



Rampion Offshore Wind Farm



ES Section 6 – Physical Environment Appendix 6.1 (Part one)

Fugro Geoconsulting Ltd

Document 6.3.6i

December 2012

APFP Regulation 5(2)(a)

Revision A

E.ON Climate & Renewables UK Rampion Offshore Wind Limited

**PART A (SOIL PARAMETERS FOR DESIGN)
PART B (GEOTECHNICAL DATA)
PART C (FIELD OPERATIONS)
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION,
QUADRANT 99
FOR
E.ON CLIMATE AND RENEWABLES**

Ultimate Client	E.ON Climate and Renewables
Contract No.	RO-1017
Client Address	Westwood Way Westwood Business Park Coventry CV4 8LG United Kingdom
Client Consultant	Atkins Global
Fugro Report No.	J11056-2 (01)
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Confidentiality	Report distribution restricted to project participants approved by the Client.

Abstract

At the request of E.on Climate and Renewables, Fugro GeoConsulting Limited acted as the main contractor for a geotechnical site investigation at the Rampion Offshore Wind Farm Site which is located approximately 13 kilometres south of Brighton, West Sussex within the English Channel. The field work was performed using the M/V Fugro Saltire from 27 March to 6 April 2011 and the M/V Willendeavour from 5 April to 9 April 2011.

The objective of this investigation was to provide sufficient geotechnical information to allow the detailed design of two Met Mast locations and provide geotechnical data to assess the soil conditions across the site. The water depth was in the range of 8.2 m to 44.9 m corrected to Lowest Astronomical Tide, as measured by the drillstring.

This report presents the following:

1. Details of the geotechnical site investigation, including description of the methods employed for the in-situ testing and sampling;
2. Results of in-situ testing and sampling;
3. Results and details of the offshore and onshore laboratory testing;
4. Borehole logs and descriptions of the soil strata, with onshore strength and plasticity data;
5. Derived soil parameters without recommended design lines.

Issue	Report Status	Prepared	Checked	Approved	Date
01	Complete Report	DBR	MAB	TMC	26/07/2011



Our ref: J11056-2 (01) /DBR

Date: 26 July 2011

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Attention: **Mr Neville Horton**

Dear Sir(s),

**Rampion Offshore Wind Farm Site Investigation
Quadrant 99, English Channel**

We have pleasure in submitting our Part A, B and C report (Geotechnical Data and Field Operations) for the above project.

We thank you for the opportunity to be of service to you on this phase of the project. If you require any additional information or clarification please contact those listed below.

This report was prepared by Mr Dan Rudkin and Mr Alistair Youngson under the supervision of Mr Matt Bean.

Yours faithfully,

Fugro GeoConsulting Limited

Dan Rudkin

Project Engineer

Tim Carrington

Associate Director - Geotechnics

Distribution: 1 electronic copy to Mr Neville Horton

RAMPION OFFSHORE WIND FARM SITE INVESTIGATION
ENGLISH CHANNEL, QUADRANT 99

EXECUTIVE SUMMARY

PART A SOIL PARAMETERS	PART B GEOTECHNICAL DATA	PART C FIELD OPERATIONS
Report No: J11056-3(01) Date: 26/07/11 Issue No: 01 Status: Complete	Report No: J11056-2(01) Date: 26/07/11 Issue No: 01 Status: Draft	Report No: J11056-2(01) Date: 26/07/11 Issue No: 01 Status: Draft
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Note: Current Report Shaded

QUALITY ASSURANCE RECORD

Section	Prepared By	Checked By	Approved By
PART A			
A. Summary	DBR/AY	MAB	TMC
A.1 Summary of Soil Conditions	DBR/AY	MAB	TMC
A.2 Interpretation and Evaluation of Geotechnical Data	DBR/AY	MAB	TMC
A.3 List of Symbols and Classification System Used	DBR/AY	MAB	TMC
A.4 References	DBR/AY	MAB	TMC
PART B			
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B.2 – Classification Tests	DBR/AY	MAB	TMC
B.3 – Consolidation Tests	DBR/AY	MAB	TMC
B.4 – Consolidated Triaxial Tests	DBR/AY	MAB	TMC
B.5 – Direct Simple Shear Tests	DBR/AY	MAB	TMC
B.6 – Direct Shear (Shearbox) Tests	DBR/AY	MAB	TMC
B.7 – Ring Shear Tests	DBR/AY	MAB	TMC
B.8 – Cyclic Triaxial and Direct Simple Shear Tests	DBR/AY	MAB	TMC
B.9 – Rock Testing	DBR/AY	MAB	TMC
B.10 – Cone Penetration Testing	DBR/AY	MAB	TMC
B.11 – Description of Laboratory Tests and Procedures	FGCLTD	MAB	TMC
B.12 – List of Symbols and Classification System Used	FGCLTD	MAB	TMC
B.13 – References	DBR/AY	MAB	TMC
B.14 – Guidelines on Use of Report	FGCLTD	MAB	TMC
B.15 – Fugro Alluvial Limited Laboratory Report	FGCLTD	MAB	TMC
PART C			
C. Summary	DBR/AY	MAB	TMC
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C.3 – Sampling	DBR/AY	MAB	TMC
C.4 – CPT Penetration Testing	DBR/AY	MAB	TMC
C.5 – Field Laboratory	DBR/AY	MAB	TMC
C.6 – Positioning	FSBV	MAB	TMC
C.7 – References	DBR/AY	MAB	TMC
C.8 – Health, Safety and Environment	DBR/AY	MAB	TMC

Notes:

The personnel stated above were responsible for checking and approving this report.

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EXECUTIVE SUMMARY

General

Fugro GeoConsulting Limited (FGCLTD) has been requested by E.on Energy and Renewables (E.on) to produce a factual geotechnical report to assist in the design and development of the Rampion field located in Block 3/28 of the UK Sector of the North Sea.

The data obtained from the geotechnical site investigation at the Rampion field is to assist in determining geotechnical parameters for use in the installation of the proposed monopole met mast and wind turbine locations.

The work was performed from the M/V Saltire from 27 March to 06 April 2011 and from the M/V Willendeavour from the 5 April to 9 April 2011, in accordance with instructions received from E.on.

A vicinity map and detailed location plan of the Rampion site are presented at the end of this section on Plates 1 to 2, respectively.

The water depth, relative to mean sea level, ranged between 8.2 m and 44.9 m corrected to Lowest Astronomical Tide (LAT) at the Rampion site.

Table S.1: Summary of Site Work – M/V Fugro Saltire

Location	Final Penetration [m BSF]	Sampling and Testing Details (successful samples/tests only)
BH_02	46.4	19 CPT and 24 Samples
BH_04	47.4	29 CPT and 24 Samples
BH_04a	4.2	6 Samples
BH_06	52.9	17 CPT, 37 Samples and 3 Hammers
BH_07	45.8	23 CPT, 31 Samples and 2 Hammers
BH_13	45.2	27 CPT, 27 Samples and 8 Hammers
BH_14	50.2	23 CPT and 25 Samples
BH_16	46.4	26 CPT, 19 Samples and 5 Hammers
BH_17	45.1	24 CPT and 25 Samples

Notes:

Table excludes number of tests of nil penetration / no recovery

BSF = Below seafloor

CPT = Cone Penetration Test

Table S.2: Summary of Site Work – M/V Willendeavour

Location	Final Penetration [m BSF]	Sampling and Testing Details (successful samples/tests only)
VC_03	5.6	1 Vibrocore
CPT_03	5.2	1 CPT
VC_18C	2.6	1 Vibrocore
CPT_18C	3.2	1 CPT
VC_19C	4.0	1 Vibrocore
CPT_19C	1.0	1 CPT
CPT_19Ca	1.2	1 CPT
VC_20C	1.9	1 Vibrocore
VC_20Cb	1.4	1 Vibrocore
CPT_20C	3.2	1 CPT
VC_21C	3.7	1 Vibrocore
CPT_21C	3.0	1 CPT

Soil Conditions

The soil conditions encountered during the investigation are summarised in Table S.3 to Table S.15 below. They are believed to adequately represent the soil units present at the site. See Section B.2 for more details on classification and strength testing.

Table S.3: Summary of Soil Conditions – Metmast Location BH_13

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
II	0.0	3.7	Pale olive to very dark grey sandy silica GRAVEL with cobbles. Clasts are sub-angular to sub-rounded of flint
IVa	3.7	17.6	Stiff to hard very dark greenish grey slightly sandy CLAY with thin to very thin beds and fine to coarse gravel-sized pockets of very dark greenish grey silty silica sand
IVc	17.6	33.5	Very dense dark grey to dark greenish grey fine silica SAND
IVd	33.5	44.2	Hard to very hard dark olive grey to dark grey slightly sandy CLAY with fine to medium gravel-sized pockets of dark greyish brown slightly silty silica sand
IVe	44.2	45.2*	Dark grey silty fine silica SAND occasionally with medium gravel-sized pockets of black clay with mica crystals

Notes:

BSF = Below seafloor

Table S.4: Summary of Soil Conditions – Metmast Location BH_14

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	2.8	Medium dense to dense dark greyish green very silty silica fine SAND with fine gravel-sized pockets of dark greenish grey clay with medium to coarse sub-angular to sub-rounded silica gravel
IVa	2.8	11.8	Stiff to Hard dark greenish grey slightly sandy CLAY with closely spaced thin laminae of grey and black fine to medium silica sand
IVb	11.8	31.0	Thinly to thickly interlaminated very stiff to hard dark greenish grey slightly sandy CLAY and fine to medium greenish grey silica SAND with traces of fine black silica sand and evidence of bioturbation (burrows)
IVd	31.0	37.5	Stiff to very hard dark greenish grey slightly sandy CLAY
IVe	37.5	50.2*	Very dense dark greenish grey slightly clayey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table S.5: Summary of Soil Conditions – BH_02

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.4	Very loose to medium dense SAND
IIa	0.4	5.9	Medium dense to dense very dark greenish grey fine silty silica SAND with closely spaced thick laminae and fine to medium gravel-sized pockets of dark grey sandy clay with fine to medium gravel-sized pockets of greenish grey fine silica sand
Vd	5.9	12.1	Very stiff to hard dark greenish grey slightly sandy CLAY with traces of fine gravel-sized pockets of black staining
Ve	12.1	46.4*	Thinly interlaminated to medium interbedded very dark to dark greenish grey silty fine to medium silica SAND and very dark to dark greenish grey slightly sandy CLAY occasionally with fine to coarse gravel-sized pockets of sandy clay to clayey silica sand

Notes:

BSF = Below seafloor

* = End of Borehole

Table S.6: Summary of Soil Conditions – BH_04/04a

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.1	Very loose to loose dark greenish grey fine to coarse silica SAND with fine to medium gravel and fine to coarse gravel-sized shells fragments and shells
IIIb	0.1	3.1	Firm to very stiff dark greenish grey to dark grey slightly sandy CLAY with fine gravel-sized shell fragments and shells
IVc	3.1	22.5	Dense to very dense dark greenish grey to dark grey silty to very silty fine silica SAND
Va	22.5	39.5	Hard to very hard dark grey slightly sandy CLAY with fine to medium gravel-sized pockets of dark greenish grey fine to medium silica sand
Vb	39.5	47.4*	Hard to very hard greenish grey sandy SILT with coarse gravel-sized pockets and laminations of grey fine silica sand

Notes:

BSF = Below seafloor

* = End of Borehole

Table S.7: Summary of Soil Conditions – BH_06

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.3	Medium dense to dense SAND
Va	0.3	19.0	Stiff to very stiff dark grey slightly sandy CLAY with fine gravel-sized pockets of grey sand
Vb	19.0	26.1	Dark to very dark grey slightly sandy SILT
Ve	26.1	31.0	Very stiff to hard very dark greenish grey slightly sandy CLAY and medium dense to very dense dark greenish grey slightly silty fine silica SAND with coarse sand-sized to fine gravel-sized shell fragments
Vf	31.0	42.1	Hard to very hard mottled and thinly interlaminated grey and brown CLAY
Vi	42.1	47.1	Very dense dark greyish green fine to medium silica SAND with fine gravel-sized pockets of greenish grey fine to medium silica sand
Vlb	47.1	48.5	Structureless CHALK composed of white silt with closely spaced thin laminations of slightly duller white silt (Grade Dm)
Vlc	48.5	52.9*	Structureless CHALK composed of white creamy silt and medium blocky gravel with traces of fine to medium gravel-sized flint. Chalk clasts are weak, medium density (Grade Dc)

Notes:

BSF = Below seafloor

*= End of Borehole

Table S.8: Summary of Soil Conditions – BH_07

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.3	Dense SAND
Vlb	0.3	4.0	Structureless CHALK composed of white silt and fine to coarse blocky gravel with few angular fine to coarse gravel-sized black flint. Chalk clasts are very weak, low density (Grade Dm)
Vlc	4.0	27.0	Structureless CHALK composed of white silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density (Grade Dc)
Vld	27.0	45.8*	Structureless CHALK composed of white silt and fine to coarse angular and blocky gravel. Chalk clasts are weak, low to medium density (Grade Dc)

Notes:

BSF = Below seafloor

*= End of Borehole

Table S.9: Summary of Soil Conditions – BH_16

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIa	0.0	6.0	Loose to medium dense very dark greenish grey to greenish grey slightly silty fine to coarse silica SAND with coarse sand-sized to fine gravel-sized shell fragments
IIIc	6.0	19.0	Dense to very dense very dark greenish grey to greenish grey slightly silty fine to coarse silica SAND
IIId	19.0	22.5	White grey and black sub-angular to sub-rounded fine to coarse silica GRAVEL of mixed lithologies
IIIc	22.5	27.5	Very dense olive grey silty fine silica SAND with sub-angular to sub-rounded medium silica gravel
IVb	27.5	39..5	Thin to medium interbedded dark greyish brown sandy CLAY and very dark greenish grey slightly clayey fine silica SAND
IVc	39.5	42.3	Thinly to medium interbedded dark greenish grey calcareous SANDSTONE with few brown and white fossils and very dark grey fine silica SAND
Vc	42.3	46.4*	Medium dense dark greenish grey to olive grey slightly clayey to very clayey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table S.10: Summary of Soil Conditions – BH_17

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
Ve	0.0	21.0	Thin to thickly interlaminated very stiff to hard greenish grey slightly sandy CLAY with thin laminae of light greenish grey silty fine silica sand and dark greenish grey very silty fine silica SAND
Vf	21.0	28.8	Very stiff to hard dark greenish grey slightly sandy CLAY with very closely to closely spaced thin to thick laminae of greenish grey fine silica sand
Vi	28.8	45.1*	Very dense dark greenish grey to greenish grey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table S.11: Summary of Soil Conditions – VC_03 / CPT_03

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	0.2	Light brown sandy GRAVEL. Sand is fine to coarse. Gravel is ANG-SBR fine to medium of shell and shell fragments
IIIa	0.2	0.4	Very dark brown spongy PEAT
IIIb	0.4	2.5	Very soft to soft light grey CLAY
IIIb	2.5	3.5	Light grey sandy SILT. Sand is fine
IIIb	3.5	4.0	Soft grey CLAY
IIIb	4.0	5.0	Light grey SILT
IIIb	5.0	5.4*	Very soft light grey CLAY

Notes:

BSF = Below seafloor

* = End of Borehole

ANG = Angular

SBR = Sub-rounded

Table S.12: Summary of Soil Conditions – VC_18C / CPT_18C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	1.0	Light grey/white sandy GRAVEL. Sand is fine to coarse. Gravel is SBA - SBR fine to coarse of mixed lithologies
IIId	1.0	3.2*	White clayey sandy GRAVEL. Sand is fine to coarse. Gravel is SBA fine to coarse of chalk (Structure-less granular chalk - grain supported with intergranular chalk putty/clay)

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

Table S.13: Summary of Soil Conditions – VC_19C / CPT_19C / CPT_19Ca

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIa	0.0	3.8*	Grey/brown gravelly SAND. Sand is fine to coarse. Gravel is ANG - SBR fine to medium of shell, shell fragments and mixed lithologies From 2.00m ... Becoming light brown/tan

Notes:

BSF = Below seafloor, SBR = Sub-Rounded

* = End of Borehole, SBA = Sub-angular

Table S.14: Summary of Soil Conditions – VC_20C / VC_20Cb / CPT_20C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	0.0/1.0	Brown sandy GRAVEL.. Sand is fine to coarse. Gravel is SBR fine to coarse of mixed lithologies.
IIa	0.0	0.0/1.0	Brown silty gravelly SAND. Sand is fine to coarse. Gravel is ANG - SBR fine to medium of shell, shell fragments and mixed lithologies
IIIb	1.0	3.2*	Soft to very stiff grey CLAY

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

ANG = Angular

Table S.15: Summary of Soil Conditions – VC_21C / CPT_21C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	1.0	Light grey/white sandy GRAVEL. Sand is fine to coarse. Gravel is SBA - SBR fine to coarse of mixed lithologies
IIId	1.0	3.5*	White clayey sandy GRAVEL. Sand is fine to coarse. Gravel is SBA fine to coarse chalk. (Structure-less granular chalk - grain supported with intergranular chalk putty/clay)

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

Quality of Laboratory and in-situ Data

Following recommendations by Lunne *et al.* it can be seen that the sample quality measured from the incremental oedometers and triaxial tests is of 'good to fair' to 'very good to excellent'. These tests show good agreement with index testing performed during the offshore phase of the investigation. The testing is therefore thought to accurately represent true soil conditions.

Table S.16: Summary of Laboratory testing

Test Type	Offshore Tests	Onshore Tests (BH_13 & 14)	Onshore Tests (All other Locations)
Natural Moisture Content Determination	222	-	-
Bulk and Dry Density Determination	216	-	-
Pocket Penetrometer Test	118	-	-
Torvane Test	32	-	-
Particle Size Distribution (Sieve Analysis)	-	13	46
Particle Size Distribution (Pipette & Hydrometer Analysis)	-	24	74
Atterberg Limits	-	19	57
Saturated Moisture Content Determination	-	-	2
Particle Density Determination	-	12	15
Minimum & Maximum Density Determination	-	6	8
Incremental Oedometer	-	9	4
Unconsolidated Undrained Triaxial Test (Undisturbed)	30	-	2
Unconsolidated Undrained Triaxial Test (Remoulded)	-	12	1
Anisotropically Consolidated Undrained Triaxial Compression Test	-	2	1
Isotropically Consolidated Undrained Triaxial Test	-	-	5
Isotropically Consolidated Undrained Triaxial Test (Set of Three)	-	1	-
Isotropically Consolidated Drained Triaxial Compression Test (Set of Three)	-	4	3
Cyclic Triaxial Tests	-	4	1
Direct Shear (Shearbox) Test (Set of Three)	-	2	4
Static Direct Simple Shear Test	-	4	6
Cyclic Direct Simple Shear Test	-	1	3
Multi-Reversal Shear Box Test	-	3	-
Point Load Test	-	-	2
Ring Shear Test	-	6	2
Carbonate Content Test	-	9	-
Organic Content Test	-	9	-
pH and Total Sulphate Test	-	9	-
Dry Density	-	-	7

Notes:

Unsuitable tests not included

Summary of Fieldwork and Fieldwork Problems

The fieldwork was performed in two stages from the vessel M/V Fugro Saltire from 27 March to 06 April 2011 and from the M/V Willendeavour from the 5 April to 9 April 2011.

A total of nine boreholes of combined sampling and CPT were performed from the M/V Fugro Saltire, with eight boreholes performed to a depth greater than 45 m and an additional borehole performed adjacent to BH_04.

During BH_04, an error was made in tidal correction readings, and it was discovered that the driller had drilled to 4.5 m BSF and not the required 2.5 m BSF. It was decided to continue with BH_04 and an adjacent borehole was performed to fill the data gap to 4.5 m. Corrections were made to all the recovered data and the error in depth records does not affect the quality or reliability of the data.

An error occurred with the UU triaxial testing machine, which meant it was not possible to perform UU testing at BH_02. This does not affect the quality of the data at any other locations, which are believed to adequately represent the soil conditions and show good correlation with the in-situ testing performed.

A total of 6 vibrocores and 6 Wheeldrive CPT were performed at 5 locations from the M/V Willendeavour, with a second CPT and second vibrocore attempt performed at CPT_19Ca and VC_20Cb, respectively.

Whilst attempting to recover the wave rider buoy to the M/V Willendeavour the second section of the rubber bungee became caught on the underneath of the ships anchor. After several attempts to free the bungee it was decided that the safest way to move forward was to un-attach the wave rider buoy and release the rubber with two fender buoys attached and try to manoeuvre the vessel as to free the snagged line. Whilst attempting to manoeuvre the vessel the strain became too much for the rubber and it parted roughly 10 cm below the top connector (which was attached to the two fender buoys). Crew along with a specialist team of divers onboard returned to site to recover the remaining wave buoy equipment. These buoys were then recovered along with the parted top section. The vessel and FAOL crew proceeded to recover the rest of the equipment to deck using both the ships crane and main lift winch.

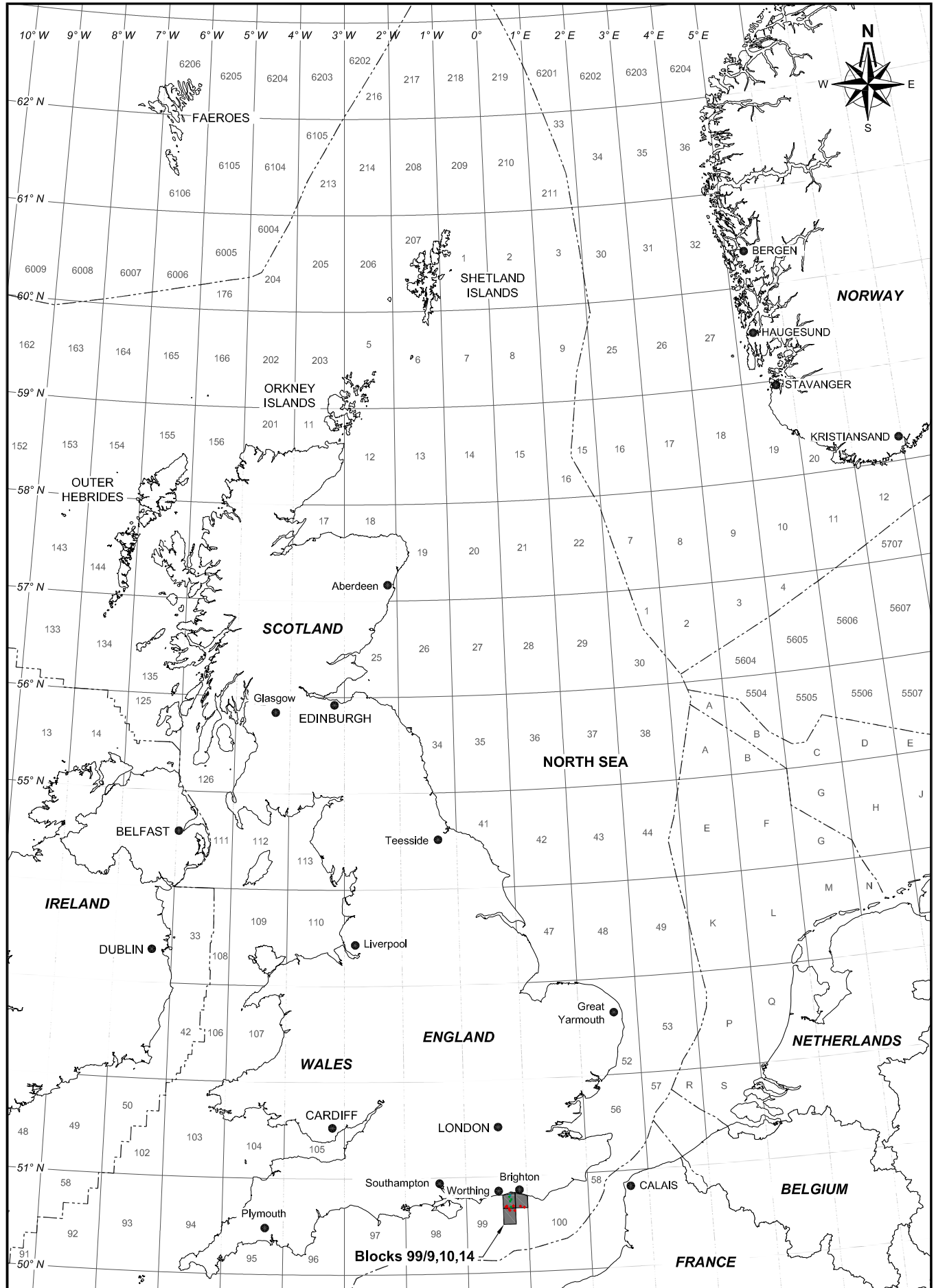
There were no other major problems associated with the geotechnical investigation.

E.ON CLIMATE AND RENEWABLES
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION



Drawn by : DRF Date : 13/04/2011

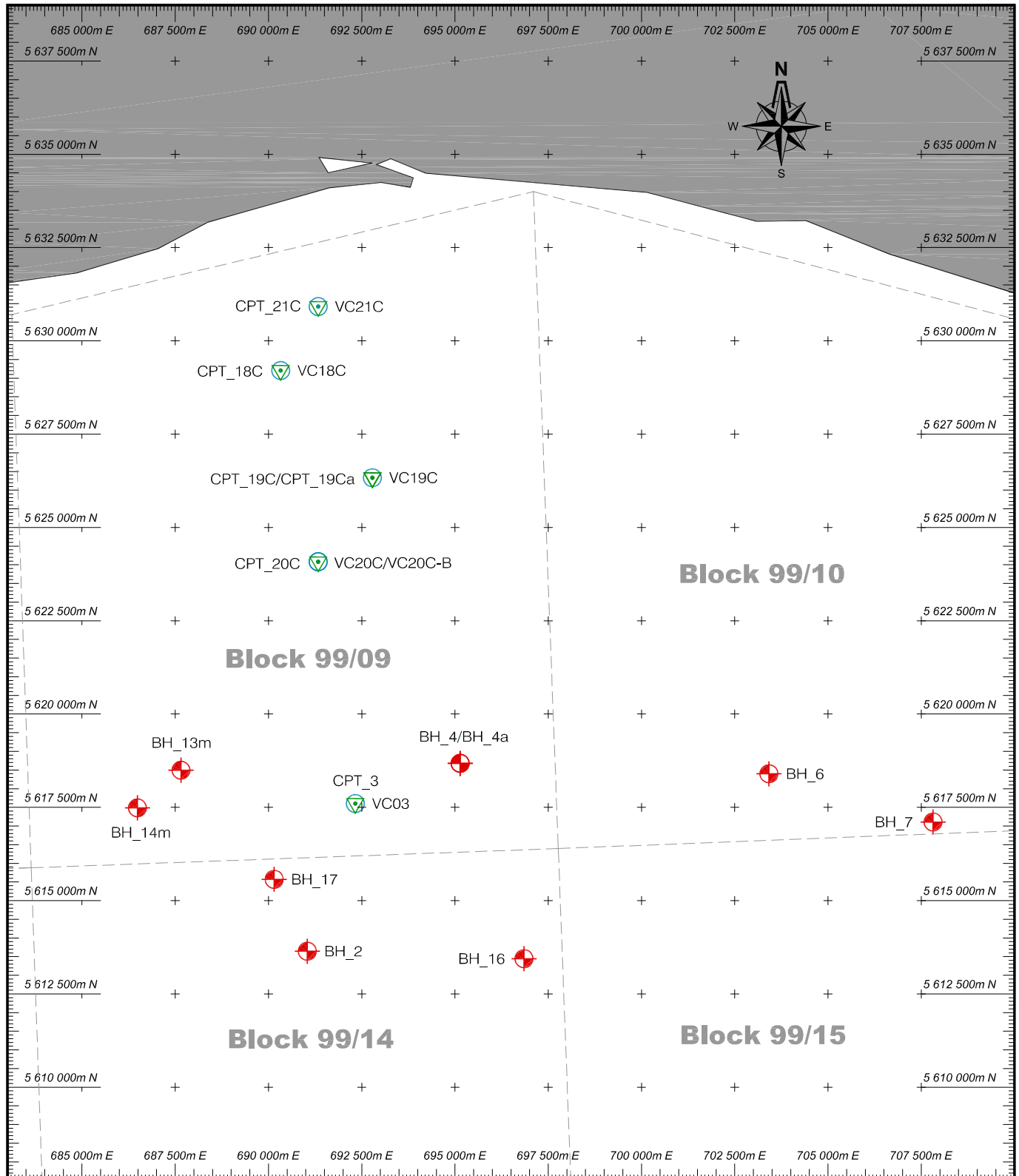
Filename: J:\J11056_Vicinity_Map.dwg



Datum: WGS84, Projection: UTM30N, Zone: 30 North, Central Meridian: 3° West

VICINITY MAP

Drawn by : DRF Date : 13/04/2011
Filename: J:\11056\11056_Detailed_Location.dwg

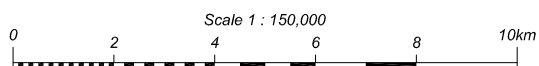


Legend :

-  Borehole Location - Sample and CPT
-  Cone Penetration Test Location
-  Vibrocore Location

Notes :

1. Datum: World Geodetic System 1984 (WGS84)
2. Projection: UTM30N
3. Hemisphere: North
4. Zone: 30 North
5. Central Meridian (CM): 3° 00' 00" West
6. Units: Metres



DETAILED LOCATION PLAN

PART A

SOIL PARAMETERS FOR DESIGN

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A.	SUMMARY
A.1	SUMMARY OF SOIL CONDITIONS
A.2	INTERPRETATION AND EVALUATION OF GEOTECHNICAL DATA
A.3	LIST OF SYMBOLS AND CLASSIFICATION SYSTEM USED
A.4	REFERENCES

A. SUMMARY

General

Fugro GeoConsulting Limited (FGCLTD) has been requested by E.on Energy and Renewables (E.on) to produce a factual geotechnical report to assist in the design and development of the Rampion field located in Block 3/28 of the UK Sector of the North Sea.

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The work was performed from the M/V Saltire from 27 March to 06 April 2011 and from the M/V Willendeavour from the 5 April to 9 April 2011, in accordance with instructions received from E.on.

The water depth, relative to mean sea level, ranged between 8.2 m and 44.9 m corrected to Lowest Astronomical Tide (LAT) at the Rampion site.

Section A of this report presents:

- (i) Summary of soil conditions;
- (ii) Interpretation and evaluation of geotechnical data;
- (iii) List of symbols and classification system used;
- (iv) References.

Table A.1: Summary of Site Work – Rampion Field - M/V Fugro Saltire

Location	Final Penetration [m BSF]	Sampling and Testing Details (successful samples/tests only)
BH_02	46.4	19 CPT and 24 Samples
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BH_06	52.9	17 CPT, 37 Samples and 3 Hammers
BH_07	45.8	23 CPT, 31 Samples and 2 Hammers
BH_13	45.2	27 CPT, 27 Samples and 8 Hammers
BH_14	50.2	23 CPT and 25 Samples
BH_16	46.4	26 CPT, 19 Samples and 5 Hammers
BH_17	45.1	24 CPT and 25 Samples

Notes:

Table excludes number of tests of nil penetration / no recovery

BSF = Below seafloor

Table A.2: Summary of Site Work – Rampion Field - M/V Willendeavour

Location	Final Penetration [m BSF]	Sampling and Testing Details (successful samples/tests only)
VC_03	5.6	1 Vibrocore
CPT_03	5.2	1 CPT
VC_18C	2.6	1 Vibrocore
CPT_18C	3.2	1 CPT
VC_19C	4.0	1 Vibrocore
CPT_19C	1.0	1 CPT
CPT_19Ca	1.2	1 CPT
VC_20C	1.9	1 Vibrocore
VC_20Cb	1.4	1 Vibrocore
CPT_20C	3.2	1 CPT
VC_21C	3.7	1 Vibrocore
CPT_21C	3.0	1 CPT

Soil conditions at the Rampion site show a great deal of lateral and lithological variability; soil conditions therefore can, and will, vary between test locations. Therefore, it is possible that there are untested areas which may have characteristic parameters which lie outside of the range of data presented.

Table A.3: Summary of Soil Conditions – Metmast Location BH_13

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
II	0.0	3.7	Pale olive to very dark grey sandy silica GRAVEL with cobbles. Clasts are sub-angular to sub-rounded of flint
IVa	3.7	17.6	Stiff to hard very dark greenish grey slightly sandy CLAY with thin to very thin beds and fine to coarse gravel-sized pockets of very dark greenish grey silty silica sand
IVc	17.6	33.5	Very dense dark grey to dark greenish grey fine silica SAND
IVd	33.5	44.2	Hard to very hard dark olive grey to dark grey slightly sandy CLAY with fine to medium gravel-sized pockets of dark greyish brown slightly silty silica sand
IVe	44.2	45.2*	Dark grey silty fine silica SAND occasionally with medium gravel-sized pockets of black clay with mica crystals

Notes:

BSF = Below seafloor

Table A.4: Summary of Soil Conditions – Metmast Location BH_14

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	2.8	Medium dense to dense dark greyish green very silty silica fine SAND with fine gravel-sized pockets of dark greenish grey clay with medium to coarse sub-angular to sub-rounded silica gravel
IVa	2.8	11.8	Stiff to Hard dark greenish grey slightly sandy CLAY with closely spaced thin laminae of grey and black fine to medium silica sand
IVb	11.8	31.0	Thinly to thickly interlaminated very stiff to hard dark greenish grey slightly sandy CLAY and fine to medium greenish grey silica SAND with traces of fine black silica sand and evidence of bioturbation (burrows)
IVd	31.0	37.5	Stiff to very hard dark greenish grey slightly sandy CLAY
IVe	37.5	50.2*	Very dense dark greenish grey slightly clayey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table A.5: Summary of Soil Conditions – BH_02

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.4	Very loose to medium dense SAND
Ila	0.4	5.9	Medium dense to dense very dark greenish grey fine silty silica SAND with closely spaced thick laminae and fine to medium gravel-sized pockets of dark grey sandy clay with fine to medium gravel-sized pockets of greenish grey fine silica sand
Vd	5.9	12.1	Very stiff to hard dark greenish grey slightly sandy CLAY with traces of fine gravel-sized pockets of black staining
Ve	12.1	46.4*	Thinly interlaminated to medium interbedded very dark to dark greenish grey silty fine to medium silica SAND and very dark to dark greenish grey slightly sandy CLAY occasionally with fine to coarse gravel-sized pockets of sandy clay to clayey silica sand

Notes:

BSF = Below seafloor

* = End of Borehole

Table S.6: Summary of Soil Conditions – BH_04/04a

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.1	Very loose to loose dark greenish grey fine to coarse silica SAND with fine to medium gravel and fine to coarse gravel-sized shells fragments and shells
IIIb	0.1	3.1	Firm to very stiff dark greenish grey to dark grey slightly sandy CLAY with fine gravel-sized shell fragments and shells
IVc	3.1	22.5	Dense to very dense dark greenish grey to dark grey silty to very silty fine silica SAND
Va	22.5	39.5	Hard to very hard dark grey slightly sandy CLAY with fine to medium gravel-sized pockets of dark greenish grey fine to medium silica sand
Vb	39.5	47.4*	Hard to very hard greenish grey sandy SILT with coarse gravel-sized pockets and laminations of grey fine silica sand

Notes:

BSF = Below seafloor

* = End of Borehole

Table A.7: Summary of Soil Conditions – BH_06

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.3	Medium dense to dense SAND
Va	0.3	19.0	Stiff to very stiff dark grey slightly sandy CLAY with fine gravel-sized pockets of grey sand
Vb	19.0	26.1	Dark to very dark grey slightly sandy SILT
Ve	26.1	31.0	Very stiff to hard very dark greenish grey slightly sandy CLAY and medium dense to very dense dark greenish grey slightly silty fine silica SAND with coarse sand-sized to fine gravel-sized shell fragments
Vf	31.0	42.1	Hard to very hard mottled and thinly interlaminated grey and brown CLAY
Vi	42.1	47.1	Very dense dark greyish green fine to medium silica SAND with fine gravel-sized pockets of greenish grey fine to medium silica sand
Vlb	47.1	48.5	Structureless CHALK composed of white silt with closely spaced thin laminations of slightly duller white silt (Grade Dm)
Vlc	48.5	52.9*	Structureless CHALK composed of white creamy silt and medium blocky gravel with traces of fine to medium gravel-sized flint. Chalk clasts are weak, medium density (Grade Dc)

Notes:

BSF = Below seafloor

*= End of Borehole

Table A.8: Summary of Soil Conditions – BH_07

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.3	Dense SAND
Vlb	0.3	4.0	Structureless CHALK composed of white silt and fine to coarse blocky gravel with few angular fine to coarse gravel-sized black flint. Chalk clasts are very weak, low density (Grade Dm)
Vlc	4.0	27.0	Structureless CHALK composed of white silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density (Grade Dc)
Vld	27.0	45.8*	Structureless CHALK composed of white silt and fine to coarse angular and blocky gravel. Chalk clasts are weak, low to medium density (Grade Dc)

Notes:

BSF = Below seafloor

*= End of Borehole

Table A.9: Summary of Soil Conditions – BH_16

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIa	0.0	6.0	Loose to medium dense very dark greenish grey to greenish grey slightly silty fine to coarse silica SAND with coarse sand-sized to fine gravel-sized shell fragments
IIIc	6.0	19.0	Dense to very dense very dark greenish grey to greenish grey slightly silty fine to coarse silica SAND
IIId	19.0	22.5	White grey and black sub-angular to sub-rounded fine to coarse silica GRAVEL of mixed lithologies
IIIc	22.5	27.5	Very dense olive grey silty fine silica SAND with sub-angular to sub-rounded medium silica gravel
IVb	27.5	39..5	Thin to medium interbedded dark greyish brown sandy CLAY and very dark greenish grey slightly clayey fine silica SAND
IVc	39.5	42.3	Thinly to medium interbedded dark greenish grey calcareous SANDSTONE with few brown and white fossils and very dark grey fine silica SAND
Vc	42.3	46.4*	Medium dense dark greenish grey to olive grey slightly clayey to very clayey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table A.10: Summary of Soil Conditions – BH_17

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
Ve	0.0	21.0	Thin to thickly interlaminated very stiff to hard greenish grey slightly sandy CLAY with thin laminae of light greenish grey silty fine silica sand and dark greenish grey very silty fine silica SAND
Vf	21.0	28.8	Very stiff to hard dark greenish grey slightly sandy CLAY with very closely to closely spaced thin to thick laminae of greenish grey fine silica sand
Vi	28.8	45.1*	Very dense dark greenish grey to greenish grey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table A.11: Summary of Soil Conditions – VC_03 / CPT_03

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	0.2	Light brown sandy GRAVEL. Sand is fine to coarse. Gravel is ANG-SBR fine to medium of shell and shell fragments
IIIa	0.2	0.4	Very dark brown spongy PEAT
IIIb	0.4	2.5	Very soft to soft light grey CLAY
IIIb	2.5	3.5	Light grey sandy SILT. Sand is fine
IIIb	3.5	4.0	Soft grey CLAY
IIIb	4.0	5.0	Light grey SILT
IIIb	5.0	5.4*	Very soft light grey CLAY

Notes:

BSF = Below seafloor

* = End of Borehole

ANG = Angular

SBR = Sub-rounded

Table A.12: Summary of Soil Conditions – VC_18C / CPT_18C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	1.0	Light grey/white sandy GRAVEL. Sand is fine to coarse. Gravel is SBA - SBR fine to coarse of mixed lithologies
IIId	1.0	3.2*	White clayey sandy GRAVEL. Sand is fine to coarse. Gravel is SBA fine to coarse of chalk (Structure-less granular chalk - grain supported with intergranular chalk putty/clay)

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

Table A.13: Summary of Soil Conditions – VC_19C / CPT_19C / CPT_19Ca

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIa	0.0	3.8*	Grey/brown gravelly SAND. Sand is fine to coarse. Gravel is ANG - SBR fine to medium of shell, shell fragments and mixed lithologies From 2.00m ... Becoming light brown/tan

Notes:

BSF = Below seafloor, SBR = Sub-Rounded

* = End of Borehole, SBA = Sub-angular

Table A.14: Summary of Soil Conditions – VC_20C / VC_20Cb / CPT_20C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	0.0/1.0	Brown sandy GRAVEL.. Sand is fine to coarse. Gravel is SBR fine to coarse of mixed lithologies.
IIa	0.0	0.0/1.0	Brown silty gravelly SAND. Sand is fine to coarse. Gravel is ANG - SBR fine to medium of shell, shell fragments and mixed lithologies
IIIb	1.0	3.2*	Soft to very stiff grey CLAY

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

Table A.15: Summary of Soil Conditions – VC_21C / CPT_21C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	1.0	Light grey/white sandy GRAVEL. Sand is fine to coarse. Gravel is SBA - SBR fine to coarse of mixed lithologies
IIId	1.0	3.5*	White clayey sandy GRAVEL. Sand is fine to coarse. Gravel is SBA fine to coarse chalk. (Structure-less granular chalk - grain supported with intergranular chalk putty/clay)

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

SECTION A.1

SUMMARY OF SOIL CONDITIONS

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A.1 SUMMARY OF SOIL CONDITIONS

Table A.1.1: Summary of Depth from Top of Unit and Unit Thickness

Location	Final Depth [m BSF]	Depth to Top of Unit [m BSF]					
		I	II	III	IV	V	VI
BH_02	46.4	0.0 (0.4)	0.4 (5.5)	-	-	5.9 (40.5*)	-
BH_04/4A	47.4	0.0 (0.1)	-	0.1 (3.0)	3.1 (19.4)	22.5 (24.9*)	-
BH_06	52.9	0.0 (0.3)	-	-	-	0.3 (46.8)	47.1 (5.8*)
BH_07	45.8	0.0 (0.3)	-	-	-	-	0.3 (45.5*)
BH_13	45.2	-	0.0 (3.7)	-	3.7 (41.5*)	-	-
BH_14	50.2	0.0 (2.8)	-	-	2.8 (47.4*)	-	-
BH_16	46.4	-	0.0 (6.0)	6.0 (16.5)	27.5 (14.8)	42.3 (4.1*)	-
BH_17	45.1	-	-	-	-	0.0 (45.1*)	-
VC_03/CPT_03	5.6	0.0 (0.2)	-	5.4 (5.2*)	-	-	-
VC_18C/CPT_18C	3.2	-	0.0 (1.0)	1.0 (2.6*)	-	-	-
VC19C/CPT19C/CA	3.8	-	0.0 (4.0*)	-	-	-	-
VC20/VC20Cb/CPT20C	3.2	-	0.0 (1.0)	1.0 (0.9*)	-	-	-
VC_21/CPT_21C	3.5	-	0.0 (1.0)	1.0 (2.7*)	-	-	-

Notes:

BSF = Below seafloor

() Unit thickness

* Indicates end of borehole, not necessarily end of the unit

'-' indicates unit not observed

A.1.1 GEOLOGICAL SETTING

A.1.1.1 Introduction

This section represents a geological appraisal of the soils specifically sampled in the Rampion Wind Farm Site Investigation 2011, and does not characterise the surrounding regional geology. A discussion on the regional geology is presented in the Rampion Engineering Geological Desk Study (FGCLTD, 2011a).

A.1.1.2 General

The Rampion site is located in Quadrant 99, UK Sector, English Channel approximately 13 km south of Shoreham, West Sussex, United Kingdom. The geology of the Rampion site within the depth range of interest for foundations (45 m below seafloor) consists of sediments deposited during the Cretaceous to the Holocene Period, 94 million years before present to the present day.

The site is characterised by a gently folded and eroded bedrock profile including the London Clay Formation overlying the Lambeth Group and the Cretaceous Upper Chalk Group. The bedrock profile is superimposed locally by Quaternary palaeochannels and a thin covering of more recent Holocene sediments. Figure A.1.1 provides a conceptual cross section illustrating the key geological features, a simplified structural map and a simplified map showing distribution of Quaternary palaeochannels.

An overview of the geological evolution of the Rampion site can be summarised as follows:

- (i) Deposition of chalk in marine environment during late Cretaceous (94 to 65 million years before present);
- (ii) Uplift of land mass at end of the Cretaceous resulting in a period of sub-aerial exposure and erosion during early Tertiary (65 to 56 million years before present);
- (iii) Deposition of Lambeth Group deposits over short geological time period in highly variable tropical environments ranging from terrestrial, mangrove and back lagoons to intertidal and shallow marine (56 to 55 million years before present);
- (iv) Deepening of basin resulting in a prolonged period of marine conditions, depositing London Clay (56 to 49 million years before present);
- (v) Fluctuation of sea level causing marine to fluviomarine conditions and deposition of Barton and Bracklesham Beds (49 to 37 million years before present);
- (vi) Folding and uplift of area by regional tectonism associated with Alpine orogeny and spreading apart of the Mid-Atlantic Ridge;
- (vii) Uplift followed by initiation of Pleistocene glacial and interglacial cycles resulted in erosion of the entirety of the Barton and Bracklesham Beds and partial removal of London Clay and Lambeth Group;
- (viii) Palaeochannels eroded and infilled during Pleistocene and late Holocene;
- (ix) Veneer of Holocene sediments deposited locally across site, subsequent waning of Holocene and underlying sediments by seafloor currents forming local gravel lags and development of sand waves in the south.

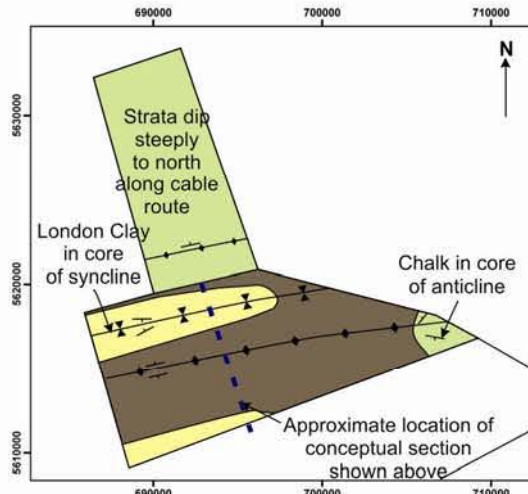
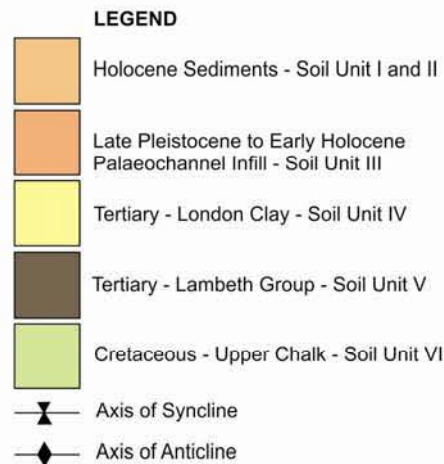
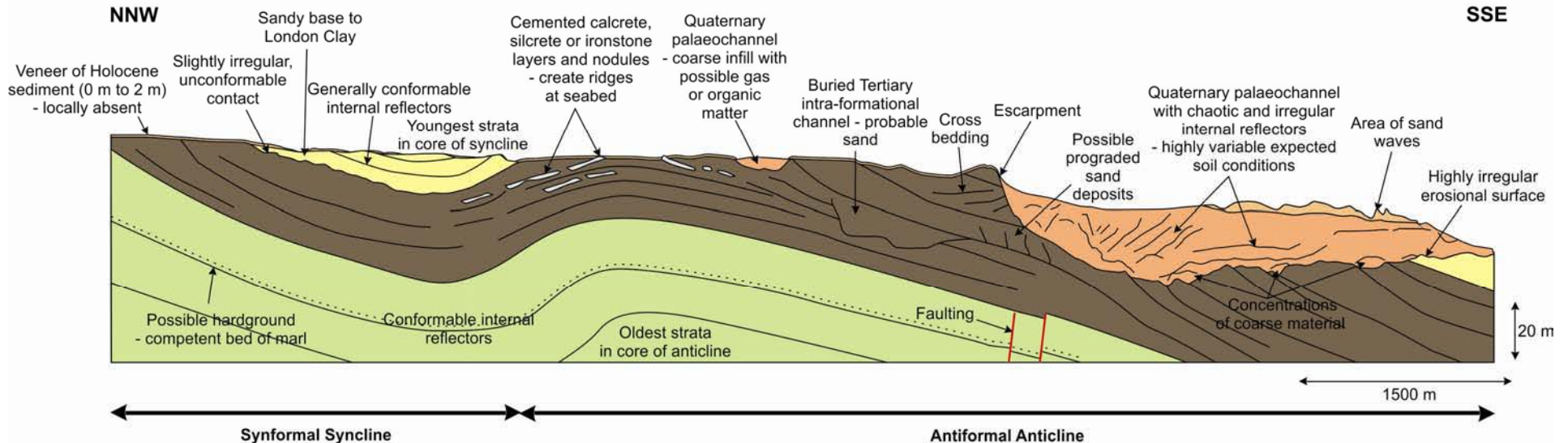
A.1.1.3 Soil Units

Six main soil units have been inferred from the soils sampled in the Rampion Wind Farm Site Investigation 2011. The soil unit nomenclature is based on that presented in the Rampion Engineering Geological Desk Study (FGCLTD, 2011a) with units further divided into subunits where relevant. Please note that Soil Units IIc and II d, predicted to be present by the desk study, are inferred not to be present in the soils sampled. A summary of the soil units is presented in Table A.1.2

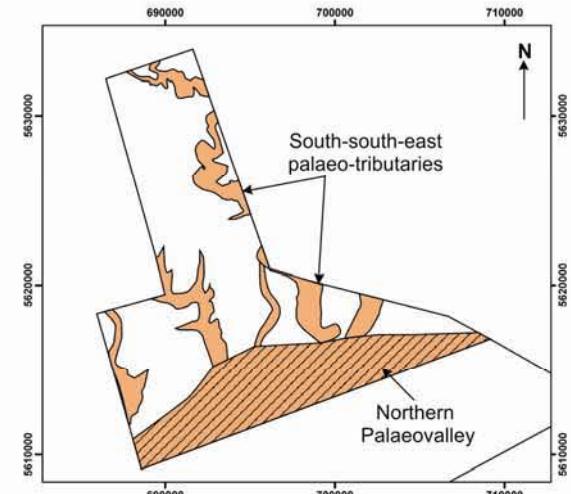
Table A.1.2: Summary of Soil Units Sampled at the Rampion Site

Soil Units	Formation Name	Summary Soil Description
I	Mobile Holocene Sediments	Very loose to medium dense SAND locally with gravel and shell fragments
IIa	Holocene Lag Deposits	Medium dense to dense slightly gravelly to gravelly fine to coarse SAND locally very silty
IIb		Sandy GRAVEL locally with cobbles and medium beds of very loose to medium dense sand
IIIa	Late Pleistocene to Early Holocene Channel Infill	Very dark brown spongy PEAT, with putrid odour
IIIb		Very soft to soft CLAY interbedded with sandy SILT
IIIc		Loose to dense silty fine SAND with thin laminae to thin beds of slightly sandy to sandy clay locally with laminae of black staining and occasional gravel
IIId		Sub-angular to sub-rounded fine to coarse GRAVEL of mixed lithologies
IVa	Tertiary Sediments - London Clay	Firm to hard locally firm slightly sandy CLAY locally with fine gravel-sized shell fragments, pockets and laminae of fine to medium sand
IVb		Thinly to thickly interlaminated very stiff to hard slightly sandy CLAY and fine to medium SAND with traces of fine black silica sand and evidence of bioturbation (burrows)
IVc		Dense to very dense slightly clayey to very silty fine SAND with pockets and layers of cemented sand and siltstone
IVd		Stiff to very hard slightly sandy CLAY locally with pockets and laminae of slightly silty sand
IVe		Very dense slightly clayey silty fine SAND locally with pockets of black clay
Va	Tertiary Sediments - Lambeth Group	Stiff to very stiff locally hard slightly sandy CLAY with fine gravel-sized pockets of sand
Vb		Hard to very hard slightly sandy SILT locally with gravel-sized pockets of very weak calcareous siltstone and fine to coarse gravel-sized shell fragments, chalk and flint. Locally with closely spaced thin laminae of fine sand
Vc		Medium dense to very dense silty fine SAND with sub-angular to sub-rounded medium gravel
Vd		Very stiff to hard slightly sandy CLAY with traces of fine gravel-sized pockets of black staining
Ve		Very stiff to very hard thinly interlaminated to medium interbedded slightly sandy to sandy CLAY and medium dense to very dense slightly clayey to slightly silty fine to medium SAND locally with sand-sized to fine gravel-sized shell fragments and with gravel-sized clasts of claystone
Vf		Very stiff to very hard dark locally slightly sandy locally laminated CLAY locally with very closely to closely spaced thin to thick laminae of greenish grey fine sand
Vg		Thin to medium interbedded calcareous SANDSTONE and very dark grey fine SAND with few fossils
Vh		Very hard sandy CLAY locally with medium to coarse sand-sized pockets of sand
Vi		Medium dense to very dense locally slightly silty fine to medium SAND locally silty and clayey
Vj		Hard to very hard sandy SILT with coarse gravel-sized pockets and laminations of fine silica sand
Vla	Cretaceous Sediments - Upper Chalk	White clayey sandy fine to coarse GRAVEL. Structureless granular chalk - grain supported with intergranular chalk clay
Vlb		Structureless CHALK composed of white silt and fine to coarse blocky gravel with few angular fine to coarse gravel-sized black flint. Chalk clasts are very weak, low density (Grade Dm)
Vlc		Structureless CHALK composed of white silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density (Grade Dc)
Vld		Structureless CHALK composed of white silt and fine to coarse angular and blocky gravel. Chalk clasts are weak, low to medium density (Grade Dc)

Conceptual Cross Section



Simplified Structural and Bedrock Map



Simplified Quaternary Palaeochannel Map

A.1.1.4 Bathymetry

The seabed slopes southerly with locally steep gradients up to 9°, particularly in the eastern part of development area, and a shallower gradient (up to 1°) profile in the west of the proposed wind farm site.

The English Channel is inferred to have been affected by glacial processes during the Pleistocene but only by variations in sea level as no evidence of direct ice action on the sediments has been identified. Cycles of sea level rise and fall in the English Channel led to exposure of the seafloor and erosion by a complex fluvial system.

The Rampion site is located on the northern edge of the Northern Palaeovalley (Hamblin et al., 1992) which is inferred to have formed during the Elsterian / Devensian glaciation when sea levels were lower. During the late Pleistocene the fluvial systems of northern Europe and the southern coast of England further eroded and infilled channel features in the English Channel giving the seafloor its present form.

The northern edge of the Northern Palaeovalley is characterised by an escarpment which is up to 14 m high and generally runs south-west to north-east.

Mobile large to very large sandwaves are located in the area of interest. The main prominent tidal direction in the region is east-west which is reflected in the seafloor geometry of the large to very large sandwaves.

The water depth are corrected to Lowest Astronomical Tide (LAT) and generally increases from north to south across the site. Shallowest water depths less than 20 m LAT occur in the northwest corner of the site with deepest water depths of approximately 60 m LAT occurring in the south and east of the proposed Rampion site. Sample location water depths range from 8.20 m LAT at VC21C along the proposed cable route in the northwest of the Rampion site to 44.90 m LAT at BH_16 located in the south of the Rampion site.

A.1.1.5 Quaternary Sediments – Soil Units I, II and III

Quaternary (Holocene and Pleistocene) sediments range from a few centimetres thick, where they occur as a veneer overlying the bedrock, to up to 34 m thick, where they infill glacial channel features and palaeochannels.

Three main soil units have been interpreted as Quaternary sediments from both the geophysical data and the sampled soils. Soil Unit I is composed of mobile sandy sediments. Soil Unit II is a gravelly lag deposit. Soil Unit III is a channel infill deposit composed of gravel, sand, silt, clay and peat.

Mobile Sediments – Soil Unit I

Mobile sediments locally overlie older deposits, particularly within the Northern Palaeovalley at the Rampion site. At the Rampion site mobile sediments have locally formed large to very large

sandwaves many of which were formed during the early Holocene and demonstrate a west to east current direction. Soil Unit I varies in the sampled soil between 0.1 m to 6.0 m thick. The thickest deposit of mobile sediments sampled is in BH_16, which is located in a sandwave field in the Northern Palaeovalley. The sandwaves cover an area of approximately 21 km² to the south of the escarpment. The mobile sediments consist predominantly of loose to medium dense fine sand (Table A.1.2) and are underlain either by a sand layer which has an increase in fines content (silty sand) and greater interpreted relative density (medium dense to very dense) (Soil Unit III, in BH_16) or by an older bedrock deposit (Soil Unit IV, V, VI). The interpreted relative density and apparent reduction in fines content indicates that Soil Unit I may have the potential for scour when seabed structures are emplaced.

Lag Deposits – Soil Units IIa and IIb

Soil Unit II is a lag deposit that is present as a thin veneer of sandy gravel and gravelly sand overlying bedrock or infill glacial channel features. The lag deposit is present as a blanket deposit in the north of the site becoming more sporadic towards the south. The sampled thickness of Soil Unit II ranges between 0.2 m and 3.7 m and is thickest and coarsest in BH_13 in the west of the Rampion site. The geophysical survey indicates that the lag deposit can be locally thicker above Quaternary palaeochannel infill sediment, however, this was not found in the soils sampled in the Northern Palaeovalley. Soil Unit II can be divided into two subunits (IIa and IIb) based on the dominance of gravel-sized fragments (Table A.1.2). Both Soil Unit IIa and IIb are medium dense to dense sand in consistency and, along with the lack of seafloor sediment bedforms, and the presence of encrusting organisms such as bryozoans and barnacles congregating on one side of clasts (Hamblin et al., 1992), are inferred to have a reduced potential for mobility compared to Soil Unit I in the present day environment.

The absence of finer material in Soil Unit II is due to winnowing by the high tidal current velocities in the region. The Soil Unit II is locally absent possibly due to the effect of bathymetry on the current winnowing strength and intensity.

Channel Infill – Soil Units IIIa, IIIb, IIIc and IIId

Soil Unit III is a channel infill deposit that can be divided into four subunits depending on grain size (Table A.1.). Soil Units IIIa and IIIb were only sampled in VC03 in a palaeochannel recorded as having acoustic blanking by the geophysical survey results (Osiris, 2010). Soil Unit IIIa overlies Soil Unit IIIb in VC03 and is 0.24 m thick and consists of spongy peat. Soil Unit IIIb was sampled underlying Soil Unit IIIa in VC03 and consists of interbedded silt and very soft to soft clay layers. Soil Unit IIIb was sampled up to the base of VC03 therefore is greater than 5.21 m thick.

Soil Unit IIIc is the most dominant and thickest subunit of Soil Unit III in the soils sampled at the Rampion site. Soil Unit IIIc occurs between 0.3 m (BH_07) and 13.0 m thick (BH_16) and is present in the Northern Palaeovalley. Soil Unit IIId is present underlying Soil Unit IIIc in BH_16 in the Northern Palaeovalley. The geophysical survey results indicate that a gravel deposit is present at the base of a large proportion of the Northern Palaeovalley (Osiris, 2010).

The varying subunit grain-sizes of the infill sediments are thought to constitute a dynamic environment of deposition during a marine transgression after the last glaciation (late Devensian) and early

Holocene consequently the environment is considered to have changed from high energy fluvial to estuarine.

The sampled palaeochannels identified by acoustic blanking in the Geophysical Survey Report (Osiris, 2010), for example VC03, have a higher proportion of finer grained sediments of clays and silts (Soil Unit IIIb) than that of sediment sampled in the Northern Palaeovalley. This suggests that towards the north of the Rampion site the palaeochannels were depositing sediment in an estuarine environment with potentially different sediment sources to that of the Northern Palaeovalley. The presence of peat in the palaeochannels (Soil Unit IIIa) suggests that there were high rates of organic sedimentation with reduced erosion from marine influences or quick burial of organic material from fluvial estuarine sediment input. Gravel (Soil Unit IIIc) in the Northern Palaeovalley is inferred to represent a high energy depositional environment compared to the energy of deposition in the other palaeochannels. The high energy deposition was possibly a flooding event which occurred after the initial formation of the valley.

A.1.1.6 Tertiary Sediments

London Clay – Soil Unit IV

At the Rampion site the London Clay Formation (Soil Unit IV) is interpreted to be present and has been divided into six subunits (IVa-f) based on grain size, strength and relative density. The London Clay Formation was sampled to the middle and west of the Rampion site in the core of a structural bedrock syncline orientated east-west (Figure A.1.1). Soil Unit IV is present underlying Soil Unit I or Soil Unit II in the soils sampled at the Rampion site. The soil unit ranges from 21.9 m in BH_4 to over 47.4 m thick in BH_14.

The subunits generally show a coarsening downwards sequence, from a top unit of clay (IVa) becoming more thinly interbedded clays and sands (IVb) to alternating fine sand and sandy clay metre thick units (IVc-IVf) (Table A.1.2). Gravel-sized clasts of siltstone and claystone have been sampled in Soil Unit IVb, IVc and IVe. Claystone nodules, laminations and beds, typically less than 1 m thick, can occur throughout the London Clay sediments and even though not sampled, they should not be ruled out as occurring at the Rampion site. Bioturbation, the re-working of sediment by organisms, is also interpreted to be present in Soil Unit IVb, which is a common geological feature of the London Clay Formation. Fugro experience suggests that bioturbated soils can cause localised fluctuations in grain size from clay to more silty and / or sandy inclusions along and perpendicular to bedding.

The general description of the London Clay Formation is a marine deposit dominated by dark brownish grey clays and silts, however at the Rampion site the London Clay Formation is much sandier, especially at its base. The Harwich Formation can be present stratigraphically underlying the London Clay Formation in southern England and consists of sand. However, due to the thickness and repetition of the sand units at the base of Soil Unit IV, the Harwich Formation is inferred not to represent Soil Units IVc-IVf in the Rampion site. The sandier base of Soil Unit IV suggests that the Rampion site was once located close to a shoreline of a marine basin where, because of possible sea level fluctuations, sediment grain size input varied depositing sand and clay units. The sandier base is inferred to also represent a transitional period between the marine environment of deposition of the London Clay to the underlying fluvial, estuarine and marine environment of deposition of the Lambeth Group.

The dense sandier base of the London Clay Formation varies in lateral extent and thickness across the Rampion site resulting in varying soil conditions within relatively short horizontal and vertical distances. Integration of subunit boundaries to the geophysical reflectors has shown a tentative correlation; however more data is needed to improve the confidence level and facilitate the mapping of these subunits across the Rampion site.

Lambeth Group – Soil Unit V

The Lambeth Group underlies the London Clay Formation (Soil Unit IV) and overlies the Cretaceous Upper Chalk (Soil Unit VI). Soil Unit V was sampled in the central part of the Rampion site and underlies the Quaternary sediment infill in the Northern Palaeovalley. It is inferred not to be present in the north and far southeast of the Rampion site where chalk is sub cropping beneath Holocene Sediment. Soil Unit V is also inferred not to sub crop within the depth of interest (45.0 m BSF) to the west of the Rampion site where the London Clay Formation is present in the bedrock structural syncline (Figure A.1.1). The Lambeth Group is inferred to be thinnest to the east of the Rampion site. The sampled thickness of the Lambeth Group varies from 23.9 m to greater than 46.8 m. Only one borehole sampled the base of the Lambeth Group (BH_06).

The Lambeth Group has been subdivided into nine subunits (Soil Units Va to Vj) based on an interpretation and credible grouping of the soils sampled at the Rampion site (Table A.1.2). Due to the highly variable stratigraphy within the Lambeth Group the subunits have been grouped together based on their grain-size, relative density and/or strength and do not necessarily represent the same depositional time period. The subunits vary from stiff to very stiff clay, interbedded dense sand and hard clay, very dense sand, hard silt to sandstone (Table A.1.2) and are expected to vary over relatively short horizontal and vertical distances. As with the basal subunit of Soil Unit IV, cross reference of subunit boundaries with the picked geophysical reflectors has shown a tentative correlation, however, more data are needed to improve the confidence level if these subunits are to be mapped across the Rampion site.

The complex lithological changes within Soil Unit V are interpreted to be due to varying sea level changes at the time of deposition at the end of the Cretaceous. During relative sea level lowstand, exposure of the sediments led to desiccation and incision of fluvial channel systems equivalent to tropical mangrove and back lagoonal environments, depositing coarser grained subunits and causing overconsolidation of previously deposited units. Subsequent sea level rise led to deposition in estuarine and marine conditions at the Rampion site, depositing coarser and finer grained subunits.

Within the Lambeth Group (Soil Unit V) occasional lignite (coal seams formed from peat) laminations may occur, deposited during phases of sea level lowstand and seafloor exposure. Organic material was sampled in Soil Unit Vf in BH_06 and BH_17, where it occurs as gravel-sized to cobble-sized fragments.

Laminations and nodules of highly competent cemented calcium carbonate (calcretes), silica (silcretes) and iron (ferricretes) can be present in Soil Unit V. They are formed by post depositional processes including saturation of the soil resulting in leaching of minerals to specific depths depending on permeability. The environment of deposition of the Lambeth Group and the post depositional

environments were very diverse, from shallow marine to fluvial and coastal plain environment, resulting in localisation of saturation and mineral leaching and thus the development of cemented material.

From the sampled sediments at the Rampion site highly competent material was locally sampled in many different subunits of Soil Unit V. Gravel-sized siltstone fragments are present in Soil Unit Vb in BH_06, sandstone pockets are present in Soil Unit Vh in BH_17 and a 10 cm thick siltstone bed is present in Soil Unit Ve in BH_06. Soil Unit Vg, sampled only in BH_16, is described as a calcareous sandstone and is 2.5 m thick. Post depositional compaction and consolidation as well as cementation could have produced the sandstone and siltstone units sampled. Beds of highly competent material may lead to an outcrop at seafloor (see Rock Ridges) where the surrounding sediment has been eroded and the area subsequently infilled by Eocene or Quaternary sediments. Highly competent nodules locally occur at seafloor as boulders (see Boulders at Seafloor) where they have broken off during periods of erosion of the surrounding sediments.

The sediments of the Lambeth Group can be highly structured, although this was not described in the sampled sediments in the Rampion site. However, structured soils within the Lambeth Group cannot be ruled out. If structured soils are locally present then it is expected to be particularly evident in clays due to desiccation and sub-aerial exposure forming small scale (< 10 mm) pedogenic fissures. These often have a soapy appearance, are extremely closely spaced, blocky and slickensided.

A.1.1.7 Cretaceous Sediments

Upper Chalk – Soil Unit VI

Four subunits (VIa-VId) of the Upper Chalk have been interpreted from the soils sampled at the Rampion site (Table A.1.2). The Upper Chalk is present subcropping to the north and east of the Rampion site underlying Holocene Sediments (Soil Units I and II). Elsewhere within the Rampion site the Upper Chalk underlies the Lambeth Group (Soil Unit V), London Clay Formation (Soil Unit IV) and Holocene Sediments (Soil Units I, II and III) (Figure A.1.2). The base of Soil Unit VI was not sampled at the Rampion site. The thickest chalk deposit was sampled in BH_07 where it was greater than 45.5 m thick.

Soil Unit VIa was sampled in the north of the site in vibrocore samples (VC18C, VC19C and VC21C). The subunit is described as clayey sandy chalk gravel and is inferred to be a weathered top section of the Upper Chalk. Soil Unit IV and Soil Unit V are not present overlying Soil Unit VIa as they have previously been eroded. Soil Unit VIa is inferred to have been sub-aerially exposed resulting in weathering to a chalk gravel.

Soil Unit VIb, VIc and VId are present to the east of the Rampion site either underlying Soil Unit V in BH_06 or underlying a thin deposit of Soil Unit III in BH_07. The subunits vary in chalk grade from Dm to Dc indicating very weak to weak, low to medium density chalk. The sampled units of the Upper Chalk indicate little lateral variability within the sediments. Locally the chalk may be faulted leading to a discontinuous fabric. Deep marine conditions continued throughout the late Cretaceous, albeit with fluctuating sea levels during the deposition of the Upper Chalk.

Gravel-sized flint fragments have been sampled in Soil Unit VIb, VIc and VId. Regional descriptions also state that nodules, hardgrounds and laminations of marlstone can also be present. The hardgrounds are inferred to have formed during periods of relative sea level low stand.

Regional descriptions indicate the chalk is generally highly structured and characterised by extremely closely spaced to widely spaced fractures ranging between closed to more than 3 mm with infill. No fractures were logged in Soil Unit VI as sampled at the Rampion site; however, in BH_07 between 14.5 m to 15.3 m the chalk is described as 'likely disturbed by hammer sampler'.

A.1.1.8 Geological Features

Escarpment

An escarpment present at the Rampion site has been mapped from the available geophysical data (Osiris, 2010). This escarpment delineates the northern edge of the Northern Palaeovalley and is 10 m to 14 m in height and generally runs parallel to the 30 m LAT bathymetry contour. The sediments to the south of the escarpment, within the Northern Palaeovalley, are generally characterised by 10 m to 30 m of Quaternary channel infill (Soil Units IIIc and IIId) underlain by a range of Cretaceous to Tertiary sediments. BH_16 was conducted within the Northern Palaeovalley and consists of mobile Holocene Sediments (Soil Unit I) underlain by Quaternary channel infill (Soil Unit III) and Lambeth Group sediments (Soil Unit V) to 46.4 m BSF where the borehole was terminated.

1.8.2 Palaeochannels

The Rampion site is located on the edge of the Northern Palaeovalley formed during the early Pleistocene as a result of fluvial and glaciofluvial erosion. BH_16 sampled the deposits of the Northern Palaeovalley. The deposits include a loose to dense silty sand (Soil Unit IIIc) and a basal fine to coarse gravel (Soil Unit IIId). The Soil Unit IIId gravel deposit is inferred to be present at the base of a large proportion of the Northern Palaeovalley (Osiris, 2010).

In addition to the Northern Palaeovalley, palaeochannels have been cut into the underlying bedrock which trend north to south. These are fluvial tributaries formed in the mid to late Pleistocene and infilled with clay, silt and organic sediments during a period of marine transgression evolving the environment from a fluvial to estuarine setting. Vibrocore VC03 conducted within one of the palaeochannels mapped from the geophysical survey report (Osiris, 2010). A very soft clay and silt soil unit (Soil Unit IIIb) was sampled underlying a layer of spongy peat (Soil Unit IIIa). Headspace gas analysis was performed on this palaeochannel sample location and the results are detailed in the issued Technical Note (FGCLTD, 2011c) and summarised in the shallow gas section below.

From the sampled soils data it is suggested that the smaller fluvial tributaries are dominated by finer grained sediments than the Northern Palaeovalley, which is dominated by coarser grained sediments. This indicated a different environment of deposition between the two types of palaeochannels in the Rampion site, lower depositional energy in the fluvial tributaries and higher depositional energy in the Northern Palaeovalley. The presence of peat in the fluvial tributaries indicates that even though the energy of deposition was lower than that in the Northern Palaeovalley the organic input was large enough to have formed the peat layer sampled.

Palaeochannels are also inferred to have formed during the Tertiary when sea level lowstand led to exposure of the seafloor and the deposition of the fluvial and estuarine deposits of the Lambeth Group (Soil Unit V). During this time fluvial and estuarine systems developed and erosion of channel systems occurred. The presence of buried channel features within the Lambeth Group results in localised lateral and vertical variability over relatively short distances as evidenced in the nine subunits of Soil Unit V (Table A.1.2).

Rock Ridges

Rock ridges and outcrops have been identified throughout the Rampion site at or near seafloor. These are inferred to be associated with highly competent beds of calcretes, silcretes and ironstone within the Lambeth Group which also occur at depth. The ridges are up to 3 m in height above the seafloor and are generally orientated in line with the strike of the bedrock. Hardgrounds may also occur within the Upper Chalk and may be locally present as ridges of highly competent material at or near seafloor. The distribution of the rock ridges has been mapped by Osiris (2010) and is presented in Figure 1 2.

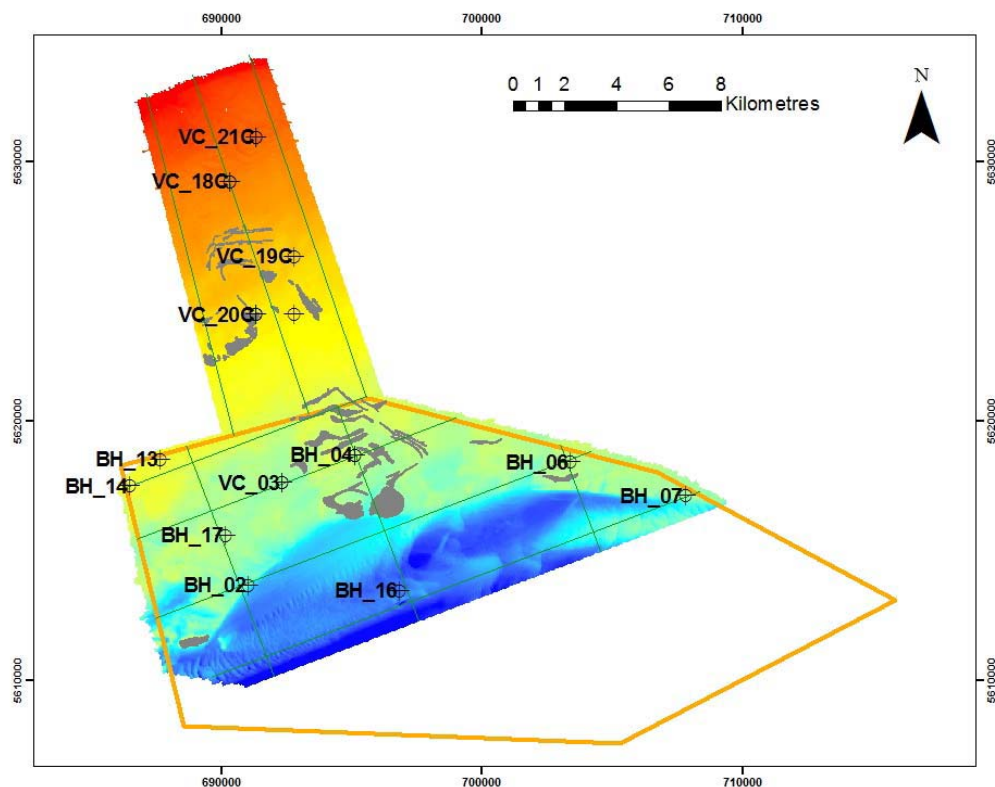


Figure A.1.2: Distribution of Rock Ridges (in grey) at the Rampion Site (Mapped by Osiris, 2010)

Boulders at Seafloor

Only boulders of more than 5 m in diameter have been mapped at the Rampion site due to their abundance at seafloor and occur within 55 m to 350 m of the proposed borehole locations. Smaller boulders may also be present and where possible have been identified from geophysical data. The boulders are expected to consist of calccrete, silcrete, marlstone, claystone or ironstone and originate from the sediments of the Lambeth Group and the London Clay Formation. The boulders were likely eroded from the bedrock and deposited by glaciers during the last Weichselian glaciation.

Shallow Gas

Acoustic blanking, high amplitude responses and phase reversals have been identified and mapped by Osiris (2010) from the geophysical site survey (Figure A.1.3) and are typical geophysical shallow gas indicators. In order to verify the geophysical interpretation, headspace gas analysis was performed in Vibrocore VC03, which is located in a palaeochannel that was observed to have shallow gas indicators. The detailed results of the headspace gas analysis are presented in the Headspace Gas Analysis Technical Note (FGCLTD, 2011c). The findings of this analysis are summarised below:

- i. High concentrations of biogenic methane were measured at and below geophysical responses indicative of shallow gas at VC03.
- ii. Peat layers have also been identified in association with geophysical responses that are associated with shallow gas;
- iii. Gas is considered to be dissolved within the pore water of the soil and thus not present as a gaseous state within the soil;
- iv. Quaternary palaeochannels act as a reservoir for biogenic methane; the lateral extent of gas-rich soils is currently understood to be constrained to the limits of the palaeochannels;
- v. Biogenic methane gas is not considered to have formed from one particular layer instead it is thought to have formed or is being formed from many different layers within these palaeochannels;
- vi. The information within the Technical Note (FGCLTD, 2011c) can be used to inform a risk assessment for drilling activities within gas-rich soils at the Rampion site. However, no assessment or comment of the risk to drilling through these gas-rich soils has been conducted as part of the study.

The study showed that gas within the soil sampled at VC03 is biogenic in origin and is present at approximately the same depth as shallow gas indicators on the geophysical survey results. This indicates that shallow gas is likely to be present within the Quaternary palaeochannels mapped by the geophysical survey.

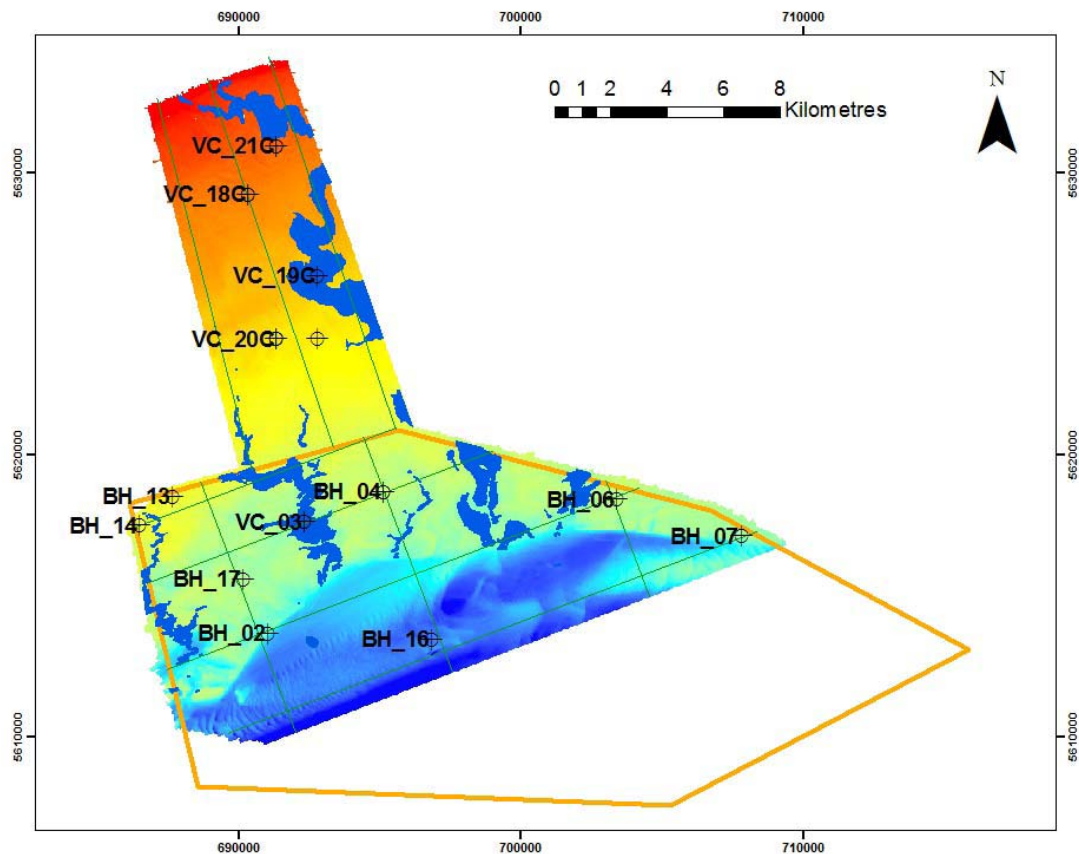


Figure A.1.3: Distribution of Acoustic Blanking (in blue) at the Rampion site (Mapped by Osiris, 2010)

Competent Laminations and Beds

Competent nodules, laminations and beds of claystone, sandstone, calcrete, silcrete, ironstone, flint or chalk hardgrounds occur throughout the Tertiary and Cretaceous sediments (Table A.1.). Reflectors identified on the geophysical data are approximately coincident with large extensive hardgrounds and large changes in soil unit lithology. The subunits of the base of Soil Unit IV and Soil Unit V, where hardgrounds and gravel-sized material are present, show a tentative correlation to some geophysical reflectors; however, more data are needed to improve the confidence level and facilitate the mapping of these hardgrounds across the Rampion site.

Variable Soil Conditions

Variable soils are expected within all the formations present at the Rampion site as a result of variable and locally complex depositional environments. This variability of soil conditions can particularly be expected in the Quaternary sediments (Soil Unit III), where they infill channel features and variation can be expected over short horizontal and vertical distances.

The basal units of the London Clay Formation (Soil Unit IV) and the Lambeth Group (Soil Unit V) have variable soil conditions which are characterised by cycles of marine and fluvial deposition leading to

variability in geotechnical properties. Where intraformational channels were eroded, during periods of fluvial erosion and deposition, soil conditions can be expected to vary over relatively short horizontal and vertical distances from the axis of the channel.

Additionally within the Lambeth Group, competent nodules, laminations and beds of calcrete, silcrete and ironstone are inferred to be present throughout the formation formed by cementation. A sandstone layer (Soil Unit Vg) is present in the Lambeth group and is inferred to have been lithified by post depositional compaction and consolidation. 'Shelly' beds, which are formed by the cementation of coquinas, locally occur at the top of the Lambeth Group sequence in the London Basin and become more sporadic to the east and north of the formation deposit (BGS, 2011). No shelly beds have currently been sampled at the Rampion site however sporadic deposits may be present throughout the site.

Coarse-grained Inclusions

Coarse-grained material transported in the fluvial systems which eroded and deposited within the palaeochannels is present throughout the Rampion site (Soil Unit III). Coarse sand to gravel is present locally at the base of these palaeochannels. For example BH_16 located in the Northern Palaeovalley has a gravel layer present that is inferred to be the base of a channel infill deposit and is 3.5 m thick (Soil Unit IIId).

Highly competent material was locally sampled in many different subunits of Soil Unit V (Lambeth Group) at the Rampion site ranging from gravel-sized siltstone fragments to a calcareous sandstone layer 2.5 m thick. The gravel-sized fragments are inferred to have been deposited in river systems, whereas the sandstone layer is inferred to be affected by post depositional compaction and consolidation resulting in lithification.

Additionally, gravel-sized siltstone and claystone have been sampled in subunits of the London Clay Formation and gravel-sized flint fragments have been sampled in the Upper Chalk at the Rampion site. The gravel is inferred to have been deposited during periods of relative sea level lowstand during deposition of the respective soil units.

Faulting

Offset of reflectors is observed within the geophysical data (Osiris, 2010) and is inferred to relate to structural inversion at the end of the Cretaceous / start of the Tertiary. The faulting is generally restricted to the east of the Rampion site within the Cretaceous Chalk where structural uplift has formed an anticline feature. The offset of the reflectors generally ranges between less than 1 m and 2 m however smaller scale faulting may be present that is not identifiable on the geophysical data.

Bedforms

Bedforms have been identified within the Northern Palaeovalley. The bedforms generally consist of gravel streaks, large to very large sandwaves and seafloor scars and were mapped by Osiris (2010) from the side scan sonar data (Figure A.1.4). The sandwaves are locally up to 8.0 m in height and have wavelengths between approximately 100 m and 250 m. The sandwaves are orientated north-north-west to south-south-east and are asymmetrical in profile. They indicate the main current

direction is from west-south-west to east-north-east with the steepest side (up to 14°) facing the east-north-east (Osiris, 2010). BH_16 is interpreted to have sampled a 6.0 m thick unit of mobile Holocene sediment (Soil Unit I). The soil unit consists of loose to medium dense fine to coarse silica sand and is located in an area of sandwaves identified in the Geophysical survey report (Osiris, 2010).

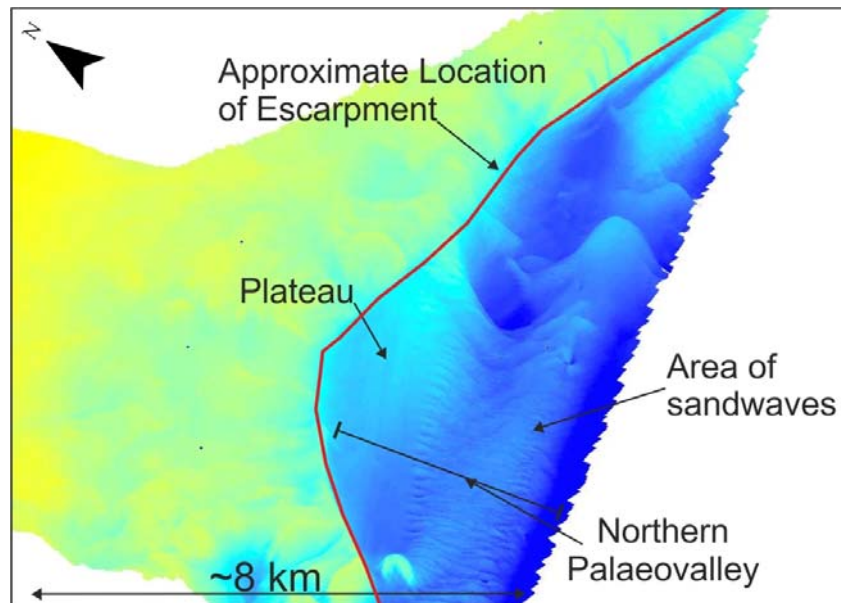


Figure A.1.4: 3D Representation of the Northern Palaeovalley and Bedform

A.1.2 SITE SPECIFIC GROUND MODEL

A.1.2.1 General

The Rampion Engineering Geological Desk Study (FGCLTD, 2011a) created a preliminary site specific engineering geological ground model for the Rampion site. Using the soil data from the Rampion Wind Farm Site Investigation (FGCLTD, 2011b) the engineering geological ground model has been updated.

The update of the model has resulted in a better understanding of the overall geological formation stratigraphy as well as a more detailed subunit stratigraphy within each formation. This has led to a greater understanding of the relationship between the geophysical reflectors and soil unit boundaries. From the soil sampling and testing performed at the Rampion site the ground model now has a more detailed geotechnical element, outlining geotechnical characteristics of each soil unit. However due to the limited amount of soil sampling in the Rampion site and the complexity of the geological stratigraphy the model has its limitations and areas of lower relative confidence which should be taken into account when applying the model.

Areas of lower relative confidence within the updated ground model are described below:

- i. Lateral boundaries between soil units and soil provinces are currently predicated on a credible estimation of location and are assumed from geophysical data only. For example the extent of subcropping chalk in the east of the Rampion site is currently unclear;
- ii. Position and boundaries of palaeochannel deposits are inferred from geophysical mapping only;
- iii. Due to the nature and depositional history of Soil Units III, IV and V the lateral and vertical variability within these Soil Units is large and thus extent of the different subunits cannot be fully defined at this stage within the project;
- iv. The availability of limited geotechnical sample data within the palaeochannels means that the soil conditions and the expected variability are not currently fully quantifiable;
- v. The spatial and vertical location of hardgrounds and coarse-grained sediment are based on a tentative correlation between the sampled geotechnical data and the picked geophysical reflectors. To further improve the correlation between geotechnical and geophysical data sets and thus increase the confidence in the mapping of these features additional sample data targeted at suspected hardground and coarse-grained sediment locations and a calibration of the geophysical data using sub bottom profiler data instead of interpreted mapping is recommended.

A.1.2.2 Soil Provinces

Using the available data the ground model established in the Rampion Engineering Geological Desk Study (FGCLTD, 2011a) has been updated and the site has been consequently divided into soil provinces based on stratigraphical, geotechnical and geophysical vertical and lateral variability. Soil provinces designate areas of similar geological and geotechnical properties.

Seven main soil provinces have been identified from the ground model. Where soil province specific data are not available the soil provinces take into account the inferred stratigraphy to a depth of 45 m

BSF, as this is considered a credible depth range of interest for the proposed turbines at the Rampion site. For soil provinces that have site specific data the associated soil profiles have been extended to the deepest termination depth BSF of the borehole to capture the range of sampled soil conditions. Each soil province has one to three soil profiles which summarise the inferred stratigraphy within the soil province. Soil Provinces 4 to 7 have three soil profiles, one without the occurrence of Quaternary palaeochannel deposits, one designated with an 'a' (e.g. Soil Province 4a), with the occurrence of Quaternary palaeochannel deposits and one designated with a 'b' (e.g. Soil Province 4b), representing where rock ridges have been mapped on the seafloor.

A soil province map has been produced along with associated soil profiles to present the inferred geotechnical and geological changes across the Rampion site (Figure A.1.4). Please note that the boundaries between the soil provinces are inferred from the data available and do not necessarily represent a sudden change in conditions but rather a gradational boundary change. Additional geotechnical and geophysical data is required for the exact boundary locations to be identified.

Soil provinces and their soil profiles are detailed below and in (Figure A.1.4). Due to the uncertainty of lateral and vertical extent of subunits within the soil units subunits are not included in the soil profiles.

Soil Province 1, 2 and 3

Soil Provinces 1, 2 and 3 occur within the Northern Palaeovalley. They all have a similar soil profile down to Soil Unit III_d. Below this unit the stratigraphy differs between soil provinces, where either Soil Unit IV, V or VI is present to the depth of interest.

Soil Provinces 4 and 5

Soil Province 4 and 5 both contain Soil Unit IV (London Clay Formation) underlying Quaternary deposits (Soil Unit I, II and / or Soil Unit III). Both soil provinces are present in the centre and west of the Rampion site along the axis of the bedrock syncline (Figure A.1.1). Soil Province 4 differs from Soil Province 5 as it is inferred to have Soil Unit V underlying Soil Unit IV at its base. Quaternary channels within Soil Provinces 4 and 5 have an extra designation 'a' indicating that Soil Unit III_a and III_b are present underlying Soil Unit I or II. Rock ridges are also present in Soil Province 4, these areas have been designated with a 'b' and represent areas where rock ridges are present and Holocene sediments are absent.

Soil Province 6

Soil Province 6 contains the Upper Chalk (Soil Unit VI – sampled only in Soil Province 6) underlying the Lambeth Group (Soil Unit V) which underlies either Soil Unit I or II of Quaternary deposits. The soil province occurs mainly in the centre of the Rampion site to the north of the Northern Palaeovalley (Figure A.1.4). Quaternary infill channels within Soil Province 6 have been designated with an 'a' indicating the presence of Soil Unit III_a and III_b underlying Soil Unit I or II. Rock ridges at seafloor within Soil Province 6 have been designated with a 'b' indicating the absence of Soil Unit I or II at seafloor.

Soil Province 7

Soil Province 7 contains the Upper Chalk (Soil Unit VI) underlying either Soil Unit I or II of Quaternary deposits. The soil province occurs in the northern section as well as a small area to the east of the Rampion site (Figure A.1.4). As in Soil Province 6, Quaternary infill channels within Soil Province 7 have been designated with an 'a' indicating the presence of Soil Unit IIIa and IIIb underlying Soil Unit I or II. Rock ridges at seafloor within Soil Province 7 have been designated with a 'b' indicating the absence of Soil Unit I or II at seafloor.

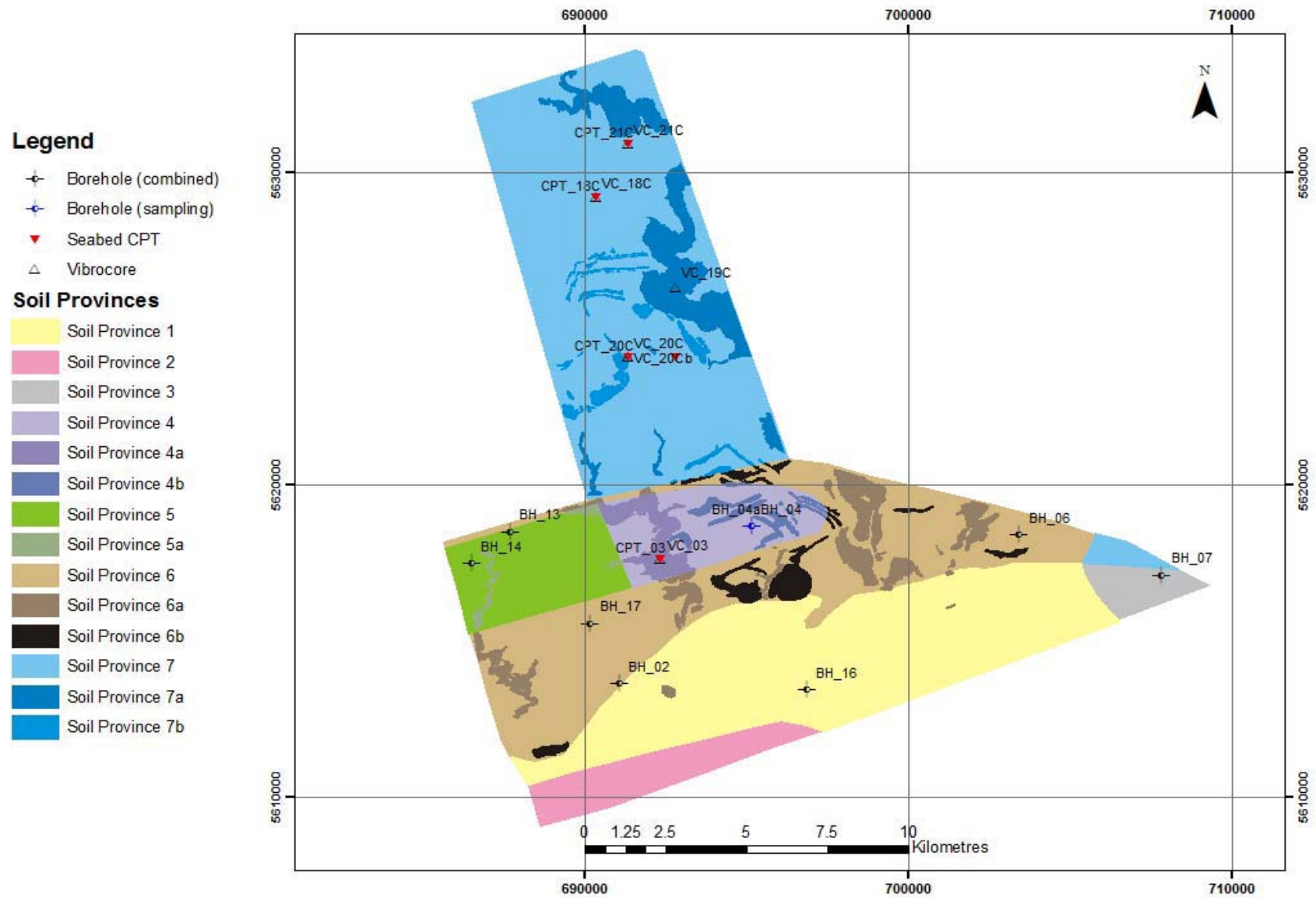


Figure A.1.4: Rampion Soil Province Map

Soil Provinces and Associated Soil Profiles for the Rampion Site

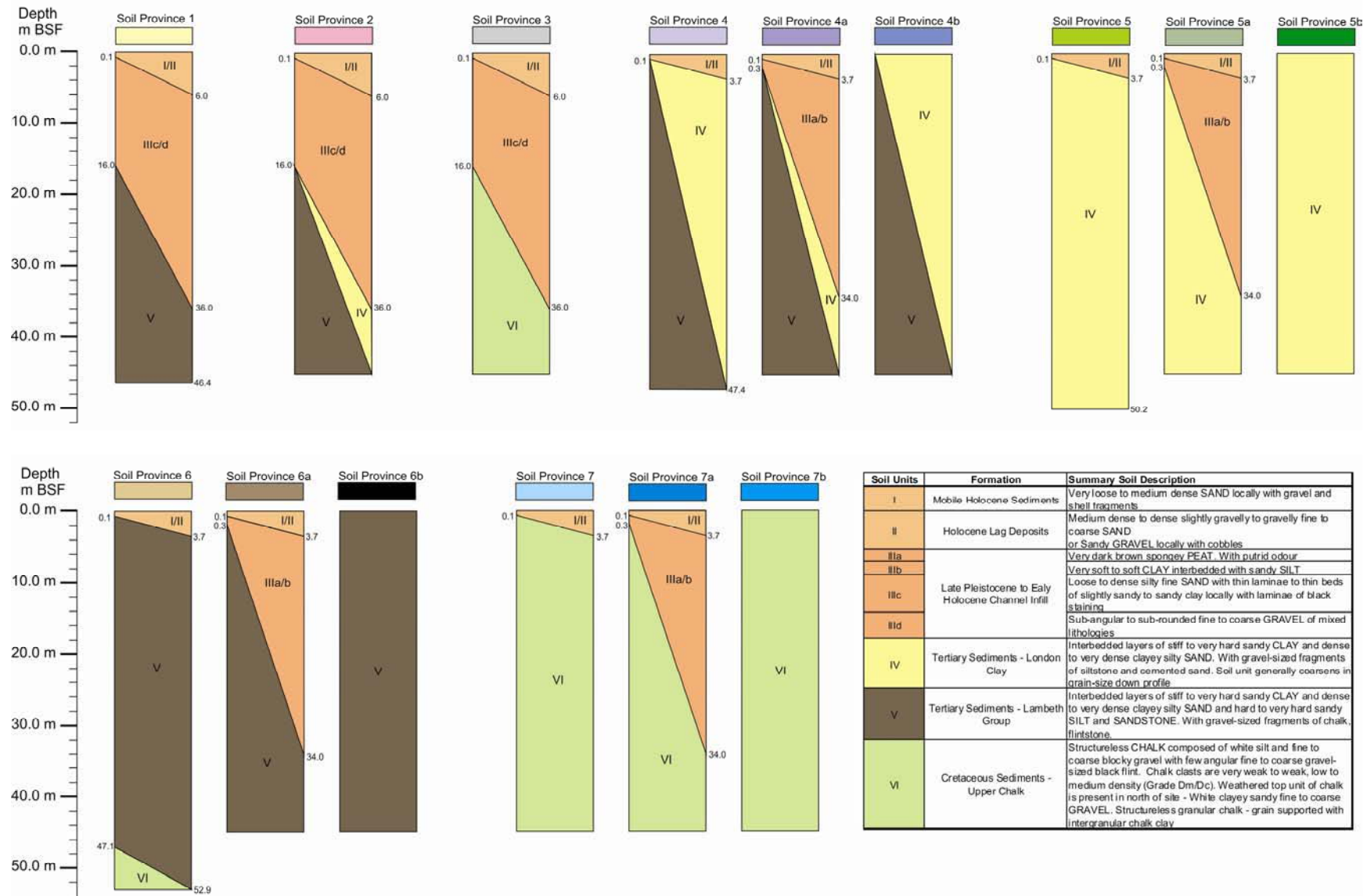


Figure A.1.5: Soil Provinces and Associated soil units

A.1.3 CONCLUSIONS AND WAY FORWARD

The engineering geological ground model has been updated using the soils data sampled at the Rampion site. The update of the ground model has improved the understanding of rock and soil stratigraphy and the geotechnical properties of the strata within the Rampion site. The updated ground model has facilitated the creation of a soil province map. The soil provinces divide the site into areas of similar geological and geotechnical properties. Soil profiles have been developed to summarise the varying stratigraphy within each soil province. The soil province map can help facilitate future predictions at the site, summarise the soil conditions and highlight areas of greater geological uncertainty and influence to development layout (i.e. palaeochannel deposits).

The Rampion soil province map shows large variability in stratigraphy across the site. The Rampion site geological structure and stratigraphy is further complicated by the many Quaternary palaeochannels that are present throughout the central and northern section. Due to the complexity and lateral variability of the site as well as the small number of geotechnical data sites and the available geophysical data, areas of reduced confidence are present within the soil province map. The areas of reduced confidence include; the exact location of boundaries between soil provinces and soil subunits, lateral extent and thickness within Soil Units III, IV, and V. The reduced confidence is a results of lack of good correlation between geophysical and geotechnical boundaries as well as the complex localised deposition of these subunits.

To improve the level of uncertainty with the ground model, and therefore the soil province map, further geotechnical and geophysical data is required. The production of a ground model is an ongoing process and requires continual updating when new data is obtained. By utilising this iterative process of development of the engineering geological ground model, data gaps and areas of reduced confidence can be more easily identified and targeted in order to characterise the Rampion site fully.

It is understood that the development of an integrated Geographic Information Systems (GIS) is proposed for the Rampion Offshore Wind Farm. The preliminary ground model should be integrated into the GIS in order to facilitate the interpretation of geotechnical datasets as they become available.

SECTION A.2

INTERPRETATION AND EVALUATION OF GEOTECHNICAL DATA

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A.2 INTERPRETATION AND EVALUATION OF GEOTECHNICAL DATA

A.2.1 SUMMARY

This section presents further discussion of the soil parameters presented and potential design. Where appropriate, data has been presented graphically at the end of this section.

It should be noted that this report does present derived soil parameters, however recommended design lines have not been presented with these plots. It should also be noted that the parameters presented in this section may not be representative of the whole Rampion site due to local variability common within this area of the English Channel.

A.2.2 QUALITY OF DATA

The data obtained as a result of the Rampion Offshore Wind Farm Site Investigation 2011 are considered to be of a high quality and representative of the soils that were tested. The consolidated triaxial data indicate that the sample quality in the clay soils were mainly 'very good to excellent' quality, whilst the incremental oedometer test results also indicated generally, 'very good to excellent' with one 'poor' sample quality according to the recommendations of Lunne et al. (1998). It is thought that the tests measured with 'poor' sample quality were performed on specimens that were subject to a degree of disturbance caused during the sampling process. Therefore it is recommended that when deriving design parameters that these values be omitted from any analysis.

A.2.3 CLASSIFICATION SOIL PARAMETERS

A.2.3.1 Summary

The classification soil parameters are reasonably consistent and are considered to be representative of the soil conditions at the borehole locations.

A.2.3.2 Water Content and Plasticity Data

The results of water content and Atterberg Limit evaluations are presented for the Rampion site on Plates A.2-1 to A.2-20. The data appears to indicate a broadly consistent data set for each unit throughout the soil profile and has a water content range of 15.0% to 50.0% within all the investigated soil provinces.

Plasticity tests were also performed. Atterburg Limits versus depth is presented on Plates A.2-11 to A.2-15 and generally indicates intermediate to very high plasticity; however it is observed that there are areas of low plasticity in Unit III. The majority of the water content values plot above the plastic limit, however this trend changes with increasing depth where water contents tend to reduce to below the soils plastic limit. A-line plots presented individually per soil province are presented on Plate A.2-16 to Plate A.2-20.

A.2.3.3 Submerged Unit Weight

Wet density values were measured directly during offshore sampling and onshore laboratory testing on wax and bag samples. Submerged unit weight values were inferred directly from wet density measurements. Submerged unit weight data is presented on Plates A.2-6 to A.2-10.

A.2.3.4 Particle Density

Particle density measurements on soil samples were generally 2.65 Mg/m³ for sand and 2.80 Mg/m³ for the clay units at the Rampion location.

A.2.3.5 Particle Size Distribution

The results of particle size distribution (PSD) tests are presented graphically on Plates A.2-21 to A.2-24 for each unit and soil province encountered at the Rampion site. It may be seen that, in general, there is good agreement in all individual units.

A.2.3.6 Carbonate content

Thirty-two carbonate content tests were performed on samples to assess the carbonate levels as a percentage of CO₂ and CaCO₃. The results are presented on Plate A.2-25 to Plate A.2-29. The results range from a CO₂ content of 0.18 % to 5.4 %, with associated CaCO₃ contents of 4.1% to 12.2 % for sand and clay at Soil provinces I,IV,V and VI. For chalk, the associated CO₂ was measured at 41.0% to 42%, with an associated CaCO₃ content of 93% to 95%.

A.2.3.7 Organic Content

Twenty-eight organic content tests were performed on selected samples. The results of the dichromate oxidation analyses show organic contents in the range of 0.9% to 9.2% throughout the Rampion site. Individual results are presented at the end of this section on Plates A.2-30 to A.2-33.

A.2.3.8 Total Sulphate Content

Twenty-eight total loss on ignition tests were performed on selected samples throughout the Rampion site. The results show sulphate contents in the range of <0.02% to 0.22%. The results are presented at the end of this section on Plates A.2-34 to A.2-37 and are separated into their respective units and soil provinces.

A.2.4 NET CONE RESISTANCE

Net cone resistance profiles for all borehole locations are presented as a function of individual soil unit and province. The net cone resistance data form the basis for the evaluation of undrained shear strength and relative density from in-situ CPT data (detailed in Sections A.2.5 and A.2.8, respectively). Individual Plots are presented at the end of this section on Plates A.2-38 to A.2-42.

A.2.5 STATIC UNDRAINED SHEAR STRENGTH OF COHESIVE STRATA

A.2.5.1 Summary

This section contains details of the methods and approaches that have been used to derive shear strength at the Rampion site.

It should be noted that preference should be given to the shear strength derived from the onshore effective stress tests when deriving low, best or high estimate design lines, as the consolidation conditions set up in these tests prior to shearing are considered to be more representative of the soils in-situ conditions.

A.2.5.2 Shear Strength From Laboratory Data

Undrained shear strength was estimated offshore using a pocket penetrometer, torvane and CPTs. Onshore, further estimates of undrained shear strength were made using UU, CAUc, CIUc and DSS tests. The consolidated triaxial data indicate that the sample quality in the clay soils was mainly “very good to excellent”. The results from these tests are within the expected range of values and as such have been used as the basis for the derivation of the recommended undrained shear strength and related parameters. For further details see Plate A.2-90 for the relationship between net cone resistance and undrained shear strength.

A.2.5.3 Shear Strength From Cone Penetration Data

Cone penetration test data often shows variations in the shear strength profile more clearly than laboratory test results.

N_{kt} values are used to infer shear strength values from cone penetration data using Equation A.2.1 below:

$$\text{Equation A.2.1:} \quad s_u = q_{net} / N_{kt}$$

where:

s_u is the undrained shear strength in compression (kPa)

q_{net} is the (inferred) Net Cone Resistance at the same elevation (kPa)

N_{kt} is an empirical factor relating Net Cone Resistance to undrained shear strength.

An N_{kt} correlation was performed using CAUc, UU, CIU and DSS test results assuming typical strength anisotropy factors. The correlations are presented on Plate A.2-90. Based on the relationship between the net cone resistance from In-situ data and undrained shear strength from these tests, an N_{kt} range of 15-20 has been used, which is typical of Quaternary sediments in the North Sea and English Channel. As such this range has been used to derive undrained shear strength from the CPT data. It should be noted that for chalk, equation A.2.1 does not apply when deriving shear strength from in-situ data. Therefore no N_{kt} and q_{net} correlation has been performed.

Table A.2.1: Recommended Range of N_{kt} Values

UNIT	N_{kt} lower	N_{kt} upper
Unit II	15	20
Unit III	15	20
Unit IV	15	20
Unit V	15	20
Unit VI	-	-

Note: N_{kt} assessment not applicable for chalk

A.2.5.4 Strength Anisotropy

UU, CAU and DSS tests have been performed to accurately measure in-situ shear strength and also to assess strength anisotropy by measuring the ratios between the final values. Direct measurements of anisotropy from adjacent tests have been used where possible to derive S_{ua} values for use in the N_{kt} correlation:

$$s_{uu} = 0.90 * s_{ua}$$

$$s_{ud} = 0.85 * s_{ua}$$

$$s_{up} = 0.70 * s_{ua}$$

If it is critical for design, these theoretical values would need to be further substantiated by appropriate laboratory test measurements if strength anisotropy were to be taken into account for any foundation design.

A.2.5.5 Strain at 50% Deviator Stress

The strain at 50% peak deviator stress (ϵ_{50}) was measured from triaxial compression tests. Based on a very large number of tests on North Sea clays performed in Fugro's laboratory, the ϵ_{50} values in Quaternary clays are generally consistent with data presented by Hight et al. (1985). Using Hight's data, it is possible to relate ϵ_{50} to the overconsolidation ratio (OCR).

$$\text{Equation A.2.2: } \epsilon_{50} = 0.5 + 1.177 \log_{10}(\text{OCR})$$

This value may be confirmed as being appropriate by converting average OCR to ϵ_{50} using the equation above. It should be noted that Hight's correlation with ϵ_{50} and OCR is based on a limited data set and should therefore not be relied upon by itself as an accurate measurement of ϵ_{50} . In this case the OCR derived ϵ_{50} doesn't correlate well with measured strain in the onshore total and effective stress testing. Therefore when making design lines, priority should be given to measured values ϵ_{50} from UU and CAU tests.

A.2.6 SENSITIVITY

Sensitivity recommendations have been based on values from remoulded unconsolidated undrained triaxial tests. Where remoulded tests were unavailable, sensitivity recommendations have been based upon the relationship between the inferred undrained shear strength and sleeve friction as measured from the CPT profiles, together with sensitivity parameters derived from Skempton and Mohan. Sensitivity values are presented on Plates A.2-52 to A.2-56.

A.2.7 REMOULDED UNDRAINED SHEAR STRENGTH OF COHESIVE STRATA

Eleven remoulded unconsolidated undrained triaxial tests (UUr) were performed on samples from BH_13 and BH_14. These show very good agreement with the measured sleeve friction and while it is not a direct measurement of remoulded shear strength, it is recognised that the measured sleeve friction from an electric cone can be used to estimate the soil's remoulded shear strength (Quiros and Young, 1988).

A.2.8 RELATIVE DENSITY OF COHESIONLESS STRATA

The relative density of cohesionless soils has been estimated using the equation below which is the relationship proposed by Jamiolkowski et al. (1988) with q_{net} substituted for q_c . In sand soils with no generated excess pore-water pressure and high cone resistance values relative to the overburden pressure, this substitution will have a negligible effect, as q_{net} will be very close to q_c .

$$\text{Equation A.2.3: } D_r = \left(\frac{1}{0.0296} \right) \ln \left(q_c + \left(2.494 \left(\frac{\sigma'_m}{100} \right) \right)^{0.46} \right)$$

where: D_r is the estimated relative density (%)
 q_{net} is the net cone resistance (kPa)
 σ'_m is the estimated mean effective stress at the test depth (kPa)

and:

$$\text{Equation A.2.4: } \sigma'_m = \left(\frac{p_o' (1 + 2K_o)}{3} \right)$$

where: p_o' is the effective overburden pressure (kPa)
 K_o is the coefficient of lateral earth pressure (0.5 to 1.0)

Values for relative density are presented on Plates A.2-62 to A.2-65.

A.2.9 UNDRAINED AND DRAINED FRICTION ANGLE

Effective friction angles were measured for clay units in undrained tests, in four soil provinces (I, III, IV and VI) using eight consolidated undrained triaxial tests. The samples were consolidated to their in-situ conditions, each specific to its lateral earth pressure coefficient derived from CPT testing. In general the results are thought to be representative of the soils tested. Individual tests are presented on Plates A.2-66 and Plate A.2-69

Drained friction angles were measured for sand units in two soil provinces (I and V) using six 'set of three' shearbox tests and seven 'set of three' consolidated isotropically drained triaxial tests. Three multi reversal shearbox tests were also performed on selected sand samples in order to measure the peak and residual drained soil to steel interface friction angles. The samples were prepared to an initial dry density based on a best estimate of the relative density at the specimen depth estimated from the adjacent CPT. It is thought that the results from these tests are of good quality and representative of the soils tested. Individual tests are presented on Plates A.2-70 and Plate A.2-73.

A.2.10 IN-SITU STRESSES AND STRESS HISTORY

A.2.10.1 Effective Overburden Pressure

By integrating the recommended values for submerged unit weight used during the onshore laboratory phase of testing, average effective overburden pressure versus depth may be derived. Note that these profiles implicitly assume that there are no excess hydrostatic pressures in the soil, as there is no evidence that such conditions exist.

A.2.10.2 Preconsolidation Pressure and Maximum Additional Previous Pressure

Thirteen incremental oedometer tests were performed on clay samples in 3 soil provinces (IV, V and VI). One of the primary purposes of these tests was to estimate the preconsolidation pressure (or yield stress), p_c' , of the selected units. The preconsolidation pressure was inferred from oedometer data using the Casagrande (1936) and Silva (1970) construction methods. The maximum additional previous effective pressure ($\Delta p'$) may be calculated simply by subtracting the estimated current vertical effective stress from the estimated preconsolidation pressure, i.e.

$$\text{Equation A.2.5: } \Delta p' = p_c' - p_o'$$

In general, $\Delta p'$ is considered to be a more reliable method to estimate the stress history to p_c' as it is independent of depth.

Measured change in voids ratio often yields information on the relative disturbance of test specimens. An estimation of sample quality can be made based on Lunne et al. (1998). An assessment of the changes that occurred as the test specimens were consolidated back to the estimated in-situ overburden pressures suggest tests were performed mainly on soil specimens that would be classified as 'very good to excellent' quality. As a consequence, FGCLTD consider that the measured preconsolidation pressures from the oedometer tests to be good estimates of the soils true values.

Assessments of $\Delta p'$ have also been made using empirical relationships between $\Delta p'$ and undrained shear strengths measured from UU, CAU and DSS tests. The relationship used to estimate $\Delta p'$ is of the form proposed by Mayne (1982), i.e.:

$$\text{Equation A.2.6: } \Delta p' = p_o' * \{[(s_u / p_o')_{oc} / (s_u / p_o')_{nc}]^{1/\Lambda_o} - 1\}$$

where: s_u = undrained shear strength (kPa)
 $(s_u / p_o')_{oc}$ = measured strength ratio for overconsolidated soil
 $(s_u / p_o')_{nc}$ = strength ratio for normally consolidated soil

and:

$$\text{Equation A.2.7: } \Lambda_o = 1 - (C_s / C_c), \text{ calculated from oedometer test results}$$

where: C_s = swelling index (measured in oedometer test)
 C_c = compression index (measured in oedometer test)

$\Delta p'$ has been derived for the sand units at the Rampion site and has been assumed the same as the adjacent clay layers.

Plates A.2-82 to A.2-85 presents p_c' values interpreted from shear strength and oedometer data.

A.2.10.3 Overconsolidation Ratio

Overconsolidation ratio (OCR) has been calculated from the recommended $\Delta p'$ values using the equation below:

$$\text{Equation A.2.8: } \text{OCR} = (\Delta p + p_o') / p_o'.$$

OCR data, calculated from overburden pressure (p_o') and shear strength derived Δp values are presented at the end of this section. Plots presenting oedometer and shear strength data have been presented at the end of this section on Plates A.2-78 to A.2-81.

A.2.10.4 Coefficient of Lateral Earth Pressure at Rest

As the in-situ horizontal stresses have not been measured directly, the coefficient of lateral earth pressure (K_o) has been estimated, at all locations, using the correlation presented in Equation A.2.9, based on Mayne and Kulhawy (1982).

$$\text{Equation A.2.9: } K_o = (1 - \sin \phi') \times \text{OCR}^{\sin \phi'}$$

Recommended K_o values, which have been derived from recommended OCR and ϕ' values (See Sections A.2.10.3) are presented at the end of this section and are compared with K_o values estimated from oedometer tests on Plates A.2-74 to A.2-77.

It should be noted that if a high K_o value were conservative in the design, such as for example in the evaluation of friction on skirts during installation using effective stress methods, then reasonable upper bound K_o values should be considered.

A.2.11 SETTLEMENT PARAMETERS

A.2.11.1 Soil Modulus Values

Constrained modulus, M , has been calculated from incremental oedometer testing by recording the coefficient of compressibility. In clay soils M can also be estimated directly from the undrained shear strength of the soil using Equation A.2.10, as presented by Lunne et al. (1981).

$$\begin{aligned}\text{Equation A.2.10:} \quad M &= 100 \cdot s_{ua} \text{ (from } s_u) \\ M &= 1/m_v \text{ (from oedometer)}\end{aligned}$$

M values have been calculated using the s_{ua} derived from CPT data using the criteria specified in Section A.2.10. This method shows reasonably good correlation with M values measured during the incremental oedometer tests.

Constrained Modulus for the sand units is also presented and can be based upon CPT cone resistance, q_c , using the recommendations of Lunne and Christophersen (1983) where M_o is the tangent Constrained Modulus:

$$\begin{aligned}M_o &= 4 q_c && \text{for } q_c < 10 \text{ MPa} \\ M_o &= 2 q_c + 20 && \text{for } 10 < q_c < 50 \text{ MPa} \\ M_o &= 120 && \text{for } q_c > 50 \text{ MPa}\end{aligned}$$

Corresponding values of drained and undrained Young's Modulus, E_u , may be calculated from the constrained modulus using elastic theory, as shown below:

$$\text{Equation A.2.11} \quad E_d = M \cdot [(1 + \nu) \cdot (1 - 2\nu)] / (1 - \nu)$$

$$\text{Equation A.2.12} \quad E_u = 1.5 \cdot E_d / (1 + \nu)$$

Plates A.2-86 to A.2-89 presents constrained modulus values based on shear strength data from the onshore laboratory testing phase and offshore in-situ testing.

A.2.12 SOIL – STEEL INTERFACE PARAMETERS

A series of soil-steel interface ring shear tests were performed on selected samples to assess the residual drained soil-steel friction angle behaviour of the soils. The individual test results are plotted against plasticity index on Plate A.2-91. The result shows good agreement with the ICP best-fit line

and are considered representative of the sampled soil. Due to this, the best fit line can be used to derive residual drained friction angles from the plasticity data.

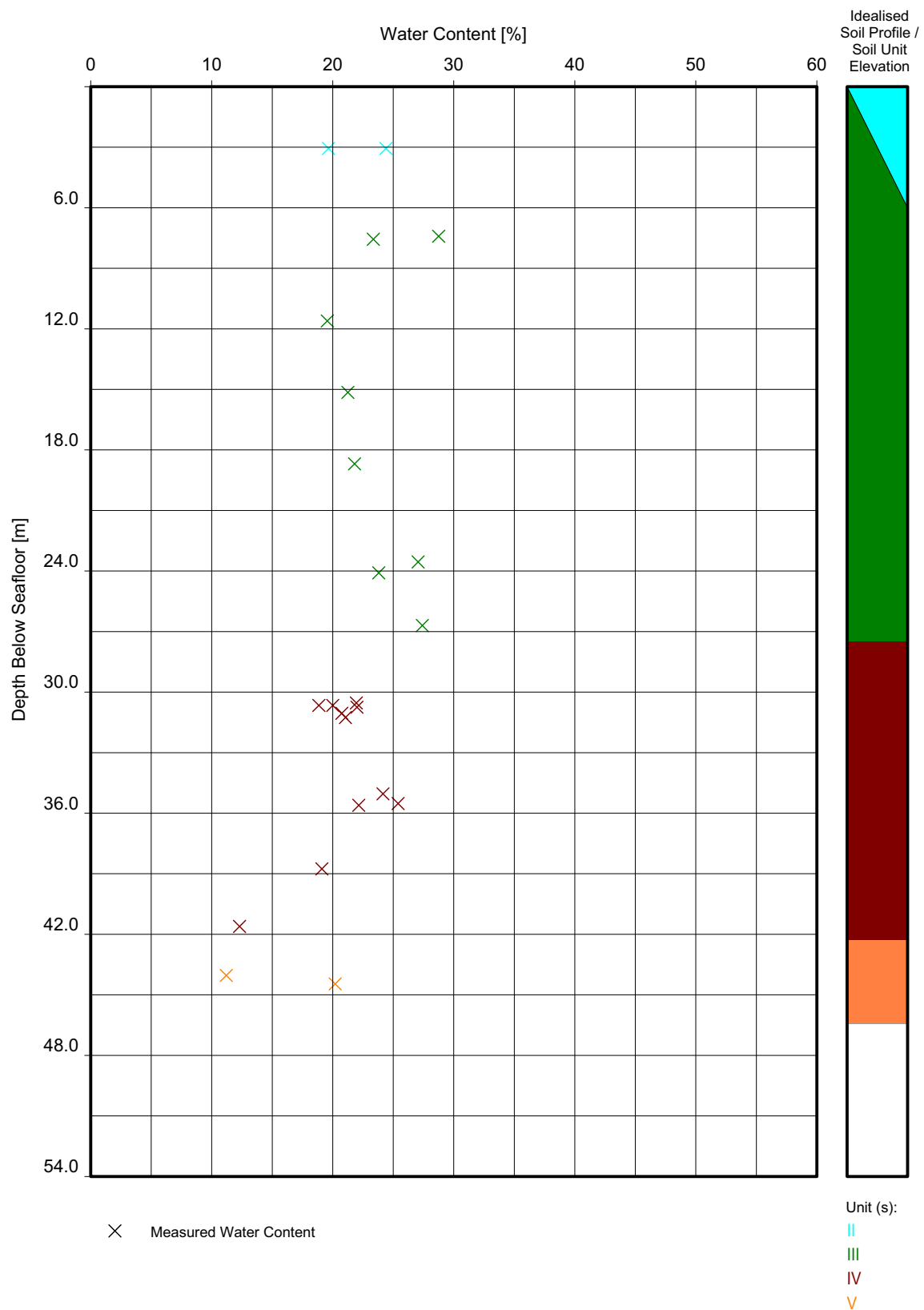
A.2.13 DRY DENSITY OF CHALK

In order to derive a model for the chalk's behaviour, several dry density values have been presented as a function of depth. Clayton (1983) has reported that dry density and saturated moisture content correlate well with a particular chalk's density state (i.e low, medium or high). Dry density is measured as standard during all total and effective stress tests. It can be seen from the data presented on Plate A.2-92 that the chalk encountered in BH_07 in Soil Province III is low becoming medium dense.

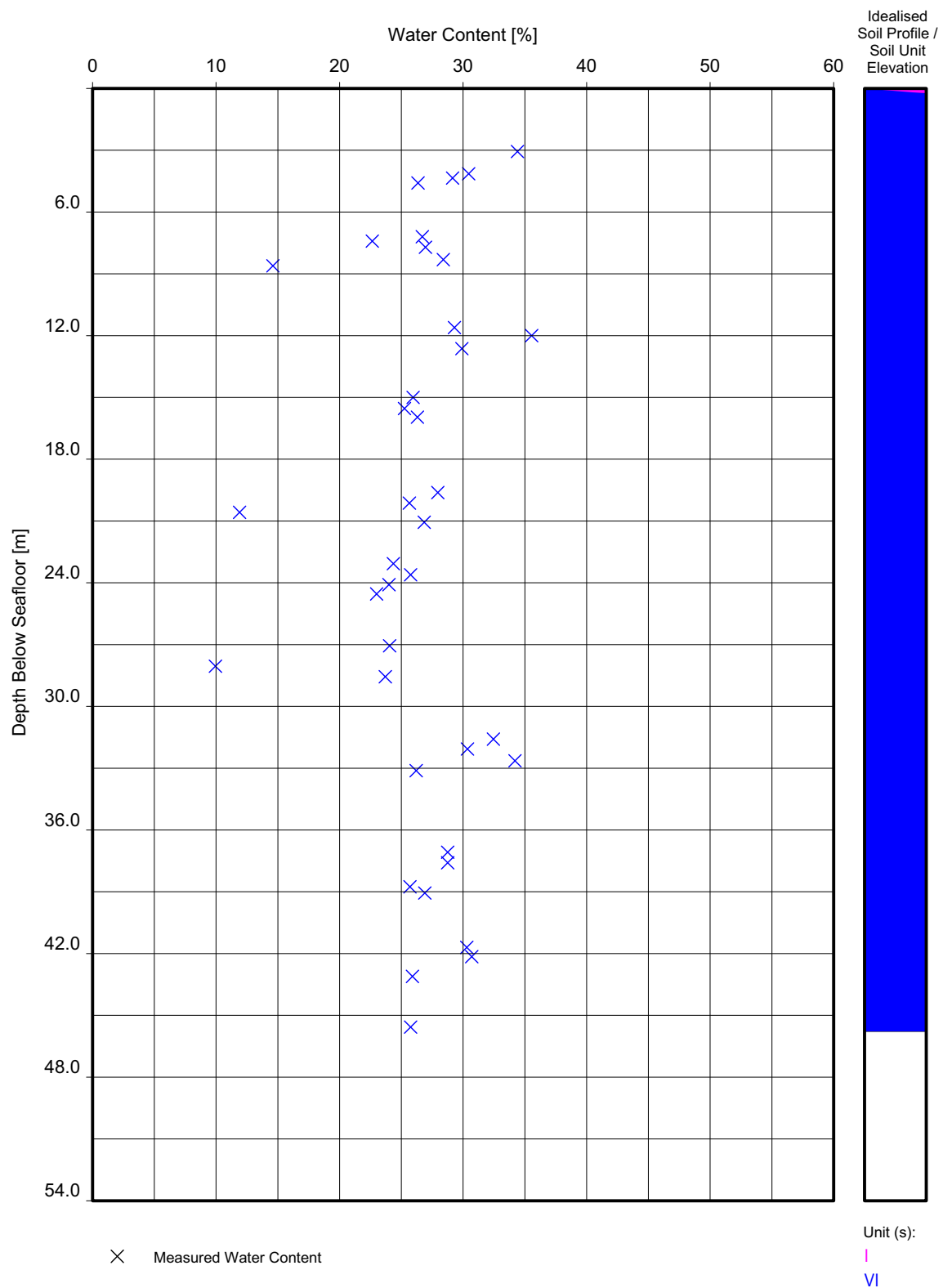
INTERPRETATION AND EVALUATION OF GEOTECHNICAL DATA

LIST OF PLATES – SECTION A.2

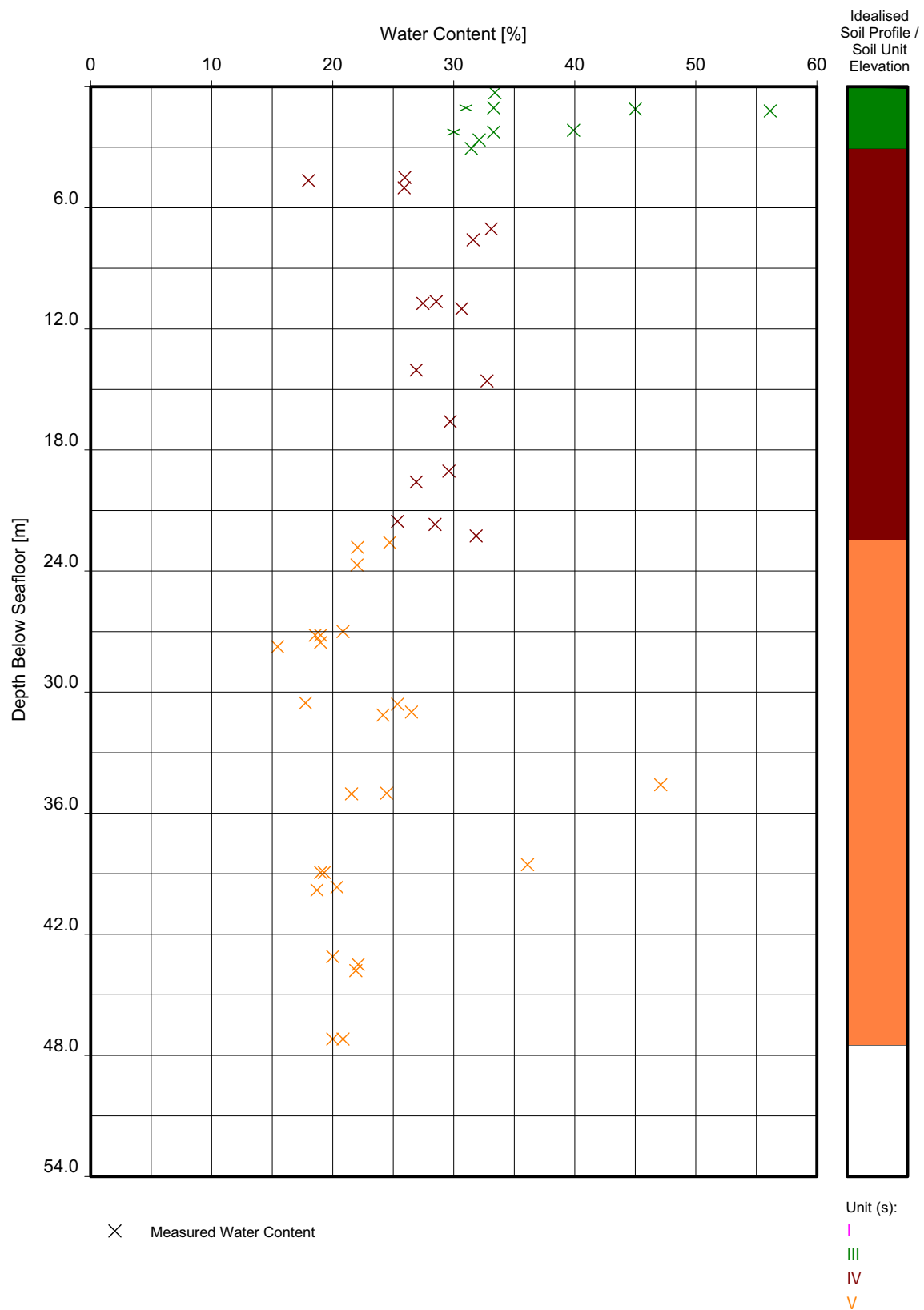
Description	Plate
Water Content versus Depth – Soil Province I, III, IV, V and VI	A.2-1 to A.2-5
Submerged Unit Weight versus Depth – Soil Province I, III, IV, V and VI	A.2-6 to A.2-10
Plastic and Liquid Limit versus Depth – Soil Province I, III, IV, V and VI	A.2-11 to A.2-14
Plasticity Index versus Liquid Limit – Soil Province I, III, IV, V and VI	A.2-16 to A.2-20
Particle Size Distribution Range – Soil Province I, III, IV, V and VI	A.2-21 to A.2-24
Carbonate Content versus Depth	A.2-25 to A.2-29
Total Organic Matter versus Depth	A.2-30 to A.2-33
Sulphate Content versus Depth	A.2-34 to A.2-37
Net Cone Resistance versus Depth – Soil Province I, III, IV, V and VI	A.2-38 to A.2-42
Undrained Shear Strength versus Depth – Soil Province I, III, IV, V and VI	A.2-43 to A.2-47
Strain at 50% Peak Deviator Stress versus Depth – Soil Province I, IV, V and VI	A.2-48 to A.2-51
Sensitivity versus Depth – Soil Province I, III, IV, V and VI	A.2-52 to A.2-56
Remoulded Shear Strength versus Depth – Soil Province I, III, IV, V and VI	A.2-57 to A.2-61
Relative Density versus Depth – Soil Province I, III, IV, V and VI	A.2-62 to A.2-65
Undrained Friction Angle versus Depth – Soil Province I, III, V and VI	A.2-66 to A.2-69
Drained Friction Angle versus Depth – Soil Province I, IV, V and VI	A.2-70 to A.2-73
Coefficient of Lateral Earth Pressure versus Depth – Soil Province I, III, IV, V and VI	A.2-74 to A.2-77
Overconsolidation Ratio versus Depth – Soil Province I, III, IV, V and VI	A.2-78 to A.2-81
Effective Overburden and Preconsolidation Stress versus Depth – Soil Province I, III, IV, V and VI	A.2-82 to A.2-85
Constrained Modulus versus Depth – Soil Province I, III, IV, V and VI	A.2-86 to A.2-89
Net Cone Resistance versus Undrained Shear Strength – Soil Province I, IV, V and VI	A.2-90
Residual Soil-Steel Friction Angle versus Plasticity Index	A.2-91
Dry Density versus Depth – Soil Province III	A.2-92



WATER CONTENT VERSUS DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation

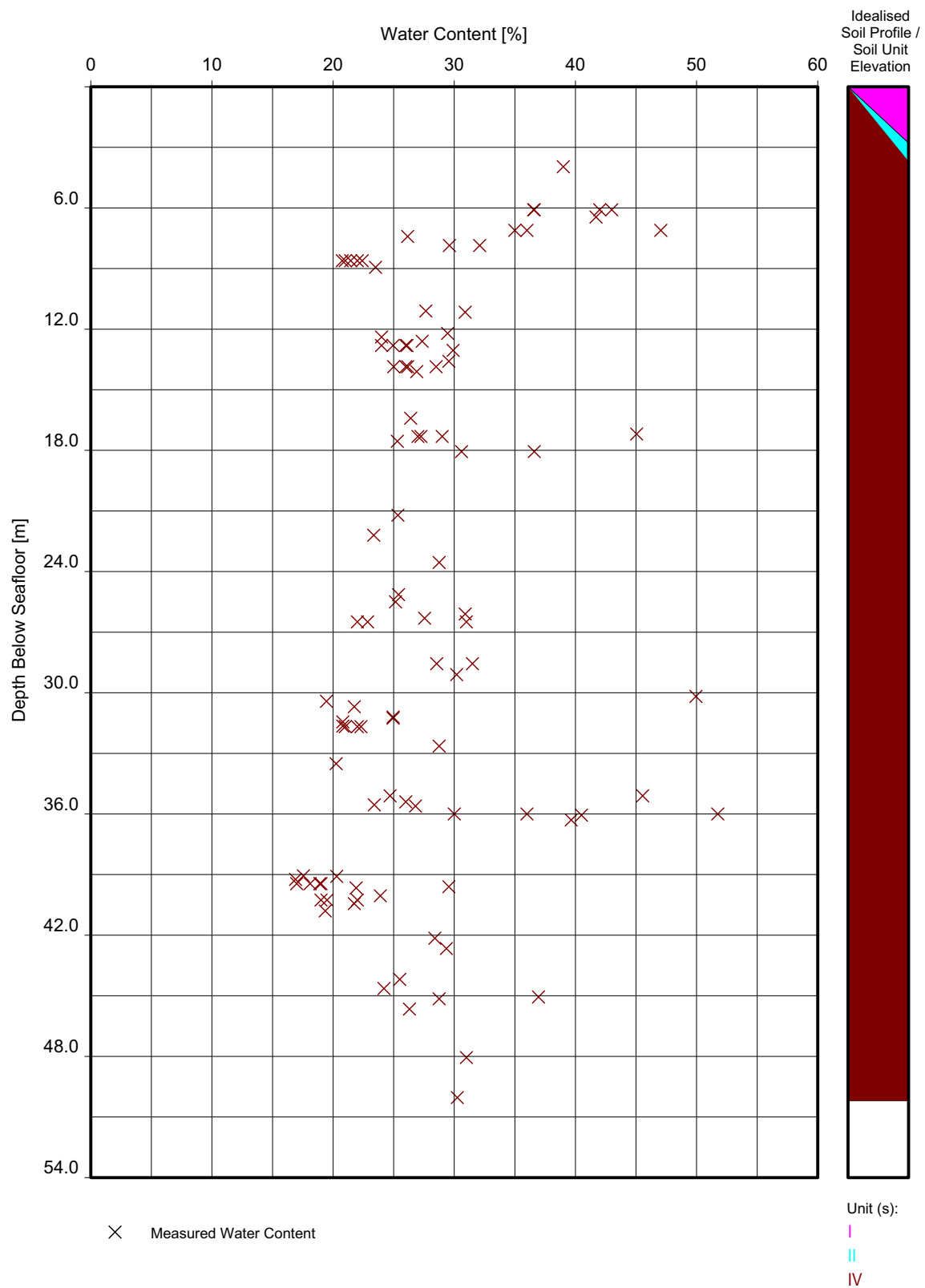


WATER CONTENT VERSUS DEPTH
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation

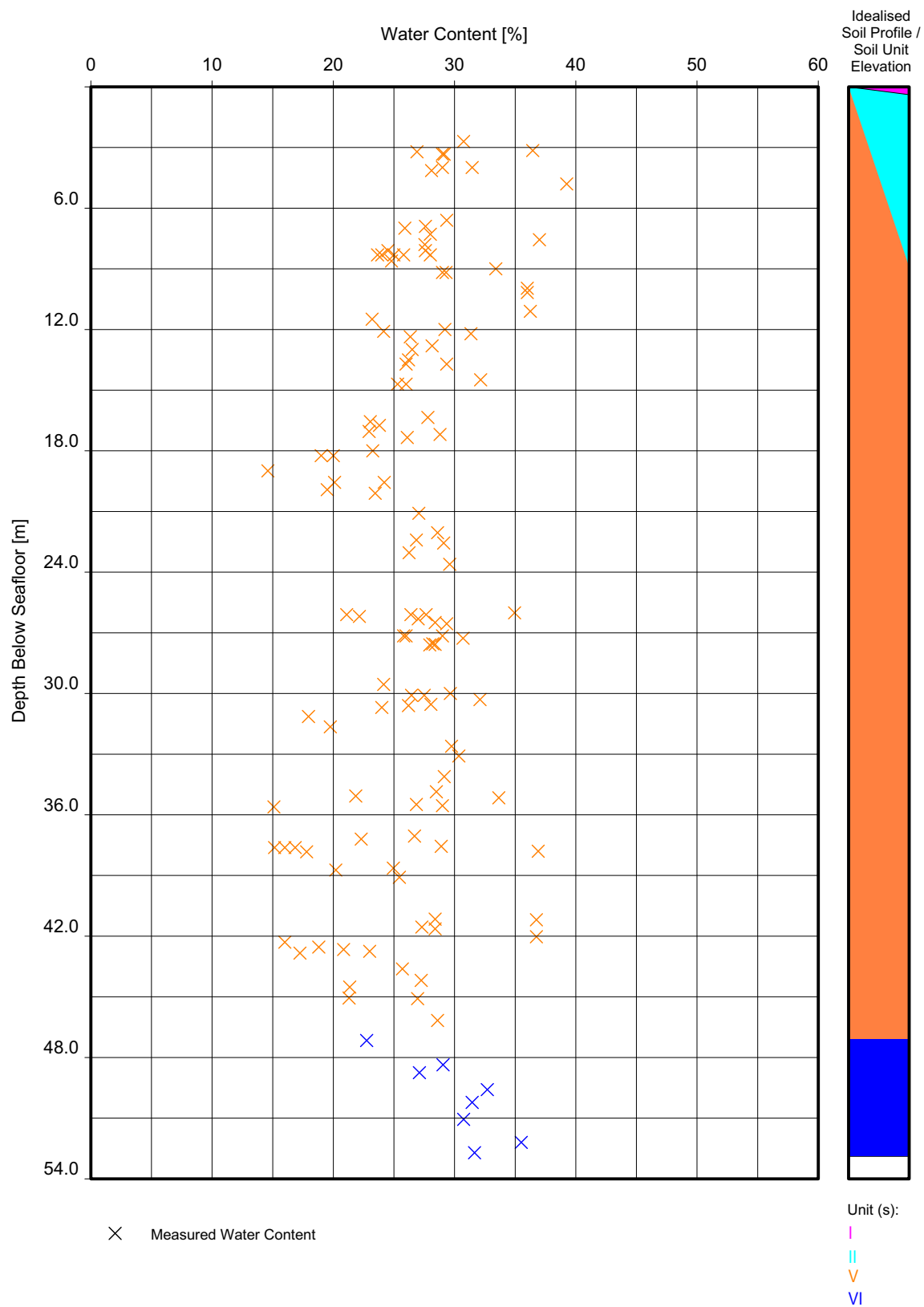


WATER CONTENT VERSUS DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation

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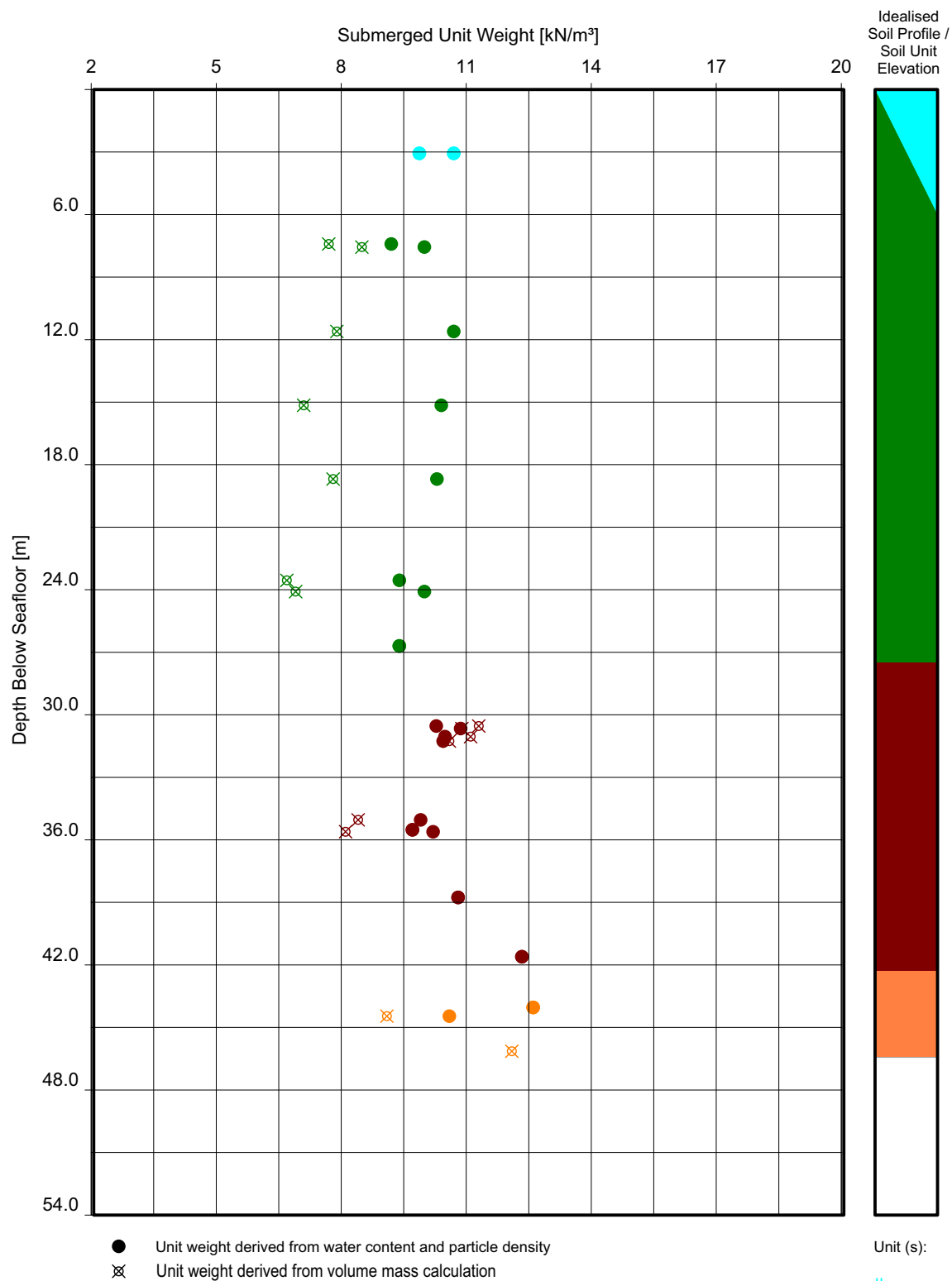


WATER CONTENT VERSUS DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



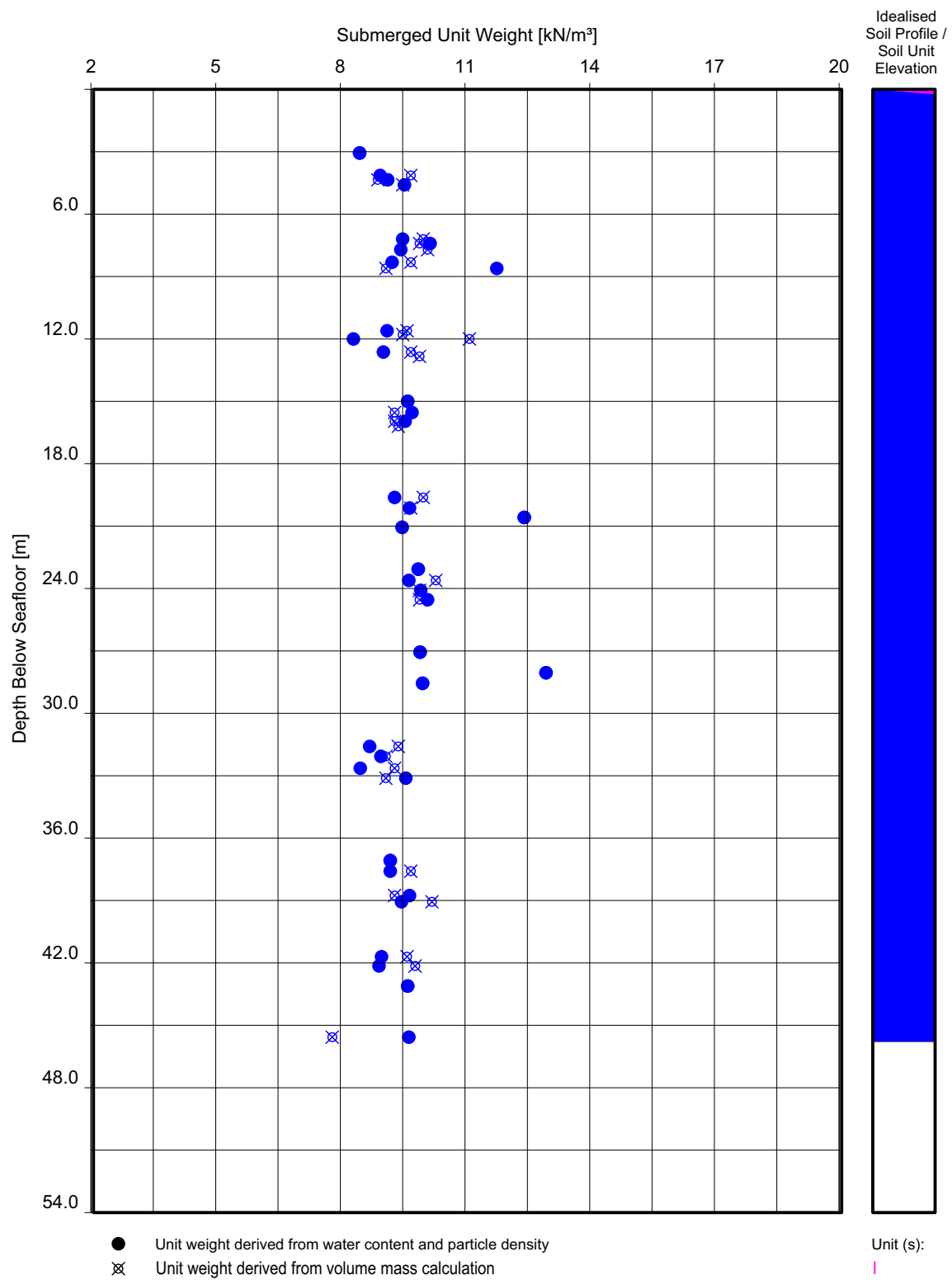
WATER CONTENT VERSUS DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation

GeODirWater Content vs Depth SP1.GLO/2011-07-25 12:56:48

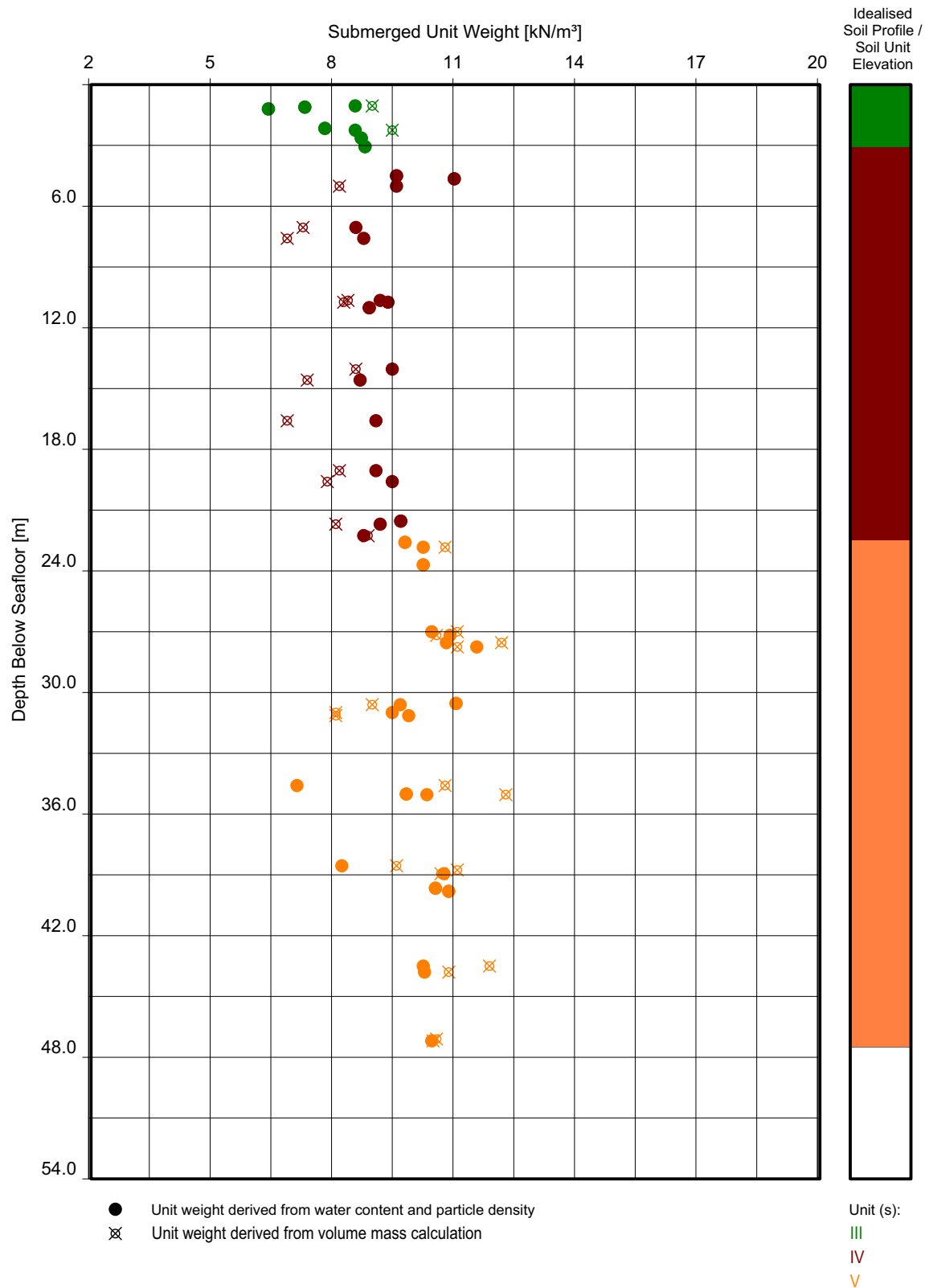


SUBMERGED UNIT WEIGHT VERSUS DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation

GeODir/Unit Weight vs Depth - Units.GI.O/2011-07-25 14:38:05

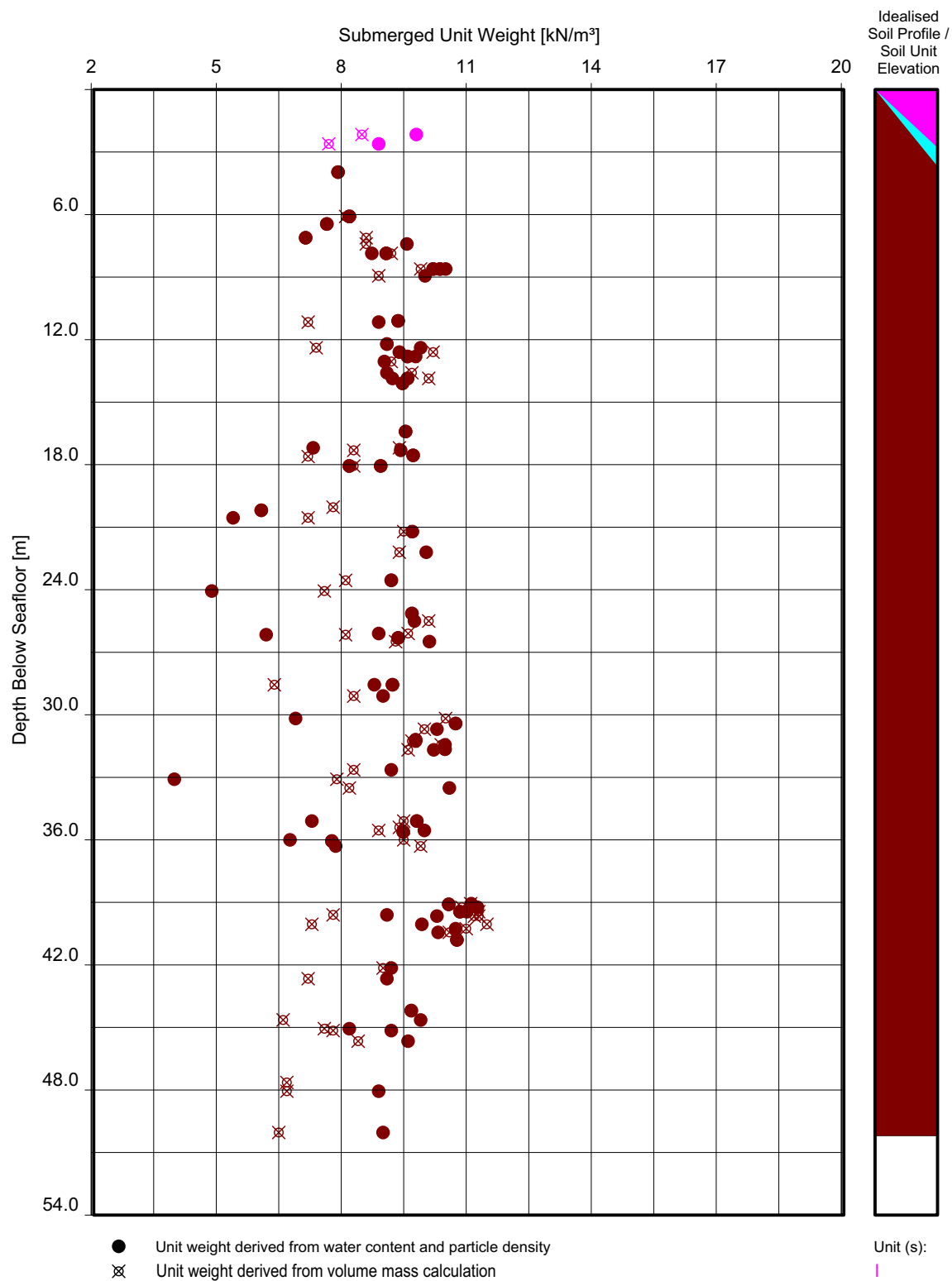


SUBMERGED UNIT WEIGHT VERSUS DEPTH
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation



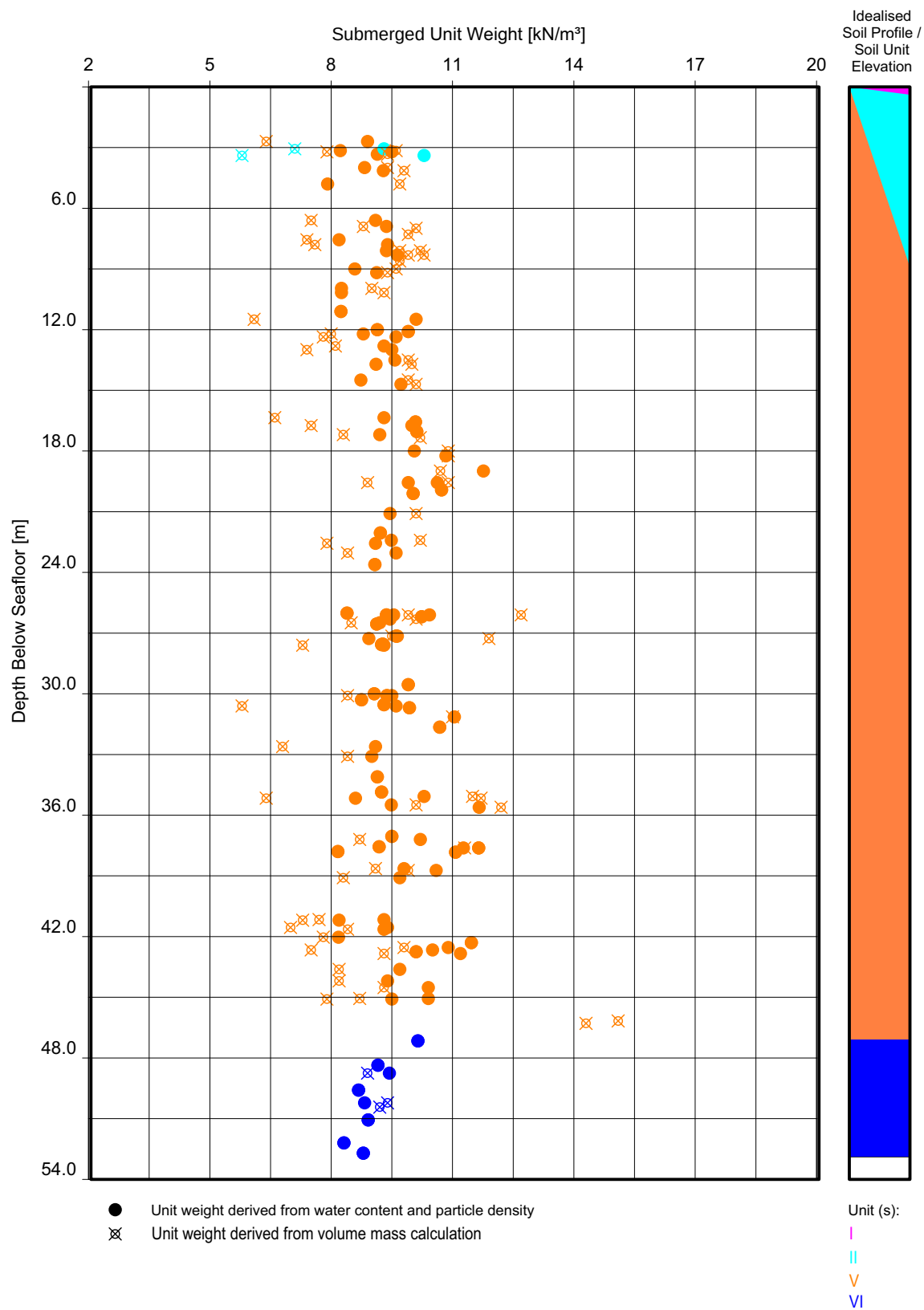
SUBMERGED UNIT WEIGHT VERSUS DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation

GeODir/Unit Weight vs Depth - Units.GI.O/2011-07-25 14:29:25



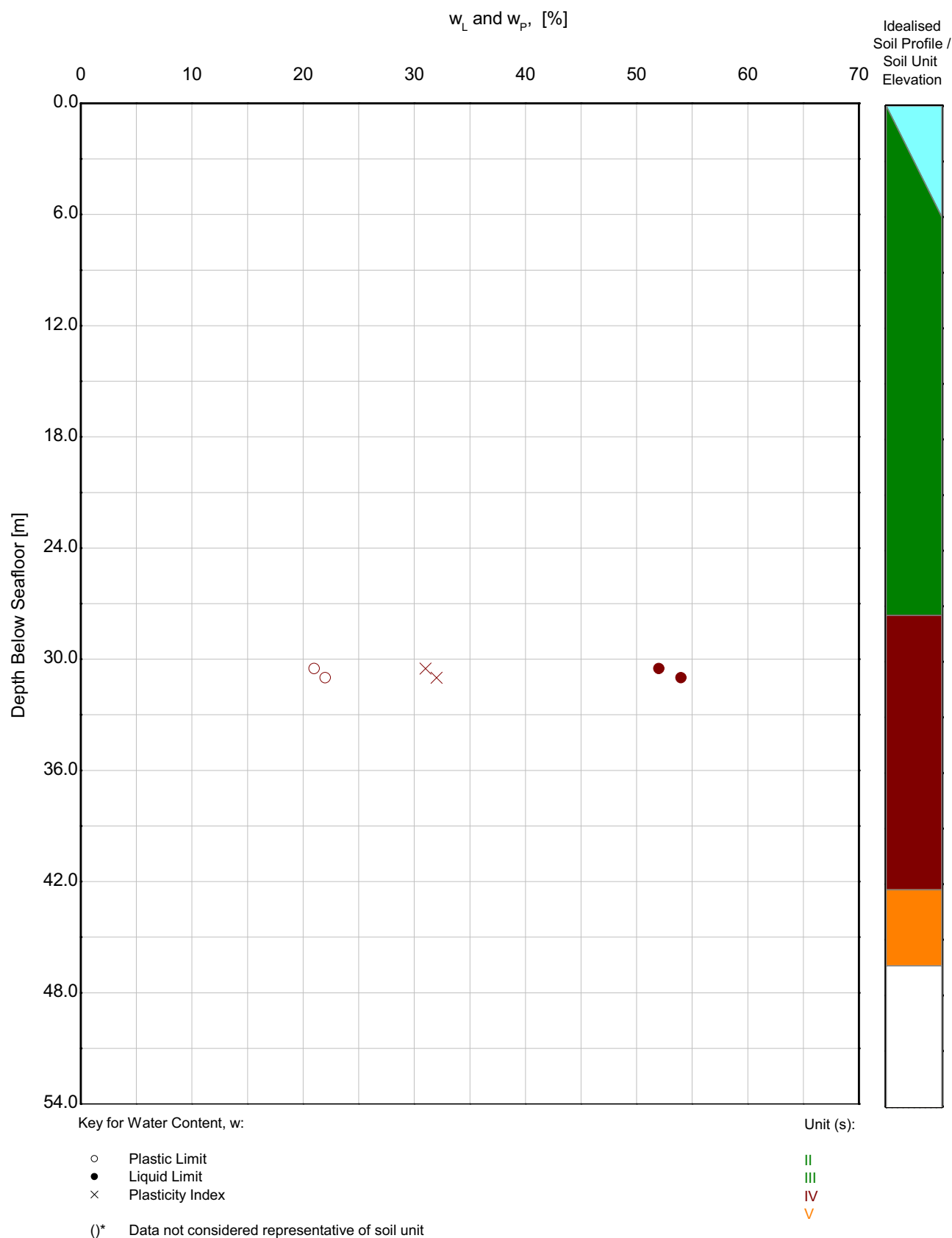
SUBMERGED UNIT WEIGHT VERSUS DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation

GeODir/Unit Weight vs Depth - Units.GI.O/2011-07-25 14:26:50

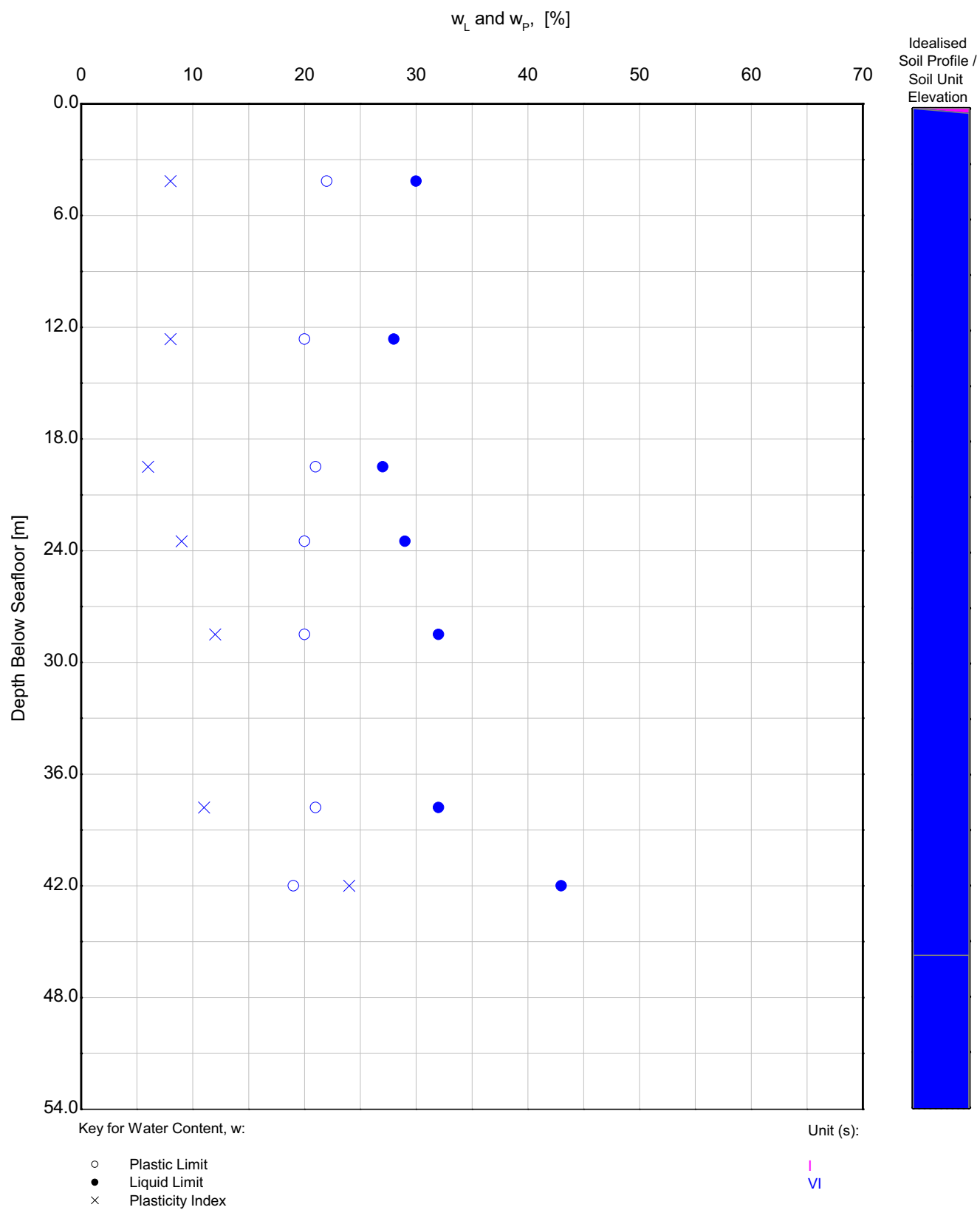


SUBMERGED UNIT WEIGHT VERSUS DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation

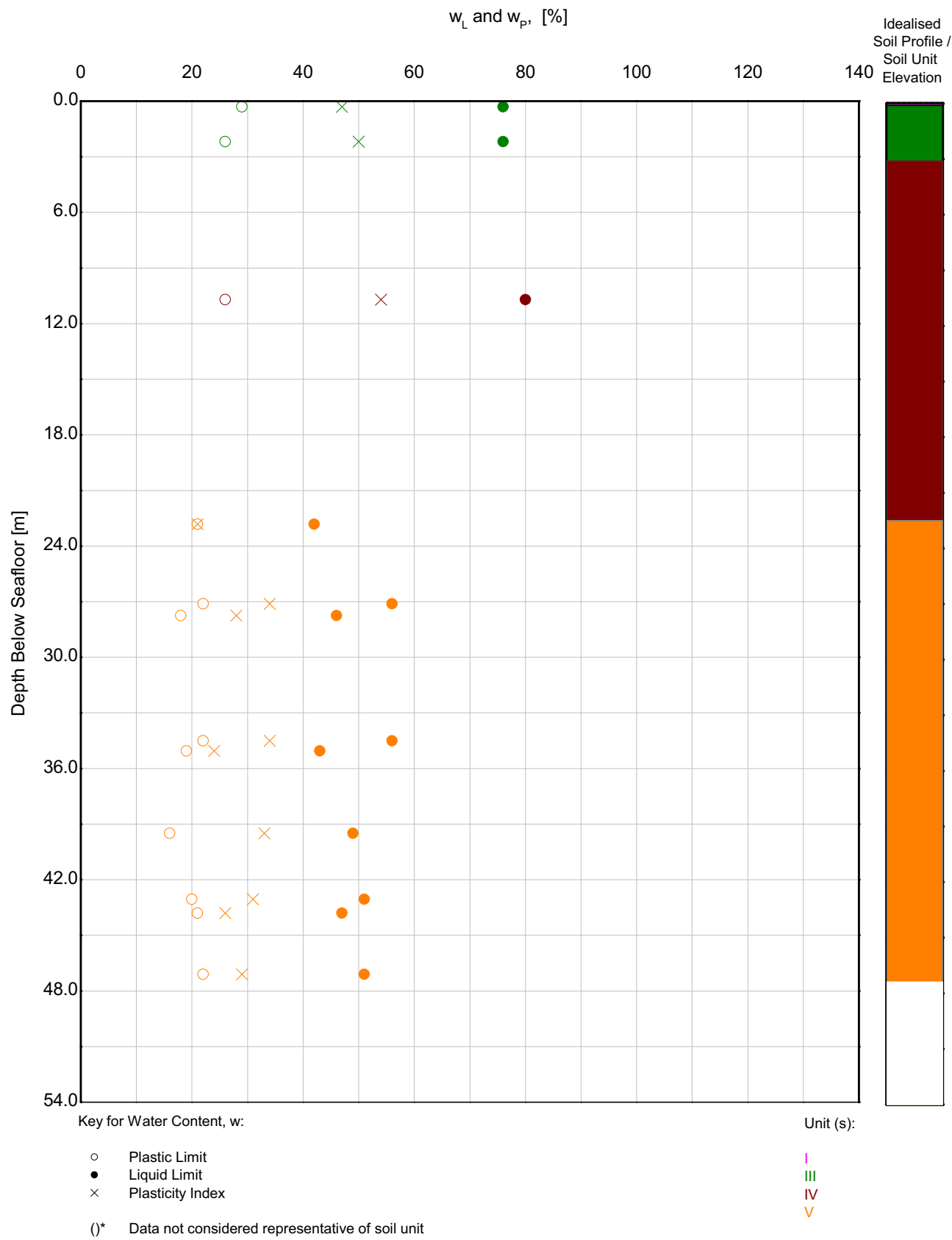
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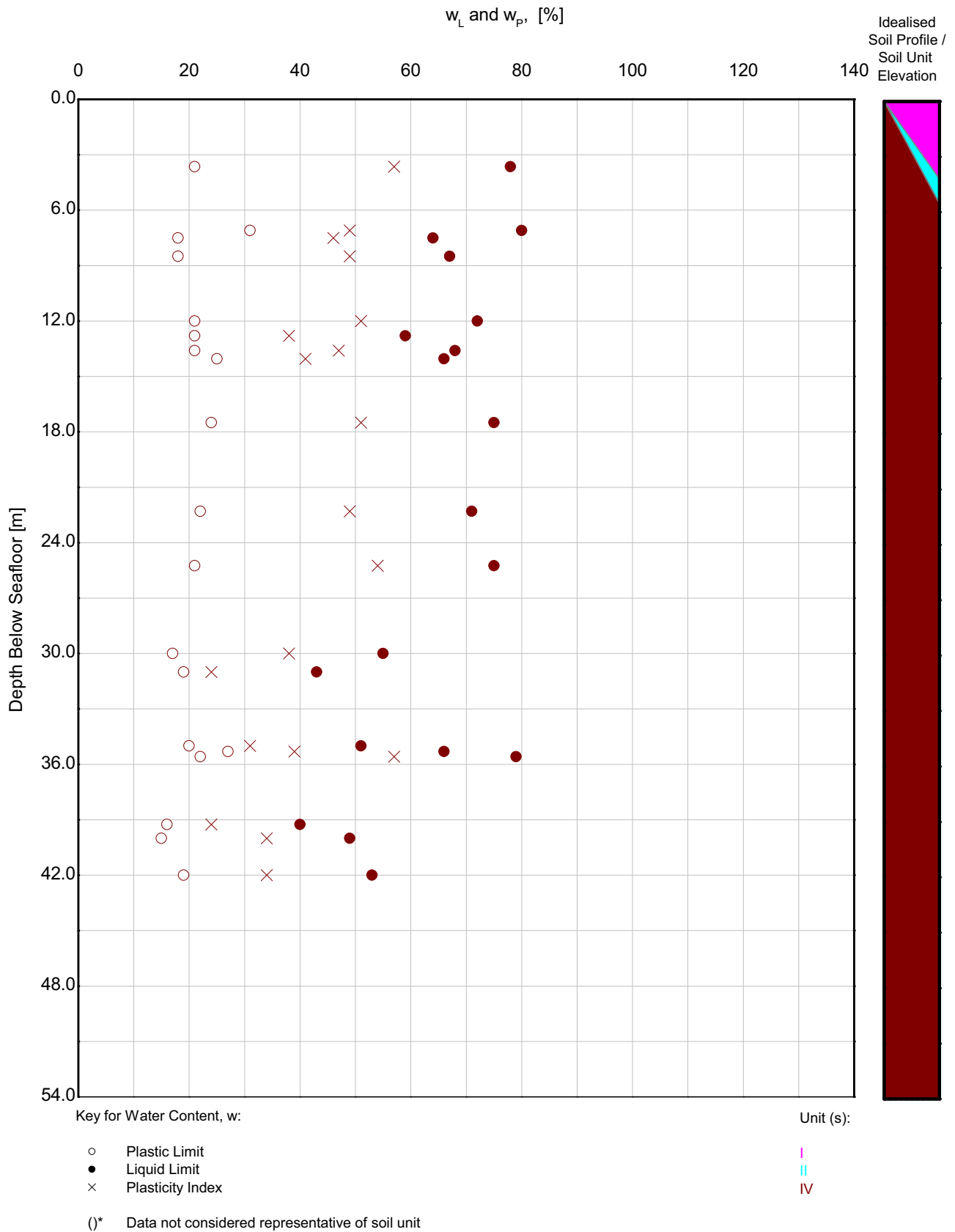
LIQUID LIMIT AND PLASTIC LIMIT versus DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



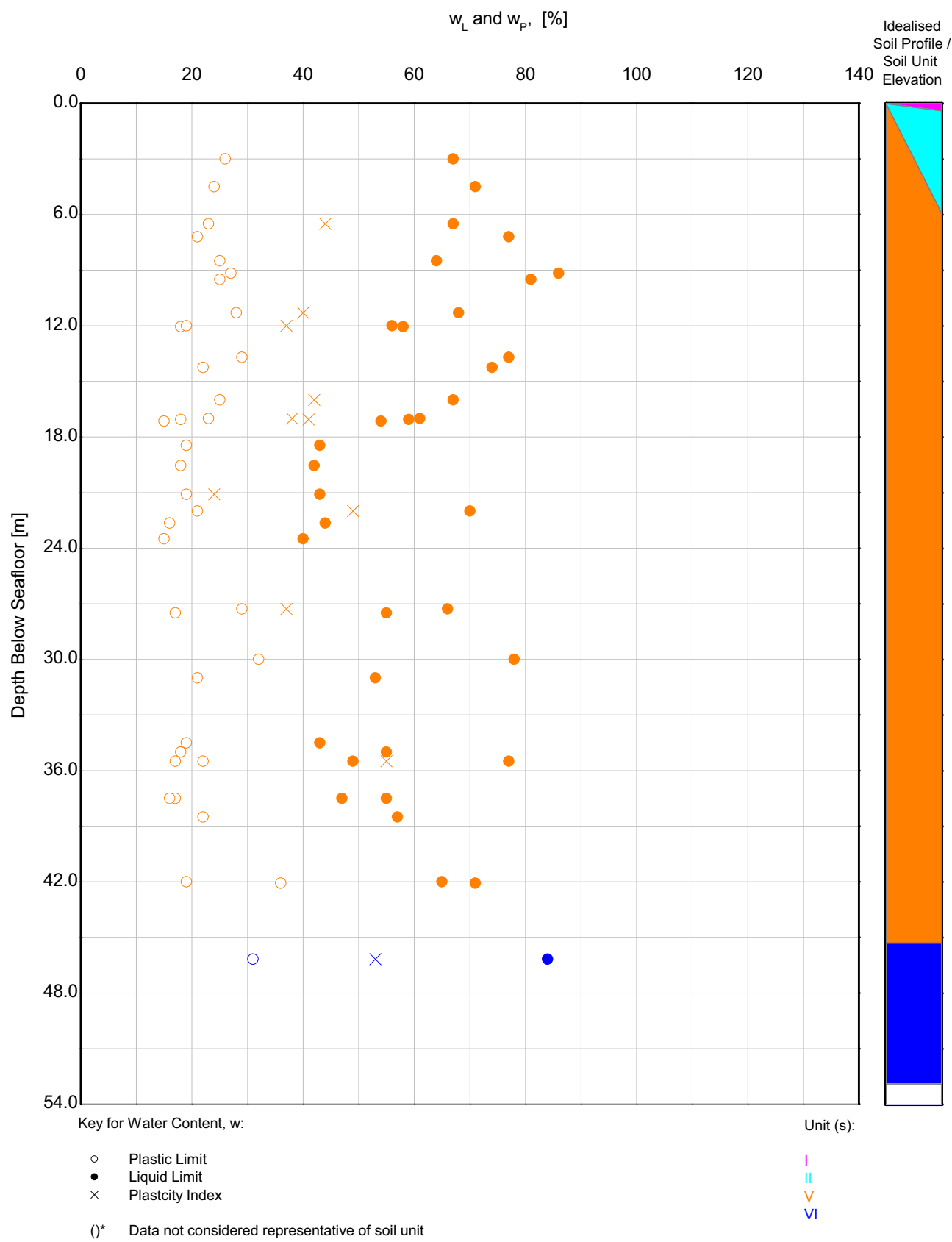
LIQUID LIMIT AND PLASTIC LIMIT versus DEPTH
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation



LIQUID LIMIT AND PLASTIC LIMIT versus DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation



LIQUID LIMIT AND PLASTIC LIMIT versus DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



LIQUID LIMIT AND PLASTIC LIMIT versus DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation

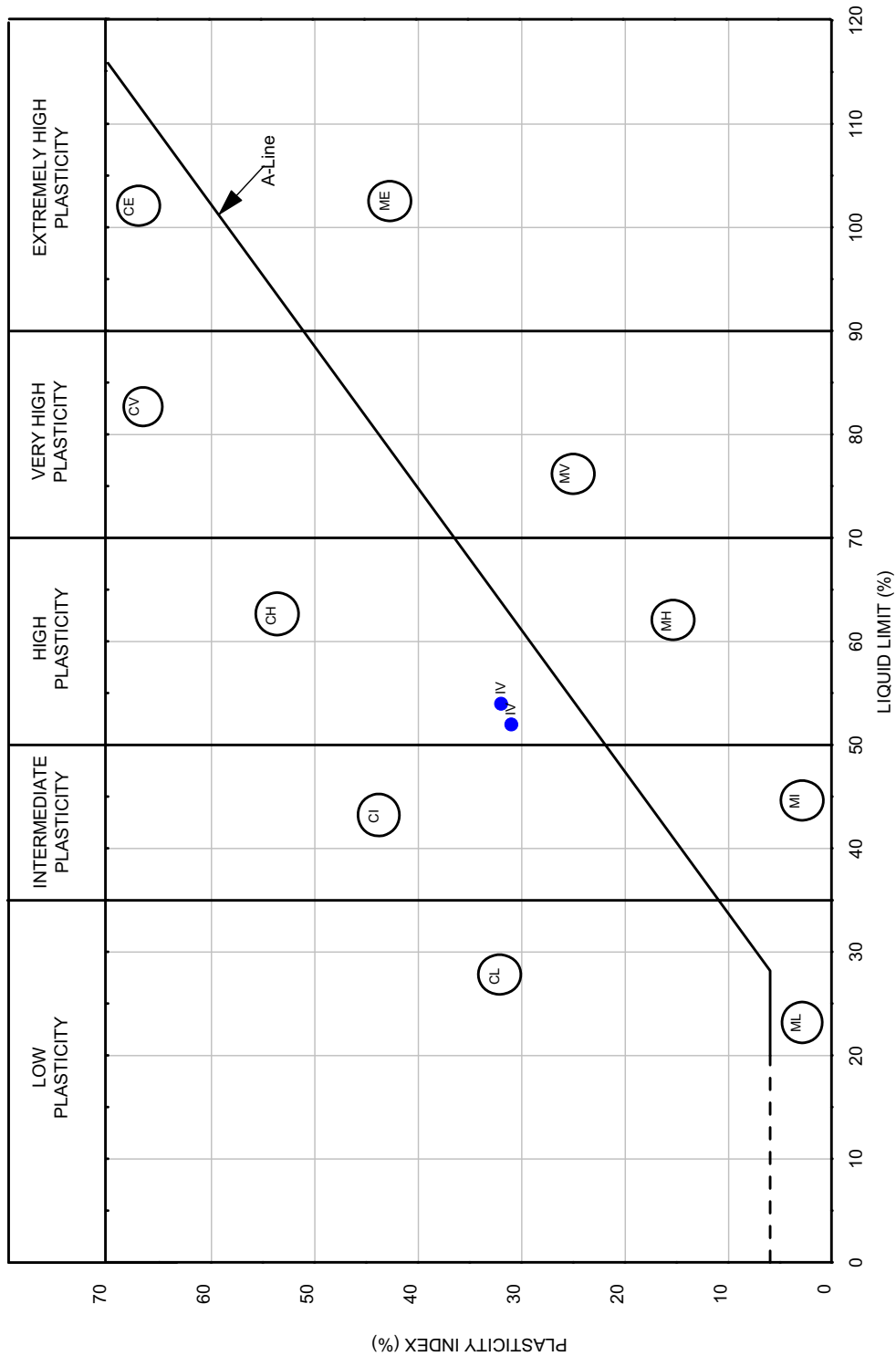


KEY TO TERMS USED :

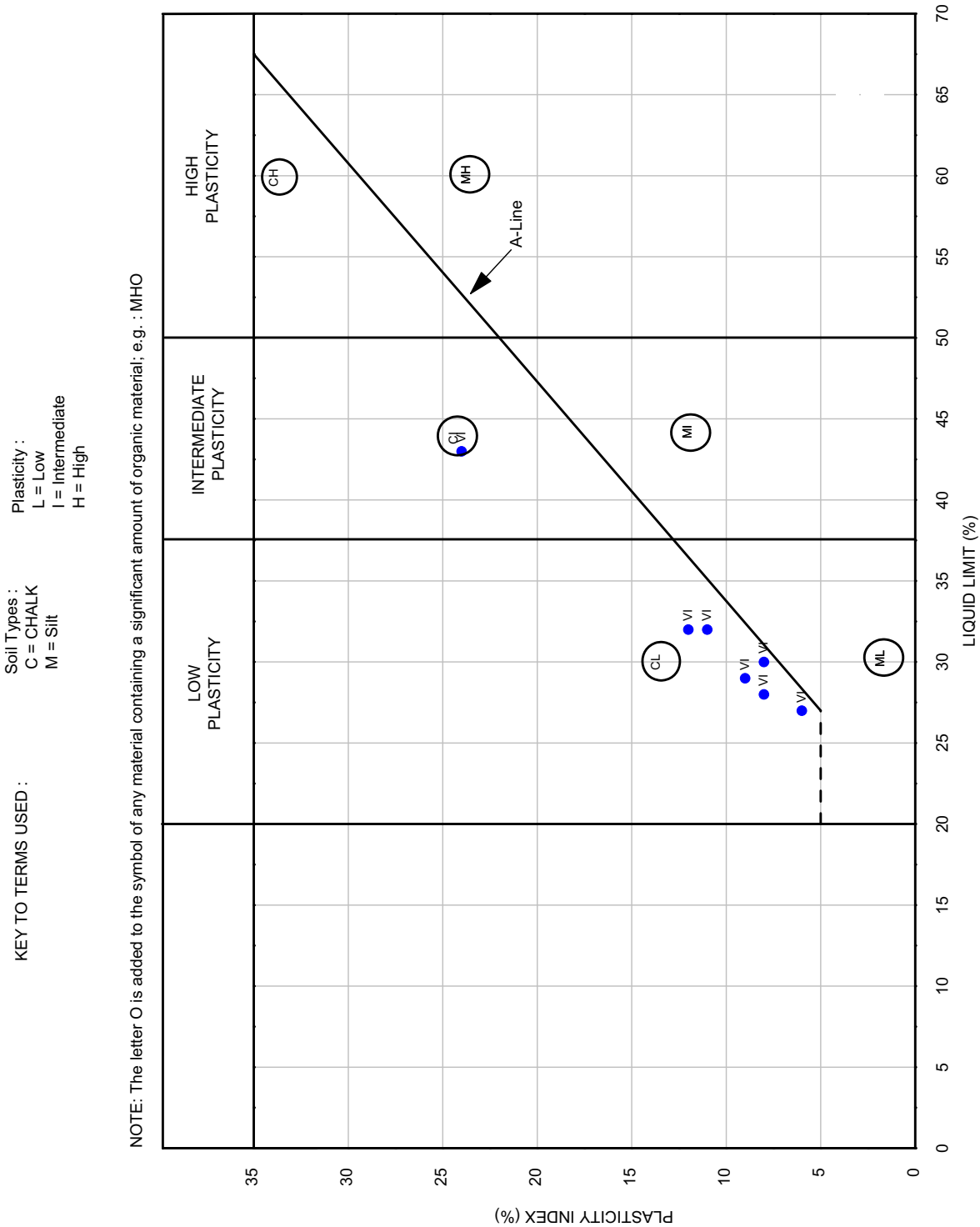
Soil Types :
C = Clay
M = Silt

Plasticity :
L = Low
I = Intermediate
H = High
V = Very high
E = Extremely High

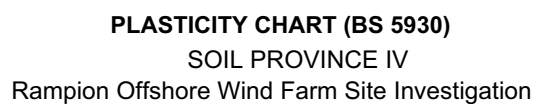
NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



PLASTICITY CHART (BS 5930)
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



PLASTICITY CHART FOR CHALK
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation





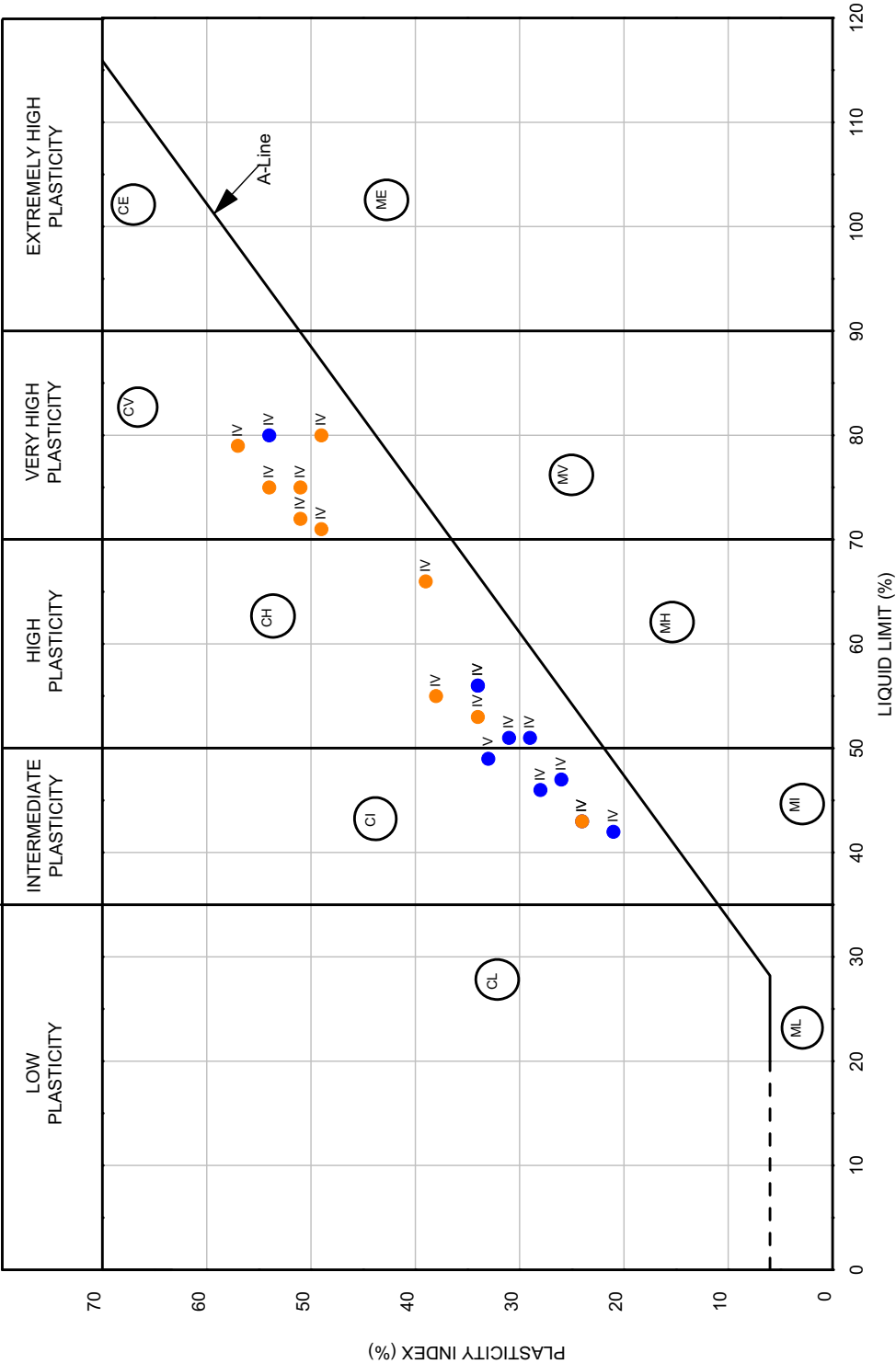
KEY TO TERMS USED :

Soil Types :
C = Clay
M = Silt

Plasticity :
L = Low
I = Intermediate
H = High

V = Very high
E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



PLASTICITY CHART (BS 5930)
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



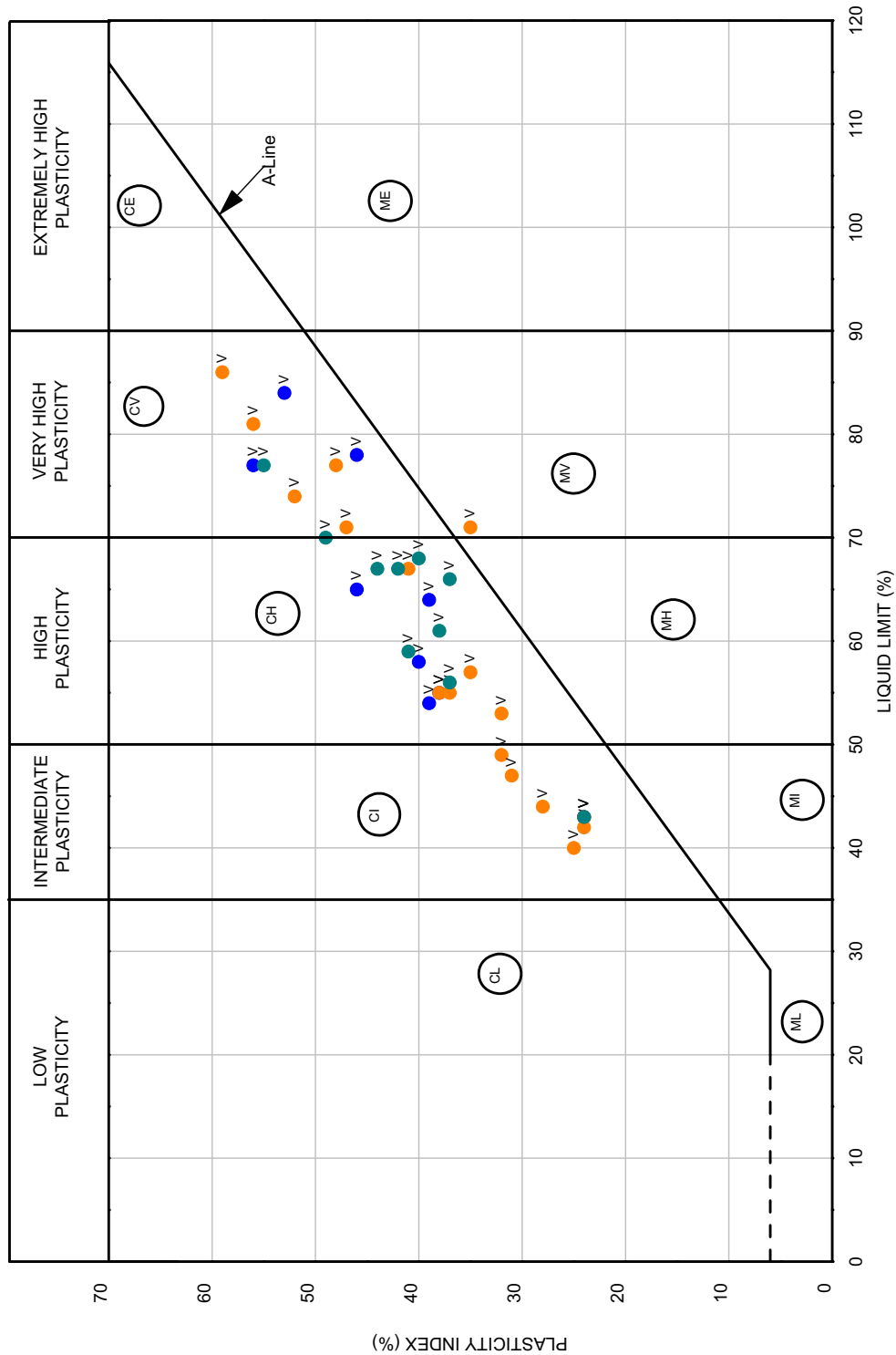
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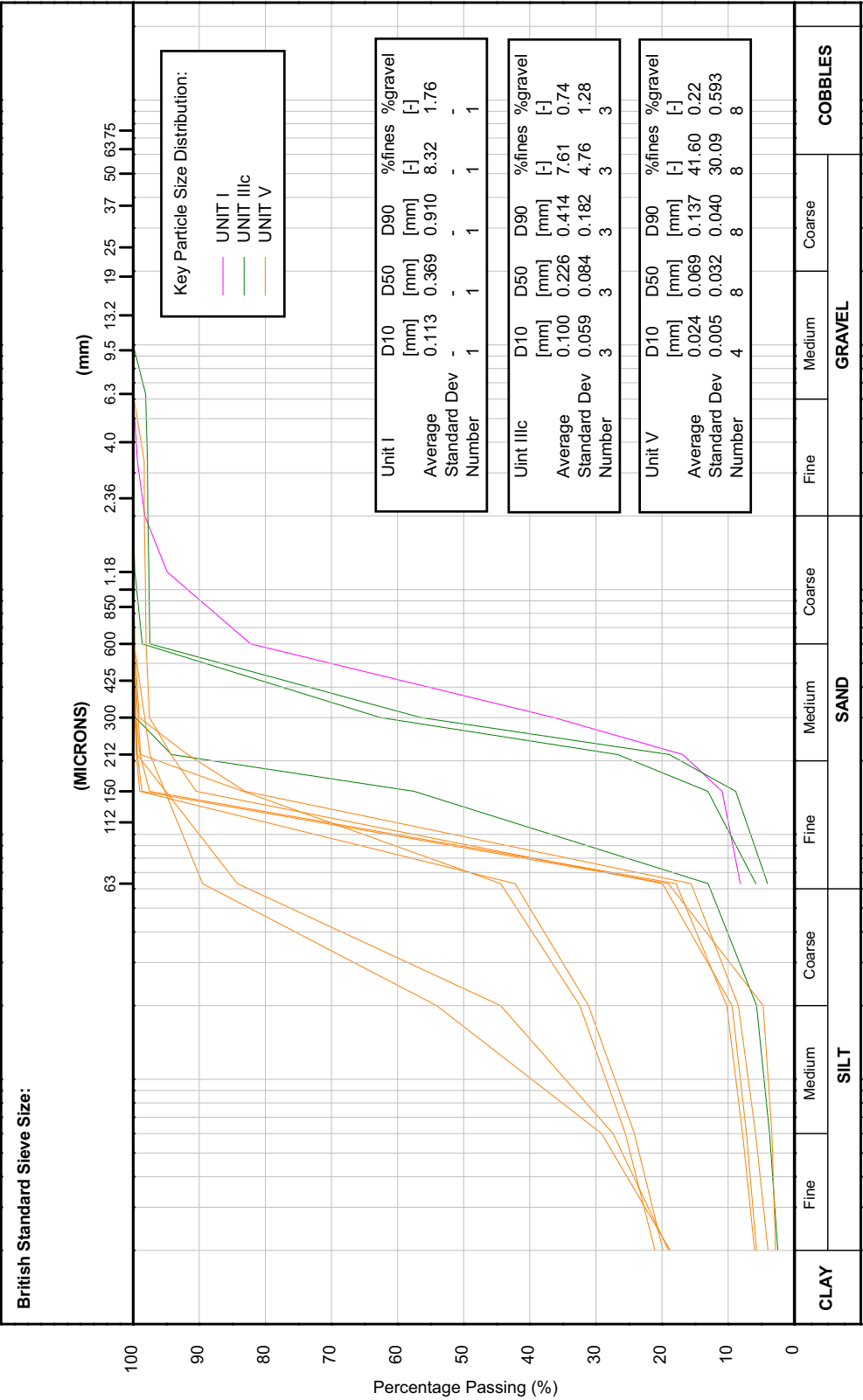
Soil Types :
C = Clay
M = Silt

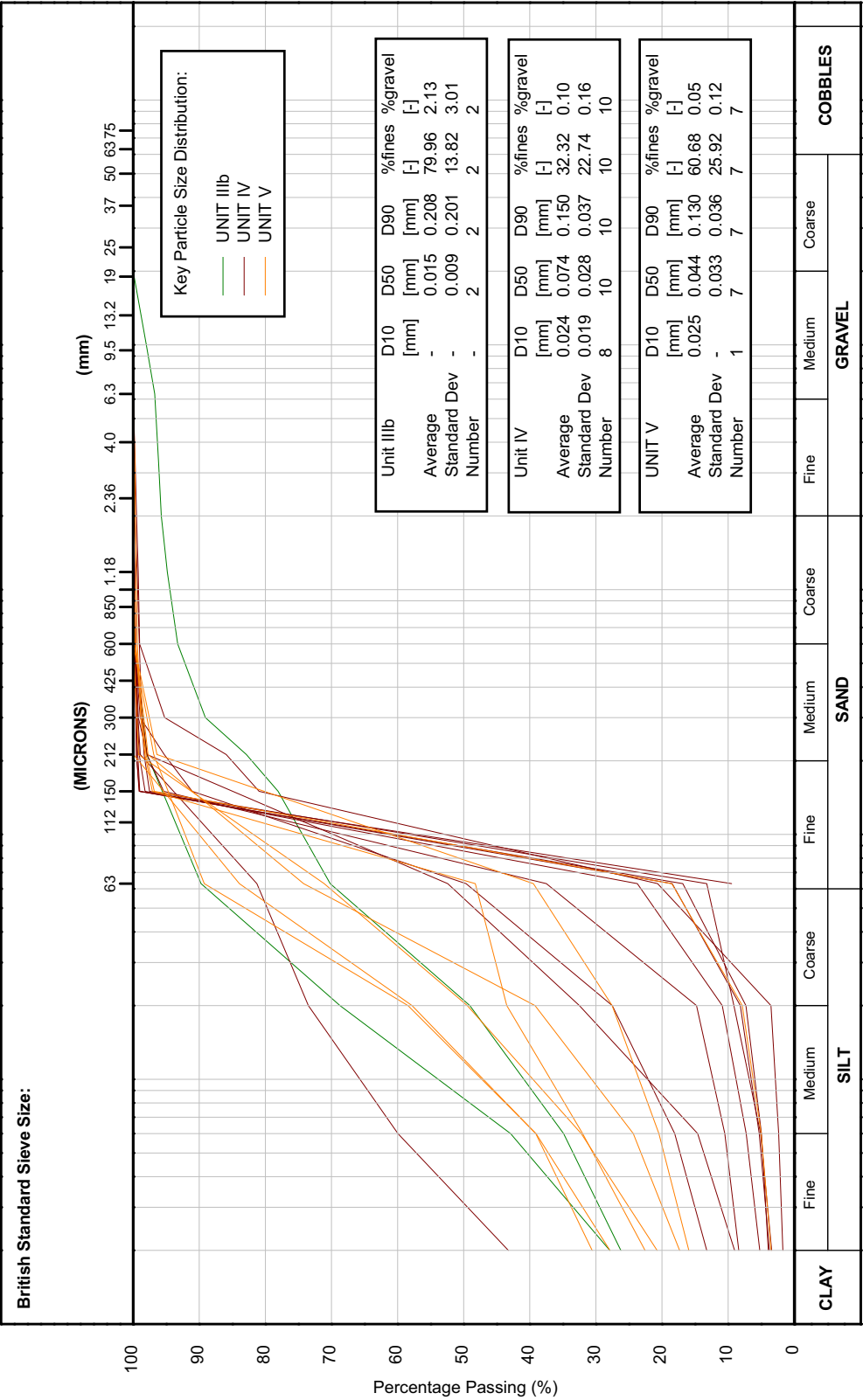
Plasticity :
L = Low
I = Intermediate
H = High

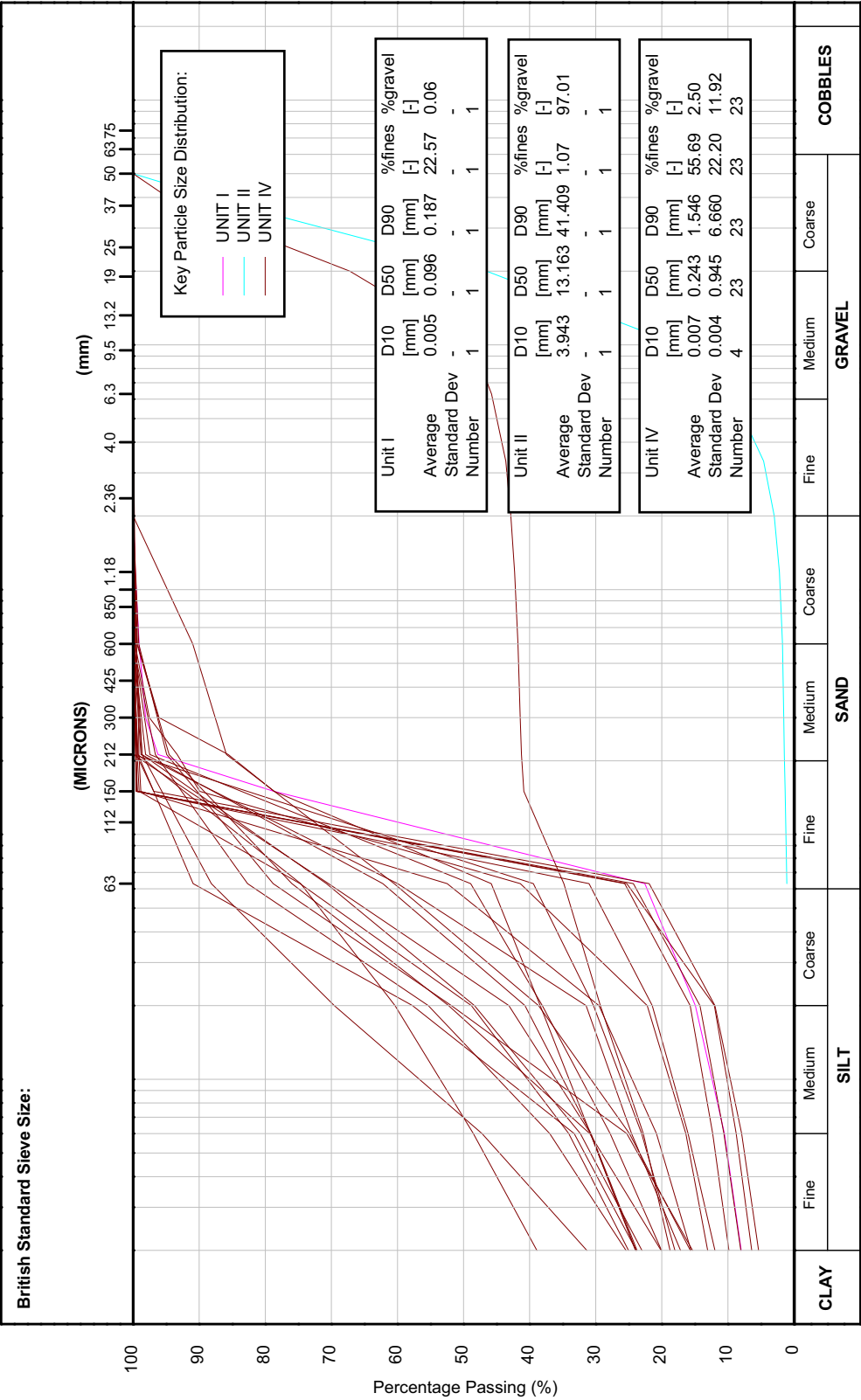
V = Very high
E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO

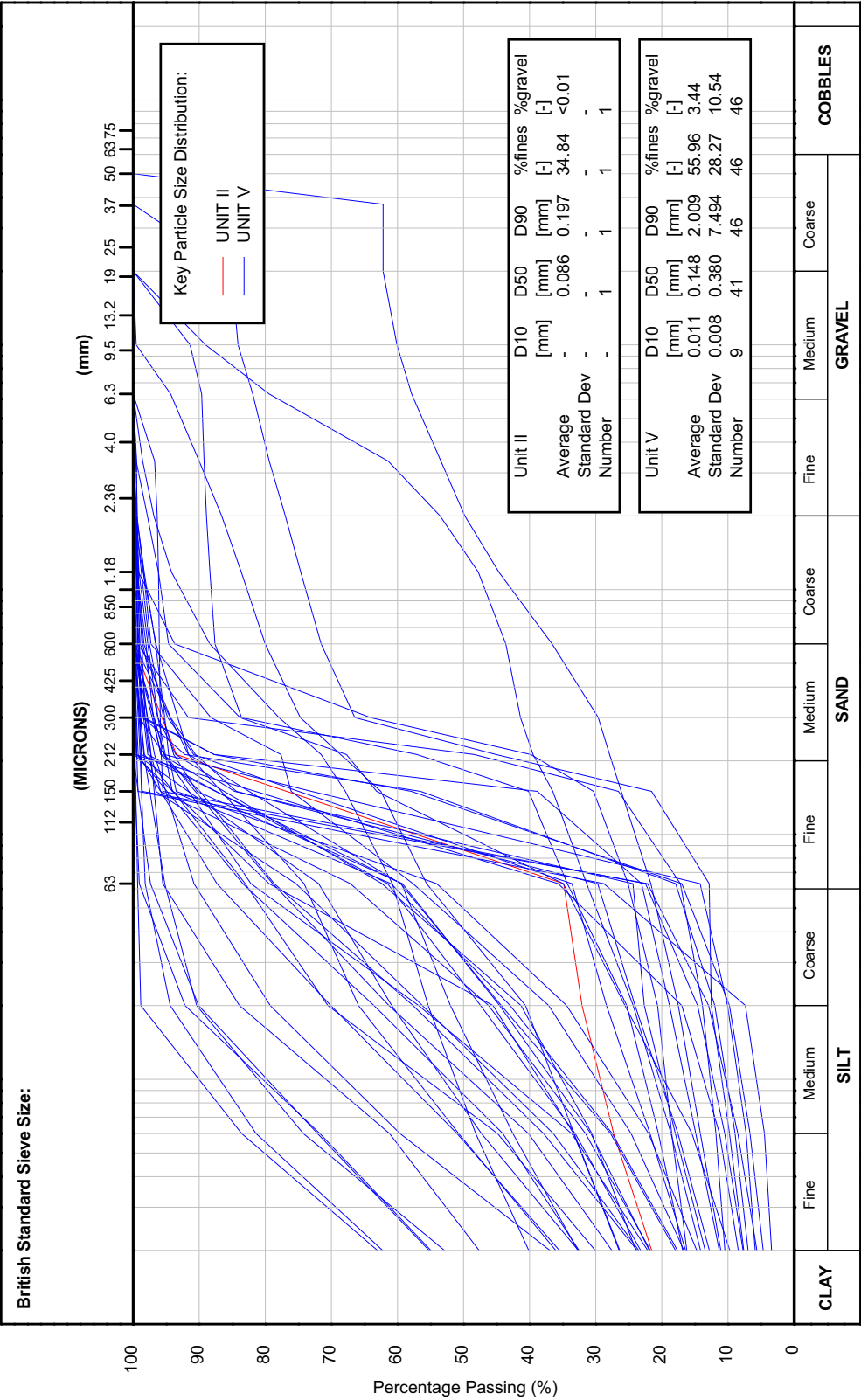




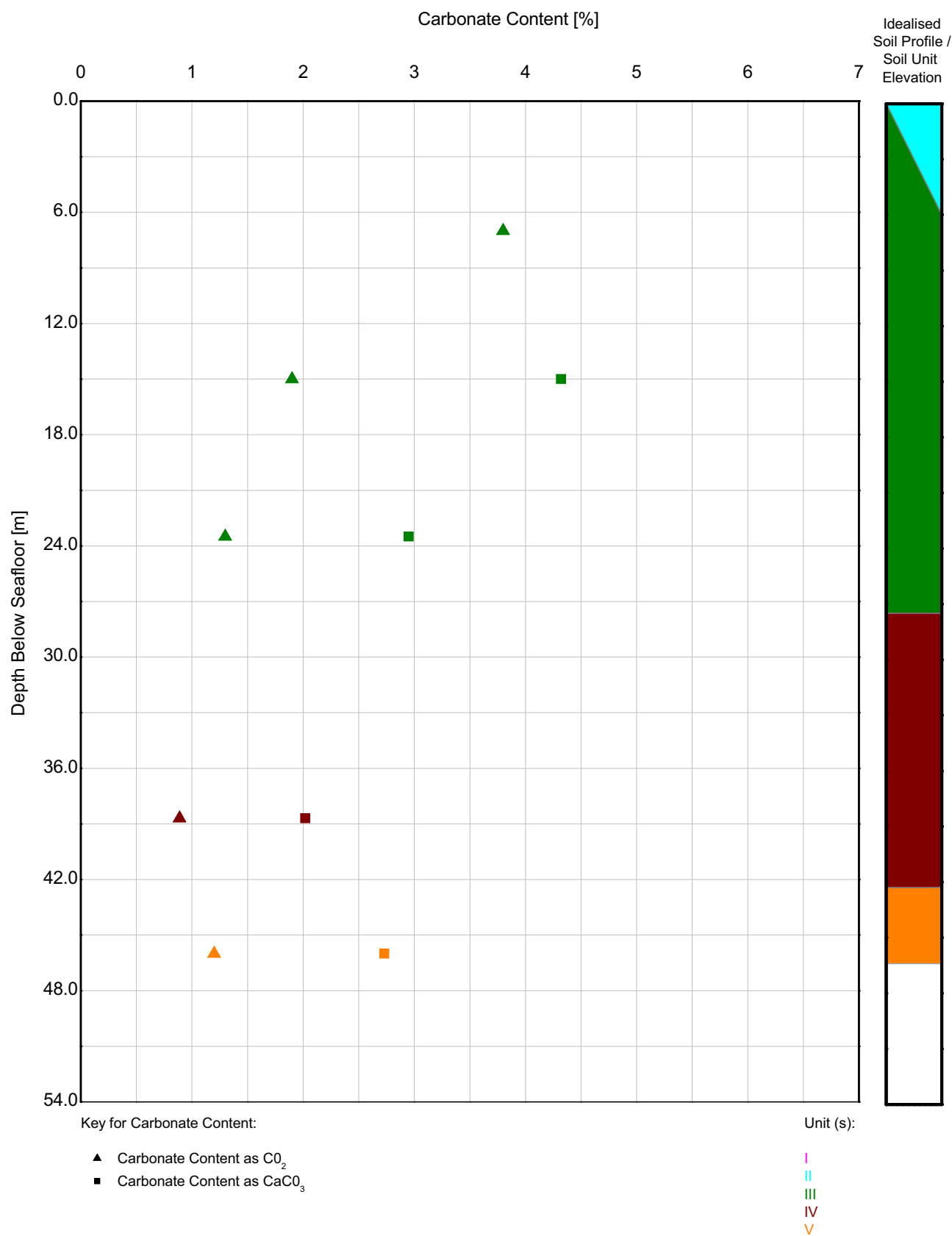




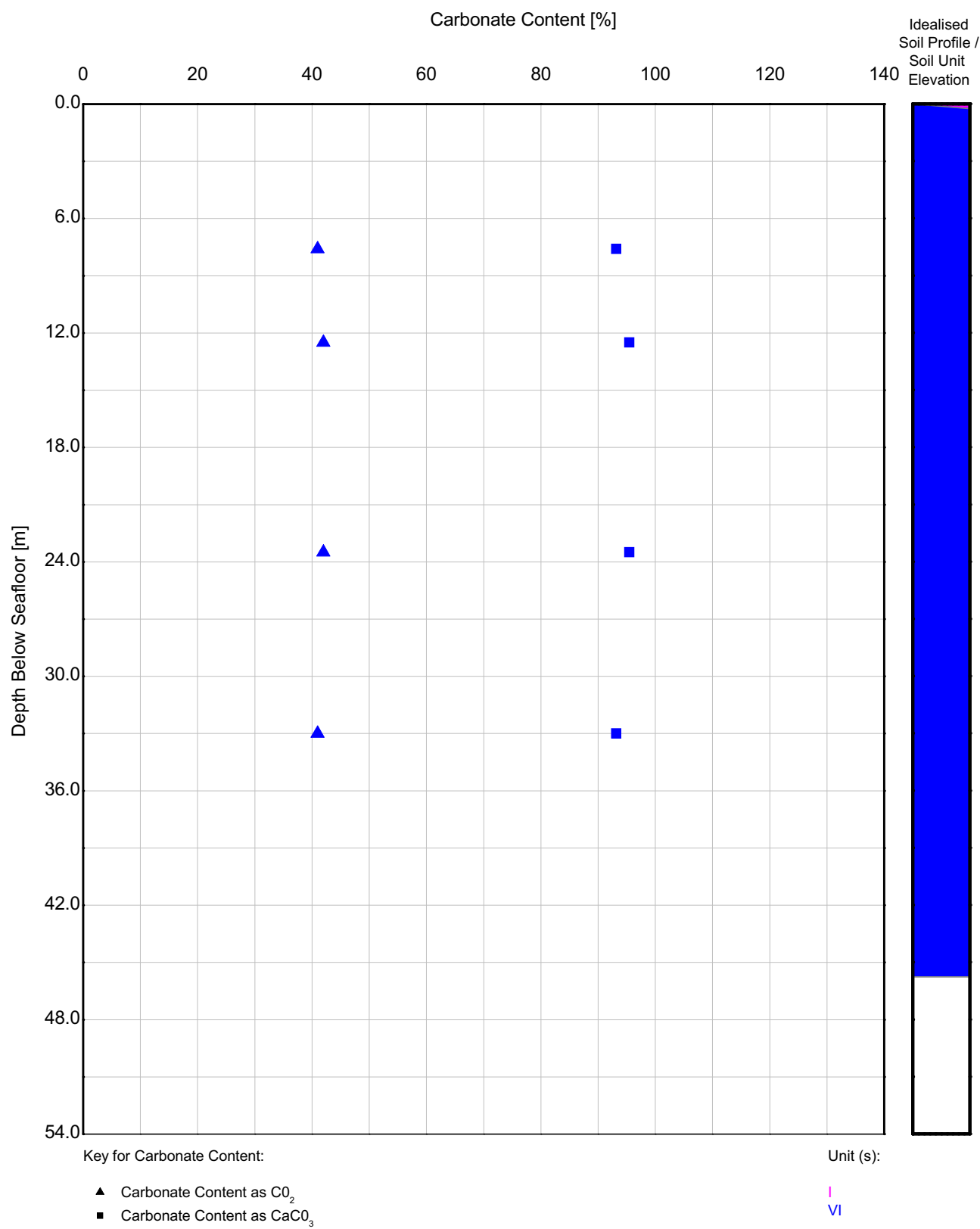
PARTICLE SIZE DISTRIBUTION RANGE
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



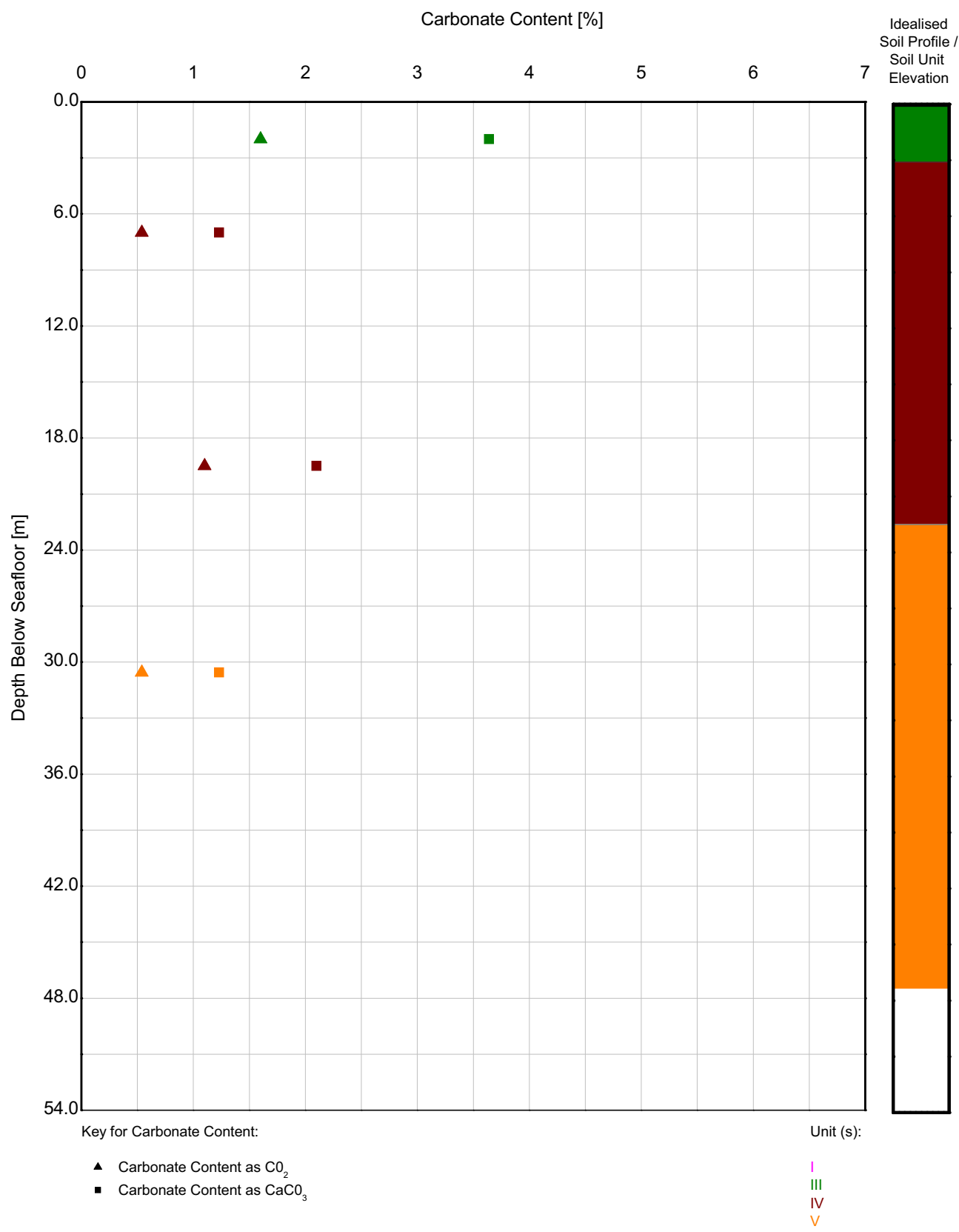
PARTICLE SIZE DISTRIBUTION RANGE
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation



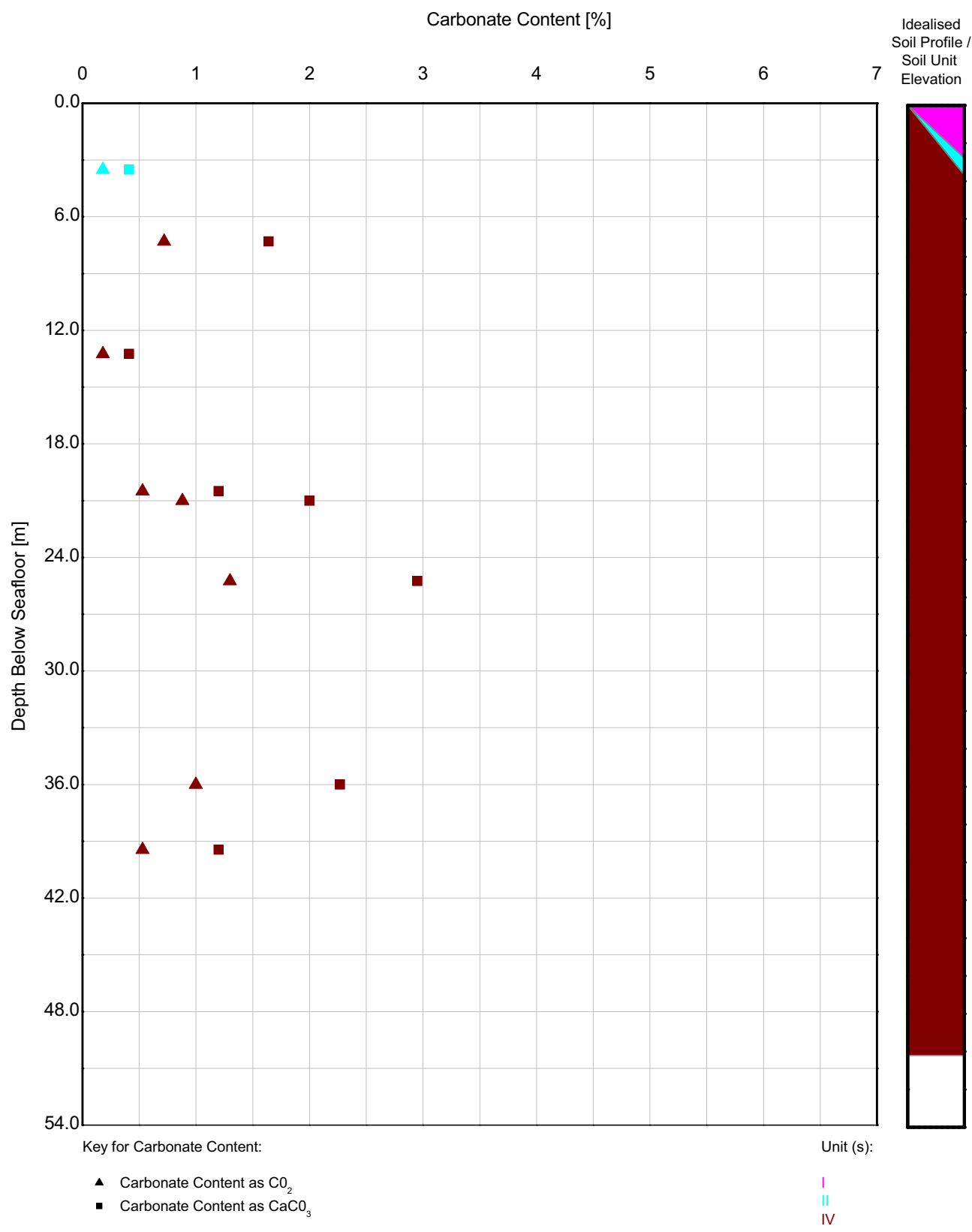
CARBONATE CONTENT versus DEPTH
SOIL PROVINCE I
Rampion Geotechnical Site Investigation 2011



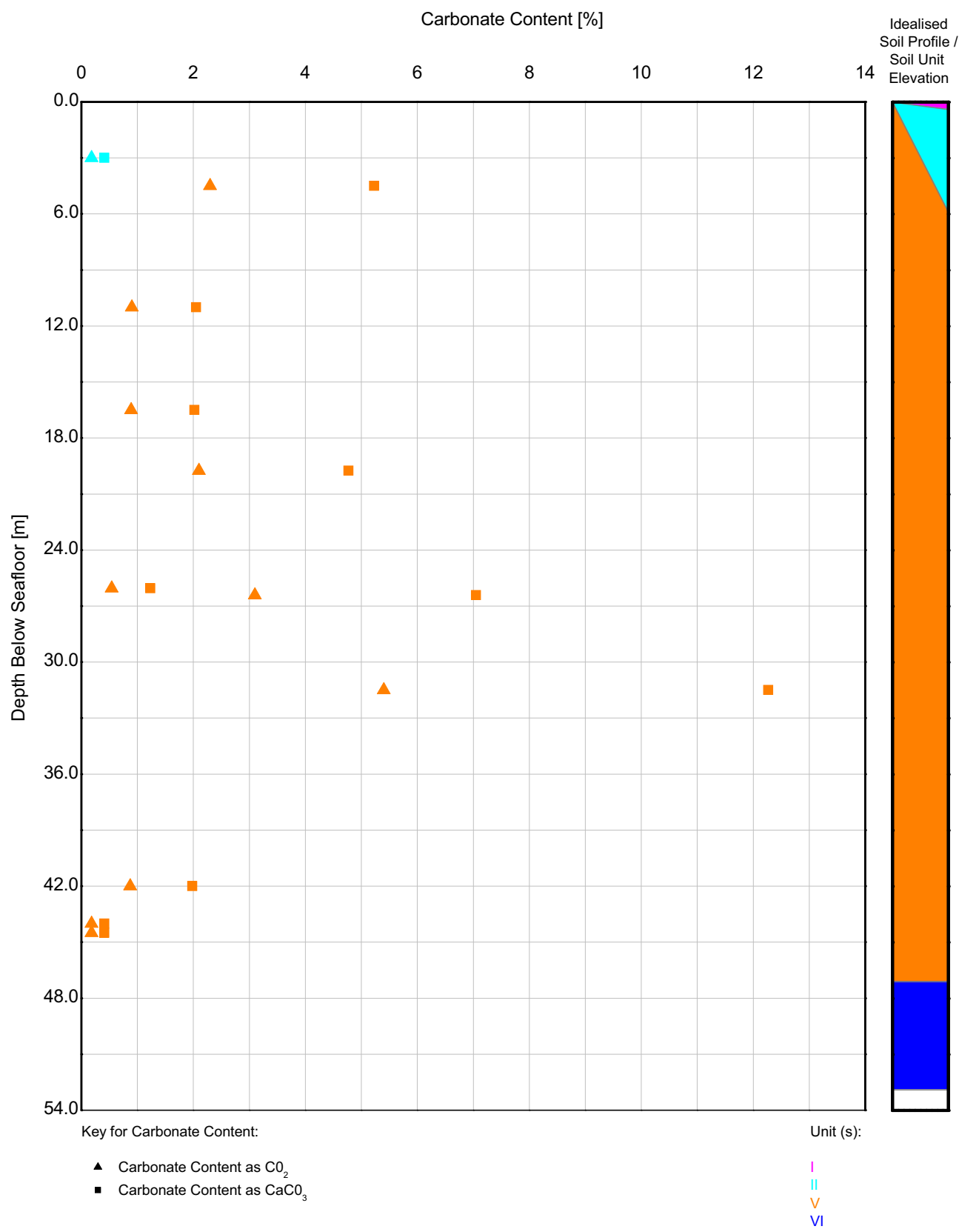
CARBONATE CONTENT versus DEPTH
SOIL PROVINCE iii
Rampion Geotechnical Site Investigation 2011



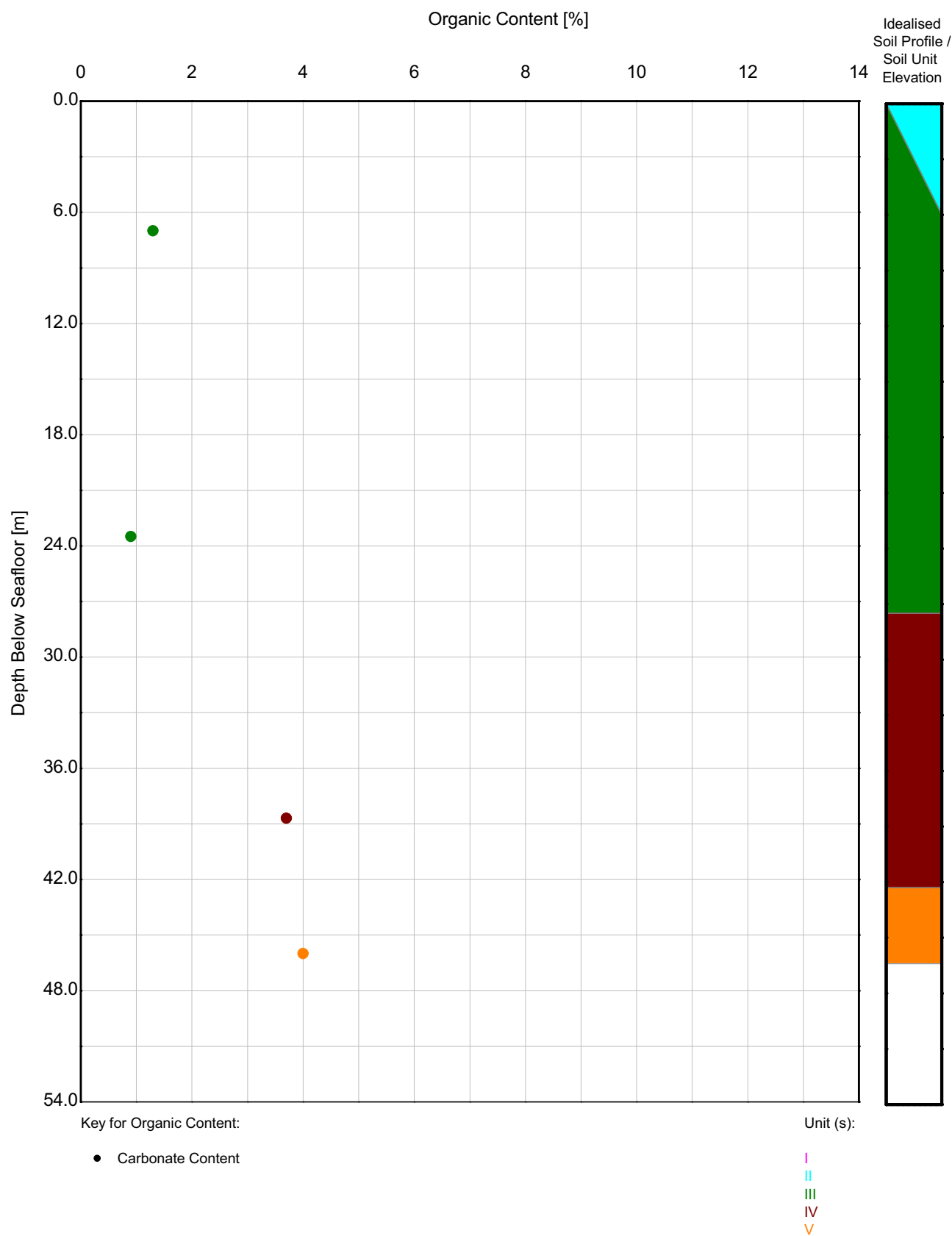
CARBONATE CONTENT versus DEPTH
SOIL PROVINCE IV
Rampion Geotechnical Site Investigation 2011



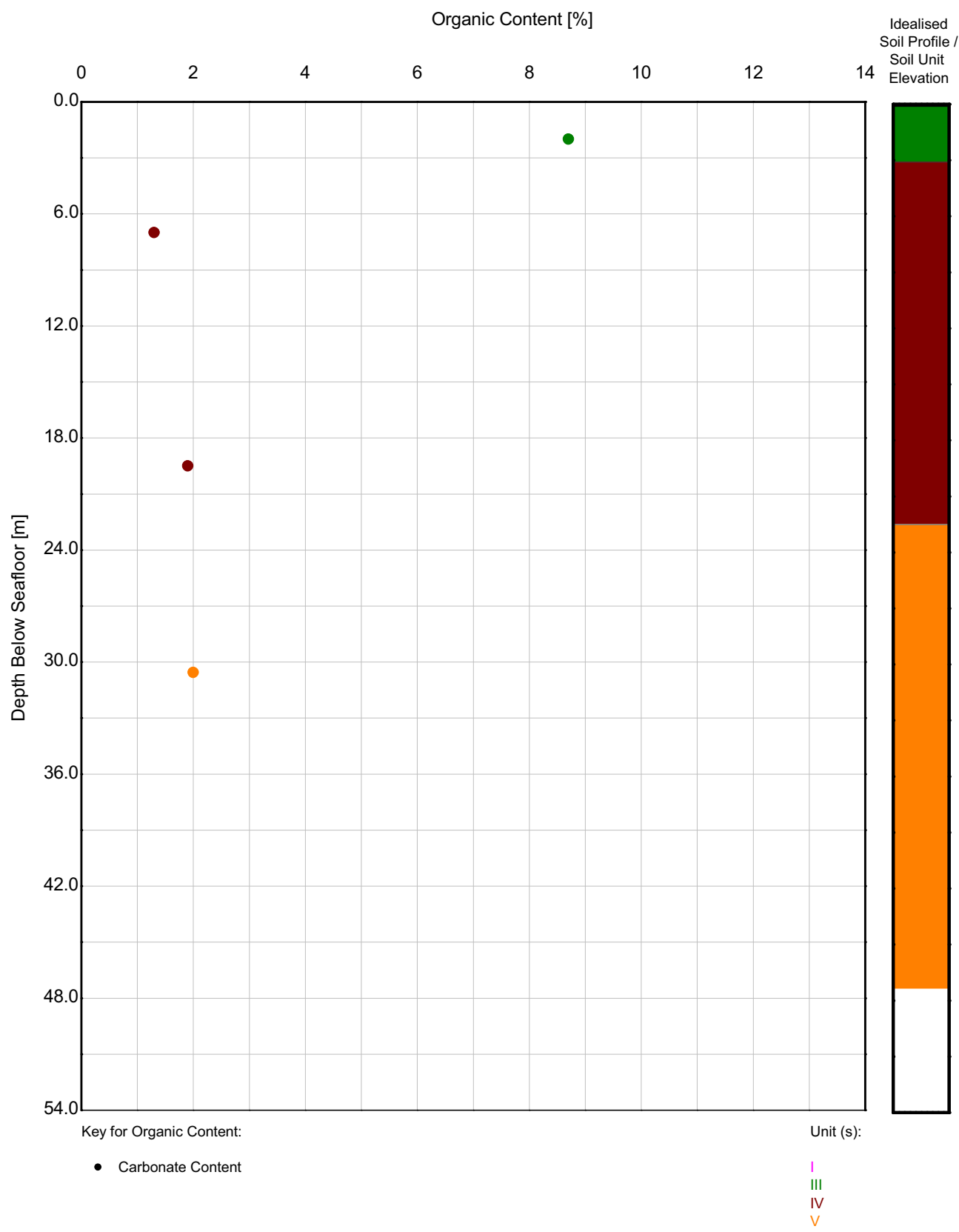
CARBONATE CONTENT versus DEPTH
SOIL PROVINCE V
Rampion Geotechnical Site Investigation 2011



