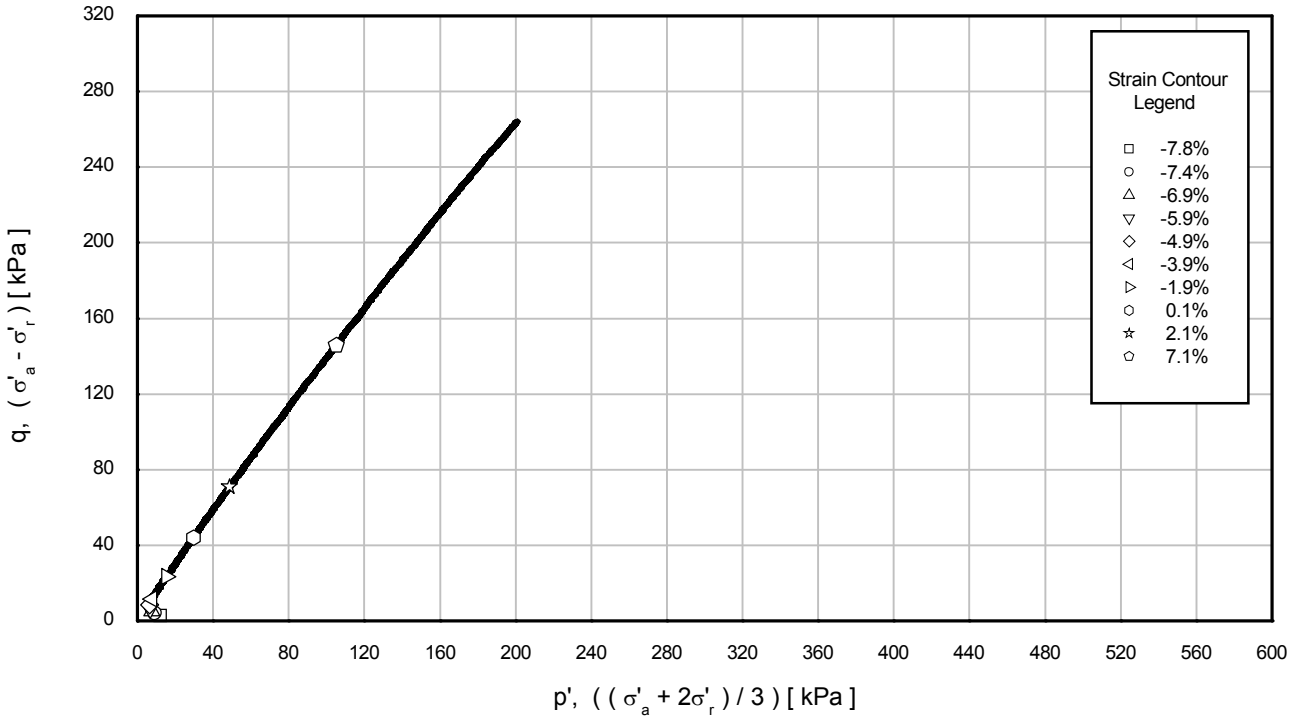


Initial σ'_r	:	12	kPa	Batch	: 4
Initial σ'_a	:	13	kPa	Sample	: CTX_4-5
q_{peak}	:	265	kPa	Unit	: E5b (Tongeren)
Ext. ε at q_{peak}	:	16.17	%	Test No.	: CTX21
Rate of strain	:	0.49	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	12 kPa	Batch	:	4
Initial σ'_a	:	13 kPa	Sample	:	CTX_4-5
q_{peak}	:	265 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	16.17 %	Test No.	:	CTX21
Rate of strain	:	0.49 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	15/01/2016
Type of sample	Re-compacted
Type of drains fitted	One end only

INITIAL		
Diameter	[mm]	70.0
Length	[mm]	140.0
Moisture content	[%]	10.0
Bulk density	[Mg/m³]	1.78
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.641
Degree of saturation	[%]	41
Assumed particle density	[Mg/m³]	2.65
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-

TESTING PROCEDURES USED	
Specimen Set-up	BS1377: 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 BS1377: Part 8: 1990 Clause 5.3
Consolidation - Isotropic Consolidation - Anisotropic	BS1377: Part 8: 1990 Clause 6 Fugro testing procedure L-T-023 Clause 5.3.6
Shearing	BS1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available upon request	

QUALITY ASSURANCE	
Template Issue	1.0
Filename	J11302 \ Batch 4_CTX-4-6_CTX22
Processed by Date	HJ 11/03/2016
Checked by Date	PH 15/03/2016
Approved by Date	PH 15/03/2016

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-6
Unit	E5b (Tongeren)
Test number	CTX22

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SATURATION		
Pressure increments applied	[kPa]	Drained ramp with subsequent 100 kPa increments
Differential pressure used	[kPa]	10
Cell pressure	[kPa]	1200
Base PWP	[kPa]	1177
Mid height PWP	[kPa]	-
B value achieved	[-]	0.96

CONSOLIDATION: ISOTROPIC		
Cell pressure	[kPa]	1577
Back pressure	[kPa]	1177
Base PWP	[kPa]	1177
Mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	400
Effective axial pressure	[kPa]	400
Deviator stress	[kPa]	0
Volumetric strain	[%]	2.25
External axial strain	[%]	0.68
Local axial strain	[%]	-
Local radial strain	[%]	-
Moisture content	[%]	22.8
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.604
Degree of saturation	[%]	100

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-6
Unit	E5b (Tongeren)
Test number	CTX22

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

STRESS-CONTROLLED CYCLIC LOADING STAGE		
Reference stress (deviator)	[kPa]	800
Mean q_{av}	[kPa]	0
Mean q_{cy}	[kPa]	96
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	38
External ε_{av} at N_f	[%]	-1.74
External ε_{cy} at N_f	[%]	1.90
Local ε_{av} at N_f	[%]	-
Local ε_{cy} at N_f	[%]	-
Δ base PWP at N_f	[kPa]	305
Δ mid height PWP at N_f	[kPa]	-
Moisture content	[%]	22.8
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65
Void ratio	[-]	0.604
Degree of saturation	[%]	100

Cycle (N)	ε_{av} [%]	ε_{cy} [%]	E_{ext} [MPa]	E_{loc} [MPa]	λ_{ext} [%]	λ_{loc} [%]
1	0.00	0.05	187.51	-	9.41	-
2	-0.01	0.05	202.54	-	7.06	-
5	-0.01	0.05	196.92	-	6.06	-
10	-0.02	0.05	183.47	-	6.21	-
15	-0.02	0.06	170.05	-	6.69	-
20	-0.03	0.06	155.63	-	7.46	-
25	-0.04	0.07	138.91	-	8.65	-
30	-0.05	0.08	115.92	-	10.73	-
35	-0.11	0.14	71.03	-	16.41	-
38	-1.74	1.90	4.98	-	25.86	-

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-6
Unit	E5b (Tongeren)
Test number	CTX22

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SHEARING STAGE		
Initial effective radial pressure	[kPa]	0
Initial effective axial pressure	[kPa]	1
Rate of strain	[%/hour]	4.42
At peak deviator stress		
Corrected deviator stress	[kPa]	234
Membrane correction applied	[kPa]	2
Drain correction applied	[kPa]	0
External axial strain	[%]	20.73
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	316
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	83
Effective axial pressure	[kPa]	317
Principal effective stress ratio	[-]	3.81
ε_{50}	[%]	14.62
Secant modulus (E_{50}) at ε_{50}	[kPa]	541
At peak principal effective stress ratio		
Corrected deviator stress	[kPa]	5
Membrane correction applied	[kPa]	0
Drain correction applied	[kPa]	0
External axial strain	[%]	1.03
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	398
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	0
Effective axial pressure	[kPa]	5
Principal effective stress ratio	[-]	489.32
At 10% external axial strain		
Corrected deviator stress	[kPa]	45
Membrane correction applied	[kPa]	1
Drain correction applied	[kPa]	0
External axial strain	[%]	9.99
Local axial strain	[%]	-
Local radial strain	[%]	-
Excess base PWP	[kPa]	386
Excess mid height PWP	[kPa]	-
Effective radial pressure	[kPa]	13
Effective axial pressure	[kPa]	57
Principal effective stress ratio	[-]	4.49

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-6
Unit	E5b (Tongeren)
Test number	CTX22

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

SPECIMEN PHOTOGRAPHS



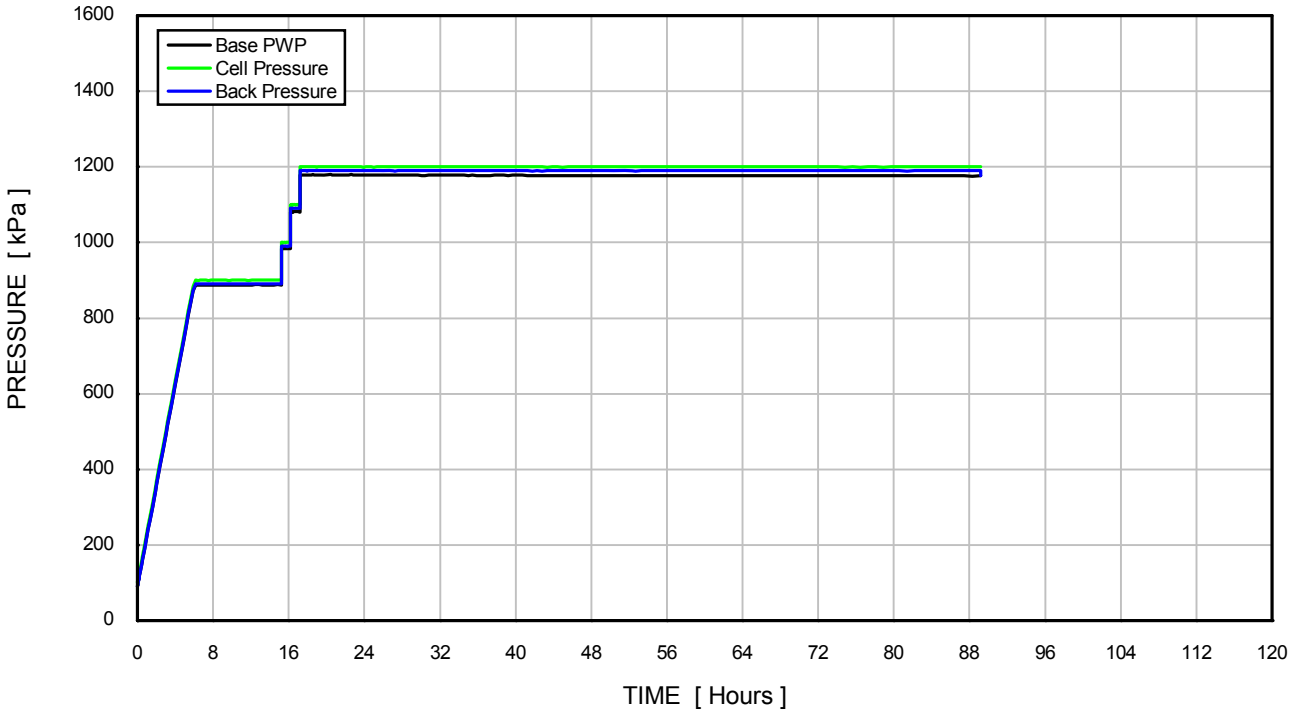


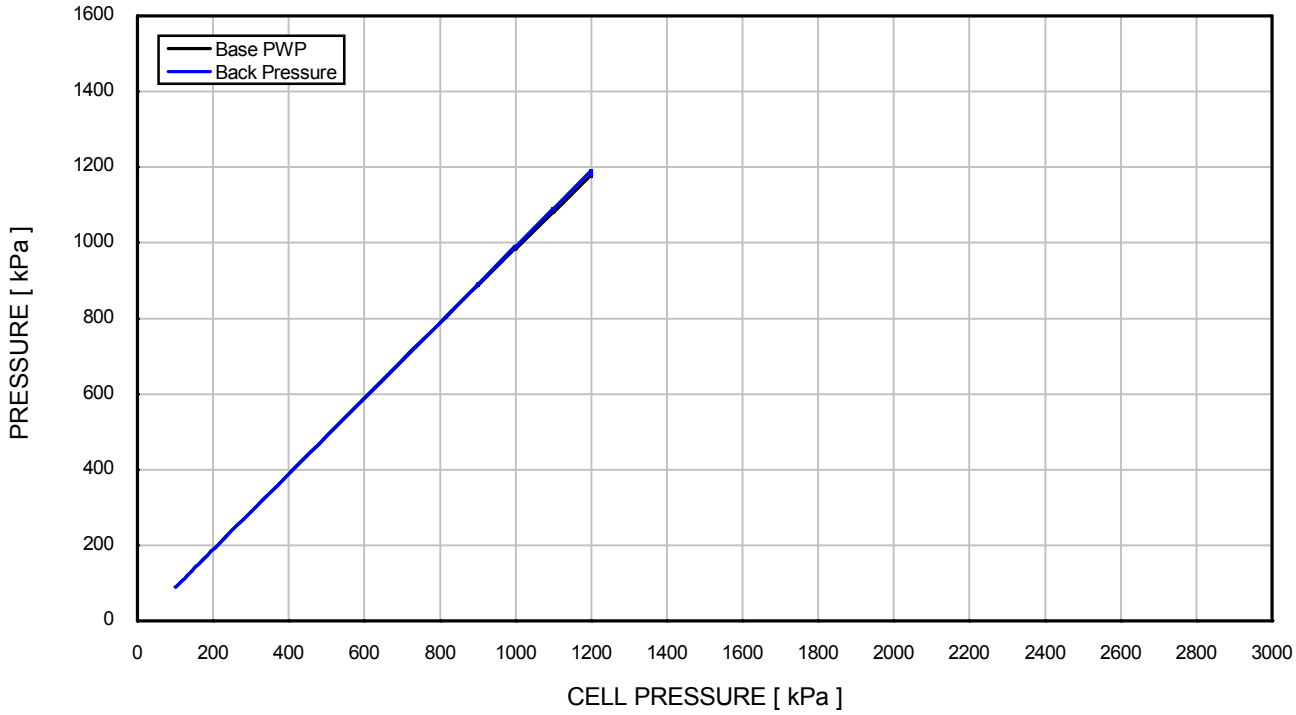
FINAL CONDITIONS		
Moisture content	[%]	22.8
Bulk density	[Mg/m³]	2.03
Dry density	[Mg/m³]	1.65

TEST IDENTIFICATION	
Batch	4
Sample	CTX_4-6
Unit	E5b (Tongeren)
Test number	CTX22

SUMMARY OF ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST

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

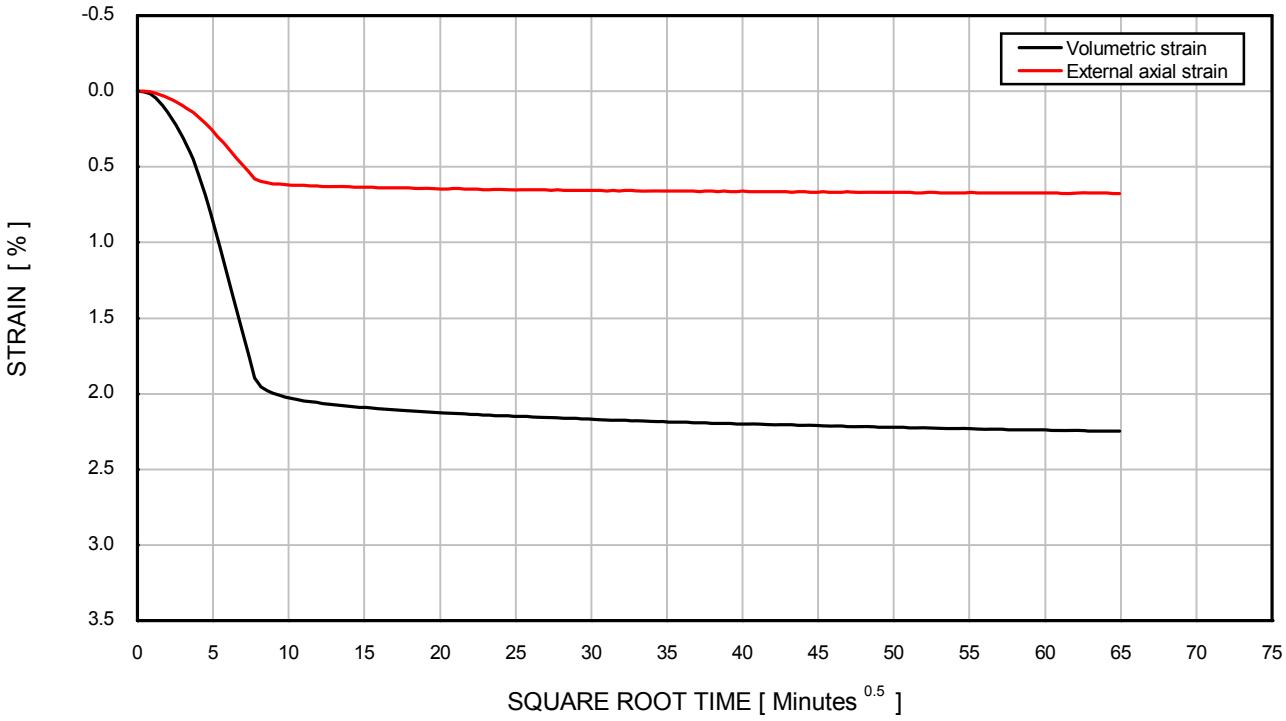


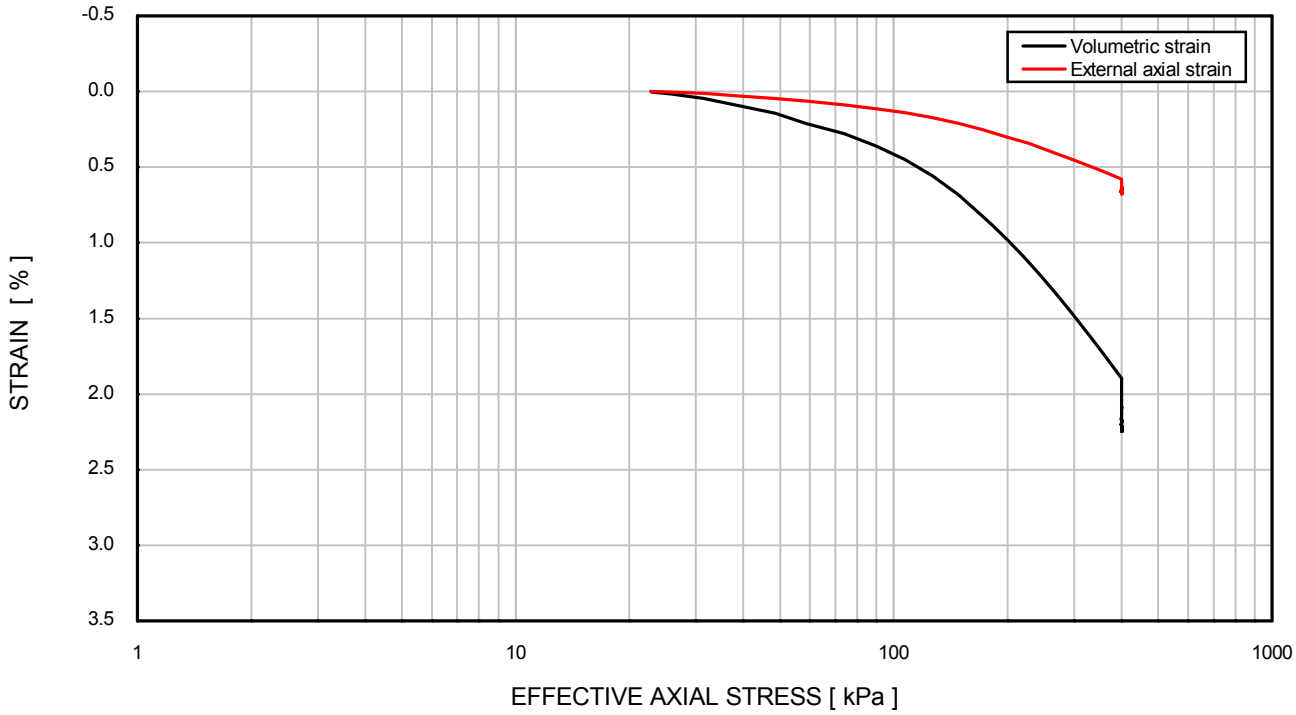


B value	:	0.96			
Initial σ'_r	:	10	kPa	Batch	: 4
Initial σ'_a	:	10	kPa	Sample	: CTX_4-6
Final σ'_r	:	23	kPa	Unit	: E5b (Tongeren)
Final σ'_a	:	23	kPa	Test No.	: CTX22

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SATURATION STAGE - DRAINED

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

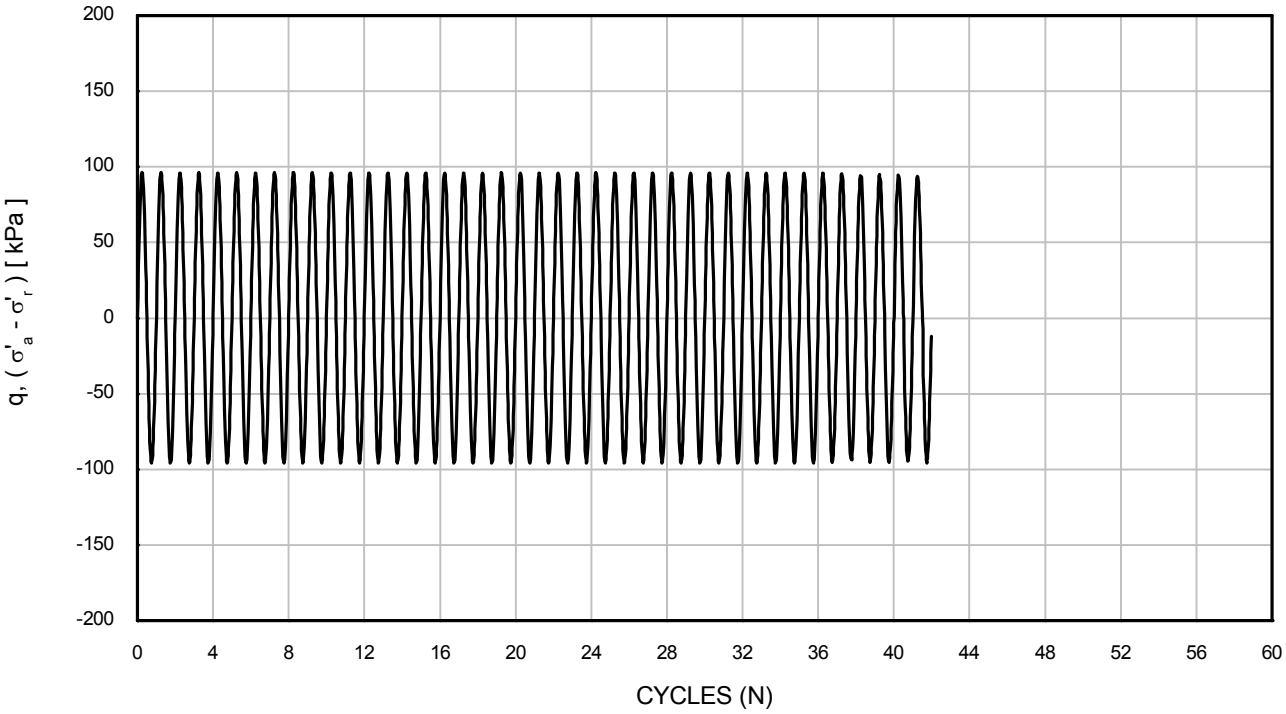


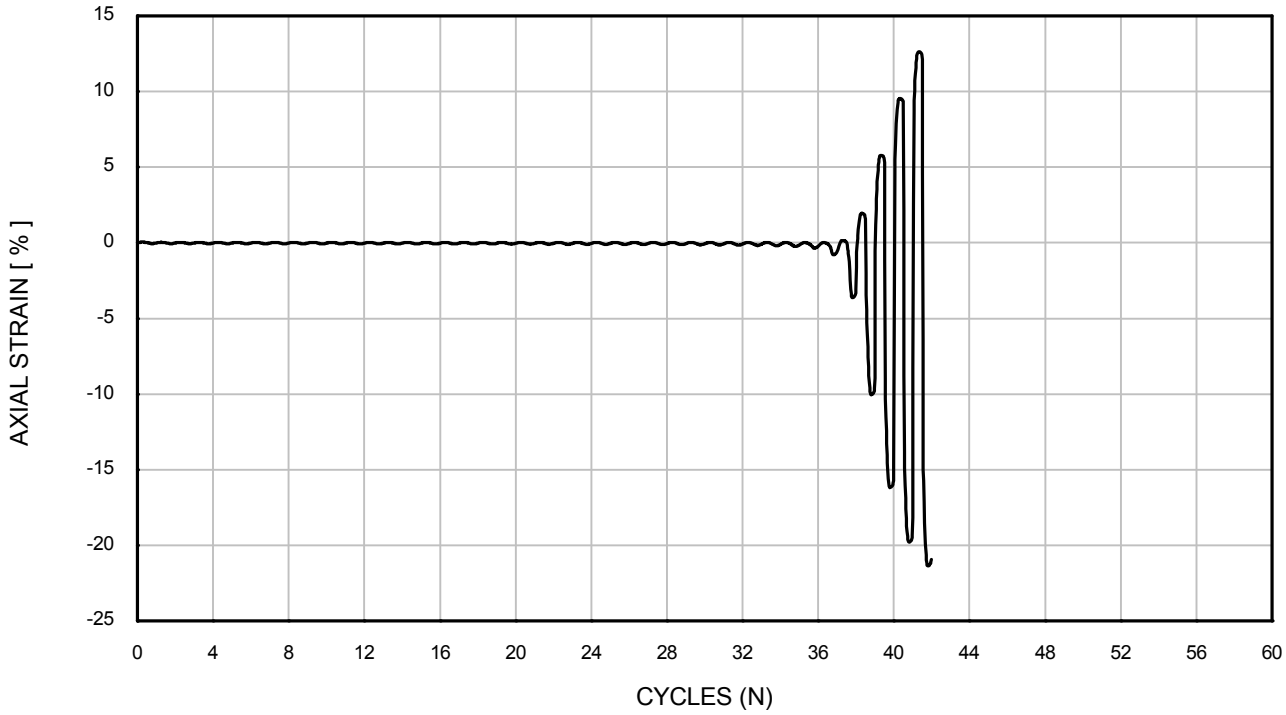


σ'_{rc}	: 400 kPa	Batch	: 4
σ'_{ac}	: 400 kPa	Sample	: CTX_4-6
		Unit	: E5b (Tongeren)
		Test No.	: CTX22

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
ISOTROPIC CONSOLIDATION STAGE

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

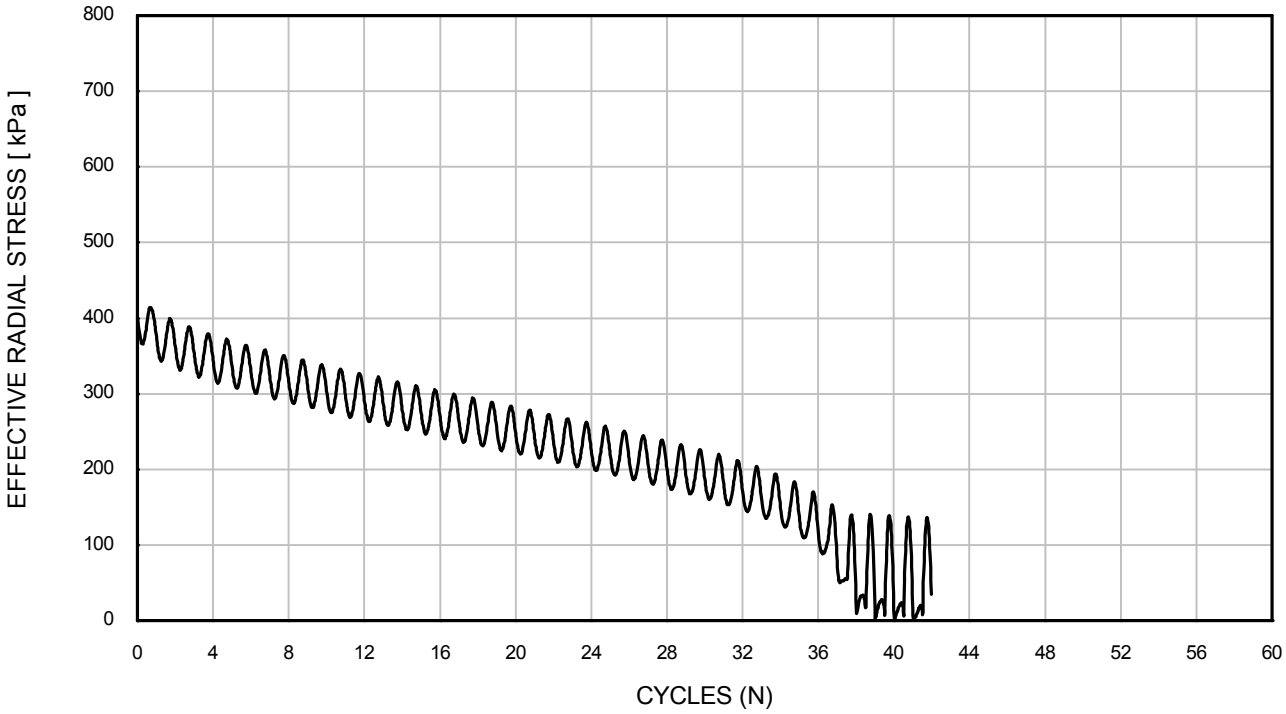


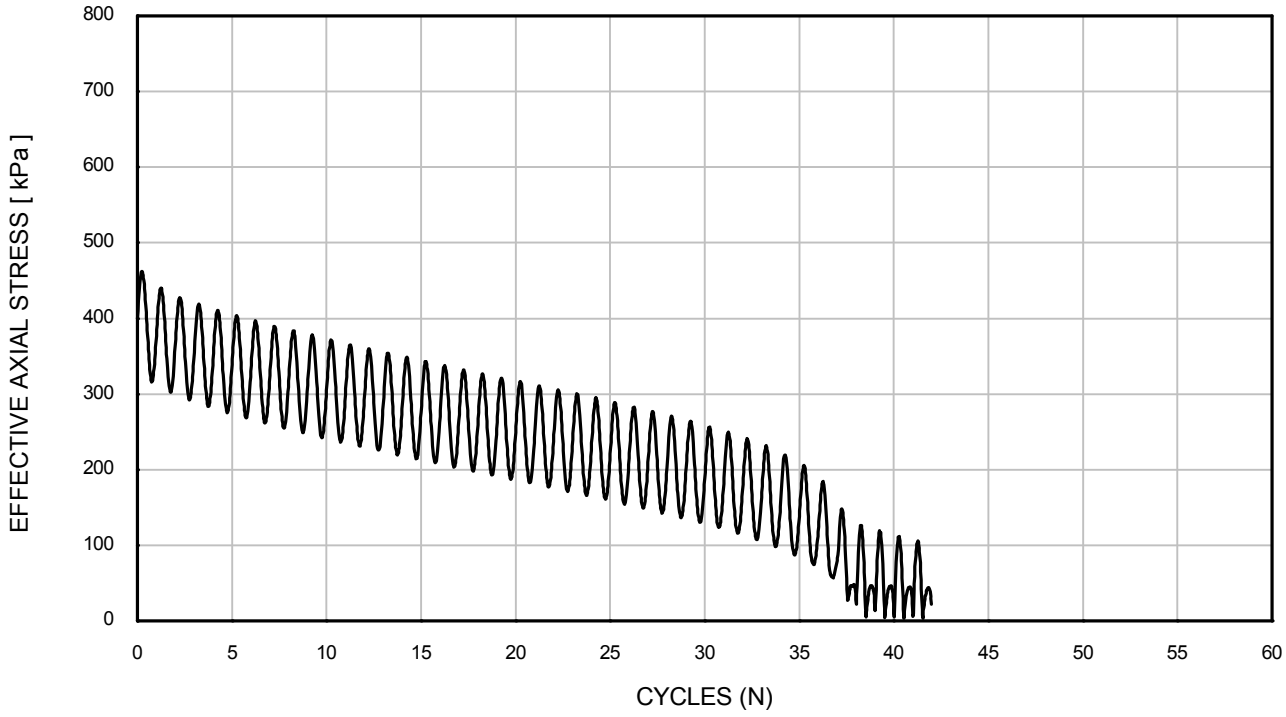


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-6
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	96 kPa	Test No.	:	CTX22
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

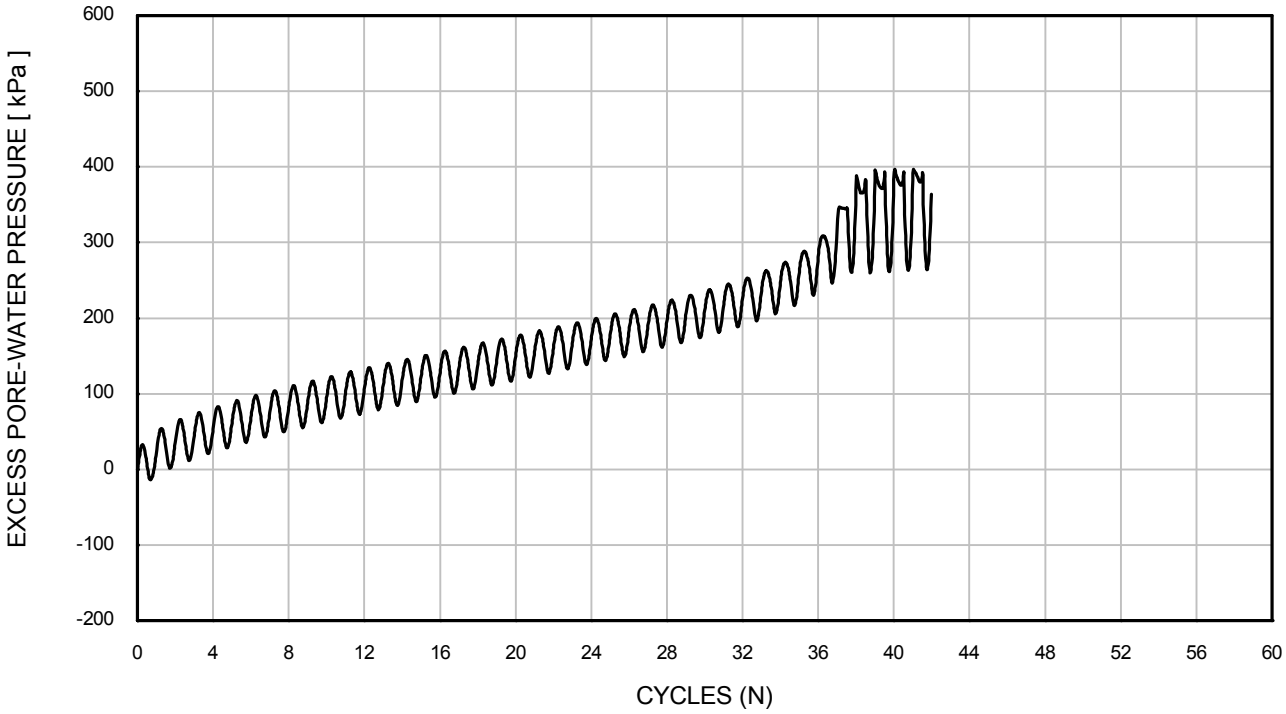


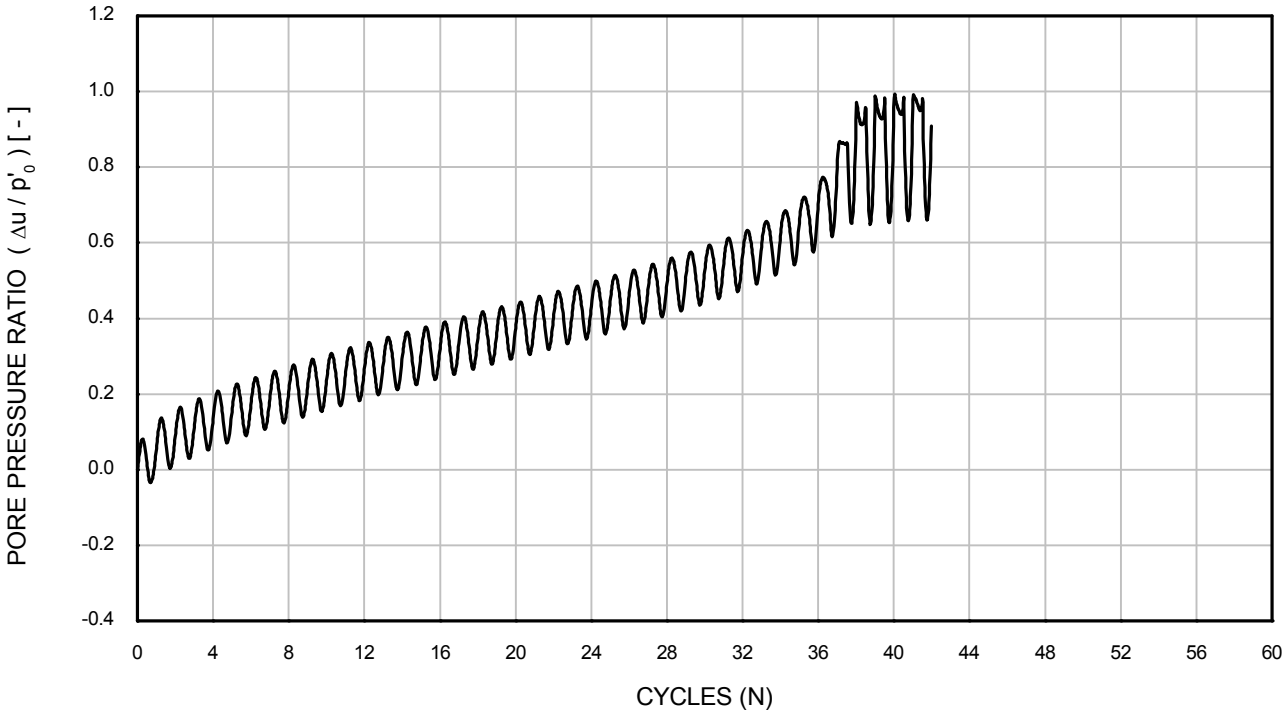


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-6
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	96 kPa	Test No.	:	CTX22
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

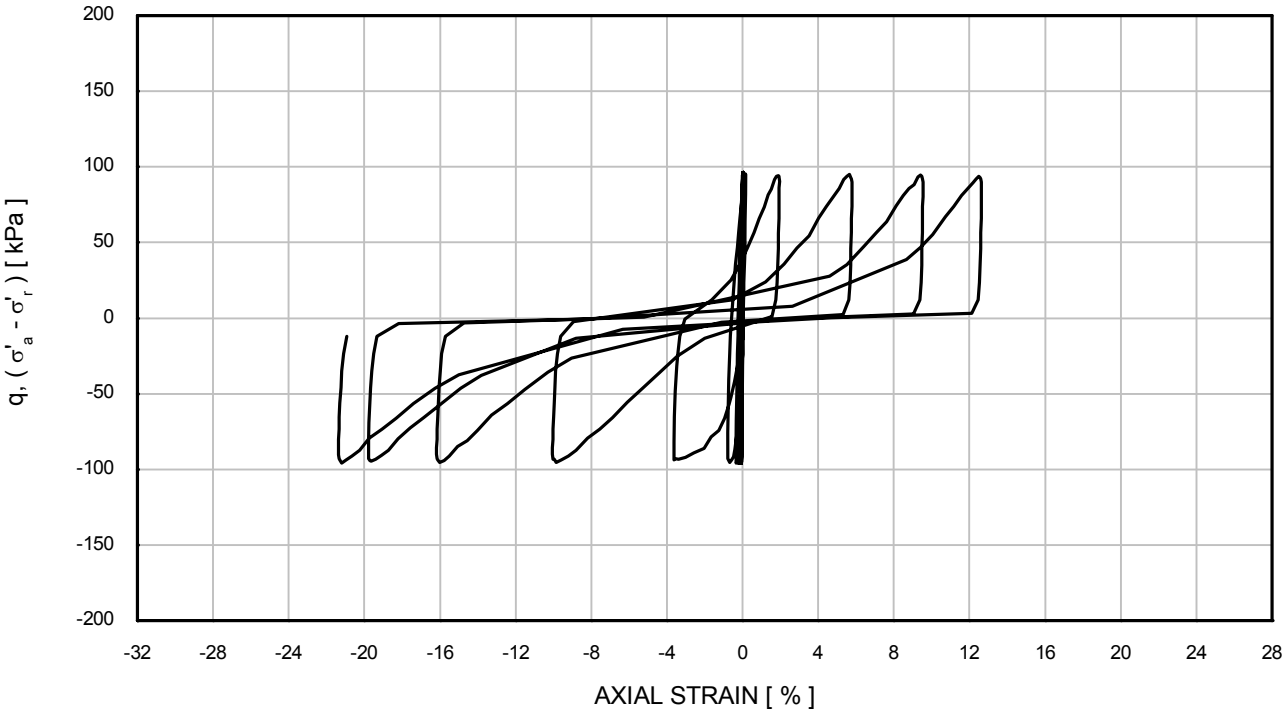


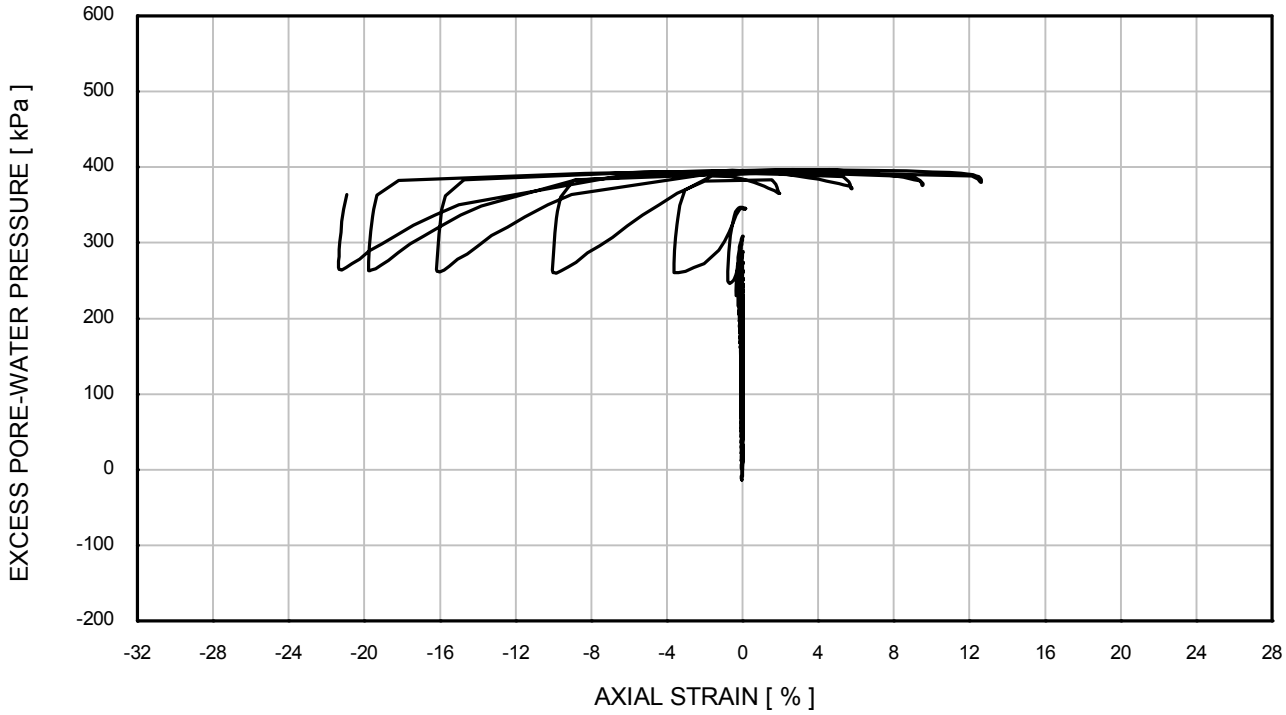


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-6
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	96 kPa	Test No.	:	CTX22
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

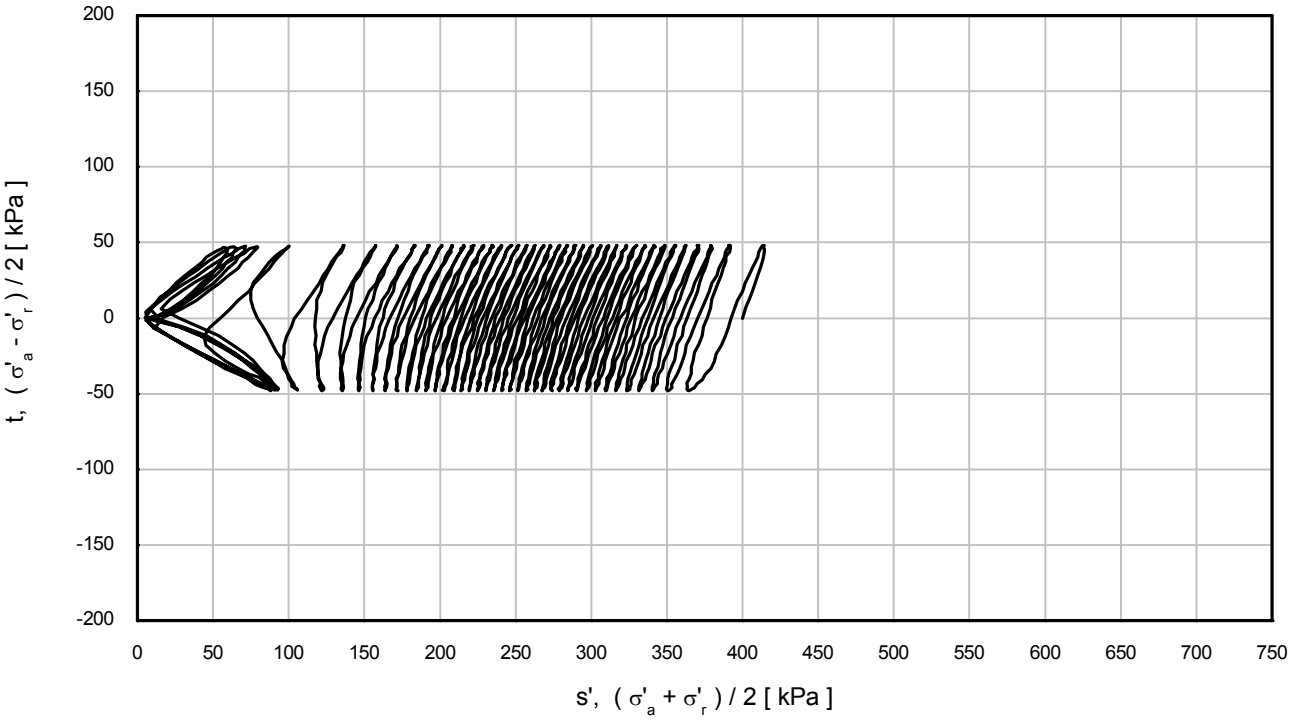


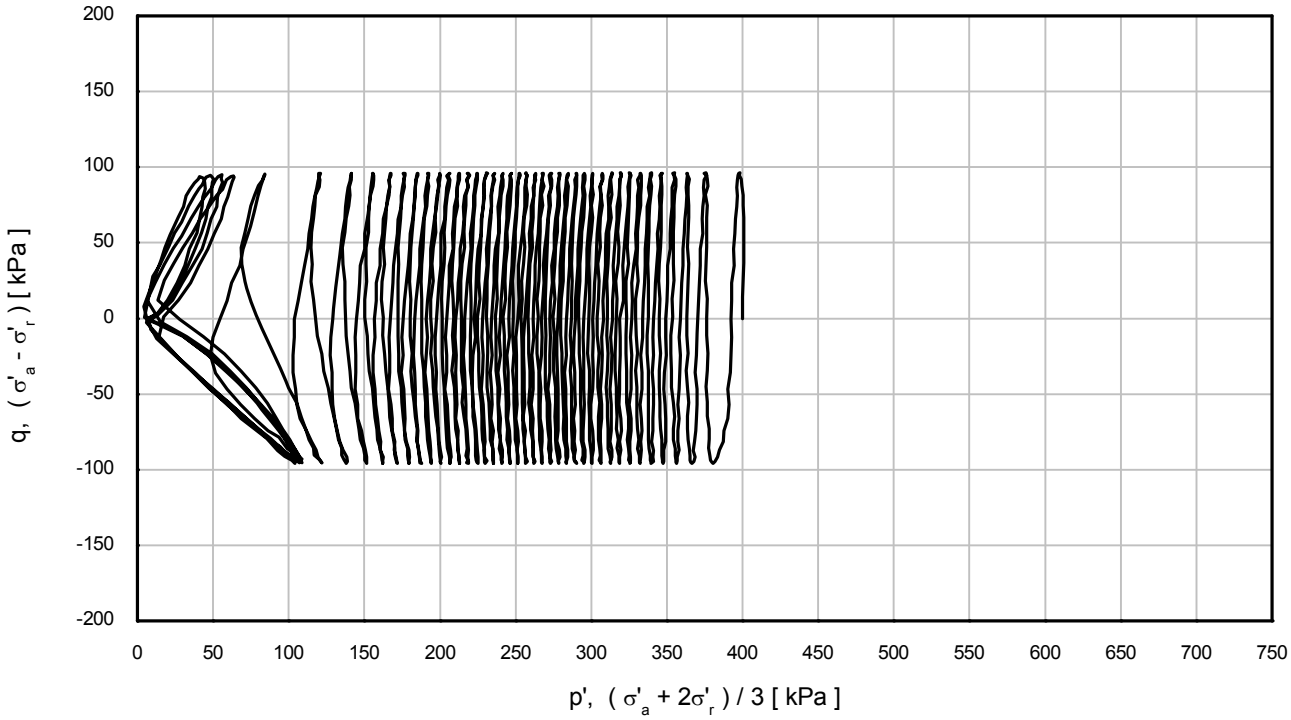


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-6
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	96 kPa	Test No.	:	CTX22
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

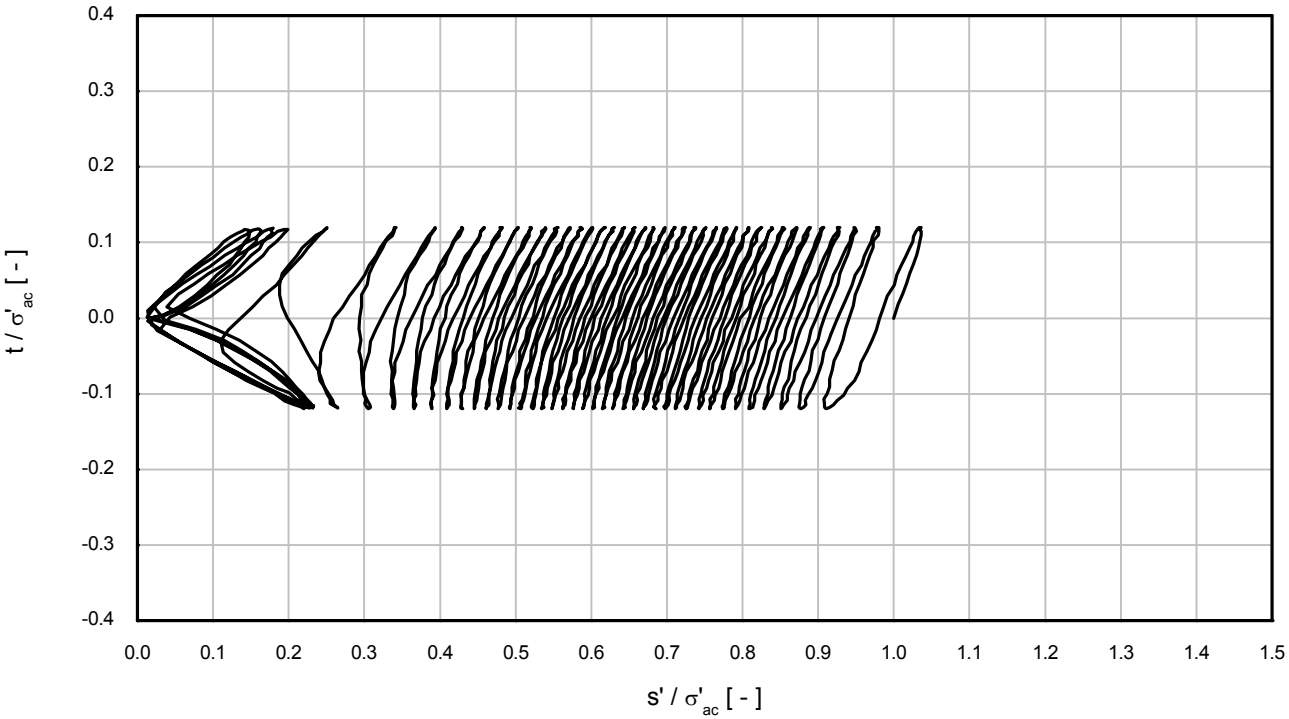


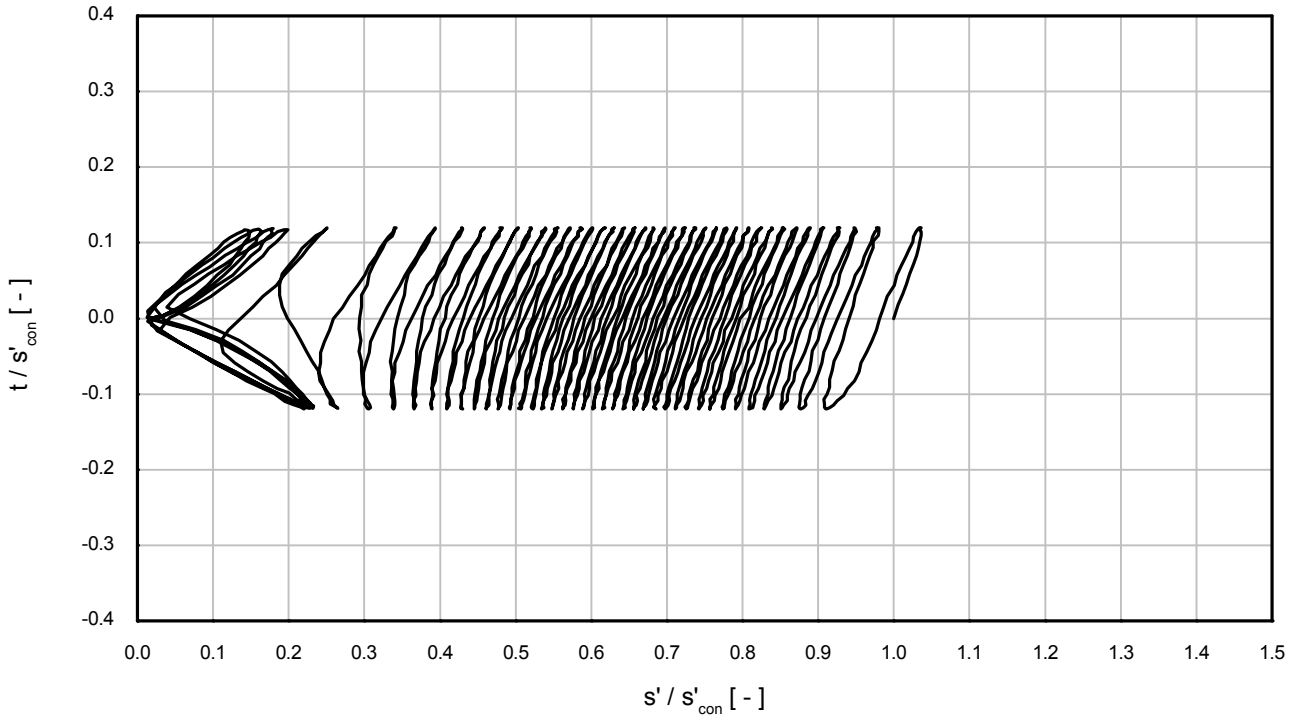


Initial σ'_r	:	400	kPa	Batch	: 4
Initial σ'_a	:	400	kPa	Sample	: CTX_4-6
q_{av}	:	0	kPa	Unit	: E5b (Tongeren)
q_{cy}	:	96	kPa	Test No.	: CTX22
Frequency	:	0.10	Hz		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

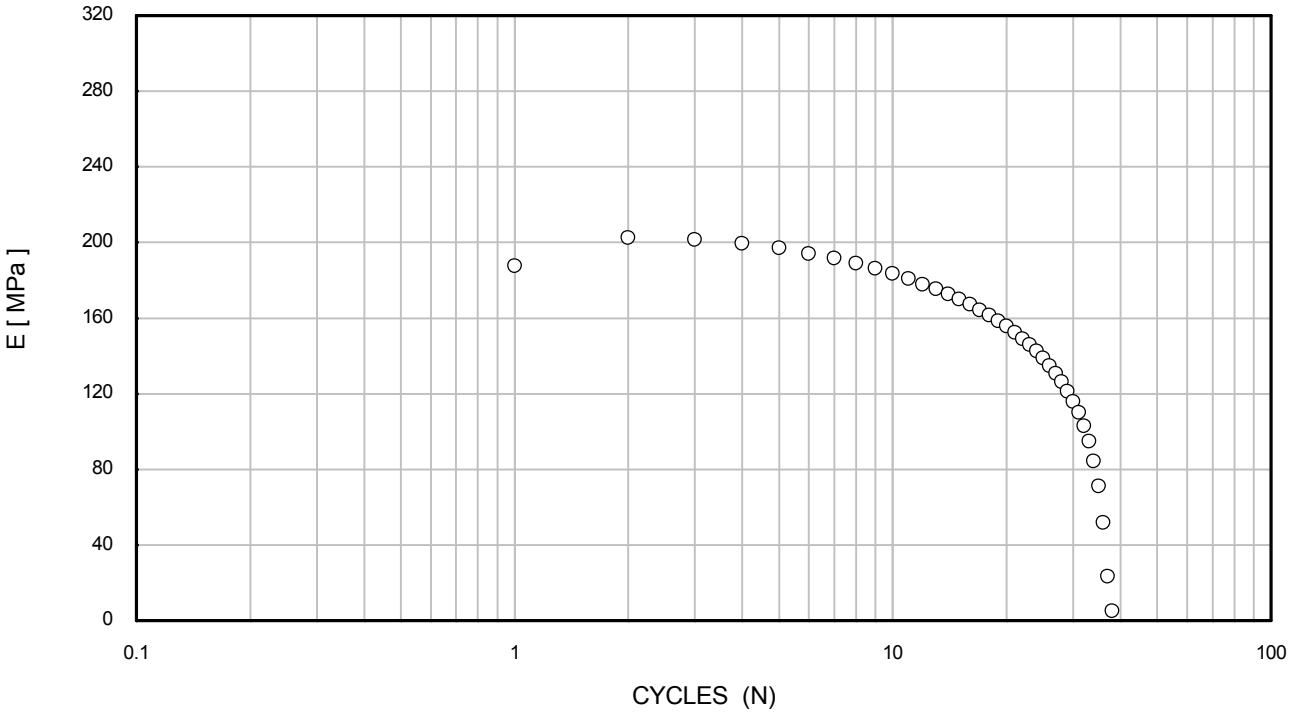


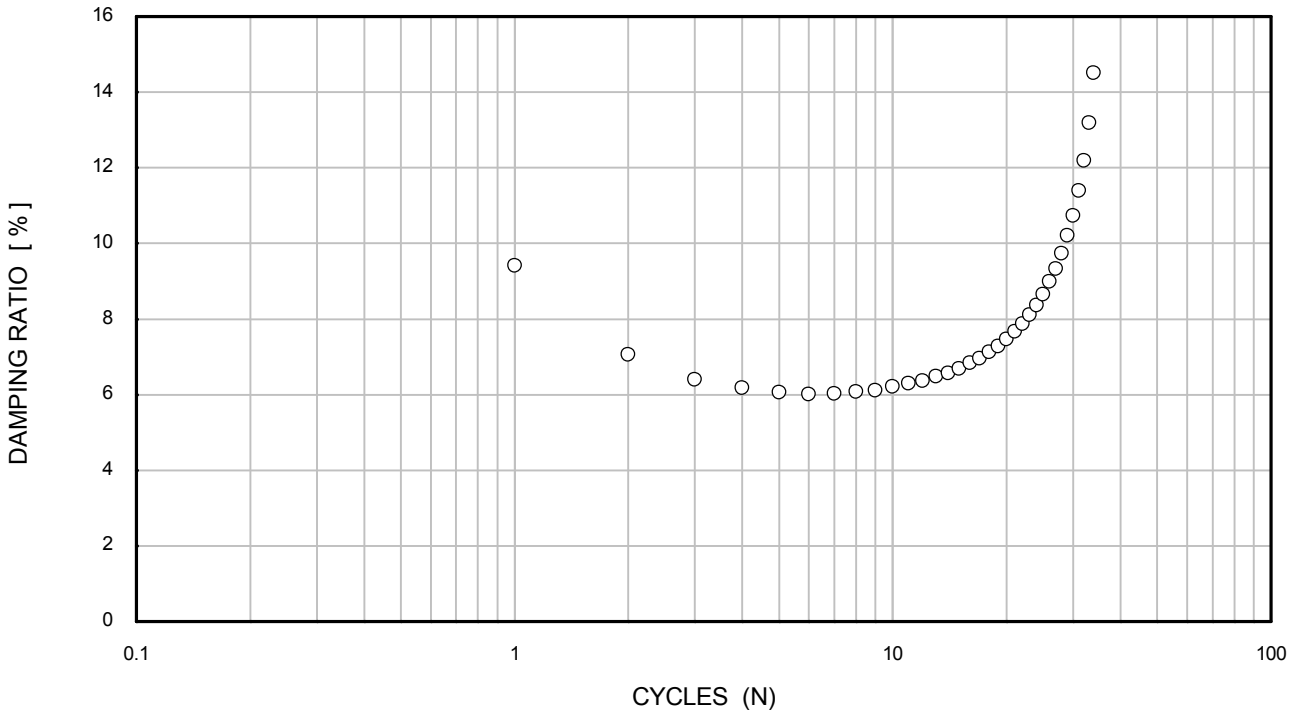


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-6
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	96 kPa	Test No.	:	CTX22
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

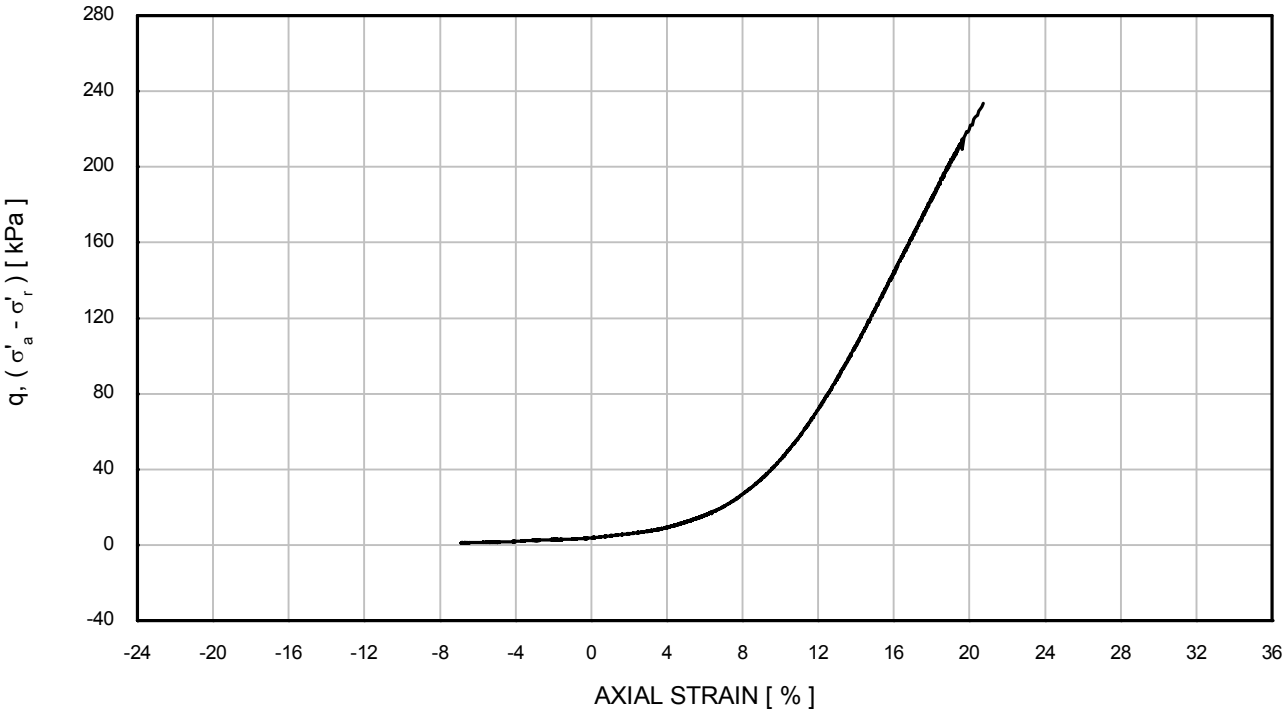


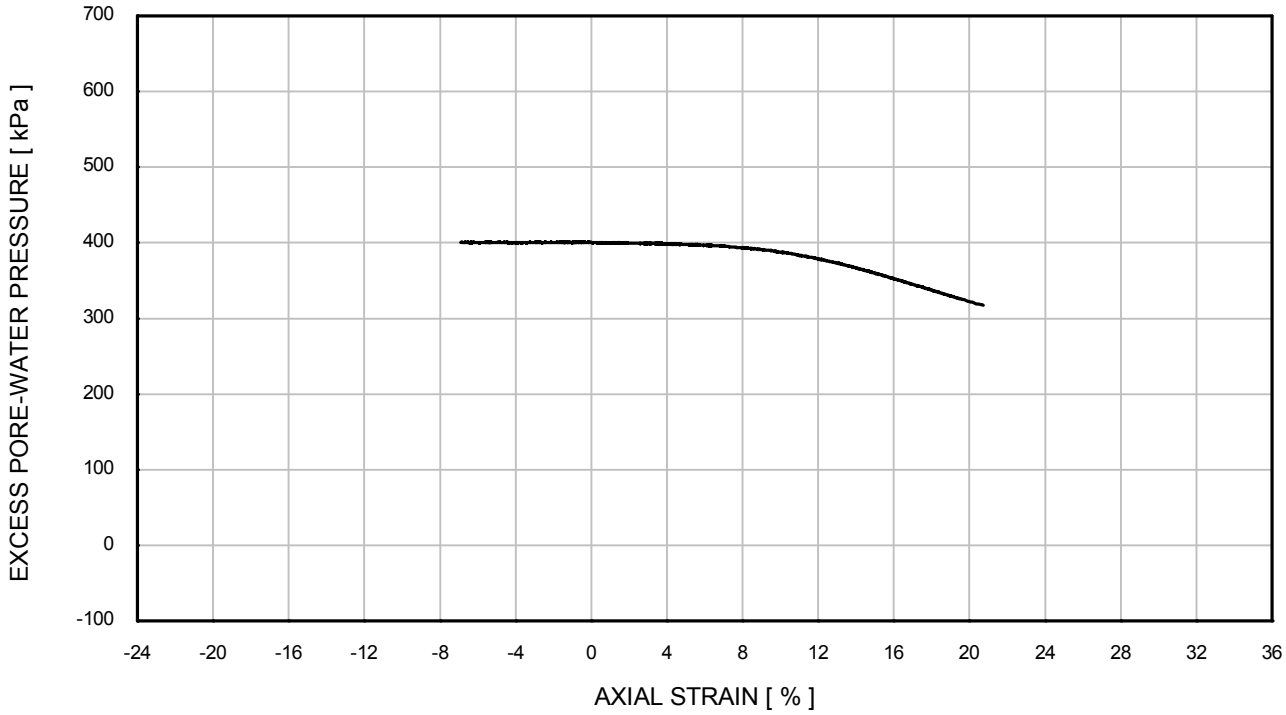


Initial σ'_r	:	400 kPa	Batch	:	4
Initial σ'_a	:	400 kPa	Sample	:	CTX_4-6
q_{av}	:	0 kPa	Unit	:	E5b (Tongeren)
q_{cy}	:	96 kPa	Test No.	:	CTX22
Frequency	:	0.10 Hz			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE - UNDRAINED

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

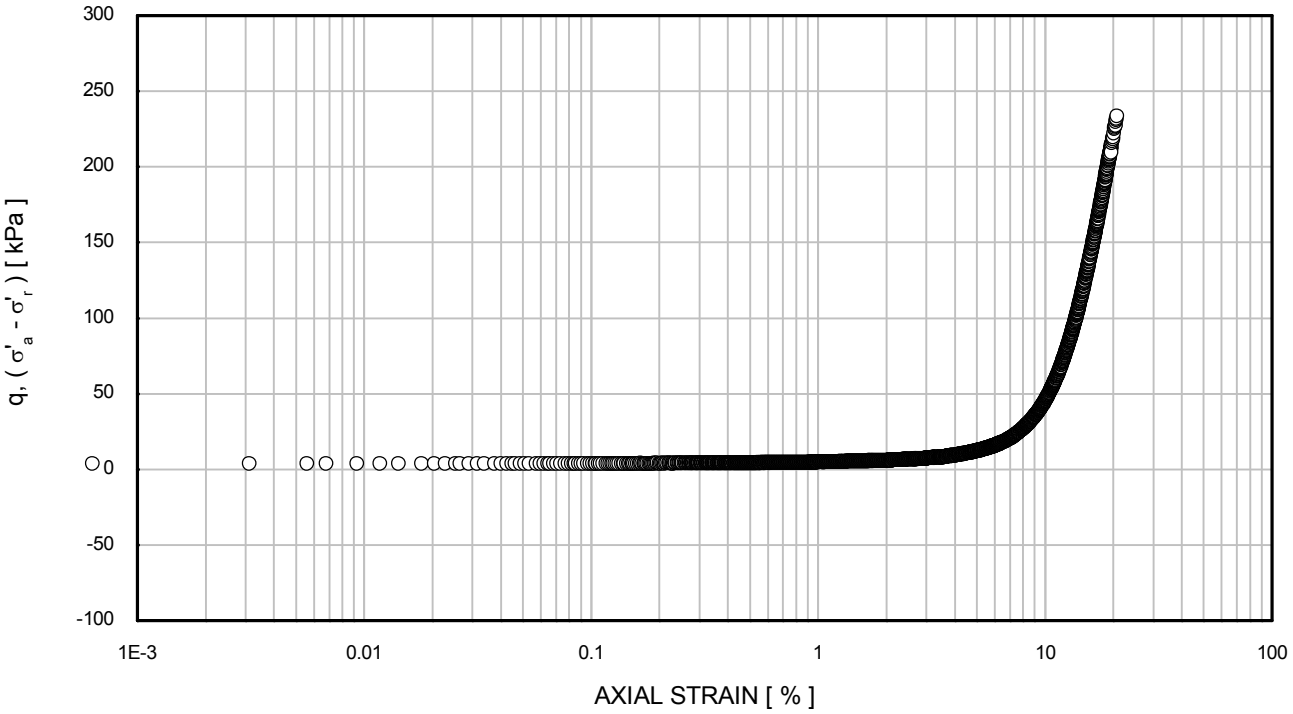


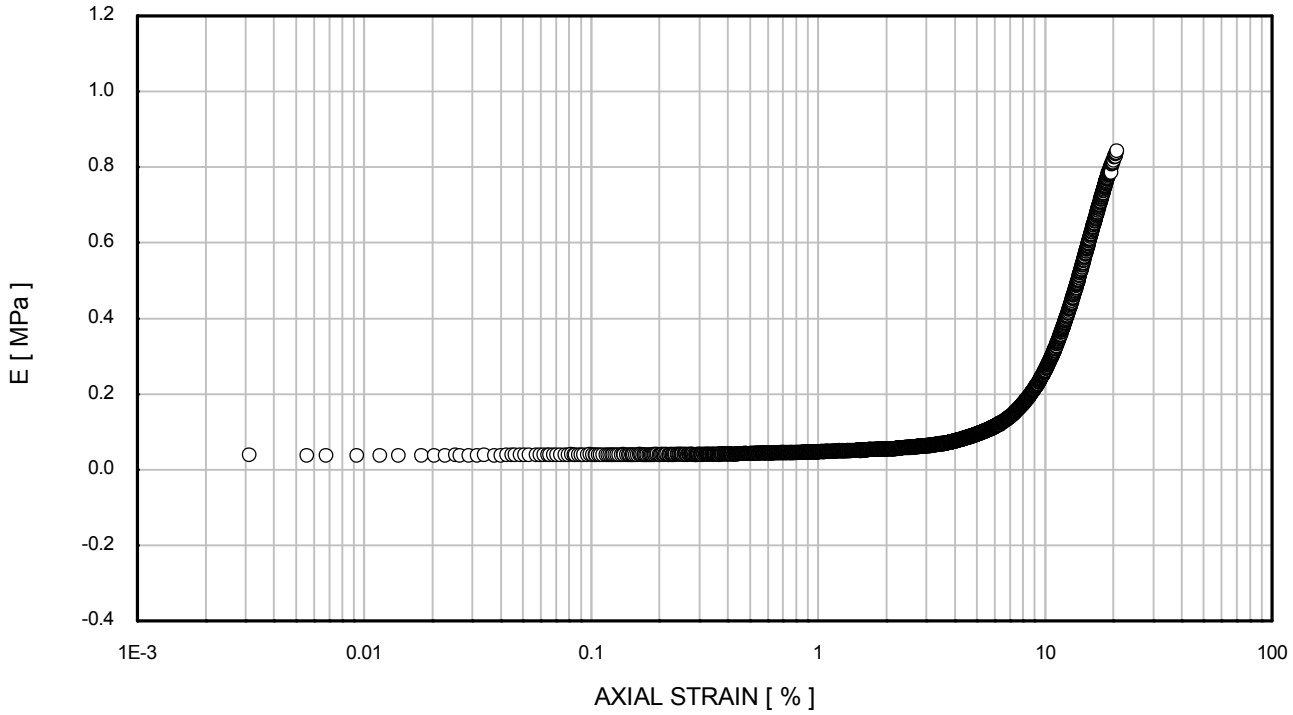


Initial σ'_r	:	0 kPa	Batch	:	4
Initial σ'_a	:	1 kPa	Sample	:	CTX_4-6
q_{peak}	:	234 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	20.73 %	Test No.	:	CTX22
Rate of strain	:	4.42 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

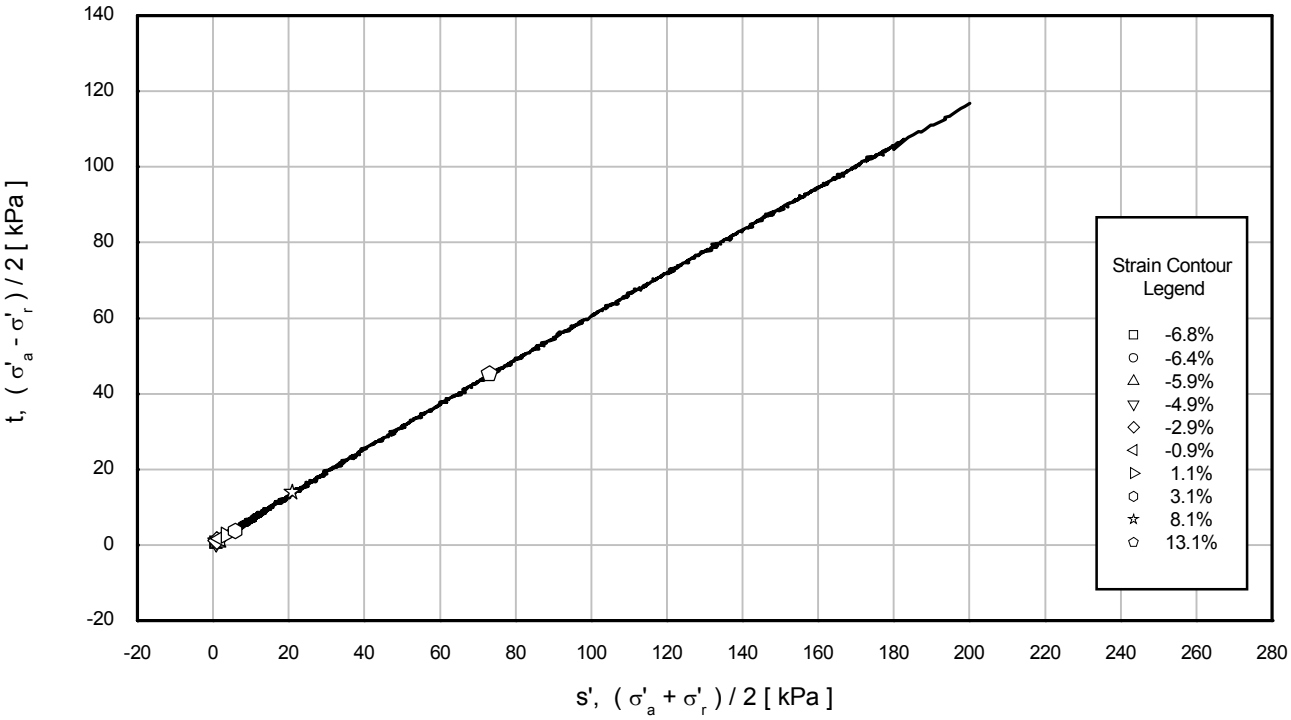


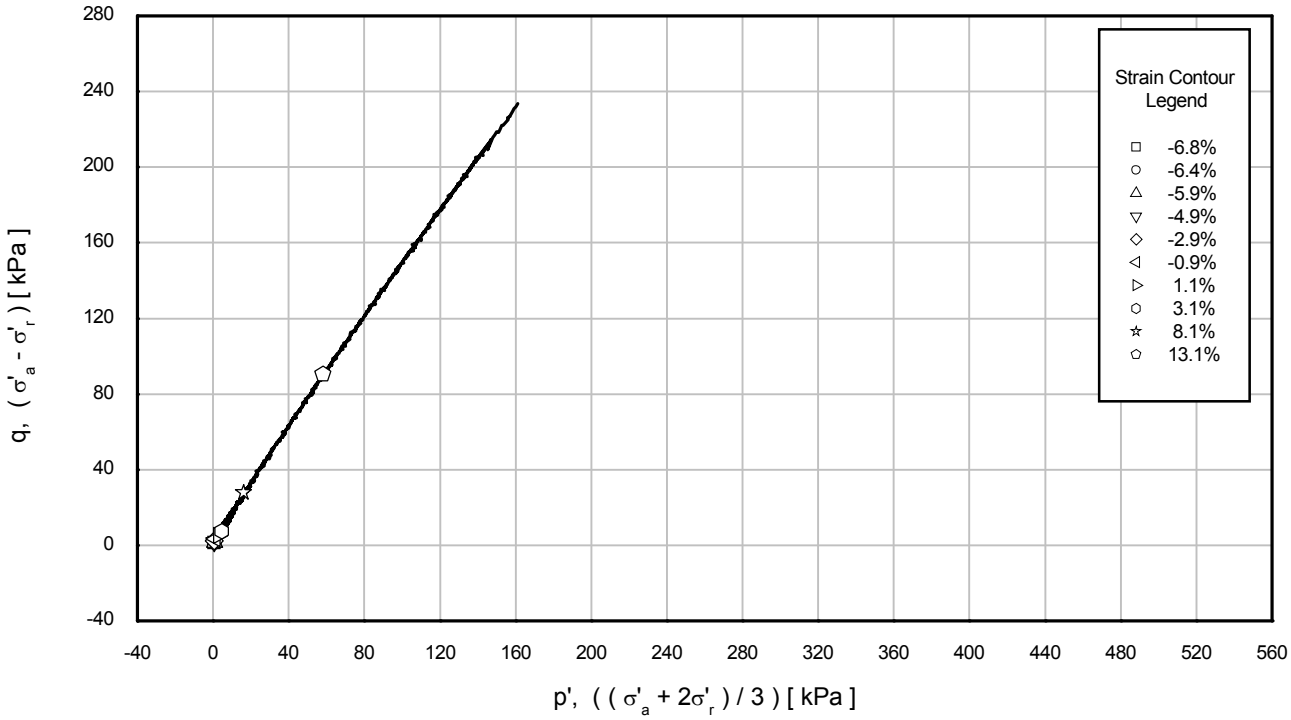


Initial σ'_r	:	0 kPa	Batch	:	4
Initial σ'_a	:	1 kPa	Sample	:	CTX_4-6
q_{peak}	:	234 kPa	Unit	:	E5b (Tongeren)
Ext. ε at q_{peak}	:	20.73 %	Test No.	:	CTX22
Rate of strain	:	4.42 %/hour			

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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





Initial σ'_r	:	0	kPa	Batch	: 4
Initial σ'_a	:	1	kPa	Sample	: CTX_4-6
q_{peak}	:	234	kPa	Unit	: E5b (Tongeren)
Ext. ε at q_{peak}	:	20.73	%	Test No.	: CTX22
Rate of strain	:	4.42	%/hour		

ISOTROPICALLY CONSOLIDATED CYCLIC TRIAXIAL TEST
SHEARING STAGE - UNDRAINED

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

SECTION A7: CYCLIC DIRECT SIMPLE SHEAR TESTS

LIST OF PLATES IN SECTION A7: Plate

Cyclic Direct Simple Shear Test - Cohesive Specimens	A7.1-1 to A7.1-144
Cyclic Direct Simple Shear Test - Cohesionless Specimens	A7.2-1 to A7.2-224

VISUAL DESCRIPTION
Very dark grey CLAY

GENERAL	
Date test started	04/12/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	30.0
Moisture content	[%]	33.1
Bulk density	[Mg/m³]	1.90
Dry density	[Mg/m³]	1.43
Void ratio	[-]	0.887
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	163
Pocket penetrometer	[kPa]	233
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_2WAXD_CSS01
Template issue	1.3
Processed by	GG
Date	09/12/2015
Checked by	LJ
Date	16/12/2015
Approved by	PH
Date	13/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.40
Test number	CSS01

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	799
Vertical strain	[%]	4.44
Bulk density	[Mg/m^3]	1.95
Dry density	[Mg/m^3]	1.50
Void ratio	[-]	0.804
Moisture content	[%]	30.0

CONSOLIDATION		
σ_{vc}	[kPa]	254
Vertical strain	[%]	3.93
Bulk density	[Mg/m^3]	1.94
Dry density	[Mg/m^3]	1.49
Void ratio	[-]	0.813
Moisture content	[%]	30.4

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	175
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	89
Frequency	[Hz]	0.10
Number of cycles applied (N)	[-]	1500
γ_{av} at N	[%]	-0.03
γ_{cy} at N	[%]	1.17
Shear induced -$\Delta\sigma_v$ at N	[kPa]	1
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.03	0.66	13.63	10.74
2	-0.02	0.71	12.70	11.08
5	-0.01	0.77	11.66	11.56
10	-0.01	0.81	11.02	11.99
20	-0.01	0.86	10.38	12.46
30	-0.01	0.90	10.02	12.63
40	-0.01	0.92	9.76	12.81
50	-0.01	0.94	9.59	13.00
100	-0.01	0.99	9.05	13.56
500	-0.03	1.11	8.07	14.18
1000	-0.03	1.15	7.77	14.32
1500	-0.03	1.17	7.65	14.45

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.40
Test number	CSS01

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	188
Shear strain	[%]	12.59
Shear induced $-\Delta\sigma_v$	[kPa]	-35
Vertical stress	[kPa]	289
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.98
At 15 % shear strain		
Shear stress	[kPa]	186
Shear induced $-\Delta\sigma_v$	[kPa]	-36
Vertical stress	[kPa]	290
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.40
Test number	CSS01

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

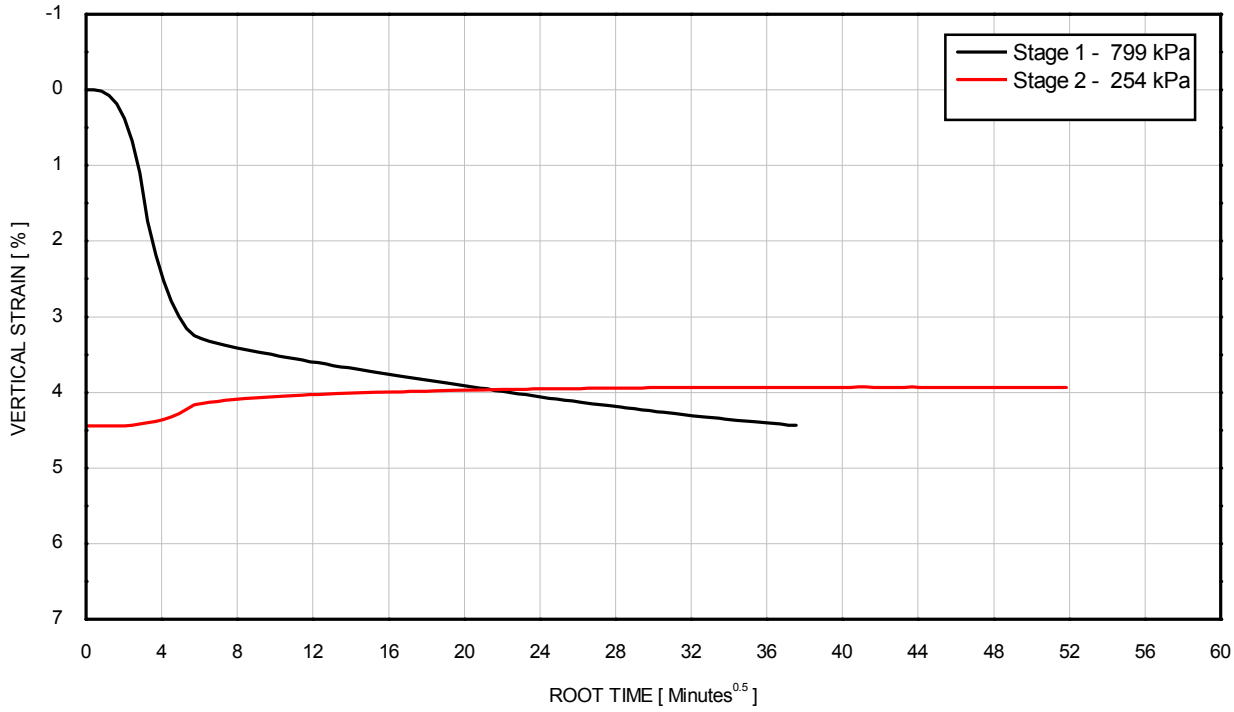
SPECIMEN PHOTOGRAPH

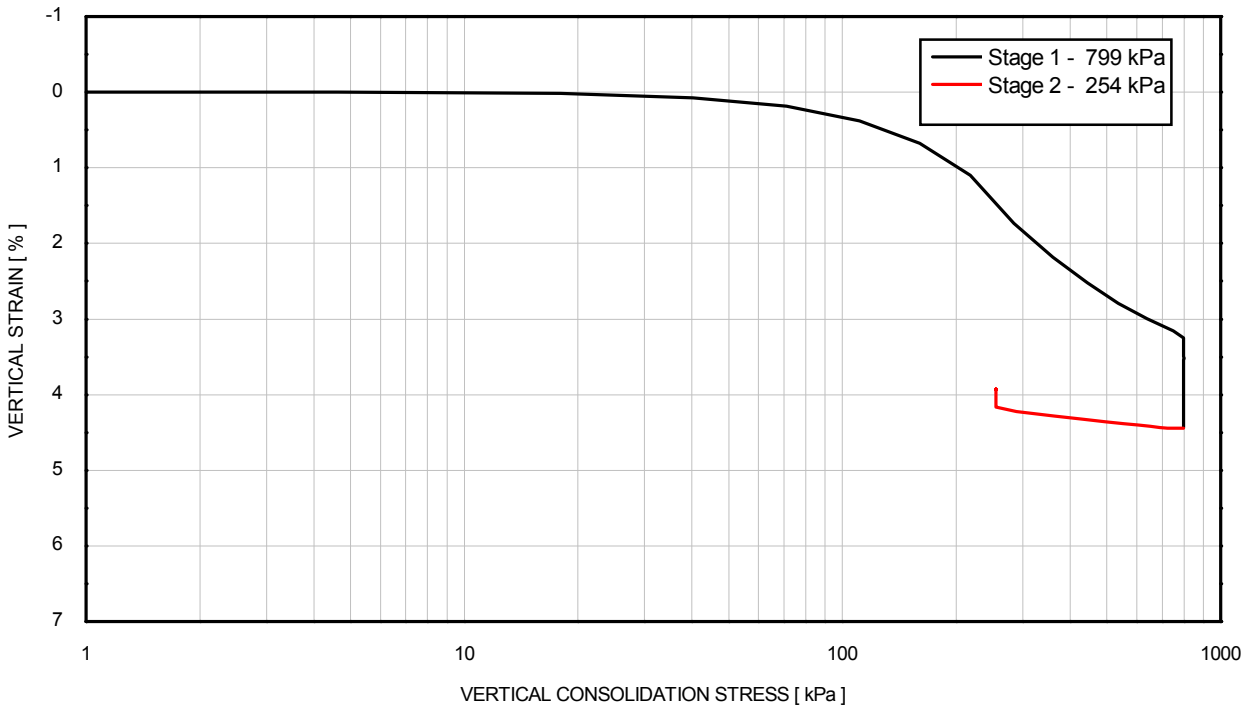


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.40
Test number	CSS01

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

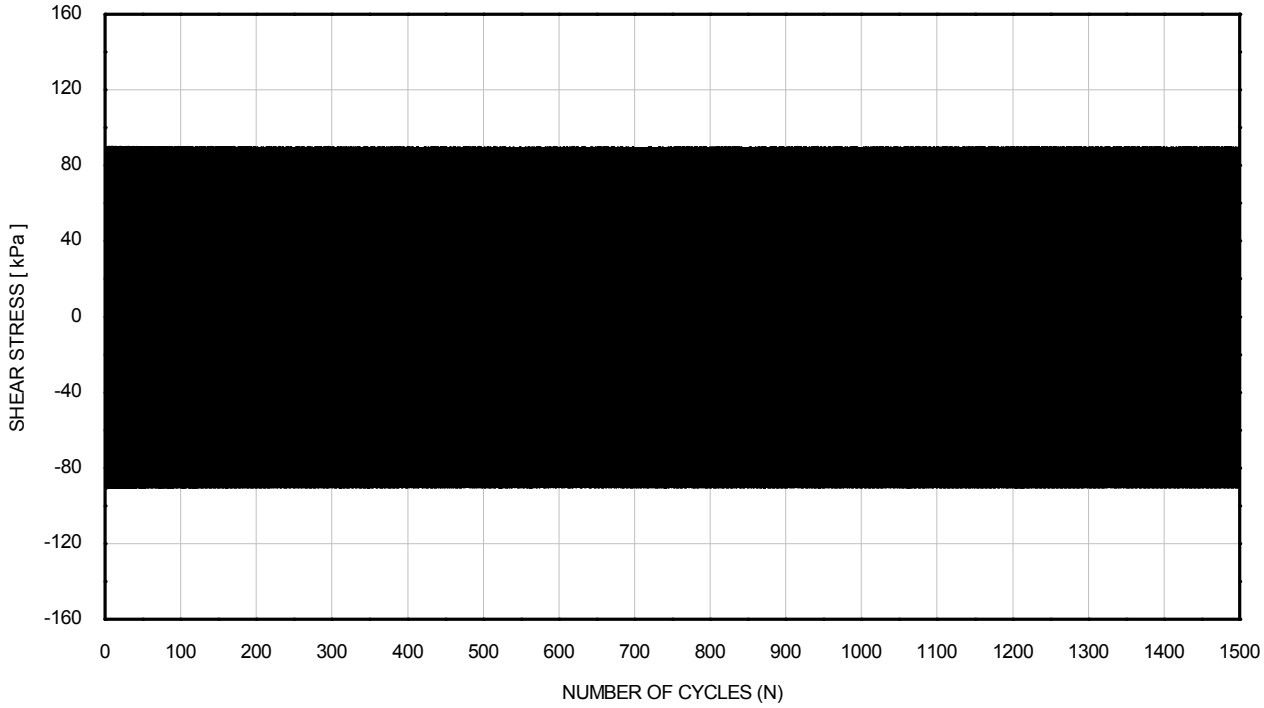


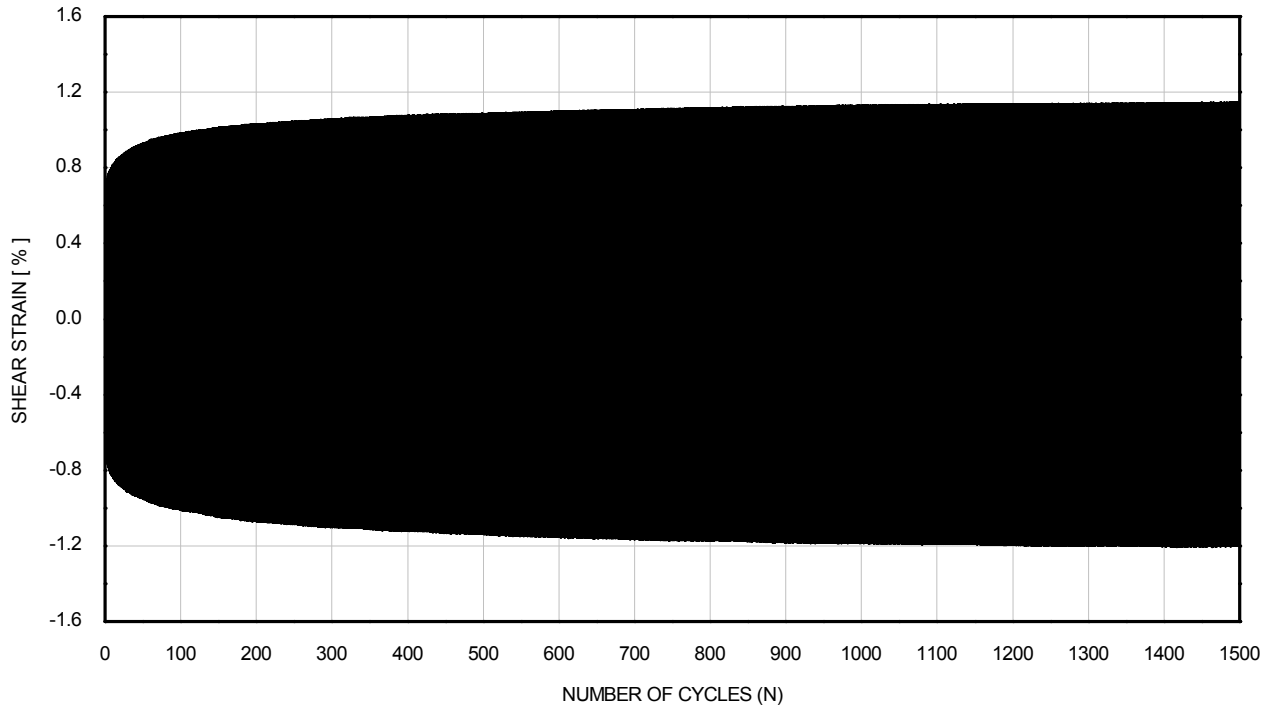


σ_{vc}	: 254 kPa	Borehole	: BH-WFS3-4A
		Sample	: 2WaxD
		Unit	: F1c (Dongen)
		Depth [m]	: 23.40
		Test No.	: CSS01

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

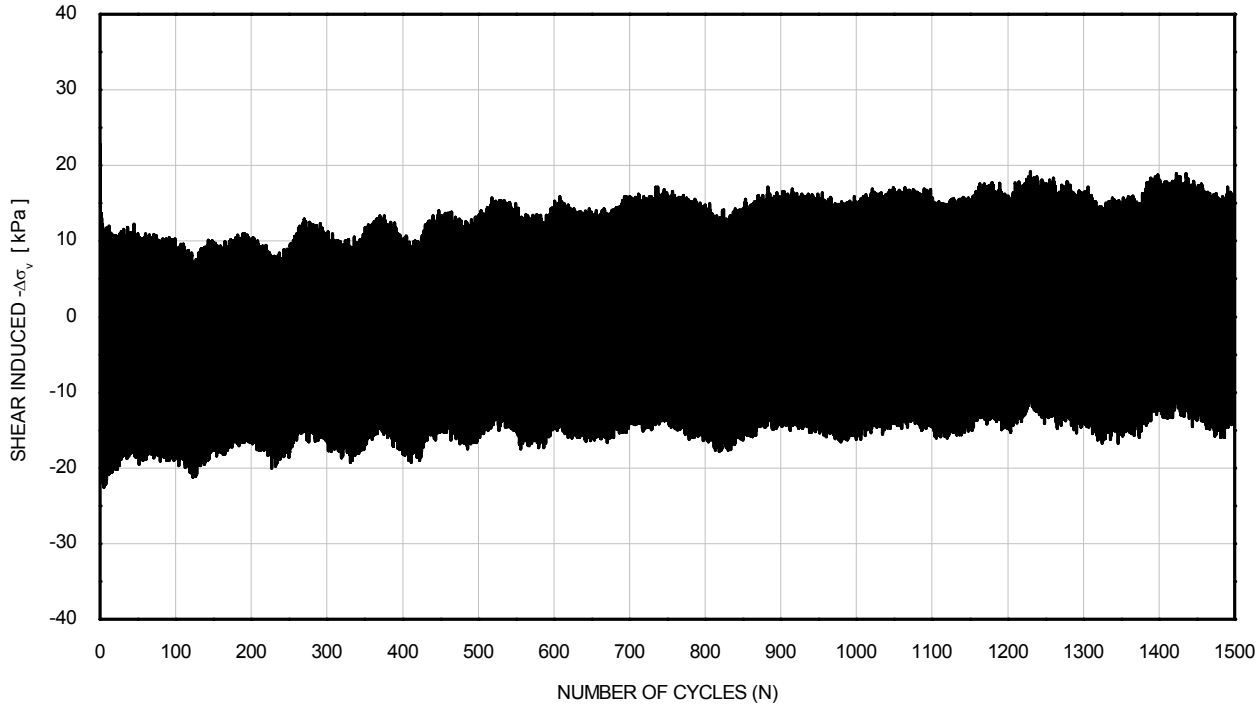


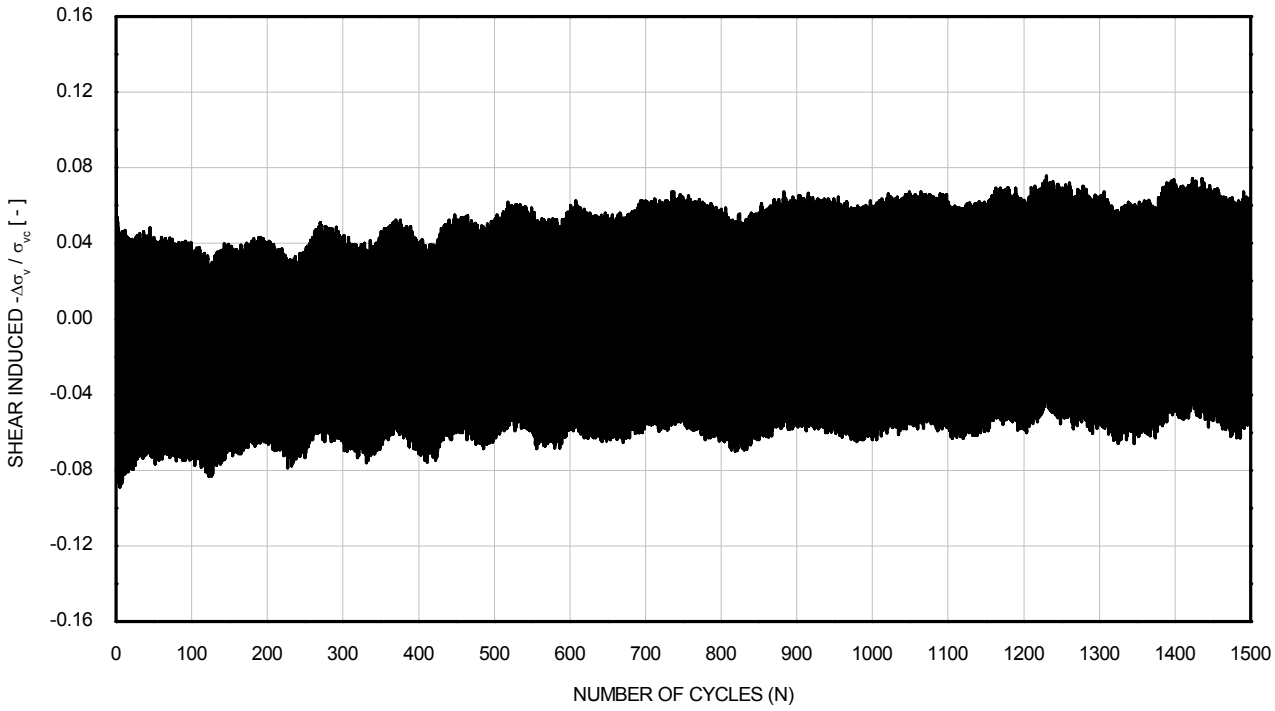


σ_{vc}	:	254 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	89 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.40
			Test No.	:	CSS01

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

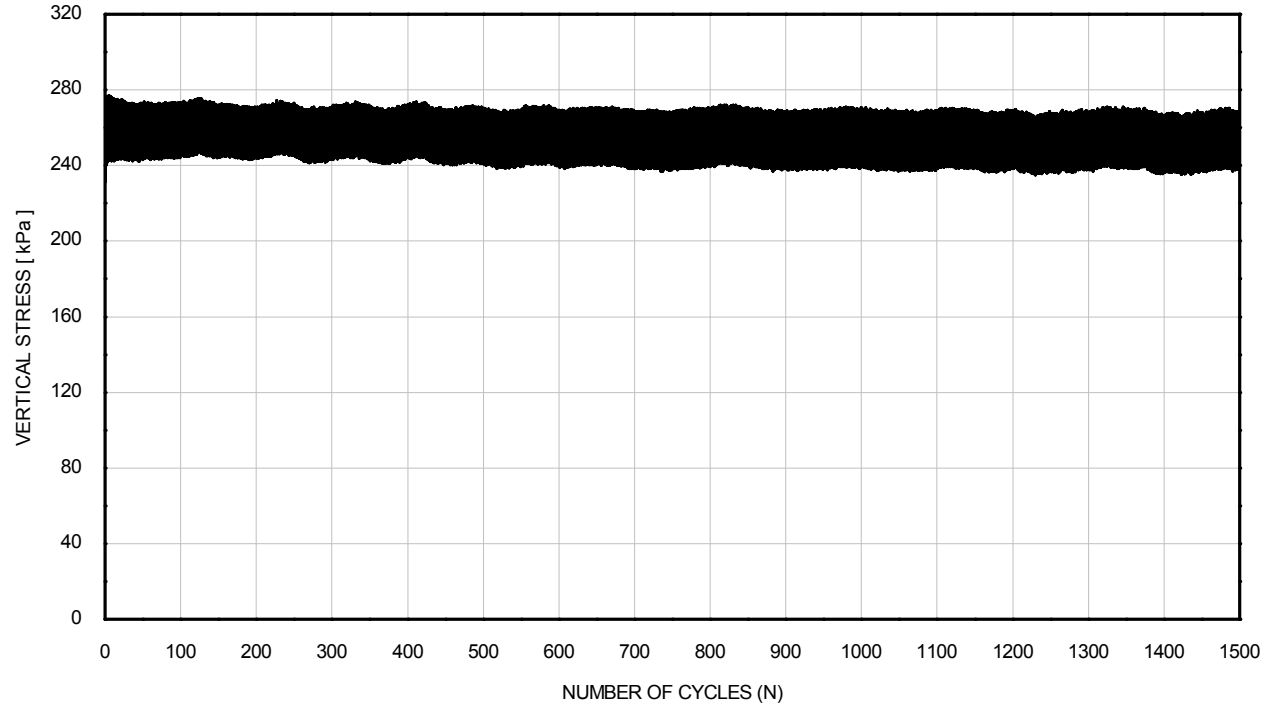


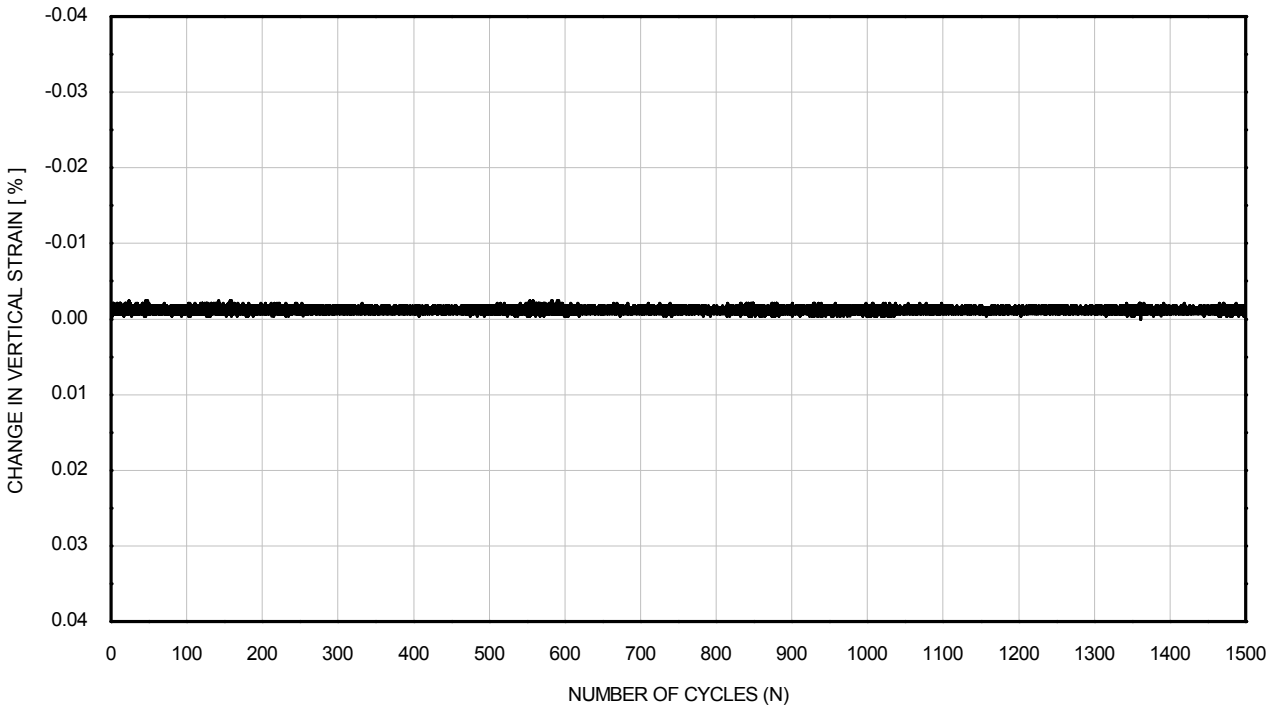


σ_{vc}	:	254 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	89 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.40
			Test No.	:	CSS01

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

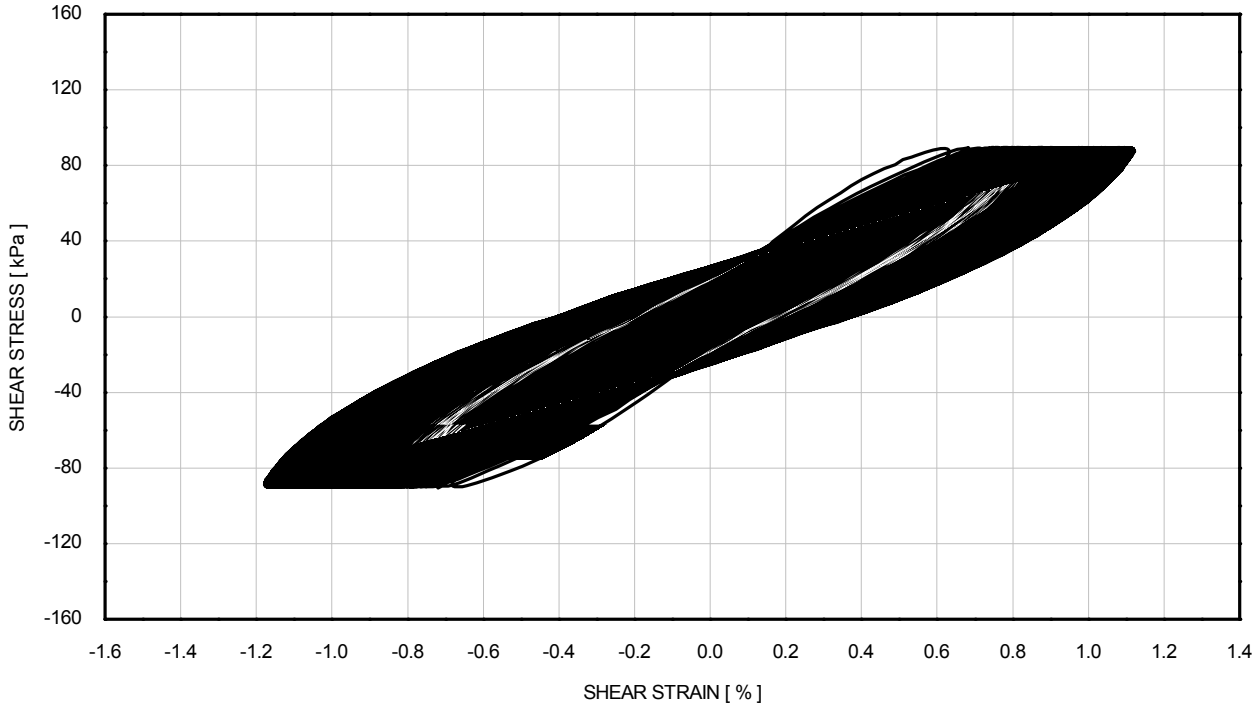


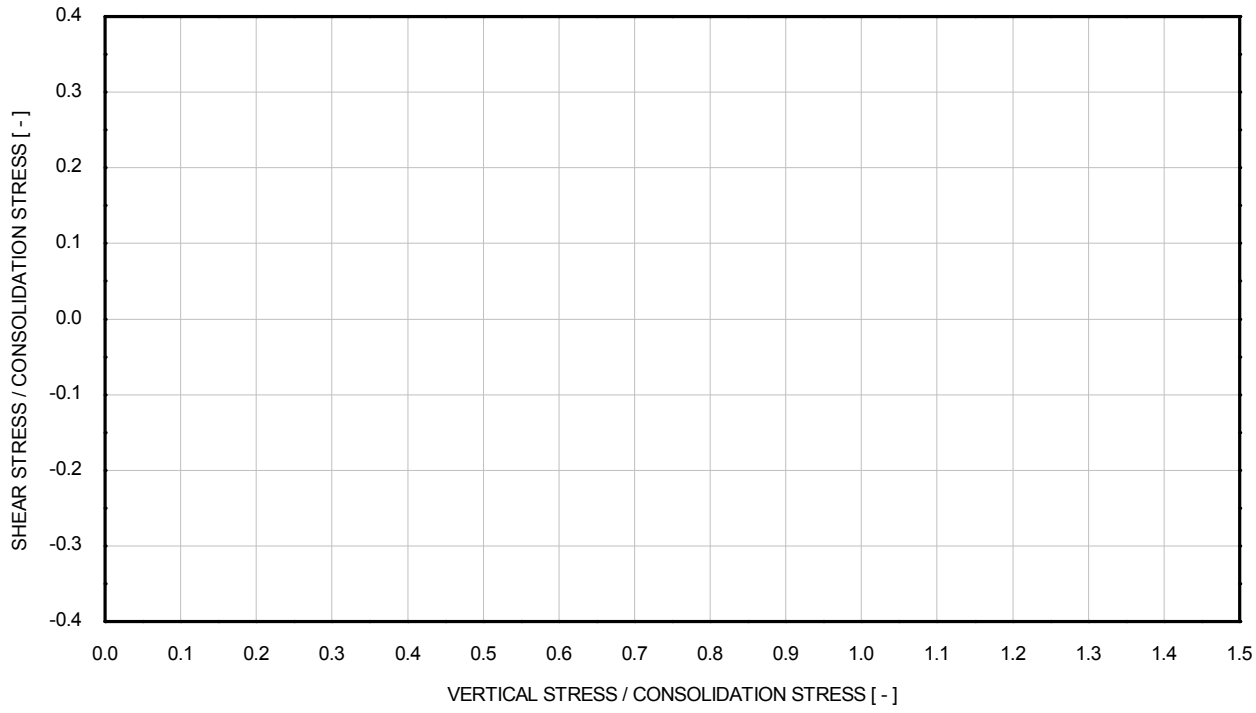


σ_{vc}	:	254 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	89 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.40
			Test No.	:	CSS01

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

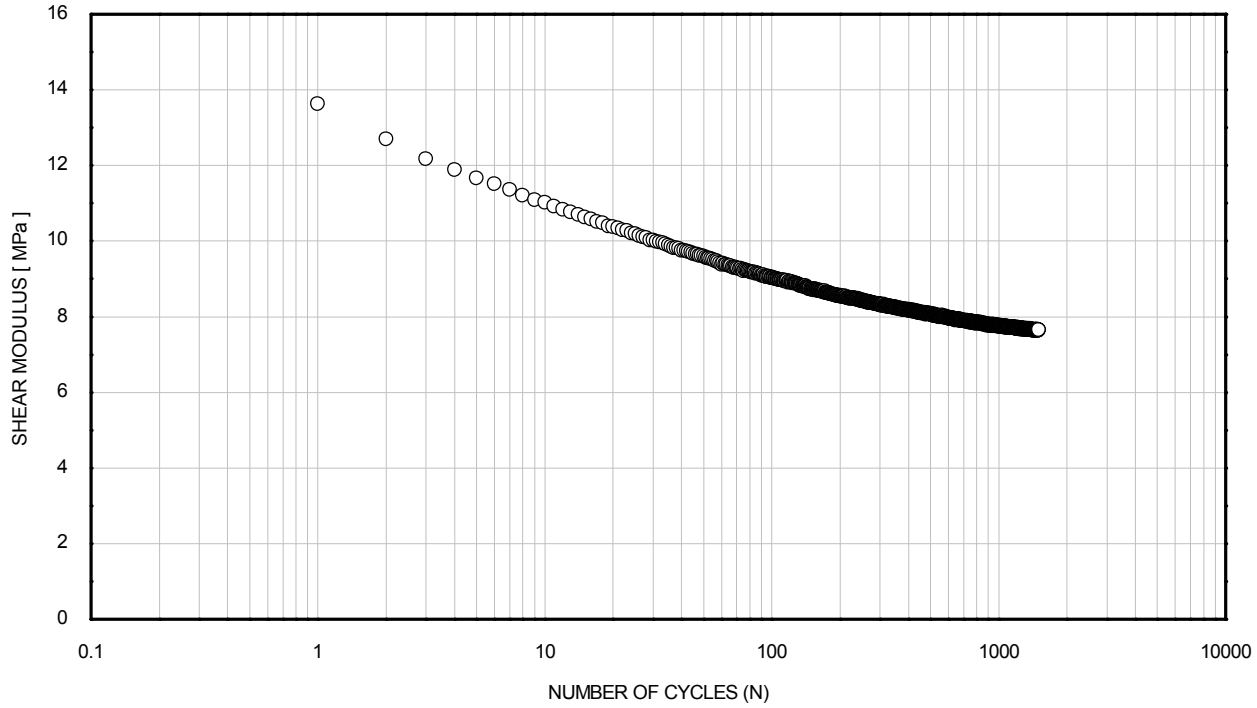


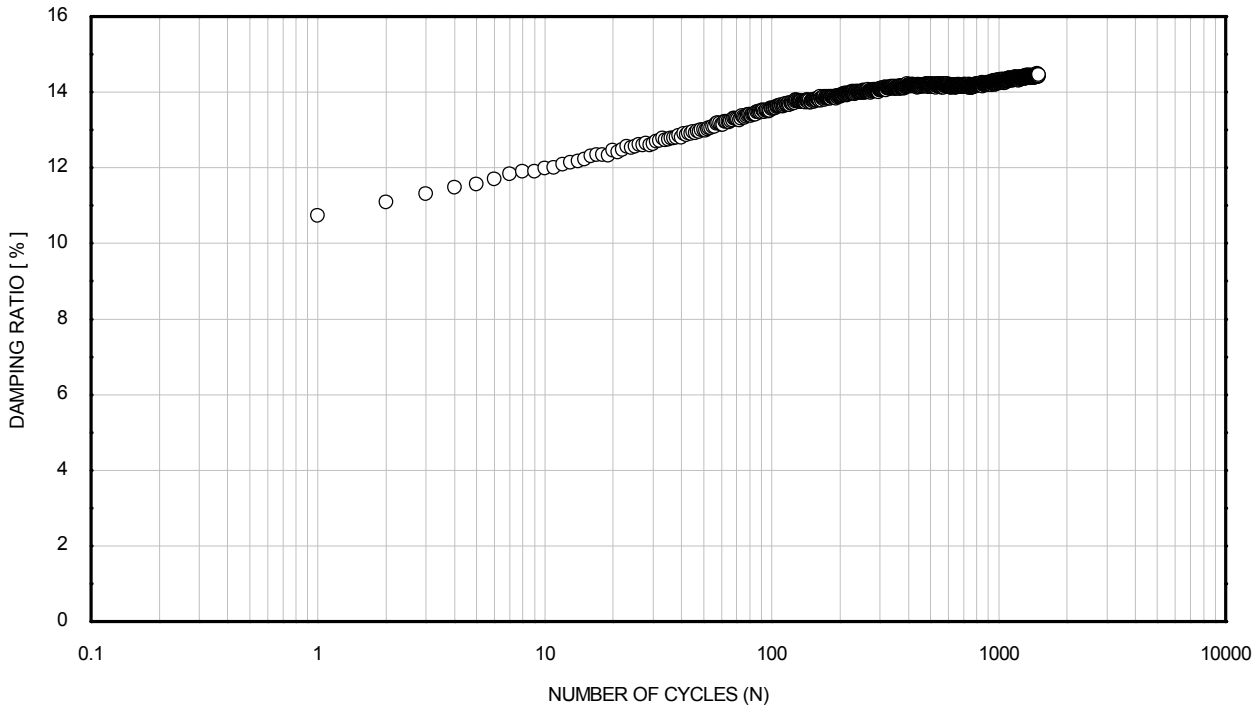


σ_{vc}	:	254 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	89 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.40
			Test No.	:	CSS01

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

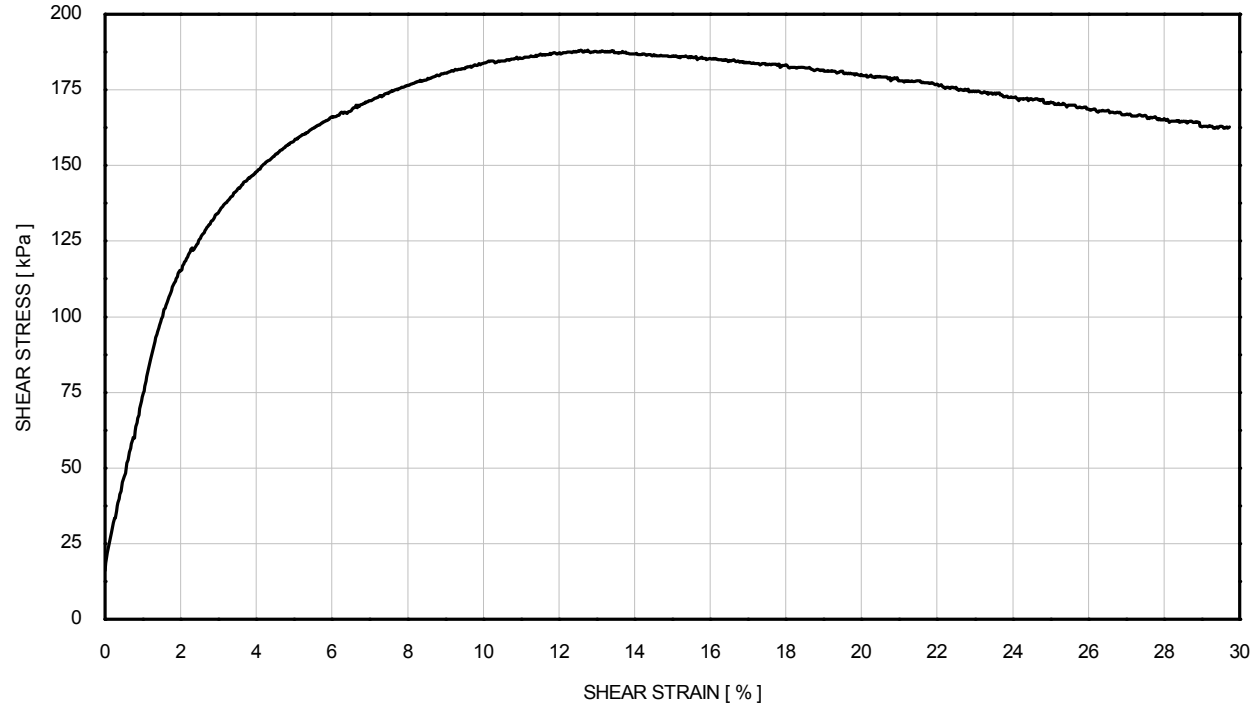


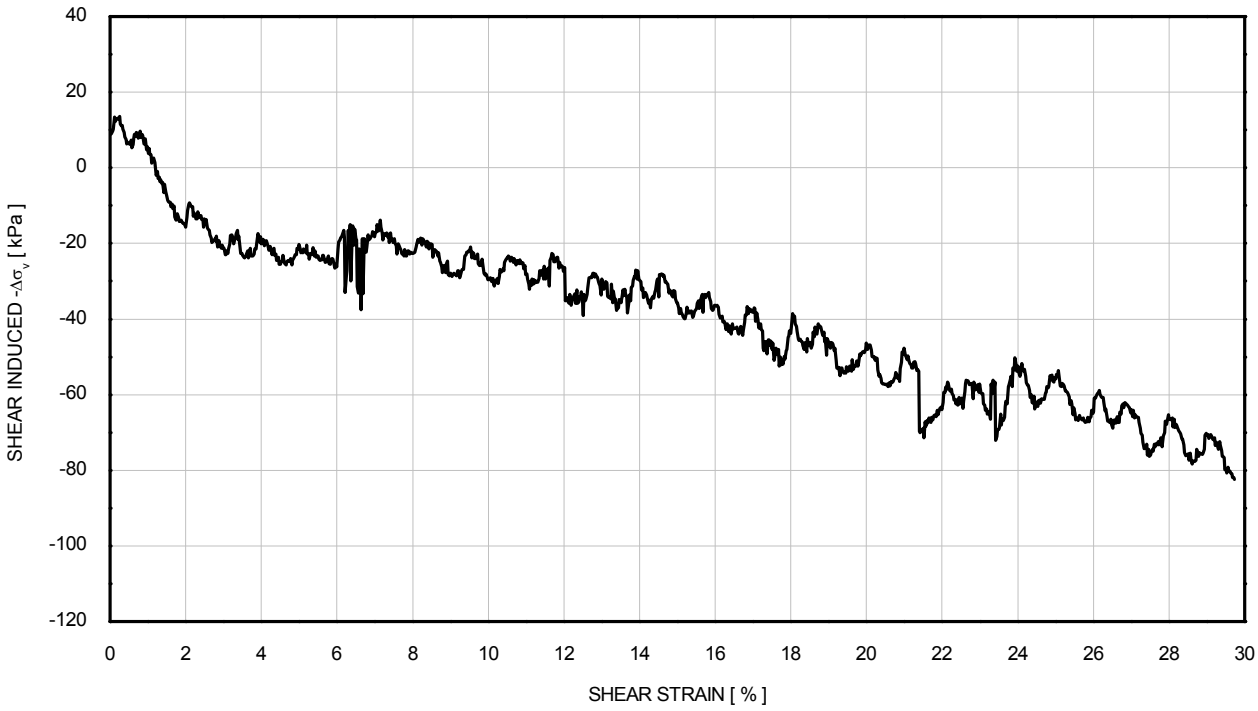


σ_{vc}	:	254 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	89 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.40
			Test No.	:	CSS01

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

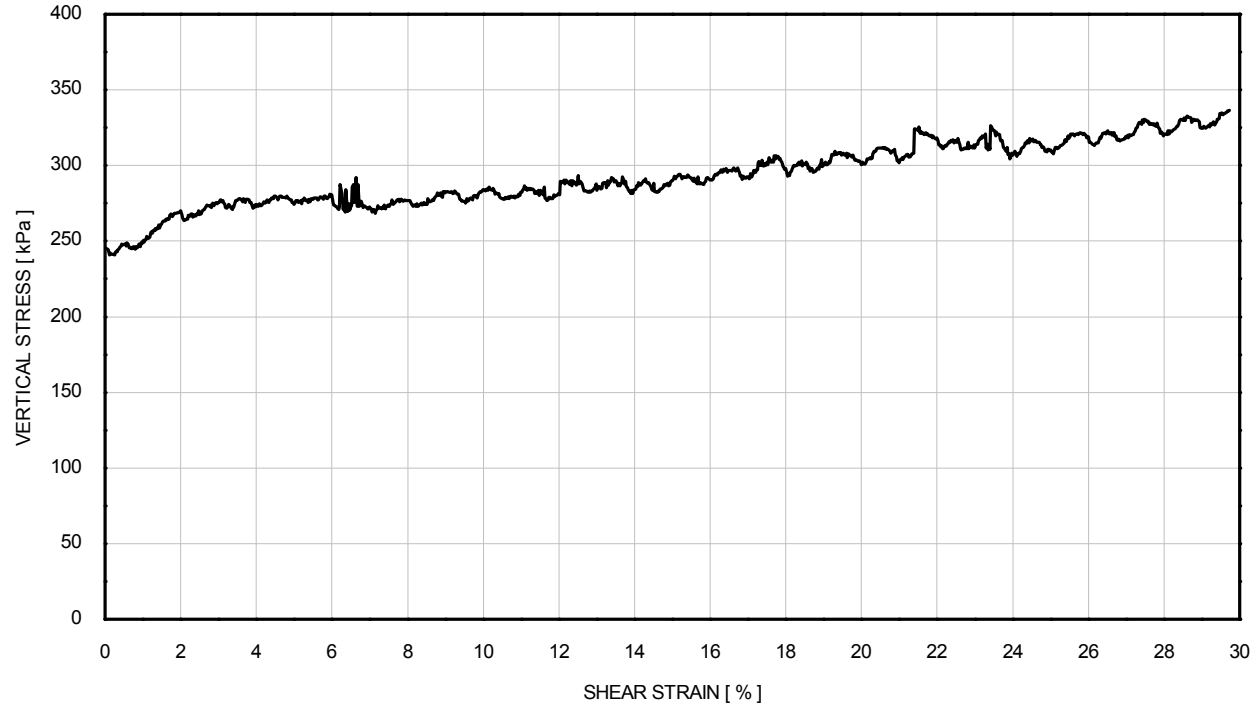


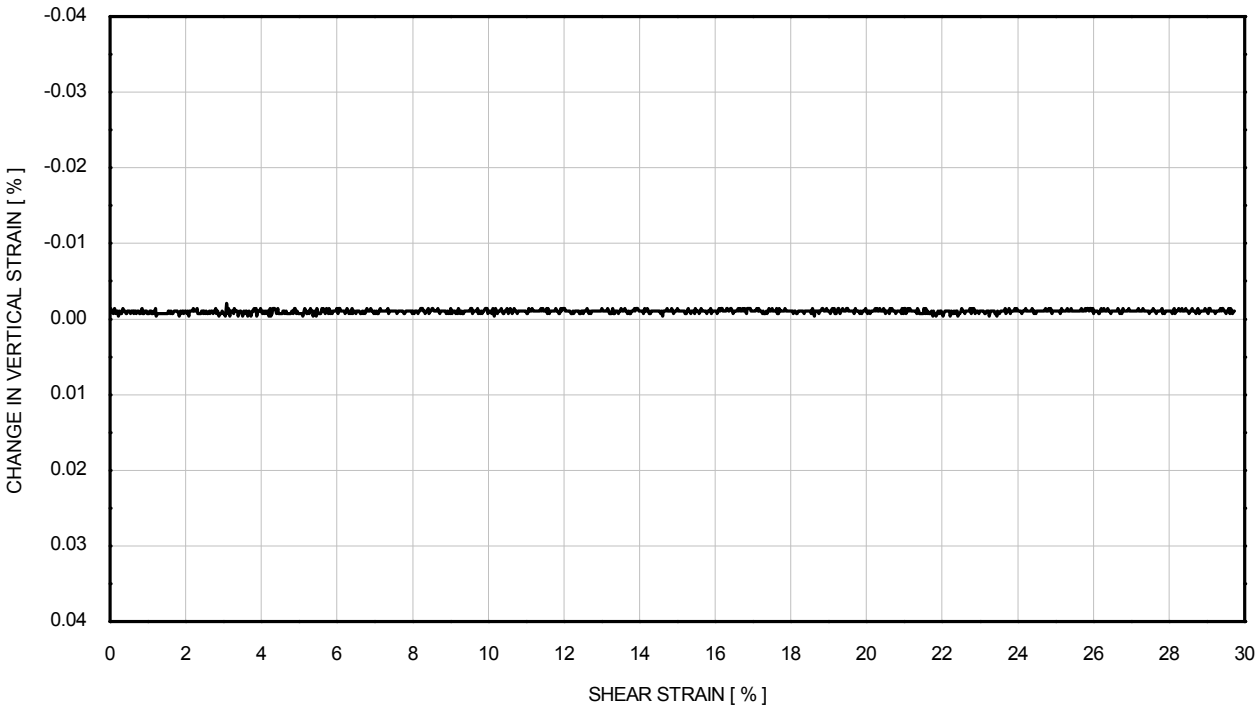


σ_{vc}	: 254 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 188 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 12.59 %	Unit	: F1c (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 23.40
		Test No.	: CSS01

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

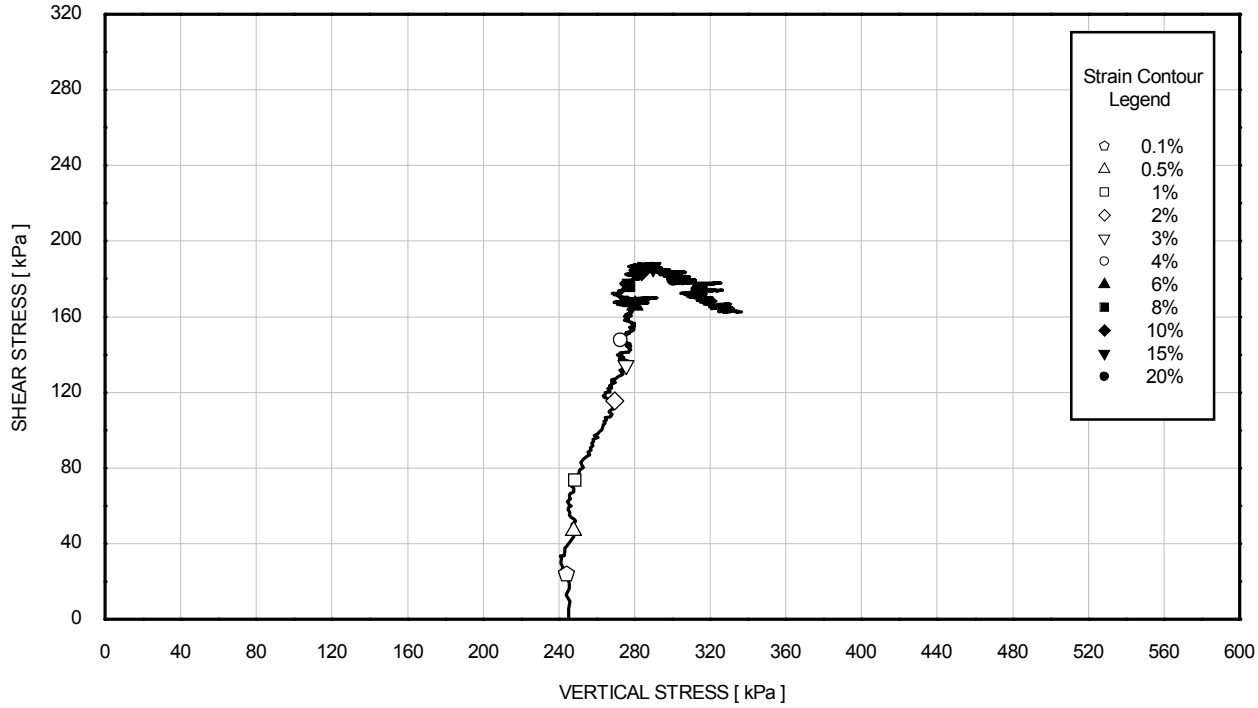


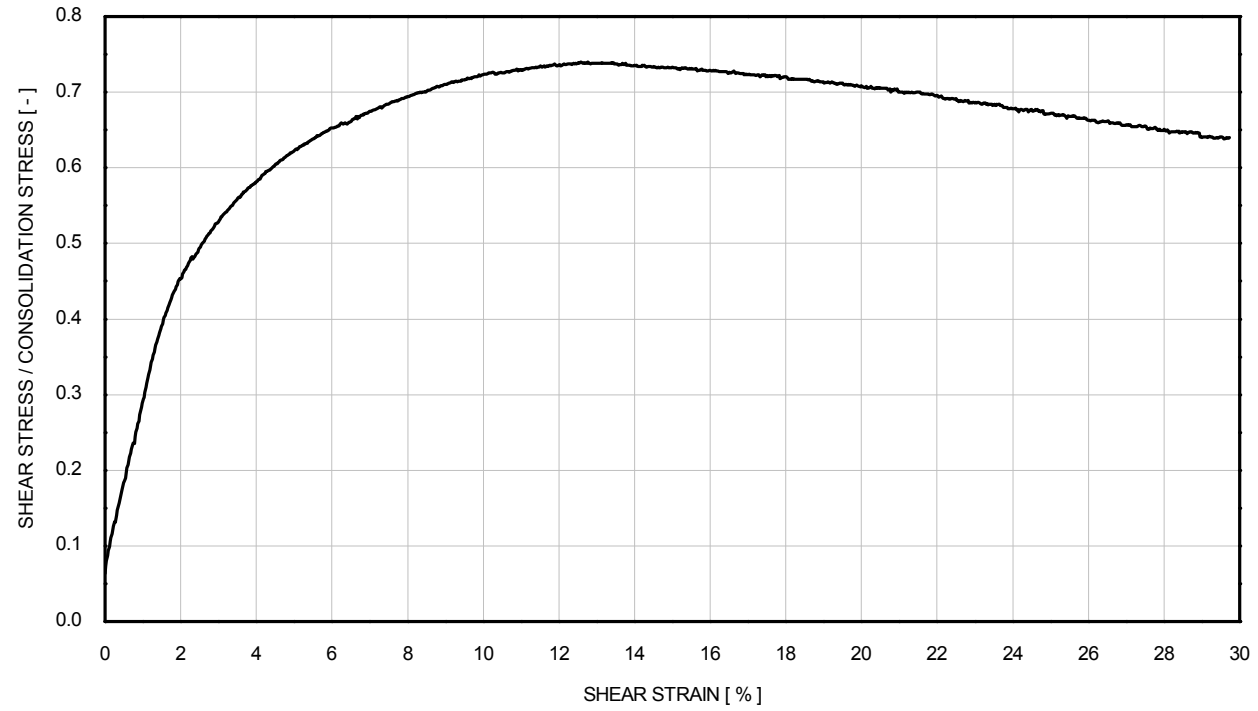


σ_{vc}	: 254 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 188 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 12.59 %	Unit	: F1c (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 23.40
		Test No.	: CSS01

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

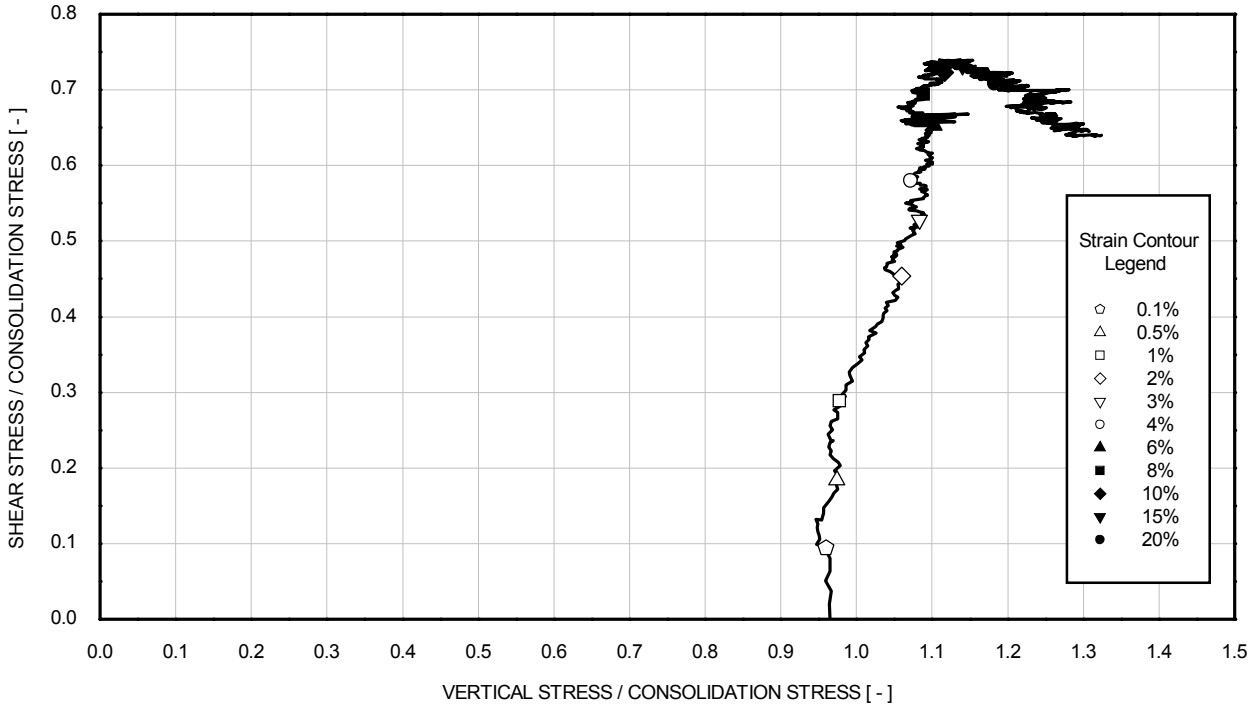


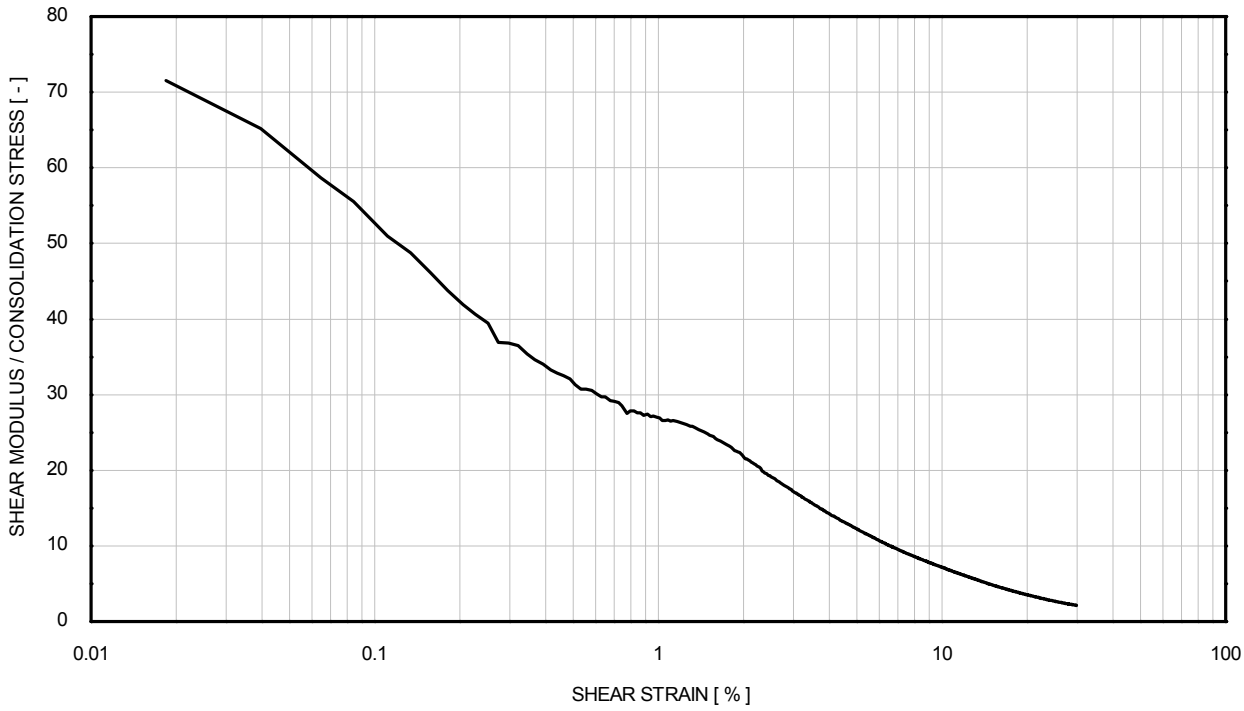


σ_{vc}	:	254 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	188 kPa	Sample	:	2WaxD
γ at τ_{peak}	:	12.59 %	Unit	:	F1c (Dongen)
Rate of strain	:	2.98 %/hour	Depth [m]	:	23.40
			Test No.	:	CSS01

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 254 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 188 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 12.59 %	Unit	: F1c (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 23.40
		Test No.	: CSS01

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Very dark grey CLAY

GENERAL	
Date test started	12/01/2016
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	29.9
Moisture content	[%]	33.1
Bulk density	[Mg/m³]	1.91
Dry density	[Mg/m³]	1.43
Void ratio	[-]	0.883
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	163
Pocket penetrometer	[kPa]	233
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_2WAXD_CSS02
Template issue	1.3
Processed by	RN
Date	28/01/2016
Checked by	HJ
Date	29/01/2016
Approved by	DT
Date	02/02/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.44
Test number	CSS02

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	738
Vertical strain	[%]	5.13
Bulk density	[Mg/m^3]	1.96
Dry density	[Mg/m^3]	1.51
Void ratio	[-]	0.786
Moisture content	[%]	29.6

CONSOLIDATION		
σ_{vc}	[kPa]	235
Vertical strain	[%]	2.87
Bulk density	[Mg/m^3]	1.94
Dry density	[Mg/m^3]	1.48
Void ratio	[-]	0.829
Moisture content	[%]	31.1

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	175
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	98
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1391
γ_{av} at N_f	[%]	1.44
γ_{cy} at N_f	[%]	15.25
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	22
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.05	1.19	8.34	15.52
2	0.07	1.29	7.70	14.96
5	0.07	1.39	7.17	14.85
10	0.07	1.46	6.79	14.95
20	0.08	1.54	6.43	14.81
30	0.07	1.59	6.23	14.97
40	0.07	1.63	6.13	14.90
50	0.07	1.66	6.01	14.82
100	0.08	1.74	5.73	14.90
500	0.08	1.98	4.99	15.08
1000	-0.06	2.37	4.11	16.09
1391	1.44	15.25	0.61	31.11

* Please note that specimen failure was observed to occur along or close to the loading platen interface.

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.44
Test number	CSS02

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	104
Shear strain	[%]	29.05
Shear induced $-\Delta\sigma_v$	[kPa]	-41
Vertical stress	[kPa]	276
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.99
At 15 % shear strain		
Shear stress	[kPa]	76
Shear induced $-\Delta\sigma_v$	[kPa]	34
Vertical stress	[kPa]	200
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.44
Test number	CSS02

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

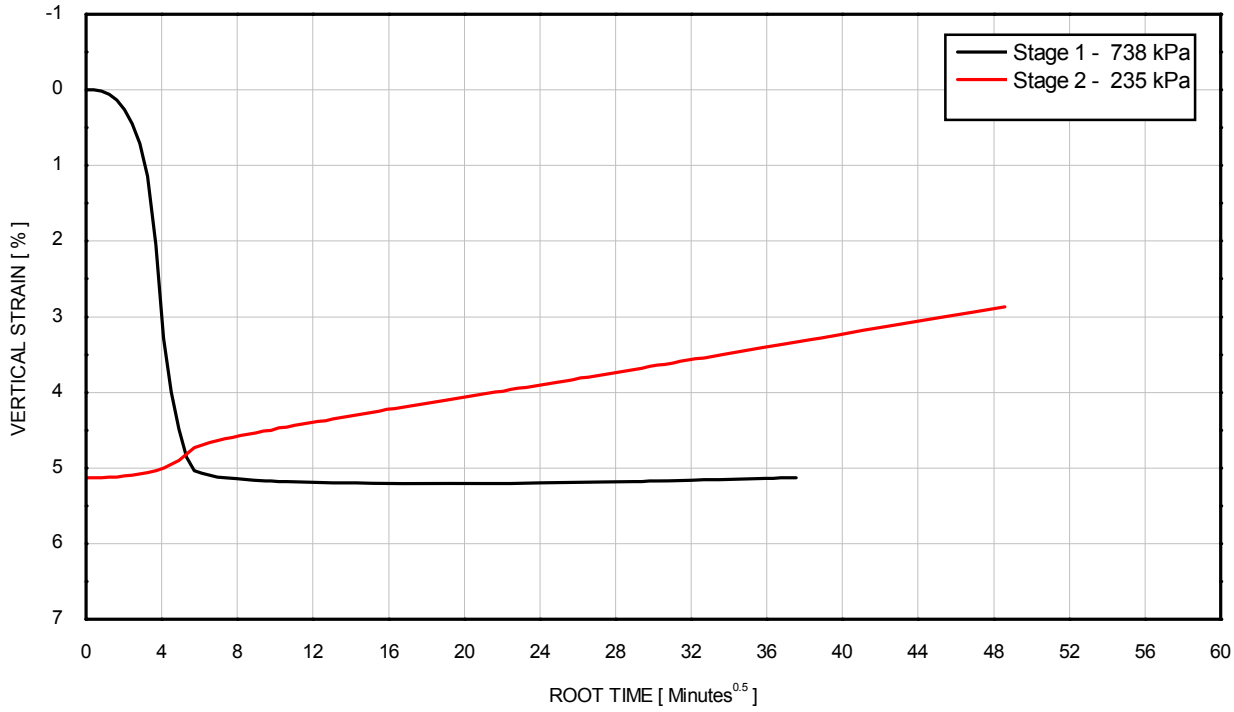
SPECIMEN PHOTOGRAPH

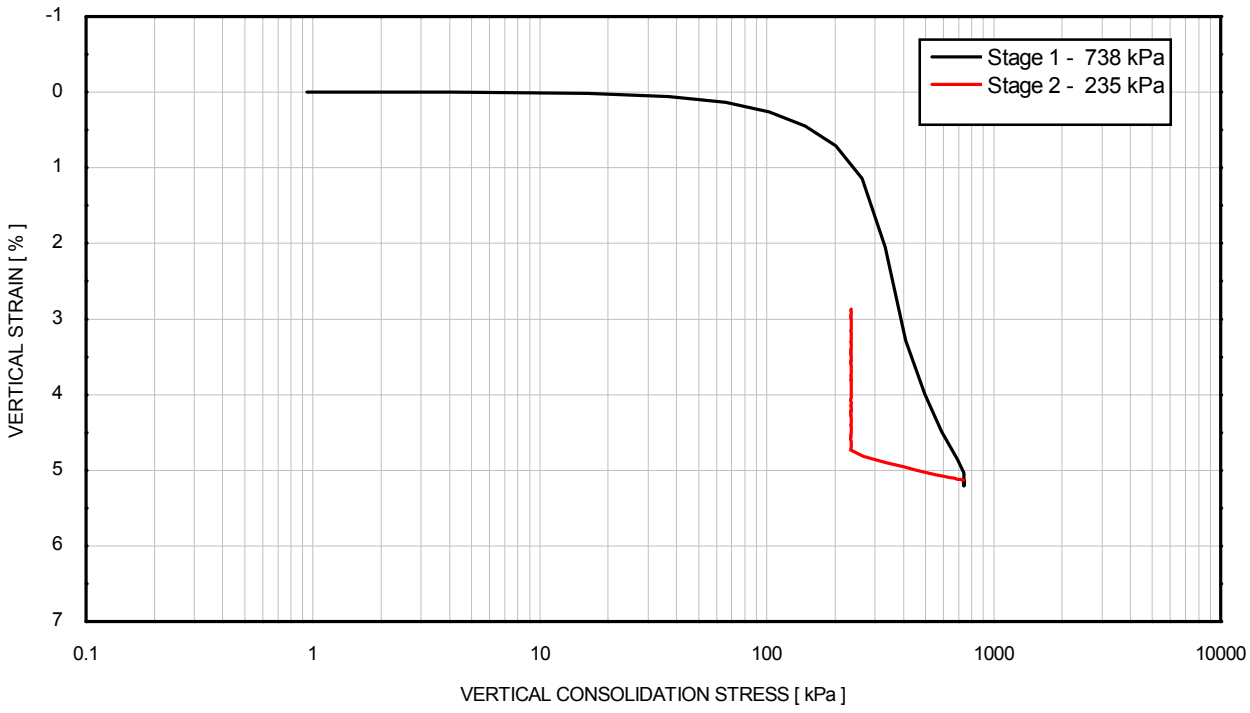


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.44
Test number	CSS02

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

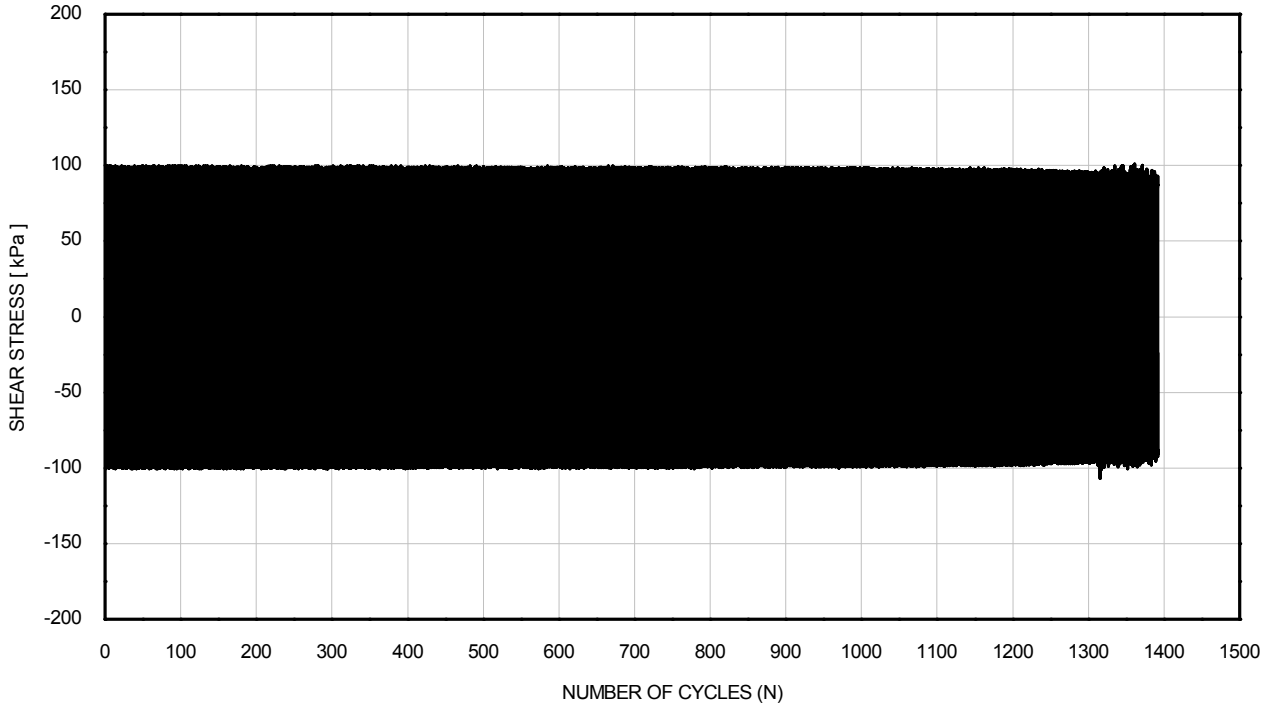


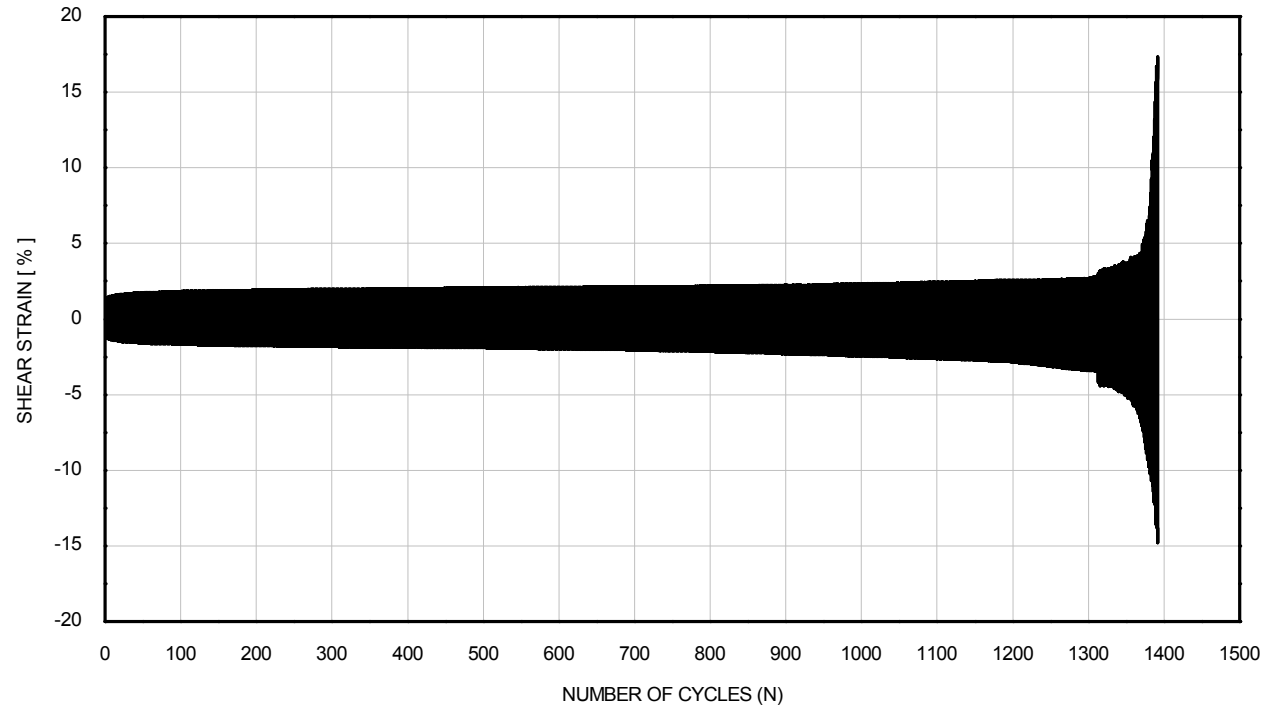


σ_{vc}	: 235 kPa	Borehole	: BH-WFS3-4A
		Sample	: 2WaxD
		Unit	: F1c (Dongen)
		Depth [m]	: 23.44
		Test No.	: CSS02

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

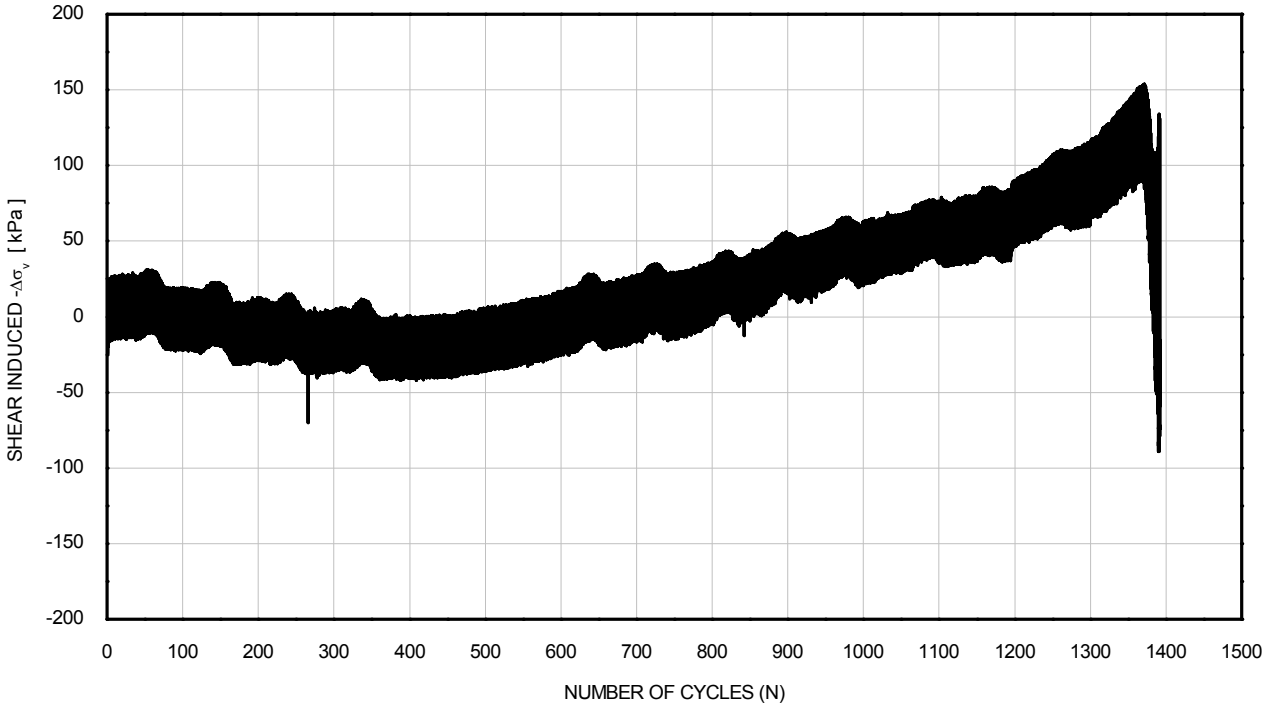


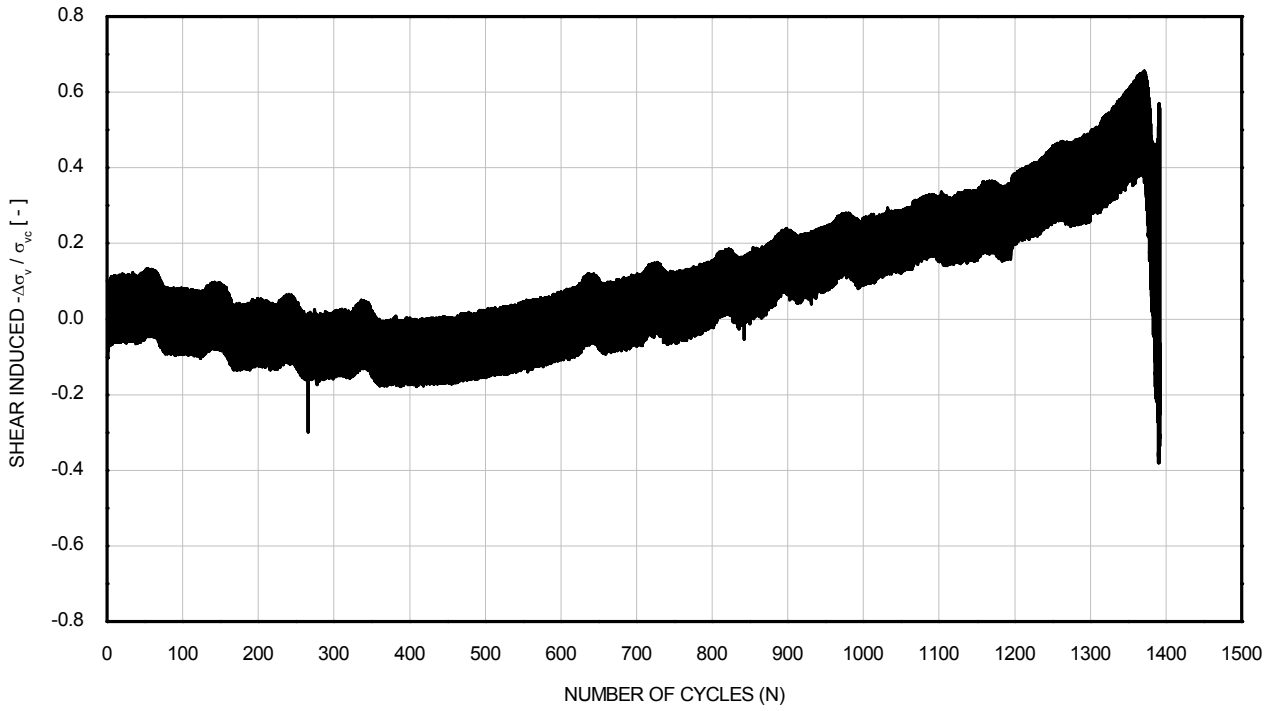


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	98 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.44
			Test No.	:	CSS02

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

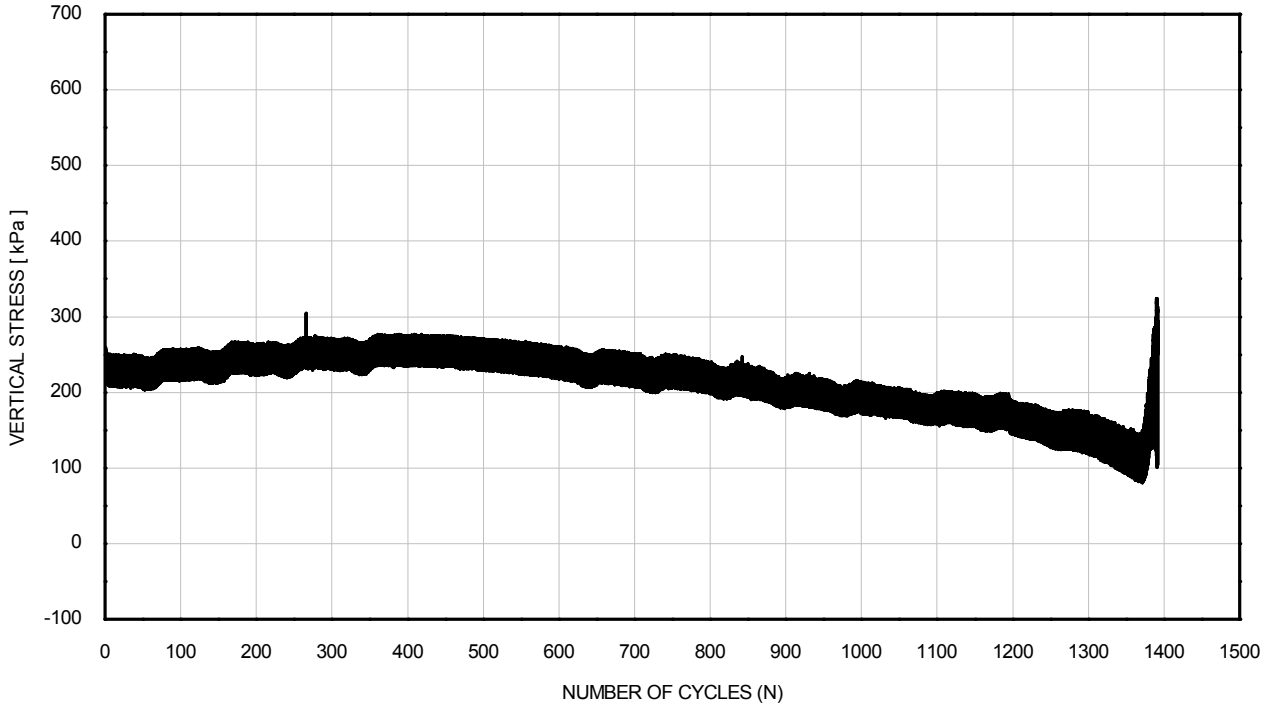


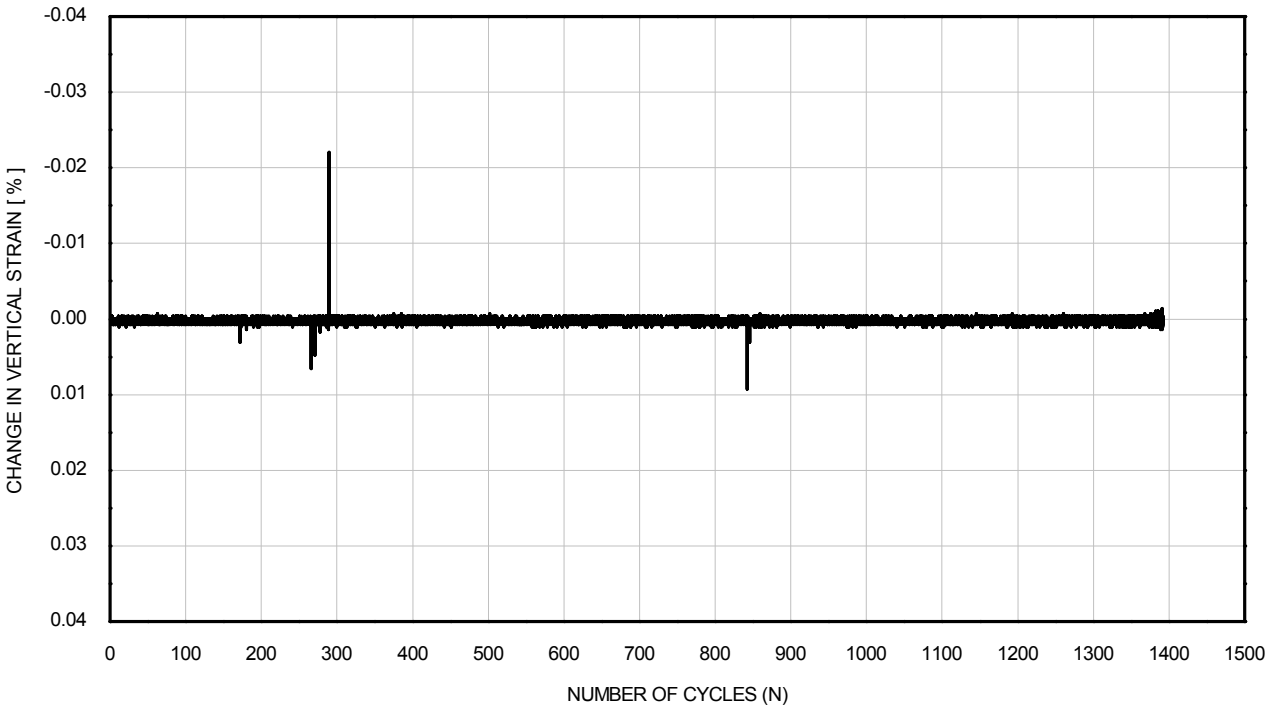


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	98 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.44
			Test No.	:	CSS02

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

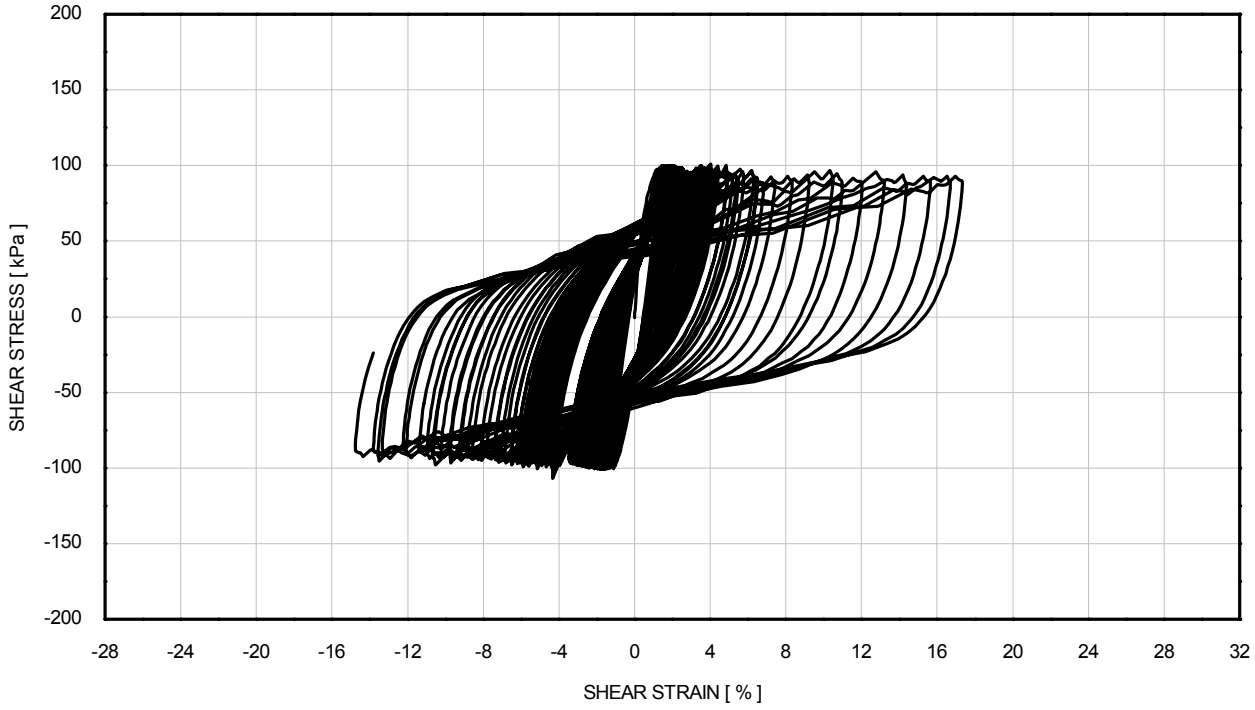


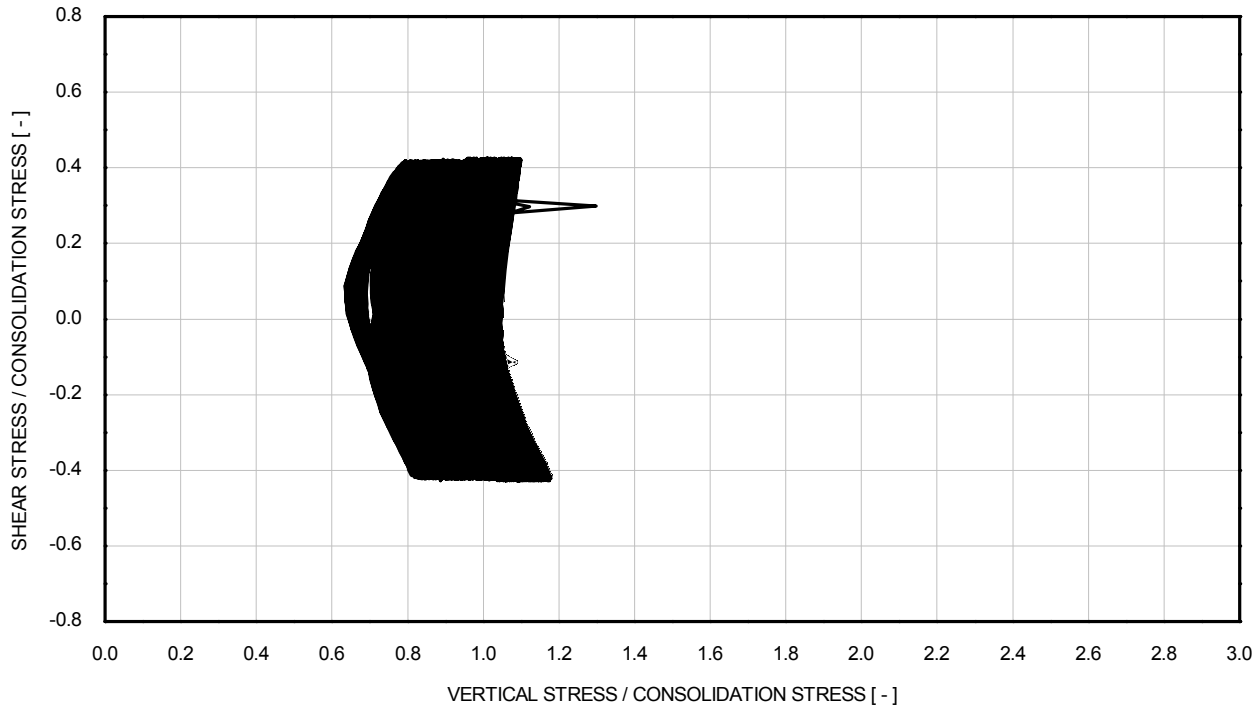


σ_{vc}	:	235 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	: 2WaxD
Mean τ_{cy}	:	98 kPa	Unit	: F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	: 23.44
			Test No.	: CSS02

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

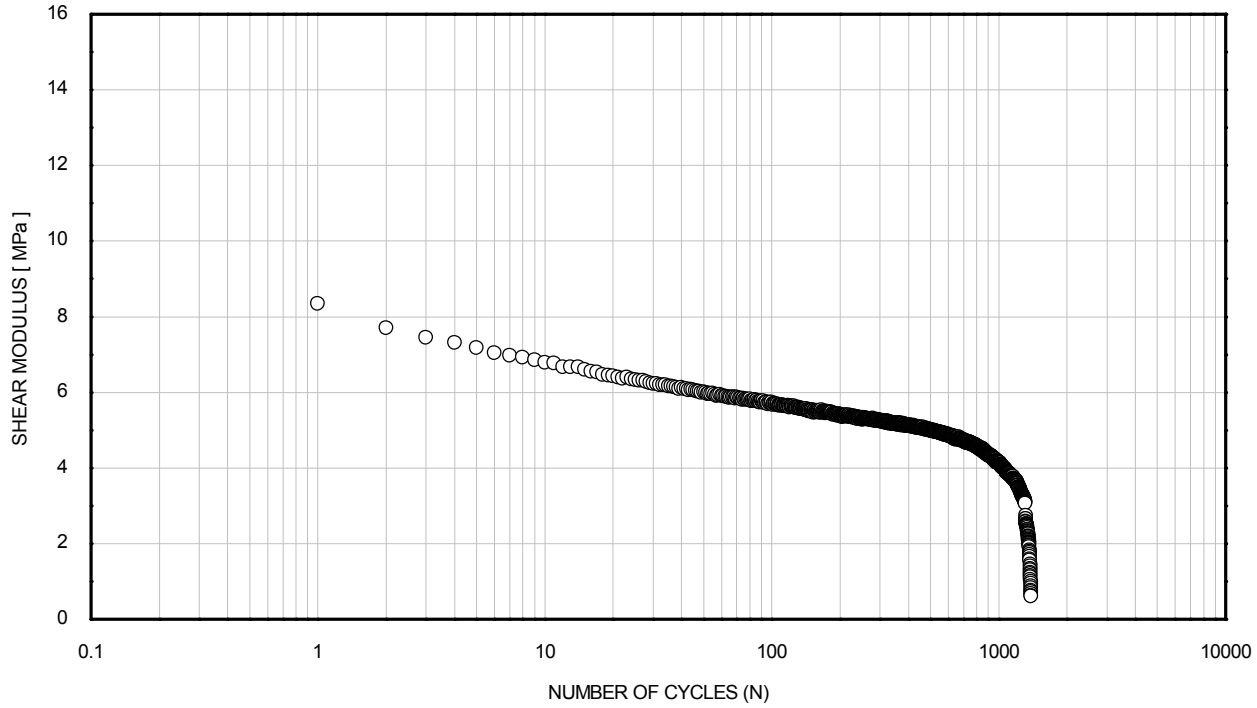


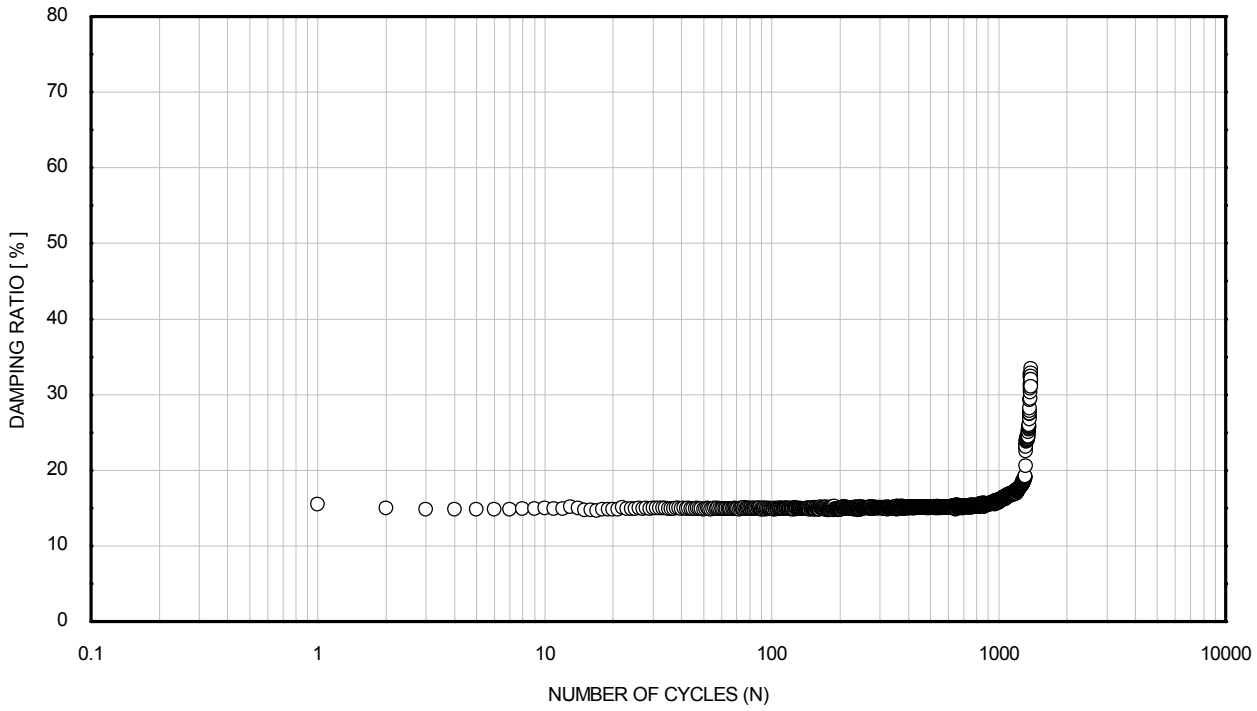


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	98 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.44
			Test No.	:	CSS02

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

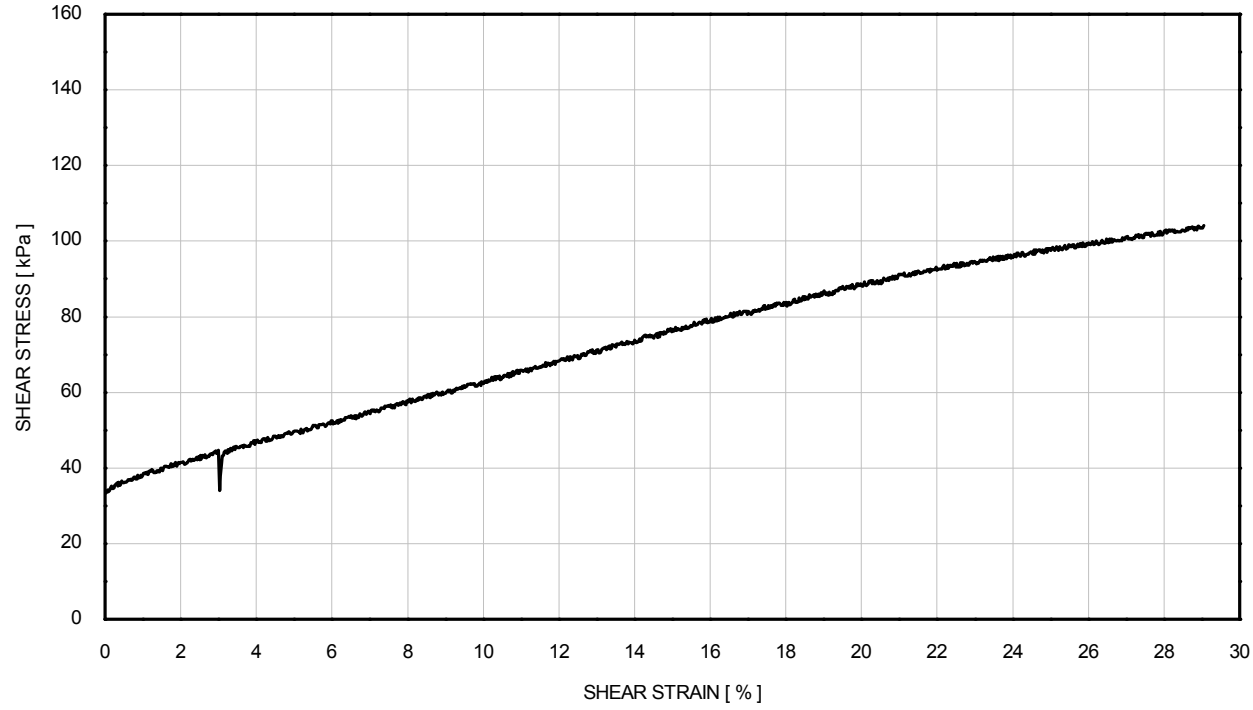


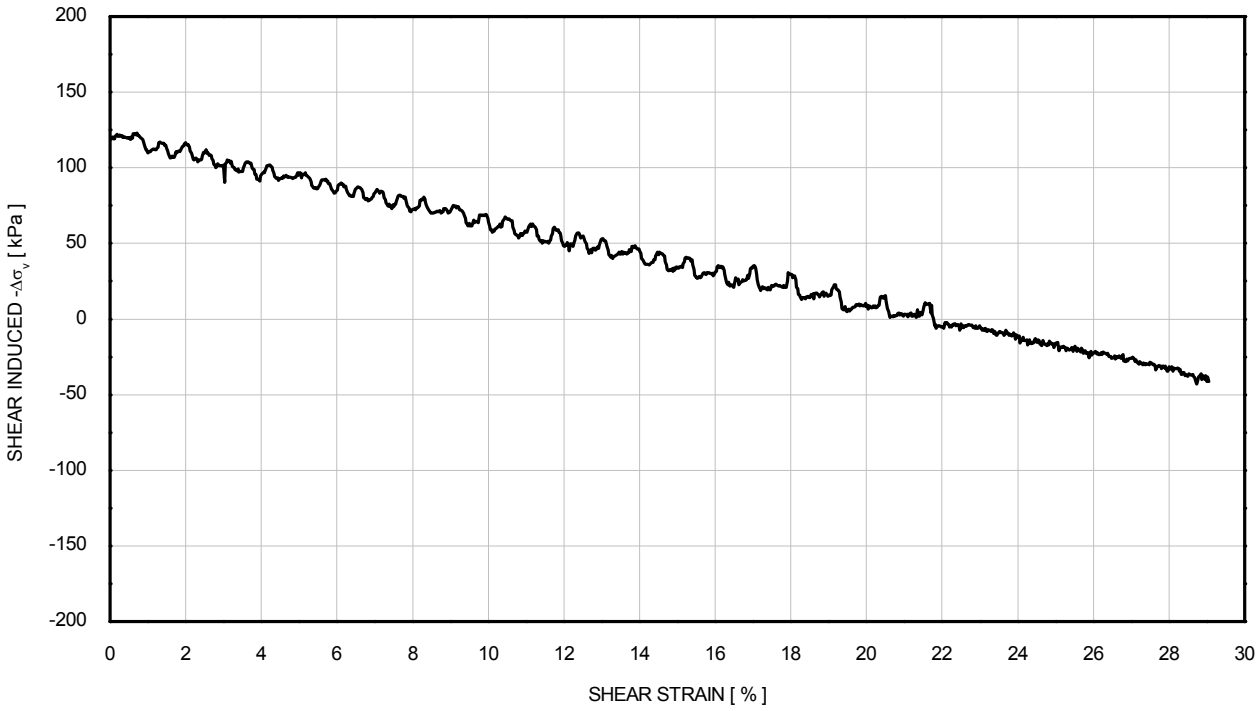


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	98 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.44
			Test No.	:	CSS02

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

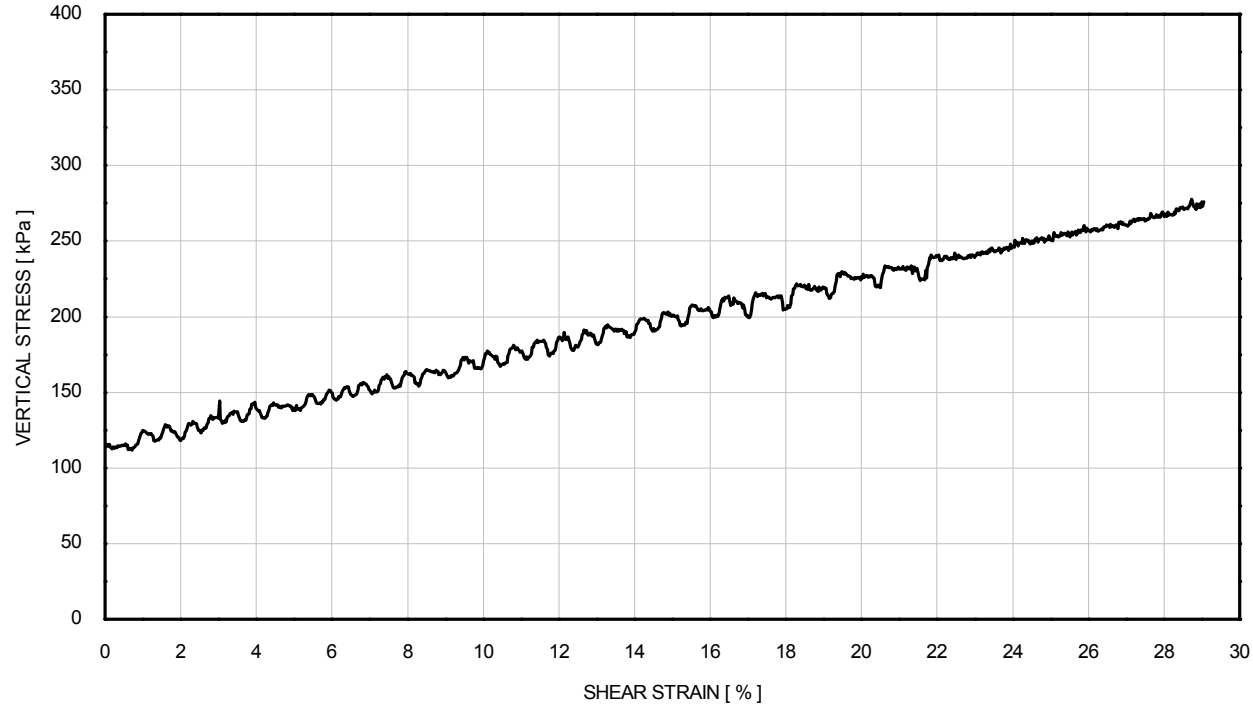


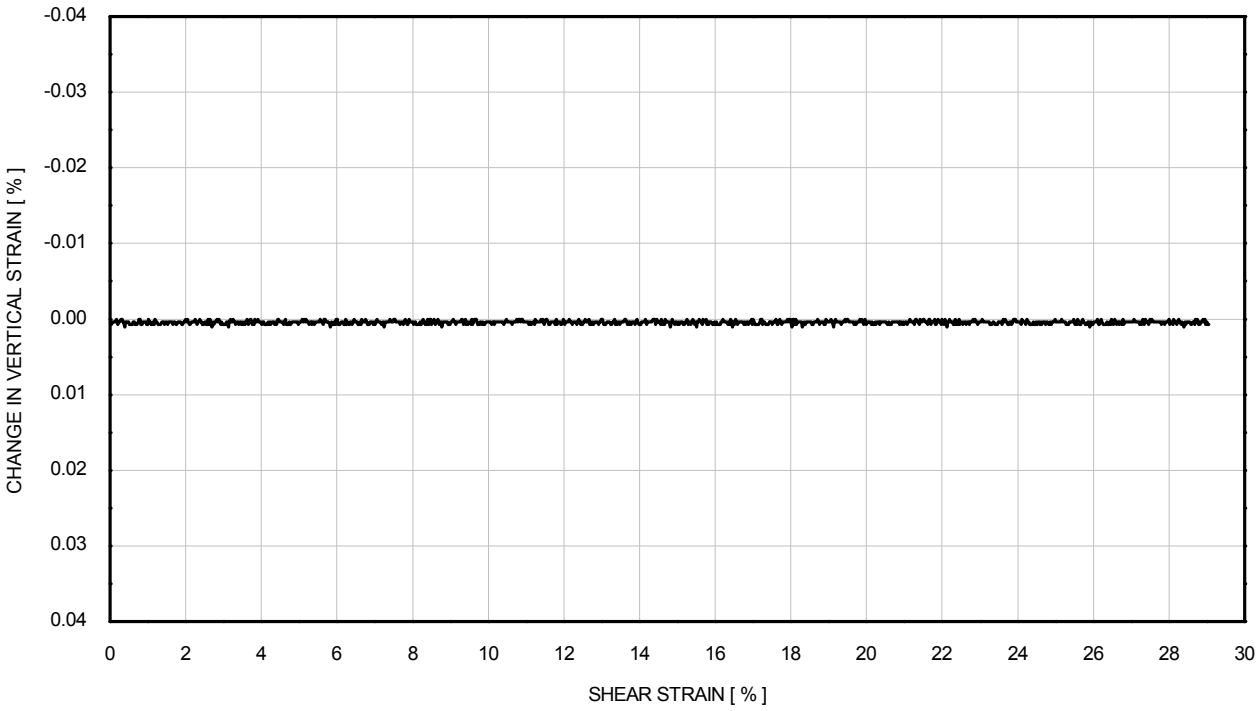


σ_{vc}	: 235 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 104 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 29.05 %	Unit	: F1c (Dongen)
Rate of strain	: 2.99 %/hour	Depth [m]	: 23.44
		Test No.	: CSS02

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

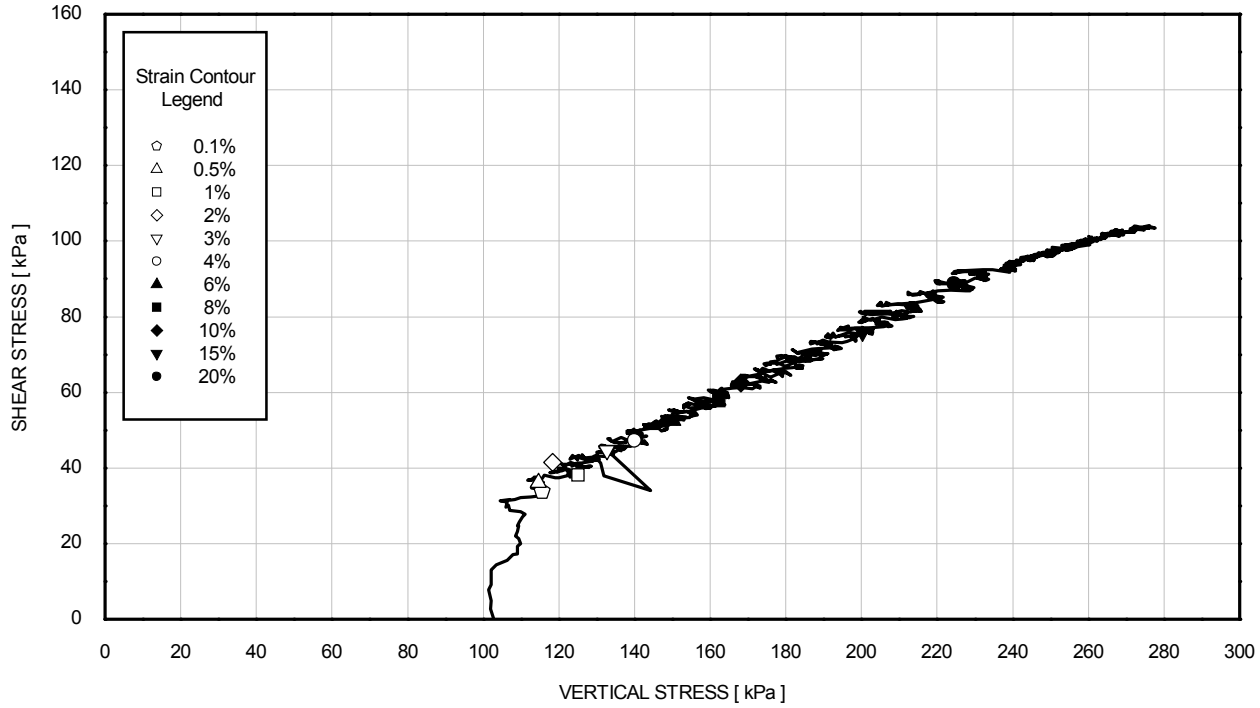


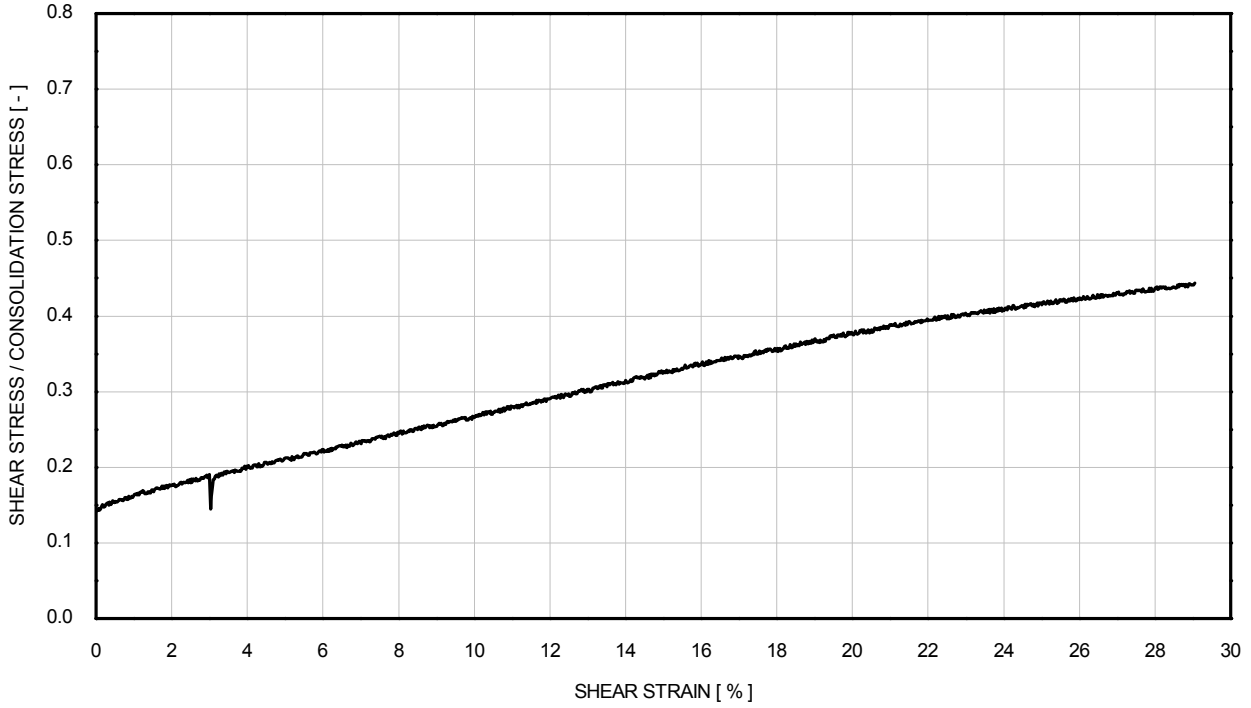


σ_{vc}	: 235 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 104 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 29.05 %	Unit	: F1c (Dongen)
Rate of strain	: 2.99 %/hour	Depth [m]	: 23.44
		Test No.	: CSS02

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

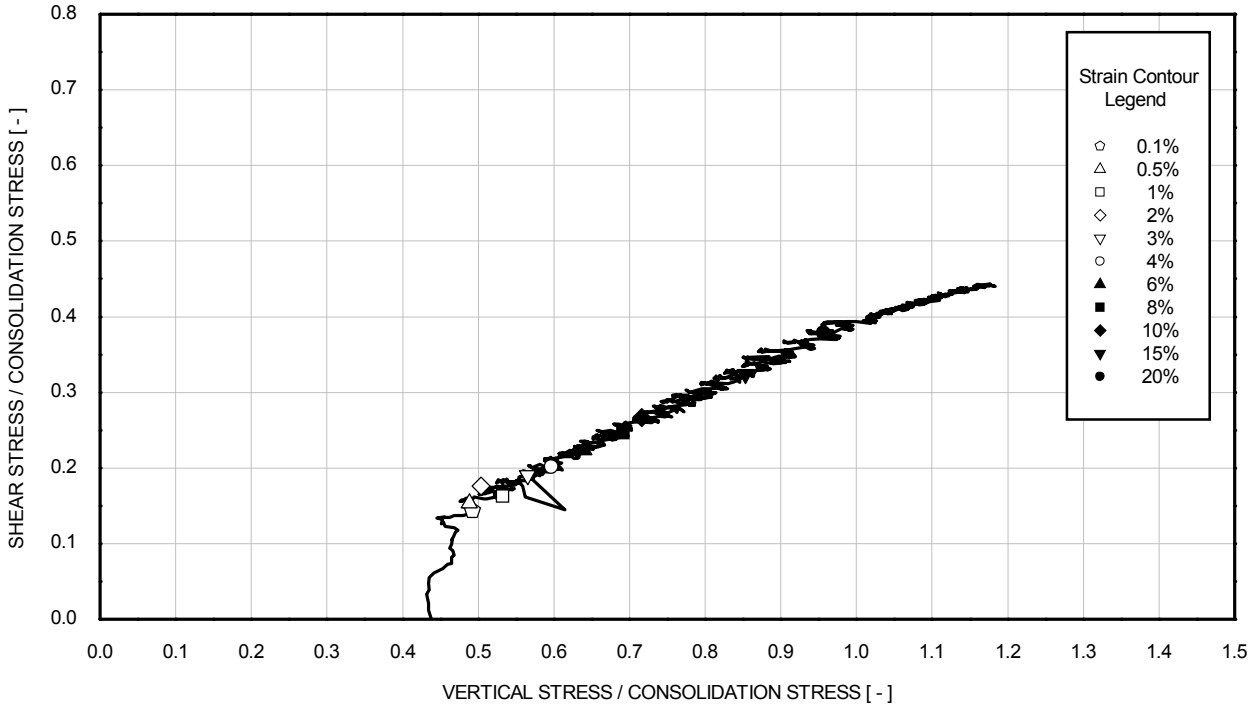


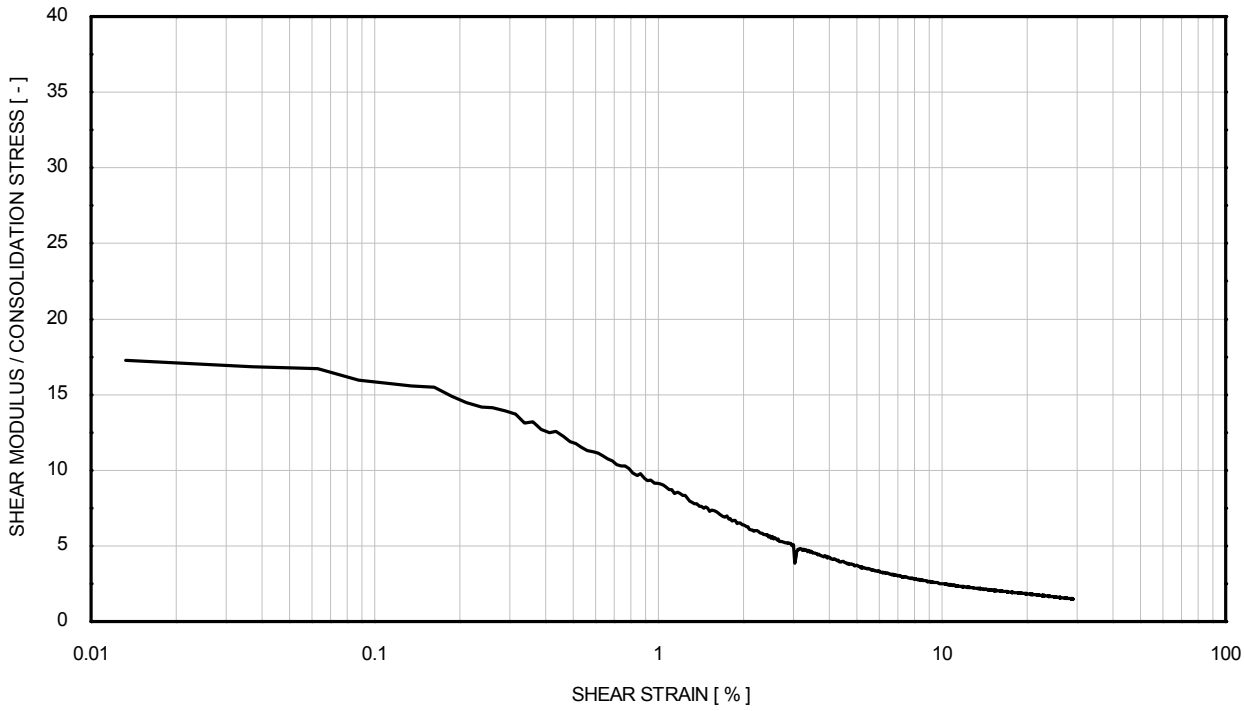


σ_{vc}	: 235 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 104 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 29.05 %	Unit	: F1c (Dongen)
Rate of strain	: 2.99 %/hour	Depth [m]	: 23.44
		Test No.	: CSS02

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	104 kPa	Sample	:	2WaxD
γ at τ_{peak}	:	29.05 %	Unit	:	F1c (Dongen)
Rate of strain	:	2.99 %/hour	Depth [m]	:	23.44
			Test No.	:	CSS02

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Very dark grey CLAY

GENERAL	
Date test started	04/02/2016
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	29.9
Moisture content	[%]	33.1
Bulk density	[Mg/m³]	1.90
Dry density	[Mg/m³]	1.43
Void ratio	[-]	0.887
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	163
Pocket penetrometer	[kPa]	233
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_2WAXD_CSS03
Template issue	1.3
Processed by Date	HJ 09/02/2016
Checked by Date	PH 16/02/2016
Approved by Date	PH 16/02/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.48
Test number	CSS03

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	738
Vertical strain	[%]	4.28
Bulk density	[Mg/m^3]	1.95
Dry density	[Mg/m^3]	1.49
Void ratio	[-]	0.806
Moisture content	[%]	30.1

CONSOLIDATION		
σ_{vc}	[kPa]	235
Vertical strain	[%]	2.23
Bulk density	[Mg/m^3]	1.93
Dry density	[Mg/m^3]	1.46
Void ratio	[-]	0.845
Moisture content	[%]	31.6

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	175
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	111
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1500
γ_{av} at N_f	[%]	0.18
γ_{cy} at N_f	[%]	5.00
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	-34
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.01	1.50	7.46	15.63
2	0.03	1.65	6.80	15.82
5	0.05	1.82	6.18	16.10
10	0.06	1.95	5.76	16.29
20	0.08	2.10	5.36	16.56
30	0.09	2.19	5.12	16.70
40	0.11	2.27	4.96	16.84
50	0.12	2.33	4.82	17.01
100	0.16	2.55	4.40	17.59
500	0.24	3.34	3.35	20.49
1000	0.20	4.00	2.77	22.95
1500	0.18	5.00	2.17	26.77

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.48
Test number	CSS03

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	136
Shear strain	[%]	18.79
Shear induced $-\Delta\sigma_v$	[kPa]	-101
Vertical stress	[kPa]	337
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	3.00
At 15 % shear strain		
Shear stress	[kPa]	135
Shear induced $-\Delta\sigma_v$	[kPa]	-87
Vertical stress	[kPa]	322
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.48
Test number	CSS03

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

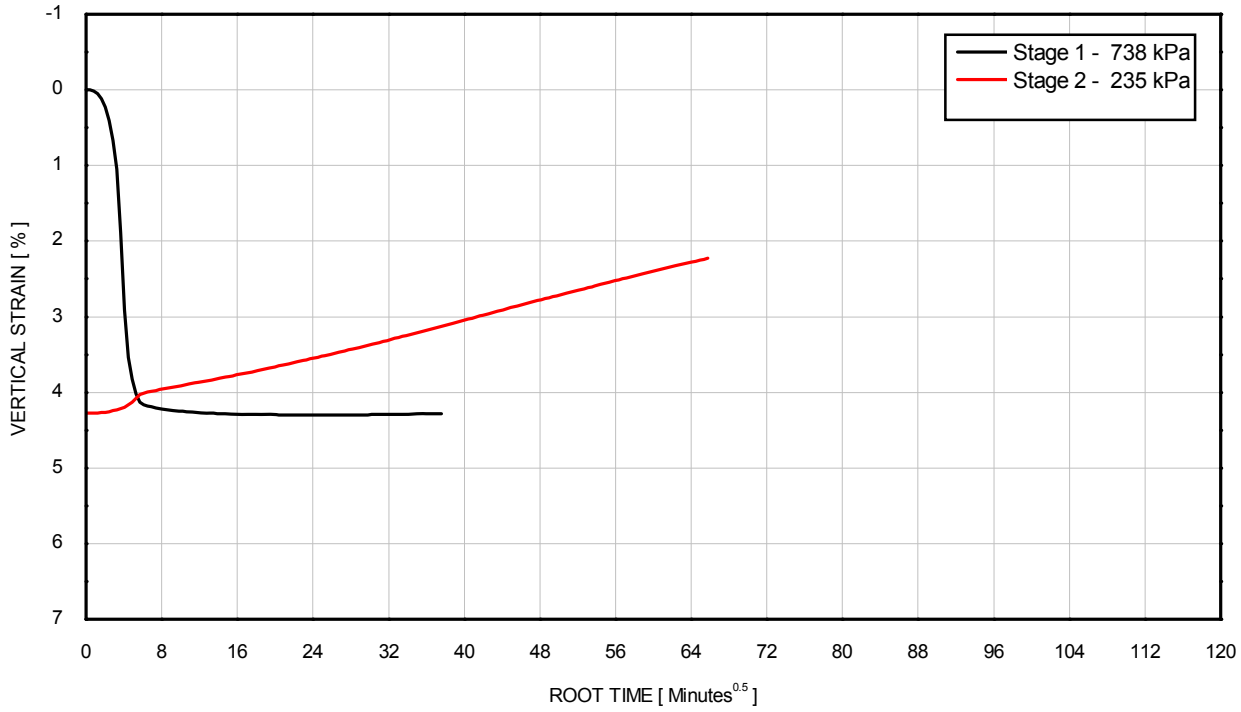
SPECIMEN PHOTOGRAPH

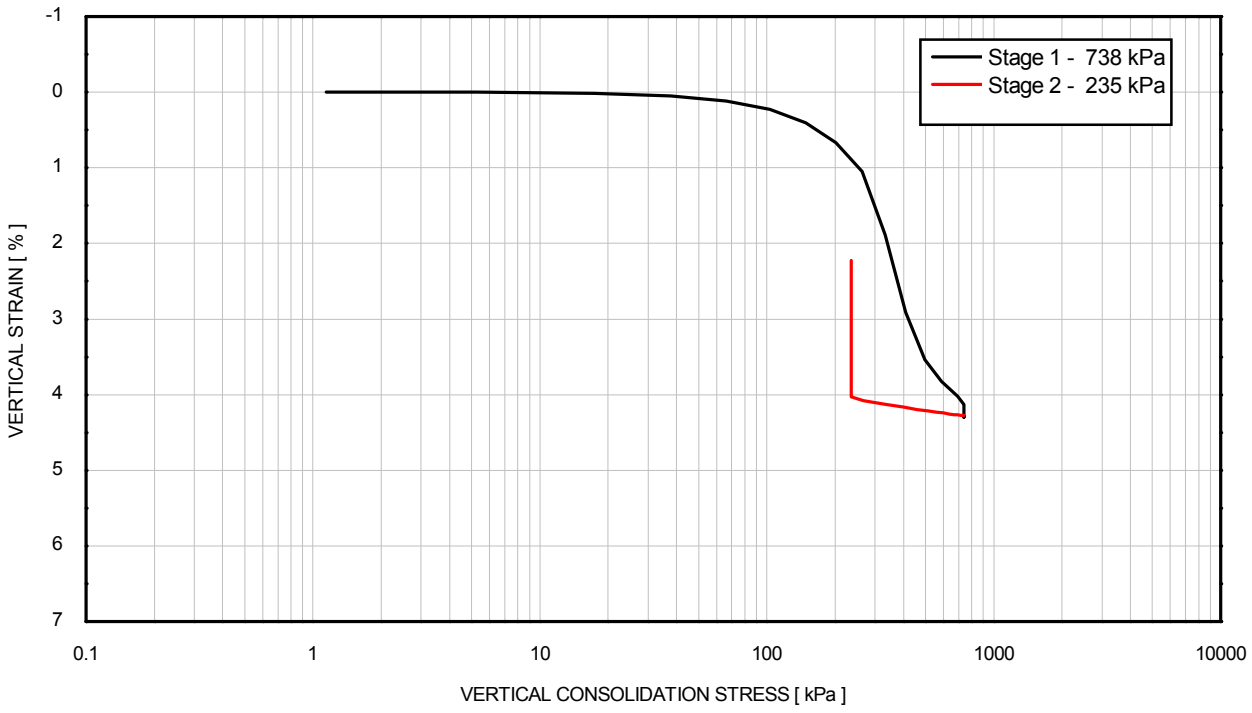


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	2WaxD
Unit	F1c (Dongen)
Depth [m]	23.48
Test number	CSS03

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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