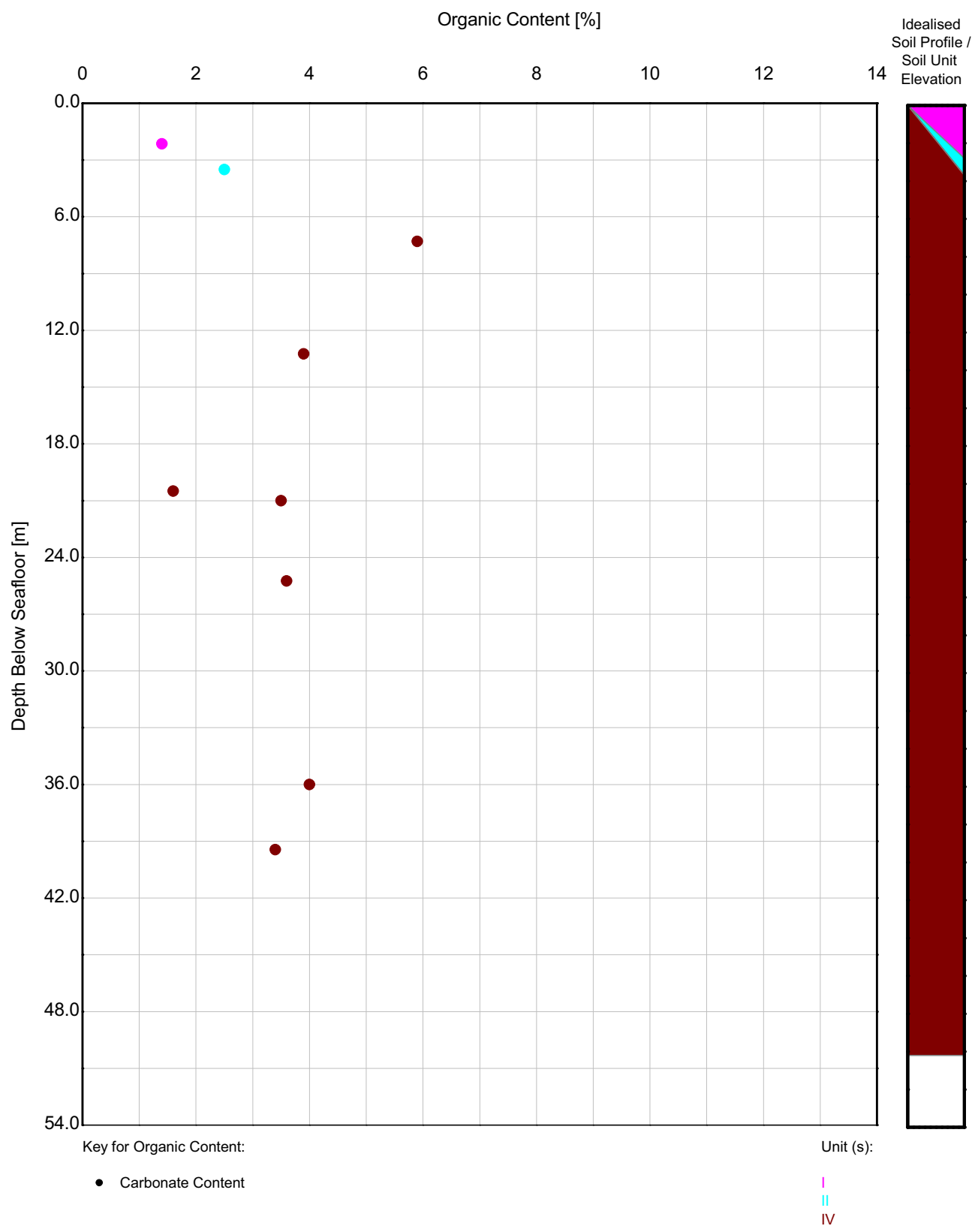
CARBONATE CONTENT versus DEPTH
SOIL PROVINCE VI
Rampion Geotechnical Site Investigation 2011



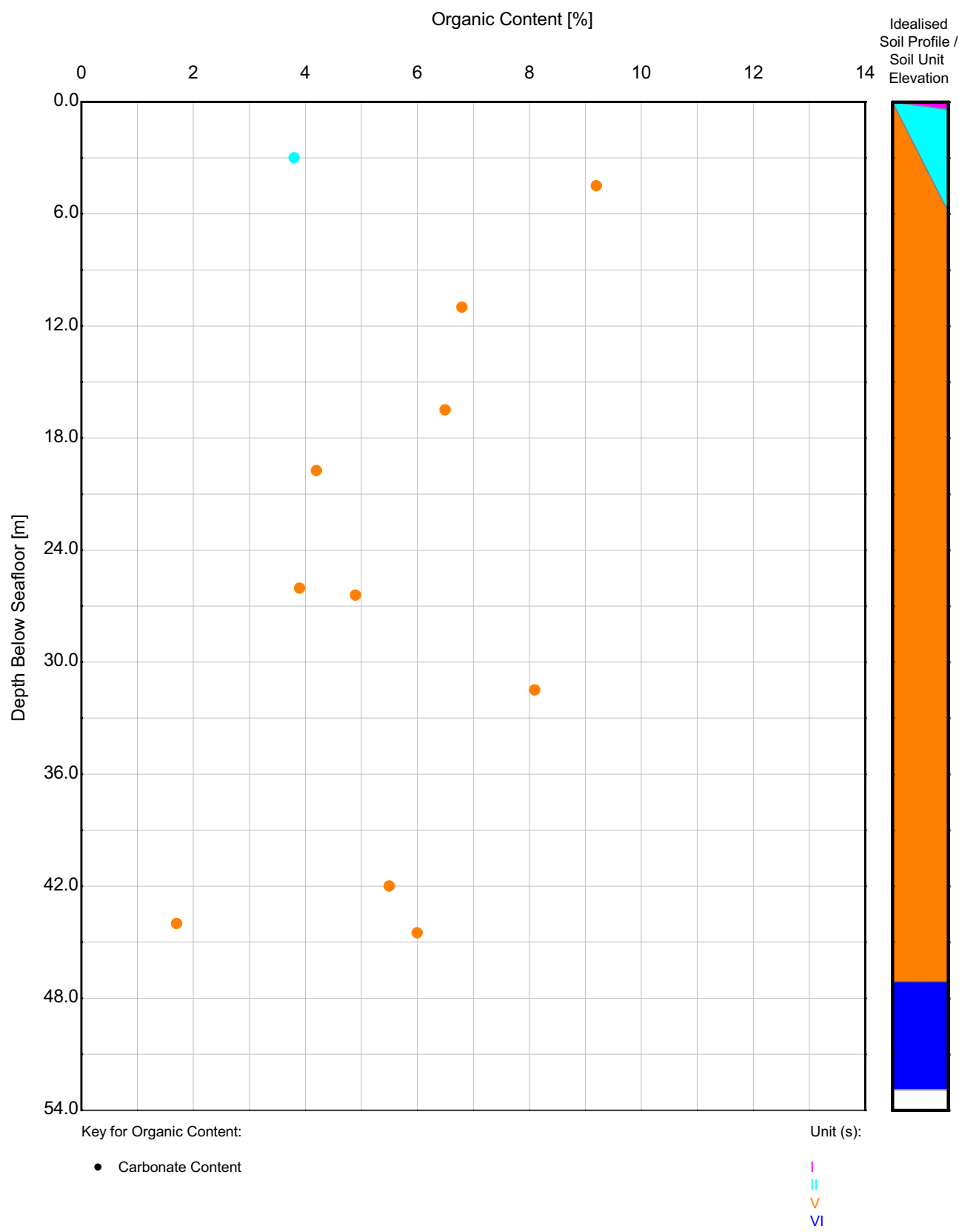
ORGANIC CONTENT versus DEPTH
SOIL PROVINCE I
Rampion Geotechnical Site Investigation 2011



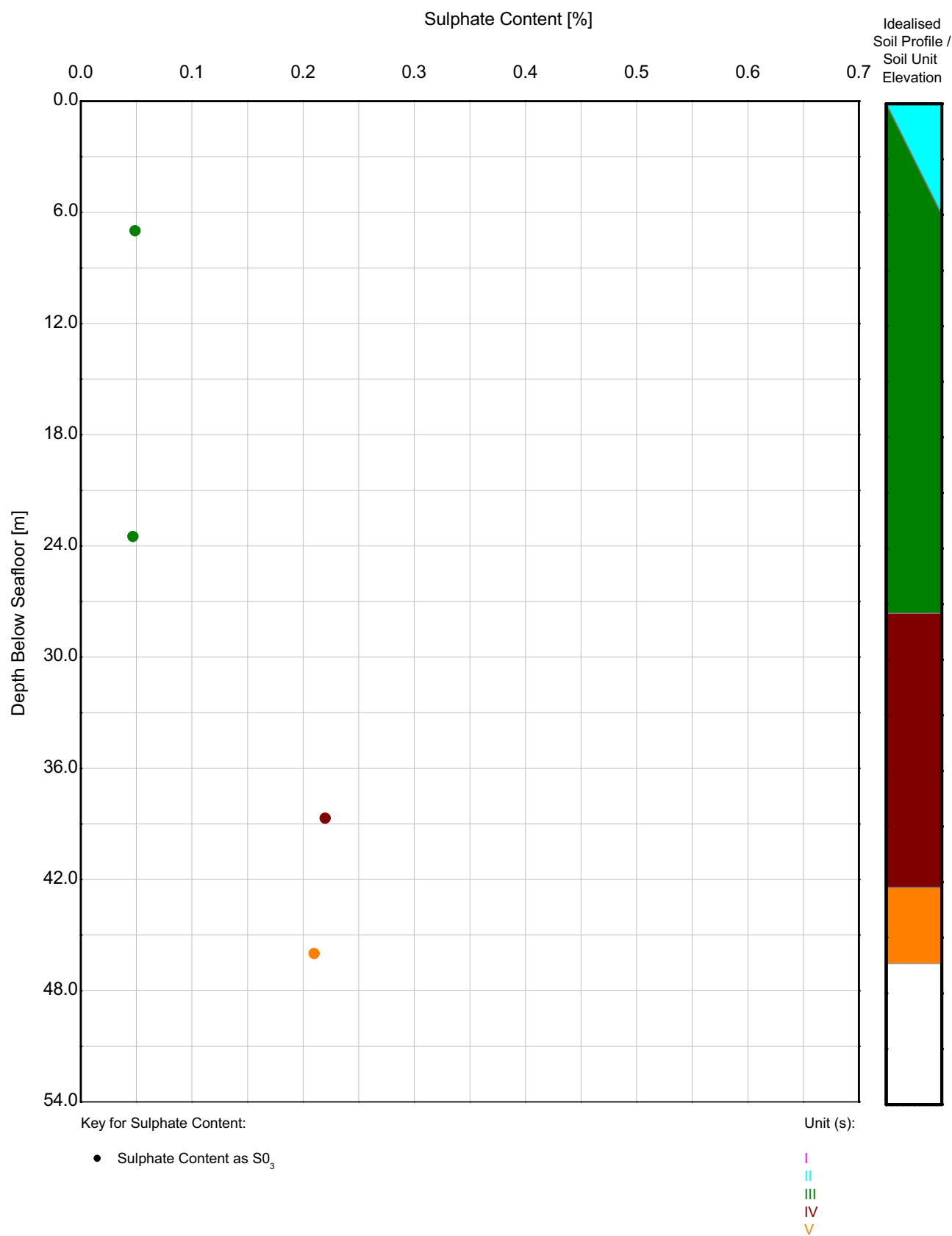
ORGANIC CONTENT versus DEPTH
SOIL PROVINCE IV
Rampion Geotechnical Site Investigation 2011



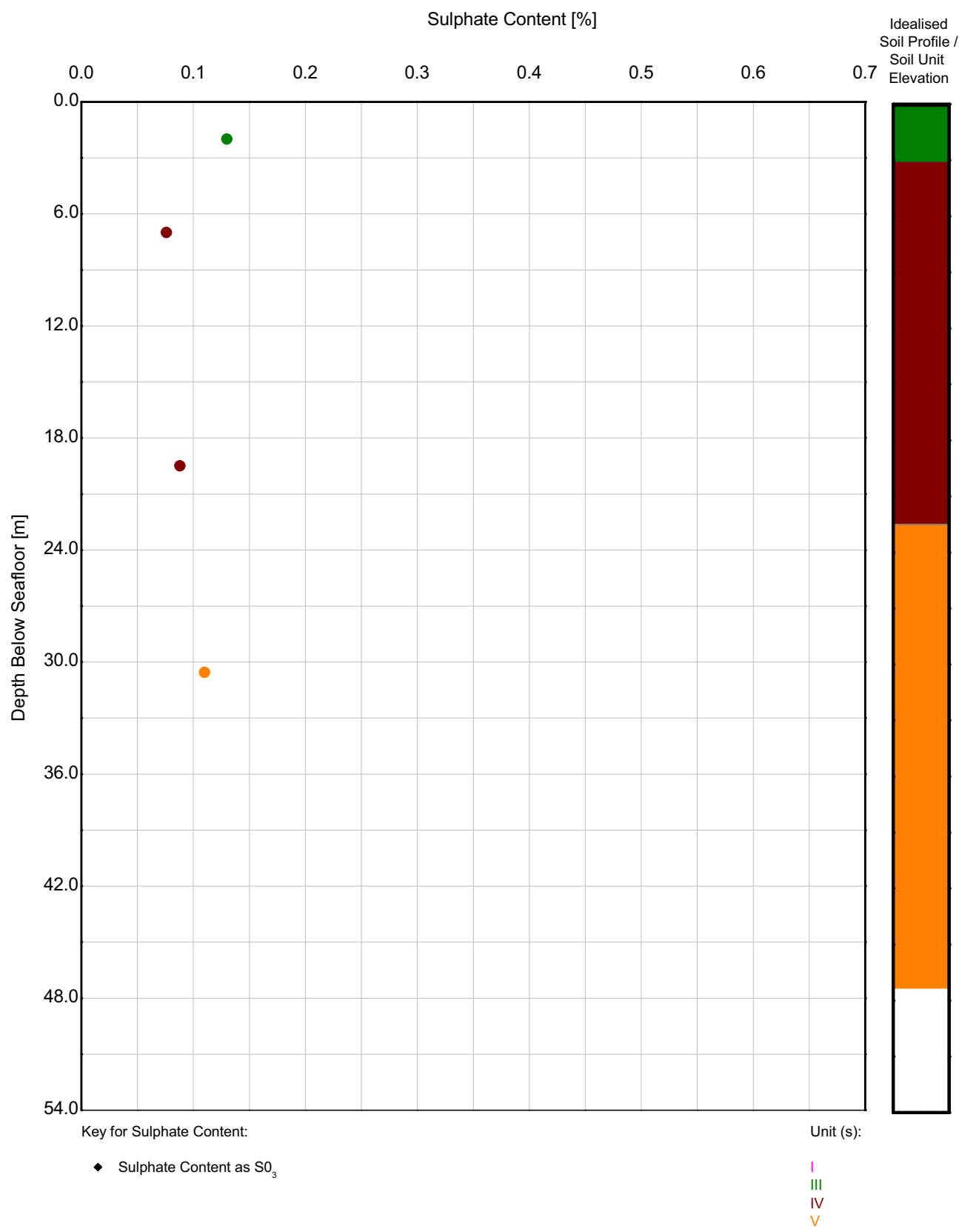
ORGANIC CONTENT versus DEPTH
SOIL PROVINCE V
Rampion Geotechnical Site Investigation 2011



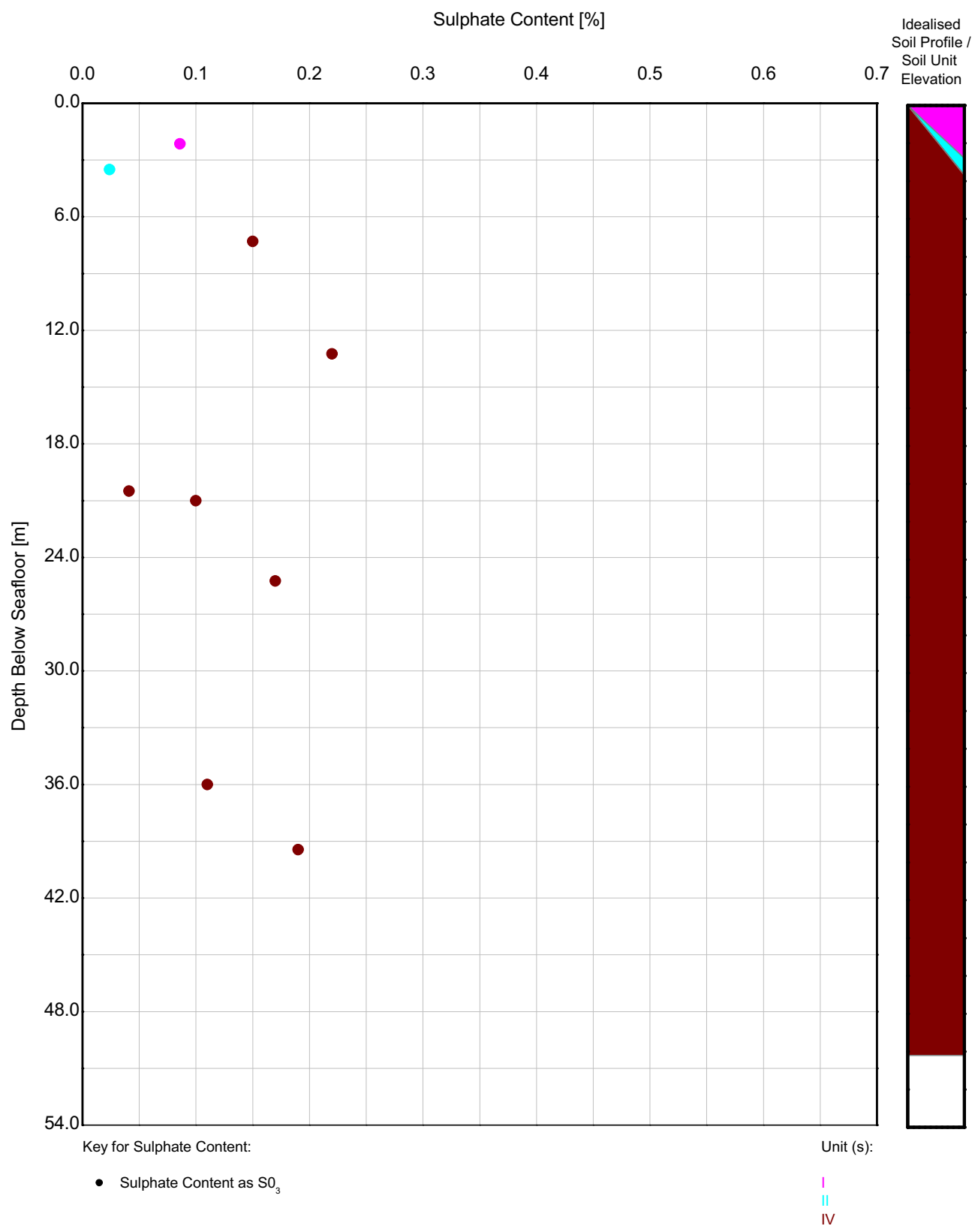
ORGANIC CONTENT versus DEPTH
SOIL PROVINCE VI
Rampion Geotechnical Site Investigation 2011



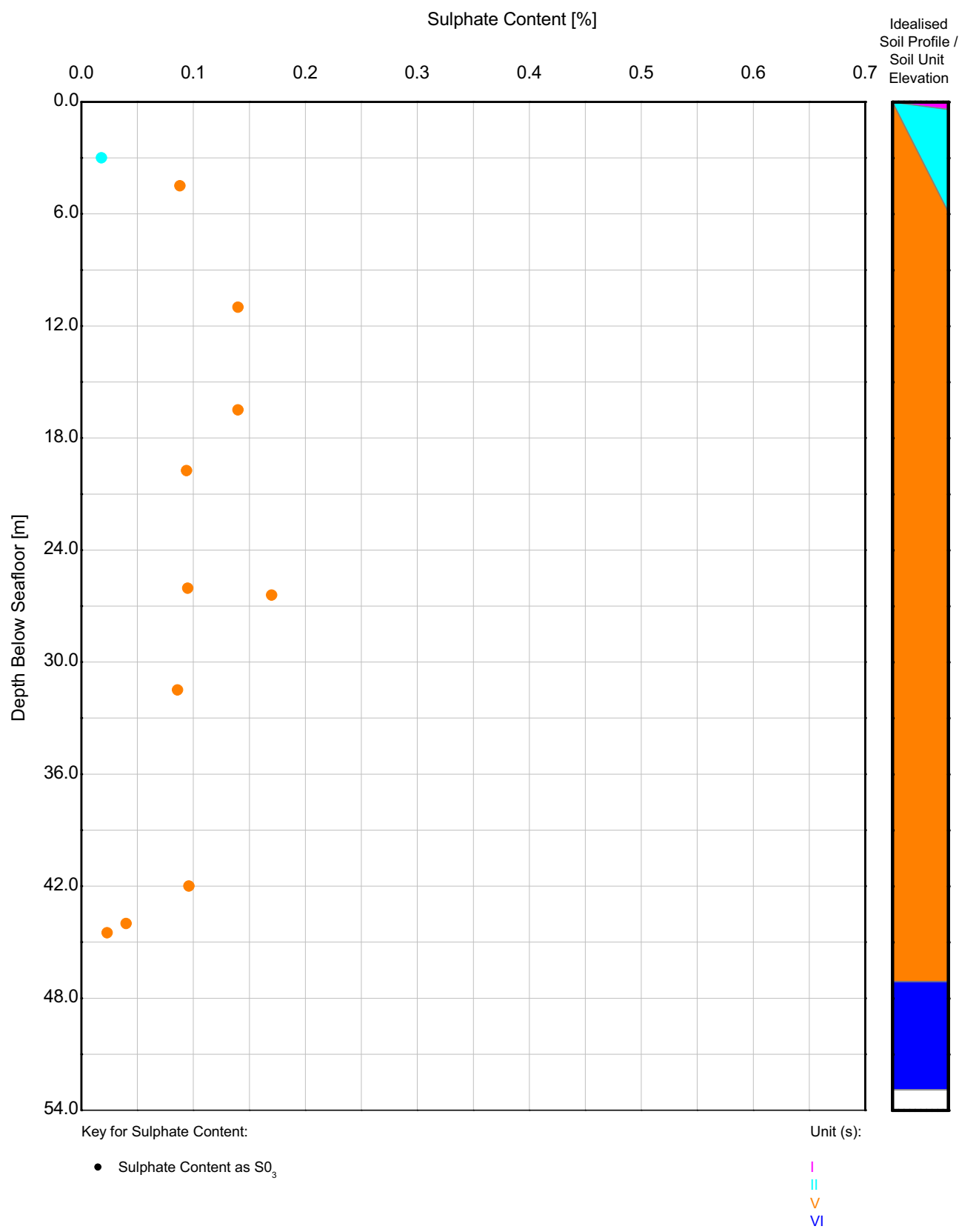
TOTAL SULPHATE CONTENT versus DEPTH
SOIL PROVINCE I
Rampion Geotechnical Site Investigation 2011



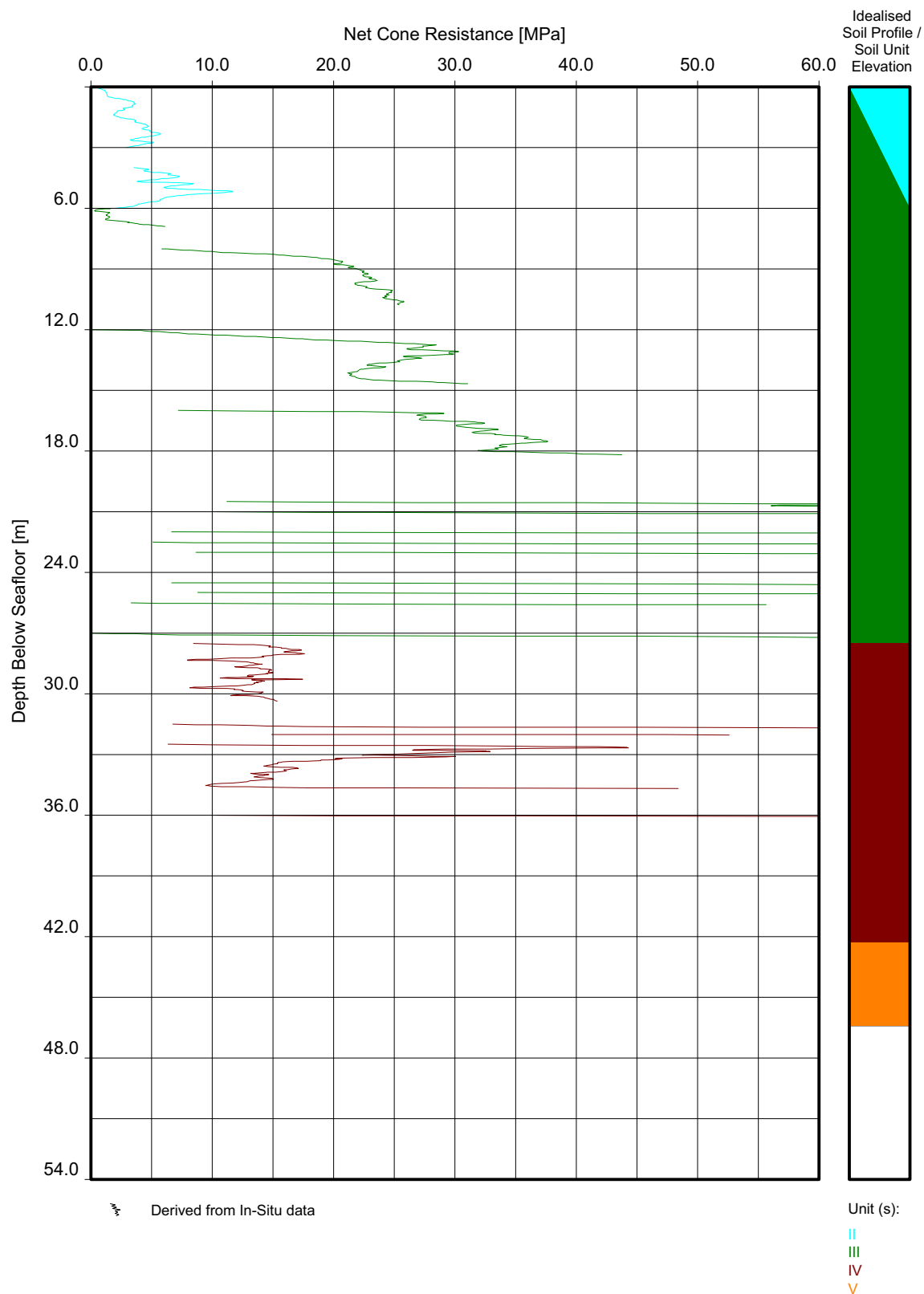
TOTAL SULPHATE CONTENT versus DEPTH
SOIL PROVINCE IV
Rampion Geotechnical Site Investigation 2011



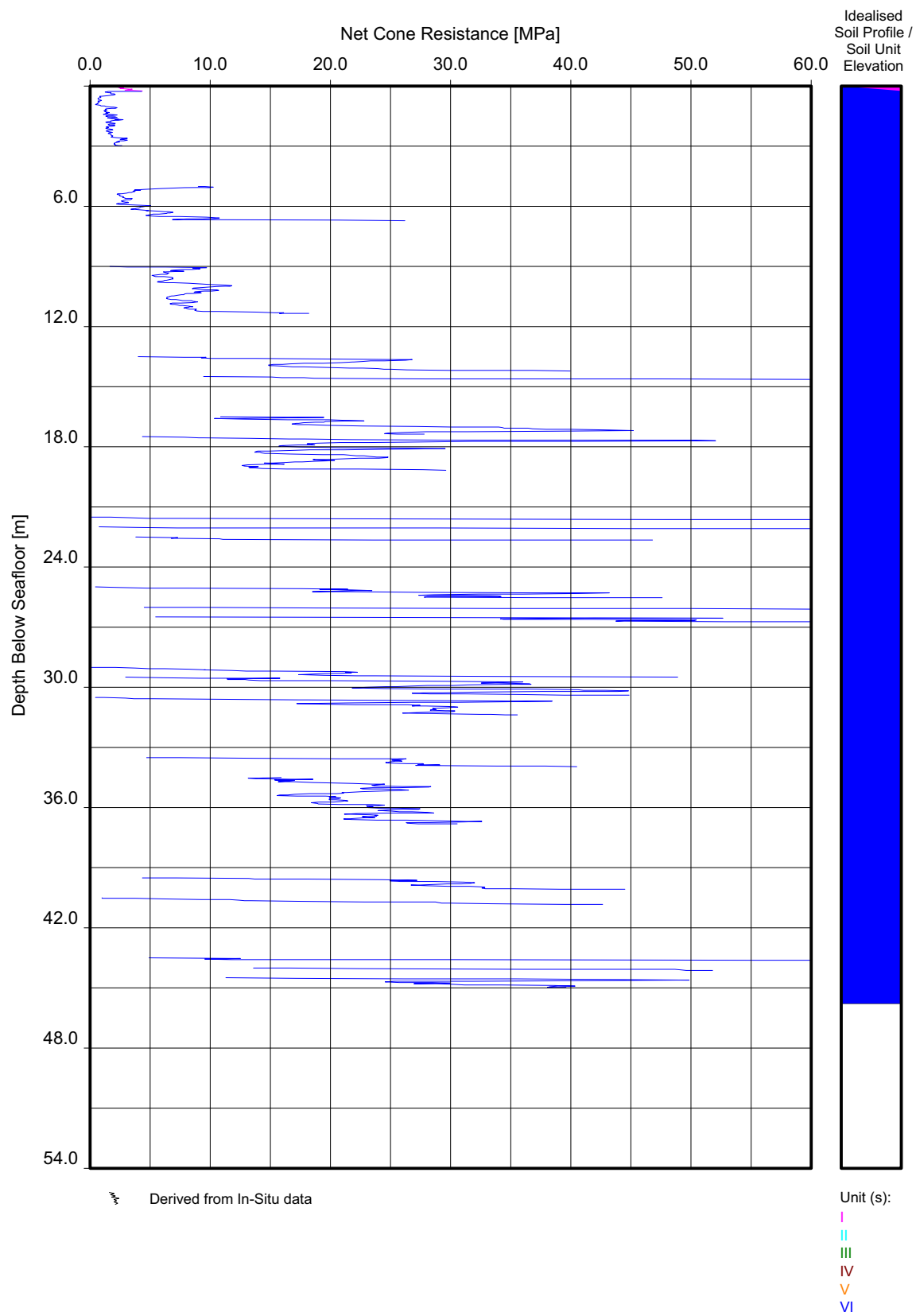
TOTAL SULPHATE CONTENT versus DEPTH
SOIL PROVINCE V
Rampion Geotechnical Site Investigation 2011



TOTAL SULPHATE CONTENT versus DEPTH
SOIL PROVINCE VI
Rampion Geotechnical Site Investigation 2011

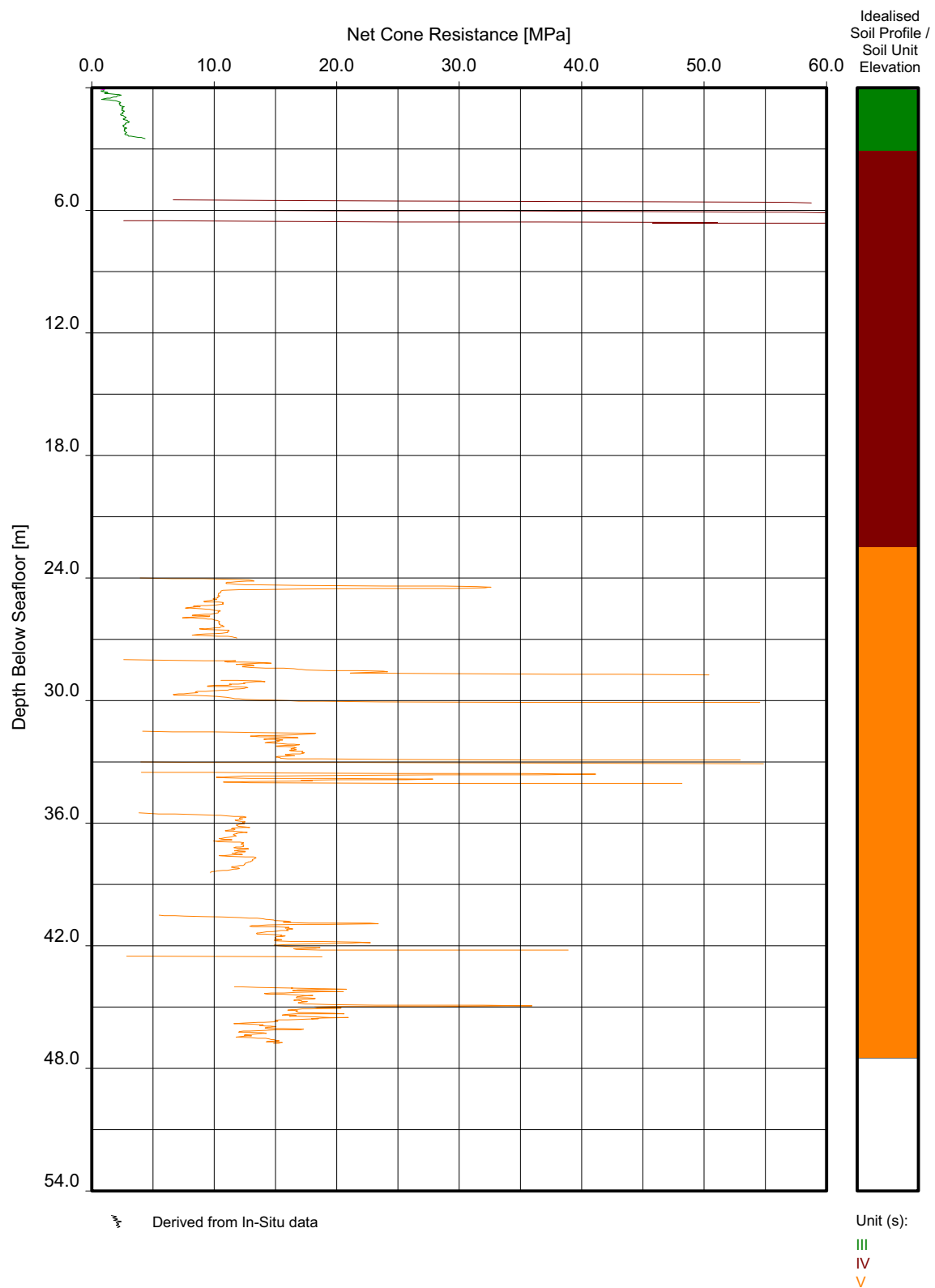


NET CONE RESISTANCE VERSUS DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation

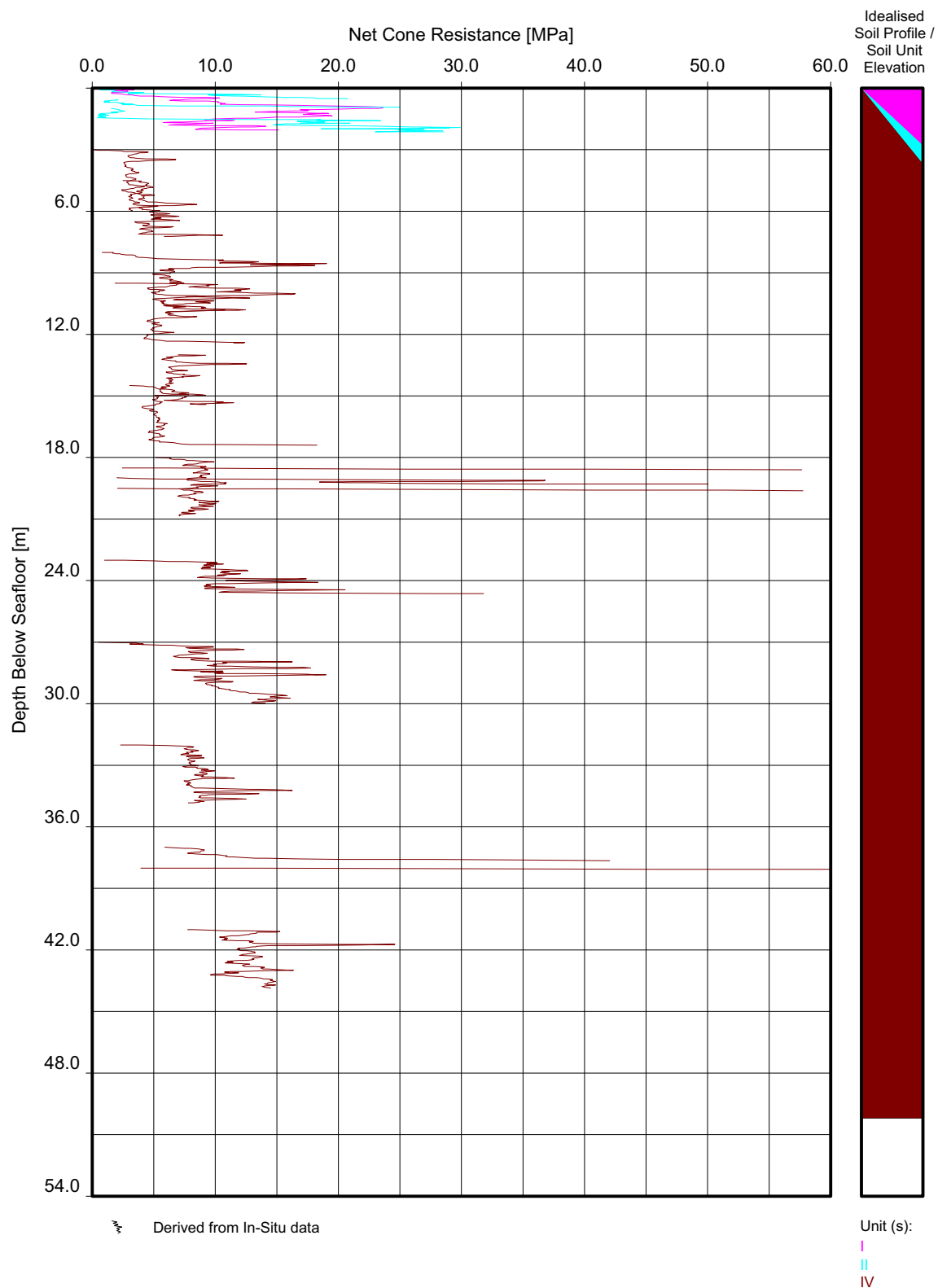


NET CONE RESISTANCE VERSUS DEPTH
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation

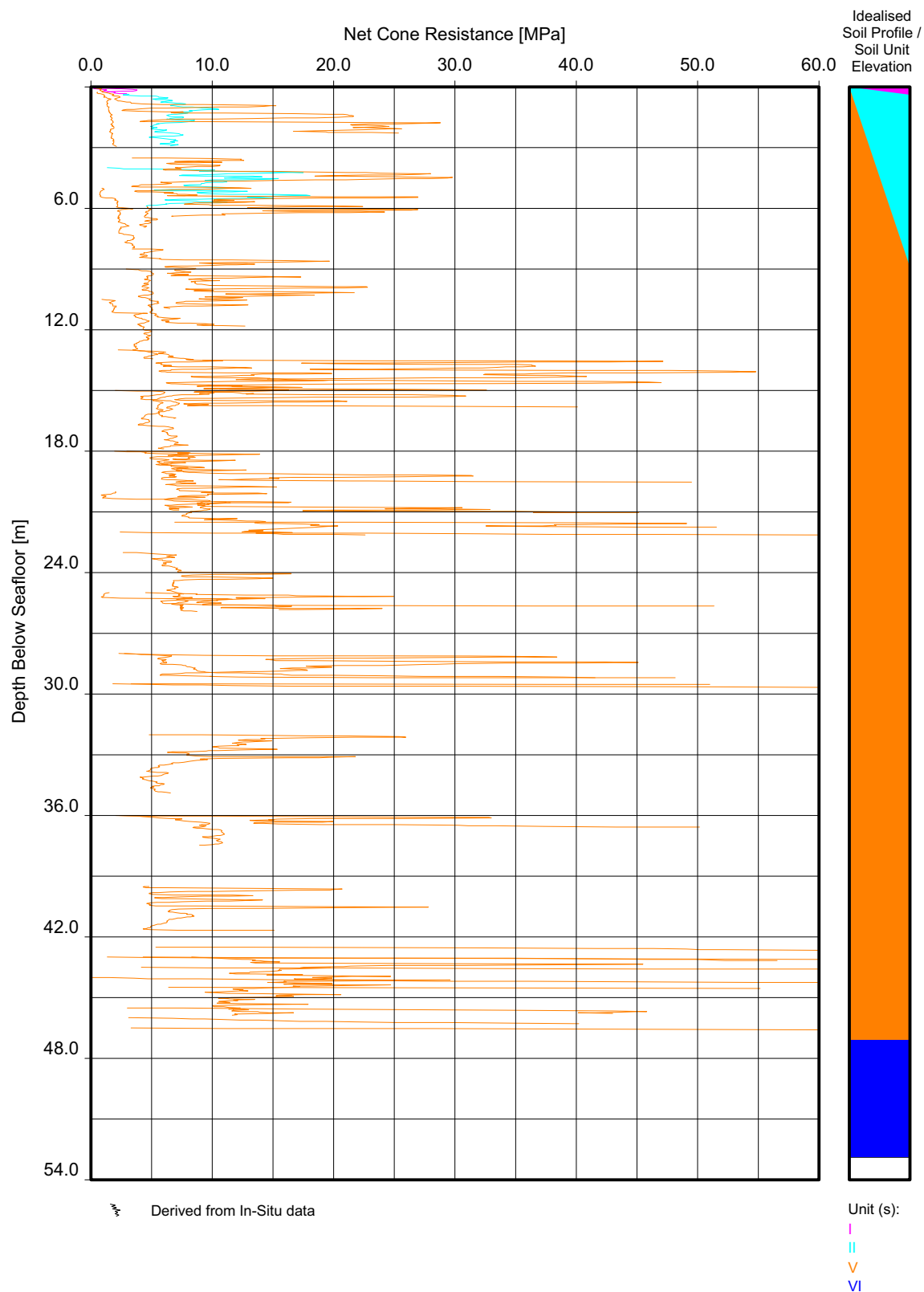
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NET CONE RESISTANCE VERSUS DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation

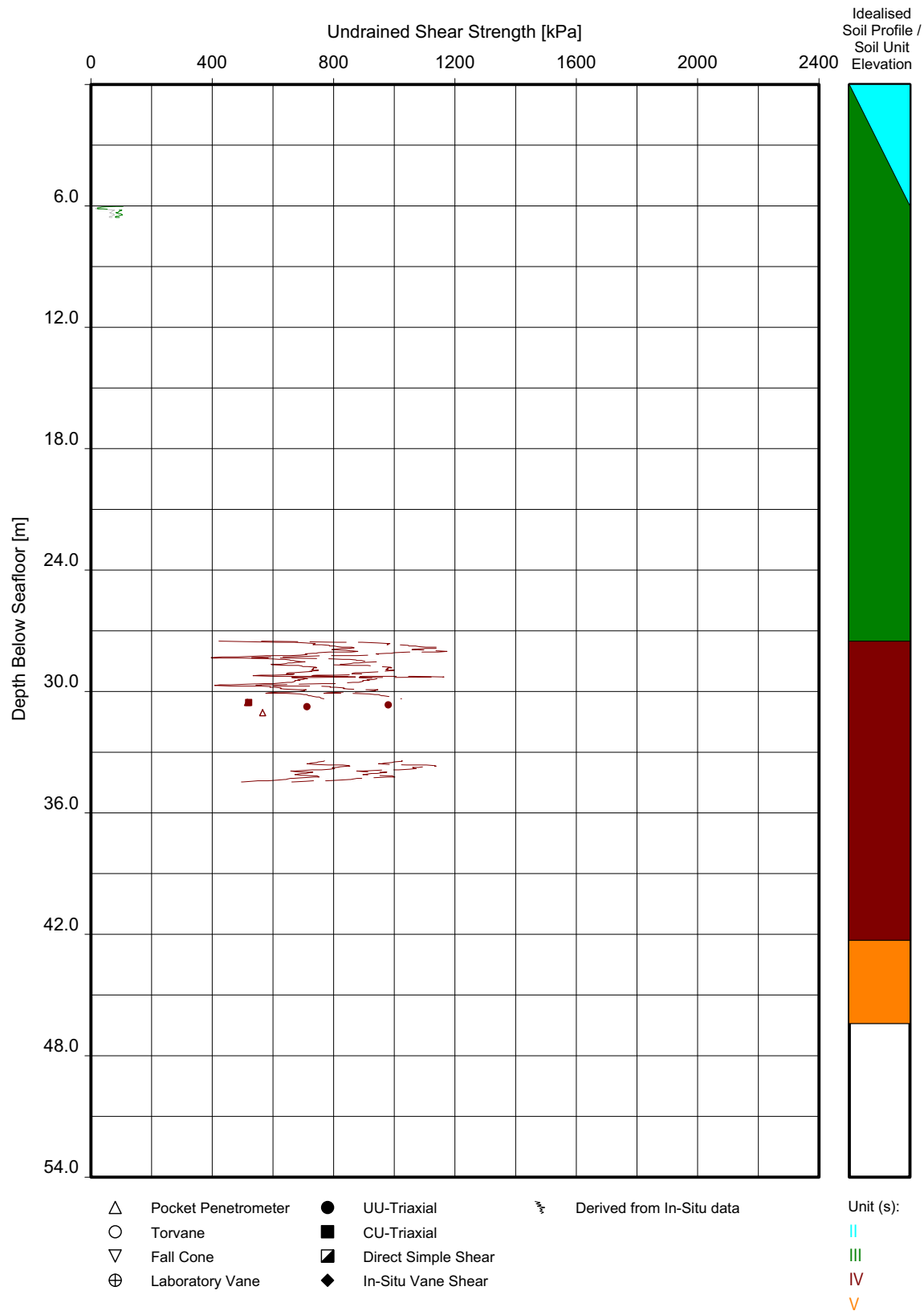


NET CONE RESISTANCE VERSUS DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



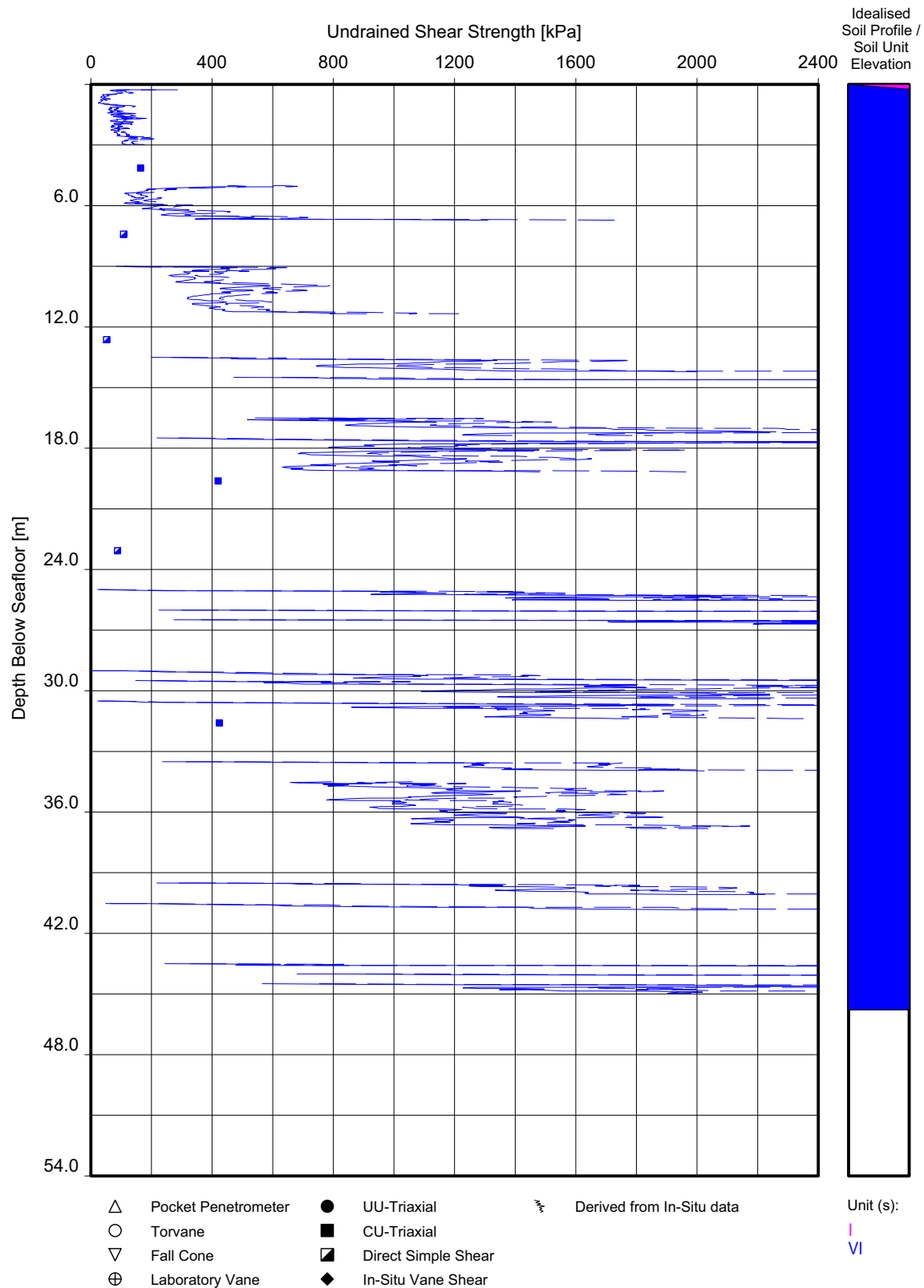
NET CONE RESISTANCE VERSUS DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation

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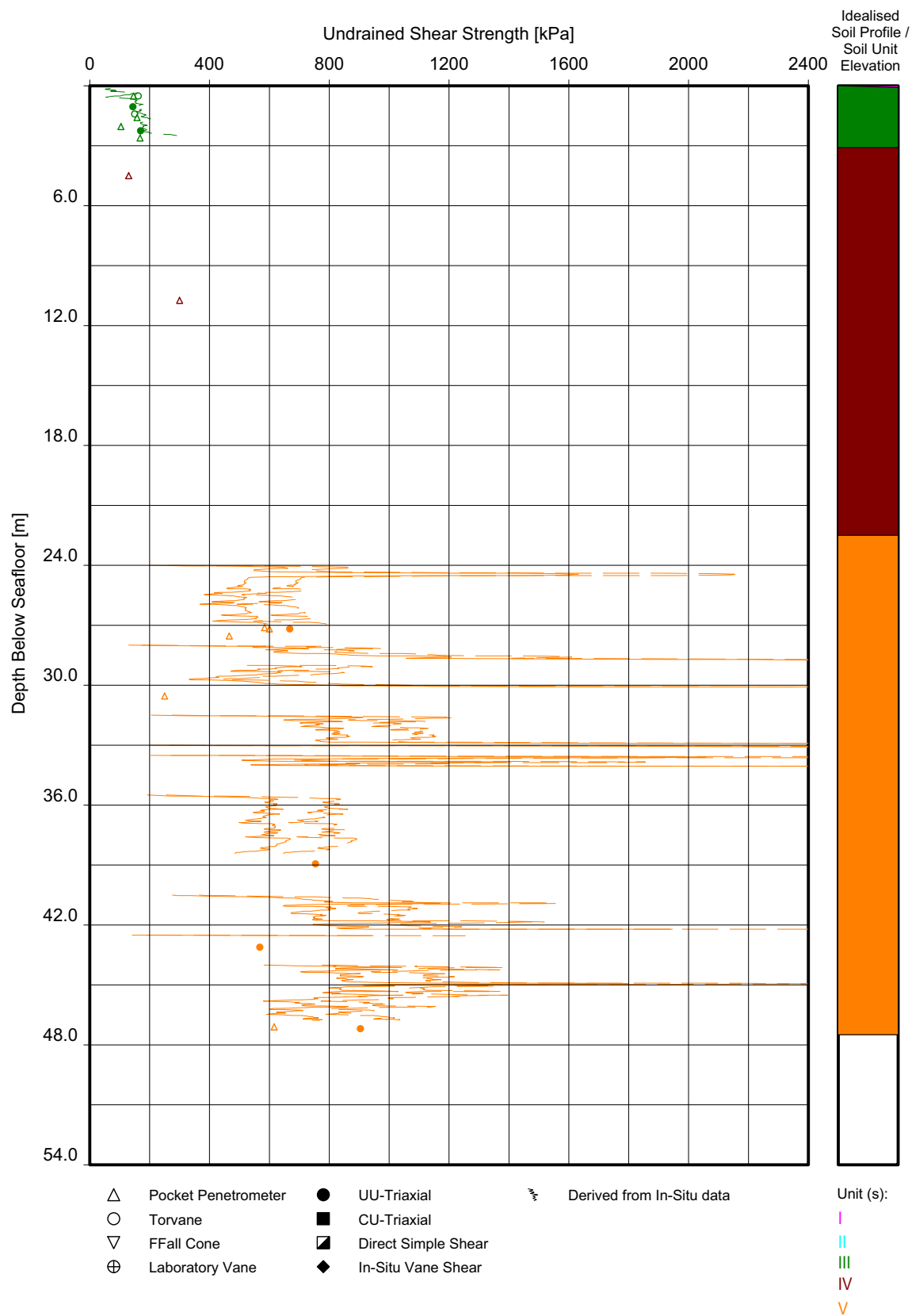
UNDRAINED SHEAR STRENGTH VERSUS DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation

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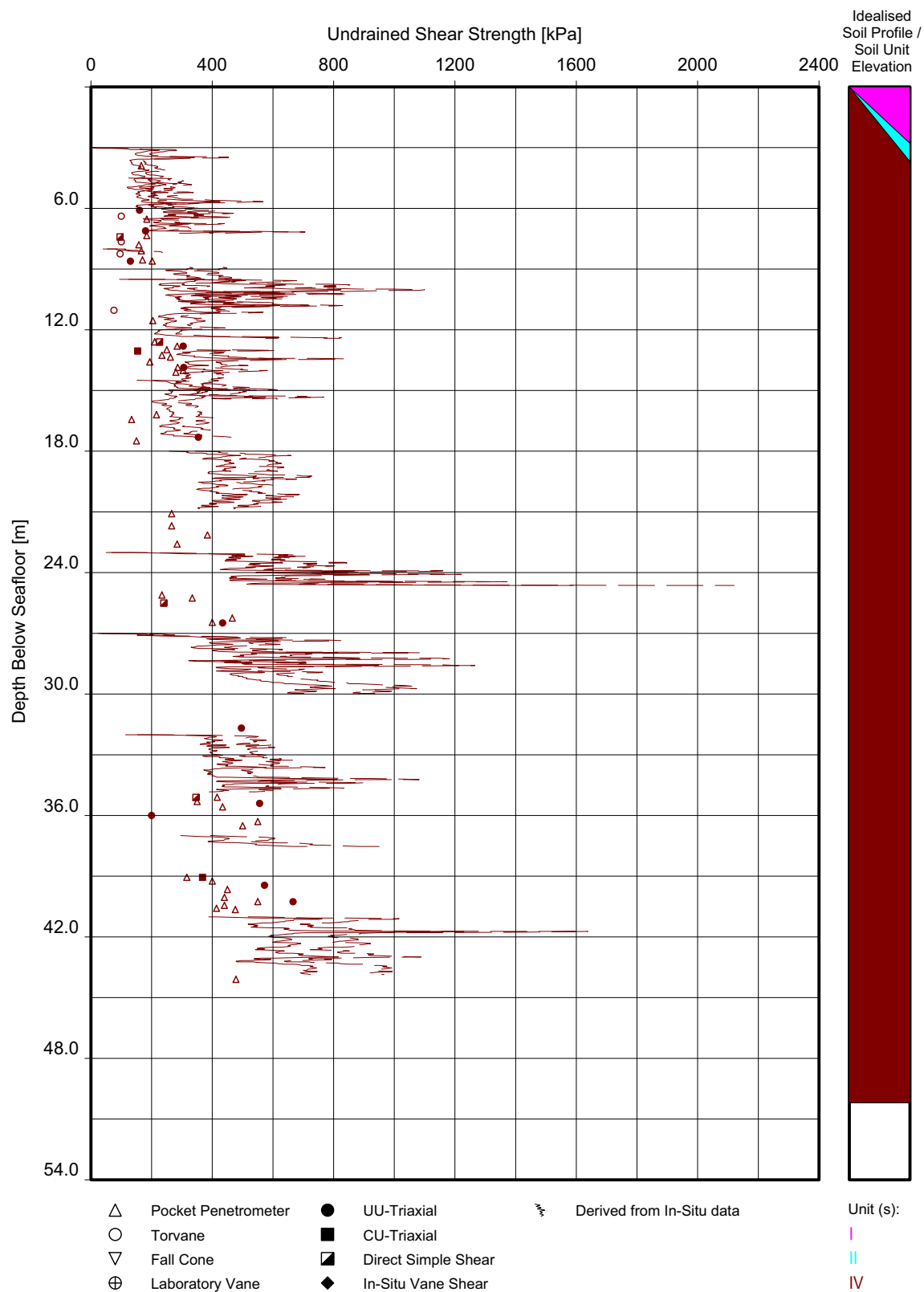
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UNDRAINED SHEAR STRENGTH VERSUS DEPTH
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation



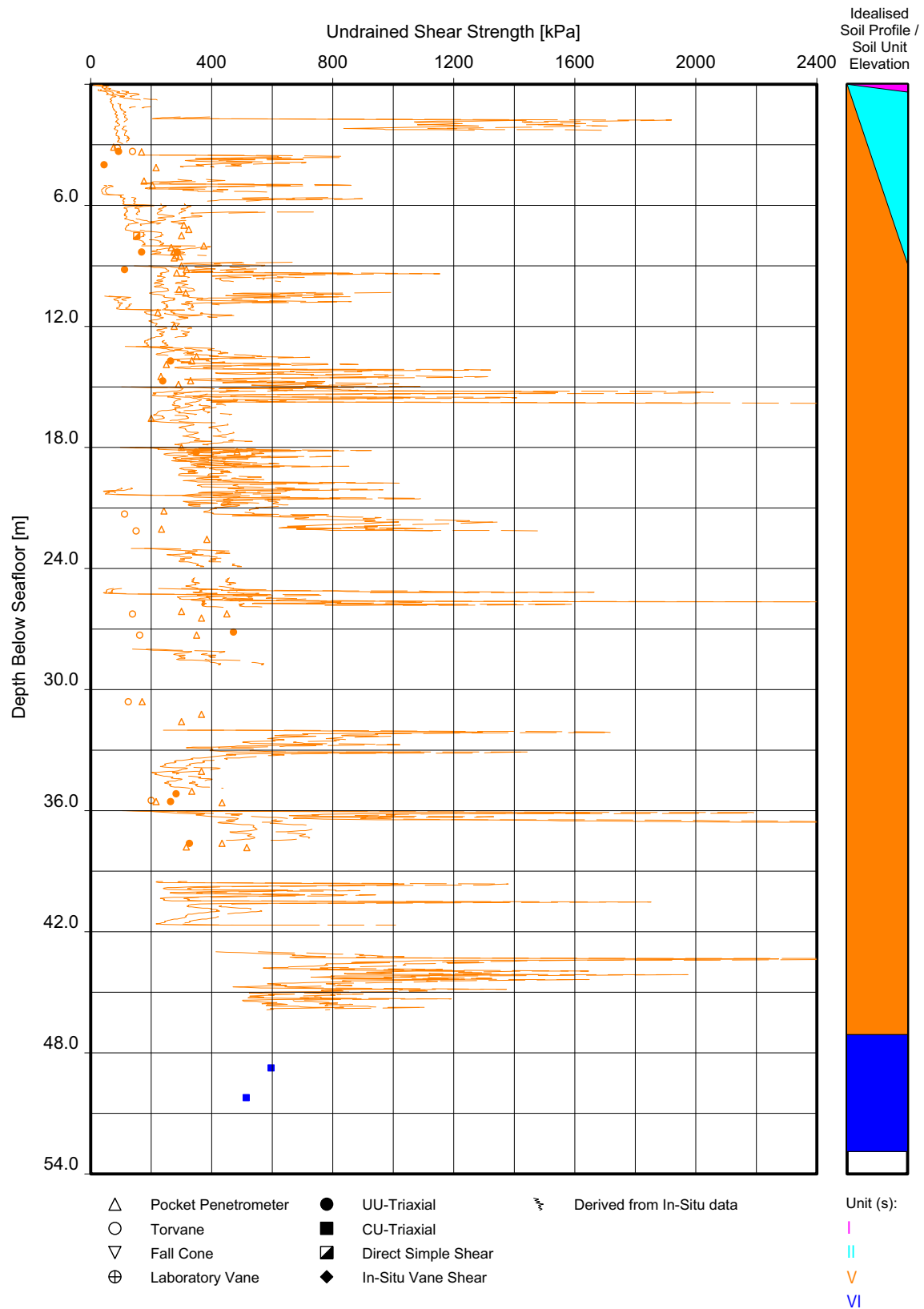
UNDRAINED SHEAR STRENGTH VERSUS DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation

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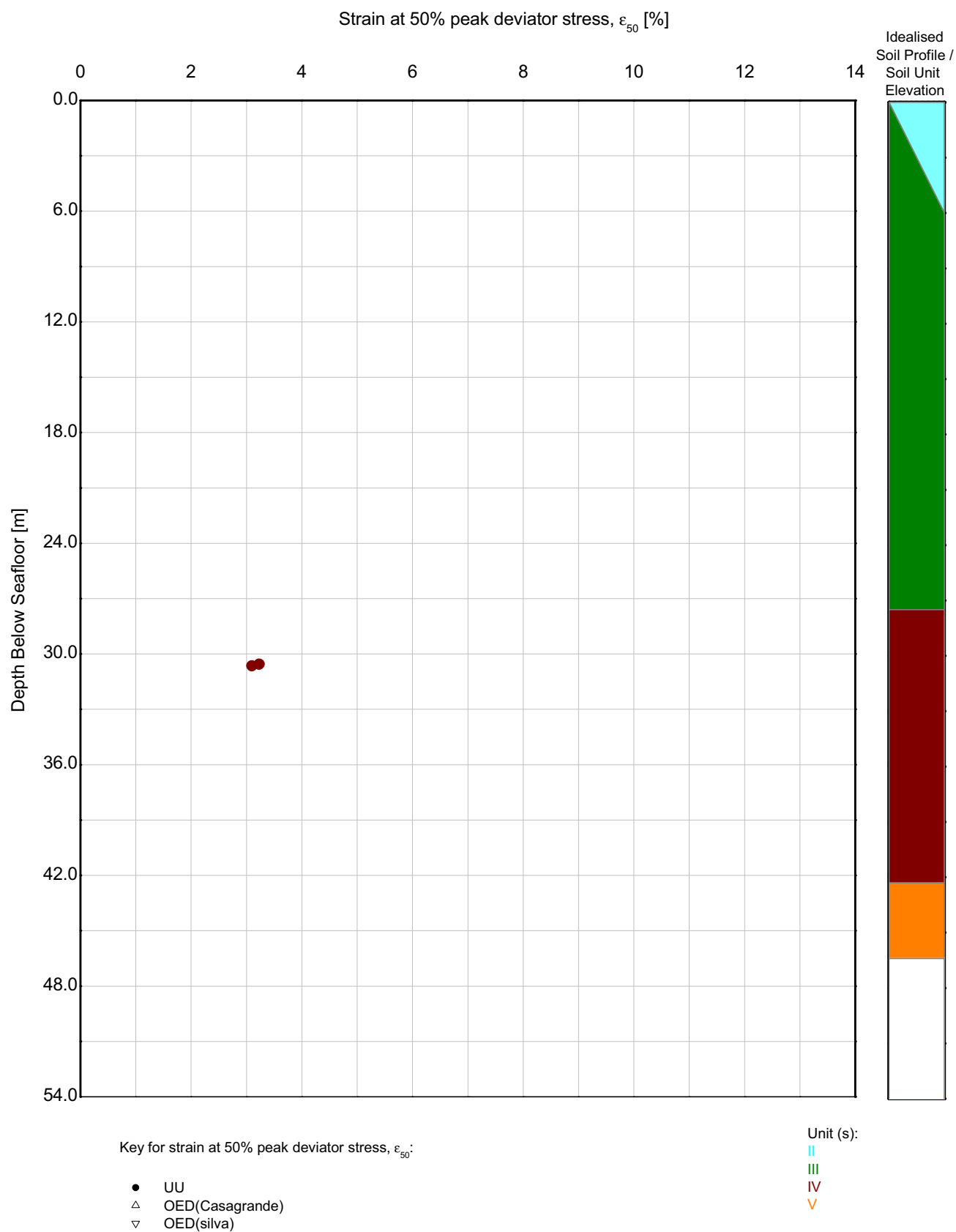


UNDRAINED SHEAR STRENGTH VERSUS DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation

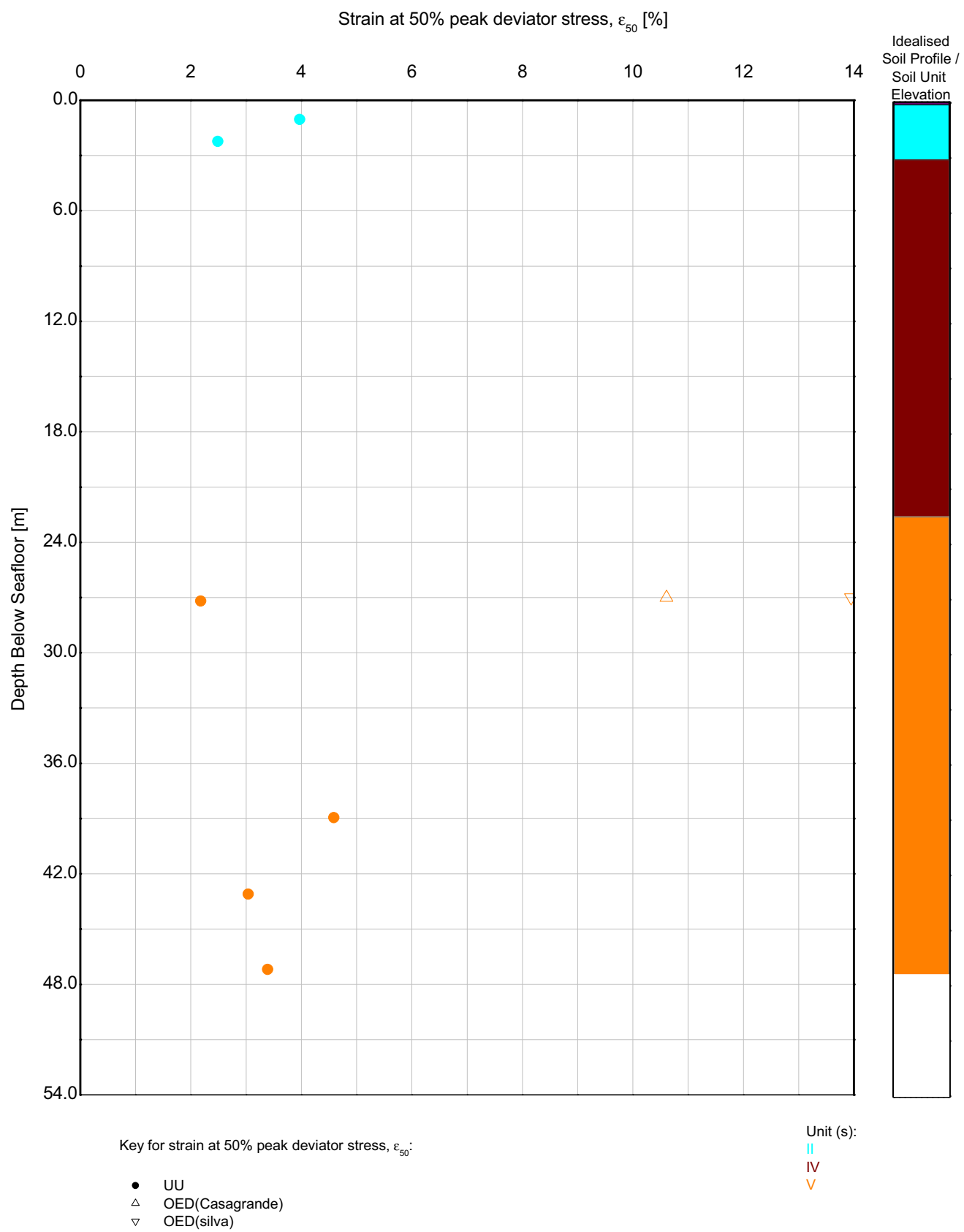
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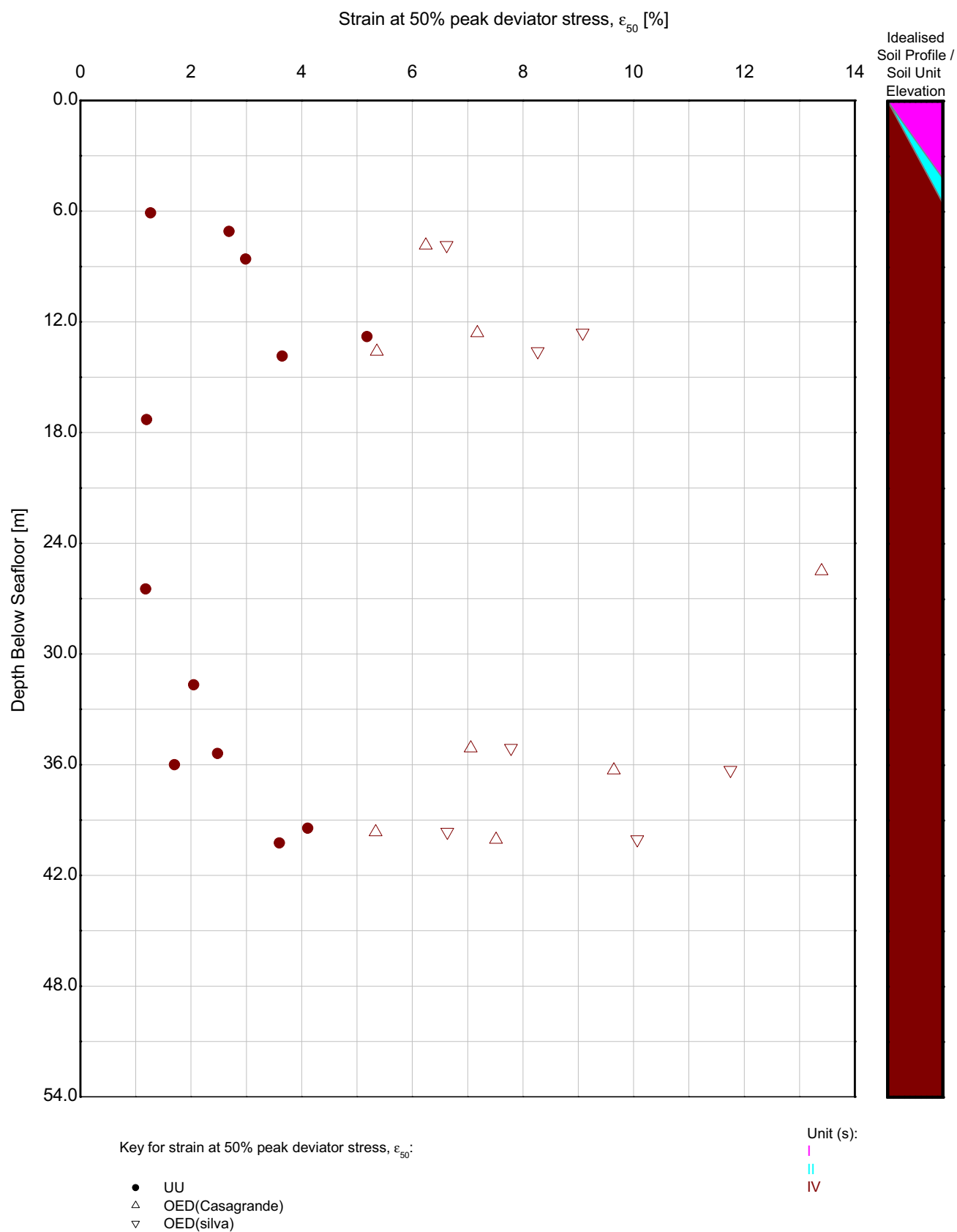
UNDRAINED SHEAR STRENGTH VERSUS DEPTH
 SOIL PROVINCE VI
 Rampion Offshore Wind Farm Site Investigation



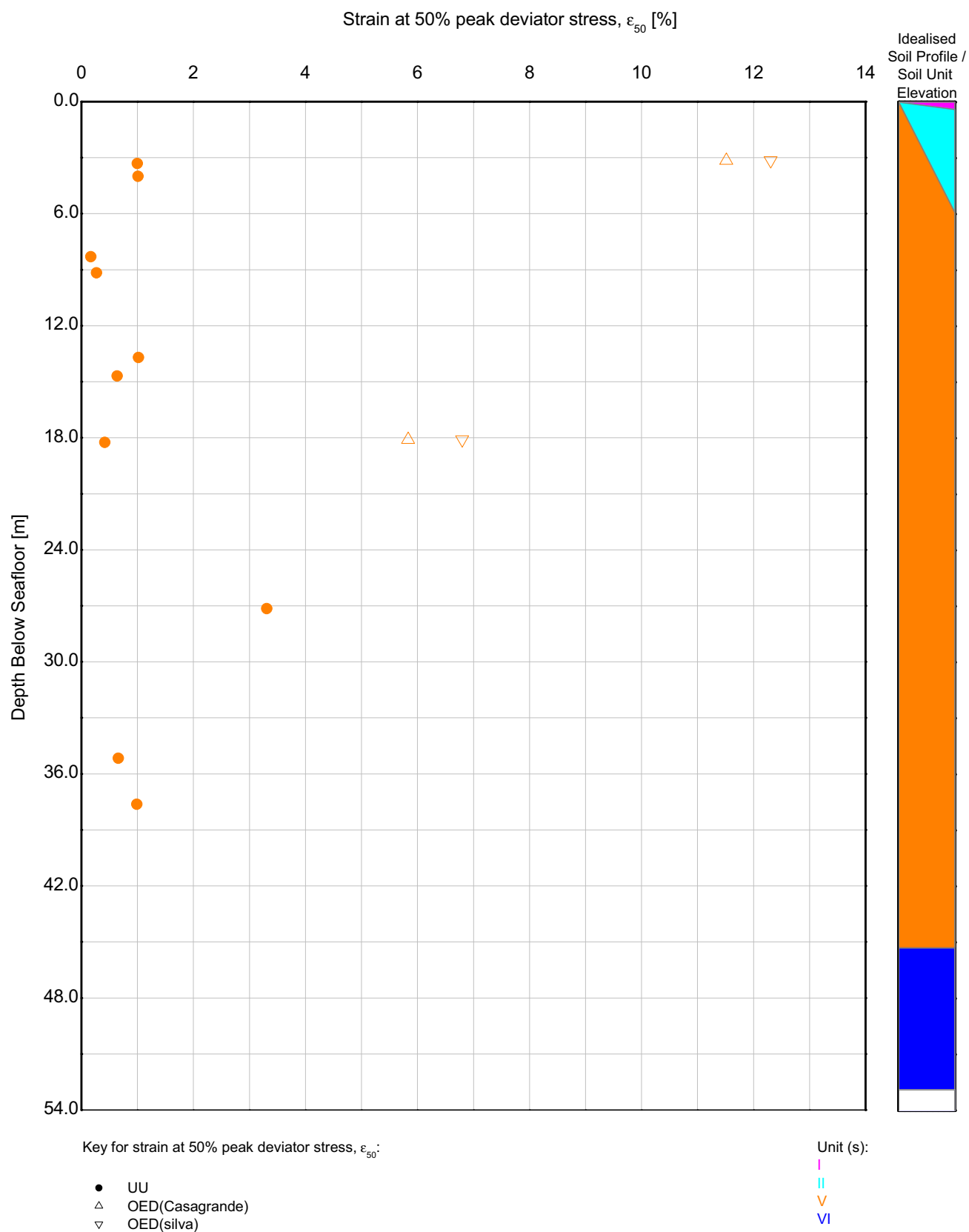
STRAIN AT 50% PEAK DEVIATOR STRESS versus DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



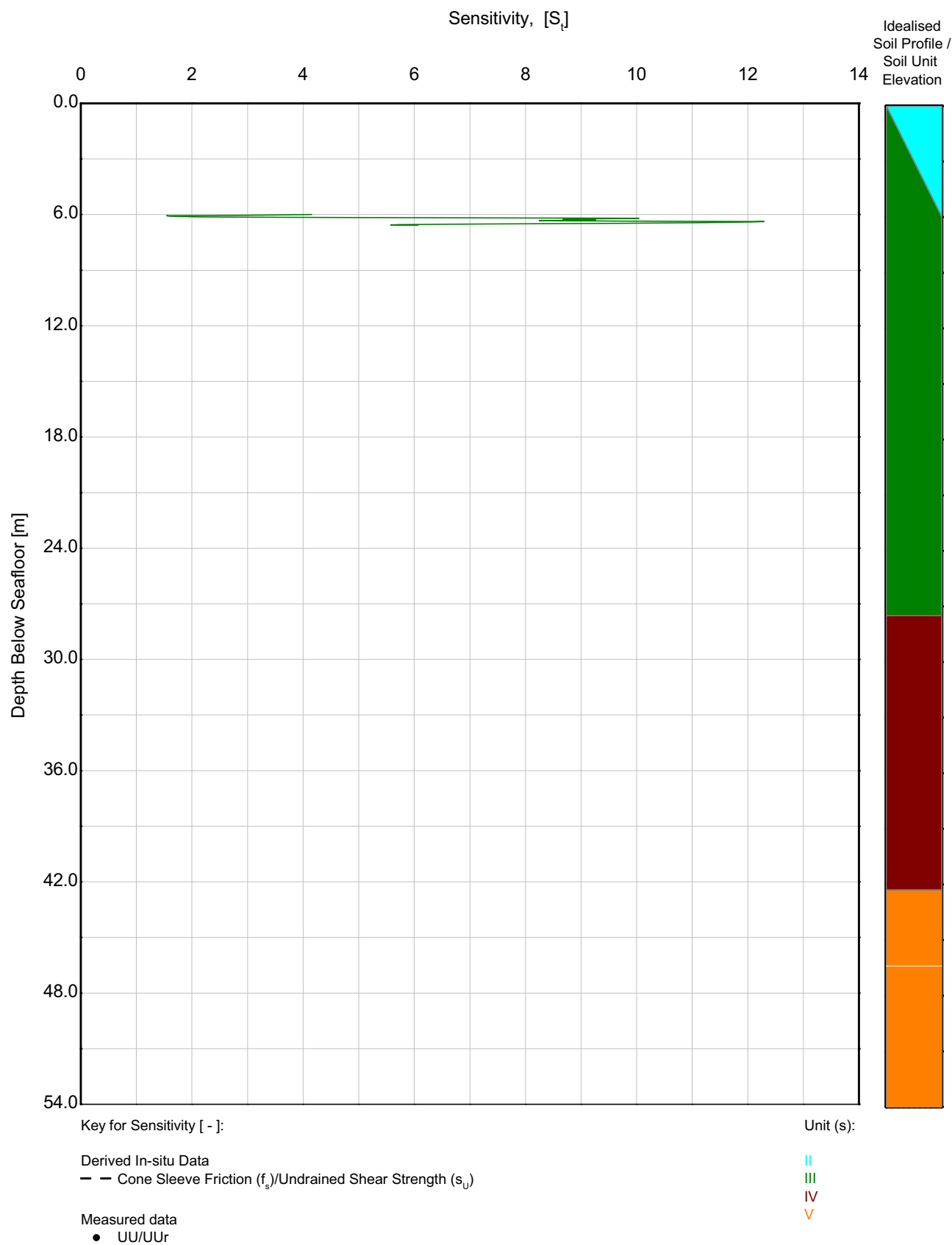
STRAIN AT 50% PEAK DEVIATOR STRESS versus DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation



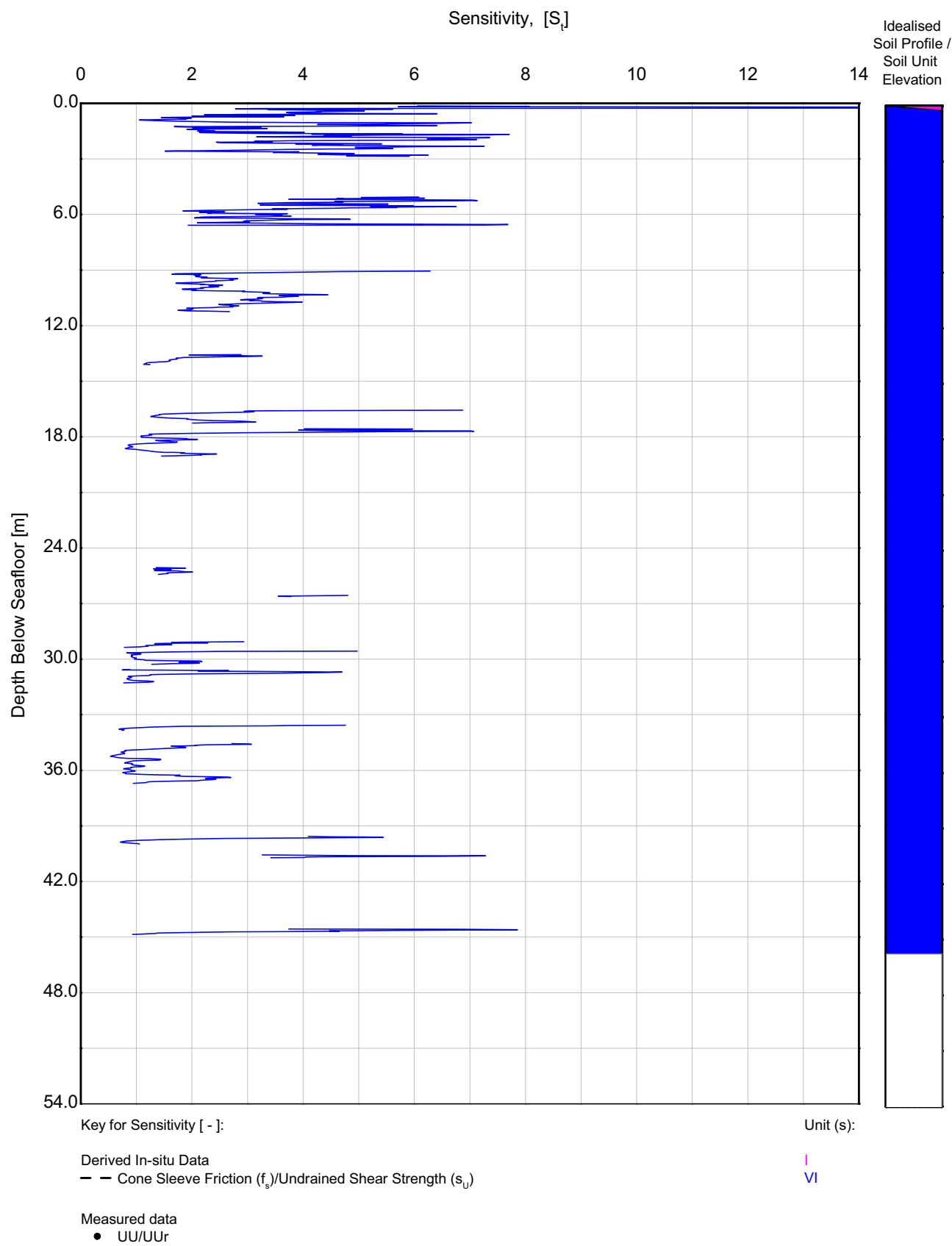
STRAIN AT 50% PEAK DEVIATOR STRESS versus DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



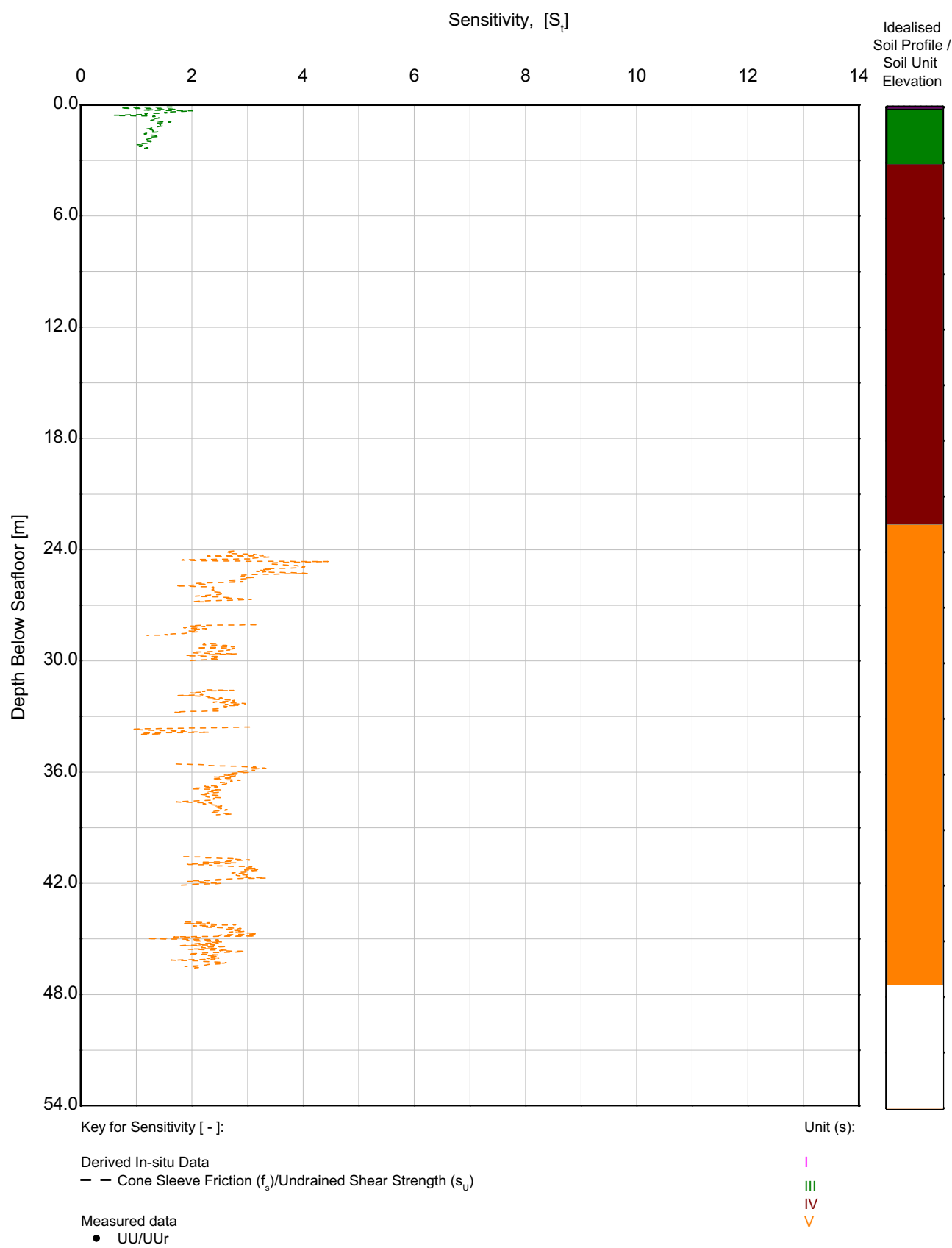
STRAIN AT 50% PEAK DEVIATOR STRESS versus DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation



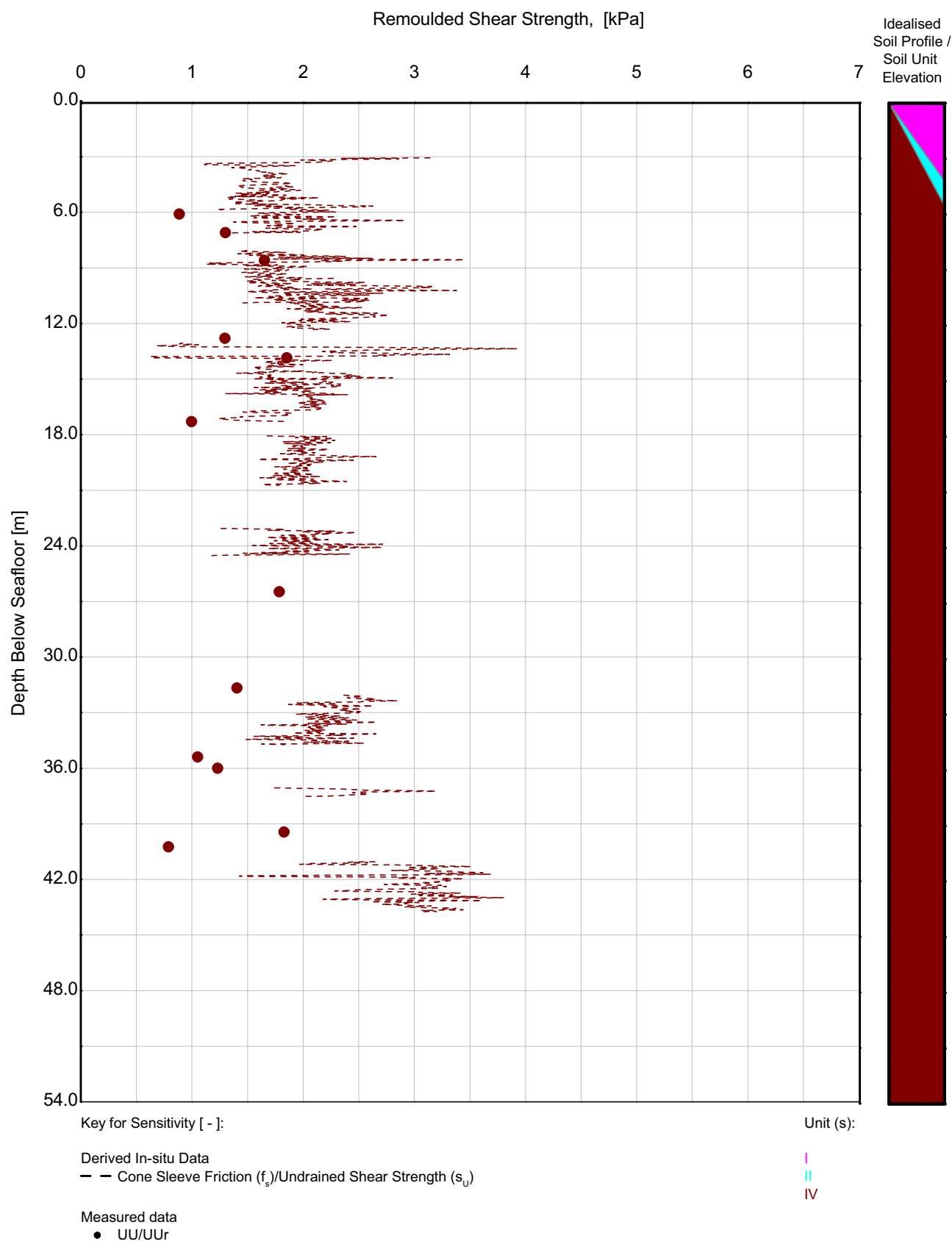
SENSITIVITY versus DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



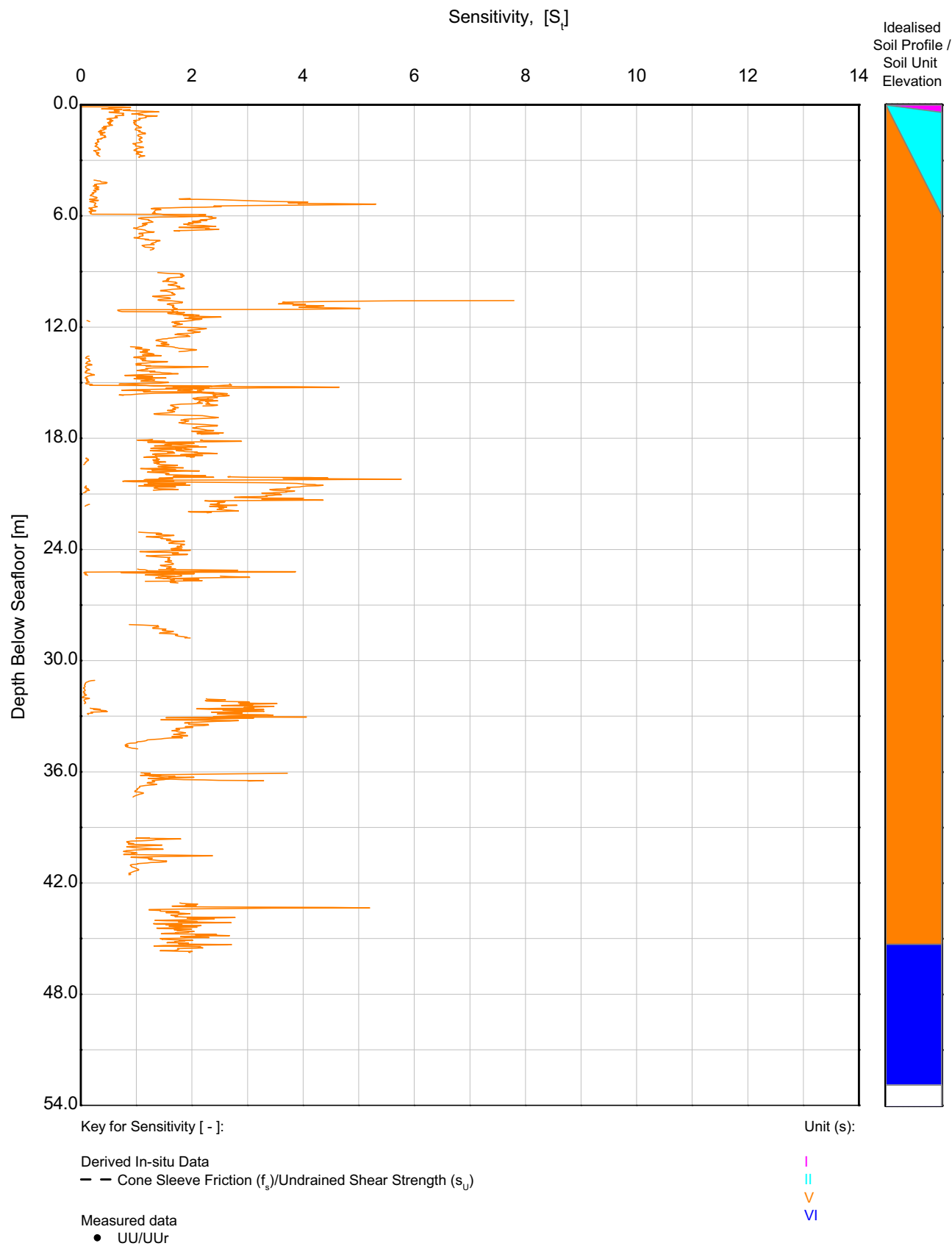
SENSITIVITY VERSUS DEPTH
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation



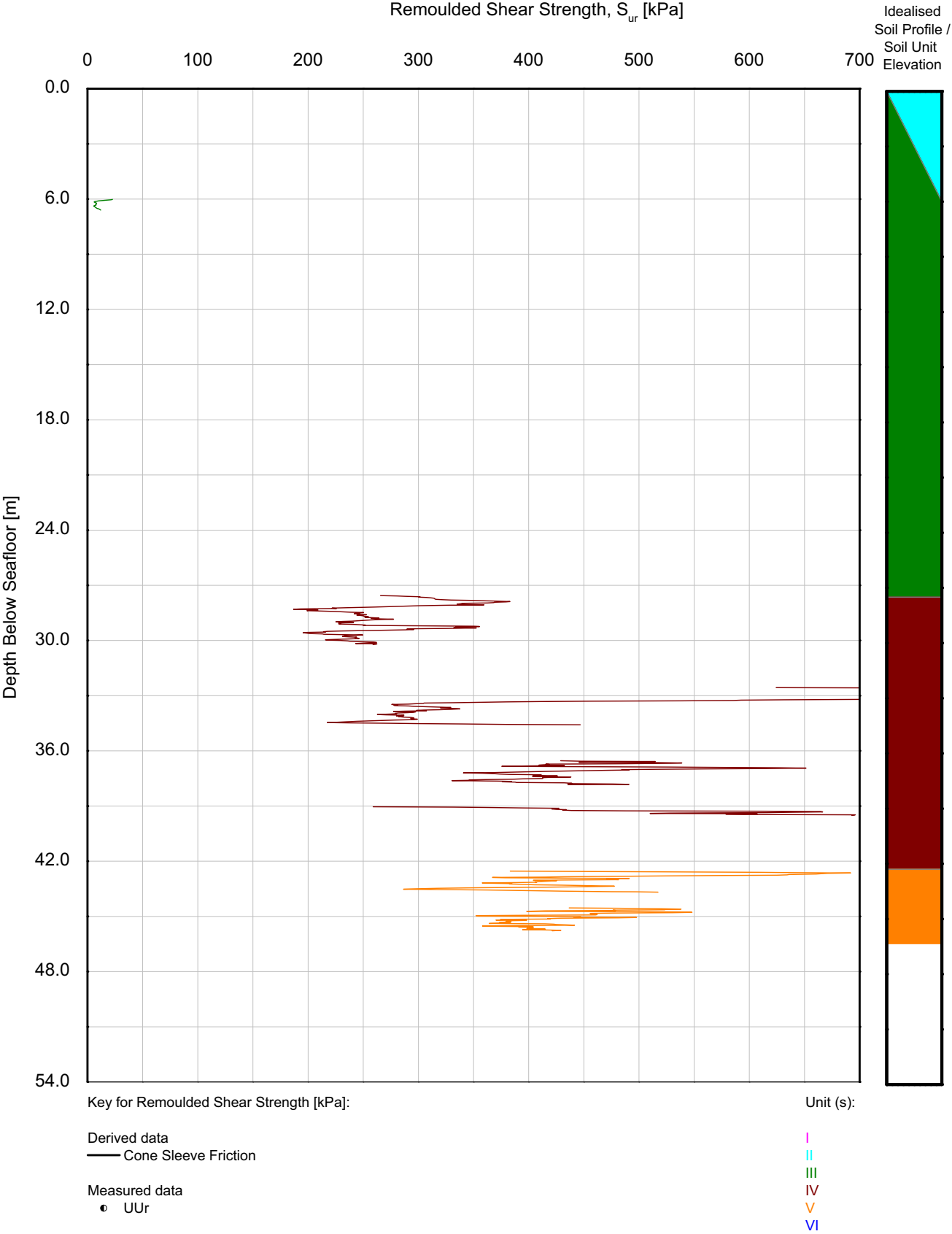
SENSITIVITY versus DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation



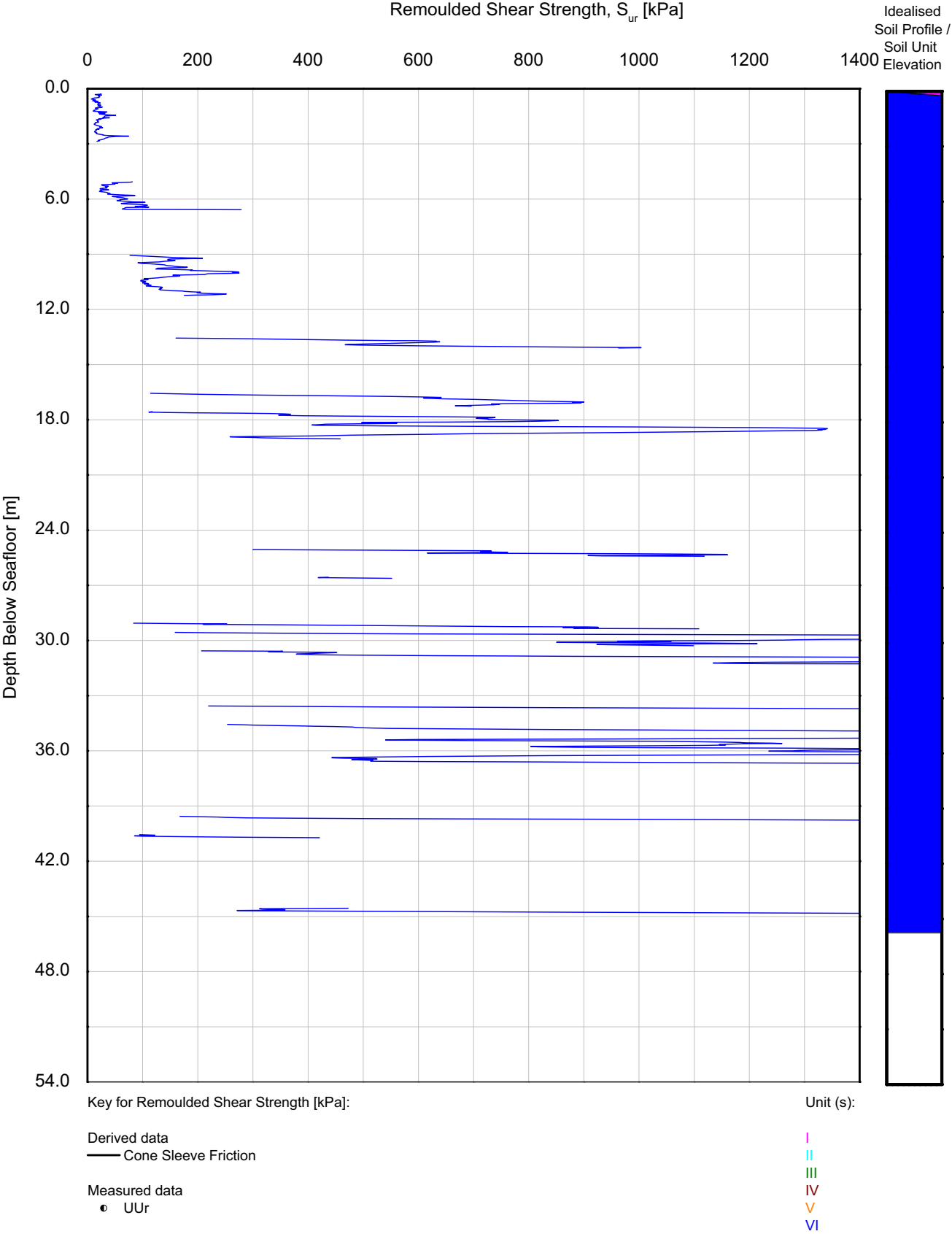
SENSITIVITY versus DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



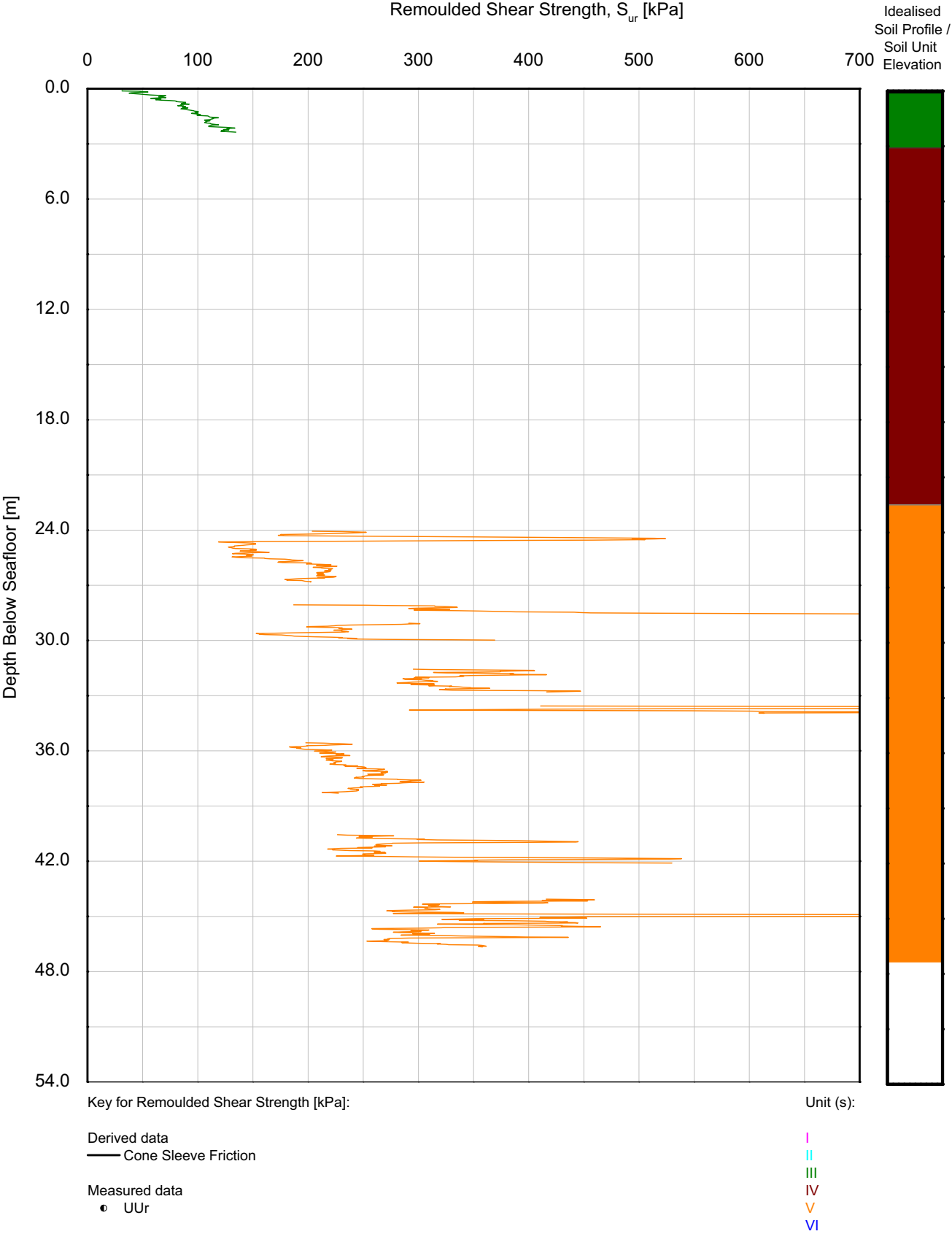
SENSITIVITY versus DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation



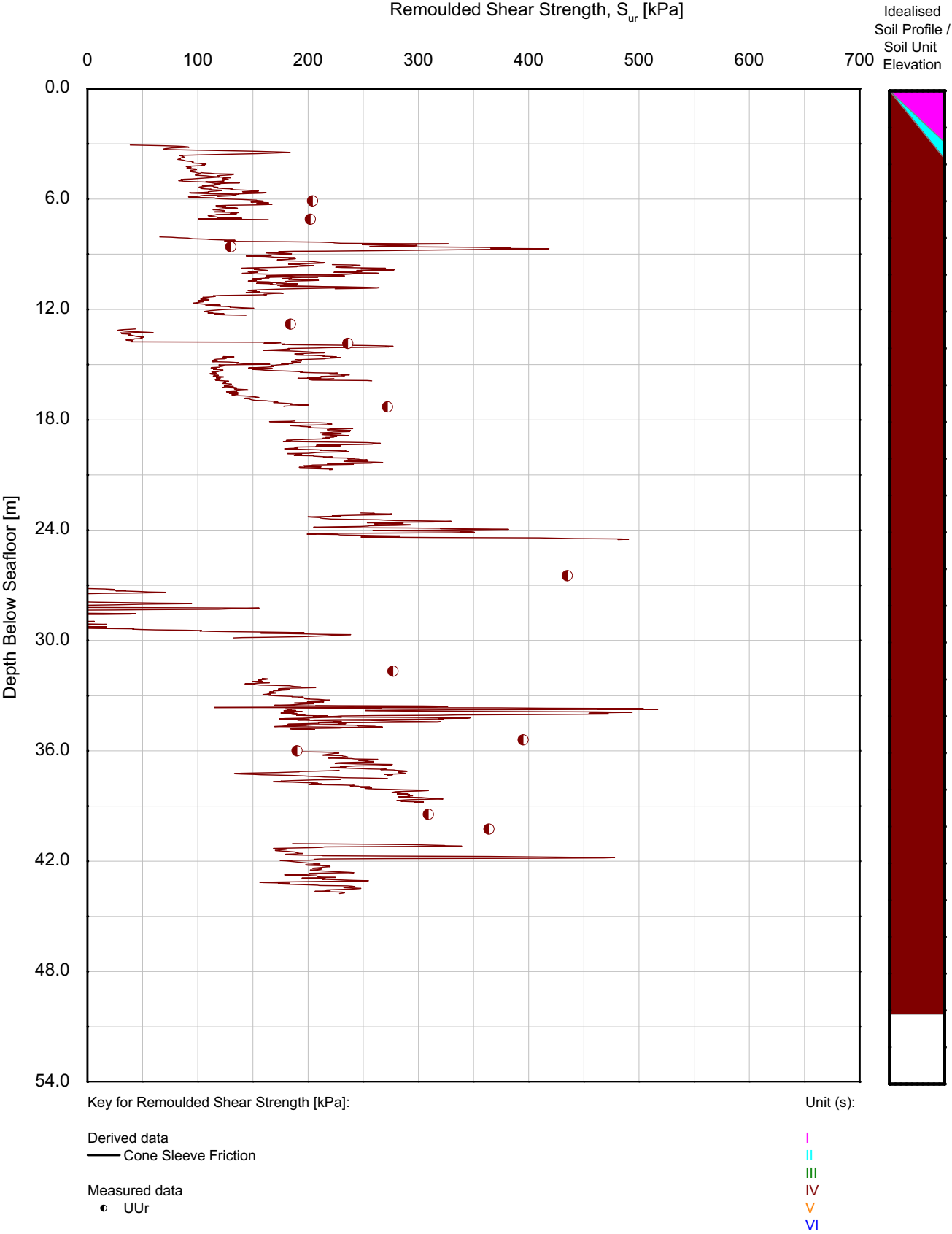
REMOULDED SHEAR STRENGTH versus DEPTH
SOIL PROVINCE I
RAMPION GEOTECHNICAL SITE INVESTIGATION 2011



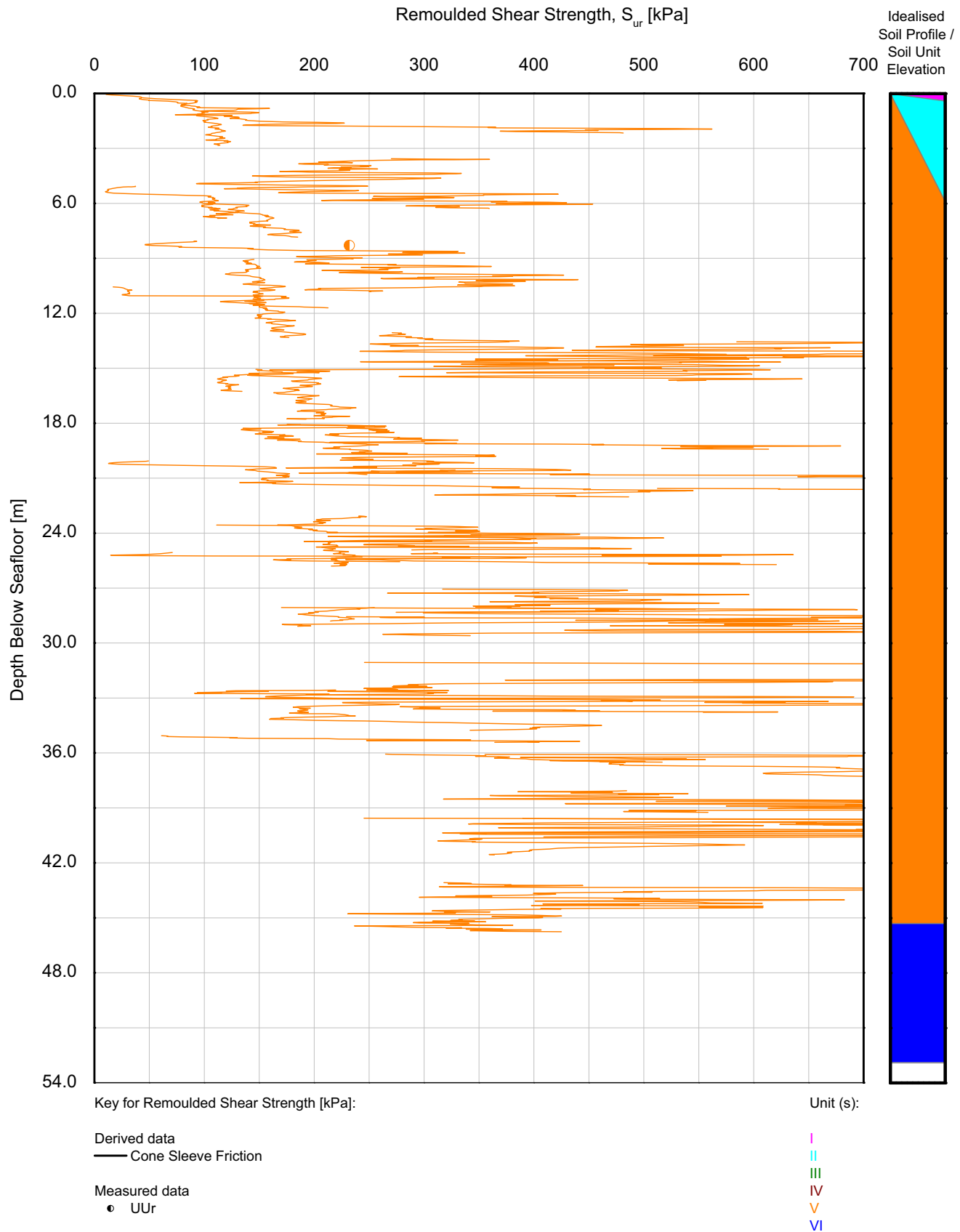
REMOULDED SHEAR STRENGTH versus DEPTH
SOIL PROVINCE III
RAMPION GEOTECHNICAL SITE INVESTIGATION 2011



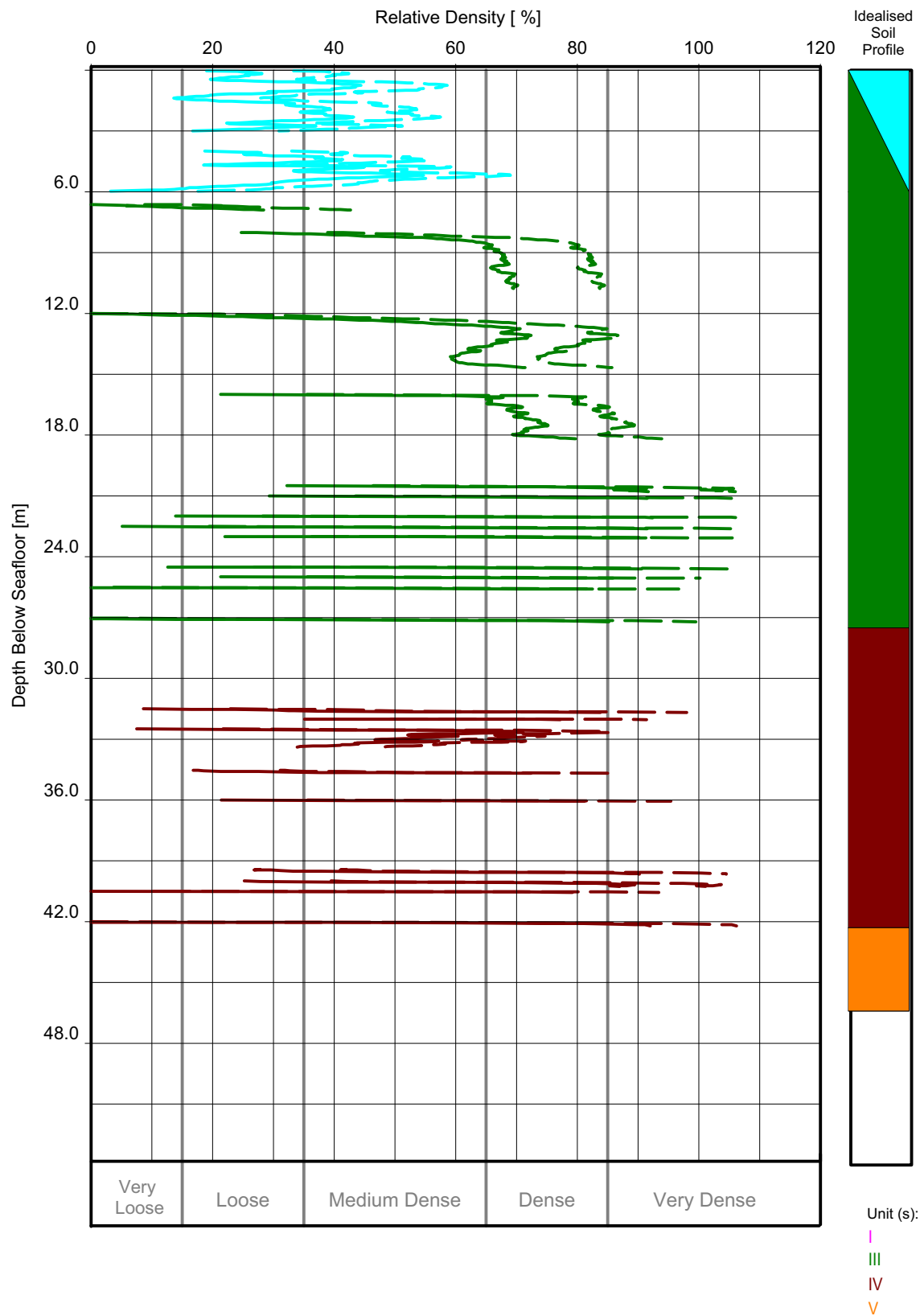
REMOULDED SHEAR STRENGTH versus DEPTH
SOIL PROVINCE IV
RAMPION GEOTECHNICAL SITE INVESTIGATION 2011



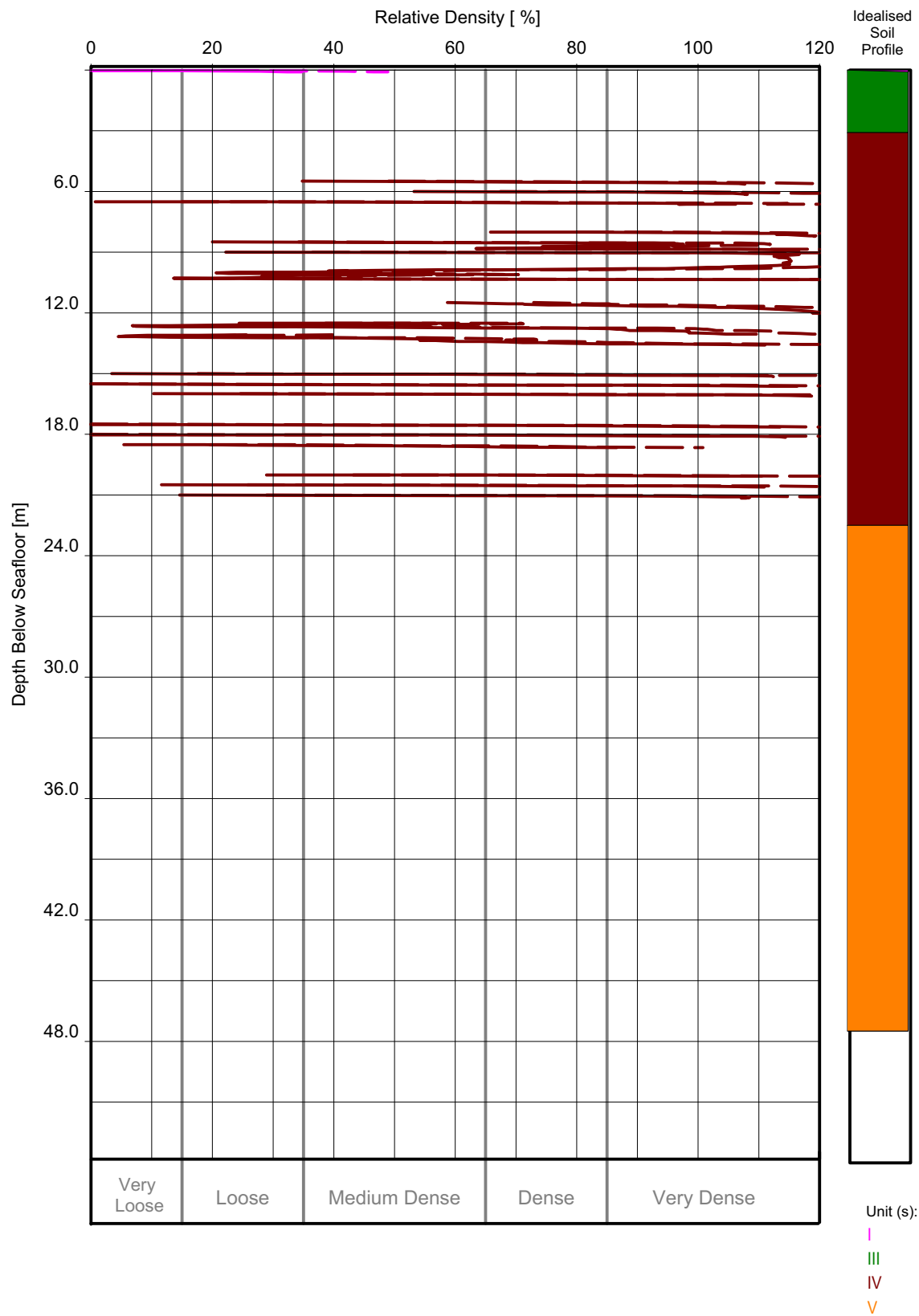
REMOULDED SHEAR STRENGTH versus DEPTH
SOIL PROVINCE V
RAMPION GEOTECHNICAL SITE INVESTIGATION 2011



REMOULDED SHEAR STRENGTH versus DEPTH
 SOIL PROVINCE VI
 RAMPION GEOTECHNICAL SITE INVESTIGATION 2011

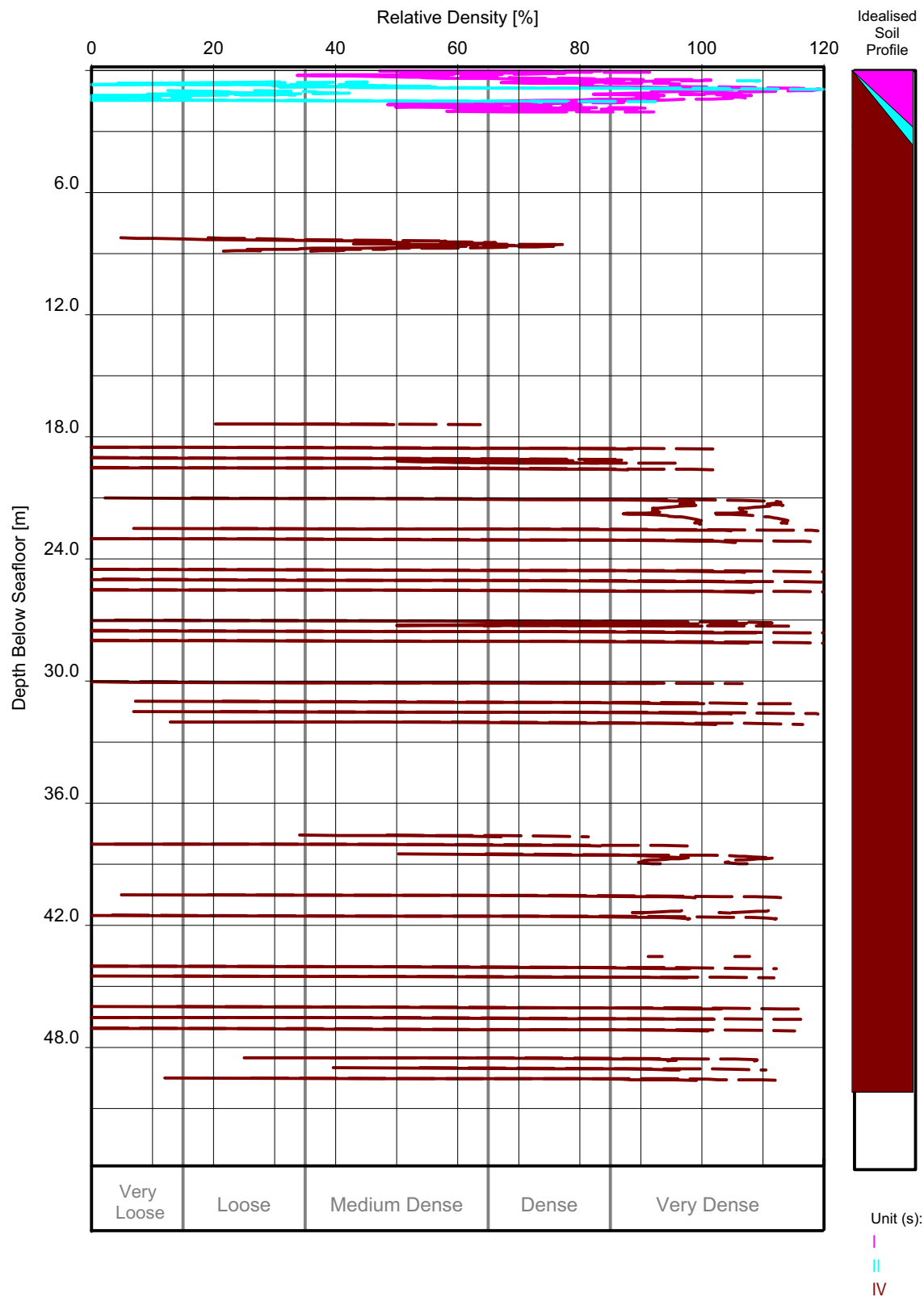


RELATIVE DENSITY VERSUS DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



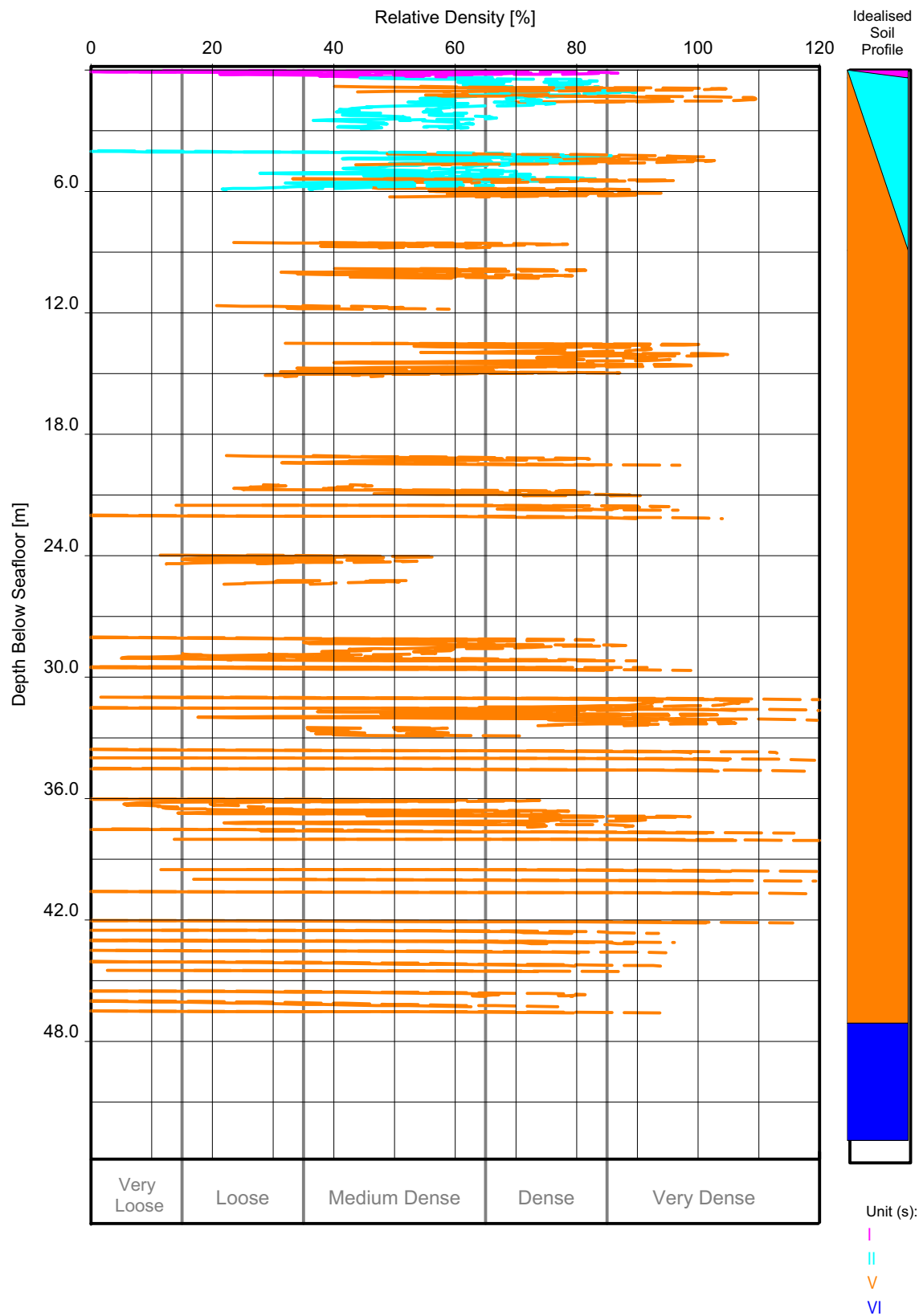
RELATIVE DENSITY VERSUS DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation

GeODir/Relative Density.GLO/2011-07-25 10:18:45



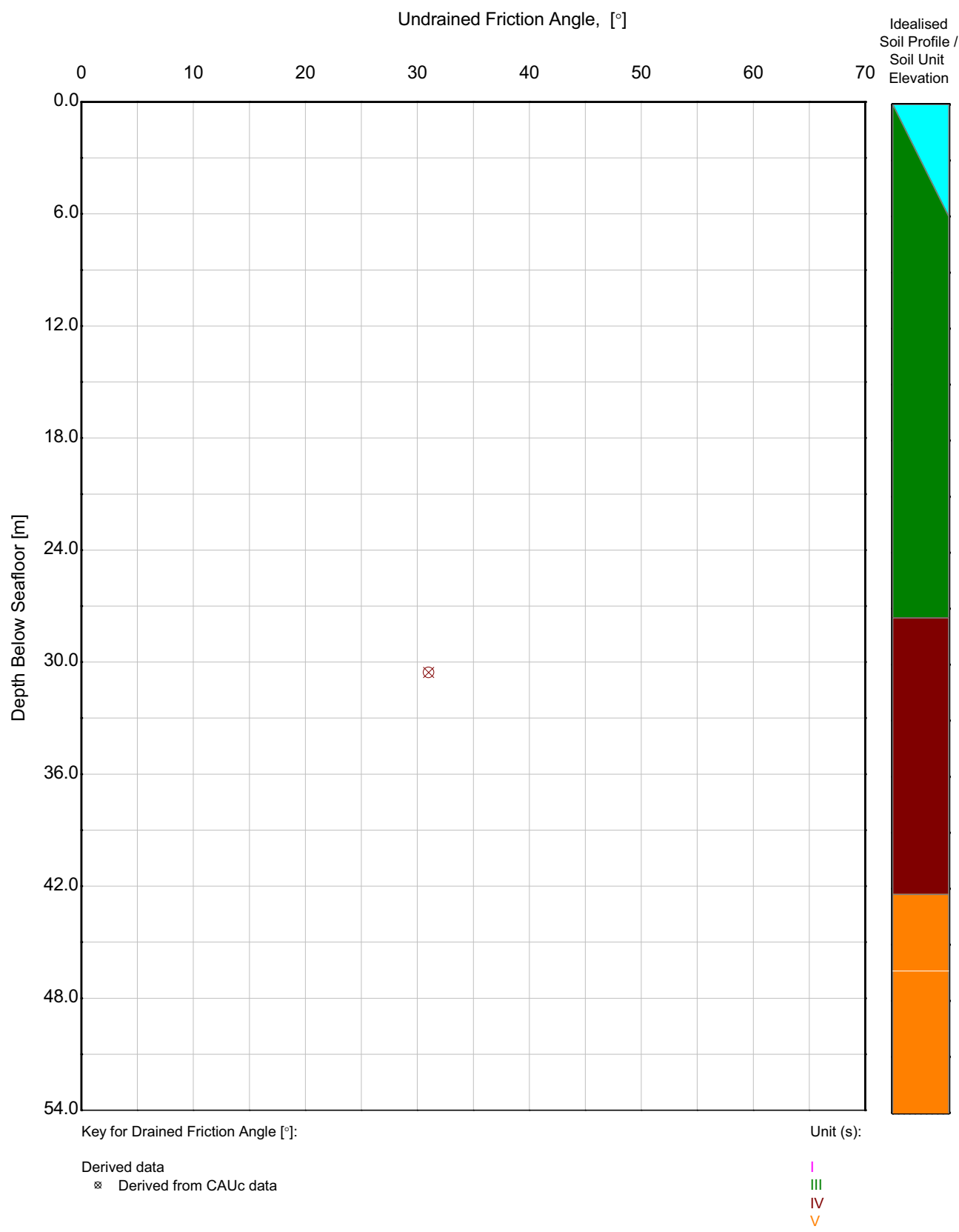
RELATIVE DENSITY VERSUS DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation

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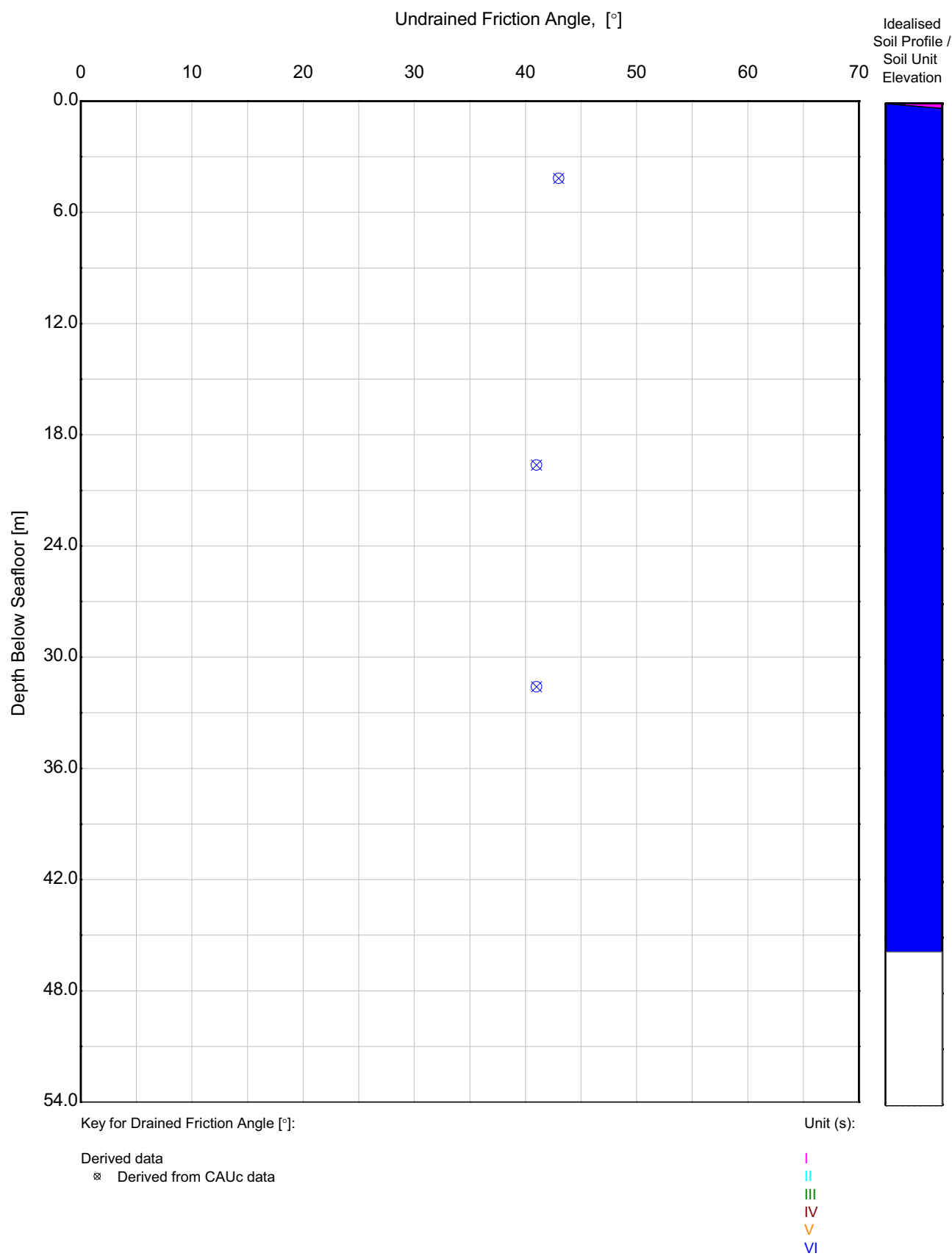


RELATIVE DENSITY VERSUS DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation

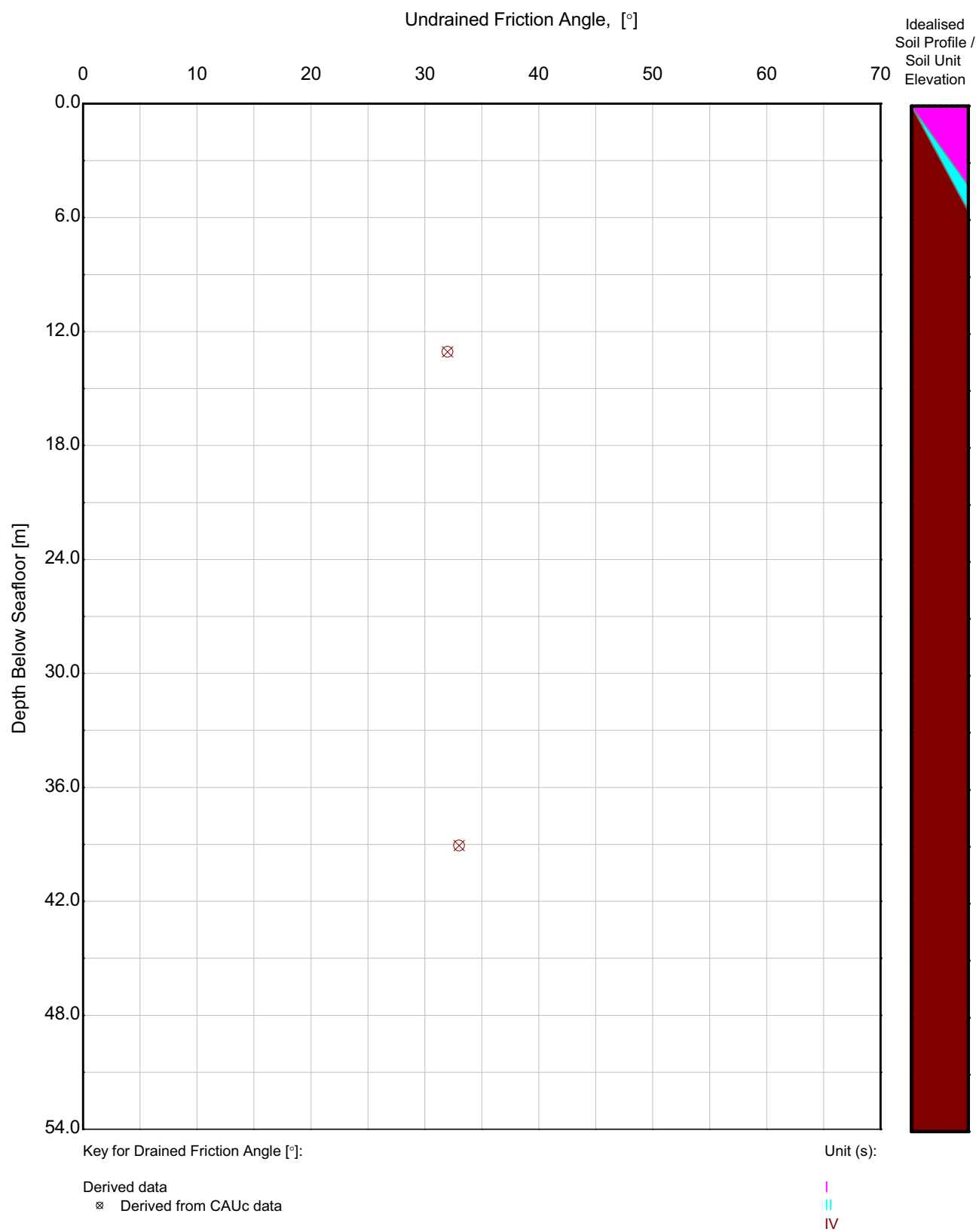
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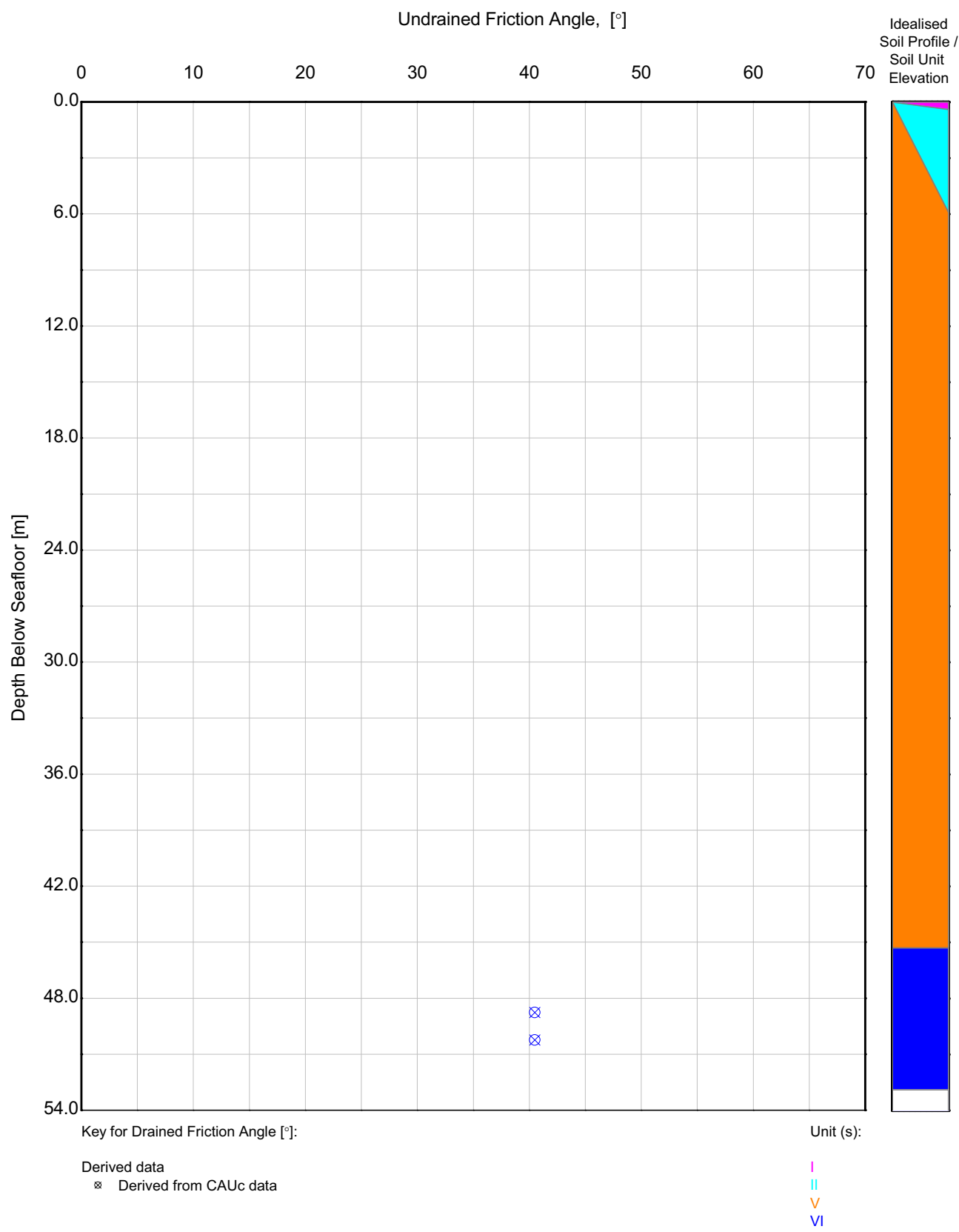
UNDRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



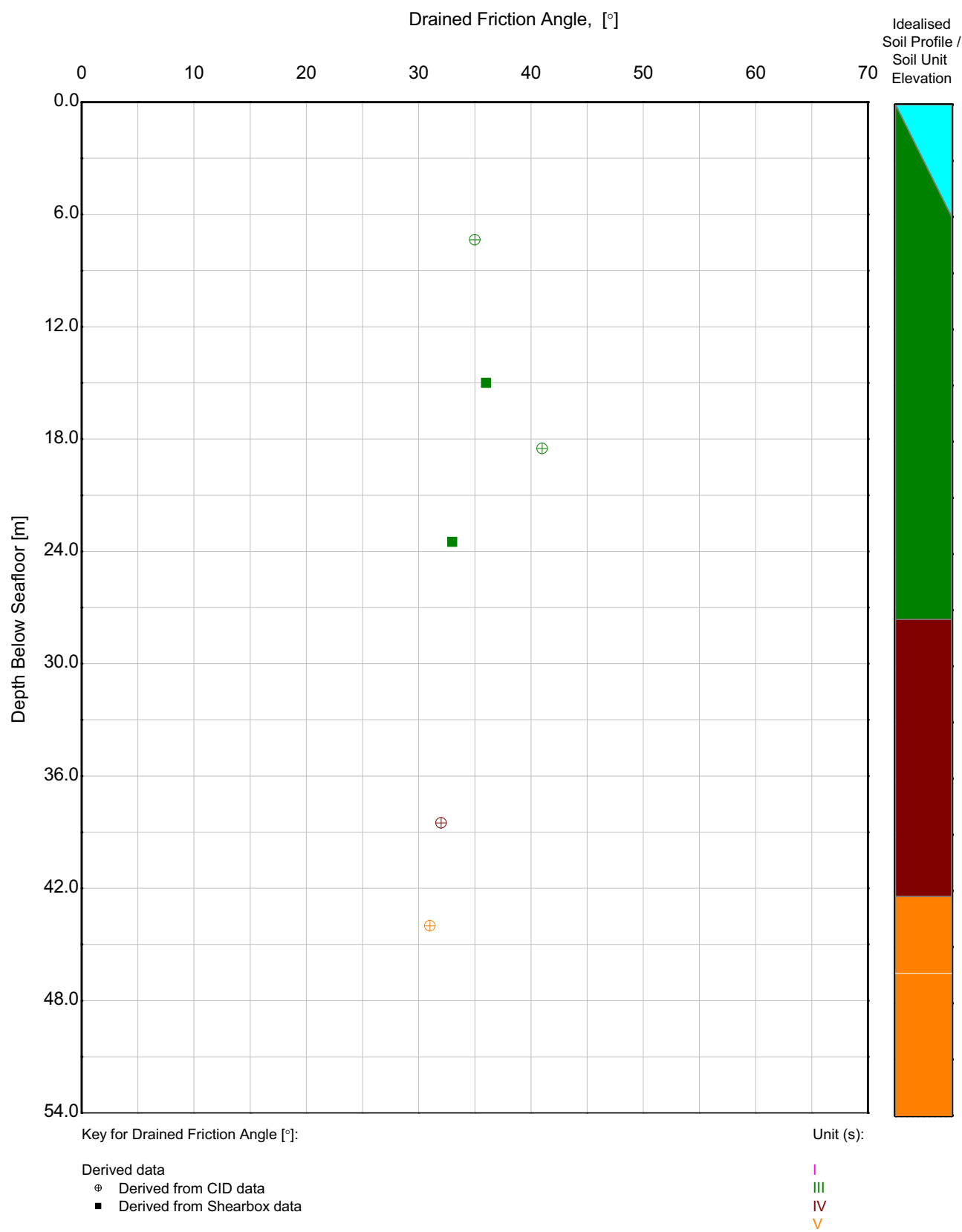
UNDRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE III
Rampion Offshore Wind Farm Site Investigation



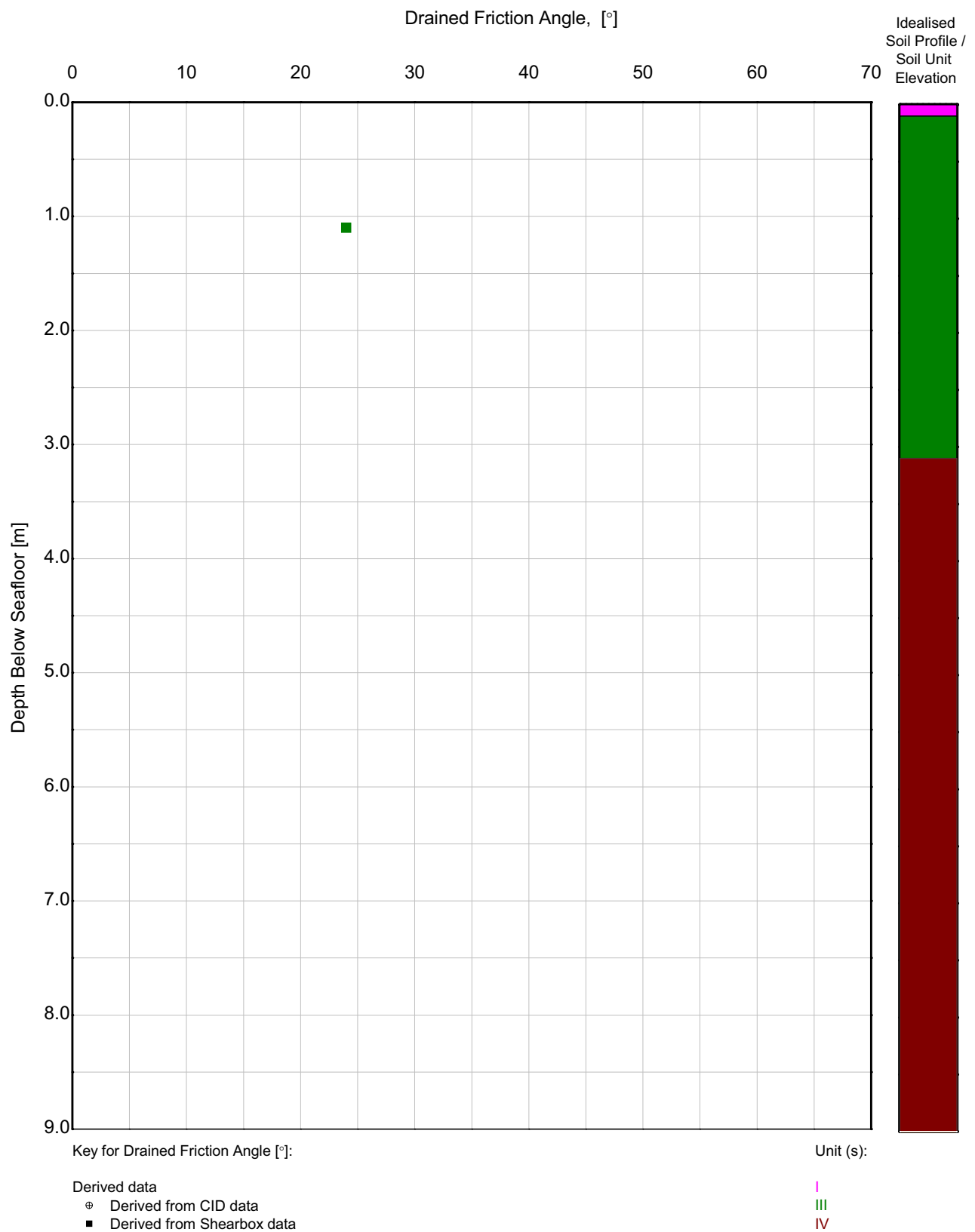
UNDRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



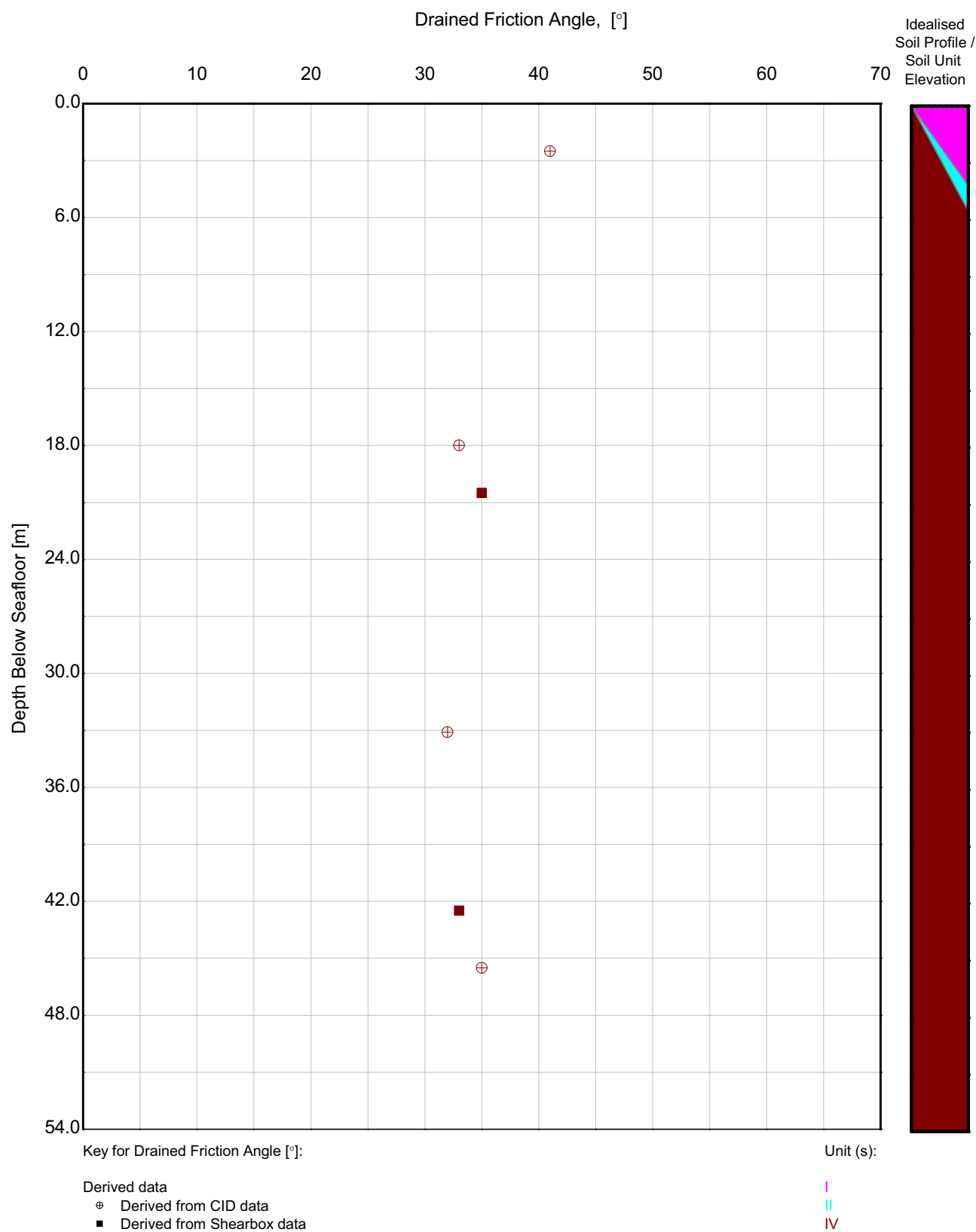
UNDRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation



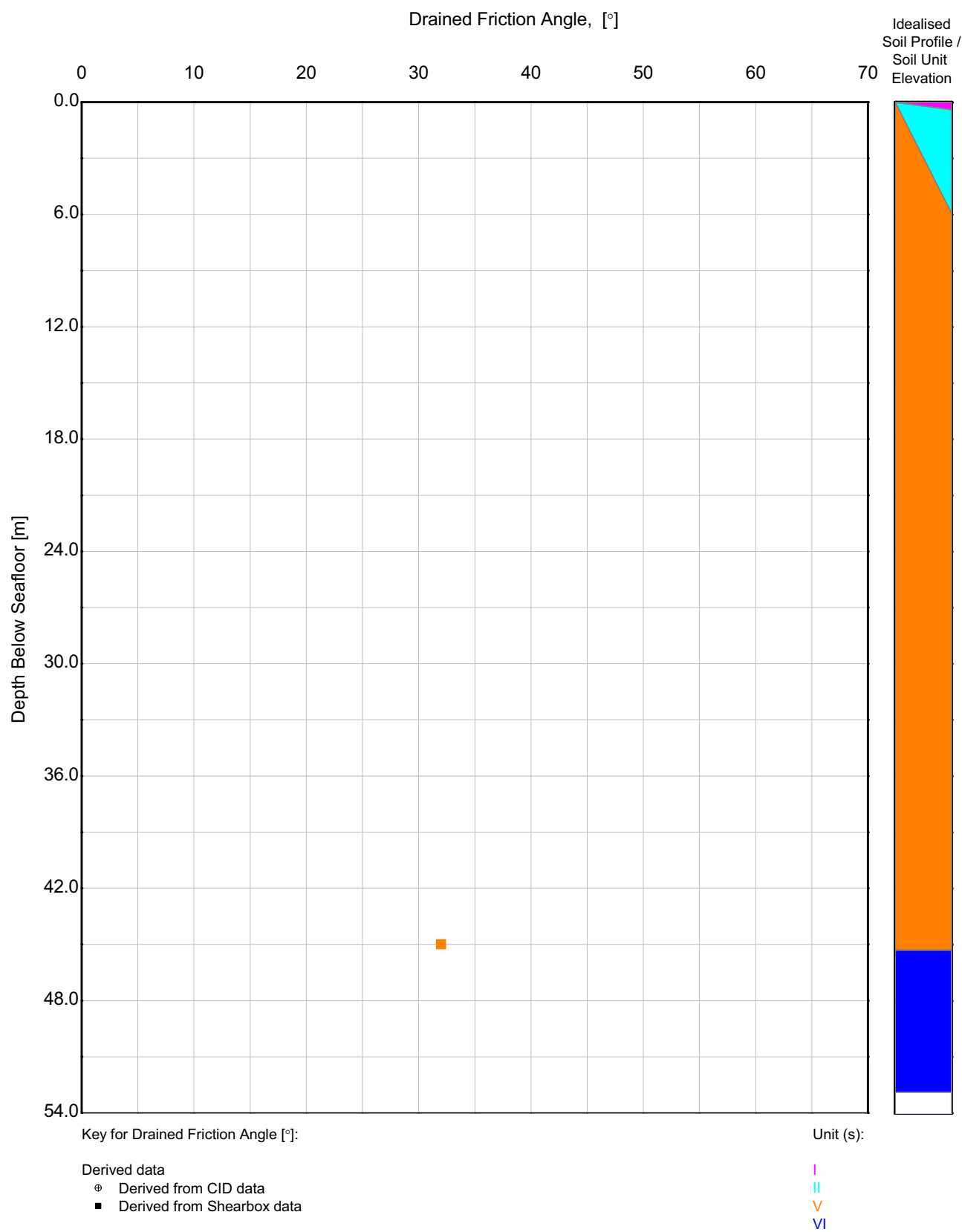
DRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



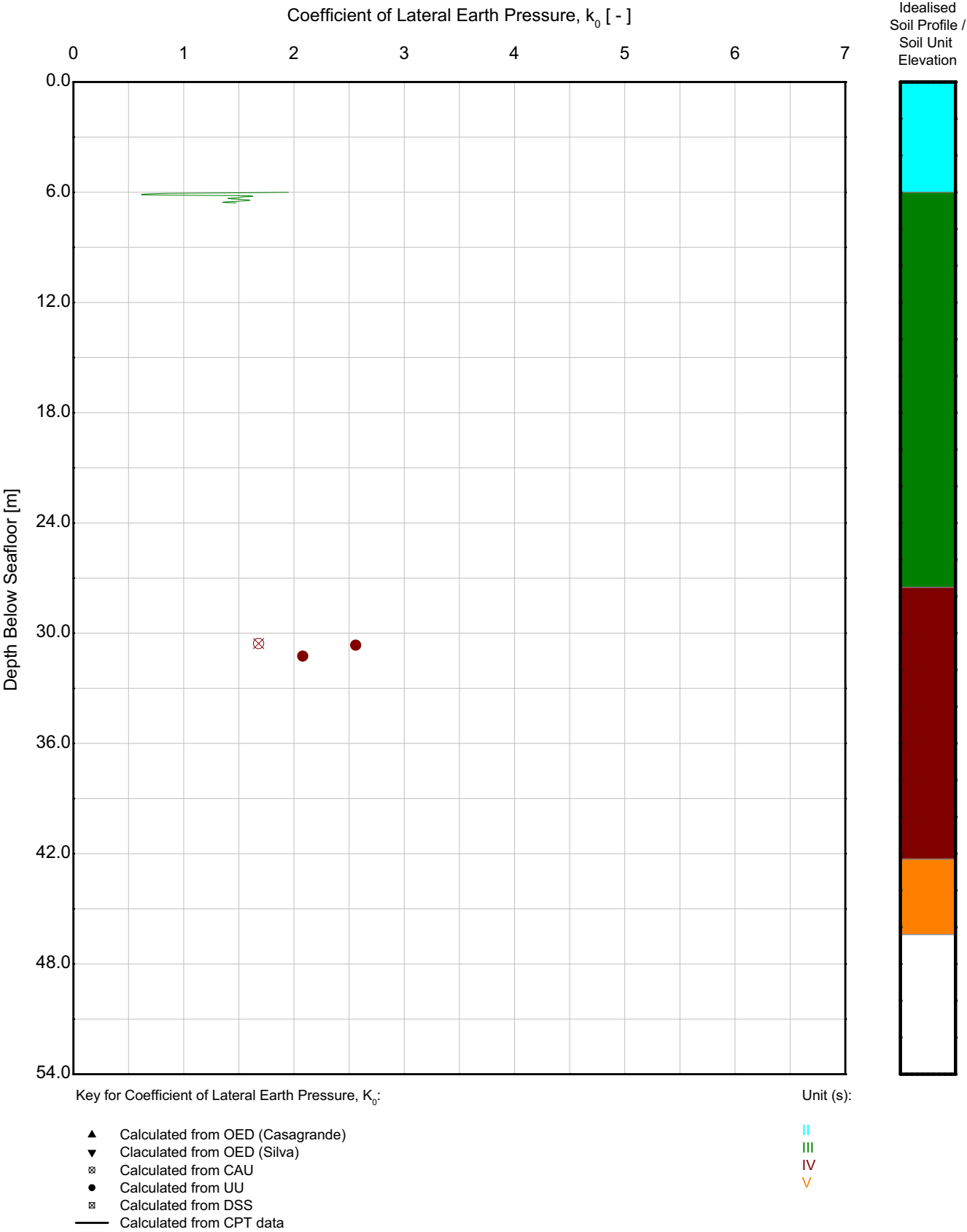
DRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation



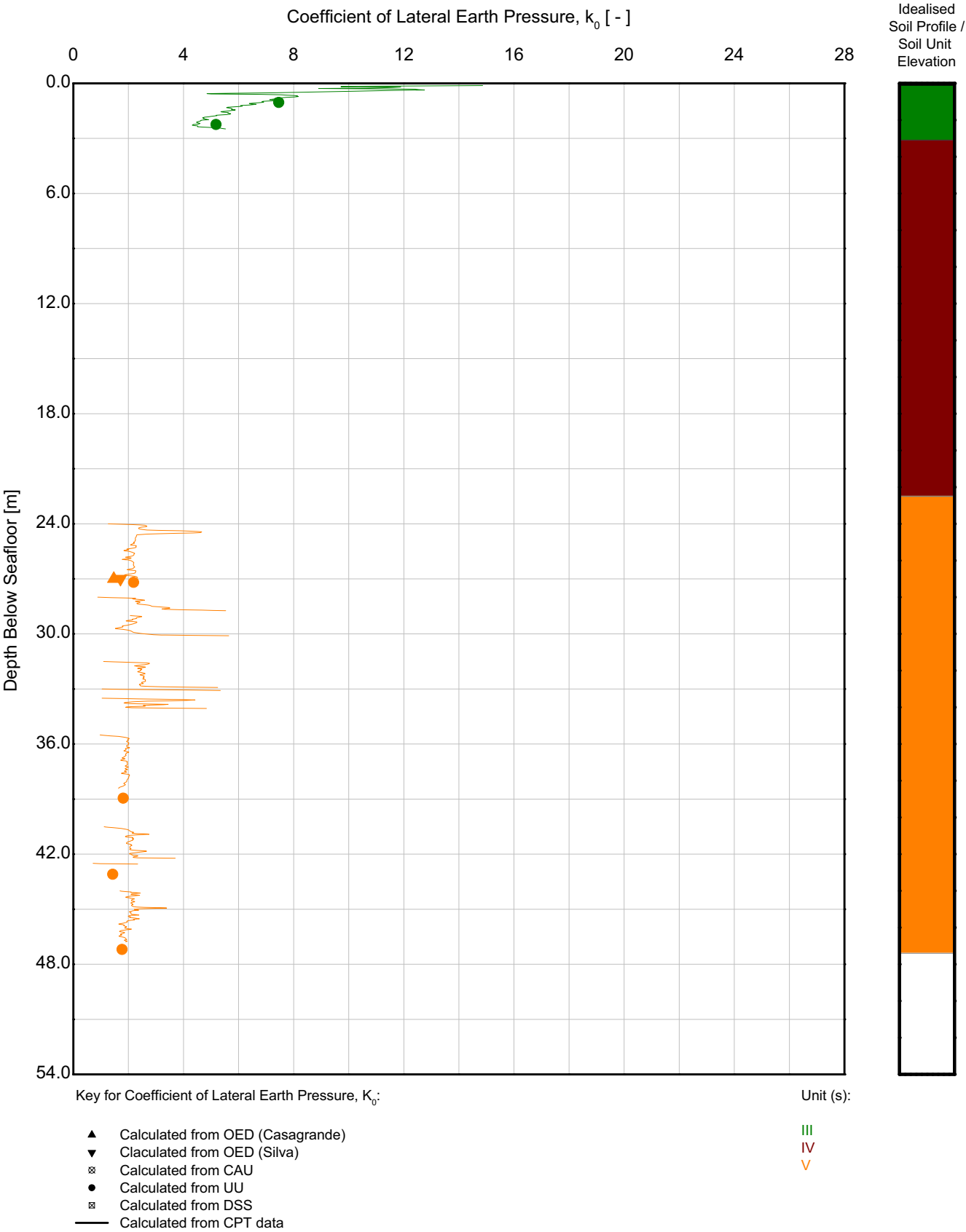
DRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



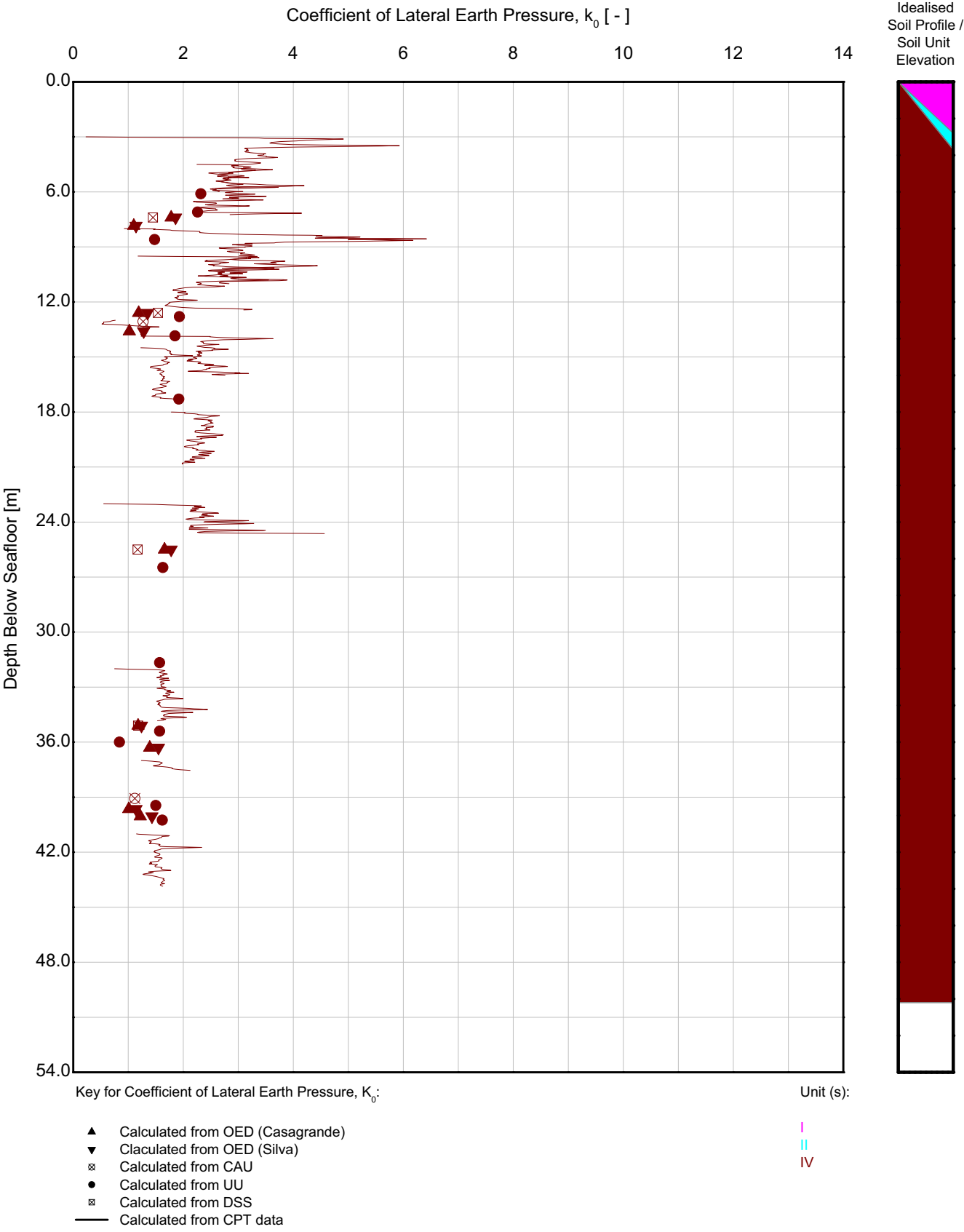
DRAINED FRICTION ANGLE versus DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation



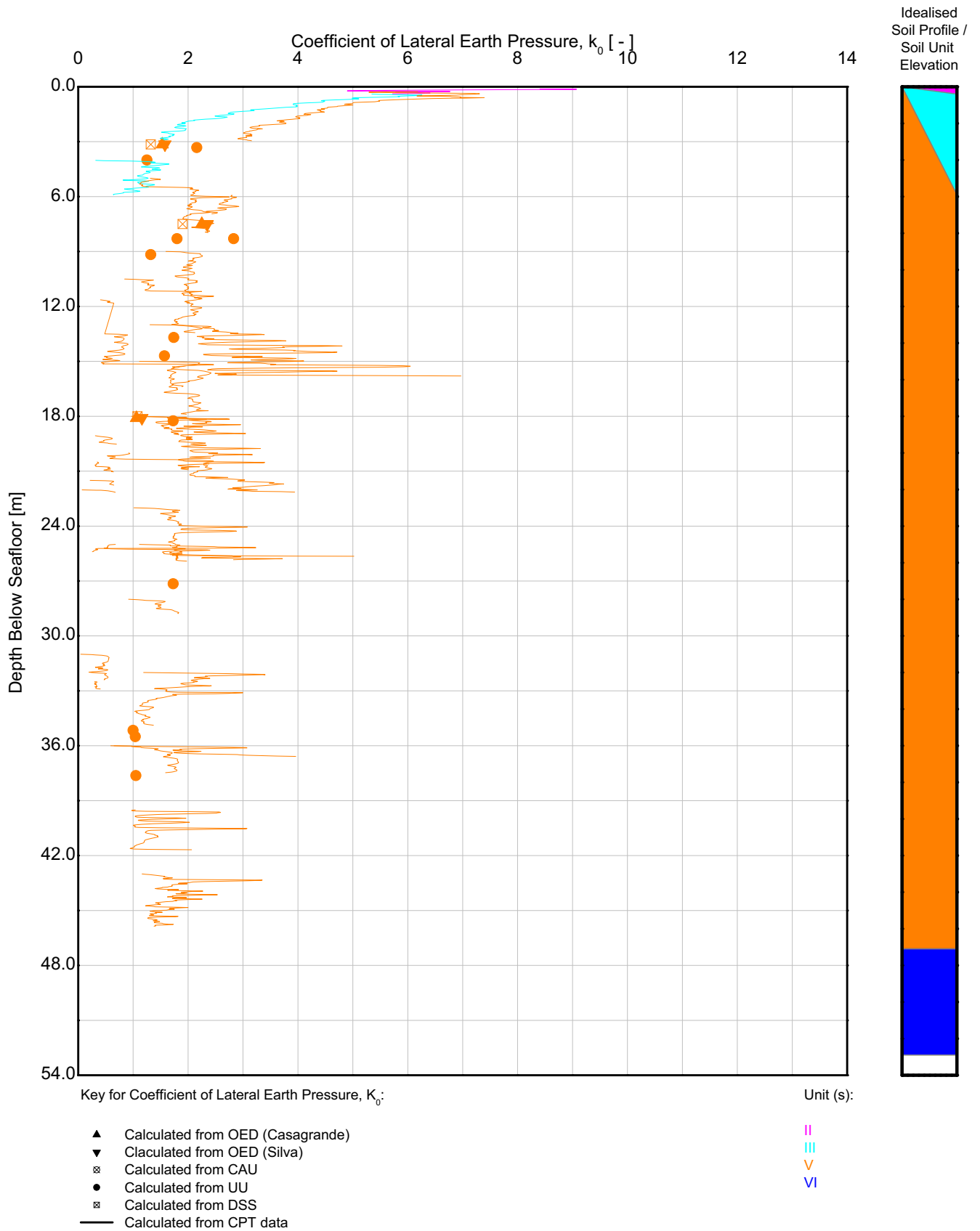
COEFFICIENT OF LATERAL EARTH PRESSURE versus DEPTH
SOIL PROVINCE I
Rampion Geotechnical Site Investigation 2011



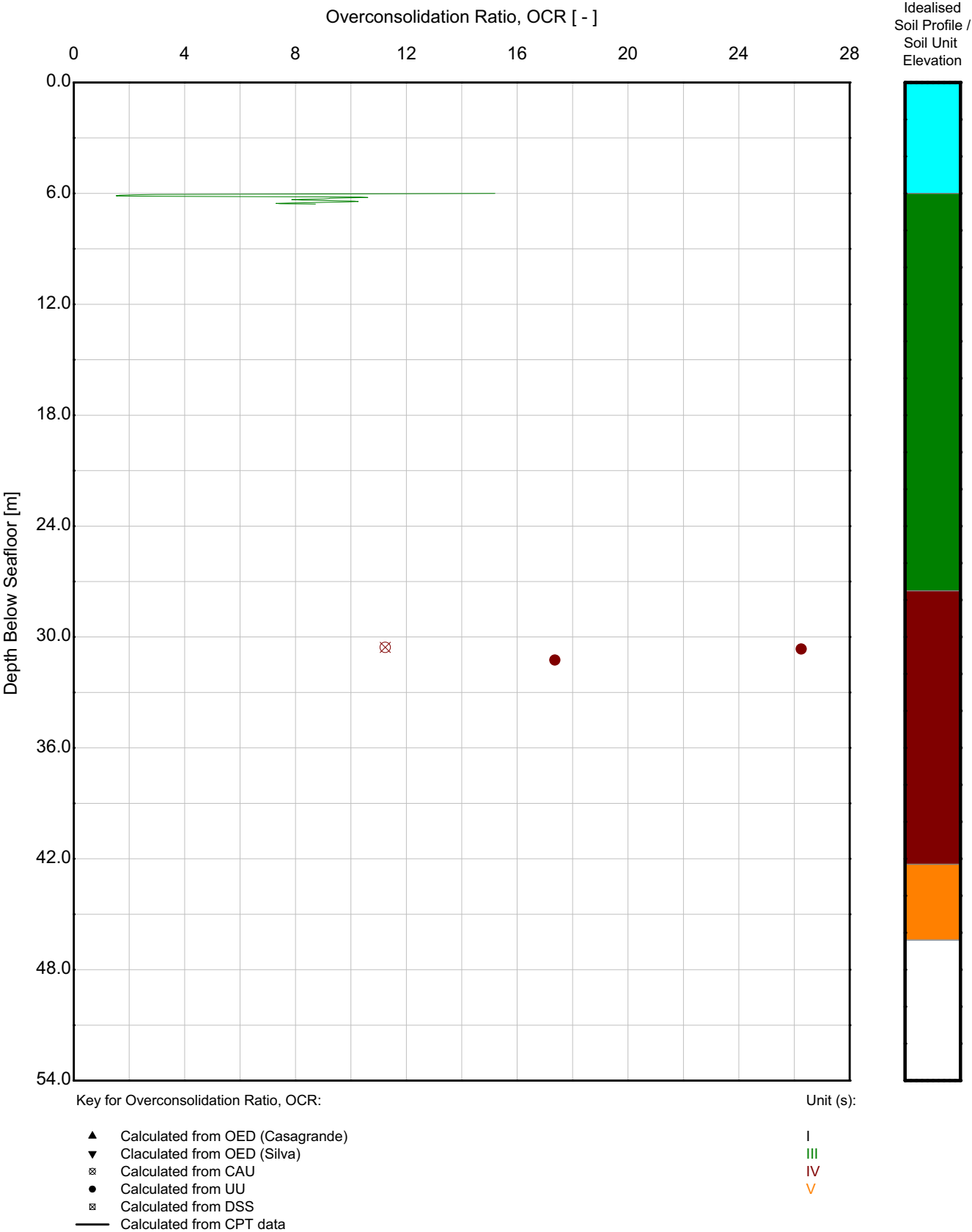
COEFFICIENT OF LATERAL EARTH PRESSURE versus DEPTH
SOIL PROVINCE IV
Rampion Geotechnical Site Investigation 2011



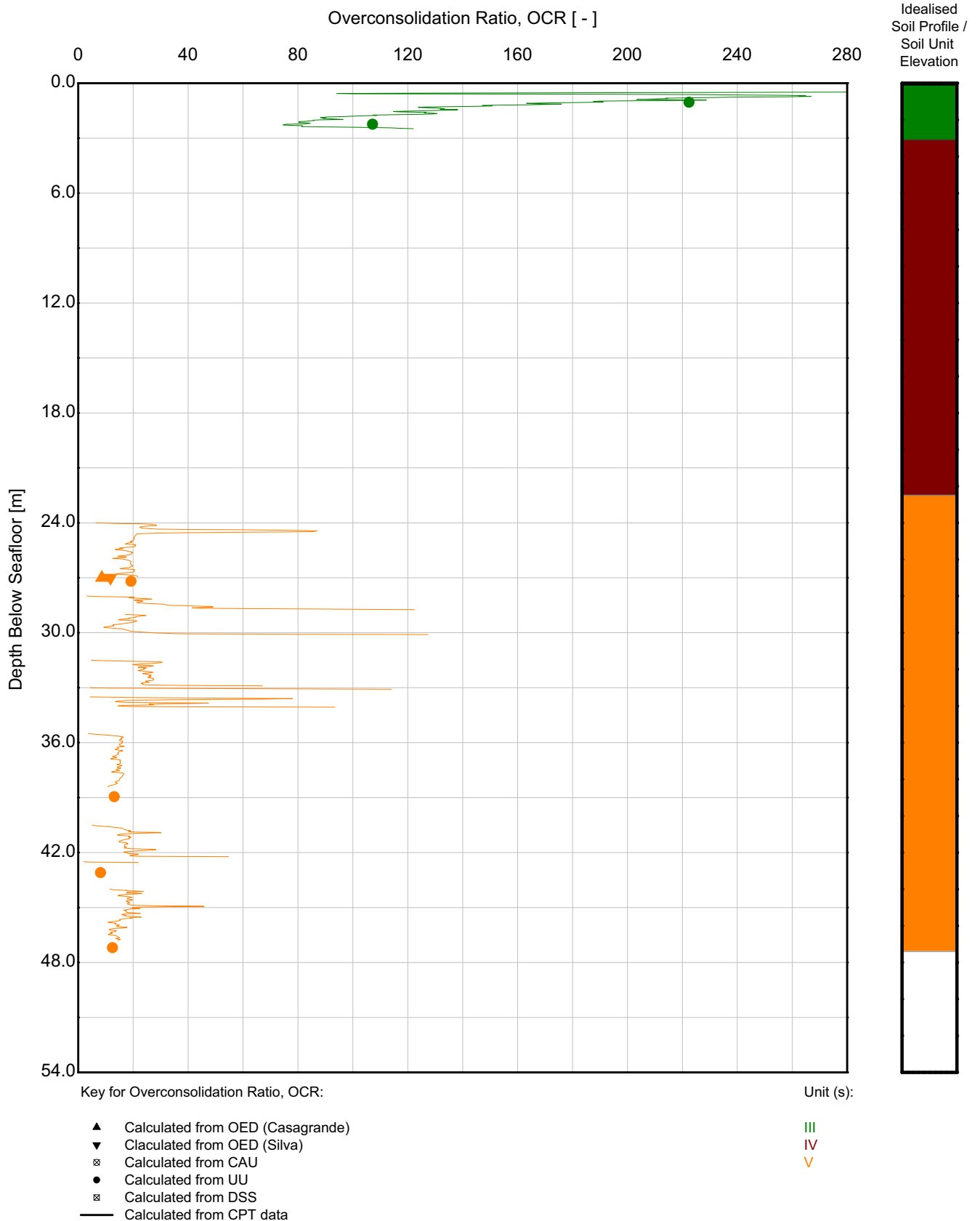
COEFFICIENT OF LATERAL EARTH PRESSURE versus DEPTH
SOIL PROVINCE V
Rampion Geotechnical Site Investigation 2011



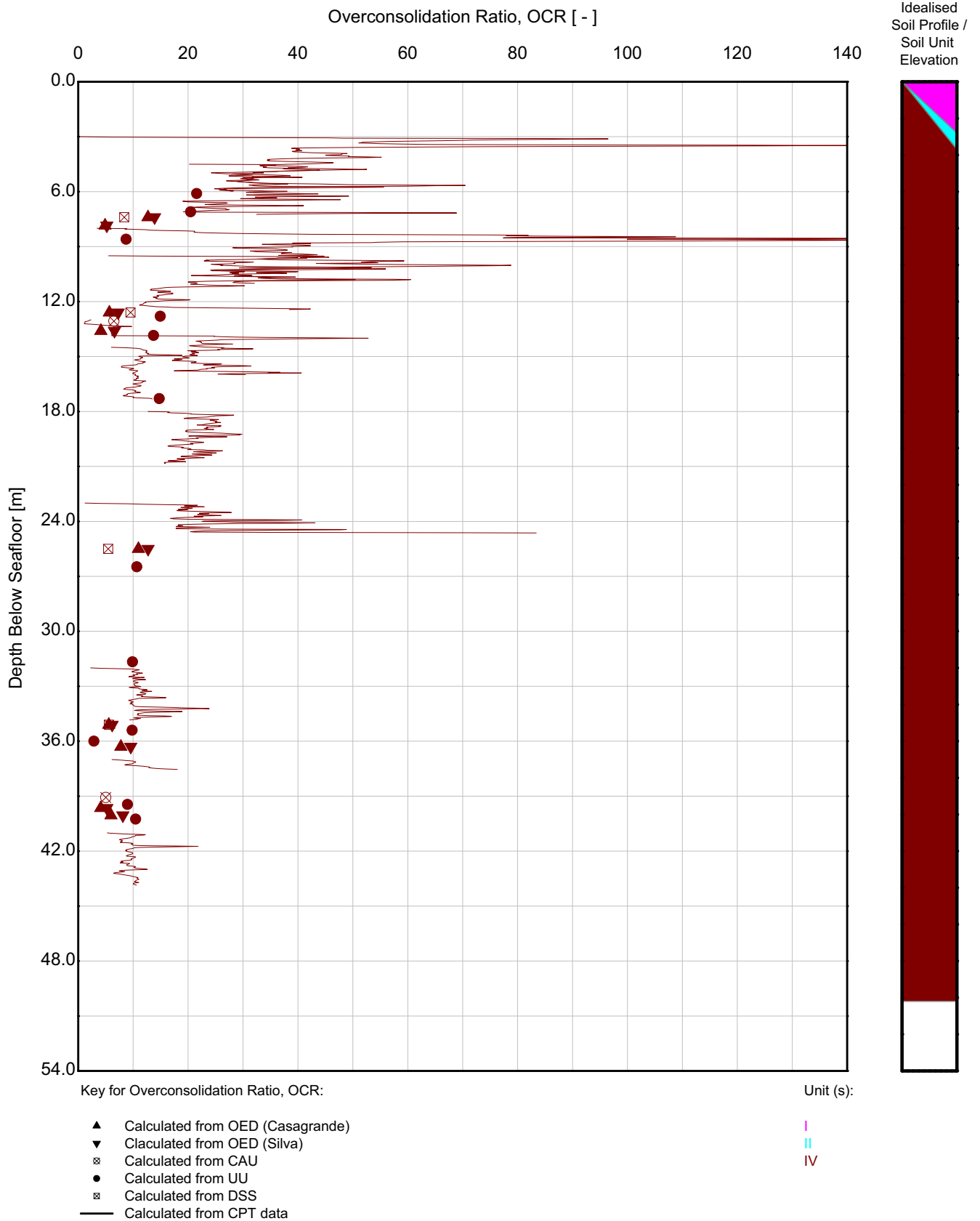
COEFFICIENT OF LATERAL EARTH PRESSURE versus DEPTH
 SOIL PROVINCE VI
 Rampion Geotechnical Site Investigation 2011



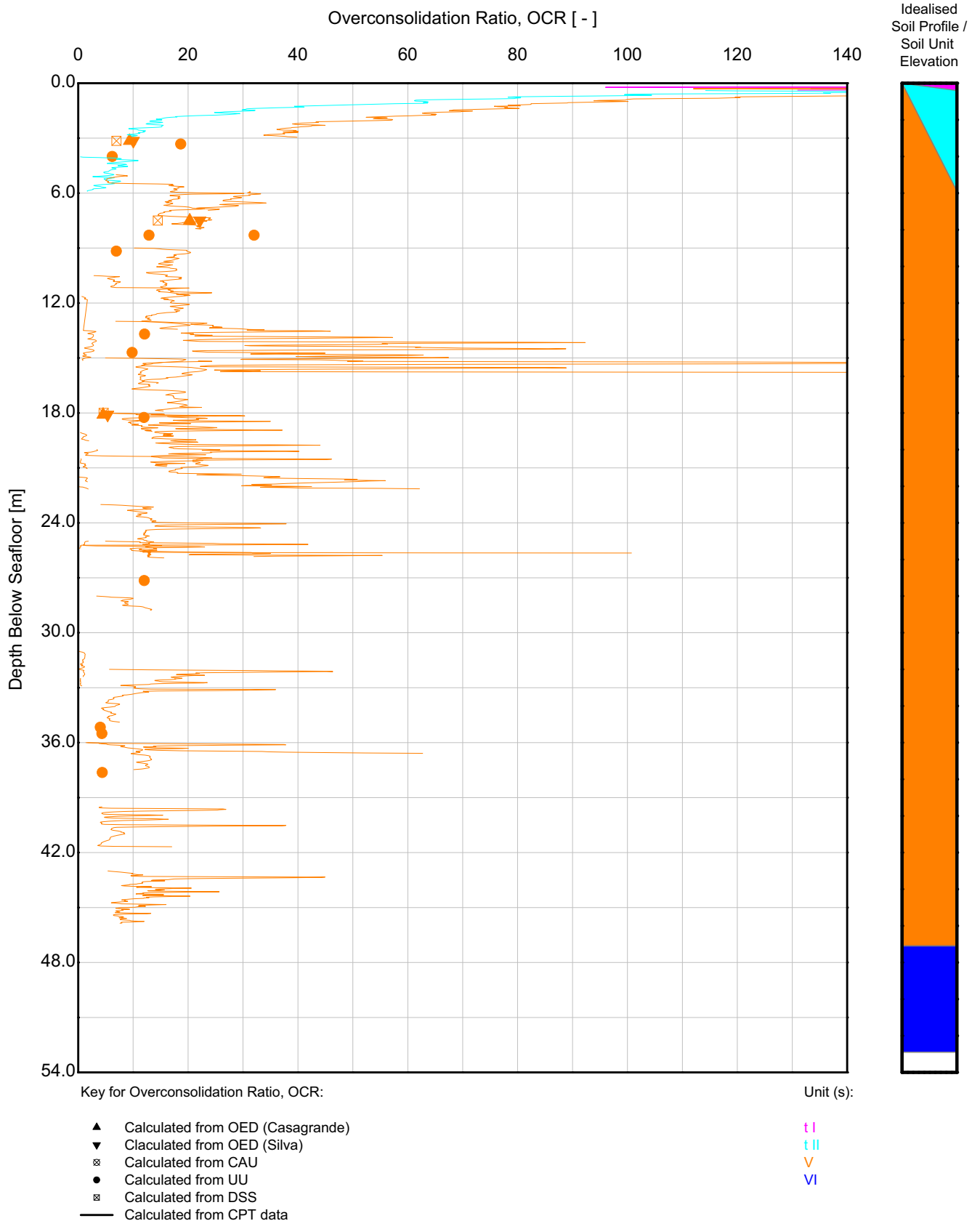
OVERCONSOLIDATION RATIO versus DEPTH
SOIL PROVINCE I
Rampion Geotechnical Site Investigation 2011



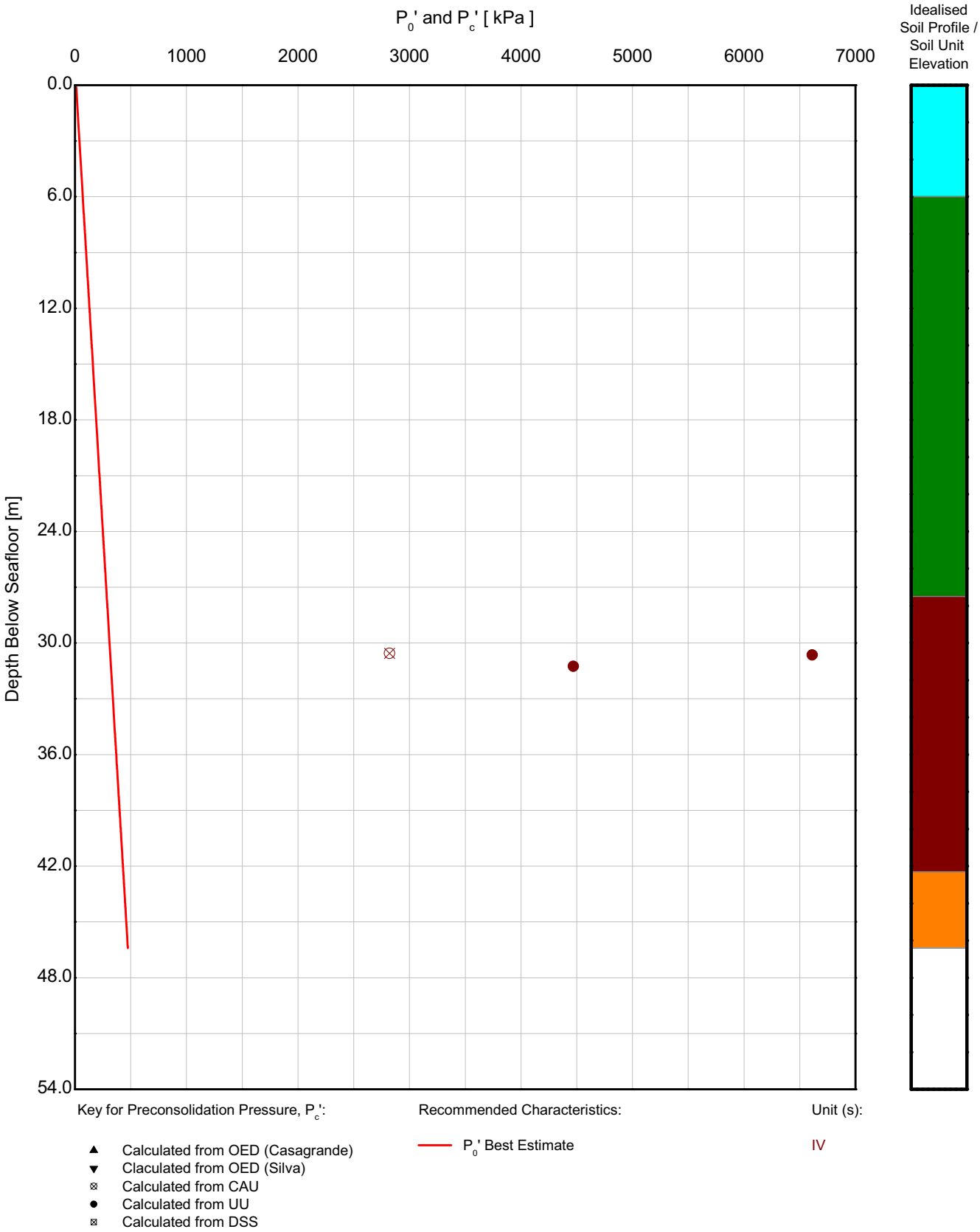
OVERCONSOLIDATION RATIO versus DEPTH
 SOIL PROVINCE IV
 Rampion Geotechnical Site Investigation 2011



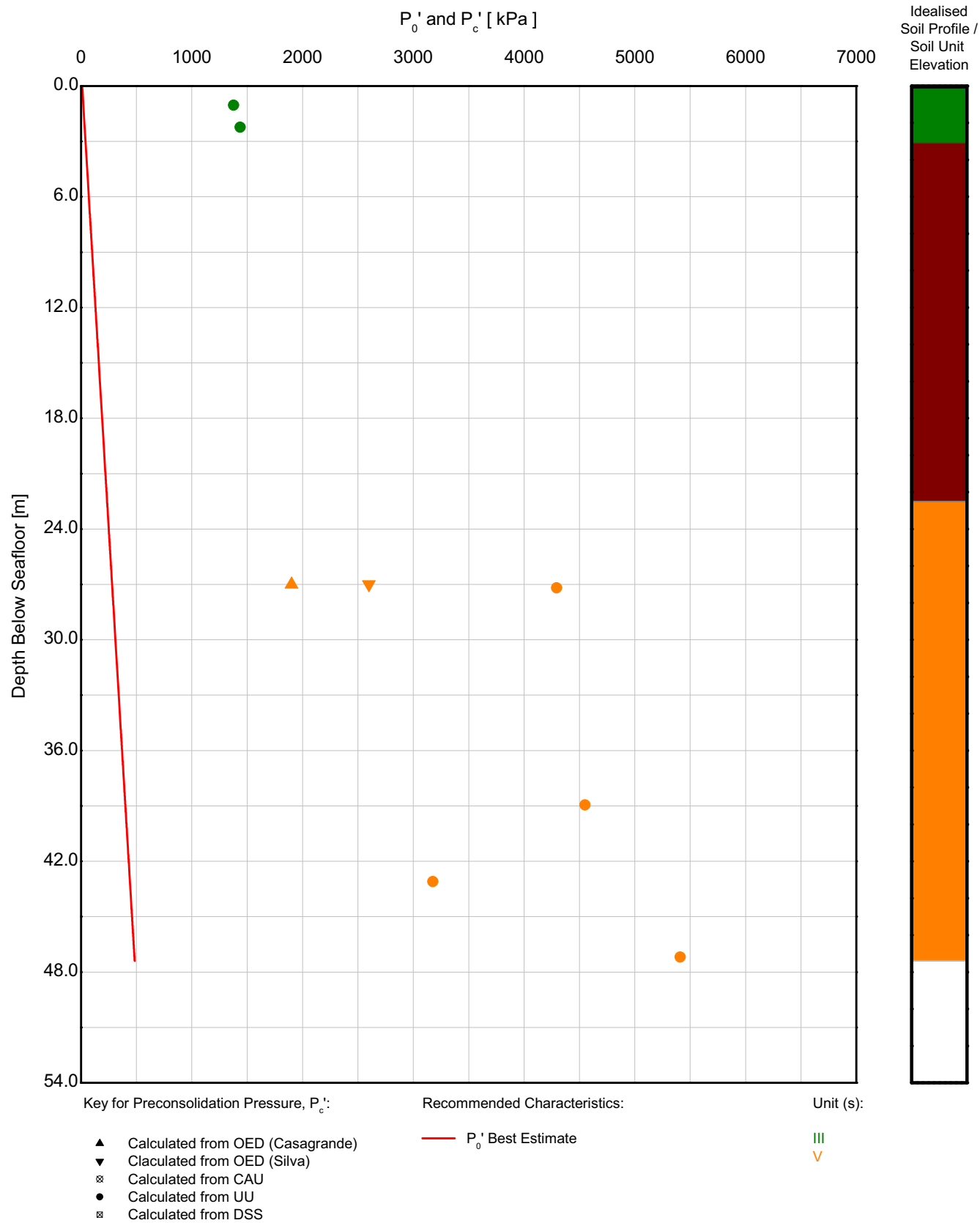
OVERCONSOLIDATION RATIO versus DEPTH
 SOIL PROVINCE V
 Rampion Geotechnical Site Investigation 2011



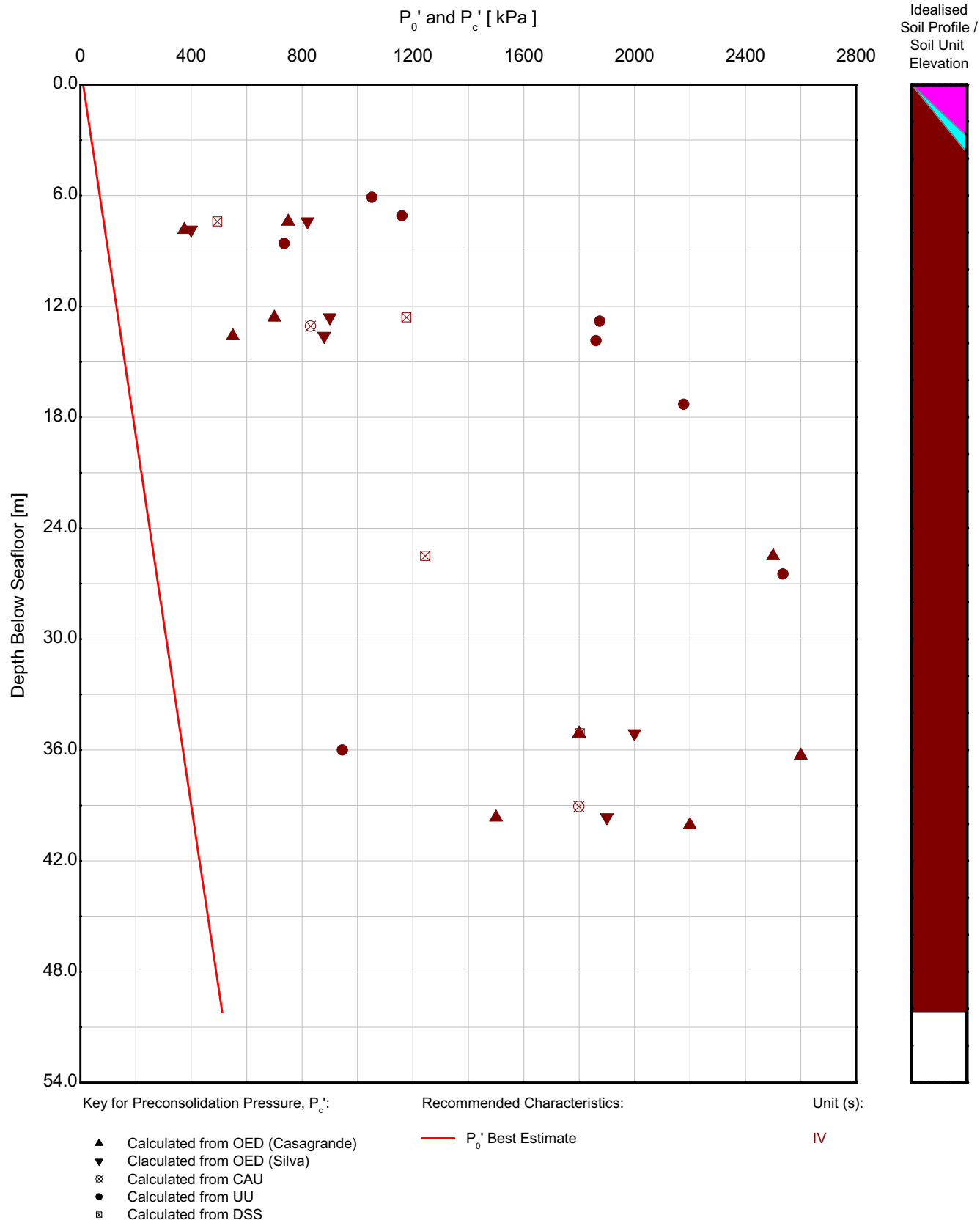
OVERCONSOLIDATION RATIO versus DEPTH
 SOIL PROVINCE VI
 Rampion Geotechnical Site Investigation 2011



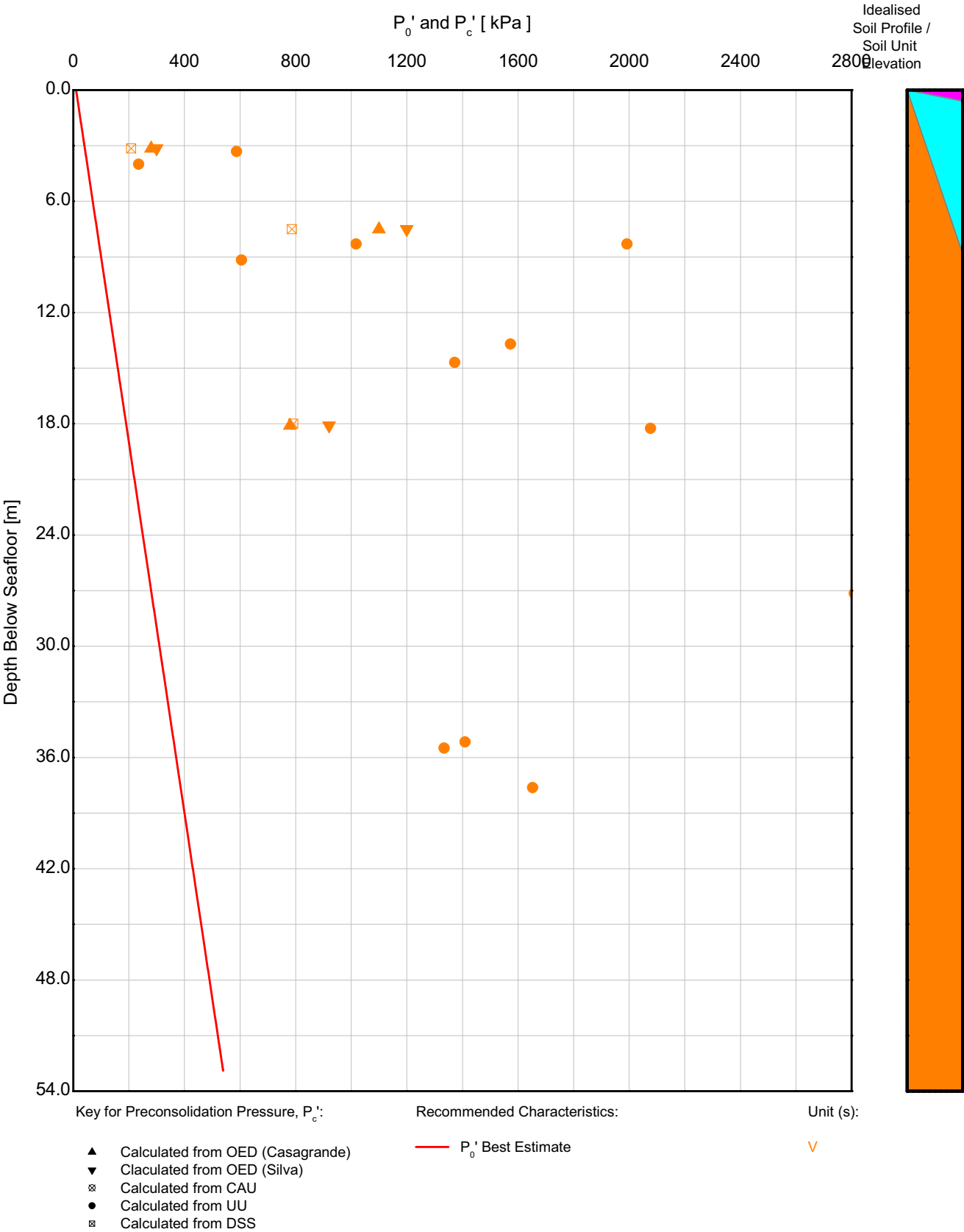
EFFECTIVE OVERBURDEN AND PRECONSOLIDATION PRESSURES versus DEPTH
SOIL PROVINCE I
Rampion Offshore Wind Farm Site Investigation



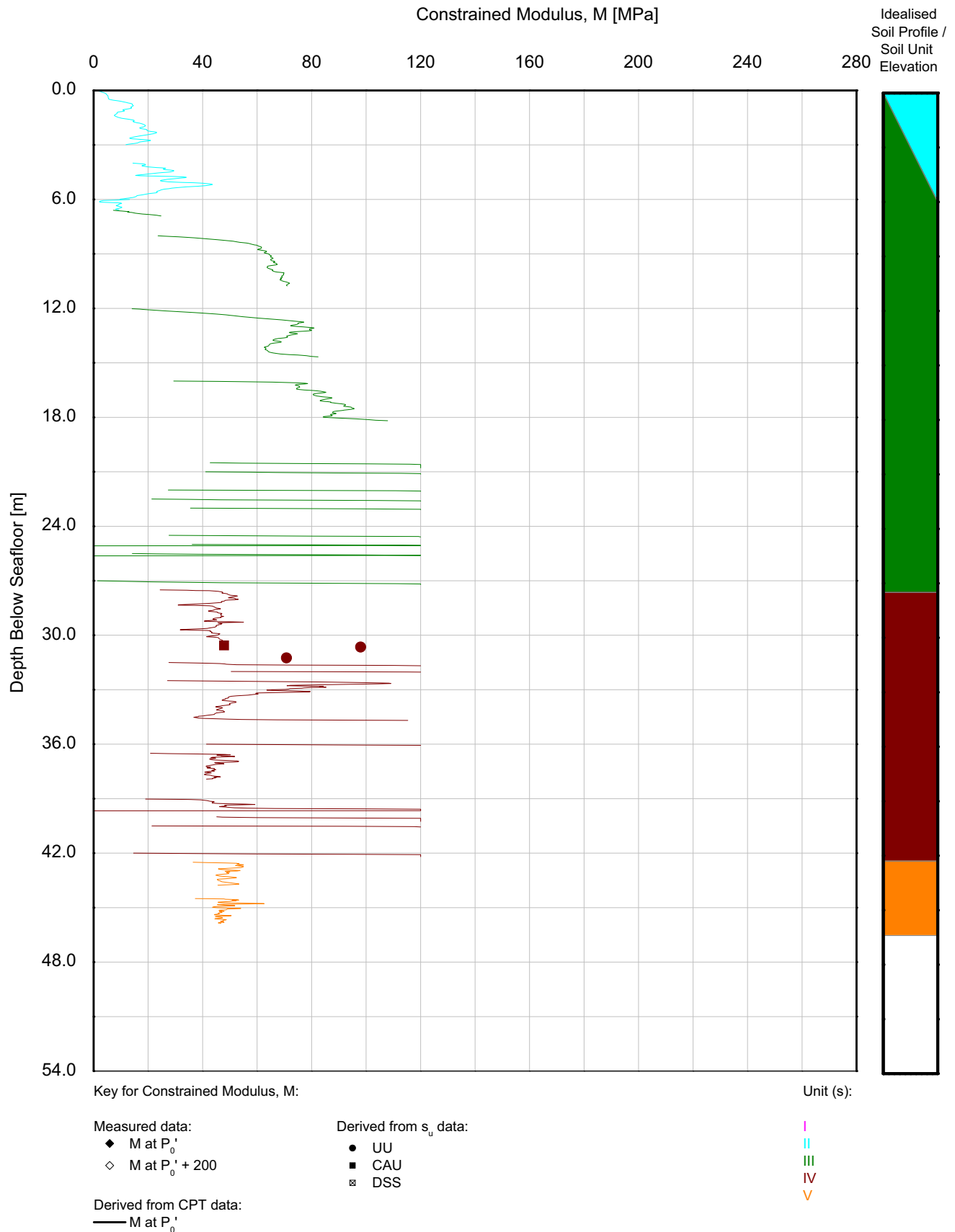
EFFECTIVE OVERBURDEN AND PRECONSOLIDATION PRESSURES versus DEPTH
SOIL PROVINCE IV
Rampion Offshore Wind Farm Site Investigation



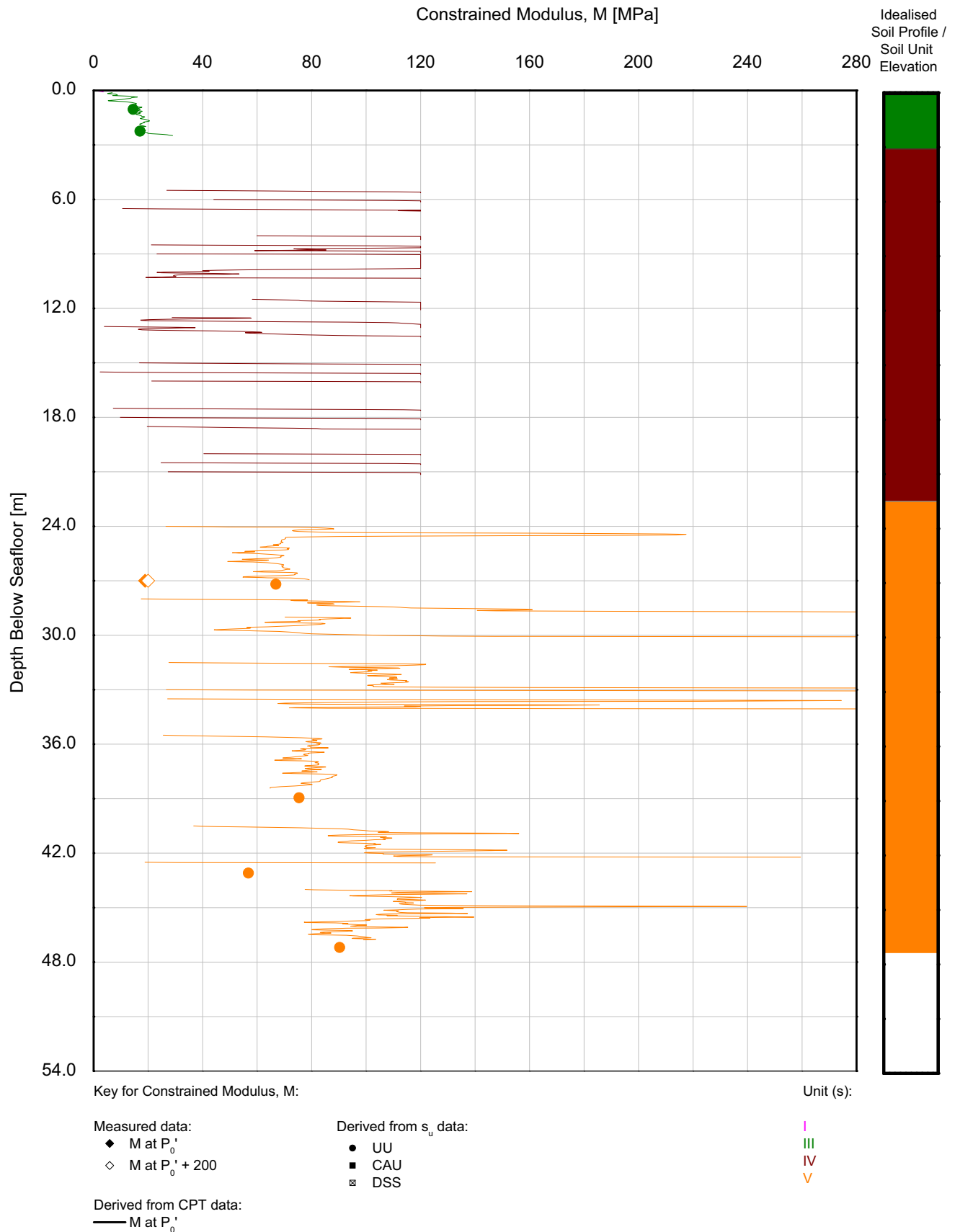
EFFECTIVE OVERBURDEN AND PRECONSOLIDATION PRESSURES versus DEPTH
SOIL PROVINCE V
Rampion Offshore Wind Farm Site Investigation



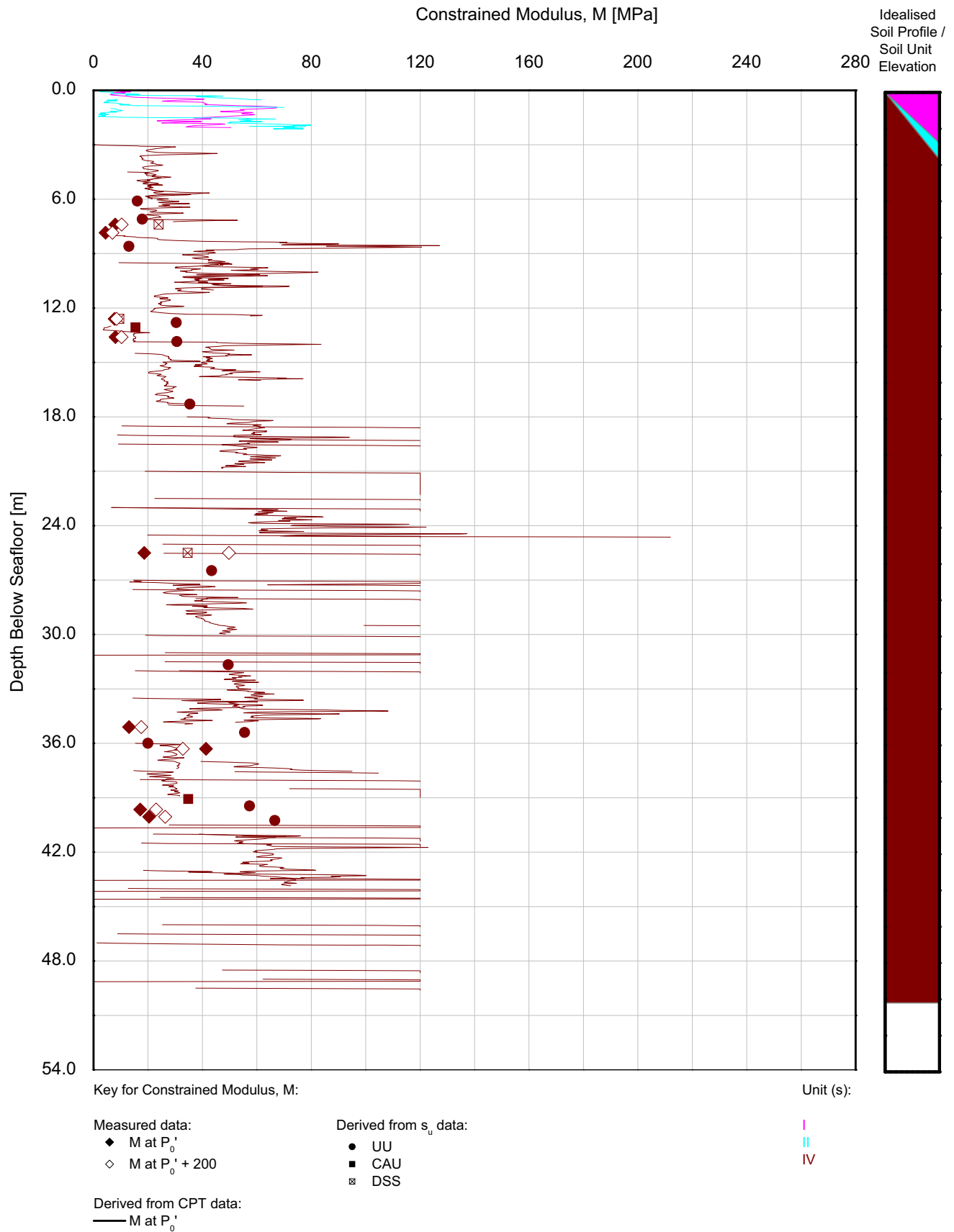
EFFECTIVE OVERBURDEN AND PRECONSOLIDATION PRESSURES versus DEPTH
SOIL PROVINCE VI
Rampion Offshore Wind Farm Site Investigation



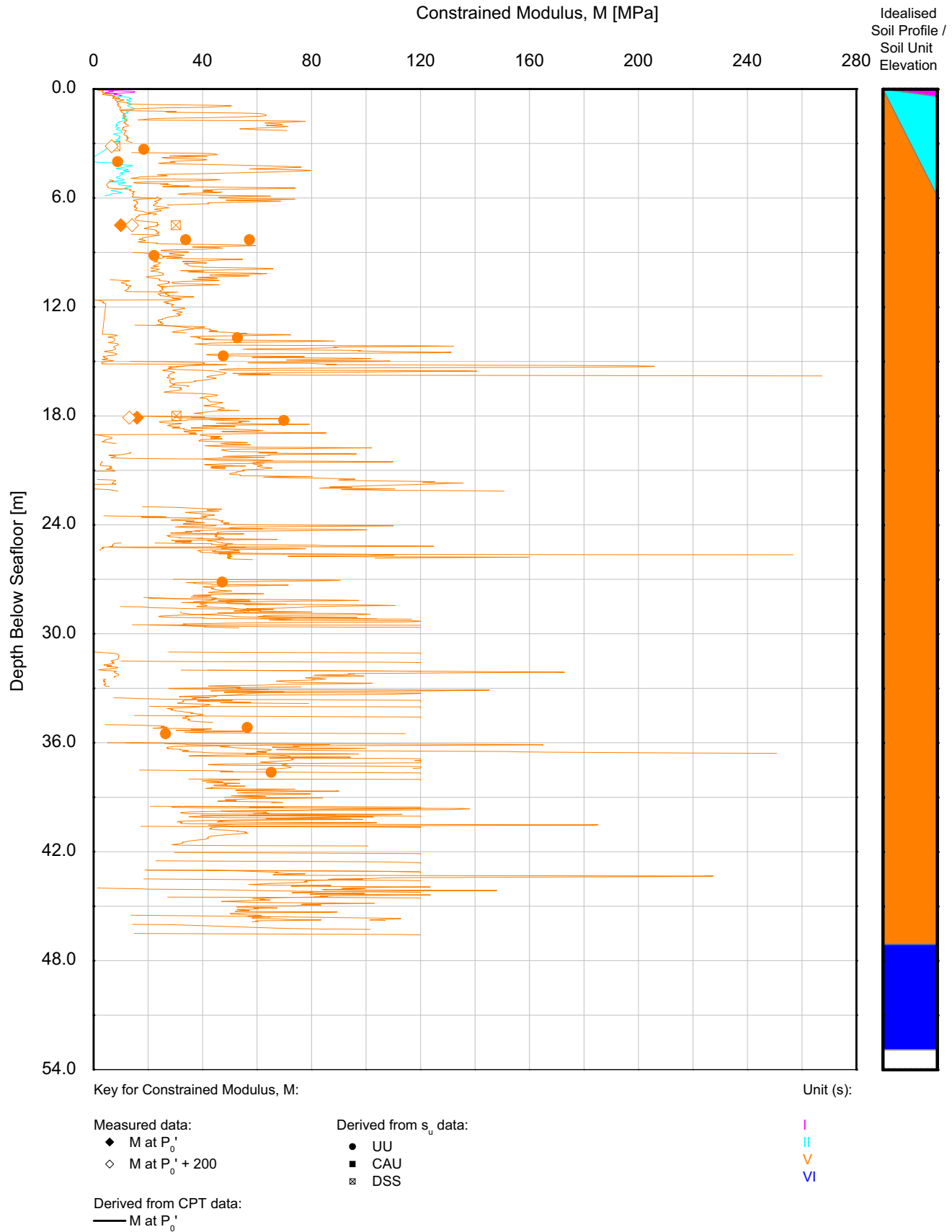
CONSTRAINED MODULUS versus DEPTH
 SOIL PROVINCE I
 Rampion Geotechnical Site Investigation 2011



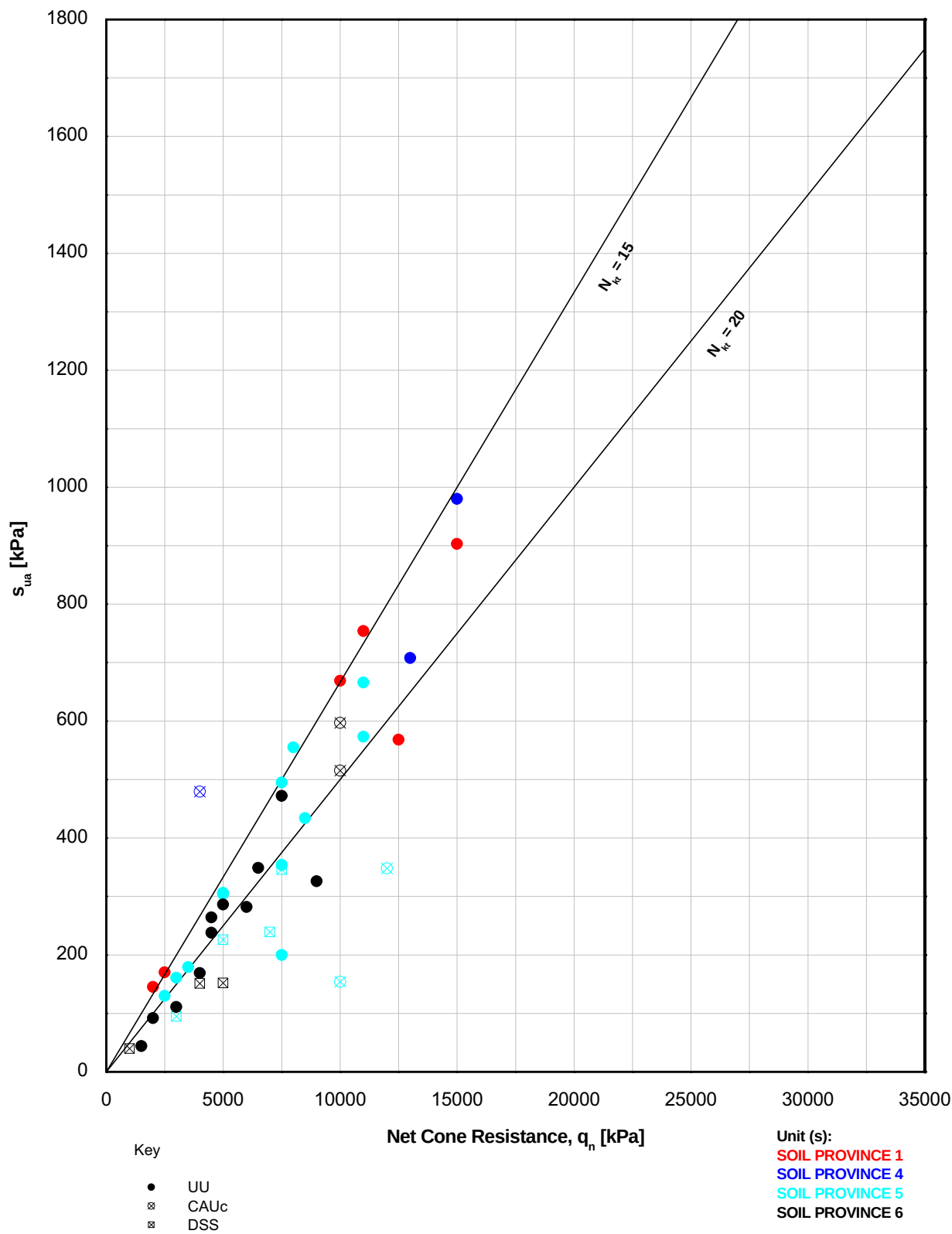
CONSTRAINED MODULUS versus DEPTH
 SOIL PROVINCE IV
 Rampion Geotechnical Site Investigation 2011

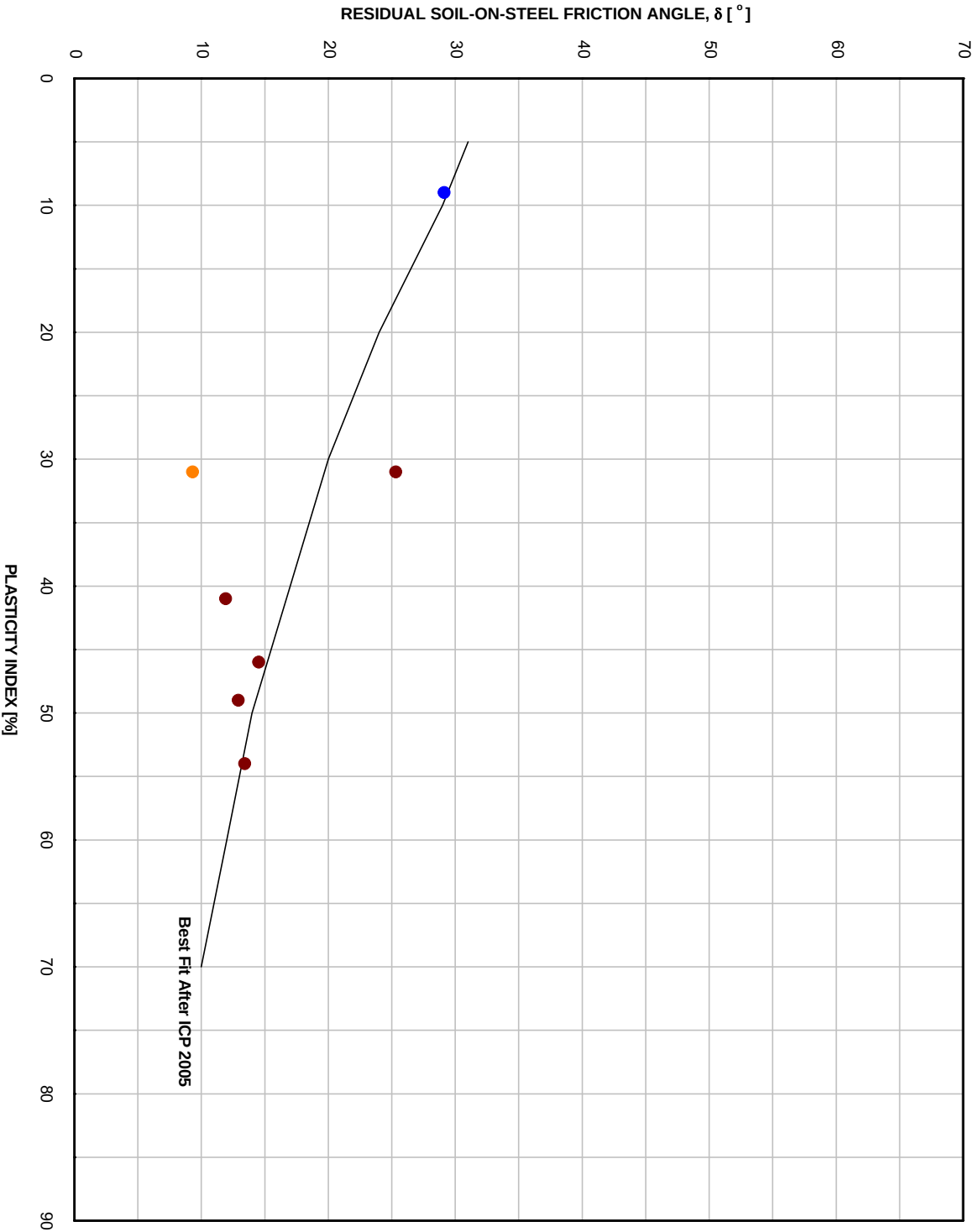


CONSTRAINED MODULUS versus DEPTH
 SOIL PROVINCE V
 Rampion Geotechnical Site Investigation 2011



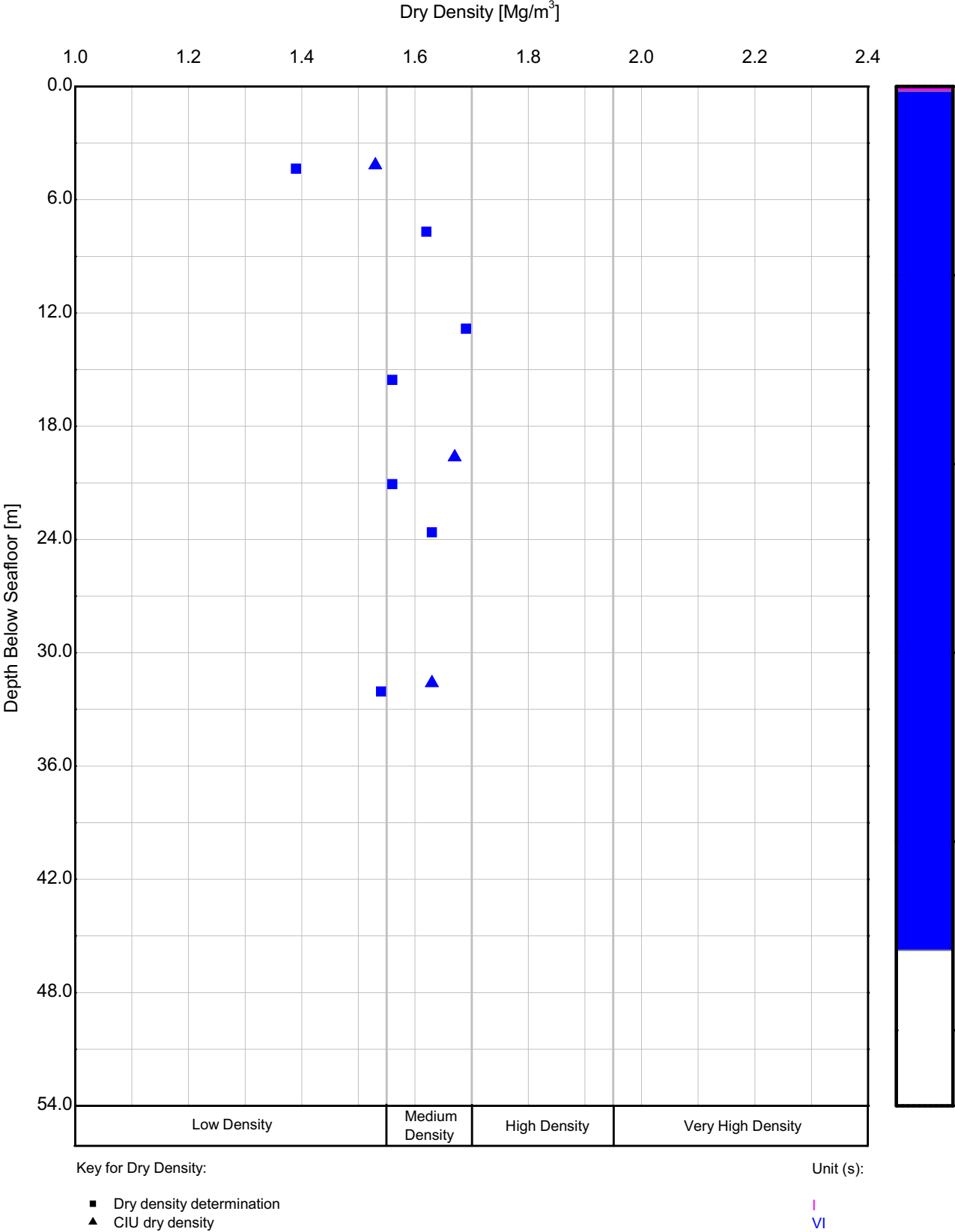
CONSTRAINED MODULUS versus DEPTH
 SOIL PROVINCE VI
 Rampion Geotechnical Site Investigation 2011





Locations:
SOIL PROVINCE 3 - Unit VI
SOIL PROVINCE 5 - Unit IV
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RESIDUAL SOIL-STEEL FRICTION ANGLE versus PLASTICITY INDEX
SOIL PROVINCE III, V AND VI
Rampion Offshore Wind Farm Site Investigation



DRY DENSITY versus DEPTH (FOR CHALK)
SOIL PROVINCE III
Rampion Geotechnical Site Investigation 2011

SECTION A.3

LIST OF SYMBOLS AND CLASSIFICATION SYSTEM USED

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A.3 LIST OF SYMBOLS AND CLASSIFICATION SYSTEM USED

A.3.1 LIST OF SYMBOLS AND TERMS

a	=	attraction (in terms of effective stress) (Use List Style)
A_f	=	Skempton's pore-water pressure parameter at failure
B	=	Skempton's pore-pressure parameter
BSF	=	below seafloor
(CC)	=	core catcher 'tulip' used in sample tube
c'	=	cohesion (in terms of effective stress)
c_v	=	coefficient of consolidation
CAUc	=	anisotropically consolidated undrained triaxial compression test
CAUe	=	anisotropically consolidated undrained triaxial extension test
CIU	=	isotropically consolidated undrained triaxial test
CPT	=	cone penetration test
CRS	=	constant rate of strain 'oedometer' test
D	=	Janbu's 'D' parameter
D_r	=	relative density
DSS	=	static direct simple shear test
CSS	=	cyclic direct simple shear test
E_d	=	drained elastic modulus
E_u	=	undrained elastic modulus
E_{50}	=	secant elastic modulus (measured at half the deviator stress at failure)
e	=	voids ratio
e_o	=	initial voids ratio
FC	=	fallcone
G	=	shear modulus
I_p	=	plasticity index = $w_L - w_p$
k	=	coefficient of permeability
L & F	=	Ladd et al. (1977)
LI	=	liquidity index
LL	=	liquid limit
LV	=	labvane
M	=	constrained modulus (one-dimensional consolidation)
m	=	Janbu (1985) deformation parameter
m_v	=	coefficient of compressibility
M & K	=	Mayne and Kulhawy (1982)
MC	=	moisture content
n	=	porosity

N	=	number of cycles
N_F	=	number of cycles to failure
N_{kt}	=	cone factor (q_{net}/s_u)
OCR	=	overconsolidation ratio (p_c'/p_o')
OED	=	incremental oedometer test
K_o	=	coefficient of earth pressure at rest
P72	=	Piston sample in sample tube of 72mm internal diameter
PD	=	particle density
PI	=	plasticity index
PL	=	plastic limit
PP	=	pocket penetrometer
PSD	=	particle size distribution
p'	=	$(\sigma_1' + 2K_o \sigma_3')/3$
p_o'	=	effective overburden pressure in situ
Δp	=	$p_c' - p_o'$
p_c'	=	vertical effective pre-consolidation pressure in situ
p_r'	=	reference stress for Janbu (1985) approach to settlement calculation
q	=	$(\sigma_1' - \sigma_3')$
s'	=	$(\sigma_1' + \sigma_3')/2$
SD	=	standard deviation
S & N	=	Skempton and Northey (1952)
S_r	=	degree of saturation
s_u	=	undrained shear strength
s_{ua}	=	undrained shear strength from CAUc test
s_{ud}	=	undrained shear strength from DSS test
s_{uu}	=	undrained shear strength from UU test
s_{up}	=	undrained shear strength from CAUe test
$s_{u(pp)}$	=	undrained shear strength from pocket penetrometer test
$s_u(R)$	=	remoulded shear strength
(TW)	=	Thick walled shelby tube
t	=	$(\sigma_1 - \sigma_3)/2$
TV	=	torvane
UU	=	unconsolidated undrained triaxial compression test
u	=	pore-water pressure
u_f	=	pore-water pressure at failure
u_N	=	pore-water pressure after N cycles
W72	=	WIP sample in sample tube of 72mm internal diameter
W50	=	WIP sample in sample tube of 50mm internal diameter

w	=	water content
w_i	=	initial water content
w_f	=	final water content
w_L	=	liquid limit
w_p	=	plastic limit
$\Delta\sigma_1$	=	change in major principal stress, σ_1
$\Delta\sigma_2$	=	change in minor principal stress, σ_2
$\Delta\sigma_3$	=	change in minor principal stress, σ_3
$\Delta\sigma_d$	=	change in deviator stress ($\Delta\sigma_a - \Delta\sigma_r$)
$\Delta\sigma_r$	=	change in total radial stress
$\Delta\sigma_r'$	=	change in effective radial stress
$\Delta\sigma_m'$	=	change in mean effective stress
$\Delta\sigma_v$	=	change in total vertical stress
$\Delta\sigma_v'$	=	change in effective vertical stress
Δu	=	change in pore-water pressure
Δu_f	=	change in pore-water pressure at failure
ε_{50}	=	vertical strain at half the maximum deviator stress
ε_v	=	vertical strain
ε_{vc}	=	vertical strain after consolidation
ε_{vf}	=	vertical strain at failure
ε_{vol}	=	volumetric strain
$\tan \phi$	=	internal friction
$\tan \rho$	=	mobilised internal friction
β	=	ratio of pore-water pressure generation in cyclic test relative to number of cycles and confining pressure.
β	=	pore-water pressure correction factor (CPTu)
ϕ_u	=	undrained friction angle
ϕ_d	=	drained friction angle
ϕ'	=	effective friction angle
ϕ_{cv}	=	friction angle at constant volume
ϕ_{res}	=	ultimate friction angle at large strain
γ_w	=	unit weight of water
γ_{av}	=	average cyclic shear strain
γ_{cy}	=	cyclic shear strain
γ_f	=	shear strain at failure
γ'	=	effective unit weight of soil
γ_d	=	unit dry weight of soil
γ_{dmin}	=	minimum dry unit weight of soil

γ_{dmax}	=	maximum dry unit weight of soil
γ_N	=	cyclic shear strain after N cycles
γ_s	=	unit weight of solid particles
ρ	=	density of soil
ρ_s	=	density of solid particles
σ_1'	=	effective major principal stress
σ_3'	=	effective minor principal stress
σ_c'	=	effective consolidation pressure (isotropic)
σ_r'	=	radial effective stress
σ_{rc}'	=	radial effective consolidation stress
σ_v'	=	vertical effective stress
σ_{vc}'	=	vertical effective consolidation stress
σ_{oct}'	=	octahedral stress
τ	=	shear stress
τ_{av}	=	average shear stress during cyclic test
τ_{cy}	=	cyclic shear stress
τ_{res}	=	residual horizontal shear stress at large strain
#	=	test performed offshore

A.3.2 SOIL CLASSIFICATION SYSTEM

The limits of consistency that have been adopted for the predominantly cohesive soils are based on BS 5930 (1999), and are presented in Table A.4.1. Note that an additional range for "Very Hard" soils is included to cover the full range of strength of soils.

Table A.3.1: Ranges of Shear Strength for Soil Description

Consistency	Shear Strength [kPa]
Very soft	0 – 20
Soft	20 – 40
Firm	40 – 75
Stiff	75 – 150
Very Stiff	150 – 300
Hard	300 – 600
Very Hard	Greater than 600

The limits of consistency adopted in sand soils are based on the ranges presented in Table A.4.2 (Lambe and Whitman, 1969).

Table A.3.2: Ranges of Relative Density for Soil Description

Consistency	Relative Density [%]
Very Loose	0 – 15
Loose	15 – 35
Medium Dense	35 – 65
Dense	65 – 85
Very Dense	85 – 100

A.3.3 CHALK CLASSIFICATION SYSTEM

The limits of consistency that have been adopted for the rock core samples are based on BS 5930 and EN ISO 14689-1 methods, and are presented in Tables A.4.3 and A.4.4 below.

Figures presented in the geotechnical logs in Section B.1 are listed as:

Table A.3.3: Descriptive terms relating to RQD (BS 5930)

RQD %	Term
0 to 25	Very Poor
25 to 50	Poor
50 to 75	Fair
75 to 90	Good
90 to 100	Excellent

- (i) **RQD: Rock Quality Designation.** The length of solid core recovered in pieces each more than 100mm long as a percentage of the core run. See equation below:

$$RQD = 100e^{-0.01\gamma} (0.1\gamma + 1)$$

Where:

γ = Number of fractures per metre or FI (Fracture Index)

- (ii) **TCR: Total Core Recovery.** The length of the total amount of core sample recovered, expressed as a percentage of the length of the core run.
- (iii) **SCR: Solid Core Recovery.** The length of solid core recovered, expressed as a percentage of the core run. Solid core is defined as that length of core which has a full diameter, but not necessarily a full circumference. Only natural fractures are considered. Drilling or handling induced fractures are ignored.
- (iv) **FI: Fracture Index.** The number of discontinuities expressed as fractures per metre, measured over any convenient length of consistent fracture characteristics. Zones of atypical fracturing are identified within the description of strata.

Table A.3.4: Rock material strength (BS 5930) and BS EN ISO 14689-1

RQD %	Term	MPa
Extremely Weak	Gravel-sized lumps may be crushed between finger and thumb. Can be indented by finger nail	0.6 - 1.0
Very Weak	Crumbles under firm hammer blows, can be peeled by knife	1.0 - 5.0
Weak	Can be peeled with difficulty, hammer makes shallow indents	5.0 – 25.0
Medium Strong	Cannot be peeled with knife, rock can be broken by a single hammer blow	25.0 – 50.0
Strong	When resting on a solid surface, rock can be broken by hammer blows	50.0 – 100.0
Very Strong	Requires many hammer blows to break specimen	100.0 – 250.0
Extremely Strong	Rock rings on hammer blows. Only broken by sledge hammer	>250

SECTION A.4

REFERENCES

A.4 REFERENCES

1

A.4 REFERENCES

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PART B

GEOTECHNICAL DATA

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B. SUMMARY

Fugro GeoConsulting Limited (FGCLTD) has been requested by E.on Energy and Renewables (E.on) to produce a factual geotechnical report to assist in the design and development of the Rampion field located in Block 3/28 of the UK Sector of the North Sea.

The data obtained from the geotechnical site investigation at the Rampion field is to assist in determining geotechnical parameters for use in the installation of the proposed monopole met mast and wind turbine locations.

The work was performed from the M/V Saltire from 27 March to 06 April 2011 and from the M/V Willendeavour from the 5 April to 9 April 2011, in accordance with instructions received from E.on.

The water depth, relative to mean sea level, ranged between 8.2 m and 44.9 m corrected to Lowest Astronomical Tide (LAT) at the Rampion site.

Part B of this report presents:

- (i) Borehole and CPT Logs;
- (ii) Results of laboratory testing;
- (iii) Results of cone penetration tests;
- (iv) Laboratory method statements;
- (v) Laboratory and in-situ data report from Fugro Alluvial Limited (FAOL)

Further classification and advanced testing was performed onshore to compliment the offshore work and aid with design. Incremental oedometer testing has been performed to provide data on stress history and to provide settlement parameters and consolidated triaxial and ring shear tests have been performed to provide additional data for use in design.

The final scope of work is presented in Table B.1 and Table B.2 and a summary soil conditions found at the Rampion location is presented in Table B.3 to Table B.15. A summary of the laboratory testing is presented in Table B.16.

It should be noted that this report focusus on the data relevant to the geotechnical site investigation conducted from the M/V Fugro Saltire. All data relating to the work carried out from the M/V Willendeavour has been presented in Section B.15 in a laboratory and in-situ report prepared by FAOL.

Table B.1: Summary of Site Work – M/V Fugro Saltire

Location	Final Penetration [m BSF]	Sampling and Testing Details (successful samples/tests only)
BH_02	46.4	19 CPT and 24 Samples
BH_04	47.4	29 CPT and 24 Samples
BH_04a	4.2	6 Samples
BH_06	52.9	17 CPT, 37 Samples and 3 Hammers
BH_07	45.8	23 CPT, 31 Samples and 2 Hammers
BH_13	45.2	27 CPT, 27 Samples and 8 Hammers
BH_14	50.2	23 CPT and 25 Samples
BH_16	46.4	26 CPT, 19 Samples and 5 Hammers
BH_17	45.1	24 CPT and 25 Samples

Notes:

Table excludes number of tests of nil penetration / no recovery

BSF = Below seafloor

Table B.2: Summary of Site Work – M/V Willendeavour

Location	Final Penetration [m BSF]	Sampling and Testing Details (successful samples/tests only)
VC_03	5.6	1 Vibrocore
CPT_03	5.2	1 CPT
VC_18C	2.6	1 Vibrocore
CPT_18C	3.2	1 CPT
VC_19C	4.0	1 Vibrocore
CPT_19C	1.0	1 CPT
CPT_19Ca	1.2	1 CPT
VC_20C	1.9	1 Vibrocore
VC_20Cb	1.4	1 Vibrocore
CPT_20C	3.2	1 CPT
VC_21C	3.7	1 Vibrocore
CPT_21C	3.0	1 CPT

Soil Conditions

The soil conditions encountered during the investigation are summarised in Table B.3 and Table B.15 below. They are believed to adequately represent the soil units present at the site. Details on classification and strength testing are describe further in this section

Table B.3: Summary of Soil Conditions – Metmast Location BH_13

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
II	0.0	3.7	Pale olive to very dark grey sandy silica GRAVEL with cobbles. Clasts are sub-angular to sub-rounded of flint
IVa	3.7	17.6	Stiff to hard very dark greenish grey slightly sandy CLAY with thin to very thin beds and fine to coarse gravel-sized pockets of very dark greenish grey silty silica sand
IVc	17.6	33.5	Very dense dark grey to dark greenish grey fine silica SAND
IVd	33.5	44.2	Hard to very hard dark olive grey to dark grey slightly sandy CLAY with fine to medium gravel-sized pockets of dark greyish brown slightly silty silica sand
IVe	44.2	45.2*	Dark grey silty fine silica SAND occasionally with medium gravel-sized pockets of black clay with mica crystals

Notes:

BSF = Below seafloor

Table B.4: Summary of Soil Conditions – Metmast Location BH_14

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	2.8	Medium dense to dense dark greyish green very silty silica fine SAND with fine gravel-sized pockets of dark greenish grey clay with medium to coarse sub-angular to sub-rounded silica gravel
IVa	2.8	11.8	Stiff to Hard dark greenish grey slightly sandy CLAY with closely spaced thin laminae of grey and black fine to medium silica sand
IVb	11.8	31.0	Thinly to thickly interlaminated very stiff to hard dark greenish grey slightly sandy CLAY and fine to medium greenish grey silica SAND with traces of fine black silica sand and evidence of bioturbation (burrows)
IVd	31.0	37.5	Stiff to very hard dark greenish grey slightly sandy CLAY
IVe	37.5	50.2*	Very dense dark greenish grey slightly clayey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table B.5: Summary of Soil Conditions – BH_02

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.4	Very loose to medium dense SAND
Ila	0.4	5.9	Medium dense to dense very dark greenish grey fine silty silica SAND with closely spaced thick laminae and fine to medium gravel-sized pockets of dark grey sandy clay with fine to medium gravel-sized pockets of greenish grey fine silica sand
Vd	5.9	12.1	Very stiff to hard dark greenish grey slightly sandy CLAY with traces of fine gravel-sized pockets of black staining
Ve	12.1	46.4*	Thinly interlaminated to medium interbedded very dark to dark greenish grey silty fine to medium silica SAND and very dark to dark greenish grey slightly sandy CLAY occasionally with fine to coarse gravel-sized pockets of sandy clay to clayey silica sand

Notes:

BSF = Below seafloor

* = End of Borehole

Table B.6: Summary of Soil Conditions – BH_04/04a

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.1	Very loose to loose dark greenish grey fine to coarse silica SAND with fine to medium gravel and fine to coarse gravel-sized shells fragments and shells
IIIb	0.1	3.1	Firm to very stiff dark greenish grey to dark grey slightly sandy CLAY with fine gravel-sized shell fragments and shells
IVc	3.1	22.5	Dense to very dense dark greenish grey to dark grey silty to very silty fine silica SAND
Va	22.5	39.5	Hard to very hard dark grey slightly sandy CLAY with fine to medium gravel-sized pockets of dark greenish grey fine to medium silica sand
Vb	39.5	47.4*	Hard to very hard greenish grey sandy SILT with coarse gravel-sized pockets and laminations of grey fine silica sand

Notes:

BSF = Below seafloor

* = End of Borehole

Table B.7: Summary of Soil Conditions – BH_06

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.3	Medium dense to dense SAND
Va	0.3	19.0	Stiff to very stiff dark grey slightly sandy CLAY with fine gravel-sized pockets of grey sand
Vb	19.0	26.1	Dark to very dark grey slightly sandy SILT
Ve	26.1	31.0	Very stiff to hard very dark greenish grey slightly sandy CLAY and medium dense to very dense dark greenish grey slightly silty fine silica SAND with coarse sand-sized to fine gravel-sized shell fragments
Vf	31.0	42.1	Hard to very hard mottled and thinly interlaminated grey and brown CLAY
Vi	42.1	47.1	Very dense dark greyish green fine to medium silica SAND with fine gravel-sized pockets of greenish grey fine to medium silica sand
Vlb	47.1	48.5	Structureless CHALK composed of white silt with closely spaced thin laminations of slightly duller white silt (Grade Dm)
Vlc	48.5	52.9*	Structureless CHALK composed of white creamy silt and medium blocky gravel with traces of fine to medium gravel-sized flint. Chalk clasts are weak, medium density (Grade Dc)

Notes:

BSF = Below seafloor

*= End of Borehole

Table B.8: Summary of Soil Conditions – BH_07

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
I	0.0	0.3	Dense SAND
Vlb	0.3	4.0	Structureless CHALK composed of white silt and fine to coarse blocky gravel with few angular fine to coarse gravel-sized black flint. Chalk clasts are very weak, low density (Grade Dm)
Vlc	4.0	27.0	Structureless CHALK composed of white silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density (Grade Dc)
Vld	27.0	45.8*	Structureless CHALK composed of white silt and fine to coarse angular and blocky gravel. Chalk clasts are weak, low to medium density (Grade Dc)

Notes:

BSF = Below seafloor

*= End of Borehole

Table B.9: Summary of Soil Conditions – BH_16

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIa	0.0	6.0	Loose to medium dense very dark greenish grey to greenish grey slightly silty fine to coarse silica SAND with coarse sand-sized to fine gravel-sized shell fragments
IIIc	6.0	19.0	Dense to very dense very dark greenish grey to greenish grey slightly silty fine to coarse silica SAND
IIId	19.0	22.5	White grey and black sub-angular to sub-rounded fine to coarse silica GRAVEL of mixed lithologies
IIIc	22.5	27.5	Very dense olive grey silty fine silica SAND with sub-angular to sub-rounded medium silica gravel
IVb	27.5	39..5	Thin to medium interbedded dark greyish brown sandy CLAY and very dark greenish grey slightly clayey fine silica SAND
IVc	39.5	42.3	Thinly to medium interbedded dark greenish grey calcareous SANDSTONE with few brown and white fossils and very dark grey fine silica SAND
Vc	42.3	46.4*	Medium dense dark greenish grey to olive grey slightly clayey to very clayey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table B.10: Summary of Soil Conditions – BH_17

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
Ve	0.0	21.0	Thin to thickly interlaminated very stiff to hard greenish grey slightly sandy CLAY with thin laminae of light greenish grey silty fine silica sand and dark greenish grey very silty fine silica SAND
Vf	21.0	28.8	Very stiff to hard dark greenish grey slightly sandy CLAY with very closely to closely spaced thin to thick laminae of greenish grey fine silica sand
Vi	28.8	45.1*	Very dense dark greenish grey to greenish grey fine silica SAND

Notes:

BSF = Below seafloor

* = End of Borehole

Table B.11: Summary of Soil Conditions – VC_03 / CPT_03

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	0.2	Light brown sandy GRAVEL. Sand is fine to coarse. Gravel is ANG-SBR fine to medium of shell and shell fragments
IIIa	0.2	0.4	Very dark brown spongy PEAT
IIIb	0.4	2.5	Very soft to soft light grey CLAY
IIIb	2.5	3.5	Light grey sandy SILT. Sand is fine
IIIb	3.5	4.0	Soft grey CLAY
IIIb	4.0	5.0	Light grey SILT
IIIb	5.0	5.4*	Very soft light grey CLAY

Notes:

BSF = Below seafloor

* = End of Borehole

ANG = Angular

SBR = Sub-rounded

Table B.12: Summary of Soil Conditions – VC_18C / CPT_18C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	1.0	Light grey/white sandy GRAVEL. Sand is fine to coarse. Gravel is SBA - SBR fine to coarse of mixed lithologies
IIId	1.0	3.2*	White clayey sandy GRAVEL. Sand is fine to coarse. Gravel is SBA fine to coarse of chalk (Structure-less granular chalk - grain supported with intergranular chalk putty/clay)

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

Table B.13: Summary of Soil Conditions – VC_19C / CPT_19C / CPT_19Ca

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIa	0.0	3.8*	Grey/brown gravelly SAND. Sand is fine to coarse. Gravel is ANG - SBR fine to medium of shell, shell fragments and mixed lithologies From 2.00m ... Becoming light brown/tan

Notes:

BSF = Below seafloor, SBR = Sub-Rounded

* = End of Borehole, SBA = Sub-angular

Table B.14: Summary of Soil Conditions – VC_20C / VC_20Cb / CPT_20C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	0.0/1.0	Brown sandy GRAVEL.. Sand is fine to coarse. Gravel is SBR fine to coarse of mixed lithologies.
IIa	0.0	0.0/1.0	Brown silty gravelly SAND. Sand is fine to coarse. Gravel is ANG - SBR fine to medium of shell, shell fragments and mixed lithologies
IIIb	1.0	3.2*	Soft to very stiff grey CLAY

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

Table B.15: Summary of Soil Conditions – VC_21C / CPT_21C

Depth Range of Soil [m BSF]			Soil Description
Soil Unit	Top	Base	
IIb	0.0	1.0	Light grey/white sandy GRAVEL. Sand is fine to coarse. Gravel is SBA - SBR fine to coarse of mixed lithologies
IIId	1.0	3.5*	White clayey sandy GRAVEL. Sand is fine to coarse. Gravel is SBA fine to coarse chalk. (Structure-less granular chalk - grain supported with intergranular chalk putty/clay)

Notes:

BSF = Below seafloor

* = End of Borehole

SBA = Sub-angular

SBR = Sub-Rounded

Table S.16: Summary of Laboratory testing

Test Type	Offshore Tests	Onshore Tests (BH_13 & 14)	Onshore Tests (All other Locations)
Natural Moisture Content Determination	222	-	-
Bulk and Dry Density Determination	216	-	-
Pocket Penetrometer Test	118	-	-
Torvane Test	32	-	-
Particle Size Distribution (Sieve Analysis)	-	13	46
Particle Size Distribution (Pipette & Hydrometer Analysis)	-	24	74
Atterberg Limits	-	19	57
Saturated Moisture Content Determination	-	-	2
Particle Density Determination	-	12	15
Minimum & Maximum Density Determination	-	6	8
Incremental Oedometer	-	9	4
Unconsolidated Undrained Triaxial Test (Undisturbed)	30	-	2
Unconsolidated Undrained Triaxial Test (Remoulded)	-	12	1
Anisotropically Consolidated Undrained Triaxial Compression Test	-	2	1
Isotropically Consolidated Undrained Triaxial Test	-	-	5
Isotropically Consolidated Undrained Triaxial Test (Set of Three)	-	1	-
Isotropically Consolidated Drained Triaxial Compression Test (Set of Three)	-	4	3
Cyclic Triaxial Tests	-	4	1
Direct Shear (Shearbox) Test (Set of Three)	-	2	4
Static Direct Simple Shear Test	-	4	6
Cyclic Direct Simple Shear Test	-	1	3
Multi-Reversal Shear Box Test	-	3	-
Point Load Test	-	-	2
Ring Shear Test	-	6	2
Carbonate Content Test	-	9	-
Organic Content Test	-	9	-
pH and Total Sulphate Test	-	9	-
Dry Density	-	-	7

Notes:

Unsuitable tests not included

Summary of Fieldwork and Fieldwork Problems

The fieldwork was performed in two stages from the vessel M/V Fugro Saltire from 27 March to 06 April 2011 and from the M/V Willendeavour from the 5 April to 9 April 2011.

A total of nine boreholes of combined sampling and CPT were performed from the M/V Fugro Saltire, with eight boreholes performed to a depth greater than 45 m and an additional borehole performed adjacent to BH_04.

During BH_04, an error was made in tidal correction readings, and it was discovered that the driller had drilled to 4.5 m BSF and not the required 2.5 m BSF. It was decided to continue with BH_04 and an adjacent borehole was performed to fill the data gap to 4.5 m. Corrections were made to all the recovered data and the error in depth records does not affect the quality or reliability of the data.

An error occurred with the UU triaxial testing machine, which meant it was not possible to perform UU testing at BH_02. This does not affect the quality of the data at any other locations, which are believed to adequately represent the soil conditions and show good correlation with the in-situ testing performed.

A total of 6 vibrocores and 6 Wheeldrive CPT were performed at 5 locations from the M/V Willendeavour, with a second CPT and second vibrocore attempt performed at CPT_19Ca and VC_20Cb, respectively.

Whilst attempting to recover the wave rider buoy to the M/V Willendeavour the second section of the rubber bungee became caught on the underneath of the ships anchor. After several attempts to free the bungee it was decided that the safest way to move forward was to un-attach the wave rider buoy and release the rubber with two fender buoys attached and try to manoeuvre the vessel as to free the snagged line. Whilst attempting to manoeuvre the vessel the strain became too much for the rubber and it parted roughly 10 cm below the top connector (which was attached to the two fender buoys). Crew along with a specialist team of divers onboard returned to site to recover the remaining wave buoy equipment. These buoys were then recovered along with the parted top section. The vessel and FAOL crew proceeded to recover the rest of the equipment to deck using both the ships crane and main lift winch.

There were no other major problems associated with the geotechnical investigation.

SECTION B.1

SOIL DESCRIPTION AND BORING PROFILES

B.1	SOIL DESCRIPTION AND BORING PROFILES	1
B.1.1	SUMMARY	1
B.1.2	INTERPRETATION OF UNDRAINED SHEAR STRENGTH FROM CONE PENETRATION TESTS	1
B.1.3	INTERPRETATION OF RELATIVE DENSITY FROM CONE PENETRATION TESTS	1
B.1.4	DISCUSSION OF SOIL CONDITIONS	2

B.1 SOIL DESCRIPTION AND BORING PROFILES

B.1.1 SUMMARY

Borehole logs for the Rampion location are presented in this section. The logs have been compiled based upon laboratory test results and in-situ test data. The borehole logs indicate measured and inferred:

- (i) Soil layering, including classifications of undrained shear strength in fine-grained cohesive soils;
- (ii) Measured undrained shear strength values;
- (iii) Undrained shear strength interpreted from cone penetration test (CPT) data;
- (iv) Measured moisture content and soil density data;
- (v) Measured cone resistance data;
- (vi) Sample and in-situ test depths.

An explanation of the symbols and terms used on the borehole log is presented on Plate B.1-1.

The methods used to interpret the results of CPTs are presented in the following sections.

B.1.2 INTERPRETATION OF UNDRAINED SHEAR STRENGTH FROM CONE PENETRATION TESTS

In fine-grained cohesive (clay) soils, undrained shear strength has been interpreted from CPT data using the relationship:

$$s_u = q_{net}/N_{kt}$$

where :

- s_u is the inferred undrained shear strength (kPa)
- q_{net} is the net cone resistance (kPa)
- N_{kt} is an empirical factor relating cone resistance to undrained shear strength

Based on a review of the s_u and q_{net} data, it has been considered appropriate to adopt an N_{kt} value of 15 – 20 to infer the s_u profiles that are presented on the borehole log. Further details of the methods used to infer q_{net} from CPT data are presented in Section B.10.

B.1.3 INTERPRETATION OF RELATIVE DENSITY FROM CONE PENETRATION TESTS

In cohesionless soil, the relative density has been estimated from the cone resistance data using the following relationship proposed by Jamiolkowski *et al.* (2003):

$$D_r = \left(\frac{1}{0.0296} \right) \ln \left(q_c \div \left(2.494 \left(\frac{\sigma'_m}{100} \right) \right)^{0.46} \right)$$

where:

- D_r is the estimated relative density (%)
 q_c is the measured cone resistance (kPa)
 σ'_m is the estimated mean effective stress at the test depth (kPa)

and:

$$\sigma'_m = \left(\frac{p_o' (1 + 2K_0)}{3} \right)$$

where:

- p_o' is the effective overburden pressure (kPa)
 K_0 is the coefficient of lateral earth pressure

Using the Jamiolkowski *et al.* (2003) chart, which presents a relationship between relative density, cone resistance and mean effective stress, the sensitivity of inferred relative density to changes in estimated horizontal stress may be evaluated. For this report a range of K_0 of between 0.5 and 2.0 has been used to estimate the relative density profiles that are presented on the borehole log.

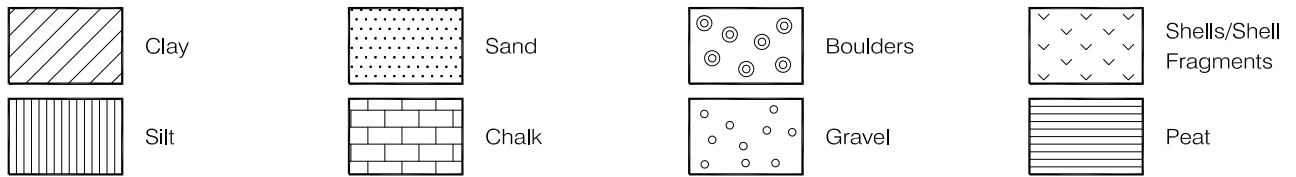
B.1.4 DISCUSSION OF SOIL CONDITIONS

The results of the tests performed both in-situ and on recovered soils, are of good quality and accurately characterise the soils across the Rampion Wind Farm Development. In general there is good correlation with the results obtained from the in-situ testing and laboratory testing.

SOIL DESCRIPTION AND BORING PROFILES

LIST OF PLATES – SECTION B.1

Description	Plate
Symbols and Terms Used on Borehole Logs	B.1-1
BH_13	B.1-2 to B.1-3
BH_14	B.1-4 to B.1-5
BH_02	B.1-6 to B.1-7
BH_04/04a	B.1-8 to B.1-9
BH_06	B.1-10 to B.1-11
BH_07	B.1-12 to B.1-15
BH_16	B.1-16 to B.1-17
BH_17	B.1-18 to B.1-19

SOIL IDENTIFICATION SYMBOLS

Note - Although the soil identification symbols differ from BS 5930 they are used in order to conform with those generally adopted for offshore purposes

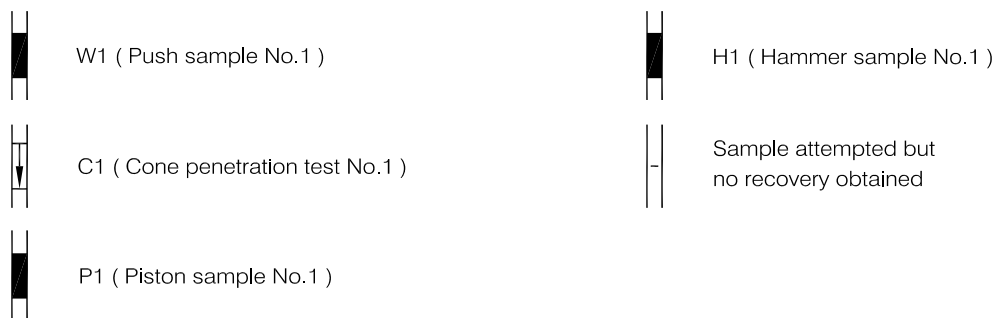
SOIL STRUCTURE SYMBOLS

Note - (I) Pockets are not continuous through the sample
 (II) Partings are 1 to 2 grains thick
 (III) Thinly laminated is under 6mm thick
 (IV) Thickly laminated is between 6 and 20mm thick

(V) Very thinly bedded is between 20 to 60mm thick
 (VI) Thinly bedded is between 60 to 200mm thick
 (VII) Medium bedded is between 200 to 600mm thick
 (VIII) Thickly bedded is between 600 to 2000mm thick
 (IX) Very thickly bedded is over 2000mm thick

SOIL STRATIFICATION SYMBOLS

Note - Depth and thickness of layers detected during drilling are less accurate than those determined by sampling or cone penetration tests

SOIL SAMPLING/TESTING SYMBOLSTERMS FOR SOIL CONSISTENCY AND DENSITY

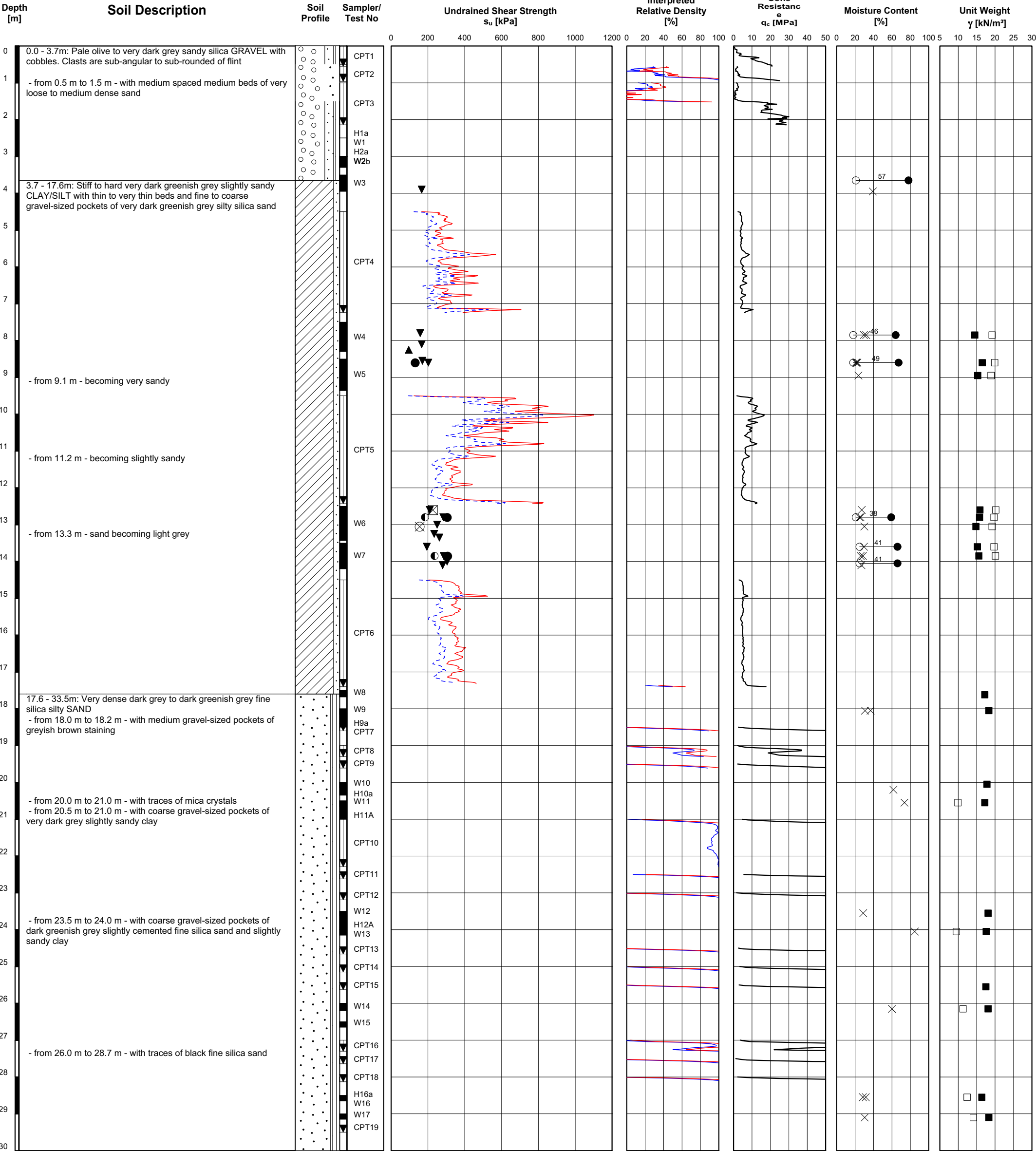
FINE-GRAINED SOILS

CONSISTENCY	UNDRAINED SHEAR STRENGTH (kPa)
VERY SOFT	0 to 20
SOFT	20 to 40
FIRM	40 to 75
STIFF	75 to 150
VERY STIFF	150 to 300
HARD	300 to 600
VERY HARD	Greater than 600

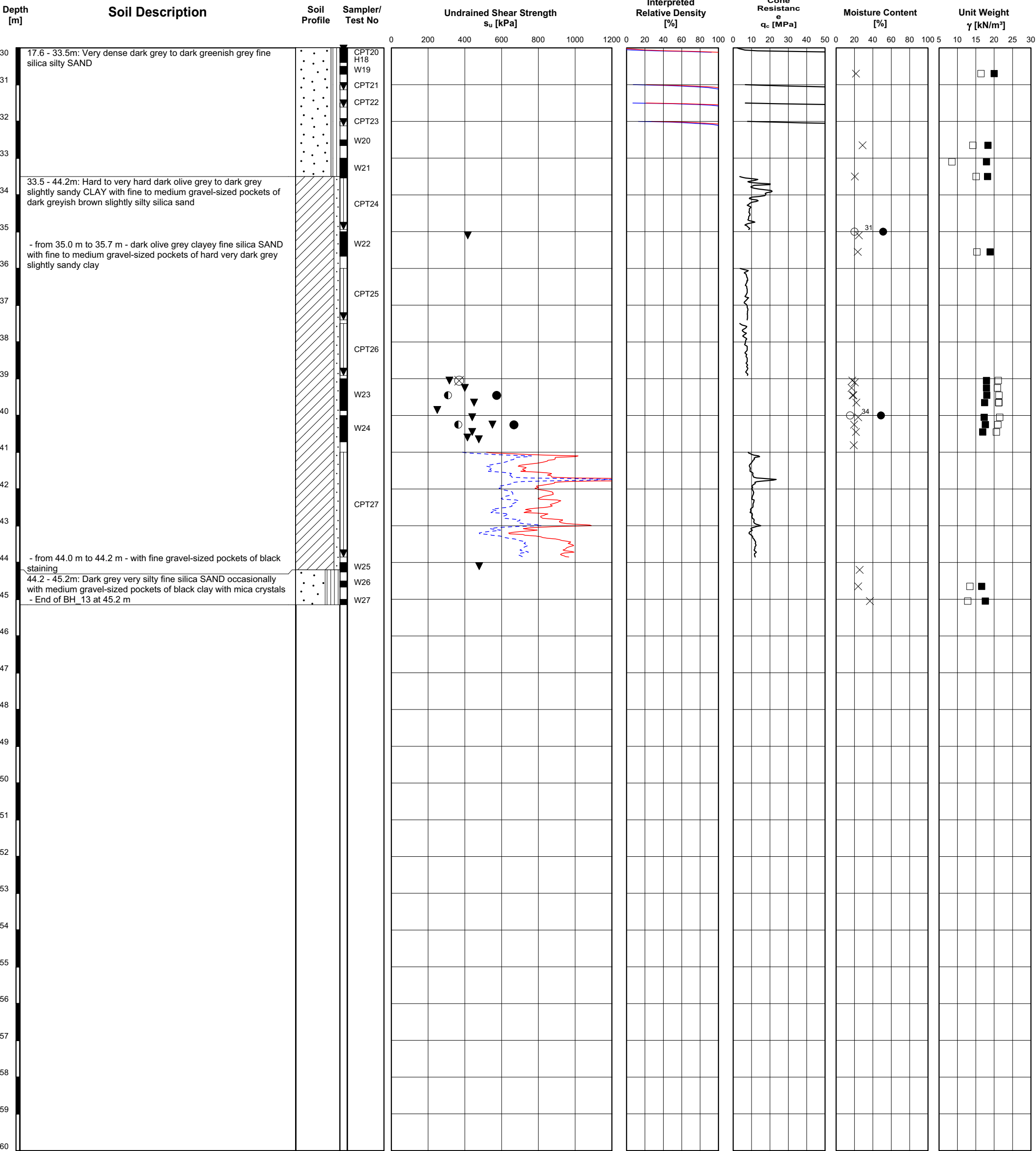
COARSE-GRAINED SOILS

ESTIMATED NATURAL DENSITY	ESTIMATED RELATIVE DENSITY (%)
VERY LOOSE	0 to 15
LOOSE	15 to 35
MEDIUM DENSE	35 to 65
DENSE	65 to 85
VERY DENSE	85 to 100

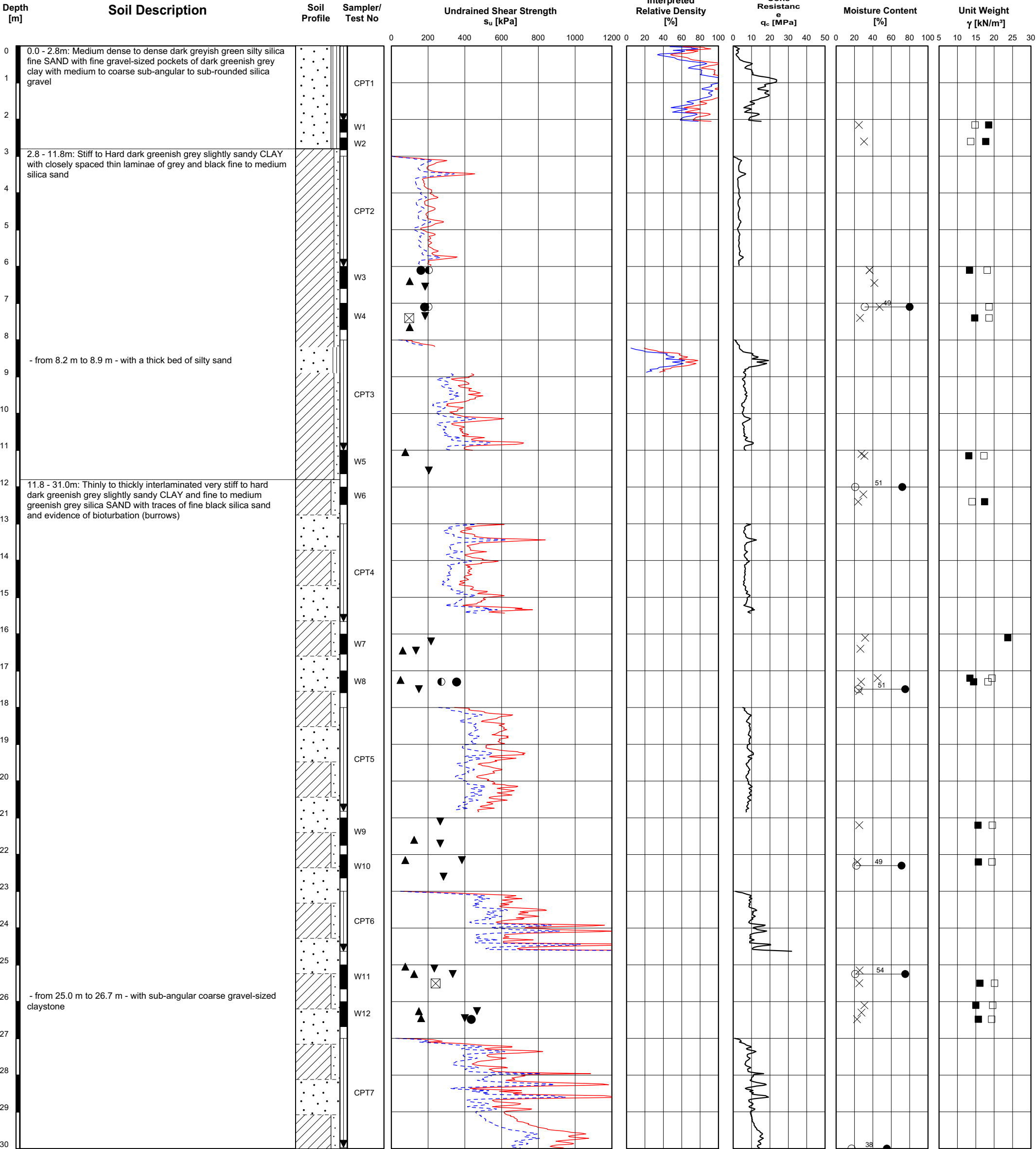
SYMBOLS AND TERMS USED ON BOREHOLE LOGS



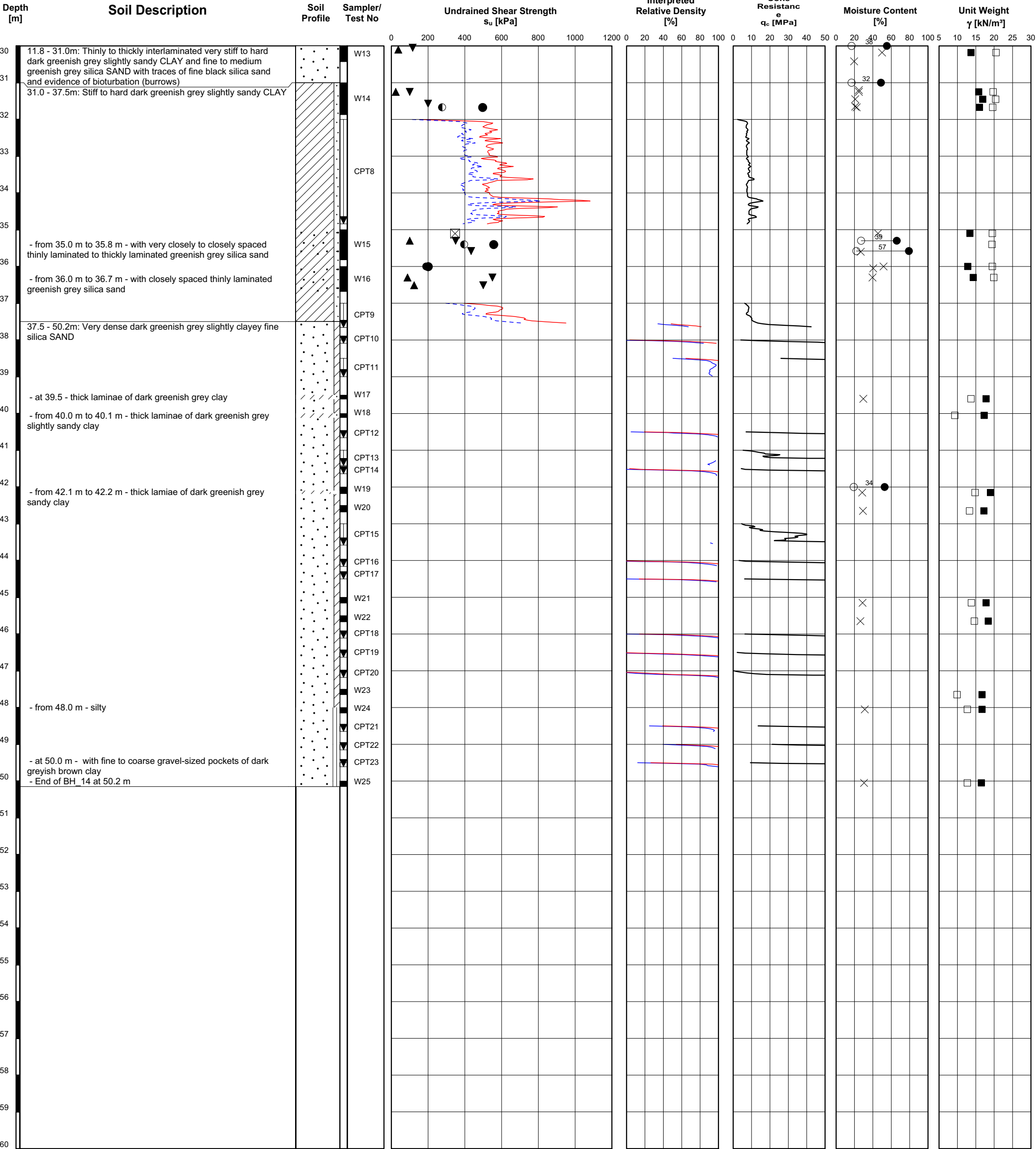
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_13	KEY FOR UNDRAINED SHEAR STRENGTH: ▲s_u (Torvane) ■s_u (Labvane) ●s_u (Undrained Triaxial) +s_u (In-situ Vane) ✱s_u (Remoulded In-situ Vane) estimated from CPT data (N_{kt} = 15 - 20) ▼s_u (Pocket Pentrometer) ◆s_u (Fallcone) ⊗s_u (CAU) ⊠s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ○● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 687654mE 5618494mN ⁽¹⁾	DATE : 28/03/2011 ⁽¹⁾ WATER DEPTH : 19m LAT ⁽¹⁾



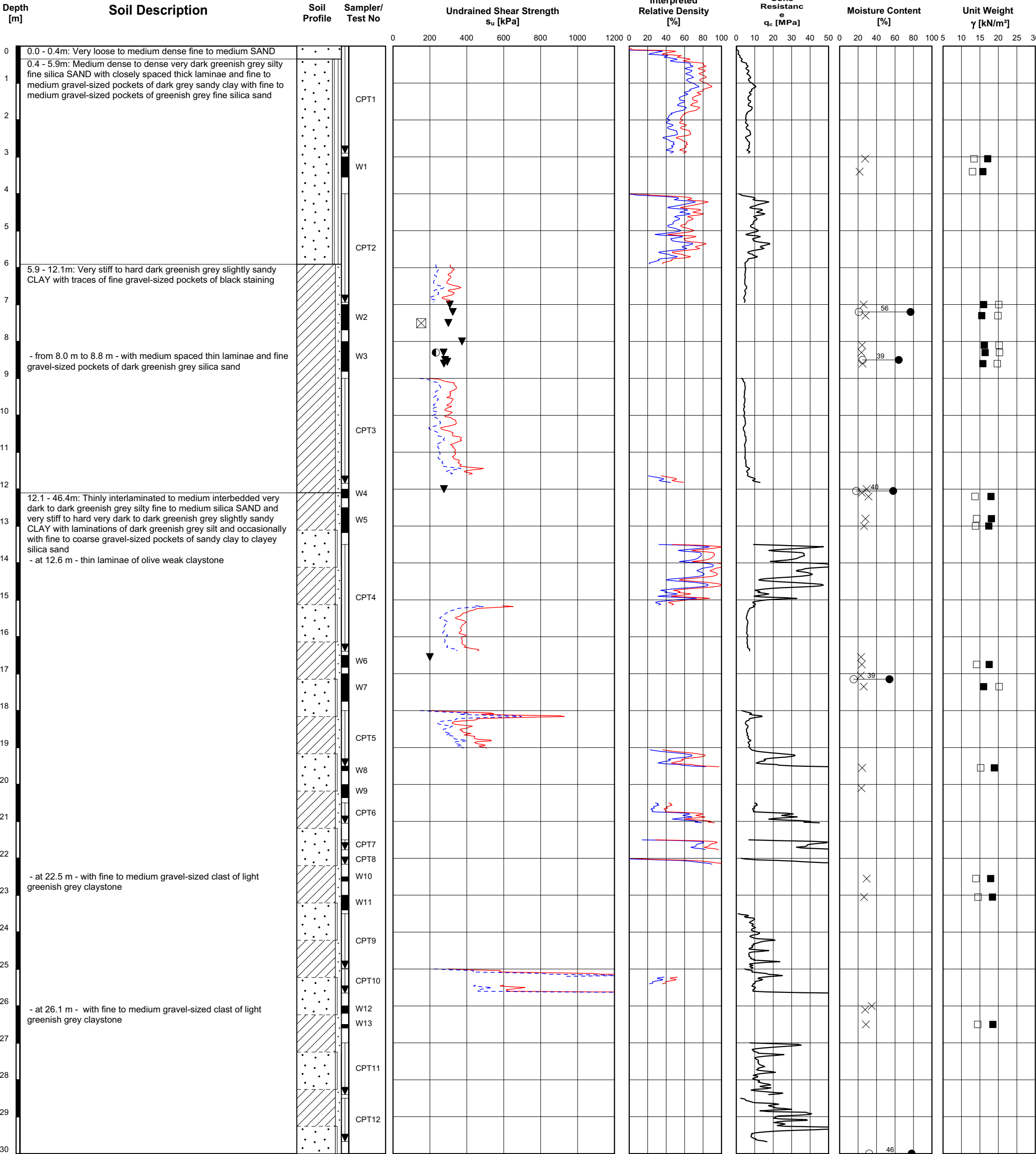
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes(1) BH_13	KEY FOR UNDRAINED SHEAR STRENGTH: ▲su (Torvane) ▼su (Pocket Pentrometer) ■su (Labvane) ◆su (Fallcone) ●su (Undrained Triaxial) ⊗su (CAU) +su (In-situ Vane) ⊠su (DSS) *su (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ●Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION: Rampion Offshore Wind Farm - English Channel CO-ORDINATES: 687654mE 5618494mN (1)	DATE: 28/03/2011 (1) WATER DEPTH : 19m LAT (1)



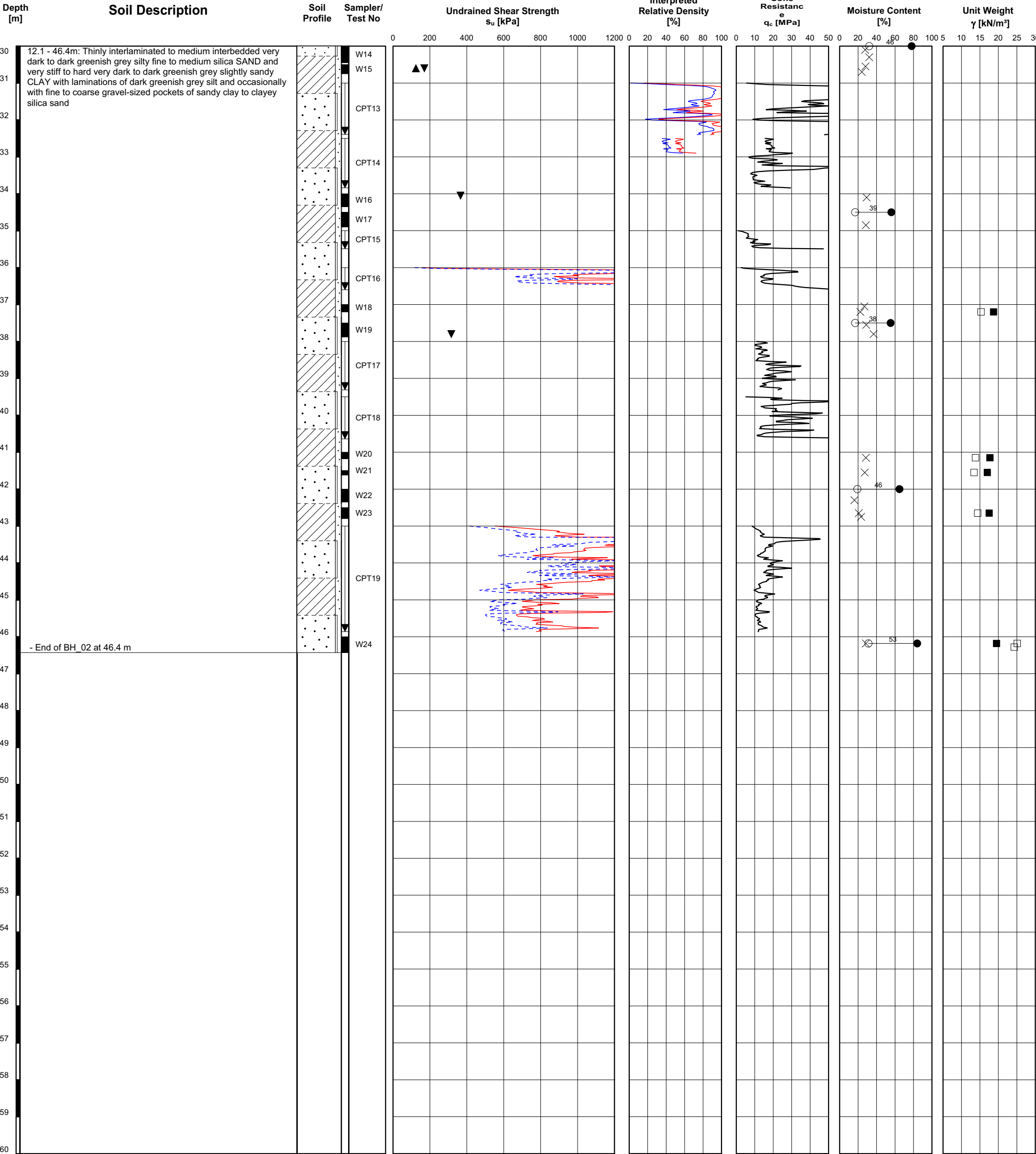
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_14	KEY FOR UNDRAINED SHEAR STRENGTH: ▲s_u (Torvane) ■s_u (Labvane) ●s_u (Undrained Triaxial) +s_u (In-situ Vane) ✱s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼s_u (Pocket Pentrometer) ◆s_u (Fallcone) ⊗s_u (CAU) ⊠s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ○●Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 686487mE 5617486mN ⁽¹⁾	DATE : 29/03/2011 ⁽¹⁾ WATER DEPTH : 20m LAT ⁽¹⁾



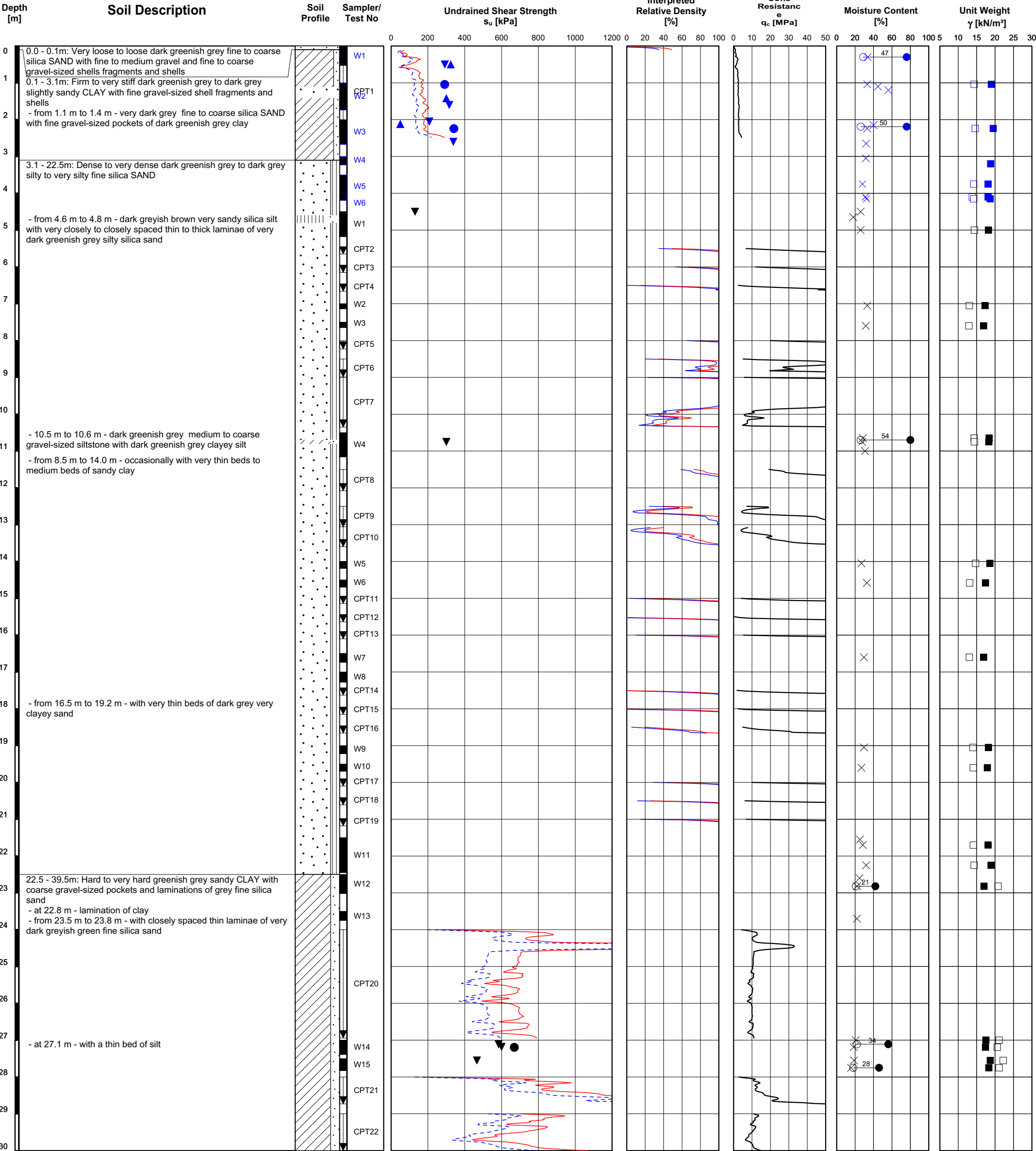
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes(1) BH_14	KEY FOR UNDRAINED SHEAR STRENGTH: ▲su (Torvane) ▼su (Pocket Pentrometer) ■su (Labvane) ◆su (Fallcone) ●su (Undrained Triaxial) ⊗su (CAU) +su (In-situ Vane) ⊠su (DSS) ※su (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ○● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 686487mE 5617486mN (1)	DATE : 29/03/2011 (1) WATER DEPTH : 20m LAT (1)



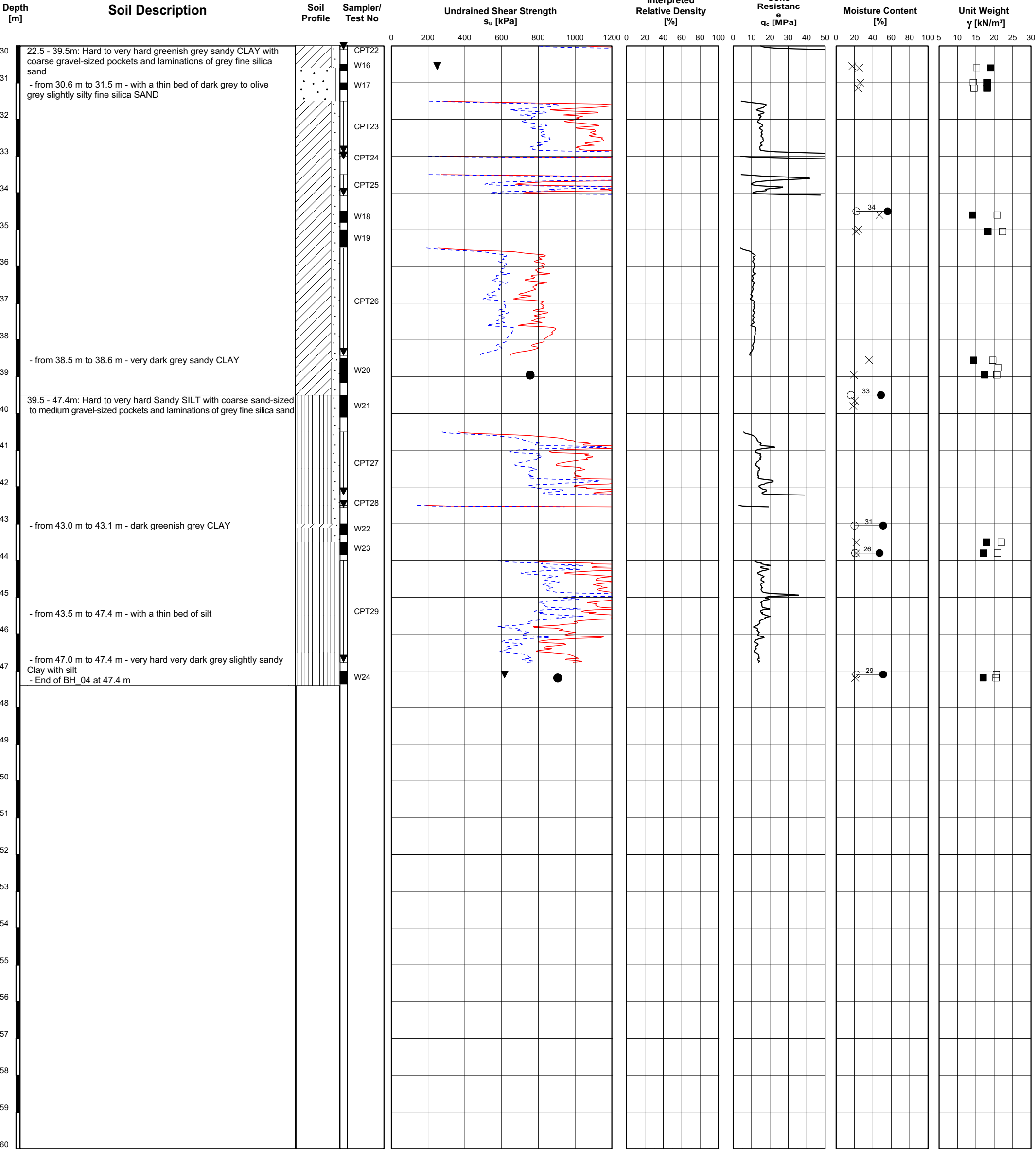
DRILLING REMARKS: Type of Bit 5 Wing Drag Type of Mud Bentonite / Seawater Notes ⁽¹⁾ BH_02	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ▼ s_u (Pocket Pentrometer) ■ s_u (Labvane) ◆ s_u (Fallcone) ● s_u (Undrained Triaxial) ⊗ s_u (CAU) + s_u (In-situ Vane) ⊠ s_u (DSS) ※ s_u (Remoulded In-situ Vane) ↗ / ↘ estimated from CPT data ($N_{kt} = 15 - 20$) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests		KEY FOR MOISTURE CONTENT: × Water Content (w) ● Liquid Limit (LL) ○ Plastic Limit (PL) ○● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■ Natural Wet Unit Weight (γ_w) □ Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 691041mE 5613643mN ⁽¹⁾		DATE : 04/04/2011 ⁽¹⁾ WATER DEPTH : 33m LAT ⁽¹⁾



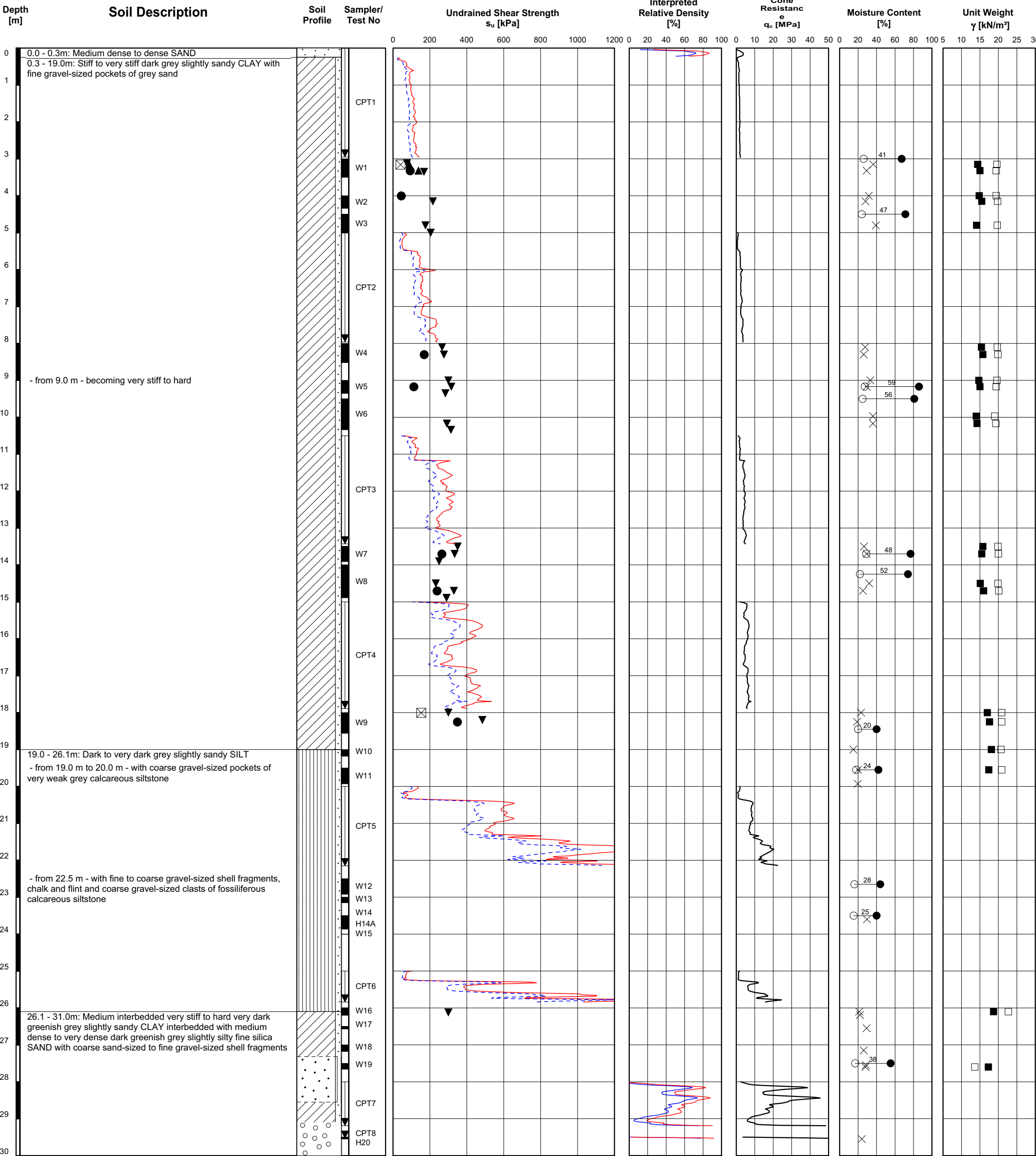
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_02	KEY FOR UNDRAINED SHEAR STRENGTH: ▲s_u (Torvane) ▼s_u (Pocket Pentrometer) ■s_u (Labvane) ◆s_u (Fallcone) ●s_u (Undrained Triaxial) ⊗s_u (CAU) +s_u (In-situ Vane) ⊠s_u (DSS) *s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ⊖●Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 691041mE 5613643mN ⁽¹⁾	DATE : 04/04/2011 ⁽¹⁾ WATER DEPTH : 33m LAT ⁽¹⁾



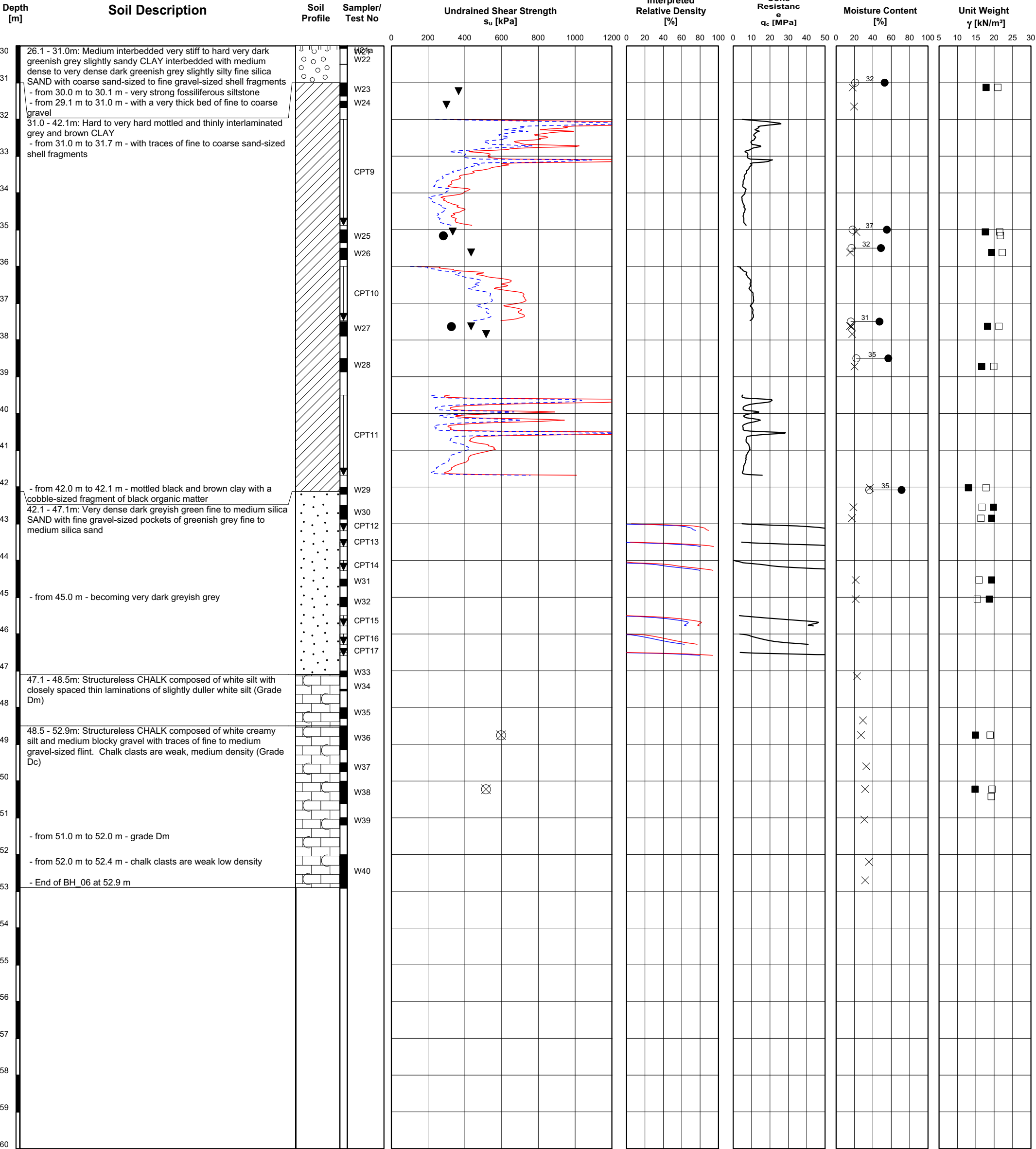
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes (1) BH_04 (2) BH_04A	KEY FOR UNDRAINED SHEAR STRENGTH: ▲s_u (Torvane) ■s_u (Labvane) ●s_u (Undrained Triaxial) +s_u (In-situ Vane) ✱s_u (Remoulded In-situ Vane) estimated from CPT data (N_{kt} = 15 - 20) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
FUGRO	LOCATION: Rampion Offshore Wind Farm - English Channel CO-ORDINATES: 695137mE 5618678mN (1) 695142mE 5618678mN (2)	DATE: 01/04/2011 (1) 02/04/2011 (2) WATER DEPTH: 25m LAT (1) 24m LAT (2)

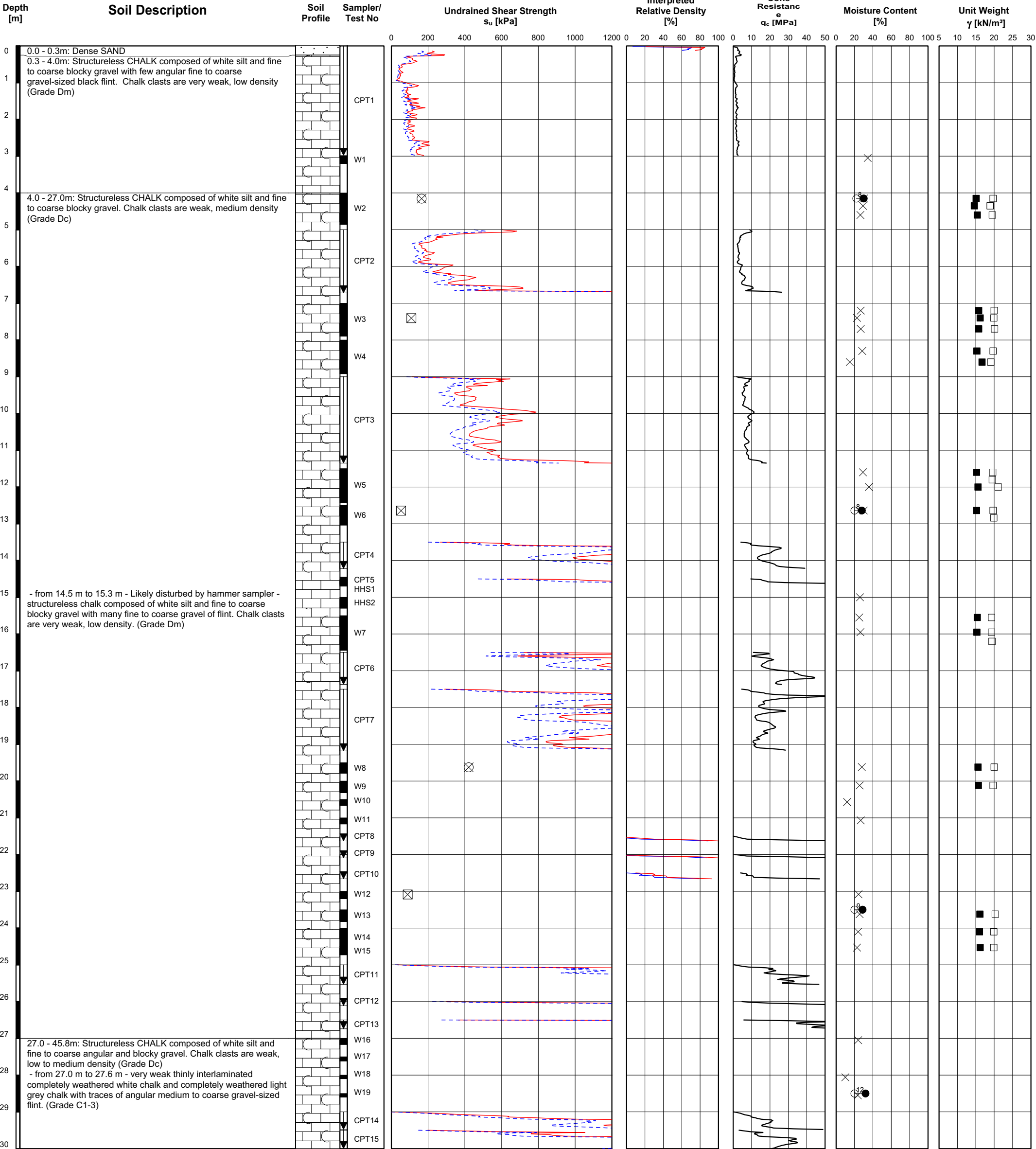


DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes (1) BH_04 (2) BH_04A	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ▼ s_u (Pocket Pentrometer) ■ s_u (Labvane) ◆ s_u (Fallcone) ● s_u (Undrained Triaxial) ⊗ s_u (CAU) ✦ s_u (In-situ Vane) ⊠ s_u (DSS) ※ s_u (Remoulded In-situ Vane)  estimated from CPT data (N_{kt} = 15 - 20) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: × Water Content (w) ● Liquid Limit (LL) ○ Plastic Limit (PL) ○ PI ● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■ Natural Wet Unit Weight (γ_w) □ Natural Dry Unit Weight (γ_d)
 LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 695137mE 5618678mN ⁽¹⁾ 695142mE 5618678mN ⁽²⁾	DATE : 01/04/2011 ⁽¹⁾ 02/04/2011 ⁽²⁾ WATER DEPTH : 25m LAT ⁽¹⁾ 24m LAT ⁽²⁾	

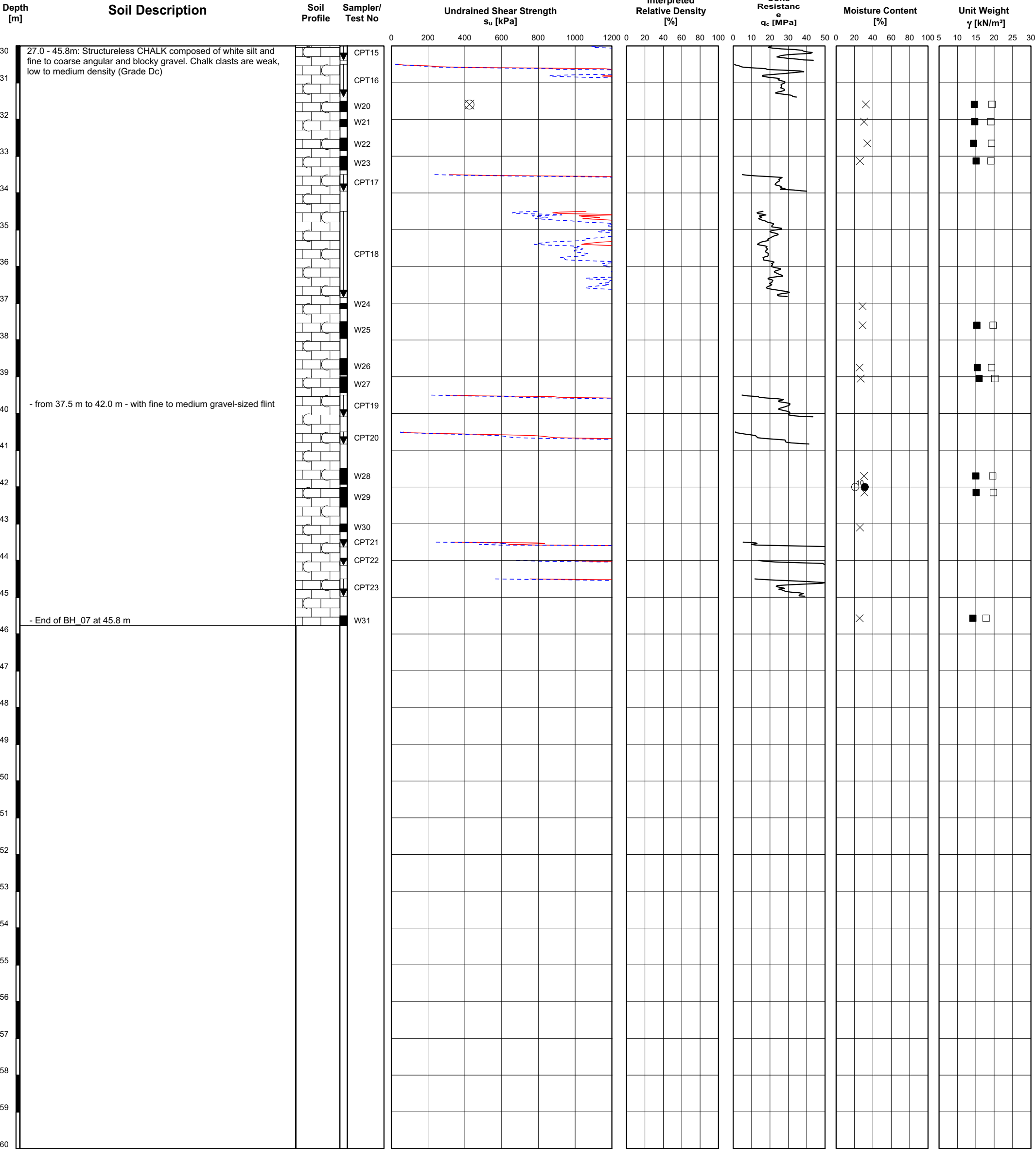


DRILLING REMARKS: Type of Bit 5 Wing Drag Type of Mud Bentonite / Seawater Notes ⁽¹⁾ BH_06	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ■ s_u (Labvane) ● s_u (Undrained Triaxial) + s_u (In-situ Vane) ✱ s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼ s_u (Pocket Pentrometer) ◆ s_u (Fallcone) ⊗ s_u (CAU) ⊠ s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: × Water Content (w) ● Liquid Limit (LL) ○ Plastic Limit (PL) ○● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■ Natural Wet Unit Weight (γ_w) □ Natural Dry Unit Weight (γ_d)
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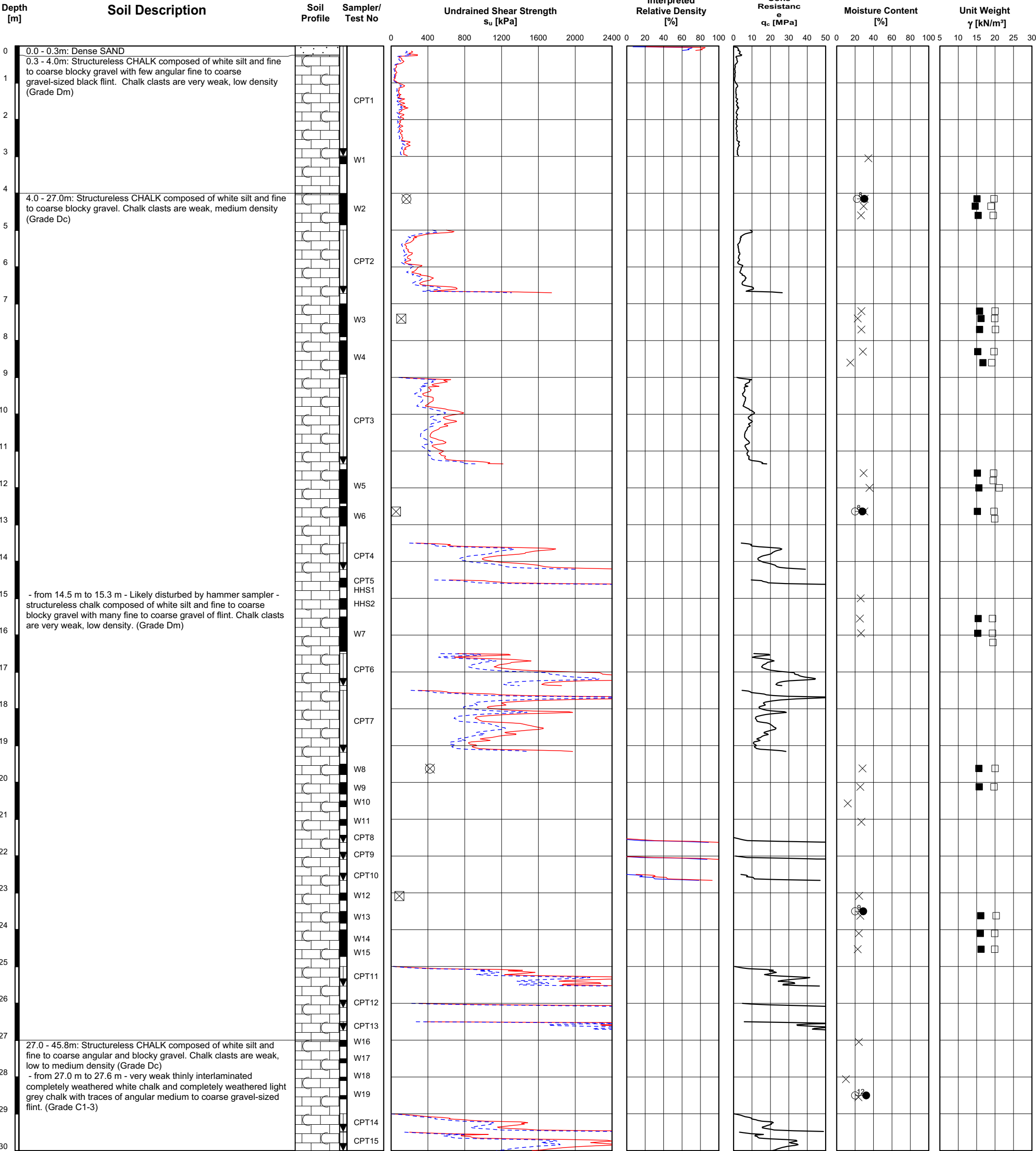




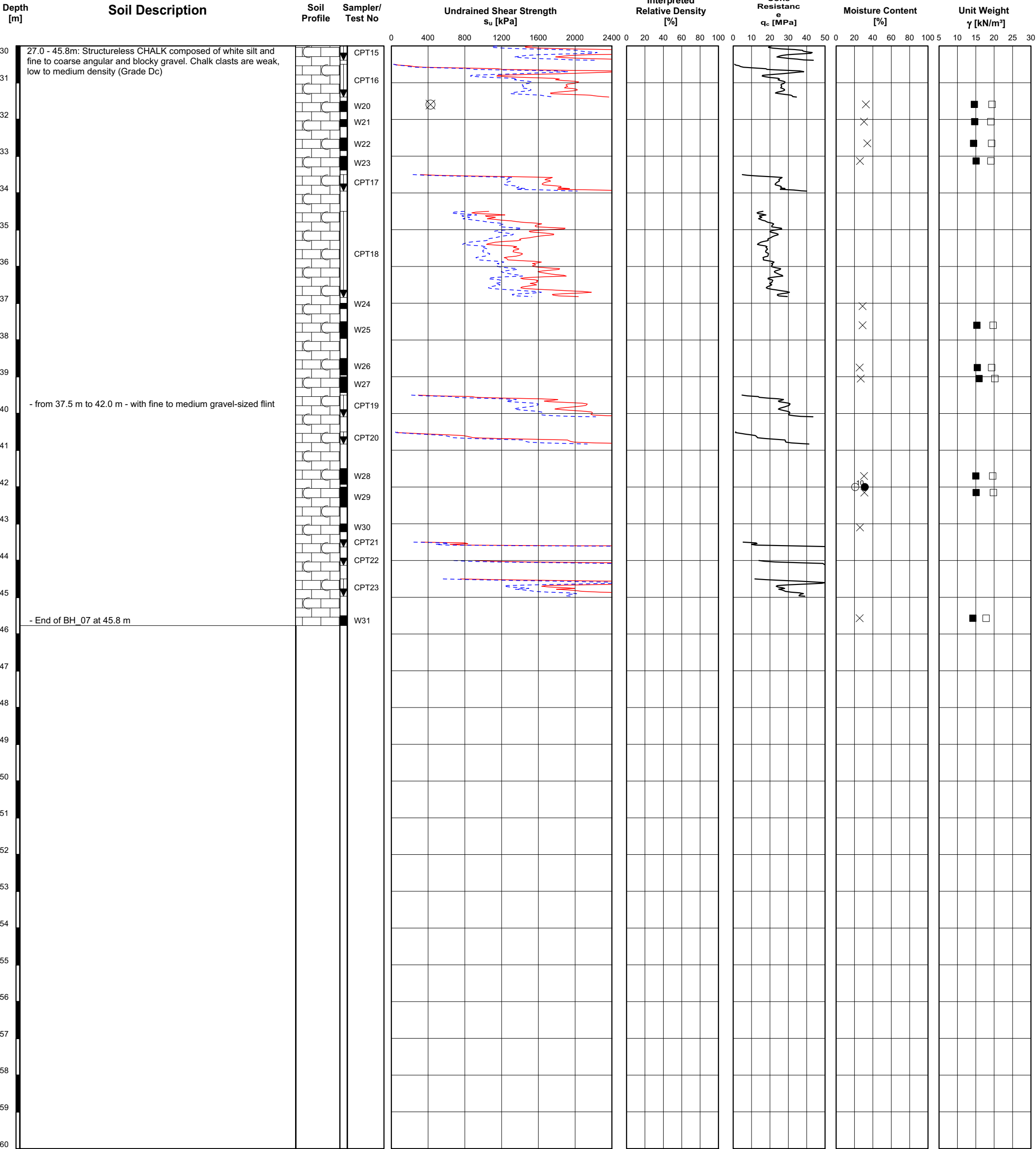
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_07	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ▼ s_u (Pocket Pentrometer) ■ s_u (Labvane) ◆ s_u (Fallcone) ● s_u (Undrained Triaxial) ⊗ s_u (CAU) ✦ s_u (In-situ Vane) ⊗ s_u (DSS) ※ s_u (Remoulded In-situ Vane)  estimated from CPT data (N_{kt} = 15 - 20) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: × Water Content (w) ● Liquid Limit (LL) ○ Plastic Limit (PL) ○ PI ● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■ Natural Wet Unit Weight (γ_w) □ Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 707817mE 5617108mN ⁽¹⁾	DATE : 03/04/2011 ⁽¹⁾ WATER DEPTH : 28m LAT ⁽¹⁾



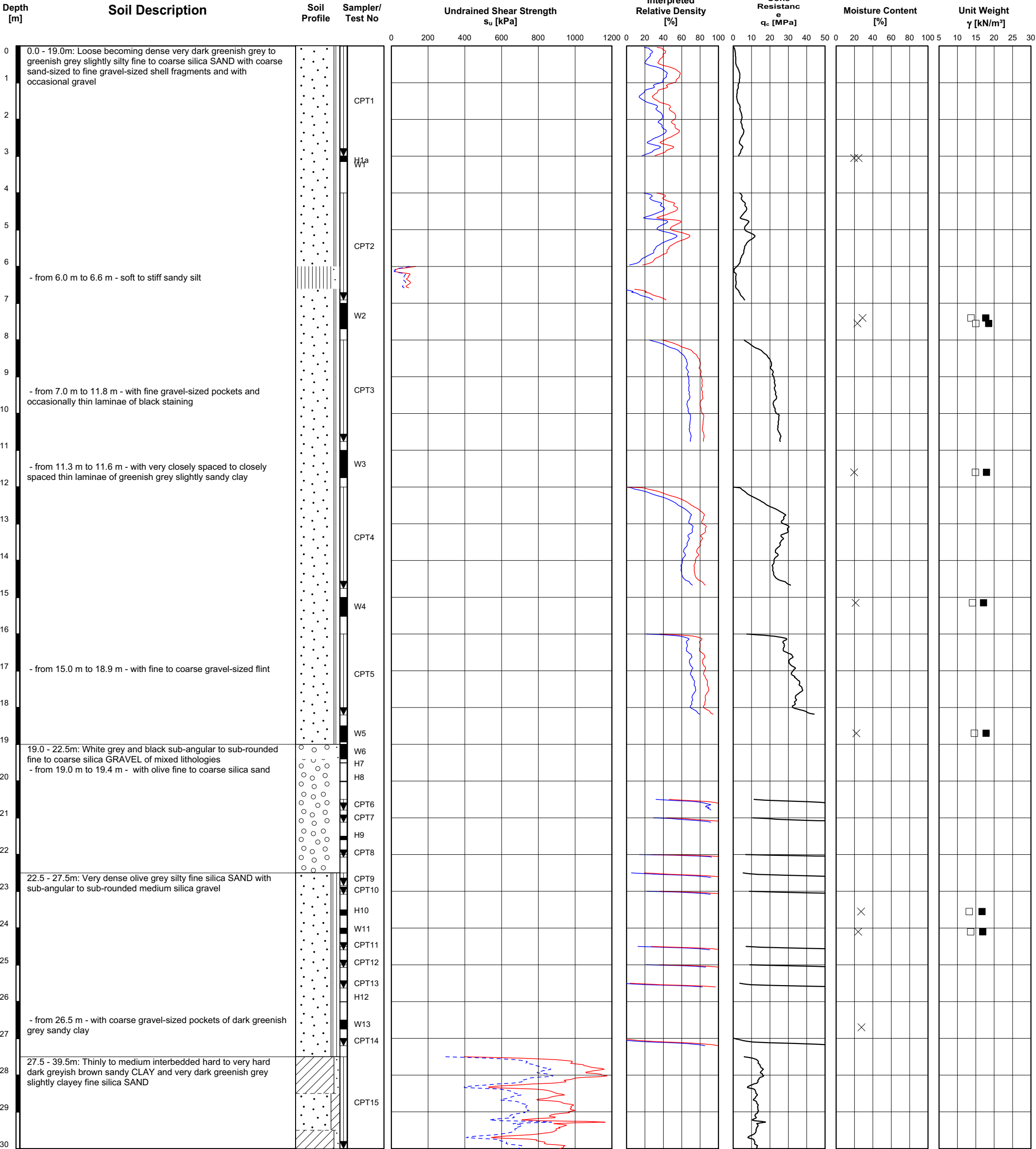
DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_07	KEY FOR UNDRAINED SHEAR STRENGTH: ▲s_u (Torvane) ■s_u (Labvane) ●s_u (Undrained Triaxial) +s_u (In-situ Vane) ✱s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼s_u (Pocket Pentrometer) ◆s_u (Fallcone) ⊗s_u (CAU) ⊠s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ○●^{PI}Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION: Rampion Offshore Wind Farm - English Channel CO-ORDINATES: 707817mE 5617108mN ⁽¹⁾	DATE: 03/04/2011 ⁽¹⁾ WATER DEPTH : 28m LAT ⁽¹⁾



DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_07	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ■ s_u (Labvane) ● s_u (Undrained Triaxial) + s_u (In-situ Vane) ✱ s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼ s_u (Pocket Pentrometer) ◆ s_u (Fallcone) ⊗ s_u (CAU) ⊠ s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: × Water Content (w) ● Liquid Limit (LL) ○ Plastic Limit (PL) ○● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■ Natural Wet Unit Weight (γ_w) □ Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 707817mE 5617108mN ⁽¹⁾	DATE : 03/04/2011 ⁽¹⁾ WATER DEPTH : 28m LAT ⁽¹⁾

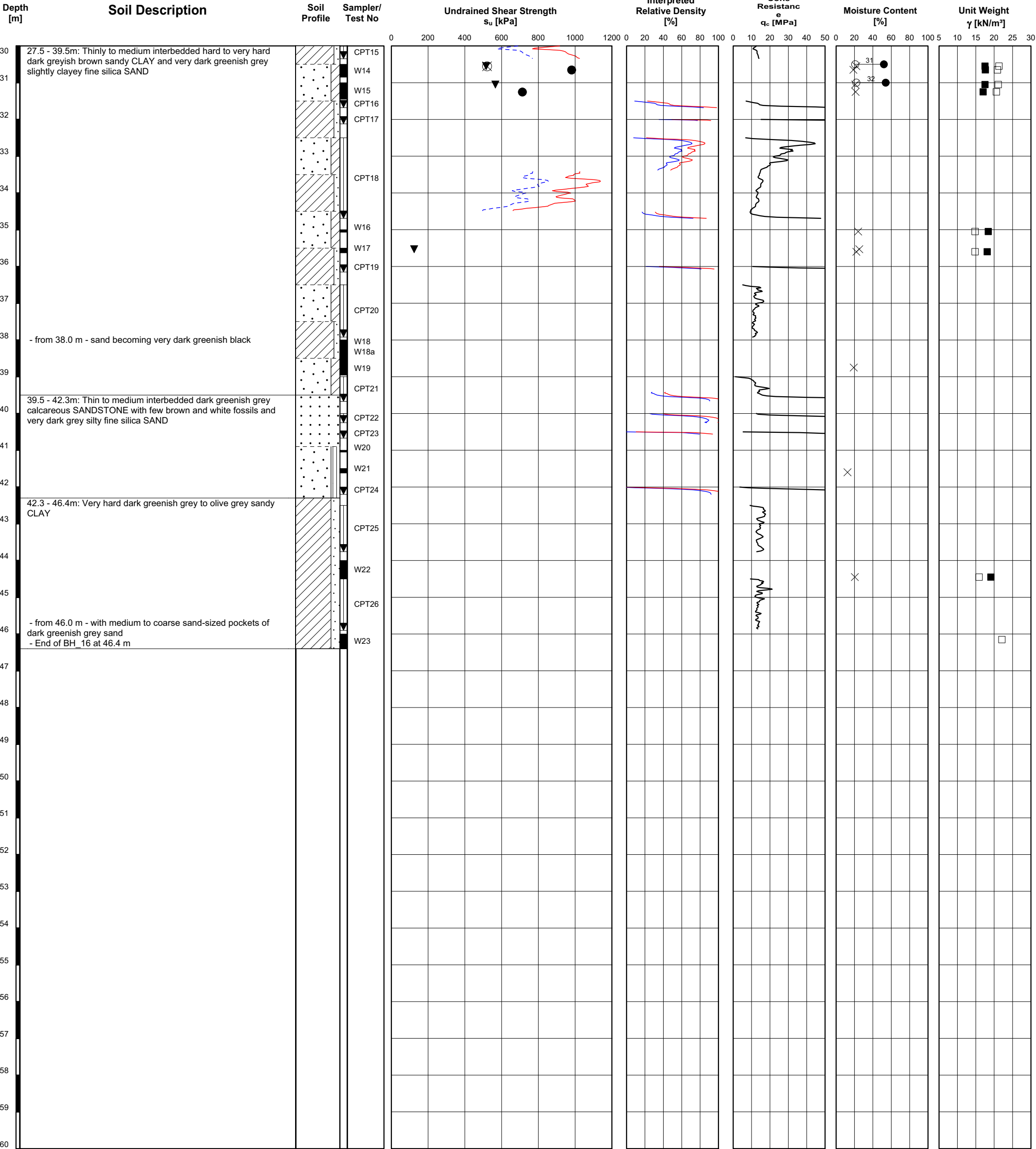


DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_07	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ■ s_u (Labvane) ● s_u (Undrained Triaxial) + s_u (In-situ Vane) ✱ s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼ s_u (Pocket Pentrometer) ◆ s_u (Fallcone) ⊗ s_u (CAU) ⊠ s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: × Water Content (w) ● Liquid Limit (LL) ○ Plastic Limit (PL) ○● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■ Natural Wet Unit Weight (γ_w) □ Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 707817mE 5617108mN ⁽¹⁾	DATE : 03/04/2011 ⁽¹⁾ WATER DEPTH : 28m LAT ⁽¹⁾

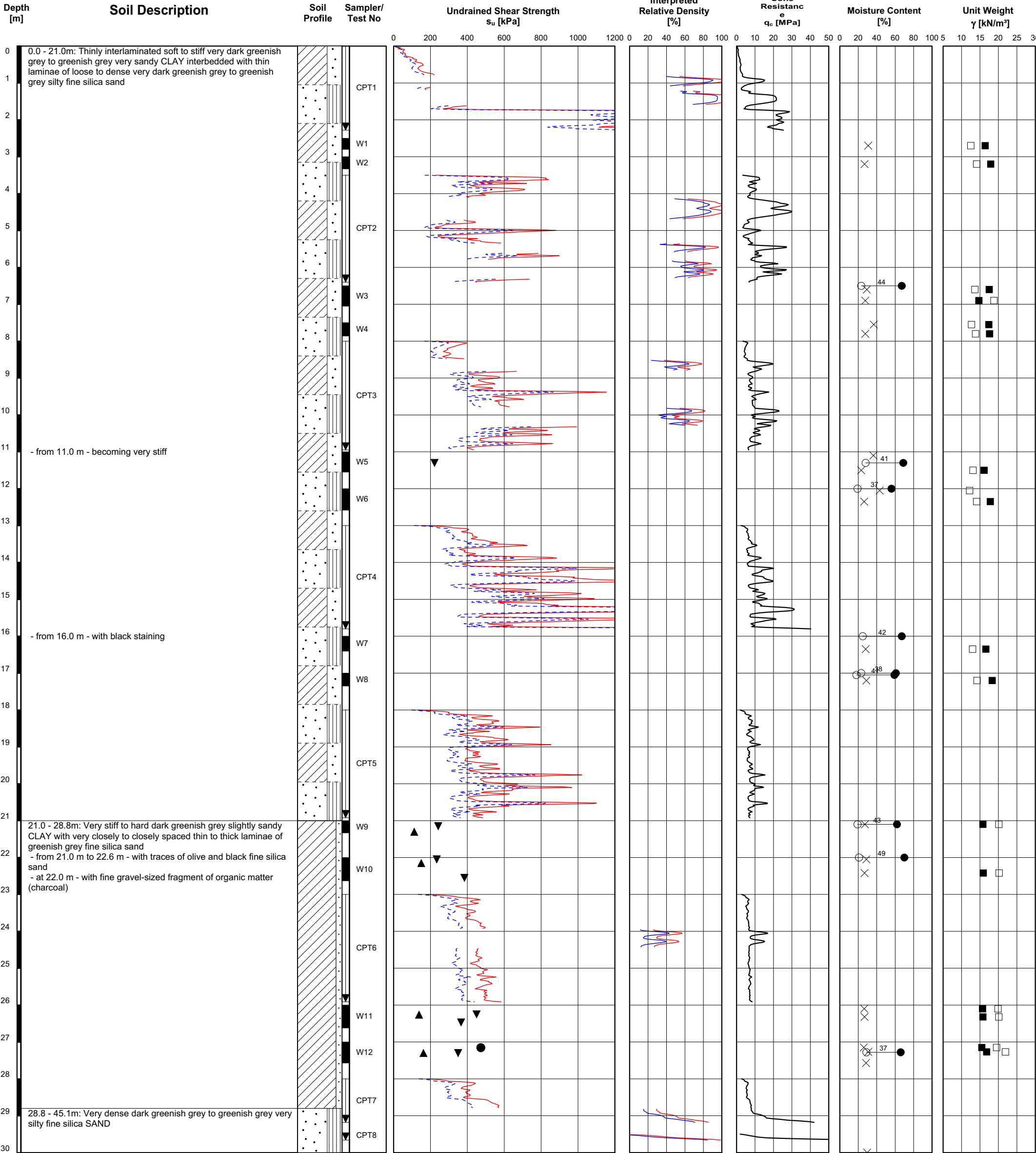


DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_16	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ■ s_u (Labvane) ● s_u (Undrained Triaxial) + s_u (In-situ Vane) ✱ s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼ s_u (Pocket Pentrometer) ◆ s_u (Fallcone) ⊗ s_u (CAU) ⊠ s_u (DSS)

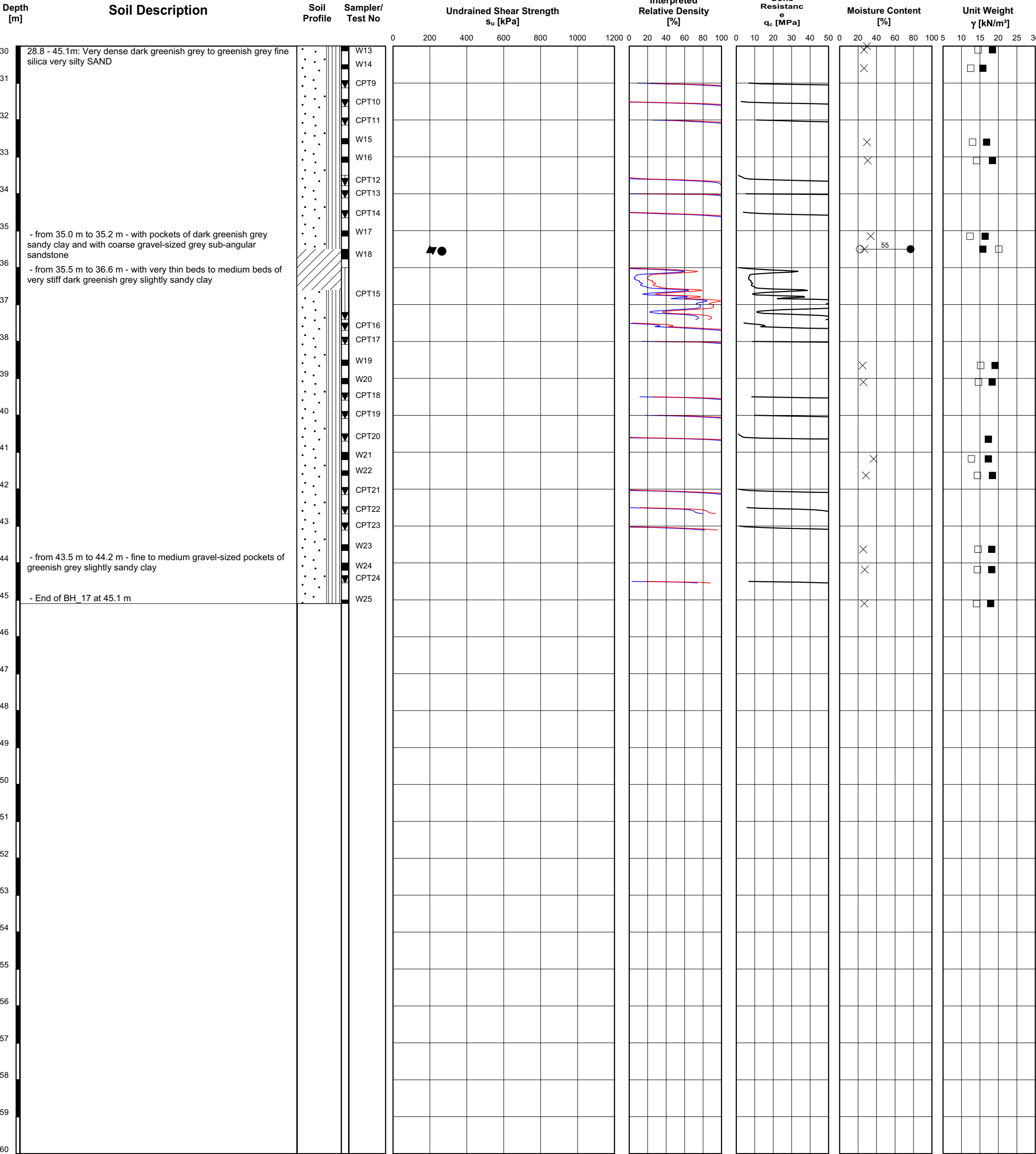
Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests



DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_16	KEY FOR UNDRAINED SHEAR STRENGTH: ▲s_u (Torvane) ▼s_u (Pocket Pentrometer) ■s_u (Labvane) ◆s_u (Fallcone) ●s_u (Undrained Triaxial) ⊗s_u (CAU) +s_u (In-situ Vane) ⊠s_u (DSS) ✱s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ○●Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 696851mE 5613444mN ⁽¹⁾	DATE : 31/03/2011 ⁽¹⁾ WATER DEPTH : 45m LAT ⁽¹⁾



DRILLING REMARKS: Type of Bit 5 Wing Drag Type of Mud Bentonite / Seawater Notes ⁽¹⁾ BH_17	KEY FOR UNDRAINED SHEAR STRENGTH: ▲ s_u (Torvane) ■ s_u (Labvane) ● s_u (Undrained Triaxial) + s_u (In-situ Vane) ✱ s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼ s_u (Pocket Pentrometer) ◆ s_u (Fallcone) ⊗ s_u (CAU) ⊠ s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests				KEY FOR MOISTURE CONTENT: × Water Content (w) ● Liquid Limit (LL) ○ Plastic Limit (PL) ○● Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■ Natural Wet Unit Weight (γ_w) □ Natural Dry Unit Weight (γ_d)	
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 690153mE 5615571mN ⁽¹⁾				DATE : 30/03/2011 ⁽¹⁾ WATER DEPTH : 27m LAT ⁽¹⁾	



DRILLING REMARKS: Type of Bit5 Wing Drag Type of MudBentonite / Seawater Notes⁽¹⁾ BH_17	KEY FOR UNDRAINED SHEAR STRENGTH: ▲s_u (Torvane) ■s_u (Labvane) ●s_u (Undrained Triaxial) +s_u (In-situ Vane) ✱s_u (Remoulded In-situ Vane) estimated from CPT data ($N_{kt} = 15 - 20$) ▼s_u (Pocket Pentrometer) ◆s_u (Fallcone) ⊗s_u (CAU) ⊠s_u (DSS) Open symbols refer to tests performed onshore; full symbols refer to tests performed offshore; half full symbols refer to remoulded tests	KEY FOR MOISTURE CONTENT: ×Water Content (w) ●Liquid Limit (LL) ○Plastic Limit (PL) ○^{PI}●Plasticity Index (PI) KEY FOR UNIT WEIGHT: ■Natural Wet Unit Weight (γ_w) □Natural Dry Unit Weight (γ_d)
	LOCATION : Rampion Offshore Wind Farm - English Channel CO-ORDINATES : 690153mE 5615571mN ⁽¹⁾	DATE : 30/03/2011 ⁽¹⁾ WATER DEPTH : 27m LAT ⁽¹⁾



SECTION B.2

CLASSIFICATION TESTS

B.2	CLASSIFICATION TESTS	1
B.2.1	SUMMARY	1
B.2.2	BASIC CLASSIFICATION TESTS	1

B.2 CLASSIFICATION TESTS

B.2.1 SUMMARY

In general, the results of the laboratory classification testing are considered to be representative of the soils tested at the Rampion site. In general, the laboratory tests were performed according to BS 1377 (1990), details of which are presented in Section 11.

B.2.2 BASIC CLASSIFICATION TESTS

B.2.2.1 Moisture Content & Wet and Dry Density

A total of 222 moisture content tests and 216 density measurements were performed offshore during the Rampion site investigation.

The results of these tests are presented on the borehole logs in Section B.1 on Plates B.1-1 to B.1-23 and at the end of this section on the 'Summary of Laboratory Test Results' sheets, Plates B.2-1 to B.2-37.

B.2.2.2 Atterberg Limits

Seventy-four (76) Atterberg limit tests were performed on selected samples of fine-grained soils.

The results are summarised at the end of this section on Plates B.2-38 to B.2-46 and are also presented graphically on a plasticity chart (BS 5930, 1999) Plates B.2-47 to B.2-55. The results are also presented on the borehole logs in Section B.1 and on the 'Summary of Laboratory Test Results' sheets at the end of this section.

B.2.2.3 Particle Size Distribution

Particle size distribution (PSD) analyses were performed on 98 selected samples to confirm and clarify the descriptions made offshore.

The results of the tests are presented graphically at the end of this section on B.2-56 to B.2-84. In general, the PSD results confirmed the visual descriptions made offshore.

B.2.2.4 Particle Density

Twenty-seven (27) particle density tests were performed on selected samples. The results range from 2.65 Mg/m³ to 2.80 Mg/m³ for all soils.

The results of these tests are presented at the end of this section on Plate B.2-85.

B.2.2.5 Index Soil Strength Tests

Index soil strength tests provide a fast method for clarification of undrained shear strength in fine-grained cohesive soils. During this investigation a total of 118 hand-held pocket penetrometer (PP) and 32 torvane (TV) tests were performed.

The results of these tests are presented on the borehole logs in Section B.1 and at the end of this section on the 'Summary of Laboratory Test Results' sheets on Plates B.2-1 to B.2-37.

B.2.2.6 Maximum and Minimum Dry Density Determinations

Maximum and minimum dry density determinations were performed on fourteen (14) coarse-grained samples to provide reference data for the assessment of in-situ dry density.

The results are summarised at the end of this section on Plate B.2-86.

B.2.2.7 Unconsolidated Undrained Triaxial Tests

Thirty (30) undisturbed unconsolidated undrained (UU) triaxial tests were performed offshore, with an additional two (2) UU tests performed onshore, to better define the undrained shear strength on the fine-grained cohesive material. Thirteen (13) complimentary remoulded unconsolidated undrained (UU_r) triaxial tests were performed to provide soil sensitivity data.

As per standard FGCLTD practice, unless the shear stress peaked at a lower strain, the shearing was stopped at 20 % strain.

These results are summarised at the end on this section on Plates B.2-87 to B.2-88 and individual test results are presented on Plates B.2-89 and B.2-120. The results are also presented on the borehole logs in Section B.1 and on the 'Summary of Laboratory Test Results' sheets at the end of this section.

Soil sensitivity ranged from 0.79 to 1.85 at locations BH_13 and BH_14.

The results are considered to be of good quality in that they are representative of the soils tested and show good agreement with other index strength testing results and with values derived from CPT data.

B.2.2.8 Carbonate Content

Thirty-two carbonate content tests were performed on samples to assess the carbonate levels as a percentage of CO₂ and CaCO₃. The results range from a CO₂ content of 0.18 % to 5.4 %, with associated CaCO₃ contents of 4.1% to 12.2 % for sand and clay at Soil provinces I,IV,V and VI. For chalk, the associated CO₂ was measured at 41.0% to 42%, with an associated CaCO₃ content of 93% to 95%.

The results of the testing are presented at the end of this section on Plates B.2-121 and B.2-122.

B.2.2.9 Organic Content

Twenty-eight organic content tests were performed on selected samples. The results of the dichromate oxidation analyses show organic contents in the range of 0.9% to 9.2% throughout the Rampion site.

The results of the testing are presented at the end of this section on Plates B.2-123 and B.2-124.

B.2.2.10 pH and Sulphate Content

Twenty-eight total loss on ignition tests were performed on selected samples throughout the Rampion site. The results show sulphate contents in the range of <0.02% to 0.22%.

The results of the testing are presented at the end of this section on Plates B.2-125 and B.2-126.

CLASSIFICATION TESTS

LIST OF PLATES – SECTION B.2

Description	Plate
Summary of Laboratory Test Results	B.2-1 to B.2-37
Summary of Atterberg Limit Test Results and Plasticity Charts (BS 5930)	B.2-38 to B.2-55
Particle Size Distribution Test Results	B.2-56 to B.2-84
Particle Density Test Results	B.2-85
Summary of Minimum and Maximum Density Test Results	B.2-86
Summary of Unconsolidated Undrained Triaxial Test Results	B.2-87 to B.2-88
Unconsolidated Undrained Triaxial Test Results	B.2-89 to B.2-120
Carbonate Content Test Results	B.2-121 to B.2-122
Organic Content Test Results	B.2-123 to B.2-124
pH and Sulphide Content Test Results	B.2-125 to B.2-126

BH_13

Key:	W	:	MC	:	Moisture Content	UU	:	Unconsolidated Undrained	PP	:	Pocket Penetrometer
	P	:	LL	:	Liquid Limit	LV	:	Laboratory Vane	S _u	:	Undrained Shear Strength
	H	:	PL	:	Plastic Limit	FC	:	Fall Cone	100	:	refers to test performed offshore
		:	PI	:	Plasticity Index	TV	:	Torvane	100	:	refers to remoulded test
		:		:			:			:	
		:		:			:			:	

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Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests					Remarks					
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	PP _{S_u} (kPa)						
6	12.5	13.4	W6	12.5 m to 13.4 m - very stiff to hard very dark greenish grey (10Y-3/1) slightly sandy CLAY with thin to very thin beds and many fine to medium gravel-sized pockets of very dark greenish grey silty silica sand	8.6	22				67	18	49	130				201	6: 3" Thick Wall				
					8.9	23													210			
					12.6	27																
					12.8	26											304				285	
					12.8	24		59	21	38	184						250					
7	13.5	14.2	W7	13.5 m to 14.2 m - very stiff to hard very dark grey (2.5Y-3/1) slightly sandy CLAY with thin to thick laminae and medium to coarse gravel-sized pockets of light grey silty silica sand	13.0													7: 3" Thick Wall				
					13.1	30	19.2														233	
					13.3																262	
					13.4																193	
					13.6	30	19.7	66	25	41												
8	17.5	17.7	W8	17.5 m to 17.6 m - disturbed - very dark grey slightly sandy CLAY 17.6 m to 17.7 m - very dark grey (2.5Y-3/1) silty fine silica SAND with fine sand-sized mica crystals	13.9	26												8: 3" Thick Wall				
					13.9	25															287	
					14.0																305	
					14.1																	280
					14.1	27		66	25	41												
9	18.0	18.2	W9	18.0 m to 18.2 m - very dark grey (5Y-3/1) silty fine silica SAND with medium gravel-sized pockets of dark greyish brown staining	17.5												9: 3" Thick Wall					
					17.6		17.2															
							18.3															
9a		18.5	H9a	18.0 m - very dark grey (5Y-3/1) sandy CLAY with coarse gravel-sized pockets of dark greyish brown slightly clayey fine silica sand	18.1	37											9a: Tested due to poor penetration with W9					
10	20.0	20.1	W10	20.0 m to 20.1 m - very dark grey (5Y-3/1) fine silica SAND with traces of mica crystals	20.1		17.8											10: 3" Thick Wall				
Key:				W : W/P or Push Sampler	MC : Moisture Content		UU : Unconsolidated Undrained		PP : Pocket Penetrometer													
	P : Piston Sampler	LL : Liquid Limit		LV : Laboratory Vane			LV : Undrained Shear Strength		S _u : Undrained Shear Strength													
	H : Hammer Sampler	PL : Plastic Limit		PI : Plasticity Index			FC : Fall Cone		100 : refers to test performed offshore													
							TV : Tonvane		100 : refers to remoulded test													

SUMMARY OF LABORATORY TEST RESULTS

BH_13

E.ON CLIMATE AND RENEWABLES
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION



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Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	
10a		20.4	H10a	20.0 m to 20.4 m - very dark grey (5Y-3/1) fine silica SAND with coarse gravel-sized pockets of slightly sandy very dark grey clay and with traces of mica crystals	20.2	61									10a: Tested due to poor penetration with W10
11	20.5	20.7	W11	20.5 m to 20.7 m - very dark grey fine silica SAND with traces of mica crystals	20.6	74	17.2				9.9				11: 2" Thick Wall with Core Catcher
11A		21.0	H11A	20.5 m to 21.0 m - very dark grey (5Y-3/1) fine silica SAND with coarse gravel-sized pockets of slightly sandy very dark grey clay and with traces of mica crystals	20.5										11A: Tested due to poor penetration with W11
12	23.5	23.6	W12	23.5 m - 23.6 m - dark greenish grey (10Y-4/1) fine silica SAND with coarse gravel-sized pockets of dark greenish grey slightly cemented fine silica sand and dark greenish grey slightly	23.6		18.1								12: 2" Thick Wall with Core Catcher
12A		24.0	H12A	23.5 m to 24.0 m - dark greenish grey (10Y-4/1) fine silica SAND with coarse gravel-sized pockets of dark greenish grey clay and with few coarse gravel-sized pockets of dark greenish grey slightly cemented fine silica sand	23.6	29									12A: 50 blows
13	24.0	24.2	W13	24.0 m - 24.2 m - dark greenish grey (10Y-4/1) fine silica SAND with traces of mica crystals	24.1	85	17.6				9.5				13: 2" Thick Wall with Core Catcher
14	26.0	26.2	W14	26.0 m - 26.2 m - dark greenish grey (10Y-4/1) fine silica SAND with coarse gravel-sized pockets of slightly sandy dark greenish grey clay and with traces of black fine silica sand	26.2	60	18.1				11.3				14: 2" Thick Wall with Core Catcher - Dense sand expanded in tube
15	26.5	26.7	W15	26.5 m to 26.7 m - dark greenish grey (10Y-4/1) fine silica SAND with traces of black fine silica sand	26.5										15: 2" Thick Wall with Core Catcher - Dense sand expanded in tube
16a	28.5	28.6	H16a	28.5 m to 28.6 m - dark greenish grey (10Y-4/1) sandy CLAY with coarse gravel-sized pockets of dark greenish grey fine sand	28.6	29									16a: 50 blows
16		28.7	W16	28.5 m to 28.7 m - dark greenish grey (10Y-4/1) fine silica SAND with traces of black fine silica sand	28.6	32	16.4				12.4				16: 2" Thick Wall with Core Catcher - Dense sand expanded in tube
17	29.0	29.2	W17	29.0 m to 29.1 m - dark greenish grey (10Y-4/1) clayey fine silica SAND	29.0										17: 3" Thick Wall - Dense sand expanded in tube
18	30.0	30.4	H18	29.1 m to 29.2 m - dark greenish grey (10Y-4/1) silica SAND	29.1	30	18.3				14.1				18: Auto Trip Hammer
19	30.5	30.7	W19	30.0 m to 30.4 m - dark greenish grey (10Y-4/1) clayey silica SAND with fine gravel-sized pockets of sandy clay	30.0										19: 3" Thick wall - Dense sand expanded in tube
				30.5 m to 30.6 m - dark greenish grey (10Y-4/1) slightly clayey fine silica SAND	30.5										
20	32.5	32.7	W20	30.6 m to 30.7 m - dark greenish grey (10Y-4/1) slightly cemented fine silica SAND	30.7	22	20.0				16.4				
				32.5 m to 32.7 m - dark greenish grey (10Y-4/1) slightly clayey fine silica SAND	32.7	29	18.3				14.2				20: 3" Thick Wall - Dense sand expanded in tube
Key: W : WIP or Push Sampler P : Piston Sampler H : Hammer Sampler MC : Moisture Content LL : Liquid Limit PL : Plastic Limit PI : Plasticity Index UU : Unconsolidated Undrained LV : Laboratory Vane FC : Fall Cone TV : Torvane PP : Pocket Penetrometer S _u : Undrained Shear Strength 100 : refers to test performed offshore 100 : refers to remould test															

SUMMARY OF LABORATORY TEST RESULTS
BH_13

Made By: SF/KF Date: 29/03/2011

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Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	
21	33.0	33.5	W21	33.0 m to 33.1 m - dark greenish grey (10Y-4/1) slightly clayey silica SAND with extremely to very closely spaced thin to thick laminations of olive green silica sand 33.1 m to 33.5 m - dark greenish grey (10Y-4/1) fine silica SAND	33.0	11 20	17.9 18.2	8.5 15.1							21: 3" Thick Wall - Dense sand expanded in tube	
22	35.0	35.7	W22	35.0 m to 35.7 m - dark olive grey (5Y-3/2) clayey fine silica SAND with fine to medium gravel-sized pockets of hard very dark greyslightly sandy clay and fine gravel-sized pockets of olive grey silty sand	35.0	25 23	21.1 20.9	17.9 15.3	51	20	31				22: 3" Thick Wall	
23	39.0	39.9	W23	39.0 m to 39.9 m - hard to very hard dark olive grey slightly sandy CLAY with pockets of dark greyish brown slightly silty sand with traces of sub-rounded medium gravel	39.1 39.3 39.5 39.5 39.7 39.7 40.0	18 19 17	21.2 21.3	17.4				573 309			23: 3" Thick Wall Pockets of dense sand expanded in tube	
24	40.0	40.7	W24	40.0 m to 40.7 m - hard to very hard dark grey (5Y-4/1) sandy CLAY with pockets of dark greyish brown slightly silty sand with dark greyish green staining	40.1 40.3 40.3 40.5 40.6 40.7	24 19	21.5	17.3	49	15	34				24: 3" Thick Wall	
Key:				W : WIP or Push Sampler P : Piston Sampler H : Hammer Sampler	MC : Moisture Content LL : Liquid Limit PL : Plastic Limit PI : Plasticity Index	UU : Unconsolidated Undrained LV : Laboratory Vane FC : Fall Cone TV : Torvane	PP : Pocket Penetrometer S _u : Undrained Shear Strength 100 : refers to test performed offshore 100 : refers to remoulded test									

SUMMARY OF LABORATORY TEST RESULTS

BH_13

Made By: SF/KF Date: 29/03/2011

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Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	
25	44.0	44.3	W25	44.0 m to 44.2 m - hard dark grey (5Y-4/1) slightly sandy CLAY with fine to medium gravel-sized pockets of dark greyish brown slightly silty sand and coarse sand-sized to fine gravel-sized pockets of black staining	40.8	19								25: 3" Thick Wall - Dense sand expanded in tube		
				44.2 m to 44.3 m - dark grey (5Y-4/1) very silty SAND	44.2	26										
26	44.5	44.7	W26	44.5 m to 44.7 m - dark grey (5Y-4/1) silty SAND with fine to medium gravel-sized pockets of olive grey silty sand	44.7	24	16.6	13.4						26: 3" Thick Wall		
27	45.0	45.2	W27	45.0 m to 45.2 m - dark grey (5Y-4/1) slightly silty fine silica SAND with medium gravel-sized pockets of black clay with fine to medium sand-sized mica crystals	45.1	37	17.6	12.8						27: 3" Thick Wall		

SUMMARY OF LABORATORY TEST RESULTS

BH_13



Made By: SF/KF Date: 29/03/2011

GeODir-System/ Labsum.GLO / 26/07/2011/17:58:21

Sample Details				Index Soil Strength Tests										Remarks			
No.	From (m)	To (m)	Type	Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)		FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)
1	2.0	2.4	W1	2.0 m to 2.1 m - dark greyish green (SGY-4/1) very silty silica SAND with fine gravel-sized pockets of dark greenish grey clay with medium to coarse sub-angular to sub-rounded silica gravel and with fine to medium gravel-sized pockets of olive silty silica sand 2.1 m to 2.4 m - dark greyish green (SGY-4/2) very silty fine silica SAND 2.5 m to 2.8 m - dark greyish green (SGY-4/2) very silty fine silica SAND 6.0 m to 6.6 m - stiff to very stiff dark greenish grey (SGY-4/1) slightly sandy CLAY with closely spaced thin laminae of grey and black fine to medium silica sand	2.0												1: 3" thick walled
2	2.5	2.8	W2		2.2	25	18.5	14.8									
3	6.0	6.6	W3		2.6	31	17.7	13.6				161					2: 3" thick walled
					6.1	43											3: 3" thick walled
					6.1	42						204					
					6.4										100		
					6.5	42											
					6.6												
4	7.0	7.7	W4	7.0 m to 7.7 m - stiff to very stiff dark greenish grey (SGY-4/1) slightly sandy CLAY with closely spaced thin laminae of grey and black fine to medium silica sand	7.1	35						179					4: 3" thick walled
					7.1	36			80	31	49	202					
					7.4												
					7.4	26	18.6	14.7									
					7.7												
5	11.0	11.6	W5	11.0 m to 11.6 m - stiff to very stiff dark greenish grey (SGY-4/1) slightly sandy CLAY with closely spaced thin laminae of grey and black fine to medium silica sand	11.1												5: 3" thick walled
					11.1	28											
					11.2	31	17.2	13.1									
					11.6												
6	12.0	12.5	W6	12.0 m to 12.5 m - thinly to thickly interlaminated dark greenish grey (SGY-4/1) slightly sandy CLAY and fine to medium greenish grey (SGY-5/1) silica SAND with traces of black fine silica sand	12.0				72	21	51						6: 3" thick walled
Key:				W : W/P or Push Sampler	MC : Moisture Content	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	UU : Unconsolidated Undrained	LV : Laboratory Vane	FC : Fall Cone	TV : Torvane	PP : Pocket Penetrometer	S _u : Undrained Shear Strength			
P	H			: Piston Sampler													
				: Hammer Sampler													

SUMMARY OF LABORATORY TEST RESULTS

BH_14



Made By: SF/KF Date: 29/03/2011

GeoDir-System/ Labsum.GLO / 26/07/2011/17:58:21

Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	
7	16.0	16.6	W7	16.0 m to 16.6 m - thinly to thickly interlaminated stiff to very stiff dark greenish grey (SGY-4/1) slightly sandy CLAY and fine to medium greenish grey (SGY-5/1) silica SAND with traces of black fine silica sand and evidence of bioturbation (burrows)	12.2	29	17.4	14.0						217	7: 3" thick walled	
					12.4	24										
					16.2											
8	17.0	17.6	W8	17.0 m to 17.6 m - thinly to thickly interlaminated stiff to very stiff dark greenish grey (SGY-4/1) slightly sandy CLAY and fine to medium greenish grey (SGY-5/1) silica SAND with traces of black fine silica sand and evidence of bioturbation (burrows)	16.4	26	19.4	13.4						133	8: 3" thick walled	
					16.5											
					17.2	45										
9	21.0	21.8	W9	21.0 m to 21.8 m - thinly to thickly interlaminated stiff to very stiff dark greenish grey (SGY-4/1) slightly sandy CLAY and fine to medium greenish grey (SGY-5/1) silica SAND with traces of black fine silica sand and evidence of bioturbation (burrows)	17.3	27	19.5	15.6	75	24	51			150	9: 3" thick walled	
					17.3											
					17.5	25										
10	22.0	22.6	W10	22.0 m to 22.6 m - thinly to thickly interlaminated very stiff to hard dark greenish grey (SGY-4/1) slightly sandy CLAY and fine to medium greenish grey (SGY-5/1) silica SAND with traces of black fine silica sand and evidence of bioturbation (burrows)	21.2	25	19.4	15.7	71	22	49			267	10: 3" thick walled	
					21.7											
					22.2	23										
					22.2									383		
					22.3									283		
					22.6											
Key:				W : W/P or Push Sampler P : Piston Sampler H : Hammer Sampler	MC : Moisture Content LL : Liquid Limit PL : Plastic Limit PI : Plasticity Index		UU : Unconsolidated Undrained Laboratory Vane LV : Fall Cone FC : Torvane					PP : Pocket Penetrometer S _u : Undrained Shear Strength 100 : refers to test performed offshore 100 : refers to remoulded test				

SUMMARY OF LABORATORY TEST RESULTS

BH_14



Made By: SF/KF Date: 29/03/2011

GeODir-System/ Labsum.GLO / 26/07/2011/17:58:21

Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	
11	25.0	25.7	W11	25.1											11: 3" thick walled	
				25.2	25											
				25.3				75	21	54						
				25.5	25		20.1	16.1								
12	26.0	26.7	W12	26.1	31		19.6	15.0							12: 3" thick walled	
				26.3												
				26.3	28											
				26.5												
				26.5	22							434				
				26.5								435				
13	30.0	30.4	W13	30.0											13: 3" thick walled	
				30.2	50		20.5	13.7								
				30.4	19											
				31.0												
				31.2	25											
				31.3	25		19.7	15.8								
				31.5	21		20.4	16.9								
				31.7	21											
				31.7	21							495				
				31.7								277				
Key:				W	:	WIP or Push Sampler	MC	:	Moisture Content	UU	:	Unconsolidated Undrained	PP	:	Pocket Penetrometer	
				P	:	Piston Sampler	LL	:	Liquid Limit	LV	:	Laboratory Vane	S _u	:	Undrained Shear Strength	
				H	:	Hammer Sampler	PL	:	Plastic Limit	FC	:	Fall Cone	100	:	refers to test performed offshore	
					:		PI	:	Plasticity Index	TV	:	Torvane	100	:	refers to remoulded test	

SUMMARY OF LABORATORY TEST RESULTS

BH_14



Made By: SF/KF Date: 29/03/2011

GeODir-System/ Labsum.GLO / 26/07/2011/17:58:21

Sample Details				Index Soil Strength Tests										Remarks			
No.	From (m)	To (m)	Type	Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests					
									LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	PP _{S_u} (kPa)	
15	35.0	35.8	W15	35.0 m to 35.8 m - hard dark greenish grey (5GY-4/1) slightly sandy CLAY with very closely to closely spaced thinly to thickly laminated greenish grey silica sand	35.1	46	19.5	13.4									
					35.3				66	27	39						350
					35.4								555				
					35.4								395				
					35.6					79	22	57					433
					35.6		27										
16	36.0	36.7	W16	36.0 m to 36.7 m - hard dark greenish grey (5GY-4/1) slightly sandy CLAY with closely spaced thinly laminated greenish grey silica sand	36.0	36						200					
					36.0								190				
					36.1	41		14.3									550
					36.3	40	19.9										500
					36.5												
					39.5												17: 3" Thick Wall
17	39.5	39.6	W17	39.5 m to 39.5 m - dark greenish grey (5GY-4/1) slightly sandy CLAY with coarse gravel-sized pockets of very dark greenish grey silica sand 39.5 m to 39.6 m - very dark greenish grey (10Y-3/1) fine silica SAND 40.0 m to 40.02 m - dark greenish grey (5GY-4/1) slightly sandy CLAY with coarse gravel-sized pockets of very dark greenish grey silica sand	39.5												
					39.6	30	17.8	13.7									18: 3" Thick Wall - Dense sand expanded in tube
18	40.0	40.1	W18		40.0												
					40.1		17.3	9.3									19: 3" Thick Wall
19	42.0	42.2	W19		42.0							34					
					42.2	28	19.0	14.8									20: 3" Thick Wall - Dense sand expanded in tube
20	42.5	42.7	W20	42.5 m to 42.7 m - dark greenish grey (5GY-4/1) slightly clayey fine silica SAND 45.0 m to 45.2 m - dark greenish grey (5GY-4/1) slightly clayey fine silica SAND 45.5 m to 45.7 m - dark greenish grey (5GY-4/1) slightly clayey fine silica SAND	42.7	29	17.2	13.3									
					42.7												21: 3" Thick Wall - Dense sand expanded in tube
21	45.0	45.2	W21		45.2	29	17.8	13.8									22: 3" Thick Wall - Dense sand expanded in tube
					45.7	26	18.4	14.6									22: 3" Thick Wall - Dense sand expanded in tube
22	45.5	45.7	W22		45.7												
Key:				W : WIP or Push Sampler	MC : Moisture Content	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	UU : Unconsolidated Undrained Laboratory Vane	LV : Fall Cone	FC : Torvane	TV : Torvane	PP : Pocket Penetrometer	S _u : Undrained Shear Strength	100 : refers to test performed offshore	100 : refers to remoulded test	

SUMMARY OF LABORATORY TEST RESULTS

BH_14



Made By: SF/KF Date: 29/03/2011

GeODir-System/ Labsum.GLO / 26/07/2011/17:58:21

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests					Remarks
No.	From (m)	To (m)	Type					LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)	
23	47.5	47.7	W23	47.5 m to 47.7 m - dark greenish grey (5GY-4/1) fine silica SAND	47.5		9.9									23: 3" Thick Wall
24	48.0	48.2	W24	48.0 m to 48.2 m - dark greenish grey (5GY-4/1) silty fine silica SAND	48.1	31	16.7									24: 3" Thick Wall
25	50.0	50.2	W25	50.0 m to 50.2 m - dark greenish grey (5GY-4/1) silty fine silica SAND with fine to coarse gravel-sized pockets of dark greyish brown clay	50.1	30	16.5									25: 2" Thick Wall with core catcher - Dense sand expanded in tube
Key: W : WIP or Push Sampler MC : Moisture Content PP : Pocket Penetrometer P : Piston Sampler LL : Liquid Limit S _u : Undrained Shear Strength H : Hammer Sampler PL : Plastic Limit FC : Fall Cone TV : Torvane PI : Plasticity Index																

SUMMARY OF LABORATORY TEST RESULTS

BH_14



Made By: SF/KF Date:

GeODin-System/ Labsum.GLO / 26/07/2011/17:49:09

Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																															
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)		PP _{S_u} (kPa)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
1	3.0	3.6	W1	3.0 m to 3.6 m - very dark greenish grey (5GY-3/1) fine silty silica SAND with closely spaced thick laminae and fine to medium gravel-sized pockets of dark grey sandy clay with fine to medium gravel-sized pockets of greenish grey fine silica sand	3.1	28	17.1	13.4							1: 3" Thick Wall																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
2	7.0	7.7	W2	7.0 m to 7.7 m - hard dark greenish grey (10Y-4/1) slightly sandy CLAY with traces of fine gravel-sized pockets of black staining	3.4	22	15.8	13.0							308																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																
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3	8.0	8.8	W3	8.0 m to 8.8 m - very stiff to hard dark greenish grey (10Y-4/1) slightly sandy CLAY with medium spaced thin laminae and fine gravel-sized pockets of dark greenish grey silica sand and with traces of fine gravel-sized pockets of black staining	8.1	25	20.2	16.2									3: 3" Thick Wall																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
4	12.0	12.2	W4	12.0 m to 12.1 m - very stiff dark greenish grey (10Y-3/1) slightly sandy CLAY 12.1 m to 12.1 m - dark greenish grey (10Y-3/1) very sandy CLAY with fine gravel-sized pockets of very dark greyish green and olive silica sand and with fine gravel-sized pockets of dark greenish grey slightly sandy clay	8.3																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																										
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5	12.5	13.2	W5	12.0 m to 12.1 m - very stiff dark greenish grey (10Y-3/1) slightly sandy CLAY 12.1 m to 12.1 m - dark greenish grey (10Y-3/1) very sandy CLAY with fine gravel-sized pockets of very dark greyish green and olive silica sand and with fine gravel-sized pockets of dark greenish grey slightly sandy clay 12.1 m to 12.2 m - very dark greyish green (5G-2.5) silty silica SAND 12.5 m to 12.6 m - greenish black (5G-2.5/1) silty fine silica SAND with very closely to closely spaced thin laminae of dark grey slightly sandy clay	12.0	29																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																									

SUMMARY OF LABORATORY TEST RESULTS

BH_02

E.ON CLIMATE AND RENEWABLES
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION



GeODir-System/ Labsum.GLO / 26/07/2011/17:49:09

Made By: SF/KF

Date:

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits				Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)	
			at 12.6 m - with a thin laminae of olive (5Y-4/4) weak CLAYSTONE	12.6												
			12.7 m to 13.2 m - very dark greyish green (5G-2.5/2) silty fine silica SAND with medium spaced olive grey to very dark grey thin laminae of slightly sandy clay	12.8	28	18.1	14.1									
6	16.5	16.8	16.5 m to 16.7 m - very stiff very dark greenish grey (5GY-3/1) very sandy CLAY	13.0	27	17.4	13.8									6: 3" Thick Wall
			16.7 m to 16.8 m - very dark greenish grey (5GY-3/1) silty fine silica SAND with fine to medium gravel-sized pockets of slightly sandy clay	16.8	24	17.5	14.1									
7	17.0	17.8	17.0 m to 17.2 m - dark greenish grey (10GY-4/1) silty fine to medium silica SAND with medium gravel-sized pockets of dark grey slightly sandy clay	17.1	23											7: 3" Thick Wall
			17.2 m to 17.8 m - dark greenish grey (5Y-4/1) sandy CLAY with very closely spaced thin laminae and many fine gravel-sized pockets of greenish grey silica sand	17.2				54	15	39						
				17.4	26	20.2	16.0									
8	19.5	19.6	19.5 m to 19.6 m - very dark greenish grey (5GY-3/1) silty fine silica SAND with traces of black staining	19.6	24	18.9	15.2									8: 3" Thick Wall
			at 19.6 m - with a thin laminae of dark grey silt	19.6												
9	20.0	20.4	20.0 m to 20.4 m - thinly to thickly interlaminated dark greenish grey (5Y-4/1) silty fine silica SAND with dark grey (5Y-4/1) slightly sandy CLAY	20.1	23											9: 3" Thick Wall
10	22.5	22.6	22.5 m to 22.6 m - very dark greenish grey (10GY-3/1) silty fine to medium silica SAND with traces of fine gravel-sized pockets of dark grey slightly sandy clay and with a fine to medium gravel-sized clast of light greenish grey	22.6	29	17.9	13.9									10: 3" Thick Wall
11	23.0	23.4	23.4 m - very dark greenish grey (5GY-4/1) silty fine to medium silica SAND with fine to medium gravel-sized clast of light greenish grey claystone	23.1	26	18.4	14.5									11: 3" Thick Wall. Dense sand expanded in sampler
			26.0 m to 26.1 m - very dark greenish grey (5GY-4/1) slightly sandy CLAY	26.0	35											12: 3" Thick Wall. Dense sand expanded in sampler
12	26.0	26.2	26.1 m to 26.2 m - very dark greenish grey (5GY-4/1) silty fine to medium silica SAND with traces of fine gravel-sized pockets of dark greenish grey slightly sandy clay and with a fine gravel-sized clast of light greenish grey claystone	26.1	28											
Key:			W : WIP or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer										
P			: Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	S _u : Undrained Shear Strength										
H			: Hammer Sampler	PL : Plastic Limit	FC : Fall Cone	TV : refers to test performed offshore										
				PI : Plasticity Index	Tv : Torvane	100 : refers to remoulded test										

SUMMARY OF LABORATORY TEST RESULTS
BH_02



Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/17:49:10

Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	
13	26.5	26.6	W13	26.5 m to 26.6 m - thinly to thickly interlaminated very dark greyish green (5GY-3/2) and dark greenish grey slightly silty silica SAND with traces of fine gravel-sized pockets of dark greenish grey slightly sandy clay	26.5	28	18.5	14.4								13: 3" Thick Wall
14	30.0	30.5	W14	30.0 m to 30.5 m - thinly to thickly interlaminated greenish grey (5GY-4/1) slightly sandy CLAY and dark greenish grey (10Y-5/1) slightly silty SAND	30.0				78	32	46					14: 3" Thick Wall. Dense sand expanded in sampler
					30.1	28										
					30.3	32										
15	30.5	30.8	W15	30.5 m to 30.8 m - thinly to thickly interlaminated stiff to very stiff greenish grey (5GY-4/1) slightly sandy CLAY and dark greenish grey (10Y-5/1) slightly silty SAND	30.6	28										15: 3" Thick Wall
					30.6											
					30.7	24									125	171
16	34.0	34.4	W16	34.0 m to 34.4 m - thinly to thickly interlaminated hard greenish grey (5GY-4/1) slightly sandy CLAY and dark greenish grey (10Y-5/1) slightly silty SAND. More clay than above.	34.1	29										16: 3" Thick Wall. Dense sand expanded in sampler
					34.1											
17	34.5	34.9	W17	34.5 m to 34.9 m - greenish grey (5GY-4/1) slightly sandy CLAY with very closely spaced thin laminae of dark greenish grey slightly silty SAND and with traces of medium to coarse gravel-sized pockets of light brownish grey clay	34.5				56	17	39					17: 3" Thick Wall. Dense sand expanded in sampler
					34.9	28										
18	37.0	37.2	W18	37.0 m to 37.2 m - thinly interlaminated to thinly interbedded greenish grey (5GY-4/1) slightly sandy CLAY and dark greenish grey (10Y-5/1) slightly silty SAND	37.1	27		15.3								18: 3" Thick Wall. Dense sand expanded in sampler
					37.2	22	18.7									
19	37.5	37.9	W19	37.5 m to 37.9 m - hard greenish grey (10Y-5/1) slightly sandy CLAY with very closely spaced thin laminae of dark greenish grey fine to medium silica sand and with one thin lamination of light brownish grey clay at 37.65 m	37.5				55	17	38					19: 3" Thick Wall. Dense sand expanded in sampler
					37.6	29										
					37.8	37									317	
Key:				W : W/P or Push Sampler	MC : Moisture Content	UU : Undrained Shear Strength	LV : Undrained Shear Strength	FC : Undrained Shear Strength	TV : Undrained Shear Strength	PP : Pocket Penetrometer						
	P : Piston Sampler	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index												
	H : Hammer Sampler															

SUMMARY OF LABORATORY TEST RESULTS

BH_02

Made By: SF/KF Date:

GeODin-System/ Labsum.GLO / 26/07/2011/17:49:10

Sample Details				Atterberg Limits				Index Soil Strength Tests					Remarks				
No.	From (m)	To (m)	Type	Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	LL (%)	PL (%)	PI (%)	UU S _u (kPa)		LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)
20	41.0	41.2	W20	41.0 m to 41.2 m - dark greenish grey (10Y-5/1) fine to medium silica SAND with fine to coarse gravel-sized pockets of dark greenish grey sandy clay	41.2	28	17.7	13.8									20: 3" Thick Wall. Dense sand expanded in sampler
21	41.5	41.6	W21	41.5 m to 41.6 m - greenish grey (5GY-4/1) slightly sandy CLAY with coarse gravel-sized pockets of light brownish grey clay	41.5												21: 3" Thick Wall
				41.6 m to 41.6 m - dark greenish grey (10Y-5/1) fine to medium silica SAND	41.6	27	17.0	13.4									
22	42.0	42.4	W22	42.0 m to 42.4 m - greenish grey (10Y-5/1) CLAY with very closely spaced thin laminae of dark greenish grey fine silica sand and with traces of fine to medium gravel-sized pockets of very dark greyish green slightly clayey sand	42.0				65	19	46						22: 3" Thick Wall. Dense sand expanded in sampler
					42.3	16											
23	42.5	42.8	W23	42.5 m to 42.8 m - thinly to thickly laminated greenish grey (10Y-5/1) slightly sandy CLAY and dark greenish grey fine to medium silica sand and with one thick laminae of light brownish grey clay	42.7	21	17.5	14.4									23: 3" Thick Wall. Dense sand expanded in sampler
					42.8	23											
24	46.0	46.4	W24	46.0 m to 46.4 m - greenish grey (10Y-5/1) CLAY with very closely spaced thin laminae of dark greenish grey fine to medium silica sand	46.2	29	25.1	19.5	84	31	53						24: 3" Thick Wall
					46.3		24.3										
Key:				W : W/P or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer										
	P	H		: Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	S _u : Undrained Shear Strength										
				: Hammer Sampler	PL : Plastic Limit	FC : Fall Cone	100 : refers to test performed offshore										
					PI : Plasticity Index	TV : Torvane	100 : refers to remoulded test										

SUMMARY OF LABORATORY TEST RESULTS

BH_02

GeODir-System/ Labsum.GLO / 26/07/2011/17:51:00 Made By: SF/KF Date:

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits				Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type					LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)	
1	4.5	5.2	W1	4.5 m to 4.6 m - stiff very dark greenish grey (10Y-3/1) CLAY with very closely spaced thin laminae of very dark greyish green silica sand	4.5	26									129	1: 2" Core Catcher - Dense sand expanded in sampler
				4.6 m to 4.8 m - dark greyish brown (2.5Y-4/2) very sandy silica SILT with very closely to closely spaced thin to thick laminae of very dark greenish grey silty silica sand	4.7	18										
				At 10 and 13 cm - 1cm of very hard silt, unable to penetrate with vspp, strong reaction with HCl												
				4.8 m to 5.2 m - very dark greyish olive (10Y-3/2) silty fine silica SAND	5.0	26	14.4									
2	7.0	7.1	W2	7.0 m to 7.1 m - very dark greyish olive (10Y-3/2) silty fine silica SAND	7.1	33	13.0									
3	7.5	7.7	W3	7.5 m to 7.7 m - very dark greyish olive (10Y-3/2) silty fine silica SAND with fine gravel-sized pockets of olive grey silt	7.6	32	12.9									
4	10.5	11.2	W4	10.5 m to 10.6 m - dark greenish grey (10Y-3/1) medium to coarse gravel-sized SILTSTONE with dark greenish grey to greenish grey clayey silt	10.5											
				10.6 m to 10.7 m - very dark greenish grey (10Y-3/1) very silty fine silica SAND with extremely closely spaced thin laminae of light greenish grey very silty fine silica sand	10.7	29	14.3									
				10.7 m to 10.8 m - hard dark greenish grey (5GY-4/1) slightly sandy CLAY	10.7											
				10.8 m to 11.2 m - very dark greenish grey (10Y-3/1) very silty fine silica SAND with extremely closely spaced thin laminae of light greenish grey very silty fine silica sand	10.8	27	14.4									
5	14.0	14.2	W5	14.0 m to 14.2 m - dark grey (5Y-4/1) very silty fine silica SAND	14.1	27	14.7									
6	14.5	14.7	W6	14.5 m to 14.7 m - dark grey (5Y-4/1) very silty fine silica SAND	14.6	33	13.1									
7	16.5	16.7	W7	16.5 m to 16.7 m - dark grey (5Y-4/1) very silty fine silica SAND with a very thin bed of dark grey very clayey sand	16.6	30	13.0									
Key: W : WIP or Push Sampler MC : Moisture Content PP : Pocket Penetrometer P : Piston Sampler LL : Liquid Limit S _u : Undrained Shear Strength H : Hammer Sampler PL : Plastic Limit FC : Fall Cone 100 : refers to test performed offshore TV : Torvane PI : Plasticity Index 100 : refers to remould test																

SUMMARY OF LABORATORY TEST RESULTS

BH_04

E.ON CLIMATE AND RENEWABLES
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION



Made By: SF/KF Date:

GeoDir-System/ Labsum.GLO / 26/07/2011/17:51:00

Sample Details				Atterberg Limits				Index Soil Strength Tests				Remarks					
No.	From	To	Type	Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	LL (%)	PL (%)	PI (%)		UU Su (kPa)	LV Su (kPa)	FC Su (kPa)	TV Su (kPa)	PP Su (kPa)
8	17.0	17.3	W8	17.0 m to 17.2 m - dark grey (5y-4/1) very silty fine silica SAND with a very thin bed of dark grey very clayey sand	17.0												8: 2" Core Catcher - Dense sand expanded in sampler and likely sand in drill bit
9	19.0	19.2	W9	19.0 m to 19.2 m - dark grey (5Y-4/1) very silty fine silica SAND with a thick laminae of dark grey very clayey sand	19.1	30	18.2	14.0									9: 2" Core Catcher - Dense sand expanded in sampler and likely sand in drill bit
10	19.5	19.7	W10	19.5 m to 19.6 m - dark grey (5Y-4/1) very silty fine silica SAND with thin laminations of very dark greenish grey very silty fine silica sand	19.5												10: 2" Core Catcher - Dense sand expanded in sampler and likely sand in drill bit
11	21.5	22.5	W11	19.6 m to 19.7 m - dark grey (5Y-4/1) very silty fine silica SAND with thin laminations of very dark greenish grey very silty fine silica sand	19.6	27	17.9	14.1									11: 2" Thick Wall with Core Catcher
				21.5 m to 21.6 m - dark greenish grey (5GY-4/1) slightly sandy SILT	21.5	25											
				21.6 m to 22.0 m - Thinly to thickly interlaminated very dark greenish grey (10Y-3/1) SAND and light greenish grey (10Y-7/1) SAND	21.6												
				21.7	28	18.1	14.1										
				22.3	32	18.9	14.3										
12	22.5	23.0	W12	22.0 m to 22.5 m - very dark greenish grey (10Y-3/1) sandy SILT. Sand is fine	22.3											12: 3" Thick Wall	
				22.5 m to 22.6 m - dark greenish grey (5GY-4/1) slightly sandy CLAY with coarse gravel-sized pockets of very dark greyish green slightly sandy silt	22.5												
				22.6 m to 23.0 m - very dark greenish grey (10Y-3/1) sandy SILT with convaluted thin to thick laminae of very dark greyish green slightly sandy silt from 22.6 m - 22.7 m. Sand is fine	22.6	25											
13	23.5	23.8	W13	23.5 m to 23.8 m - very dark greenish grey (10Y-3/1) sandy SILT with closely spaced thin laminae of very dark greyish green fine silica sand. Sand is fine	22.8	22	20.8	17.0	42	21	21					13: 3" Thick Wall	
				23.7	22												
14	27.0	27.4	W14	27.0 m to 27.4 m - hard dark grey (2.5Y-4/1) slightly sandy CLAY	27.0	21	21.1	17.5								14: 3" Thick Wall	
				27.1				56	22	34						583	
				27.2												600	
				27.2	19	20.6	17.4								669		
Key:				W : WIP or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer										
	P		: Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	FC : Fall Cone	TV : Undrained Shear Strength										
	H		: Hammer Sampler	PL : Plastic Limit	PI : Tonvane	100 : refers to test performed offshore											
				PI : Plasticity Index													: refers to remoulded test

SUMMARY OF LABORATORY TEST RESULTS
BH_04



Made By: SF/KF Date:

GeoDir-System/ Labsum.GLO / 26/07/2011/17:51:00

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits				Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	PP _{S_u} (kPa)	
15	27.5	27.8	W15	27.5 m to 27.8 m - hard dark grey (2.5Y-4/1) sandy CLAY with medium to coarse gravel-sized pockets of dark grey fine silica sand and with traces of fine gravel-sized white cylindrical fossils	27.6	19	22.2	18.7								15: 3" Thick Wall - Dense sand expanded in sampler and likely sand in drill bit
16	30.5	30.7	W16	30.5 m to 30.6 m - very stiff dark grey (2.5Y-4/1) sandy CLAY with medium gravel-sized pockets of dark greenish grey fine to medium silica sand	30.5	15	21.1	18.3	46	18	28					16: 3" Thick Wall
17	31.0	31.2	W17	31.0 m to 31.1 m - olive grey (5Y-4/2) slightly silty fine silica SAND with medium to coarse gravel-sized pockets of dark olive grey slightly sandy clay	30.6	18	19.0	15.2								17: 3" Thick Wall - Dense sand expanded in sampler and likely sand in drill bit
18	34.5	34.8	W18	31.1 m to 31.2 m - olive grey (5Y-4/2) fine silica SAND	31.0	26	18.1	14.3								18: 3" Thick Wall - Dense sand expanded in sampler
19	35.0	35.5	W19	34.5 m to 34.8 m - very dark greenish grey (10Y-3/1) sandy SILT with coarse gravel-sized pockets of very dark grey slightly sandy clay and burrows of dark greyish brown fine silica sand	34.5	24	20.8	14.1	56	22	34					19: 3" Thick Wall
20	38.5	39.2	W20	35.0 m to 35.5 m - greenish grey (10Y-5/1) sandy SILT with very closely spaced thin laminae of dark greyish brown fine silica sand	34.6	47										20: 3" Thick Wall
21	39.5	40.1	W21	38.5 m to 38.6 m - very dark grey (2.5Y-3/1) sandy CLAY	35.1	22	22.3	18.3								21: 3" Thick Wall
				38.6 m to 39.2 m - greenish grey (10Y-5/1) sandy SILT	38.6	36	19.6	14.4								
				39.5 m to 40.1 m - greenish grey (10Y-5/1) sandy SILT with coarse sand-sized to medium gravel-sized pockets and extremely closely spaced thin laminae of grey fine silica sand and with traces of coarse sand sized-organic charcoal and shell fragments	38.8	19	20.7	17.4								
					39.0	20			49	16	33					
					39.5	19										
					39.7											
					39.8											
Key:			W : WIP or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer	LV : Undrained Shear Strength	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	TV : Torvane	FC : Fall Cone	TV : Torvane	FC : Fall Cone	TV : Torvane	FC : Fall Cone

SUMMARY OF LABORATORY TEST RESULTS

BH_04

Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/17:51:00

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests					Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)	
22	43.0	43.3	W22	43.0 to 43.1 m - dark greenish grey (10Y-4/1) CLAY	43.0			51	20	31						22: 3" Thick Wall - Dense sand expanded in sampler and likely sand in drill bit
				43.1 m to 43.3 m - very dark grey (5Y-3/1) sandy SILT with coarse sand sized to medium gravel sized pockets and laminations of grey fine silica sand	43.1	20										
23	43.5	43.9	W23	43.5 m to 43.9 m - greenish grey (10Y-5/1) sandy SILT with clay - sample has a higher clay percentage than the previous sample	43.5	22	21.9	17.9			568					23: 3" Thick Wall
					43.8	22	20.9	17.1	21	26						
24	47.0	47.4	W24	47.0 m to 47.4 m - very hard very dark grey (5Y-3/1) slightly sandy CLAY with silt	47.1		20.6	51	22	29						24: 3" Thick Wall - Dense sand expanded in sampler
					47.2	20	20.5	17.0			903					
Key: W : WIP or Push Sampler MC : Moisture Content PP : Pocket Penetrometer P : Piston Sampler LL : Liquid Limit S _u : Undrained Shear Strength H : Hammer Sampler PL : Plastic Limit FC : Fall Cone TV : Torvane PI : Plasticity Index TV : Torvane																

SUMMARY OF LABORATORY TEST RESULTS

BH_04

Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/17:52:10

Sample Details				Index Soil Strength Tests										Remarks			
No.	From (m)	To (m)	Type	Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			UU S _u (kPa)	LV S _u (kPa)		FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)
1	0.0	0.5	W1	0.0 m to 0.1 m - dark greenish grey (10Y-4/1) fine to coarse silica SAND with fine to medium gravel of mixed lithologies and fine to coarse gravel-sized shell fragments and shells 0.1 m to 0.5 m - stiff to very stiff dark greenish grey (5GY-4/1) CLAY with coarse gravel-sized pockets of fine to coarse silica sand and with closely spaced thin laminae of fine silica sand	0.0												1: 3" Thick Wall
					0.3	33				76	29	47				163	146
					0.5												
					0.5												
2	1.0	1.7	W2	1.0 m to 1.1 m - dark greenish grey (5GY-4/1) slightly sandy CLAY with fine gravel-sized shell fragments and shells 1.1 m to 1.4 m - very dark grey (2.5Y-3/1) fine to coarse silica SAND with fine to coarse gravel-sized gravel and shell fragments and with fine gravel-sized pockets of dark greenish grey clay	1.0	31	19.0	14.3									2: 3" Thick Wall
					1.1	45											
					1.2	56											
					1.4												
					1.6												
3	2.0	2.7	W3	1.4 m to 1.7 m - very stiff dark greenish grey (5GY-4/1) slightly sandy CLAY with fine gravel-sized shell fragments and shells 2.0 m to 2.2 m - stiff dark grey (2.5Y-4/1) CLAY with fine to medium gravel-sized shell fragments and shells	2.0												3: 3" Thick Wall
					2.2	40											158
					2.2	46				76	26	50					104
					2.2	30	19.5	14.6									
					2.6												
					2.7	32											
4	3.0	3.2	W4	3.0 m to 3.1 m - dark greenish grey (10Y-4/1) slightly sandy CLAY 3.1 m to 3.2 m - dark greenish grey (10Y-4/1) slightly clayey fine silica SAND with coarse sand-sized to fine gravel-sized pockets of very dark greyish olive fine silica sand	3.0												4: 3" Thick Wall. Sand expanded in sampler
					3.1	31											
Key:				W : WIP or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer										
	P		: Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	FC : Fall Cone	TV : Torvane										
	H		: Hammer Sampler	PL : Plastic Limit	PI : Plasticity Index												

SUMMARY OF LABORATORY TEST RESULTS

BH_04A

Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/17:52:11

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests					Remarks
No.	From (m)	To (m)	Type					LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)	
5	3.5	4.1	W5	3.5 m to 4.1 m - dark greenish grey (10Y-4/1) slightly clayey fine silica SAND with traces of mica crystals	3.2	28	18.8									5: 3" Thick Wall. Sand expanded in sampler
6	4.0	4.2	W6	4.0 m to 4.2 m - dark greenish grey (10Y-4/1) slightly clayey fine silica SAND with traces of mica crystals and fine gravel-sized pockets of very dark greyish olive fine silica sand	3.8 4.1 4.2	31 32	18.1 18.7									6: 3" Thick Wall
Key: W : WIP or Push Sampler MC : Moisture Content UU : Unconsolidated Undrained PP : Pocket Penetrometer P : Piston Sampler LL : Liquid Limit LV : Laboratory Vane S _u : Undrained Shear Strength H : Hammer Sampler PL : Plastic Limit FC : Fall Cone TV : Torvane 100 : refers to remould test																

SUMMARY OF LABORATORY TEST RESULTS BH_04A

Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/17:52:59

Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests					Remarks	
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU Su (kPa)	LV Su (kPa)	FC Su (kPa)	TV Su (kPa)	PP Su (kPa)		
1	3.0	3.5	W1	3.0 m to 3.5 m - stiff to very stiff dark grey (5Y-4/1) slightly sandy CLAY	3.0				67	26	41					77	1: 3" Thick Wall	
					3.1													
					3.2	36	19.6	14.4							88			
					3.3	29	19.4	15.0					92		138			
					3.4											168		
2	4.0	4.3	W2	4.0 m to 4.3 m - very stiff dark grey (5Y-4/1) slightly sandy CLAY	4.0	29	19.4	14.8				44				217	2: 3" Thick Wall	
				4.2	28	19.8	15.5											
3	4.5	5.0	W3	4.5 m to 5.0 m - very stiff dark grey (5Y-4/1) slightly sandy CLAY	4.5				71	24	47					175	3: 3" Thick Wall - Oversample. Top 0.30 m disturbed	
				4.8	39	19.7	14.1											
4	8.0	8.5	W4	8.0 m to 8.5 m - very stiff dark grey (5Y-4/1) slightly sandy CLAY with fine gravel-sized pockets of grey fine silica sand	8.1	28	19.7	15.4								204	4: 3" Thick Wall	
				8.3	28	19.9	15.8					169						
5	9.0	9.4	W5	9.0 m to 9.4 m - very stiff to hard dark grey (5Y-4/1) slightly sandy CLAY with fine gravel-sized pockets of grey sand	9.0	33	19.6	14.7								300	5: 3" Thick Wall	
				9.2	29	19.4	15.0		86	27	59	111						
6	9.5	10.3	W6	9.5 m to 10.3 m - very stiff to hard dark grey (5Y-4/1) slightly sandy CLAY with fine gravel-sized pockets of grey sand	9.5				81	25	56					283	6: 3" Thick Wall - Oversample. Top 0.45 m disturbed	
				10.0	36	19.0	14.0											
				10.2	36	19.3	14.2								292			
				10.3											313			
7	13.5	13.9	W7	13.5 m to 13.9 m - very stiff to hard dark grey (5Y-4/1) slightly sandy CLAY with fine gravel-sized pockets of grey sand	13.5	26	19.9	15.8							350	7: 3" Thick Wall		
				13.7	26	20.0	15.5		77	29	48	264			333			
				13.9											250			
Key:				W : W/P or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer											
	P : Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	FC : Undrained Shear Strength														
	H : Hammer Sampler	PL : Plastic Limit	PI : Plasticity Index	TV : Torvane														

SUMMARY OF LABORATORY TEST RESULTS

BH_06



Made By: SF/KF

GeODin-System/ Labsum.GLO / 26/07/2011/17:53:00

Date:

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S_u (kPa)	LV S_u (kPa)	FC S_u (kPa)	TV S_u (kPa)	
8	14.0	14.9	W8	14.0 m to 14.9 m - very stiff to hard dark grey (5Y-4/1) slightly sandy CLAY with fine gravel-sized pockets of grey sand	14.3			74	22	52					8: 3" Thick Wall - Oversample. Top 0.50 m disturbed
					14.5	32	19.9								231
					14.7	26	20.1				238				330
					14.9										290
9	18.0	18.6	W9	18.0 m to 18.5 m - very hard dark grey (5Y-4/1) slightly sandy CLAY with fine gravel-sized pockets of grey sand	18.0	23	20.9								300
				at 18.2 m - a very thin bed of dark grey (5Y-4/1) slightly silty fine silica sand	18.2										483
					18.3	20	20.9				349				
				at 18.5 m - with a medium sub-rounded gravel	18.4										
				18.5 m to 18.6 m - very dark grey (5Y-3/1) sandy CLAY with many fine gravel-sized pockets and thin laminae of grey sand	18.5			40	20	20					
10	19.0	19.2	W10	19.0 m to 19.2 m - olive grey (5Y-4/2) slightly sandy SILT with a coarse gravel-sized pocket of very weak grey siltstone	19.0	15	20.7								10: 3" Thick Wall
11	19.5	19.9	W11	19.5 m to 19.9 m - dark grey (5Y-4/1) slightly sandy SILT with a coarse gravel-sized pocket of very weak grey (5Y-5/1) siltstone and traces of medium gravel-sized shell fragments	19.6	20	20.9								11: 3" Thick Wall
					19.9	20									
12	22.5	22.9	W12	22.5 m to 22.7 m - very dark grey (5Y-3/1) slightly sandy SILT with fine to medium gravel of black flint	22.5										12: 3" Thick Wall
				22.7 m to 22.9 m - dark grey (5Y-4/1) slightly sandy SILT with many coarse sand-sized to medium gravel-sized shell fragments and coarse gravel-sized pockets of light olive grey silt with a medium gravel of flint and with traces of fine gravel-sized flint fragments	22.7			44	16	28					
13	23.0	23.2	W13	23.0 m to 23.2 m - very dark grey (5Y-3/1) slightly sandy SILT with many coarse sand-sized to medium gravel-sized shell fragments	23.0										13: 3" Thick Wall
14	23.5	23.6	W14	23.5 m to 23.6 m - grey (2.5Y-5/1) slightly sandy SILT with fine to coarse gravel-sized shell fragments, chalk and coarse gravel-sized clasts of fossiliferous calcareous siltstone. Clasts are moderately strong, high density	23.5										14: 3" Thick Wall
14A		23.9	H14A	23.5 m to 23.9 m - grey (2.5Y-5/1) slightly sandy SILT with fine to coarse gravels of flint and chalk. Flint is rounded and chalk is sub-angular.	23.6	30									14A: 50 Blows
Key:			W : WIP or Push Sampler	MC : Moisture Content		UU : Unconsolidated Undrained	LV : Laboratory Vane	FC : Fall Cone	TV : Torvane	PP : Pocket Penetrometer	UU S_u : Undrained Shear Strength	LV S_u : Undrained Shear Strength	FC S_u : Undrained Shear Strength	TV S_u : Undrained Shear Strength	

SUMMARY OF LABORATORY TEST RESULTS

BH_06

Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{Su} (kPa)	LV _{Su} (kPa)	FC _{Su} (kPa)	TV _{Su} (kPa)	
15	24.0	24.0	W15		24.0										15: 3" Thick Wall. Unrecovered soil is likely to have been silt as in previous sample was not retained due to absence of core catcher in the 3"thick wall tube which was requested to be used	
16	26.0	26.2	W16		26.0										16: 3" Thick Wall	
					26.1	21	22.7	18.7							300	
					26.1											
					26.2	22										
17	26.5	26.6	W17		26.6	29									17: 3" Thick Wall	
18	27.0	27.2	W18		27.0										18: 3" Thick Wall	
					27.2	26									19: 3" Thick Wall	
19	27.5	27.7	W19		27.5											
					27.6	28										
					27.6	28	17.3	13.6							20: 50 Blows	
20	29.5	29.6	H20		29.5											
					29.6	24										
Key:				W	:	WIP or Push Sampler	MC	:	Moisture Content	UU	:	Unconsolidated Undrained	PP	:	Pocket Penetrometer	
	P	:	Piston Sampler	LL	:	Liquid Limit	LV	:	Laboratory Vane	LV	:	Undrained Shear Strength	Su	:	Undrained Shear Strength	
	H	:	Hammer Sampler	PL	:	Plastic Limit	FC	:	Fail Cone	FC	:	refers to test performed offshore	100	:	refers to test performed offshore	
				PI	:	Plasticity Index	TV	:	Torvane	TV	:	refers to remoulded test	100	:	refers to remoulded test	

BH 06

BH 06

	:	WIP or Push Sampler	: MC	:	Moisture Content	UU	:	Unconsolidated Undrained	PP	:	Pocket Penetrometer
Key:	:	Piston Sampler	LL	:	Liquid Limit	LV	:	Laboratory Vane	S _u	:	Undrained Shear Strength
	:	Hammer Sampler	PL	:	Plastic Limit	FC	:	Fall Cone	100	:	refers to test performed offshore
	:		PI	:	Plasticity Index	TV	:	Torvane	100	:	refers to remoulded test

Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/17:53:00

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	
28	38.5	38.9	W28	37.6	15	21.3	18.2	57	22	35	326				28: 3" Thick Wall
				37.6	16										433
				37.8	18										517
29	42.0	42.2	W29	38.5											
				38.7	20	19.9	16.6								
				42.0	37	17.8	13.0								29: 3" Thick Wall
30	42.5	42.9	W30	42.1	37			71	36	35					
				42.1											
				42.1											
31	44.5	44.7	W31	42.6	19	19.8	16.7								30: 3" Thick Wall
				42.9	17	19.3	16.4								
				44.5	21	19.3	15.9								31: 3" Thick Wall
32	45.0	45.3	W32	45.1	21	18.7	15.4								
				45.1											32: 3" Thick Wall
33	47.0	47.2	W33	47.0											
				47.0											33: 3" Thick Wall
				47.2	23										
34	47.5	47.6	W34	47.5											
				47.5											34: 3" Thick Wall
35	48.0	48.3	W35	48.0											
				48.0											35: 3" Thick Wall
Key:			W : WIP or Push Sampler	MC : Moisture Content	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	UU : Unconsolidated Undrained	LV : Laboratory Vane	FC : Fall Cone	TV : Torvane	PP : Pocket Penetrometer	S _u : Undrained Shear Strength	100 : refers to test performed offshore	
P			: Piston Sampler											100	
H			: Hammer Sampler											100	
															refers to remould test

SUMMARY OF LABORATORY TEST RESULTS

BH_06

Made By: SF/KF Date:

GeoDir-System/ Labsum.GLO / 26/07/2011/17:53:00

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	
			at 48.1 m - with a coarse gravel of flint (70 x 60 x 40 mm)	48.1											
36	48.5	49.2	W36 composed of white (9.5N) creamy silt and medium blocky gravel. Chalk clasts are weak medium density (Grade Dc).	48.4	29	18.9	14.9								36: 3" Thick Wall
37	49.5	49.8	W37 composed of white (9.5N) creamy silt and medium blocky gravel. Chalk clasts are weak medium density (Grade Dc).	49.5											37: 3" Thick Wall
38	50.0	50.6	W38 composed of white (9.5N) creamy silt and a medium blocky gravel. Chalk clasts are weak medium density (Grade Dc).	49.6	33										38: 3" Thick Wall
39	51.0	51.2	W39 composed of white (9.5N) creamy silt with pockets of very dark greyish green silt and fine to medium gravel of flint. (Grade Dm)	50.2	31	19.4	14.8								39: 3" Thick Wall
40	52.0	52.9	W40 composed of white (9.5N) creamy silt and medium gravel with traces of fine gravels of flint (Grade Dc). Chalk clasts are weak low density. 52.4 m to 52.9 m - structureless CHALK composed of white (9.5N) creamy silt and medium blocky gravel. Chalk clasts are weak medium density. (grade Dc)	50.4		19.2									40: 3" Thick Wall
			52.8 m to 52.9 m - with a thick laminae of fine to medium gravel of flint	51.1	31										
				52.2	36										
				52.7	32										
				52.8											
Key:			W : WIP or Push Sampler	MC : Moisture Content	UU : Undrained Shear Strength	LV : Undrained Shear Strength	FC : Undrained Shear Strength	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	PP : Pocket Penetrometer	TV : Undrained Shear Strength	FC : Undrained Shear Strength	TV : Undrained Shear Strength	
	P : Piston Sampler		LL : Liquid Limit	MC : Moisture Content	UU : Undrained Shear Strength	LV : Undrained Shear Strength	FC : Undrained Shear Strength	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	PP : Pocket Penetrometer	TV : Undrained Shear Strength	FC : Undrained Shear Strength	TV : Undrained Shear Strength	
	H : Hammer Sampler		PL : Plastic Limit	MC : Moisture Content	UU : Undrained Shear Strength	LV : Undrained Shear Strength	FC : Undrained Shear Strength	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	PP : Pocket Penetrometer	TV : Undrained Shear Strength	FC : Undrained Shear Strength	TV : Undrained Shear Strength	
			PI : Plasticity Index	MC : Moisture Content	UU : Undrained Shear Strength	LV : Undrained Shear Strength	FC : Undrained Shear Strength	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	PP : Pocket Penetrometer	TV : Undrained Shear Strength	FC : Undrained Shear Strength	TV : Undrained Shear Strength	

SUMMARY OF LABORATORY TEST RESULTS

BH_06



Made By: SF/KF Date: 03/04/2011

GeODir-System/ Labsum.GLO / 26/07/2011/17:54:37

Sample Details				Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	
1	3.0	3.2	W1	3.0 m to 3.2 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel and with few angular fine to coarse gravel-sized black flint. Chalk clasts are very weak, low density and white. (Grade Dm)	3.1	34									1: 3" Thick Wall - Sample plugged by flint cobble	
2	4.0	4.9	W2	4.0 m to 4.9 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel with few occasional angular coarse gravel of black flint. Chalk clasts are very weak, low density and white. (Grade Dc)	4.2	30	19.7	15.1	30	22	8				2: 3" Thick Wall	
3	7.0	7.9	W3	7.0 m to 7.2 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel with few angular coarse gravel of black flint. Chalk clasts are weak, low to medium density and white. (Grade Dc) at 7.0 m - with fragments of a black flint cobble at 7.7 m - with a thick laminae of black flint fragments	4.3	29	18.9	14.6							3: 3" Thick Wall	
					4.6	26	19.5	15.4								
					7.0											
4	8.0	8.9	W4	8.0 m to 8.9 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, low to medium density and white. (Grade Dc)	7.2	27	20.0	15.8							4: 3" Thick Wall	
					7.4	23	19.9	16.2							5: 3" Thick Wall	
					7.7	27	20.1	15.8								
					8.3	28	19.7	15.3								
5	11.5	12.4	W5	11.5 m to 12.4 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	8.6	15	19.1	16.7							6: 3" Thick Wall	
					11.6	29	19.6	15.2								
					11.8		19.5									
6	12.5	13.0	W6	12.5 m to 12.6 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc) 12.6 m to 12.7 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are very weak, low density and white. (Grade Dc)	12.0	36	21.1	15.6								
					12.5											
					12.6											
Key:				W : W/P or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer									
	P		: Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	FC : Fall Cone	S _u : Undrained Shear Strength									
	H		: Hammer Sampler	PL : Plastic Limit	TV : Torvane	FC : Fall Cone	100 : refers to test performed offshore									
				PI : Plasticity Index		TV : Torvane	100 : refers to remoulded test									

SUMMARY OF LABORATORY TEST RESULTS

BH_07



Made By: SF/KF Date: 03/04/2011

GeODin-System/ Labsum.GLO / 26/07/2011/17:54:37

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests				Remarks		
No.	From (m)	To (m)						Type	LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)		TV _{S_u} (kPa)	PP _{S_u} (kPa)
HS1	14.5	14.7	HHS1	12.7 m to 13.0 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	12.6	30	19.7	15.2	28	20	8					HS1: 50 Blows	
					12.8		19.9										
					14.5												
HS2	15.0	15.3	HHS2	14.5 m to 14.7 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel with many fine to coarse gravel of flint. Chalk clasts are very weak, low density and white. (Grade Dm)	15.0	26										HS2: 50 Blows	
					15.6	25	19.3	15.4									
					16.0	26	19.3	15.3									
7	15.5	16.4	W7	15.0 m to 15.3 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dm)	15.6	25	19.3	15.4								7: 3" Thick Wall	
					16.2		19.4										
					19.6	28	20.0	15.6									
8	19.5	19.8	W8	15.5 m to 16.4 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, low to medium density and white. (Grade Dc)	19.6	28	20.0	15.6								8: 3" Thick Wall	
					20.1	26	19.7	15.7									
					20.6	12											
9	20.0	20.3	W9	20.5 m to 20.7 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel and with traces of fine gravel-sized pockets of brown organic matter. Chalk clasts are weak, medium density and white. (Grade Dc)	20.6	12										9: 3" Thick Wall	
					21.1	27											
					23.1	24											
10	20.5	20.7	W10	23.0 m to 23.2 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	23.1	24										10: 3" Thick Wall	
					23.5												
					23.6	26	20.3	16.1									
11	21.0	21.2	W11	23.5 m to 23.8 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	23.5											11: 3" Thick Wall	
					23.6												
					23.7												
12	23.0	23.2	W12	20.0 m to 20.3 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel and with traces of fine gravel-sized pockets of brown organic matter. Chalk clasts are weak, medium density and white. (Grade Dc)	20.1	26	19.7	15.7								12: 3" Thick Wall	
					20.6	12											
					21.1	27											
13	23.5	23.8	W13	23.0 m to 23.2 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	23.1	24										13: 3" Thick Wall	
					23.5												
					23.6	26	20.3	16.1									
Key: W : W/P or Push Sampler P : Piston Sampler H : Hammer Sampler MC : Moisture Content LL : Liquid Limit PL : Plastic Limit PI : Plasticity Index UU : Unconsolidated Undrained LV : Laboratory Vane FC : Fall Cone TV : Torvane PP : Pocket Penetrometer _{S_u} : Undrained Shear Strength 100 : refers to test performed offshore 100 : refers to remoulded test																	

SUMMARY OF LABORATORY TEST RESULTS

BH_07

E.ON CLIMATE AND RENEWABLES
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION



Made By: SF/KF Date: 03/04/2011

GeODin-System/ Labsum.GLO / 26/07/2011/17:54:37

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits				Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S_u (kPa)	LV S_u (kPa)	FC S_u (kPa)	TV S_u (kPa)	PP S_u (kPa)	
14	24.0	24.5	W14	24.0 m to 24.5 m - structureless CHALK composed of white (9.5/N) fine to coarse angular and blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	24.1	24	19.9	16.0								14: 3" Thick Wall
15	24.5	24.7	W15	24.5 m to 24.7 m - structureless CHALK composed of white (9.5/N) fine to medium angular and blocky gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	24.5	23	19.9	16.2								15: 3" Thick Wall
16	27.0	27.2	W16	27.0 m to 27.2 m - very weak low to medium density thinly interlaminated completely weathered white (9.5/N) CHALK and completely weathered light grey (5Y-7/1) CHALK with traces of angular medium to coarse gravel-sized flint. Grade (C1-3)	27.1	24										16: 3" Thick Wall
17	27.5	27.6	W17	27.5 m to 27.6 m - very weak low to medium density thinly interlaminated (sub-horizontal) completely weathered white (9.5/N) CHALK and completely weathered light grey (5Y-7/1) CHALK with pockets of coarse gravel-sized white silt and coarse sand-sized flint. Grade (C1-3) fractures are very close infilled with structureless white chalk. (Grade Dm)	27.5											17: 3" Thick Wall
18	28.0	28.1	W18	28.0 m to 28.2 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel. Chalk clasts are weak, medium density and white. (Grade Dc)	28.1	10										18: 3" Thick Wall
19	28.5	28.6	W19	28.5 m to 28.6 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel with traces of angular fine to medium gravel-sized flint. Chalk clasts are weak, medium density and white. (Grade Dc)	28.5	28			32	20	12					19: 3" Thick Wall
20	31.5	31.8	W20	31.5 m to 31.8 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel. Chalk clasts are weak, low to medium density and white. (Grade Dc)	31.6	32	19.4	14.6								20: 3" Thick Wall
21	32.0	32.2	W21	32.0 m to 32.2 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel with traces of angular medium to coarse gravel-sized flint. Chalk clasts are weak, low to medium density and white. (Grade Dc)	32.1	30	19.1	14.7								21: 3" Thick Wall
22	32.5	32.9	W22	32.5 m to 32.9 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel. Chalk clasts are weak, low to medium density and white. (Grade Dc)	32.7	34	19.3	14.4								22: 3" Thick Wall
23	33.0	33.4	W23	33.0 m to 33.4 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel. Chalk clasts are weak, low to medium density and white with traces of dark olive grey surface staining (Grade Dc)	33.1	26	19.1	15.1								23: 3" Thick Wall
Key:			W : WIP or Push Sampler	MC : Moisture Content	LL : Liquid Limit	PL : Plastic Limit	PI : Plasticity Index	UU : Unconsolidated Undrained Laboratory Vane	LV : Fall Cone	FC : Torvane	PP : Pocket Penetrometer	TV : Undrained Shear Strength				
P	H		: Piston Sampler								S_u					
			: Hammer Sampler								100					

SUMMARY OF LABORATORY TEST RESULTS
BH_07



Made By: SF/KF Date: 03/04/2011

GeODin-System/ Labsum.GLO / 26/07/2011/17:54:37

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits				Index Soil Strength Tests				Remarks
No.	From (m)	To (m)	Type					LL (%)	PL (%)	PI (%)	UU S_u (kPa)	LV S_u (kPa)	FC S_u (kPa)	TV S_u (kPa)	PP S_u (kPa)	
24	37.0	37.2	W24	37.0 m to 37.1 m - coarse gravel-sized gravel of black flint 37.1 m to 37.2 m - structureless CHALK composed of white (9.5/N) silt and fine to medium blocky/angular gravel. Chalk clasts are weak, low to medium density and white. (Grade Dc)	37.0	29										24: 3" Thick Wall
25	37.5	38.0	W25	37.5 m to 38.0 m - structureless CHALK composed of white (9.5/N) silt and fine to medium blocky/angular gravel. Chalk clasts are weak, low to medium density and white with medium to coarse gravel-sized flint. (Grade Dc)	37.6	29	19.7	15.3								25: 3" Thick Wall
26	38.5	39.0	W26	38.5 m to 39.0 m - structureless CHALK composed of white (9.5/N) silt and fine to medium blocky/angular gravel. Chalk clasts are weak, low to medium density and white with medium to coarse gravel-sized flint. (Grade Dc)	38.8	26	19.3	15.4								26: 3" Thick Wall
27	39.0	39.4	W27	39.0 m to 39.4 m - structureless CHALK composed of white (9.5/N) silt and fine to medium blocky/angular gravel. Chalk clasts are weak, low to medium density and white with fine to medium gravel-sized flint. (Grade Dc)	39.1	27	20.2	15.9								27: 3" Thick Wall
28	41.5	41.9	W28	41.5 m to 41.9 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel. Chalk clasts are weak, low to medium density and white with fine to medium gravel-sized flint. (Grade Dc)	41.7	30	19.6	15.0								28: 3" Thick Wall
29	42.0	42.6	W29	42.0 m to 42.6 m - structureless CHALK composed of white (9.5/N) silt and fine to coarse blocky/angular gravel. Chalk clasts are weak, low to medium density and white. (Grade Dc)	42.0	31			31	21	10					29: 3" Thick Wall
30	43.0	43.2	W30	43.0 m to 43.2 m - structureless CHALK composed of white (9.5/N) silt and fine to medium blocky/angular gravel. Chalk clasts are weak, low to medium density and white. (Grade Dc)	42.2	31	19.8	15.1								30: 3" Thick Wall
31	45.5	45.8	W31	45.5 m to 45.8 m - structureless CHALK composed of white (9.5/N) silt and fine to medium blocky/angular gravel with one coarse gravel at top of sample. Chalk clasts are weak, low to medium density and white. (Grade Dc)	45.6	26	17.8	14.2								31: 3" Thick Wall
Key:			W : WIP or Push Sampler P : Piston Sampler H : Hammer Sampler	MC : Moisture Content LL : Liquid Limit PL : Plastic Limit PI : Plasticity Index	Content	UU : Unconsolidated Undrained LV : Laboratory Vane FC : Fall Cone TV : Torvane	PP : Pocket Penetrometer S_u : Undrained Shear Strength 100 : refers to test performed offshore 100 : refers to remoulded test									

SUMMARY OF LABORATORY TEST RESULTS BH_07

Made By: SF/KF Date: 01/04/2011

GeoDir-System/ Labsum.GLO / 26/07/2011/17:59:19

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	
1a	3.0	3.1	H1a	3.0 m to 3.1 m - very dark greenish grey (10Y-3/1) slightly silty medium to coarse silica SAND with coarse sand-sized to fine gravel-sized shell fragments and with medium gravel-sized shell fragments	3.1	20									1a: 50 Blows
1		3.2	W1	3.0 m to 3.2 m - very dark greenish grey (10Y-3/1) slightly silty fine to coarse silica SAND with coarse sand-sized to fine gravel-sized shell fragments	3.1	24									1: 3" Thick Wall - Sample fell out of tube on to deck
2	7.0	7.7	W2	7.0 m to 7.7 m - greenish grey (10Y-5/1) silty fine to medium silica SAND with thin laminae and fine gravel-sized pockets of black staining and traces of coarse sand-sized shell fragments	7.4	29	17.7	13.7							2: 2" Thick Wall with core catcher
3	11.0	11.8	W3	11.0 m to 11.8 m - greenish grey (10Y-5/1) slightly silty fine to medium silica SAND with traces of medium sand-sized shell fragments and with traces of fine gravel-sized pockets of black staining	11.0										3: 2" Thick Wall with core catcher
4	15.0	15.5	W4	11.3 m to 11.6 m - with very closely spaced to closely spaced thin laminae of greenish grey slightly sandy CLAY	11.6	20	17.9	14.9							4: 2" Thick Wall with core catcher
5	18.5	18.9	W5	15.0 m to 15.5 m - greenish grey (10Y-5/1) slightly silty medium silica SAND with coarse sand-sized to fine gravel-sized shell fragments with medium gravel-sized flint at the top	15.2	21	17.1	14.1							5: 2" Thick Wall with core catcher
6	19.0	19.4	W6	18.5 m to 18.9 m - grey (2.5Y-5/1) slightly silty medium silica SAND with traces of coarse sand-sized to fine gravel-sized shell fragments with traces of fine gravel with light greenish grey to very dark grey fine to coarse gravel-sized silica gravel (flint)	18.7	22	17.8	14.6							6: 2" Thick Wall with core catcher
7	19.5	19.5	H7	19.0 m to 19.3 m - light greenish grey (10Y-7/1) to very dark greenish grey (N3) sub-angular to sub-rounded fine to medium silica GRAVEL with olive fine to coarse silica sand and traces of coarse sand-sized shell fragments	19.0										7: 50 Blows
8	20.0	20.0	H8	19.3 m to 19.4 m - grey (2.5Y-5/1) to black (2.5Y-2.5/1) sub-angular to sub-rounded fine to medium silica GRAVEL with pockets of olive medium silica sand	19.3										8: 50 Blows
9	21.5	21.6	H9	19.5 m to 19.5 m - white (2.5Y-8/1) to black (2.5Y-2.5/1) sub-angular to sub-rounded fine to medium silica GRAVEL	19.5										9: 50 Blows
				20.0 m to 20.0 m - white (2.5Y-8/1) to black (2.5Y-2.5/1) sub-angular to sub-rounded fine to coarse silica GRAVEL	20.0										
				21.5 m to 21.6 m - white (2.5Y-8/1) to black (2.5Y-2.5/1) sub-angular to sub-rounded fine to coarse silica GRAVEL	21.5										
Key:			W : WIP or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer									
	P : Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	FC : Fall Cone	TV : Torvane	S _u : Undrained Shear Strength									
	H : Hammer Sampler	PL : Plastic Limit	PI : Plasticity Index			100									

SUMMARY OF LABORATORY TEST RESULTS

BH_16

E.ON CLIMATE AND RENEWABLES
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION



Made By: SF/KF Date: 01/04/2011

GeODir-System/ Labsum.GLO / 26/07/2011/17:59:19

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	
10	23.5	23.7	H10	23.6	27	16.7	13.2								10: 50 Blows
11	24.0	24.2	W11	24.1	24	16.9	13.6								11: 2" Thick Wall with core catcher - Dense sand expanded in sampler 12: 50 Blows
12	26.0	26.0	H12	26.0											
13	26.5	26.8	W13	26.7	27										13: 2" Thick Wall with Core Catcher - Dense sand expanded in sampler
14	30.5	30.9	W14	30.5				52	21	31					14: 3" Thick Wall
				30.6	22	21.3	17.5				980				517
				30.7	20	20.9	17.6				711				
				30.8	22										
15	31.0	31.5	W15	31.0				54	22	32					15: 3" Thick Wall - possibly 10 cm cuttings
				31.1	21	21.1	17.5								567
				31.3	21	20.6	17.0								
				35.1	24	18.4	14.8								
16	35.0	35.1	W16	35.0											16: 3" Thick Wall
17	35.5	35.6	W17	35.5	25										17: 3" Thick Wall
				35.6	22	18.1	14.8								
18	38.0	38.1	W18	38.0											18: 3" Thick Wall
18a	38.6	38.6	W18a	38.2											18a: 3" Thick Wall - Dense sand expanded in sampler
19	38.5	39.0	W19	38.8	19										19: 3" Thick Wall
Key:			W : WIP or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	LV : Laboratory Vane	FC : Fall Cone	TV : Torvane	PP : Pocket Penetrometer	S _u : Undrained Shear Strength					
P			: Piston Sampler	LL : Liquid Limit	UU	LV	FC	TV	PP	S _u					
H			: Hammer Sampler	PL : Plastic Limit	100	100	100	100	100	100					
				PI : Plasticity Index											

SUMMARY OF LABORATORY TEST RESULTS
BH_16



Made By: SF/KF Date: 01/04/2011

GeODir-System/ Labsum.GLO / 26/07/2011/17:59:19

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests					Remarks
No.	From (m)	To (m)	Type					LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)	
20	41.0	41.1	W20	41.0 m to 41.1 m - dark greenish grey (10Y-4/1) calcareous SANDSTONE with few brown and white fossils (possible cobble)	41.0											20: 3" Thick Wall
21	41.5	41.6	W21	41.5 m to 41.6 m - dark greenish grey (10Y-4/1) calcareous SANDSTONE with few brown and white fossils (possible cobble)	41.5											21: 3" Thick Wall
22	44.0	44.5	W22	41.6 m to 41.6 m - very dark grey (5Y-3/1) fine silica SAND	41.6	12										22: 3" Thick Wall
				44.0 m to 44.5 m - dark greenish grey (5GY-4/1) slightly clayey fine silica SAND	44.1	11										
					44.5	20	15.9									
23	46.0	46.4	W23	46.0 m to 46.4 m - dark olive grey (5Y-3/2) very clayey fine silica SAND with medium to coarse sand-sized pockets of dark greenish grey clay	46.2		22.1									23: 3" Thick Wall - Dense sand expanded in sampler
Key: W : WIP or Push Sampler MC : Moisture Content PP : Pocket Penetrometer P : Piston Sampler LL : Liquid Limit S _u : Undrained Shear Strength H : Hammer Sampler PL : Plastic Limit FC : Fall Cone TV : Torvane 100 : refers to remould test																

SUMMARY OF LABORATORY TEST RESULTS
BH_16

Made By: SF/KF Date:

GeODin-System/ Labsum.GLO / 26/07/2011/18:00:00

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits				Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	PP S _u (kPa)	
1	2.5	2.8	W1	2.5												1. 3" Thick Wall
2	3.0	3.3	W2	2.7	31	16.4	12.5									2. 3" Thick Wall - sand sampled expanded in sampler
3	6.5	7.1	W3	3.2	27	17.9	14.1									3. 3" Thick Wall
4	7.5	7.9	W4	6.5				67	23	44						4. 3" Thick Wall
5	11.0	11.6	W5	6.6	29	17.5	13.6									5. 3" Thick Wall
				6.9	28	18.8	14.7									
				7.6	37	17.4	12.7									
				7.8	28	17.6	13.8									
				11.1	36											
				11.3											223	
				11.5	23	16.1	13.1	69	28	41						
				12.0												
6	12.0	12.6	W6	12.4	26	17.8	14.1	56	19	37						6. 3" Thick Wall
Key: W : WIP or Push Sampler P : Piston Sampler H : Hammer Sampler MC : Moisture Content LL : Liquid Limit PL : Plastic Limit PI : Plasticity Index UU : Unconsolidated Undrained LV : Laboratory Vane FC : Fall Cone TV : Torvane PP : Pocket Penetrometer S _u : Undrained Shear Strength 100 : refers to test performed offshore 100 : refers to remould test																

SUMMARY OF LABORATORY TEST RESULTS

BH_17



Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/18:00:00

Sample Details				Index Soil Strength Tests										Remarks				
No.	From (m)	To (m)	Type	Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests						
									LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	PP _{S_u} (kPa)		
7	16.0	16.4	W7	16.0 m to 16.4 m - thinly to thickly interlaminated greenish grey (SGY-5/1) slightly sandy CLAY with thin laminae of light greenish grey (10Y-7/1) silty silica sand and dark greenish grey (5GY-4/1) very silty fine silica SAND with black staining and with medium gravel-sized pockets of light yellowish brown clay	16.0				67	25	42						7: 3" Thick Wall	
8	17.0	17.4	W8	17.0 m to 17.1 m - dark greenish grey (5Y-4/1) slightly sandy SILT with fine to medium gravel-sized pockets of dark greenish grey slightly sandy clay 17.1 m to 17.4 m - thinly to thickly interlaminated greenish grey (SGY-5/1) slightly sandy CLAY with thin laminae of light greenish grey (10Y-7/1) silty silica sand and dark greenish grey very silty fine silica SAND with black staining	16.4	28	16.6	13.0									8: 3" Thick Wall	
					17.0													
					17.1													
9	21.0	21.3	W9	21.0 m to 21.3 m - stiff to very stiff dark greenish grey (5GY-4/1) slightly sandy CLAY with very closely to closely spaced thin to thick laminae of greenish grey fine silica sand with traces of olive and black fine silica sand	17.2	29	18.3	14.2									9: 3" Thick Wall	
					21.1	27	20.1	15.8										
					21.2													
10	22.0	22.6	W10	22.0 m to 22.6 m - very stiff to hard dark greenish grey (5GY-4/1) slightly sandy CLAY with closely spaced thin laminae of greenish grey fine silica sand with traces of olive and black fine silica sand and a fine gravel-sized fragment of organic matter (piece of charcoal)	21.3											10: 3" Thick Wall		
					22.0													
					22.1	29												
11	26.0	26.6	W11	26.0 m to 26.6 m - stiff to hard dark greenish grey (5GY-4/1) slightly sandy CLAY with closely spaced thin laminae (~1mm) of greenish grey fine silica sand	22.2											11: 3" Thick Wall		
					22.4	27	20.2	15.9										
					22.6													
					26.1	26	19.9	15.7										
					26.3													
					26.3													
Key:				W : W/P or Push Sampler	MC : Moisture Content	UU : Unconsolidated Undrained	PP : Pocket Penetrometer											
	P			: Piston Sampler	LL : Liquid Limit	LV : Laboratory Vane	S _u : Undrained Shear Strength											
	H			: Hammer Sampler	PL : Plastic Limit	FC : Fall Cone	100 : refers to test performed offshore											
					PI : Plasticity Index	TV : Tonvane	100 : refers to remoulded test											

SUMMARY OF LABORATORY TEST RESULTS

BH_17

Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/18:00:00

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m³)	Natural Dry Unit Weight (kN/m³)	Atterberg Limits			Index Soil Strength Tests					Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU _{S_u} (kPa)	LV _{S_u} (kPa)	FC _{S_u} (kPa)	TV _{S_u} (kPa)	PP _{S_u} (kPa)	
12	27.0	27.6	W12	27.0 m to 27.6 m - very stiff to hard dark greenish grey (SGY-4/1) slightly sandy CLAY with closely spaced thin laminae (~1mm) of greenish grey fine silica sand	26.3 26.5 27.2	27 29 31	20.1 19.5 15.8				473				367	12: 3" Thick Wall
13	30.0	30.1	W13	30.0 m to 30.1 m - dark greenish grey (SGY-4/1) slightly sandy CLAY	27.3 27.3 27.3 27.6 30.0	31 28 30	16.8	66	29	37						13: 3" Thick Wall - Dense sand expanded in sampler
14	30.5	30.6	W14	30.1 m to 30.1 m - very dark greenish grey (SGY-3/1) fine silica SAND	30.1	26	14.5									14: 3" Thick Wall - Dense sand expanded in sampler
15	32.5	32.7	W15	30.5 m to 30.6 m - very dark greenish grey (SGY-3/1) fine silica SAND	30.6	26	12.5									15: 3" Thick Wall
16	33.0	33.2	W16	32.5 m to 32.7 m - very dark greenish grey (SGY-3/1) fine silica SAND with one medium sub-angular gravel of grey fine grained sandstone	32.6	30	16.8									16: 3" Thick Wall - Dense sand expanded in sampler
17	35.0	35.2	W17	33.0 m to 33.2 m - very dark greenish grey (SGY-3/1) fine silica SAND with medium to coarse gravel-sized pockets of dark greenish grey slightly clayey fine silica sand	33.1	30	14.1									17: 3" Thick Wall - Dense sand expanded in sampler
18	35.5	35.8	W18	35.0 m to 35.2 m - very dark greenish grey (SGY-3/1) fine silica SAND with pockets of dark greenish grey sandy clay and a single coarse gravel-sized fragment of grey sub-angular sandstone	35.0 35.2 35.5	34 27	12.3	77	22	55				200		18: 3" Thick Wall - Dense sand expanded in sampler
19	38.5	38.7	W19	35.5 m to 35.6 m - very stiff dark greenish grey (SGY-4/1) slightly sandy CLAY	35.6 38.5	29					265				217	19: 3" Thick Wall - Dense sand expanded in sampler

Key:		W	:	WIP or Push Sampler	MC	:	Moisture Content	UU	:	Unconsolidated Undrained	PP	:	Pocket Penetrometer
P	:	Piston Sampler	LL	:	Liquid Limit	LV	:	Laboratory Vane	LV	:	Undrained Shear Strength		
H	:	Hammer Sampler	PL	:	Plastic Limit	FC	:	Fall Cone	TV	:	refers to test performed offshore		
			PI	:	Plasticity Index	TV	:	Torvane			100	:	refers to remould test

SUMMARY OF LABORATORY TEST RESULTS

BH_17

Made By: SF/KF Date:

GeODir-System/ Labsum.GLO / 26/07/2011/18:00:00

Sample Details			Description of Sample	Depth of Test (m)	MC (%)	Natural Wet Unit Weight (kN/m ³)	Natural Dry Unit Weight (kN/m ³)	Atterberg Limits			Index Soil Strength Tests				Remarks
No.	From (m)	To (m)						LL (%)	PL (%)	PI (%)	UU S _u (kPa)	LV S _u (kPa)	FC S _u (kPa)	TV S _u (kPa)	
20	39.0	39.2	W20	39.00 m to 39.2 m - very dark greenish grey (SGY-3/1) fine silica SAND	38.7	25	19.1	15.2							20: 3" Thick Wall
21	41.0	41.2	W21	41.0 m to 41.2 m - very dark greenish grey (SGY-3/1) fine silica SAND	41.0	25	18.3	14.6							21: 3" Thick Wall
22	41.5	41.6	W22	41.5 m to 41.6 m - very dark greenish grey (SGY-3/1) fine silica SAND	41.2	37	17.3	12.7							22: 3" Thick Wall
23	43.5	43.7	W23	43.5 m to 43.7 m - very dark greenish grey (SGY-3/1) fine silica SAND with fine to medium gravel-sized pockets of dark greenish grey clay	41.6	28	18.4	14.3							23: 3" Thick Wall - Dense sand expanded in sampler
24	44.0	44.2	W24	44.0 m to 44.2 m - very dark greenish grey (SGY-3/1) fine silica SAND with fine to medium gravel-sized pockets of greenish grey slightly sandy clay	43.6	26	18.2	14.5							24: 3" Thick Wall - Dense sand expanded in sampler
25	45.0	45.1	W25	45.0 m to 45.1 m - very dark greenish grey (SGY-3/1) fine silica SAND with fine to medium gravel-sized pockets of greenish grey slightly sandy clay	44.2	27	18.2	14.3							25: 3" Thick Wall - Dense sand expanded in sampler
					45.0										
					45.1	27	17.9	14.1							
Key: W : WIP or Push Sampler MC : Moisture Content PP : Pocket Penetrometer P : Piston Sampler LL : Liquid Limit S _u : Undrained Shear Strength H : Hammer Sampler PL : Plastic Limit FC : Fall Cone 100 : refers to test performed offshore TV : Torvane PI : Plasticity Index 100 : refers to remould test															

SUMMARY OF LABORATORY TEST RESULTS

BH_17

Date: 04/05/2011

Drawn by: ALB

Template Issue: 4

Filename: J11056 / Labdata / Class / BH_13_P1.XLS

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_13	3BagB	3.65	4.3/5.3/5.4	4.2.4	47	78	21	57
2	BH_13	4BagA	7.50	4.3/5.3/5.4	4.2.3	100	64	18	46
3	BH_13	5BagA	8.50	4.3/5.3/5.4	4.2.3	100	67	18	49
4	BH_13	6UU	12.80	4.3/5.3/5.4	4.2.3	100	59	21	38
5	BH_13	7WaxA	13.60	4.3/5.3/5.4	4.2.3				
6	BH_13	7BagB	14.05	4.3/5.3/5.4	4.2.3	100	66	25	41
7	BH_13	22BagA	35.00	4.3/5.3/5.4	4.2.3	100	51	20	31
8	BH_13	23WaxB	39.25	4.3/5.3/5.4	4.2.3				
9	BH_13	24BagA	40.00	4.3/5.3/5.4	4.2.3	100	49	15	34

Note: I/S denotes Insufficient Sample

Date:

Checked by:

Date:

Approved by:

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 04/05/2011

Drawn by: ALB

Template Issue: 2:2

Filename: J11056 / Labdata / Class / BH_13_PLOPJ

Checked by:

Approved by:

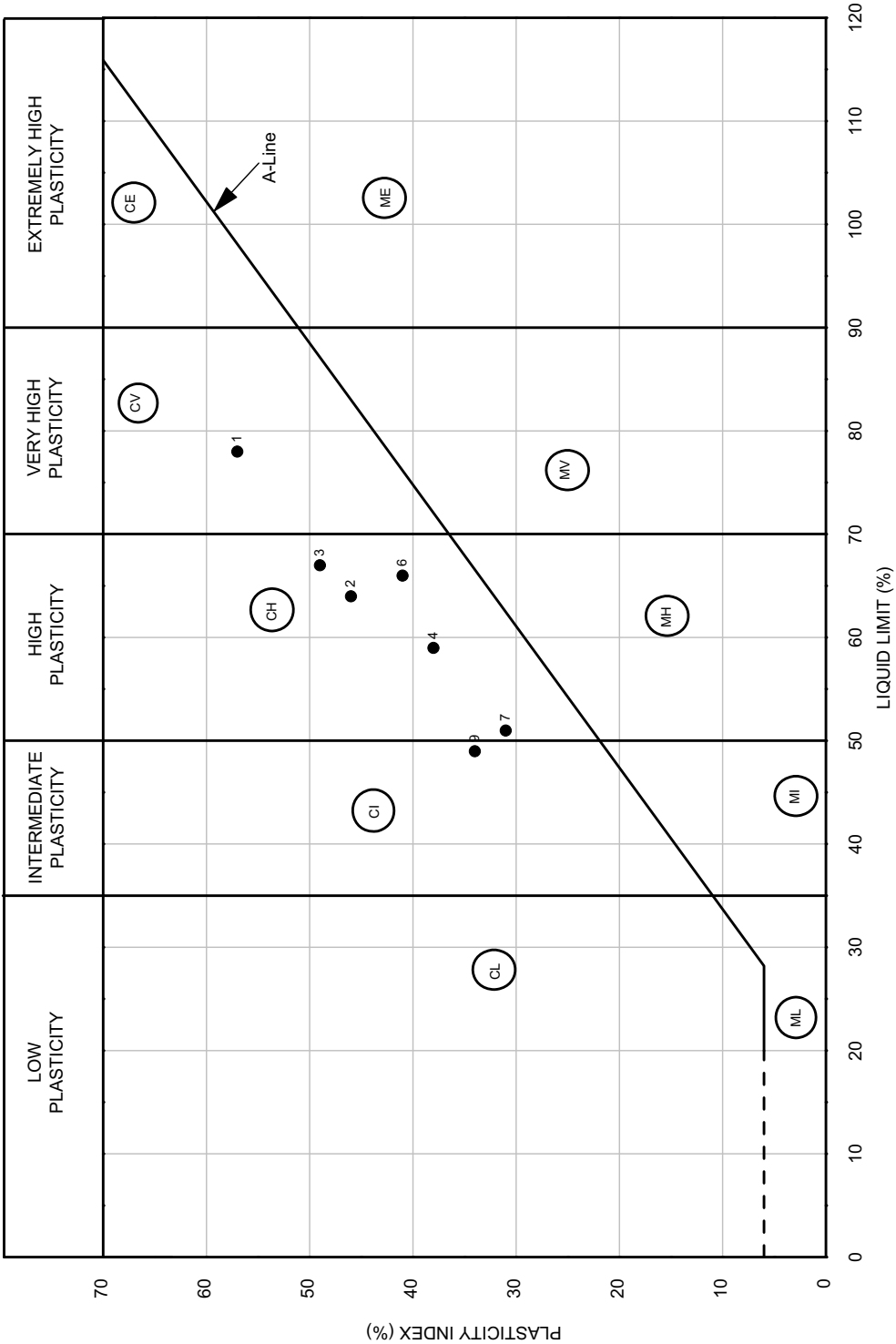
KEY TO TERMS USED :

Soil Types :
C = Clay
M = Silt

Plasticity :
L = Low
I = Intermediate
H = High

V = Very high
E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

PLASTICITY CHART (BS 5930)
BOREHOLE BH_13

Date: 04/05/2011

Drawn by: ALB

Template Issue: 4

Date: 19/05/2011

Checked by: PH

Filename: J11056 / Labdata / Class / BH_14_P1.XLS

Date:
Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_14	4BagUU	7.10	4.3/5.3/5.4	4.2.3	100	80	31	49
2	BH_14	6BagA	12.00	4.3/5.3/5.4	4.2.3	100	72	21	51
3	BH_14	8BagB	17.50	4.3/5.3/5.4	4.2.3	100	75	24	51
4	BH_14	10BagB	22.30	4.3/5.3/5.4	4.2.3	100	71	22	49
5	BH_14	11BagB	25.25	4.3/5.3/5.4	4.2.3	100	75	21	54
6	BH_14	13BagA	30.00	4.3/5.3/5.4	4.2.3	100	55	17	38
7	BH_14	14BagA	31.00	4.3/5.3/5.4	4.2.3	100	43	19	24
8	BH_14	15BagB	35.30	4.3/5.3/5.4	4.2.3	100	66	27	39
9	BH_14	15BagC	35.58	4.3/5.3/5.4	4.2.3	100	79	22	57
10	BH_14	17BagB	39.53	4.3/5.3/5.4	4.2.3	-	-	N/P	-
11	BH_14	19BagA	42.00	4.3/5.3/5.4	4.2.3	100	53	19	34

Note: I/S denotes Insufficient Sample

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 04/05/2011

Drawn by: ALB

Template Issue: 2.2

Filename: J11056 / Labdata / Class / BH_14_PLOPJ

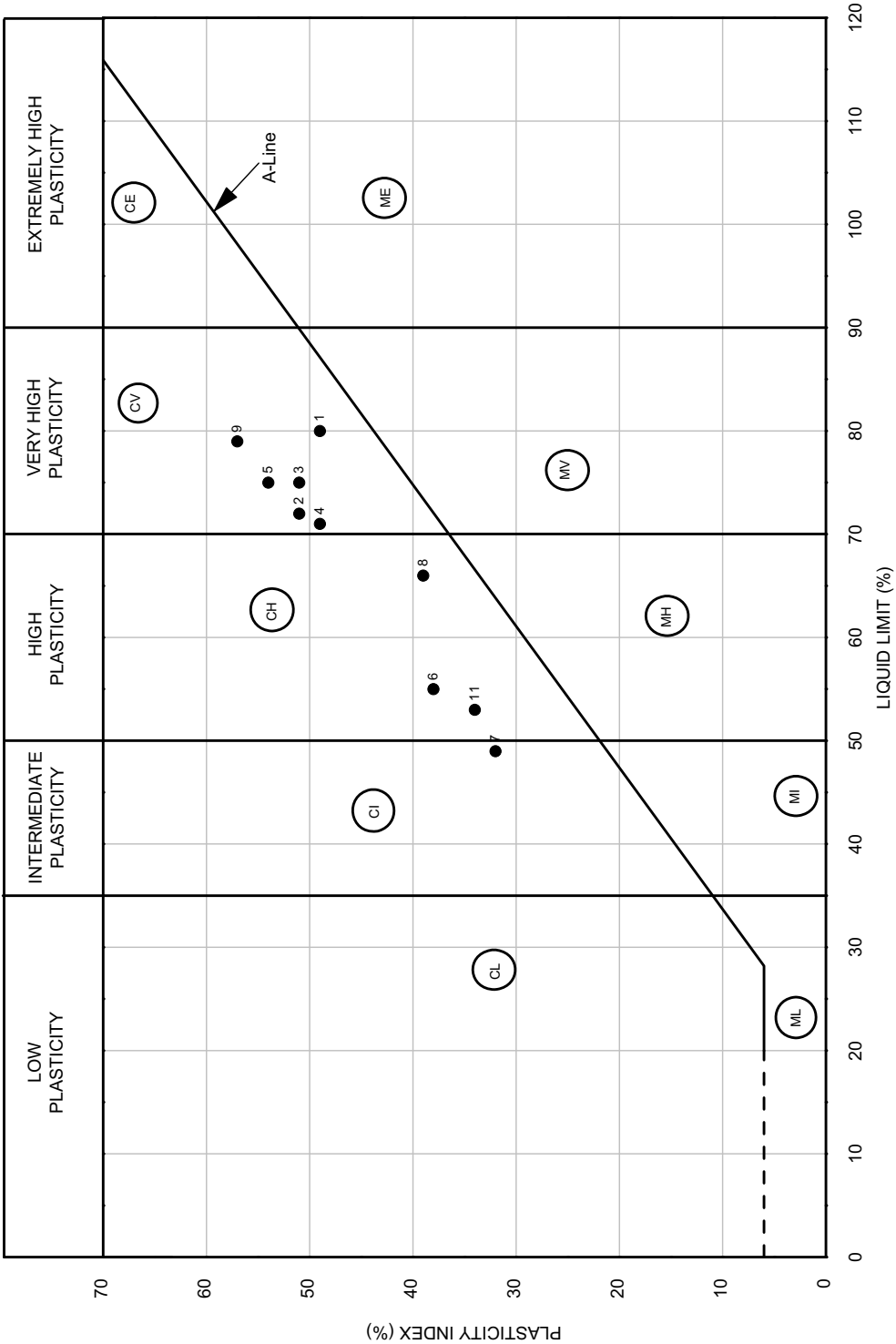
Date : 19/05/2011

Checked by: PH
Approved by:

KEY TO TERMS USED :

Soil Types :	Plasticity :
C = Clay	L = Low
M = Silt	I = Intermediate
	H = High
	V = Very high
	E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

PLASTICITY CHART (BS 5930)
BOREHOLE BH_14

Date: 23/05/2011

Drawn by: ALB

Template Issue: 4

Date: 24/05/2011

Checked by: PH

Filename: J11056 / Labdata / Class / BH_02_Pl.XLS

Date:
Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_02	2BagA	7.20	4.3/5.3/5.4	4.2.3	100	77	21	56
2	BH_02	3BagB	8.50	4.3/5.3/5.4	4.2.3	100	64	25	39
3	BH_02	4BagB	12.05	4.3/5.3/5.4	4.2.3	100	58	18	40
4	BH_02	7BagB	17.15	4.3/5.3/5.4	4.2.3	100	54	15	39
5	BH_02	9BagA	20.00	4.3/5.3/5.4	4.2.3	-	-	N/P	-
6	BH_02	14BagA	30.00	4.3/5.3/5.4	4.2.3	100	78	32	46
7	BH_02	17BagA	34.50	4.3/5.3/5.4	4.2.3	100	43	19	24
8	BH_02	19BagA	37.50	4.3/5.3/5.4	4.2.3	100	55	17	38
9	BH_02	20BagA	41.00	4.3/5.3/5.4	4.2.3	-	-	N/P	-
10	BH_02	22BagA	42.00	4.3/5.3/5.4	4.2.3	100	65	19	46
11	BH_02	24WaxA	46.18	4.3/5.3/5.4	4.2.3	100	84	31	53

Note: I/S denotes Insufficient Sample

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 23/05/2011

Drawn by: ALB

Template Issue: 2:2

Filename: J11056 / Labdata / Class / BH_02_PLOPJ

Date : 24/05/2011

Date :

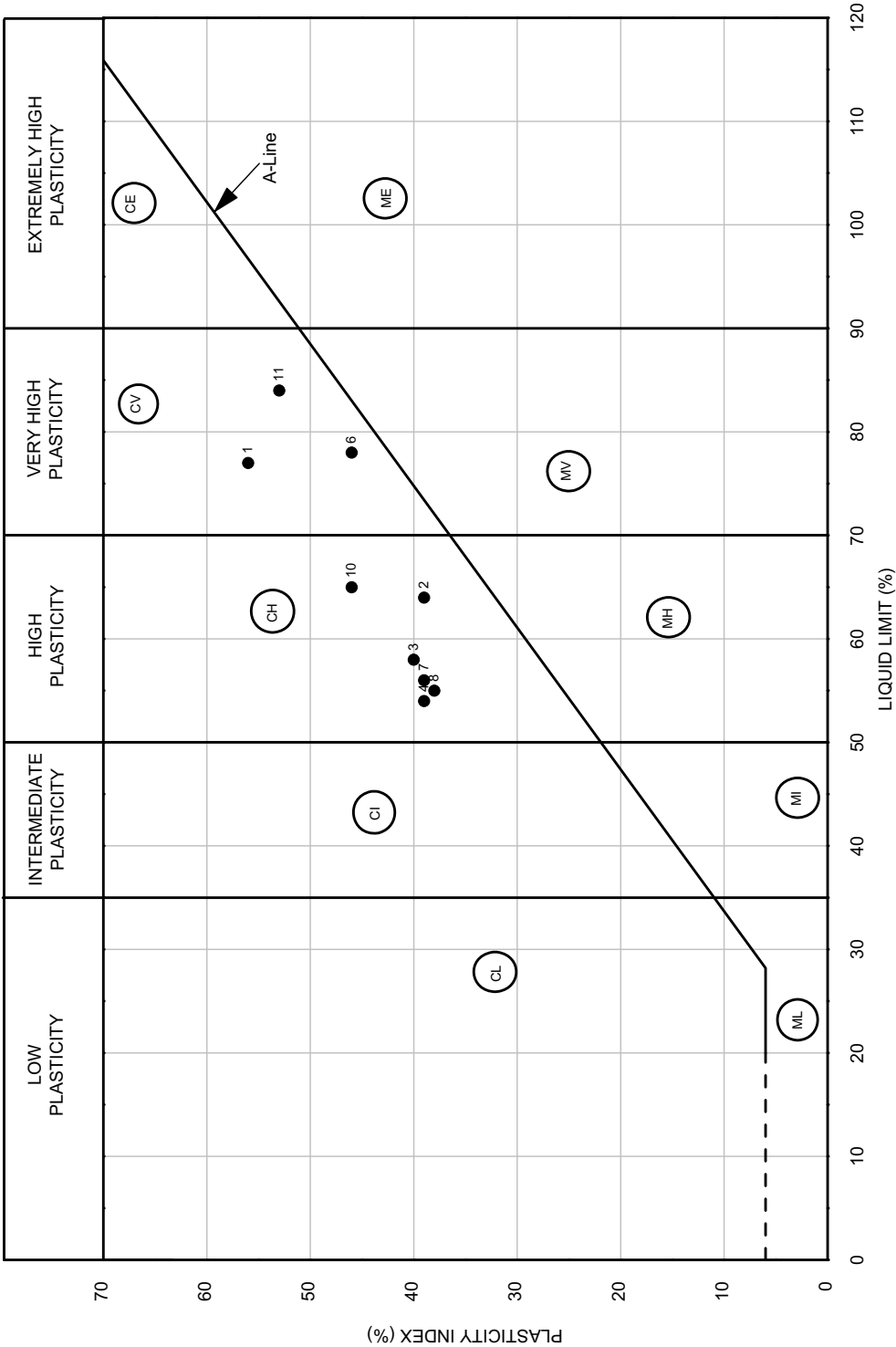
Checked by: PH

Approved by:

KEY TO TERMS USED :

Soil Types :	Plasticity :
C = Clay	L = Low
M = Silt	I = Intermediate
	H = High
	V = Very high
	E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

PLASTICITY CHART (BS 5930)
BOREHOLE BH_02

Date: 04/05/2011

Drawn by: ALB

Template Issue: 4

Date: 14/06/2011

Checked by: PH

Filename: J11056 / Labdata / Class / BH_04_Pi.XLS

Date:
Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_04	4BagC	10.70	4.3/5.3/5.4	4.2.3	100	80	26	54
2	BH_04	8BagA	17.00	4.3/5.3/5.4	4.2.3	-	-	N/P	-
3	BH_04	12WaxB	22.82	4.3/5.3/5.4	4.2.3	100	42	21	21
4	BH_04	14BagA	27.11	4.3/5.3/5.4	4.2.3	100	56	22	34
5	BH_04	15WaxB	27.75	4.3/5.3/5.4	4.2.3	100	46	18	28
6	BH_04	18BagA	34.50	4.3/5.3/5.4	4.2.3	100	56	22	34
7	BH_04	19WaxA	35.05	4.3/5.3/5.4	4.2.3	100	43	19	24
8	BH_04	21BagA	39.50	4.3/5.3/5.4	4.2.3	100	49	16	33
9	BH_04	22BagB	43.05	4.3/5.3/5.4	4.2.3	100	51	20	31
10	BH_04	23BagA	43.80	4.3/5.3/5.4	4.2.3	100	47	21	26
11	BH_04	24BagA	47.10	4.3/5.3/5.4	4.2.3	100	51	22	29

Note: I/S denotes Insufficient Sample

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Checked by: PH

Approved by:

Date : 14/06/2011

Date :

Template Issue: 2:2

Filename: J11056 / Labdata / Class / BH_04_PLOPJ

Drawn by: ALB

Date : 04/05/2011

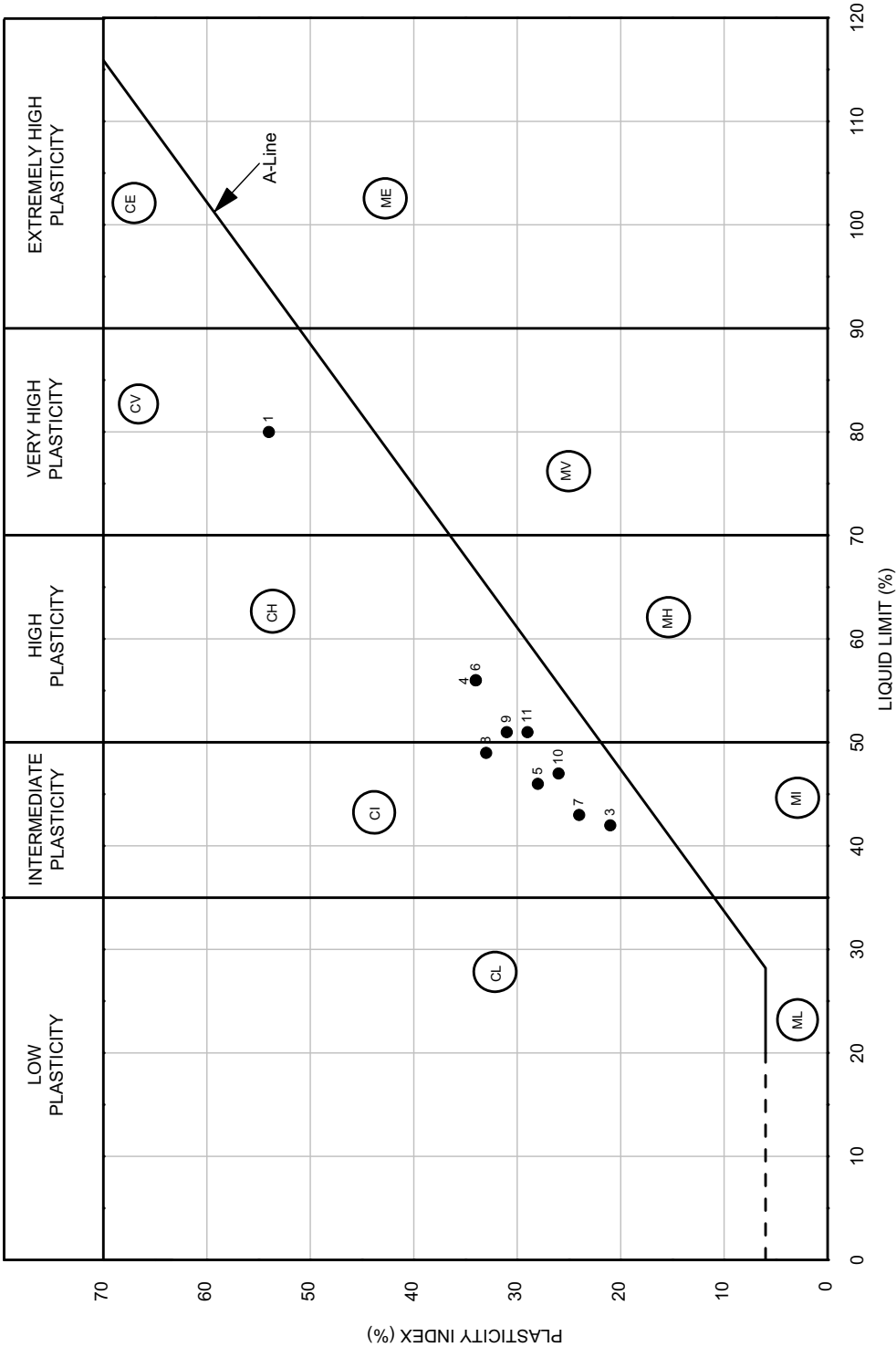
KEY TO TERMS USED :

Soil Types :
C = Clay
M = Silt

Plasticity :
L = Low
I = Intermediate
H = High

V = Very high
E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

Date: 18/05/2011

Drawn by: ALB

Template Issue: 4

Filename: J11056 / Labdata / Class / BH_04A_P1.XLS

Date: 27/05/2011

Checked by: PH

Date: Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_04A	1BagC	0.30	4.3/5.3/5.4	4.2.3	100	76	29	47
2	BH_04A	3BagB	2.19	4.3/5.3/5.4	4.2.4	96	76	26	50

Note: I/S denotes Insufficient Sample

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 18/05/2011

Drawn by: ALB

Template Issue: 2:2

Filename: J11056 / Labdata / Class / BH_04A_P1.OPJ

Date : 27/05/2011

Date :

Checked by: PH

Approved by:

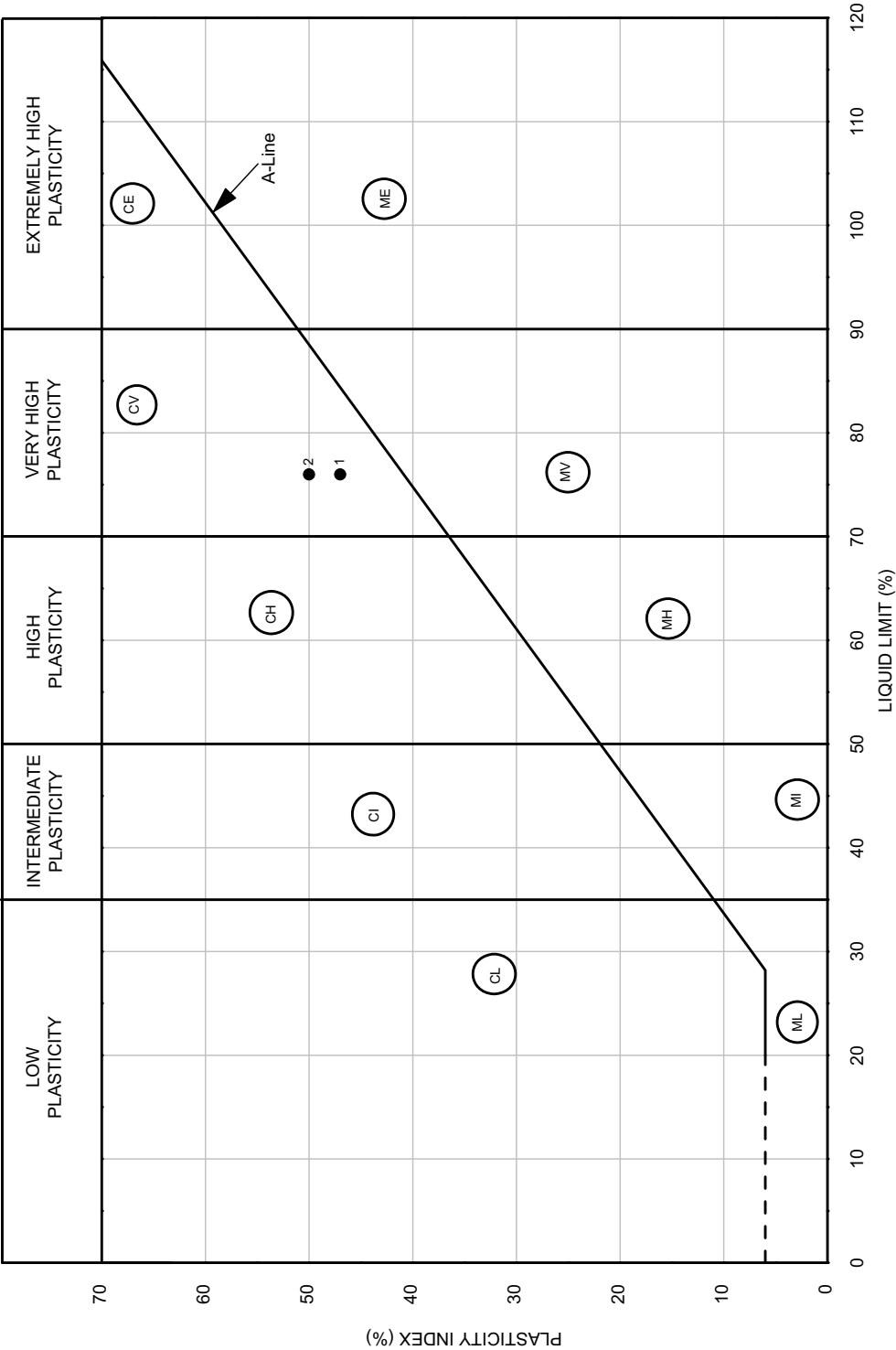
KEY TO TERMS USED :

Soil Types :
C = Clay
M = Silt

Plasticity :
L = Low
I = Intermediate
H = High

V = Very high
E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

PLASTICITY CHART (BS 5930)
BOREHOLE BH_04A

Date: 26/05/2011

Drawn by: ALB

Template Issue: 4

Date: 27/05/2011

Checked by: PH

Filename: J11056 / Labdata / Class / BH_06_Pl.XLS

Date:
Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_06	1BagA	3.00	4.3/5.3/5.4	4.2.3	100	67	26	41
2	BH_06	3BagA	4.50	4.3/5.3/5.4	4.2.3	100	71	24	47
3	BH_06	5BagUU	9.17	4.3/5.3/5.4	4.2.3	100	86	27	59
4	BH_06	6BagA	9.50	4.3/5.3/5.4	4.2.3	100	81	25	56
5	BH_06	7BagUU	13.70	4.3/5.3/5.4	4.2.3	100	77	29	48
6	BH_06	8BagB	14.25	4.3/5.3/5.4	4.2.3	100	74	22	52
7	BH_06	9BagA	18.45	4.3/5.3/5.4	4.2.3	100	43	19	24
8	BH_06	11WaxA	19.55	4.3/5.3/5.4	4.2.3	100	42	18	24
9	BH_06	12BagB	22.65	4.3/5.3/5.4	4.2.4	71	44	16	28
10	BH_06	14ABagA	23.50	4.3/5.3/5.4	4.2.4	59	40	15	25
11	BH_06	18BagA	27.00	4.3/5.3/5.4	4.2.3	-	-	N/P	-
12	BH_06	19BagA	27.50	4.3/5.3/5.4	4.2.3	100	55	17	38
13	BH_06	23BagA	31.00	4.3/5.3/5.4	4.2.4	62	53	21	32
14	BH_06	25BagA	35.00	4.3/5.3/5.4	4.2.3	100	55	18	37
15	BH_06	26BagA	35.50	4.3/5.3/5.4	4.2.3	100	49	17	32
16	BH_06	27BagA	37.50	4.3/5.3/5.4	4.2.3	100	47	16	31
17	BH_06	28BagA	38.50	4.3/5.3/5.4	4.2.3	100	57	22	35
18	BH_06	29BagA	42.08	4.3/5.3/5.4	4.2.4	93	71	36	35

Note: I/S denotes Insufficient Sample

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 26/05/2011

Drawn by: ALB

Template Issue: 2:2

Filename: J11056 / Labdata / Class / BH_06_PLOPJ

Date : 27/05/2011

Date :

Checked by: PH

Approved by:

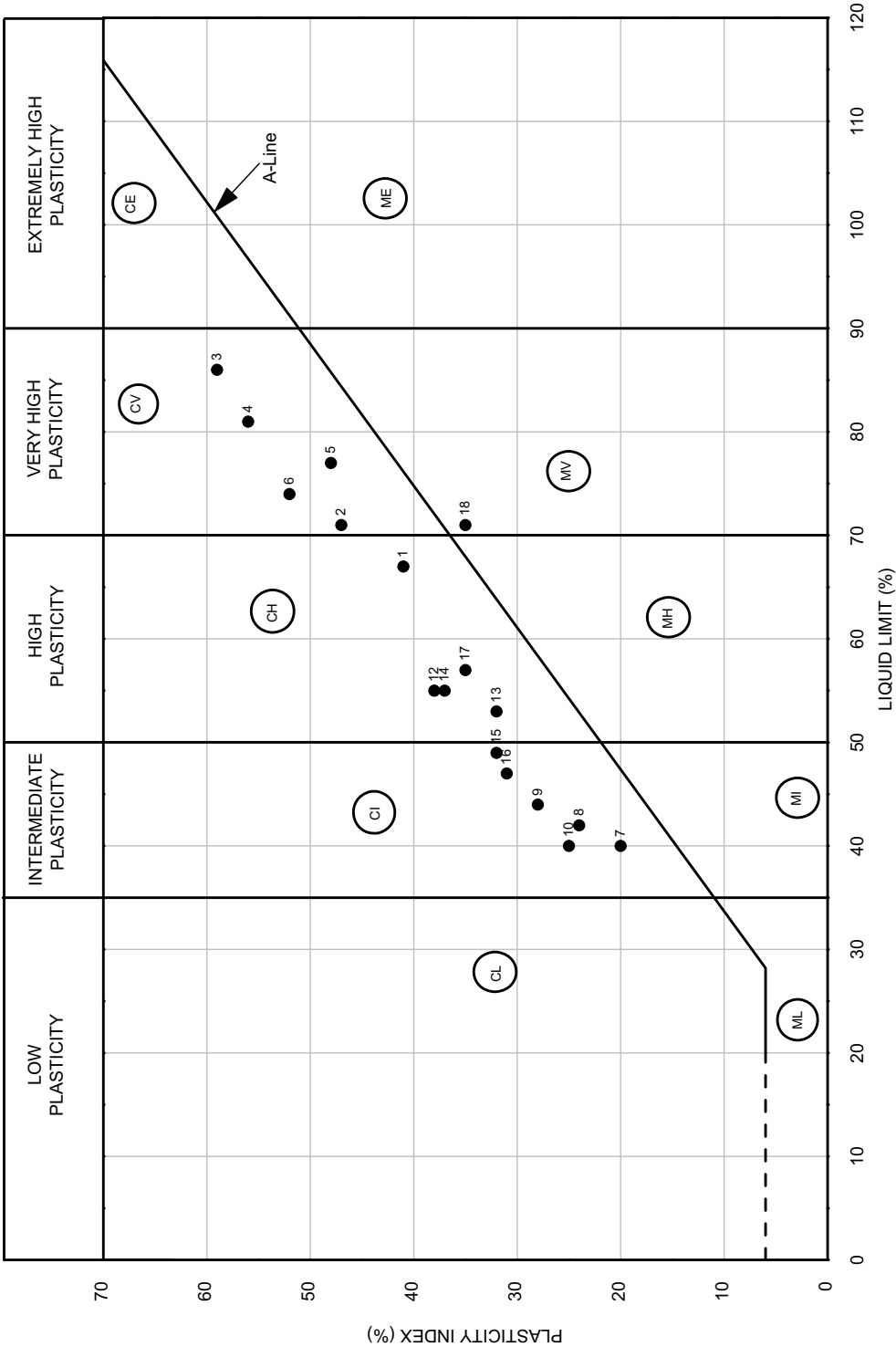
KEY TO TERMS USED :