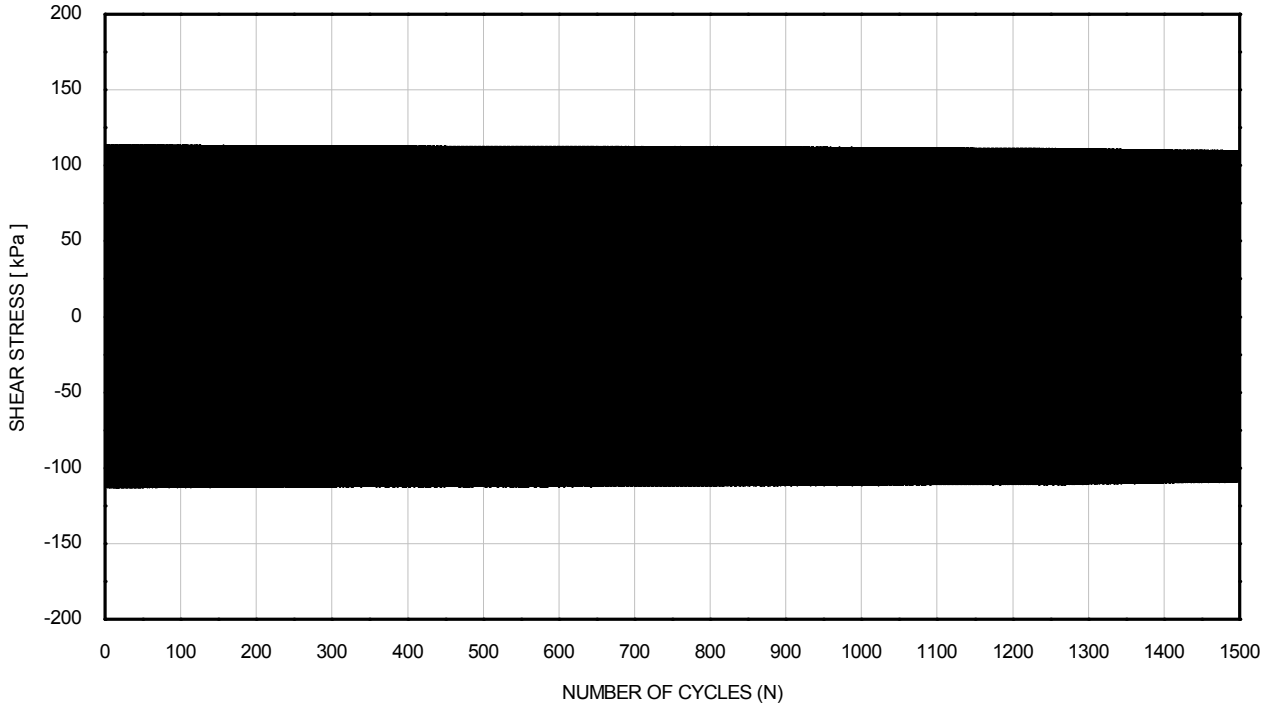


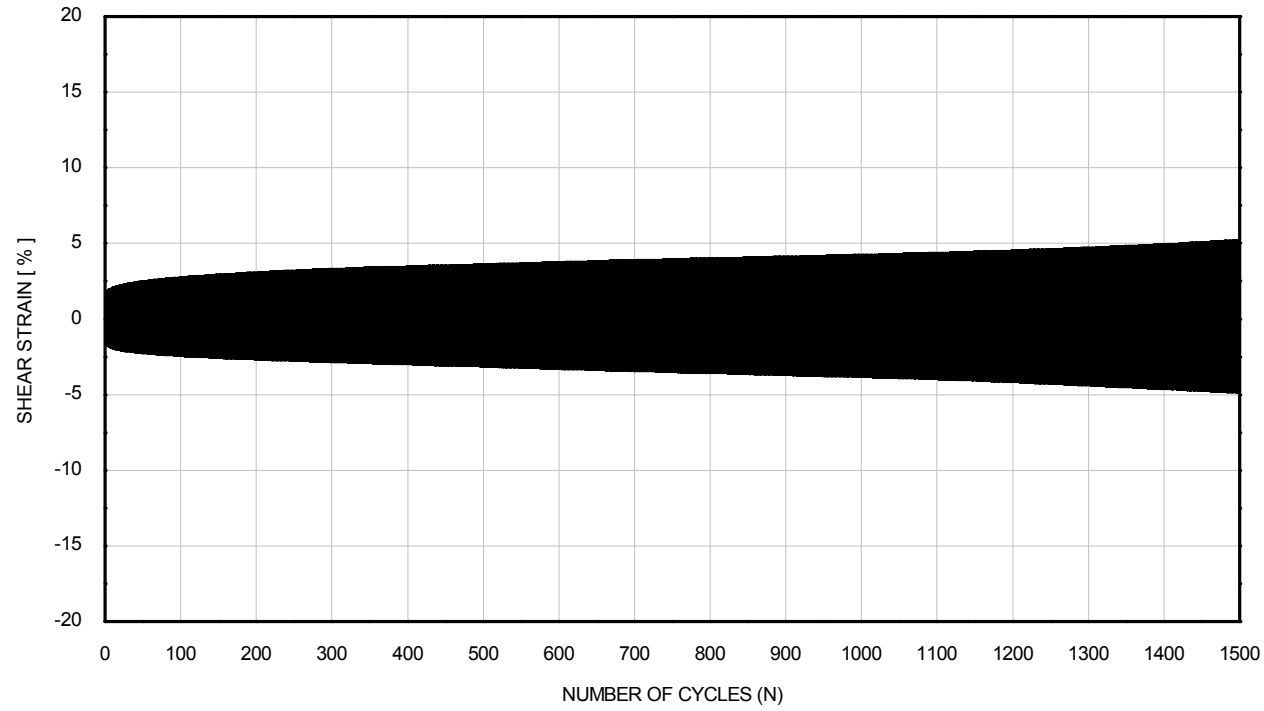
σ_{vc} : 235 kPa

Borehole	: BH-WFS3-4A
Sample	: 2WaxD
Unit	: F1c (Dongen)
Depth [m]	: 23.48
Test No.	: CSS03

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

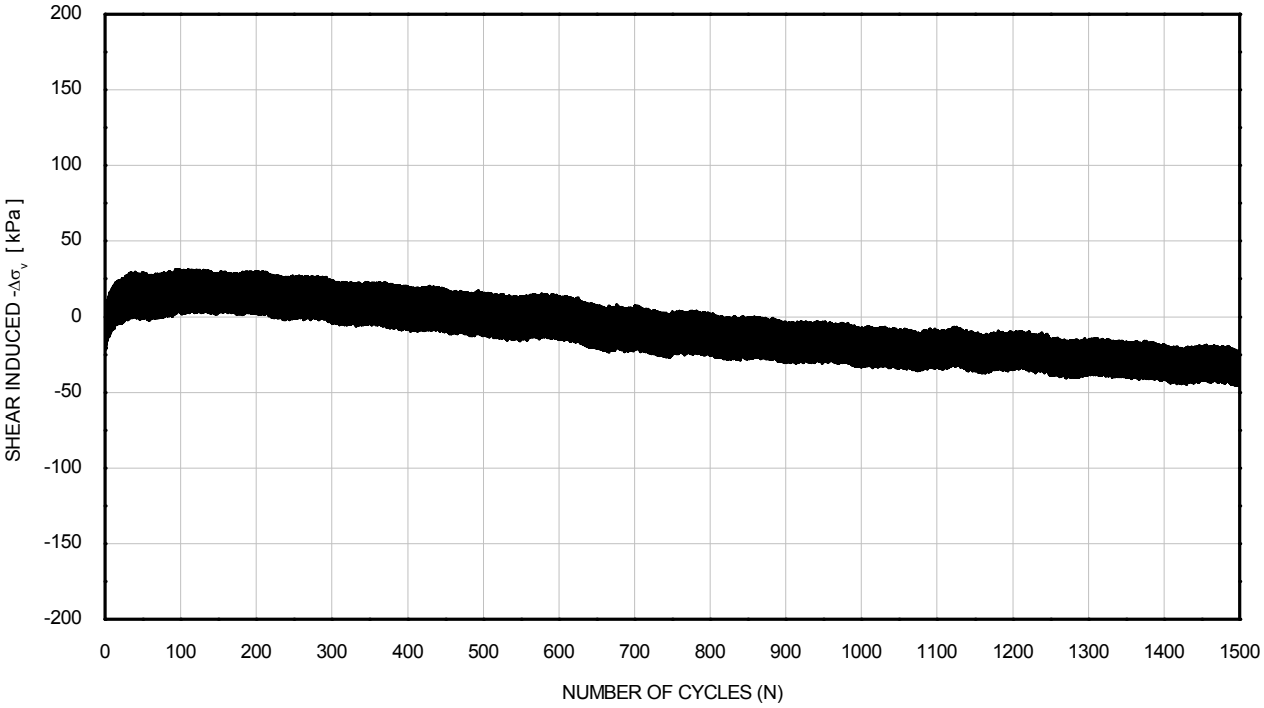


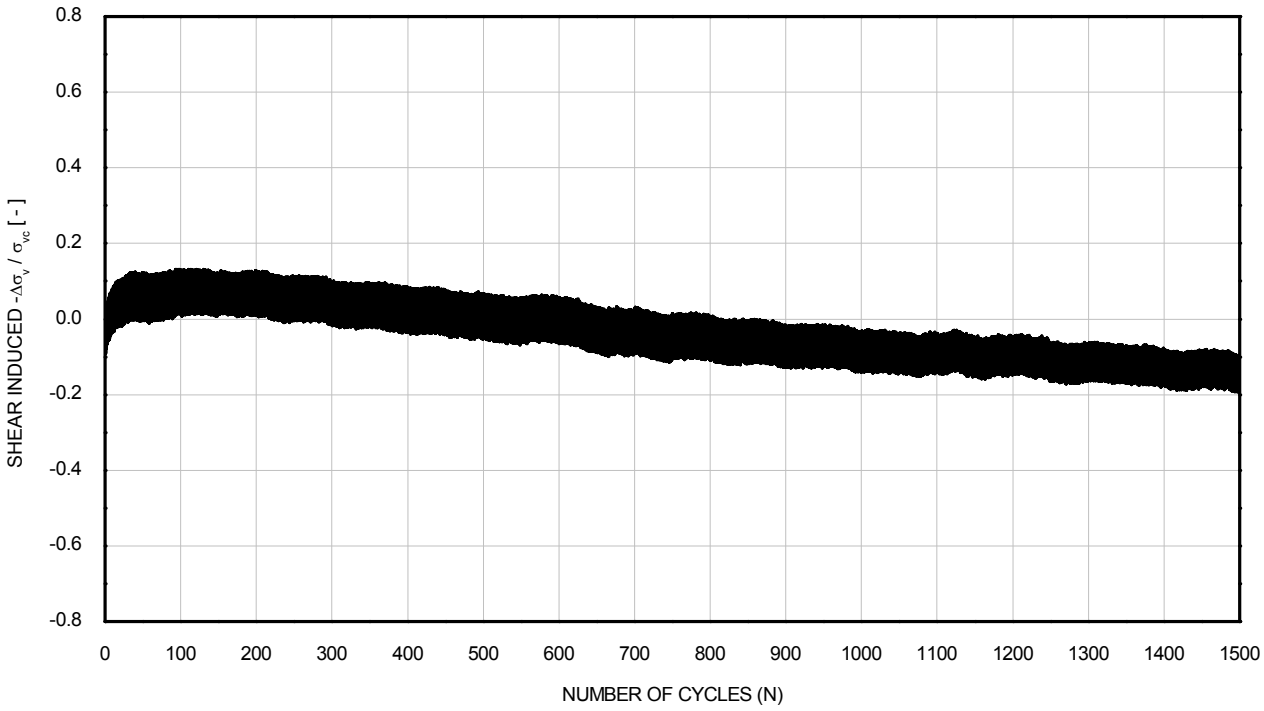


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	111 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.48
			Test No.	:	CSS03

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

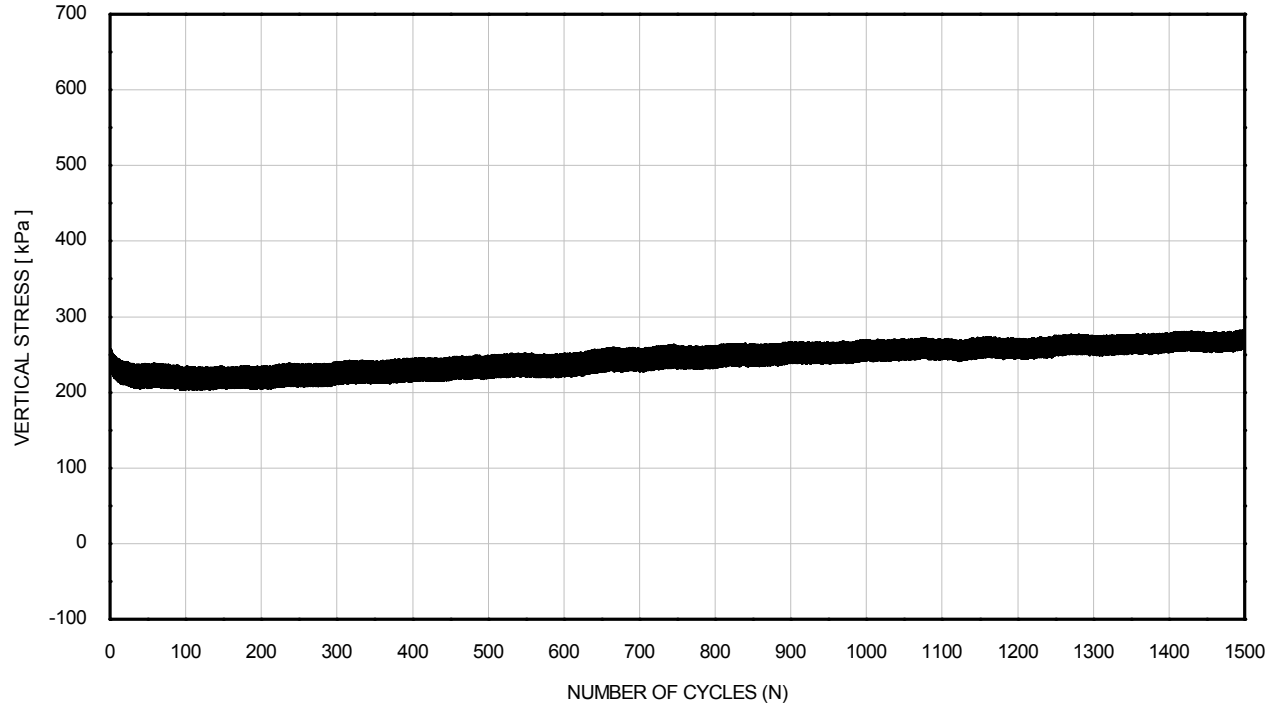


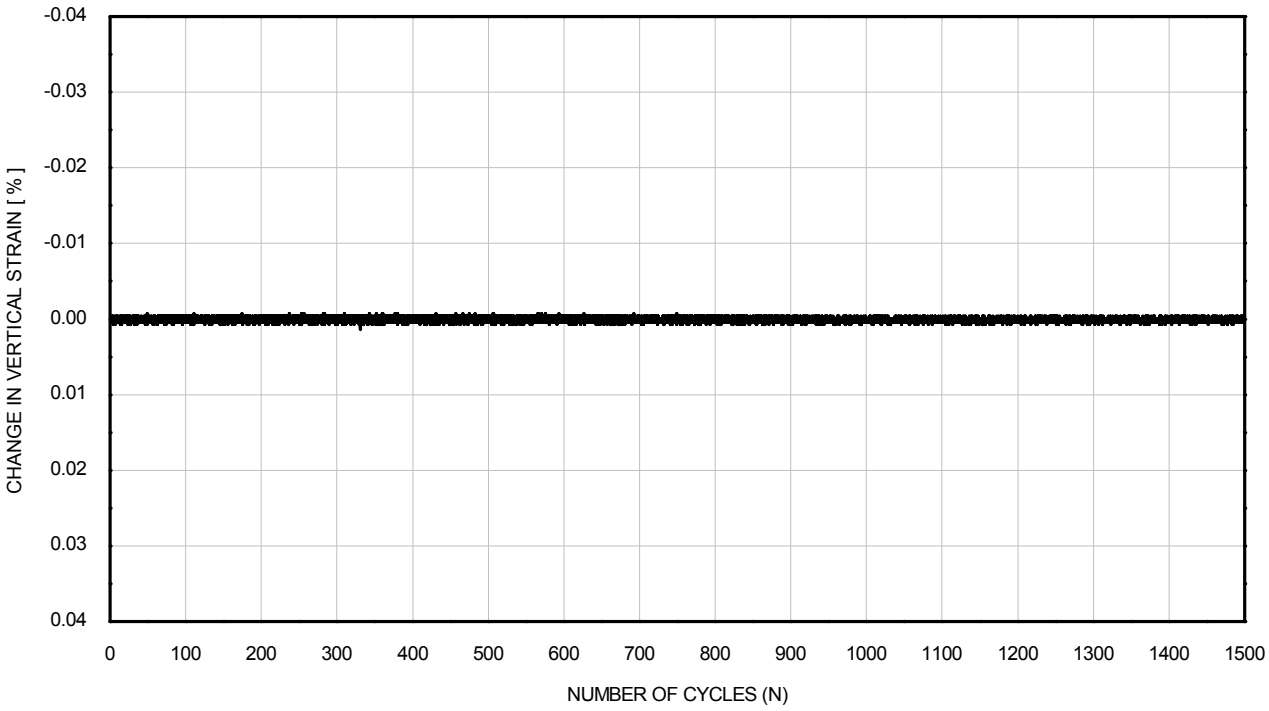


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	111 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.48
			Test No.	:	CSS03

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

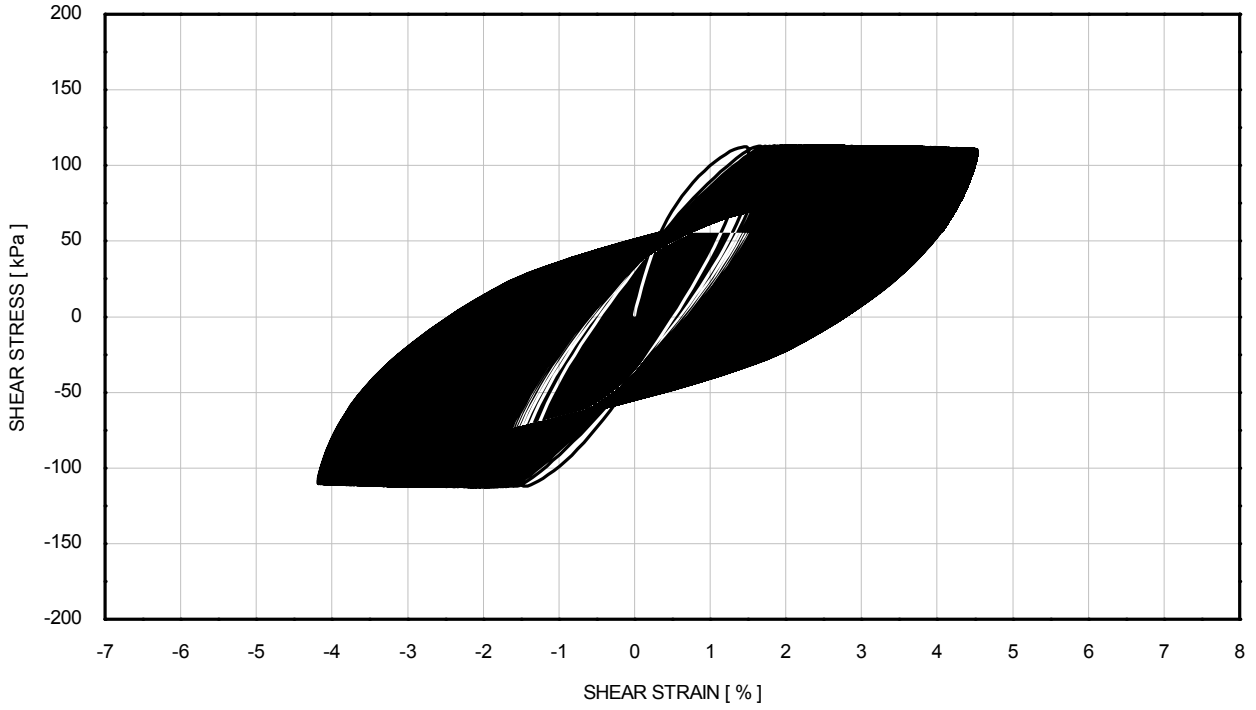


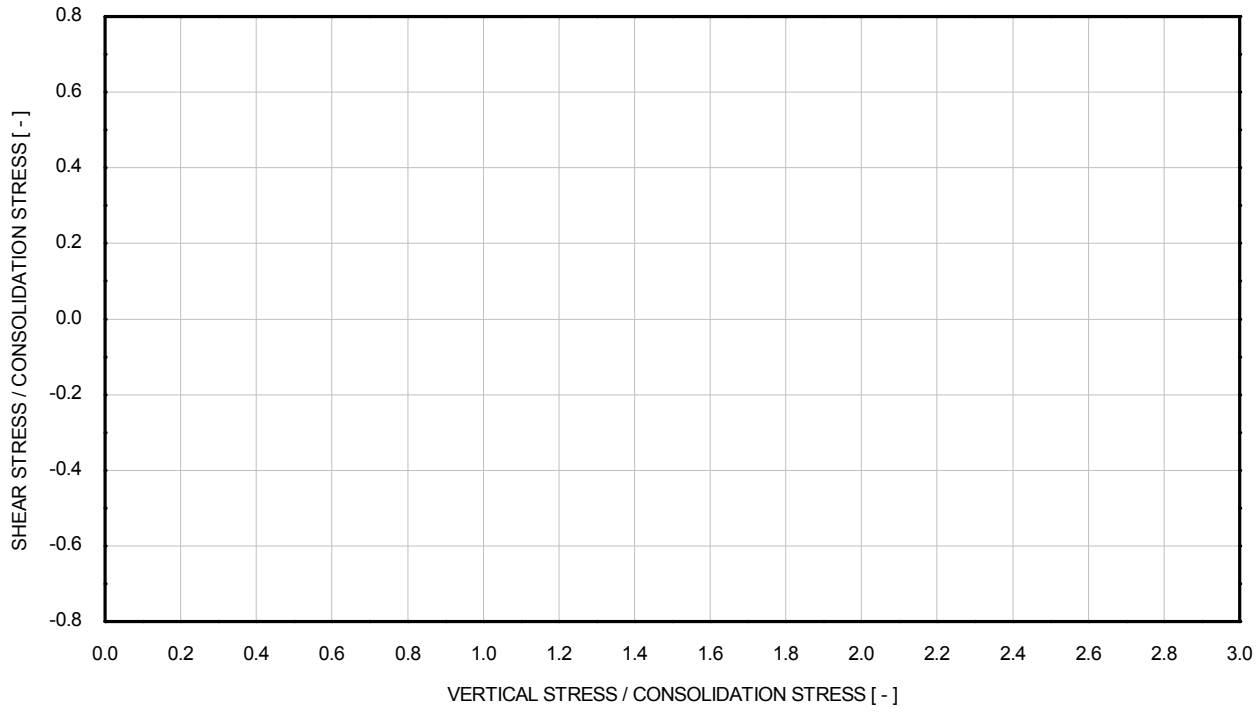


σ_{vc}	:	235 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	: 2WaxD
Mean τ_{cy}	:	111 kPa	Unit	: F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	: 23.48
			Test No.	: CSS03

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

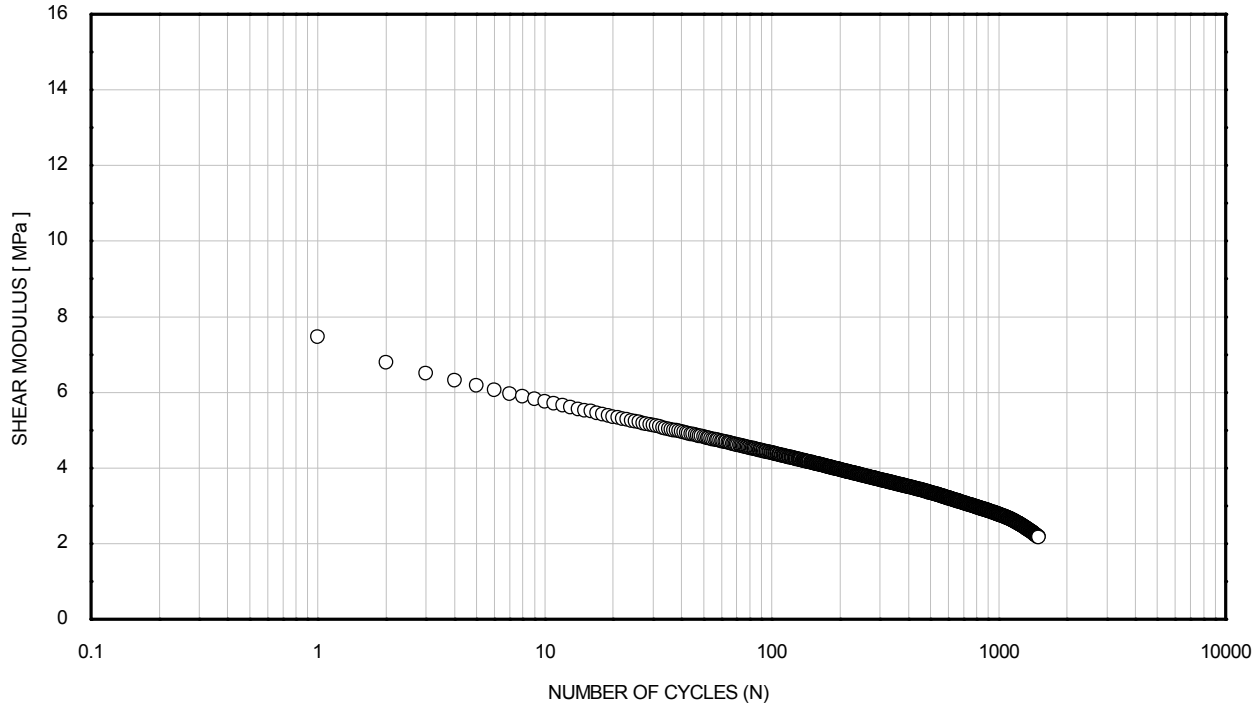


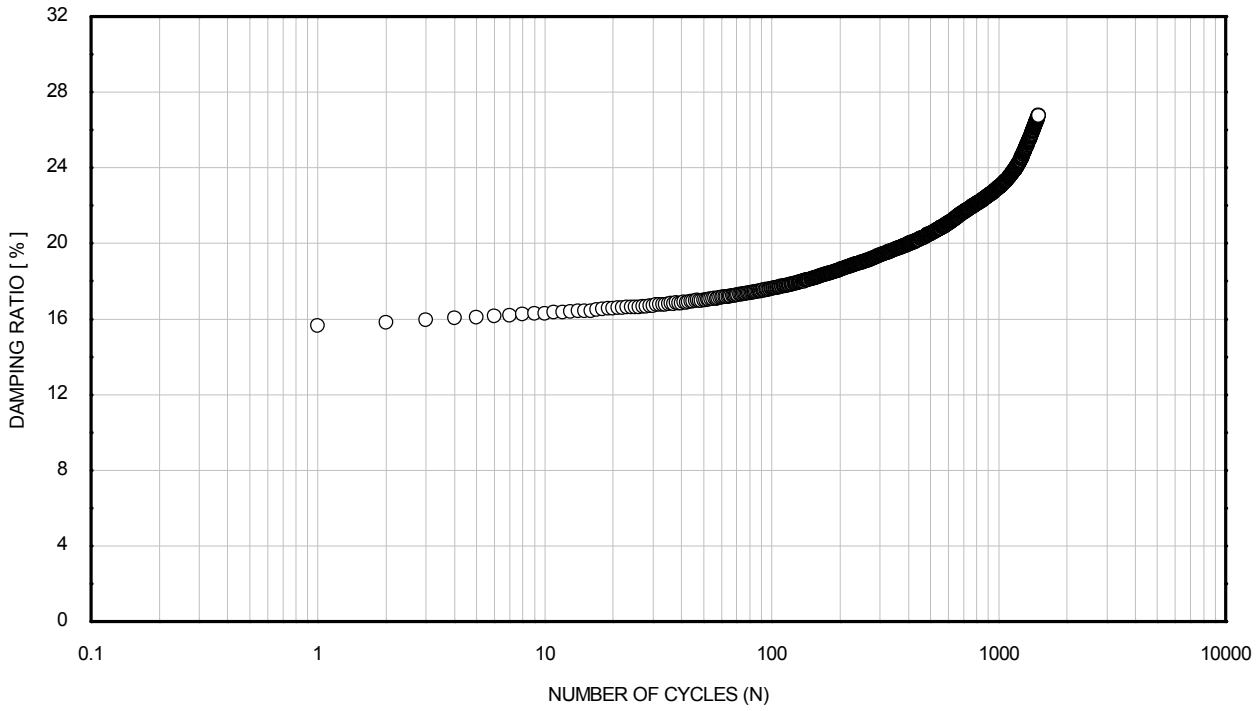


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	111 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.48
			Test No.	:	CSS03

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

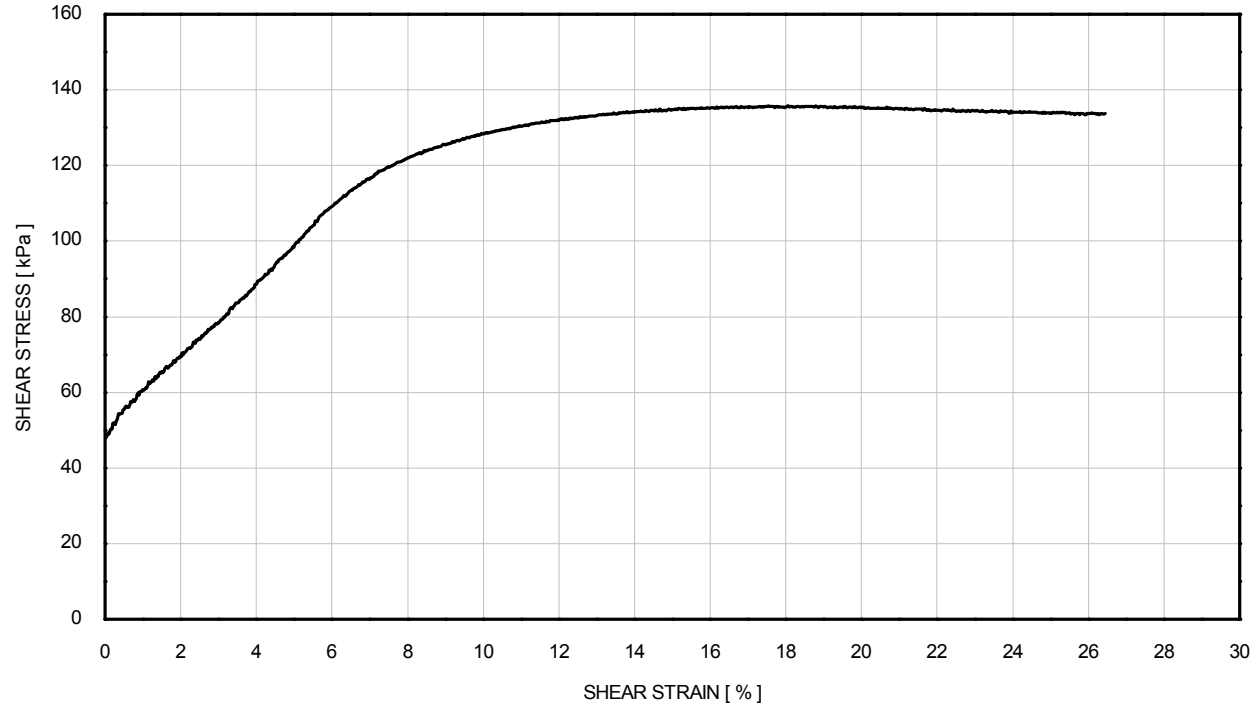


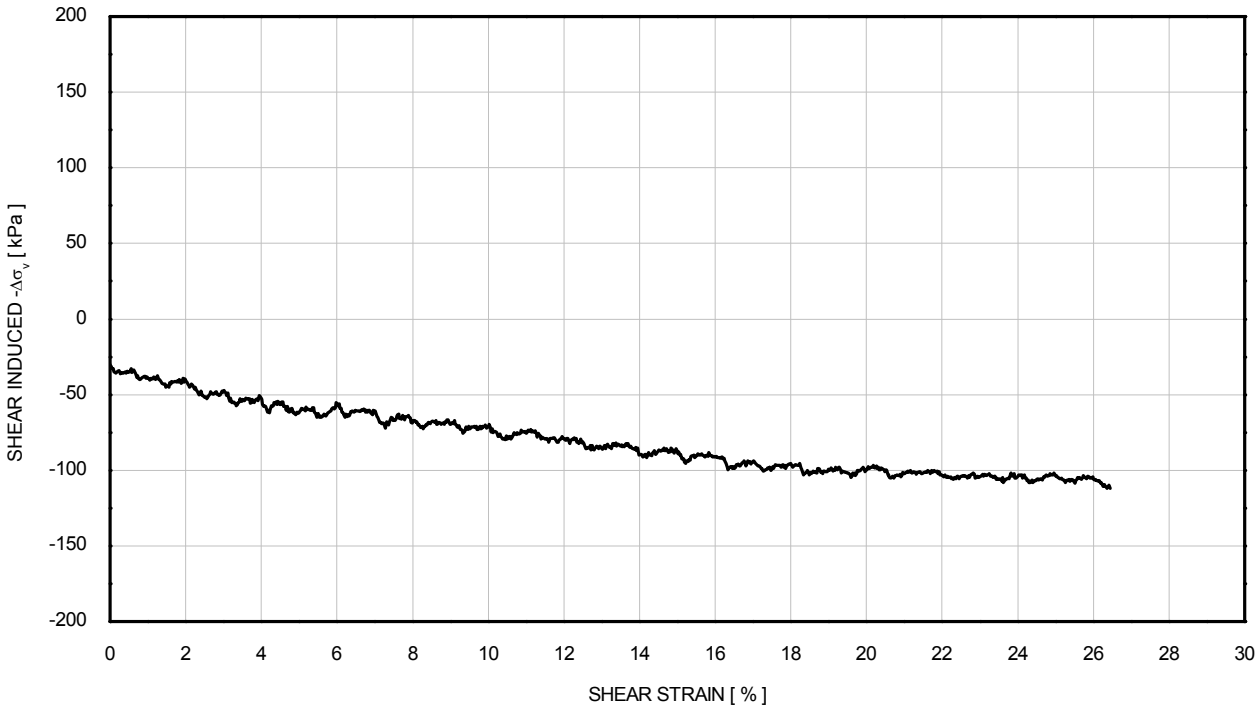


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	2WaxD
Mean τ_{cy}	:	111 kPa	Unit	:	F1c (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	23.48
			Test No.	:	CSS03

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

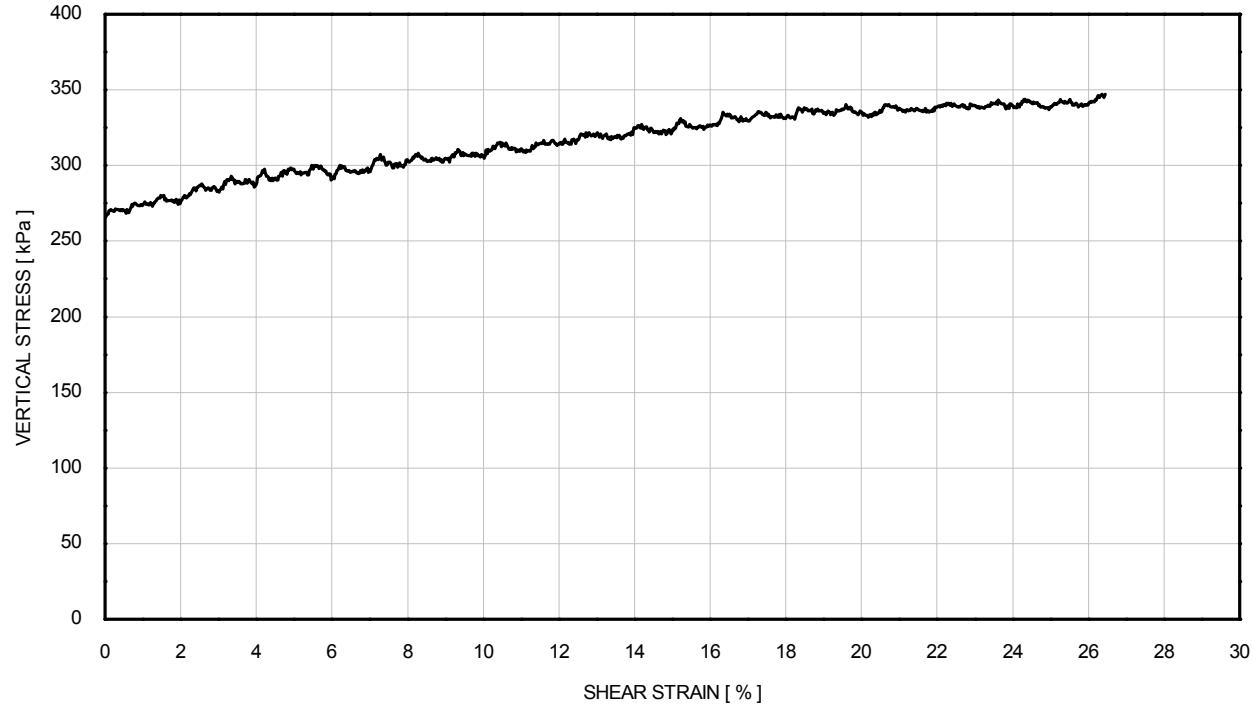


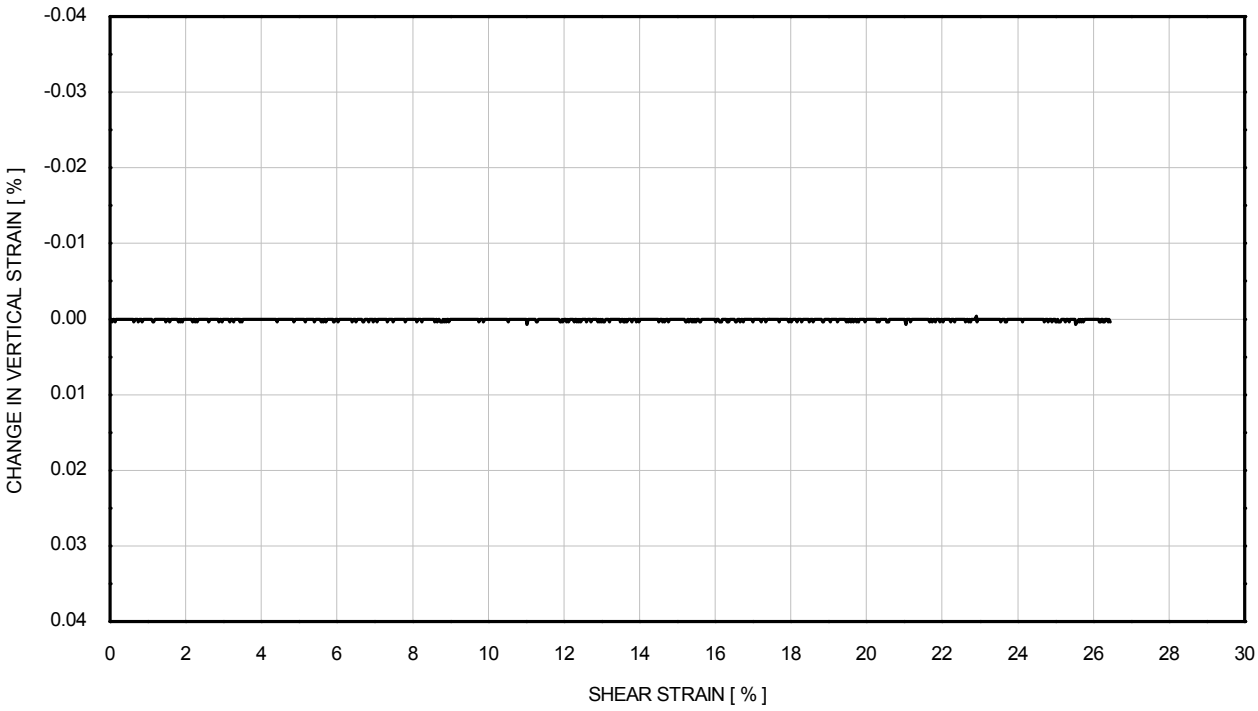


σ_{vc}	: 235 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 136 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 18.79 %	Unit	: F1c (Dongen)
Rate of strain	: 3.00 %/hour	Depth [m]	: 23.48
		Test No.	: CSS03

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

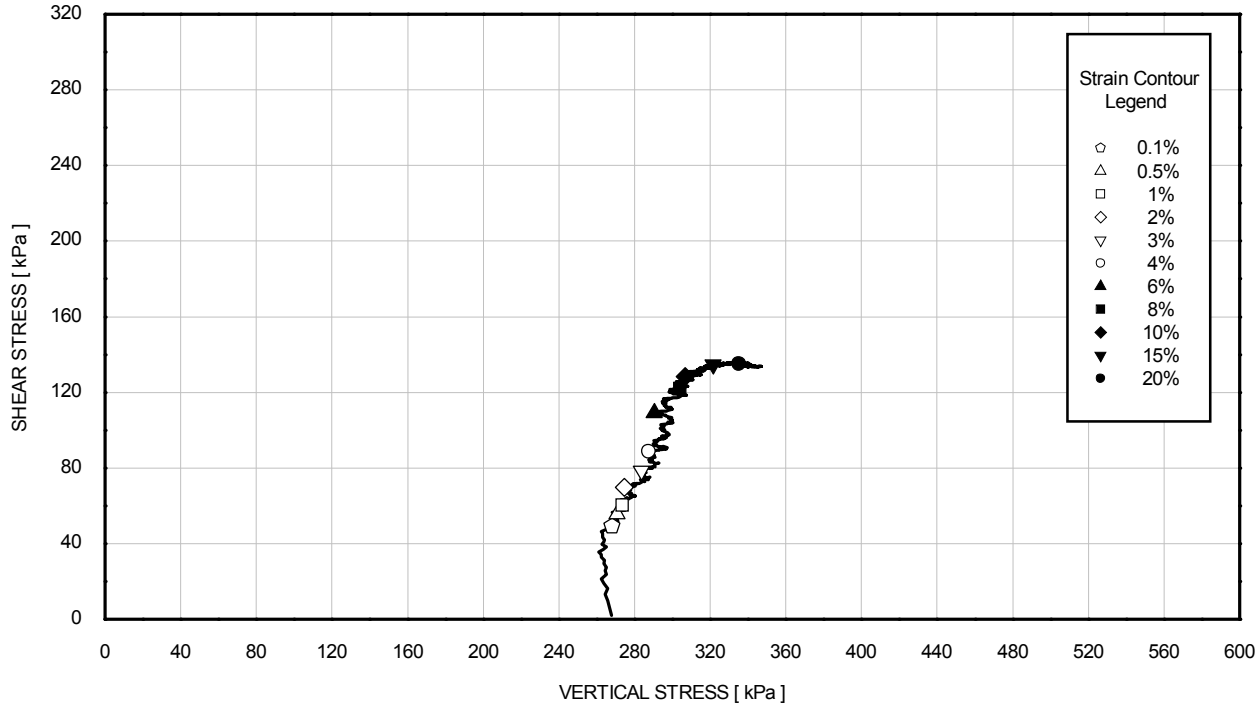


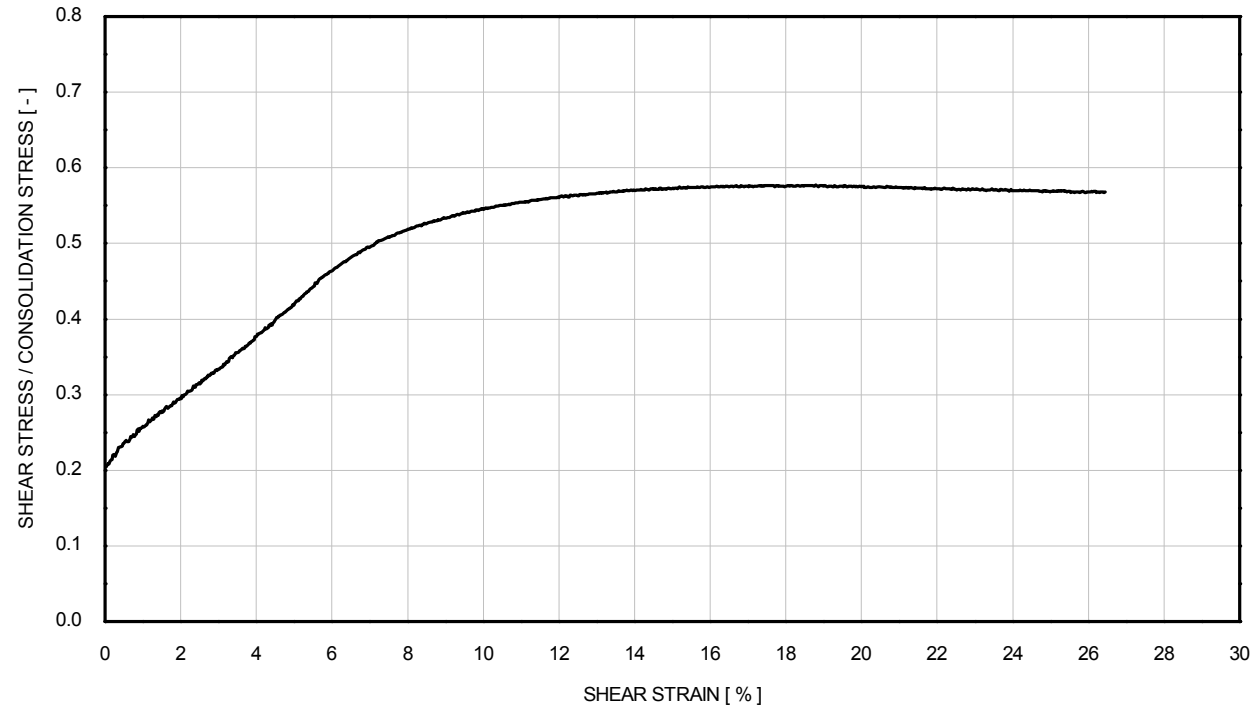


σ_{vc}	: 235 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 136 kPa	Sample	: 2WaxD
γ at τ_{peak}	: 18.79 %	Unit	: F1c (Dongen)
Rate of strain	: 3.00 %/hour	Depth [m]	: 23.48
		Test No.	: CSS03

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

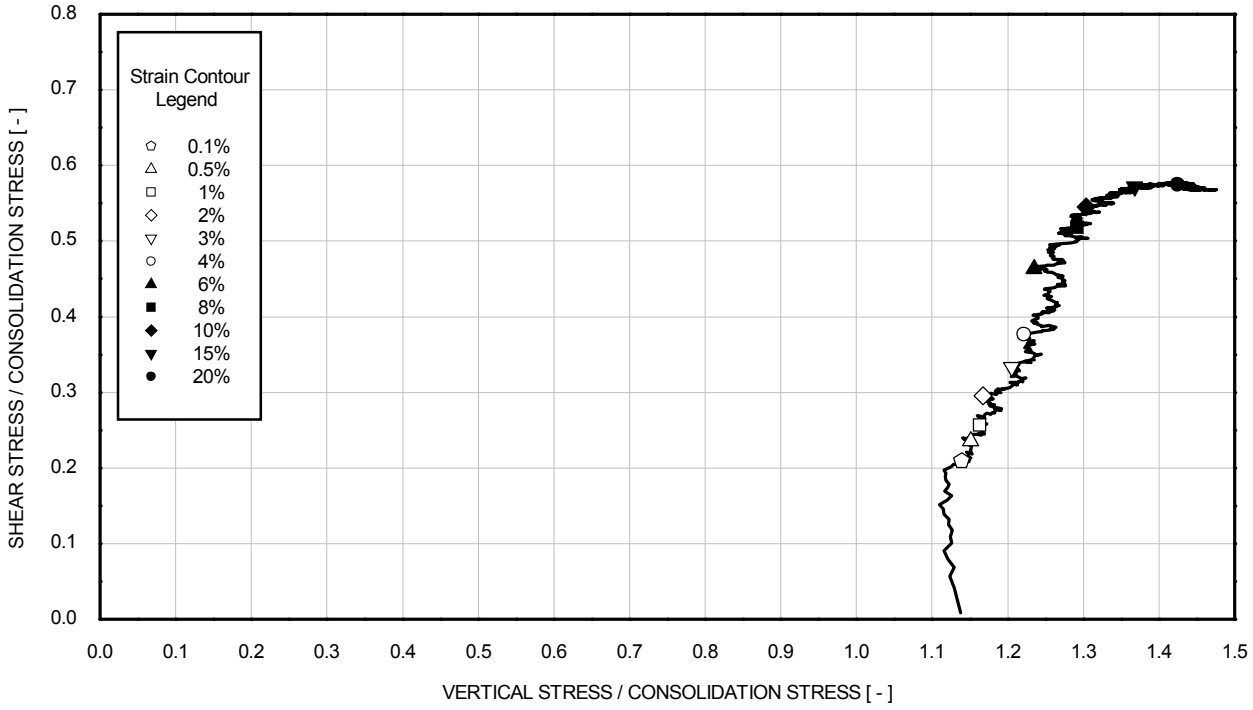


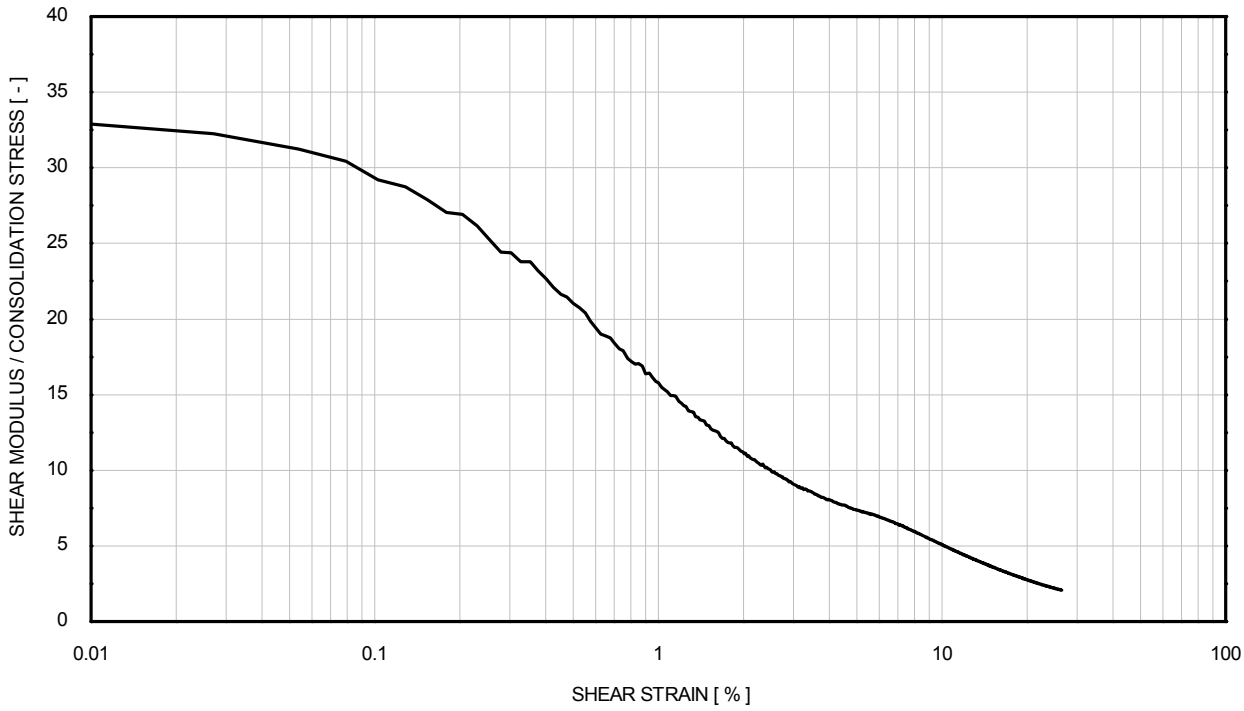


σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	136 kPa	Sample	:	2WaxD
γ at τ_{peak}	:	18.79 %	Unit	:	F1c (Dongen)
Rate of strain	:	3.00 %/hour	Depth [m]	:	23.48
			Test No.	:	CSS03

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	235 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	136 kPa	Sample	:	2WaxD
γ at τ_{peak}	:	18.79 %	Unit	:	F1c (Dongen)
Rate of strain	:	3.00 %/hour	Depth [m]	:	23.48
			Test No.	:	CSS03

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark greenish grey fissured slightly sandy CLAY

GENERAL	
Date test started	04/12/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.9
Length	[mm]	29.9
Moisture content	[%]	39.4
Bulk density	[Mg/m³]	1.84
Dry density	[Mg/m³]	1.32
Void ratio	[-]	1.045
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	242
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_6WAXD_CSS04
Template issue	1.3
Processed by	GG
Date	10/12/2015
Checked by	LJ
Date	11/12/2015
Approved by	PH
Date	13/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxD
Unit	F3 (Dongen)
Depth [m]	33.40
Test number	CSS04

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	885
Vertical strain	[%]	3.92
Bulk density	[Mg/m^3]	1.88
Dry density	[Mg/m^3]	1.37
Void ratio	[-]	0.964
Moisture content	[%]	36.5

CONSOLIDATION		
σ_{vc}	[kPa]	320
Vertical strain	[%]	2.77
Bulk density	[Mg/m^3]	1.87
Dry density	[Mg/m^3]	1.36
Void ratio	[-]	0.988
Moisture content	[%]	37.3

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	235
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	146
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	144
γ_{av} at N_f	[%]	3.41
γ_{cy} at N_f	[%]	15.51
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	-93
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.21	1.52	9.84	16.84
2	0.36	1.70	8.84	16.85
5	0.66	1.99	7.57	17.98
10	0.91	2.44	6.15	21.34
20	1.46	3.67	4.05	26.16
30	1.86	4.85	3.04	26.15
40	2.09	5.46	2.70	25.94
50	2.24	5.85	2.51	25.96
100	2.69	7.46	1.93	26.35
144	3.41	15.51	0.93	31.30

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxD
Unit	F3 (Dongen)
Depth [m]	33.40
Test number	CSS04

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME*		
At peak shear stress		
Shear stress	[kPa]	152
Shear strain	[%]	29.11
Shear induced $-\Delta\sigma_v$	[kPa]	-52
Vertical stress	[kPa]	372
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.99
At 15 % shear strain		
Shear stress	[kPa]	113
Shear induced $-\Delta\sigma_v$	[kPa]	33
Vertical stress	[kPa]	287
Vertical strain	[%]	0.00

* Please note that specimen failure was observed to occur along a horizontal fissure or slickensided surface, approximately, in the middle of the specimen.

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxD
Unit	F3 (Dongen)
Depth [m]	33.40
Test number	CSS04

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

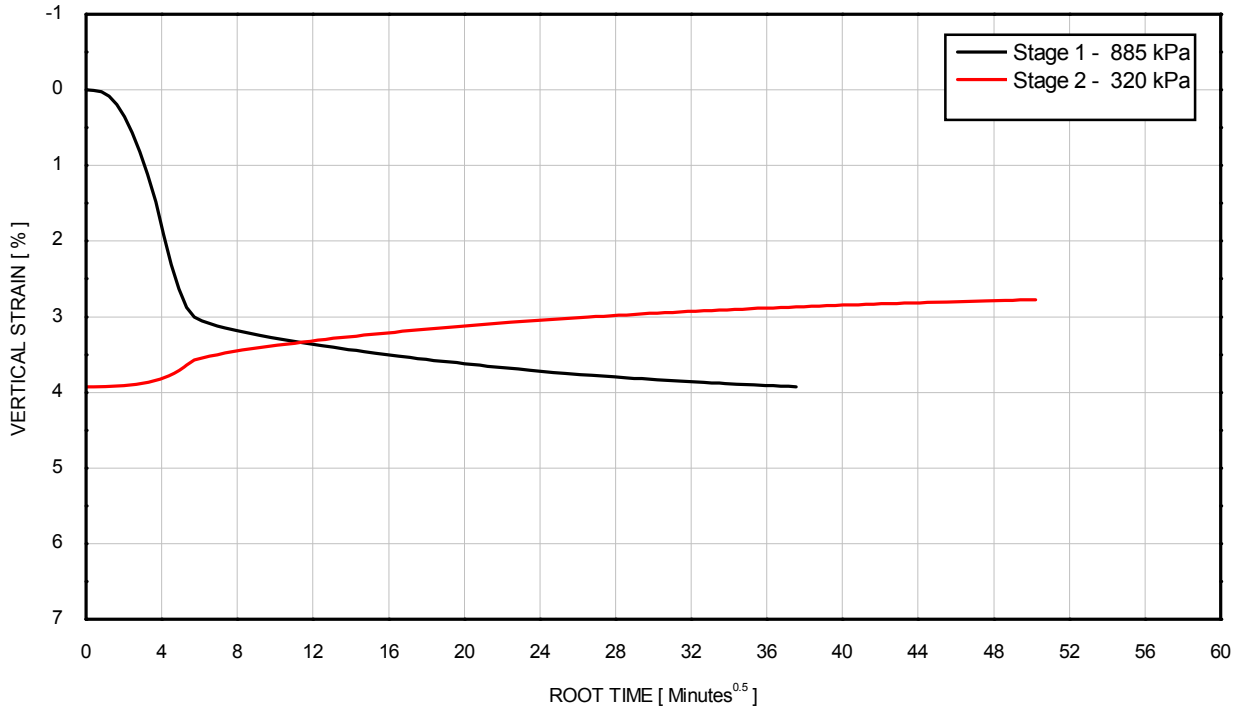
SPECIMEN PHOTOGRAPH

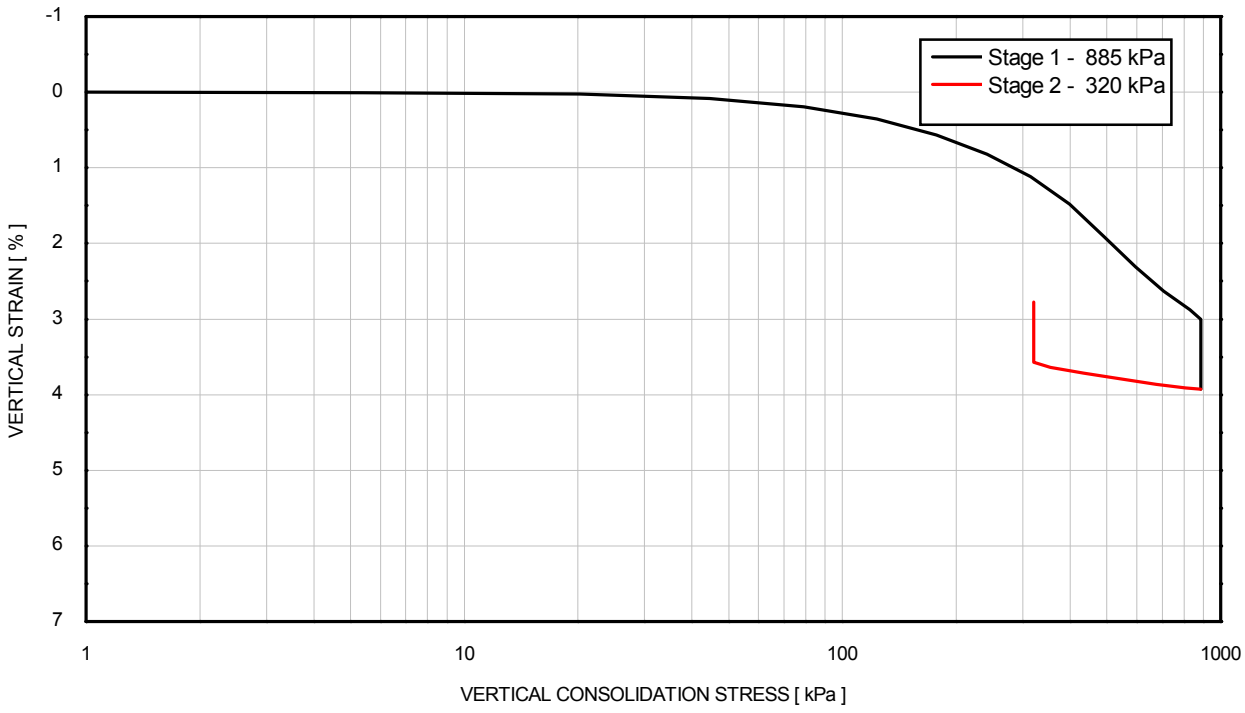


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxD
Unit	F3 (Dongen)
Depth [m]	33.40
Test number	CSS04

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

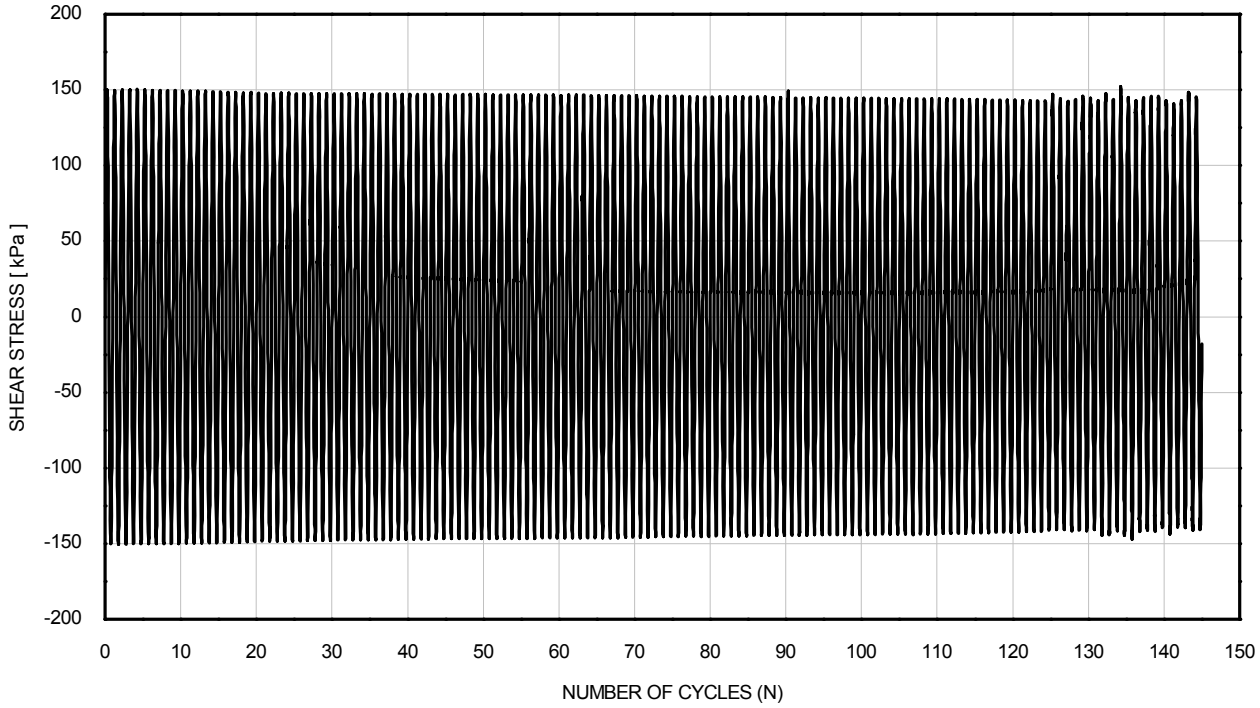


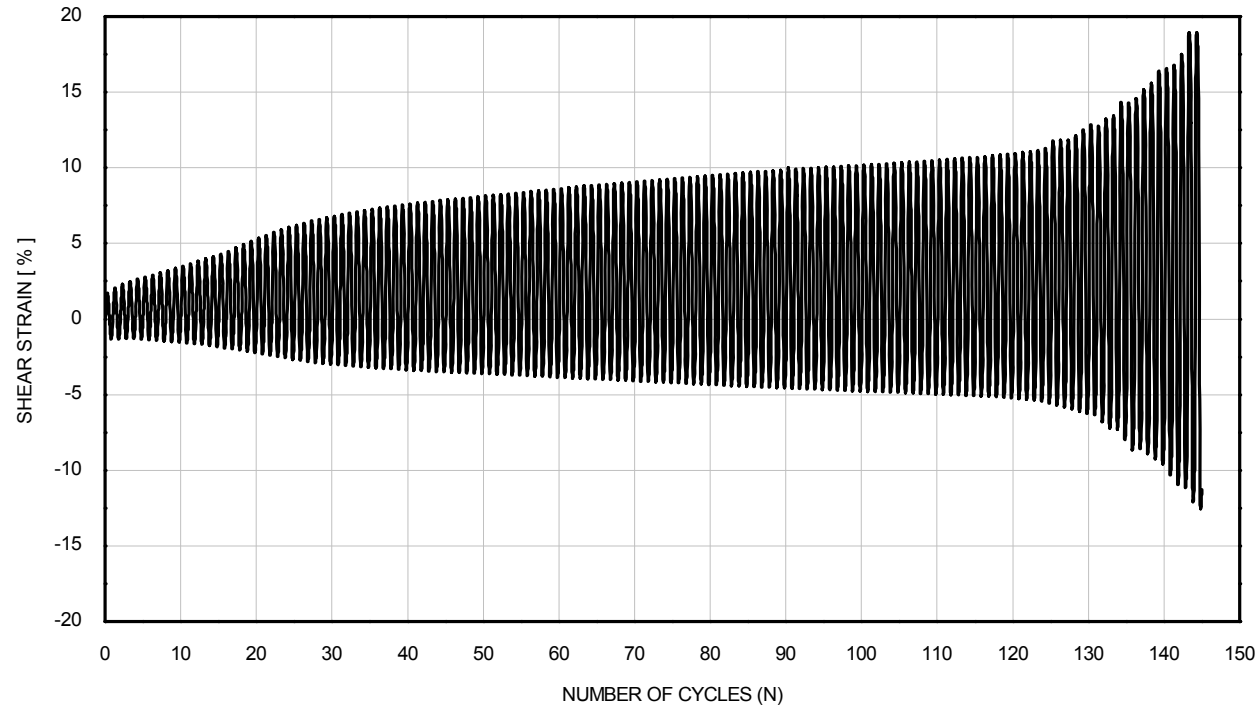


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
		Sample	: 6WaxD
		Unit	: F3 (Dongen)
		Depth [m]	: 33.40
		Test No.	: CSS04

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

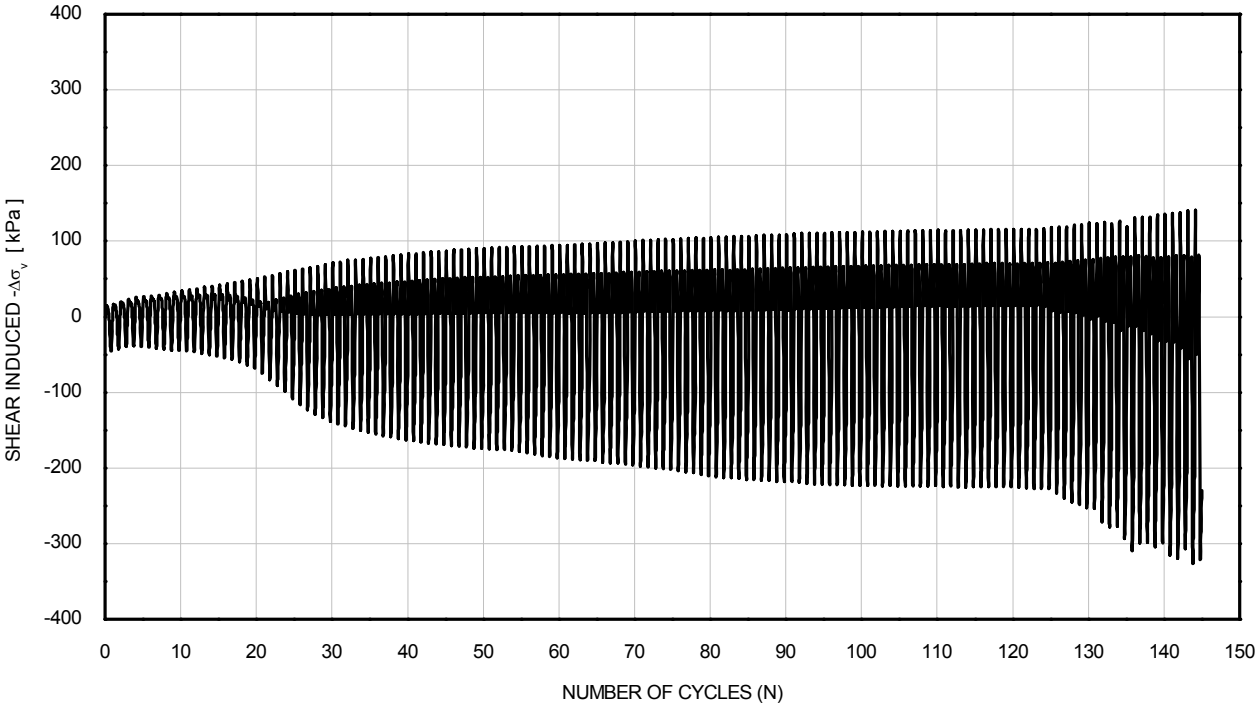


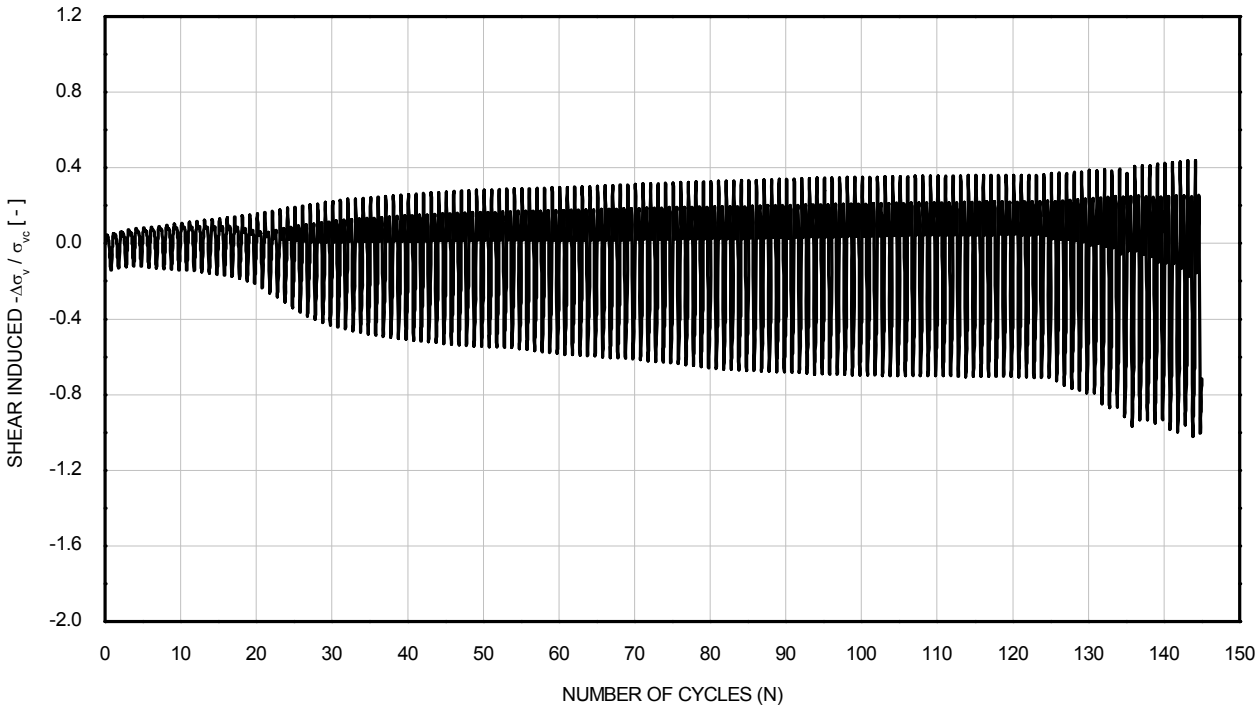


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	6WaxD
Mean τ_{cy}	:	146 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.40
			Test No.	:	CSS04

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

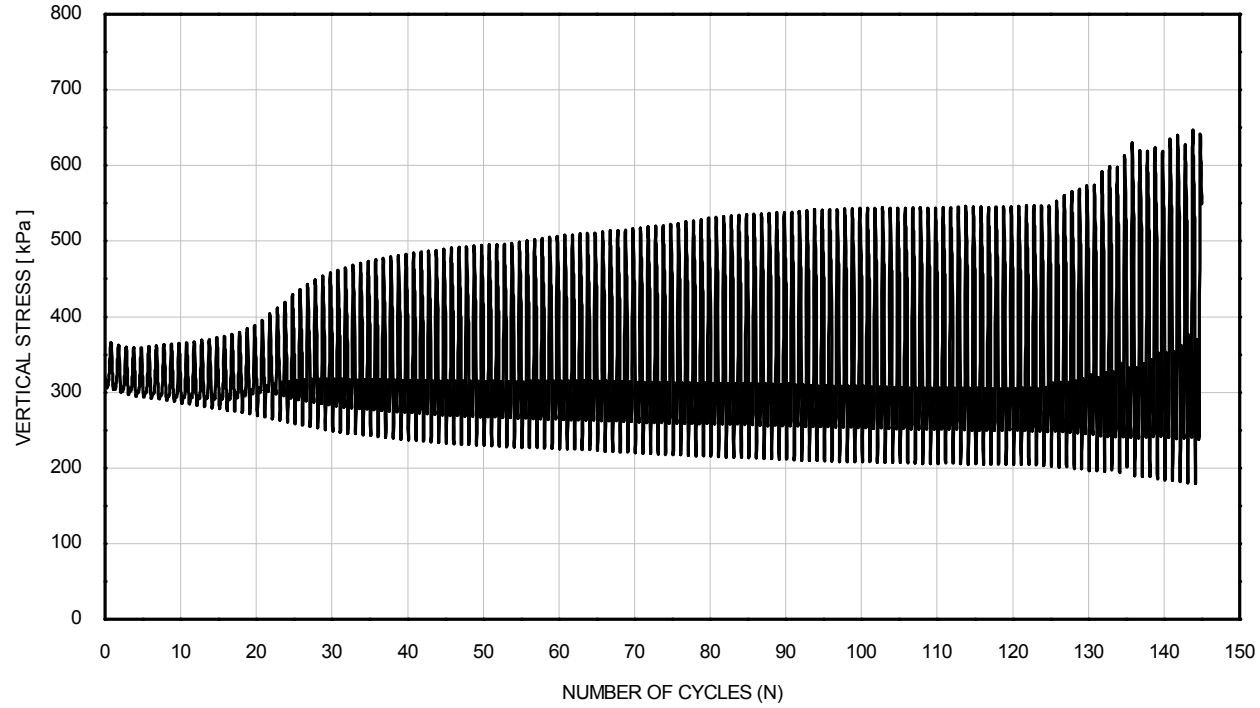


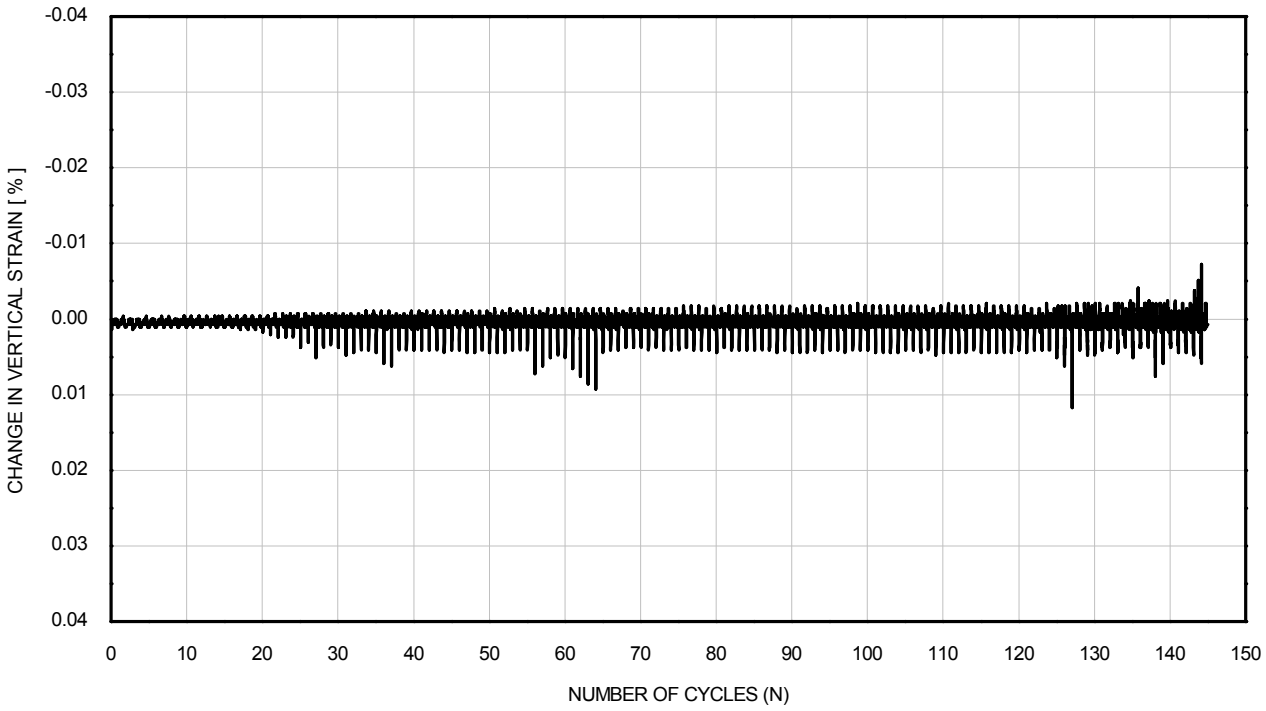


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	6WaxD
Mean τ_{cy}	:	146 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.40
			Test No.	:	CSS04

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

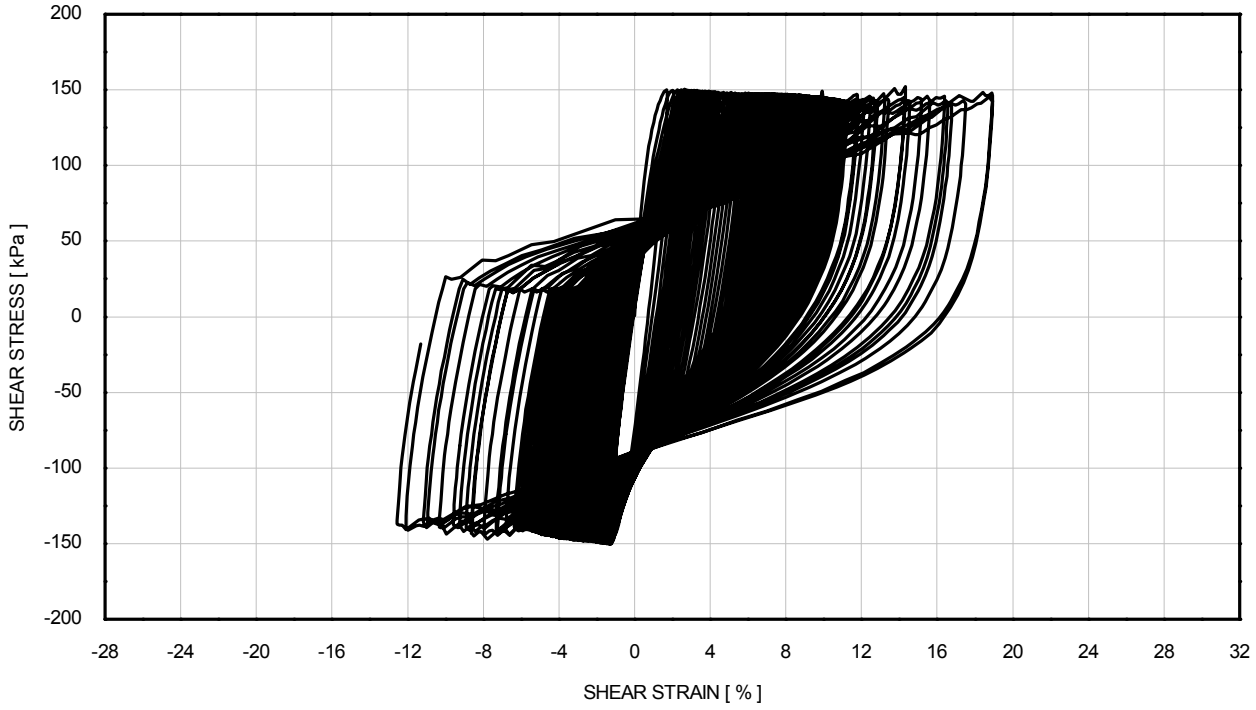


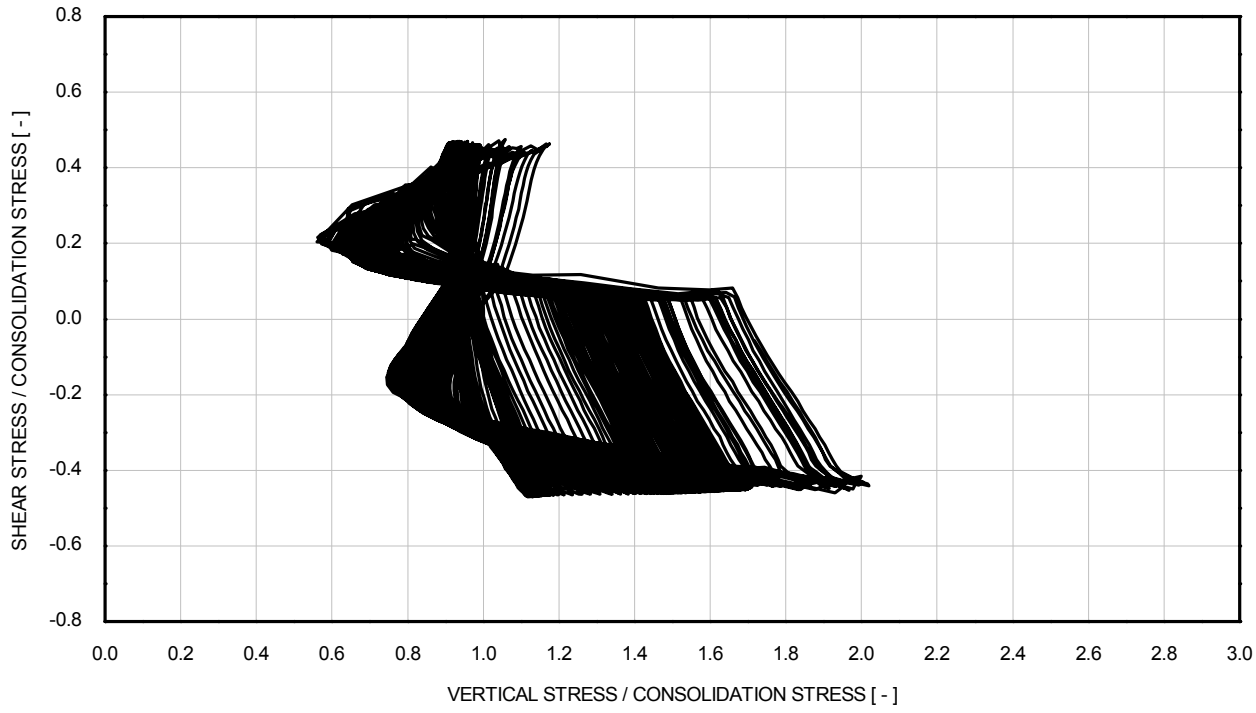


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	6WaxD
Mean τ_{cy}	:	146 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.40
			Test No.	:	CSS04

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

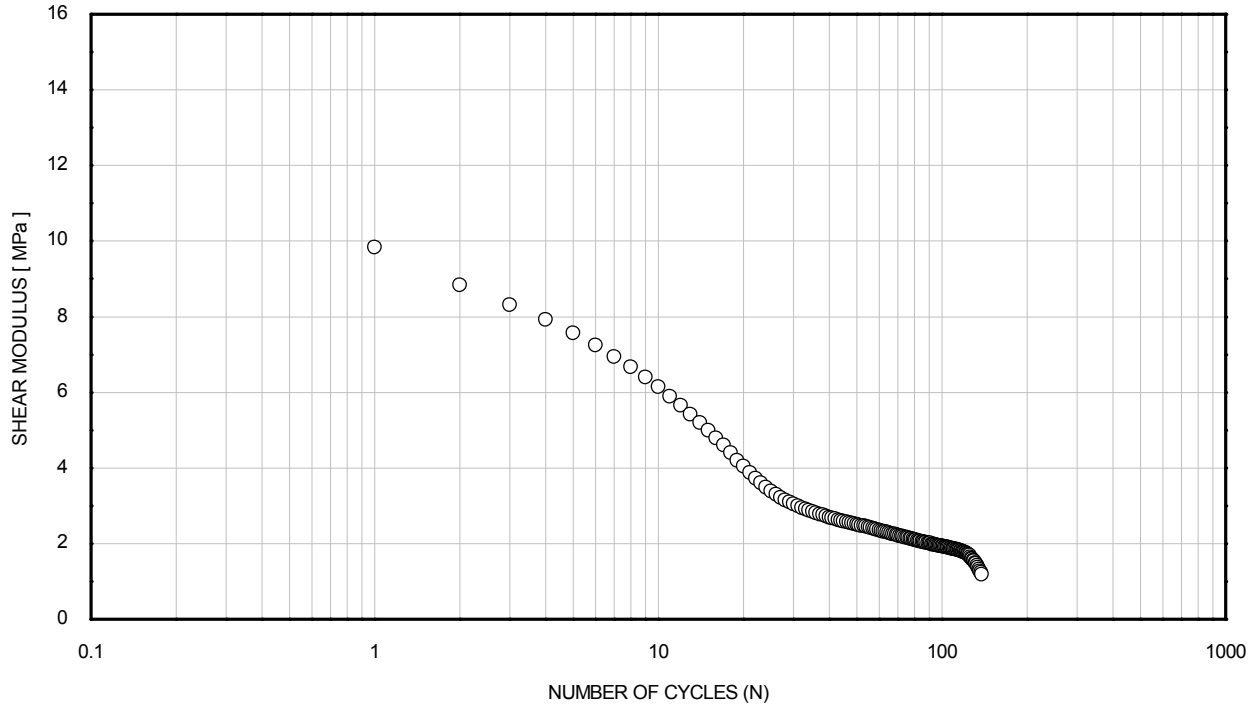


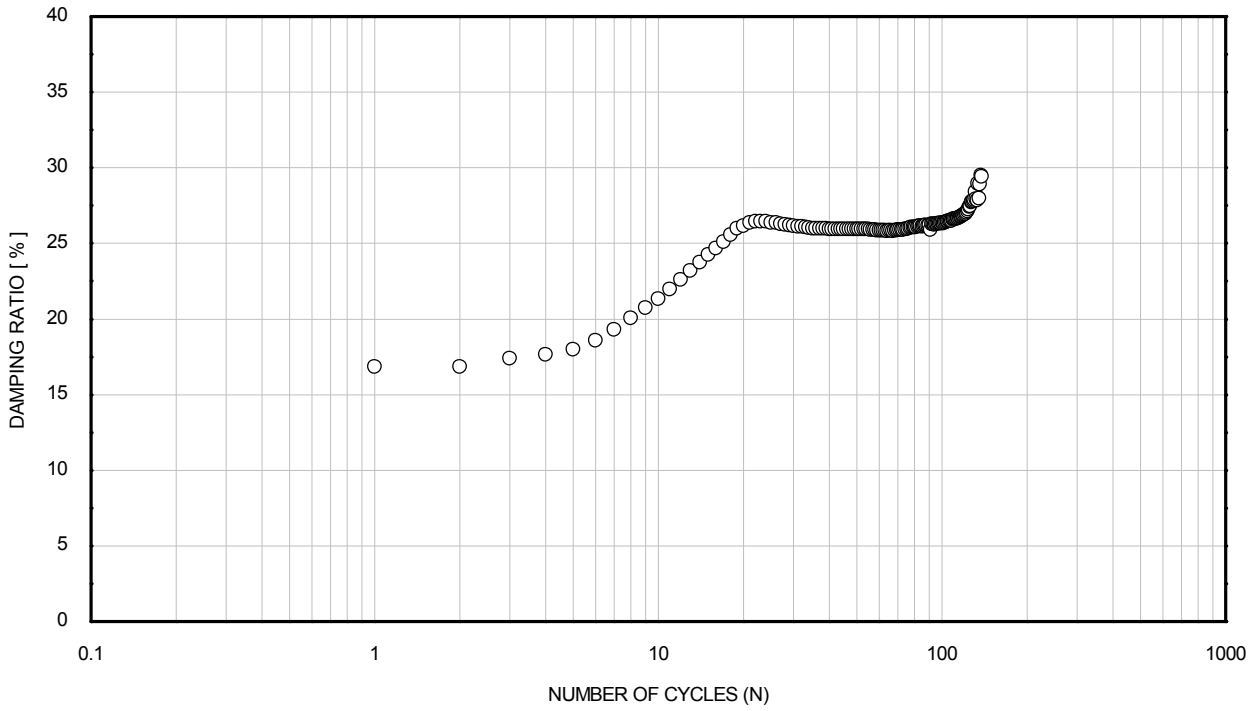


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	6WaxD
Mean τ_{cy}	:	146 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.40
			Test No.	:	CSS04

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

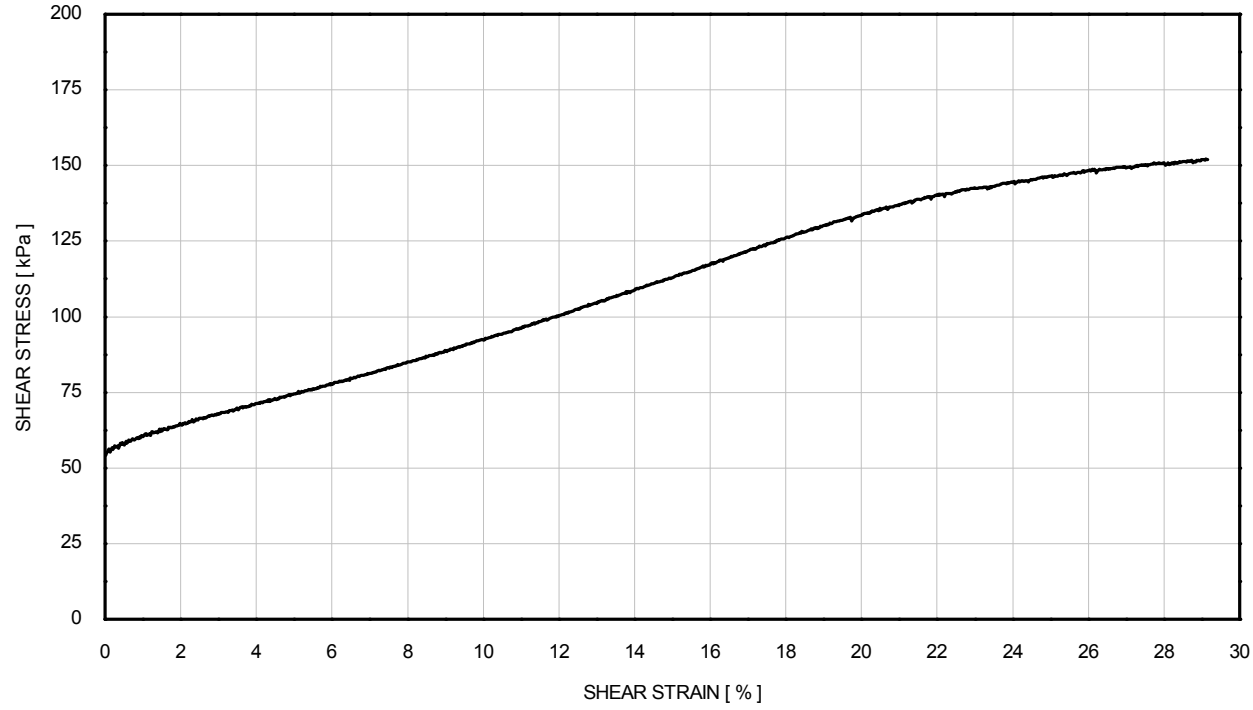


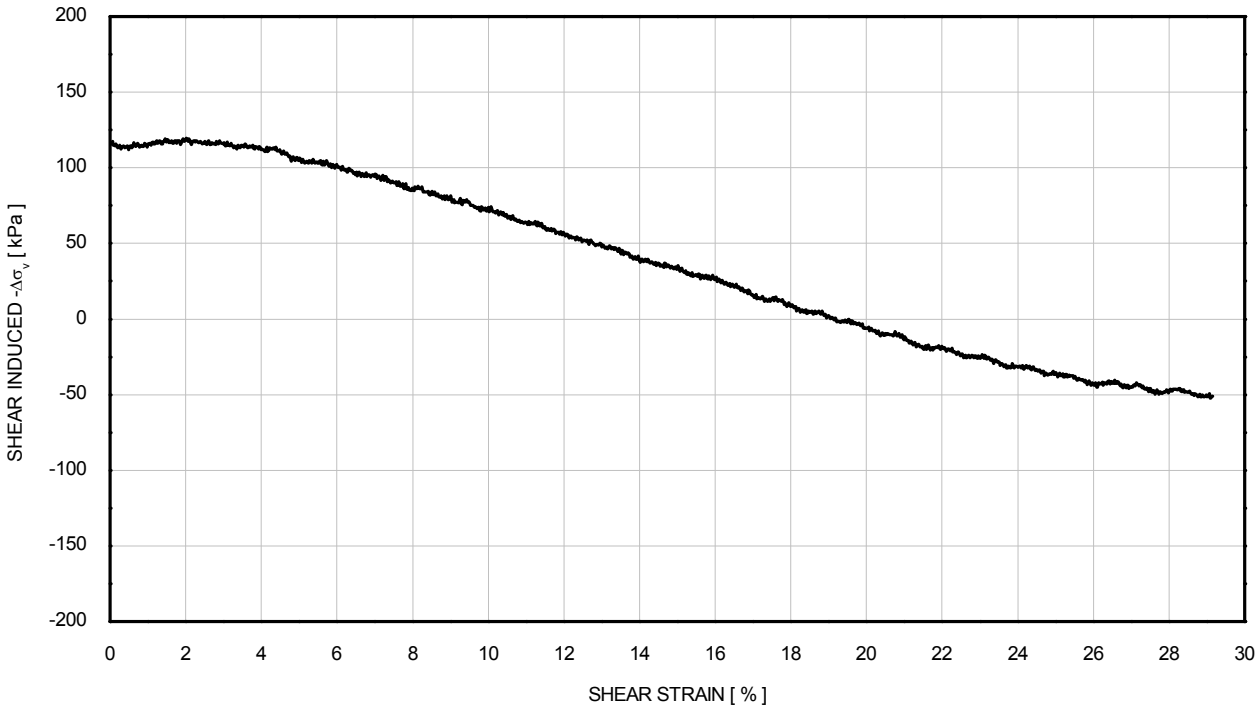


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	0 kPa	Sample	:	6WaxD
Mean τ_{cy}	:	146 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.40
			Test No.	:	CSS04

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

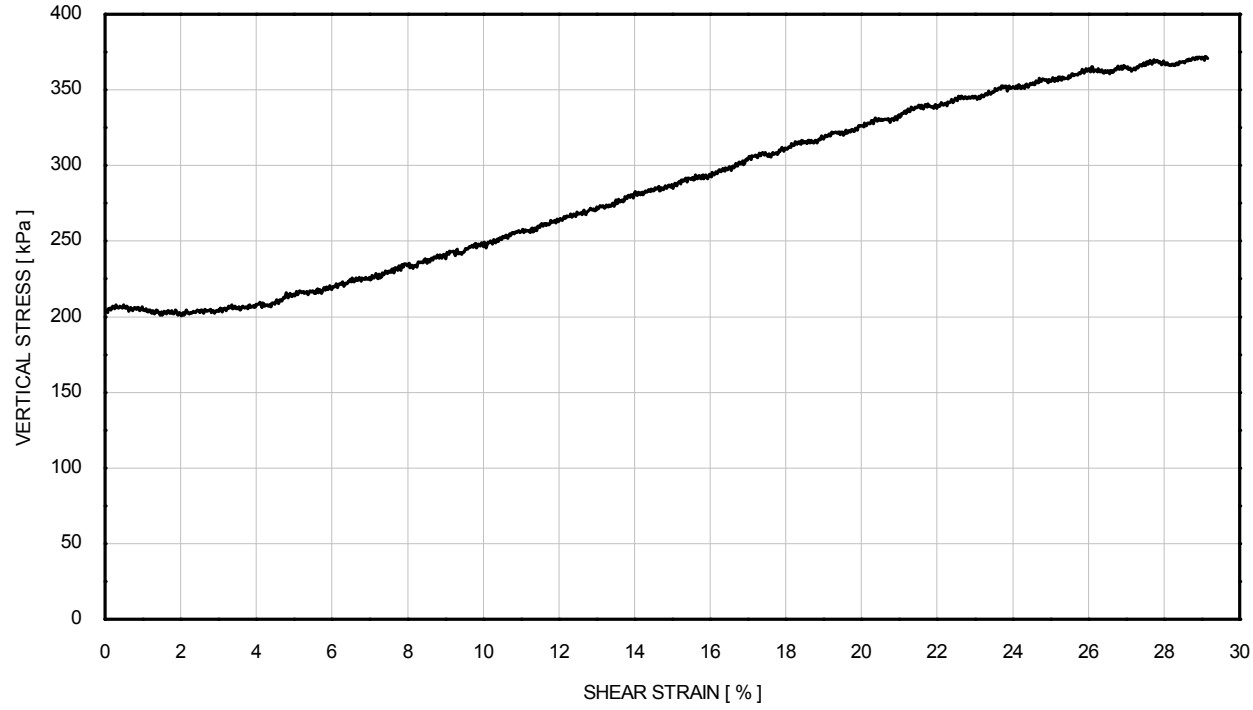


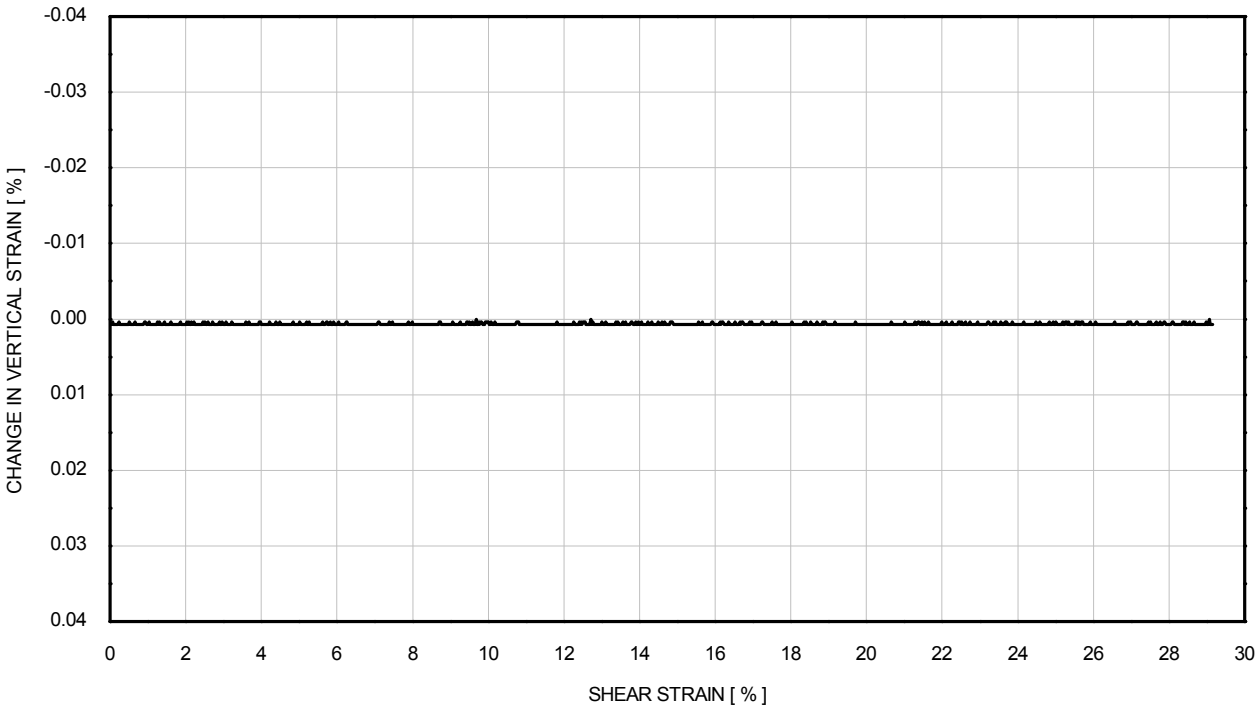


σ_{vc}	:	320 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	:	152 kPa	Sample	: 6WaxD
γ at τ_{peak}	:	29.11 %	Unit	: F3 (Dongen)
Rate of strain	:	2.99 %/hour	Depth [m]	: 33.40
			Test No.	: CSS04

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

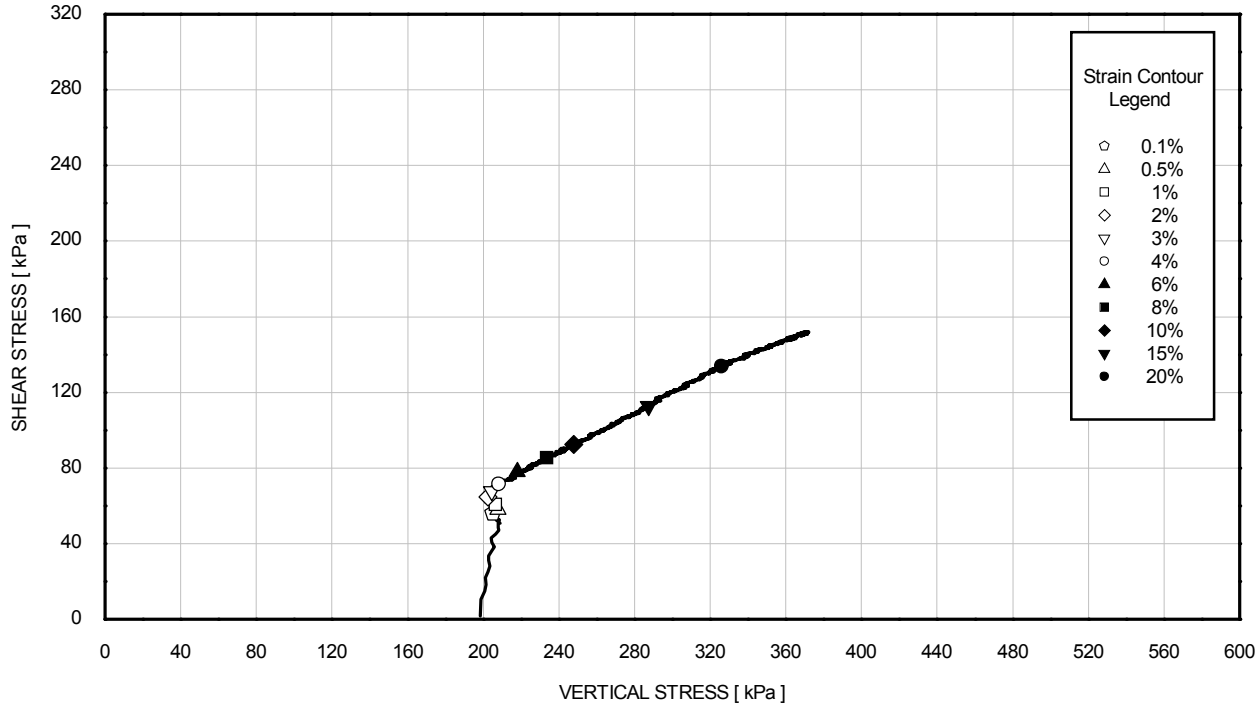


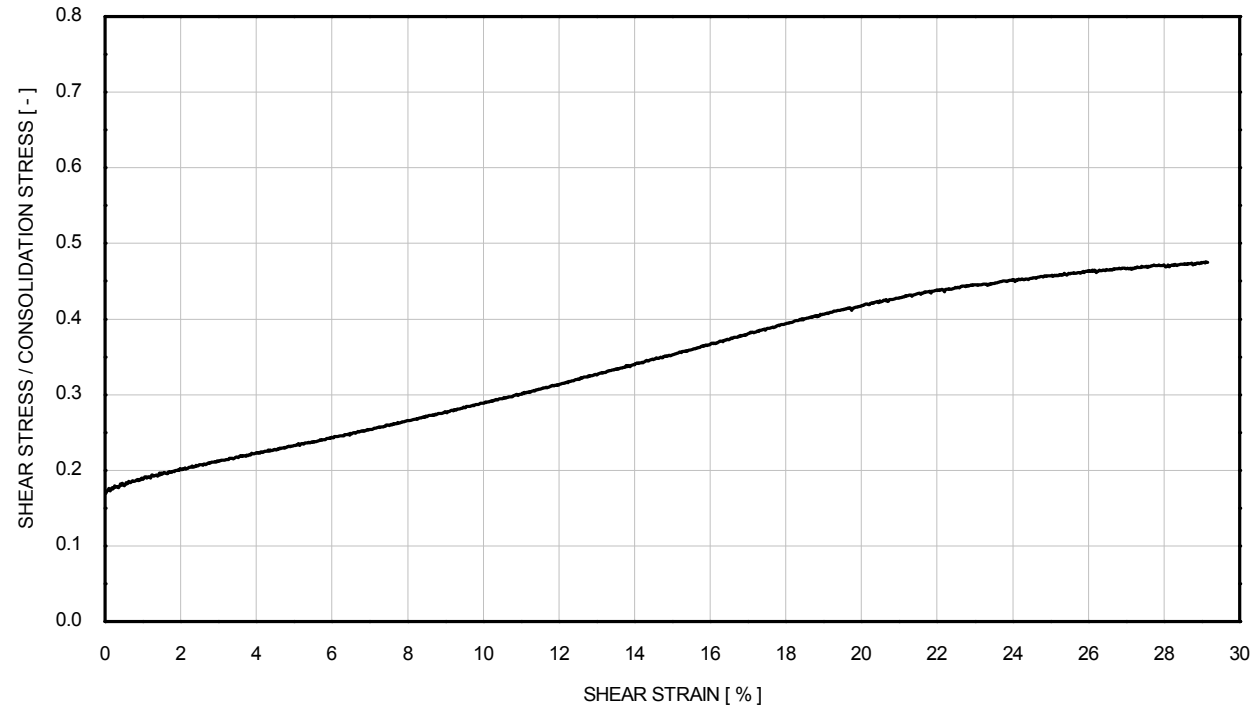


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 152 kPa	Sample	: 6WaxD
γ at τ_{peak}	: 29.11 %	Unit	: F3 (Dongen)
Rate of strain	: 2.99 %/hour	Depth [m]	: 33.40
		Test No.	: CSS04

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

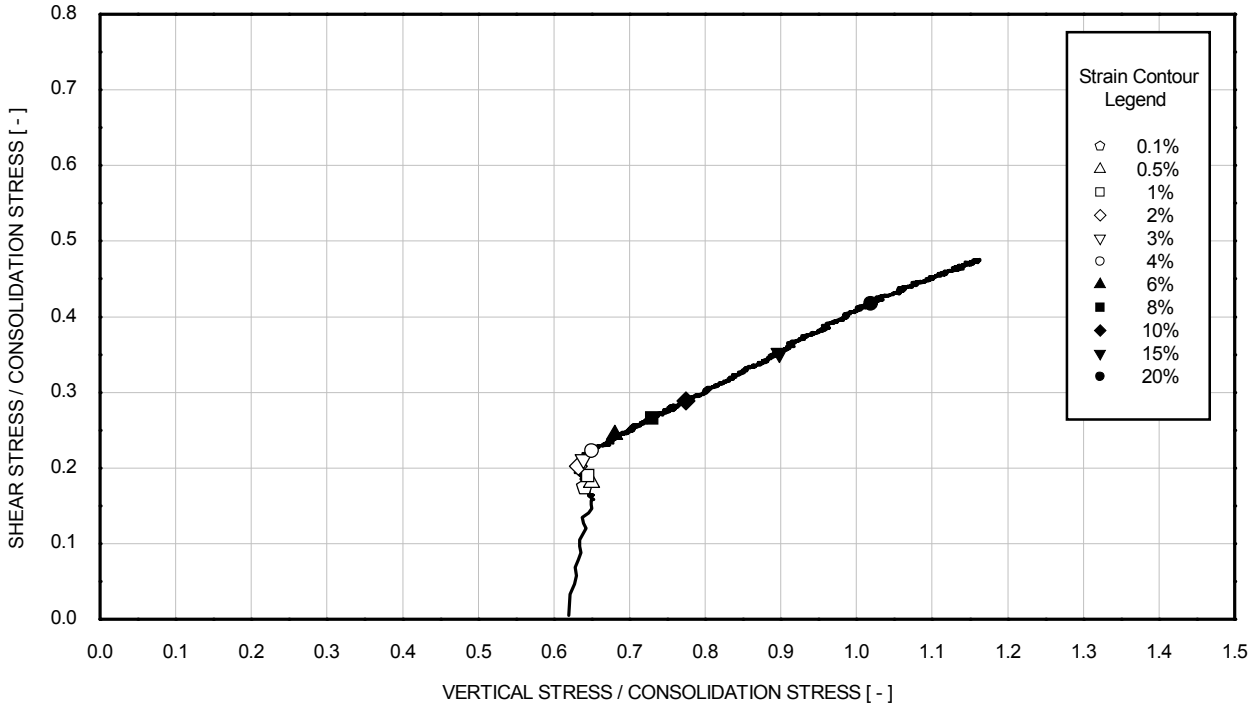


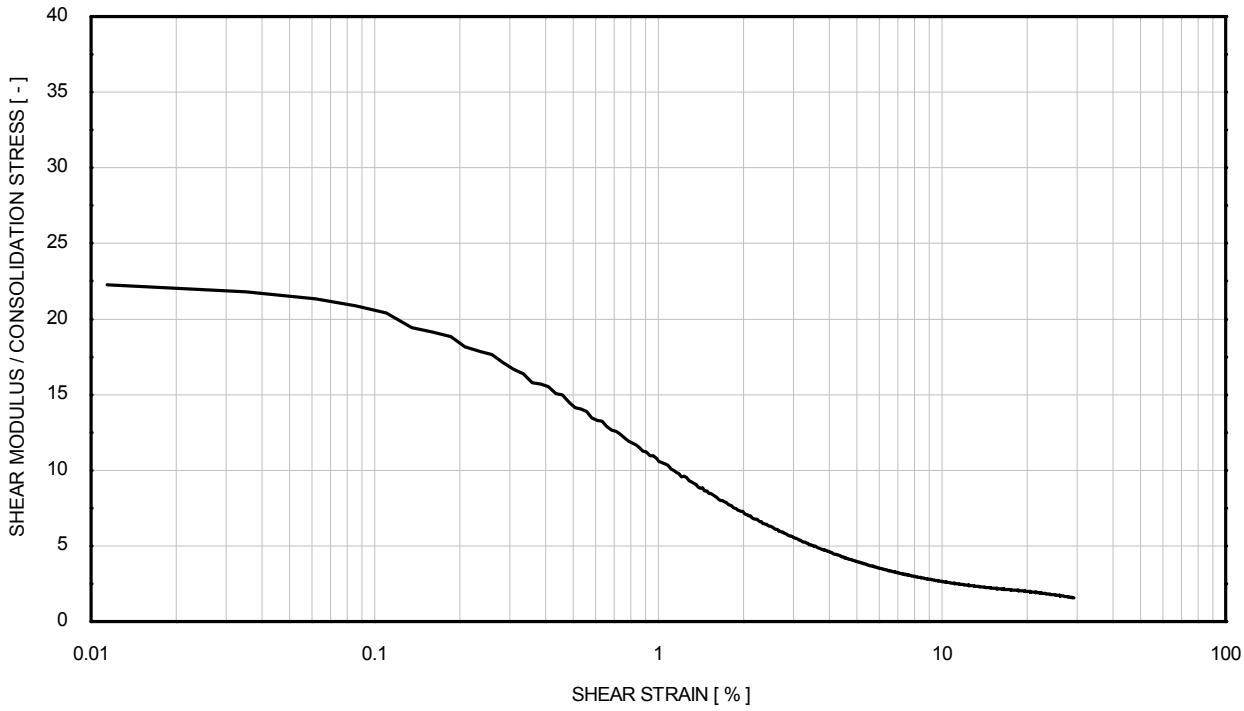


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	152 kPa	Sample	:	6WaxD
γ at τ_{peak}	:	29.11 %	Unit	:	F3 (Dongen)
Rate of strain	:	2.99 %/hour	Depth [m]	:	33.40
			Test No.	:	CSS04

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	152 kPa	Sample	:	6WaxD
γ at τ_{peak}	:	29.11 %	Unit	:	F3 (Dongen)
Rate of strain	:	2.99 %/hour	Depth [m]	:	33.40
			Test No.	:	CSS04

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Very dark greenish grey slightly sandy CLAY

GENERAL	
Date test started	04/12/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.9
Length	[mm]	29.8
Moisture content	[%]	37.2
Bulk density	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.36
Void ratio	[-]	0.978
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	312
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_6WAXF_CSS05
Template issue	1.3
Processed by	RN
Date	11/12/2015
Checked by	LJ
Date	11/12/2015
Approved by	PH
Date	13/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxF
Unit	F3 (Dongen)
Depth [m]	33.61
Test number	CSS05

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	885
Vertical strain	[%]	3.06
Bulk density	[Mg/m^3]	1.90
Dry density	[Mg/m^3]	1.41
Void ratio	[-]	0.918
Moisture content	[%]	34.9

CONSOLIDATION		
σ_{vc}	[kPa]	320
Vertical strain	[%]	2.86
Bulk density	[Mg/m^3]	1.90
Dry density	[Mg/m^3]	1.40
Void ratio	[-]	0.922
Moisture content	[%]	35.1

HORIZONTAL PRE-LOADING – CONSTANT VOLUME		
Initial σ_v	[kPa]	320
Shear stress	[kPa]	76
Shear strain	[%]	0.65
Total hold period	[minutes]	70
Vertical strain	[%]	0.00
Bulk density	[Mg/m^3]	1.90
Dry density	[Mg/m^3]	1.40
Void ratio	[-]	0.922
Shear induced -$\Delta\sigma_v$	[kPa]	2.8

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxF
Unit	F3 (Dongen)
Depth [m]	33.61
Test number	CSS05

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	235
Mean τ_{av}	[kPa]	76
Mean τ_{cy}	[kPa]	113
Frequency	[Hz]	0.10
Number of cycles applied (N)	[-]	1500
γ_{av} at N	[%]	3.41
γ_{cy} at N	[%]	1.18
Shear induced $-\Delta\sigma_v$ at N	[kPa]	38
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	1.17	0.87	12.94	20.07
2	1.33	0.92	12.25	15.67
5	1.55	0.97	11.60	14.17
10	1.73	1.01	11.19	13.59
20	1.92	1.04	10.84	13.34
30	2.05	1.06	10.64	13.20
40	2.13	1.08	10.49	13.13
50	2.20	1.09	10.38	13.08
100	2.43	1.13	10.04	12.98
500	3.01	1.18	9.64	12.84
1000	3.26	1.18	9.59	12.70
1500	3.41	1.18	9.58	12.62

SHEARING – CONSTANT VOLUME		
At peak shear stress*		
Shear stress	[kPa]	264
Shear strain	[%]	14.54
Shear induced $-\Delta\sigma_v$	[kPa]	-113
Vertical stress	[kPa]	433
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.98
At 15 % shear strain		
Shear stress	[kPa]	263
Shear induced $-\Delta\sigma_v$	[kPa]	-119
Vertical stress	[kPa]	439
Vertical strain	[%]	0.00

* Please note that specimen failure was observed to occur along or close to the loading platen interface.

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxF
Unit	F3 (Dongen)
Depth [m]	33.61
Test number	CSS05

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

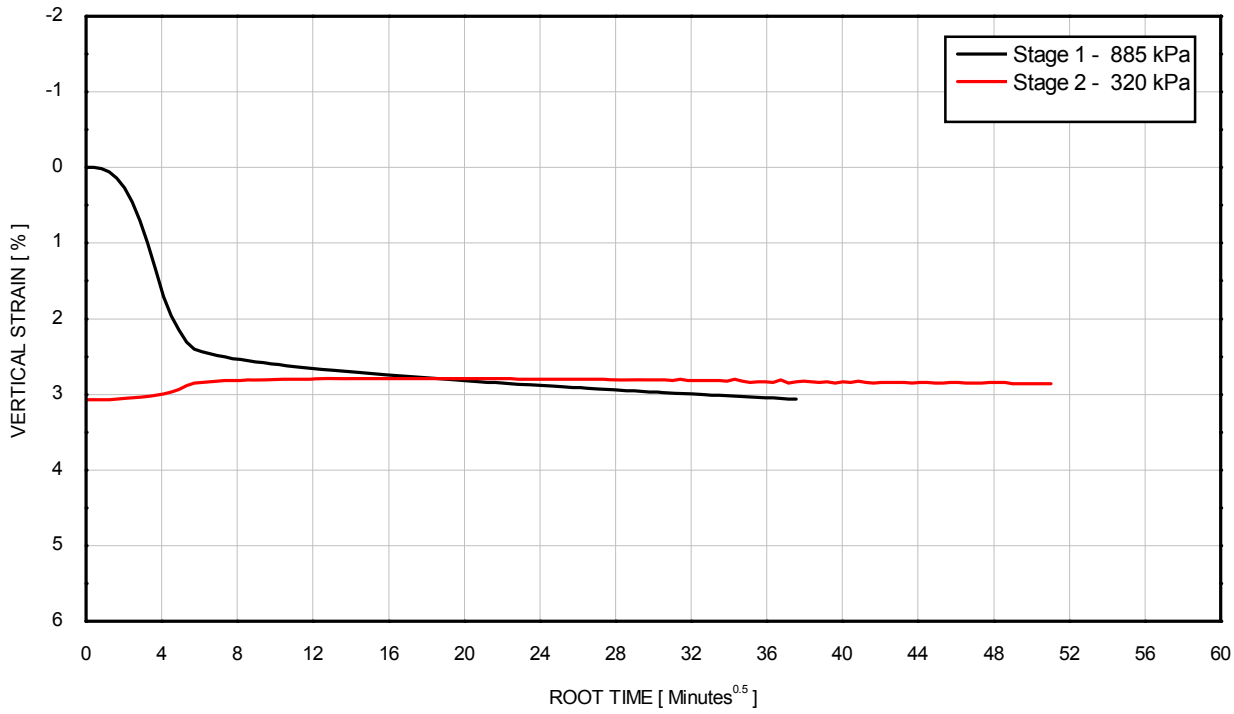
SPECIMEN PHOTOGRAPH

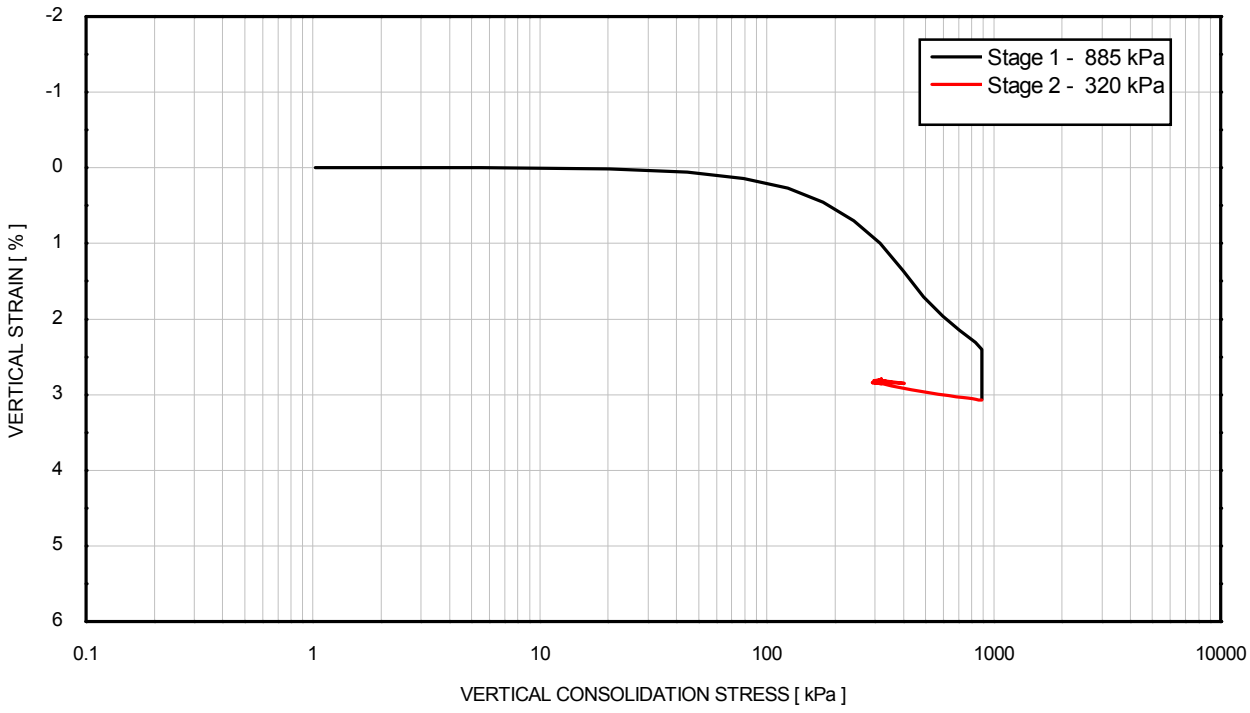


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxF
Unit	F3 (Dongen)
Depth [m]	33.61
Test number	CSS05

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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



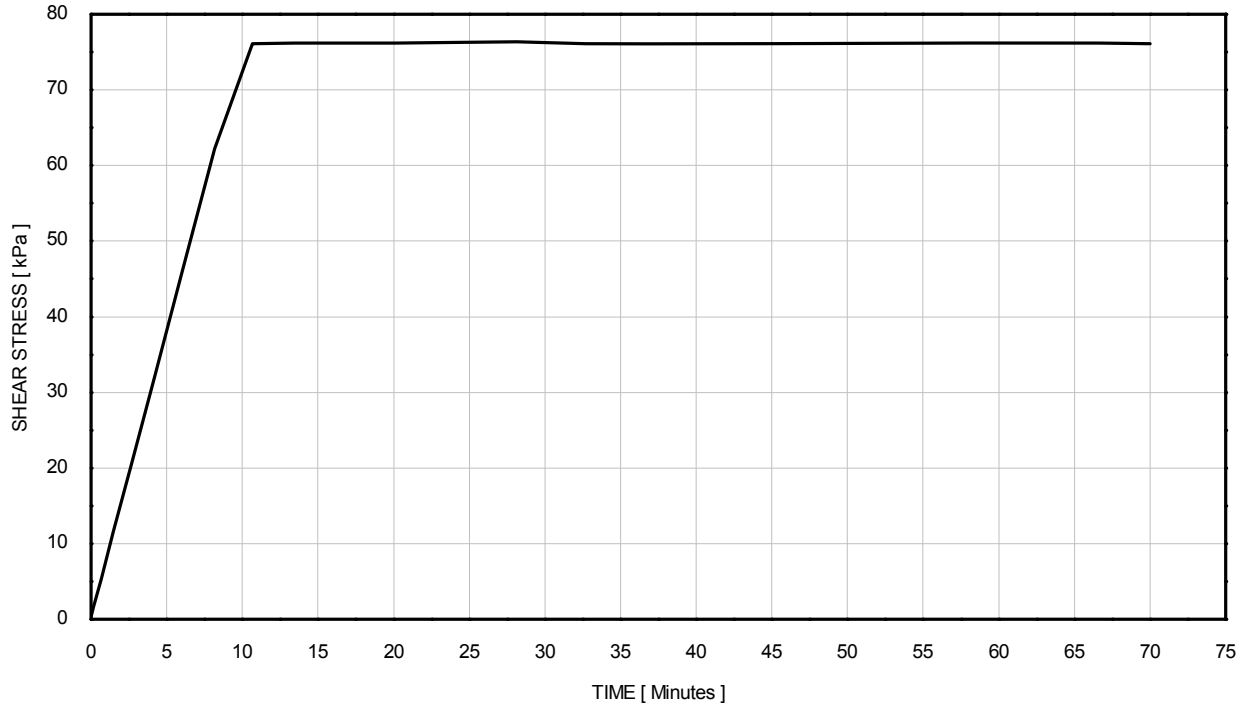


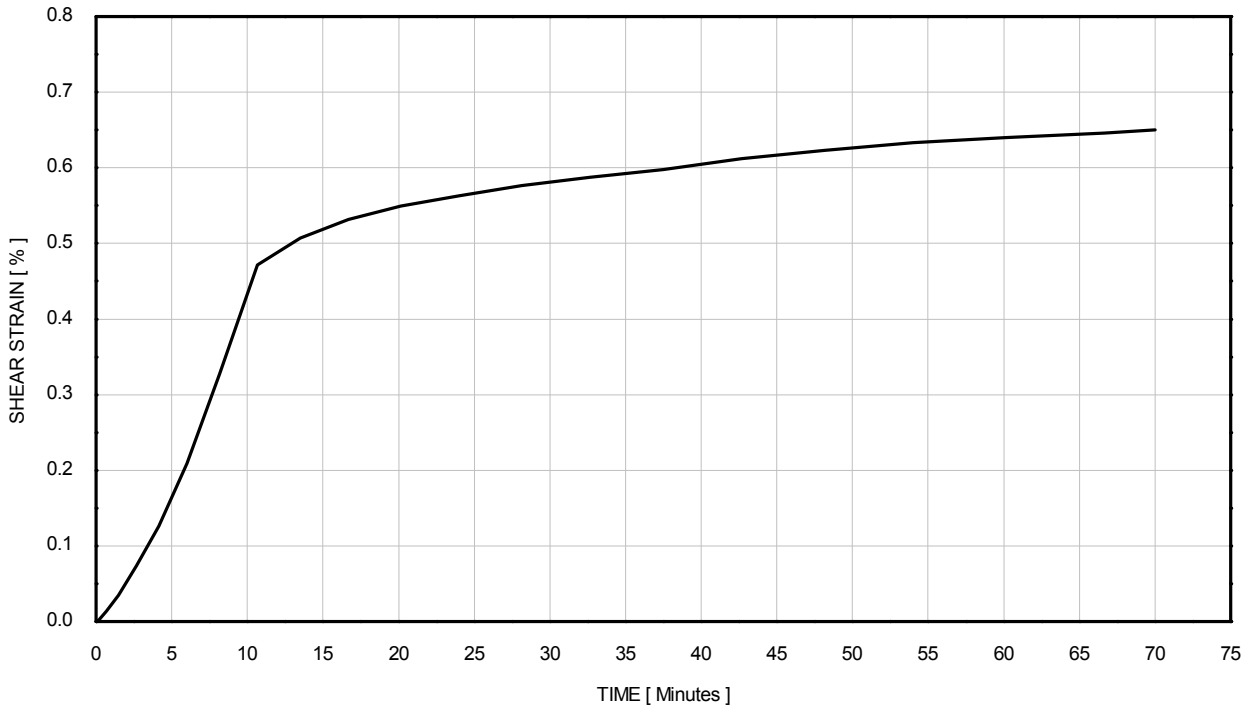
σ_{vc} : 320 kPa

Borehole	: BH-WFS3-4A
Sample	: 6WaxF
Unit	: F3 (Dongen)
Depth [m]	: 33.61
Test No.	: CSS05

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

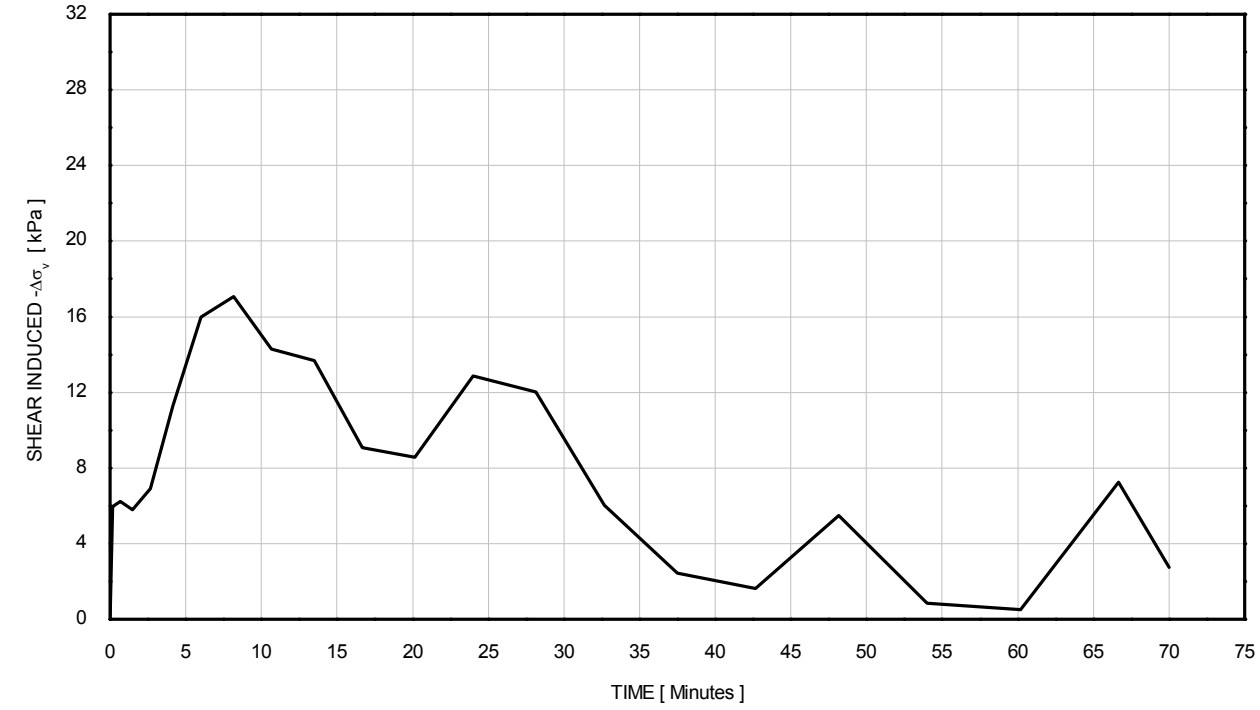


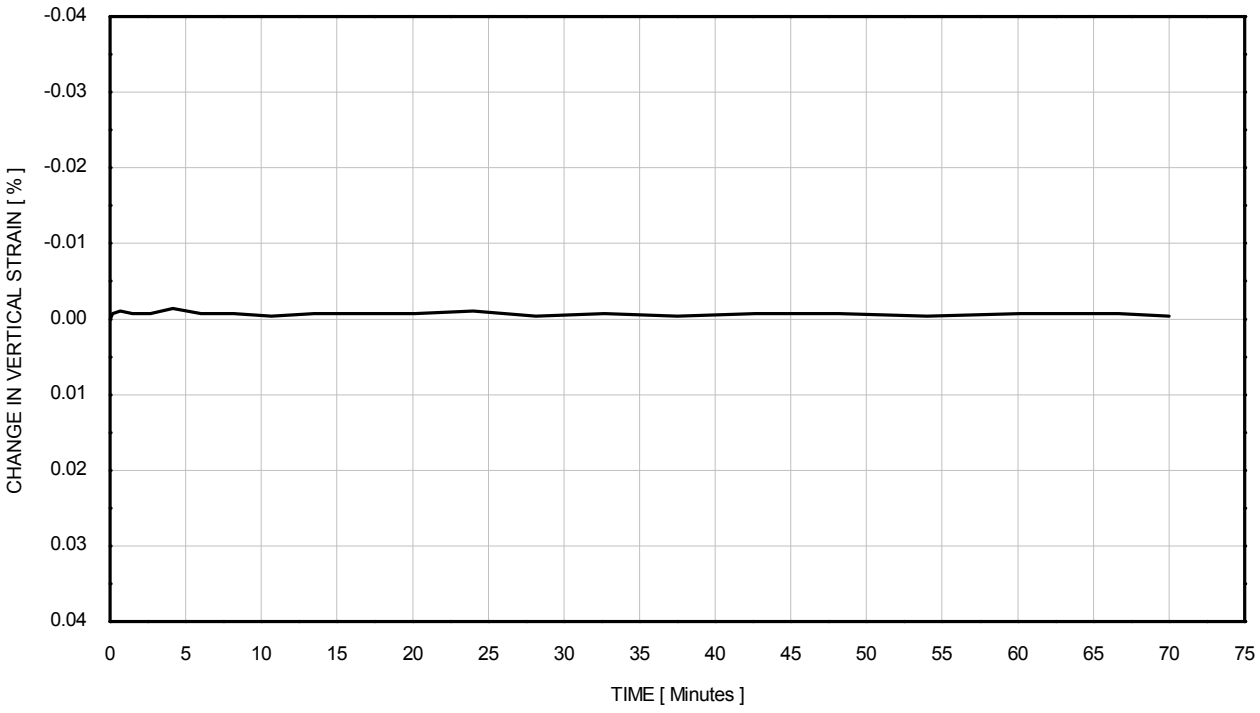


σ_{vc}	:	320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	:	76 kPa	Sample	: 6WaxF
Mean τ_{cy}	:	113 kPa	Unit	: F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	: 33.61
			Test No.	: CSS05

CONSOLIDATED CYCLIC DSS TEST
HORIZONTAL PRE-LOADING STAGE - CONSTANT VOLUME

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

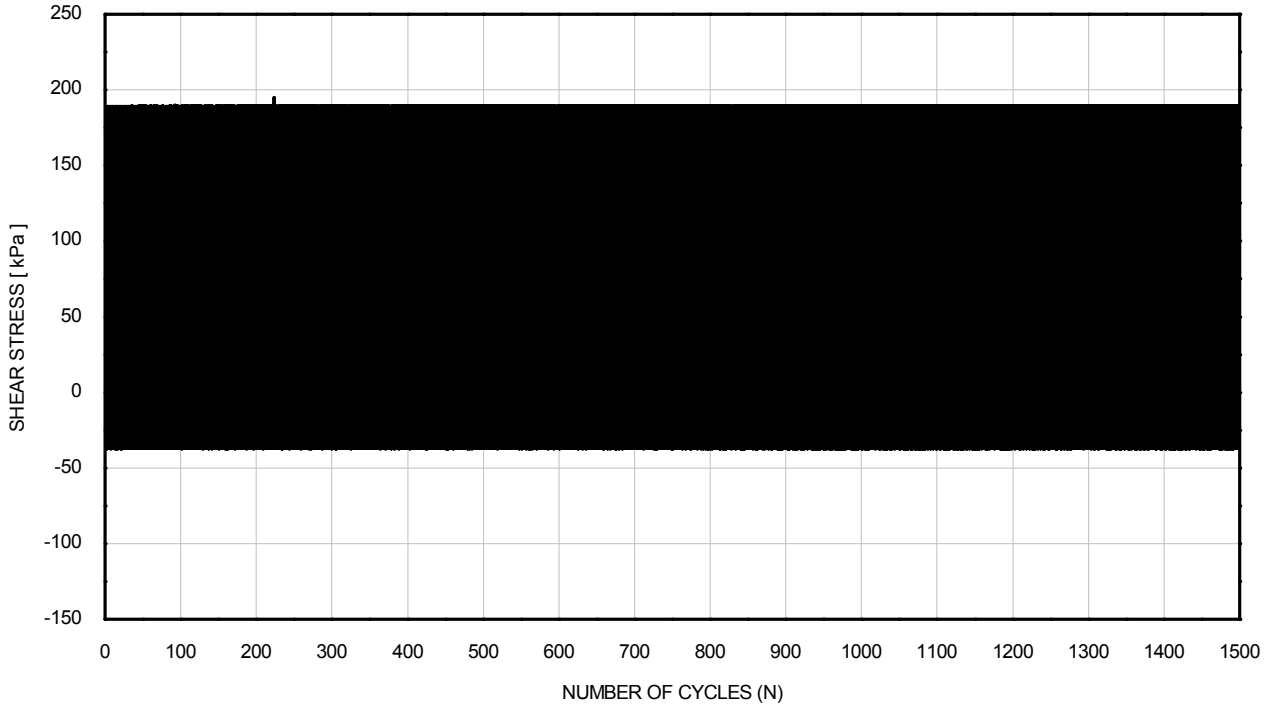


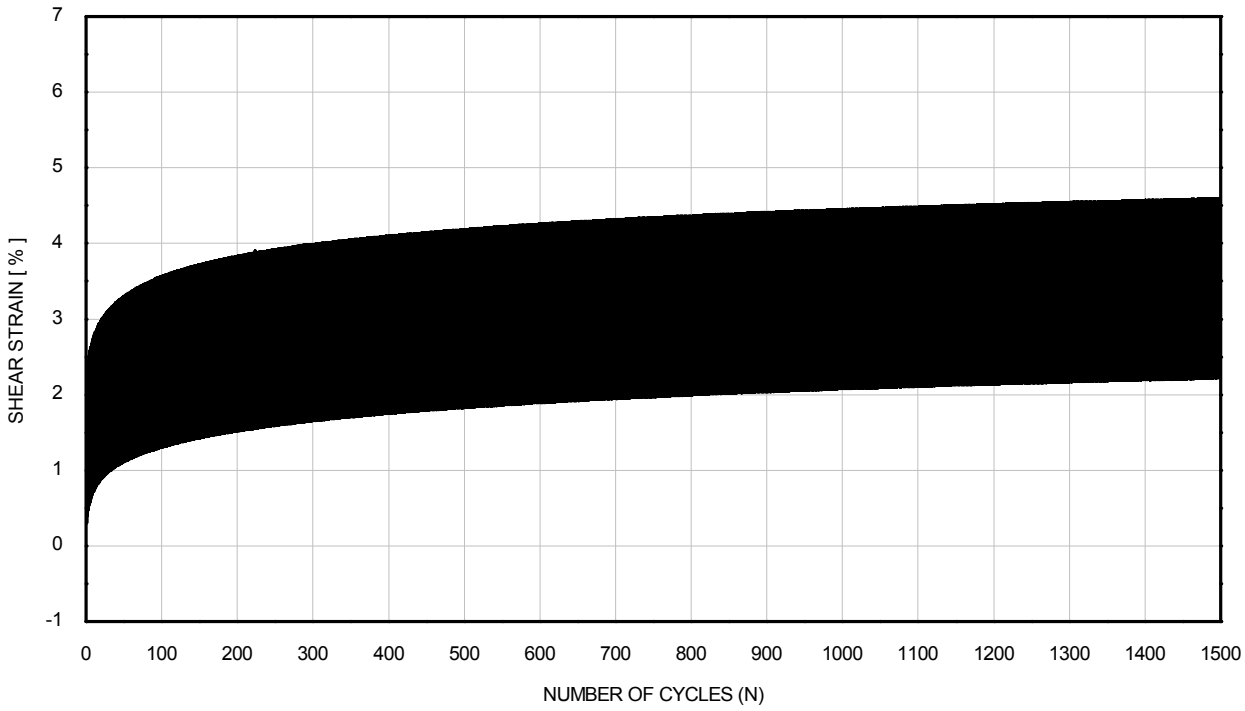


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	76 kPa	Sample	:	6WaxF
Mean τ_{cy}	:	113 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.61
			Test No.	:	CSS05

CONSOLIDATED CYCLIC DSS TEST
HORIZONTAL PRE-LOADING STAGE - CONSTANT VOLUME

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

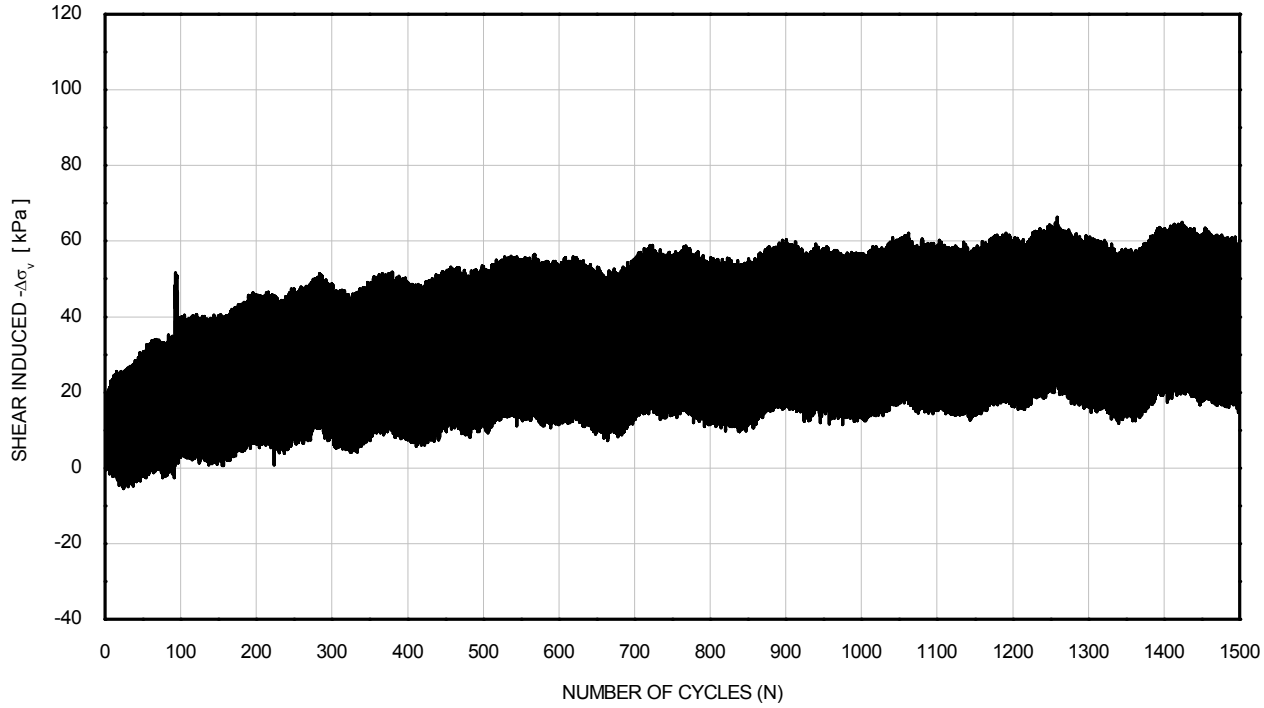


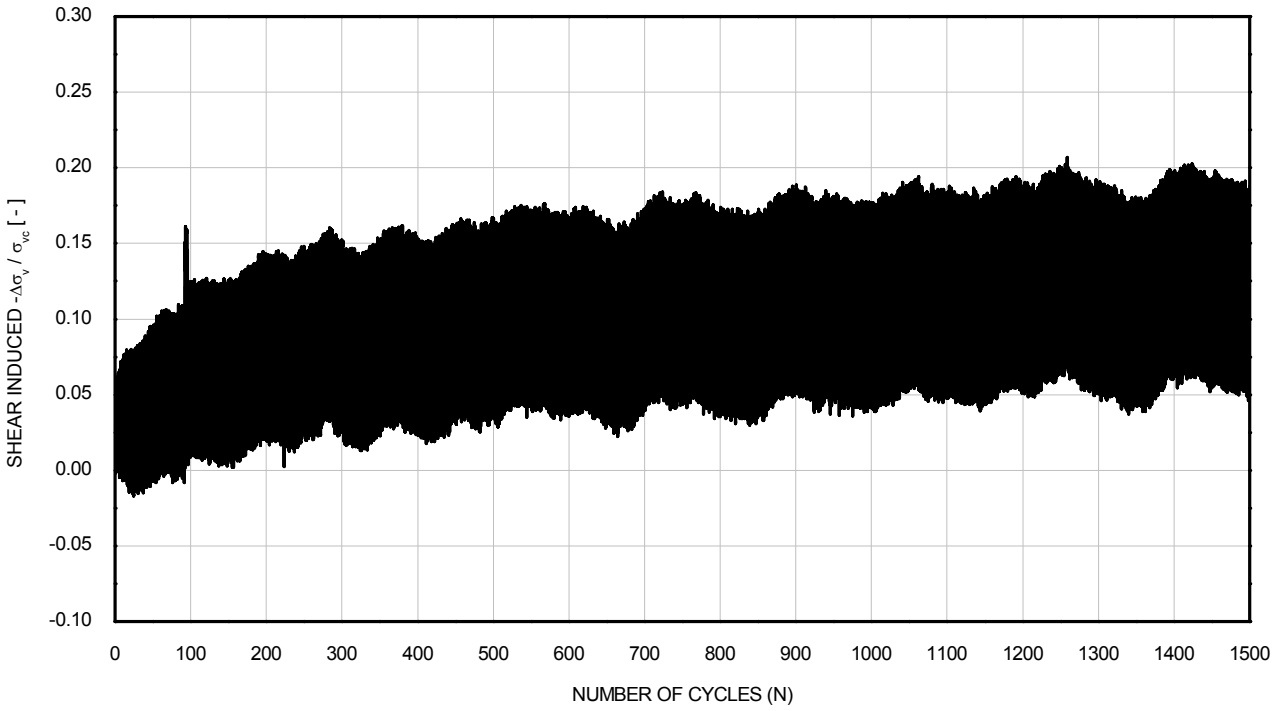


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	76 kPa	Sample	:	6WaxF
Mean τ_{cy}	:	113 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.61
			Test No.	:	CSS05

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

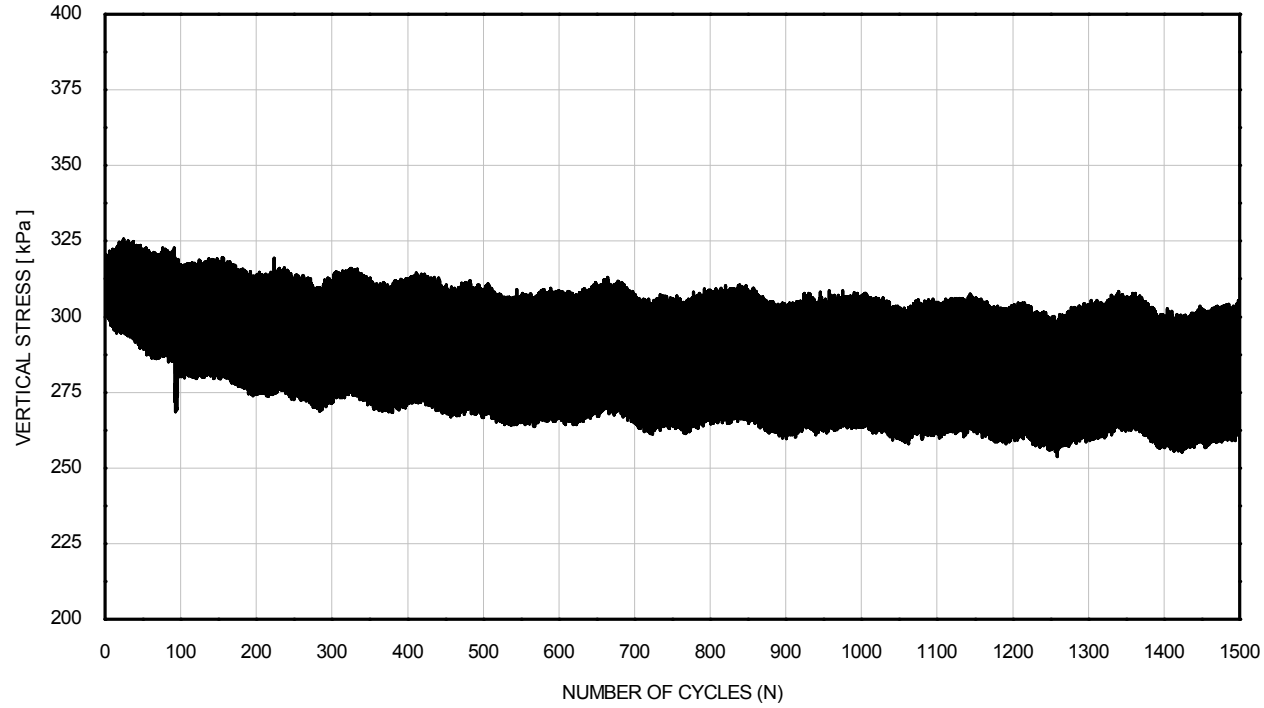


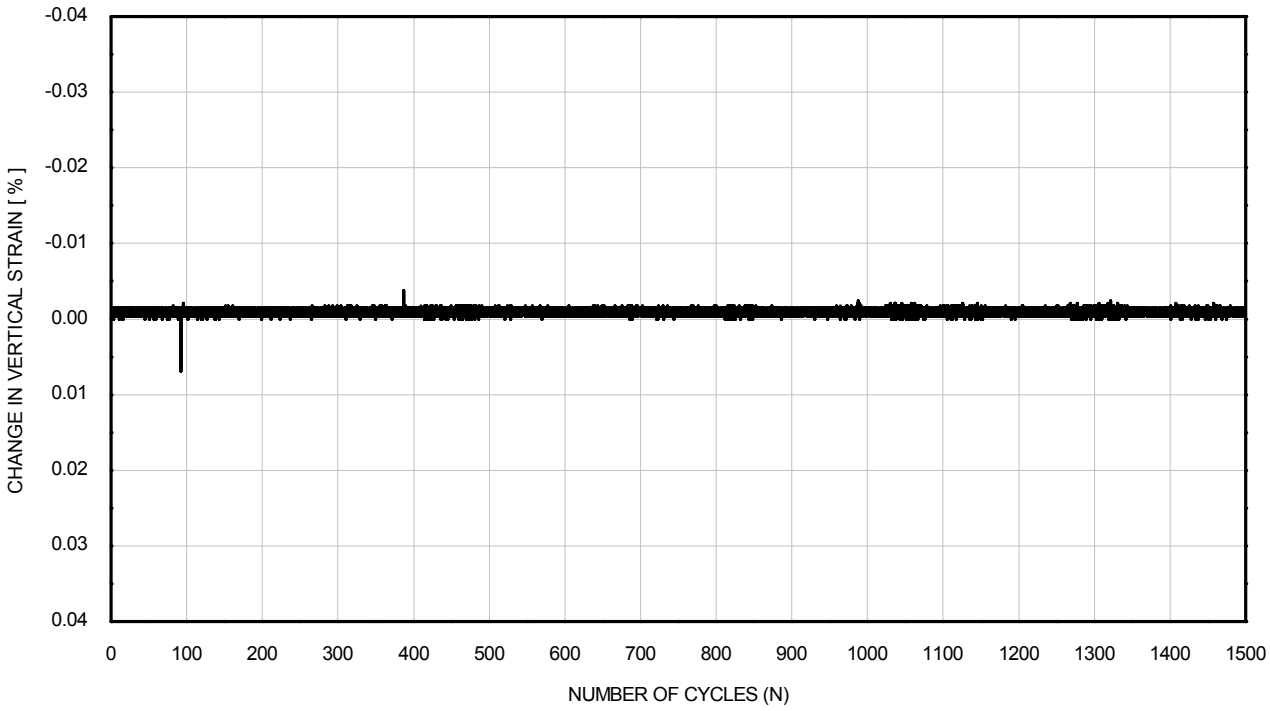


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 76 kPa	Sample	: 6WaxF
Mean τ_{cy}	: 113 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.61
		Test No.	: CSS05

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

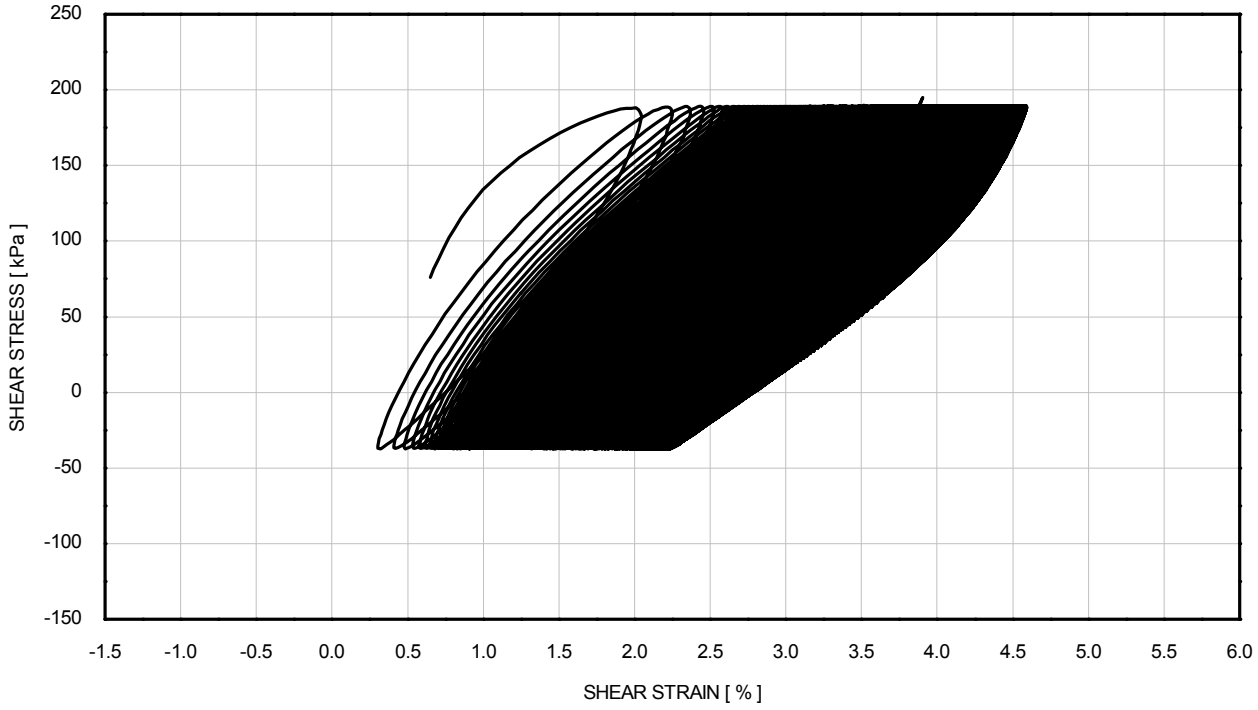


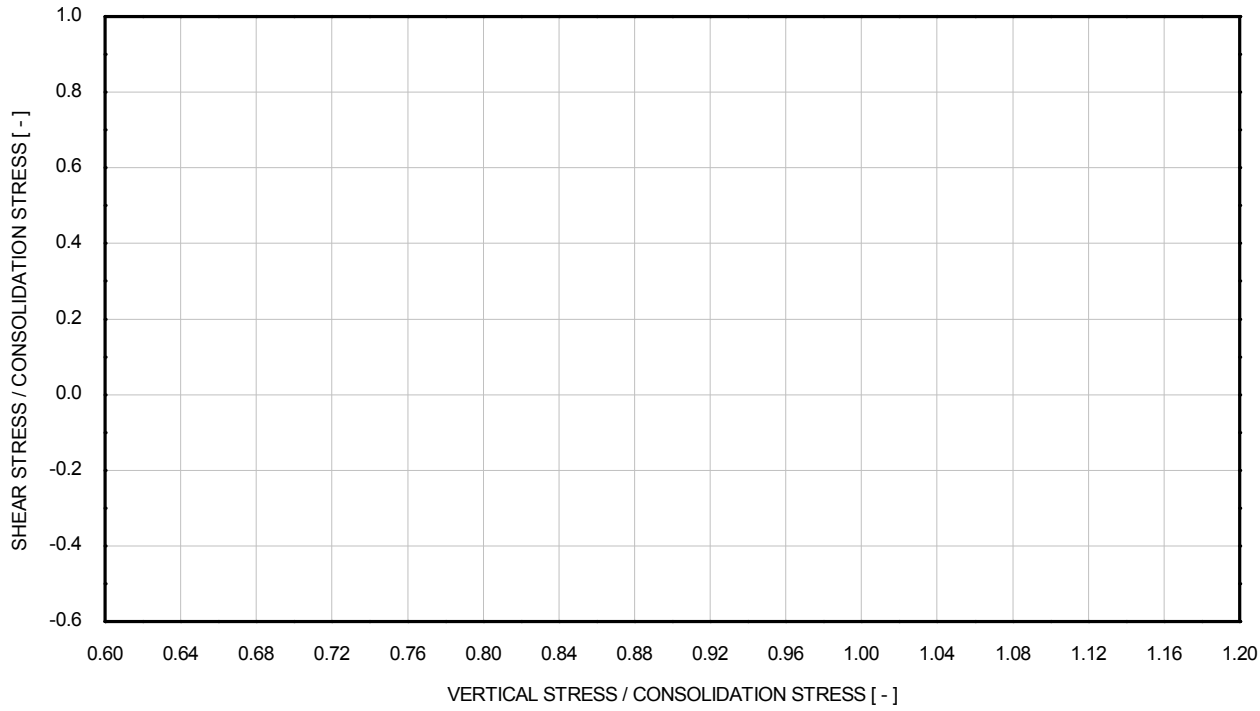


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	76 kPa	Sample	:	6WaxF
Mean τ_{cy}	:	113 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.61
			Test No.	:	CSS05

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

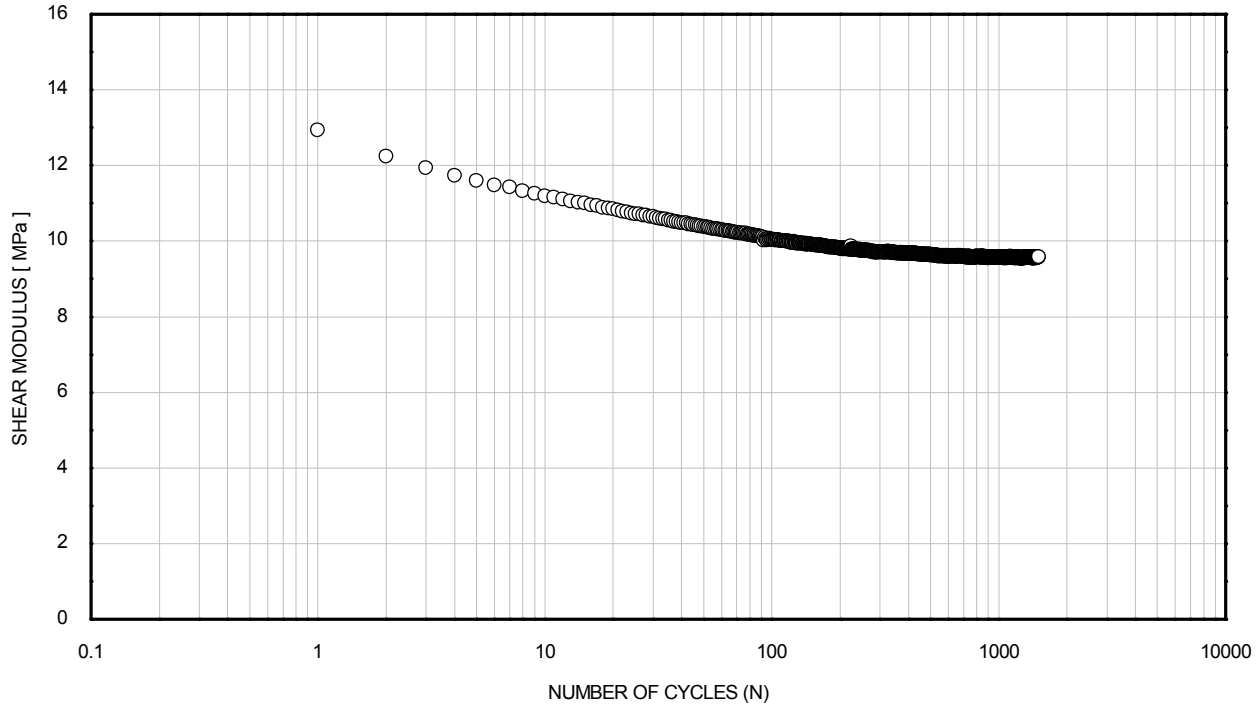


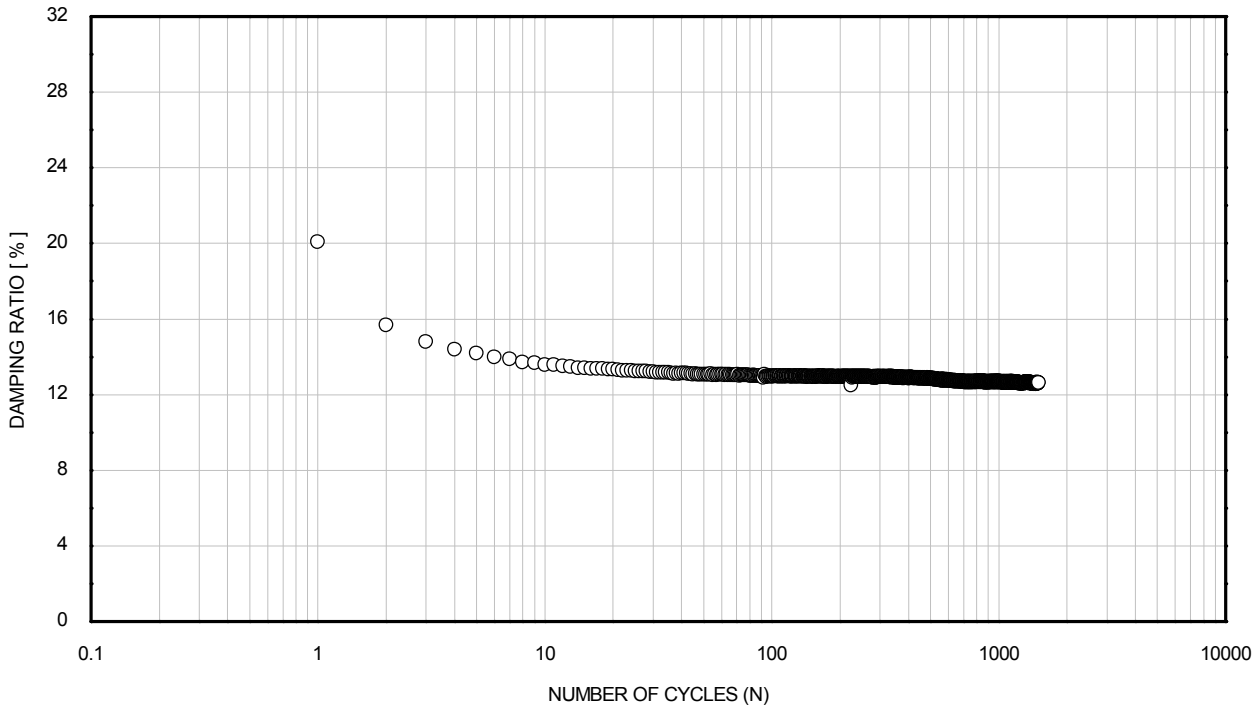


σ_{vc}	: 320	kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 76	kPa	Sample	: 6WaxF
Mean τ_{cy}	: 113	kPa	Unit	: F3 (Dongen)
Frequency	: 0.10	Hz	Depth [m]	: 33.61
			Test No.	: CSS05

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

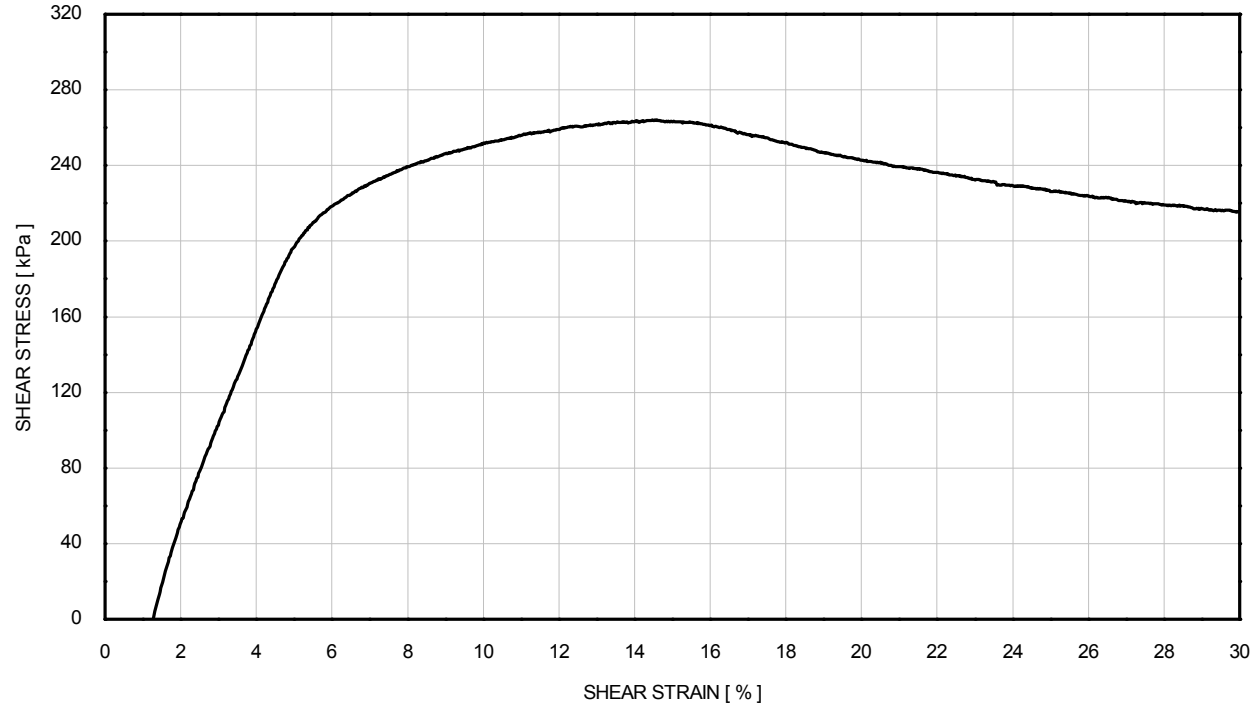


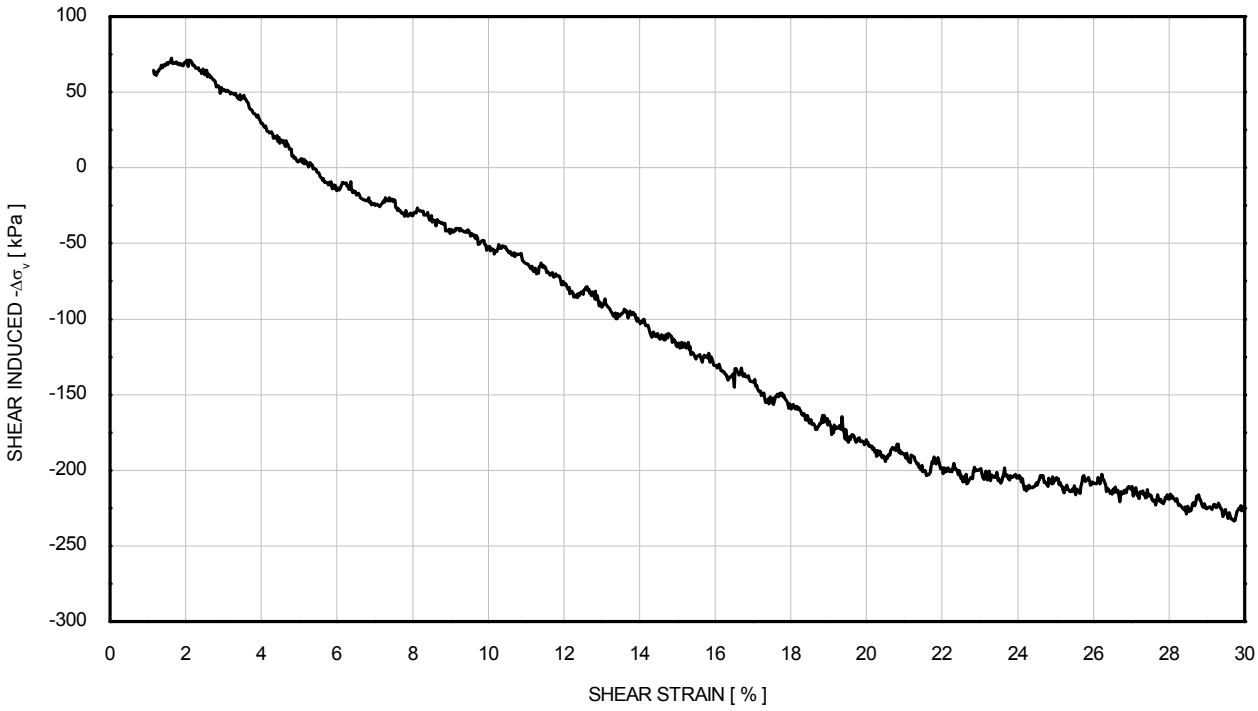


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
Mean τ_{av}	:	76 kPa	Sample	:	6WaxF
Mean τ_{cy}	:	113 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	33.61
			Test No.	:	CSS05

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

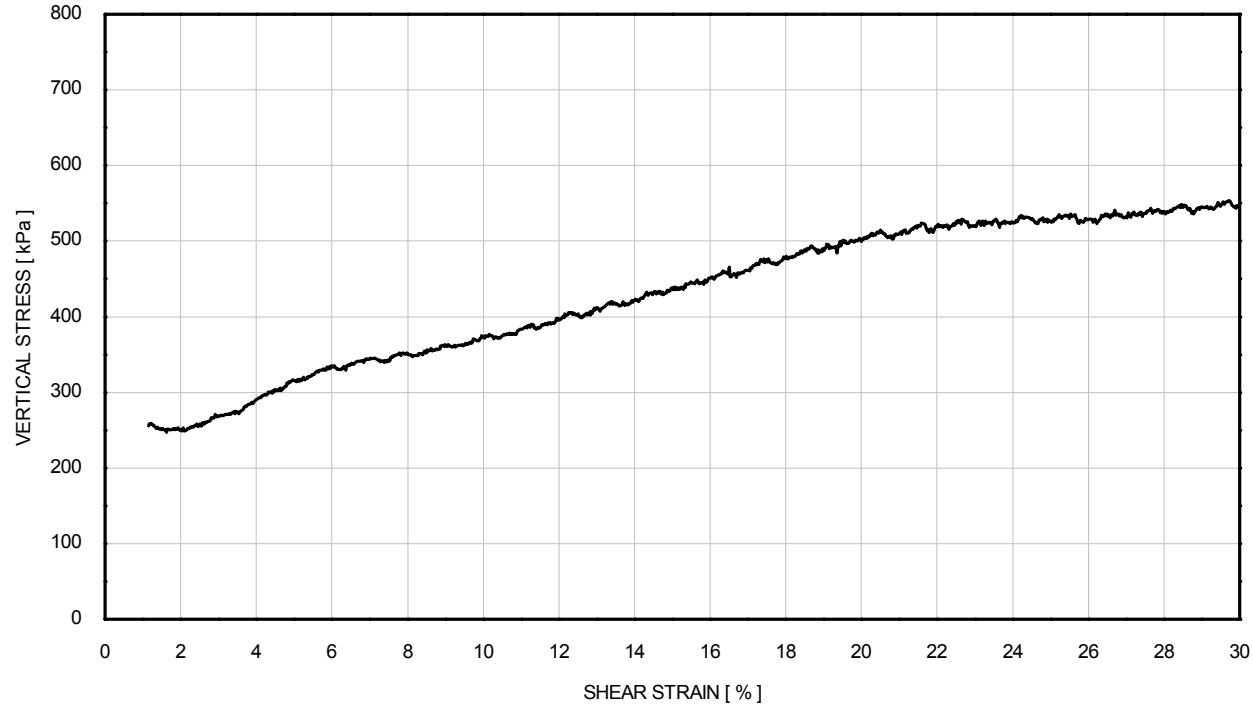


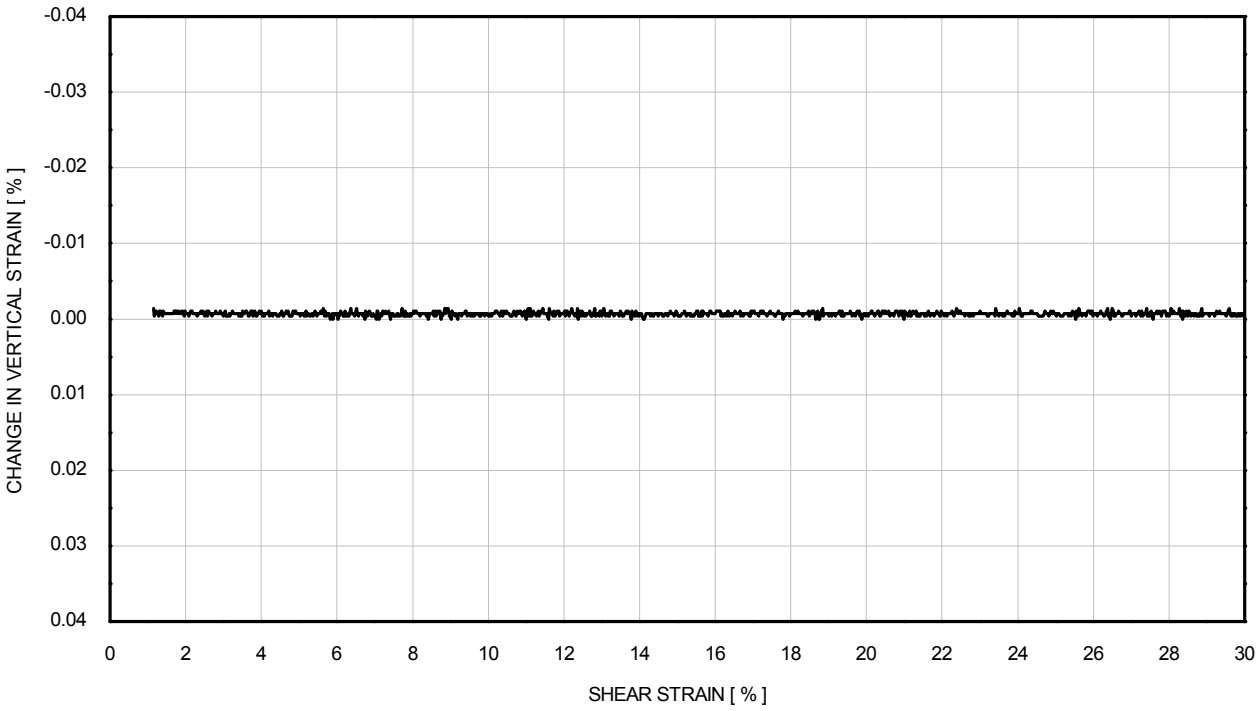


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 264 kPa	Sample	: 6WaxF
γ at τ_{peak}	: 14.54 %	Unit	: F3 (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 33.61
		Test No.	: CSS05

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

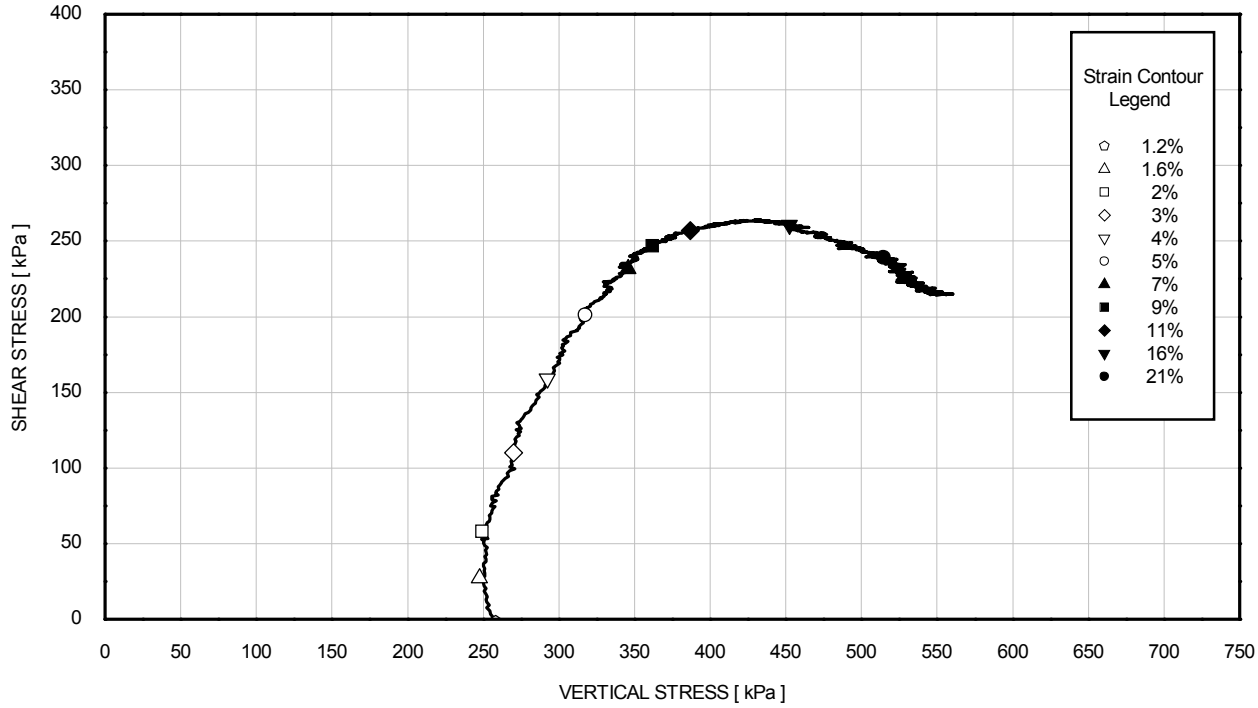


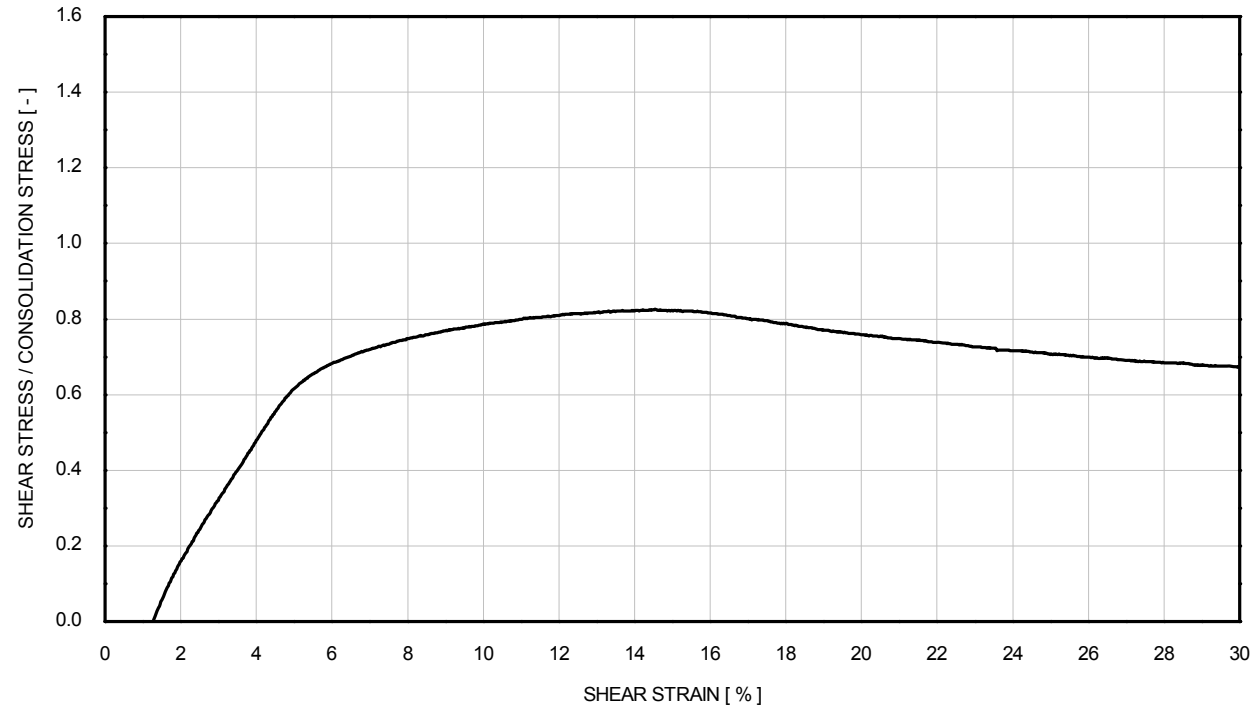


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 264 kPa	Sample	: 6WaxF
γ at τ_{peak}	: 14.54 %	Unit	: F3 (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 33.61
		Test No.	: CSS05

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

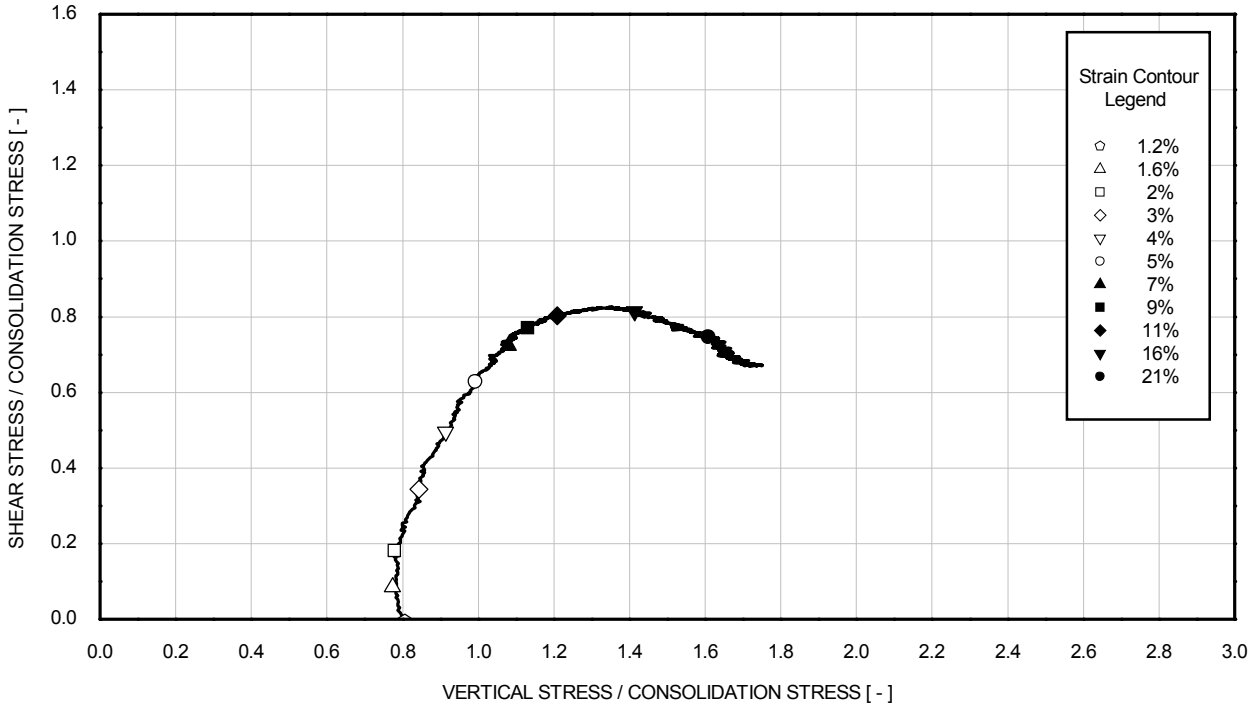


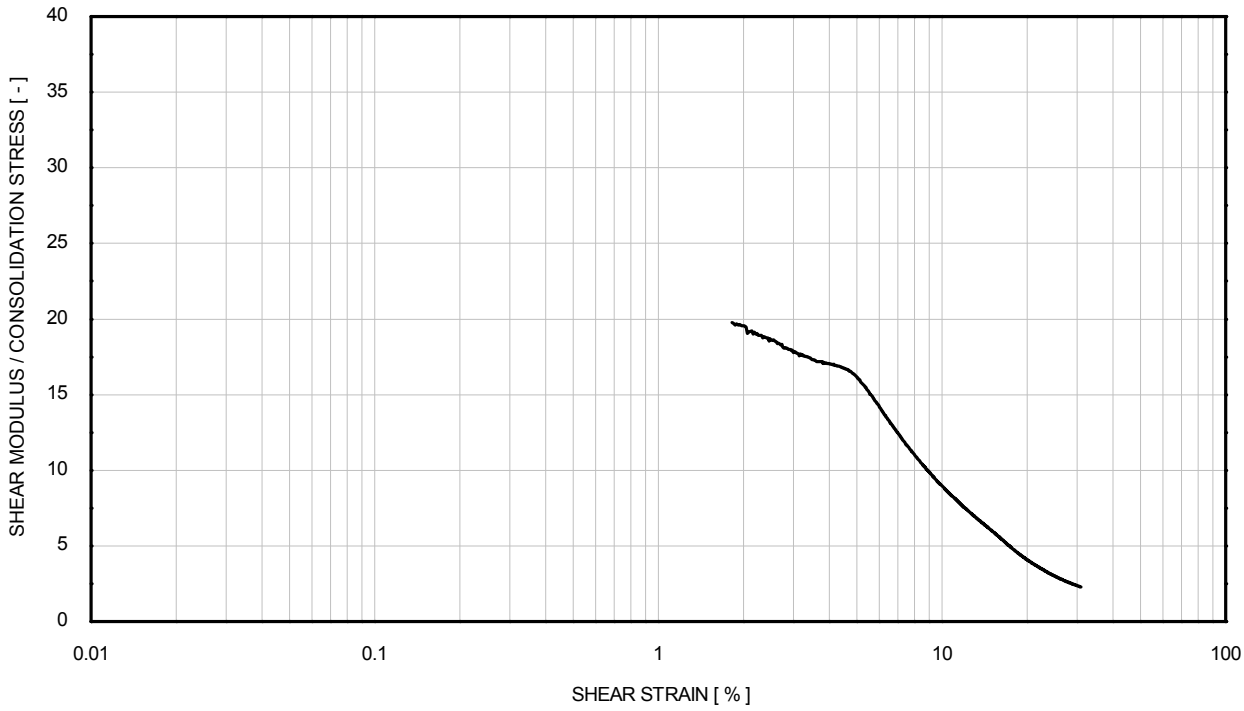


σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	264 kPa	Sample	:	6WaxF
γ at τ_{peak}	:	14.54 %	Unit	:	F3 (Dongen)
Rate of strain	:	2.98 %/hour	Depth [m]	:	33.61
			Test No.	:	CSS05

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	320 kPa	Borehole	:	BH-WFS3-4A
τ_{peak}	:	264 kPa	Sample	:	6WaxF
γ at τ_{peak}	:	14.54 %	Unit	:	F3 (Dongen)
Rate of strain	:	2.98 %/hour	Depth [m]	:	33.61
			Test No.	:	CSS05

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Very stiff very dark greenish grey CLAY

GENERAL	
Date test started	04/03/2016
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	29.9
Moisture content	[%]	39.5
Bulk density	[Mg/m³]	1.85
Dry density	[Mg/m³]	1.33
Void ratio	[-]	1.033
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	188
Pocket penetrometer	[kPa]	247
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS3-4A_6WAXB_CSS06R
Template issue	1.3
Processed by Date	HJ 08/03/2016
Checked by Date	PH 14/03/2016
Approved by Date	PH 14/03/2016

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxB
Unit	F3 (Dongen)
Depth [m]	33.12
Test number	CSS06R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	885
Vertical strain	[%]	4.49
Bulk density	[Mg/m^3]	1.89
Dry density	[Mg/m^3]	1.39
Void ratio	[-]	0.942
Moisture content	[%]	36.1

CONSOLIDATION		
σ_{vc}	[kPa]	320
Vertical strain	[%]	2.43
Bulk density	[Mg/m^3]	1.87
Dry density	[Mg/m^3]	1.36
Void ratio	[-]	0.984
Moisture content	[%]	37.7

HORIZONTAL PRE-LOADING – CONSTANT VOLUME		
Initial σ_v	[kPa]	320
Shear stress	[kPa]	114
Shear strain	[%]	4.12
Total hold period	[minutes]	70
Vertical strain	[%]	0.00
Bulk density	[Mg/m^3]	1.87
Dry density	[Mg/m^3]	1.36
Void ratio	[-]	0.984
Shear induced -$\Delta\sigma_v$	[kPa]	-31

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxB
Unit	F3 (Dongen)
Depth [m]	33.12
Test number	CSS06R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	235
Mean τ_{av}	[kPa]	112
Mean τ_{cy}	[kPa]	101
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	2
γ_{av} at N_f	[%]	15.46
γ_{cy} at N_f	[%]	3.66
Shear induced $-\Delta\sigma_v$ at N_f	[kPa]	-101
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	8.96	4.84	2.10	25.71
2	15.46	3.66	2.75	27.01

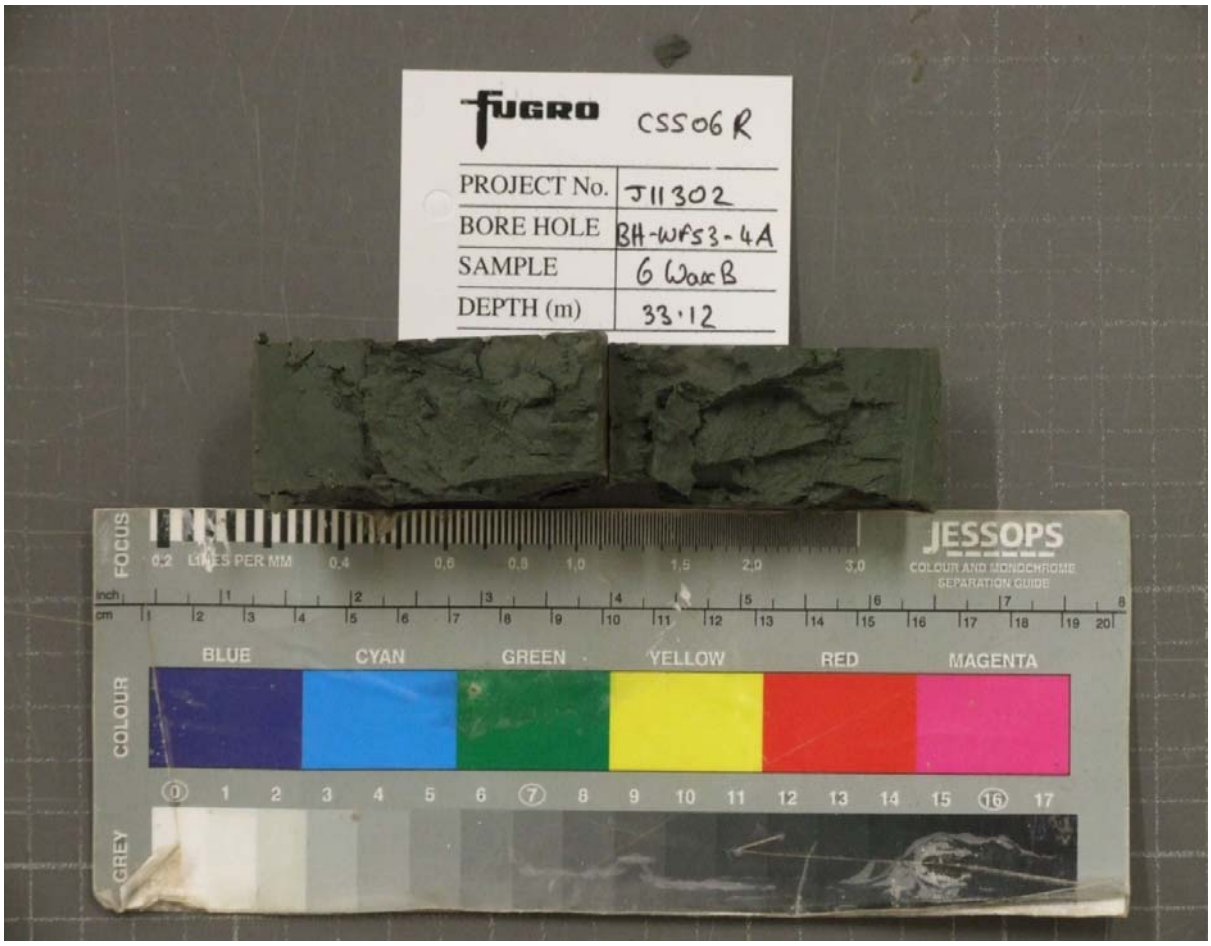
SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	153
Shear strain	[%]	27.52
Shear induced $-\Delta\sigma_v$	[kPa]	-72
Vertical stress	[kPa]	393
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	3.02
At 15 % shear strain		
Shear stress	[kPa]	-
Shear induced $-\Delta\sigma_v$	[kPa]	-
Vertical stress	[kPa]	-
Vertical strain	[%]	-

TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxB
Unit	F3 (Dongen)
Depth [m]	33.12
Test number	CSS06R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

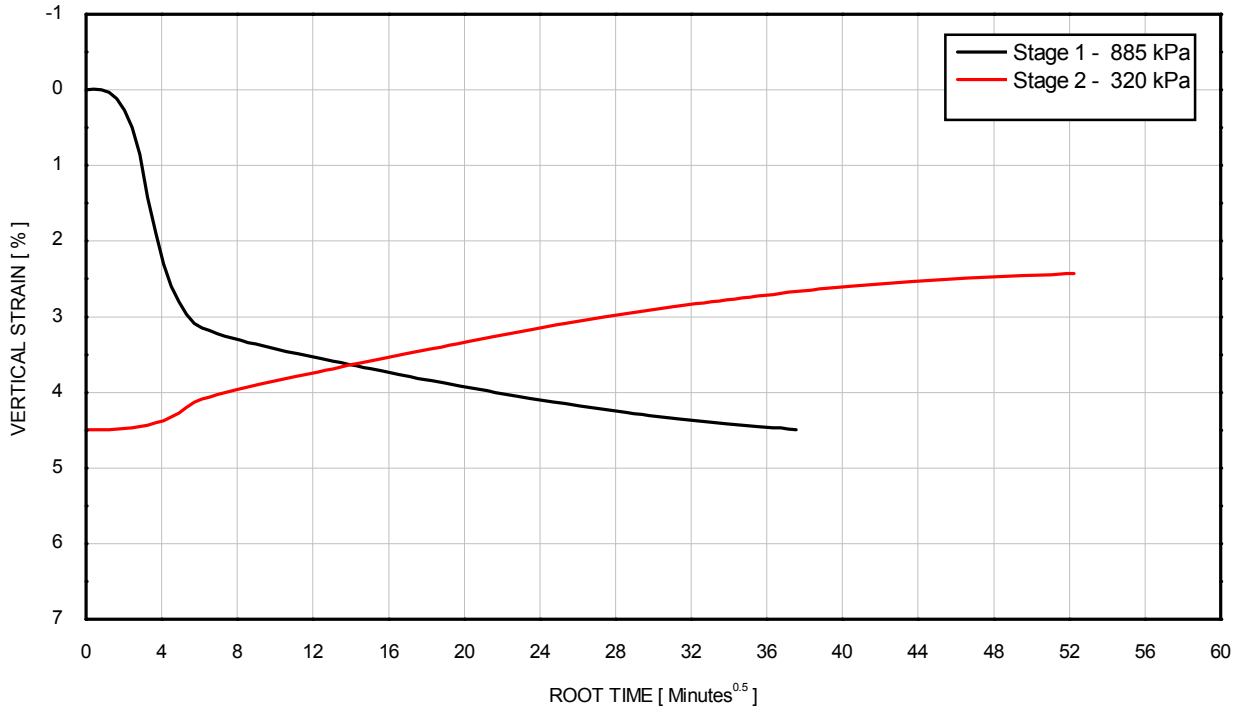
SPECIMEN PHOTOGRAPH

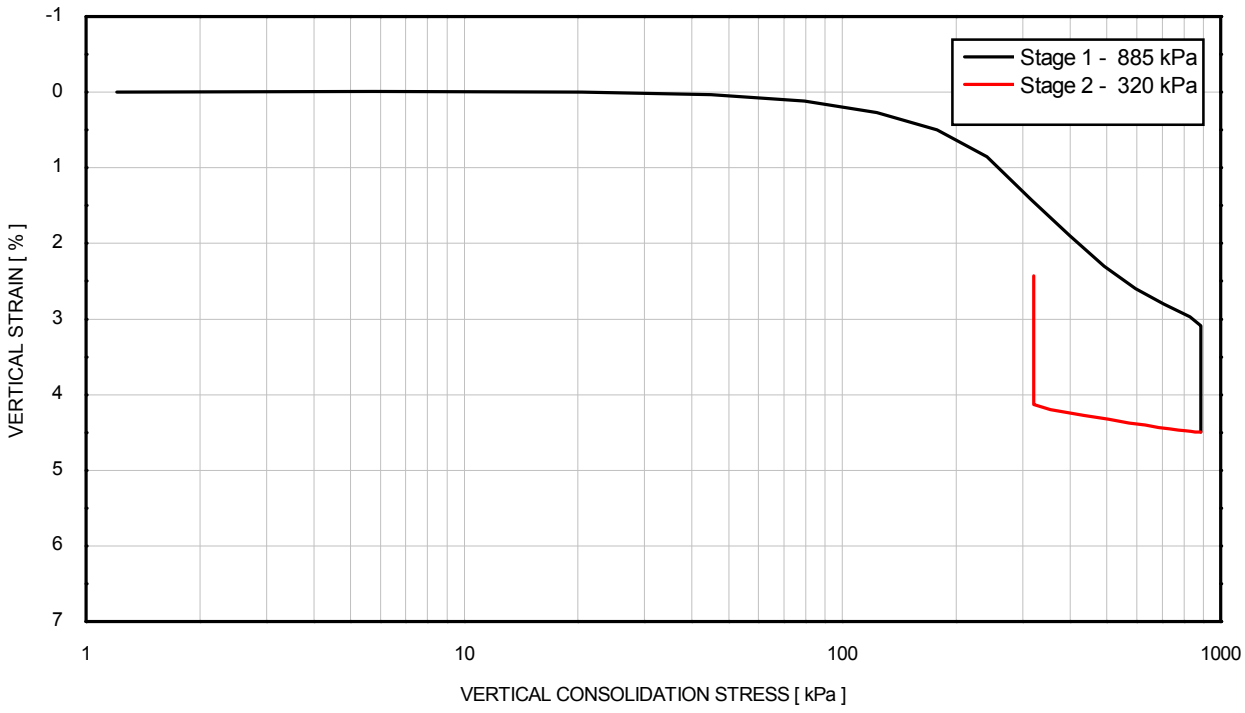


TEST IDENTIFICATION	
Borehole	BH-WFS3-4A
Sample	6WaxB
Unit	F3 (Dongen)
Depth [m]	33.12
Test number	CSS06R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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



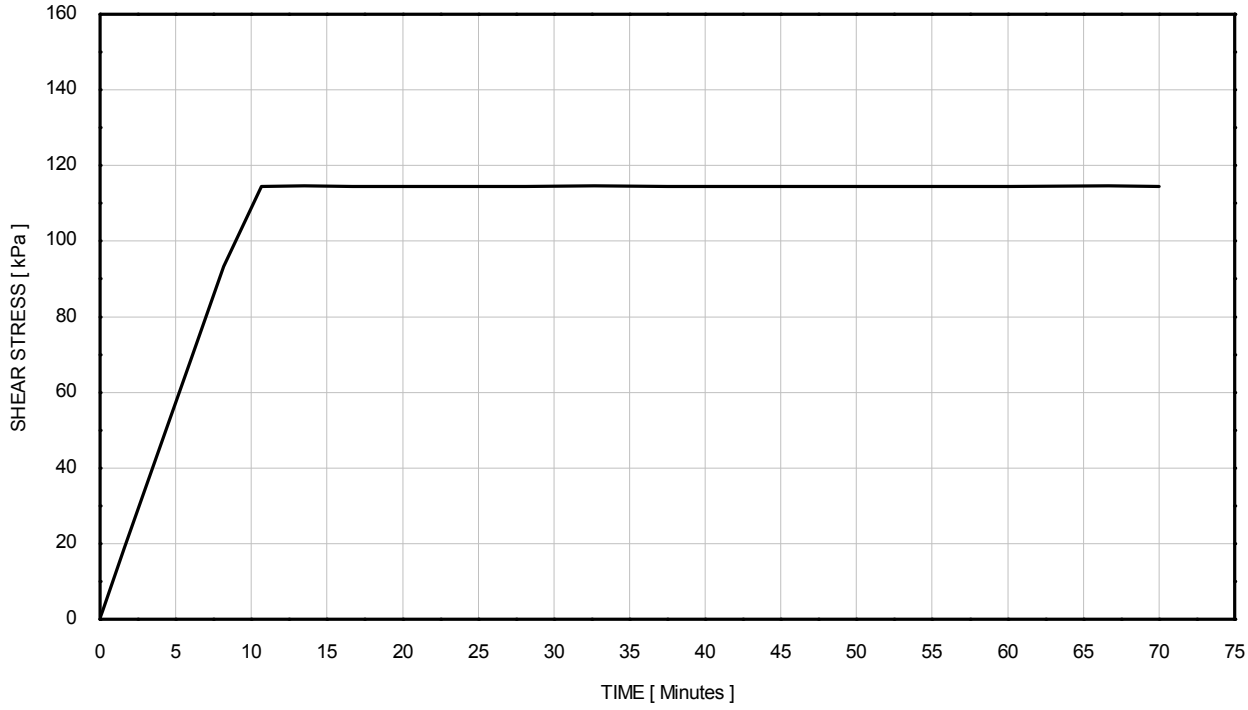


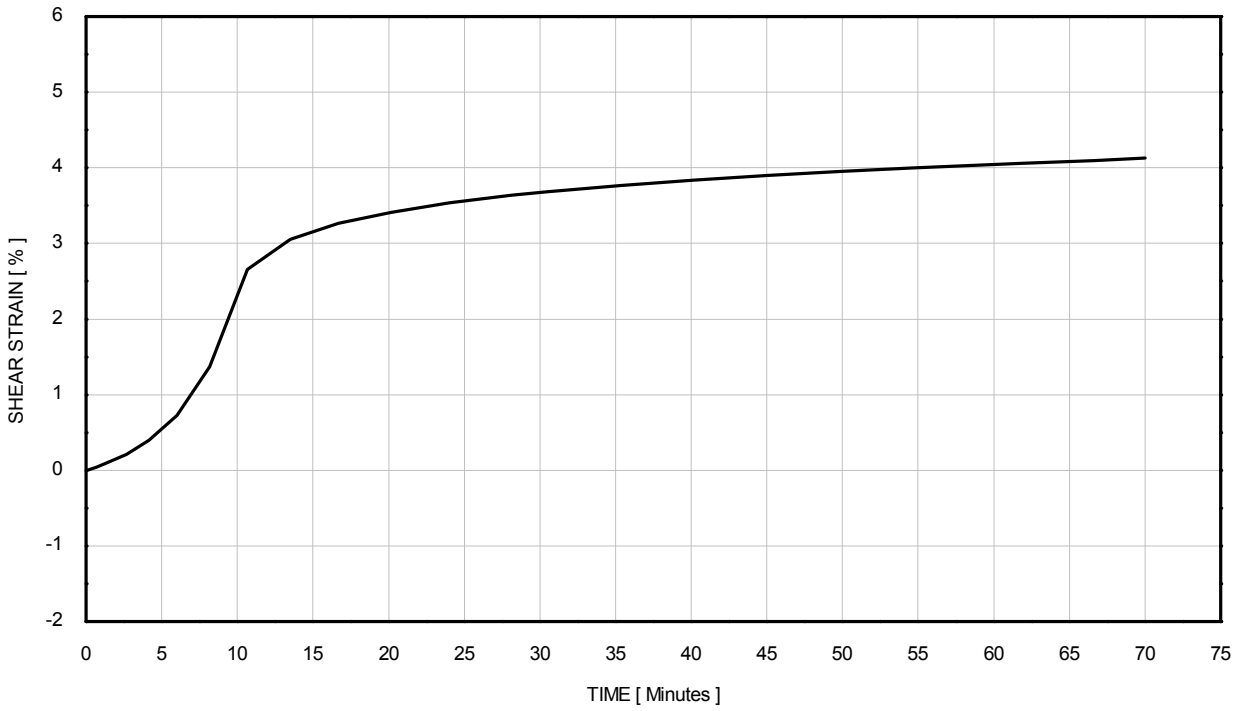
σ_{vc} : 351 kPa

Borehole	: BH-WFS3-4A
Sample	: 6WaxB
Unit	: F3 (Dongen)
Depth [m]	: 33.12
Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

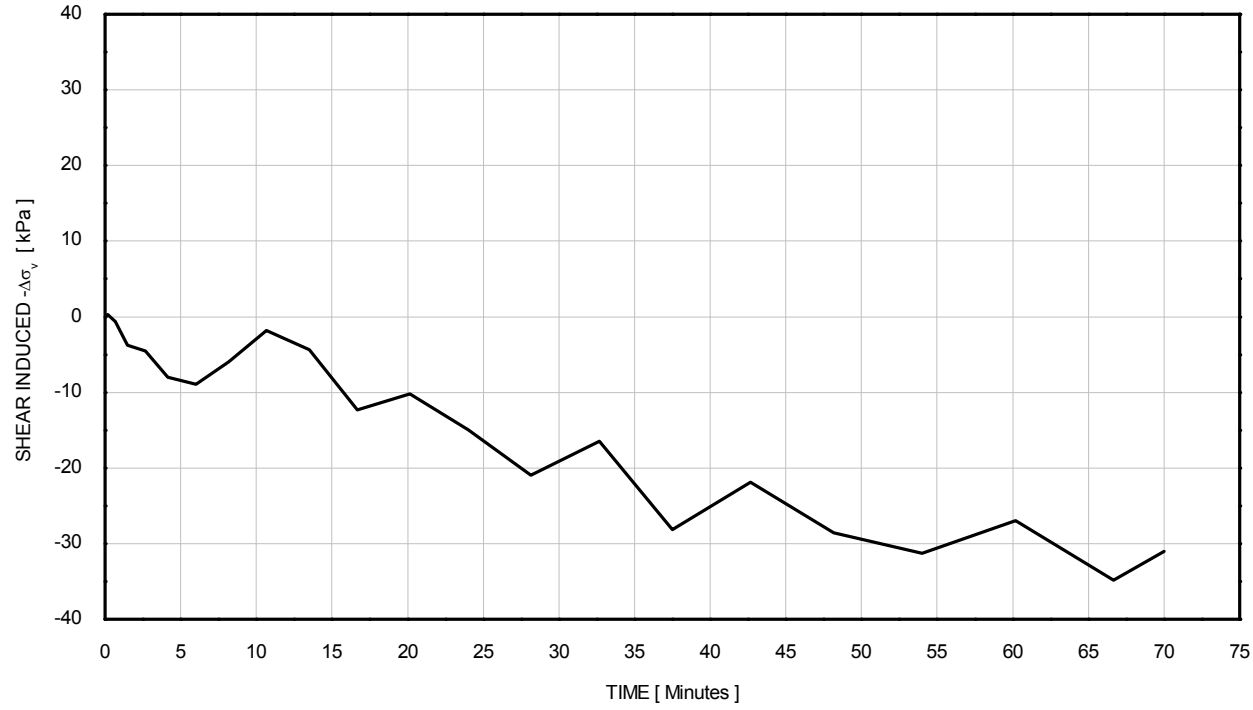


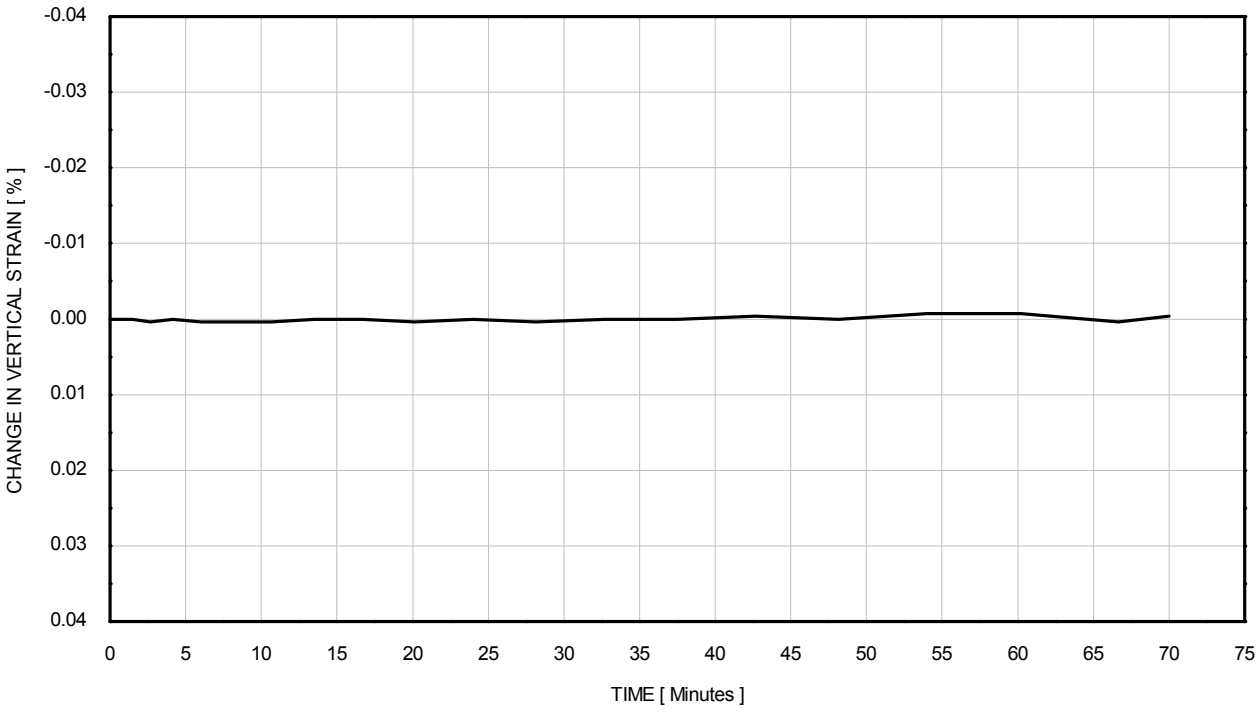


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 112 kPa	Sample	: 6WaxB
Mean τ_{cy}	: 101 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
HORIZONTAL PRE-LOADING STAGE - CONSTANT VOLUME