Soil Types :
C = Clay
M = Silt

Plasticity :
L = Low
I = Intermediate
H = High

V = Very high
E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

PLASTICITY CHART (BS 5930)
BOREHOLE BH_06

Date: 04/05/2011

Drawn by: ALB

Template Issue: 4

Filename: J11056 / Labdata / Class / BH_07_Pi.XLS

Date: 15/06/2011

Checked by: PH

Date:
Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_07	2WaxA	4.15	4.3/5.3/5.4	4.2.3	100	30	22	8
2	BH_07	6WaxA	12.64	4.3/5.3/5.4	4.2.3	100	28	20	8
3	BH_07	8BagA	19.50	4.3/5.3/5.4	4.2.3	100	27	21	6
4	BH_07	13BagA	23.50	4.3/5.3/5.4	4.2.4	99	29	20	9
5	BH_07	19BagA	28.50	4.3/5.3/5.4	4.2.4	84	32	20	12
6	BH_07	25BagB	37.80	4.3/5.3/5.4	4.2.3 HP	100	32	21	11
7	BH_07	29BagA	42.00	4.3/5.3/5.4	4.2.3 HP	100	43	19	24

Note: I/S denotes Insufficient Sample

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

4.3	Cone penetrometer method
4.4	One point cone penetrometer method
4.5	Casagrande method
4.6	One point Casagrande method
5.3	Plastic limit method
5.4	Plasticity index

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

4.2.3	Natural soil
4.2.4	Sieved specimen
HP	Hand picked

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 04/05/2011

Drawn by: ALB

Template Issue: 2.2

Date : 15/06/2011

Checked by: PH

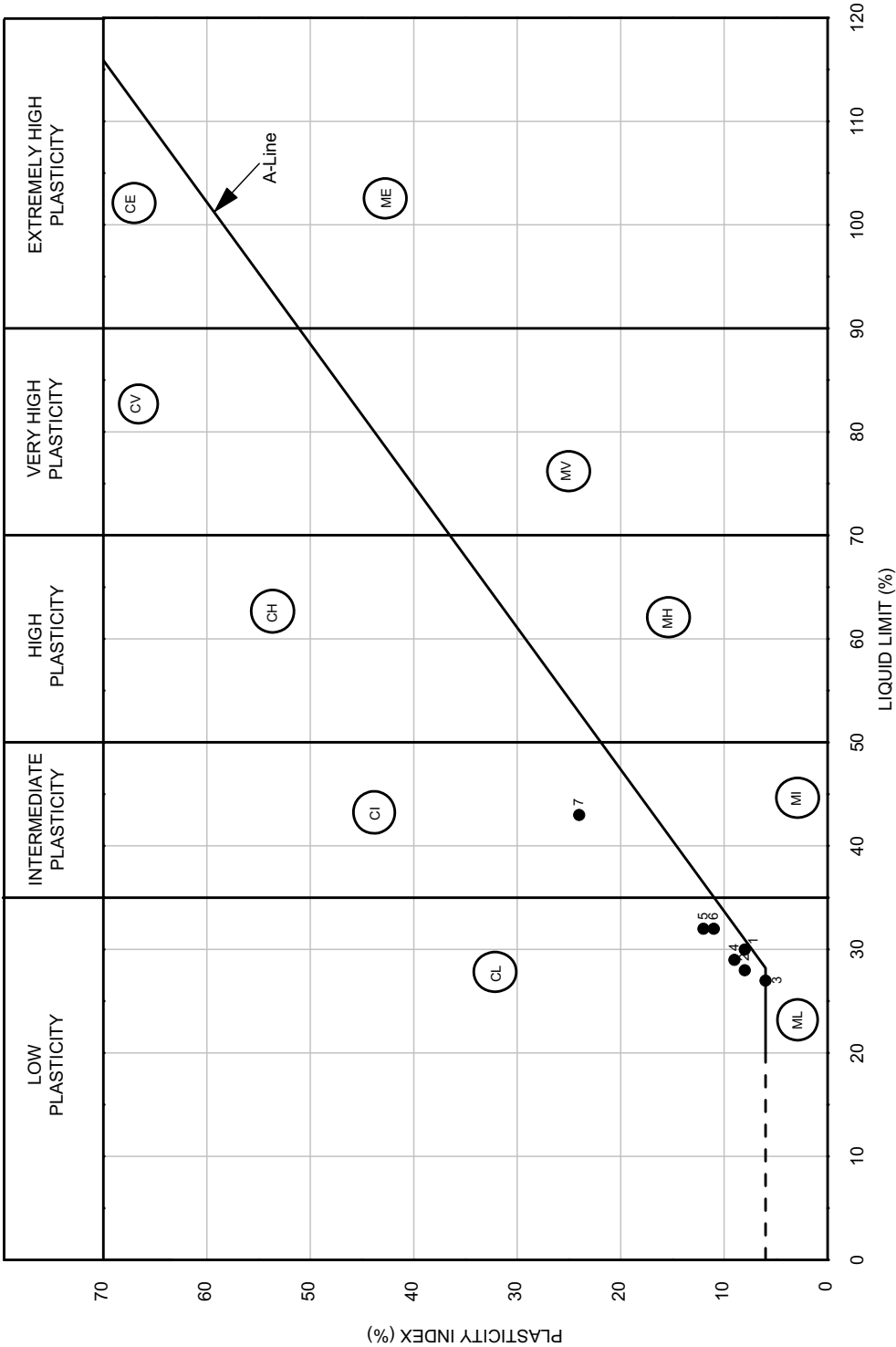
Filename: J11056 / Labdata / Class / BH_07_Pi.OPJ

Date :
Approved by:

KEY TO TERMS USED :

Soil Types :	Plasticity :
C = Clay	L = Low
M = Silt	I = Intermediate
	H = High
	V = Very high
	E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

PLASTICITY CHART (BS 5930)
BOREHOLE BH_07

Date: 18/05/2011

Drawn by: ALB

Template Issue: 4

Filename: J11056 / Labdata / Class / BH_16_Pl.XLS

Date: 31/05/2011

Checked by: PH

Date: Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_16	14BagA	30.50	4.3/5.3/5.4	4.2.3	100	52	21	31
2	BH_16	15BagA	31.00	4.3/5.3/5.4	4.2.3	100	54	22	32
3	BH_16	17BagB	35.55	4.3/5.3/5.4	4.2.3	-	-	N/P	-

Note: I/S denotes Insufficient Sample

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 18/05/2011

Drawn by: ALB

Template Issue: 2.2

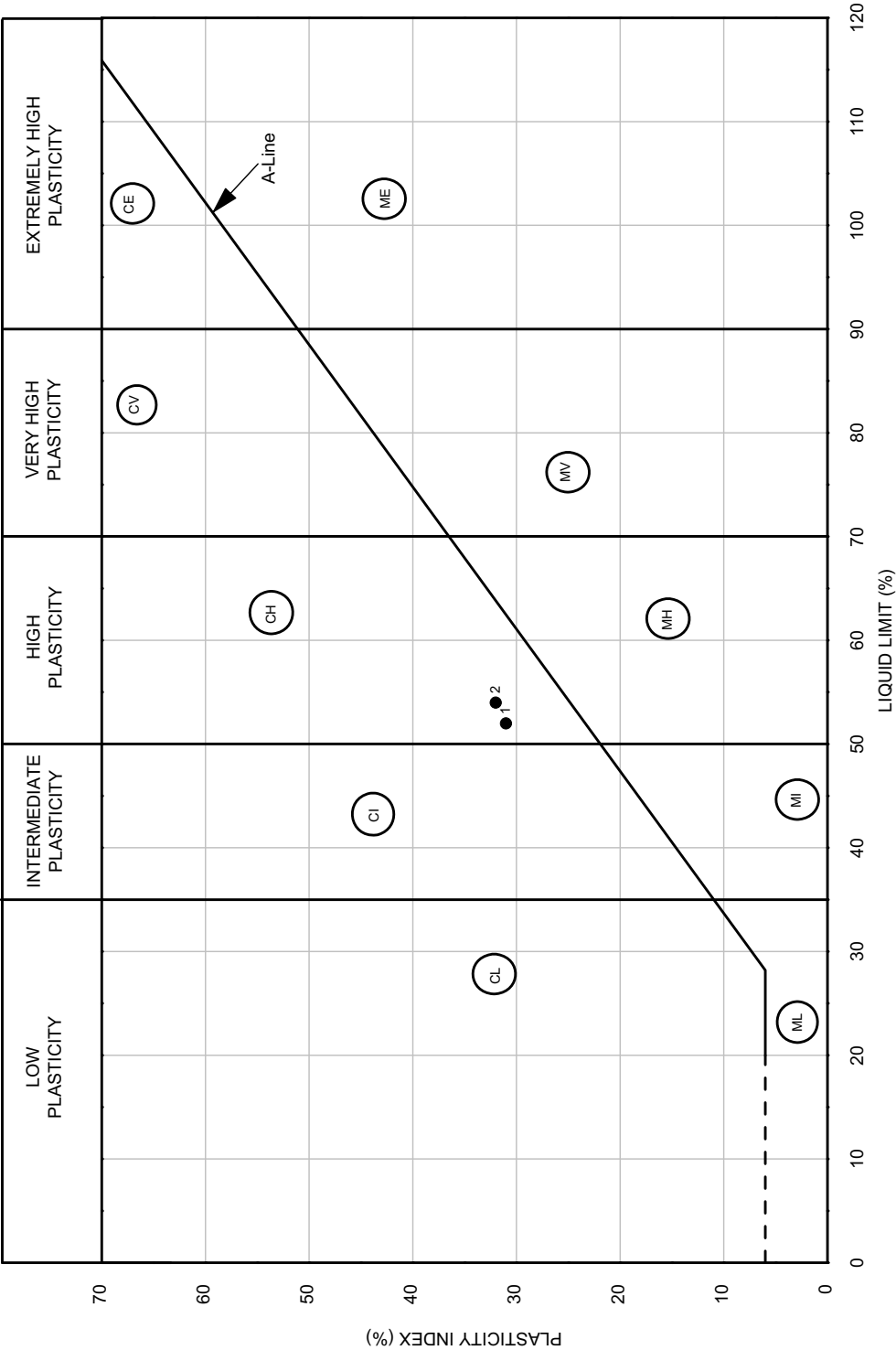
Filename: J11056 / Labdata / Class / BH_16_PLOPJ

Date : 31/05/2011

Checked by: PH
Approved by:

KEY TO TERMS USED :
Soil Types :
C = Clay
M = Silt
Plasticity :
L = Low
I = Intermediate
H = High
V = Very high
E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols

PLASTICITY CHART (BS 5930)
BOREHOLE BH_16

Date: 16/05/2011

Drawn by: ALB

Template Issue: 4

Date: 17/05/2011

Checked by: PH

Filename: J11056 / Labdata / Class / BH_17_P1.XLS

Date:
Approved by:

Symbol Number	Borehole	Sample	Depth (m)	BS Test Method *	Preparation Method †	Passing 425µm (%)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)
1	BH_17	3BagA	6.50	4.3/5.3/5.4	4.2.3	100	67	23	44
2	BH_17	5BagB	11.30	4.3/5.3/5.4	4.2.3	100	68	28	40
3	BH_17	6BagA	12.00	4.3/5.3/5.4	4.2.3	100	56	19	37
4	BH_17	7BagA	16.00	4.3/5.3/5.4	4.2.3	100	67	25	42
5	BH_17	8BagA	17.00	4.3/5.3/5.4	4.2.3	100	61	23	38
6	BH_17	8BagB	17.05	4.3/5.3/5.4	4.2.3	100	59	18	41
7	BH_17	9BagB	21.10	4.3/5.3/5.4	4.2.3	100	43	19	24
8	BH_17	10BagA	22.00	4.3/5.3/5.4	4.2.3	100	70	21	49
9	BH_17	12BagA	27.28	4.3/5.3/5.4	4.2.3	100	66	29	37
10	BH_17	18BagA	35.50	4.3/5.3/5.4	4.2.3	100	77	22	55

Note: I/S denotes Insufficient Sample

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

- 4.3 Cone penetrometer method
- 4.4 One point cone penetrometer method
- 4.5 Casagrande method
- 4.6 One point Casagrande method
- 5.3 Plastic limit method
- 5.4 Plasticity index

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

- 4.2.3 Natural soil
- 4.2.4 Sieved specimen

The symbol N/P in the Plastic Limit column indicates that the sample is Non-Plastic and no Atterberg Limits could be determined

SUMMARY OF ATTERBERG LIMITS TEST RESULTS



Date : 16/05/2011

Drawn by: ALB

Template Issue: 2.2

Filename: J11056 / Labdata / Class / BH_17_PLOPJ

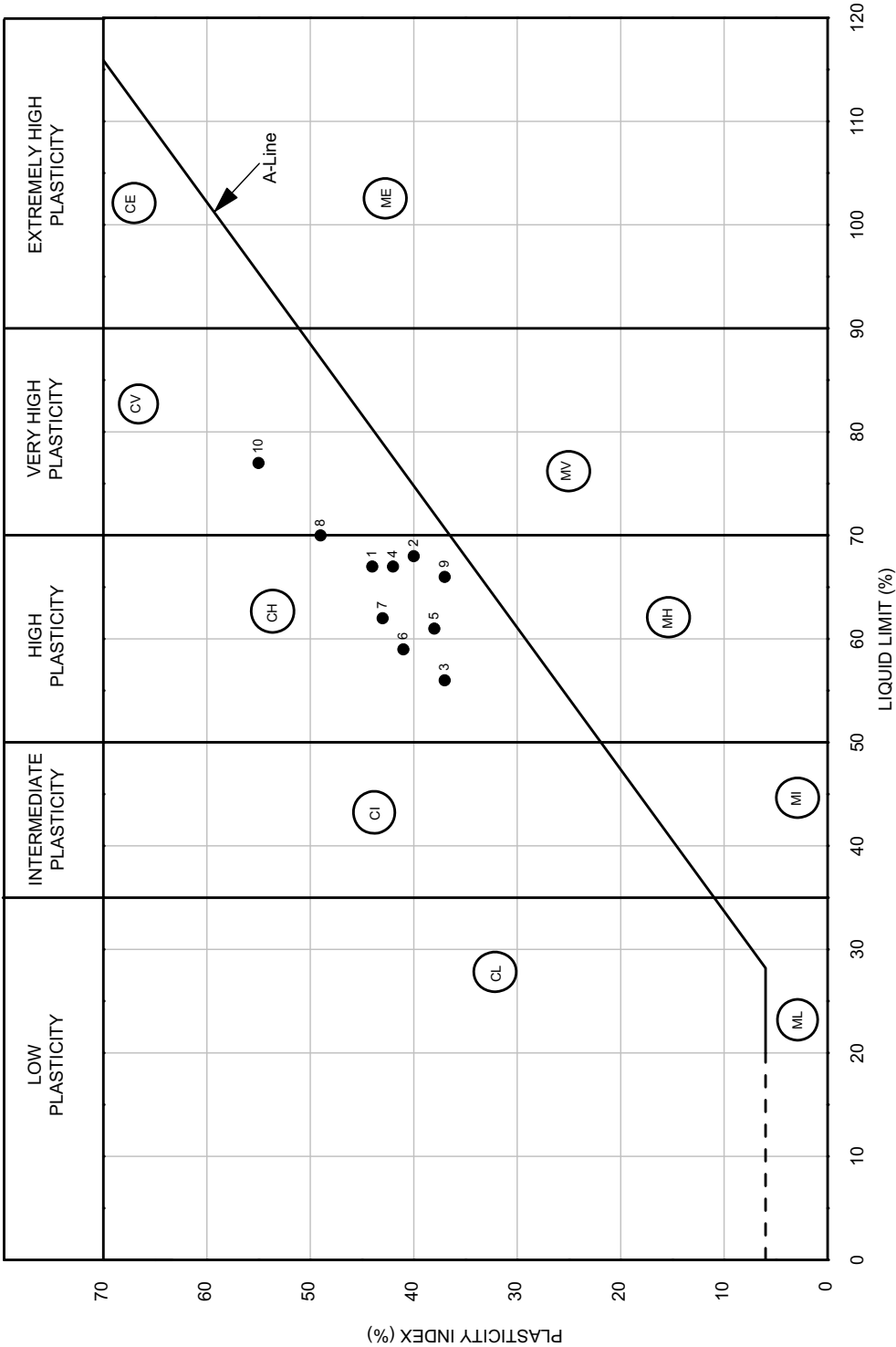
Date : 17/05/2011

Checked by: PH
Approved by:

KEY TO TERMS USED :

Soil Types :	Plasticity :
C = Clay	L = Low
M = Silt	I = Intermediate
	H = High
	V = Very high
	E = Extremely High

NOTE: The letter O is added to the symbol of any material containing a significant amount of organic material; e.g. : MHO



See summary sheet for key to symbols



Checked by: PH

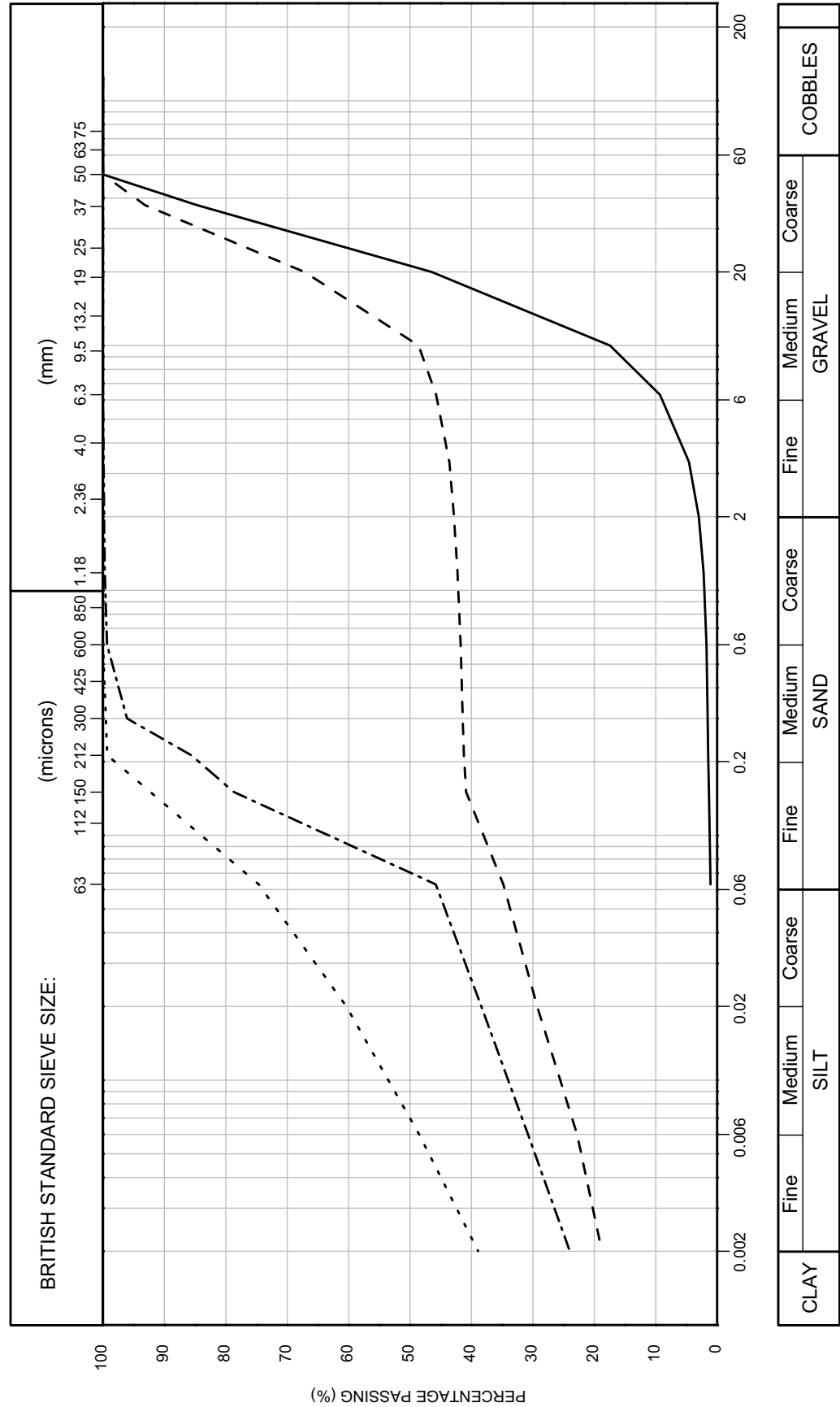
Approved by:

Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_13_2bBagA_ps.OPJ

Drawn by: ALB

Date: 23/05/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
—	BH_13	2bBagA	3.00	9.2	N/A	-	1	2	97	-
- -	BH_13	3bBagB	3.65	9.2/9.4	N/A	19	15	9	57	-
- . - .	BH_13	4bBagA	7.50	9.4	N/A	39	34	27	-	-
- . - .	BH_13	5bBagB	9.10	9.2/9.4	N/A	24	21	55	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

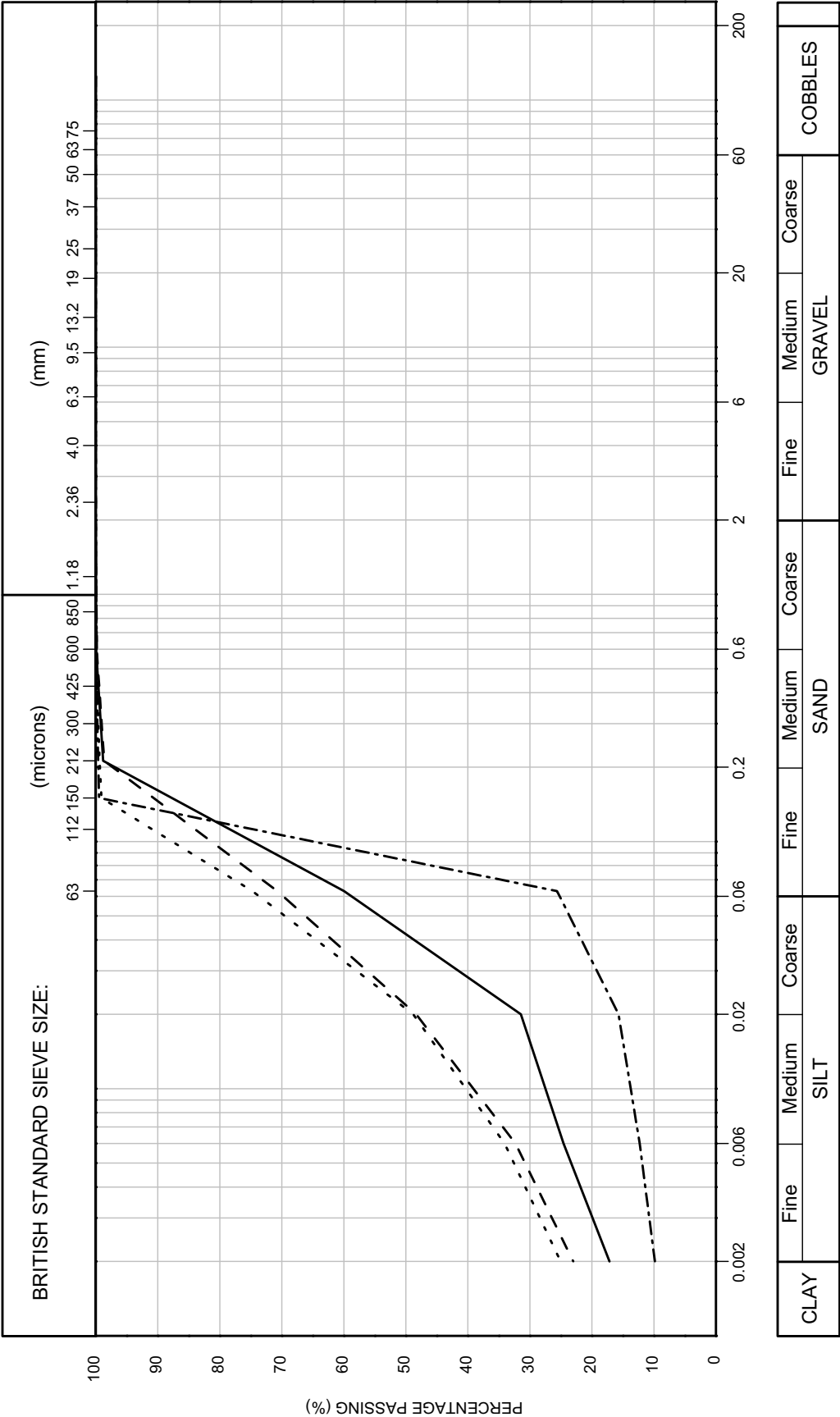
Filename: J11056 \ CLASS \ BH-13_6WaxA_ps.OPJ

Date: 03/06/2011

Date:

Drawn by: ALB

Date: 23/05/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types					
						Clay	Silt†	Sand	Gravel	Cobbles	
    	BH_13	6WaxA	12.60	9.4	N/A	17	40	43	-	9.2	Wet sieve
	BH_13	7BagA	13.50	9.4	N/A	23	46	31	-	9.3	Dry sieve
	BH_13	7BagB	14.05	9.2/9.4	N/A	25	47	28	-	9.4	Sedimentation by pipette
	BH_13	9BagA	18.00	9.2/9.4	N/A	10	15	75	-	9.5	Sedimentation by hydrometer



Checked by: PH

Approved by:

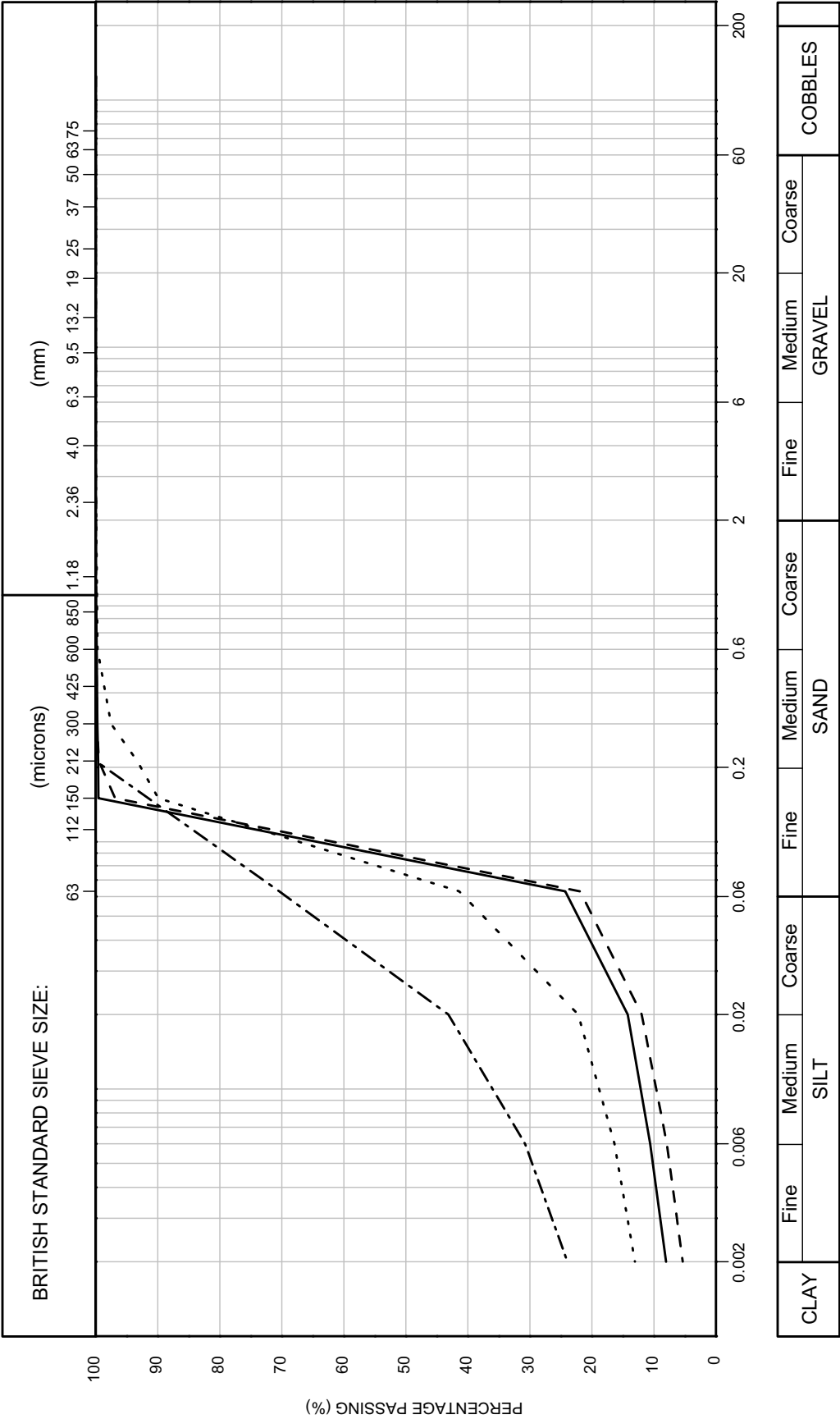
Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_13_11BagA_ps.OPJ

Date: 03/06/2011

Date: 23/05/2011

Drawn by: ALB





Checked by: PH

Approved by:

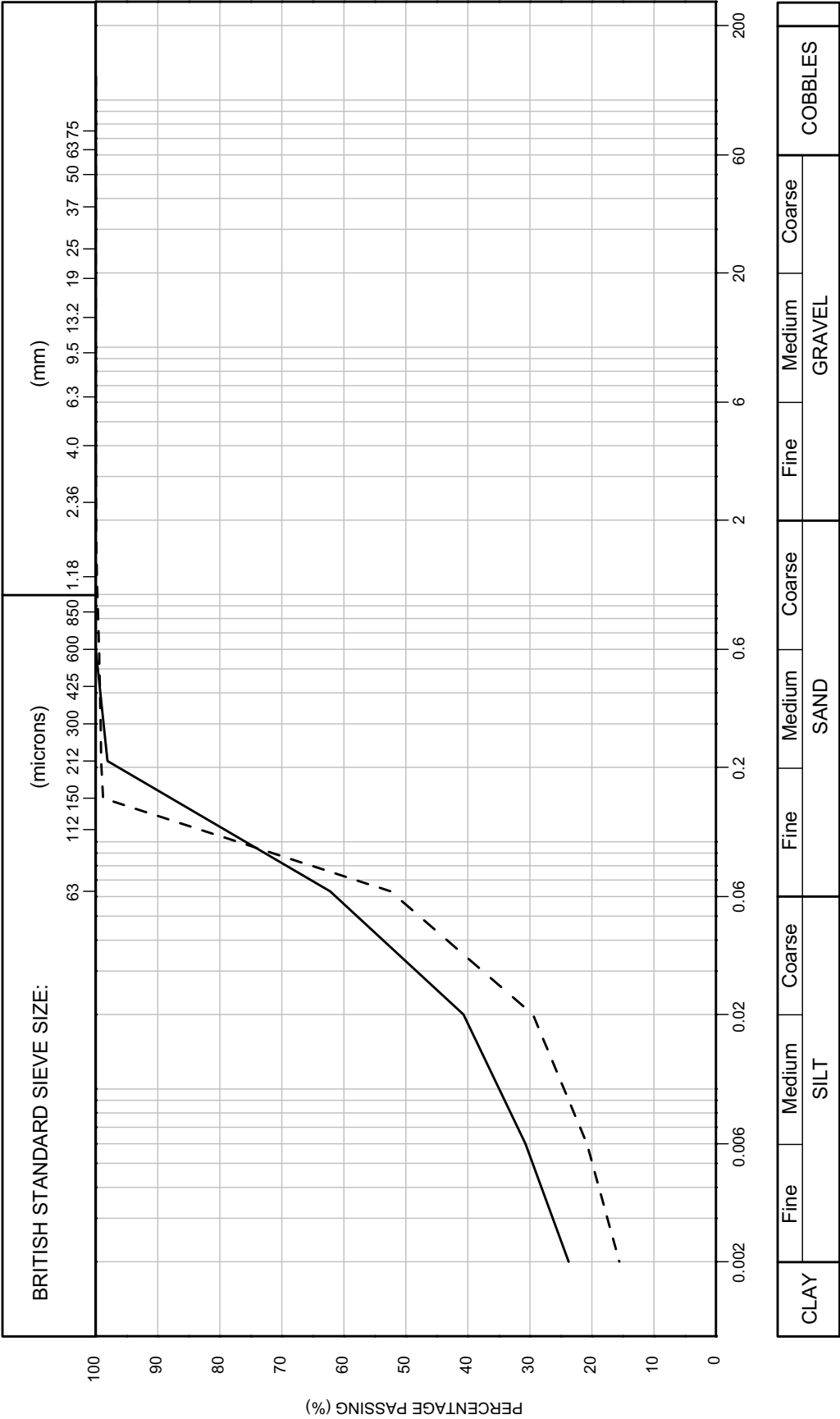
Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_13_24BagA_ps.OPJ

Date: 03/06/2011

Date: 23/05/2011

Drawn by: ALB



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
 	BH_13 BH_13	24BagA 26BagA	40.00	9.4	N/A	24	36	40	-	-
			44.50	9.2/9.4	N/A	16	35	49	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

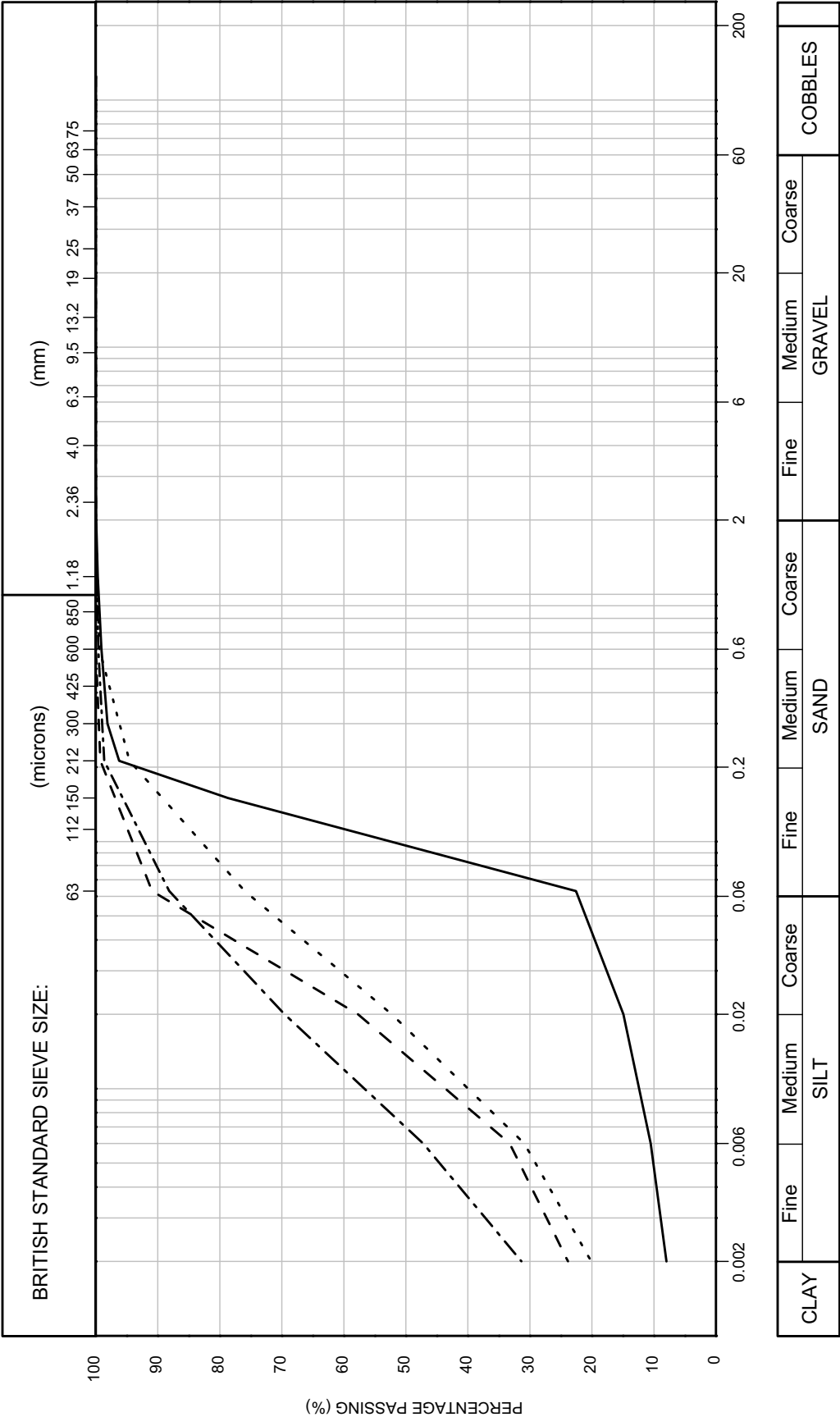
Filename: J11056 \ CLASS \ BH_14_1BagB_ps.OPJ

Date: 25/05/2011

Date:

Drawn by: ALB

Date: 24/05/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
—	BH_14	1BagB	2.15	9.2/9.4	N/A	8	14	78	-	-
- -	BH_14	4BagUU	7.10	9.4	N/A	24	64	12	-	-
- . - .	BH_14	6BagA	12.00	9.4	N/A	20	54	26	-	-
- - - -	BH_14	8BagB	17.50	9.4	N/A	31	55	14	-	-

* 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



Checked by: PH

Approved by:

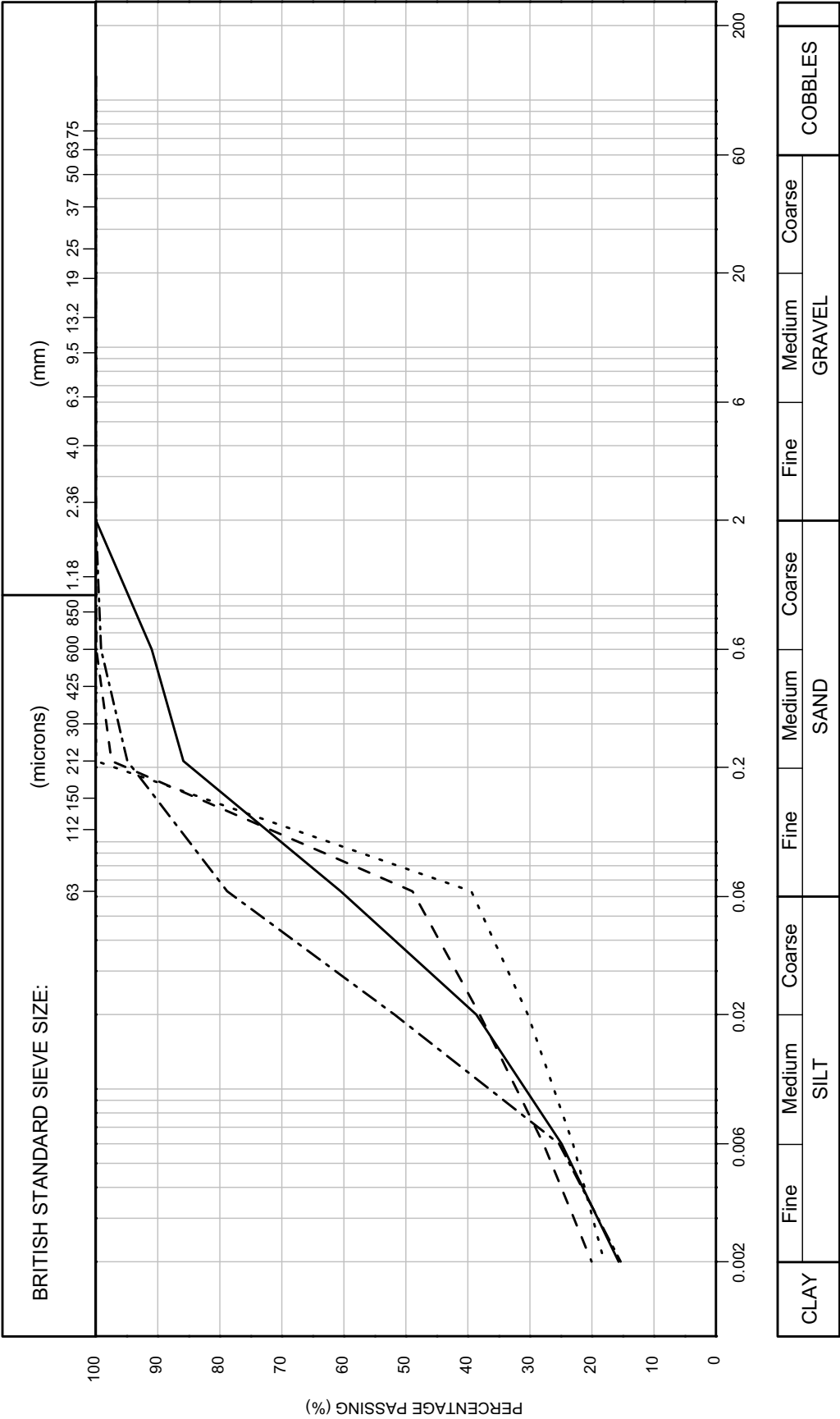
Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_14_10BagB_ps.OPJ

Date: 25/05/2011

Date: 23/05/2011

Drawn by: ALB



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
10BagB	BH_14	10BagB	22.30	9.4	N/A	16	43	41	-	-
13BagA	BH_14	13BagA	30.00	9.4	N/A	20	28	52	-	-
14BagA	BH_14	14BagA	31.00	9.4	N/A	18	20	62	-	-
15BagB	BH_14	15BagB	35.30	9.4	N/A	15	61	24	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

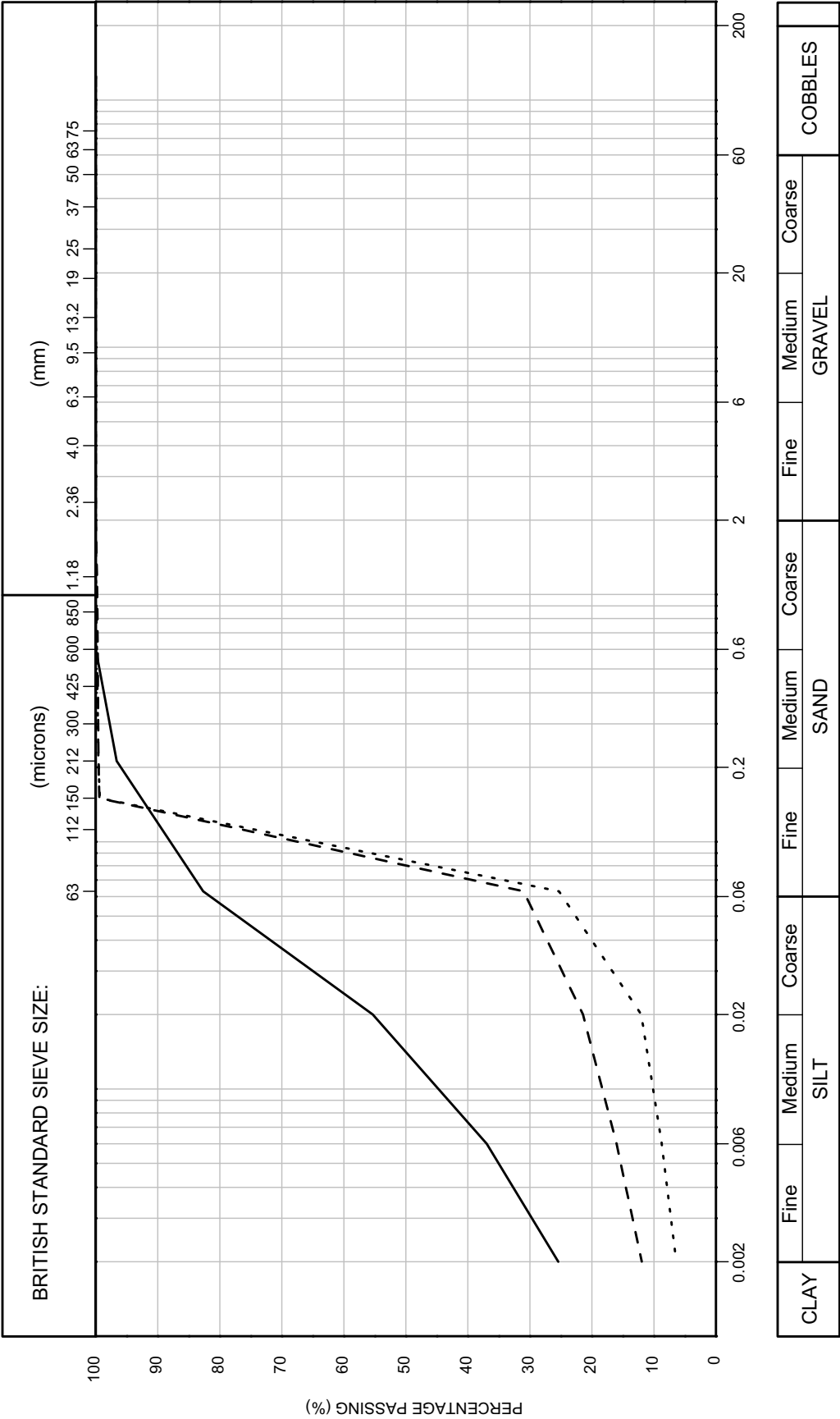
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Date: 25/05/2011

Date:

Drawn by: ALB

Date: 23/05/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
1	BH_14	15BagC	35.58	9.4	N/A	25	55	20	-	-
2	BH_14	20BagA	42.50	9.2/9.4	N/A	12	18	70	-	-
3	BH_14	23BagA	47.50	9.2/9.4	N/A	6	17	77	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

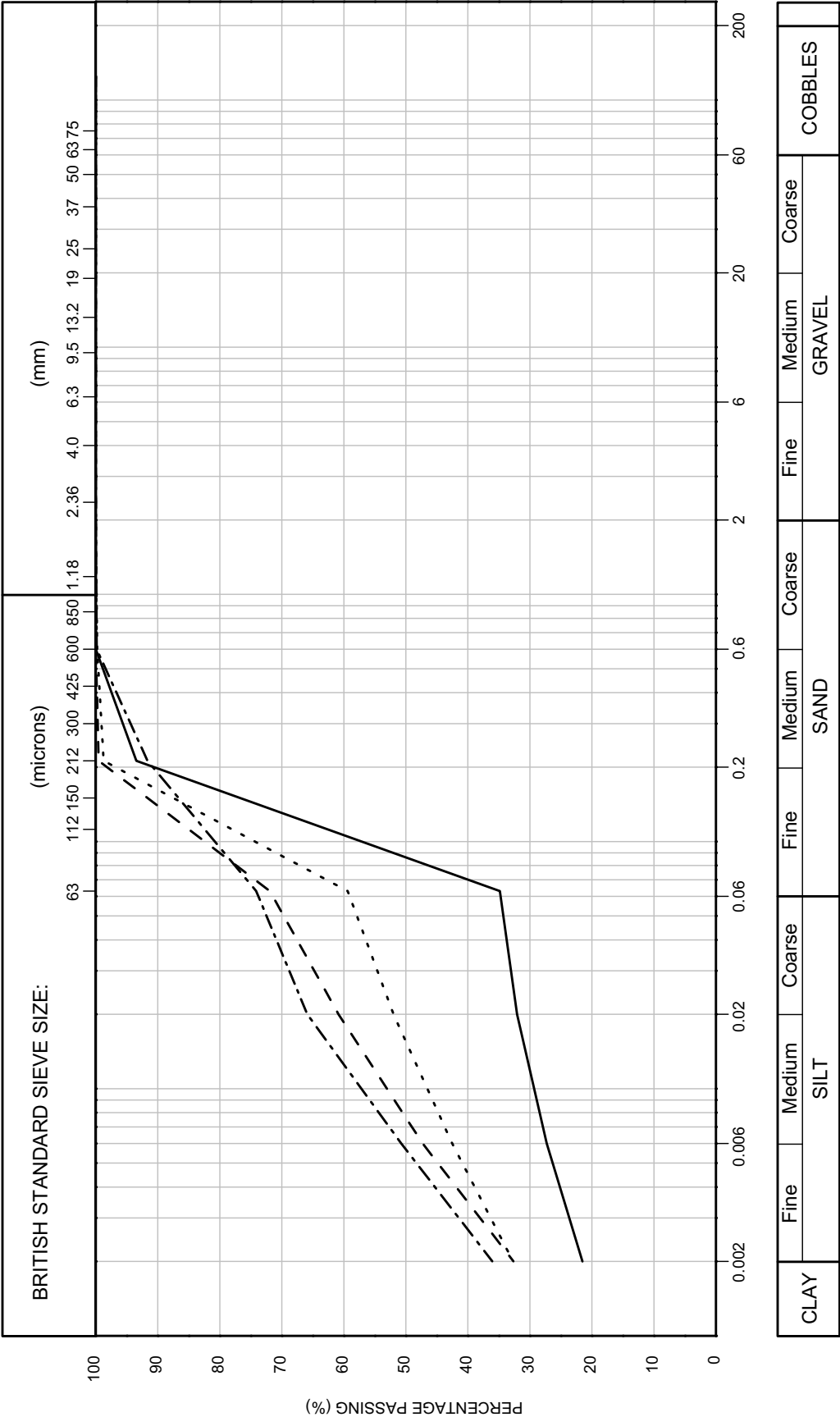
Filename: J11056 \ CLASS \ BH_02_1BagB_ps.OPJ

Date: 31/05/2011

Date:

Drawn by: ALB

Date: 31/05/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
1	BH_02	1BagB	3.25	9.4	N/A	22	13	65	-	-
2	BH_02	2BagA	7.20	9.4	N/A	33	38	29	-	-
3	BH_02	3BagB	8.50	9.4	N/A	33	26	41	-	-
4	BH_02	4BagB	12.05	9.4	N/A	36	37	27	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

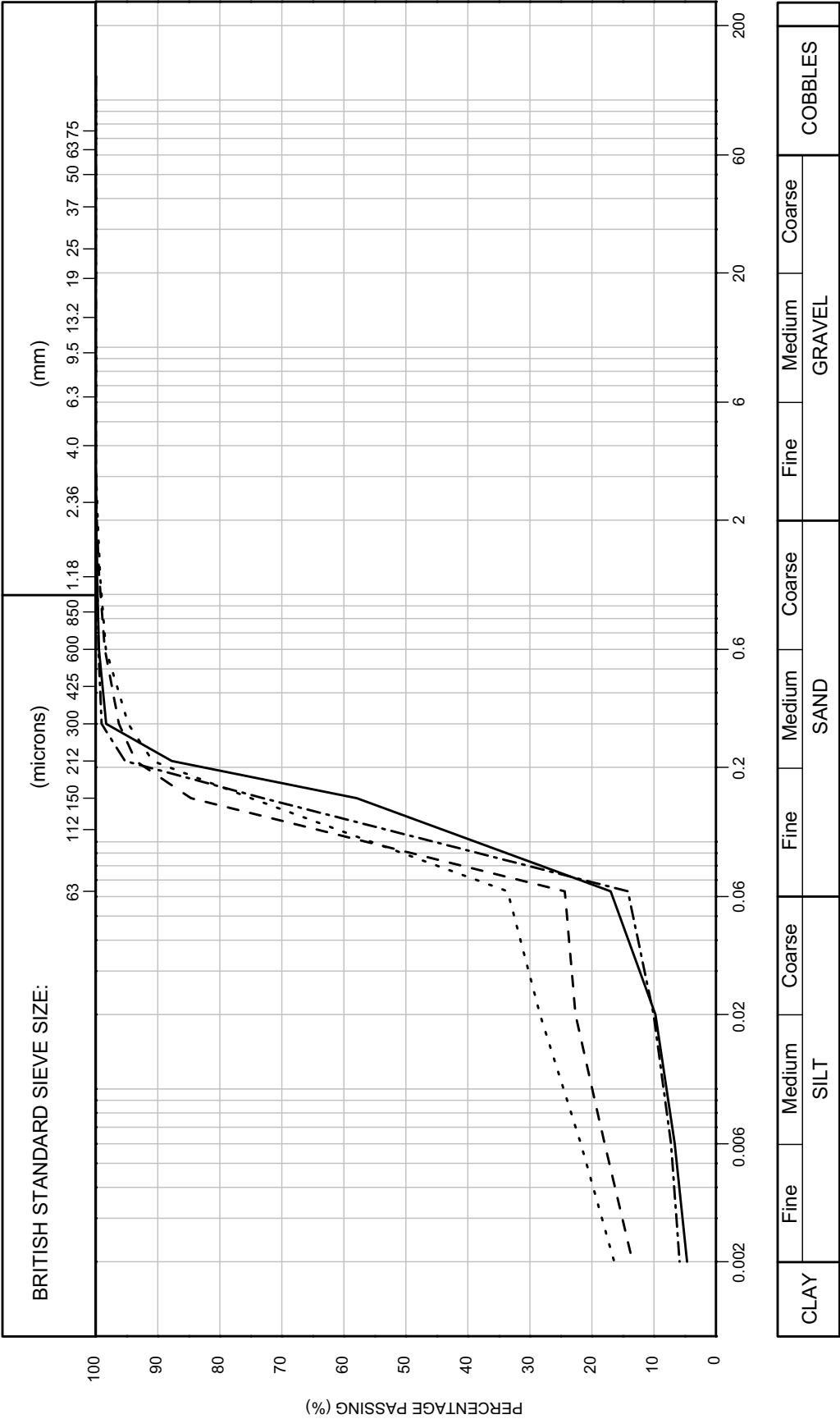
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Date: 31/05/2011

Date:

Drawn by: ALB

Date: 31/05/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types					* Tested in accordance with the following clauses of BS 1377: Part 2, 1990:			
						Clay	Silt†	Sand	Gravel	Cobbles				
5BagB	BH_02	5BagB	12.70	9.2/9.4	N/A	5	11	84	-	-	9.2	Wet sieve		
6BagB	BH_02	6BagB	16.65	9.2/9.4	N/A	13	10	77	-	-	9.3	Dry sieve		
7BagB	BH_02	7BagB	17.15	9.2/9.4	N/A	16	16	68	-	-	9.4	Sedimentation by pipette		
8BagA	BH_02	8BagA	19.55	9.2/9.4	N/A	6	8	86	-	-	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



Checked by: PH

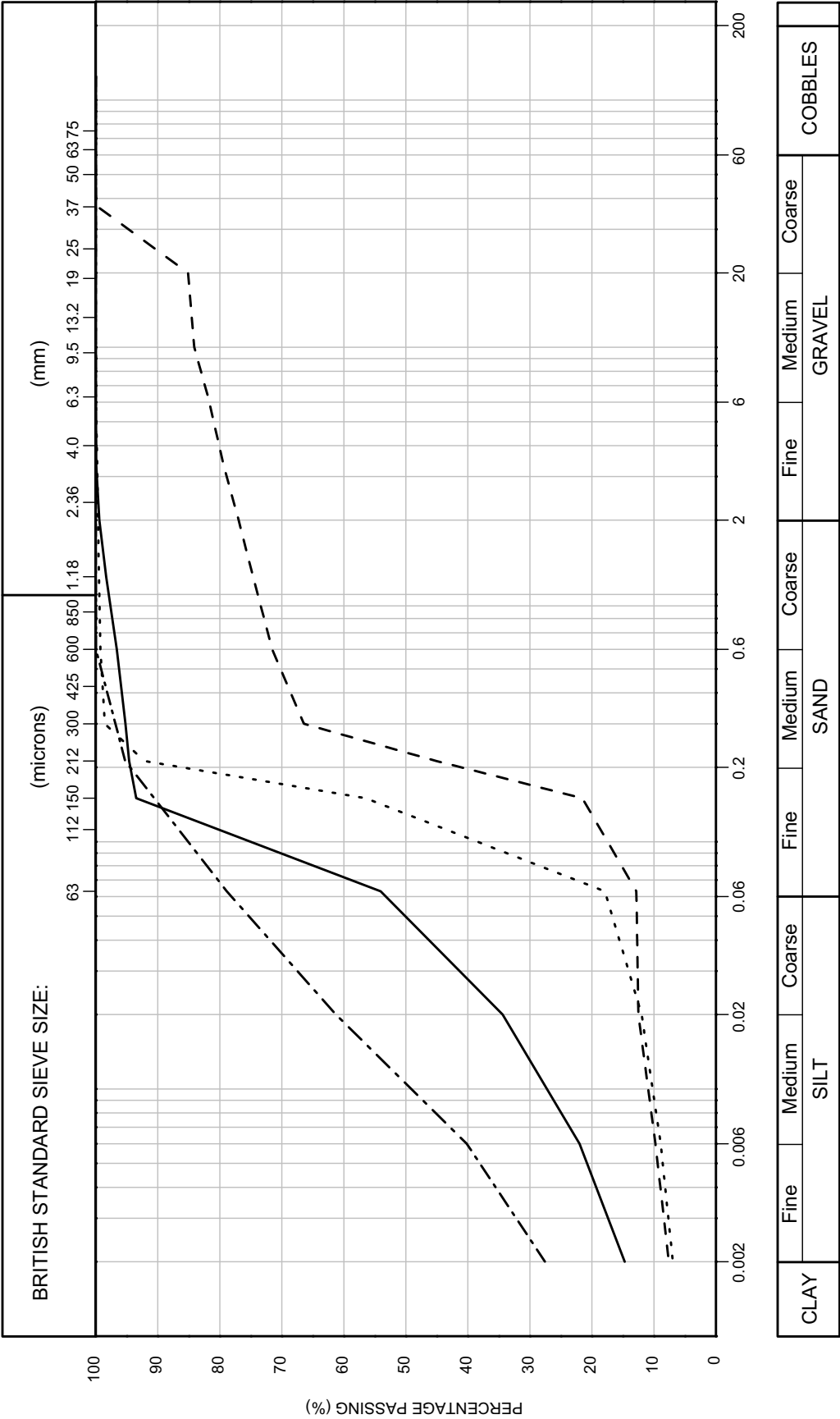
Approved by:

Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_02_9BagA_ps.OPJ

Drawn by: ALB

Date: 31/05/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types					Tested in accordance with the following clauses of BS 1377: Part 2: 1990:				
						Clay	Silt†	Sand	Gravel	Cobbles	9.2	9.3	9.4	9.5	
1	BH_02	9BagA	20.00	9.2/9.4	N/A	15	37	48	-	-	9.2	9.3	9.4	9.5	Wet sieve
2	BH_02	11BagA	23.00	9.2/9.4	N/A	8	5	64	23	-					Dry sieve
3	BH_02	13BagA	26.50	9.2/9.4	N/A	7	10	83	-	-					Sedimentation by pipette
4	BH_02	14BagA	30.00	9.4	N/A	28	50	22	-	-					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



Checked by: PH

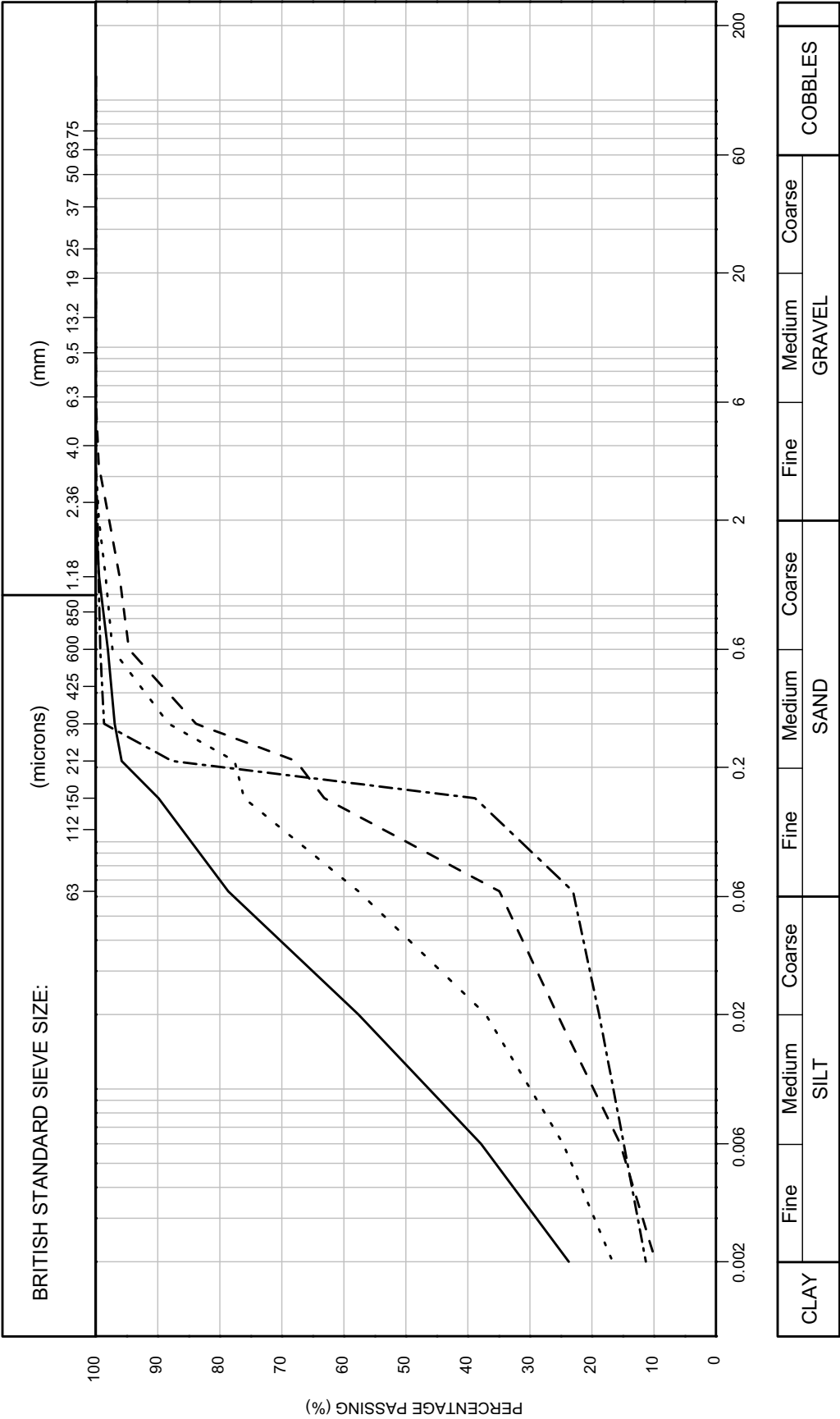
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Drawn by: ALB

Date: 31/05/2011



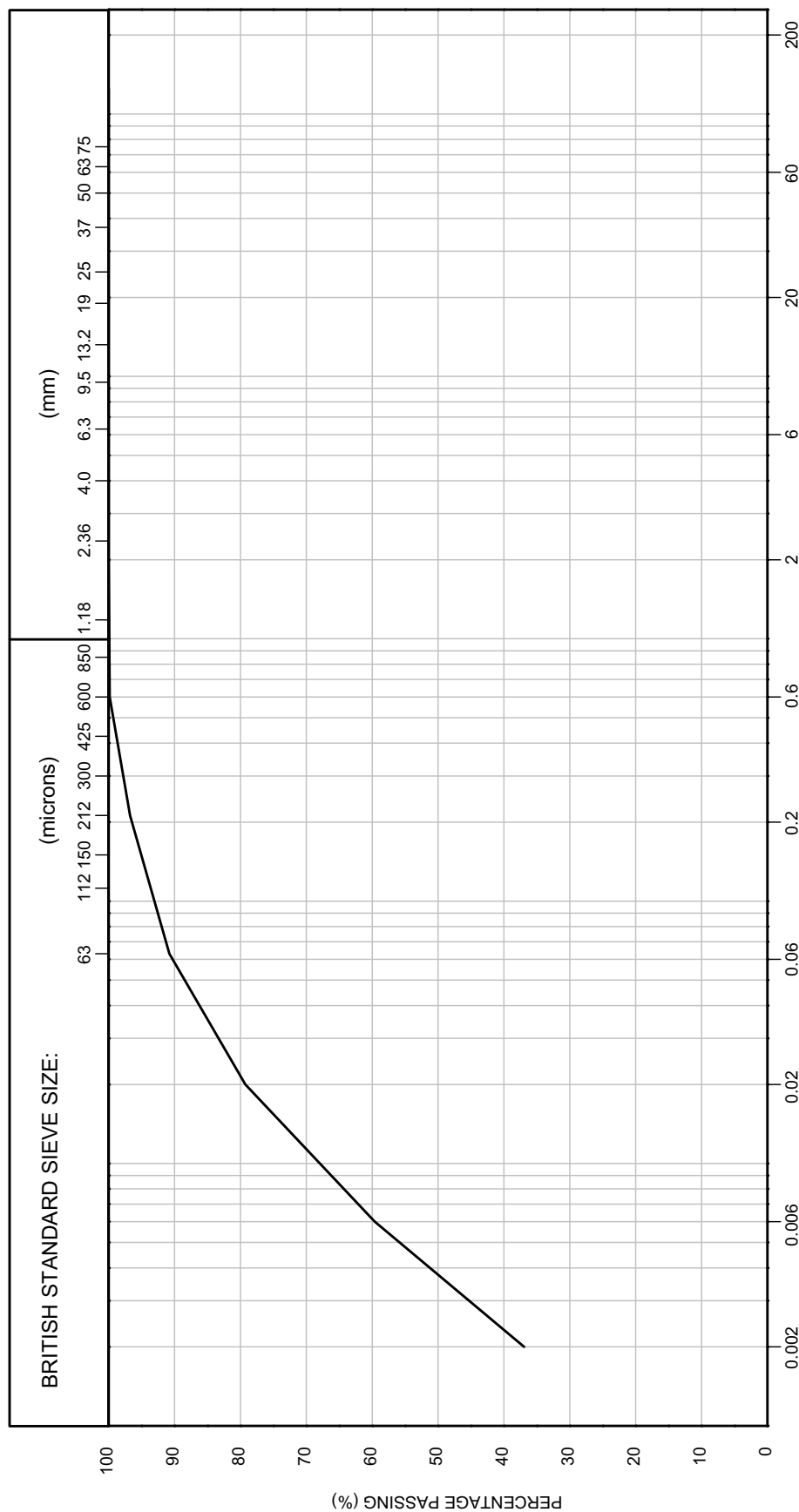
PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
14BagB	BH_02	14BagB	30.20	9.2/9.4	N/A	24	53	23	-	-
17BagA	BH_02	17BagA	34.50	9.2/9.4	N/A	10	24	64	2	-
19BagA	BH_02	19BagA	37.50	9.2/9.4	N/A	17	39	44	-	-
20BagA	BH_02	20BagA	41.00	9.2/9.4	N/A	11	11	78	-	-

* 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



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

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types					* Tested in accordance with the following clauses of BS 1377: Part 2: 1990:	
						Clay	Silt†	Sand	Gravel	Cobbles		
	BH_02	24WaxA	46.18	9.4	N/A	37	53	10	-	-	9.2 9.3 9.4 9.5	Wet sieve Dry sieve Sedimentation by pipette 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



Checked by: PH

Approved by:

Template Issue: 4.2

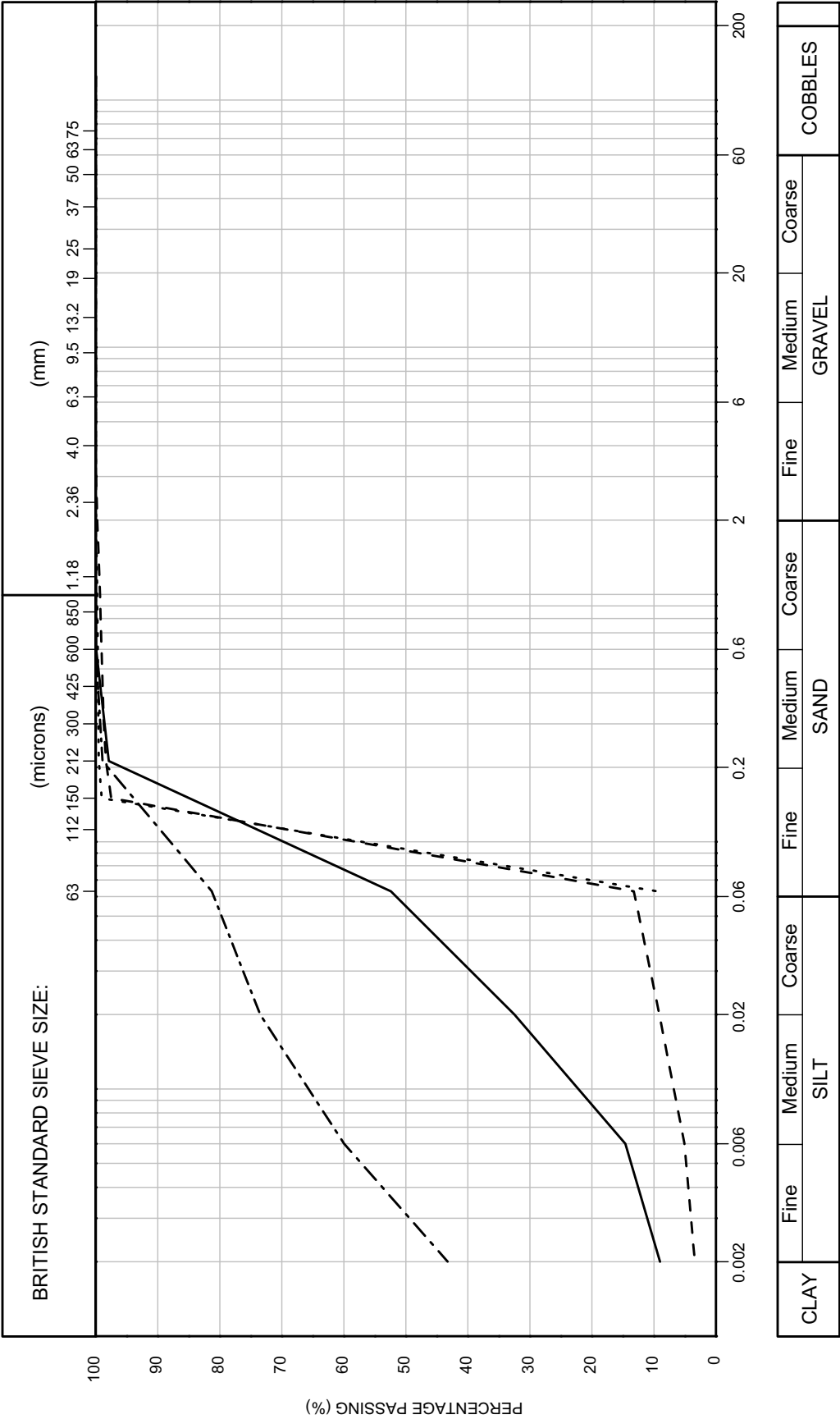
Filename: J11056 \ CLASS \ BH_04_1BagB_ps.OPJ

Date: 01/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
1	BH_04	1BagB	4.55	9.4	N/A	9	42	49	-	-
2	BH_04	1BagC	4.75	9.2/9.4	N/A	3	9	88	-	-
3	BH_04	3BagA	7.50	9.2	N/A	-	9	91	-	-
4	BH_04	4BagC	10.70	9.4	N/A	43	37	20	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

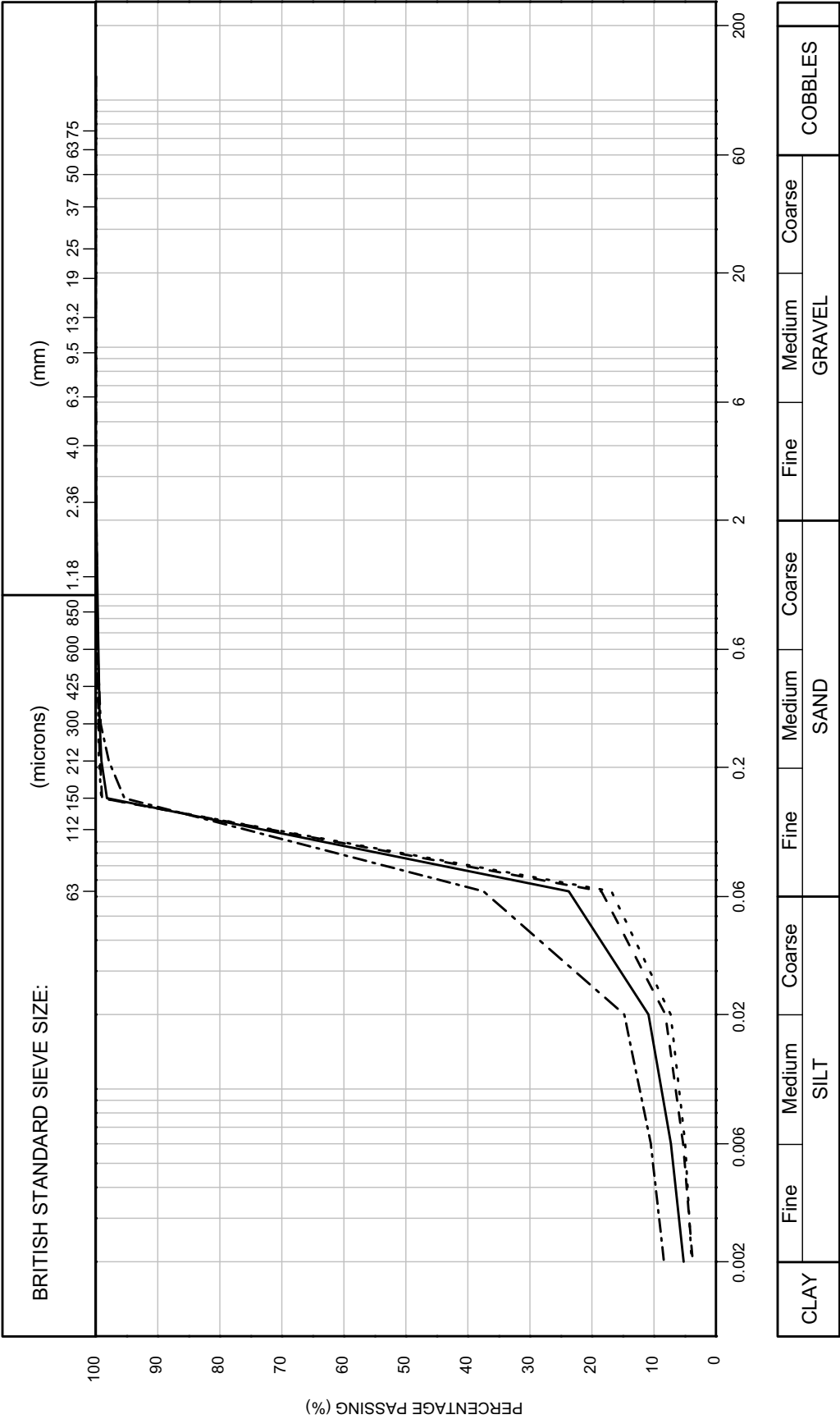
Filename: J11056 \ CLASS \ BH_04_4BagD_ps.OPJ

Date: 01/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types					Tested in accordance with the following clauses of BS 1377: Part 2: 1990:			
						Clay	Silt†	Sand	Gravel	Cobbles				
—	BH_04	4BagD	10.77	9.2/9.4	N/A	5	17	78	-	-	9.2	Wet sieve		
- -	BH_04	5BagA	14.00	9.2/9.4	N/A	4	13	83	-	-	9.3	Dry sieve		
- . - .	BH_04	8BagA	17.00	9.2/9.4	N/A	4	12	84	-	-	9.4	Sedimentation by pipette		
- - - -	BH_04	9BagA	19.00	9.2/9.4	N/A	8	27	65	-	-	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



Checked by: PH

Approved by:

Template Issue: 4.2

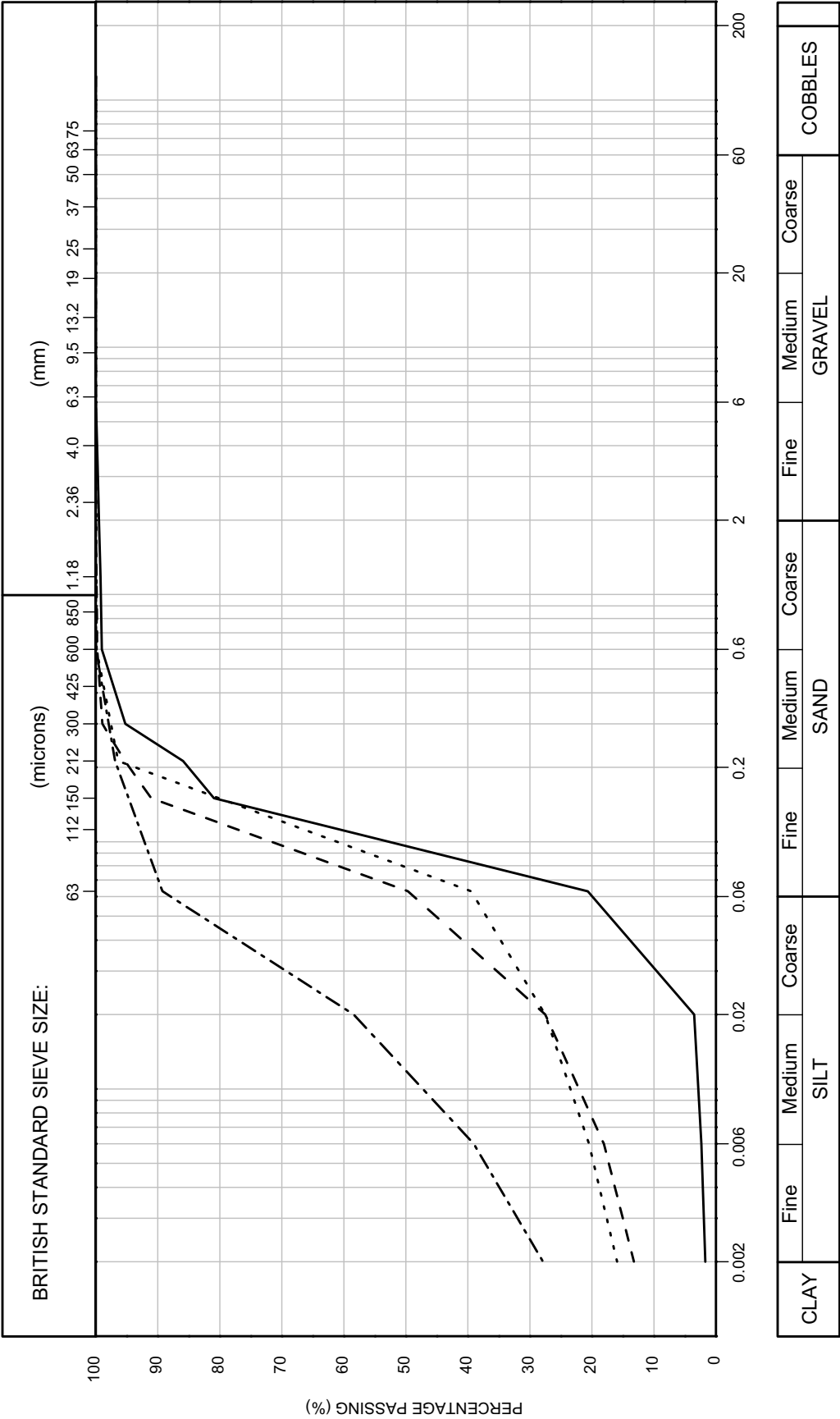
Filename: J11056 \ CLASS \ BH_04_11BagB_ps.OPJ

Date: 01/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
11BagB	BH_04	11BagB	21.55	9.2/9.4	N/A	2	17	81	-	-
11BagC	BH_04	11BagC	21.95	9.2/9.4	N/A	13	34	53	-	-
12WaxB	BH_04	12WaxB	22.82	9.4	N/A	16	22	62	-	-
14BagA	BH_04	14BagA	27.11	9.4	N/A	28	59	13	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

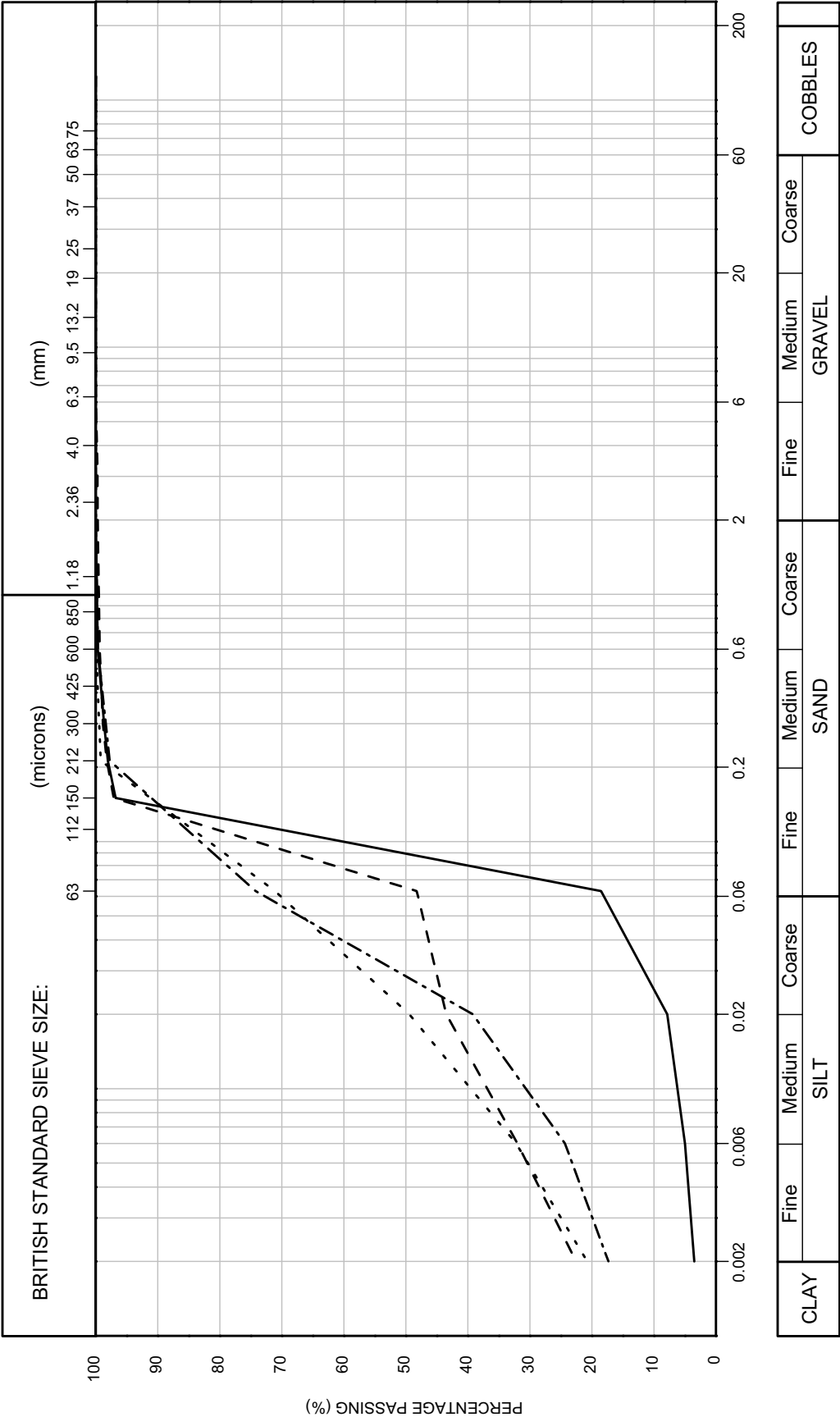
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Date: 01/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
17BagB	BH_04	17BagB	31.10	9.2/9.4	N/A	3	14	83	-	-
18BagA	BH_04	18BagA	34.50	9.2/9.4	N/A	23	25	52	-	-
21BagA	BH_04	21BagA	39.50	9.4	N/A	21	48	31	-	-
23BagA	BH_04	23BagA	43.80	9.4	N/A	17	54	29	-	-

* 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



Checked by: PH

Approved by:

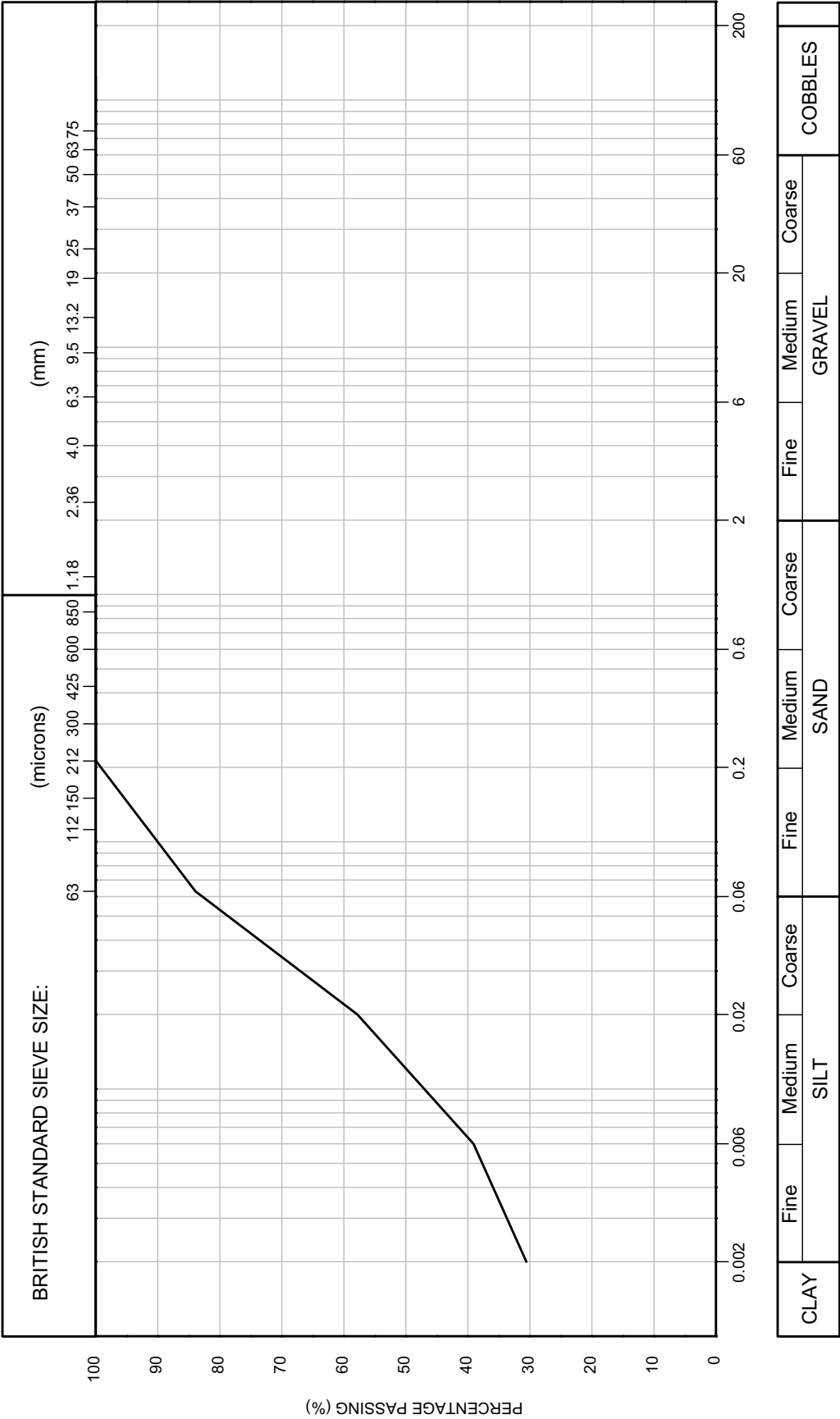
Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_04_24BagA_ps.OPJ

Date: 01/06/2011

Date: 01/06/2011

Drawn by: ALB





Checked by: PH

Approved by:

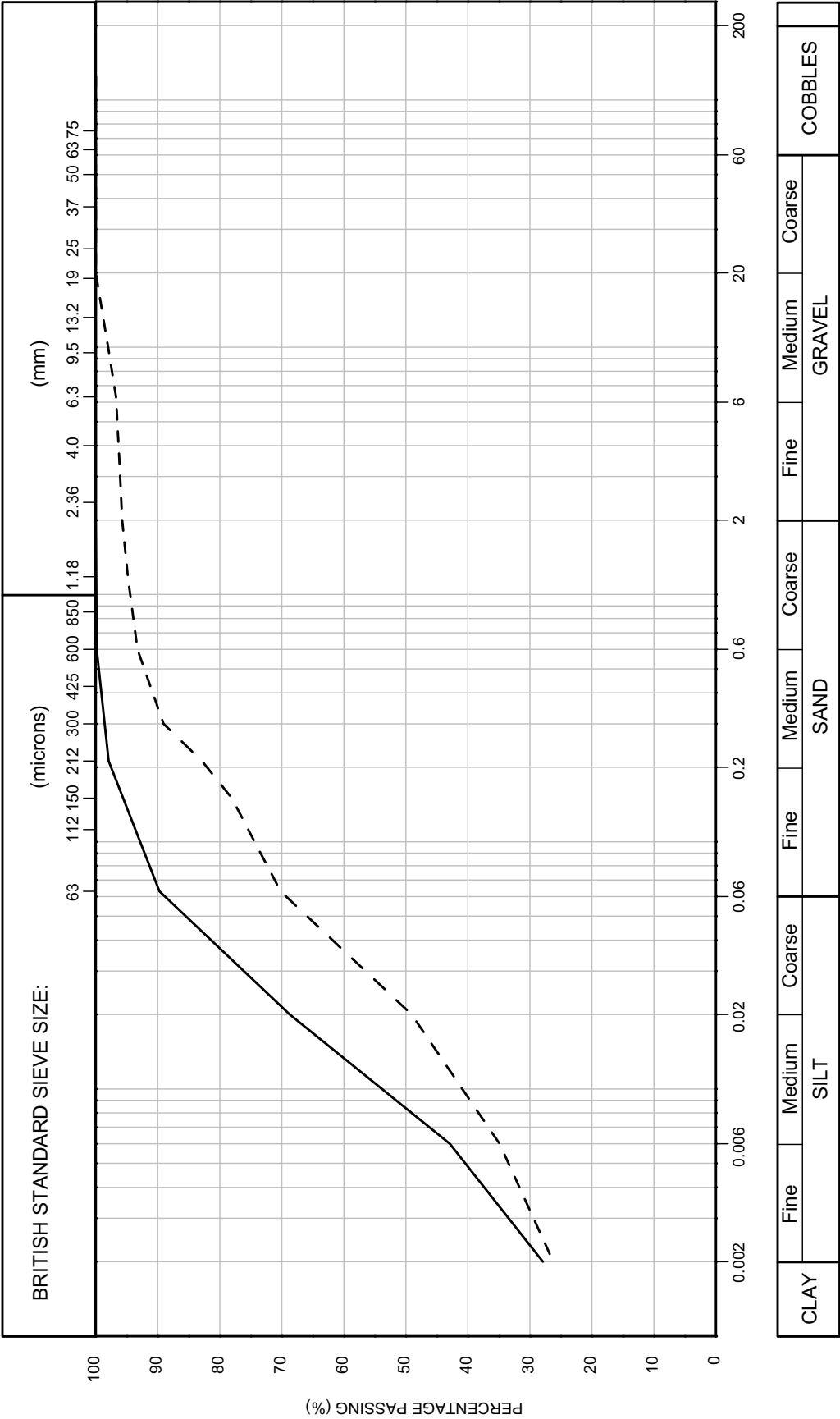
Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_04A_1BagC_ps.OPJ

Date: 01/06/2011

Date: 01/06/2011

Drawn by: ALB



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
1	BH_04A	1BagC	0.30	9.4	N/A	28	60	12	-	-
			1.10	9.2/9.4	N/A	26	42	28	4	-
2	BH_04A	2BagB	0.30	9.4	N/A	28	60	12	-	-
			1.10	9.2/9.4	N/A	26	42	28	4	-

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

9.2

9.3

9.4

9.5

Wet sieve

Dry sieve

Sedimentation by pipette

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



Checked by: PH

Approved by:

Template Issue: 4.2

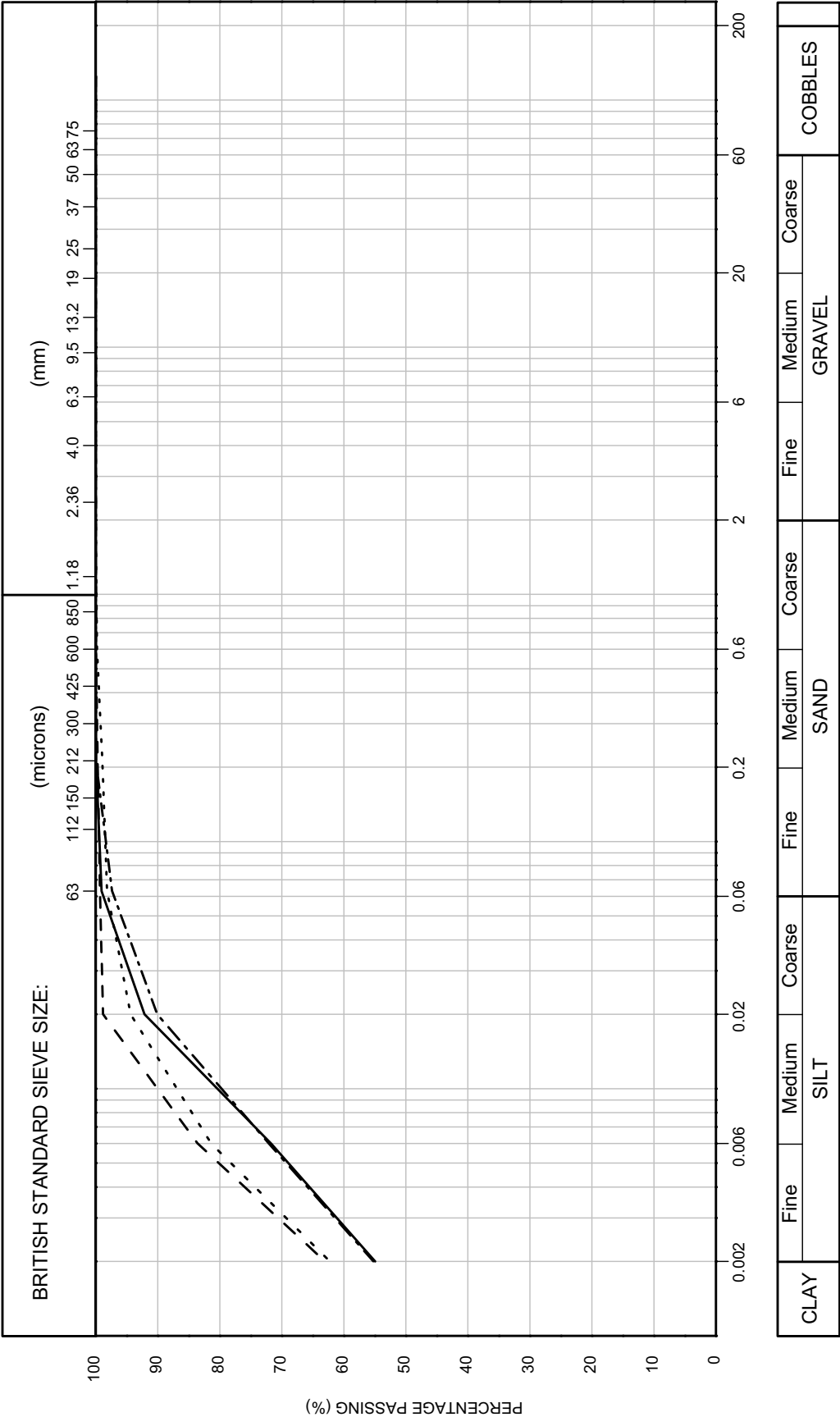
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Date: 02/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types			
						Clay	Silt†	Sand	Cobbles
1	BH_06	1BagA	3.00	9.4	N/A	55	43	2	-
2	BH_06	3BagA	4.50	9.4	N/A	63	36	1	-
3	BH_06	5BagUU	9.17	9.4	N/A	62	35	3	-
4	BH_06	8BagB	14.25	9.4	N/A	55	41	4	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

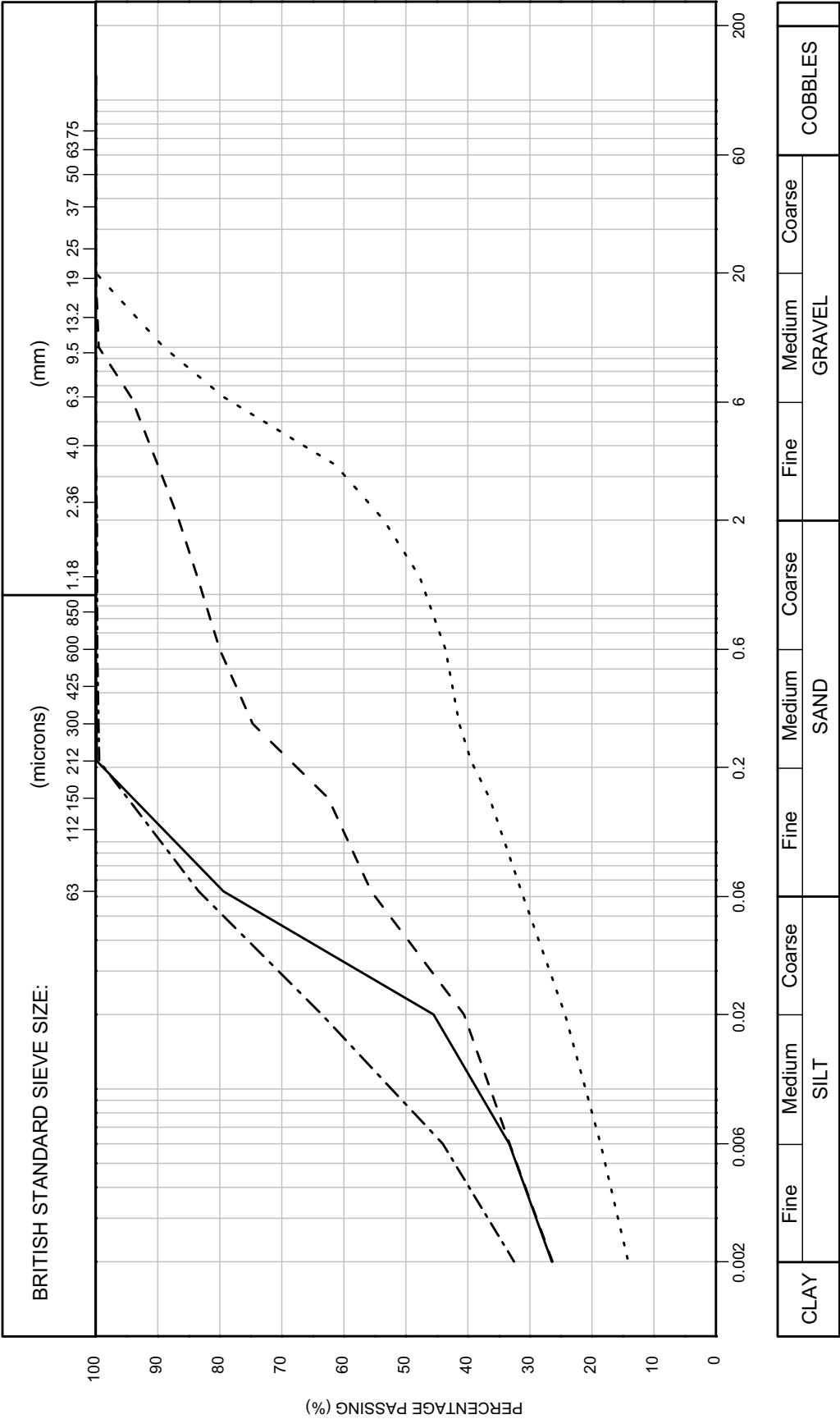
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Date: 06/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types			
						Clay	Silt†	Sand	Cobbles
—	BH_06	11WaxA	19.55	9.4	N/A	26	50	24	-
- -	BH_06	12BagB	22.65	9.2/9.4	N/A	26	28	33	-
- . - .	BH_06	14ABagA	23.50	9.2/9.4	N/A	14	16	24	-
- . - .	BH_06	19BagA	27.50	9.4	N/A	33	49	18	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

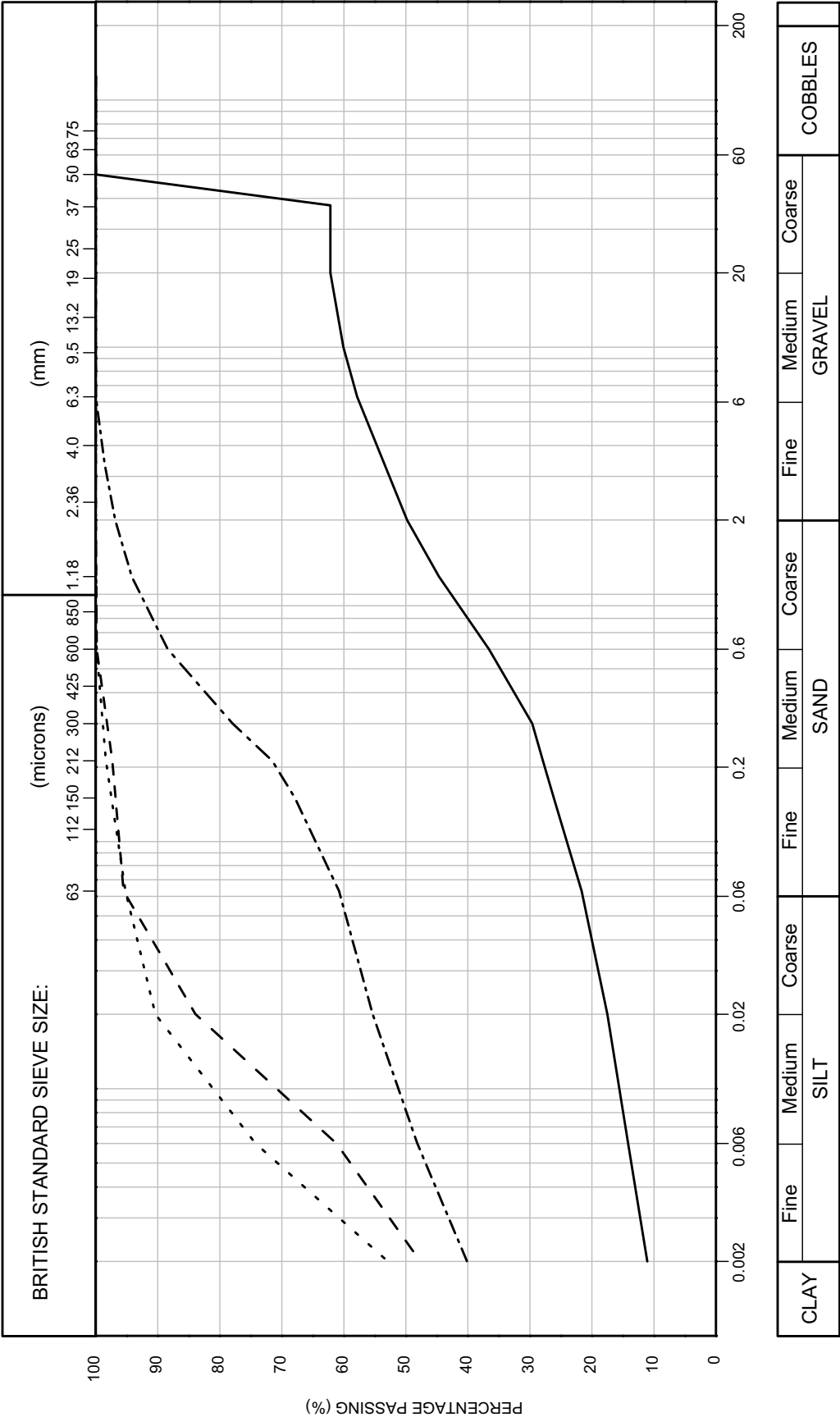
Filename: J11056 \ CLASS \ BH_06_23BagA_ps.OPJ

Date: 13/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
—	BH_06	23BagA	31.00	9.2/9.4	N/A	11	10	29	50	-
- -	BH_06	26BagA	35.50	9.4	N/A	48	47	5	-	-
- . - .	BH_06	28BagA	38.50	9.4	N/A	53	41	6	-	-
- - - -	BH_06	29BagA	42.08	9.2/9.4	N/A	40	20	37	3	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

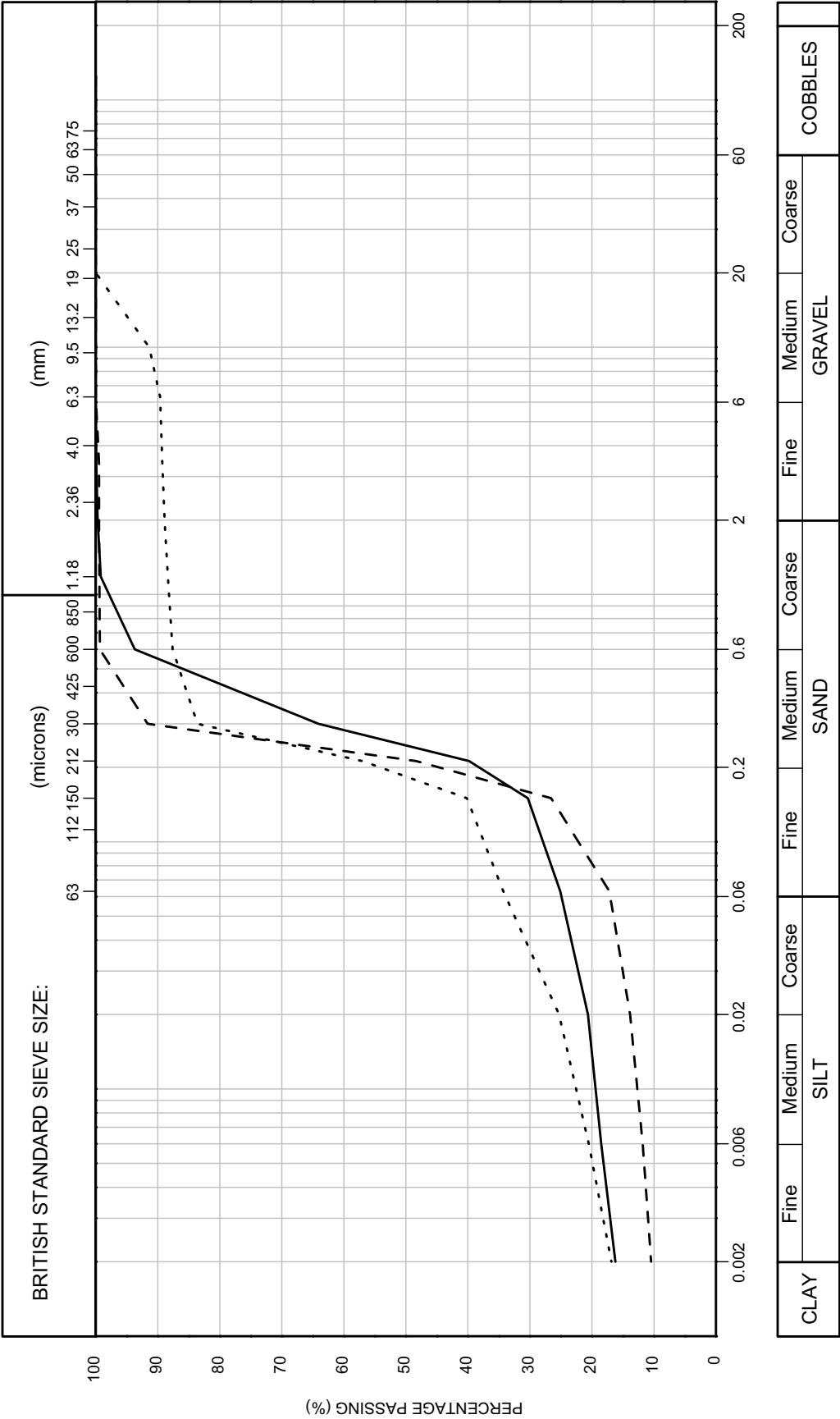
Filename: J11056 \ CLASS \ BH_06_30BagA_ps.OPJ

Date: 06/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types			
						Clay	Silt†	Sand	Cobbles
—	BH_06	30BagA	42.56	9.2/9.4	N/A	16	8	76	-
- -	BH_06	32BagA	45.00	9.2/9.4	N/A	10	6	84	-
- . -	BH_06	33BagA	47.00	9.2/9.4	N/A	17	16	56	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

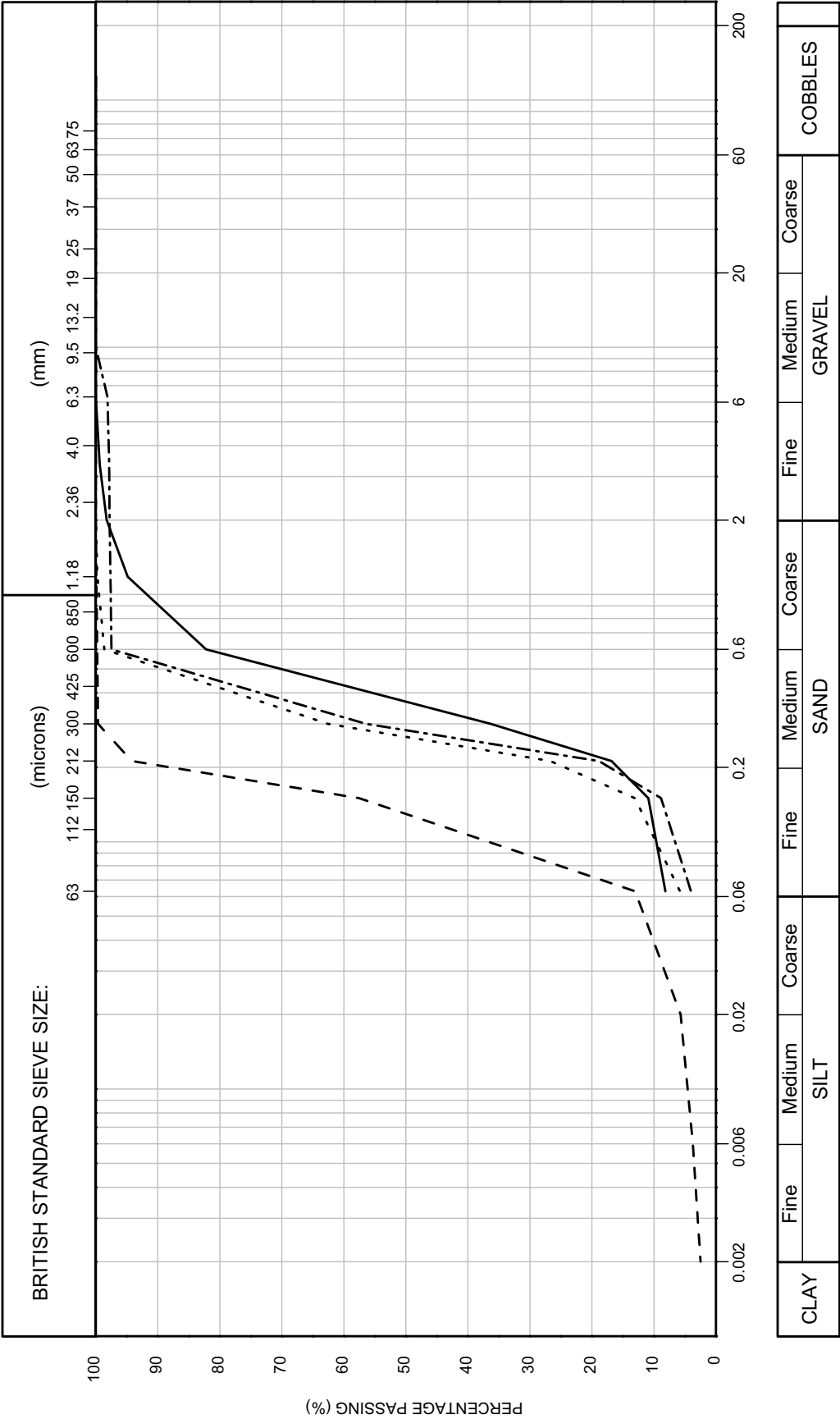
Filename: J11056 \ CLASS \ BH_16_1BagA_ps.OPJ

Date: 06/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
1	BH_16	1BagA	3.00	9.2	N/A	-	8	91	1	-
2	BH_16	2BagB	7.35	9.2	N/A	2	10	88	-	-
3	BH_16	4BagA	15.00	9.2	N/A	-	5	95	-	-
4	BH_16	5BagA	18.50	9.2	N/A	-	4	94	2	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

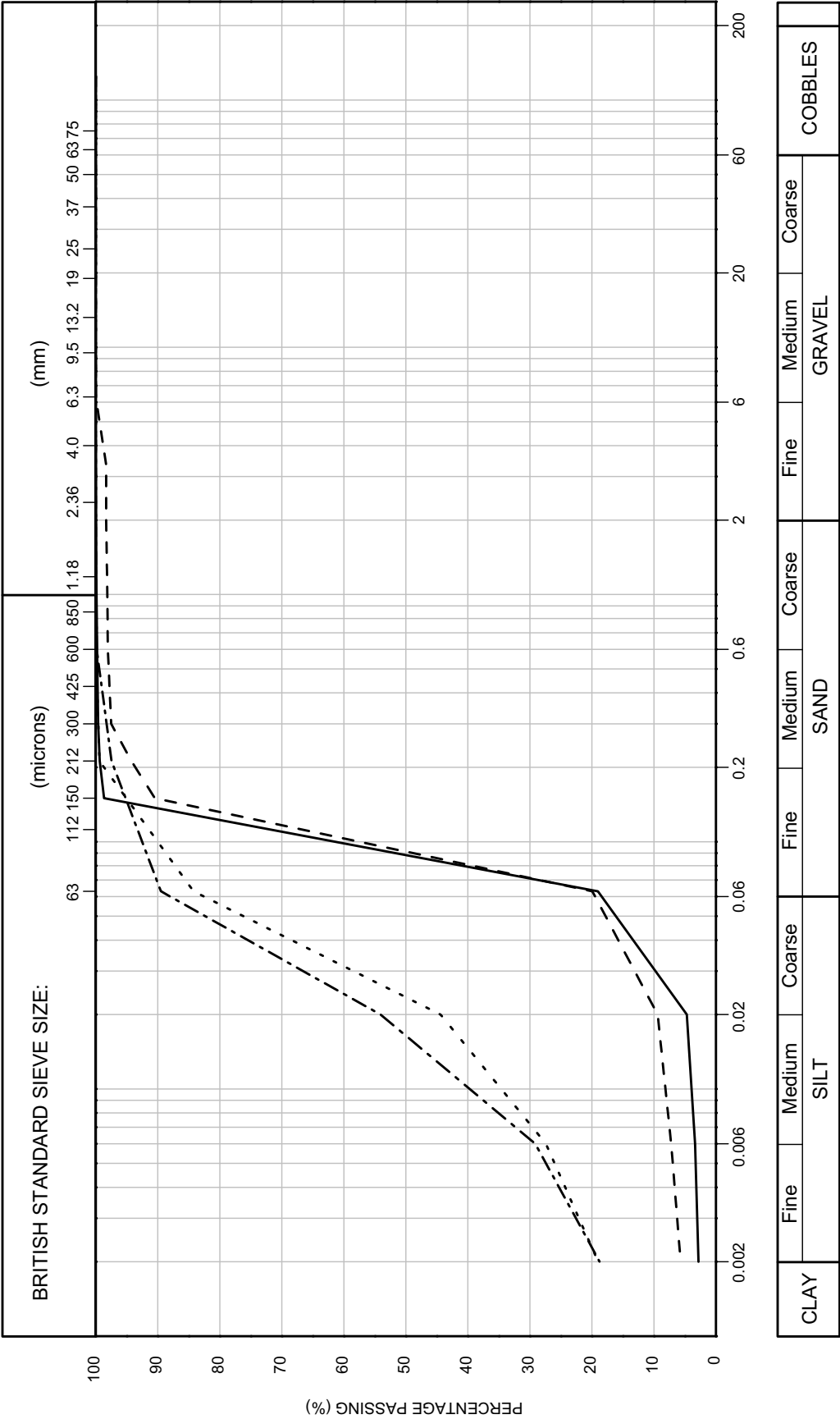
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Date: 06/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
1	BH_16	11BagA	24.00	9.2/9.4	N/A	3	15	82	-	-
2	BH_16	13BagA	26.50	9.2/9.4	N/A	6	13	80	1	-
3	BH_16	14BagA	30.50	9.4	N/A	19	62	19	-	-
4	BH_16	15BagA	31.00	9.4	N/A	19	68	13	-	-

* 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



Checked by: PH

Approved by:

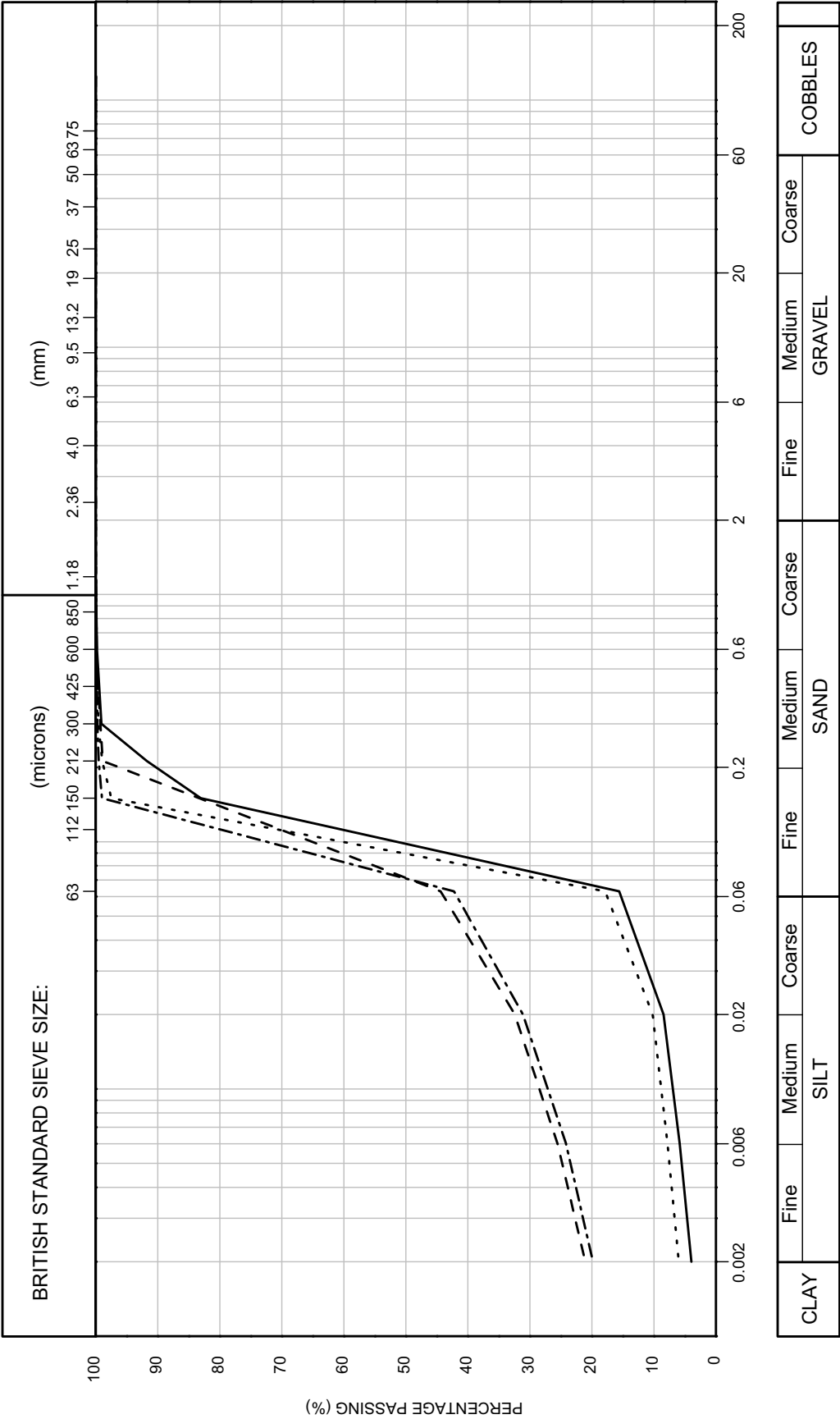
Date: 06/06/2011

Template Issue: 4.2

Filename: J11056 \ CLASS \ BH_16_17BagB_ps.OPJ

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
1	BH_16	17BagB	35.55	9.2/9.4	N/A	4	11	85	-	-
2	BH_16	19BagA	38.50	9.4	N/A	21	22	57	-	-
3	BH_16	21BagB	41.55	9.2/9.4	N/A	6	11	83	-	-
4	BH_16	22BagA	44.00	9.2/9.4	N/A	20	21	59	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

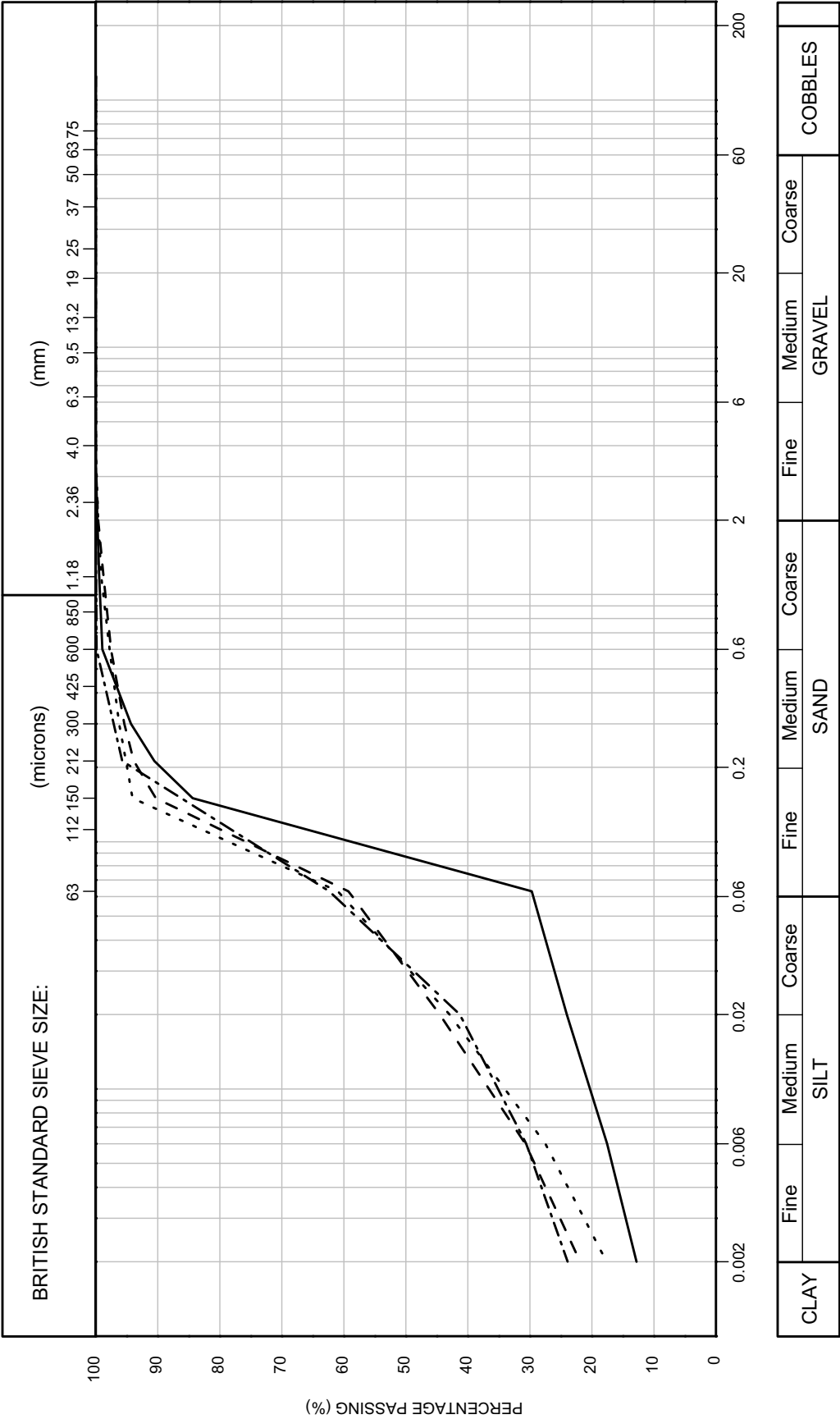
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Date: 06/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types					Tested in accordance with the following clauses of BS 1377: Part 2: 1990:				
						Clay	Silt†	Sand	Gravel	Cobbles	9.2	9.3	9.4	9.5	
1	BH_17	1BagB	2.60	9.2/9.4	N/A	13	16	71	-	-	9.2	9.3	9.4	9.5	Wet sieve
2	BH_17	3BagA	6.50	9.2/9.4	N/A	22	36	42	-	-					Dry sieve
3	BH_17	5BagB	11.30	9.2/9.4	N/A	18	42	40	-	-					Sedimentation by pipette
4	BH_17	6BagA	12.00	9.4	N/A	24	36	40	-	-					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



Checked by: PH

Approved by:

Template Issue: 4.2

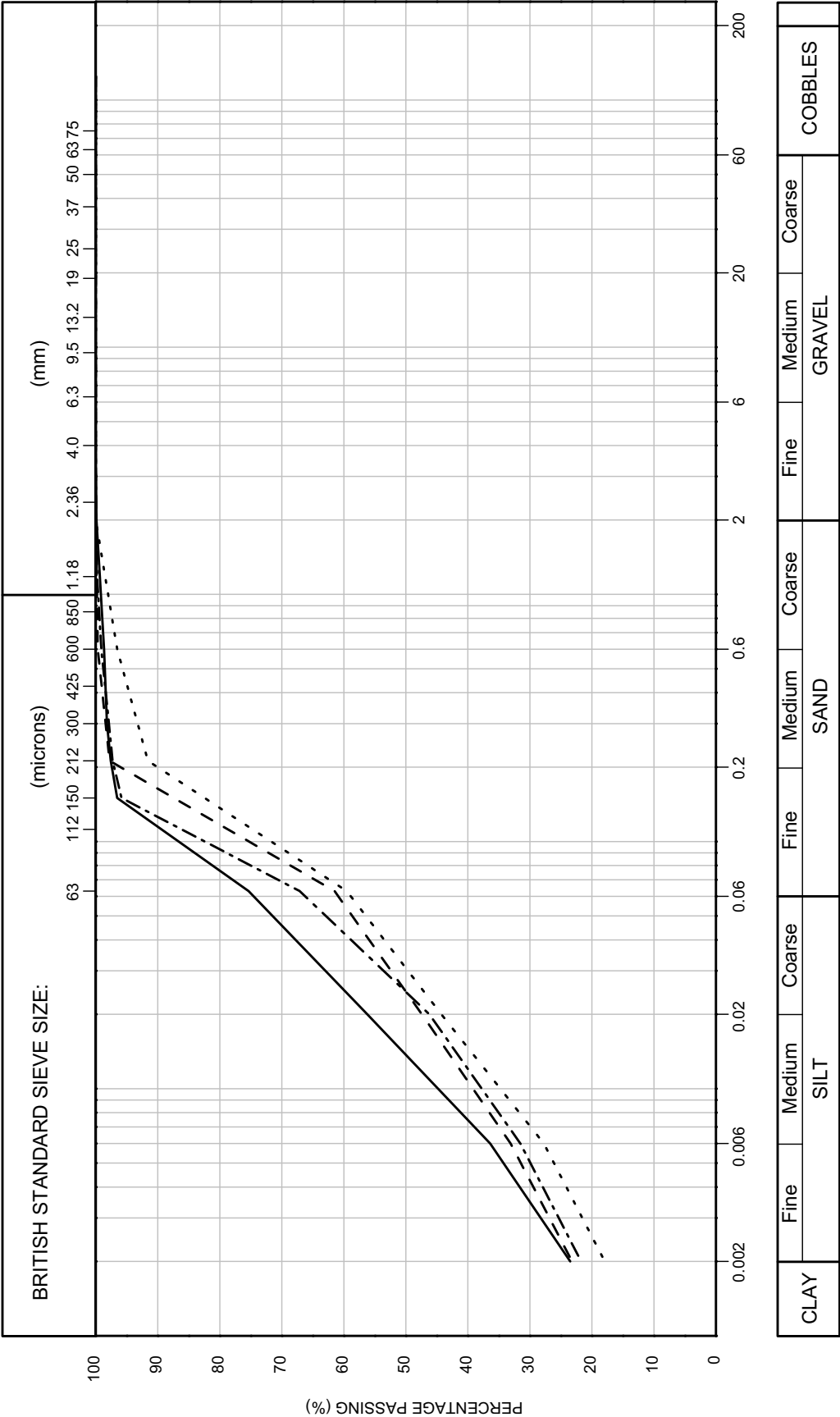
Filename: J11056 \ CLASS \ BH_17_7BagA_ps.OPJ

Date: 02/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
7BagA	BH_17	7BagA	16.00	9.2/9.4	N/A	24	50	26	-	-
8BagA	BH_17	8BagA	17.00	9.4	N/A	23	37	40	-	-
8BagB	BH_17	8BagB	17.05	9.4	N/A	18	40	42	-	-
9BagB	BH_17	9BagB	21.10	9.2/9.4	N/A	22	43	35	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

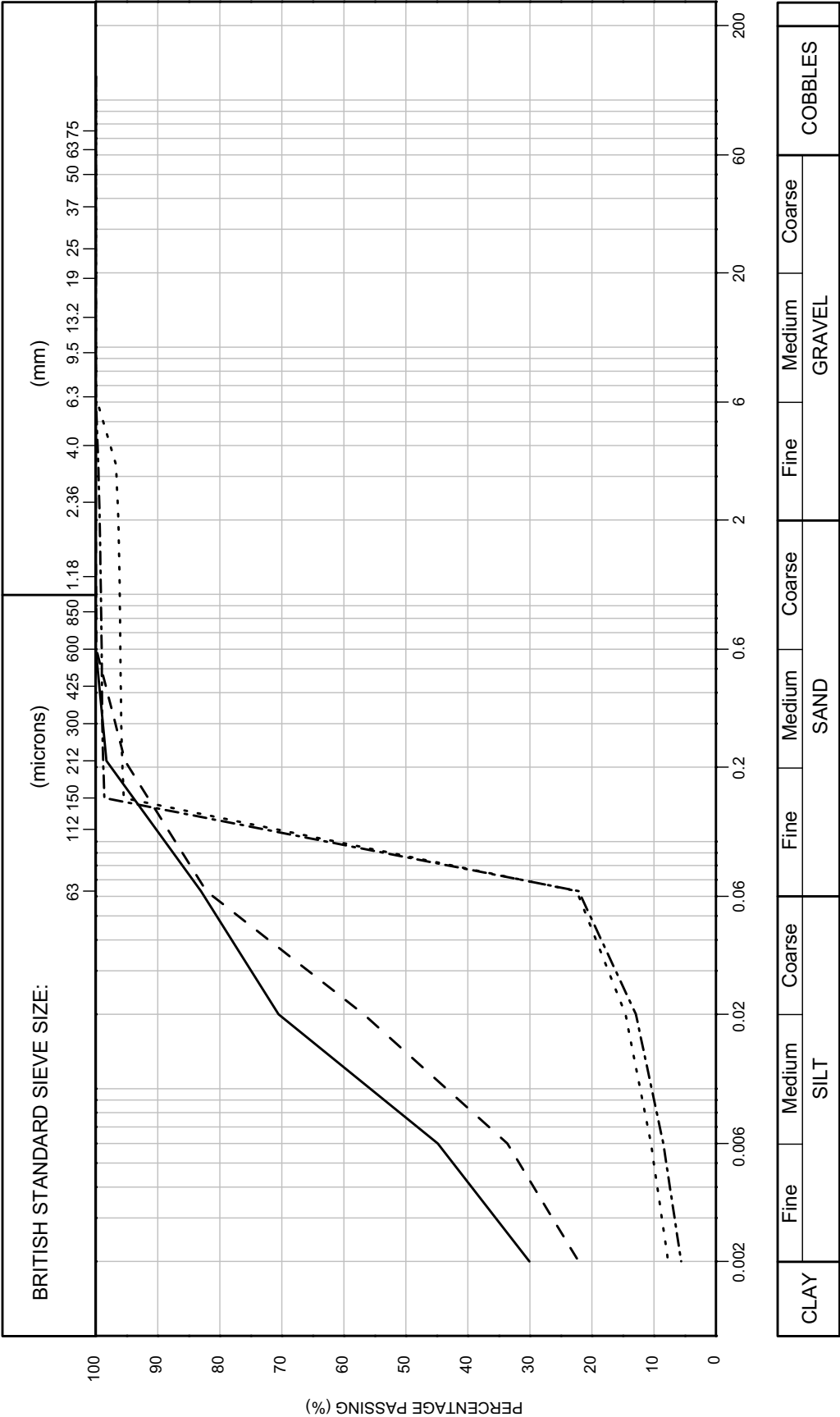
Filename: J11056 \ CLASS \ BH_17_10BagA_ps.OPJ

Date: 06/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
—	BH_17	10BagA	22.00	9.4	N/A	30	52	18	-	-
- -	BH_17	12BagA	27.28	9.4	N/A	22	58	20	-	-
- . - .	BH_17	15BagA	32.50	9.2/9.4	N/A	8	14	75	3	-
- - - -	BH_17	17BagA	35.00	9.2/9.4	N/A	6	15	79	-	-

* 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



Checked by: PH

Approved by:

Template Issue: 4.2

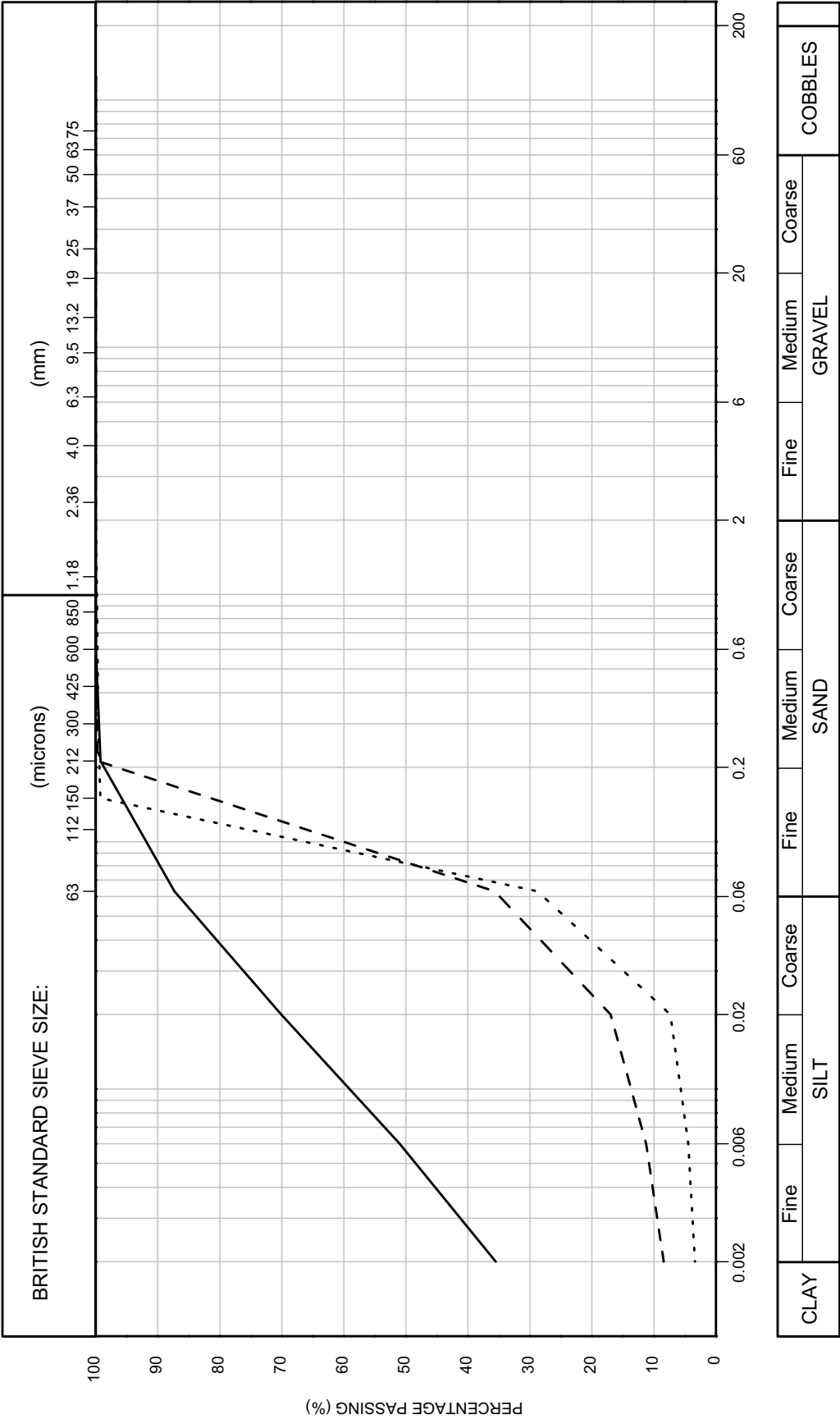
Filename: J11056 \ CLASS \ BH_17_18BagA_ps.OPJ

Date: 06/06/2011

Date:

Drawn by: ALB

Date: 01/06/2011



PARTICLE SIZE DISTRIBUTION TEST RESULTS

Curve	Borehole	Sample	Depth (m)	BS Test * Method	Pretreatment Method	Percentage soil types				
						Clay	Silt†	Sand	Gravel	Cobbles
18BagA	BH_17	18BagA	35.50	9.4	N/A	35	50	15	-	-
19BagA	BH_17	19BagA	38.50	9.4	N/A	8	25	67	-	-
21BagA	BH_17	21BagA	41.00	9.2/9.4	N/A	3	23	74	-	-

* 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

Date: 04/05/2011

Drawn by: ALB

Template Issue: 3

Filename: J11056 / Labdata / Class / BH_13_PD.XLS

Date:

Date:

Checked by:

Approved by:

Borehole	Sample	Depth (m)	Particle Density (Mg/m ³)
BH_13	4WaxA	7.85	2.67
BH_13	6WaxA	12.60	2.74
BH_13	9BagA	18.00	2.65
BH_13	24WaxA	40.05	2.71
BH_14	1BagB	2.15	2.70
BH_14	4WaxA	7.40	2.75
BH_14	6BagA	12.00	2.77
BH_14	10BagB	22.30	2.76
BH_14	11WaxA	25.50	2.73
BH_14	14BagA	31.00	2.68
BH_14	15WaxA	35.10	2.73
BH_14	23BagA	47.50	2.71
BH_02	1BagA	3.00	2.72
BH_02	2WaxB	7.50	2.73
BH_02	6BagB	16.65	2.70
BH_02	13BagA	26.50	2.69
BH_04	12WaxB	22.82	2.79
BH_04	15WaxB	27.75	2.75
BH_06	5BagUU	9.17	2.72
BH_06	9WaxA	18.00	2.80
BH_06	11WaxA	19.55	2.72
BH_06	29WaxA	42.00	2.72
BH_06	32BagA	45.00	2.71
BH_16	4BagA	15.00	2.66
BH_16	13BagA	26.50	2.74
BH_17	2BagA	3.00	2.73
BH_17	10WaxA	22.42	2.73

Tested in accordance with BS 1377: Part 2: 1990: Clause 8.3

(Small pycnometer method)

Average value of Particle Density (previously Specific Gravity) quoted

SUMMARY OF PARTICLE DENSITY TEST RESULTS

Borehole	Sample	Depth (m)	Optimum Moisture Content (%)	Maximum Dry Density (Mg/m ³)	Minimum Dry Density (Mg/m ³)
BH_13	9BagA	18.00	12	1.90	1.16
BH_13	11BagA	20.50	12	1.91	1.19
BH_13	21BagB	33.10	12	2.03	1.15
BH_14	2BagA	2.50	12	1.92	1.26
BH_14	20BagA	42.50	12	1.98	1.18
BH_14	23BagA	47.50	12	1.89	1.23
BH_04A	2BagB	1.10	10	2.06	1.05
BH_06	32BagA	45.00	9	2.19	1.28
BH_16	2BagB	7.35	10	1.92	1.42
BH_16	4BagA	15.00	9	1.92	1.49
BH_16	5BagA	18.50	10	1.89	1.50
BH_16	10 & 11BagA	23.50	11	1.82	1.19
BH_16	19BagA	38.50	12	2.07	1.13
BH_16	22BagA	44.00	12	2.10	1.12

Minimum density determination - tested in accordance with Fugro testing procedure L-T-029.
 Multi-point maximum density determination by compaction - tested in accordance with
 BS 1377: Part 4: 1990: Clause 3.7, supplemented by Fugro testing procedure L-T-028.
 (Fugro testing procedures are available on request)

SUMMARY OF MINIMUM AND MAXIMUM DENSITY TEST RESULTS

E.ON CLIMATE AND RENEWABLES
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION



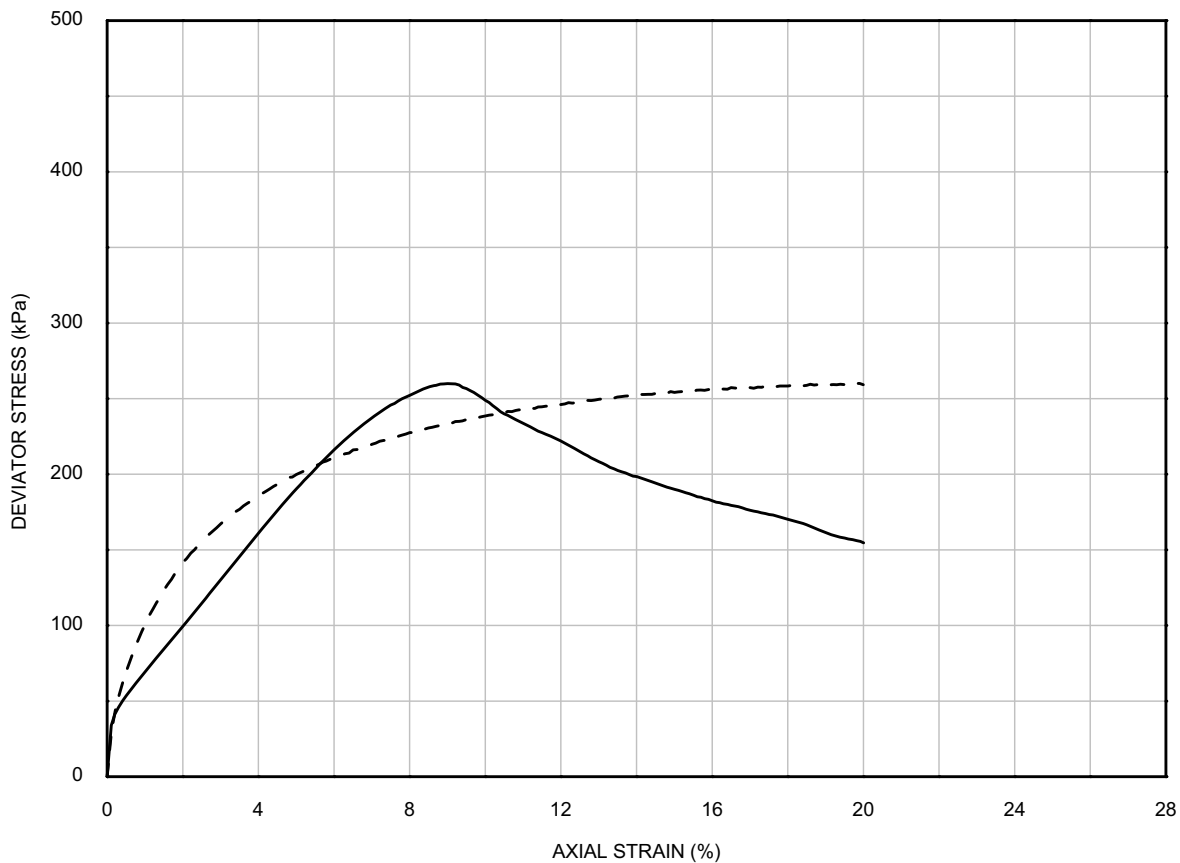
BH No	SAMPLE No	DEPTH (m)	TEST TYPE	INDEX PROPERTIES				CELL PRESSURE (kPa)	SHEARING		
				ρ_{bulk}	w_l	w_l	I_p		s_u	STRAIN AT FAILURE	EPSILON 50
				(Mg/m ³)	(%)	(%)	(%)		(kPa)	(%)	(%)
BH_13	5UU	8.60	UU	2.03	21	67	49	390	130	9.0	2.99
BH_13	5UU	8.60	UUr	2.05	22	67	49	390	130	19.8	-
BH_13	6UU	12.80	UU	2.07	26	59	38	474	304	13.3	5.18
BH_13	6UU	12.80	UUr	2.06	24	59	38	474	184	18.5	-
BH_13	7UU	13.85	UU	2.14	26	66	41	495	306	9.3	3.65
BH_13	7UU	13.85	UUr	2.13	25	66	41	495	236	16.7	-
BH_13	23UU	39.45	UU	2.17	19	40	24	1017	573	12.6	4.11
BH_13	23UU	39.45	UUr	2.16	17	40	24	1017	309	19.5	-
BH_13	24UU	40.25	UU	2.14	19	49	34	1023	666	10.2	3.60
BH_13	24UU	40.25	UUr	2.14	22	49	34	1023	364	13.0	-
BH_14	3UU	6.10	UU	1.85	43	80	49	322	161	6.6	1.27
BH_14	3UU	6.10	UUr	1.84	42	80	49	322	204	7.2	-
BH_14	4UU	7.10	UU	1.90	35	80	49	362	179	14.3	2.69
BH_14	4UU	7.10	UUr	1.89	36	80	49	362	202	8.8	-
BH_14	8UU	17.30	UU	1.87	27	75	51	546	354	4.7	1.20
BH_14	8UU	17.30	UUr	1.89	29	75	51	546	272	7.9	-
BH_14	12UU	26.48	UU	1.97	22	75	54	729	434	4.1	1.18
BH_14	12UU	26.48	UUr	1.96	31	75	54	729	435	10.6	-
BH_14	14UU	31.67	UU	2.00	21	43	24	832	495	6.9	2.05
BH_14	14UU	31.67	UUr	1.99	22	43	24	832	277	17.5	-
BH_14	15UU	35.40	UU	1.98	-	66	39	904	555	6.2	2.48
BH_14	15UU	35.40	UUr	1.98	26	66	39	904	395	9.7	-
BH_14*	16UU	36.00	UU	1.99	36	79	57	920	200	20.0	1.70
BH_14	16UU	36.00	UUr	1.97	30	79	57	920	190	8.6	-
BH_02	3WaxB	8.30	UU	2.03	25	64	39	493	286	9.5	1.88
BH_02	3WaxB	8.30	UUr	2.01	24	64	39	493	232	11.4	-
BH_04	14UU	27.19	UU	2.09	19	56	34	1083	669	6.8	2.18
BH_04	21UU	38.95	UU	2.10	19	49	33	1029	754	13.1	4.59
BH_04	22WaxA	43.10	UU	2.05	20	51	31	1110	568	12.9	3.04
BH_04	24UU	47.19	UU	2.09	20	51	29	1194	903	11.2	3.39
BH_04A	2UU	1.04	UU	1.93	31	76	47	278	145	12.0	3.97
BH_04A	3UU	2.24	UU	1.98	30	76	50	1194	170	12.8	2.49
BH_06	1UU	3.32	UU	1.98	29	67	41	341	92	10.9	1.00
BH_06	2UU	4.00	UU	1.97	29	71	47	355	44	7.8	1.01
BH_06	4UU	8.30	UU	2.03	28	86	59	441	169	4.9	0.17
BH_06	5UU	9.17	UU	1.98	29	86	59	458	111	4.1	0.27
BH_06	7UU	13.70	UU	2.03	26	77	48	529	264	6.0	1.02
BH_06	8UU	14.70	UU	2.04	26	74	52	569	238	4.5	0.64
BH_06	9UU	18.25	UU	2.14	20	43	24	640	349	6.8	0.42
BH_06	25UU	35.16	UU	2.21	-	55	37	978	282	6.0	0.66
BH_06	27UU	37.63	UU	2.17	16	47	31	1028	326	13.1	0.99
BH_16	14UU	30.65	UU	2.10	20	52	31	1083	980	7.5	3.23
BH_16	15UU	31.25	UU	2.11	22	54	32	1083	708	9.2	3.10
BH_17	12UU	27.15	UU	1.99	29	66	37	853	472	8.0	3.31
Bold indicates UU test performed offshore											
Failure is taken at 20% axial strain when testing continued beyond 20% and did not reach failure are marked with an *.											
Tests which did not reach failure or 20% axial strain are marked with **.											

SUMMARY OF UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS



BH No	SAMPLE No	DEPTH (m)	TEST TYPE	INDEX PROPERTIES				CELL PRESSURE (kPa)	SHEARING		
				ρ_{bulk} (Mg/m ³)	w_l (%)	w_l (%)	I_p (%)		s_u (kPa)	STRAIN AT FAILURE (%)	EPSILON 50 (%)
BH_17	18UU	35.50	UU	2.05	29	77	55	980	264	7.8	1.03
Bold indicates UU test performed offshore Failure is taken at 20% axial strain when testing continued beyond 20% and did not reach failure are marked with an *. Tests which did not reach failure or 20% axial strain are marked with **.											

SUMMARY OF UNCONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	390	390
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	260	260
Strain at failure	(%)	9.0	19.8
Undrained shear strength	(kPa)	130	130

Undisturbed

Shear failure

Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	148.0	100.7
Sample diameter	(mm)	72.0	49.0
Membrane thickness	(mm)	0.30	0.28
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	2.03	2.05
Dry density	(Mg/m ³)	1.67	1.68
Moisture content	(%)	21	22

Barrel failure

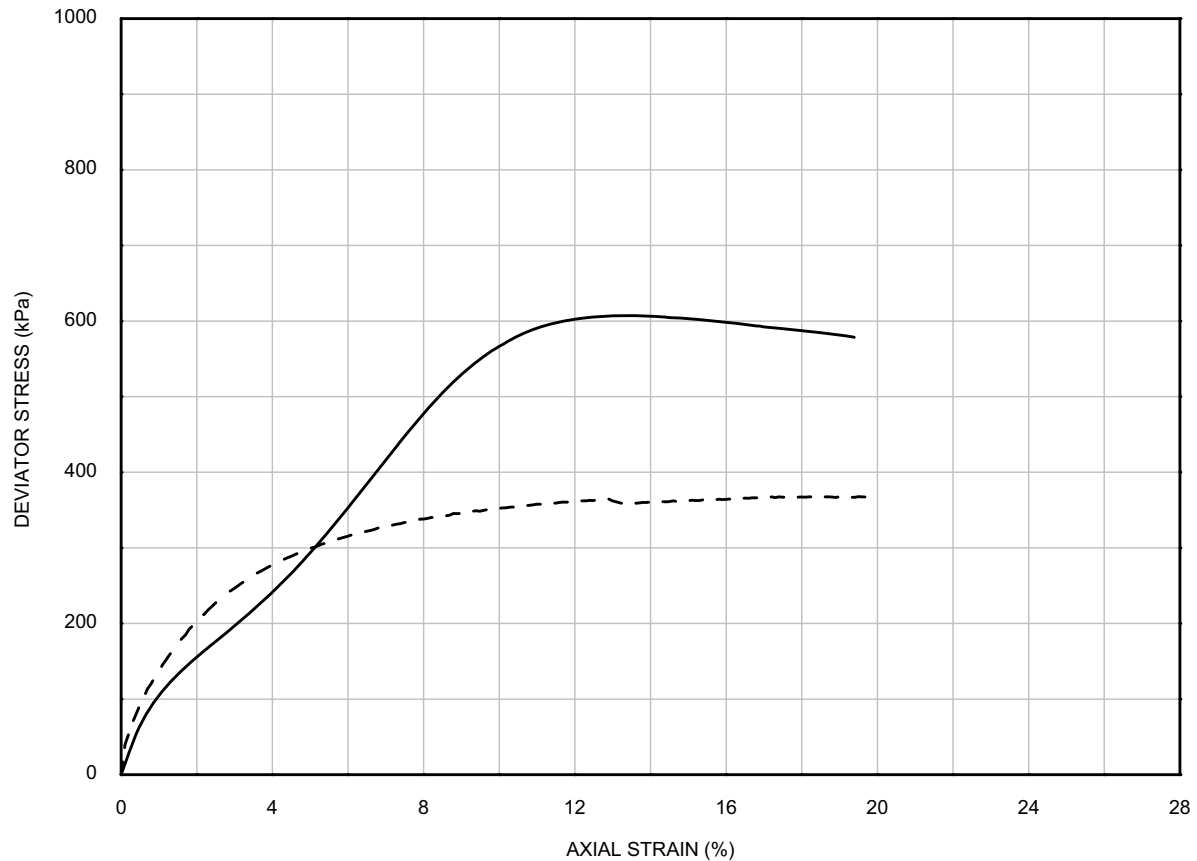
Borehole : BH_13

Sample : 5UU

Depth (m) : 8.60

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	474	474
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	608	368
Strain at failure	(%)	13.3	18.5
Undrained shear strength	(kPa)	304	184

Undisturbed

Shear failure

Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	148.0	102.7
Sample diameter	(mm)	71.0	49.1
Membrane thickness	(mm)	0.30	0.27
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	2.07	2.06
Dry density	(Mg/m ³)	1.64	1.66
Moisture content	(%)	26	24

Barrel failure

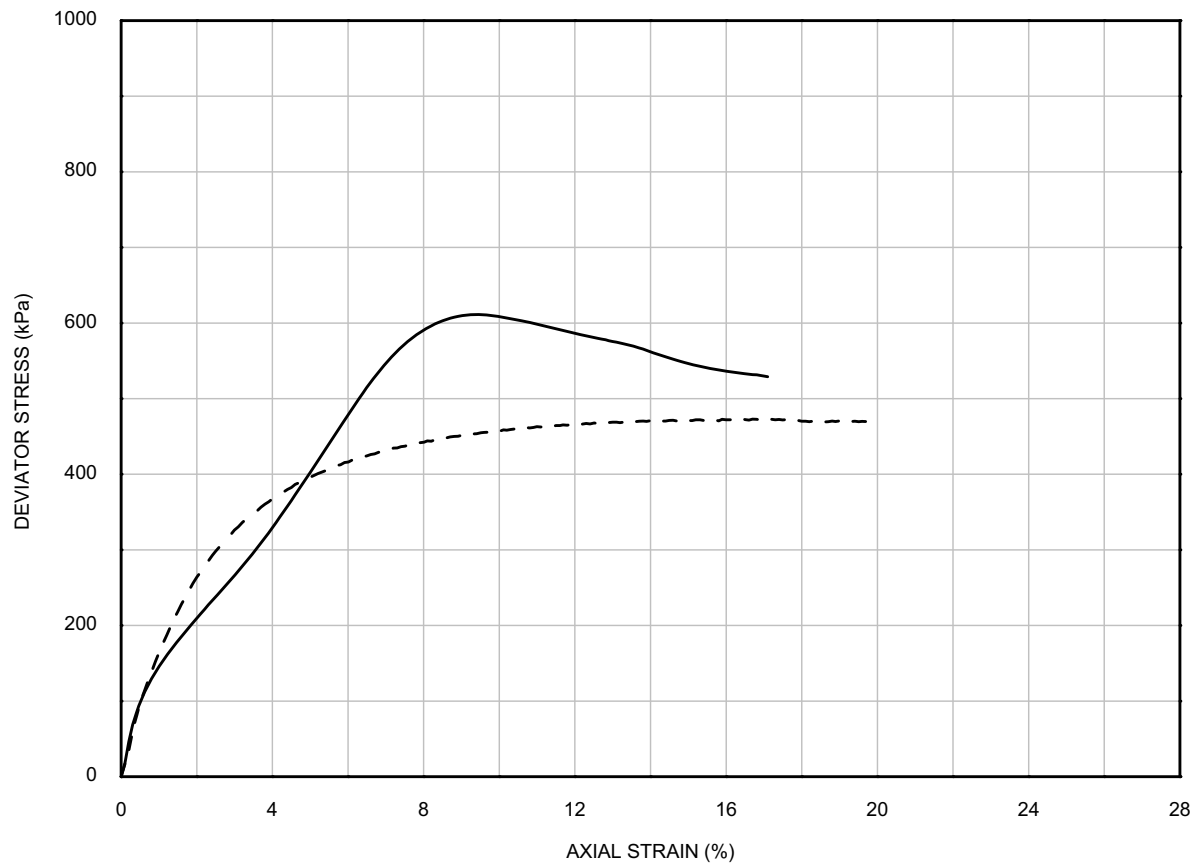
Borehole : BH_13

Sample : 6UU

Depth (m) : 12.80

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	495	495
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	611	473
Strain at failure	(%)	9.3	16.7
Undrained shear strength	(kPa)	306	236

Undisturbed

Shear failure

Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	139.0	99.7
Sample diameter	(mm)	72.0	49.0
Membrane thickness	(mm)	0.30	0.26
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	2.14	2.13
Dry density	(Mg/m ³)	1.70	1.70
Moisture content	(%)	26	25

Barrel failure

Borehole : BH_13

Sample : 7UU

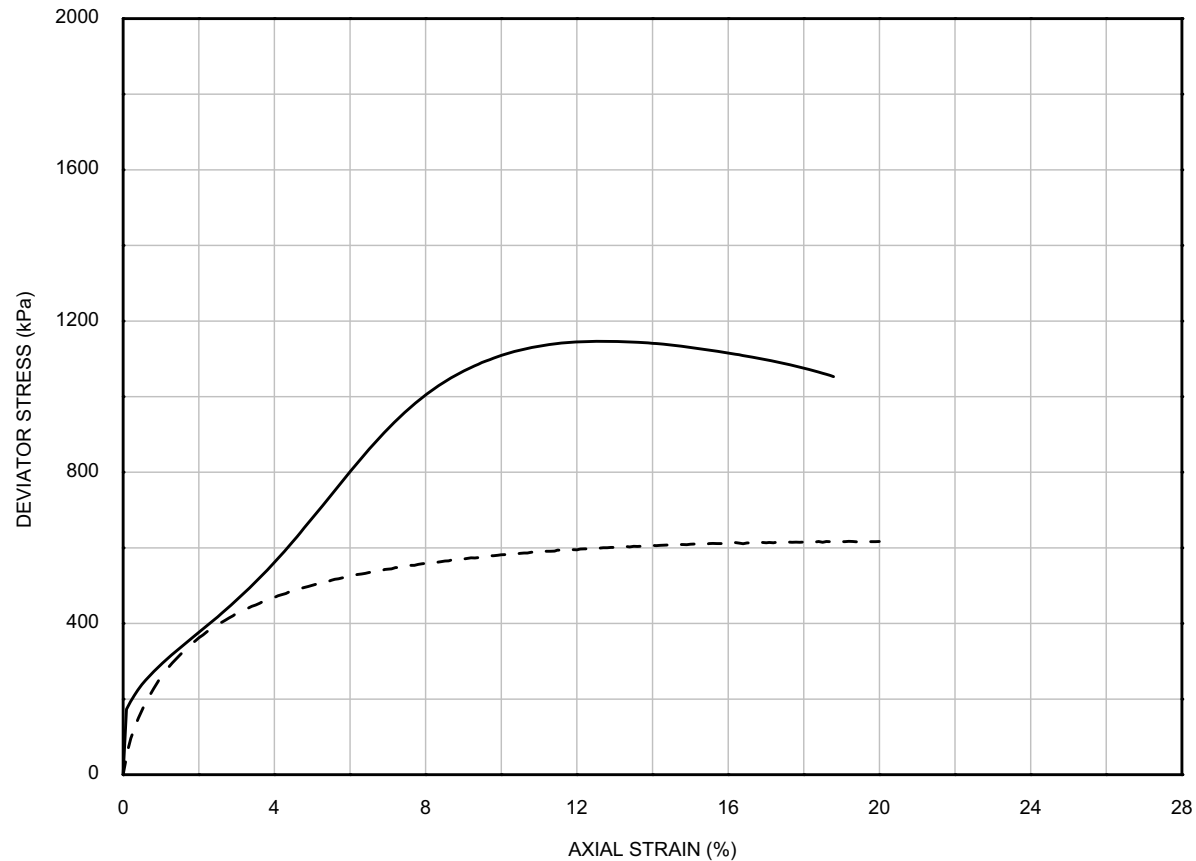
Depth (m) : 13.85

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS



Template Issue: 3.4
Date: 03/06/2011
Checked by: PH
Approved by:
Filename: J11056 \ Labdata \ Triaxial \ BH_13_23UU_ur.OPJ
Date: 03/06/2011
Drawn by: ALB



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1017	1017
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	1146	617
Strain at failure	(%)	12.6	19.5
Undrained shear strength	(kPa)	573	309

Undisturbed
Shear failure
Remoulded

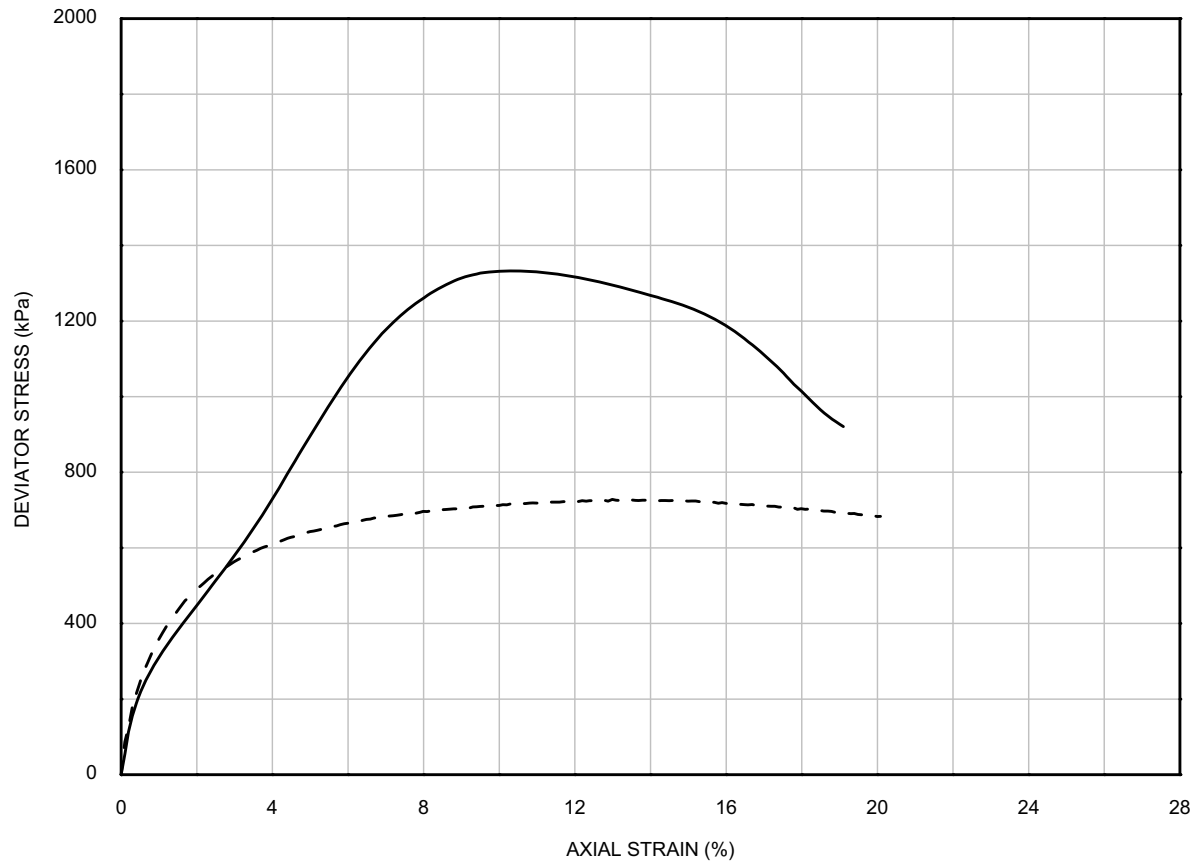
Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	148.0	102.7
Sample diameter	(mm)	72.0	49.1
Membrane thickness	(mm)	0.30	0.28
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	2.17	2.16
Dry density	(Mg/m ³)	1.82	1.84
Moisture content	(%)	19	17

Barrel failure

Borehole	: BH_13
Sample	: 23UU
Depth (m)	: 39.45

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST
UNDISTURBED AND REMOULDED SPECIMENS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	1023	1023
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	1333	728
Strain at failure	(%)	10.2	13.0
Undrained shear strength	(kPa)	666	364

Undisturbed

Shear failure

Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	149.0	101.9
Sample diameter	(mm)	72.0	49.0
Membrane thickness	(mm)	0.30	0.28
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	2.14	2.14
Dry density	(Mg/m ³)	1.80	1.76
Moisture content	(%)	19	22

Barrel failure

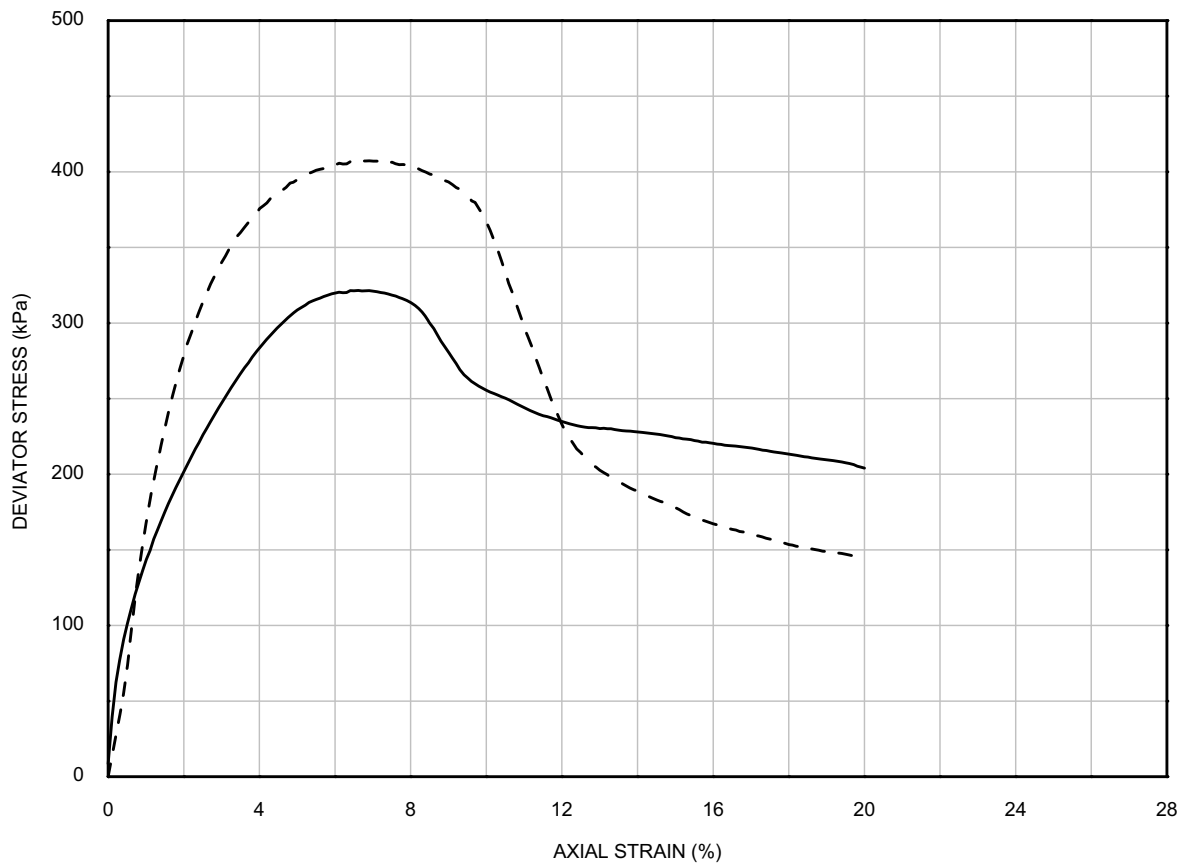
Borehole : BH_13

Sample : 24UU

Depth (m) : 40.25

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	322	322
Membrane correction	(kPa)	1	1
Corrected deviator stress	(kPa)	322	407
Strain at failure	(%)	6.6	7.2
Undrained shear strength	(kPa)	161	204

Undisturbed

Shear failure

Remoulded

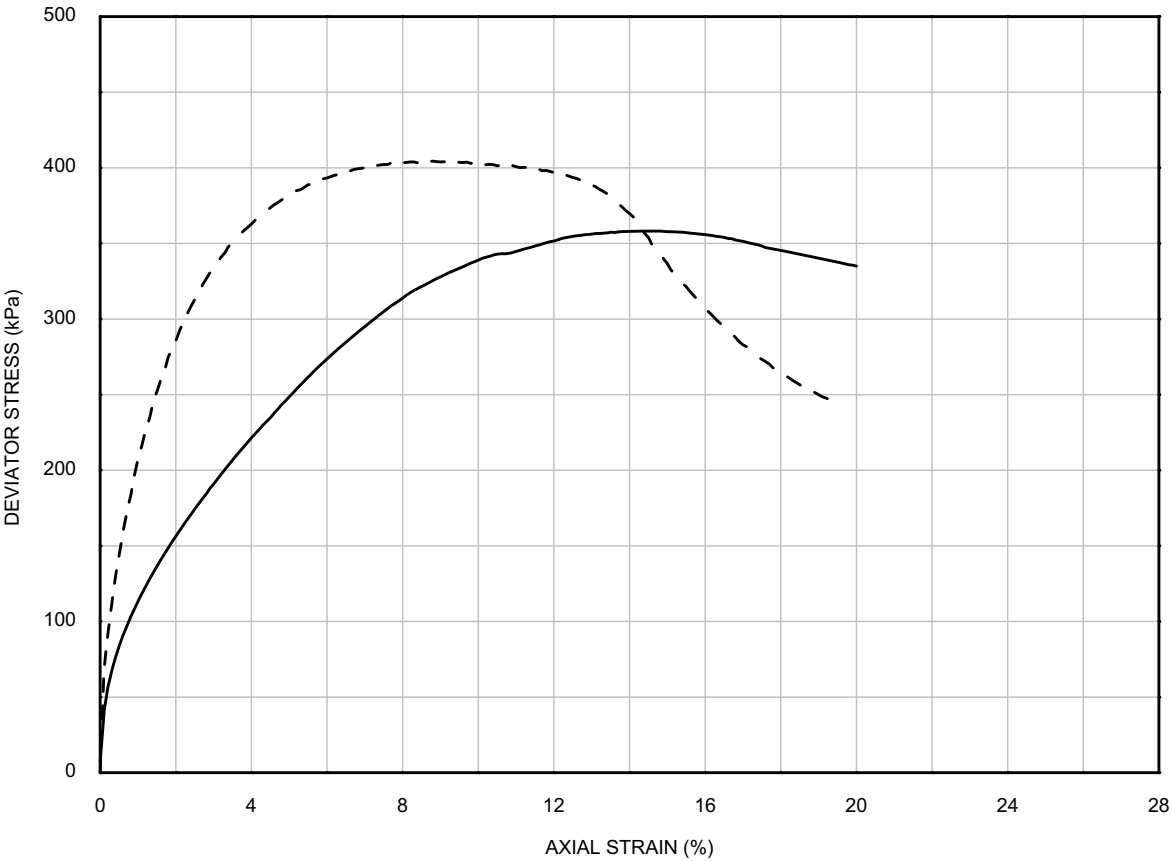
Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	101.7
Sample diameter	(mm)	72.5	49.0
Membrane thickness	(mm)	0.30	0.30
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	1.85	1.84
Dry density	(Mg/m ³)	1.29	1.30
Moisture content	(%)	43	42

Shear failure

Borehole : BH_14
Sample : 3BagUU
Depth (m) : 6.10

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	362	362
Membrane correction	(kPa)	1	1
Corrected deviator stress	(kPa)	358	404
Strain at failure	(%)	14.3	8.8
Undrained shear strength	(kPa)	179	202

Undisturbed
Shear failure
Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	102.4
Sample diameter	(mm)	72.5	49.0
Membrane thickness	(mm)	0.30	0.25
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	1.90	1.89
Dry density	(Mg/m ³)	1.41	1.39
Moisture content	(%)	35	36

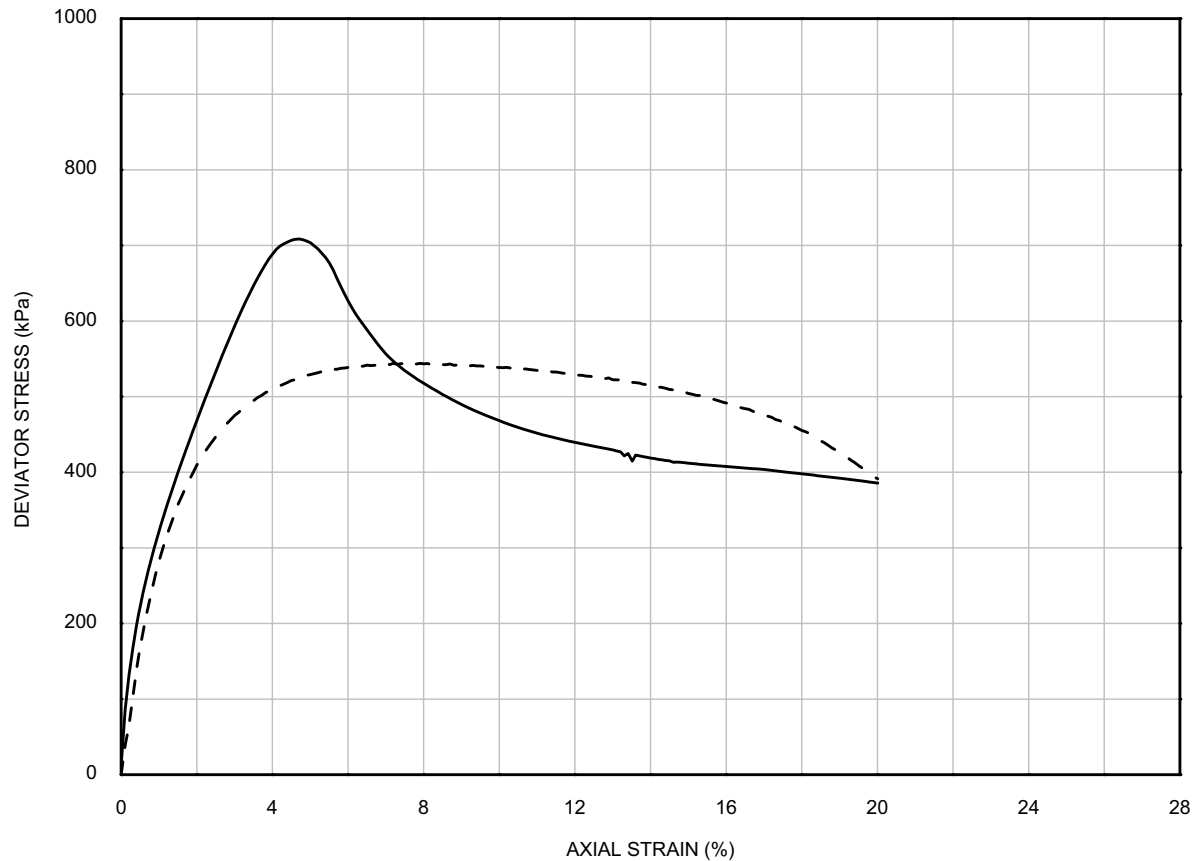
Shear failure

Borehole	: BH_14
Sample	: 4BagUU
Depth (m)	: 7.10

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST
UNDISTURBED AND REMOULDED SPECIMENS

Drawn by: ALB
Date: 03/06/2011
Template Issue: 3.4
Filename: J11056 \ Labdata \ Triaxial \ BH_14_4BagUU_ur.OPJ
Date : 03/06/2011
Date :
Checked by: PH
Approved by:



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	546	546
Membrane correction	(kPa)	0	1
Corrected deviator stress	(kPa)	708	544
Strain at failure	(%)	4.7	7.9
Undrained shear strength	(kPa)	354	272

Undisturbed

Shear failure

Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	100.6
Sample diameter	(mm)	72.5	49.2
Membrane thickness	(mm)	0.30	0.35
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	1.87	1.89
Dry density	(Mg/m ³)	1.47	1.46
Moisture content	(%)	27	29

Shear failure

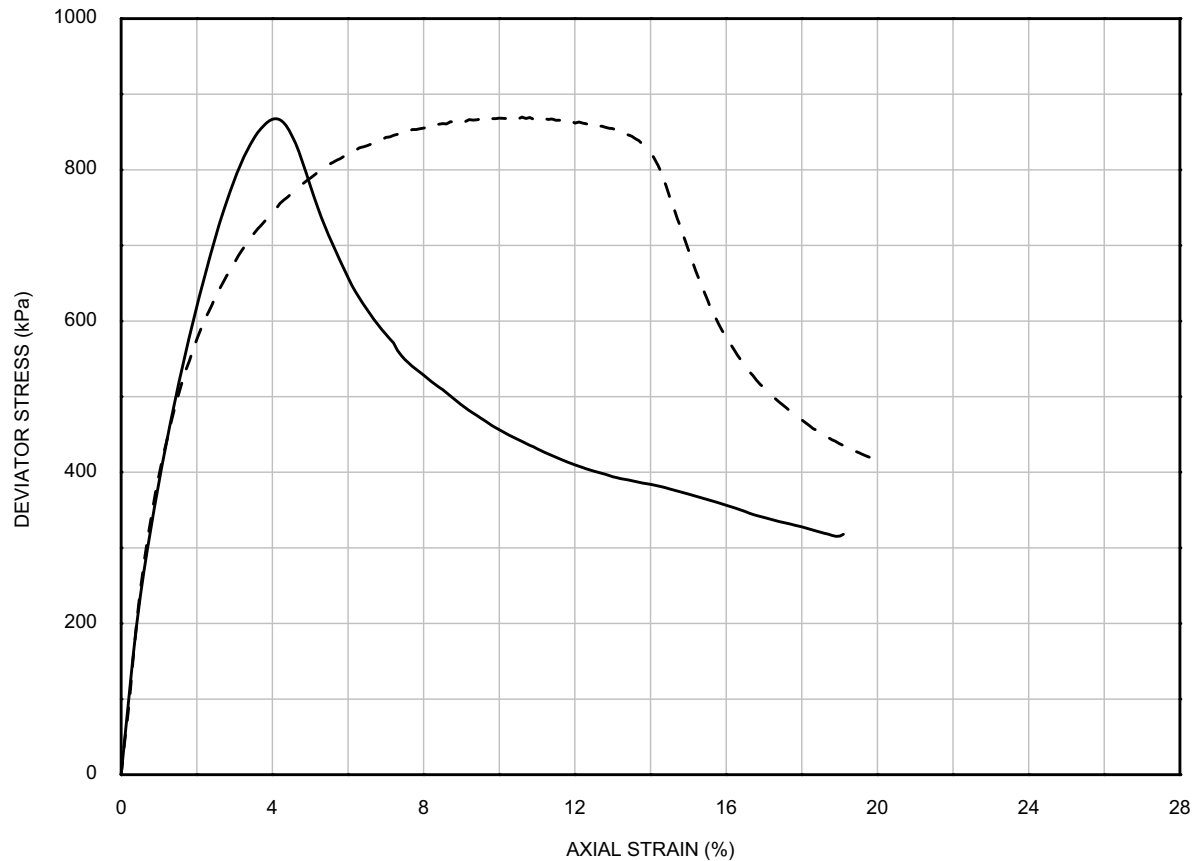
Borehole : BH_14

Sample : 8BagUU

Depth (m) : 17.30

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	729	729
Membrane correction	(kPa)	0	2
Corrected deviator stress	(kPa)	868	870
Strain at failure	(%)	4.1	10.6
Undrained shear strength	(kPa)	434	435

Undisturbed
Shear failure
Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	101.7
Sample diameter	(mm)	72.5	49.1
Membrane thickness	(mm)	0.30	0.35
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	1.97	1.96
Dry density	(Mg/m ³)	1.62	1.50
Moisture content	(%)	22	31

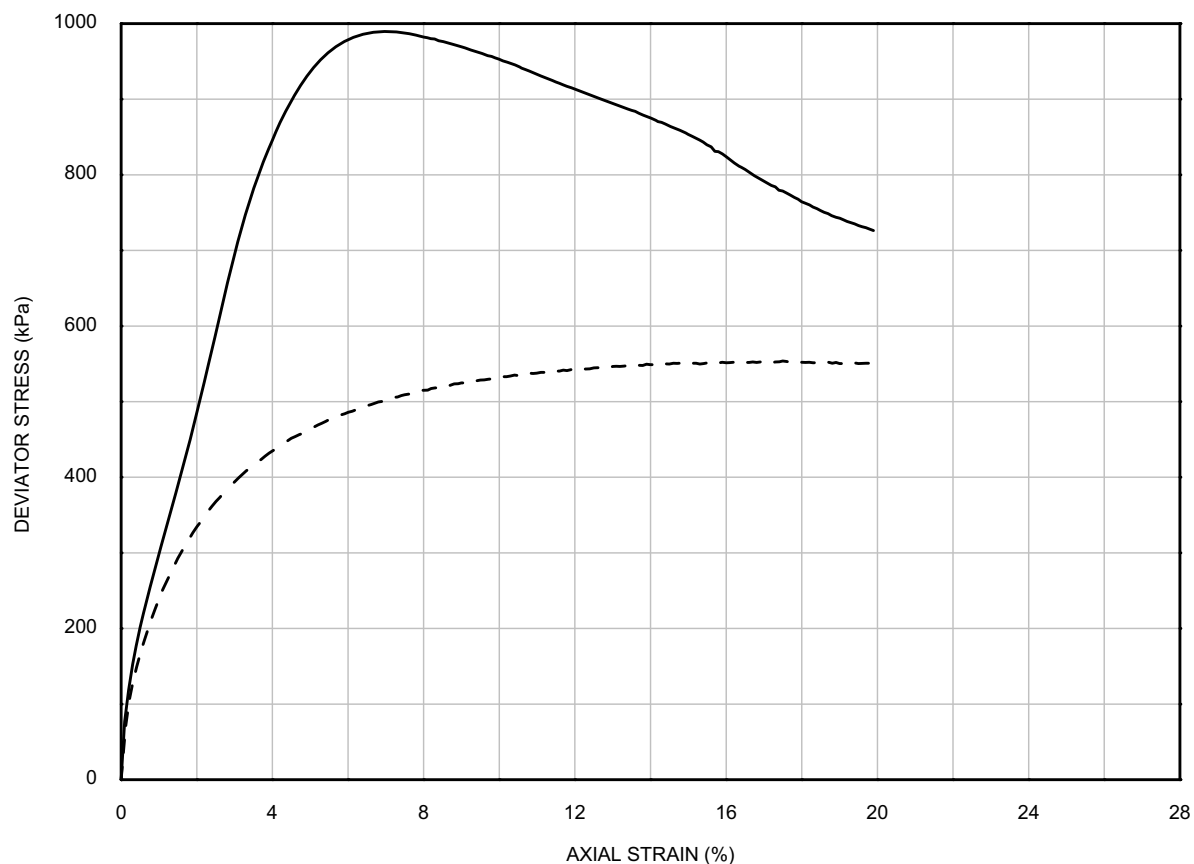
Shear failure

Borehole	: BH_14
Sample	: 12BagUU
Depth (m)	: 26.48

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST
UNDISTURBED AND REMOULDED SPECIMENS

Drawn by: ALB
Date: 03/06/2011
Template Issue: 3.4
Filename: J11056 \ Labdata \ Triaxial \ BH_14_12BagUU_ur.OPJ
Date : 03/06/2011
Date :
Checked by: PH
Approved by:



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	832	832
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	990	554
Strain at failure	(%)	6.9	17.5
Undrained shear strength	(kPa)	495	277

Undisturbed

Shear failure

Remoulded

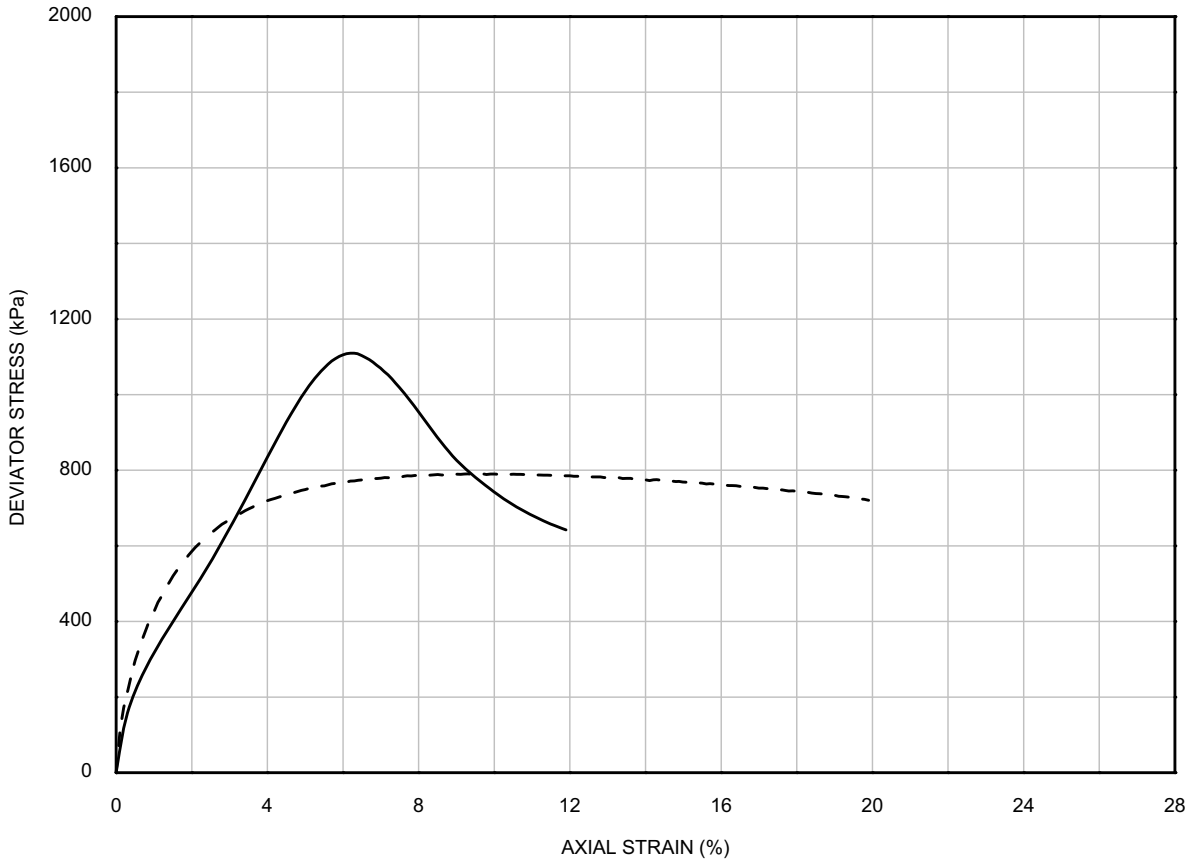
Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	99.9
Sample diameter	(mm)	72.5	48.9
Membrane thickness	(mm)	0.30	0.30
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	2.00	1.99
Dry density	(Mg/m ³)	1.65	1.63
Moisture content	(%)	21	22

Barrel failure

Borehole : BH_14
Sample : 14BagUU
Depth (m) : 31.67

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST UNDISTURBED AND REMOULDED SPECIMENS



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	904	904
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	1110	791
Strain at failure	(%)	6.2	9.7
Undrained shear strength	(kPa)	555	395

Undisturbed
Shear failure
Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	99.9
Sample diameter	(mm)	72.5	49.0
Membrane thickness	(mm)	0.30	0.36
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	1.98	1.98
Dry density	(Mg/m ³)	1.23	1.58
Moisture content	(%)	--	26

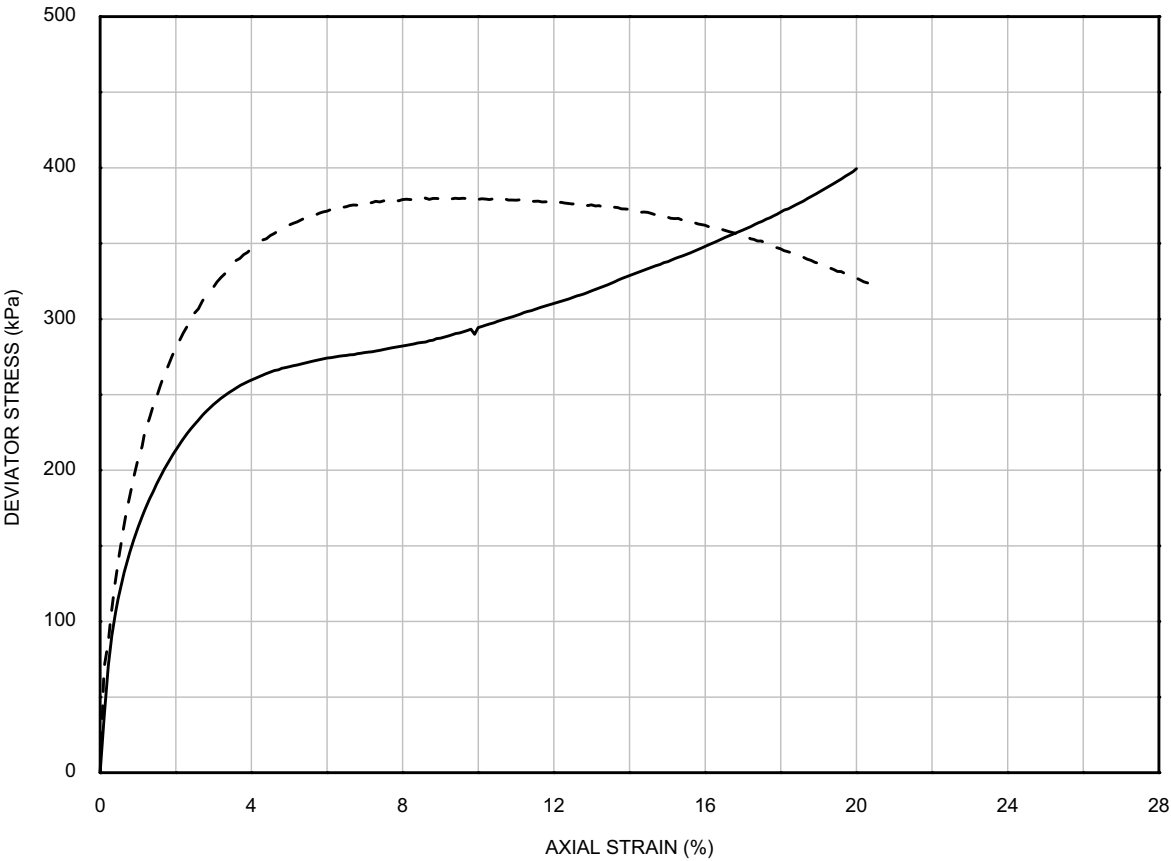
Barrel failure

Borehole	: BH_14
Sample	: 15BagUU
Depth (m)	: 35.40

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST
UNDISTURBED AND REMOULDED SPECIMENS

Template Issue: 3.4
Filename: J11056 \ Labdata \ Triaxial \ BH_14_15BagUU_ur.OPJ
Date: 06/06/2011
Date: 06/06/2011
Checked by: PH
Approved by: ALB
Drawn by: ALB
Date: 06/06/2011



— Undisturbed : Sample tested Offshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	920	920
Membrane correction	(kPa)	2	1
Corrected deviator stress	(kPa)	399	380
Strain at failure	(%)	20.0	8.6
Undrained shear strength	(kPa)	200	190

Undisturbed
Barrel failure
Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	146.3	101.7
Sample diameter	(mm)	72.5	49.1
Membrane thickness	(mm)	0.30	0.28
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	1.99	1.97
Dry density	(Mg/m ³)	1.46	1.52
Moisture content	(%)	36	30

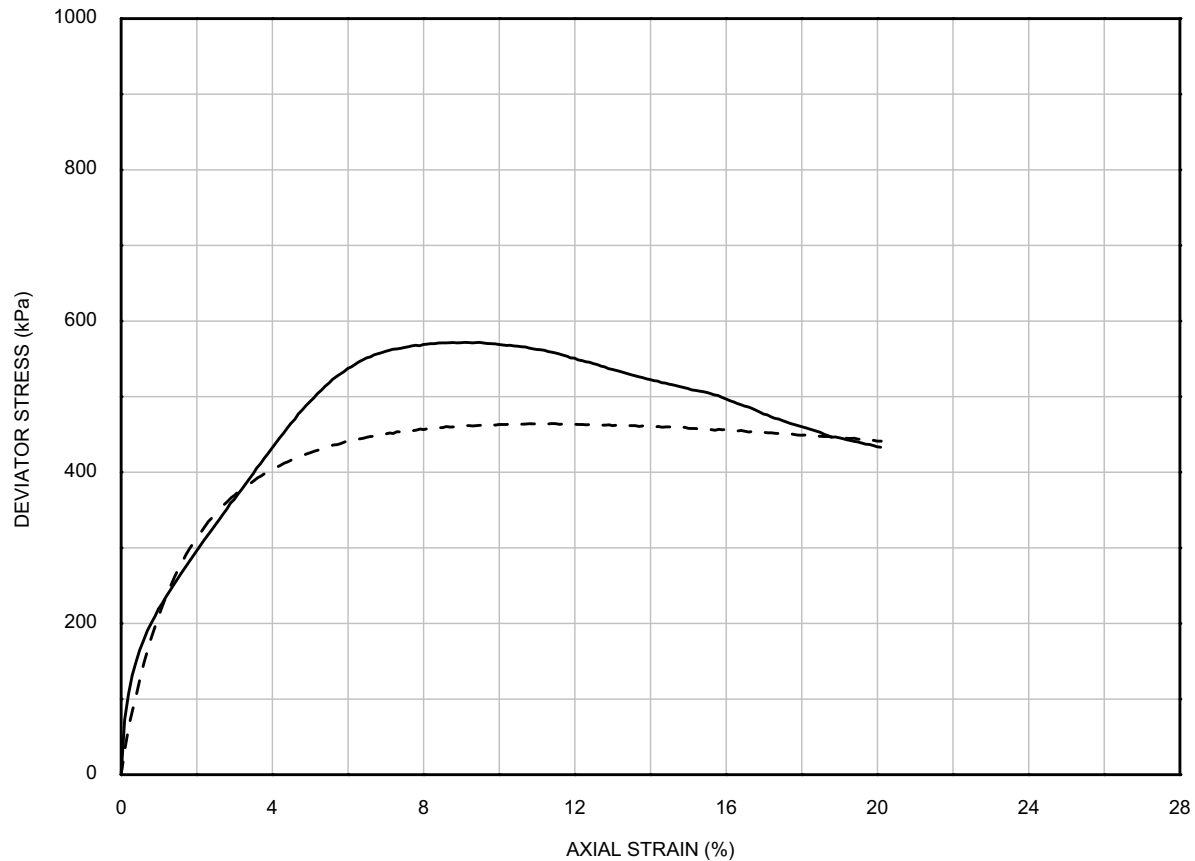
Shear failure

Borehole	: BH_14
Sample	: 16BagUU
Depth (m)	: 36.00

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST
UNDISTURBED AND REMOULDED SPECIMENS

Template Issue: 3.4
Filename: J11056 \ Labdata \ Triaxial \ BH_14_16BagUU_ur.OPJ
Date: 06/06/2011
Date: 06/06/2011
Checked by: PH
Approved by: ALB
Drawn by: ALB



— Undisturbed : Sample tested Onshore
- - - Remoulded : Sample tested Onshore

Failure Shapes:

Failure Conditions		Undisturbed	Remoulded
Cell pressure	(kPa)	493	493
Membrane correction	(kPa)	1	2
Corrected deviator stress	(kPa)	572	464
Strain at failure	(%)	9.5	11.4
Undrained shear strength	(kPa)	286	232

Undisturbed
Shear failure
Remoulded

Initial Conditions		Undisturbed	Remoulded
Sample length	(mm)	139.7	100.4
Sample diameter	(mm)	72.2	49.1
Membrane thickness	(mm)	0.25	0.30
Rate of strain	(%/min)	2.0	2.0
Bulk density	(Mg/m ³)	2.03	2.01
Dry density	(Mg/m ³)	1.63	1.63
Moisture content	(%)	25	24

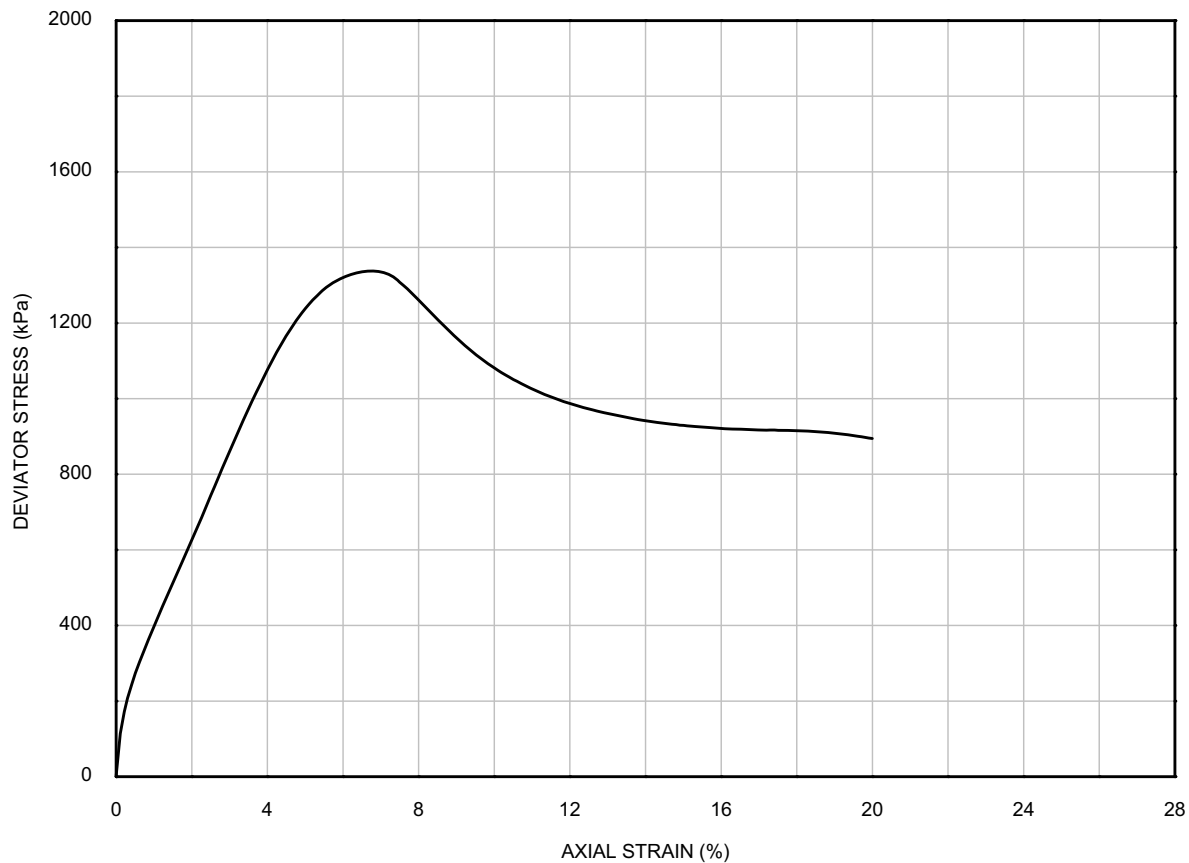
Barrel failure

Borehole	: BH_02
Sample	: 3WaxB
Depth (m)	: 8.30

Tested in accordance with BS 1377: Part 7: 1990: Clause 8 (Offshore tests not UKAS accredited)

UNCONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST
UNDISTURBED AND REMOULDED SPECIMENS

Template Issue: 3.4
Filename: J11056 \ Labdata \ Triaxial \ BH-02_UU2_ur.OPJ
Date: 03/06/2011
Date: 03/06/2011
Checked by: PH
Approved by: ALB
Drawn by: ALB
Date: 03/06/2011



— Undisturbed Sample tested Offshore

Failure shape

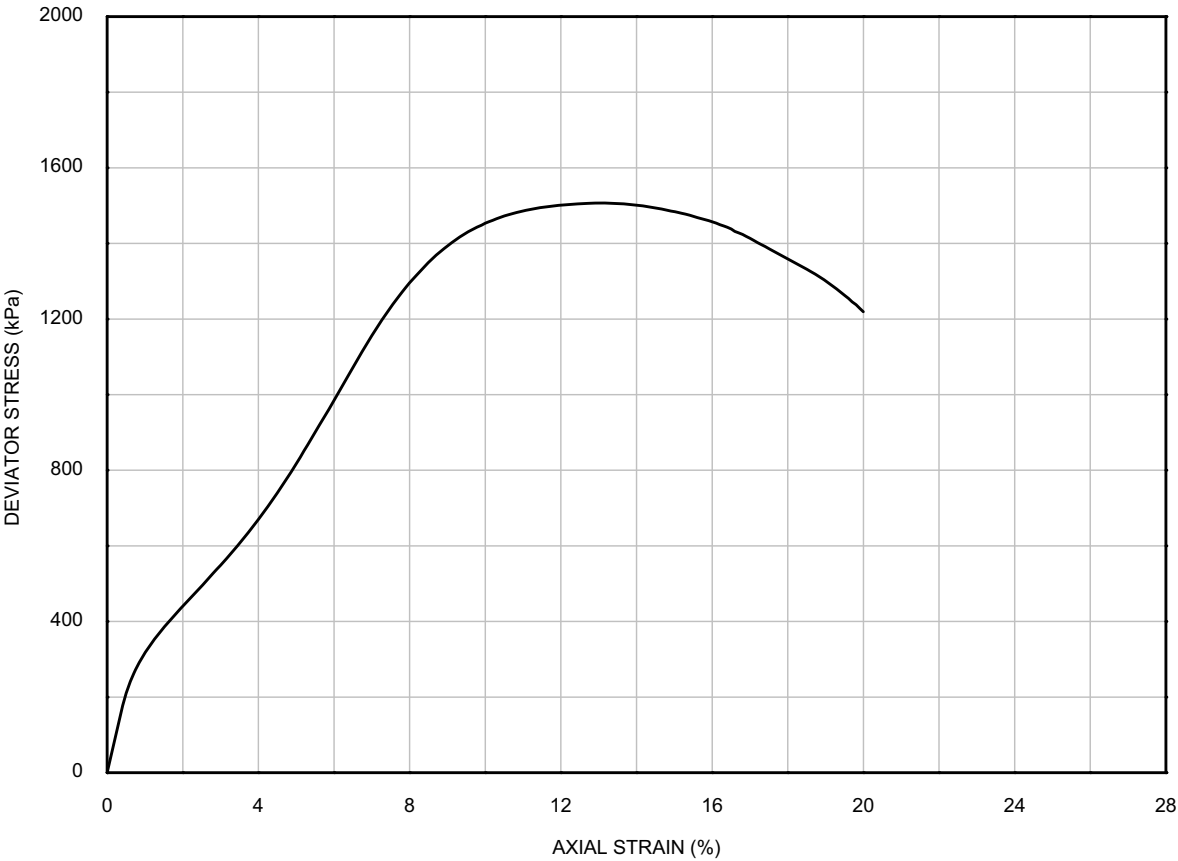
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 1083
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 1337
Strain at failure	(%)	: 6.8
Undrained shear strength	(kPa)	: 669

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 2.09 Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.76 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 19 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_04
			Sample	: 14UU
			Depth (m)	: 27.19

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

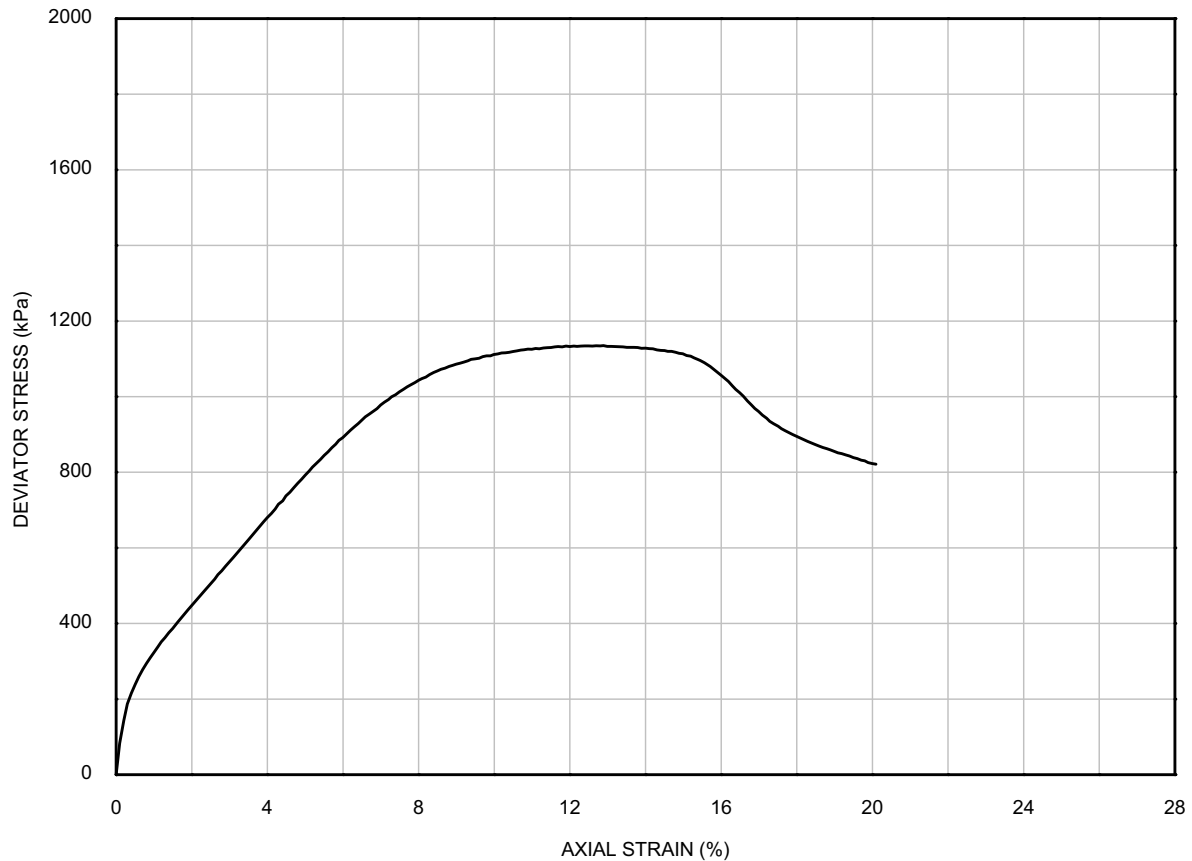
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 1029
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 1507
Strain at failure	(%)	: 13.1
Undrained shear strength	(kPa)	: 754

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 2.10 Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.77 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 19 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_04
			Sample	: 21UU
			Depth (m)	: 38.95

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Onshore

Failure shape

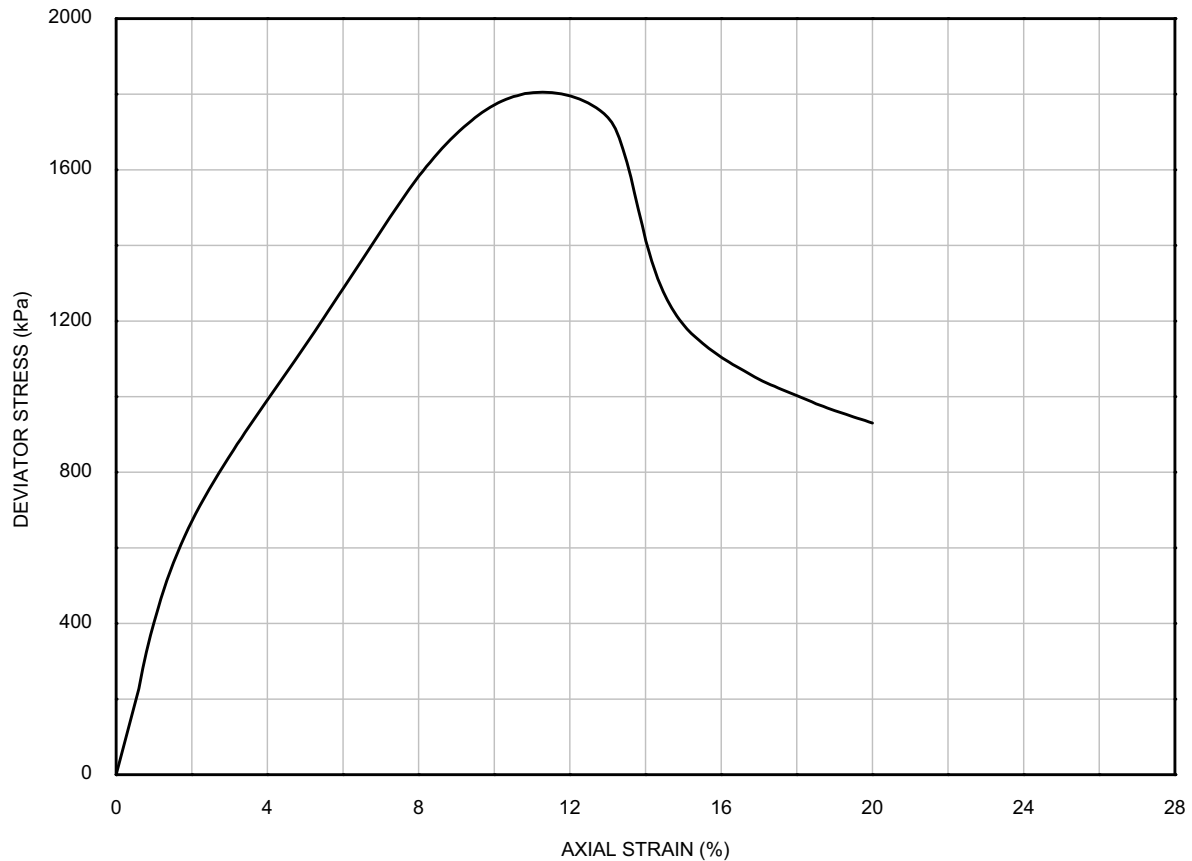
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 1110
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 1135
Strain at failure	(%)	: 12.9
Undrained shear strength	(kPa)	: 568

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 139.2	mm	Bulk density	: 2.05 Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.70 Mg/m ³
Membrane thickness	: 0.18	mm	Moisture content	: 20 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_04
			Sample	: 22WaxA
			Depth (m)	: 43.10

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

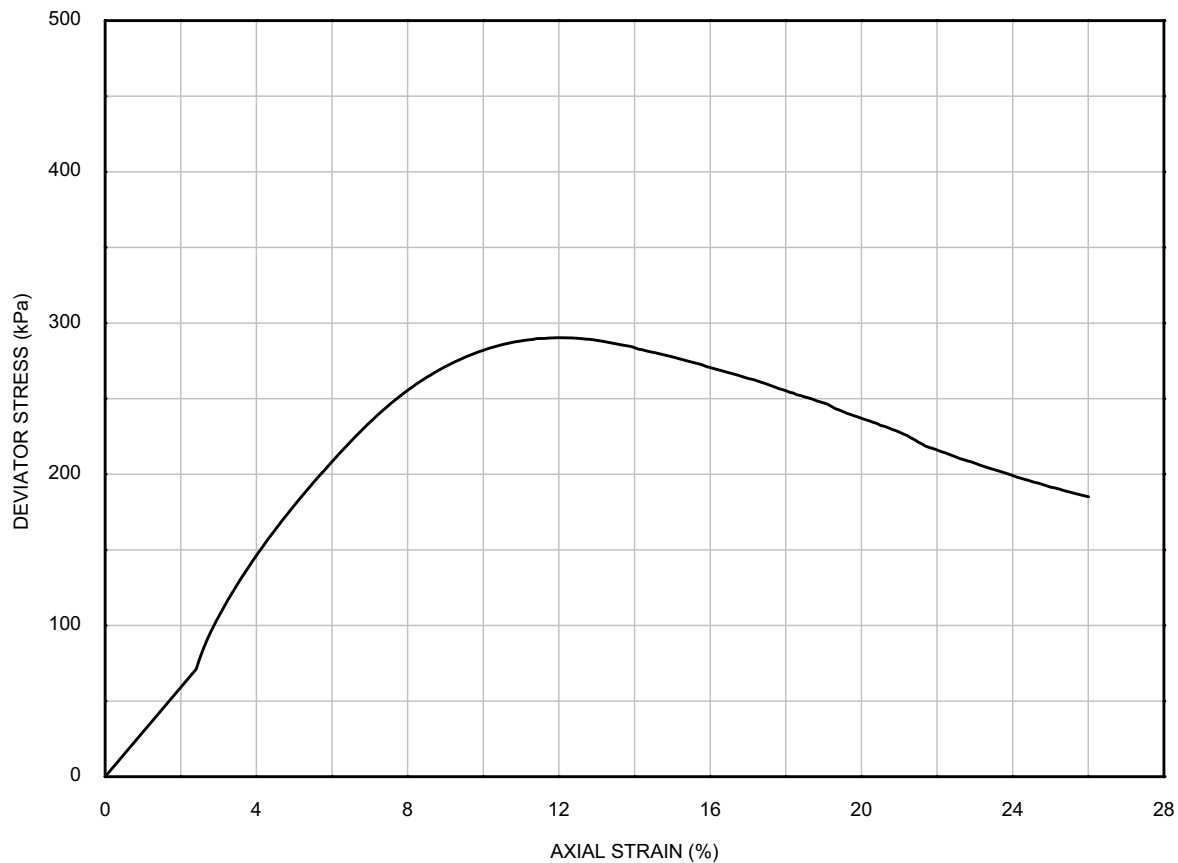
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 1194
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 1805
Strain at failure	(%)	: 11.2
Undrained shear strength	(kPa)	: 903

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 2.09 Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.74 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 20 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_04
			Sample	: 24UU
			Depth (m)	: 47.19

UNCONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

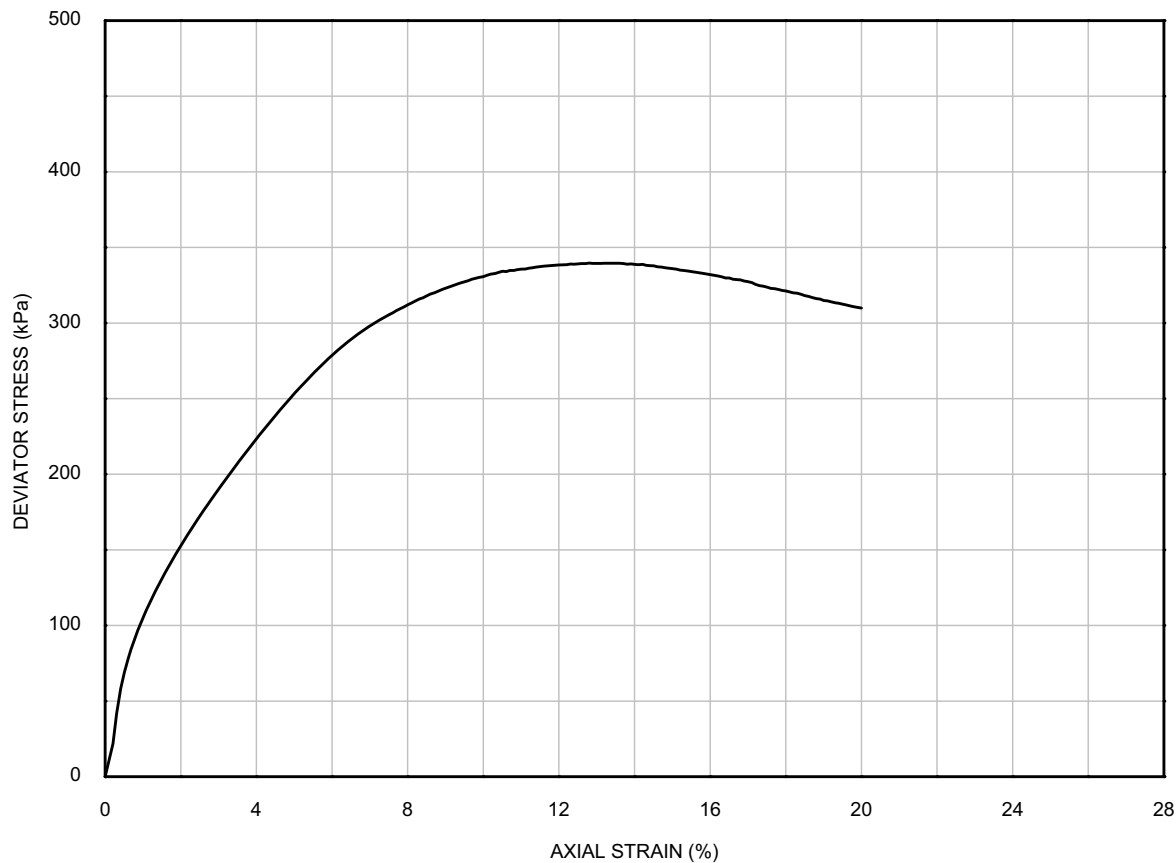
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 278
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 290
Strain at failure	(%)	: 12.0
Undrained shear strength	(kPa)	: 145

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.0	mm	Bulk density	: 1.93 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.48 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 31 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_04A
			Sample	: 2UU
			Depth (m)	: 1.04

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

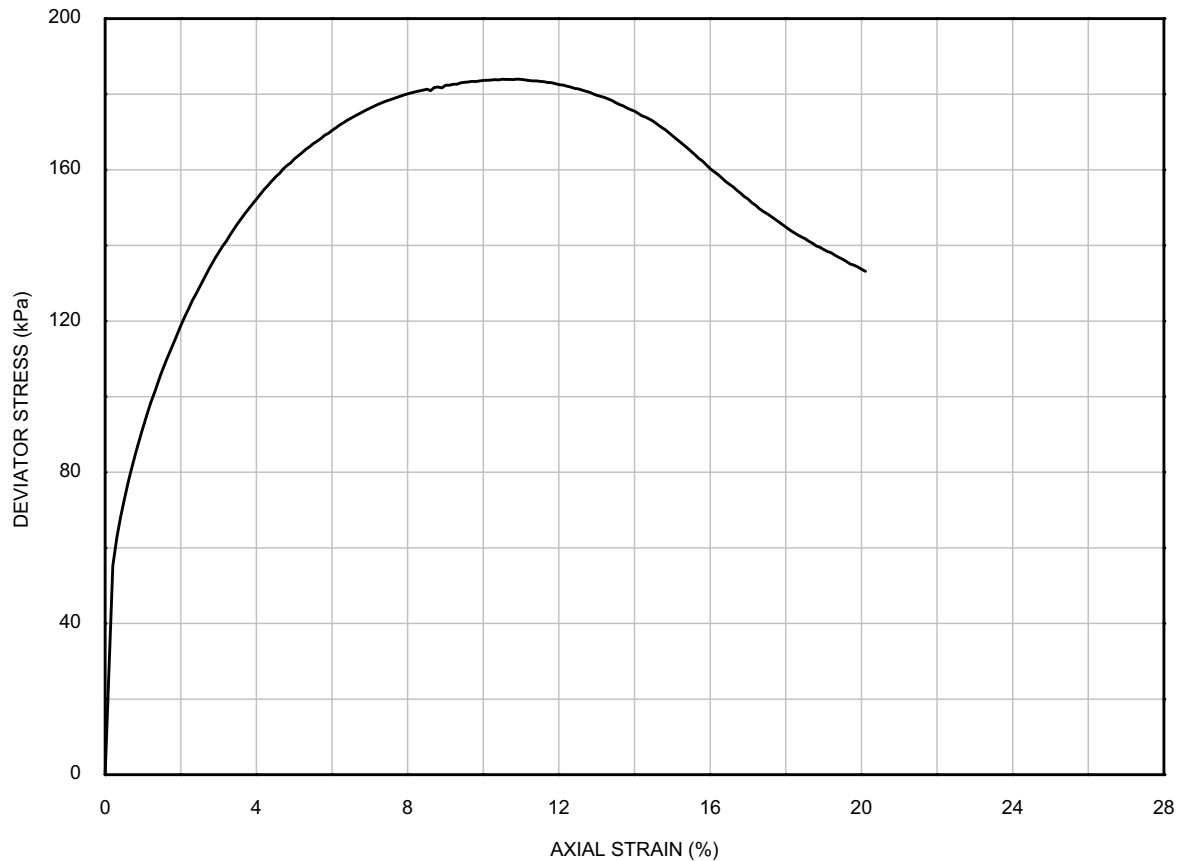
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 1194
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 340
Strain at failure	(%)	: 12.8
Undrained shear strength	(kPa)	: 170

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 1.98 Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.53 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 30 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_04A
			Sample	: 3UU
			Depth (m)	: 2.24

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

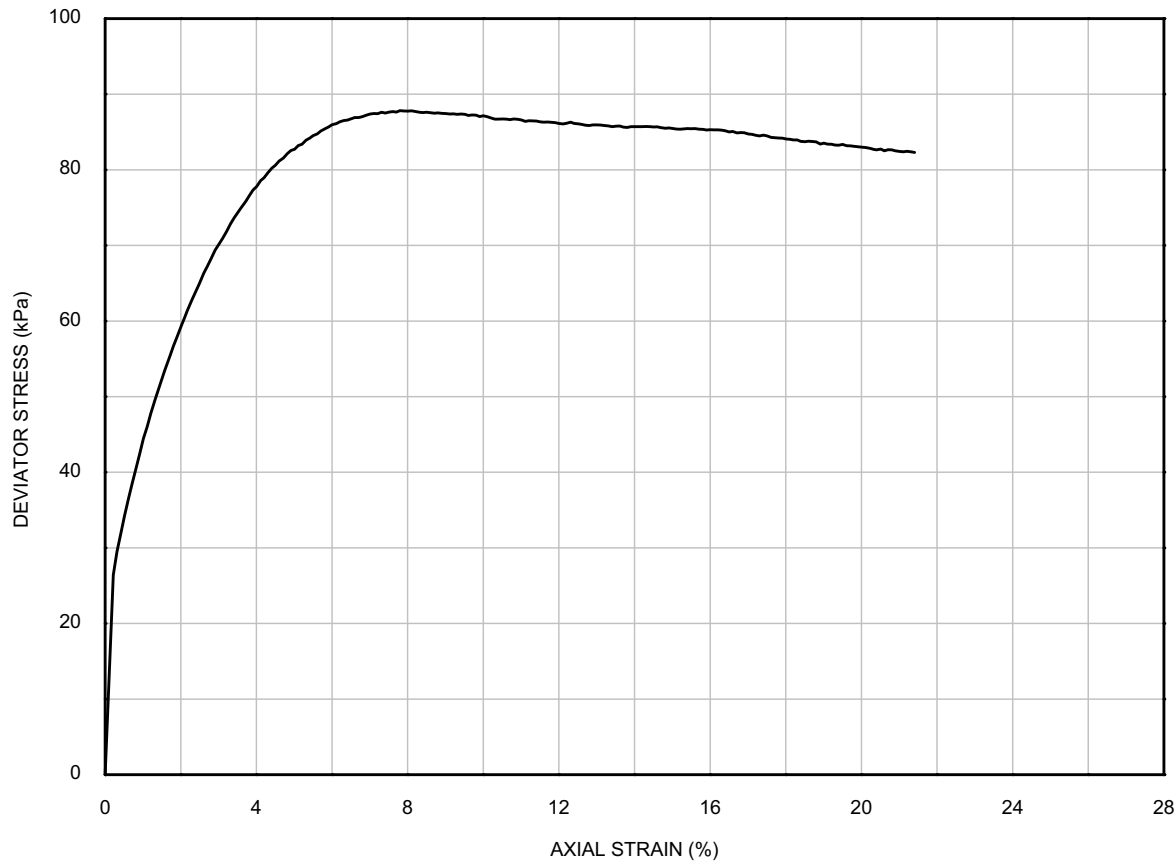
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 341
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 184
Strain at failure	(%)	: 10.9
Undrained shear strength	(kPa)	: 92

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 148.0	mm	Bulk density	: 1.98 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.53 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 29 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 1UU
			Depth (m)	: 3.32

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

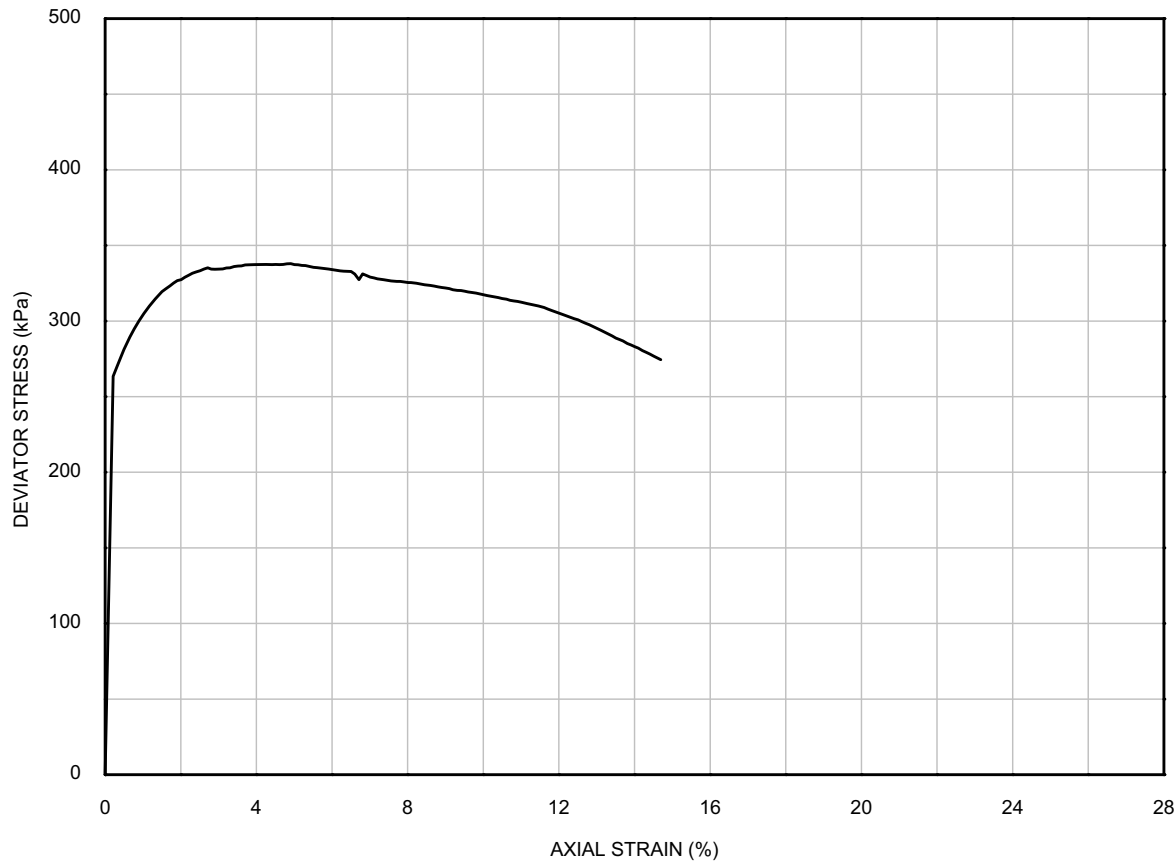
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 355
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 88
Strain at failure	(%)	: 7.8
Undrained shear strength	(kPa)	: 44

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 148.0	mm	Bulk density	: 1.97 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.53 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 29 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 2UU
			Depth (m)	: 4.00

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

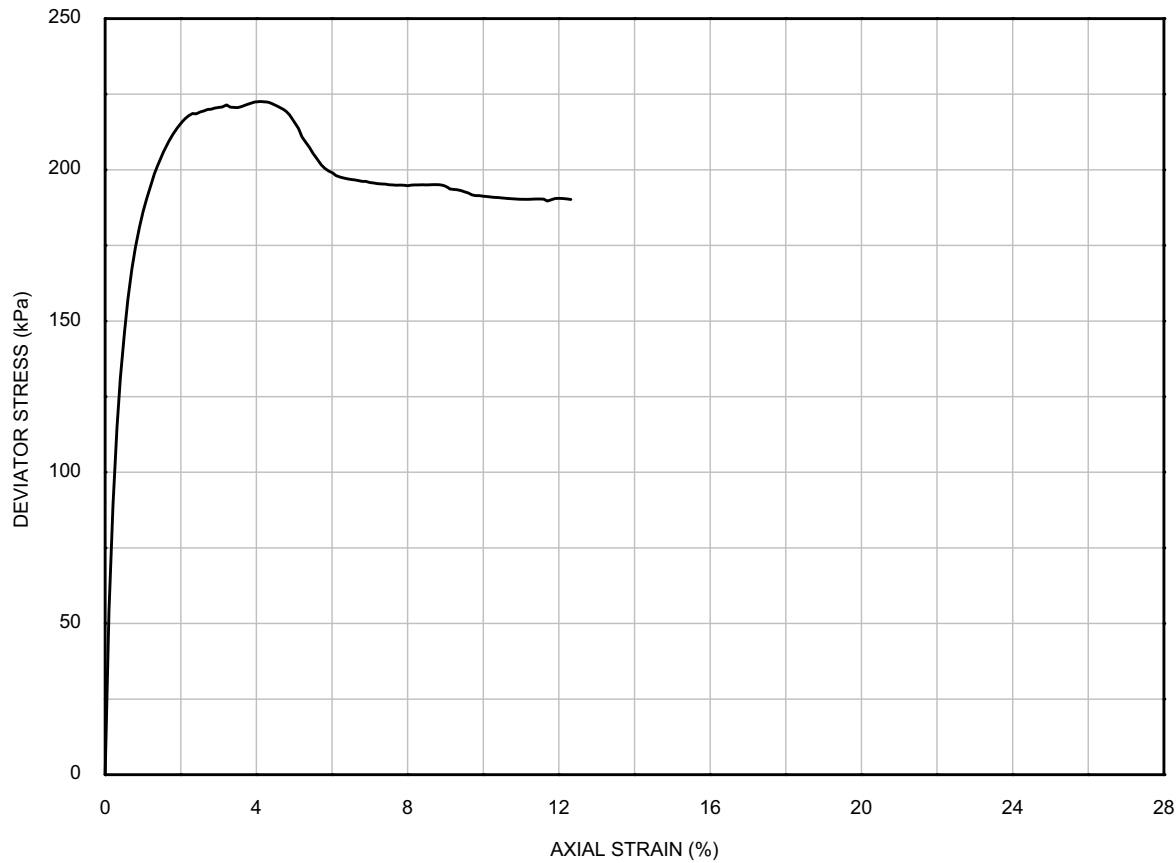
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 441
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 338
Strain at failure	(%)	: 4.9
Undrained shear strength	(kPa)	: 169

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 148.0	mm	Bulk density	: 2.03 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.58 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 28 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 4UU
			Depth (m)	: 8.30

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 458
Membrane correction	(kPa)	: 0
Corrected deviator stress	(kPa)	: 223
Strain at failure	(%)	: 4.1
Undrained shear strength	(kPa)	: 111

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 148.0	mm	Bulk density	: 1.98 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.53 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 29 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 5UU
			Depth (m)	: 9.17

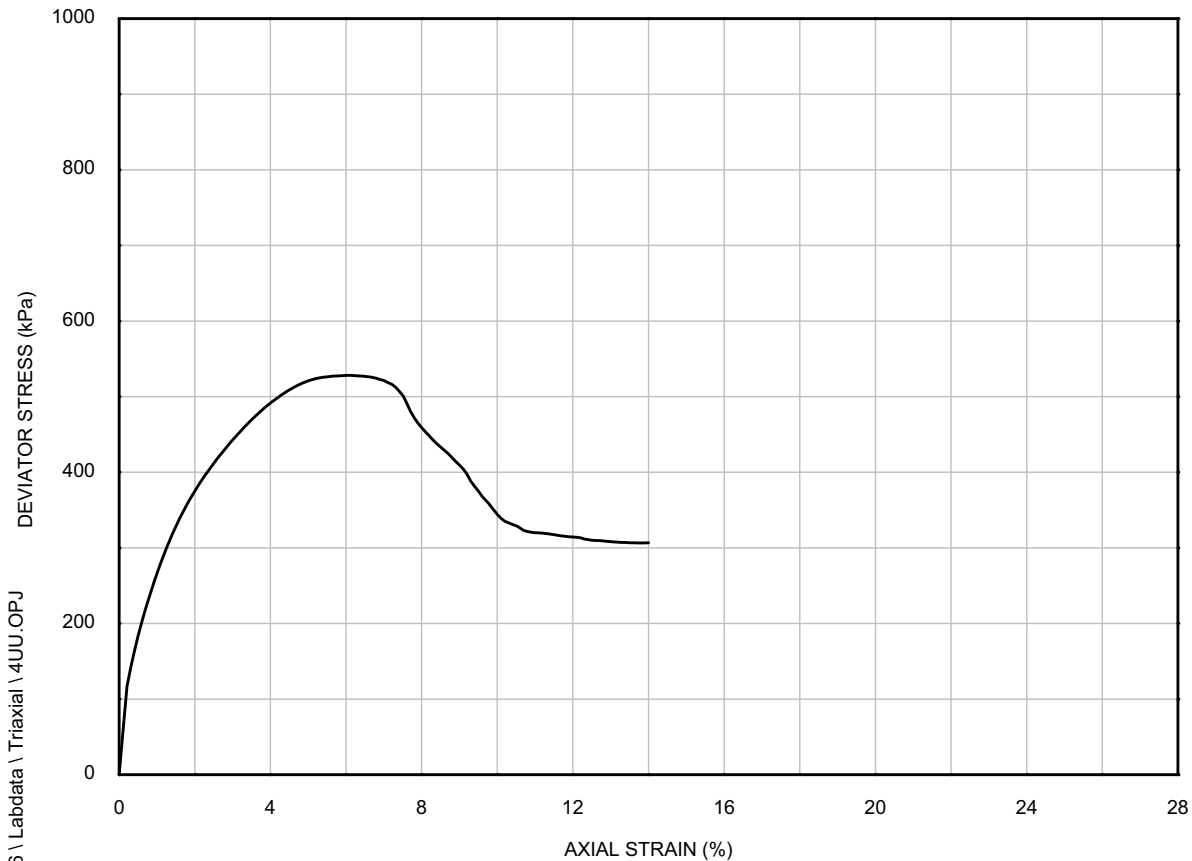
UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



Drawn by: ESF Date: 03/04/2011

Template Issue: 2

Filename: J11056 \ Labdata \ Triaxial \ 4UU.OPJ



— Undisturbed Sample tested Offshore

Failure shape

Shear failure

Date :

Date :

Failure Conditions		
Cell pressure	(kPa)	: 529
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 528
Strain at failure	(%)	: 6.0
Undrained shear strength	(kPa)	: 264

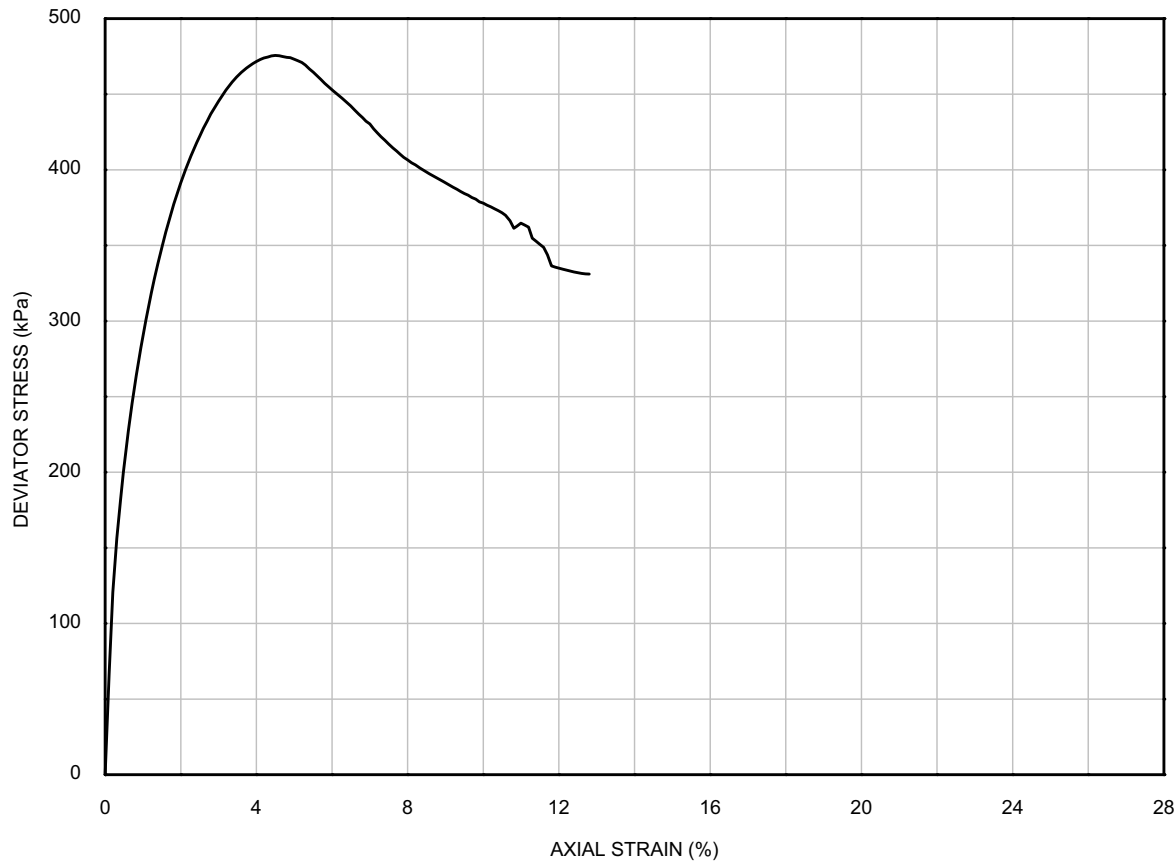
Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Checked by:

Approved by:

Initial Conditions				
Sample length	: 147.0	mm	Bulk density	: 2.03 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.61 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 26 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 7UU
			Depth (m)	: 13.70

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

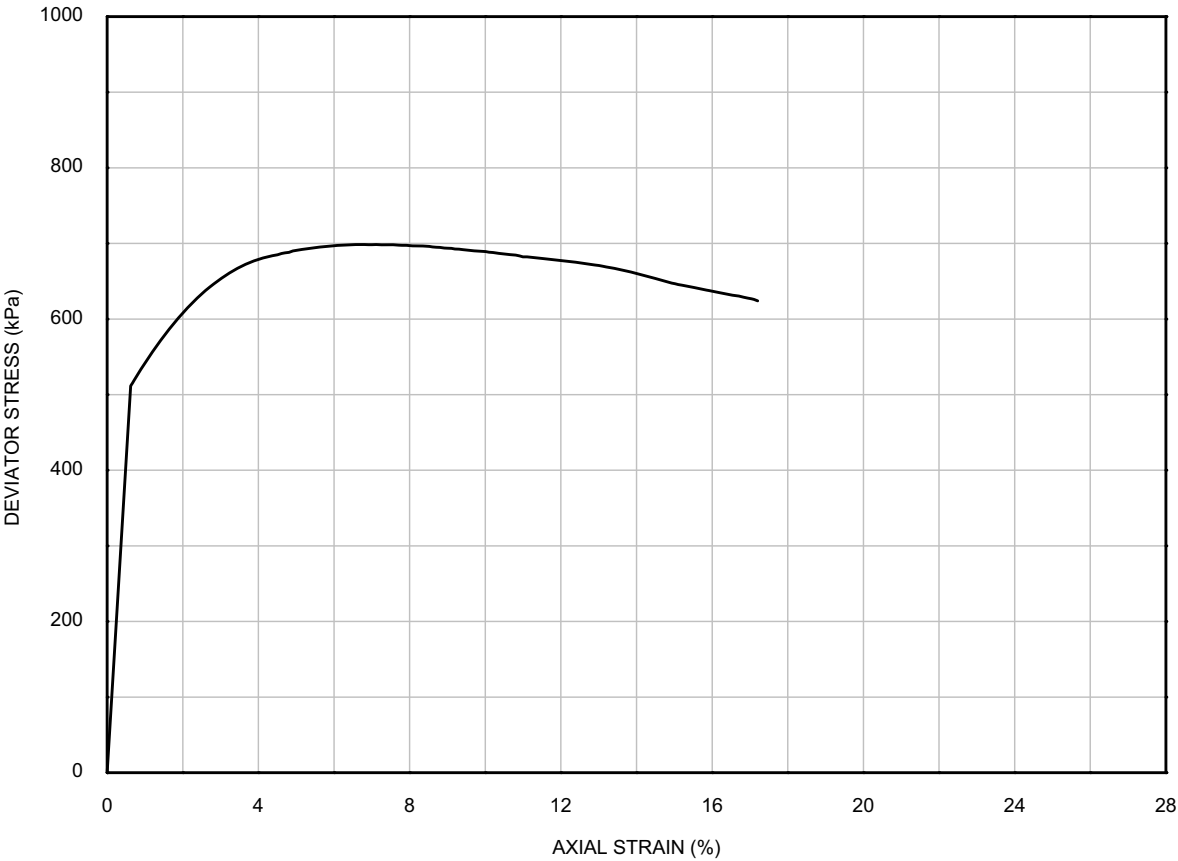
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 569
Membrane correction	(kPa)	: 0
Corrected deviator stress	(kPa)	: 476
Strain at failure	(%)	: 4.5
Undrained shear strength	(kPa)	: 238

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.0	mm	Bulk density	: 2.04 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.62 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 26 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 8UU
			Depth (m)	: 14.70

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST

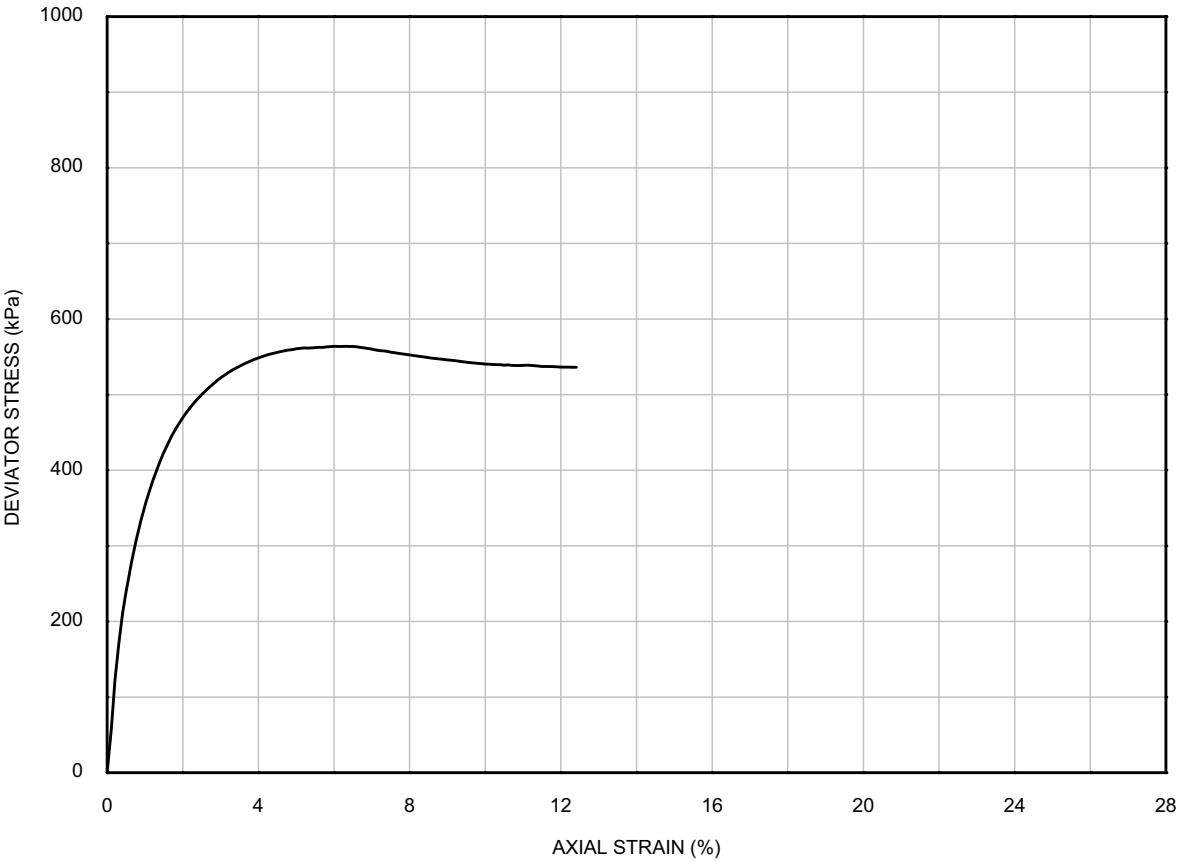


Failure Conditions		
Cell pressure	(kPa)	: 640
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 699
Strain at failure	(%)	: 6.8
Undrained shear strength	(kPa)	: 349

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 135.5	mm	Bulk density	: 2.14 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.78 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 20 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 9UU
			Depth (m)	: 18.25

UNCONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST



Undisturbed Sample tested Offshore

Failure shape

Barrel failure

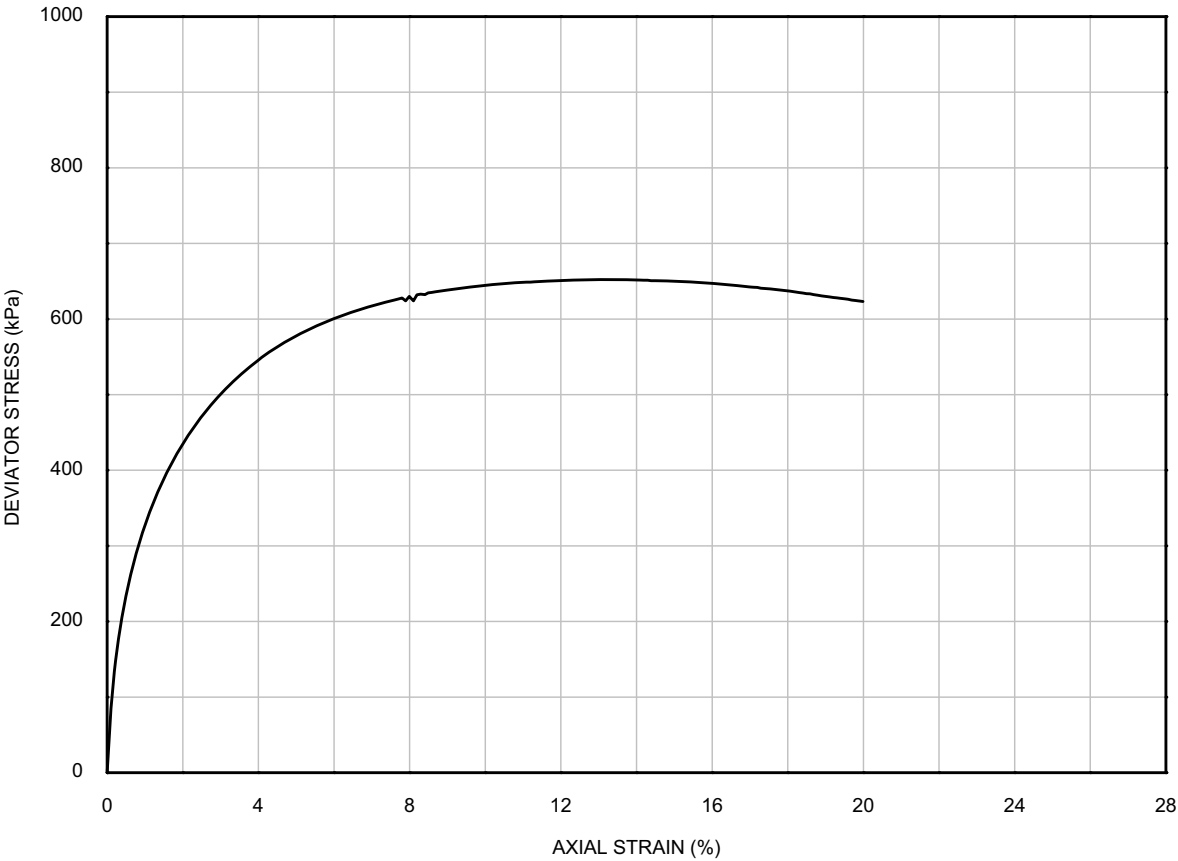
Failure Conditions		
Cell pressure	(kPa)	: 978
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 564
Strain at failure	(%)	: 6.0
Undrained shear strength	(kPa)	: 282

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 2.21 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: -- Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: -- %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 25UU
			Depth (m)	: 35.16

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST

Drawn by: JS
Date: 00/01/1900
Template Issue: 2
Filename: J11056 \ Labdata \ Triaxial \ 25UU.OPJ
Checked by:
Approved by:
Date :
Date :



— Undisturbed Sample tested Offshore

Failure shape

Barrel failure

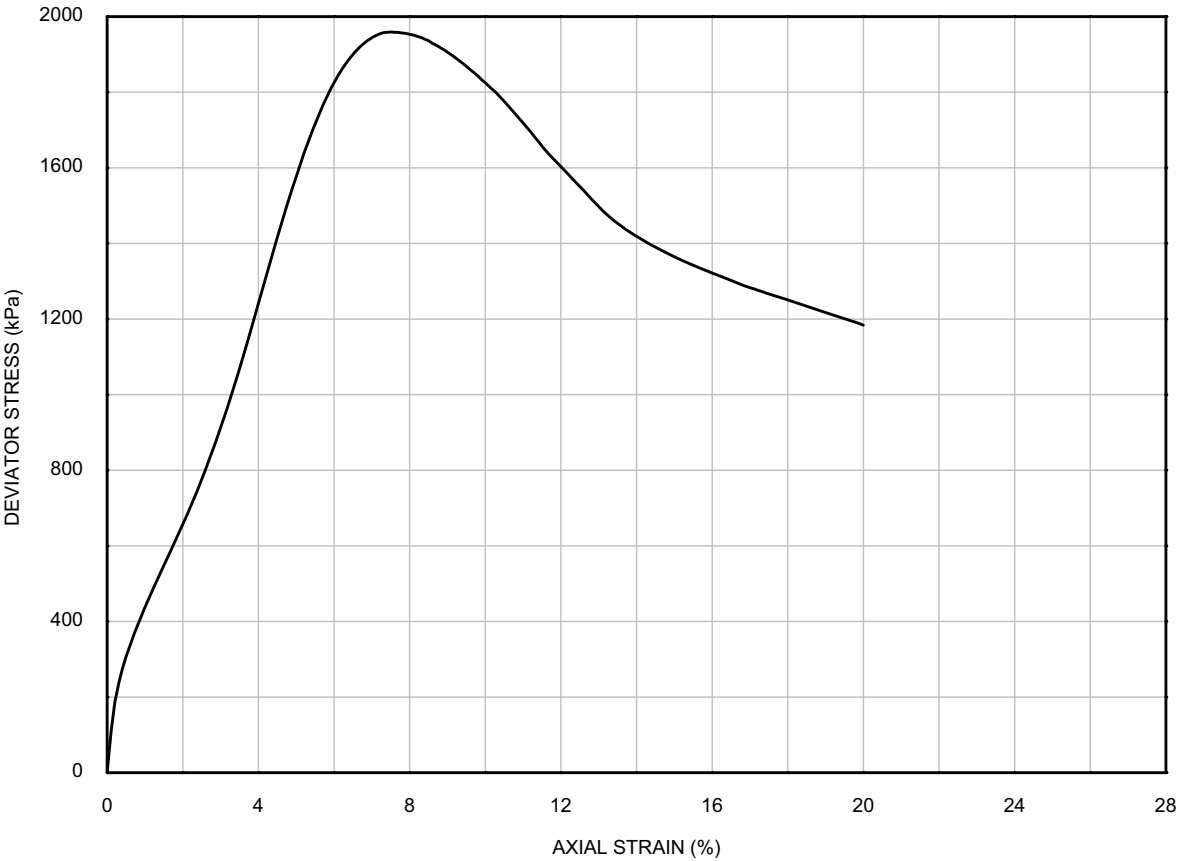
Failure Conditions		
Cell pressure	(kPa)	: 1028
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 652
Strain at failure	(%)	: 13.1
Undrained shear strength	(kPa)	: 326

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 2.17 Mg/m ³
Sample diameter	: 72.0	mm	Dry density	: 1.87 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 16 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_06
			Sample	: 27UU
			Depth (m)	: 37.63

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST

Drawn by: ESF Date: 03/04/2011
Template Issue: 2
Filename: J11056 \ Labdata \ Triaxial \ 27U.OPJ
Date :
Date :
Checked by:
Approved by:



— Undisturbed Sample tested Offshore

Failure shape

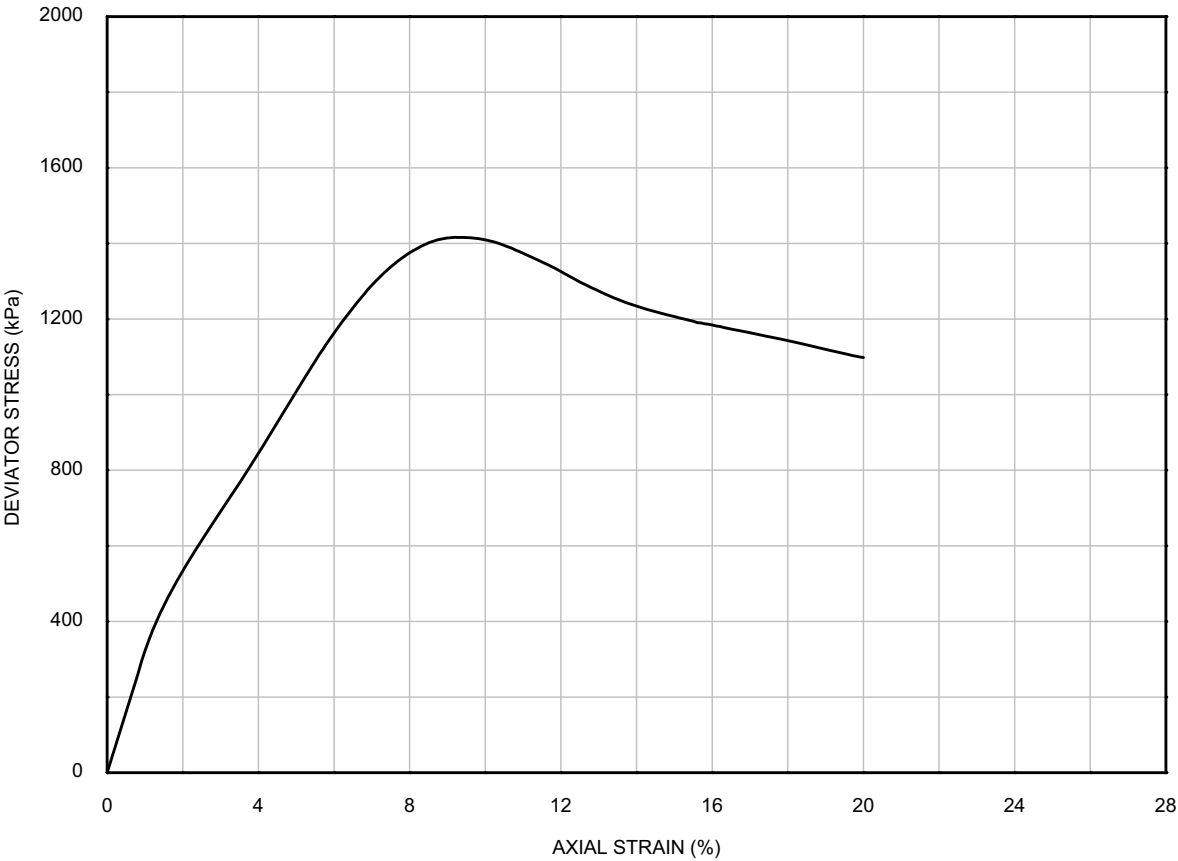
Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 1083
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 1959
Strain at failure	(%)	: 7.5
Undrained shear strength	(kPa)	: 980

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 2.10 Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.75 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 20 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_16
			Sample	: 14UU
			Depth (m)	: 30.65

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



— Undisturbed Sample tested Offshore

Failure shape

Shear failure

Failure Conditions		
Cell pressure	(kPa)	: 1083
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 1416
Strain at failure	(%)	: 9.2
Undrained shear strength	(kPa)	: 708

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions				
Sample length	: 146.3	mm	Bulk density	: 2.11 Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.72 Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 22 %
Rate of strain	: 2.0	%/min		
			Borehole	: BH_16
			Sample	: 15UU
			Depth (m)	: 31.25

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST

Drawn by: T.W Date: 05/05/2011
Template Issue: 2
Filename: J11056 \ Labdata \ Triaxial \ 15U.OPJ
Date :
Date :
Checked by:
Approved by:



Drawn by: T.W Date: 31/03/2011

Template Issue: 2

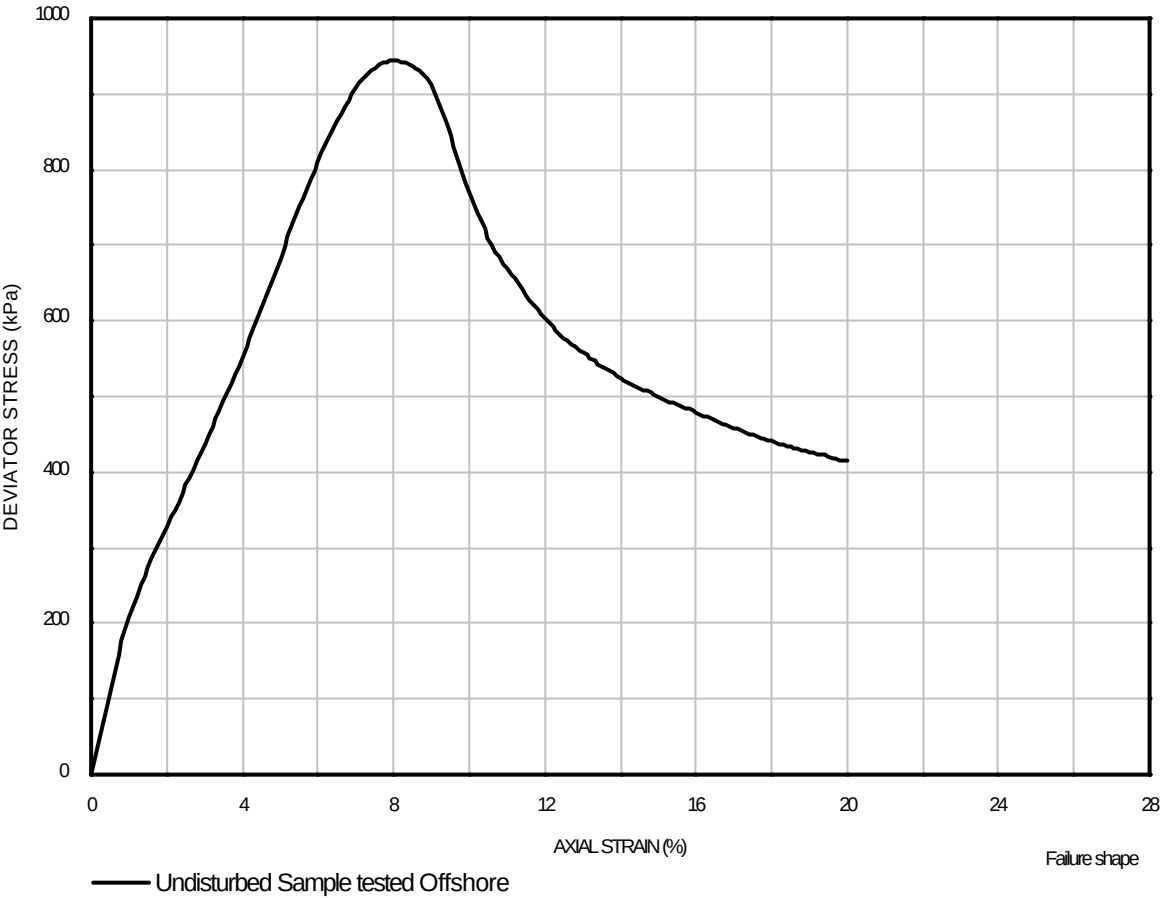
Filename: J11056 \ Labdata \ Triaxial \ 12U.OPJ

Date :

Date :

Checked by:

Approved by:



Failure Conditions		
Cell pressure	(kPa)	: 853
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 944
Strain at failure	(%)	: 8.0
Undrained shear strength	(kPa)	: 472

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions					
Sample length	: 146.3	mm	Bulk density	: 1.99	Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.54	Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 29	%
Rate of strain	: 2.0	%/min			
				Borehole	: BH-17
				Sample	: 12UU
				Depth (m)	: 27.15

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST



Drawn by: T.W Date: 31/03/2011

Template Issue: 2

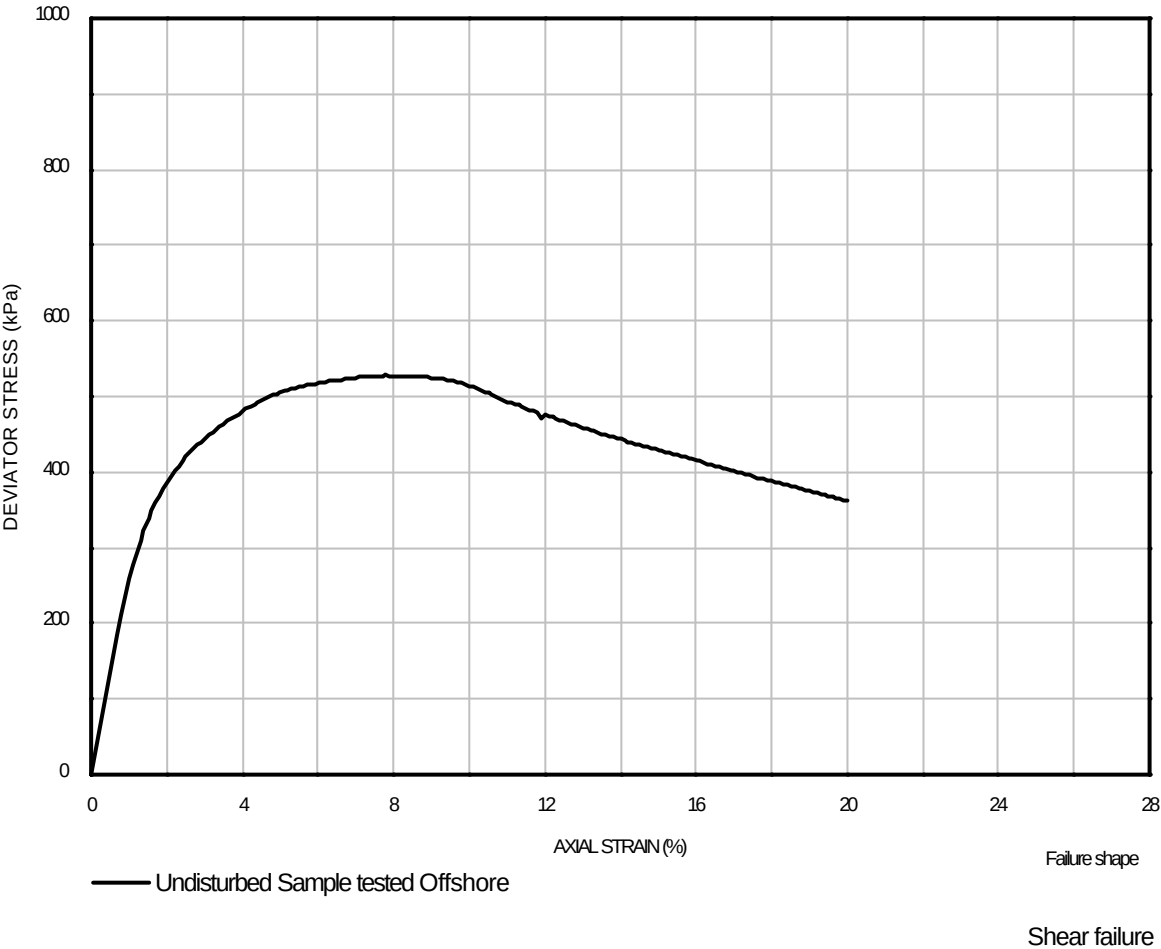
Filename: J11056 \ Labdata \ Triaxial \ 18U.OPJ

Date :

Date :

Checked by:

Approved by:



Failure Conditions		
Cell pressure	(kPa)	: 980
Membrane correction	(kPa)	: 1
Corrected deviator stress	(kPa)	: 528
Strain at failure	(%)	: 7.8
Undrained shear strength	(kPa)	: 264

Tested in accordance with BS 1377: Part 7: 1990: Clause 8

Initial Conditions					
Sample length	: 146.3	mm	Bulk density	: 2.05	Mg/m ³
Sample diameter	: 72.5	mm	Dry density	: 1.58	Mg/m ³
Membrane thickness	: 0.3	mm	Moisture content	: 29	%
Rate of strain	: 2.0	%/min			
				Borehole	: BH-17
				Sample	: 18UU
				Depth (m)	: 35.50

UNCONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST

Date: 27/05/2011

Drawn by: TPD

Template Issue: 2

Date: 01/06/2011

Checked by: PH

Filename: J11056 / Labdata / Chemical / ALL_CO3.XLS

Date:
Approved by:

Borehole	Sample	Depth (m)	Carbonate Content (% as CO ₂)	Carbonate Content (% as CaCO ₃)
BH_13	3BagA	3.50	0.18	0.41
BH_13	6BagB	13.25	0.18	0.41
BH_13	11ABagA	20.50	0.53	1.20
BH_13	23UU	39.45	0.53	1.20
BH_14	1BagB	2.15	0.53	1.20
BH_14	4BagB	7.30	0.72	1.64
BH_14	9BagA	21.00	0.88	2.00
BH_14	11BagB	25.25	1.30	2.95
BH_14	16BagUU	36.00	1.00	2.27

Note: This testing was not performed by Fugro and was subcontracted

SUMMARY OF CARBONATE CONTENT TEST RESULTS

Date: 10/06/2011

Drawn by: PH

Template Issue: 2

Filename: J11056 / Labdata / Chemical / ALL_CO3.XLS

Date:

Date:

Checked by:

Approved by:

Borehole	Sample	Depth (m)	Carbonate Content (% as CO ₂)	Carbonate Content (% as CaCO ₃)
BH_02	1BagA	3.00	0.18	0.41
BH_02	6BagA	16.50	0.89	2.02
BH_02	12BagB	26.05	0.54	1.23
BH_02	22BagA	42.00	0.87	1.98
BH_04	2BagA	7.00	0.54	1.23
BH_04	10BagA	19.50	1.10	2.50
BH_04	16BagB	30.55	0.54	1.23
BH_04A	3BagA	2.00	1.60	3.64
BH_06	3BagA	4.50	2.30	5.23
BH_06	11BagB	19.75	2.10	4.77
BH_06	24BagA	31.50	5.40	12.27
BH_06	31BagA	44.50	0.18	0.41
BH_07	3BagB	7.60	41.00	93.18
BH_07	6BagA	12.50	42.00	95.45
BH_07	13BagA	23.50	42.00	95.45
BH_07	23BagA	33.00	41.00	93.18
BH_16	2BagA	7.00	3.80	8.64
BH_16	4BagA	15.00	1.90	4.32
BH_16	10 & 11BagA	23.50 - 24.15	1.30	2.95
BH_16	19BagB	38.70	0.89	2.02
BH_16	23BagA	46.00	1.20	2.73
BH_17	5BagA	11.00	0.90	2.05
BH_17	11BagC	26.42	3.10	7.05
BH_17	24BagA	44.00	0.18	0.41

Note: This testing was not performed by Fugro and was subcontracted

SUMMARY OF CARBONATE CONTENT TEST RESULTS

Date: 27/05/2011

Drawn by: TPD

Template Issue: 3

Filename: J11056 / Labdata / Chemical / ALL_OR.XLS

Date: 01/06/2011

Date:

Checked by: PH

Approved by:

Borehole	Sample	Depth (m)	Loss on Ignition dried solids (%)
BH_13	3BagA	3.50	2.5
BH_13	6BagB	13.25	3.9
BH_13	11ABagA	20.50	1.6
BH_13	23UU	39.45	3.4
BH_14	1BagB	2.15	1.4
BH_14	4BagB	7.30	5.9
BH_14	9BagA	21.00	3.5
BH_14	11BagB	25.25	3.6
BH_14	16BagUU	36.00	4.0

Note: This testing was not performed by Fugro and was subcontracted

SUMMARY OF ORGANIC MATTER TEST RESULTS

Date: 10/06/2011

Drawn by: PH

Template Issue: 3

Date:

Checked by:

Filename: J11056 / Labdata / Chemical / ALL_OR.XLS

Date:

Approved by:

Borehole	Sample	Depth (m)	Loss on Ignition dried solids (%)
BH_02	1BagA	3.00	3.8
BH_02	6BagA	16.50	6.5
BH_02	12BagB	26.05	3.9
BH_02	22BagA	42.00	5.5
BH_04	2BagA	7.00	1.3
BH_04	10BagA	19.50	1.9
BH_04	16BagB	30.55	2.0
BH_04A	3BagA	2.00	8.7
BH_06	3BagA	4.50	9.2
BH_06	11BagB	19.75	4.2
BH_06	24BagA	31.50	8.1
BH_06	31BagA	44.50	6.0
BH_16	2BagA	7.00	1.3
BH_16	10 & 11BagA	23.50 - 24.15	0.9
BH_16	19BagB	38.70	3.7
BH_16	23BagA	46.00	4.0
BH_17	5BagA	11.00	6.8
BH_17	11BagC	26.42	4.9
BH_17	24BagA	44.00	1.7

Note: This testing was not performed by Fugro and was subcontracted

SUMMARY OF ORGANIC MATTER TEST RESULTS

Date: 27/05/2011

Drawn by: TPD

Template Issue: 2

Date: 01/06/2011

Checked by: PH

Approved by: Date:

Filename: J11056 / Labdata / Chemical / ALL_SO3_pH_soil.XLS

Borehole	Sample	Depth (m)	Total Sulphate (% as SO ₃)	Total Sulphate (% as SO ₄)	pH Value
BH_13	3BagA	3.50	0.024	-	9.1
BH_13	6BagB	13.25	0.22	-	7.2
BH_13	11ABagA	20.50	0.041	-	8.6
BH_13	23UU	39.45	0.19	-	7.5
BH_14	1BagB	2.15	0.086	-	8.4
BH_14	4BagB	7.30	0.15	-	7.7
BH_14	9BagA	21.00	0.10	-	8.5
BH_14	11BagB	25.25	0.17	-	8.0
BH_14	16BagUU	36.00	0.11	-	7.9

Note: This testing was not performed by Fugro and was subcontracted

SUMMARY OF SULPHATE & pH TEST RESULTS

Date: 14/06/2011

Drawn by: TPD

Template Issue: 2

Date:

Checked by:

Filename: J11056 / Labdata / Chemical / ALL_SO3_pH_soil.XLS

Date:

Approved by:

Borehole	Sample	Depth (m)	Total Sulphate (% as SO ₃)	Total Sulphate (% as SO ₄)	pH Value
BH_02	1BagA	3.00	0.018	-	7.7
BH_02	6BagA	16.50	0.14	-	8.2
BH_02	12BagB	26.05	0.095	-	7.3
BH_02	22BagA	42.00	0.096	-	8.0
BH_04	2BagA	7.00	0.076	-	8.3
BH_04	10BagA	19.50	0.088	-	8.5
BH_04	16BagB	30.55	0.11	-	8.2
BH_04A	3BagA	2.00	0.13	-	8.5
BH_06	3BagA	4.50	0.088	-	8.7
BH_06	11BagB	19.75	0.094	-	8.4
BH_06	24BagA	31.50	0.086	-	8.1
BH_06	31BagA	44.50	0.023	-	8.4
BH_16	2BagA	7.00	0.049	-	8.9
BH_16	10 & 11BagA	23.50 - 24.15	0.047	-	8.6
BH_16	19BagB	38.70	0.22	-	7.6
BH_16	23BagA	46.00	0.21	-	8.2
BH_17	5BagA	11.00	0.14	-	7.6
BH_17	11BagC	26.42	0.17	-	7.8
BH_17	24BagA	44.00	0.040	-	8.4

Note: This testing was not performed by Fugro and was subcontracted

SUMMARY OF SULPHATE & pH TEST RESULTS

SECTION B.3

CONSOLIDATION TESTS

B.3	CONSOLIDATION TESTS	1
B.3.1	SUMMARY	1
B.3.2	INCREMENTAL OEDOMETER TESTS	1
B.3.3	DISCUSSION OF RESULTS	1

B.3 CONSOLIDATION TESTS

B.3.1 SUMMARY

This section gives brief details of the consolidation tests that have been performed. Further details of the laboratory procedures are presented in Section B.11.

B.3.2 INCREMENTAL OEDOMETER TESTS

Thirteen (13) incremental oedometer tests were performed on cohesive soil specimens in order to help determine the stress history, drained stiffness and time dependant behaviour of the Rampion soils under one-dimensional strain conditions.

All tests were performed according to the procedures presented in BS 1377 (1990). All test specimens were loaded up beyond their pre-consolidation pressures to enable actual pre-consolidation pressure as well as the permeability, coefficient of consolidation and drained stiffness to be estimated.

The results of these tests are summarised on Plate B.3-1 and individual results are presented on Plates B.3-2 to B.3-27 at the end of this section.

B.3.3 DISCUSSION OF RESULTS

Sample disturbance was evaluated using the recommendations of Lunne *et. al.*, (1998) which is based on changes in vertical strain noted between the start of a test and the estimated in-situ overburden pressure.

Table B.3.1: Proposed Criteria for Evaluation of Sample Quality (after Lunne *et. al.*, 1998)

Overconsolidation Ratio	$\Delta e/e_o$			
	Very Good to Excellent	Good to Fair	Poor	Very Poor
1-2	<0.04	0.04-0.07	0.07-0.14	>0.14
2-4	<0.03	0.03-0.05	0.05-0.10	>0.10

Using the proposed criteria (Table B.3.1) the test results show that the samples range from “poor” to “very good to excellent” in quality with the majority of samples rated “very good to excellent”.



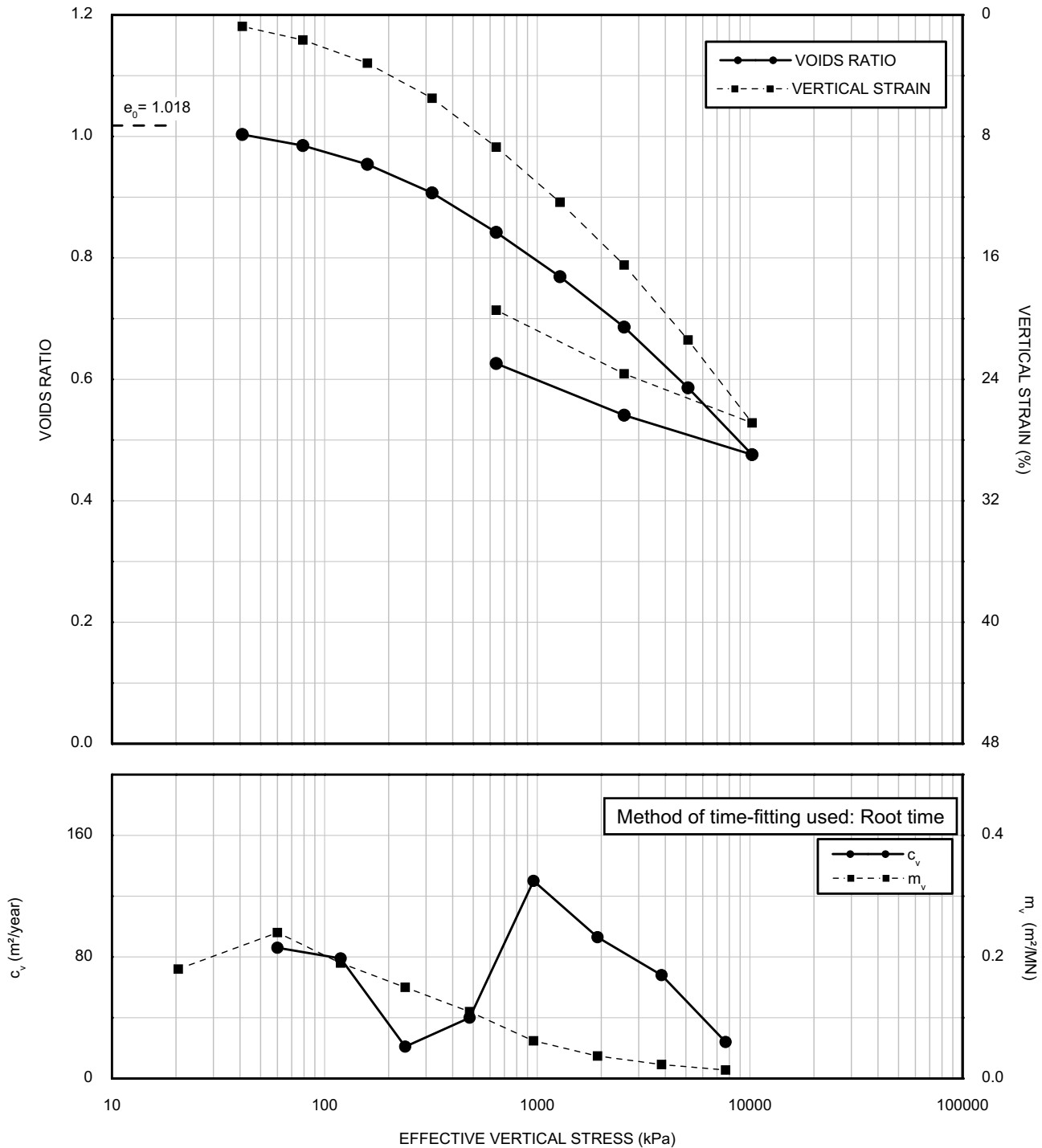
CONSOLIDATION TESTS

LIST OF PLATES – SECTION B.3

Description	Plate
Summary of Consolidation Test Results	B.3-1
Consolidation Test Results	B.3-2 to B.3-27

BH No.	SAMPLE No.	DEPTH (m)	TEST TYPE	INDEX PROPERTIES				CONSOLIDATION PARAMETERS						COMMENTS
				w _i (%)	w _f (%)	w _p (%)	I _p (%)	Initial Bulk Density (Mg/m³)	Sr (%)	PD (measured) (Mg/m³)	ε _v at Est. p _{o'} (%)	σ' _v at first unload (kPa)	Δe/e ₀	
BH_13	4WaxA	7.85	OED	28	26	18	46	1.7	75	2.67	1.64	10242	0.033	vg-e
BH_13	6WaxA	12.60	OED	27	21	21	38	1.88	87	2.74	0.84	20482	0.019	vg-e
BH_13	7WaxA	13.60	OED	27	17	25	41	1.89	90	2.70*	0.74	28000	0.017	vg-e
BH_13	23WaxC	39.65	OED	20	12	15	34	2.02	90	2.71	2.69	37990	0.071	p
BH_13	24WaxA	40.05	OED	21	13	15	34	2.00	90	2.71	1.06	38022	0.028	vg-e
BH_14	4WaxA	7.40	OED	39	31	31	49	1.83	99	2.75	0.35	15360	0.007	vg-e
BH_14	11WaxA	25.50	OED	30	20	21	54	1.91	96	2.73	1.07	28000	0.022	vg-e
BH_14	15WaxA	35.10	OED	28	16	27	39	1.91	92	2.70*	2.15	38007	0.046	g-f
BH_14	16WaxA	36.30	OED	30	17	22	57	1.95	101	2.70*	0.81	38040	0.019	vg-e
BH_02	2WaxB	7.50	OED	26	11	21	56	1.98	96	2.73	-0.10	25600	-0.001	Initial Swelling
BH_04	14WaxA	27.00	OED	23	18	22	34	2.01	94	2.70*	0.66	27999	0.012	vg-e
BH_06	1WaxA	3.15	OED	28	25	26	41	1.94	97	2.70*	-0.12	9600	-0.003	Initial Swelling
BH_06	9WaxA	18.00	OED	26	19	19	24	1.98	93	2.80	0.79	28000	0.016	vg-e
Notes: Sample Quality: vg-e = very good to excellent p = poor g-f = good to fair vp = very poor														
* = Assumed PD														

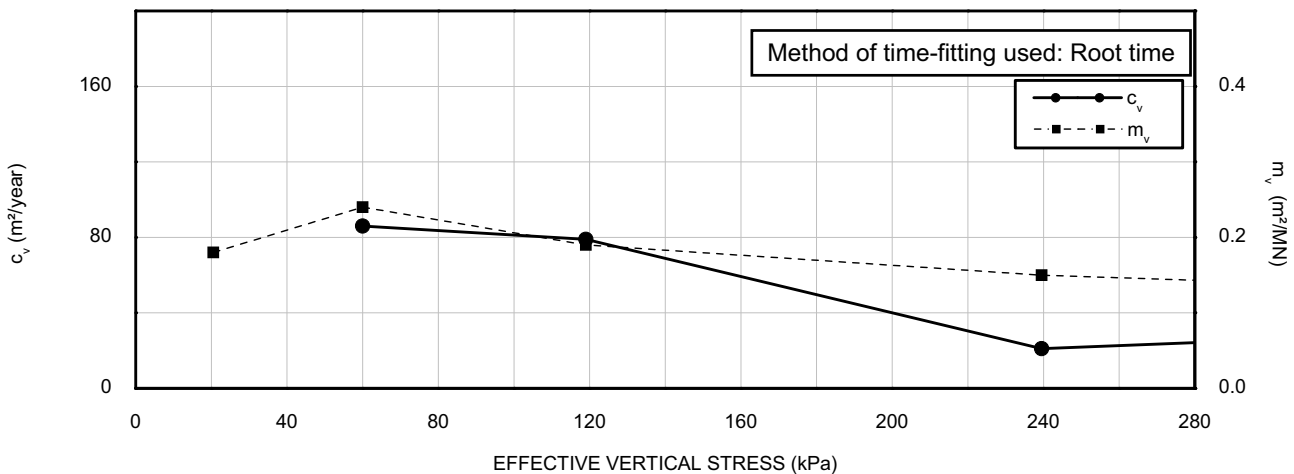
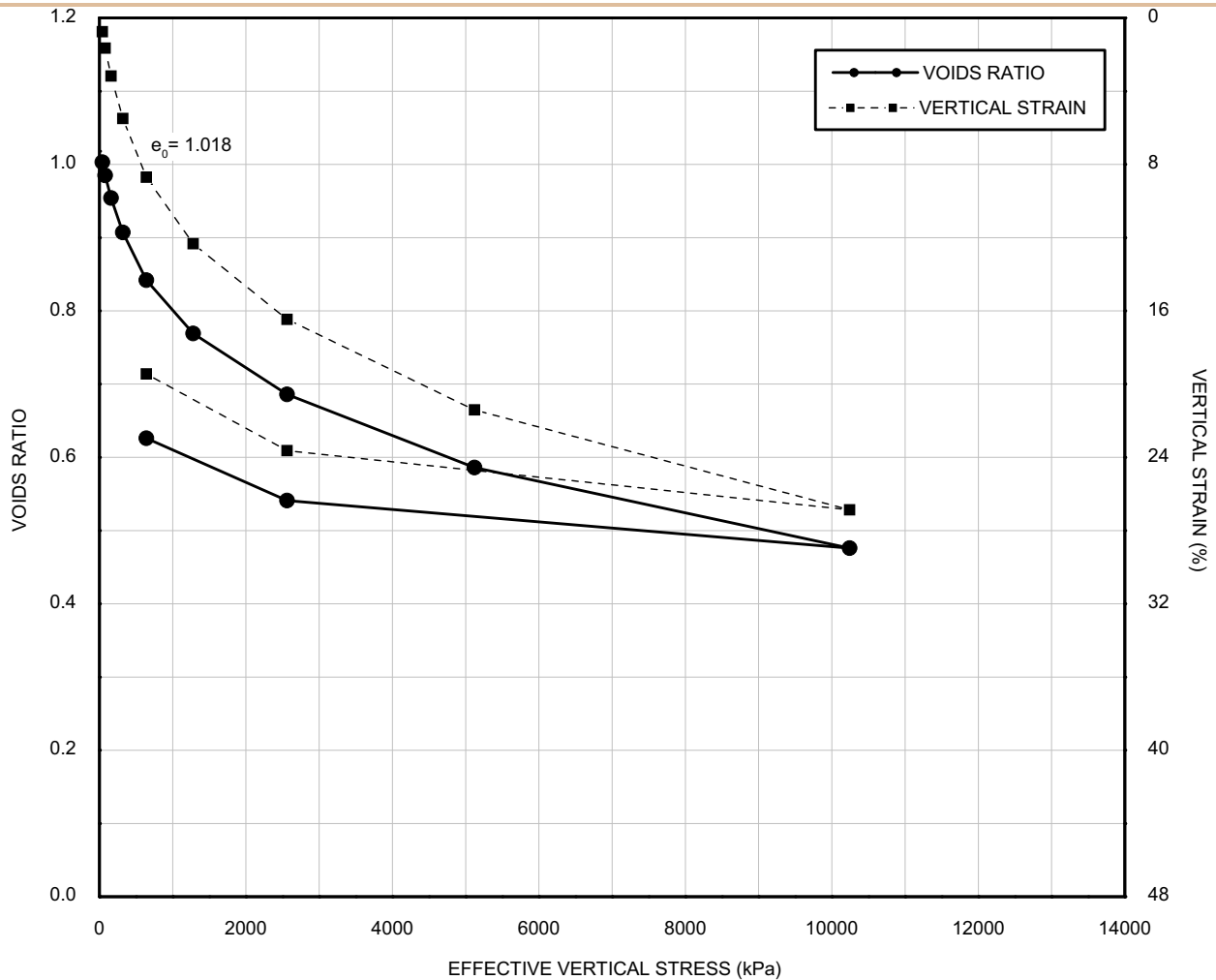
SUMMARY OF CONSOLIDATION TEST RESULTS



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.70 Mg/m ³	Borehole : BH_13 Sample : 4WaxA Depth (m) : 7.85
Specimen diameter : 50.1 mm	Dry density : 1.32 Mg/m ³	
Degree of saturation : 75 %	Moisture content : 28 %	
Particle density : 2.67 Mg/m ³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

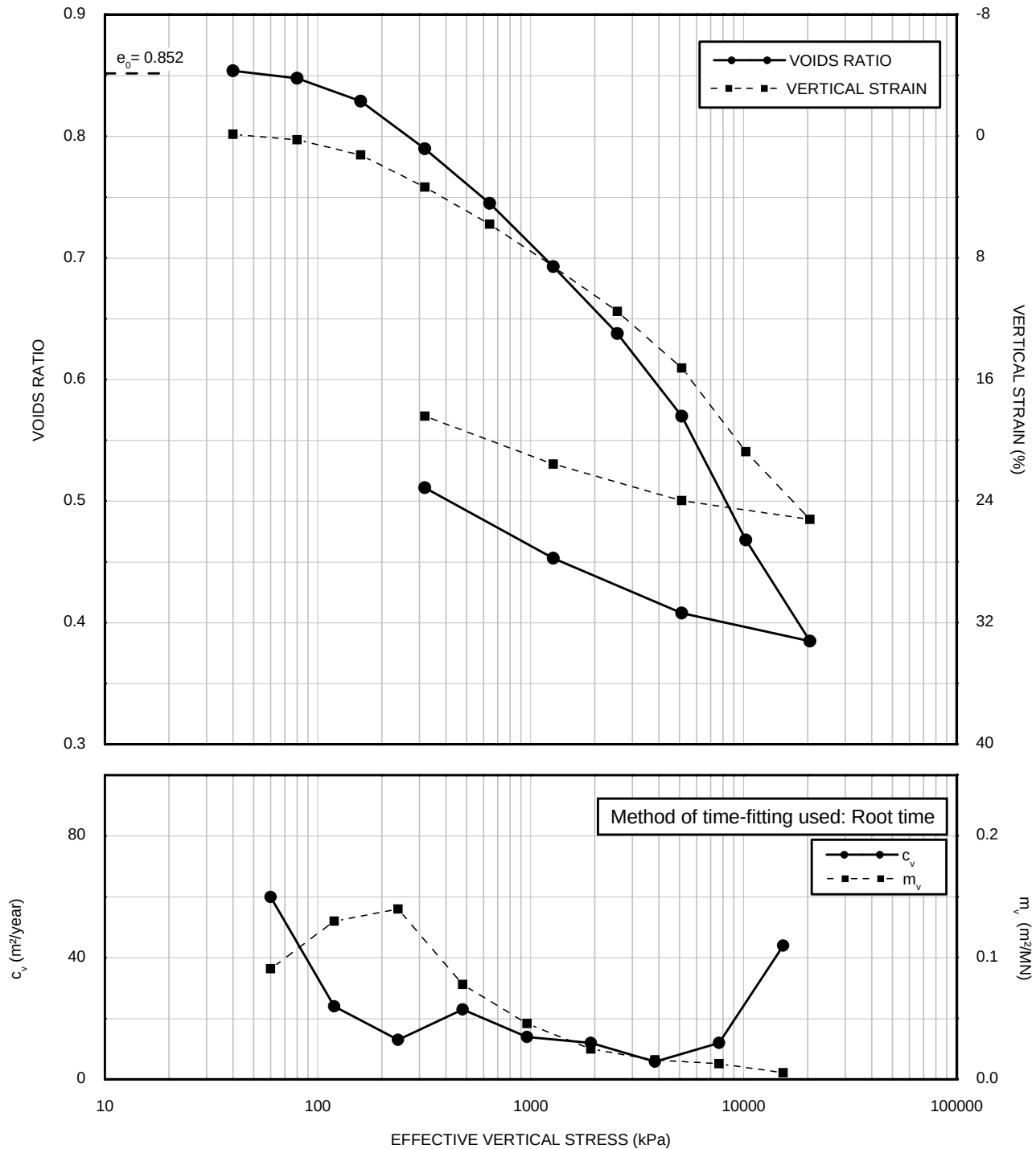
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.70 Mg/m ³	Borehole : BH_13
Specimen diameter : 50.1 mm	Dry density : 1.32 Mg/m ³	
Degree of saturation : 75 %	Moisture content : 28 %	Sample : 4WaxA
Particle density : 2.67 Mg/m ³	Lab. temperature : 20 °C	
(Measured)	Swelling pressure : NA kPa	Depth (m): 7.85
Specimen condition : Undisturbed		
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

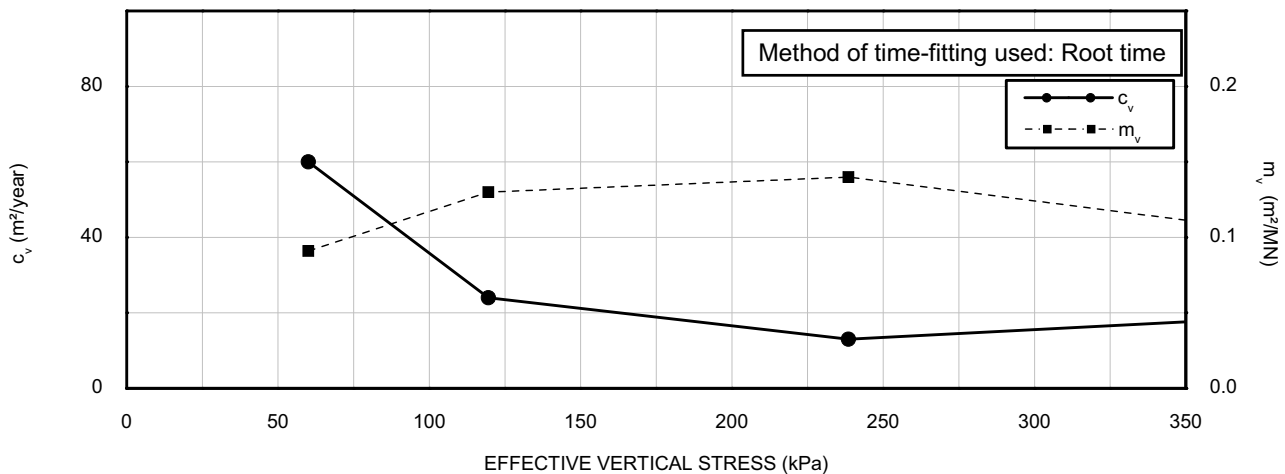
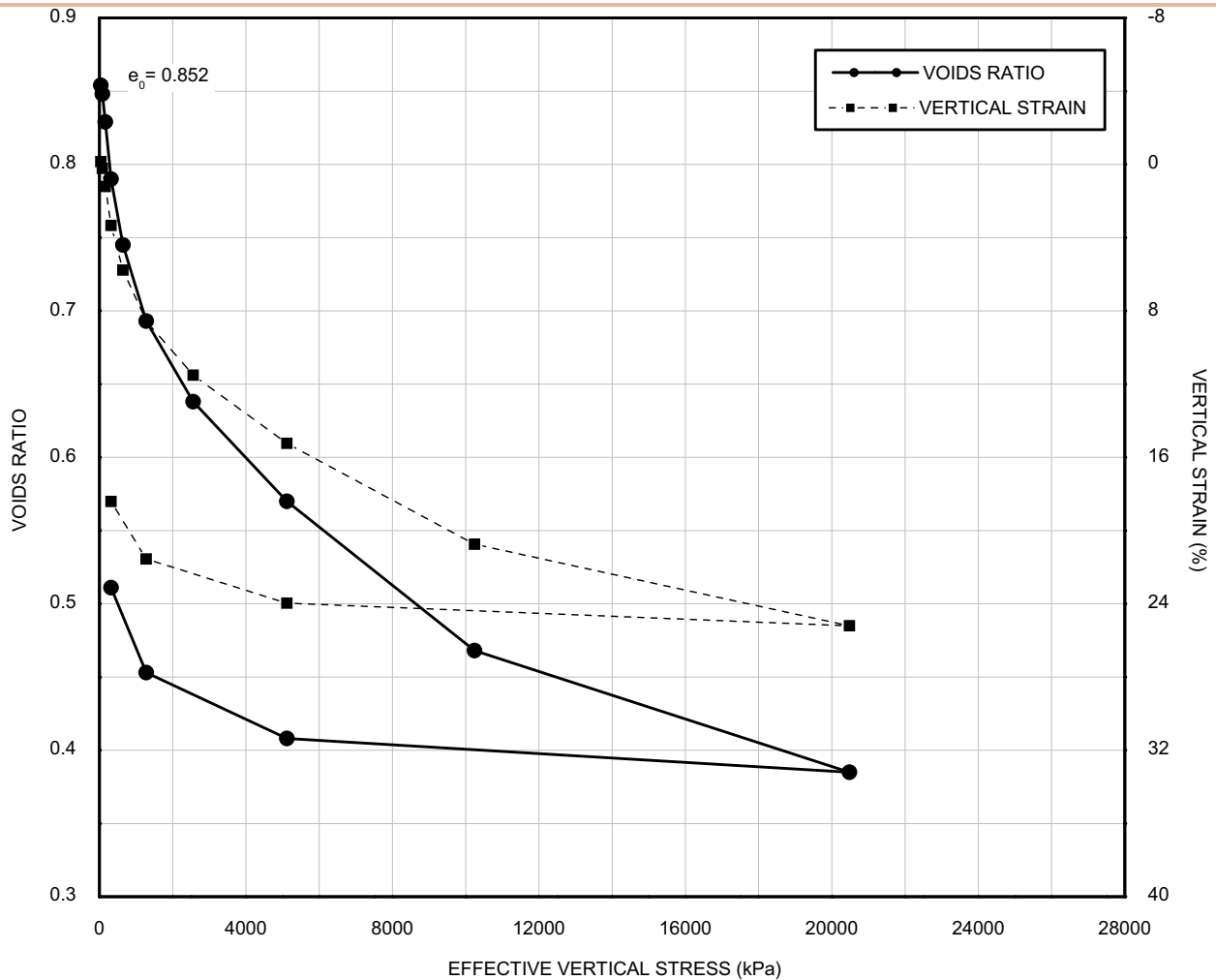
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.2 mm	Bulk density : 1.88 Mg/m³	Borehole : BH_13 Sample : 6WaxA Depth (m) : 12.60
Specimen diameter : 37.3 mm	Dry density : 1.48 Mg/m³	
Degree of saturation : 87 %	Moisture content : 27 %	
Particle density : 2.74 Mg/m³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

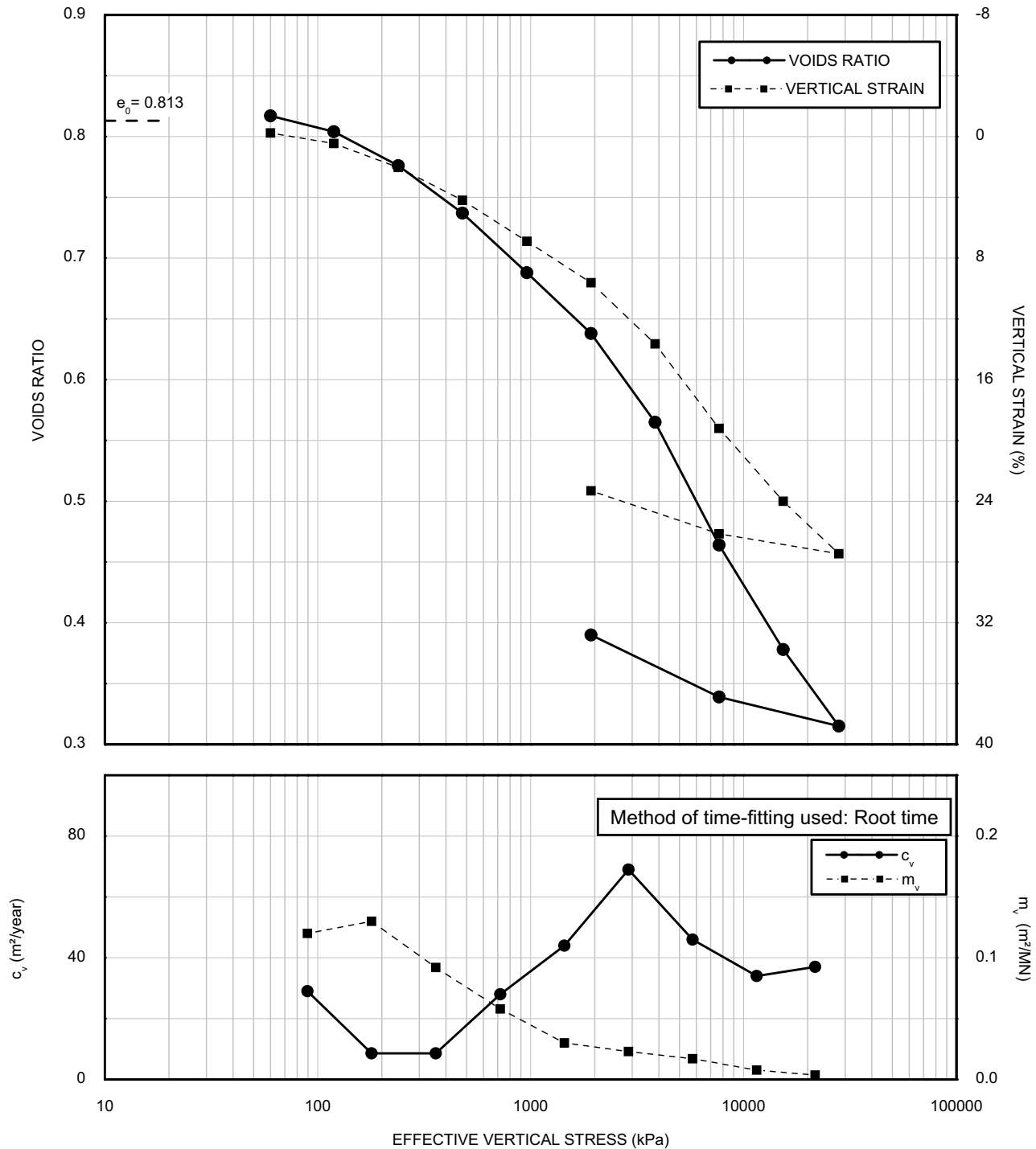
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.2 mm	Bulk density : 1.88 Mg/m³	Borehole : BH_13
Specimen diameter : 37.3 mm	Dry density : 1.48 Mg/m³	
Degree of saturation : 87 %	Moisture content : 27 %	Sample : 6WaxA
Particle density : 2.74 Mg/m³	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	Depth (m): 12.60
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

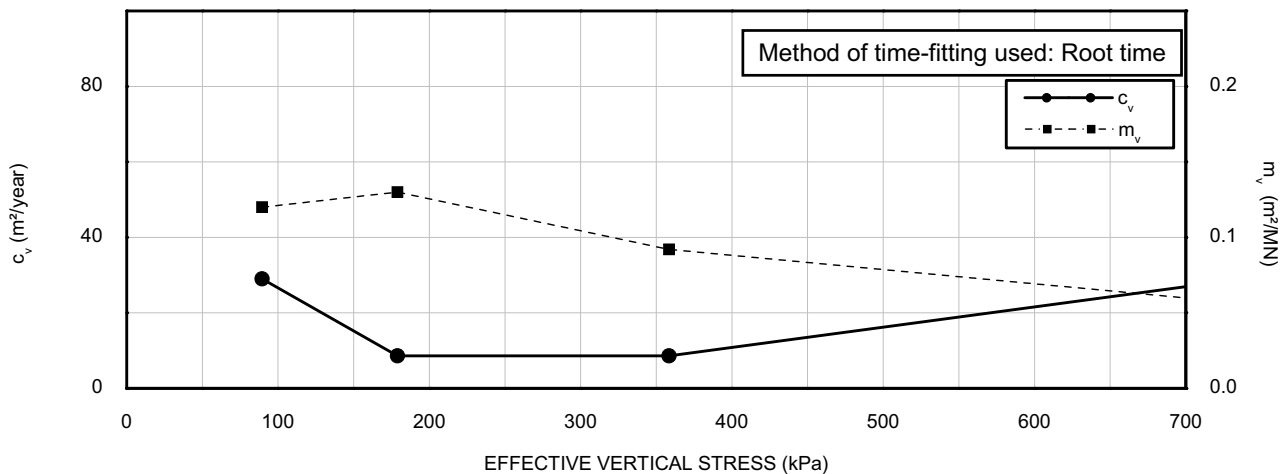
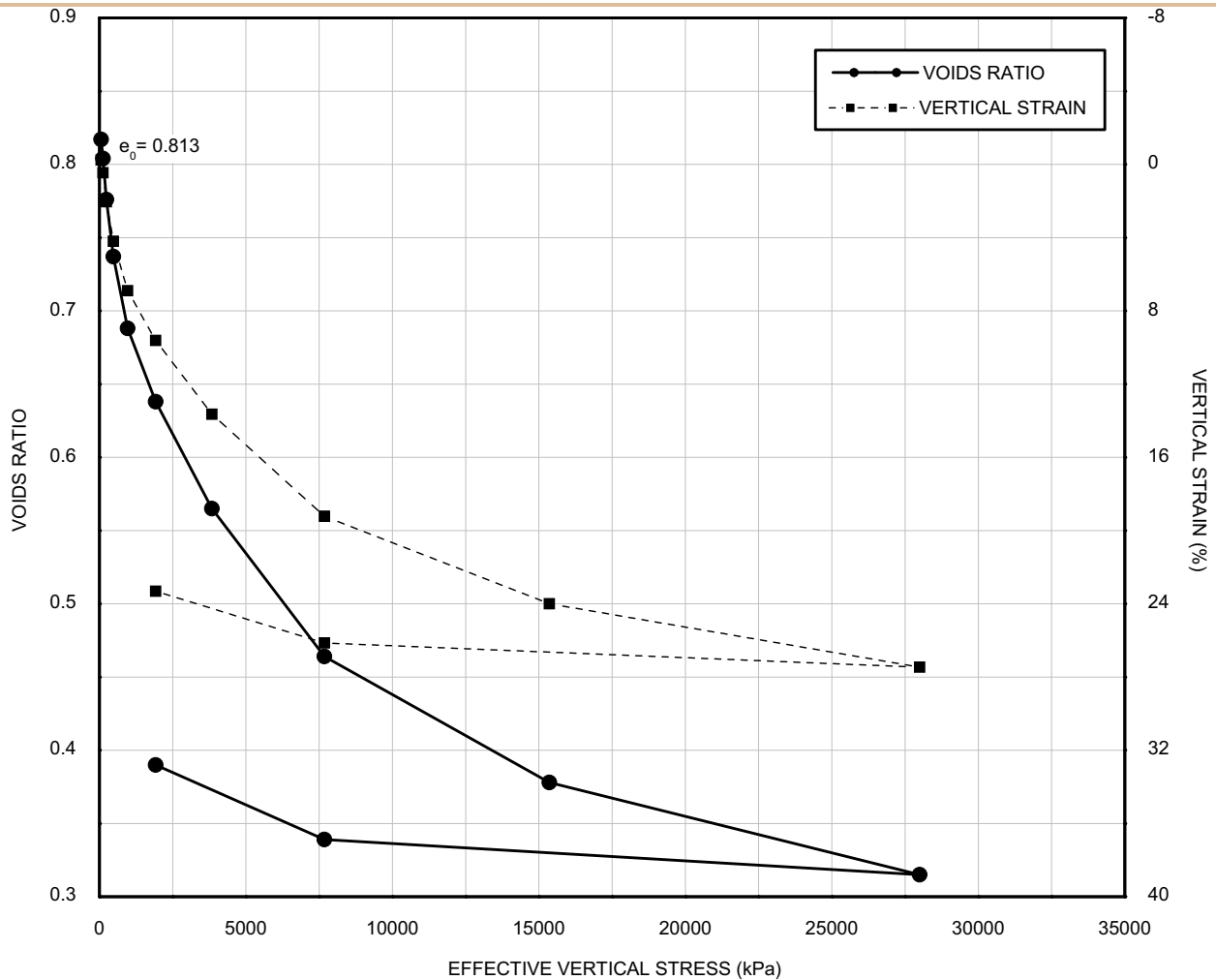
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.89 Mg/m³	Borehole : BH_13 Sample : 7WaxA Depth (m) : 13.60
Specimen diameter : 37.3 mm	Dry density : 1.49 Mg/m³	
Degree of saturation : 90 %	Moisture content : 27 %	
Particle density : 2.70 Mg/m³ (Assumed)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

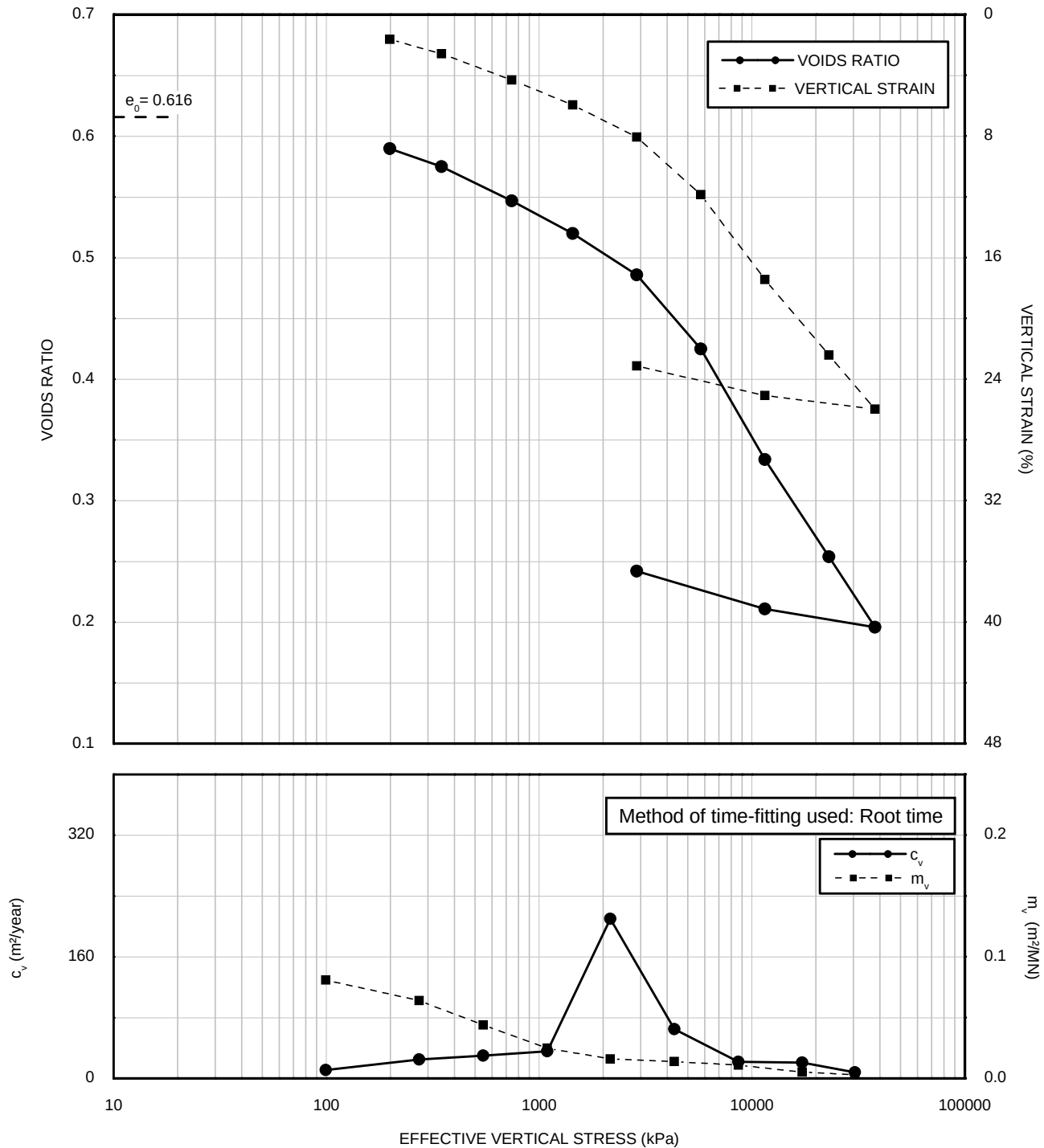
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 19.0 mm	Bulk density : 1.89 Mg/m ³
Specimen diameter	: 37.3 mm	
Degree of saturation	: 90 %	Dry density : 1.49 Mg/m ³
Particle density	: 2.70 Mg/m ³	
	(Assumed)	Moisture content : 27 %
Specimen condition	: Undisturbed	
Method of time fitting	: Root Time Method	Lab. temperature : 20 °C
		Swelling pressure : NA kPa
		Borehole : BH_13
		Sample : 7WaxA
		Depth (m): 13.60

Tested in accordance with BS1377: Part 5: 1990: Clause 3

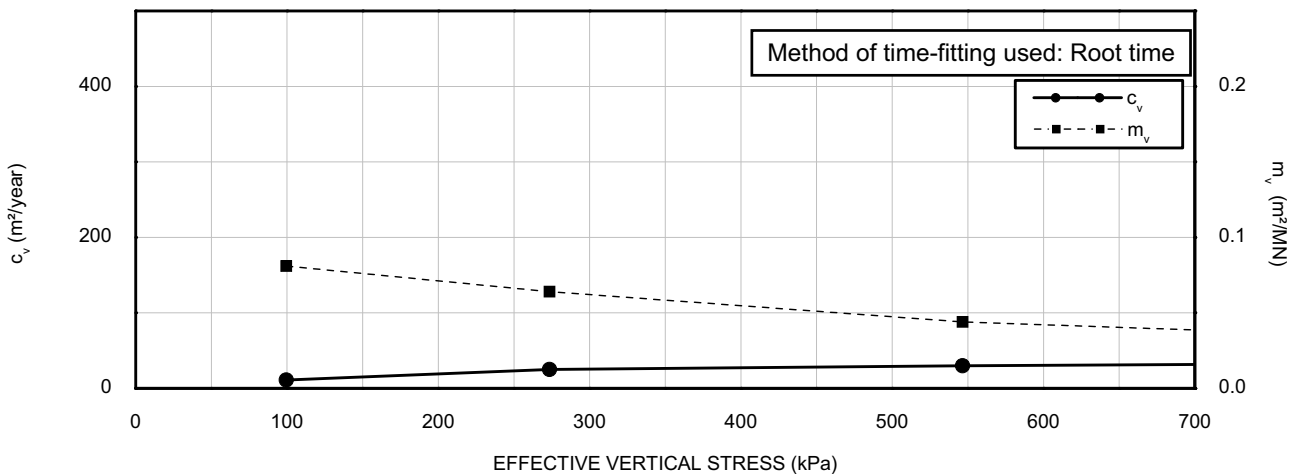
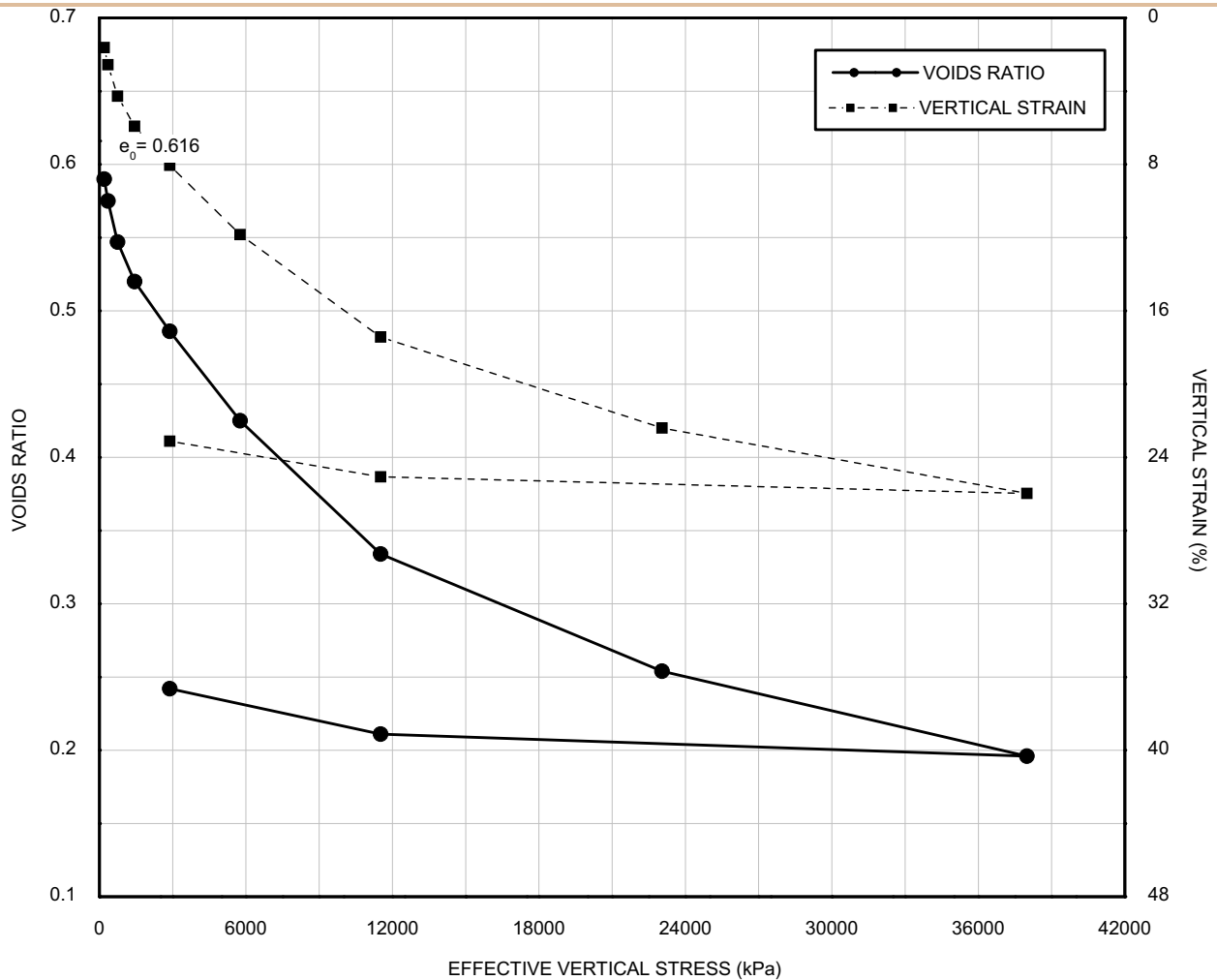
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.1 mm	Bulk density : 2.02 Mg/m³	Borehole : BH_13 Sample : 23WaxC Depth (m) : 39.65
Specimen diameter : 37.3 mm	Dry density : 1.68 Mg/m³	
Degree of saturation : 90 %	Moisture content : 20 %	
Particle density : 2.71 Mg/m³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

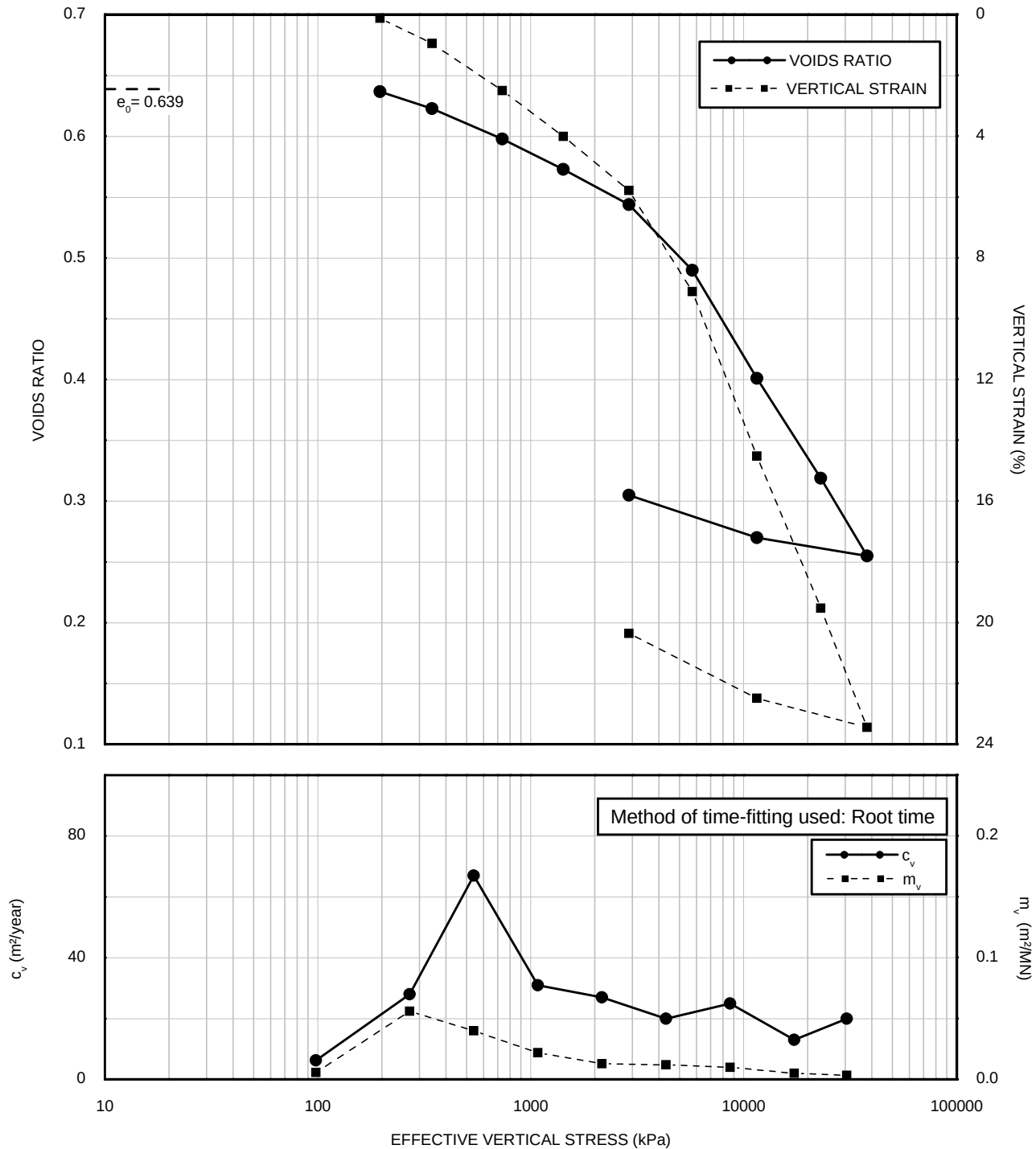
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.1 mm	Bulk density : 2.02 Mg/m³	Borehole : BH_13
Specimen diameter : 37.3 mm	Dry density : 1.68 Mg/m³	
Degree of saturation : 90 %	Moisture content : 20 %	Sample : 23WaxC
Particle density : 2.71 Mg/m³	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	Depth (m) : 39.65
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

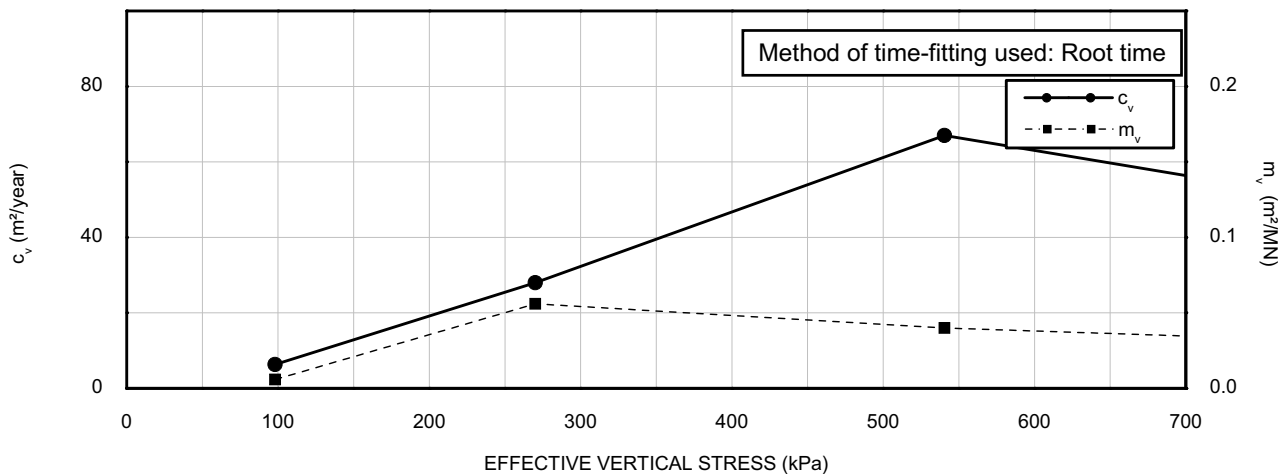
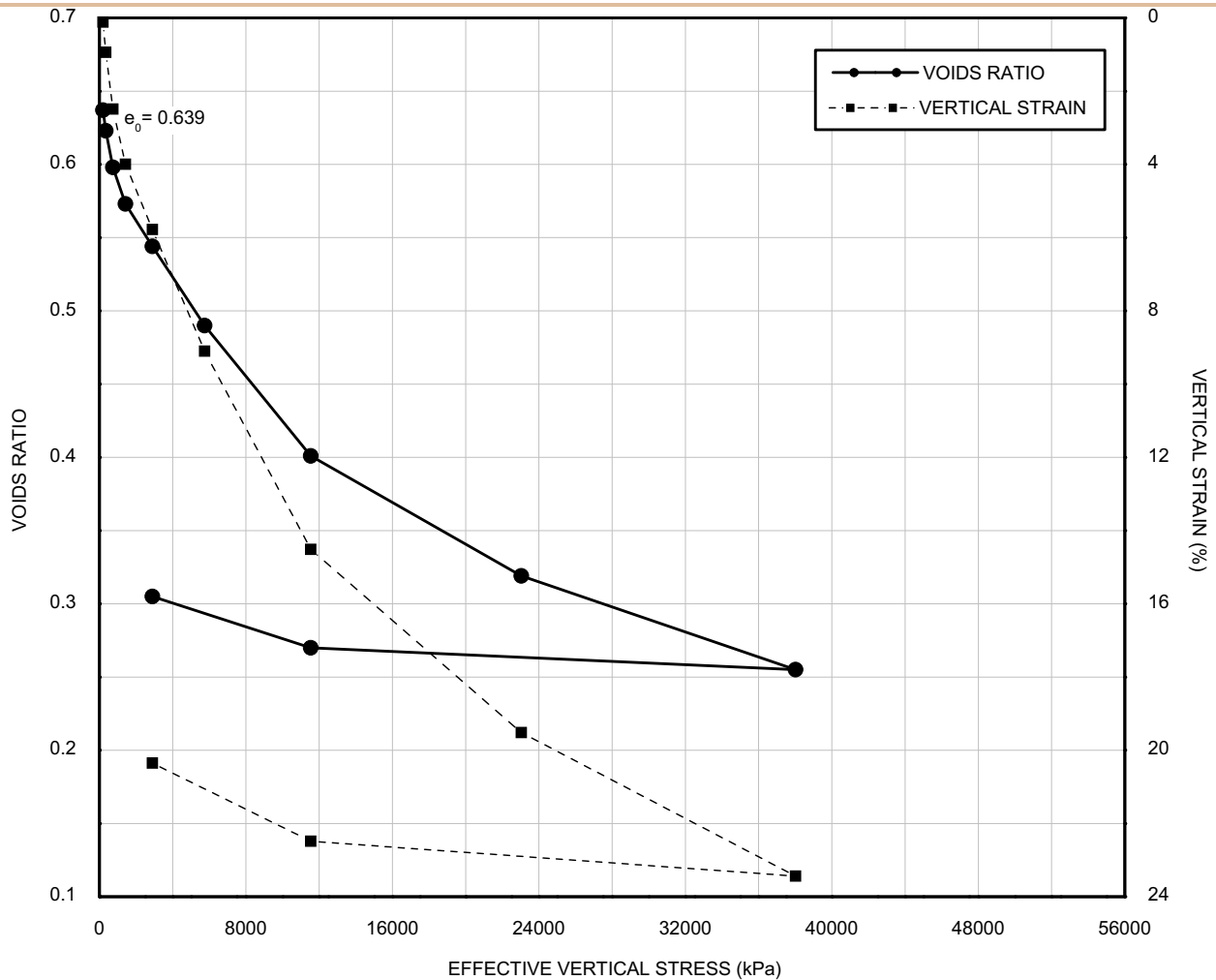
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.1 mm	Bulk density : 2.00 Mg/m³	Borehole : BH_13 Sample : 24WaxA Depth (m) : 40.05
Specimen diameter : 37.3 mm	Dry density : 1.65 Mg/m³	
Degree of saturation : 90 %	Moisture content : 21 %	
Particle density : 2.71 Mg/m³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

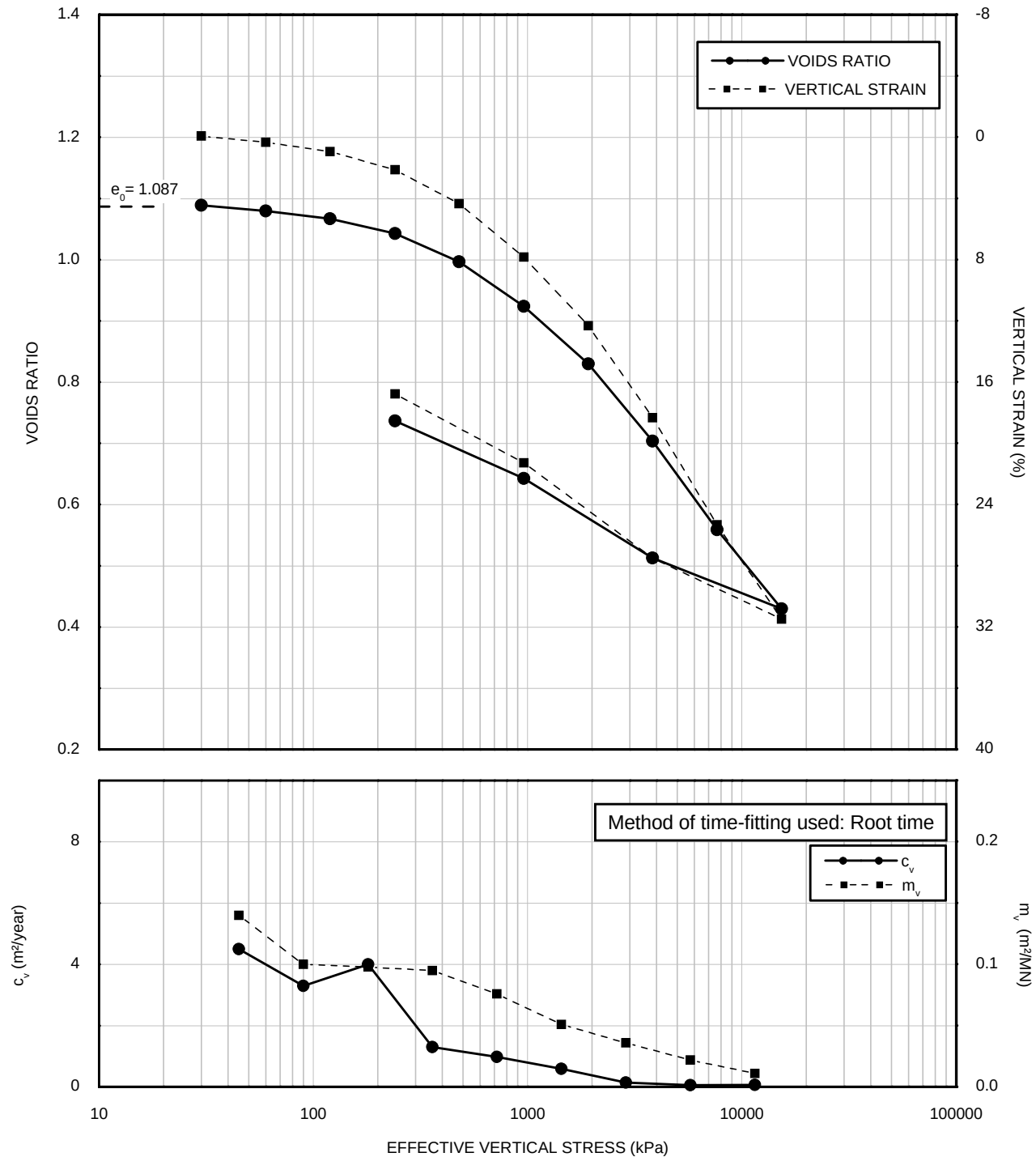
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 19.1 mm	Bulk density : 2.00 Mg/m³
Specimen diameter	: 37.3 mm	
Degree of saturation	: 90 %	Dry density : 1.65 Mg/m³
Particle density	: 2.71 Mg/m³	
	(Measured)	Moisture content : 21 %
Specimen condition	: Undisturbed	
Method of time fitting	: Root Time Method	Lab. temperature : 20 °C
		Swelling pressure : NA kPa
		Borehole : BH_13
		Sample : 24WaxA
		Depth (m): 40.05

Tested in accordance with BS1377: Part 5: 1990: Clause 3

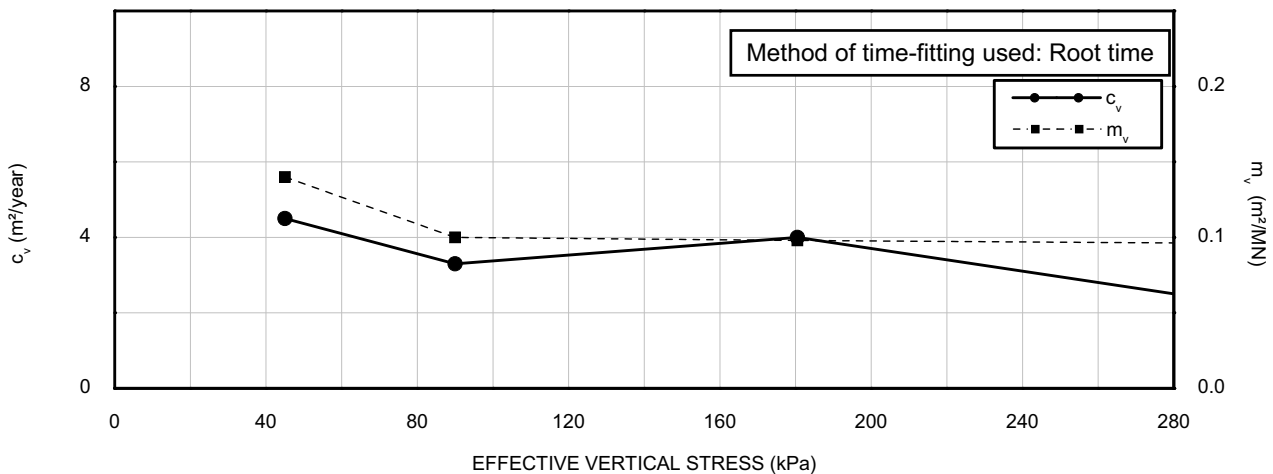
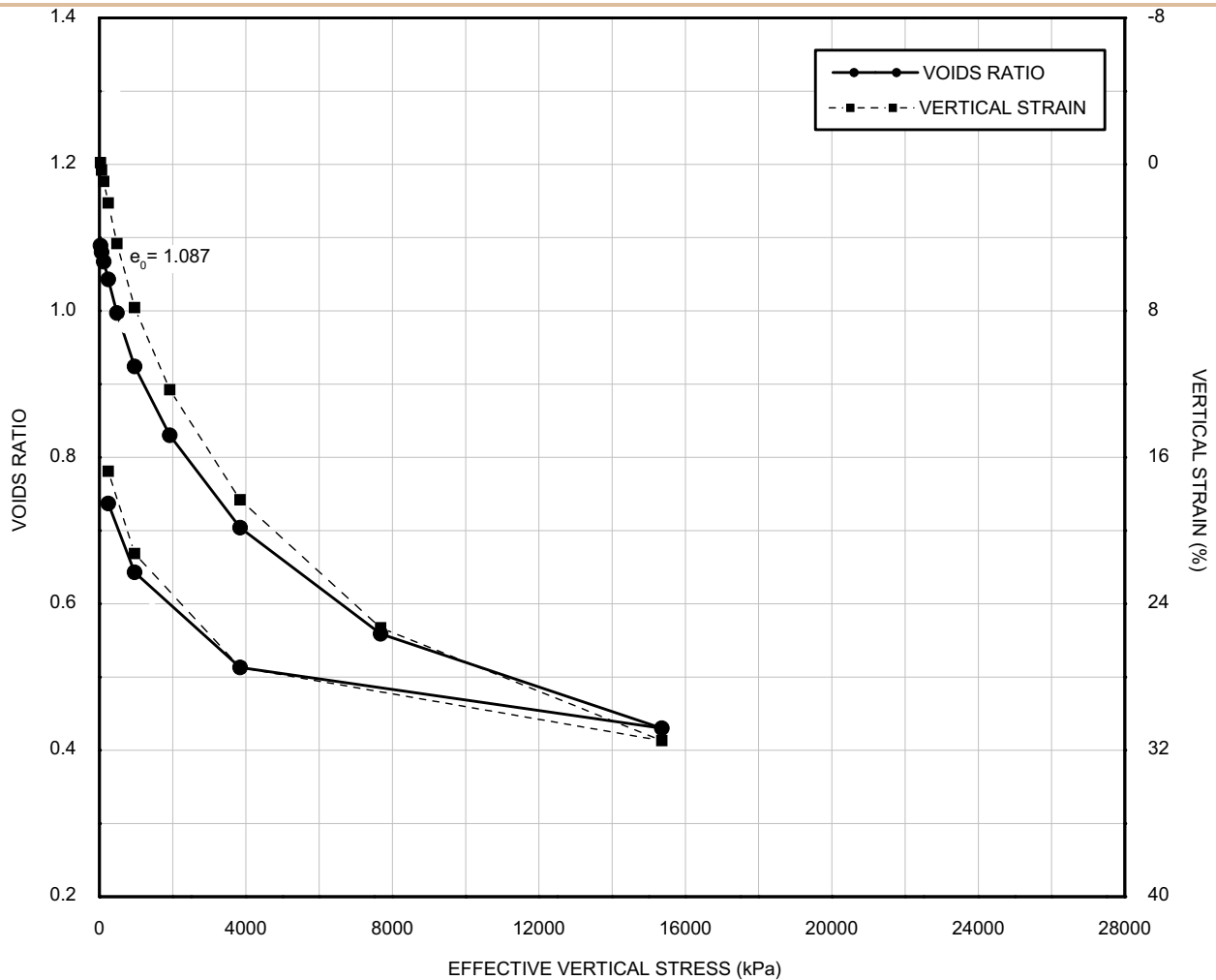
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.2 mm	Bulk density : 1.83 Mg/m³	Borehole : BH_14 Sample : 4WaxA Depth (m) : 7.40
Specimen diameter : 50.1 mm	Dry density : 1.32 Mg/m³	
Degree of saturation : 99 %	Moisture content : 39 %	
Particle density : 2.75 Mg/m³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

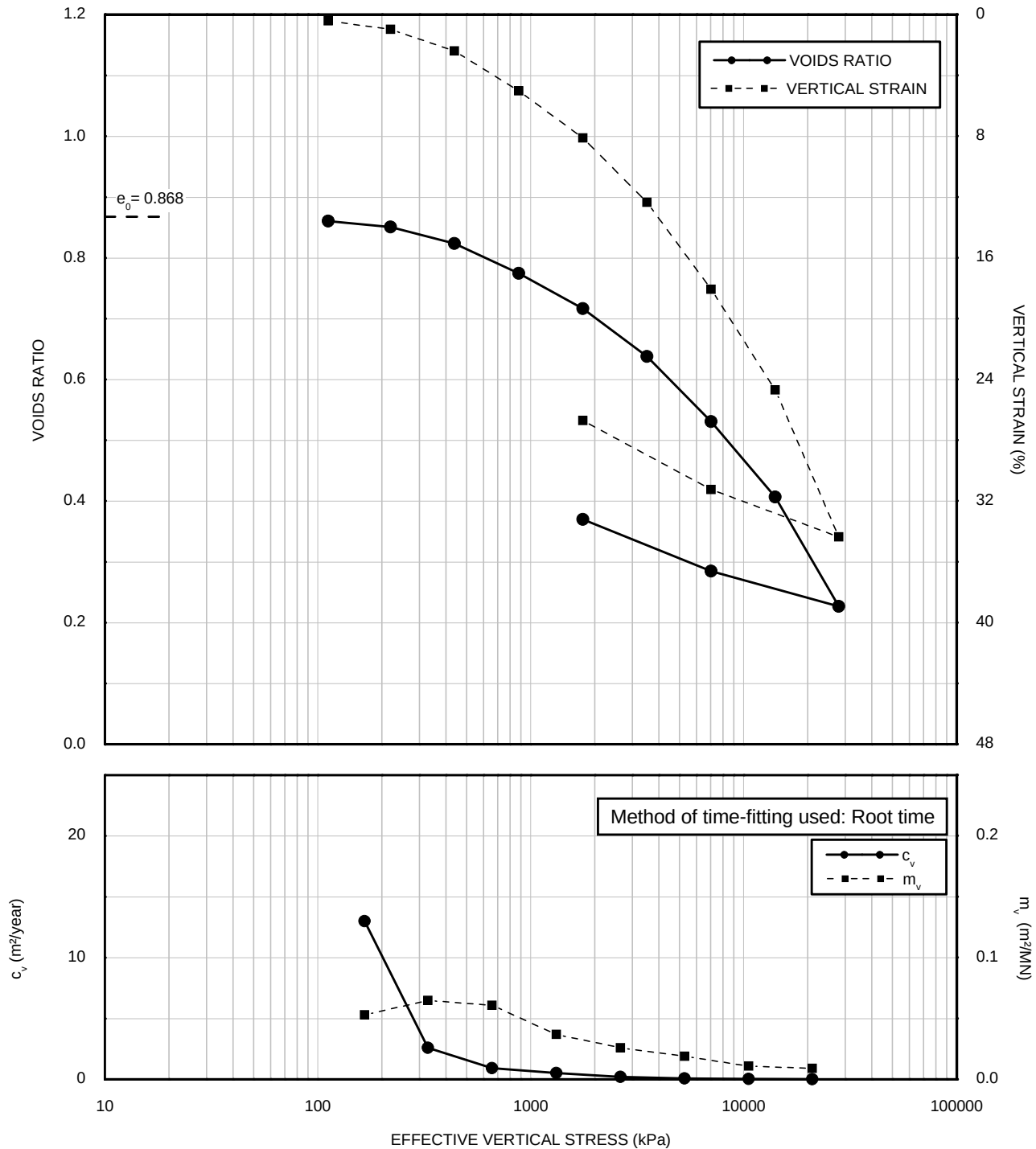
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 19.2 mm	Bulk density : 1.83 Mg/m³
Specimen diameter	: 50.1 mm	
Degree of saturation	: 99 %	Dry density : 1.32 Mg/m³
Particle density	: 2.75 Mg/m³	Moisture content : 39 %
	(Measured)	Lab. temperature : 20 °C
Specimen condition	: Undisturbed	Swelling pressure : NA kPa
Method of time fitting	: Root Time Method	
		Borehole : BH_14
		Sample : 4WaxA
		Depth (m): 7.40

Tested in accordance with BS1377: Part 5: 1990: Clause 3

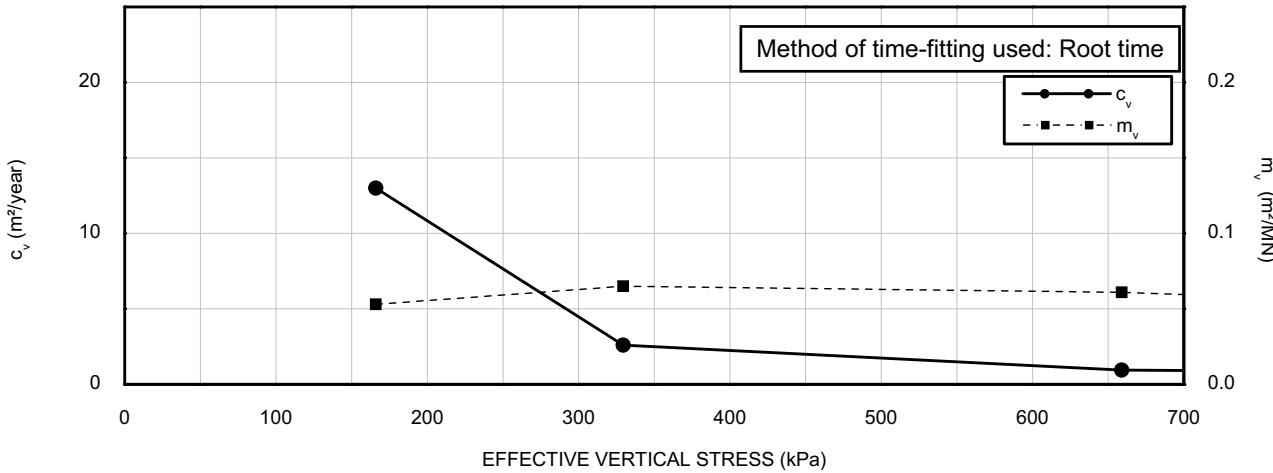
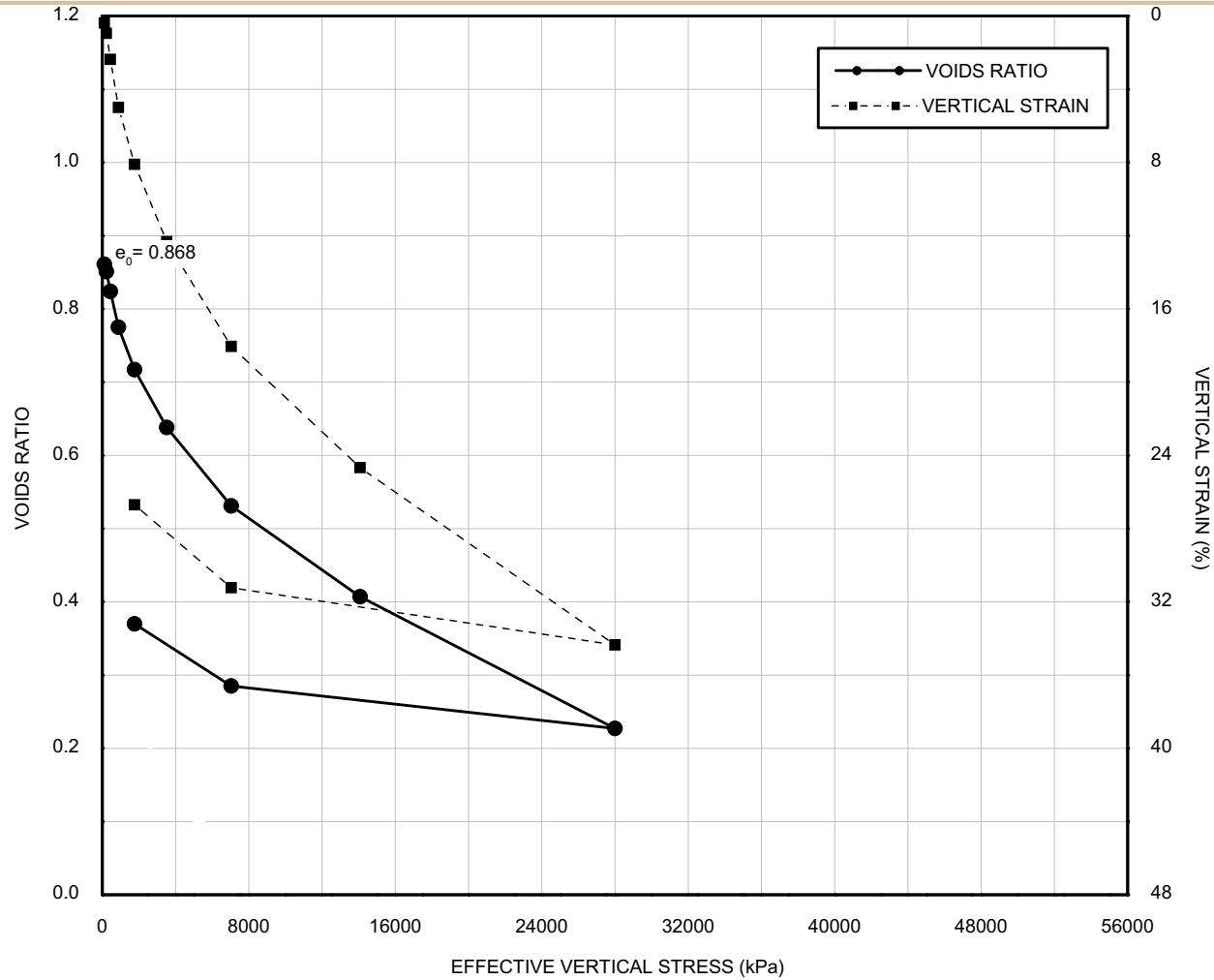
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 18.9 mm	Bulk density : 1.91 Mg/m ³	Borehole : BH_14 Sample : 11WaxA Depth (m) : 25.50
Specimen diameter : 37.2 mm	Dry density : 1.46 Mg/m ³	
Degree of saturation : 96 %	Moisture content : 30 %	
Particle density : 2.73 Mg/m ³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

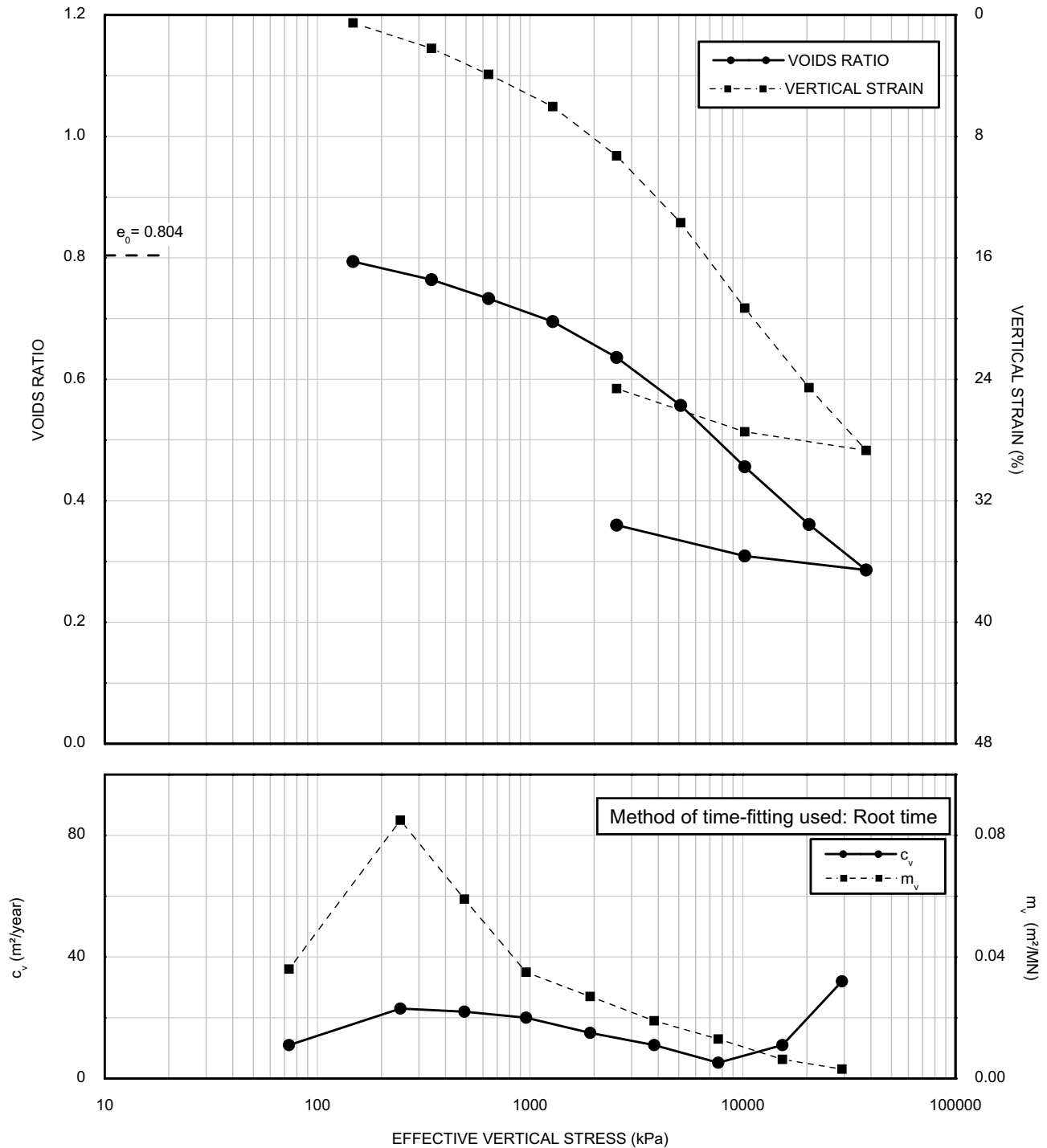
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 18.9 mm	Bulk density : 1.91 Mg/m³
Specimen diameter	: 37.2 mm	
Degree of saturation	: 96 %	Dry density : 1.46 Mg/m³
Particle density	: 2.73 Mg/m³	
	(Measured)	Moisture content : 30 %
Specimen condition	: Undisturbed	Lab. temperature : 20 °C
Method of time fitting	: Root Time Method	Swelling pressure : NA kPa
		Borehole : BH_14
		Sample : 11WaxA
		Depth (m): 25.50

Tested in accordance with BS1377: Part 5: 1990: Clause 3

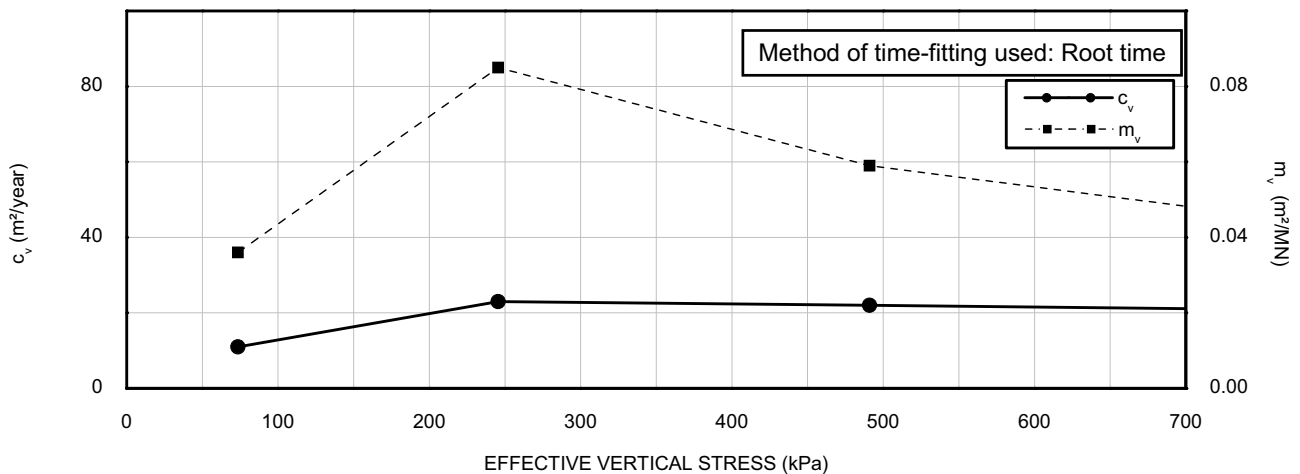
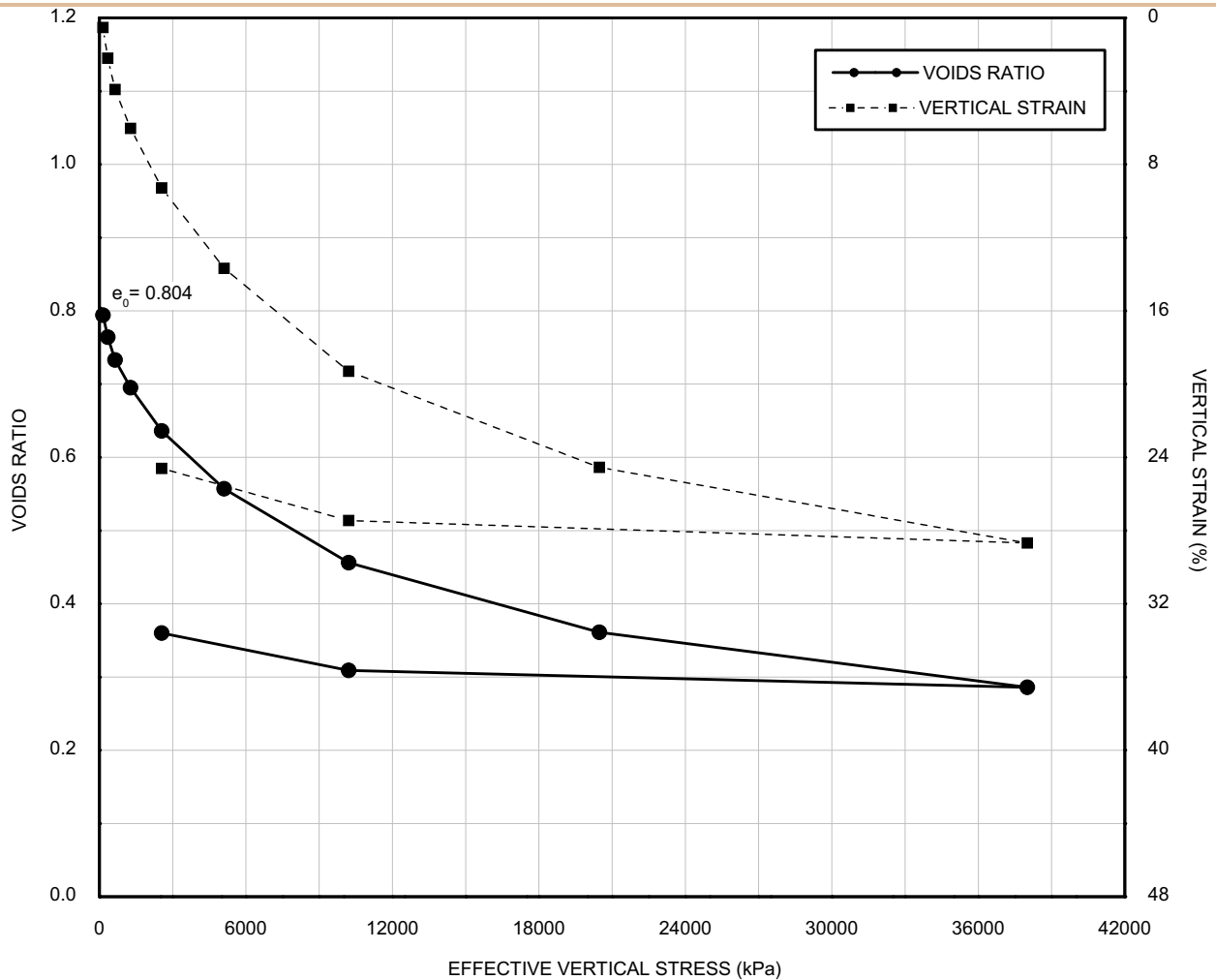
ONE - DIMENSIONAL
CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.91 Mg/m ³	Borehole : BH_14 Sample : 15WaxA Depth (m) : 35.10
Specimen diameter : 37.3 mm	Dry density : 1.50 Mg/m ³	
Degree of saturation : 92 %	Moisture content : 27 %	
Particle density : 2.70 Mg/m ³ (Assumed)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

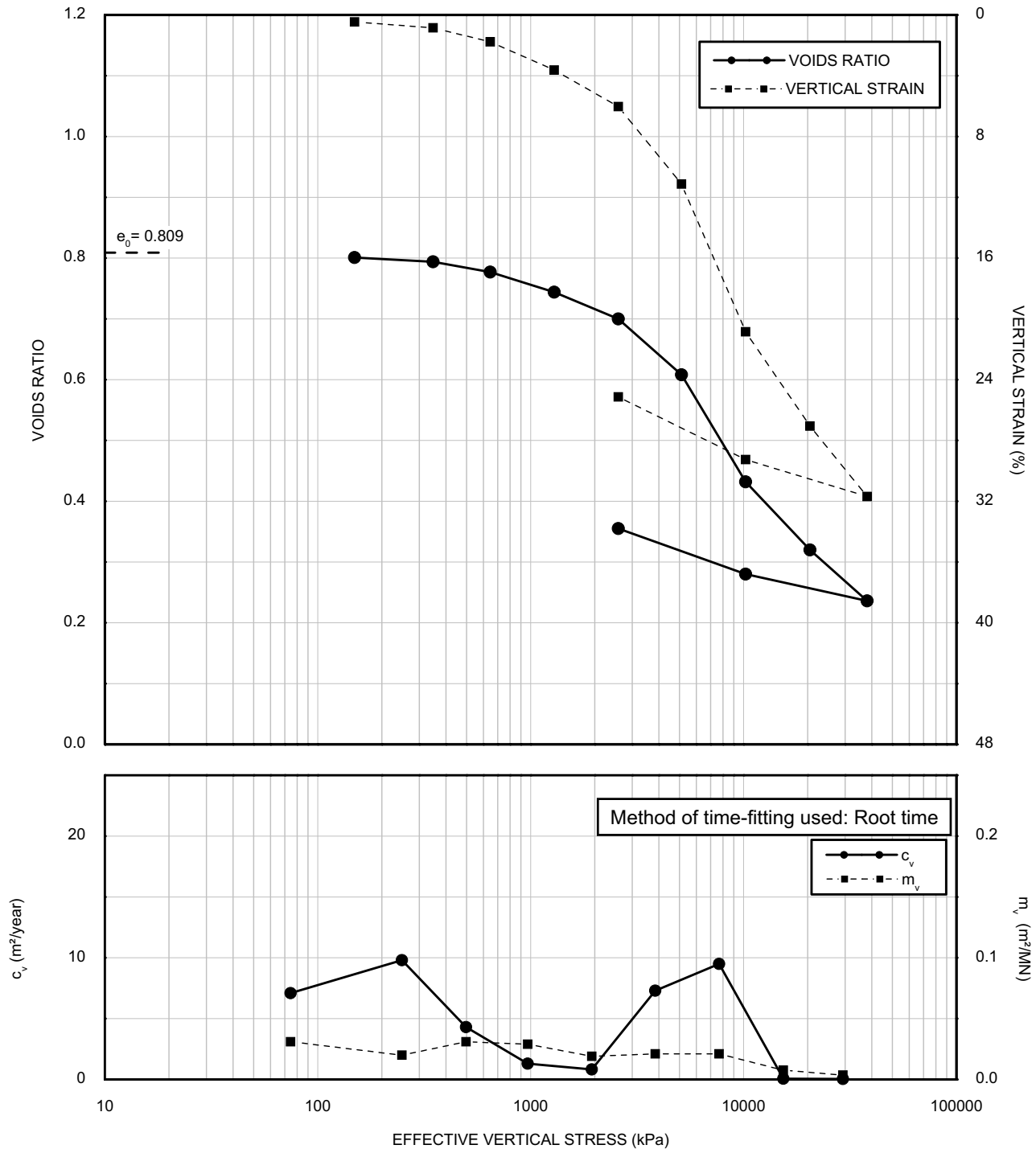
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 19.0 mm	Bulk density : 1.91 Mg/m³
Specimen diameter	: 37.3 mm	
Degree of saturation	: 92 %	Dry density : 1.50 Mg/m³
Particle density	: 2.70 Mg/m³	
	(Assumed)	Moisture content : 27 %
Specimen condition	: Undisturbed	Lab. temperature : 20 °C
Method of time fitting	: Root Time Method	Swelling pressure : NA kPa
		Borehole : BH_14
		Sample : 15WaxA
		Depth (m): 35.10

Tested in accordance with BS1377: Part 5: 1990: Clause 3

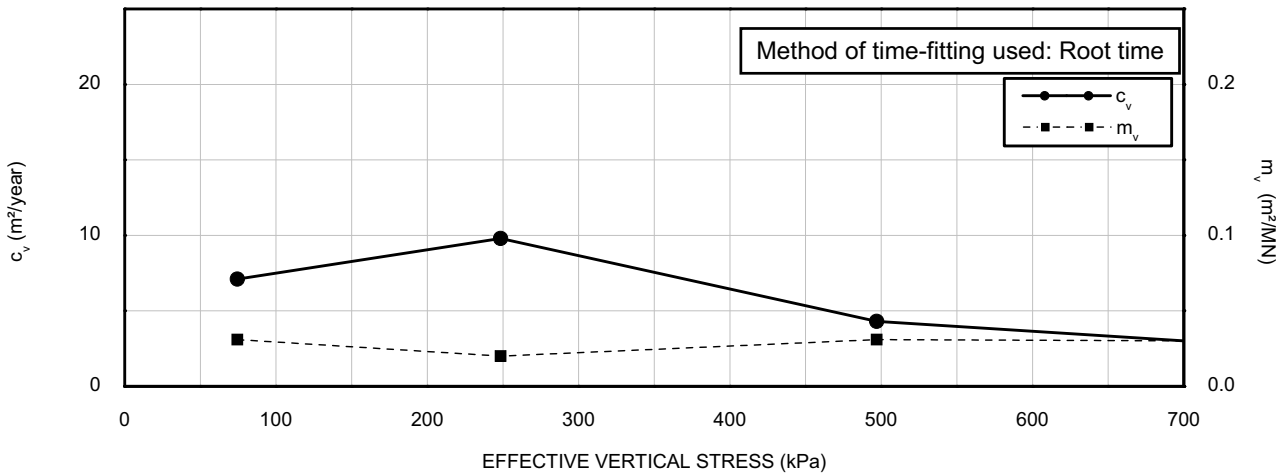
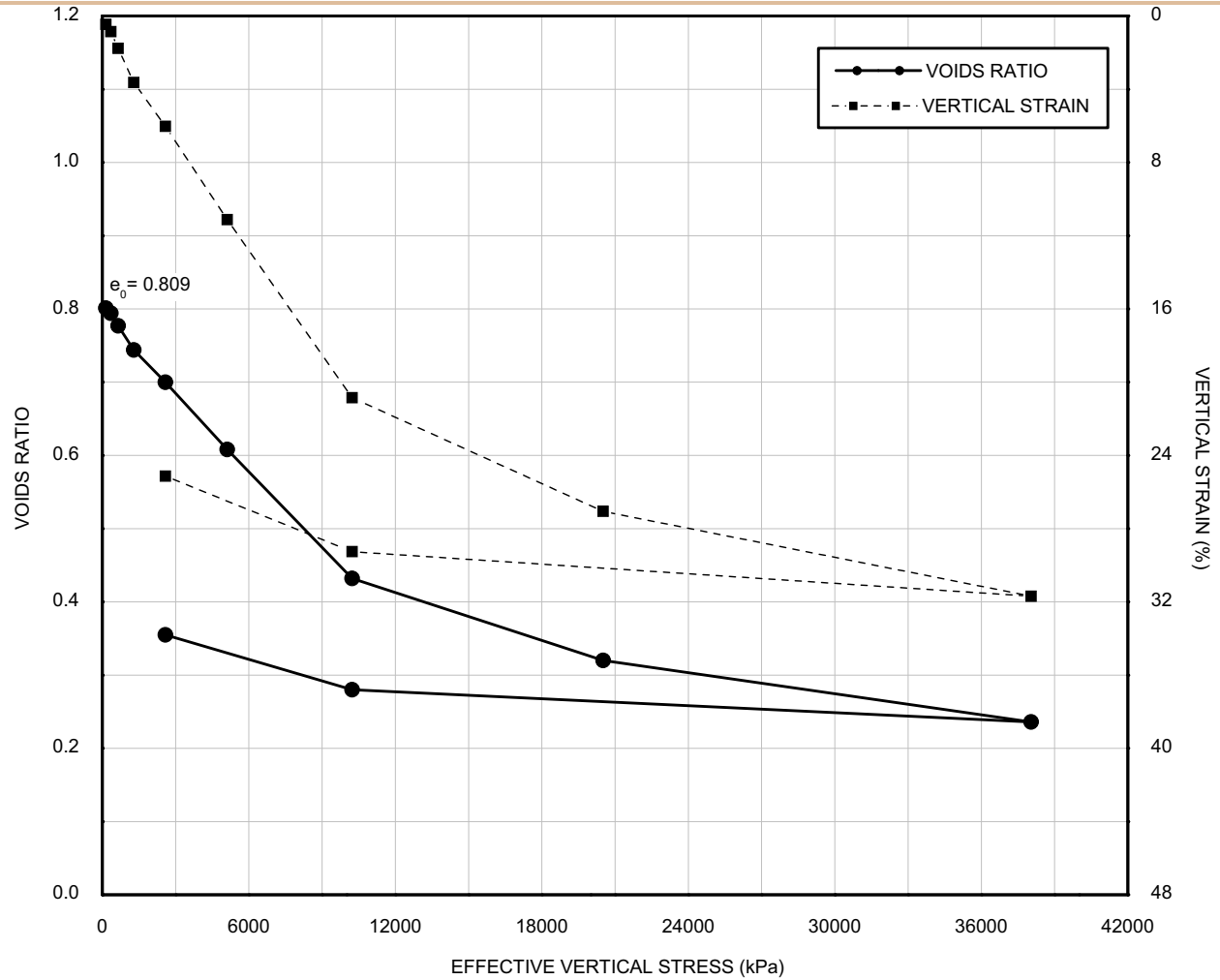
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.2 mm	Bulk density : 1.95 Mg/m ³	Borehole : BH_14 Sample : 16WaxA Depth (m) : 36.30
Specimen diameter : 37.3 mm	Dry density : 1.49 Mg/m ³	
Degree of saturation : 100 %	Moisture content : 30 %	
Particle density : 2.70 Mg/m ³ (Assumed)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

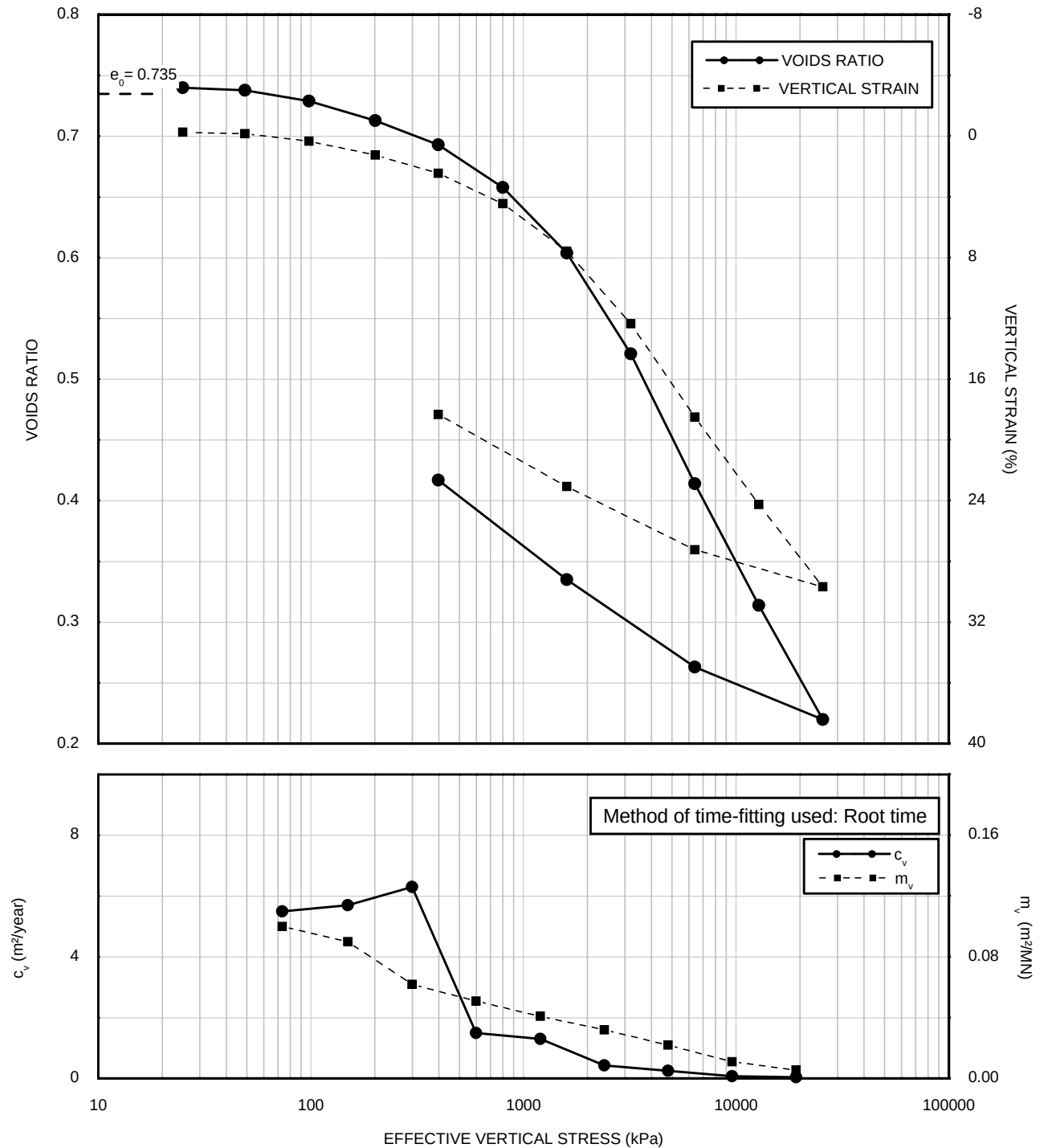
**ONE - DIMENSIONAL
CONSOLIDATION TEST (OEDOMETER)**



Initial Conditions		
Specimen height	: 19.2 mm	Bulk density : 1.95 Mg/m³
Specimen diameter	: 37.3 mm	
Degree of saturation	: 100 %	Dry density : 1.49 Mg/m³
Particle density	: 2.70 Mg/m³	
	(Assumed)	Moisture content : 30 %
Specimen condition	: Undisturbed	Lab. temperature : 20 °C
Method of time fitting	: Root Time Method	Swelling pressure : NA kPa
		Borehole : BH_14
		Sample : 16WaxA
		Depth (m): 36.30

Tested in accordance with BS1377: Part 5: 1990: Clause 3

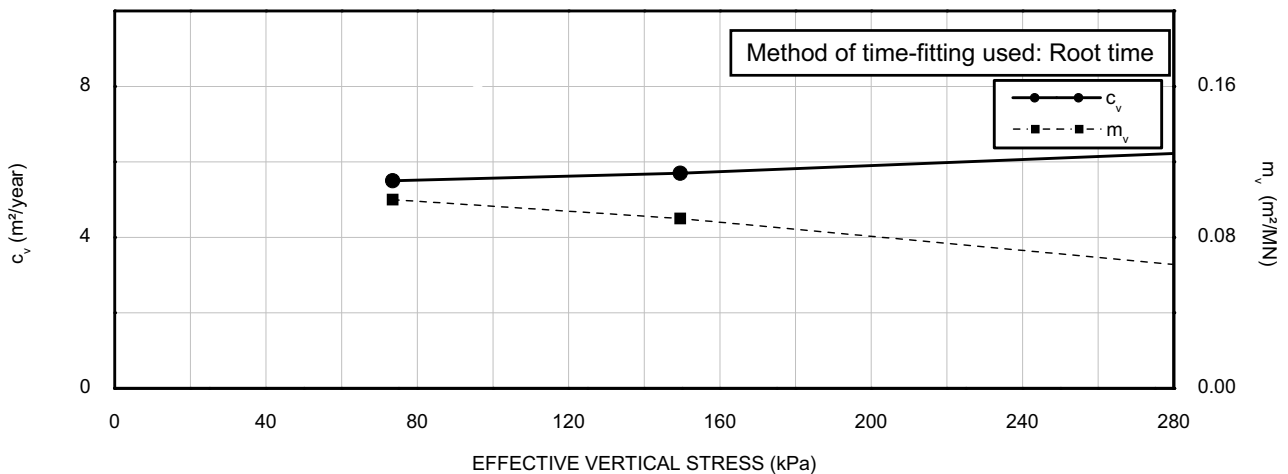
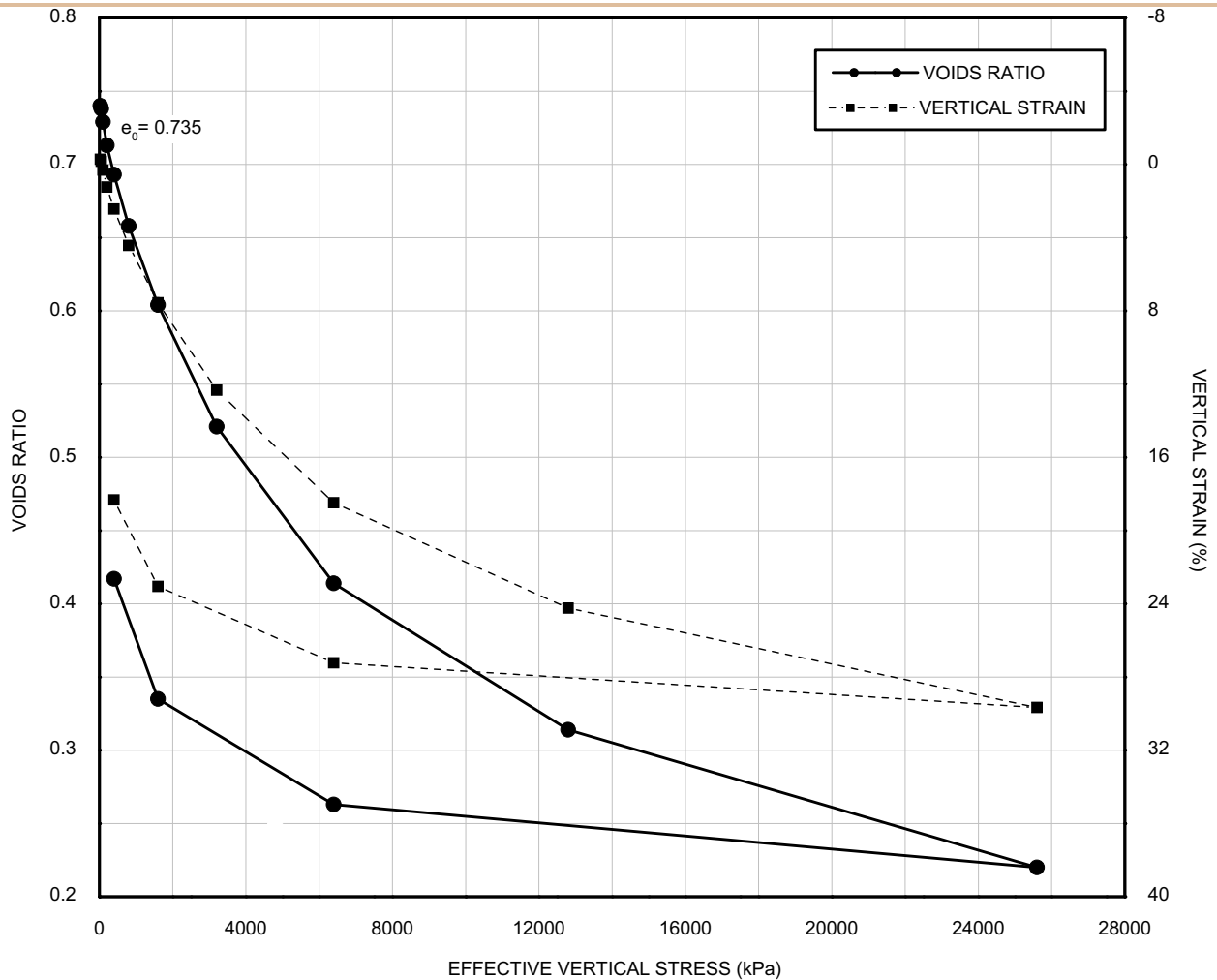
ONE - DIMENSIONAL
CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.98 Mg/m³	Borehole : BH_02 Sample : 2WaxB Depth (m) : 7.50
Specimen diameter : 37.3 mm	Dry density : 1.57 Mg/m³	
Degree of saturation : 96 %	Moisture content : 26 %	
Particle density : 2.73 Mg/m³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

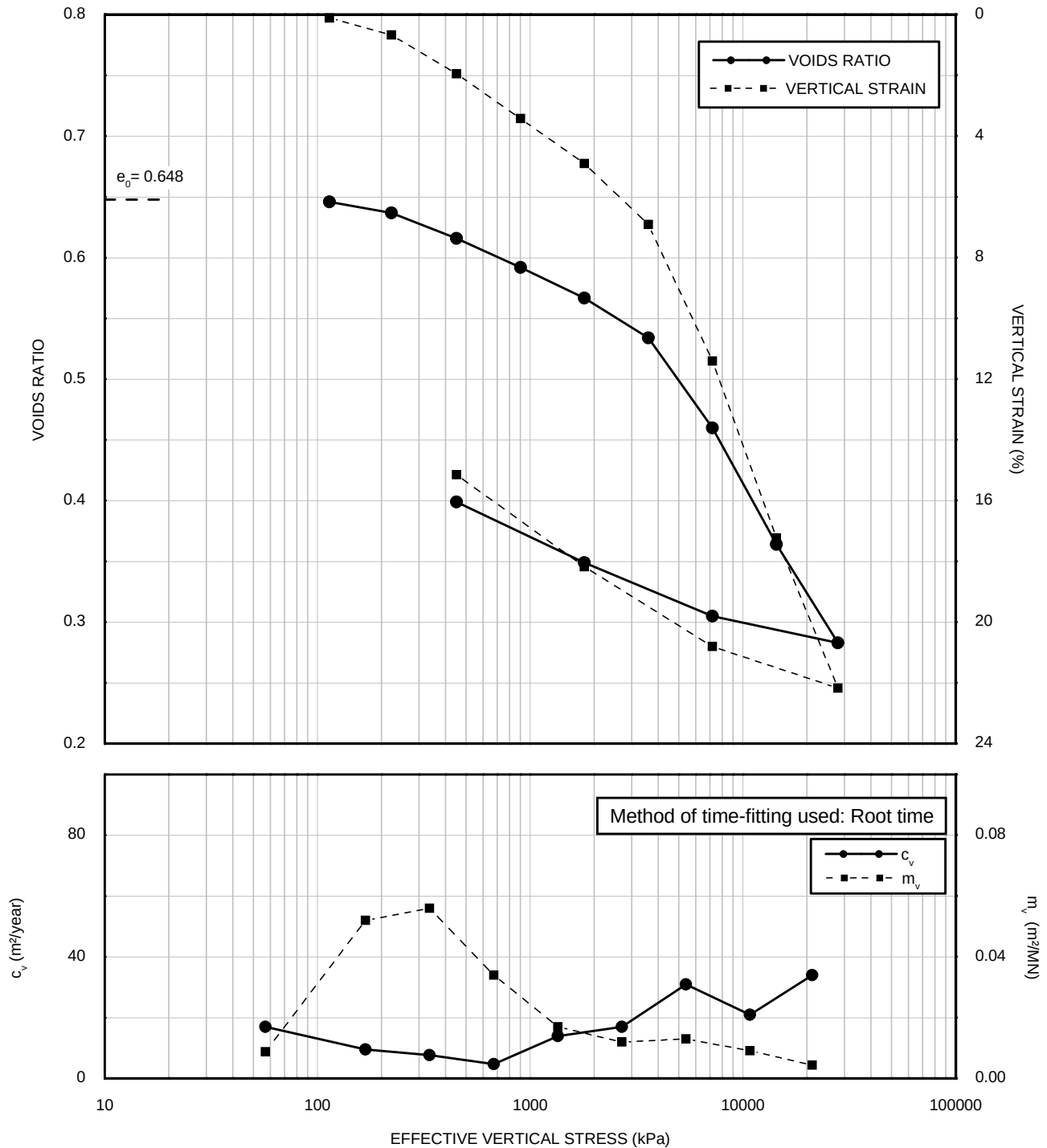
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.98 Mg/m³	Borehole : BH_02
Specimen diameter : 37.3 mm	Dry density : 1.57 Mg/m³	
Degree of saturation : 96 %	Moisture content : 26 %	Sample : 2WaxB
Particle density : 2.73 Mg/m³	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	Depth (m): 7.50
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

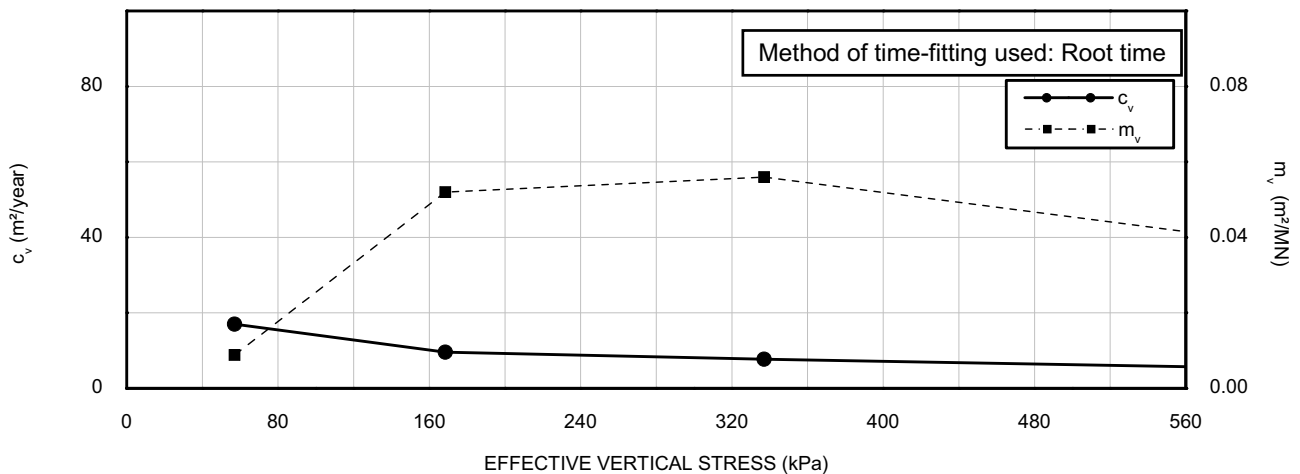
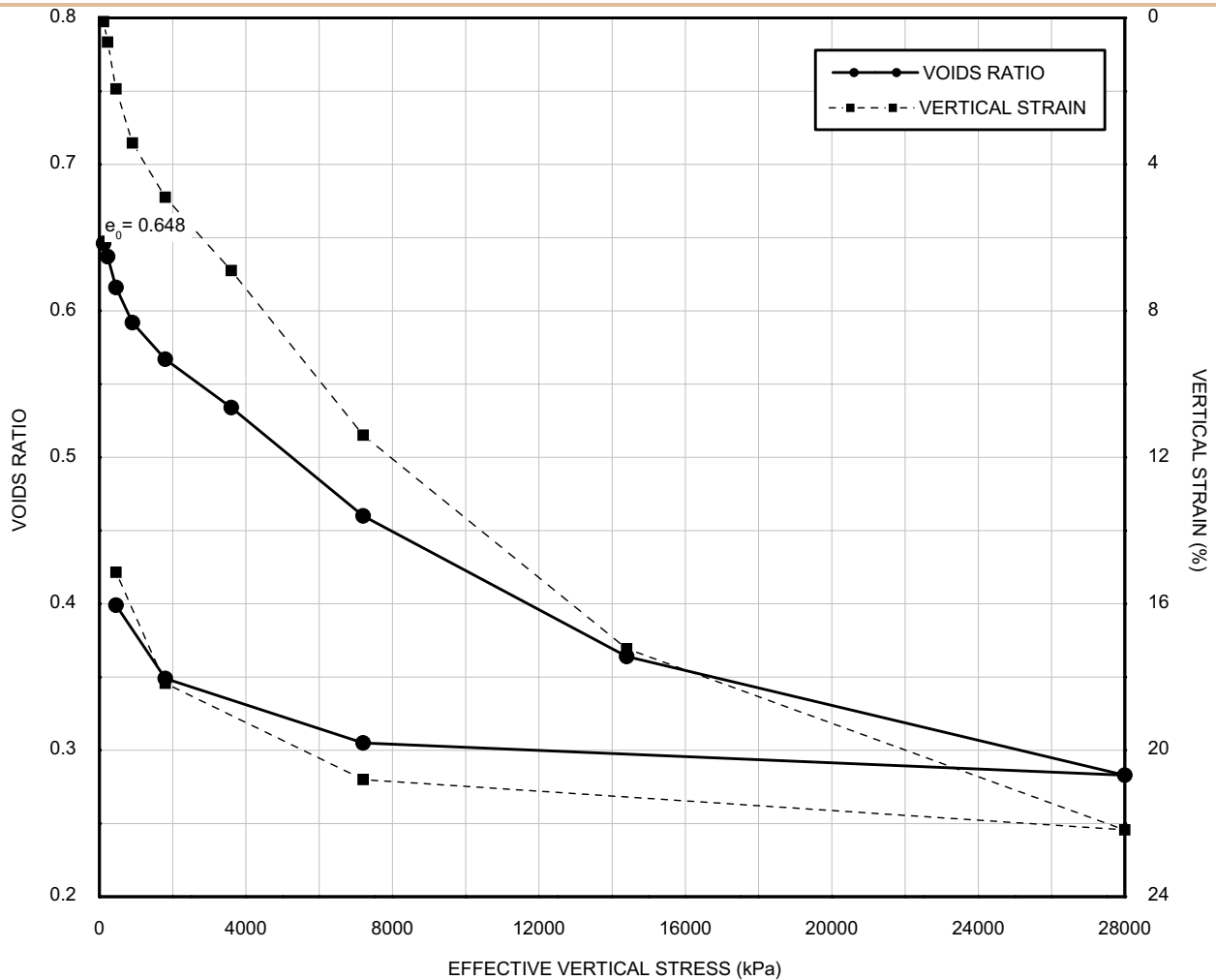
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 19.0 mm	Borehole : BH_04 Sample : 14WaxA Depth (m) : 27.00
Specimen diameter	: 37.2 mm	
Degree of saturation	: 94 %	
Particle density	: 2.70 Mg/m ³ (Assumed)	
Specimen condition	: Undisturbed	
Method of time fitting	: Root Time Method	
Bulk density	: 2.01 Mg/m ³	
Dry density	: 1.64 Mg/m ³	
Moisture content	: 23 %	
Lab. temperature	: 20 °C	
Swelling pressure	: NA kPa	

Tested in accordance with BS1377: Part 5: 1990: Clause 3

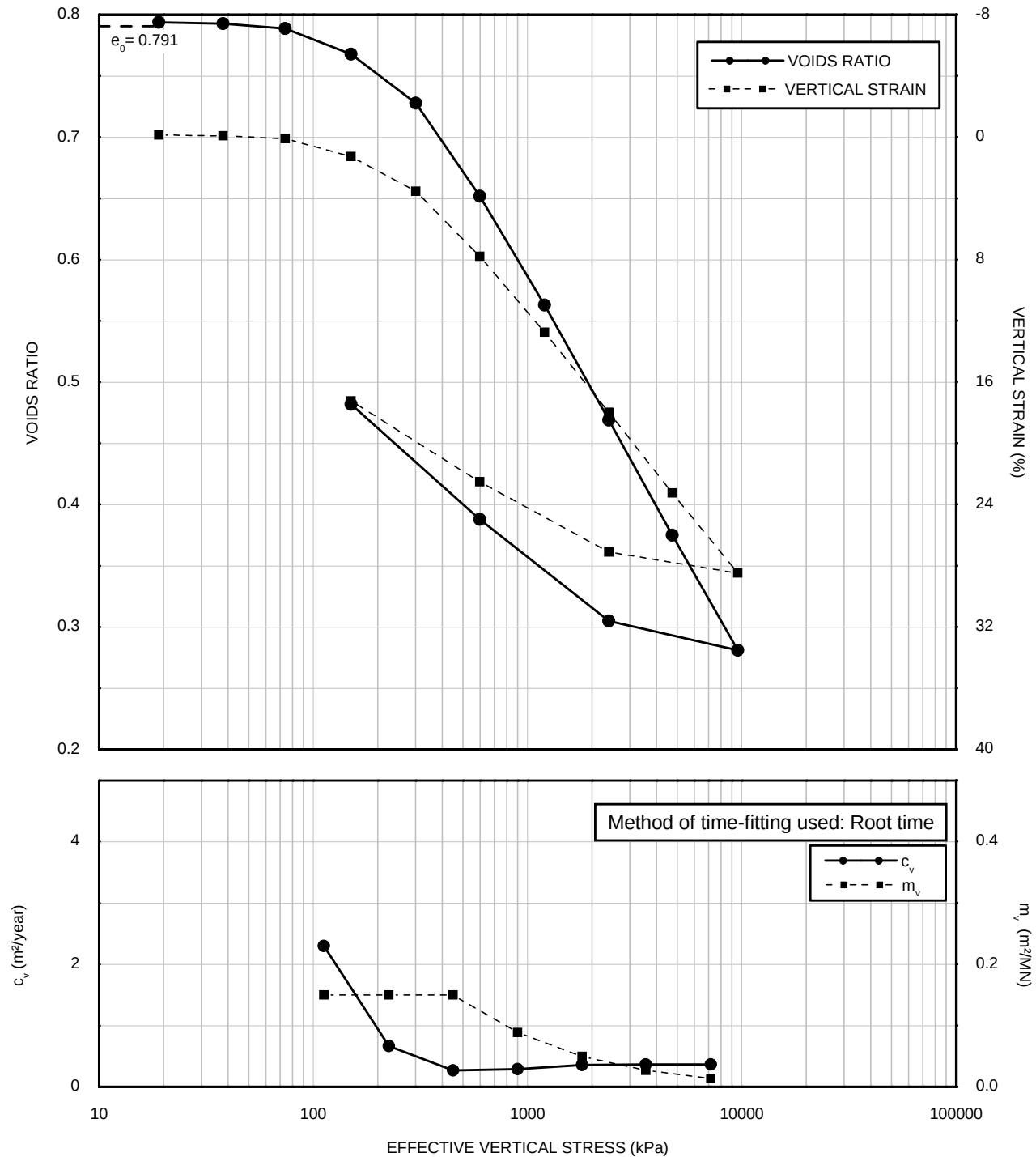
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 19.0 mm	Borehole : BH_04 Sample : 14WaxA Depth (m): 27.00
Specimen diameter	: 37.2 mm	
Degree of saturation	: 94 %	
Particle density	: 2.70 Mg/m³	
Specimen condition	: Undisturbed	
Method of time fitting	: Root Time Method	
Bulk density	: 2.01 Mg/m³	
Dry density	: 1.64 Mg/m³	
Moisture content	: 23 %	
Lab. temperature	: 20 °C	
Swelling pressure	: NA kPa	

Tested in accordance with BS1377: Part 5: 1990: Clause 3

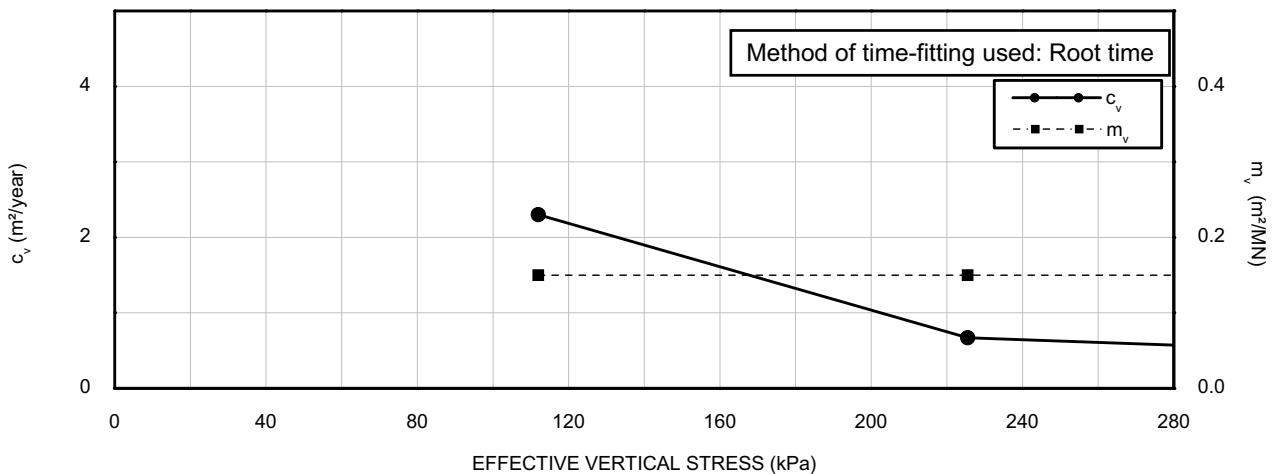
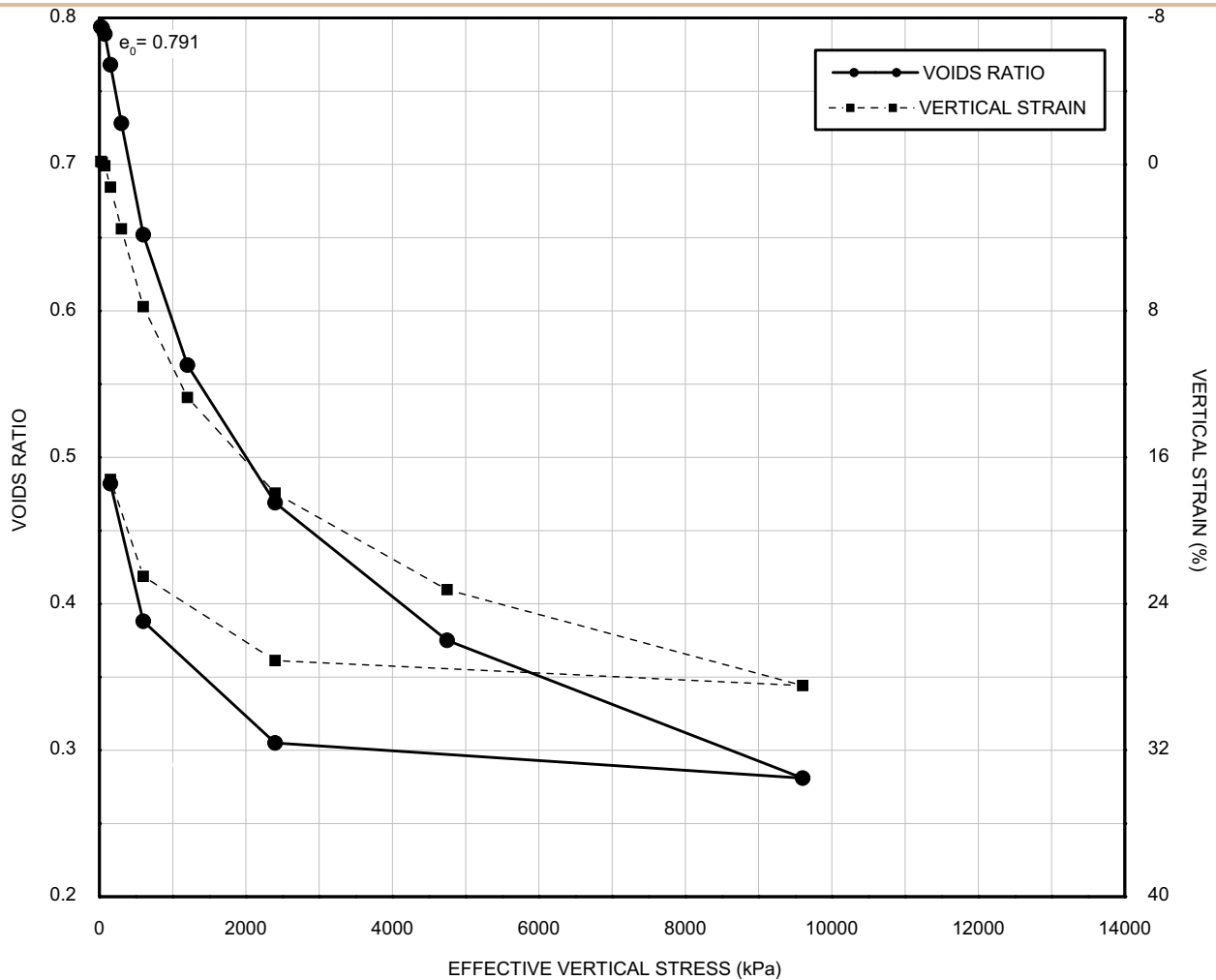
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.94 Mg/m³	Borehole : BH_06 Sample : 1WaxA Depth (m) : 3.15
Specimen diameter : 50.1 mm	Dry density : 1.51 Mg/m³	
Degree of saturation : 97 %	Moisture content : 28 %	
Particle density : 2.70 Mg/m³ (Assumed)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

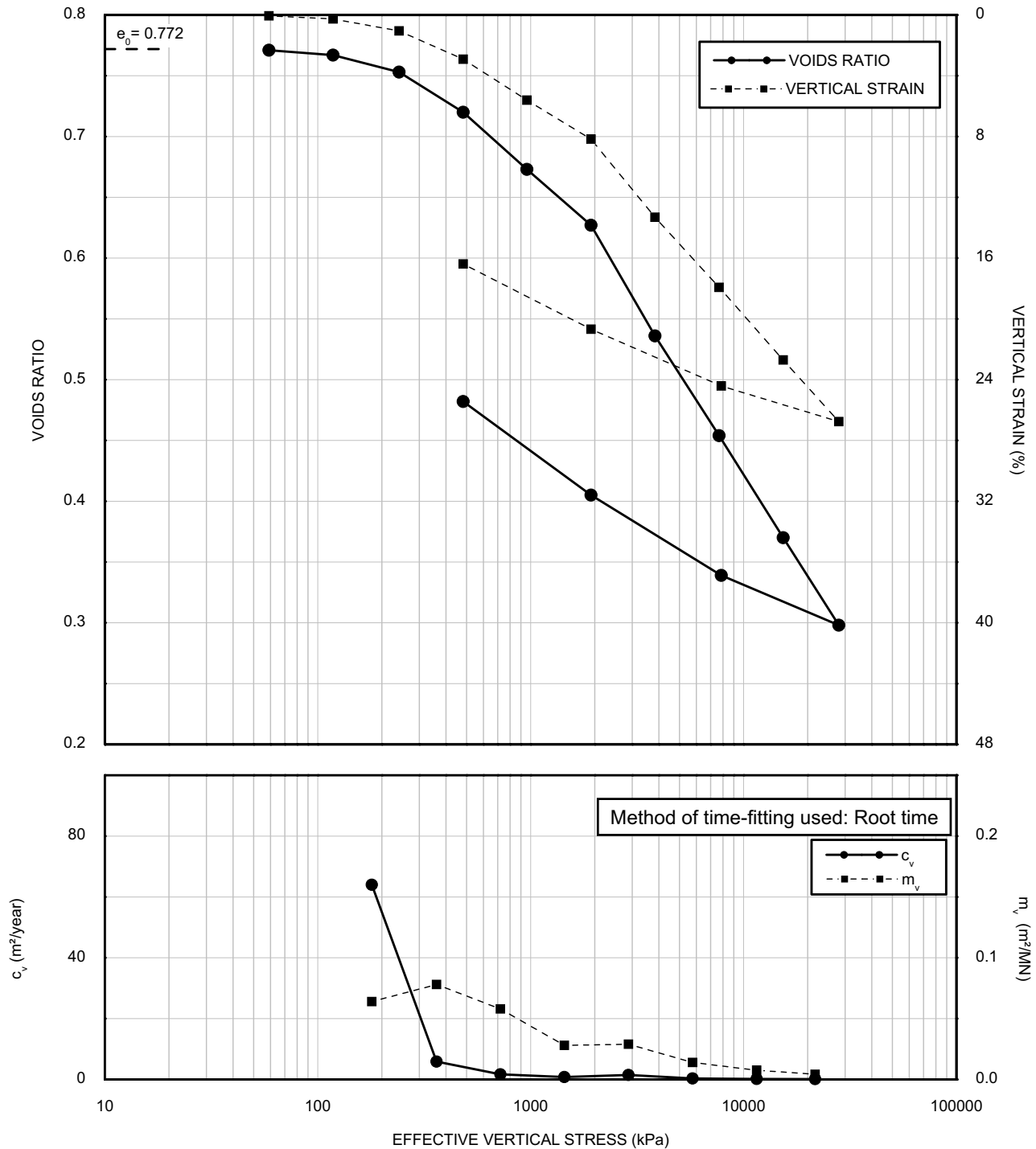
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.0 mm	Bulk density : 1.94 Mg/m ³	Borehole : BH_06
Specimen diameter : 50.1 mm	Dry density : 1.51 Mg/m ³	
Degree of saturation : 97 %	Moisture content : 28 %	Sample : 1WaxA
Particle density : 2.70 Mg/m ³	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	Depth (m): 3.15
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

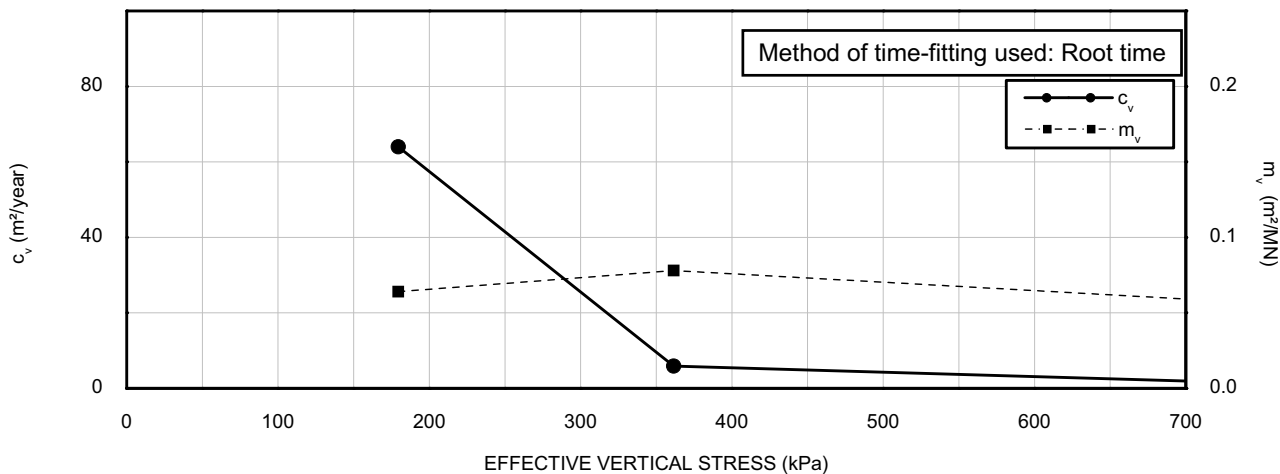
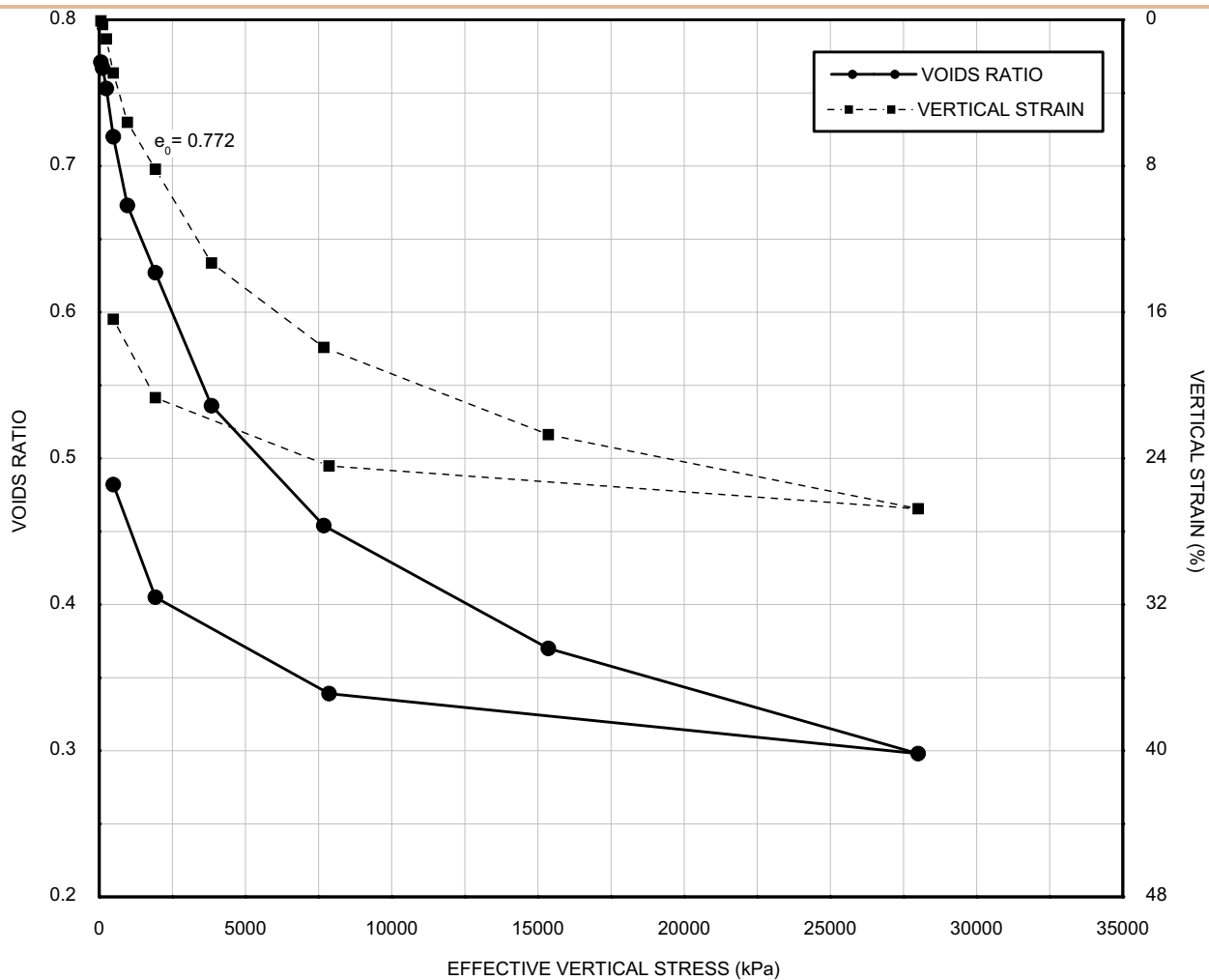
ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height : 19.1 mm	Bulk density : 1.98 Mg/m ³	Borehole : BH_06
Specimen diameter : 37.1 mm	Dry density : 1.58 Mg/m ³	
Degree of saturation : 93 %	Moisture content : 26 %	Sample : 9WaxA
Particle density : 2.80 Mg/m ³ (Measured)	Lab. temperature : 20 °C	
Specimen condition : Undisturbed	Swelling pressure : NA kPa	Depth (m) : 18.10
Method of time fitting : Root Time Method		

Tested in accordance with BS1377: Part 5: 1990: Clause 3

ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)



Initial Conditions		
Specimen height	: 19.1 mm	Borehole : BH_06 Sample : 9WaxA Depth (m): 18.10
Specimen diameter	: 37.1 mm	
Degree of saturation	: 93 %	
Particle density	: 2.80 Mg/m ³	
Specimen condition	: Undisturbed	
Method of time fitting	: Root Time Method	
Bulk density	: 1.98 Mg/m ³	
Dry density	: 1.58 Mg/m ³	
Moisture content	: 26 %	
Lab. temperature	: 20 °C	
Swelling pressure	: NA kPa	

Tested in accordance with BS1377: Part 5: 1990: Clause 3

ONE - DIMENSIONAL CONSOLIDATION TEST (OEDOMETER)

SECTION B.4

CONSOLIDATED TRIAXIAL TESTS

B.4	CONSOLIDATED TRIAXIAL TESTS	1
B.4.1	SUMMARY	1
B.4.2	CONSOLIDATED TRIAXIAL TESTS	1

B.4 CONSOLIDATED TRIAXIAL TESTS

B.4.1 SUMMARY

Effective stress testing was performed to complement offshore strength testing and provide additional data to be used for design. All samples were consolidated to a best estimate of their in-situ stress conditions based on overburden and lateral earth pressures, derived from the effective overburden pressure and undrained shear strength relationship. Details of the laboratory test procedures are presented in Section B.11.

B.4.2 CONSOLIDATED TRIAXIAL TESTS

B.4.2.1 Cohesive Soils

Three (3) undrained anisotropically consolidated compression (CAUc) tests and five (5) undrained isotropically consolidated (CIU) tests were performed on selected samples of cohesive soil across the Rampion site. The results are summarised on Plate B.4-1 and individual results are presented on Plates B.4-4 to B.4-51.

B.4.2.2 Cohesionless Soils

Seven (7) 'set of three' drained isotropically consolidated (CID) tests and one (1) 'set of three' CIU test were performed on selected samples of cohesionless soil. Test specimens were prepared to an initial dry density based on an estimate of relative density at the specimen depth.

Results of these tests are summarised on Plate B.4-2 and individual tests results are presented on Plates B.4-51 to B.4-101.

B.4.2.3 DISCUSSION OF RESULTS

As per standard FGCLTD practice for consolidated triaxial tests, unless the shear stress peaked at a lower strain, failure was taken at 10% strain.

An assessment of the sample disturbance in cohesive soils using the method specified by Lunne *et. al.*, (1998) shows the samples to be of "very good to excellent" quality across the Rampion site.

TRIAXIAL TESTS

LIST OF PLATES – SECTION B.4

Description	Plate
Summary of Consolidated Triaxial Test Results – Clay Samples	B.4-1
Summary of Consolidated Triaxial Test Results – Sand Samples	B.4-2
Consolidated Compression Triaxial Test Results – Clay Samples	B.4-3 to B.4-50
Consolidated Compression Triaxial Test Results – Sand Samples	B.4-51 to B.4-101

SUMMARY OF CONSOLIDATED UNDRAINED TRIAXIAL TEST RESULTS - CLAY SAMPLES

Date:

Drawn by :

Date:

Date:

Checked by:
Approved by:

BH No.	SAMPLE No.	DEPTH	TEST TYPE	INDEX PROPERTIES			CONSOLIDATION										SHEARING STAGE							NOTES																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
				w _i	ρ _{dry}	Dr _i	B	σ _{cell}	σ _{back}	σ' _c	ε _{vc}	ε _{vo}	w _f	ρ _{dry}	50% peak σ _d	Δu _f	ε _{v-f}	ε ₅₀	E ₅₀	A _f	c'	φ'																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
		(m)		(%)	(Mg/m ³)	(%)	(-)	(kPa)	(kPa)	(kPa)	(%)	(%)	(%)	(Mg/m ³)	(kPa)	(kPa)	(%)	(MPa)	(-)	(kPa)	(°)																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
BH_13	9BagA	18.00	CID	9.5	1.60	70	0.97	415	300	115	0.44	2.26	24	1.62	138	0	10.00	0.67	20	0	0	33																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				9.5	1.60	70	0.98	530	300	230	0.72	2.56	23	1.64	267	0	10.00	1.30	21	0	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				9.8	1.59	70	0.95	860	400	460	1.02	2.95	23	1.64	538	0	10.00	1.57	34	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BH_13	21BagB	33.10	CID	9.8	1.77	80	0.98	500	300	200	1.59	0.53	16	1.85	324	0	4.32	1.32	24	0		32																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				9.8	1.76	80	1.00	700	300	400	2.32	1.21	15	1.89	586	0	4.52	1.17	50	0	59																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				9.8	1.76	80	0.94	1100	300	800	2.69	2.67	15	1.91	1004	0	9.24	1.28	78	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BH_14	2BagA	2.50	CID	10.0	1.74	80	1.00	365	350	15	-0.06	-1.94	20	1.74	39	0	2.13	0.37	10	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
				10.0	1.74	80	1.00	330	300	30	0.08	-1.40	20	1.74	75	0	2.13	0.34	22	0	5	41																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				10.0	1.74	80	0.95	360	300	60	0.23	-0.96	19	1.75	126	0	2.51	0.61	21	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BH_14	22BagA	45.50	CID	9.0	1.73	80	0.95	575	300	275	0.40	-0.63	19	1.75	465	0	3.95	0.51	91	0		35																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				9.0	1.73	80	1.00	850	300	550	0.74	0.00	19	1.76	852	0	5.59	0.68	125	0	50																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				9.0	1.73	80	1.00	1400	300	1100	0.89	0.69	19	1.78	1584	0	8.18	0.95	167	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BH_16	2BagB	7.35	CID	9.7	1.79	50	0.95	440	400	40	0.09	-0.72	23	1.64	73	0	2.62	0.11	65	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
				9.7	1.79	50	0.94	380	300	80	0.14	-0.53	23	1.64	123	0	3.17	0.33	37	0	9	35																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				9.9	1.77	50	0.96	460	300	160	0.36	-0.35	24	1.63	229	0	4.79	0.85	27	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BH_16	5BagA	18.50	CID	11.0	1.77	90	0.95	500	400	100	0.29	-1.13	18	1.78	218	0	2.60	0.61	36	0		41																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				11.0	1.77	90	0.92	600	400	200	0.37	-0.91	18	1.79	424	0	2.74	0.52	82	0	16																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				11.0	1.78	90	0.91	800	400	400	0.86	-0.65	17	1.82	781	0	2.99	0.70	112	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BH_16	19BAGA	38.50	CIU	10.0	1.90	90	0.96	620	400	220	3.21	9.06	11	2.09	264	10	10.00	1.39	19	0.03		32																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				10.0	1.91	90	0.99	840	400	440	3.10	8.77	11	2.10	302	198	10.00	0.57	53	1.18	5																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				10.0	1.90	90	0.98	1280	400	880	3.13	8.85	11	2.09	564	396	10.00	0.58	98	1.58																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								
BH_16	22BagA	44.00	CID	10.1	1.93	90	0.96	650	400	250	7.53	19.63	10	2.07	332	0	7.68	1.13	29	0		31																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																						
				10.1	1.93	90	0.96	900	400	500	3.96	11.01	10	2.11	652	0	8.00	1.49	44	0	56																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																							
				10.1	1.93	90	0.99	1400	400	1000	4.53	12.47	10	2.21	1120	0	10.00	1.37	82	0																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																								

Notes: Failure is taken at 10% shear strain when testing continued beyond 10% and did not reach failure are marked with an *.

SUMMARY OF CONSOLIDATED TRIAXIAL TEST RESULTS - SAND SAMPLES

Date: 24/05/2011

Drawn by: NAC

Template Issue: 3

Filename: J11056 / EFFECTIVE / BH_13_6WaxB_ca.XLS

Date: 25/05/2011

Date:

Checked by: PH

Approved by:

VISUAL DESCRIPTION

Stiff to very stiff dark grey CLAY with pockets of fine sand.

GENERAL

Date test started	10/05
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL

Diameter	(mm)	73.2
Length	(mm)	127.6
Moisture content	(%)	23
Bulk density	(Mg/m ³)	1.91
Dry density	(Mg/m ³)	1.55
Voids ratio		0.740
Degree of saturation	(%)	83

SATURATION

Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	547
Cell pressure on completion	(kPa)	551
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	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	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_13
Sample	6WaxB
Depth (m)	13.07

SUMMARY OF ANISOTROPICALLY CONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN

Drawn by: NAC
Date: 24/05/2011

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	551
Back pressure	(kPa)	300
Effective cell pressure	(kPa)	251
Pore pressure on completion	(kPa)	300
Pore pressure dissipation	(%)	100
Moisture content	(%)	19
Bulk density	(Mg/m ³)	1.97
Dry density	(Mg/m ³)	1.66
Voids ratio		0.623
Degree of saturation	(%)	80

Template Issue: 3
Filename: J11056 / EFFECTIVE / BH_13_6WaxB_ca.XLS

CONSOLIDATION : ANISOTROPIC		
Cell pressure	(kPa)	551
Back pressure	(kPa)	300
Axial pressure	(kPa)	428
Effective cell pressure	(kPa)	251
Effective axial pressure	(kPa)	128
Pore pressure after consol	(kPa)	300
Moisture content	(%)	18
Bulk density	(Mg/m ³)	1.98
Dry density	(Mg/m ³)	1.67
Voids ratio		0.617
Degree of saturation	(%)	80
Volumetric strain	(%)	7.10
Axial strain	(%)	1.78

Mode of failure: Brittle failure

Checked by: PH
Approved by:
Date: 25/05/2011
Date:

Borehole	BH_13
Sample	6WaxB
Depth (m)	13.07

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 24/05/2011

Drawn by: NAC

Template Issue: 3

Filename: J11056 / EFFECTIVE / BH_13_6WaxB_ca.XLS

Date: 25/05/2011

Date:

Checked by: PH

Approved by:

SHEARING		
Initial pore pressure	(kPa)	300
Initial effective cell pressure	(kPa)	251
Rate of strain	(%/hour)	0.29
Initial deviator stress	(kPa)	-123
At peak deviator stress		
Corrected deviator stress	(kPa)	308
Membrane correction applied	(kPa)	0.0
Drain correction applied	(kPa)	0
Axial strain	(%)	5.01
Excess pore pressure	(kPa)	168
Major principal effective stress	(kPa)	391
Minor principal effective stress	(kPa)	83
Principal effective stress ratio		4.71
e 50	(%)	0.53
Secant modulus at e 50	(kPa)	40784
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	296
Membrane correction applied	(kPa)	0.0
Drain correction applied	(kPa)	0
Axial strain	(%)	4.01
Excess pore pressure	(kPa)	177
Major principal effective stress	(kPa)	370
Minor principal effective stress	(kPa)	74
Principal effective stress ratio		5.02
e 50	(%)	0.50
Secant modulus at e 50	(kPa)	42123
At 10% axial strain		
Corrected deviator stress	(kPa)	235
Membrane correction applied	(kPa)	0.0
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	166
Major principal effective stress	(kPa)	320
Minor principal effective stress	(kPa)	85
Principal effective stress ratio		3.78
e 50	(%)	0.37
Secant modulus at e 50	(kPa)	48098
FINAL CONDITIONS		
Moisture content	(%)	18
Bulk density	(Mg/m ³)	1.98
Dry density	(Mg/m ³)	1.67
Borehole		BH_13
Sample		6WaxB
Depth (m)		13.07

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: PH
Approved by:
Date: 25/05/2011
Date:
Template Issue: 3
Filename: J11056 / EFFECTIVE / BH_13_6WaxB_ca.XLS
Drawn by: NAC
Date: 24/05/2011

SPECIMEN PHOTOGRAPHS



Borehole
Sample
Depth (m)

BH_13
6WaxB
13.07

SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN



Drawn by: NAC

Date: 24/05/2011

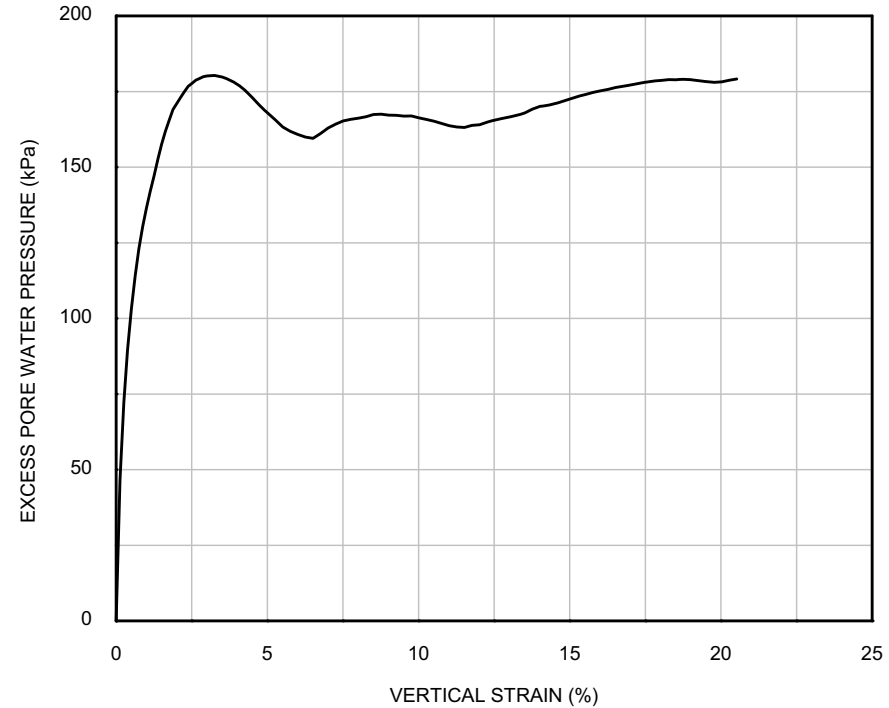
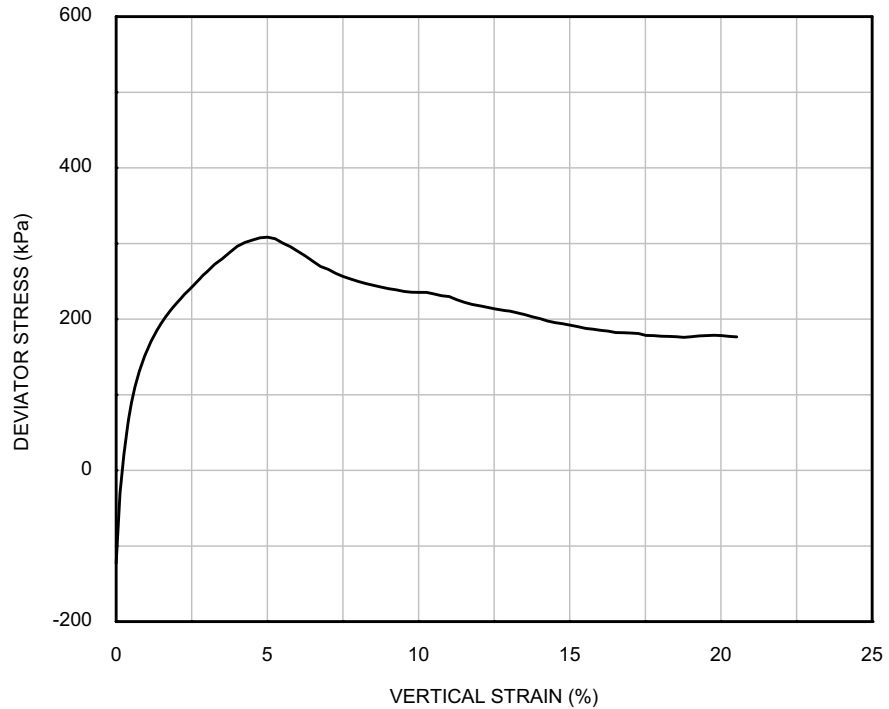
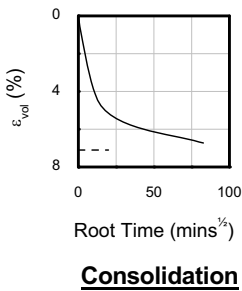
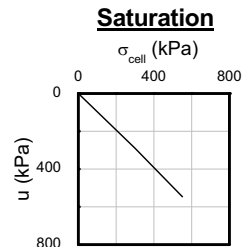
Template Issue: 4.1

Date: 25/05/2011

Checked by: PH

Filename: J11056 \ EFFECTIV \ BH_13_6WaxB_ca.OPJ

Date: Approved by:



Curve	Specimen	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	251	128	BH_13	6WaxB	13.05

**ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN**



Drawn by: NAC Date: 24/05/2011

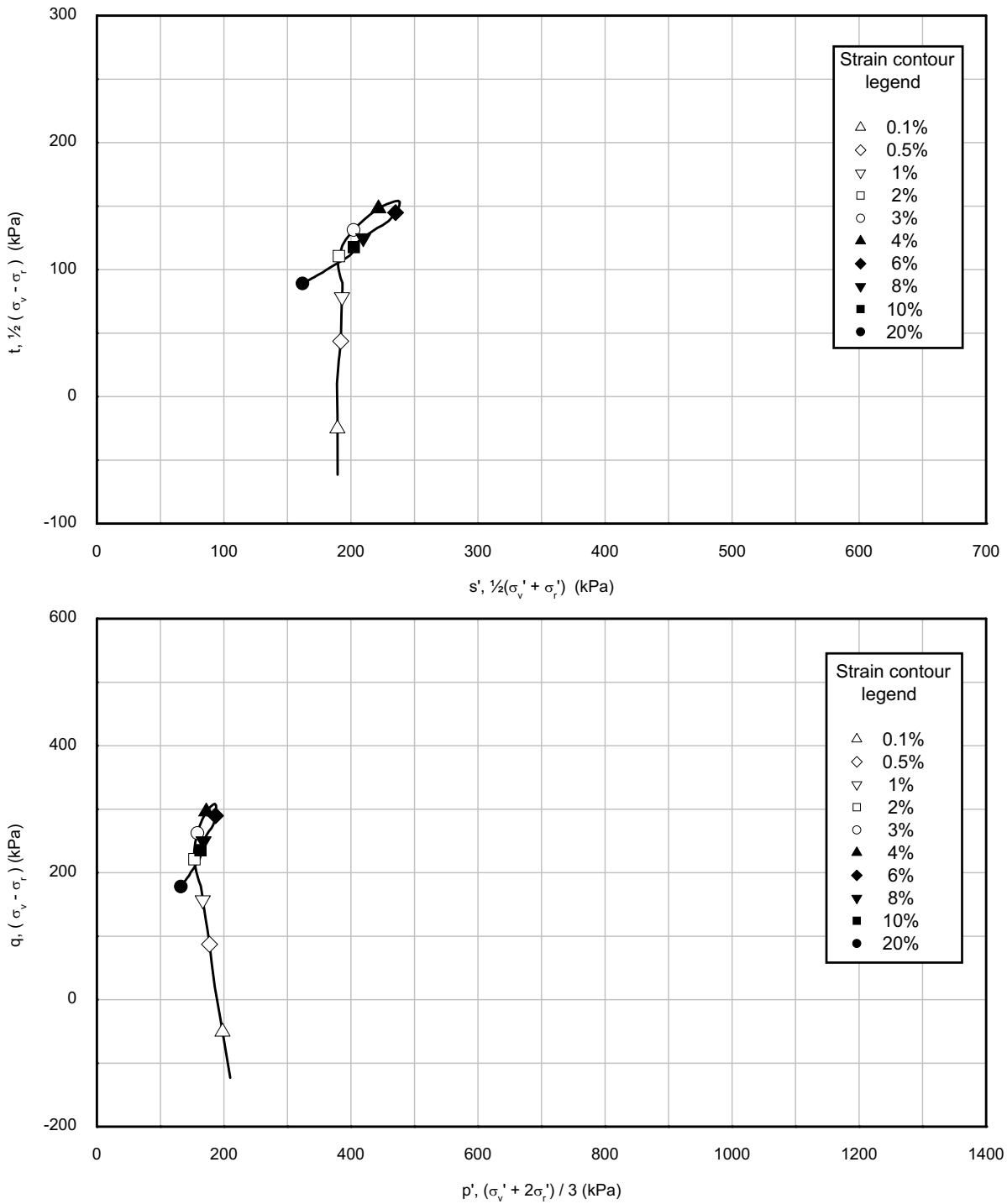
Template Issue: 4.1

Date: 25/05/2011

Checked by: PH

Filename: J11056 \ EFFECTIV \ BH_13_6WaxB_ca.OPJ

Date: Approved by:



Curve	Specimen	σ_{1c}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	251	128	BH_13	6WaxB	13.05

ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 02/06/2011

Drawn by: ALB

Template Issue: 3

Filename: J11056 / EFFECTIVE / BH_13_23WaxA_ca.XLS

Date: 02/06/2011

Date:

Checked by: PH

Approved by:

VISUAL DESCRIPTION	
Very stiff dark grey sandy CLAY	

GENERAL	
Date test started	10/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL	
Diameter (mm)	73.7
Length (mm)	139.9
Moisture content (%)	18
Bulk density (Mg/m ³)	2.04
Dry density (Mg/m ³)	1.72
Voids ratio	0.565
Degree of saturation (%)	86

SATURATION	
Pressure increments applied (kPa)	100
Differential pressure used (kPa)	N/A
Pore pressure on completion (kPa)	727
Cell pressure on completion (kPa)	1164
B value achieved	0.95

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	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	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_13
Sample	23WaxA
Depth (m)	39.07

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**

Drawn by: ALB Date: 02/06/2011

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	1164
Back pressure	(kPa)	600
Effective cell pressure	(kPa)	564
Pore pressure on completion	(kPa)	600
Pore pressure dissipation	(%)	100
Moisture content	(%)	18
Bulk density	(Mg/m ³)	2.04
Dry density	(Mg/m ³)	1.73
Voids ratio		0.56
Degree of saturation	(%)	86

Template Issue: 3
Filename: J11056 / EFFECTIVE / BH_13_23WaxA_ca.XLS

CONSOLIDATION : ANISOTROPIC		
Cell pressure	(kPa)	1164
Back pressure	(kPa)	600
Axial pressure	(kPa)	959
Effective cell pressure	(kPa)	564
Effective axial pressure	(kPa)	359
Pore pressure after consol	(kPa)	600
Moisture content	(%)	18
Bulk density	(Mg/m ³)	2.04
Dry density	(Mg/m ³)	1.73
Voids ratio		0.561
Degree of saturation	(%)	86
Volumetric strain	(%)	0.27
Axial strain	(%)	-0.79

Mode of failure: Compound failure

Checked by: PH Date: 02/06/2011
Approved by: Date:

Borehole	BH_13
Sample	23WaxA
Depth (m)	39.07

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 02/06/2011

Drawn by: ALB

Template Issue: 3

Filename: J11056 / EFFECTIVE / BH_13_23WaxA_ca.XLS

Date: 02/06/2011

Date:

Checked by: PH

Approved by:

SHEARING		
Initial pore pressure	(kPa)	600
Initial effective cell pressure	(kPa)	564
Rate of strain	(%/hour)	0.42
Initial deviator stress	(kPa)	-205
At peak deviator stress		
Corrected deviator stress	(kPa)	738
Membrane correction applied	(kPa)	1.0
Drain correction applied	(kPa)	0
Axial strain	(%)	14.23
Excess pore pressure	(kPa)	156
Major principal effective stress	(kPa)	1147
Minor principal effective stress	(kPa)	408
Principal effective stress ratio		2.81
e 50	(%)	1.73
Secant modulus at e 50	(kPa)	27343
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	597
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	7.74
Excess pore pressure	(kPa)	309
Major principal effective stress	(kPa)	852
Minor principal effective stress	(kPa)	255
Principal effective stress ratio		3.35
e 50	(%)	1.03
Secant modulus at e 50	(kPa)	39129
At 10% axial strain		
Corrected deviator stress	(kPa)	695
Membrane correction applied	(kPa)	0.7
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	245
Major principal effective stress	(kPa)	1014
Minor principal effective stress	(kPa)	319
Principal effective stress ratio		3.18
e 50	(%)	1.46
Secant modulus at e 50	(kPa)	30792
FINAL CONDITIONS		
Moisture content	(%)	18
Bulk density	(Mg/m ³)	2.04
Dry density	(Mg/m ³)	1.73
Borehole		BH_13
Sample		23WaxA
Depth (m)		39.07

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: PH
Approved by:
Date: 02/06/2011
Date:
Template Issue: 3
Filename: J11056 /EFFECTIVE /BH_13_23WaxA_ca.XLS
Drawn by: ALB
Date: 02/06/2011

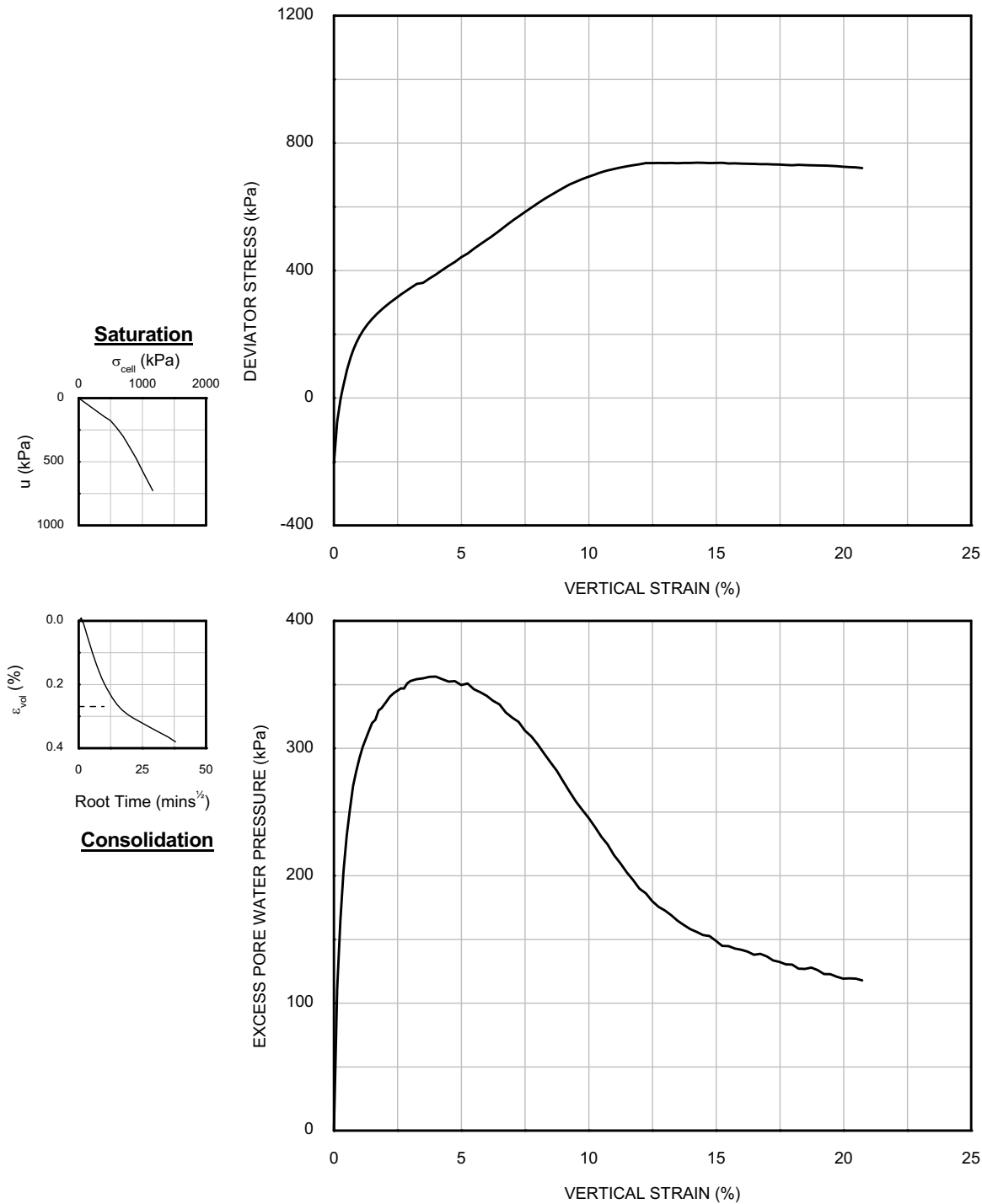
SPECIMEN PHOTOGRAPHS



Borehole
Sample
Depth (m)

BH_13
23WaxA
39.07

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**



Curve	Specimen	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	564	359	BH_13	23WaxA	39.07

ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN



Drawn by: ALB Date: 02/06/2011

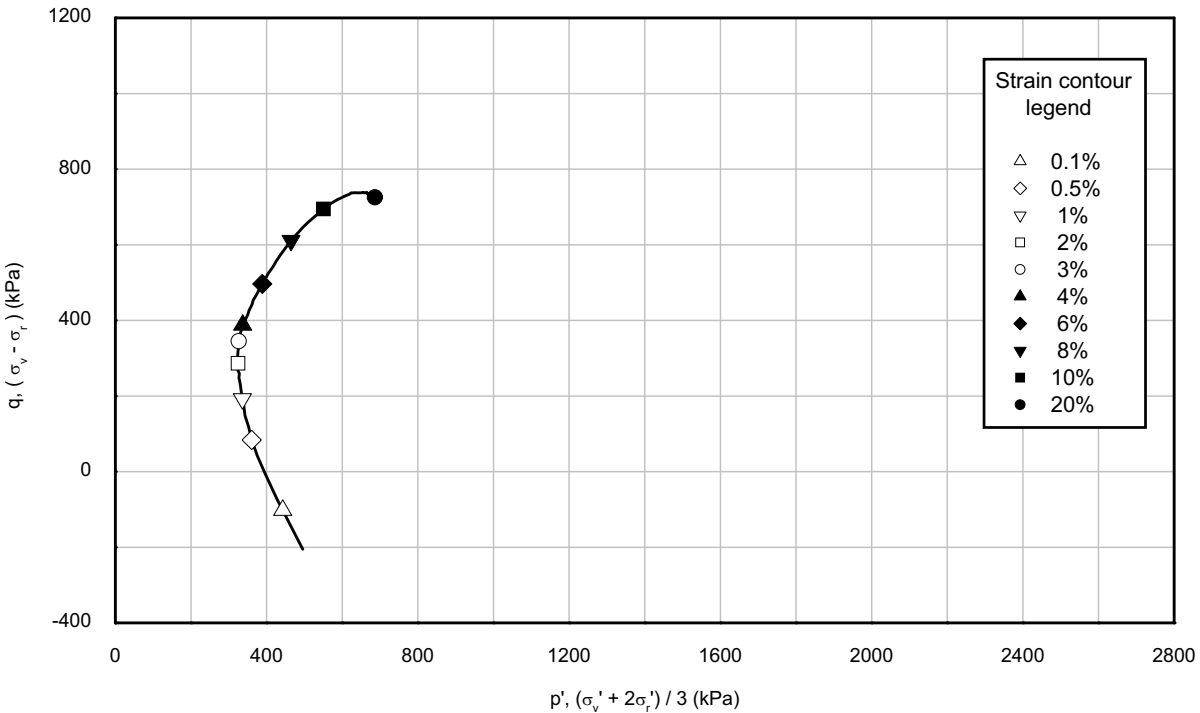
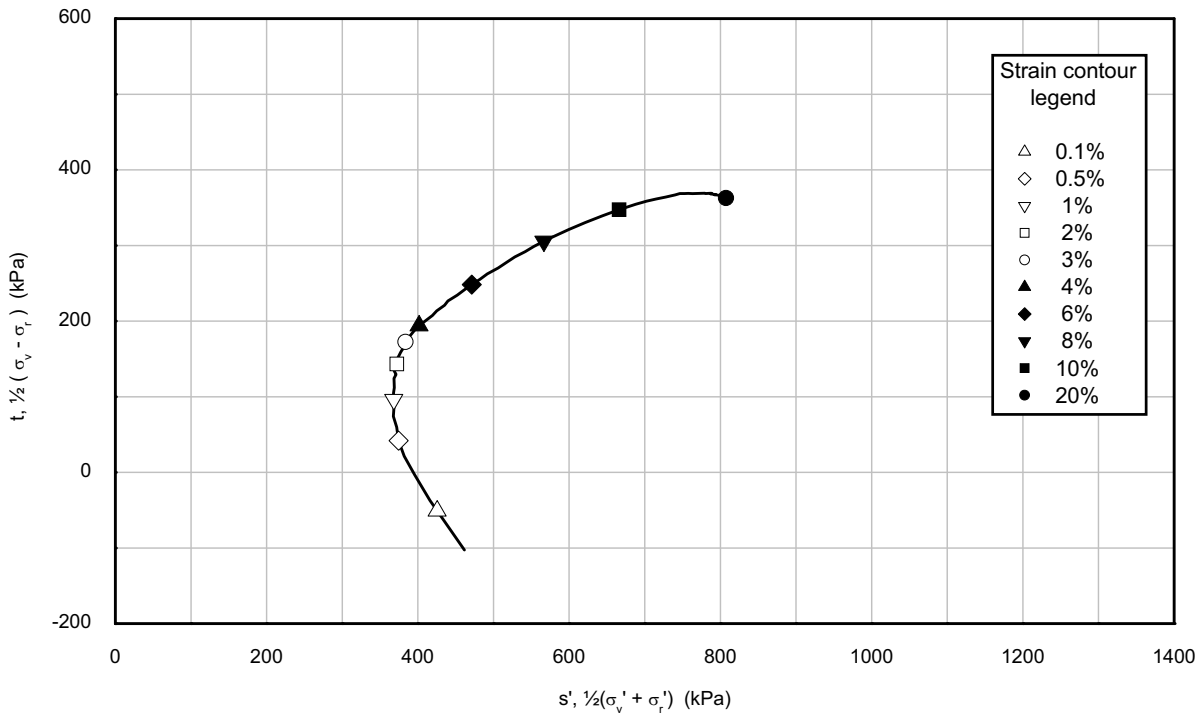
Template Issue: 4.1

Date : 02/06/2011

Checked by: PH

Filename: J11056 \ EFFECTIV \ BH_13_23WaxA_ca.OPJ

Approved by:



Curve	Specimen	σ_{1c}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	564	359	BH_13	23WaxA	39.07

ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 02/06/2011

Drawn by: ALB

Template Issue: 3

Filename: J11056 / EFFECTIVE / BH_16_14WaxA_ca.XLS

Date: 02/06/2011

Date:

Checked by: PH

Approved by:

VISUAL DESCRIPTION

Very stiff to hard dark grey fine slightly sandy CLAY.

GENERAL

Date test started	12/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL

Diameter	(mm)	50.4
Length	(mm)	97.2
Moisture content	(%)	20
Bulk density	(Mg/m ³)	2.11
Dry density	(Mg/m ³)	1.76
Voids ratio		0.532
Degree of saturation	(%)	100

SATURATION

Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	798
Cell pressure on completion	(kPa)	988
B value achieved		0.95

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	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	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_16
Sample	14WaxA
Depth (m)	30.56

SUMMARY OF ANISOTROPICALLY CONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN

Drawn by: ALB Date: 02/06/2011

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	988
Back pressure	(kPa)	500
Effective cell pressure	(kPa)	488
Pore pressure on completion	(kPa)	500
Pore pressure dissipation	(%)	100
Moisture content	(%)	19
Bulk density	(Mg/m ³)	2.12
Dry density	(Mg/m ³)	1.79
Voids ratio		0.51
Degree of saturation	(%)	99

Template Issue: 3

Filename: J11056 / EFFECTIVE / BH_16_14WaxA_ca.XLS

CONSOLIDATION : ANISOTROPIC		
Cell pressure	(kPa)	988
Back pressure	(kPa)	500
Axial pressure	(kPa)	752
Effective cell pressure	(kPa)	488
Effective axial pressure	(kPa)	252
Pore pressure after consol	(kPa)	500
Moisture content	(%)	19
Bulk density	(Mg/m ³)	2.13
Dry density	(Mg/m ³)	1.79
Voids ratio		0.506
Degree of saturation	(%)	99
Volumetric strain	(%)	1.65
Axial strain	(%)	-0.08

Mode of failure: Brittle failure

Checked by: PH Date: 02/06/2011

Approved by: Date:

Borehole	BH_16
Sample	14WaxA
Depth (m)	30.56

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 02/06/2011

Drawn by: ALB

Template Issue: 3

Filename: J11056 / EFFECTIVE / BH_16_14WaxA_ca.XLS

Date: 02/06/2011

Date:

Checked by: PH

Approved by:

SHEARING		
Initial pore pressure	(kPa)	500
Initial effective cell pressure	(kPa)	488
Rate of strain	(%/hour)	0.42
Initial deviator stress	(kPa)	-237
At peak deviator stress		
Corrected deviator stress	(kPa)	1041
Membrane correction applied	(kPa)	1.8
Drain correction applied	(kPa)	0
Axial strain	(%)	20.50
Excess pore pressure	(kPa)	-86
Major principal effective stress	(kPa)	1615
Minor principal effective stress	(kPa)	574
Principal effective stress ratio		2.81
e 50	(%)	1.96
Secant modulus at e 50	(kPa)	32520
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	735
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	4.75
Excess pore pressure	(kPa)	162
Major principal effective stress	(kPa)	1061
Minor principal effective stress	(kPa)	326
Principal effective stress ratio		3.25
e 50	(%)	0.96
Secant modulus at e 50	(kPa)	50481
At 10% axial strain		
Corrected deviator stress	(kPa)	958
Membrane correction applied	(kPa)	1.1
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	11
Major principal effective stress	(kPa)	1435
Minor principal effective stress	(kPa)	477
Principal effective stress ratio		3.01
e 50	(%)	1.66
Secant modulus at e 50	(kPa)	35993
FINAL CONDITIONS		
Moisture content	(%)	19
Bulk density	(Mg/m ³)	2.13
Dry density	(Mg/m ³)	1.79
Borehole		BH_16
Sample		14WaxA
Depth (m)		30.56

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: PH
Approved by:
Date: 02/06/2011
Date:
Template Issue: 3
Filename: J11056 / EFFECTIVE / BH_16_14WaxA_ca.XLS
Drawn by: ALB
Date: 02/06/2011

SPECIMEN PHOTOGRAPHS



Borehole	BH_16
Sample	14WaxA
Depth (m)	30.56

SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN



Drawn by: ALB

Date: 02/06/2011

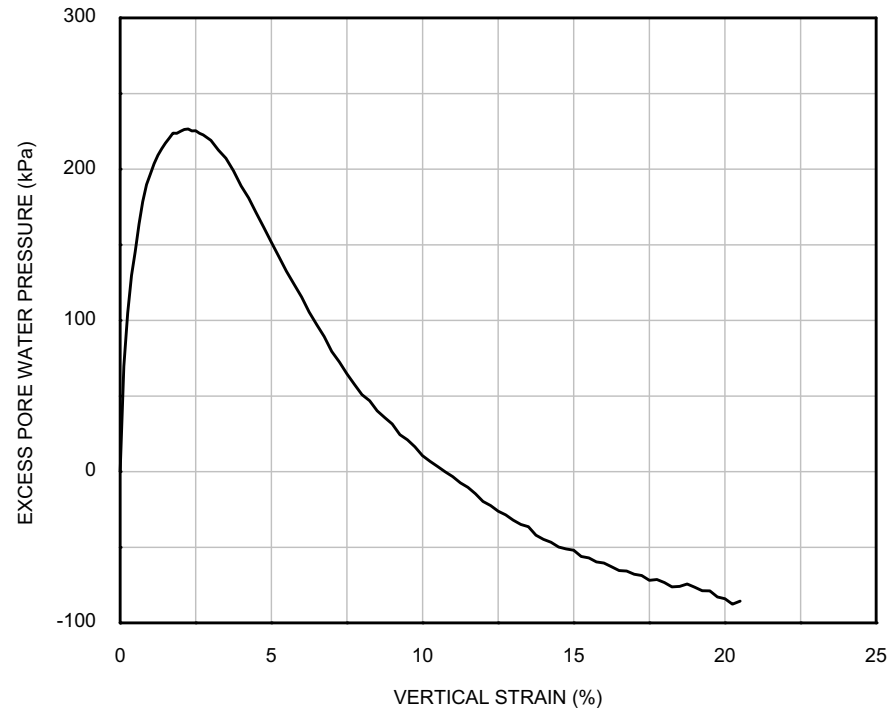
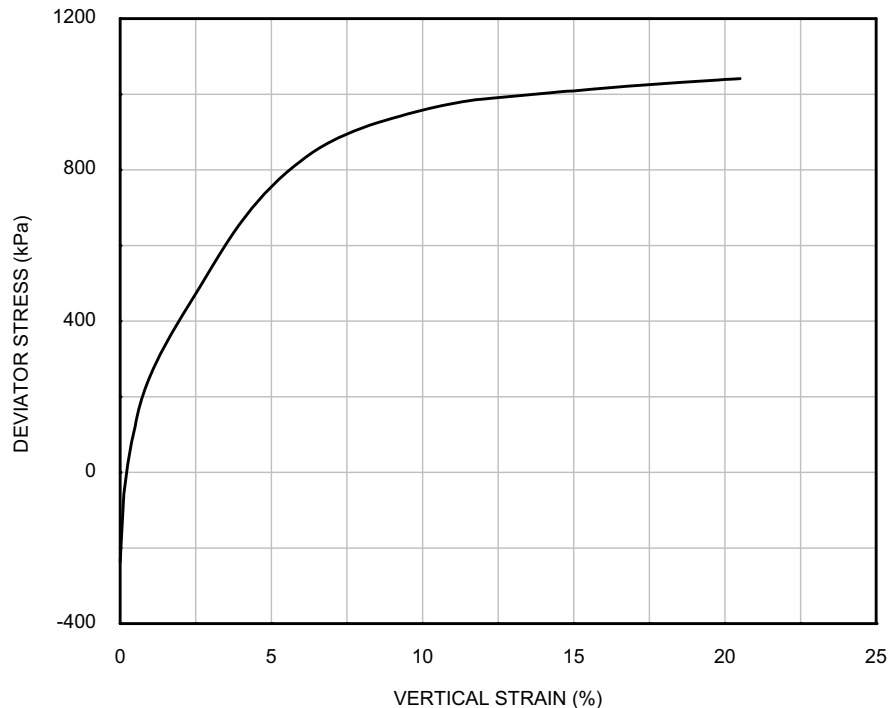
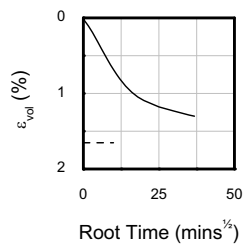
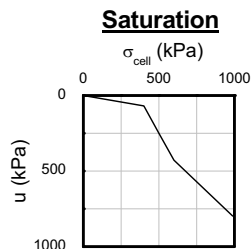
Template Issue: 4.1

Date: 02/06/2011

Checked by: PH

Filename: J11056 \ EFFECTIV \ BH_16_14WaxA_ca.OPJ

Date: Approved by:



Curve	Specimen	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	488	252	BH_16	14WaxA	30.56

**ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN**

Drawn by: ALB Date: 02/06/2011

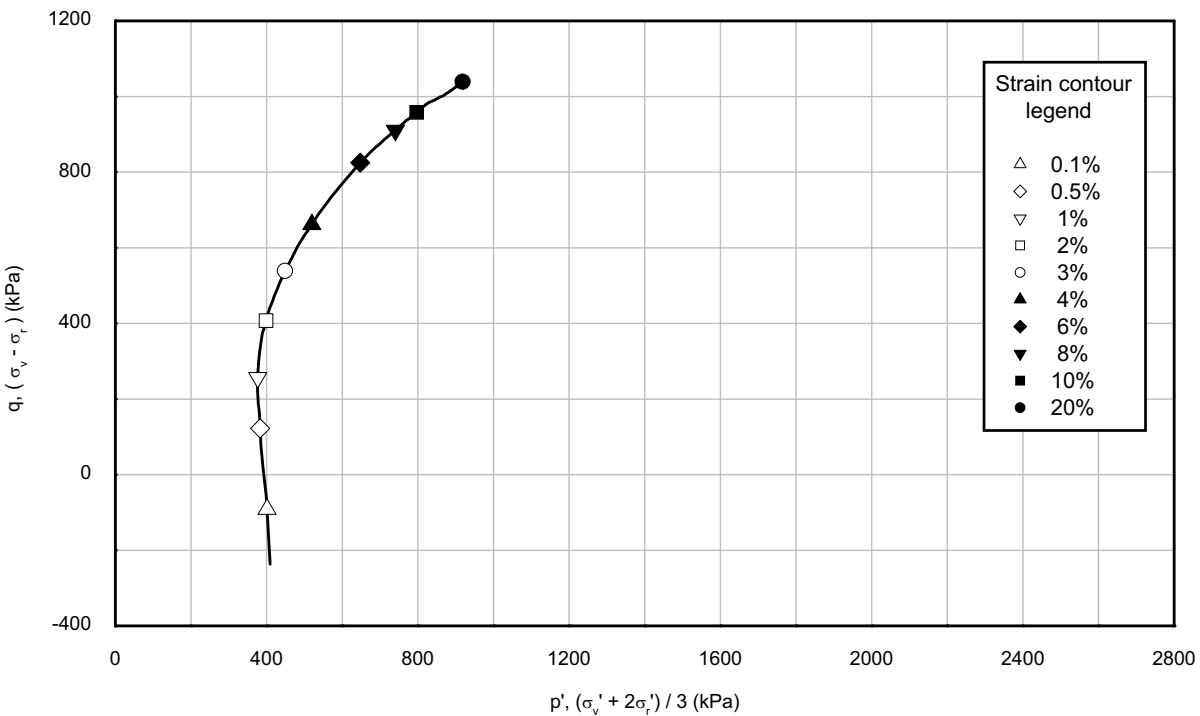
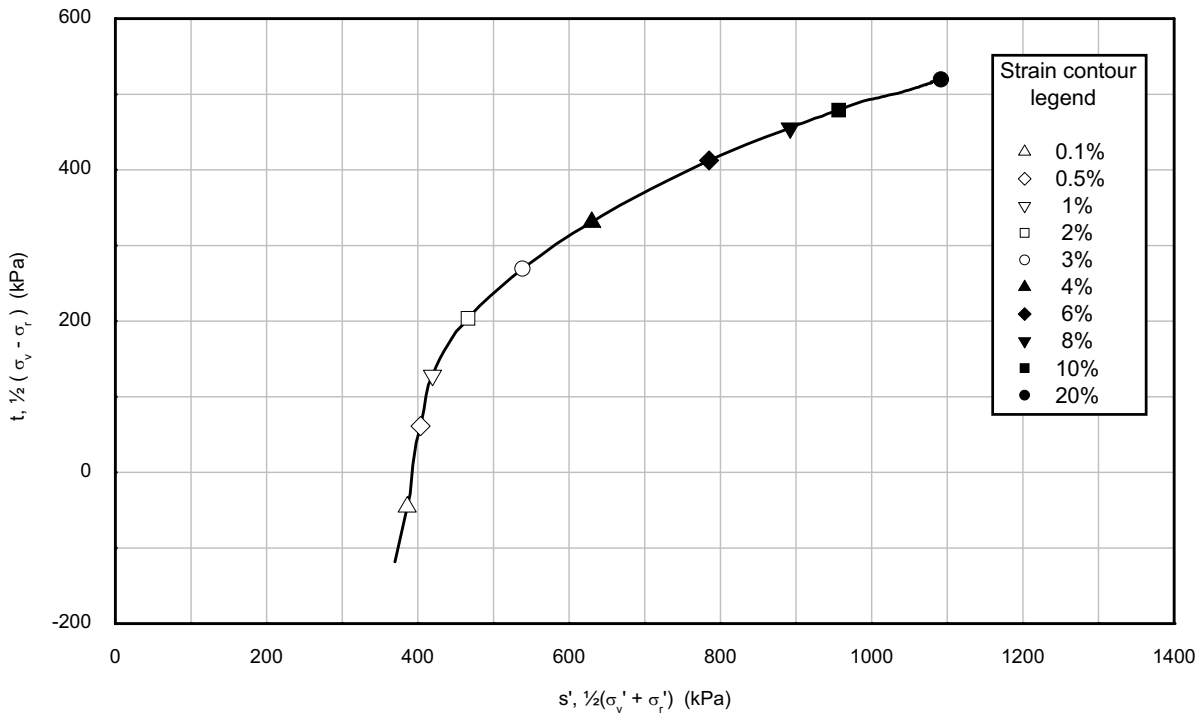
Template Issue: 4.1

Date : 02/06/2011

Checked by: PH

Filename: J11056 \ EFFECTIV \ BH_16_14WaxA_ca.OPJ

Approved by:



Curve	Specimen	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	488	252	BH_16	14WaxA	30.56

ANISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_06_36WaxA_CU.XLS

Date: 23/05/2011

Approved by: PH

VISUAL DESCRIPTION

Very stiff off white CHALK with some black flecks.