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

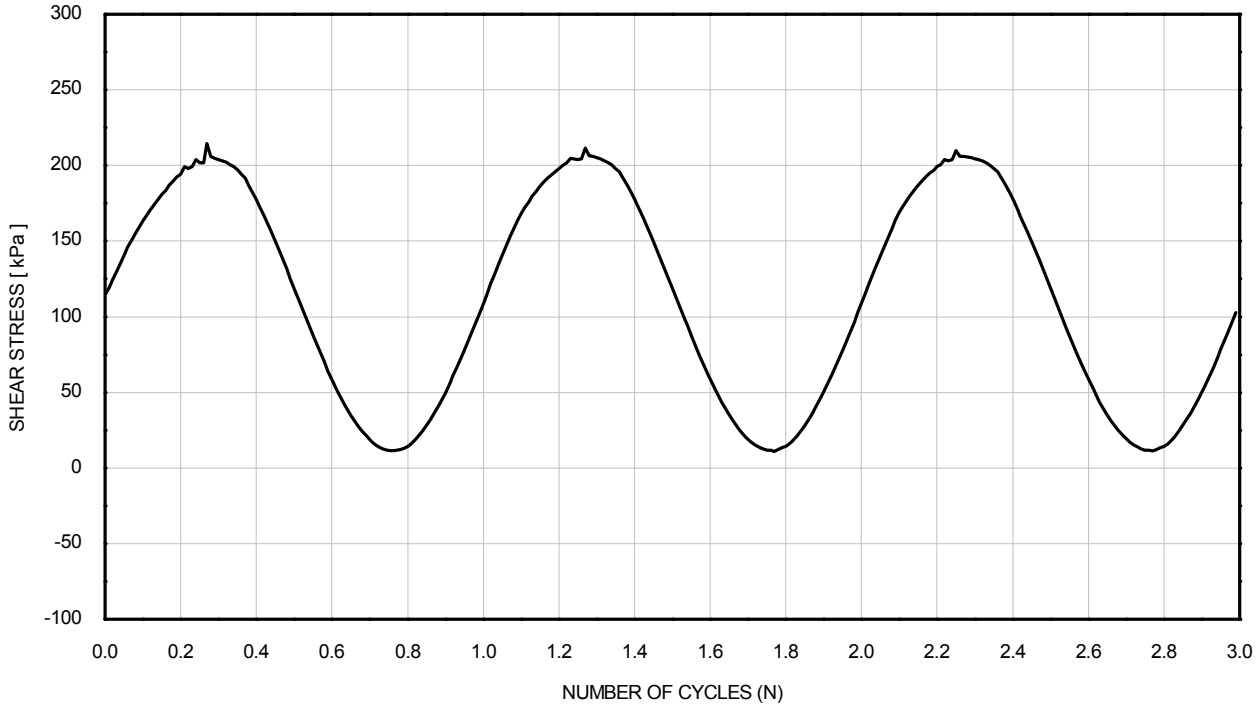


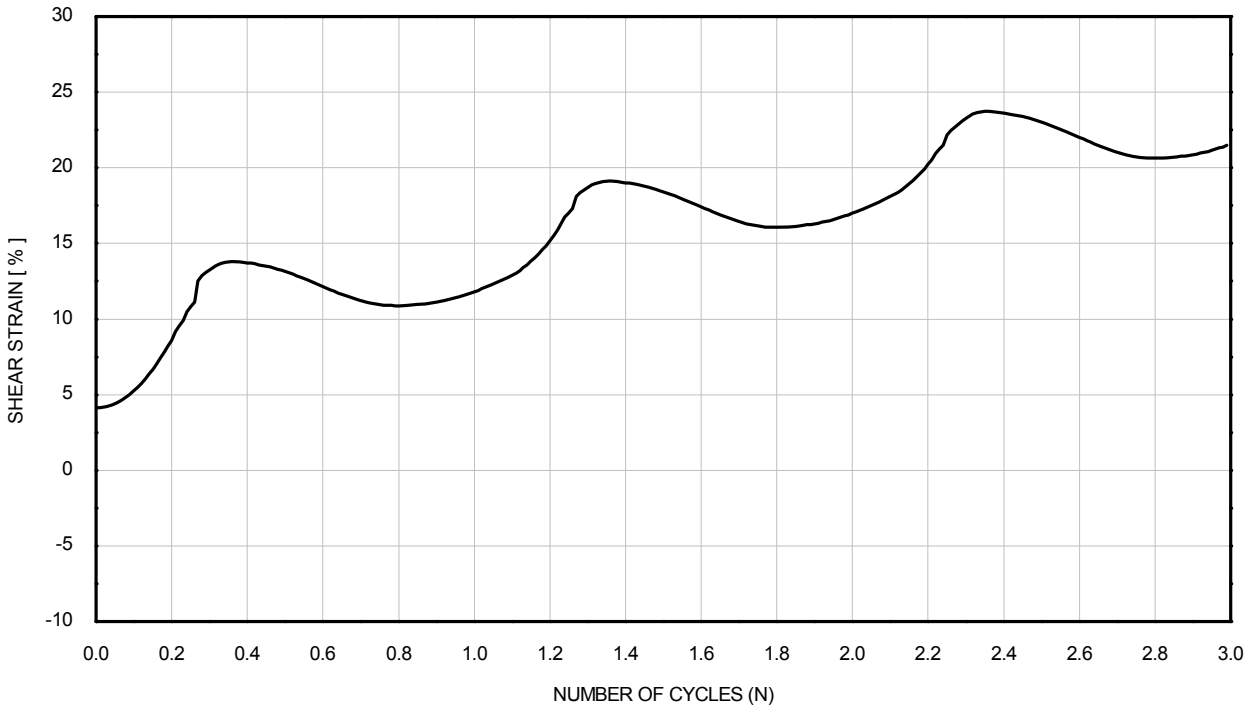


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 112 kPa	Sample	: 6WaxB
Mean τ_{cy}	: 101 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
HORIZONTAL PRE-LOADING STAGE - CONSTANT VOLUME

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

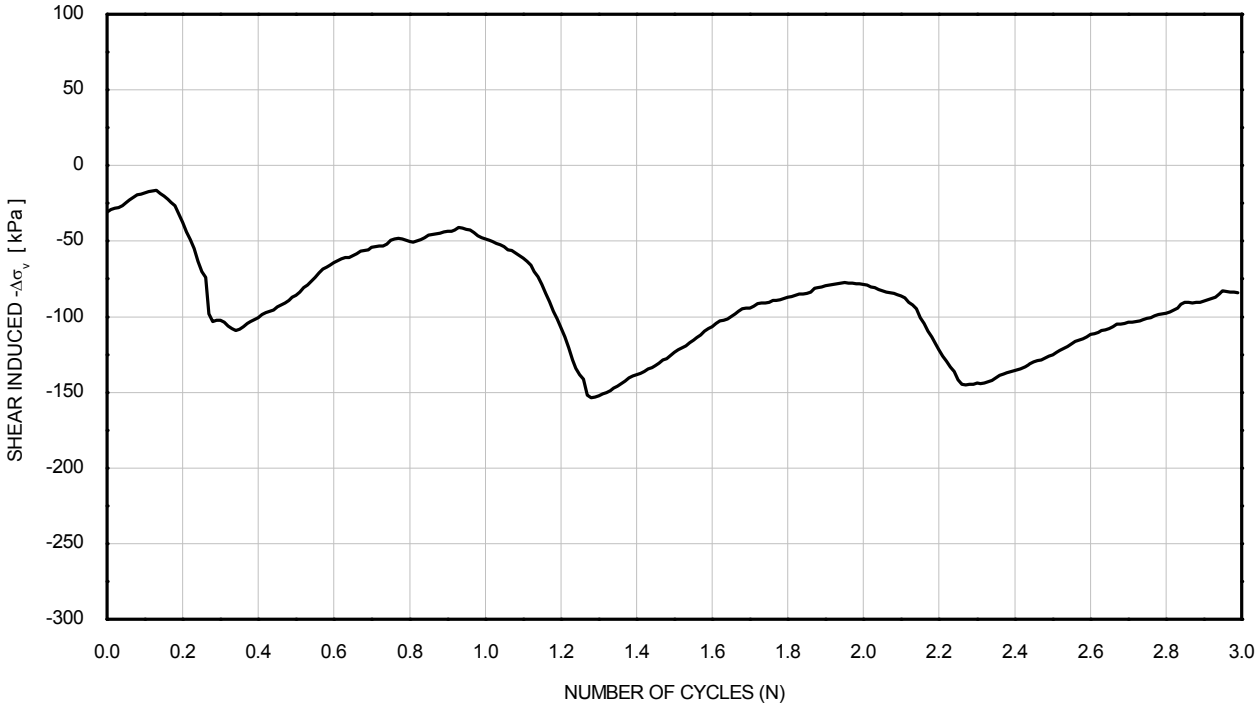


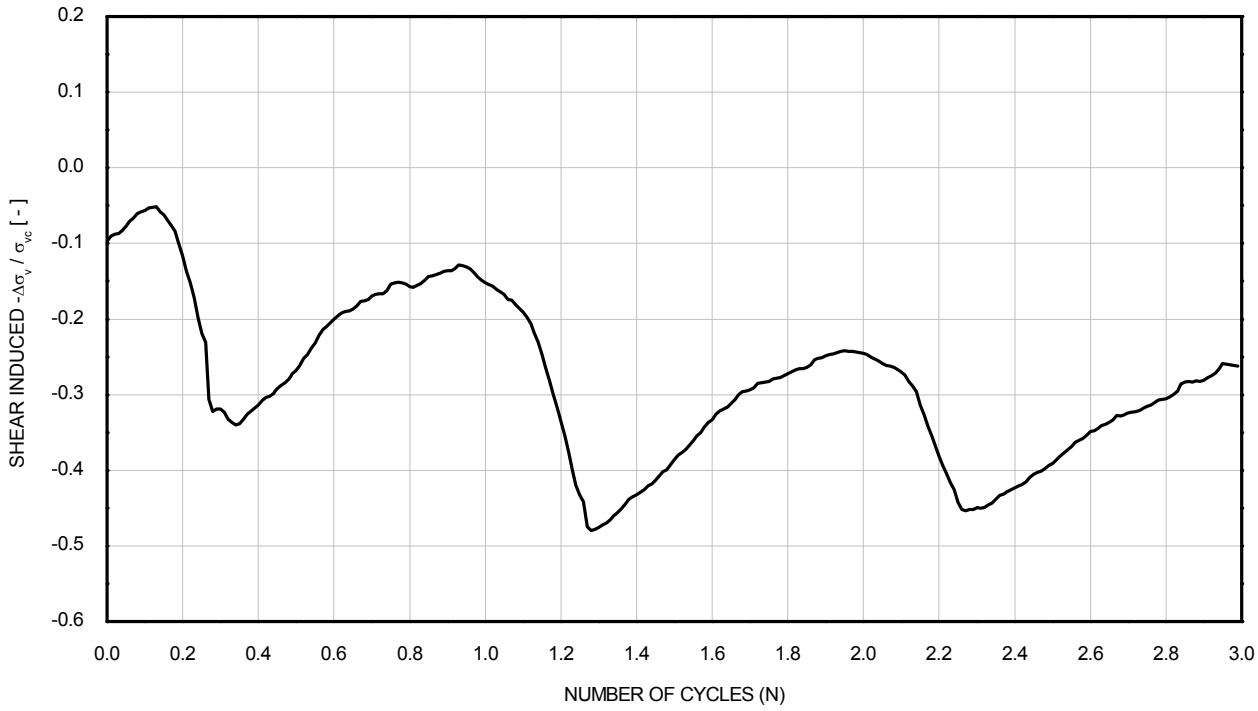


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 112 kPa	Sample	: 6WaxB
Mean τ_{cy}	: 101 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

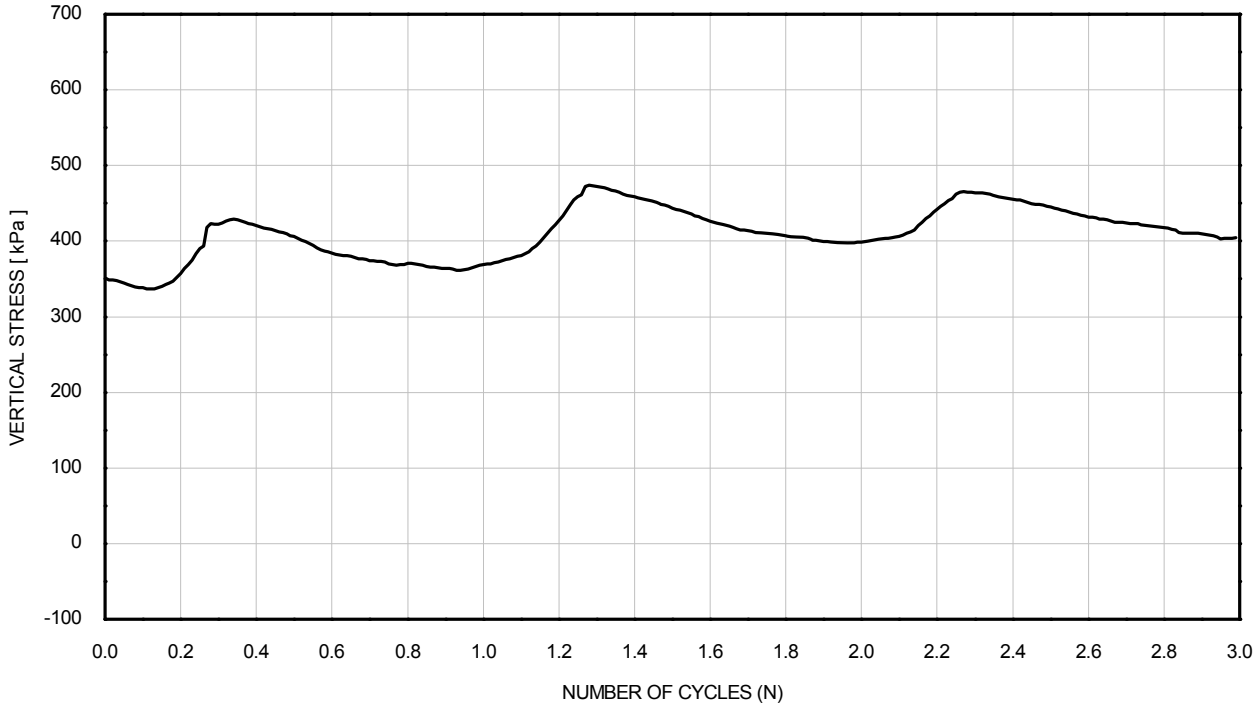


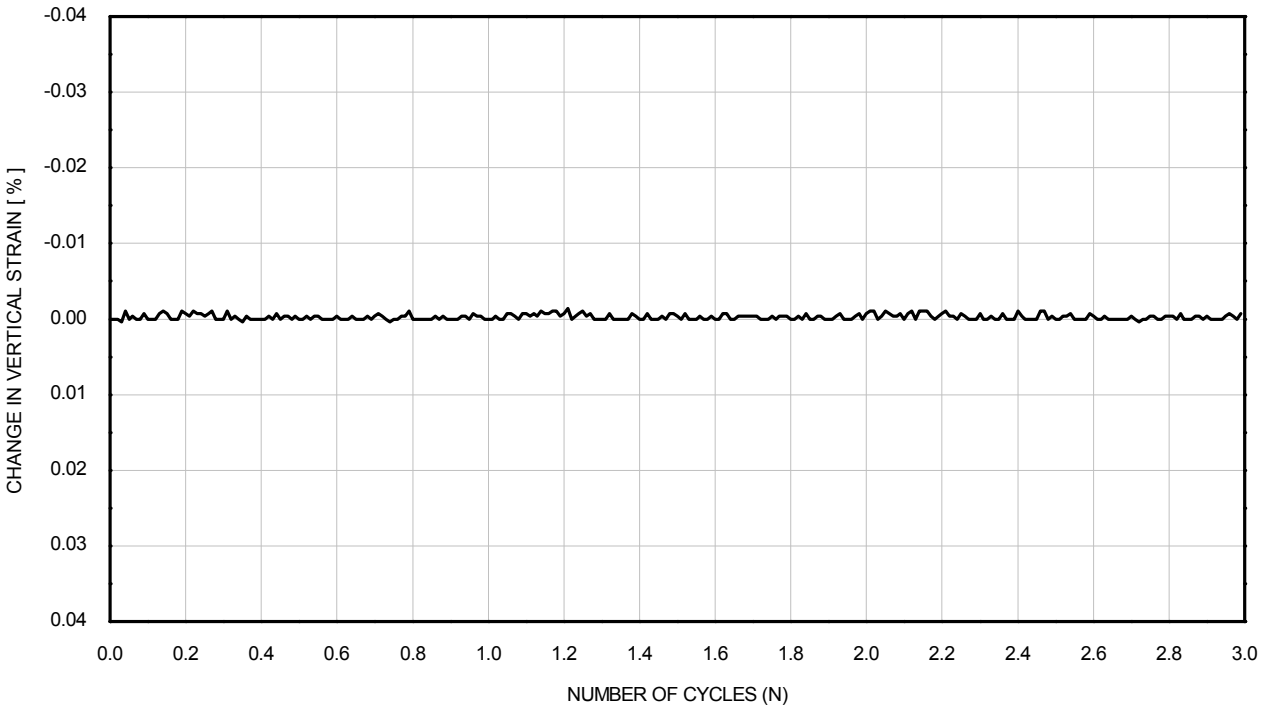


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 112 kPa	Sample	: 6WaxB
Mean τ_{cy}	: 101 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

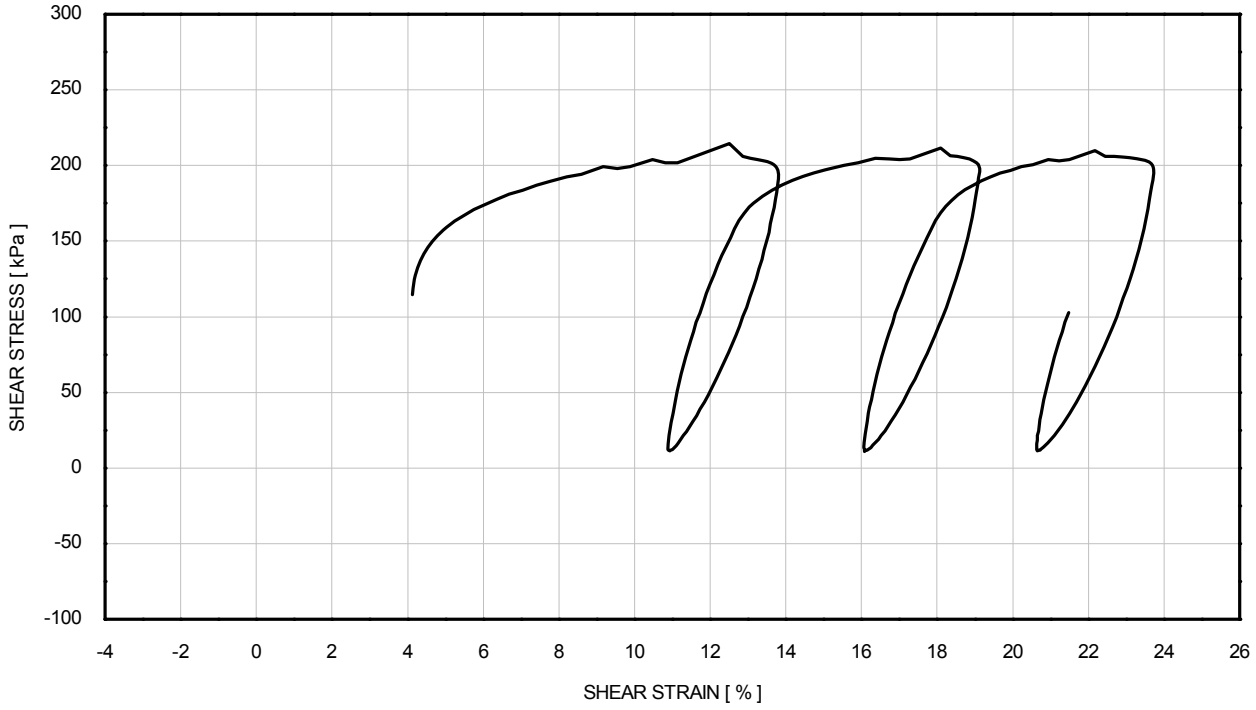


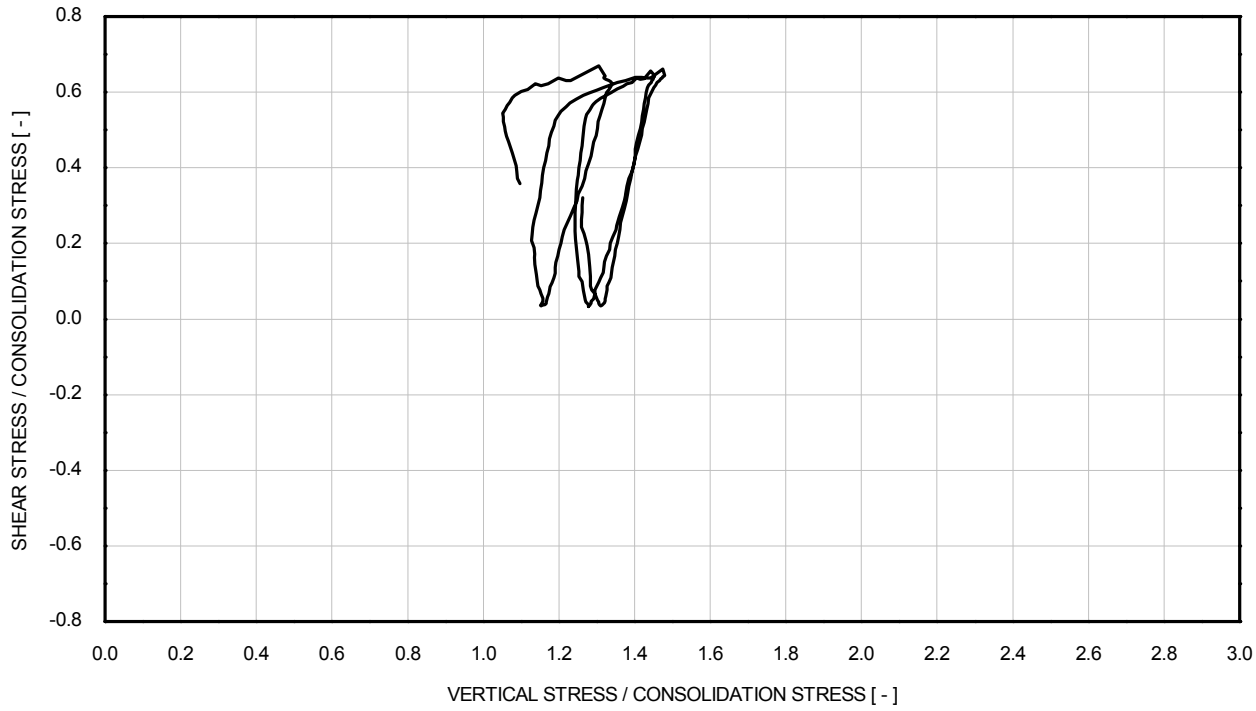


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 112 kPa	Sample	: 6WaxB
Mean τ_{cy}	: 101 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

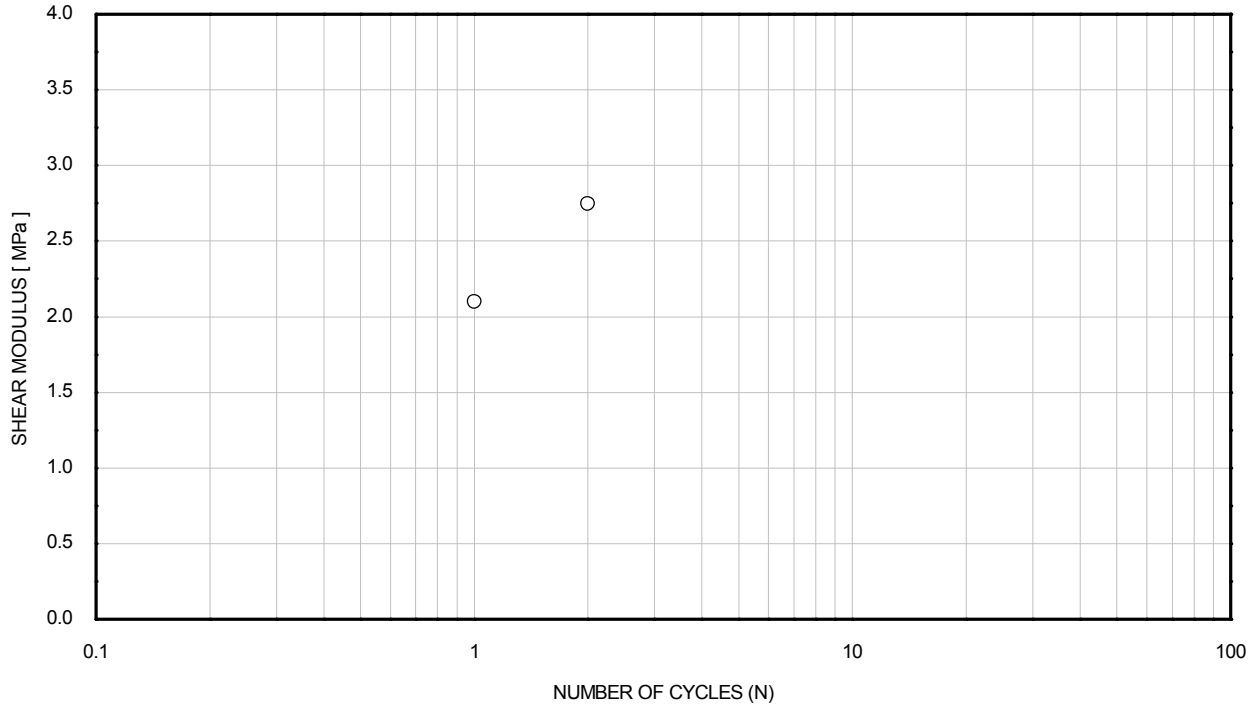


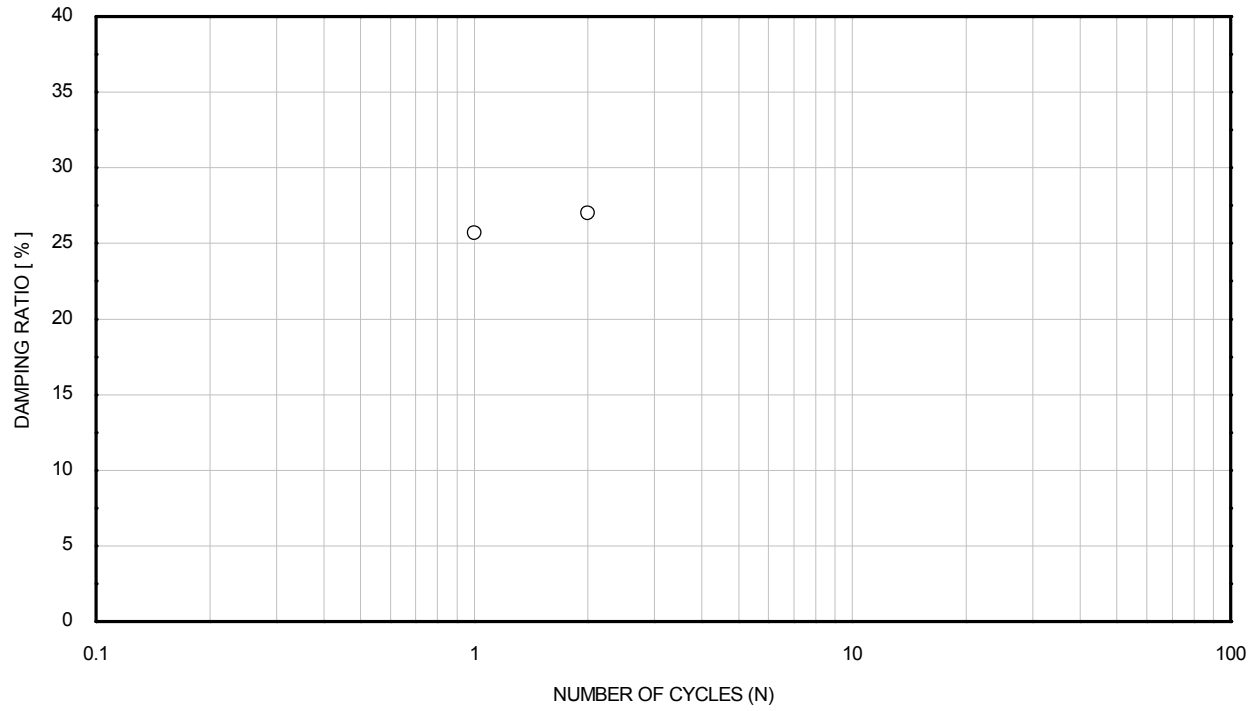


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 112 kPa	Sample	: 6WaxB
Mean τ_{cy}	: 101 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

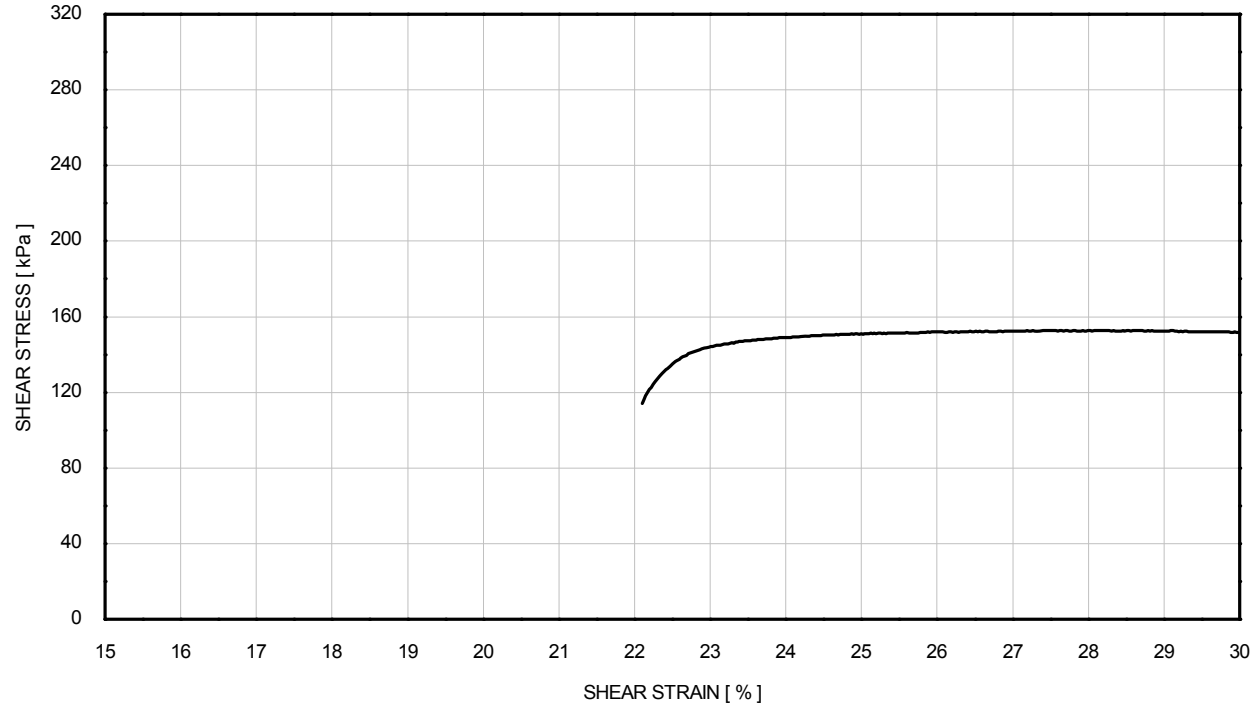


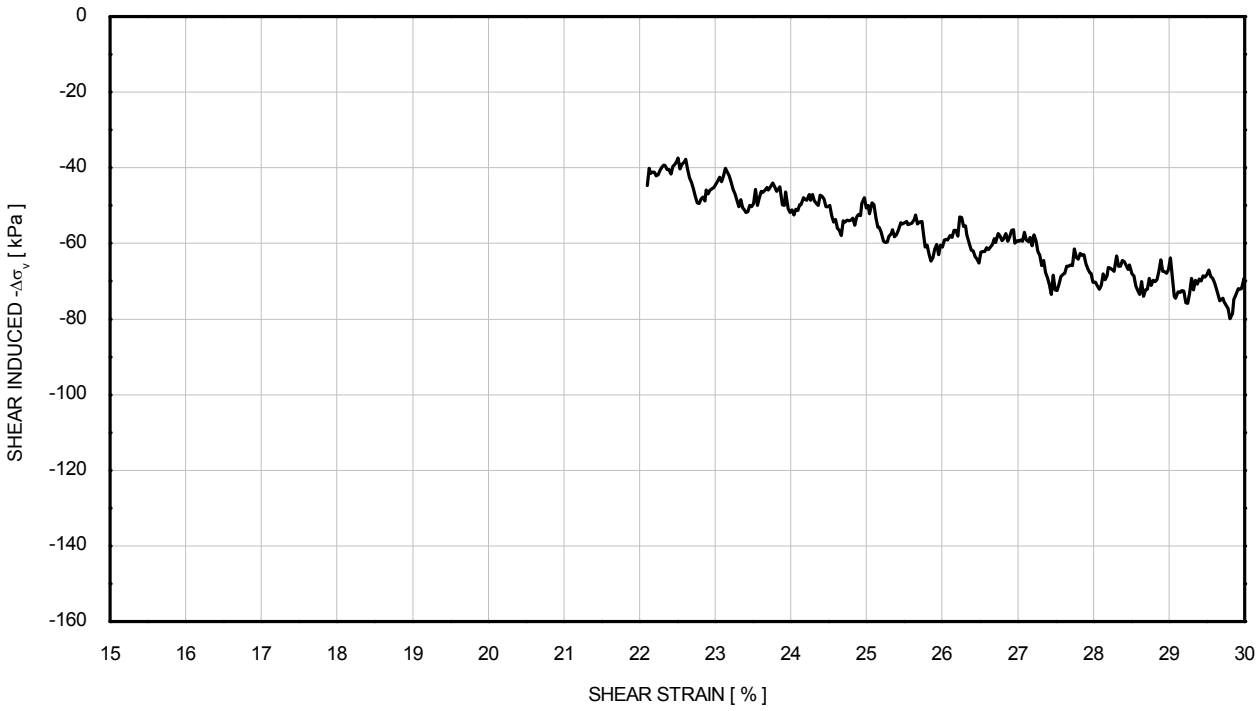


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
Mean τ_{av}	: 112 kPa	Sample	: 6WaxB
Mean τ_{cy}	: 101 kPa	Unit	: F3 (Dongen)
Frequency	: 0.10 Hz	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

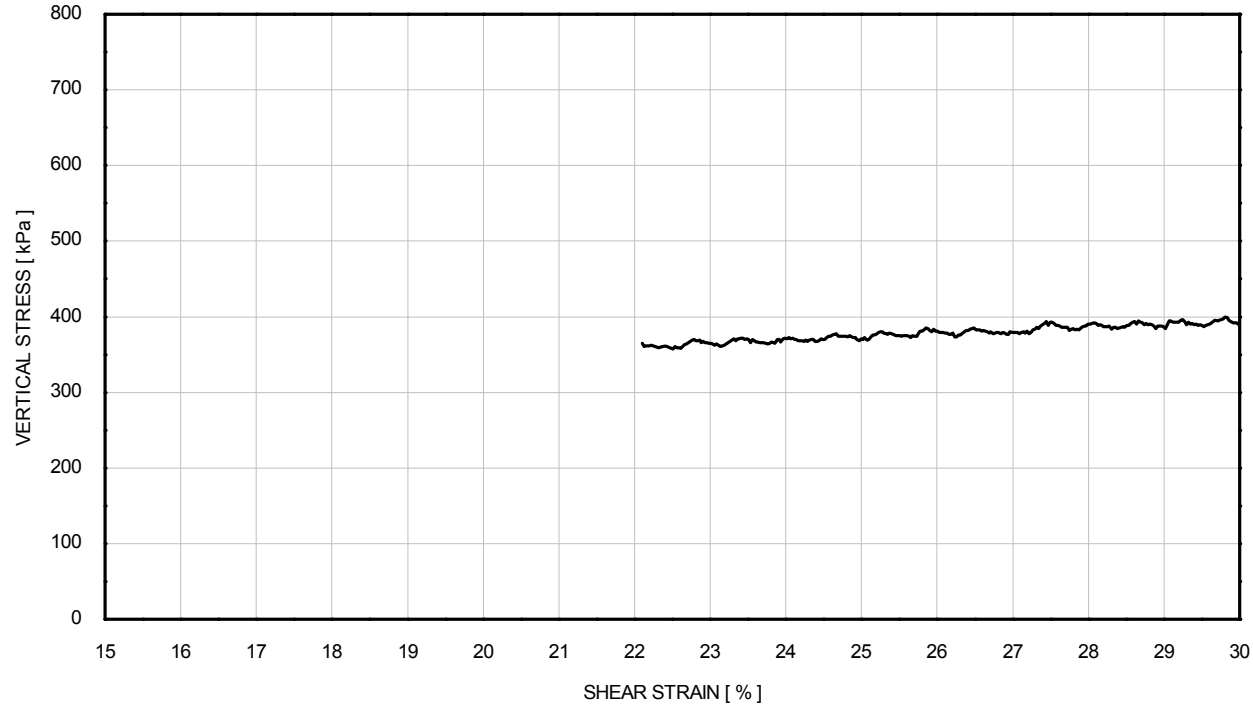


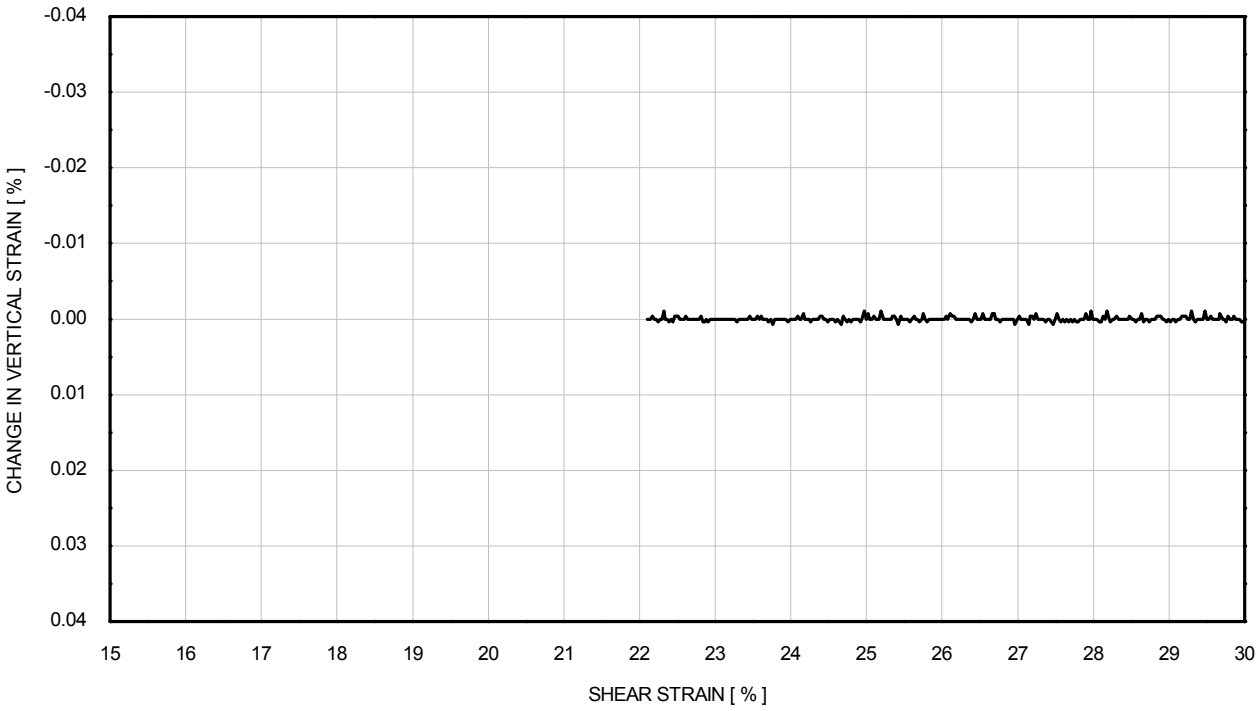


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 153 kPa	Sample	: 6WaxB
γ at τ_{peak}	: 27.52 %	Unit	: F3 (Dongen)
Rate of strain	: 3.02 %/hour	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

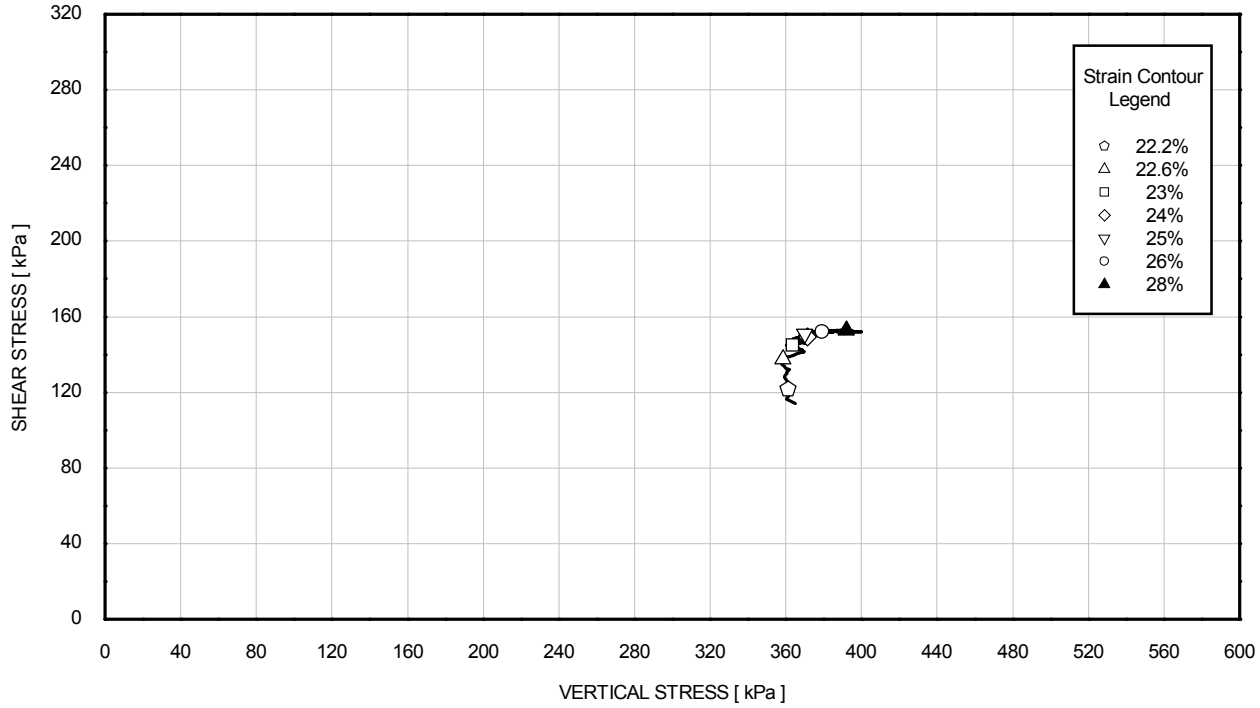


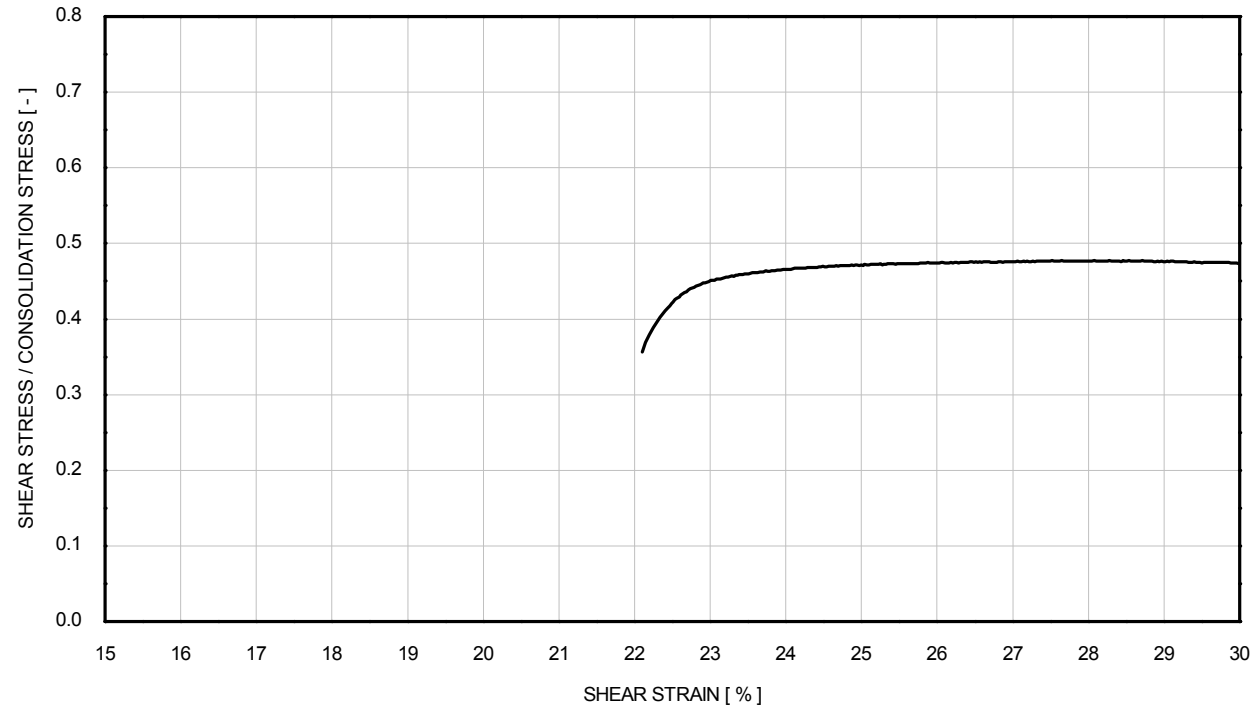


σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 153 kPa	Sample	: 6WaxB
γ at τ_{peak}	: 27.52 %	Unit	: F3 (Dongen)
Rate of strain	: 3.02 %/hour	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

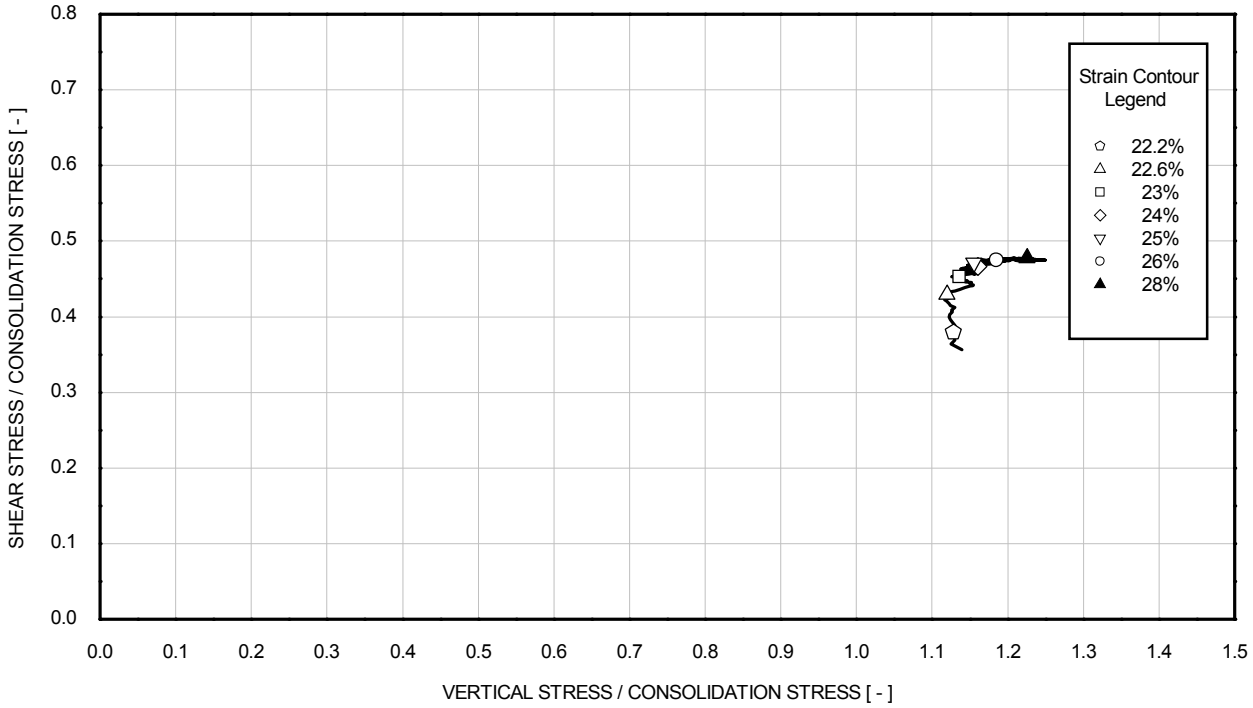


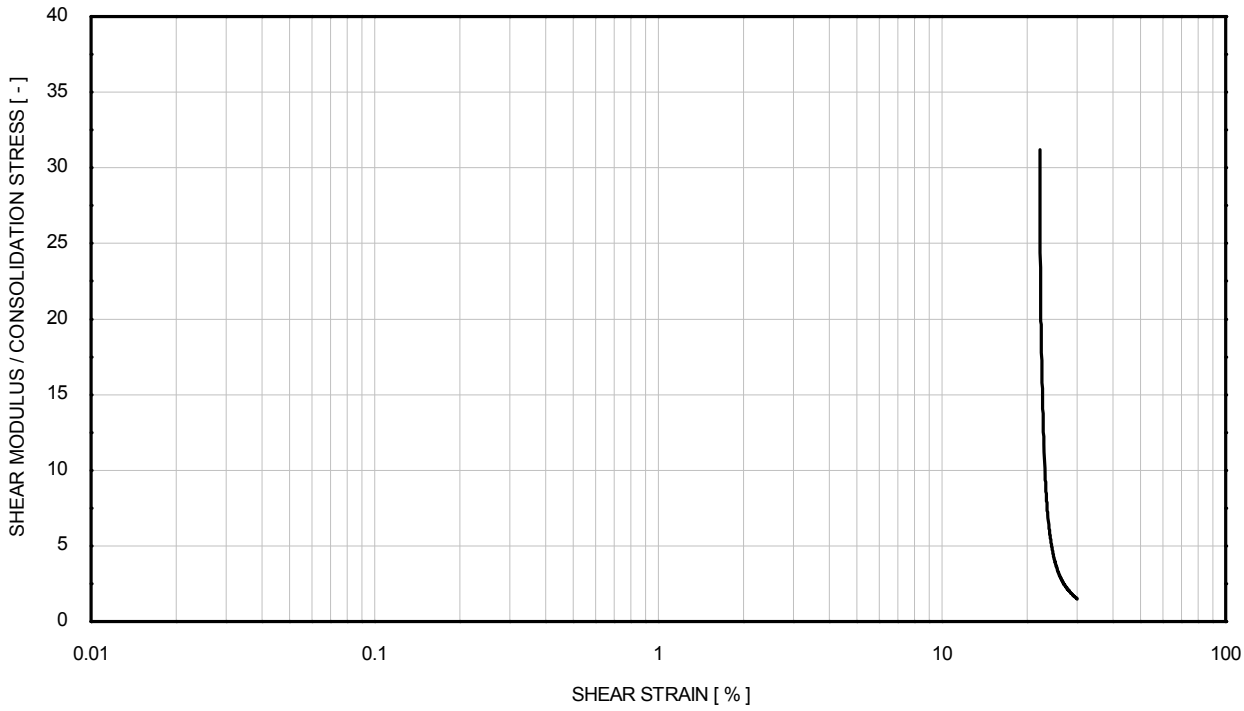


σ_{vc}	: 320	kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 153	kPa	Sample	: 6WaxB
γ at τ_{peak}	: 27.52	%	Unit	: F3 (Dongen)
Rate of strain	: 3.02	%/hour	Depth [m]	: 33.12
			Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 320 kPa	Borehole	: BH-WFS3-4A
τ_{peak}	: 153 kPa	Sample	: 6WaxB
γ at τ_{peak}	: 27.52 %	Unit	: F3 (Dongen)
Rate of strain	: 3.02 %/hour	Depth [m]	: 33.12
		Test No.	: CSS06R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark greenish grey CLAY with few pockets of black silt and with burrows infilled with light grey silt and with closely spaced horizontal fissures

GENERAL	
Date test started	04/12/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	19.8
Moisture content	[%]	41.2
Bulk density	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.27
Void ratio	[-]	1.132
Degree of saturation	[%]	98
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	125
Pocket penetrometer	[kPa]	283
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-1A_23WAXB_CSS07
Template issue	1.3
Processed by	RN
Date	11/12/2015
Checked by	LJ
Date	11/12/2015
Approved by	PH
Date	14/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	23WaxB
Unit	F3 (Dongen)
Depth [m]	38.24
Test number	CSS07

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	913
Vertical strain	[%]	3.83
Bulk density	[Mg/m^3]	1.82
Dry density	[Mg/m^3]	1.32
Void ratio	[-]	1.050
Moisture content	[%]	38.2

CONSOLIDATION		
σ_{vc}	[kPa]	365
Vertical strain	[%]	2.73
Bulk density	[Mg/m^3]	1.81
Dry density	[Mg/m^3]	1.30
Void ratio	[-]	1.074
Moisture content	[%]	39.0

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	245
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	153
Frequency	[Hz]	0.10
Number of cycles applied (N)	[-]	1500
γ_{av} at N	[%]	0.05
γ_{cy} at N	[%]	1.46
Shear induced -$\Delta\sigma_v$ at N	[kPa]	3
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.05	0.93	16.44	10.62
2	0.05	0.97	15.77	9.77
5	0.06	1.02	15.08	9.67
10	0.06	1.05	14.58	9.66
20	0.05	1.09	14.05	9.65
30	0.05	1.12	13.74	9.64
40	0.05	1.14	13.51	9.67
50	0.05	1.15	13.33	9.66
100	0.05	1.20	12.80	9.65
500	0.05	1.33	11.50	9.62
1000	0.05	1.41	10.89	9.60
1500	0.05	1.46	10.53	9.58

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	23WaxB
Unit	F3 (Dongen)
Depth [m]	38.24
Test number	CSS07

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress*		
Shear stress	[kPa]	282
Shear strain	[%]	7.99
Shear induced $-\Delta\sigma_v$	[kPa]	-64
Vertical stress	[kPa]	429
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	3.22
At 15 % shear strain		
Shear stress	[kPa]	237
Shear induced $-\Delta\sigma_v$	[kPa]	-45
Vertical stress	[kPa]	410
Vertical strain	[%]	0.00

* Please note that specimen failure was observed to occur along or close to the loading platen interface.

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	23WaxB
Unit	F3 (Dongen)
Depth [m]	38.24
Test number	CSS07

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

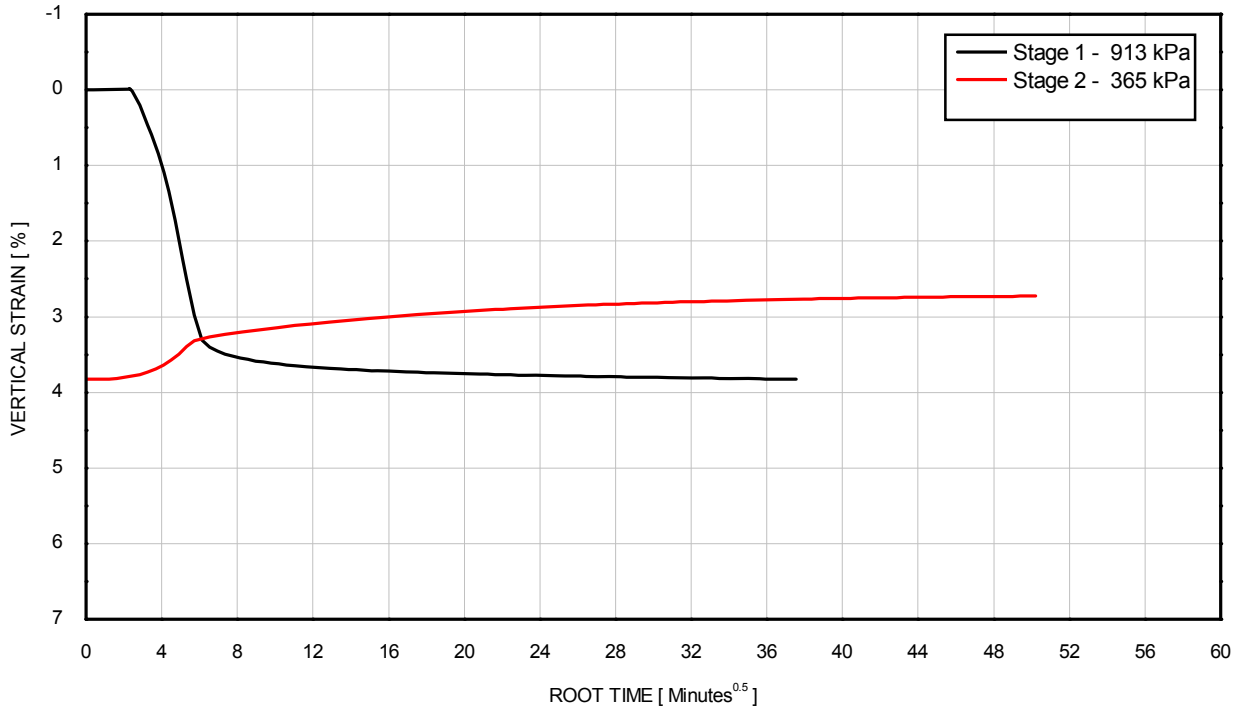
SPECIMEN PHOTOGRAPH

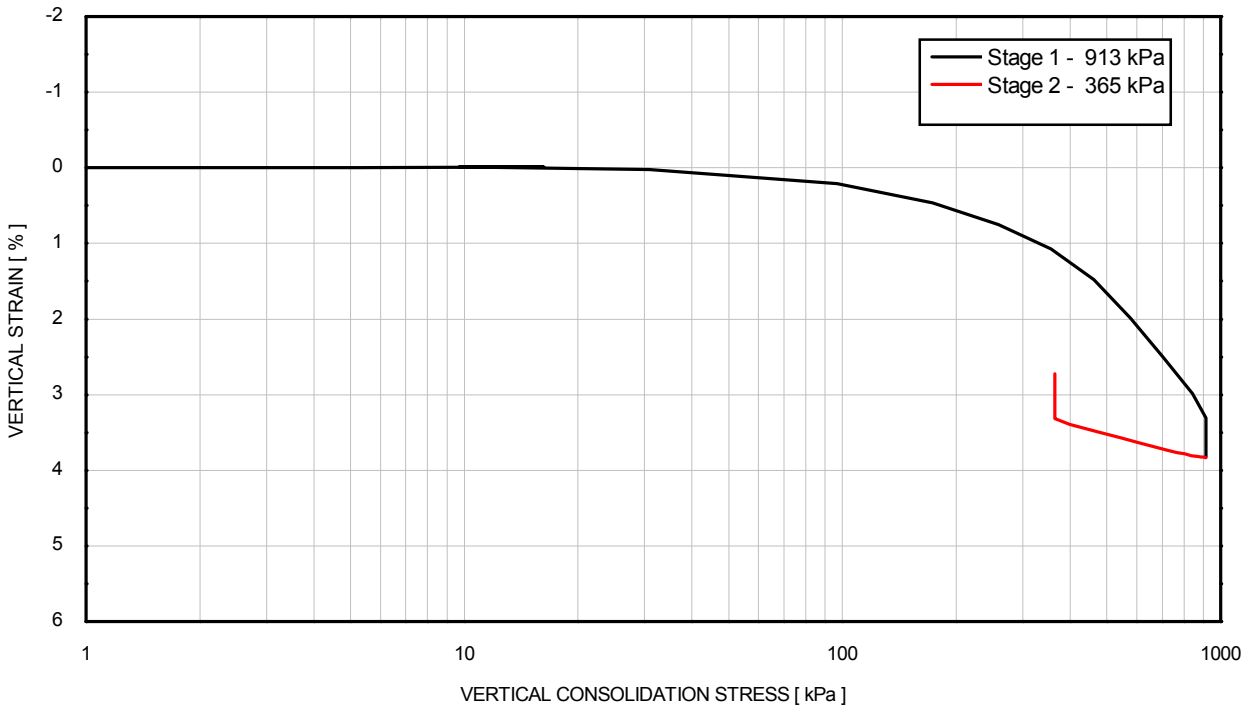


TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	23WaxB
Unit	F3 (Dongen)
Depth [m]	38.24
Test number	CSS07

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

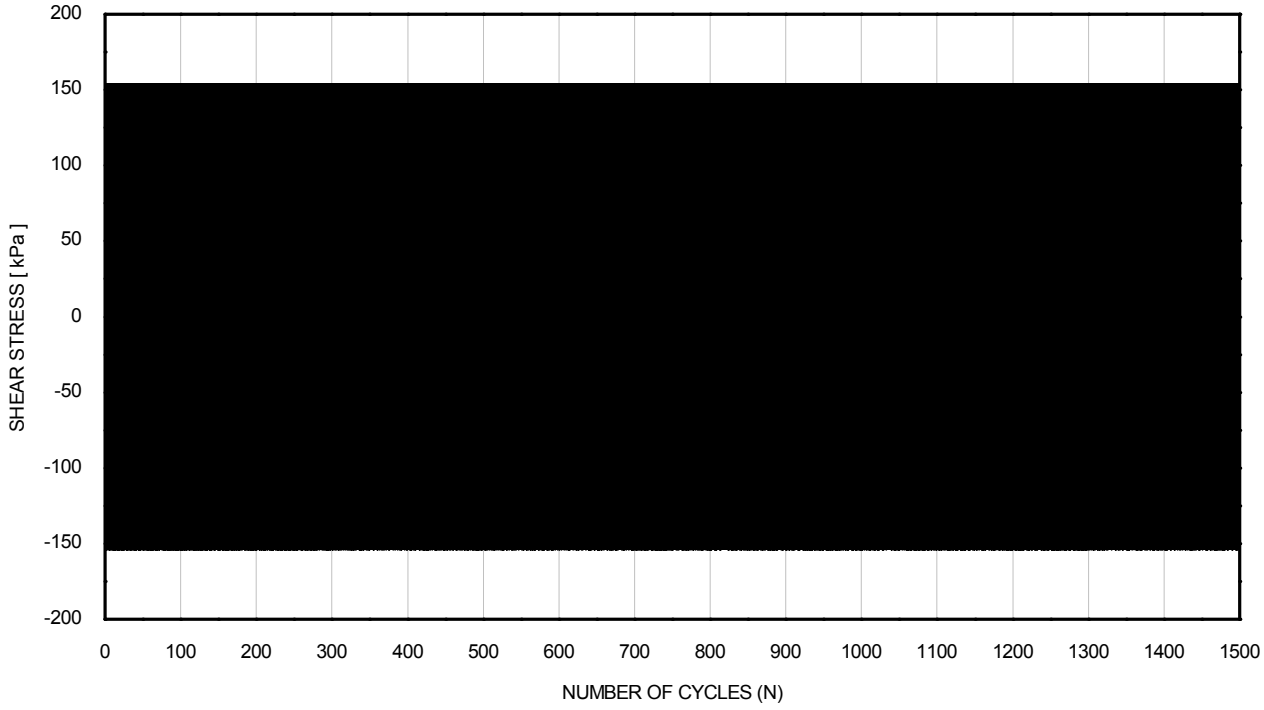


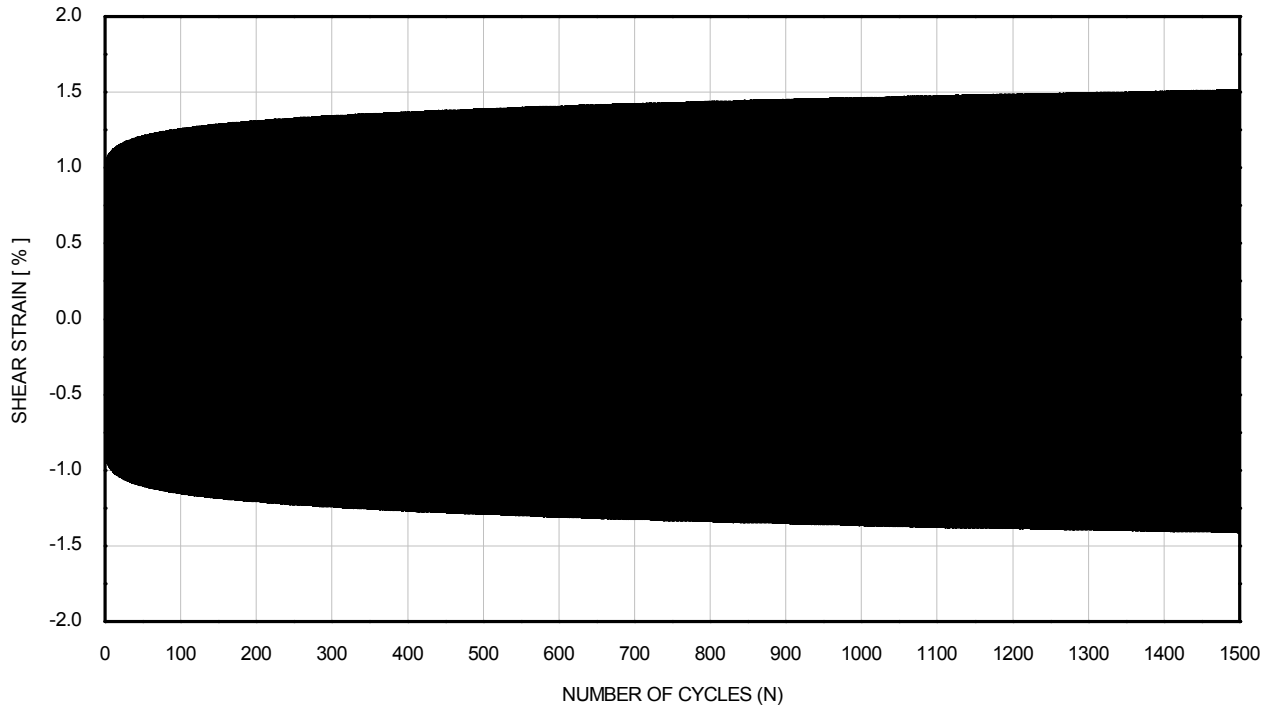


σ_{vc}	: 365 kPa	Borehole	: BH-WFS4-1A
		Sample	: 23WaxB
		Unit	: F3 (Dongen)
		Depth [m]	: 38.24
		Test No.	: CSS07

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

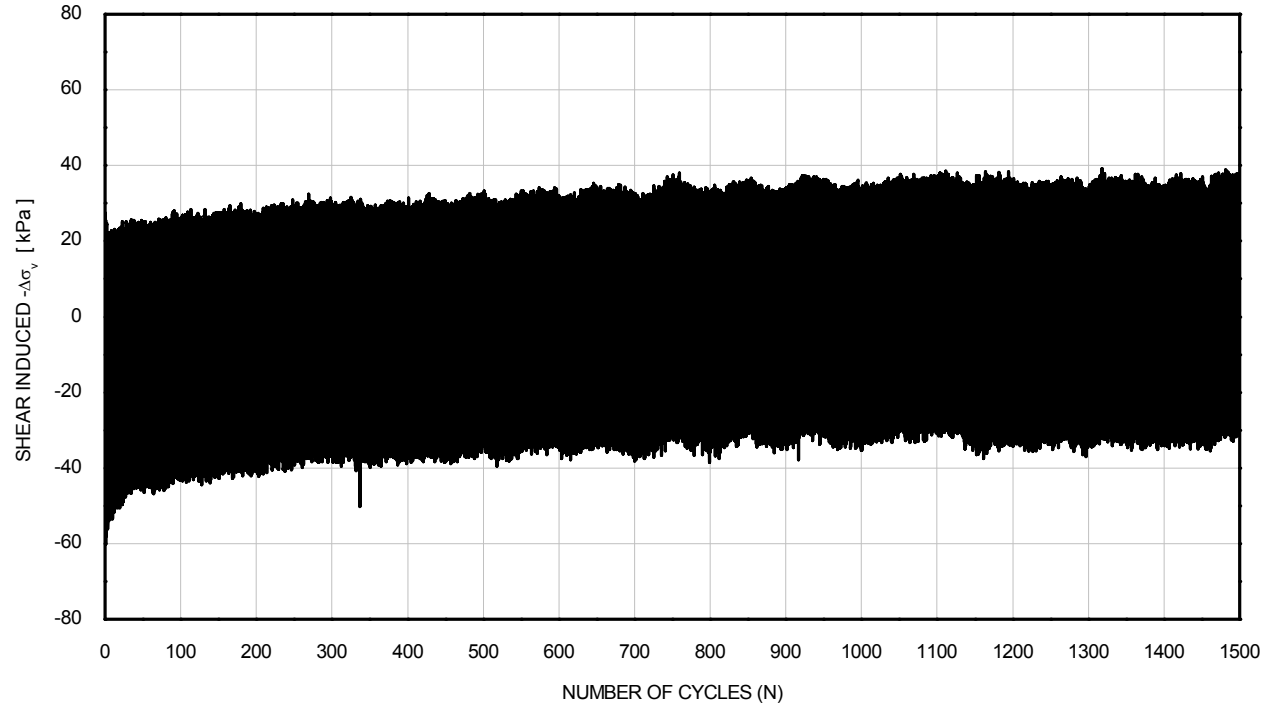


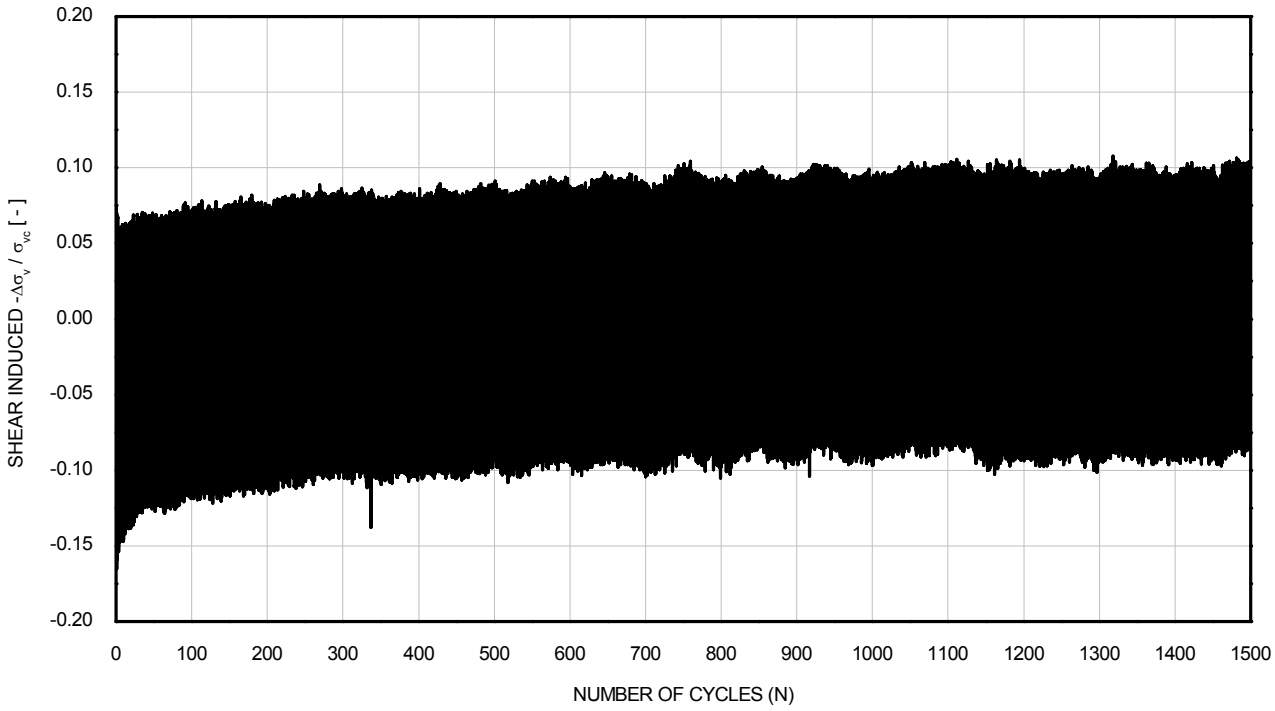


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	23WaxB
Mean τ_{cy}	:	153 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

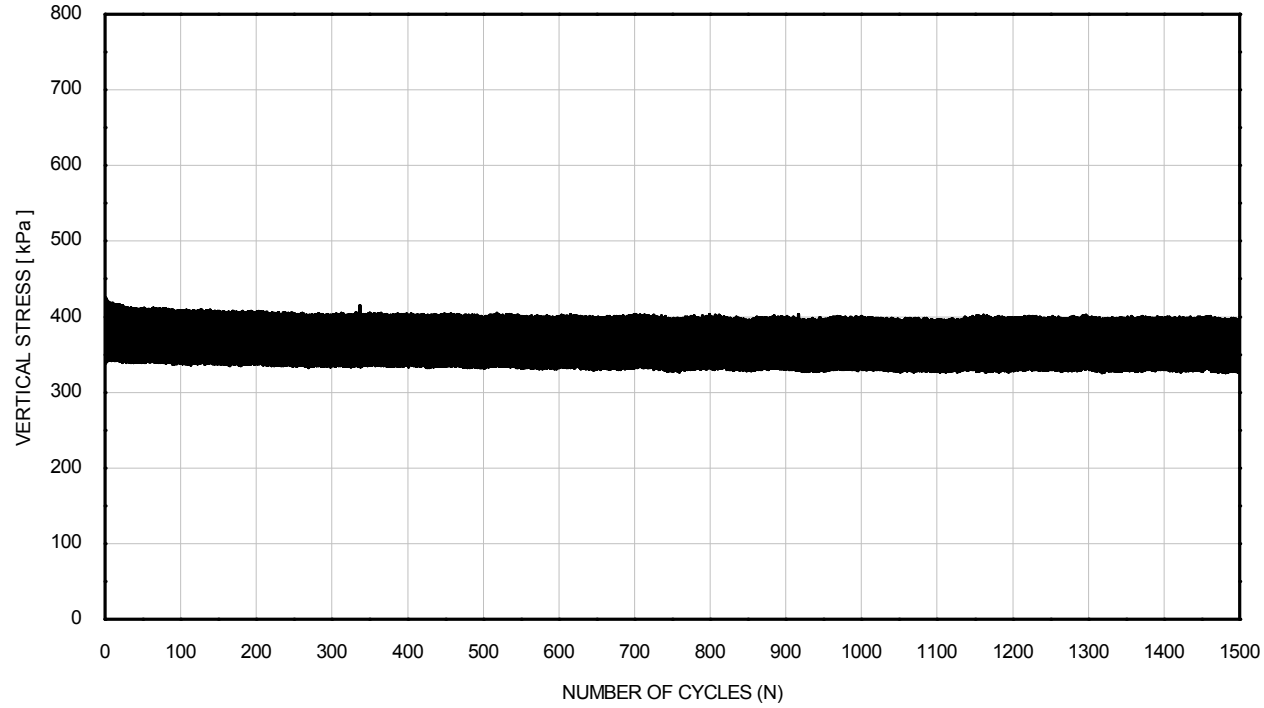


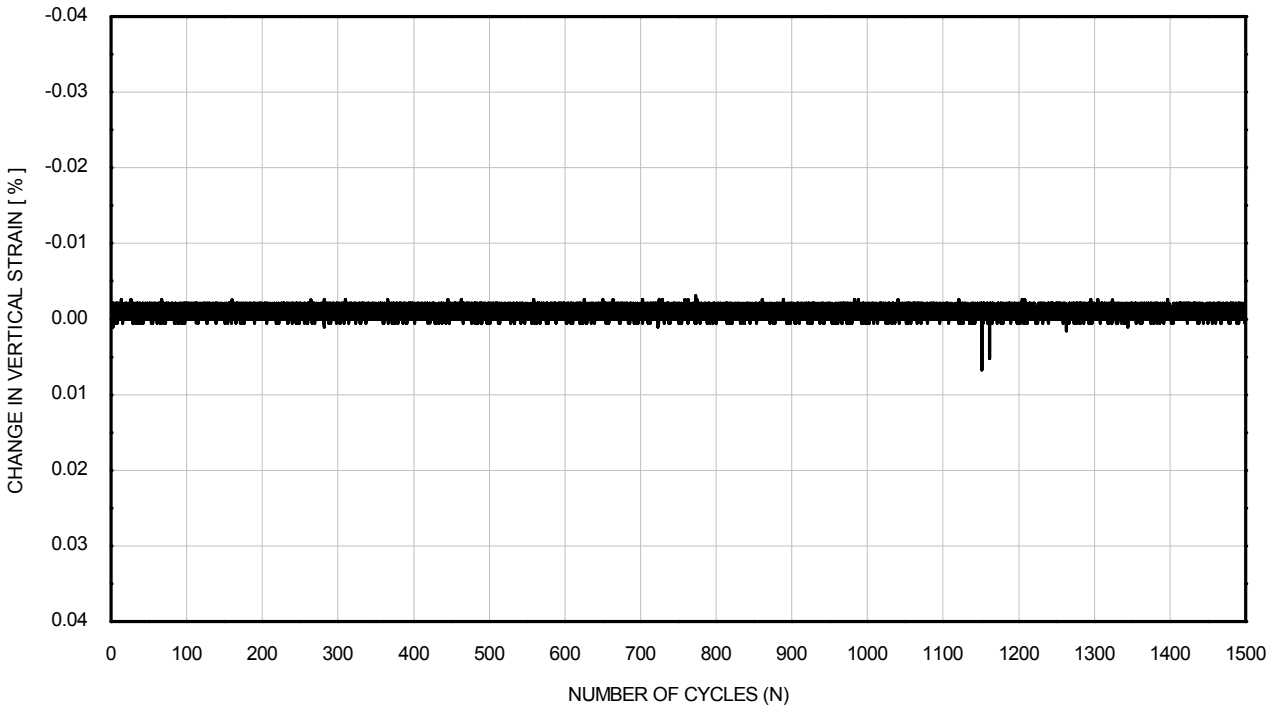


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	23WaxB
Mean τ_{cy}	:	153 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

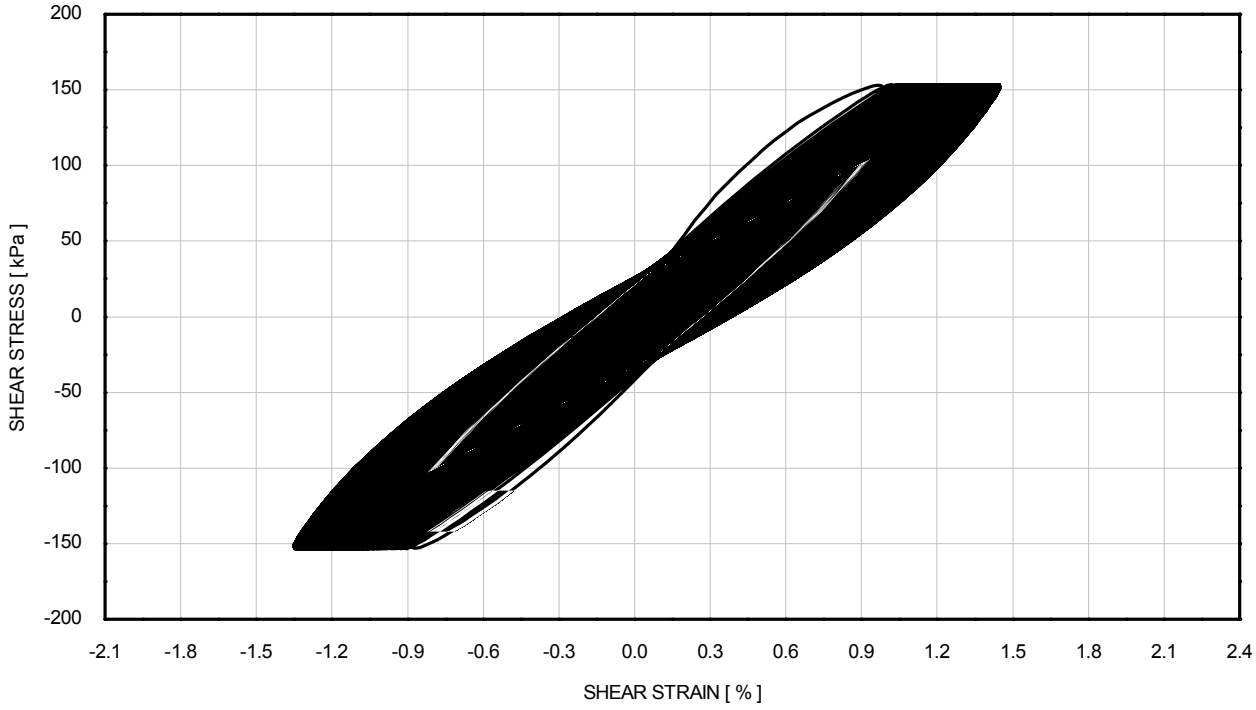


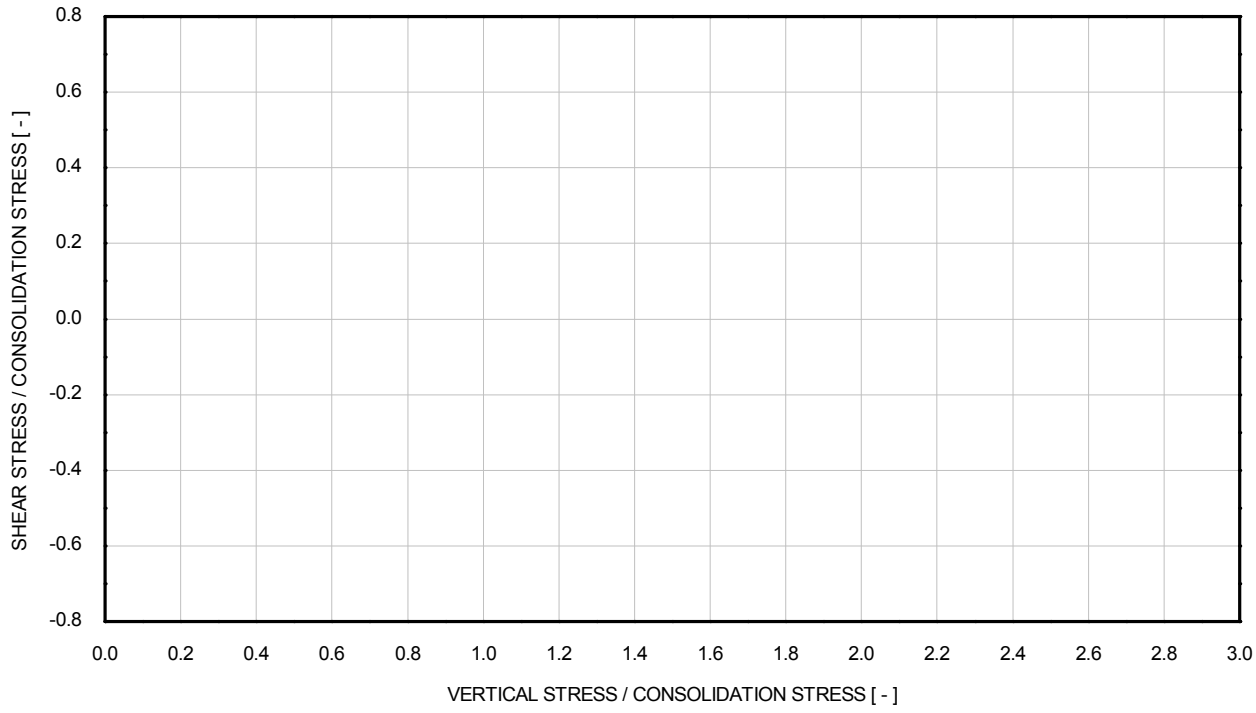


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	23WaxB
Mean τ_{cy}	:	153 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

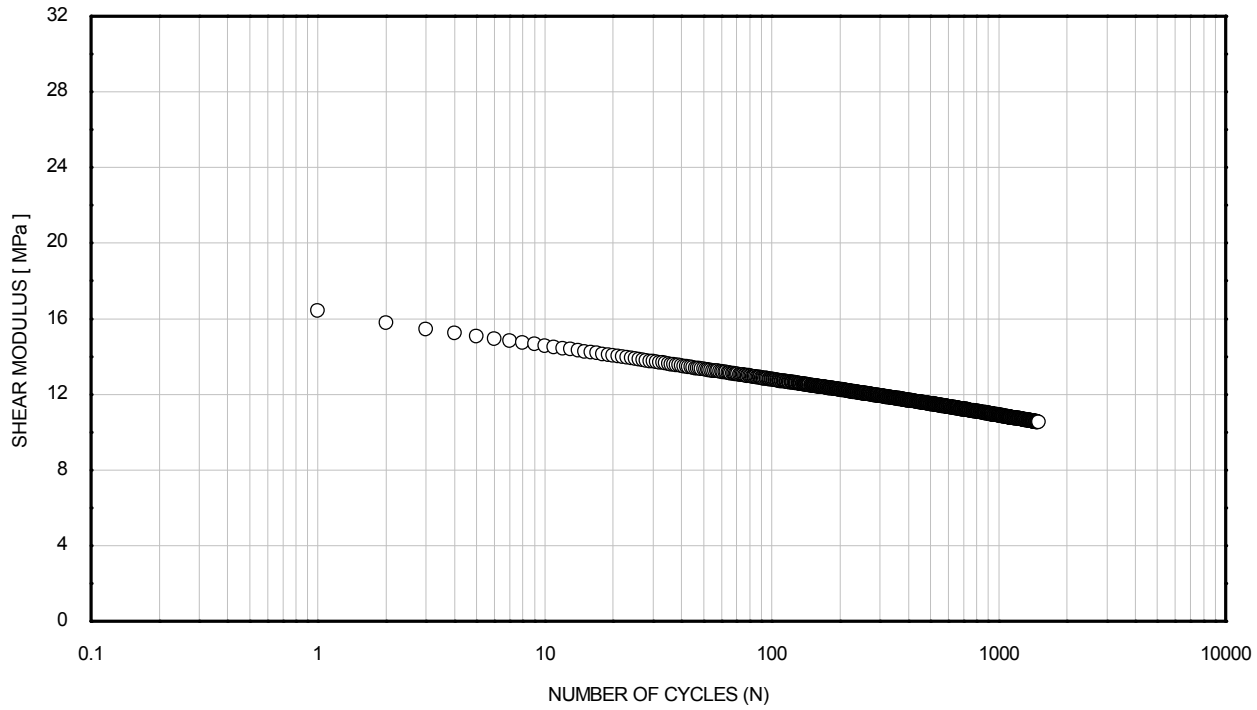


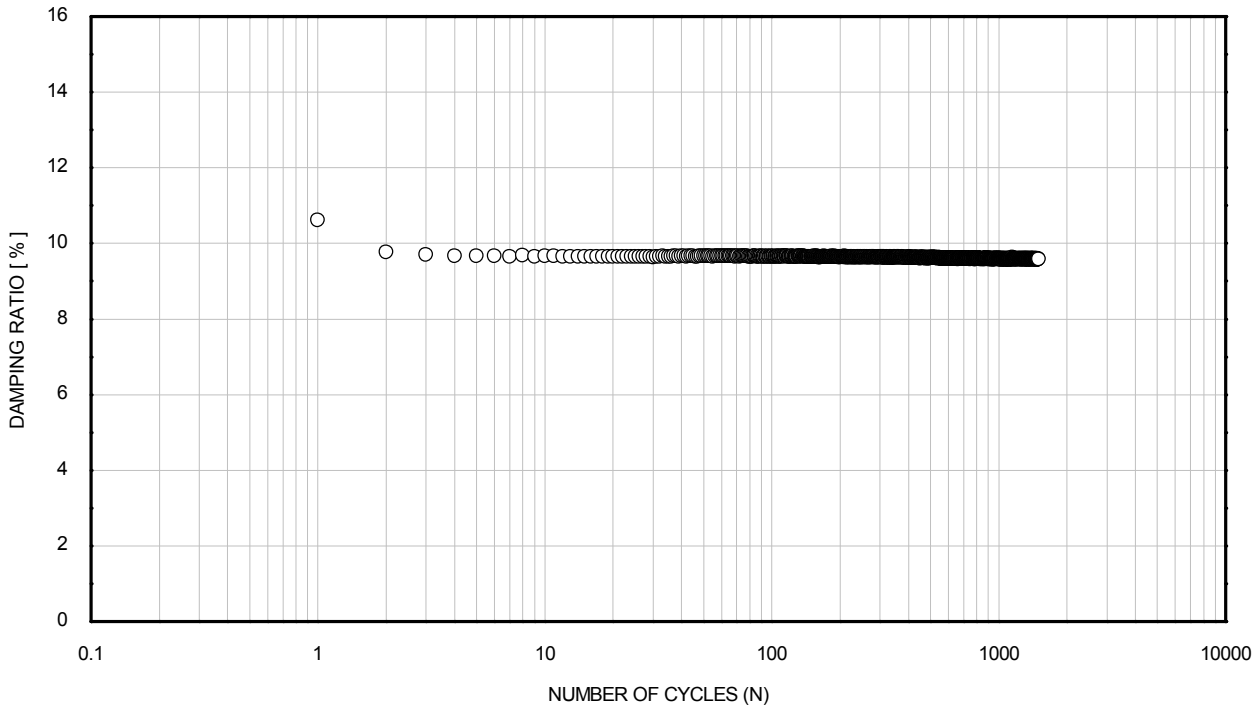


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	23WaxB
Mean τ_{cy}	:	153 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

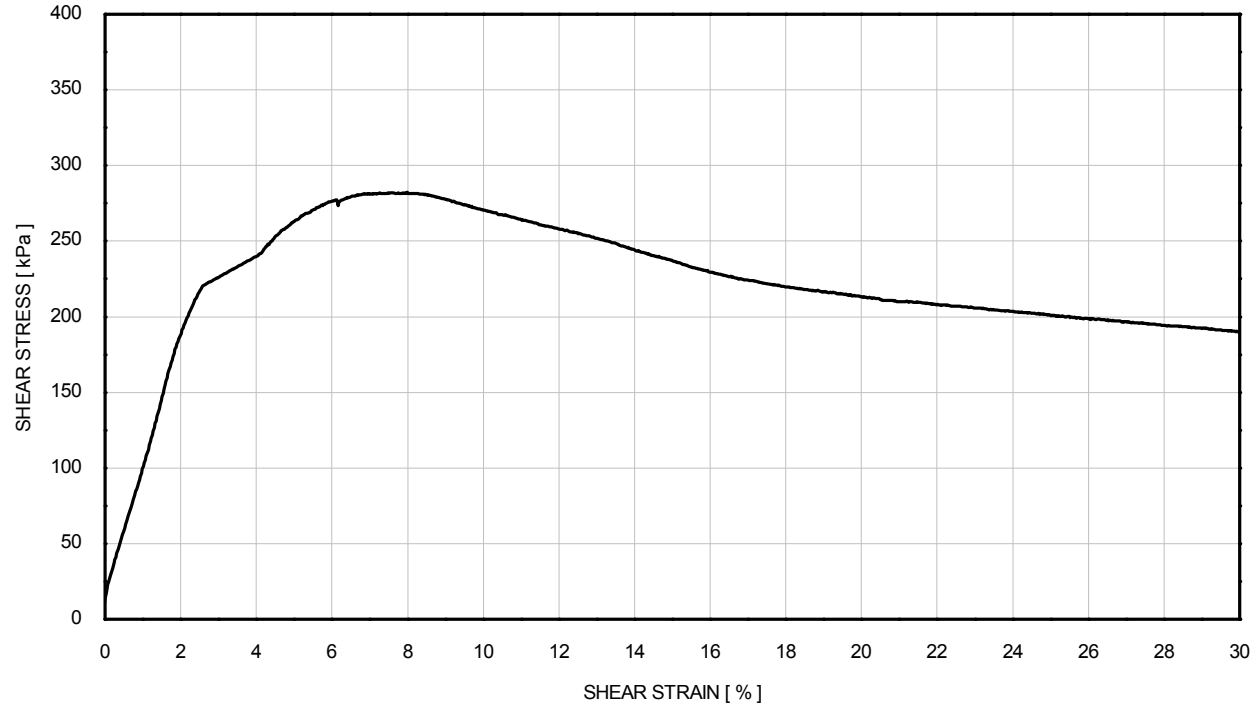


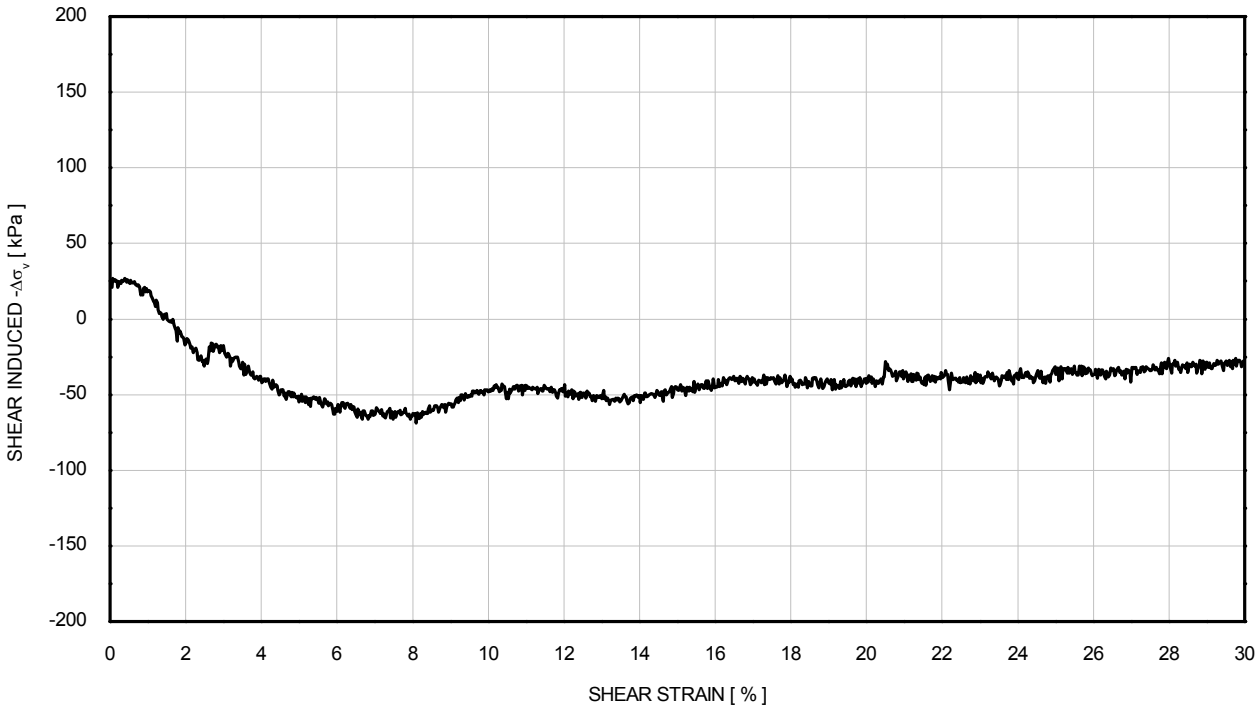


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	23WaxB
Mean τ_{cy}	:	153 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

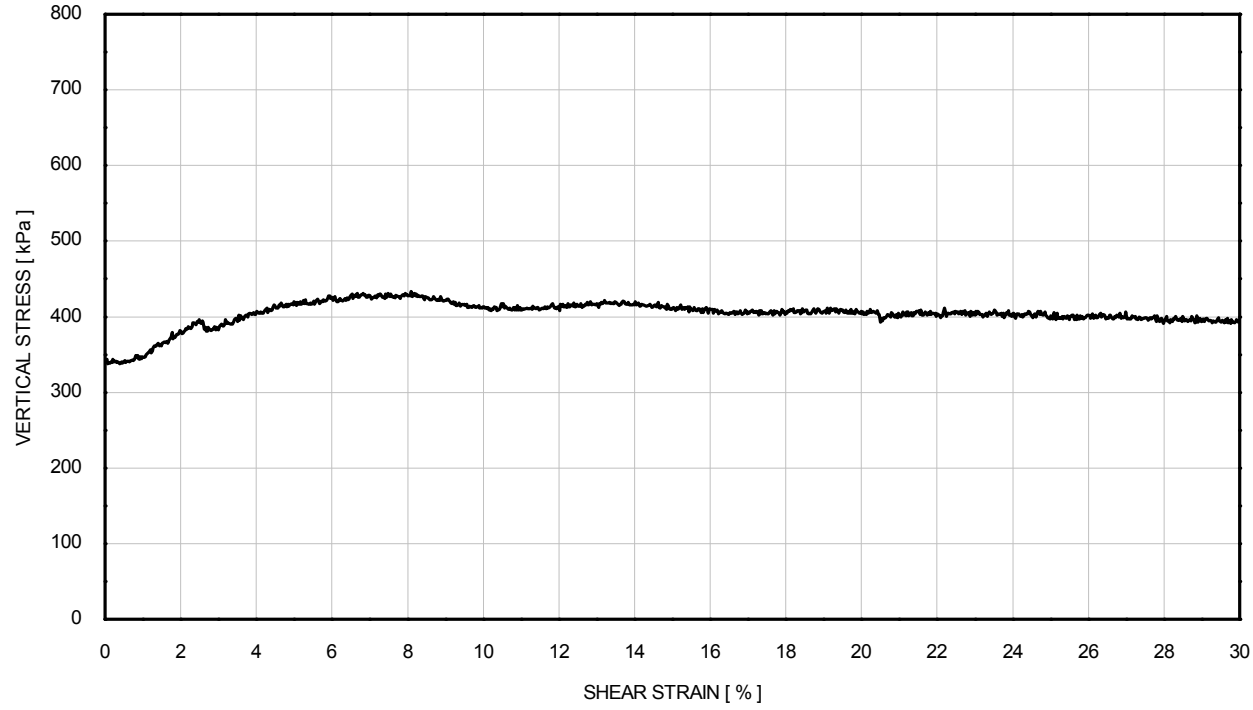


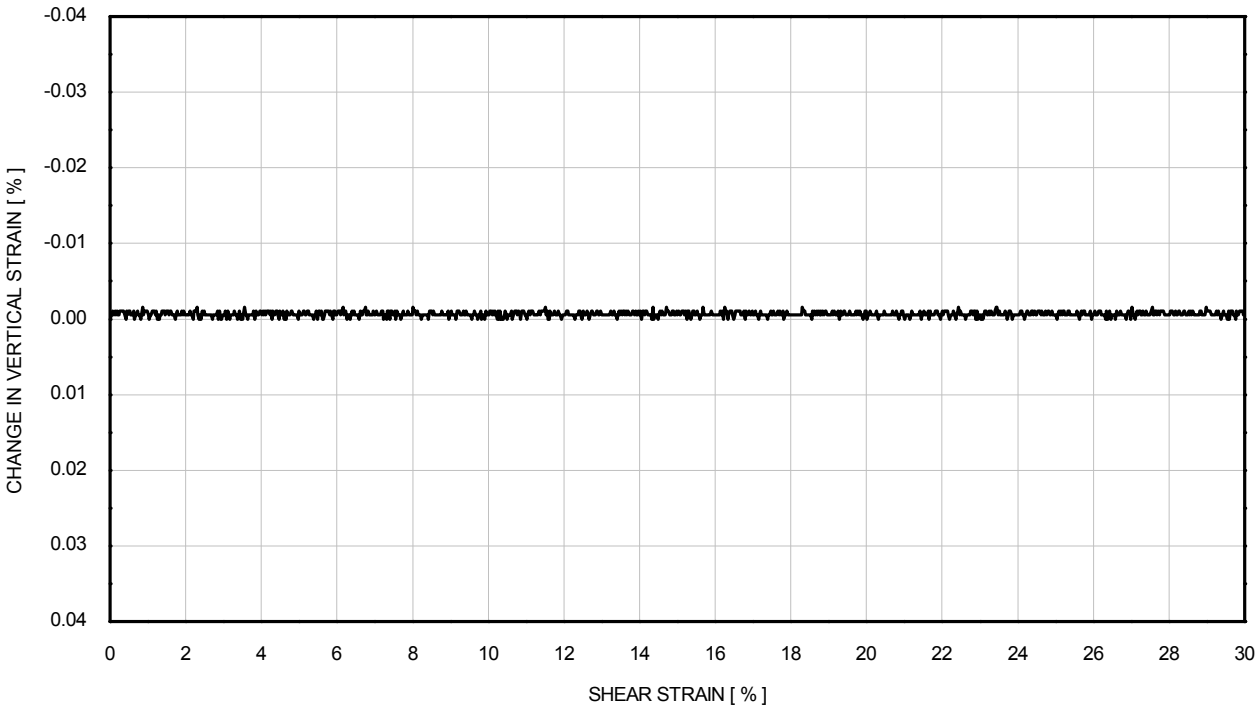


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
τ_{peak}	:	282 kPa	Sample	:	23WaxB
γ at τ_{peak}	:	7.99 %	Unit	:	F3 (Dongen)
Rate of strain	:	3.22 %/hour	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

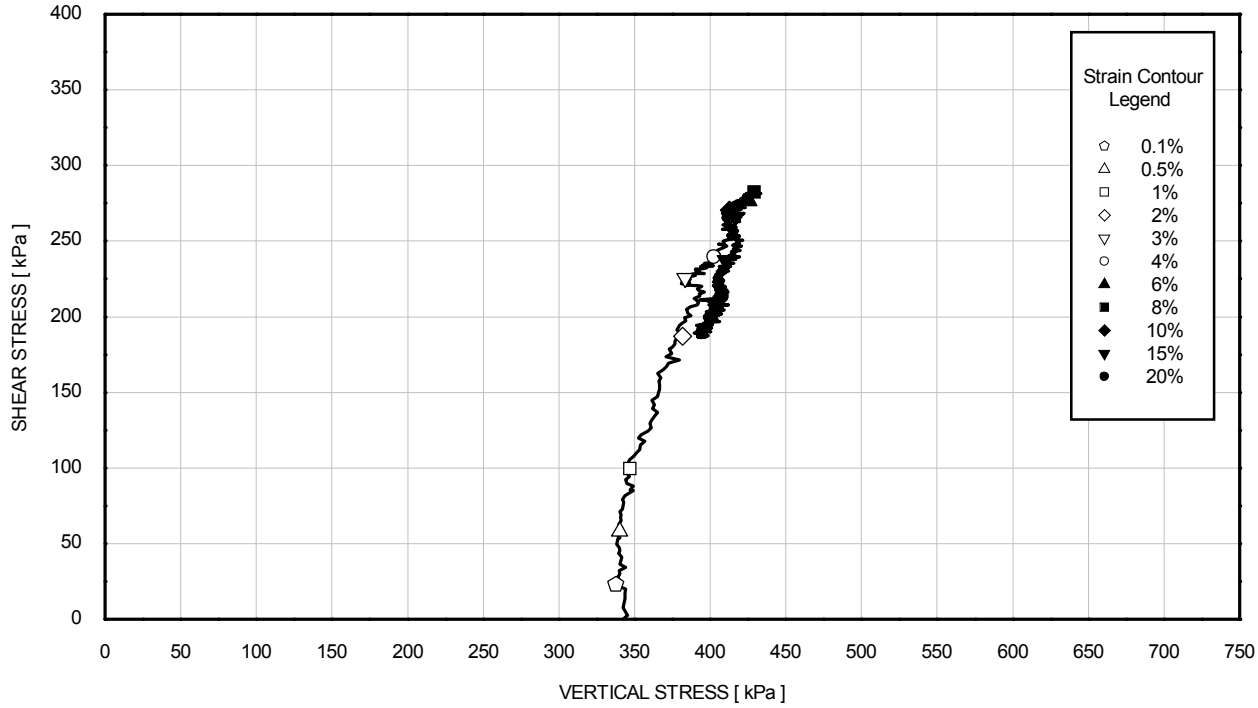


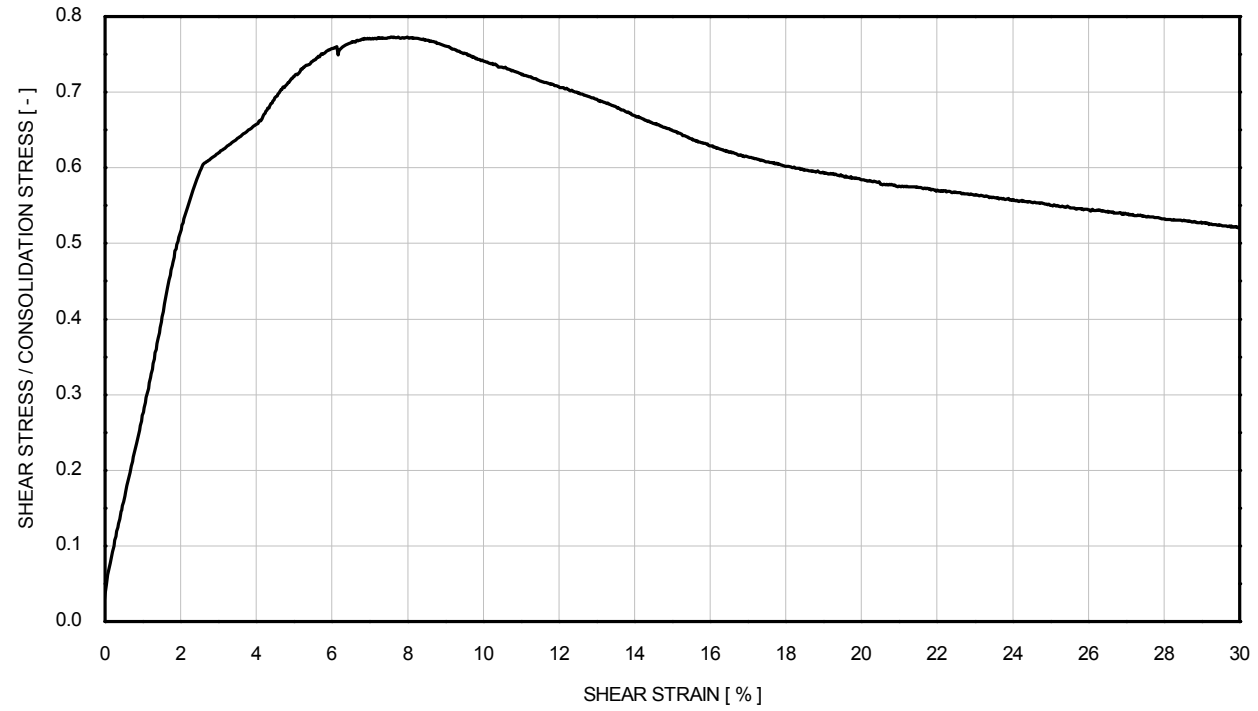


σ_{vc}	:	365 kPa	Borehole	: BH-WFS4-1A
τ_{peak}	:	282 kPa	Sample	: 23WaxB
γ at τ_{peak}	:	7.99 %	Unit	: F3 (Dongen)
Rate of strain	:	3.22 %/hour	Depth [m]	: 38.24
			Test No.	: CSS07

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

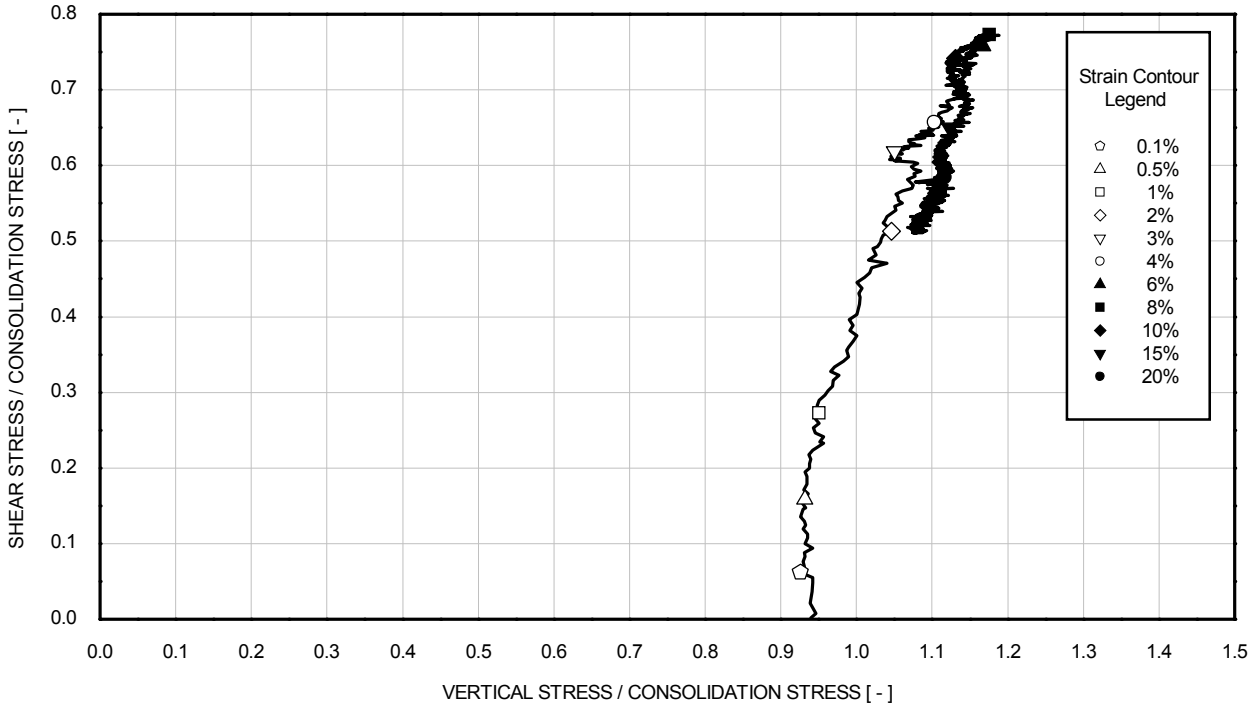


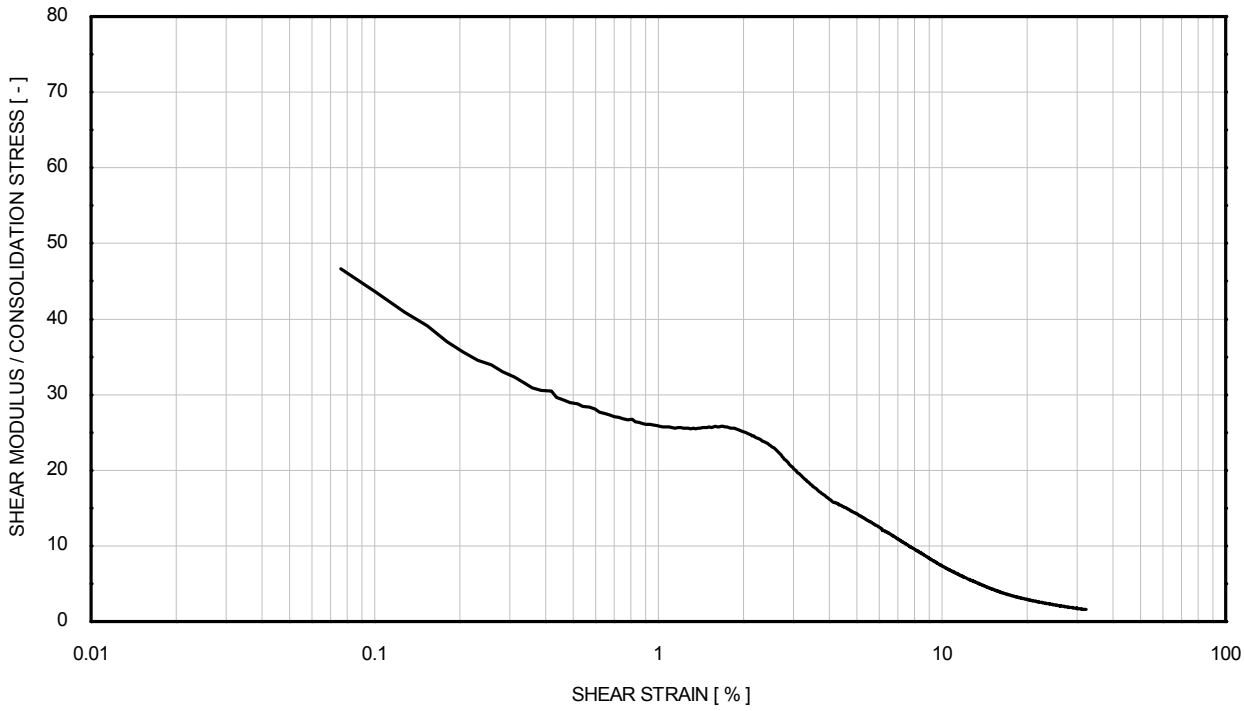


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
τ_{peak}	:	282 kPa	Sample	:	23WaxB
γ at τ_{peak}	:	7.99 %	Unit	:	F3 (Dongen)
Rate of strain	:	3.22 %/hour	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
τ_{peak}	:	282 kPa	Sample	:	23WaxB
γ at τ_{peak}	:	7.99 %	Unit	:	F3 (Dongen)
Rate of strain	:	3.22 %/hour	Depth [m]	:	38.24
			Test No.	:	CSS07

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Stiff to very stiff dark greenish grey CLAY with extremely closely to very closely spaced partings of grey silt and fine sand and with few fine gravel-sized pockets of black pyritic fine sand

GENERAL	
Date test started	11/01/2016
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	29.8
Moisture content	[%]	32.3
Bulk density	[Mg/m³]	1.82
Dry density	[Mg/m³]	1.37
Void ratio	[-]	0.967
Degree of saturation	[%]	90
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	232
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-1A_24WAXB_CSS08
Template issue	1.3
Processed by	RN
Date	2701/2016
Checked by	HJ
Date	28/01/2016
Approved by	DT
Date	03/02/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	24WAXB
Unit	F3 (Dongen)
Depth [m]	42.18
Test number	CSS08

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	913
Vertical strain	[%]	6.21
Bulk density	[Mg/m^3]	1.87
Dry density	[Mg/m^3]	1.46
Void ratio	[-]	0.845
Moisture content	[%]	27.8

CONSOLIDATION		
σ_{vc}	[kPa]	365
Vertical strain	[%]	5.40
Bulk density	[Mg/m^3]	1.86
Dry density	[Mg/m^3]	1.45
Void ratio	[-]	0.861
Moisture content	[%]	28.4

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	245
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	184
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	209
γ_{av} at N_f	[%]	0.67
γ_{cy} at N_f	[%]	15.81
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	149
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.06	2.03	9.12	15.11
2	-0.06	2.19	8.47	15.54
5	-0.07	2.40	7.71	15.12
10	-0.09	2.60	7.12	14.89
20	-0.10	2.86	6.47	14.66
30	-0.11	3.06	6.06	14.57
40	-0.12	3.23	5.74	14.54
50	-0.13	3.38	5.48	14.53
100	-0.12	4.10	4.52	14.71
209	0.67	15.81	1.10	31.46

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	24WAXB
Unit	F3 (Dongen)
Depth [m]	42.18
Test number	CSS08

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	158
Shear strain	[%]	19.97
Shear induced $-\Delta\sigma_v$	[kPa]	108
Vertical stress	[kPa]	257
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	2.98
At 15 % shear strain		
Shear stress	[kPa]	146
Shear induced $-\Delta\sigma_v$	[kPa]	125
Vertical stress	[kPa]	239
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	24WAXB
Unit	F3 (Dongen)
Depth [m]	42.18
Test number	CSS08

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

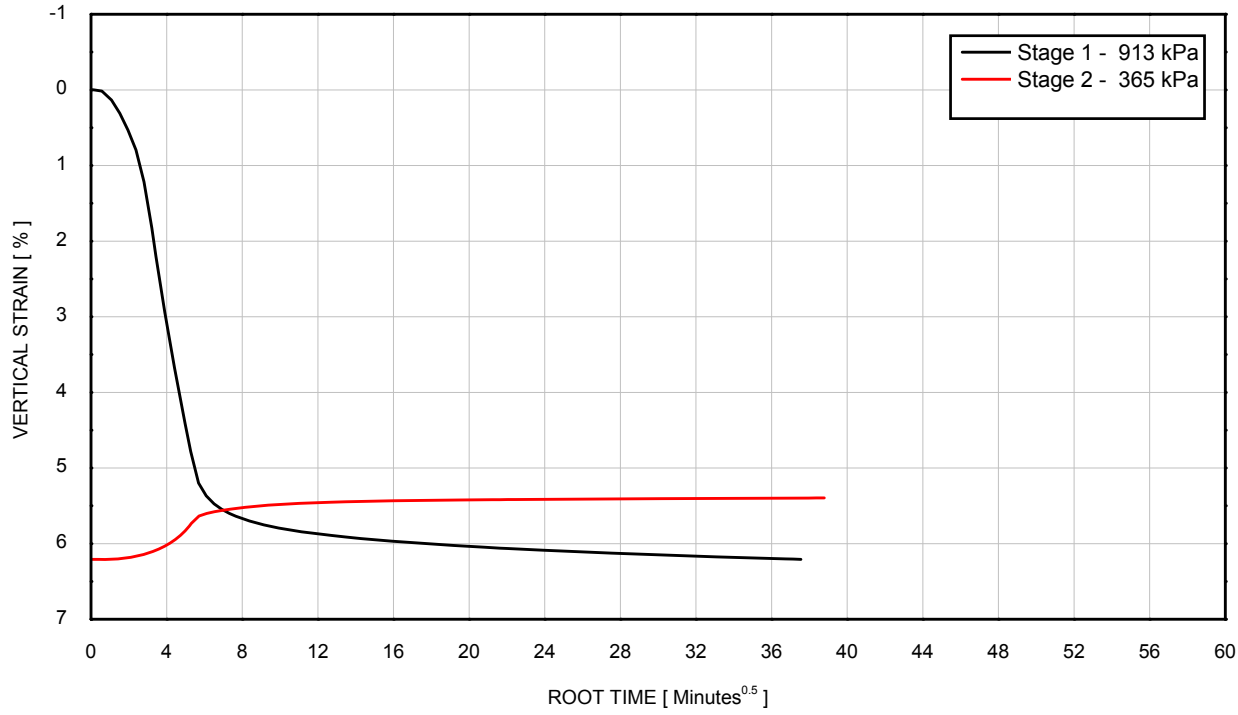
SPECIMEN PHOTOGRAPH

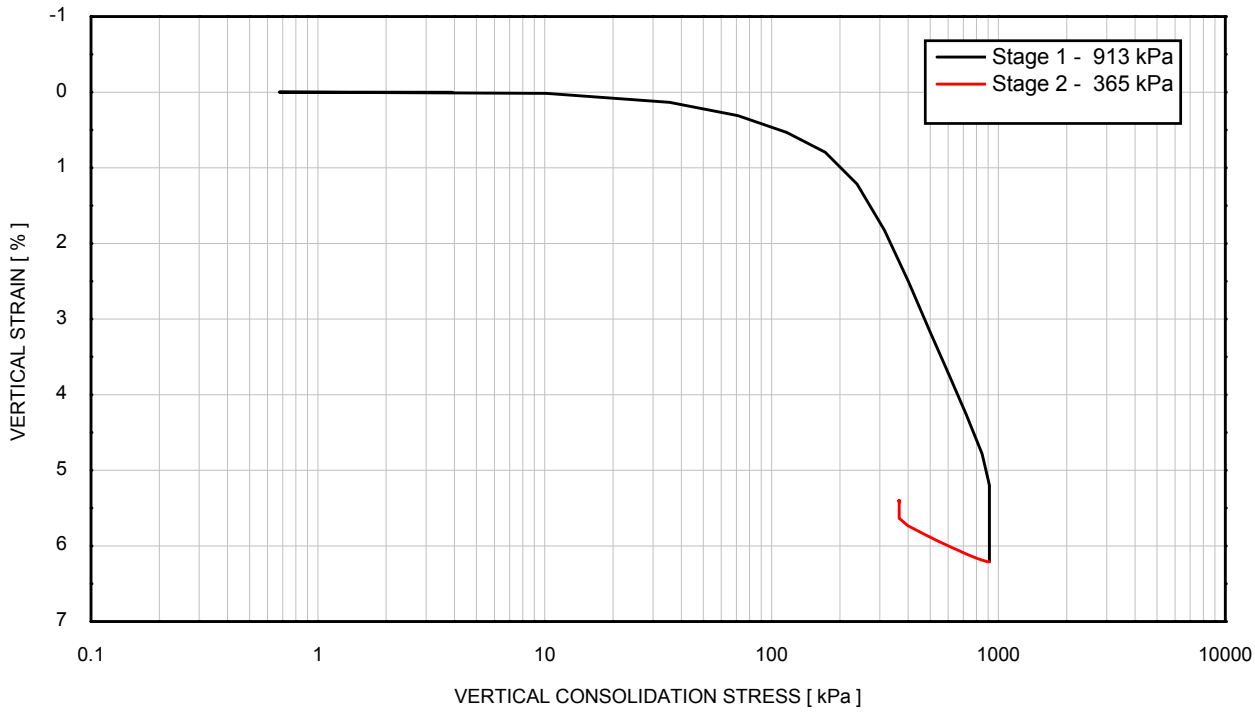


TEST IDENTIFICATION	
Borehole	BH-WFS4-1A
Sample	24WAXB
Unit	F3 (Dongen)
Depth [m]	42.18
Test number	CSS08

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

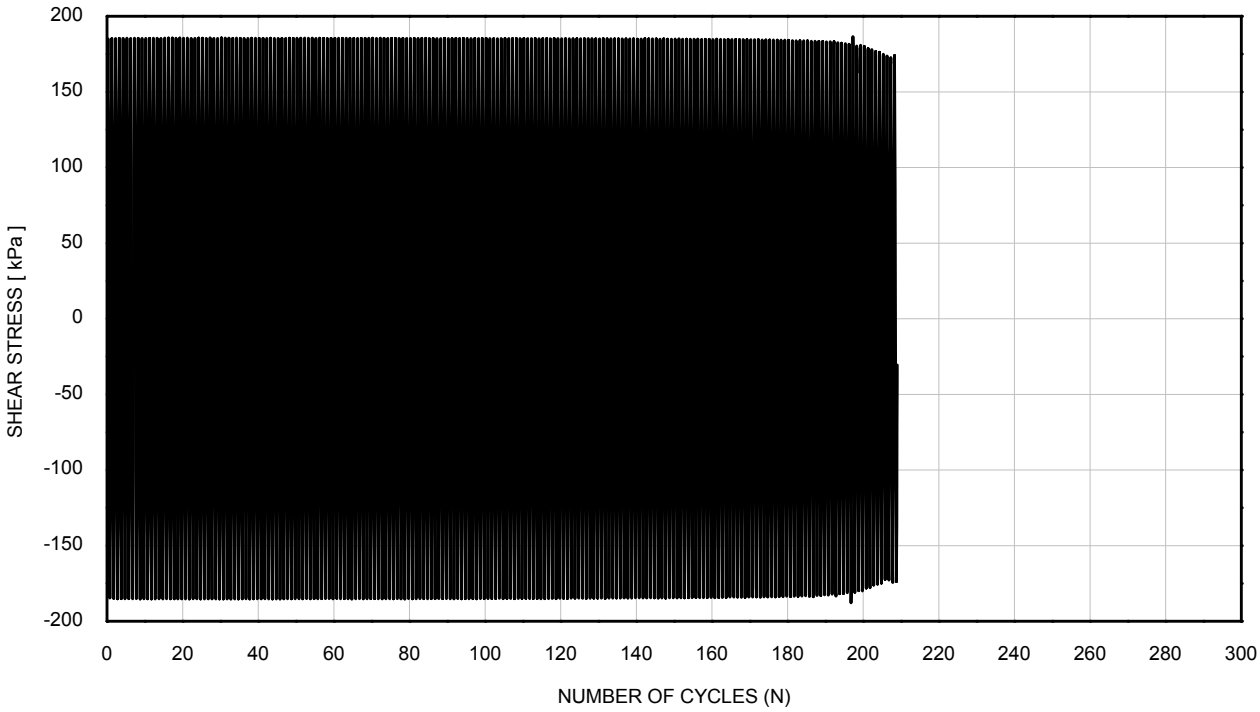


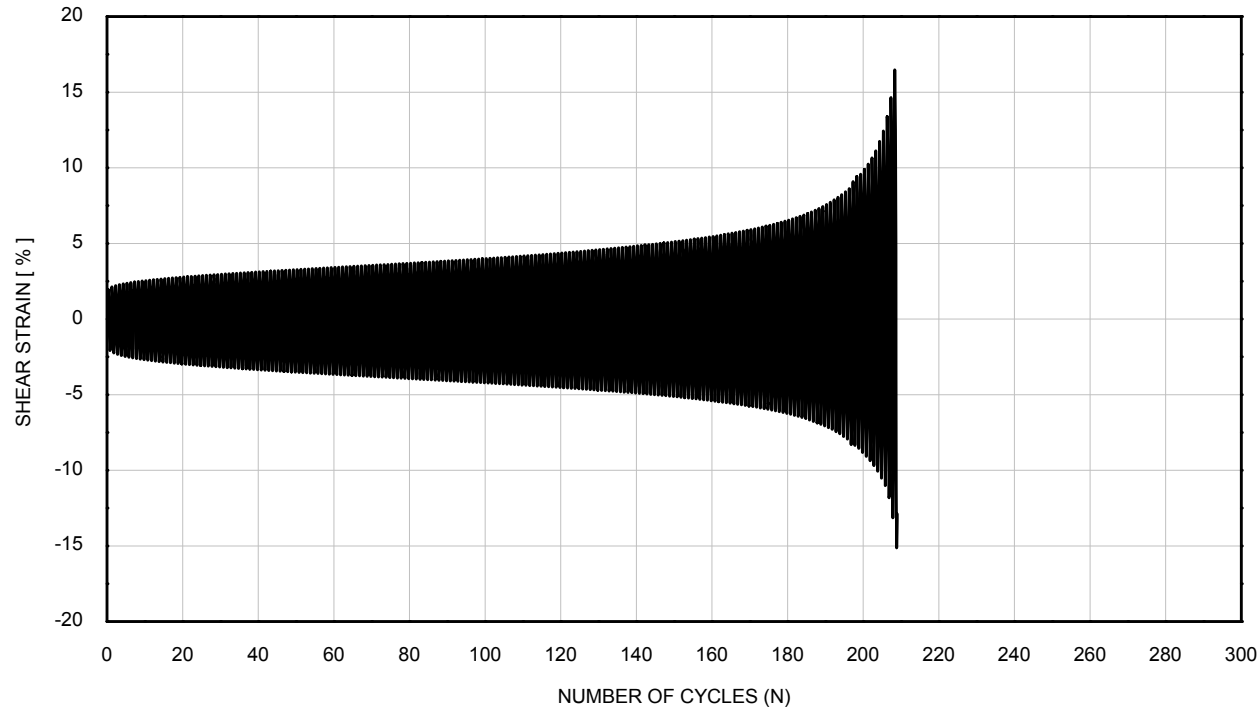


σ_{vc}	: 365 kPa	Borehole	: BH-WFS4-1A
		Sample	: 24WaxB
		Unit	: F3 (Dongen)
		Depth [m]	: 42.18
		Test No.	: CSS08

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

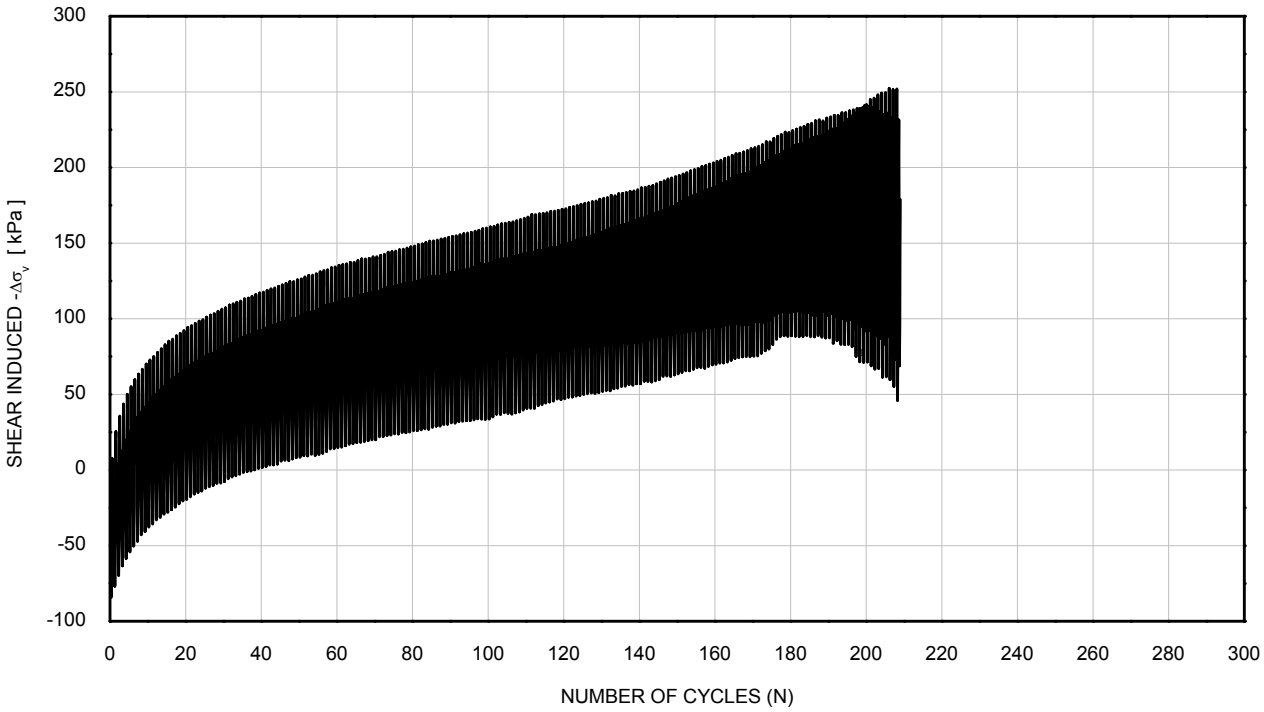


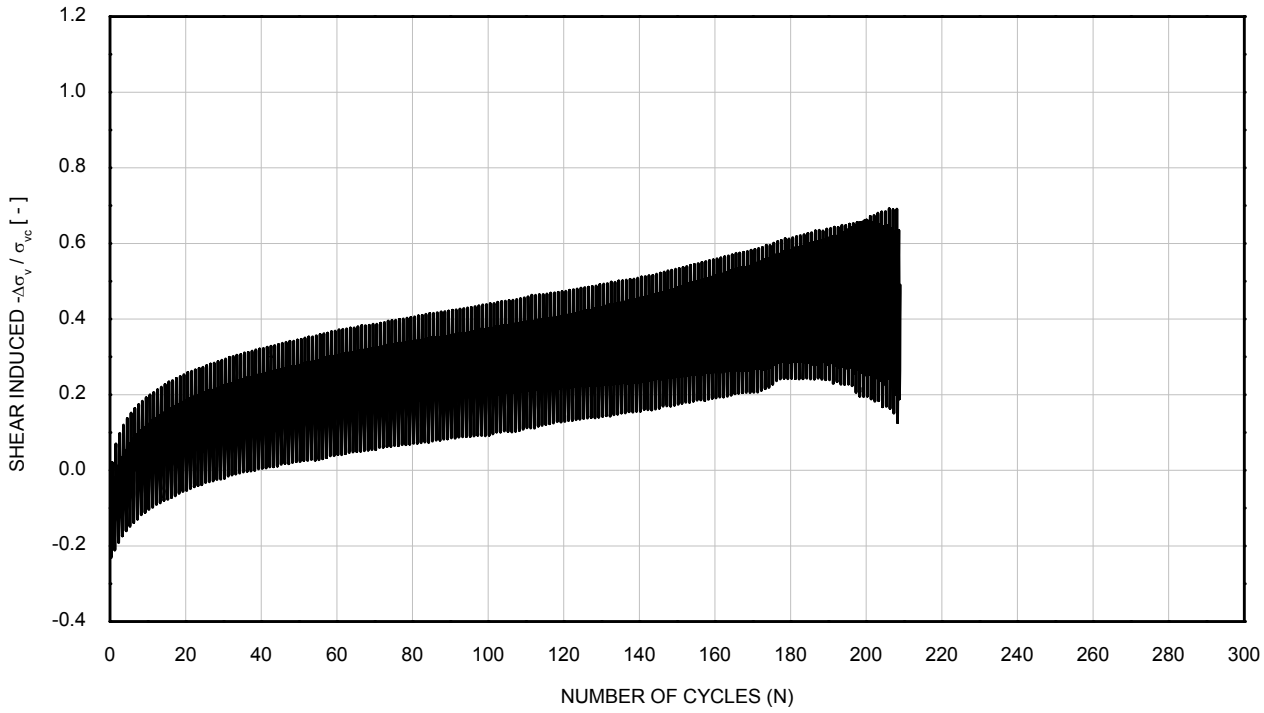


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	24WaxB
Mean τ_{cy}	:	184 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	42.18
			Test No.	:	CSS08

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

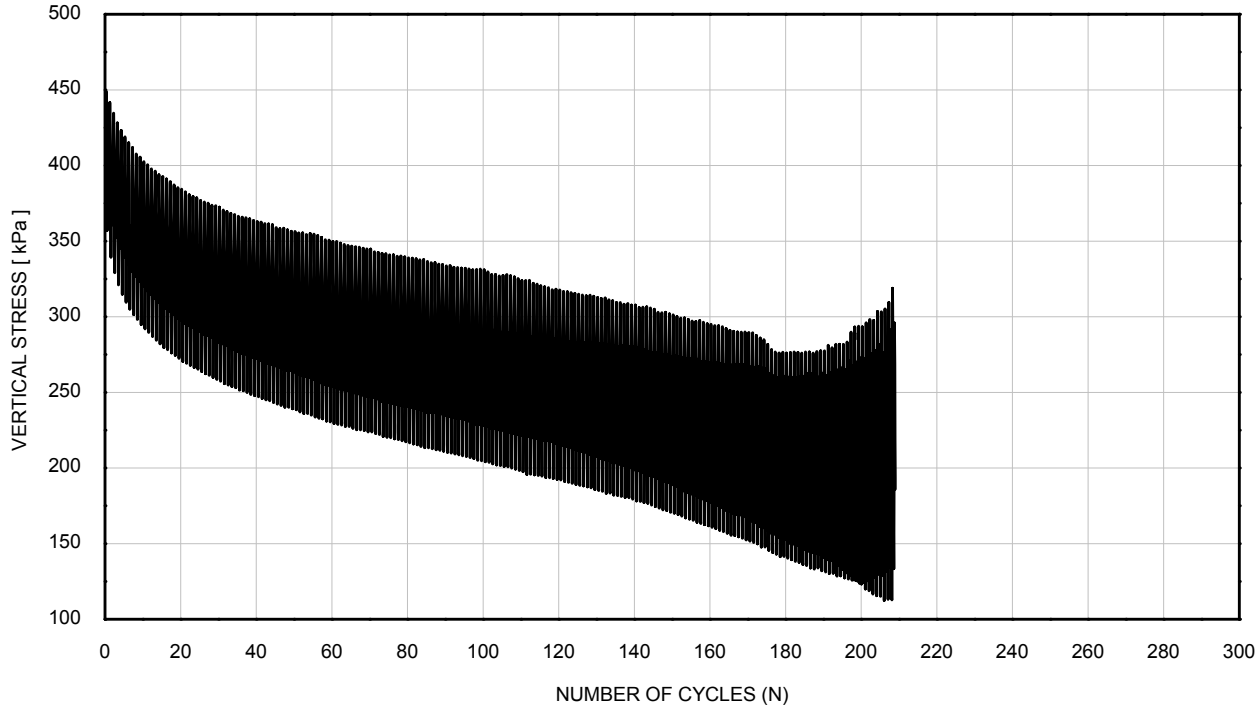


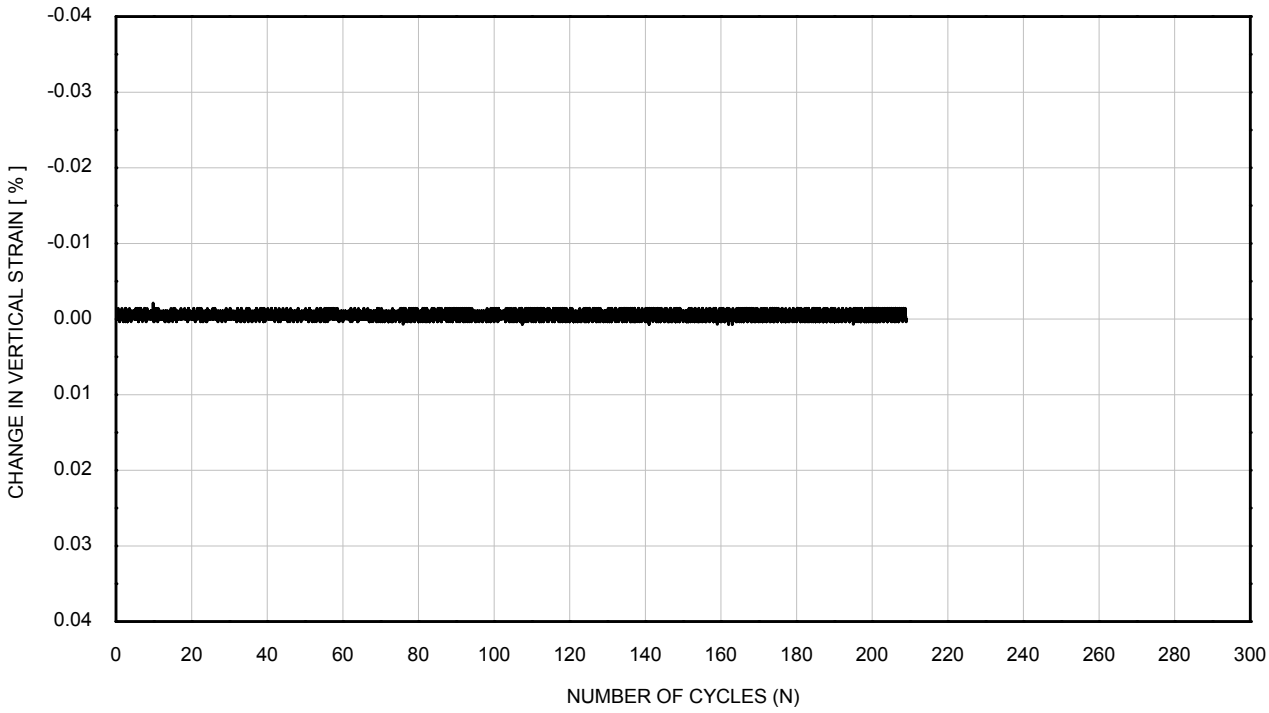


σ_{vc}	:	365 kPa	Borehole	: BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	: 24WaxB
Mean τ_{cy}	:	184 kPa	Unit	: F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	: 42.18
			Test No.	: CSS08

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

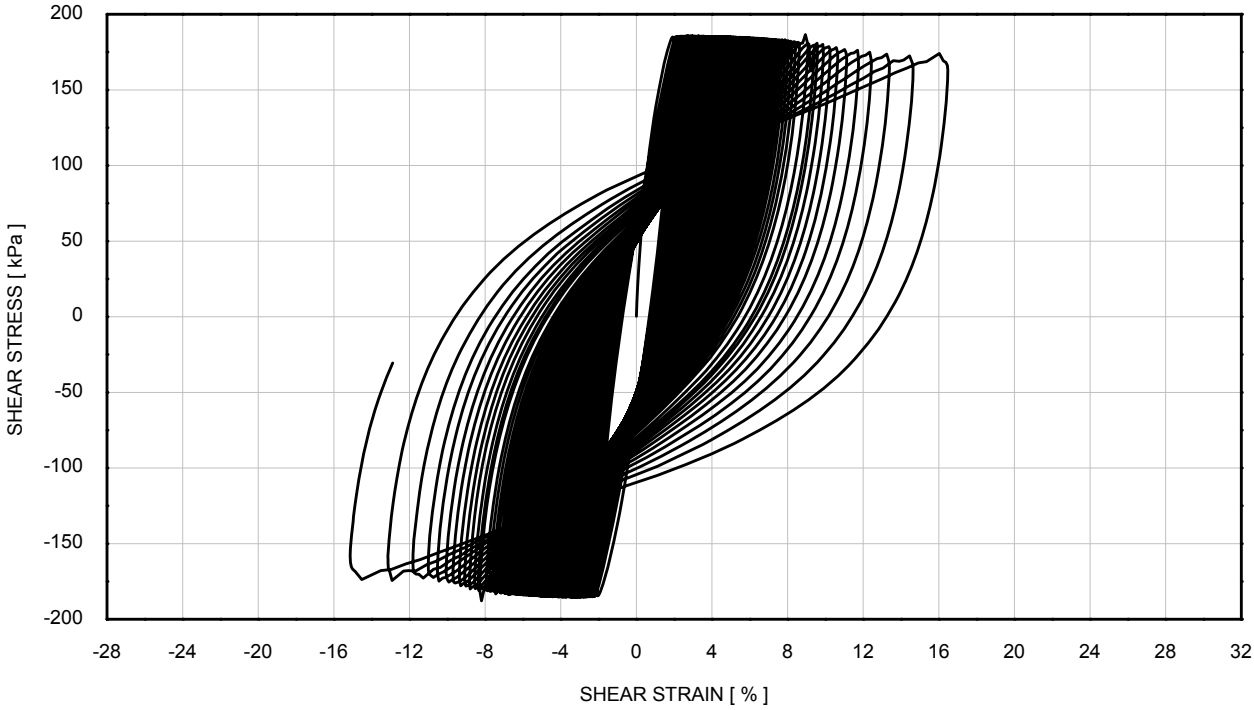


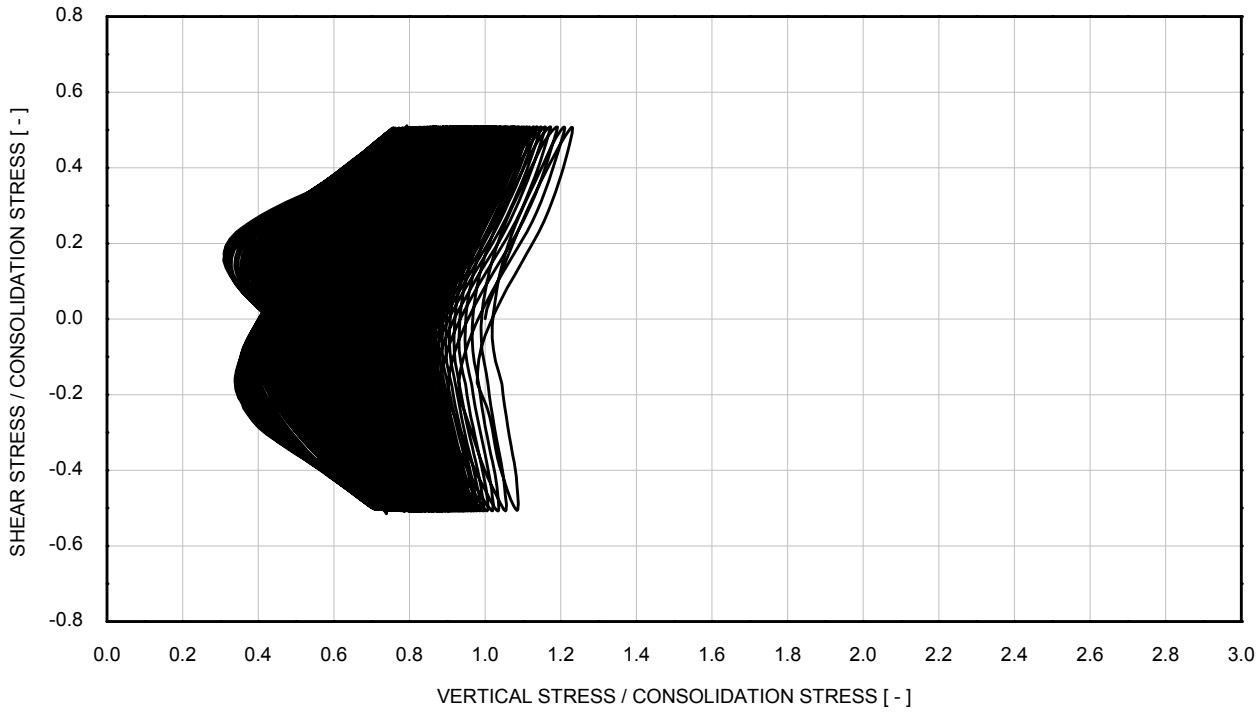


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	24WaxB
Mean τ_{cy}	:	184 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	42.18
			Test No.	:	CSS08

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

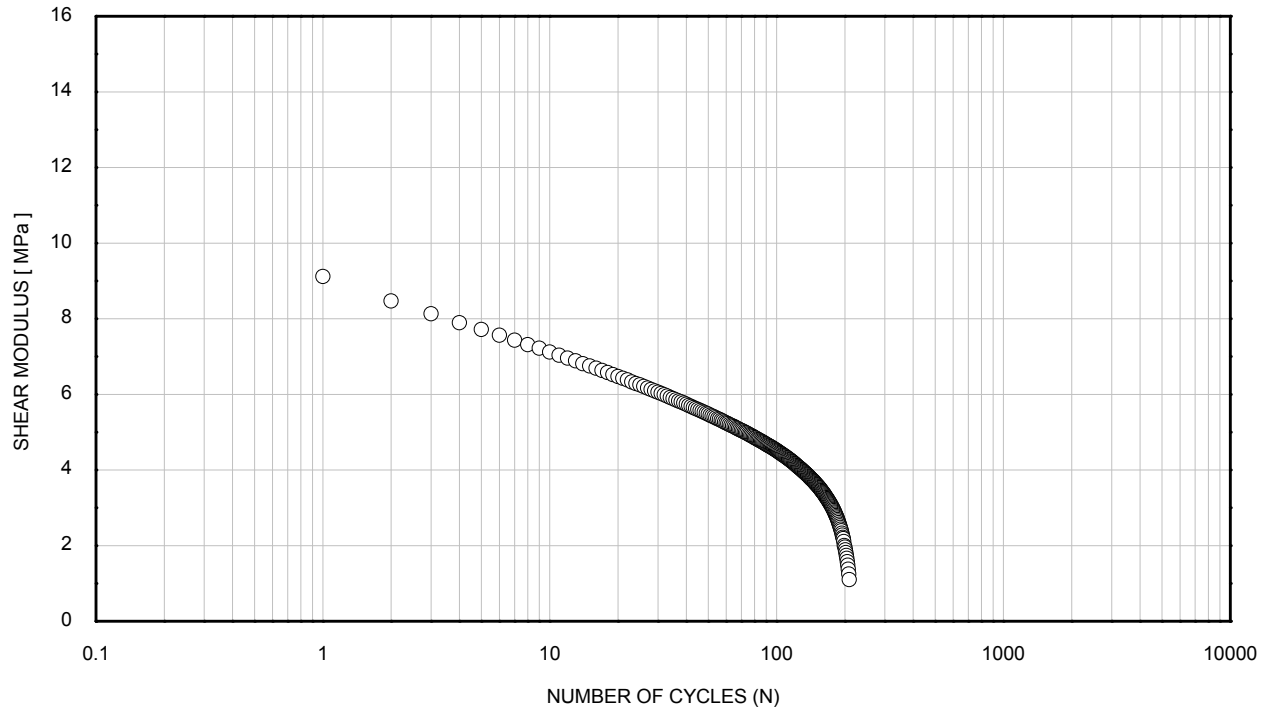


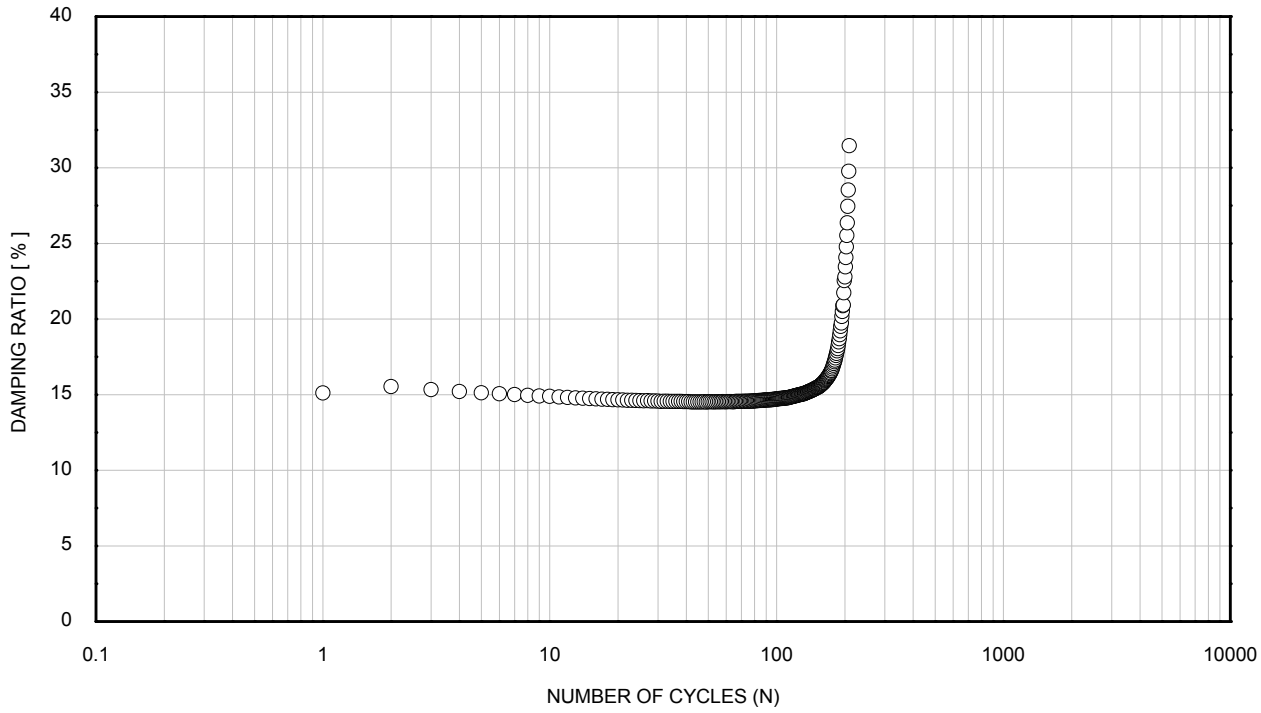


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	24WaxB
Mean τ_{cy}	:	184 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	42.18
			Test No.	:	CSS08

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

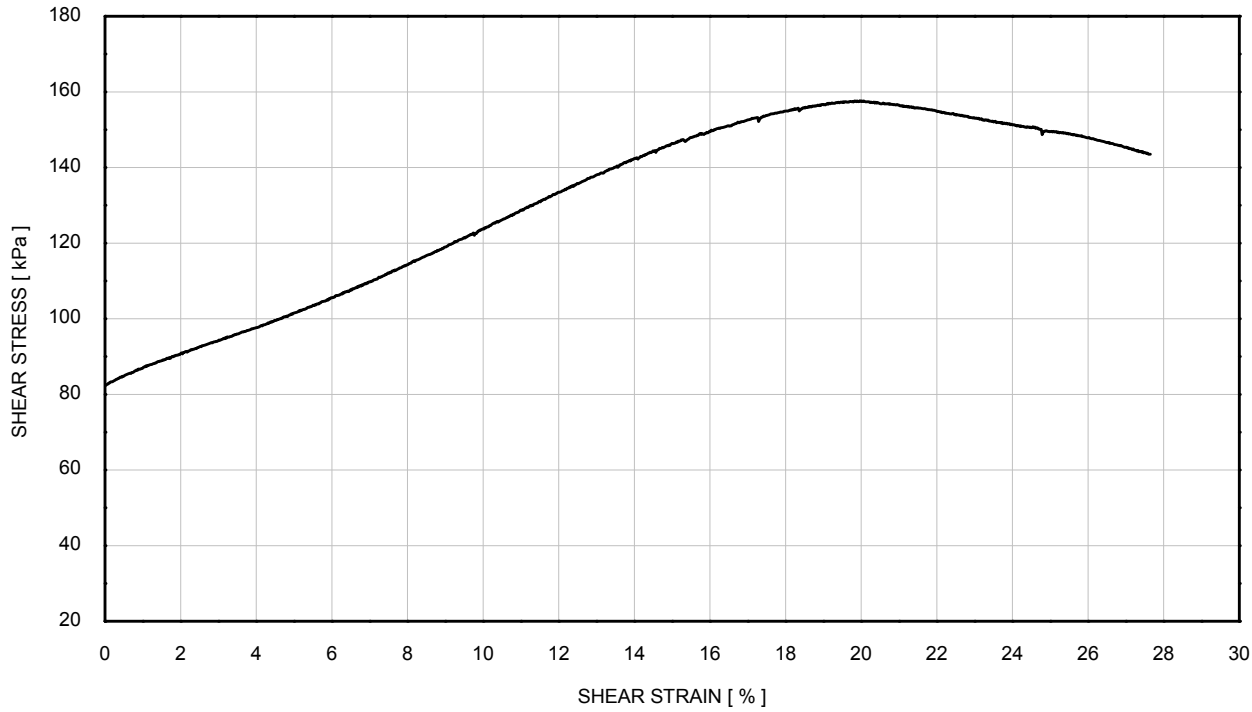


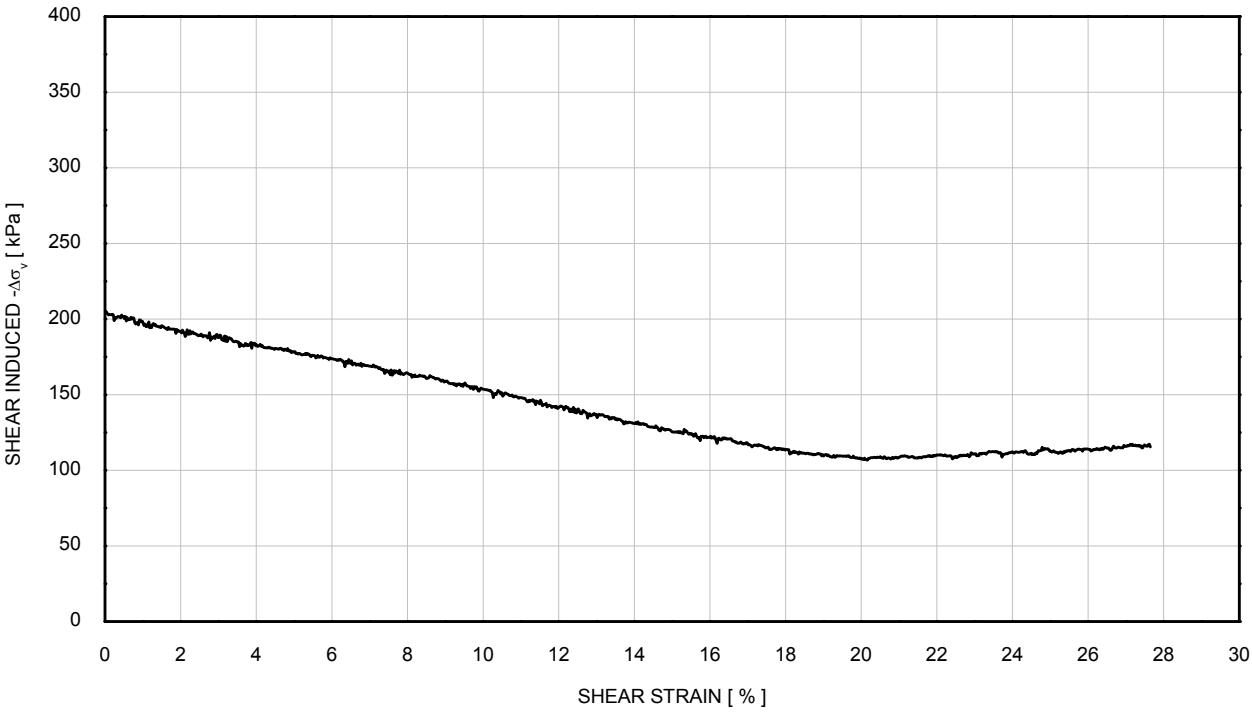


σ_{vc}	:	365 kPa	Borehole	:	BH-WFS4-1A
Mean τ_{av}	:	0 kPa	Sample	:	24WaxB
Mean τ_{cy}	:	184 kPa	Unit	:	F3 (Dongen)
Frequency	:	0.10 Hz	Depth [m]	:	42.18
			Test No.	:	CSS08

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

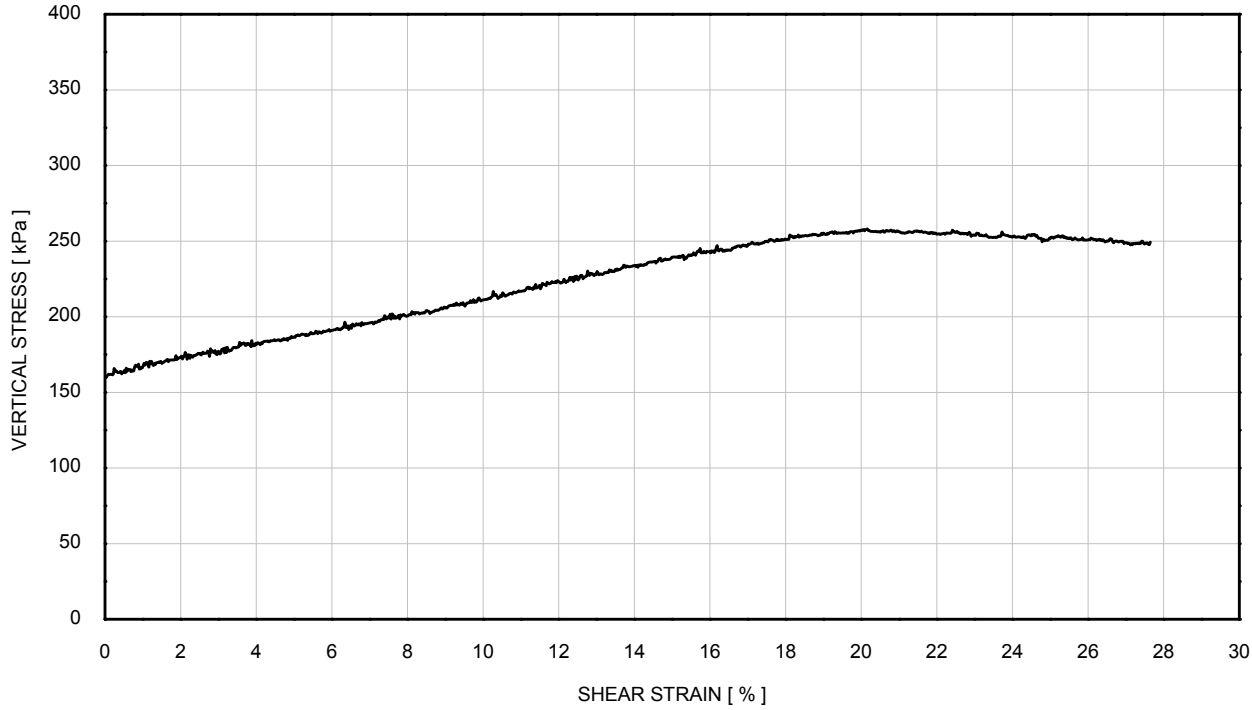


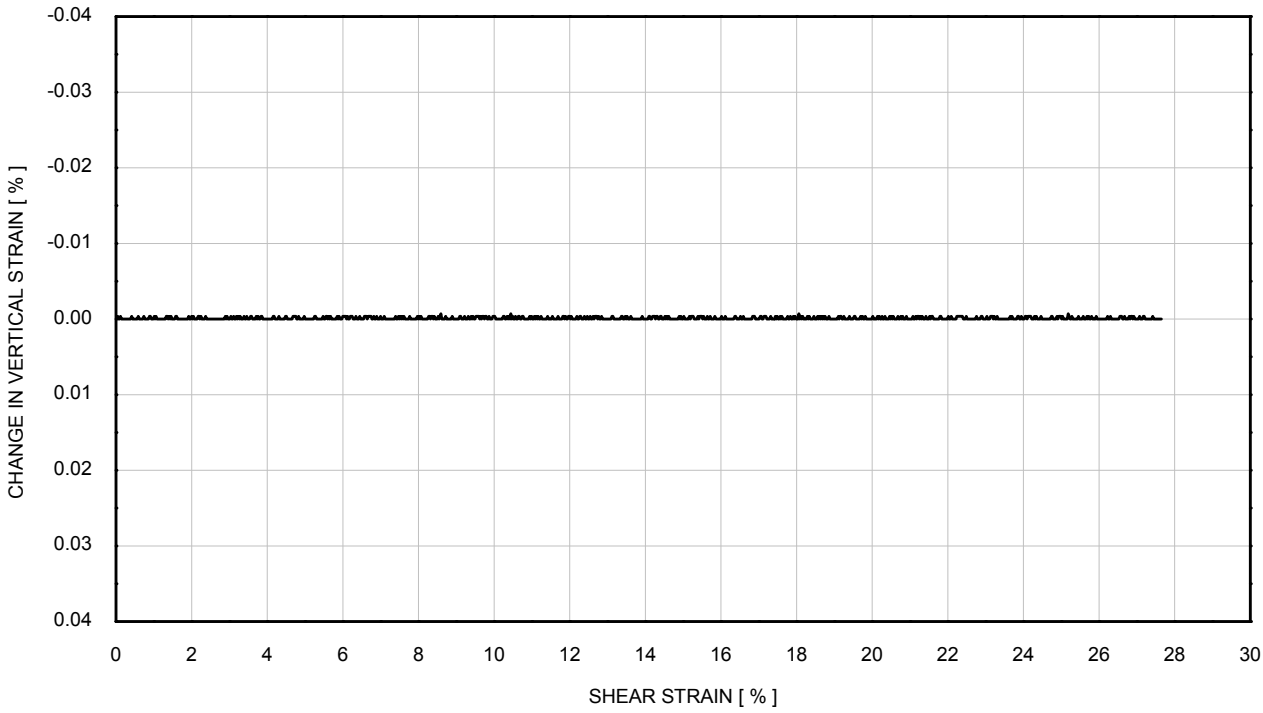


σ_{vc}	: 365 kPa	Borehole	: BH-WFS4-1A
τ_{peak}	: 158 kPa	Sample	: 24WaxB
γ at τ_{peak}	: 19.97 %	Unit	: F3 (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 42.18
		Test No.	: CSS08

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

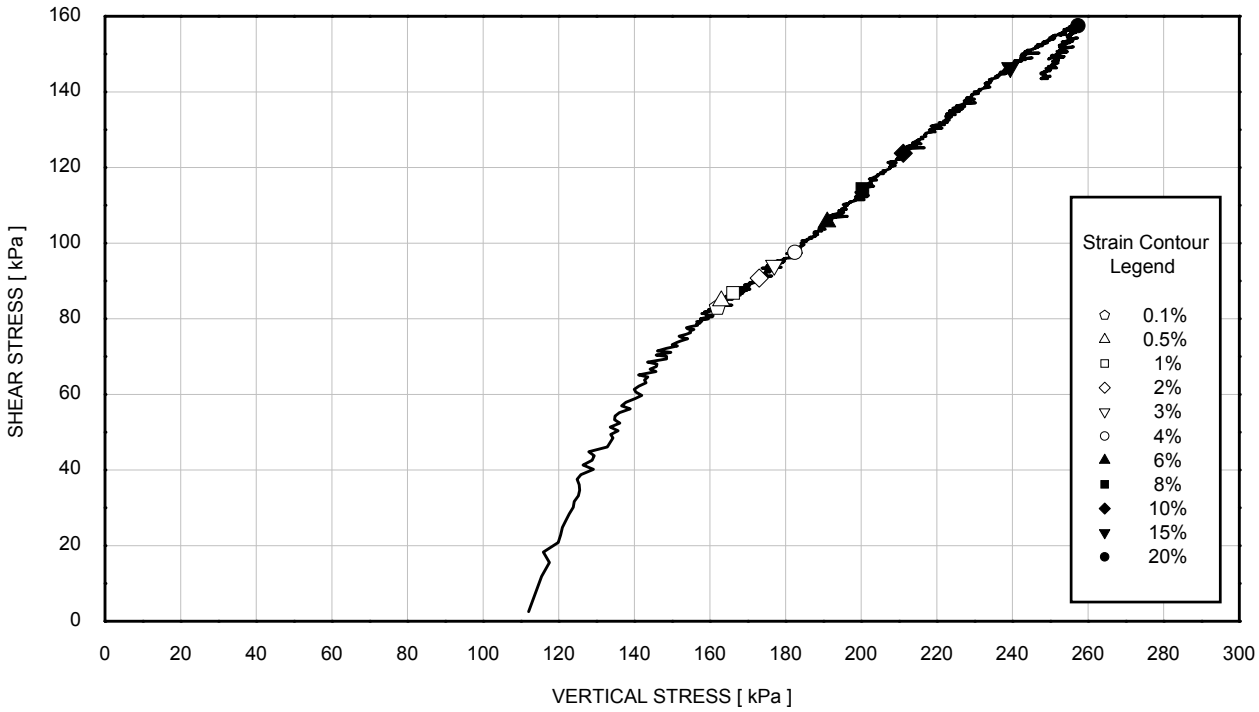


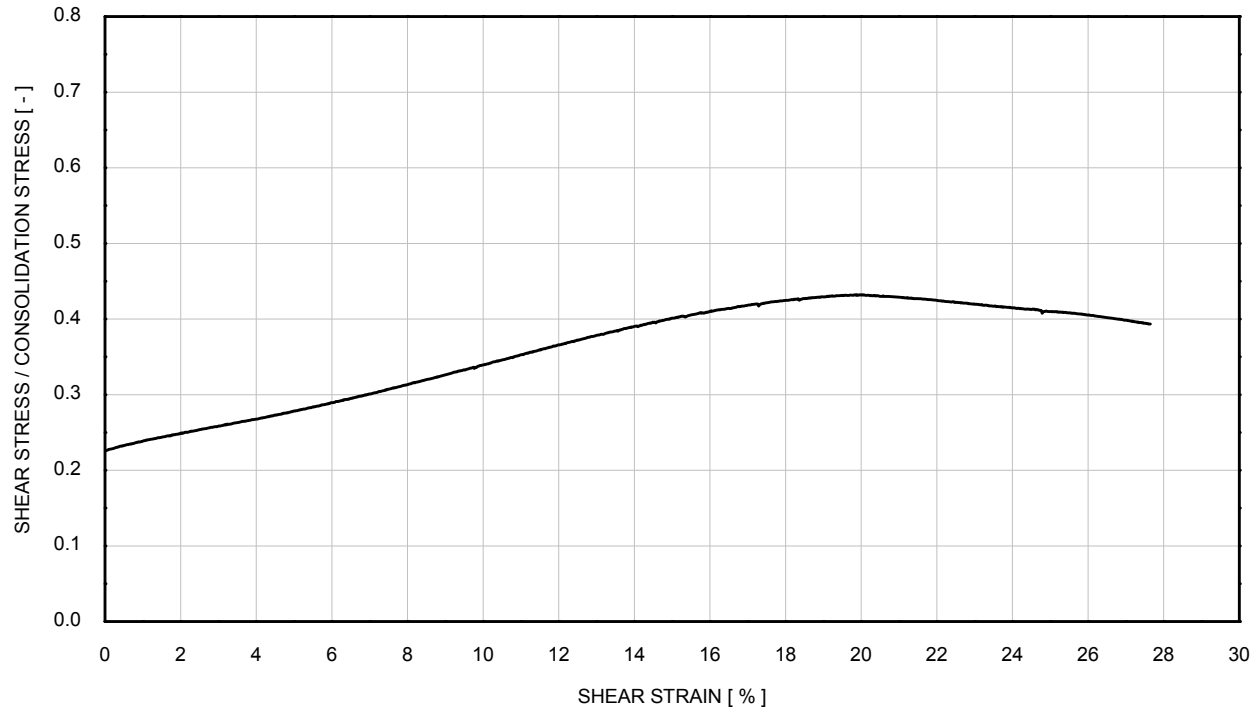


σ_{vc}	: 365 kPa	Borehole	: BH-WFS4-1A
τ_{peak}	: 158 kPa	Sample	: 24WaxB
γ at τ_{peak}	: 19.97 %	Unit	: F3 (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 42.18
		Test No.	: CSS08

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

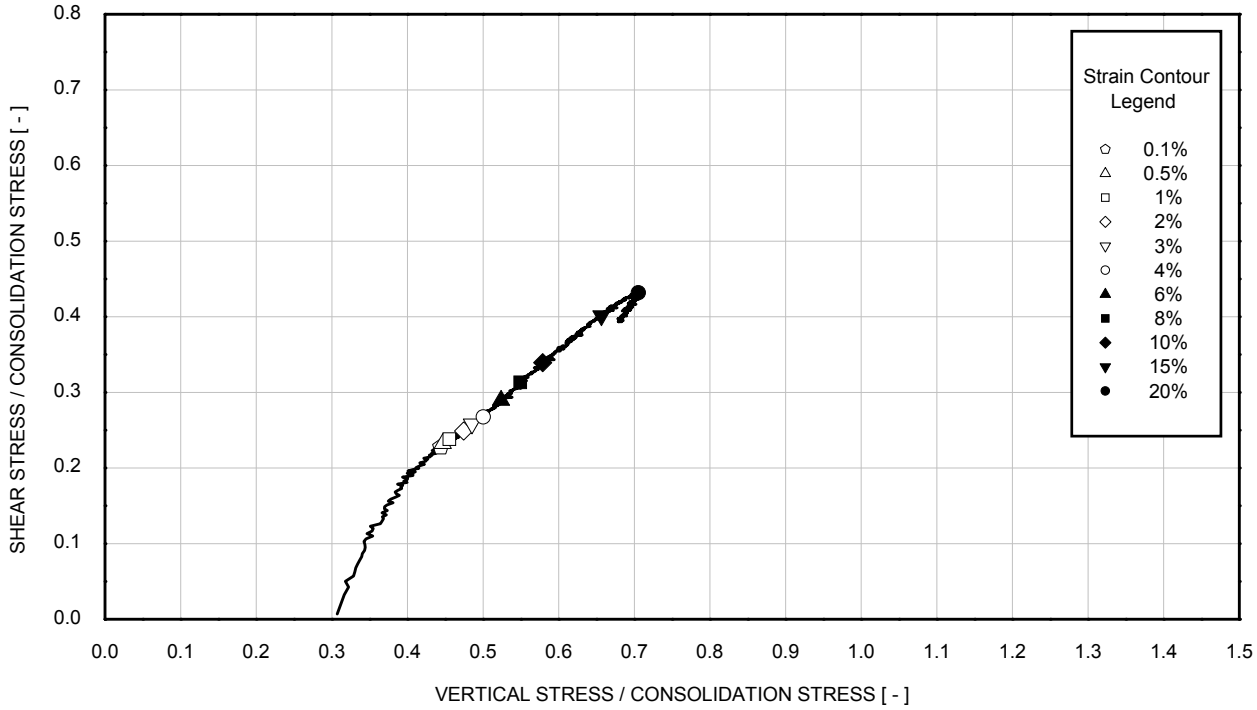


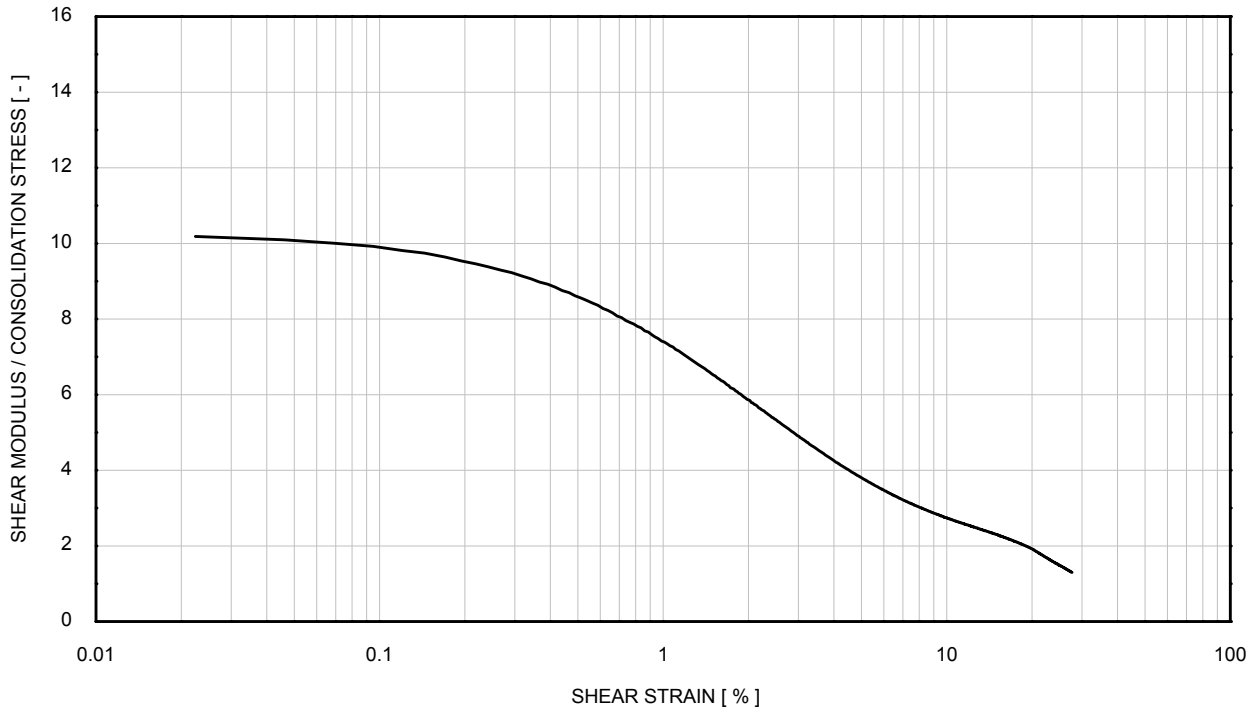


σ_{vc}	: 365 kPa	Borehole	: BH-WFS4-1A
τ_{peak}	: 158 kPa	Sample	: 24WaxB
γ at τ_{peak}	: 19.97 %	Unit	: F3 (Dongen)
Rate of strain	: 2.98 %/hour	Depth [m]	: 42.18
		Test No.	: CSS08

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 365	kPa	Borehole	: BH-WFS4-1A
τ_{peak}	: 158	kPa	Sample	: 24WaxB
γ at τ_{peak}	: 19.97	%	Unit	: F3 (Dongen)
Rate of strain	: 2.98	%/hour	Depth [m]	: 42.18
			Test No.	: CSS08

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark greenish grey CLAY with traces of fine gravel-sized pockets of black pyritic fine sand

GENERAL	
Date test started	12/01/2016
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.8
Length	[mm]	29.9
Moisture content	[%]	34.1
Bulk density	[Mg/m³]	1.95
Dry density	[Mg/m³]	1.45
Void ratio	[-]	0.860
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	-
Pocket penetrometer	[kPa]	-
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-7_22WAXD_CSS09R
Template issue	1.3
Processed by	RN
Date	28/01/2015
Checked by	DT
Date	04/02/2016
Approved by	DT
Date	04/02/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.68
Test number	CSS09R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	230
Vertical strain	[%]	0.98
Bulk density	[Mg/m^3]	1.96
Dry density	[Mg/m^3]	1.47
Void ratio	[-]	0.841
Moisture content	[%]	33.4

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	250
Mean τ_{av}	[kPa]	-2
Mean τ_{cy}	[kPa]	168
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	9
γ_{av} at N_f	[%]	1.50
γ_{cy} at N_f	[%]	16.90
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	69
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.24	5.01	3.35	23.58
2	-0.29	6.18	2.71	20.94
3	-0.17	7.02	2.39	20.00
4	-0.09	7.84	2.14	19.74
5	0.05	8.71	1.92	20.24
6	0.19	10.07	1.66	22.09
7	0.62	12.06	1.37	23.25
8	1.24	14.30	1.17	23.84
9	1.50	16.90	1.02	23.73

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.68
Test number	CSS09R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	154
Shear strain	[%]	29.46
Shear induced $-\Delta\sigma_v$	[kPa]	-88
Vertical stress	[kPa]	318
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	3.01
At 15 % shear strain		
Shear stress	[kPa]	112
Shear induced $-\Delta\sigma_v$	[kPa]	34
Vertical stress	[kPa]	196
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.68
Test number	CSS09R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

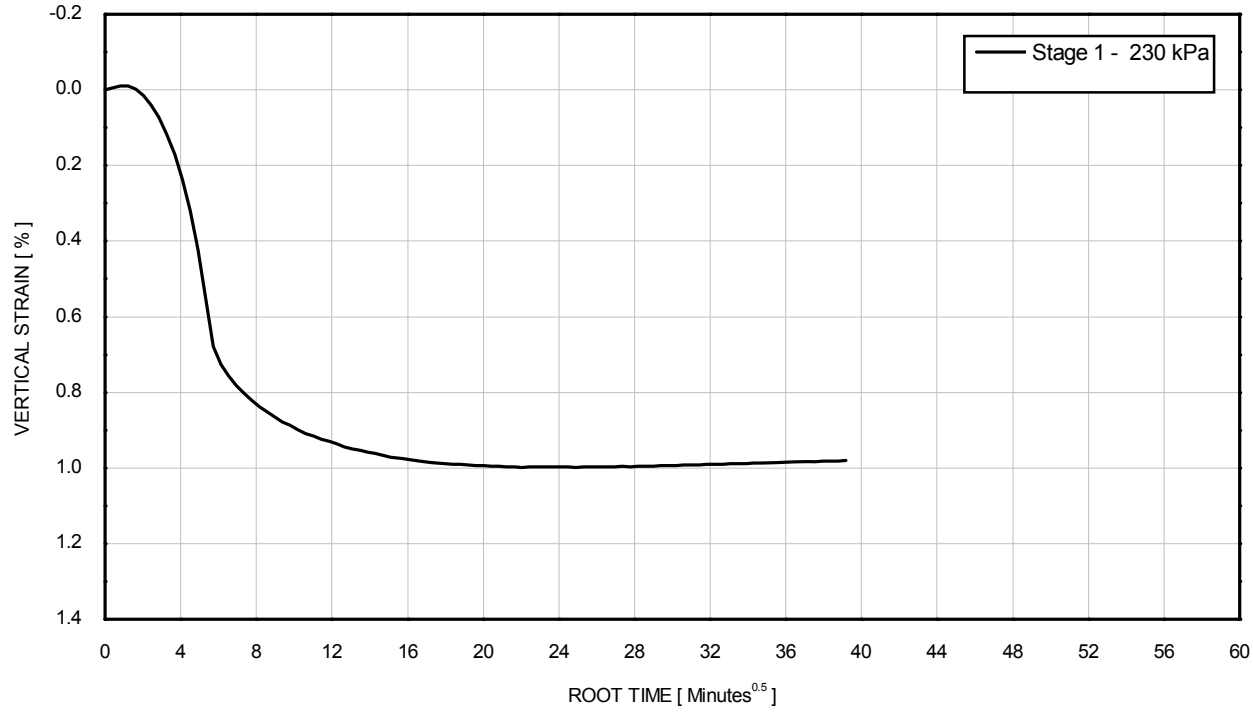
SPECIMEN PHOTOGRAPH

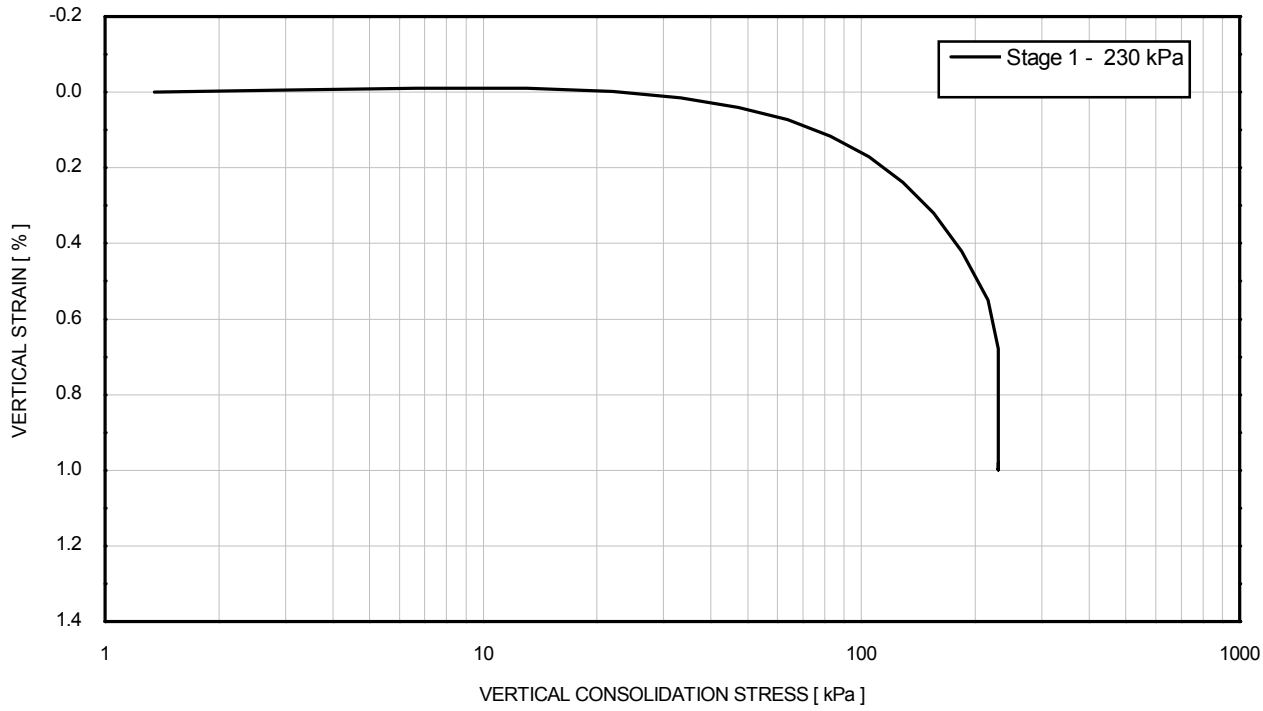


TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.68
Test number	CSS09R

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

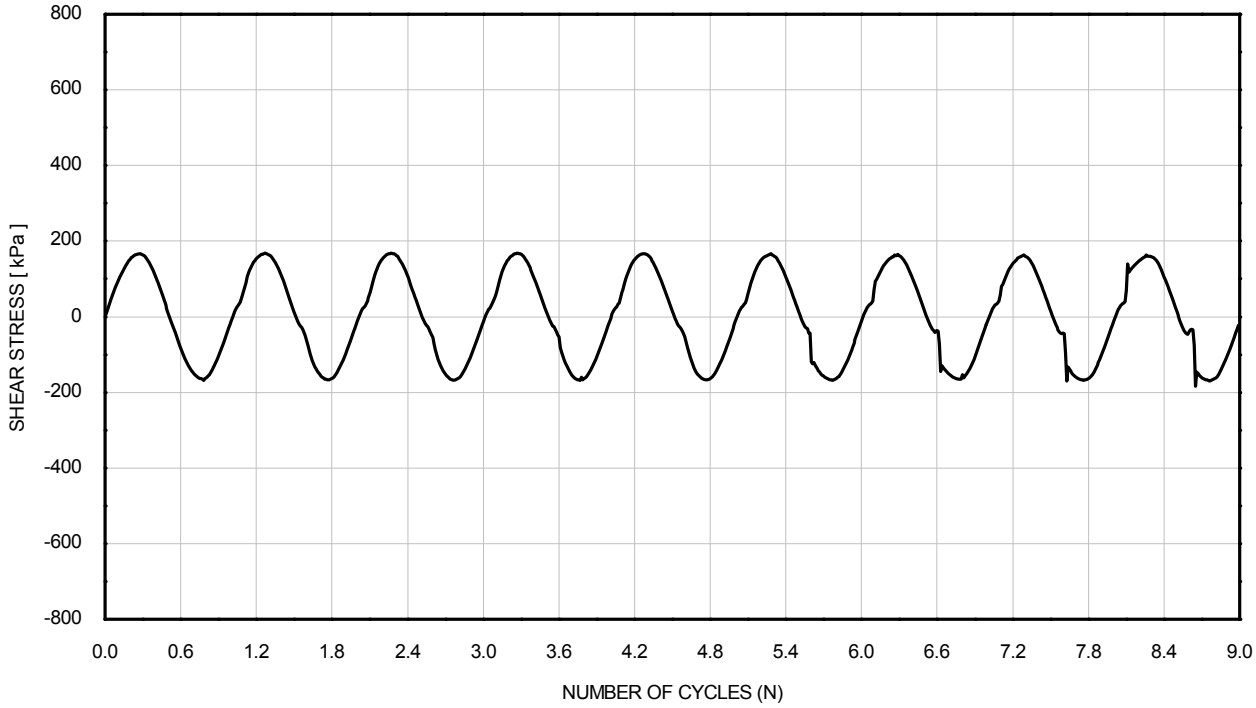


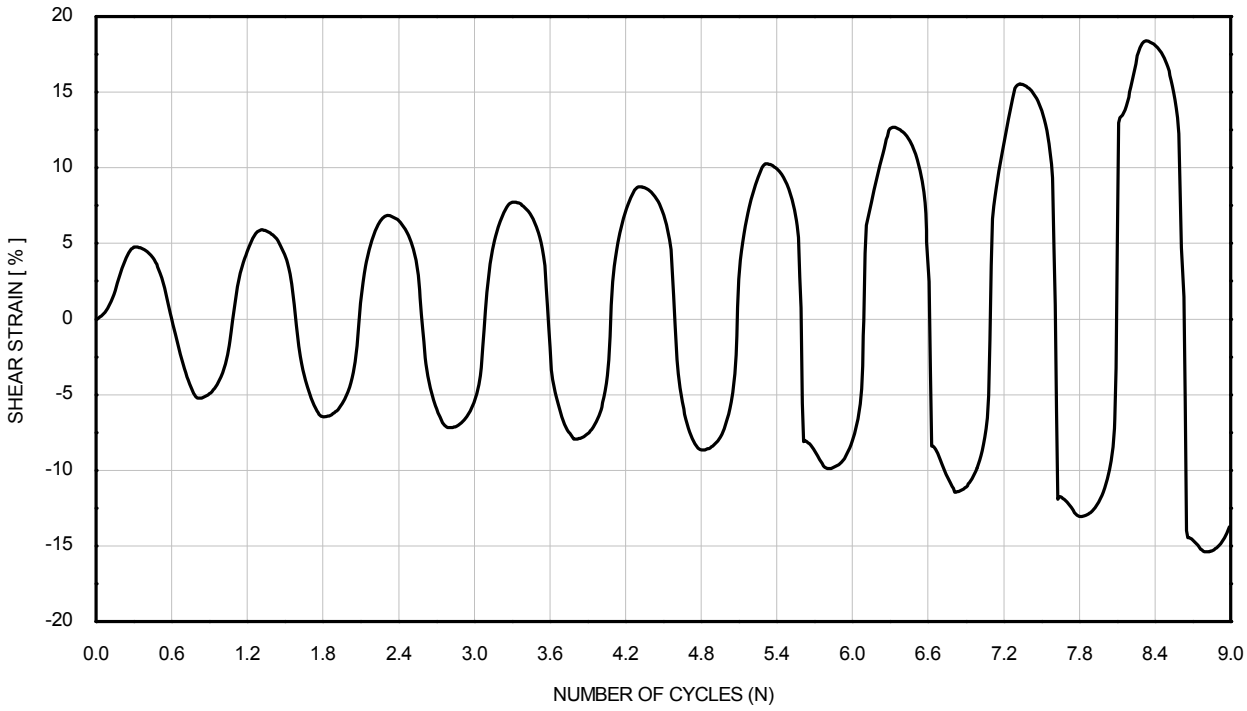


σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
		Sample	: 22WaxD
		Unit	: D (Rupel)
		Depth [m]	: 23.68
		Test No.	: CSS09R

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

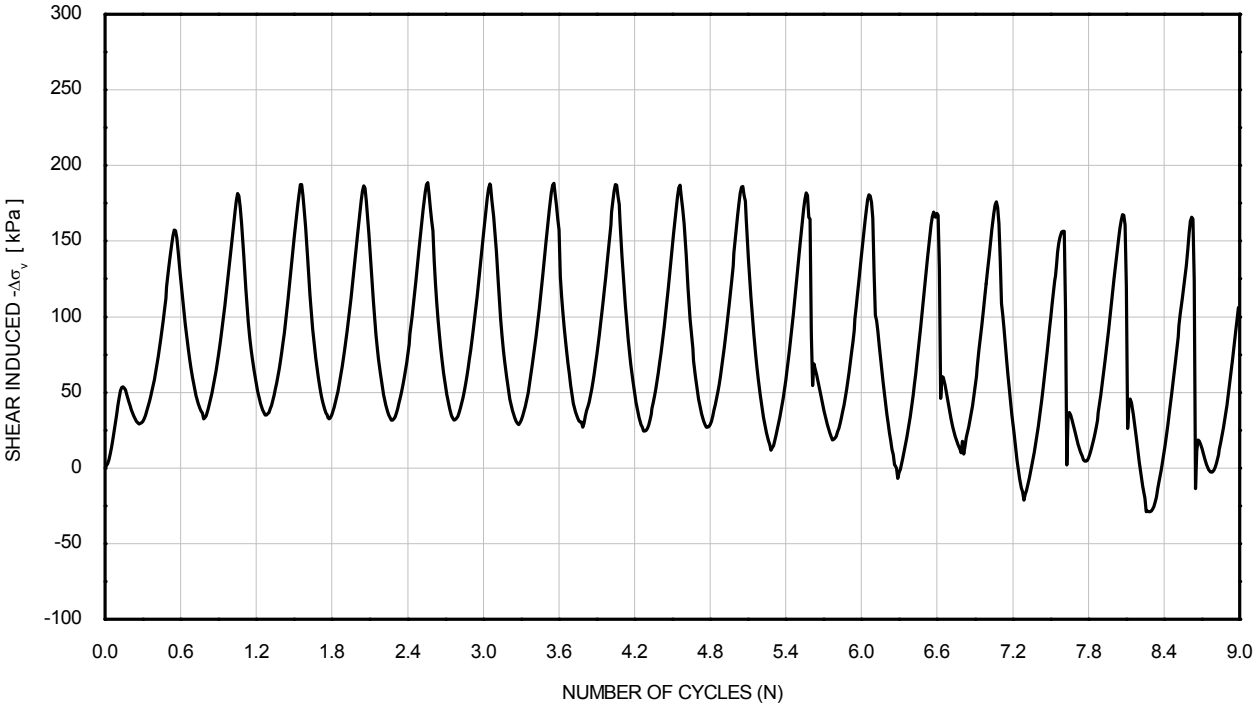


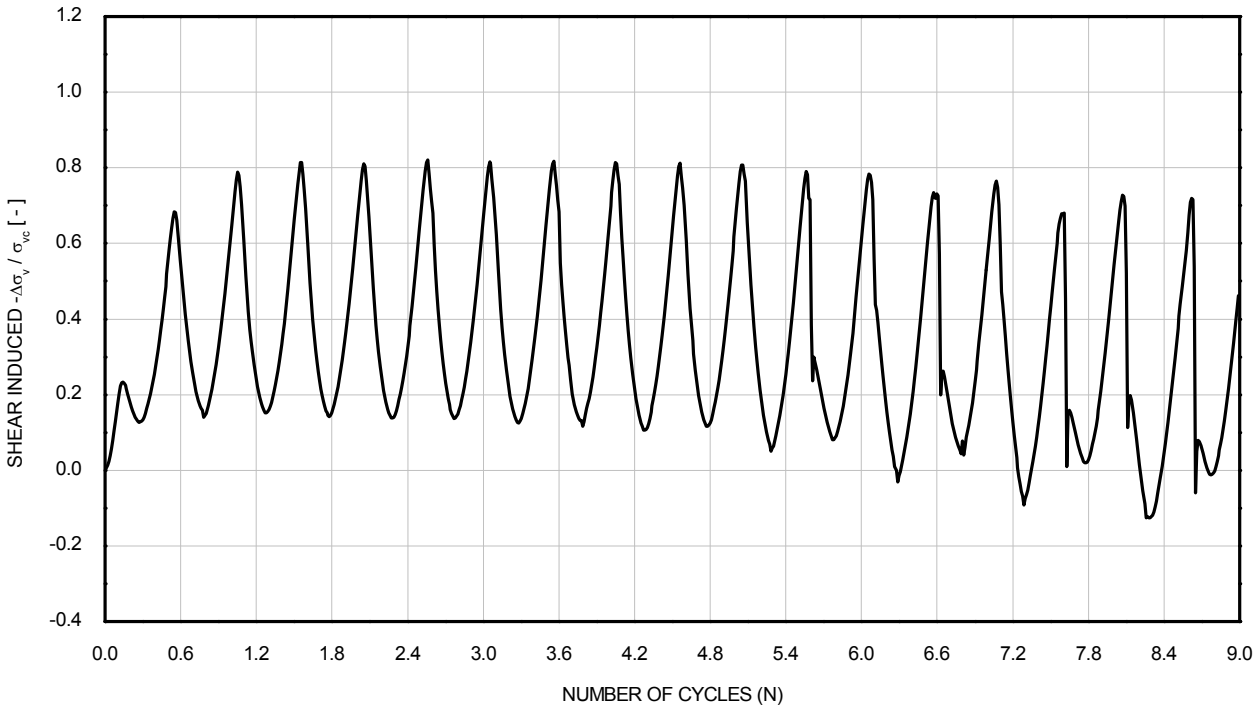


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	-2 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	168 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.68
			Test No.	:	CSS09R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

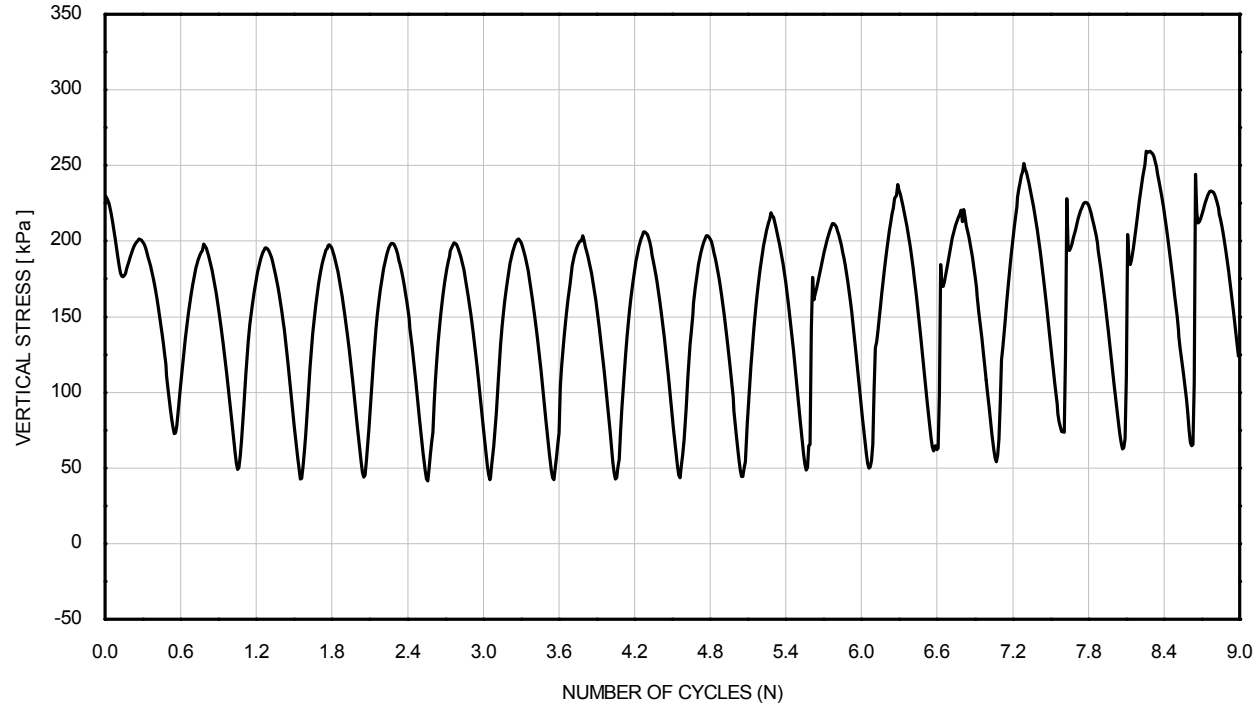


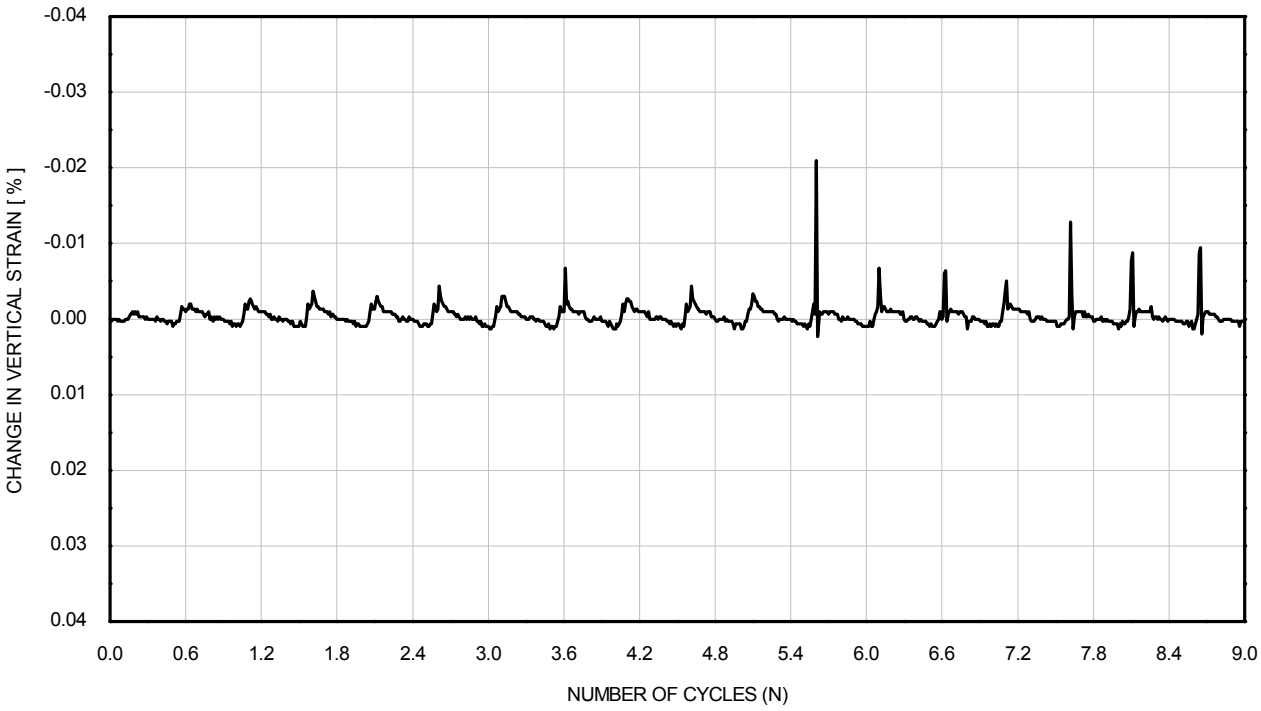


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	-2 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	168 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.68
			Test No.	:	CSS09R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

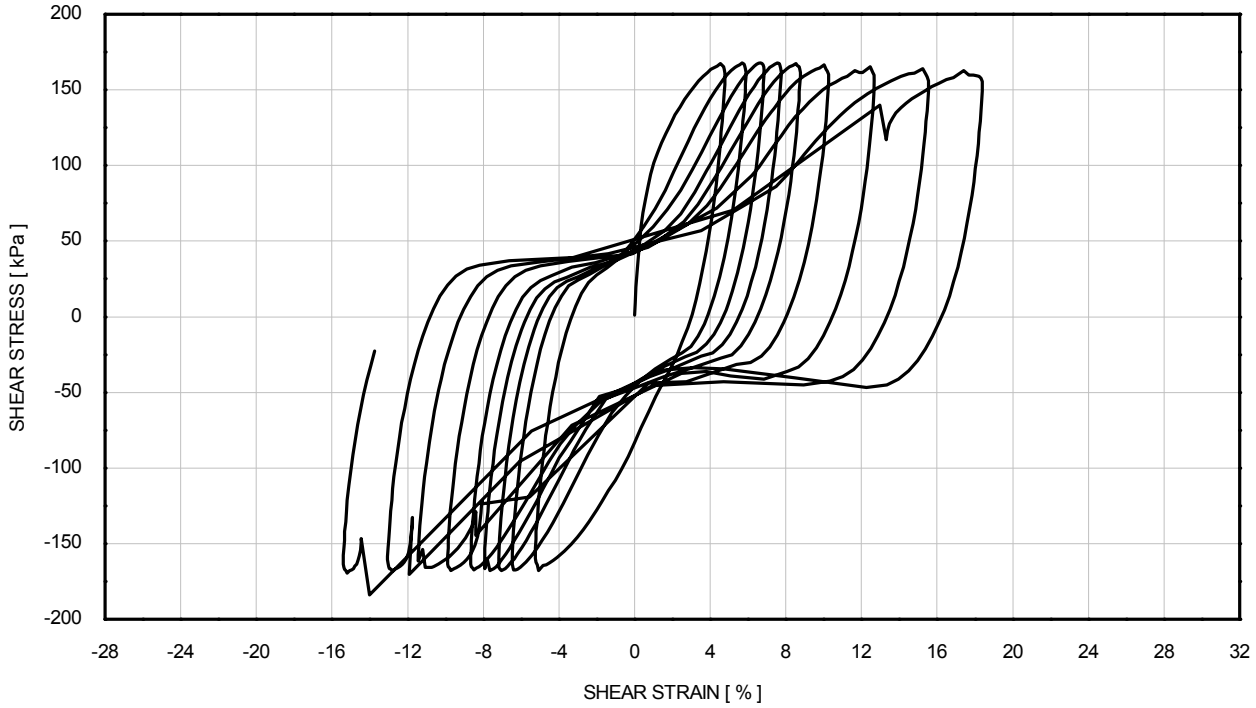


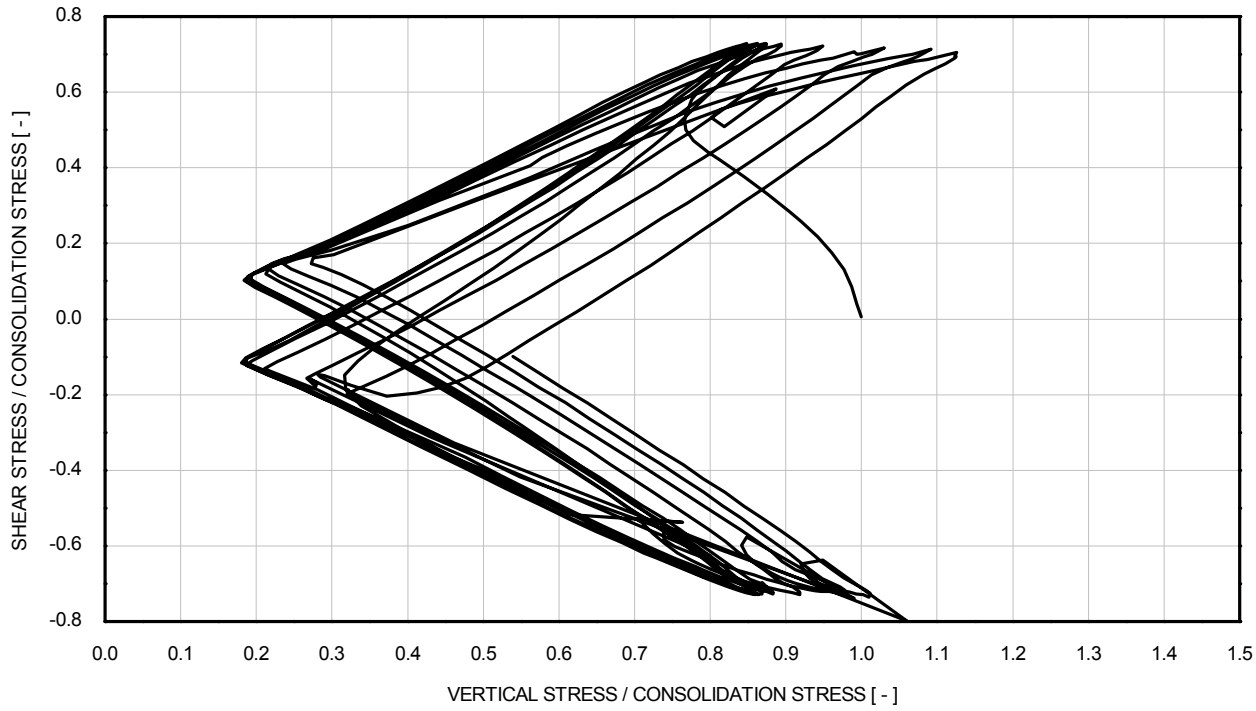


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	-2 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	168 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.68
			Test No.	:	CSS09R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

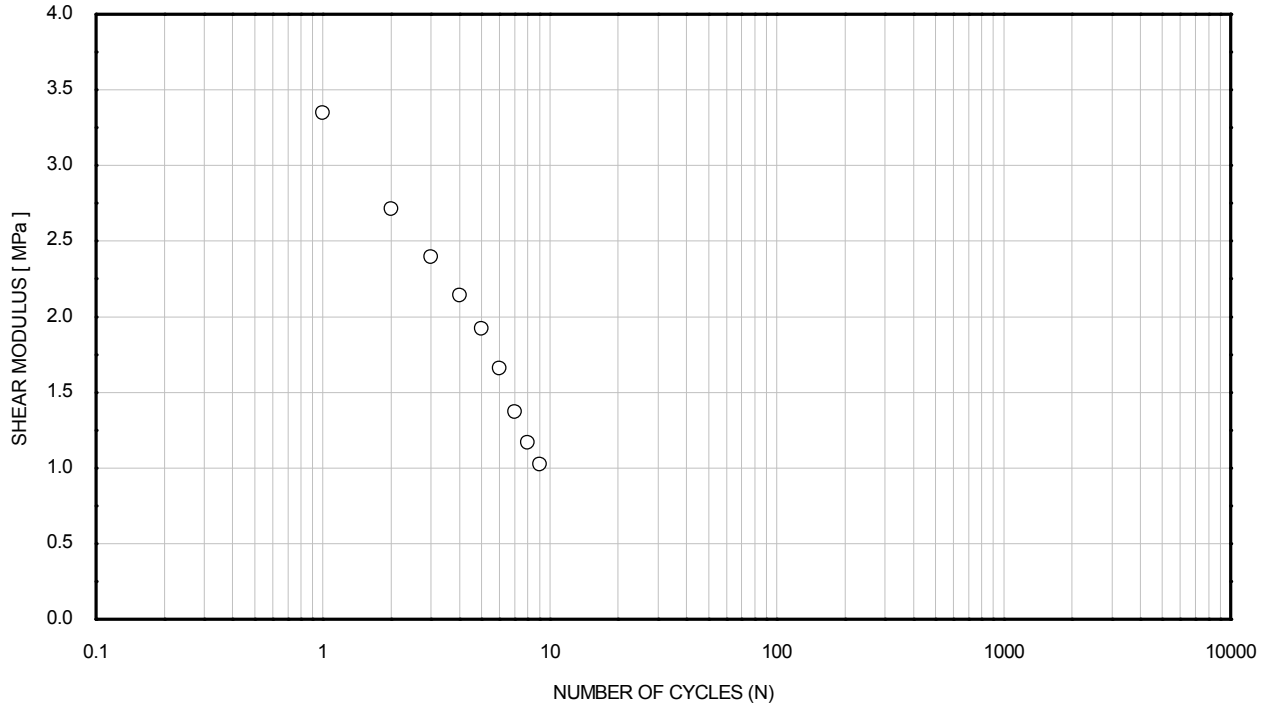


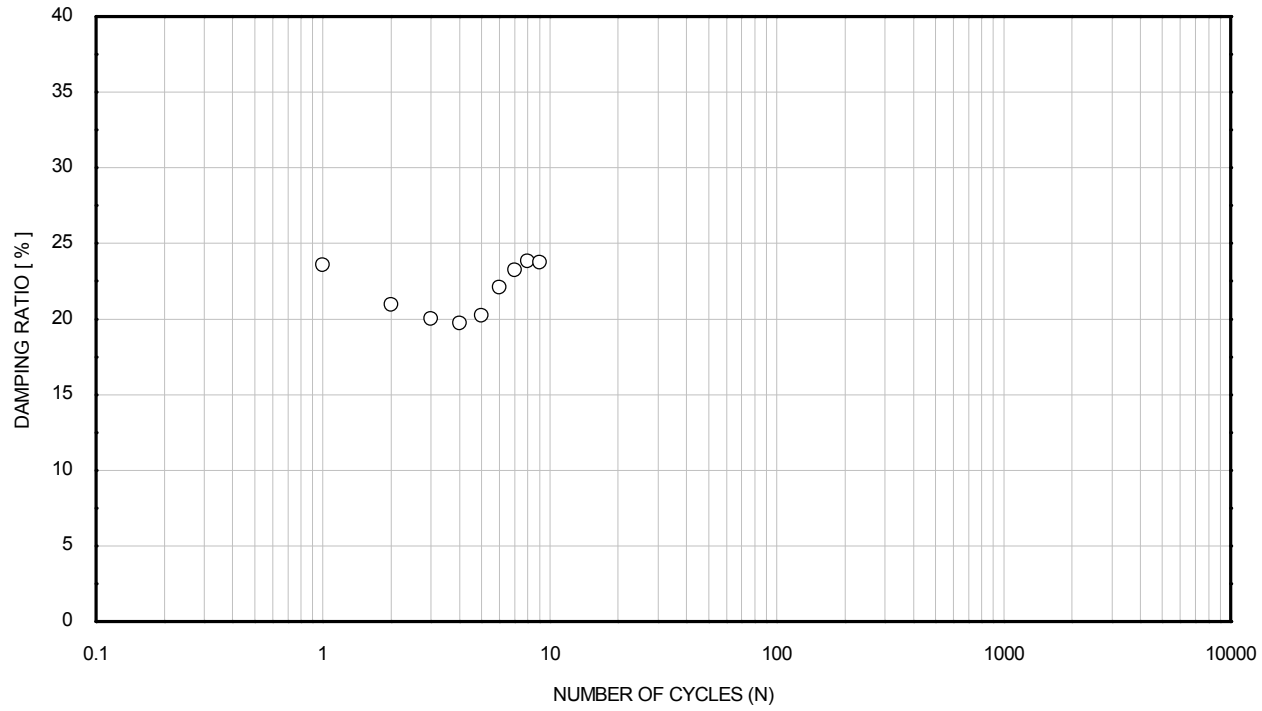


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	-2 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	168 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.68
			Test No.	:	CSS09R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

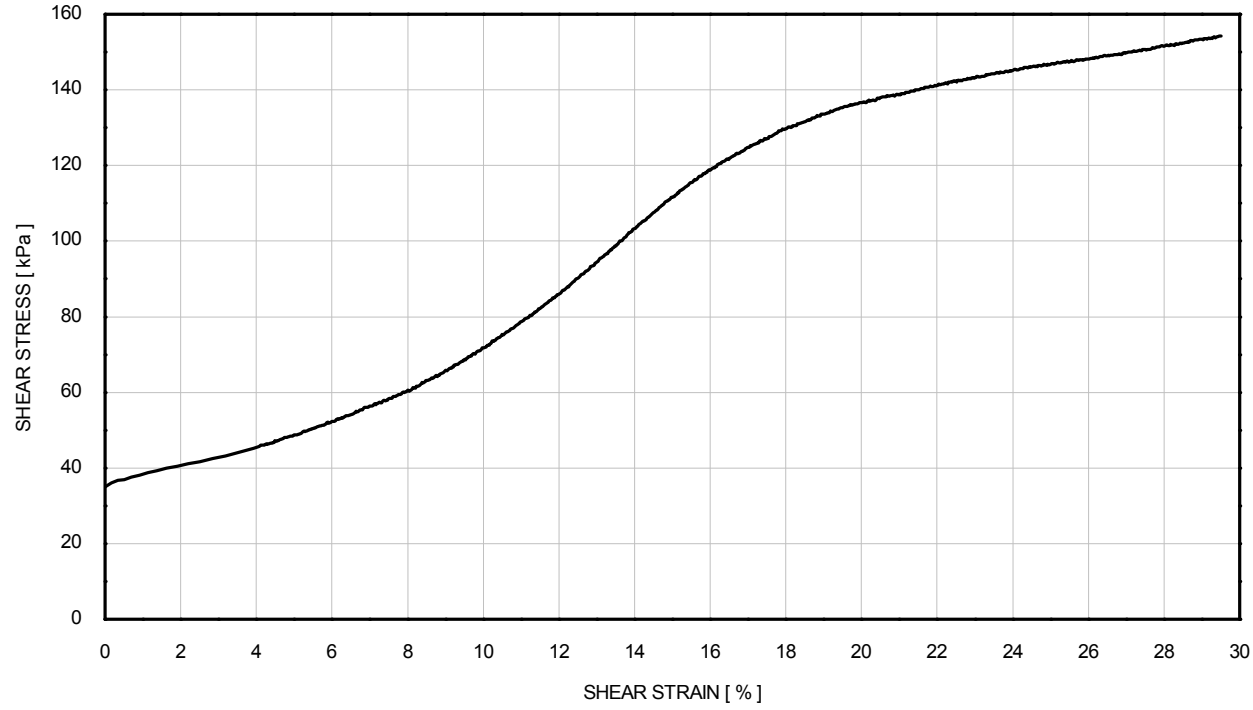


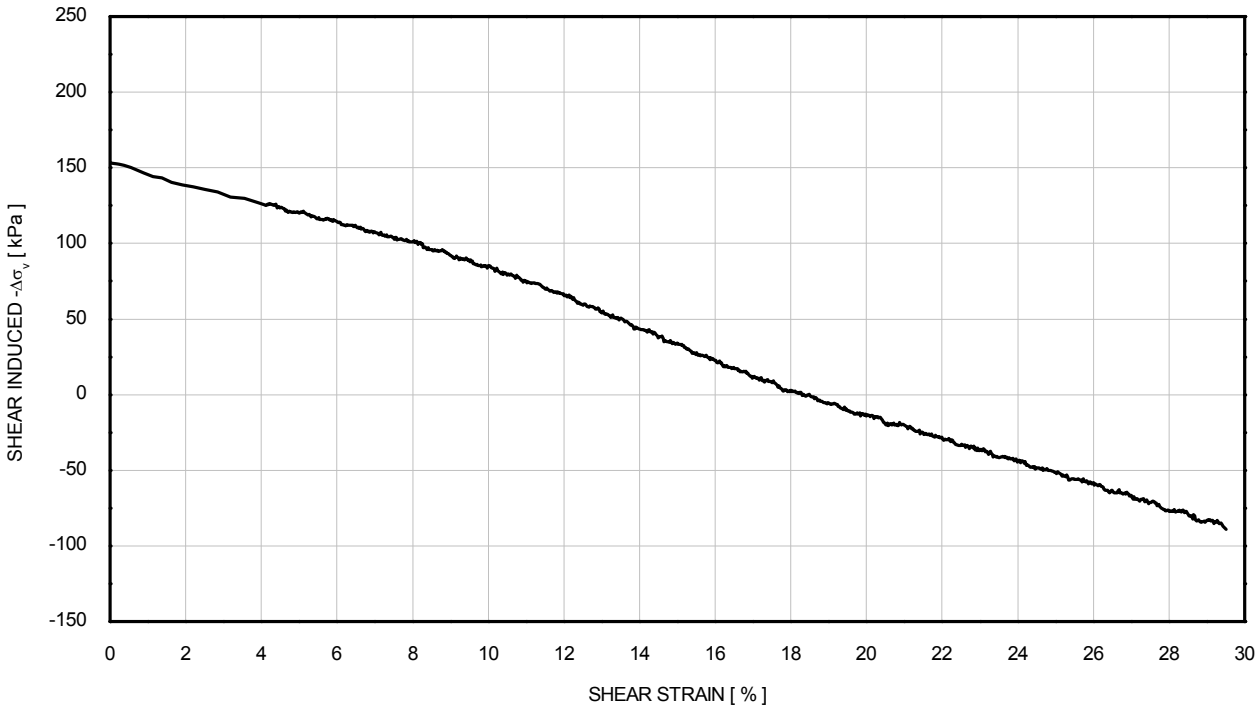


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	-2 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	168 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.68
			Test No.	:	CSS09R

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

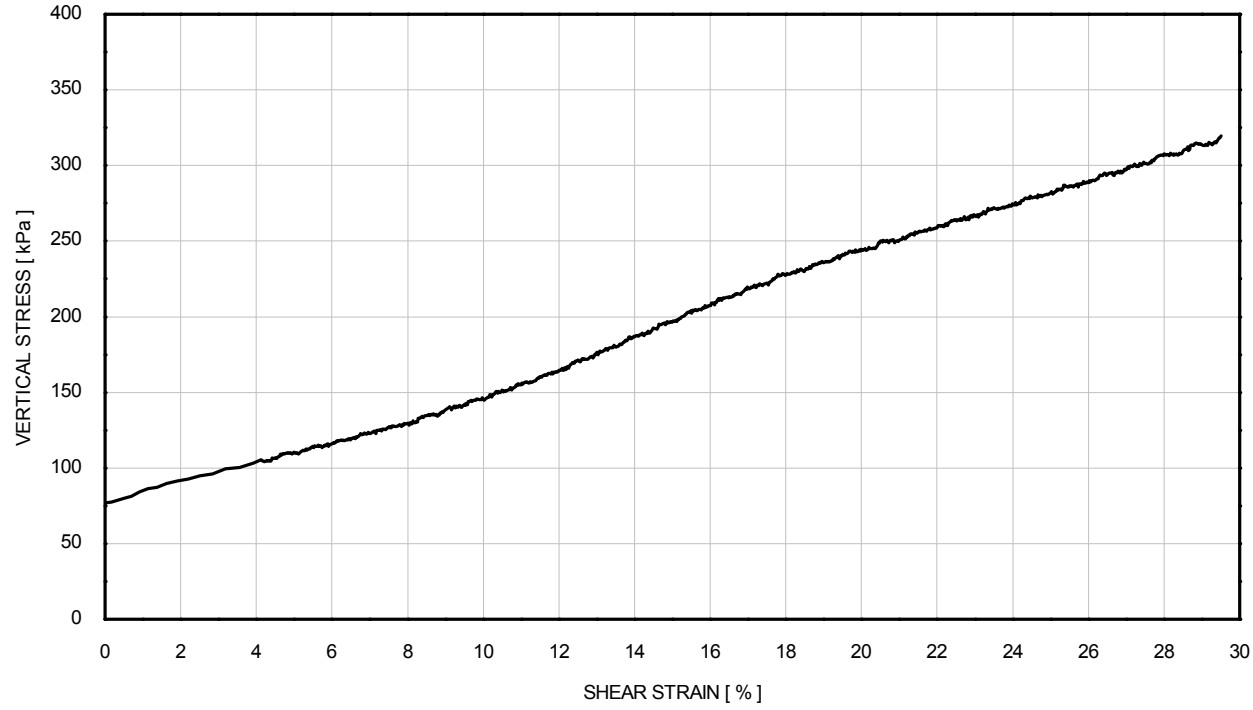


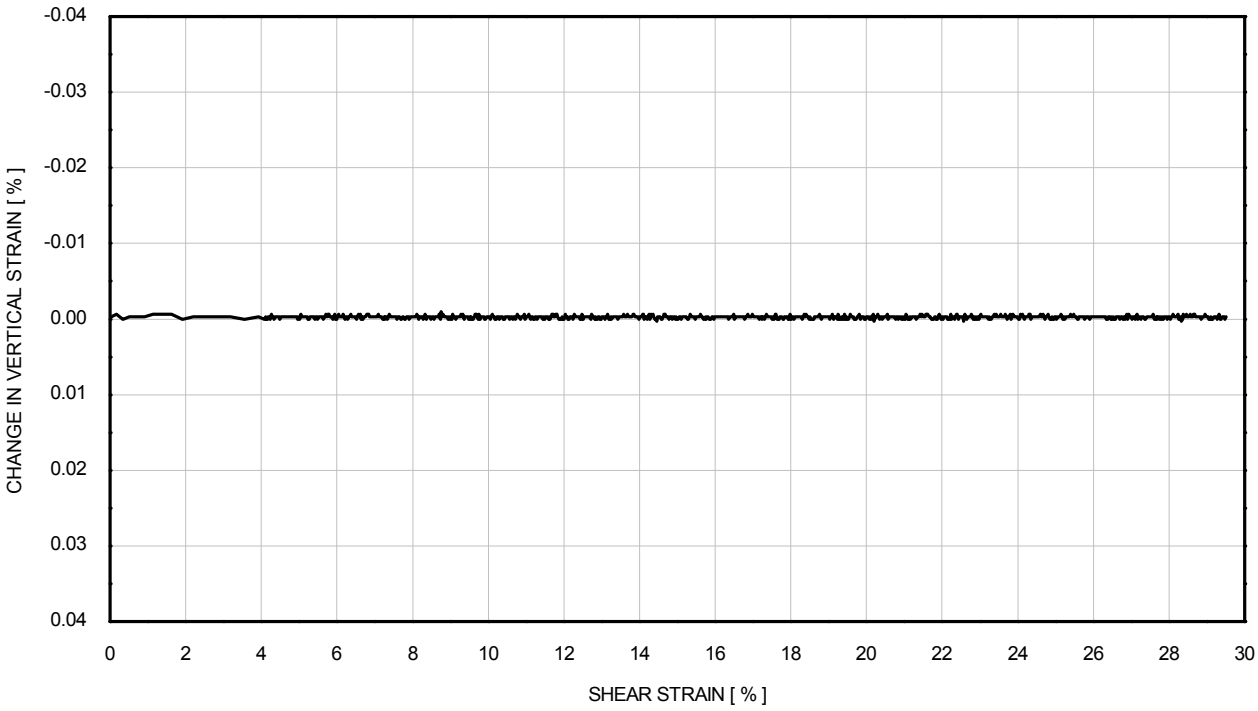


σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 154 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 29.46 %	Unit	: D (Rupel)
Rate of strain	: 3.01 %/hour	Depth [m]	: 23.68
		Test No.	: CSS09R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

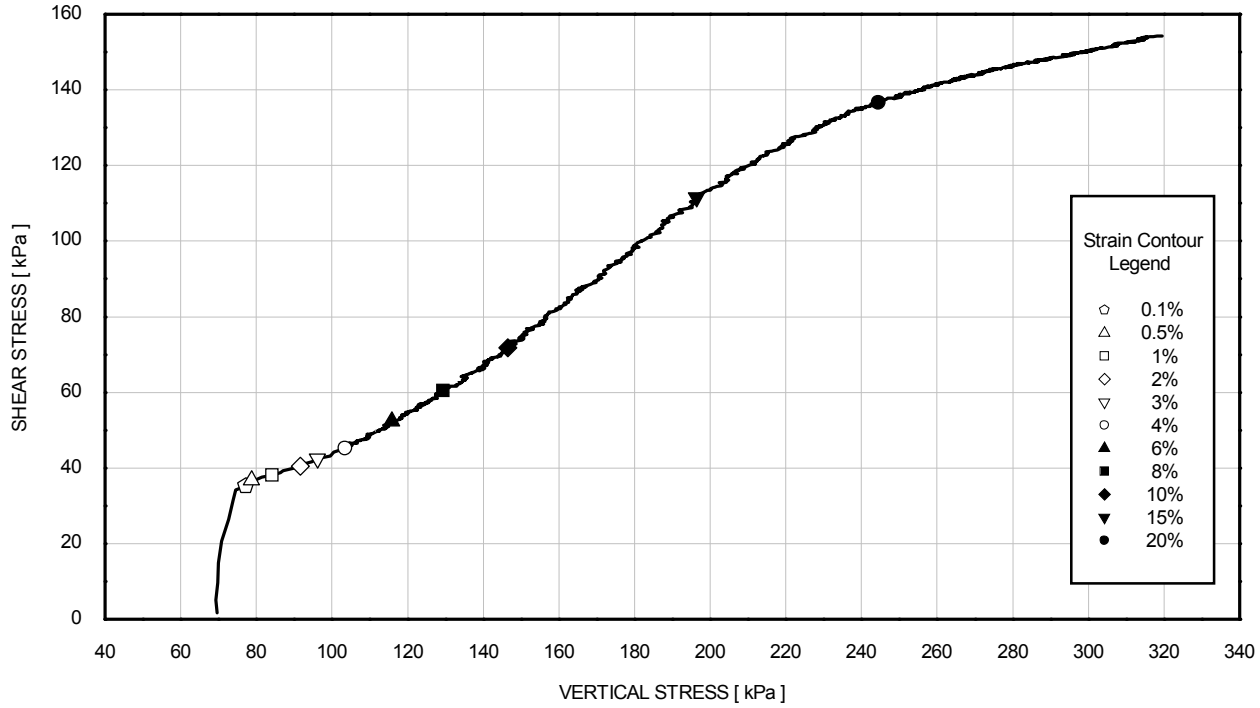


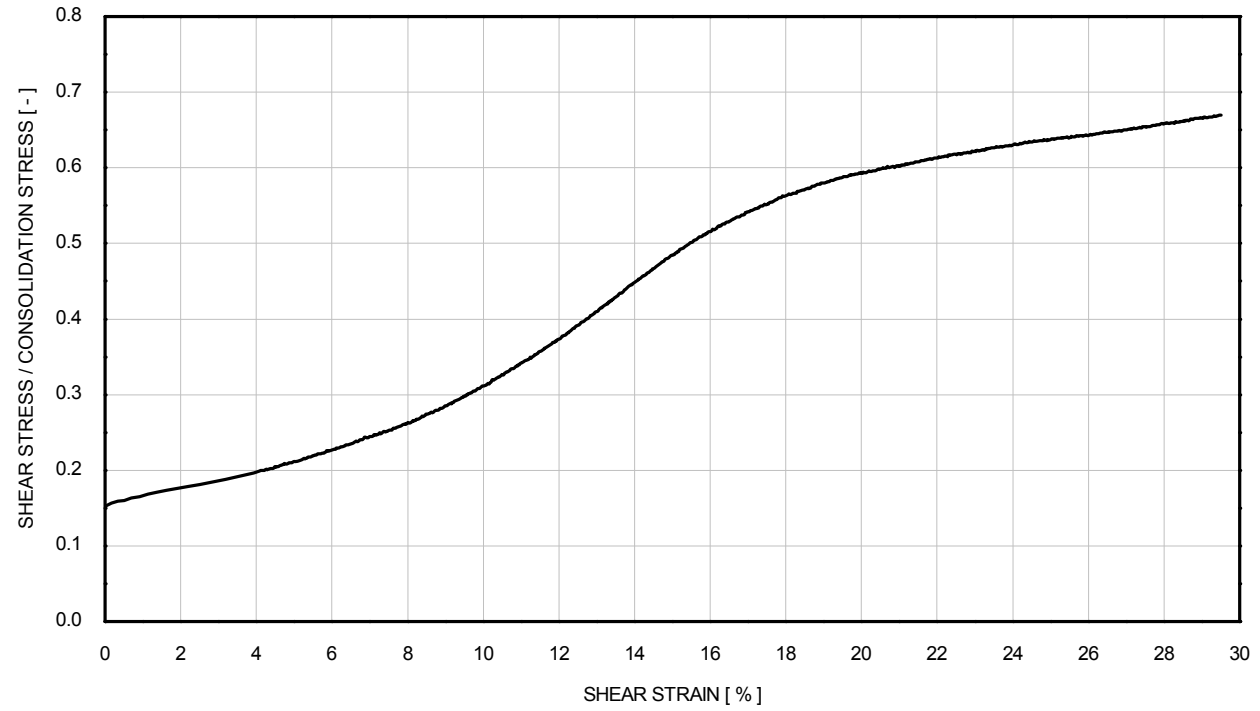


σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 154 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 29.46 %	Unit	: D (Rupel)
Rate of strain	: 3.01 %/hour	Depth [m]	: 23.68
		Test No.	: CSS09R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

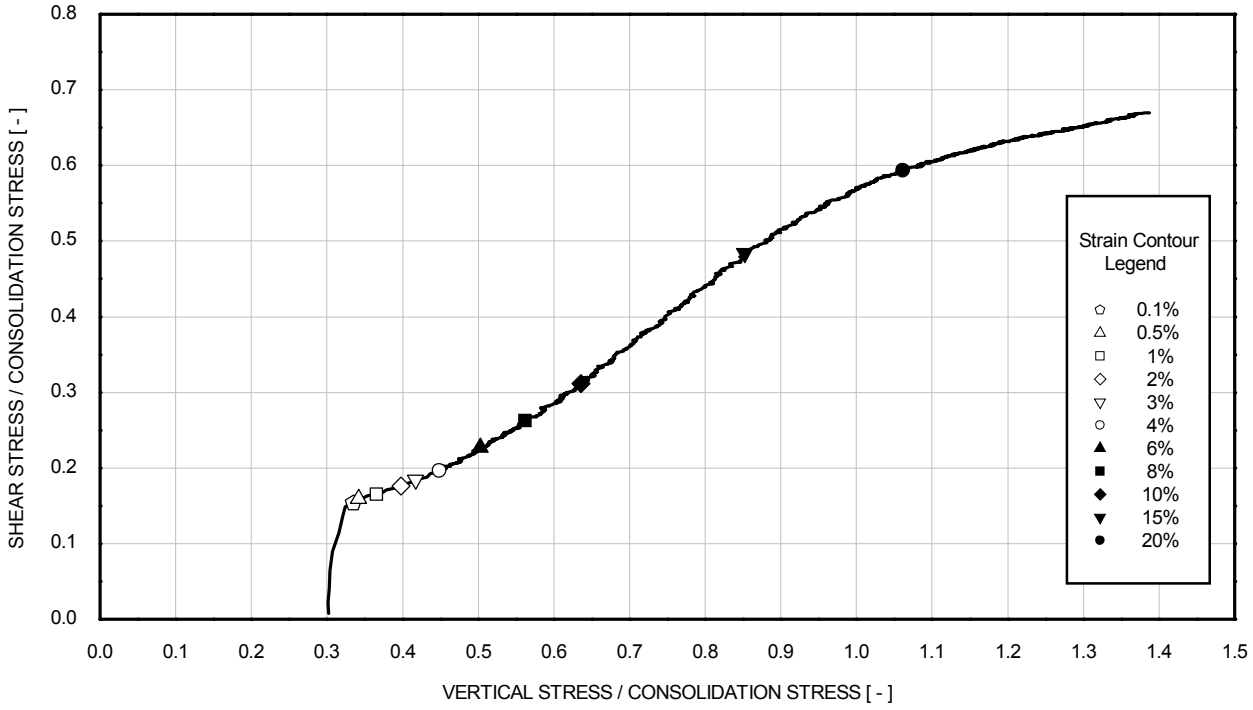


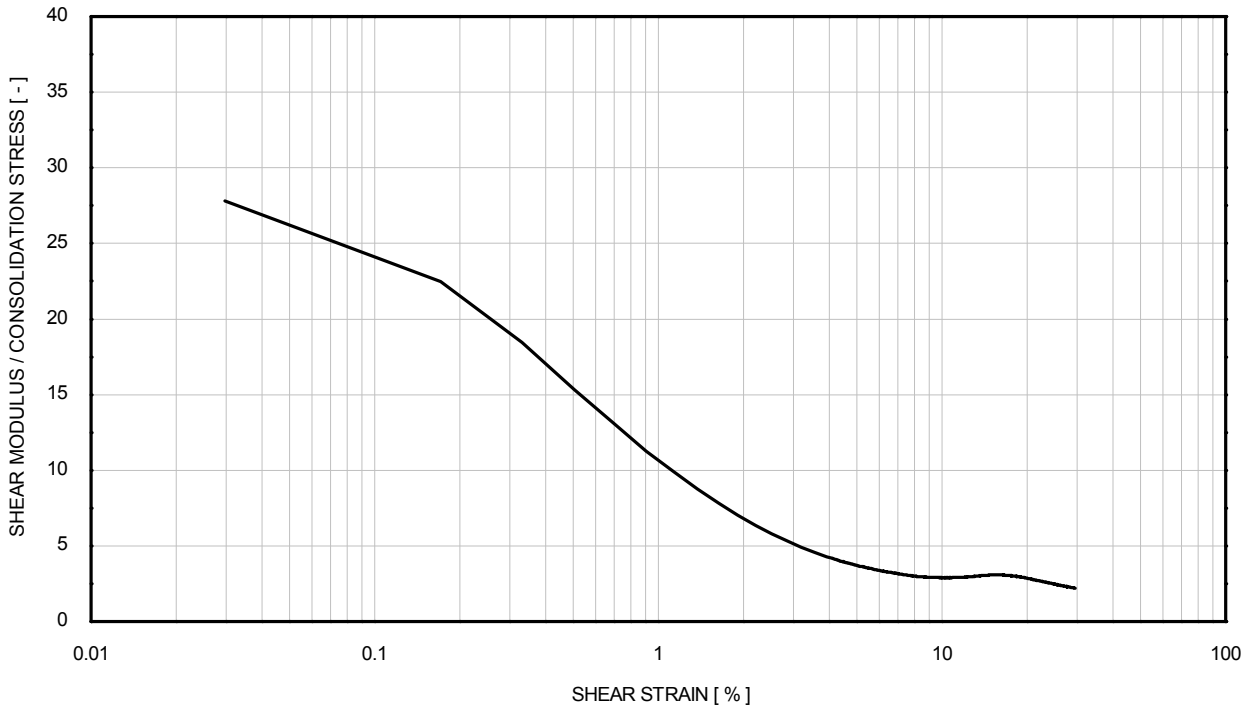


σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 154 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 29.46 %	Unit	: D (Rupel)
Rate of strain	: 3.01 %/hour	Depth [m]	: 23.68
		Test No.	: CSS09R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 154 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 29.46 %	Unit	: D (Rupel)
Rate of strain	: 3.01 %/hour	Depth [m]	: 23.68
		Test No.	: CSS09R

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Dark greenish grey fissured CLAY with traces of fine gravel-sized pockets of black pyritic fine sand and silt

GENERAL	
Date test started	04/12/2015
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	[mm]	65.9
Length	[mm]	29.9
Moisture content	[%]	34.1
Bulk density	[Mg/m³]	1.93
Dry density	[Mg/m³]	1.44
Void ratio	[-]	0.877
Degree of saturation	[%]	100
Assumed particle density	[Mg/m³]	2.70
Torvane	[kPa]	175
Pocket penetrometer	[kPa]	267
Torvane 90°	[kPa]	-
Pocket penetrometer 90°	[kPa]	-

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ BH-WFS4-7_22WAXD_CSS10
Template issue	1.3
Processed by	RN
Date	11/12/2015
Checked by	LJ
Date	11/12/2015
Approved by	PH
Date	14/01/2016

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.64
Test number	CSS10

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	548
Vertical strain	[%]	2.06
Bulk density	[Mg/m^3]	1.95
Dry density	[Mg/m^3]	1.47
Void ratio	[-]	0.839
Moisture content	[%]	32.7

CONSOLIDATION		
σ_{vc}	[kPa]	230
Vertical strain	[%]	0.82
Bulk density	[Mg/m^3]	1.94
Dry density	[Mg/m^3]	1.45
Void ratio	[-]	0.862
Moisture content	[%]	33.5

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	250
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	158
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	825
γ_{av} at N_f	[%]	1.73
γ_{cy} at N_f	[%]	15.23
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	-199
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.05	2.42	6.54	16.19
2	0.00	2.68	5.92	16.68
5	0.02	2.97	5.34	16.66
10	0.03	3.20	4.95	16.56
20	0.05	3.47	4.58	16.37
30	0.06	3.64	4.37	16.30
40	0.07	3.77	4.21	16.26
50	0.08	3.87	4.11	16.24
100	0.13	4.20	3.78	16.15
500	0.36	5.28	3.00	16.65
825	1.73	15.23	1.02	28.12

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.64
Test number	CSS10

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress*		
Shear stress	[kPa]	164
Shear strain	[%]	28.09
Shear induced $-\Delta\sigma_v$	[kPa]	-279
Vertical stress	[kPa]	509
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	3.00
At 15 % shear strain		
Shear stress	[kPa]	117
Shear induced $-\Delta\sigma_v$	[kPa]	-141
Vertical stress	[kPa]	371
Vertical strain	[%]	0.00

* Please note that specimen failure was observed to occur along or close to the loading platen interface.

TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.64
Test number	CSS10

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SPECIMEN PHOTOGRAPHS

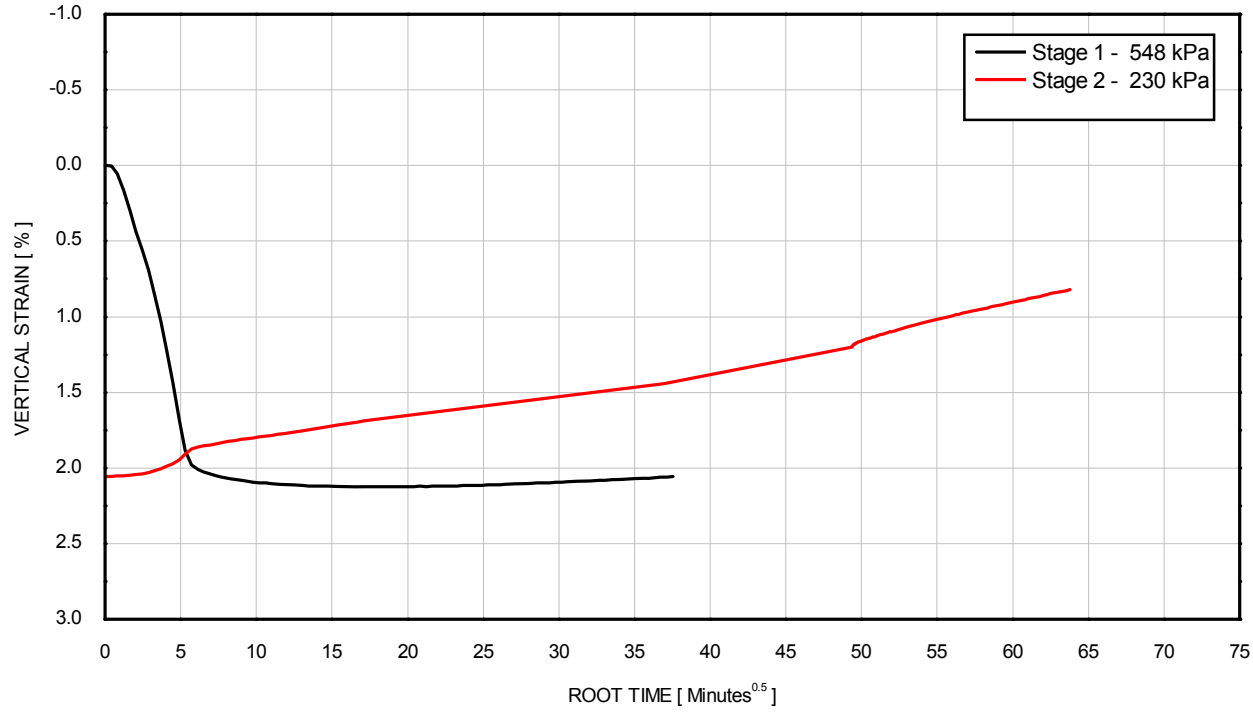


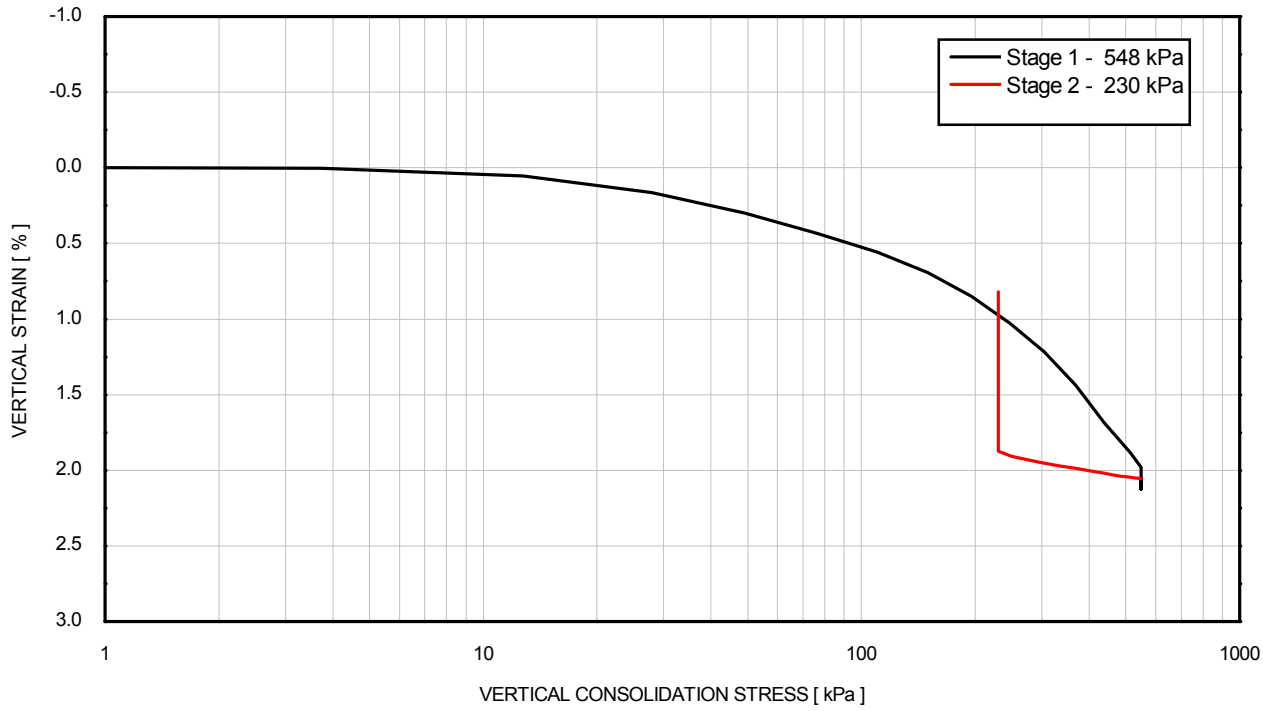


TEST IDENTIFICATION	
Borehole	BH-WFS4-7
Sample	22WaxD
Unit	D (Rupel)
Depth [m]	23.64
Test number	CSS10

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

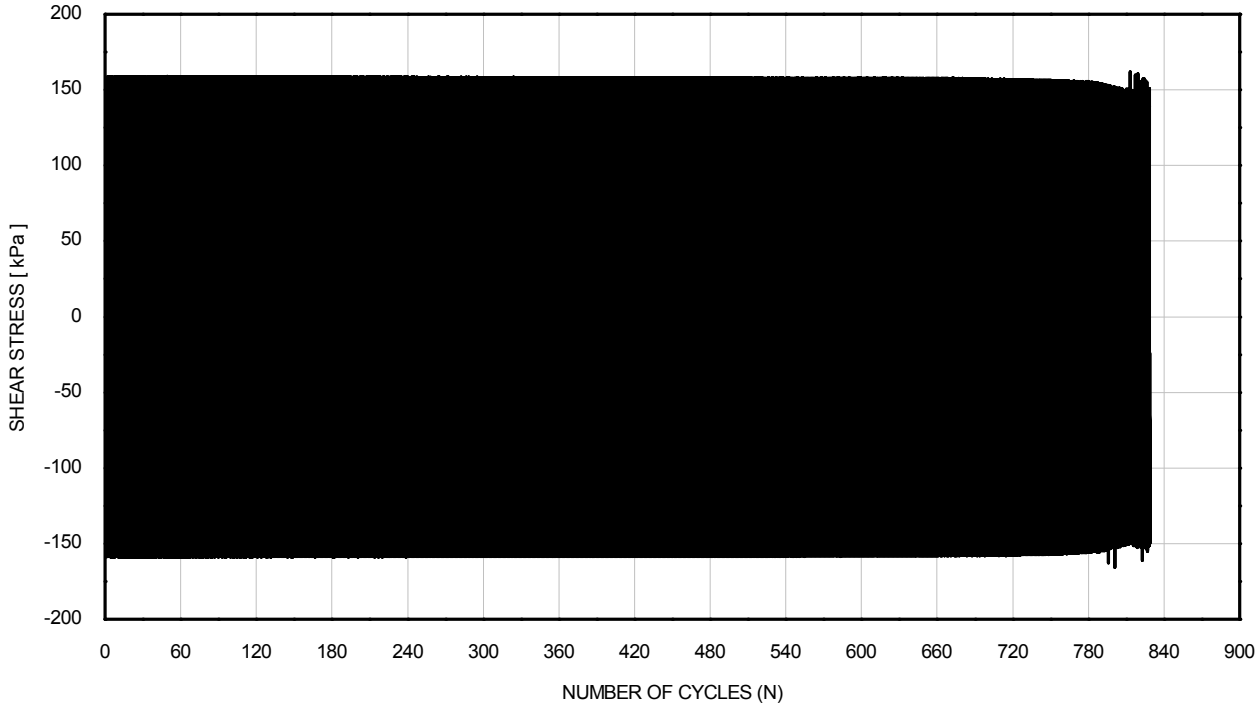


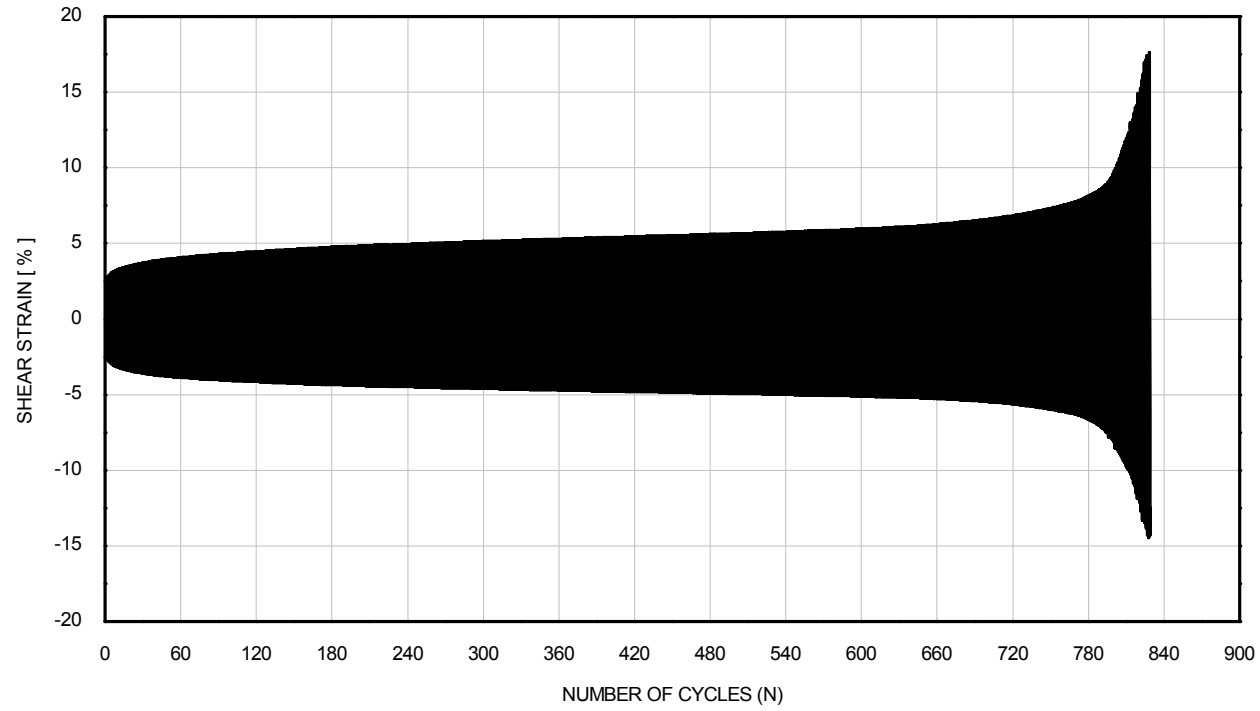


σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
		Sample	: 22WaxD
		Unit	: D (Rupel)
		Depth [m]	: 23.64
		Test No.	: CSS10

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

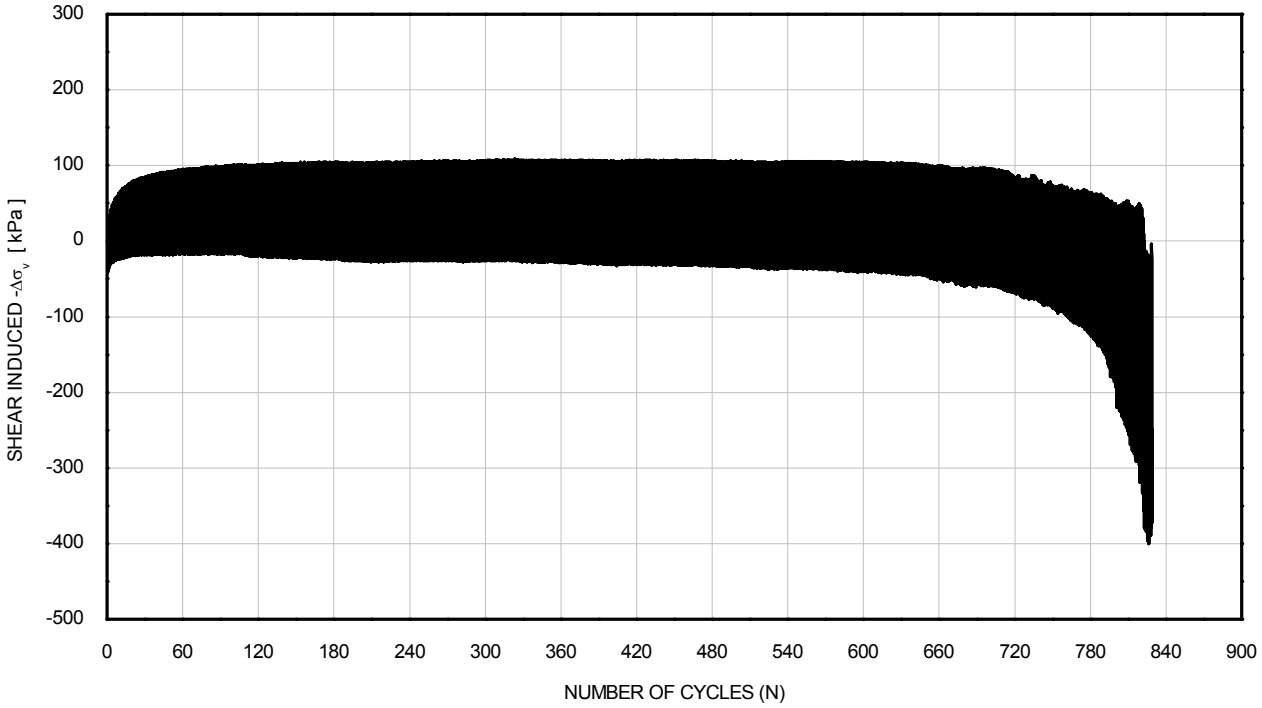


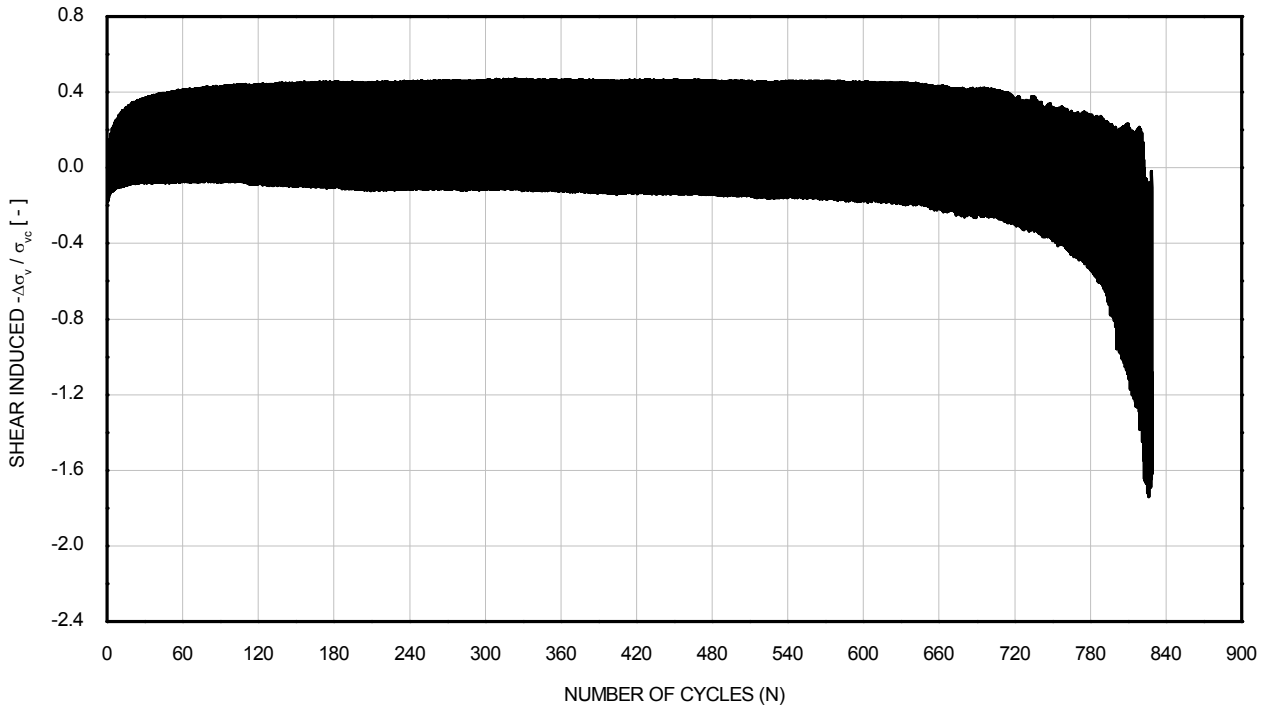


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	0 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	158 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.64
			Test No.	:	CSS10

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

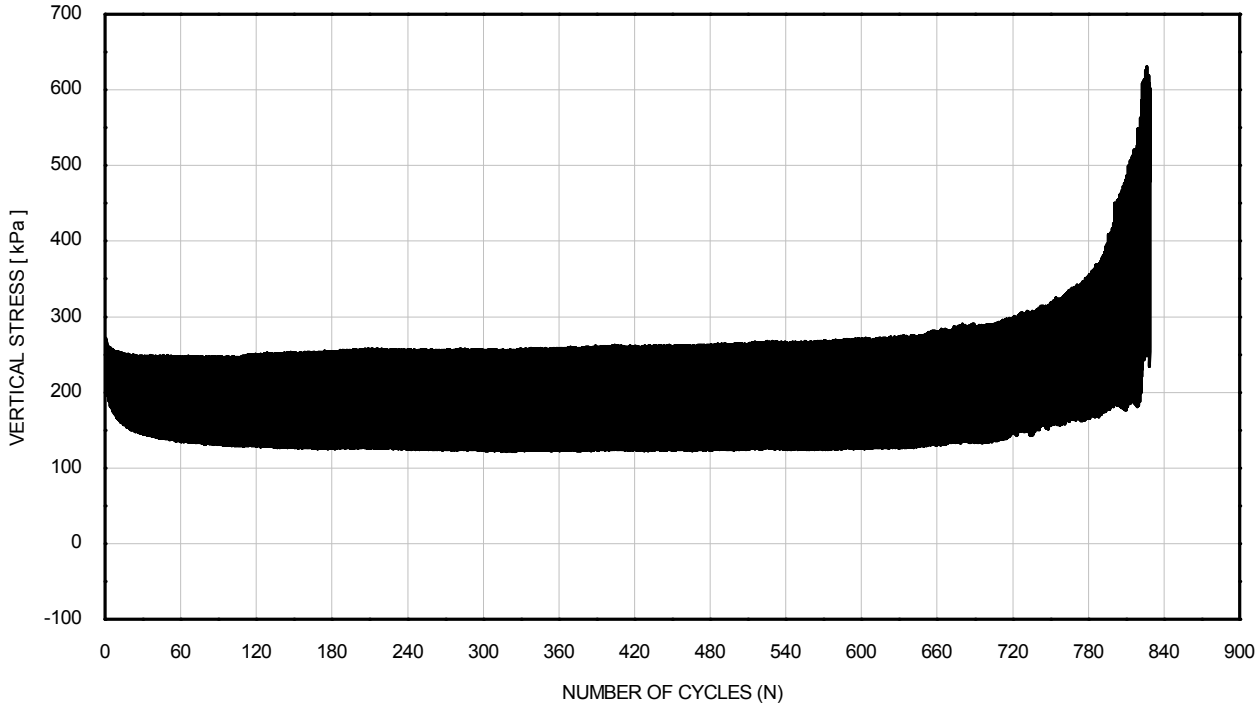


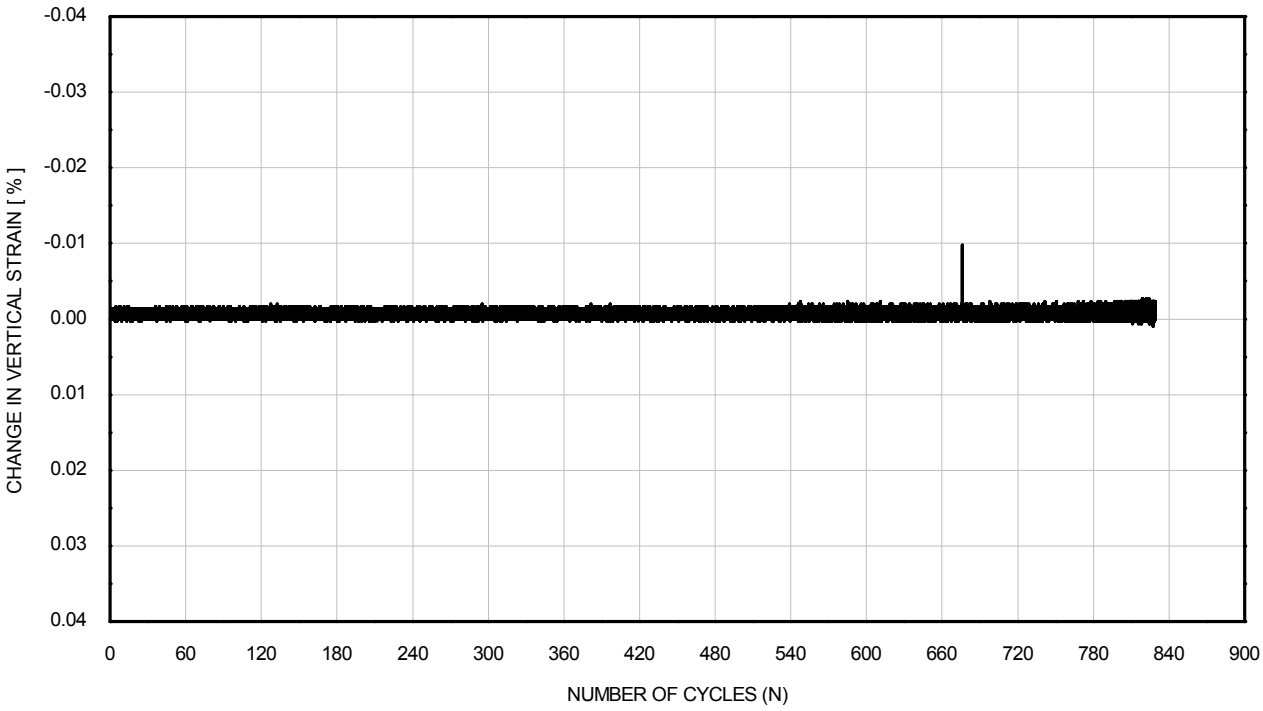


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	0 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	158 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.64
			Test No.	:	CSS10

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

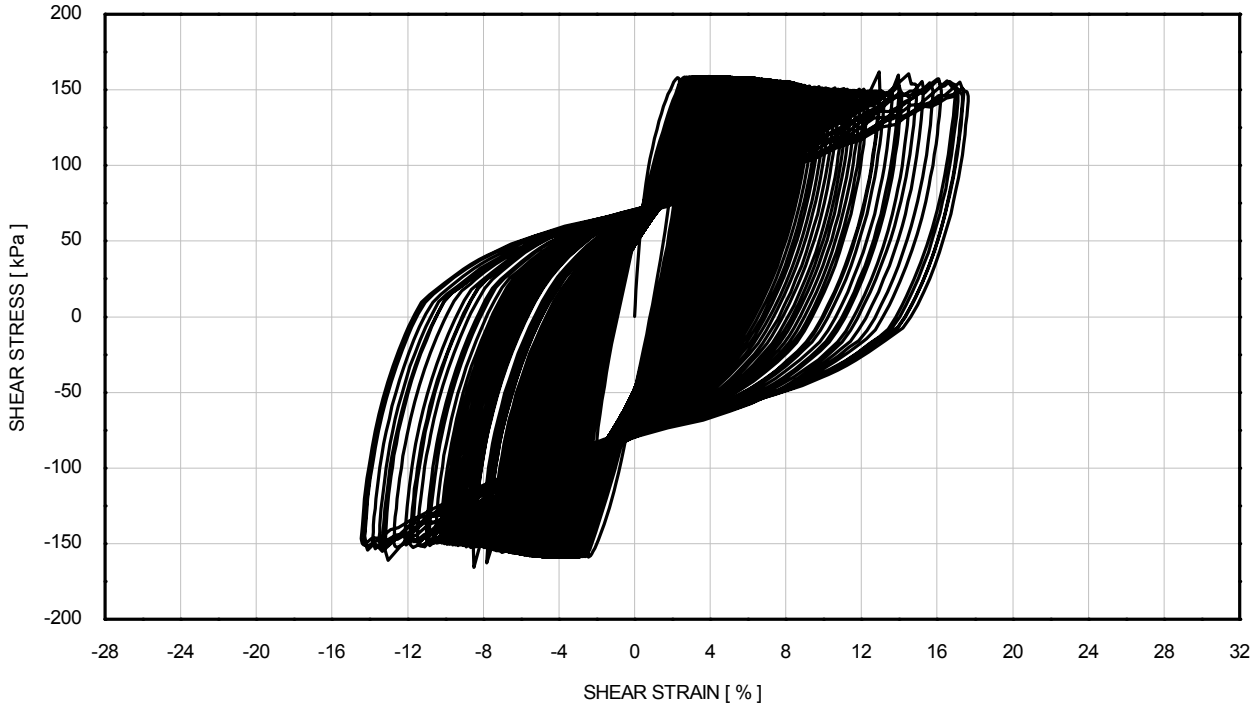


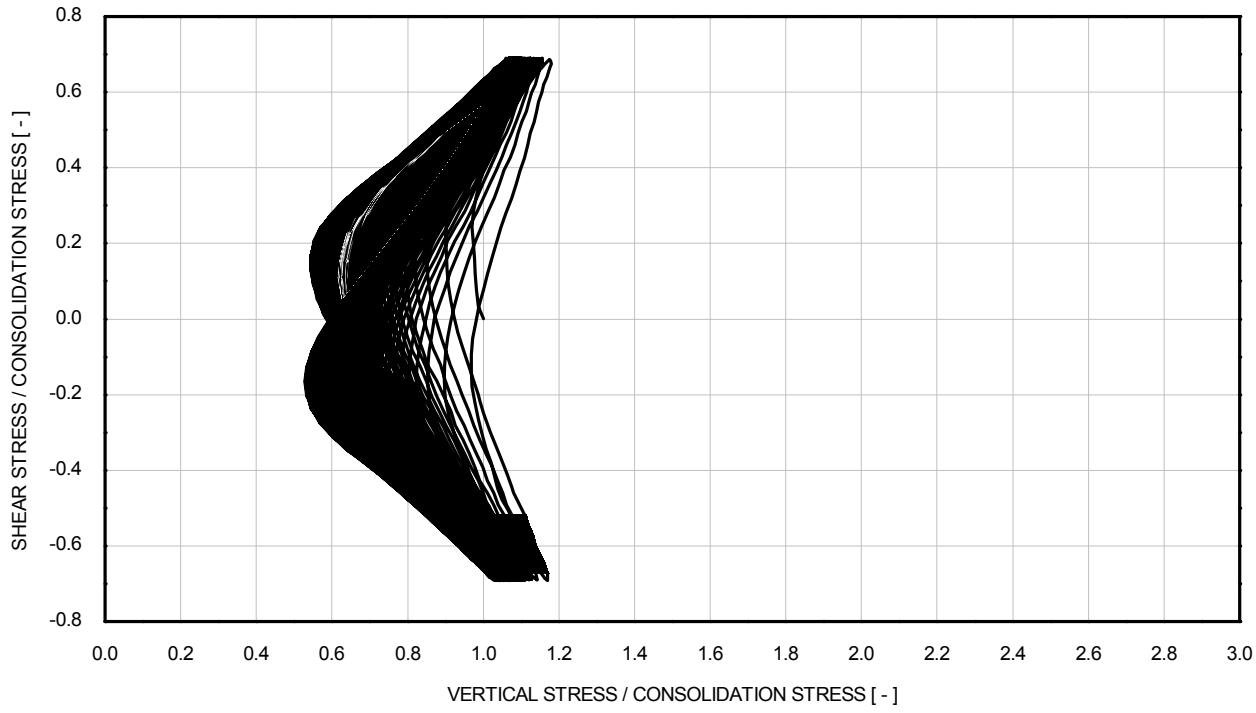


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	0 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	158 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.64
			Test No.	:	CSS10

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

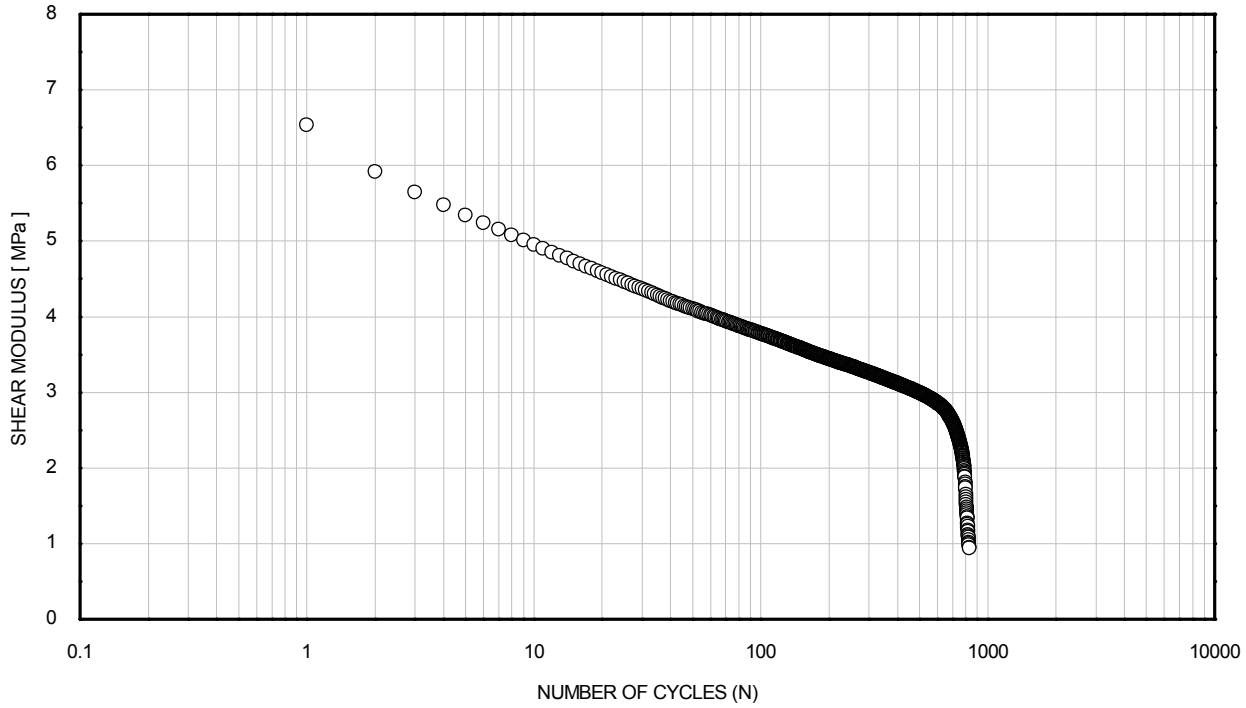


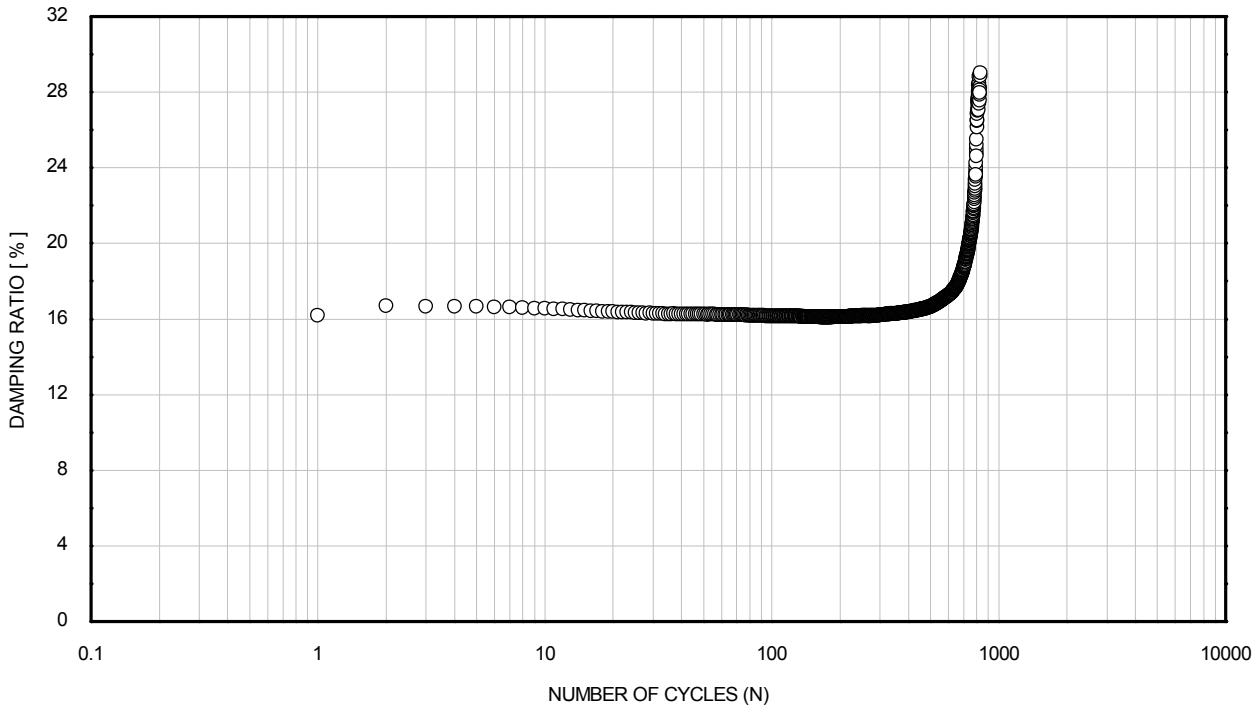


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	0 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	158 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.64
			Test No.	:	CSS10

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

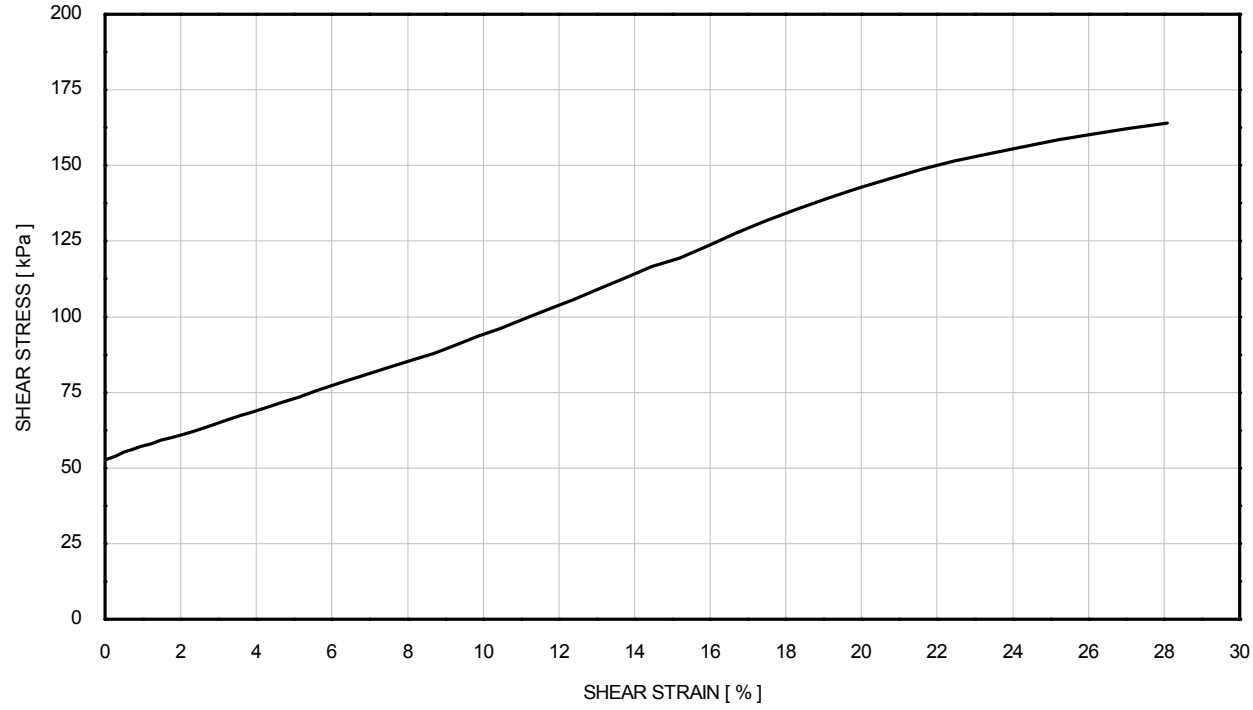


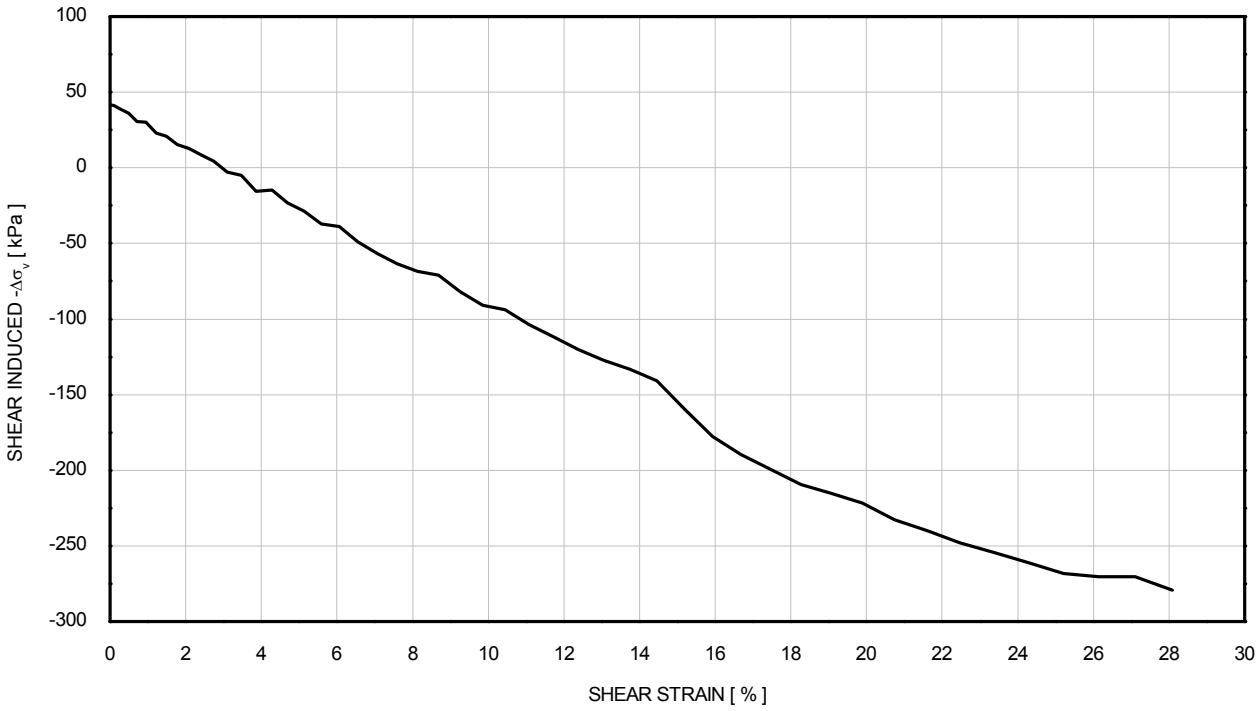


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
Mean τ_{av}	:	0 kPa	Sample	:	22WaxD
Mean τ_{cy}	:	158 kPa	Unit	:	D (Rupel)
Frequency	:	0.10 Hz	Depth [m]	:	23.64
			Test No.	:	CSS10

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

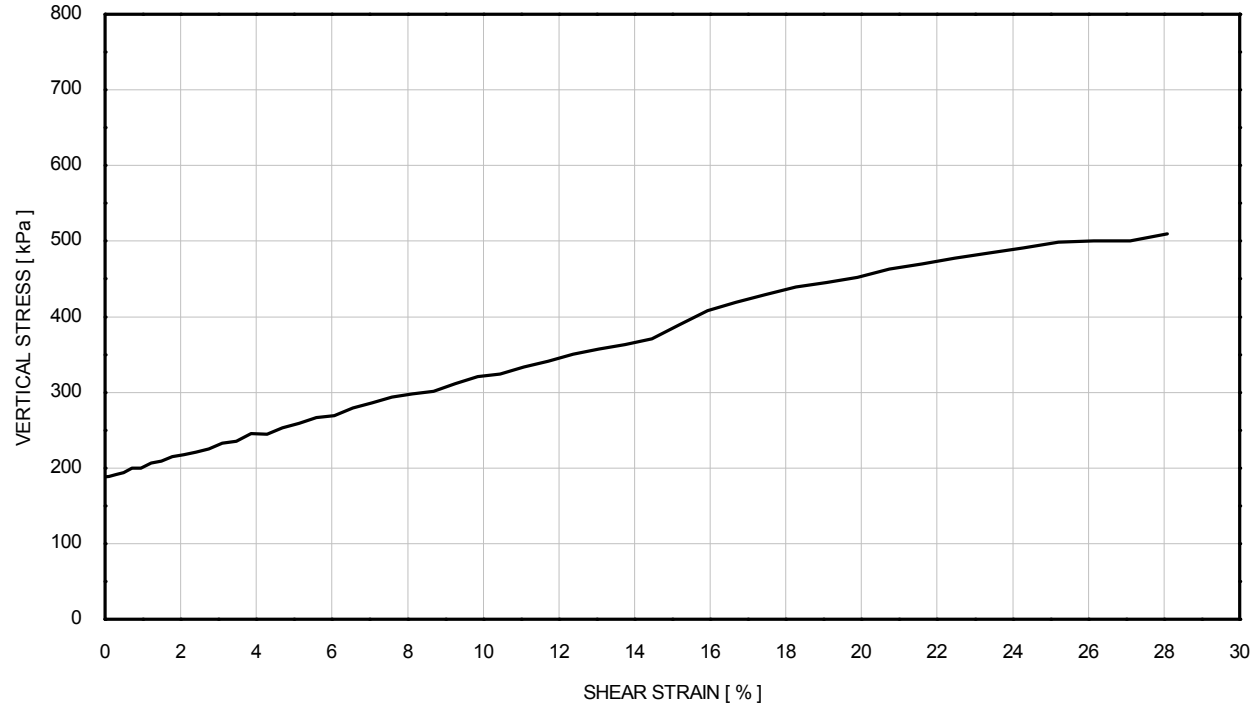


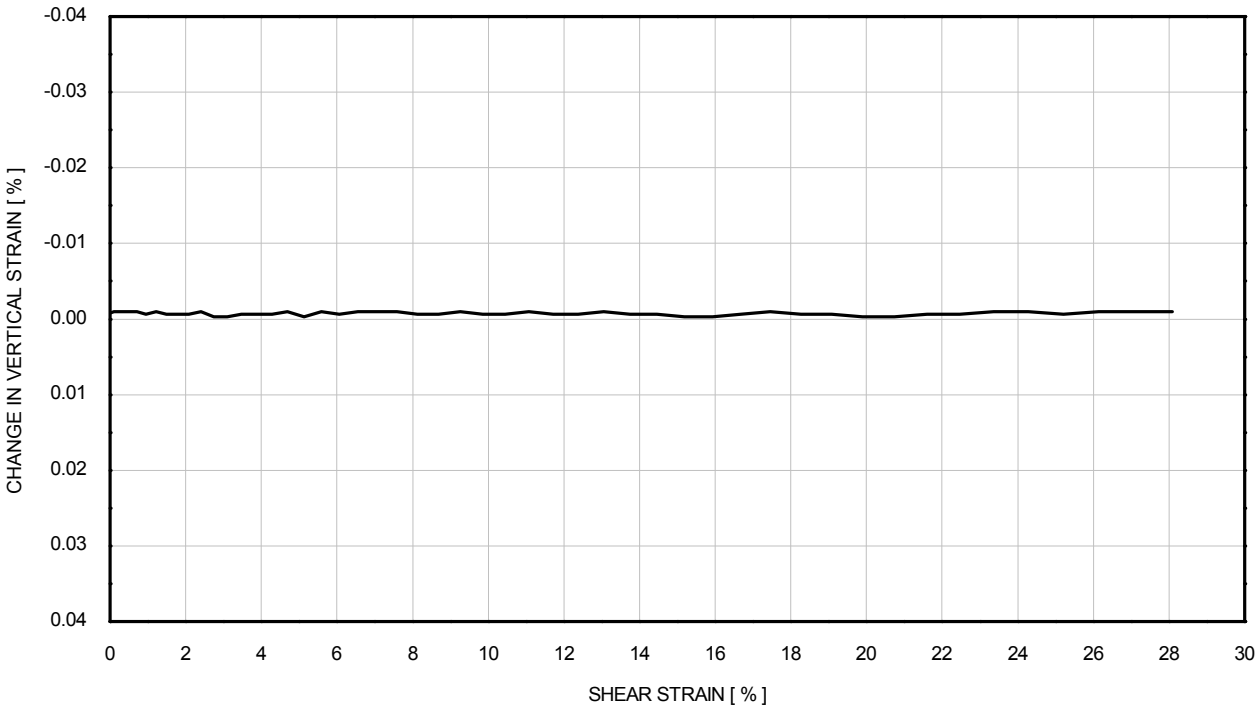


σ_{vc}	:	230 kPa	Borehole	:	BH-WFS4-7
τ_{peak}	:	164 kPa	Sample	:	22WaxD
γ at τ_{peak}	:	28.09 %	Unit	:	D (Rupel)
Rate of strain	:	3.00 %/hour	Depth [m]	:	23.64
			Test No.	:	CSS10

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

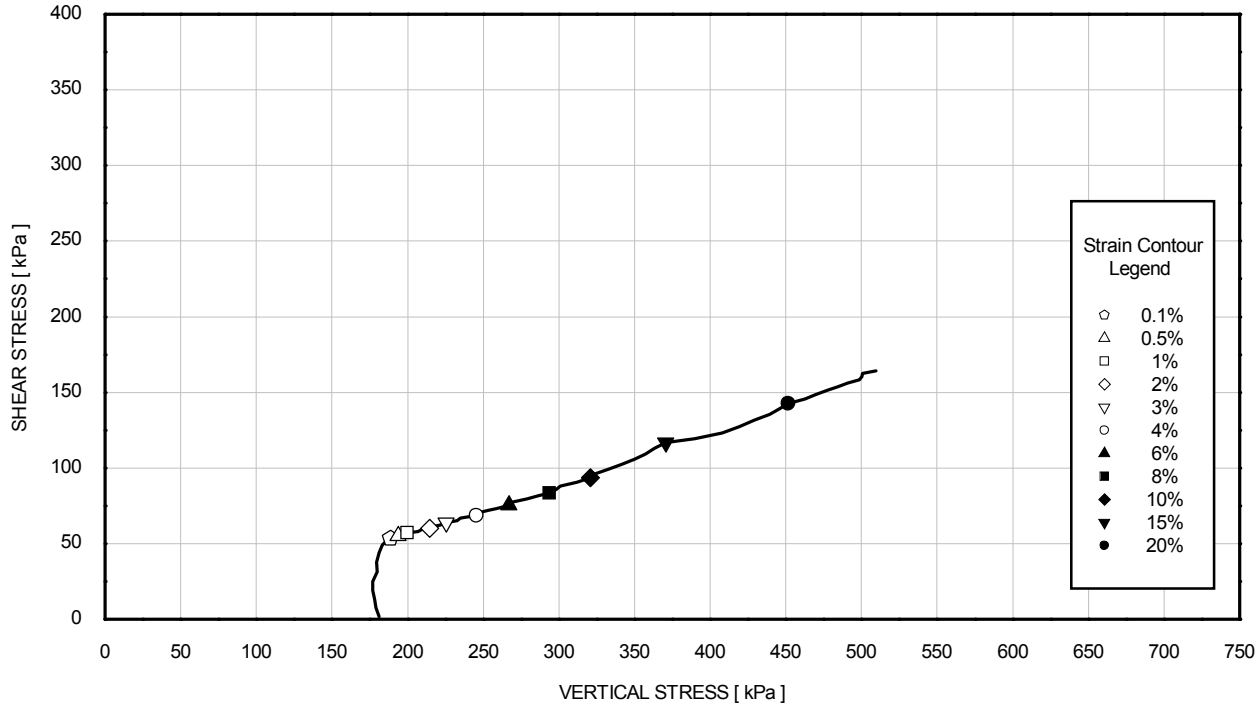


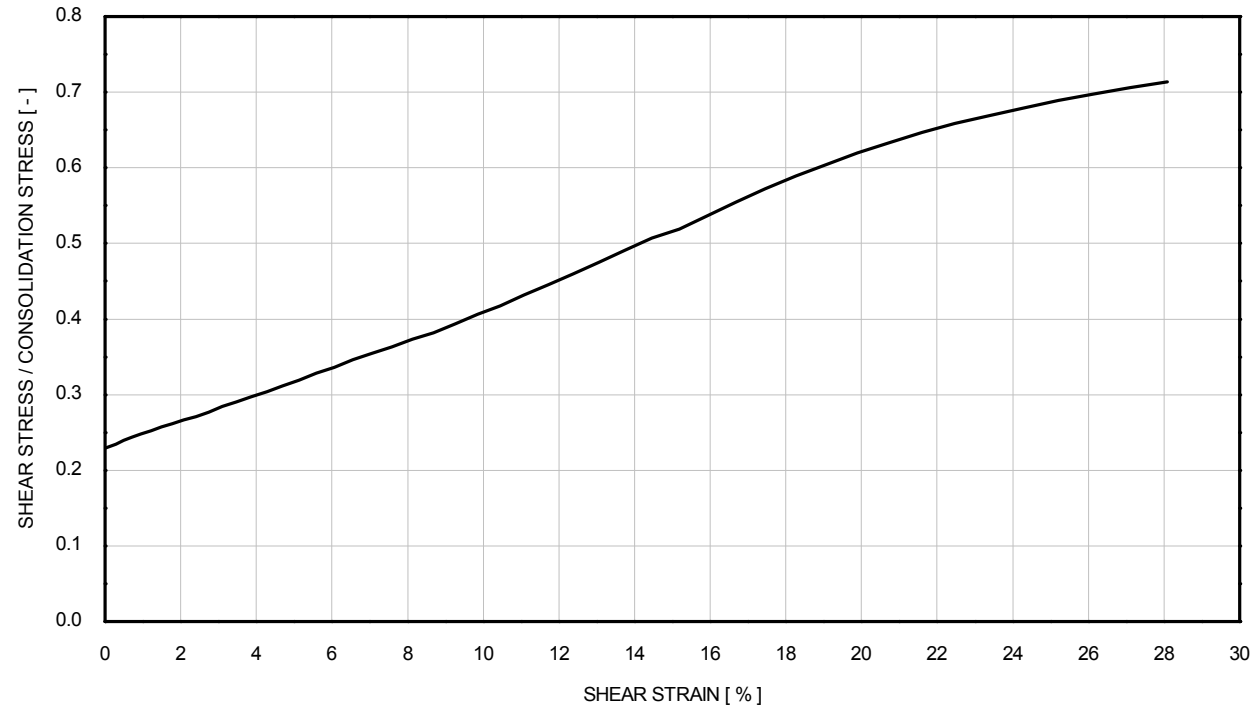


σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 164 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 28.09 %	Unit	: D (Rupel)
Rate of strain	: 3.00 %/hour	Depth [m]	: 23.64
		Test No.	: CSS10

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

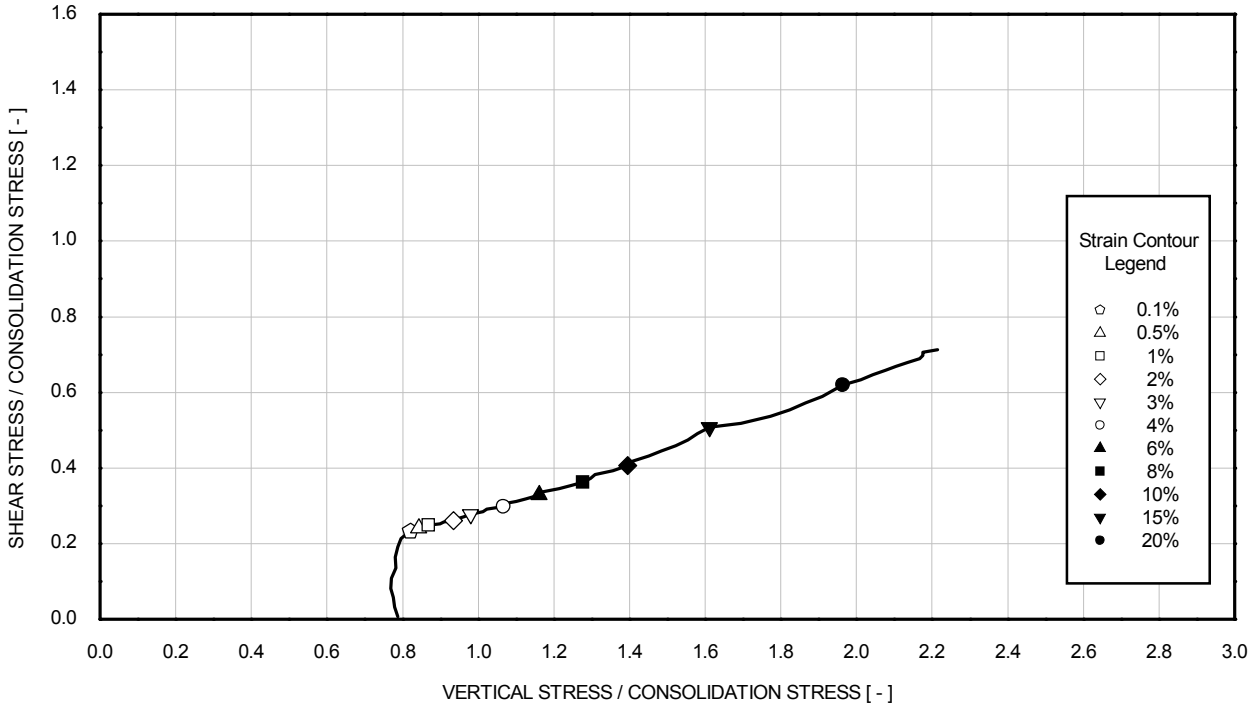


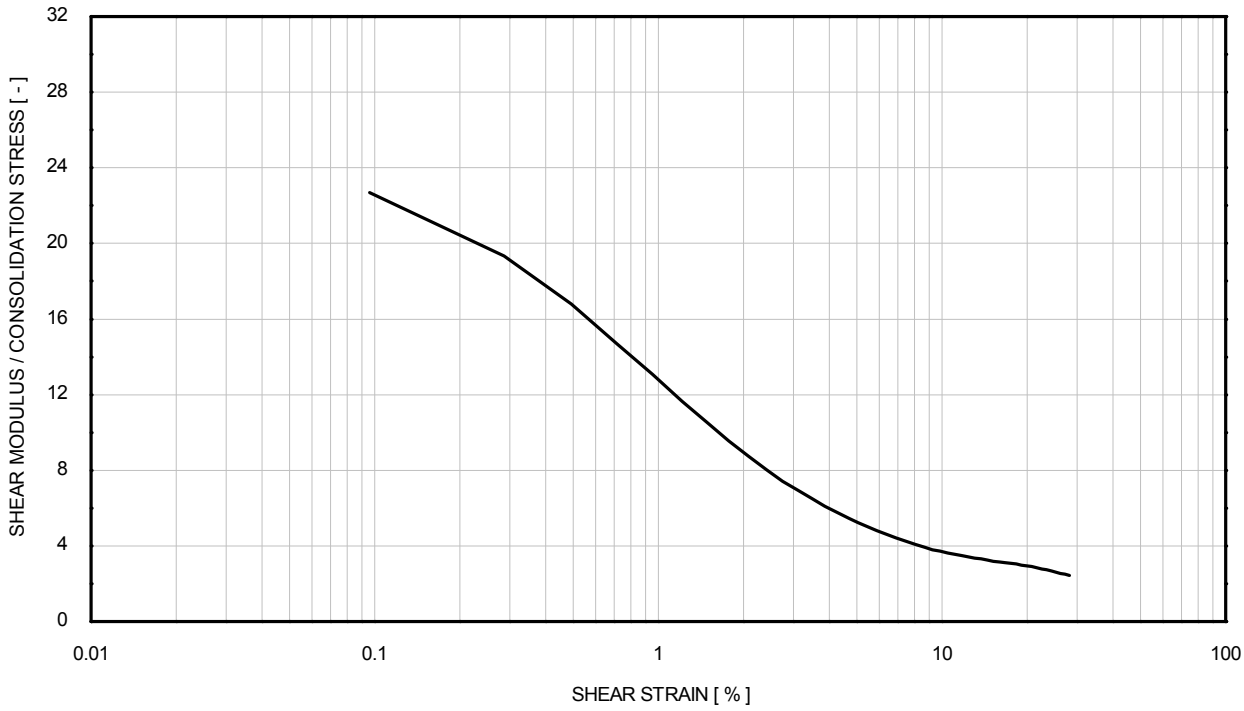


σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 164 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 28.09 %	Unit	: D (Rupel)
Rate of strain	: 3.00 %/hour	Depth [m]	: 23.64
		Test No.	: CSS10

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 230 kPa	Borehole	: BH-WFS4-7
τ_{peak}	: 164 kPa	Sample	: 22WaxD
γ at τ_{peak}	: 28.09 %	Unit	: D (Rupel)
Rate of strain	: 3.00 %/hour	Depth [m]	: 23.64
		Test No.	: CSS10

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	03/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.4
Length	[mm]	30.0
Moisture content after compaction	[%]	11.5
Bulk density after compaction	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.649
Degree of saturation after compaction	[%]	47
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.5
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 1_CSS 1-1_CSS11
Template issue	1.3
Processed by	HJ
Date	09/02/2016
Checked by	PH
Date	16/02/2016
Approved by	PH
Date	16/02/2016

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-1
Unit	A (Southern Bight)
Test number	CSS11

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	25
Vertical strain	[%]	0.26
Bulk density	[Mg/m^3]	2.00
Dry density	[Mg/m^3]	1.61
Void ratio	[-]	0.645
Moisture content	[%]	24.3

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	25
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	7
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	160
γ_{av} at N_f	[%]	-2.60
γ_{cy} at N_f	[%]	3.75
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	19
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.78	1.12	0.61	22.65
2	-0.88	1.70	0.40	17.62
5	-1.17	2.34	0.29	14.35
10	-1.56	2.75	0.24	13.26
20	-1.94	3.09	0.22	12.23
30	-2.14	3.27	0.21	11.41
40	-2.29	3.37	0.20	11.38
50	-2.38	3.44	0.19	11.12
100	-2.56	3.60	0.19	10.60
150	-2.59	3.71	0.18	10.42
160	-2.60	3.75	0.18	10.34

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-1
Unit	A (Southern Bight)
Test number	CSS11

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

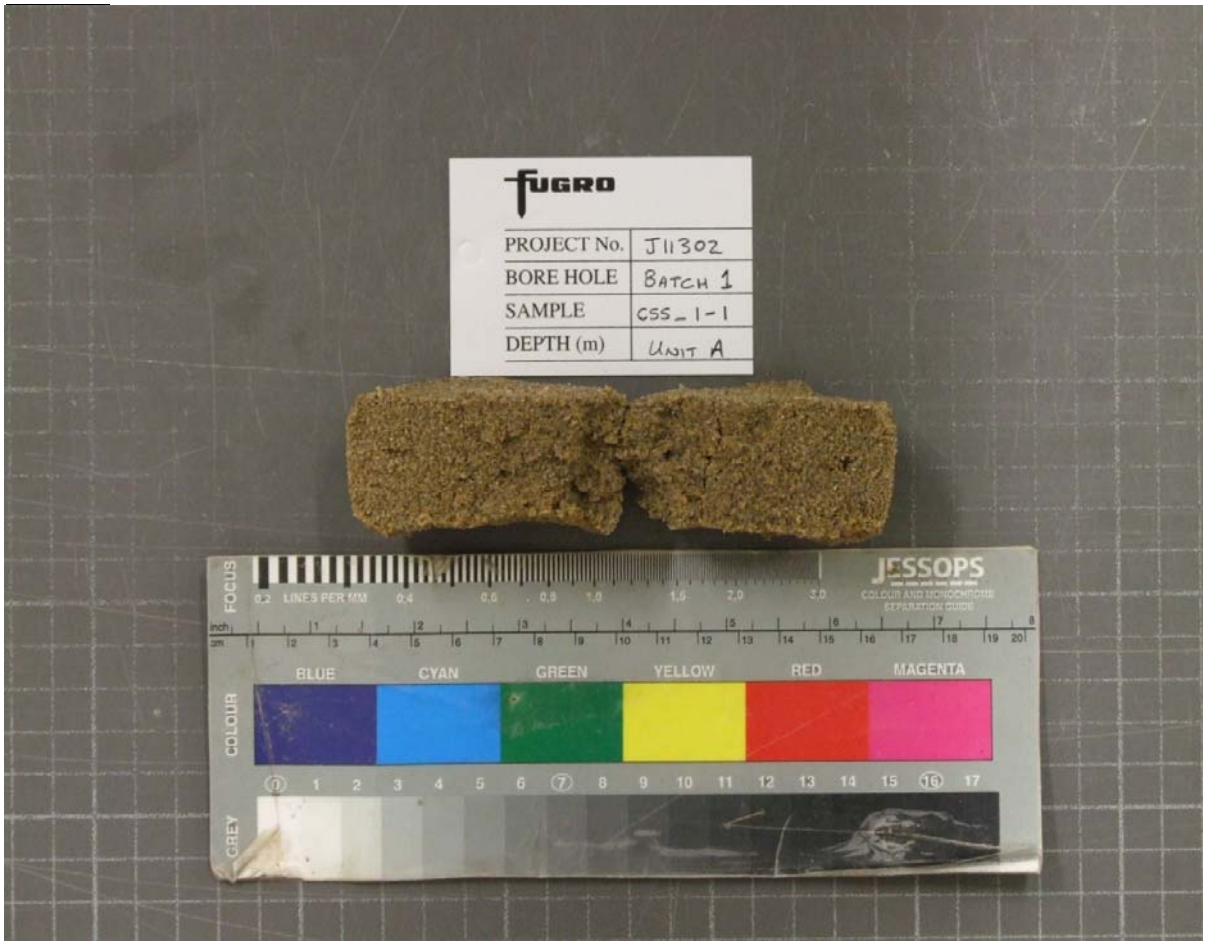
SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	209
Shear strain	[%]	29.30
Shear induced $-\Delta\sigma_v$	[kPa]	-341
Vertical stress	[kPa]	366
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.99
At 15 % shear strain		
Shear stress	[kPa]	134
Shear induced $-\Delta\sigma_v$	[kPa]	-207
Vertical stress	[kPa]	232
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-1
Unit	A (Southern Bight)
Test number	CSS11

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

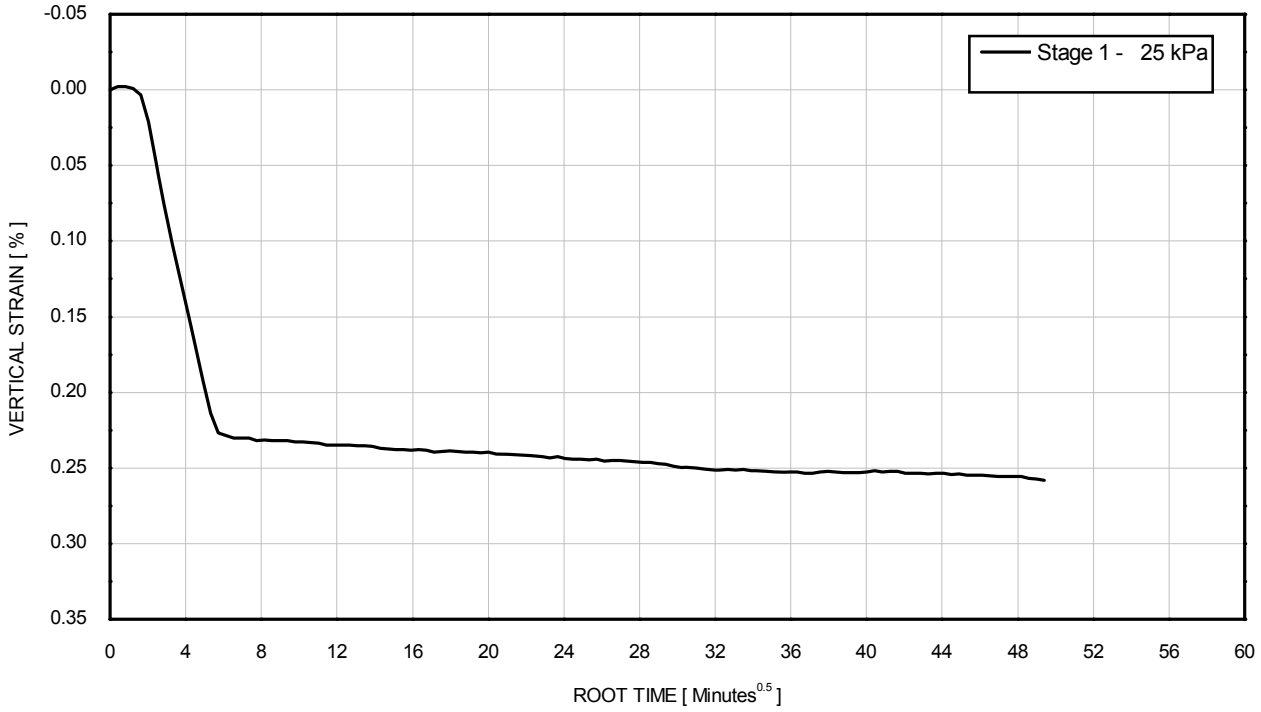
SPECIMEN PHOTOGRAPH

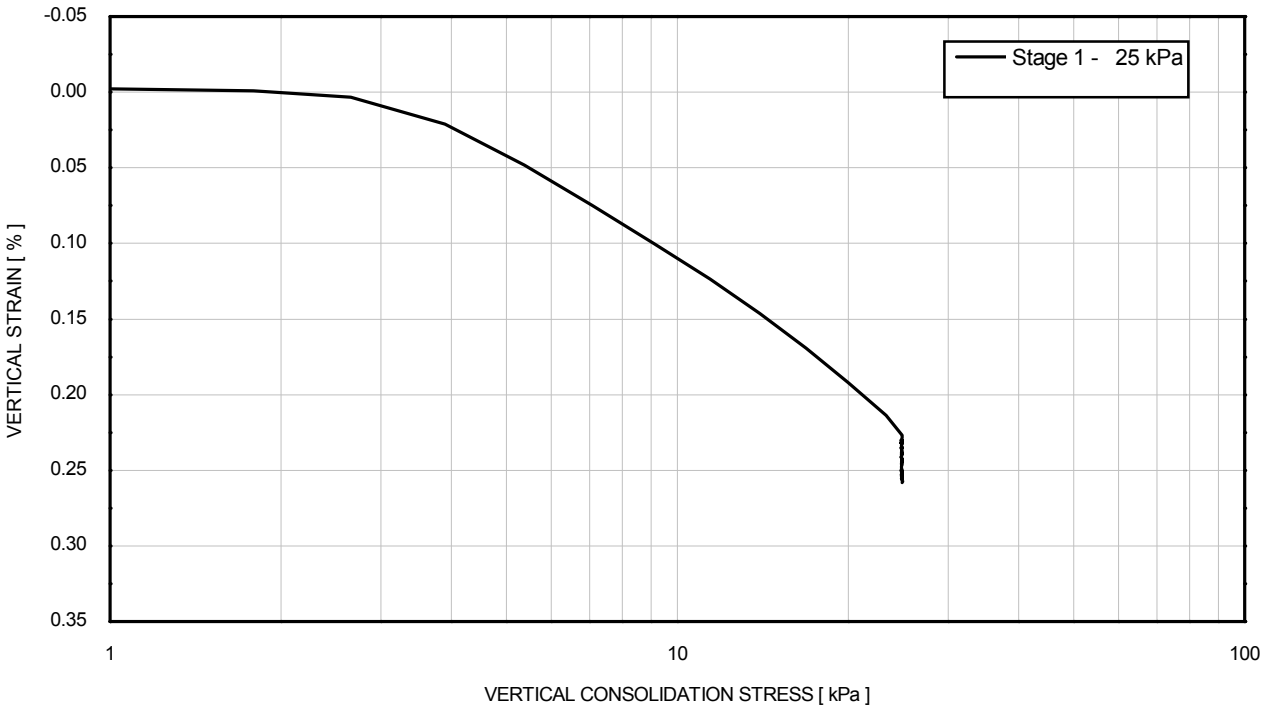


TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-1
Unit	A (Southern Bight)
Test number	CSS11

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

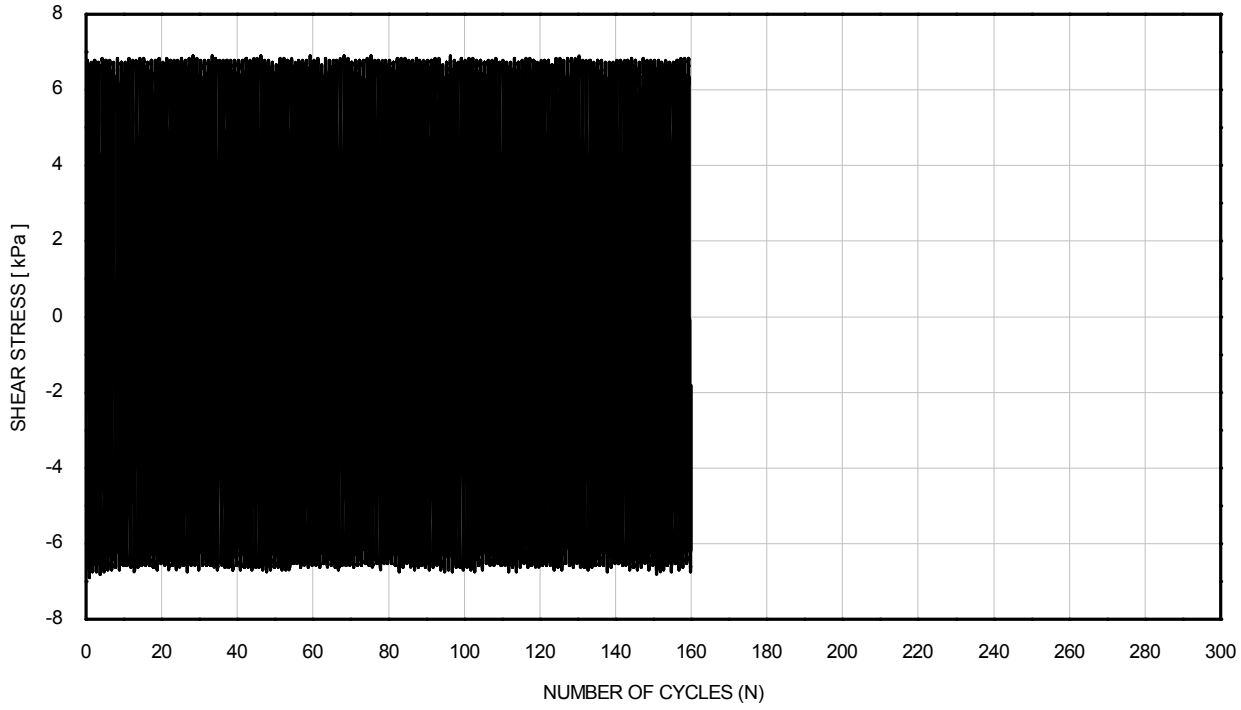


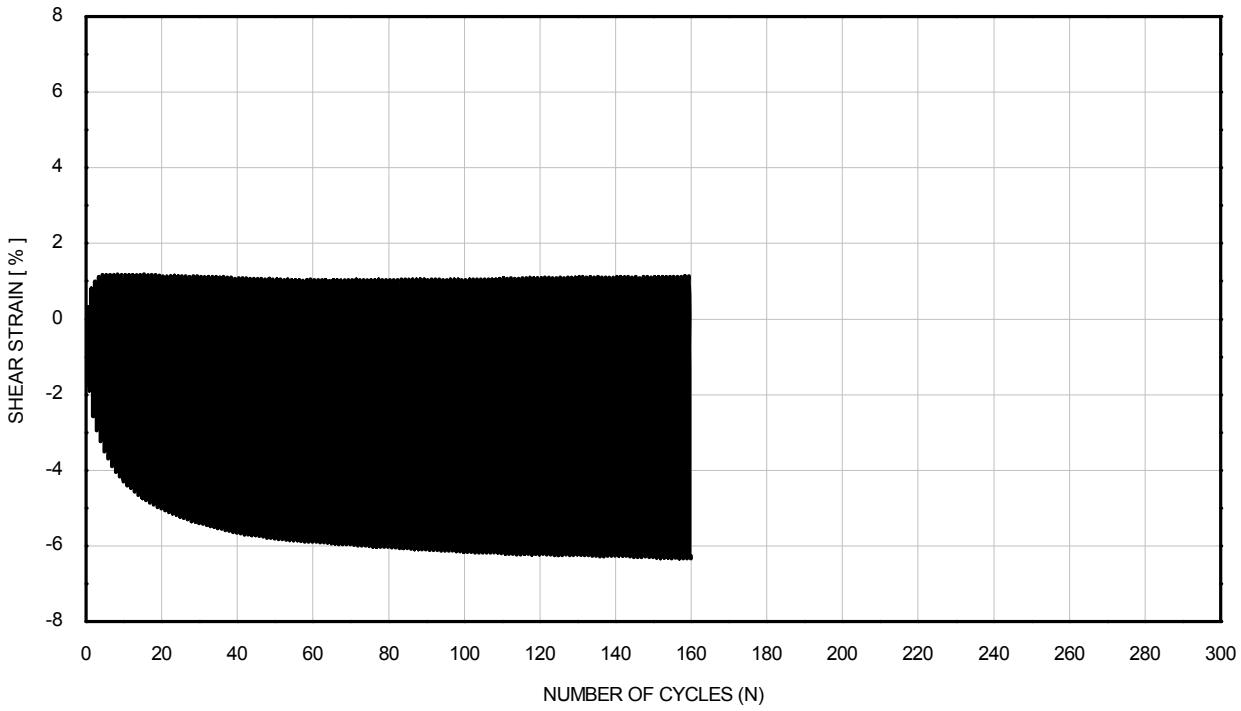


σ_{vc}	: 25 kPa	Batch	: 1
		Sample	: CSS_1-1
		Unit:	: A (Southern Bight)
		Test No.	: CSS11

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

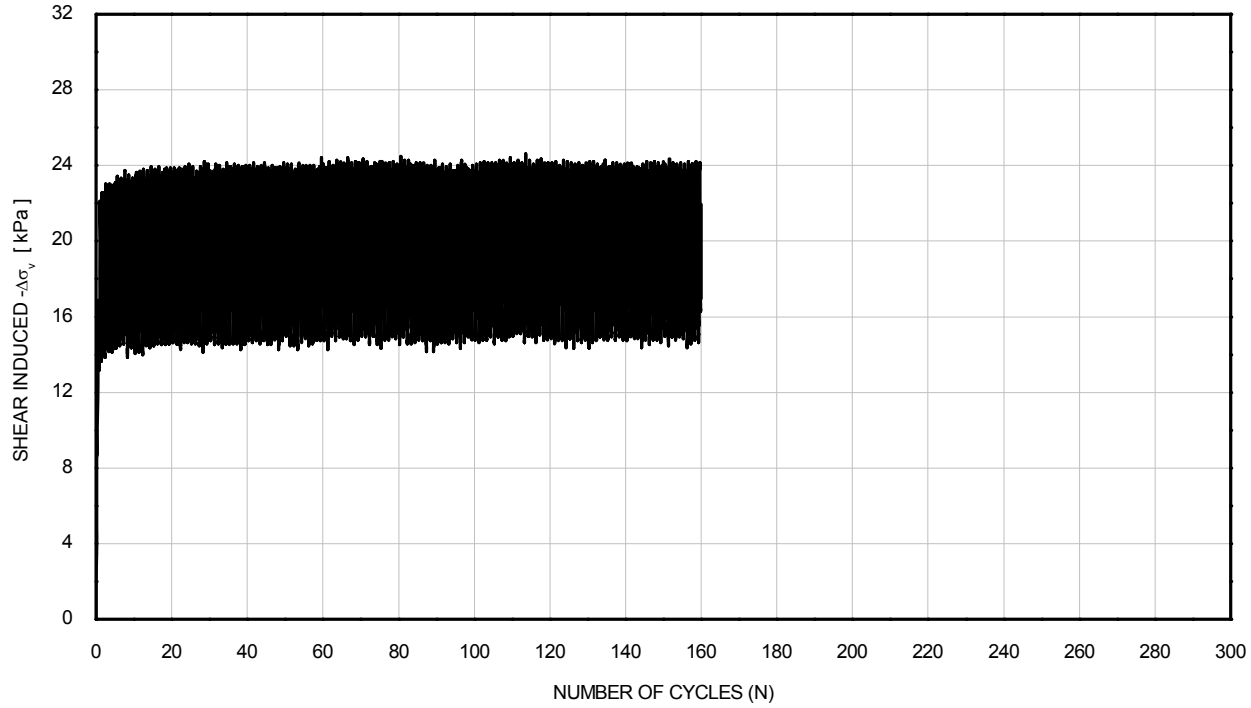


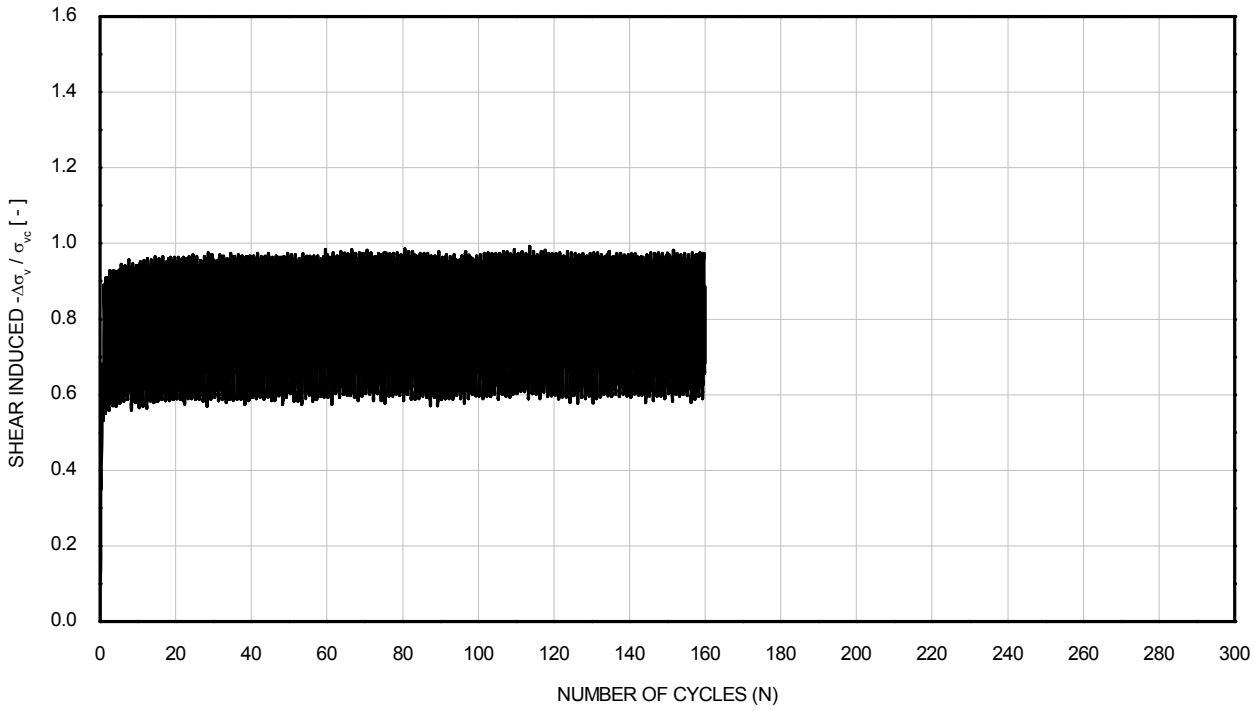


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-1
Mean τ_{cy}	:	7 kPa	Unit:	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS11

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

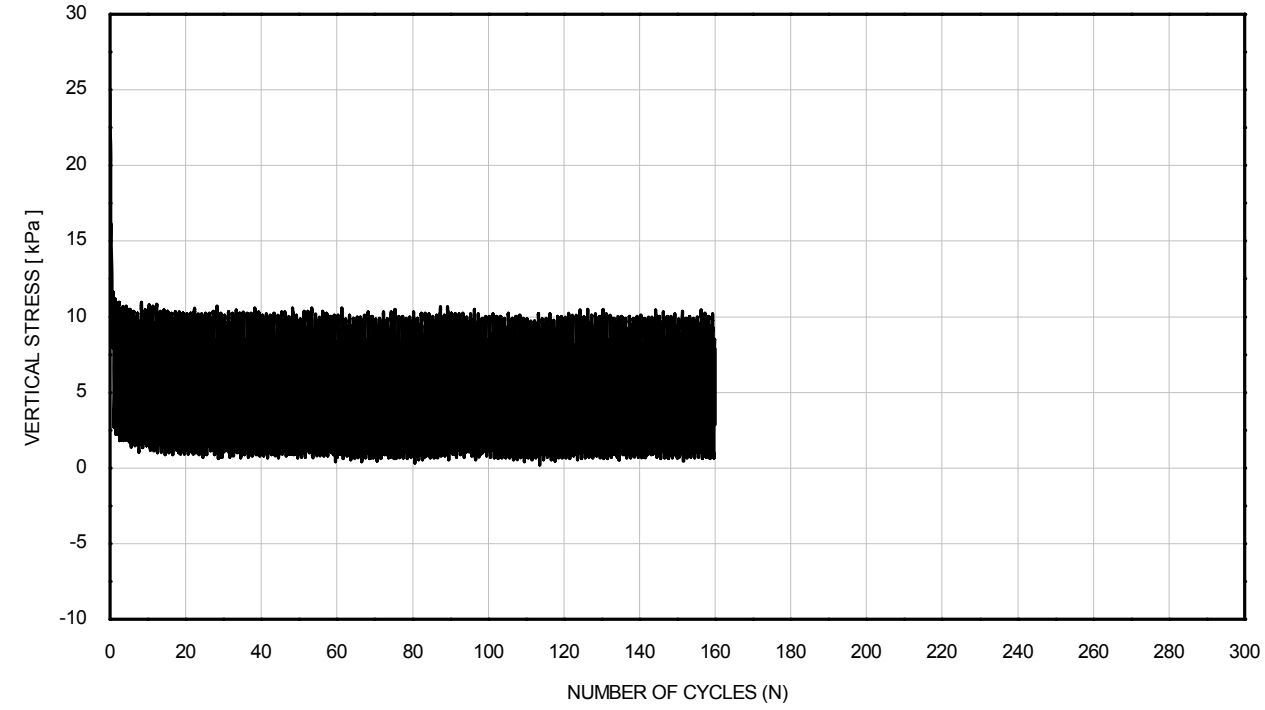


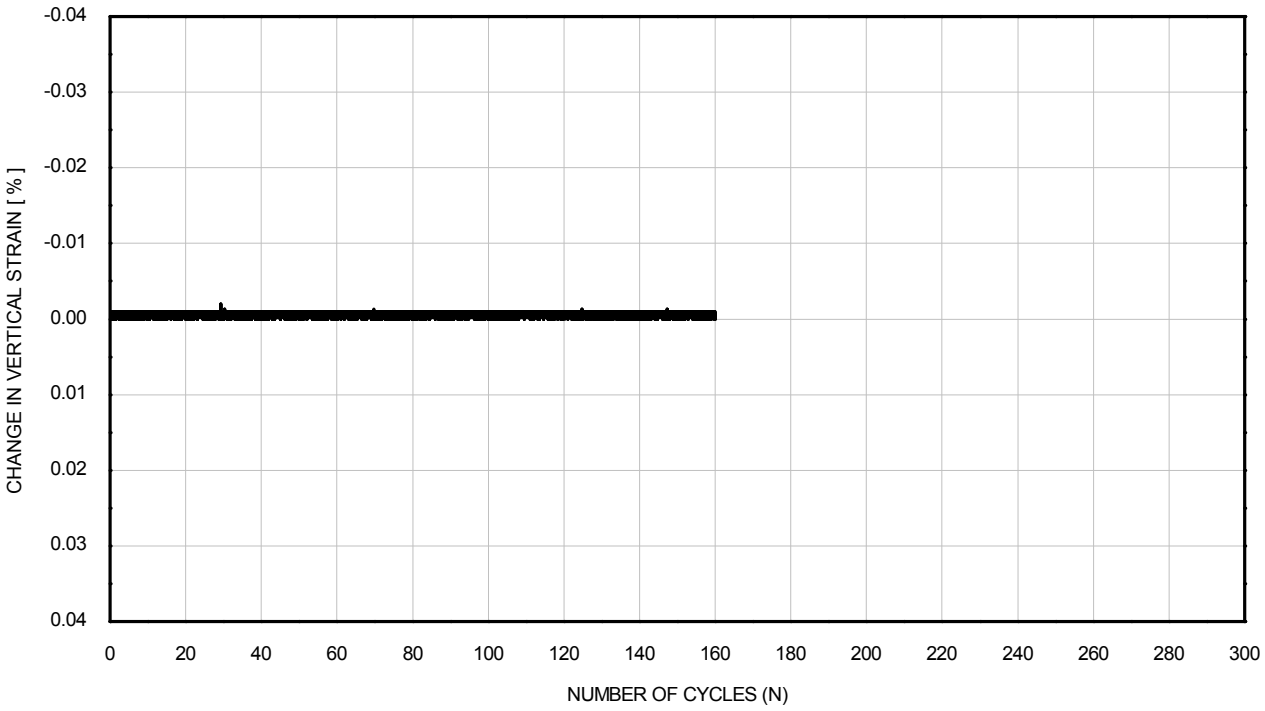


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-1
Mean τ_{cy}	:	7 kPa	Unit:	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS11

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

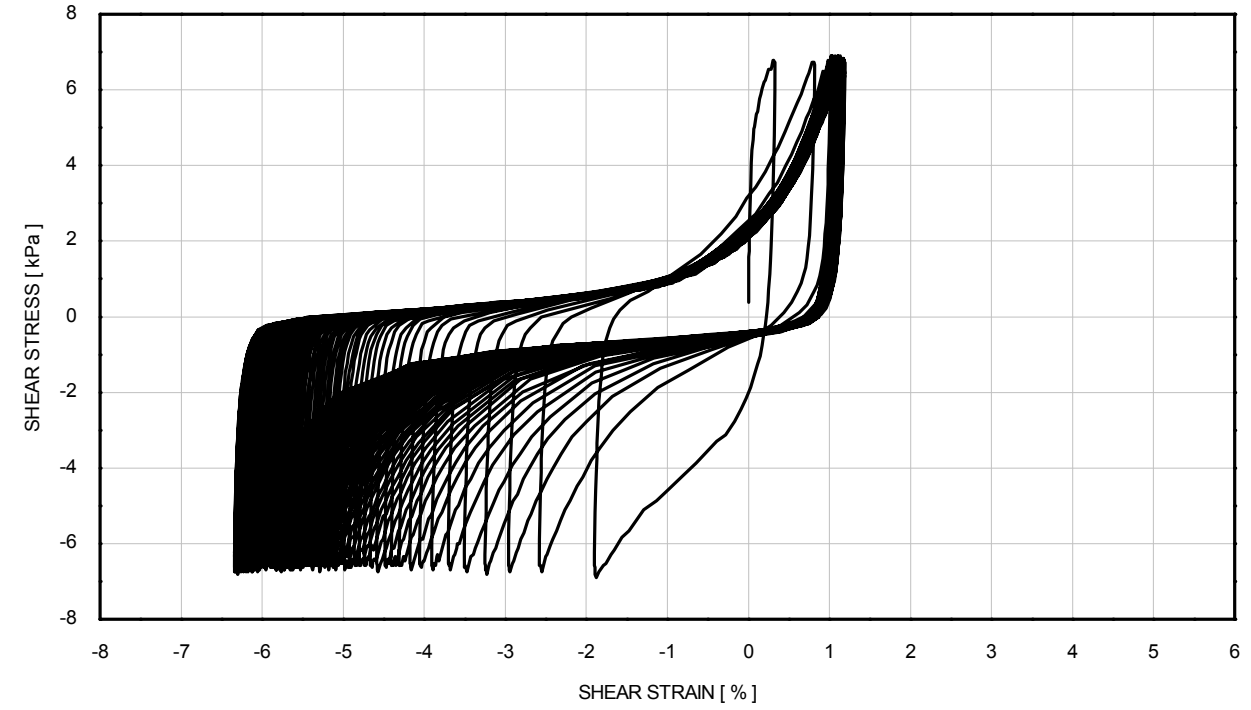


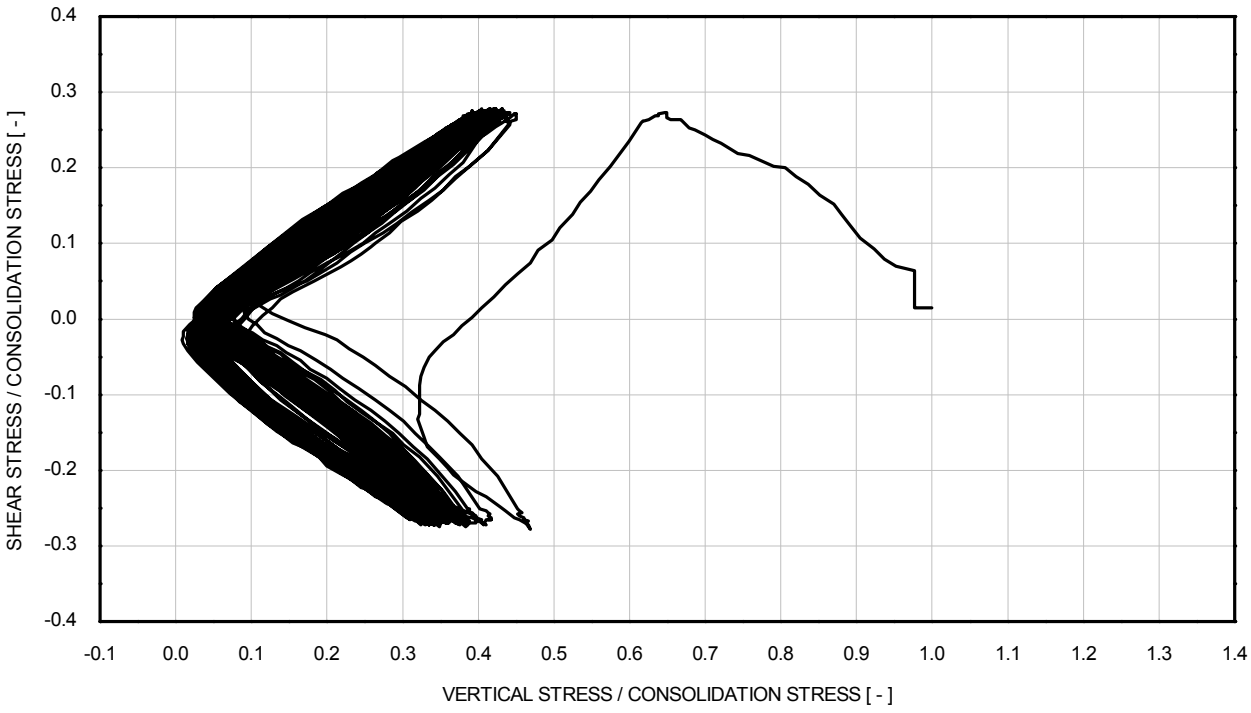


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-1
Mean τ_{cy}	:	7 kPa	Unit:	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS11

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

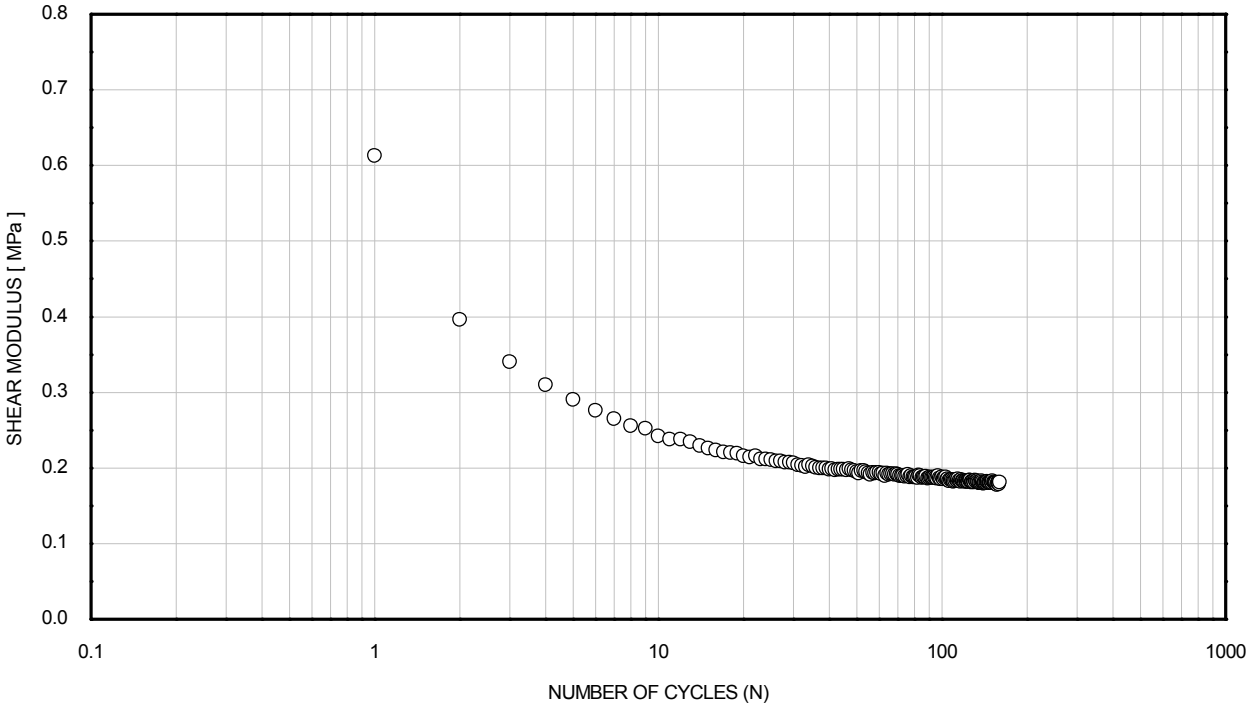


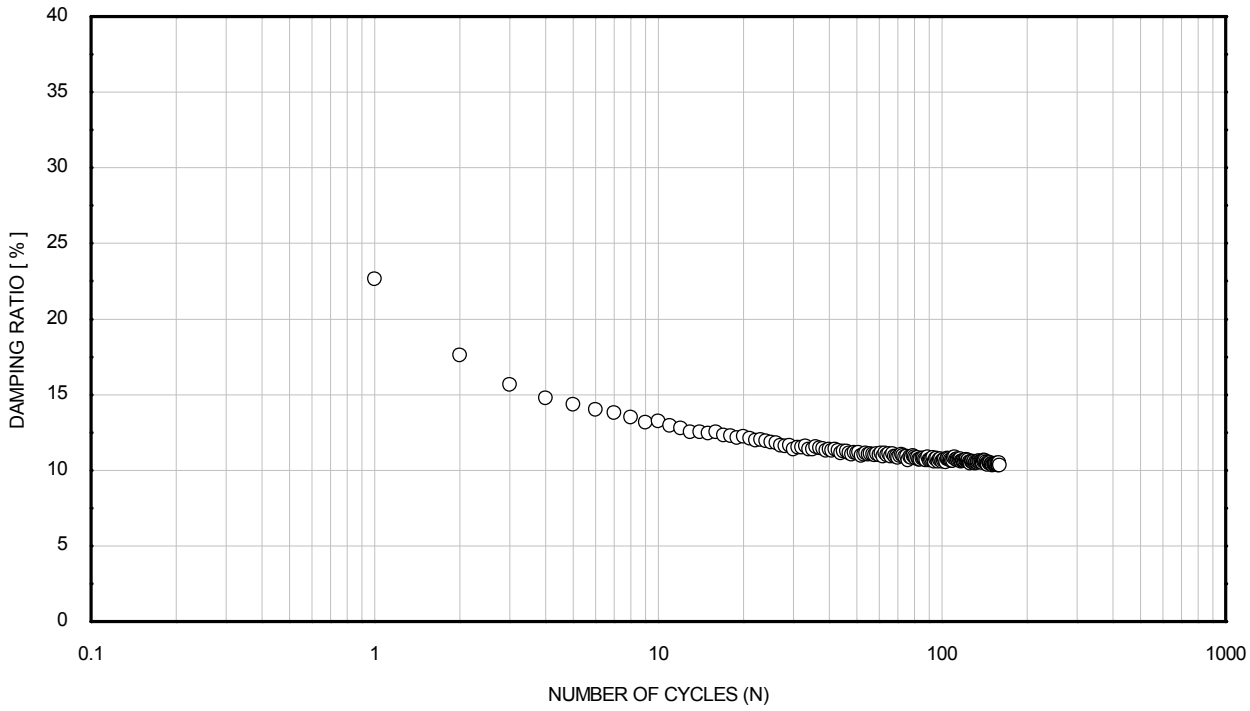


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-1
Mean τ_{cy}	:	7 kPa	Unit:	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS11

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

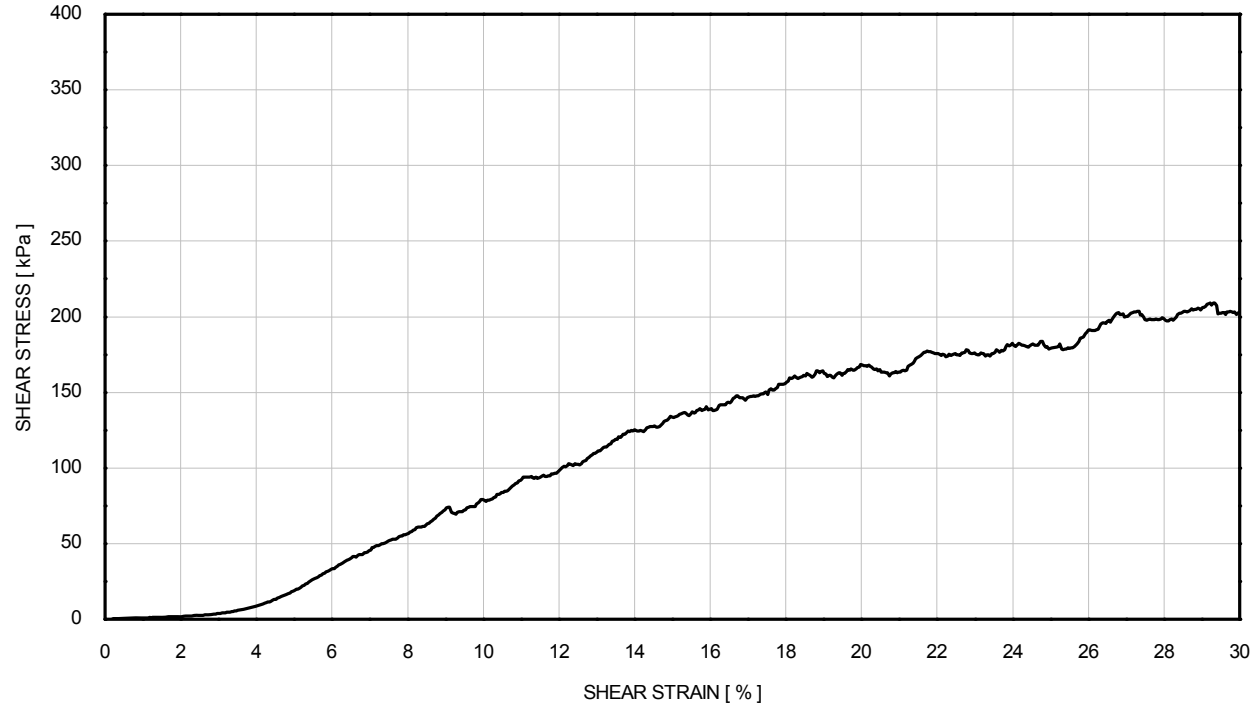


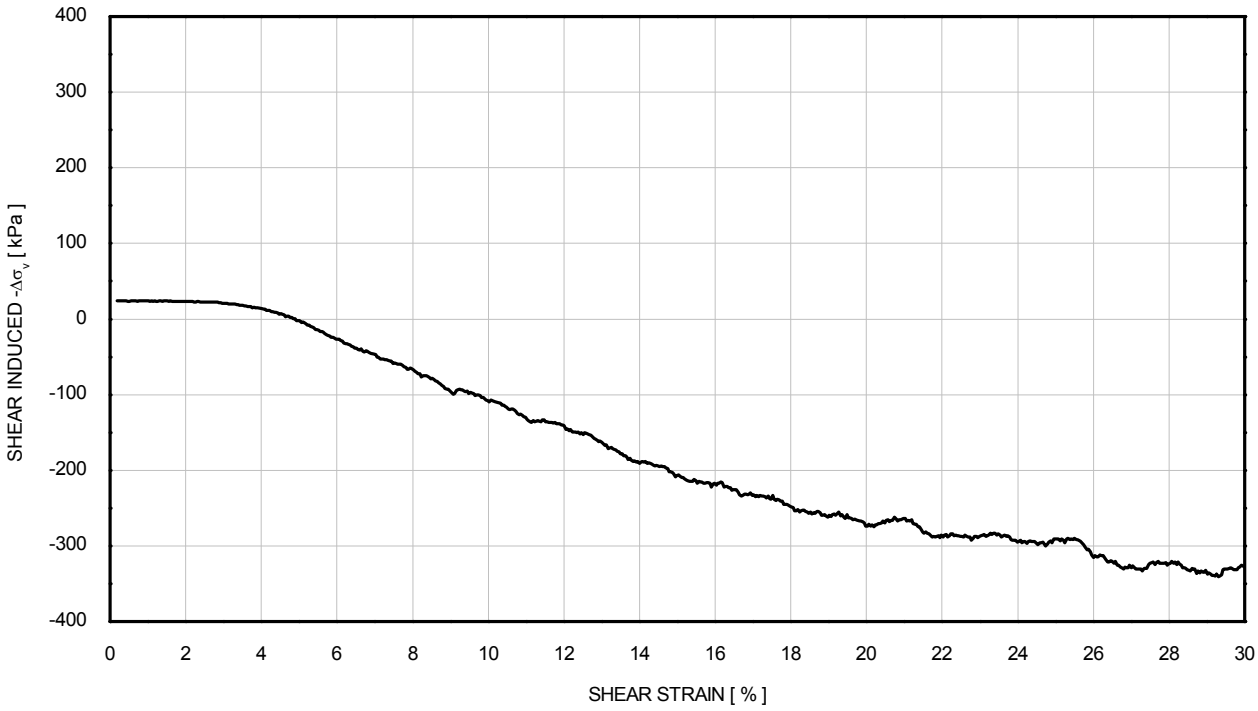


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-1
Mean τ_{cy}	:	7 kPa	Unit:	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS11

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

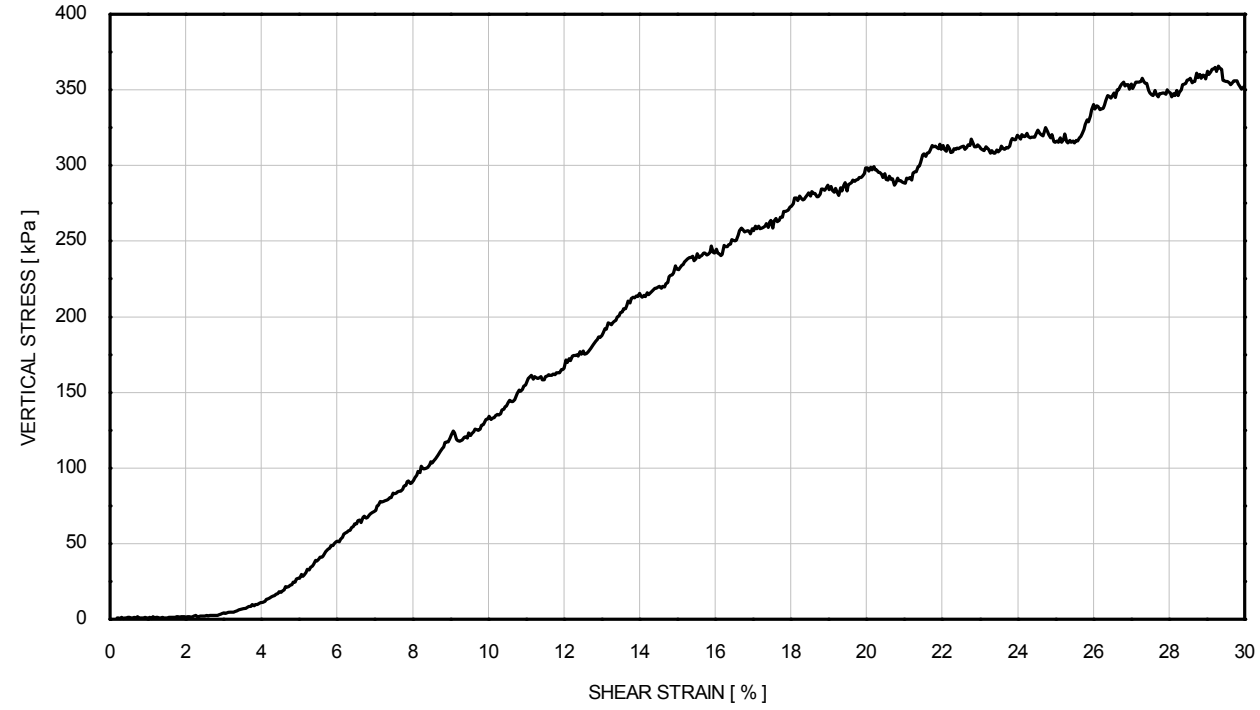


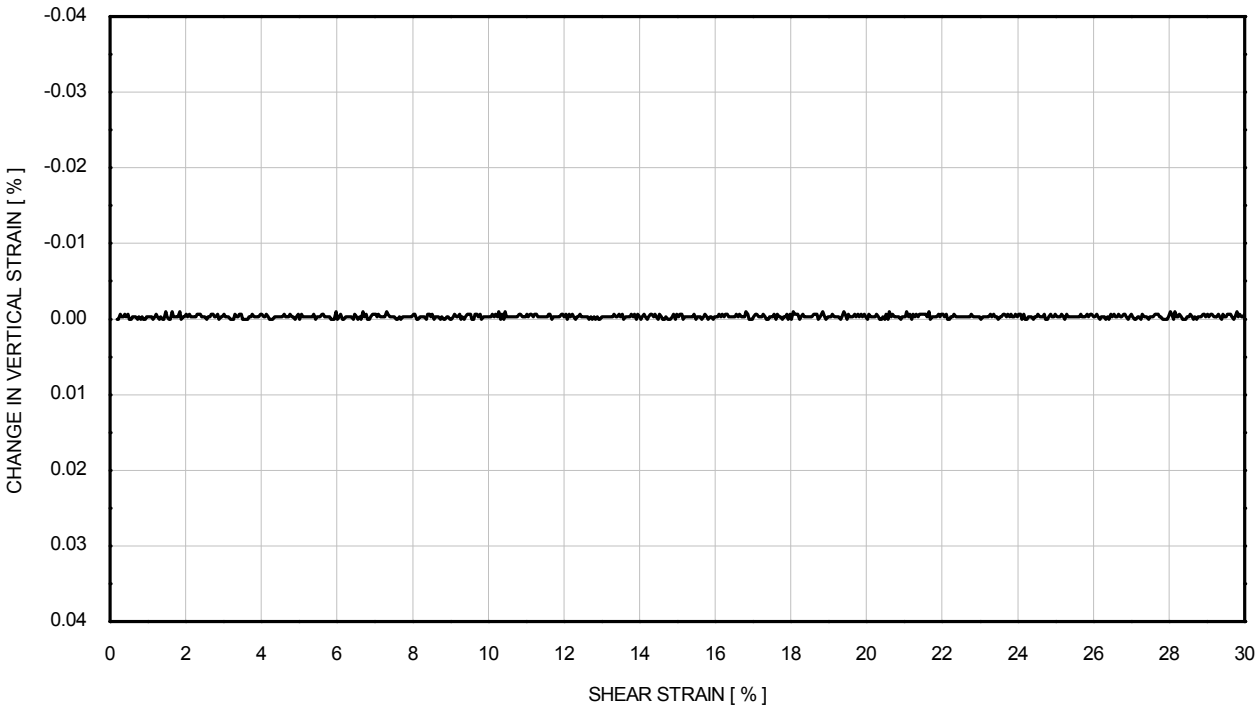


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 209 kPa	Sample	: CSS_1-1
γ at τ_{peak}	: 29.30 %	Unit:	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS11

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

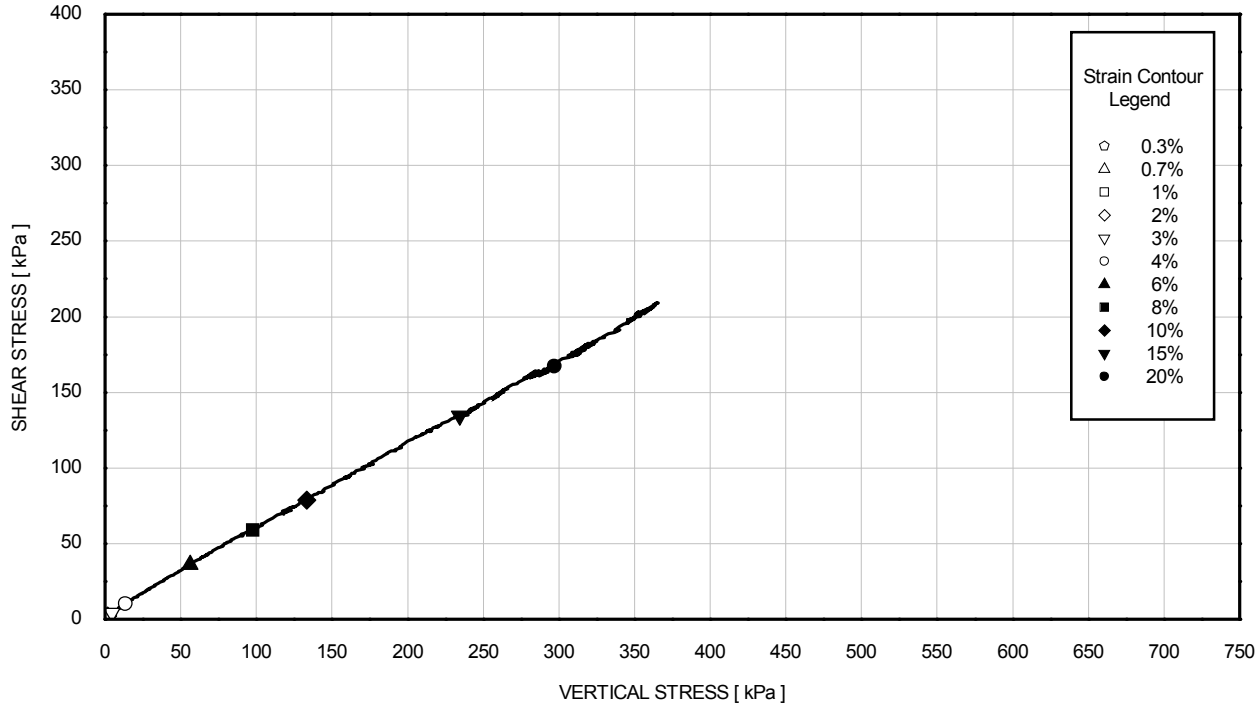


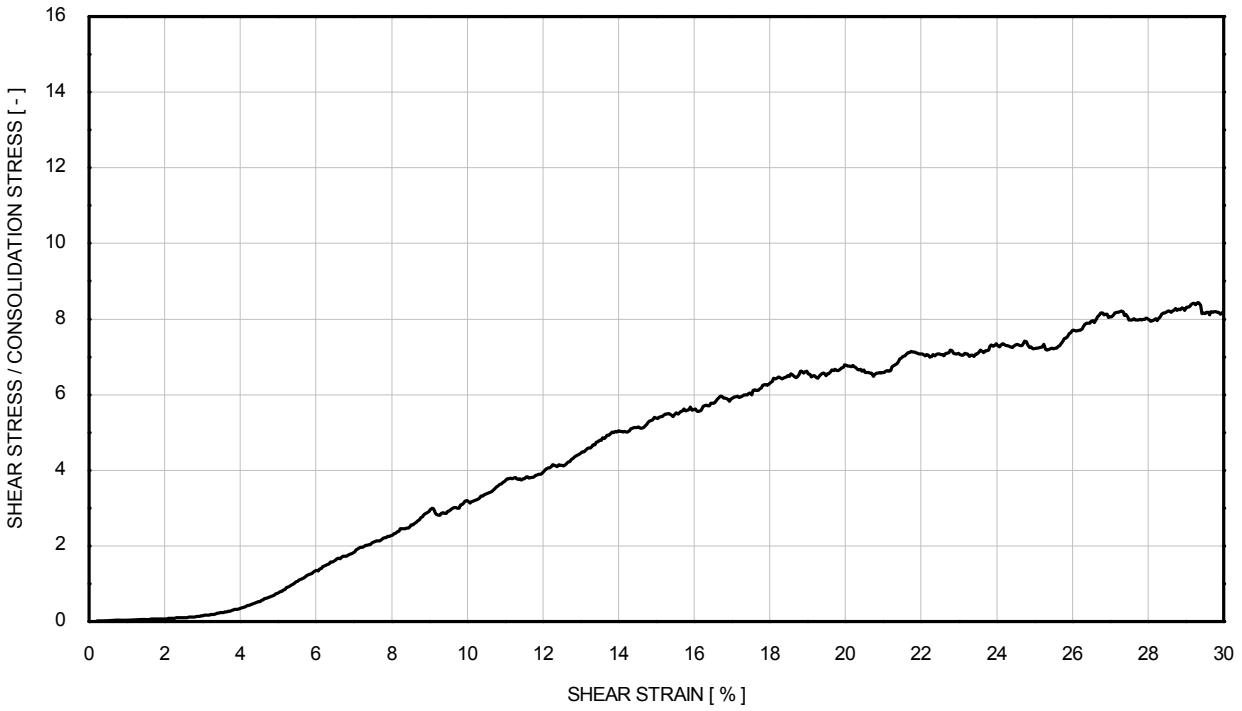


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 209 kPa	Sample	: CSS_1-1
γ at τ_{peak}	: 29.30 %	Unit:	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS11

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

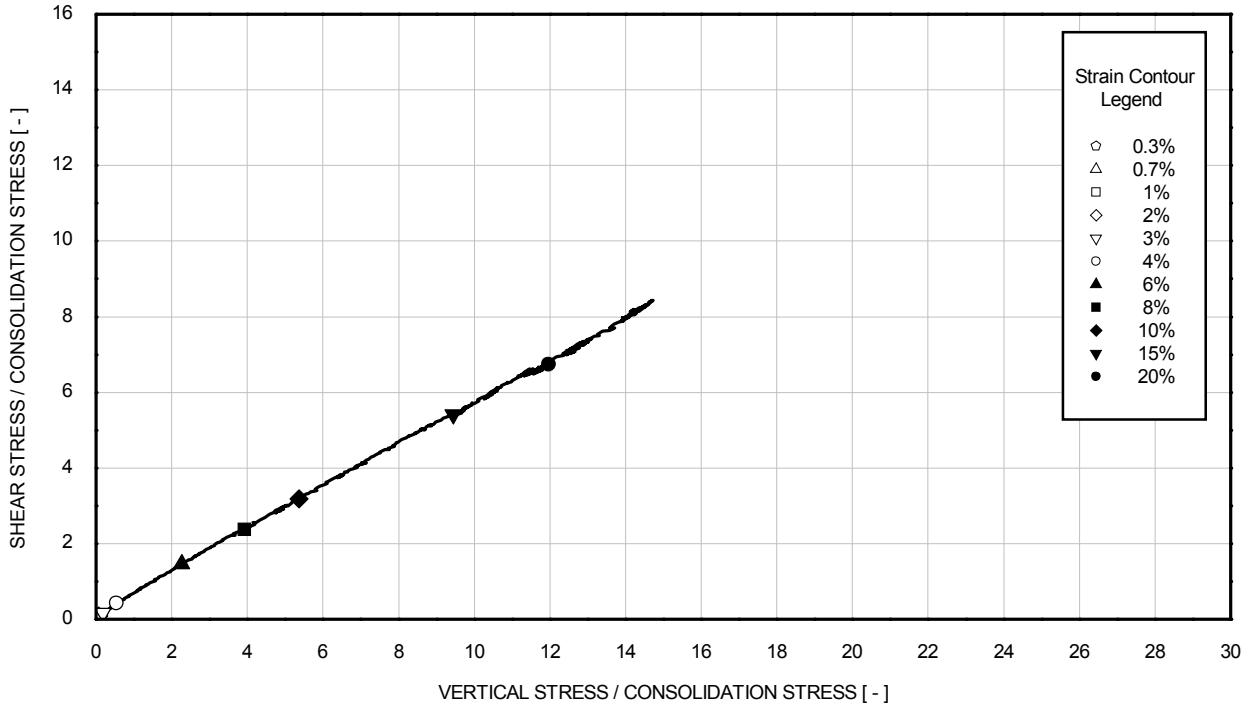


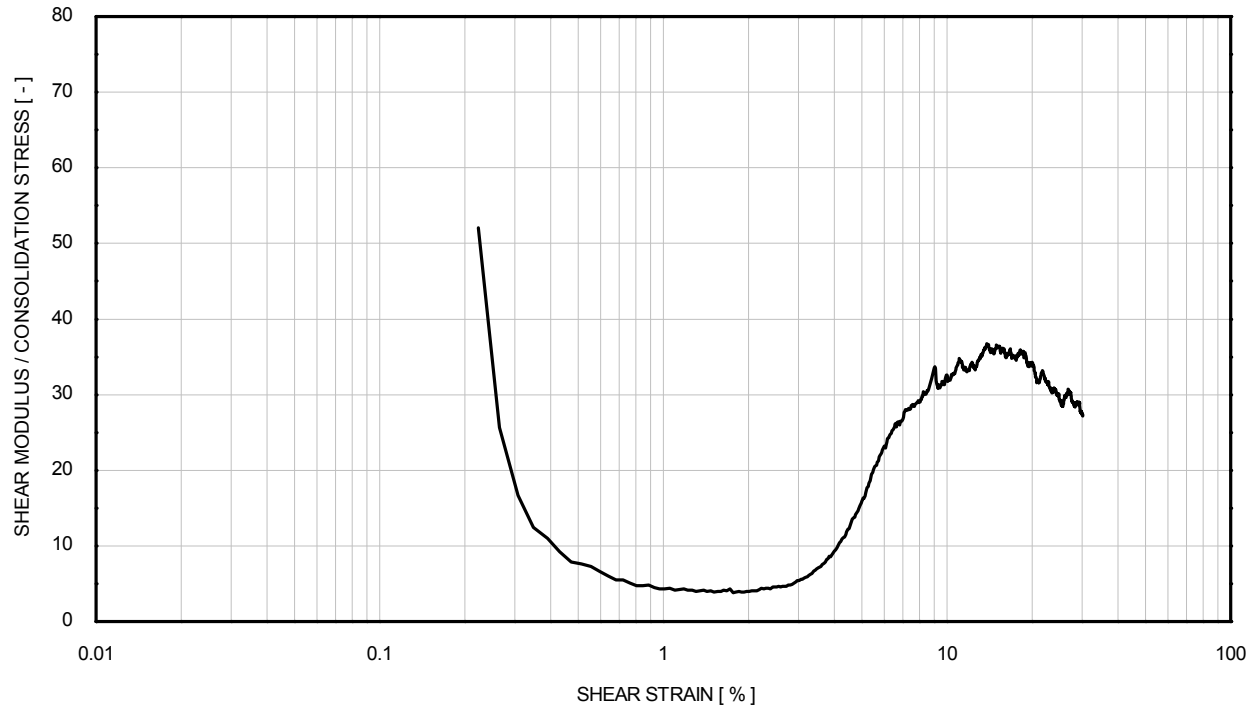


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 209 kPa	Sample	: CSS_1-1
γ at τ_{peak}	: 29.30 %	Unit:	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS11

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 209 kPa	Sample	: CSS_1-1
γ at τ_{peak}	: 29.30 %	Unit:	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS11

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	13/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.3
Length	[mm]	30.0
Moisture content after compaction	[%]	11.0
Bulk density after compaction	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.640
Degree of saturation after compaction	[%]	45
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.2
Bulk density at start of test	[Mg/m³]	2.01
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07

Note:
Vertical stress / vertical strain refers to the directionality of load application within the equipment

QUALITY ASSURANCE	
Filename	J11302 \ Batch 1_CSS 1-2_CSS12
Template issue	1.3
Processed by	HJ
Date	18/02/2016
Checked by	PH
Date	14/03/2016
Approved by	PH
Date	14/03/2016

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-2
Unit	A (Southern Bight)
Test number	CSS12

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	25
Vertical strain	[%]	0.30
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.62
Void ratio	[-]	0.635
Moisture content	[%]	24.0

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	25
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	9
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	10
γ_{av} at N_f	[%]	-0.18
γ_{cy} at N_f	[%]	3.68
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	13
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.11	1.83	0.50	25.11
2	-0.02	2.37	0.39	19.64
3	-0.01	2.69	0.34	18.25
4	-0.03	2.92	0.32	17.67
5	-0.05	3.11	0.30	17.26
6	-0.08	3.25	0.28	16.82
7	-0.11	3.38	0.27	16.71
8	-0.12	3.49	0.26	16.31
9	-0.14	3.59	0.26	16.24
10	-0.18	3.68	0.25	15.94

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-2
Unit	A (Southern Bight)
Test number	CSS12

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

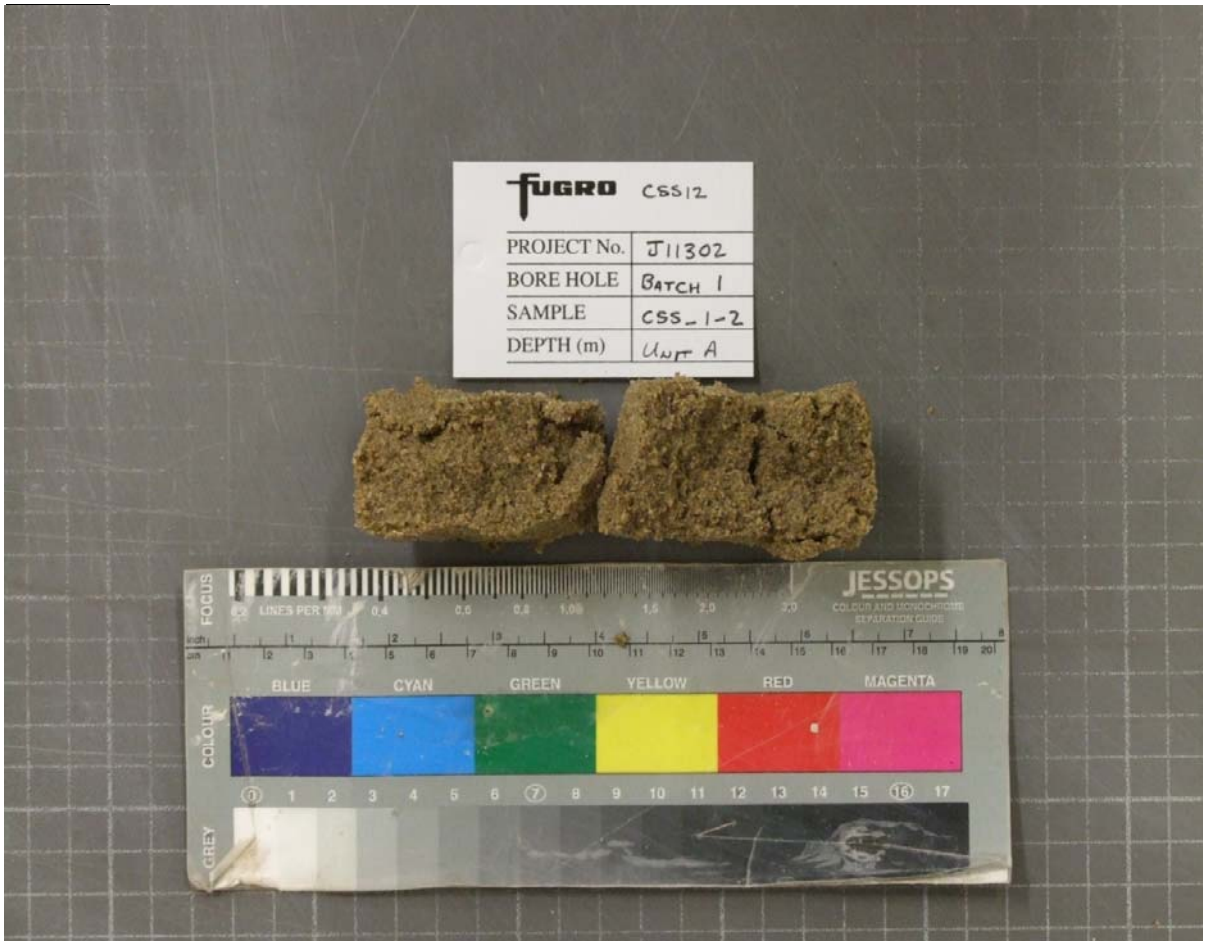
SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	834
Shear strain	[%]	28.60
Shear induced $-\Delta\sigma_v$	[kPa]	-1418
Vertical stress	[kPa]	1444
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.98
At 15 % shear strain		
Shear stress	[kPa]	381
Shear induced $-\Delta\sigma_v$	[kPa]	-607
Vertical stress	[kPa]	632
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-2
Unit	A (Southern Bight)
Test number	CSS12

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

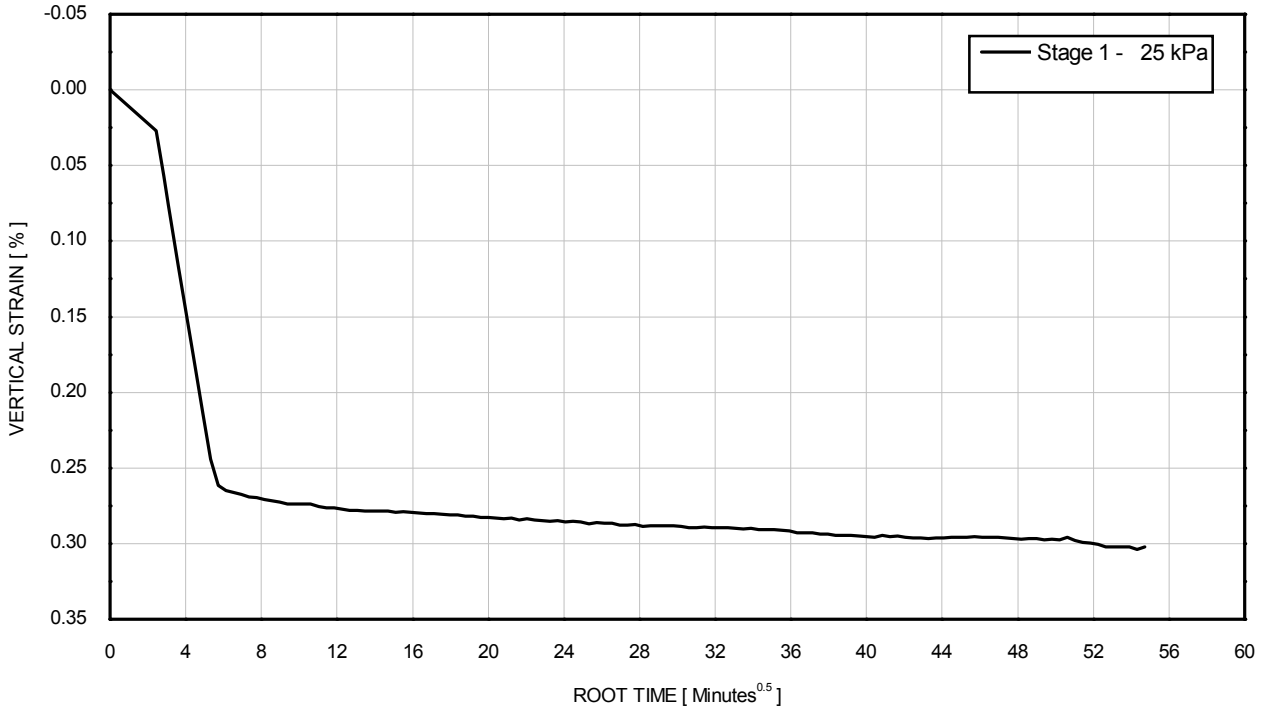
SPECIMEN PHOTOGRAPH

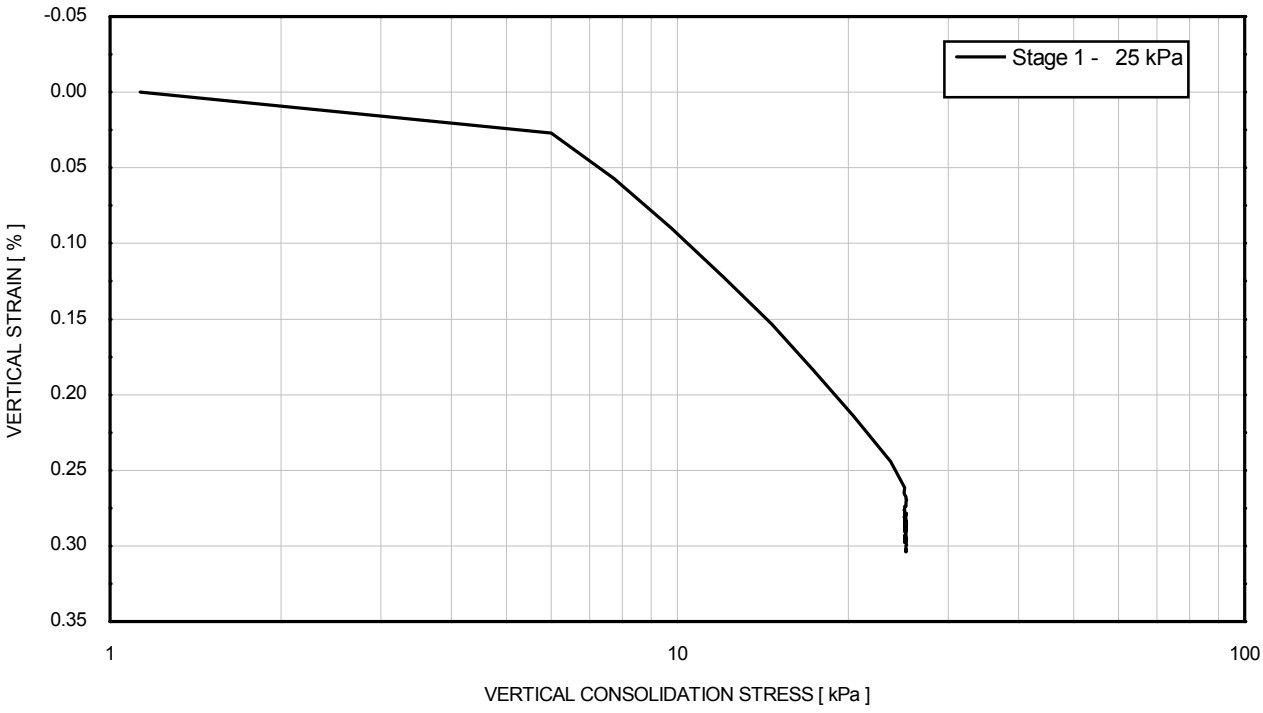


TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-2
Unit	A (Southern Bight)
Test number	CSS12

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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



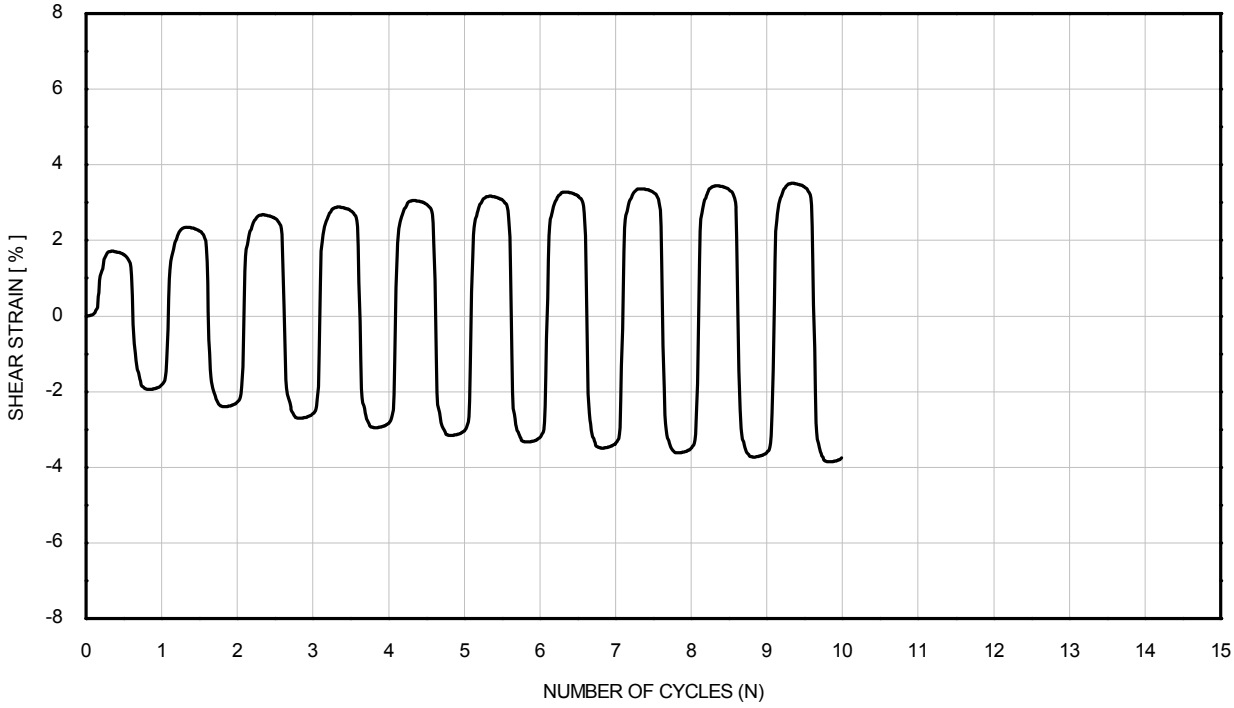


σ_{vc}	: 25 kPa	Batch	: 1
		Sample	: CSS_1-2
		Unit	: A (Southern Bight)
		Test No.	: CSS12

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

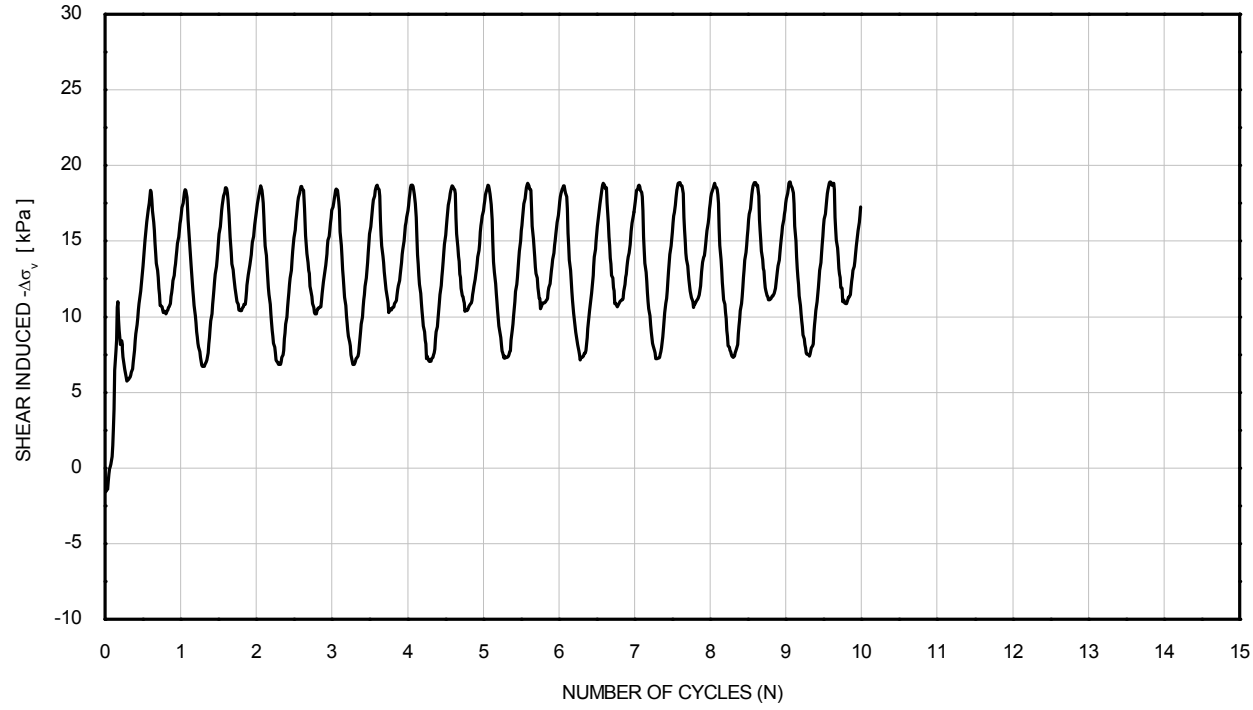


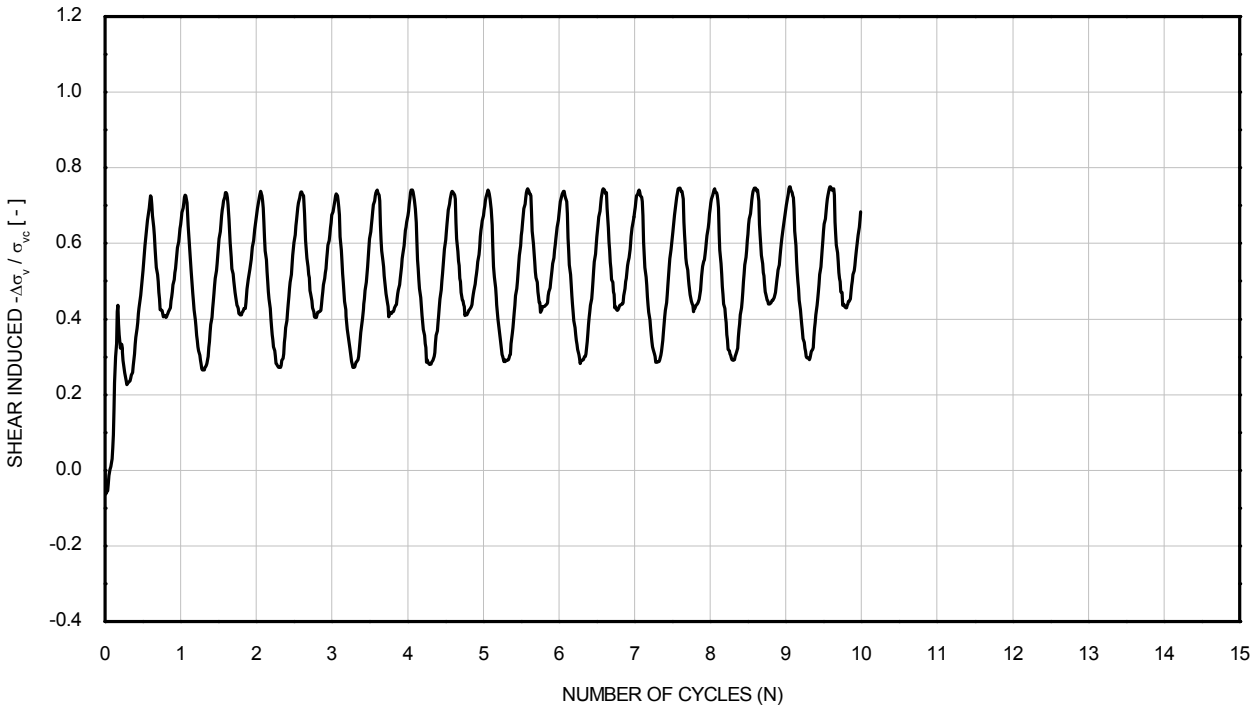


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-2
Mean τ_{cy}	:	9 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS12

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

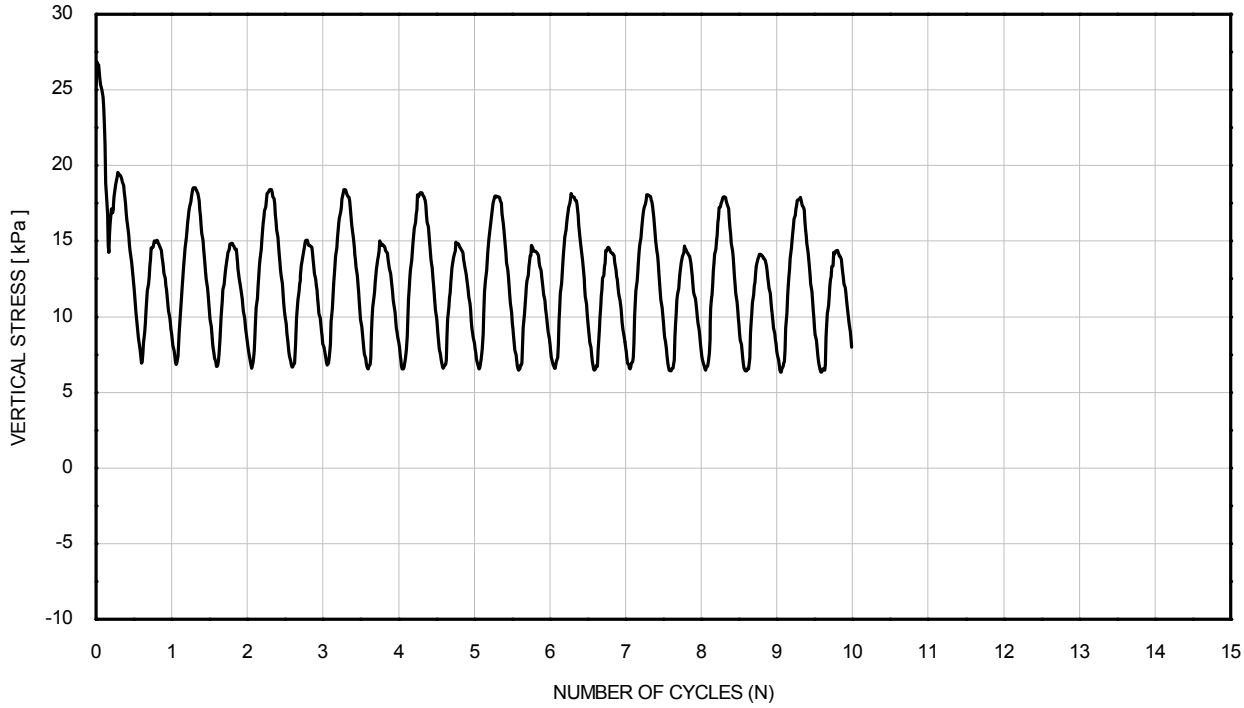


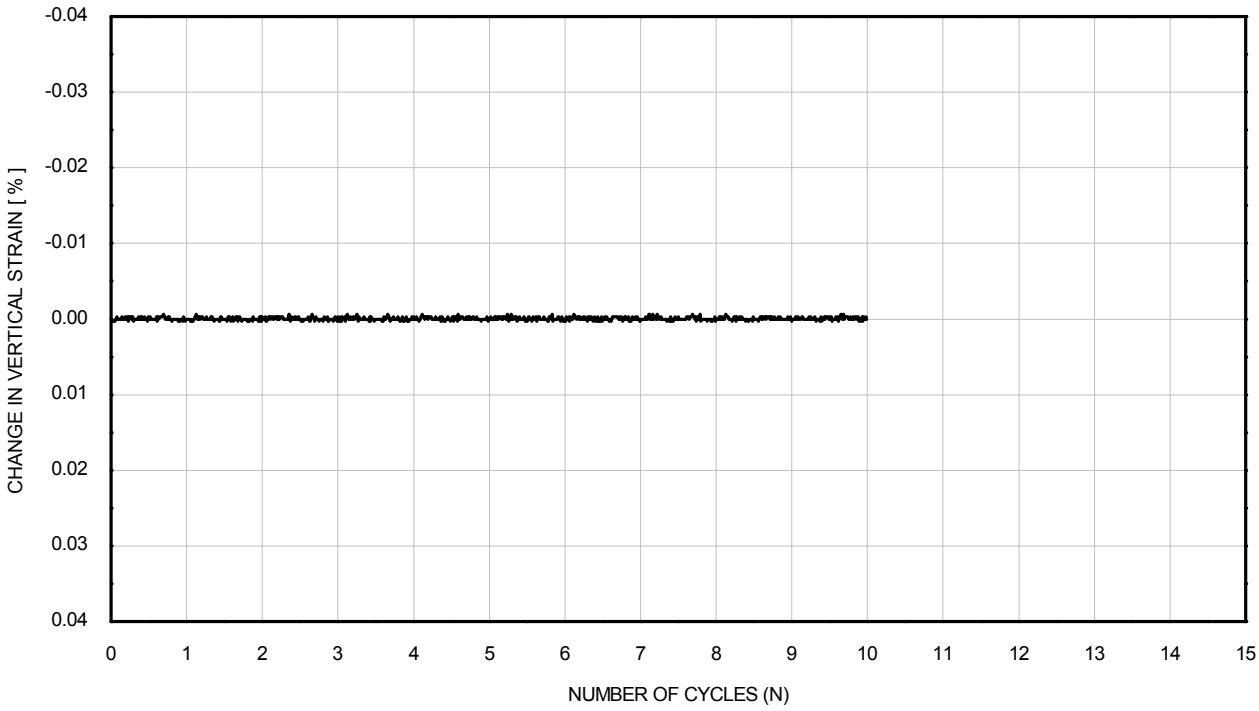


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-2
Mean τ_{cy}	:	9 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS12

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

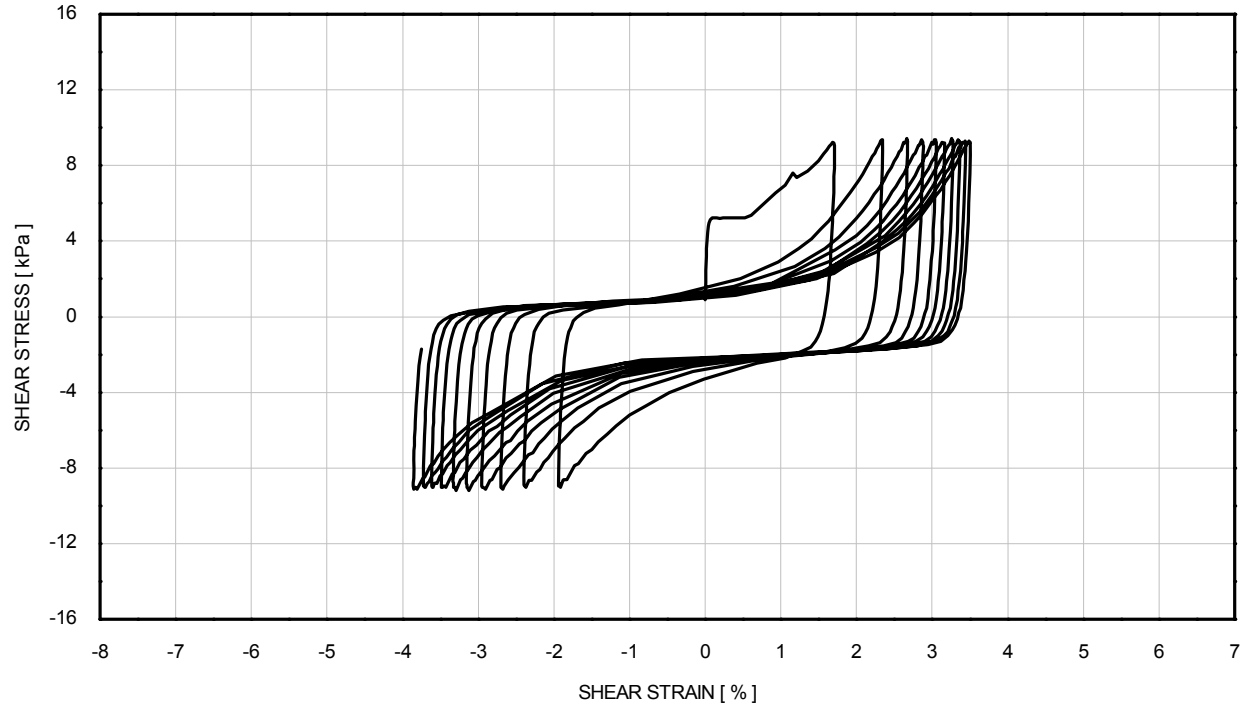


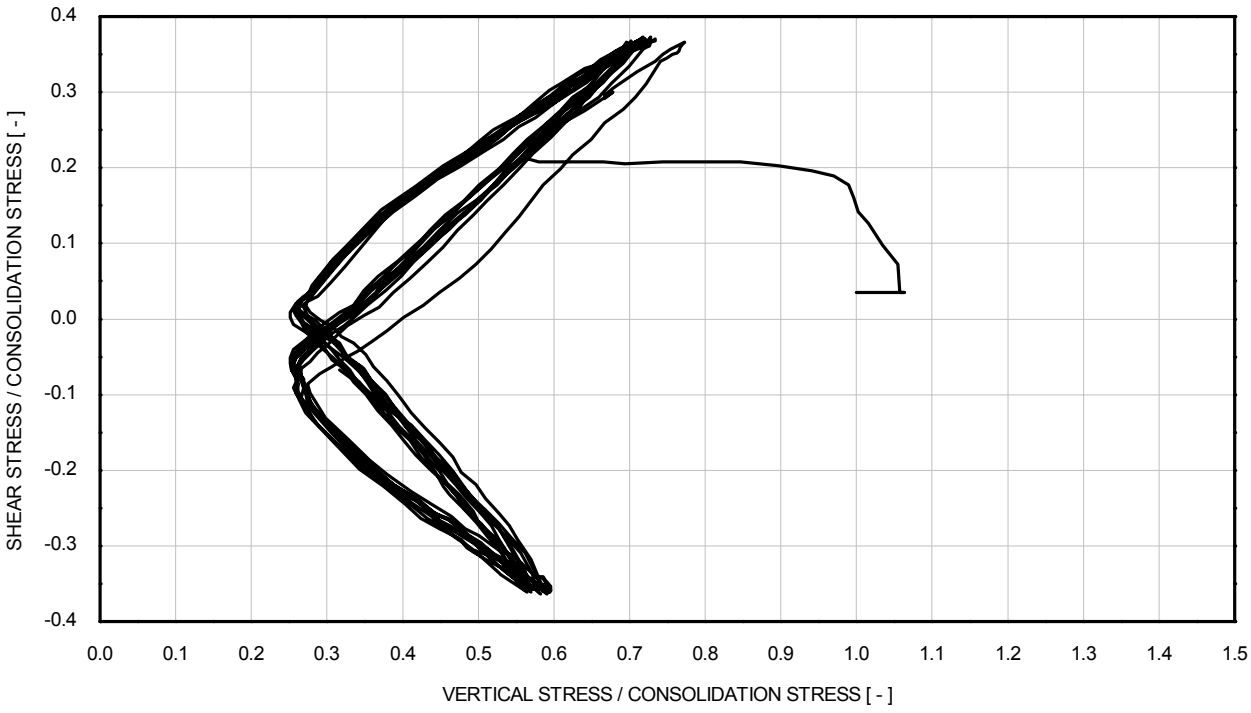


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-2
Mean τ_{cy}	:	9 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS12

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

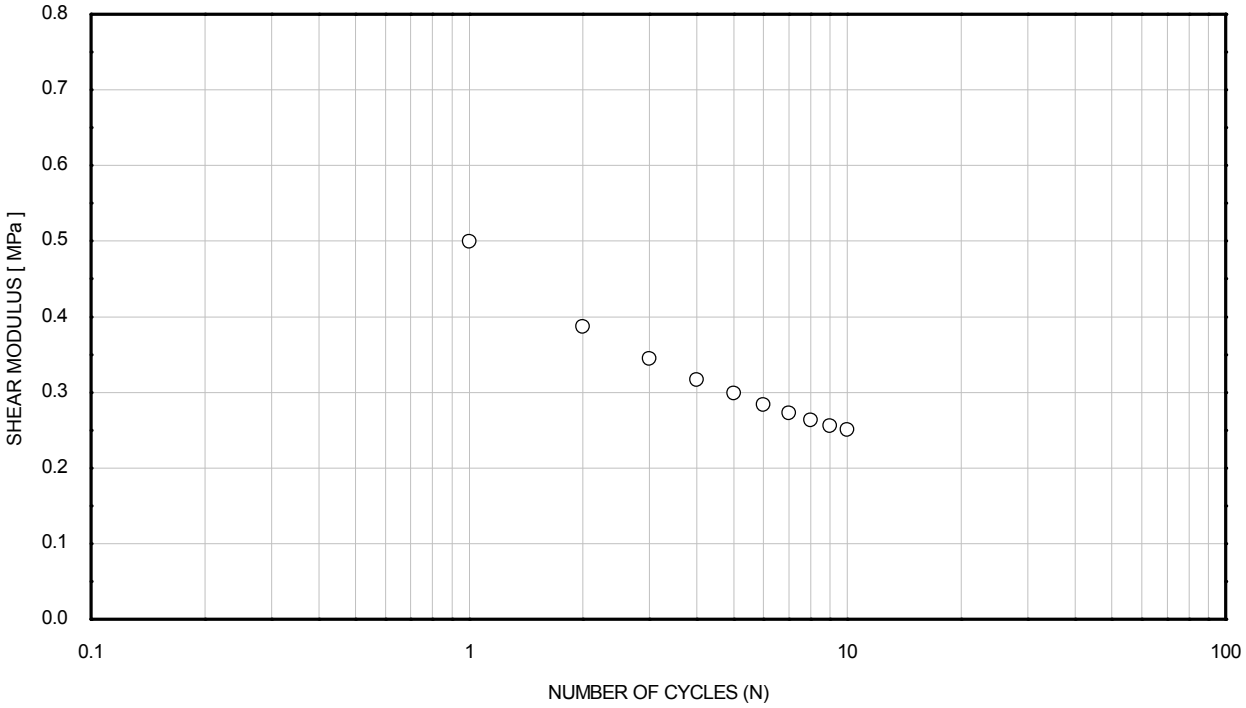


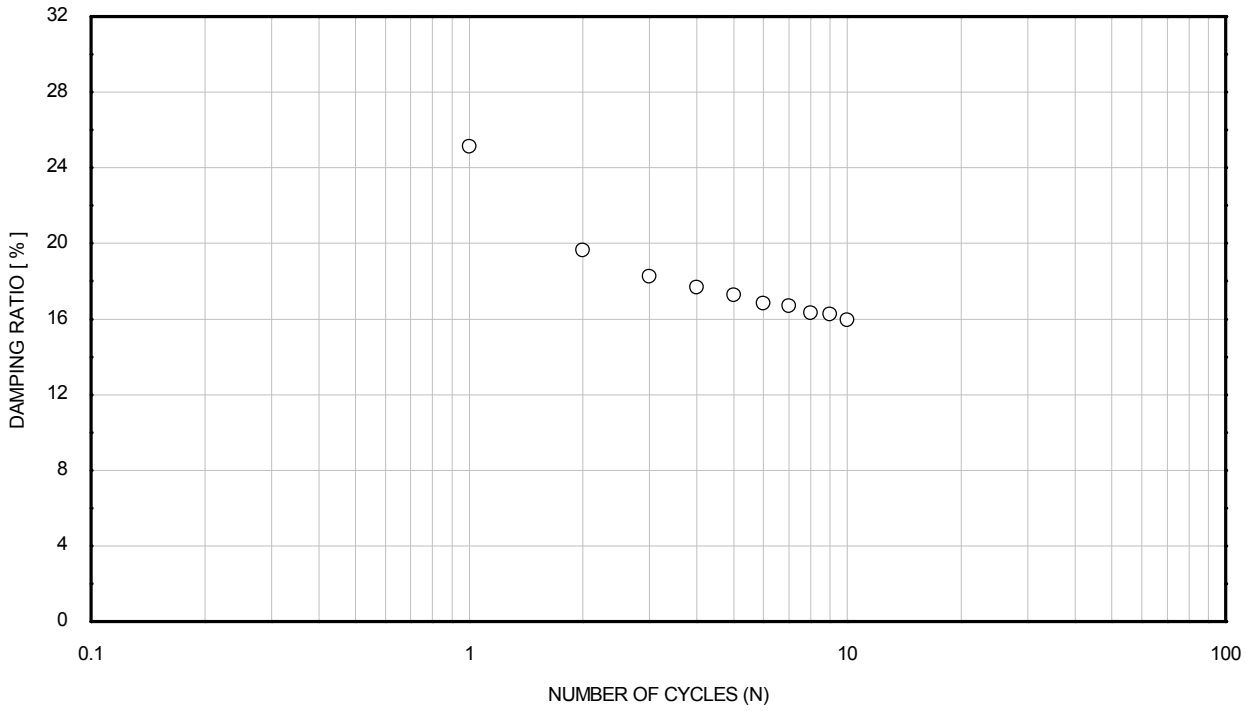


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-2
Mean τ_{cy}	:	9 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS12

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

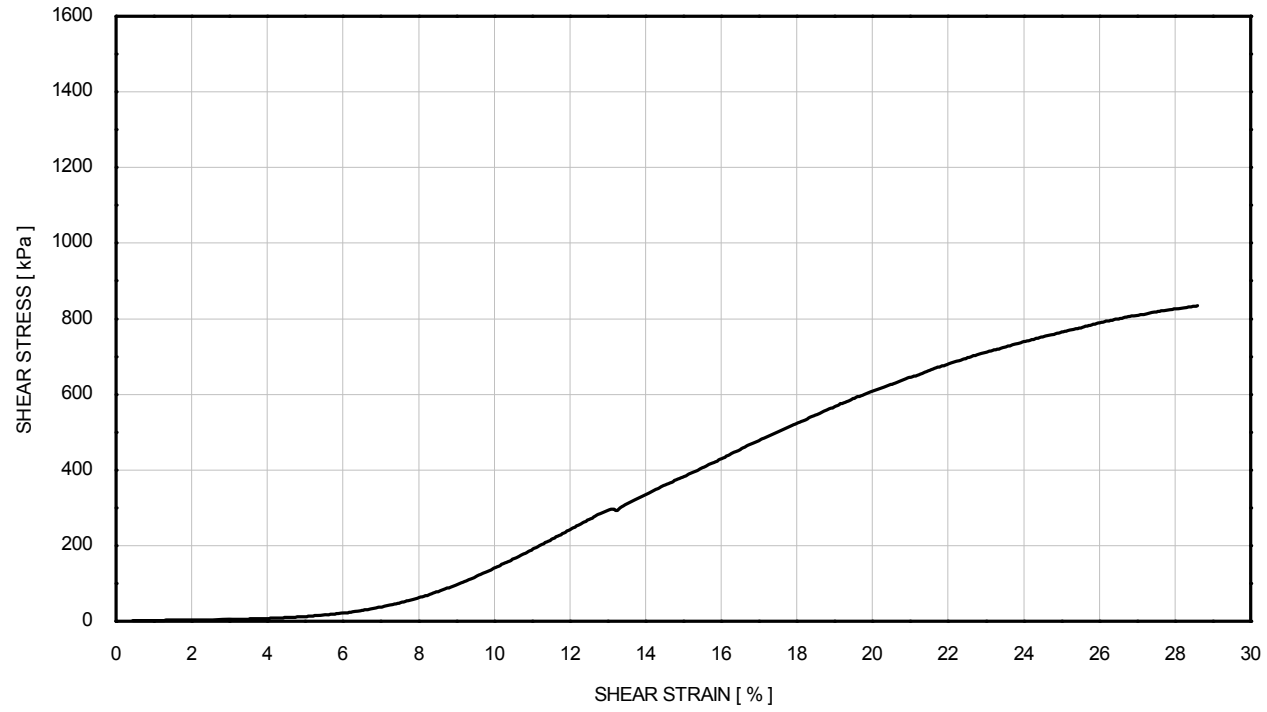


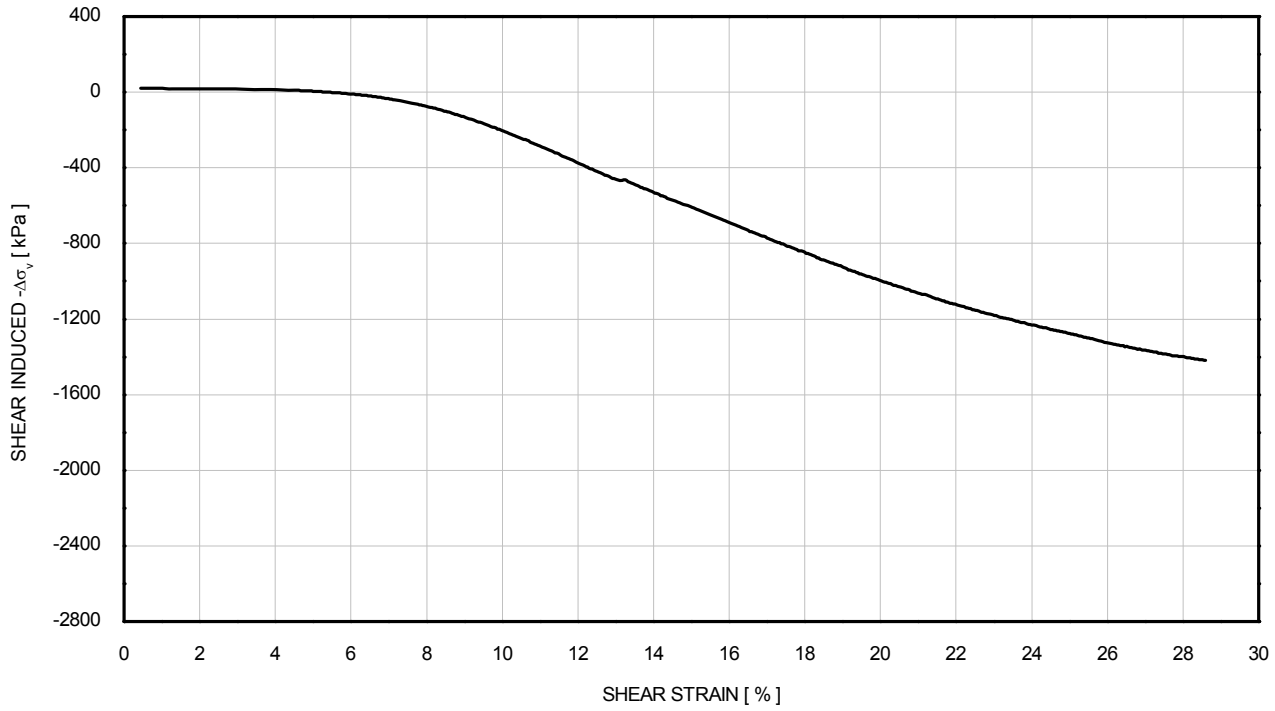


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-2
Mean τ_{cy}	:	9 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS12

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

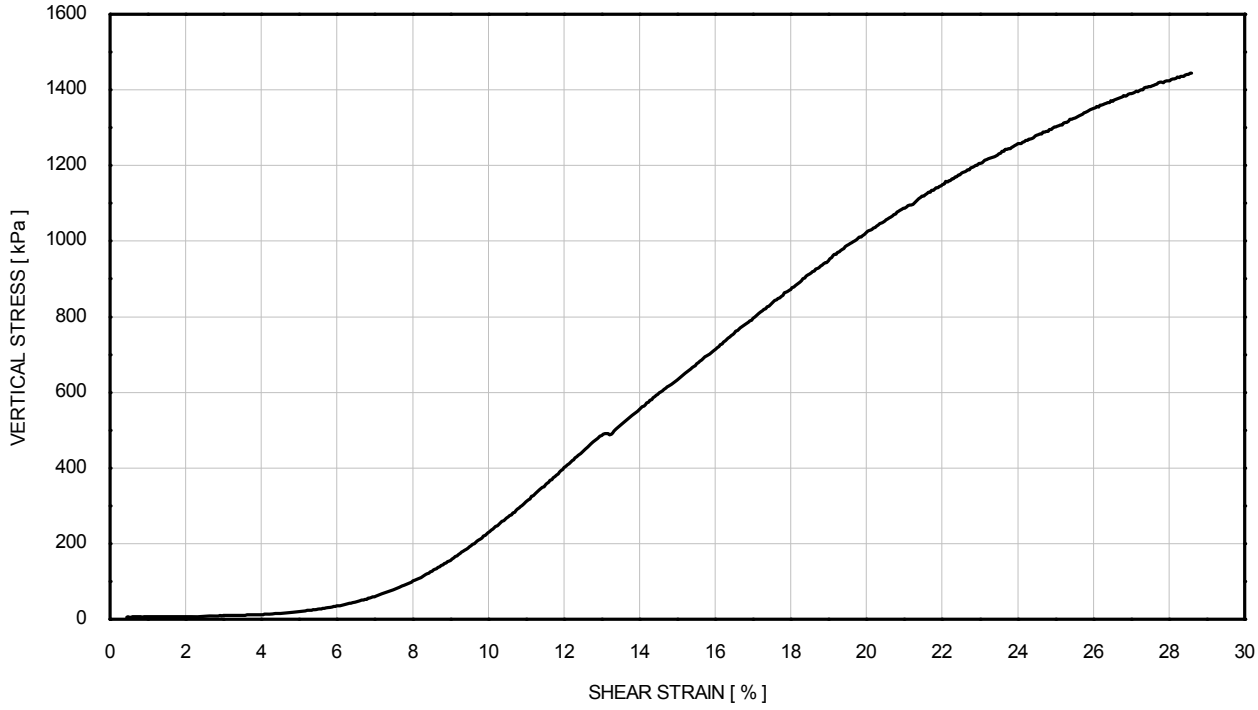


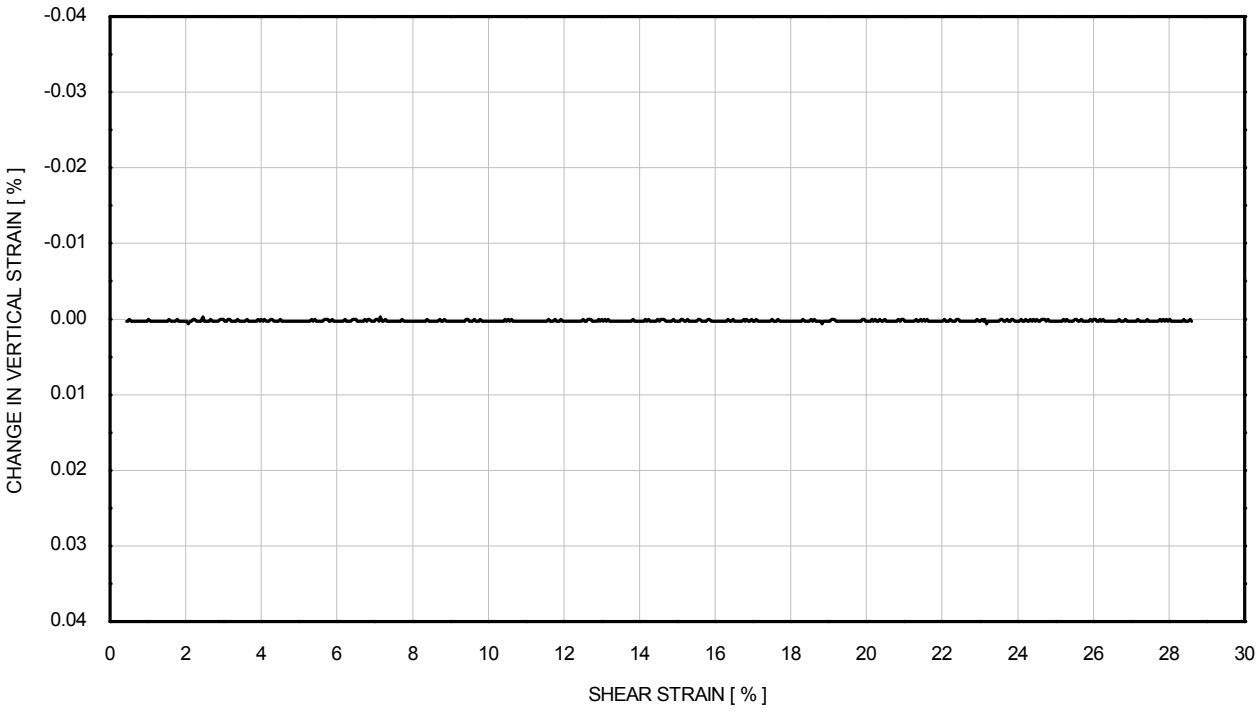


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 834 kPa	Sample	: CSS_1-2
γ at τ_{peak}	: 28.60 %	Unit	: A (Southern Bight)
Rate of strain	: 4.98 %/hour	Test No.	: CSS12

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

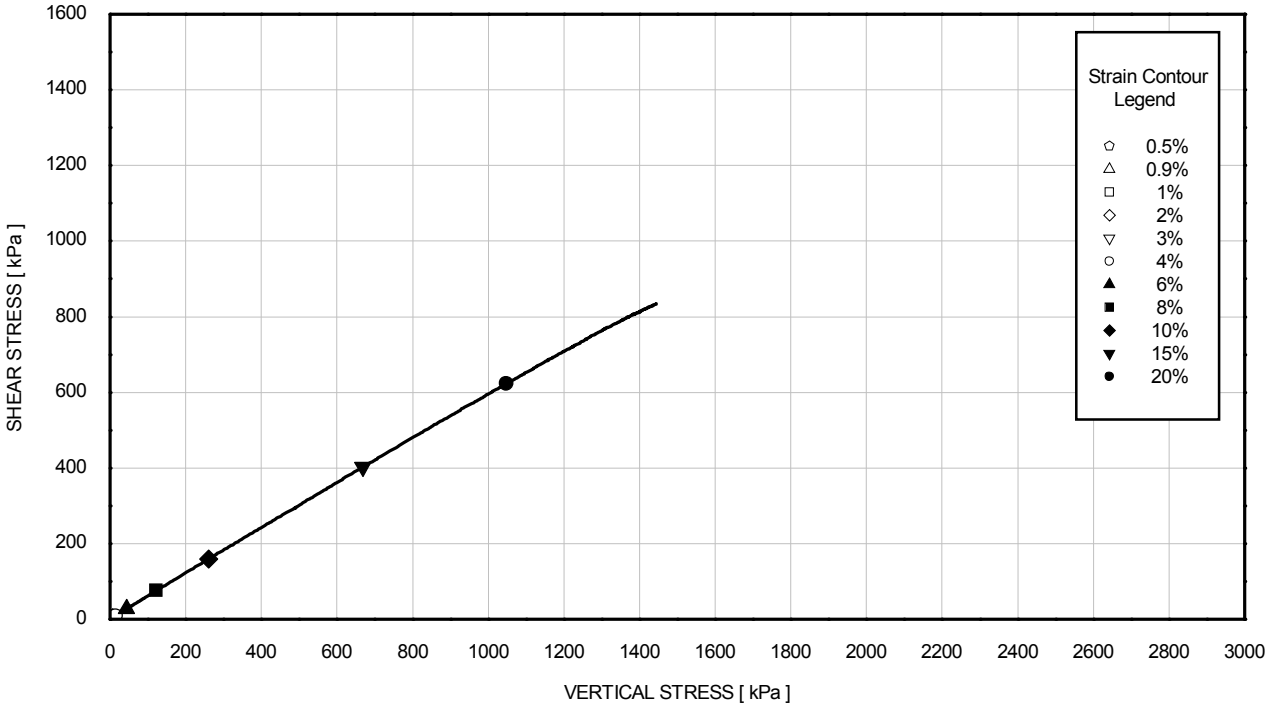


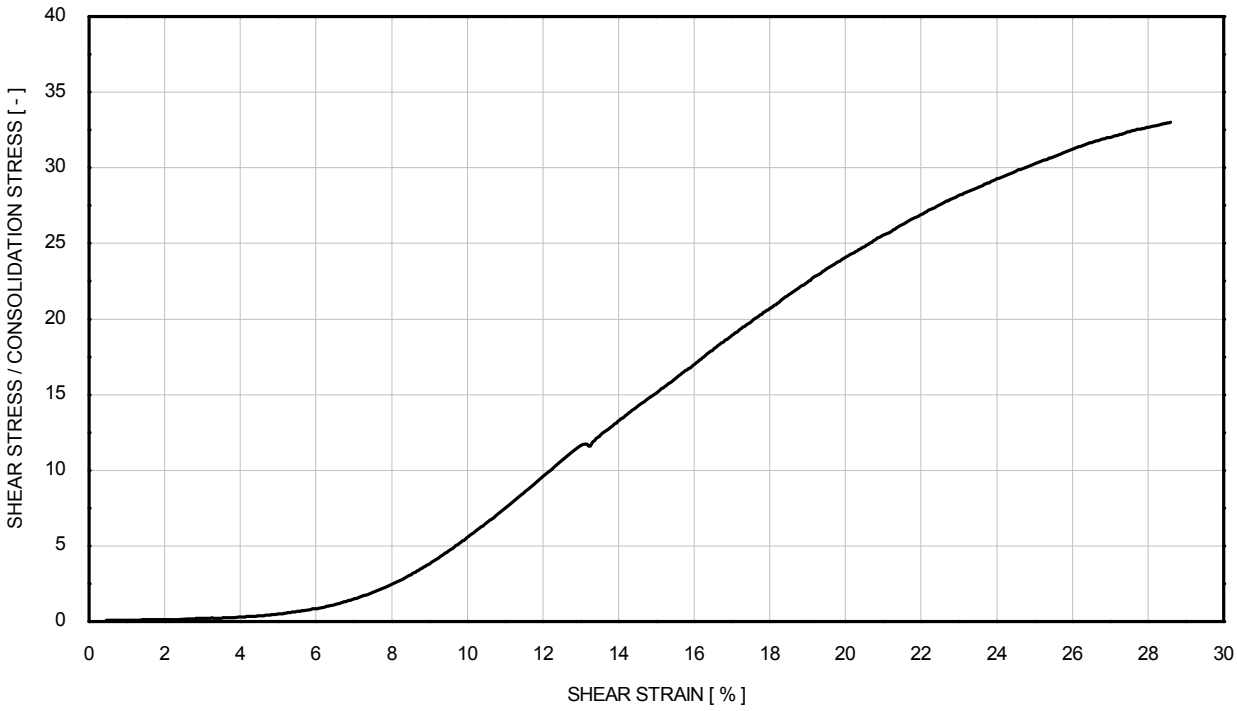


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 834 kPa	Sample	: CSS_1-2
γ at τ_{peak}	: 28.60 %	Unit	: A (Southern Bight)
Rate of strain	: 4.98 %/hour	Test No.	: CSS12

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

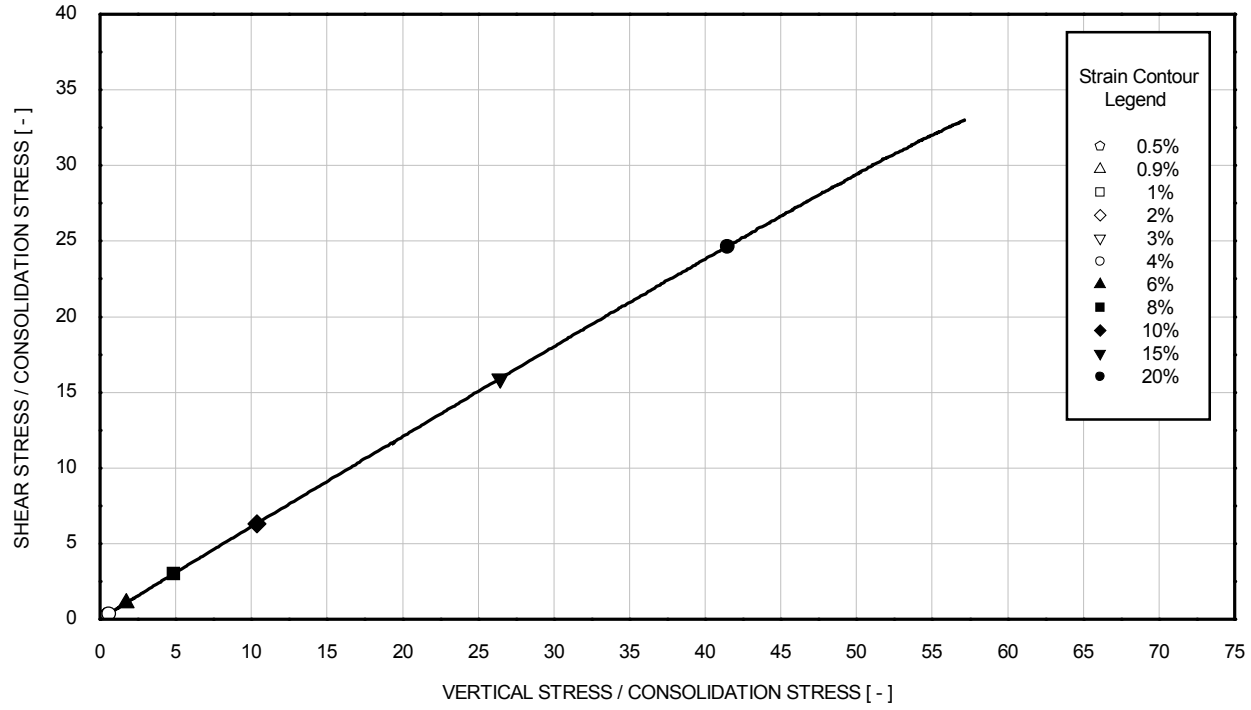


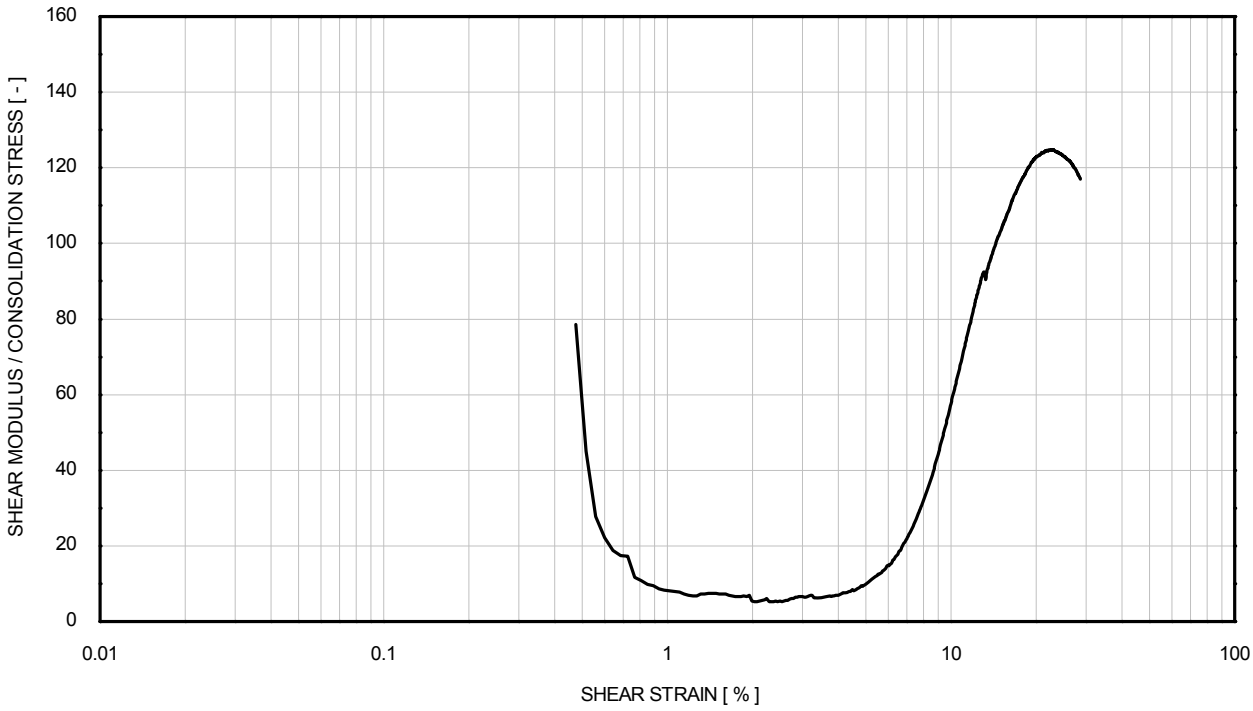


σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	834 kPa	Sample	:	CSS_1-2
γ at τ_{peak}	:	28.60 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.98 %/hour	Test No.	:	CSS12

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	834 kPa	Sample	:	CSS_1-2
γ at τ_{peak}	:	28.60 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.98 %/hour	Test No.	:	CSS12

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	19/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.7
Length	[mm]	30.0
Moisture content after compaction	[%]	10.3
Bulk density after compaction	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.63
Void ratio	[-]	0.630
Degree of saturation after compaction	[%]	43
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	23.8
Bulk density at start of test	[Mg/m³]	2.01
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 1_CSS 1-3_CSS13
Template issue	1.3
Processed by	HJ
Date	24/02/2016
Checked by	PH
Date	14/03/2016
Approved by	PH
Date	14/03/2016

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-3
Unit	A (Southern Bight)
Test number	CSS13

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	25
Vertical strain	[%]	0.16
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.628
Moisture content	[%]	23.7

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	25
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	8
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	9
γ_{av} at N_f	[%]	0.50
γ_{cy} at N_f	[%]	3.67
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	19
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.03	0.46	1.75	29.81
2	0.10	1.01	0.80	22.55
3	0.16	1.52	0.53	17.26
4	0.18	1.93	0.42	14.32
5	0.20	2.29	0.35	12.85
6	0.26	2.63	0.30	12.26
7	0.35	2.98	0.27	11.70
8	0.41	3.32	0.24	11.39
9	0.50	3.67	0.22	11.13

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-3
Unit	A (Southern Bight)
Test number	CSS13

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	347
Shear strain	[%]	29.93
Shear induced $-\Delta\sigma_v$	[kPa]	-555
Vertical stress	[kPa]	580
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.99
At 15 % shear strain		
Shear stress	[kPa]	107
Shear induced $-\Delta\sigma_v$	[kPa]	-149
Vertical stress	[kPa]	175
Vertical strain	[%]	0.00

* Please note that specimen failure was observed to occur along the loading platen interface.