GENERAL

Date test started	12/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL

Diameter	(mm)	71.3
Length	(mm)	138.1
Moisture content	(%)	26
Bulk density	(Mg/m ³)	2.05
Dry density	(Mg/m ³)	1.62
Voids ratio		0.663
Degree of saturation	(%)	100

SATURATION

Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	880
Cell pressure on completion	(kPa)	886
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_06
Sample	36WaxA
Depth (m)	48.77

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_06_36WaxA_CU.XLS

Date: 19/05/2011

Date: 23/05/2011

Checked by:

Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	886
Back pressure	(kPa)	400
Effective cell pressure	(kPa)	486
Pore pressure on completion	(kPa)	400
Pore pressure dissipation	(%)	100
Moisture content	(%)	26
Bulk density	(Mg/m ³)	2.06
Dry density	(Mg/m ³)	1.64
Voids ratio		0.646
Degree of saturation	(%)	100
Cvi	(m ² /year)	755.1
Mvi	(m ² /MN)	0.021
Permeability	(m/s)	4.98E-09

Mode of failure: Brittle failure

Borehole	BH_06
Sample	36WaxA
Depth (m)	48.77

**SUMMARY OF
 ISOTROPICALLY CONSOLIDATED UNDRAINED
 TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_06_36WaxA_CU.XLS

Date: 23/05/2011

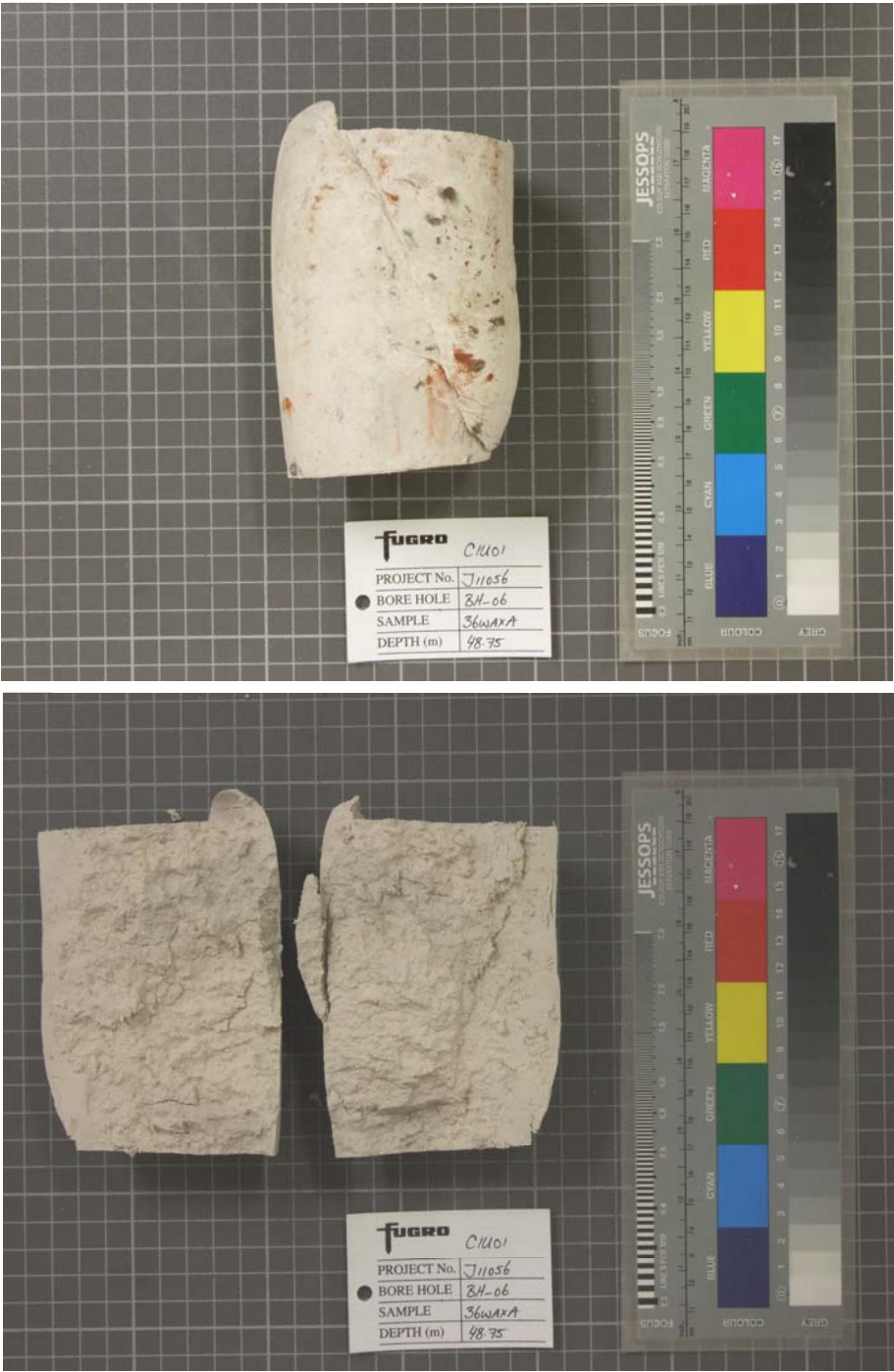
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	486
Rate of strain	(%/hour)	0.29
At peak deviator stress		
Corrected deviator stress	(kPa)	1193
Membrane correction applied	(kPa)	0.4
Drain correction applied	(kPa)	0
Axial strain	(%)	4.66
Excess pore pressure	(kPa)	146
Major principal effective stress	(kPa)	1533
Minor principal effective stress	(kPa)	340
Principal effective stress ratio		4.51
e 50	(%)	0.83
Secant modulus at e 50	(kPa)	71439
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	999
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	2.16
Excess pore pressure	(kPa)	226
Major principal effective stress	(kPa)	1259
Minor principal effective stress	(kPa)	260
Principal effective stress ratio		4.85
e 50	(%)	0.61
Secant modulus at e 50	(kPa)	82191
At 10% axial strain		
Corrected deviator stress	(kPa)	893
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	214
Major principal effective stress	(kPa)	1165
Minor principal effective stress	(kPa)	272
Principal effective stress ratio		4.29
e 50	(%)	0.50
Secant modulus at e 50	(kPa)	88879
FINAL CONDITIONS		
Moisture content	(%)	26
Bulk density	(Mg/m ³)	2.06
Dry density	(Mg/m ³)	1.64
Borehole		BH_06
Sample		36WaxA
Depth (m)		48.77

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: Approved by: PH Date: 19/05/2011 Date: 23/05/2011
Template Issue: 2 Filename: J11056 / EFFECTIV / BH_06_36WaxA_CU.XLS
Drawn by: NAC Date: 18/05/2011

SPECIMEN PHOTOGRAPHS



Borehole	BH_06
Sample	36WaxA
Depth (m)	48.77

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



Drawn by: NAC

Date: 18/05/2011

Template Issue: 4.1

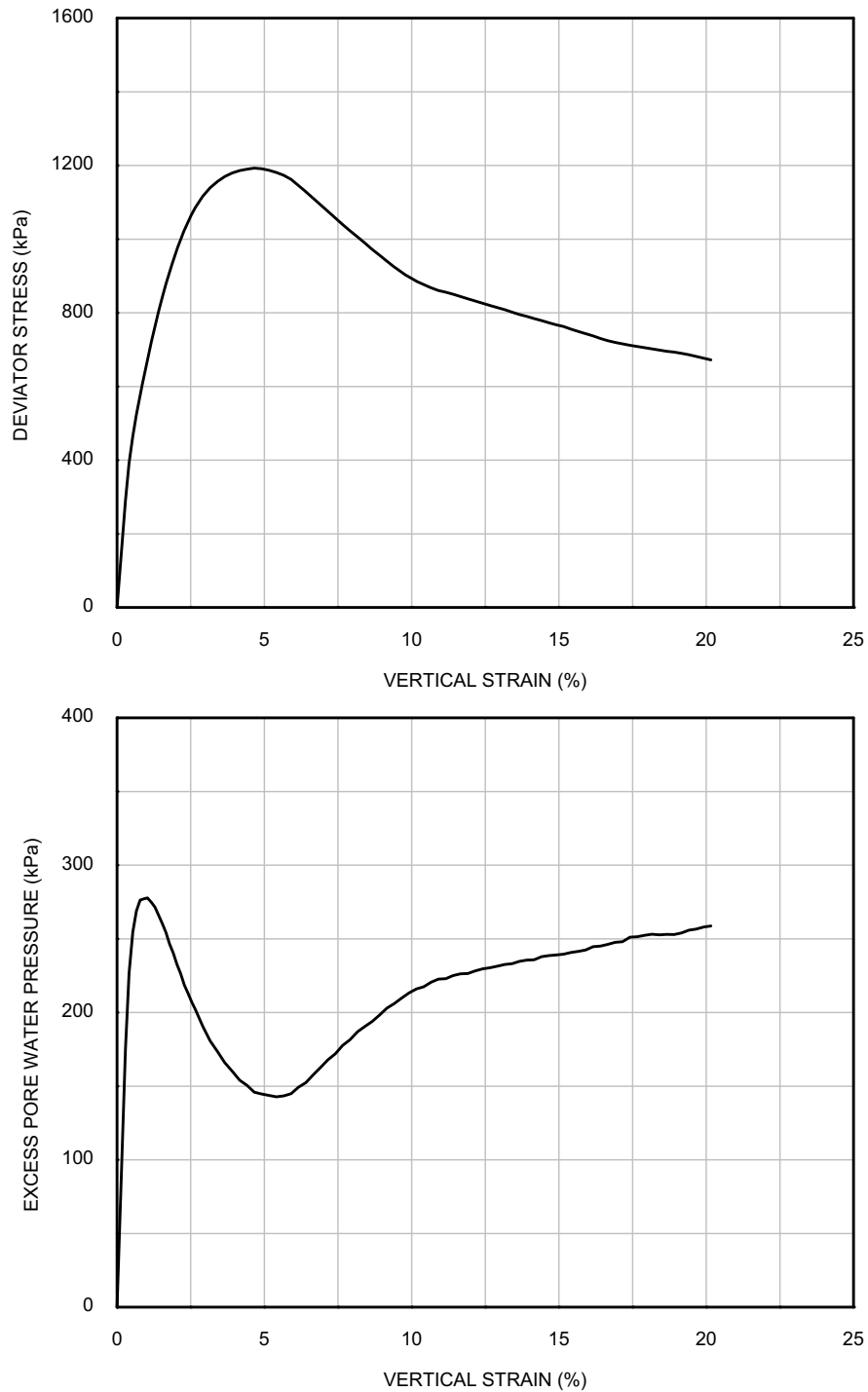
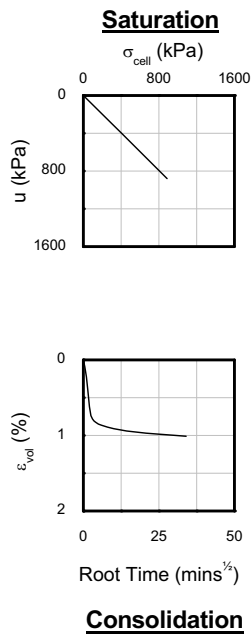
Date : 19/05/2011

Checked by: ALB

Filename: J11056 \ EFFECTIV \ BH_06_36WaxA_CU.OPJ

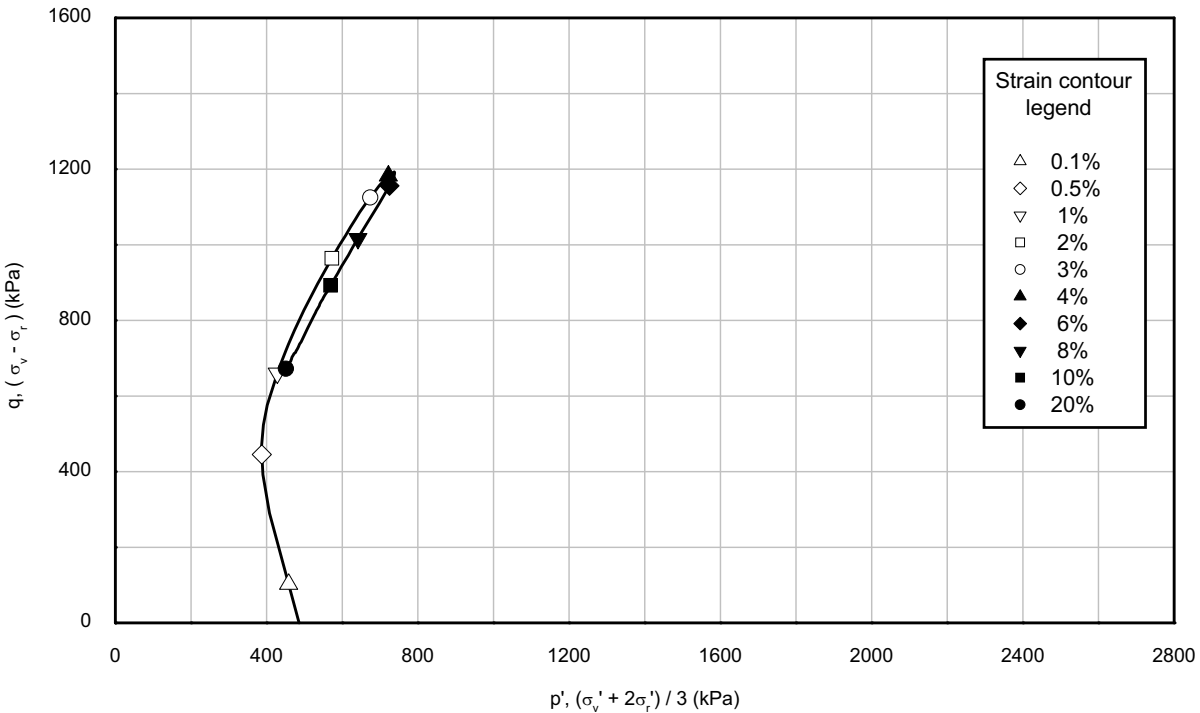
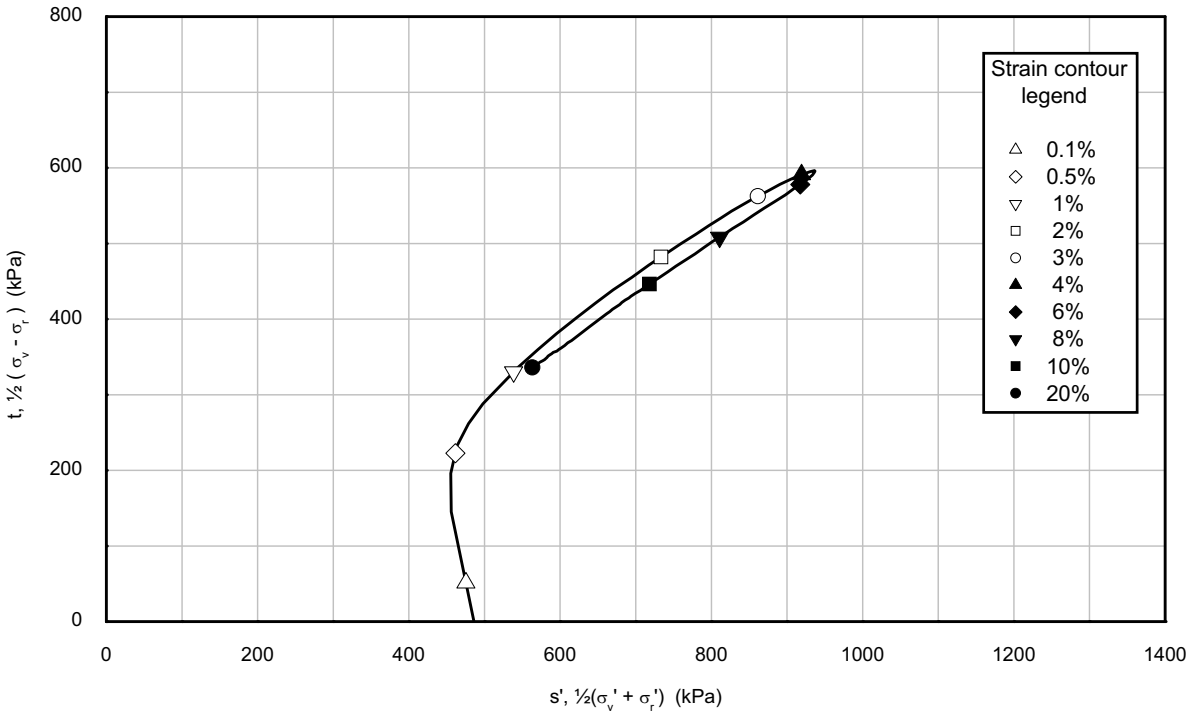
Date : 23/05/2011

Approved by: PH



Curve	Specimen	σ_{1c}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	486	486	BH_06	36WaxA	48.77

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST: SINGLE SPECIMEN



Curve	Specimen	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	486	486	BH_06	36WaxA	48.77

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_06_38WaxA_CU.XLS

Date: 24/05/2011

Approved by: PH

VISUAL DESCRIPTION	
Very stiff off white CHALK with some black flecks.	

GENERAL	
Date test started	12/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL	
Diameter (mm)	71.8
Length (mm)	138.3
Moisture content (%)	29
Bulk density (Mg/m ³)	1.98
Dry density (Mg/m ³)	1.53
Voids ratio	0.767
Degree of saturation (%)	100

SATURATION	
Pressure increments applied (kPa)	100
Differential pressure used (kPa)	N/A
Pore pressure on completion (kPa)	899
Cell pressure on completion (kPa)	900
B value achieved	1.00

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH_06
Sample	38WaxA
Depth (m)	50.24

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_06_38WaxA_CU.XLS

Date: 19/05/2011

Date: 24/05/2011

Checked by:

Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	900
Back pressure	(kPa)	400
Effective cell pressure	(kPa)	500
Pore pressure on completion	(kPa)	400
Pore pressure dissipation	(%)	100
Moisture content	(%)	27
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.58
Voids ratio		0.704
Degree of saturation	(%)	100
Cvi	(m ² /year)	2516.8
Mvi	(m ² /MN)	0.074
Permeability	(m/s)	5.77E-08

Mode of failure: Brittle failure

Borehole	BH_06
Sample	38WaxA
Depth (m)	50.24

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_06_38WaxA_CU.XLS

Date: 24/05/2011

Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	500
Rate of strain	(%/hour)	0.29
At peak deviator stress		
Corrected deviator stress	(kPa)	1029
Membrane correction applied	(kPa)	0.4
Drain correction applied	(kPa)	0
Axial strain	(%)	4.96
Excess pore pressure	(kPa)	215
Major principal effective stress	(kPa)	1313
Minor principal effective stress	(kPa)	285
Principal effective stress ratio		4.62
e 50	(%)	1.61
Secant modulus at e 50	(kPa)	31953
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	1014
Membrane correction applied	(kPa)	0.4
Drain correction applied	(kPa)	0
Axial strain	(%)	4.46
Excess pore pressure	(kPa)	224
Major principal effective stress	(kPa)	1290
Minor principal effective stress	(kPa)	276
Principal effective stress ratio		4.68
e 50	(%)	1.59
Secant modulus at e 50	(kPa)	31882
At 10% axial strain		
Corrected deviator stress	(kPa)	826
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	247
Major principal effective stress	(kPa)	1079
Minor principal effective stress	(kPa)	253
Principal effective stress ratio		4.27
e 50	(%)	1.40
Secant modulus at e 50	(kPa)	29541
FINAL CONDITIONS		
Moisture content	(%)	27
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.58
Borehole		BH_06
Sample		38WaxA
Depth (m)		50.24

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: Approved by: PH
Date: 19/05/2011 Date: 24/05/2011
Template Issue: 2
Filename: J11056 / EFFECTIV / BH_06_38WaxA_CU.XLS
Drawn by: NAC
Date: 18/05/2011

SPECIMEN PHOTOGRAPHS



Borehole
Sample
Depth (m)

BH_06
38WaxA
50.24

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



Drawn by: NAC

Date: 18/05/2011

Template Issue: 4.1

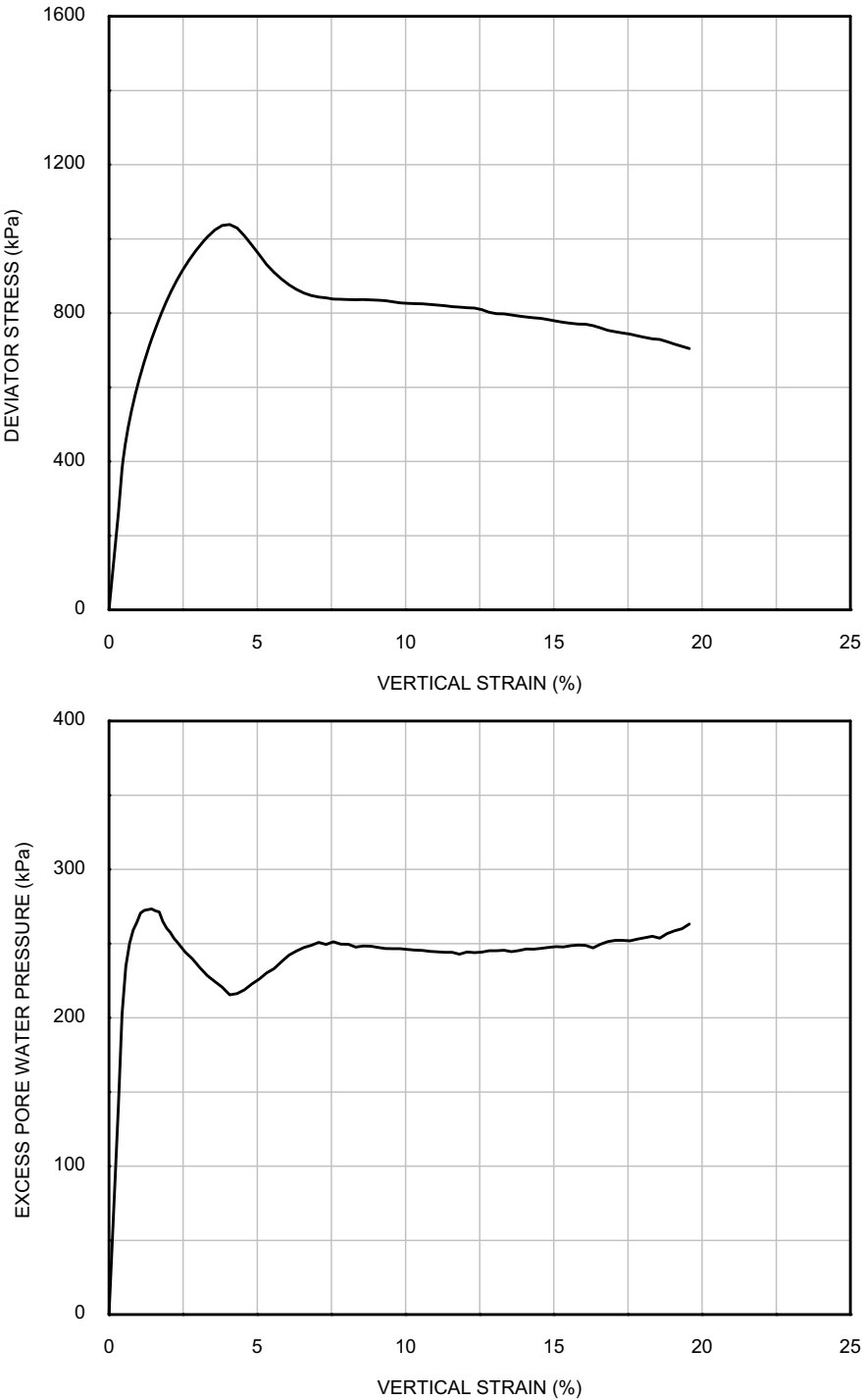
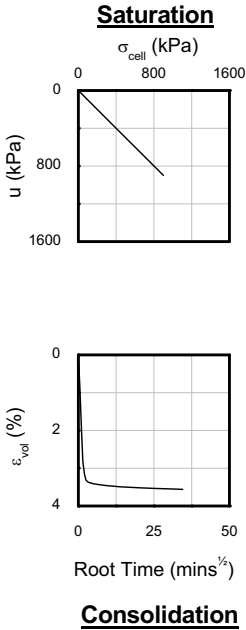
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Date : 19/05/2011

Date : 24/05/2011

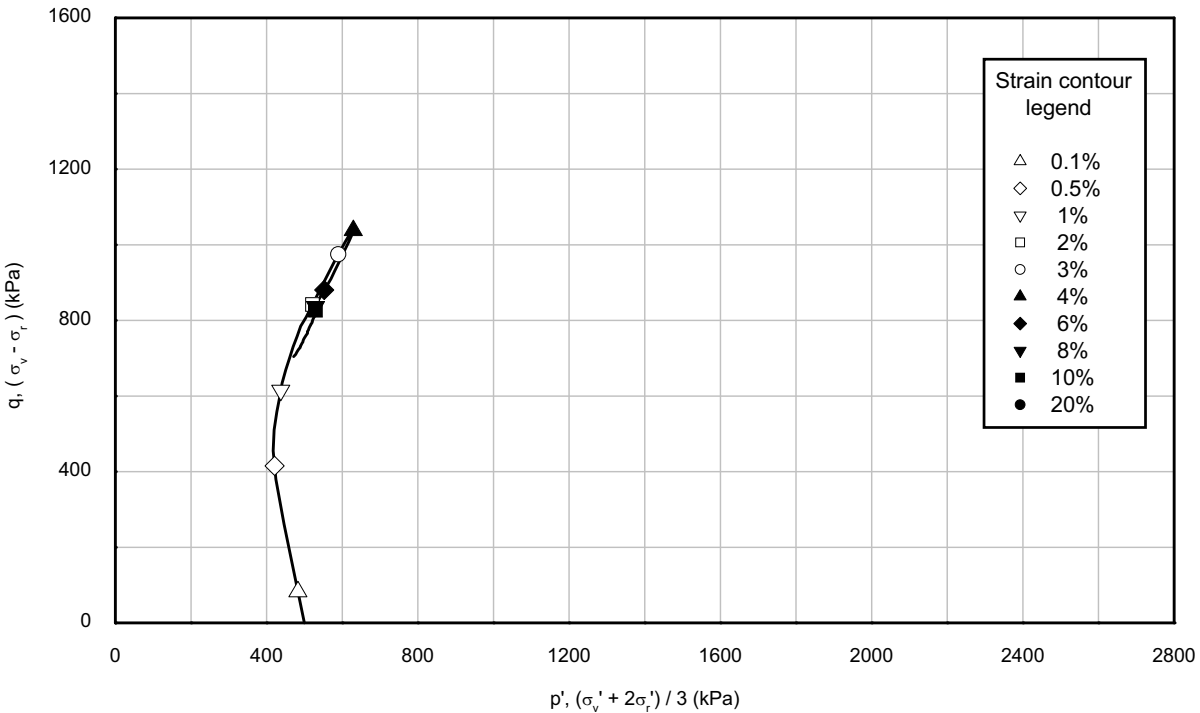
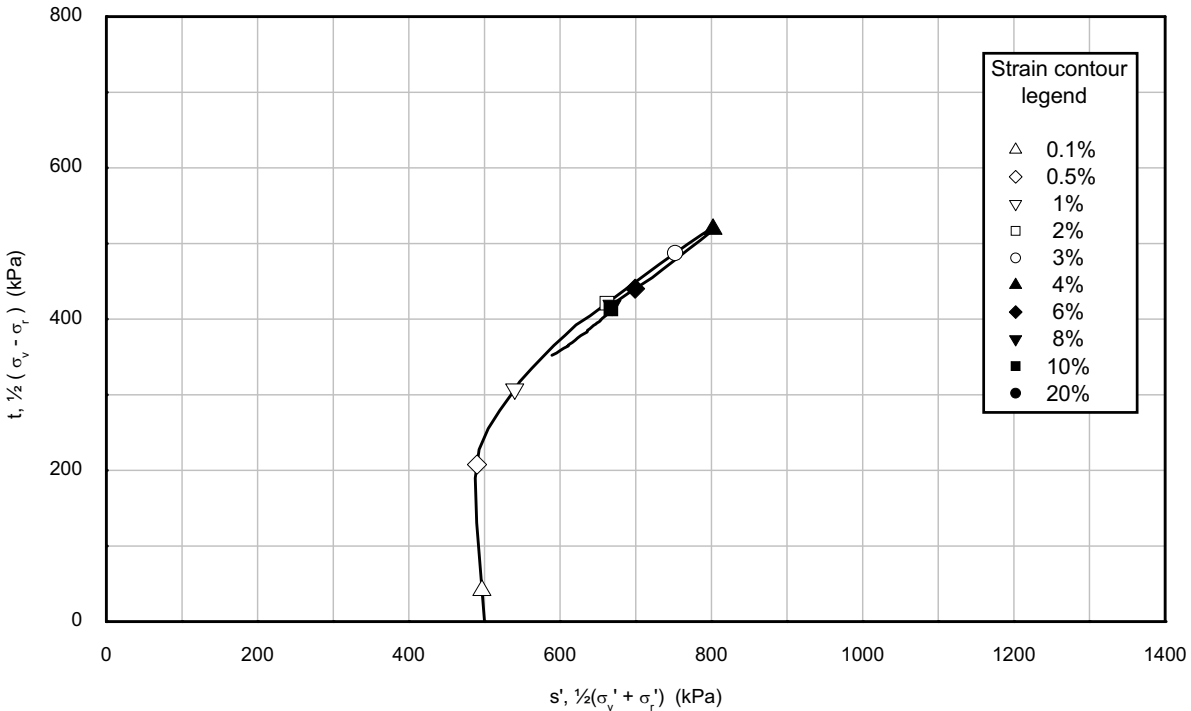
Checked by: ALB

Approved by: PH



Curve	Specimen	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	500	500	BH_06	38WaxA	50.24

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN



Curve	Specimen	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	500	500	BH_06	38WaxA	50.24

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_07_2WaxA_CU.XLS

Date: 23/05/2011

Approved by: PH

VISUAL DESCRIPTION

Very stiff off white CHALK with some black flecks.

GENERAL

Date test started	12/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL

Diameter	(mm)	72.6
Length	(mm)	134.9
Moisture content	(%)	29
Bulk density	(Mg/m ³)	1.96
Dry density	(Mg/m ³)	1.52
Voids ratio		0.777
Degree of saturation	(%)	100

SATURATION

Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	438
Cell pressure on completion	(kPa)	440
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_07
Sample	2WaxA
Depth (m)	4.17

SUMMARY OF ISOTROPICALLY CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_07_2WaxA_CU.XLS

Date: 19/05/2011

Date: 23/05/2011

Checked by:

Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	440
Back pressure	(kPa)	400
Effective cell pressure	(kPa)	40
Pore pressure on completion	(kPa)	400
Pore pressure dissipation	(%)	100
Moisture content	(%)	28
Bulk density	(Mg/m ³)	1.96
Dry density	(Mg/m ³)	1.53
Voids ratio		0.761
Degree of saturation	(%)	100
Cvi	(m ² /year)	1090.5
Mvi	(m ² /MN)	0.25
Permeability	(m/s)	8.45E-08

Mode of failure: Brittle failure

Borehole	BH_07
Sample	2WaxA
Depth (m)	4.17

**SUMMARY OF
 ISOTROPICALLY CONSOLIDATED UNDRAINED
 TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_07_2WaxA_CU.XLS

Date: 23/05/2011

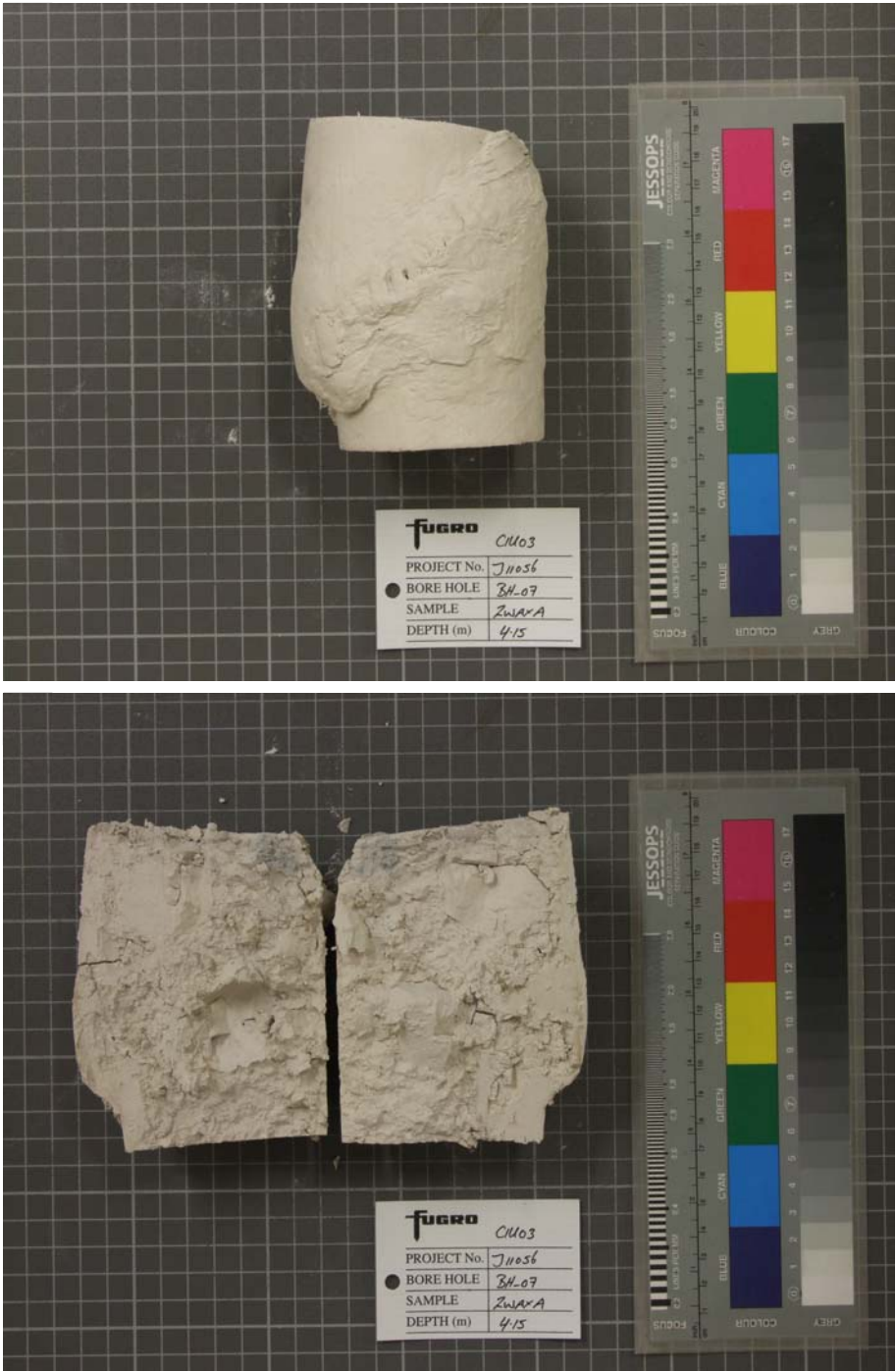
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	40
Rate of strain	(%/hour)	0.29
At peak deviator stress		
Corrected deviator stress	(kPa)	327
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	8.25
Excess pore pressure	(kPa)	-52
Major principal effective stress	(kPa)	419
Minor principal effective stress	(kPa)	92
Principal effective stress ratio		4.56
e 50	(%)	1.38
Secant modulus at e 50	(kPa)	11826
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	155
Membrane correction applied	(kPa)	0.1
Drain correction applied	(kPa)	0
Axial strain	(%)	1.25
Excess pore pressure	(kPa)	6
Major principal effective stress	(kPa)	188
Minor principal effective stress	(kPa)	34
Principal effective stress ratio		5.61
e 50	(%)	0.38
Secant modulus at e 50	(kPa)	20439
At 10% axial strain		
Corrected deviator stress	(kPa)	326
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	-55
Major principal effective stress	(kPa)	421
Minor principal effective stress	(kPa)	95
Principal effective stress ratio		4.44
e 50	(%)	1.37
Secant modulus at e 50	(kPa)	11868
FINAL CONDITIONS		
Moisture content	(%)	28
Bulk density	(Mg/m ³)	1.96
Dry density	(Mg/m ³)	1.53
Borehole		BH_07
Sample		2WaxA
Depth (m)		4.17

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: Approved by: PH
Date: 19/05/2011 Date: 23/05/2011
Template Issue: 2
Filename: J11056 / EFFECTIV / BH_07_2WaxA_CU.XLS
Drawn by: NAC
Date: 18/05/2011

SPECIMEN PHOTOGRAPHS



Borehole
Sample
Depth (m)

BH_07
2WaxA
4.17

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



Drawn by: NAC

Date: 18/05/2011

Template Issue: 4.1

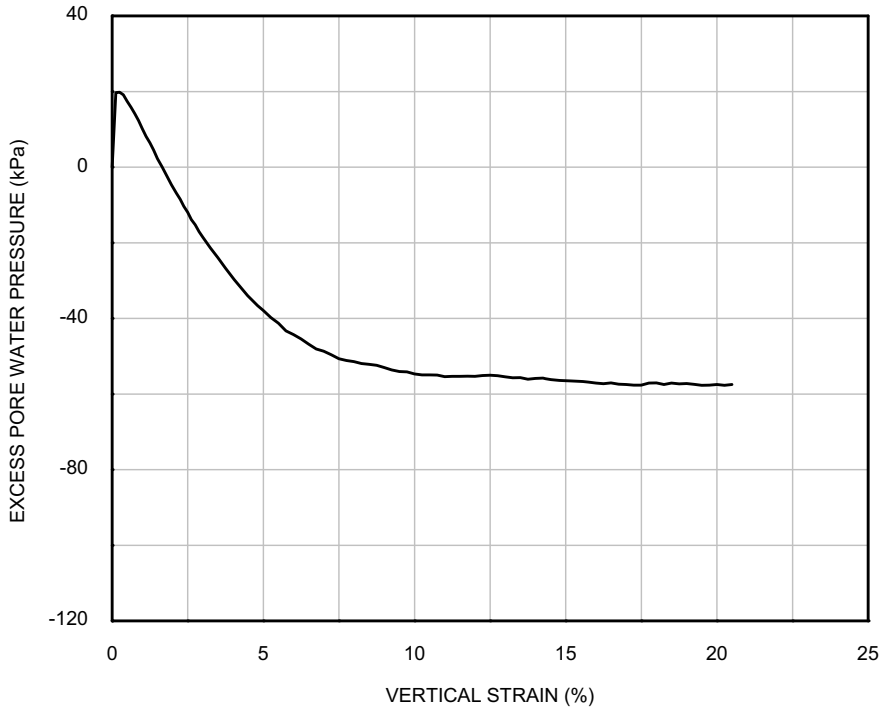
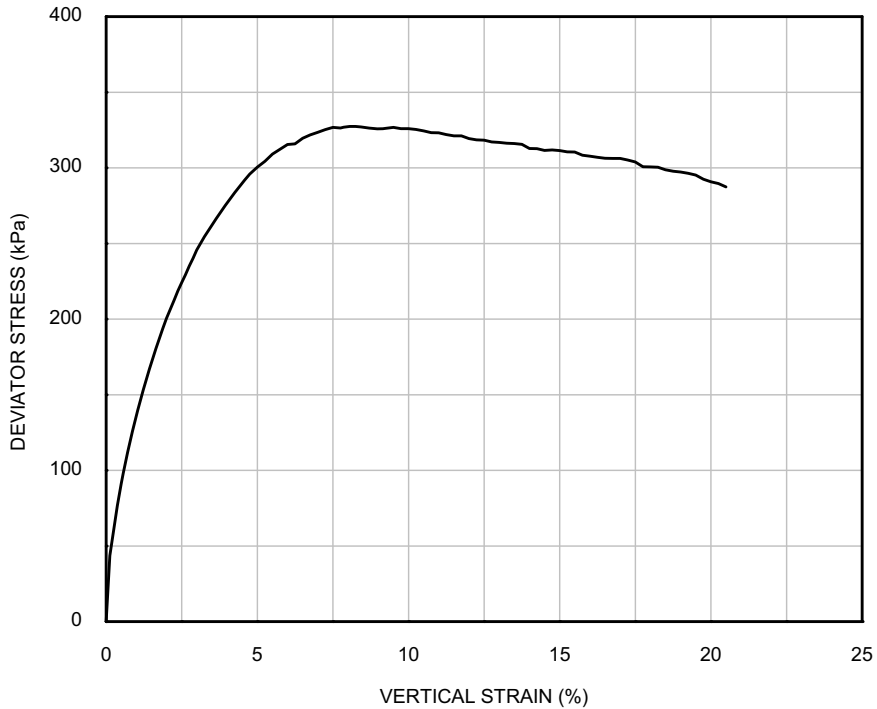
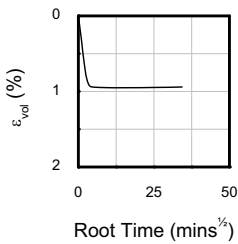
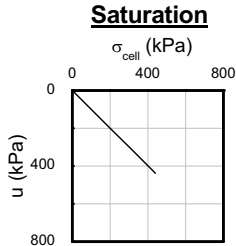
Date: 19/05/2011

Checked by: ALB

Filename: J11056 \ EFFECTIV \ BH_07_2WaxA_CU.OPJ

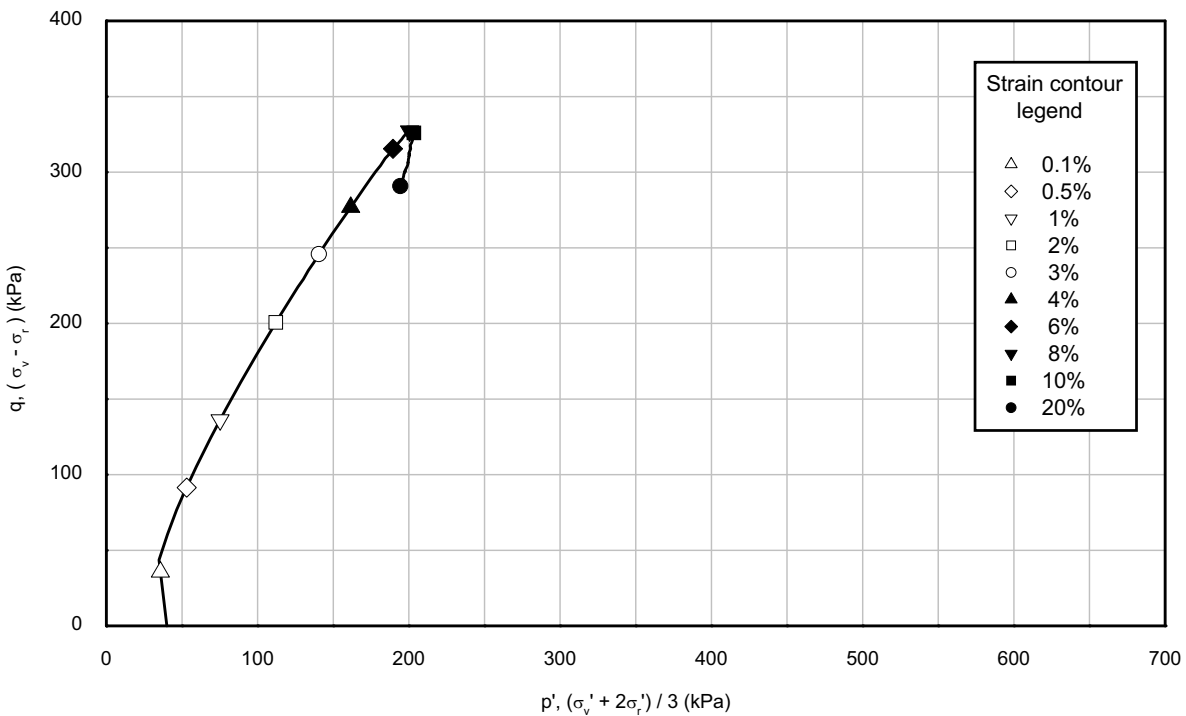
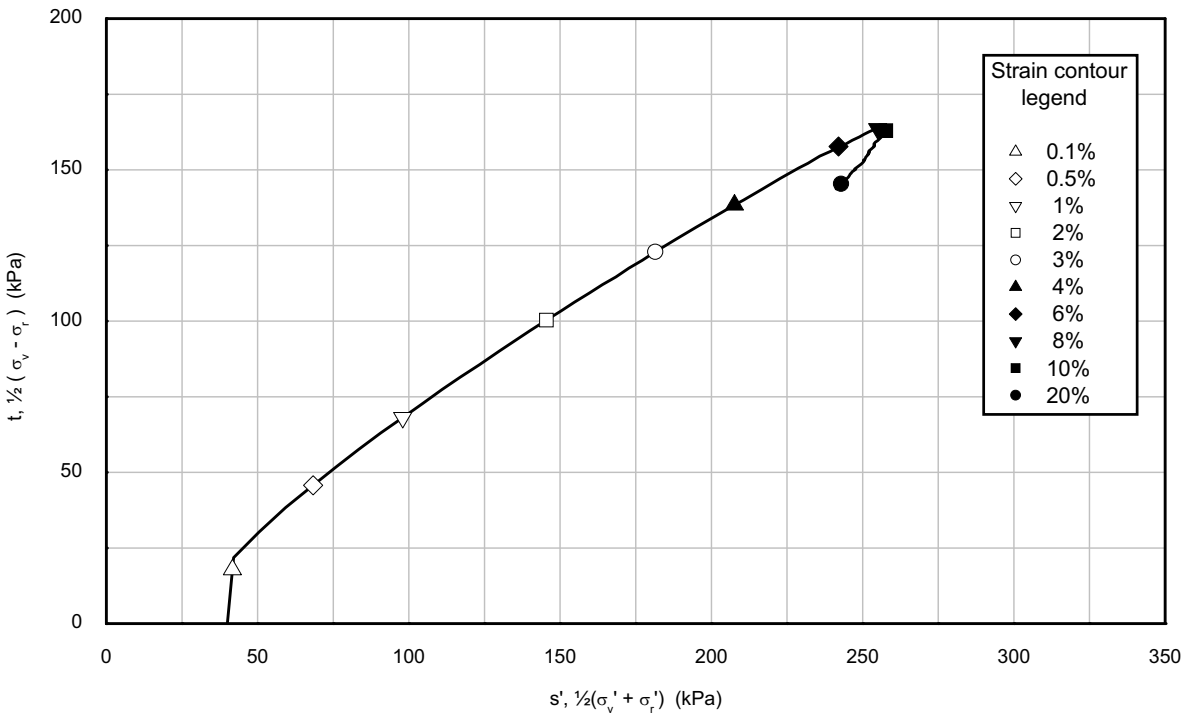
Date: 23/05/2011

Approved by: PH



Curve	Specimen	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	40	40	BH_07	2WaxA	4.17

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST: SINGLE SPECIMEN



Curve	Specimen	σ_{1c}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	40	40	BH_07	2WaxA	4.17

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_07_8WaxA_CU.XLS

Date: 24/05/2011

Approved by: PH

VISUAL DESCRIPTION	
Very stiff off white CHALK.	

GENERAL	
Date test started	12/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL	
Diameter (mm)	71.7
Length (mm)	137.8
Moisture content (%)	27
Bulk density (Mg/m ³)	2.07
Dry density (Mg/m ³)	1.63
Voids ratio	0.661
Degree of saturation (%)	100

SATURATION	
Pressure increments applied (kPa)	100
Differential pressure used (kPa)	N/A
Pore pressure on completion (kPa)	581
Cell pressure on completion (kPa)	586
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_07
Sample	8WaxA
Depth (m)	19.64

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_07_8WaxA_CU.XLS

Date: 19/05/2011

Date: 24/05/2011

Checked by:

Approved by: PH

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	586
Back pressure	(kPa)	400
Effective cell pressure	(kPa)	186
Pore pressure on completion	(kPa)	400
Pore pressure dissipation	(%)	100
Moisture content	(%)	26
Bulk density	(Mg/m ³)	2.10
Dry density	(Mg/m ³)	1.67
Voids ratio		0.620
Degree of saturation	(%)	100
Cvi	(m ² /year)	1433.4
Mvi	(m ² /MN)	0.14
Permeability	(m/s)	6.31E-08

Mode of failure: Brittle failure.

Borehole	BH_07
Sample	8WaxA
Depth (m)	19.64

**SUMMARY OF
 ISOTROPICALLY CONSOLIDATED UNDRAINED
 TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_07_8WaxA_CU.XLS

Date: 19/05/2011

Date: 24/05/2011

Checked by:

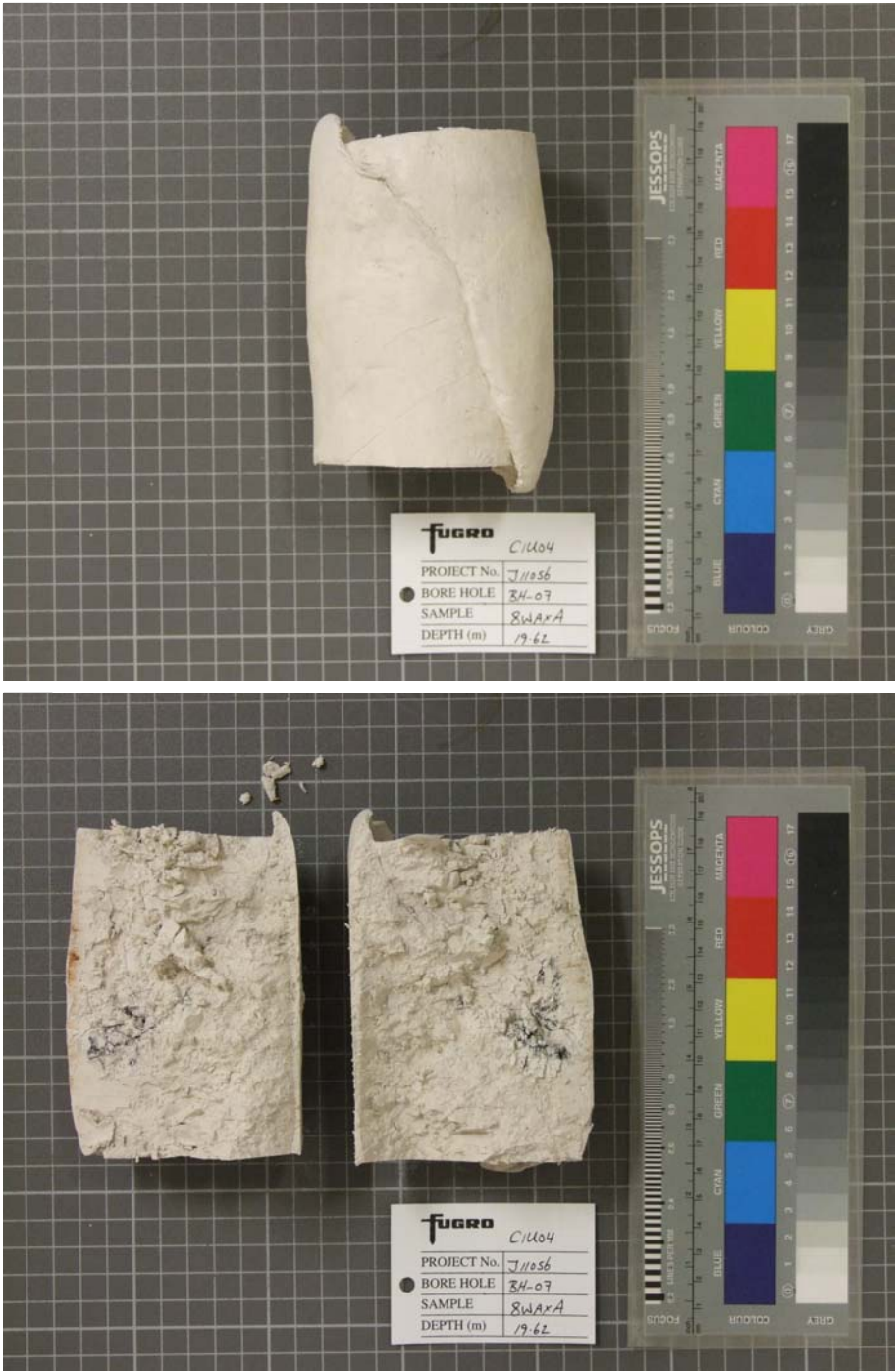
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	186
Rate of strain	(%/hour)	0.29
At peak deviator stress		
Corrected deviator stress	(kPa)	840
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	6.75
Excess pore pressure	(kPa)	-57
Major principal effective stress	(kPa)	1083
Minor principal effective stress	(kPa)	243
Principal effective stress ratio		4.45
e 50	(%)	1.77
Secant modulus at e 50	(kPa)	23717
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	492
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	2.13
Excess pore pressure	(kPa)	66
Major principal effective stress	(kPa)	611
Minor principal effective stress	(kPa)	120
Principal effective stress ratio		5.12
e 50	(%)	0.89
Secant modulus at e 50	(kPa)	27749
At 10% axial strain		
Corrected deviator stress	(kPa)	657
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	-15
Major principal effective stress	(kPa)	859
Minor principal effective stress	(kPa)	201
Principal effective stress ratio		4.26
e 50	(%)	1.27
Secant modulus at e 50	(kPa)	25832
FINAL CONDITIONS		
Moisture content	(%)	26
Bulk density	(Mg/m ³)	2.10
Dry density	(Mg/m ³)	1.67
Borehole		BH_07
Sample		8WaxA
Depth (m)		19.64

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAxIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: Approved by: PH Date: 19/05/2011 Date: 24/05/2011
Template Issue: 2 Filename: J11056 / EFFECTIV / BH_07_8WaxA_CU.XLS
Drawn by: NAC Date: 18/05/2011

SPECIMEN PHOTOGRAPHS



Borehole
Sample
Depth (m)

BH_07
8WaxA
19.64

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



Drawn by: NAC

Date: 18/05/2011

Template Issue: 4.1

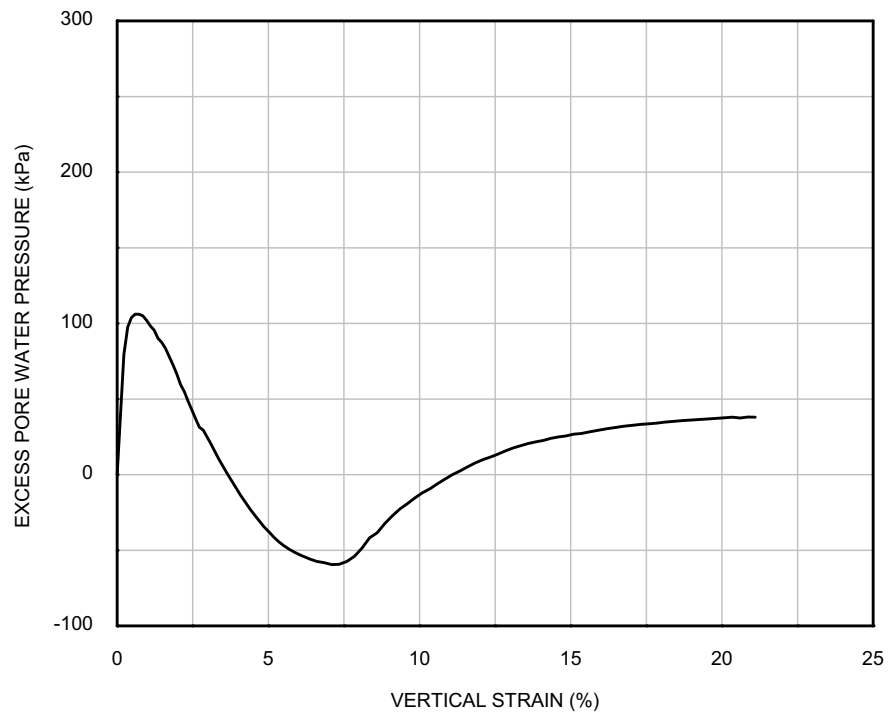
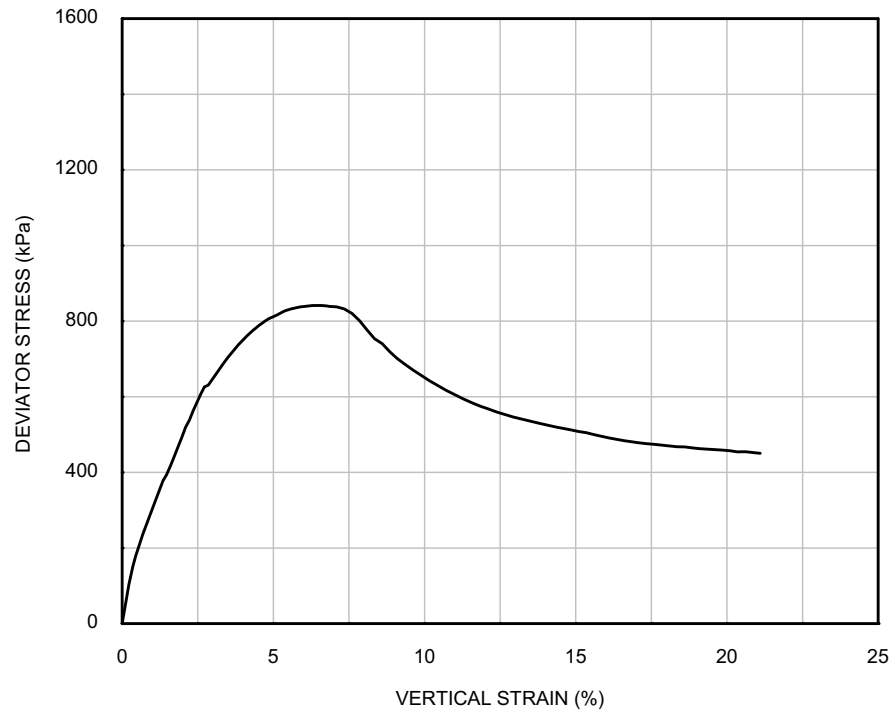
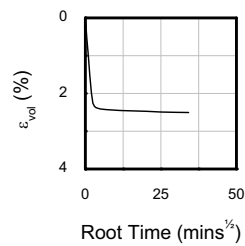
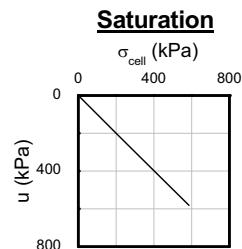
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Checked by: ALB

Filename: J11056 \ EFFECTIV \ BH_07_8WaxA_CU.OPJ

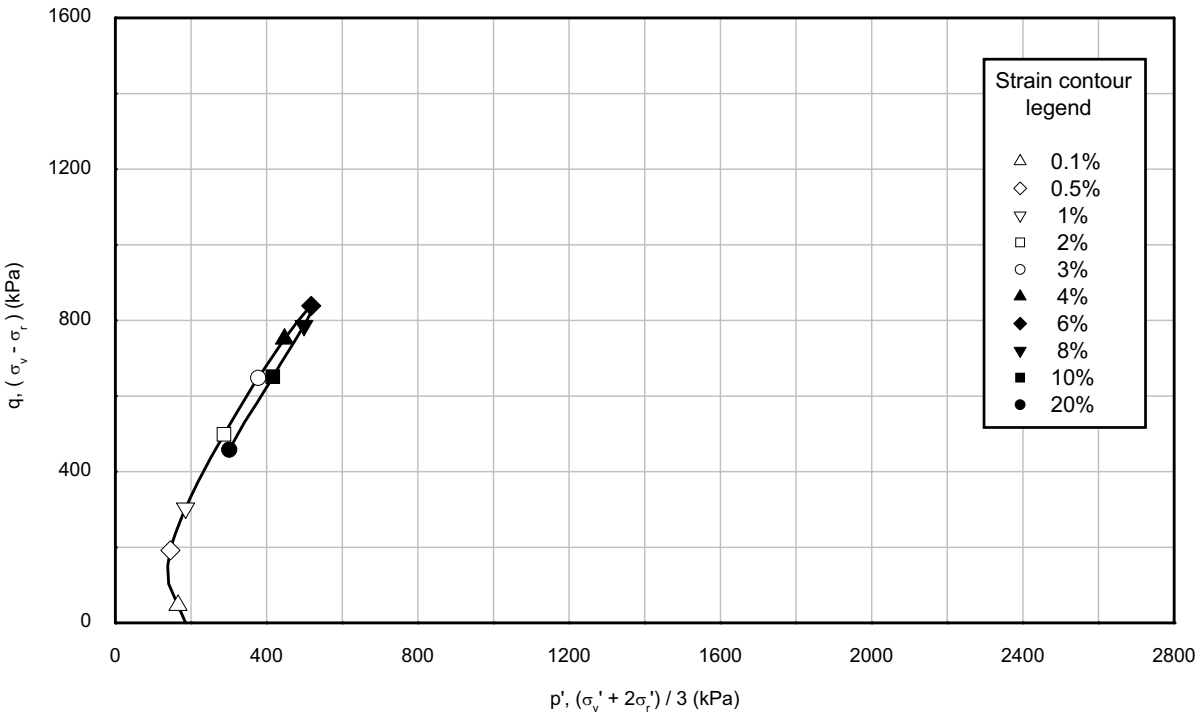
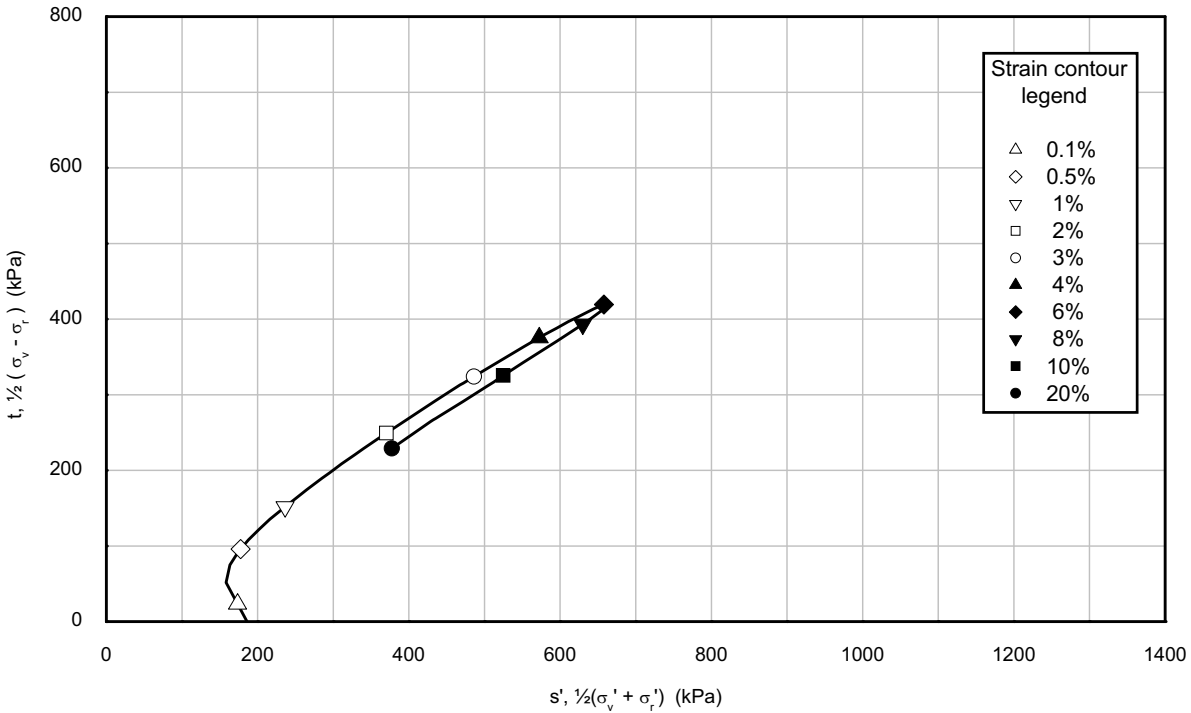
Date : 24/05/2011

Approved by: PH



Curve	Specimen	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	186	186	BH_07	8WaxA	19.64

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN



Curve	Specimen	$\sigma_{ic}' \text{ (kPa)}$	$\sigma_{vc}' \text{ (kPa)}$	Borehole	Sample	Depth (m)
—	1	186	186	BH_07	8WaxA	19.64

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_07_20WaxA_CU.XLS

Date: 23/05/2011

Approved by: PH

VISUAL DESCRIPTION	
Hard off white CHALK.	

GENERAL	
Date test started	12/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	One end

INITIAL	
Diameter (mm)	71.9
Length (mm)	140.1
Moisture content (%)	25
Bulk density (Mg/m ³)	1.99
Dry density (Mg/m ³)	1.59
Voids ratio	0.693
Degree of saturation (%)	97

SATURATION	
Pressure increments applied (kPa)	100
Differential pressure used (kPa)	N/A
Pore pressure on completion (kPa)	683
Cell pressure on completion (kPa)	700
B value achieved	0.98

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 7
Note: Fugro testing procedures are available on request	

Borehole	BH_07
Sample	20WaxA
Depth (m)	31.60

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_07_20WaxA_CU.XLS

Date: 19/05/2011

Date: 23/05/2011

Checked by:

Approved by: PH

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
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.63
Voids ratio		0.658
Degree of saturation	(%)	97
Cvi	(m ² /year)	789.3
Mvi	(m ² /MN)	0.075
Permeability	(m/s)	1.84E-08

Mode of failure: Brittle failure

Borehole	BH_07
Sample	20WaxA
Depth (m)	31.60

**SUMMARY OF
 ISOTROPICALLY CONSOLIDATED UNDRAINED
 TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_07_20WaxA_CU.XLS

Date: 23/05/2011

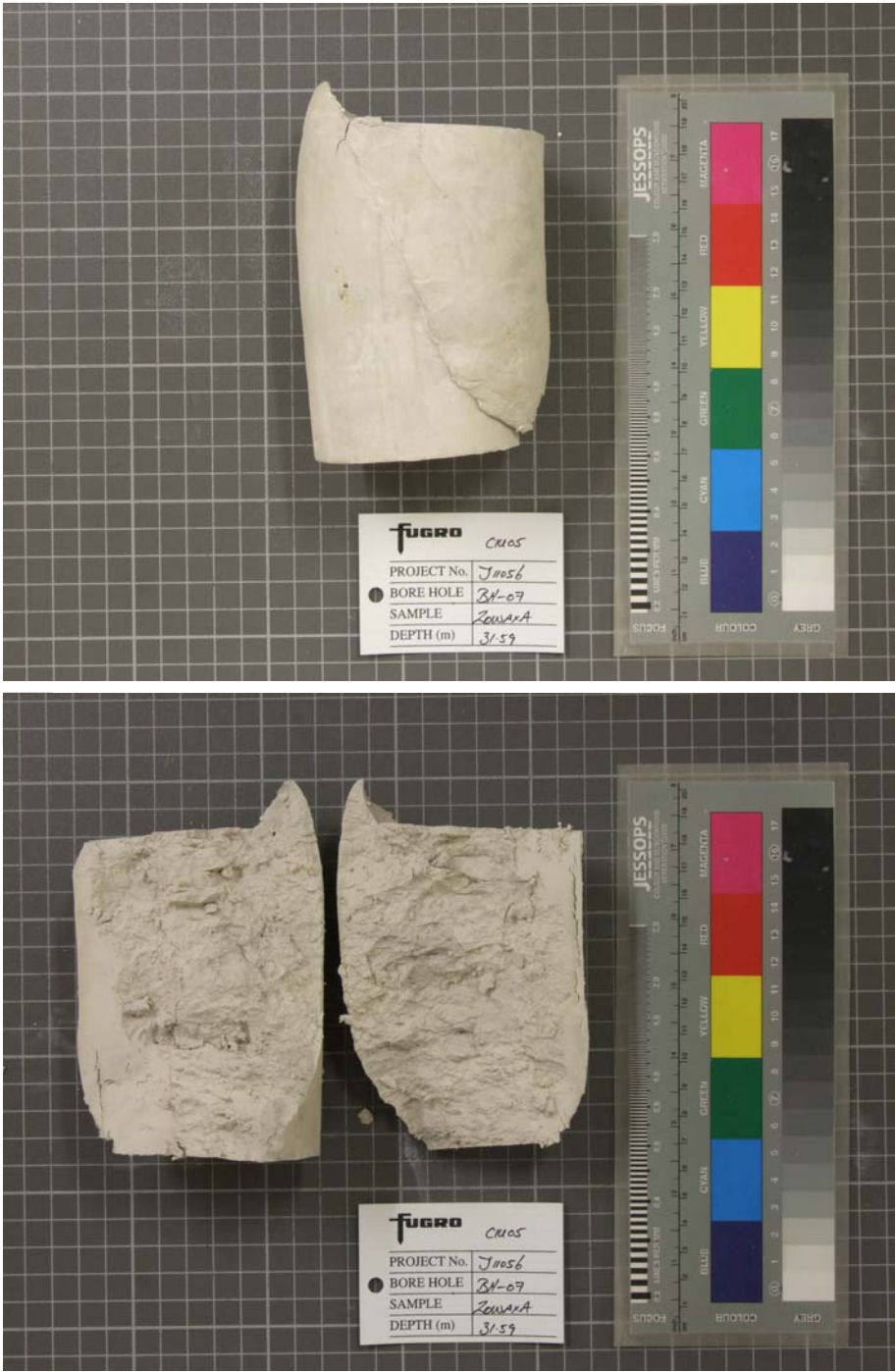
Approved by: PH

SHEARING		
Initial pore pressure	(kPa)	400
Initial effective cell pressure	(kPa)	300
Rate of strain	(%/hour)	0.29
At peak deviator stress		
Corrected deviator stress	(kPa)	847
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	5.94
Excess pore pressure	(kPa)	52
Major principal effective stress	(kPa)	1094
Minor principal effective stress	(kPa)	248
Principal effective stress ratio		4.42
e 50	(%)	1.29
Secant modulus at e 50	(kPa)	32801
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	564
Membrane correction applied	(kPa)	0.2
Drain correction applied	(kPa)	0
Axial strain	(%)	2.19
Excess pore pressure	(kPa)	156
Major principal effective stress	(kPa)	708
Minor principal effective stress	(kPa)	144
Principal effective stress ratio		4.92
e 50	(%)	0.51
Secant modulus at e 50	(kPa)	54987
At 10% axial strain		
Corrected deviator stress	(kPa)	681
Membrane correction applied	(kPa)	0.8
Drain correction applied	(kPa)	0
Axial strain	(%)	10.00
Excess pore pressure	(kPa)	87
Major principal effective stress	(kPa)	895
Minor principal effective stress	(kPa)	213
Principal effective stress ratio		4.19
e 50	(%)	0.81
Secant modulus at e 50	(kPa)	41833
FINAL CONDITIONS		
Moisture content	(%)	24
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.63
Borehole		BH_07
Sample		20WaxA
Depth (m)		31.60

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: Approved by: PH Date: 19/05/2011 Date: 23/05/2011
Template Issue: 2 Filename: J11056 / EFFECTIV / BH_07_20WaxA_CU.XLS Drawn by: NAC Date: 18/05/2011

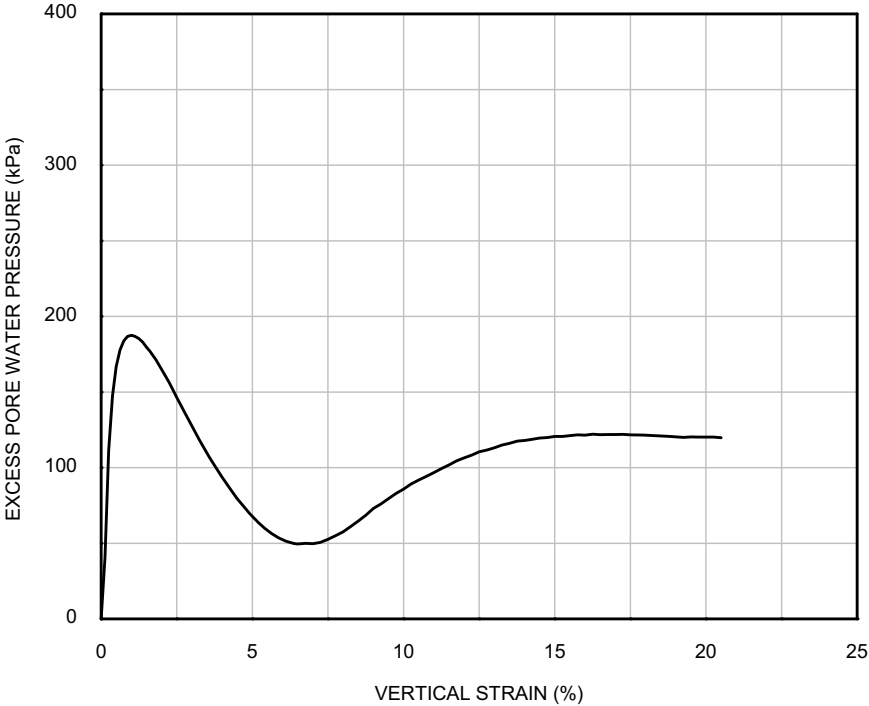
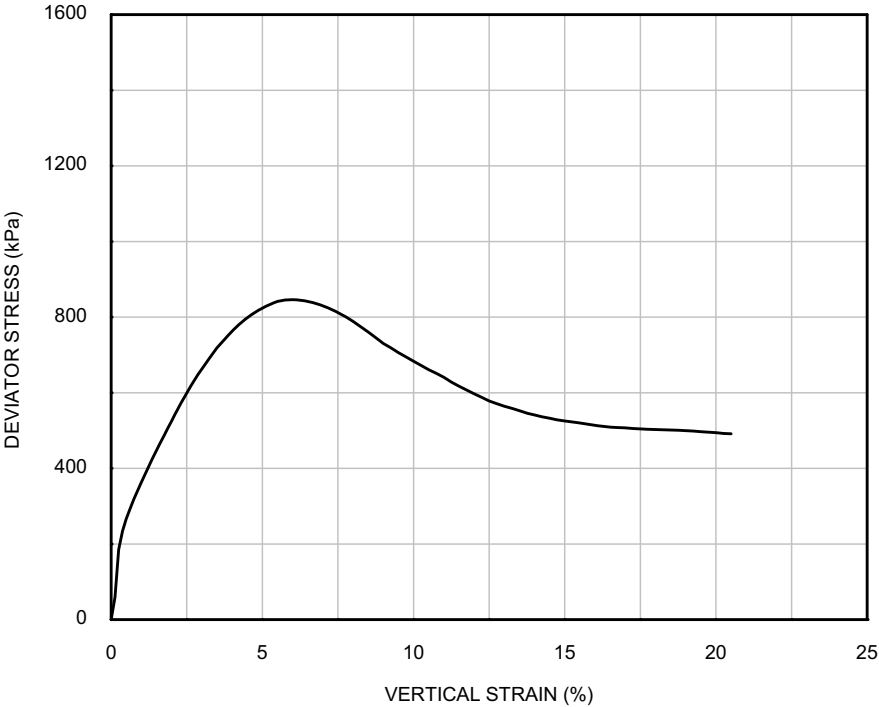
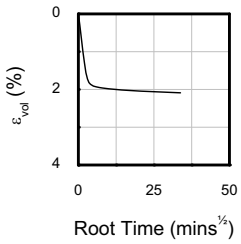
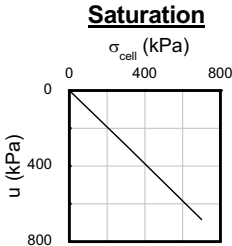
SPECIMEN PHOTOGRAPHS



Borehole
Sample
Depth (m)

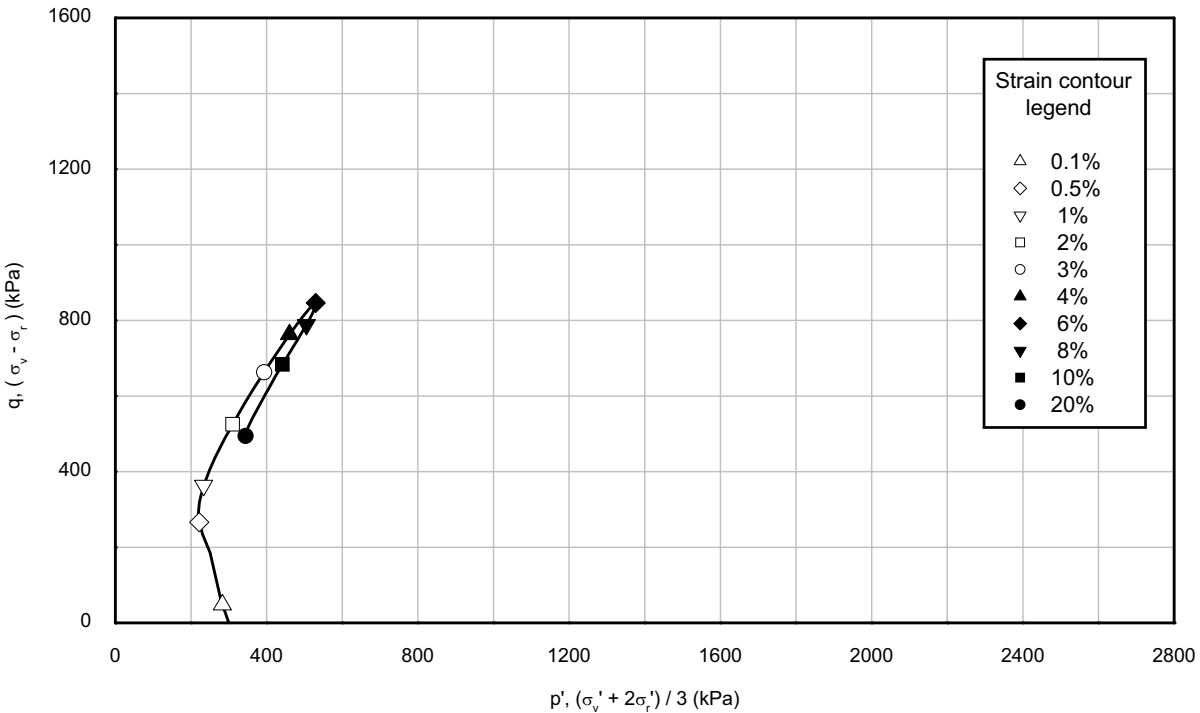
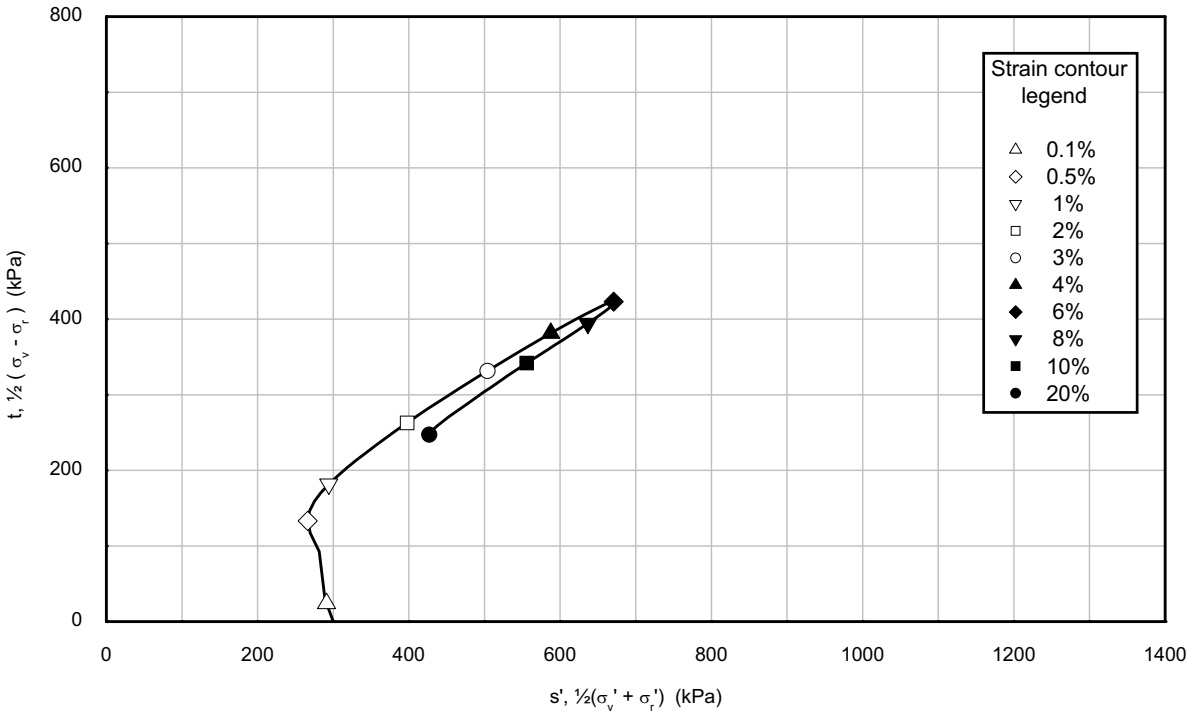
BH_07
20WaxA
31.60

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



Curve	Specimen	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	300	300	BH_07	20WaxA	31.60

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN



Curve	Specimen	$\sigma_{ic}' \text{ (kPa)}$	$\sigma_{vc}' \text{ (kPa)}$	Borehole	Sample	Depth (m)
—	1	300	300	BH_07	20WaxA	31.60

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SINGLE SPECIMEN

Date: 16/05/2011

Drawn by: NAC

Template Issue: 2

Date: 17/05/2011

Checked by: ALB

Filename: J11056 / EFFECTIV / BH_13_9BagA_D3.XLS

Date: 18/05/2011

Approved by: PH

VISUAL DESCRIPTION
Dark greyish brown fine SAND.

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	10/05/2011	10/05/2011	13/05/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	50.9	50.9	50.9
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	9.5	9.5	9.8
Bulk density	(Mg/m ³)	1.75	1.75	1.75
Dry density	(Mg/m ³)	1.60	1.60	1.59
Voids ratio		0.658	0.656	0.661
Degree of saturation	(%)	38	39	39

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	401	514	826
Cell pressure on completion	(kPa)	415	530	860
B value achieved		0.97	0.98	0.95

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH_13	BH_13	BH_13
Sample	9BagA	9BagA	9BagA
Depth (m)	18.00	18.00	18.00

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 16/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_13_9BagA_D3.XLS

Date: 17/05/2011

Date: 18/05/2011

Checked by: ALB

Approved by: PH

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	415	530	860
Back pressure	(kPa)	300	300	400
Effective cell pressure	(kPa)	115	230	460
Pore pressure on completion	(kPa)	300	300	400
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	24	23	23
Bulk density	(Mg/m ³)	2.01	2.02	2.02
Dry density	(Mg/m ³)	1.62	1.64	1.64
Voids ratio		0.636	0.620	0.612
Degree of saturation	(%)	100	100	100
Cvi	(m ² /year)	12654	15915	17936
Mvi	(m ² /MN)	0.13	0.10	0.073
Permeability	(m/s)	5.17E-07	5.05E-07	4.04E-07

Mode of failure: Compound failure Compound failure Compound failure

Borehole	BH_13	BH_13	BH_13
Sample	9BagA	9BagA	9BagA
Depth (m)	18.00	18.00	18.00

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 16/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_13_9BagA_D3.XLS

Date: 17/05/2011

Date: 18/05/2011

Checked by: ALB

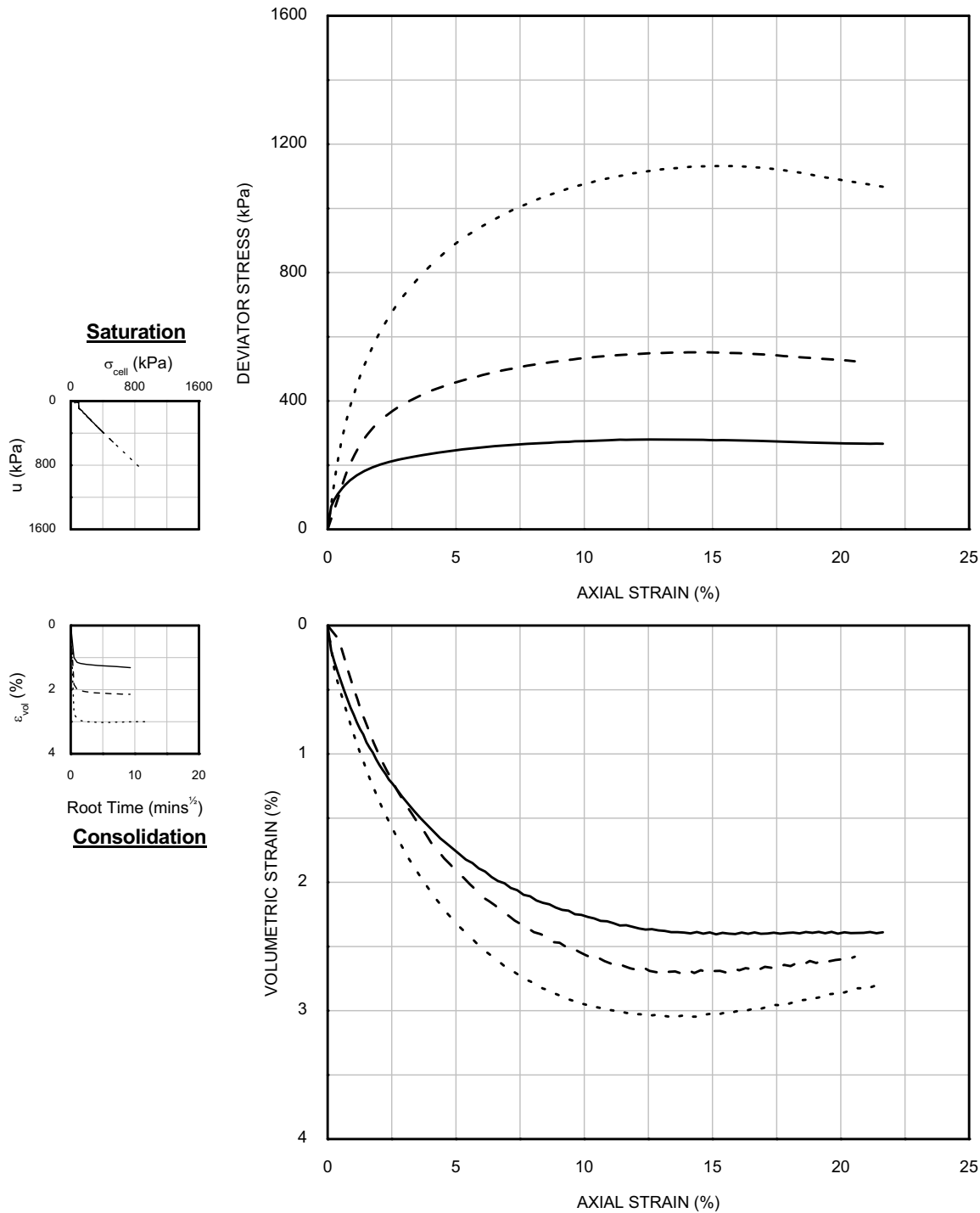
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	400
Initial effective cell pressure	(kPa)	115	230	460
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	280	552	1132
Membrane correction applied	(kPa)	1.3	1.4	1.5
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	12.89	14.30	15.41
Volumetric strain	(%)	2.37	2.71	3.02
Major principal effective stress	(kPa)	396	782	1592
Minor principal effective stress	(kPa)	116	231	460
Principal effective stress ratio		3.42	3.39	3.46
ϵ 50	(%)	0.70	1.37	1.74
Secant modulus at ϵ 50	(kPa)	19867	20088	32625
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	280	552	1132
Membrane correction applied	(kPa)	1.3	1.4	1.5
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	12.39	14.30	15.41
Volumetric strain	(%)	2.37	2.71	3.02
Major principal effective stress	(kPa)	395	782	1592
Minor principal effective stress	(kPa)	115	231	460
Principal effective stress ratio		3.42	3.39	3.46
ϵ 50	(%)	0.70	1.37	1.74
Secant modulus at ϵ 50	(kPa)	19885	20088	32625
At 10% axial strain				
Corrected deviator stress	(kPa)	275	534	1075
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	2.26	2.56	2.95
Major principal effective stress	(kPa)	391	764	1535
Minor principal effective stress	(kPa)	116	230	460
Principal effective stress ratio		3.37	3.32	3.34
ϵ 50	(%)	0.67	1.30	1.57
Secant modulus at ϵ 50	(kPa)	20408	20554	34176
FINAL CONDITIONS				
Moisture content	(%)	24	23	23
Bulk density	(Mg/m ³)	2.01	2.02	2.02
Dry density	(Mg/m ³)	1.62	1.64	1.64
Borehole		BH_13	BH_13	BH_13
Sample		9BagA	9BagA	9BagA
Depth (m)		18.00	18.00	18.00

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

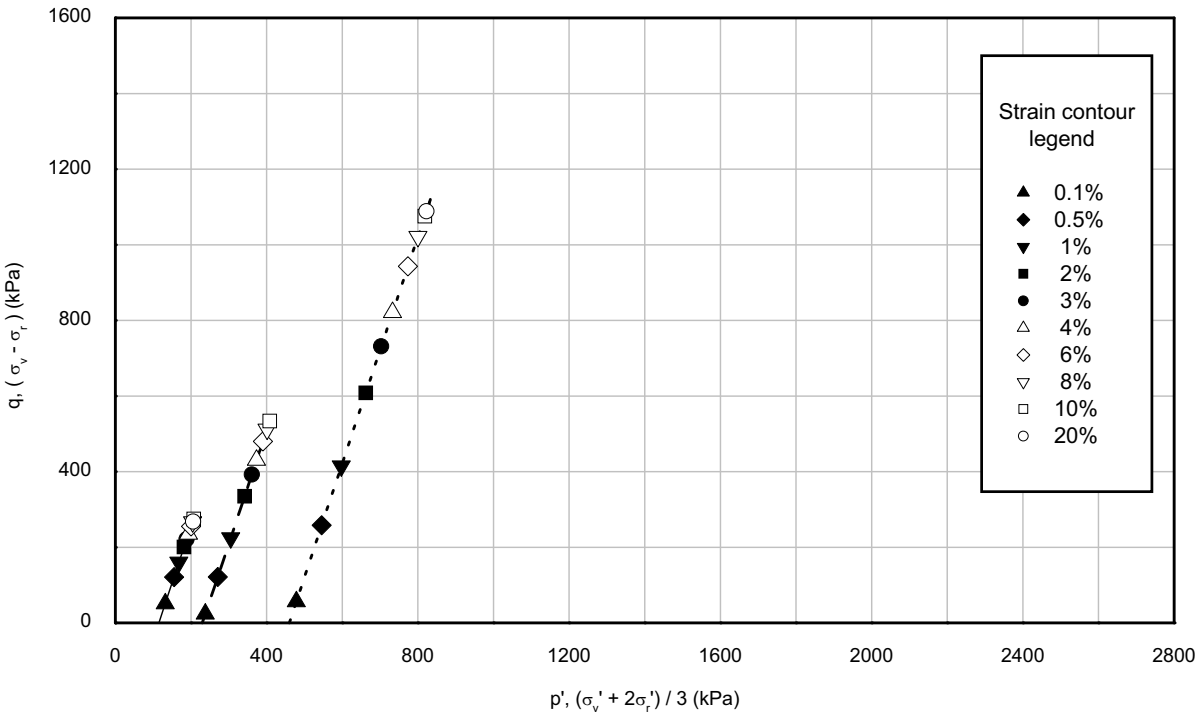
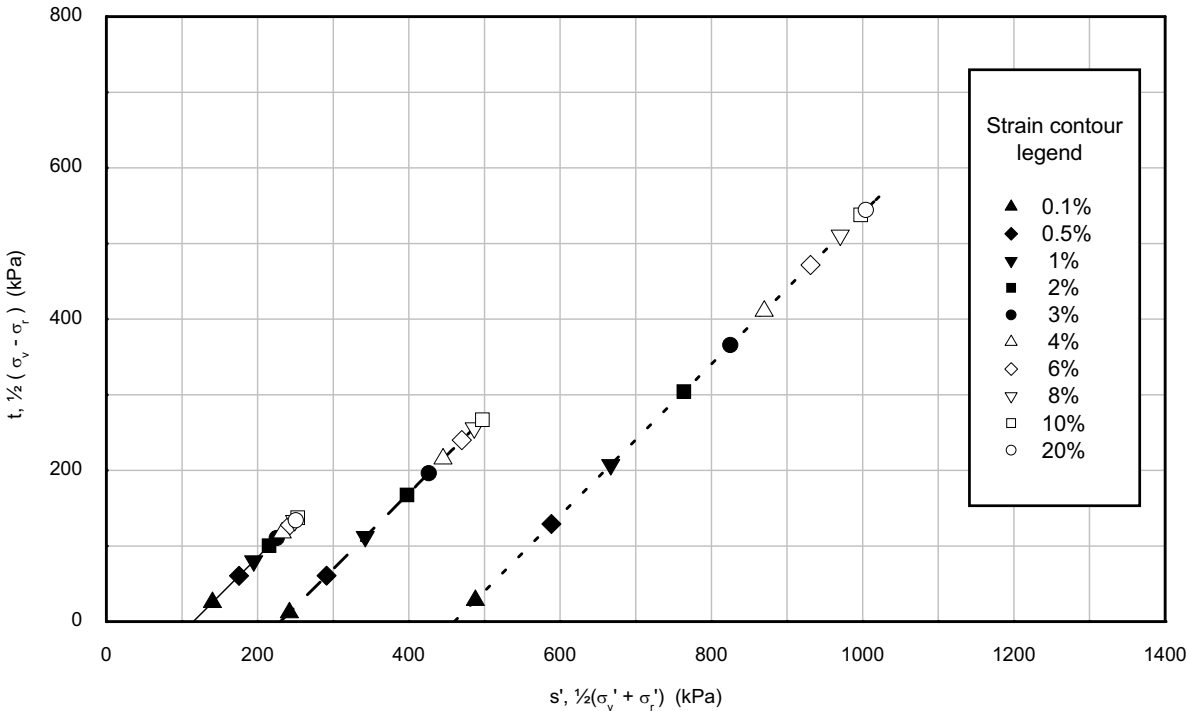


Drawn by: NAC
Date: 16/05/2011
Template Issue: 4
Filename: J11056 \EFFECTIV \BH_13_9BagA_D3.OPJ
Date : 17/05/2011
Date : 18/05/2011
Checked by: ALB
Approved by: PH



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	115	115	BH_13	9BagA	18.00
- - -	2	230	230			
. . .	3	460	460			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST: SET OF THREE SPECIMENS

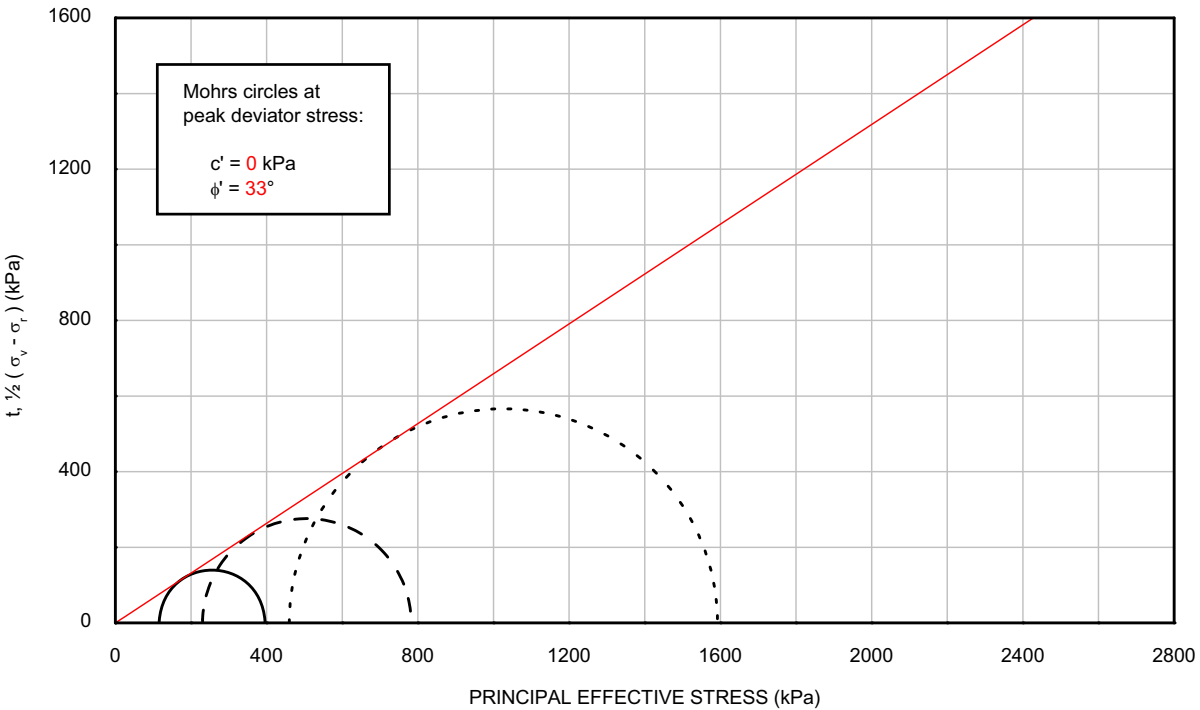
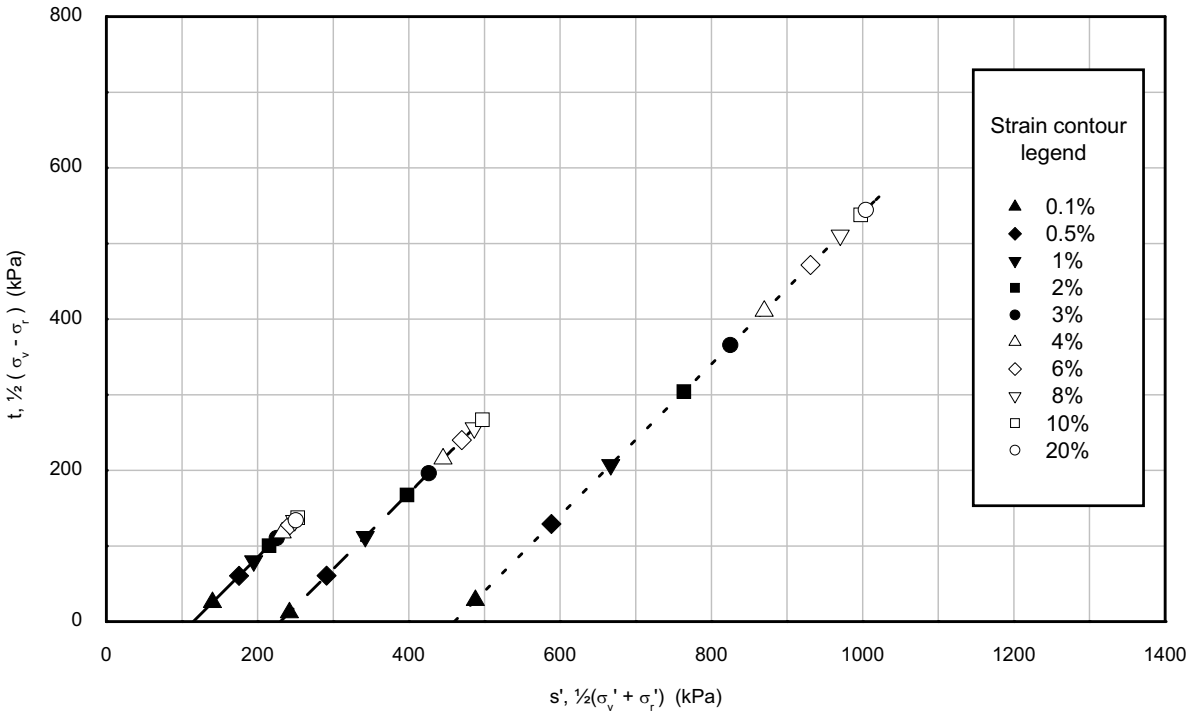


Date: 17/05/2011
Date: 18/05/2011

Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	115	115	BH_13	9BagA	18.00
- - -	2	230	230			
. . .	3	460	460			

Checked by: ALB
Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	115	115	BH_13	9BagA	18.00
- - -	2	230	230			
· · ·	3	460	460			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Date: 16/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_13_21BagB_D3.XLS

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION
Olive brown fine SAND

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	12/05/2011	12/05/2011	12/05/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	50.9	50.9	50.9
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	9.8	9.8	9.8
Bulk density	(Mg/m ³)	1.94	1.94	1.93
Dry density	(Mg/m ³)	1.77	1.76	1.76
Voids ratio		0.501	0.503	0.504
Degree of saturation	(%)	52	52	52

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	485	689	1042
Cell pressure on completion	(kPa)	500	700	1100
B value achieved		0.98	1.00	0.94

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH_13	BH_13	BH_13
Sample	21BagB	21BagB	21BagB
Depth (m)	33.10	33.10	33.10

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**



Date: 16/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_13_21BagB_D3.XLS

Date:

Date:

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Approved by:

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	500	700	1100
Back pressure	(kPa)	300	300	300
Effective cell pressure	(kPa)	200	400	800
Pore pressure on completion	(kPa)	300	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	16	15	15
Bulk density	(Mg/m ³)	2.15	2.18	2.19
Dry density	(Mg/m ³)	1.85	1.89	1.91
Voids ratio		0.431	0.403	0.389
Degree of saturation	(%)	100	100	100
Cvi	(m ² /year)	2420	3263	3389
Mvi	(m ² /MN)	0.26	0.18	0.11
Permeability	(m/s)	1.97E-07	1.85E-07	1.18E-07

Mode of failure: Compound failure Compound failure Compound failure

Borehole	BH_13	BH_13	BH_13
Sample	21BagB	21BagB	21BagB
Depth (m)	33.10	33.10	33.10

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 16/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_13_21BagB_D3.XLS

Date:

Date:

Checked by:

Approved by:

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	300
Initial effective cell pressure	(kPa)	200	400	800
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	647	1171	2007
Membrane correction applied	(kPa)	0.5	0.5	1.0
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	4.32	4.52	9.24
Volumetric strain	(%)	0.53	1.21	2.67
Major principal effective stress	(kPa)	848	1572	2806
Minor principal effective stress	(kPa)	201	401	799
Principal effective stress ratio		4.22	3.92	3.51
ϵ 50	(%)	1.32	1.17	1.28
Secant modulus at ϵ 50	(kPa)	24437	49903	78139
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	647	1171	2007
Membrane correction applied	(kPa)	0.5	0.5	1.0
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	4.32	4.52	9.24
Volumetric strain	(%)	0.53	1.21	2.67
Major principal effective stress	(kPa)	848	1572	2806
Minor principal effective stress	(kPa)	201	401	799
Principal effective stress ratio		4.22	3.92	3.51
ϵ 50	(%)	1.32	1.17	1.28
Secant modulus at ϵ 50	(kPa)	24437	49903	78139
At 10% axial strain				
Corrected deviator stress	(kPa)	555	1074	2005
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-0.14	1.09	2.74
Major principal effective stress	(kPa)	756	1474	2804
Minor principal effective stress	(kPa)	201	401	799
Principal effective stress ratio		3.76	3.68	3.51
ϵ 50	(%)	1.14	1.06	1.28
Secant modulus at ϵ 50	(kPa)	24247	50628	78156
FINAL CONDITIONS				
Moisture content	(%)	16	15	15
Bulk density	(Mg/m ³)	2.15	2.18	2.19
Dry density	(Mg/m ³)	1.85	1.89	1.91
Borehole		BH_13	BH_13	BH_13
Sample		21BagB	21BagB	21BagB
Depth (m)		33.10	33.10	33.10

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**



Drawn by: NAC

Date: 16/05/2011

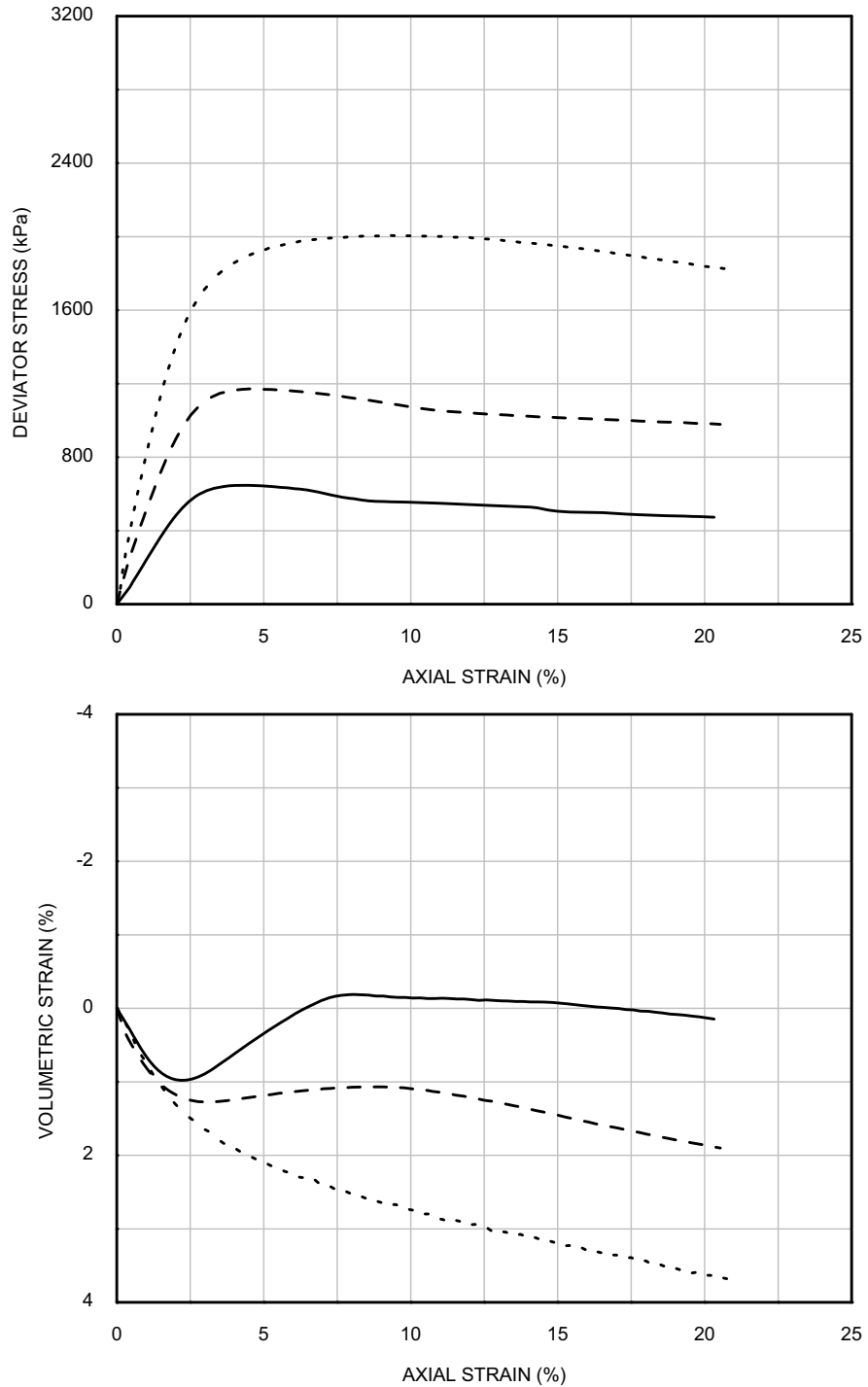
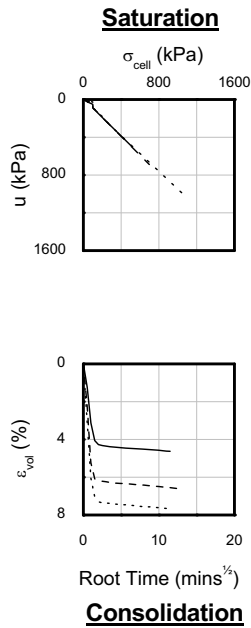
Template Issue: 4

Date: 17/05/2011

Checked by: PH

Filename: J11056 \EFFECTIV \BH_13_21BagB_D3.OPJ

Date: Approved by:



Curve	Specimen(3)	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	200	200	BH_13	21BagB	33.10
- - -	2	400	400			
. . .	3	800	800			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Drawn by: NAC Date: 16/05/2011

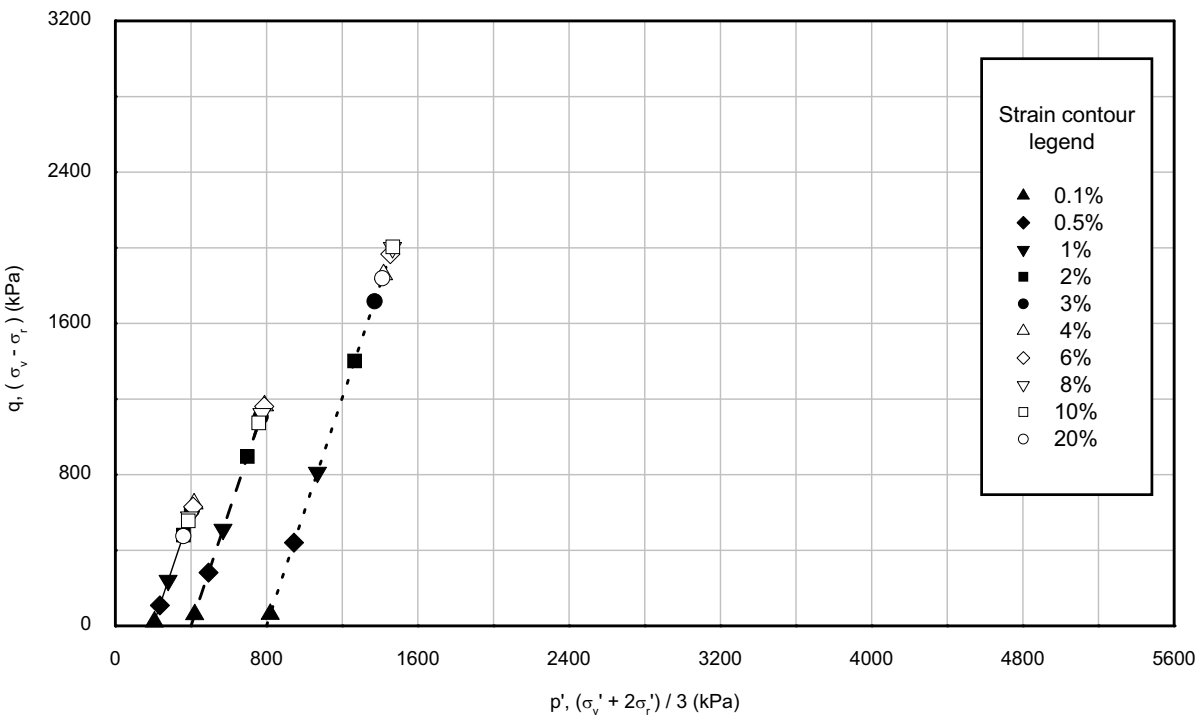
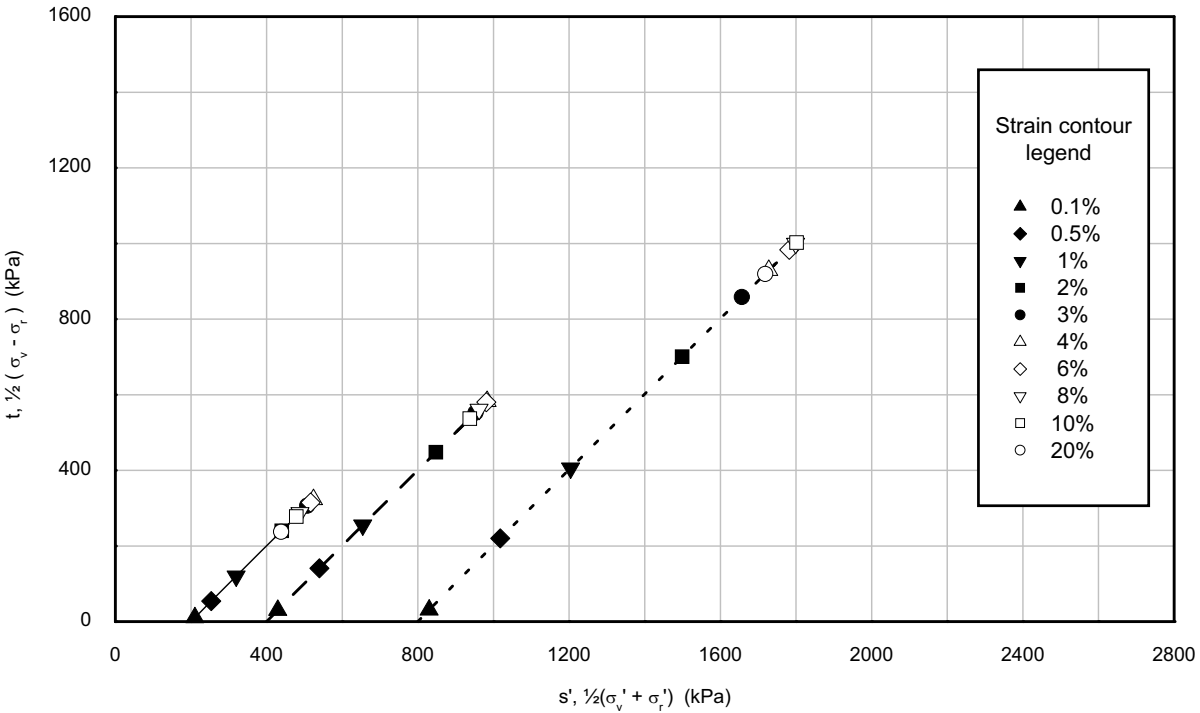
Template Issue: 4

Date: 17/05/2011

Checked by: PH

Filename: J11056 \EFFECTIV \BH_13_21BagB_D3.OPJ

Approved by:



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	200	200	BH_13	21BagB	33.10
- - -	2	400	400			
. . .	3	800	800			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Drawn by: NAC Date: 16/05/2011

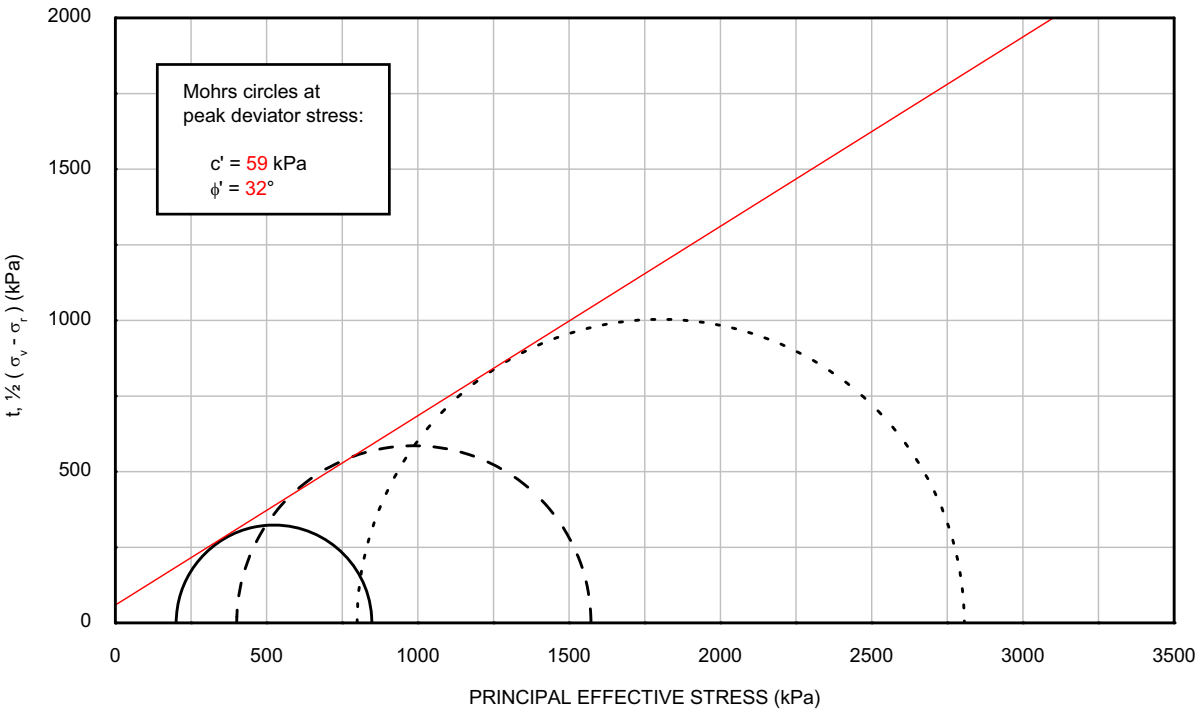
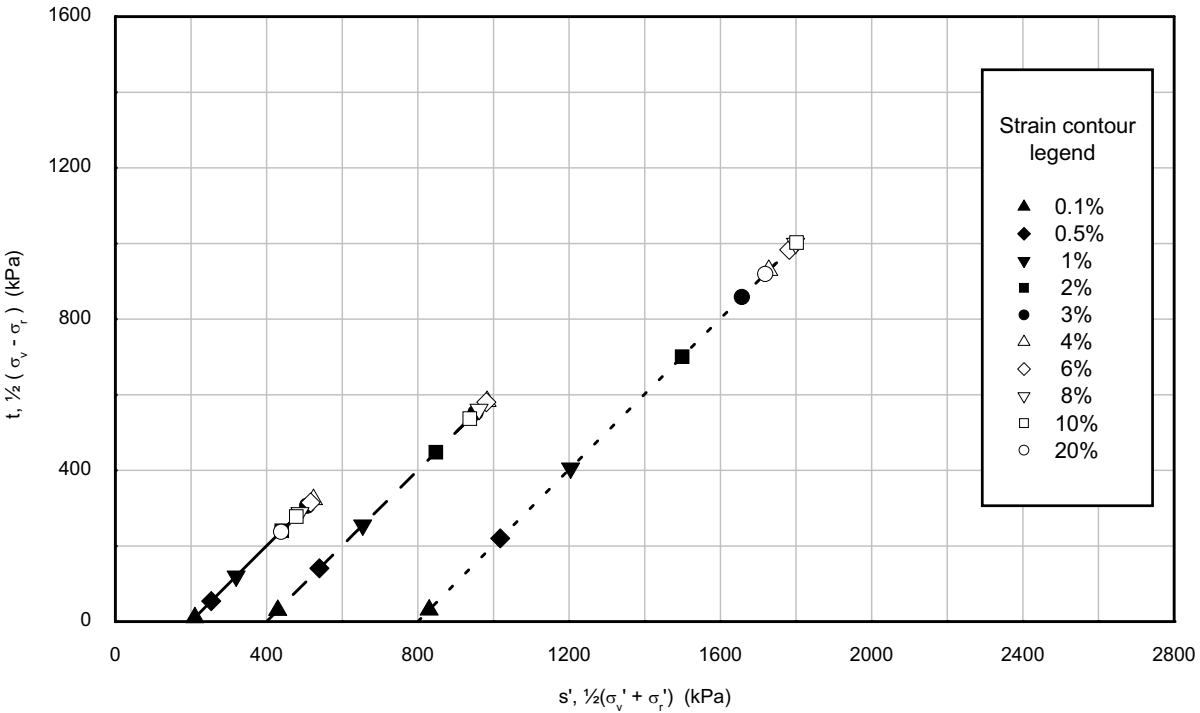
Template Issue: 4

Date: 17/05/2011

Checked by: PH

Filename: J11056 \EFFECTIV\BH_13_21BagB_D3.OPJ

Approved by:



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	200	200	BH_13	21BagB	33.10
- - -	2	400	400			
...	3	800	800			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Date: 12/05/2011

Drawn by: ALB

Template Issue: 2

Date: 12/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_14_2BagA_D3.XLS

Date:

Approved by:

VISUAL DESCRIPTION			
Olive grey fine SAND.			

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	10/05/2011	10/05/2011	10/05/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL				
Diameter	(mm)	50.9	50.9	50.9
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10	10	10
Bulk density	(Mg/m ³)	1.92	1.91	1.91
Dry density	(Mg/m ³)	1.74	1.74	1.74
Voids ratio		0.523	0.523	0.524
Degree of saturation	(%)	51	51	51

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	356	320	347
Cell pressure on completion	(kPa)	365	330	360
B value achieved		1.00	1.00	0.95

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH_14	BH_14	BH_14
Sample	2BagA	2BagA	2BagA
Depth (m)	2.50	2.50	2.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Drawn by: ALB

Template Issue: 2

Date: 12/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_14_2BagA_D3.XLS

Date:

Approved by:

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	365	330	360
Back pressure	(kPa)	350	300	300
Effective cell pressure	(kPa)	15	30	60
Pore pressure on completion	(kPa)	350	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	20	20	19
Bulk density	(Mg/m ³)	2.08	2.09	2.09
Dry density	(Mg/m ³)	1.74	1.74	1.75
Voids ratio		0.525	0.520	0.513
Degree of saturation	(%)	100	100	100

Mode of failure: Compound failure Compound failure Compound failure

Borehole	BH_14	BH_14	BH_14
Sample	2BagA	2BagA	2BagA
Depth (m)	2.50	2.50	2.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 12/05/2011

Drawn by: ALB

Template Issue: 2

Date: 12/05/2011

Checked by: PH

Filename: J11056 / EFFECTIV / BH_14_2BagA_D3.XLS

Date:

Approved by:

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	350	300	300
Initial effective cell pressure	(kPa)	15	30	60
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	77	149	252
Membrane correction applied	(kPa)	0.3	0.3	0.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.13	2.13	2.51
Volumetric strain	(%)	-1.94	-1.40	-0.96
Major principal effective stress	(kPa)	93	180	313
Minor principal effective stress	(kPa)	16	31	61
Principal effective stress ratio		5.93	5.77	5.17
ϵ 50	(%)	0.37	0.34	0.61
Secant modulus at ϵ 50	(kPa)	10493	22198	20840
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	77	149	252
Membrane correction applied	(kPa)	0.2	0.3	0.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.00	2.13	2.51
Volumetric strain	(%)	-1.78	-1.40	-0.96
Major principal effective stress	(kPa)	92	180	313
Minor principal effective stress	(kPa)	15	31	61
Principal effective stress ratio		6.05	5.77	5.17
ϵ 50	(%)	0.36	0.34	0.61
Secant modulus at ϵ 50	(kPa)	10531	22198	20840
At 10% axial strain				
Corrected deviator stress	(kPa)	46	89	165
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-6.34	-3.76	-3.12
Major principal effective stress	(kPa)	62	120	226
Minor principal effective stress	(kPa)	16	31	61
Principal effective stress ratio		3.84	3.91	3.72
ϵ 50	(%)	0.16	0.15	0.39
Secant modulus at ϵ 50	(kPa)	14638	29800	21326
FINAL CONDITIONS				
Moisture content	(%)	20	20	19
Bulk density	(Mg/m ³)	2.08	2.09	2.09
Dry density	(Mg/m ³)	1.74	1.74	1.75
Borehole		BH_14	BH_14	BH_14
Sample		2BagA	2BagA	2BagA
Depth (m)		2.50	2.50	2.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**



Drawn by: ALB

Date: 12/05/2011

Template Issue: 4

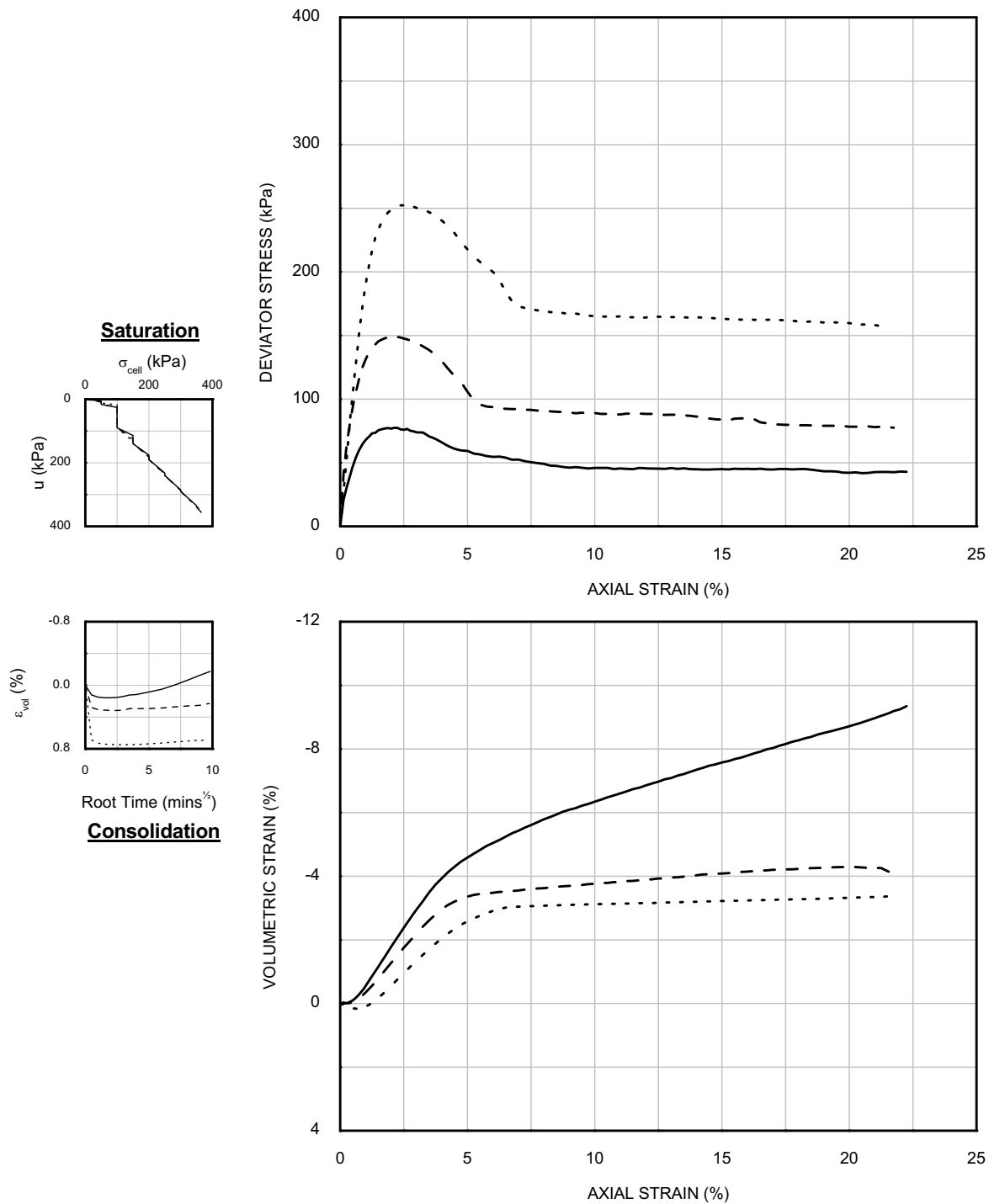
Date: 12/05/2011

Checked by: PH

Filename: J11056 \EFFECTIV\BH_14_2BagA_D3.OPJ

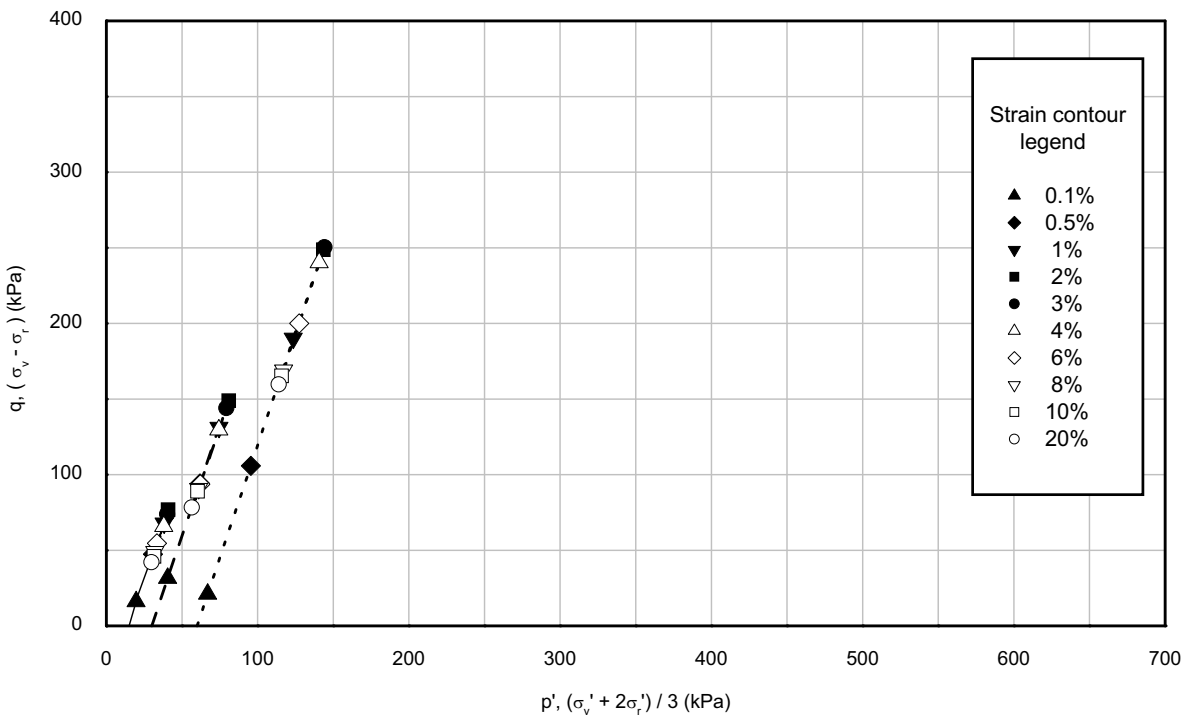
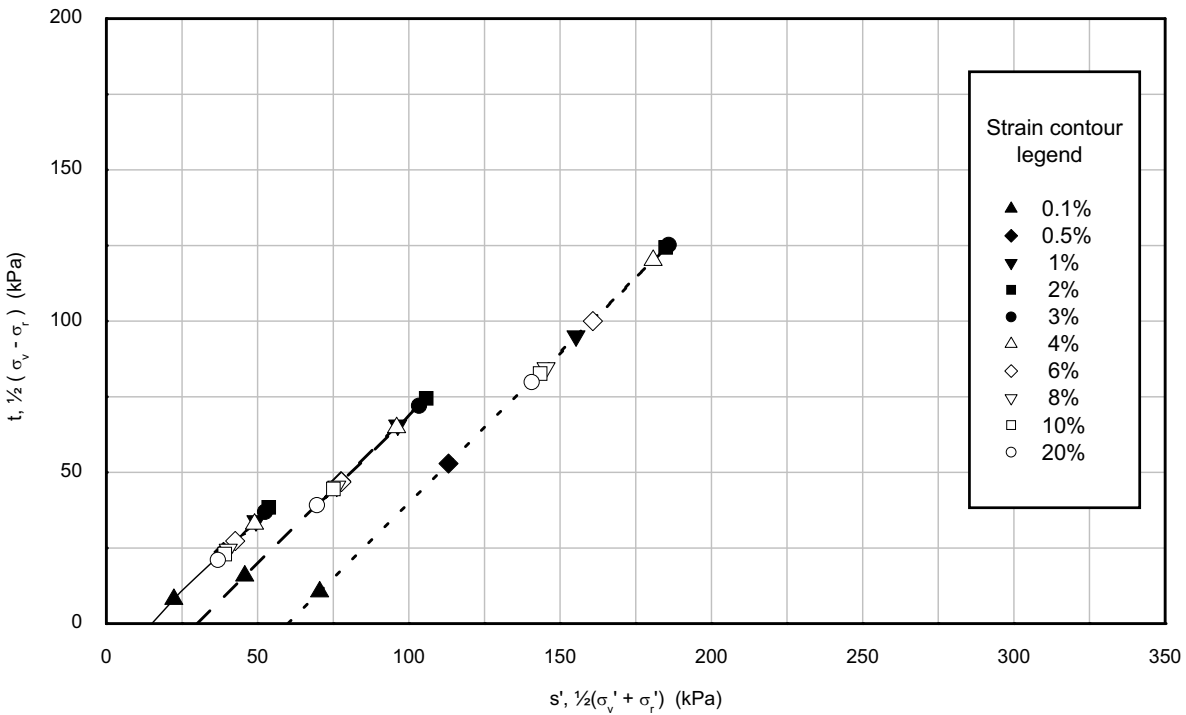
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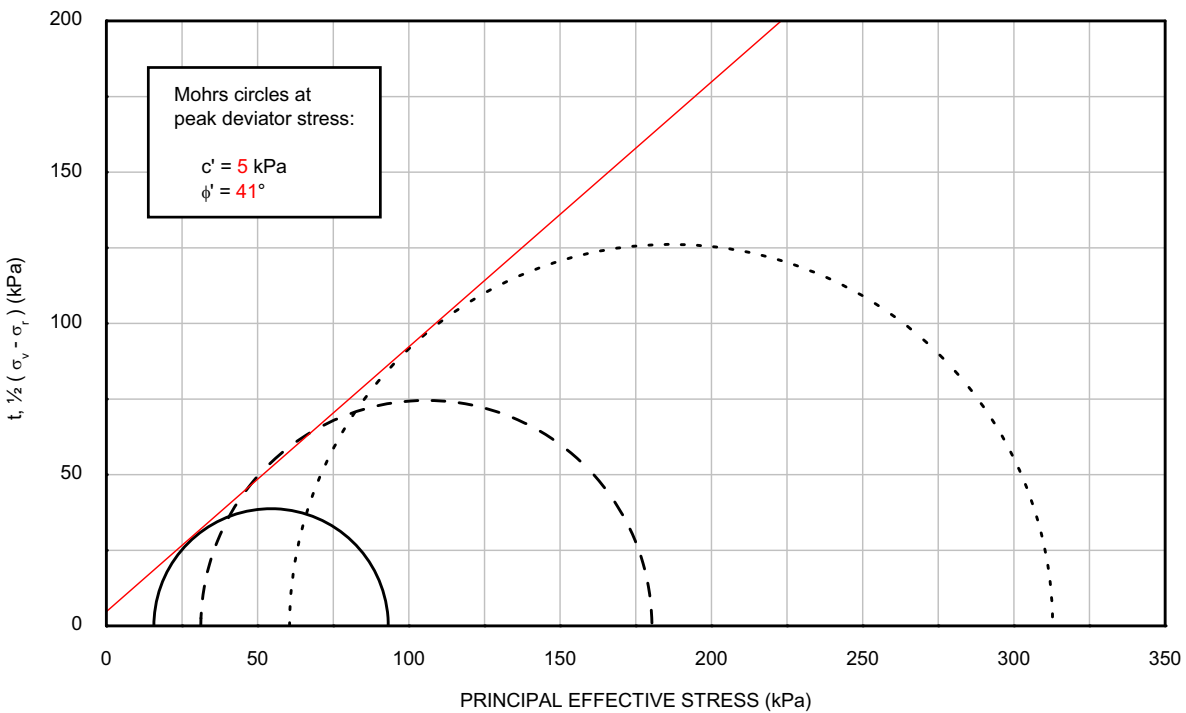
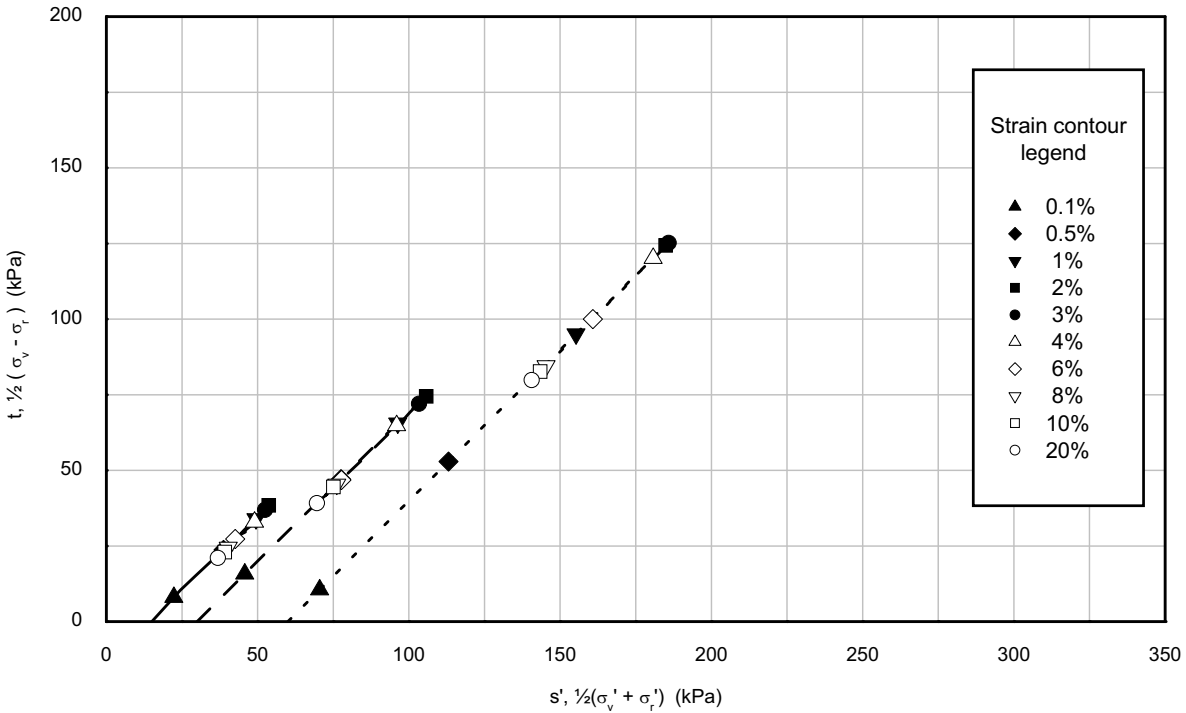
Curve	Specimen(3)	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	15	15	BH_14	2BagA	2.50
- - -	2	30	30			
. . .	3	60	60			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	15	15	BH_14	2BagA	2.50
- - -	2	30	30			
...	3	60	60			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Date: 12/05/2011

Date:

Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	15	15	BH_14	2BagA	2.50
- - -	2	30	30			
· · ·	3	60	60			

Checked by: PH

Approved by:

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Date: 13/05/2011

Drawn by: NAC

Template Issue: 2

Date: 13/05/2011

Checked by: ALB

Filename: J11056 / EFFECTIV / BH_14_22BagA_D3.XLS

Approved by: PH

VISUAL DESCRIPTION			
Light olive brown fine SAND.			

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	11/05/2011	11/05/2011	11/05/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL			
Diameter (mm)	50.9	50.9	50.9
Length (mm)	90.0	90.0	90.0
Moisture content (%)	9.0	9.0	9.0
Bulk density (Mg/m ³)	1.88	1.88	1.89
Dry density (Mg/m ³)	1.73	1.73	1.73
Voids ratio	0.534	0.536	0.532
Degree of saturation (%)	45	45	45

SATURATION			
Pressure increments applied (kPa)	50	50	50
Differential pressure used (kPa)	10	10	10
Pore pressure on completion (kPa)	552	838	1390
Cell pressure on completion (kPa)	575	850	1400
B value achieved	0.95	1.00	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 8
Note: Fugro testing procedures are available on request	

Borehole	BH_14	BH_14	BH_14
Sample	22BagA	22BagA	22BagA
Depth (m)	45.50	45.50	45.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**



Date: 13/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_14_22BagA_D3.XLS

Date: 13/05/2011

Checked by: ALB

Approved by: PH

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	575	850	1400
Back pressure	(kPa)	300	300	300
Effective cell pressure	(kPa)	275	550	1100
Pore pressure on completion	(kPa)	300	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	19	19	19
Bulk density	(Mg/m ³)	2.09	2.10	2.11
Dry density	(Mg/m ³)	1.75	1.76	1.78
Voids ratio		0.516	0.502	0.492
Degree of saturation	(%)	100	100	100
Cvi	(m ² /year)	18153	15456	13484
Mvi	(m ² /MN)	0.048	0.042	0.025
Permeability	(m/s)	2.67E-07	1.99E-07	1.04E-07

Mode of failure: Compound failure Compound failure Compound failure

Borehole	BH_14	BH_14	BH_14
Sample	22BagA	22BagA	22BagA
Depth (m)	45.50	45.50	45.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 13/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_14_22BagA_D3.XLS

Date: 13/05/2011

Checked by: ALB

Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	300	300	300
Initial effective cell pressure	(kPa)	275	550	1100
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	930	1704	3167
Membrane correction applied	(kPa)	0.5	0.7	0.9
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	3.95	5.59	8.18
Volumetric strain	(%)	-0.63	0.00	0.69
Major principal effective stress	(kPa)	1206	2255	4270
Minor principal effective stress	(kPa)	276	551	1103
Principal effective stress ratio		4.36	4.09	3.87
ε 50	(%)	0.51	0.68	0.95
Secant modulus at ε 50	(kPa)	91107	124806	167226
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	930	1704	3165
Membrane correction applied	(kPa)	0.5	0.7	0.9
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	3.95	5.59	7.93
Volumetric strain	(%)	-0.63	0.00	0.70
Major principal effective stress	(kPa)	1206	2255	4268
Minor principal effective stress	(kPa)	276	551	1102
Principal effective stress ratio		4.36	4.09	3.87
ε 50	(%)	0.51	0.68	0.95
Secant modulus at ε 50	(kPa)	91107	124806	167262
At 10% axial strain				
Corrected deviator stress	(kPa)	723	1559	3137
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-1.64	-0.60	0.53
Major principal effective stress	(kPa)	1000	2110	4240
Minor principal effective stress	(kPa)	276	551	1102
Principal effective stress ratio		3.62	3.83	3.85
ε 50	(%)	0.35	0.61	0.93
Secant modulus at ε 50	(kPa)	102505	127424	167982
FINAL CONDITIONS				
Moisture content	(%)	19	19	19
Bulk density	(Mg/m ³)	2.09	2.10	2.11
Dry density	(Mg/m ³)	1.75	1.76	1.78
Borehole		BH_14	BH_14	BH_14
Sample		22BagA	22BagA	22BagA
Depth (m)		45.50	45.50	45.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**



Drawn by: NAC

Date: 13/05/2011

Template Issue: 4

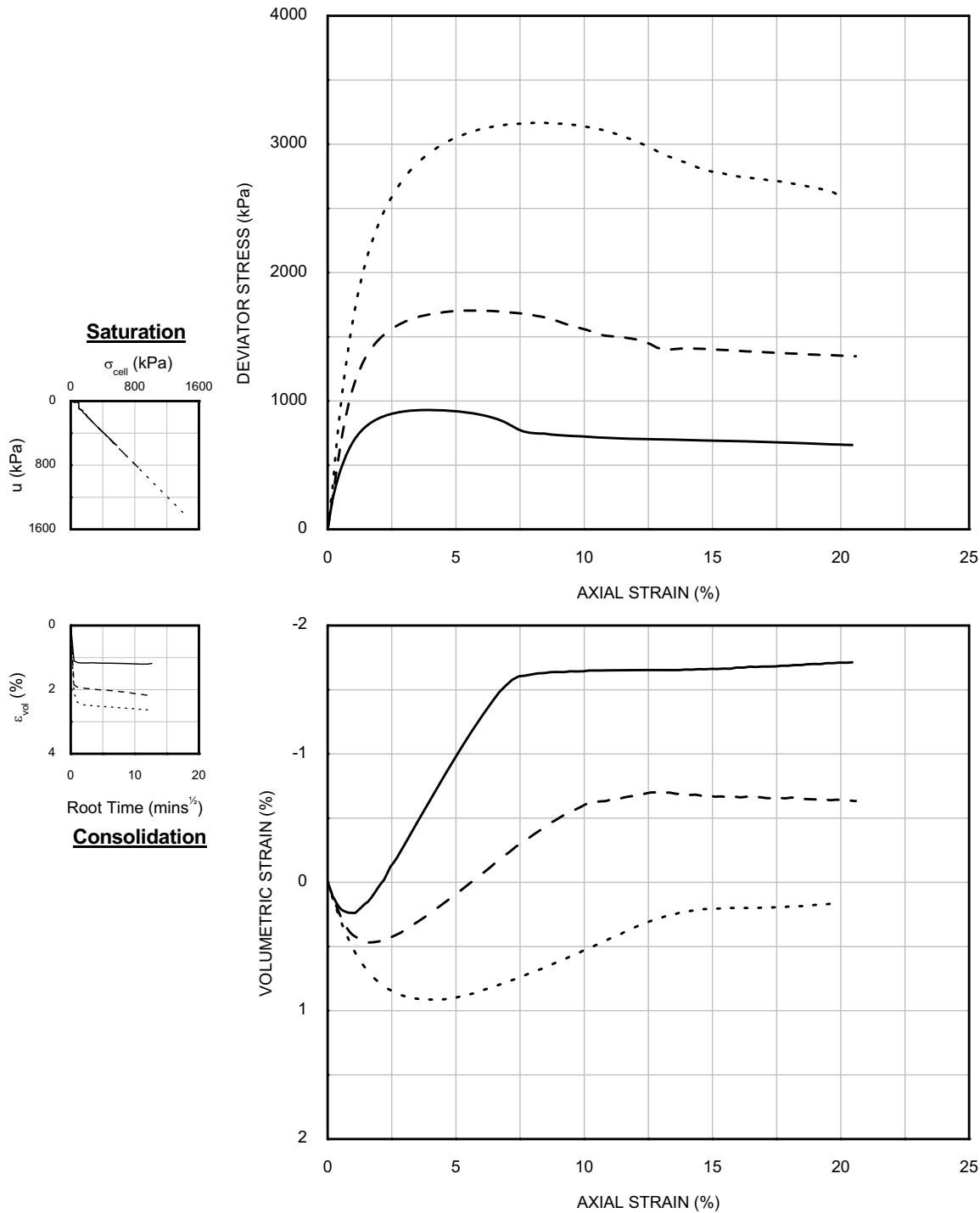
Date: 13/05/2011

Checked by: ALB

Filename: J11056 \EFFECTIV \BH_14_22BagA_D3.OPJ

Date: 17/05/2011

Approved by: PH



Curve	Specimen(3)	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	275	275	BH_14	22BagA	45.50
- - -	2	550	550			
. . .	3	1100	1100			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Drawn by: NAC Date: 13/05/2011

Template Issue: 4

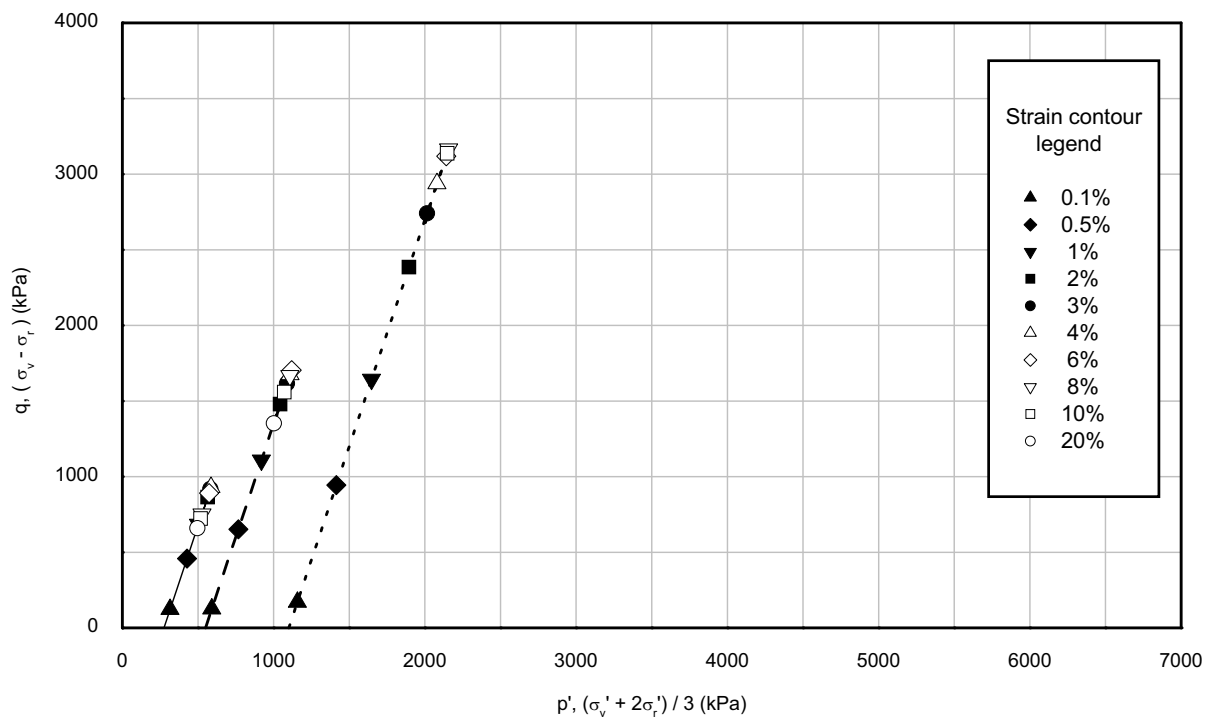
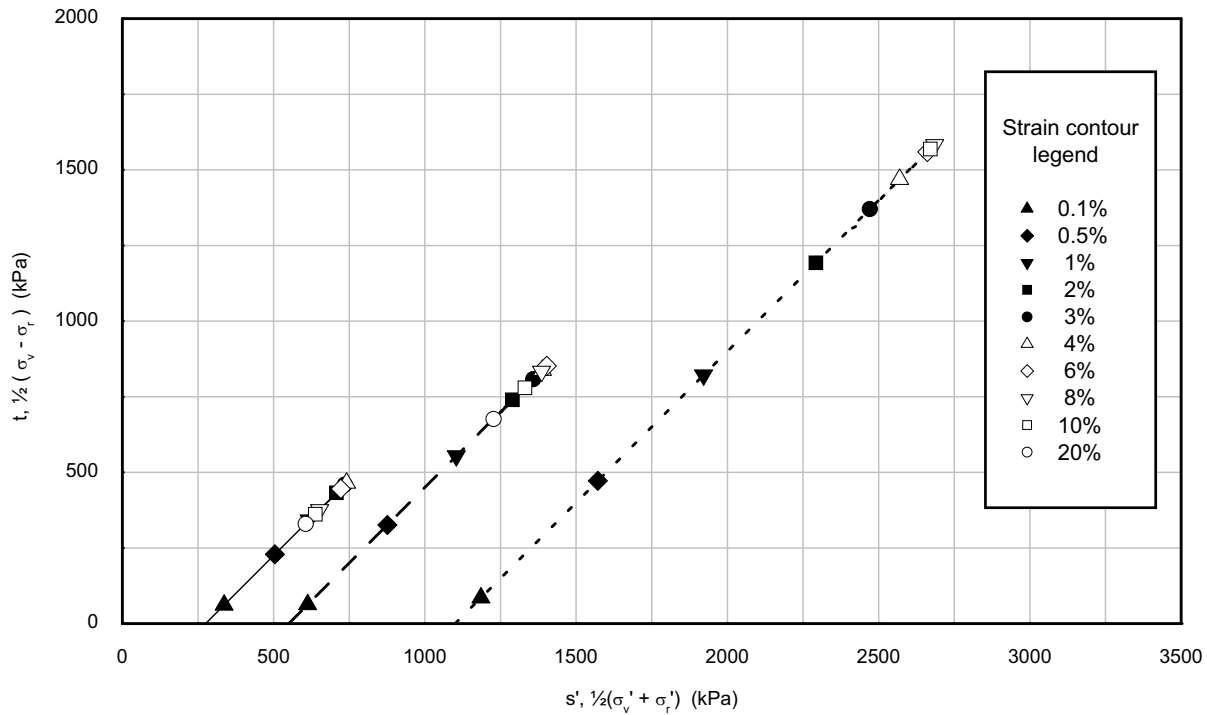
Date: 13/05/2011

Checked by: ALB

Filename: J11056 \EFFECTIV \BH_14_22BagA_D3.OPJ

Date: 17/05/2011

Approved by: PH



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	275	275	BH_14	22BagA	45.50
- - -	2	550	550			
. . .	3	1100	1100			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Drawn by: NAC
Date: 13/05/2011

Template Issue: 4

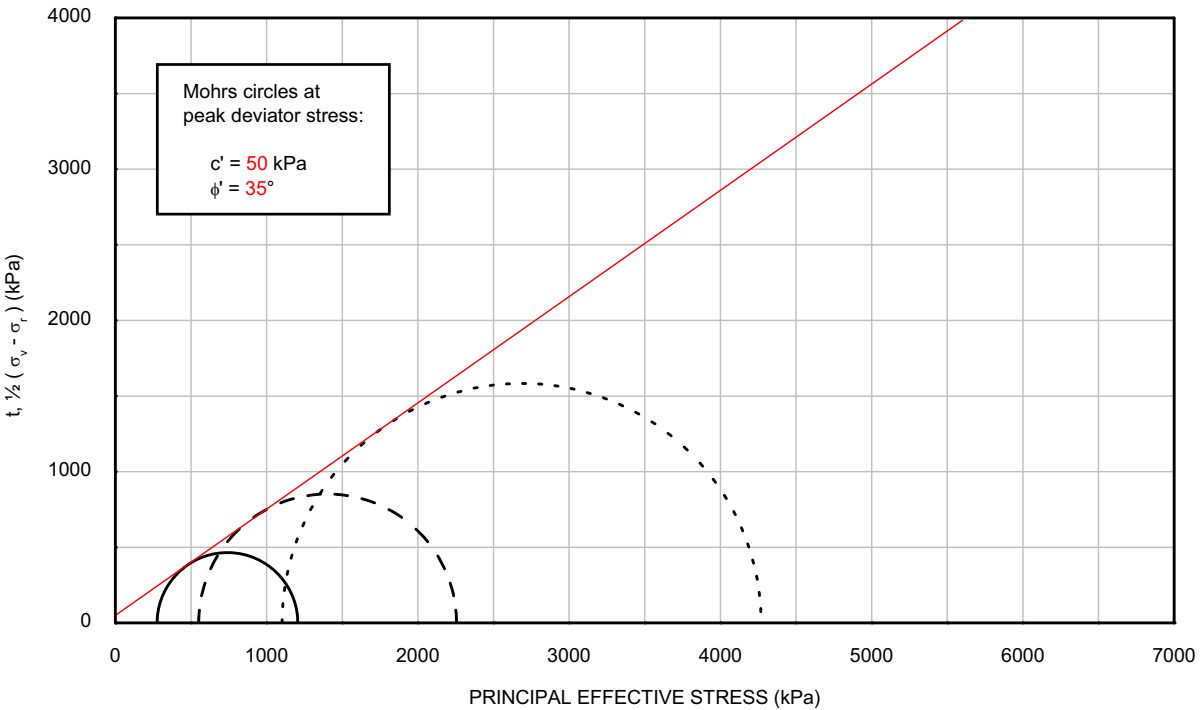
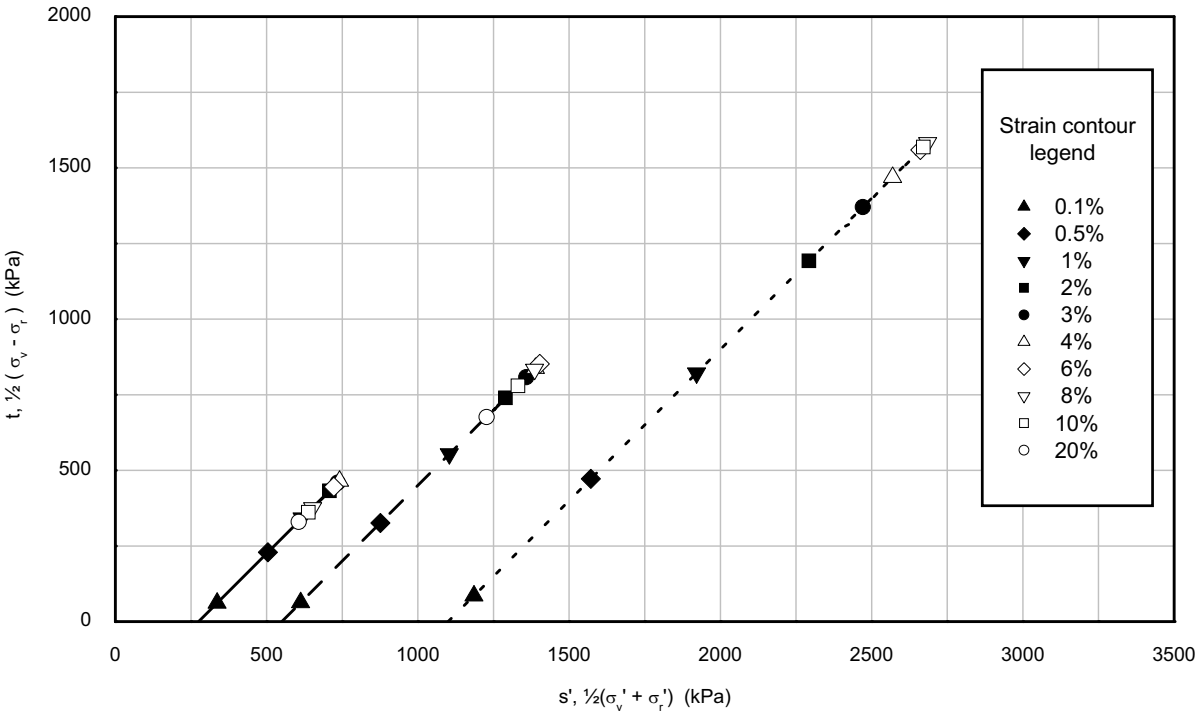
Date: 13/05/2011

Checked by: ALB

Filename: J11056 \ EFFECTIV \ BH_14_22BagA_D3.OPJ

Date: 17/05/2011

Approved by: PH



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	275	275	BH_14	22BagA	45.50
- - -	2	550	550			
...	3	1100	1100			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Date: 20/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: ALB

Filename: J11056 / EFFECTIV / BH_16_2BagB_D3.XLS

Date: 31/05/2011

Approved by: PH

VISUAL DESCRIPTION			
Dark greyish brown fine SAND.			

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	13/05/2011	13/05/2011	17/05/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL			
Diameter (mm)	50.9	50.9	50.9
Length (mm)	90.0	90.0	90.0
Moisture content (%)	9.7	9.7	9.9
Bulk density (Mg/m ³)	1.79	1.79	1.77
Dry density (Mg/m ³)	1.64	1.63	1.61
Voids ratio	0.621	0.622	0.644
Degree of saturation (%)	41	41	41

SATURATION			
Pressure increments applied (kPa)	50	50	50
Differential pressure used (kPa)	10	10	10
Pore pressure on completion (kPa)	428	365	440
Cell pressure on completion (kPa)	440	380	460
B value achieved	0.95	0.94	0.96

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8
Note: Fugro testing procedures are available on request	

Borehole	BH_16	BH_16	BH_16
Sample	2BagB	2BagB	2BagB
Depth (m)	7.35	7.35	7.35

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 20/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_16_2BagB_D3.XLS

Date: 19/05/2011

Date: 31/05/2011

Checked by: ALB

Approved by: PH

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	440	380	460
Back pressure	(kPa)	400	300	300
Effective cell pressure	(kPa)	40	80	160
Pore pressure on completion	(kPa)	400	300	300
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	23	23	24
Bulk density	(Mg/m ³)	2.02	2.02	2.01
Dry density	(Mg/m ³)	1.64	1.64	1.63
Voids ratio		0.616	0.615	0.626
Degree of saturation	(%)	100	100	100
Cvi	(m ² /year)	15220	20272	15573
Mvi	(m ² /MN)	0.094	0.065	0.076
Permeability	(m/s)	4.42E-07	4.08E-07	3.67E-07

Mode of failure: Compound failure Compound failure Compound failure

Borehole	BH_16	BH_16	BH_16
Sample	2BagB	2BagB	2BagB
Depth (m)	7.35	7.35	7.35

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 20/05/2011

Drawn by: NAC

Template Issue: 2

Date: 19/05/2011

Checked by: ALB

Filename: J11056 / EFFECTIV / BH_16_2BagB_D3.XLS

Date: 31/05/2011

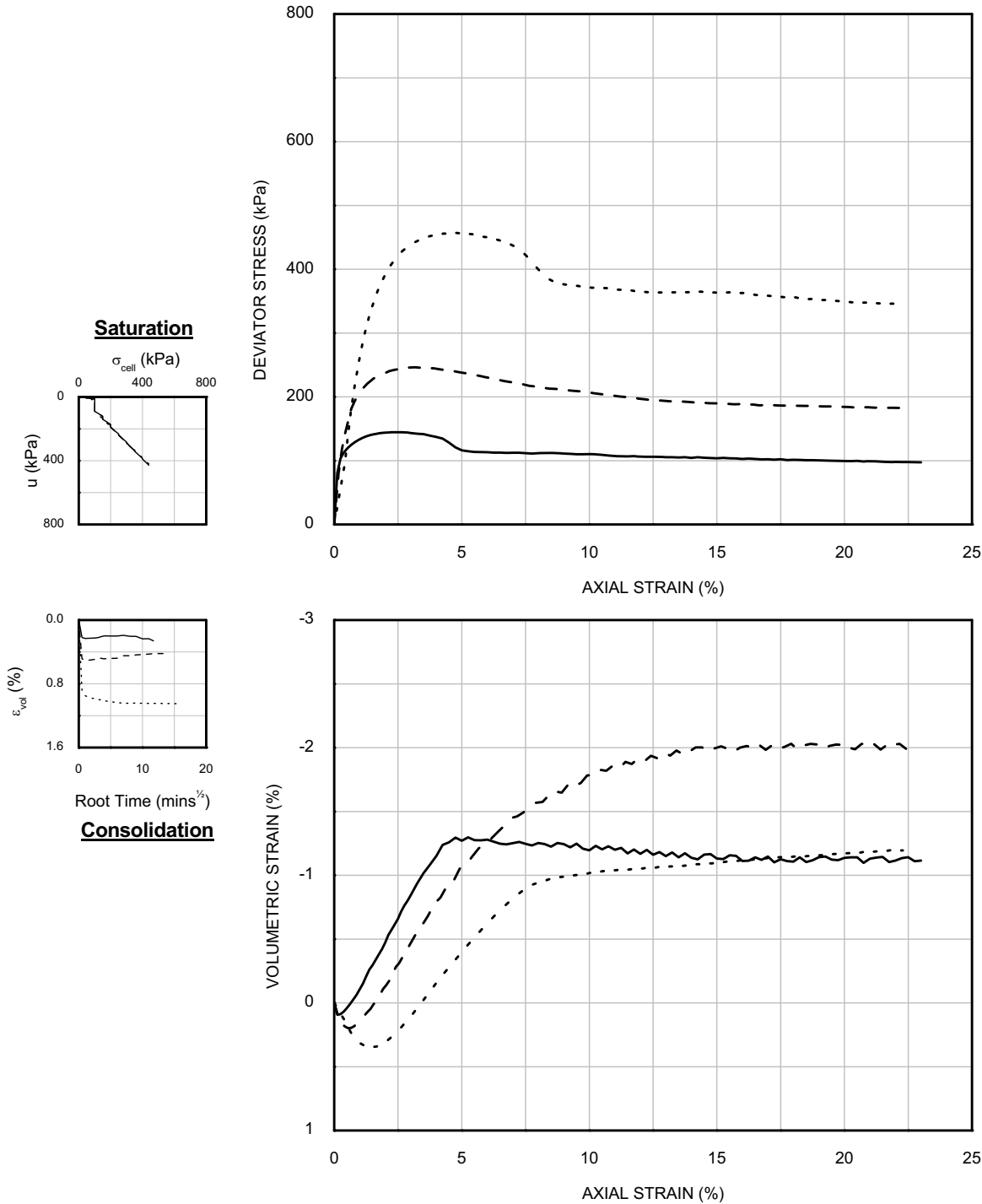
Approved by: PH

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	400	300	300
Initial effective cell pressure	(kPa)	40	80	160
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	145	246	457
Membrane correction applied	(kPa)	0.3	0.4	0.6
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.62	3.17	4.79
Volumetric strain	(%)	-0.72	-0.53	-0.35
Major principal effective stress	(kPa)	187	327	618
Minor principal effective stress	(kPa)	42	81	161
Principal effective stress ratio		4.44	4.05	3.83
ε 50	(%)	0.11	0.33	0.85
Secant modulus at ε 50	(kPa)	65084	37436	26864
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	144	246	457
Membrane correction applied	(kPa)	0.3	0.4	0.6
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.37	3.17	4.79
Volumetric strain	(%)	-0.62	-0.53	-0.35
Major principal effective stress	(kPa)	186	327	618
Minor principal effective stress	(kPa)	42	81	161
Principal effective stress ratio		4.47	4.05	3.83
ε 50	(%)	0.11	0.33	0.85
Secant modulus at ε 50	(kPa)	65084	37436	26864
At 10% axial strain				
Corrected deviator stress	(kPa)	110	207	371
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-1.20	-1.78	-1.02
Major principal effective stress	(kPa)	151	288	533
Minor principal effective stress	(kPa)	41	81	161
Principal effective stress ratio		3.72	3.57	3.30
ε 50	(%)	0.08	0.25	0.68
Secant modulus at ε 50	(kPa)	65084	41200	27133
FINAL CONDITIONS				
Moisture content	(%)	23	23	24
Bulk density	(Mg/m ³)	2.02	2.02	2.01
Dry density	(Mg/m ³)	1.64	1.64	1.63
Borehole		BH_16	BH_16	BH_16
Sample		2BagB	2BagB	2BagB
Depth (m)		7.35	7.35	7.35

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

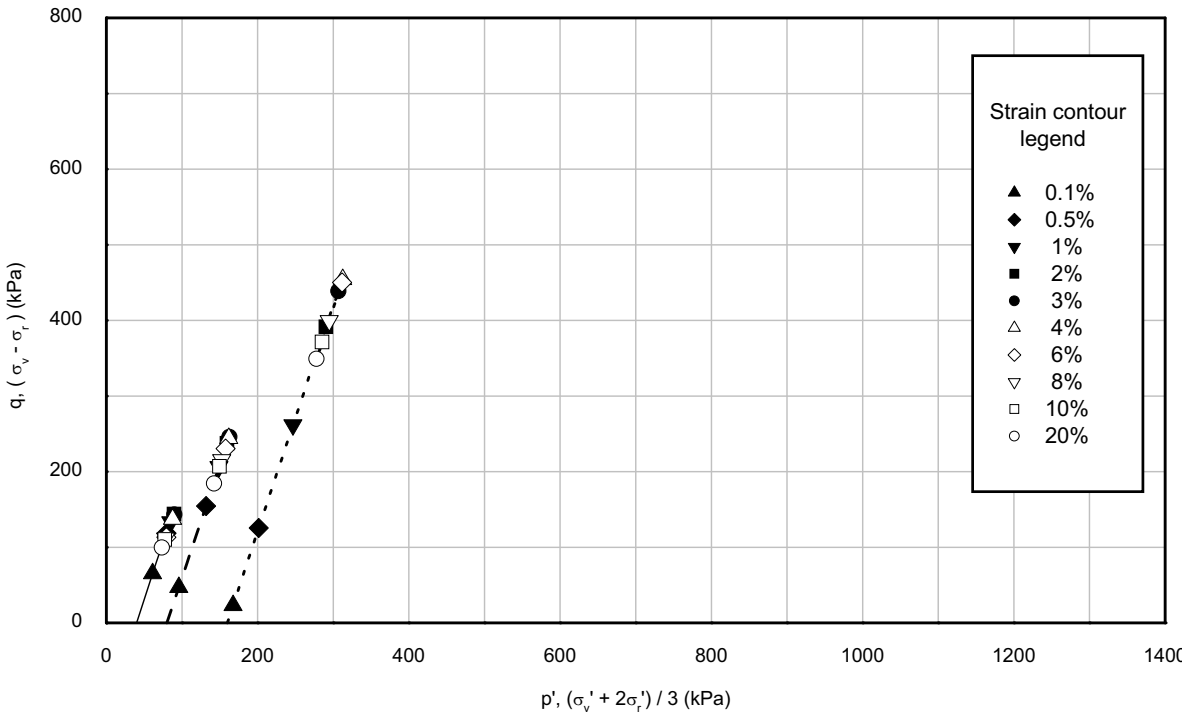
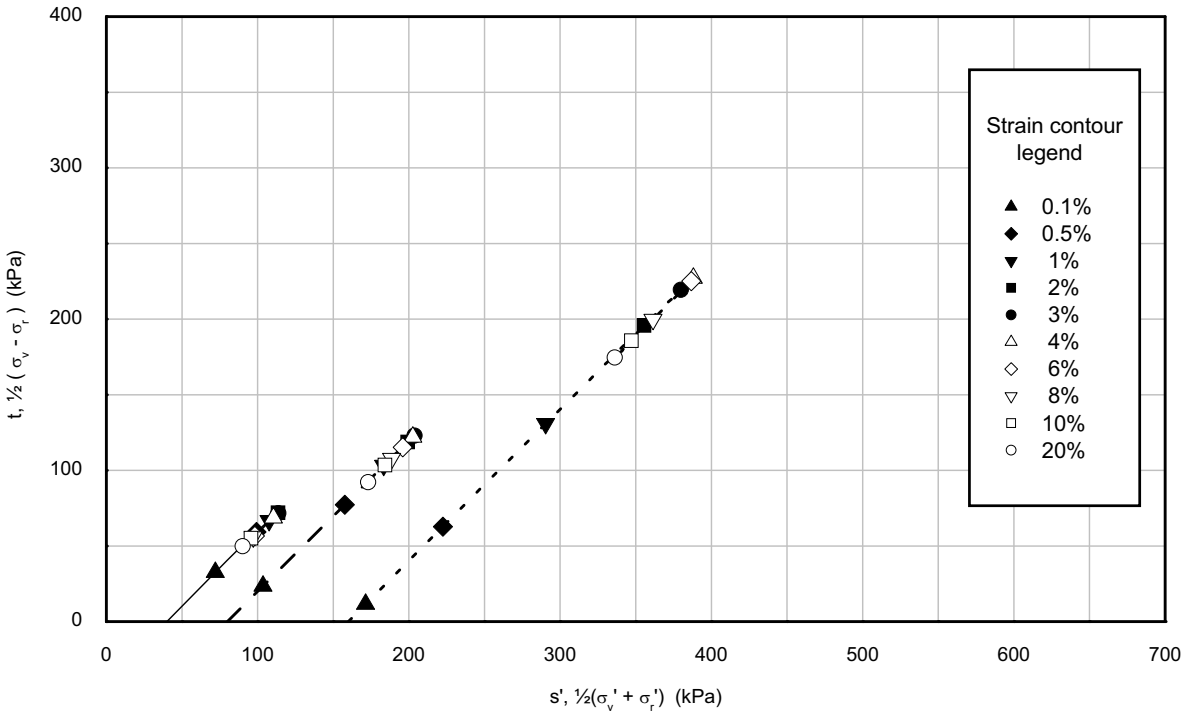


Drawn by: NAC
Date: 20/05/2011
Template Issue: 4
Filename: J11056 \EFFECTIV \BH_16_2BagB_D3.OPJ
Date: 20/05/2011
Date: 31/05/2011
Checked by: ALB
Approved by: PH



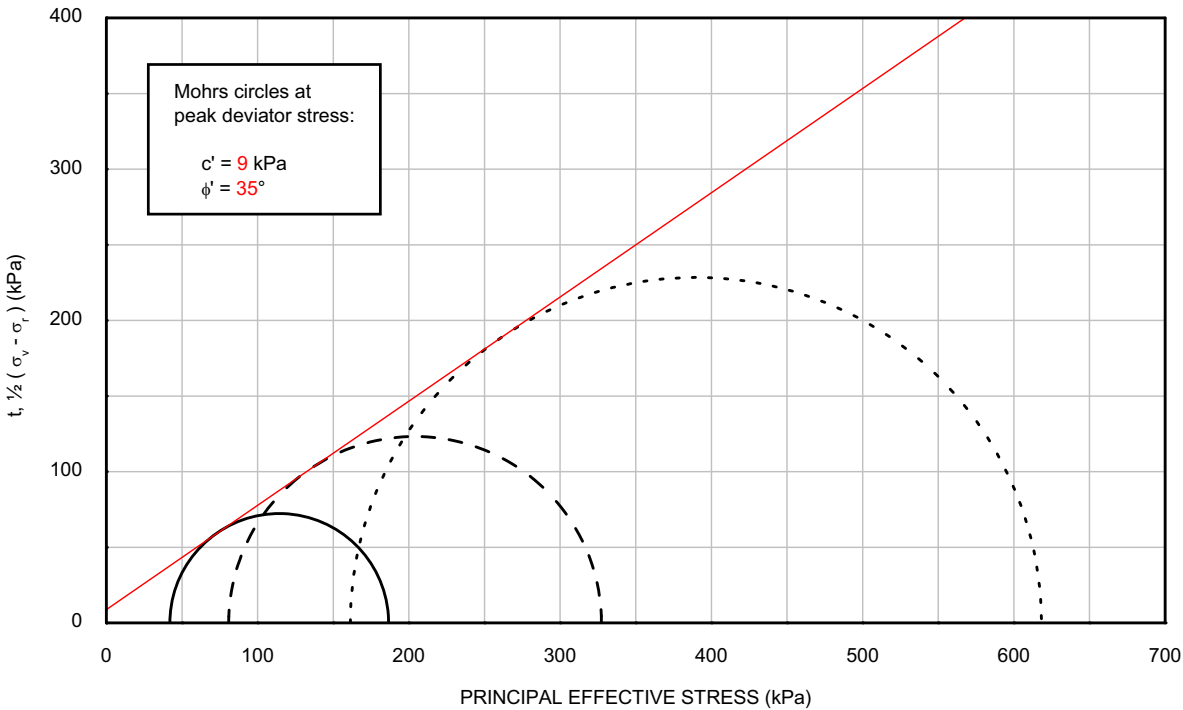
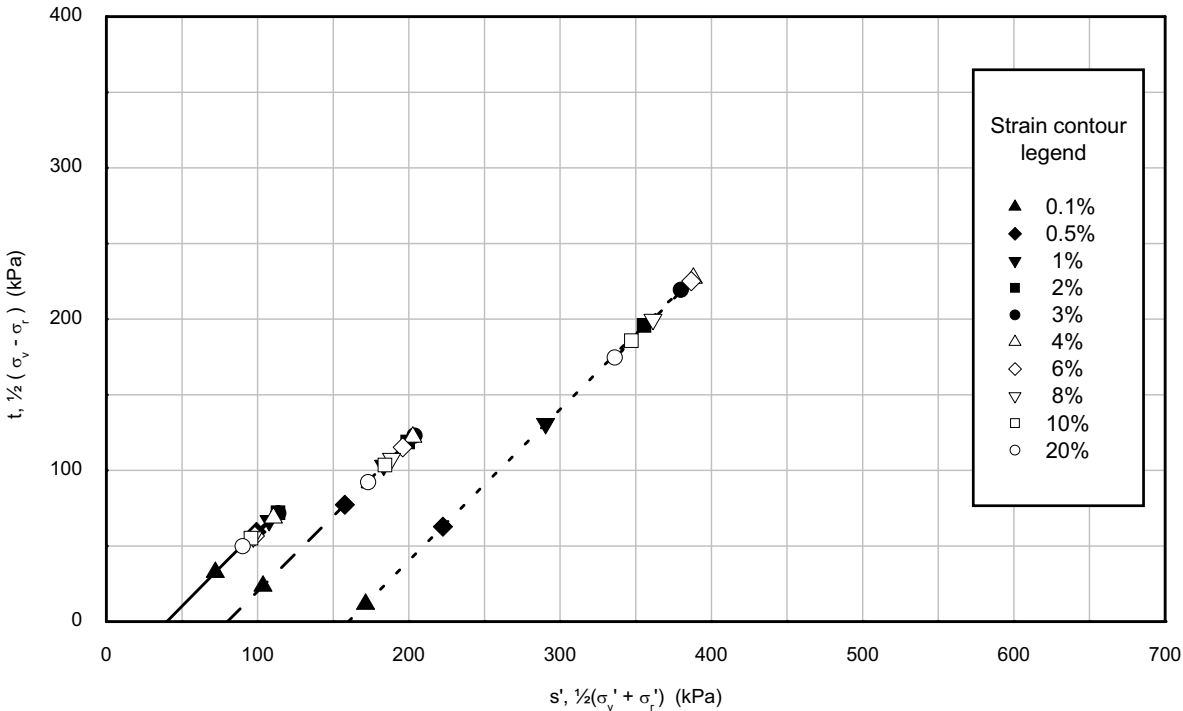
Curve	Specimen(3)	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	40	40	BH_16	2BagB	7.35
- - -	2	80	80			
. . .	3	160	160			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	40	40	BH_16	2BagB	7.35
- - -	2	80	80			
...	3	160	160			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Date: 20/05/2011 Date: 31/05/2011

Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	40	40	BH_16	2BagB	7.35
- - -	2	80	80			
· · ·	3	160	160			

Checked by: ALB Approved by: PH

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_16_5BagA_D3.XLS

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION

Greyish brown medium SAND with medium and coarse gravel (dry sieved to pass 5mm sieve.)

GENERAL

	Specimen 1	Specimen 2	Specimen 3
Date test started	16/05/2011	16/05/2011	16/05/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL

Diameter	(mm)	50.9	50.9	50.9
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	11	11	11
Bulk density	(Mg/m ³)	1.96	1.96	1.97
Dry density	(Mg/m ³)	1.77	1.77	1.78
Voids ratio		0.499	0.498	0.492
Degree of saturation	(%)	58	58	59

SATURATION

Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	485	574	752
Cell pressure on completion	(kPa)	500	600	800
B value achieved		0.95	0.92	0.91

TESTING PROCEDURES USED

Specimen Set-up	BS 1377: Part 8: 1990 Clause 4 Fugro testing procedure L-T-023 Clause 5.2.2
Saturation	Fugro testing procedure L-T-023 Clause 5.2.3 BS 1377: Part 8: 1990: Clause 5.3
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Not applicable
Shearing	BS 1377: Part 8: 1990 Clause 8

Note: Fugro testing procedures are available on request

Borehole	BH_16	BH_16	BH_16
Sample	5BagA	5BagA	5BagA
Depth (m)	18.50	18.50	18.50

SUMMARY OF ISOTROPICALLY CONSOLIDATED DRAINED TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_16_5BagA_D3.XLS

Date:

Date:

Checked by:

Approved by:

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	500	600	800
Back pressure	(kPa)	400	400	400
Effective cell pressure	(kPa)	100	200	400
Pore pressure on completion	(kPa)	400	400	400
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	18	18	17
Bulk density	(Mg/m ³)	2.11	2.11	2.13
Dry density	(Mg/m ³)	1.78	1.79	1.82
Voids ratio		0.486	0.481	0.454
Degree of saturation	(%)	100	100	100
Cvi	(m ² /year)	18819	15135	8568
Mvi	(m ² /MN)	0.10	0.064	0.073
Permeability	(m/s)	5.93E-07	3.00E-07	1.95E-07

Mode of failure: Compound failure Compound failure Compound failure

Borehole	BH_16	BH_16	BH_16
Sample	5BagA	5BagA	5BagA
Depth (m)	18.50	18.50	18.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 18/05/2011

Drawn by: NAC

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_16_5BagA_D3.XLS

Date:

Date:

Checked by:

Approved by:

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	400	400	400
Initial effective cell pressure	(kPa)	100	200	400
Rate of strain	(%/hour)	1.33	1.33	1.33
At peak deviator stress				
Corrected deviator stress	(kPa)	435	847	1562
Membrane correction applied	(kPa)	0.3	0.3	0.4
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.60	2.74	2.99
Volumetric strain	(%)	-1.13	-0.91	-0.65
Major principal effective stress	(kPa)	535	1048	1963
Minor principal effective stress	(kPa)	101	201	401
Principal effective stress ratio		5.32	5.22	4.90
ϵ 50	(%)	0.61	0.52	0.70
Secant modulus at ϵ 50	(kPa)	35872	81558	111621
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	435	847	1562
Membrane correction applied	(kPa)	0.3	0.3	0.4
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	2.60	2.74	2.99
Volumetric strain	(%)	-1.13	-0.91	-0.65
Major principal effective stress	(kPa)	535	1048	1963
Minor principal effective stress	(kPa)	101	201	401
Principal effective stress ratio		5.32	5.22	4.90
ϵ 50	(%)	0.61	0.52	0.70
Secant modulus at ϵ 50	(kPa)	35872	81558	111621
At 10% axial strain				
Corrected deviator stress	(kPa)	265	547	977
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	-2.93	-4.11	-2.75
Major principal effective stress	(kPa)	366	749	1378
Minor principal effective stress	(kPa)	101	201	402
Principal effective stress ratio		3.63	3.72	3.43
ϵ 50	(%)	0.37	0.29	0.43
Secant modulus at ϵ 50	(kPa)	35832	93937	113393
FINAL CONDITIONS				
Moisture content	(%)	18	18	17
Bulk density	(Mg/m ³)	2.11	2.11	2.13
Dry density	(Mg/m ³)	1.78	1.79	1.82
Borehole		BH_16	BH_16	BH_16
Sample		5BagA	5BagA	5BagA
Depth (m)		18.50	18.50	18.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**



Drawn by: NAC

Date: 18/05/2011

Template Issue: 4

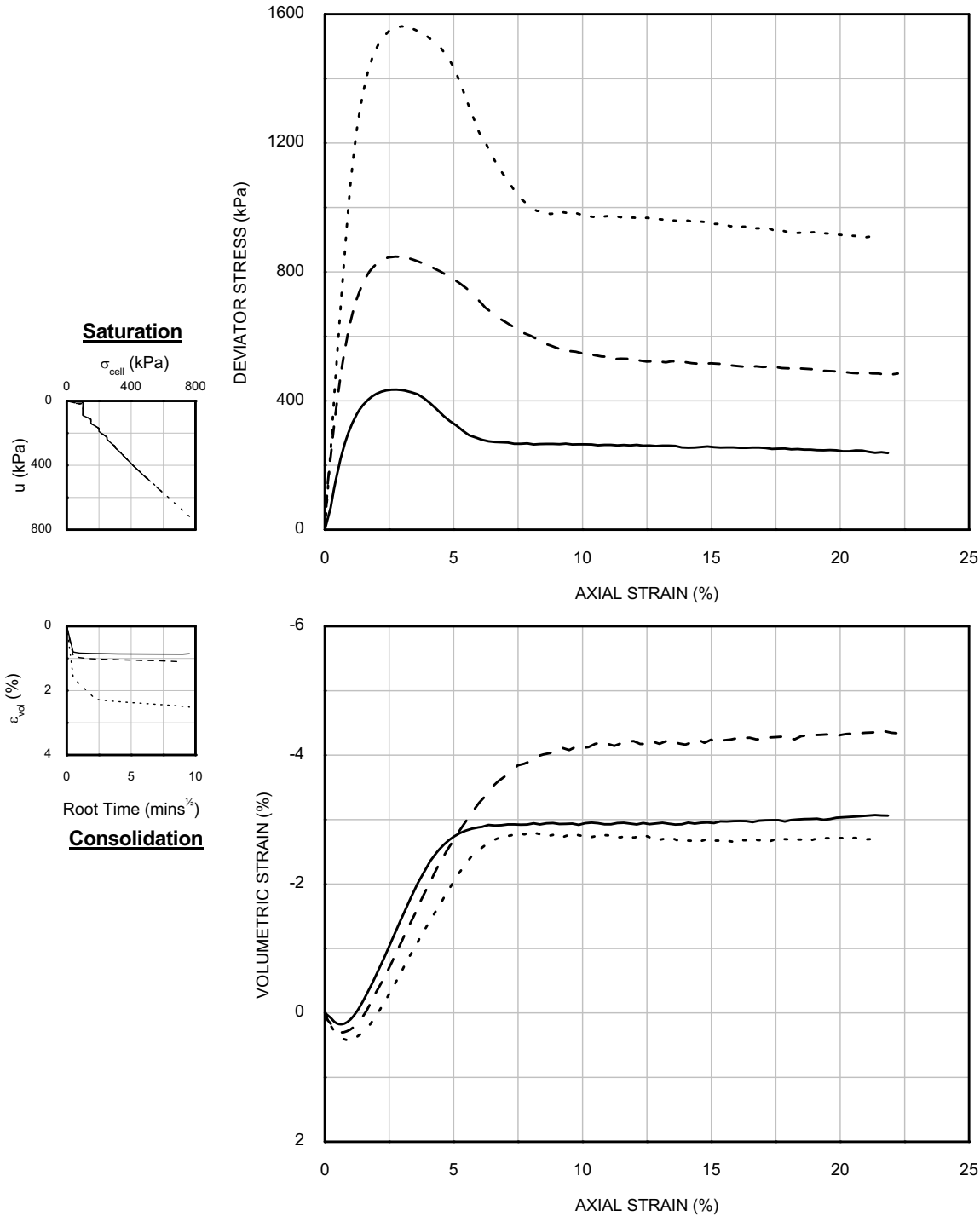
Date: 19/05/2011

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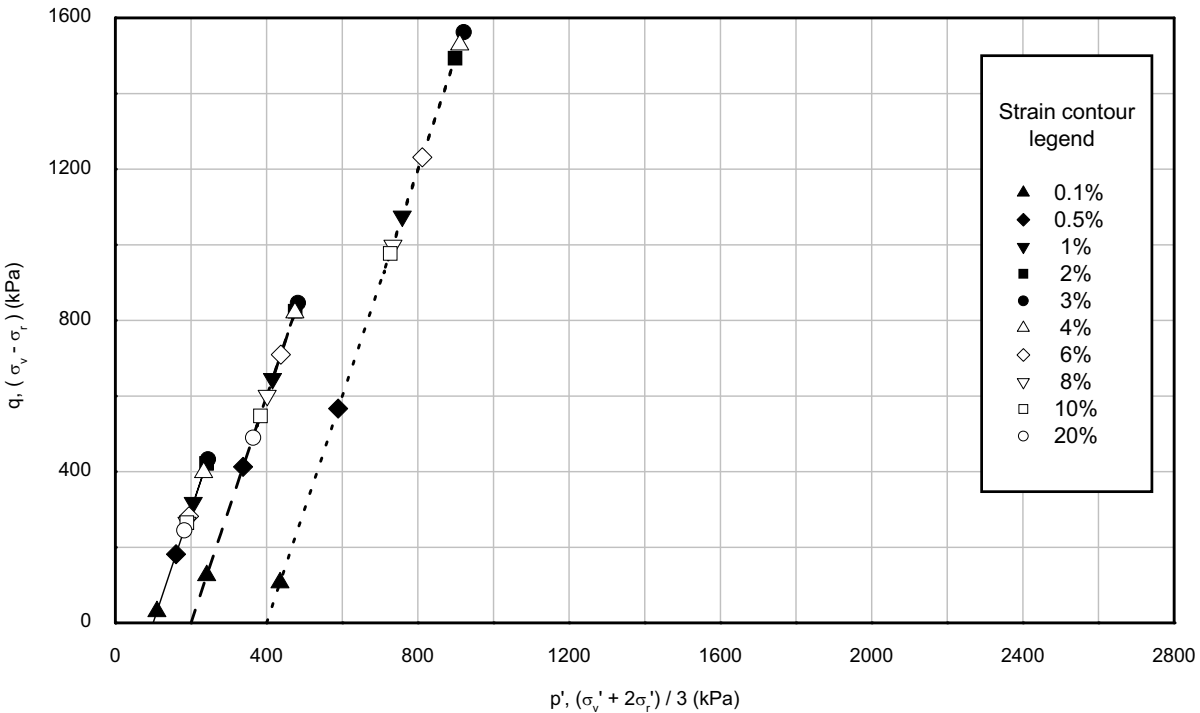
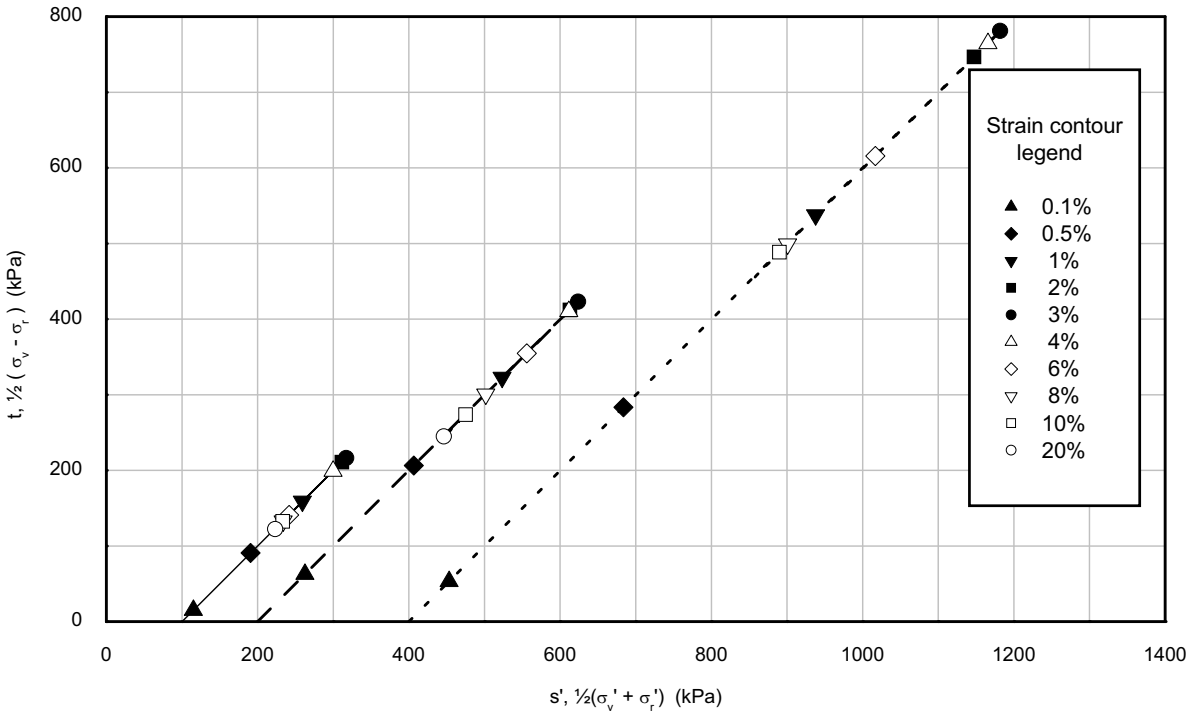
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Approved by: PH



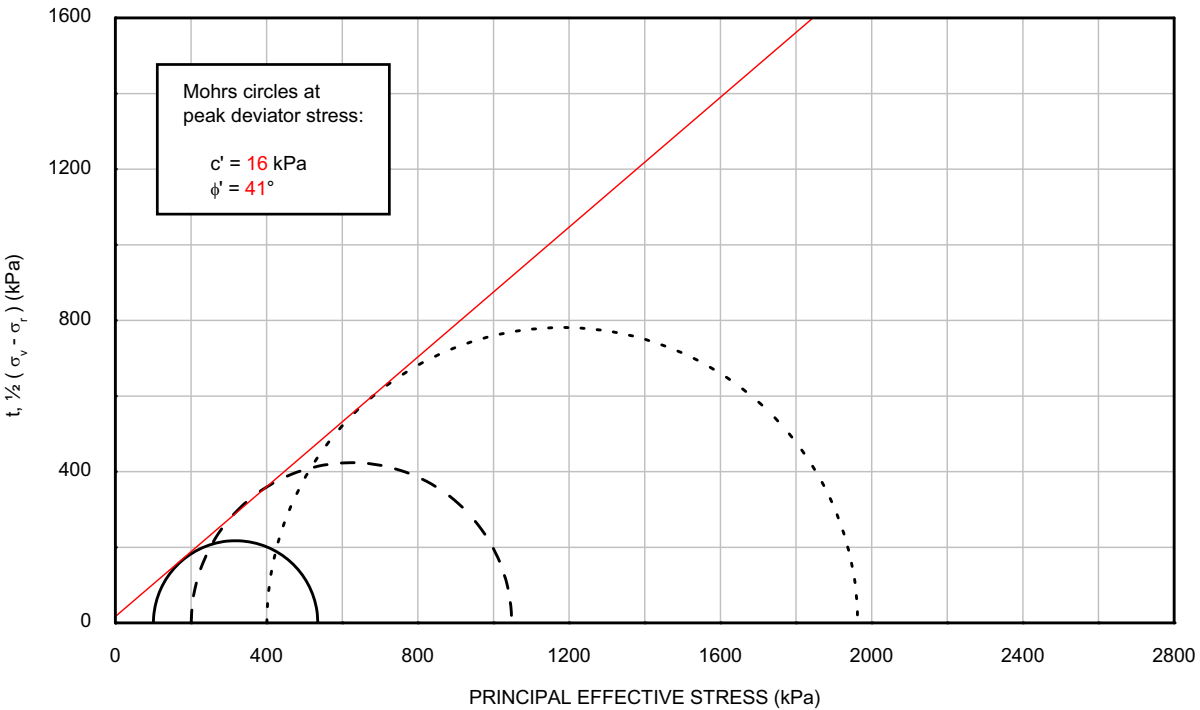
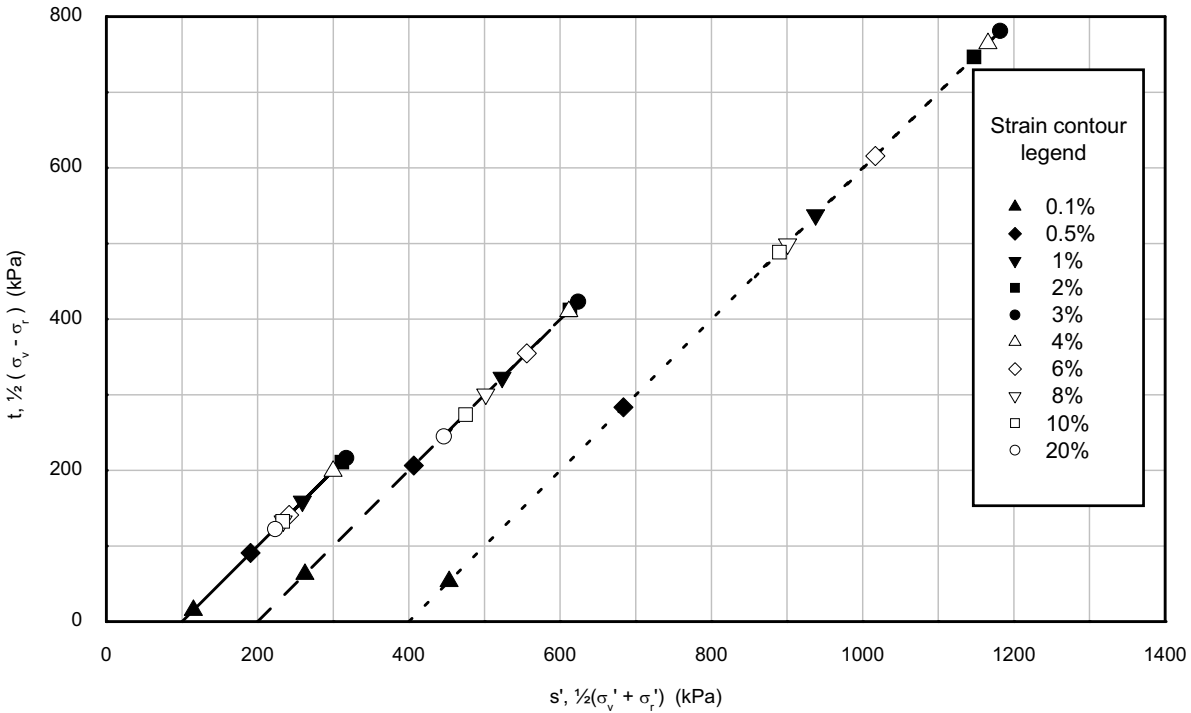
Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	100	100	BH_16	5BagA	18.50
- - -	2	200	200			
. . .	3	400	400			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	100	100	BH_16	5BagA	18.50
- - -	2	200	200			
...	3	400	400			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	100	100	BH_16	5BagA	18.50
- - -	2	200	200			
...	3	400	400			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Date: 08/06/2011

Drawn by: PH

Template Issue: 2

Filename: J11056 / EFFECTIV /

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION			
Dark olive brown sandy CLAY.			

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	25/05/2011	10/06/2011	25/05/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	Radial & one end	Radial & one end	Radial & one end

INITIAL				
Diameter	(mm)	50.9	50.9	50.9
Length	(mm)	90.0	90.0	90.0
Moisture content	(%)	10	10	10
Bulk density	(Mg/m ³)	2.10	2.10	2.10
Dry density	(Mg/m ³)	1.90	1.91	1.90
Voids ratio		0.418	0.411	0.418
Degree of saturation	(%)	67	64	67

SATURATION				
Pressure increments applied	(kPa)	50	50	50
Differential pressure used	(kPa)	10	10	10
Pore pressure on completion	(kPa)	602	820	1256
Cell pressure on completion	(kPa)	620	840	1280
B value achieved		0.96	0.99	0.98

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	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_16	BH_16	BH_16
Sample	19BagA	19BagA	19BagA
Depth (m)	38.50	38.50	38.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 08/06/2011

Drawn by: PH

Template Issue: 2
 Filename: J11056 / EFFECTIV /

Date:
 Date:

Checked by:
 Approved by:

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	620	840	1280
Back pressure	(kPa)	400	400	400
Effective cell pressure	(kPa)	220	440	880
Pore pressure on completion	(kPa)	400	406	400
Pore pressure dissipation	(%)	100	99	100
Moisture content	(%)	11	11	11
Bulk density	(Mg/m ³)	2.32	2.32	2.32
Dry density	(Mg/m ³)	2.09	2.10	2.09
Voids ratio		0.290	0.287	0.293
Degree of saturation	(%)	100	100	100
Cvi	(m ² /year)	0.17	0.45	0.99
Mvi	(m ² /MN)	0.49	0.23	0.11
Permeability	(m/s)	2.56E-11	3.26E-11	3.48E-11

Mode of failure: Plastic failure Plastic failure Compound failure

Borehole	BH_16	BH_16	BH_16
Sample	19BagA	19BagA	19BagA
Depth (m)	38.50	38.50	38.50

**SUMMARY OF
 ISOTROPICALLY CONSOLIDATED UNDRAINED
 TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 08/06/2011

Drawn by: PH

Template Issue: 2

Filename: J11056 / EFFECTIV /

Date:

Date:

Checked by:

Approved by:

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	400	400	400
Initial effective cell pressure	(kPa)	220	440	880
Rate of strain	(%/hour)	0.42	0.42	0.42
At peak deviator stress				
Corrected deviator stress	(kPa)	542	637	1137
Membrane correction applied	(kPa)	1.4	1.7	1.3
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	14.61	19.67	12.48
Excess pore pressure	(kPa)	-9	163	386
Major principal effective stress	(kPa)	772	915	1631
Minor principal effective stress	(kPa)	229	277	494
Principal effective stress ratio		3.37	3.30	3.30
e 50	(%)	1.47	0.65	0.58
Secant modulus at e 50	(kPa)	18491	48685	97183
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	462	606	1128
Membrane correction applied	(kPa)	0.6	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	5.09	10.13	9.98
Excess pore pressure	(kPa)	45	198	396
Major principal effective stress	(kPa)	637	848	1612
Minor principal effective stress	(kPa)	175	242	484
Principal effective stress ratio		3.63	3.51	3.33
e 50	(%)	1.09	0.58	0.58
Secant modulus at e 50	(kPa)	21126	52683	97662
At 10% axial strain				
Corrected deviator stress	(kPa)	527	604	1128
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Excess pore pressure	(kPa)	10	198	396
Major principal effective stress	(kPa)	736	846	1612
Minor principal effective stress	(kPa)	210	242	484
Principal effective stress ratio		3.51	3.49	3.33
e 50	(%)	1.39	0.57	0.58
Secant modulus at e 50	(kPa)	18908	52956	97653
FINAL CONDITIONS				
Moisture content	(%)	11	11	11
Bulk density	(Mg/m ³)	2.32	2.32	2.32
Dry density	(Mg/m ³)	2.09	2.10	2.09
Borehole		BH_16	BH_16	BH_16
Sample		19BagA	19BagA	19BagA
Depth (m)		38.50	38.50	38.50

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 08/06/2011
Drawn by: PH
Template Issue: 2
Filename: J11056 / EFFECTIV /
Checked by: Date:
Approved by: Date:

SPECIMEN 1 PHOTOGRAPHS.



Borehole	BH_16	BH_16	BH_16
Sample	19BagA	19BagA	19BagA
Depth (m)	38.50	38.50	38.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

Date: 08/06/2011
Drawn by: PH
Template Issue: 2
Filename: J11056 / EFFECTIV /
Checked by: Date:
Approved by: Date:

SPECIMEN 2 PHOTOGRAPHS

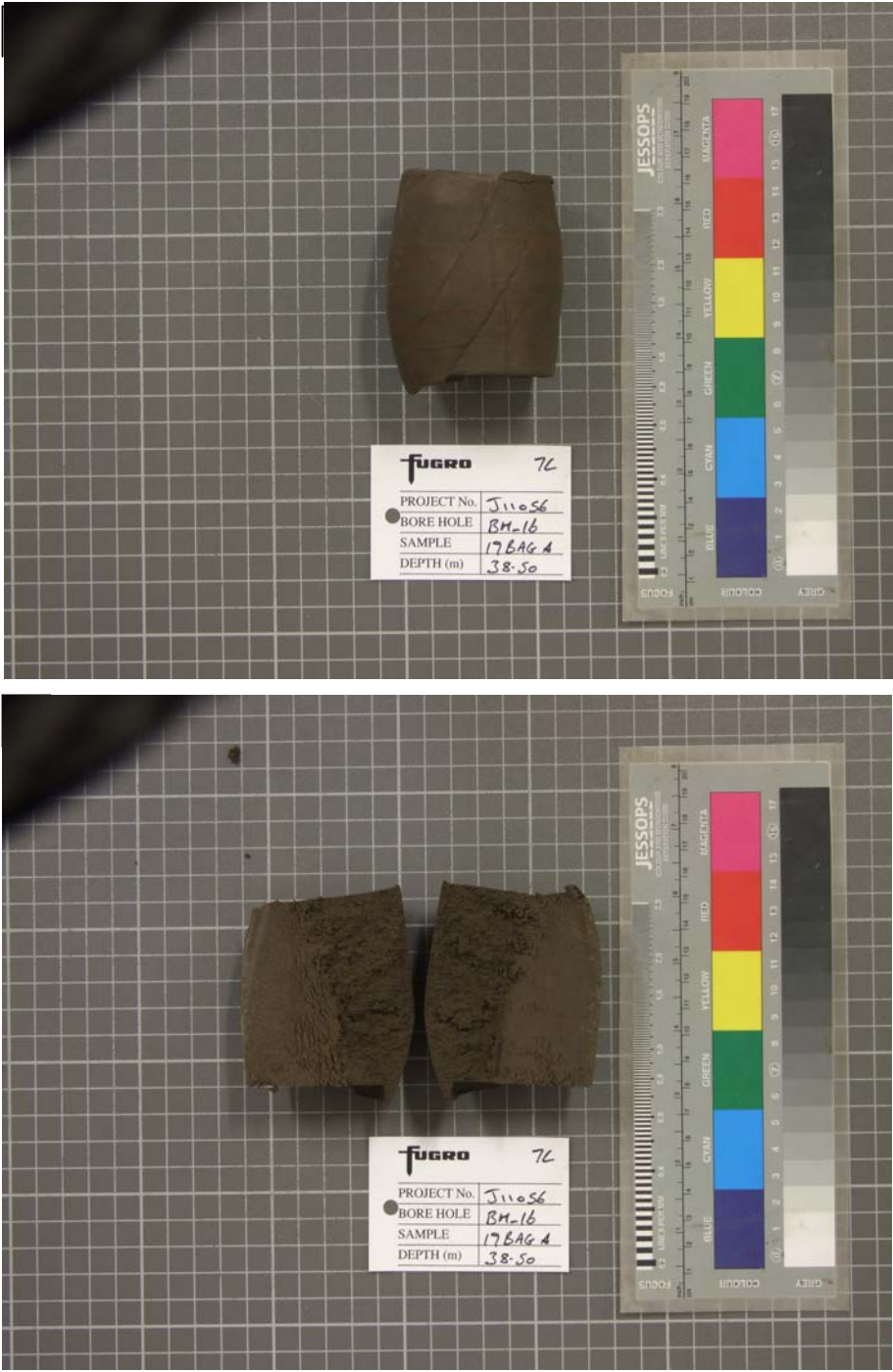


Borehole	BH_16	BH_16	BH_16
Sample	19BagA	19BagA	19BagA
Depth (m)	38.50	38.50	38.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

Date: 08/06/2011
Drawn by: PH
Template Issue: 2
Filename: J11056 / EFFECTIV /
Checked by: Date:
Approved by: Date:

SPECIMEN 3 PHOTOGRAPHS



Borehole	BH_16	BH_16	BH_16
Sample	19BagA	19BagA	19BagA
Depth (m)	38.50	38.50	38.50

SUMMARY OF
ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS



Drawn by: PH

Date: 08/06/2011

Template Issue: 2

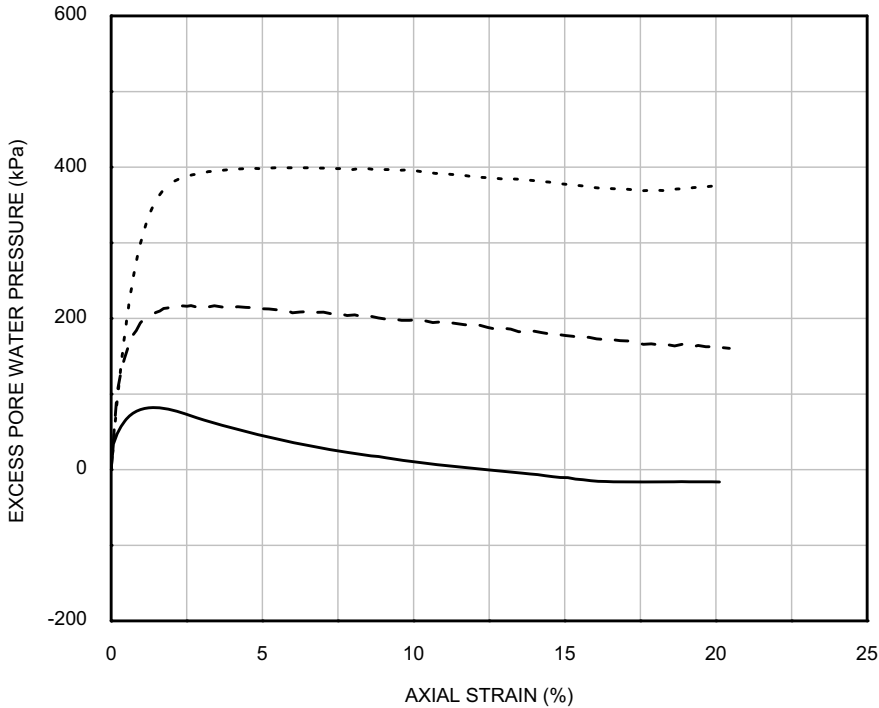
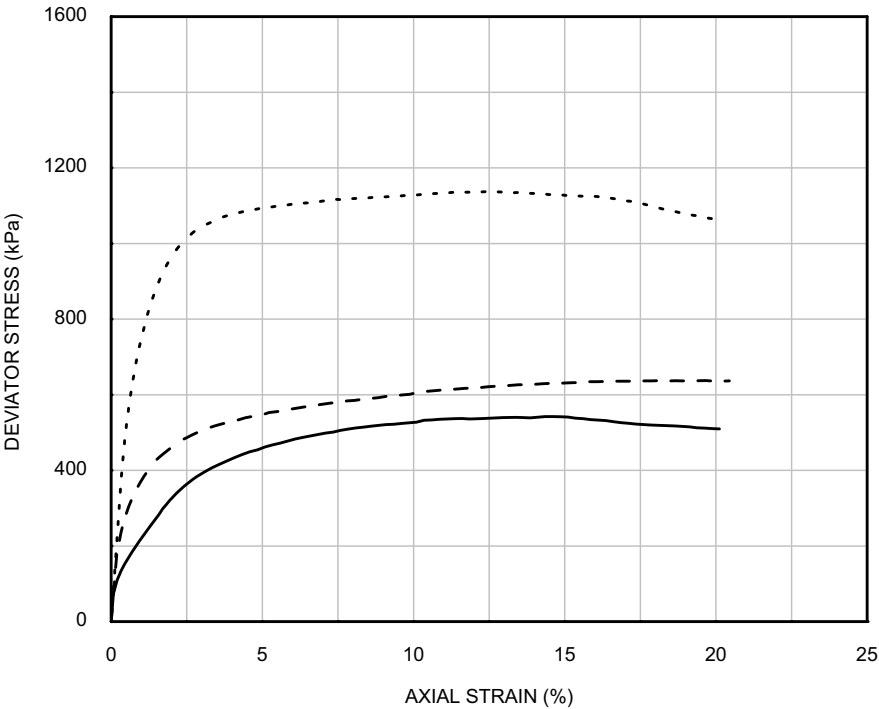
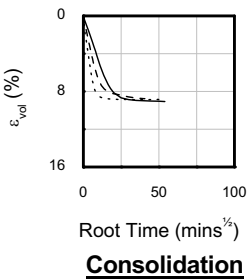
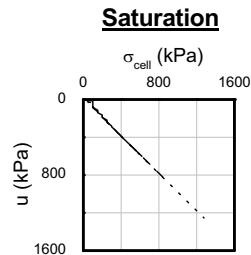
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Date :

Date :

Checked by:

Approved by:



Curve	Specimen(3)	σ'_{ic} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	220	220	BH_16	19BagA	38.50
- - -	2	440	440			
. . .	3	880	880			

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE



Drawn by: PH Date: 08/06/2011

Template Issue: 2

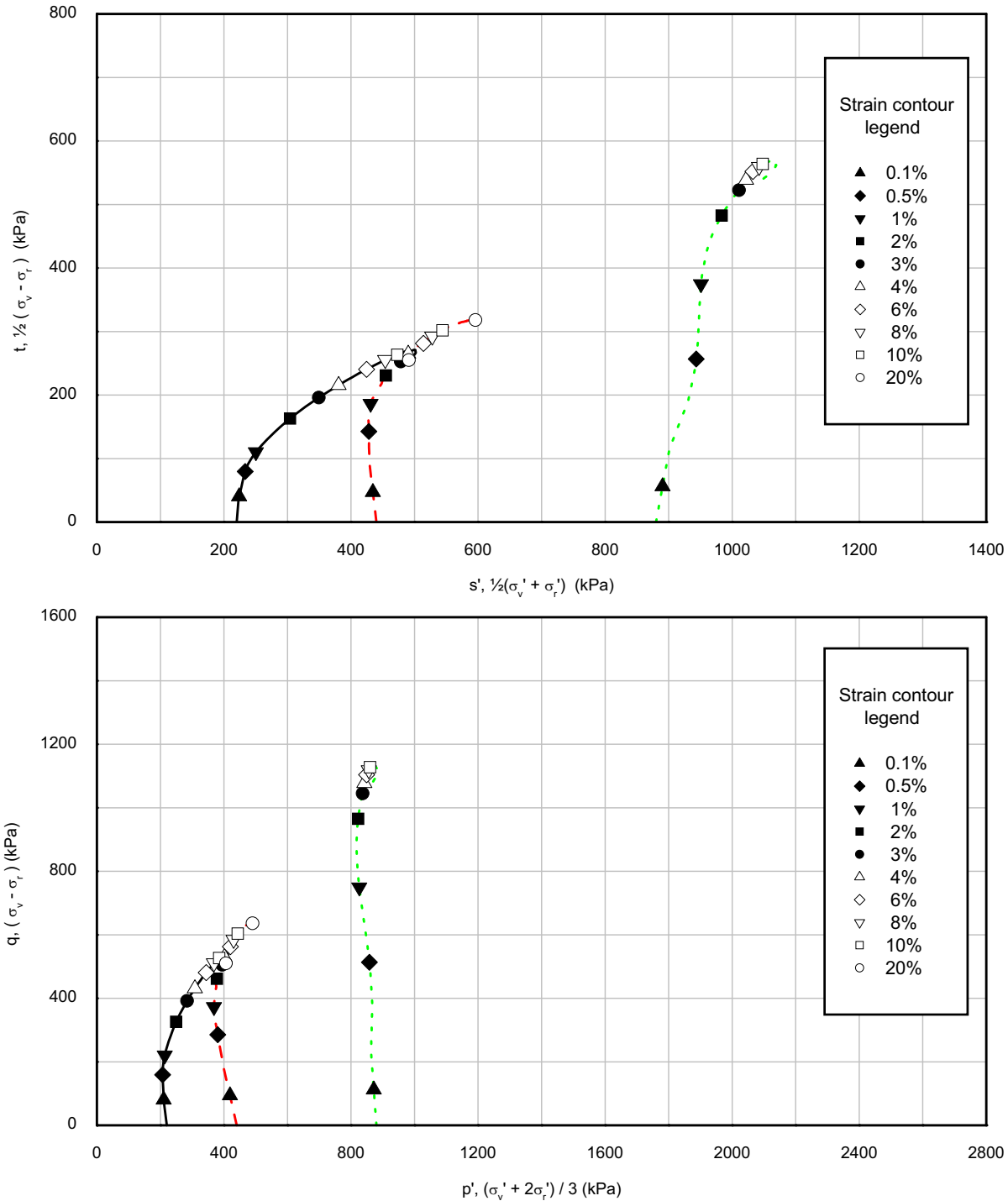
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Date :

Date :

Checked by:

Approved by:



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	220	220	BH_16	19BagA	38.50
- - -	2	440	440			
. . .	3	880	880			

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE



Drawn by: PH Date: 08/06/2011

Template Issue: 2

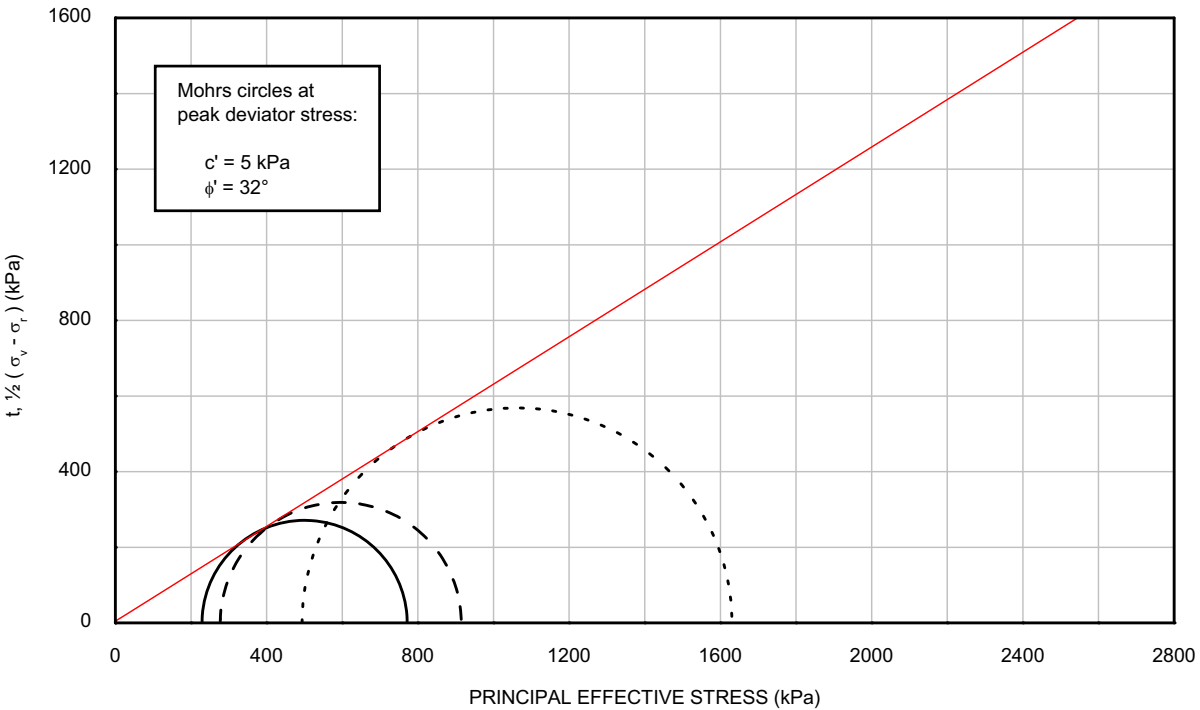
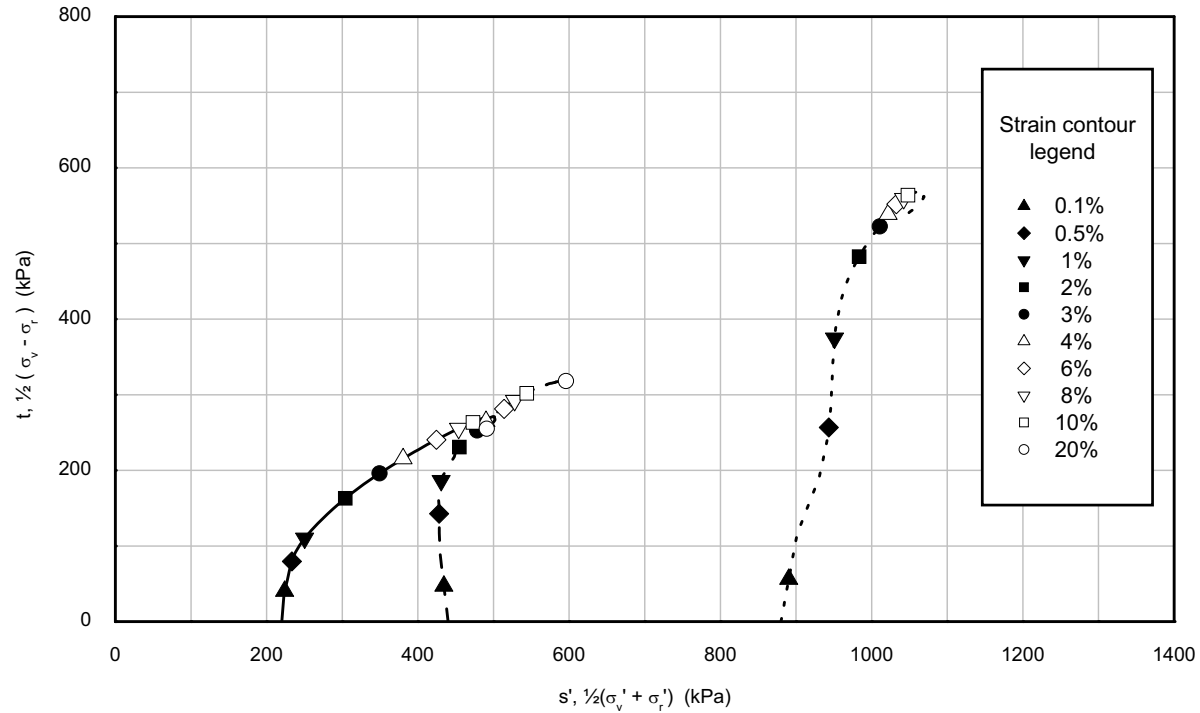
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Date :

Date :

Checked by:

Approved by:



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	220	220	BH_16	19BagA	38.50
- - -	2	440	440			
...	3	880	880			

ISOTROPICALLY CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE

Date: 20/07/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_16_22BagA_D3.XLS

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION			
Dark greyish brown fine SAND.			

GENERAL	Specimen 1	Specimen 2	Specimen 3
Date test started	25/06/2011	25/06/2011	21/06/2011
Type of sample	Recompacted	Recompacted	Recompacted
Specimen orientation	Vertical	Vertical	Vertical
Type of drains fitted	One end	One end	One end

INITIAL			
Diameter (mm)	50.9	50.9	50.9
Length (mm)	90.0	90.0	90.0
Moisture content (%)	11	11	9.1
Bulk density (Mg/m ³)	2.12	2.12	2.12
Dry density (Mg/m ³)	1.92	1.92	1.95
Voids ratio	0.380	0.380	0.361
Degree of saturation (%)	74	74	67

SATURATION			
Pressure increments applied (kPa)	50	50	50
Differential pressure used (kPa)	10	10	10
Pore pressure on completion (kPa)	634	860	1387
Cell pressure on completion (kPa)	650	900	1400
B value achieved	0.98	0.94	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 8
Note: Fugro testing procedures are available on request	

Borehole	BH_16	BH_16	BH_16
Sample	22BagA	22BagA	22BagA
Depth (m)	44.00	44.00	44.00

SUMMARY OF ISOTROPICALLY CONSOLIDATED DRAINED TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS

Date: 20/07/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_16_22BagA_D3.XLS

Date:

Date:

Checked by:

Approved by:

CONSOLIDATION : ISOTROPIC		Specimen 1	Specimen 2	Specimen 3
Cell pressure	(kPa)	650	900	1400
Back pressure	(kPa)	400	400	400
Effective cell pressure	(kPa)	250	500	1000
Pore pressure on completion	(kPa)	400	400	400
Pore pressure dissipation	(%)	100	100	100
Moisture content	(%)	10.5	9.6	7.6
Bulk density	(Mg/m ³)	2.29	2.31	2.37
Dry density	(Mg/m ³)	2.07	2.11	2.21
Voids ratio		0.279	0.255	0.201
Degree of saturation	(%)	100	100	100
Cvi	(m ² /year)	10	19	85
Mvi	(m ² /MN)	0.34	0.22	0.14
Permeability	(m/s)	1.0E-09	1.3E-09	3.6E-09

Mode of failure: Compound failure Compound failure Compound failure

Borehole	BH_16	BH_16	BH_16
Sample	22BagA	22BagA	22BagA
Depth (m)	44.00	44.00	44.00

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST : SET OF THREE SPECIMENS**

Date: 20/07/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / EFFECTIV / BH_16_22BagA_D3.XLS

Date:

Date:

Checked by:

Approved by:

SHEARING		Specimen 1	Specimen 2	Specimen 3
Initial pore pressure	(kPa)	400	400	400
Initial effective cell pressure	(kPa)	250	500	1000
Rate of strain	(%/hour)	0.12	0.12	0.04
At peak deviator stress				
Corrected deviator stress	(kPa)	603	1173	2353
Membrane correction applied	(kPa)	0.9	1.6	1.6
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	7.97	16.24	16.54
Volumetric strain	(%)	1.48	1.61	6.57
Major principal effective stress	(kPa)	856	1680	3325
Minor principal effective stress	(kPa)	253	507	972
Principal effective stress ratio		3.39	3.31	3.42
ε 50	(%)	1.15	1.52	1.70
Secant modulus at ε 50	(kPa)	26318	38500	69384
At peak principal effective stress ratio				
Corrected deviator stress	(kPa)	603	1151	2333
Membrane correction applied	(kPa)	0.9	1.4	1.4
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	7.97	13.99	14.28
Volumetric strain	(%)	1.48	1.53	6.26
Major principal effective stress	(kPa)	856	1636	3295
Minor principal effective stress	(kPa)	253	485	962
Principal effective stress ratio		3.39	3.37	3.43
ε 50	(%)	1.15	1.48	1.67
Secant modulus at ε 50	(kPa)	26318	38810	70000
At 10% axial strain				
Corrected deviator stress	(kPa)	589	1080	2215
Membrane correction applied	(kPa)	1.1	1.1	1.1
Drain correction applied	(kPa)	0	0	0
Axial strain	(%)	10.00	10.00	10.00
Volumetric strain	(%)	1.45	1.40	5.35
Major principal effective stress	(kPa)	842	1579	3169
Minor principal effective stress	(kPa)	253	499	954
Principal effective stress ratio		3.33	3.16	3.32
ε 50	(%)	1.10	1.36	1.50
Secant modulus at ε 50	(kPa)	26795	39753	73801
FINAL CONDITIONS				
Moisture content	(%)	10.5	9.6	7.6
Bulk density	(Mg/m ³)	2.29	2.31	2.37
Dry density	(Mg/m ³)	2.07	2.11	2.21
Borehole		BH_16	BH_16	BH_16
Sample		22BagA	22BagA	22BagA
Depth (m)		44.00	44.00	44.00

**SUMMARY OF
ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST : SET OF THREE SPECIMENS**



Drawn by: ALB Date: 20/07/2011

Template Issue: 4

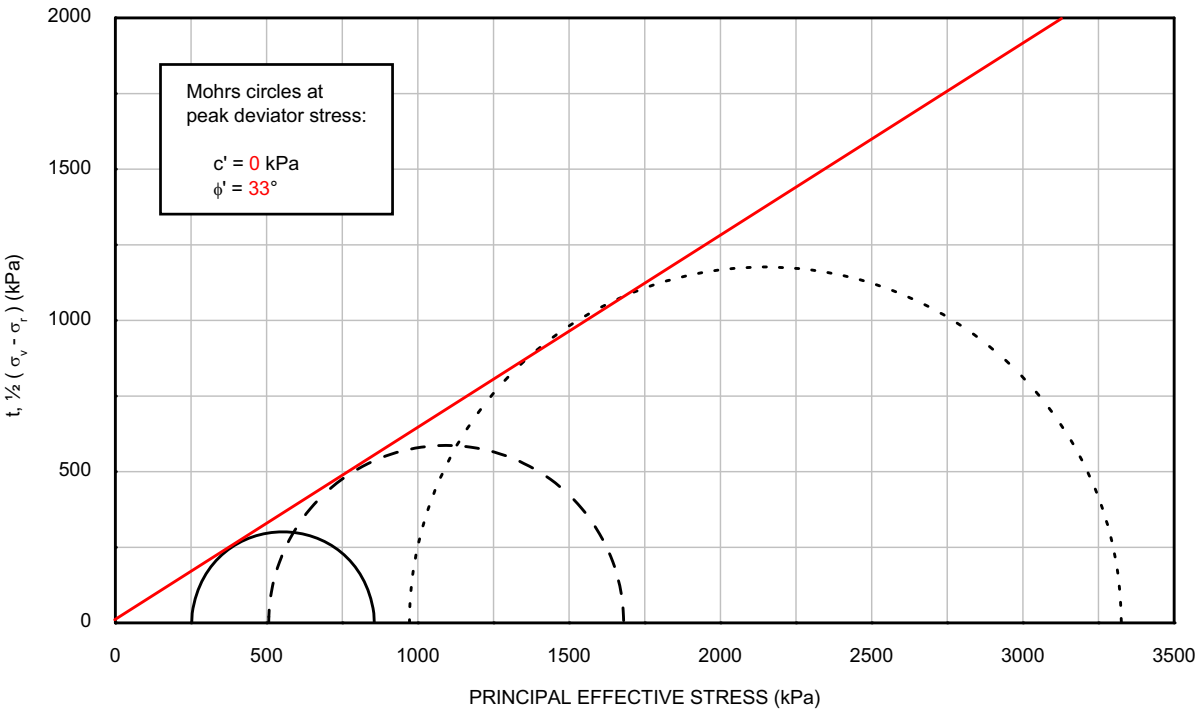
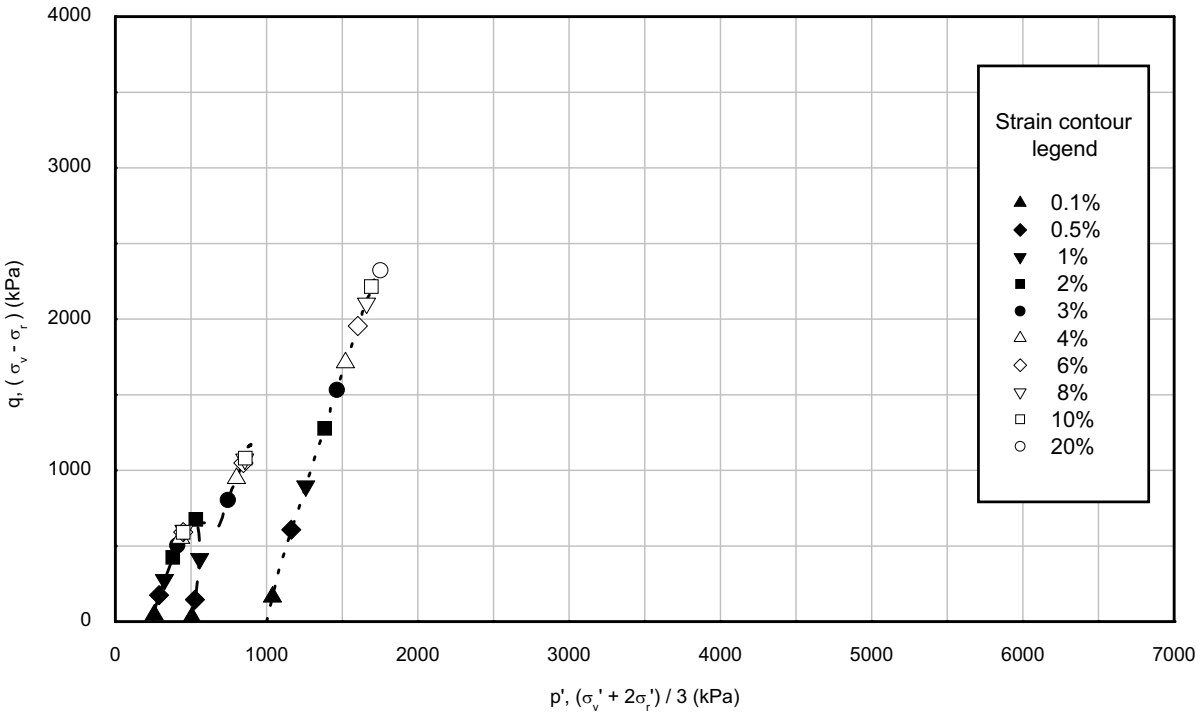
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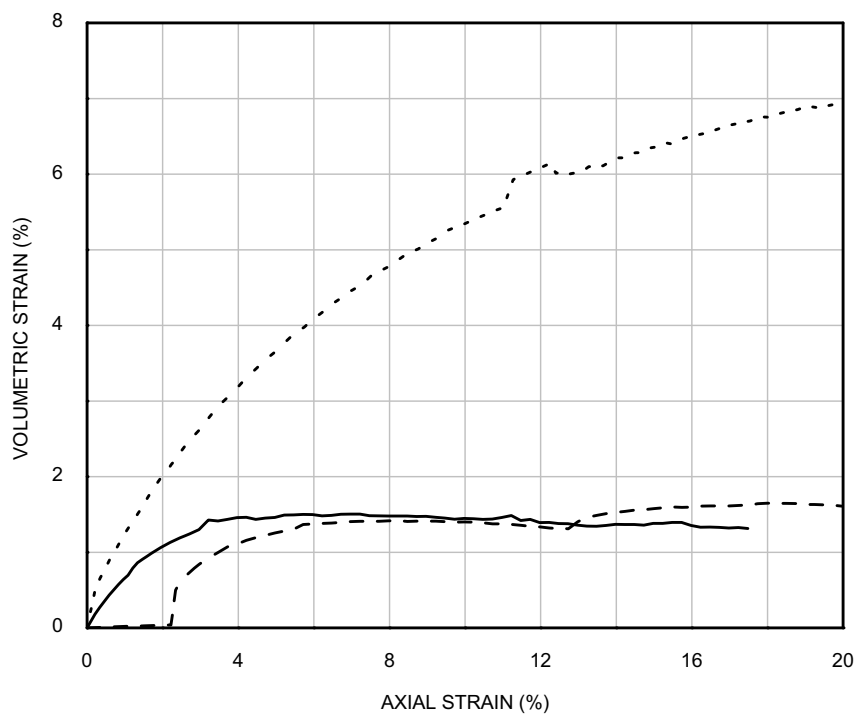
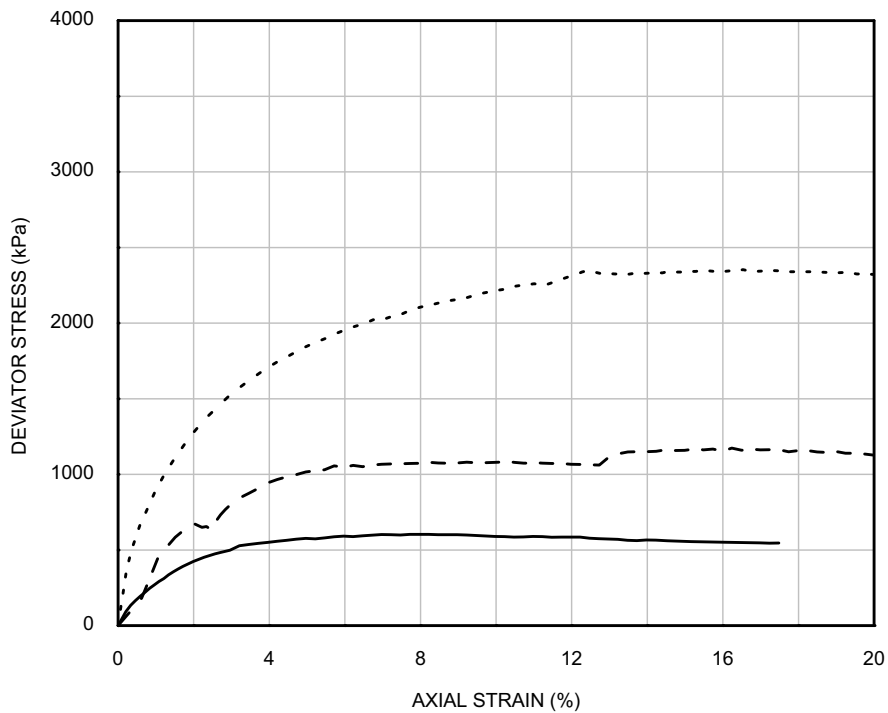
Date :

Approved by:



Curve	Specimen(3)	$\sigma_{ic}' \text{ (kPa)}$	$\sigma_{vc}' \text{ (kPa)}$	Borehole	Sample	Depth (m)
—	1	250	250	BH_16	22BagA	44.00
- - -	2	500	500			
...	3	1000	1000			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS



Curve	Specimen(3)	σ'_{vc} (kPa)	σ'_{vc} (kPa)	Borehole	Sample	Depth (m)
—	1	250	250	BH_16	22BagA	44.00
- - -	2	500	500			
. . .	3	1000	1000			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAxIAL COMPRESSION TEST: SET OF THREE SPECIMENS

Drawn by: ALB Date: 20/07/2011

Template Issue: 4

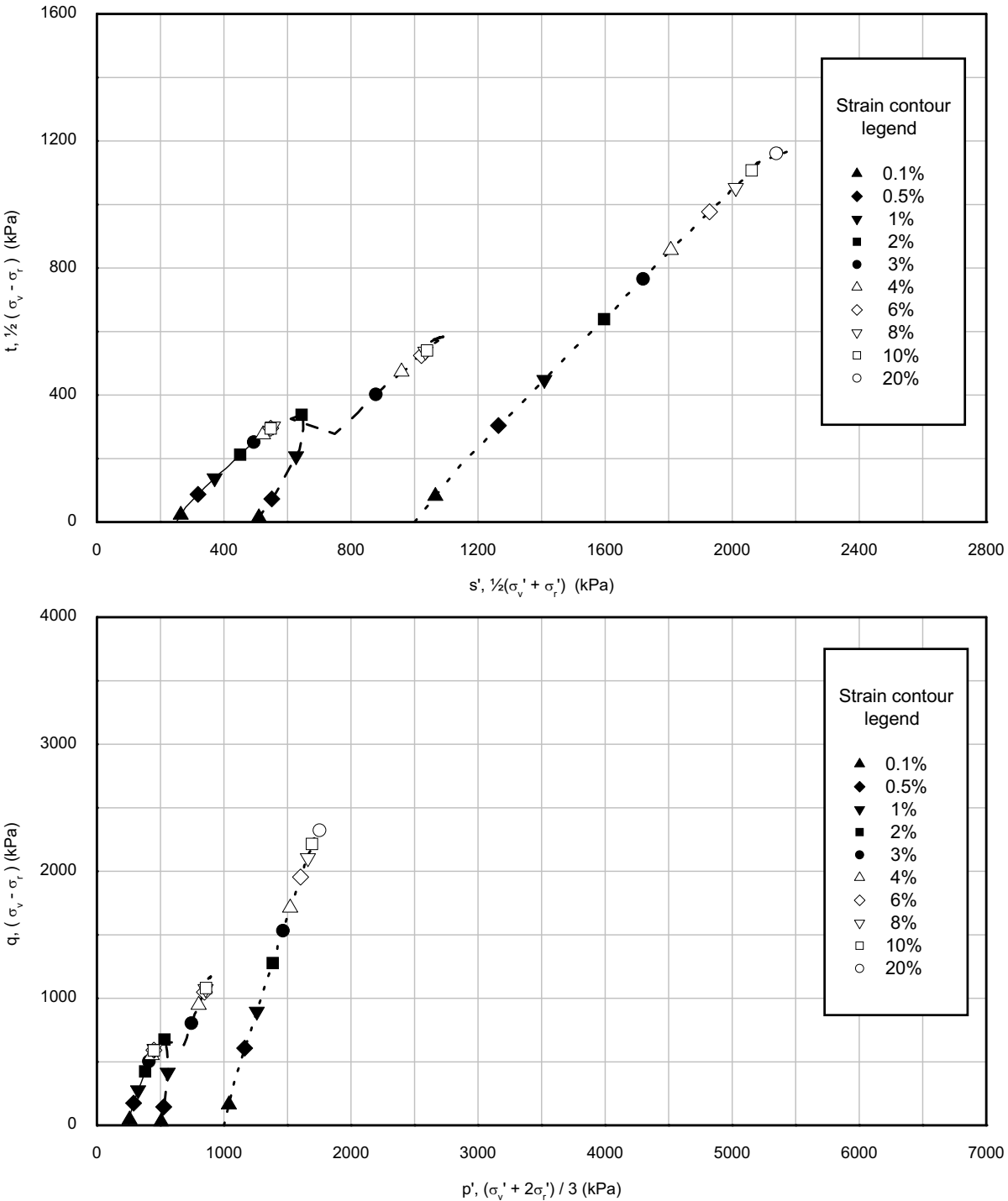
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Date :

Date :

Checked by:

Approved by:



Curve	Specimen(3)	σ_{ic}' (kPa)	σ_{vc}' (kPa)	Borehole	Sample	Depth (m)
—	1	250	250	BH_16	22BagA	44.00
- - -	2	500	500			
. . .	3	1000	1000			

ISOTROPICALLY CONSOLIDATED DRAINED
TRIAXIAL COMPRESSION TEST: SET OF THREE SPECIMENS

SECTION B.5

DIRECT SIMPLE SHEAR TESTS

B.5	DIRECT SIMPLE SHEAR TESTS	1
B.5.1	SUMMARY	1
B.5.2	DISCUSSION OF RESULTS	1

B.5 DIRECT SIMPLE SHEAR TESTS

B.5.1 SUMMARY

Ten (10) consolidated constant volume static direct simple shear (DSS) tests have been performed on selected cohesive samples from the Rampion site. The samples were consolidated to an estimate of p_c' and then unloaded, and then tested at their in-situ vertical pressure (p_o'). The test results are summarised on Plate B.5-1 and are presented at the end of this section on Plates B.5-2 to B.5-61.

B.5.2 DISCUSSION OF RESULTS

The results of the tests performed on these samples are considered to characterise the soils at the Rampion site as they show relatively good agreement with other strength tests results and from inferred CPT data.

As per standard FGCLTD practice, unless the shear stress peaked at a lower strain, failure was taken at 15% strain.



DIRECT SIMPLE SHEAR TESTS

LIST OF PLATES – SECTION B.5

Description	Plate
Summary of Direct Simple Shear Test Results	B.5-1
Direct Simple Shear Test Results	B.5-2 to B.5-61

BH No.	SAMPLE No.	DEPTH (m)	TEST TYPE	INDEX PROPERTIES				CONSOLIDATION			STATIC LOADING			NOTES
				w _i (%)	w _f (%)	w _p (%)	I _p (%)	σ' _{v max} (kPa)	σ' _{vc} (kPa)	ε _{vc} (%)	τ _f (kPa)	γ _f (%)	Δu _f (kPa)	
BH13	6WaxA	12.60	DSS	25	24	21	38	2000	124	6.73	226	13.7	-256	
BH14*	4WaxA	7.40	DSS	38	40	31	49	1346	59	1.03	95	15.0	-92	
BH14	11WaxA	25.50	DSS	26	28	21	54	2000	228	8.20	239	5.6	-190	
BH14*	15WaxA	35.10	DSS	31	23	27	39	2000	323	14.75	346	15.0	-395	
BH02*	2WaxB	7.50	DSS	26	28	21	56	2000	54	1.85	151	15.0	-182	
BH06	1WaxA	3.15	DSS	28	32	26	41	764	30	0.16	40	7.0	-42	
BH06	9WaxA	18.00	DSS	21	20	19	24	2000	171	5.64	152	6.6	-146	
BH07*	3WaxB	7.40	DSS	25	24	-	-	70	70	0.97	108	15.0	-108	
BH07*	6WaxA	12.64	DSS	25	26	20	8	120	120	2.63	51	15.0	49	
BH07*	12WaxA	23.08	DSS	21	21	20	9	220	220	3.52	88	15.0	105	
Notes: Failure is taken at 15% shear strain when testing continued beyond 15% and did not reach failure are marked with an *.														