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-3
Unit	A (Southern Bight)
Test number	CSS13

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

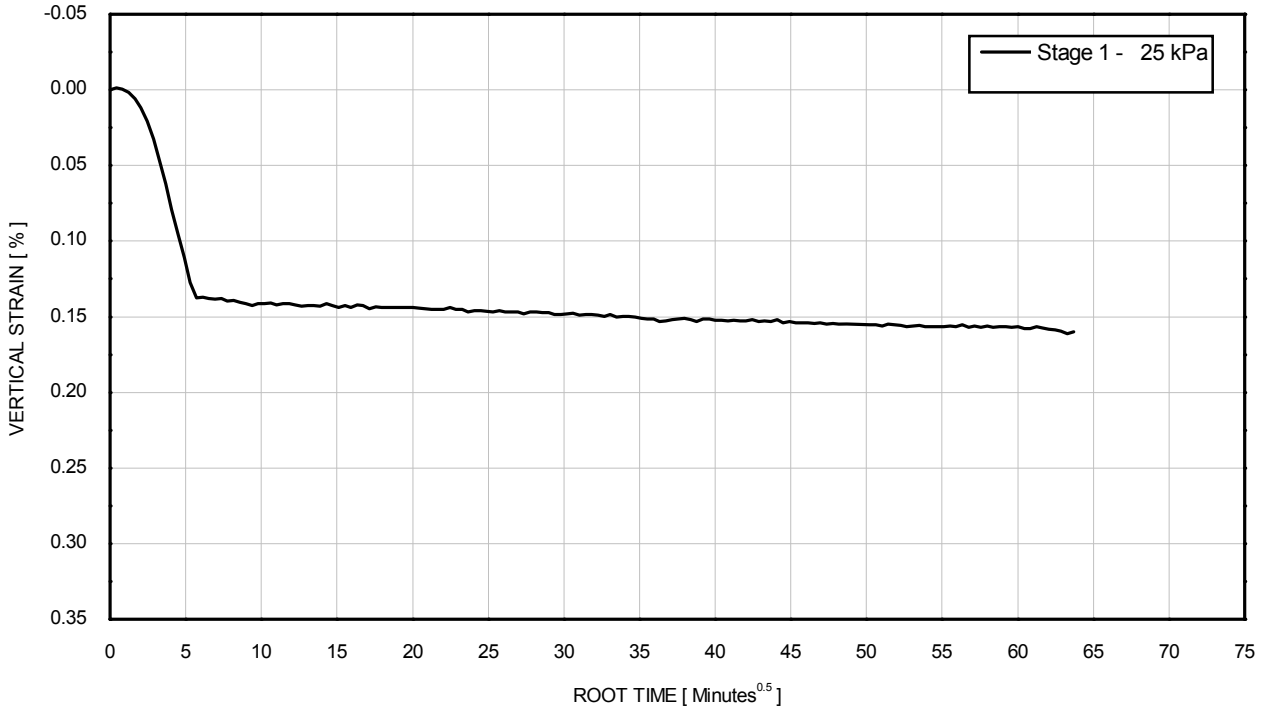
SPECIMEN PHOTOGRAPH

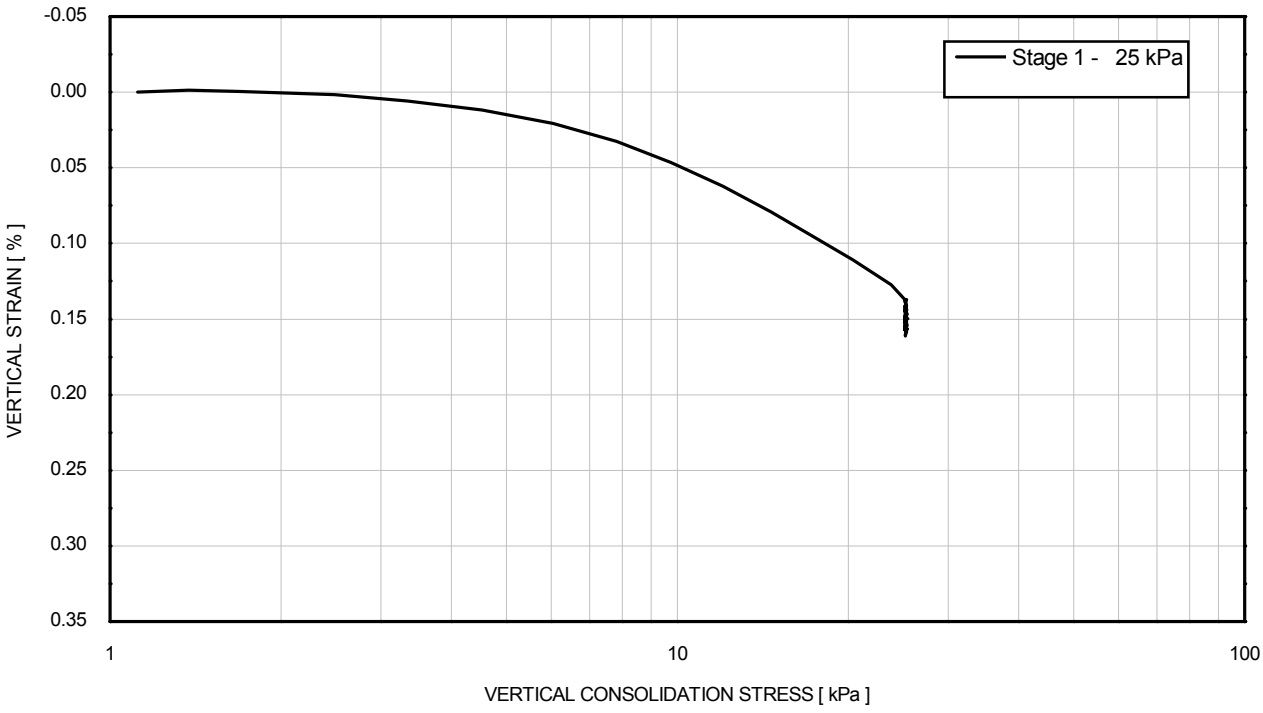


TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-3
Unit	A (Southern Bight)
Test number	CSS13

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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



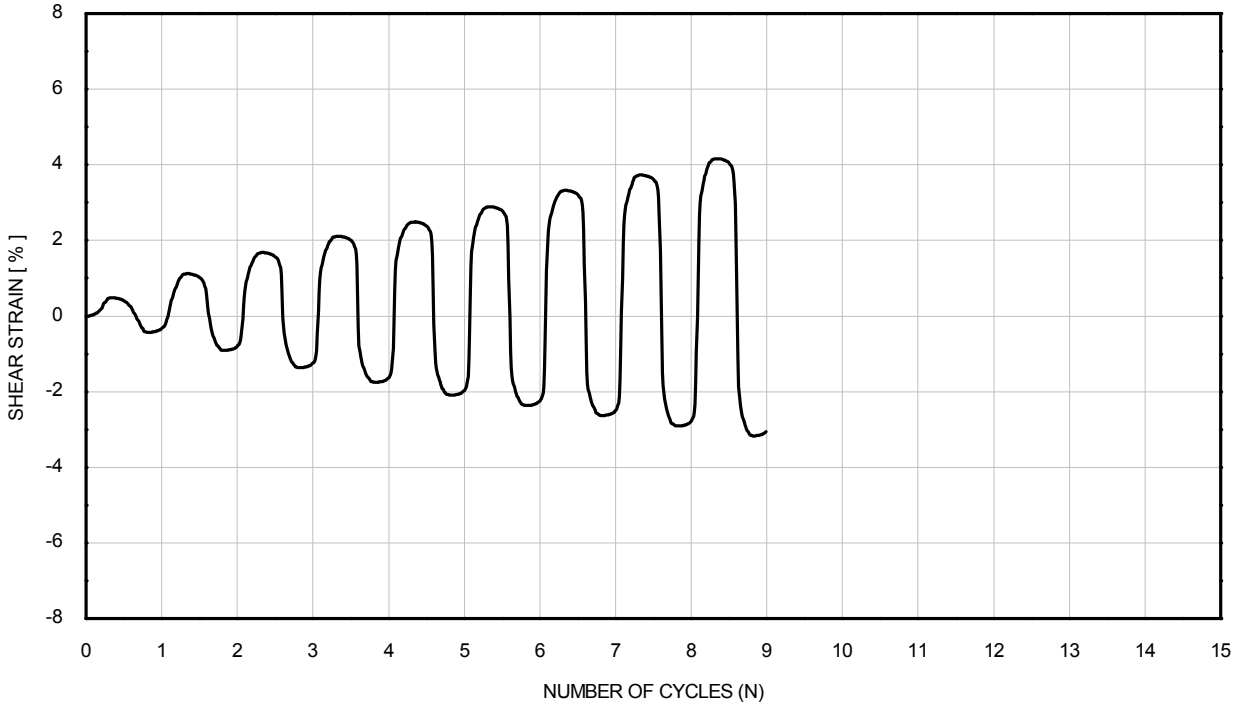


σ_{vc}	: 25 kPa	Batch	: 1
		Sample	: CSS_1-3
		Unit	: A (Southern Bight)
		Test No.	: CSS13

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

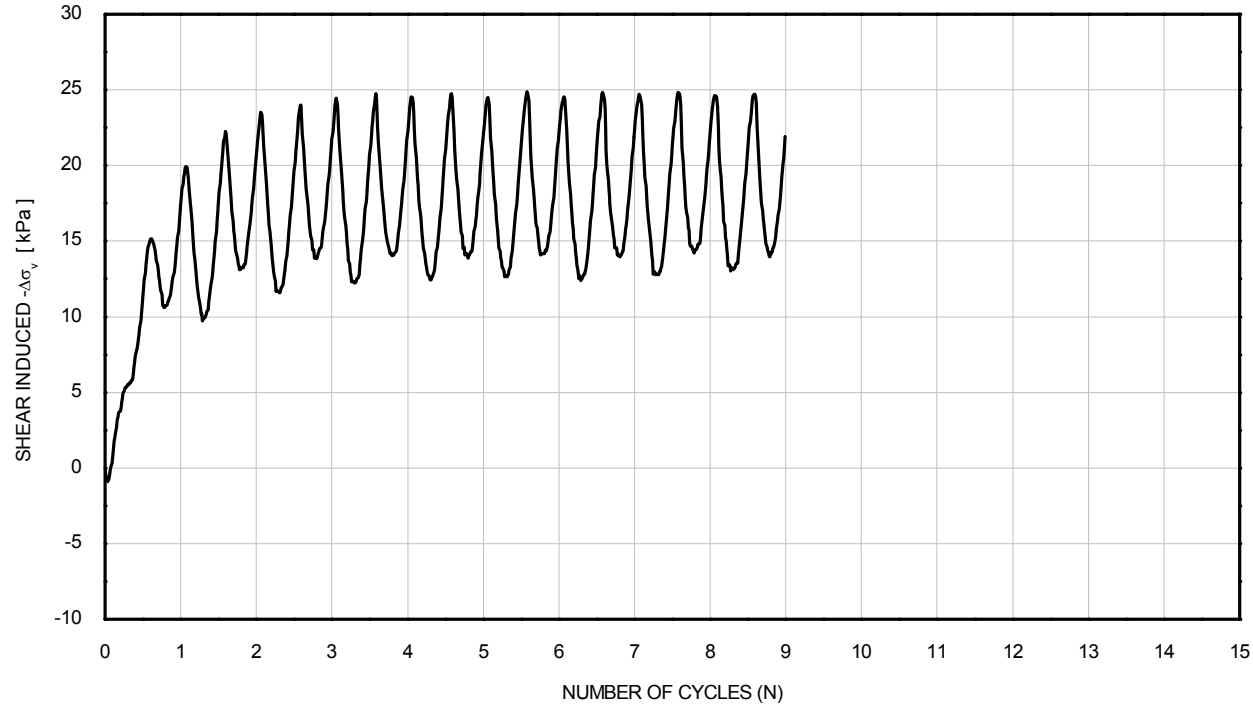


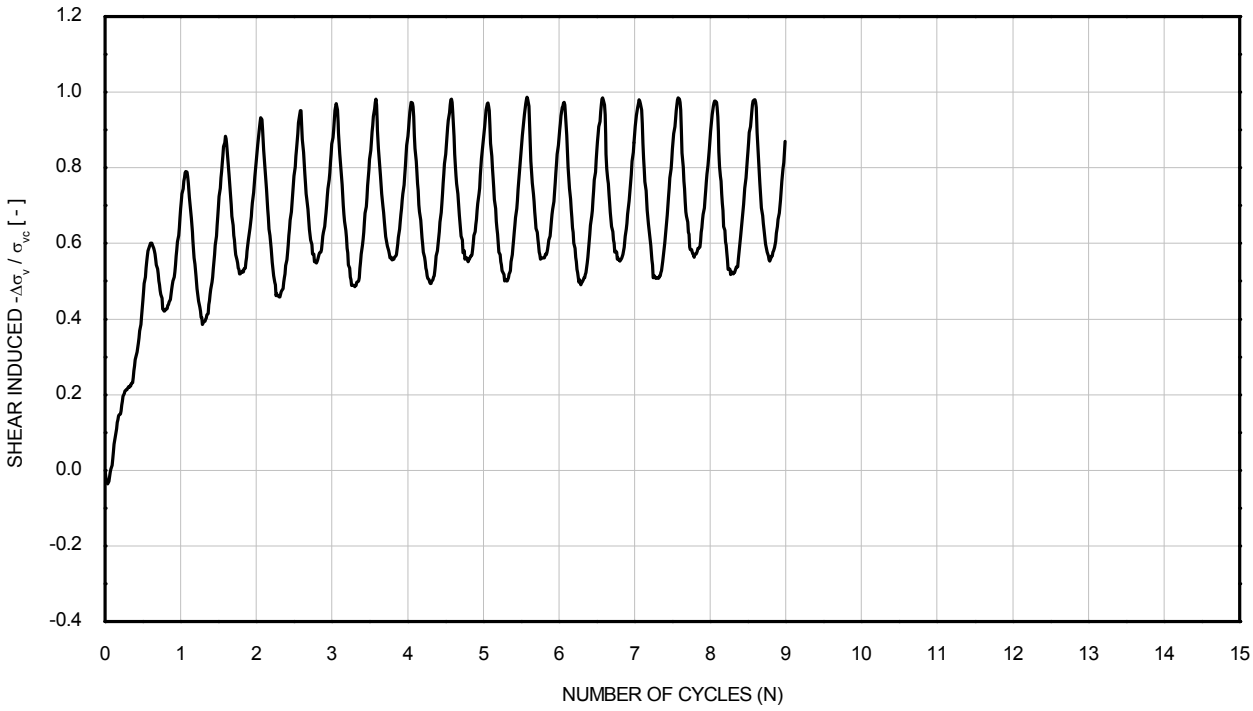


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-3
Mean τ_{cy}	:	8 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS13

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

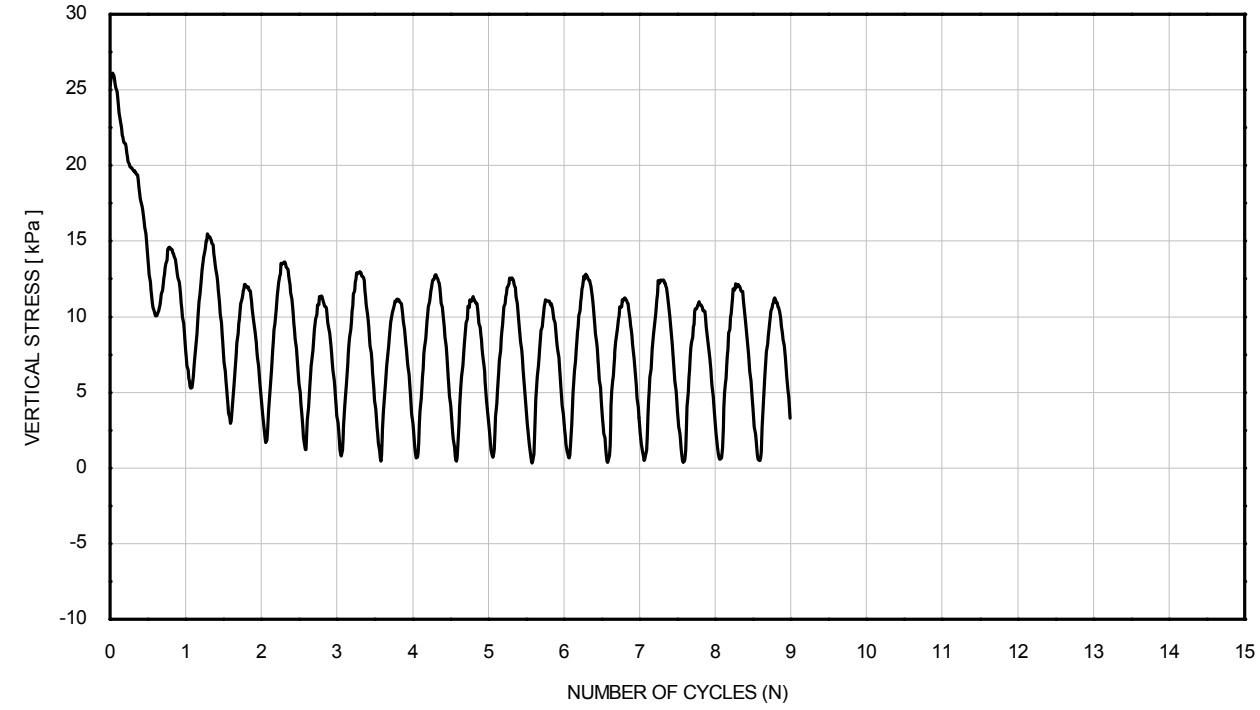


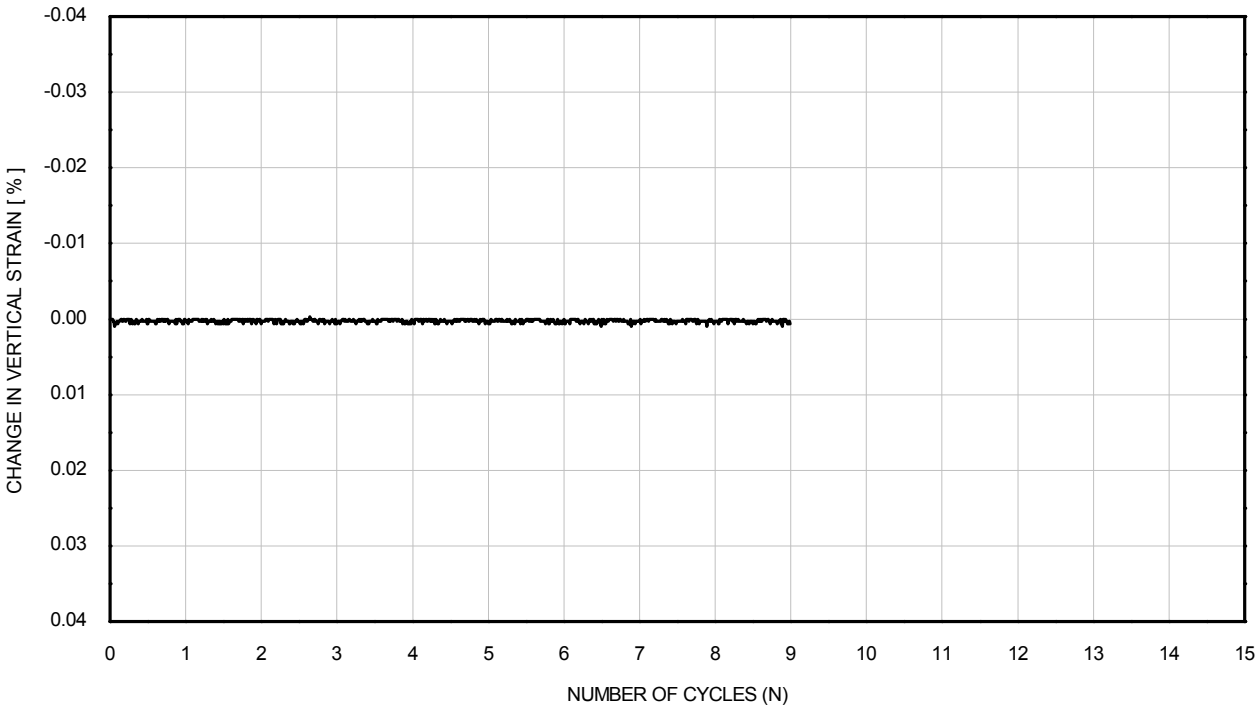


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-3
Mean τ_{cy}	:	8 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS13

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

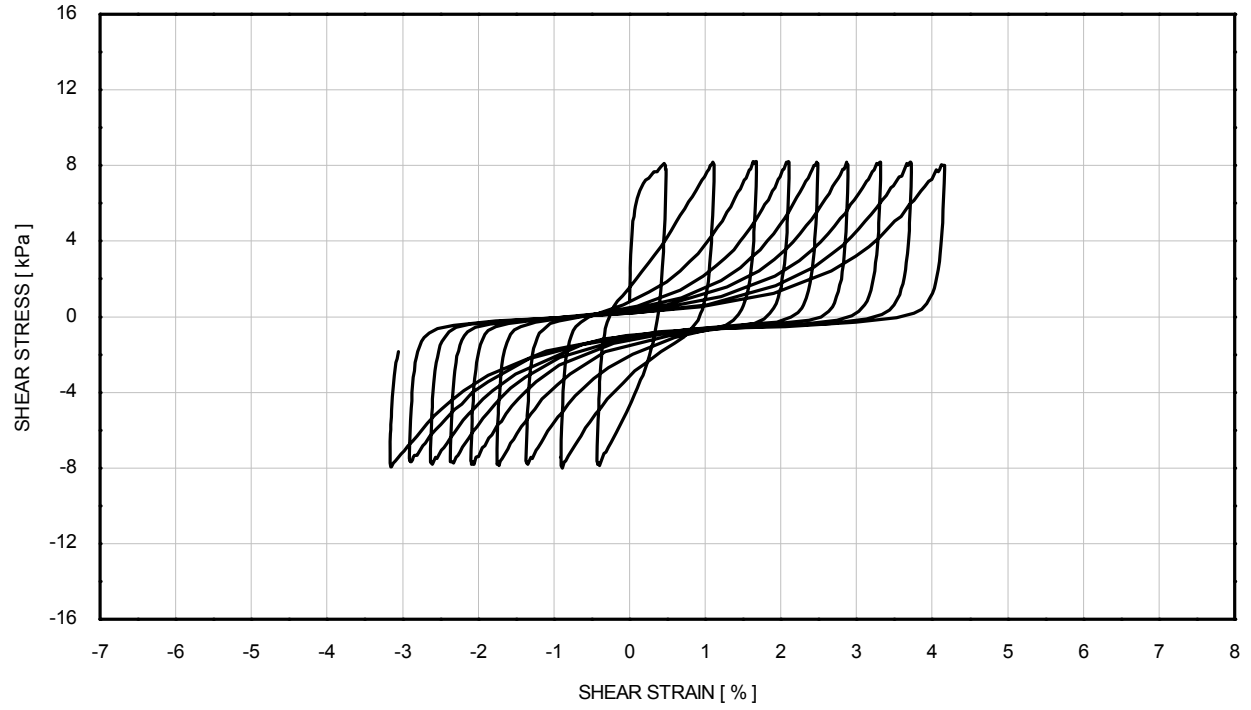


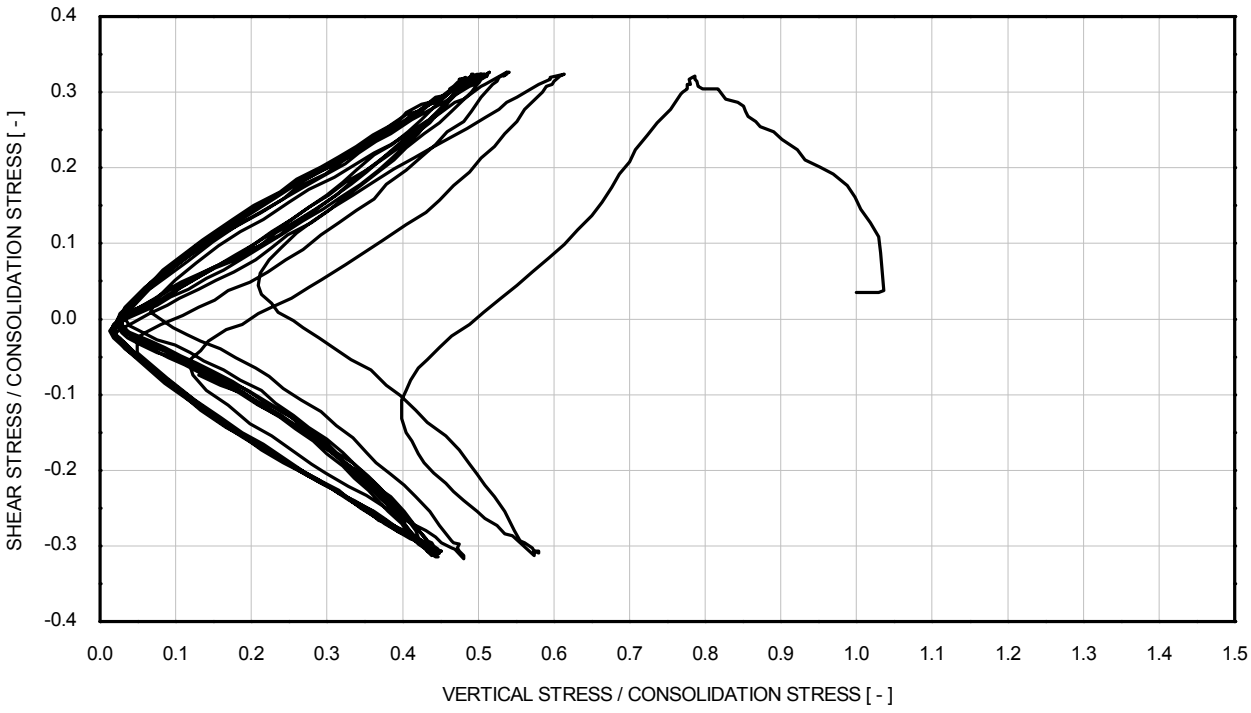


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-3
Mean τ_{cy}	:	8 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS13

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

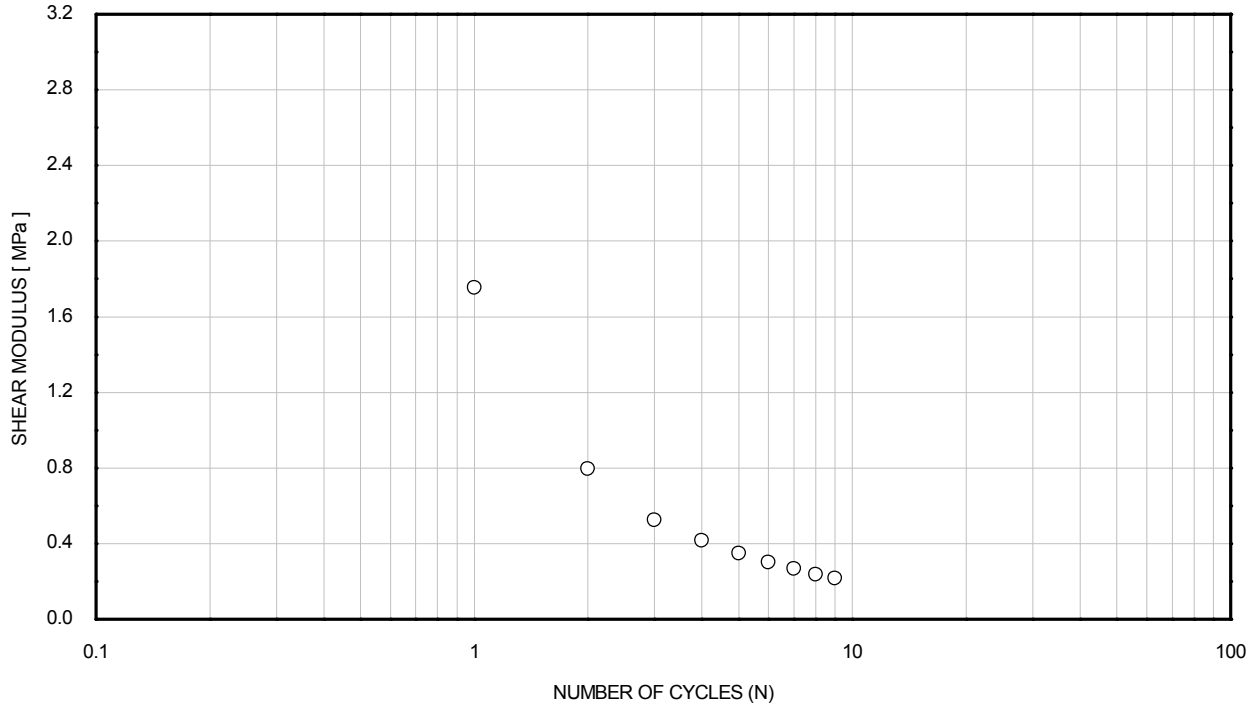


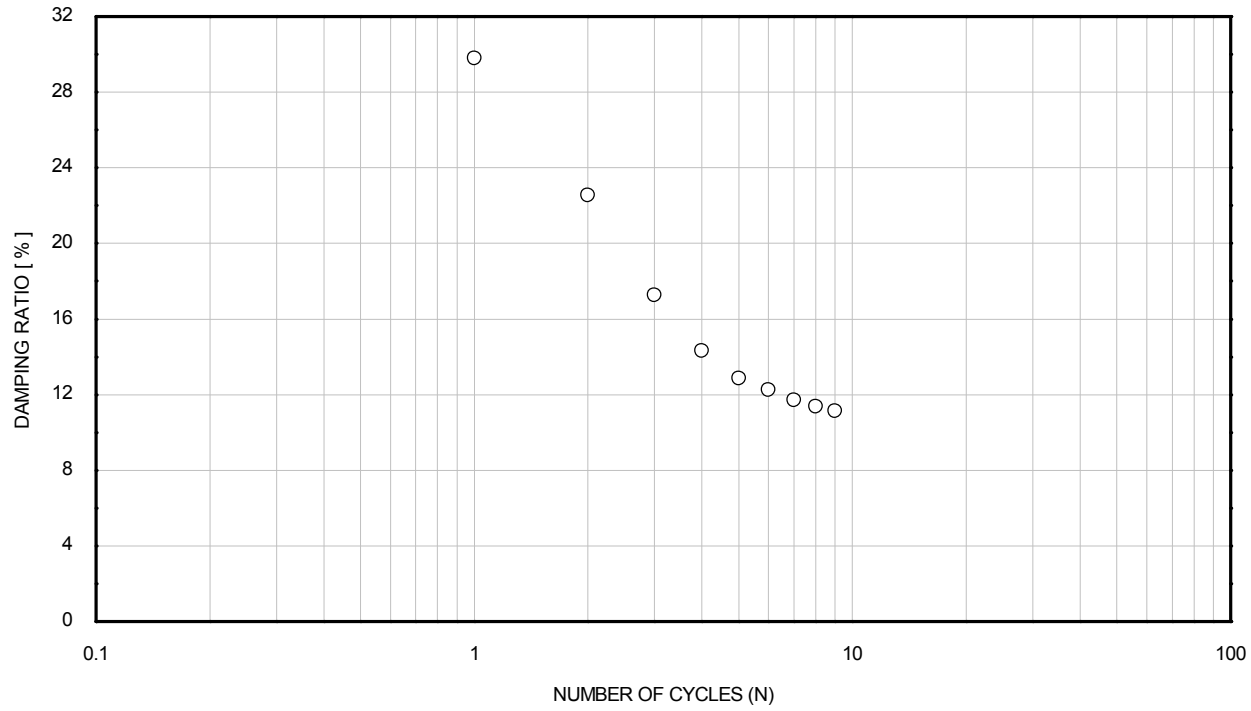


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-3
Mean τ_{cy}	:	8 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS13

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

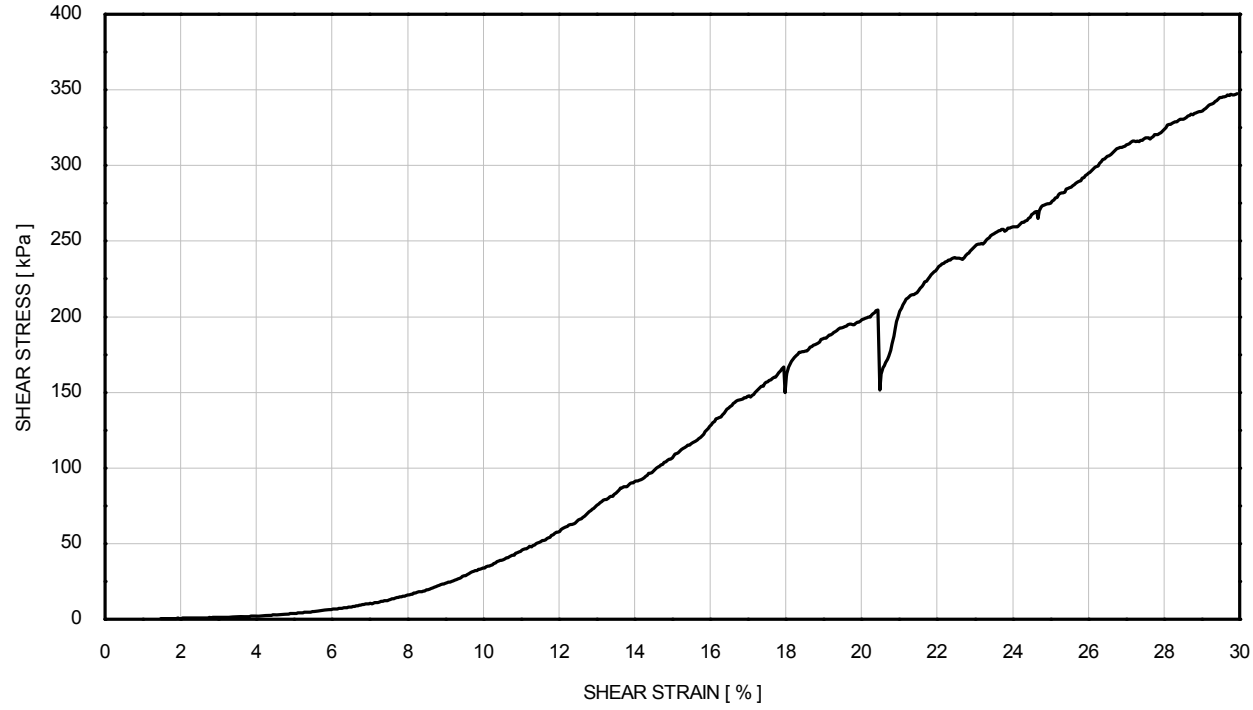


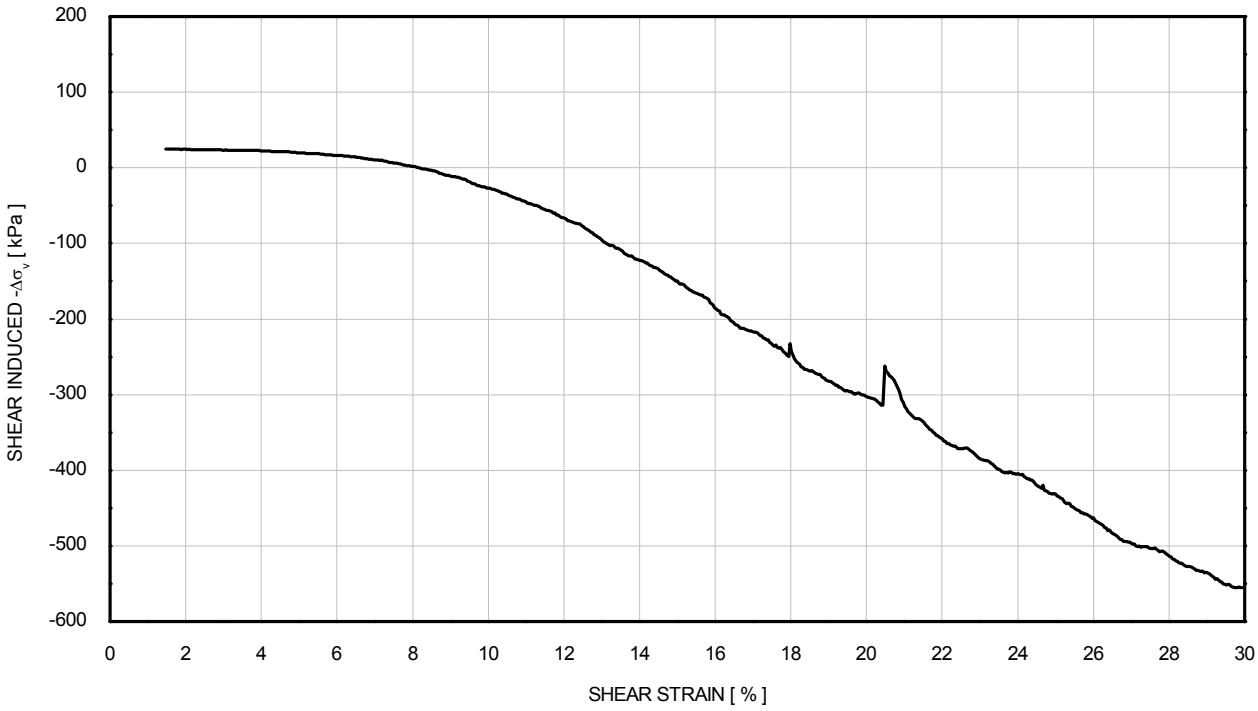


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-3
Mean τ_{cy}	:	8 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS13

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

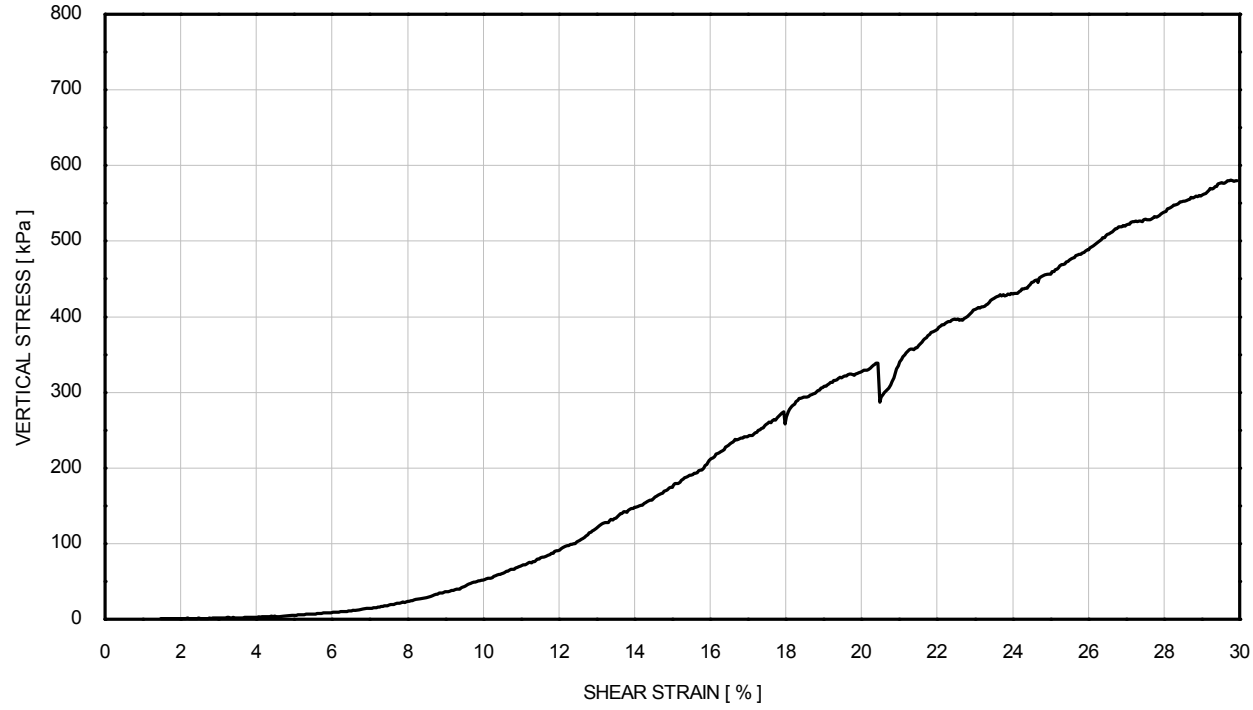


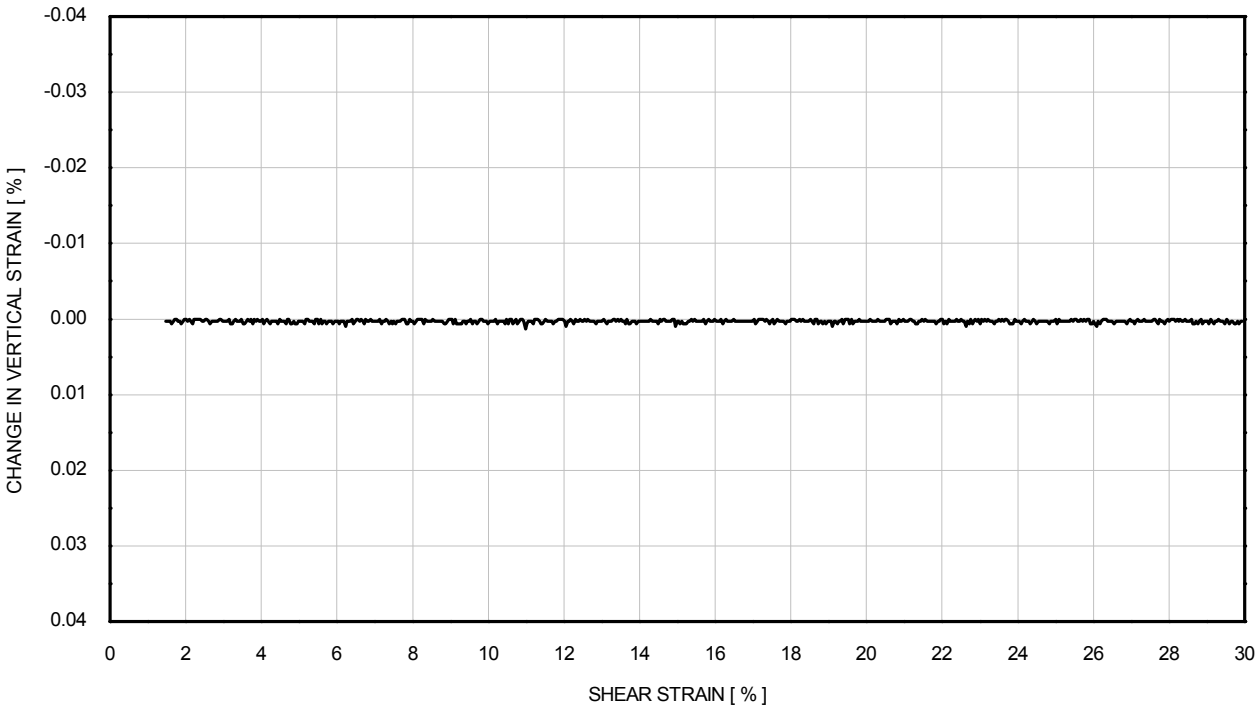


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 347 kPa	Sample	: CSS_1-3
γ at τ_{peak}	: 29.93 %	Unit	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS13

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

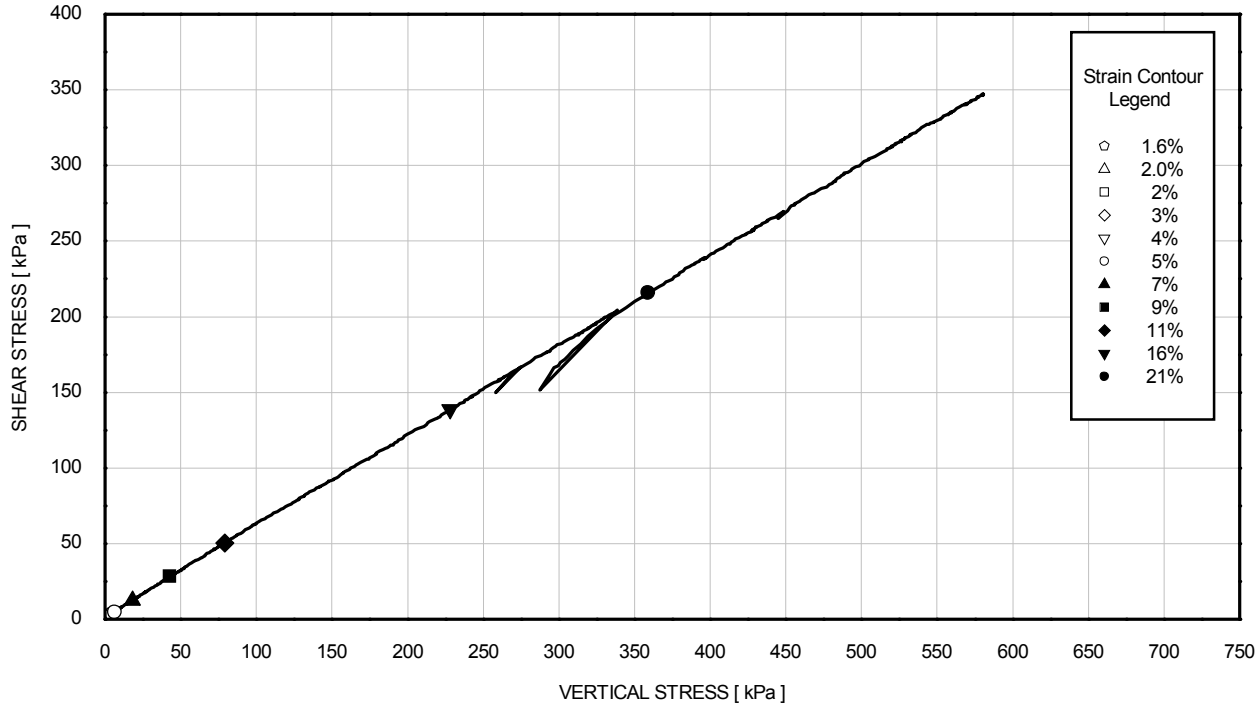


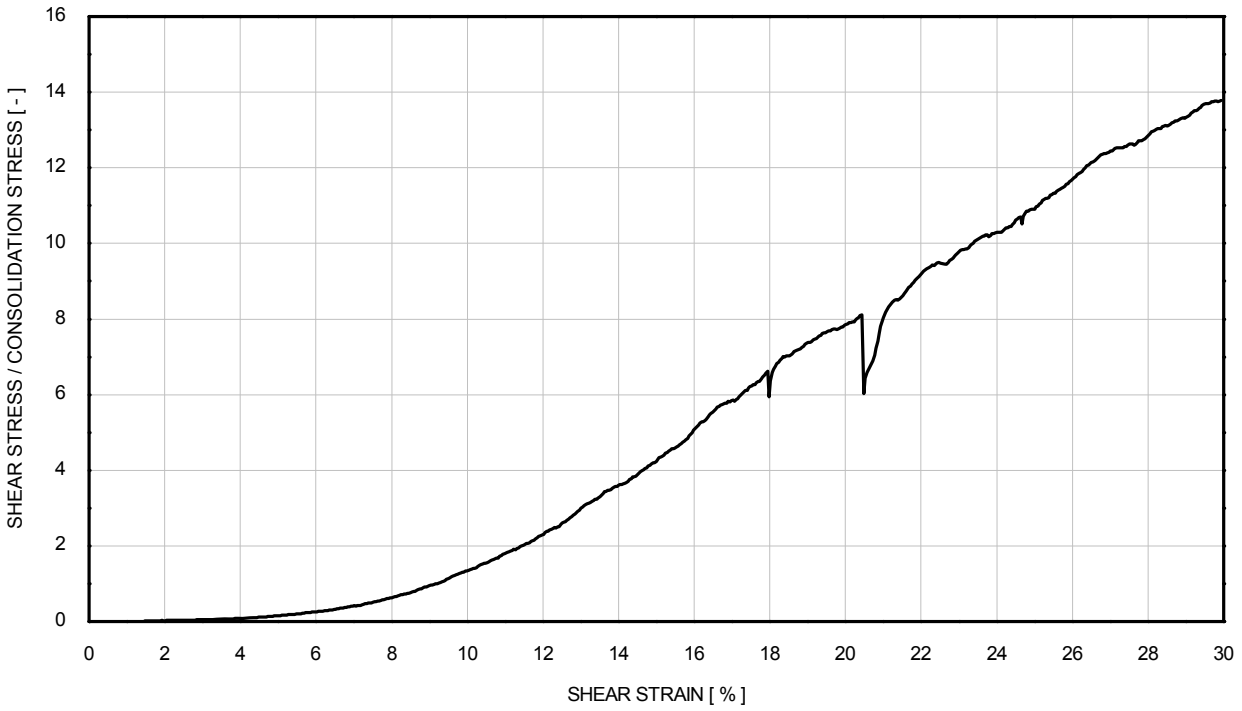


σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	347 kPa	Sample	:	CSS_1-3
γ at τ_{peak}	:	29.93 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.99 %/hour	Test No.	:	CSS13

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

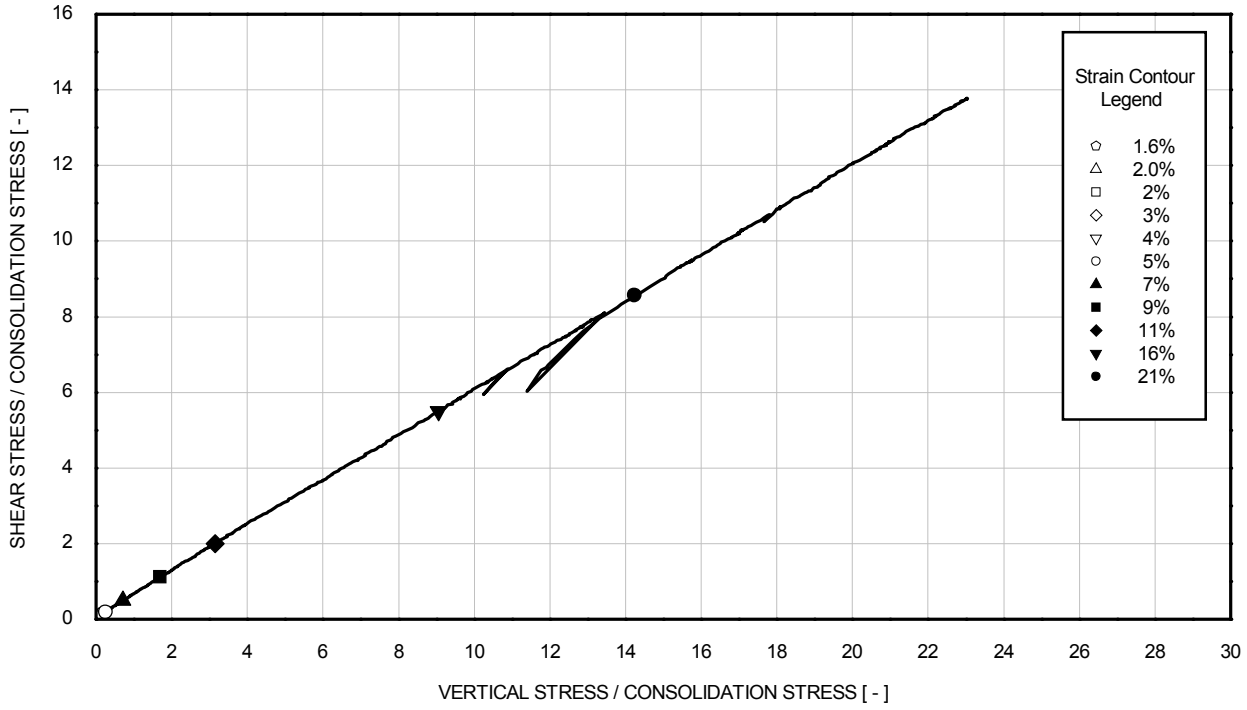


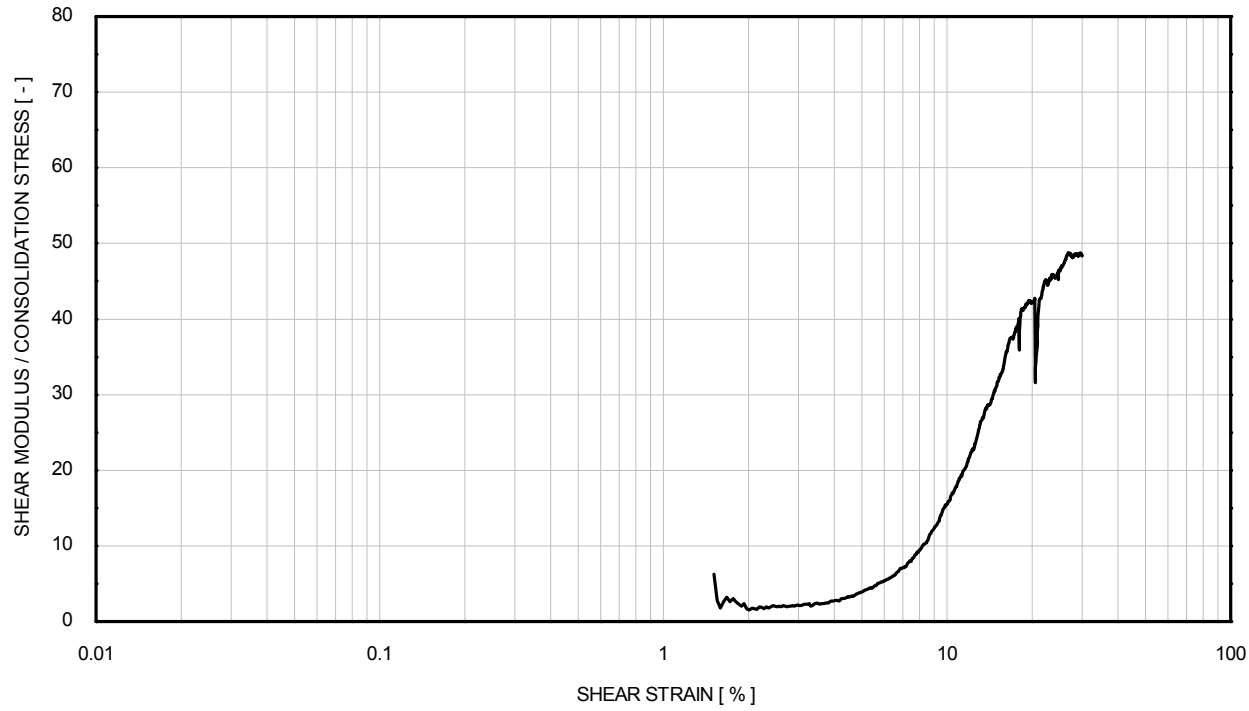


σ_{vc}	:	25 kPa	Batch	:	1
τ_{peak}	:	347 kPa	Sample	:	CSS_1-3
γ at τ_{peak}	:	29.93 %	Unit	:	A (Southern Bight)
Rate of strain	:	4.99 %/hour	Test No.	:	CSS13

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	:	25 kPa	Batch	: 1
τ_{peak}	:	347 kPa	Sample	: CSS_1-3
γ at τ_{peak}	:	29.93 %	Unit	: A (Southern Bight)
Rate of strain	:	4.99 %/hour	Test No.	: CSS13

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	26/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.5
Length	[mm]	30.0
Moisture content after compaction	[%]	11.0
Bulk density after compaction	[Mg/m³]	1.79
Dry density	[Mg/m³]	1.62
Void ratio	[-]	0.641
Degree of saturation after compaction	[%]	45
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.2
Bulk density at start of test	[Mg/m³]	2.01
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 1_CSS 1-4_CSS14
Template issue	1.3
Processed by	HJ
Date	09/03/2016
Checked by	PH
Date	14/03/2016
Approved by	PH
Date	14/03/2016

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-4
Unit	A (Southern Bight)
Test number	CSS14

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	25
Vertical strain	[%]	0.09
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.62
Void ratio	[-]	0.639
Moisture content	[%]	24.1

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	25
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	6
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	150
γ_{av} at N_f	[%]	-1.32
γ_{cy} at N_f	[%]	3.69
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	25
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.00	0.04	16.00	10.70
2	-0.01	0.04	16.22	10.37
5	-0.01	0.04	16.01	9.12
10	-0.01	0.04	15.80	9.14
20	-0.01	0.04	15.13	9.02
30	-0.01	0.04	14.52	9.27
40	-0.02	0.04	13.86	9.20
50	-0.02	0.05	13.13	9.42
100	-0.06	0.10	5.79	16.37
125	-0.42	0.99	0.54	19.38
150	-1.32	3.69	0.14	14.11

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-4
Unit	A (Southern Bight)
Test number	CSS14

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

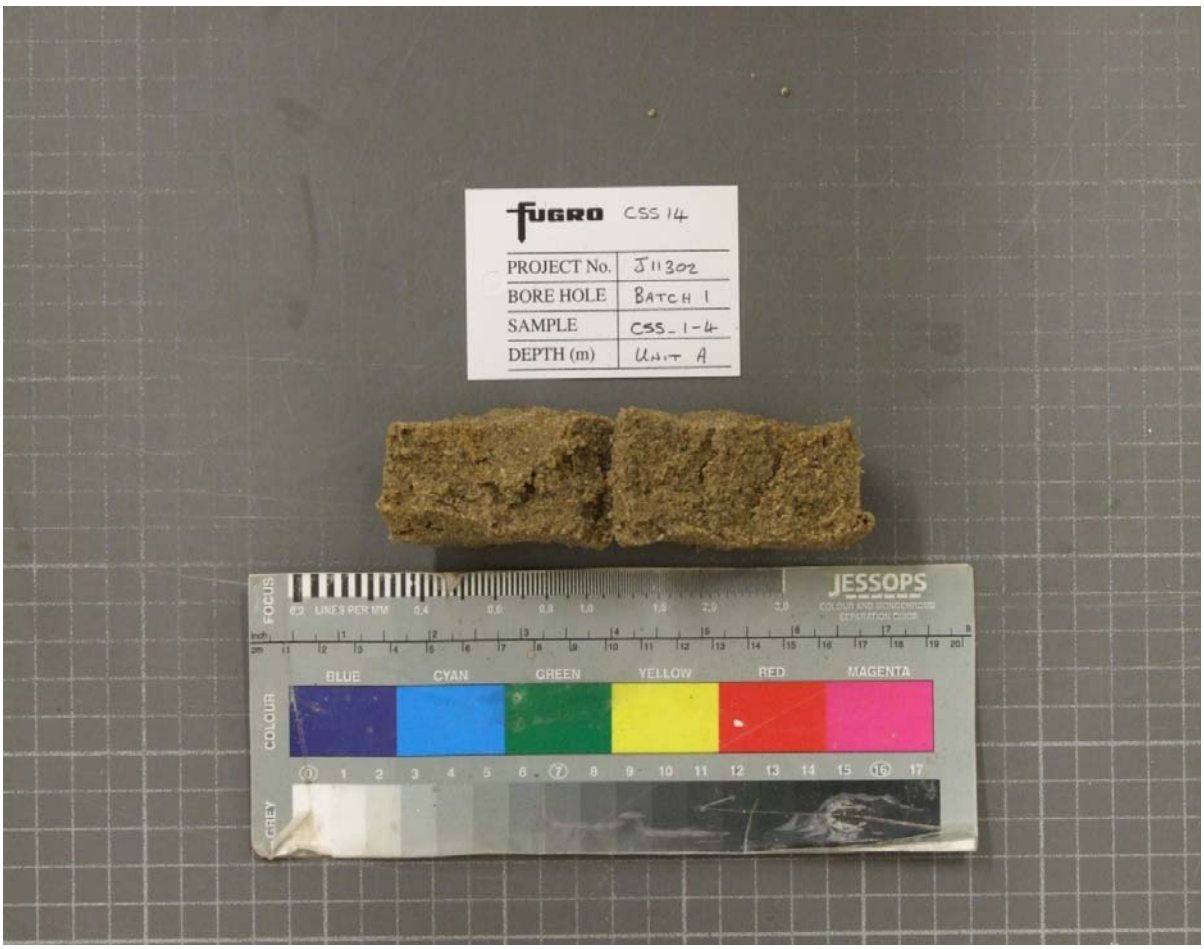
SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	274
Shear strain	[%]	30.16
Shear induced $-\Delta\sigma_v$	[kPa]	-436
Vertical stress	[kPa]	461
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.99
At 15 % shear strain		
Shear stress	[kPa]	139
Shear induced $-\Delta\sigma_v$	[kPa]	-202
Vertical stress	[kPa]	227
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-4
Unit	A (Southern Bight)
Test number	CSS14

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

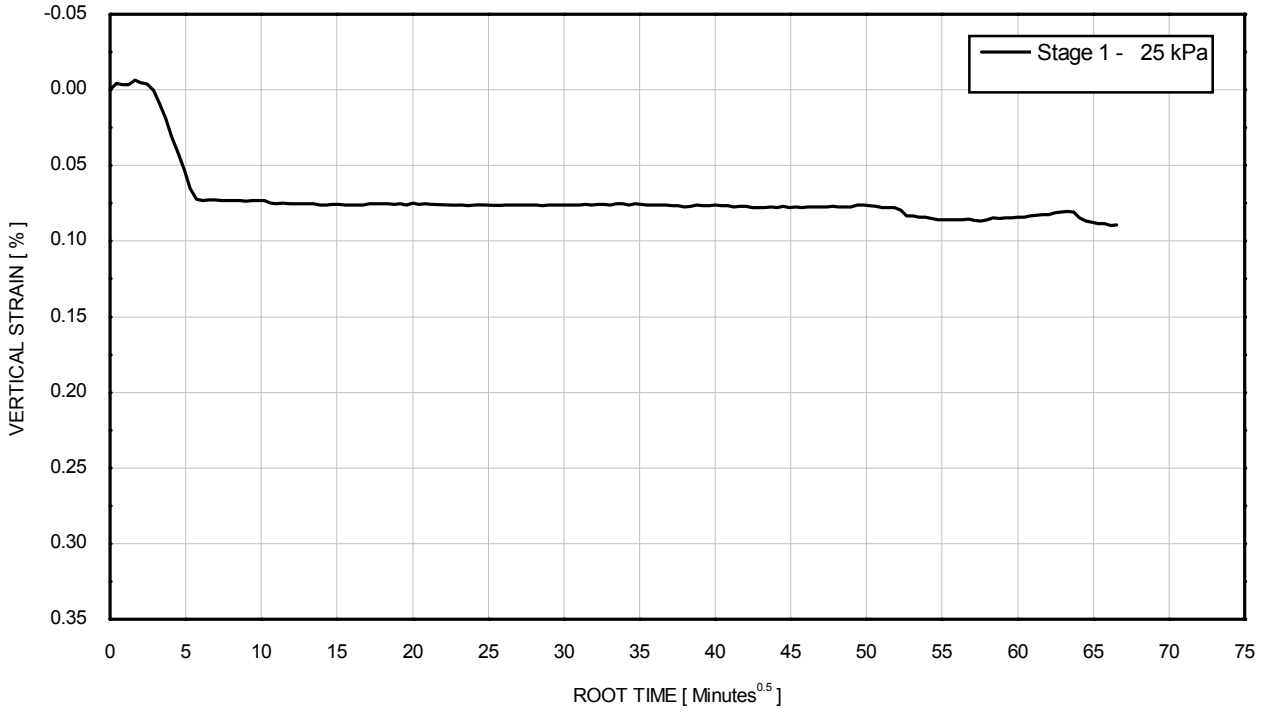
SPECIMEN PHOTOGRAPH

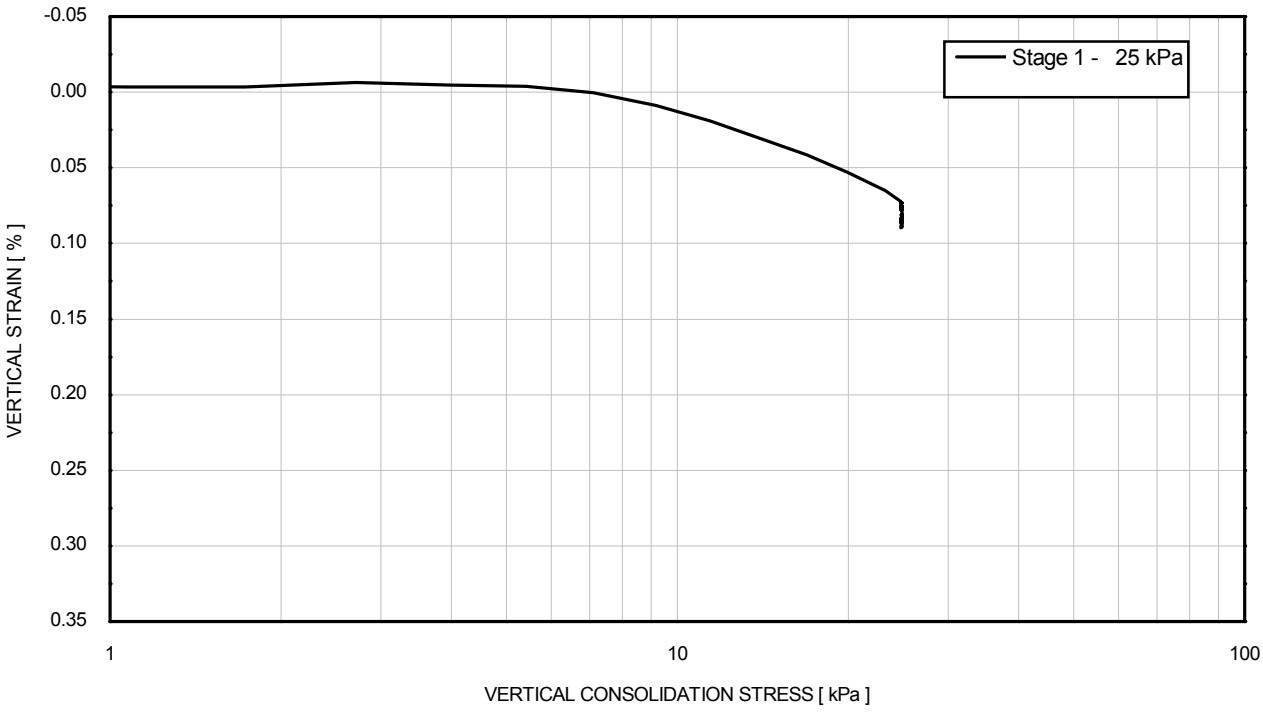


TEST IDENTIFICATION	
Batch	1
Sample	CSS_1-4
Unit	A (Southern Bight)
Test number	CSS14

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

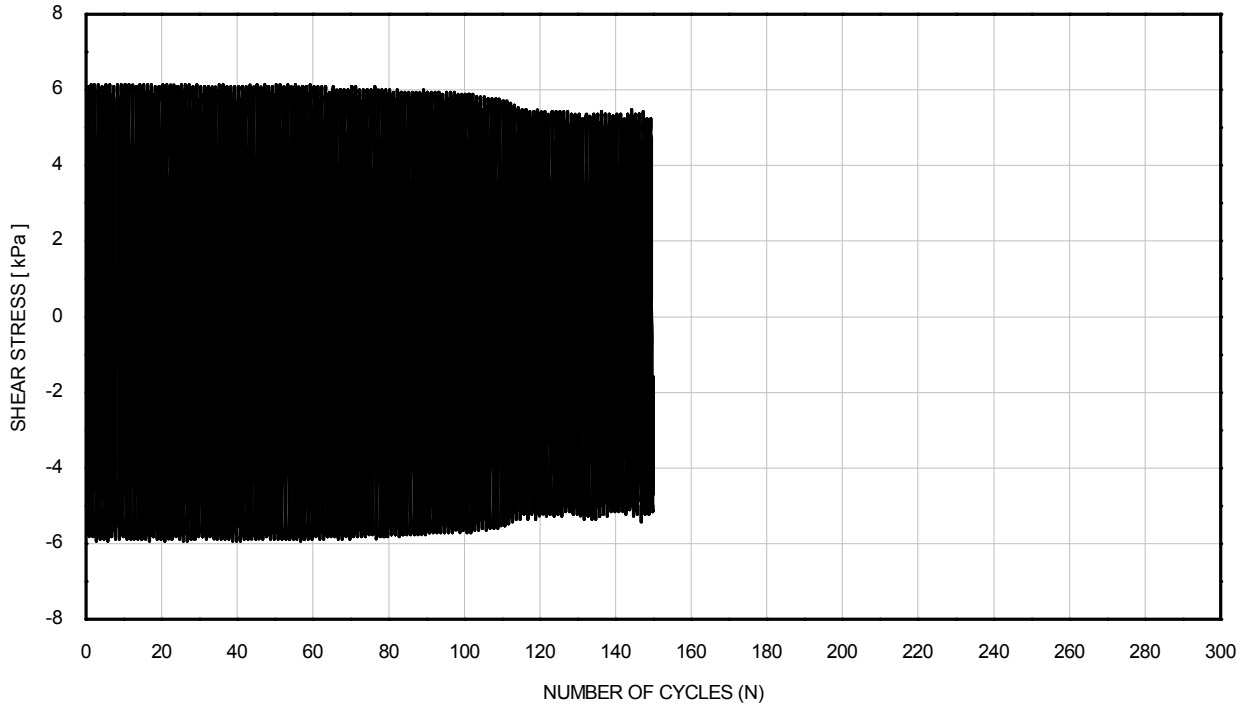


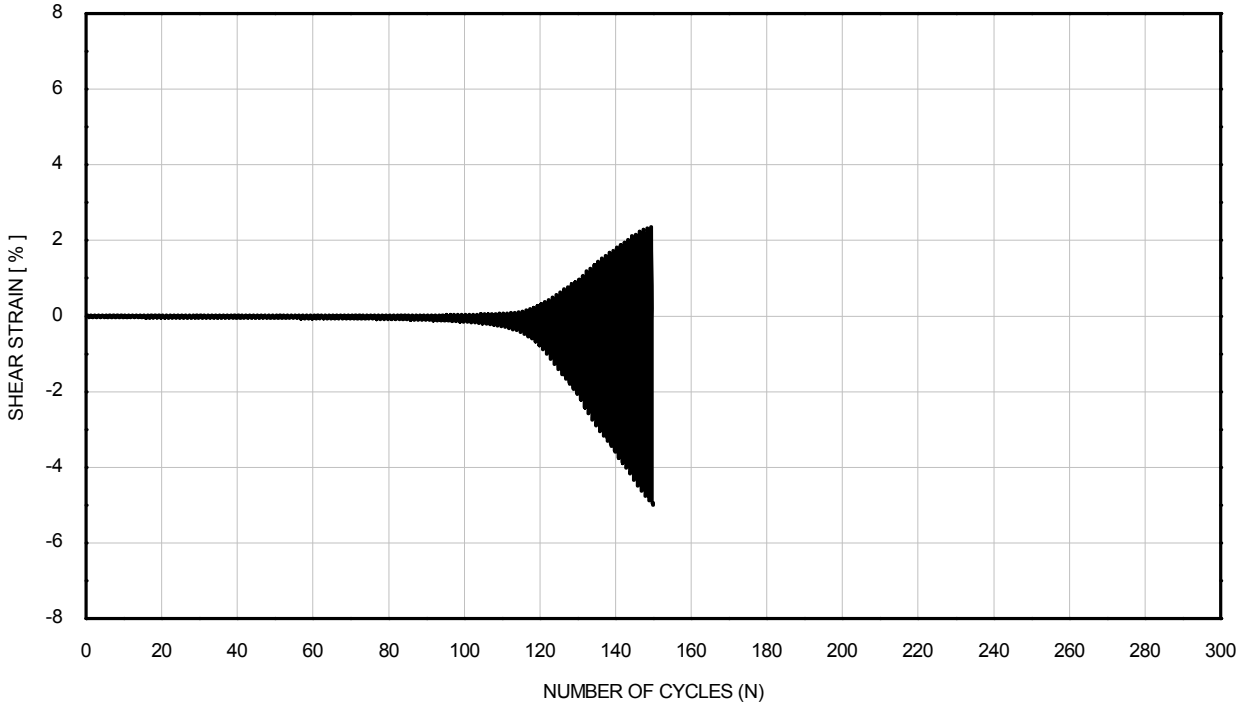


σ_{vc}	: 25 kPa	Batch	: 1
		Sample	: CSS_1-4
		Unit	: A (Southern Bight)
		Test No.	: CSS14

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

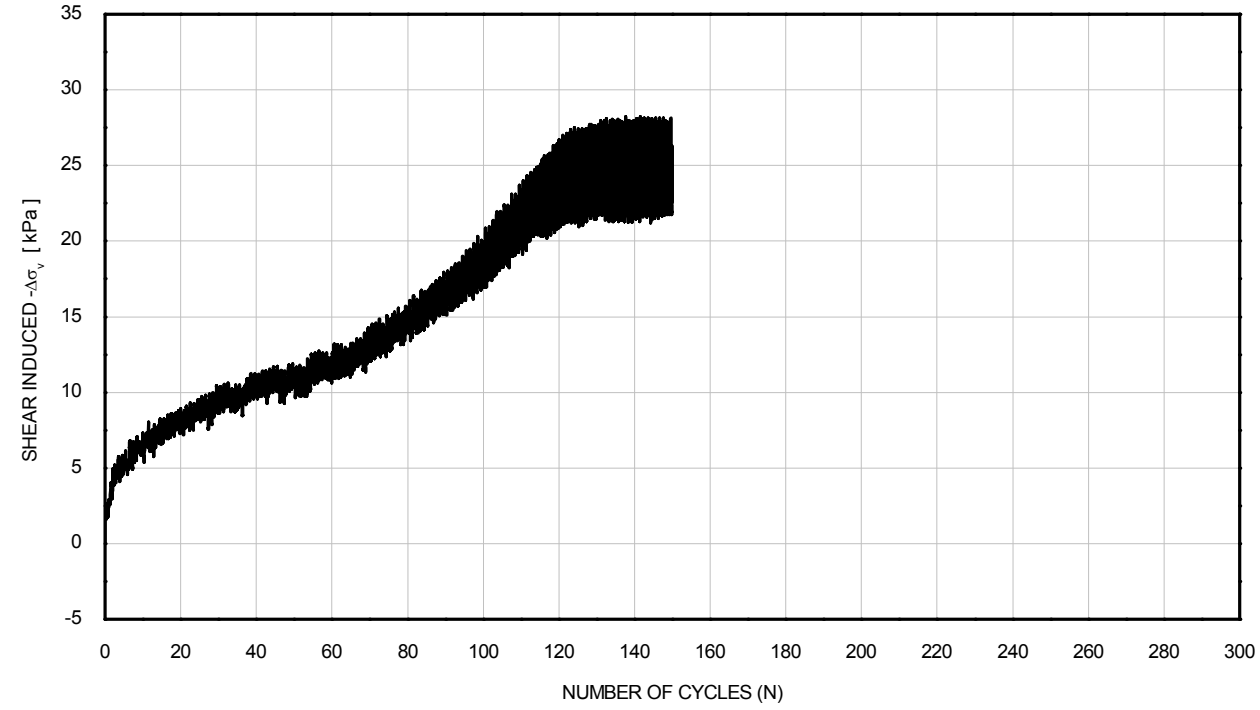


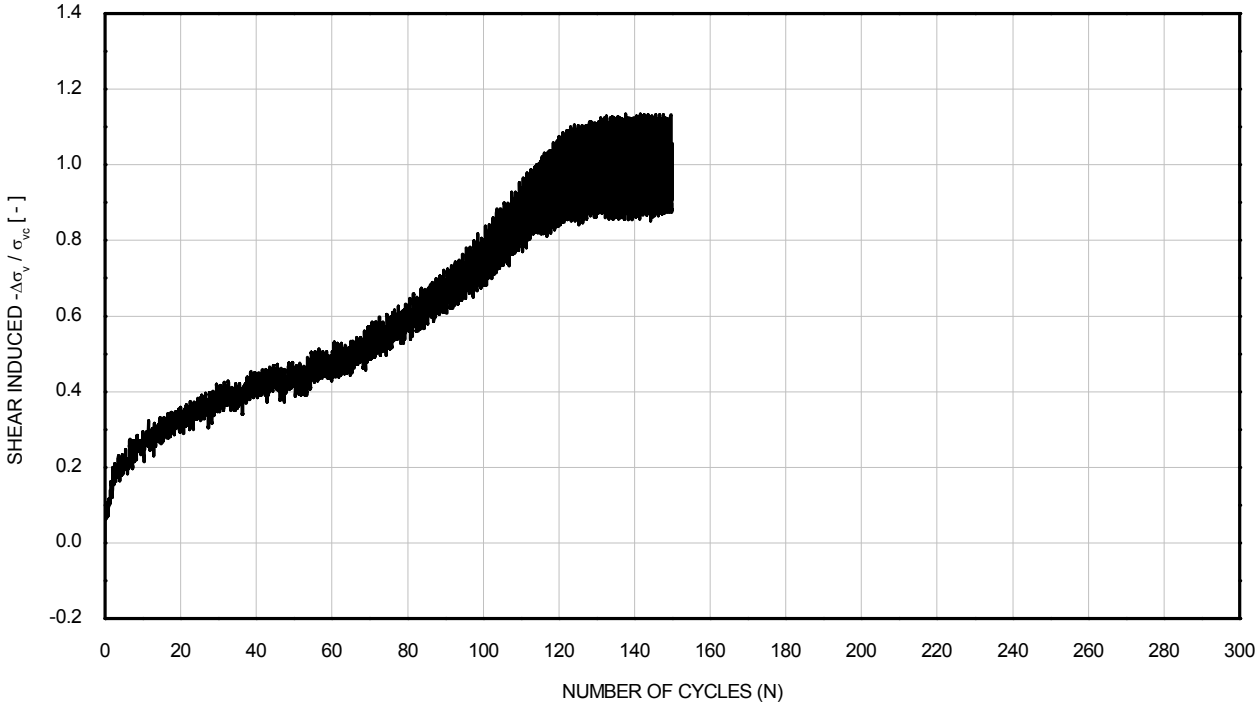


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-4
Mean τ_{cy}	:	6 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS14

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

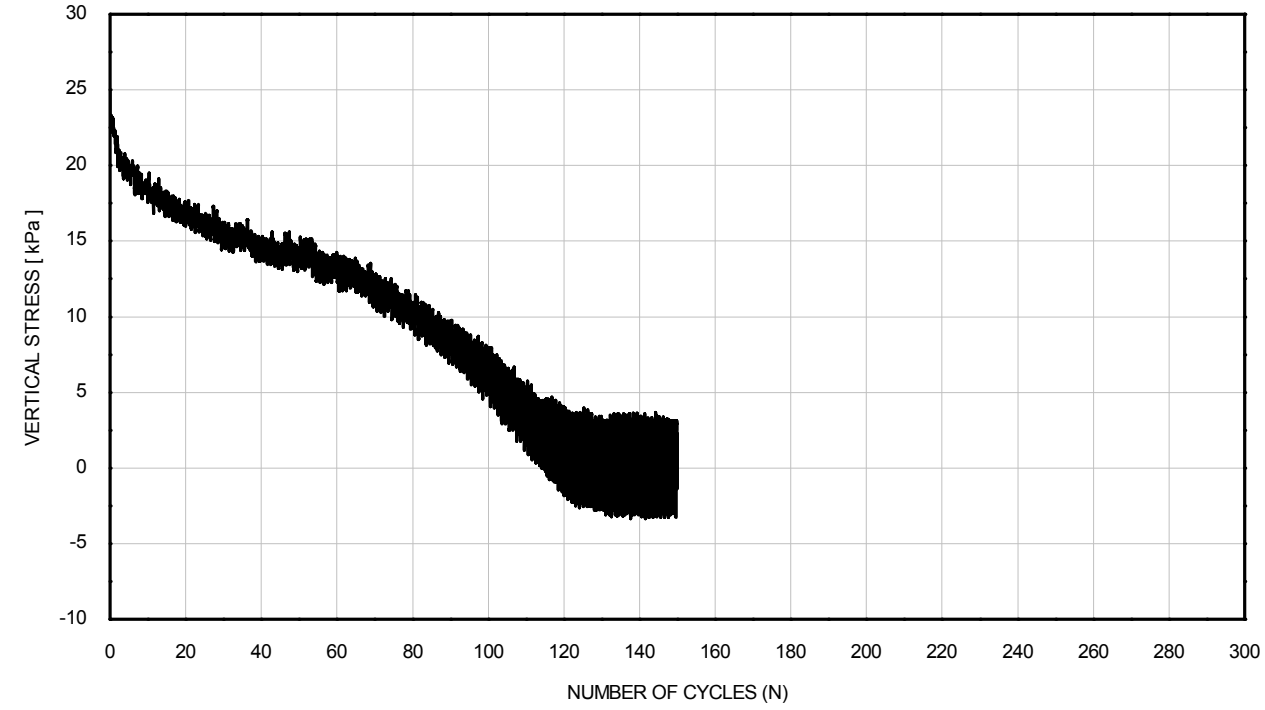


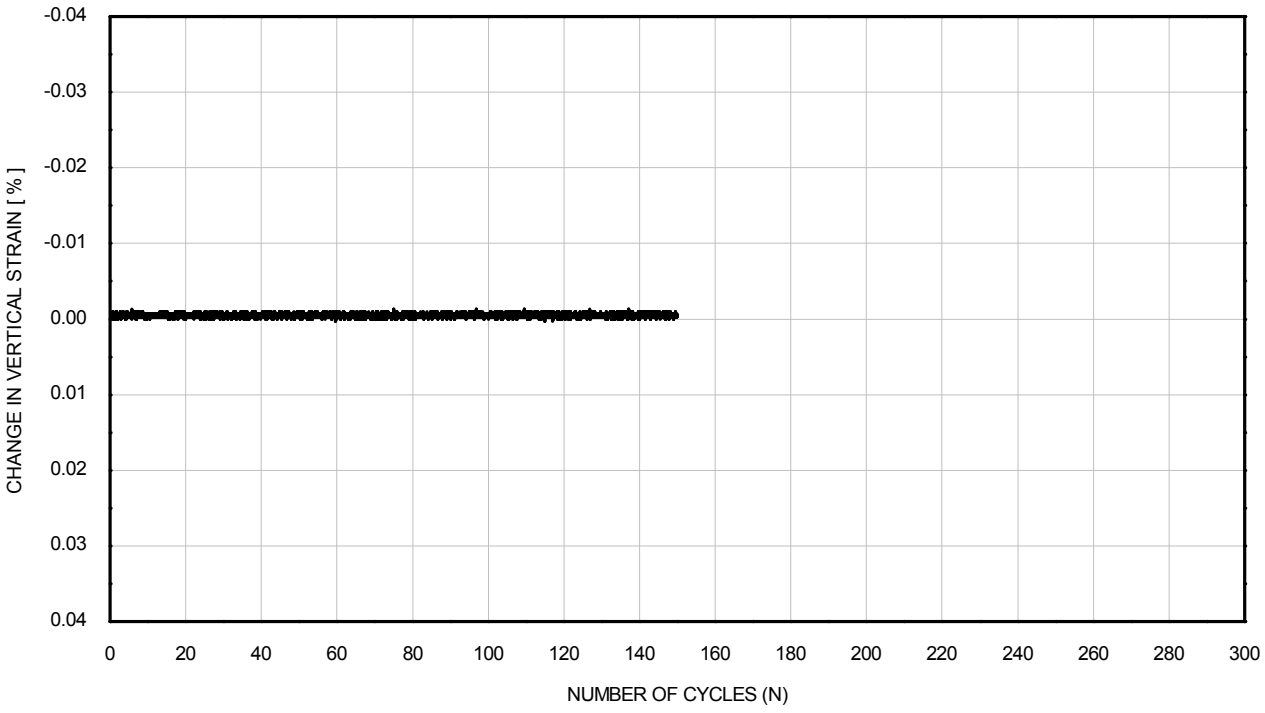


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-4
Mean τ_{cy}	:	6 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS14

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

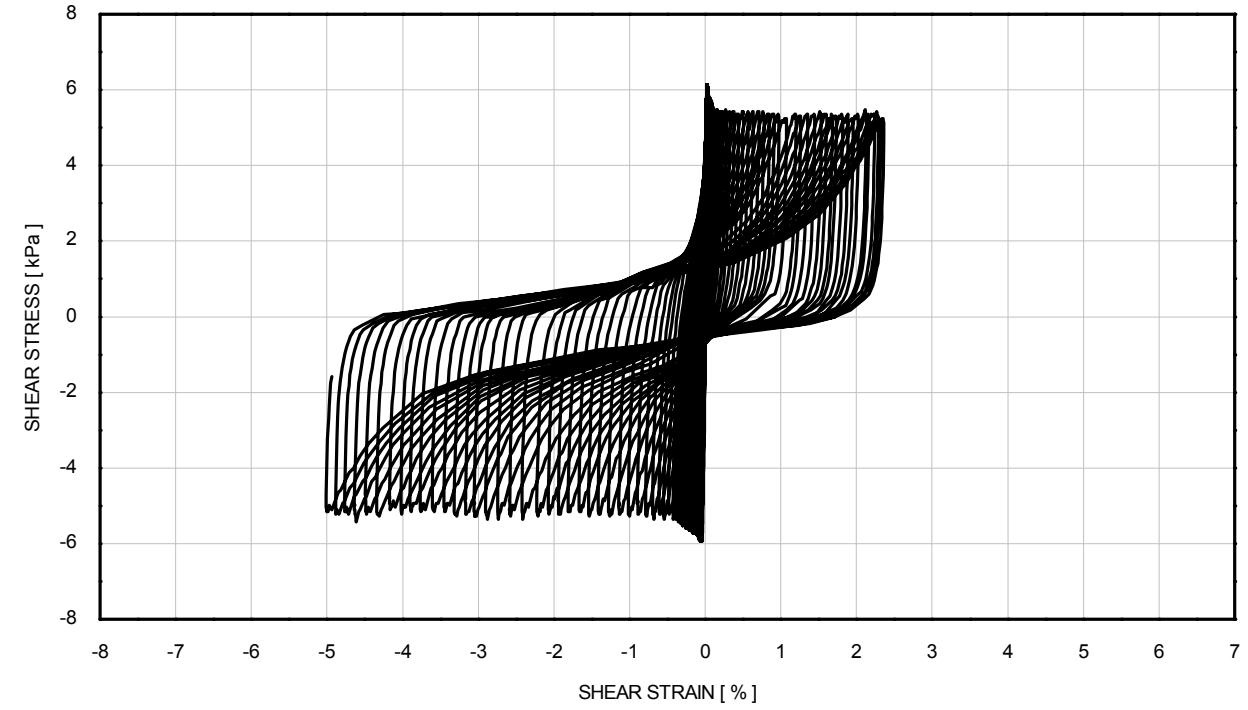


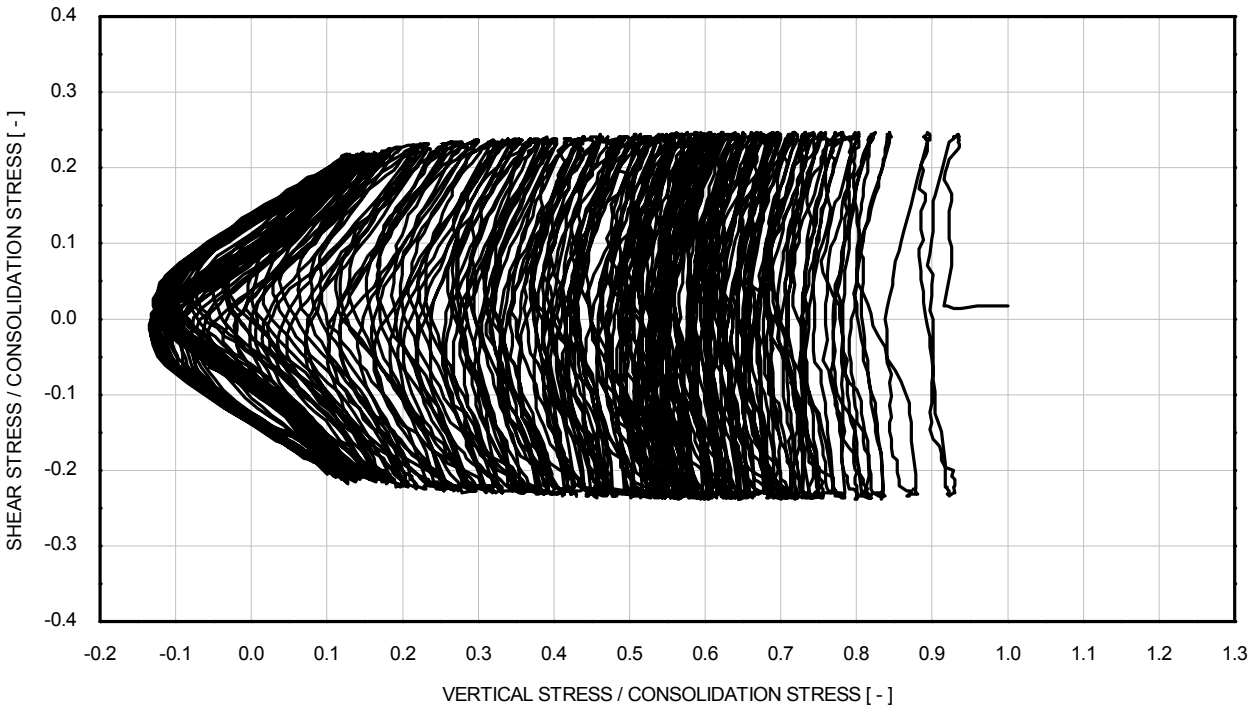


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-4
Mean τ_{cy}	:	6 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS14

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

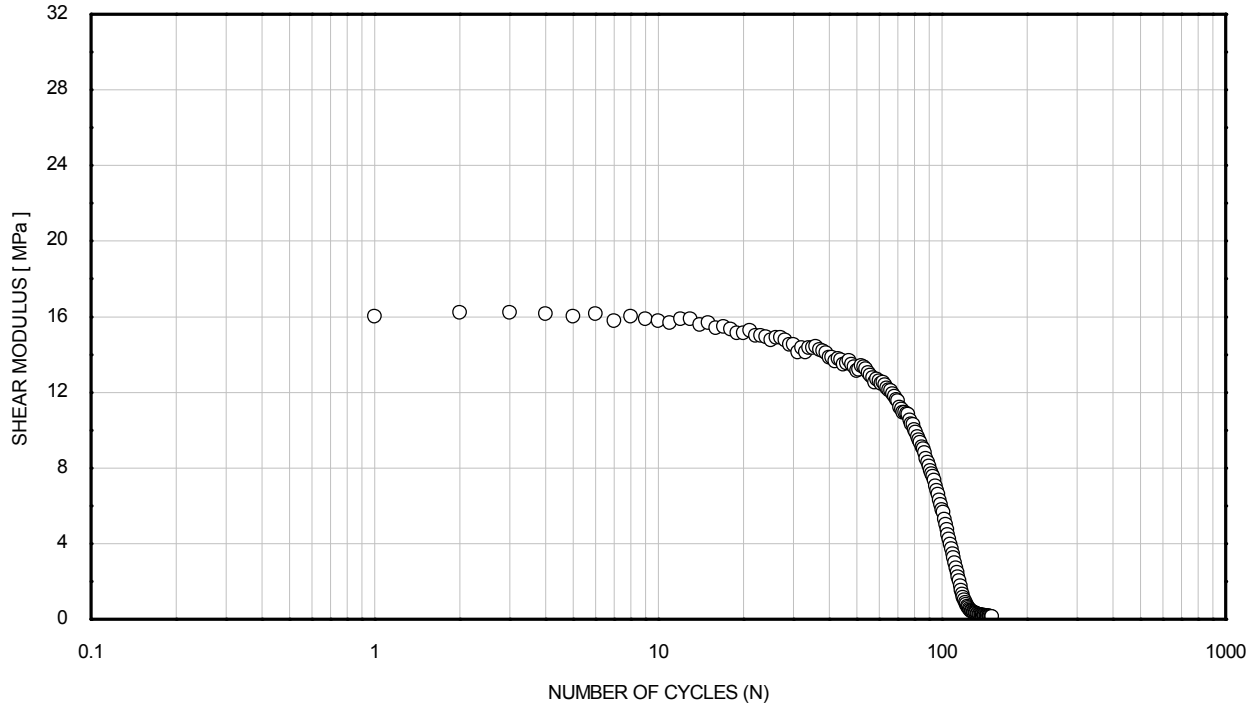


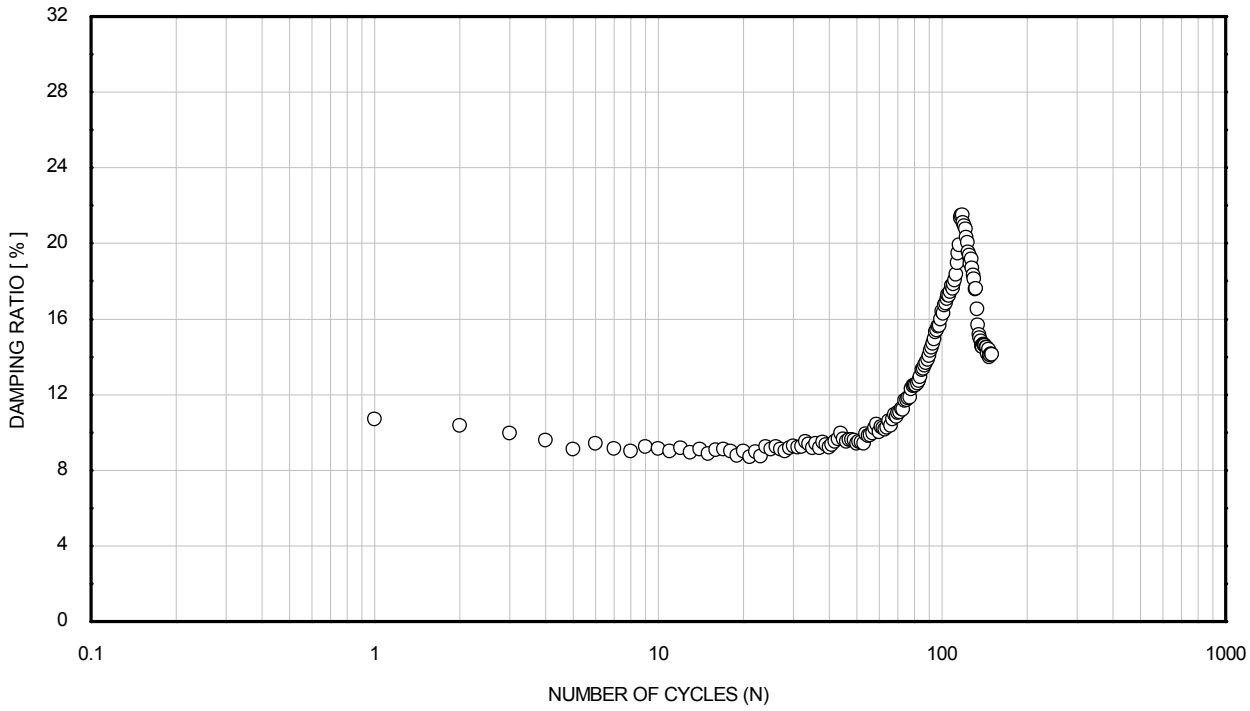


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-4
Mean τ_{cy}	:	6 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS14

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

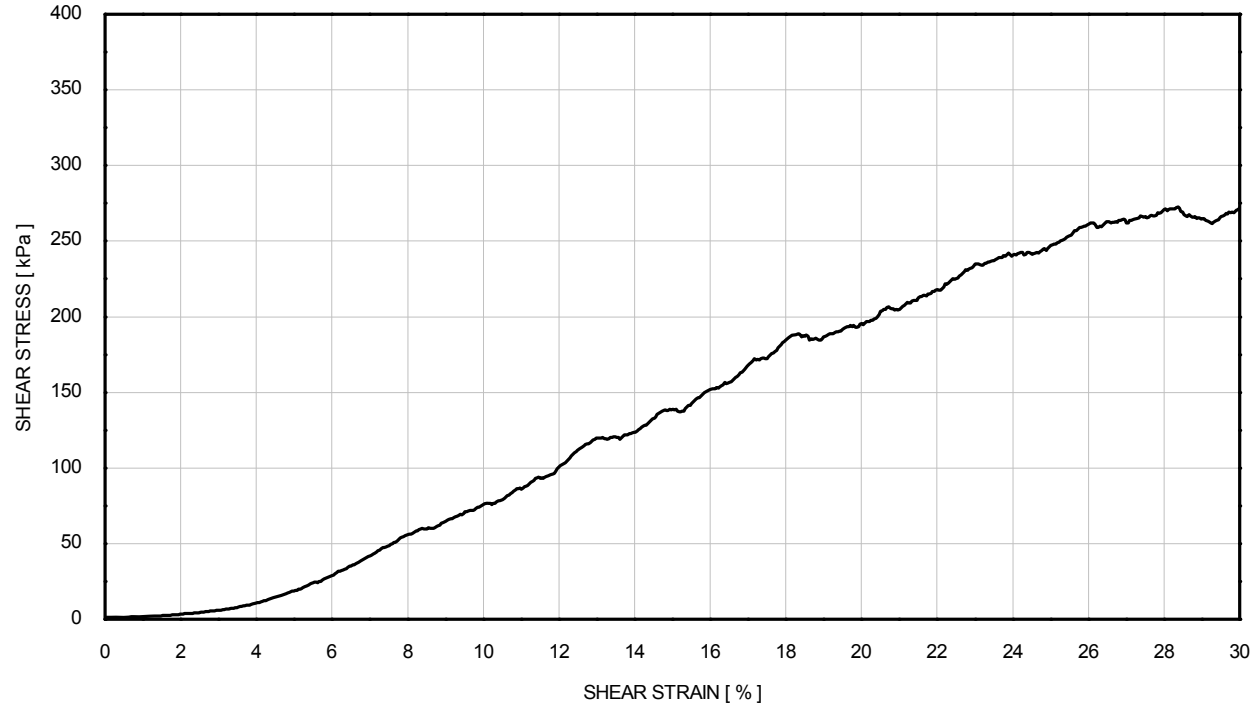


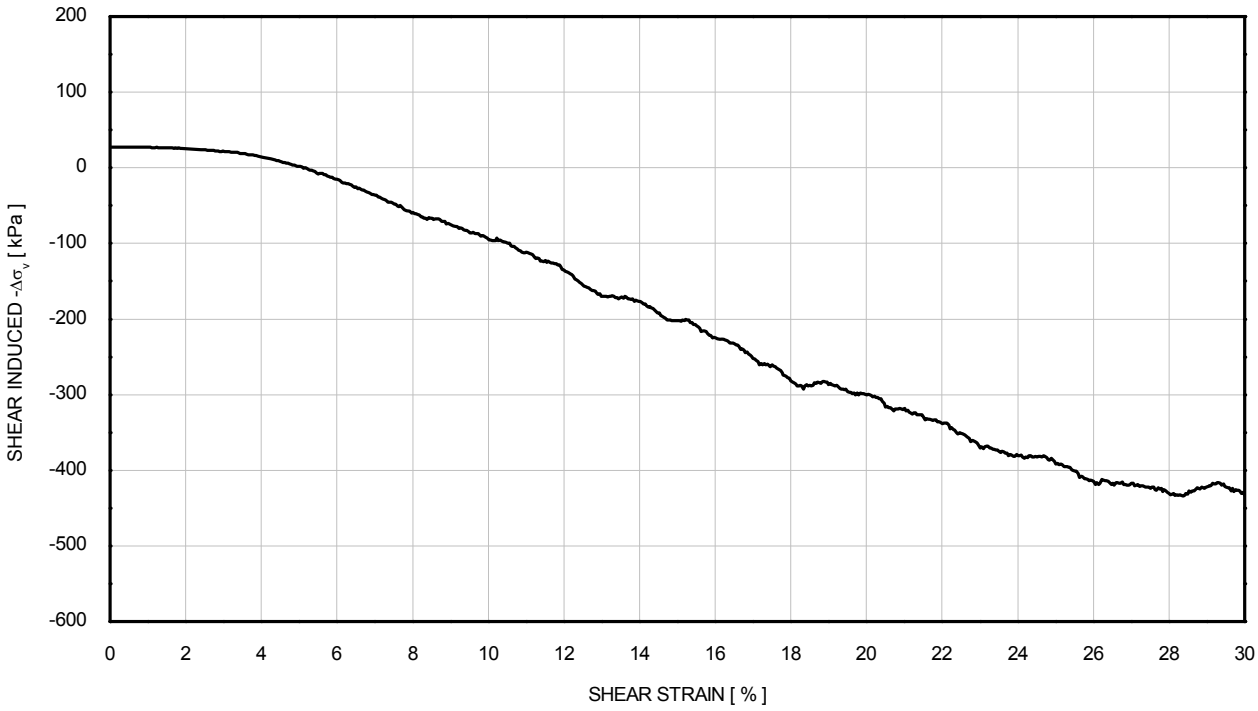


σ_{vc}	:	25 kPa	Batch	:	1
Mean τ_{av}	:	0 kPa	Sample	:	CSS_1-4
Mean τ_{cy}	:	6 kPa	Unit	:	A (Southern Bight)
Frequency	:	0.10 Hz	Test No.	:	CSS14

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

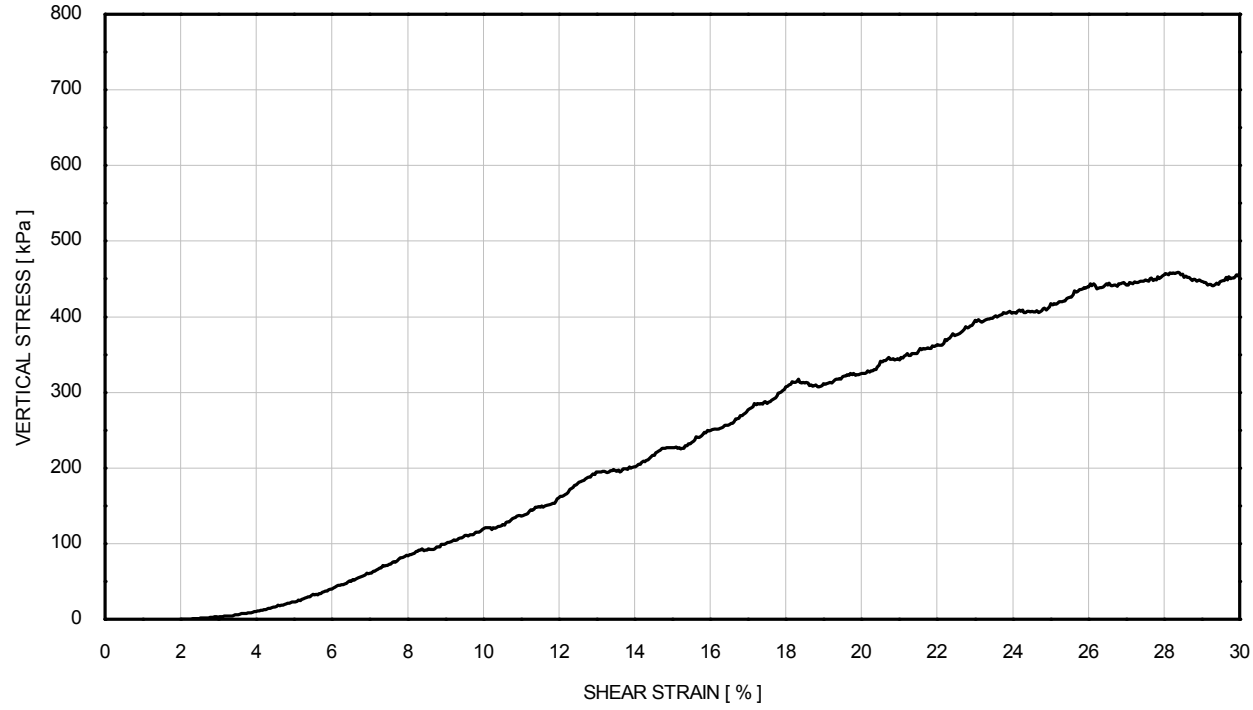


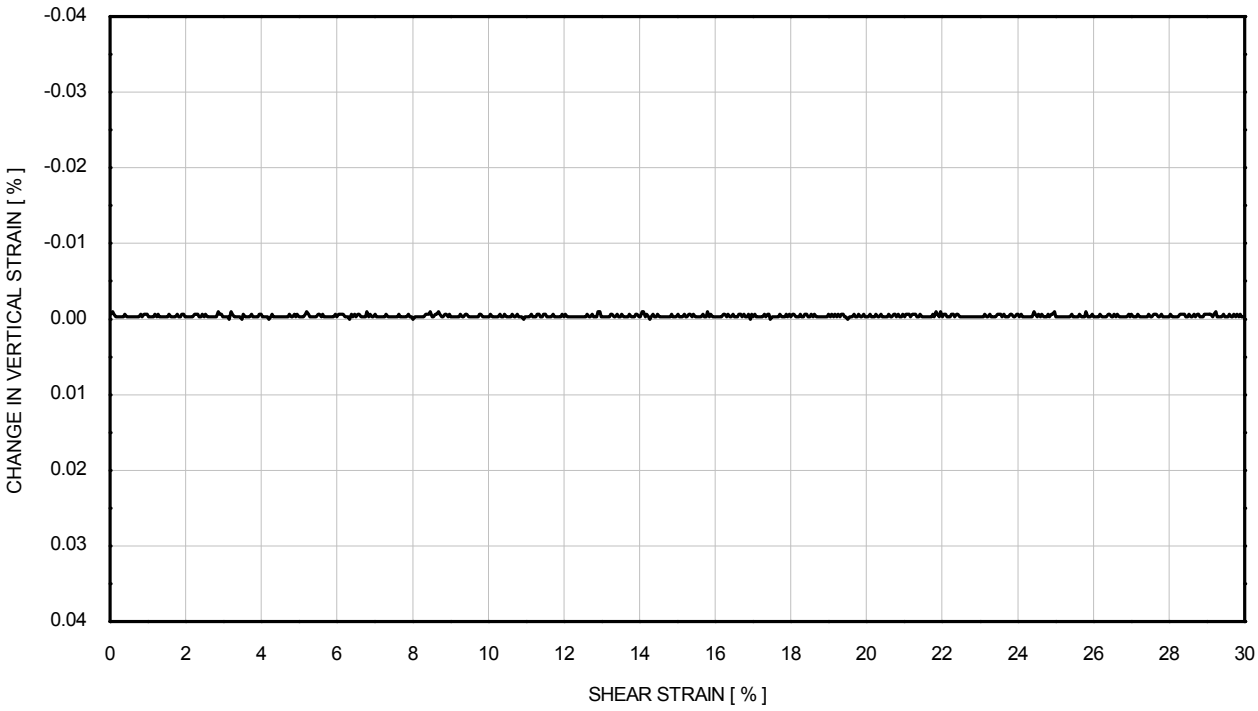


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 274 kPa	Sample	: CSS_1-4
γ at τ_{peak}	: 30.16 %	Unit	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS14

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

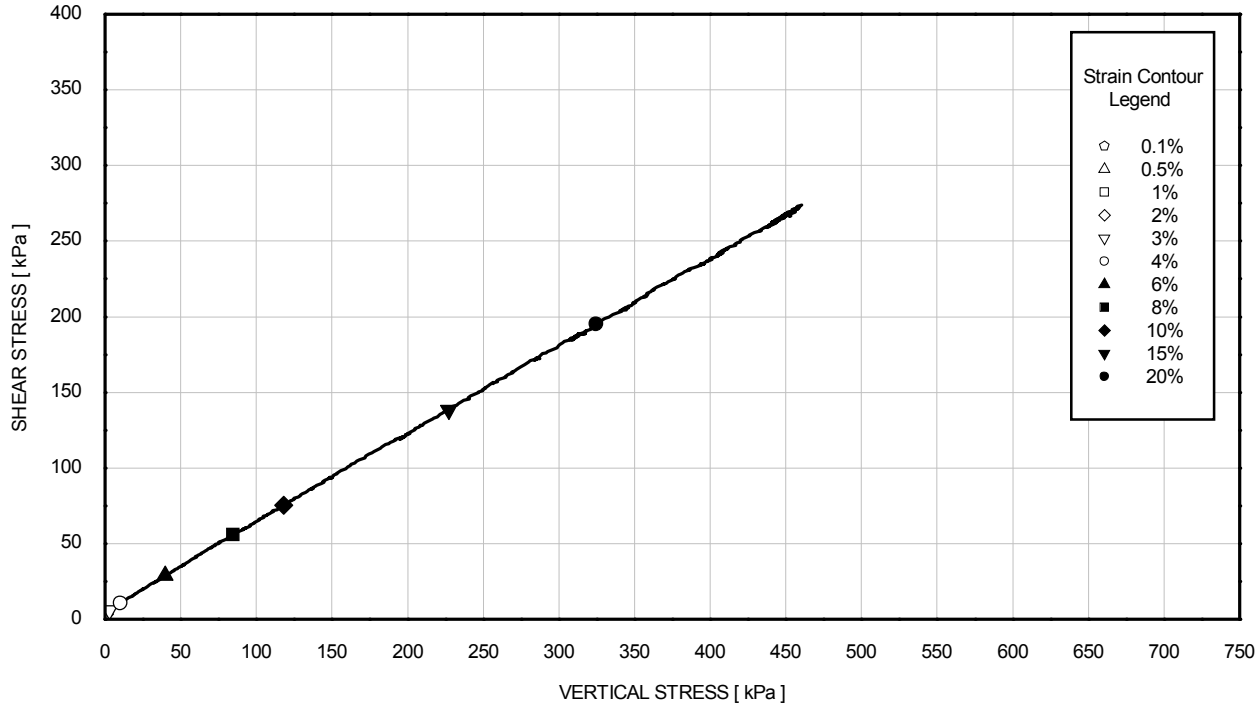


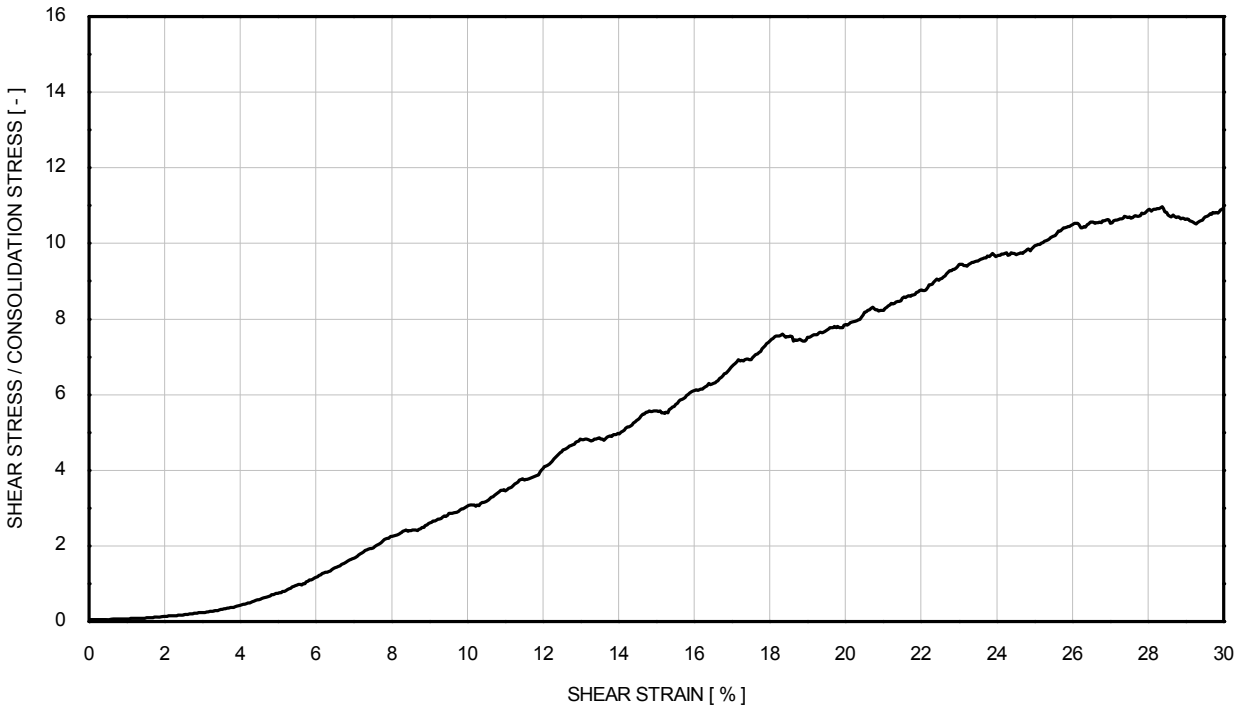


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 274 kPa	Sample	: CSS_1-4
γ at τ_{peak}	: 30.16 %	Unit	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS14

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

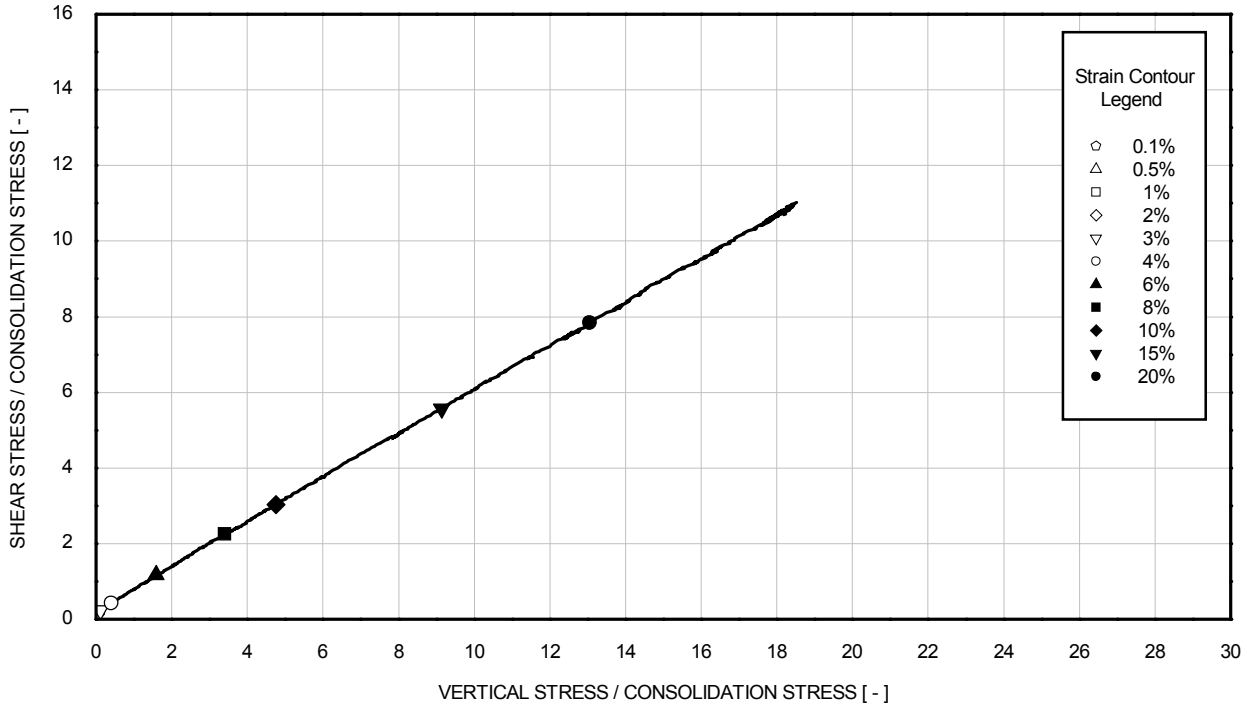


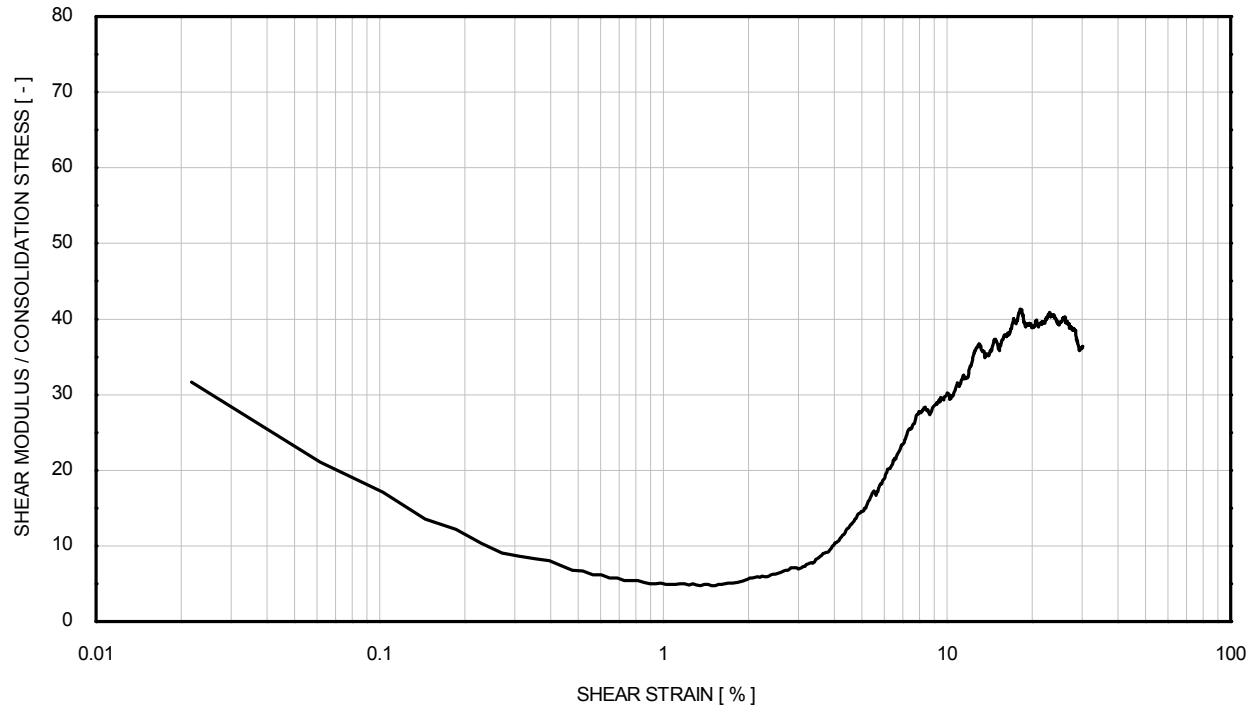


σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 274 kPa	Sample	: CSS_1-4
γ at τ_{peak}	: 30.16 %	Unit	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS14

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 25 kPa	Batch	: 1
τ_{peak}	: 274 kPa	Sample	: CSS_1-4
γ at τ_{peak}	: 30.16 %	Unit	: A (Southern Bight)
Rate of strain	: 4.99 %/hour	Test No.	: CSS14

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	04/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.4
Length	[mm]	30.0
Moisture content after compaction	[%]	9.8
Bulk density after compaction	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.556
Degree of saturation after compaction	[%]	47
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	21
Bulk density at start of test	[Mg/m³]	2.06
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 2_CSS 2-1_CSS15
Template issue	1.3
Processed by	HJ
Date	10/02/2015
Checked by	PH
Date	16/02/2016
Approved by	PH
Date	16/02/2016

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-1
Unit	B (Eem/Kreftenheye)
Test number	CSS15

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	80
Vertical strain	[%]	0.24
Bulk density	[Mg/m^3]	2.06
Dry density	[Mg/m^3]	1.71
Void ratio	[-]	0.552
Moisture content	[%]	20.8

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	80
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	22
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	6
γ_{av} at N_f	[%]	-0.10
γ_{cy} at N_f	[%]	3.59
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	65
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.10	0.40	5.79	20.54
2	-0.26	1.05	2.12	22.59
3	-0.24	1.91	1.16	16.58
4	-0.16	2.59	0.86	13.37
5	-0.12	3.09	0.73	11.98
6	-0.10	3.59	0.62	11.39

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-1
Unit	B (Eem/Kreftenheye)
Test number	CSS15

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

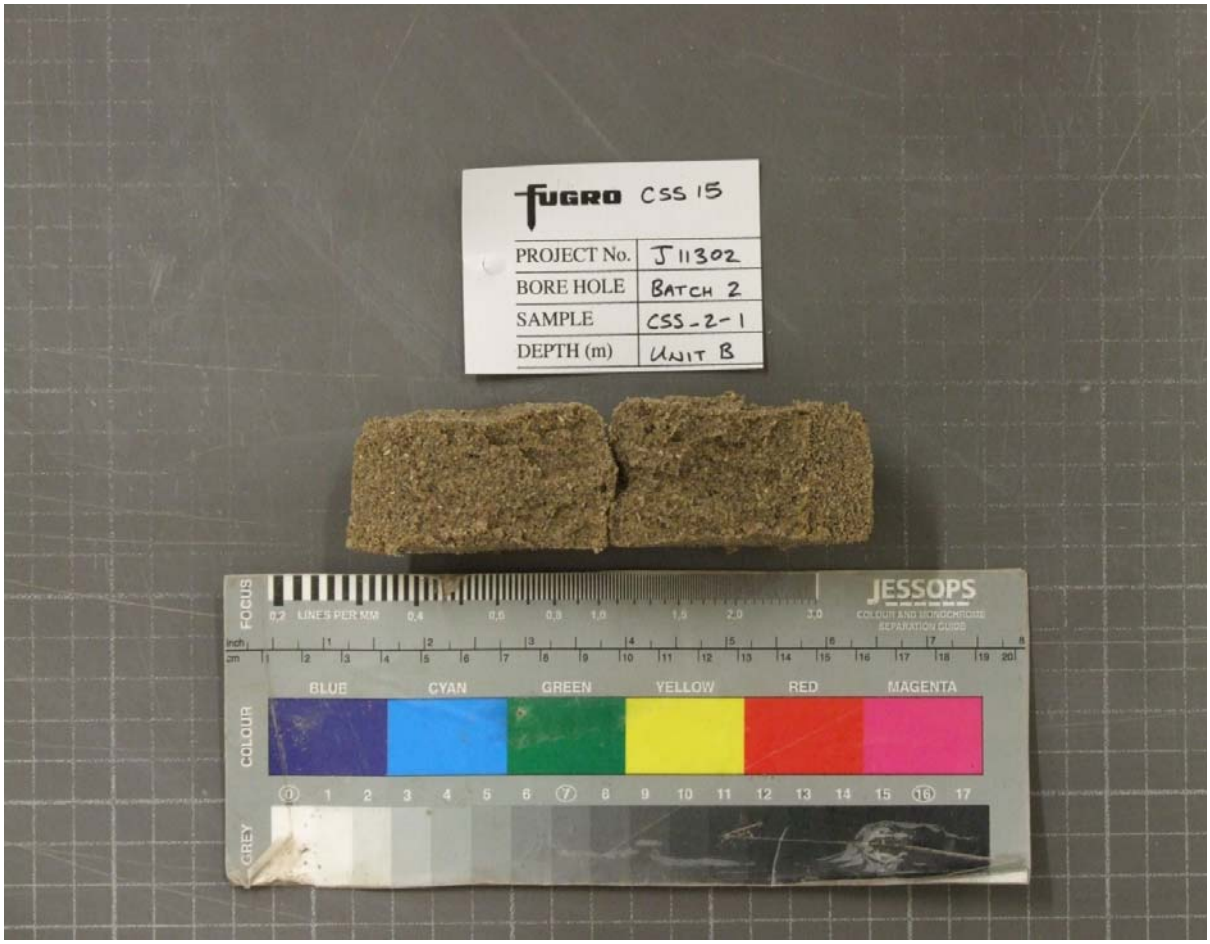
SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	447
Shear strain	[%]	29.93
Shear induced $-\Delta\sigma_v$	[kPa]	-690
Vertical stress	[kPa]	770
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.99
At 15 % shear strain		
Shear stress	[kPa]	158
Shear induced $-\Delta\sigma_v$	[kPa]	-182
Vertical stress	[kPa]	262
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-1
Unit	B (Eem/Kreftenheye)
Test number	CSS15

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

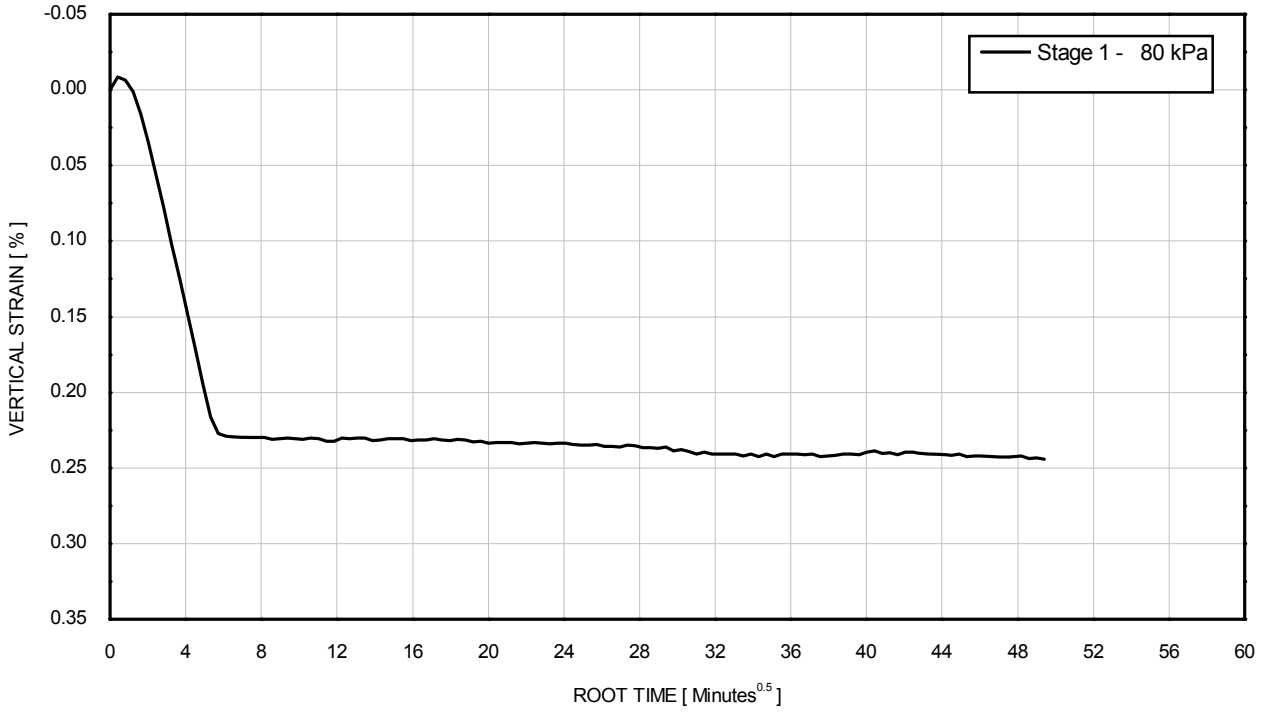
SPECIMEN PHOTOGRAPH

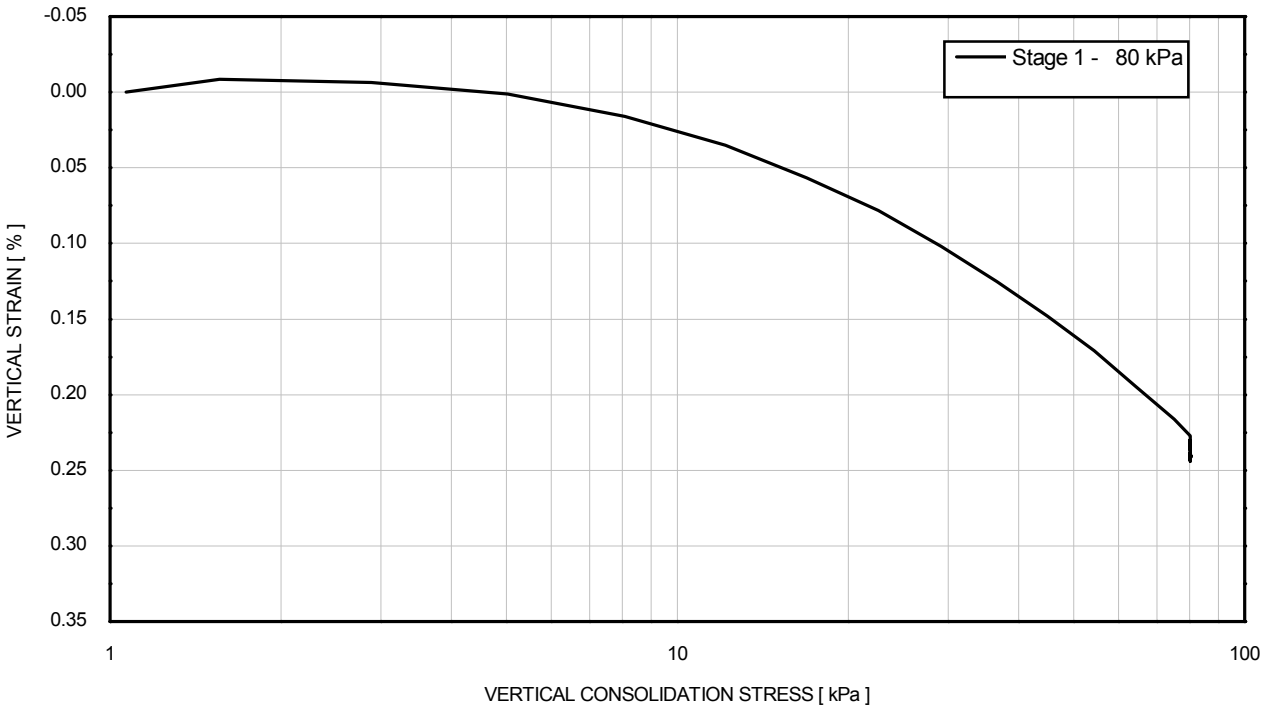


TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-1
Unit	B (Eem/Kreftenheye)
Test number	CSS15

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

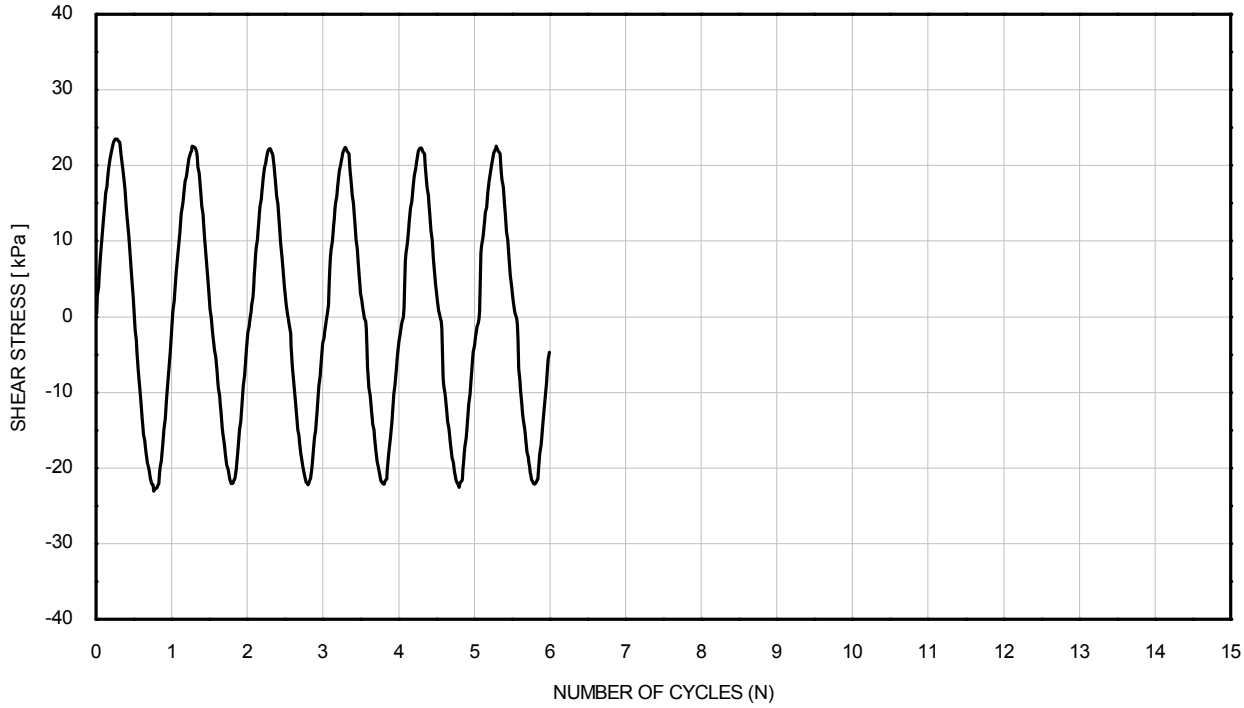


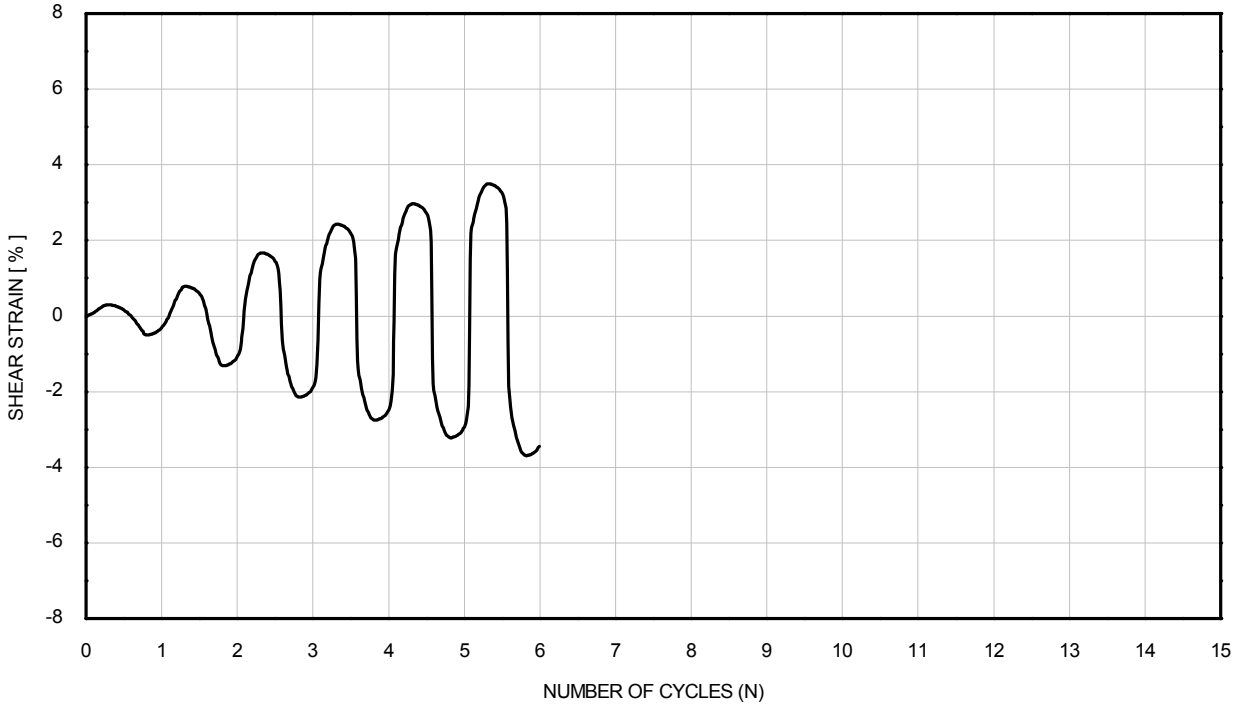


σ_{vc}	: 80 kPa	Batch	: 2
		Sample	: CSS_2-1
		Unit	: B (Eem/Kreftenheye)
		Test No.	: CSS15

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

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

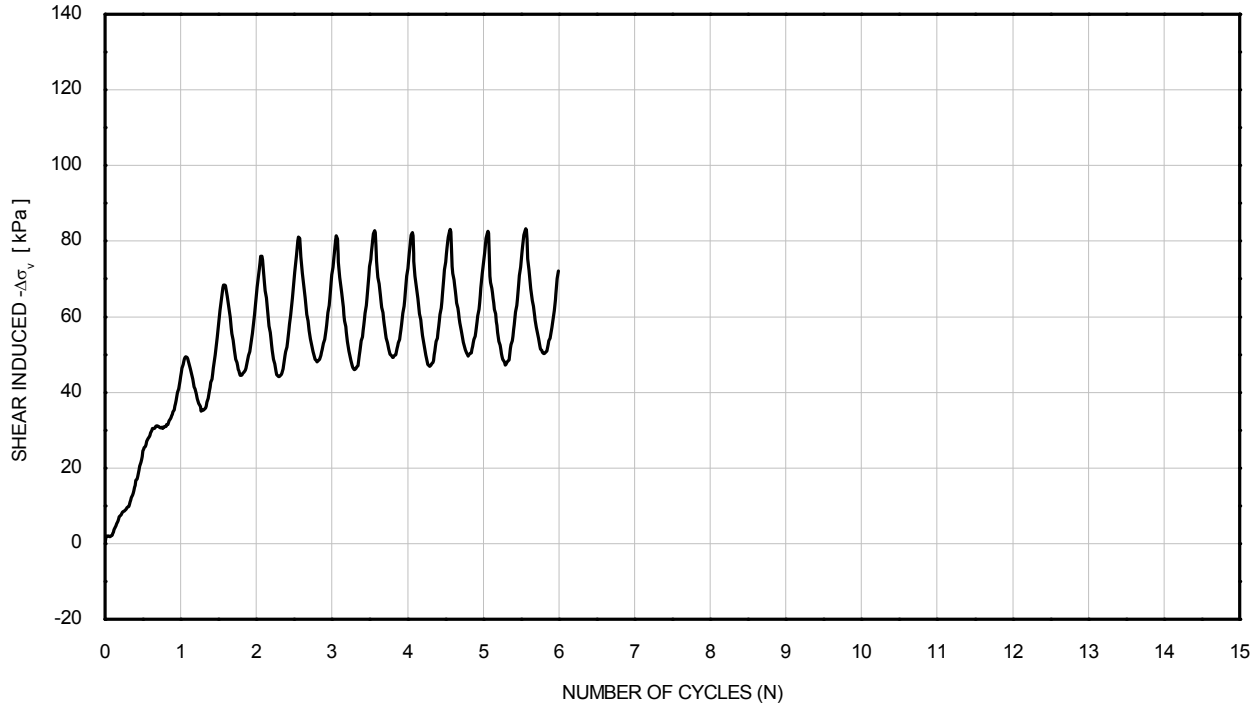


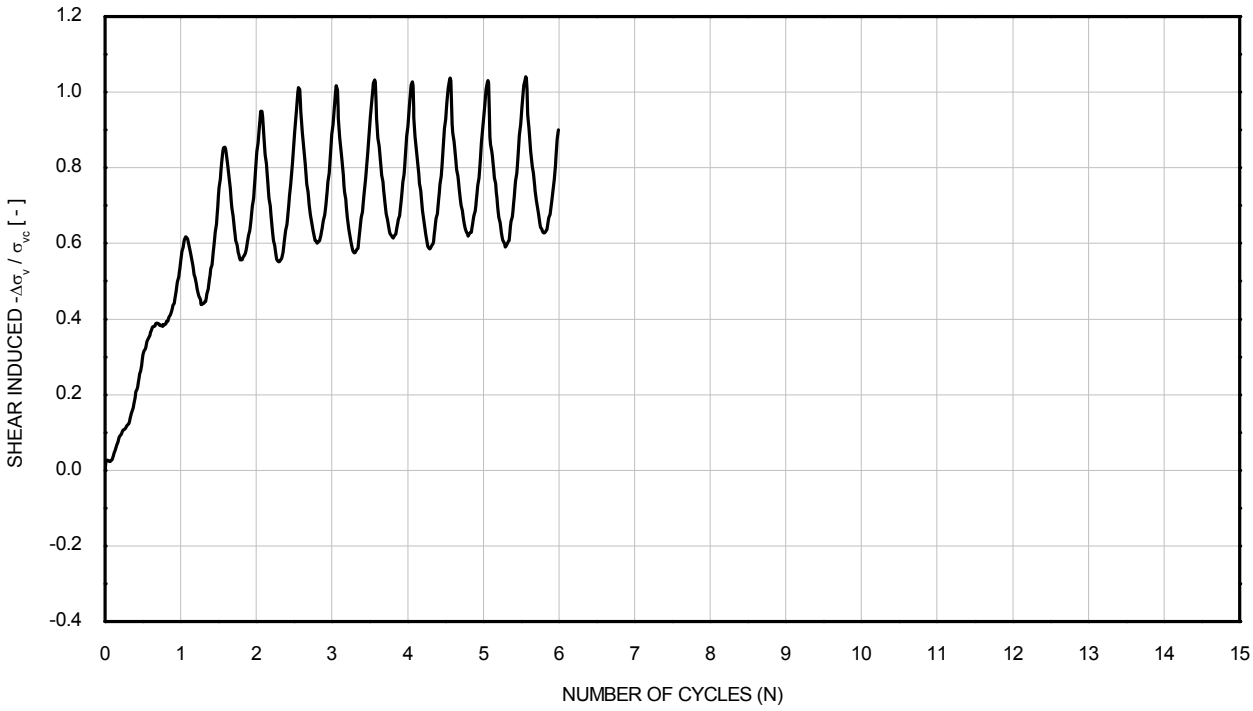


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-1
Mean τ_{cy}	:	22 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS15

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

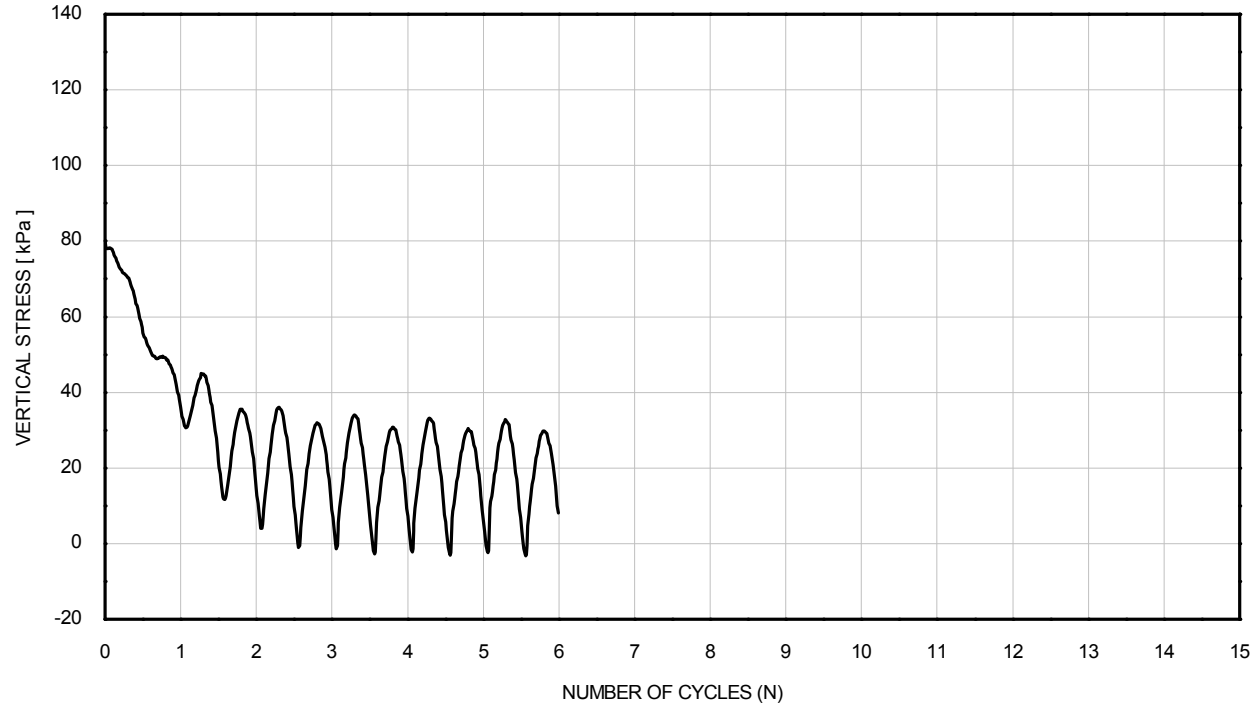


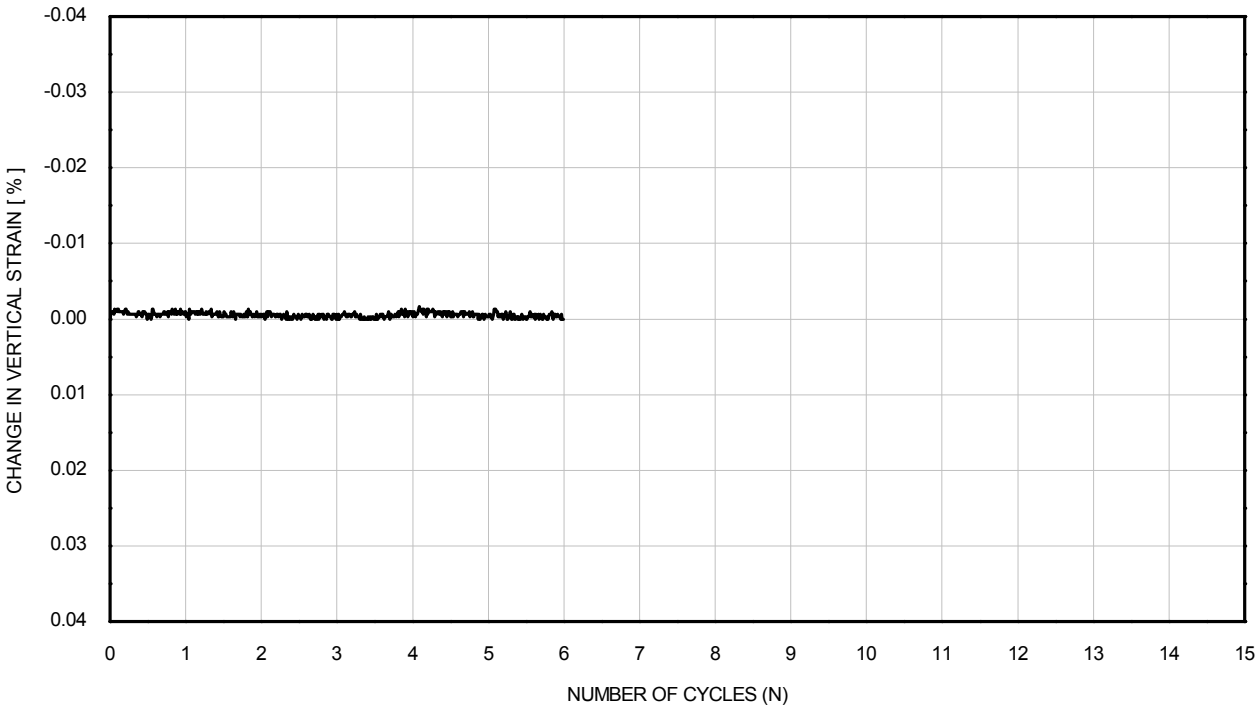


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-1
Mean τ_{cy}	:	22 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS15

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

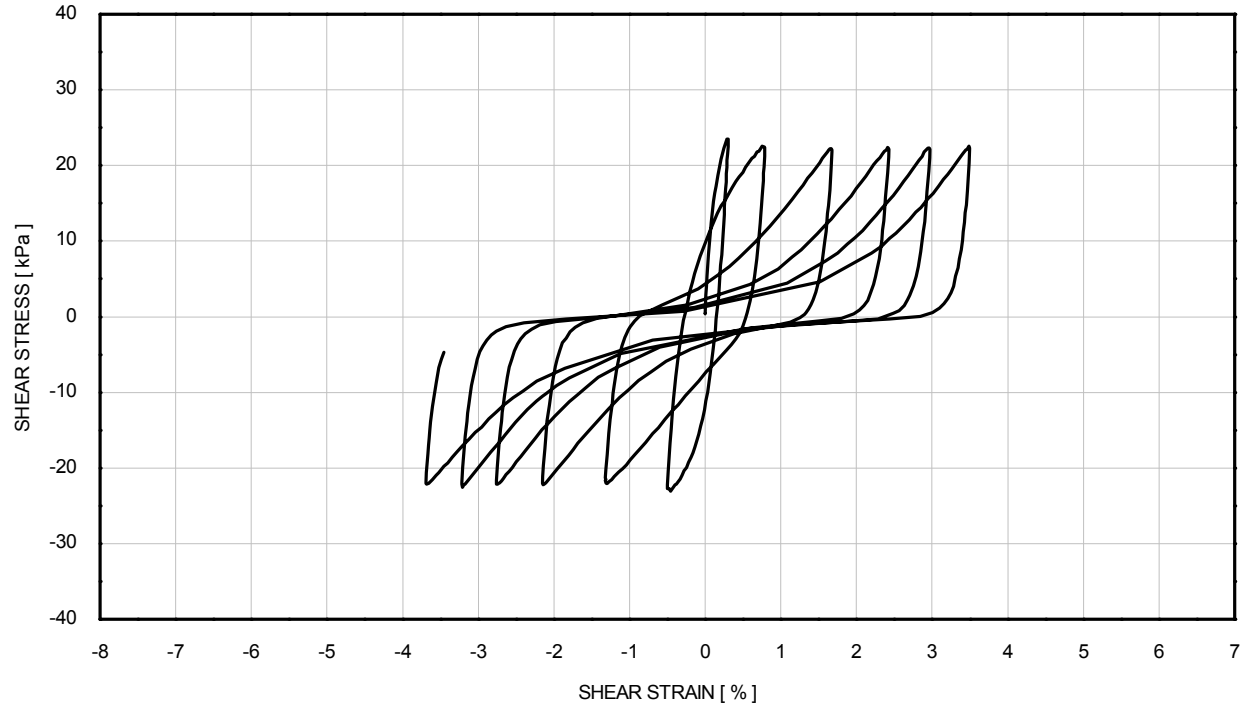


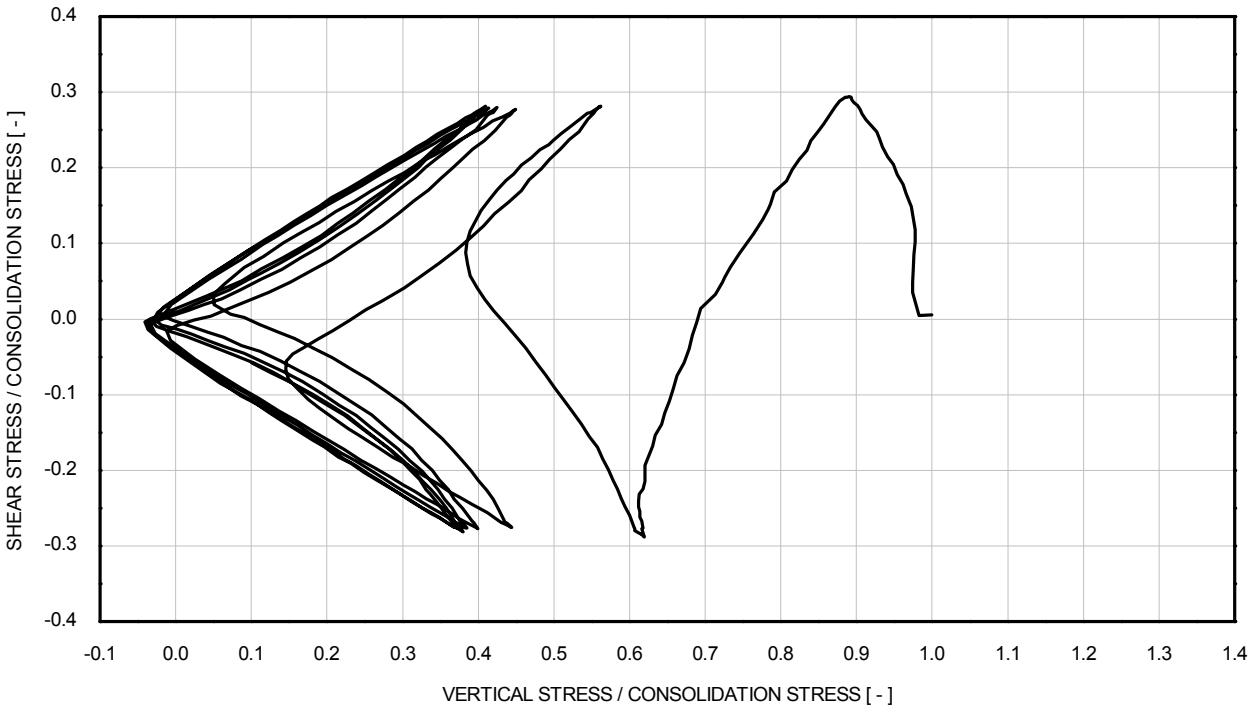


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-1
Mean τ_{cy}	:	22 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS15

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

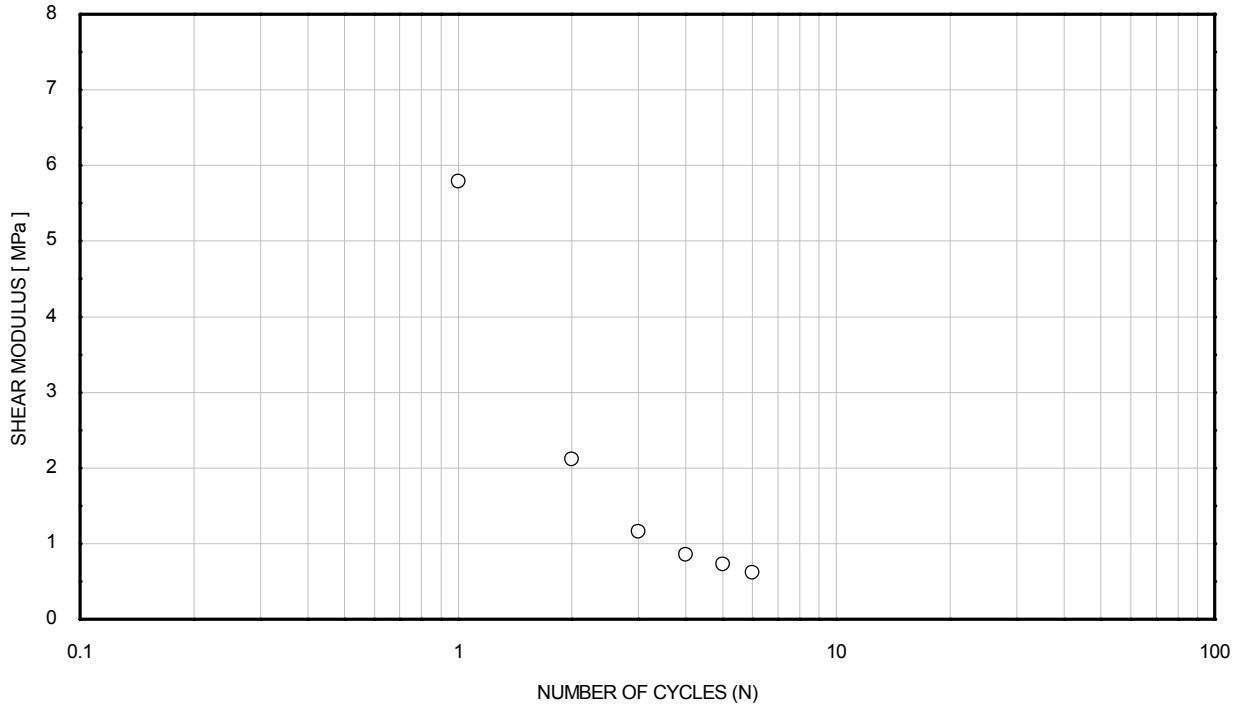


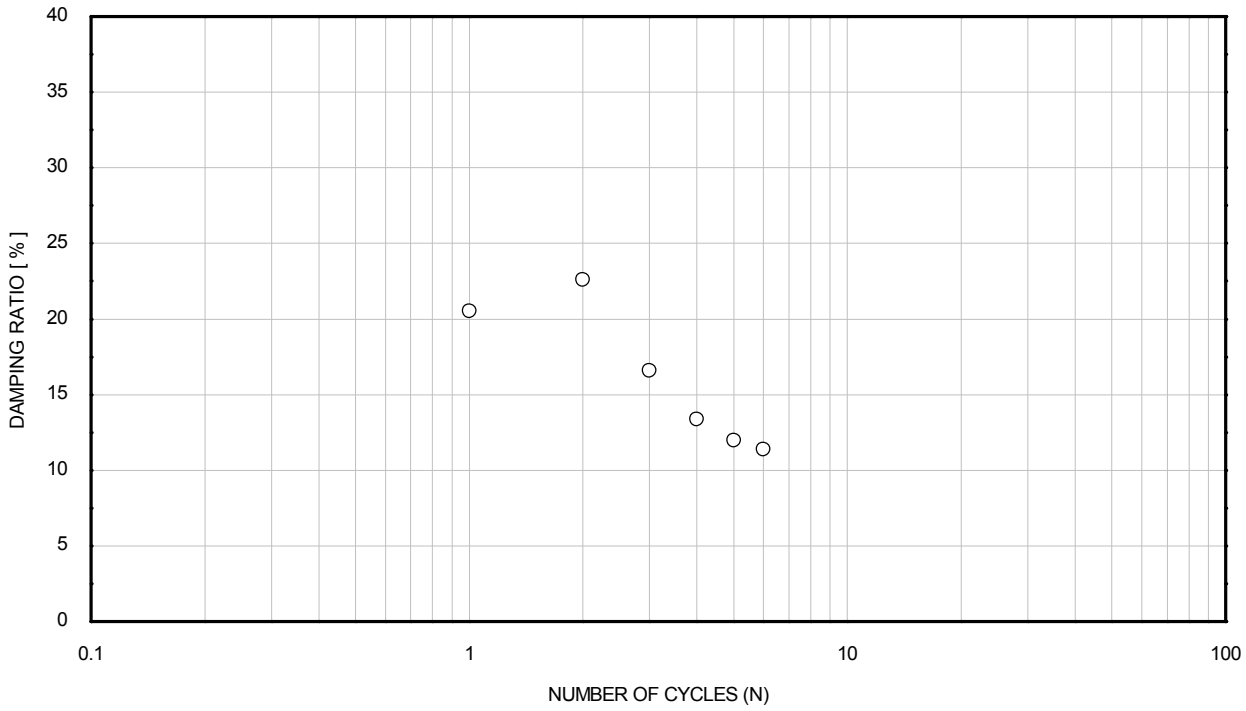


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-1
Mean τ_{cy}	:	22 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS15

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

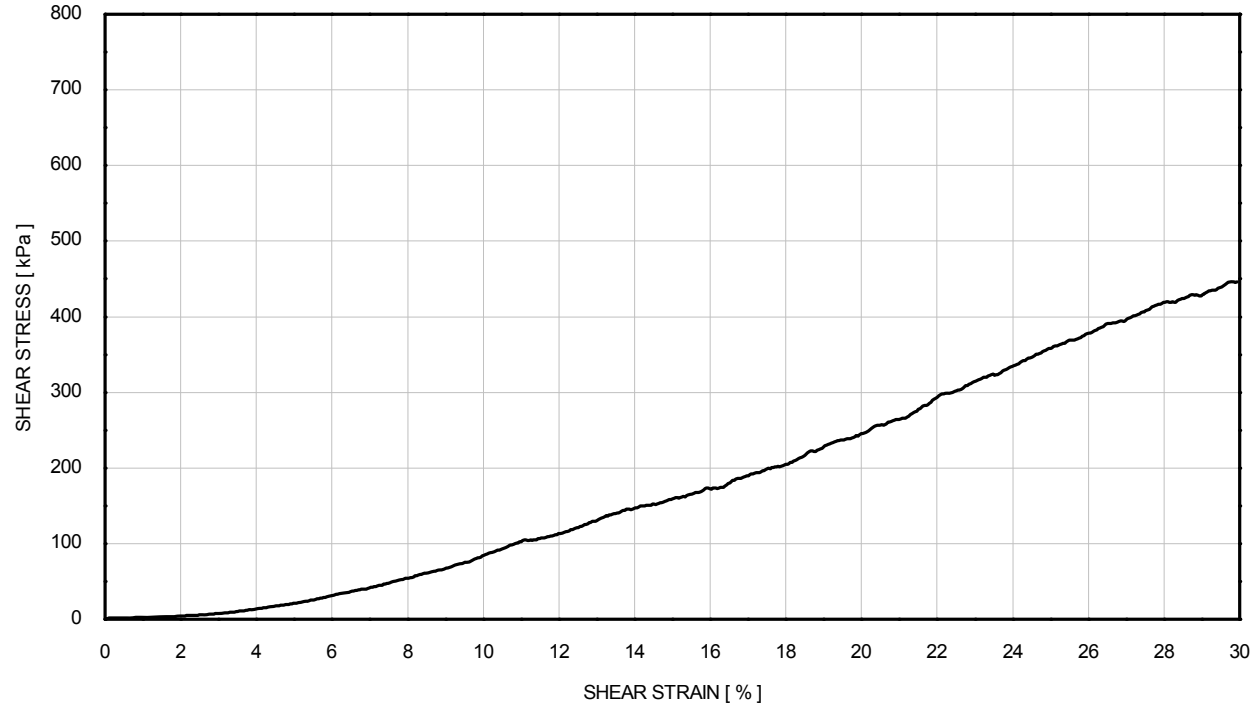


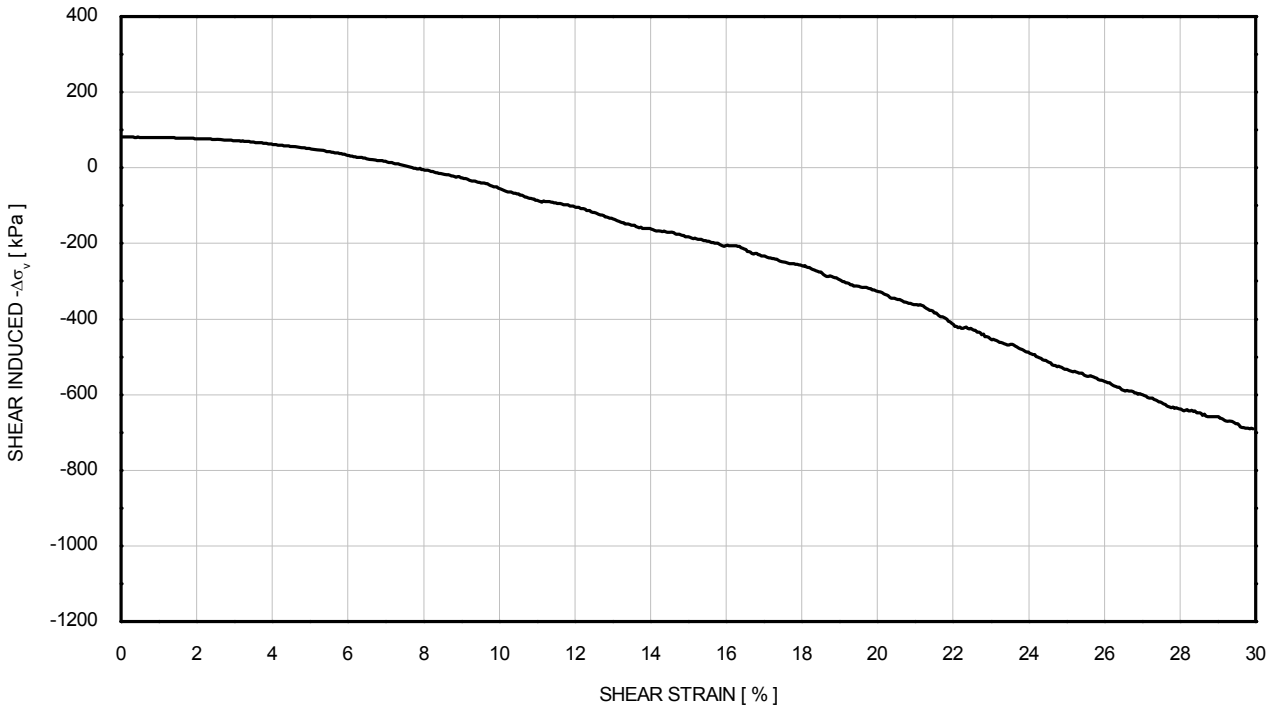


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-1
Mean τ_{cy}	:	22 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS15

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

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

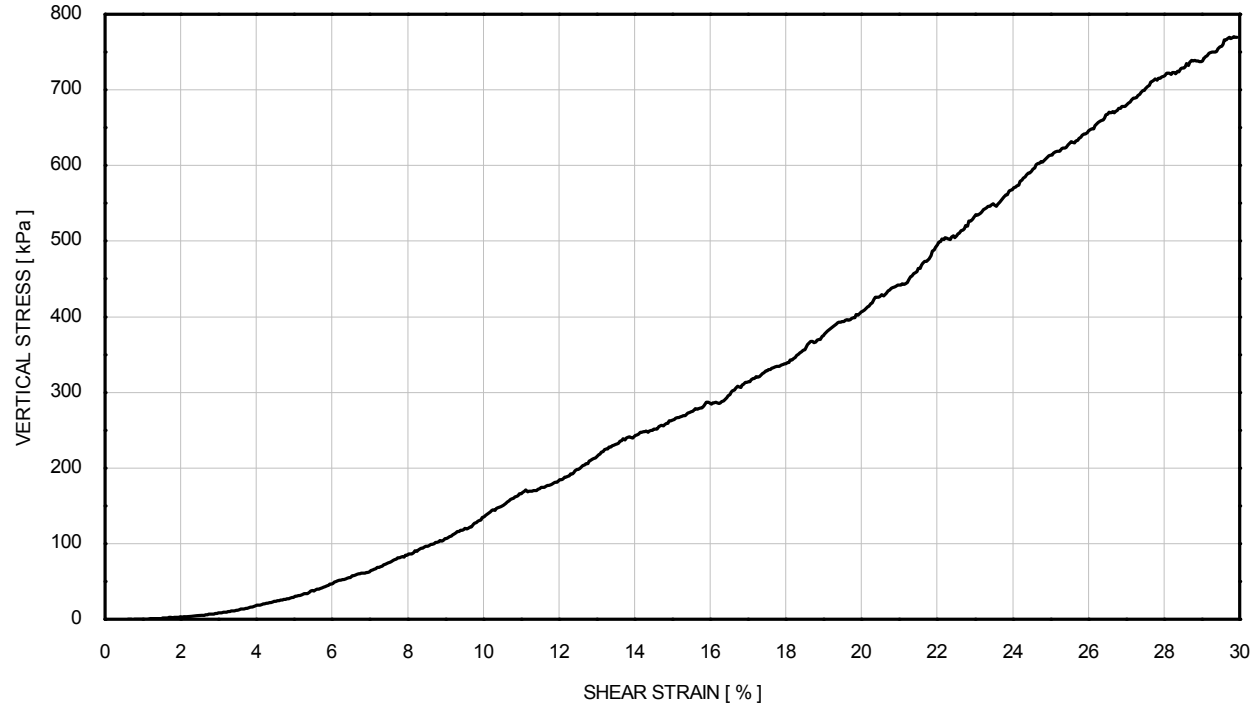


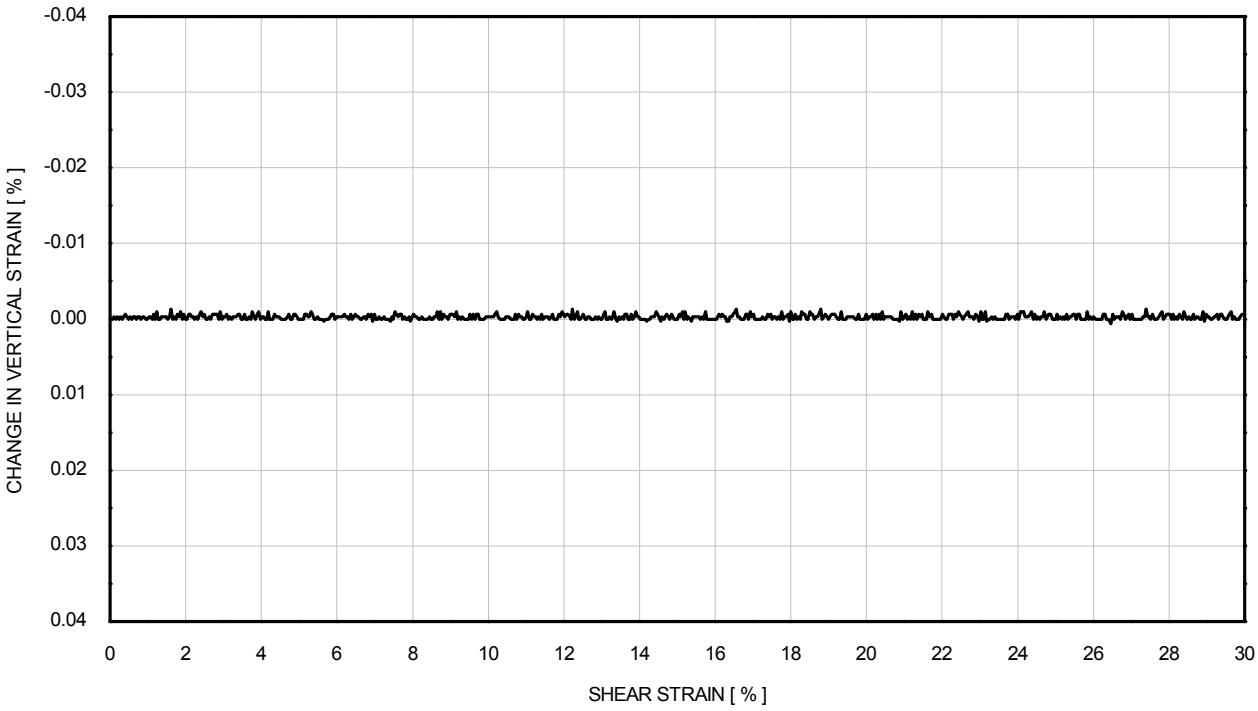


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 447 kPa	Sample	: CSS_2-1
γ at τ_{peak}	: 29.93 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: CSS15

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

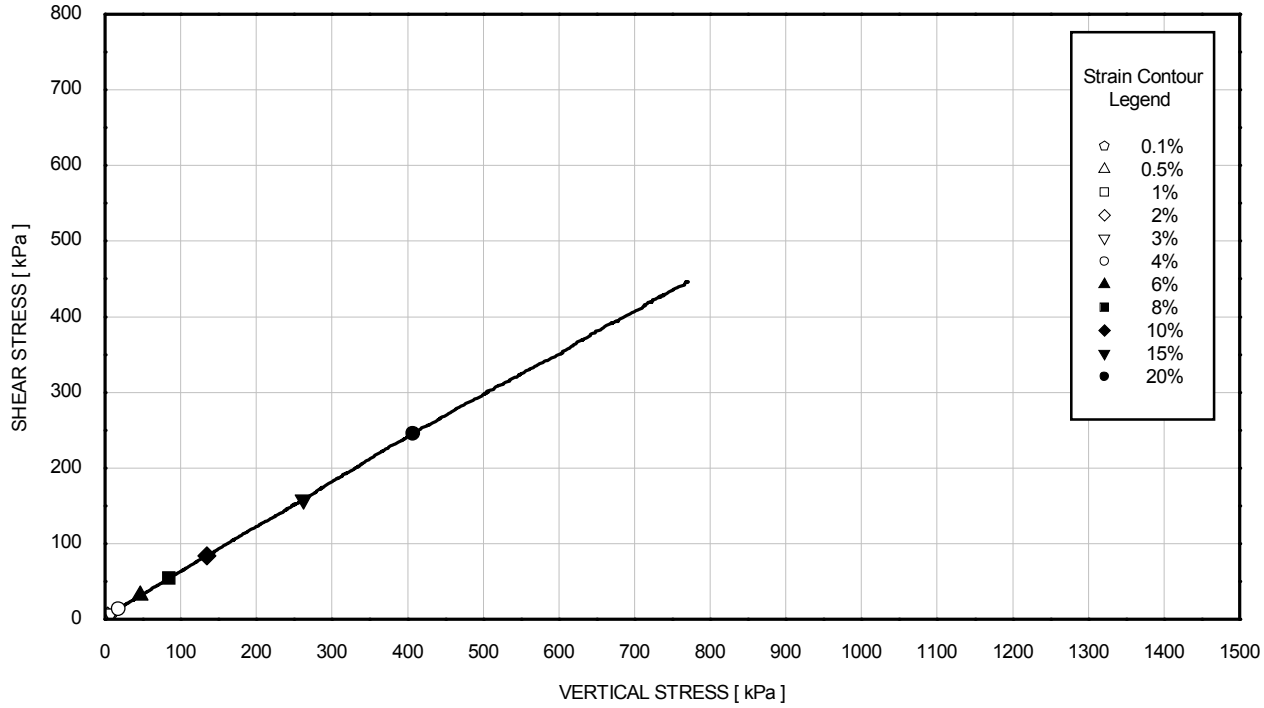


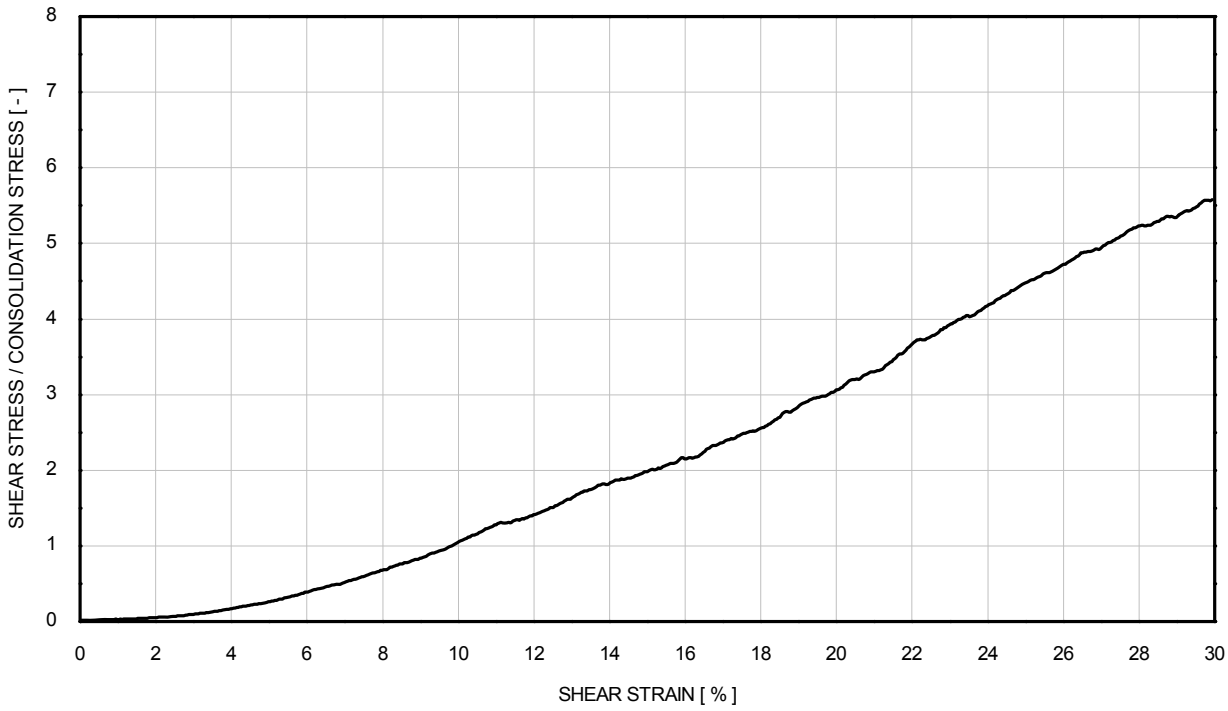


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 447 kPa	Sample	: CSS_2-1
γ at τ_{peak}	: 29.93 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: CSS15

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

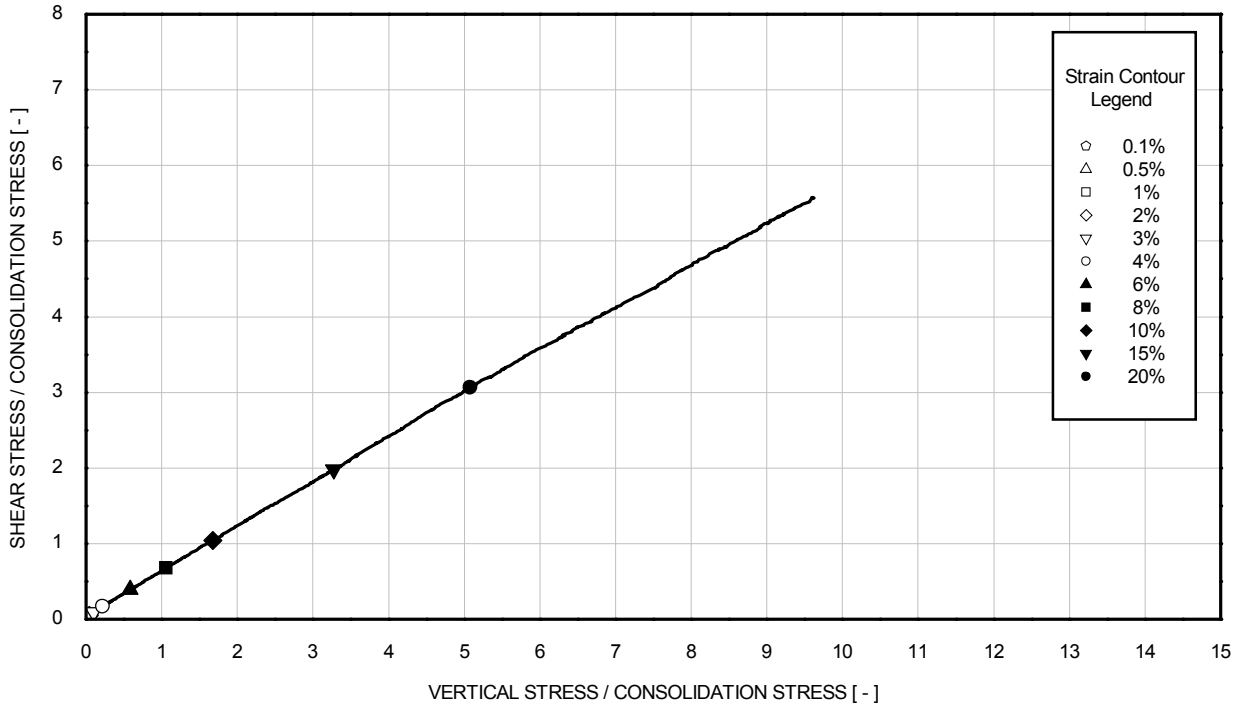


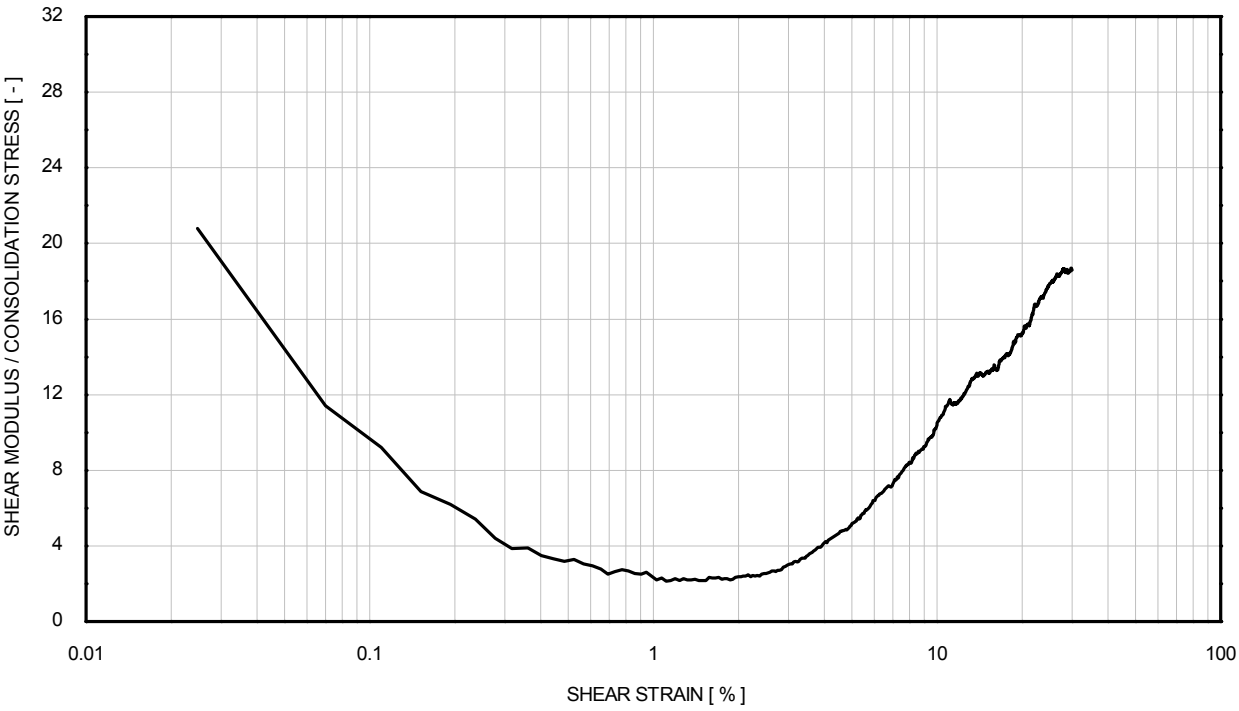


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 447 kPa	Sample	: CSS_2-1
γ at τ_{peak}	: 29.93 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: CSS15

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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





σ_{vc}	: 80	kPa	Batch	: 2
τ_{peak}	: 447	kPa	Sample	: CSS_2-1
γ at τ_{peak}	: 29.93	%	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99	%/hour	Test No.	: CSS15

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

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

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	13/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.5
Length	[mm]	30.0
Moisture content after compaction	[%]	11.1
Bulk density after compaction	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.68
Void ratio	[-]	0.574
Degree of saturation after compaction	[%]	51
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	21.7
Bulk density at start of test	[Mg/m³]	2.05
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 2_CSS 2-2_CSS16
Template issue	1.3
Processed by	HJ
Date	18/02/2016
Checked by	PH
Date	14/03/2016
Approved by	PH
Date	14/03/2016

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-2
Unit	B (Eem/Kreftenheye)
Test number	CSS16

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

CONSOLIDATION		
σ_{vc}	[kPa]	80
Vertical strain	[%]	0.21
Bulk density	[Mg/m^3]	2.05
Dry density	[Mg/m^3]	1.69
Void ratio	[-]	0.571
Moisture content	[%]	21.5

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	80
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	15
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	119
γ_{av} at N_f	[%]	-1.73
γ_{cy} at N_f	[%]	3.74
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	73
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.01	0.08	19.94	10.40
2	-0.02	0.07	21.42	9.26
5	-0.03	0.07	21.72	8.22
10	-0.04	0.08	21.13	7.78
20	-0.04	0.08	19.85	8.08
30	-0.05	0.08	18.80	8.49
40	-0.06	0.09	17.23	9.54
50	-0.08	0.11	15.07	11.40
100	-1.44	2.97	0.50	10.58
119	-1.73	3.74	0.40	9.59

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-2
Unit	B (Eem/Kreftenheye)
Test number	CSS16

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

SHEARING – CONSTANT VOLUME*		
At peak shear stress		
Shear stress	[kPa]	322
Shear strain	[%]	22.20
Shear induced $-\Delta\sigma_v$	[kPa]	-464
Vertical stress	[kPa]	544
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.99
At 15 % shear strain		
Shear stress	[kPa]	269
Shear induced $-\Delta\sigma_v$	[kPa]	-377
Vertical stress	[kPa]	457
Vertical strain	[%]	0.00

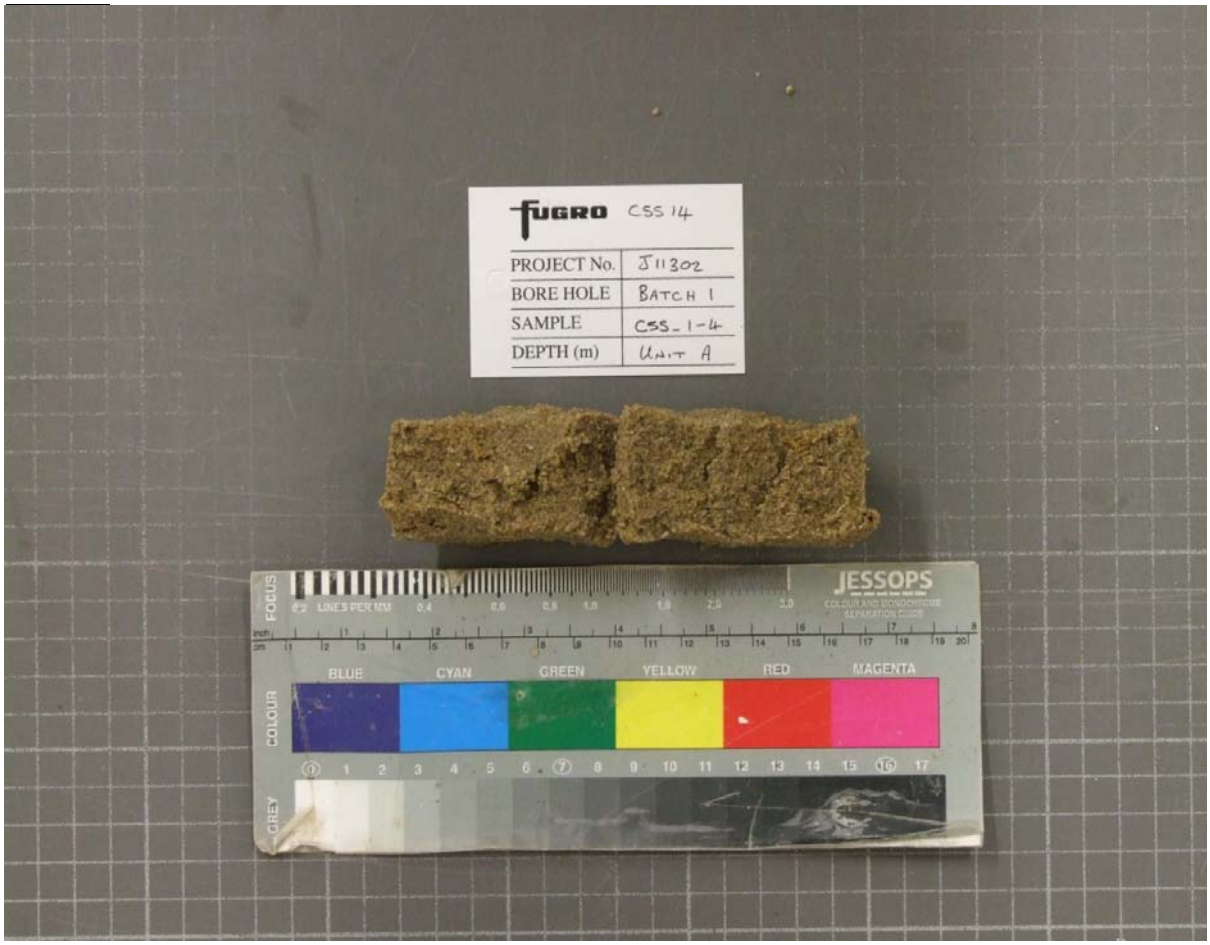
* Please note that specimen failure was observed to occur along or close to the loading platen interface.