SUMMARY OF STATIC DIRECT SIMPLE SHEAR TEST RESULTS

Date: 02/06/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / DSS / BH 13 6WaxA DSS.XLS

VISUAL DESCRIPTION

Stiff to very stiff dark grey slightly sandy CLAY with pockets of fine sand.

GENERAL

Date test started	27/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	50.1
Length	(mm)	19.3
Moisture content	(%)	25
Bulk density	(Mg/m ³)	1.94
Dry density	(Mg/m ³)	1.56
Voids ratio		0.760
Degree of saturation	(%)	88
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	257

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 on request

Borehole	BH_13
Sample	6WaxA
Depth (m)	12.60
Test Number	DSS07b

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST

Date: 02/06/2011

Drawn by: ALB

Template Issue: 2

Date: 17/05/2011

Checked by: PH

Filename: J11056 / DSS / BH 13 6WaxA DSS.XLS

Date:
Approved by:

CONSOLIDATION $\sigma_{vc(max)'$		
$\sigma_{vc(max)'$	(kPa)	2000
Vertical strain	(%)	10.30
Volumetric strain	(%)	10.30
Bulk density	(Mg/m ³)	2.05
Dry density	(Mg/m ³)	1.74

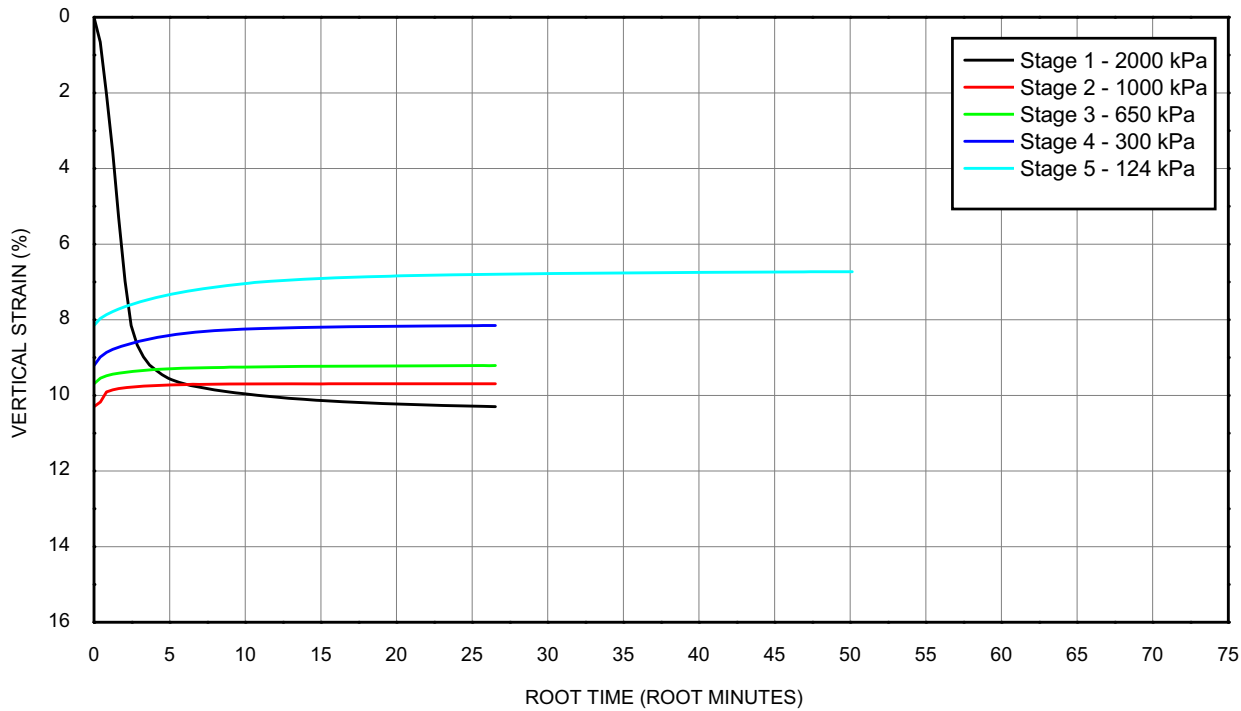
CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	124
Vertical strain	(%)	6.73
Volumetric strain	(%)	6.73
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.67

SHEARING		
At peak shear stress		
Shear stress	(kPa)	226
Shear strain	(%)	13.73
Change in pore pressure	(kPa)	-256
Rate of strain	(%/hr)	3.0
At 15 % shear strain		
Shear stress	(kPa)	224
Change in pore pressure	(kPa)	-253



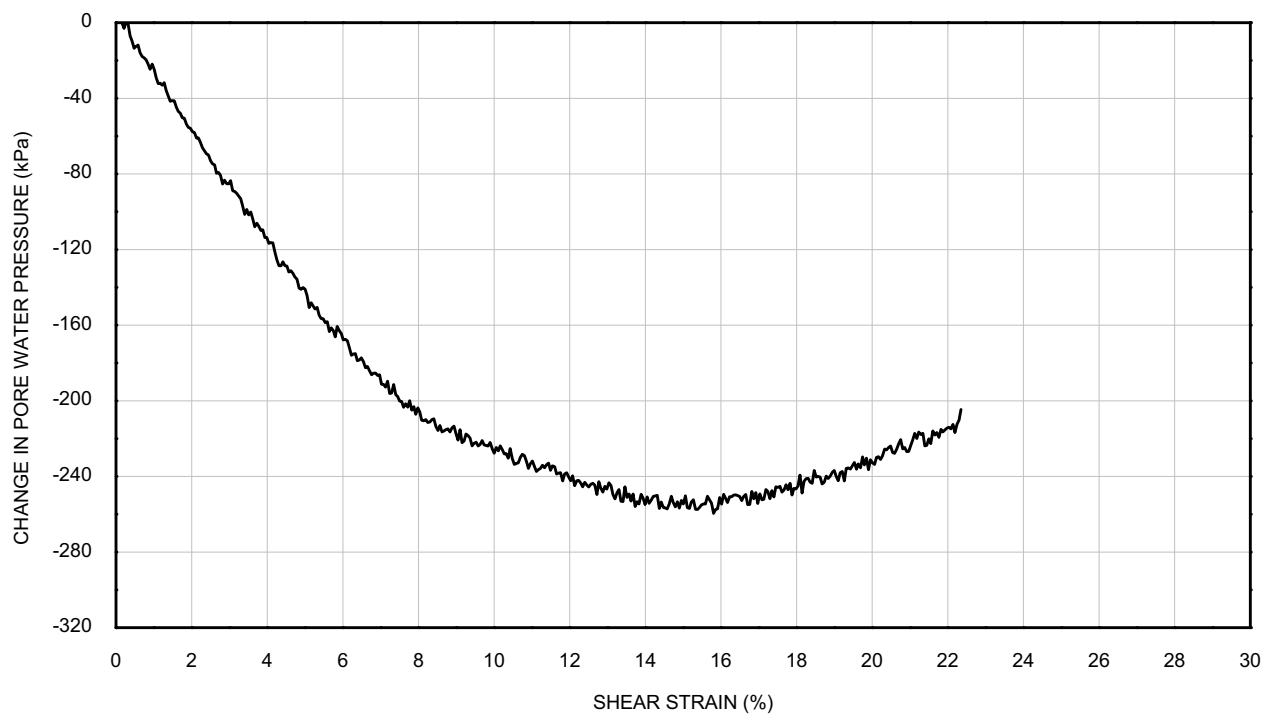
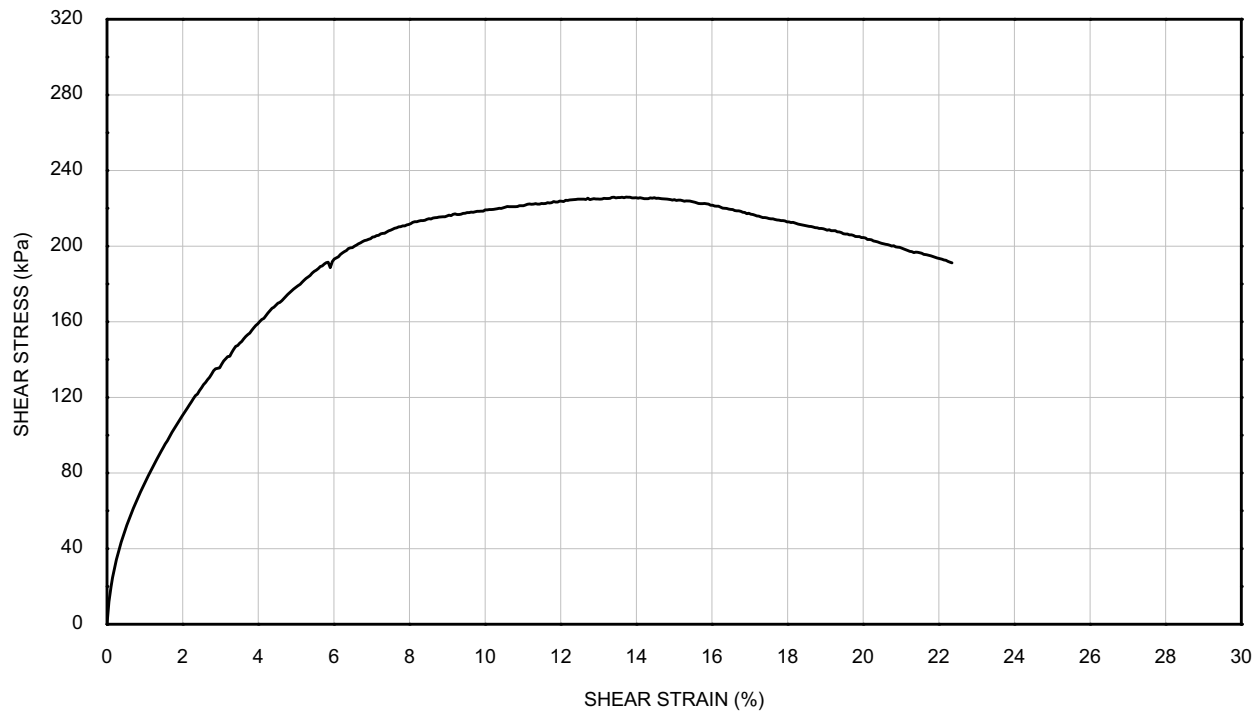
Borehole	BH_13
Sample	6WaxA
Depth (m)	12.60
Test Number	DSS07b

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



Consolidation Stresses		Borehole	: BH_13
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 6WaxA
$\sigma_{vc'}$	: 124 kPa	Depth (m)	: 12.60
Shearing Parameters		Test No	: DSS07b
Rate of Strain	: 3 %/Hour		

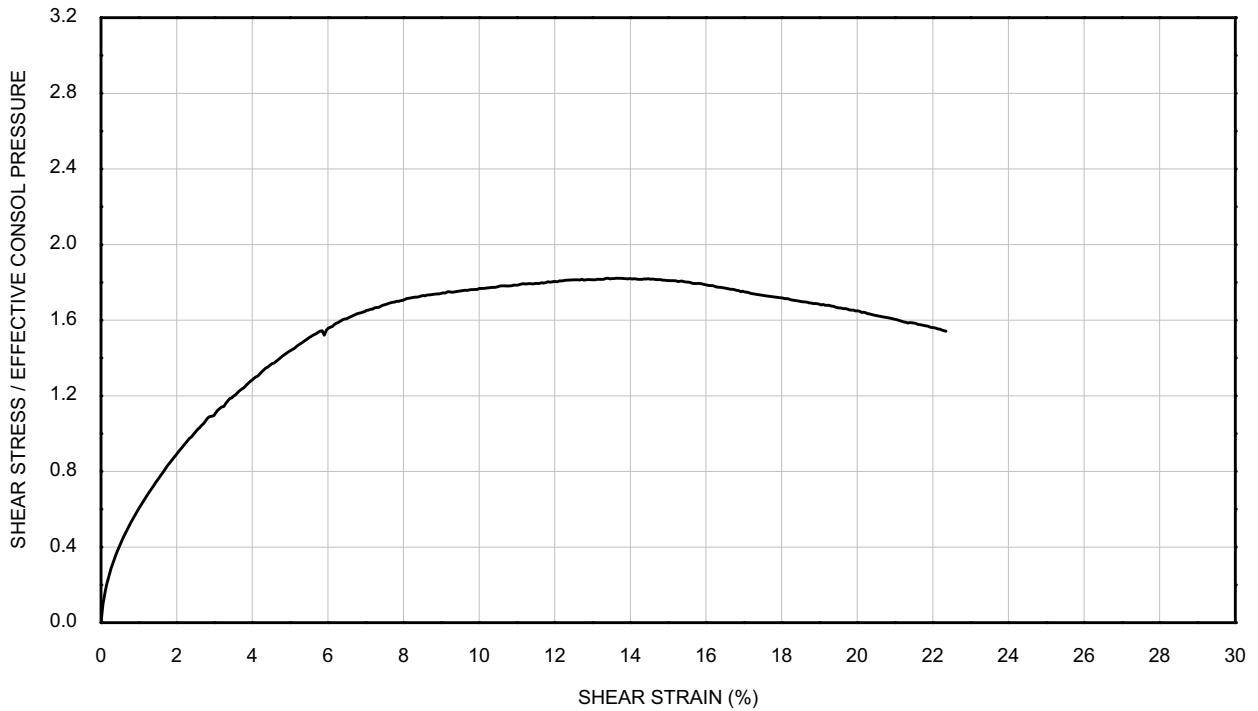
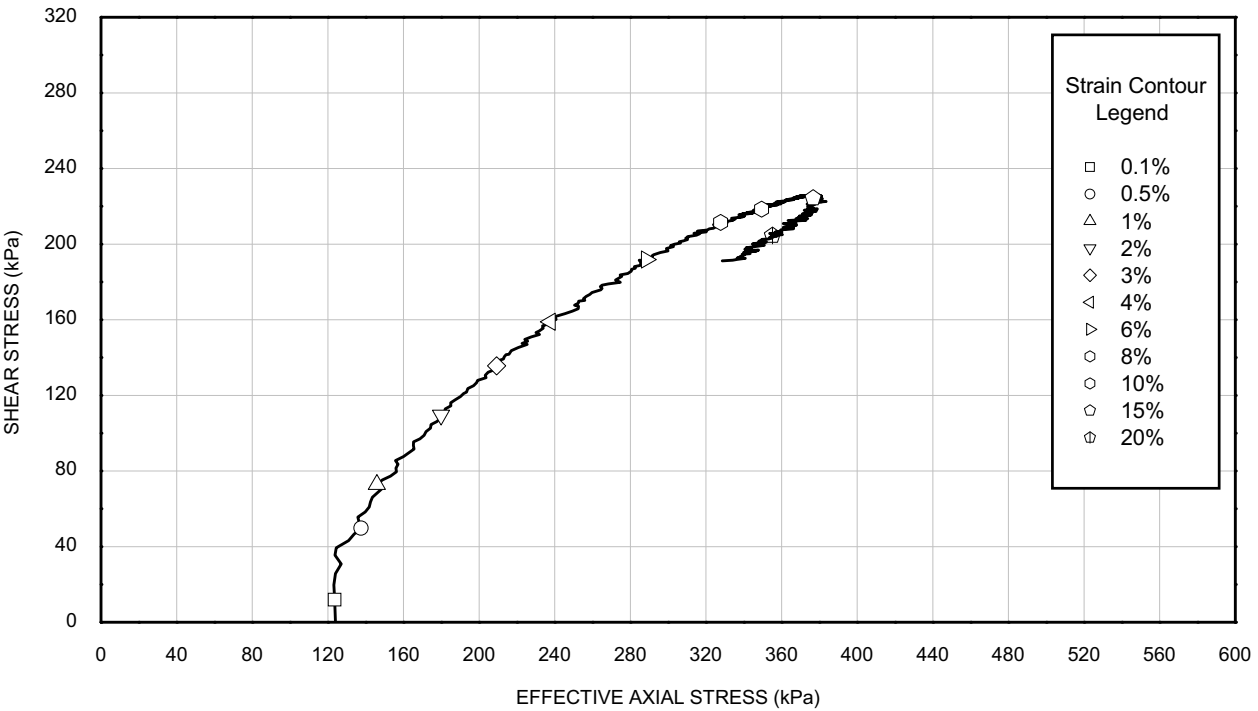
CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_13
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 6WaxA
$\sigma_{vc'}$	: 124 kPa	Depth (m)	: 12.60
Shearing Parameters		Test No	: DSS07b
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

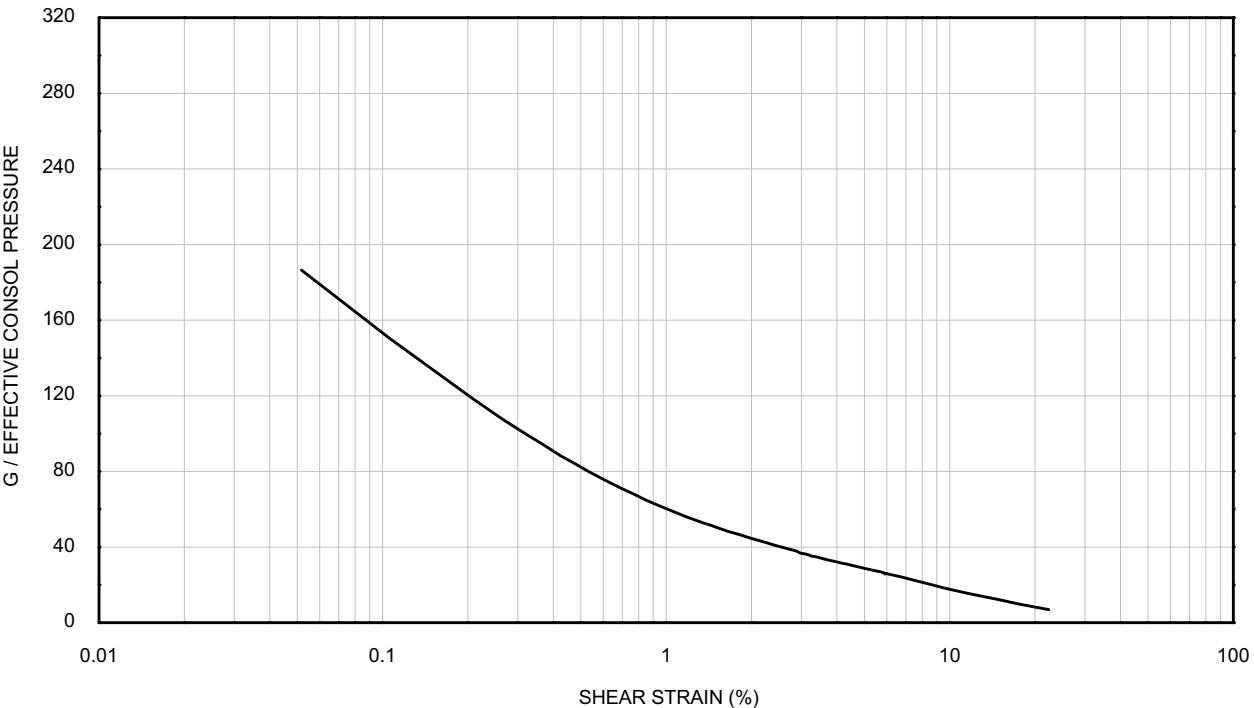
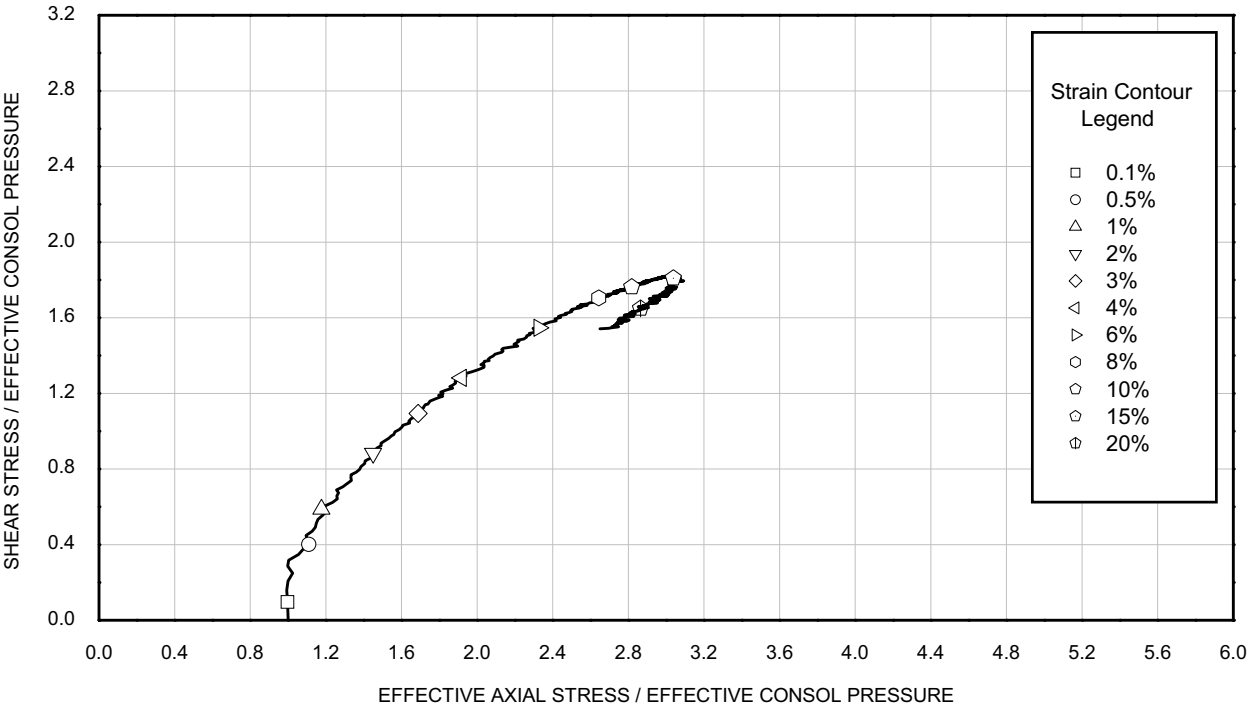
Drawn by: ALB
Date: 02/06/2011
Template Issue: 2
Filename: J11056 \ BH_13_6WaxA_DSS.OPJ
Date: 17/05/2011
Date:
Checked by: PH
Approved by:



Consolidation Stresses		Borehole	: BH_13
$\sigma_{vc} (max)'$	: 2000 kPa	Sample	: 6WaxA
σ_{vc}'	: 124 kPa	Depth (m)	: 12.60
Shearing Parameters		Test No	: DSS07b
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Template Issue: 2
Filename: J11056 \ BH_13_6WaxA_DSS.OPJ
Date: 17/05/2011
Date: 02/06/2011
Checked by: PH
Approved by:
Drawn by: ALB



Consolidation Stresses		Borehole	: BH_13
$\sigma_{vc(max)'} :$	2000 kPa	Sample	: 6WaxA
$\sigma_{vc}' :$	124 kPa	Depth (m)	: 12.60
Shearing Parameters		Test No	: DSS07b
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Date: 19/05/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / DSS / BH 14 4WaxA DSS.XLS

VISUAL DESCRIPTION

Very stiff dark grey CLAY with small pockets of fine sand.

GENERAL

Date test started	13/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	49.9
Length	(mm)	19.3
Moisture content	(%)	38
Bulk density	(Mg/m ³)	1.86
Dry density	(Mg/m ³)	1.34
Voids ratio		1.045
Degree of saturation	(%)	100
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	-

Date: 19/05/2011

Checked by: PH

Date:
Approved by:

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 on request

Borehole	BH_14
Sample	4WaxA
Depth (m)	7.40
Test Number	DSS08

**SUMMARY OF
CONSOLIDATED CONSTANT VOLUME DSS TEST**

Date: 19/05/2011

Drawn by: ALB

Template Issue: 2

Date: 19/05/2011

Checked by: PH

Filename: J11056 / DSS / BH 14 4WaxA DSS.XLS

Date:
Approved by:

CONSOLIDATION $\sigma_{vc(max)'$		
$\sigma_{vc(max)'$	(kPa)	1346
Vertical strain	(%)	8.36
Volumetric strain	(%)	8.36
Bulk density	(Mg/m ³)	1.93
Dry density	(Mg/m ³)	1.47

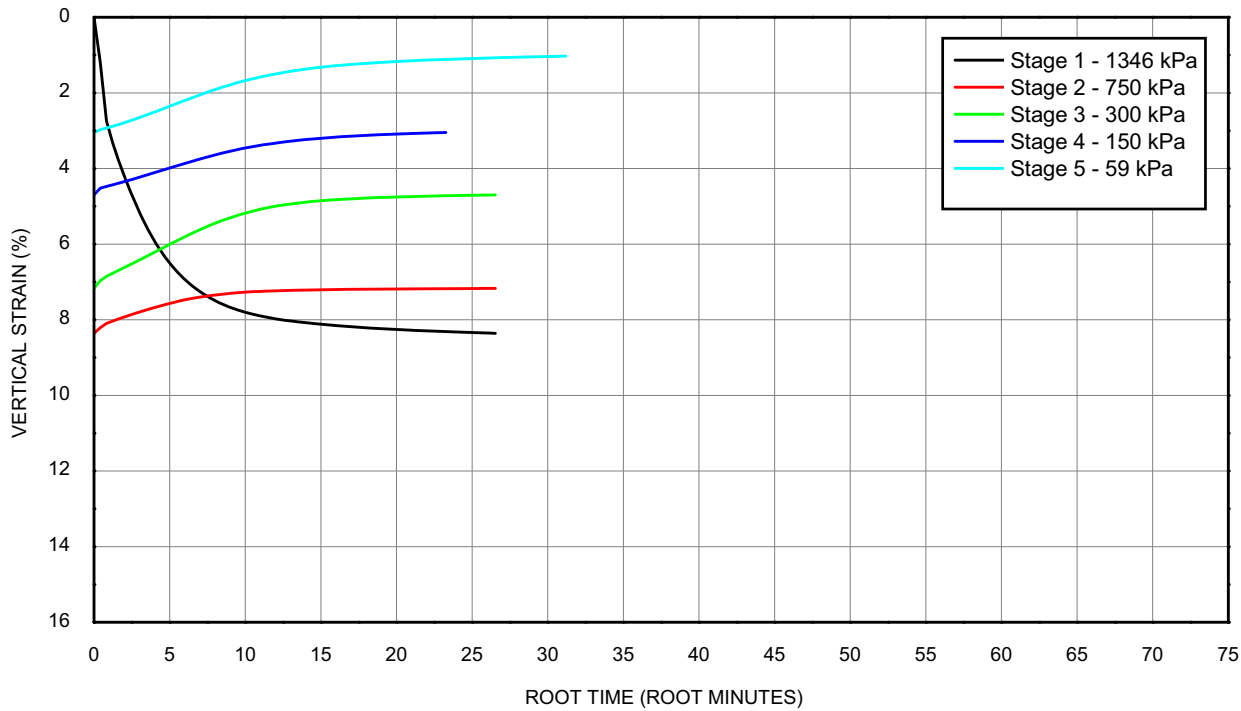
CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	59
Vertical strain	(%)	1.03
Volumetric strain	(%)	1.03
Bulk density	(Mg/m ³)	1.87
Dry density	(Mg/m ³)	1.36

SHEARING		
At peak shear stress		
Shear stress	(kPa)	95
Shear strain	(%)	15.08
Change in pore pressure	(kPa)	-92
Rate of strain	(%/hr)	3.0
At 15 % shear strain		
Shear stress	(kPa)	95
Change in pore pressure	(kPa)	-92



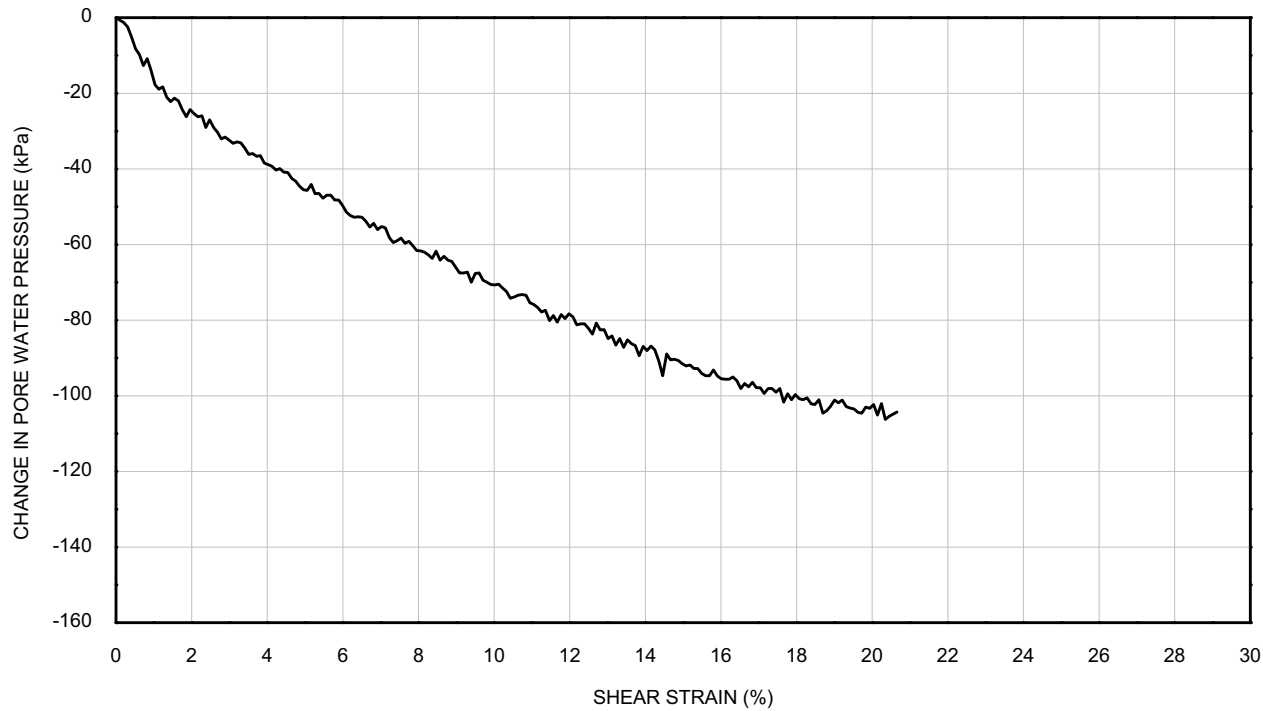
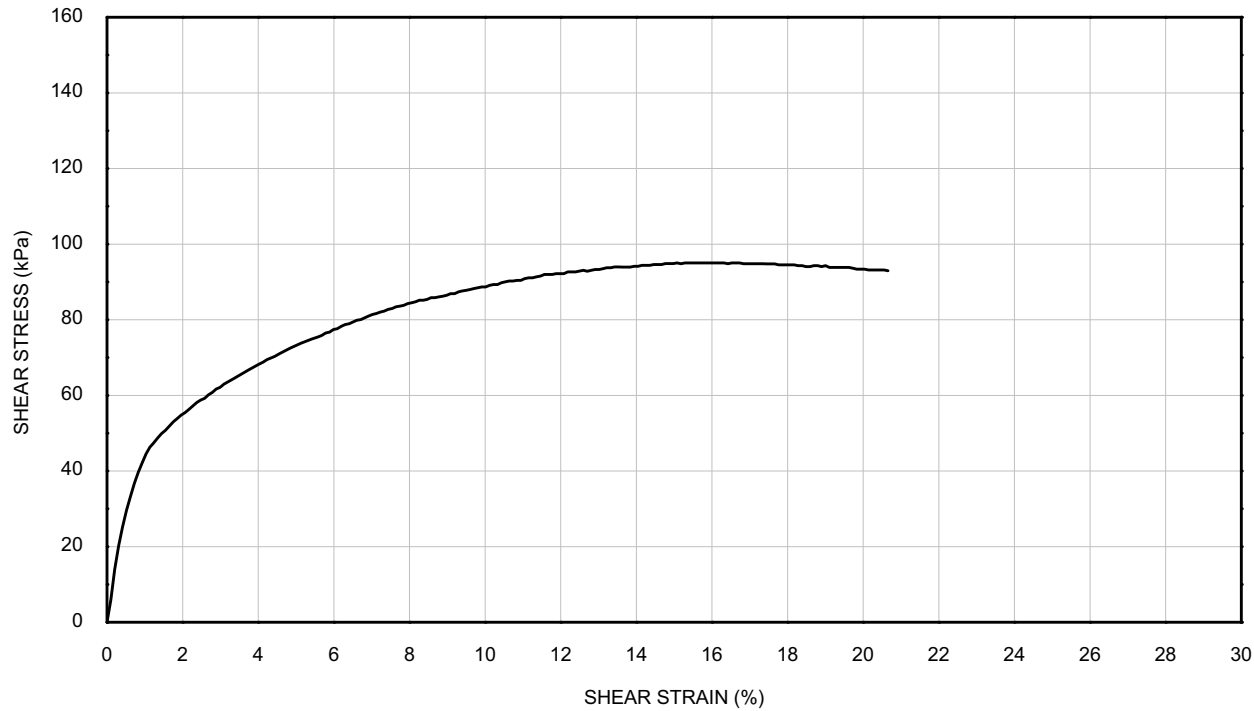
Borehole	BH_14
Sample	4WaxA
Depth (m)	7.40
Test Number	DSS08

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)}$	: 1346 kPa	Sample	: 4WaxA
$\sigma_{vc'}$	: 59 kPa	Depth (m)	: 7.40
Shearing Parameters		Test No	: DSS08
Rate of Strain	: 3 %/Hour		

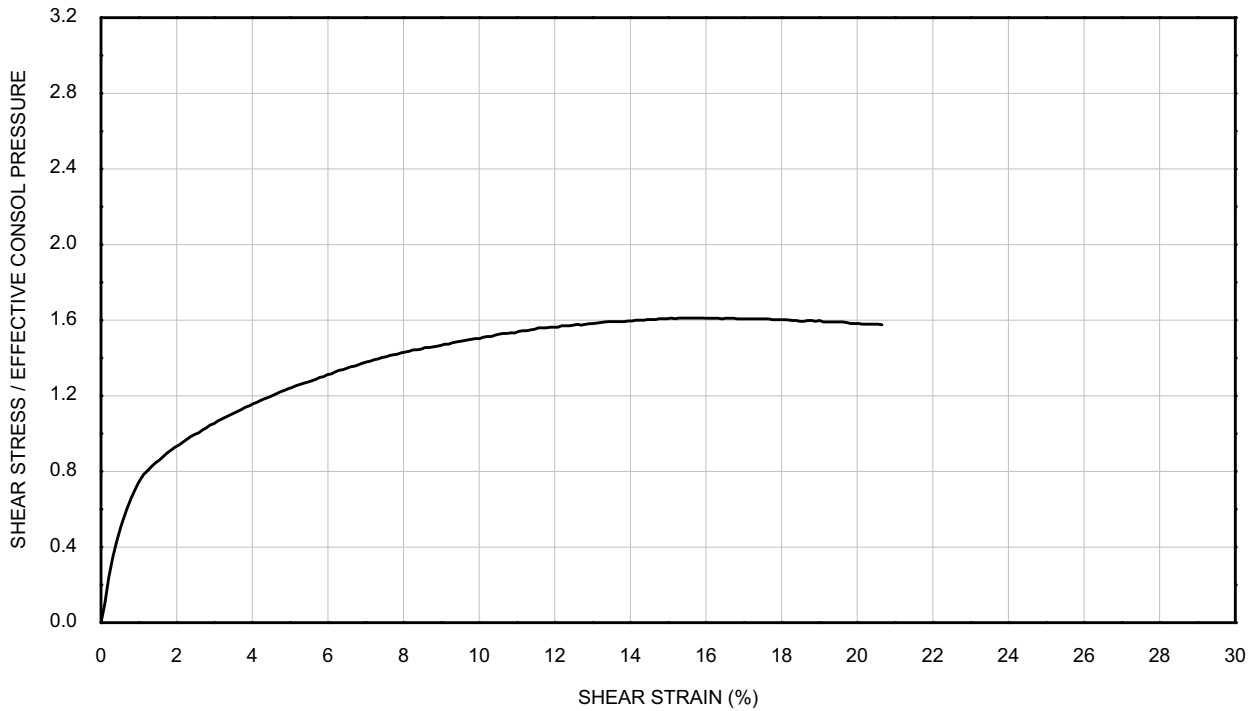
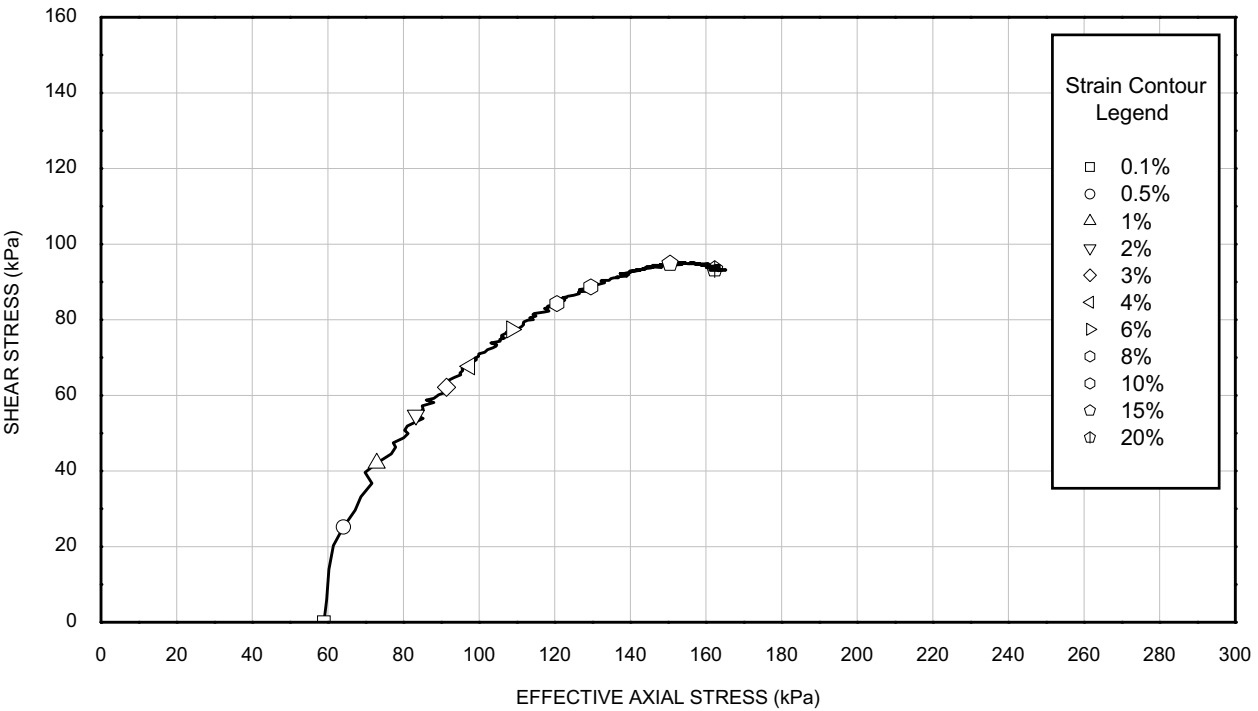
CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)'$	: 1346 kPa	Sample	: 4WaxA
σ_{vc}'	: 59 kPa	Depth (m)	: 7.40
Shearing Parameters		Test No	: DSS08
Rate of Strain	: 3 %/Hour		

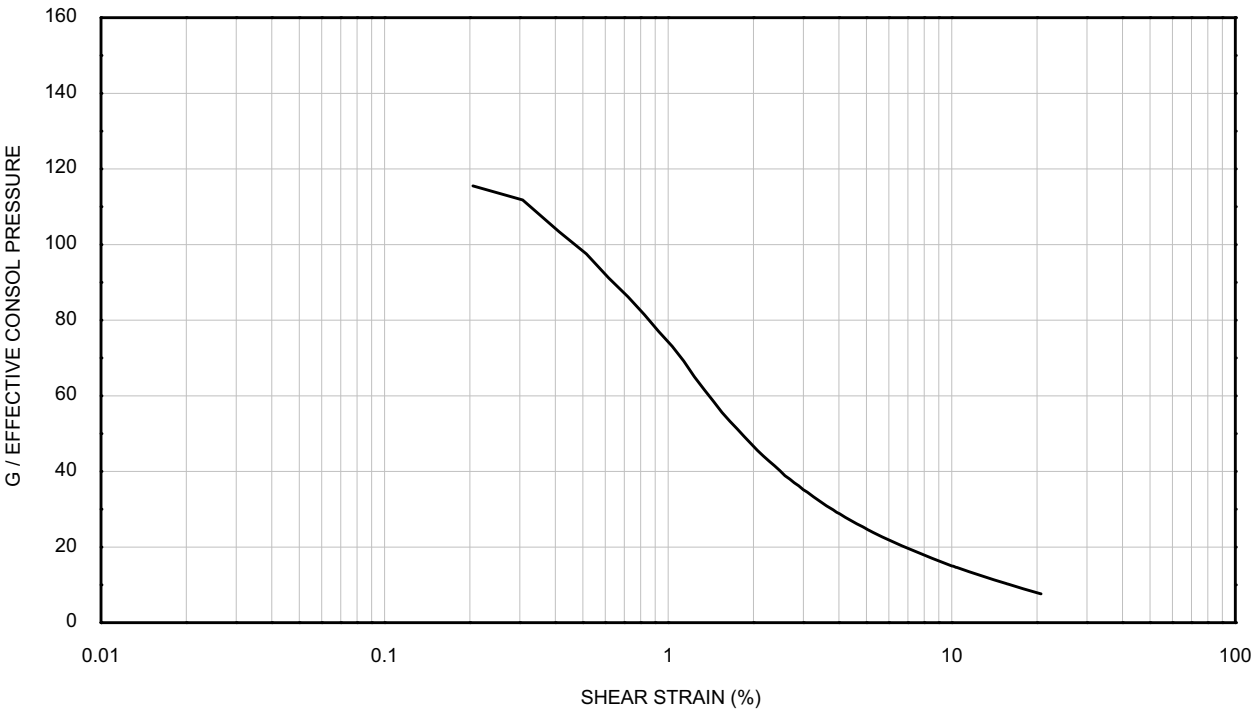
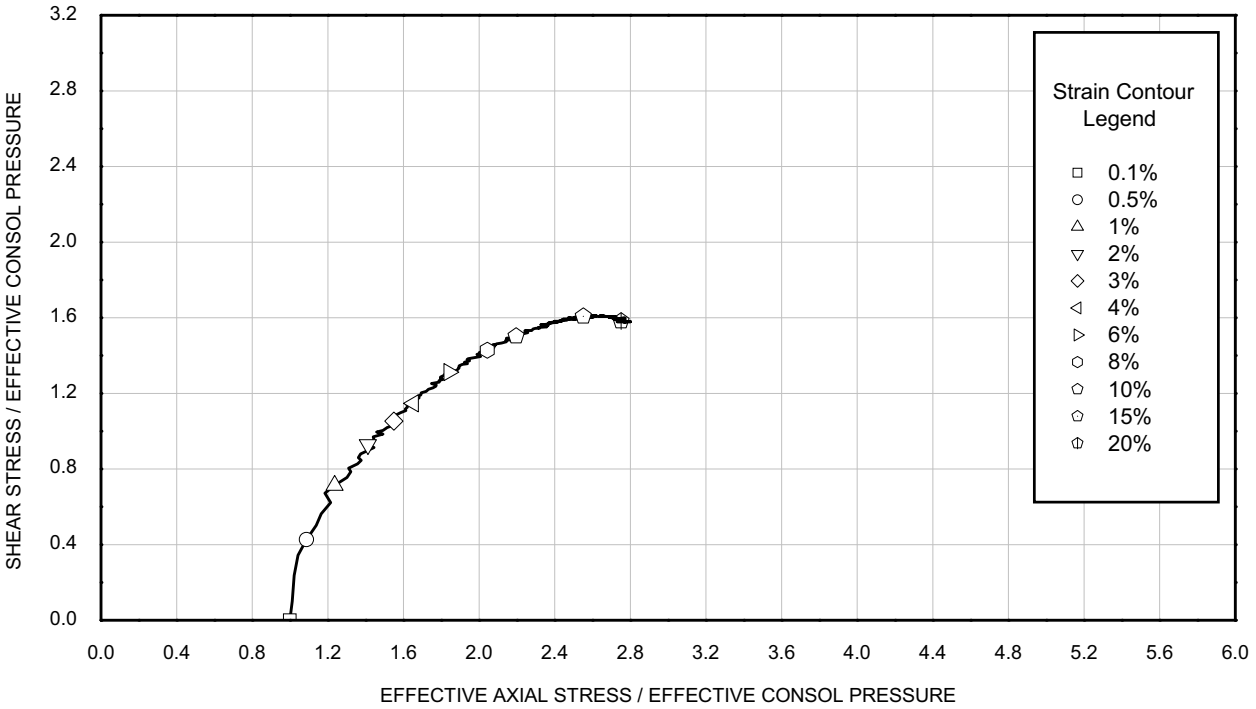
CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Drawn by: ALB
Date: 19/05/2011
Template Issue: 2
Filename: J11056 \ BH_14_4WaxA_DSS.OPJ
Date: 19/05/2011
Date:
Checked by: PH
Approved by:



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc} (max)$	: 1346 kPa	Sample	: 4WaxA
$\sigma_{vc'}$	: 59 kPa	Depth (m)	: 7.40
Shearing Parameters		Test No	: DSS08
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses

$\sigma_{vc(max)}$: 1346 kPa

$\sigma_{vc'}$: 59 kPa

Shearing Parameters

Rate of Strain : 3 %/Hour

Borehole : BH_14

Sample : 4WaxA

Depth (m) : 7.40

Test No : DSS08

**CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE**



Date: 16/05/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / DSS / BH 14 11WaxA DSS.XLS

VISUAL DESCRIPTION

Stiff to hard grey CLAY with pockets of fine sand.

GENERAL

Date test started	09/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	49.9
Length	(mm)	19.2
Moisture content	(%)	26
Bulk density	(Mg/m ³)	1.95
Dry density	(Mg/m ³)	1.55
Voids ratio		0.743
Degree of saturation	(%)	93
Torvane	(kPa)	153
Pocket penetrometer	(kPa)	380

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 on request

Borehole	BH_14
Sample	11WaxA
Depth (m)	25.50
Test Number	DSS09

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST

Date: 16/05/2011

Drawn by: ALB

Template Issue: 2

Date: 17/05/2011

Checked by: PH

Filename: J11056 / DSS / BH 14 11WaxA DSS.XLS

Date:
Approved by:

CONSOLIDATION $\sigma_{vc(max)'$		
$\sigma_{vc(max)'$	(kPa)	2000
Vertical strain	(%)	11.80
Volumetric strain	(%)	11.80
Bulk density	(Mg/m ³)	2.07
Dry density	(Mg/m ³)	1.76

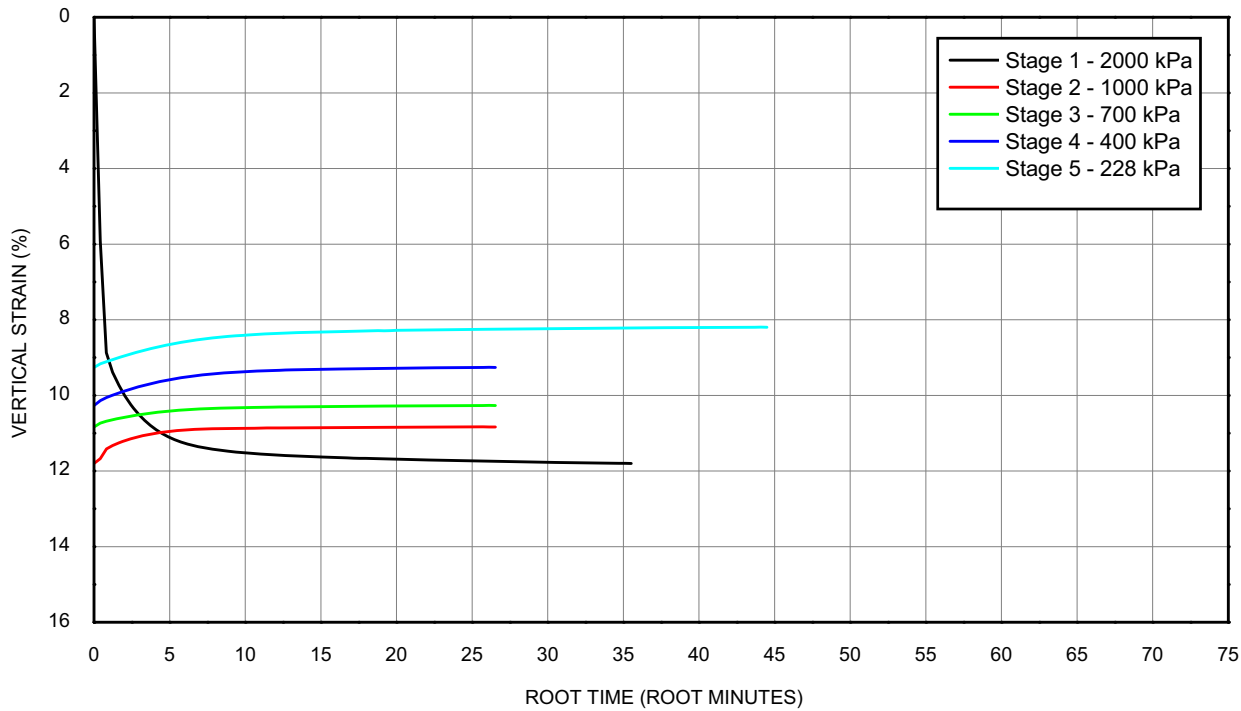
CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	228
Vertical strain	(%)	8.20
Volumetric strain	(%)	8.20
Bulk density	(Mg/m ³)	2.03
Dry density	(Mg/m ³)	1.69

SHEARING		
At peak shear stress		
Shear stress	(kPa)	239
Shear strain	(%)	5.61
Change in pore pressure	(kPa)	-190
Rate of strain	(%/hr)	3.0
At 15 % shear strain		
Shear stress	(kPa)	218
Change in pore pressure	(kPa)	-225



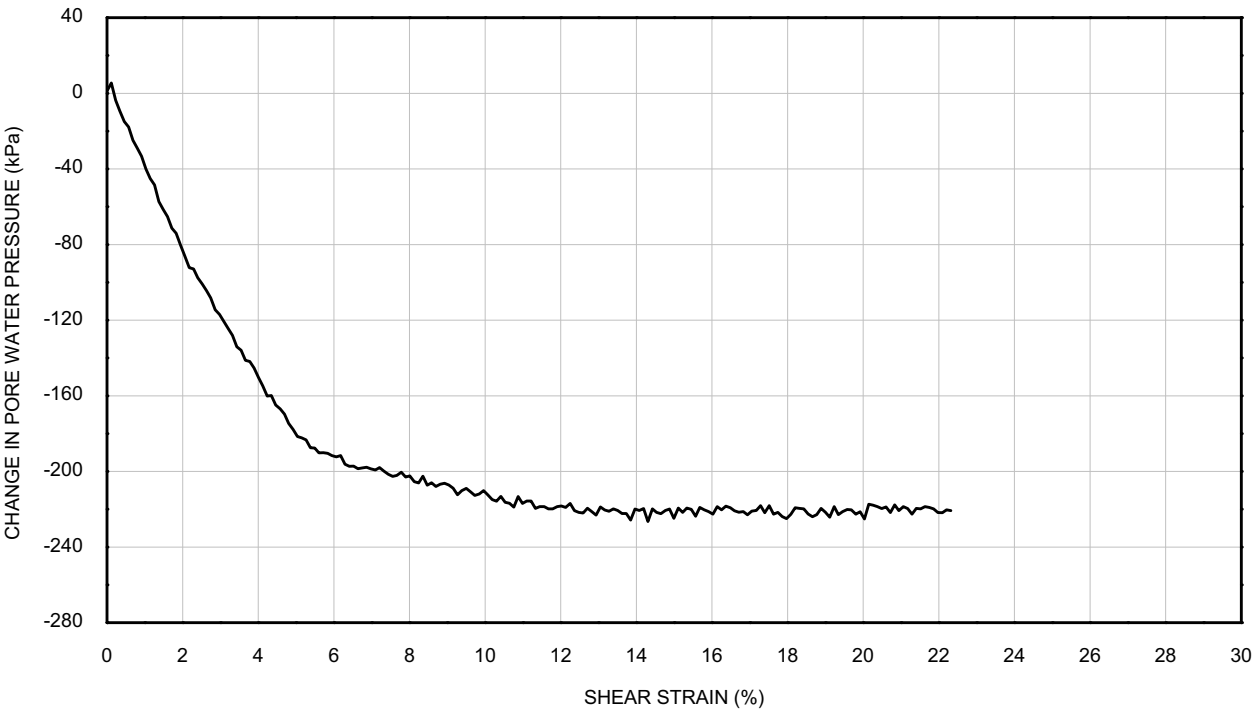
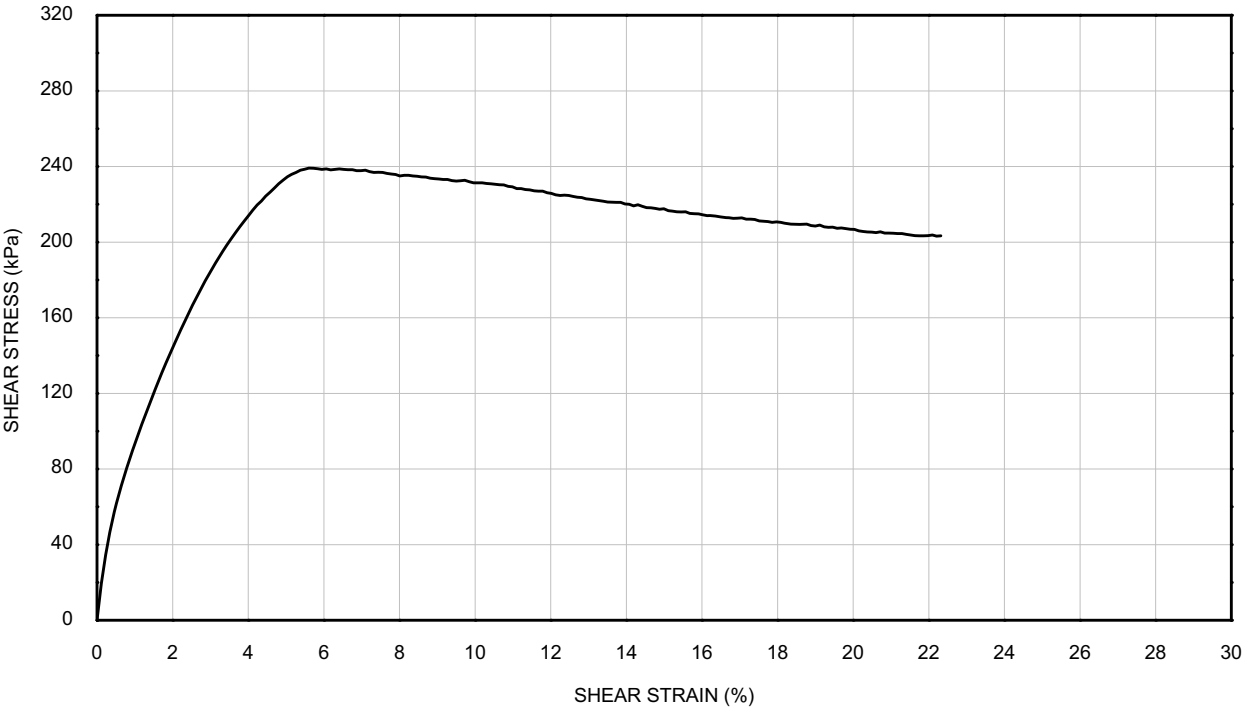
Borehole	BH_14
Sample	11WaxA
Depth (m)	25.50
Test Number	DSS09

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



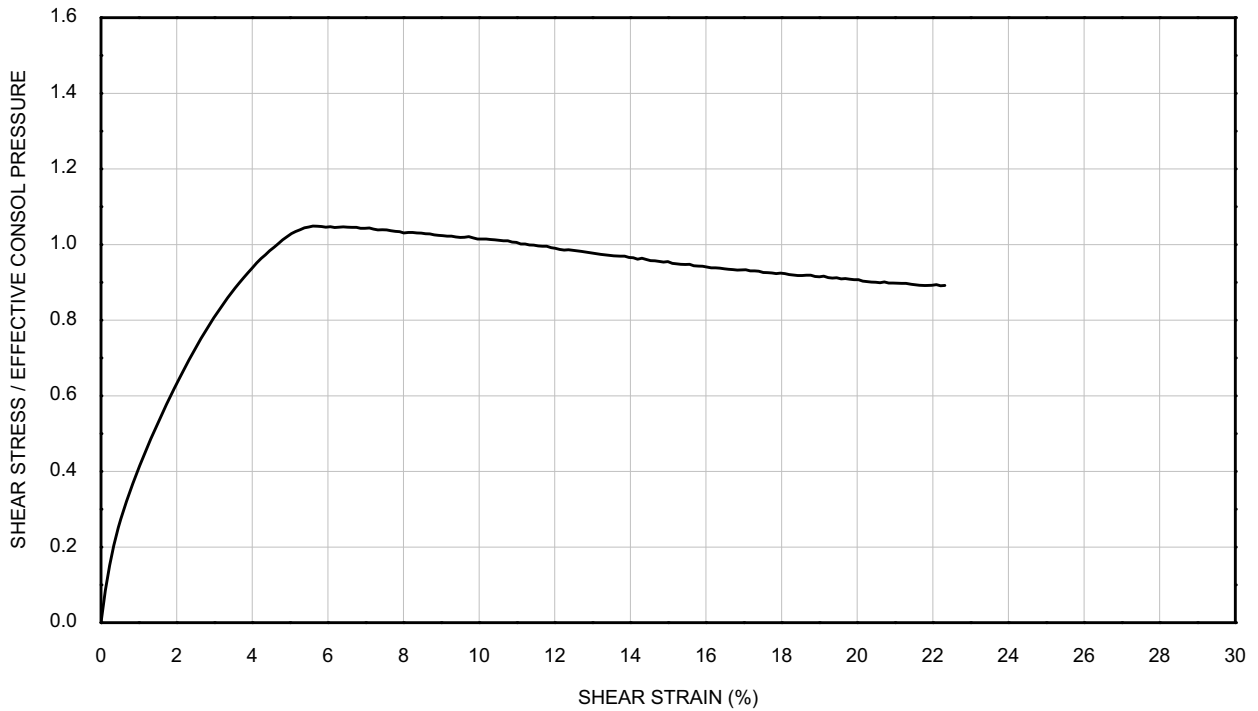
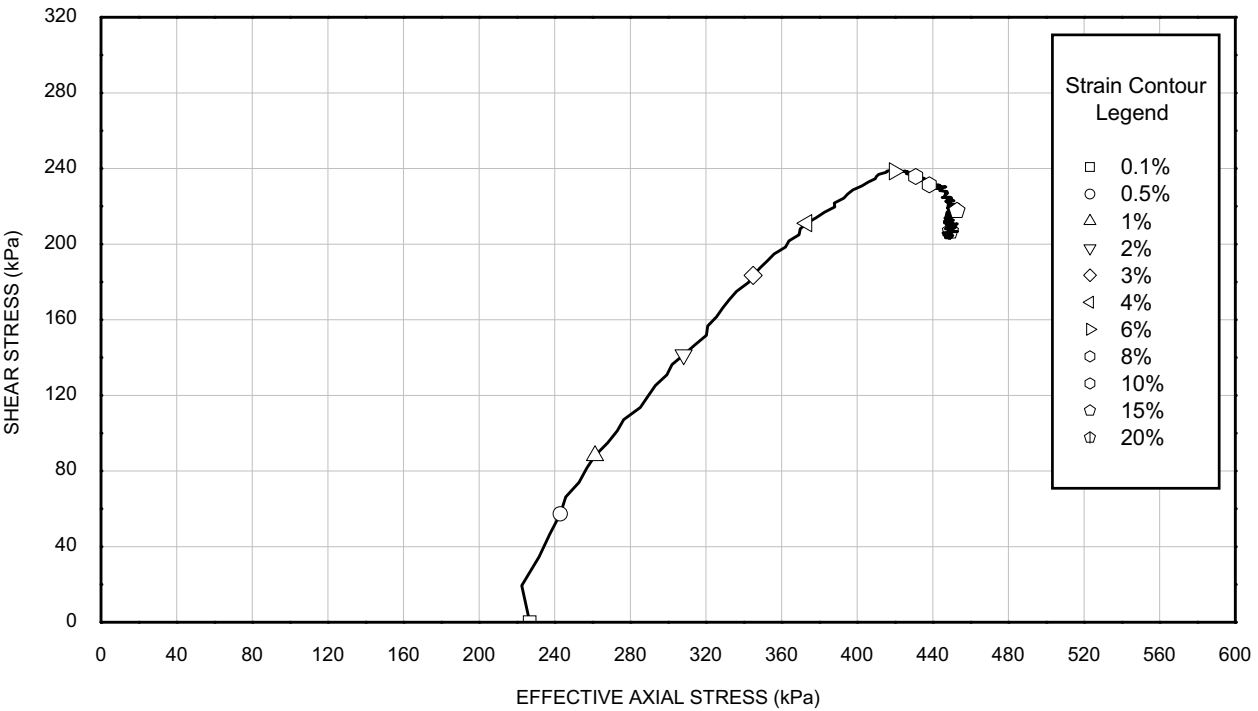
Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 11WaxA
$\sigma_{vc'}$	: 228 kPa	Depth (m)	: 25.50
Shearing Parameters		Test No	: DSS09
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 11WaxA
$\sigma_{vc'}$	: 228 kPa	Depth (m)	: 25.50
Shearing Parameters		Test No	: DSS09
Rate of Strain	: 3 %/Hour		

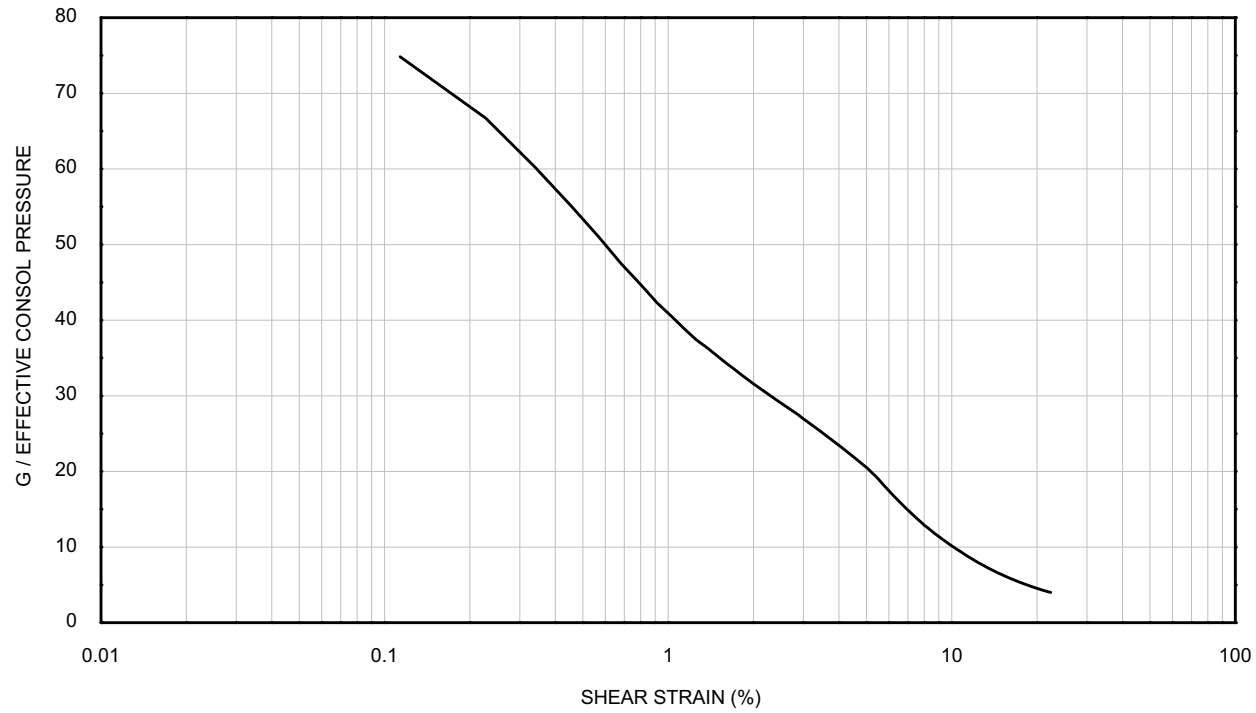
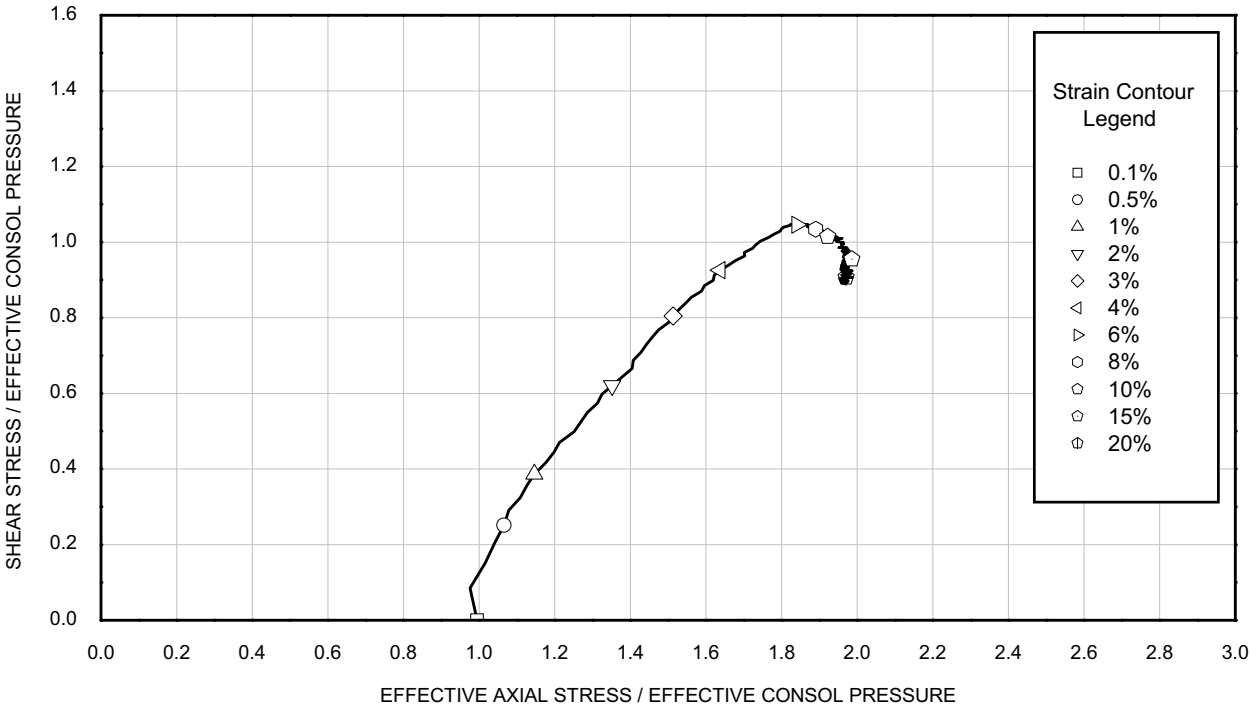
CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc} (max)$	: 2000 kPa	Sample	: 11WaxA
$\sigma_{vc'}$	: 228 kPa	Depth (m)	: 25.50
Shearing Parameters		Test No	: DSS09
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Drawn by: ALB
Date: 16/05/2011
Template Issue: 2
Filename: J11056 \ BH_14_11WaxA_DSS.OPJ
Date: 17/05/2011
Date:
Checked by: PH
Approved by:



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)'} :$	2000 kPa	Sample	: 11WaxA
$\sigma_{vc}' :$	228 kPa	Depth (m)	: 25.50
Shearing Parameters		Test No	: DSS09
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Date: 16/05/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / DSS / BH 14 15WaxA DSS.XLS

VISUAL DESCRIPTION

Stiff to very stiff dark grey CLAY with silt with some pockets of fine sand.

GENERAL

Date test started	09/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	49.9
Length	(mm)	19.2
Moisture content	(%)	31
Bulk density	(Mg/m ³)	1.97
Dry density	(Mg/m ³)	1.51
Voids ratio		0.810
Degree of saturation	(%)	100
Torvane	(kPa)	148
Pocket penetrometer	(kPa)	153

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 on request

Borehole	BH_14
Sample	15WaxA
Depth (m)	35.10
Test Number	DSS10

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST

Date: 16/05/2011

Drawn by: ALB

Template Issue: 2

Date: 16/05/2011

Checked by: PH

Filename: J11056 / DSS / BH 14 15WaxA DSS.XLS

Date:
Approved by:

CONSOLIDATION $\sigma_{vc(max)}$		
$\sigma_{vc(max)}$	(kPa)	2000
Vertical strain	(%)	16.79
Volumetric strain	(%)	16.79
Bulk density	(Mg/m ³)	2.16
Dry density	(Mg/m ³)	1.81

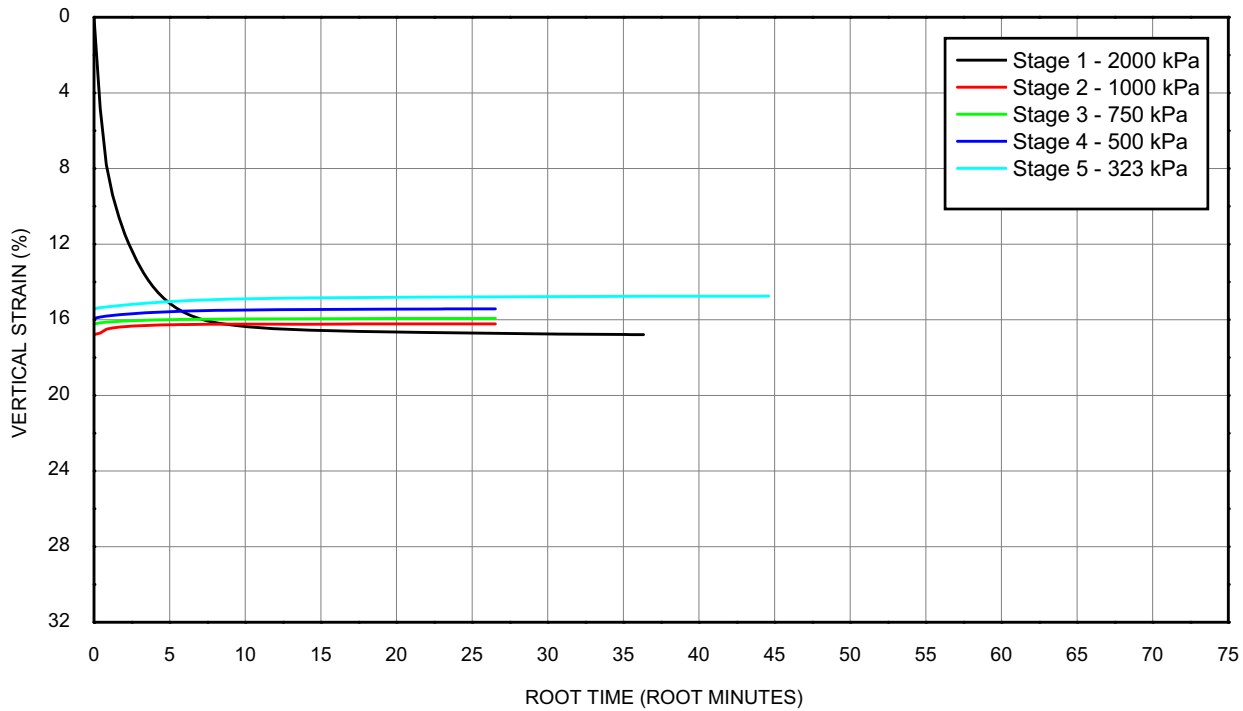
CONSOLIDATION σ_{vc}		
σ_{vc}	(kPa)	323
Vertical strain	(%)	14.75
Volumetric strain	(%)	14.75
Bulk density	(Mg/m ³)	2.14
Dry density	(Mg/m ³)	1.77

SHEARING		
At peak shear stress		
Shear stress	(kPa)	349
Shear strain	(%)	16.88
Change in pore pressure	(kPa)	-437
Rate of strain	(%/hr)	3.0
At 15 % shear strain		
Shear stress	(kPa)	346
Change in pore pressure	(kPa)	-395



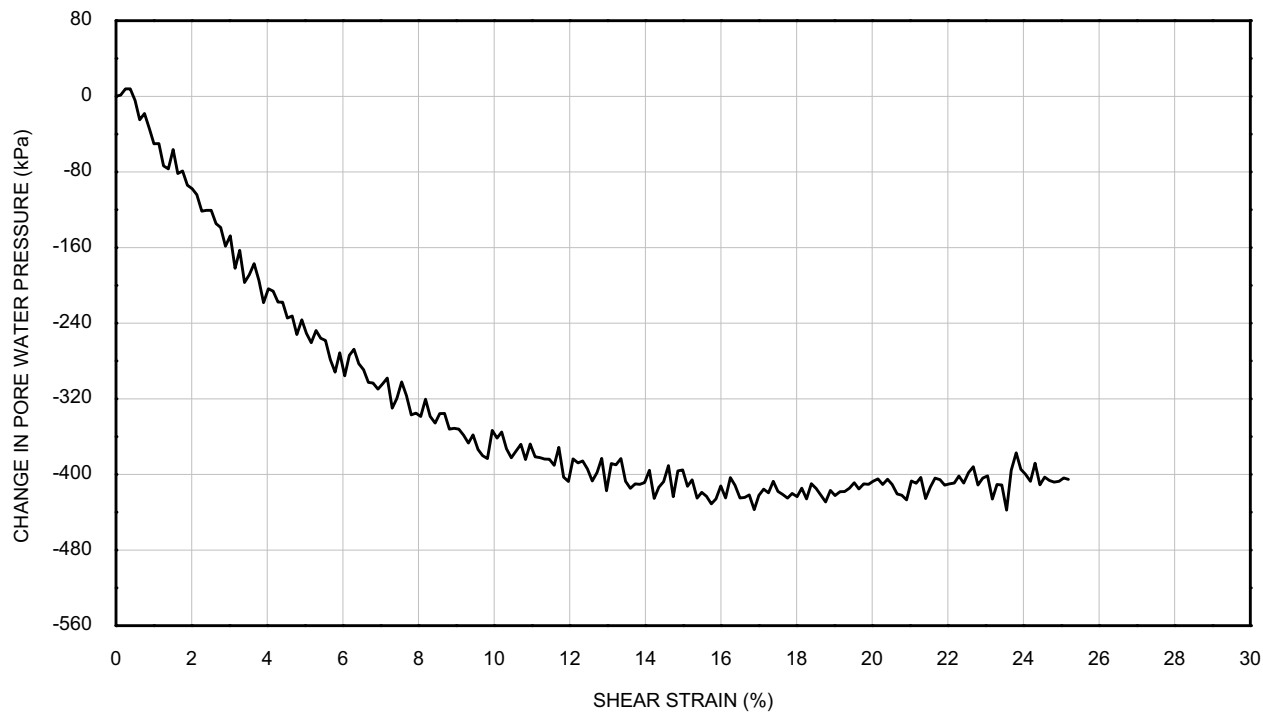
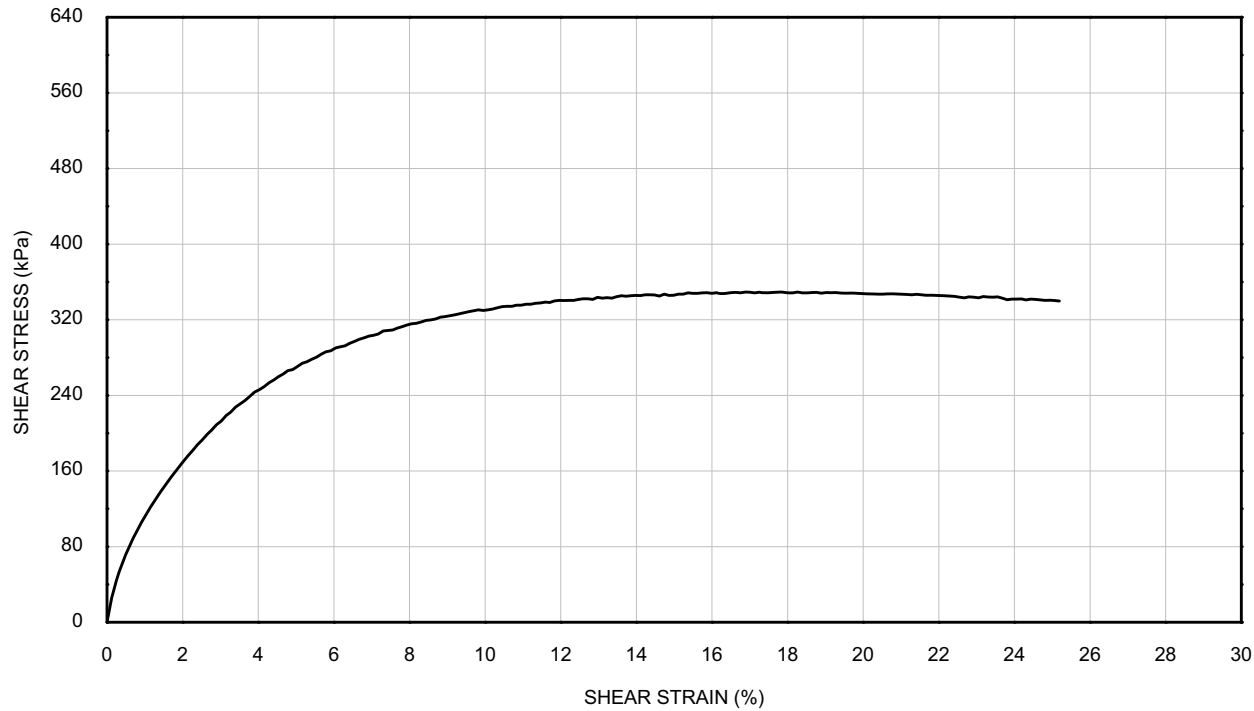
Borehole	BH_14
Sample	15WaxA
Depth (m)	35.10
Test Number	DSS10

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 15WaxA
$\sigma_{vc'}$	: 323 kPa	Depth (m)	: 35.10
Shearing Parameters		Test No	: DSS10
Rate of Strain	: 3 %/Hour		

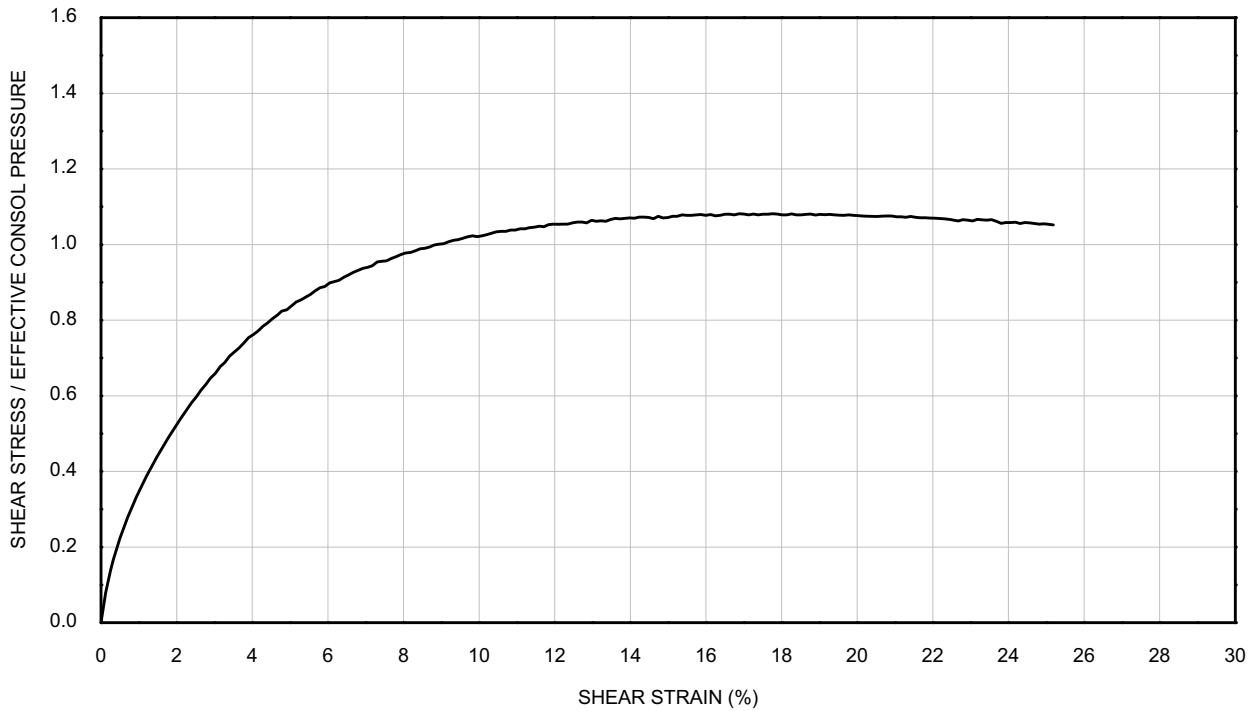
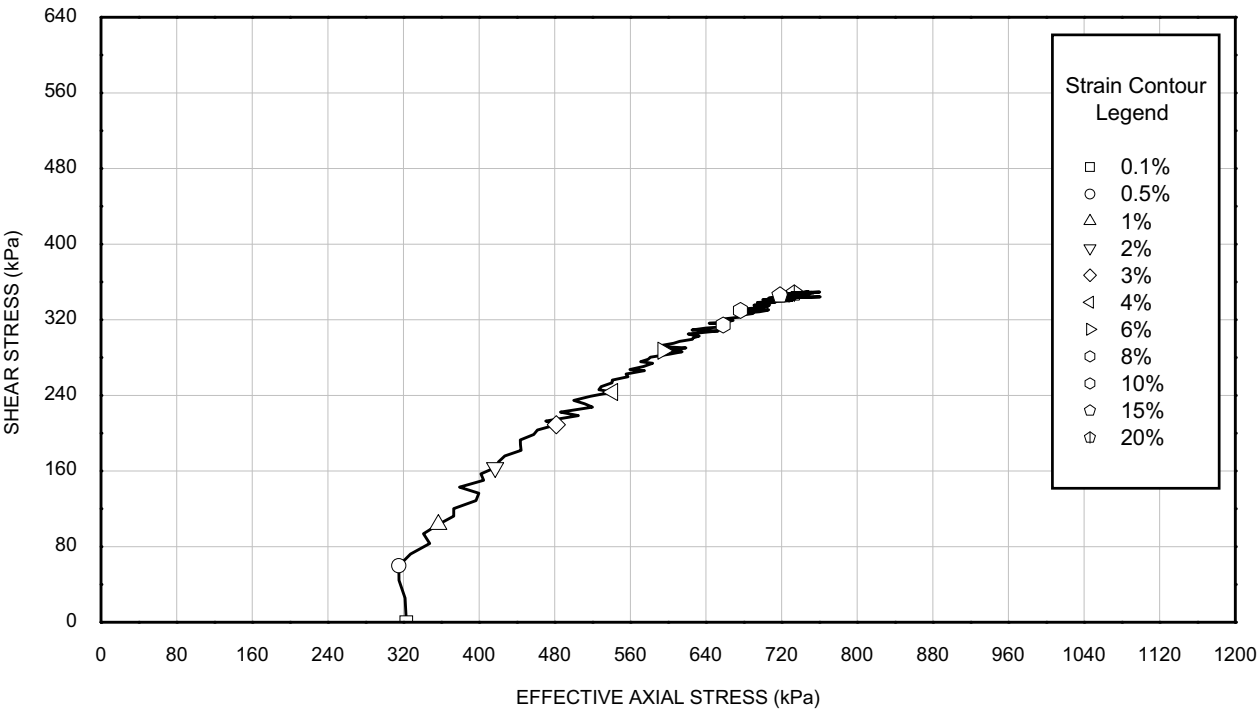
CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc} (max)'$	: 2000 kPa	Sample	: 15WaxA
σ_{vc}'	: 323 kPa	Depth (m)	: 35.10
Shearing Parameters		Test No	: DSS10
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Drawn by: ALB
Date: 16/05/2011
Template Issue: 2
Filename: J11056 \ BH_14_15WaxA_DSS.OPJ
Date: 16/05/2011
Date:
Checked by: PH
Approved by:



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 15WaxA
$\sigma_{vc'}$	: 323 kPa	Depth (m)	: 35.10
Shearing Parameters		Test No	: DSS10
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Drawn by: ALB Date: 16/05/2011

Template Issue: 2

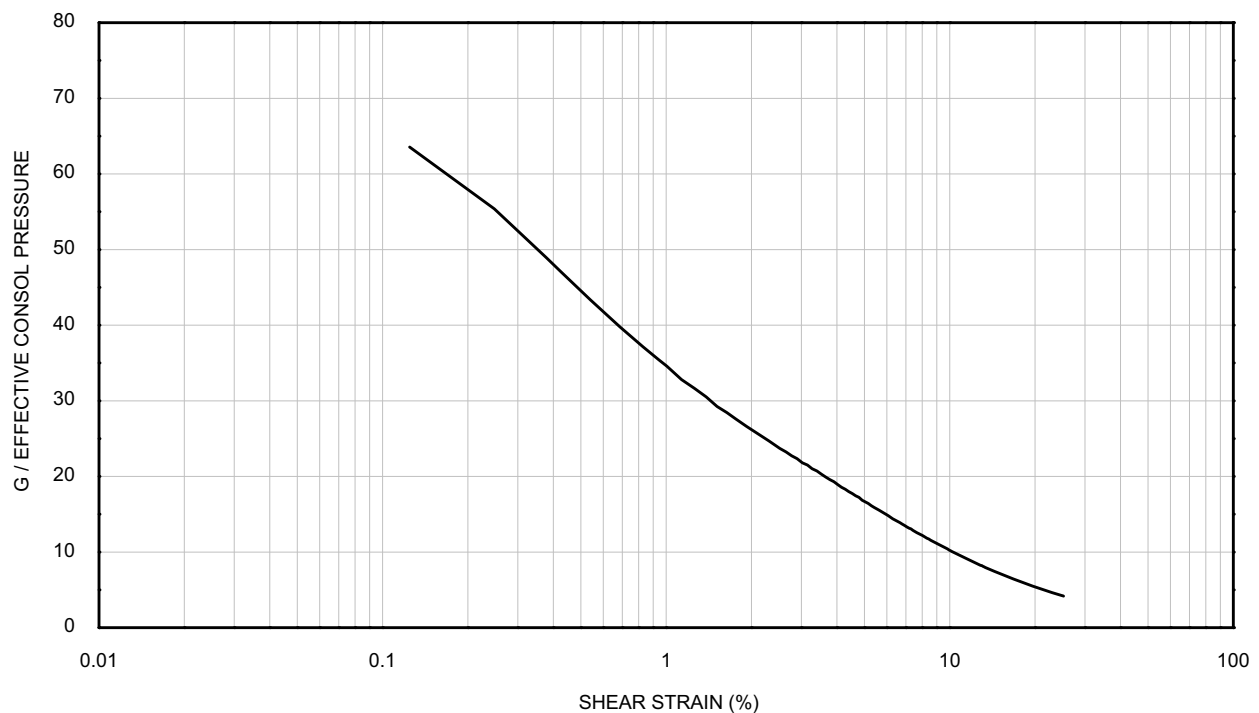
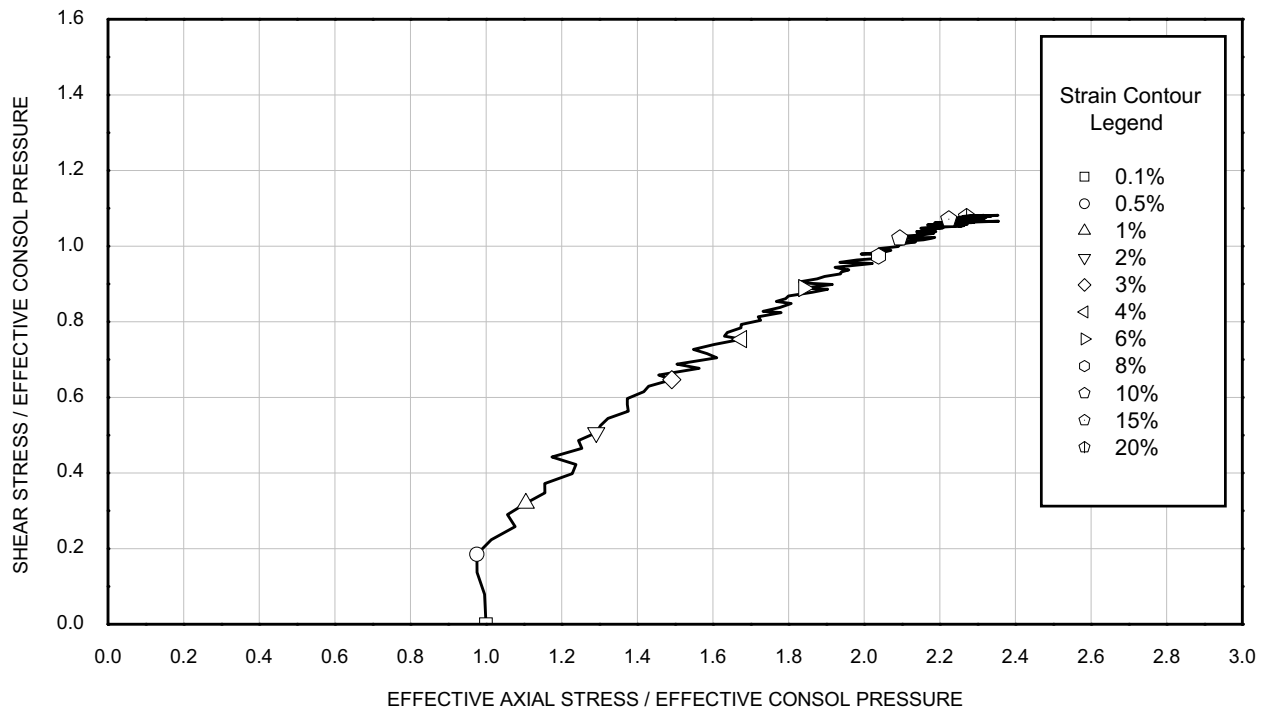
Filename: J11056 \ BH_14_15WaxA_DSS.OPJ

Date: 16/05/2011

Date:

Checked by: PH

Approved by:



Consolidation Stresses		Borehole	: BH_14
$\sigma_{vc(max)'} :$	2000 kPa	Sample	: 15WaxA
$\sigma_{vc}' :$	323 kPa	Depth (m)	: 35.10
Shearing Parameters		Test No	: DSS10
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST SHEAR STAGE



Date: 19/05/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / DSS / BH 02 2WaxA DSS.XLS

VISUAL DESCRIPTION

Hard dark greenish grey CLAY with pockets of silt and fine sand.

GENERAL

Date test started	13/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	49.9
Length	(mm)	19.3
Moisture content	(%)	26
Bulk density	(Mg/m ³)	1.99
Dry density	(Mg/m ³)	1.58
Voids ratio		0.726
Degree of saturation	(%)	97
Torvane	(kPa)	80
Pocket penetrometer	(kPa)	300

Date: 25/05/2011

Checked by: PH

Date:
Approved by:

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 on request

Borehole	BH_02
Sample	2WaxB
Depth (m)	7.50
Test Number	DSS01

**SUMMARY OF
CONSOLIDATED CONSTANT VOLUME DSS TEST**

Date: 19/05/2011

Drawn by: ALB

Template Issue: 2

Date: 25/05/2011

Checked by: PH

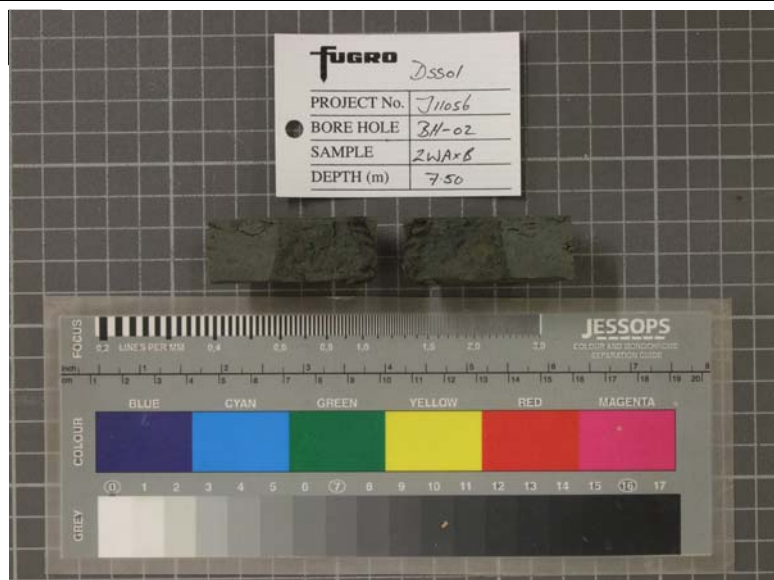
Filename: J11056 / DSS / BH 02 2WaxA DSS.XLS

Date:
Approved by:

CONSOLIDATION $\sigma_{vc(max)'$		
$\sigma_{vc(max)'$	(kPa)	2000
Vertical strain	(%)	7.98
Volumetric strain	(%)	7.98
Bulk density	(Mg/m ³)	2.07
Dry density	(Mg/m ³)	1.72

CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	54
Vertical strain	(%)	1.85
Volumetric strain	(%)	1.85
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.61

SHEARING		
At peak shear stress		
Shear stress	(kPa)	152
Shear strain	(%)	15.98
Change in pore pressure	(kPa)	-197
Rate of strain	(%/hr)	3.0
At 15 % shear strain		
Shear stress	(kPa)	151
Change in pore pressure	(kPa)	-182



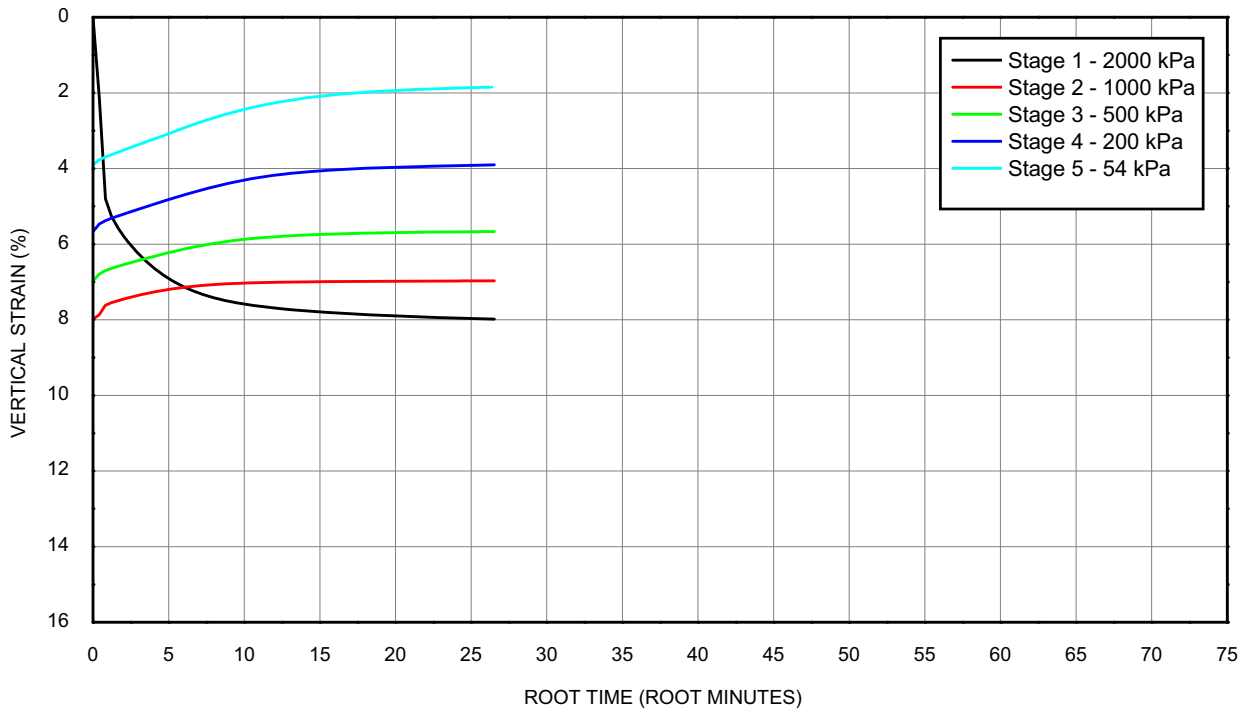
Borehole	BH_02
Sample	2WaxB
Depth (m)	7.50
Test Number	DSS01

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



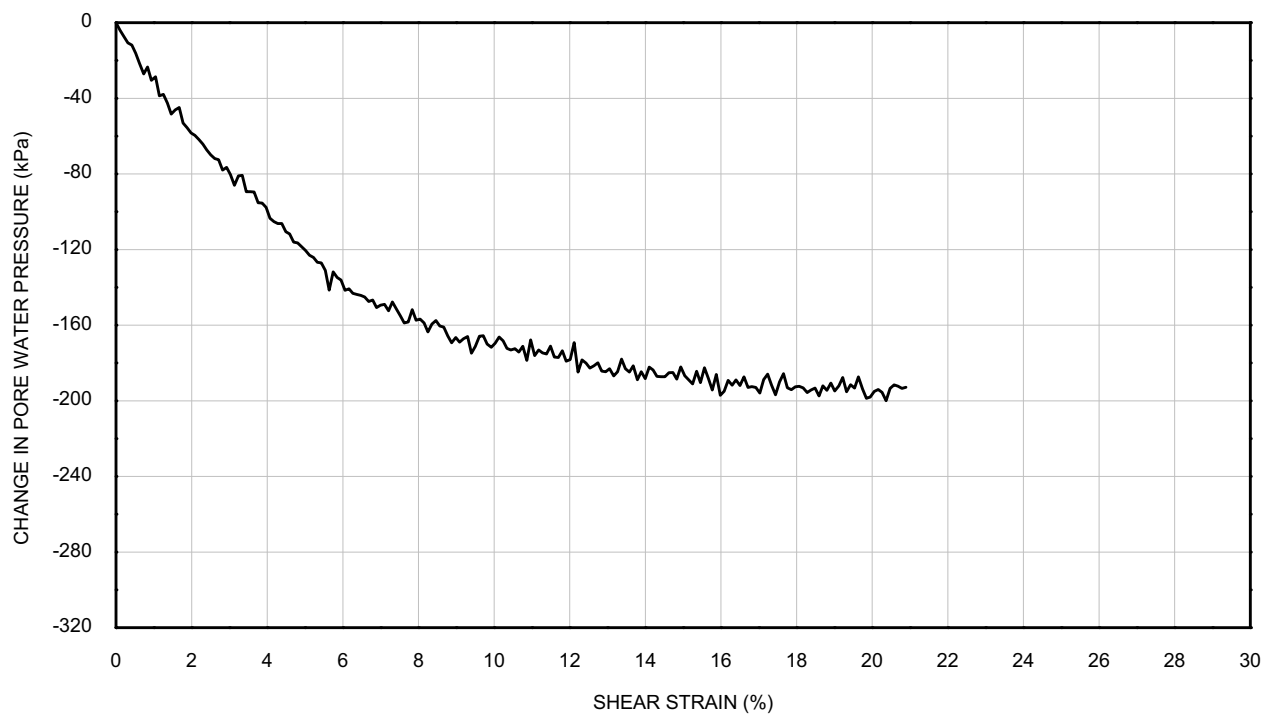
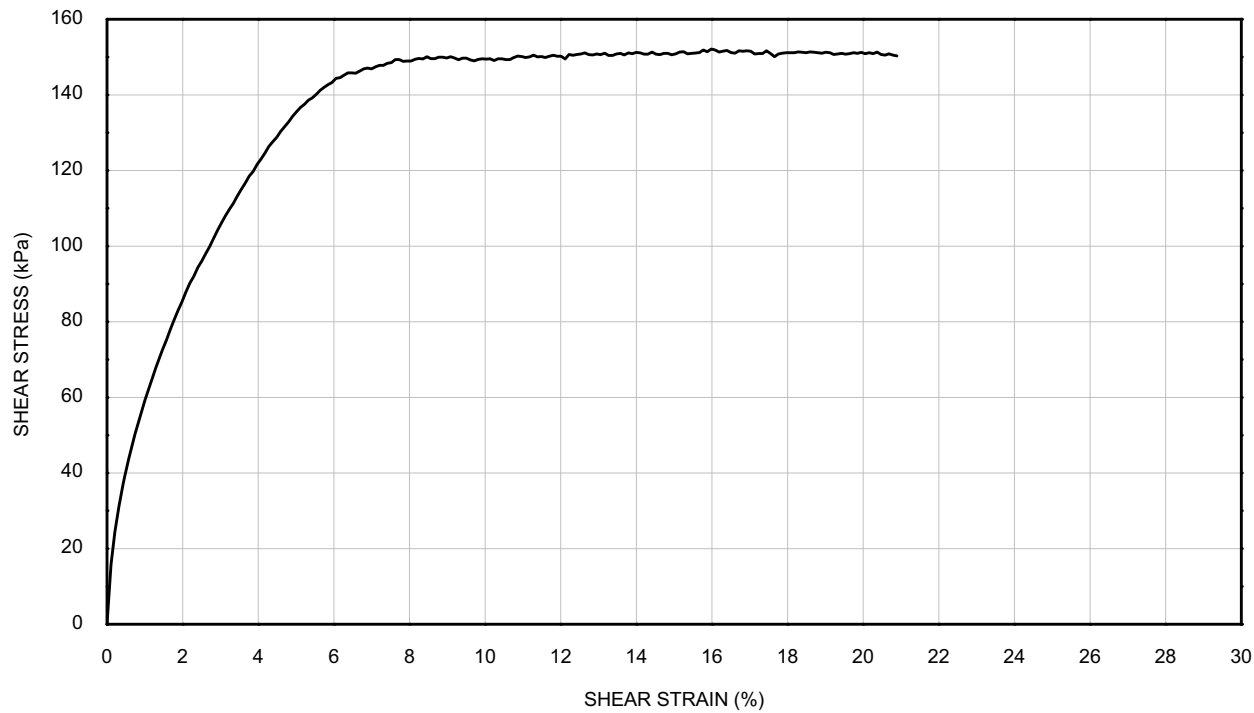
Template Issue: 2
Date: 19/05/2011
Drawn by: ALB
Filename: J11056 \ BH_02_2WaxA_DSS.OPJ

Checked by: PH
Approved by:
Date: 25/05/2011
Date:



Consolidation Stresses		Borehole	: BH_02
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 2WaxB
$\sigma_{vc'}$	: 54 kPa	Depth (m)	: 7.50
Shearing Parameters		Test No	: DSS01
Rate of Strain	: 3 %/Hour		

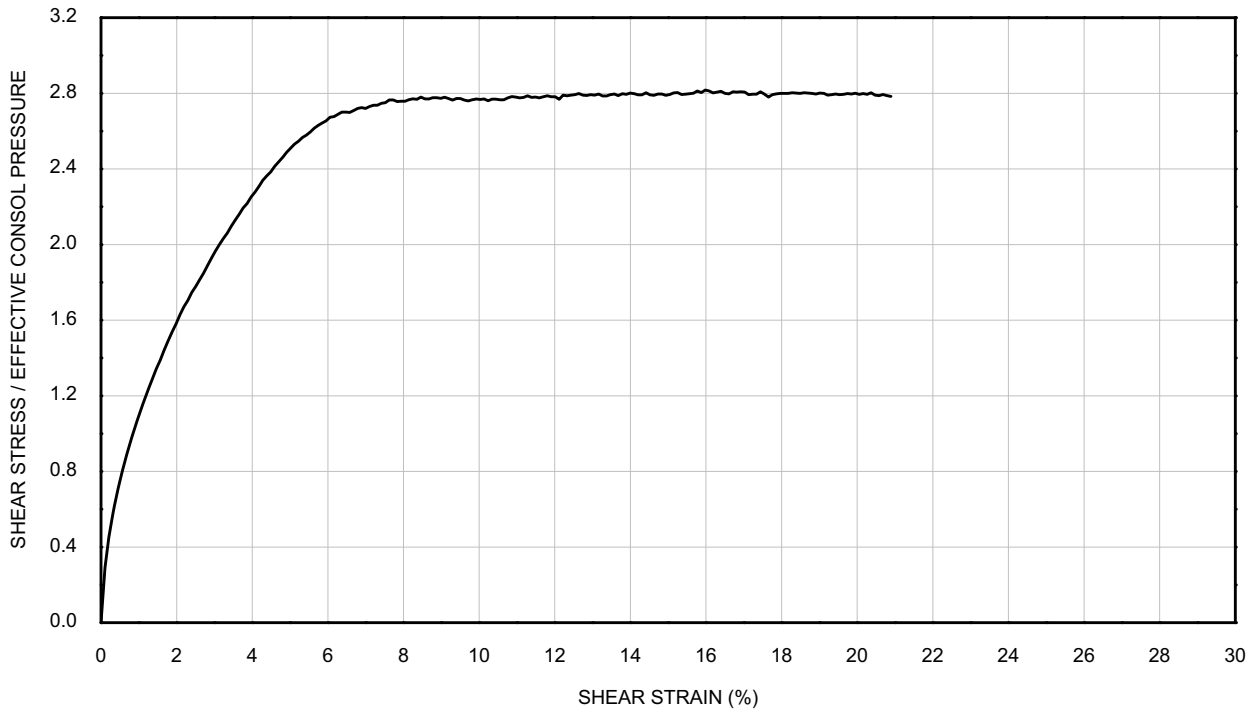
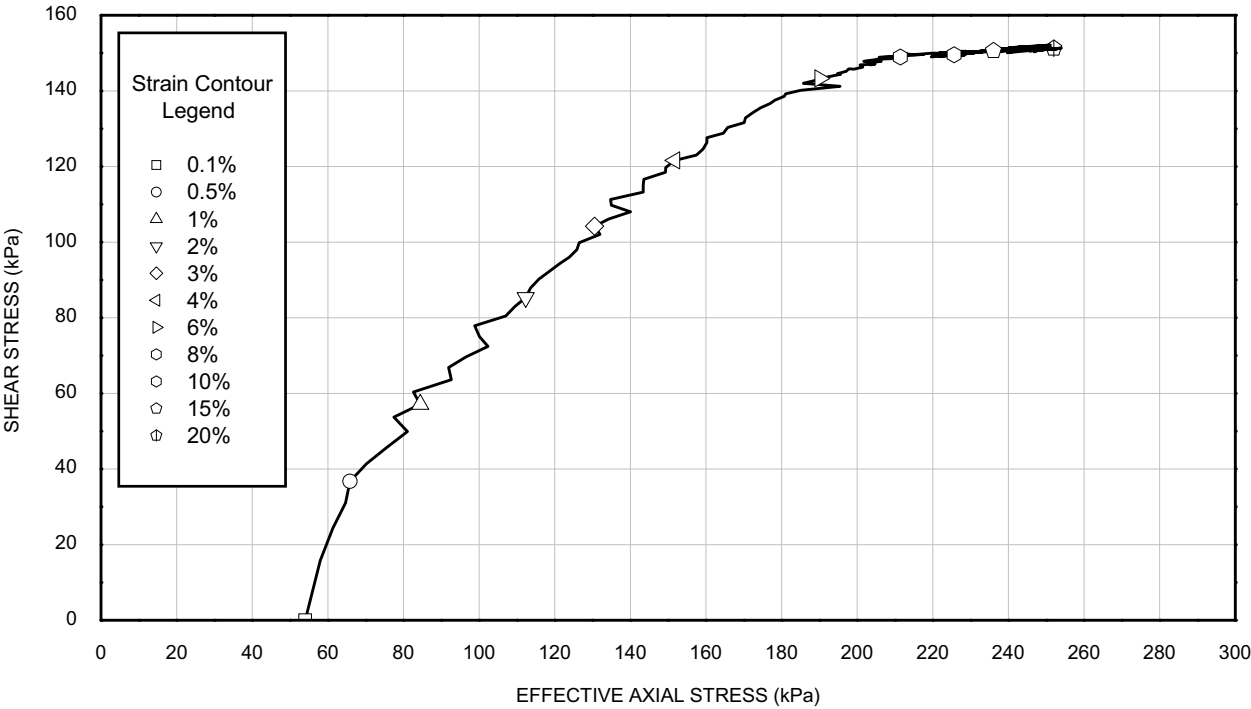
CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_02
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 2WaxB
$\sigma_{vc'}$	: 54 kPa	Depth (m)	: 7.50
Shearing Parameters		Test No	: DSS01
Rate of Strain	: 3 %/Hour		

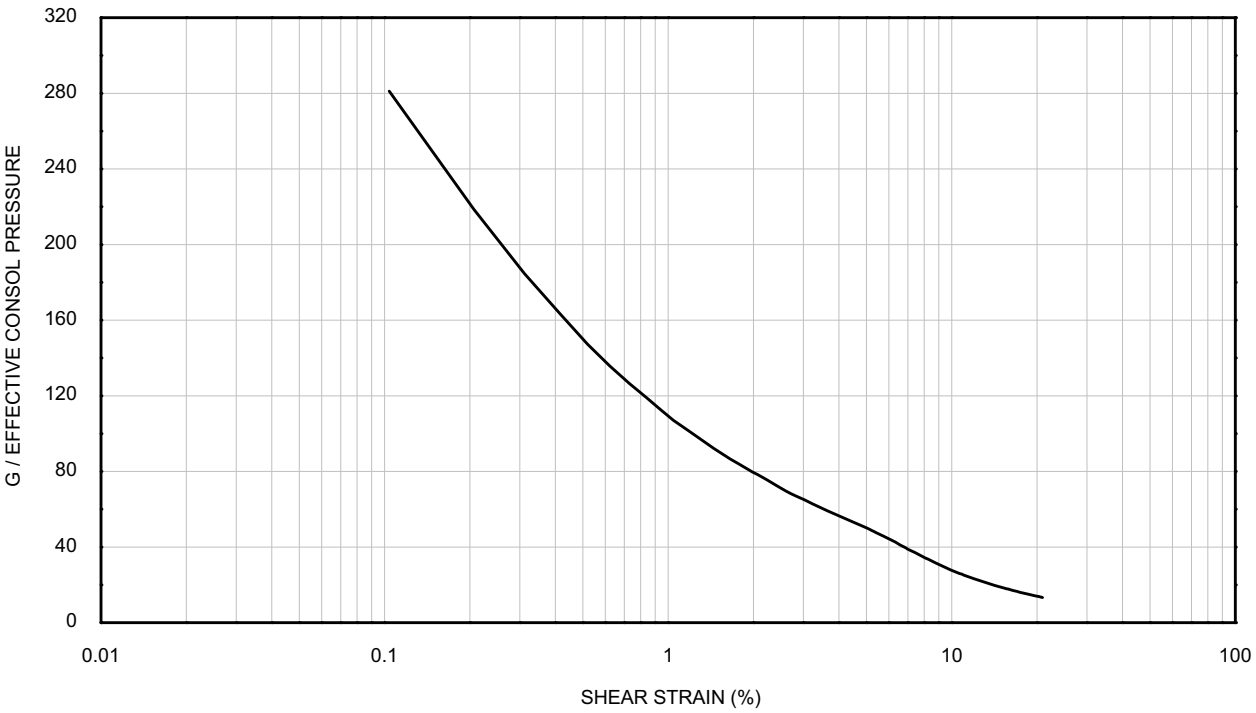
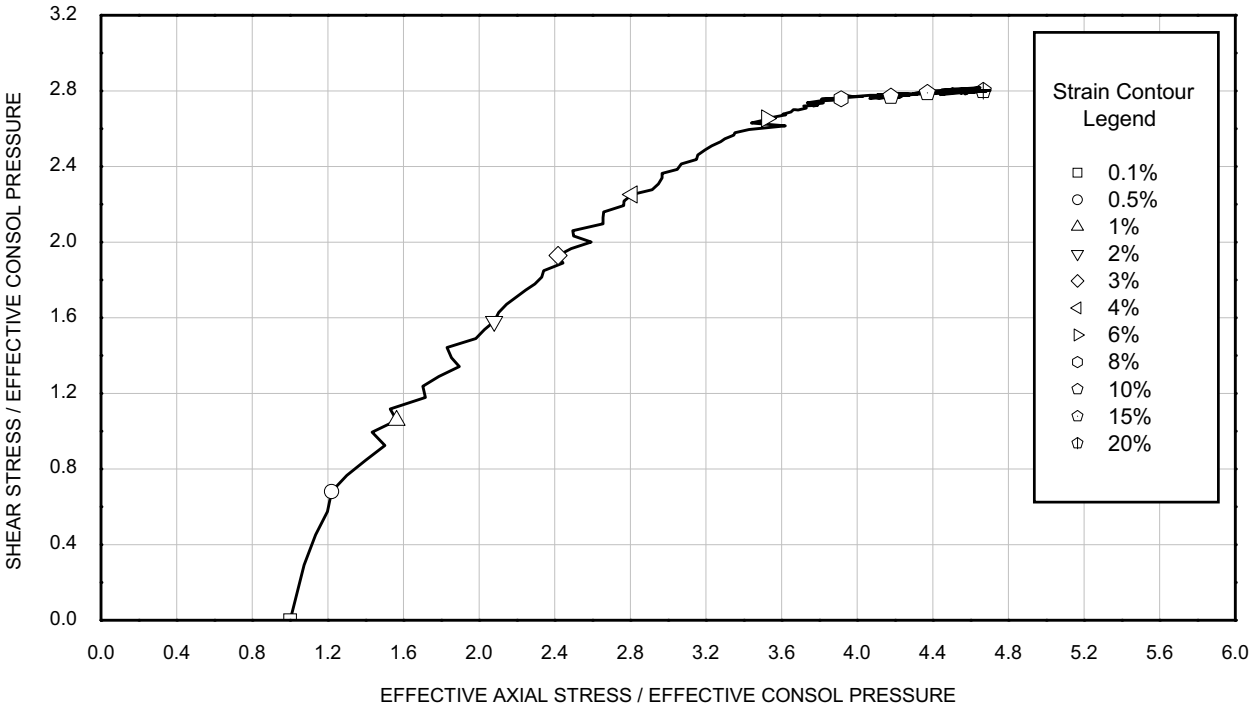
CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Drawn by: ALB
Date: 19/05/2011
Template Issue: 2
Filename: J11056 \ BH_02_2WaxA_DSS.OPJ
Date: 25/05/2011
Date:
Checked by: PH
Approved by:



Consolidation Stresses		Borehole	: BH_02
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 2WaxB
$\sigma_{vc'}$	: 54 kPa	Depth (m)	: 7.50
Shearing Parameters		Test No	: DSS01
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses		Borehole	: BH_02
$\sigma_{vc(max)'} :$	2000 kPa	Sample	: 2WaxB
$\sigma_{vc}' :$	54 kPa	Depth (m)	: 7.50
Shearing Parameters		Test No	: DSS01
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Date: 20/05/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / DSS / BH 06 1WaxA DSS.XLS

VISUAL DESCRIPTION

Stiff dark grey CLAY with traces of black staining.

GENERAL

Date test started	16/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	49.9
Length	(mm)	19.2
Moisture content	(%)	28
Bulk density	(Mg/m ³)	1.99
Dry density	(Mg/m ³)	1.55
Voids ratio		0.743
Degree of saturation	(%)	100
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	100

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 on request

Borehole	BH_06
Sample	1WaxA
Depth (m)	3.15
Test Number	DSS02

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST

Date: 20/05/2011

Drawn by: ALB

Template Issue: 2

Date: 24/05/2011

Checked by: PH

Filename: J11056 / DSS / BH 06 1WaxA DSS.XLS

Date:
Approved by:

CONSOLIDATION $\sigma_{vc(max)}$		
$\sigma_{vc(max)}$	(kPa)	764
Vertical strain	(%)	9.12
Volumetric strain	(%)	9.12
Bulk density	(Mg/m ³)	2.09
Dry density	(Mg/m ³)	1.70

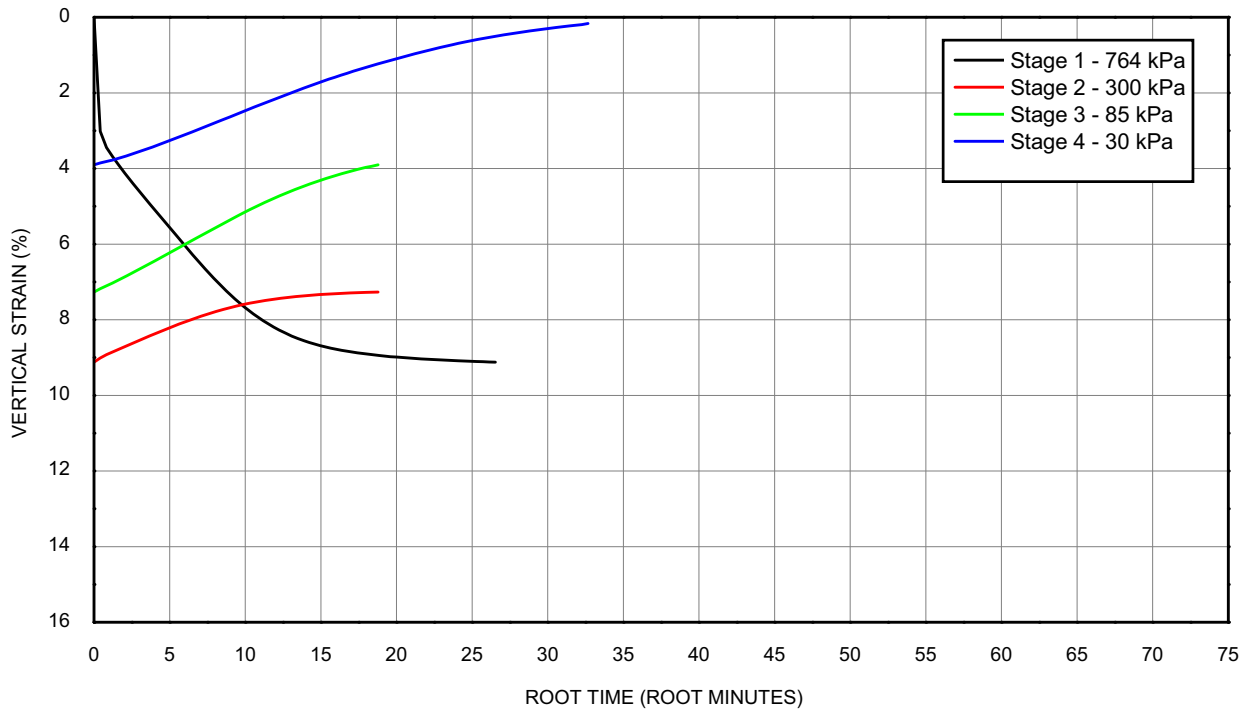
CONSOLIDATION σ_{vc}		
σ_{vc}	(kPa)	30
Vertical strain	(%)	0.16
Volumetric strain	(%)	0.16
Bulk density	(Mg/m ³)	1.99
Dry density	(Mg/m ³)	1.55

SHEARING		
At peak shear stress		
Shear stress	(kPa)	40
Shear strain	(%)	6.96
Change in pore pressure	(kPa)	-42
Rate of strain	(%/hr)	3.0
At 15 % shear strain		
Shear stress	(kPa)	35
Change in pore pressure	(kPa)	-39



Borehole	BH_06
Sample	1WaxA
Depth (m)	3.15
Test Number	DSS02

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc(max)}$	: 764 kPa	Sample	: 1WaxA
$\sigma_{vc'}$	: 30 kPa	Depth (m)	: 3.15
Shearing Parameters		Test No	: DSS02
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Drawn by: ALB
Date: 20/05/2011

Template Issue: 2

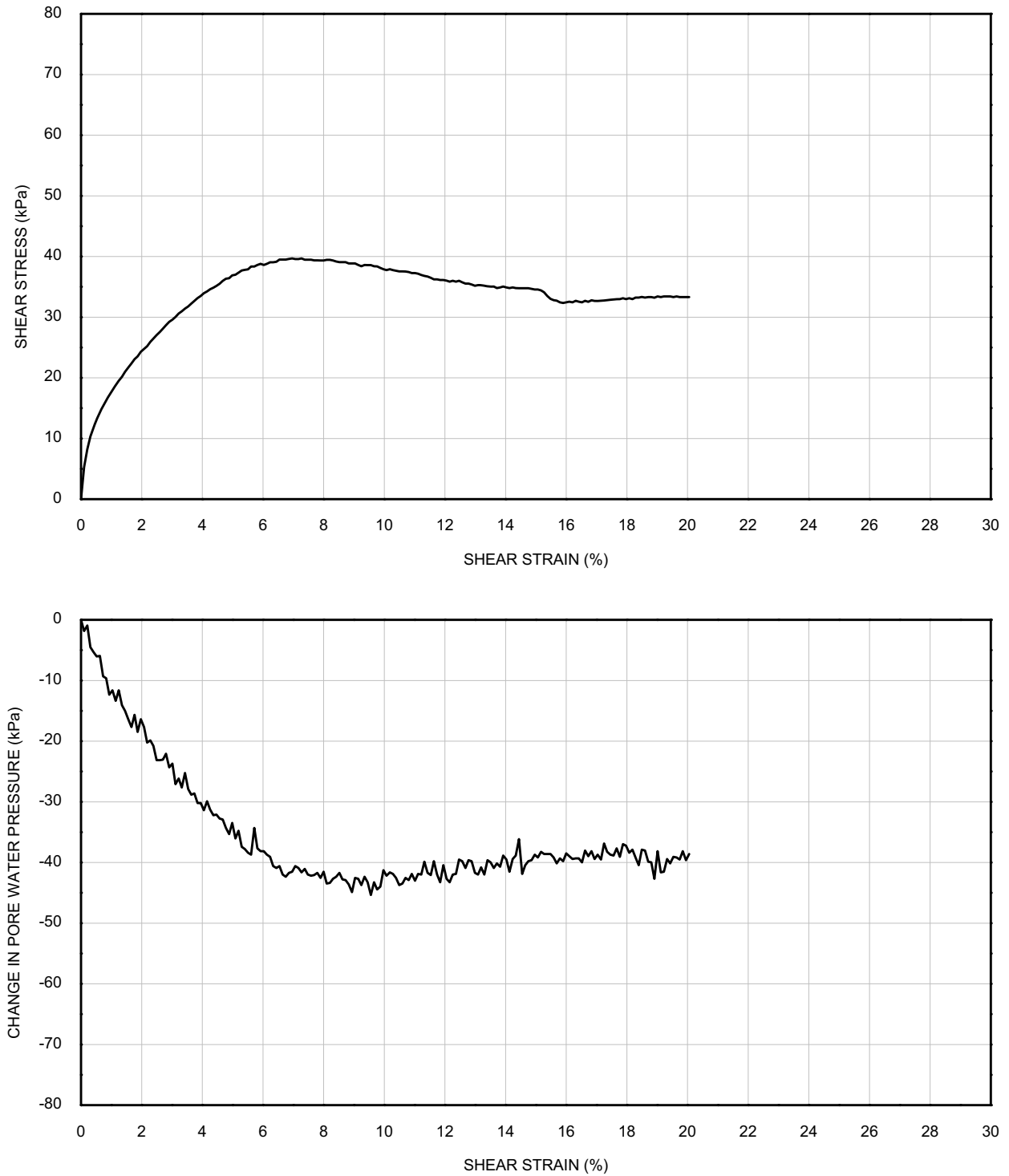
Date: 24/05/2011

Checked by: PH

Filename: J11056 \ BH_06_1WaxA_DSS.OPJ

Date:

Approved by:



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc (max) '}$	: 764 kPa	Sample	: 1WaxA
$\sigma_{vc '}$	: 30 kPa	Depth (m)	: 3.15
Shearing Parameters		Test No	: DSS02
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Drawn by: ALB Date: 20/05/2011

Template Issue: 2

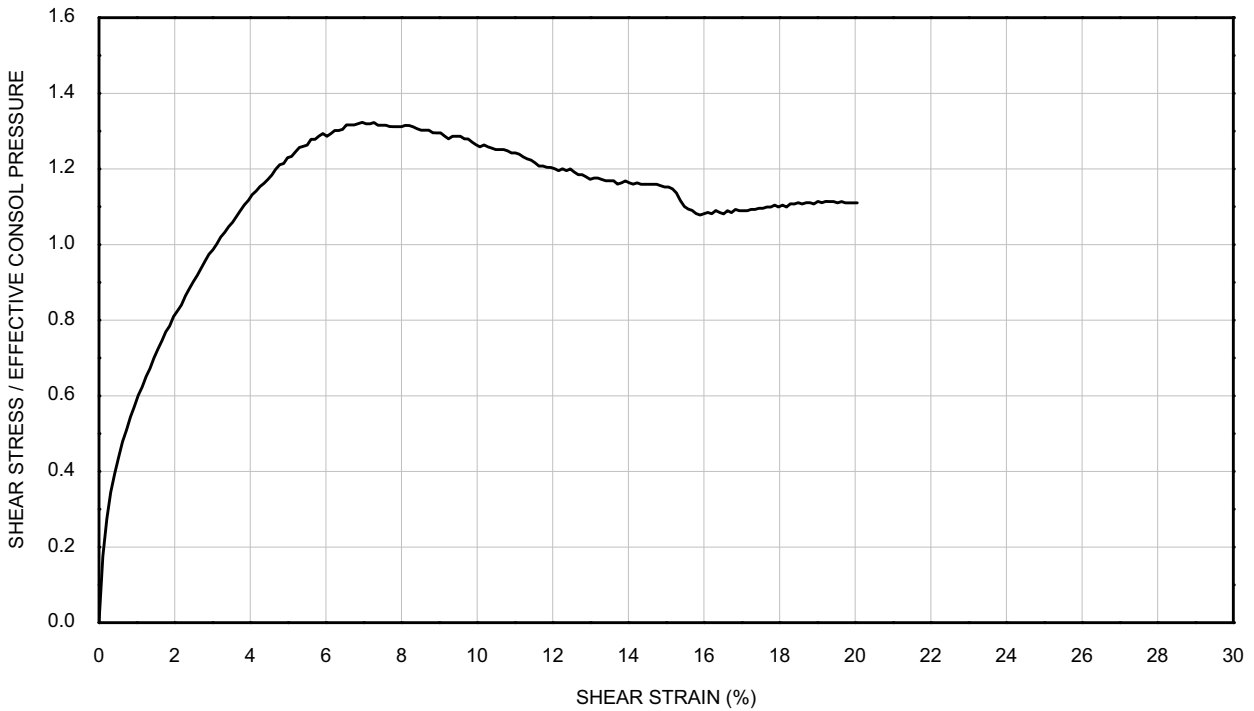
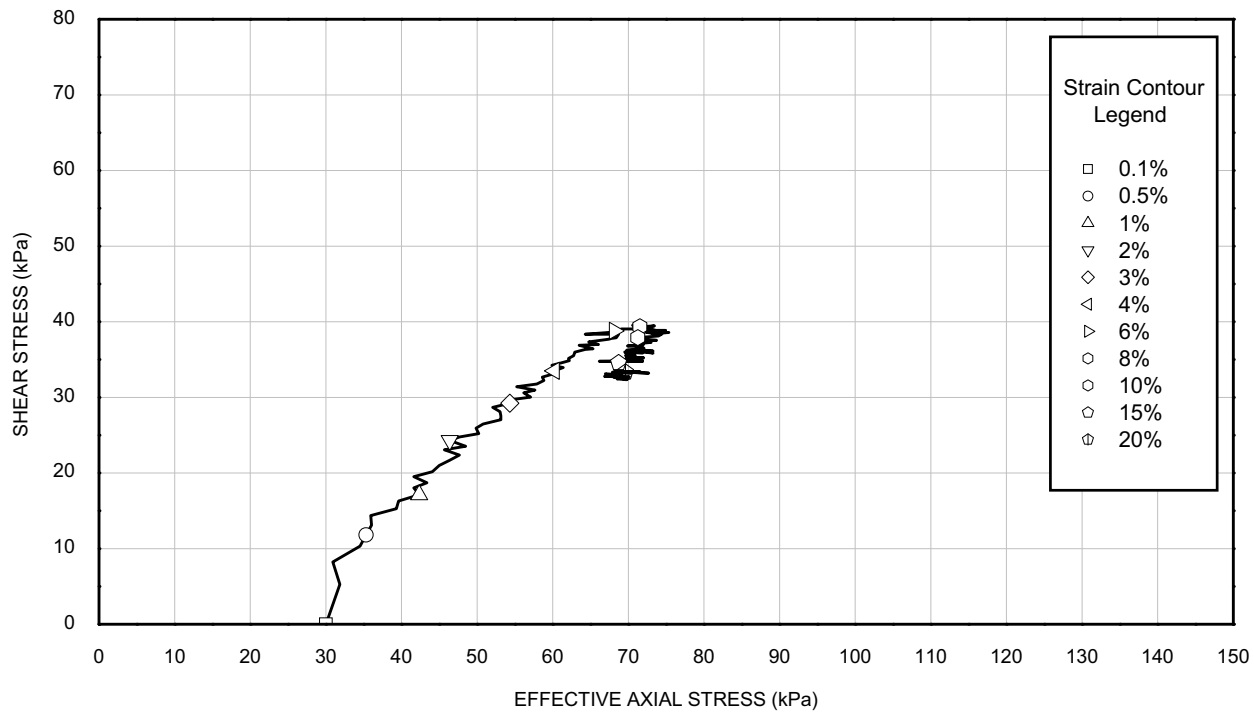
Date: 24/05/2011

Checked by: PH

Filename: J11056 \ BH_06_1WaxA_DSS.OPJ

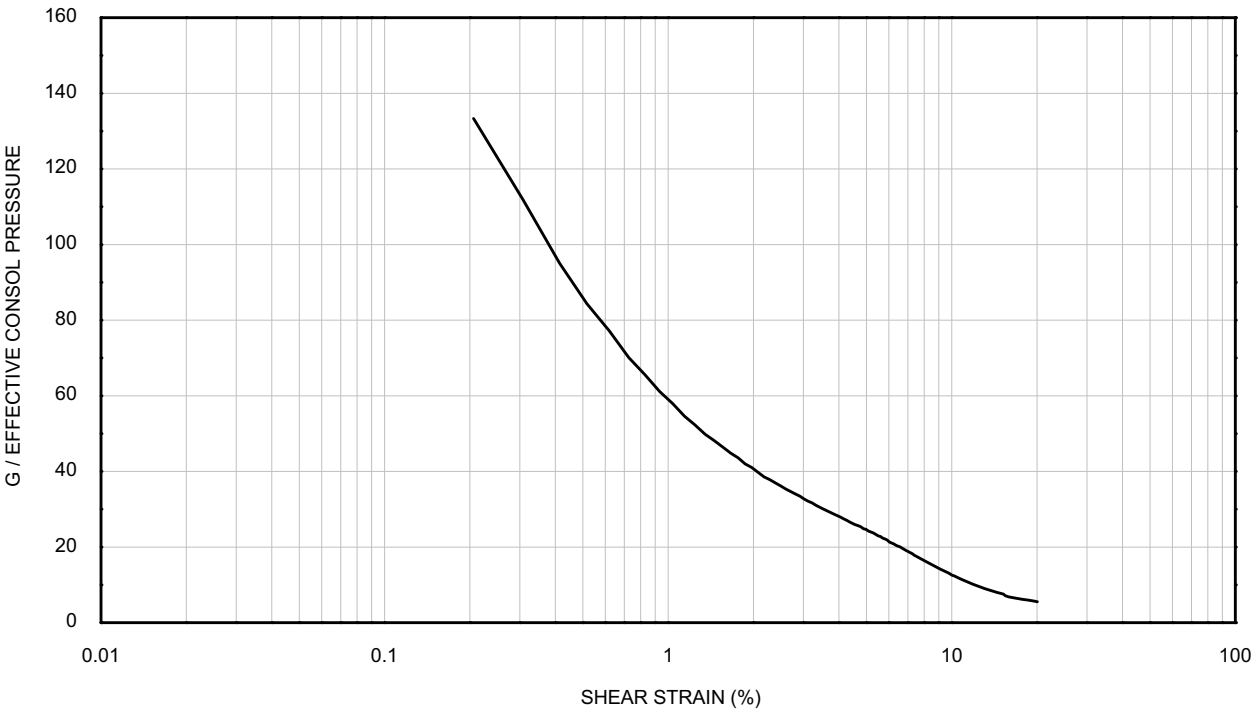
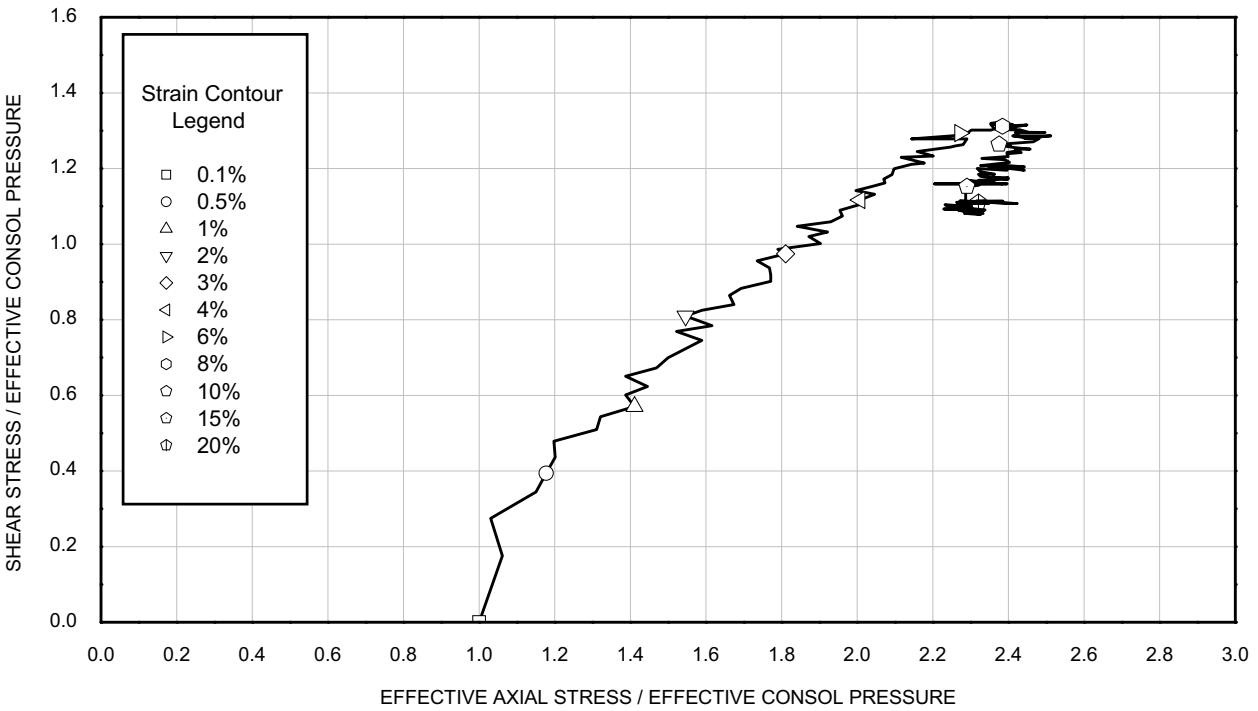
Date:

Approved by:



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc(max)}$	: 764 kPa	Sample	: 1WaxA
$\sigma_{vc'}$	: 30 kPa	Depth (m)	: 3.15
Shearing Parameters		Test No	: DSS02
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc(max)'} :$	764 kPa	Sample	: 1WaxA
$\sigma_{vc}' :$	30 kPa	Depth (m)	: 3.15
Shearing Parameters		Test No	: DSS02
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Drawn by: ALB Date: 20/05/2011
Template Issue: 2
Filename: J11056 \ BH_06_1WaxA_DSS.OPJ
Date: 24/05/2011
Date:
Checked by: PH
Approved by:



Date: 17/05/2011

Drawn by: ALB

Template Issue: 2

Filename: J11056 / DSS / BH 06 9WaxA DSS.XLS

VISUAL DESCRIPTION

Hard very dark grey CLAY with small pockets of fine sand.

GENERAL

Date test started	13/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	49.9
Length	(mm)	19.2
Moisture content	(%)	21
Bulk density	(Mg/m ³)	2.23
Dry density	(Mg/m ³)	1.84
Voids ratio		0.466
Degree of saturation	(%)	100
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	500

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 on request

Borehole	BH_06
Sample	9WaxA
Depth (m)	18.00
Test Number	DSS03

**SUMMARY OF
CONSOLIDATED CONSTANT VOLUME DSS TEST**

Date: 17/05/2011

Drawn by: ALB

Template Issue: 2

Date: 24/05/2011

Checked by: PH

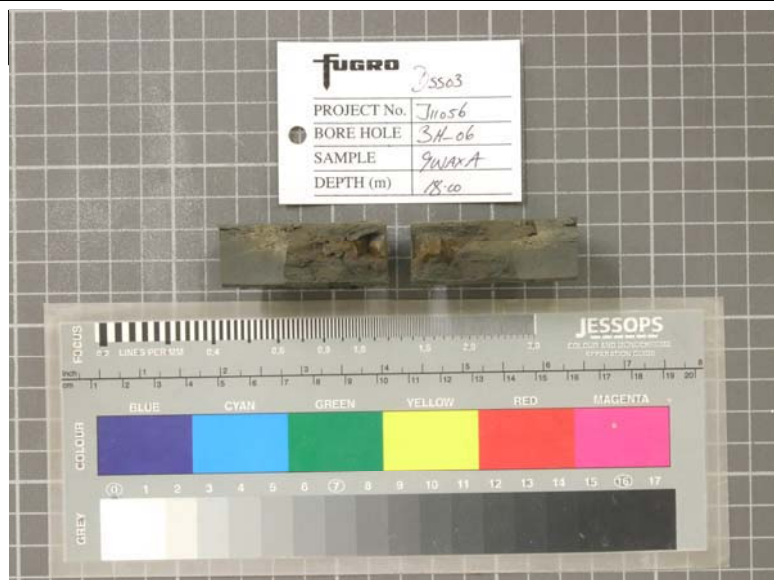
Filename: J11056 / DSS / BH 06 9WaxA DSS.XLS

Date:
Approved by:

CONSOLIDATION $\sigma_{vc(max)'$		
$\sigma_{vc(max)'$	(kPa)	2000
Vertical strain	(%)	9.43
Volumetric strain	(%)	9.43
Bulk density	(Mg/m ³)	2.36
Dry density	(Mg/m ³)	2.03

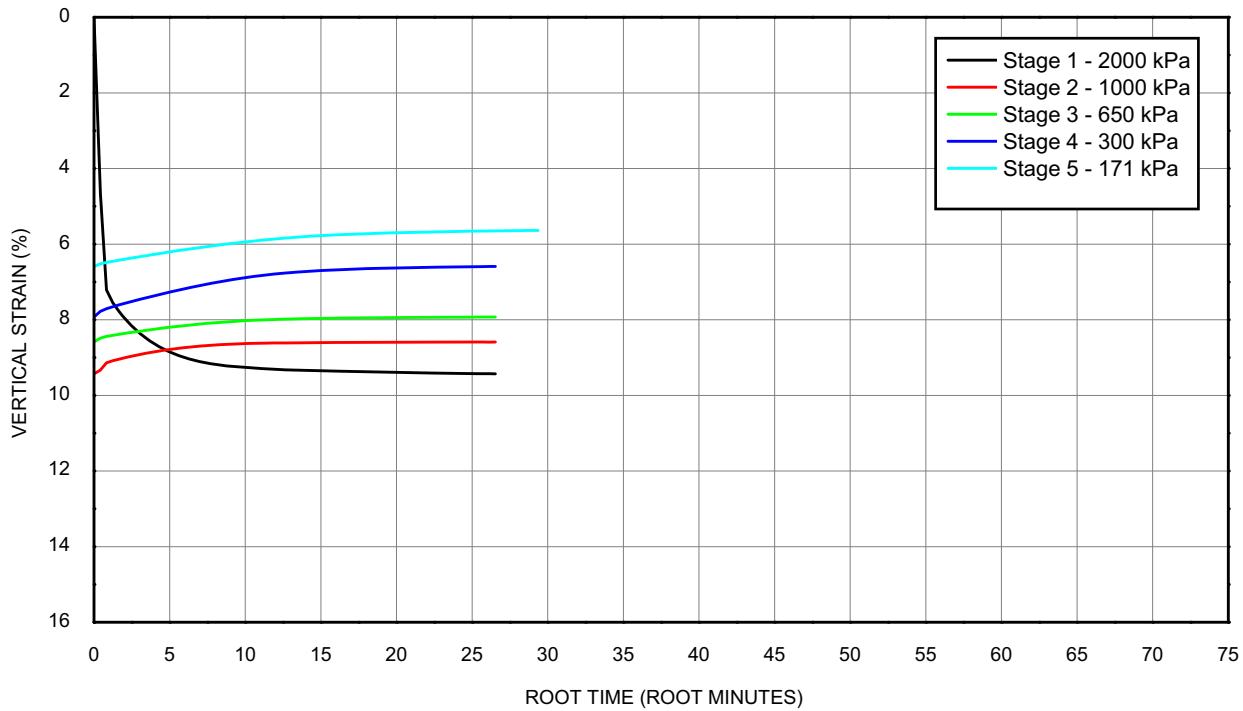
CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	171
Vertical strain	(%)	5.64
Volumetric strain	(%)	5.64
Bulk density	(Mg/m ³)	2.30
Dry density	(Mg/m ³)	1.95

SHEARING		
At peak shear stress		
Shear stress	(kPa)	152
Shear strain	(%)	6.56
Change in pore pressure	(kPa)	-146
Rate of strain	(%/hr)	3.0
At 15 % shear strain		
Shear stress	(kPa)	137
Change in pore pressure	(kPa)	-156



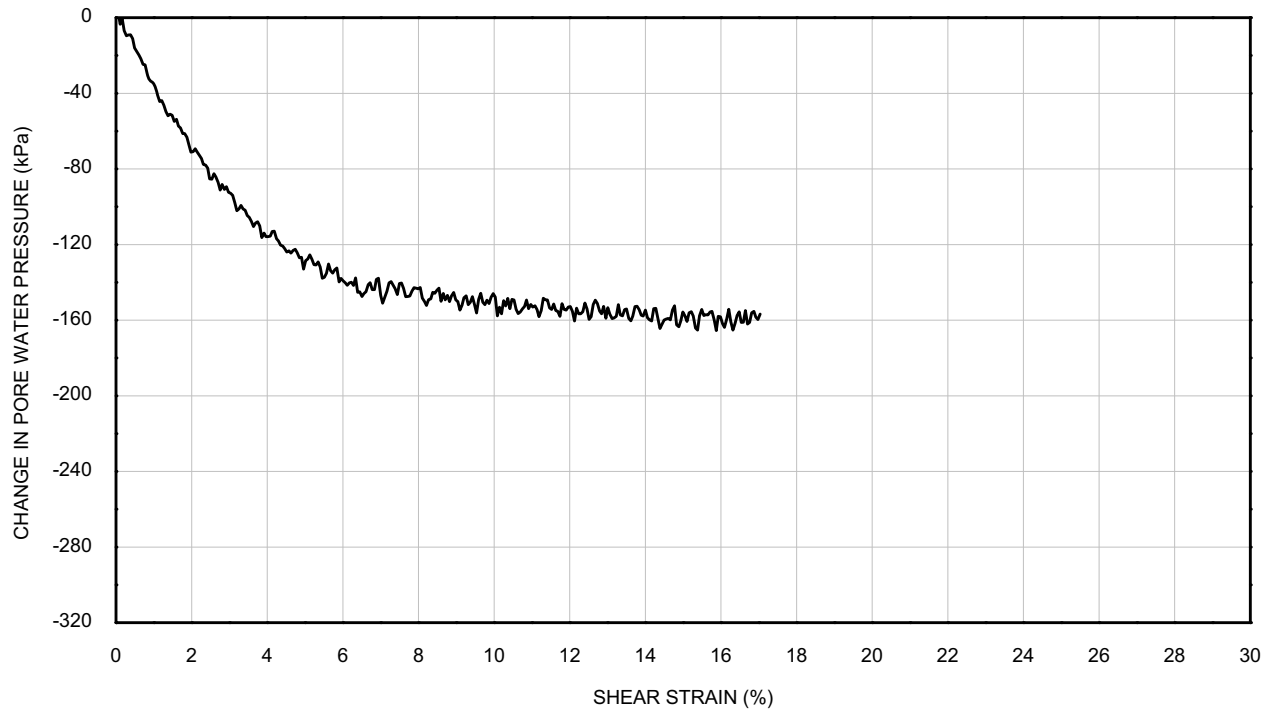
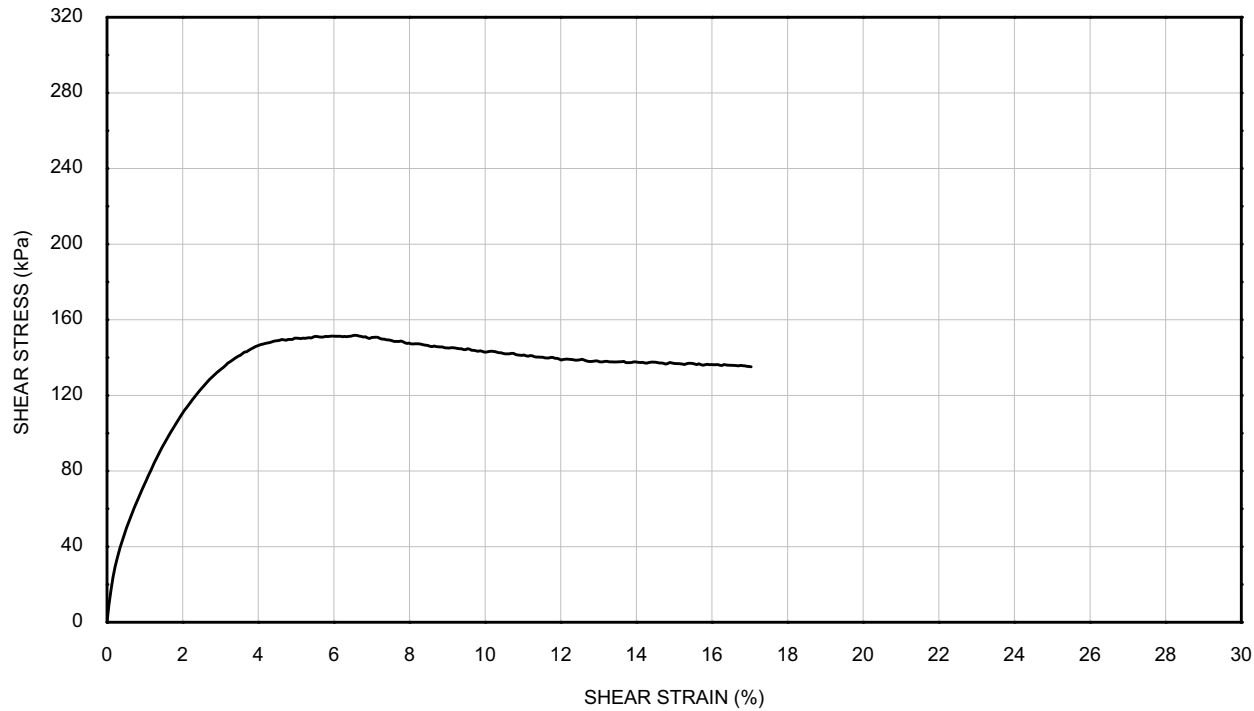
Borehole	BH_06
Sample	9WaxA
Depth (m)	18.00
Test Number	DSS03

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc(max)}$	: 2000 kPa	Sample	: 9WaxA
$\sigma_{vc'}$	: 171 kPa	Depth (m)	: 18.00
Shearing Parameters		Test No	: DSS03
Rate of Strain	: 3 %/Hour		

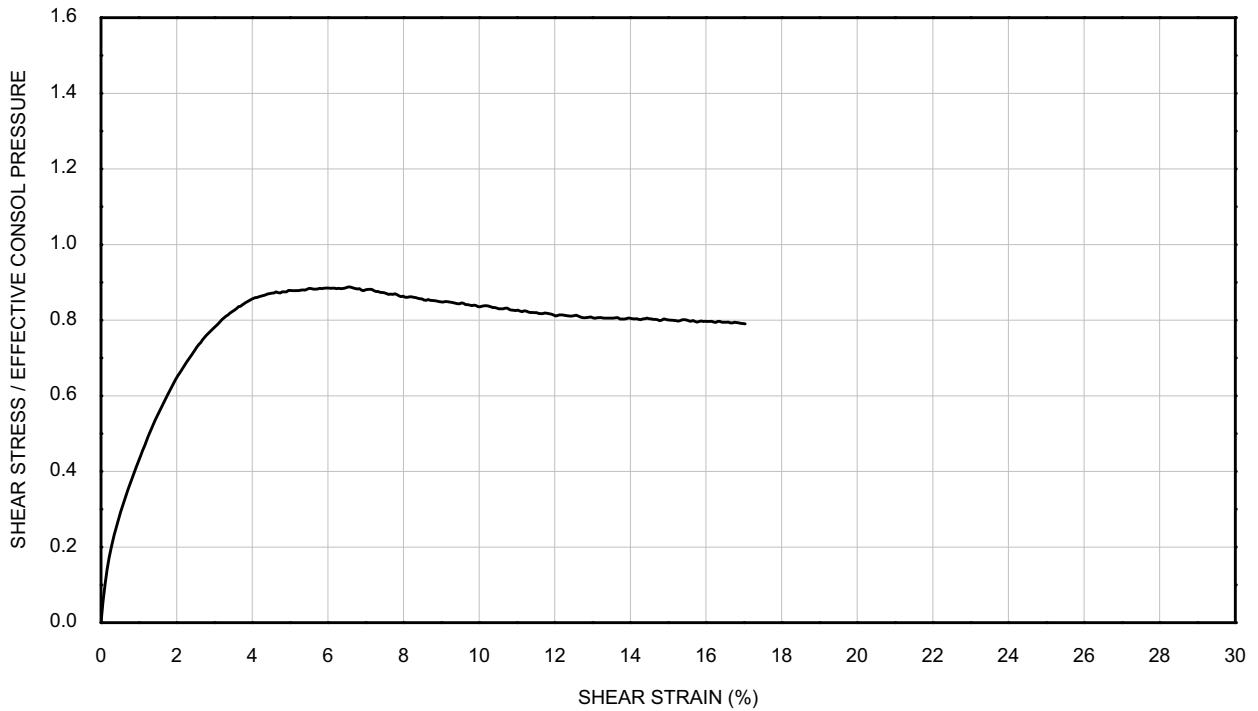
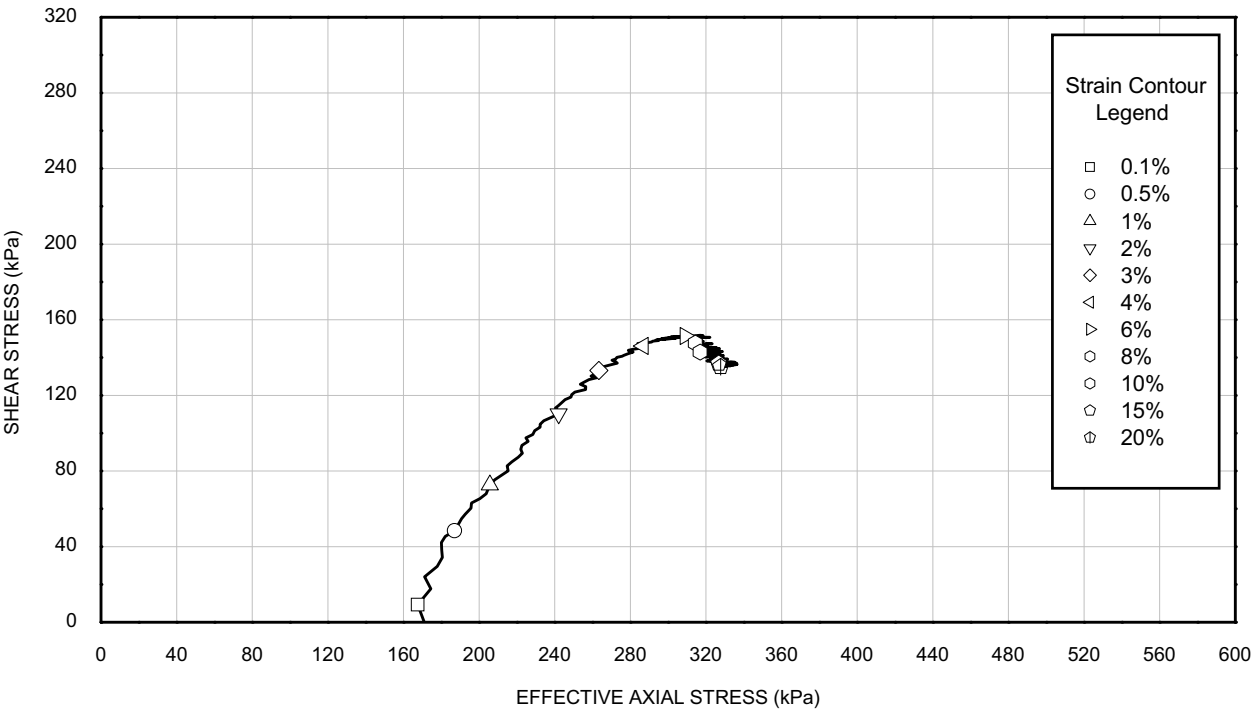
CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc} (max)'$	: 2000 kPa	Sample	: 9WaxA
σ_{vc}'	: 171 kPa	Depth (m)	: 18.00
Shearing Parameters		Test No	: DSS03
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

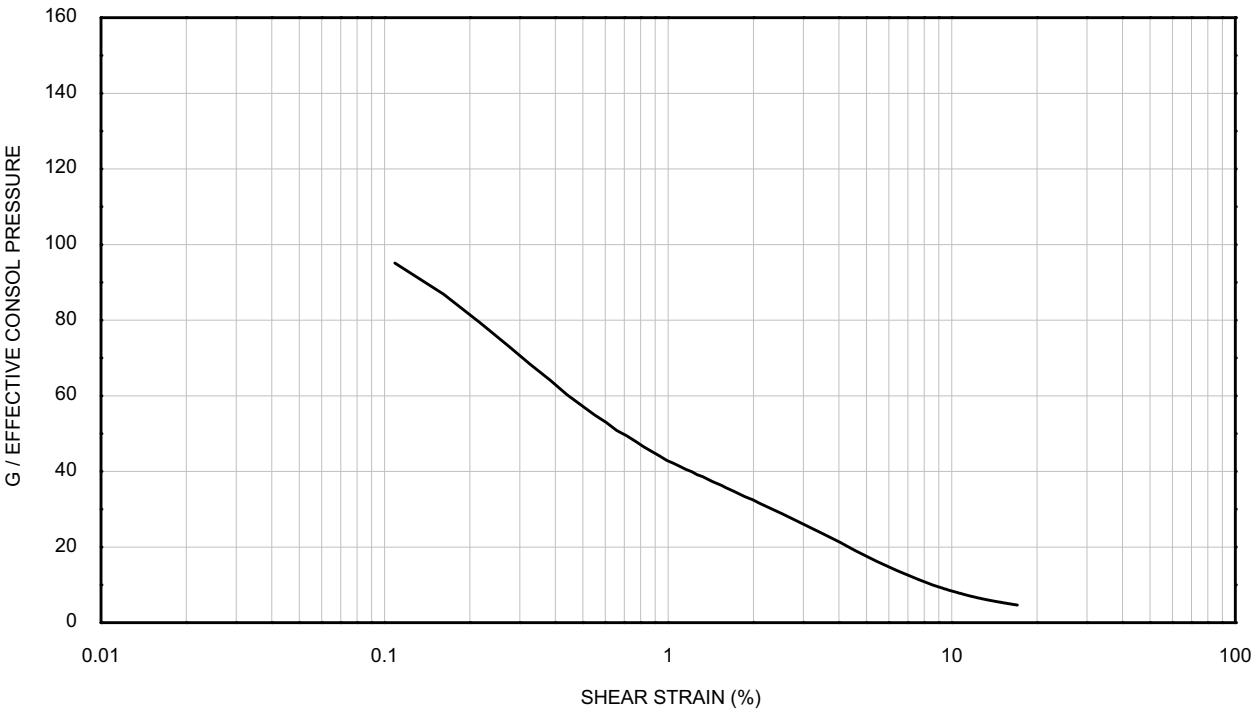
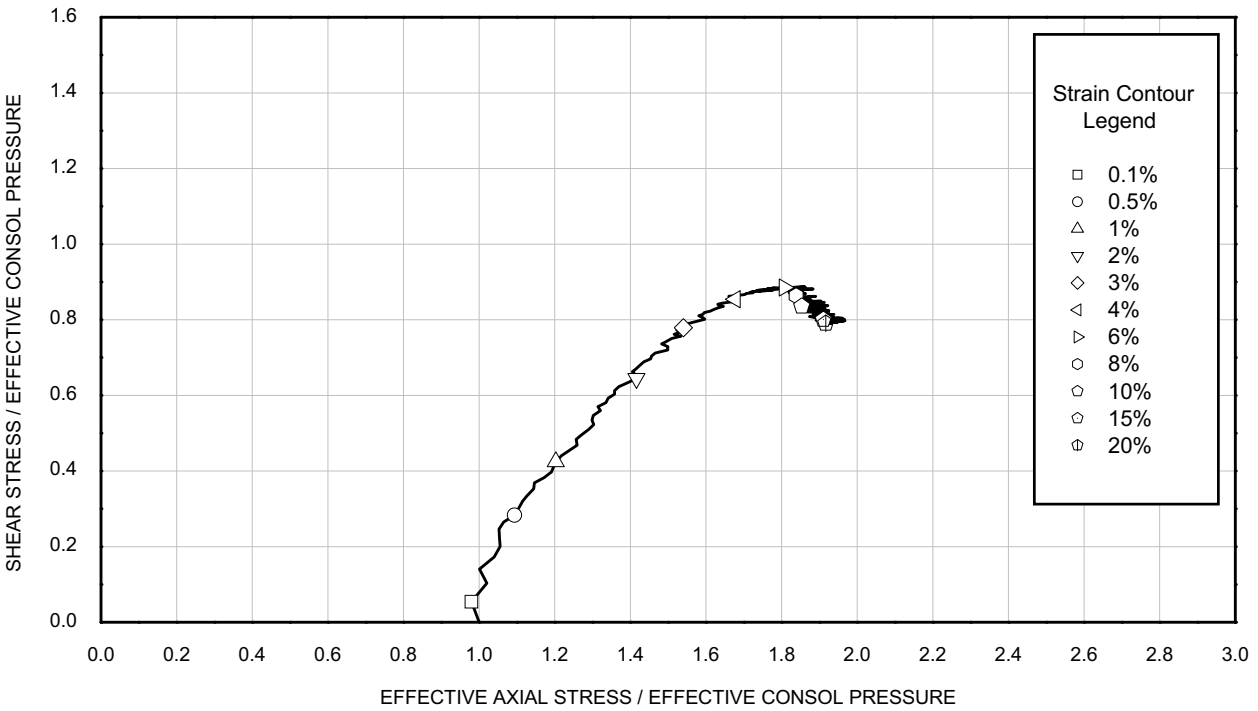
Drawn by: ALB
Date: 17/05/2011
Template Issue: 2
Filename: J11056 \ BH_06_9WaxA_DSS.OPJ
Date: 24/05/2011
Date:
Checked by: PH
Approved by:



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc} (max)$	: 2000 kPa	Sample	: 9WaxA
$\sigma_{vc'}$	: 171 kPa	Depth (m)	: 18.00
Shearing Parameters		Test No	: DSS03
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Drawn by: ALB Date: 17/05/2011
Template Issue: 2
Filename: J11056 \ BH_06_9WaxA_DSS.OPJ
Date: 24/05/2011
Checked by: PH
Approved by:



Consolidation Stresses		Borehole	: BH_06
$\sigma_{vc(max)'} :$	2000 kPa	Sample	: 9WaxA
$\sigma_{vc}' :$	171 kPa	Depth (m)	: 18.00
Shearing Parameters		Test No	: DSS03
Rate of Strain	: 3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Date: 31/05/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / DSS / BH-07_03B_DSS.XLS

VISUAL DESCRIPTION

Stiff to very stiff white CHALK.

GENERAL

Date test started	13/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	66.6
Length	(mm)	19.9
Moisture content	(%)	25
Bulk density	(Mg/m ³)	2.05
Dry density	(Mg/m ³)	1.64
Voids ratio		0.647
Degree of saturation	(%)	100
Torvane	(kPa)	125
Pocket penetrometer	(kPa)	267

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 on request

Borehole	BH_07
Sample	3WaxB
Depth (m)	7.40
Test Number	DSS4

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST

Date: 31/05/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / DSS / BH-07_03B_DSS.XLS

Date: 02/06/2011

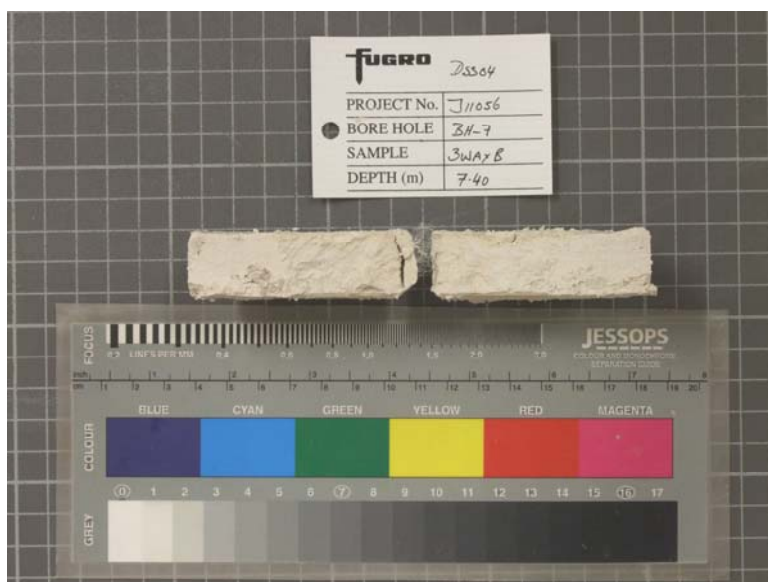
Date:

Checked by: PH

Approved by:

CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	70
Vertical strain	(%)	0.97
Volumetric strain	(%)	0.97
Bulk density	(Mg/m ³)	2.06
Dry density	(Mg/m ³)	1.66

SHEARING		
At peak shear stress		
Shear stress	(kPa)	116
Shear strain	(%)	18.57
Change in pore pressure	(kPa)	-125
Rate of strain	(%/hr)	2.8
At 15% shear strain		
Shear stress	(kPa)	108
Change in pore pressure	(kPa)	-108



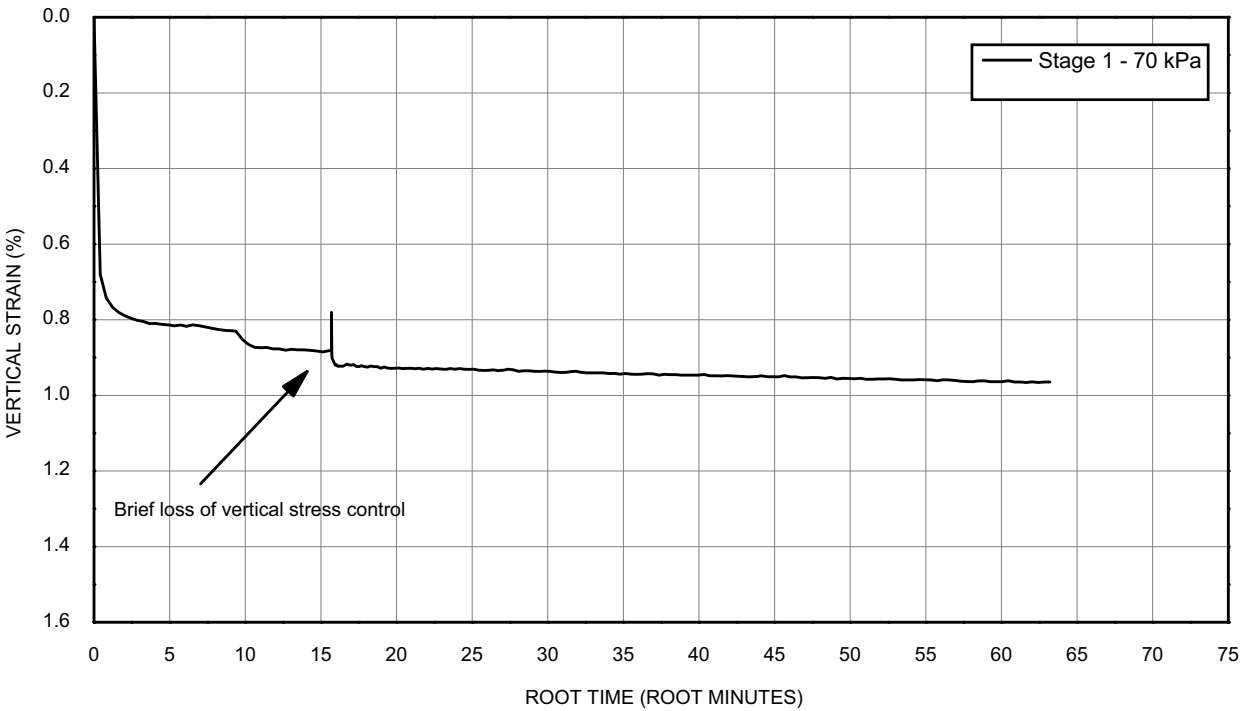
Borehole	BH_07
Sample	3WaxB
Depth (m)	7.40
Test Number	DSS4

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



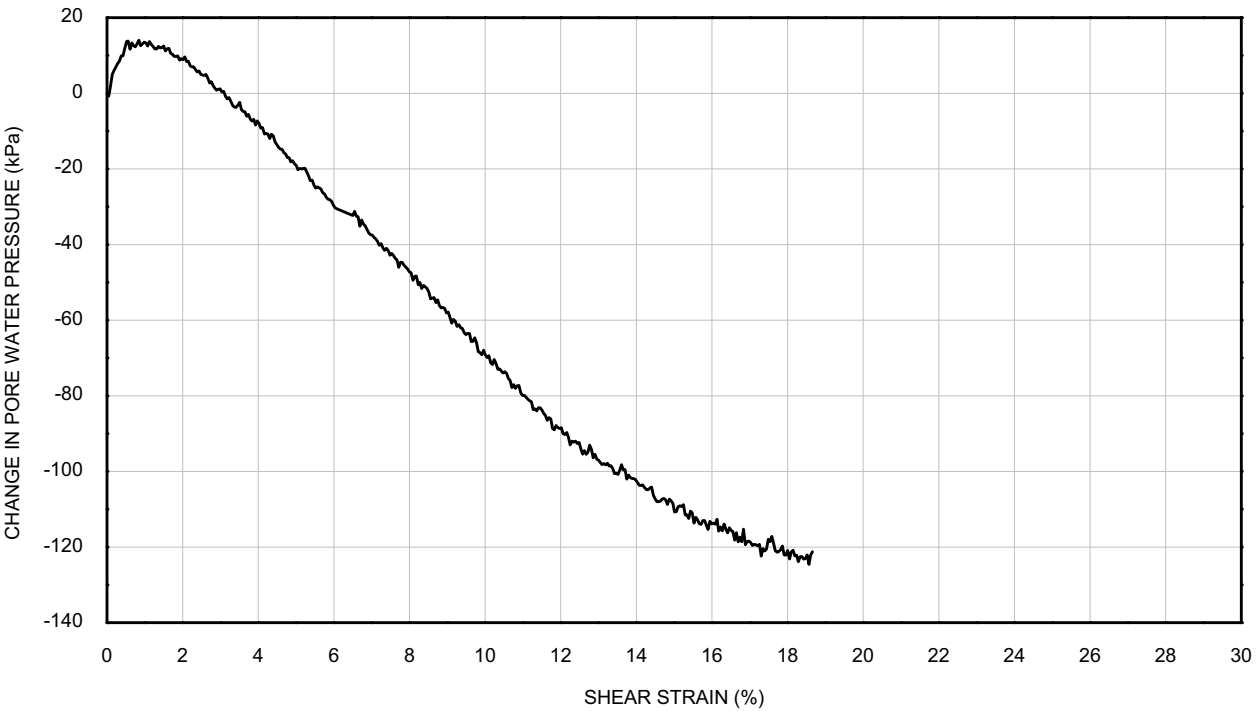
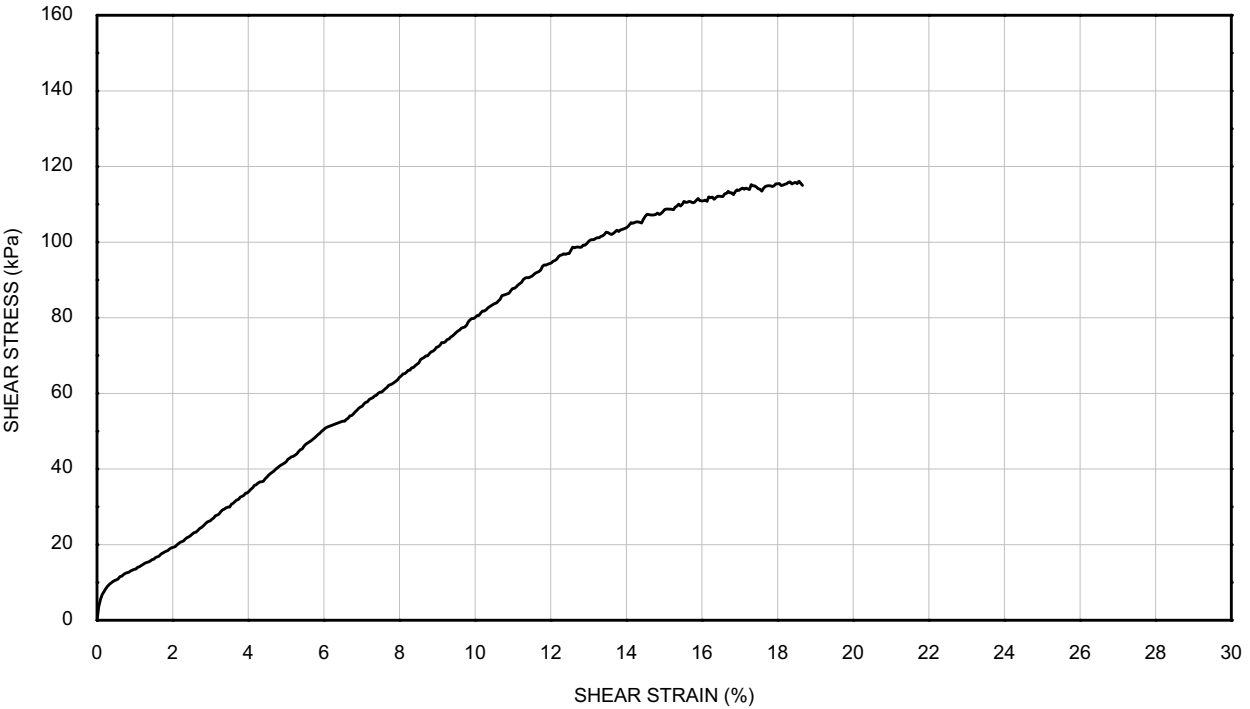
Template Issue: 2
Filename: J11056 \ BH-07_03B_DSS.OPJ
Date: 31/05/2011
Drawn by: PR

Checked by: PH
Approved by:
Date: 02/06/2011



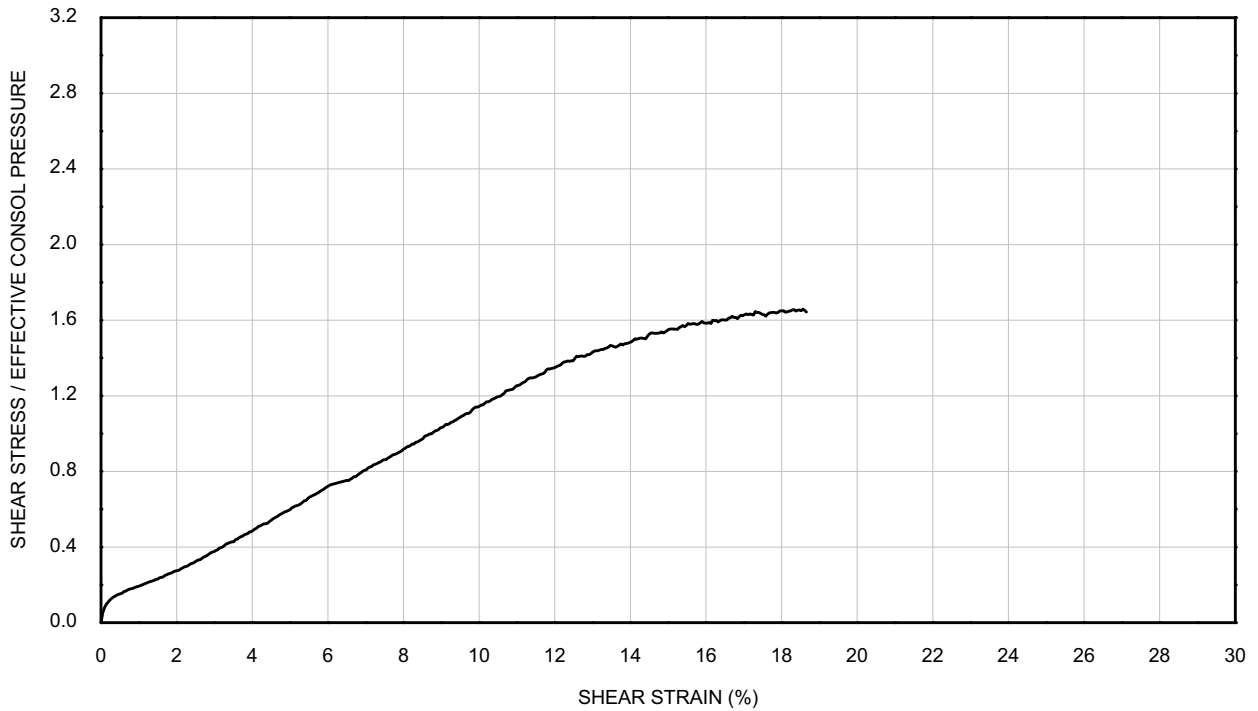
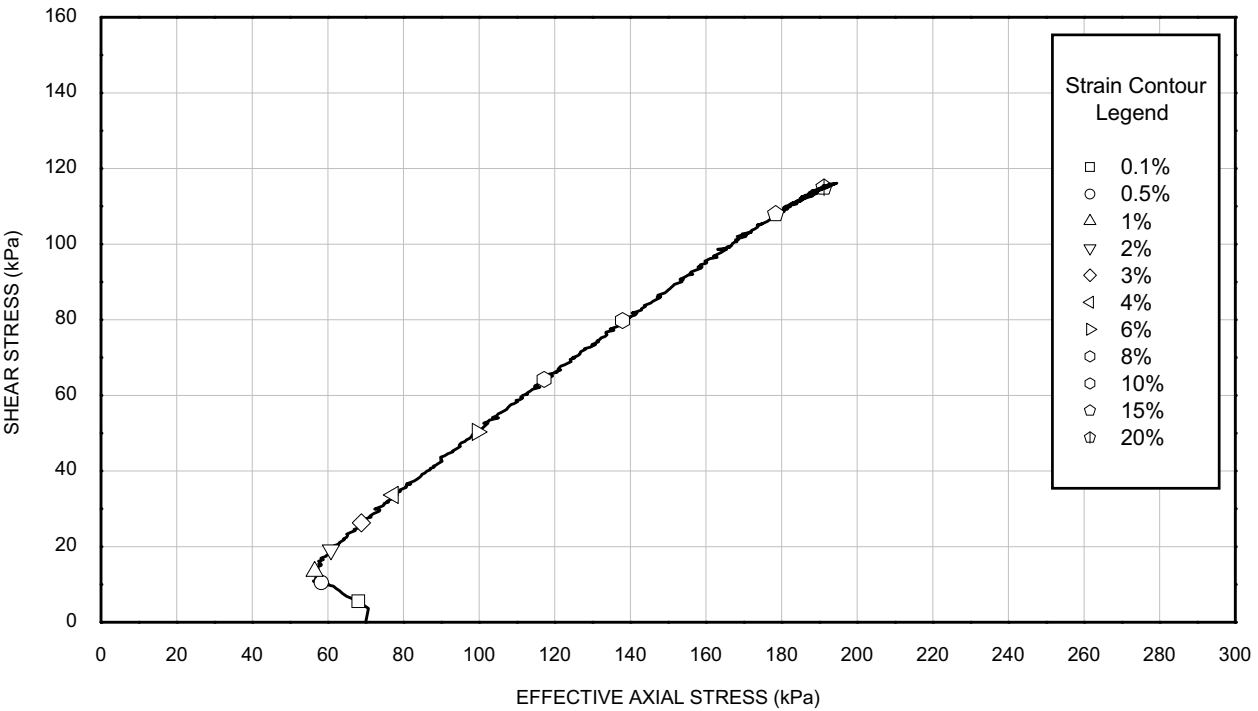
Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)}$	: 70 kPa	Sample	: 3WaxB
$\sigma_{vc'}$	: 70 kPa	Depth (m)	: 7.40
Shearing Parameters		Test No	: DSS4
Rate of Strain	: 2.8 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	70 kPa	Sample	: 3WaxB
$\sigma_{vc}' :$	70 kPa	Depth (m)	: 7.40
Shearing Parameters		Test No	: DSS4
Rate of Strain	: 2.8 %/Hour		

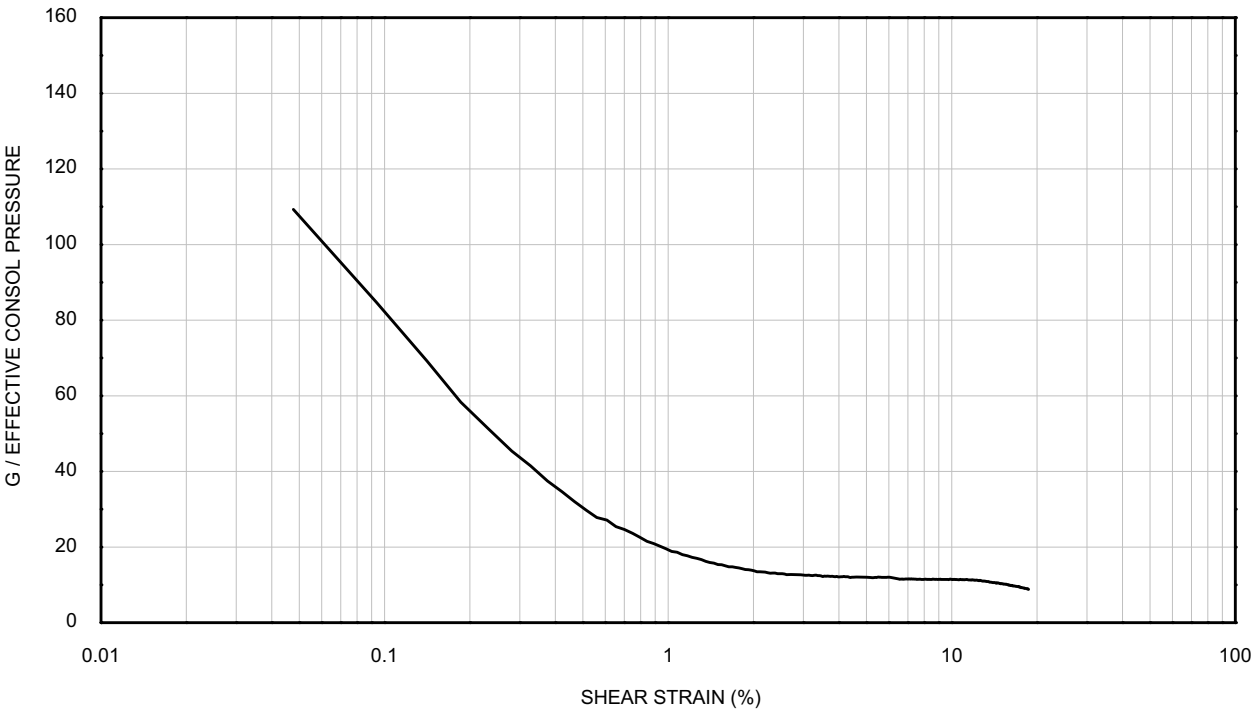
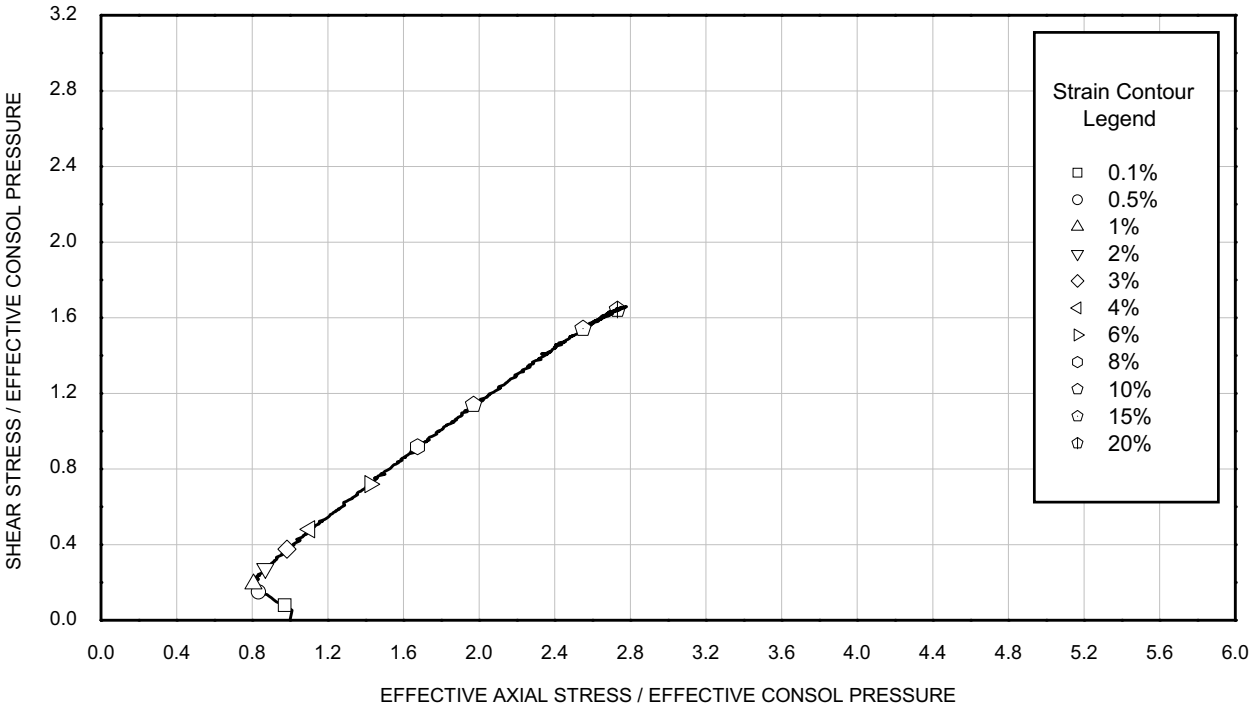
CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	70 kPa	Sample	: 3WaxB
$\sigma_{vc}' :$	70 kPa	Depth (m)	: 7.40
Shearing Parameters		Test No	: DSS4
Rate of Strain	: 2.8 %/Hour		

Checked by: PH Date: 02/06/2011
Approved by: Date:

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	70 kPa	Sample	: 3WaxB
$\sigma_{vc}' :$	70 kPa	Depth (m)	: 7.40
Shearing Parameters		Test No	: DSS4
Rate of Strain	: 2.8 %/Hour		

Checked by: PH Date: 02/06/2011
Approved by: Date:

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Date: 31/05/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / DSS / BH-07_06A_DSS.XLS

VISUAL DESCRIPTION

Very stiff white CHALK.

GENERAL

Date test started	13/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	65.9
Length	(mm)	19.9
Moisture content	(%)	25
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.62
Voids ratio		0.671
Degree of saturation	(%)	99
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	200

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 on request

Borehole	BH_07
Sample	6WaxA
Depth (m)	12.64
Test Number	DSS5

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST

Date: 31/05/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / DSS / BH-07_06A_DSS.XLS

Date:

Date:

Checked by:

Approved by:

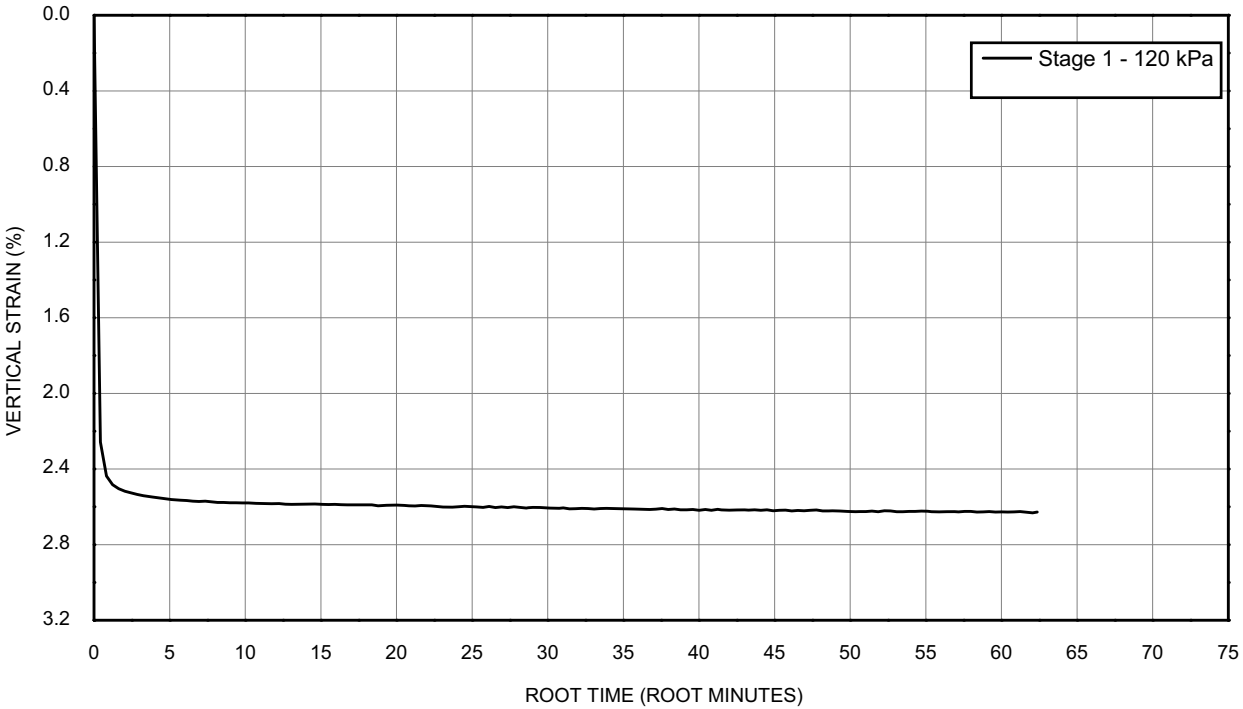
CONSOLIDATION $\sigma_{vc'}$		
$\sigma_{vc'}$	(kPa)	120
Vertical strain	(%)	2.63
Volumetric strain	(%)	2.63
Bulk density	(Mg/m ³)	2.04
Dry density	(Mg/m ³)	1.66

SHEARING		
At peak shear stress		
Shear stress	(kPa)	61
Shear strain	(%)	22.54
Change in pore pressure	(kPa)	32
Rate of strain	(%/hr)	3.3
At 15% shear strain		
Shear stress	(kPa)	51
Change in pore pressure	(kPa)	49



Borehole	BH_07
Sample	6WaxA
Depth (m)	12.64
Test Number	DSS5

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)}$	: 120 kPa	Sample	: 6WaxA
$\sigma_{vc'}$	: 120 kPa	Depth (m)	: 12.64
Shearing Parameters		Test No	: DSS5
Rate of Strain	: 3.3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Drawn by: PR
Date: 31/05/2011

Template Issue: 2

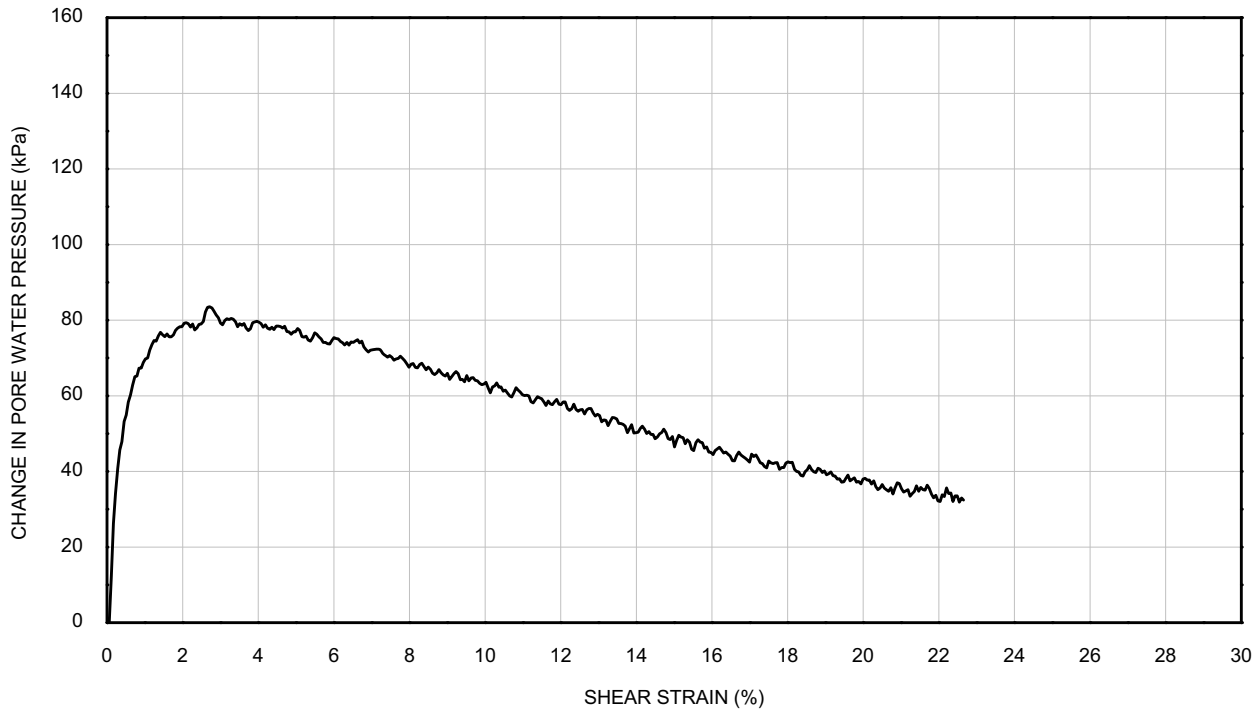
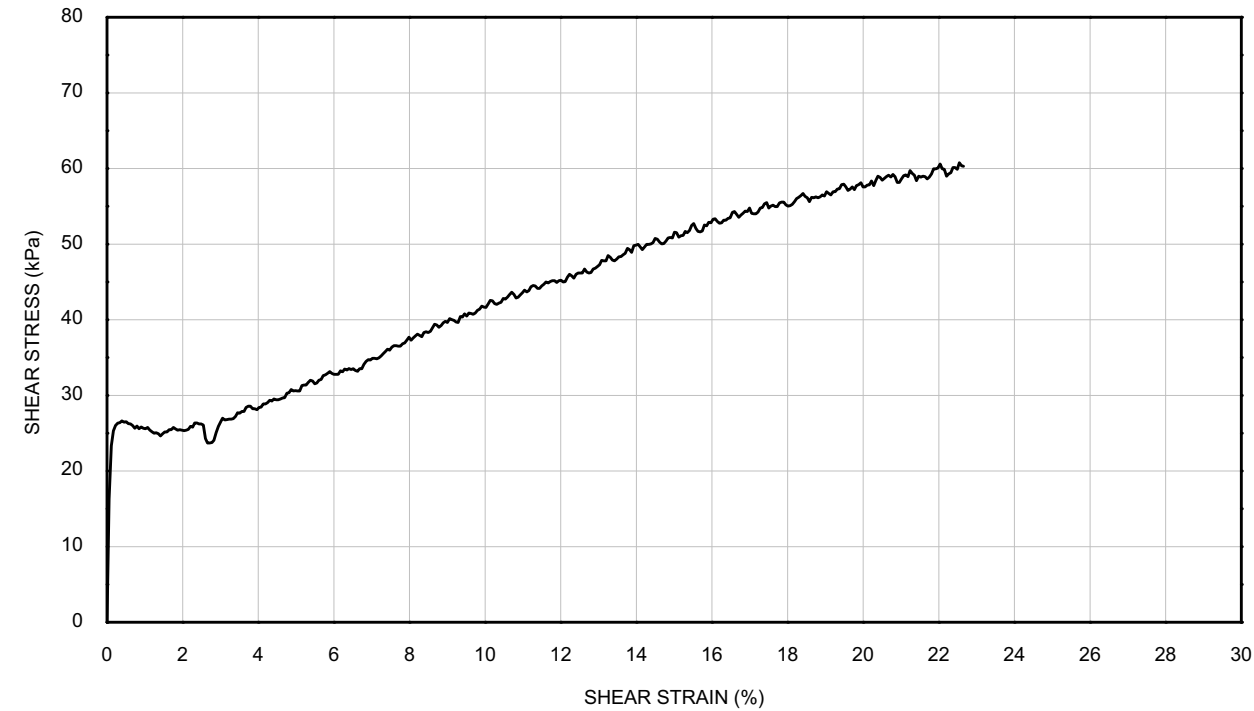
Date: 02/06/2011

Checked by: PH

Filename: J11056 \ BH-07_06A_DSS.OPJ

Date:

Approved by:



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	120 kPa	Sample	: 6WaxA
$\sigma_{vc}' :$	120 kPa	Depth (m)	: 12.64
Shearing Parameters		Test No	: DSS5
Rate of Strain	: 3.3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Drawn by: PR Date: 31/05/2011

Template Issue: 2

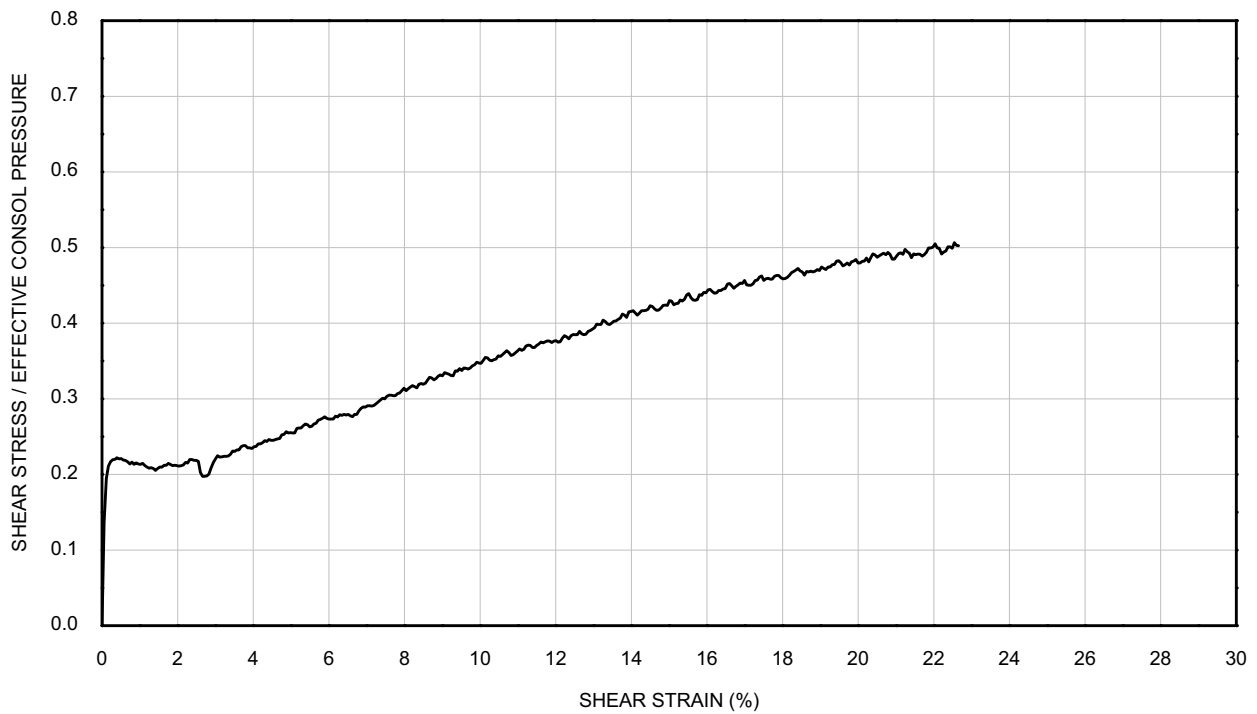
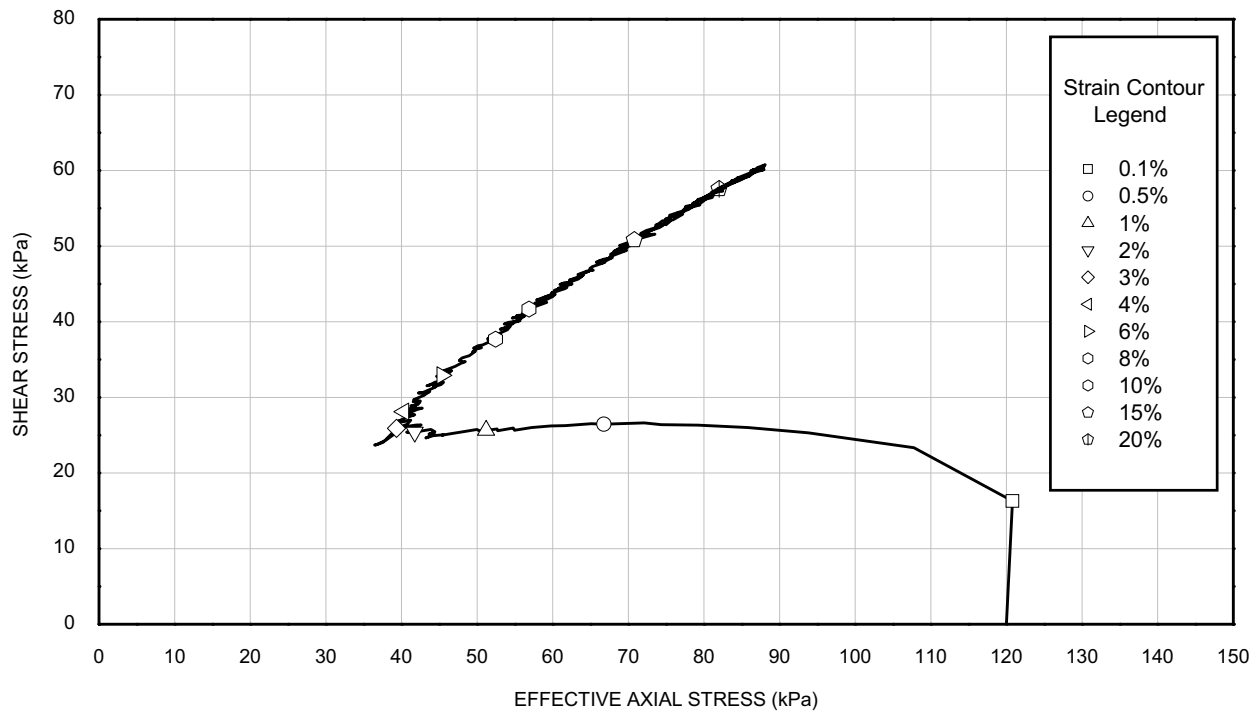
Date: 02/06/2011

Checked by: PH

Filename: J11056 \ BH-07_06A_DSS.OPJ

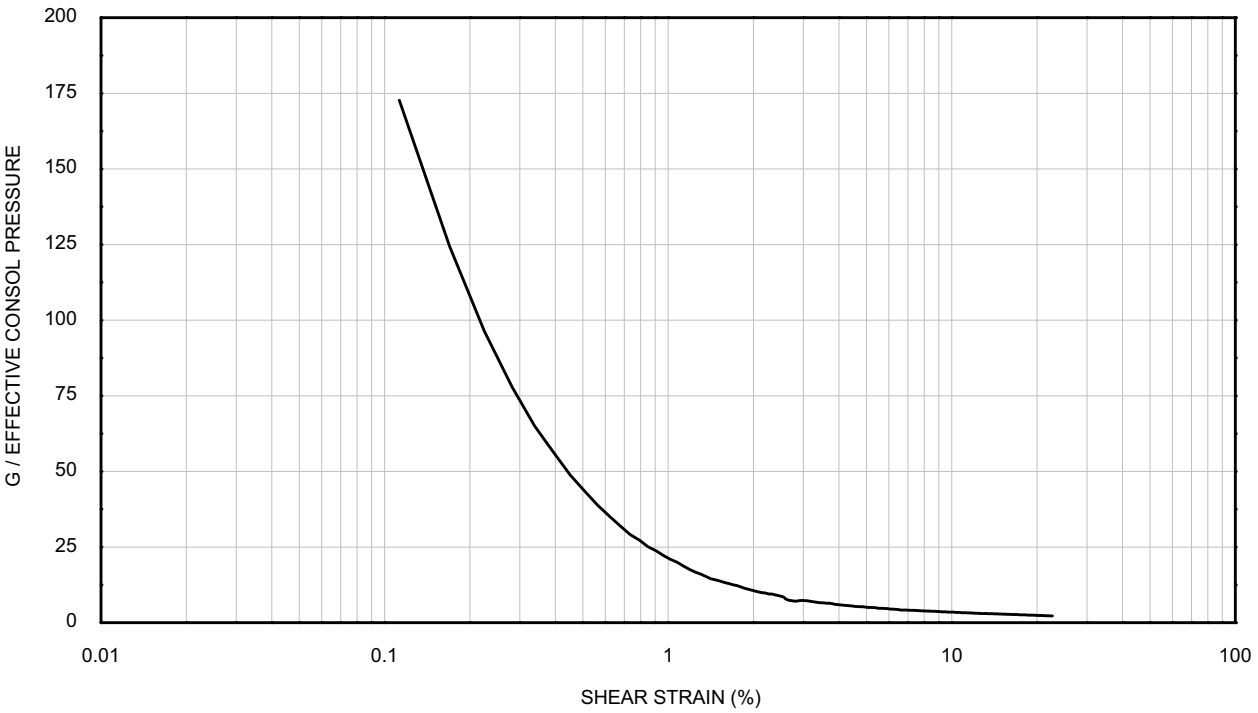
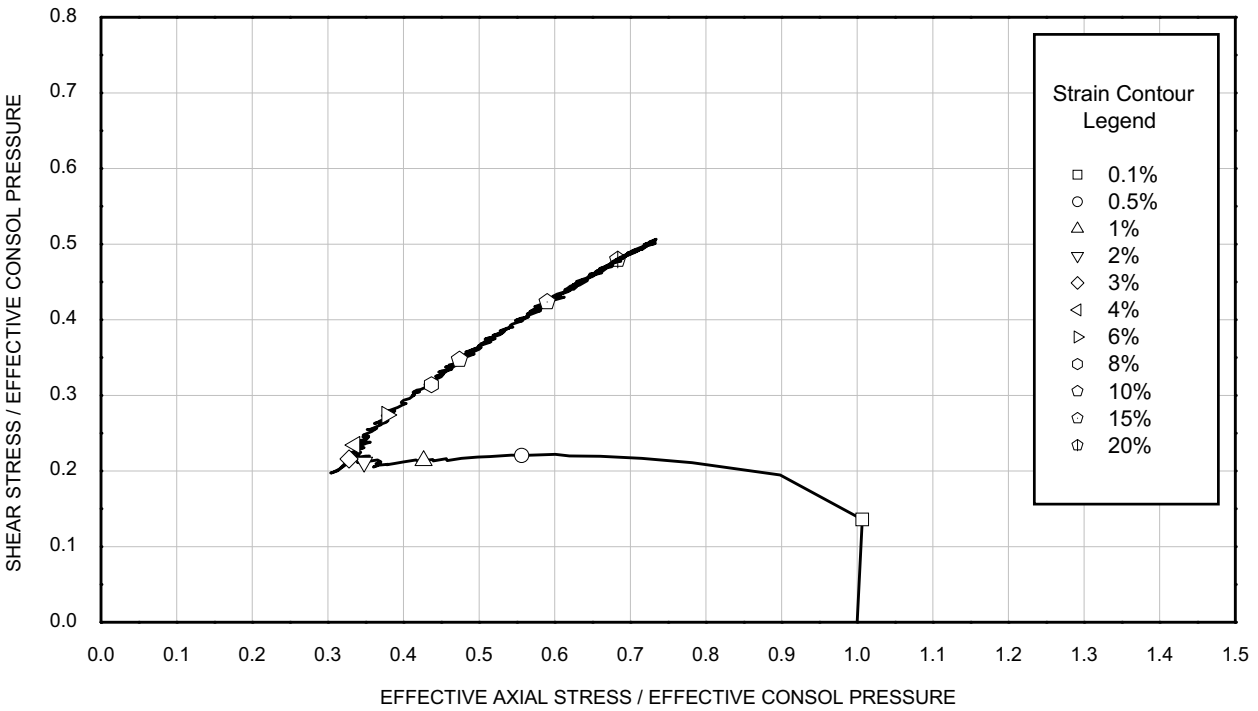
Date:

Approved by:



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	120 kPa	Sample	: 6WaxA
$\sigma_{vc}' :$	120 kPa	Depth (m)	: 12.64
Shearing Parameters		Test No	: DSS5
Rate of Strain	: 3.3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)}$	: 120 kPa	Sample	: 6WaxA
$\sigma_{vc'}$	: 120 kPa	Depth (m)	: 12.64
Shearing Parameters		Test No	: DSS5
Rate of Strain	: 3.3 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

Date: 31/05/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / DSS / BH-07_12A_DSS.XLS

VISUAL DESCRIPTION	
Hard white chalk	

GENERAL	
Date test started	13/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL		
Diameter	(mm)	66.5
Length	(mm)	20.0
Moisture content	(%)	21
Bulk density	(Mg/m ³)	2.06
Dry density	(Mg/m ³)	1.70
Voids ratio		0.588
Degree of saturation	(%)	96
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	387

Date: 02/06/2011

Checked by: PH

Date:
Approved by:

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 on request	

Borehole	BH_07
Sample	12WaxA
Depth (m)	23.08
Test Number	DSS6

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST

Date: 31/05/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / DSS / BH-07_12A_DSS.XLS

Date: 02/06/2011

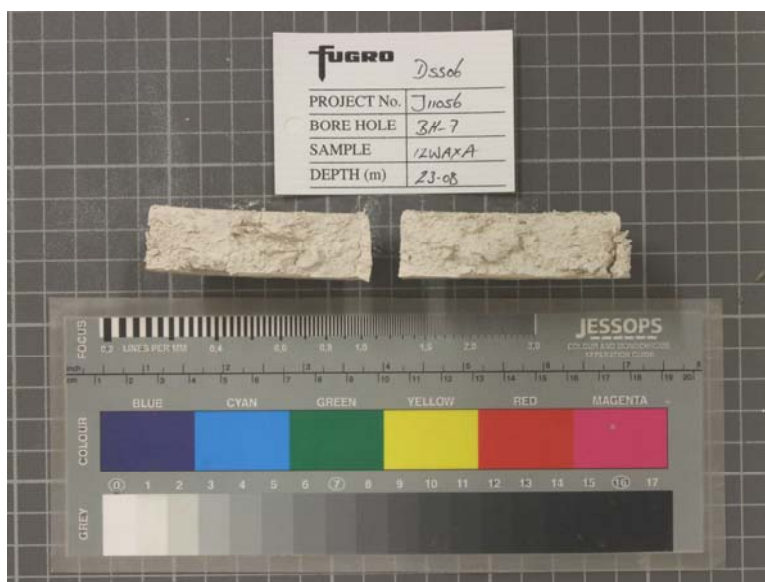
Date:

Checked by: PH

Approved by:

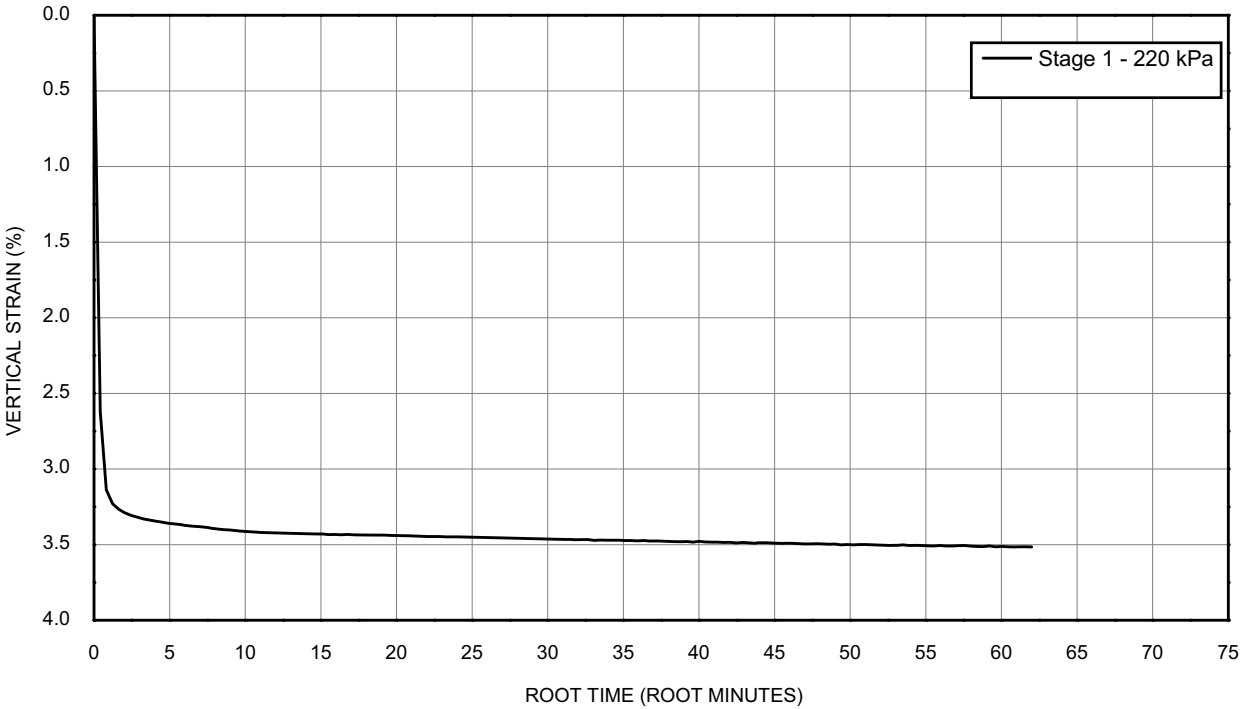
CONSOLIDATION $\sigma_{vc'}$		
$\sigma_{vc'}$	(kPa)	220
Vertical strain	(%)	3.52
Volumetric strain	(%)	3.52
Bulk density	(Mg/m ³)	2.10
Dry density	(Mg/m ³)	1.76

SHEARING		
At peak shear stress		
Shear stress	(kPa)	95
Shear strain	(%)	21.31
Change in pore pressure	(kPa)	93
Rate of strain	(%/hr)	3.1
At 15% shear strain		
Shear stress	(kPa)	88
Change in pore pressure	(kPa)	105



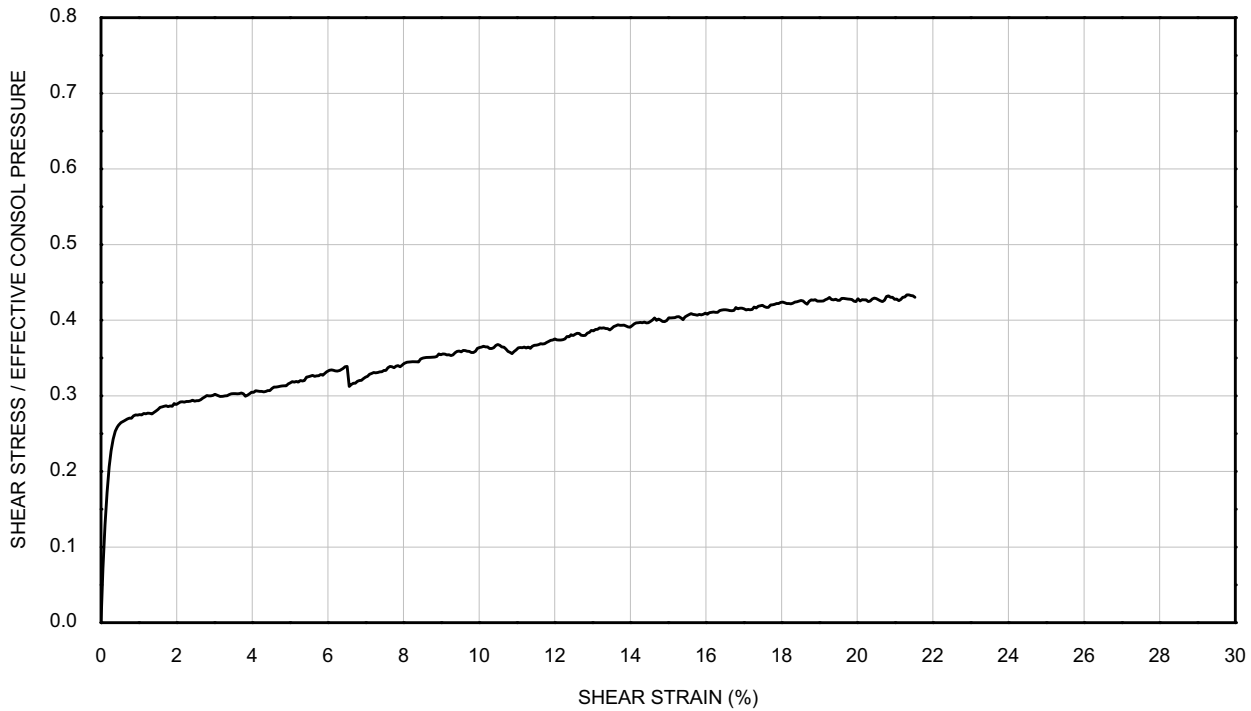
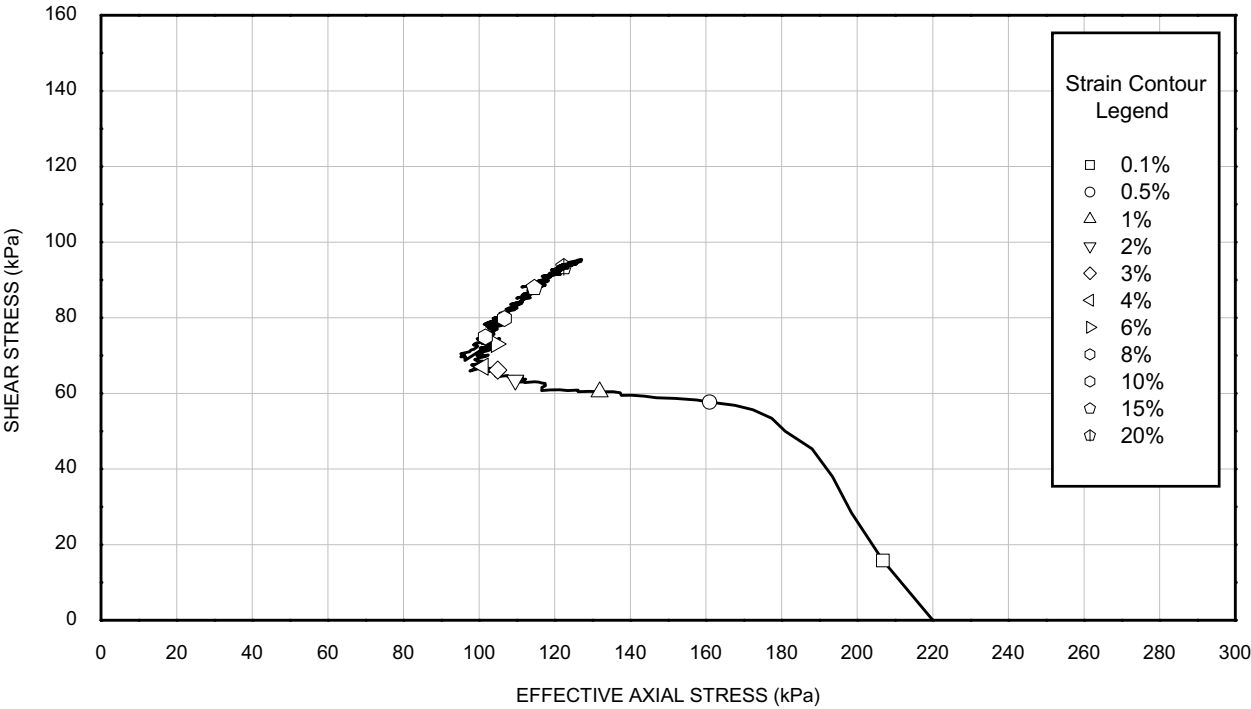
Borehole	BH_07
Sample	12WaxA
Depth (m)	23.08
Test Number	DSS6

SUMMARY OF CONSOLIDATED CONSTANT VOLUME DSS TEST



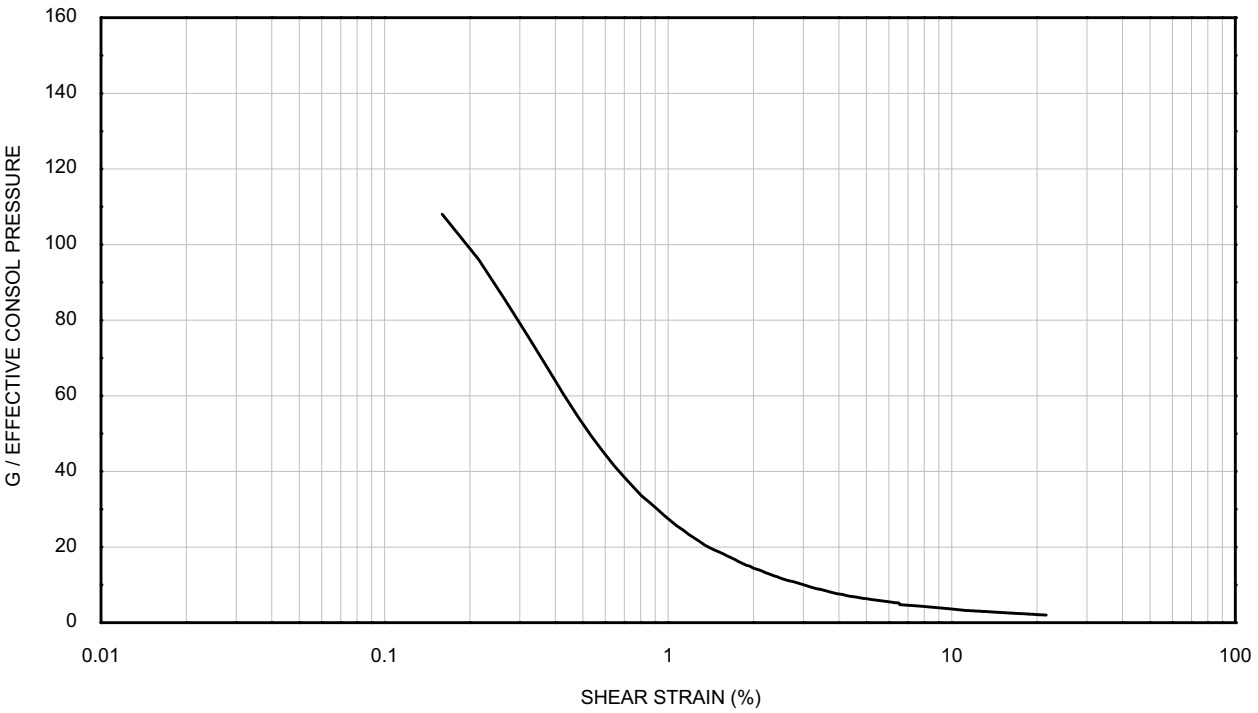
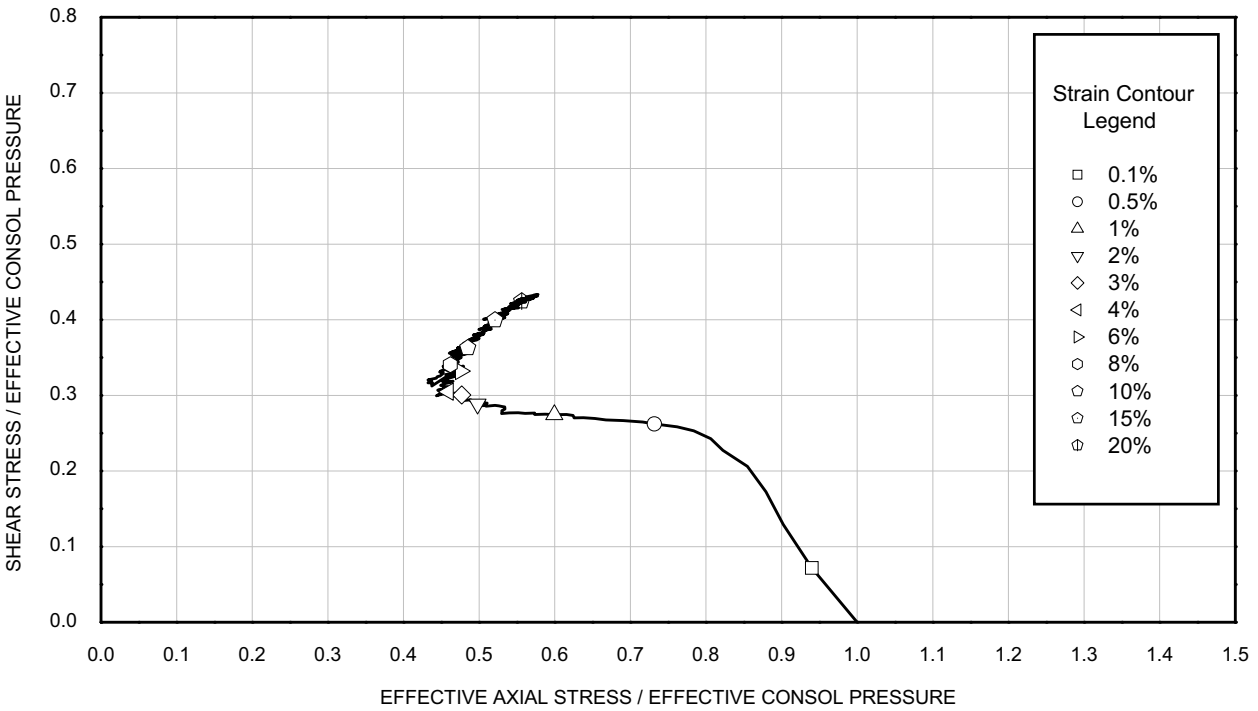
Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)}$	: 220 kPa	Sample	: 12WaxA
$\sigma_{vc'}$	: 220 kPa	Depth (m)	: 23.08
Shearing Parameters		Test No	: DSS6
Rate of Strain	: 3.1 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
CONSOLIDATION STAGE



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	220 kPa	Sample	: 12WaxA
$\sigma_{vc}' :$	220 kPa	Depth (m)	: 23.08
Shearing Parameters		Test No	: DSS6
Rate of Strain	: 3.1 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE

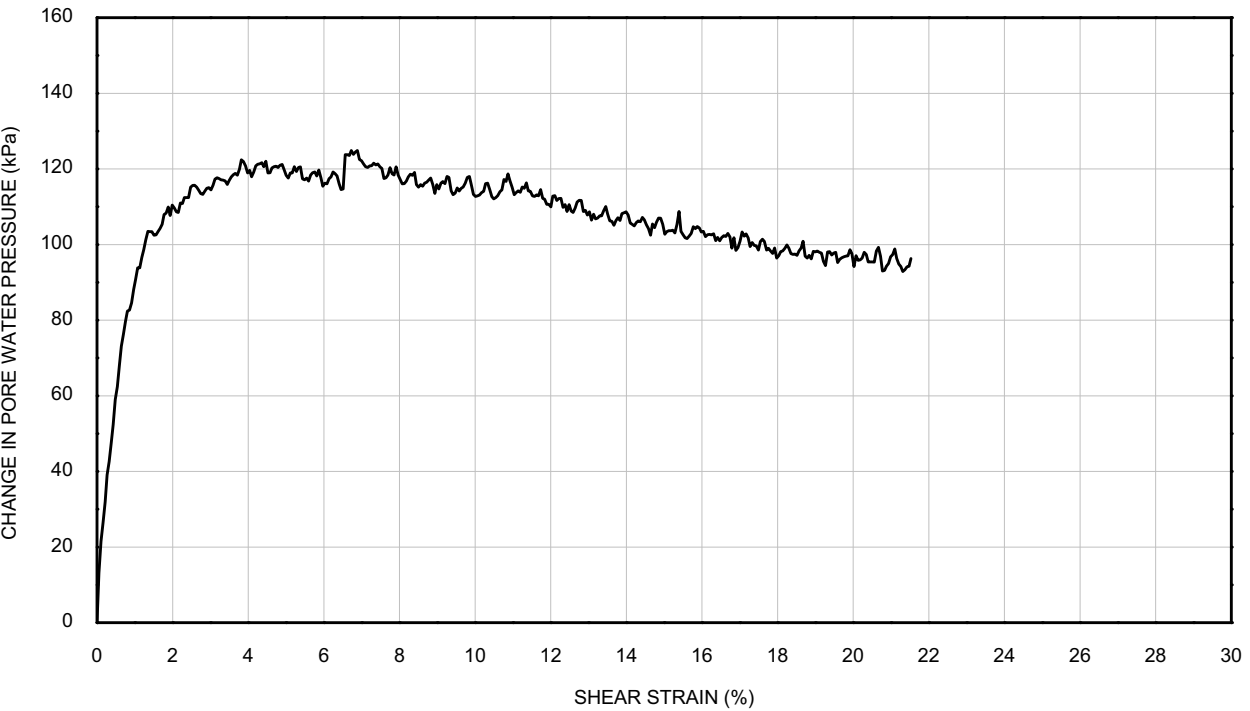
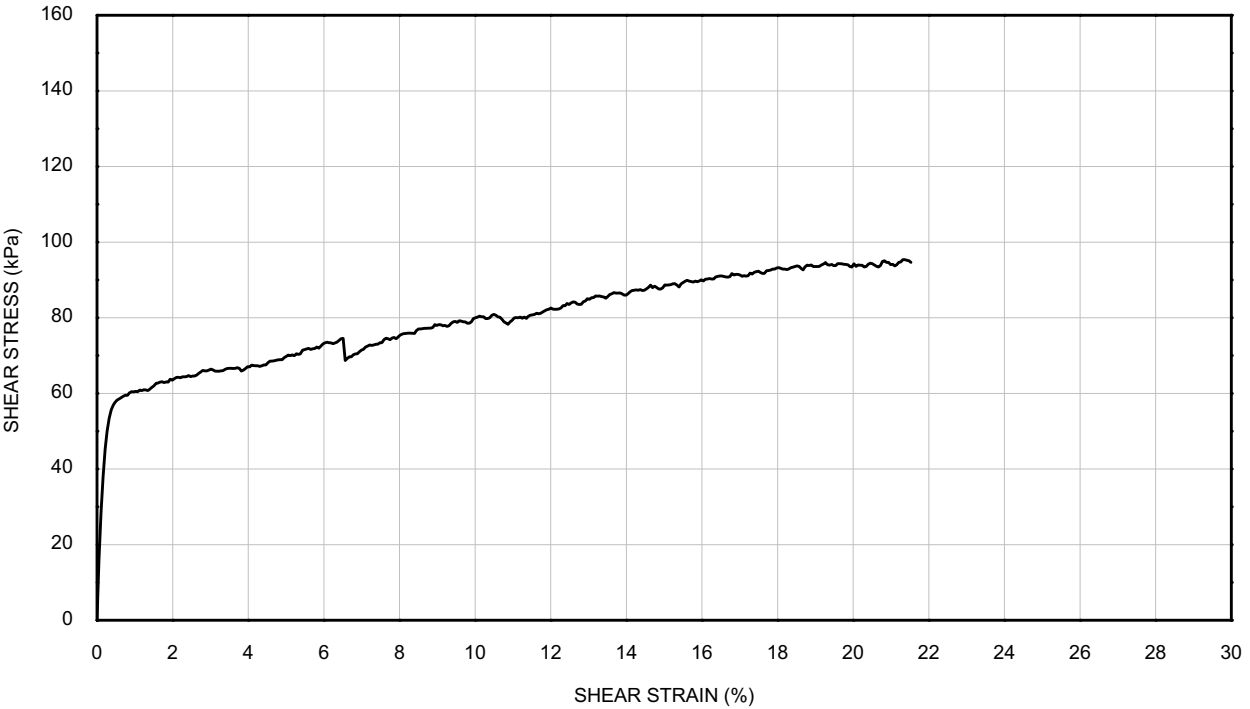


Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	220 kPa	Sample	: 12WaxA
$\sigma_{vc}' :$	220 kPa	Depth (m)	: 23.08
Shearing Parameters		Test No	: DSS6
Rate of Strain	: 3.1 %/Hour		

Date: Date: 02/06/2011

Checked by: PH Approved by:

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



Consolidation Stresses		Borehole	: BH_07
$\sigma_{vc(max)'} :$	220 kPa	Sample	: 12WaxA
$\sigma_{vc}' :$	220 kPa	Depth (m)	: 23.08
Shearing Parameters		Test No	: DSS6
Rate of Strain	: 3.1 %/Hour		

CONSOLIDATED CONSTANT VOLUME DSS TEST
SHEAR STAGE



SECTION B.6

DIRECT SHEAR (SHEAR BOX) TESTS

B.6	DIRECT SHEAR (SHEAR BOX) TESTS	1
B.6.1	SUMMARY	1
B.6.2	SHEAR BOX	1
B.6.3	DISCUSSION OF RESULTS	1

B.6 DIRECT SHEAR (SHEAR BOX)

B.6.1 SUMMARY

The test specimens were prepared to an initial dry density based on a best estimate of the relative density at the specimen depth estimated from the adjacent CPT. Details of laboratory test procedures are presented in Section B.11. A tabulated summary, followed by individual test results are presented at the end of this section on Plates B.6-1 to B.6-2 and Plates B.6-3 to B.6-35, respectively.

B.6.2 SHEAR BOX

Four (4) “set of three” shear box tests were performed on soil-soil interfaces to assess the internal friction angle (ϕ) of the cohesionless soils at the Rampion Site. In addition two (2) “set of three” shear box tests were performed on a soil-steel interface, with a steel surface roughness of approximately 10 microns, to assess the soil-steel friction angle (δ).

B.6.3 MULTI-REVERSAL SHEAR BOX

In order to assess the residual soil-steel friction angle (δ_{ult}) three (3) “multi-reversal” shear box tests were performed. This involved repeating the shearing stage of the test after the sample had failed., until a residual value for the drained friction angle could be recorded. Individual tests have been presented at the end of this section on Plates B.6-21 to B.6-35.

B.6.4 DISCUSSION OF RESULTS

The purpose of these tests was to provide data for input into pile installation and capacity analyses. The test results presented include recommended cohesion and friction angles based on the best-fit line through the three sets of test results. It should be noted however, that the apparent cohesion and friction angles are dependant on the effective vertical stress and so are not constant values. As a consequence, any user of the data should review the recommended best-fit values to ensure they are appropriate for the stress range being considered.

The laboratory test results are considered to be representative of the soils tested.