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-2
Unit	B (Eem/Kreftenheye)
Test number	CSS16

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

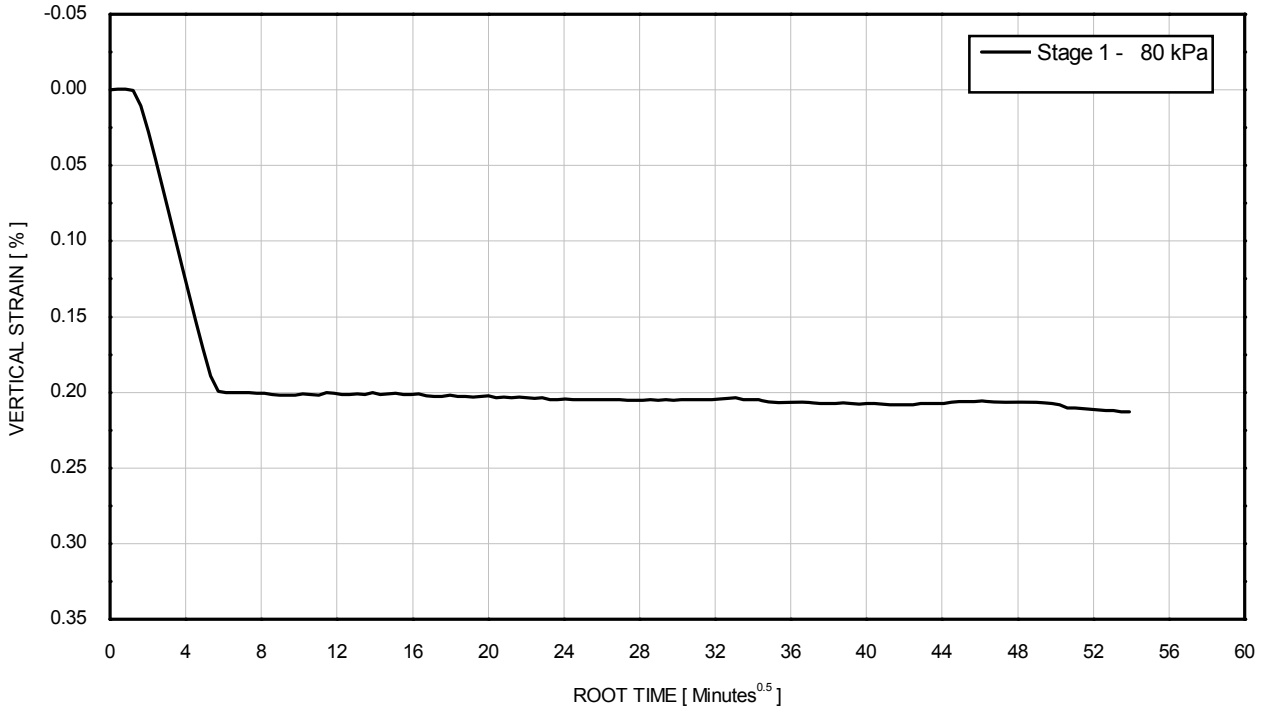
SPECIMEN PHOTOGRAPH

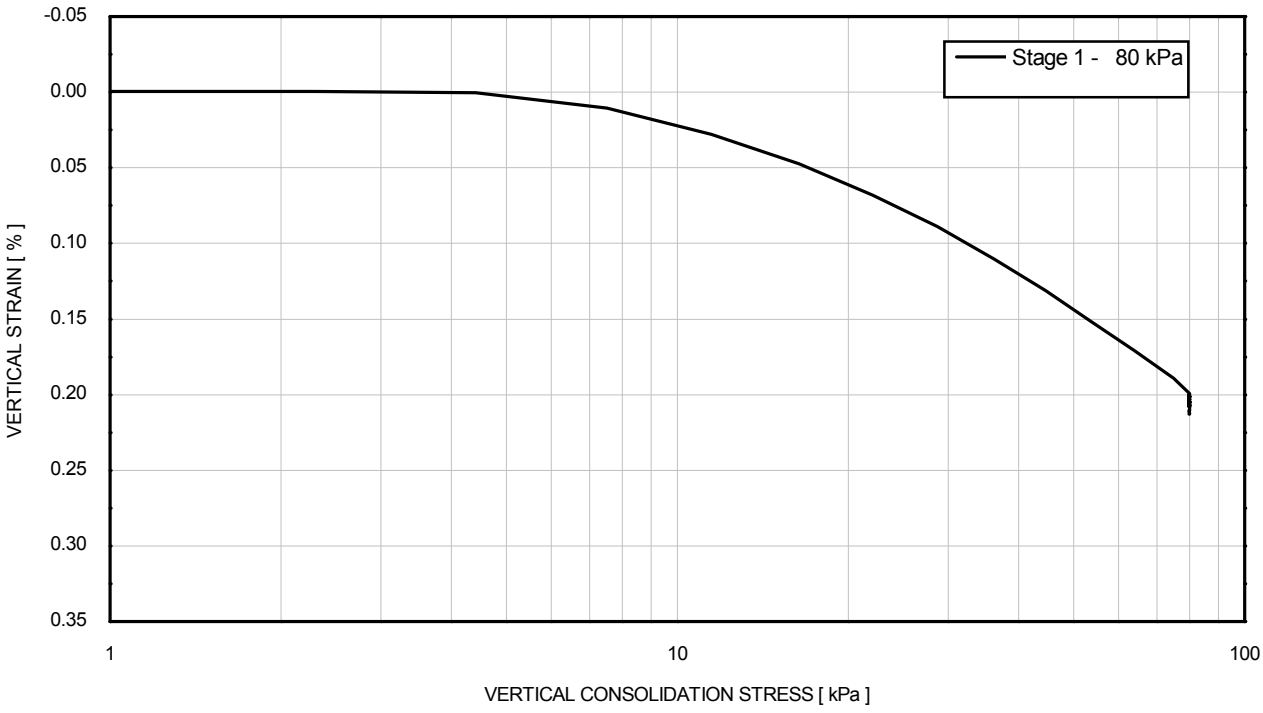


TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-2
Unit	B (Eem/Kreftenheye)
Test number	CSS16

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

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

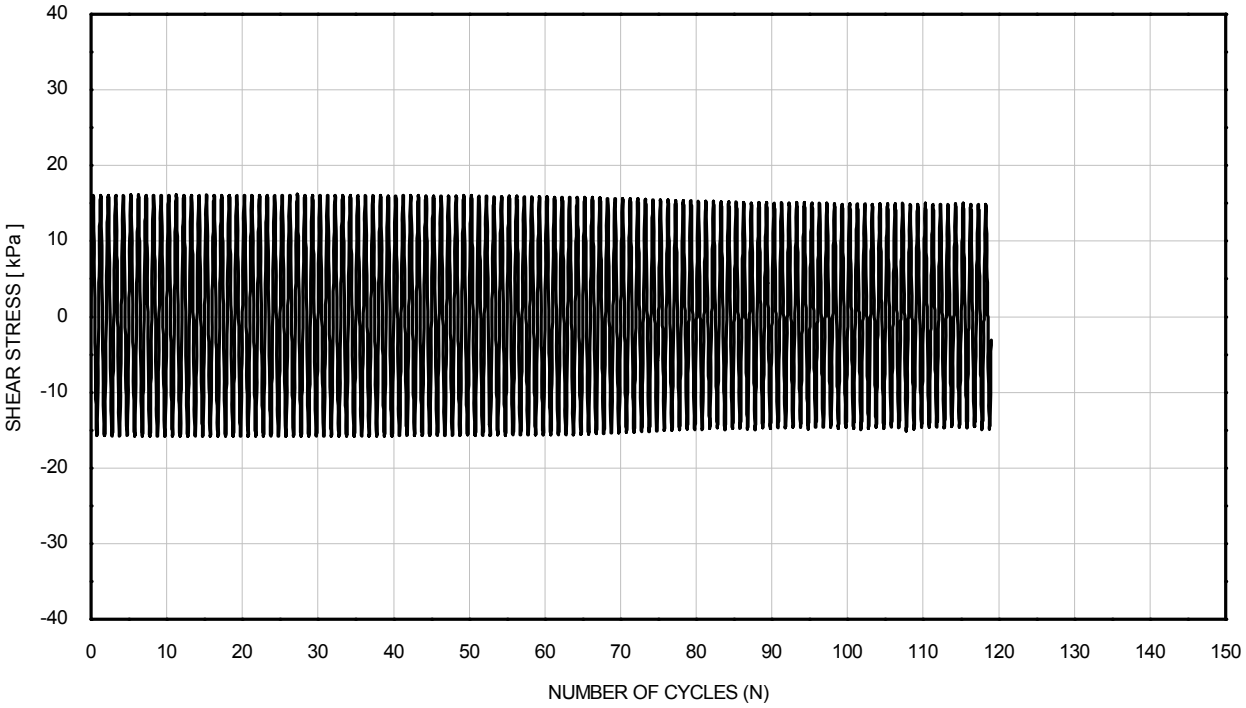


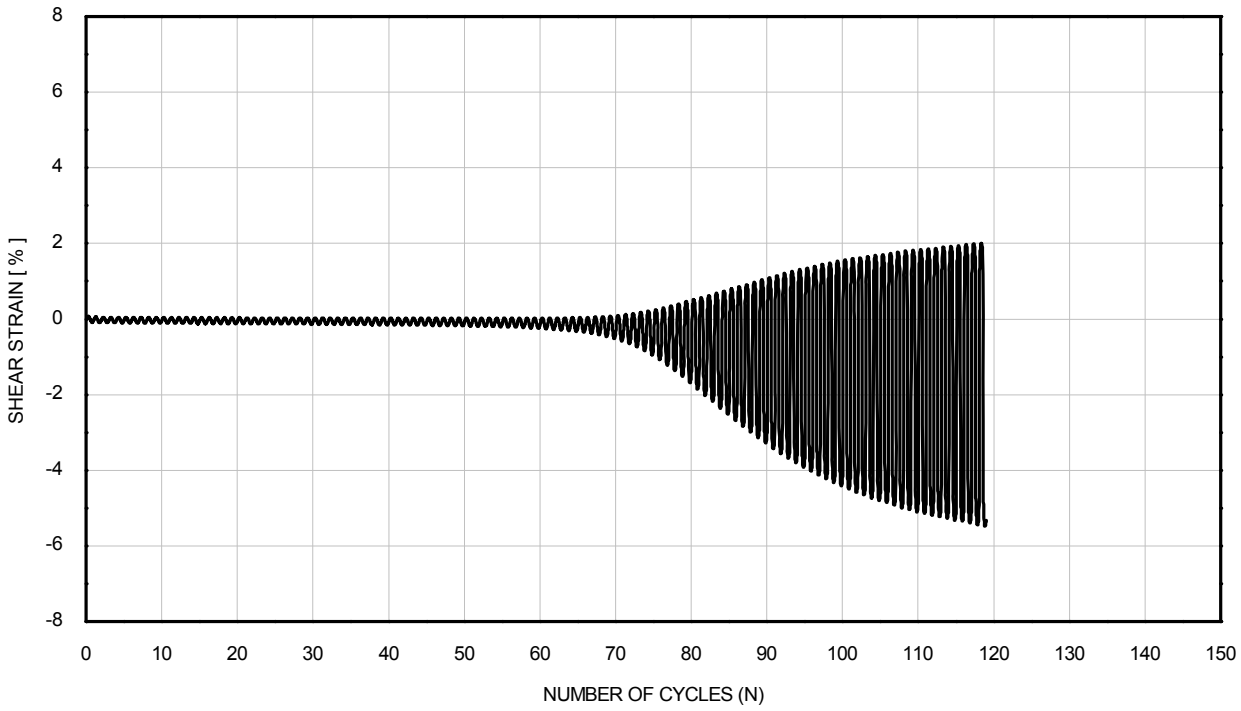


σ_{vc}	: 80 kPa	Batch	: 2
		Sample	: CSS_2-2
		Unit	: B (Eem/Kreftenheye)
		Test No.	: CSS16

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

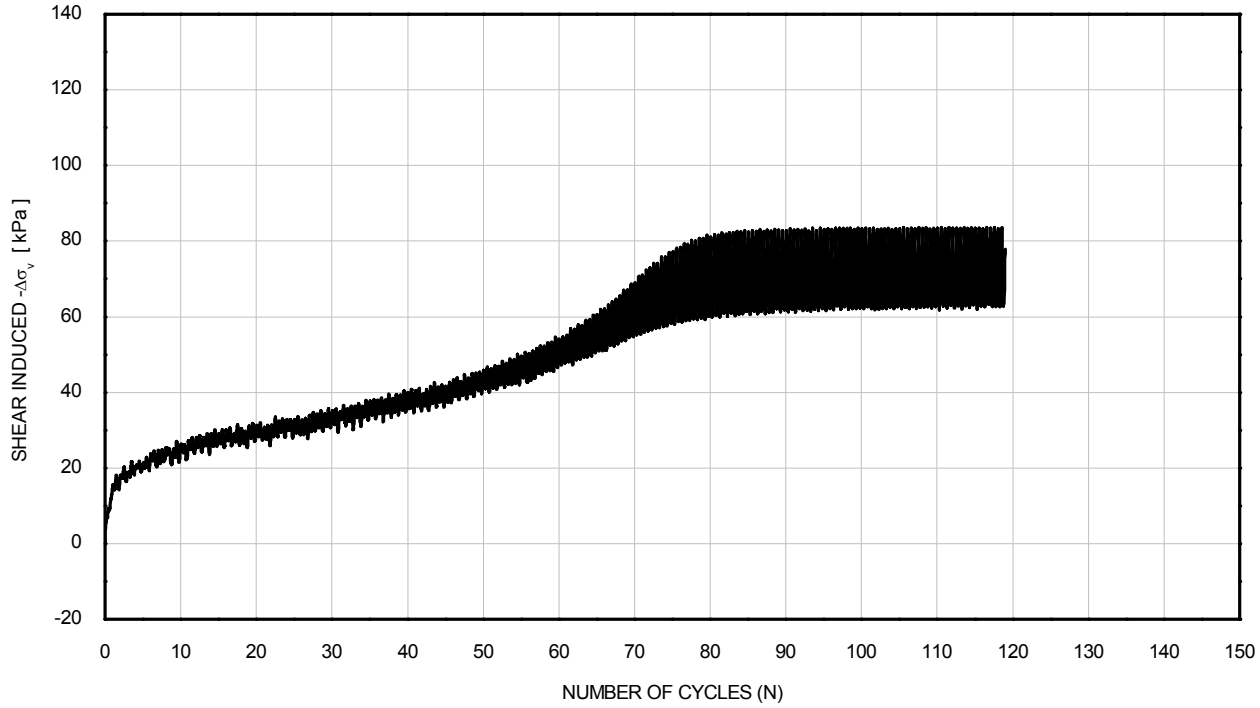


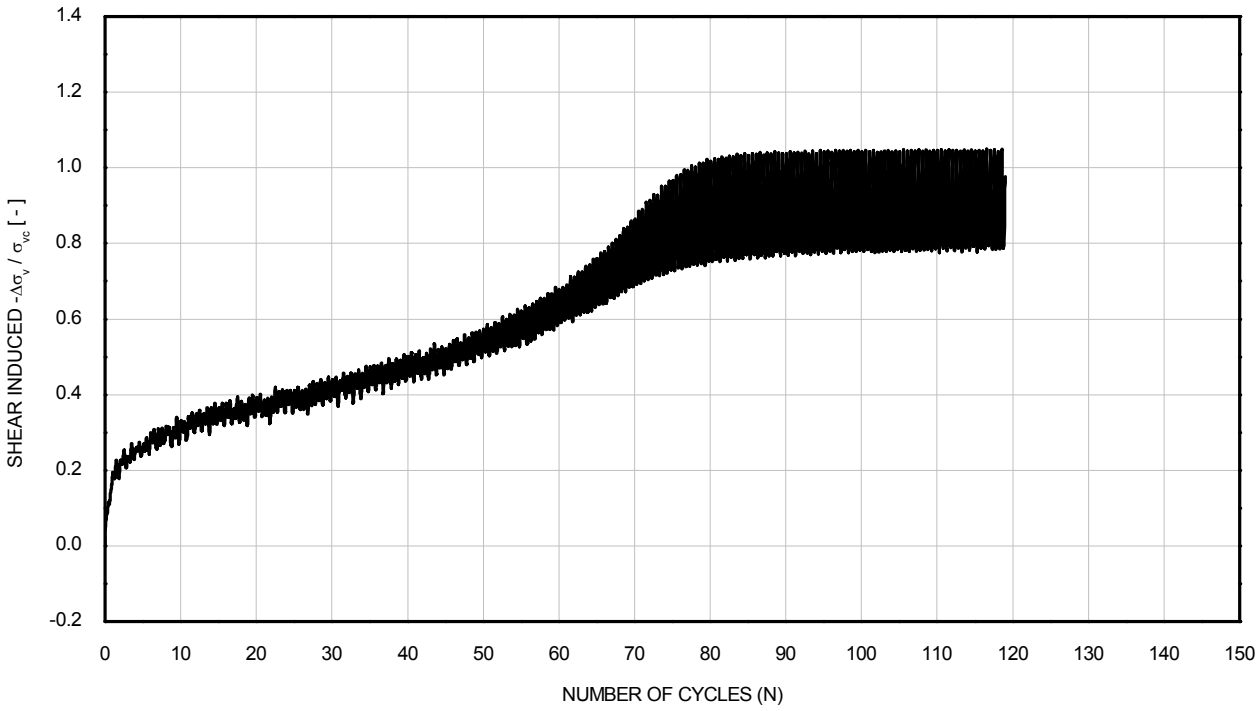


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-2
Mean τ_{cy}	:	15 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS16

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

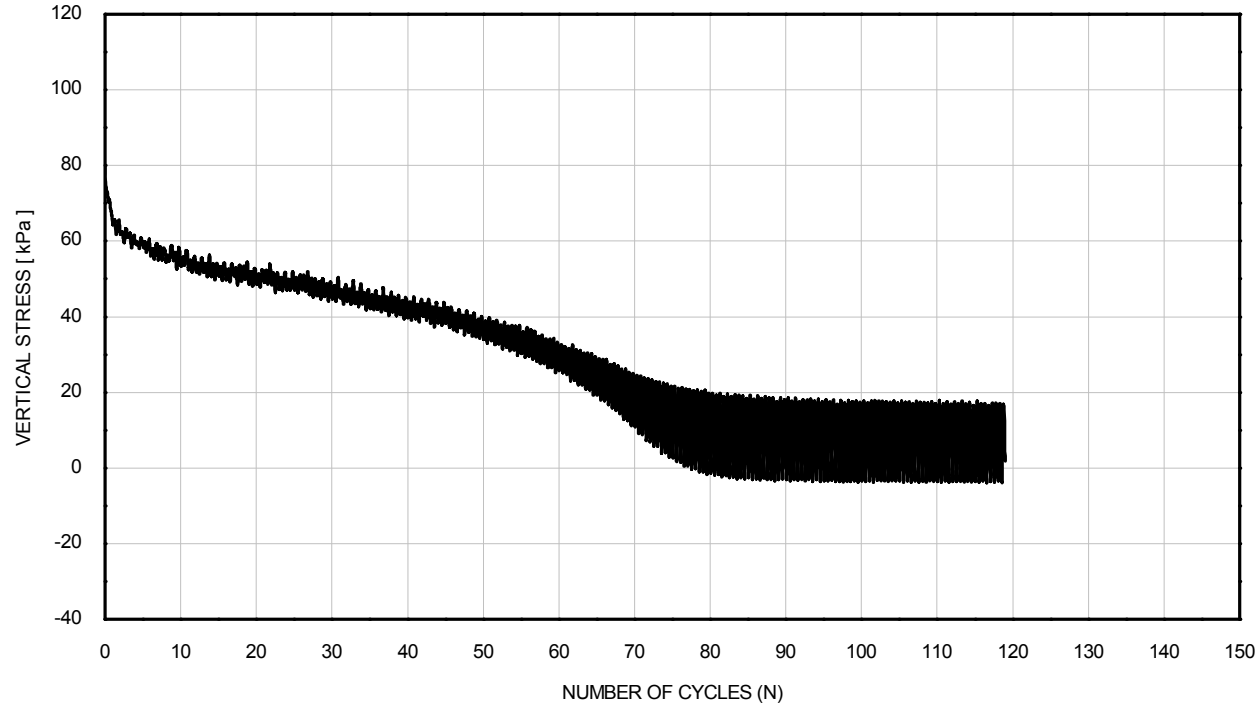


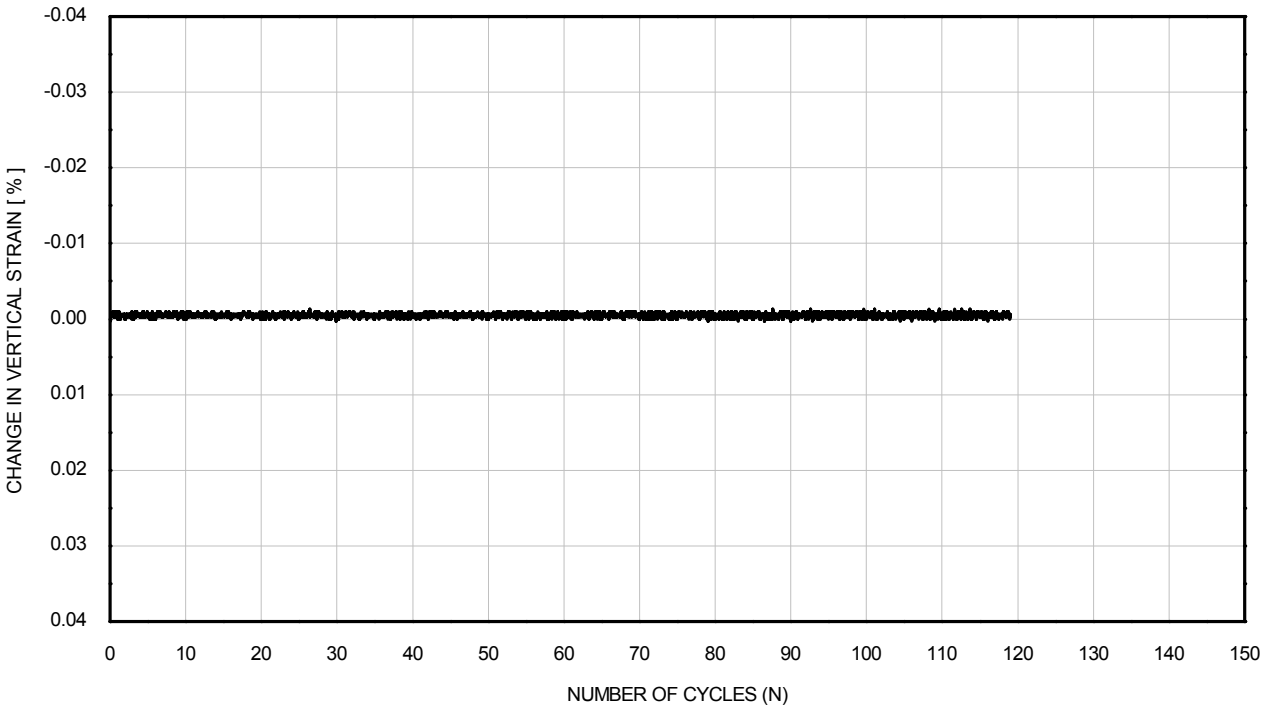


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-2
Mean τ_{cy}	:	15 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS16

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

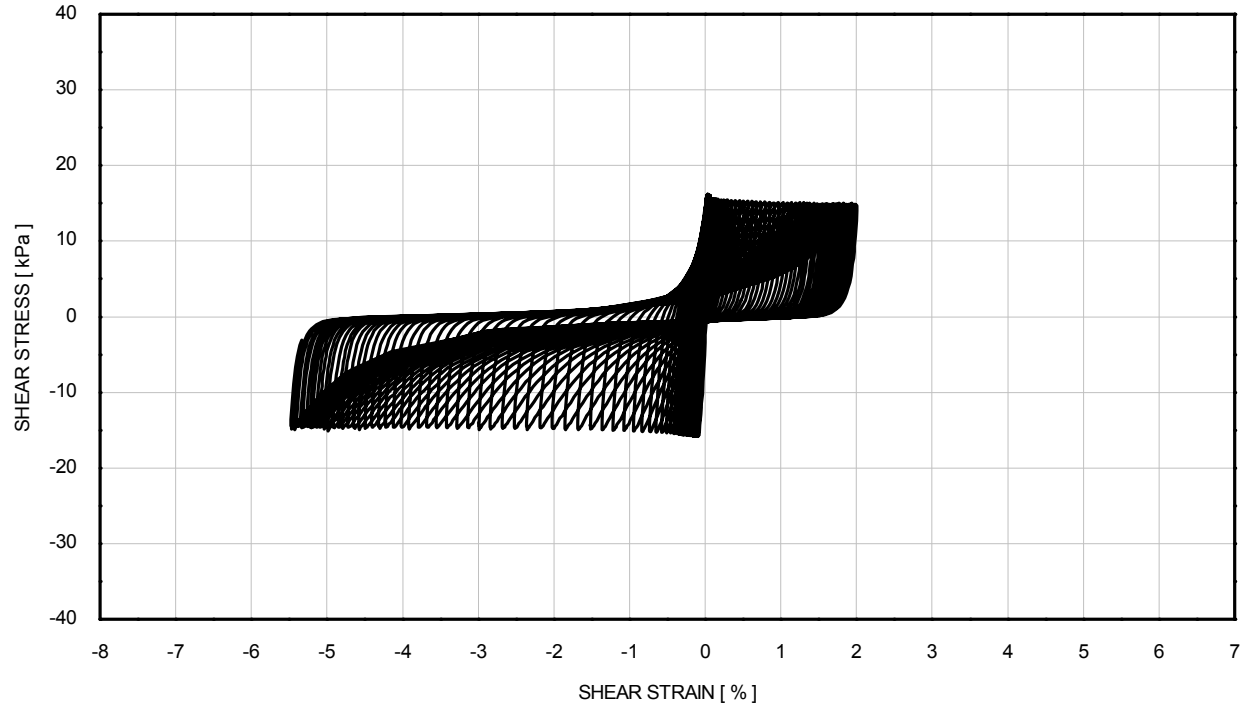


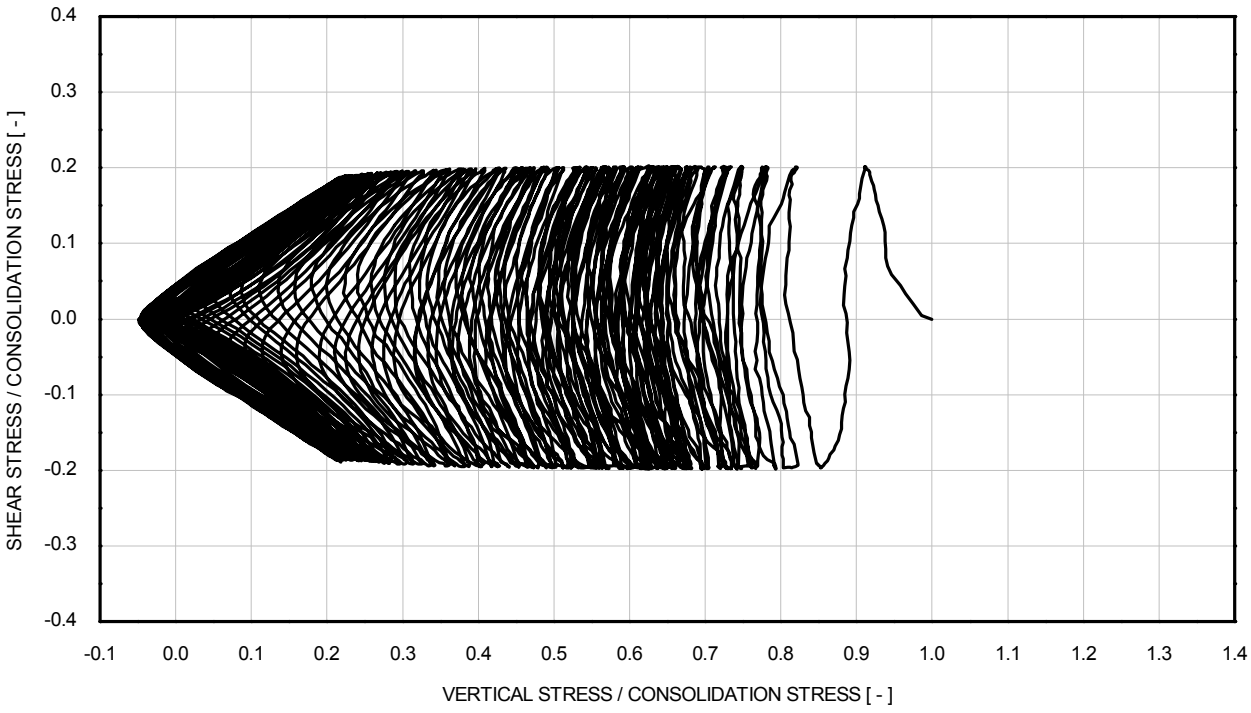


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-2
Mean τ_{cy}	:	15 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS16

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

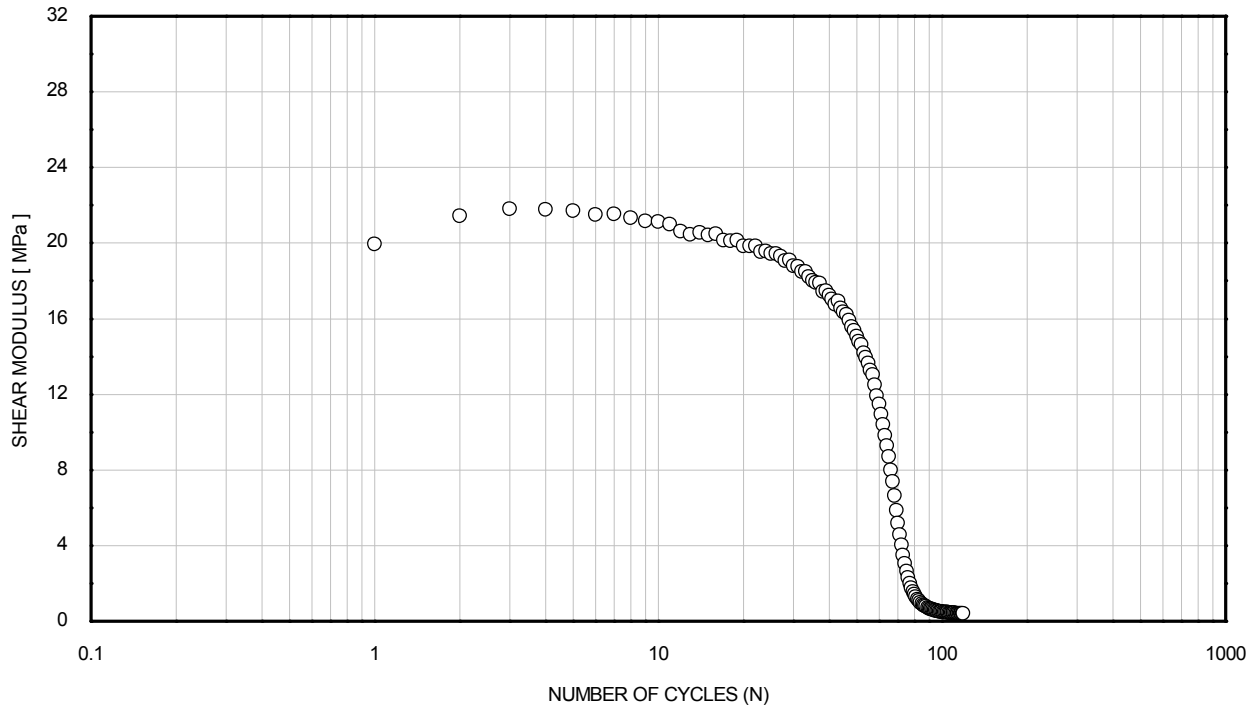


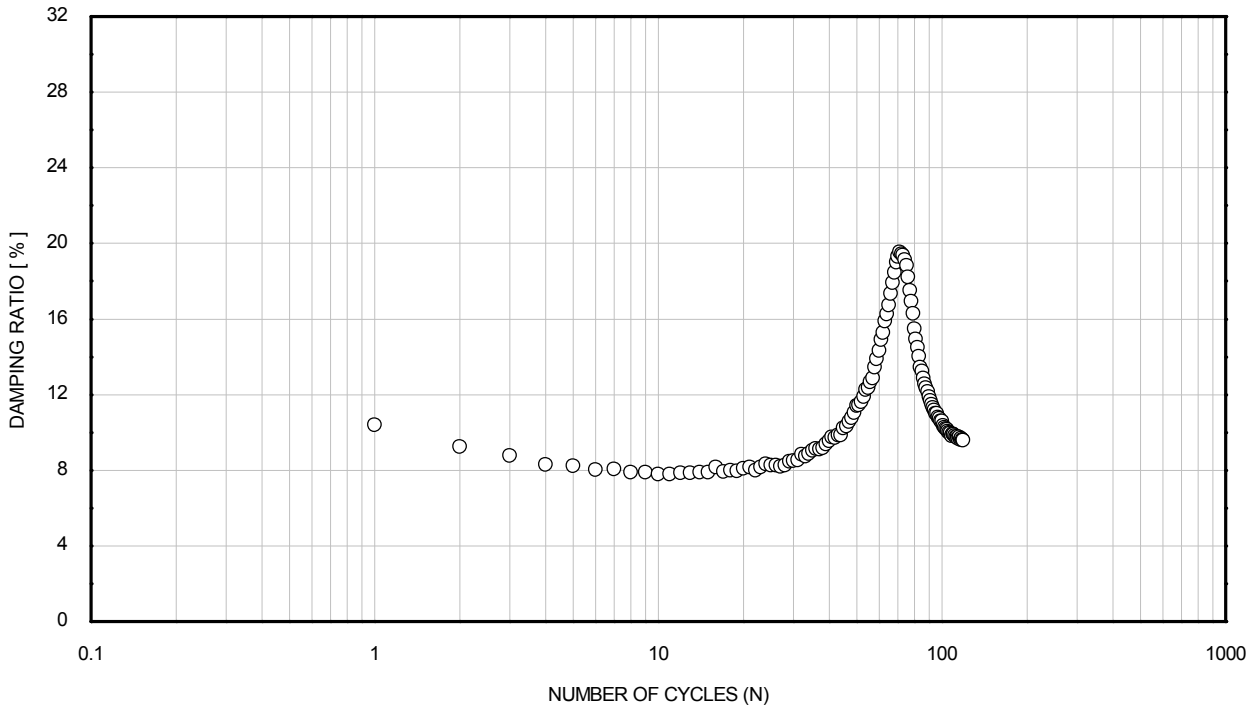


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-2
Mean τ_{cy}	:	15 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS16

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

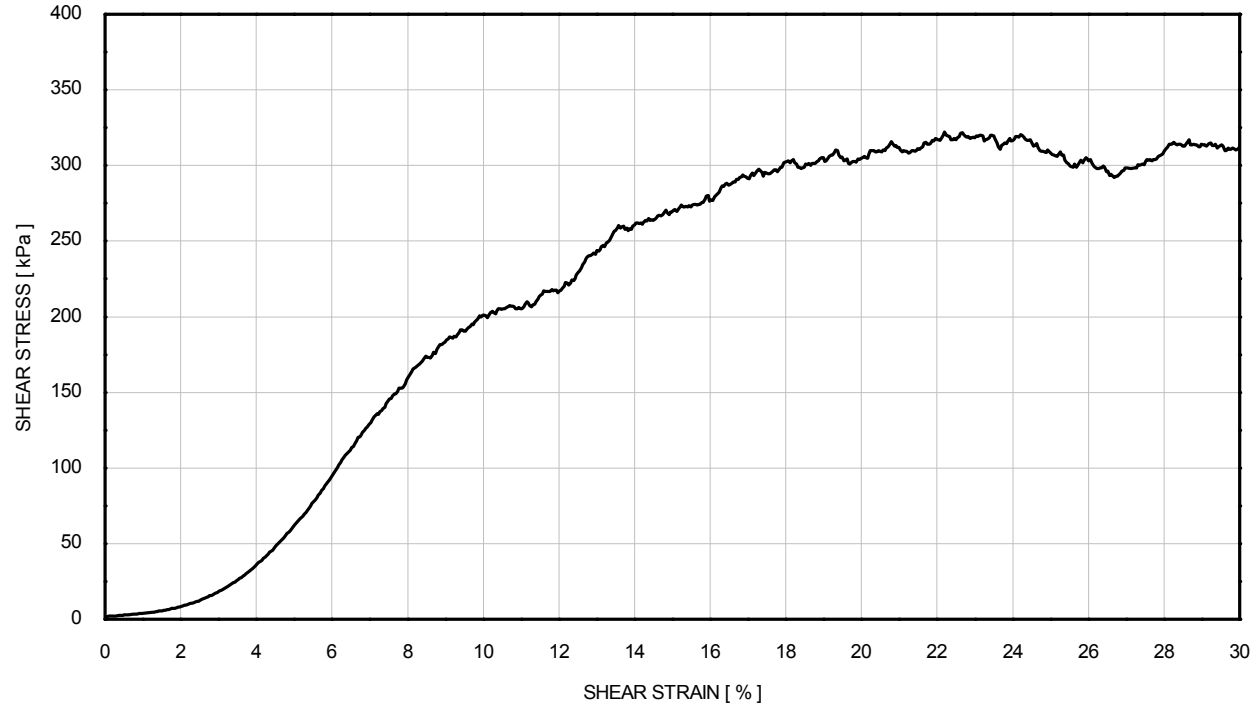


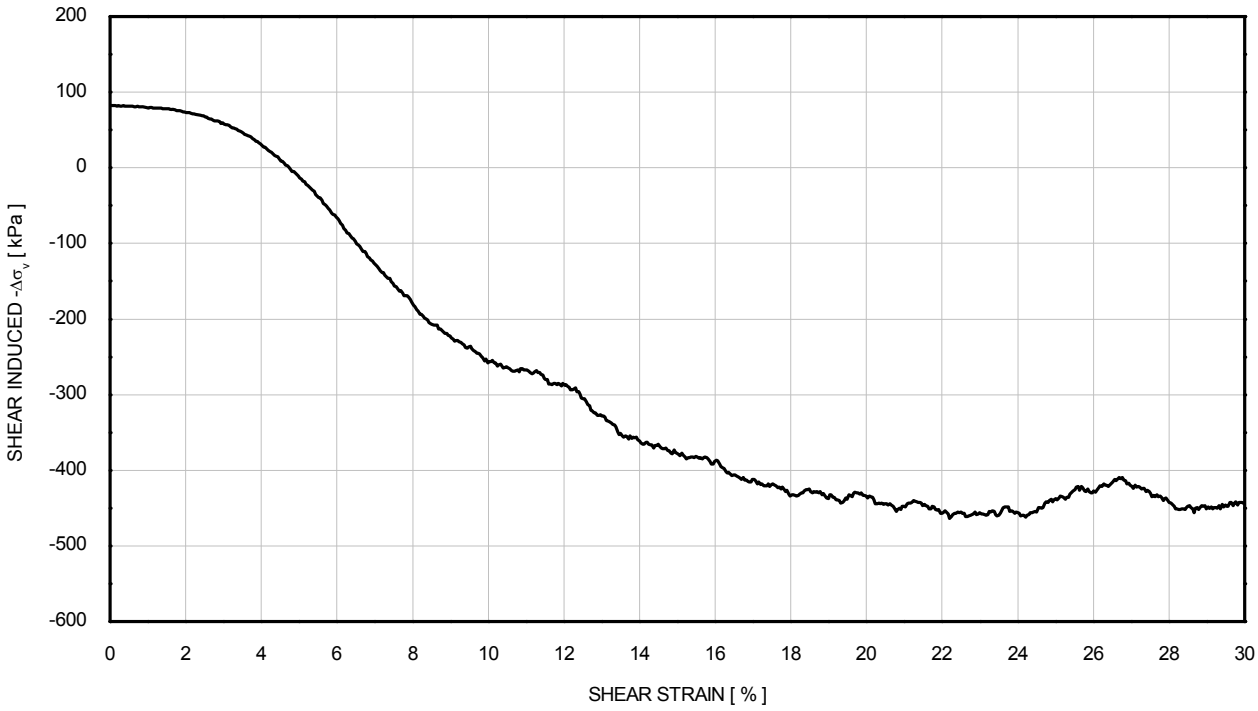


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-2
Mean τ_{cy}	:	15 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS16

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

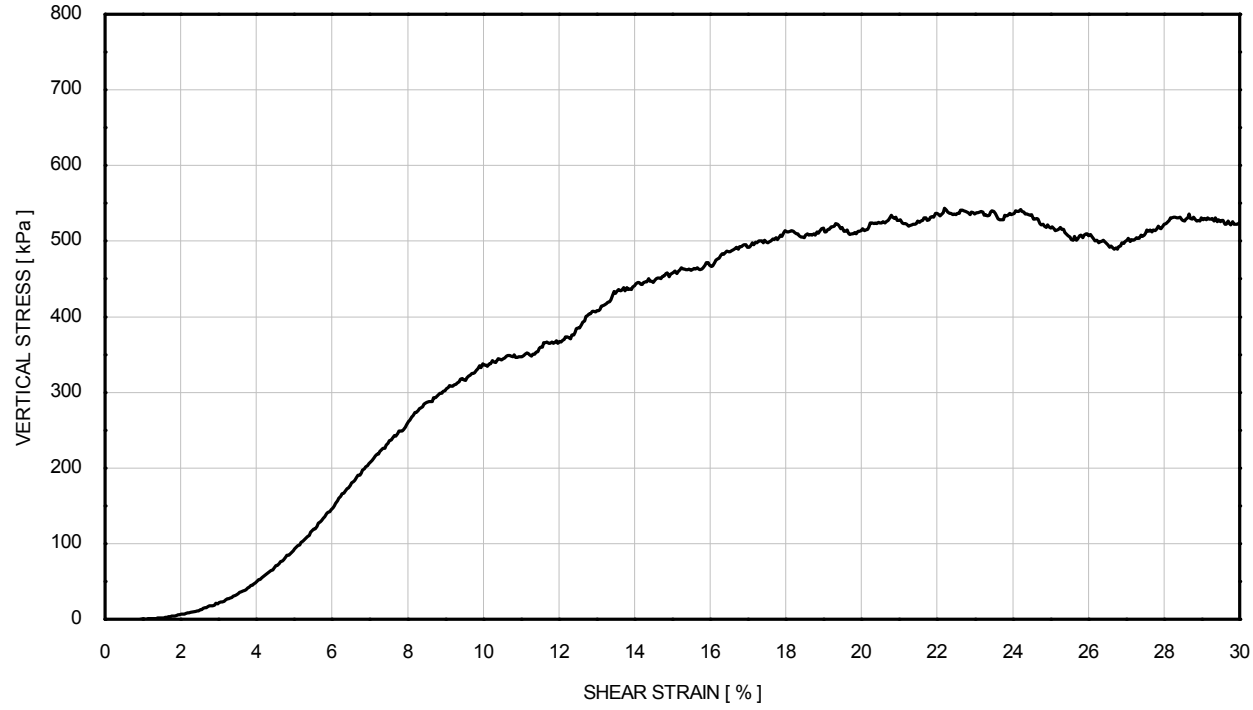


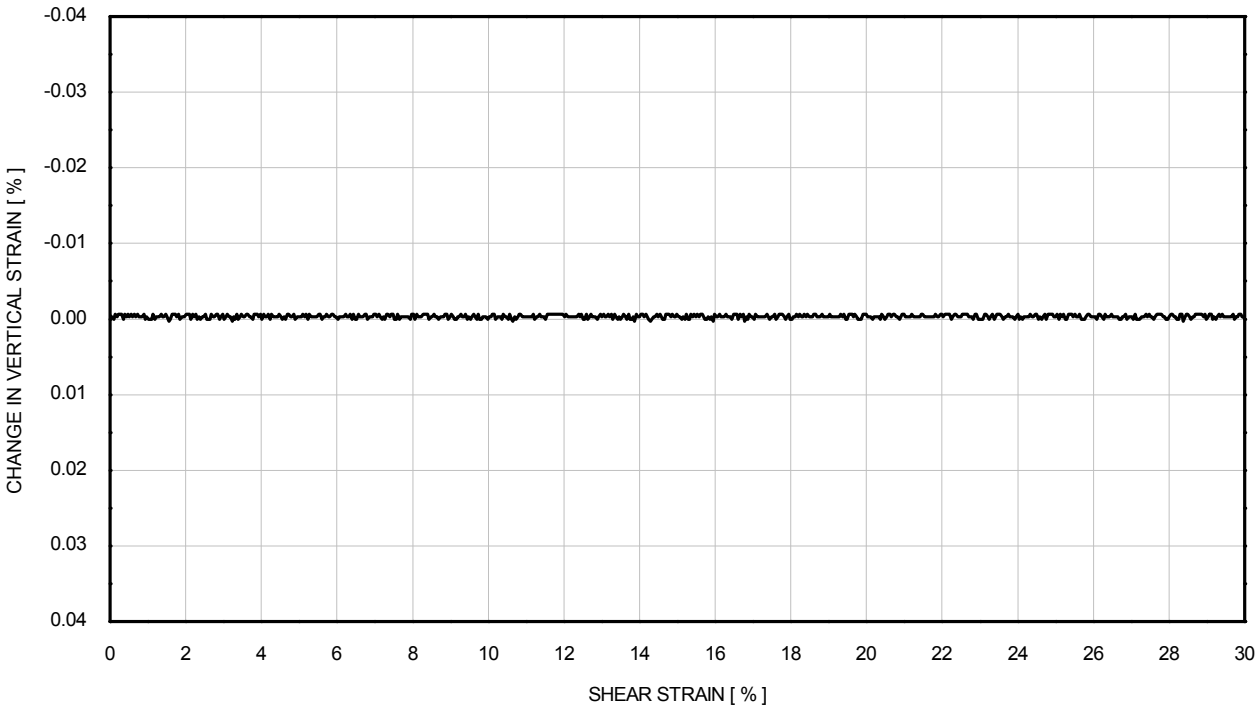


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 322 kPa	Sample	: CSS_2-2
γ at τ_{peak}	: 22.20 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: CSS16

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

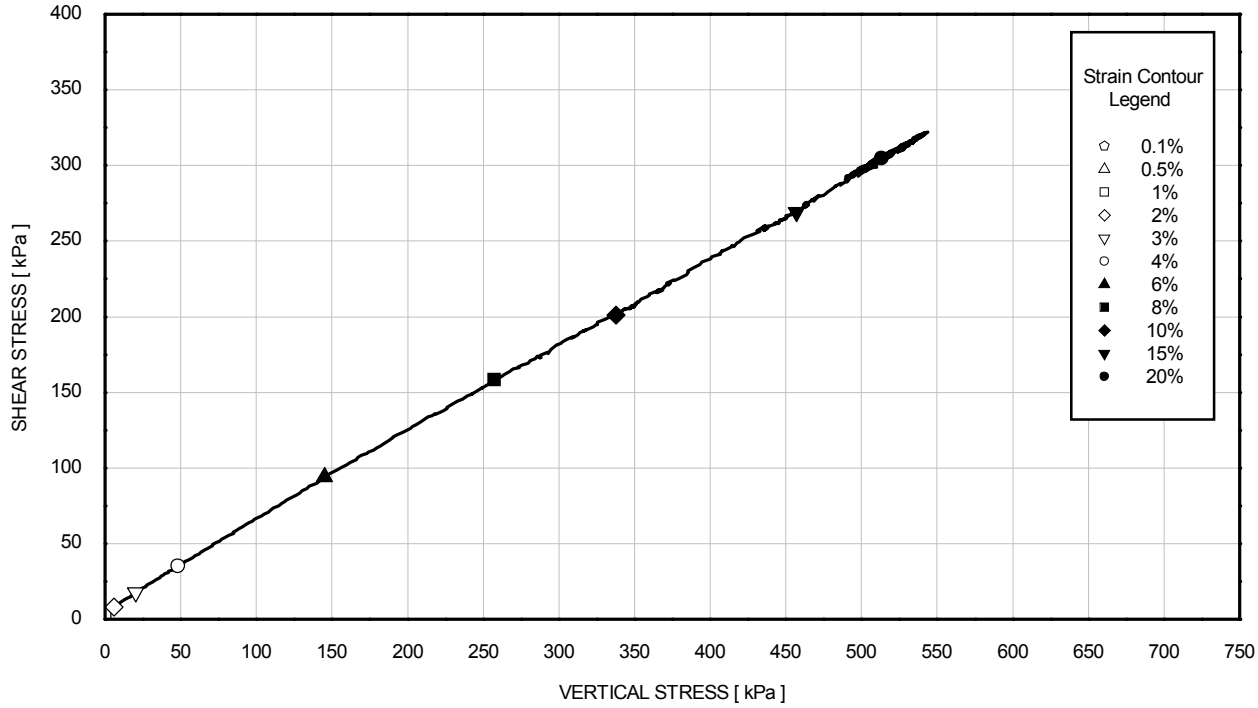


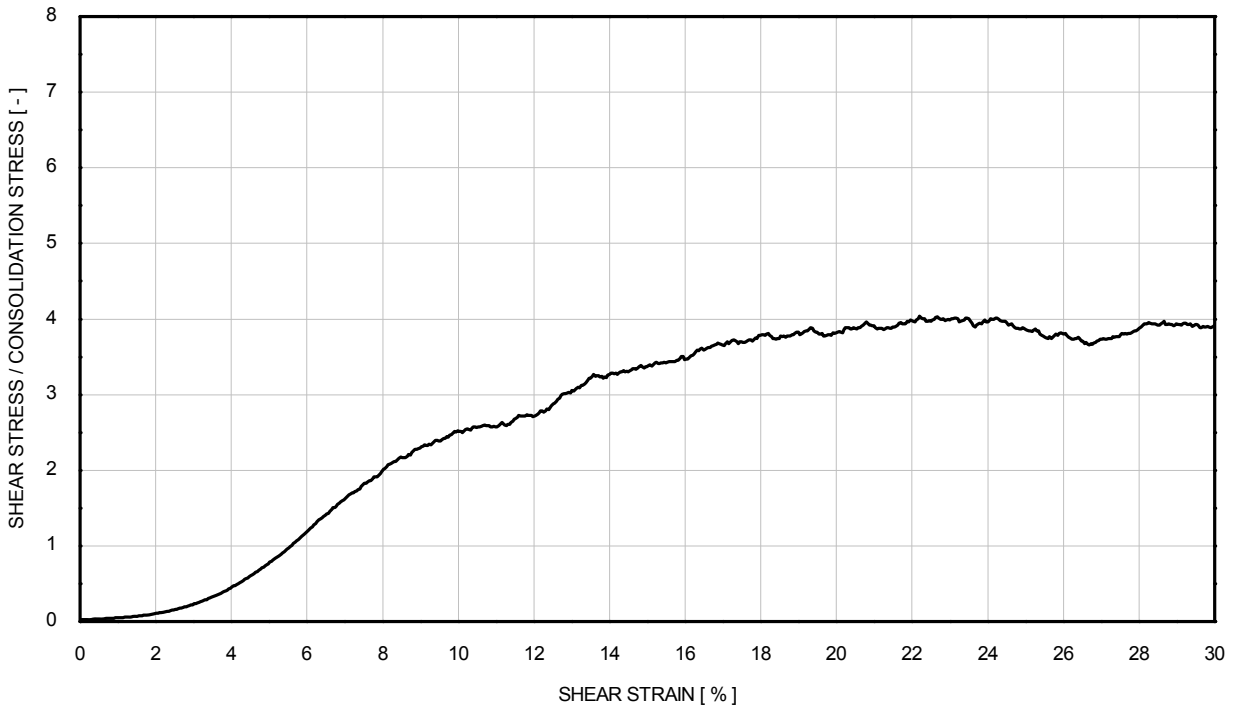


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 322 kPa	Sample	: CSS_2-2
γ at τ_{peak}	: 22.20 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: CSS16

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

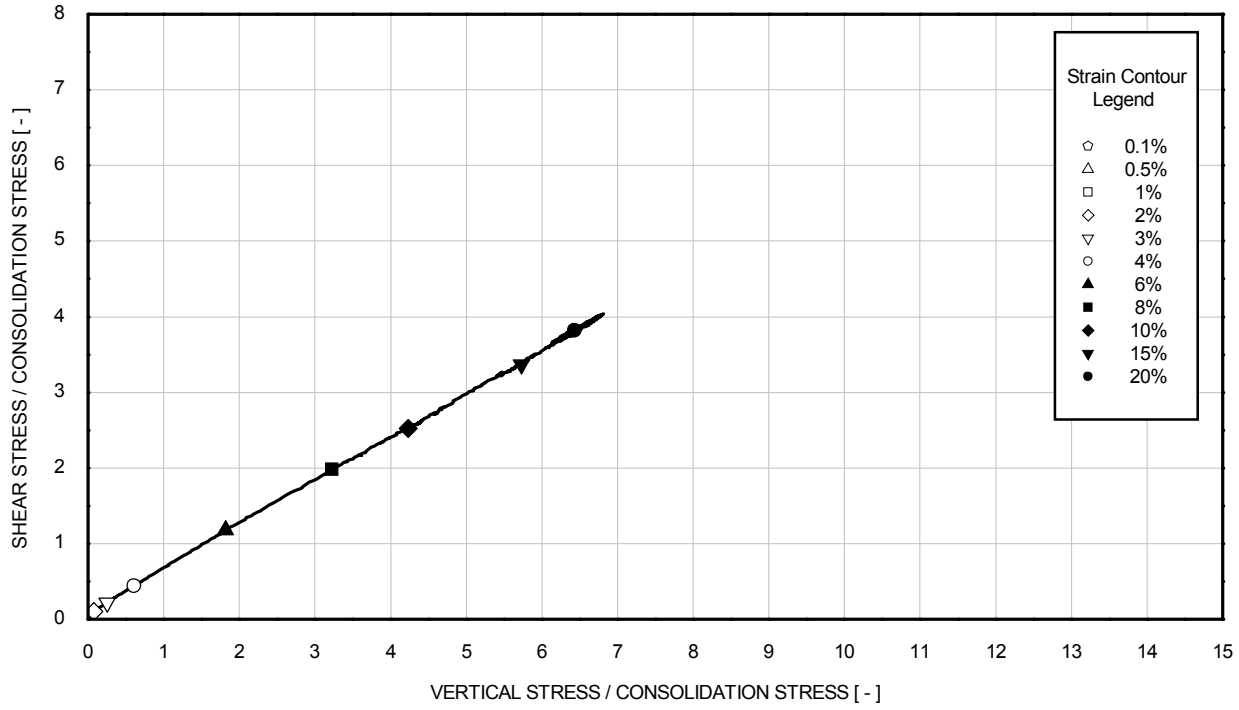


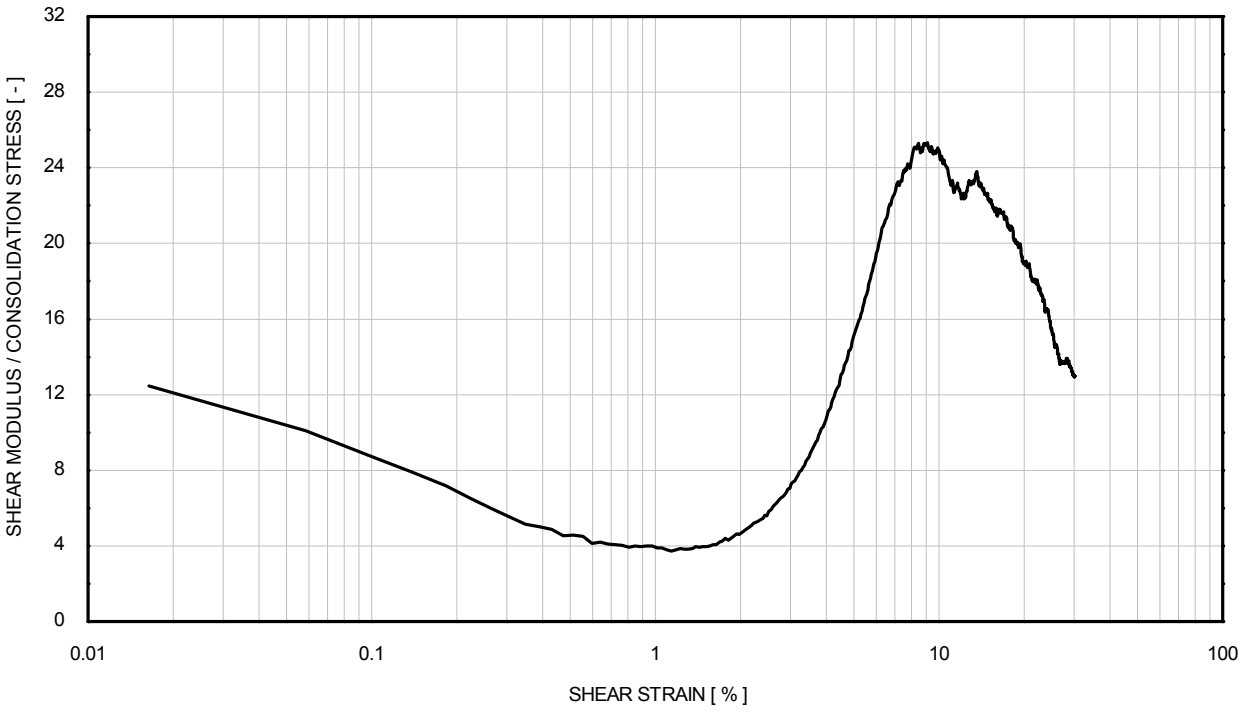


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 322 kPa	Sample	: CSS_2-2
γ at τ_{peak}	: 22.20 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: CSS16

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 322 kPa	Sample	: CSS_2-2
γ at τ_{peak}	: 22.20 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.99 %/hour	Test No.	: CSS16

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	20/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.6
Length	[mm]	30.0
Moisture content after compaction	[%]	11.2
Bulk density after compaction	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.68
Void ratio	[-]	0.575
Degree of saturation after compaction	[%]	51
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	21.7
Bulk density at start of test	[Mg/m³]	2.05
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 2_CSS 2-3_CSS17
Template issue	1.3
Processed by Date	HJ 24/02/2016
Checked by Date	PH 15/03/2016
Approved by Date	PH 15/03/2016

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-3
Unit	B (Eem/Kreftenheye)
Test number	CSS17

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	80
Vertical strain	[%]	0.24
Bulk density	[Mg/m^3]	2.05
Dry density	[Mg/m^3]	1.69
Void ratio	[-]	0.571
Moisture content	[%]	21.6

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	80
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	13
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	797
γ_{av} at N_f	[%]	-0.17
γ_{cy} at N_f	[%]	3.71
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	74
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.00	0.08	17.58	5.88
2	0.00	0.08	17.81	5.00
5	-0.01	0.08	18.12	4.20
10	-0.01	0.08	18.05	3.79
20	-0.01	0.08	17.43	3.78
30	-0.01	0.08	17.50	4.09
40	-0.01	0.08	17.28	4.05
50	-0.01	0.08	16.99	4.02
100	-0.01	0.08	16.68	4.09
500	-0.02	0.11	12.36	7.93
797	-0.17	3.71	0.34	15.15

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-3
Unit	B (Eem/Kreftenheye)
Test number	CSS17

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	319
Shear strain	[%]	29.97
Shear induced $-\Delta\sigma_v$	[kPa]	-467
Vertical stress	[kPa]	547
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.00
At 15 % shear strain		
Shear stress	[kPa]	107
Shear induced $-\Delta\sigma_v$	[kPa]	-92
Vertical stress	[kPa]	172
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-3
Unit	B (Eem/Kreftenheye)
Test number	CSS17

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

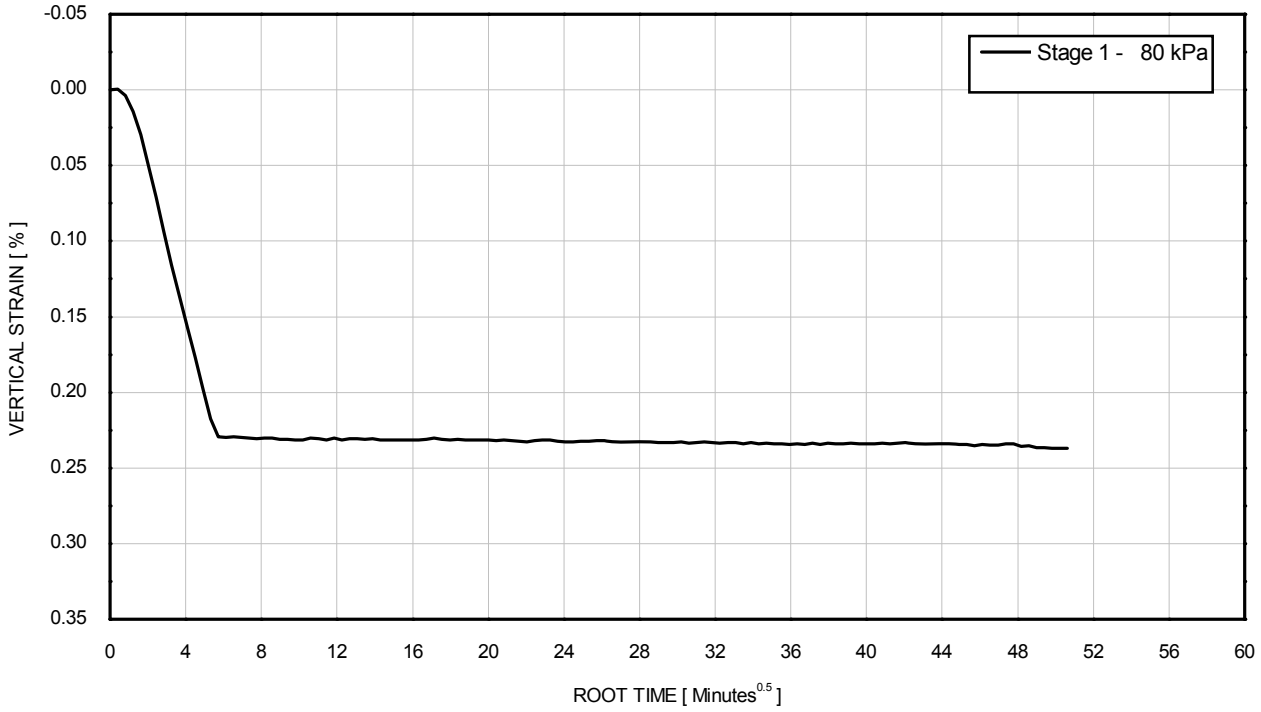
SPECIMEN PHOTOGRAPH

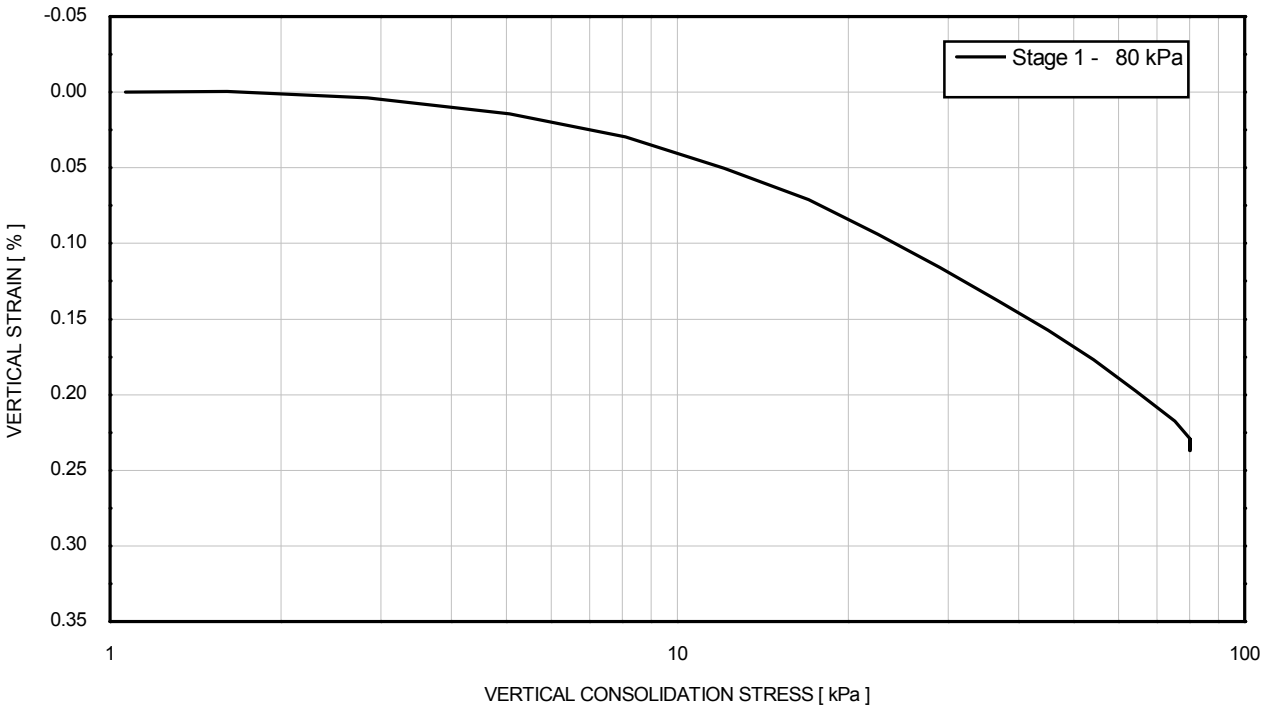


TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-3
Unit	B (Eem/Kreftenheye)
Test number	CSS17

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

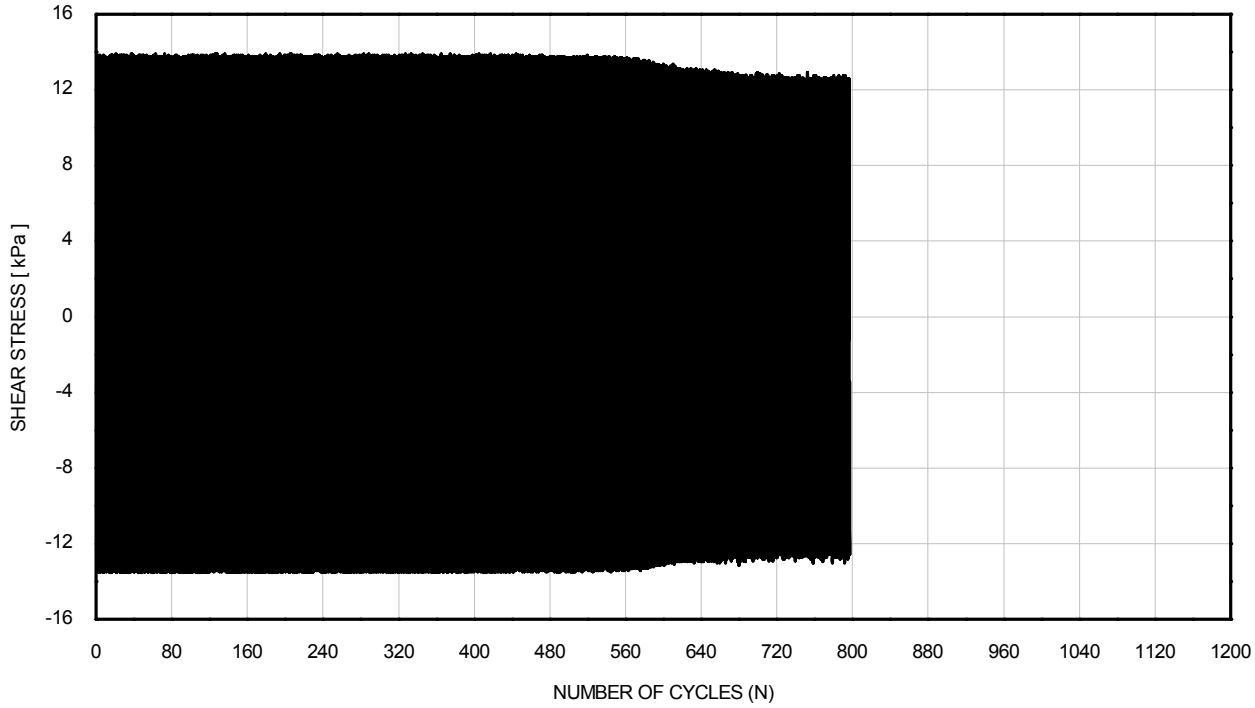


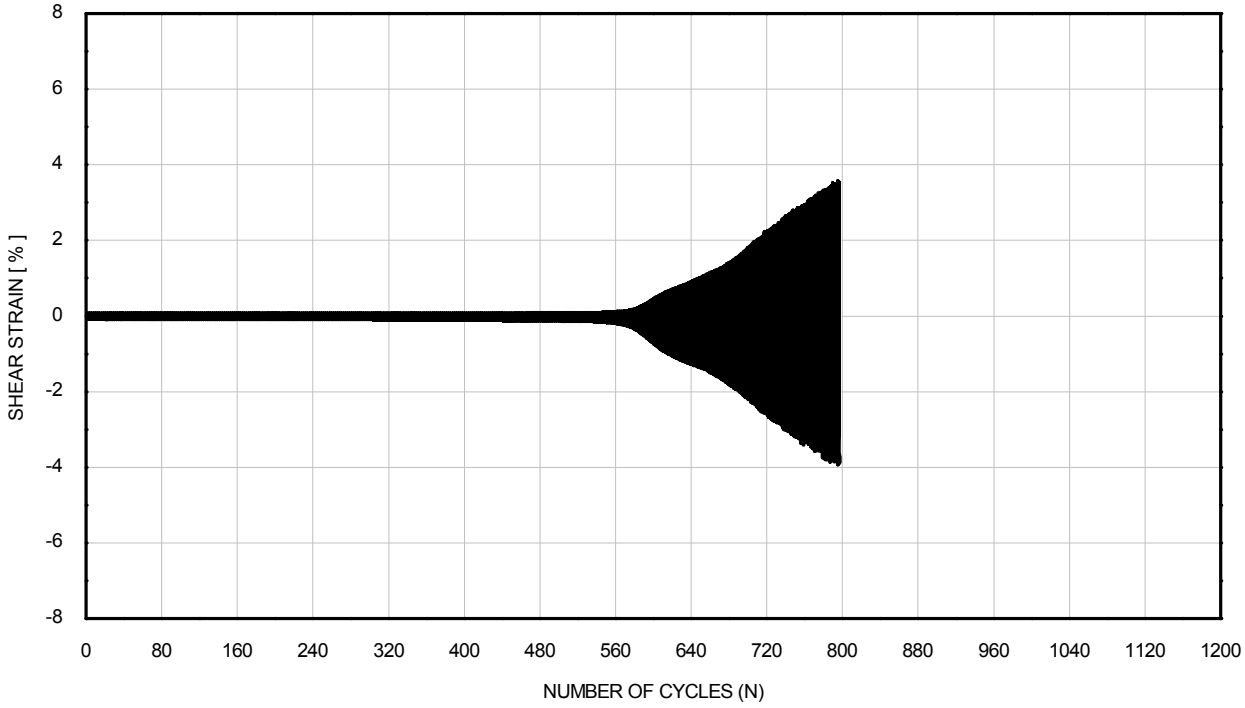


σ_{vc}	: 80 kPa	Batch	: 2
		Sample	: CSS_2-3
		Unit	: B (Eem/Kreftenheye)
		Test No.	: CSS17

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

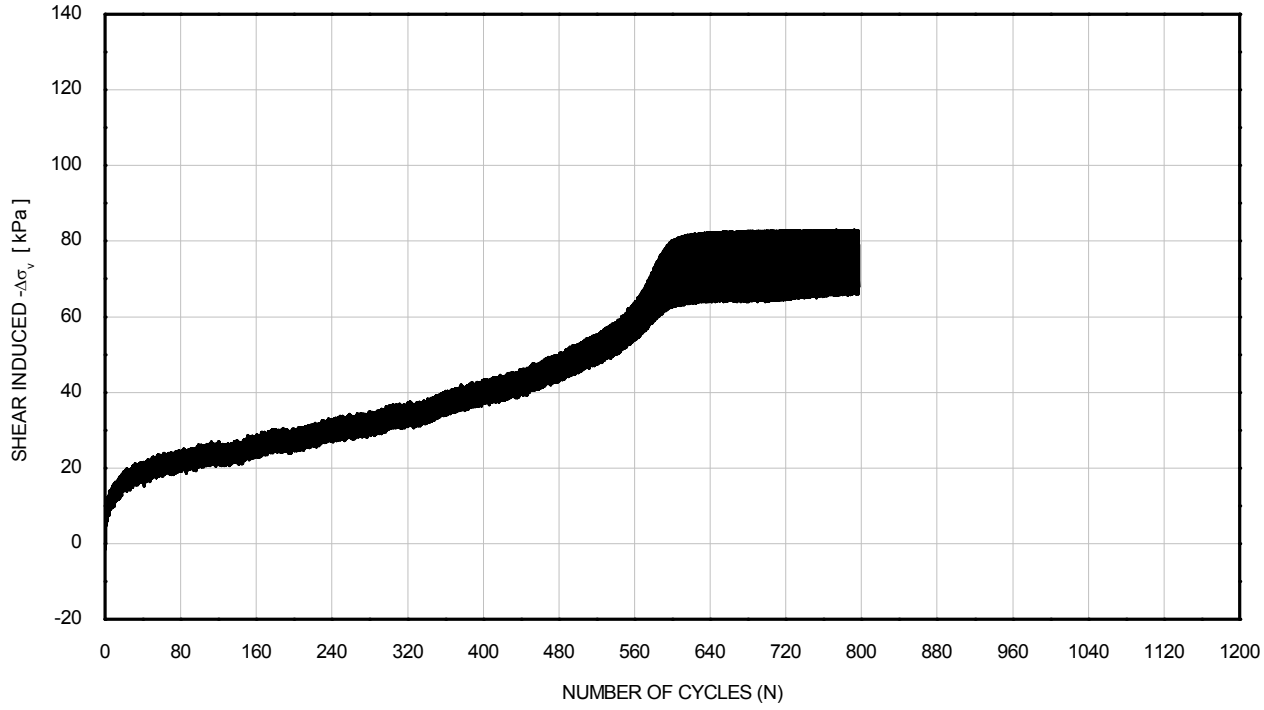


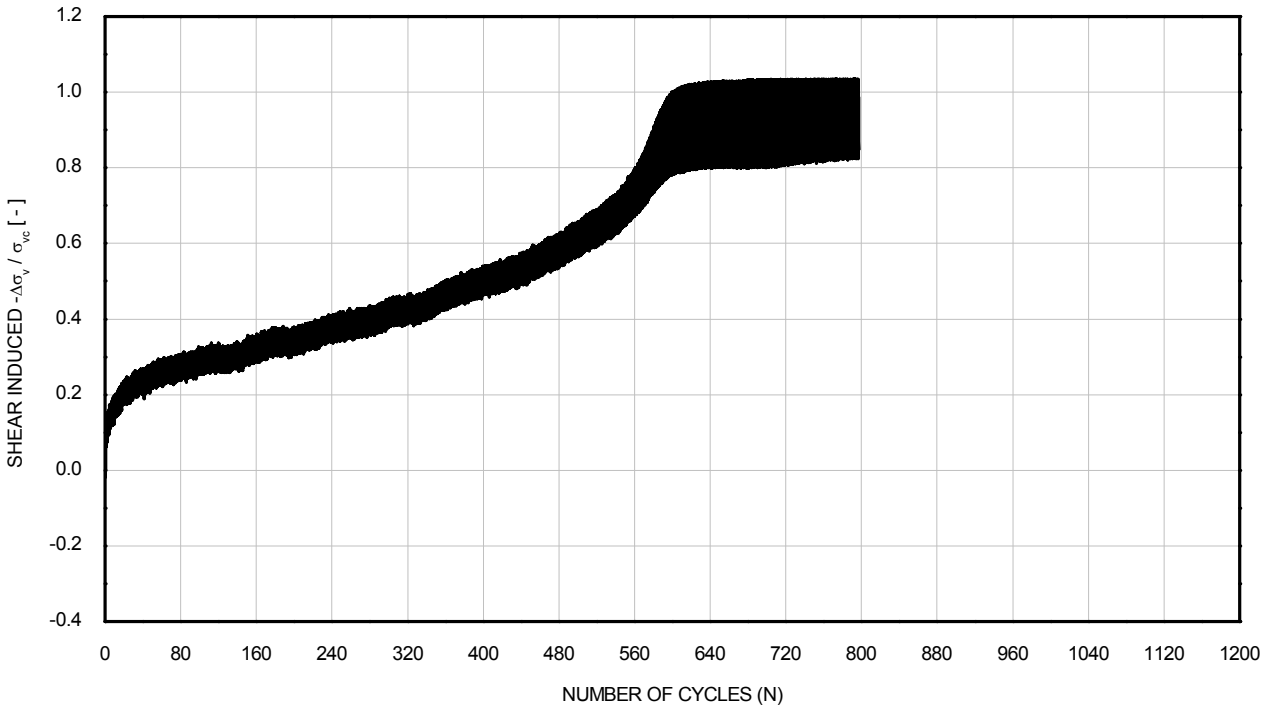


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-3
Mean τ_{cy}	:	13 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS17

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

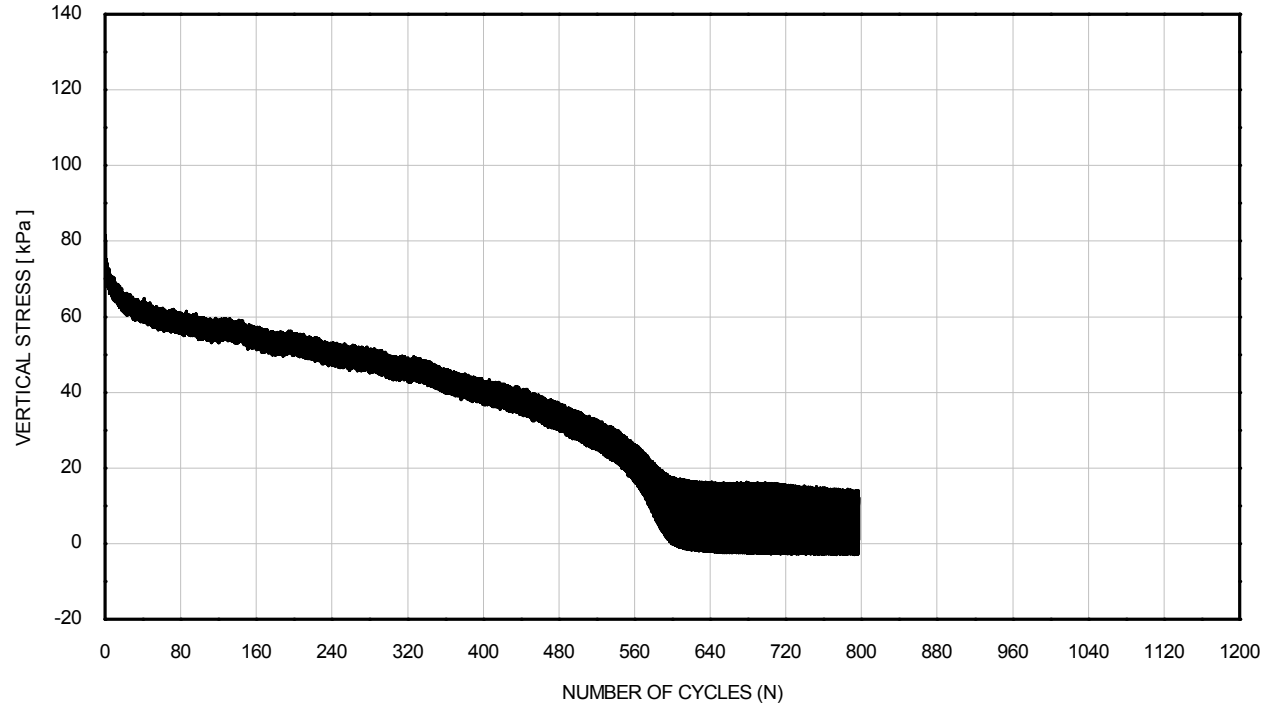


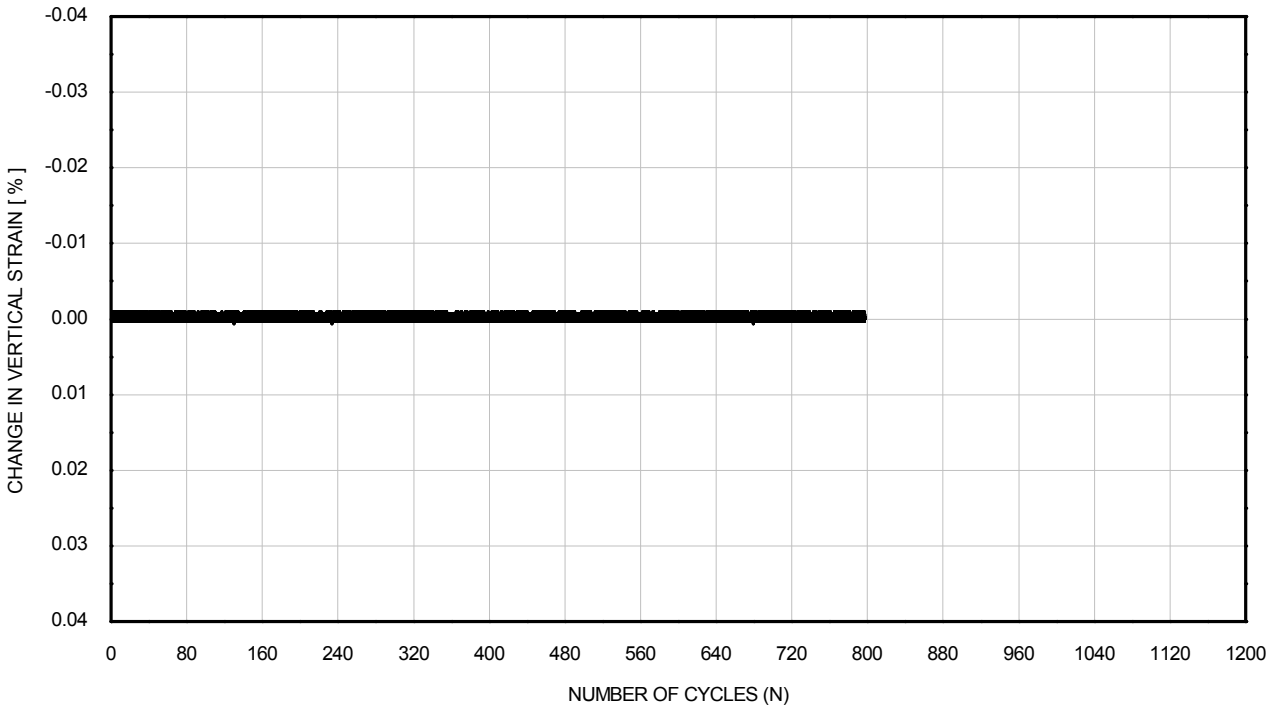


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-3
Mean τ_{cy}	:	13 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS17

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

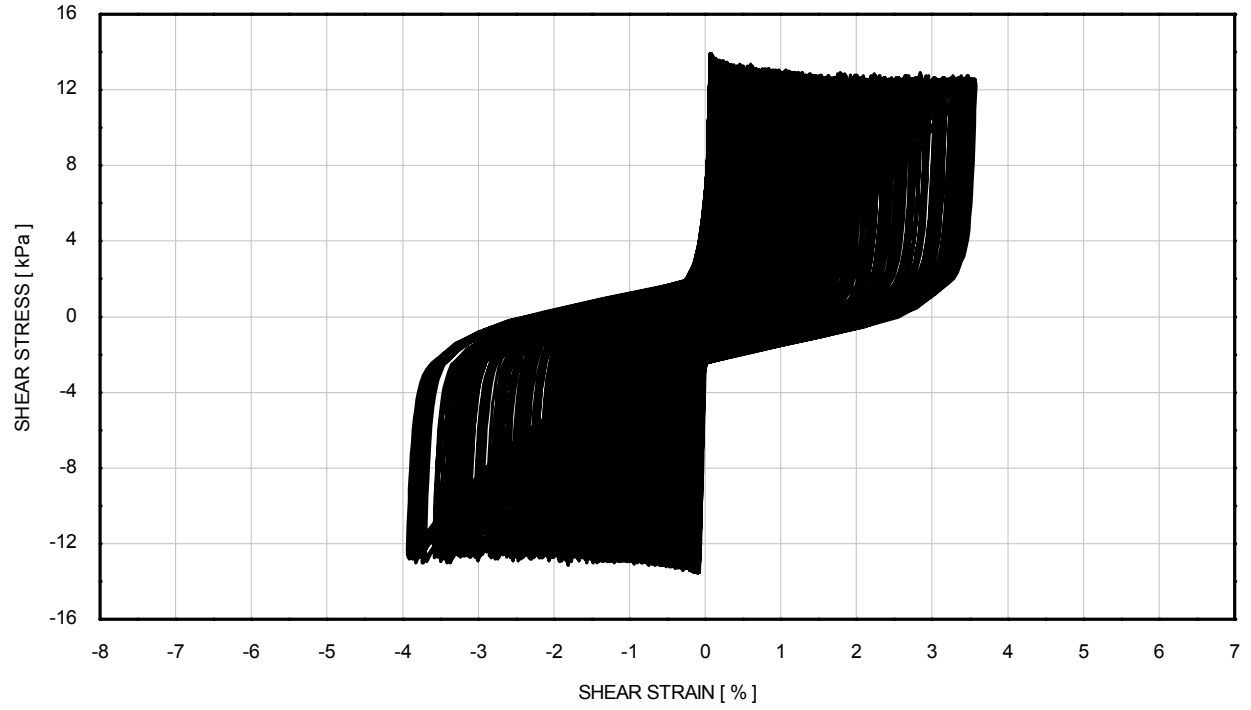


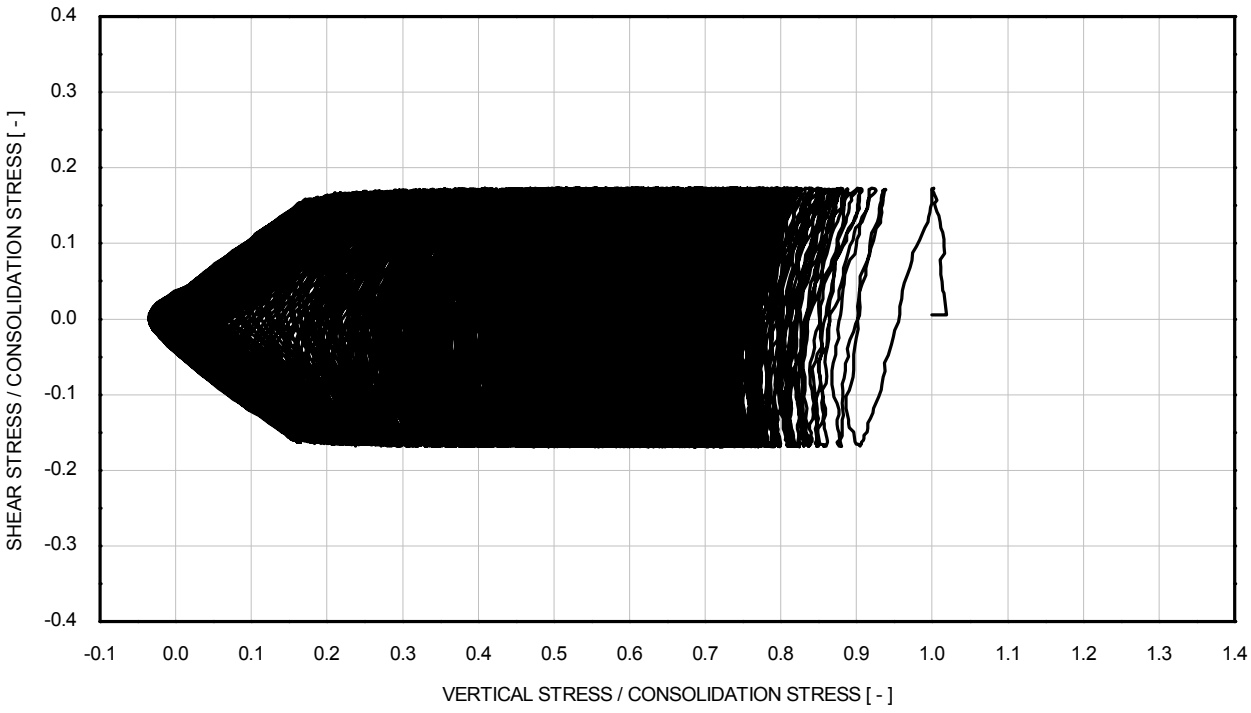


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-3
Mean τ_{cy}	:	13 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS17

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

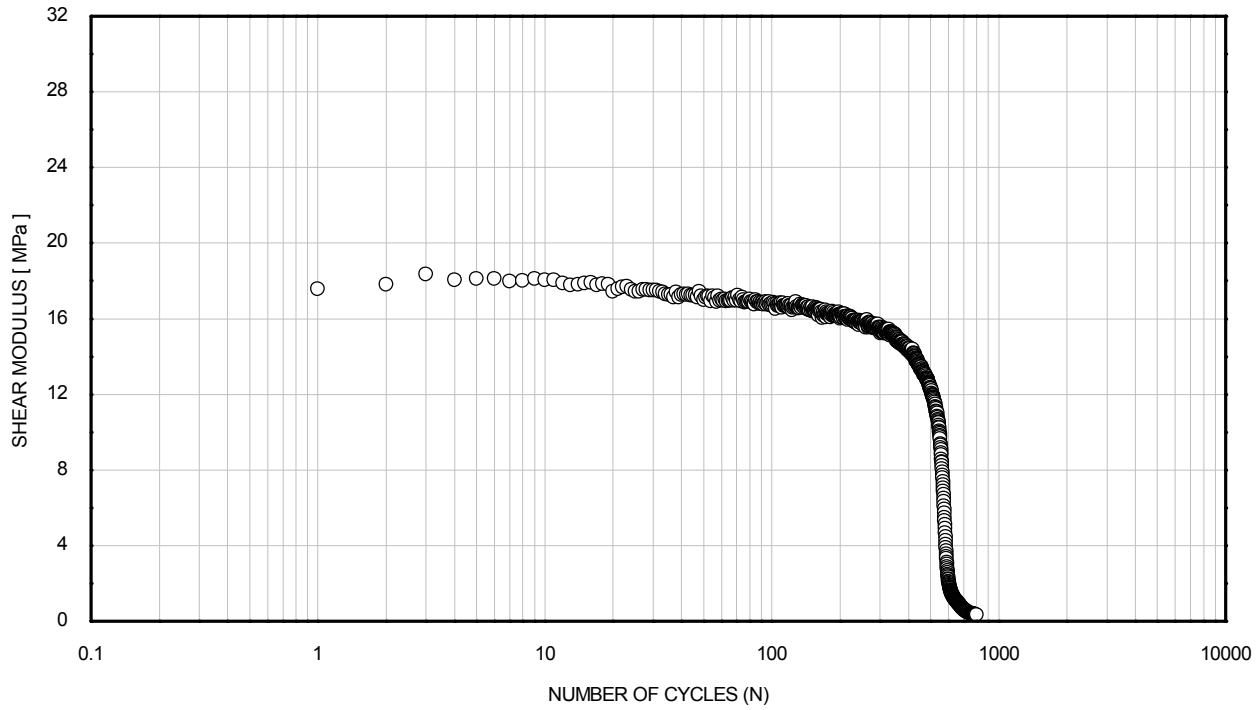


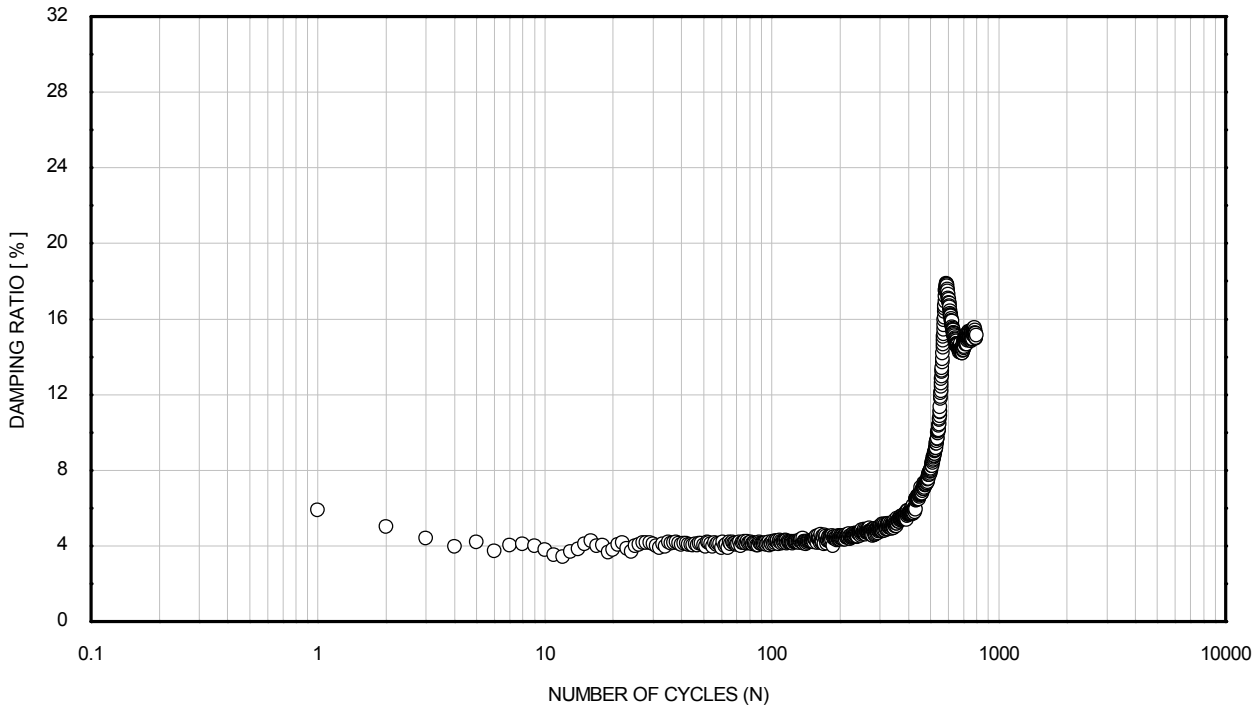


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-3
Mean τ_{cy}	:	13 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS17

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

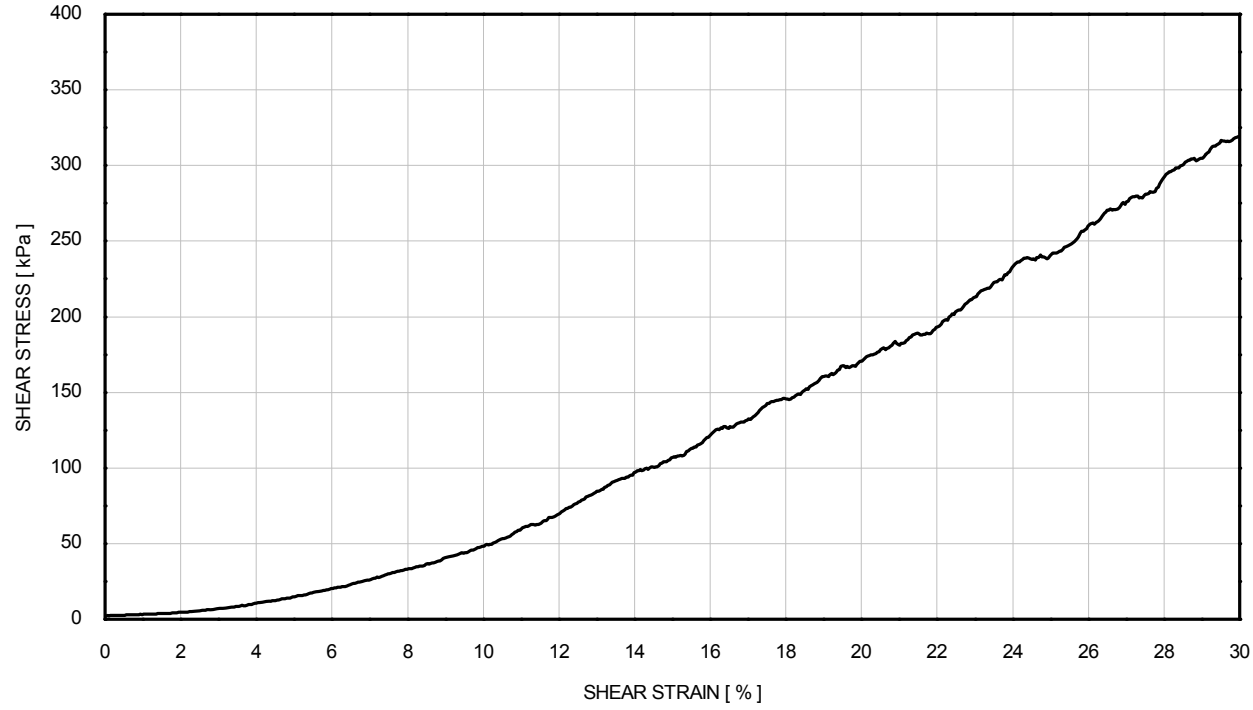


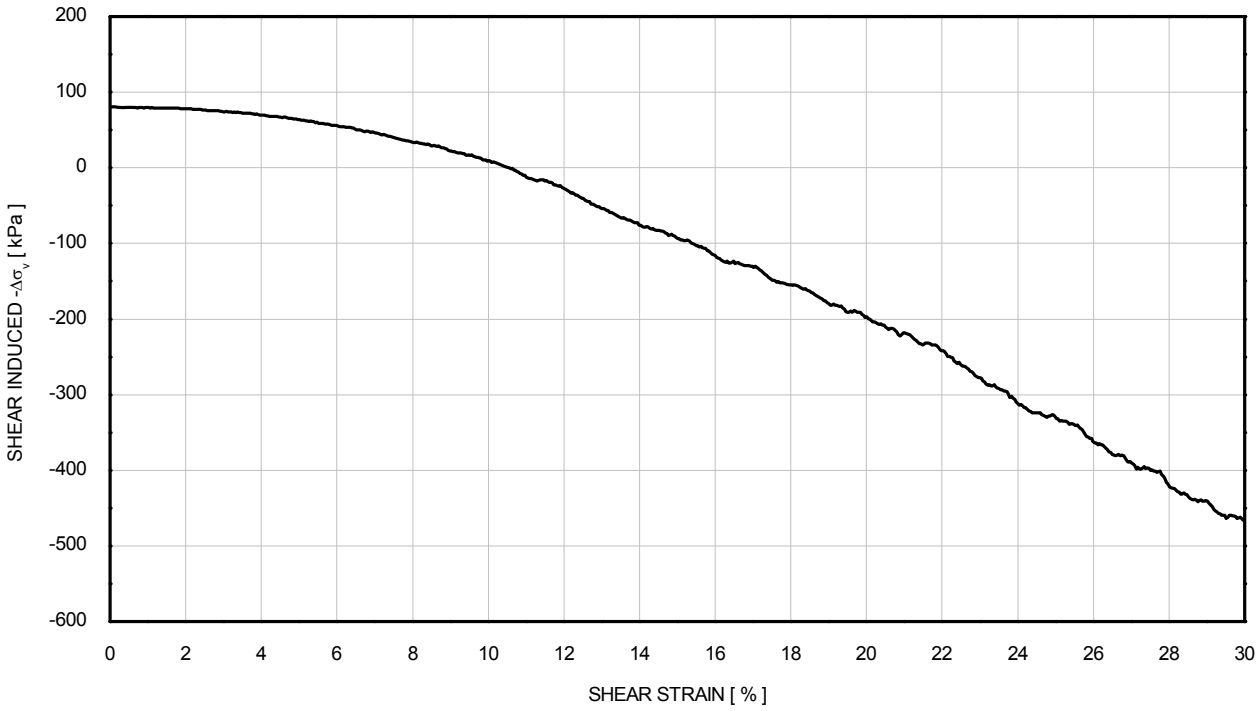


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-3
Mean τ_{cy}	:	13 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS17

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

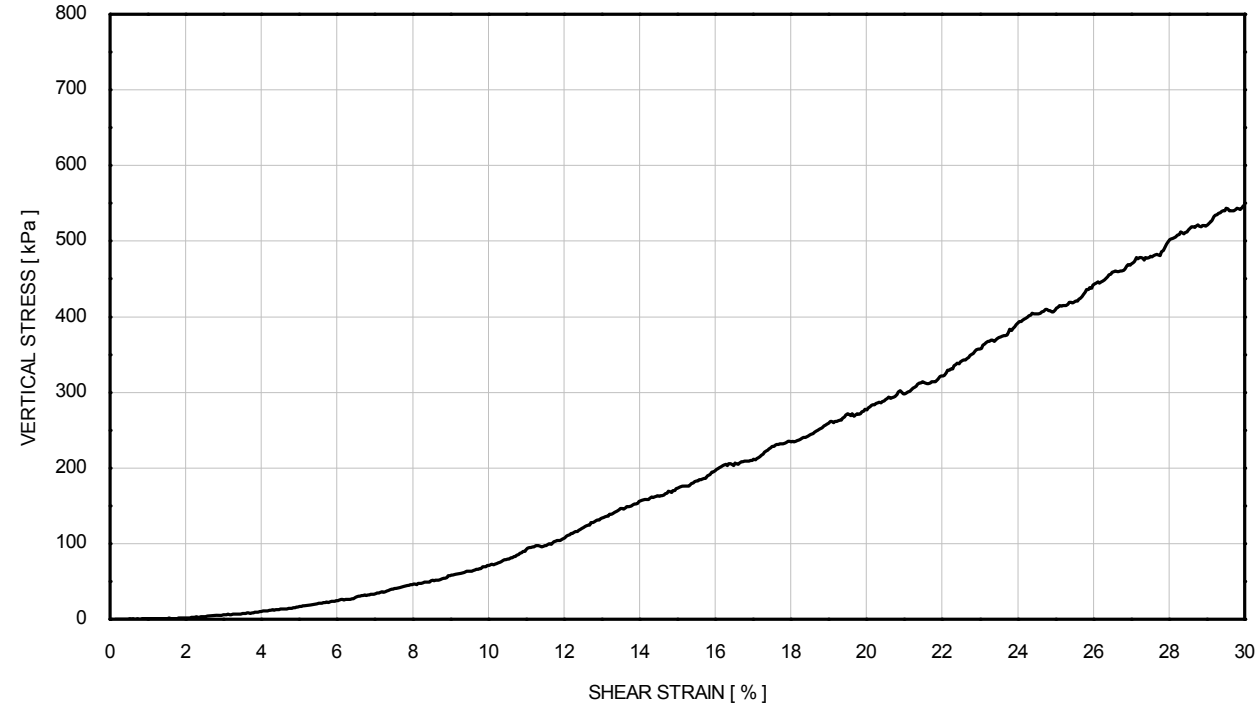


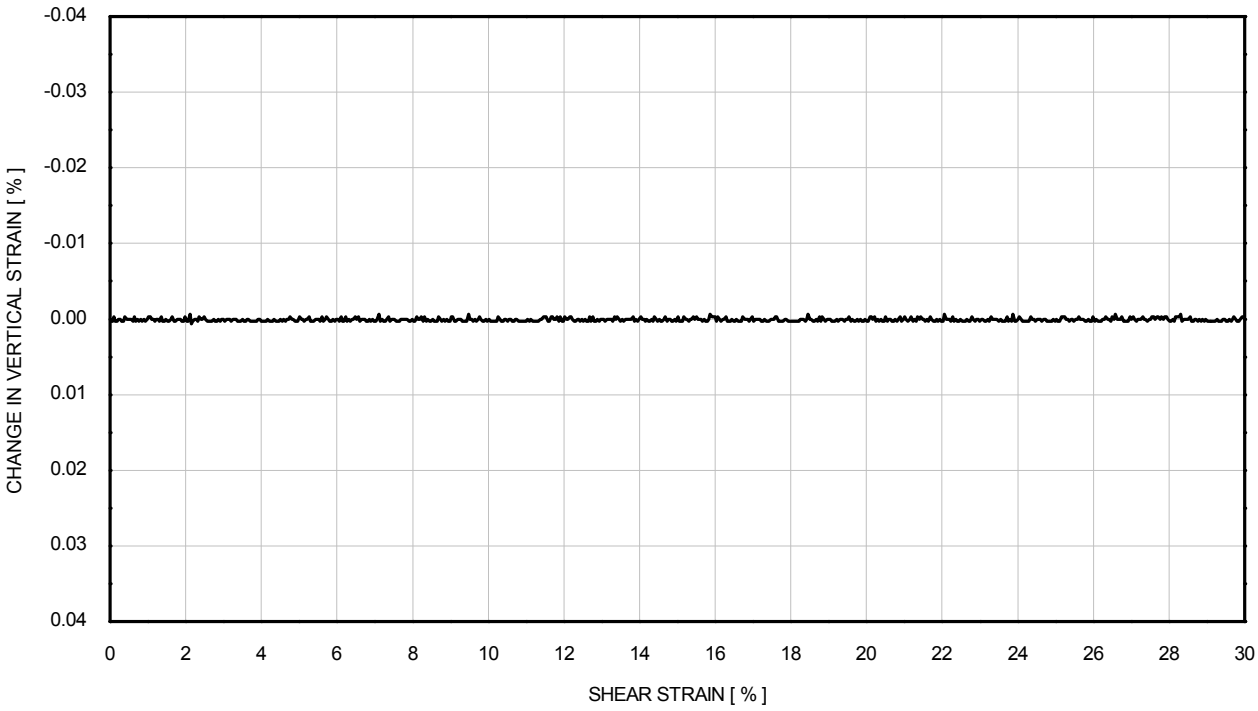


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 319 kPa	Sample	: CSS_2-3
γ at τ_{peak}	: 29.97 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 5.00 %/hour	Test No.	: CSS17

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

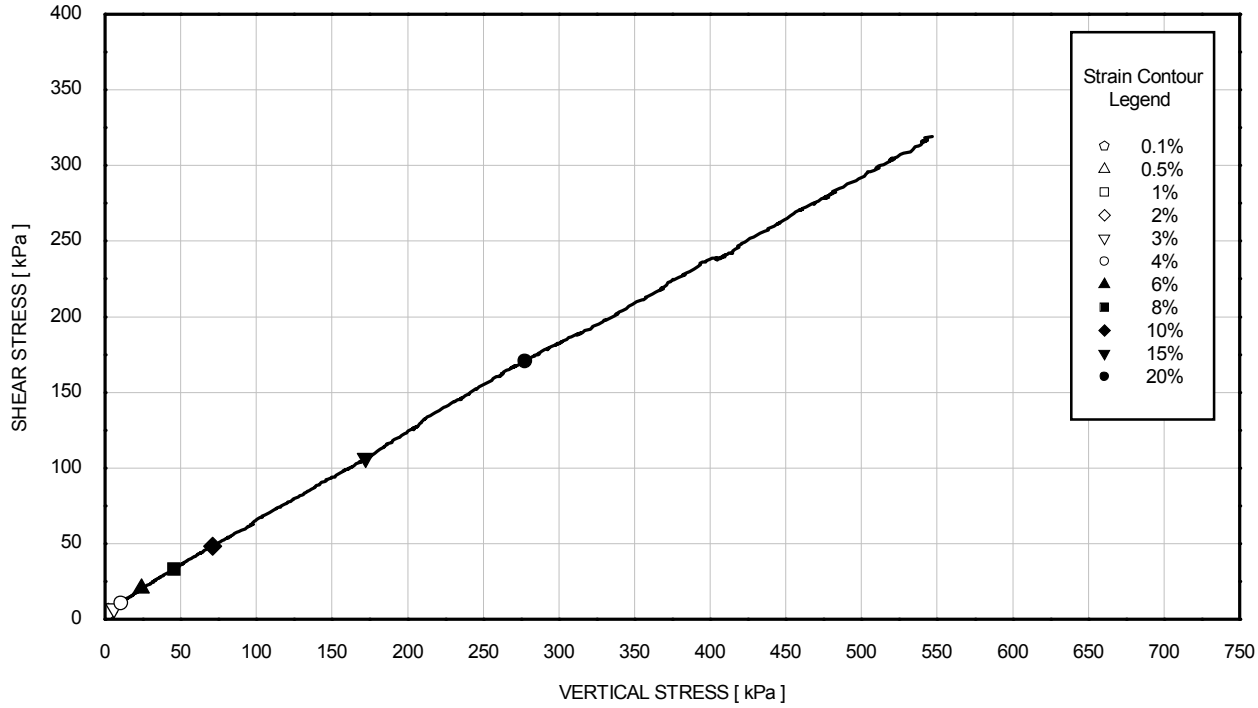


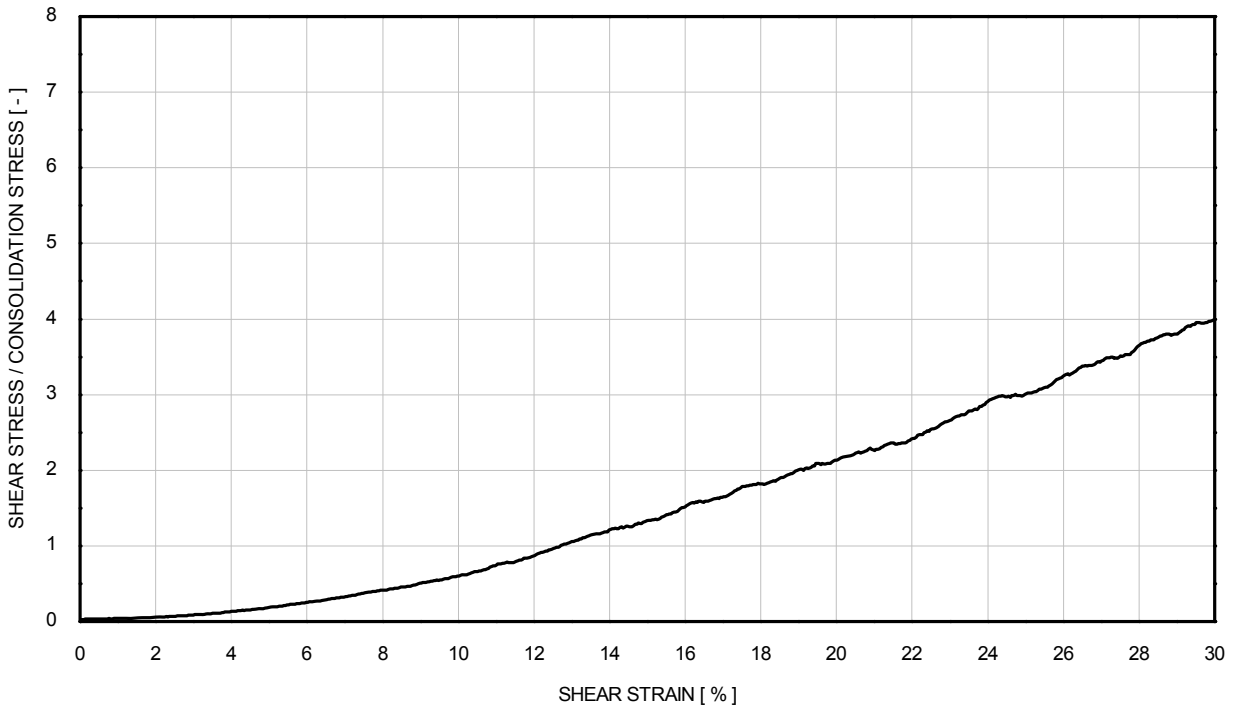


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 319 kPa	Sample	: CSS_2-3
γ at τ_{peak}	: 29.97 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 5.00 %/hour	Test No.	: CSS17

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

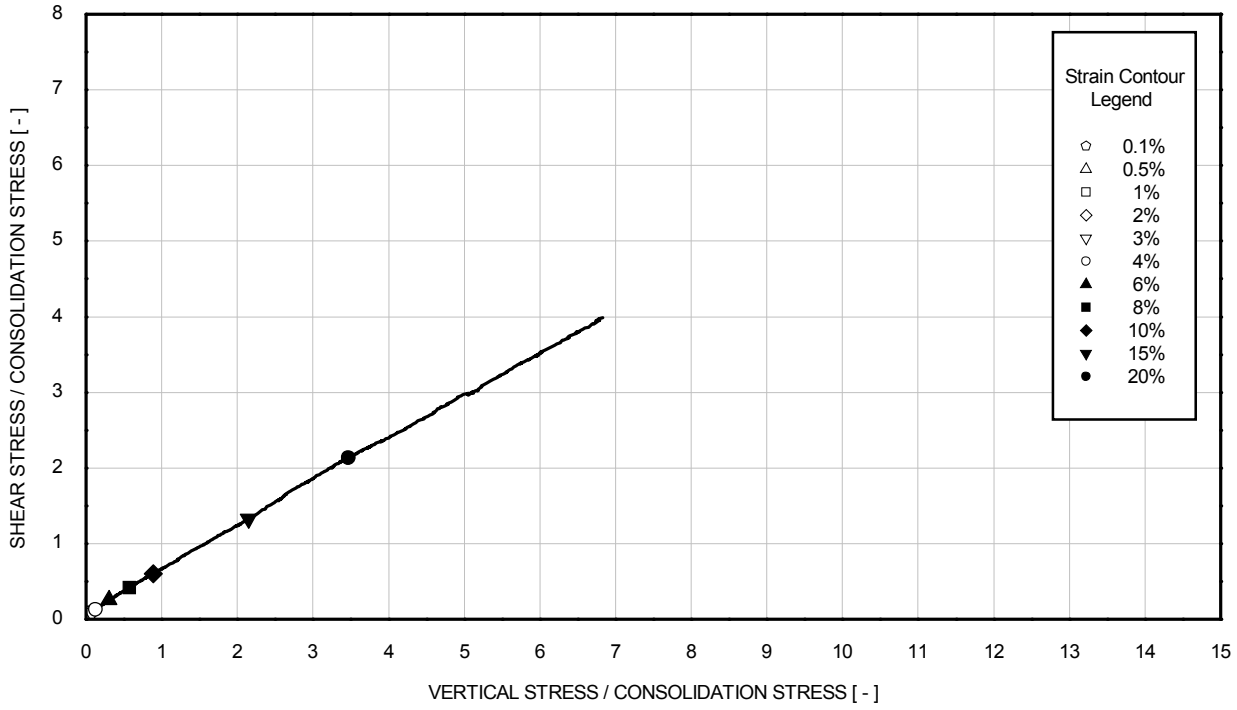


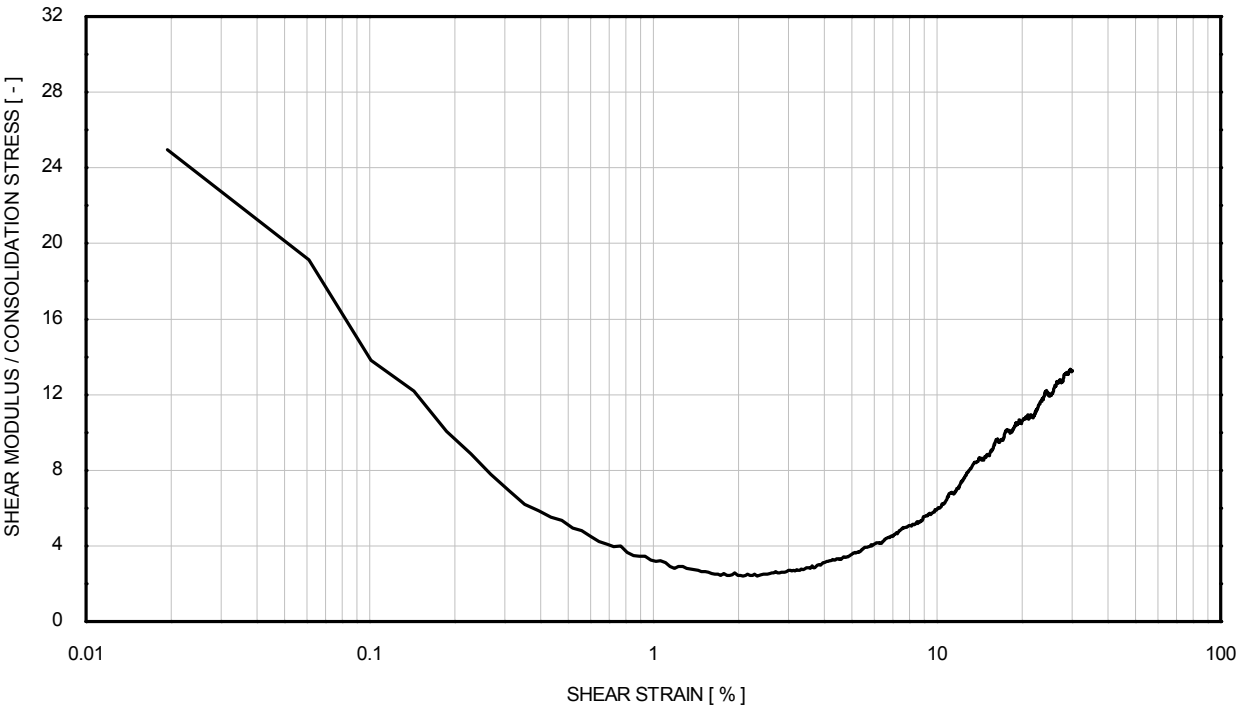


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 319 kPa	Sample	: CSS_2-3
γ at τ_{peak}	: 29.97 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 5.00 %/hour	Test No.	: CSS17

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	:	80 kPa	Batch	:	2
τ_{peak}	:	319 kPa	Sample	:	CSS_2-3
γ at τ_{peak}	:	29.97 %	Unit	:	B (Eem/Kreftenheye)
Rate of strain	:	5.00 %/hour	Test No.	:	CSS17

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Greyish brown fine to medium SAND with few shell fragments

GENERAL	
Date test started	28/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.5
Length	[mm]	30.0
Moisture content after compaction	[%]	9.9
Bulk density after compaction	[Mg/m³]	1.87
Dry density	[Mg/m³]	1.70
Void ratio	[-]	0.557
Degree of saturation after compaction	[%]	47
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	21
Bulk density at start of test	[Mg/m³]	2.06
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 2_CSS 2-4_CSS18
Template issue	1.3
Processed by	HJ
Date	08/03/2016
Checked by	PH
Date	15/03/2016
Approved by	PH
Date	15/03/2016

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-4
Unit	B (Eem/Kreftenheye)
Test number	CSS18

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	80
Vertical strain	[%]	0.22
Bulk density	[Mg/m^3]	2.06
Dry density	[Mg/m^3]	1.71
Void ratio	[-]	0.553
Moisture content	[%]	20.9

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	80
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	18
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	37
γ_{av} at N_f	[%]	0.07
γ_{cy} at N_f	[%]	3.73
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	69
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.02	0.11	16.65	15.37
2	-0.03	0.11	16.04	16.41
5	-0.05	0.16	11.75	18.27
10	-0.12	0.46	3.90	21.82
20	-0.07	2.06	0.85	11.80
25	-0.01	2.72	0.65	10.18
30	0.03	3.21	0.54	9.30
35	0.06	3.60	0.48	8.80
37	0.07	3.73	0.47	8.66

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-4
Unit	B (Eem/Kreftenheye)
Test number	CSS18

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME*		
At peak shear stress		
Shear stress	[kPa]	848
Shear strain	[%]	19.49
Shear induced $-\Delta\sigma_v$	[kPa]	-1354
Vertical stress	[kPa]	1434
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	4.95
At 15 % shear strain		
Shear stress	[kPa]	610
Shear induced $-\Delta\sigma_v$	[kPa]	-939
Vertical stress	[kPa]	1019
Vertical strain	[%]	0.00

* Please note that machine axial load limit was reached at 19.49 % shear strain.

TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-4
Unit	B (Eem/Kreftenheye)
Test number	CSS18

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

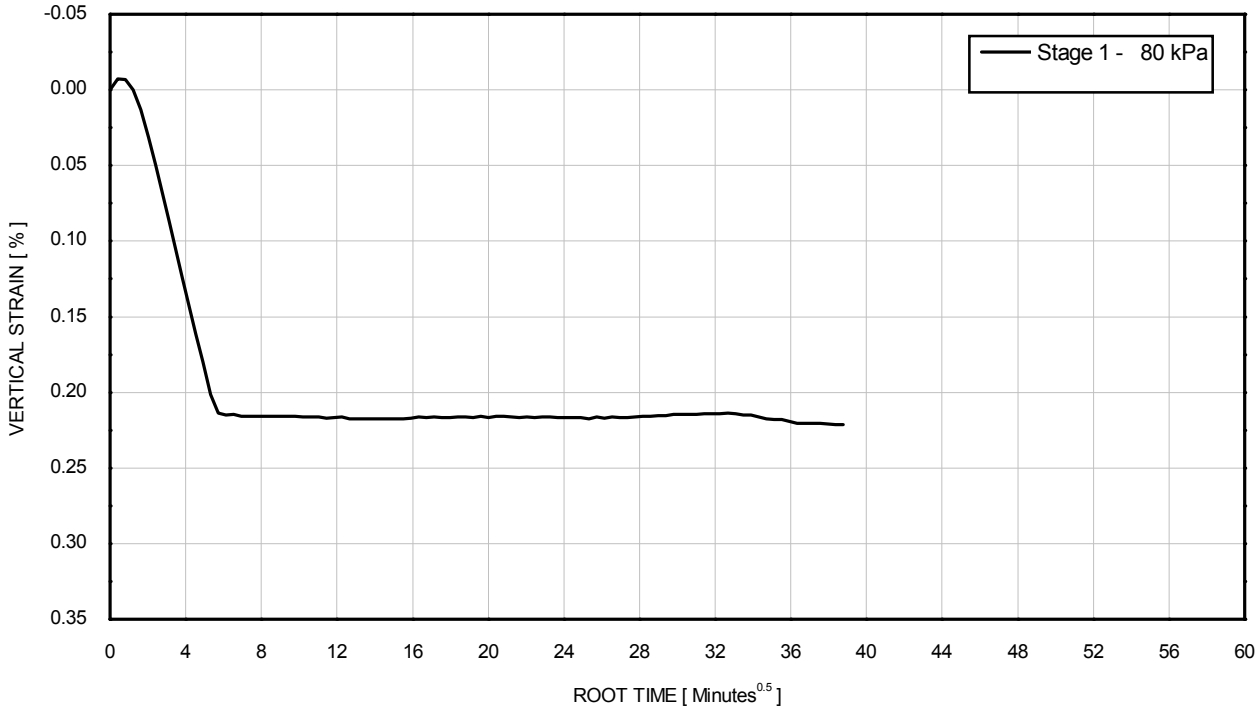
SPECIMEN PHOTOGRAPH

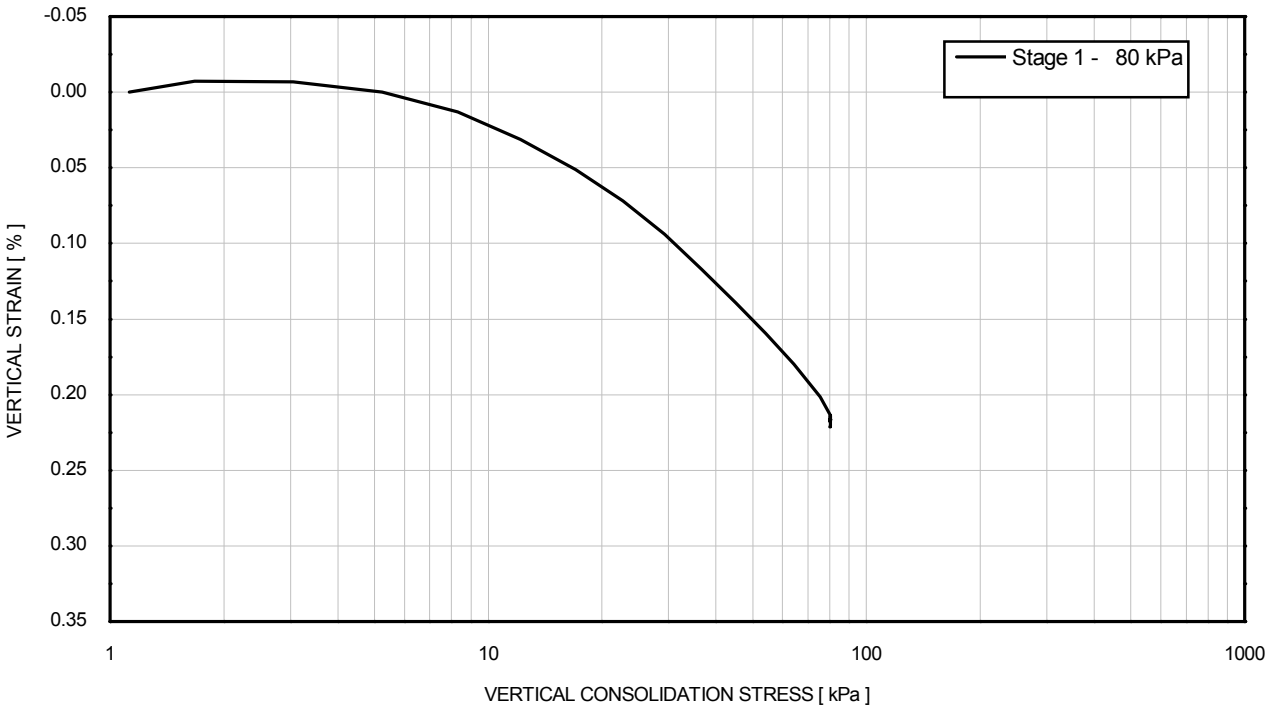


TEST IDENTIFICATION	
Batch	2
Sample	CSS_2-4
Unit	B (Eem/Kreftenheye)
Test number	CSS18

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

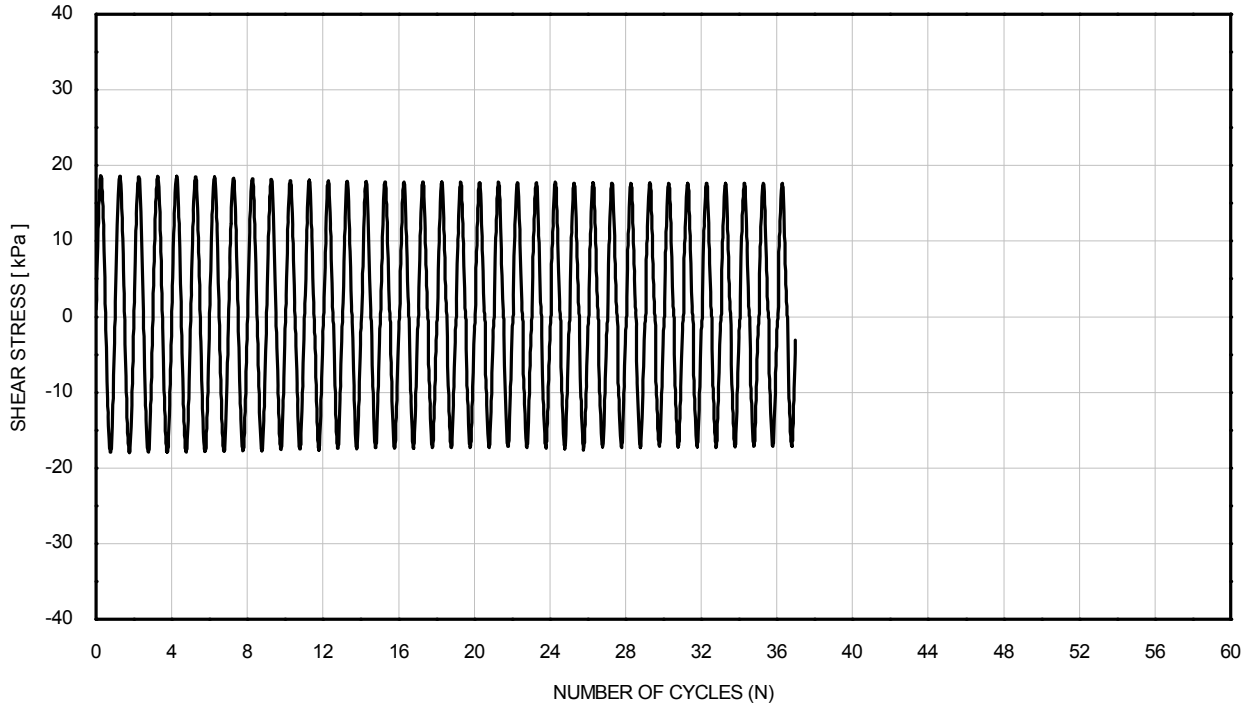


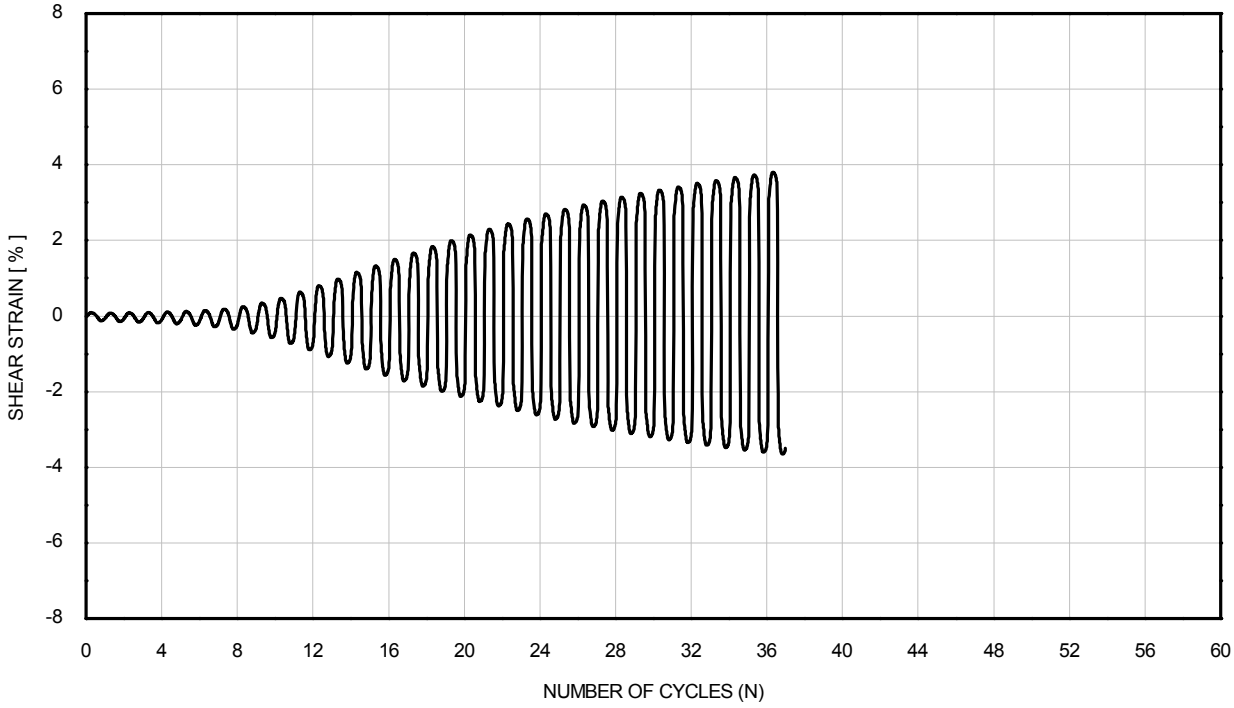


σ_{vc}	: 80 kPa	Batch	: 2
		Sample	: CSS_2-4
		Unit	: B (Eem/Kreftenheye)
		Test No.	: CSS18

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

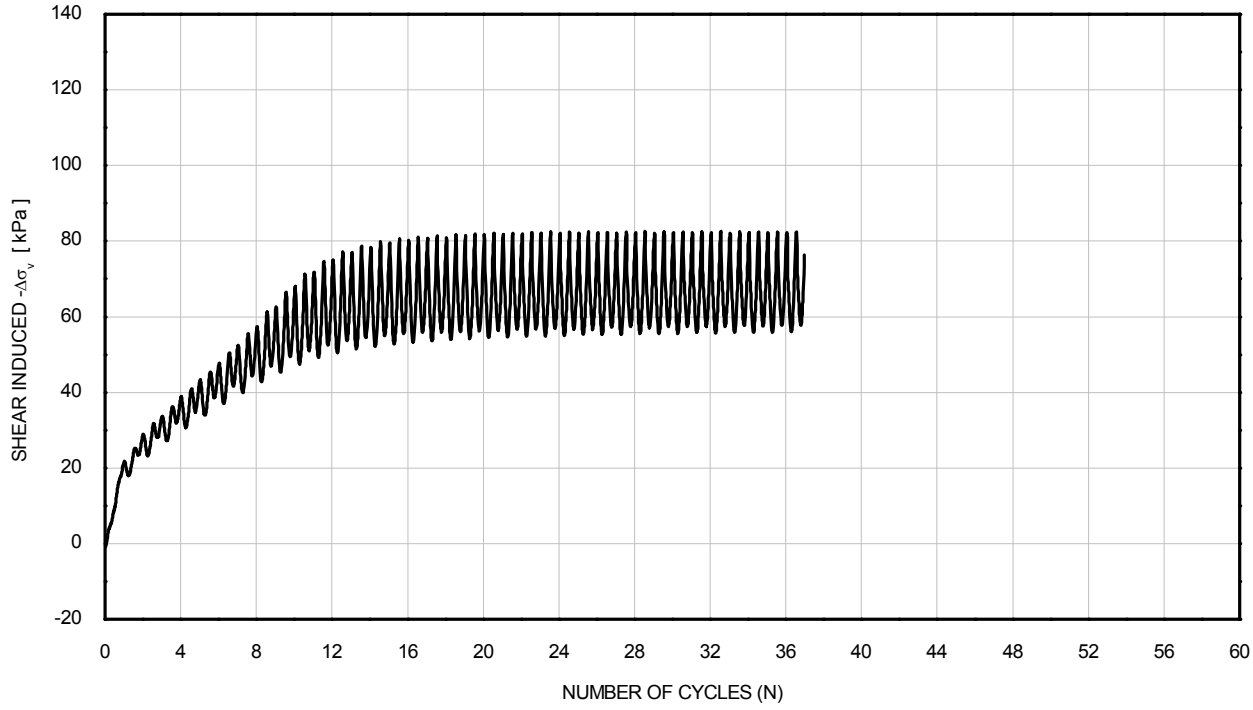


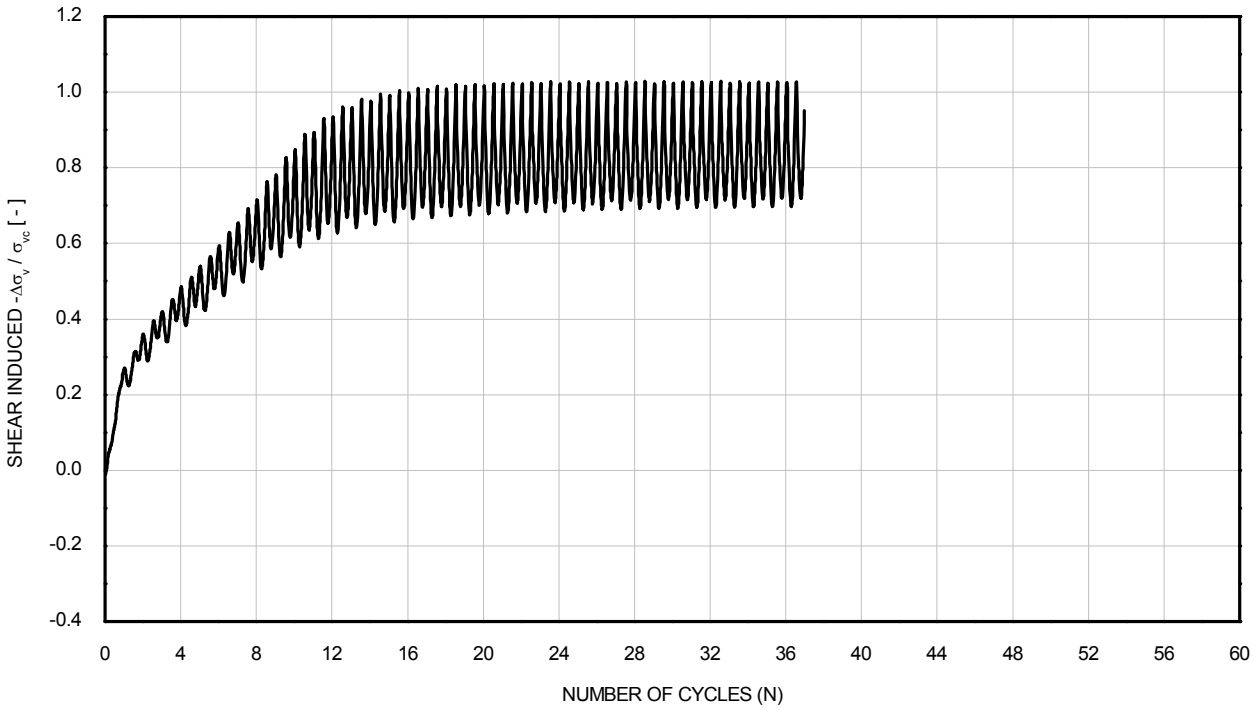


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-4
Mean τ_{cy}	:	18 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS18

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

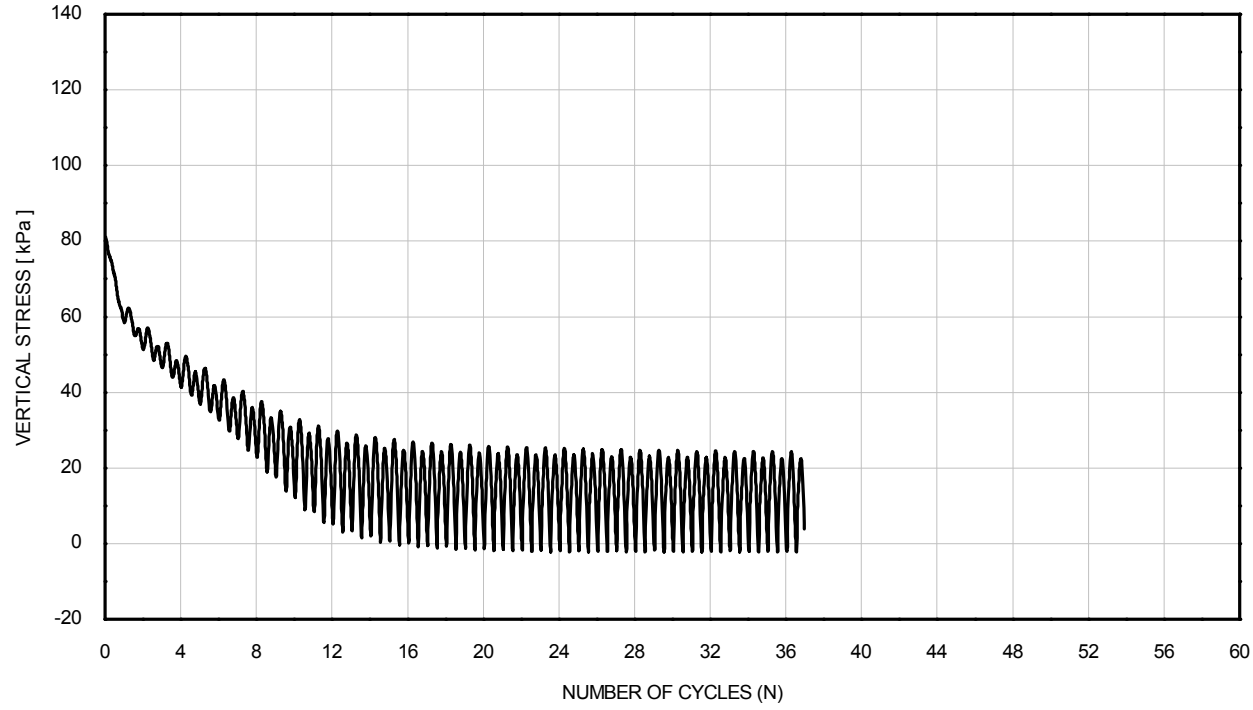


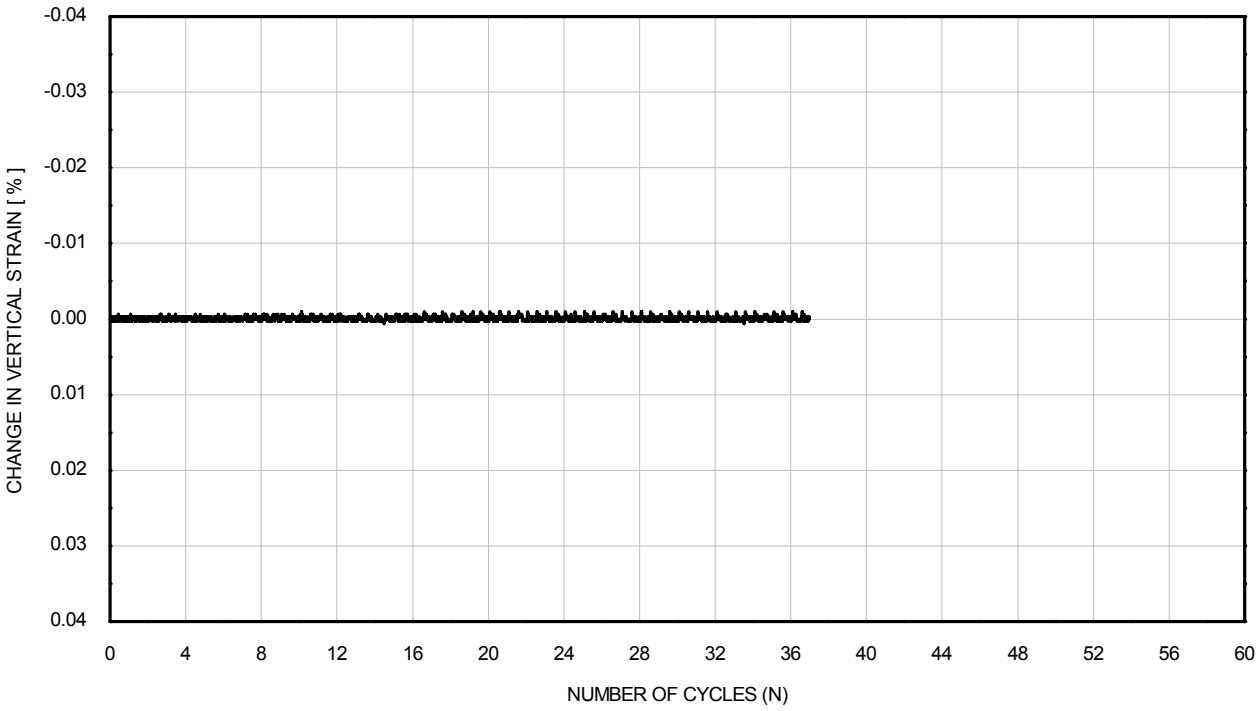


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-4
Mean τ_{cy}	:	18 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS18

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

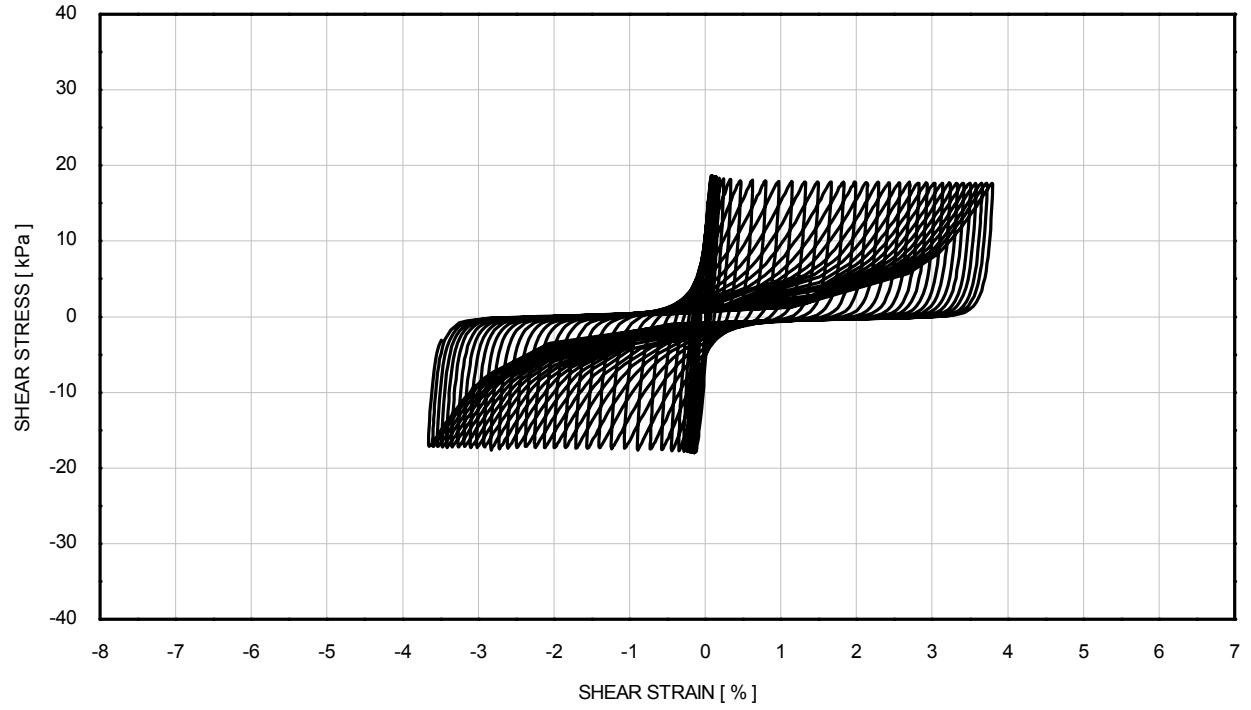


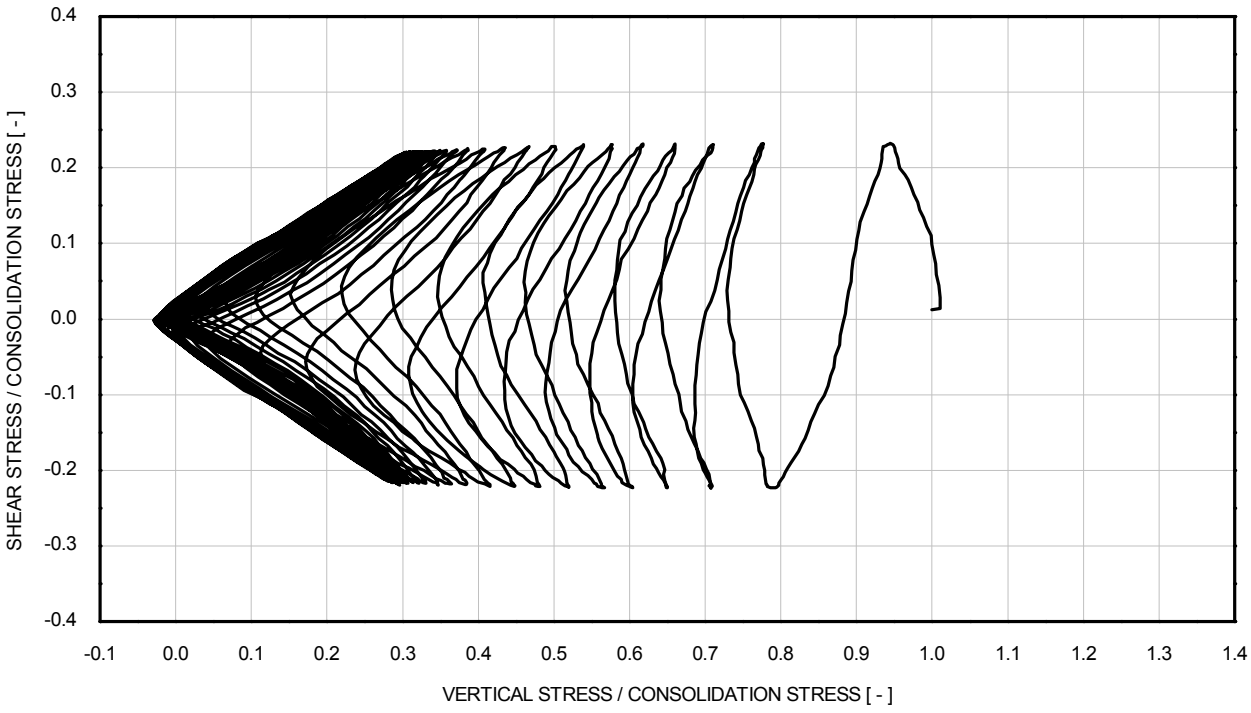


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-4
Mean τ_{cy}	:	18 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS18

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

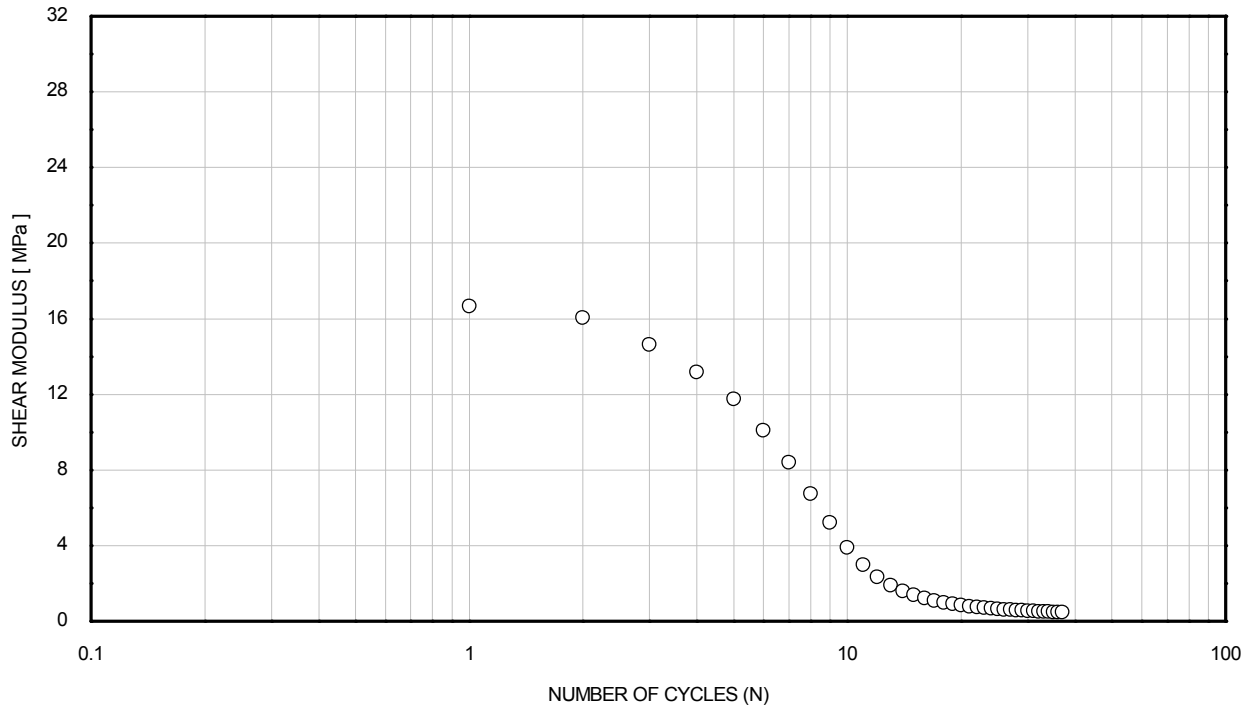


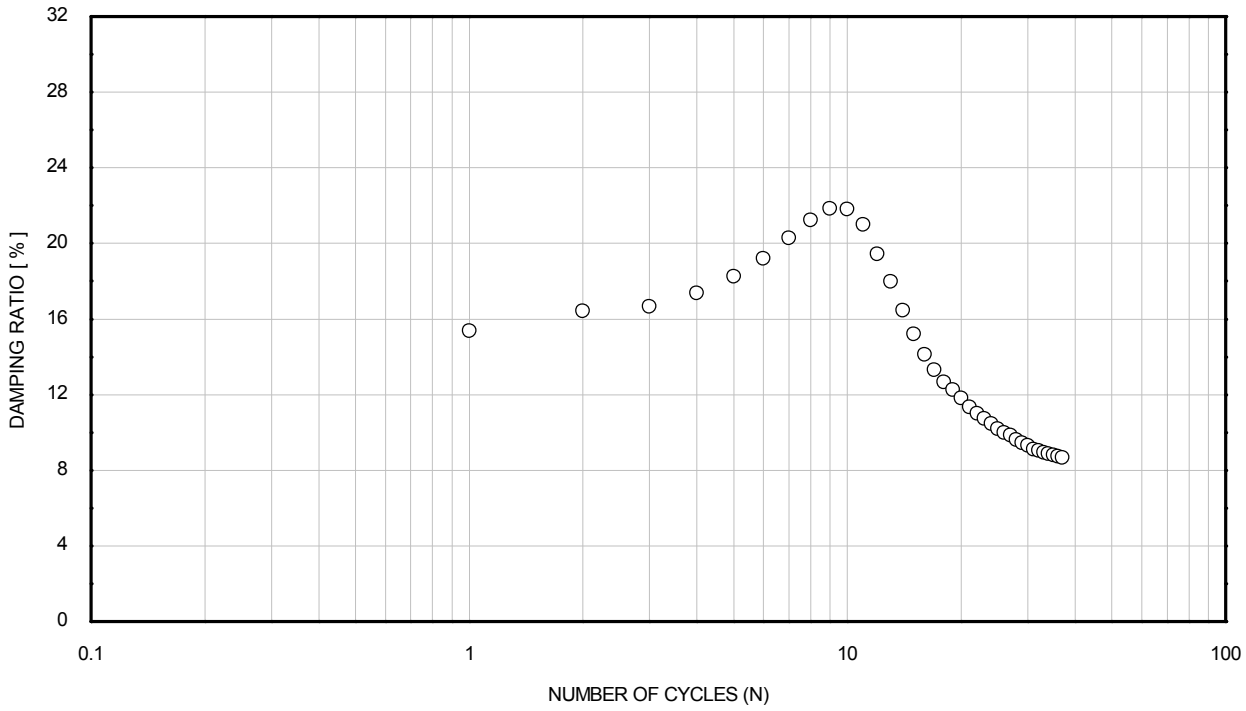


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-4
Mean τ_{cy}	:	18 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS18

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

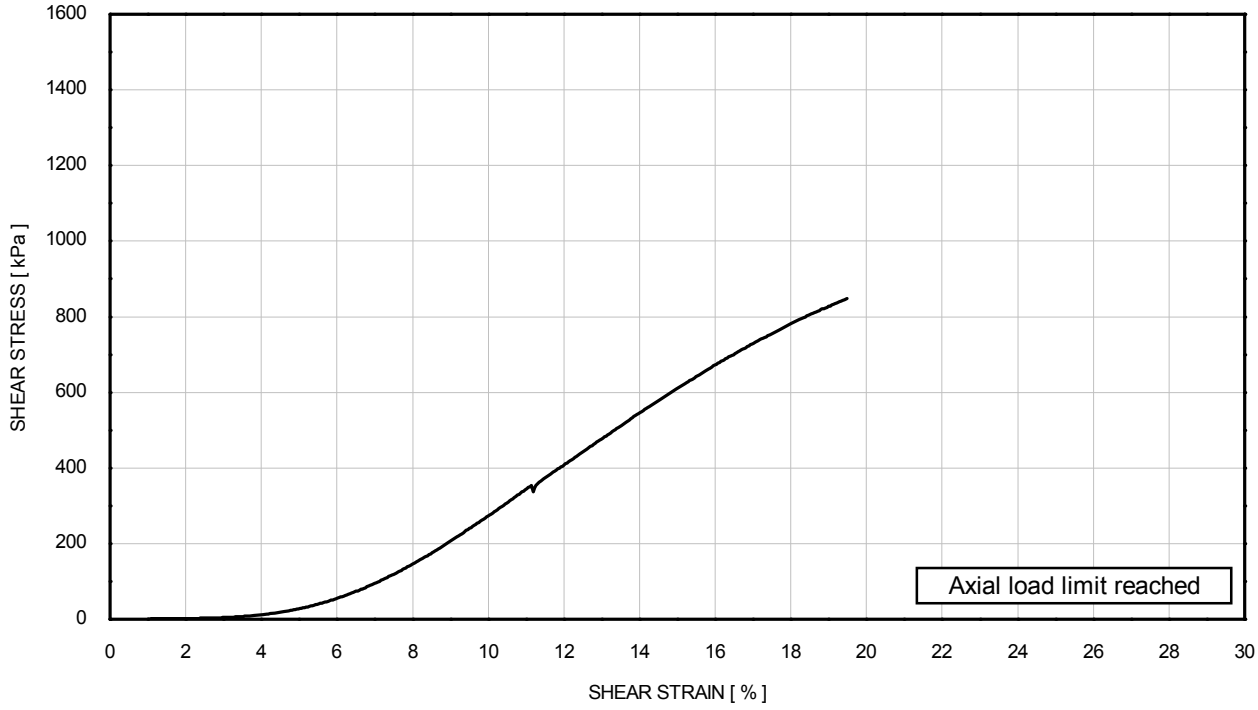


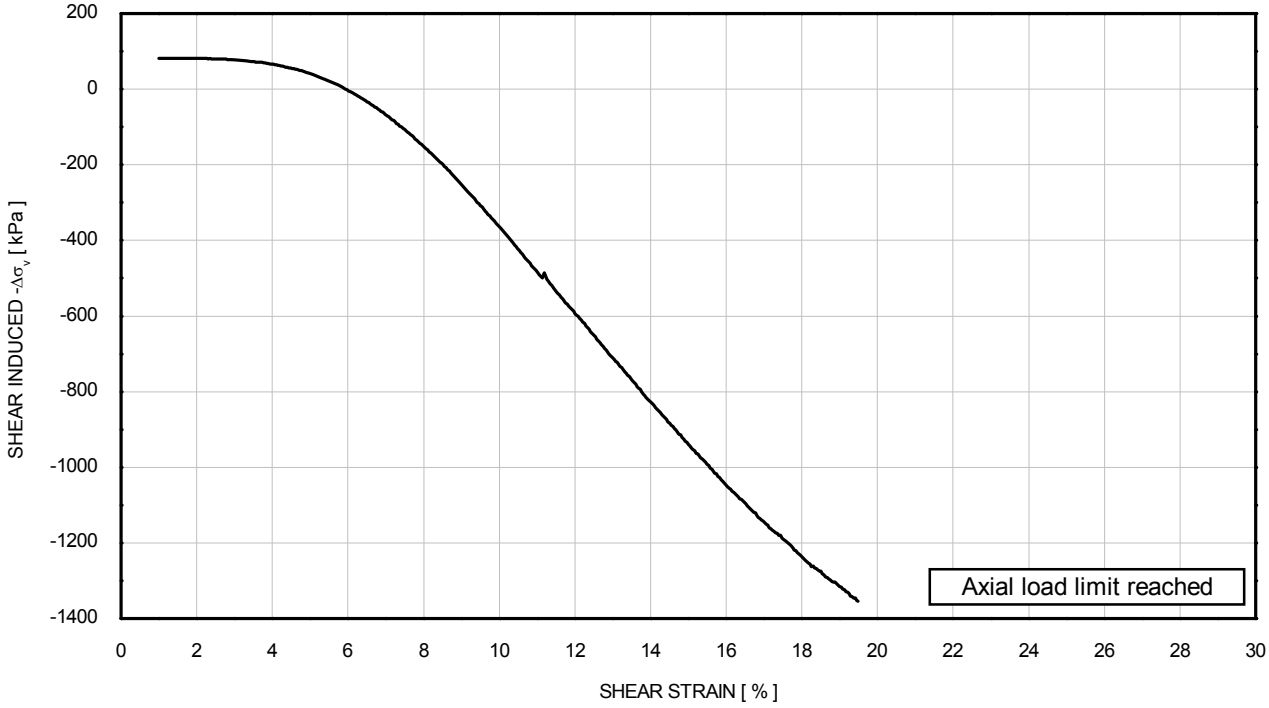


σ_{vc}	:	80 kPa	Batch	:	2
Mean τ_{av}	:	0 kPa	Sample	:	CSS_2-4
Mean τ_{cy}	:	18 kPa	Unit	:	B (Eem/Kreftenheye)
Frequency	:	0.10 Hz	Test No.	:	CSS18

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

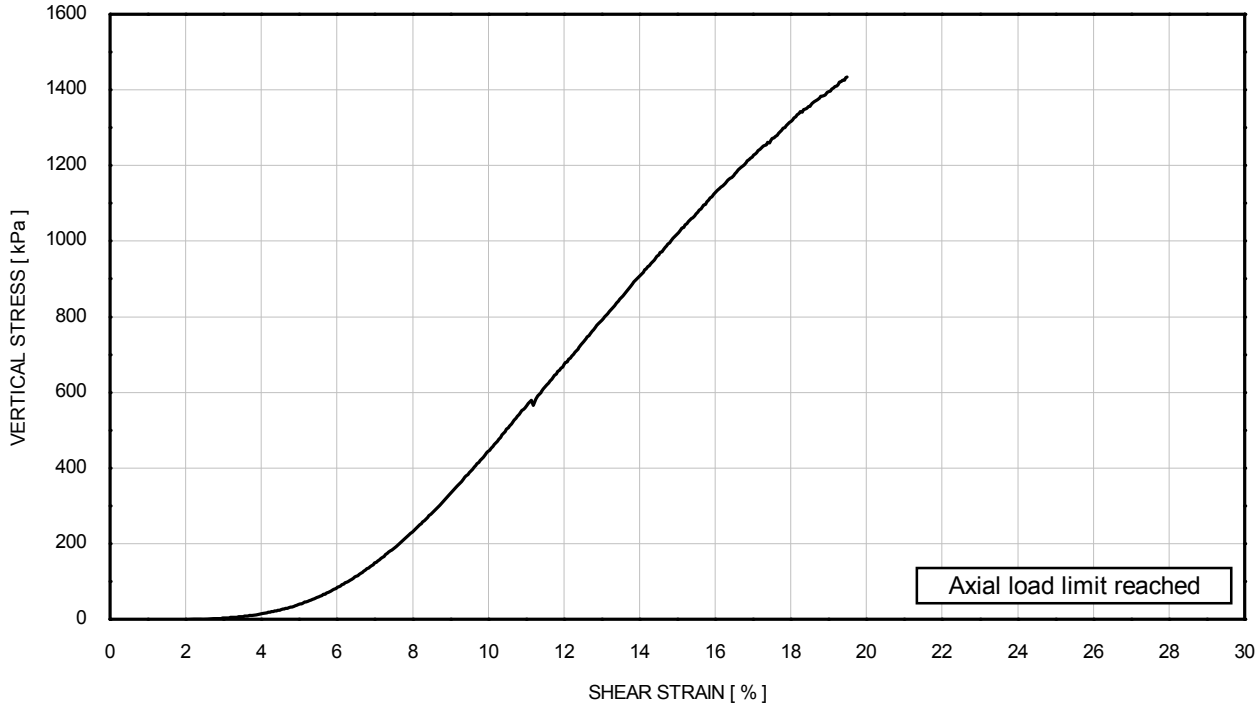


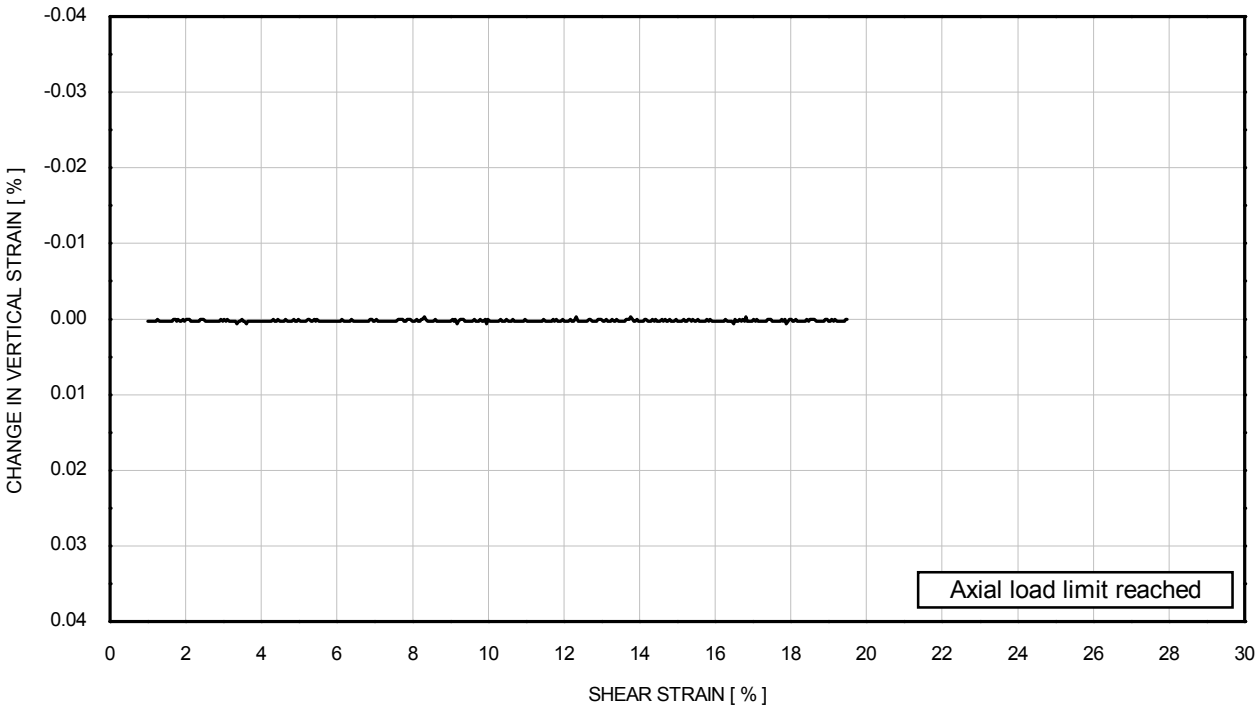


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 848 kPa	Sample	: CSS_2-4
γ at τ_{peak}	: 19.49 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.95 %/hour	Test No.	: CSS18

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

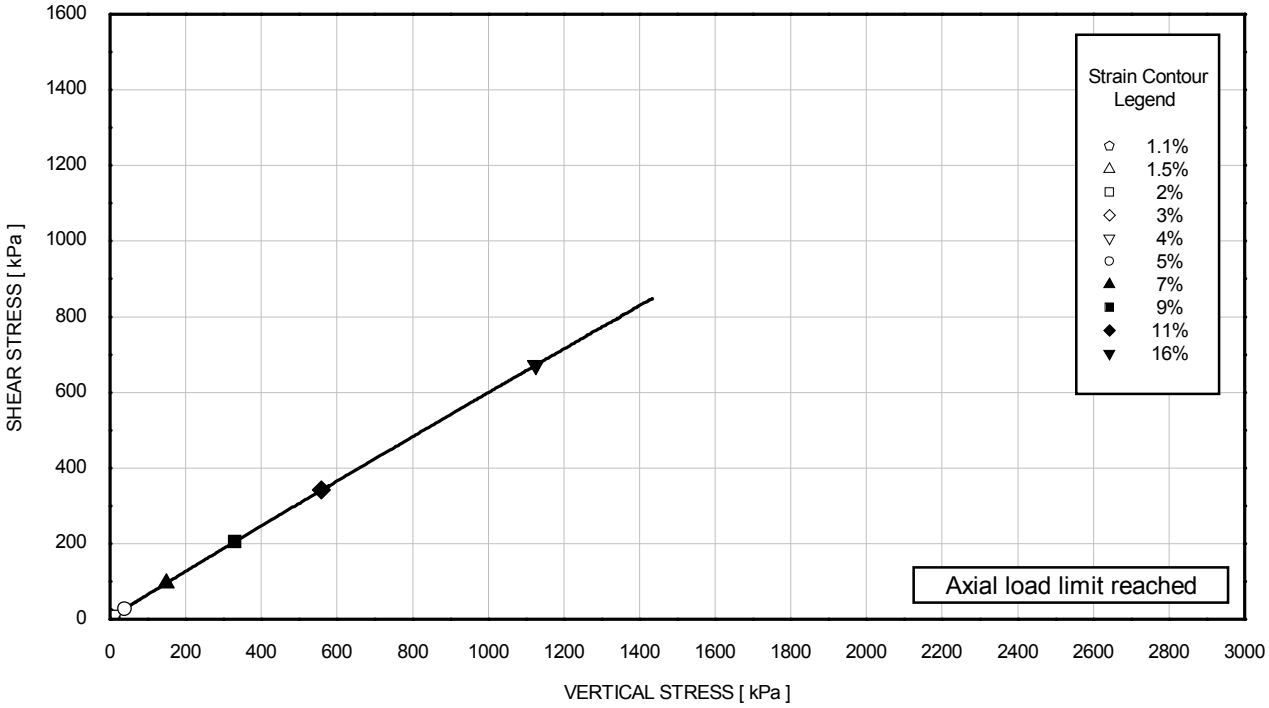


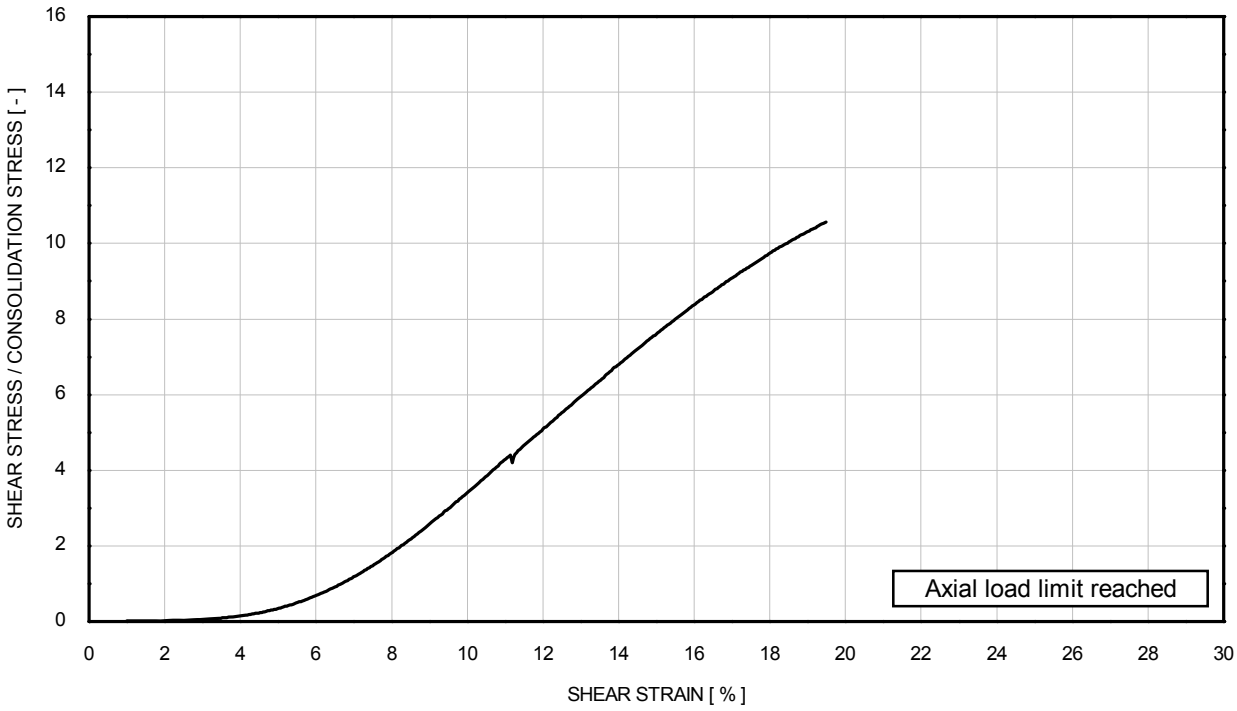


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 848 kPa	Sample	: CSS_2-4
γ at τ_{peak}	: 19.49 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.95 %/hour	Test No.	: CSS18

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

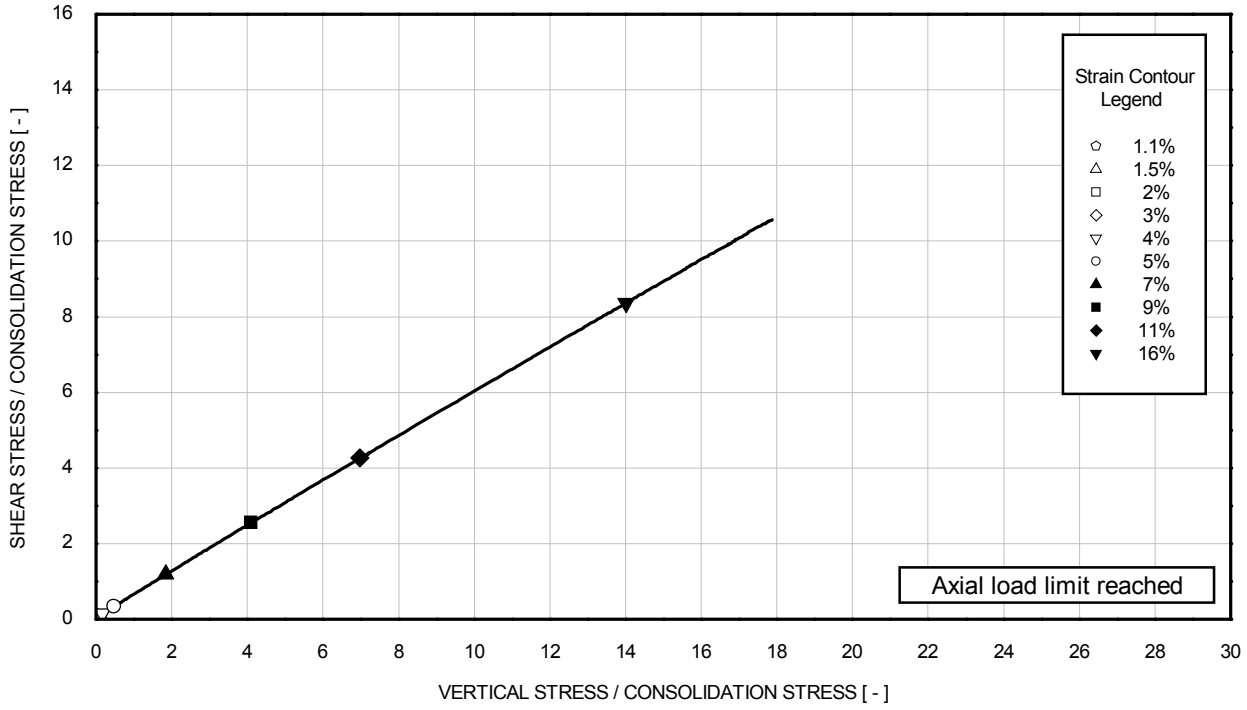


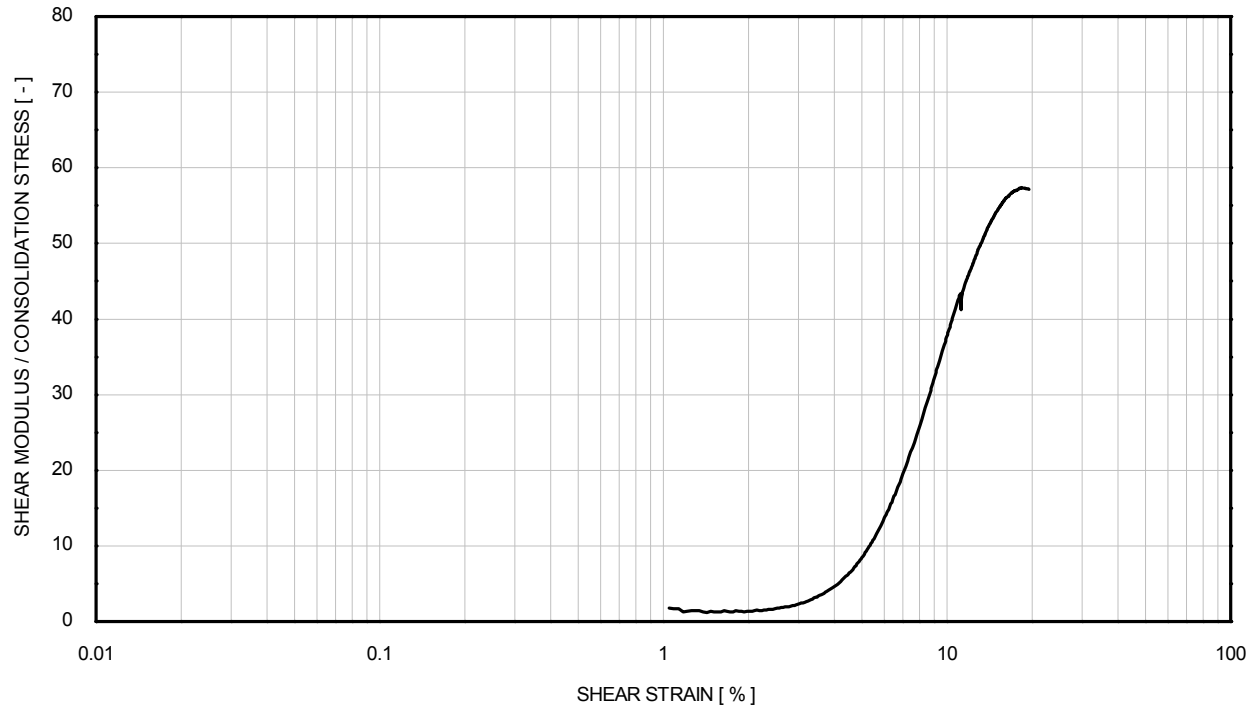


σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 848 kPa	Sample	: CSS_2-4
γ at τ_{peak}	: 19.49 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.95 %/hour	Test No.	: CSS18

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 80 kPa	Batch	: 2
τ_{peak}	: 848 kPa	Sample	: CSS_2-4
γ at τ_{peak}	: 19.49 %	Unit	: B (Eem/Kreftenheye)
Rate of strain	: 4.95 %/hour	Test No.	: CSS18

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	04/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.4
Length	[mm]	30.0
Moisture content after compaction	[%]	10.3
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.650
Degree of saturation after compaction	[%]	42
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.5
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 3_CSS 3-1_CSS19
Template issue	1.3
Processed by	HJ
Date	10/02/2016
Checked by	PH
Date	16/02/2016
Approved by	PH
Date	16/02/2016

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-1
Unit	E3 (Tongeren)
Test number	CSS19

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	300
Vertical strain	[%]	1.45
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.626
Moisture content	[%]	23.6

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	300
Mean τ_{av}	[kPa]	1
Mean τ_{cy}	[kPa]	85
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1
γ_{av} at N_f	[%]	-1.69
γ_{cy} at N_f	[%]	7.77
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	143
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-1.69	7.77	1.09	20.60

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-1
Unit	E3 (Tongeren)
Test number	CSS19

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	120
Shear strain	[%]	21.64
Shear induced $-\Delta\sigma_v$	[kPa]	94
Vertical stress	[kPa]	206
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.08
At 15 % shear strain		
Shear stress	[kPa]	87
Shear induced $-\Delta\sigma_v$	[kPa]	156
Vertical stress	[kPa]	144
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-1
Unit	E3 (Tongeren)
Test number	CSS19

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

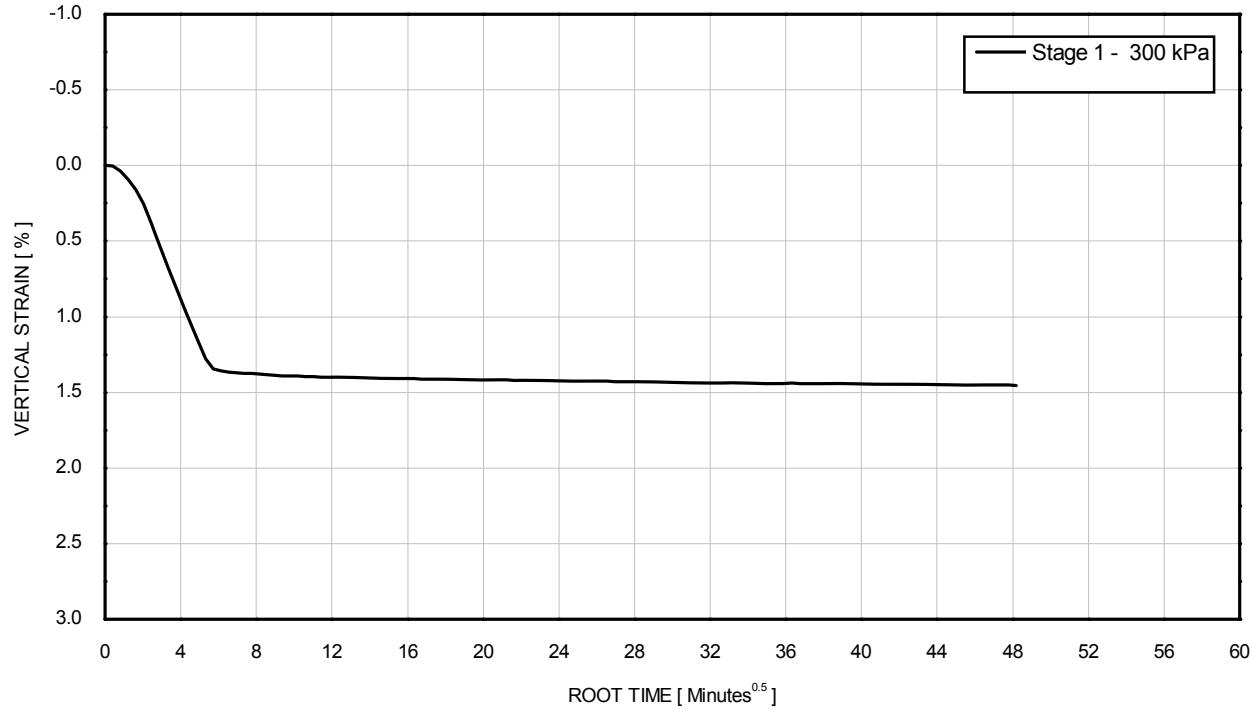
SPECIMEN PHOTOGRAPH

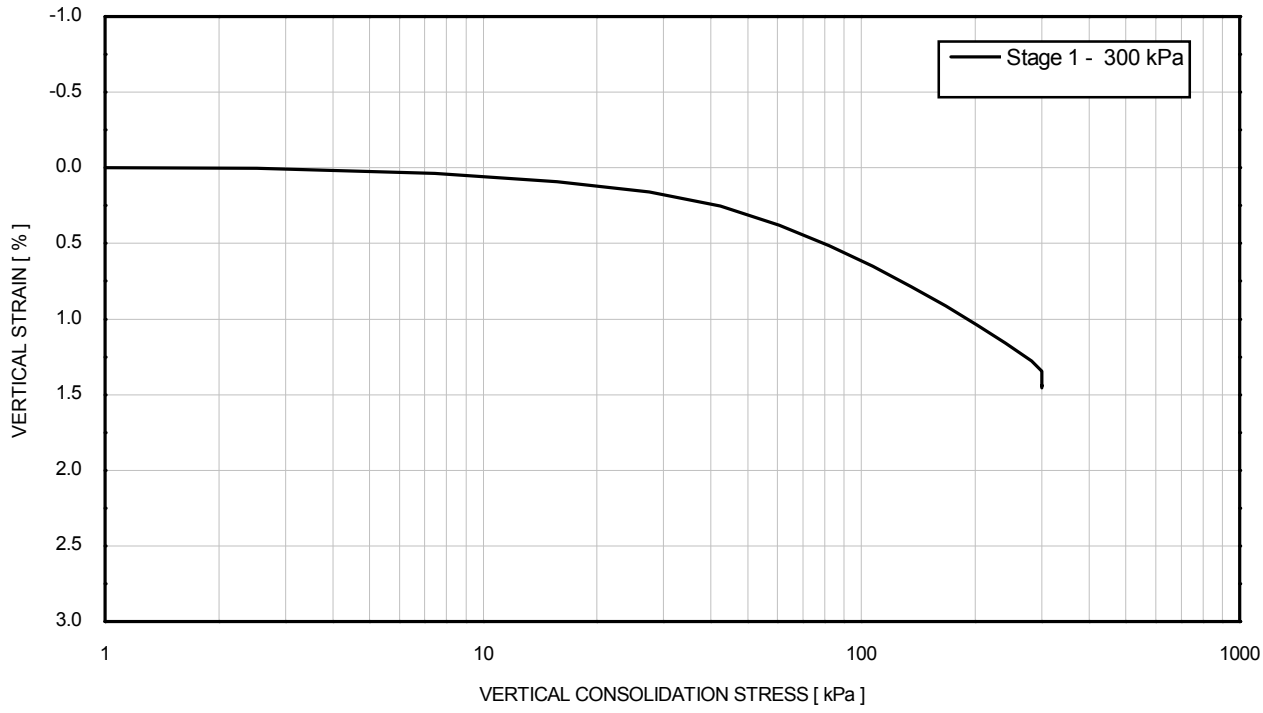


TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-1
Unit	E3 (Tongeren)
Test number	CSS19

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

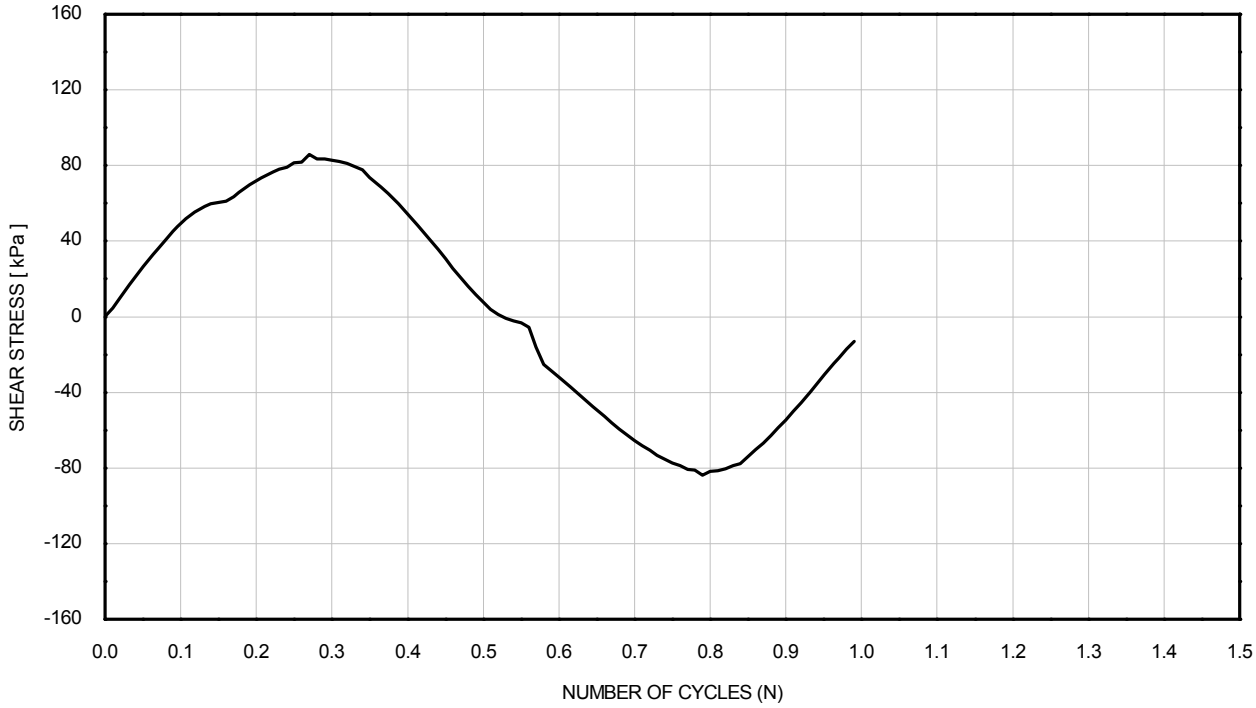


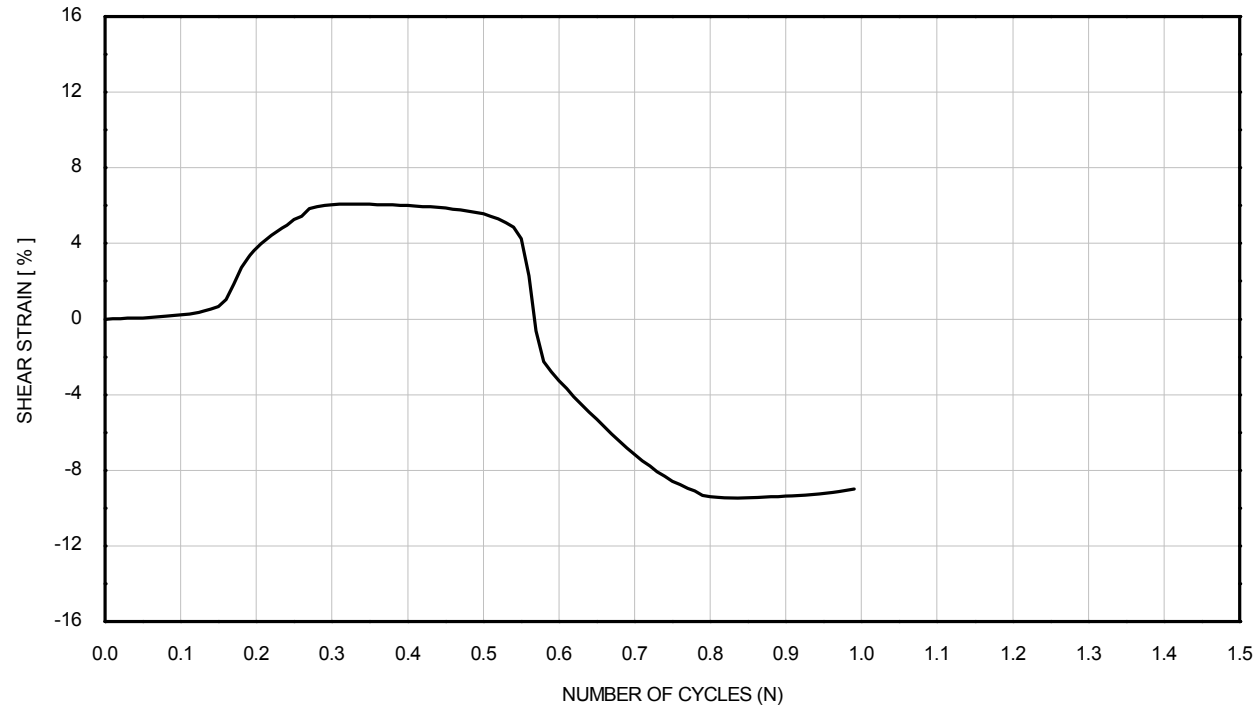


σ_{vc}	: 300 kPa	Batch	: 3
		Sample	: CSS_3-1
		Unit	: E3 (Tongeren)
		Test No.	: CSS19

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

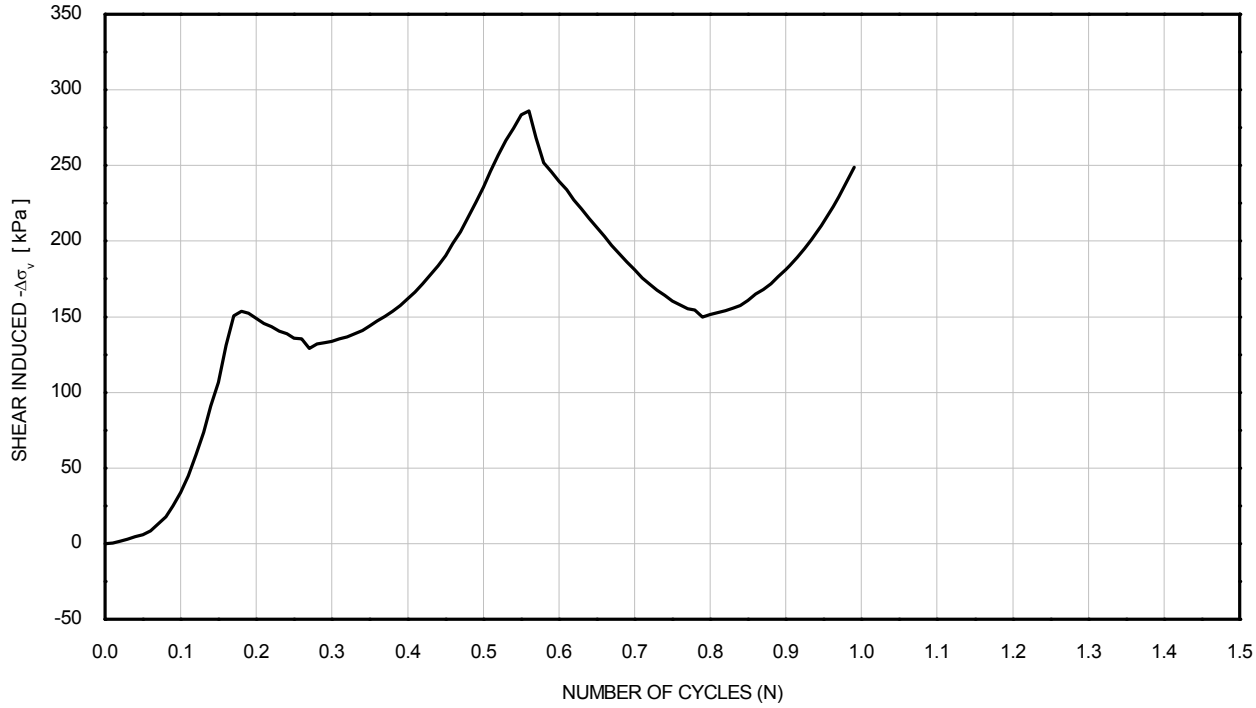


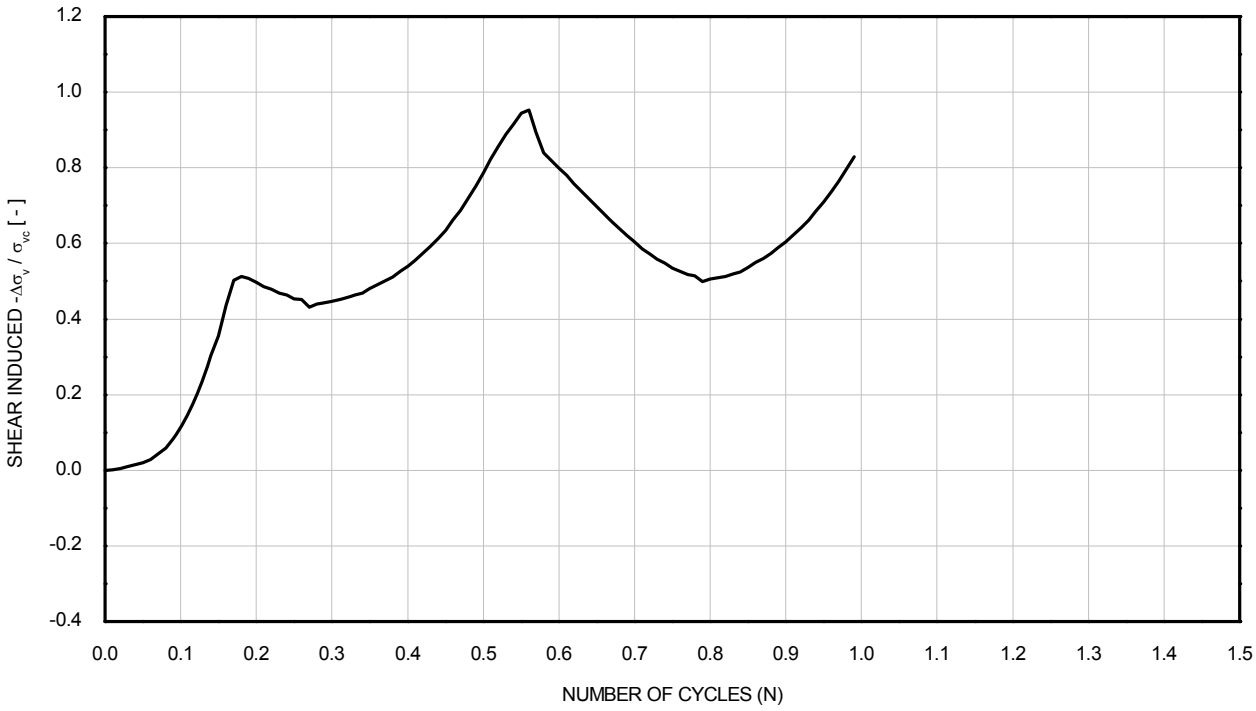


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	1 kPa	Sample	:	CSS_3-1
Mean τ_{cy}	:	85 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS19

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

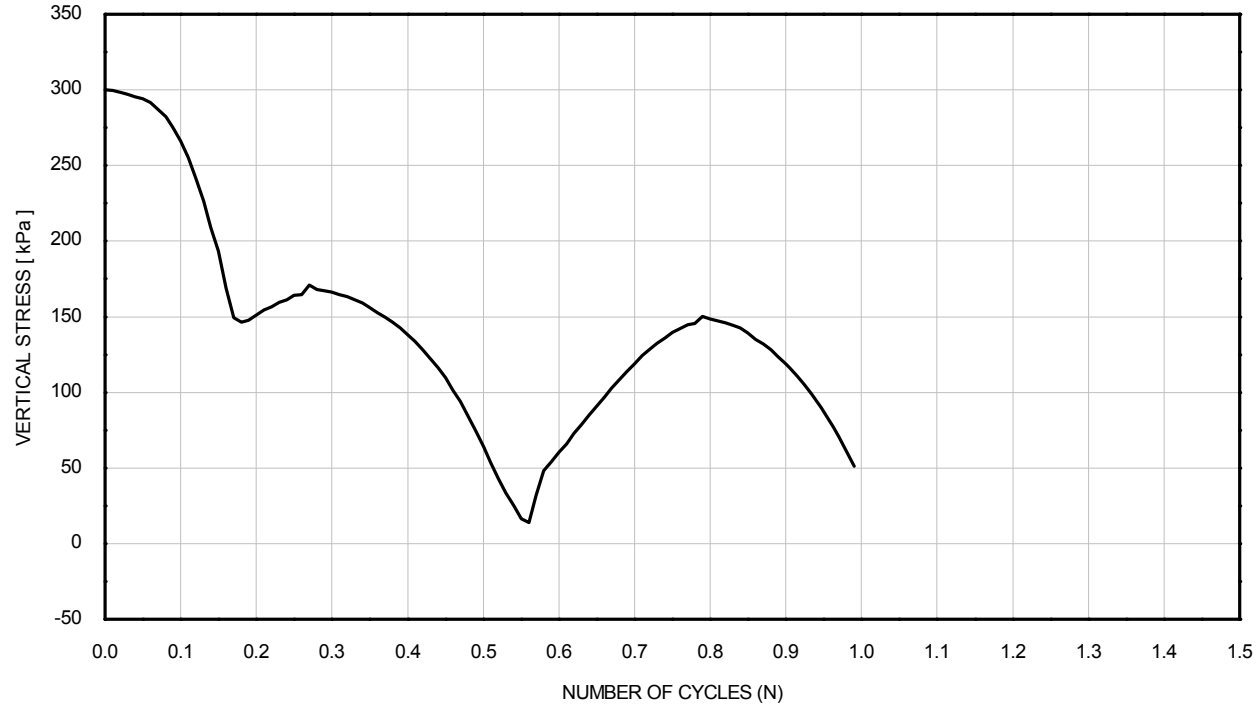


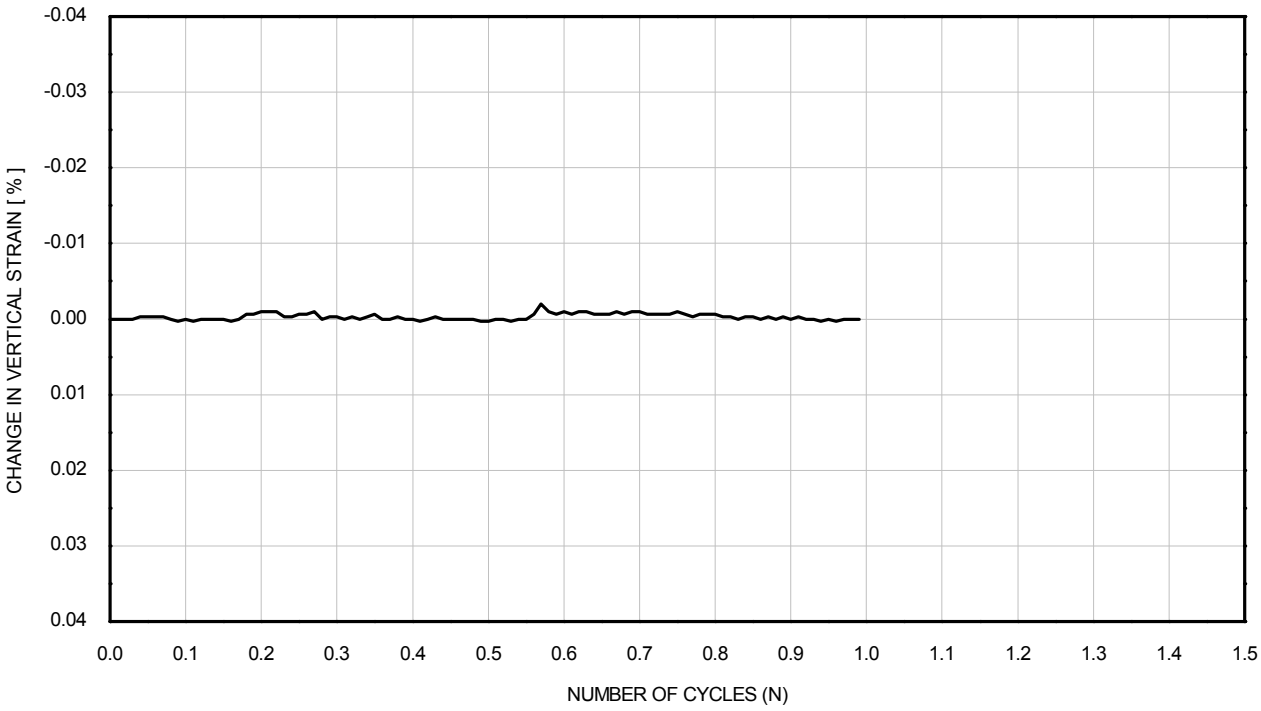


σ_{vc}	:	300 kPa	Batch	: 3
Mean τ_{av}	:	1 kPa	Sample	: CSS_3-1
Mean τ_{cy}	:	85 kPa	Unit	: E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	: CSS19

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

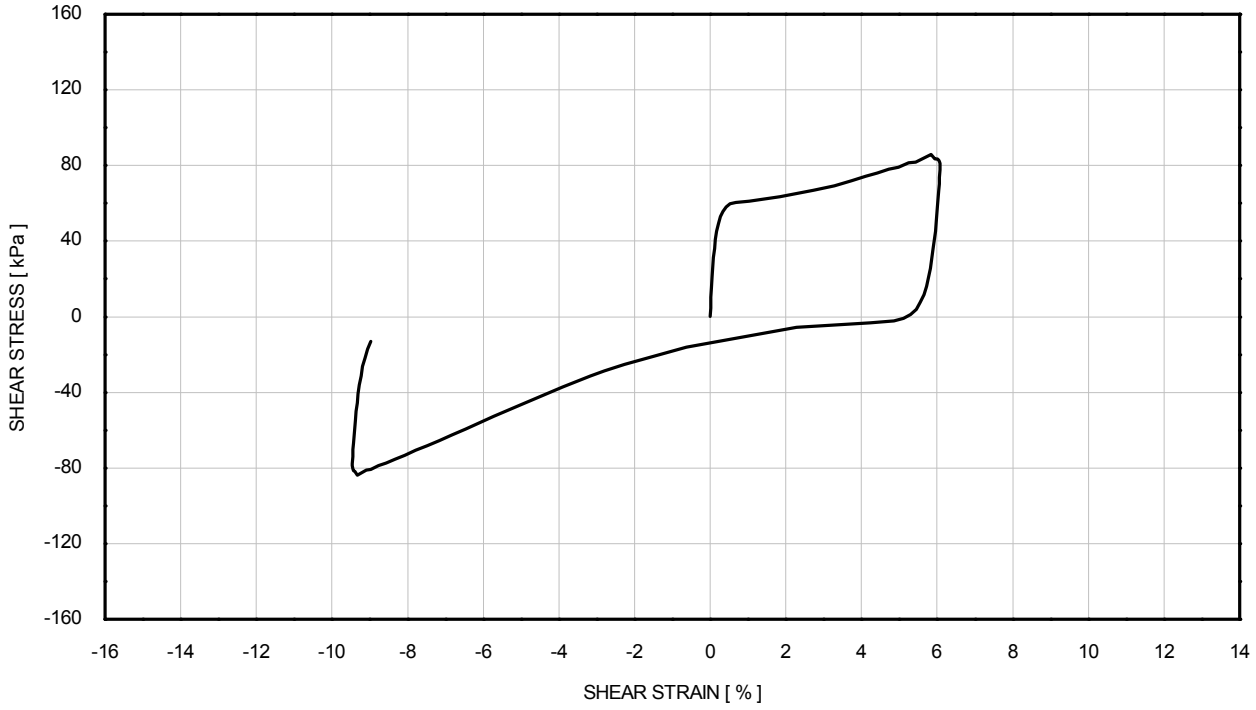


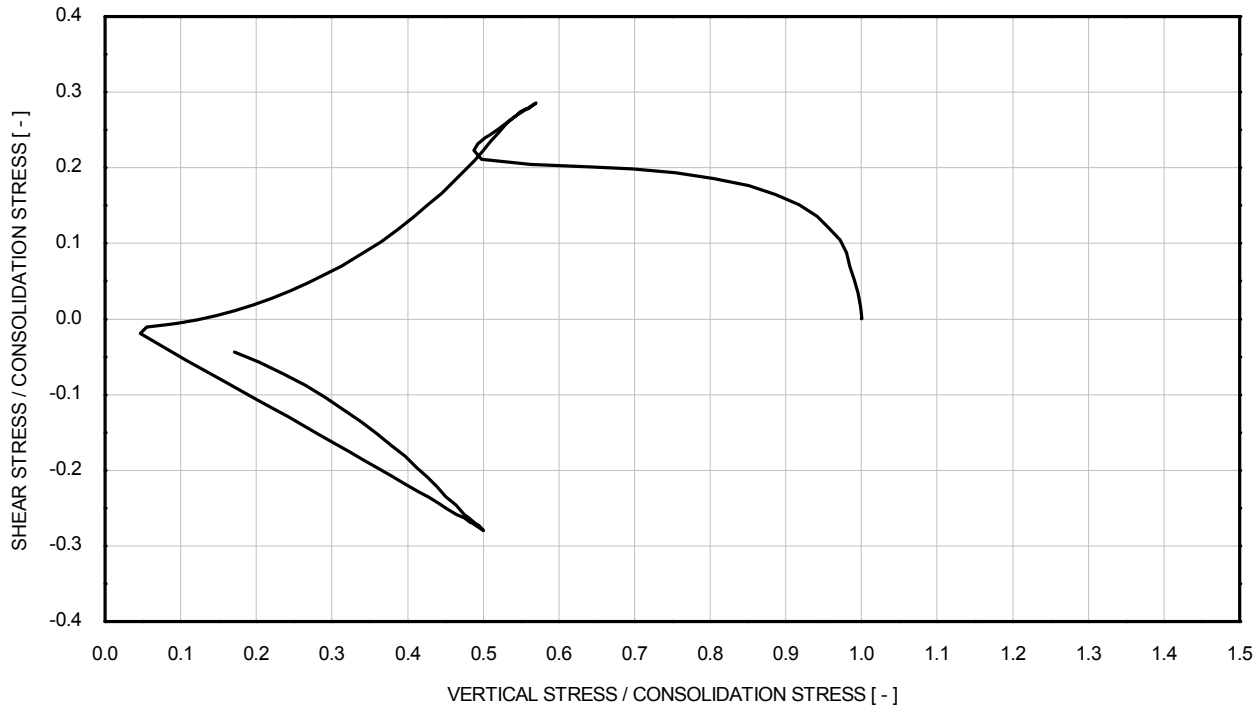


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	1 kPa	Sample	:	CSS_3-1
Mean τ_{cy}	:	85 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS19

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

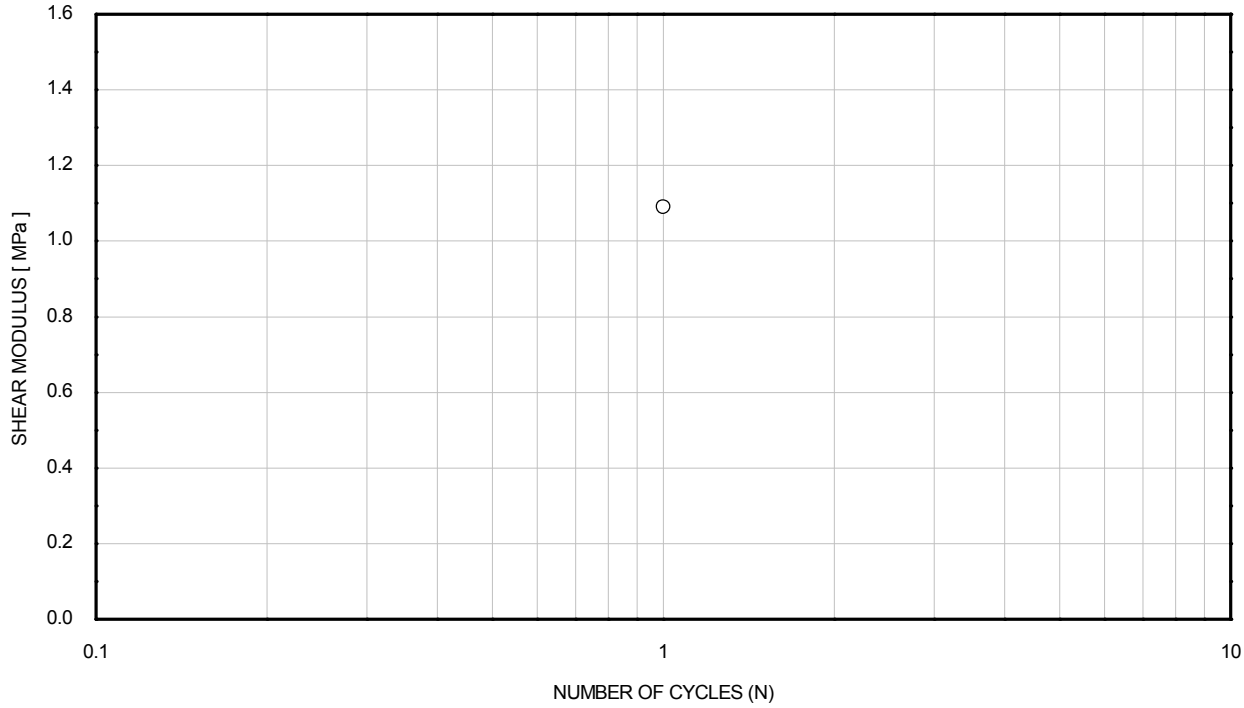


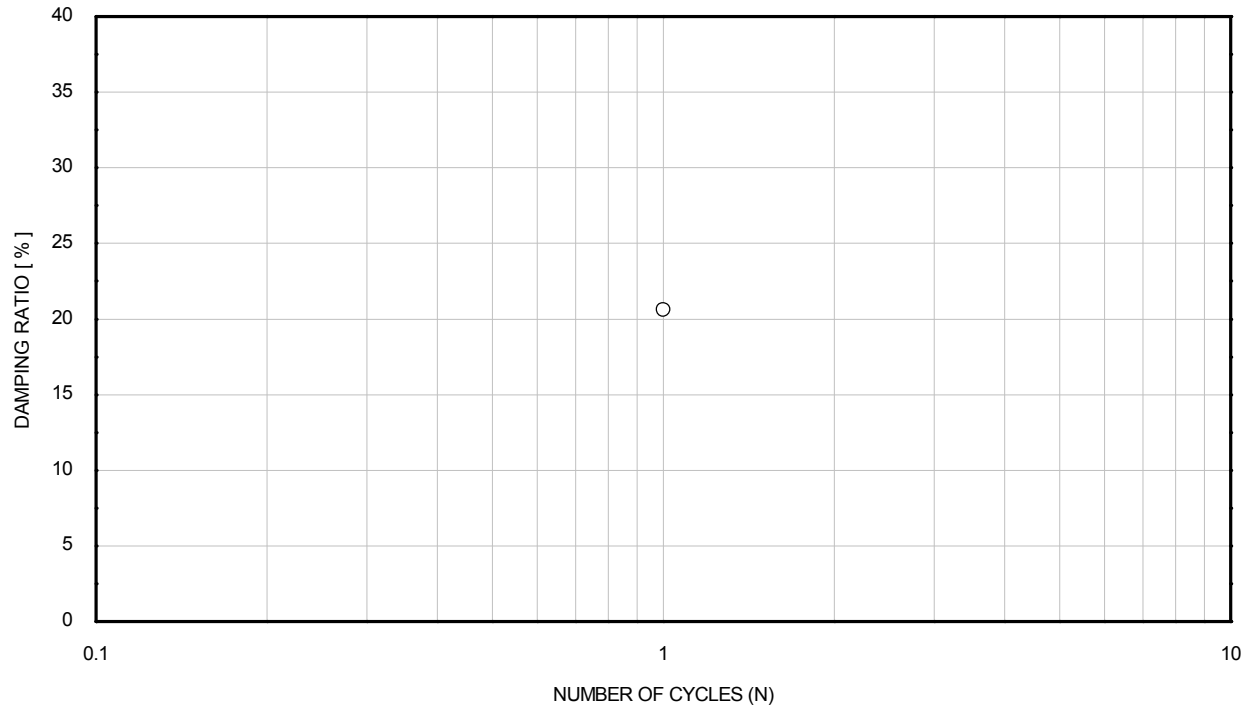


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	1 kPa	Sample	:	CSS_3-1
Mean τ_{cy}	:	85 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS19

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

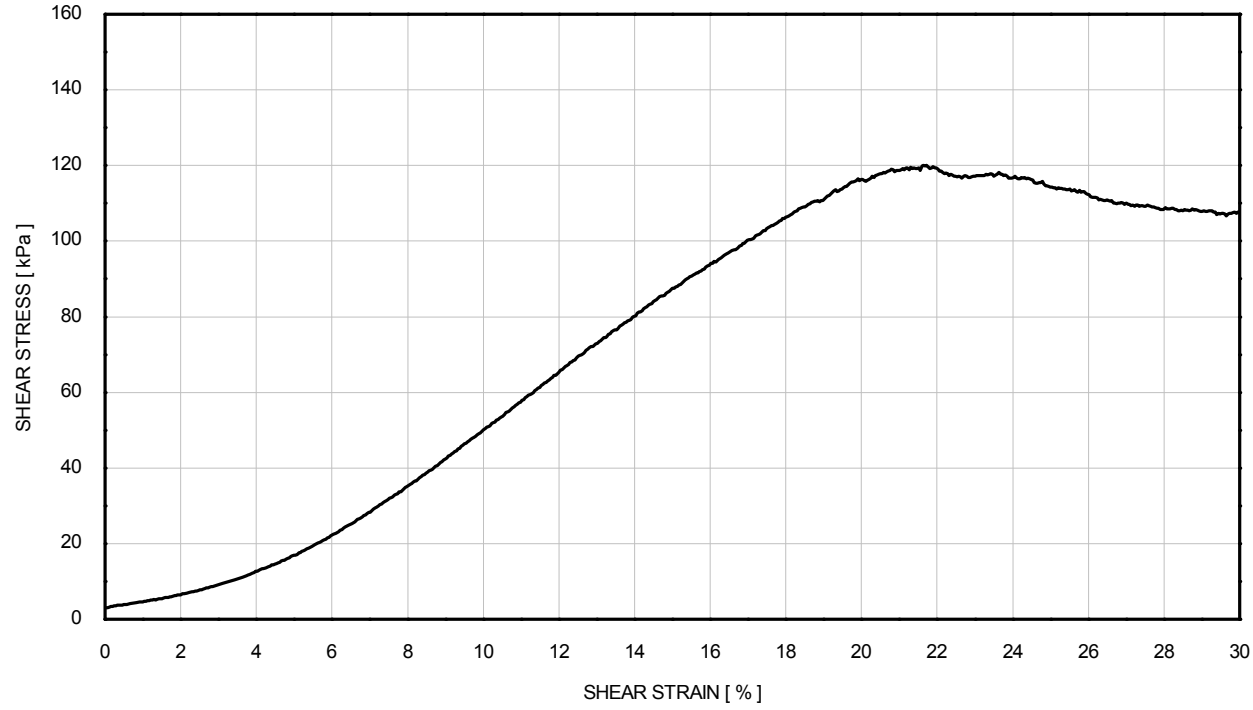


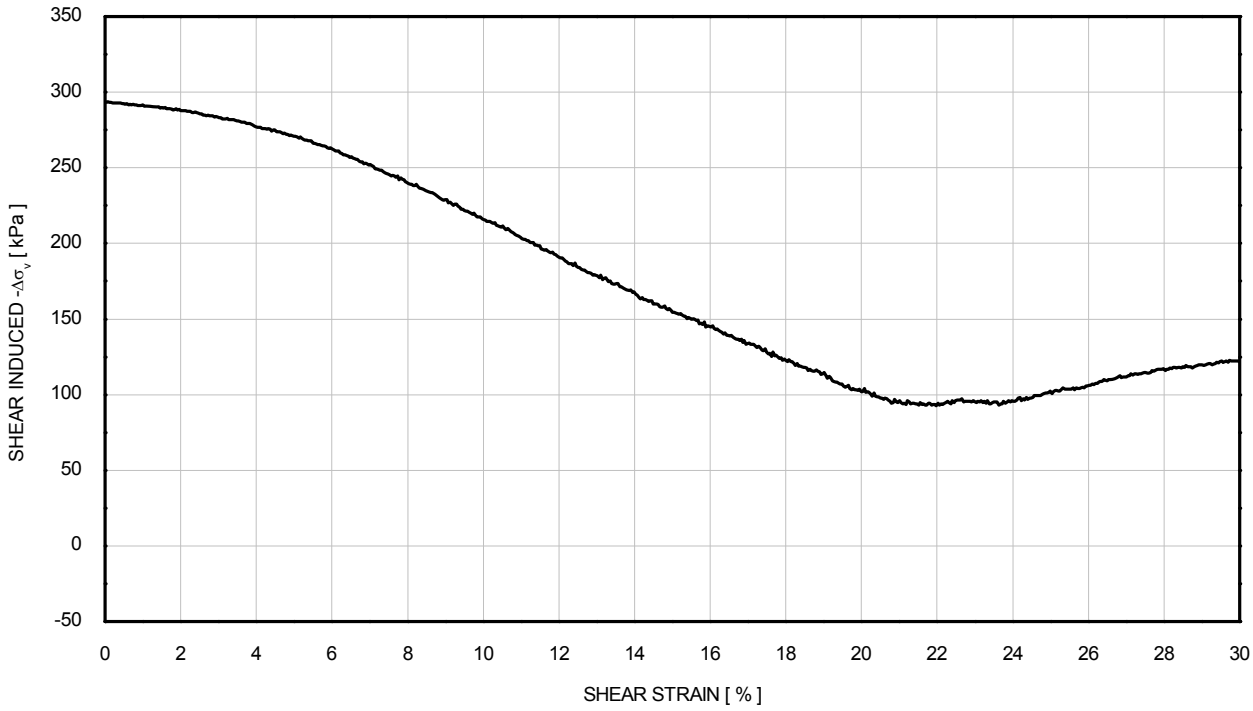


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	1 kPa	Sample	:	CSS_3-1
Mean τ_{cy}	:	85 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS19

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

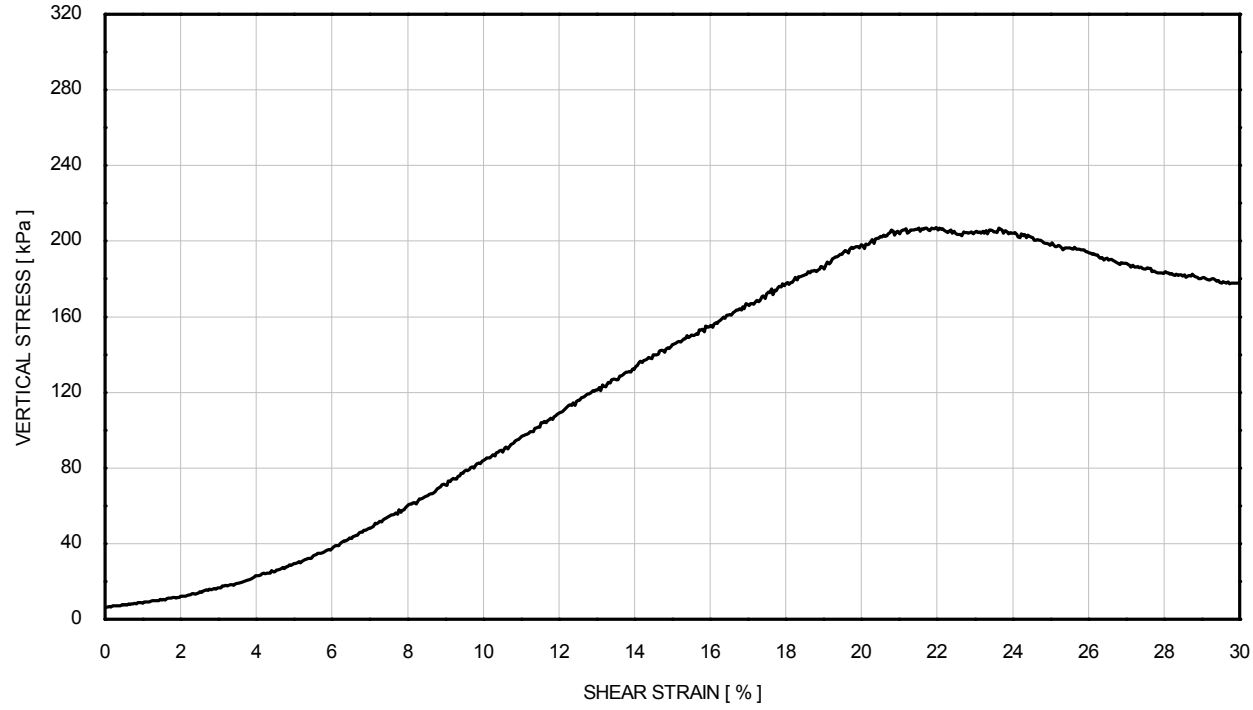


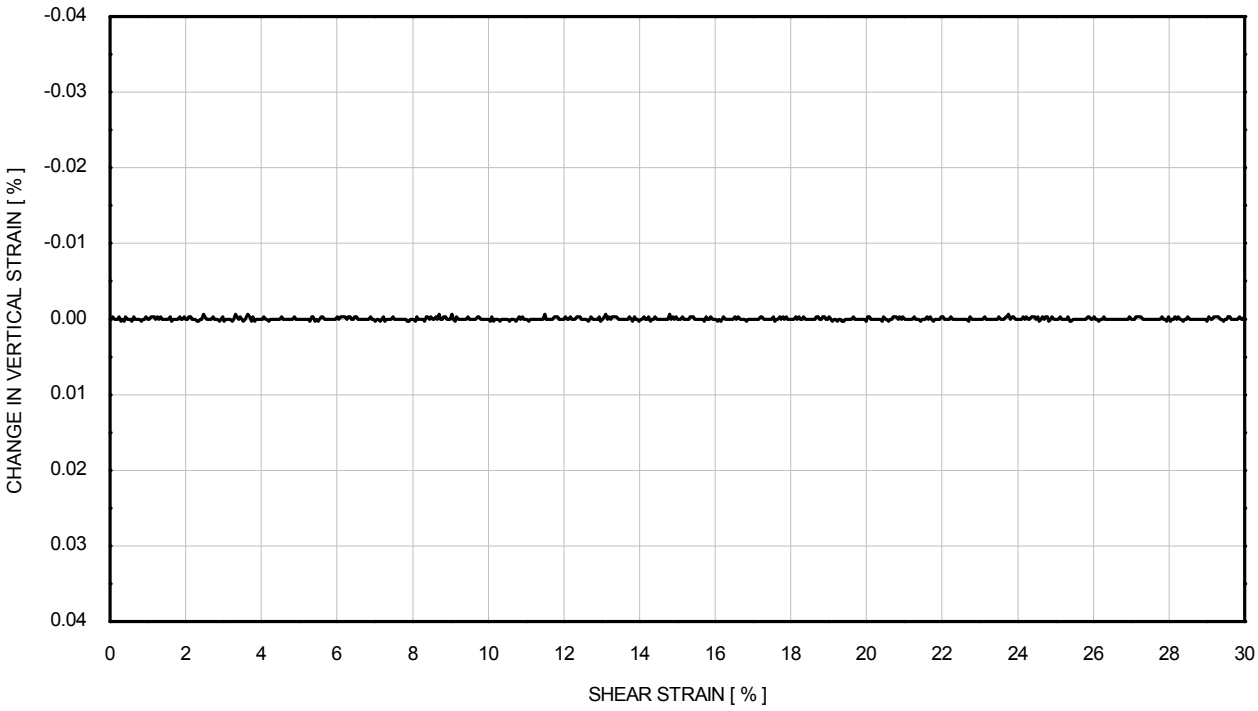


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 120 kPa	Sample	: CSS_3-1
γ at τ_{peak}	: 21.64 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.08 %/hour	Test No.	: CSS19

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

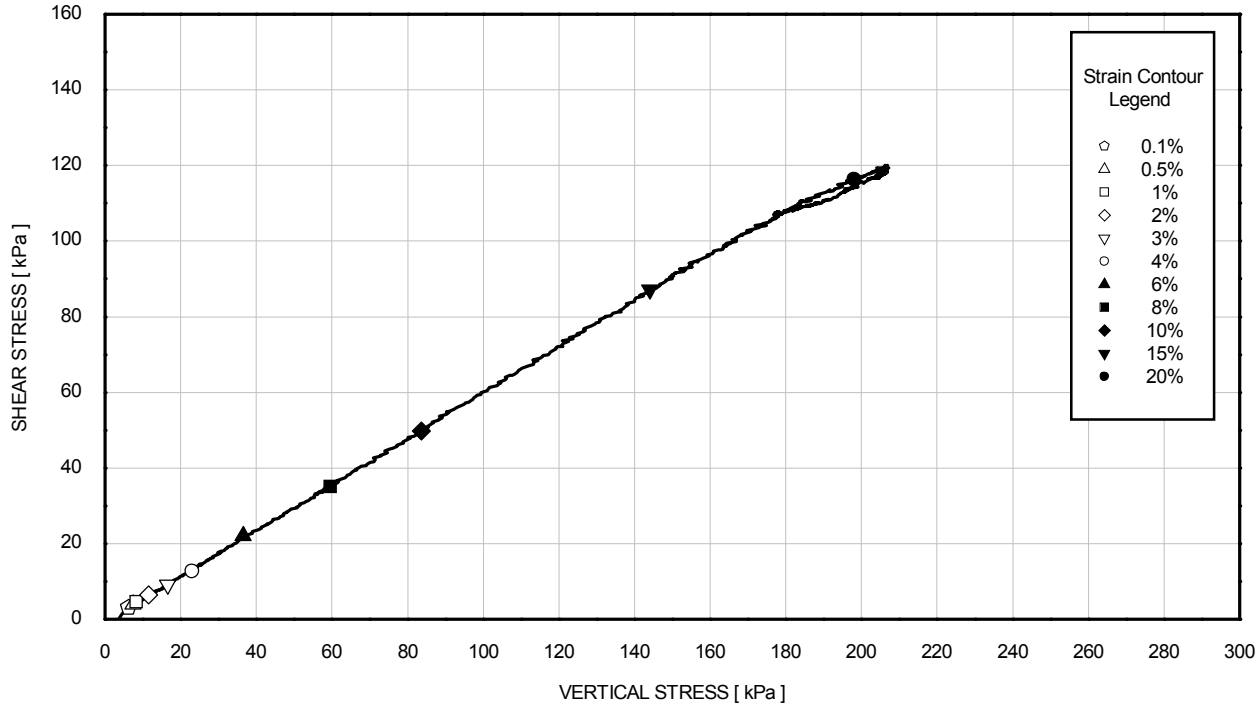


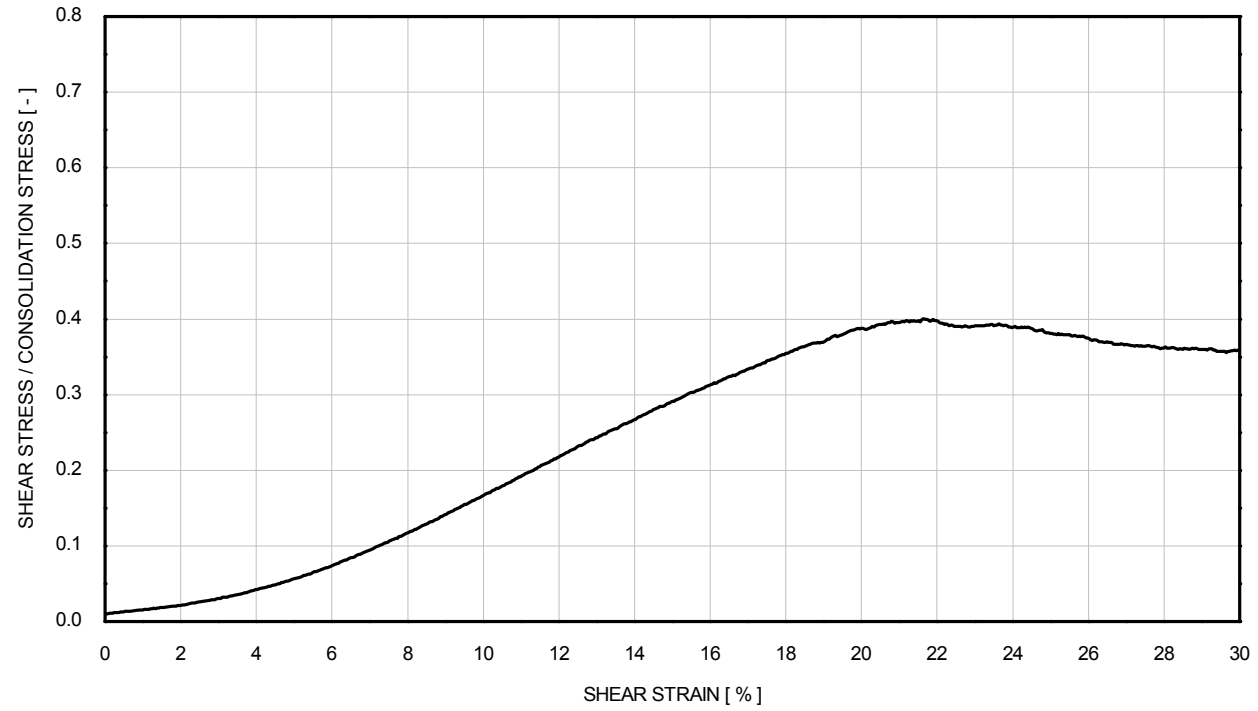


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 120 kPa	Sample	: CSS_3-1
γ at τ_{peak}	: 21.64 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.08 %/hour	Test No.	: CSS19

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

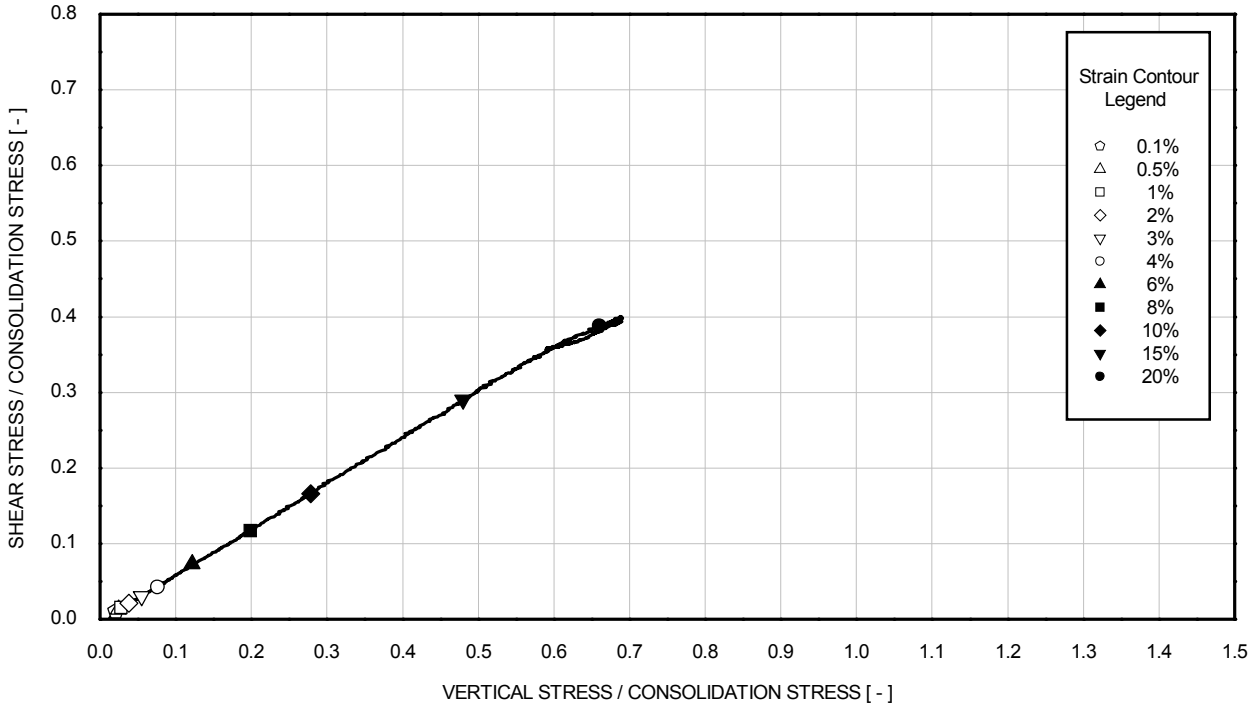


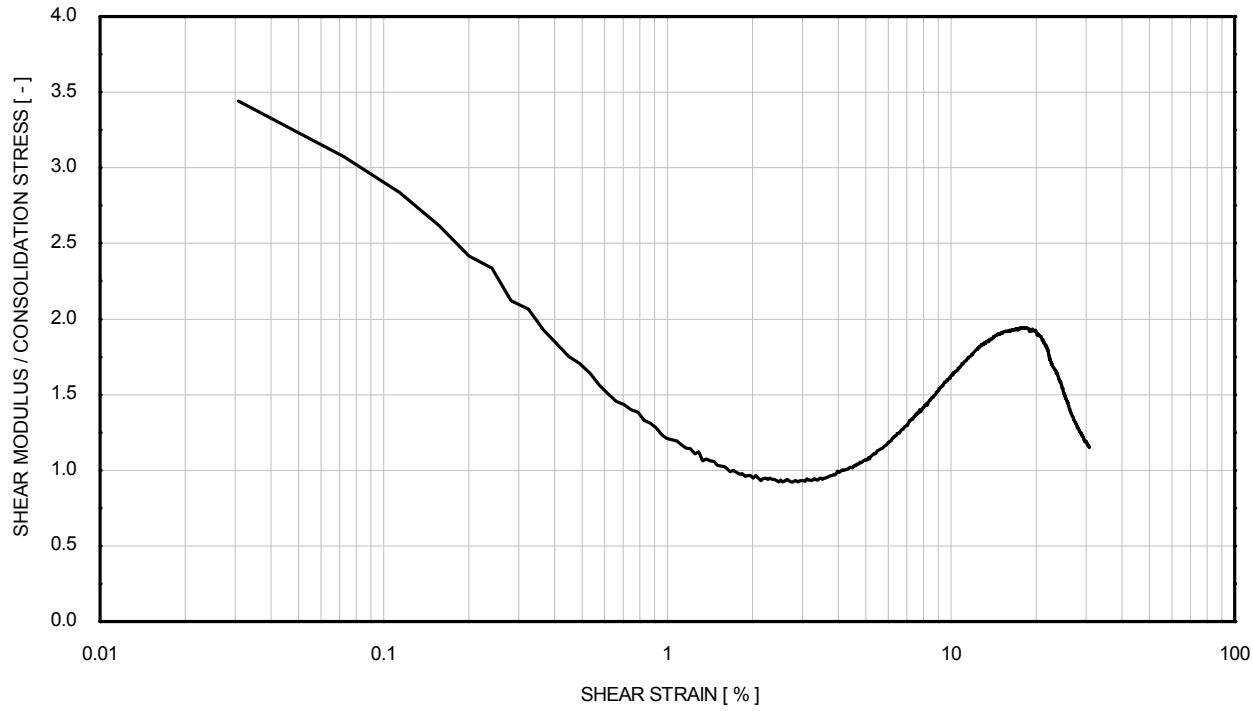


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 120 kPa	Sample	: CSS_3-1
γ at τ_{peak}	: 21.64 %		
Rate of strain	: 5.08 %/hour	Unit	: E3 (Tongeren)
		Test No.	: CSS19

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 120 kPa	Sample	: CSS_3-1
γ at τ_{peak}	: 21.64 %		
Rate of strain	: 5.08 %/hour	Unit	: E3 (Tongeren)
		Test No.	: CSS19

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	13/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.6
Length	[mm]	30.0
Moisture content after compaction	[%]	10.7
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.60
Void ratio	[-]	0.656
Degree of saturation after compaction	[%]	43
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.8
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 3_CSS 3-2_CSS20
Template issue	1.3
Processed by	HJ
Date	18/02/2016
Checked by	PH
Date	15/03/2016
Approved by	PH
Date	15/03/2016

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-2
Unit	E3 (Tongeren)
Test number	CSS20

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	300
Vertical strain	[%]	0.81
Bulk density	[Mg/m^3]	2.00
Dry density	[Mg/m^3]	1.61
Void ratio	[-]	0.643
Moisture content	[%]	24.2

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	300
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	44
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	5
γ_{av} at N_f	[%]	-0.72
γ_{cy} at N_f	[%]	2.08
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	246
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.00	0.18	25.39	14.63
2	-0.02	0.20	22.37	15.85
3	-0.05	0.28	16.00	19.38
4	-0.24	0.64	6.73	24.75
5	-0.72	2.08	2.02	22.27

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-2
Unit	E3 (Tongeren)
Test number	CSS20

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	109
Shear strain	[%]	28.22
Shear induced $-\Delta\sigma_v$	[kPa]	128
Vertical stress	[kPa]	172
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.05
At 15 % shear strain		
Shear stress	[kPa]	86
Shear induced $-\Delta\sigma_v$	[kPa]	156
Vertical stress	[kPa]	144
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-2
Unit	E3 (Tongeren)
Test number	CSS20

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

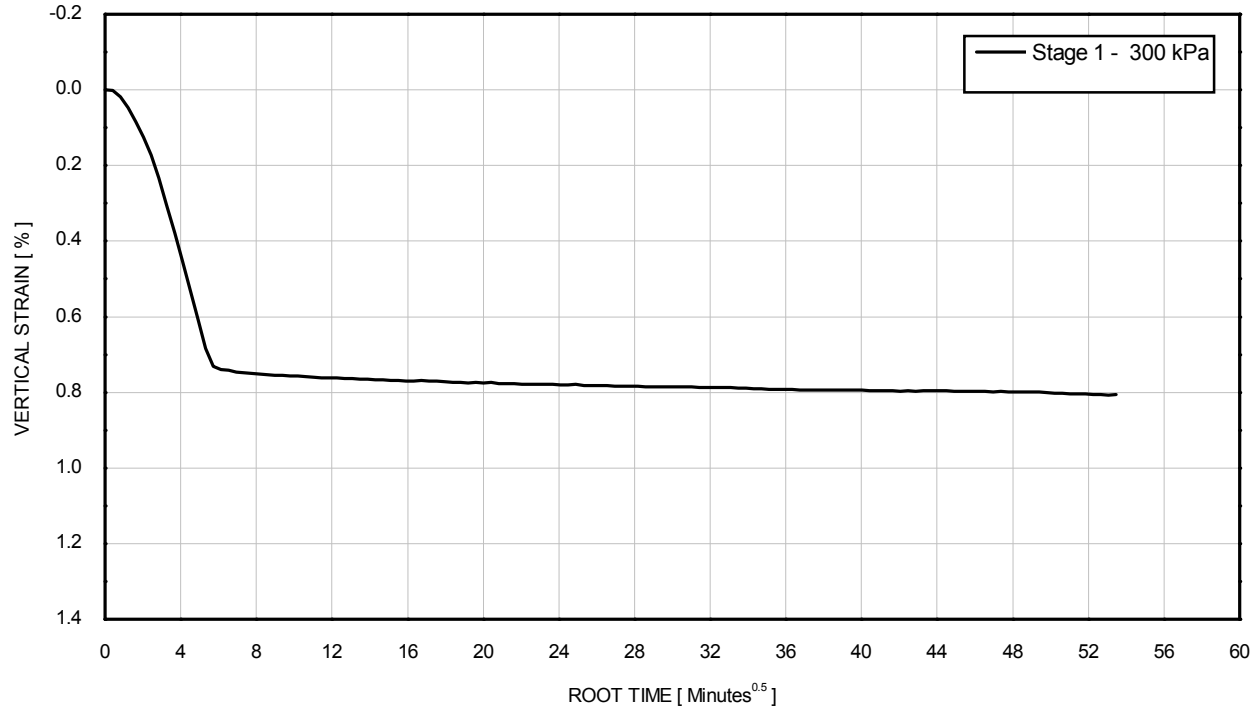
SPECIMEN PHOTOGRAPH

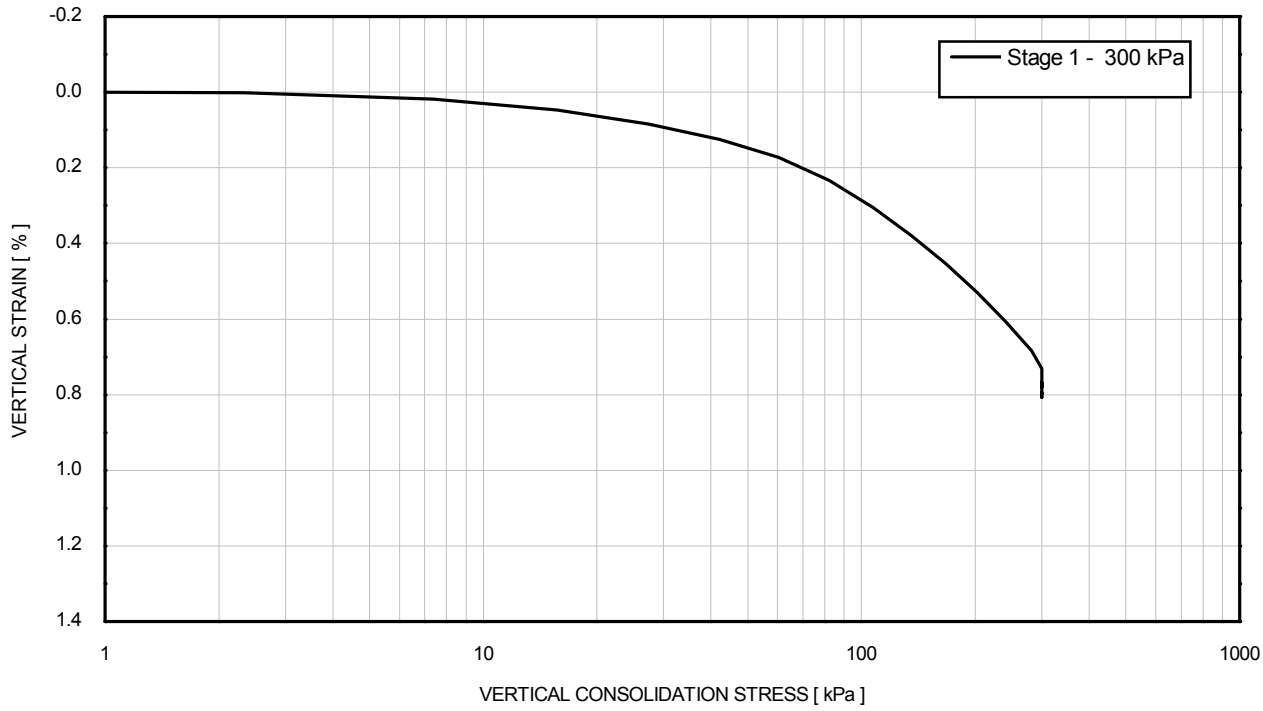


TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-2
Unit	E3 (Tongeren)
Test number	CSS20

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

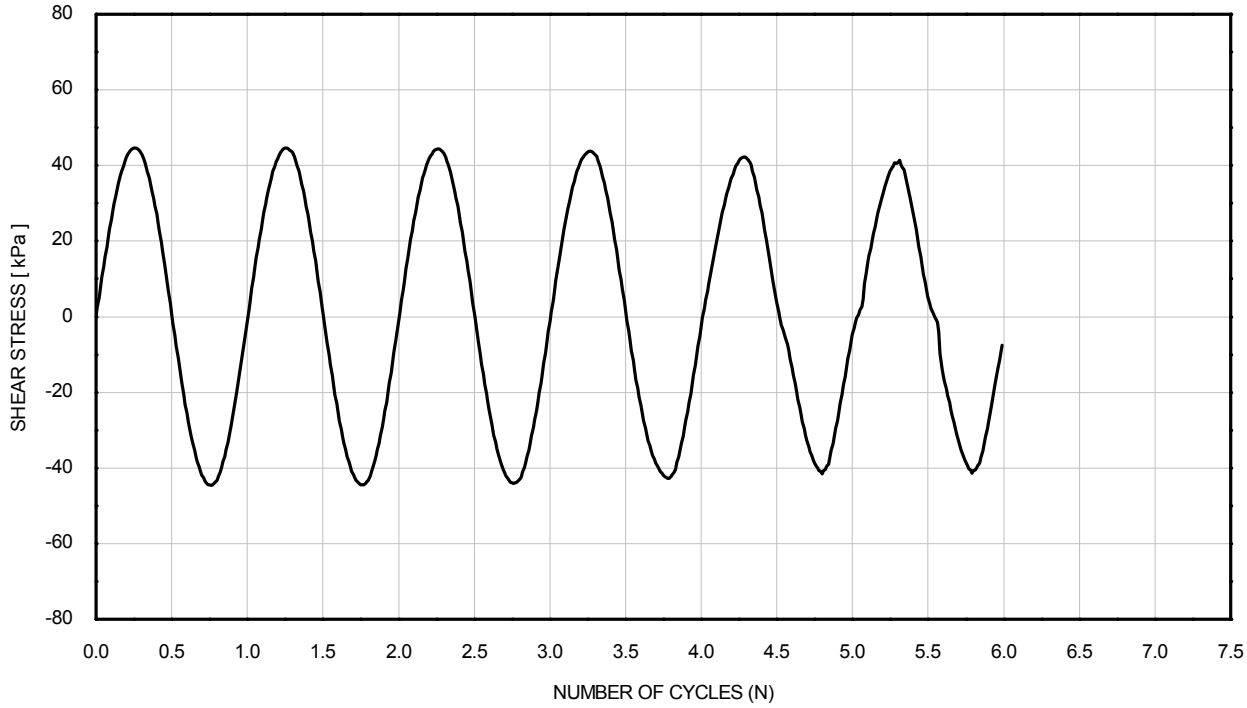


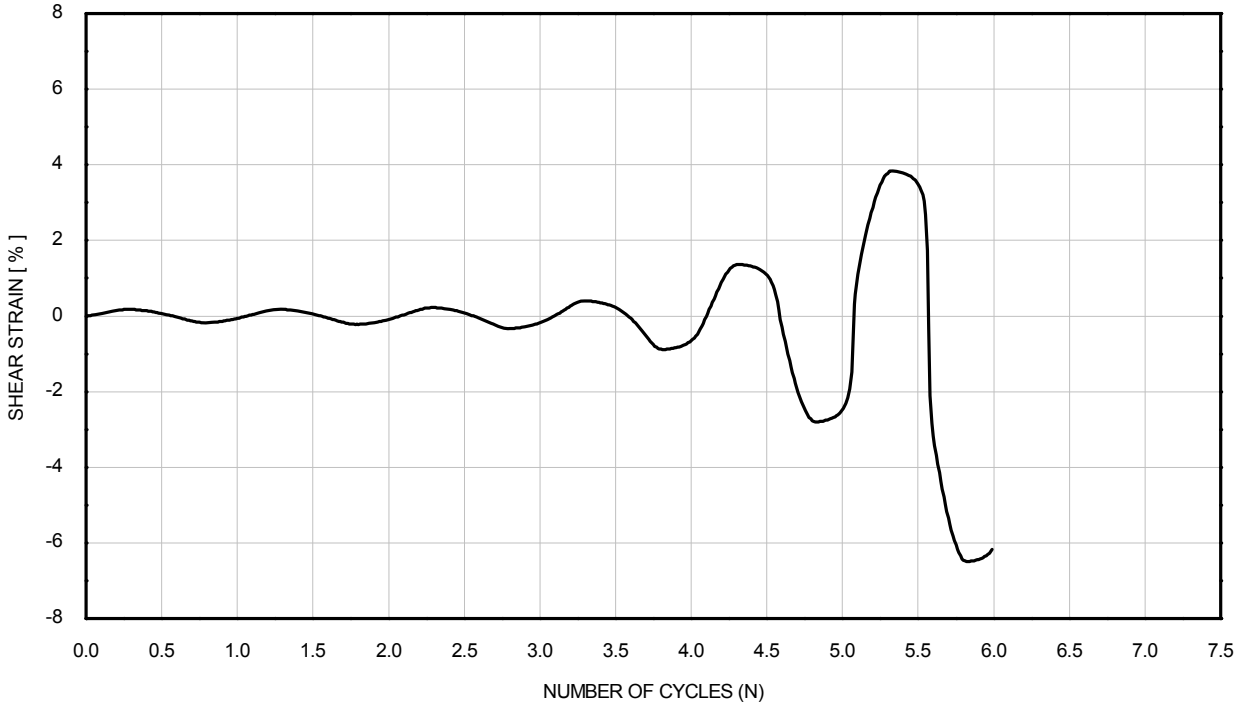


σ_{vc}	: 300 kPa	Batch	: 3
		Sample	: CSS_3-2
		Unit	: E3 (Tongeren)
		Test No.	: CSS20

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

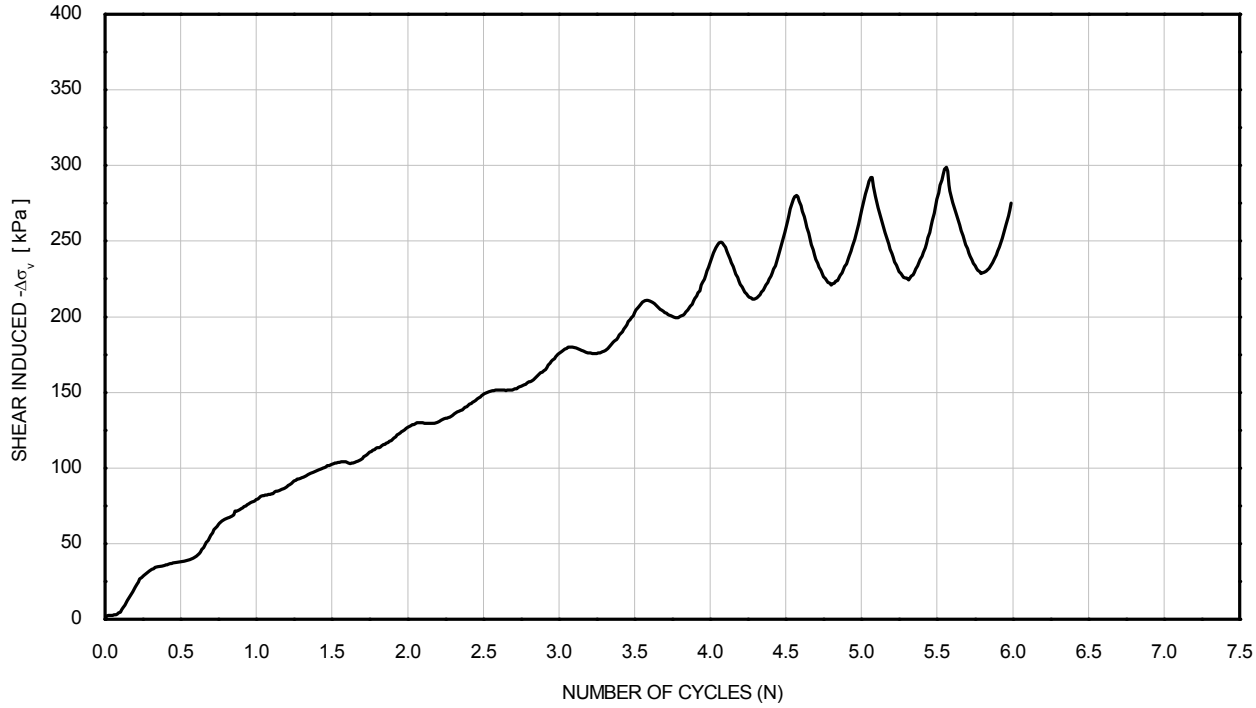


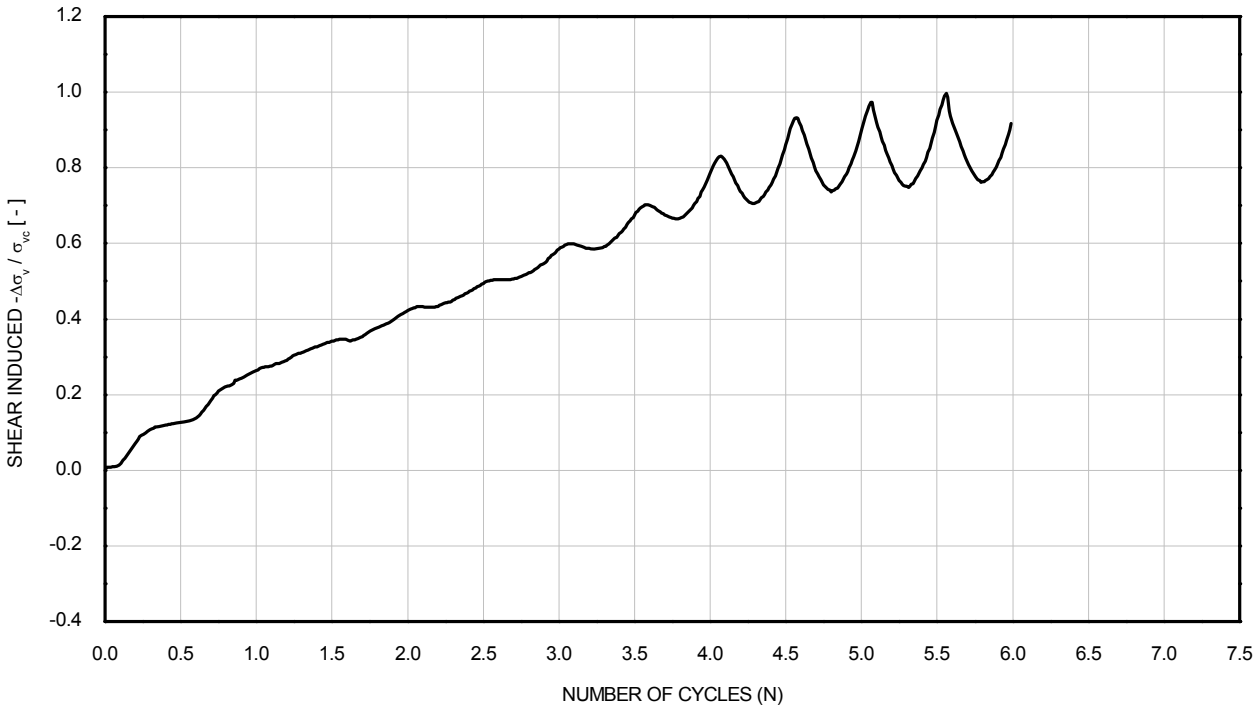


σ_{vc}	: 300	kPa	Batch	: 3
Mean τ_{av}	: 0	kPa	Sample	: CSS_3-2
Mean τ_{cy}	: 44	kPa	Unit	: E3 (Tongeren)
Frequency	: 0.10	Hz	Test No.	: CSS20

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

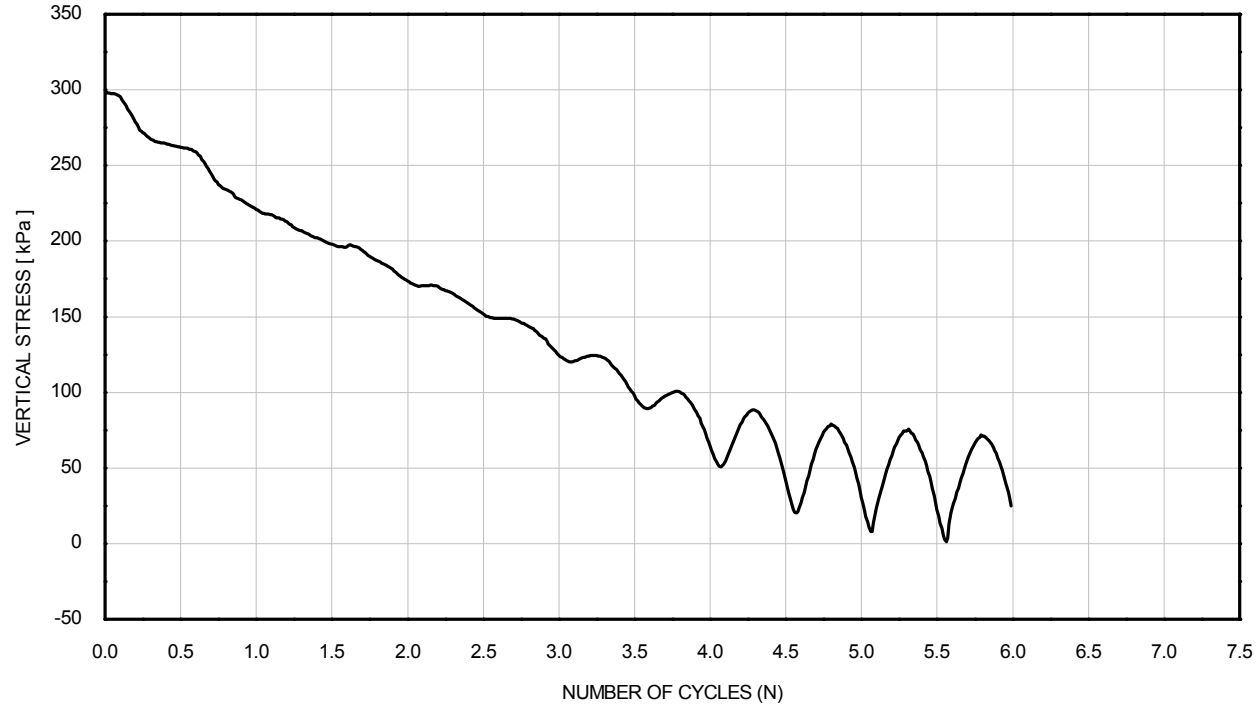


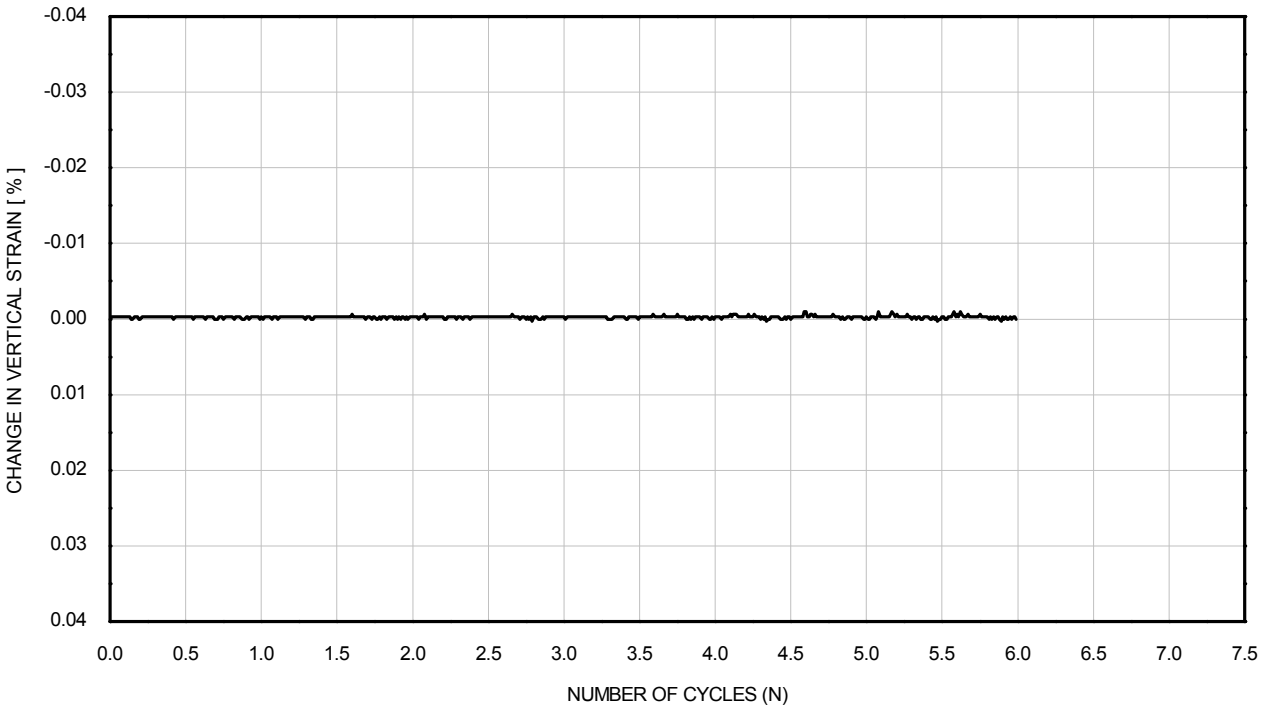


σ_{vc}	: 300	kPa	Batch	: 3
Mean τ_{av}	: 0	kPa	Sample	: CSS_3-2
Mean τ_{cy}	: 44	kPa	Unit	: E3 (Tongeren)
Frequency	: 0.10	Hz	Test No.	: CSS20

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

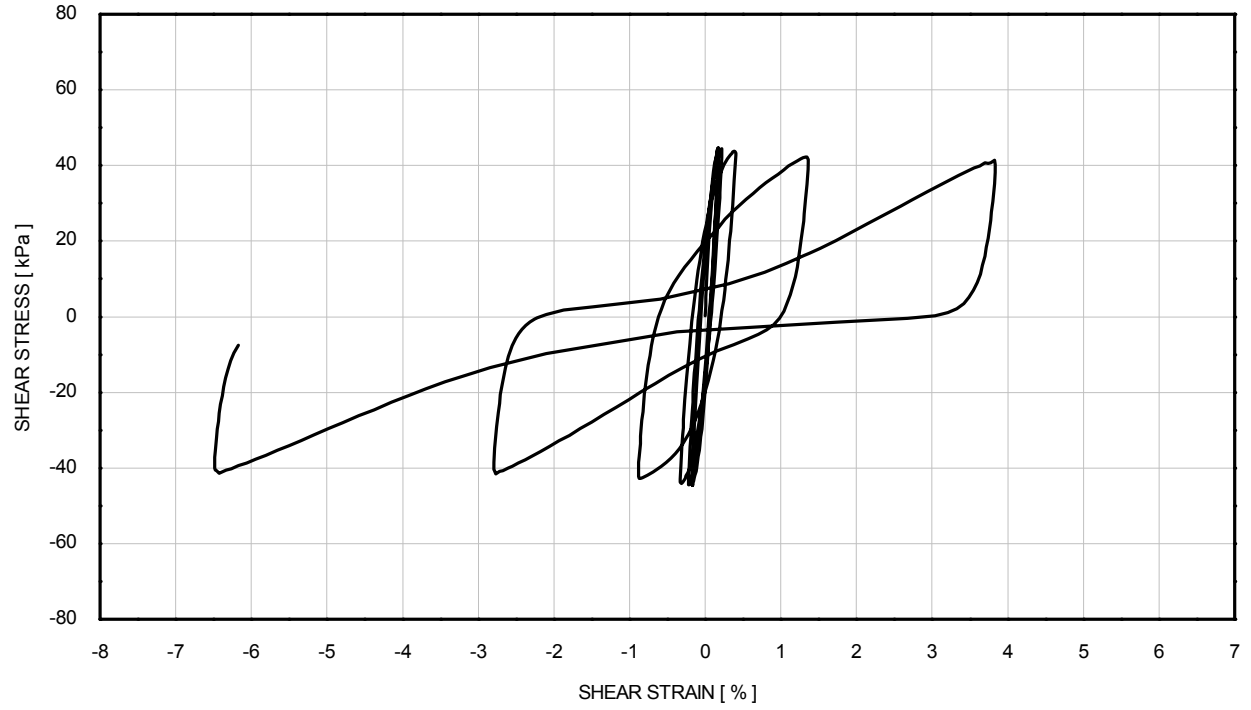


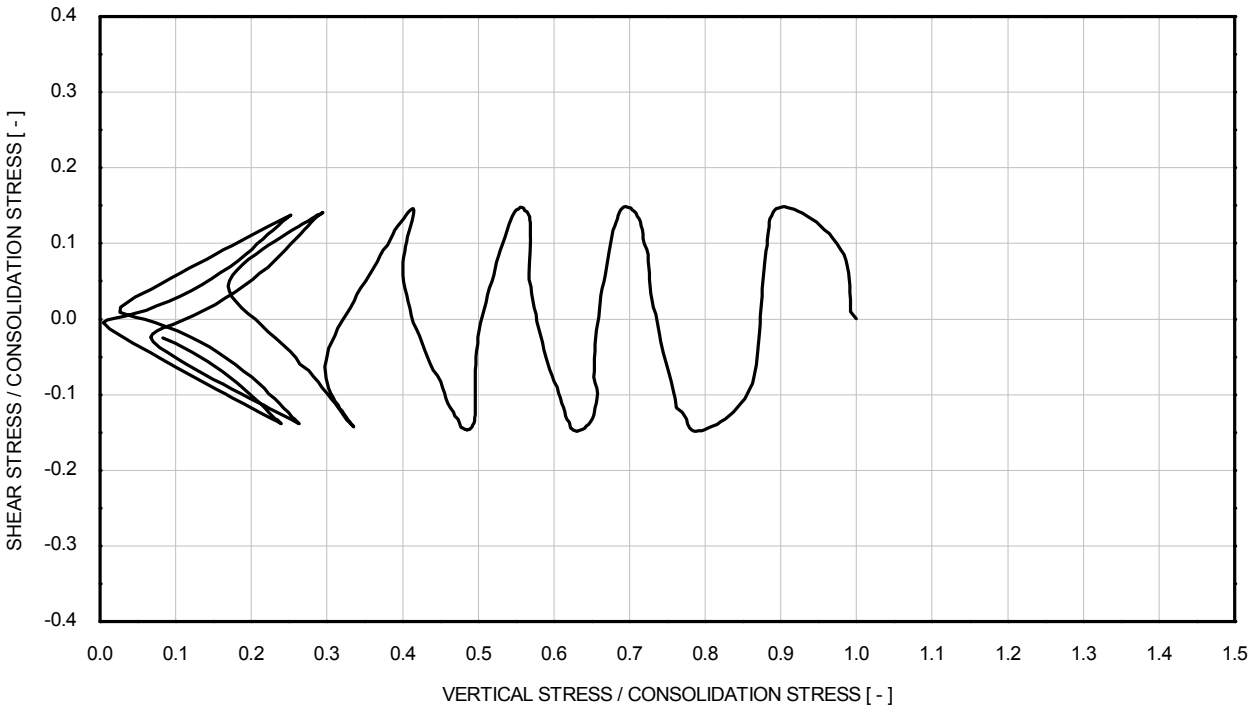


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-2
Mean τ_{cy}	:	44 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS20

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

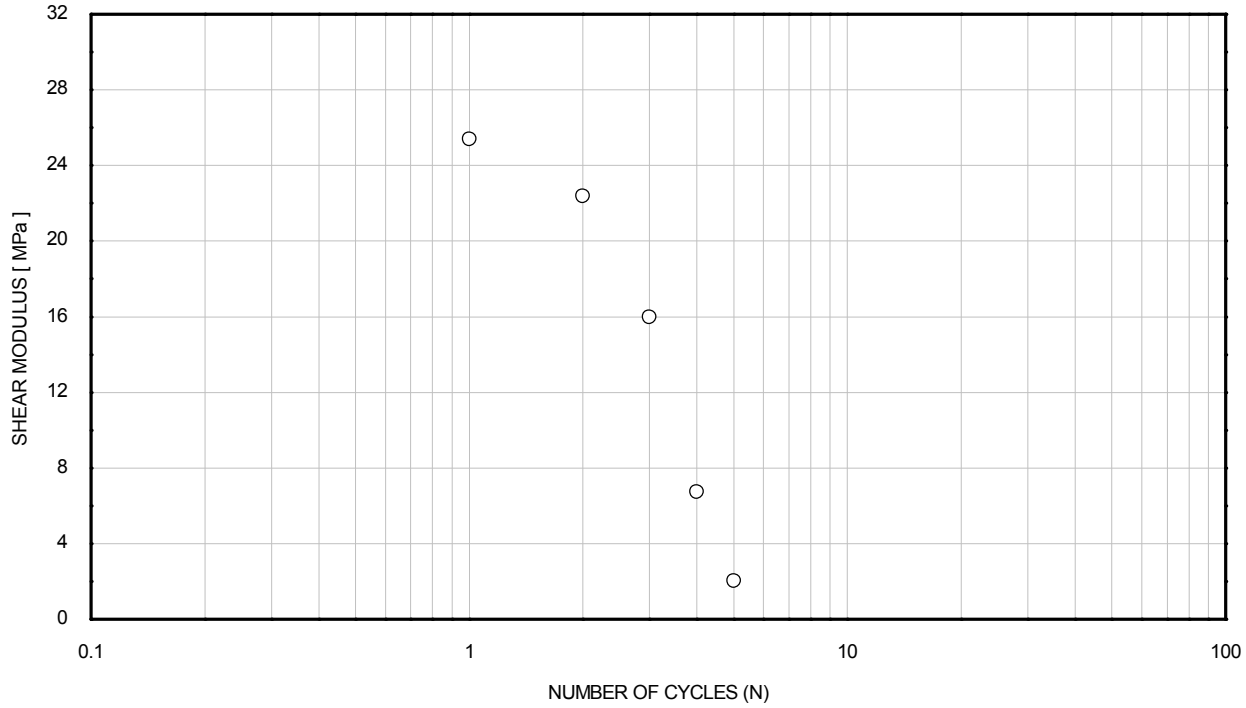


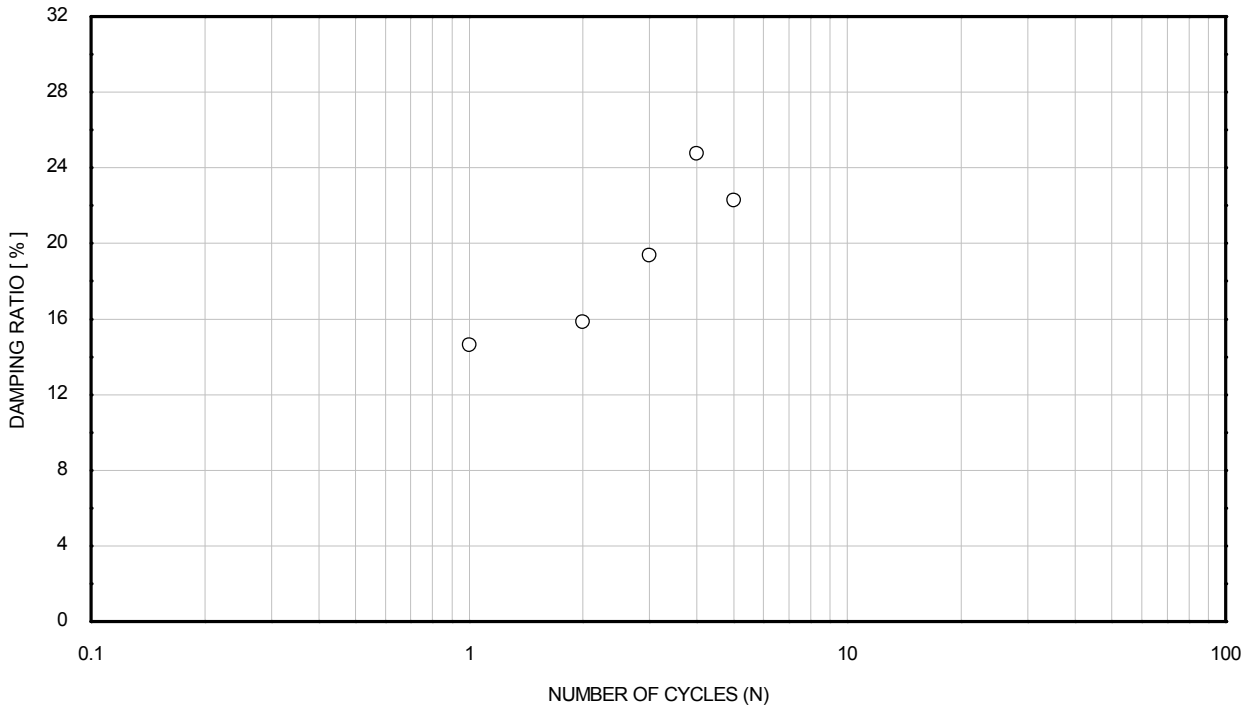


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-2
Mean τ_{cy}	:	44 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS20

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

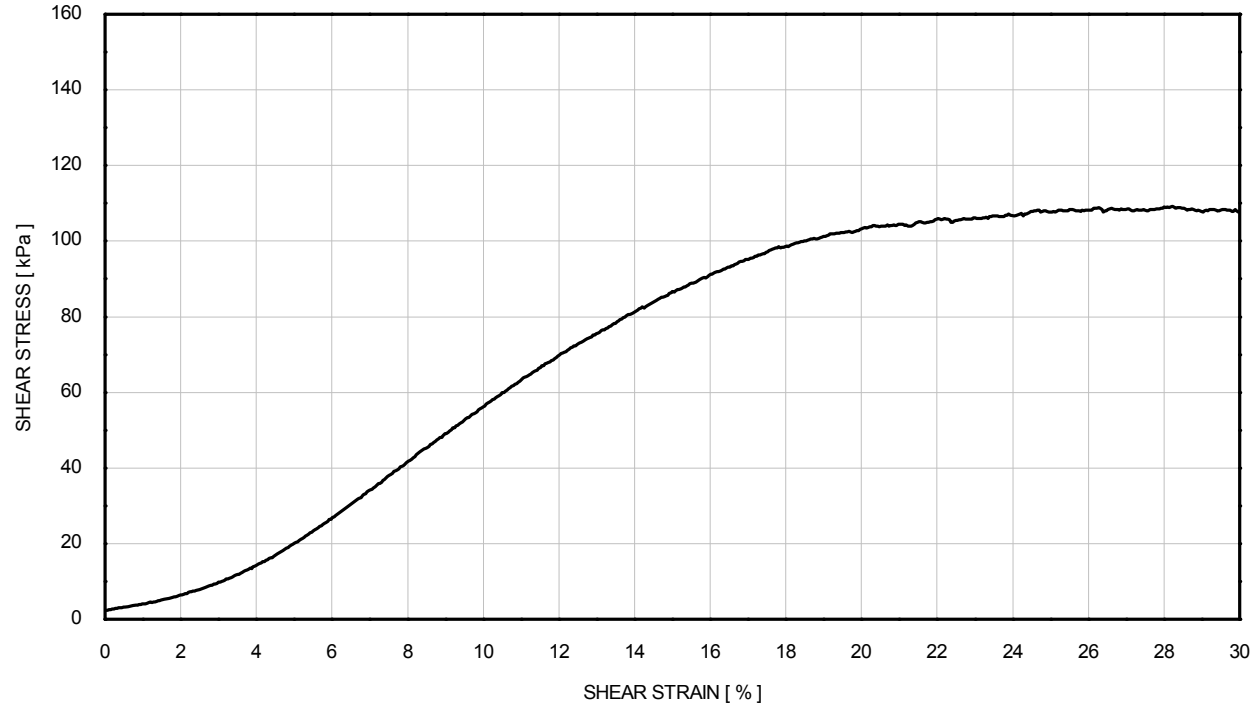


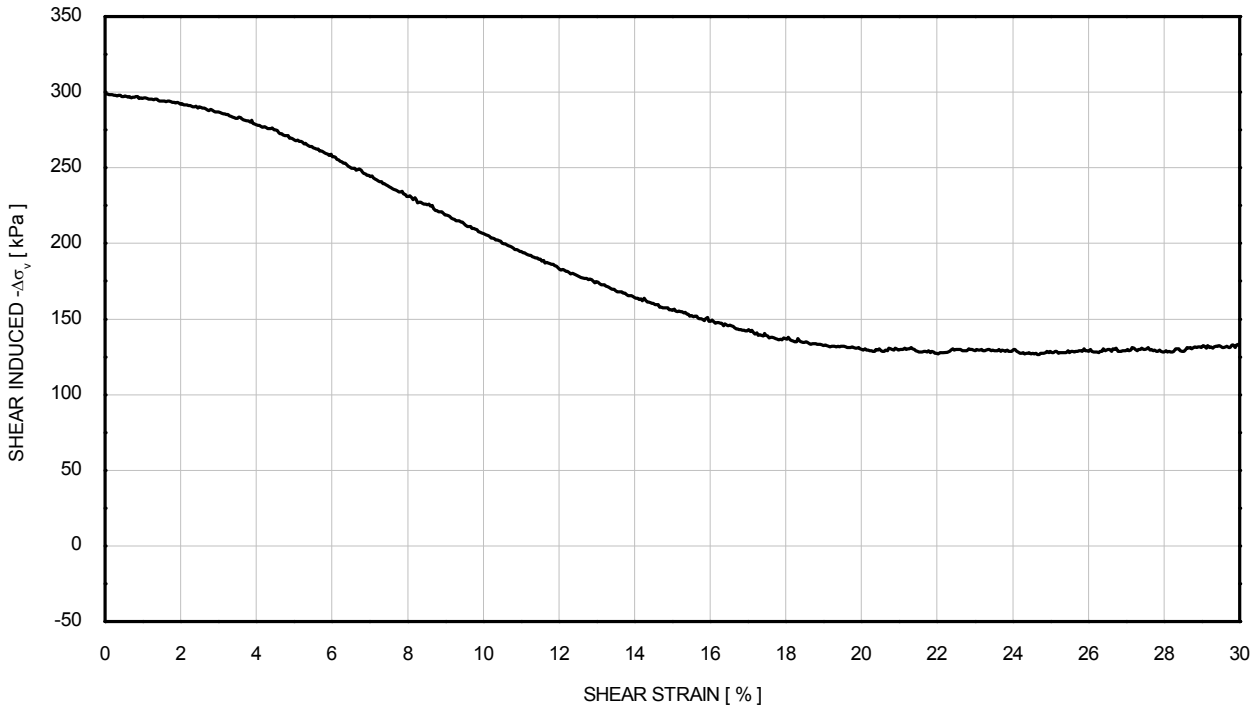


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-2
Mean τ_{cy}	:	44 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS20

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

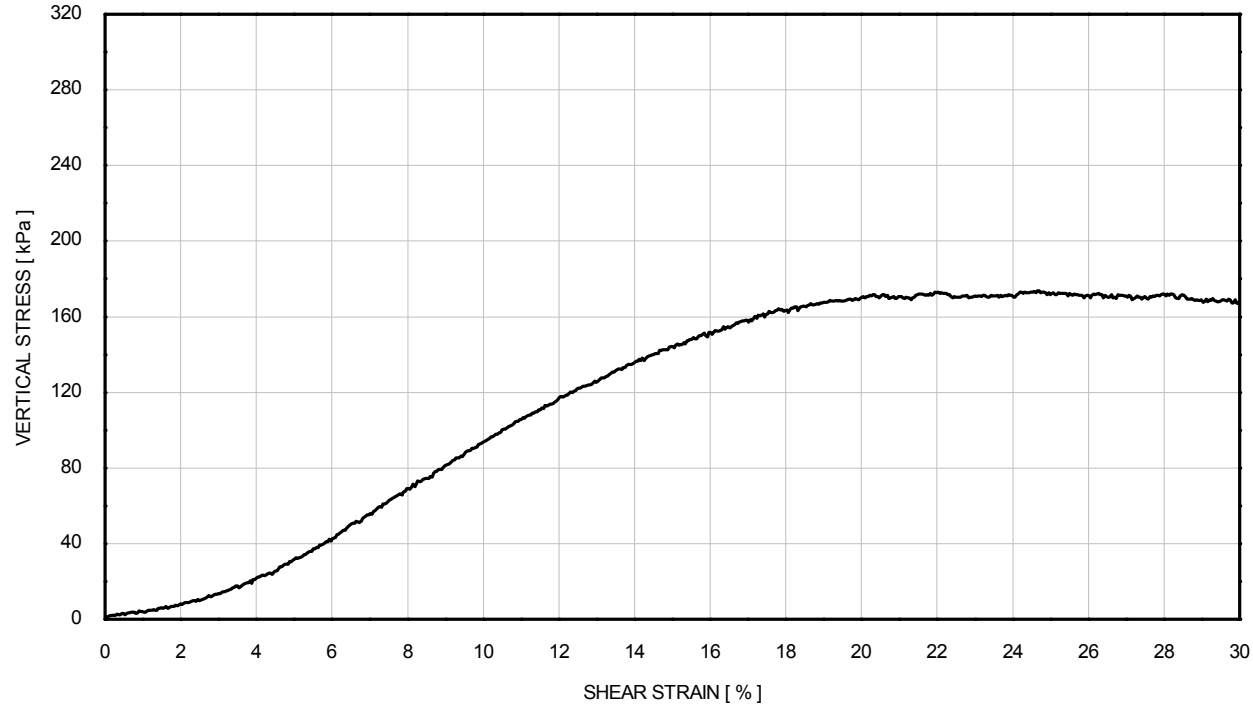


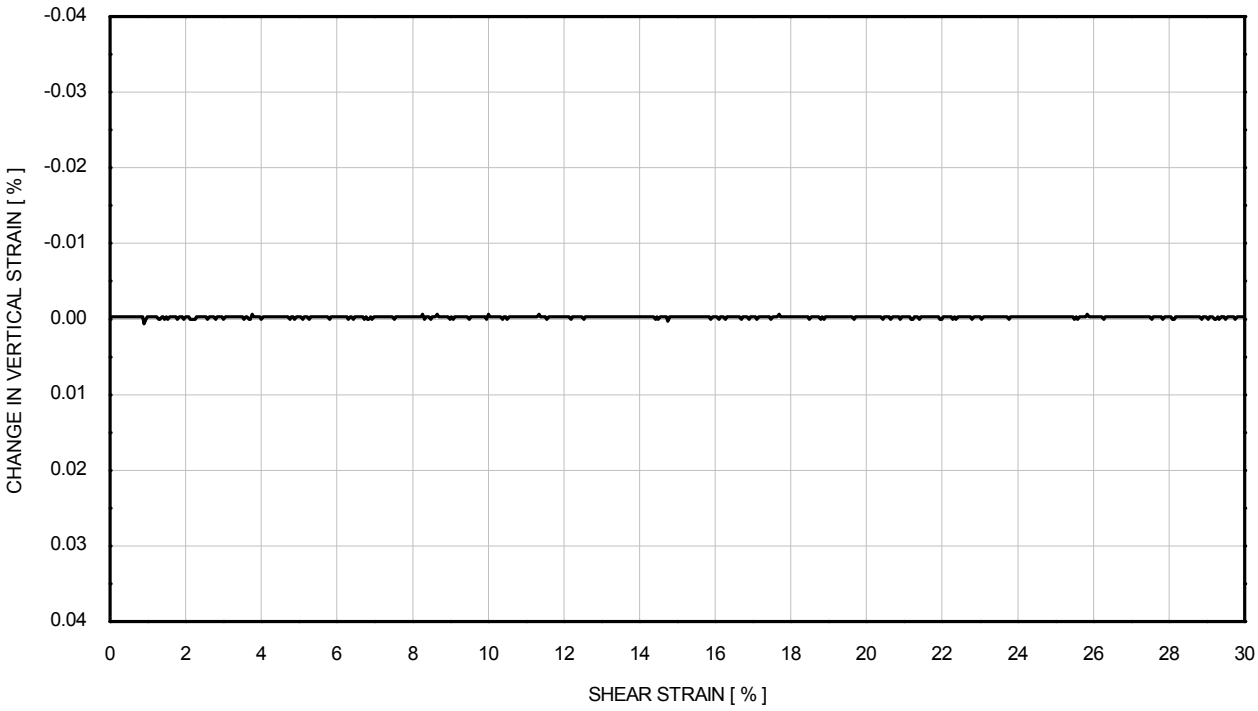


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 109 kPa	Sample	: CSS_3-2
γ at τ_{peak}	: 28.22 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.05 %/hour	Test No.	: CSS20

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

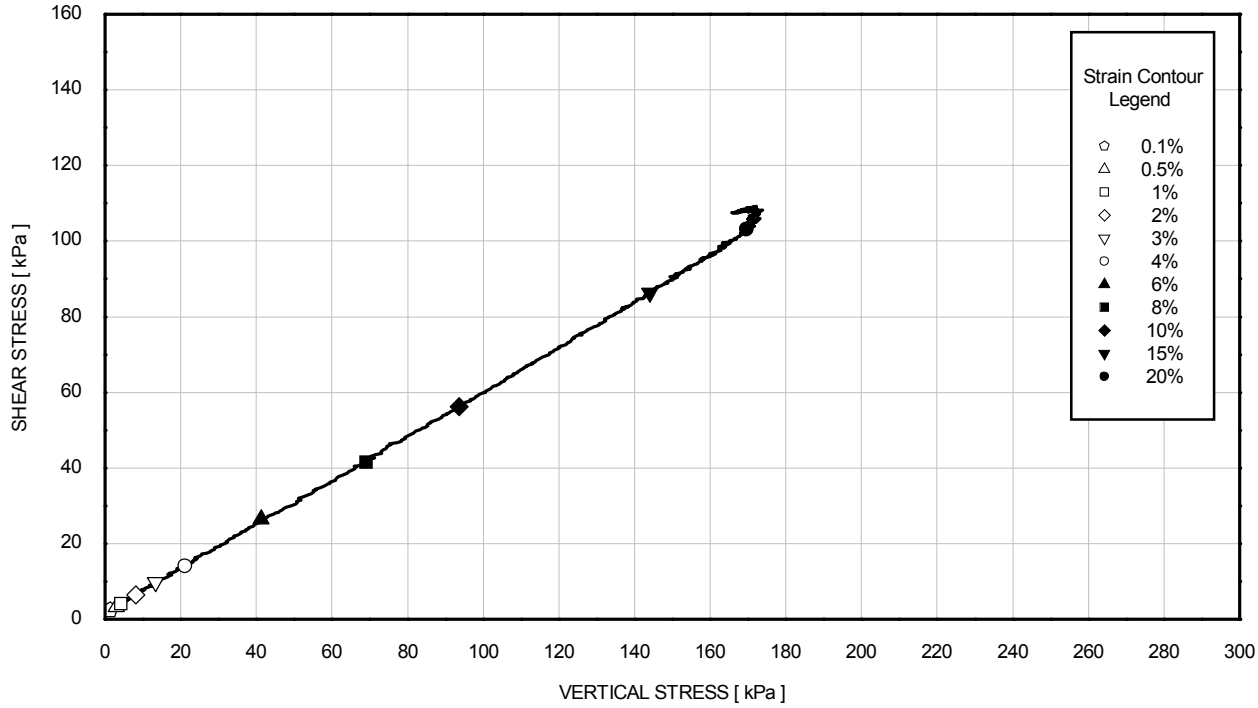


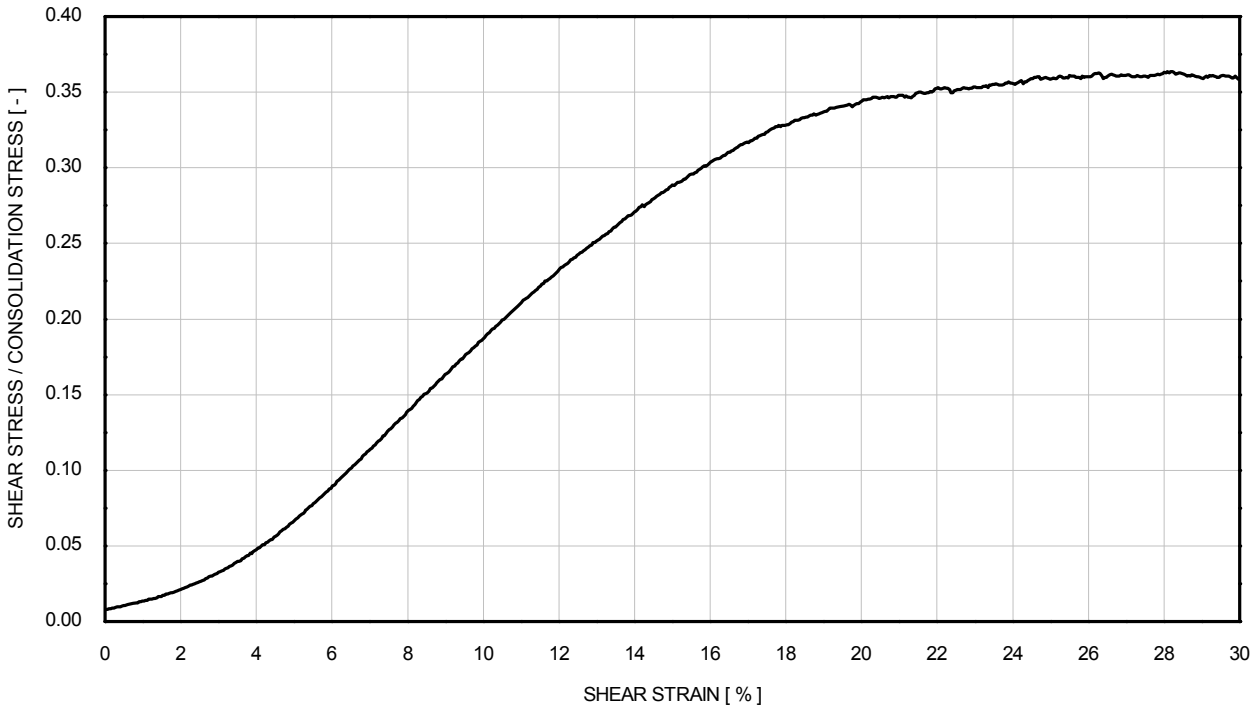


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 109 kPa	Sample	: CSS_3-2
γ at τ_{peak}	: 28.22 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.05 %/hour	Test No.	: CSS20

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

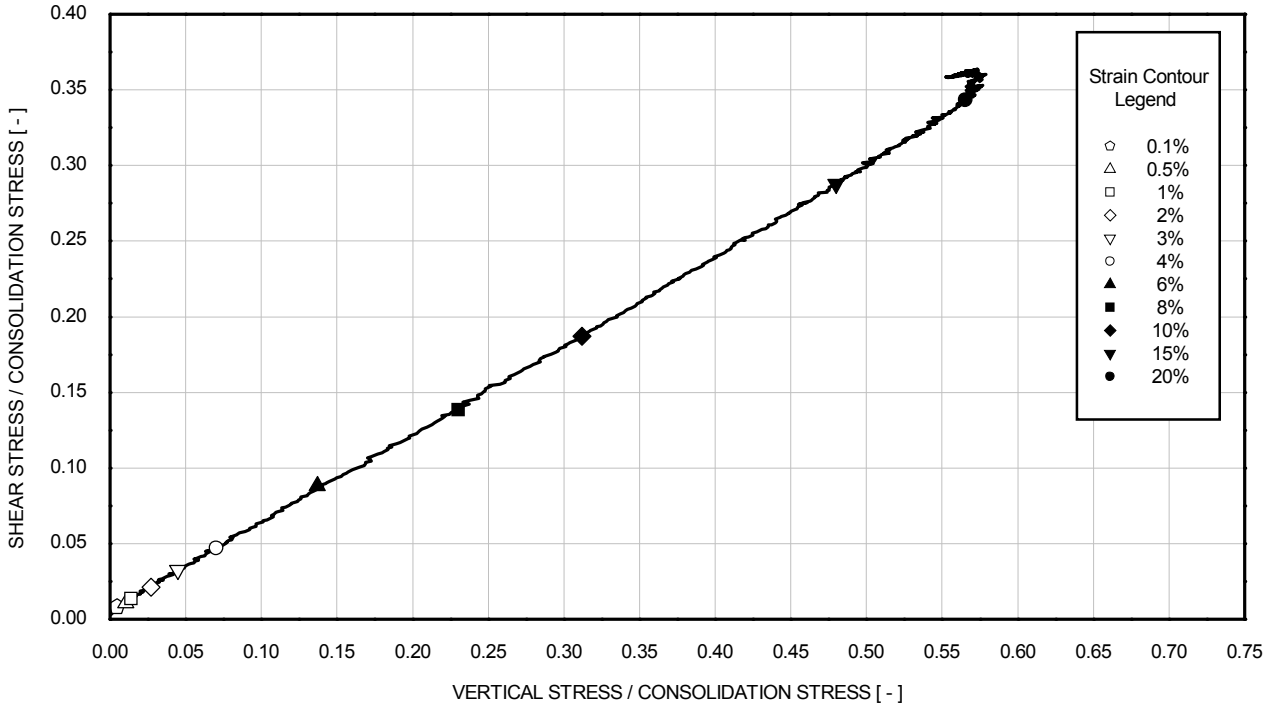


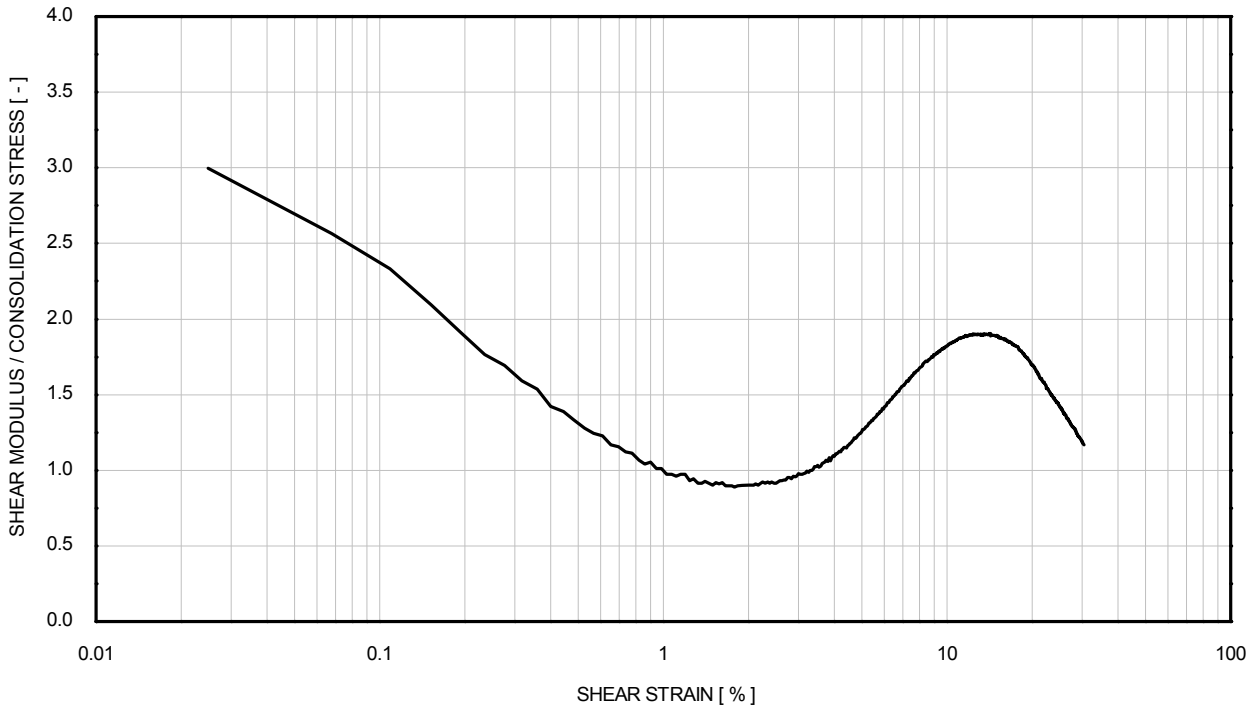


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 109 kPa	Sample	: CSS_3-2
γ at τ_{peak}	: 28.22 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.05 %/hour	Test No.	: CSS20

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 109 kPa	Sample	: CSS_3-2
γ at τ_{peak}	: 28.22 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.05 %/hour	Test No.	: CSS20

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	22/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.6
Length	[mm]	30.0
Moisture content after compaction	[%]	10.1
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.648
Degree of saturation after compaction	[%]	41
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.5
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 3_CSS 3-3_CSS21
Template issue	1.3
Processed by	HJ
Date	24/02/2016
Checked by	PH
Date	15/03/2016
Approved by	PH
Date	15/03/2016

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-3
Unit	E3 (Tongeren)
Test number	CSS21

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	300
Vertical strain	[%]	1.79
Bulk density	[Mg/m^3]	2.02
Dry density	[Mg/m^3]	1.64
Void ratio	[-]	0.619
Moisture content	[%]	23.4

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	300
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	35
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	9
γ_{av} at N_f	[%]	-1.10
γ_{cy} at N_f	[%]	3.64
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	266
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.01	0.13	26.74	12.83
2	-0.03	0.13	27.19	12.27
3	-0.04	0.14	25.06	12.69
4	-0.05	0.16	22.45	14.25
5	-0.06	0.19	18.47	16.44
6	-0.10	0.27	13.08	20.13
7	-0.34	0.65	5.32	25.04
8	-0.73	1.84	1.84	22.06
9	-1.10	3.64	0.92	15.75

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-3
Unit	E3 (Tongeren)
Test number	CSS21

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	157
Shear strain	[%]	25.34
Shear induced $-\Delta\sigma_v$	[kPa]	37
Vertical stress	[kPa]	263
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.10
At 15 % shear strain		
Shear stress	[kPa]	115
Shear induced $-\Delta\sigma_v$	[kPa]	107
Vertical stress	[kPa]	193
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-3
Unit	E3 (Tongeren)
Test number	CSS21

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

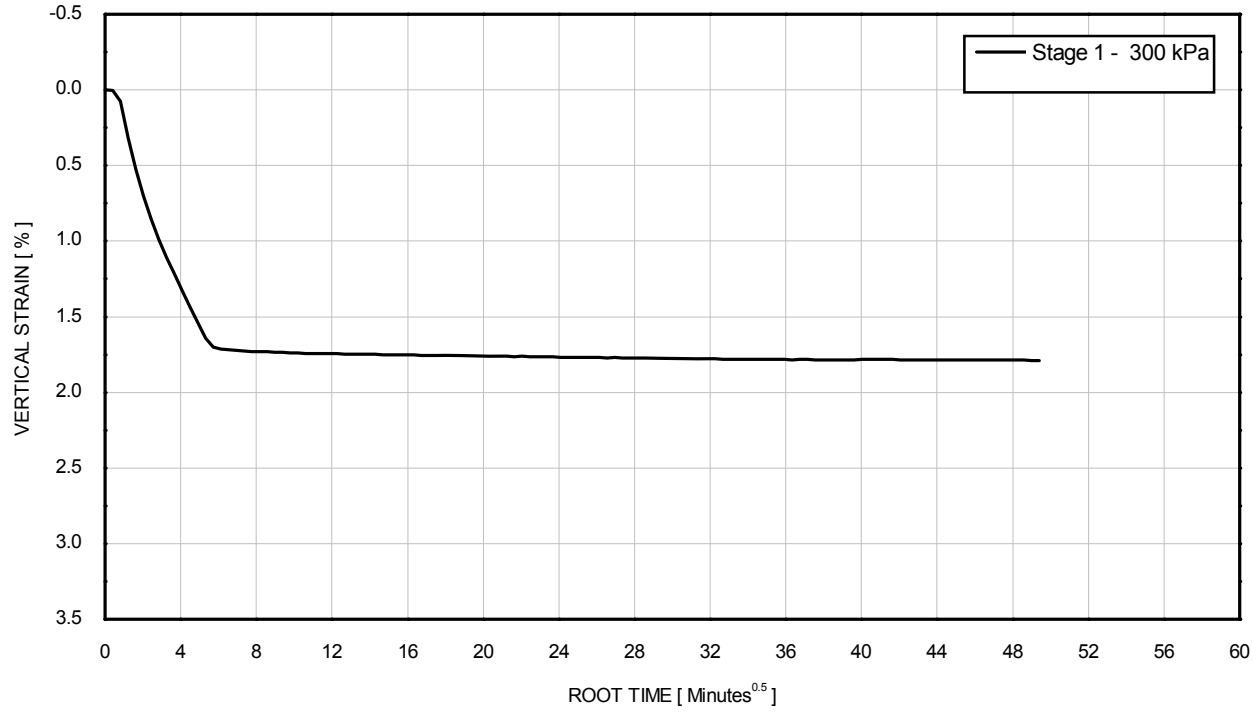
SPECIMEN PHOTOGRAPH

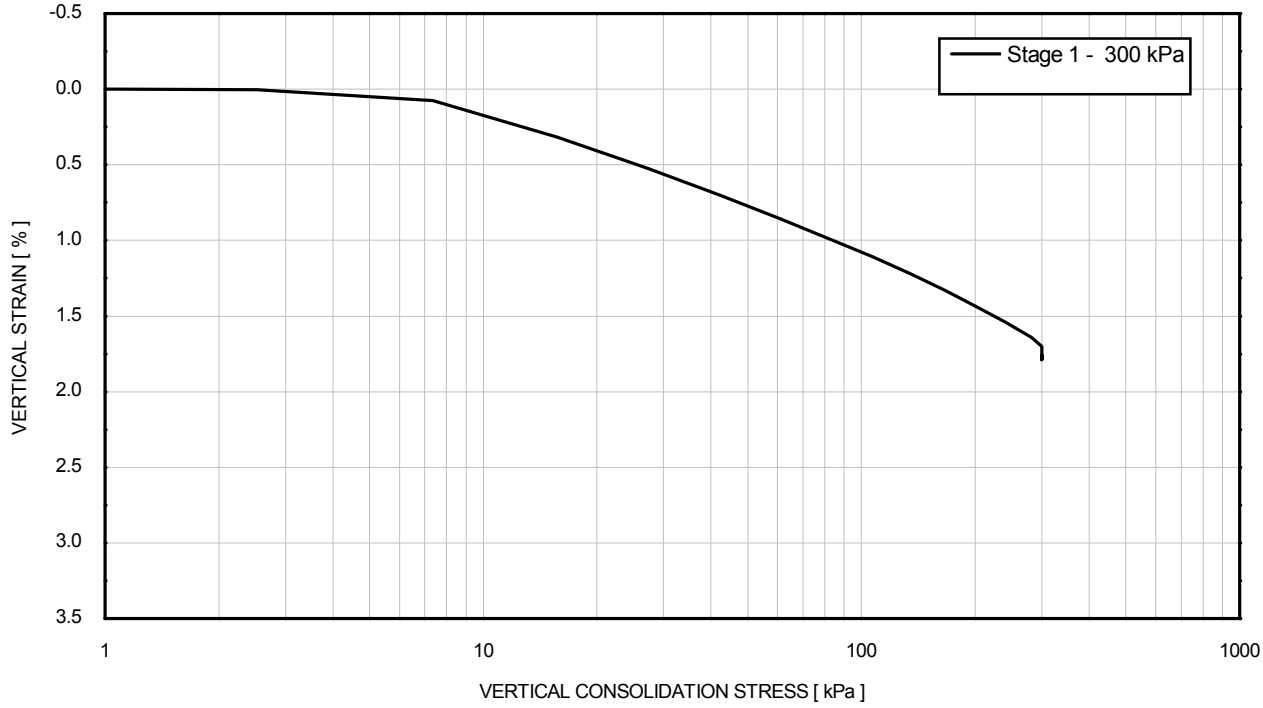


TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-3
Unit	E3 (Tongeren)
Test number	CSS21

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA



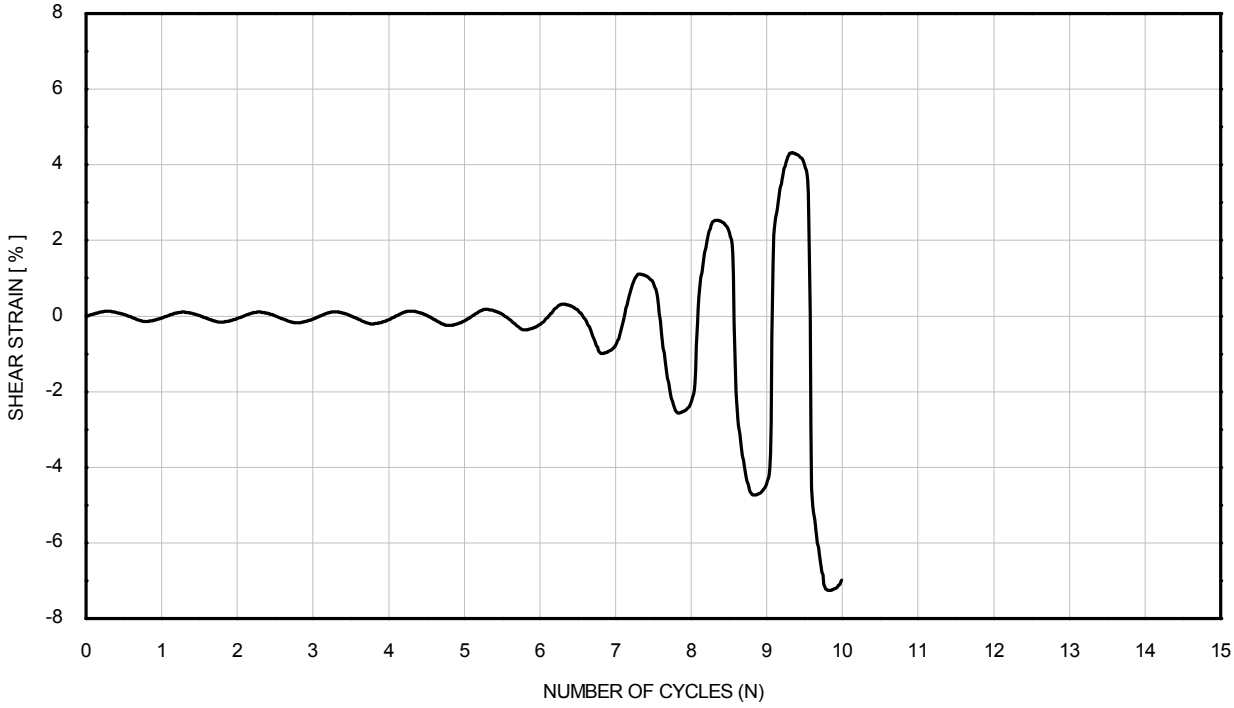


σ_{vc}	: 300 kPa	Batch	: 3
		Sample	: CSS_3-3
		Unit	: E3 (Tongeren)
		Test No.	: CSS21

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

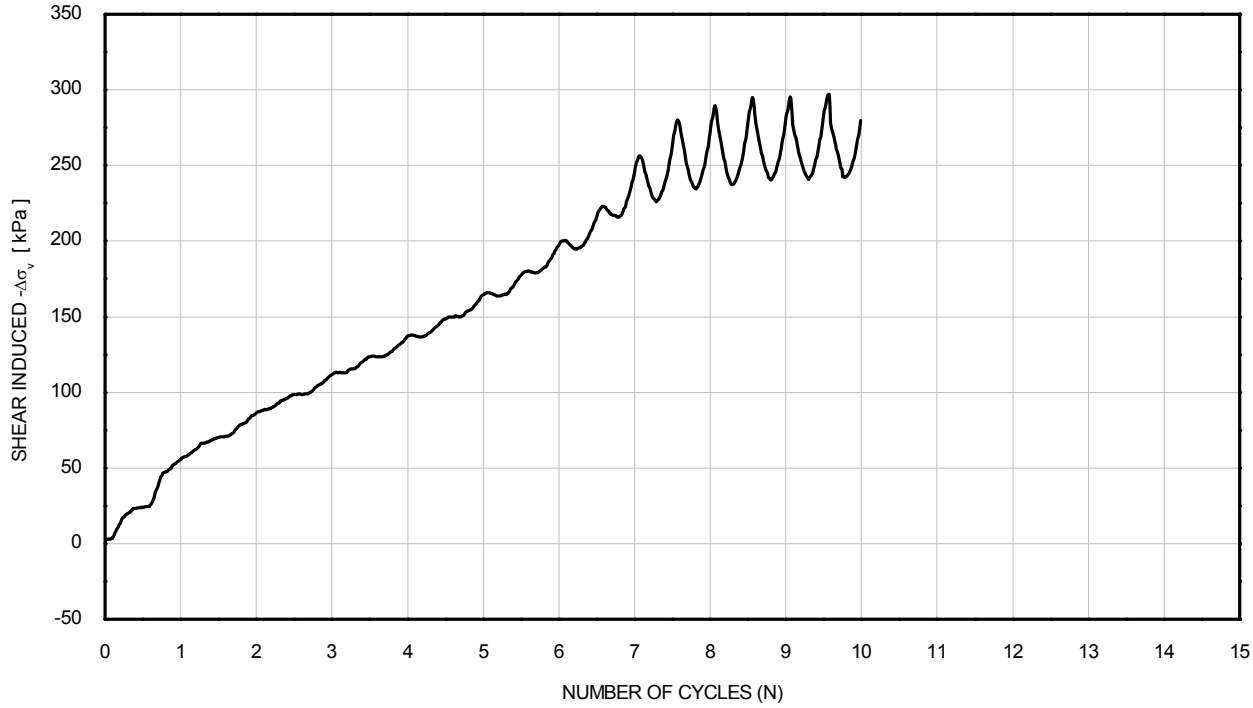


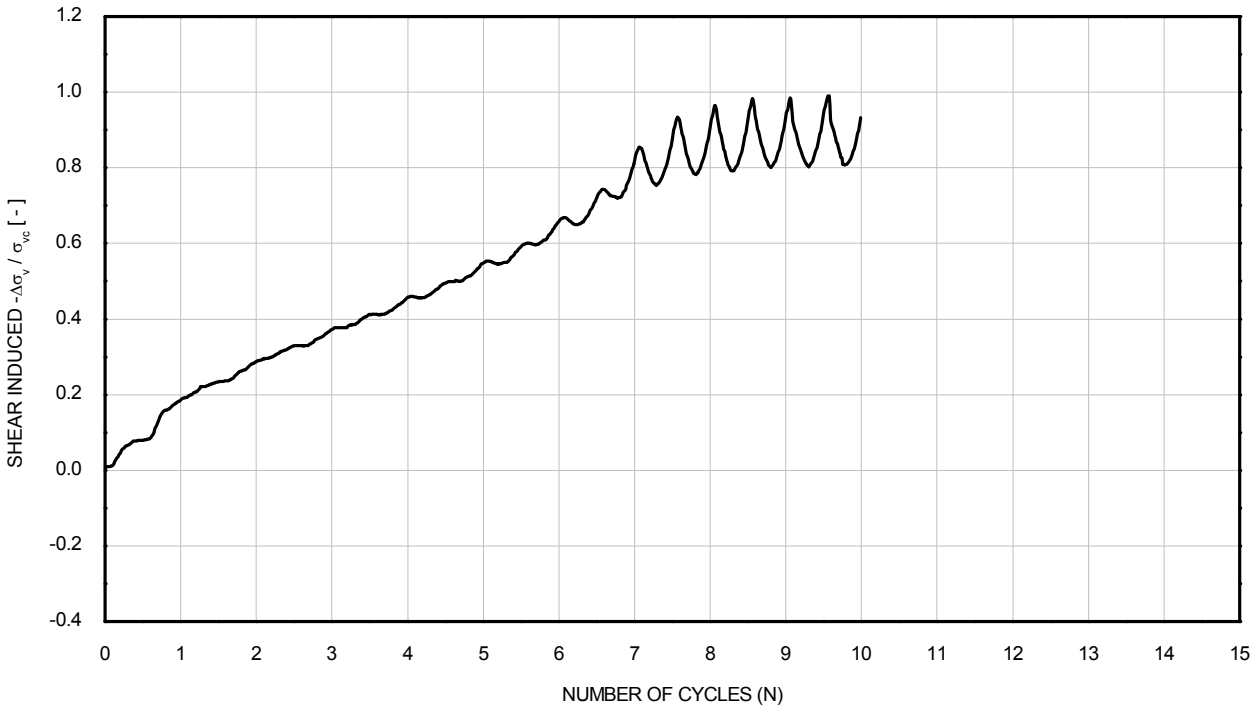


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-3
Mean τ_{cy}	:	35 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS21

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

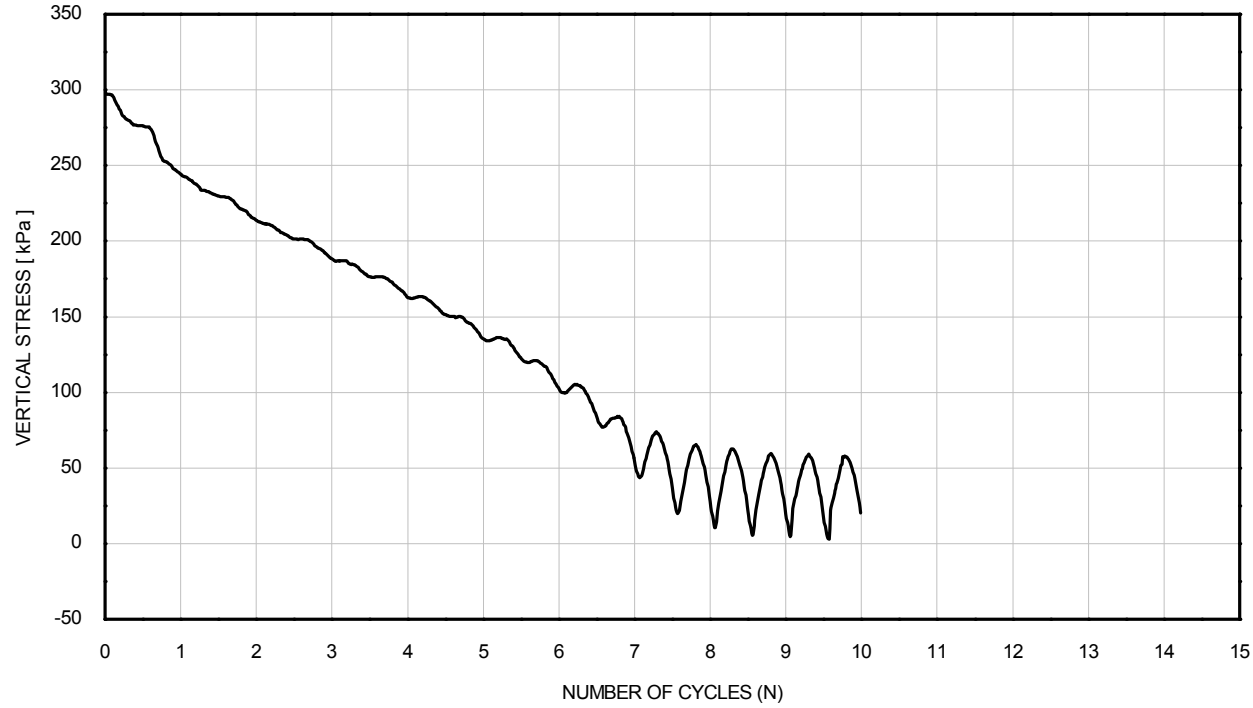


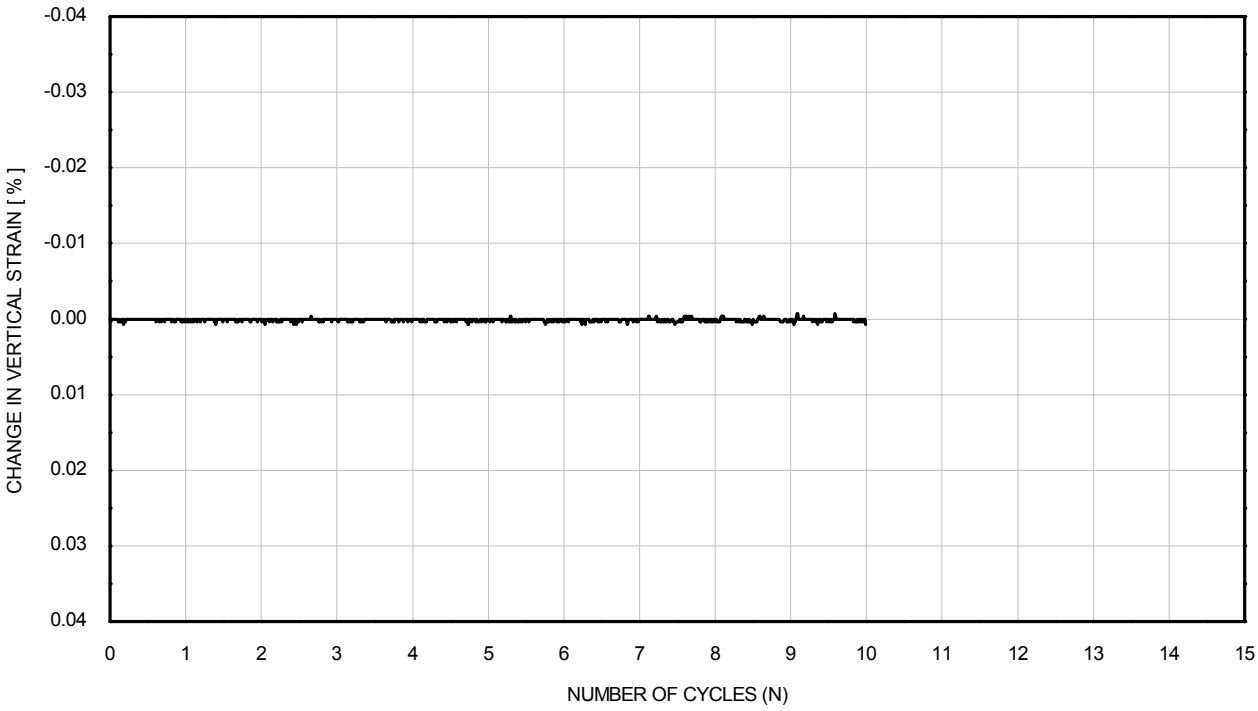


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-3
Mean τ_{cy}	:	35 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS21

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

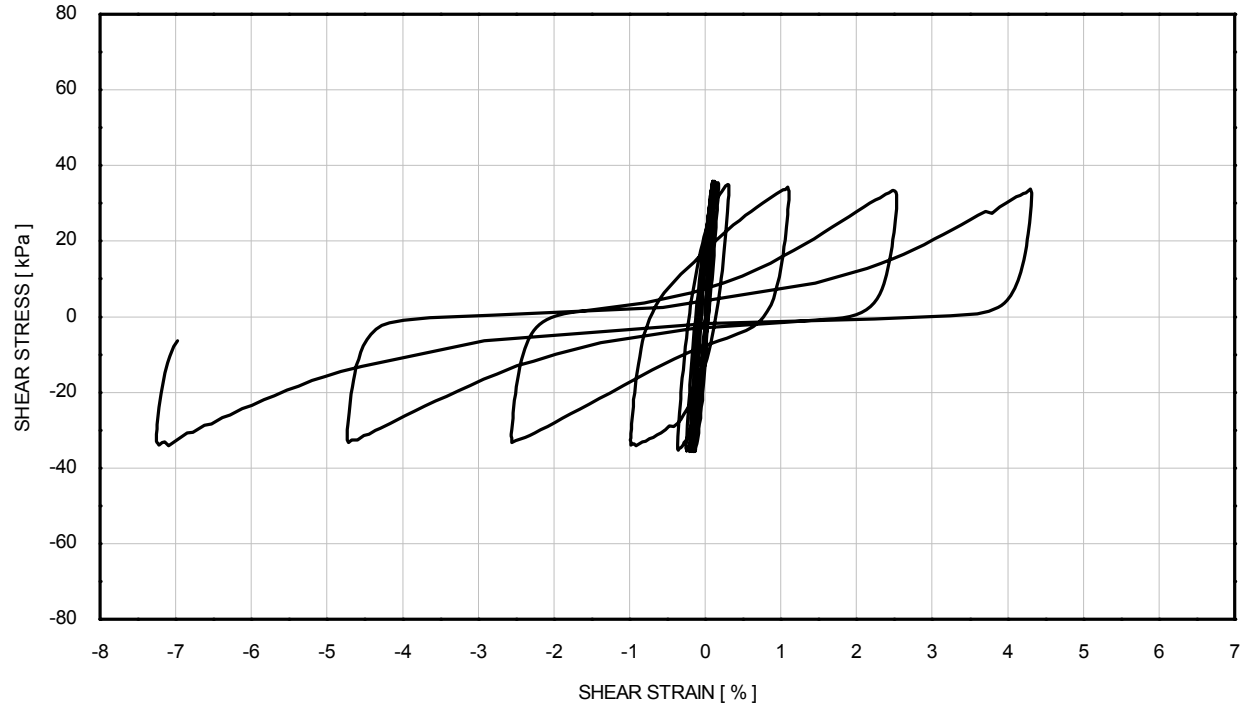


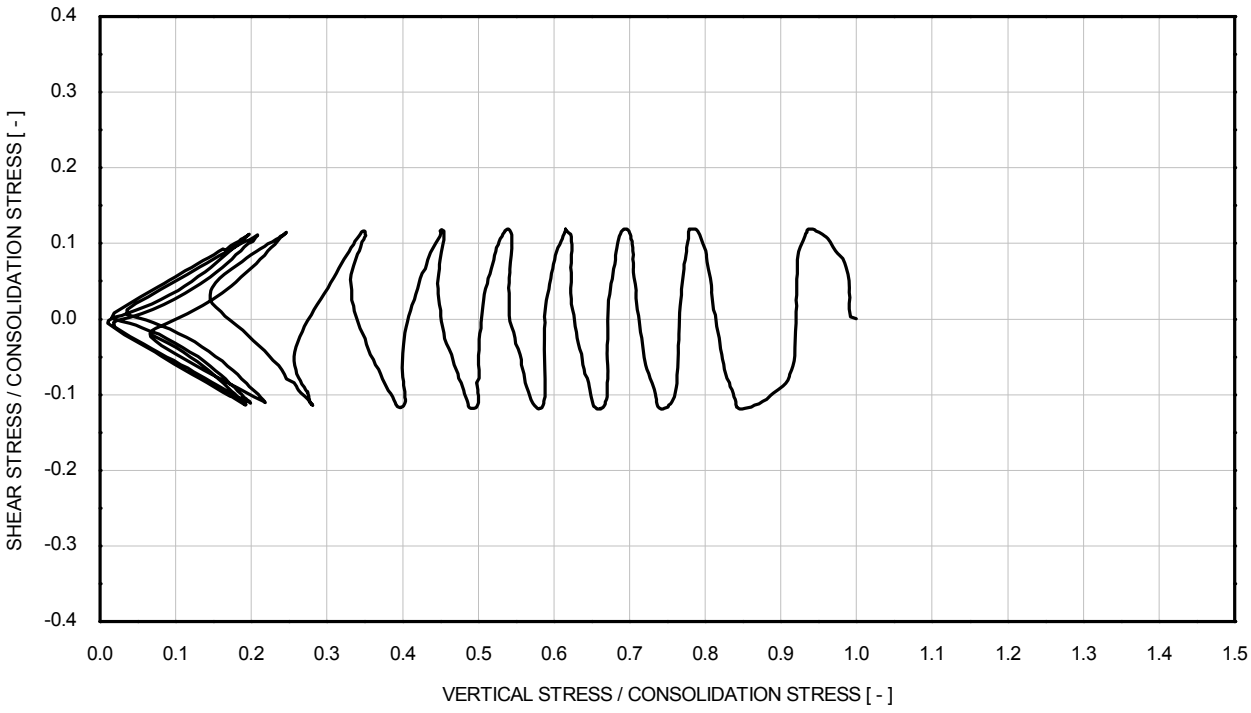


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-3
Mean τ_{cy}	:	35 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS21

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

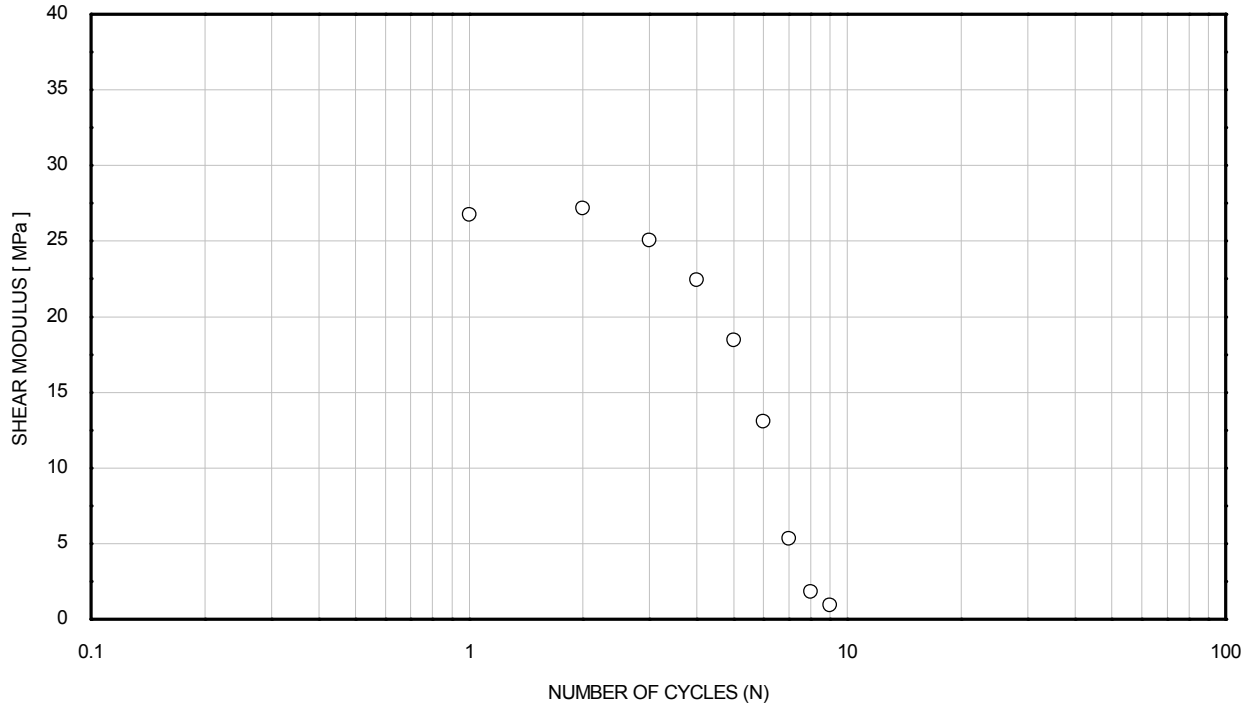


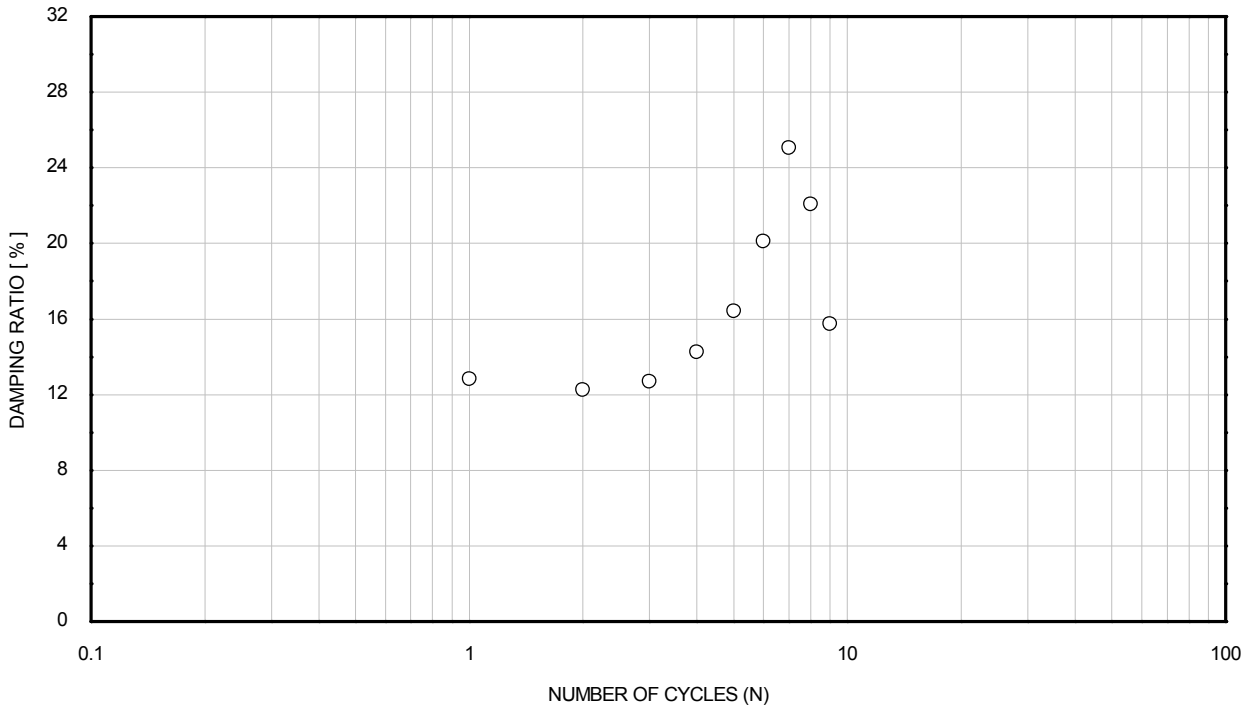


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-3
Mean τ_{cy}	:	35 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS21

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

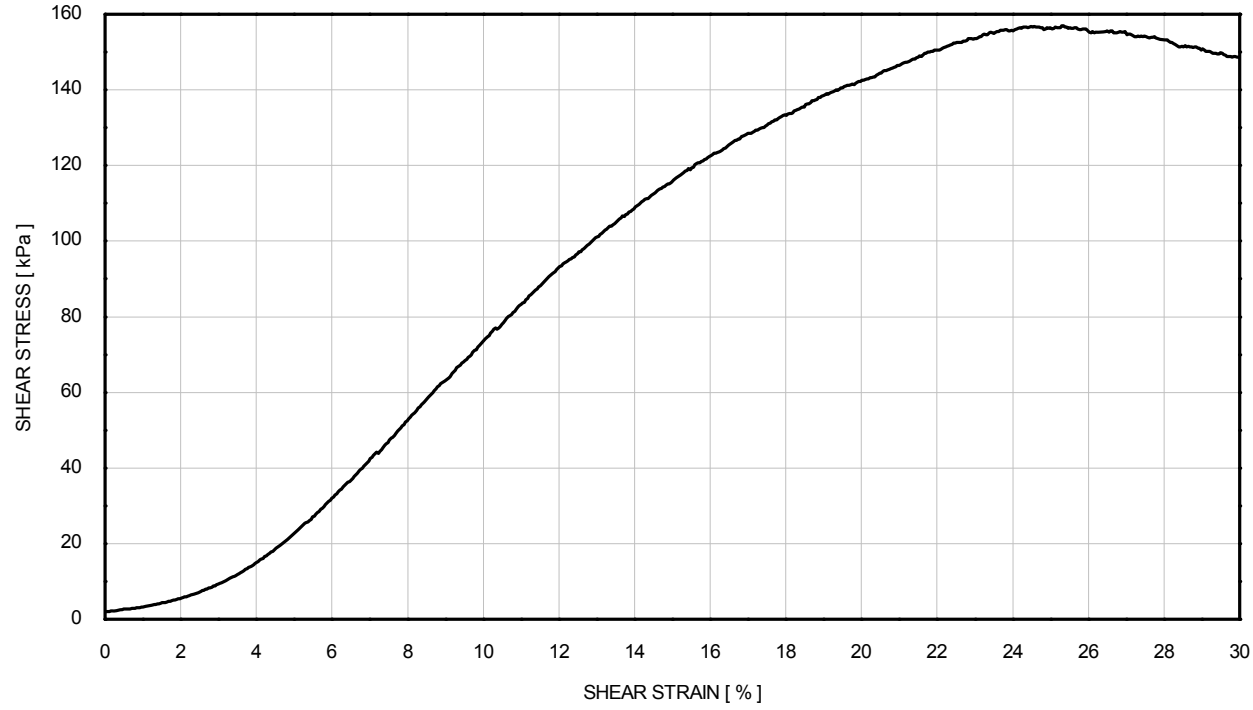


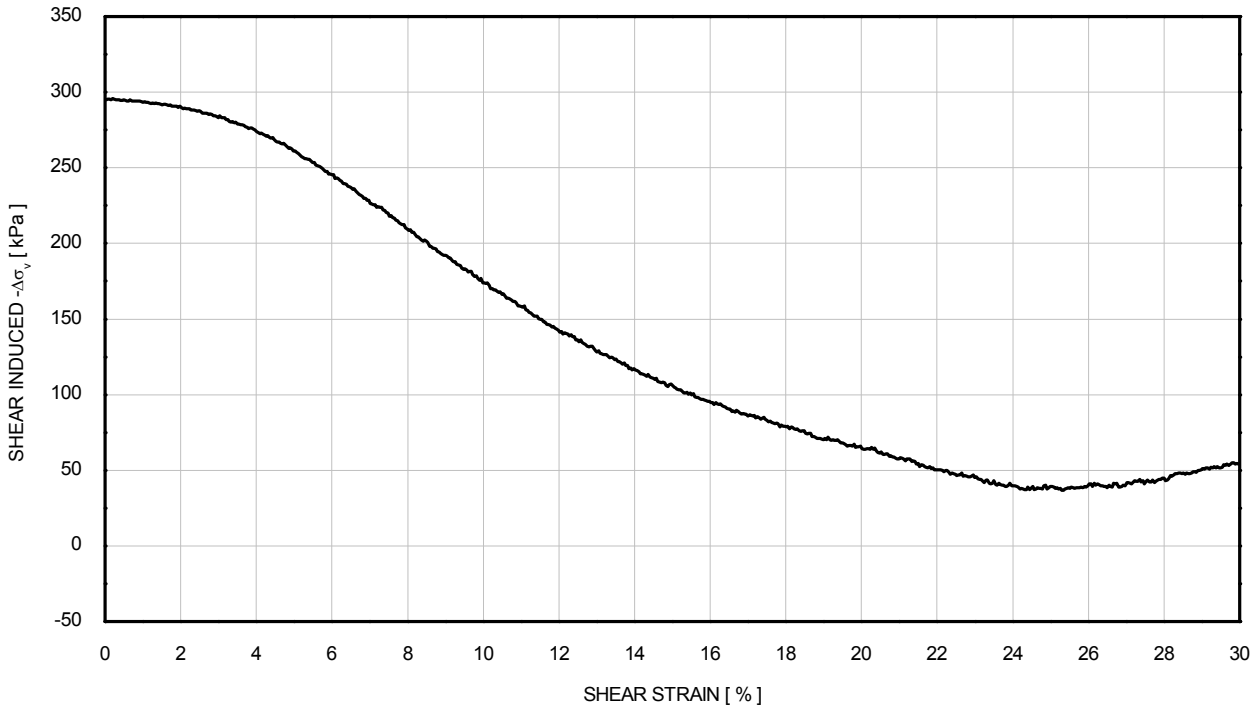


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-3
Mean τ_{cy}	:	35 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS21

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

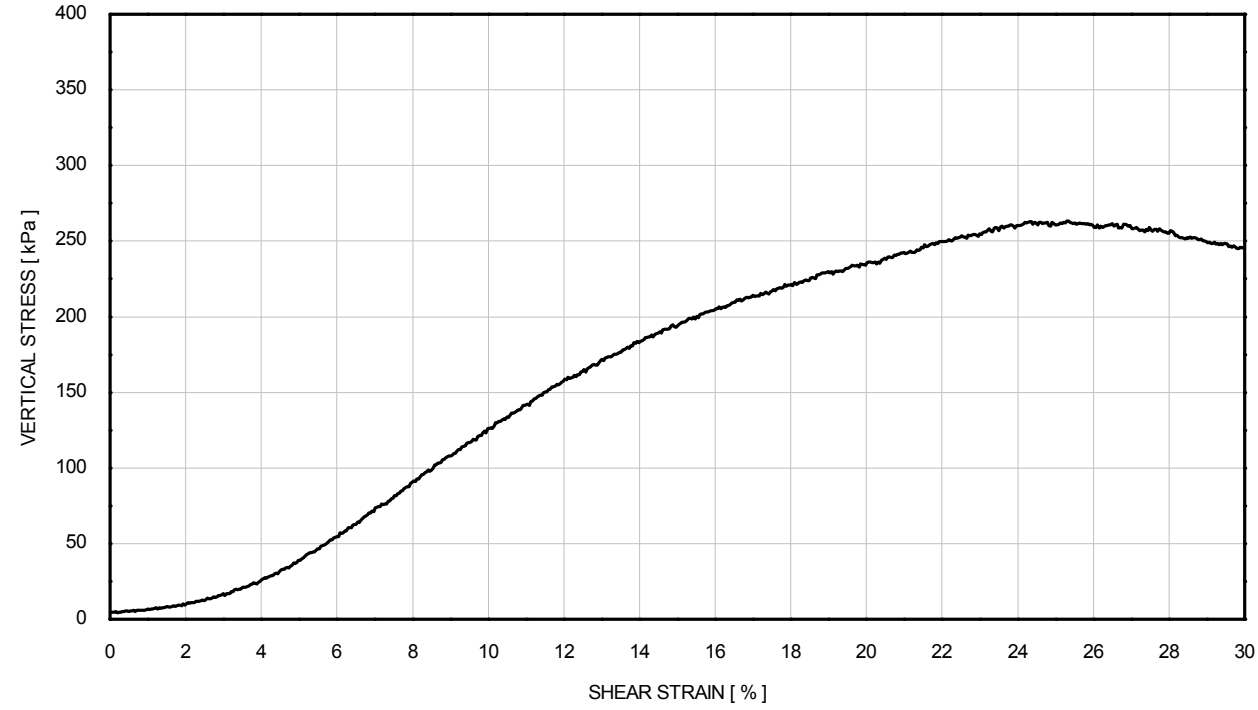


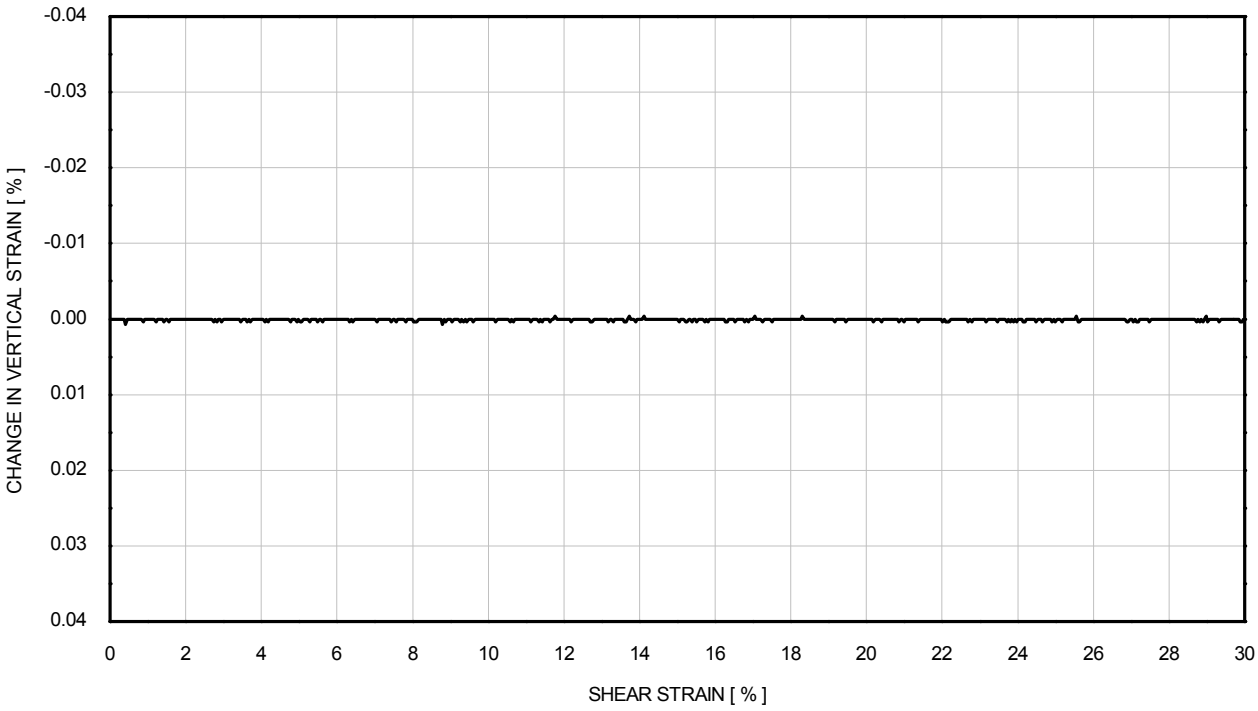


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 157 kPa	Sample	: CSS_3-3
γ at τ_{peak}	: 25.34 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: CSS21

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

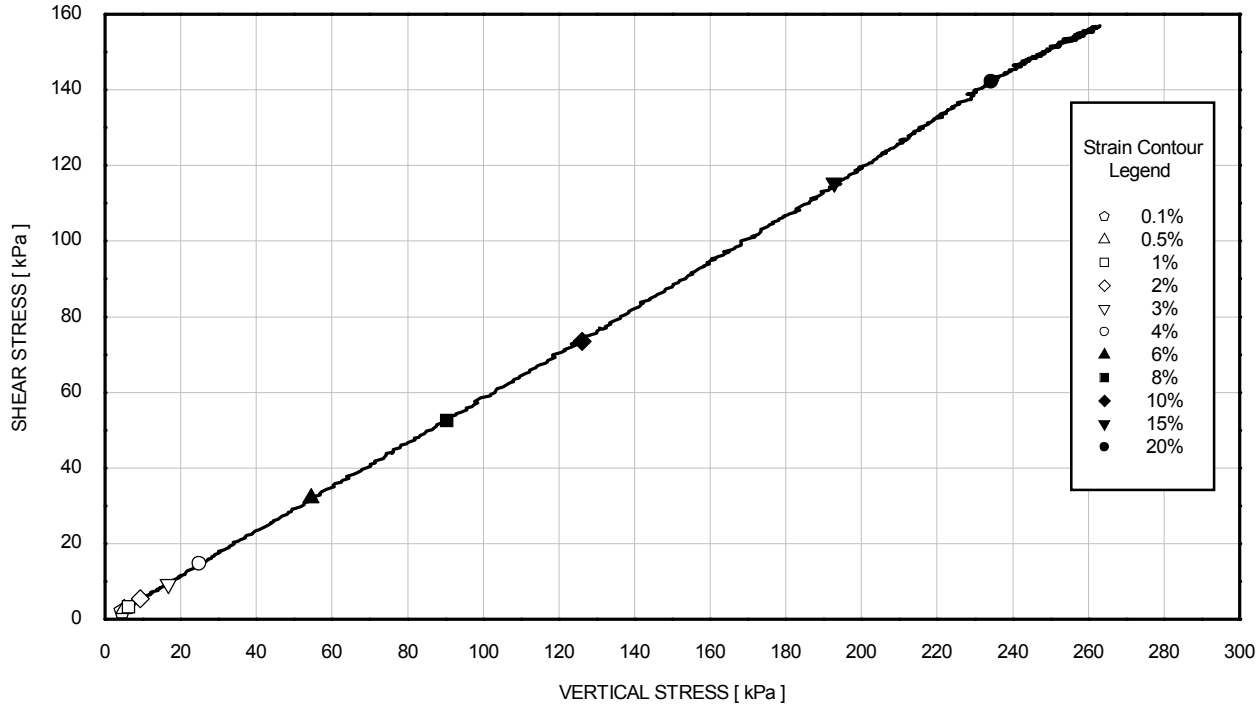


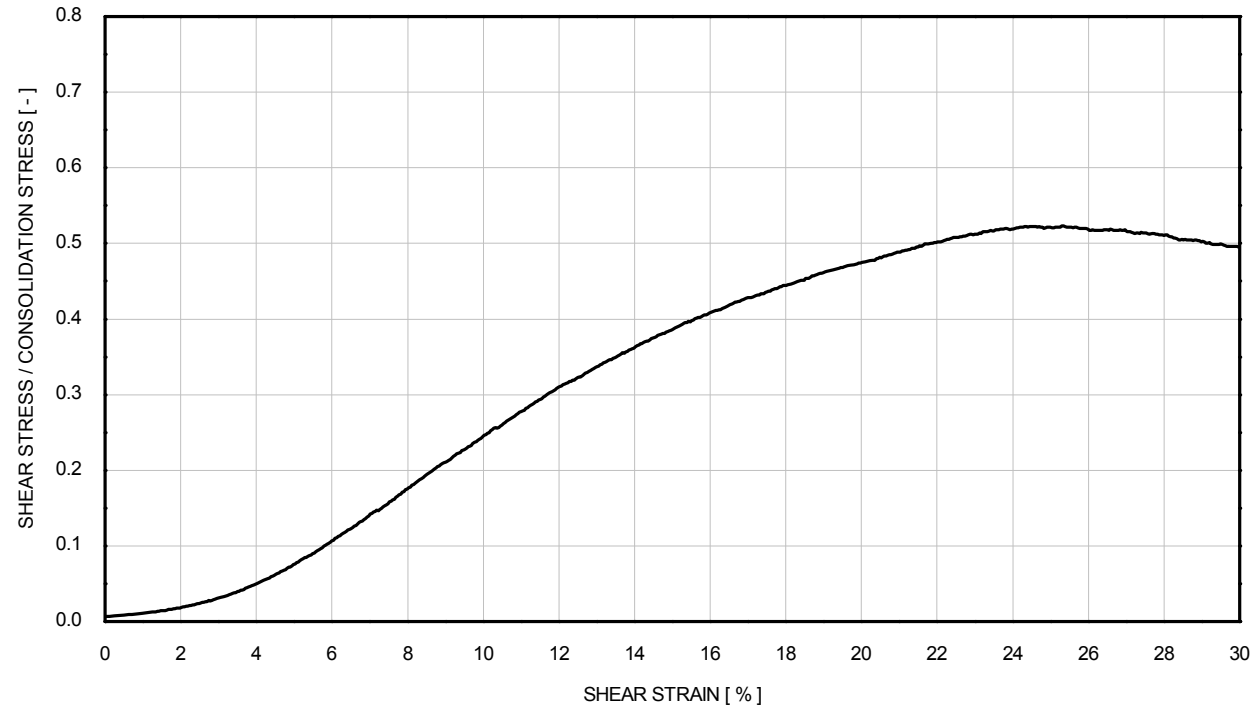


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 157 kPa	Sample	: CSS_3-3
γ at τ_{peak}	: 25.34 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: CSS21

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

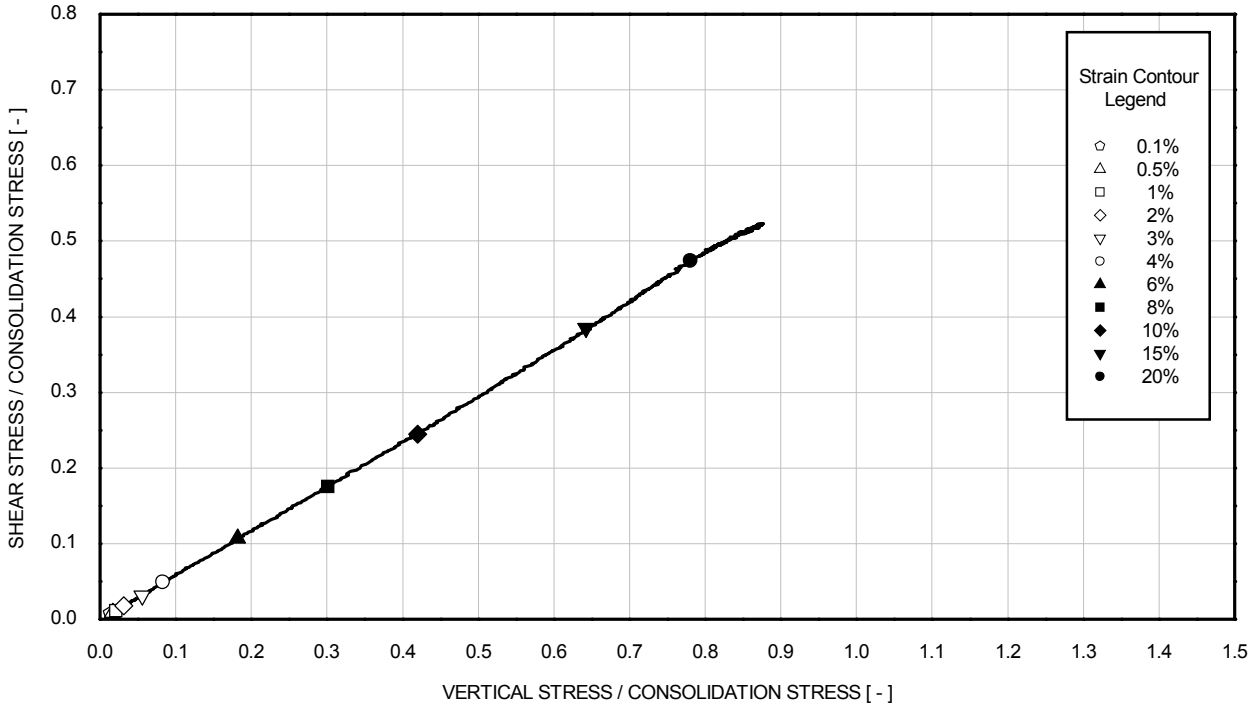


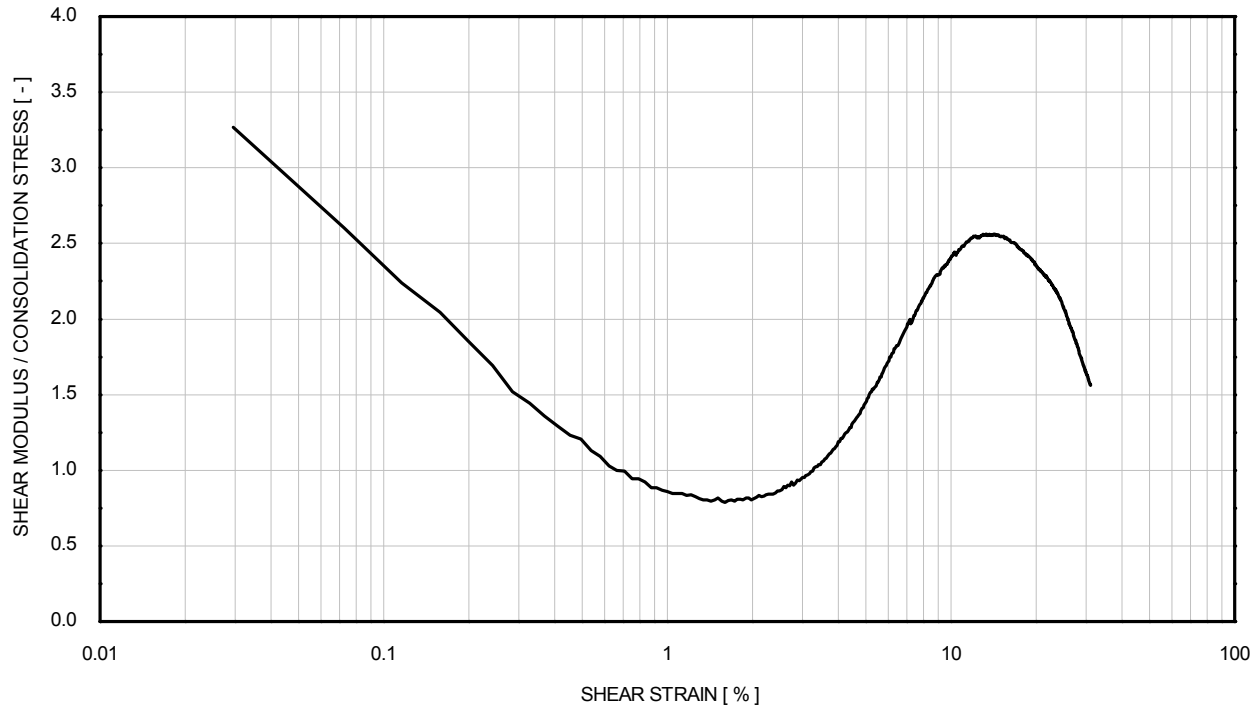


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 157 kPa	Sample	: CSS_3-3
γ at τ_{peak}	: 25.34 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: CSS21

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 157 kPa	Sample	: CSS_3-3
γ at τ_{peak}	: 25.34 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.10 %/hour	Test No.	: CSS21

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	29/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.7
Length	[mm]	30.0
Moisture content after compaction	[%]	9.9
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.61
Void ratio	[-]	0.644
Degree of saturation after compaction	[%]	41
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.3
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 3_CSS 3-4_CSS22
Template issue	1.3
Processed by	HJ
Date	09/03/2016
Checked by	PH
Date	15/03/2016
Approved by	PH
Date	15/03/2016

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-4
Unit	E3 (Tongeren)
Test number	CSS22

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	300
Vertical strain	[%]	1.47
Bulk density	[Mg/m^3]	2.02
Dry density	[Mg/m^3]	1.64
Void ratio	[-]	0.620
Moisture content	[%]	23.4

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	300
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	24
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	74
γ_{av} at N_f	[%]	-0.66
γ_{cy} at N_f	[%]	3.77
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	276
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.00	0.06	37.63	8.22
2	-0.01	0.06	39.49	6.82
5	-0.01	0.06	39.27	5.91
10	-0.02	0.06	38.06	5.77
20	-0.03	0.07	35.82	5.97
30	-0.03	0.07	33.29	6.49
40	-0.03	0.08	30.52	7.37
50	-0.04	0.09	26.79	9.02
74	-0.66	3.77	0.59	14.14

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-4
Unit	E3 (Tongeren)
Test number	CSS22

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	99
Shear strain	[%]	21.72
Shear induced $-\Delta\sigma_v$	[kPa]	124
Vertical stress	[kPa]	176
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.08
At 15 % shear strain		
Shear stress	[kPa]	83
Shear induced $-\Delta\sigma_v$	[kPa]	153
Vertical stress	[kPa]	147
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-4
Unit	E3 (Tongeren)
Test number	CSS22

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

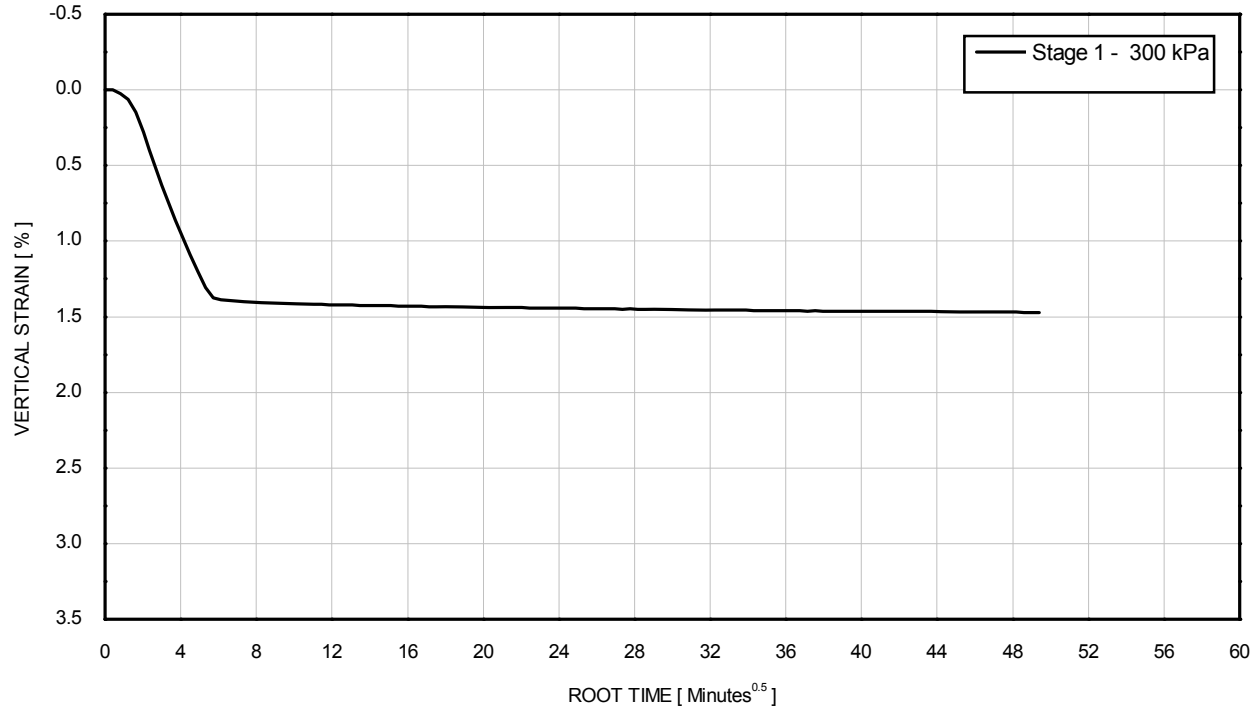
SPECIMEN PHOTOGRAPH

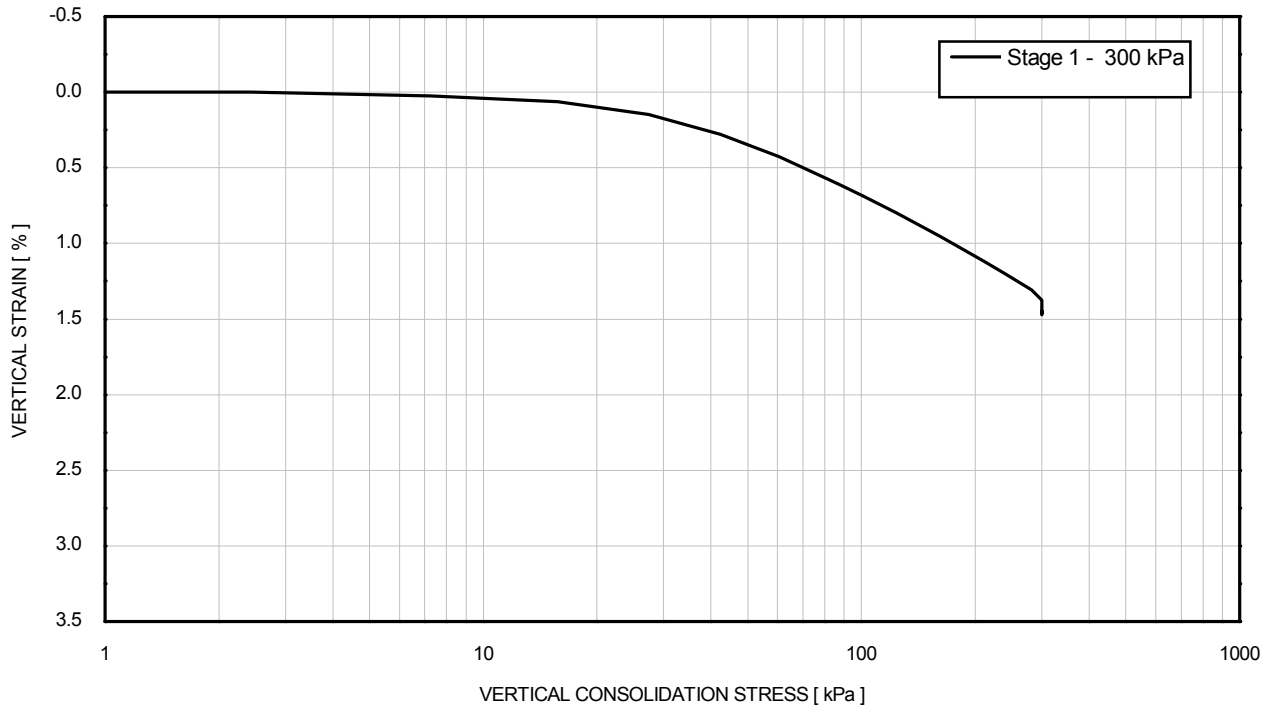


TEST IDENTIFICATION	
Batch	3
Sample	CSS_3-4
Unit	E3 (Tongeren)
Test number	CSS22

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

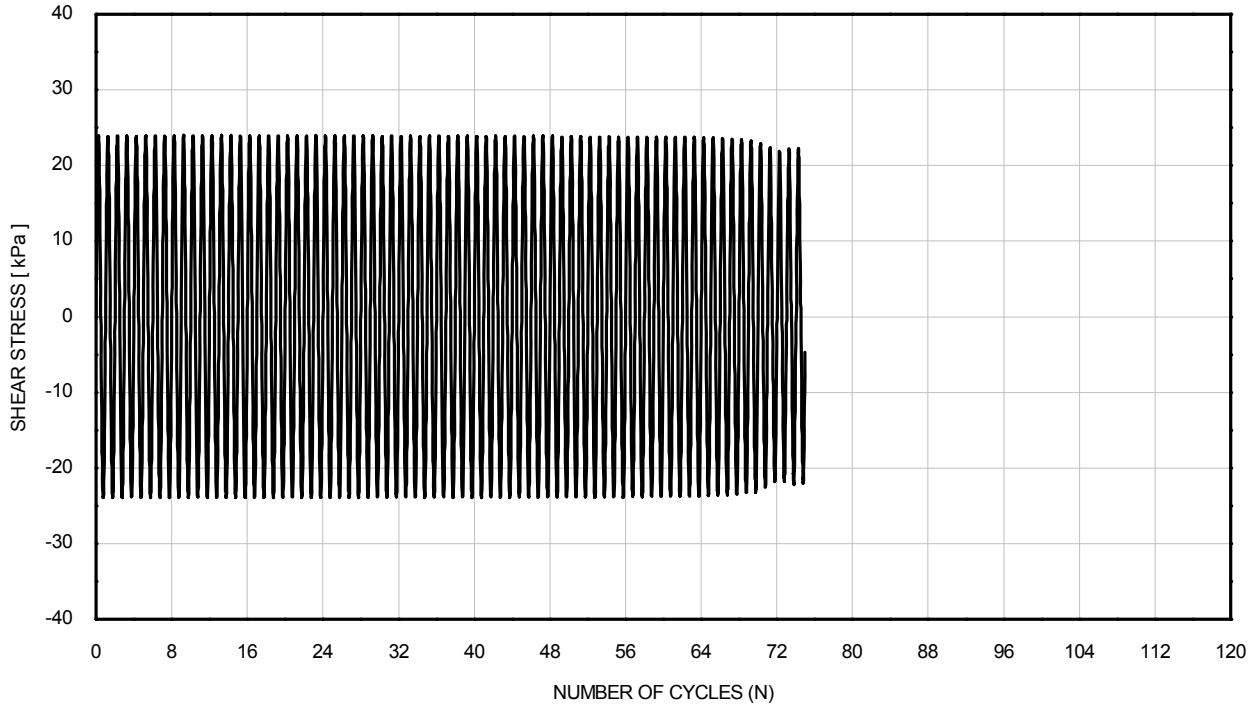


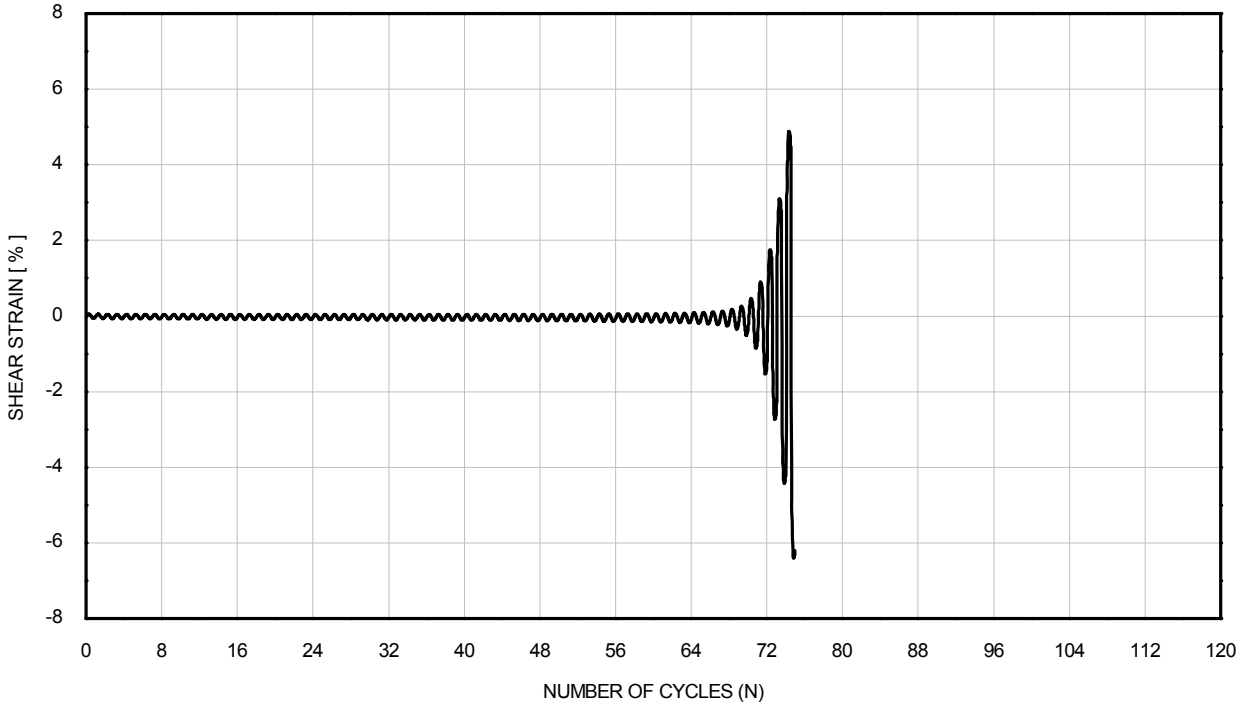


σ_{vc}	: 300 kPa	Batch	: 3
		Sample	: CSS_3-4
		Unit	: E3 (Tongeren)
		Test No.	: CSS22

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

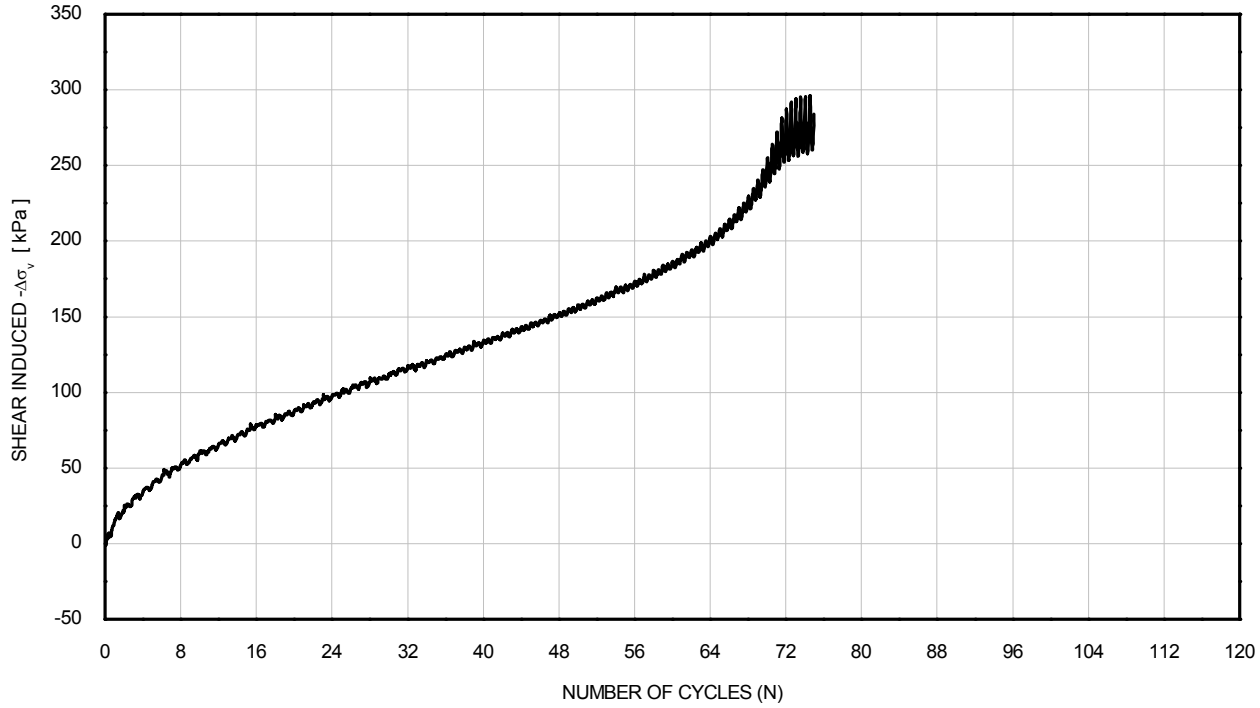


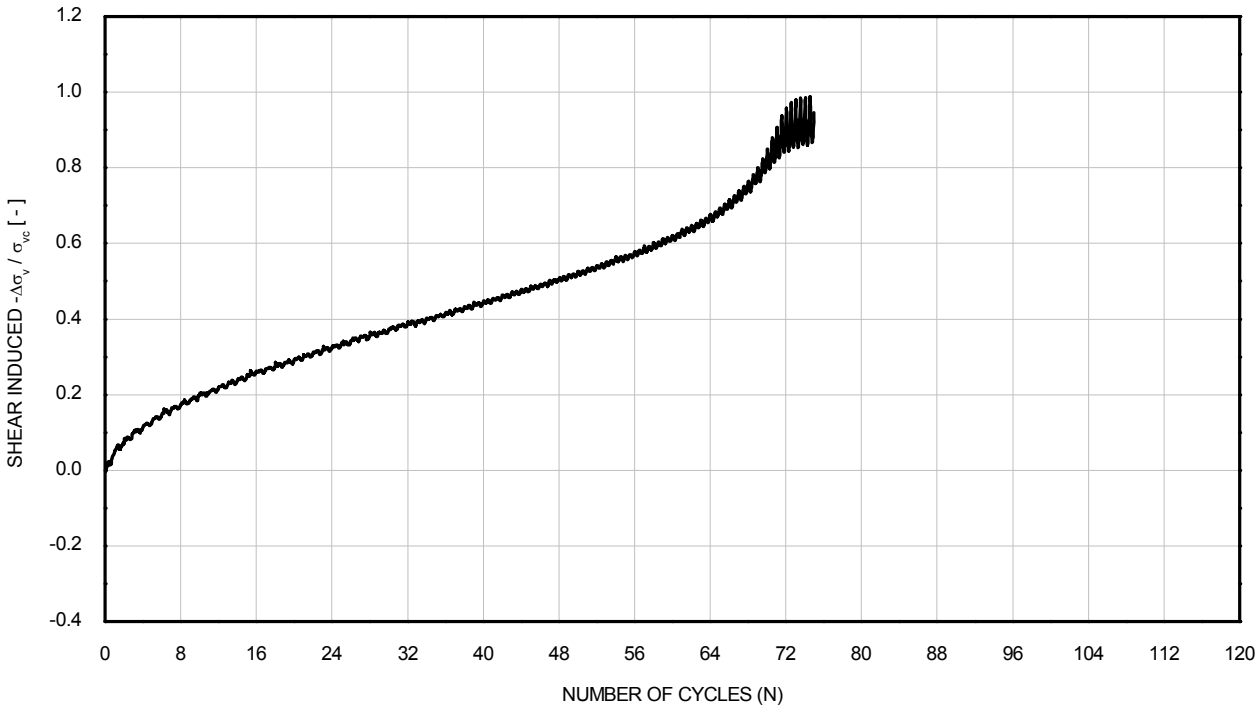


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-4
Mean τ_{cy}	:	24 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS22

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

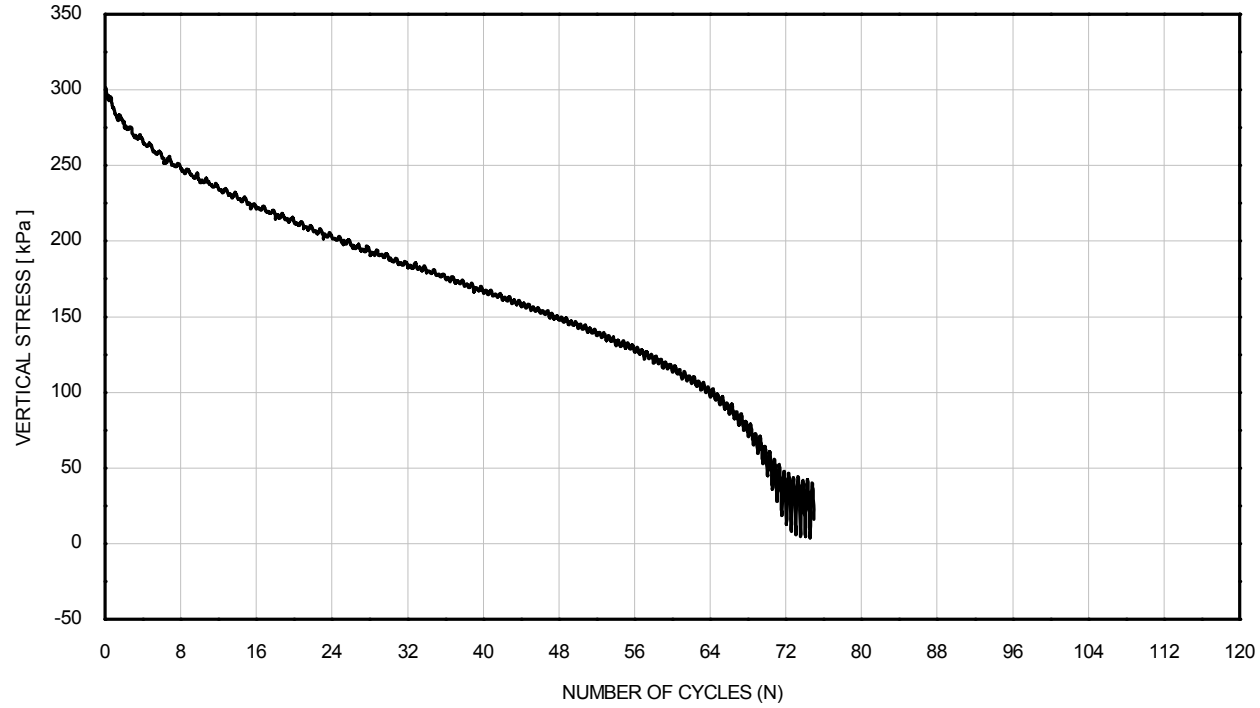


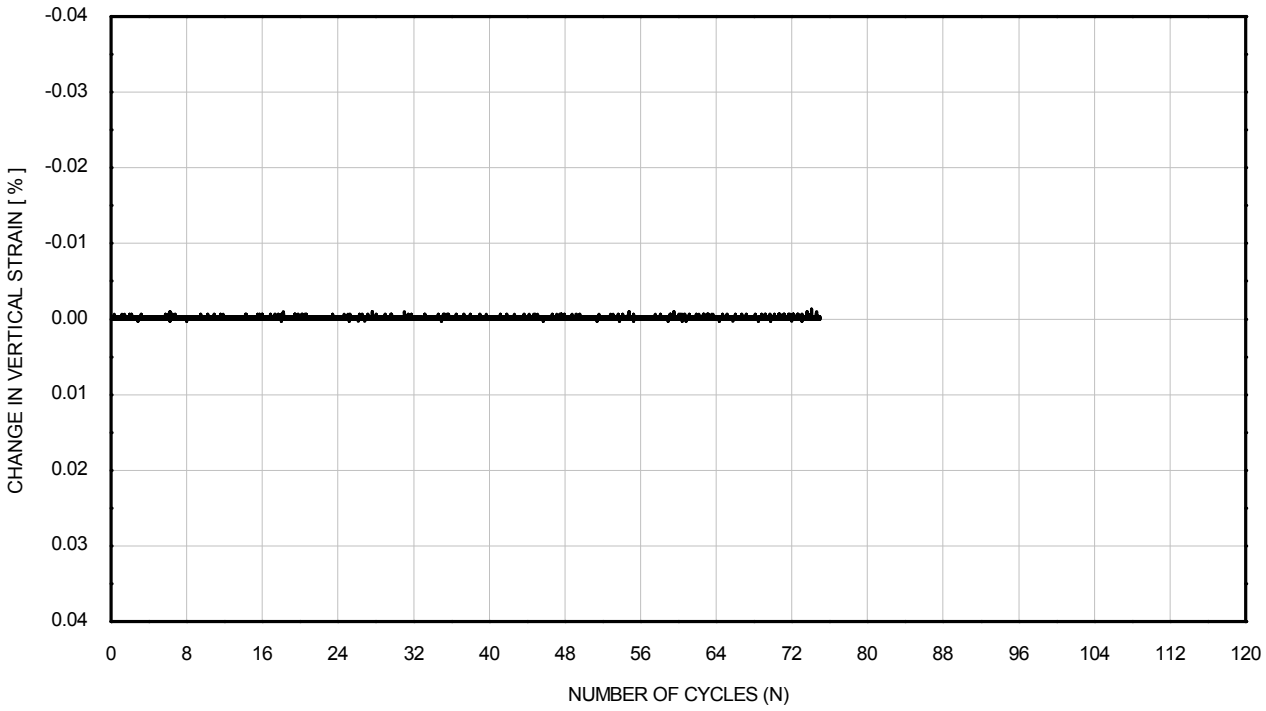


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-4
Mean τ_{cy}	:	24 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS22

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

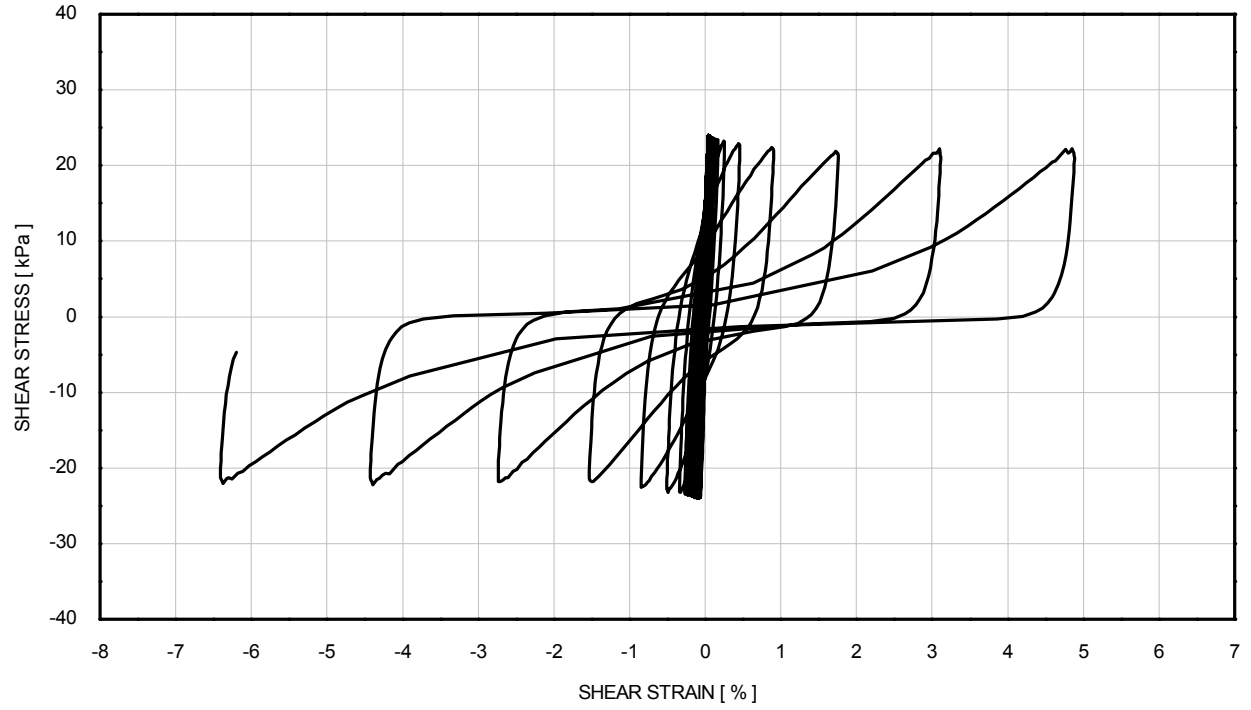


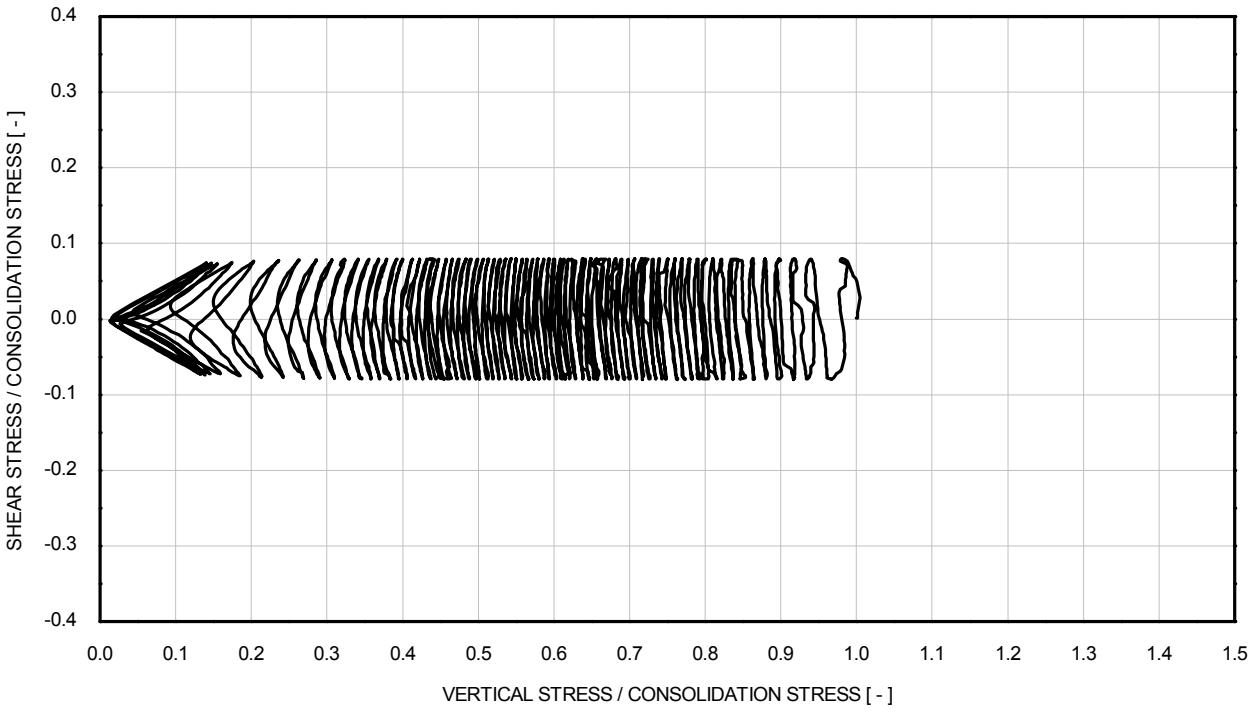


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-4
Mean τ_{cy}	:	24 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS22

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

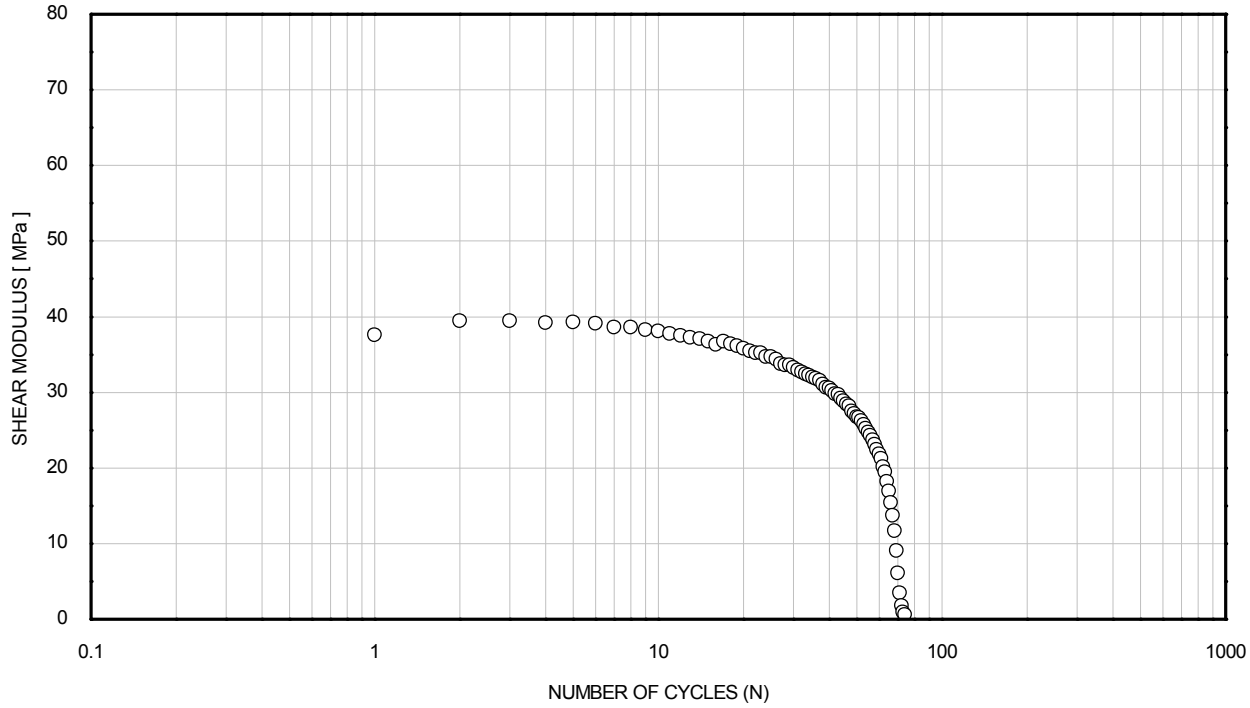


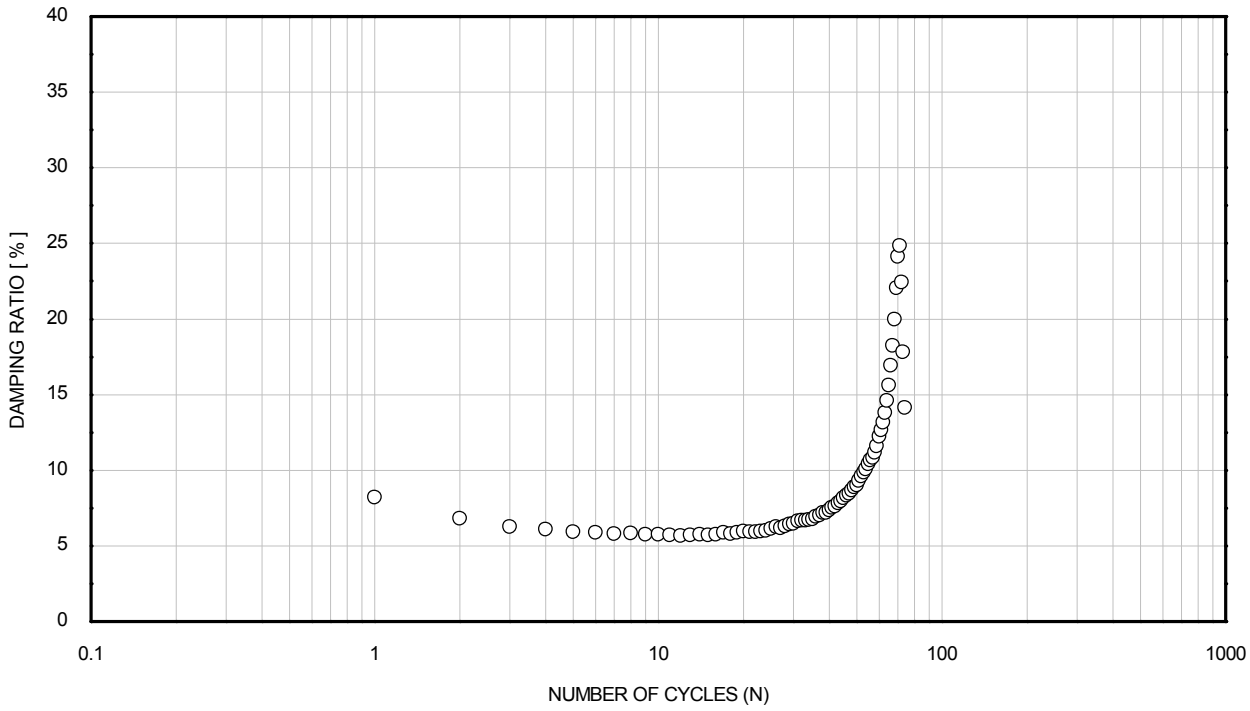


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-4
Mean τ_{cy}	:	24 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS22

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

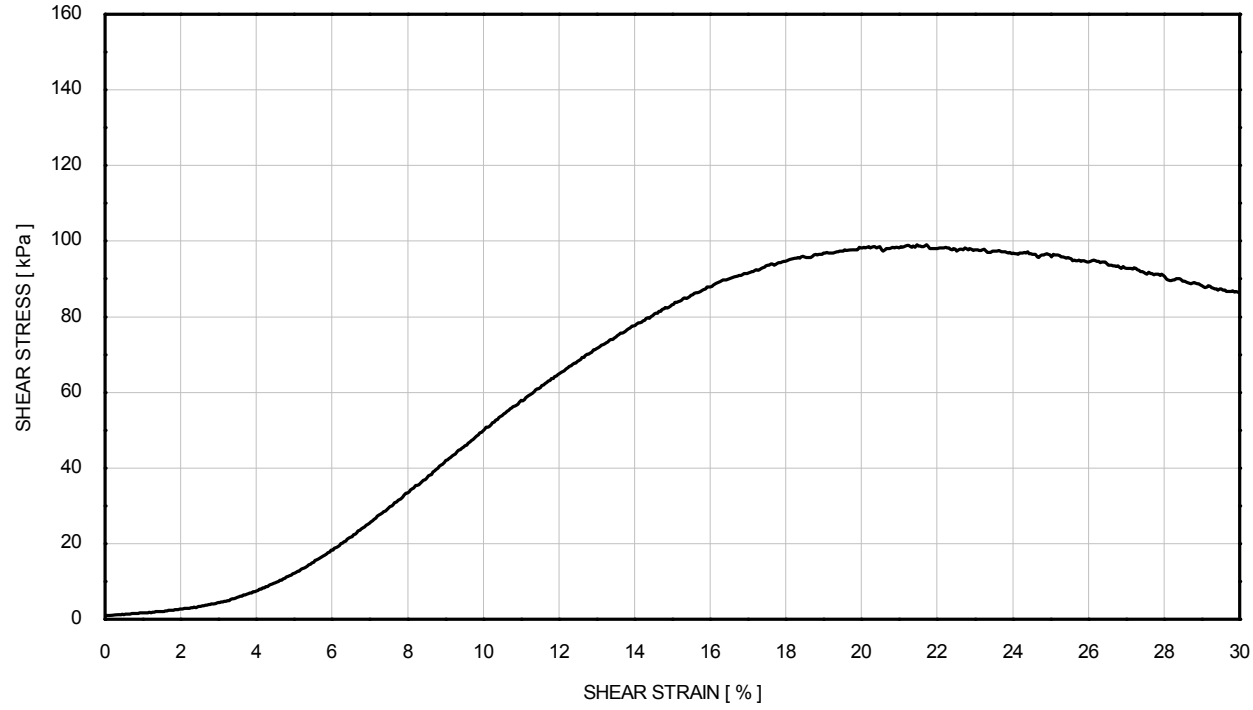


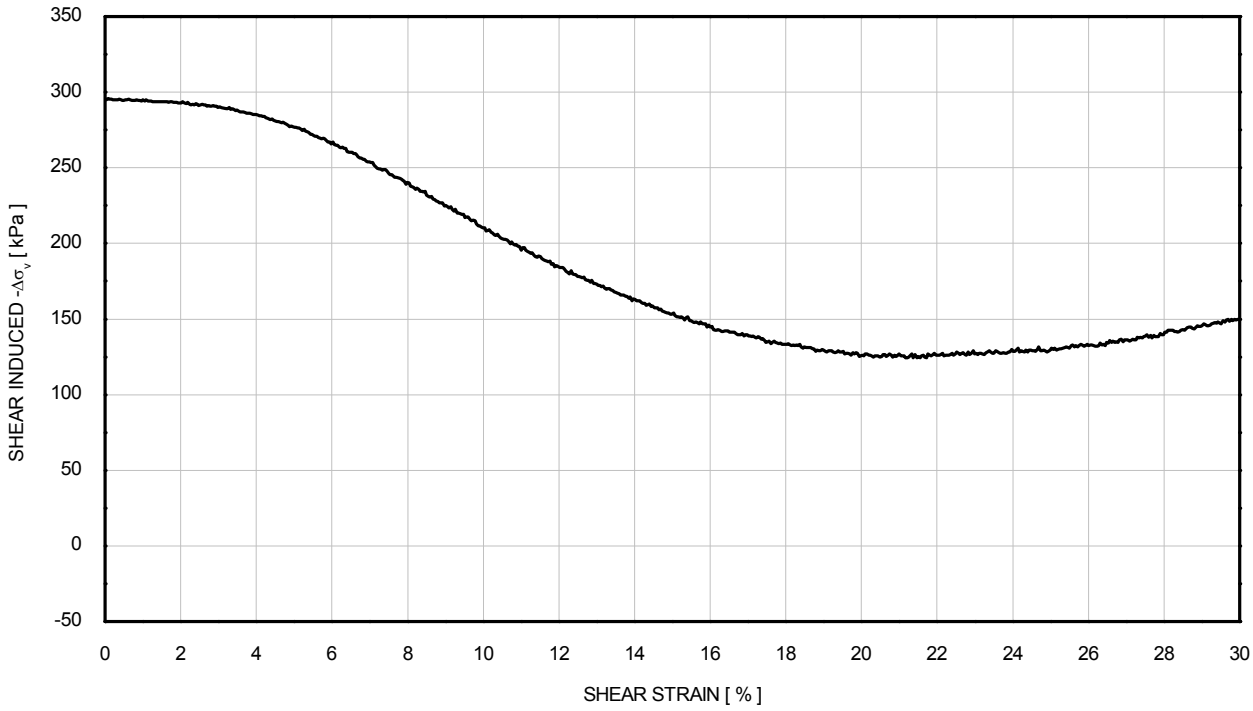


σ_{vc}	:	300 kPa	Batch	:	3
Mean τ_{av}	:	0 kPa	Sample	:	CSS_3-4
Mean τ_{cy}	:	24 kPa	Unit	:	E3 (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS22

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

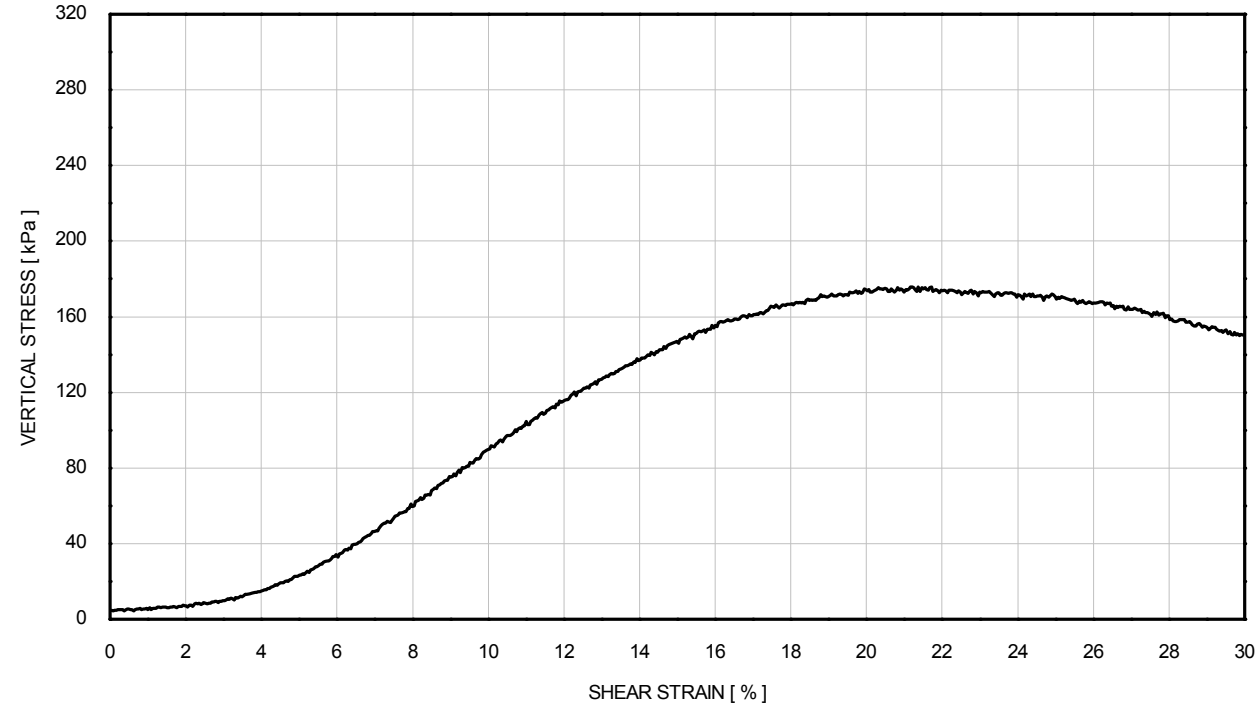


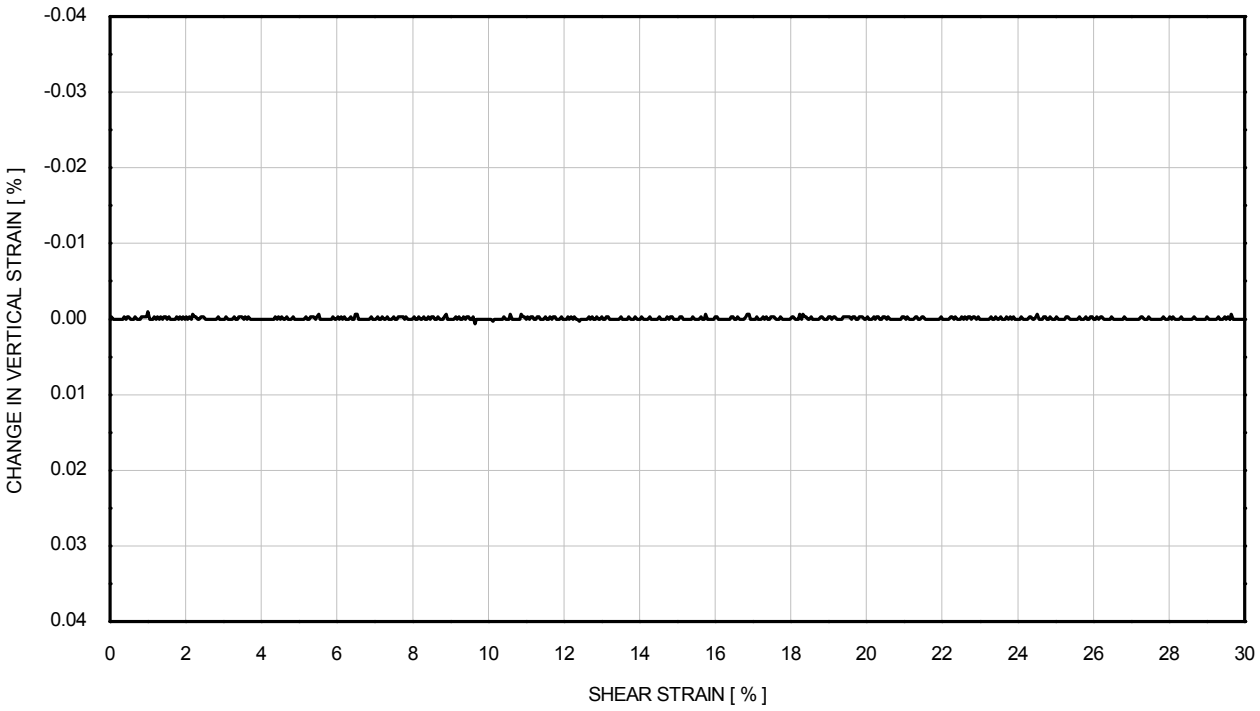


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 99 kPa	Sample	: CSS_3-4
γ at τ_{peak}	: 21.72 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.08 %/hour	Test No.	: CSS22

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

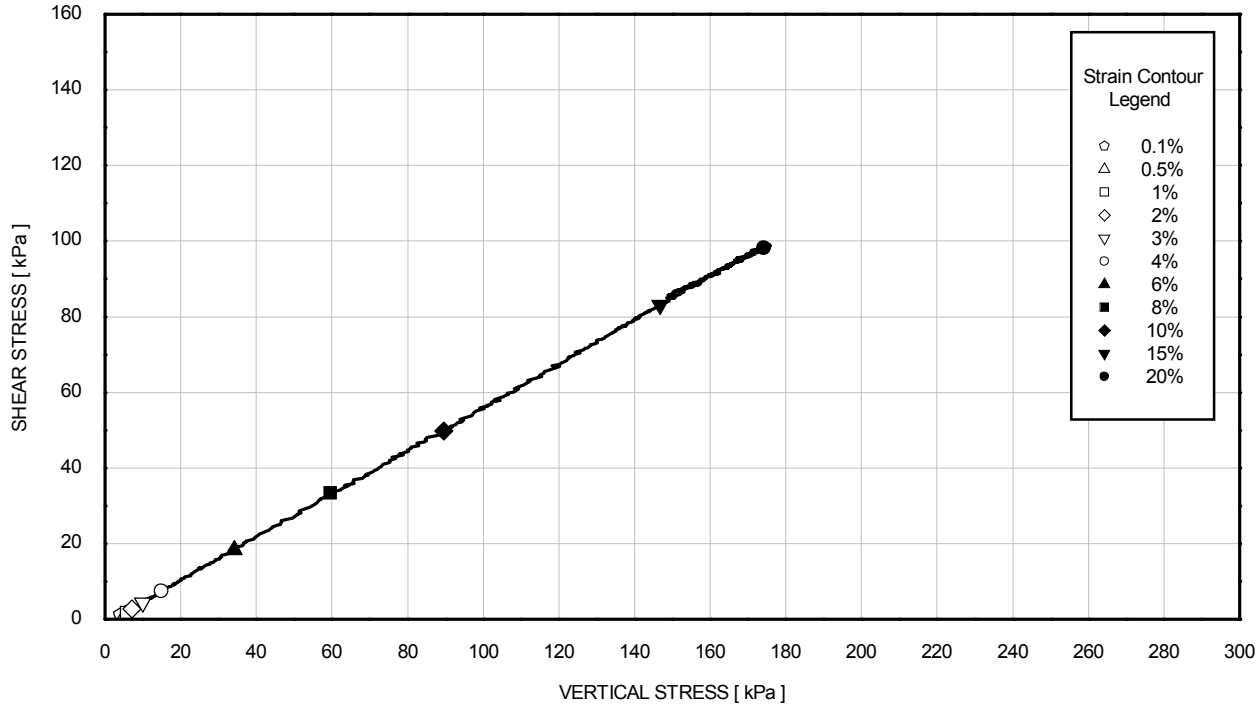


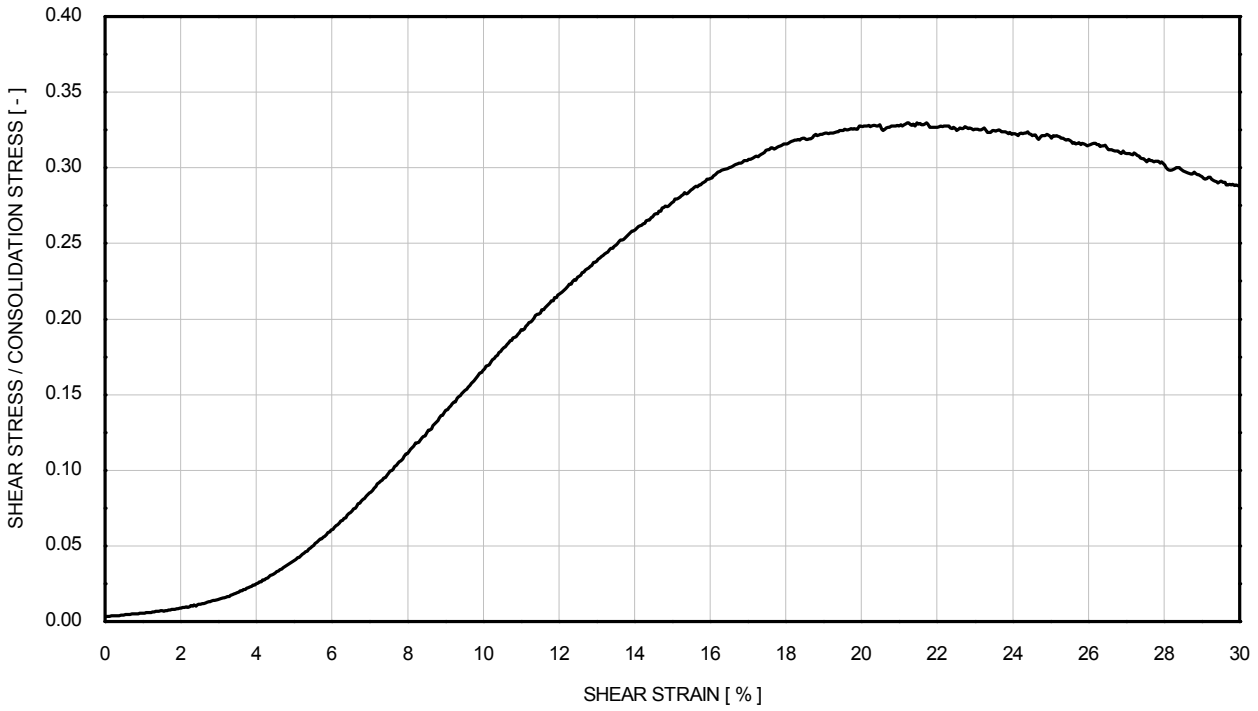


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 99 kPa	Sample	: CSS_3-4
γ at τ_{peak}	: 21.72 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.08 %/hour	Test No.	: CSS22

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

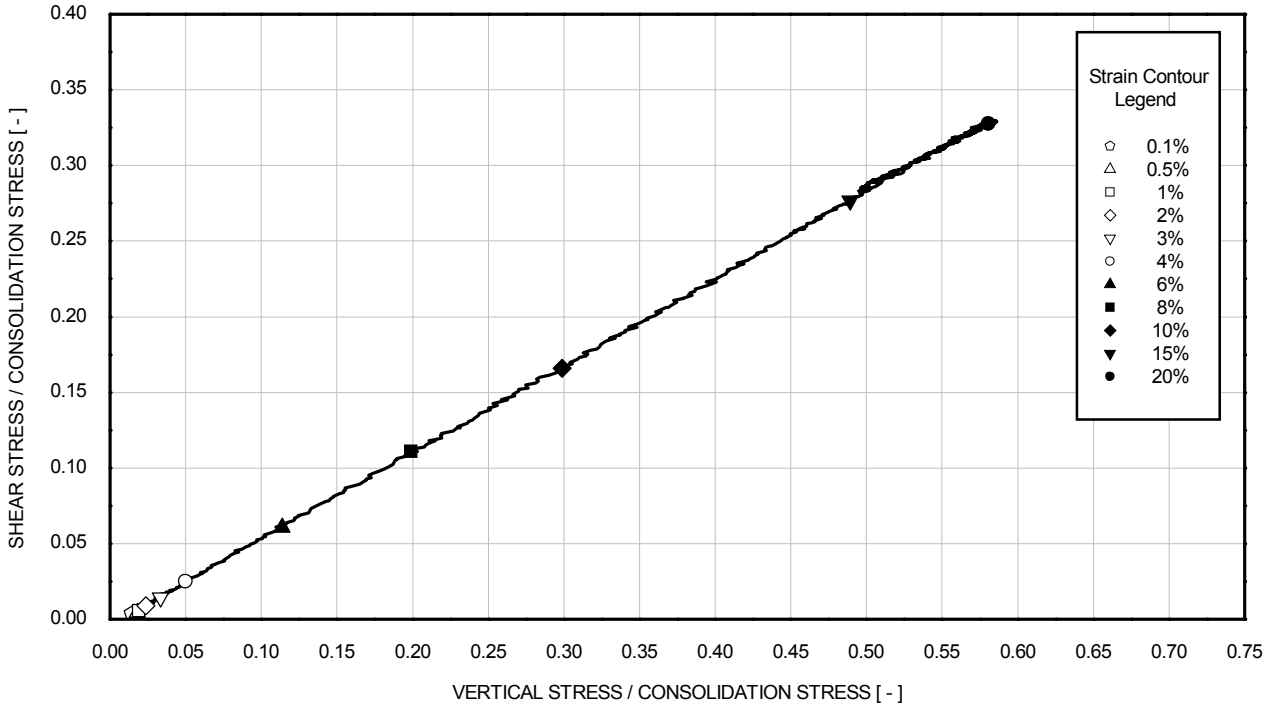


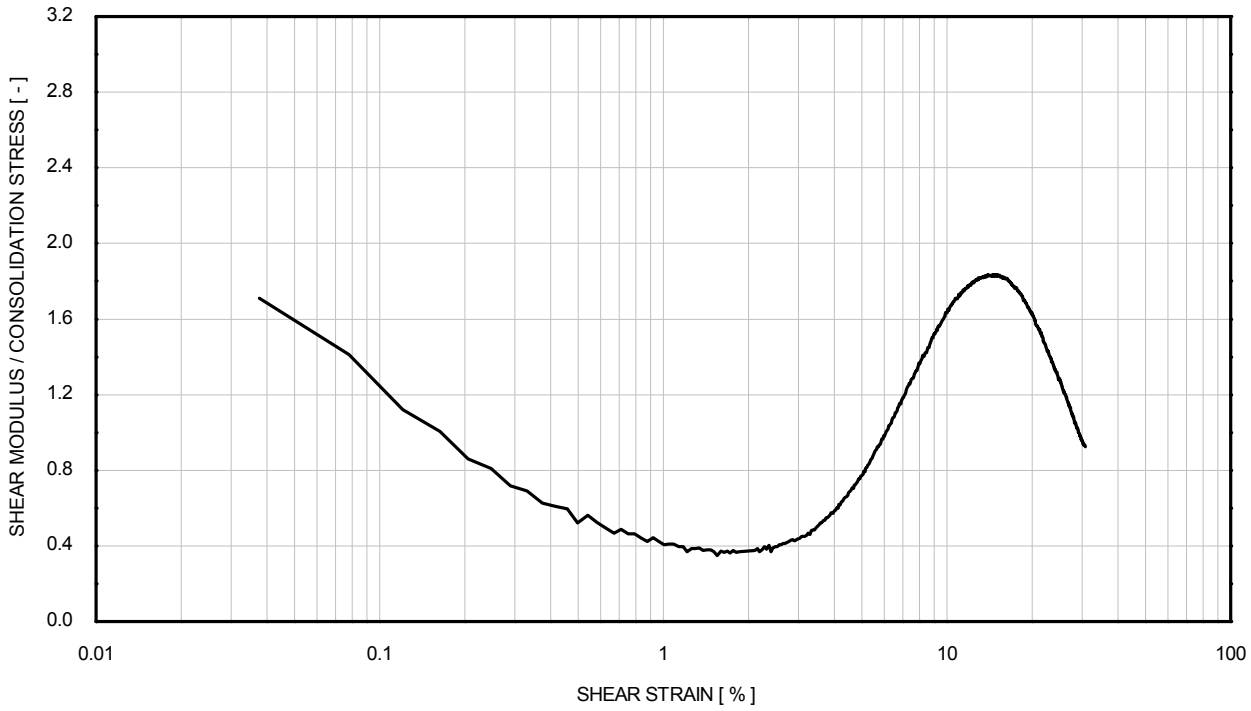


σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 99 kPa	Sample	: CSS_3-4
γ at τ_{peak}	: 21.72 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.08 %/hour	Test No.	: CSS22

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 300 kPa	Batch	: 3
τ_{peak}	: 99 kPa	Sample	: CSS_3-4
γ at τ_{peak}	: 21.72 %	Unit	: E3 (Tongeren)
Rate of strain	: 5.08 %/hour	Test No.	: CSS22

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	06/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.3
Length	[mm]	30.0
Moisture content after compaction	[%]	10.6
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.60
Void ratio	[-]	0.655
Degree of saturation after compaction	[%]	43
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.7
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 4_CSS 4-1_CSS23
Template issue	1.3
Processed by	HJ
Date	10/02/2016
Checked by	PH
Date	16/02/2016
Approved by	PH
Date	16/02/2016

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-1
Unit	E5b (Tongeren)
Test number	CSS23

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	400
Vertical strain	[%]	1.54
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.629
Moisture content	[%]	23.7

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	400
Mean τ_{av}	[kPa]	2
Mean τ_{cy}	[kPa]	111
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	1
γ_{av} at N_f	[%]	-4.24
γ_{cy} at N_f	[%]	8.00
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	164
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-4.24	8.00	1.39	24.49

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-1
Unit	E5b (Tongeren)
Test number	CSS23

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	89
Shear strain	[%]	28.07
Shear induced $-\Delta\sigma_v$	[kPa]	250
Vertical stress	[kPa]	150
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.06
At 15 % shear strain		
Shear stress	[kPa]	79
Shear induced $-\Delta\sigma_v$	[kPa]	267
Vertical stress	[kPa]	133
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-1
Unit	E5b (Tongeren)
Test number	CSS23

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

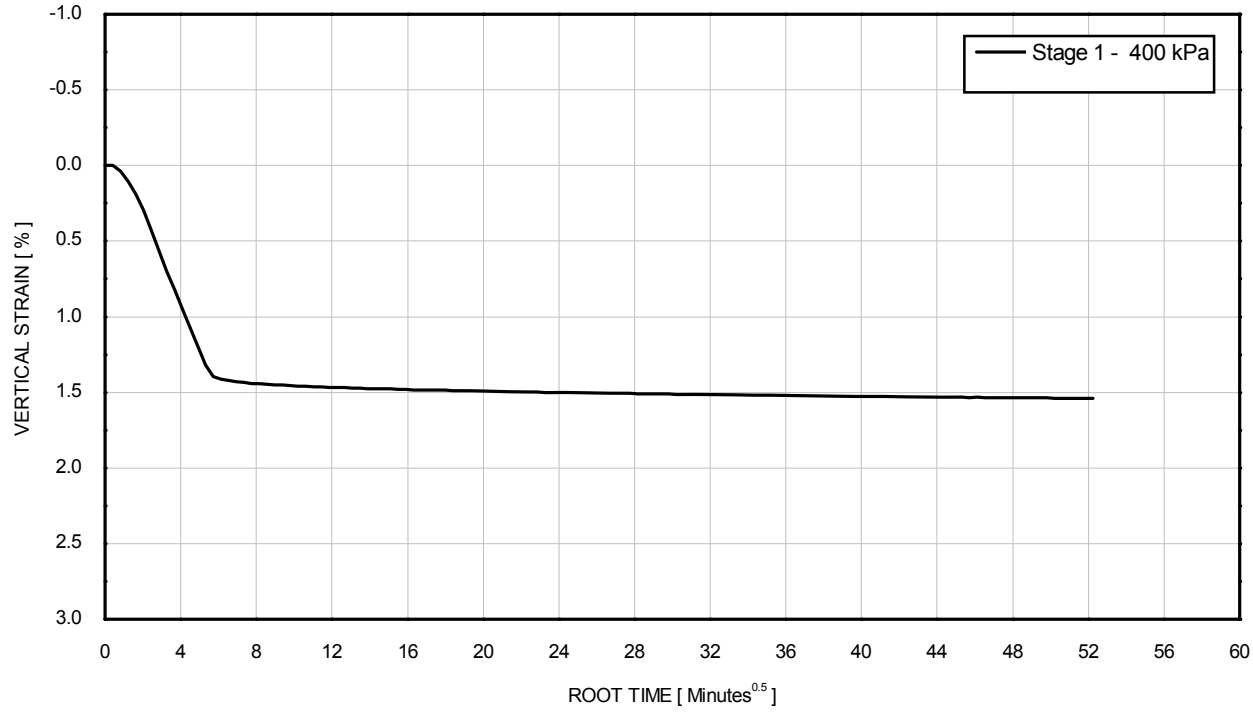
SPECIMEN PHOTOGRAPH

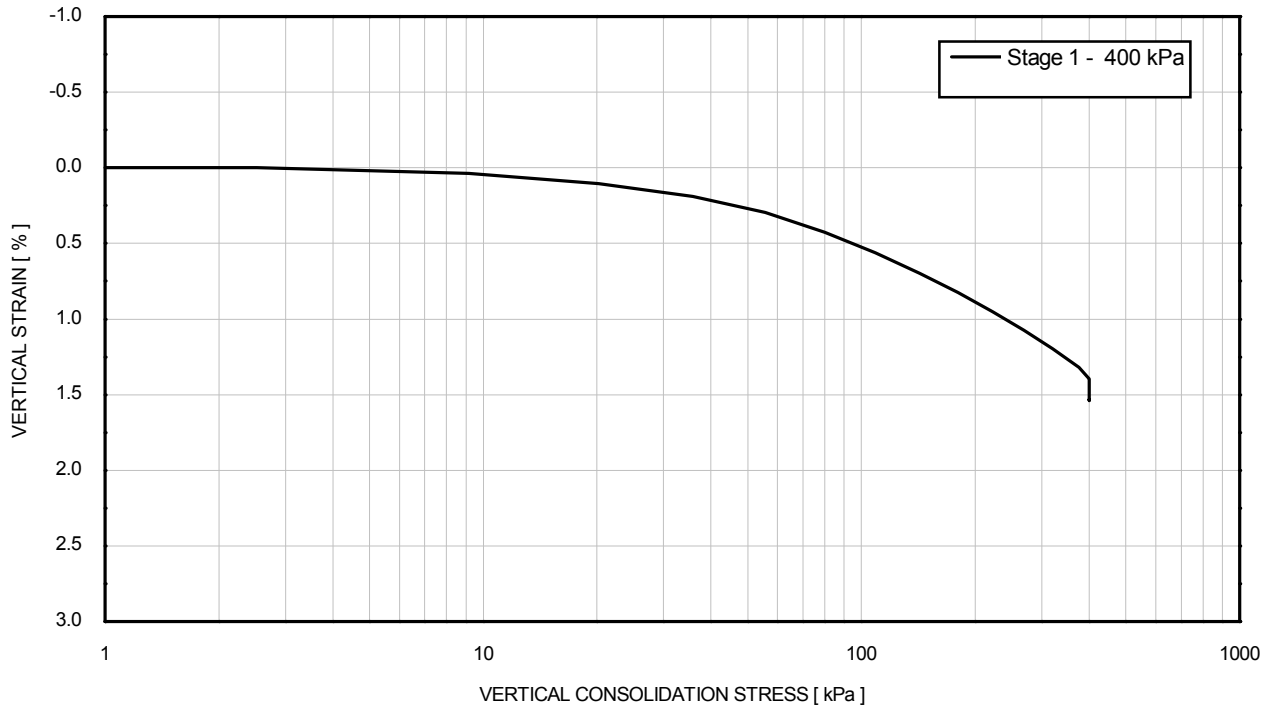


TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-1
Unit	E5b (Tongeren)
Test number	CSS23

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

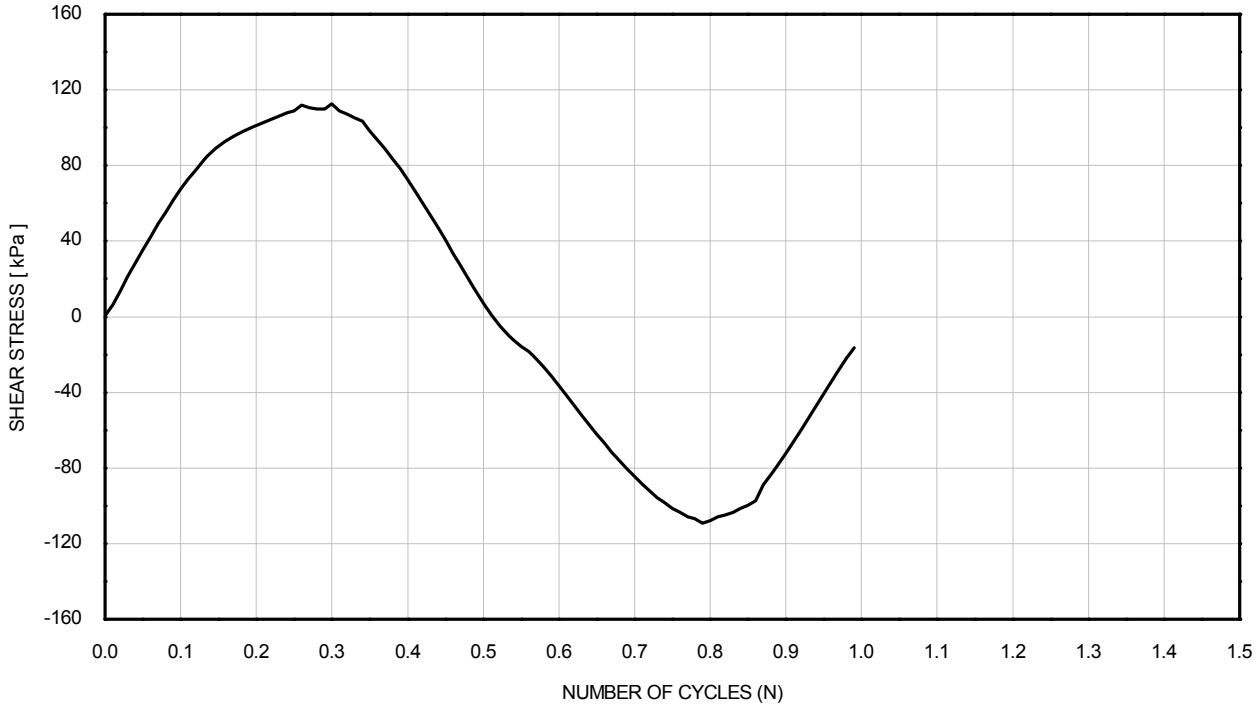


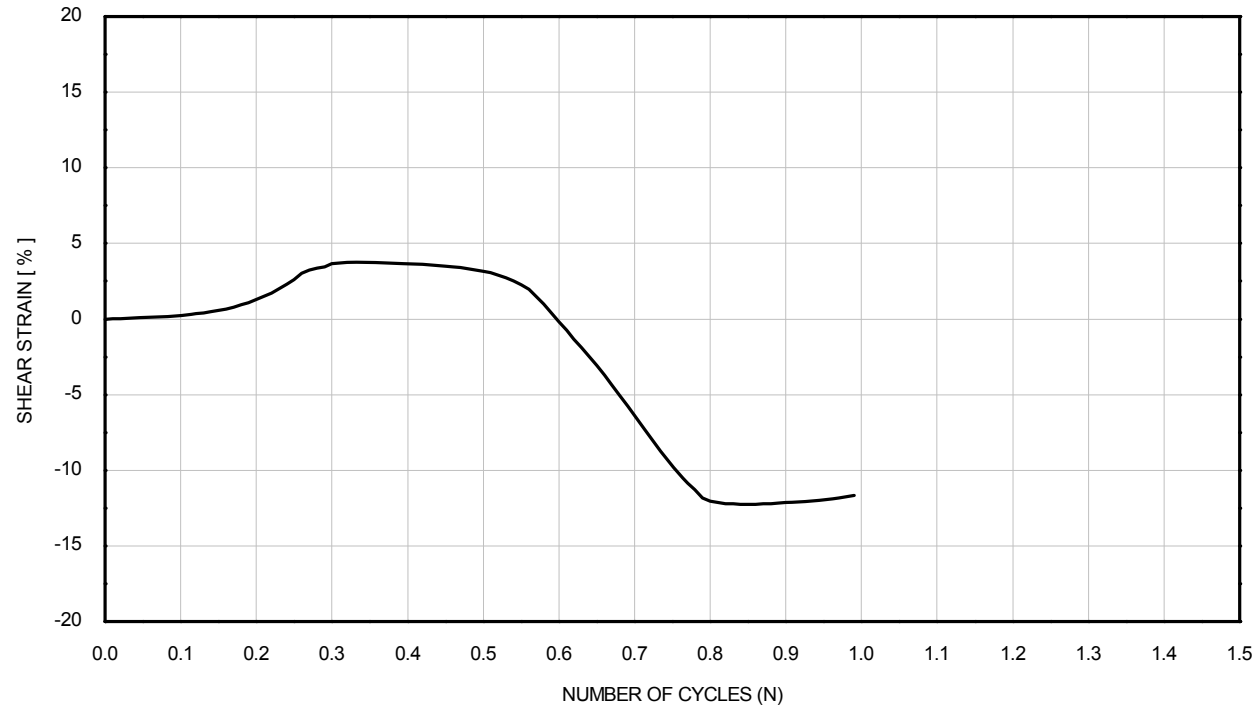


σ_{vc}	: 400 kPa	Batch	: 4
		Sample	: CSS_4-1
		Unit	: E5b (Tongeren)
		Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

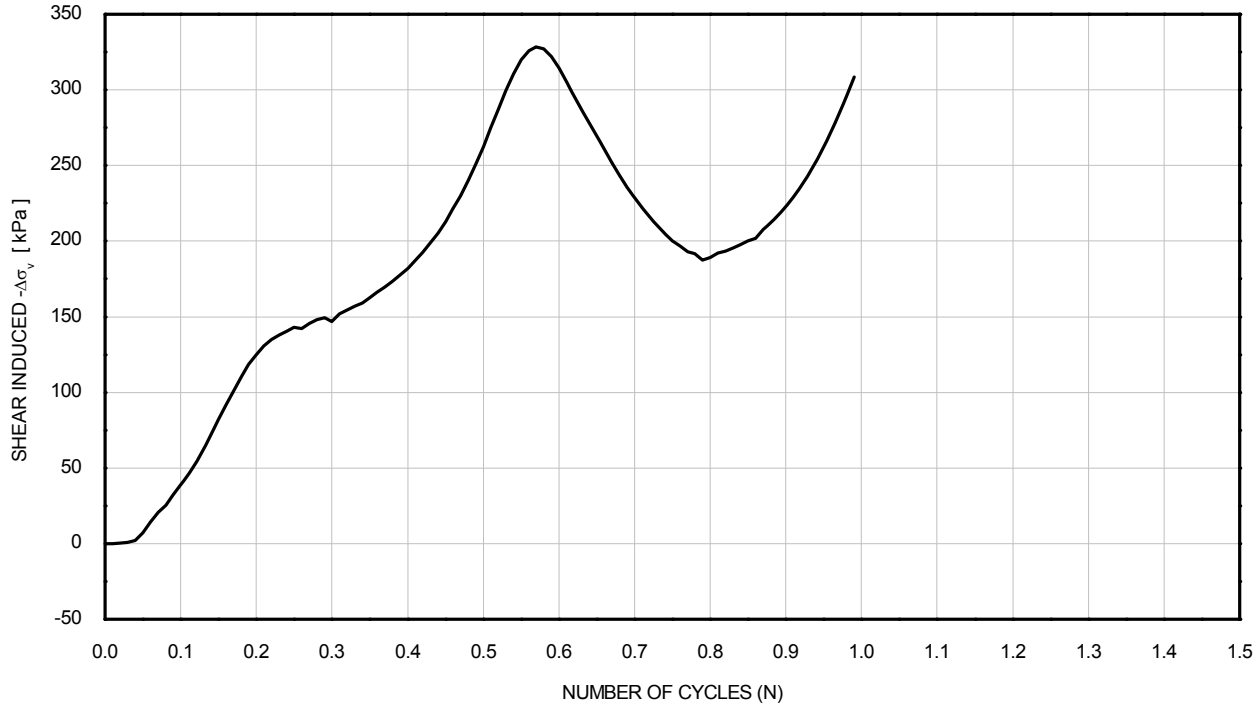


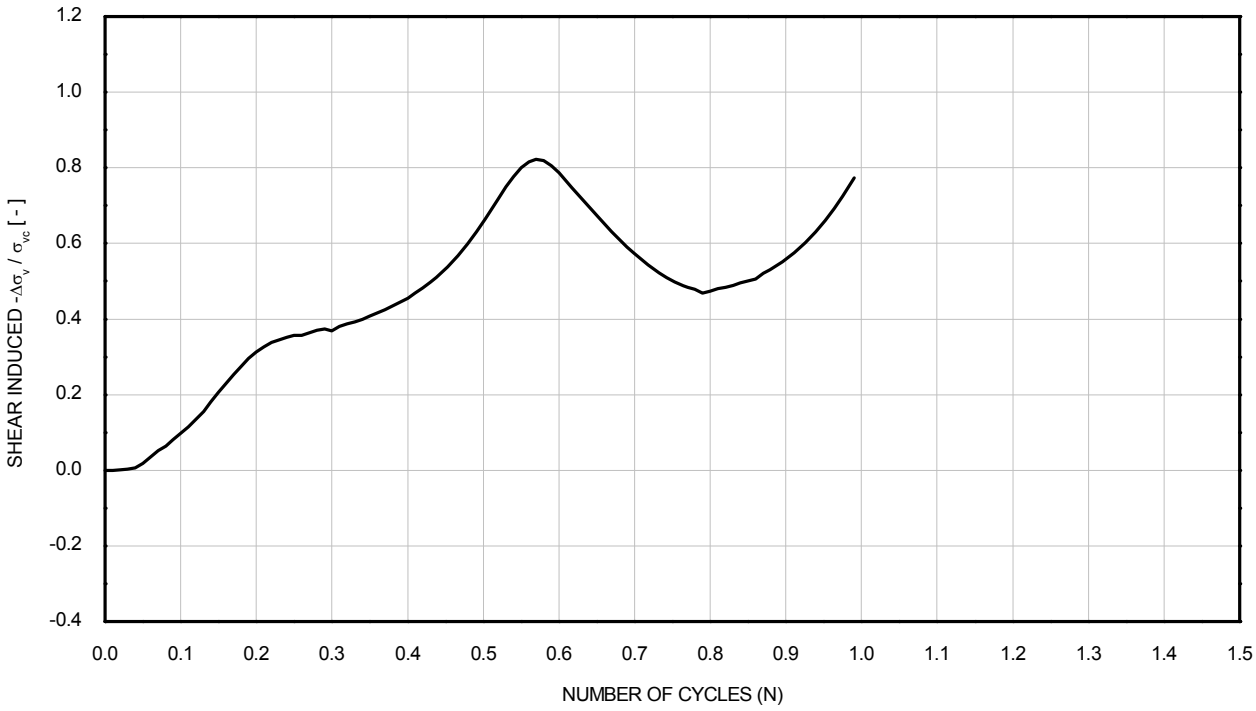


σ_{vc}	: 400	kPa	Batch	: 4
Mean τ_{av}	: 2	kPa	Sample	: CSS_4-1
Mean τ_{cy}	: 111	kPa	Unit	: E5b (Tongeren)
Frequency	: 0.10	Hz	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

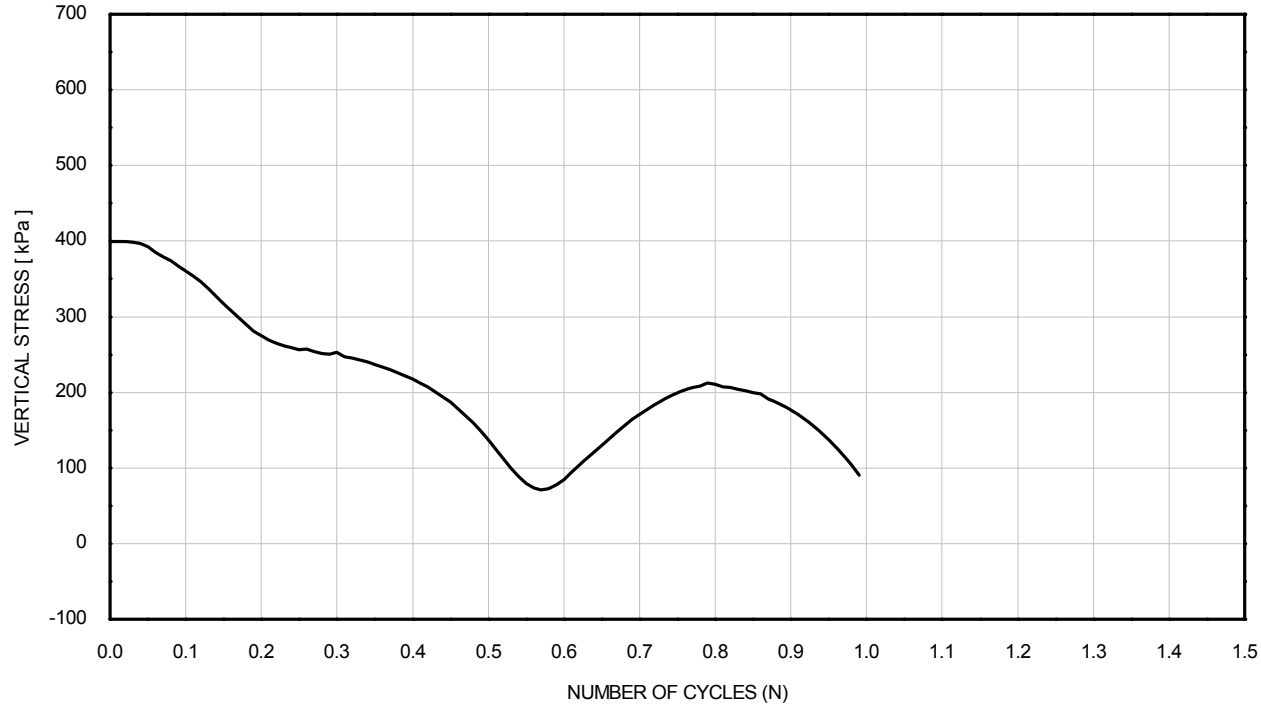


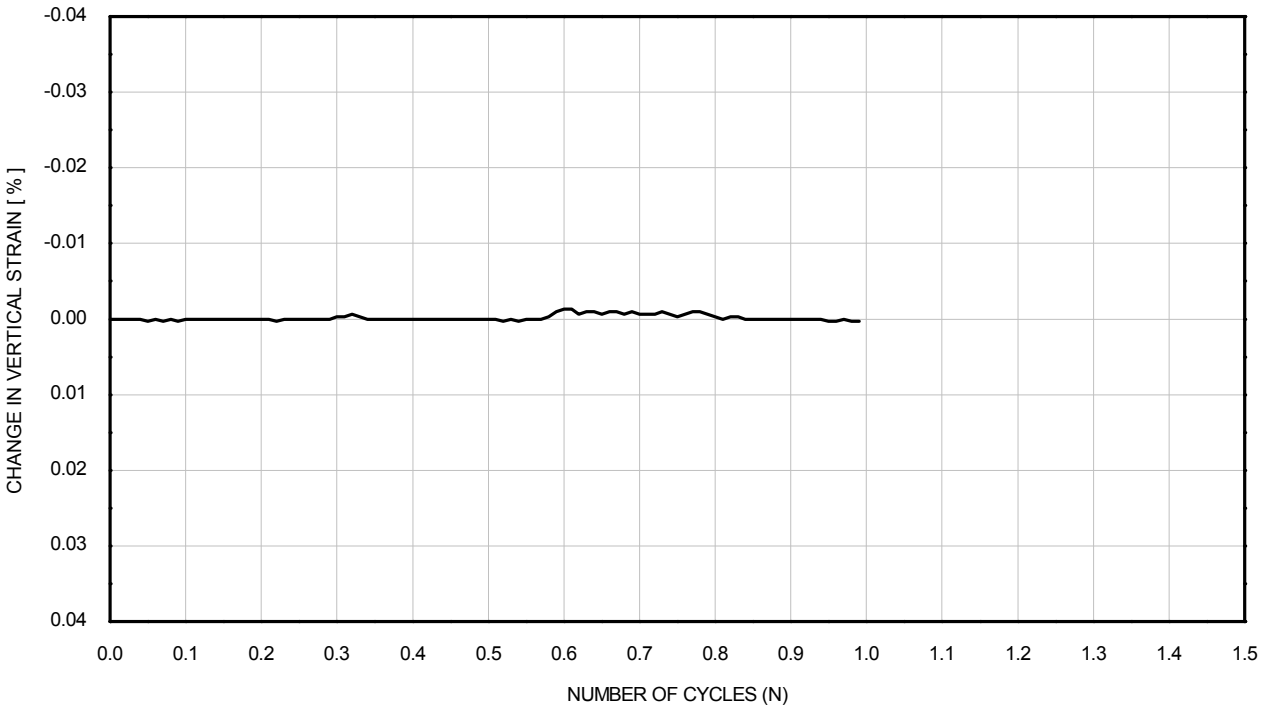


σ_{vc}	:	400 kPa	Batch	: 4
Mean τ_{av}	:	2 kPa	Sample	: CSS_4-1
Mean τ_{cy}	:	111 kPa	Unit	: E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

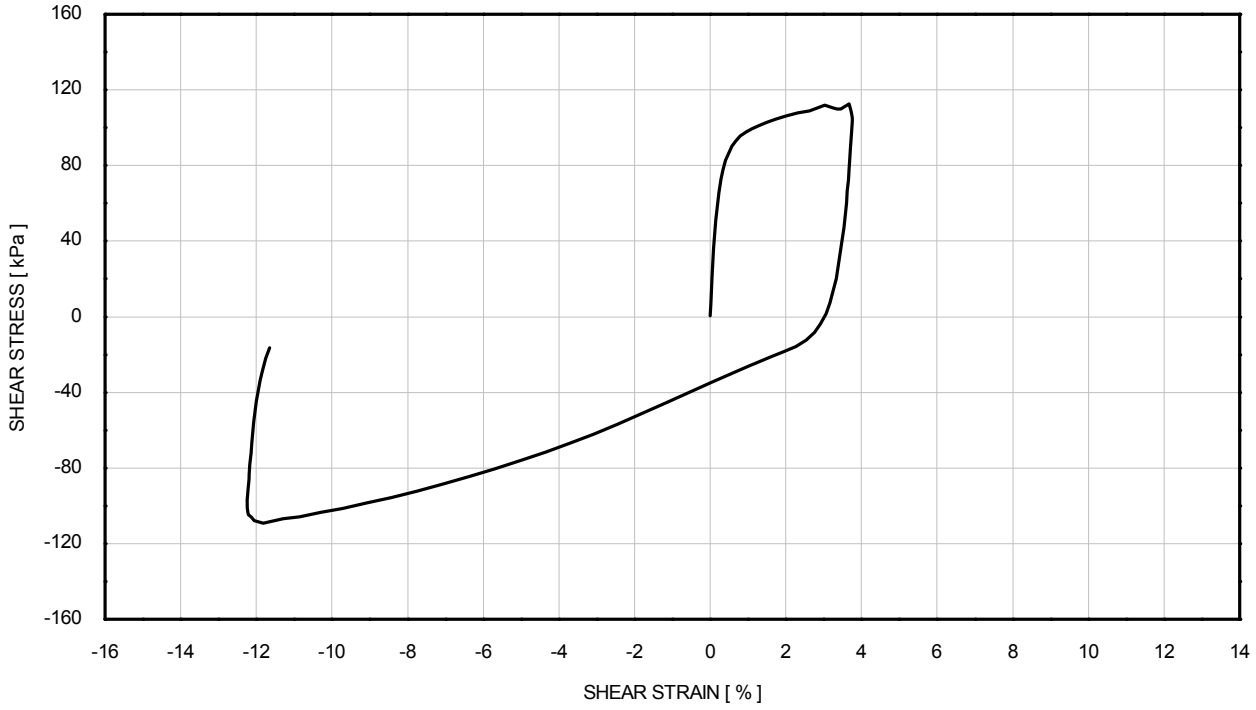


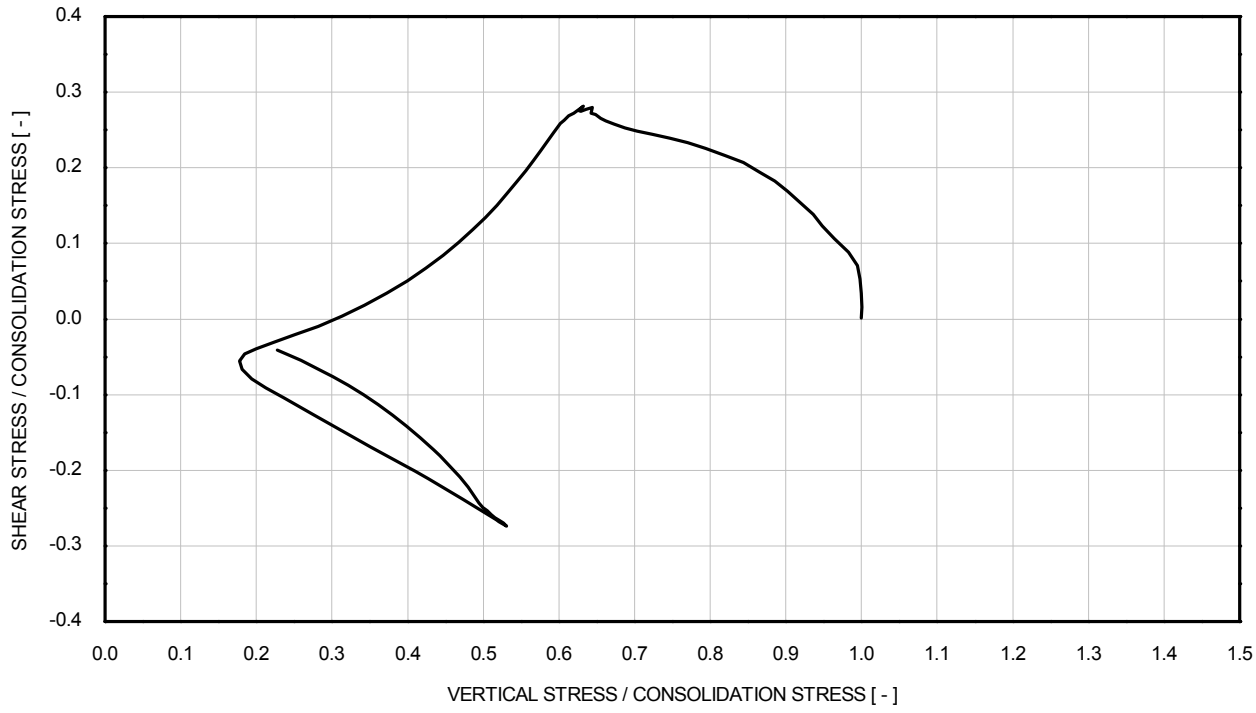


σ_{vc}	: 400	kPa	Batch	: 4
Mean τ_{av}	: 2	kPa	Sample	: CSS_4-1
Mean τ_{cy}	: 111	kPa	Unit	: E5b (Tongeren)
Frequency	: 0.10	Hz	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

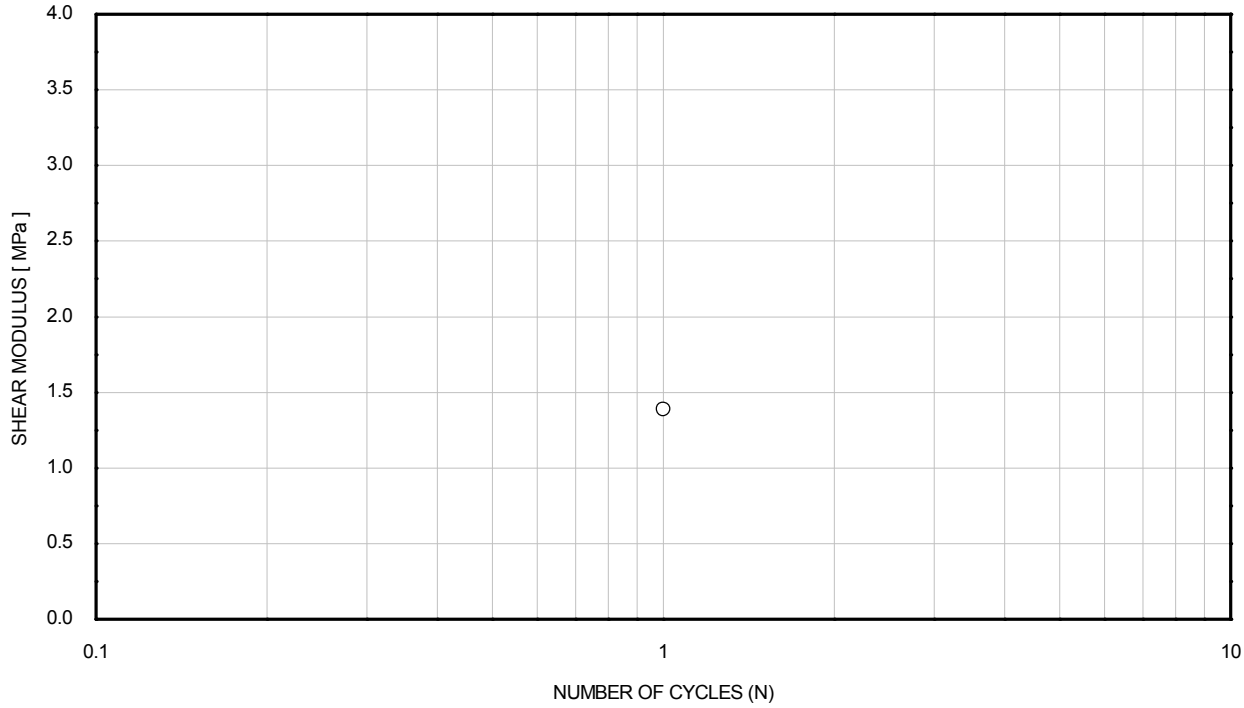


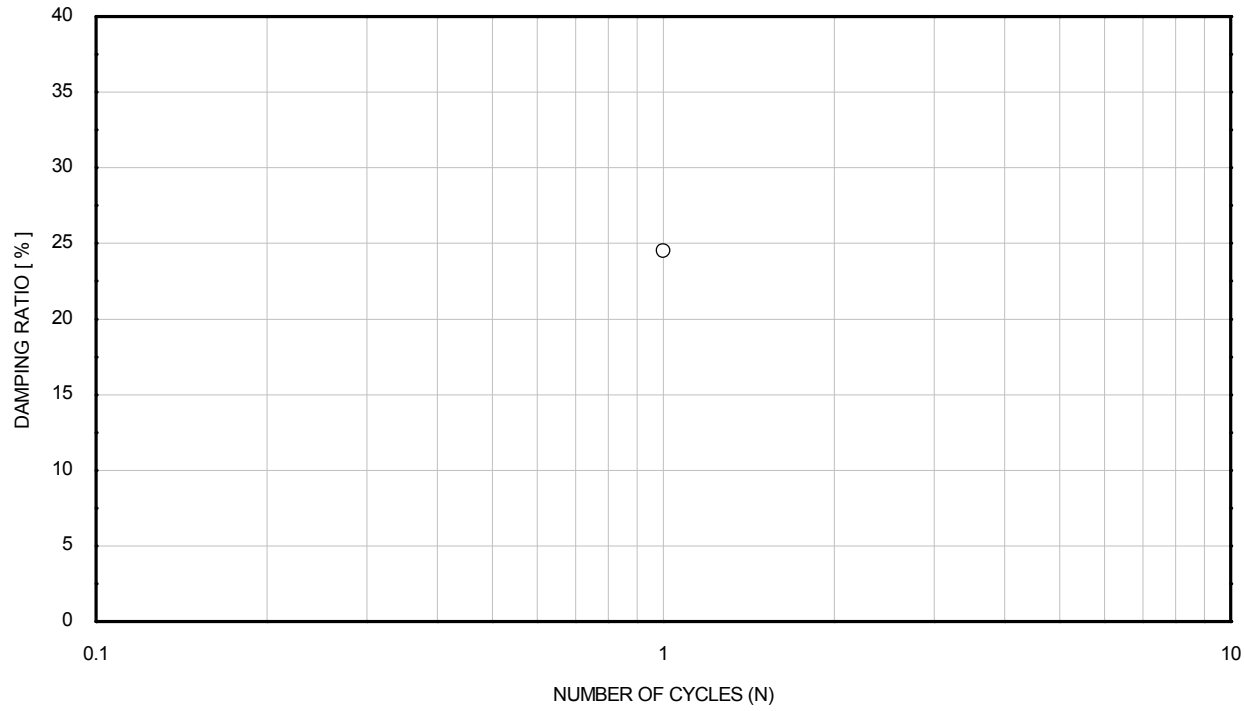


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	2 kPa	Sample	:	CSS_4-1
Mean τ_{cy}	:	111 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS23

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

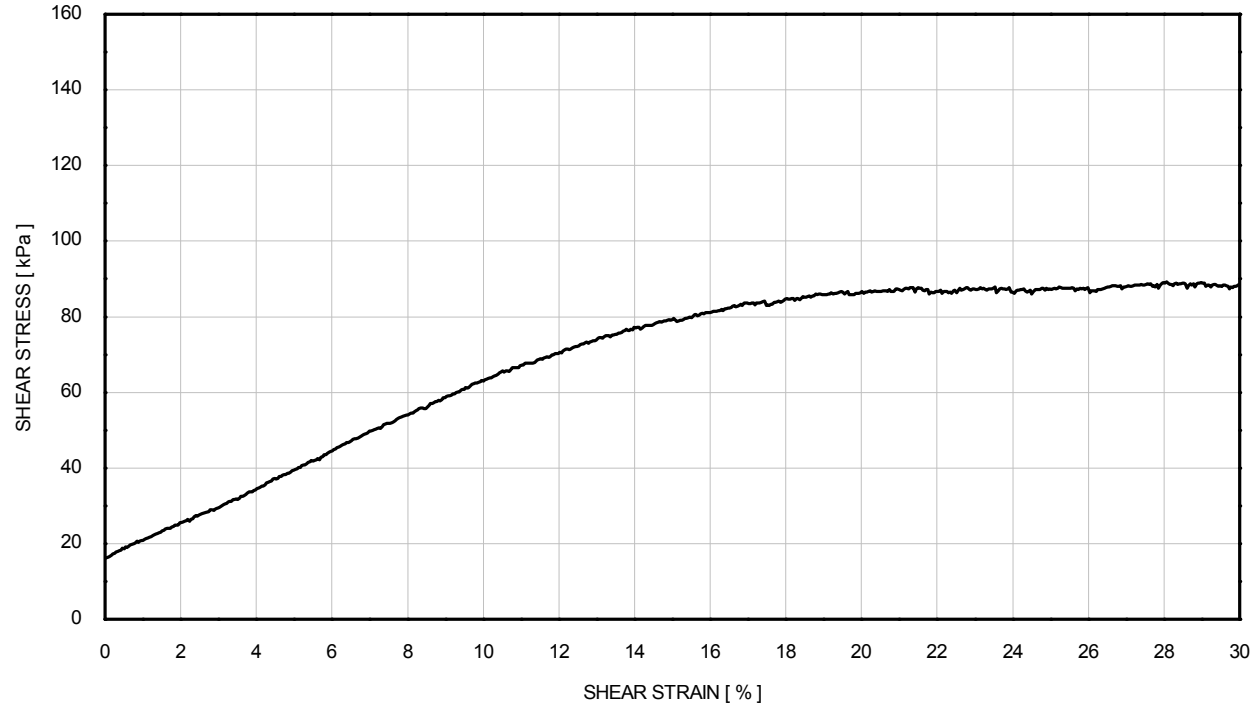


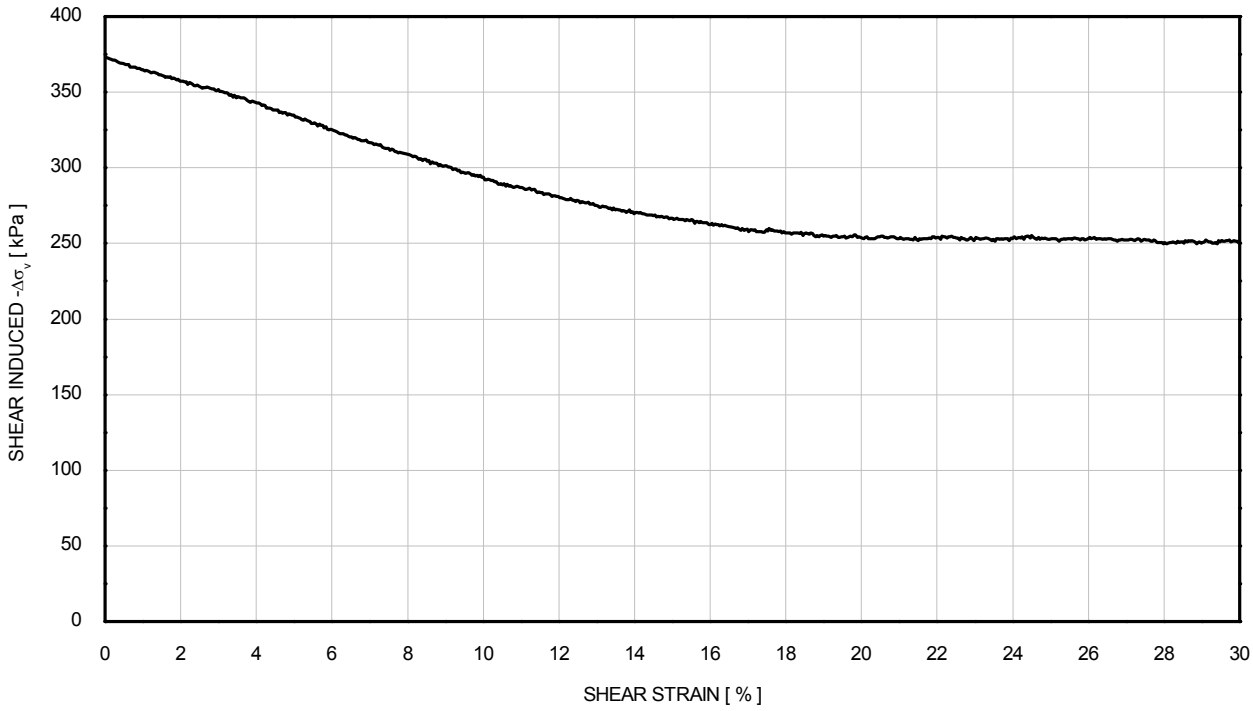


σ_{vc}	: 400 kPa	Batch	: 4
Mean τ_{av}	: 2 kPa	Sample	: CSS_4-1
Mean τ_{cy}	: 111 kPa	Unit	: E5b (Tongeren)
Frequency	: 0.10 Hz	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

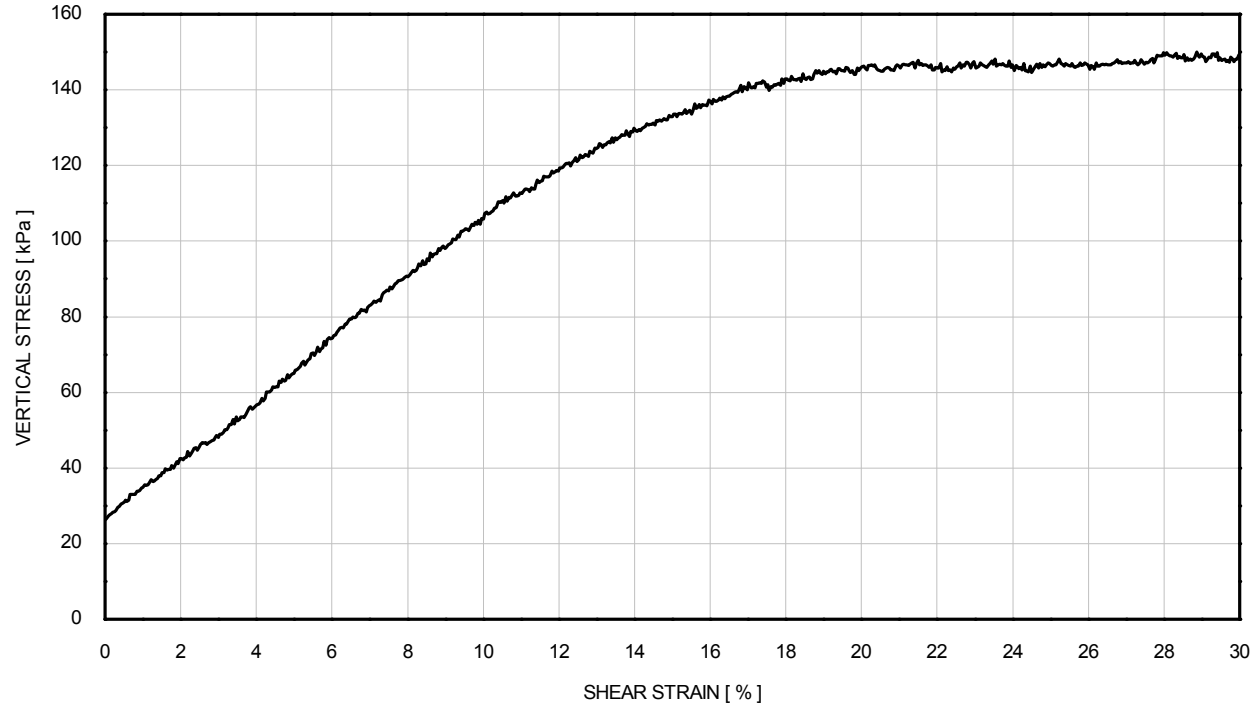


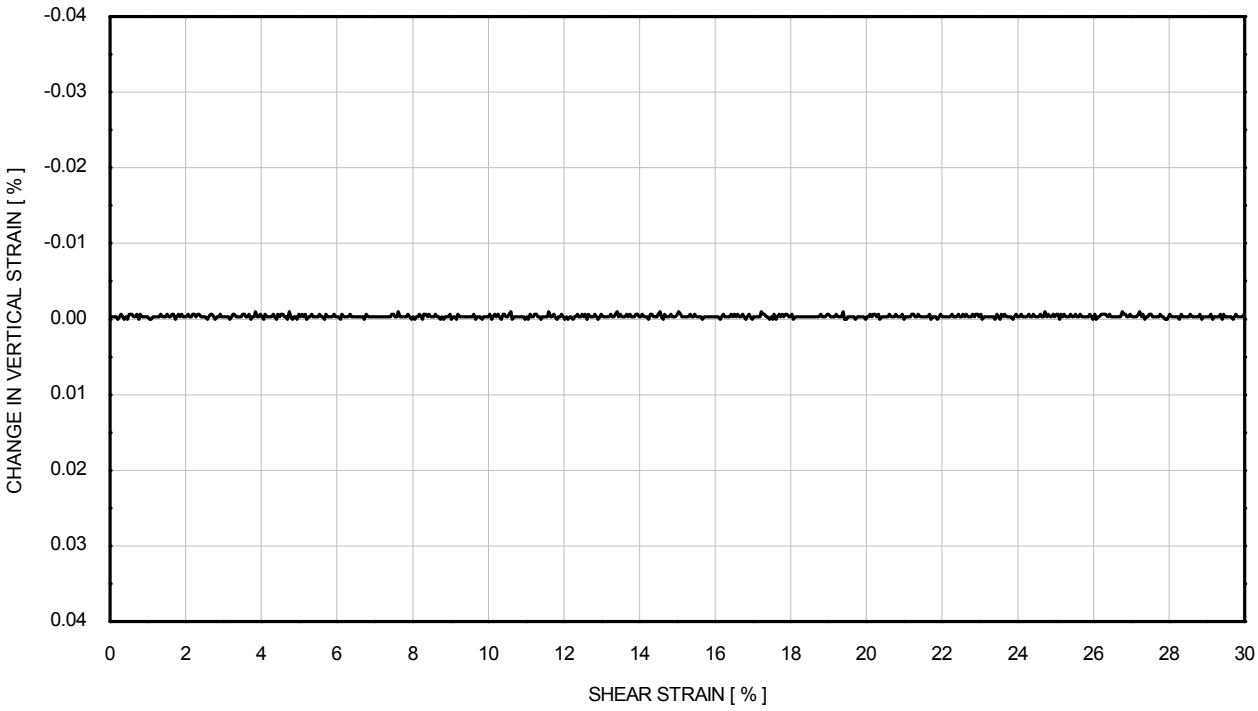


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 89 kPa	Sample	: CSS_4-1
γ at τ_{peak}	: 28.07 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.06 %/hour	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

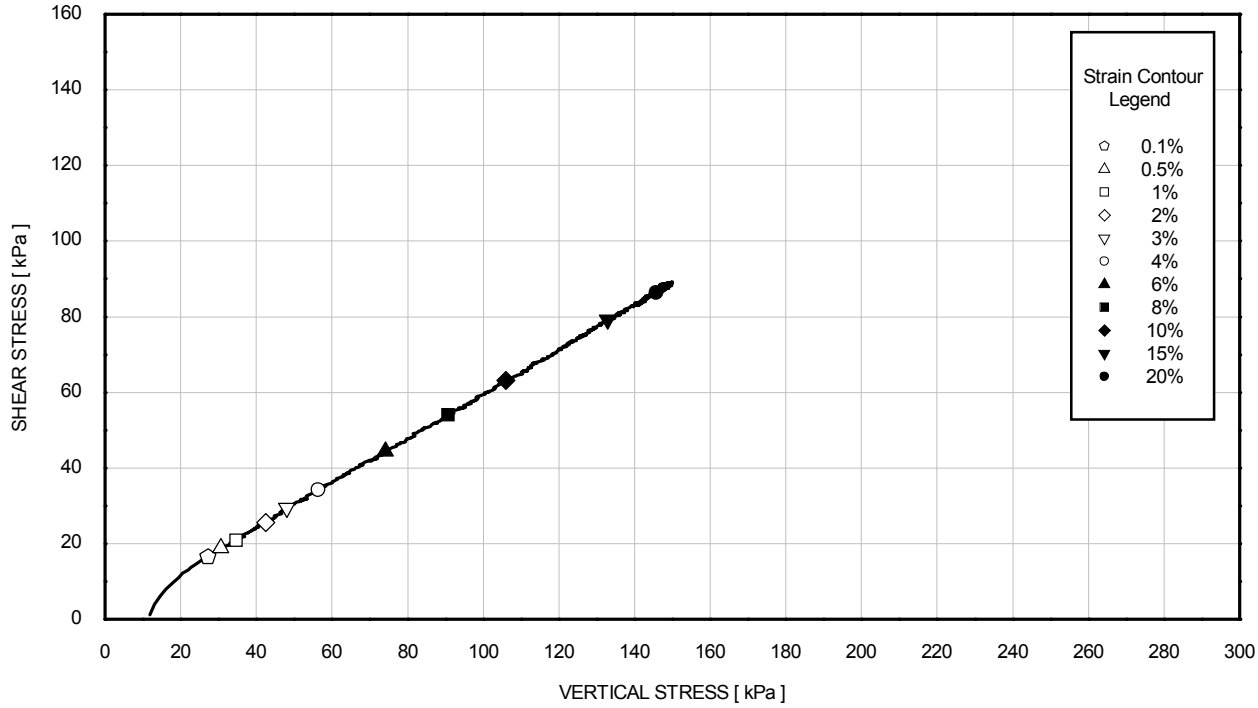


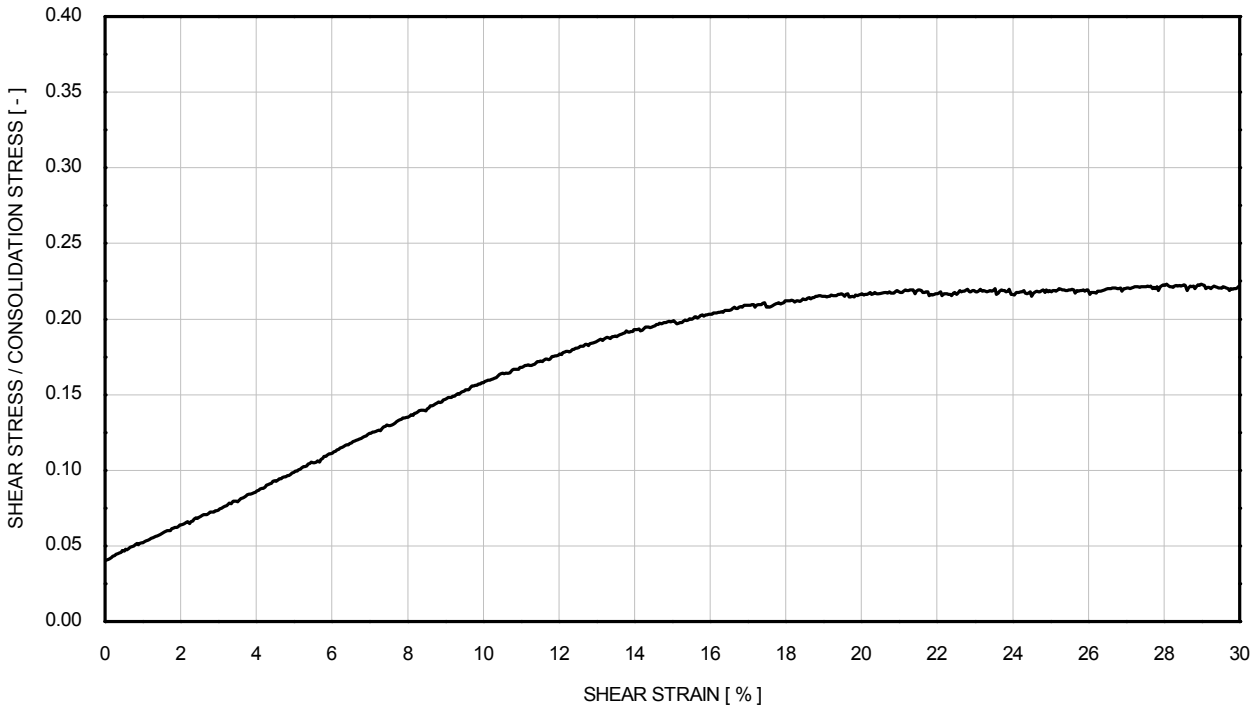


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 89 kPa	Sample	: CSS_4-1
γ at τ_{peak}	: 28.07 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.06 %/hour	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

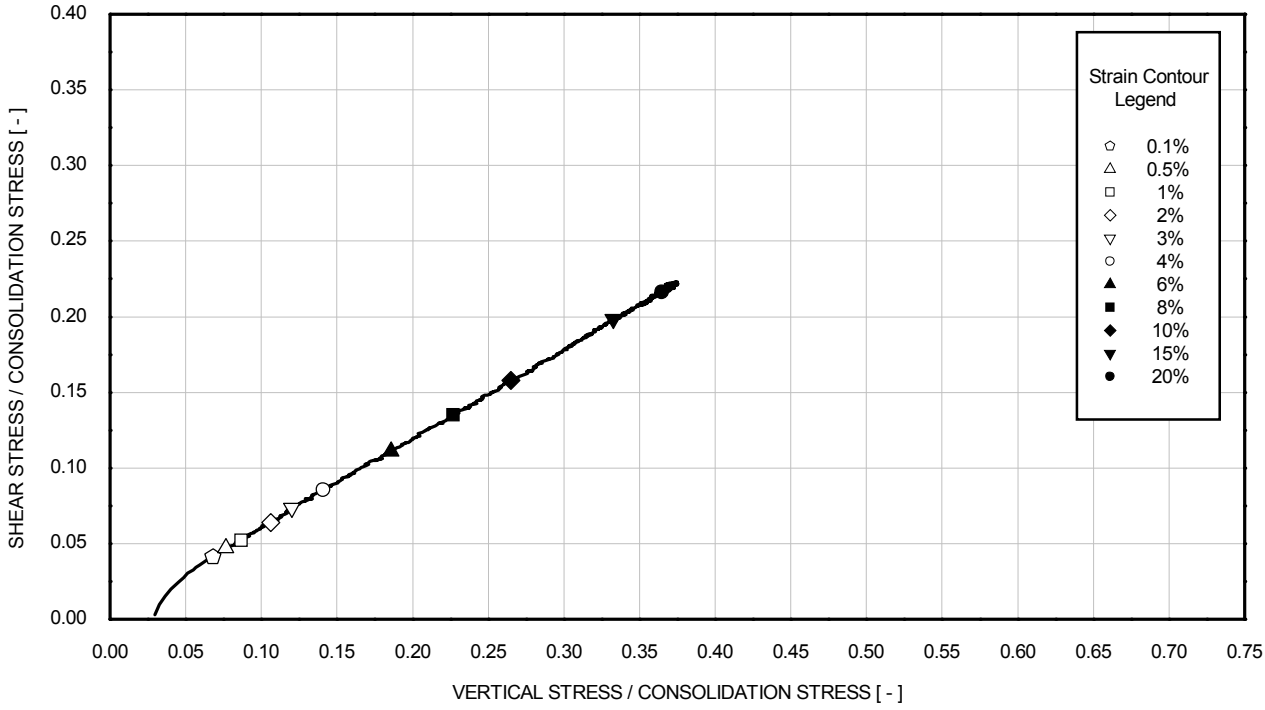


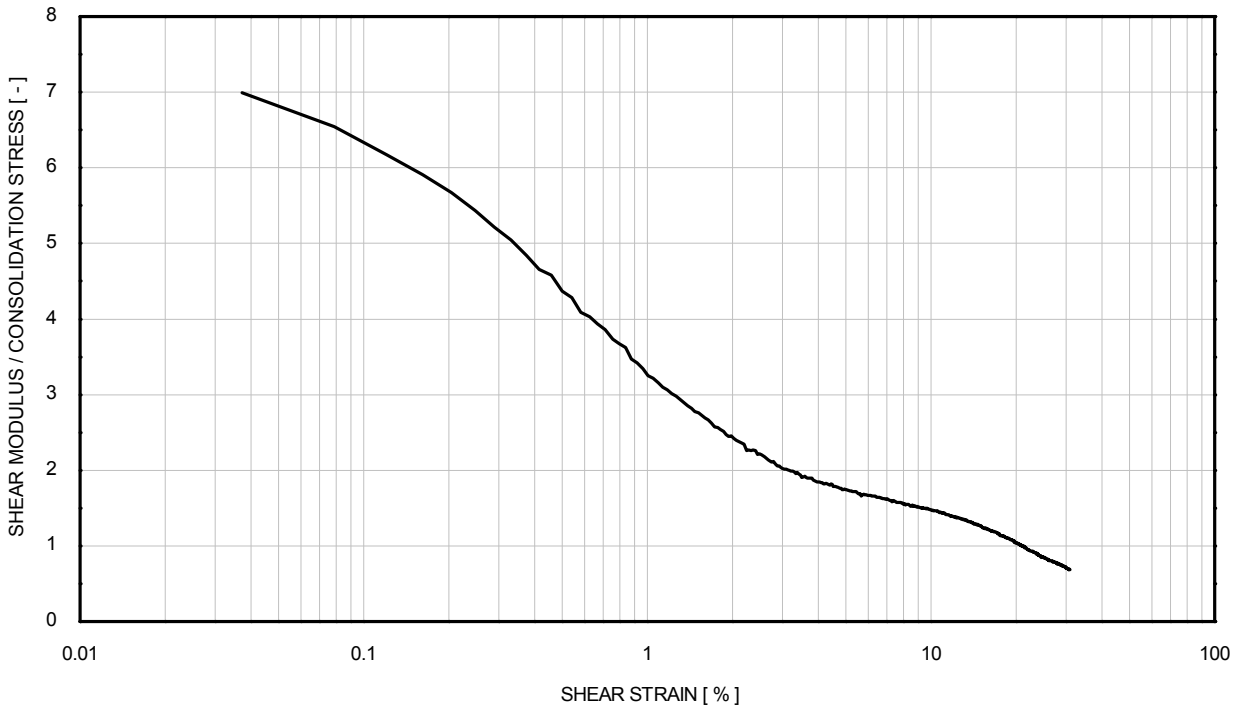


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 89 kPa	Sample	: CSS_4-1
γ at τ_{peak}	: 28.07 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.06 %/hour	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 89 kPa	Sample	: CSS_4-1
γ at τ_{peak}	: 28.07 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.06 %/hour	Test No.	: CSS23

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	13/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.4
Length	[mm]	30.0
Moisture content after compaction	[%]	11.0
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.60
Void ratio	[-]	0.661
Degree of saturation after compaction	[%]	44
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.9
Bulk density at start of test	[Mg/m³]	1.99
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 4_CSS 4-2_CSS24
Template issue	1.3
Processed by	HJ
Date	18/02/2016
Checked by	PH
Date	15/03/2016
Approved by	PH
Date	15/03/2016

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-2
Unit	E5b (Tongeren)
Test number	CSS24

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	400
Vertical strain	[%]	2.23
Bulk density	[Mg/m^3]	2.02
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.624
Moisture content	[%]	23.5

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	400
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	59
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	5
γ_{av} at N_f	[%]	-0.39
γ_{cy} at N_f	[%]	1.47
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	283
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.01	0.36	16.35	11.68
2	0.00	0.40	15.00	11.76
3	-0.01	0.46	12.80	13.78
4	-0.08	0.65	9.08	18.15
5	-0.39	1.47	3.91	23.64

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-2
Unit	E5b (Tongeren)
Test number	CSS24

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	103
Shear strain	[%]	30.66
Shear induced $-\Delta\sigma_v$	[kPa]	231
Vertical stress	[kPa]	169
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.11
At 15 % shear strain		
Shear stress	[kPa]	61
Shear induced $-\Delta\sigma_v$	[kPa]	298
Vertical stress	[kPa]	102
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-2
Unit	E5b (Tongeren)
Test number	CSS24

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

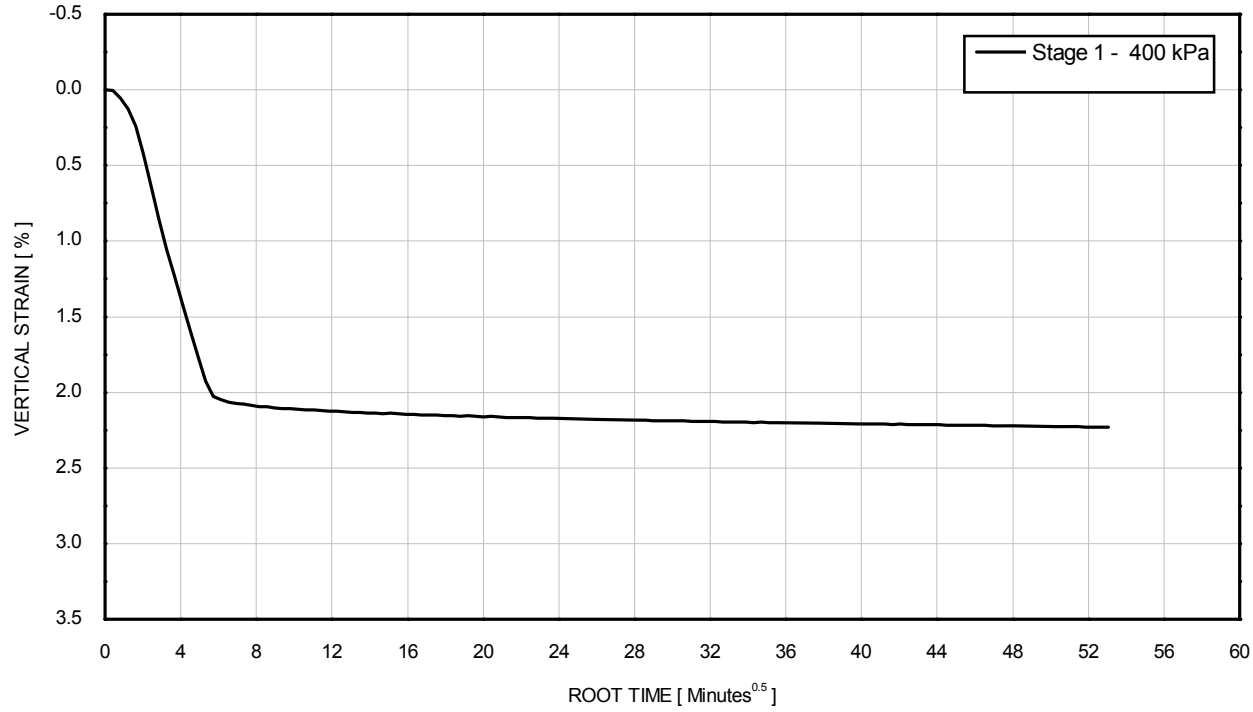
SPECIMEN PHOTOGRAPH

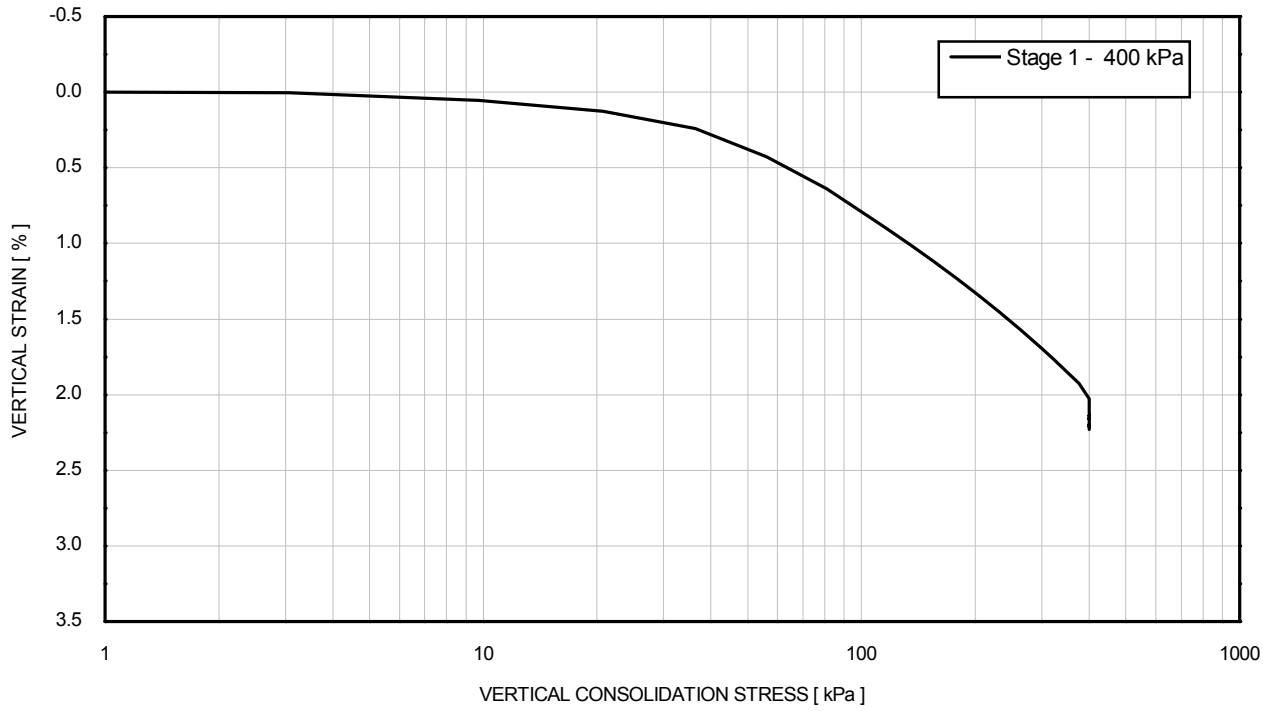


TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-2
Unit	E5b (Tongeren)
Test number	CSS24

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

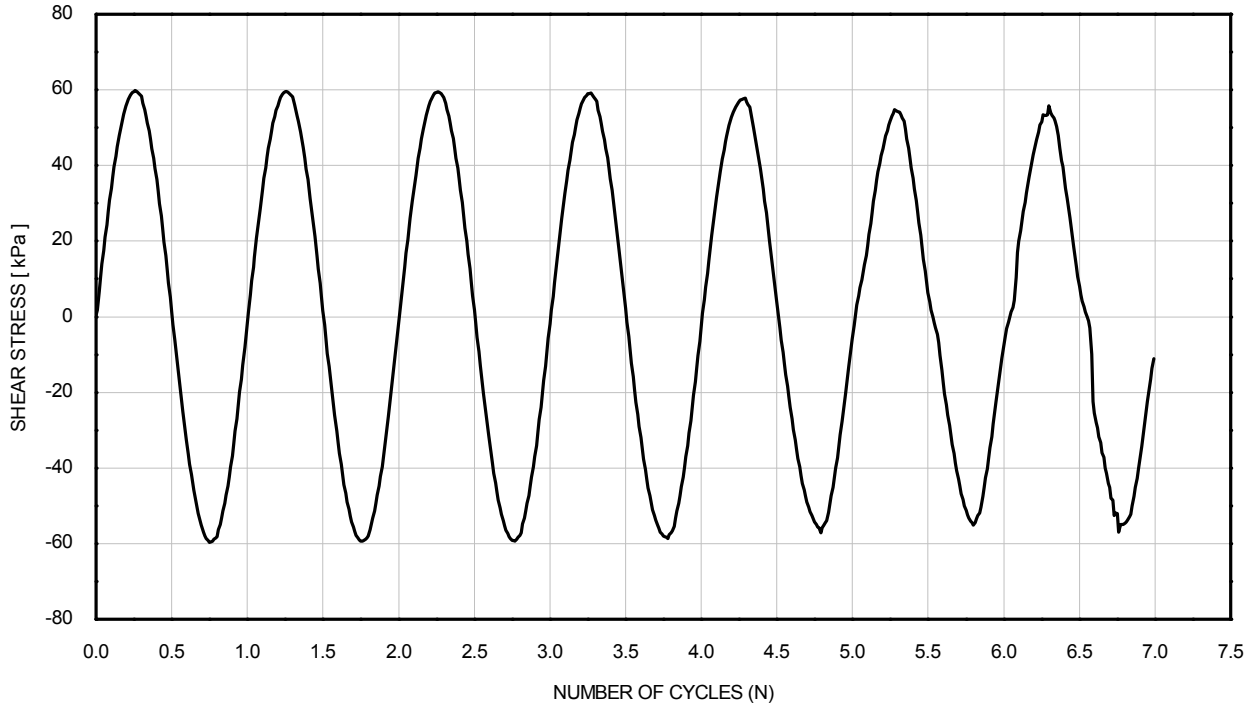


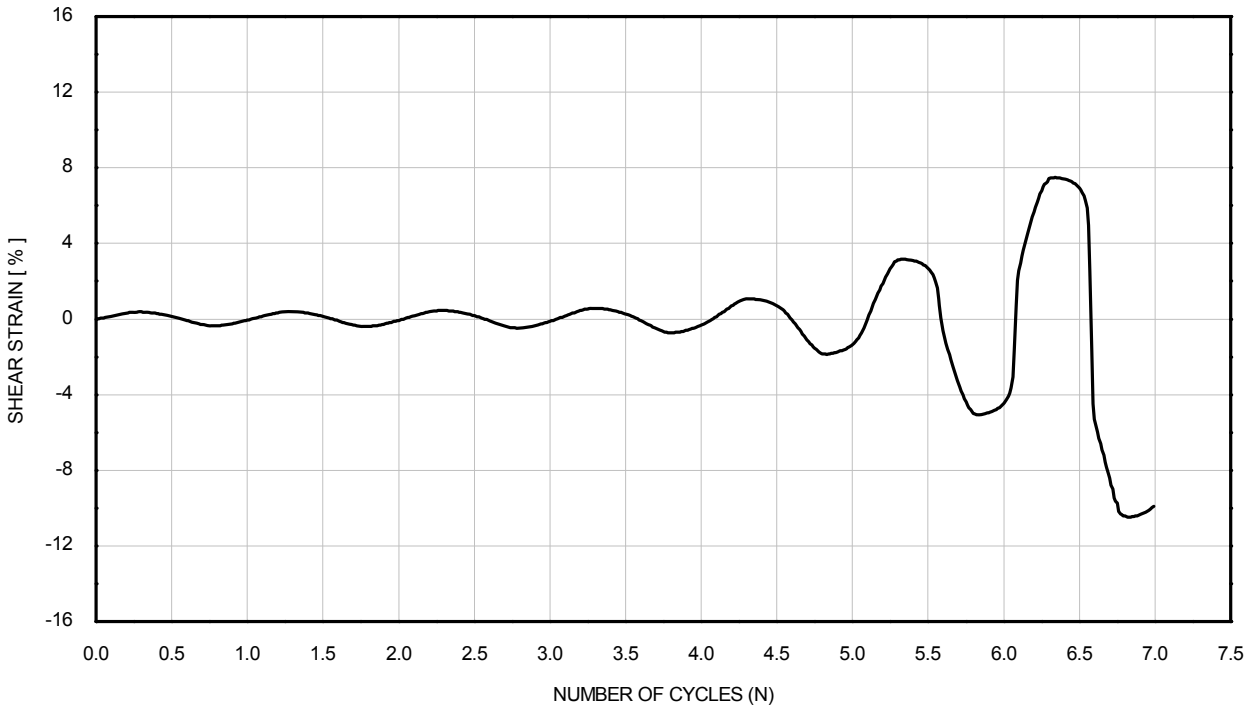


σ_{vc}	: 400 kPa	Batch	: 4
		Sample	: CSS_4-2
		Unit	: E5b (Tongeren)
		Test No.	: CSS24

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

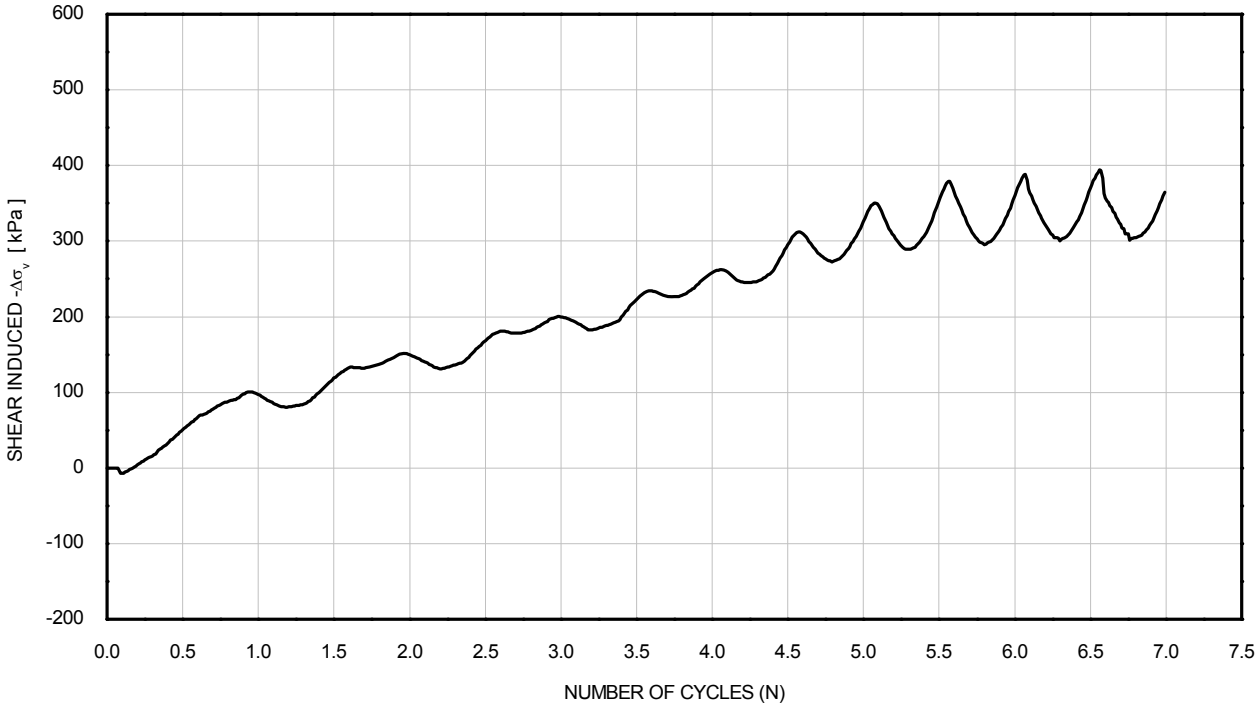


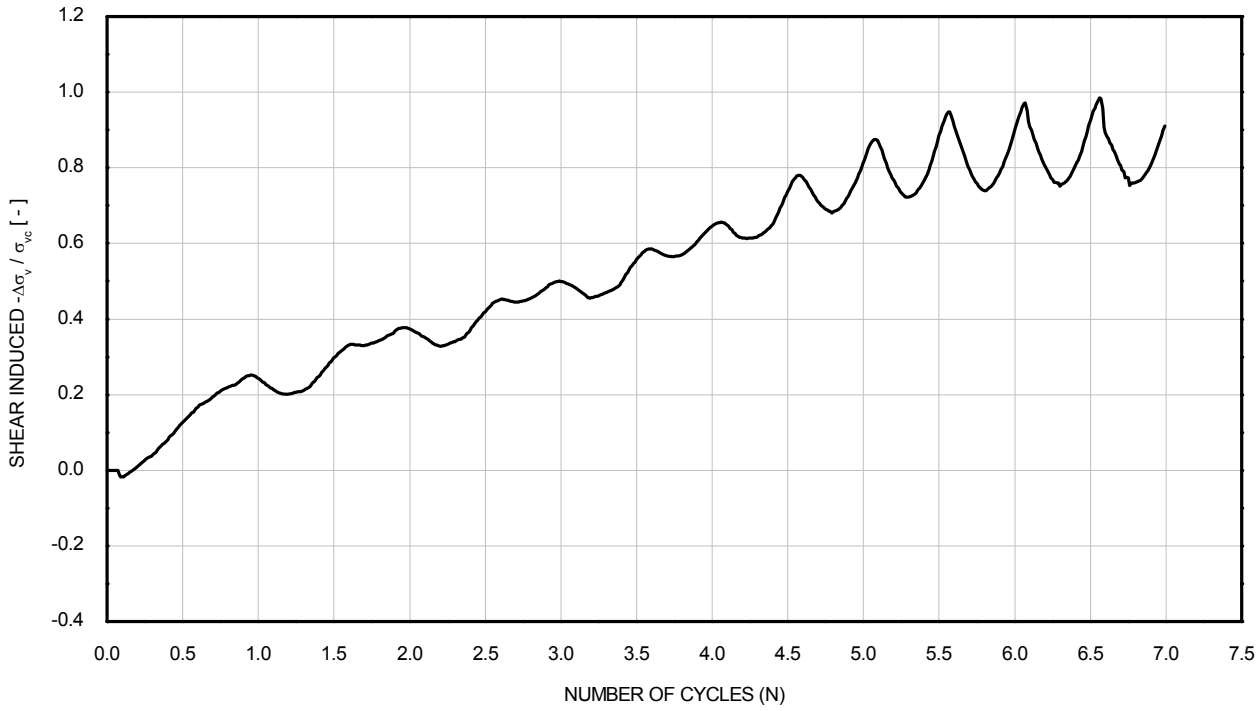


σ_{vc}	:	400 kPa	Batch	: 4
Mean τ_{av}	:	0 kPa	Sample	: CSS_4-2
Mean τ_{cy}	:	59 kPa	Unit	: E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	: CSS24

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

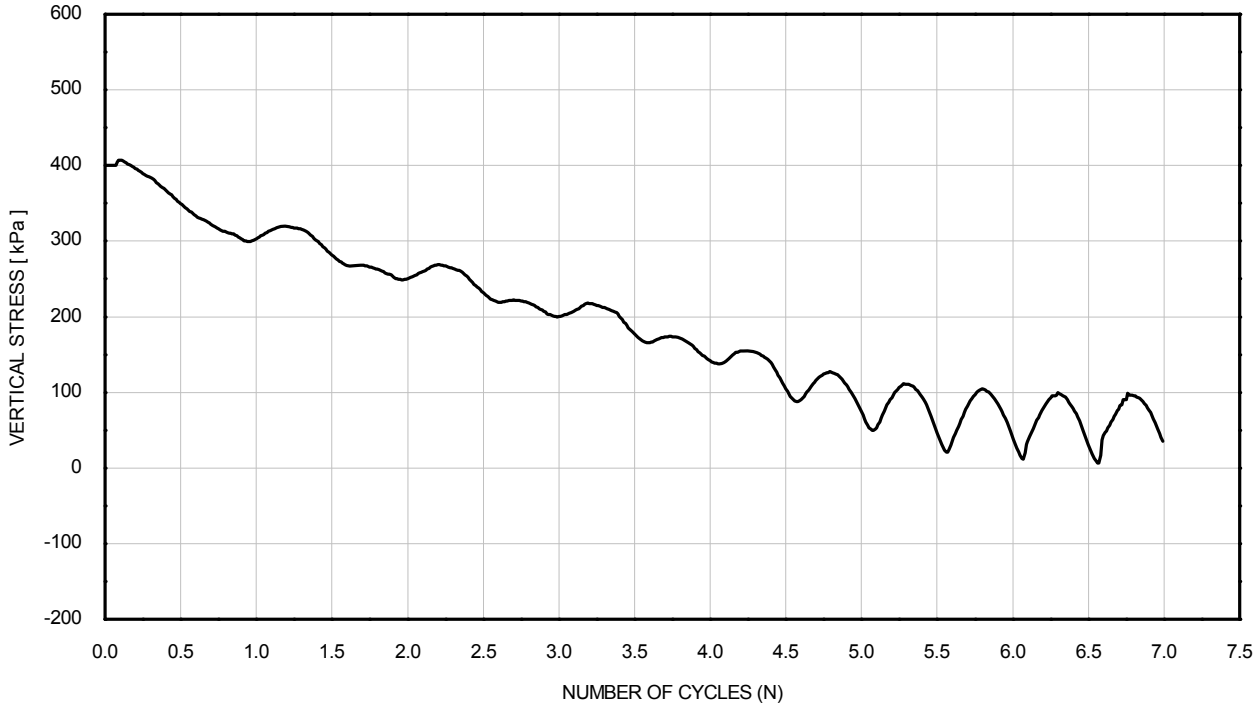


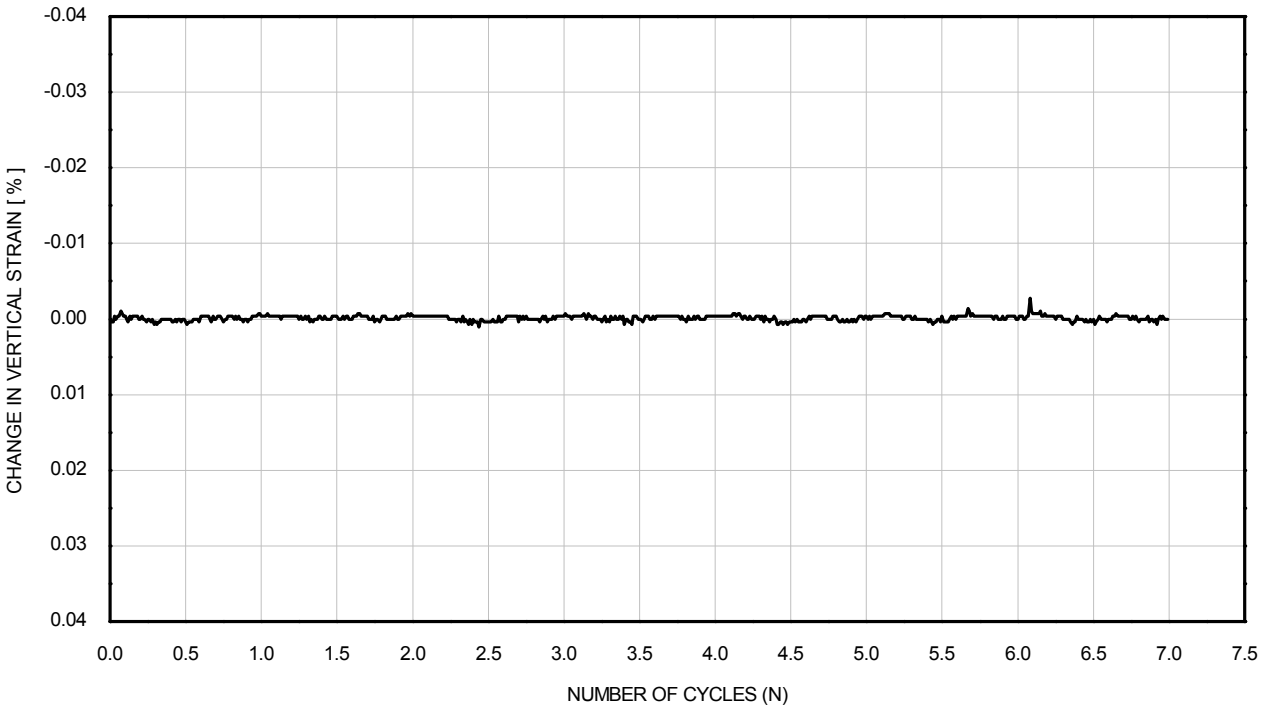


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-2
Mean τ_{cy}	:	59 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS24

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

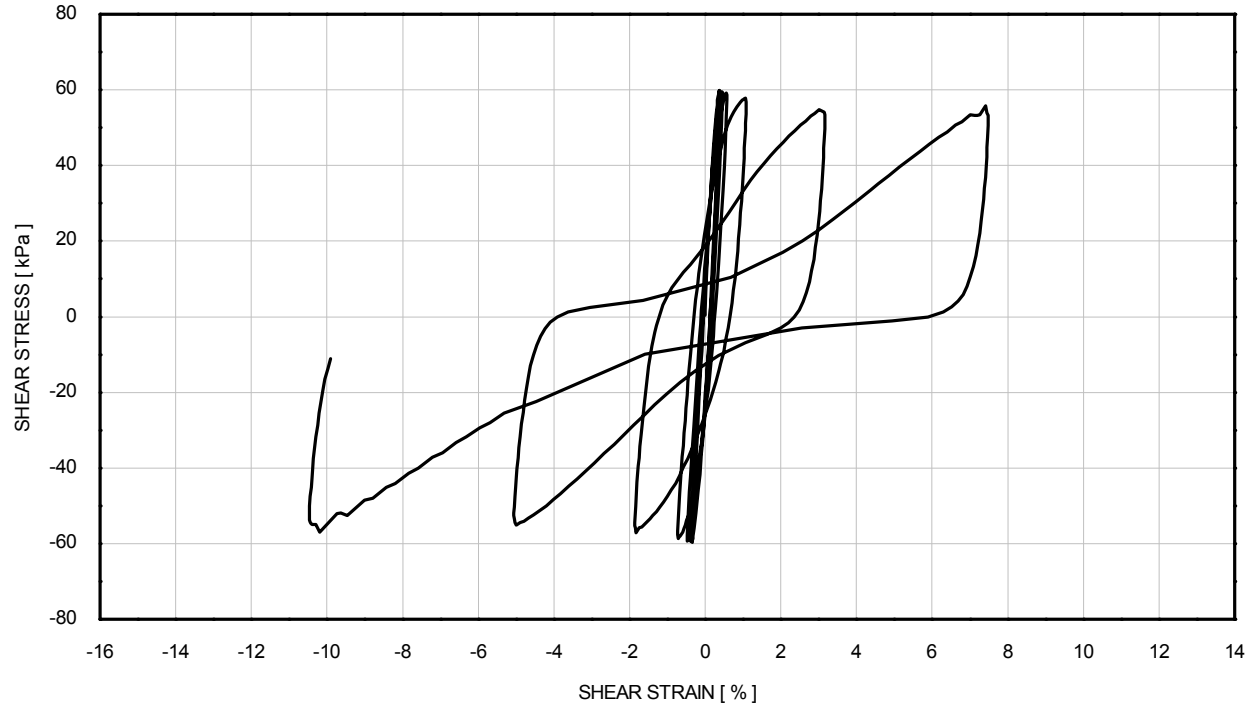


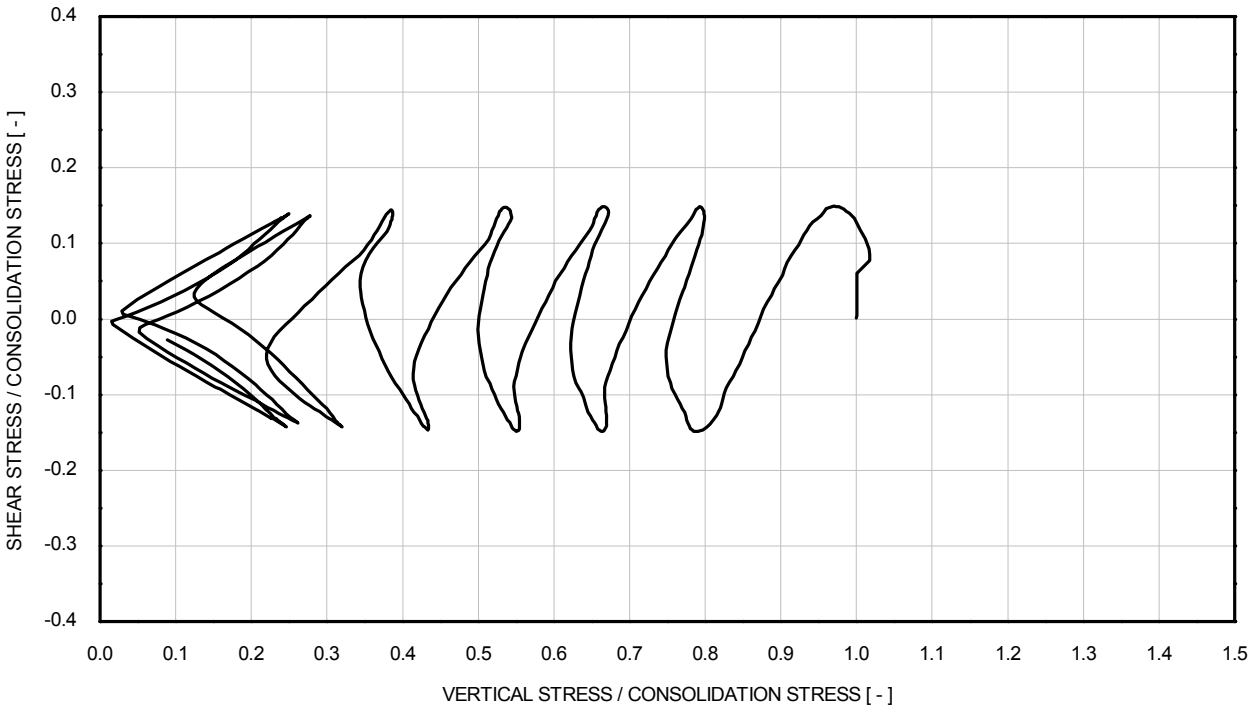


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-2
Mean τ_{cy}	:	59 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS24

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

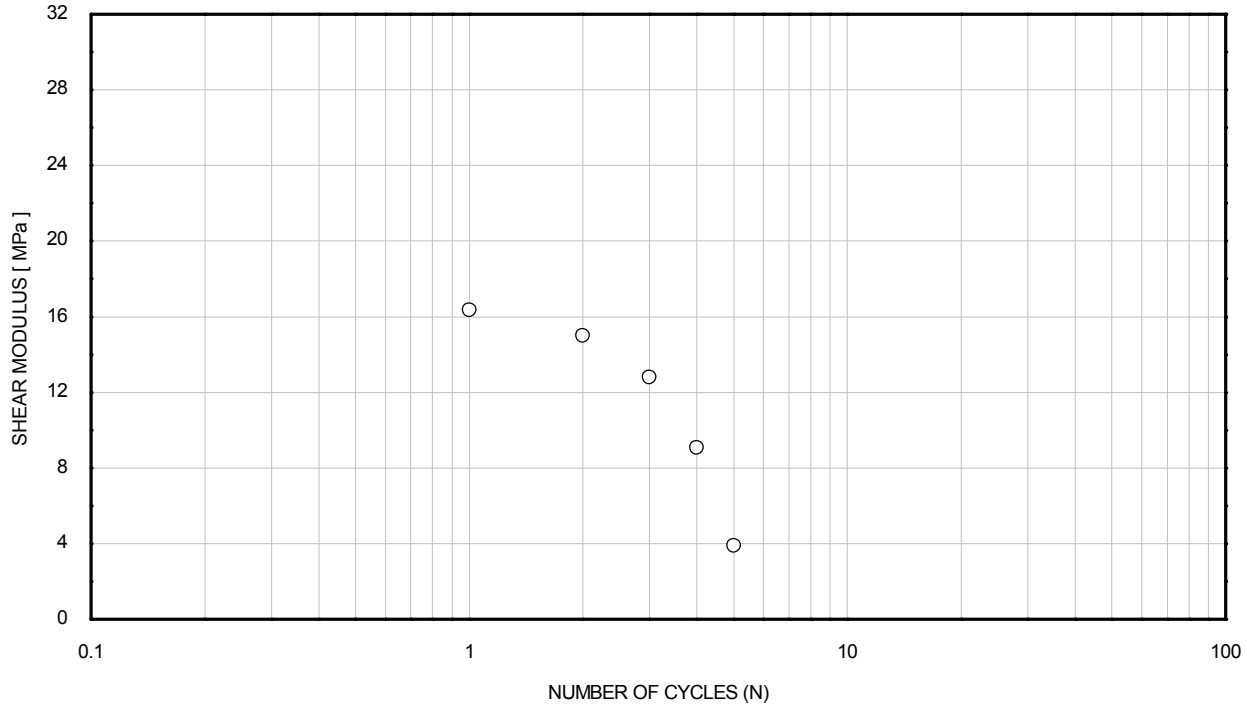


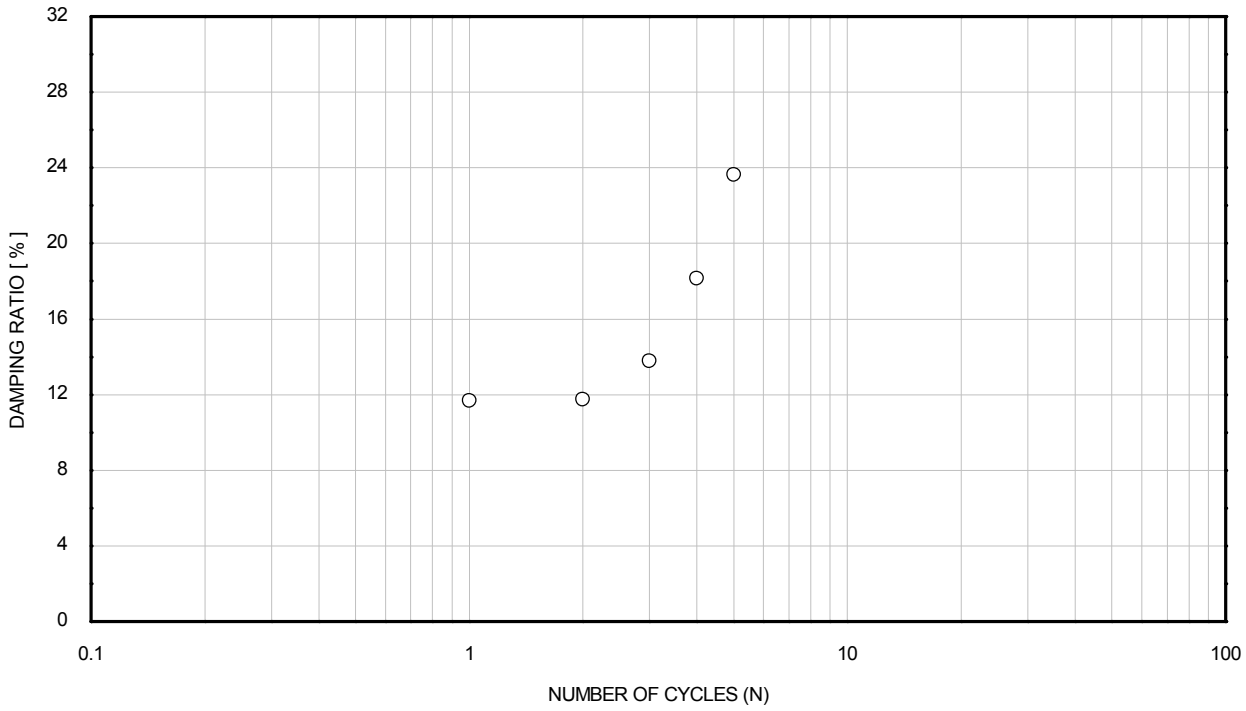


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-2
Mean τ_{cy}	:	59 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS24

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

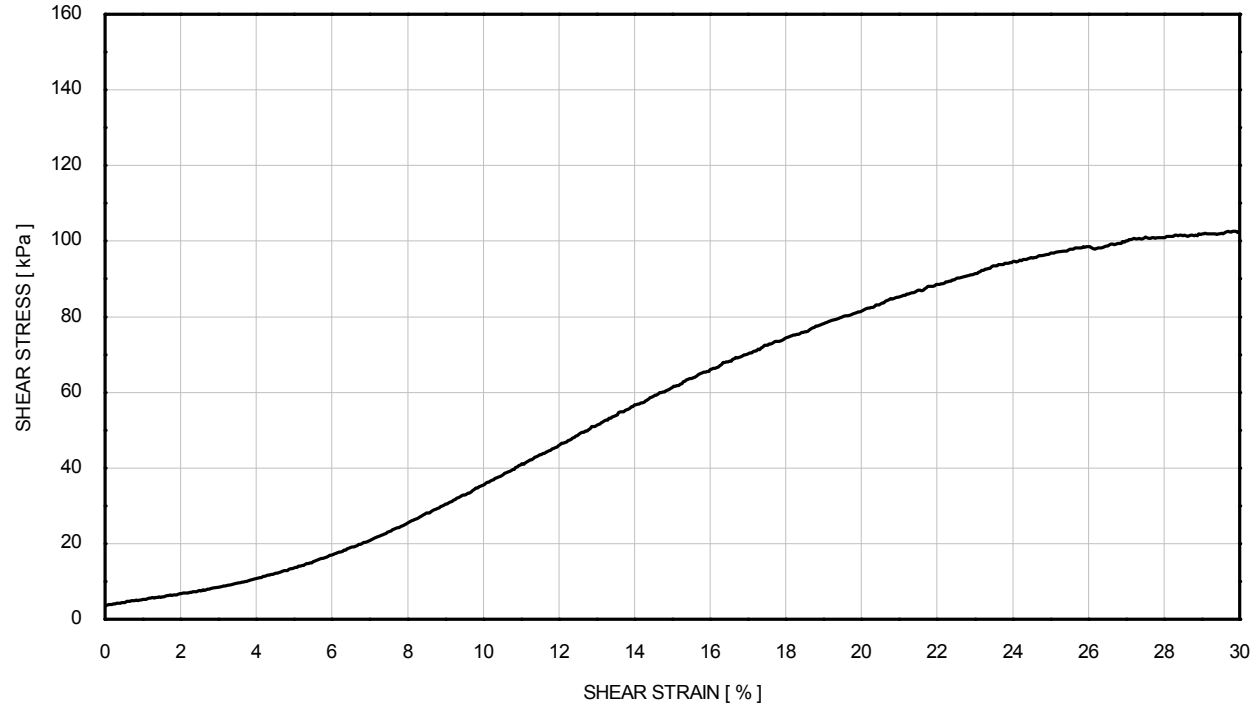


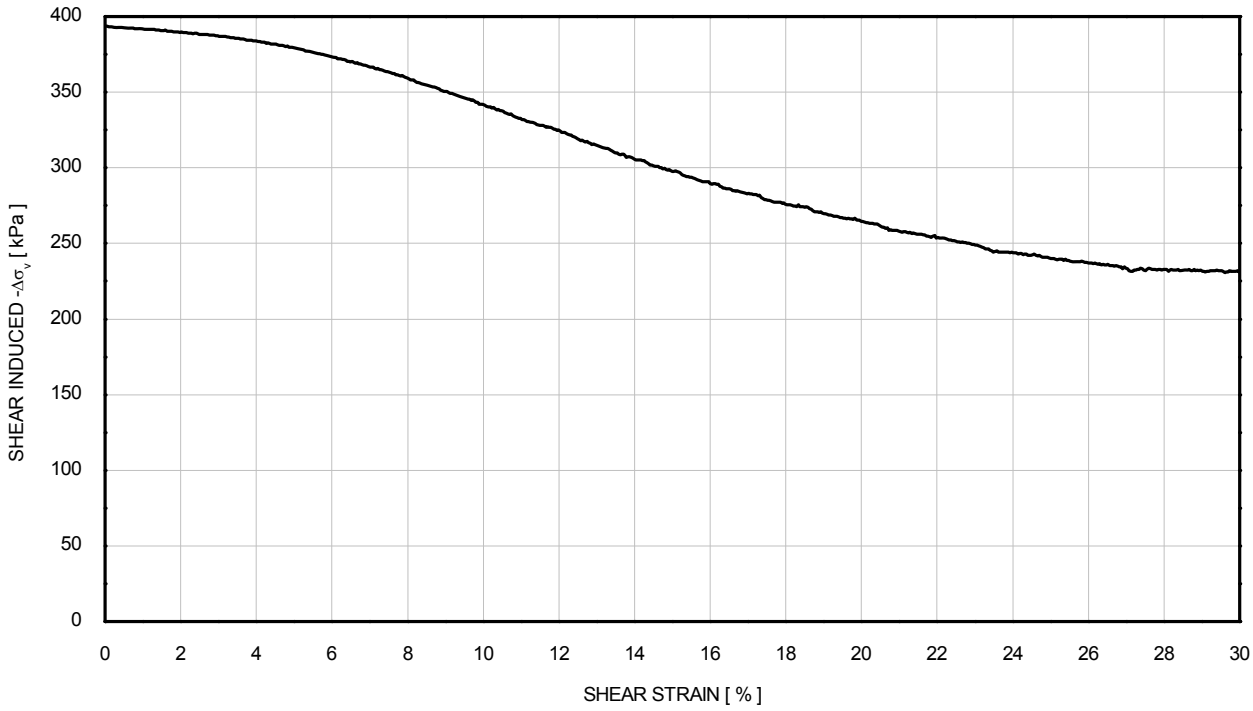


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-2
Mean τ_{cy}	:	59 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS24

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

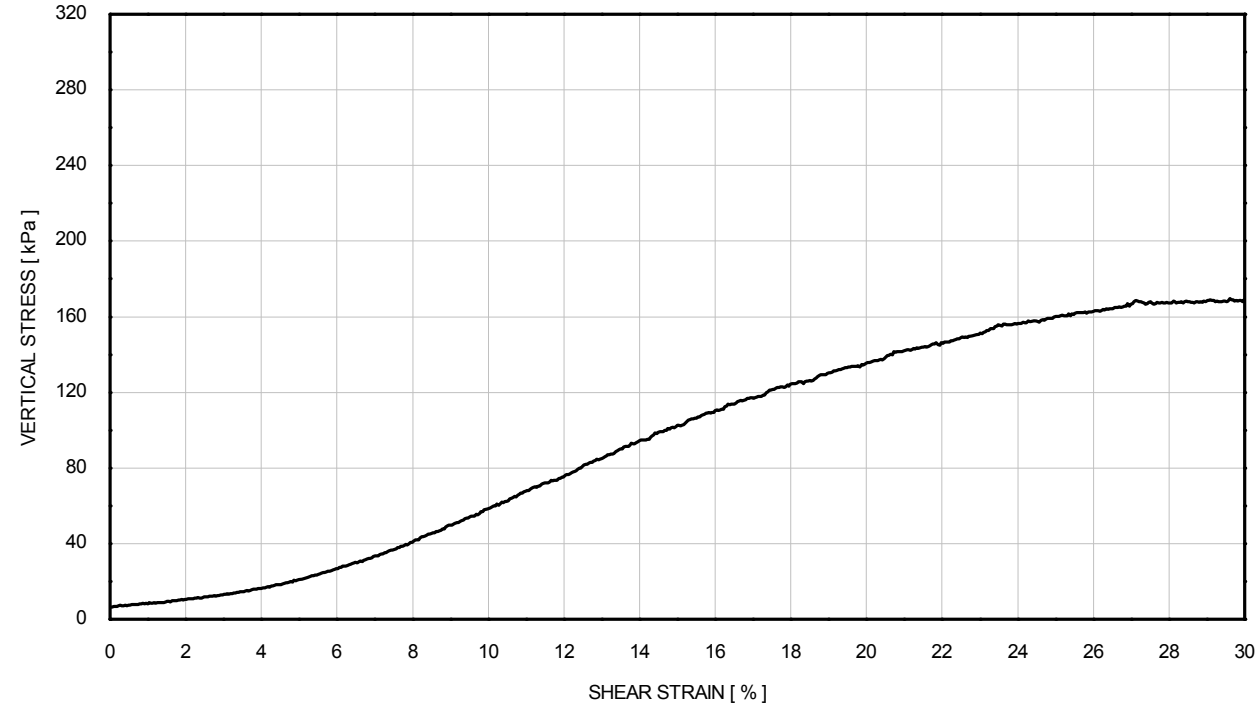


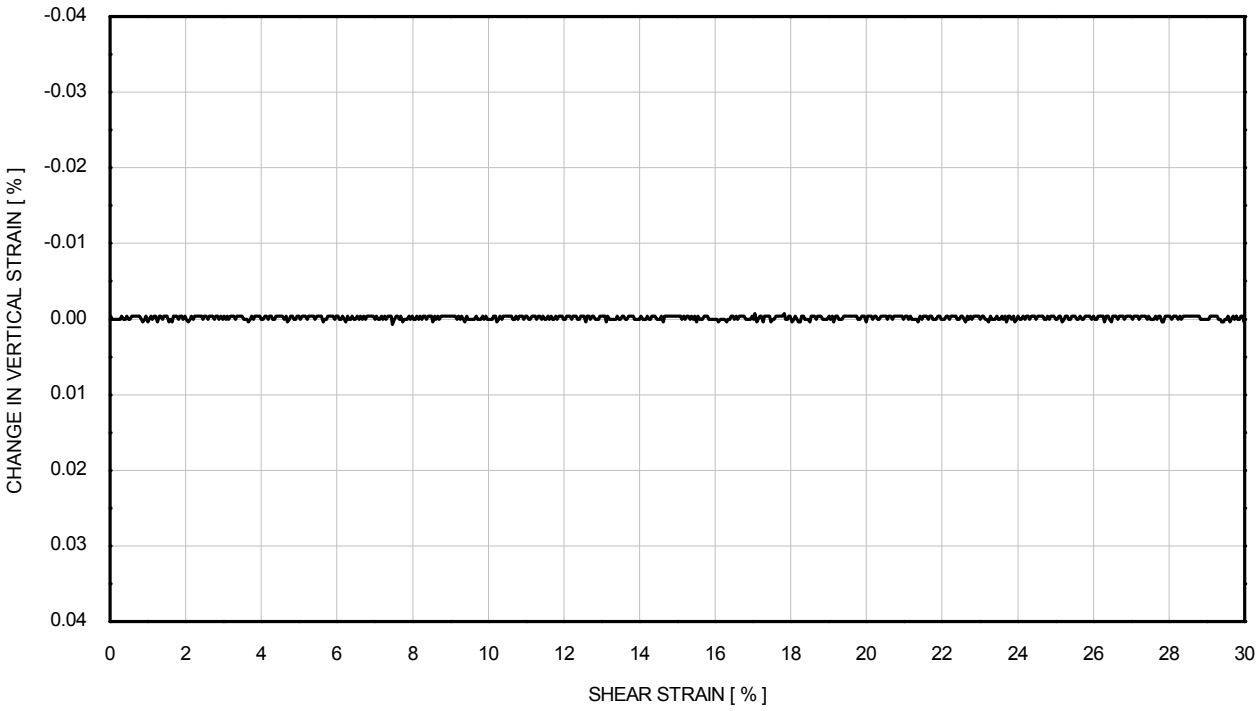


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 103 kPa	Sample	: CSS_4-2
γ at τ_{peak}	: 30.66 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.11 %/hour	Test No.	: CSS24

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

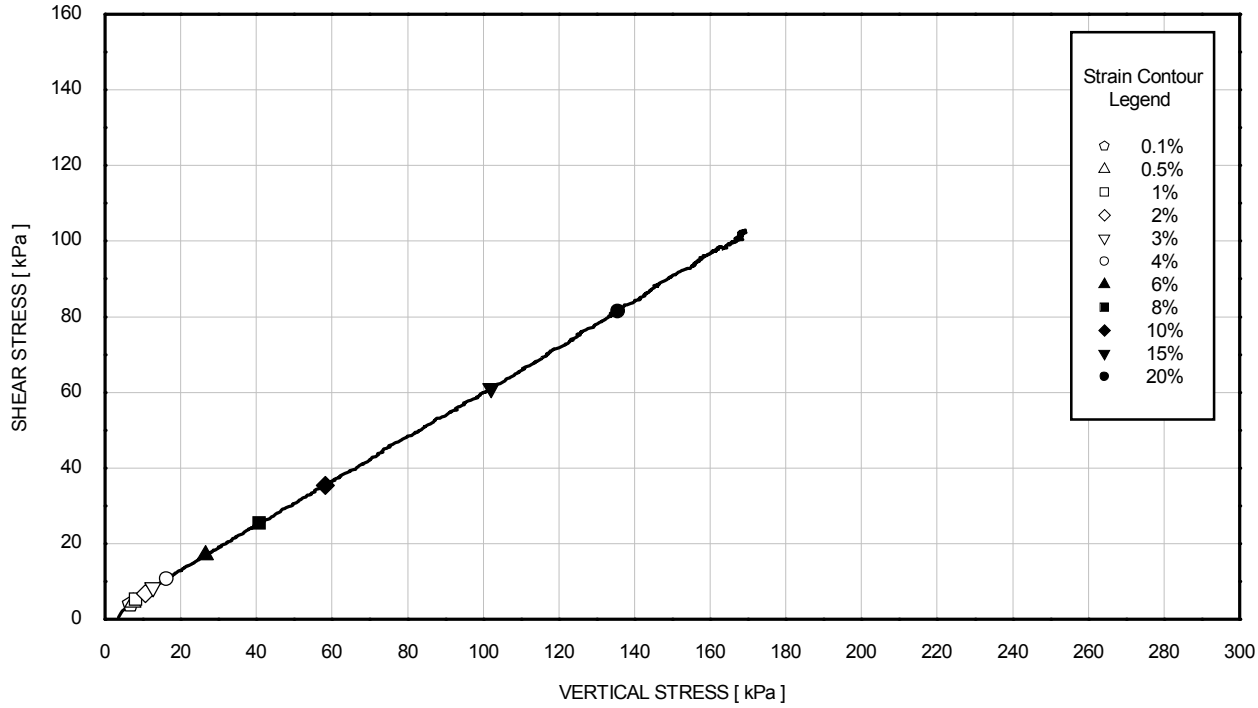


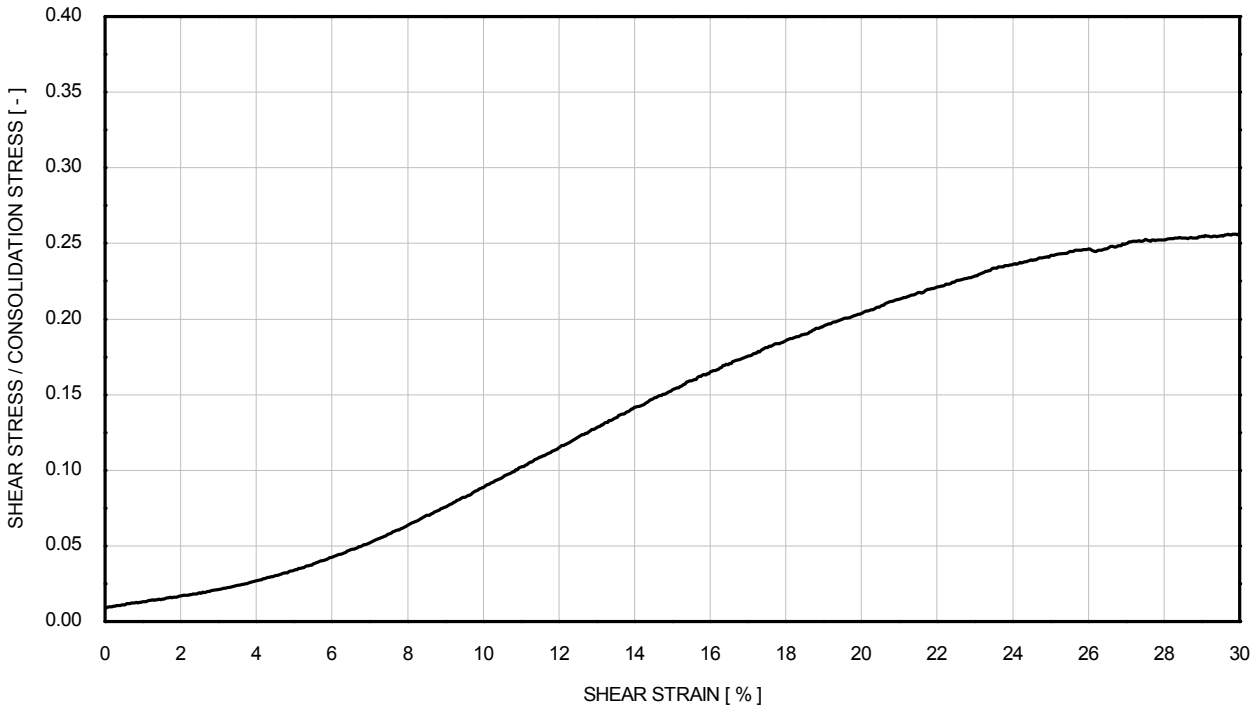


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 103 kPa	Sample	: CSS_4-2
γ at τ_{peak}	: 30.66 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.11 %/hour	Test No.	: CSS24

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

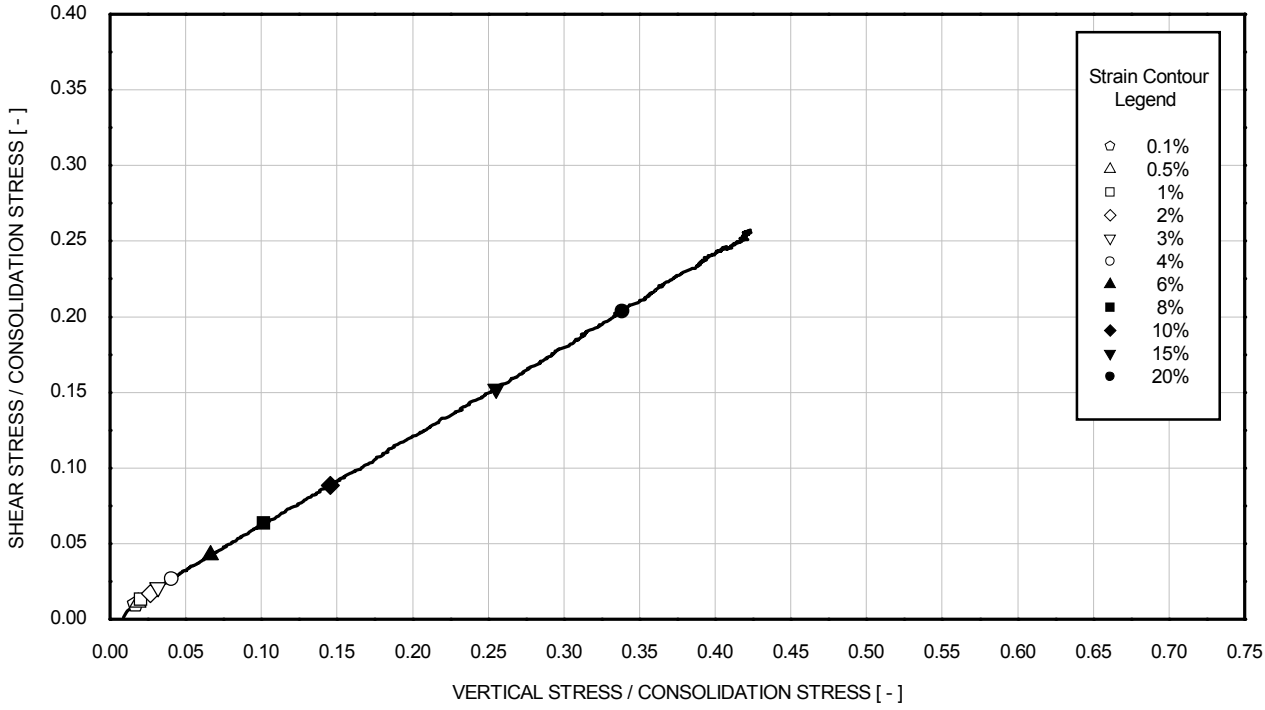


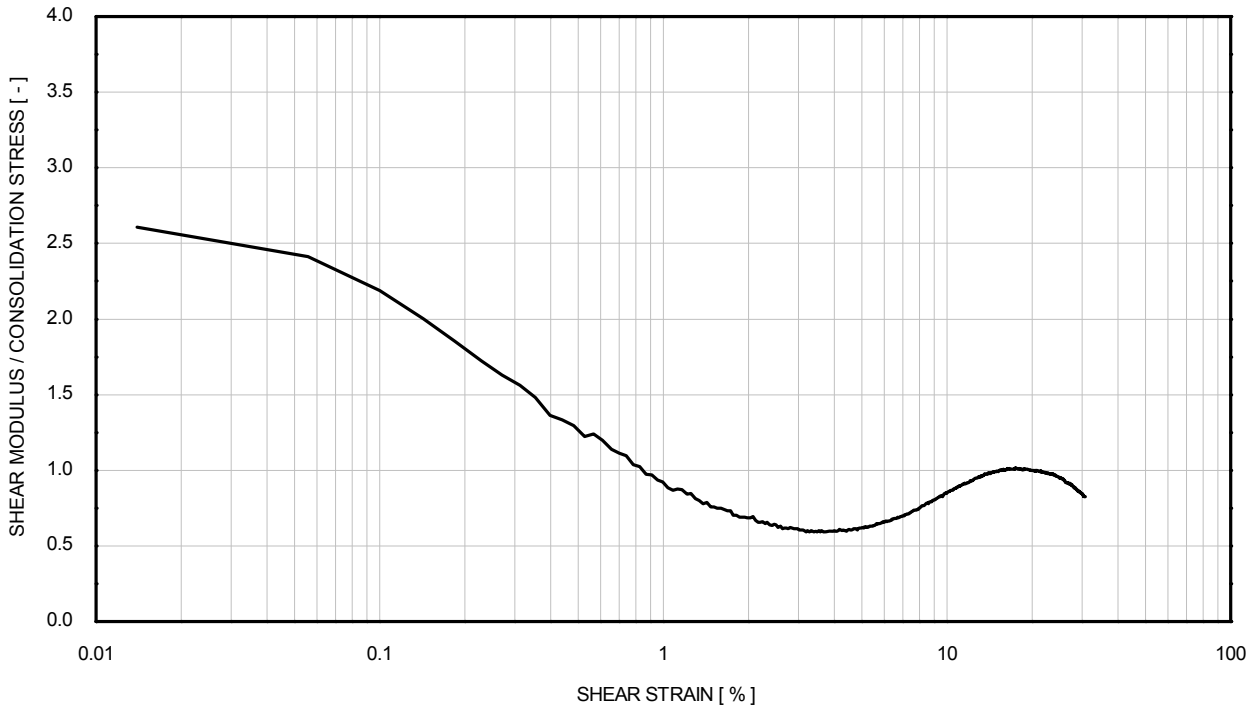


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 103 kPa	Sample	: CSS_4-2
γ at τ_{peak}	: 30.66 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.11 %/hour	Test No.	: CSS24

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 103 kPa	Sample	: CSS_4-2
γ at τ_{peak}	: 30.66 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.11 %/hour	Test No.	: CSS24

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	22/02/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.7
Length	[mm]	30.0
Moisture content after compaction	[%]	10.8
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.60
Void ratio	[-]	0.658
Degree of saturation after compaction	[%]	43
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.8
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 4_CSS 4-3_CSS25
Template issue	1.3
Processed by	HJ
Date	24/02/2016
Checked by	PH
Date	15/03/2016
Approved by	PH
Date	15/03/2016

TEST IDENTIFICATION	
Batch	Batch 4
Sample	CSS_4-3
Unit	E5b (Tongeren)
Test number	CSS25

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	400
Vertical strain	[%]	1.57
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.62
Void ratio	[-]	0.632
Moisture content	[%]	23.8

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	400
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	32
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	187
γ_{av} at N_f	[%]	-0.44
γ_{cy} at N_f	[%]	2.41
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	364
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	0.00	0.08	39.07	7.51
2	0.00	0.08	39.34	6.55
5	-0.01	0.08	38.82	5.66
10	-0.01	0.08	37.58	5.44
20	-0.01	0.09	36.45	5.53
30	-0.01	0.09	35.10	5.68
40	-0.02	0.09	34.43	5.83
50	-0.02	0.10	33.27	5.94
100	-0.02	0.11	29.30	6.85
187	-0.44	2.41	1.24	21.79

TEST IDENTIFICATION	
Batch	Batch 4
Sample	CSS_4-3
Unit	E5b (Tongeren)
Test number	CSS25

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	53
Shear strain	[%]	25.72
Shear induced $-\Delta\sigma_v$	[kPa]	316
Vertical stress	[kPa]	84
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.07
At 15 % shear strain		
Shear stress	[kPa]	38
Shear induced $-\Delta\sigma_v$	[kPa]	339
Vertical stress	[kPa]	61
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	Batch 4
Sample	CSS_4-3
Unit	E5b (Tongeren)
Test number	CSS25

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

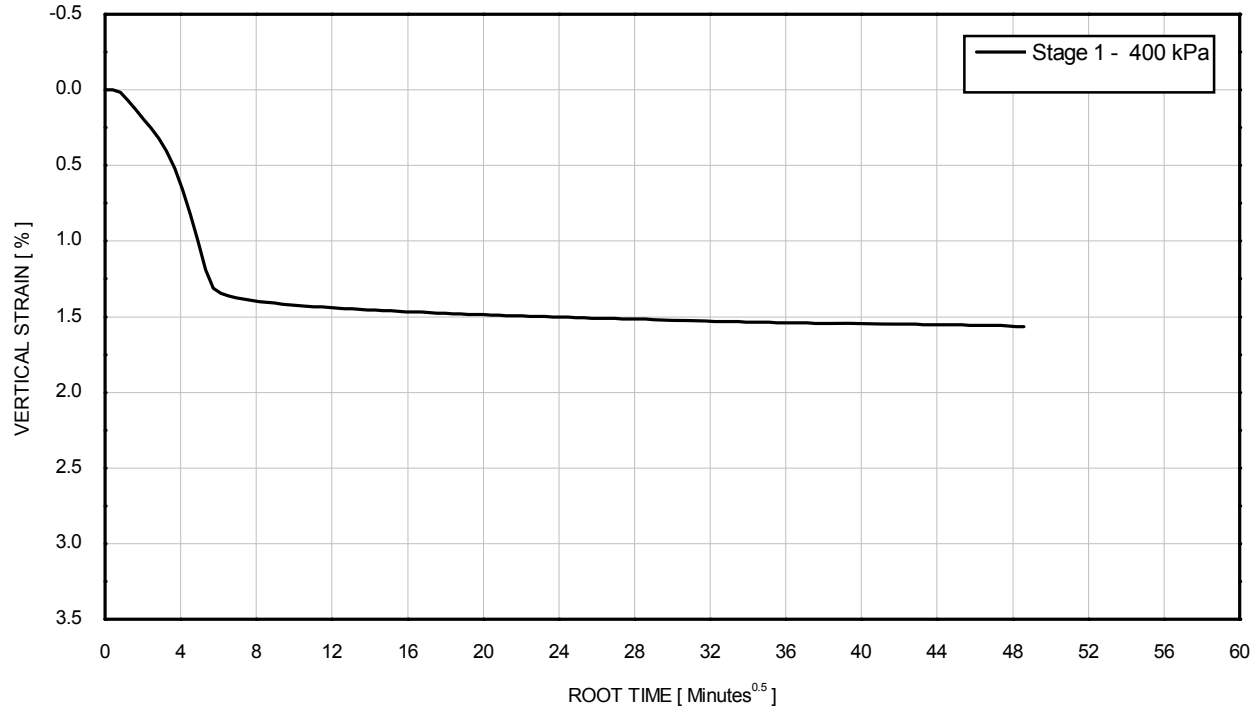
SPECIMEN PHOTOGRAPH

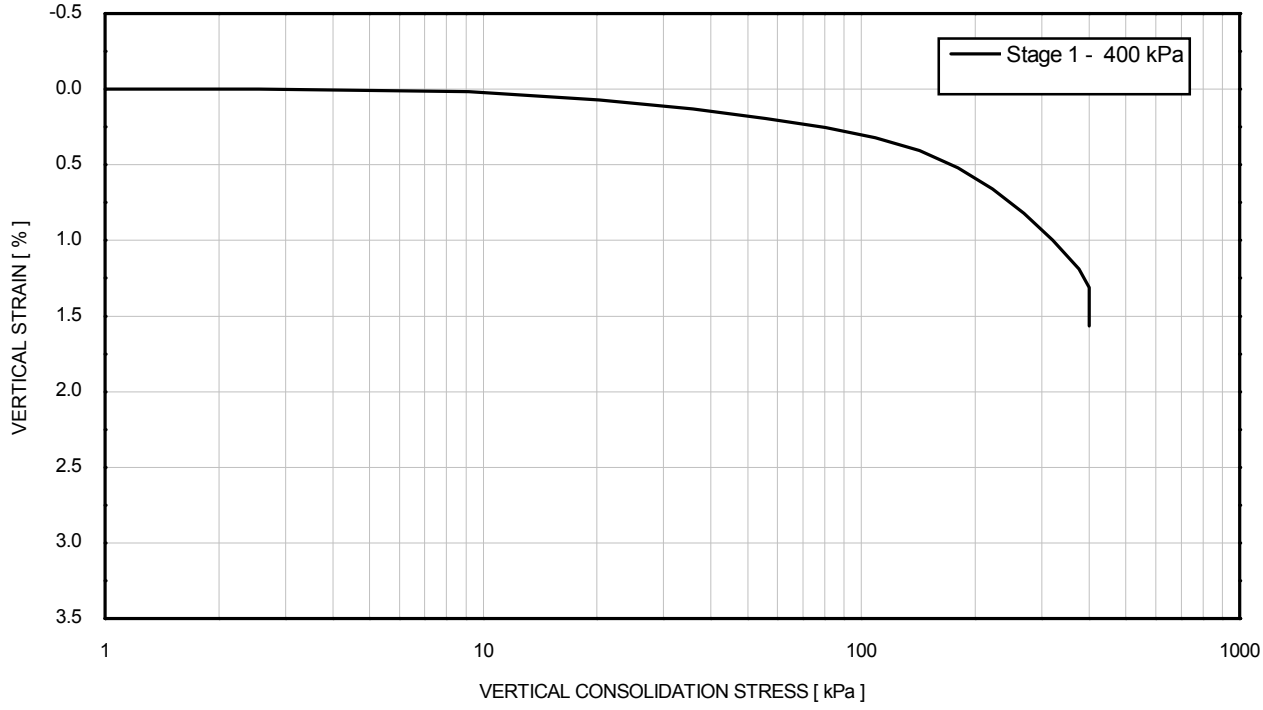


TEST IDENTIFICATION	
Batch	Batch 4
Sample	CSS_4-3
Unit	E5b (Tongeren)
Test number	CSS25

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

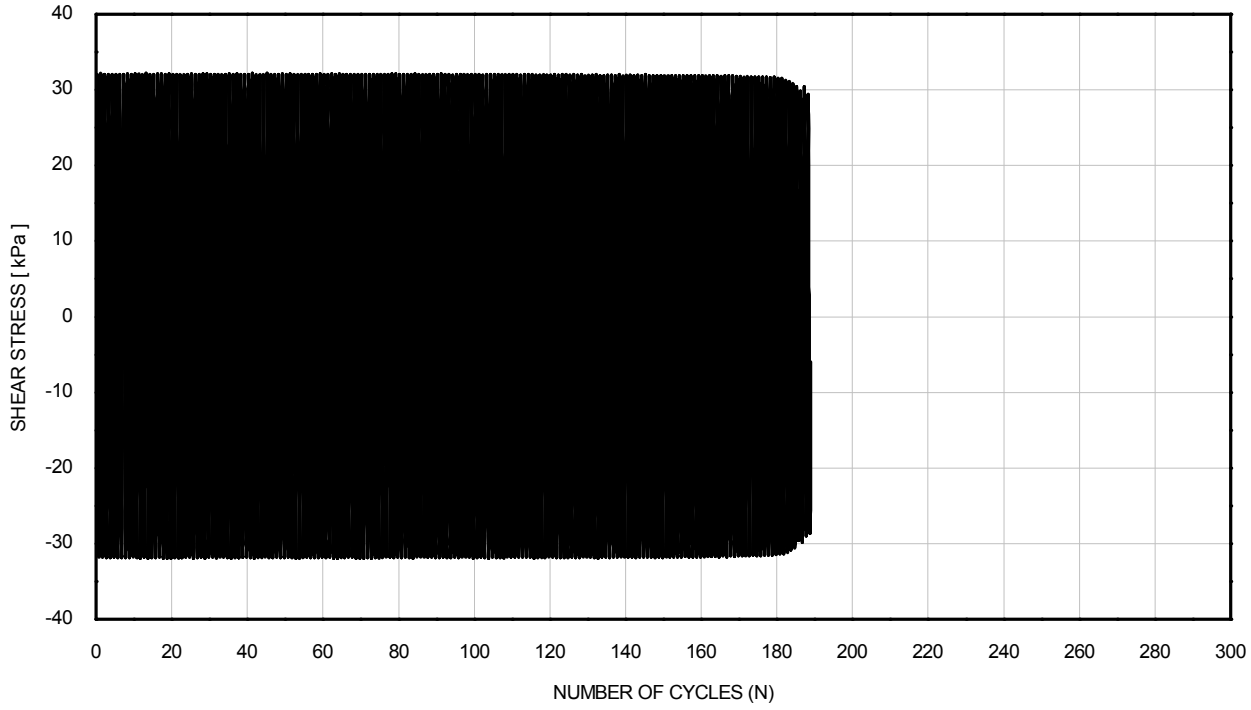


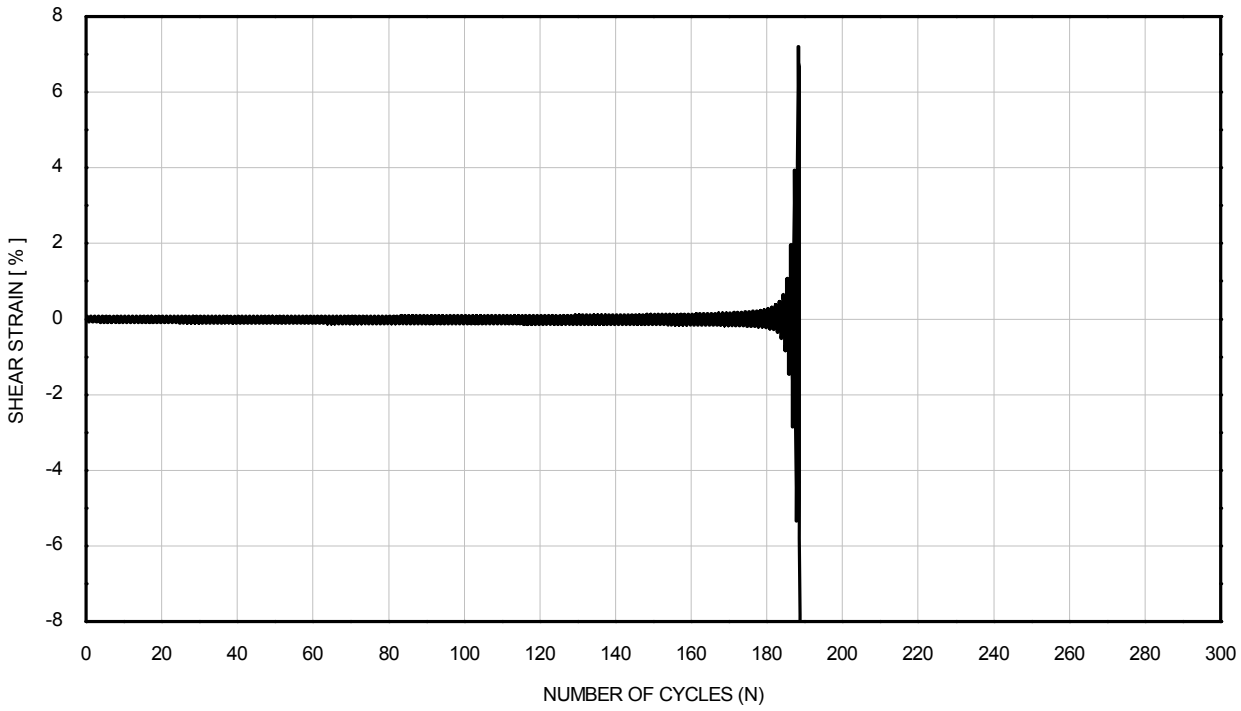


σ_{vc}	: 400 kPa	Batch	: Batch 4
		Sample	: CSS_4-3
		Unit	: E5b (Tongeren)
		Test No.	: CSS25

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

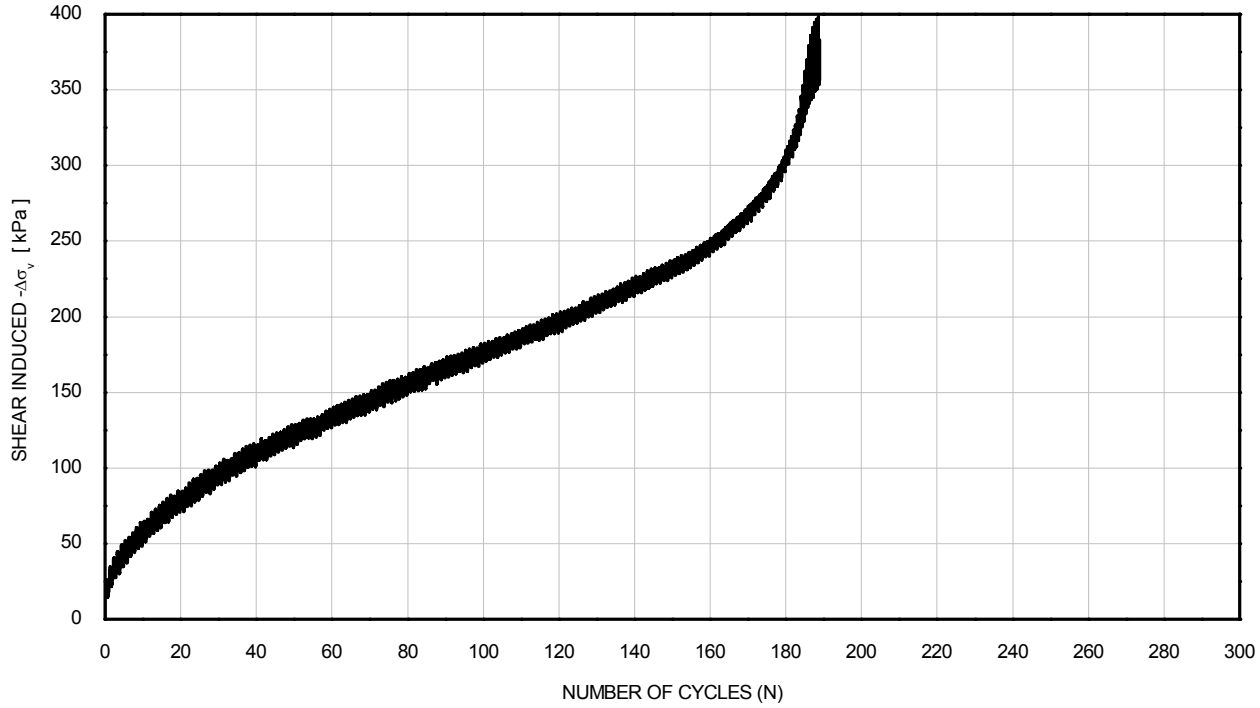


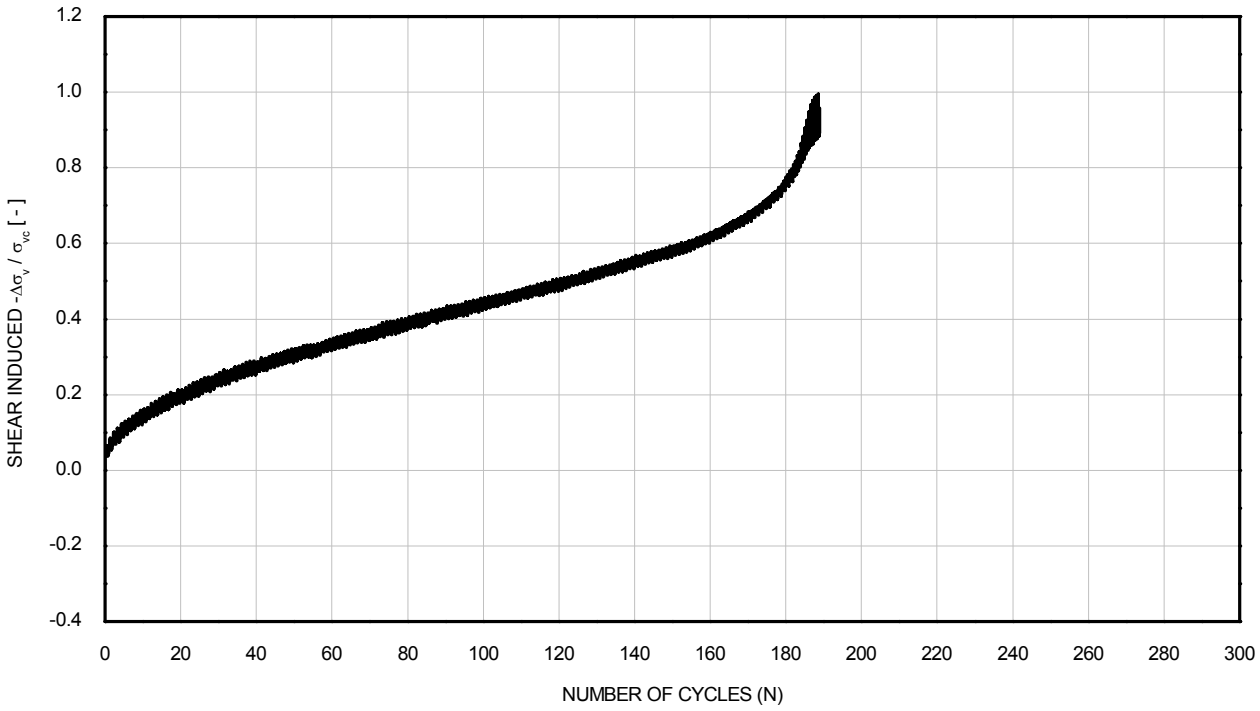


σ_{vc}	:	400 kPa	Batch	:	Batch 4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-3
Mean τ_{cy}	:	32 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS25

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

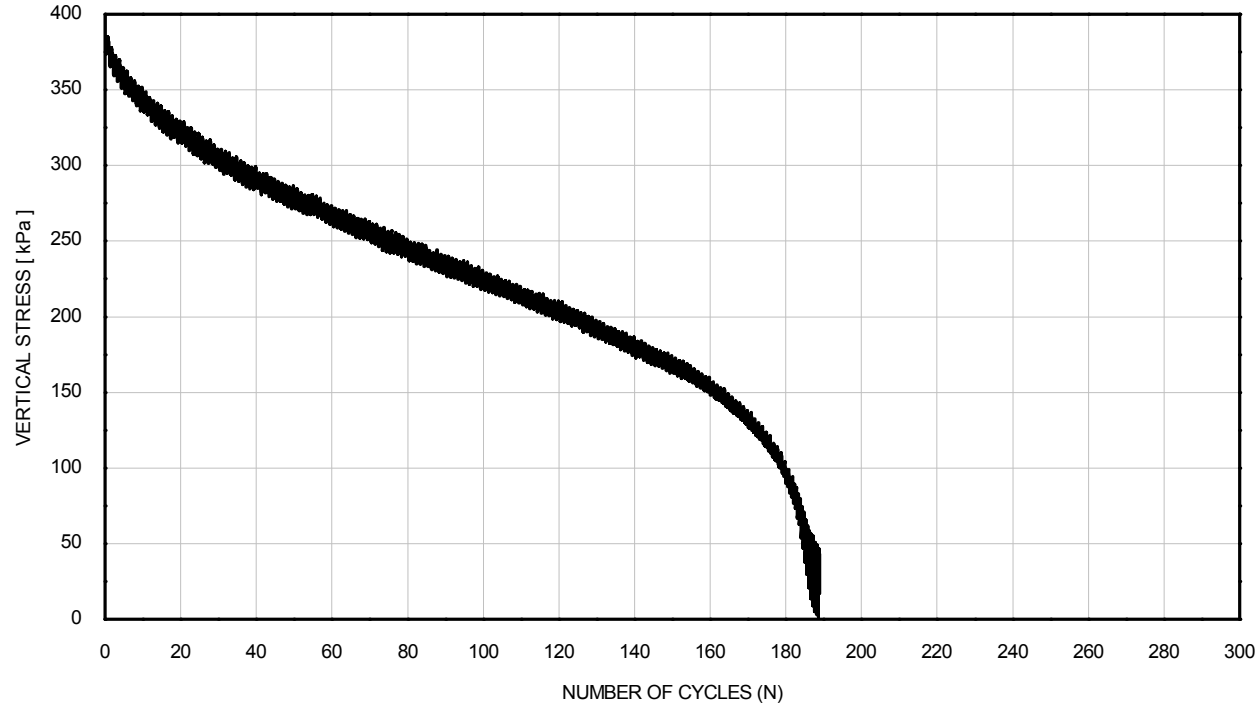


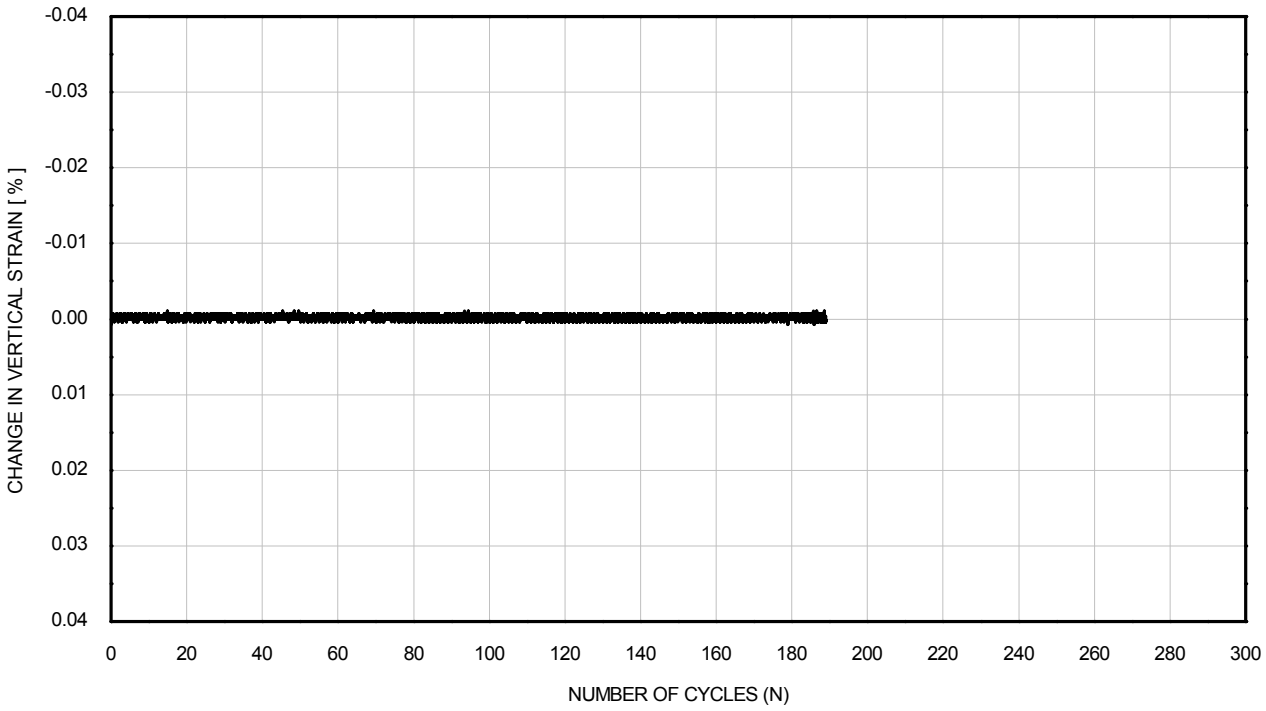


σ_{vc}	:	400 kPa	Batch	:	Batch 4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-3
Mean τ_{cy}	:	32 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS25

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

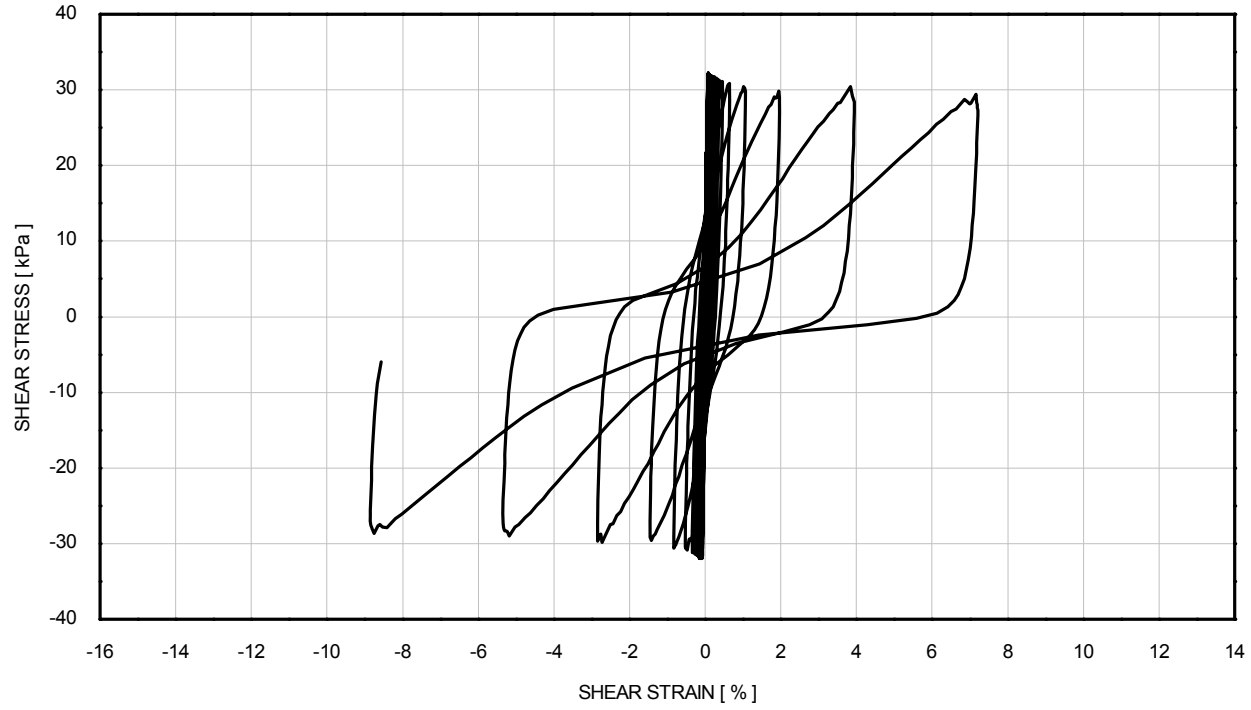


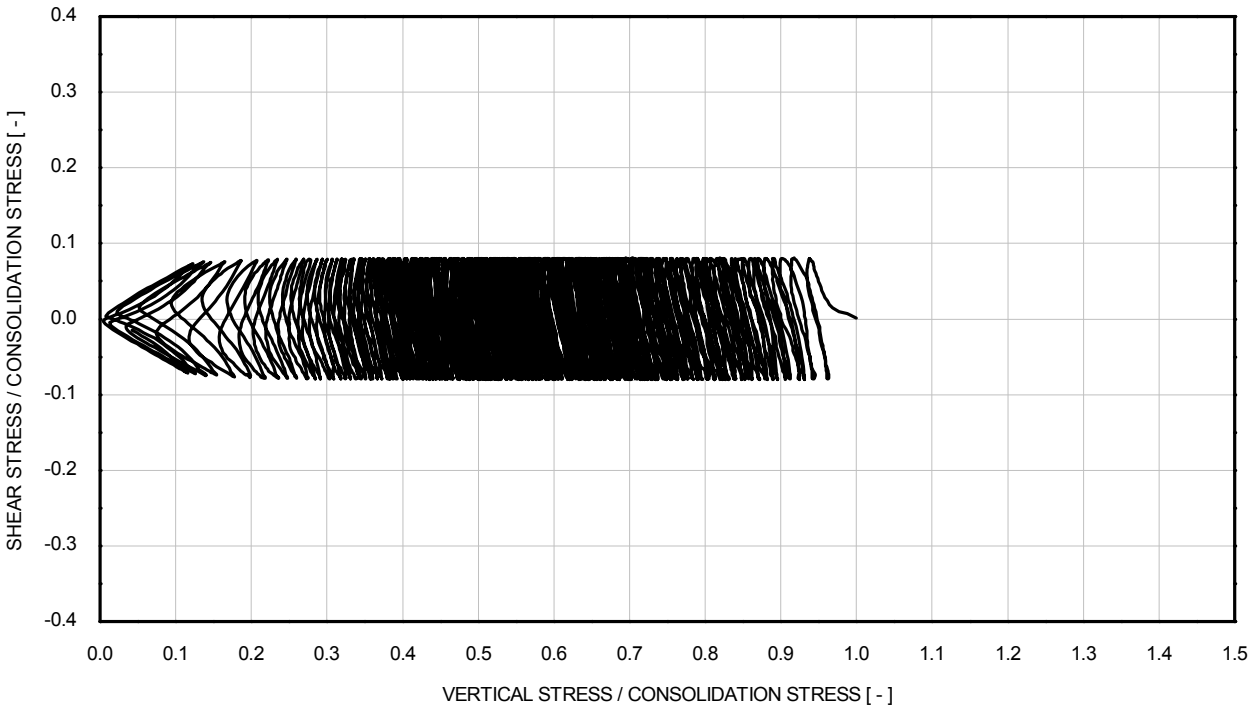


σ_{vc}	:	400 kPa	Batch	:	Batch 4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-3
Mean τ_{cy}	:	32 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS25

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

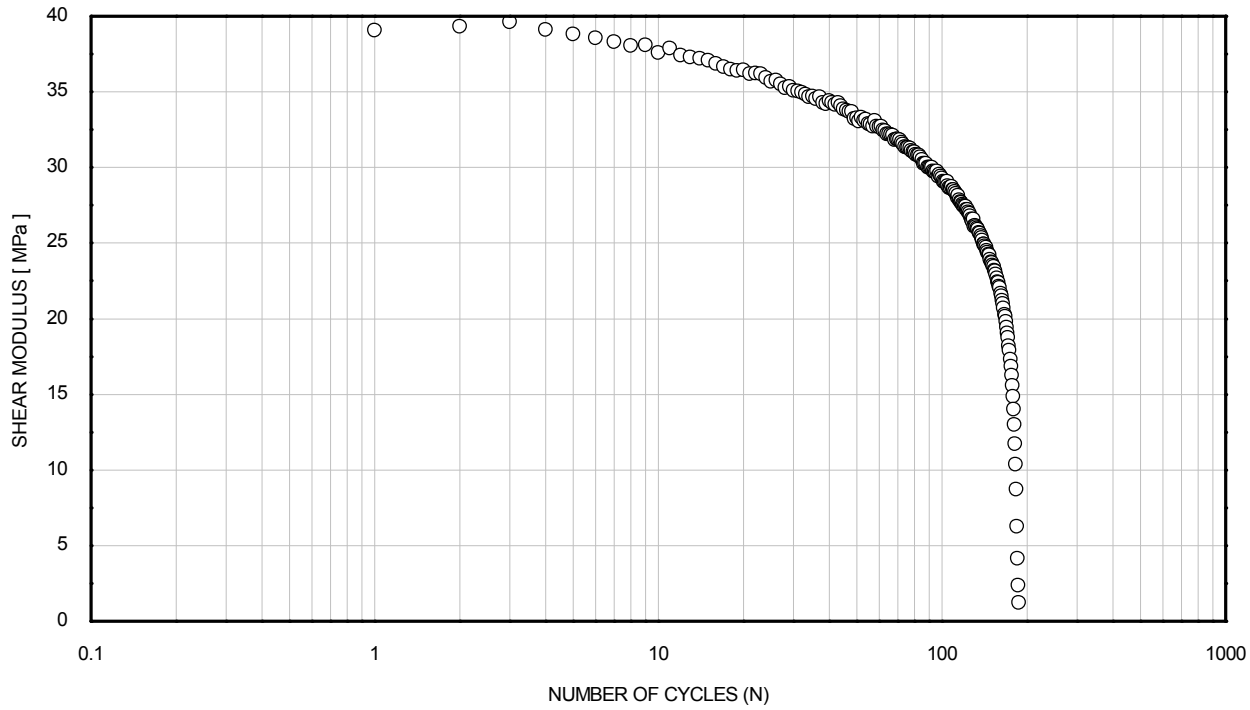


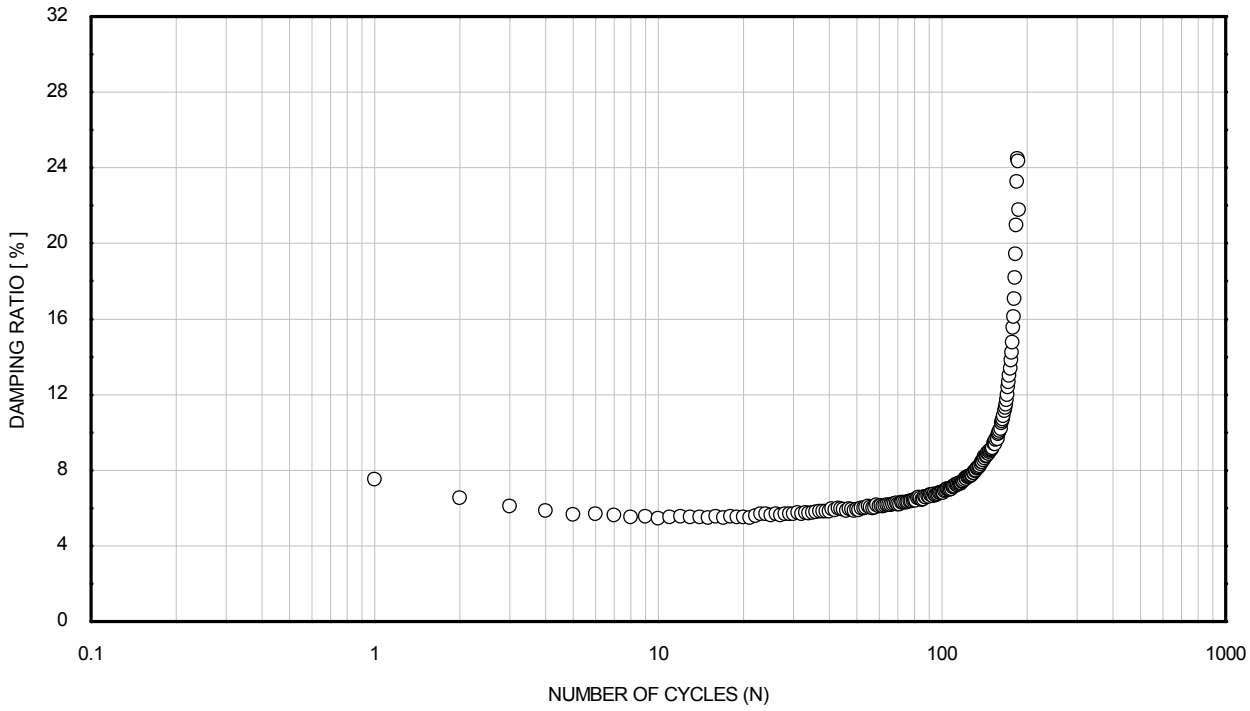


σ_{vc}	:	400 kPa	Batch	:	Batch 4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-3
Mean τ_{cy}	:	32 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS25

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

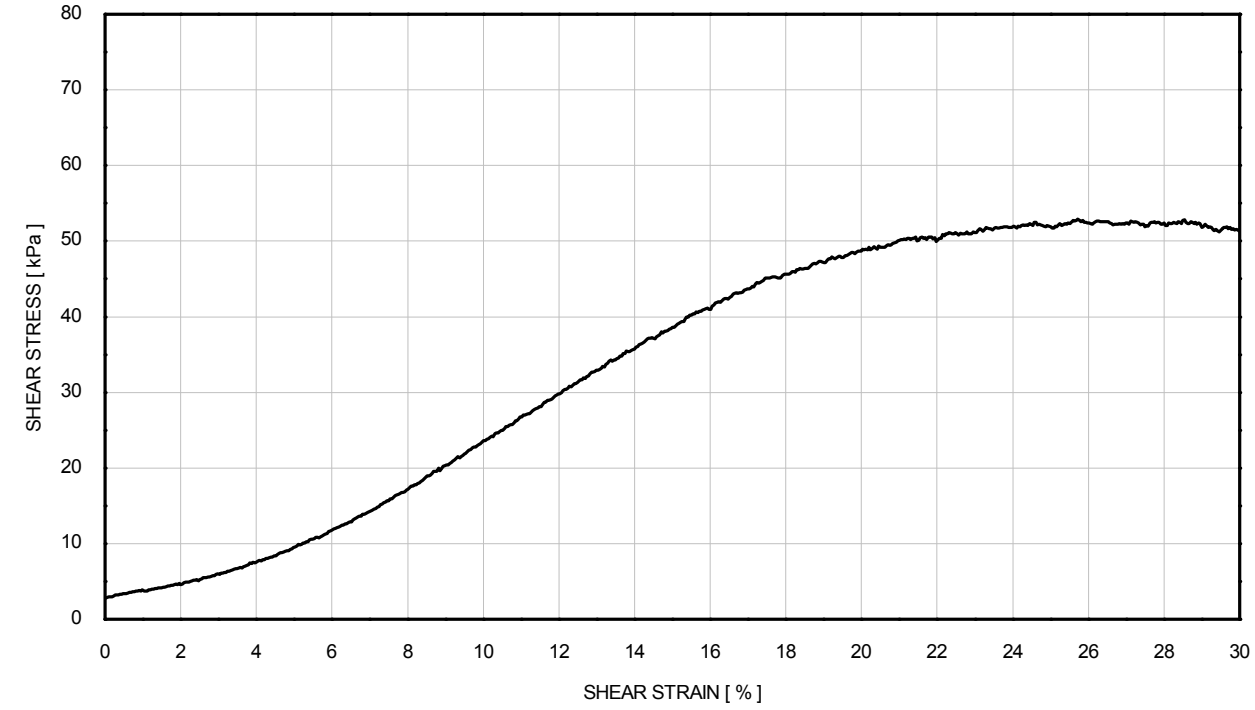


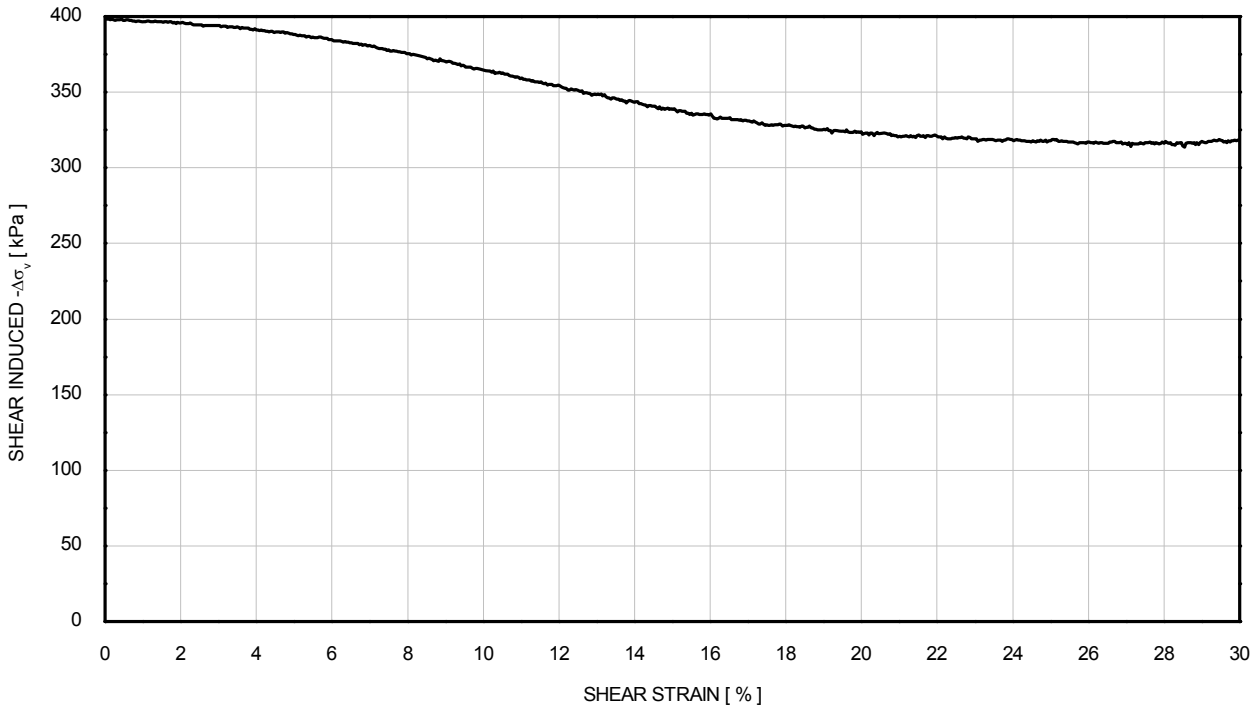


σ_{vc}	:	400 kPa	Batch	:	Batch 4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-3
Mean τ_{cy}	:	32 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS25

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

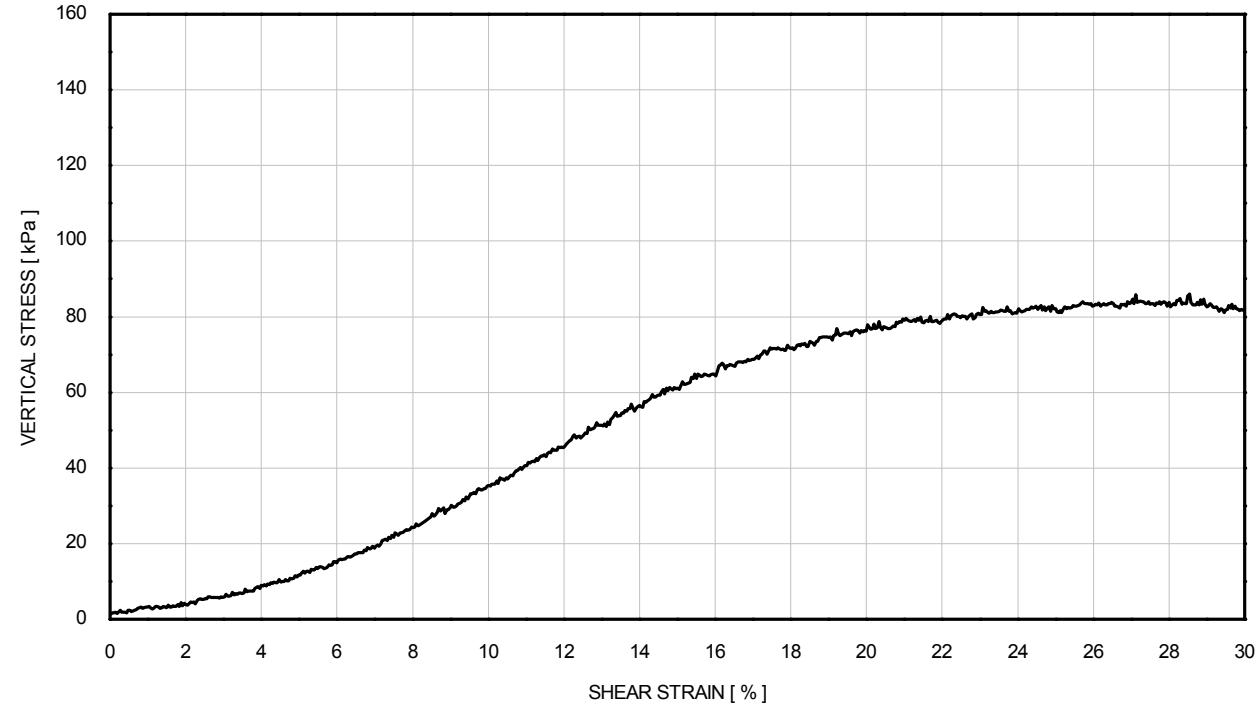


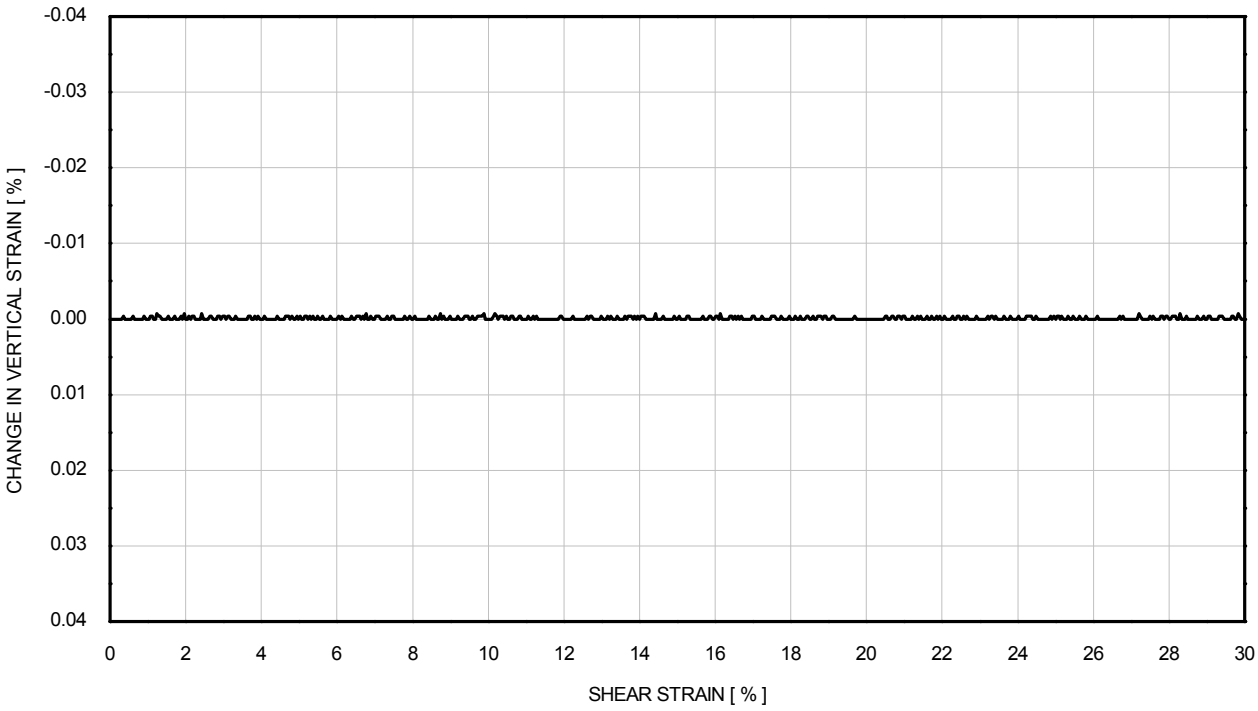


σ_{vc}	: 400 kPa	Batch	: Batch 4
τ_{peak}	: 53 kPa	Sample	: CSS_4-3
γ at τ_{peak}	: 25.72 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.07 %/hour	Test No.	: CSS25

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

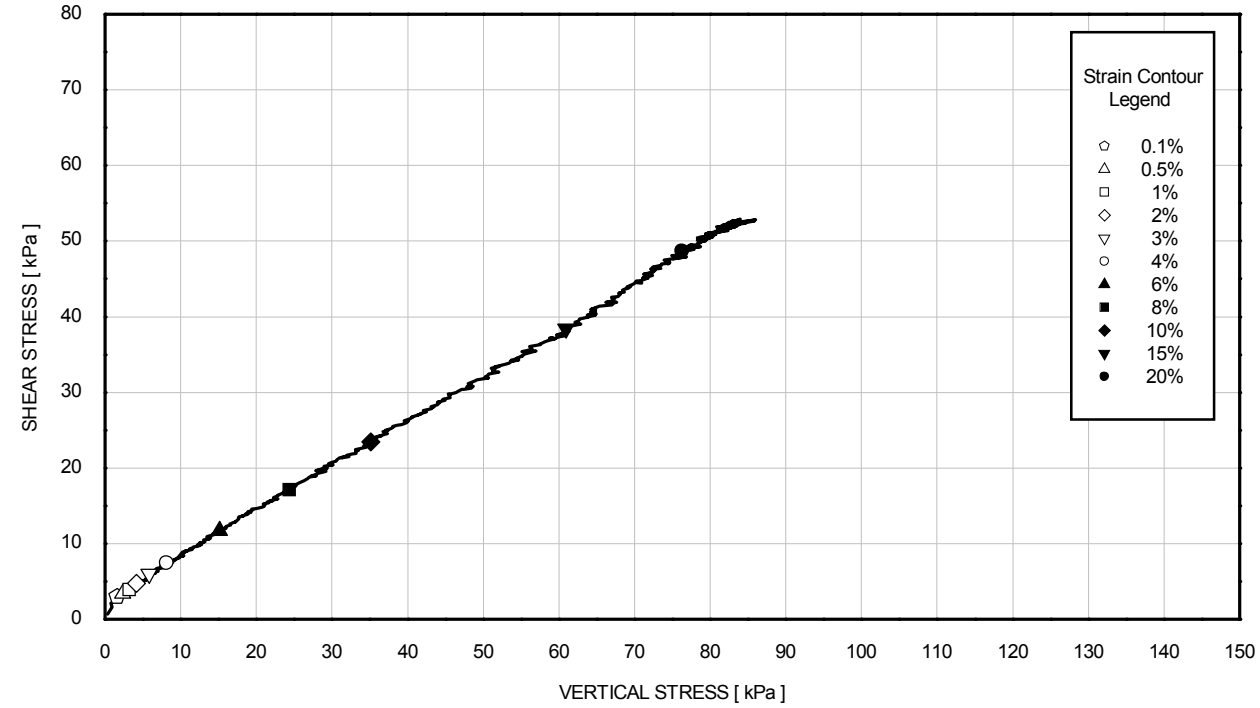


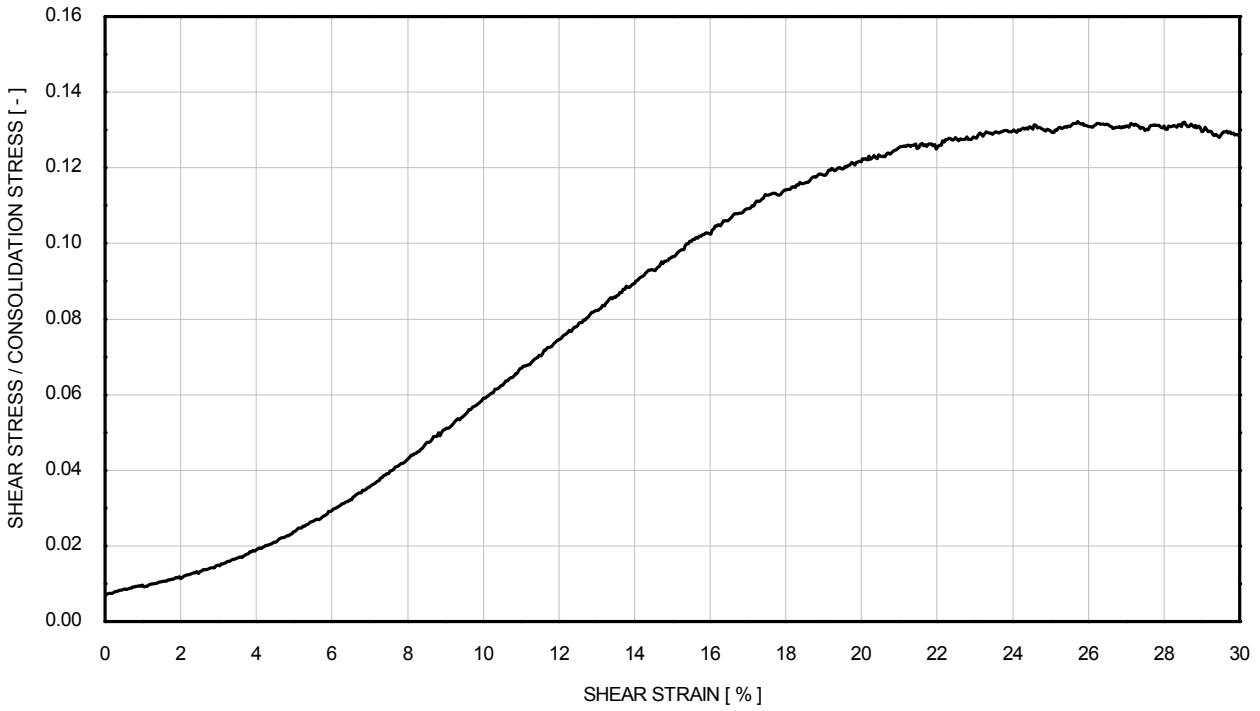


σ_{vc}	: 400 kPa	Batch	: Batch 4
τ_{peak}	: 53 kPa	Sample	: CSS_4-3
γ at τ_{peak}	: 25.72 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.07 %/hour	Test No.	: CSS25

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

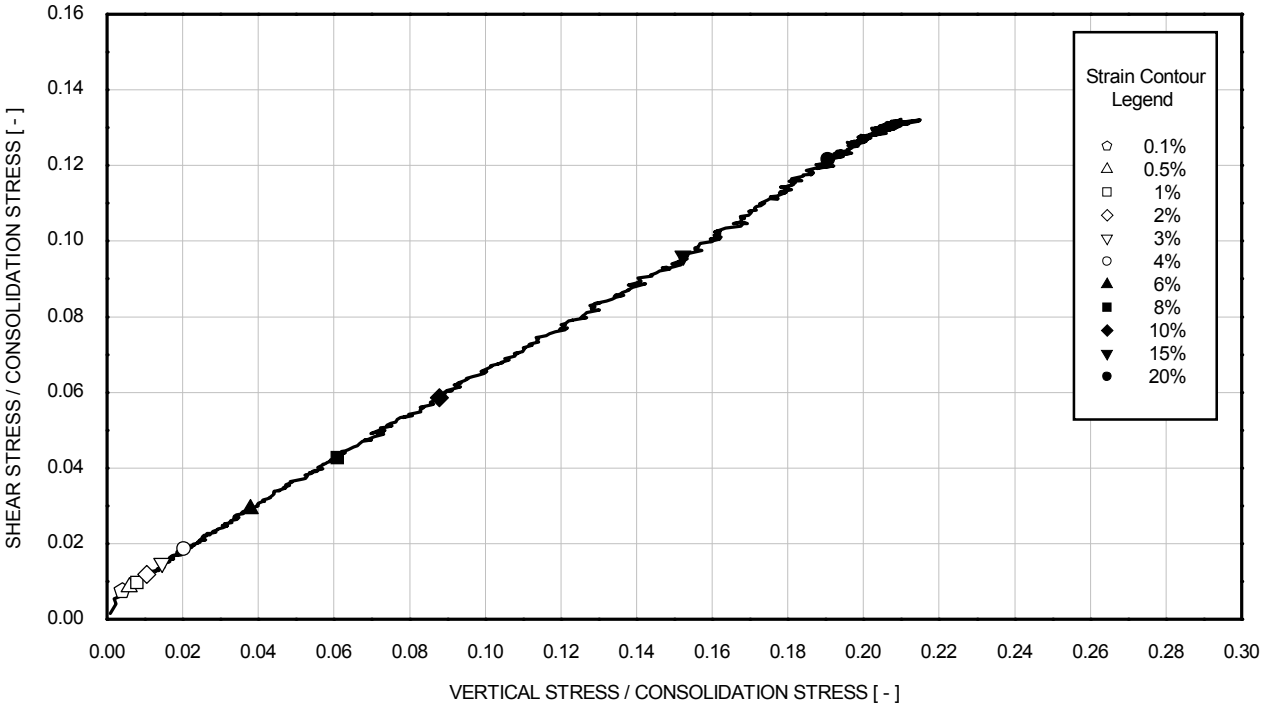


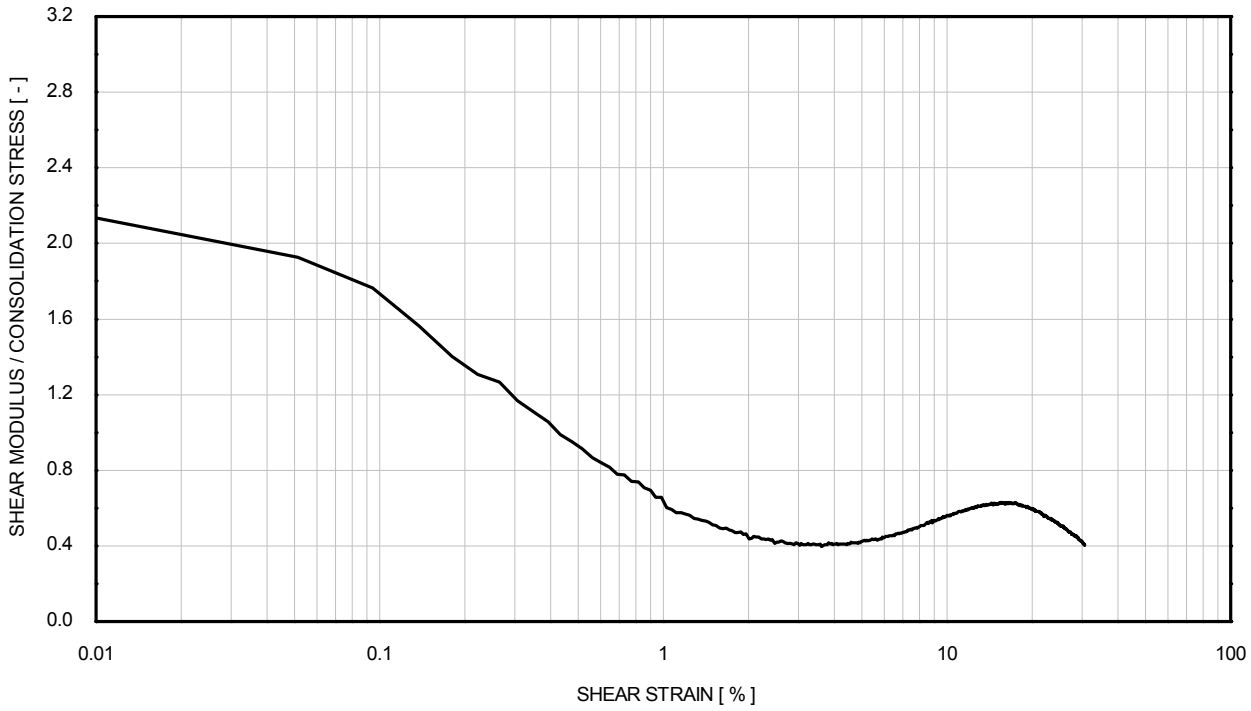


σ_{vc}	: 400 kPa	Batch	: Batch 4
τ_{peak}	: 53 kPa	Sample	: CSS_4-3
γ at τ_{peak}	: 25.72 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.07 %/hour	Test No.	: CSS25

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 400 kPa	Batch	: Batch 4
τ_{peak}	: 53 kPa	Sample	: CSS_4-3
γ at τ_{peak}	: 25.72 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.07 %/hour	Test No.	: CSS25

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

VISUAL DESCRIPTION
Dark olive grey silty fine SAND

GENERAL	
Date test started	01/03/2016
Type of sample	Re-compacted

INITIAL		
Diameter	[mm]	66.4
Length	[mm]	30.0
Moisture content after compaction	[%]	10.8
Bulk density after compaction	[Mg/m³]	1.77
Dry density	[Mg/m³]	1.60
Void ratio	[-]	0.657
Degree of saturation after compaction	[%]	43
Assumed particle density	[Mg/m³]	2.65
Moisture content at start of test	[%]	24.8
Bulk density at start of test	[Mg/m³]	2.00
Degree of saturation at start of test	[%]	100

TESTING PROCEDURES USED	
Specimen set-up	Fugro in house procedure (available upon request) based on ASTM D6528-07
Consolidation	Fugro in house procedure (available upon request) based on ASTM D6528-07
Shearing	Fugro in house procedure (available upon request) based on ASTM D6528-07
Note: Vertical stress / vertical strain refers to the directionality of load application within the equipment	

QUALITY ASSURANCE	
Filename	J11302 \ Batch 4_CSS 4-4_CSS26
Template issue	1.3
Processed by	HJ
Date	09/03/2016
Checked by	PH
Date	15/03/2016
Approved by	PH
Date	15/03/2016

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-4
Unit	E5b (Tongeren)
Test number	CSS26

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

CONSOLIDATION		
σ_{vc}	[kPa]	400
Vertical strain	[%]	1.84
Bulk density	[Mg/m^3]	2.01
Dry density	[Mg/m^3]	1.63
Void ratio	[-]	0.627
Moisture content	[%]	23.6

STRESS-CONTROLLED CYCLIC LOADING – CONSTANT VOLUME		
Reference stress	[kPa]	400
Mean τ_{av}	[kPa]	0
Mean τ_{cy}	[kPa]	47
Frequency	[Hz]	0.10
Number of cycles at failure (N_f)	[-]	20
γ_{av} at N_f	[%]	-0.98
γ_{cy} at N_f	[%]	3.57
Shear induced -$\Delta\sigma_v$ at N_f	[kPa]	344
Vertical strain	[%]	0.00

Cycle (N)	γ_{av} [%]	γ_{cy} [%]	G [MPa]	λ [%]
1	-0.03	0.27	17.86	9.00
2	-0.04	0.26	18.29	7.48
4	-0.05	0.27	17.55	6.99
6	-0.05	0.28	16.93	7.25
8	-0.05	0.30	16.19	7.76
10	-0.05	0.31	15.33	8.42
12	-0.05	0.33	14.36	9.56
14	-0.06	0.37	12.94	11.19
16	-0.08	0.45	10.58	14.54
18	-0.25	0.85	5.47	22.07
20	-0.98	3.57	1.23	22.38

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-4
Unit	E5b (Tongeren)
Test number	CSS26

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SHEARING – CONSTANT VOLUME		
At peak shear stress		
Shear stress	[kPa]	78
Shear strain	[%]	30.52
Shear induced $-\Delta\sigma_v$	[kPa]	283
Vertical stress	[kPa]	117
Vertical strain	[%]	0.00
Rate of strain	[%/hour]	5.09
At 15 % shear strain		
Shear stress	[kPa]	59
Shear induced $-\Delta\sigma_v$	[kPa]	310
Vertical stress	[kPa]	90
Vertical strain	[%]	0.00

TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-4
Unit	E5b (Tongeren)
Test number	CSS26

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

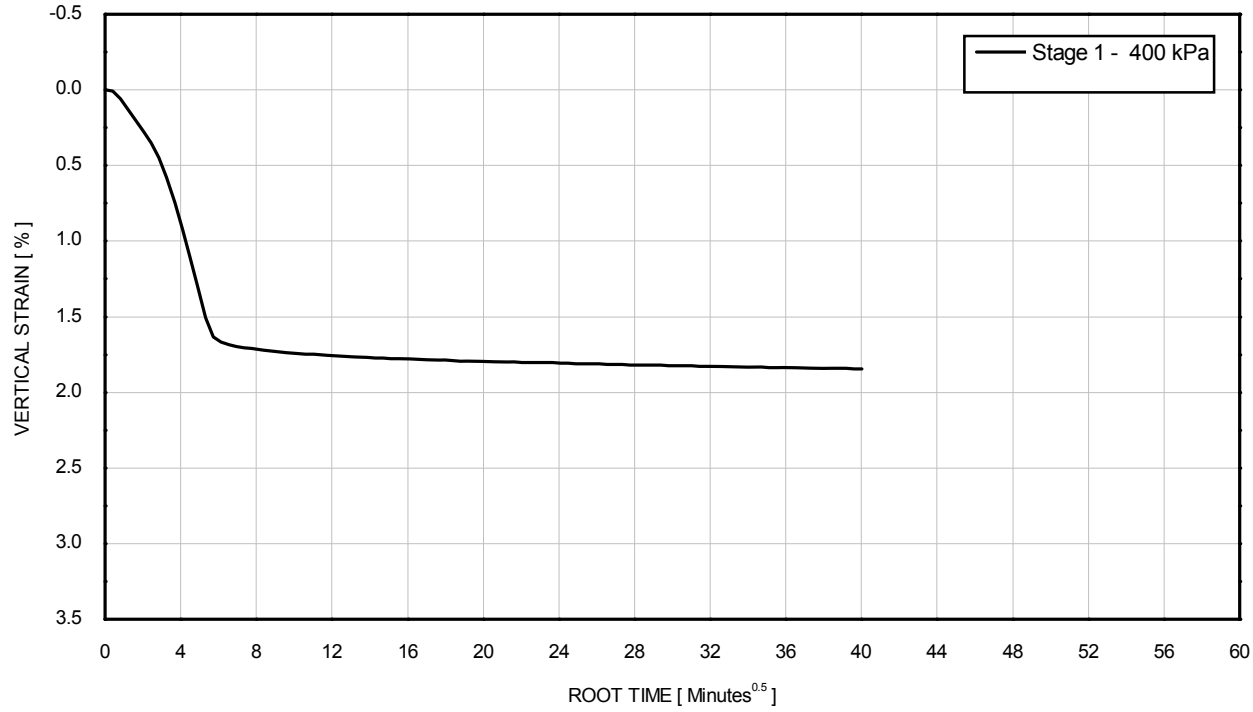
SPECIMEN PHOTOGRAPH

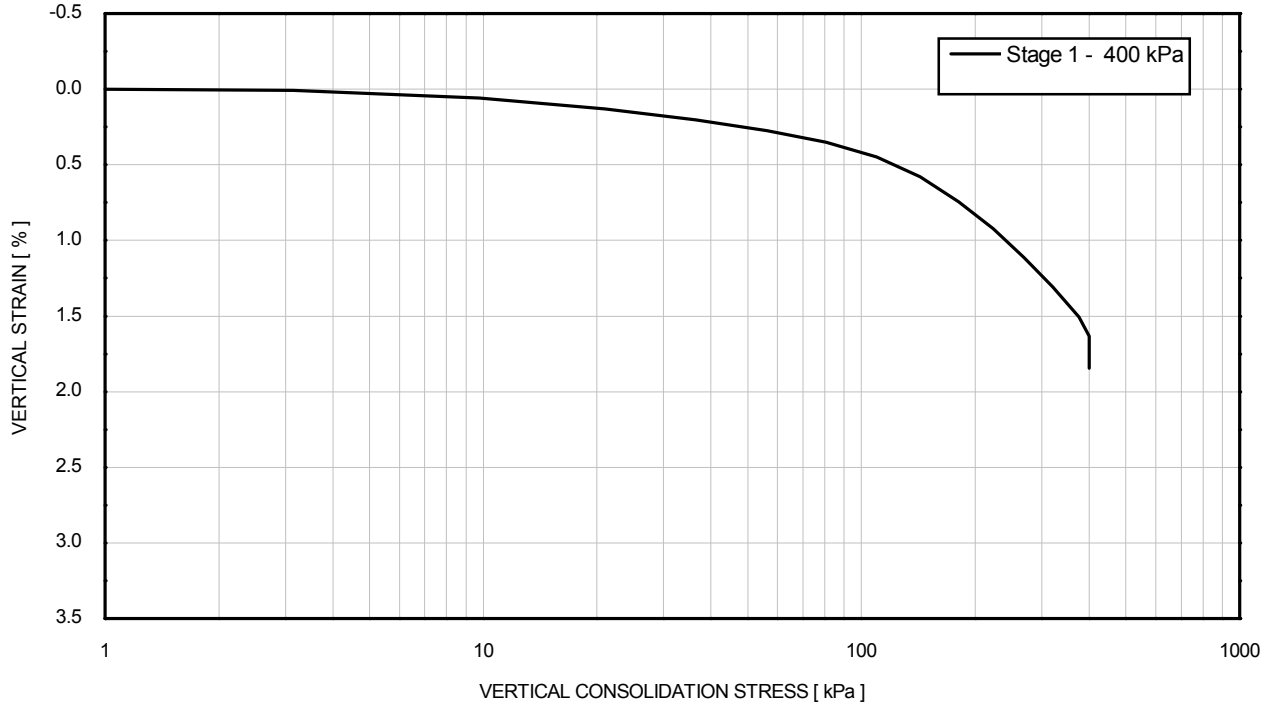


TEST IDENTIFICATION	
Batch	4
Sample	CSS_4-4
Unit	E5b (Tongeren)
Test number	CSS26

SUMMARY OF CONSOLIDATED CYCLIC DSS TEST

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

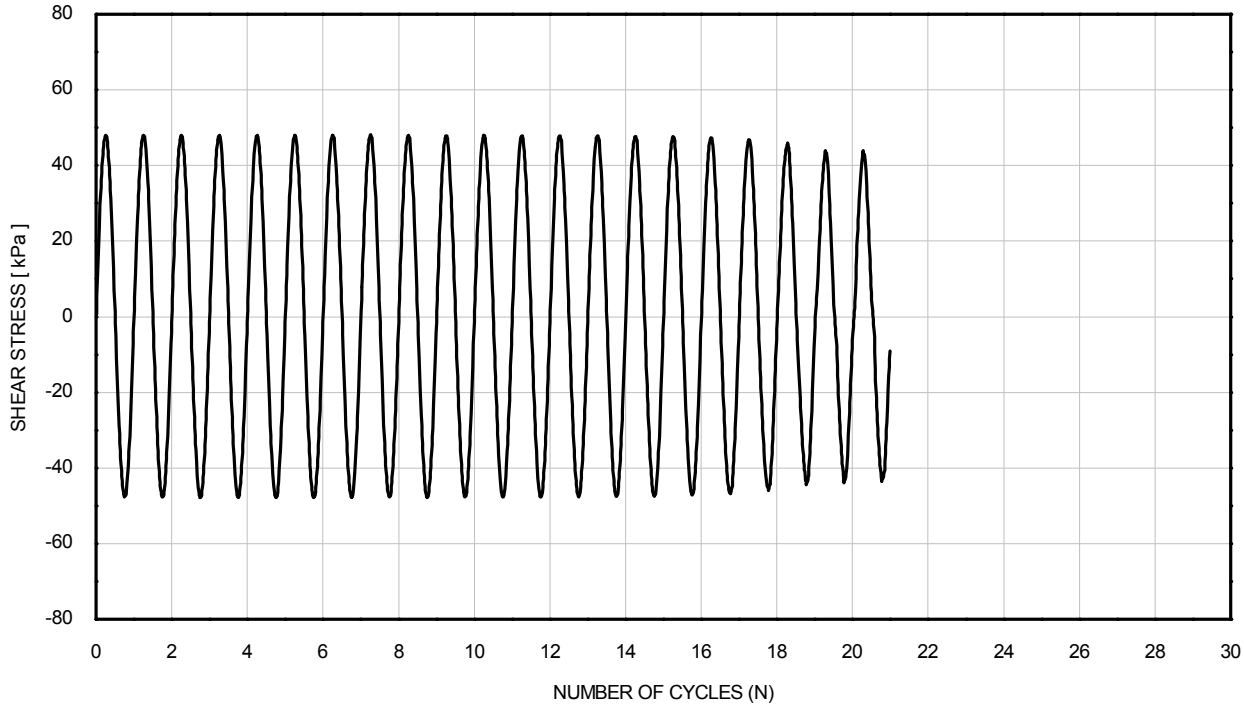


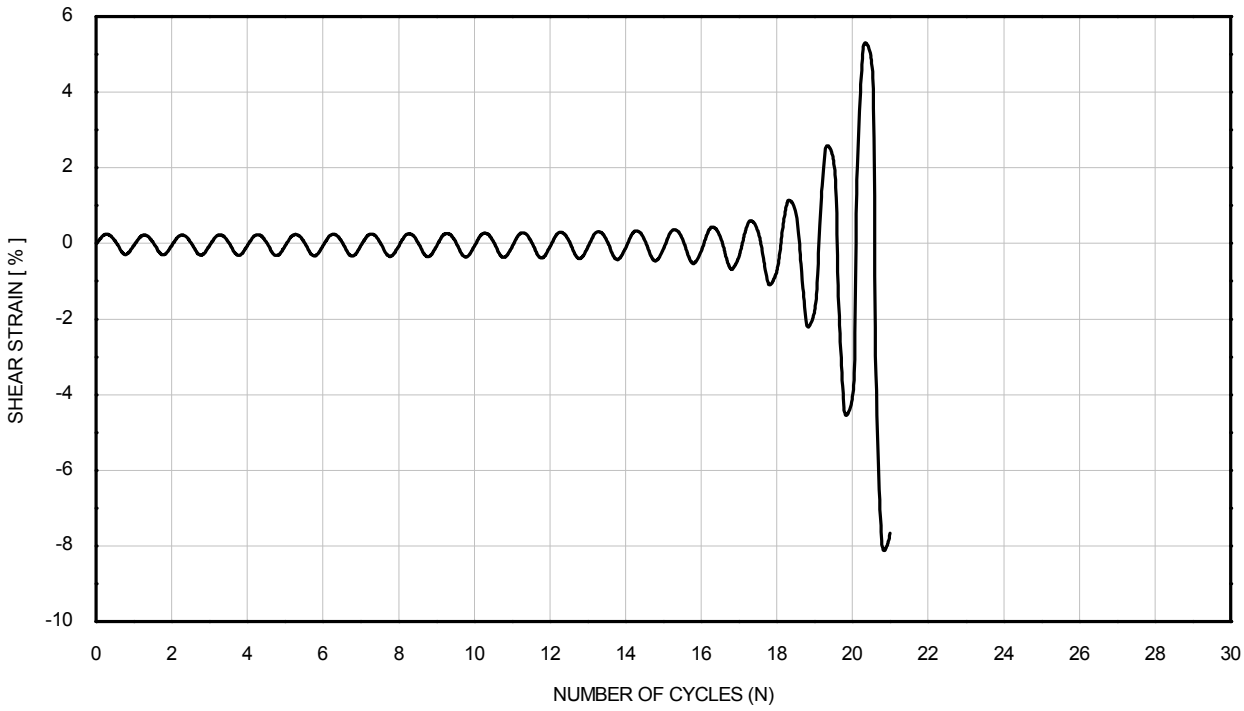


σ_{vc}	: 400 kPa	Batch	: 4
		Sample	: CSS_4-4
		Unit	: E5b (Tongeren)
		Test No.	: CSS26

CONSOLIDATED CYCLIC DSS TEST
CONSOLIDATION STAGE

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

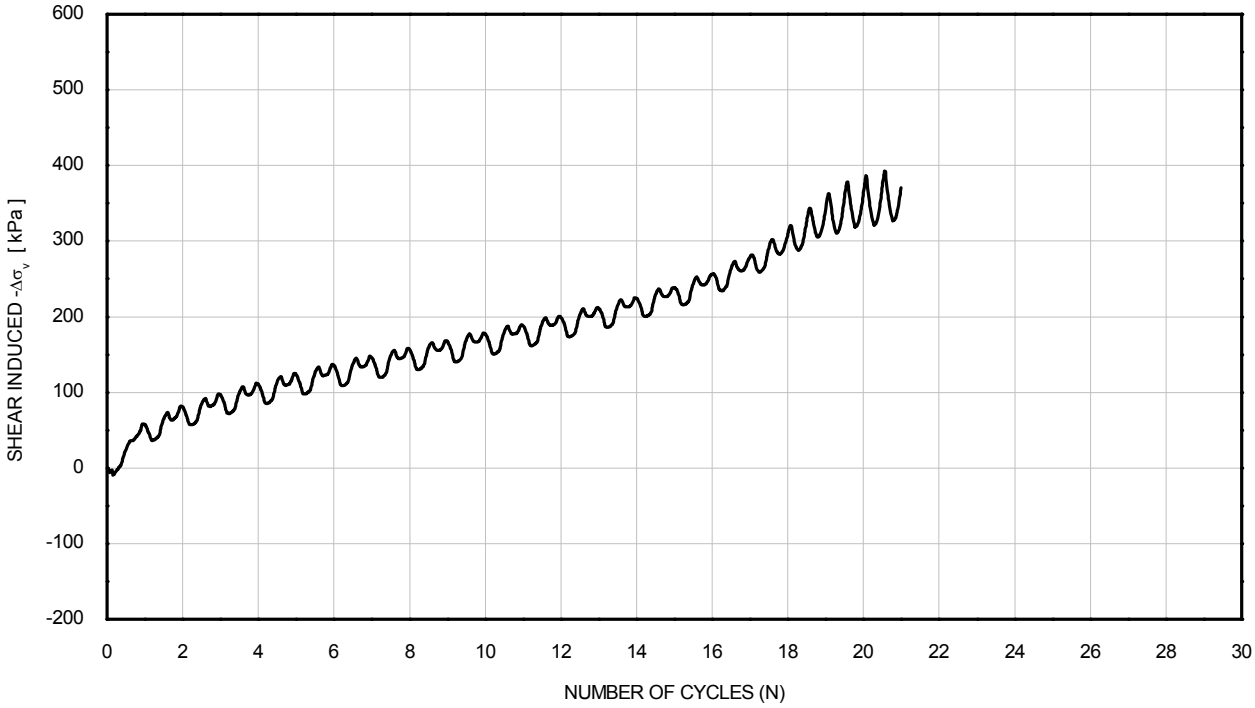


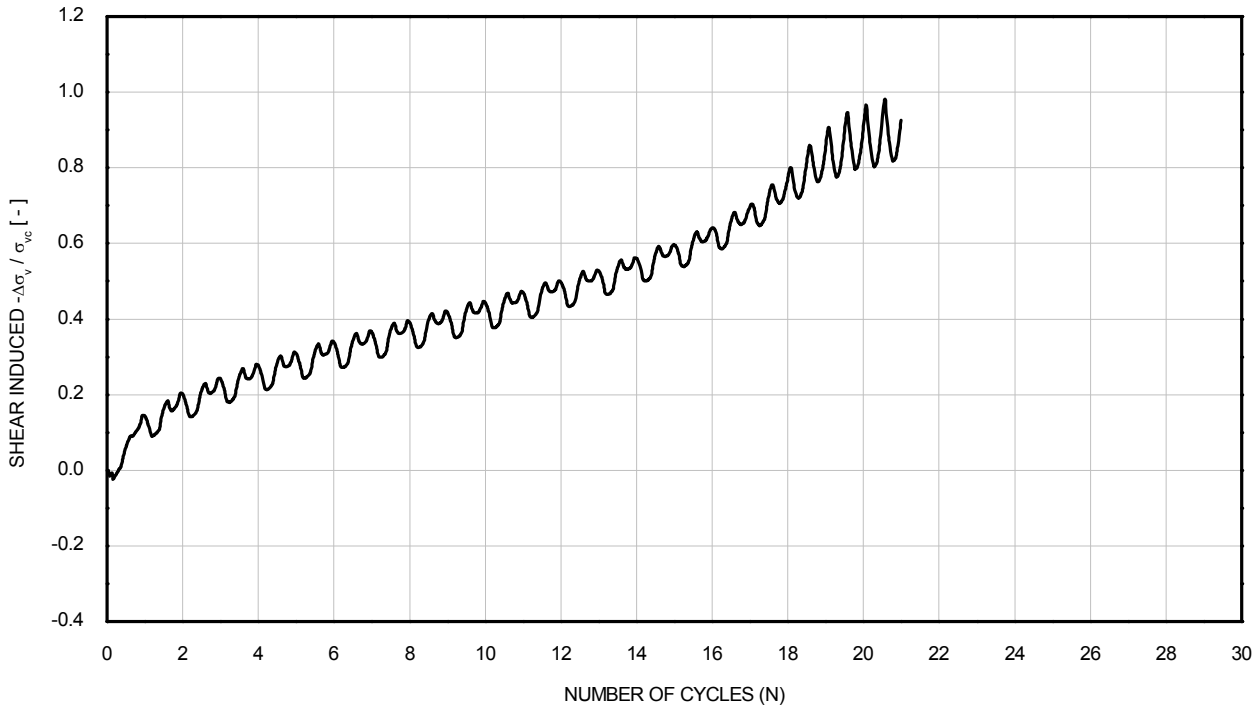


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-4
Mean τ_{cy}	:	47 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS26

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

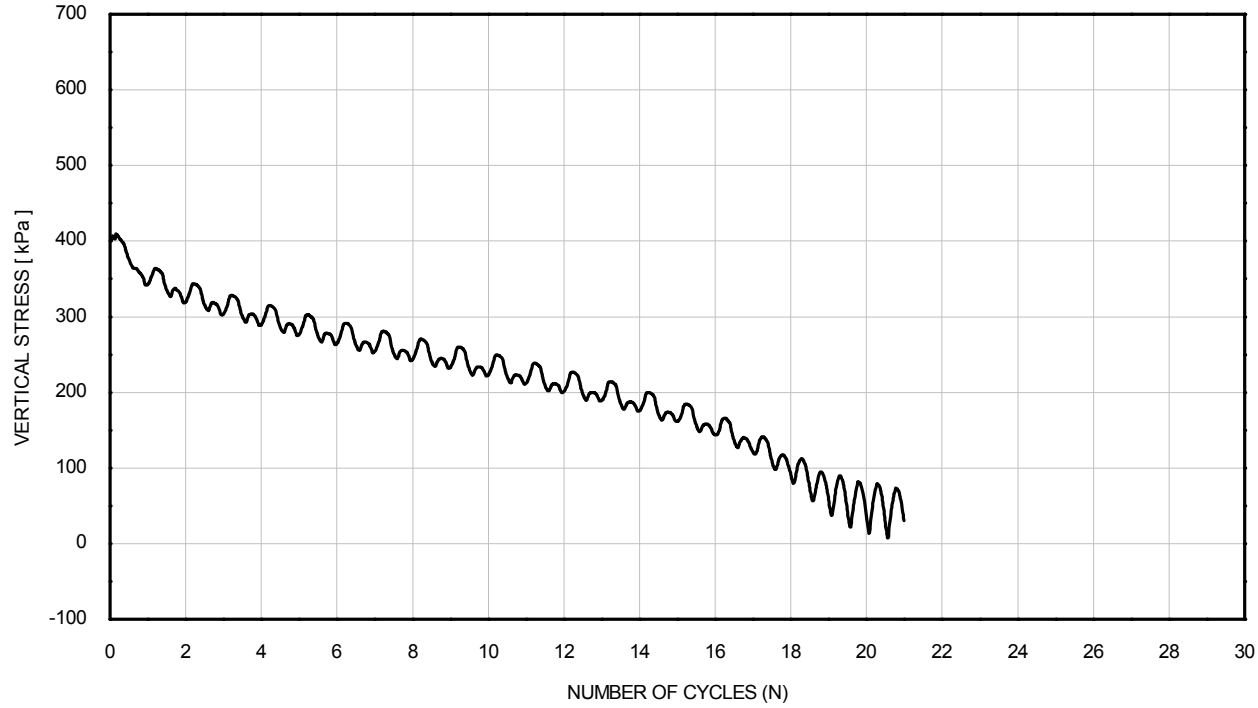


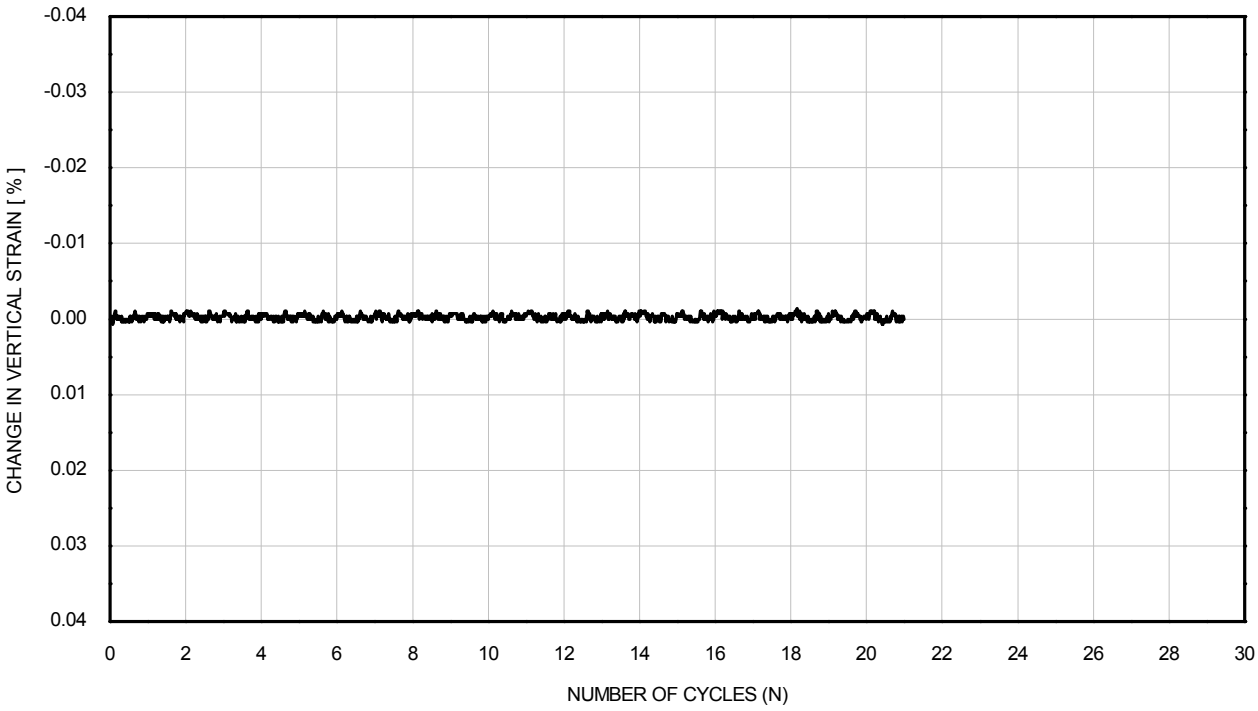


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-4
Mean τ_{cy}	:	47 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS26

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

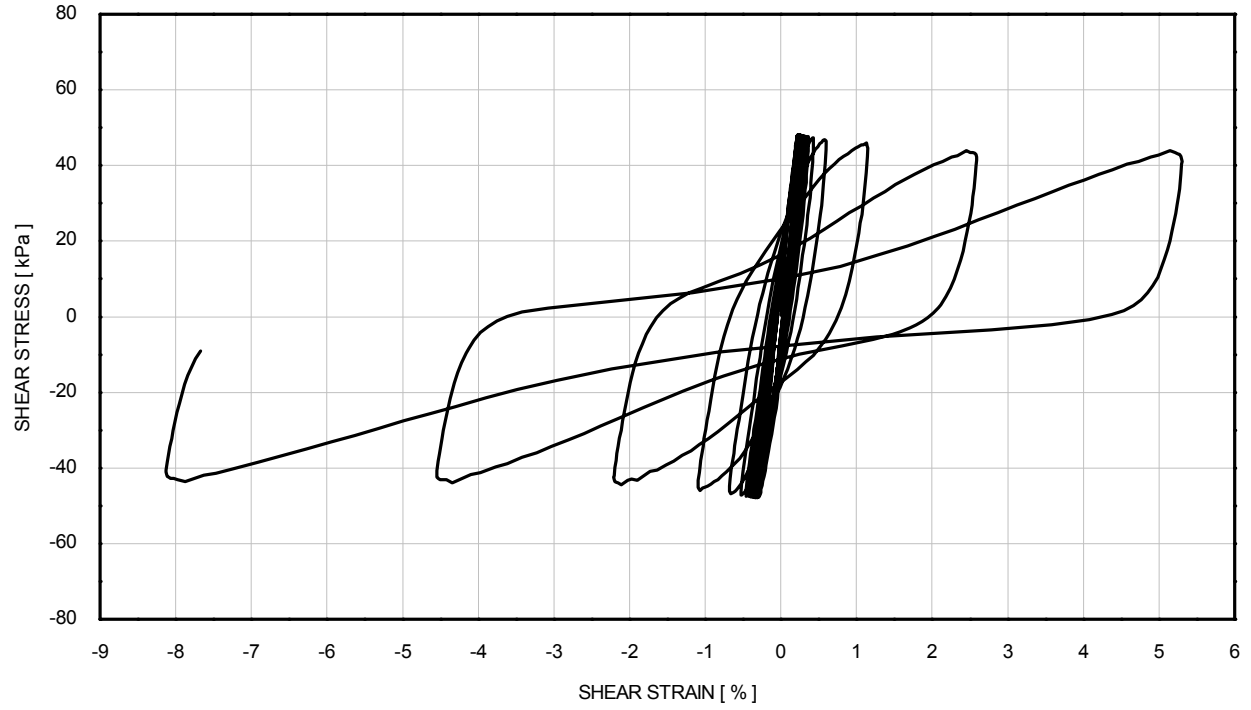


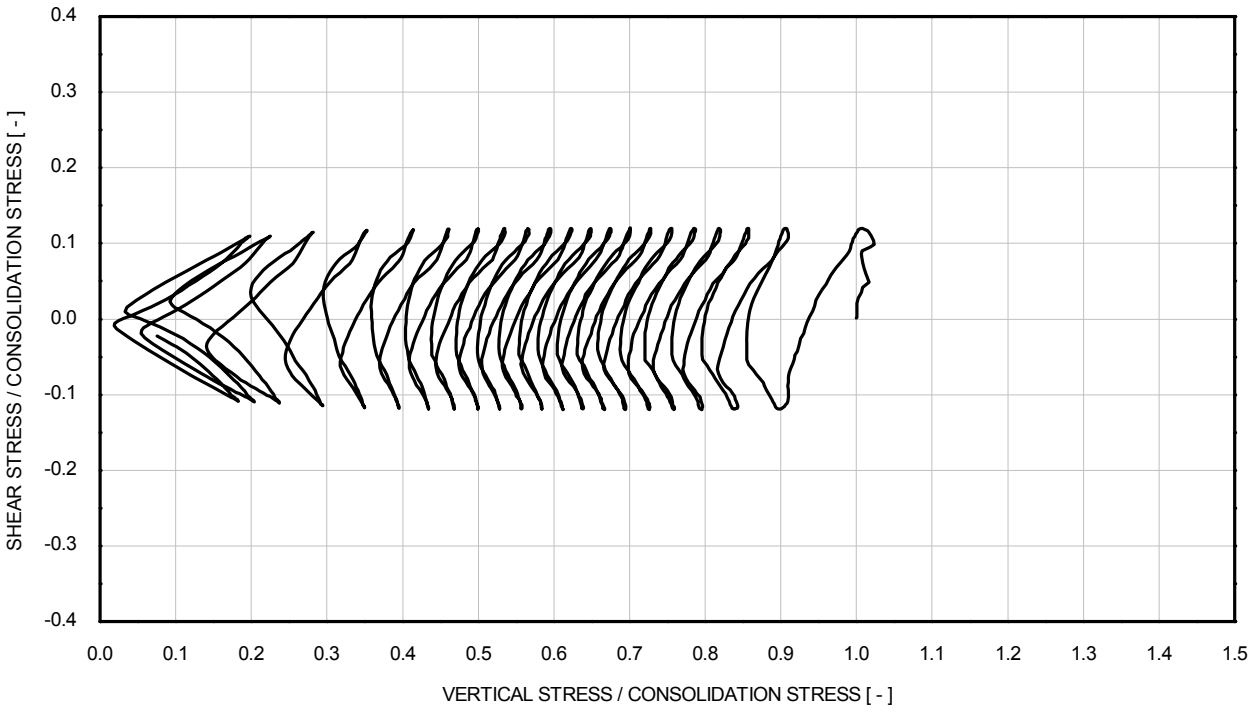


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-4
Mean τ_{cy}	:	47 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS26

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

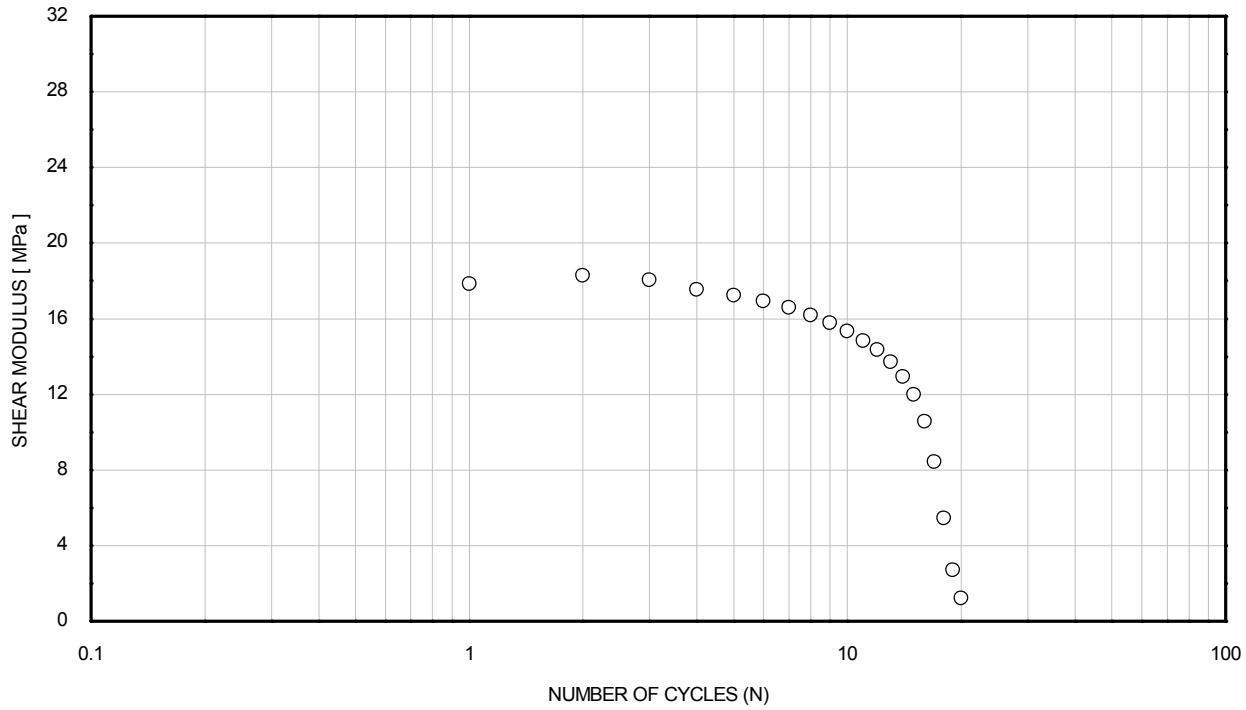


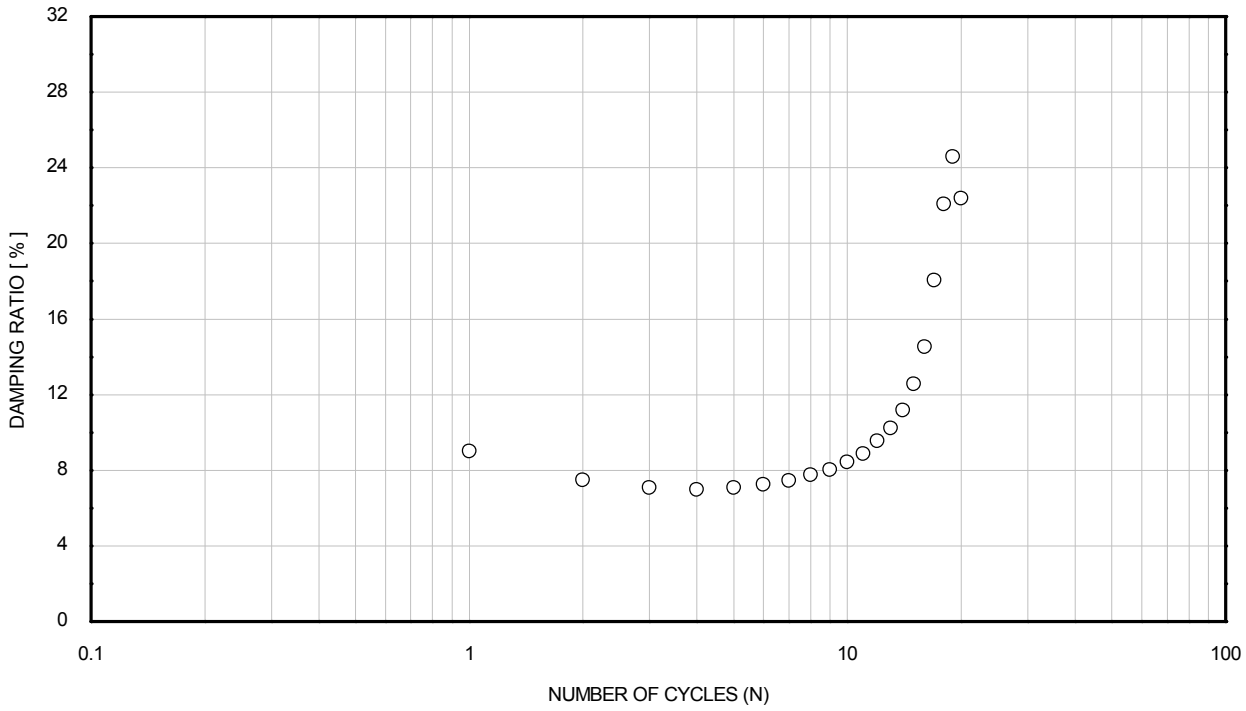


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-4
Mean τ_{cy}	:	47 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS26

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

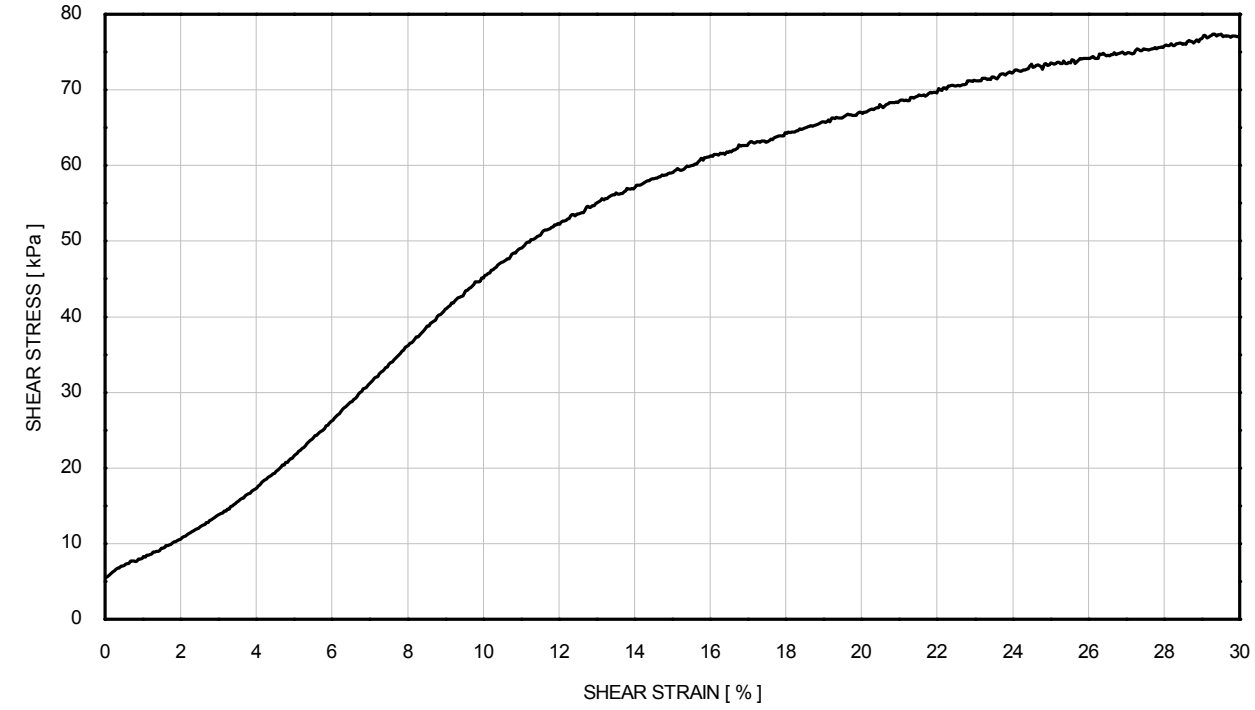


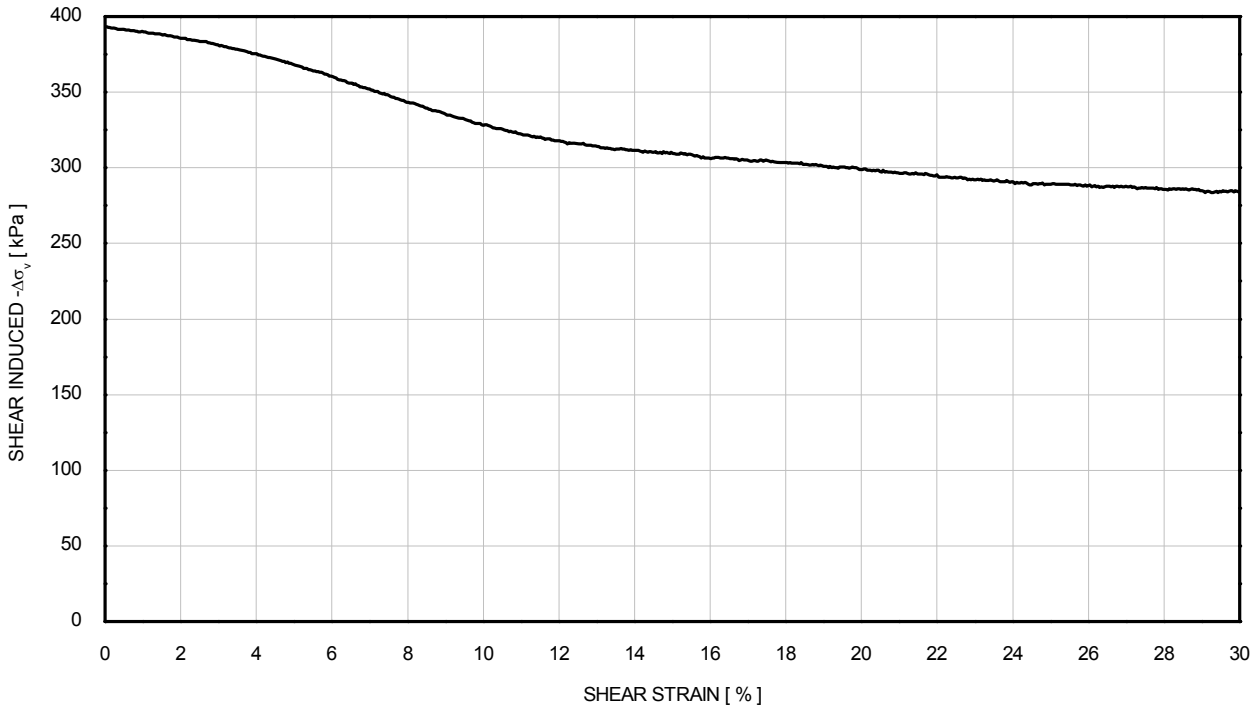


σ_{vc}	:	400 kPa	Batch	:	4
Mean τ_{av}	:	0 kPa	Sample	:	CSS_4-4
Mean τ_{cy}	:	47 kPa	Unit	:	E5b (Tongeren)
Frequency	:	0.10 Hz	Test No.	:	CSS26

CONSOLIDATED CYCLIC DSS TEST
STRESS-CONTROLLED CYCLIC LOADING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

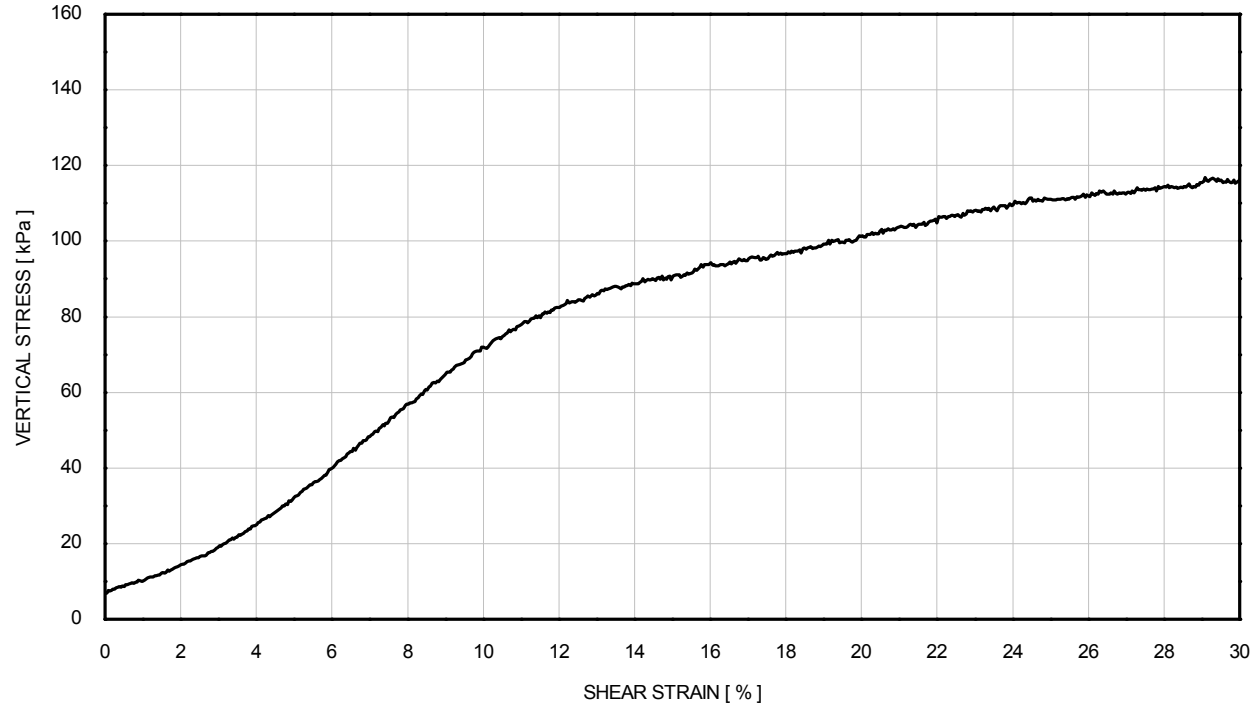


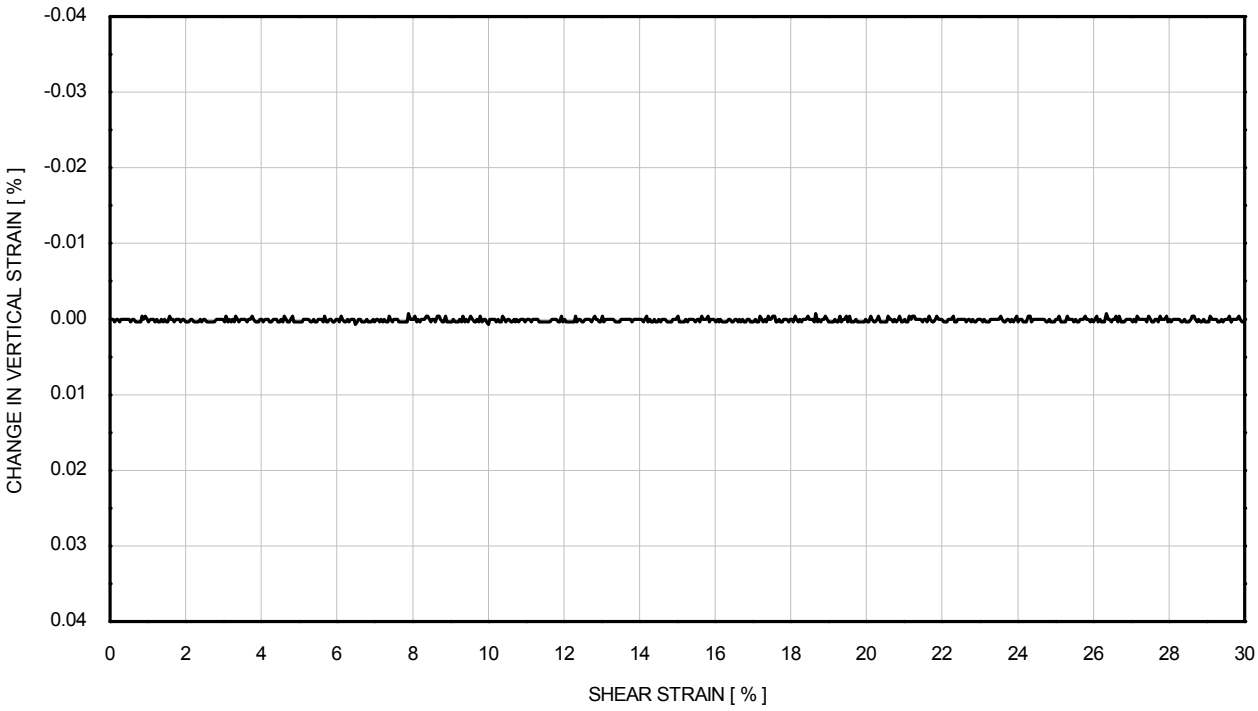


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 78 kPa	Sample	: CSS_4-4
γ at τ_{peak}	: 30.52 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.09 %/hour	Test No.	: CSS26

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

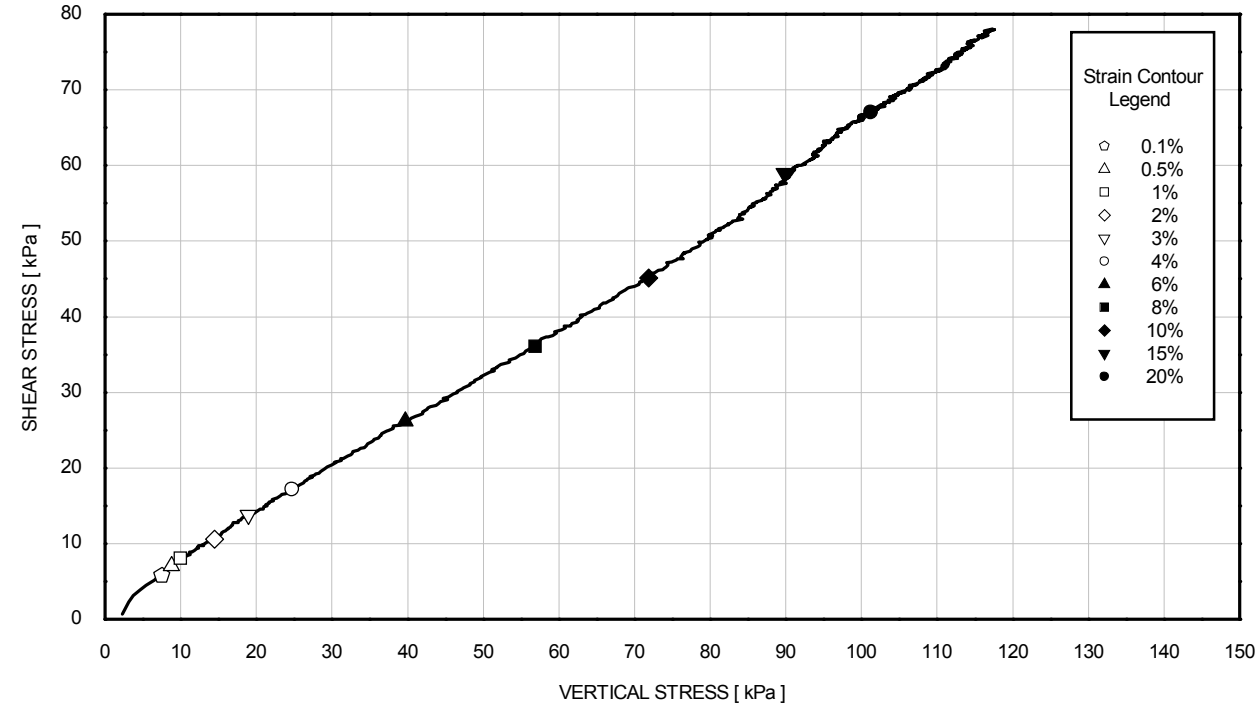


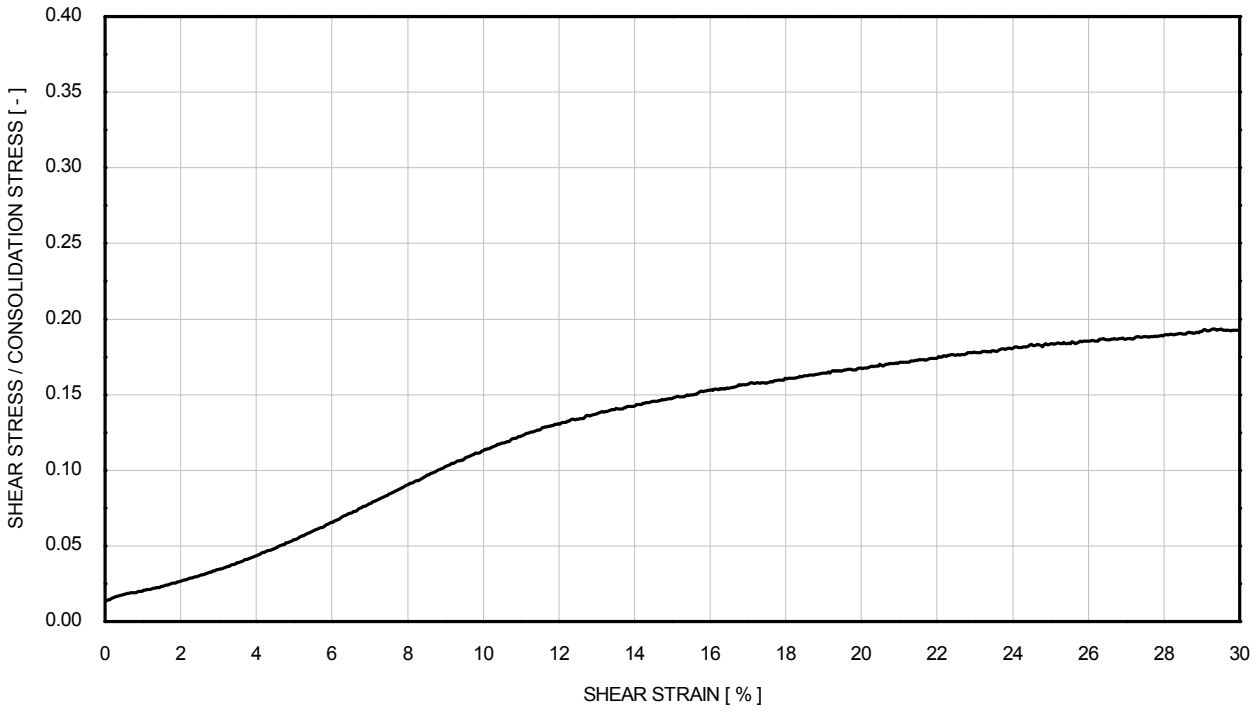


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 78 kPa	Sample	: CSS_4-4
γ at τ_{peak}	: 30.52 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.09 %/hour	Test No.	: CSS26

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

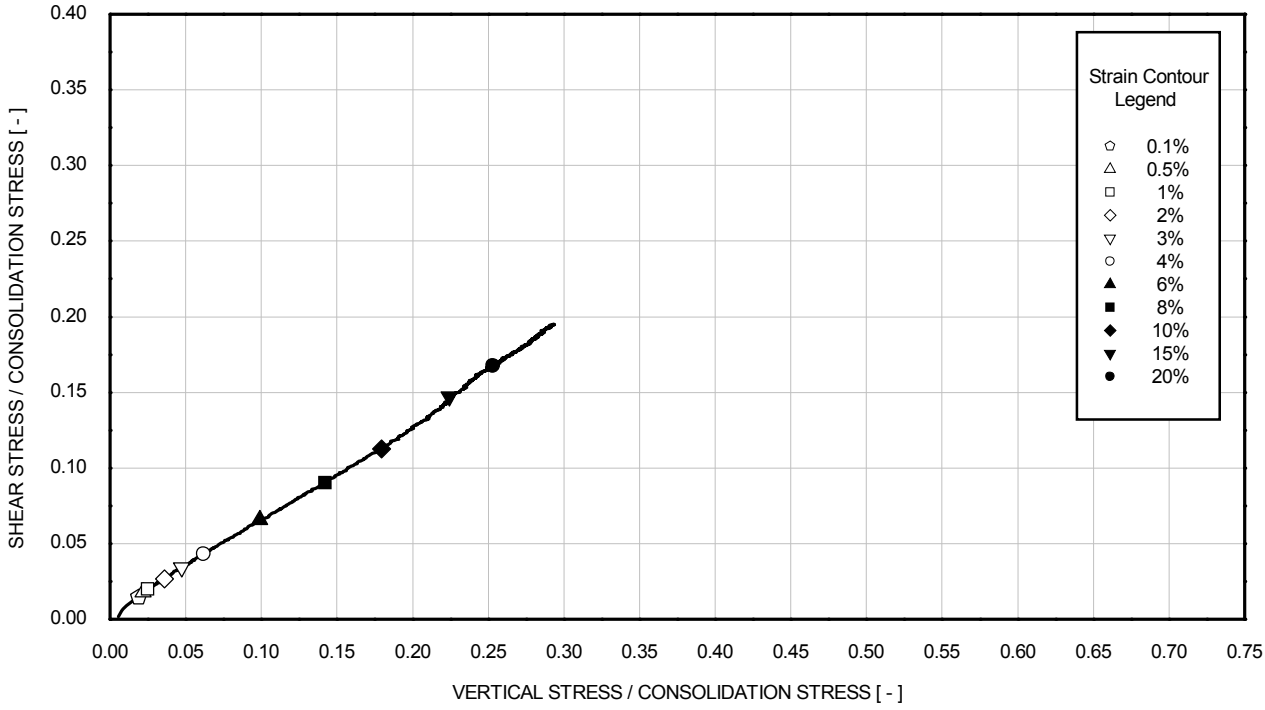


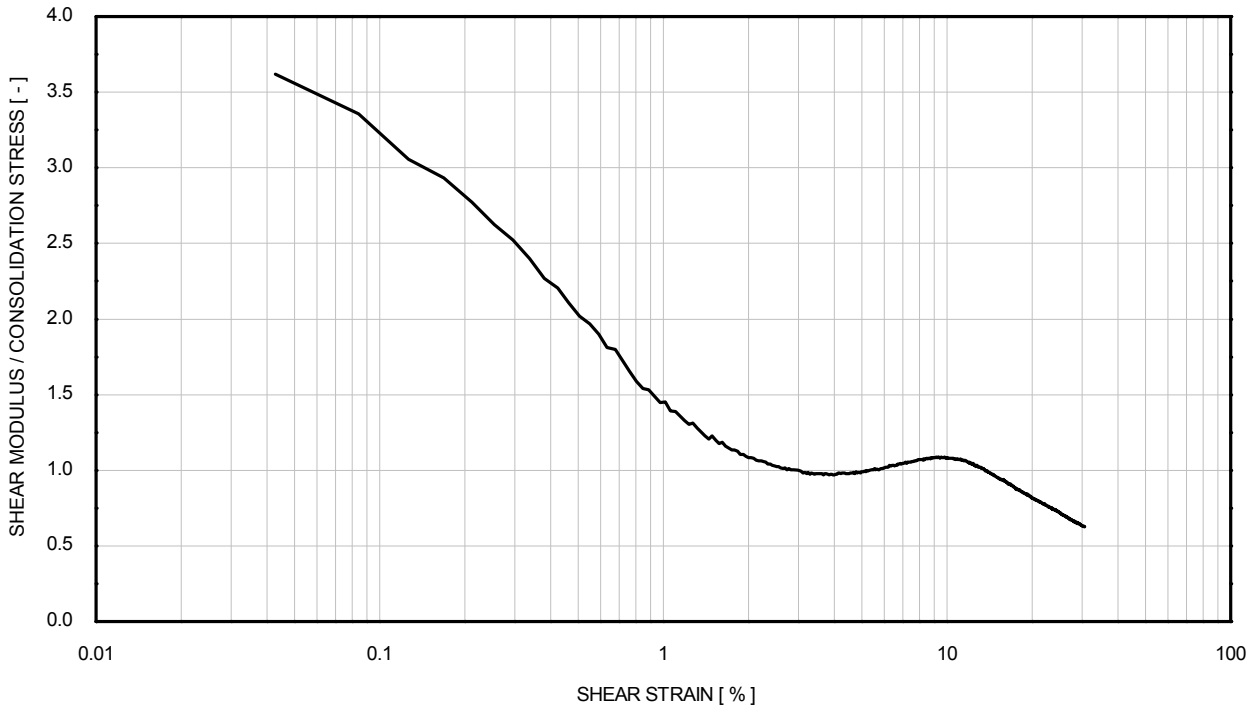


σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 78 kPa	Sample	: CSS_4-4
γ at τ_{peak}	: 30.52 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.09 %/hour	Test No.	: CSS26

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA





σ_{vc}	: 400 kPa	Batch	: 4
τ_{peak}	: 78 kPa	Sample	: CSS_4-4
γ at τ_{peak}	: 30.52 %	Unit	: E5b (Tongeren)
Rate of strain	: 5.09 %/hour	Test No.	: CSS26

CONSOLIDATED CYCLIC DSS TEST
SHEARING STAGE - CONSTANT VOLUME

BORSSELE WIND FARM ZONE, WFS III & IV - DUTCH SECTOR, NORTH SEA

SECTION B: 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.

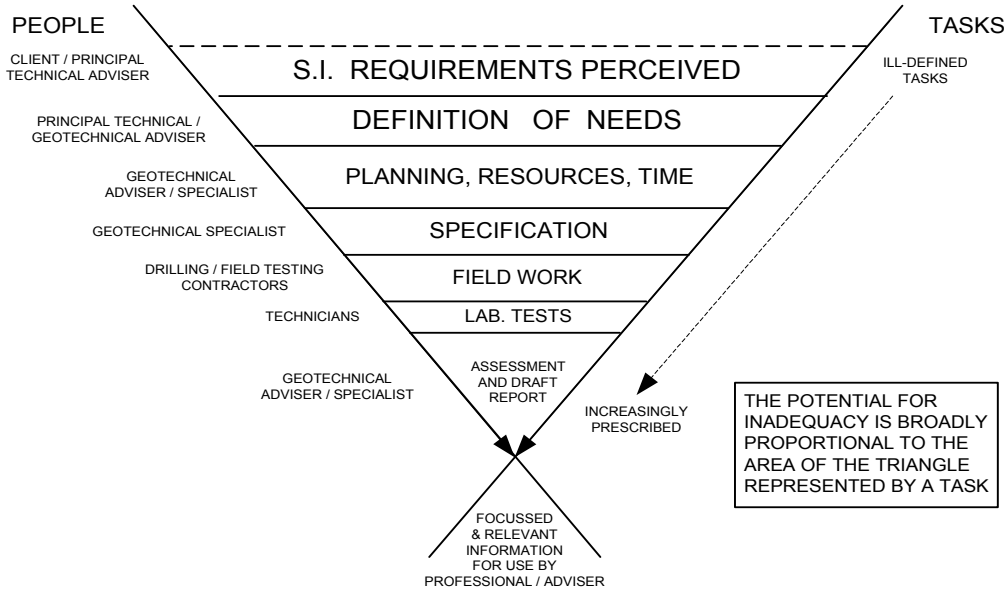
AUTHORITY, TIME AND RESOURCES NECESSARY FOR GEOTECHNICAL INVESTIGATIONS

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.

© Fugro 1996-2015
ISSUE 12

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*. London: Thomas Telford.

ISSUE 10
© Fugro 1996-2015

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.

ISSUE 12

© Fugro 1996-2015