DIRECT SHEAR (SEHEAR BOX) TESTS

LIST OF PLATES – SECTION B.6

Description	Plate
Summary of Direct Shear (Shear Box) Test Results	B.6-1
Summary of Multi-reversal Shear Box Test Results	B.6-2
Direct Shear (Shear Box) Test Results	B.6-3 to B.6-20
Multi-Reversal Shear Box Test Results	B.6-21 to B.6-35

SUMMARY OF DIRECT SHEAR (SHEAR BOX) TEST RESULTS

BH No.	SAMPLE No.	DEPTH (m)	TEST TYPE	INDEX PROPERTIES		PEAK VALUES			RESIDUAL VALUES		
				ρ_{bulk} (initial) (Mg/m ³)	ρ_{dry} (initial) (Mg/m ³)	τ (kPa)	c' (-)	δ'_{peak} (°)	τ_r (kPa)	c'_r (-)	δ'_r (°)
BH_13	10BAGA	20.00	SO:ST	1.96	1.77	126			58		
BH_13	10BAGA	20.00	SO:ST	1.96	1.78	147	64	28	107	0	31
BH_13	10BAGA	20.00	SO:ST	1.97	1.79	271			238		
BH_13	11BAGA	20.50	SO:ST	1.97	1.78	65			55		
BH_13	11BAGA	20.50	SO:ST	1.98	1.78	141	0	34	96	0	31
BH_13	11BAGA	20.50	SO:ST	1.97	1.79	272			254		
BH_14	1BAGA	2.00	SO:ST	1.86	1.69	17			12		
BH_14	1BAGA	2.00	SO:ST	1.85	1.68	33	8	37	17	5	23
BH_14	1BAGA	2.00	SO:ST	1.85	1.69	52			31		
Notes :											

SUMMARY OF MULTI-REVERSAL SHEAR BOX TEST RESULTS

Date: 23/05/2011

Drawn by: ALB

Template Issue: 5

Filename: J11056 / Labdata / Shear / BH_13_11BagA_SB.XLS

Date:

Date:

Checked by:

Approved by:

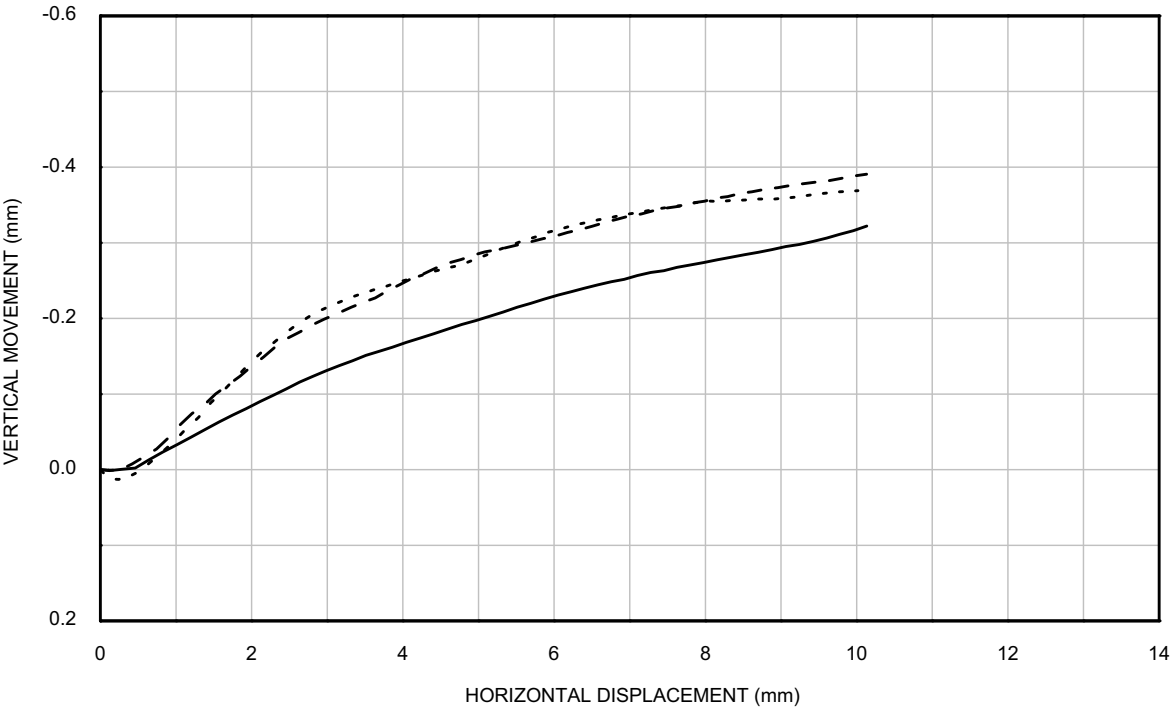
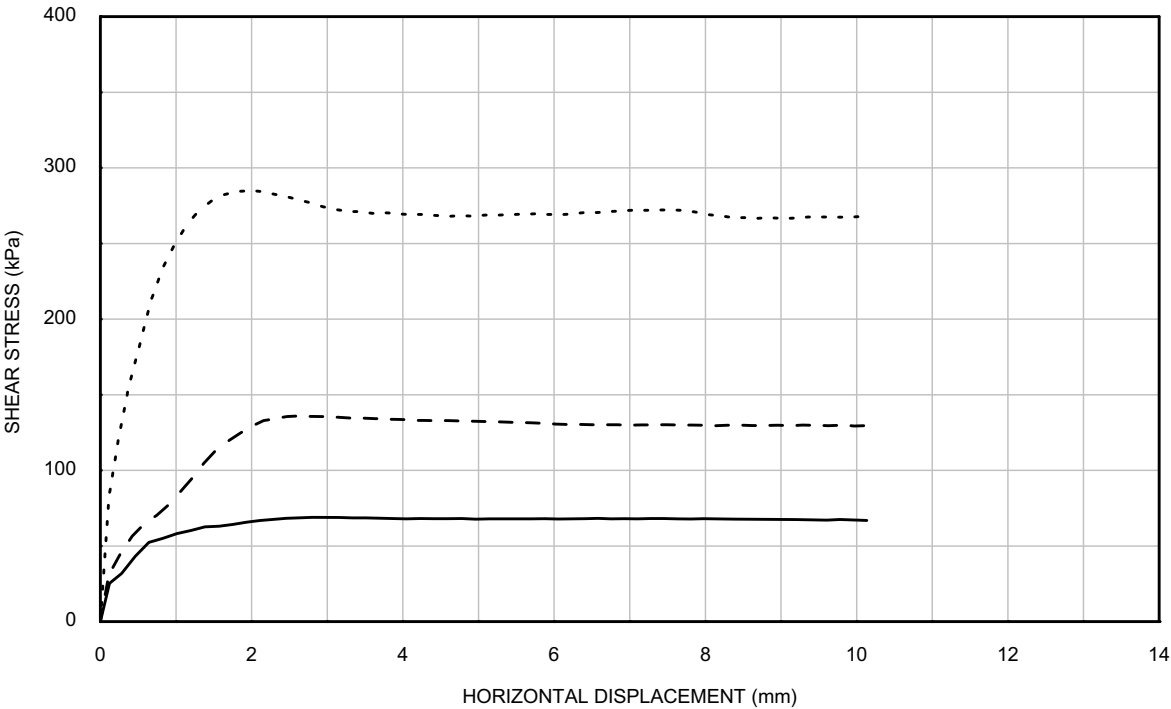
SPECIMEN	1	2	3
INITIAL CONDITIONS			
Sample length (mm)	60.0	60.0	60.0
Sample breadth (mm)	60.0	60.0	60.0
Sample height (mm)	20.6	20.0	20.2
Moisture content (%)	13.8	13.8	13.8
Bulk density (Mg/m ³)	1.99	2.05	2.02
Dry density (Mg/m ³)	1.74	1.80	1.77
Voids ratio	0.520	0.475	0.494
Degree of saturation (%)	71	77	74
Rate of displacement (mm/min)	0.016	0.016	0.016
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.475	0.443	0.464
Normal stress (kPa)	100	200	400
Maximum shear stress (kPa)	69	136	285
Horizontal displacement (mm)	2.99	2.62	1.95
Vertical movement (mm)	-0.13	-0.18	-0.14

Particle density (Mg/m ³) Specimens tested dry or submerged	2.65 (Assumed) Submerged

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4,
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

Borehole :	BH_13
Sample :	11BagA
Depth (m) :	20.5

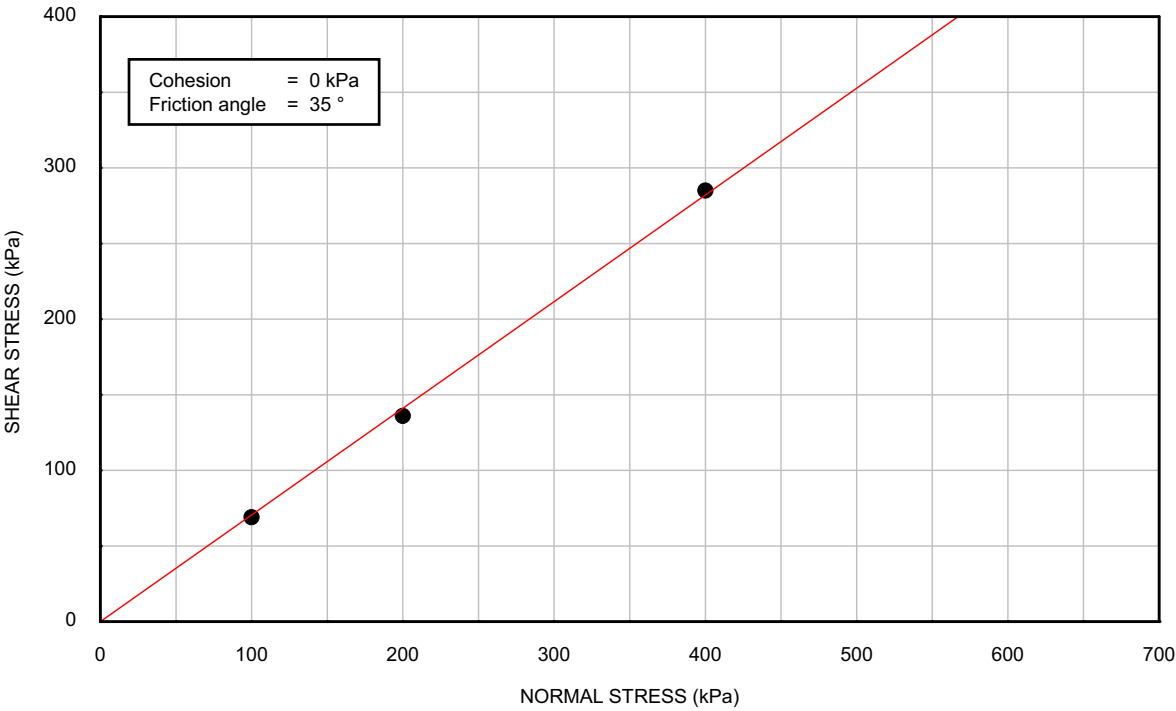
DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - STEEL INTERFACE



— Specimen 1: Normal stress 100 kPa	Borehole : BH_13
- - - Specimen 2: Normal stress 200 kPa	Sample : 11BagA
. . . . Specimen 3: Normal stress 400 kPa	Depth (m) : 20.5

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - STEEL INTERFACE

Drawn by: ALB Date: 23/05/2011
Template Issue: 4
Filename: J11056 / Labdata / Shear / BH_13_11BagA_SB.OPJ
Date: 17/05/2011
Checked by: PH
Approved by:



Specimen 1: Normal stress 100 kPa	Borehole : BH_13
Specimen 2: Normal stress 200 kPa	Sample : 11BagA
Specimen 3: Normal stress 400 kPa	Depth (m) : 20.5

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - STEEL INTERFACE

Drawn by: ALB Date: 23/05/2011
Template Issue: 4
Filename: J11056 / Labdata / Shear / BH_13_11BagA_SB.OPJ
Date : 17/05/2011
Date :
Checked by: PH
Approved by:

Date: 26/05/2011

Drawn by: NAC

Template Issue: 5

Filename: J11056 / Labdata / Shear / BH_14_20BagA_sb.XLS

SPECIMEN	1	2	3
INITIAL CONDITIONS			
Sample length (mm)	60.0	60.0	60.0
Sample breadth (mm)	60.0	60.0	60.0
Sample height (mm)	23.5	25.0	23.1
Moisture content (%)	14.1	14.1	14.1
Bulk density (Mg/m ³)	2.12	2.11	2.15
Dry density (Mg/m ³)	1.86	1.85	1.89
Voids ratio	0.423	0.430	0.405
Degree of saturation (%)	88	87	92
Rate of displacement (mm/min)	0.016	0.016	0.016
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.344	0.369	0.309
Normal stress (kPa)	195	390	780
Maximum shear stress (kPa)	153	281	528
Horizontal displacement (mm)	1.72	7.94	8.92
Vertical movement (mm)	0.04	-0.08	0.15

Particle density (Mg/m ³) Specimens tested dry or submerged	2.65 (Assumed) Submerged

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4,
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

Date: 27/05/2011

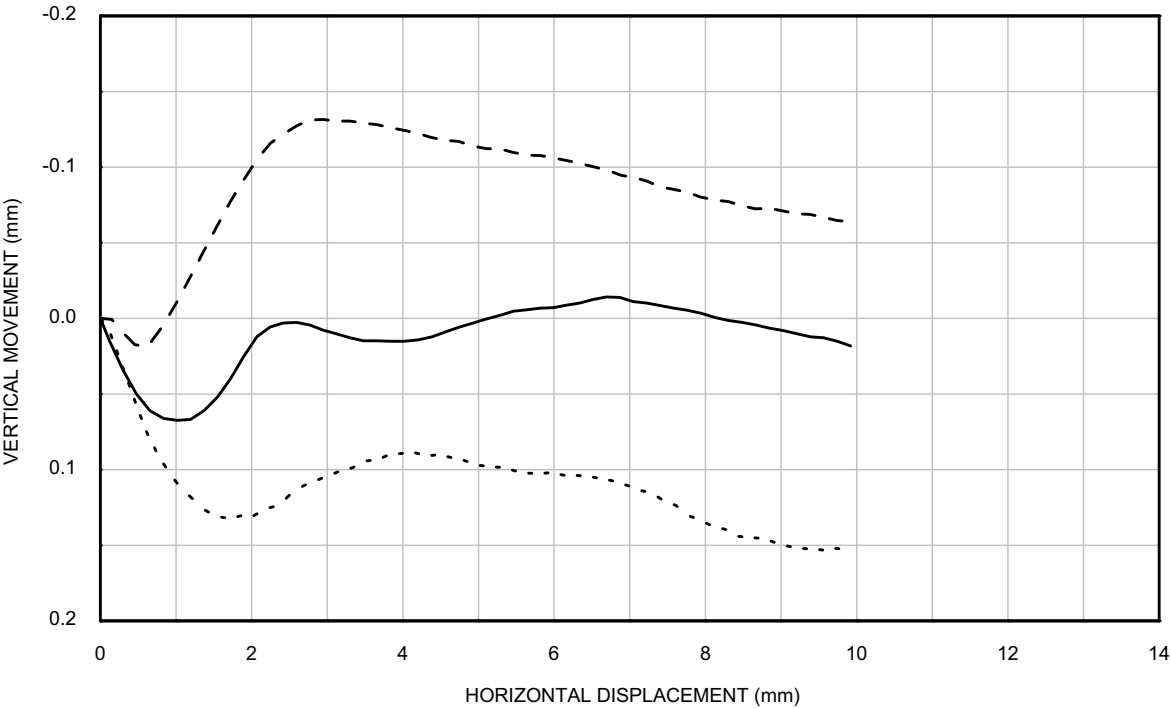
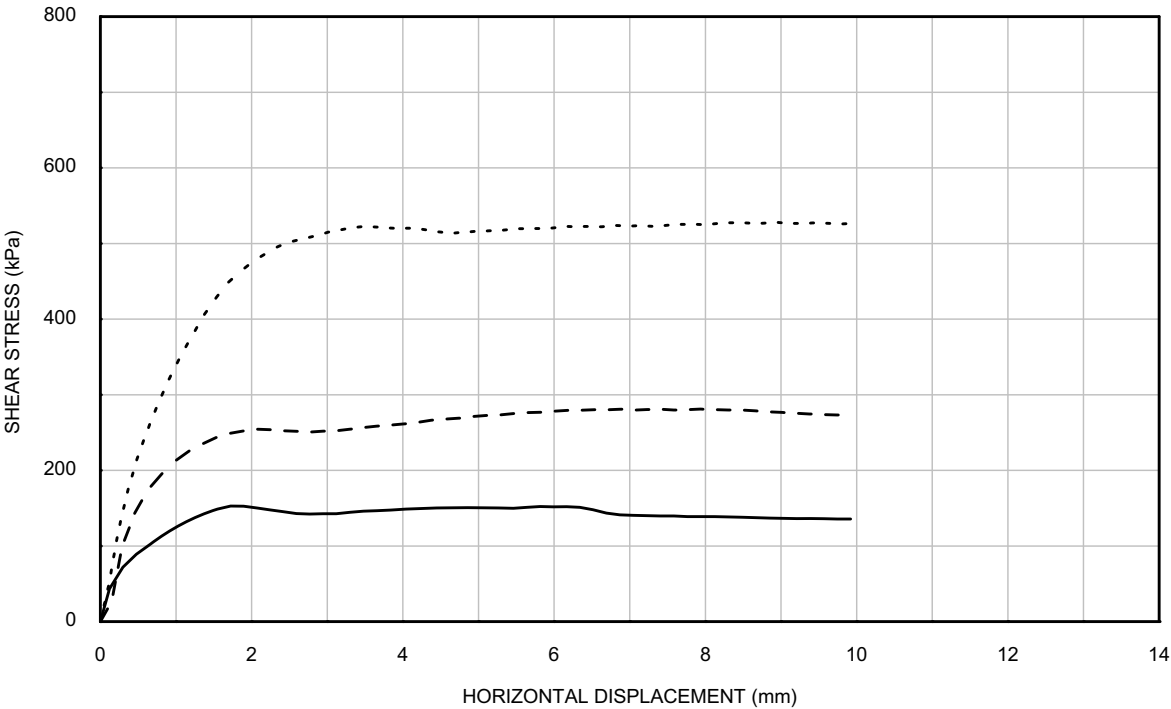
Date: 27/05/2011

Checked by: ALB

Approved by: PH

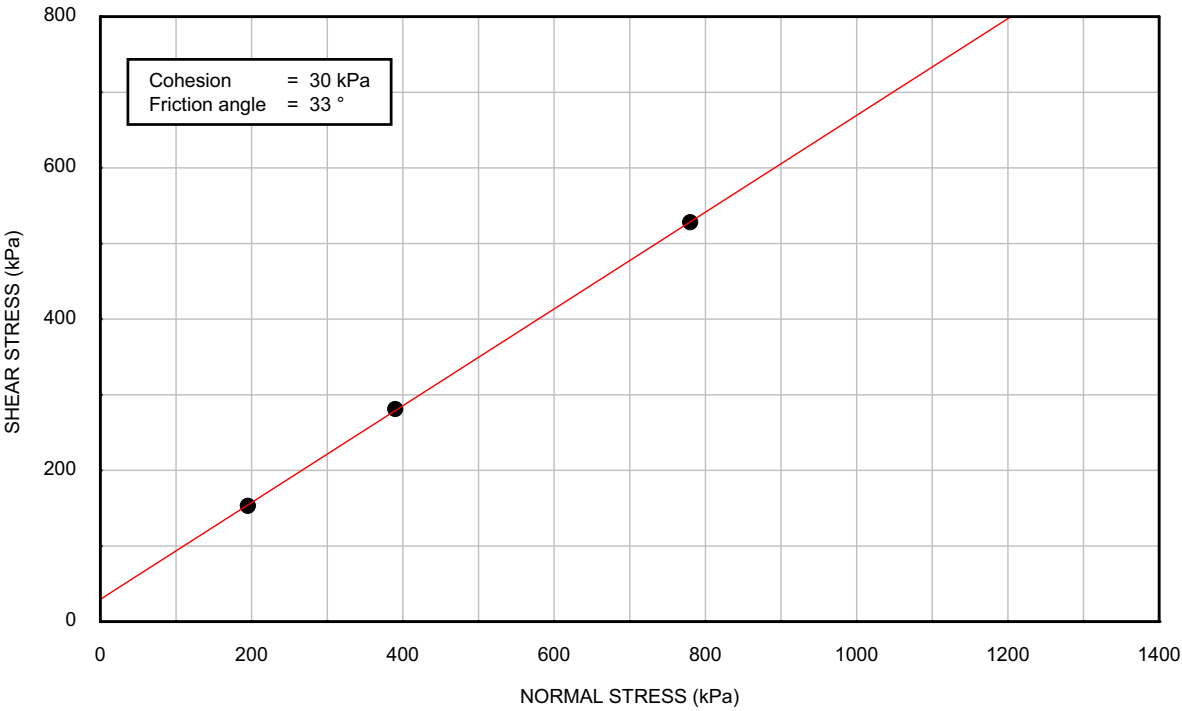
Borehole :	BH_14
Sample :	20BagA
Depth (m) :	42.5

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE



— Specimen 1: Normal stress 195 kPa	Borehole : BH_14
- - - Specimen 2: Normal stress 390 kPa	Sample : 20BagA
. . . Specimen 3: Normal stress 780 kPa	Depth (m) : 42.5

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE



Specimen 1: Normal stress 195 kPa	Borehole : BH_14
Specimen 2: Normal stress 390 kPa	Sample : 20BagA
Specimen 3: Normal stress 780 kPa	Depth (m) : 42.5

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE

Date: 24/05/2011

Drawn by: NAC

Template Issue: 5

Filename: J11056 / Labdata / Shear / BH_04A_2BagB_SB.XLS

SPECIMEN	1	2	3
INITIAL CONDITIONS			
Sample length (mm)	60.0	60.0	60.0
Sample breadth (mm)	60.0	60.0	60.0
Sample height (mm)	24.9	25.0	25.1
Moisture content (%)	13.0	13.0	13.0
Bulk density (Mg/m ³)	1.60	1.59	1.58
Dry density (Mg/m ³)	1.41	1.40	1.40
Voids ratio	0.876	0.887	0.891
Degree of saturation (%)	39	39	39
Rate of displacement (mm/min)	0.016	0.016	0.016
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.873	0.864	0.843
Normal stress (kPa)	15	30	60
Maximum shear stress (kPa)	17	21	37
Horizontal displacement (mm)	1.09	2.37	8.68
Vertical movement (mm)	-0.11	-0.05	1.16

Particle density (Mg/m ³) Specimens tested dry or submerged	2.65 (Assumed) Submerged

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4,
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

Date: 24/05/2011

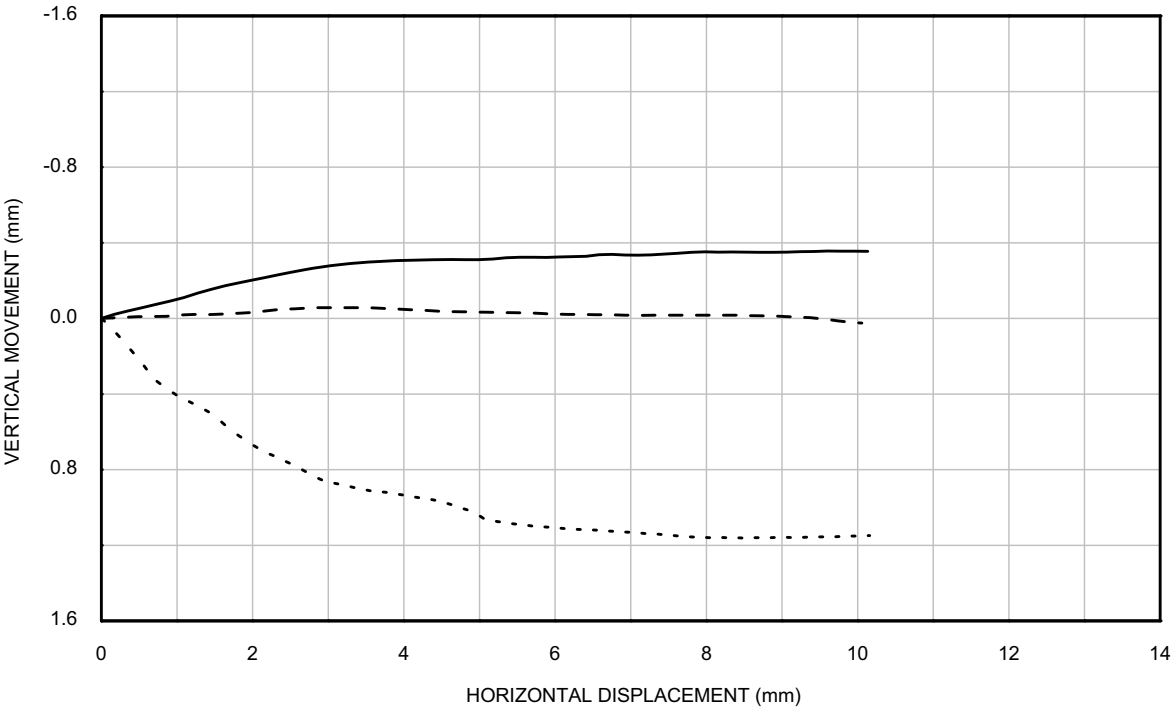
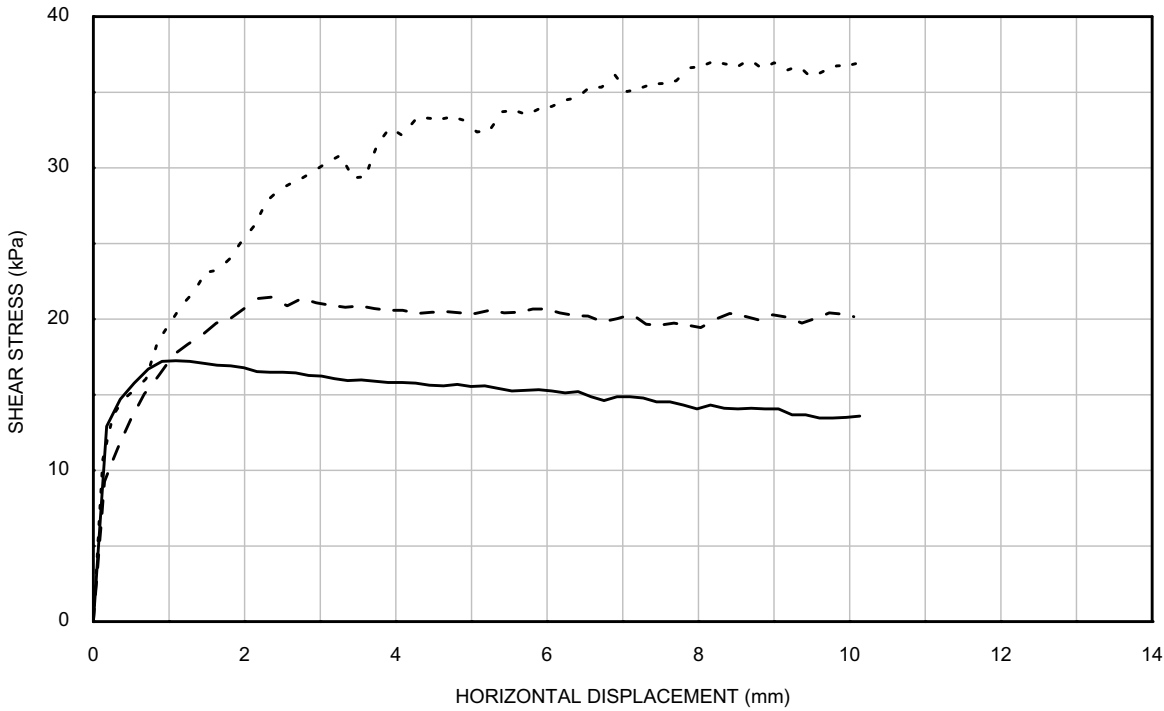
Date: 24/05/2011

Checked by: ALB

Approved by: PH

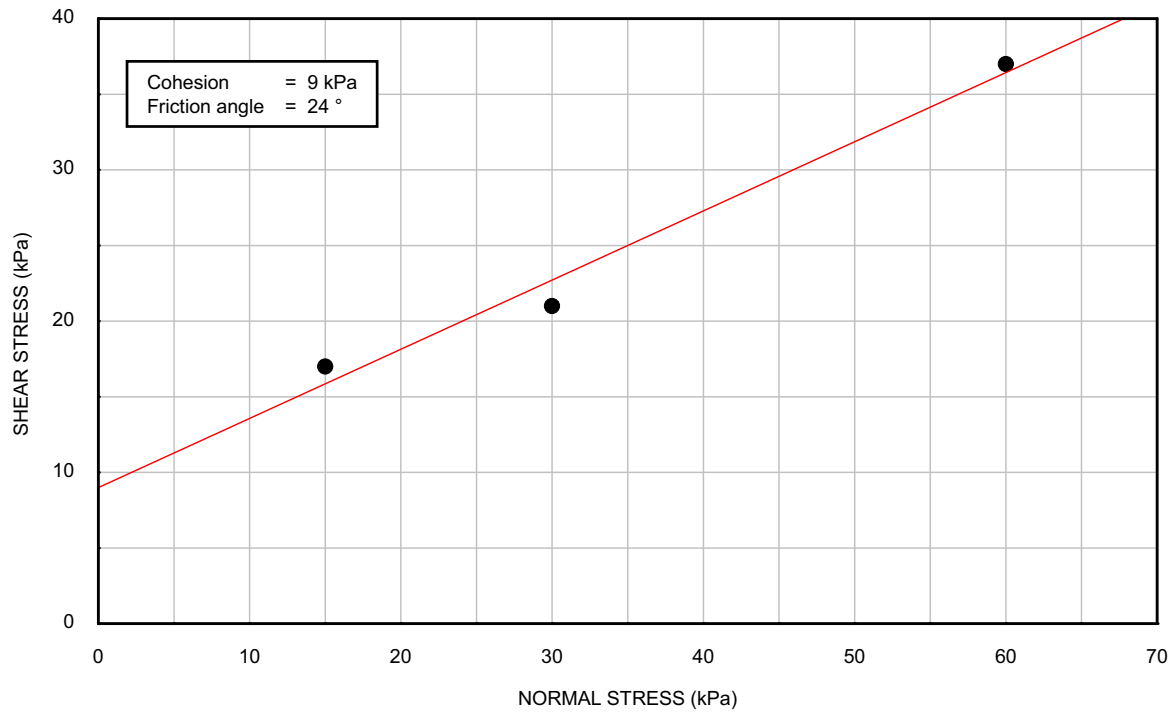
Borehole :	BH_04A
Sample :	2BagB
Depth (m) :	1.10

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE



— Specimen 1: Normal stress 15 kPa	Borehole : BH_04A
- - - Specimen 2: Normal stress 30 kPa	Sample : 2BagB
. . . . Specimen 3: Normal stress 60 kPa	Depth (m) : 1.10

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE



Specimen 1: Normal stress 15 kPa	Borehole : BH_04A
Specimen 2: Normal stress 30 kPa	Sample : 2BagB
Specimen 3: Normal stress 60 kPa	Depth (m) : 1.10

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE

Date: 23/05/2011

Drawn by: PH

Template Issue: 5

Date: 23/05/2011

Checked by: PH

Filename: J11056 / Labdata / Shear / BH_06_32BagA_sb.XLS

Date:

Approved by:

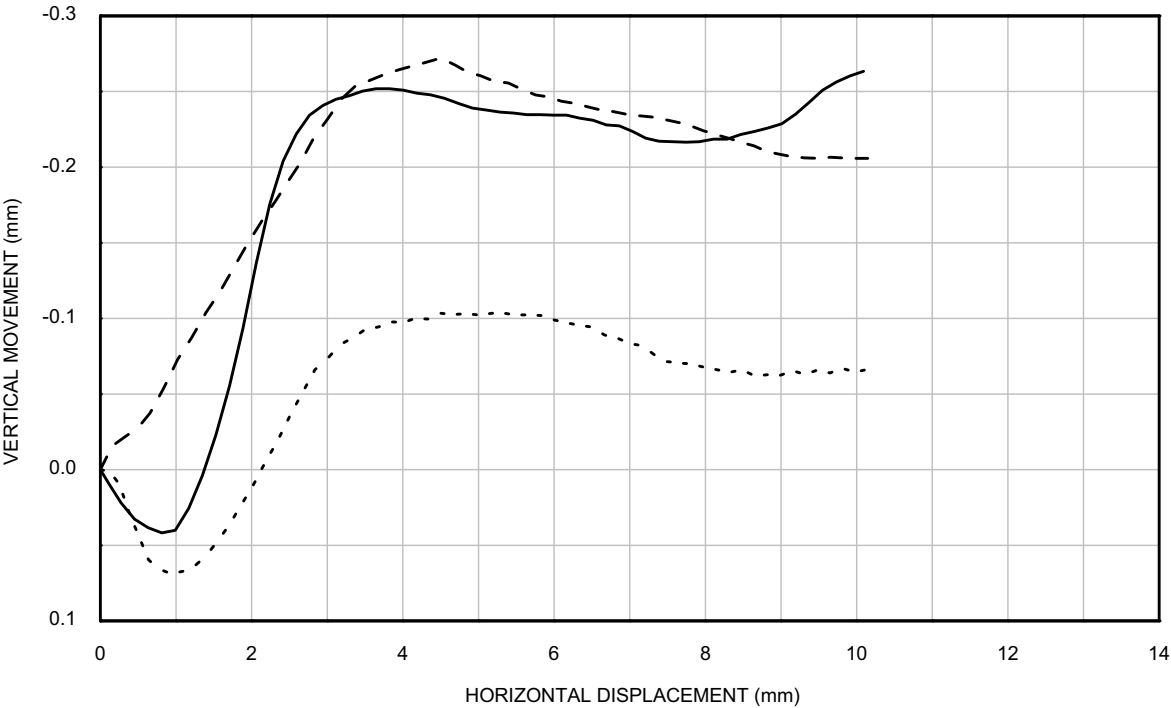
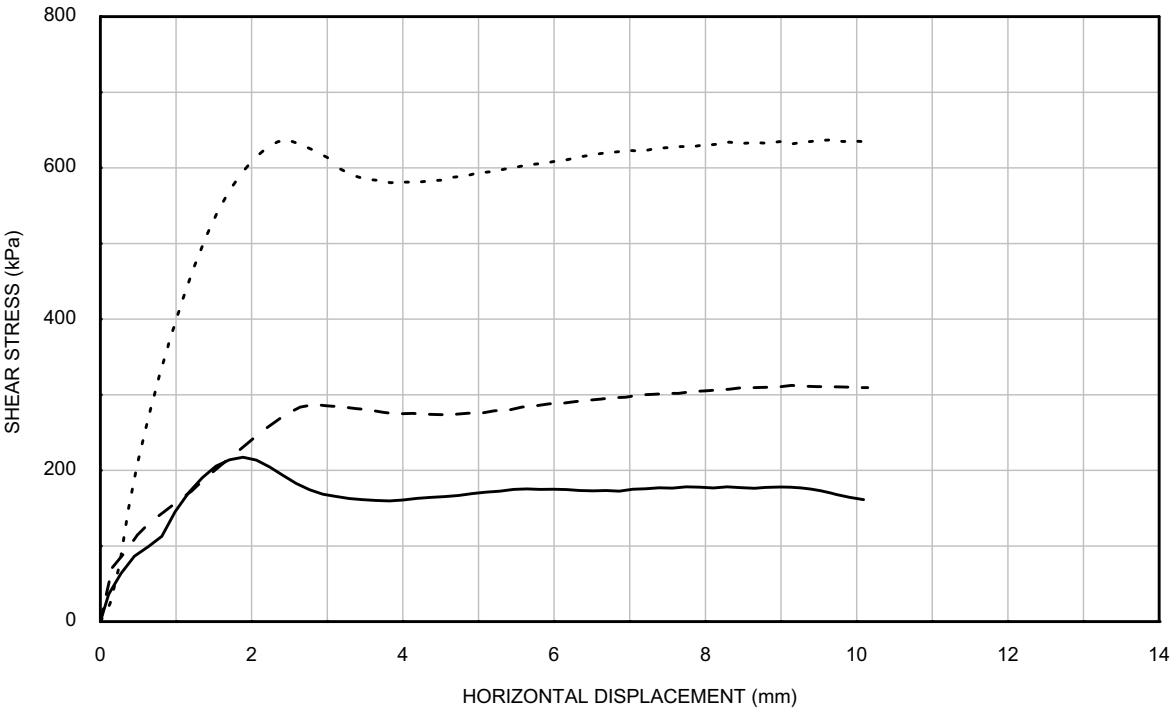
SPECIMEN	1	2	3
INITIAL CONDITIONS			
Sample length (mm)	60.0	60.0	60.0
Sample breadth (mm)	60.0	60.0	60.0
Sample height (mm)	22.1	22.3	22.7
Moisture content (%)	9.9	9.9	9.9
Bulk density (Mg/m ³)	2.38	2.37	2.33
Dry density (Mg/m ³)	2.17	2.15	2.12
Voids ratio	0.222	0.231	0.251
Degree of saturation (%)	100	100	100
Rate of displacement (mm/min)	0.016	0.016	0.016
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.168	0.174	0.195
Normal stress (kPa)	225	450	900
Maximum shear stress (kPa)	217	312	637
Horizontal displacement (mm)	1.89	9.14	9.65
Vertical movement (mm)	-0.09	-0.21	-0.06

Particle density (Mg/m ³) Specimens tested dry or submerged	2.65 (Assumed) Submerged

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4,
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

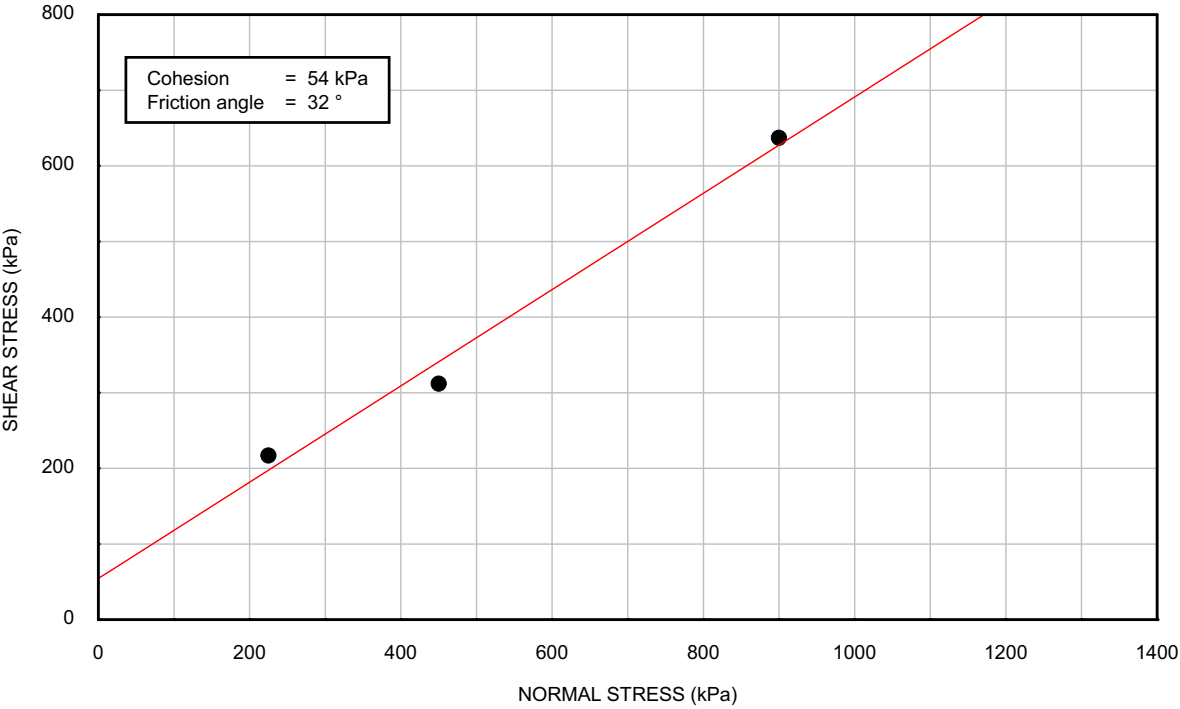
Borehole :	BH_06
Sample :	32BagA
Depth (m) :	45.00

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE



— Specimen 1: Normal stress 225 kPa	Borehole : BH_06
- - - Specimen 2: Normal stress 450 kPa	Sample : 32BagA
. . . Specimen 3: Normal stress 900 kPa	Depth (m) : 45.00

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE



Specimen 1: Normal stress 225 kPa	Borehole : BH_06
Specimen 2: Normal stress 450 kPa	Sample : 32BagA
Specimen 3: Normal stress 900 kPa	Depth (m) : 45.00

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE

Date: 23/05/2011

Drawn by: NAC

Template Issue: 5

Date: 24/05/2011

Checked by: PH

Filename: J11056 / Labdata / Shear / BH_16_4BagA_sb.XLS

Date:

Approved by:

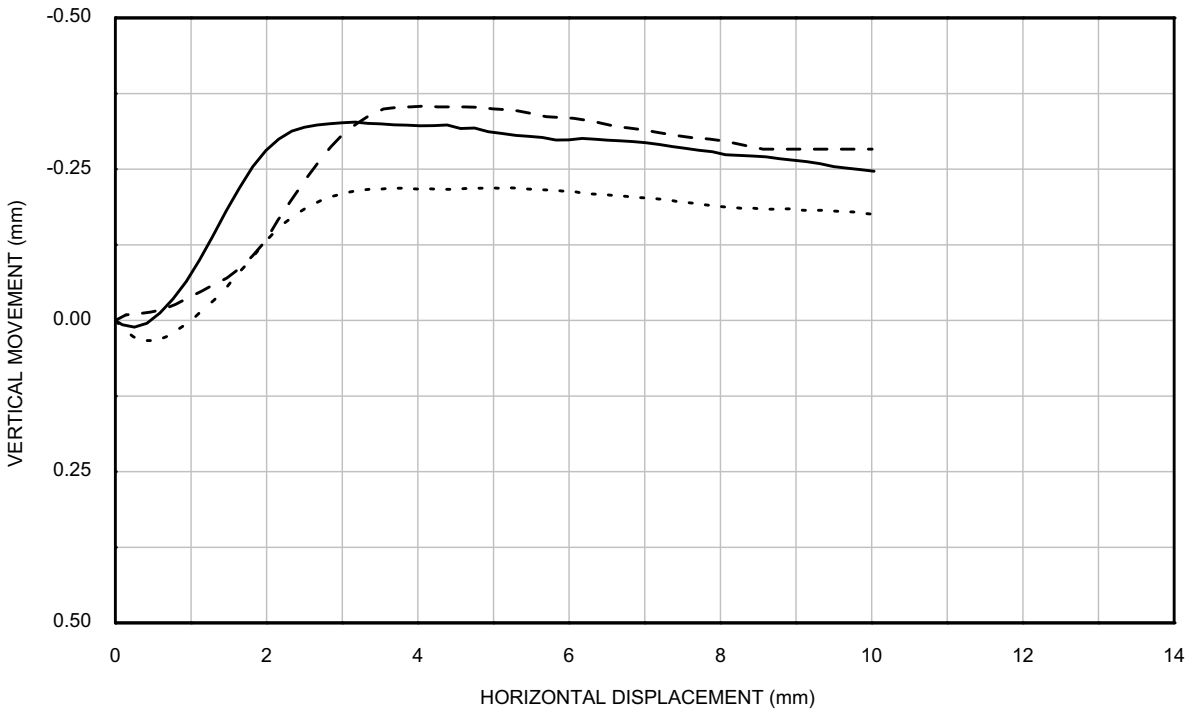
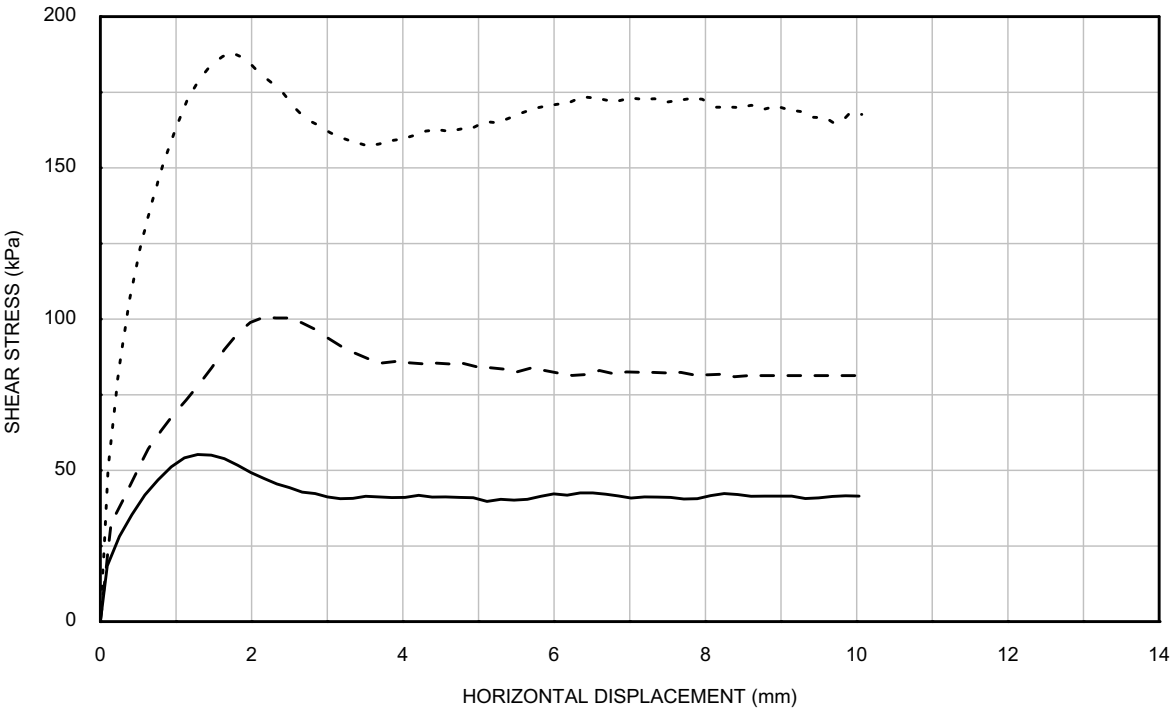
SPECIMEN	1	2	3
INITIAL CONDITIONS			
Sample length (mm)	60.0	60.0	60.0
Sample breadth (mm)	60.0	60.0	60.0
Sample height (mm)	25.0	24.8	25.0
Moisture content (%)	9.4	9.4	9.4
Bulk density (Mg/m ³)	1.94	1.96	1.93
Dry density (Mg/m ³)	1.77	1.79	1.77
Voids ratio	0.498	0.483	0.500
Degree of saturation (%)	50	52	50
Rate of displacement (mm/min)	0.9	0.9	0.9
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.480	0.430	0.449
Normal stress (kPa)	60	120	240
Maximum shear stress (kPa)	55	101	188
Horizontal displacement (mm)	1.29	2.15	1.77
Vertical movement (mm)	-0.14	-0.17	-0.10

Particle density (Mg/m ³) Specimens tested dry or submerged	2.65 (Assumed) Submerged

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4,
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

Borehole :	BH_16
Sample :	4BagA
Depth (m) :	15.00

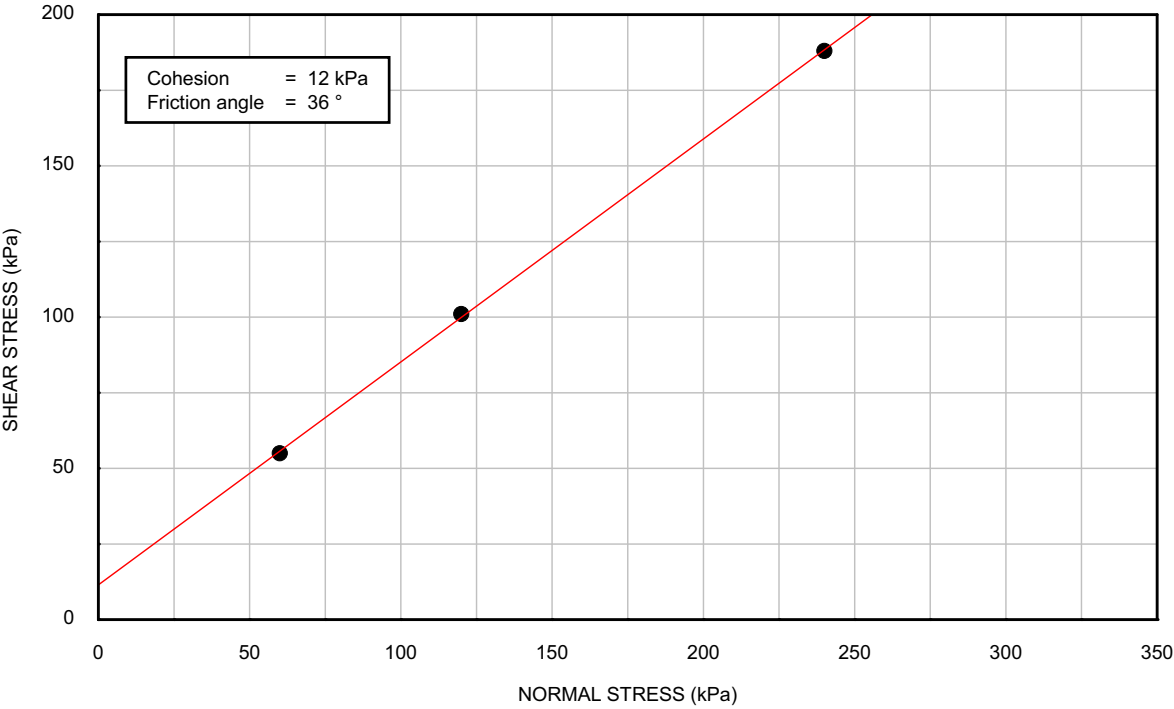
DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE



— Specimen 1: Normal stress 60 kPa	Borehole : BH_16
- - - Specimen 2: Normal stress 120 kPa	Sample : 4BagA
. . . Specimen 3: Normal stress 240 kPa	Depth (m) : 15.00

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE

Drawn by: NAC Date: 23/05/2011
Template Issue: 4
Filename: J11056 / Labdata / Shear / BH_16_4BagA_sb.OPJ
Date: 24/05/2011
Date:
Checked by: PH
Approved by:



Specimen 1: Normal stress 60 kPa	Borehole : BH_16
Specimen 2: Normal stress 120 kPa	Sample : 4BagA
Specimen 3: Normal stress 240 kPa	Depth (m) : 15.00

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - SOIL INTERFACE

Drawn by: NAC Date: 23/05/2011
Template Issue: 4
Filename: J11056 / Labdata / Shear / BH_16_4BagA_sb.OPJ
Date : 24/05/2011
Date :
Checked by: PH
Approved by:

Date: 26/05/2011

Drawn by: NAC

Template Issue: 5

Filename: J11056 / Labdata / Shear / BH_16_10BagA & 11BagA_SB.XLS

SPECIMEN	1	2	3
INITIAL CONDITIONS			
Sample length (mm)	60.0	60.0	60.0
Sample breadth (mm)	60.0	60.0	60.0
Sample height (mm)	20.4	21.1	21.0
Moisture content (%)	9.3	9.3	9.3
Bulk density (Mg/m ³)	1.94	1.87	1.88
Dry density (Mg/m ³)	1.77	1.71	1.72
Voids ratio	0.495	0.546	0.540
Degree of saturation (%)	50	45	46
Rate of displacement (mm/min)	0.9	0.9	0.9
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.476	0.506	0.509
Normal stress (kPa)	100	200	400
Maximum shear stress (kPa)	67	114	262
Horizontal displacement (mm)	5.56	1.94	6.19
Vertical movement (mm)	-0.11	-0.15	-0.19

Particle density (Mg/m ³) Specimens tested dry or submerged	2.65 (Assumed) Submerged

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4,
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

Date: 27/05/2011

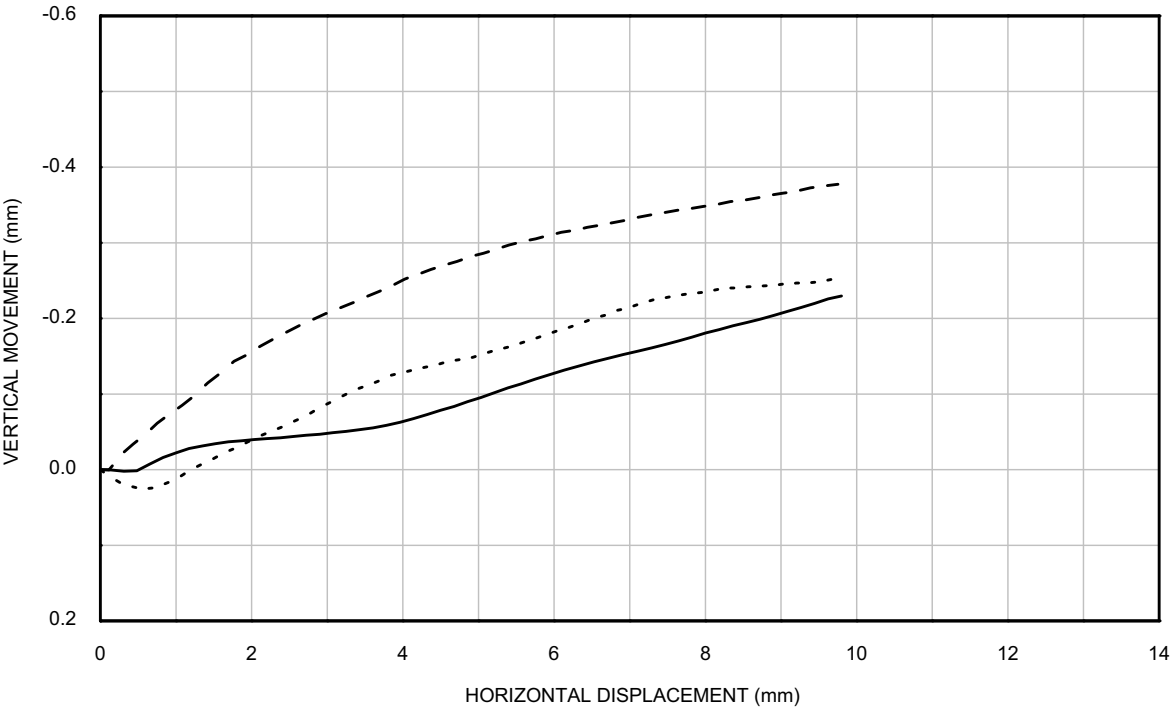
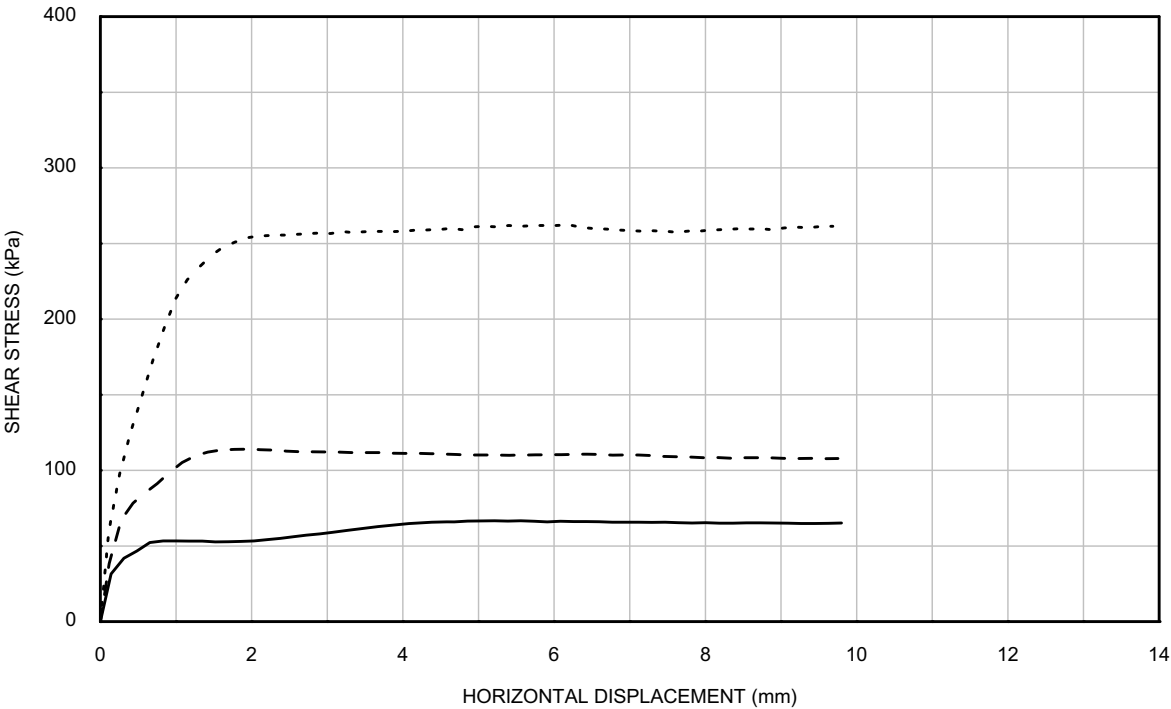
Date: 27/05/2011

Checked by: ALB

Approved by: PH

Borehole :	BH_16
Sample :	10 & 11BagA
Depth (m) :	23.50

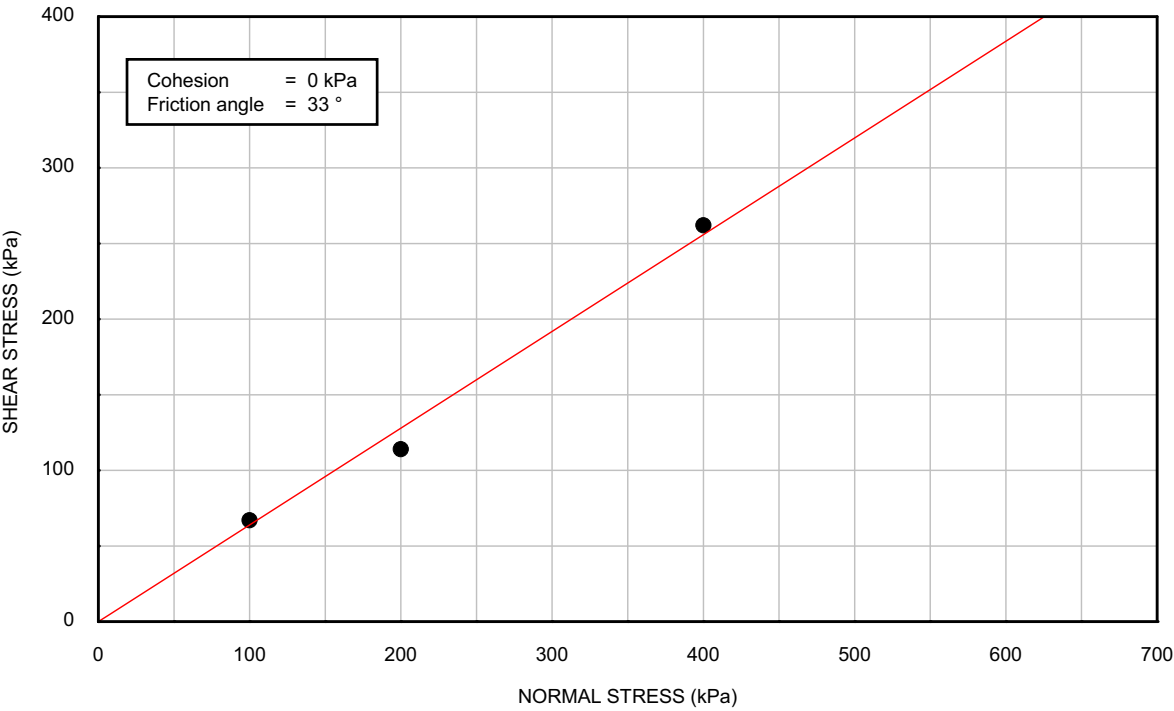
DIRECT SHEAR TEST STANDARD SHEAR BOX: SOIL - STEEL INTERFACE



— Specimen 1: Normal stress 100 kPa	Borehole : BH_16
- - - Specimen 2: Normal stress 200 kPa	Sample : 10 & 11BagA
. . . Specimen 3: Normal stress 400 kPa	Depth (m) : 23.50

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - STEEL INTERFACE

Drawn by: NAC Date: 26/05/2011
Template Issue: 4
Filename: J11056 / Labdata / Shear / BH_16_10BagA & 11BagA_SB.OPJ
Date : 27/05/2011
Date : 27/05/2011
Checked by: ALB
Approved by: PH



Specimen 1: Normal stress 100 kPa	Borehole : BH_16
Specimen 2: Normal stress 200 kPa	Sample : 10 & 11BagA
Specimen 3: Normal stress 400 kPa	Depth (m) : 23.50

DIRECT SHEAR TEST
STANDARD SHEAR BOX: SOIL - STEEL INTERFACE

Template Issue: 4
Filename: J11056 / Labdata / Shear / BH_16_10BagA & 11BagA_SB.OPJ
Checked by: ALB
Approved by: PH
Date : 27/05/2011
Date : 27/05/2011
Drawn by: NAC
Date: 26/05/2011

Date: 24/06/2011

Drawn by: PH

Template Issue: 1

Filename: J11056 / Labdata / Shear / BH_13_10BagA_sbr3.XLS

SPECIMEN	1	2	3
INITIAL SPECIMEN CONDITIONS			
Sample Length (mm)	60.0	60.0	60.0
Sample Breadth (mm)	60.0	60.0	60.0
Sample Height (mm)	21.9	22.1	22.0
Moisture content (%)	10	10	10
Bulk density (Mg/m ³)	1.96	1.96	1.97
Dry density (Mg/m ³)	1.77	1.78	1.79
Voids ratio	0.495	0.490	0.482
Degree of saturation (%)	55	56	57
Rate of displacement (mm/min)	0.9	0.9	0.9
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.493	0.431	0.467
Normal stress (kPa)	95	190	380
Maximum shear stress (kPa)	126	147	271
Horizontal displacement (mm)	10.24	2.49	2.80
Vertical movement (mm)	-0.327	-0.349	-0.106
REVERSAL STAGES			
Number of traverses	4	4	4
Final cumulative displacement (mm)	50.55	50.43	53.34
Residual shear stress (kPa)	58	107	238
Particle Density (Mg/m ³)		2.65 (Assumed)	
Specimens tested dry or submerged		Submerged	

Date: 22/06/2011

Checked by: PH

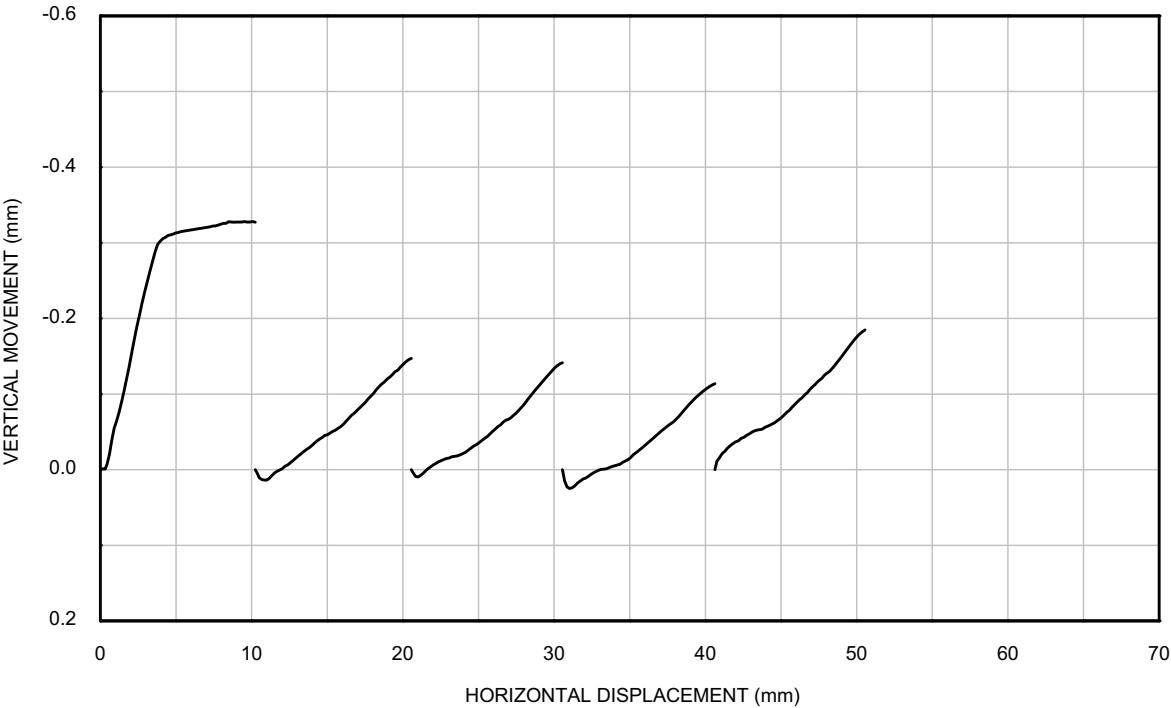
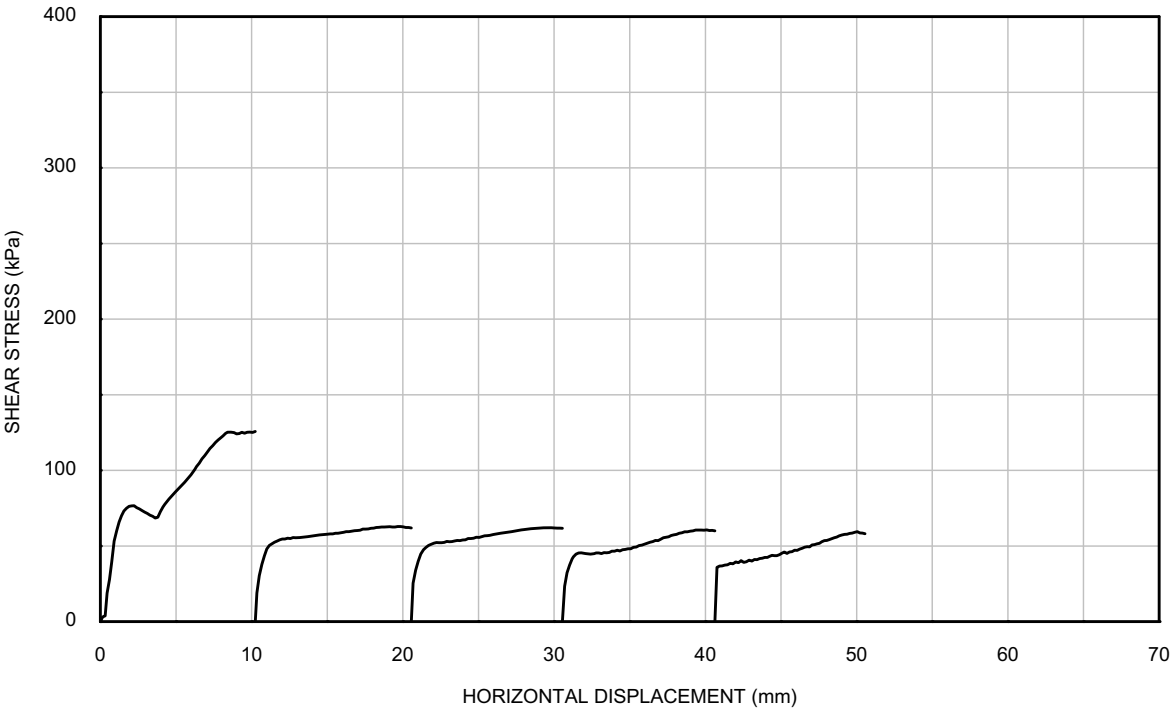
Date:

Approved by:

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4.5.5
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

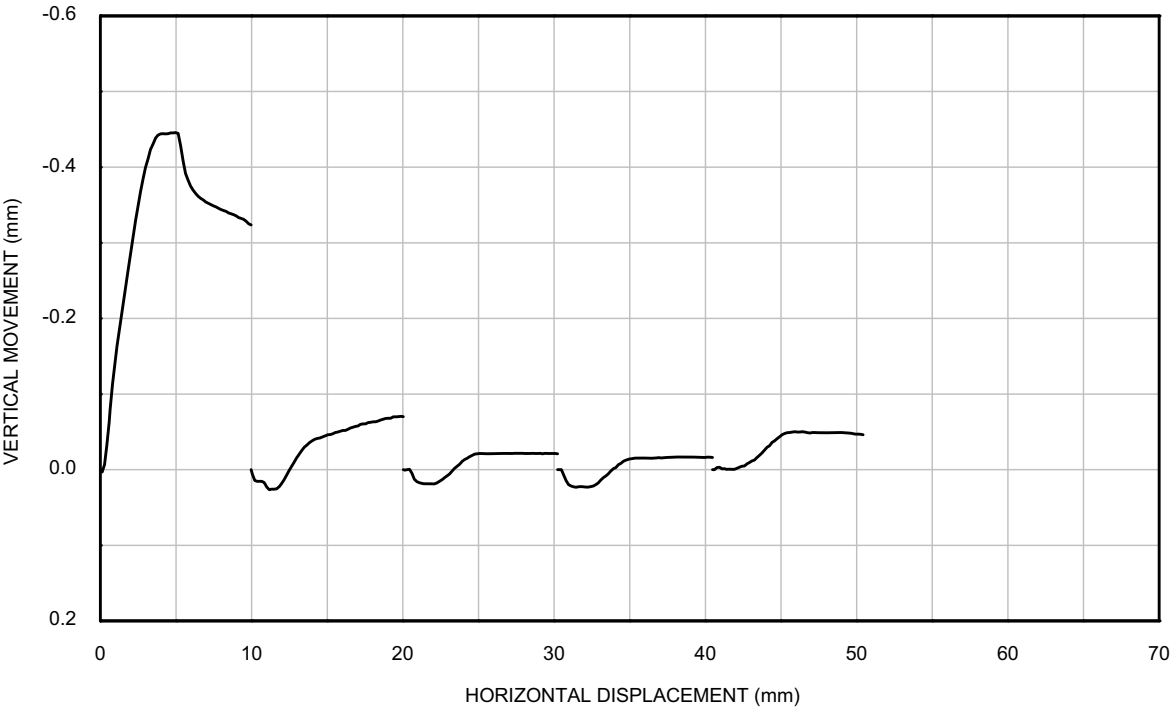
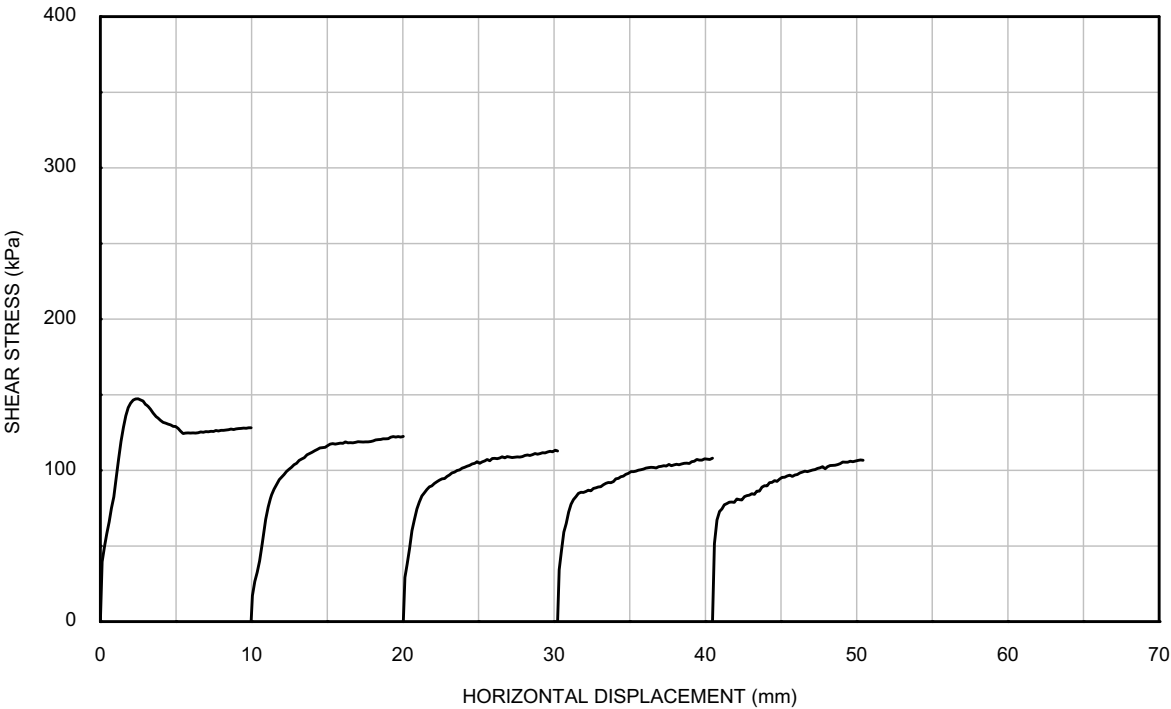
Borehole :	BH_13
Sample :	10BagA
Depth (m) :	20.00

DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX SET OF THREE
SOIL - STEEL INTERFACE



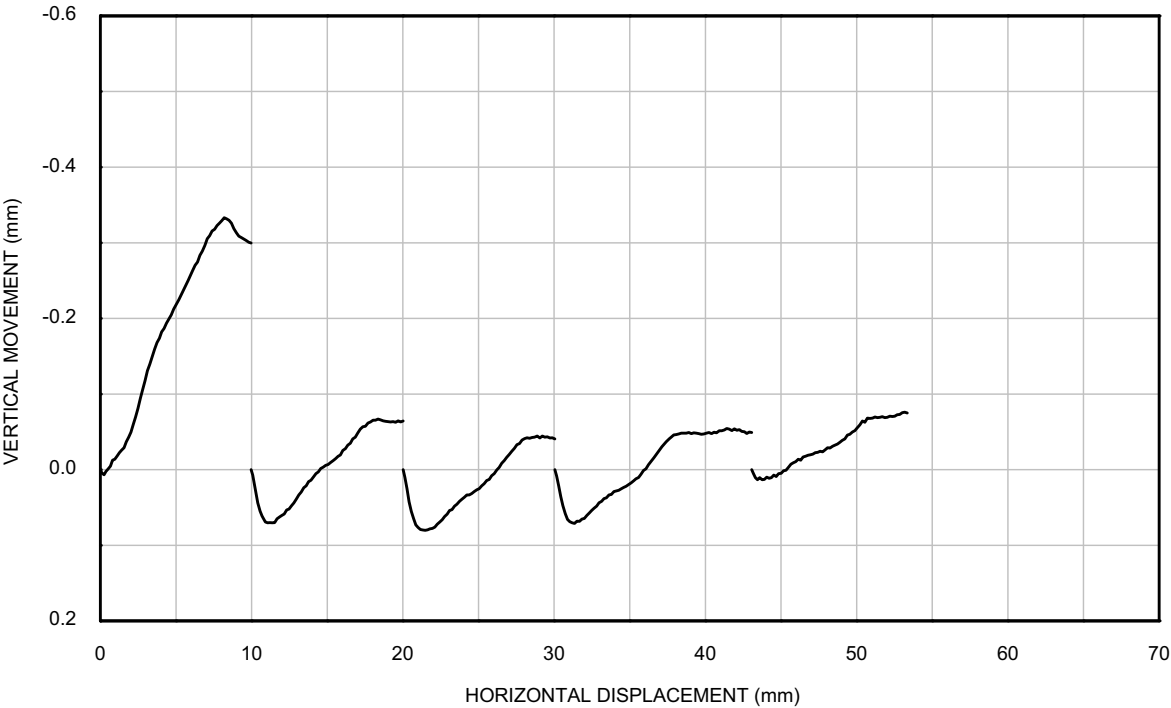
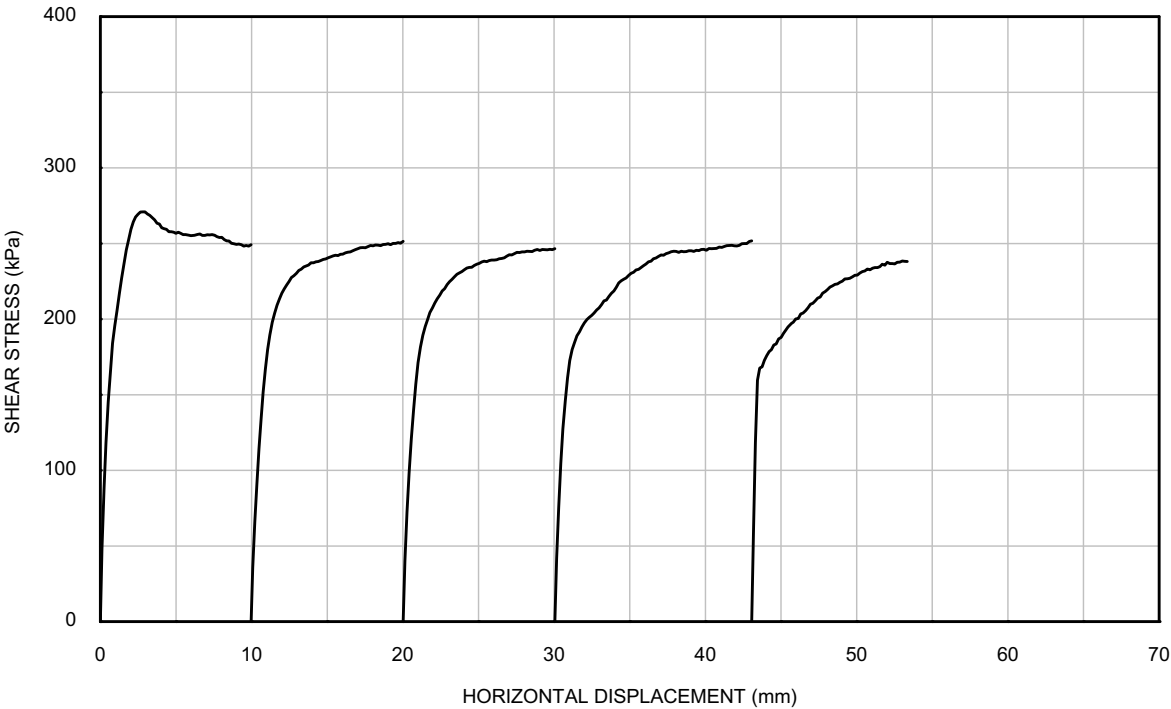
— Specimen 1: Normal stress 95 kPa	Borehole : BH_13
— Specimen 2: Normal stress 190 kPa	Sample : 10BagA
— Specimen 3: Normal stress 380 kPa	Depth (m) : 20.00

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX SET OF THREE - STAGE 1
SOIL - STEEL INTERFACE**



— Specimen 1: Normal stress 95 kPa	Borehole : BH_13
— Specimen 2: Normal stress 190 kPa	Sample : 10BagA
— Specimen 3: Normal stress 380 kPa	Depth (m) : 20.00

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX - STAGE 2
SOIL - STEEL INTERFACE**

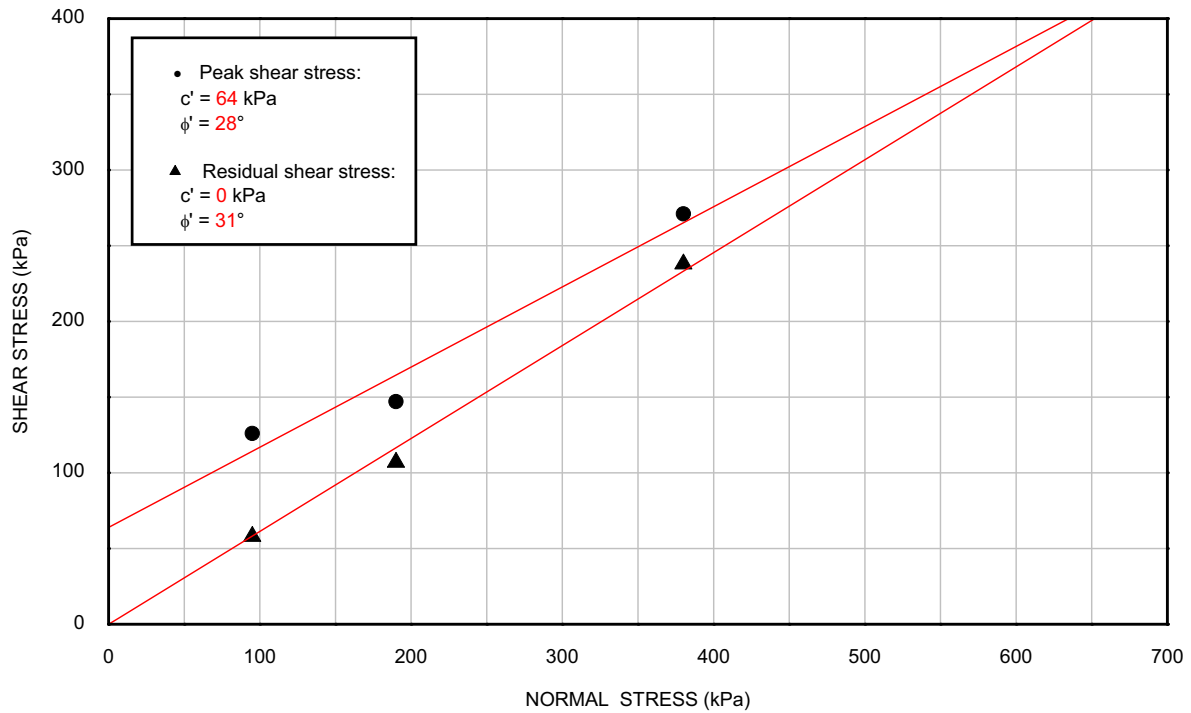


— Specimen 1: Normal stress 95 kPa	Borehole : BH_13
— Specimen 2: Normal stress 190 kPa	Sample : 10BagA
— Specimen 3: Normal stress 380 kPa	Depth (m) : 20.00

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX - STAGE 3
SOIL - STEEL INTERFACE**



Drawn by: PH
Date: 24/06/2011
Template Issue: 4
Filename: BH_13_10BagA_sbr3.OPJ
Date: 24/06/2011
Date:
Checked by: PH
Approved by:



SHEARING		Shear Stage 1	Shear Stage 2	Shear Stage 3
Rate of displacement	(mm / min)	0.9	0.9	0.9
Normal stress	(kPa)	95	190	380
Peak shear stress	(kPa)	126	147	271
Residual shear stress	(kPa)	58	107	238
Horizontal displacement at end of residual stage	(mm)	50.55	50.43	53.34

BOREHOLE : BH_13
SAMPLE : 10BagA
DEPTH (m) : 20.00

DETERMINATION OF RESIDUAL STRENGTH USING
MULTI-REVERSAL SHEAR BOX SET OF THREE

Date: 22/06/2011

Drawn by: PH

Template Issue: 1

Filename: J11056 / Labdata / Shear / BH_13_11BagA_sbr3.XLS

SPECIMEN	1	2	3
INITIAL SPECIMEN CONDITIONS			
Sample Length (mm)	60.0	60.0	60.0
Sample Breadth (mm)	60.0	60.0	60.0
Sample Height (mm)	21.9	21.9	22.1
Moisture content (%)	10	10	10
Bulk density (Mg/m ³)	1.97	1.98	1.97
Dry density (Mg/m ³)	1.78	1.79	1.79
Voids ratio	0.513	0.507	0.512
Degree of saturation (%)	54	55	54
Rate of displacement (mm/min)	0.9	0.9	0.9
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.488	0.468	0.458
Normal stress (kPa)	100	200	400
Maximum shear stress (kPa)	65	141	272
Horizontal displacement (mm)	8.45	5.02	9.93
Vertical movement (mm)	-0.214	-0.250	-0.283
REVERSAL STAGES			
Number of traverses	4	4	4
Final cumulative displacement (mm)	55.66	56.50	57.05
Residual shear stress (kPa)	55	96	254
Particle Density (Mg/m ³)	2.70 (Assumed)		
Specimens tested dry or submerged	Submerged		

Date: 22/06/2011

Checked by: PH

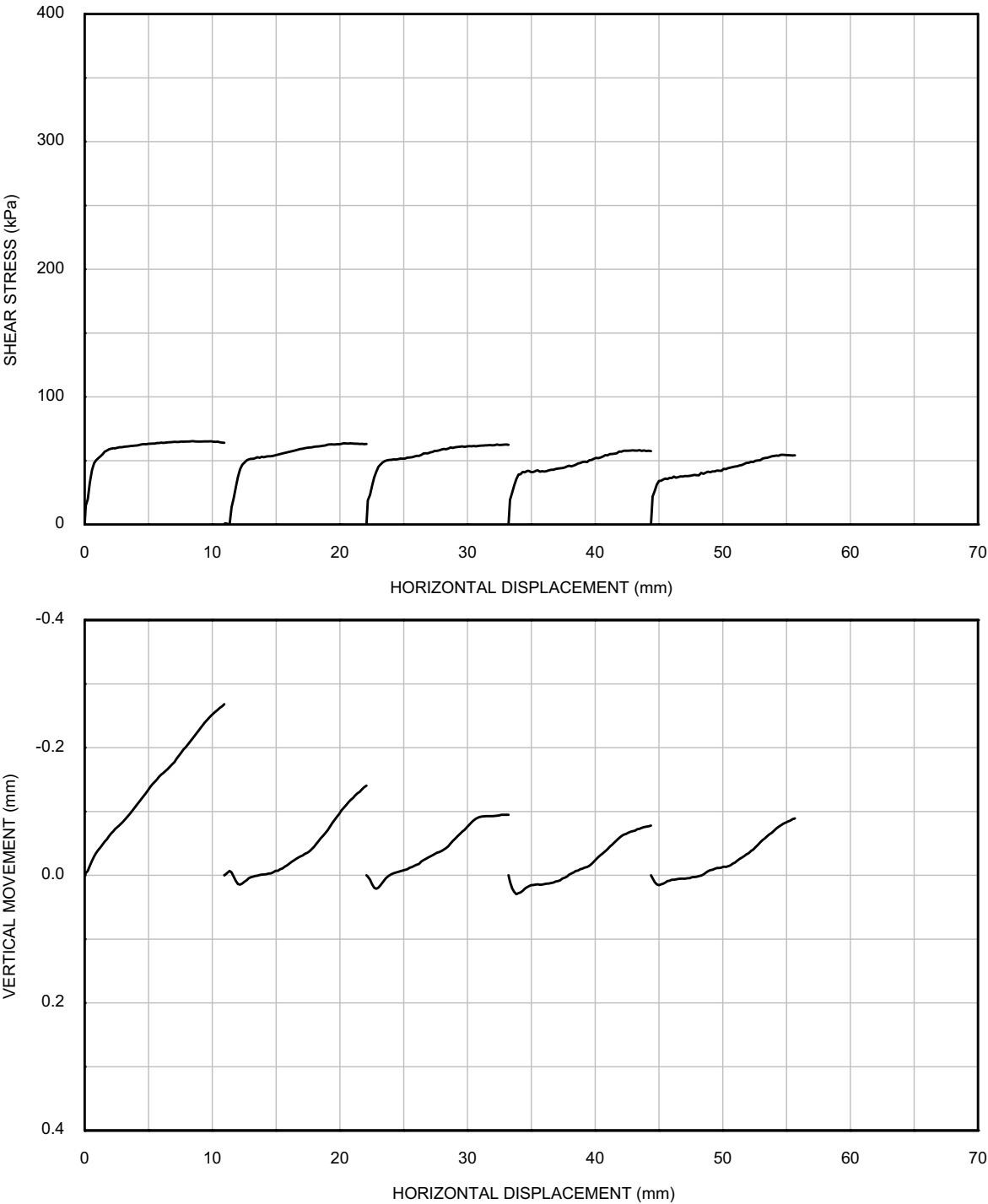
Date:

Approved by:

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4.5.5
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

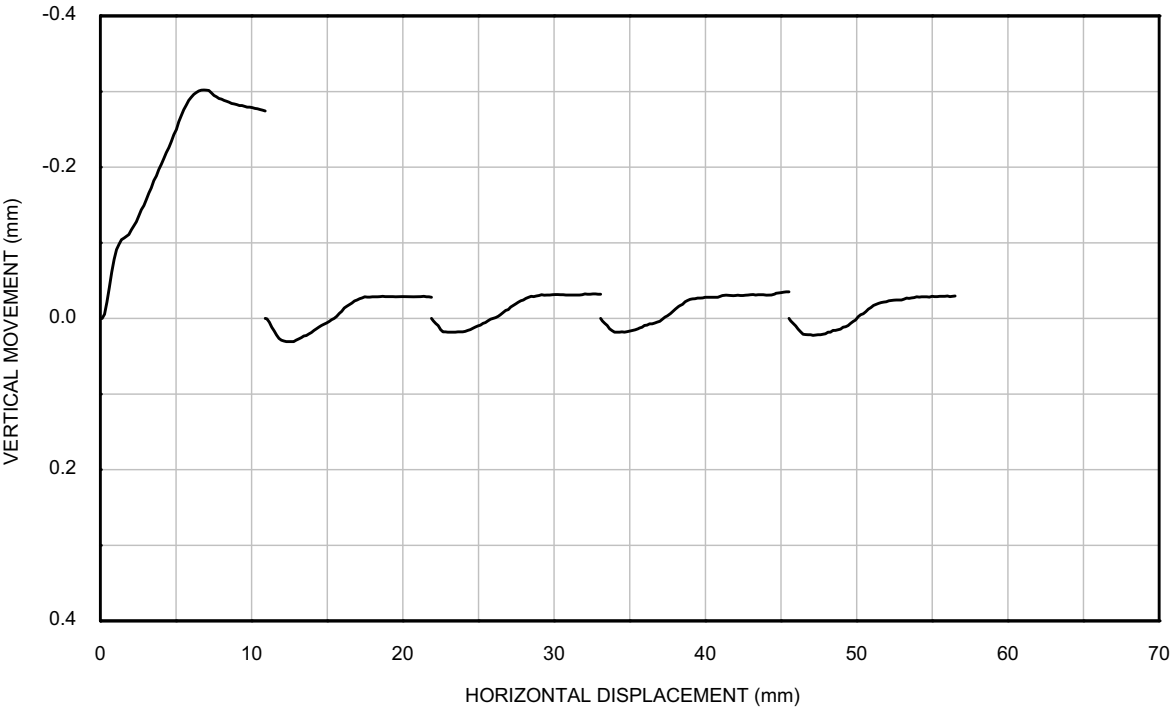
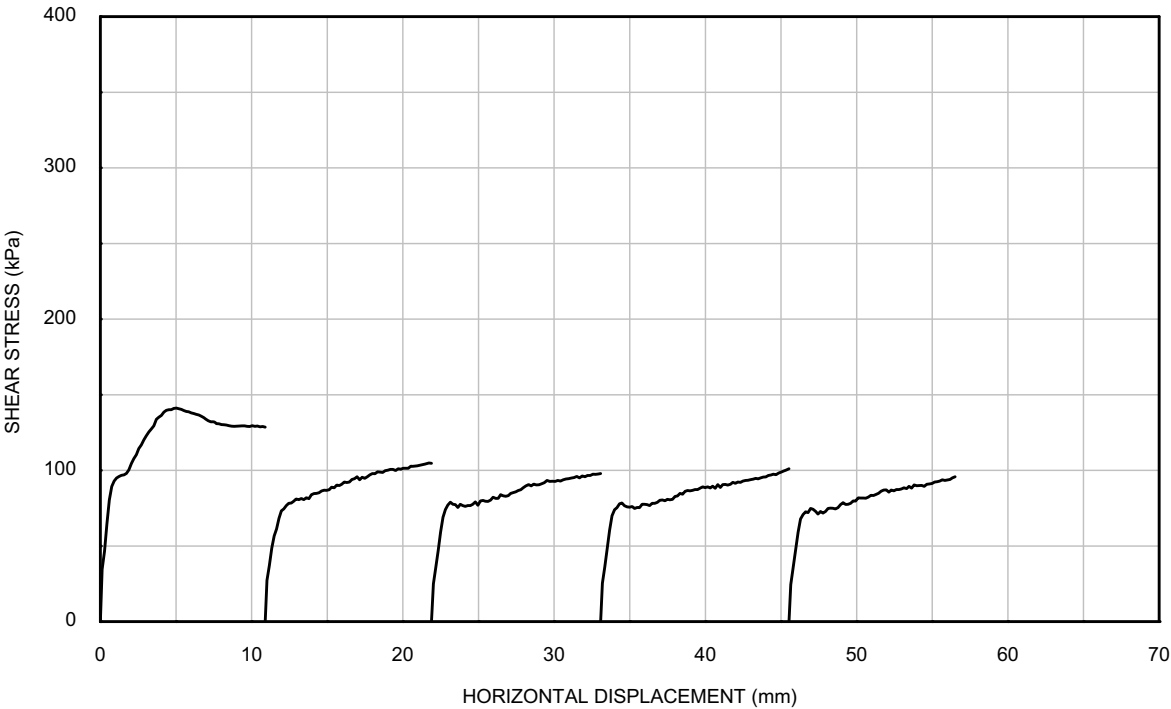
Borehole : BH_13
Sample : 11BagA
Depth (m) : 20.50

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX SET OF THREE
SOIL - STEEL INTERFACE**



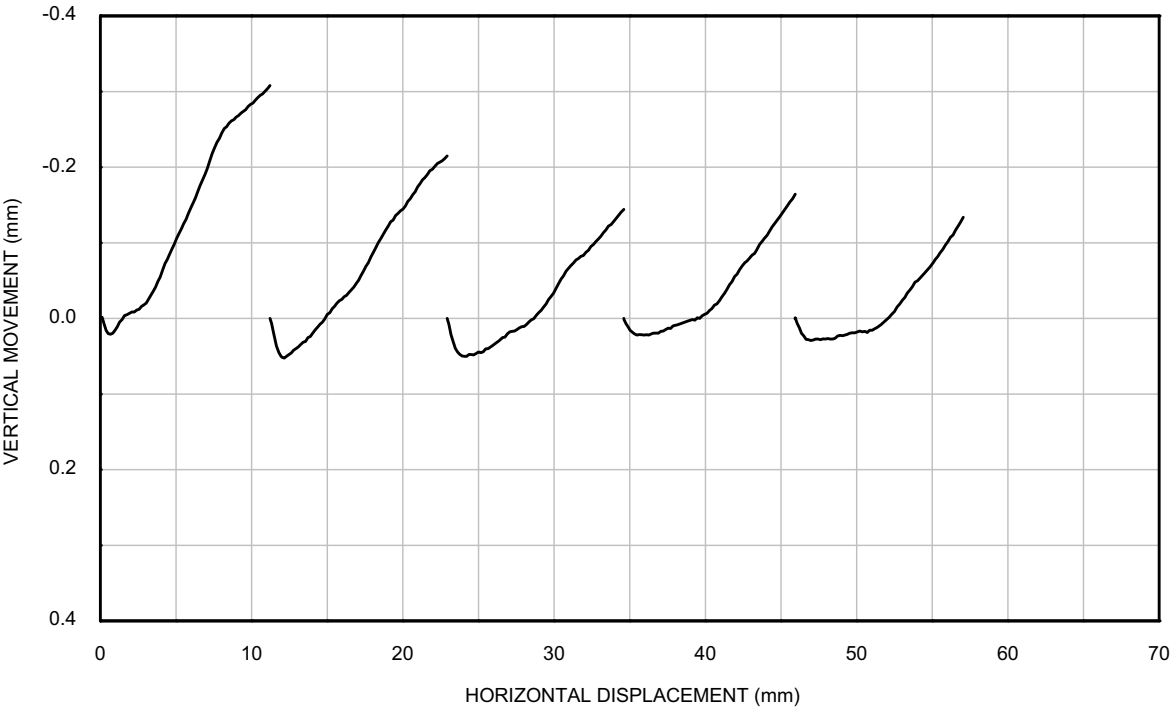
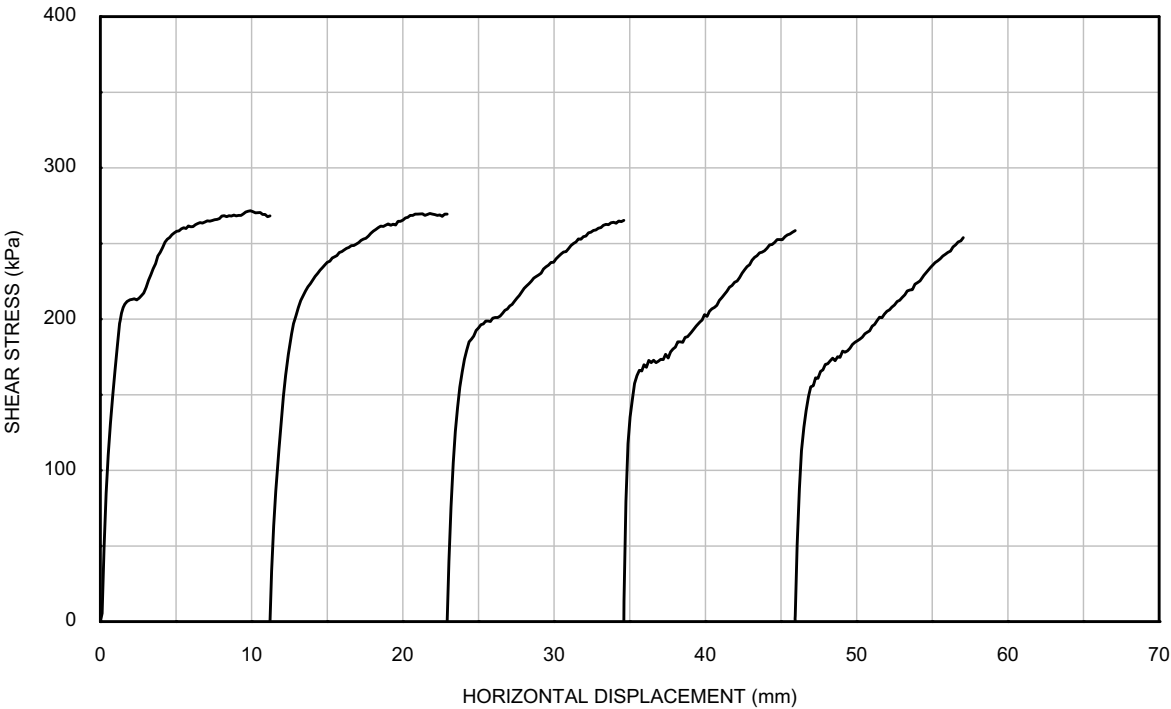
— Specimen 1: Normal stress 100 kPa	Borehole : BH_13
— Specimen 2: Normal stress 200 kPa	Sample : 11BagA
— Specimen 3: Normal stress 400 kPa	Depth (m) : 20.50

DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX SET OF THREE - STAGE 1
SOIL - STEEL INTERFACE



— Specimen 1: Normal stress 100 kPa	Borehole : BH_13
— Specimen 2: Normal stress 200 kPa	Sample : 11BagA
— Specimen 3: Normal stress 400 kPa	Depth (m) : 20.50

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX - STAGE 2
SOIL - STEEL INTERFACE**

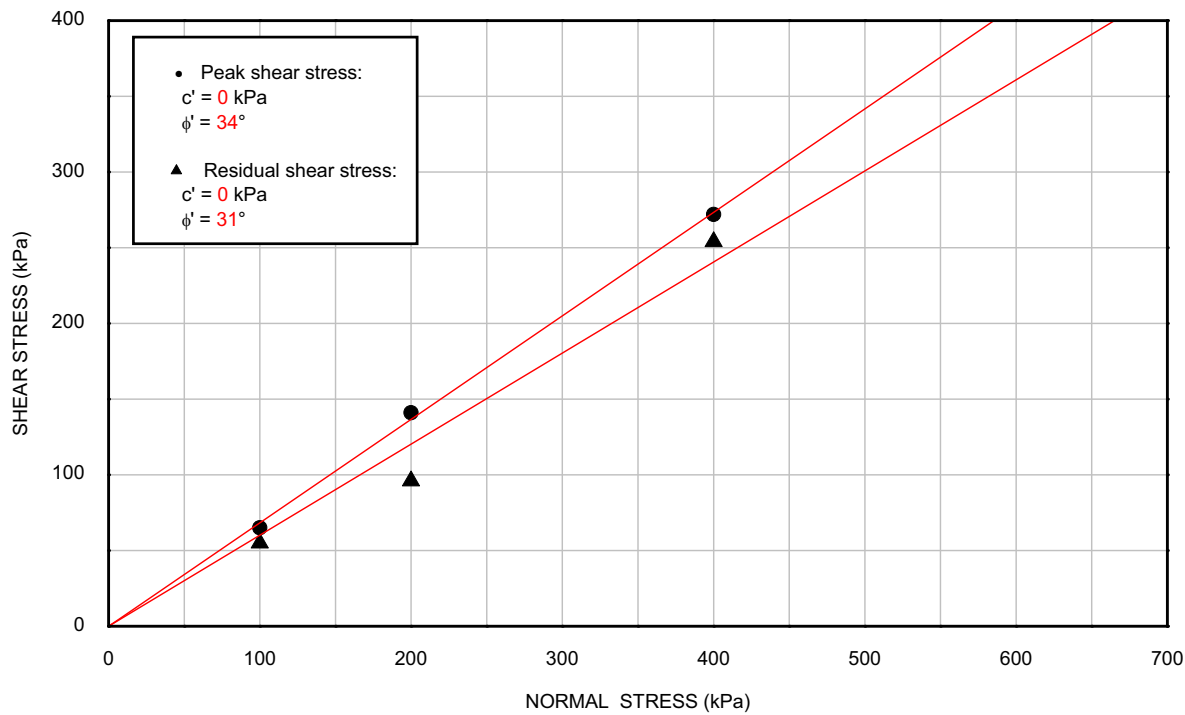


— Specimen 1: Normal stress 100 kPa	Borehole : BH_13
— Specimen 2: Normal stress 200 kPa	Sample : 11BagA
— Specimen 3: Normal stress 400 kPa	Depth (m) : 20.50

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX - STAGE 3
SOIL - STEEL INTERFACE**



Drawn by: PH
Date: 22/06/2011



Template Issue: 4
Filename: BH_13_11BagA_sbr3.OPJ

Date :
Date :

Checked by:
Approved by:

SHEARING		Shear Stage 1	Shear Stage 2	Shear Stage 3
Rate of displacement	(mm / min)	0.9	0.9	0.9
Normal stress	(kPa)	100	200	400
Peak shear stress	(kPa)	65	141	272
Residual shear stress	(kPa)	55	96	254
Horizontal displacement at end of residual stage	(mm)	55.66	56.50	57.05

BOREHOLE	: BH_13
SAMPLE	: 11BagA
DEPTH (m)	: 20.50

DETERMINATION OF RESIDUAL STRENGTH USING
MULTI-REVERSAL SHEAR BOX SET OF THREE

Drawn by: ALB Date: 29/06/2011

Template Issue: 1

Filename: J11056 / Labdata / Shear / BH_14_1BagA.XLS

Date: 22/06/2011

Checked by: PH

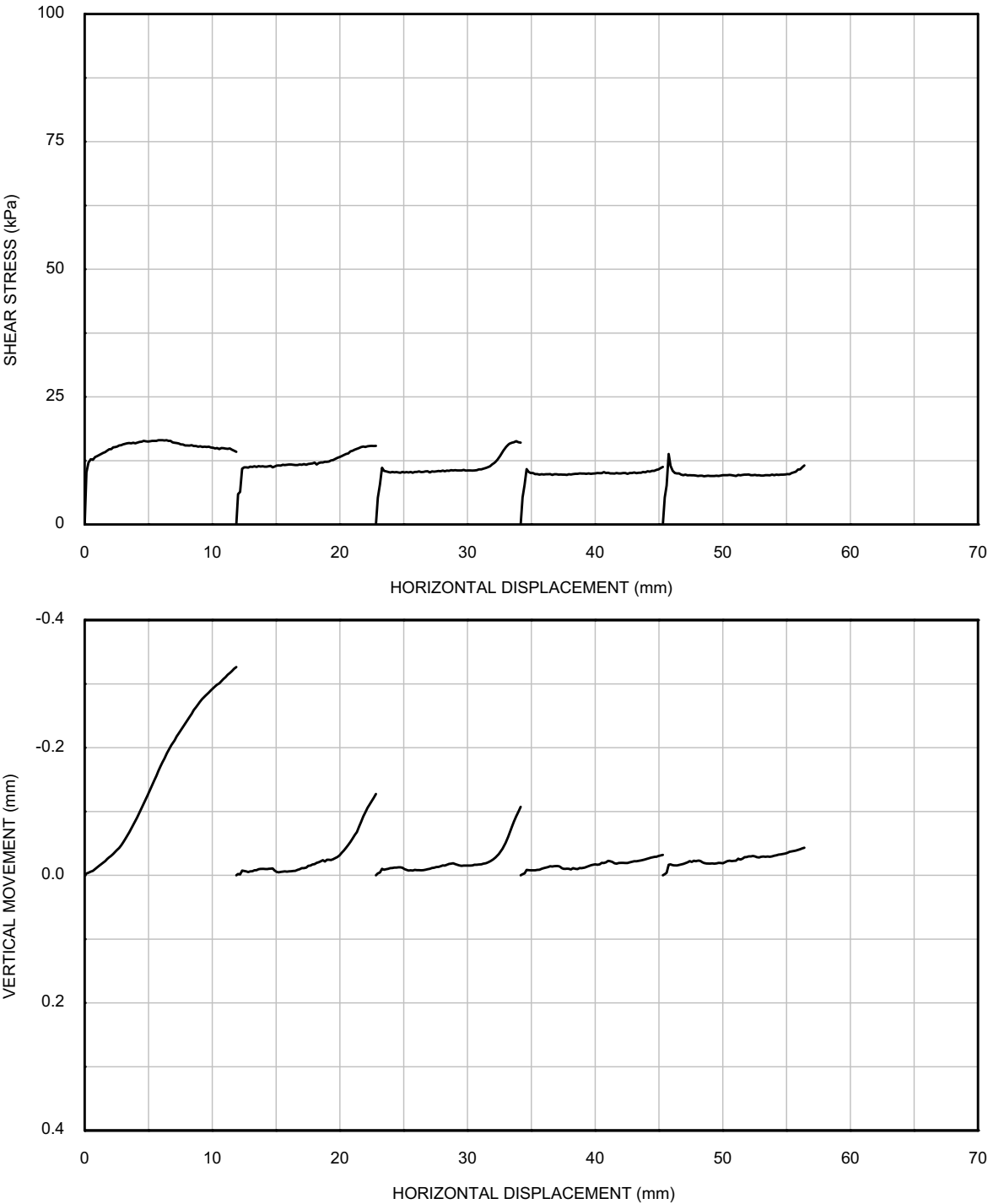
Date: Approved by:

SPECIMEN	1	2	3
INITIAL SPECIMEN CONDITIONS			
Sample Length (mm)	60.0	60.0	60.0
Sample Breadth (mm)	60.0	60.0	60.0
Sample Height (mm)	21.6	21.8	21.7
Moisture content (%)	10	10	10
Bulk density (Mg/m ³)	1.86	1.85	1.85
Dry density (Mg/m ³)	1.69	1.68	1.69
Voids ratio	0.566	0.575	0.571
Degree of saturation (%)	46	45	45
Rate of displacement (mm/min)	0.9	0.9	0.9
SHEARING (at maximum shear stress)			
Voids ratio at start of shear	0.598	0.568	0.552
Normal stress (kPa)	15	30	60
Maximum shear stress (kPa)	17	33	52
Horizontal displacement (mm)	5.78	2.71	3.02
Vertical movement (mm)	-0.164	-0.247	-0.124
REVERSAL STAGES			
Number of traverses	4	4	4
Final cumulative displacement (mm)	56.40	54.18	55.26
Residual shear stress (kPa)	12	17	31
Particle Density (Mg/m ³)	2.65 (Assumed)		
Specimens tested dry or submerged	Submerged		

Tested in accordance with BS1377 : Part 7 : 1990 : Clause 4.5.5
supplemented by Fugro testing procedure L-T-030
(Note: Fugro testing procedures are available on request)

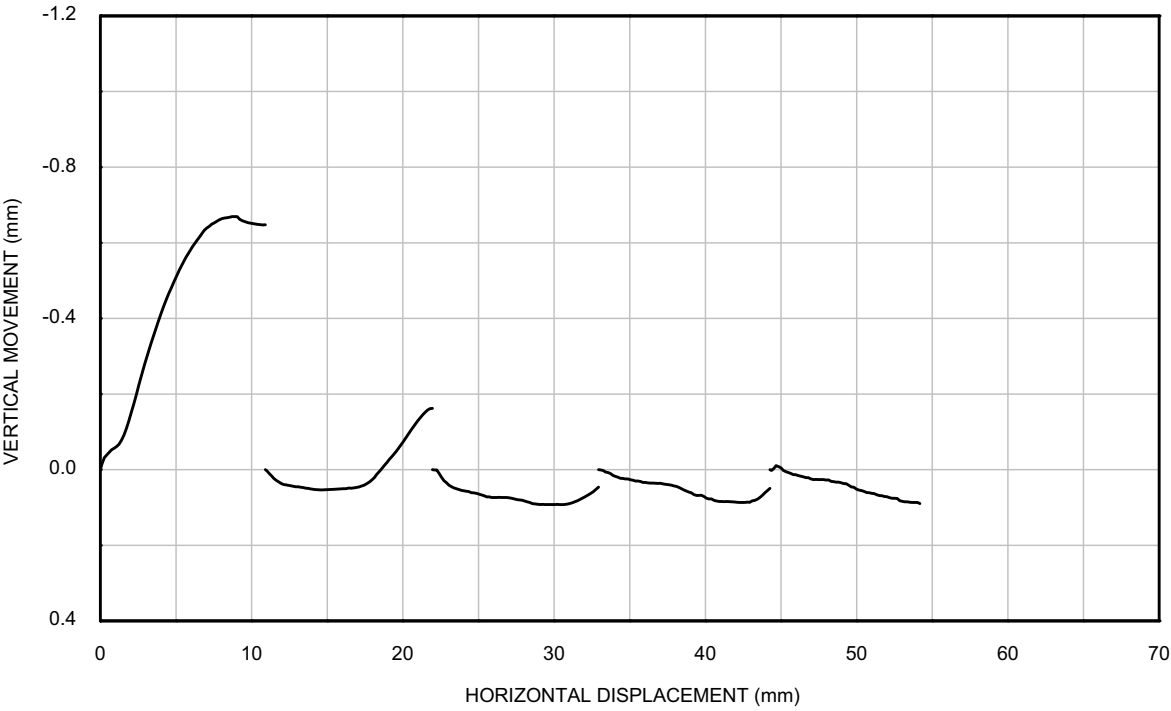
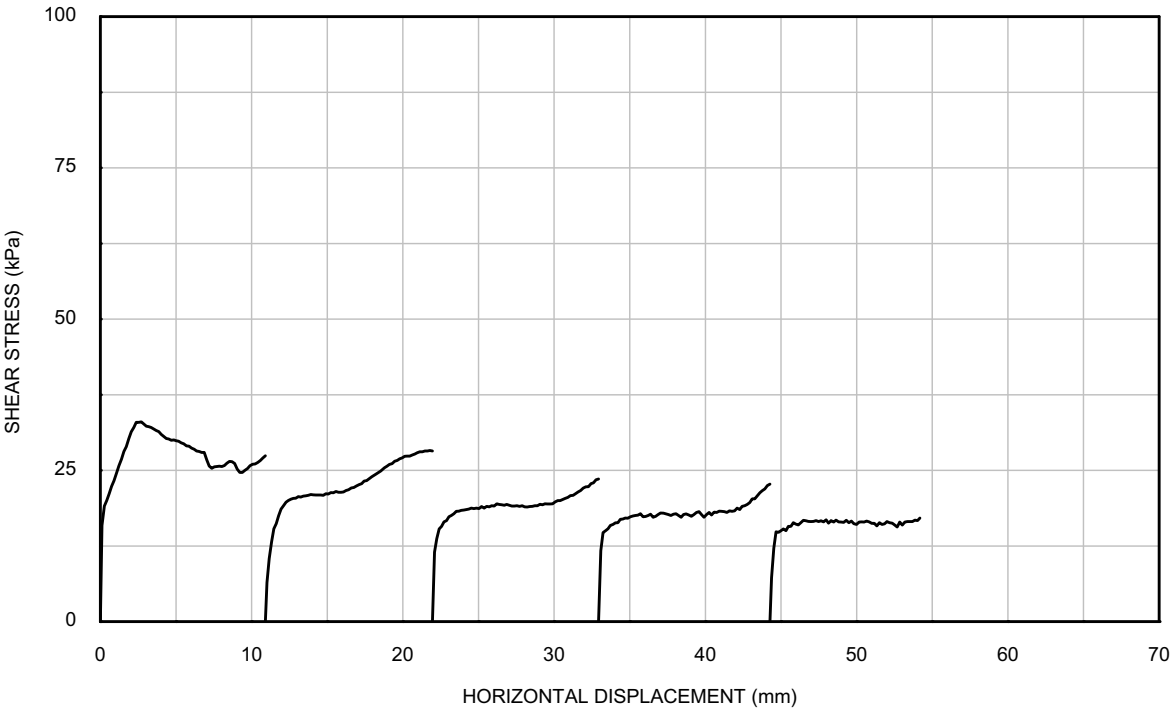
Borehole : BH_14
Sample : 1BagA
Depth (m) : 2.00

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX SET OF THREE
SOIL - STEEL INTERFACE**



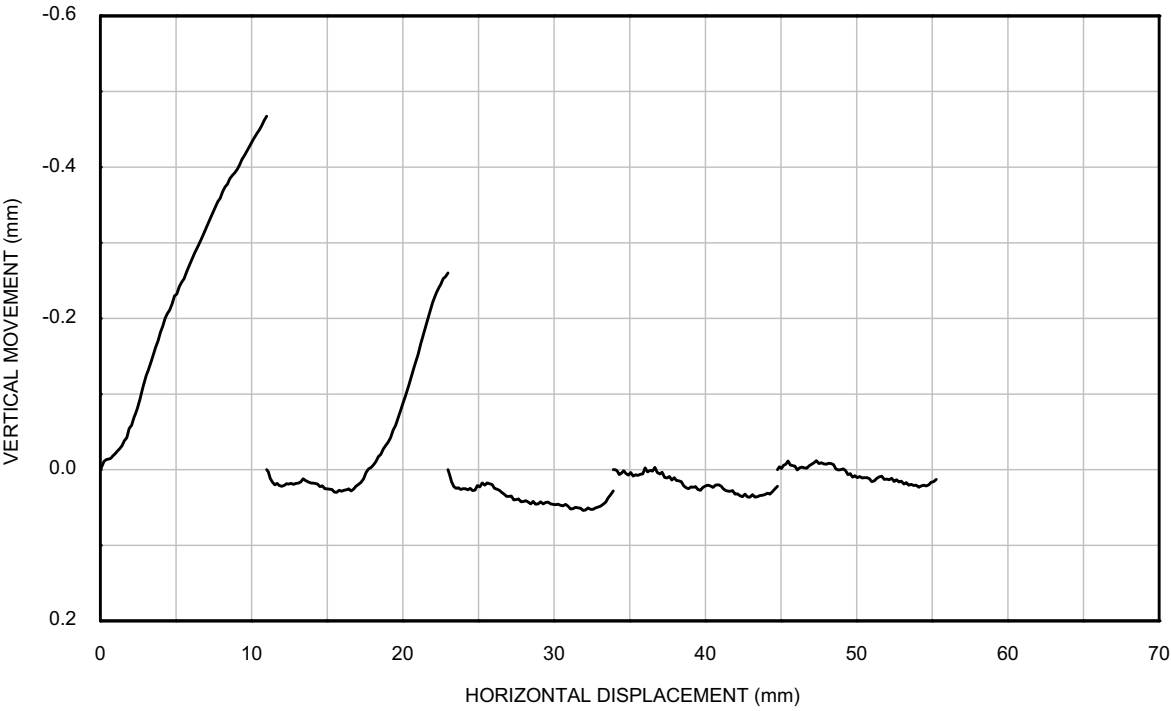
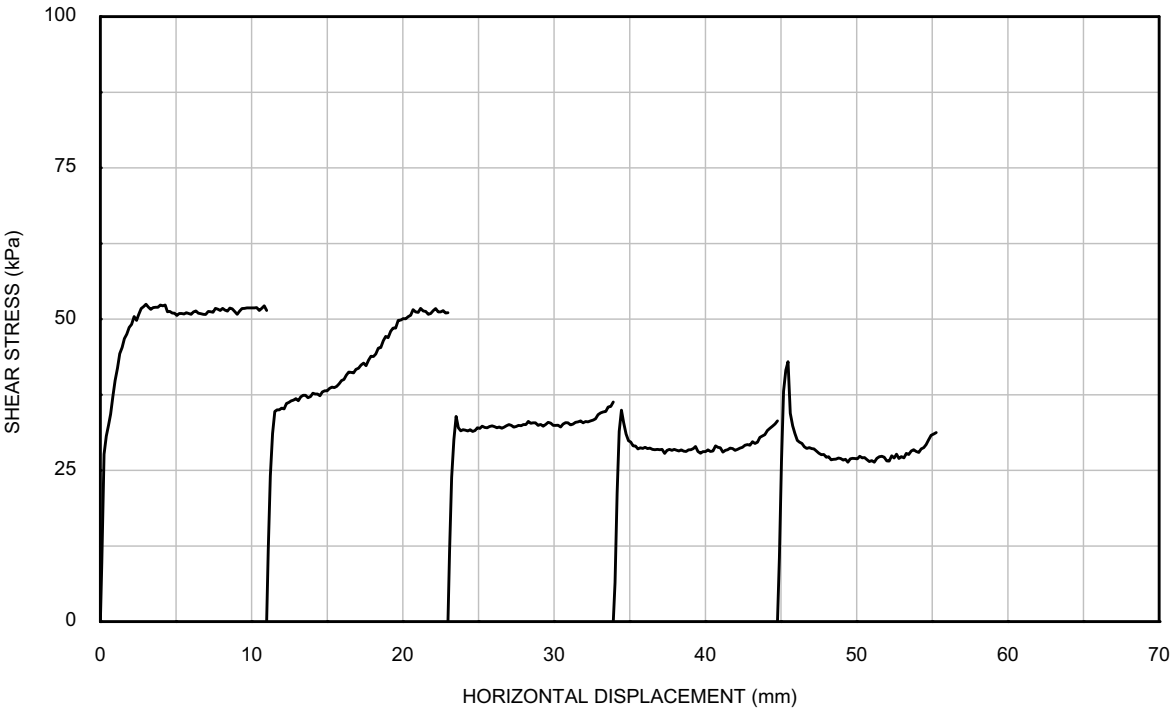
— Specimen 1: Normal stress 15 kPa	Borehole : BH_14
— Specimen 2: Normal stress 30 kPa	Sample : 1BagA
— Specimen 3: Normal stress 60 kPa	Depth (m) : 2.00

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX SET OF THREE - STAGE 1
SOIL - STEEL INTERFACE**



— Specimen 1: Normal stress 15 kPa	Borehole : BH_14
— Specimen 2: Normal stress 30 kPa	Sample : 1BagA
— Specimen 3: Normal stress 60 kPa	Depth (m) : 2.00

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX - STAGE 2
SOIL - STEEL INTERFACE**

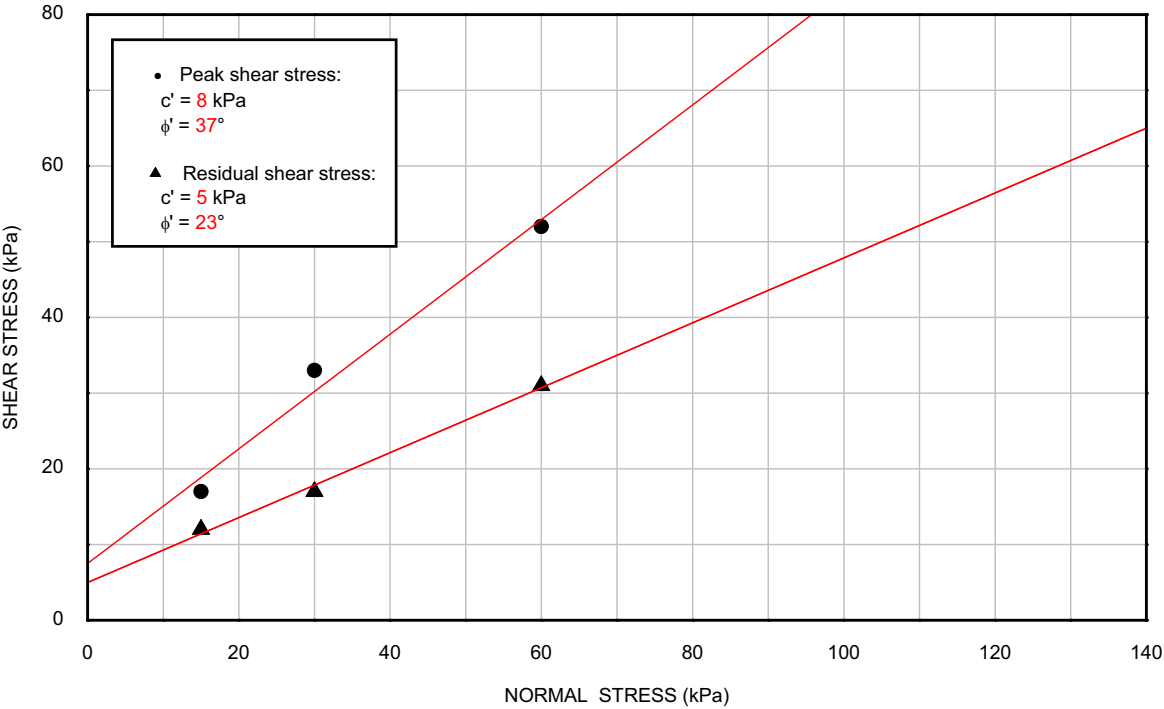


— Specimen 1: Normal stress 15 kPa	Borehole : BH_14
— Specimen 2: Normal stress 30 kPa	Sample : 1BagA
— Specimen 3: Normal stress 60 kPa	Depth (m) : 2.00

**DIRECT SHEAR TEST
MULTI-REVERSAL SHEAR BOX - STAGE 3
SOIL - STEEL INTERFACE**



Drawn by: ALB Date: 29/06/2011



Template Issue: 4

Filename: BH_14_1BagA.OPJ

SHEARING	Shear Stage 1	Shear Stage 2	Shear Stage 3
Rate of displacement (mm / min)	0.9	0.9	0.9
Normal stress (kPa)	15	30	60
Peak shear stress (kPa)	17	33	52
Residual shear stress (kPa)	12	17	31
Horizontal displacement at end of residual stage (mm)	56.40	54.18	55.26

Date :

Date :

BOREHOLE	: BH_14
SAMPLE	: 1BagA
DEPTH (m)	: 2.00

Checked by:

Approved by:

**DETERMINATION OF RESIDUAL STRENGTH USING
MULTI-REVERSAL SHEAR BOX SET OF THREE**



SECTION B.7

RING SHEAR TESTS

B.7	RING SHEAR	1
B.7.1	SUMMARY	1
B.7.2	DISCUSSION OF RESULTS	1

B.7 RING SHEAR

B.7.1 SUMMARY

Eight (8) ring shear (soil-steel interface) tests were performed according to the procedure presented by Jardine *et. al.* (2005) for use in the ICP design method. The test is performed in two stages, the first is a fast shear at a rate equivalent to an installation rate of 500 mm/min. The second is a slow shear of 0.018 mm/min to represent the pile after installation. A summary of the ring shear results are presented at the end of this section on Plate B.7-1 and the individual tests follow on Plates B.7-2 to B.7-9.

B.7.2 DISCUSSION OF RESULTS

Across the Rampion site, the peak interface angle, δ' , ranged from 18.0° to 31.8° and the ultimate interface angle, δ'_{ult} , ranged from 9.3° to 21.9°.

Three (3) of the samples tested (BH_13_22BAGA, BH_14_2BAGA, BH_07_13BAGA) have a lower peak interface angle compared to their ultimate interface value. This is largely due to these samples having a higher content of silt and/or sand forming planes of weakness.

The ring shear test results are generally considered to be representative of the soils tested.



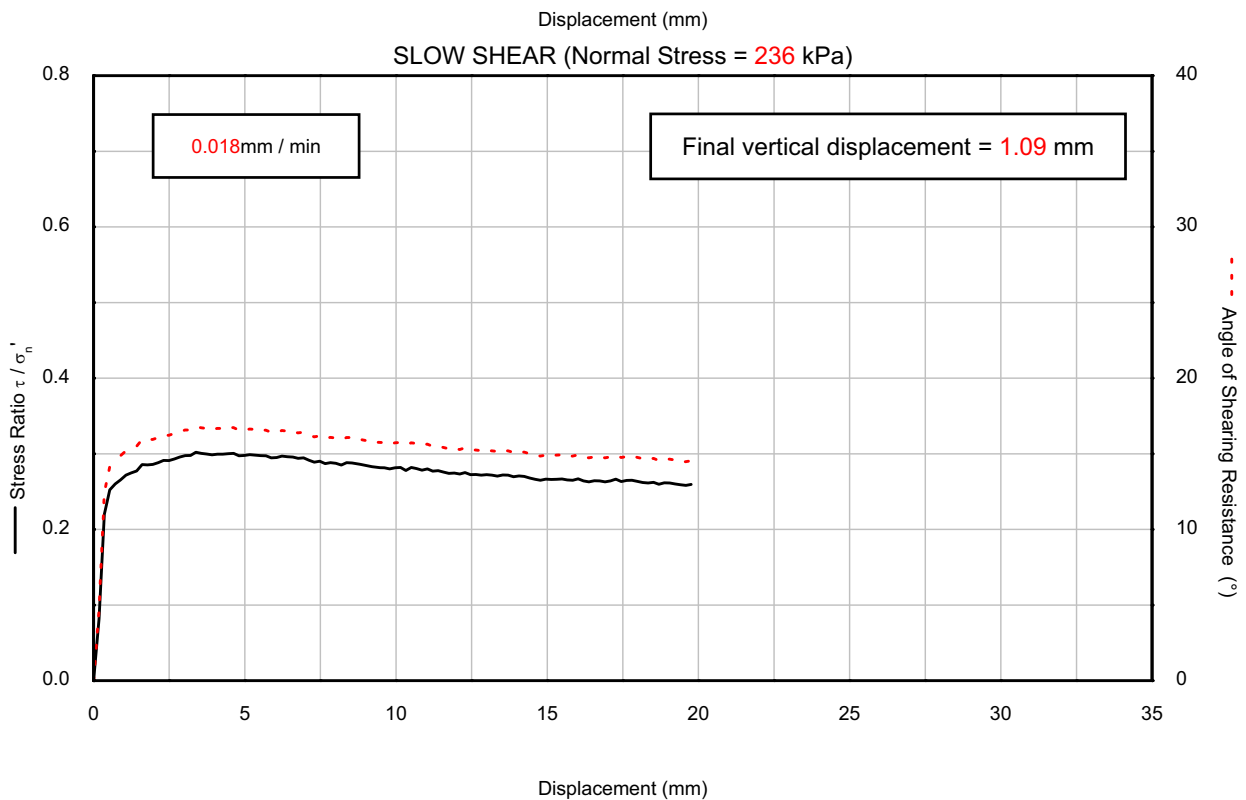
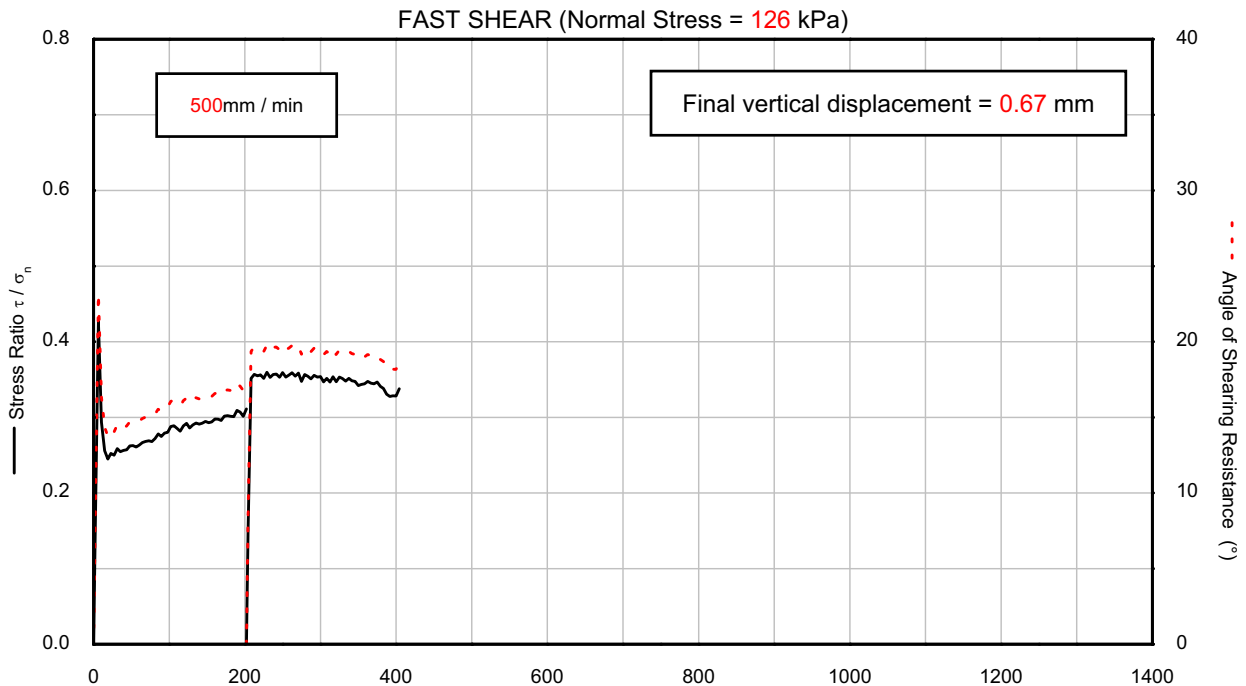
RING SHEAR TESTS

LIST OF PLATES – SECTION B.7

Description	Plate
Summary of Ring Shear Test Results	B.7-1
Ring Shear Test Results	B.7-2 to B.7-9

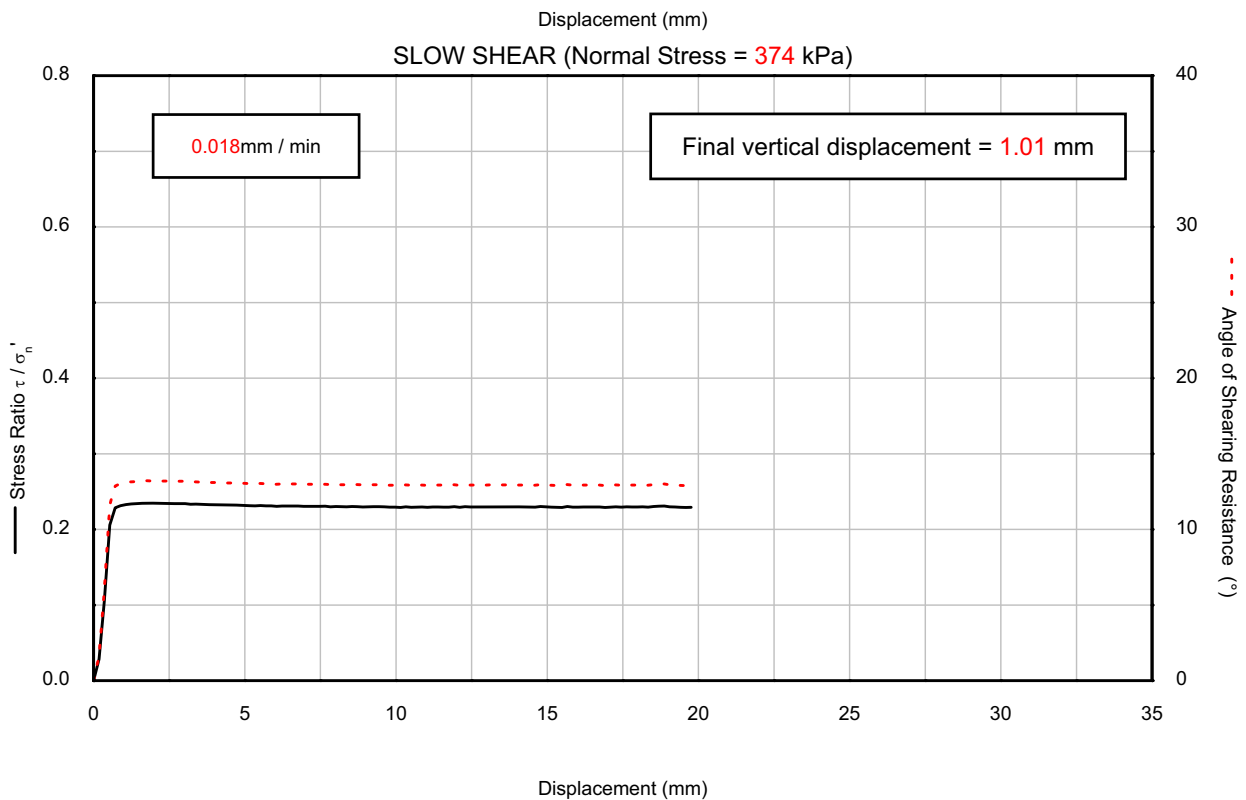
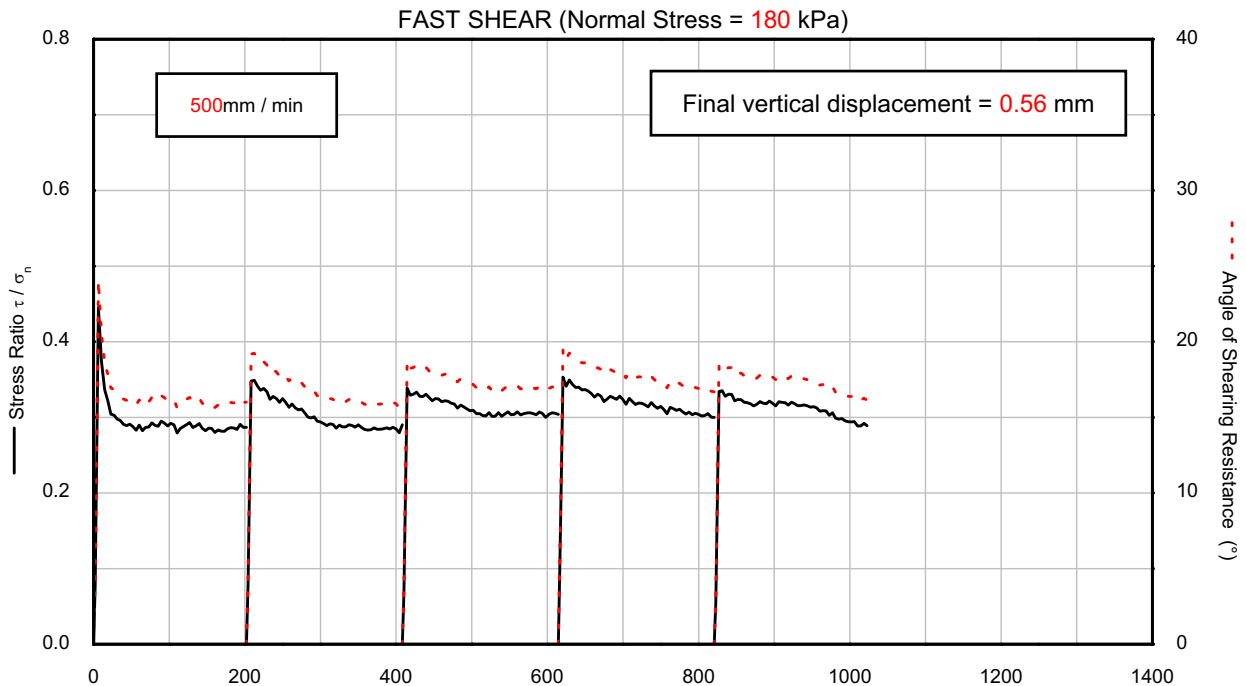
BH No.	SAMPLE No.	INDEX PROPERTIES				STAGE 1			STAGE 2		
		DEPTH (m)	w _i (%)	w _p (%)	I _p (%)	σ' _n (kPa)	τ/σ' _n η _{peak} (-)	δ' _{peak} (°)	σ' _n (kPa)	τ/σ' _n η _{ult} (-)	δ' _{ult} (°)
BH_13	4BAGA	7.50	39	18	46	126	0.43	23.1	236	0.26	14.5
BH_13	5BAGA	8.50	33	18	49	180	0.45	24.0	374	0.23	12.9
BH_13	7UU	13.85	32	25	41	235	0.62	31.8	469	0.21	11.9
BH_13	22BAGA	35.00	19	20	31	454	0.33	18.0	1000	0.47	25.3
BH_14	2BAGA	2.50	10	-	-	20	0.49	26.2	51	0.50	26.7
BH_14	11BAGB	25.25	27	21	54	382	0.54	28.4	984	0.24	13.4
BH_06	27BAGB	37.83	16	16	31	504	0.54	28.2	1000	0.16	9.3
BH_07	13BAGA	23.50	11	20	9	223	0.54	28.5	179	0.06	29.1
Notes :											

SUMMARY OF RING SHEAR TEST RESULTS



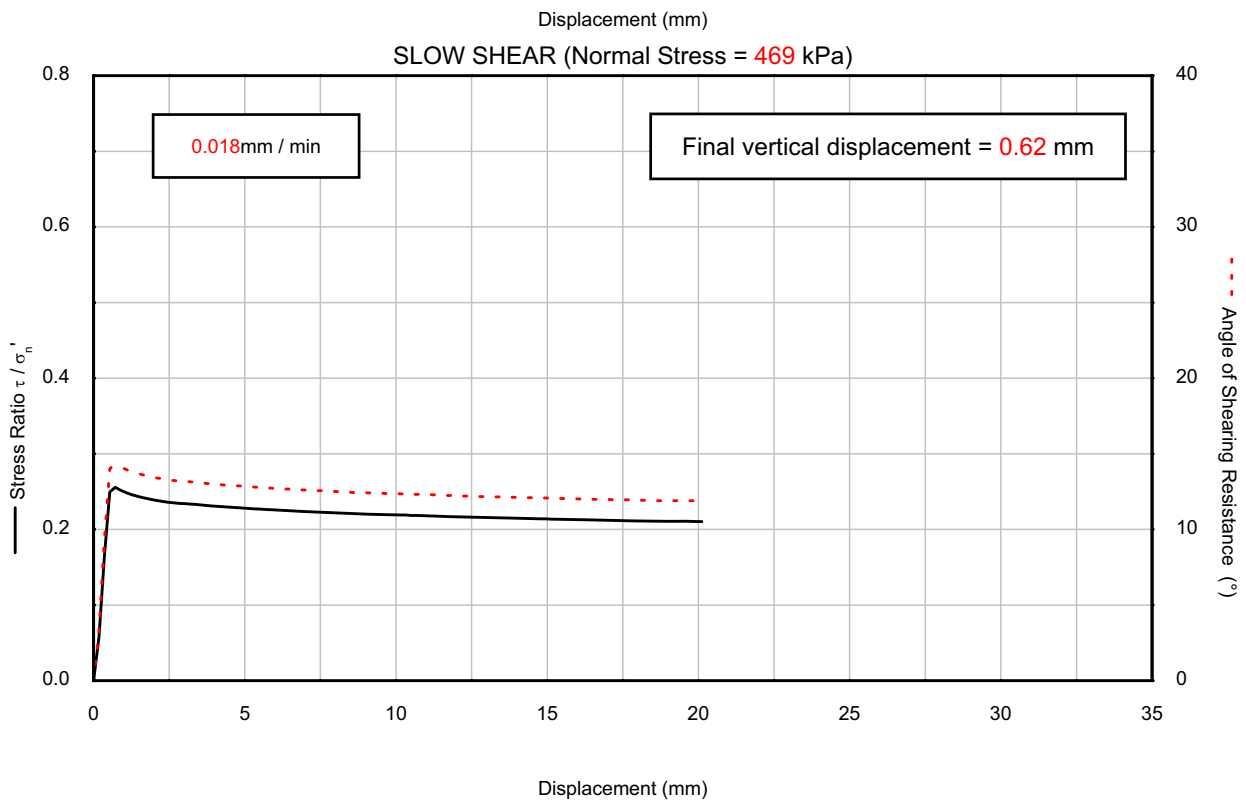
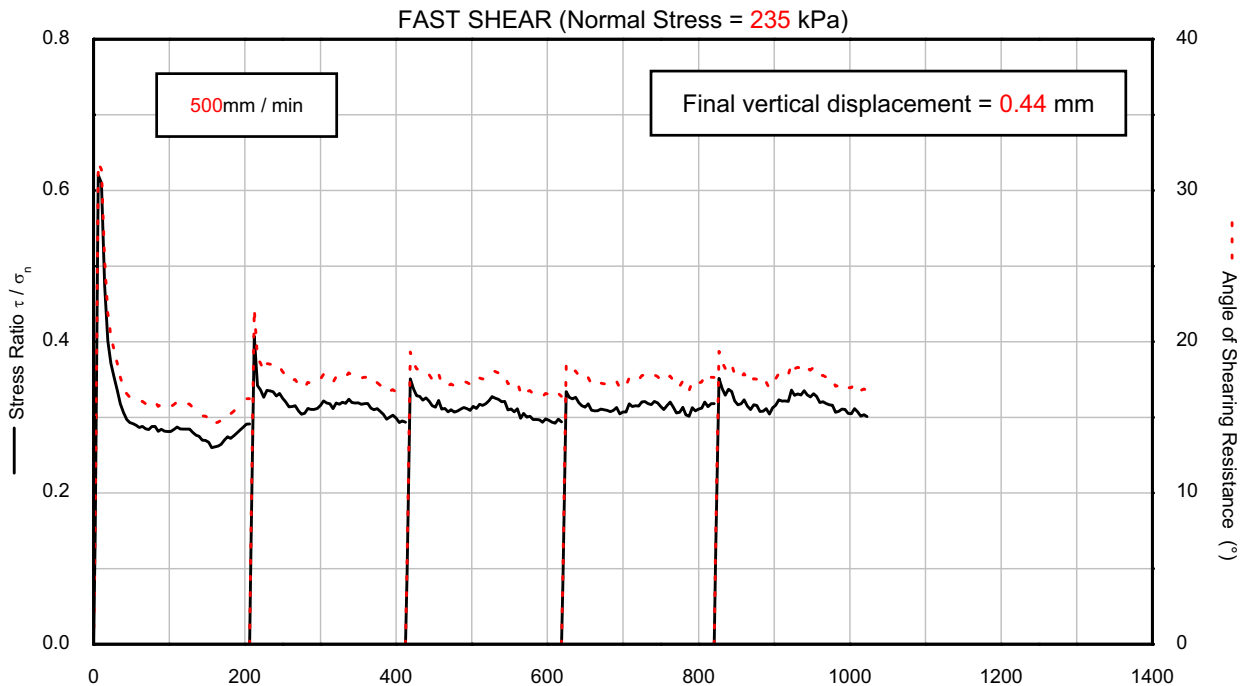
Borehole	: BH_13
Sample	: 4BagA
Depth (m)	: 7.50

RING SHEAR TEST SOIL / STEEL INTERFACE



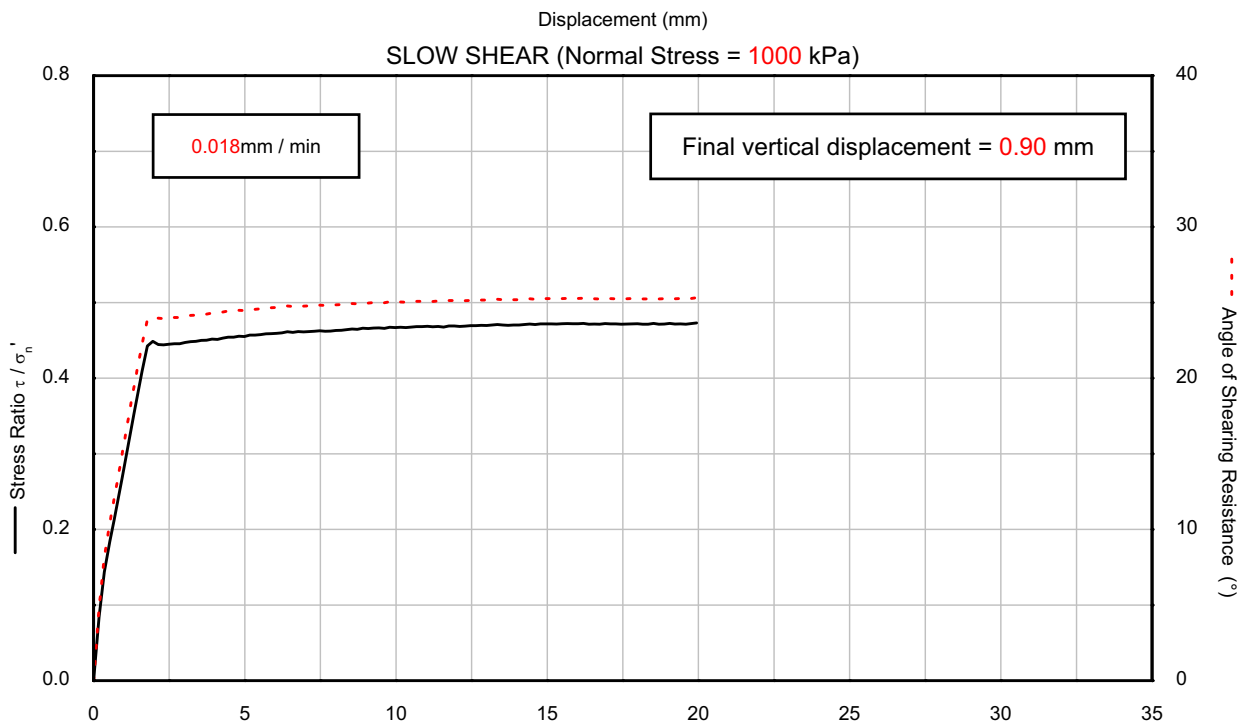
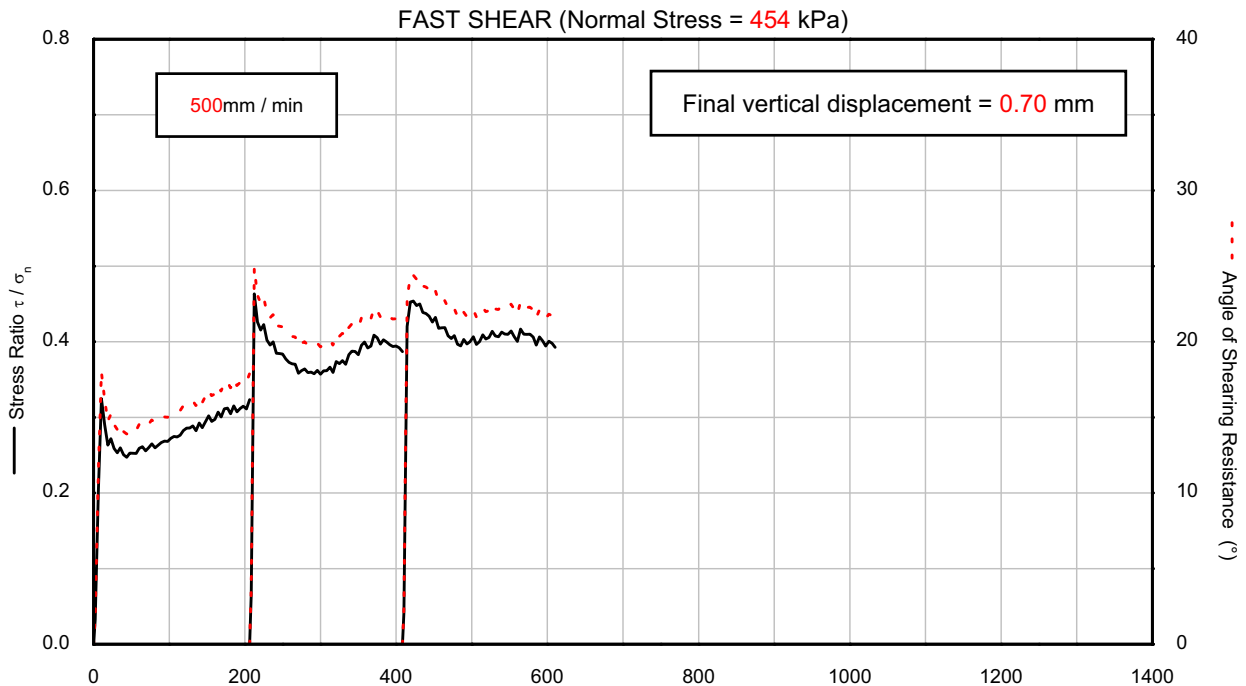
Borehole	: BH_13
Sample	: 5BagA
Depth (m)	: 8.50

**RING SHEAR TEST
 SOIL / STEEL INTERFACE**



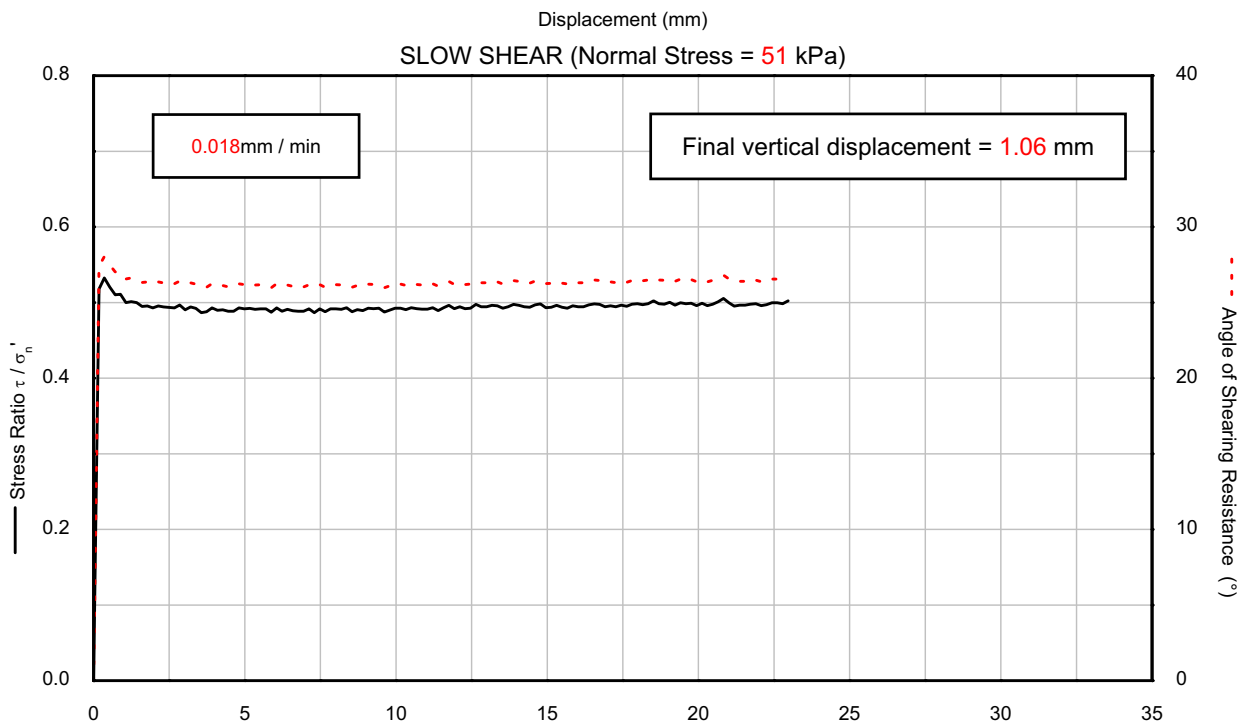
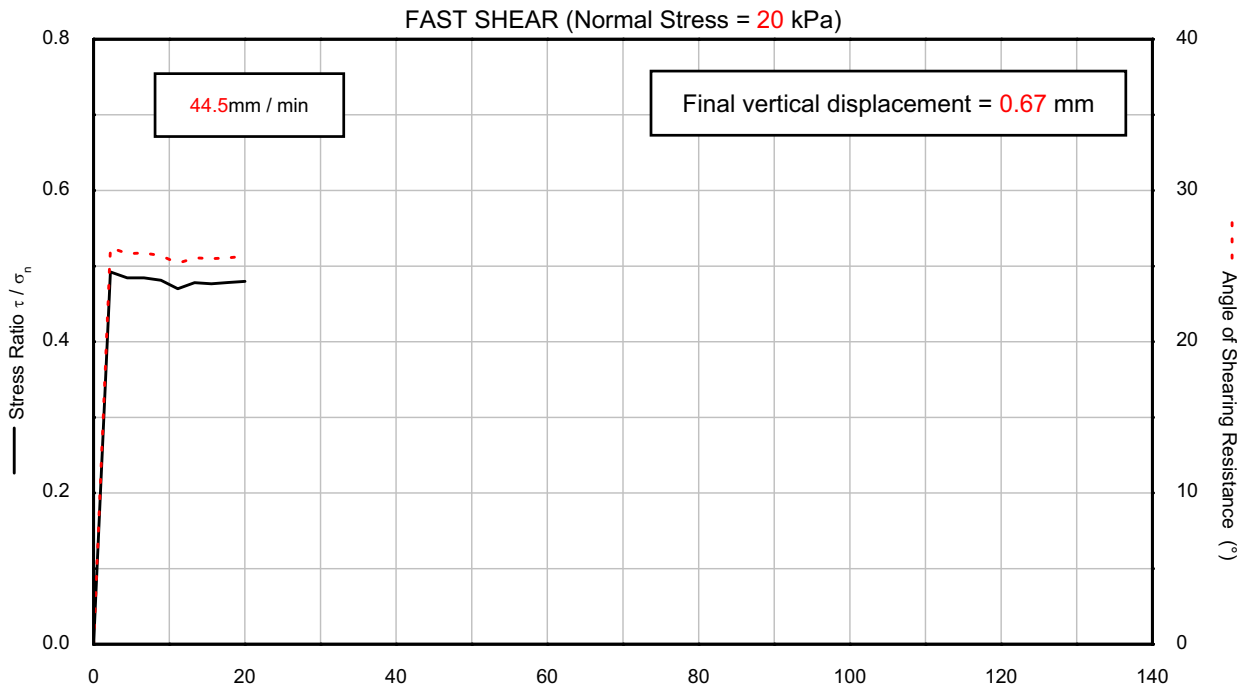
Borehole	: BH_13
Sample	: 7UU
Depth (m)	: 13.85

RING SHEAR TEST SOIL / STEEL INTERFACE



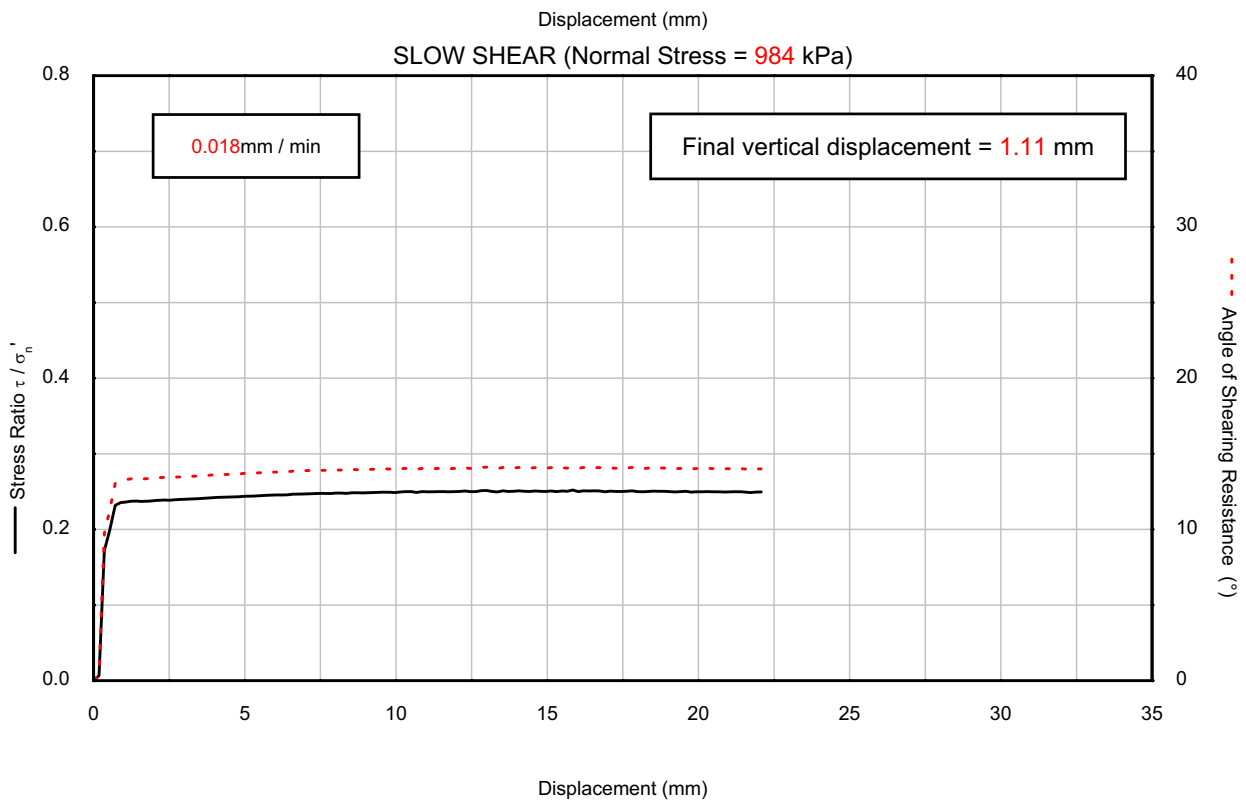
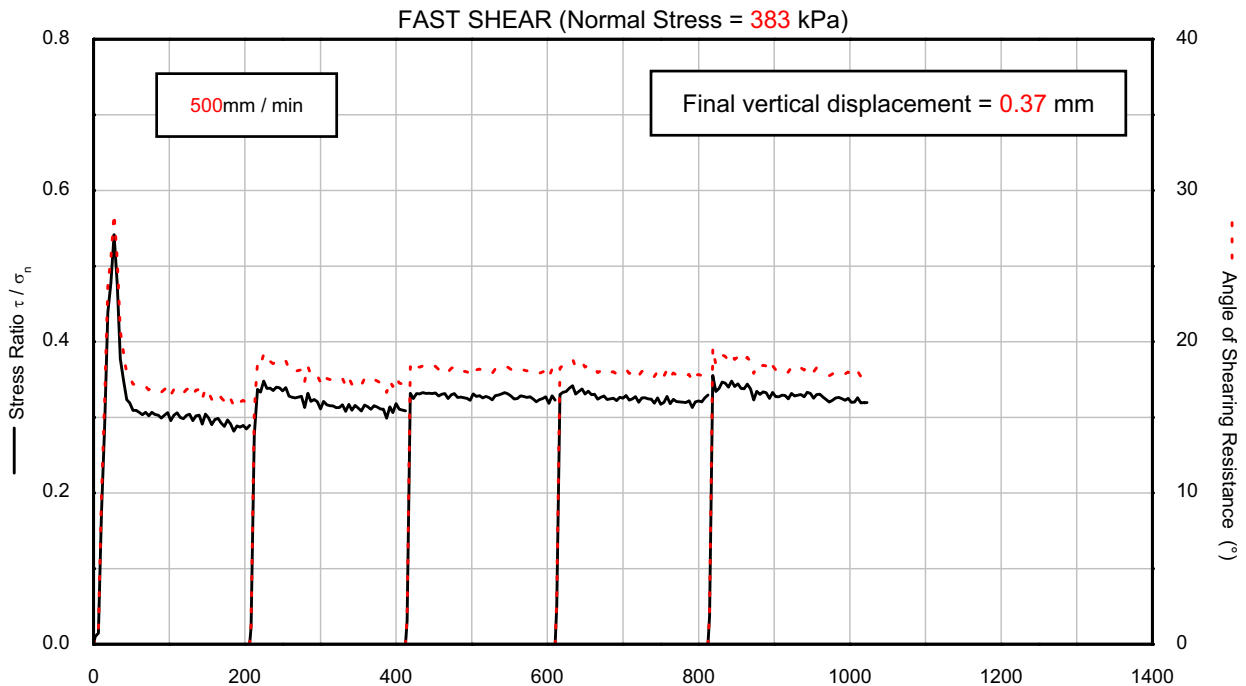
Borehole	: BH_13
Sample	: 22BagA
Depth (m)	: 35.00

RING SHEAR TEST SOIL / STEEL INTERFACE



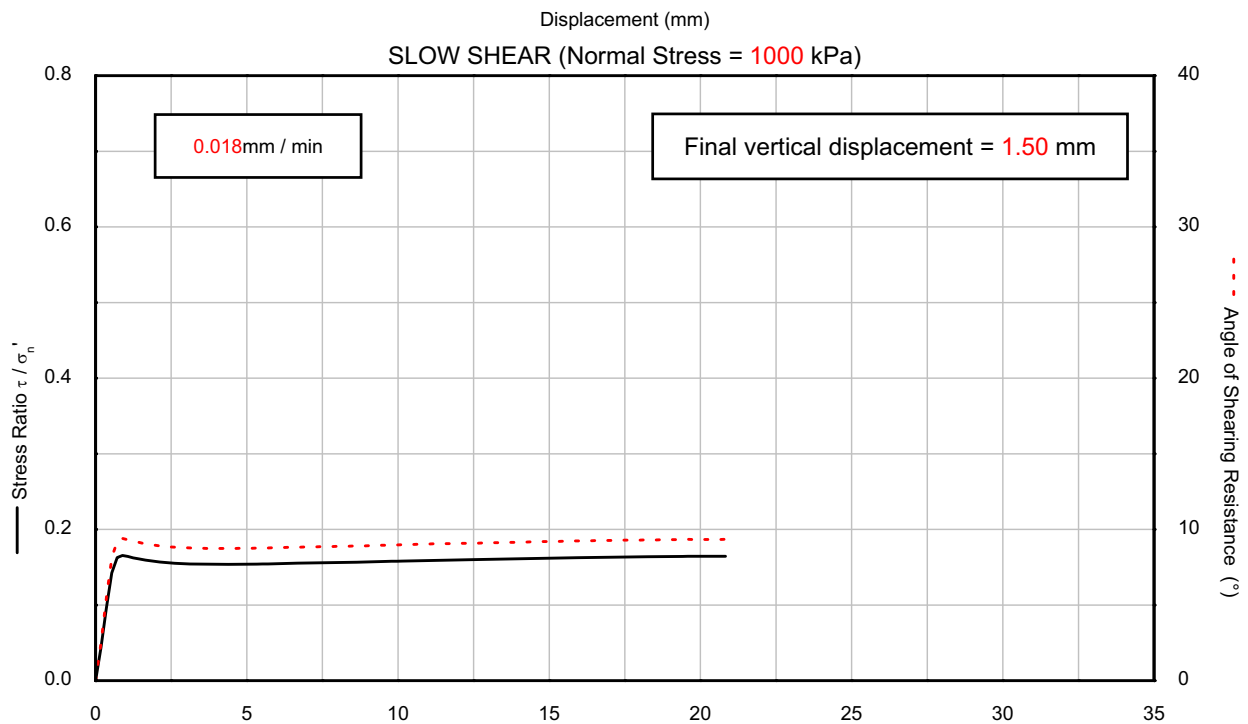
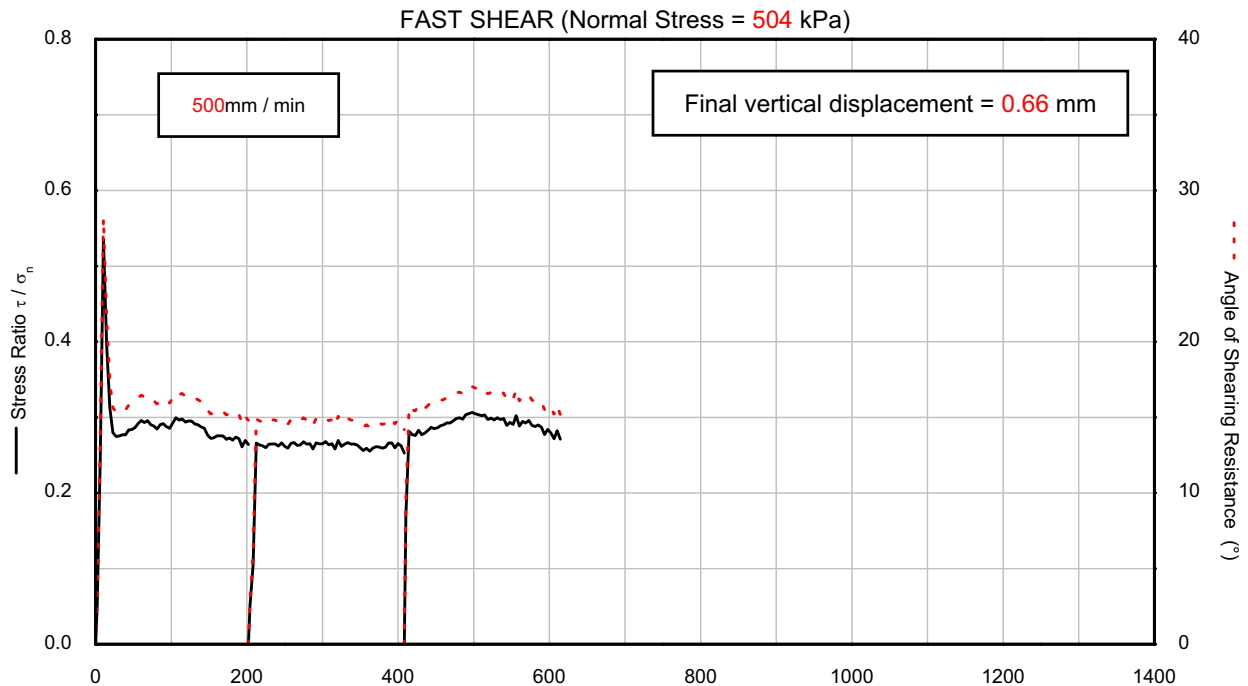
Borehole	: BH_14
Sample	: 2BagA
Depth (m)	: 2.50

RING SHEAR TEST SOIL / STEEL INTERFACE



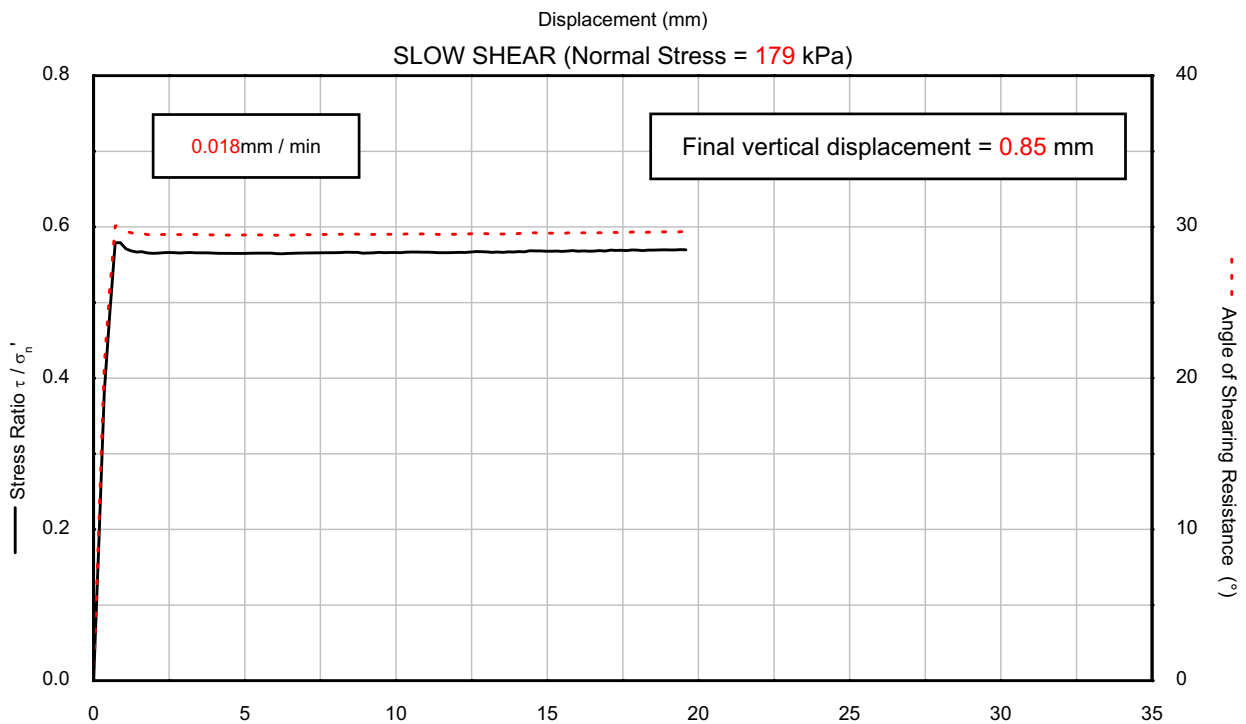
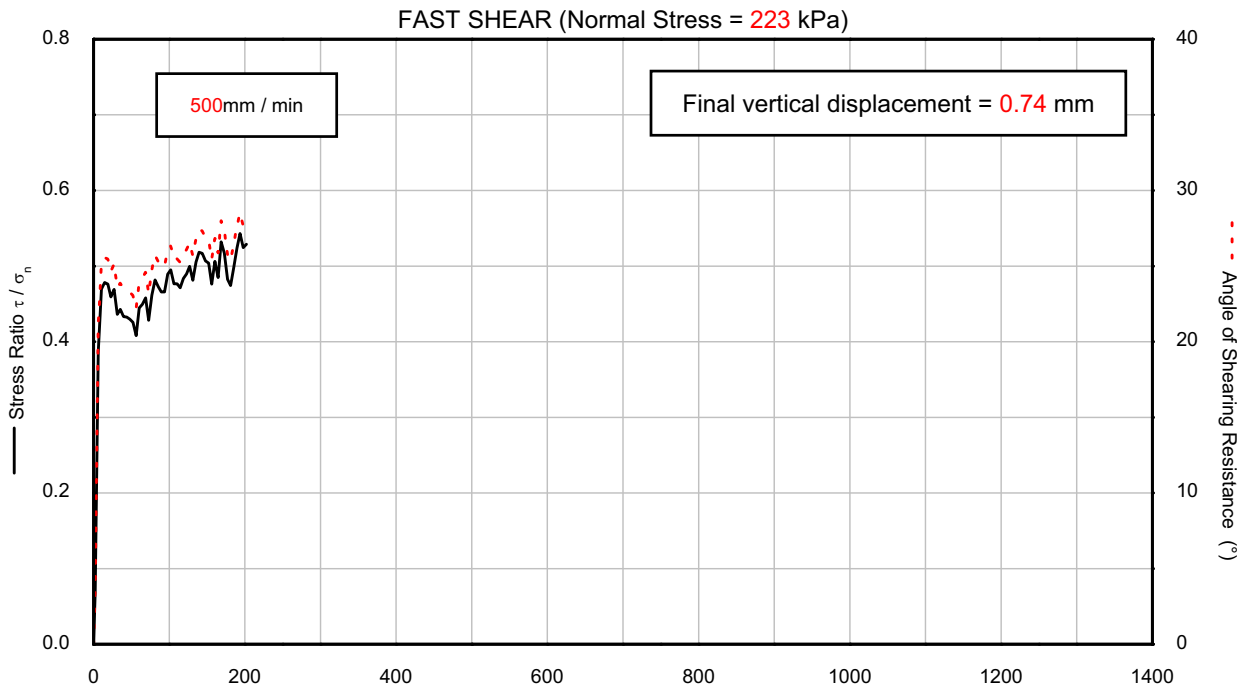
Borehole	: BH_14
Sample	: 11BagB
Depth (m)	: 25.25

RING SHEAR TEST SOIL / STEEL INTERFACE



Borehole	: BH_06
Sample	: 27BagB
Depth (m)	: 37.83

**RING SHEAR TEST
 SOIL / STEEL INTERFACE**



Borehole	: BH_07
Sample	: 13BagA
Depth (m)	: 23.50

RING SHEAR TEST SOIL / STEEL INTERFACE

SECTION B.8

CYCLIC TRIAXIAL AND DIRECT SIMPLE SHEAR TESTS

B.8	CYCLIC TRIAXIAL AND DIRECT SIMPLE SHEAR TESTS	1
B.8.1	SUMMARY	1
B.8.2	CYCLIC SIMPLE SHEAR TEST	1
B.8.3	CYCLIC TRIAXIAL TESTS	1
B.8.4	DISCUSSION OF RESULTS	2

B.8 CYCLIC TRIAXIAL AND DIRECT SIMPLE SHEAR TESTS

B.8.1 SUMMARY

B.8.2 CYCLIC SIMPLE SHEAR TEST

Five (5) cyclic direct simple shear (CSS) tests were performed to create a basic cyclic framework to assist in the development of the Rampion site. All tests were consolidated in the same manner as the static tests, i.e. first to a vertical consolidation stress, which was equal to the estimated preconsolidation stress, p_c' , and then unloaded to the estimated in-situ mean effective stress, p_0' . The value of the overconsolidation ratio, OCR, applied for each specimen was estimated from CPT data and adjusted based on existing undrained strength profiles.

The cyclic ratios applied to the simple shear tests in chalk have been based on the Imperial college method for estimating the expected friction on the shaft of a pile after installation. The estimated effective vertical stress (σ'_v) is multiplied by the coefficient of radial effective stress on shaft after full equalisation (k_c) and then corrected against the measured residual friction angle (δ) to give us τ_{lim} .

Where for Chalk:

$$\begin{aligned}\tau_{lim} &= \sigma'_{vo} \cdot \tan(\delta) \\ \sigma'_{vo} &= [(\gamma' \cdot z) \cdot k_c] \\ \tau_{cyc} &= \tau_{lim} \cdot 0.4\end{aligned}$$

Where for Clay:

$$\tau_{cyc} = 0.5 \cdot s_u$$

A summary of the CSS tests is presented on Plate B.8-1 and the individual test results are presented on Plates B.8-3 to B.8-26 at the end of this section.

B.8.3 CYCLIC TRIAXIAL TESTS

Five (5) cyclic (CTXL) tests were performed on selected samples. All tests were consolidated to the estimated in-situ effective vertical stress prior to cyclic loading. The value of the coefficient of consolidation at rest (K_0) was inferred from CPT data and the results of static triaxial testing.

As with the simple shear method, t_{cyc} has been defined by multiplying the static undrained shear strength by 0.5 and using a t_{av} value of 0.0.

Where:

$$\tau_{cyc} = 0.5 \cdot s_u$$

A summary of the cyclic triaxial tests is presented on Plate B.8-1 and the individual test results are presented on Plates B.8-27 to B.8-66 at the end of this section.

B.8.4 DISCUSSION OF RESULTS

For both triaxial and simple shear methods a frequency of 0.1 has been assumed as this is considered to accurately represent the effects of wave loading on an offshore structure. It should be noted that a malfunction during the anisotropic consolidation phase of BH_14-12WAXA@26.10 m caused an increase in pressure causing a premature failure of the sample.

All other tests are considered to be of good quality and representative of the true soil conditions under static and cyclic loading.

Due to the equipment failure, a repeat test will be performed (pending client approval) and will be presented in the second issue of this report.

LIST OF PLATES – SECTION B.8

Description	Plate
Summary of Cyclic Direct Simple Shear Test Results	B.8-1
Summary of Cyclic Triaxial Test Results	B.8-2
Cyclic Direct Simple Shear Test Results	B.8-3 to B.8-26
Cyclic Triaxial Test Results	B.8-27 to B.8-66

Date:

Drawn by :

Date:

Checked by:

Date:

Approved by:

Filename: SUM_TABLXLS (TXL)

BH No.	SAMPLE No.	DEPTH (m)	TEST TYPE	INDEX PROPERTIES				FINAL CONSOLIDATION VALUES						CYCLIC LOADING						NOTES	
				w _i (%)	w _p (%)	w _f (%)	I _p (%)	σ' _{vc} (kPa)	σ' _{rc} (kPa)	ε _{vc} (%)	ε _{vol} (%)	B (-)	s _{uref} (kPa)	τ _{av} /s _{uref} (-)	τ _{cy} /s _{uref} (-)	N (-)	γ _{av} at N (%)	γ _{cy} at N (%)	Δ u _a at N (kPa)		
BH_13	4WAXA	7.85	CTXL	26	18	64	46	77	139	-0.46	1.54	1.00	130	0.00	0.40	1500	0.4	0.7	59.0		
BH_13	7WAXA	13.60	CTXL	28	21	68	47	133	258	0.70	4.23	0.98	300	0.00	0.40	110	-5.5	15.4	109.0		
BH_13	23WAXB	29.25	CTXL	15.64	-	-	-	361	565	-0.26	0.24	0.93	380	0.00	0.40	457	-7.7	15.1	308.0		
BH_14	12WAXA	26.10	CTXL	Sample failed due to back-up power failure during anisotropic consolidation																	
BH_16	15WAXA	31.05	CTXL	19.5	22	54	32	252	488	-0.42	0.61	0.90	520	0.00	0.40	183	-12.0	13.5	180.0		
Notes:																					

SUMMARY OF CONSOLIDATED CYCLIC TRIAXIAL TEST RESULTS

BH No.	SAMPLE No.	DEPTH (m)	INDEX PROPERTIES				CONSOLIDATION			CYCLIC LOADING							NOTES
			ρ_{bulk} (Mg/m ³)	w (%)	w _p (%)	I _p (%)	$\sigma'_{v\ max}$ (kPa)	σ'_{vc} (kPa)	ϵ_{vc} (%)	S _{uref} (kPa)	τ_{av}/S_{uref} (-)	τ_{cy}/S_{uref} (-)	N (-)	γ_{av} at N (%)	γ_{cy} at N (%)	Δu_a at N (kPa)	
BH_14	15WAXA	35.10	1.92	30	22	57	2000	323	16.33	350	0.00	0.50	1500	0.1	3.0	20	
BH_07	3WAXB	7.40	2.01	25	22	8	70	70	1.32	32	0.00	0.44	194	0.1	4.6	67	
BH_07	6WAXA	12.64	2.01	24	20	8	120	120	0.70	55	0.00	0.40	53	6.4	7.8	115	
BH_07	12WAXA	23.08	2.05	21	20	9	220	220	2.57	100	0.00	0.40	267	-0.3	8.3	205	
Notes:																	

SUMMARY OF CYCLIC DIRECT SIMPLE SHEAR TEST RESULTS



Date: 13/06/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CSS / BH-14_15A_CSS4.XLS

VISUAL DESCRIPTION

GENERAL

Date test started	24/05/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	50.1
Length	(mm)	19.2
Moisture content	(%)	30.3
Bulk density	(Mg/m ³)	1.92
Dry density	(Mg/m ³)	1.47
Voids ratio		0.834
Degree of saturation	(%)	98
Torvane	(kPa)	126
Pocket penetrometer	(kPa)	-

TESTING PROCEDURES USED

Specimen Set-up	Fugro in house procedure
Consolidation	Fugro in house procedure
Shearing	Fugro in house procedure

Note: Fugro testing procedures are available on request

Borehole	BH_14
Sample	15WaxA
Depth (m)	35.10
Test Number	CSS4

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST

Date: 21/06/2011

Checked by: PH

Date:
Approved by:

Date: 13/06/2011

Drawn by: PR

Template Issue: 2

Date: 21/06/2011

Checked by: PH

Filename: J11056 / CSS / BH-14_15A_CSS4.XLS

Date:

Approved by:

CONSOLIDATION $\sigma_{vc(max)'$		
$\sigma_{vc(max)'$	(kPa)	2000
Vertical strain	(%)	16.33
Volumetric strain	(%)	16.33
Bulk density	(Mg/m ³)	2.10
Dry density	(Mg/m ³)	1.76

CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	323
Vertical strain	(%)	13.98
Volumetric strain	(%)	13.98
Bulk density	(Mg/m ³)	2.04
Dry density	(Mg/m ³)	1.71

CYCLIC LOADING STAGE		
Reference shear stress	(kPa)	350
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	175
Frequency	(Hz)	0.10
Cycles at failure	(N)	1500
Average shear strain @ N	(%)	0.14
Cyclic shear strain @ N	(%)	2.97
Change in pore pressure @ N	(kPa)	20

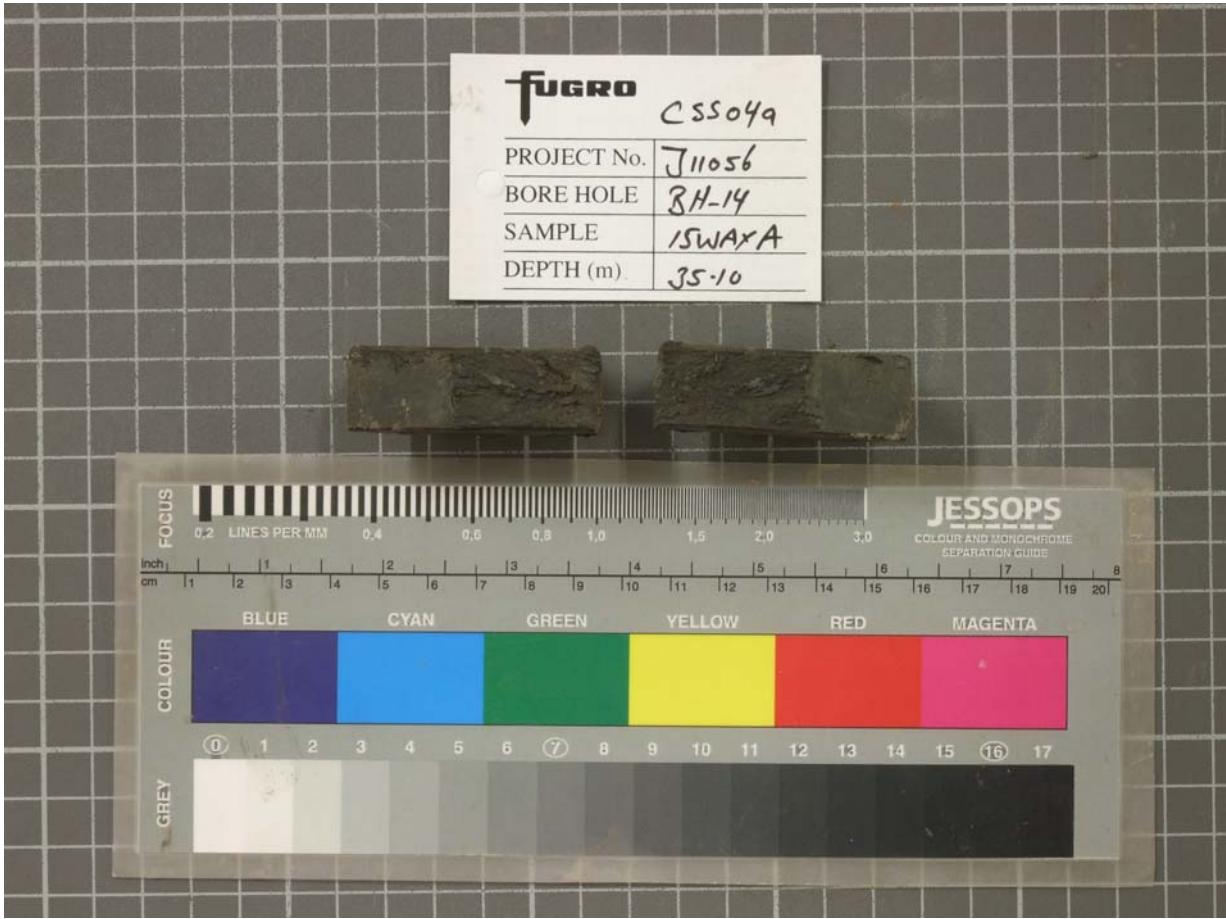
SHEARING		
At peak shear stress		
Shear stress	(kPa)	258
Shear strain	(%)	13.56
Change in pore pressure	(kPa)	-206
Rate of strain	(%/hr)	3.6

Borehole	BH_14
Sample	15WaxA
Depth (m)	35.10
Test Number	CSS4

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST



SPECIMEN PHOTOGRAPH



Borehole	BH_14
Sample	15WaxA
Depth (m)	35.10
Test Number	CSS4

SUMMARY OF
CONSOLIDATED CONSTANT VOLUME CSS TEST

Date: 13/06/2011
Drawn by: PR
Template Issue: 2
Filename: J11056 / CSS / BH-14_15A_CSS4.XLS
Date: 21/06/2011
Date:
Checked by: PH
Approved by:



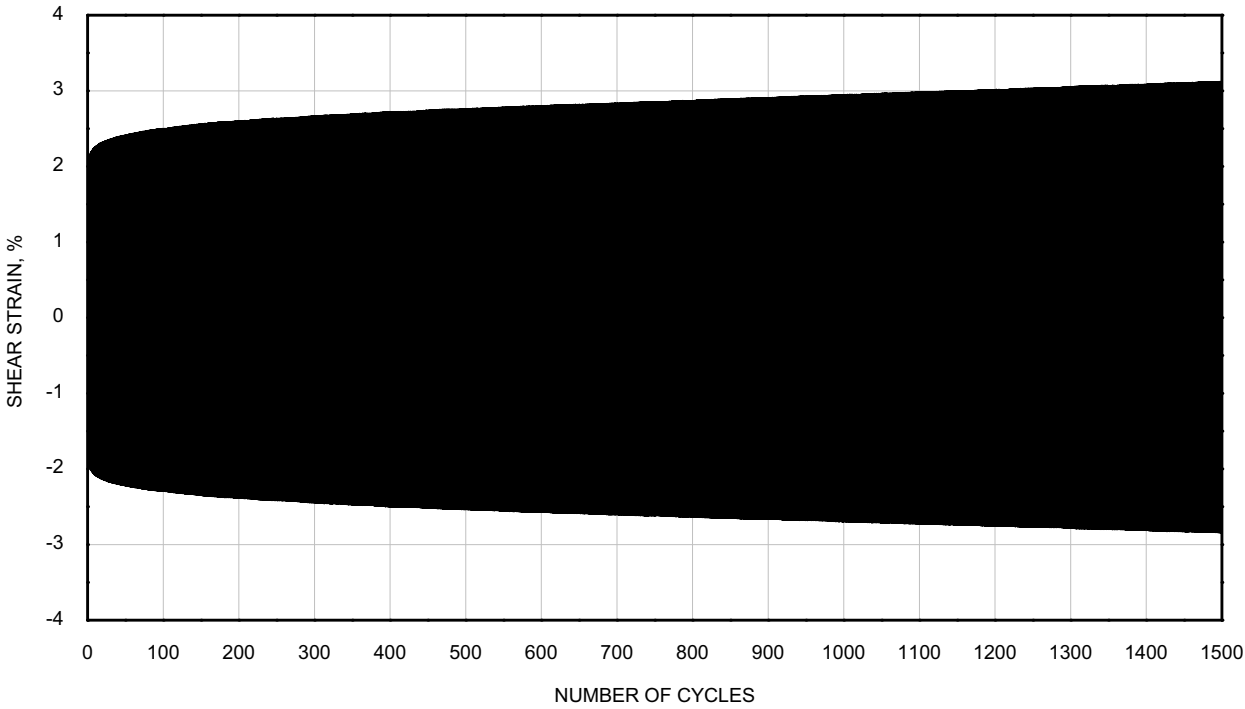
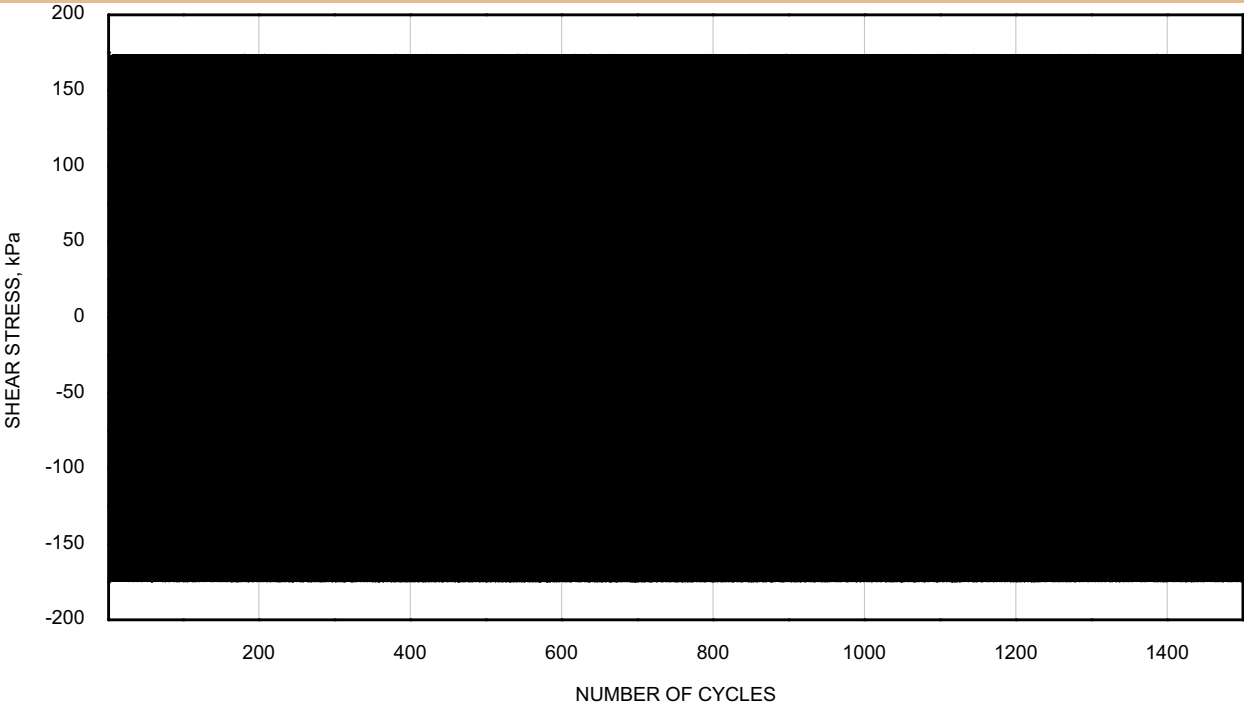
Drawn by: PR
Date: 13/06/2011

Template Issue: 2

Filename: J11056 \ BH-14_15A_CSS4.OPJ

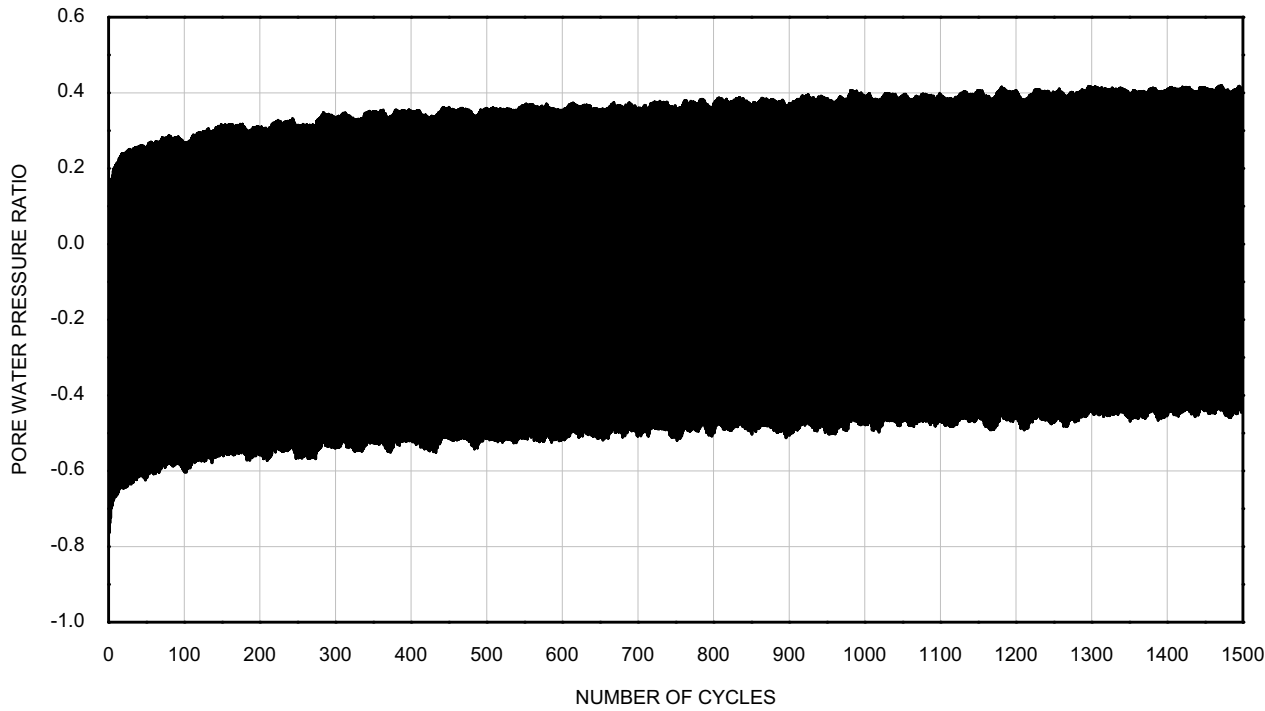
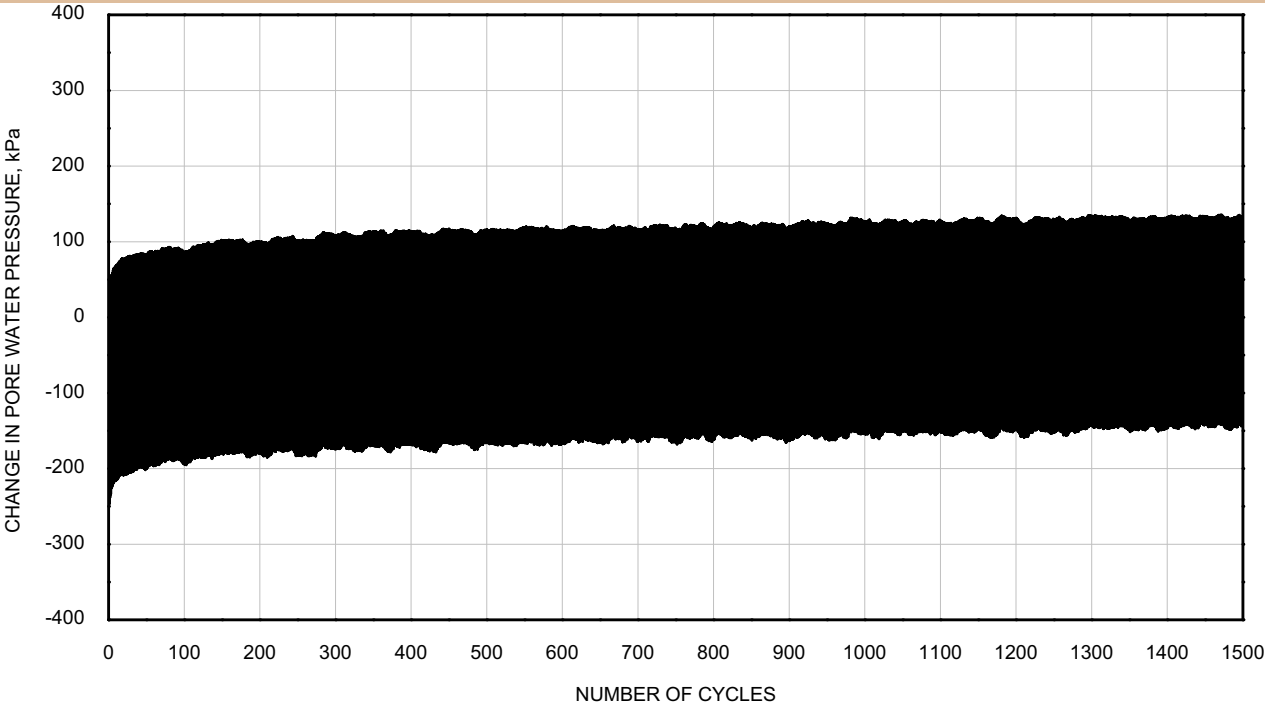
Checked by:
Date:

Approved by:
Date:



$\sigma'_{vc(max)}$	: 2000 kPa	Borehole	: BH_14
σ'_{vc}	: 323 kPa	Sample	: 15WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 35.10
Nominal τ_{cy}	: 175 kPa	Test No	: CSS4
Frequency	: 0.10 Hz		

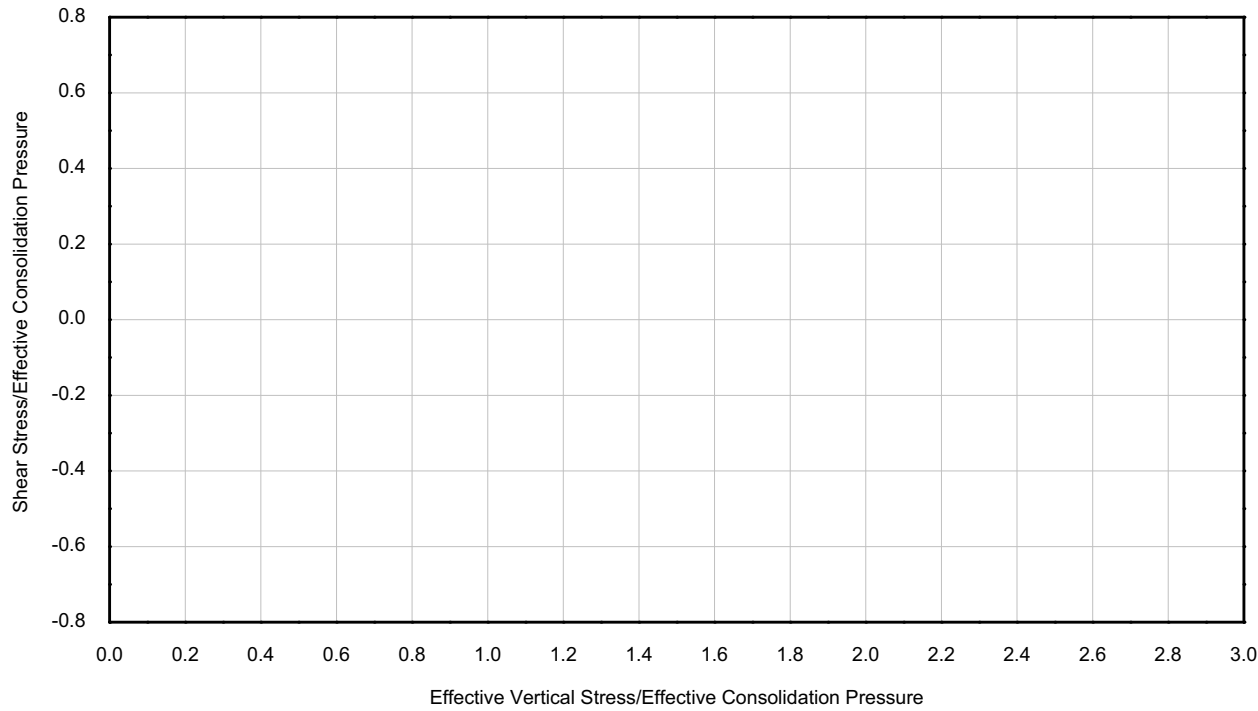
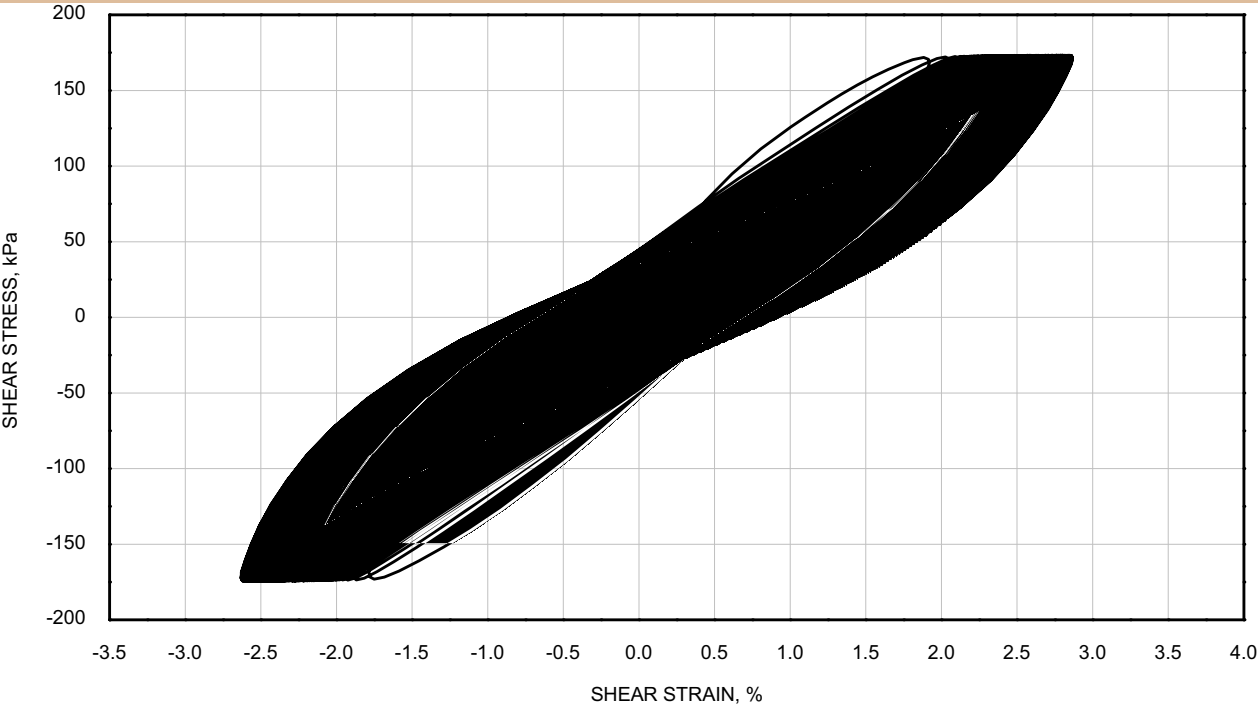
CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



$\sigma'_{vc(max)}$: 2000 kPa
 σ'_{vc} : 323 kPa
Nominal τ_{av} : 0 kPa
Nominal τ_{cy} : 175 kPa
Frequency : 0.10 Hz

Borehole : BH_14
Sample : 15WaxA
Depth (m) : 35.10
Test No : CSS4

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



$\sigma'_{vc(max)}$	: 2000 kPa	Borehole	: BH_14
σ'_{vc}	: 323 kPa	Sample	: 15WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 35.10
Nominal τ_{cy}	: 175 kPa	Test No	: CSS4
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE

Date: 15/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CSS / BH-07_03B_CSS1.XLS

VISUAL DESCRIPTION

Chalk

GENERAL

Date test started	29/06/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	66.5
Length	(mm)	20.0
Moisture content	(%)	24.6
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.61
Voids ratio		0.676
Degree of saturation	(%)	98
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	400

TESTING PROCEDURES USED

Specimen Set-up	Fugro in house procedure
Consolidation	Fugro in house procedure
Shearing	Fugro in house procedure

Note: Fugro testing procedures are available on request

Borehole	BH_07
Sample	3WaxB
Depth (m)	7.40
Test Number	CSS1

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST

Date: 15/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CSS / BH-07_03B_CSS1.XLS

Date:

Date:

Checked by:

Approved by:

CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	70
Vertical strain	(%)	1.32
Volumetric strain	(%)	1.32
Bulk density	(Mg/m ³)	2.02
Dry density	(Mg/m ³)	1.63

CYCLIC LOADING STAGE		
Reference stress	(kPa)	32
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	14
Frequency	(Hz)	0.10
Cycles at failure	(N)	194
Average shear strain @ N	(%)	15.06
Cyclic shear strain @ N	(%)	4.58
Change in pore pressure @ N	(kPa)	67

SHEARING		
At peak shear stress		
Shear stress	(kPa)	154
Shear strain	(%)	31.32
Change in pore pressure	(kPa)	-85
Rate of strain	(%/hr)	-

Borehole	BH_07
Sample	3WaxB
Depth (m)	7.40
Test Number	CSS1

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST

Date: 15/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CSS / BH-07_03B_CSS1.XLS

Date:

Date:

Checked by:

Approved by:

SPECIMEN PHOTOGRAPH



Borehole	BH_07
Sample	3WaxB
Depth (m)	7.40
Test Number	CSS1

SUMMARY OF
CONSOLIDATED CONSTANT VOLUME CSS TEST

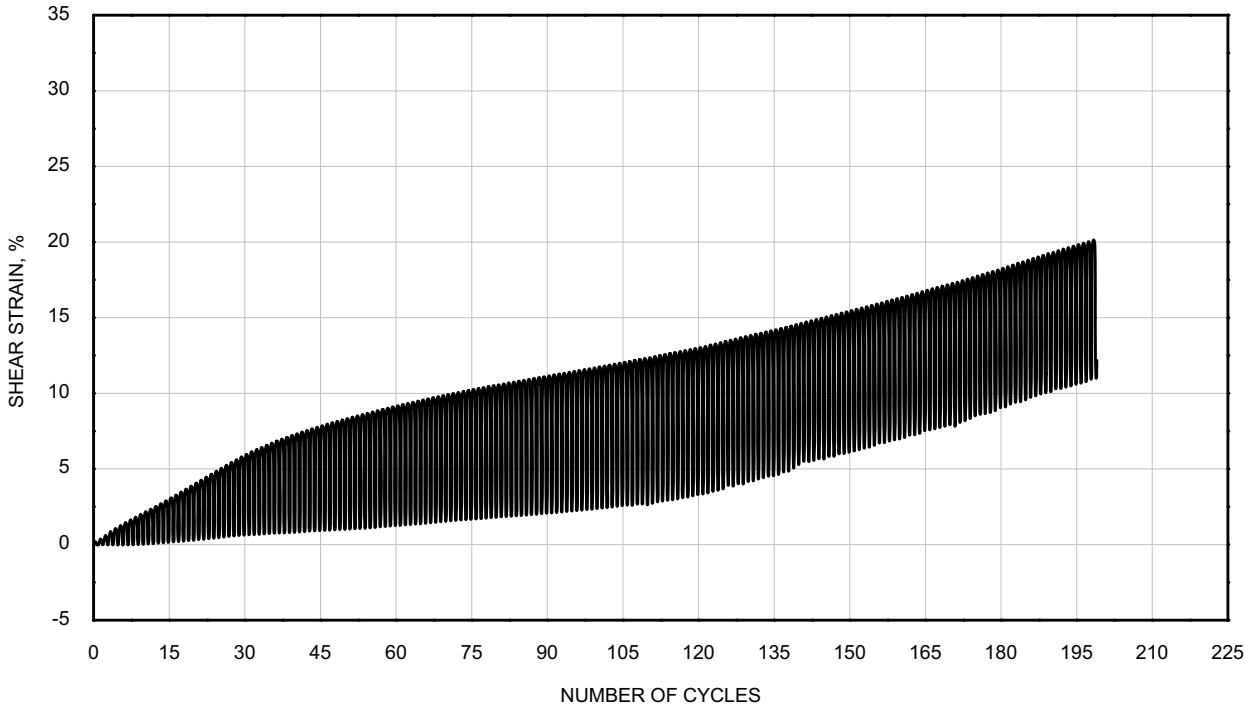
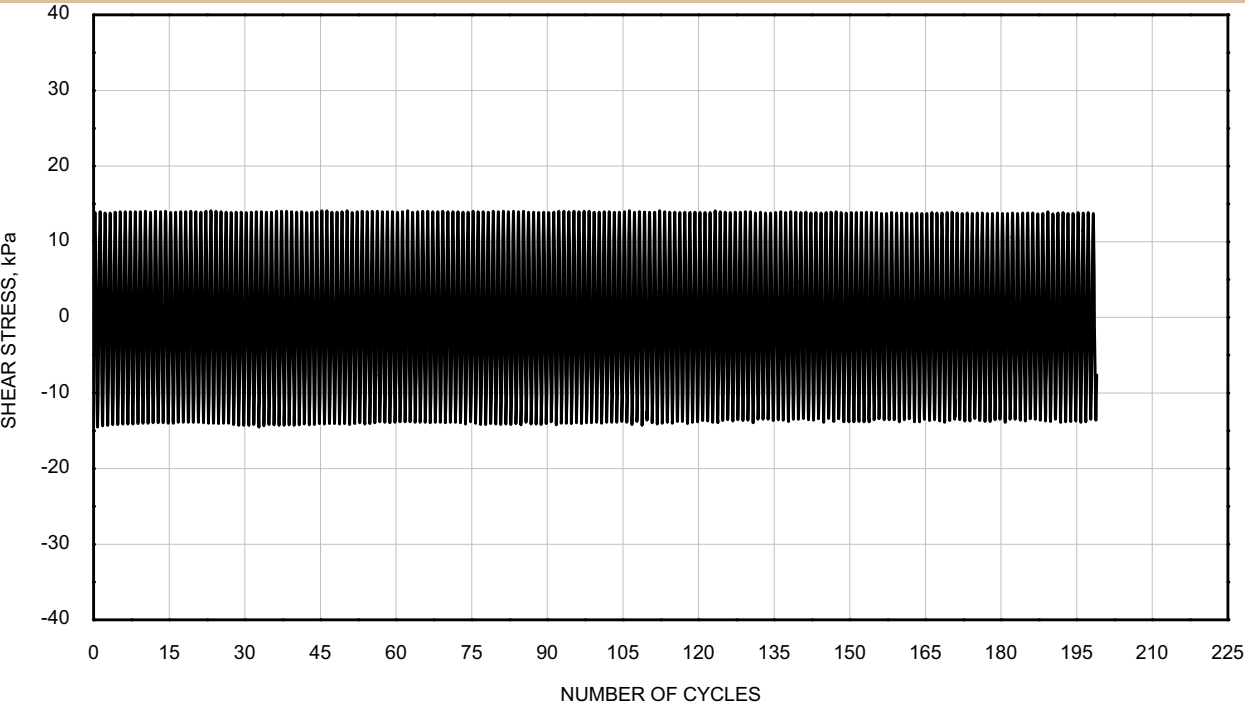
Drawn by: PR
Date: 15/07/2011

Template Issue: 2

Filename: J11056 \ BH-07_03B_CSS1.OPJ

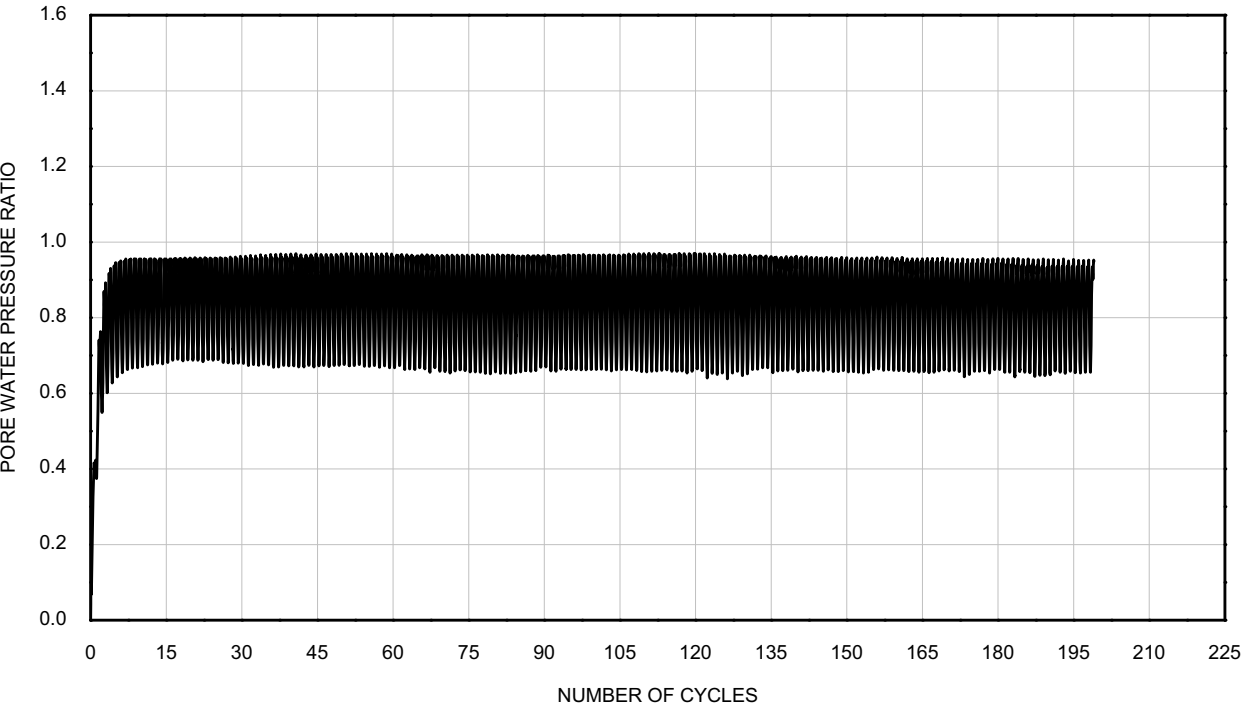
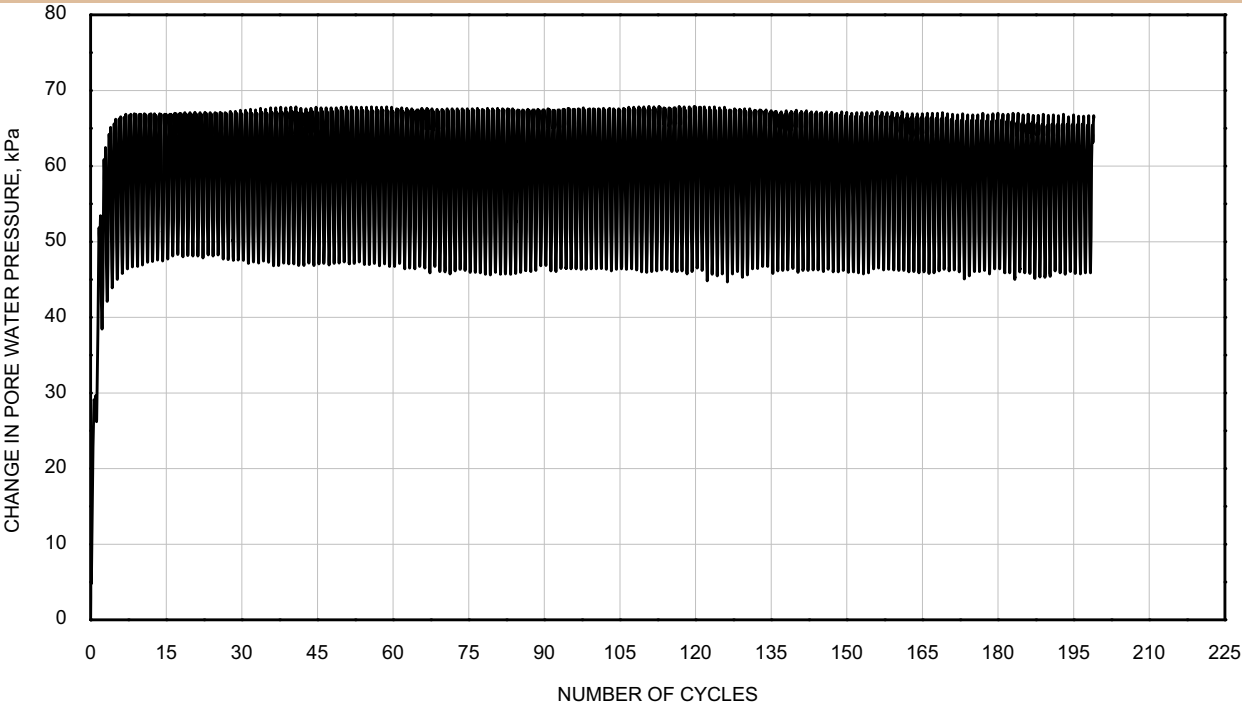
Checked by:
Date:

Approved by:
Date:



$\sigma'_{vc(max)}$	: 70 kPa	Borehole	: BH_07
σ'_{vc}	: 70 kPa	Sample	: 3WaxB
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.40
Nominal τ_{cy}	: 14 kPa	Test No	: CSS1
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



$\sigma'_{vc(max)}$	: 70 kPa	Borehole	: BH_07
σ'_{vc}	: 70 kPa	Sample	: 3WaxB
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.40
Nominal τ_{cy}	: 14 kPa	Test No	: CSS1
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



Drawn by: PR Date: 15/07/2011

Template Issue: 2

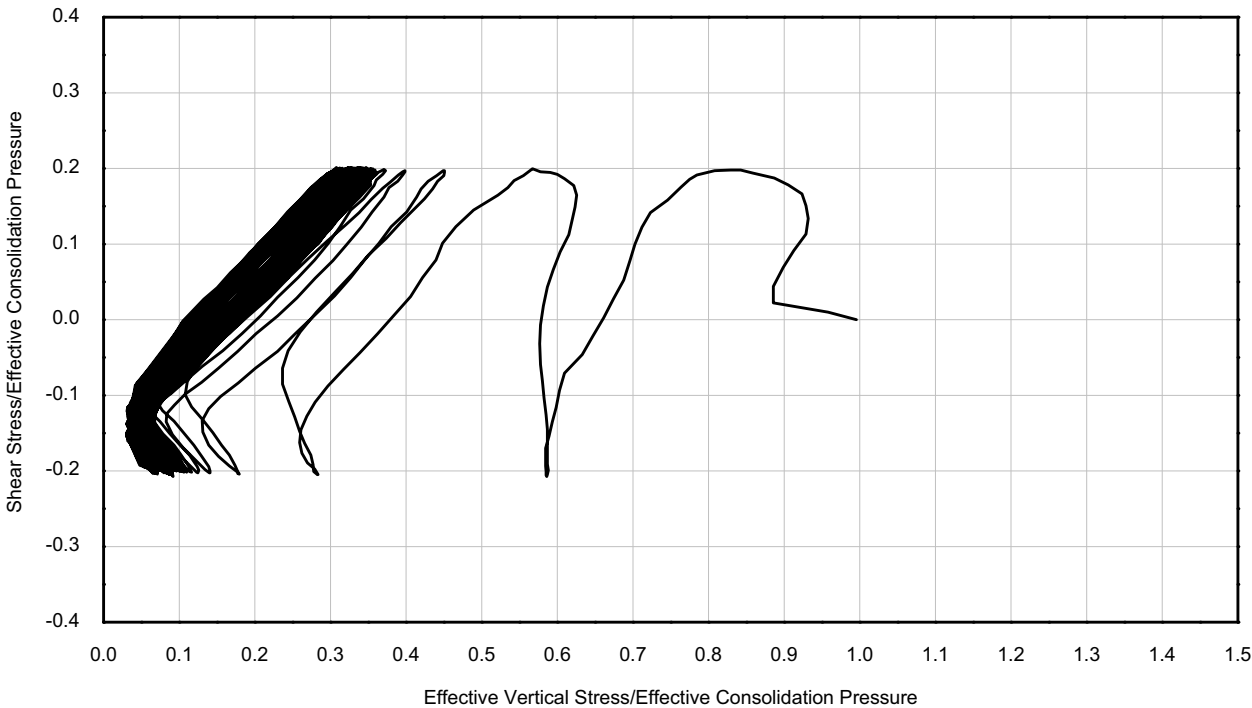
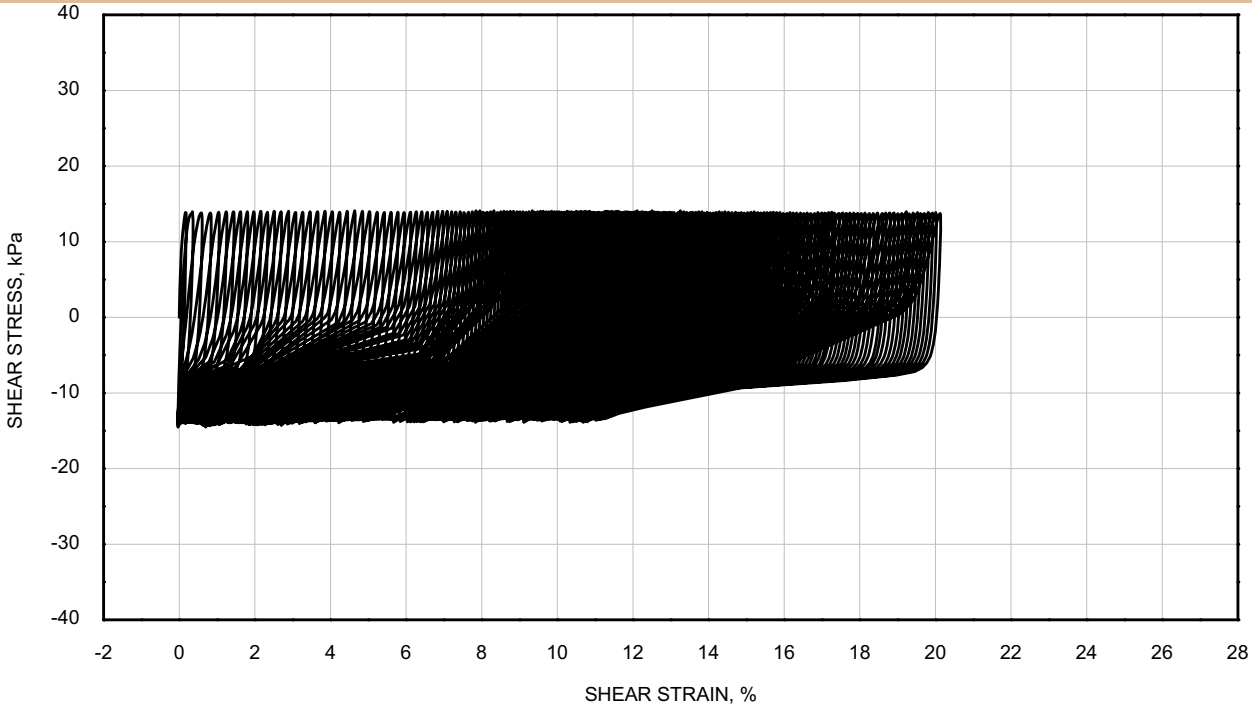
Filename: J11056\BH-07_03B_CSS1.OPJ

Date:

Date:

Checked by:

Approved by:



$\sigma'_{vc(max)}$	: 70 kPa	Borehole	: BH_07
σ'_{vc}	: 70 kPa	Sample	: 3WaxB
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.40
Nominal τ_{cy}	: 14 kPa	Test No	: CSS1
Frequency	: 0.10 Hz		

**CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE**

Date: 15/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CSS / BH-07_06A_CSS2.XLS

VISUAL DESCRIPTION

Very stiff white CHALK.

GENERAL

Date test started	29/06/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	66.5
Length	(mm)	20.0
Moisture content	(%)	24.4
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.61
Voids ratio		0.673
Degree of saturation	(%)	98
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	360

TESTING PROCEDURES USED

Specimen Set-up	Fugro in house procedure
Consolidation	Fugro in house procedure
Shearing	Fugro in house procedure

Note: Fugro testing procedures are available on request

Borehole	BH_07
Sample	6WaxA
Depth (m)	12.64
Test Number	CSS2

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST

Date: 22/07/2011

Date:

Checked by: RMB

Approved by:

Date: 15/07/2011

Drawn by: PR

Template Issue: 2

Date: 22/07/2011

Checked by: RMB

Filename: J11056 / CSS / BH-07_06A_CSS2.XLS

Date:

Approved by:

CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	120
Vertical strain	(%)	0.70
Volumetric strain	(%)	0.70
Bulk density	(Mg/m ³)	2.01
Dry density	(Mg/m ³)	1.63

CYCLIC LOADING STAGE		
Reference stress	(kPa)	55
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	22
Frequency	(Hz)	0.10
Cycles at failure	(N)	53
Average shear strain @ N	(%)	6.36
Cyclic shear strain @ N	(%)	7.78
Change in pore pressure @ N	(kPa)	115

SHEARING		
At peak shear stress		
Shear stress	(kPa)	77
Shear strain	(%)	32.94
Change in pore pressure	(kPa)	4
Rate of strain	(%/hr)	-

Borehole	BH_07
Sample	6WaxA
Depth (m)	12.64
Test Number	CSS2

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST



Date: 15/07/2011
Drawn by: PR
Template Issue: 2
Filename: J11056 / CSS / BH-07_06A_CSS2.XLS
Date: 22/07/2011
Date:
Checked by: RMB
Approved by:

SPECIMEN PHOTOGRAPH



Borehole	BH_07
Sample	6WaxA
Depth (m)	12.64
Test Number	CSS2

SUMMARY OF
CONSOLIDATED CONSTANT VOLUME CSS TEST

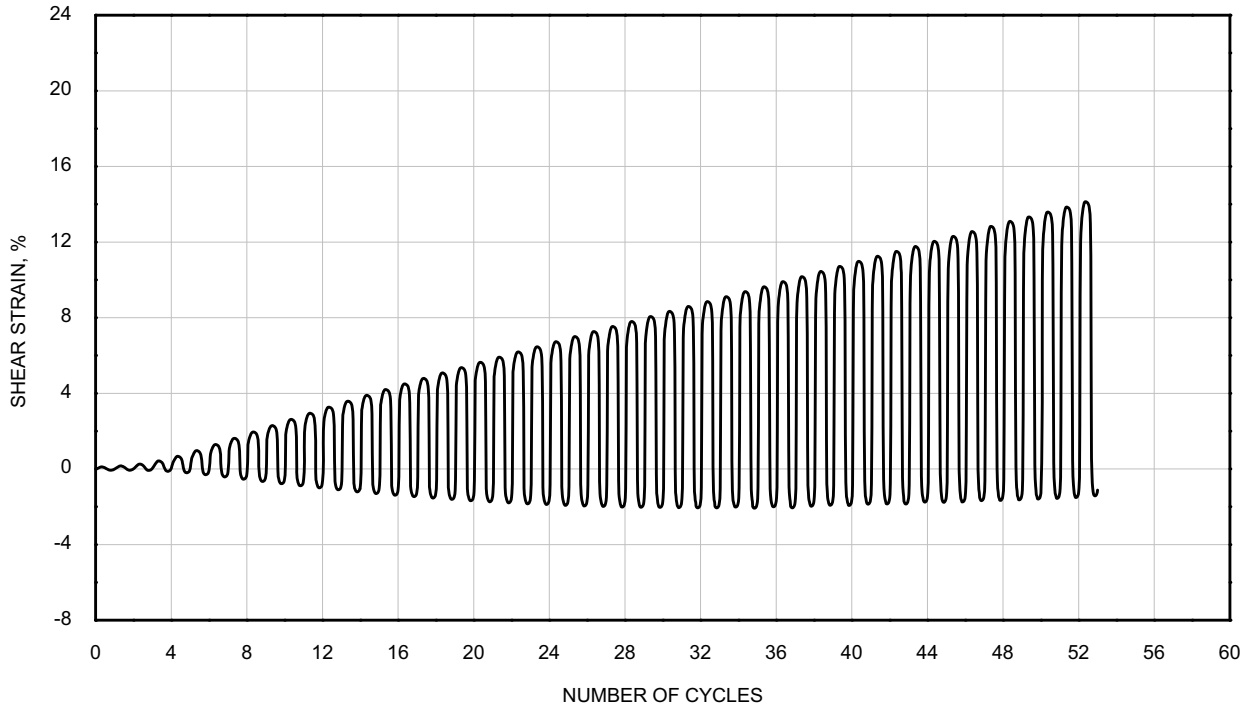
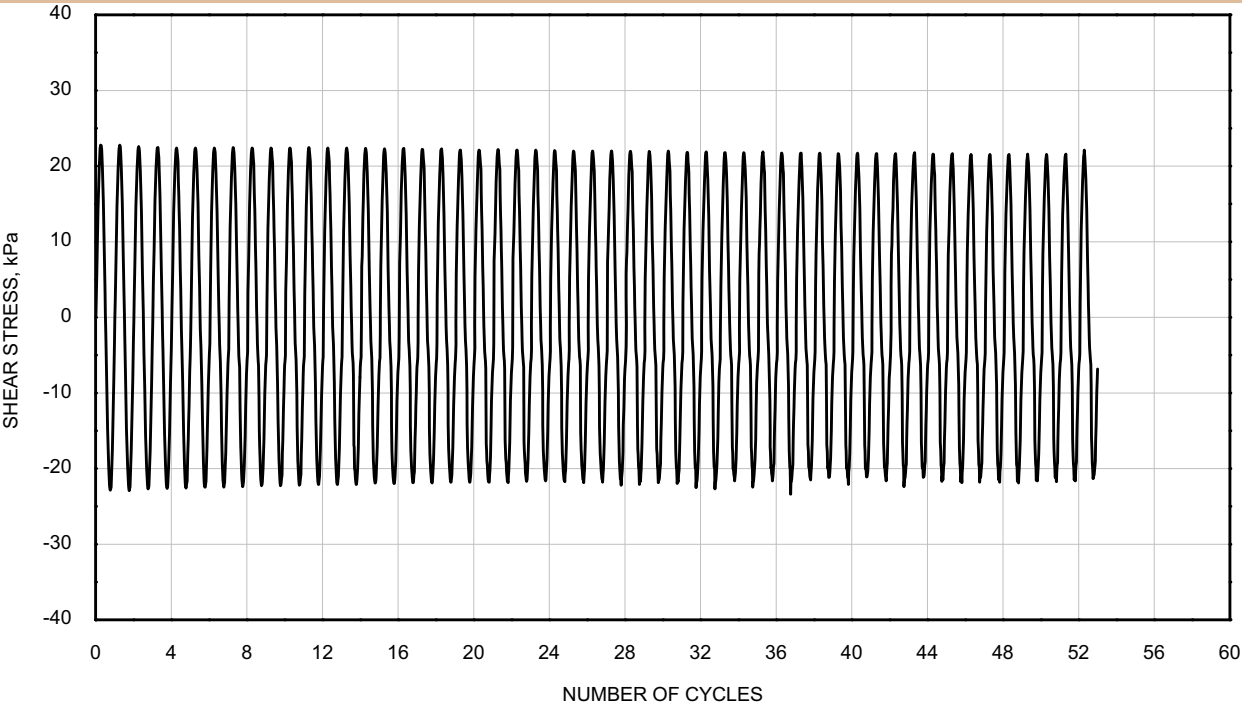
Drawn by: PR
Date: 15/07/2011

Template Issue: 2

Filename: J11056 \ BH-07_06A_CSS2.OPJ

Checked by:
Date:

Approved by:
Date:



$\sigma'_{vc(max)}$	: 120 kPa	Borehole	: BH_07
σ'_{vc}	: 120 kPa	Sample	: 6WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 12.64
Nominal τ_{cy}	: 22 kPa	Test No	: CSS2
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



Drawn by: PR Date: 15/07/2011

Template Issue: 2

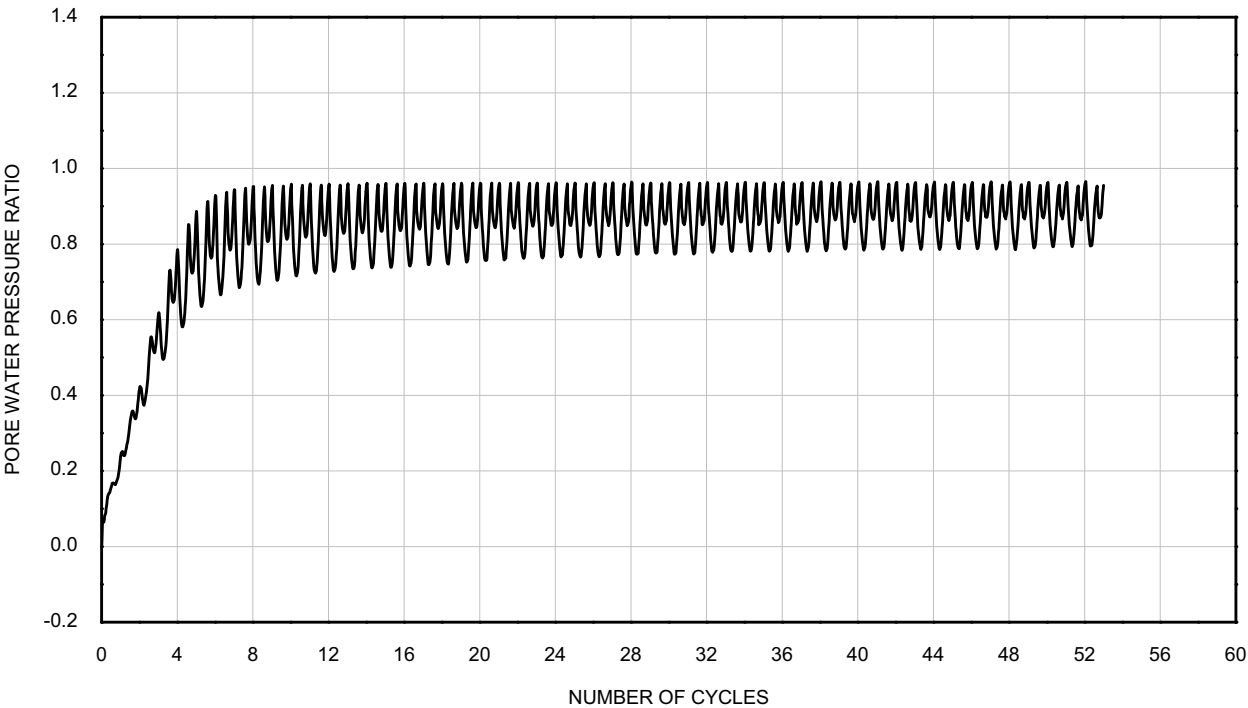
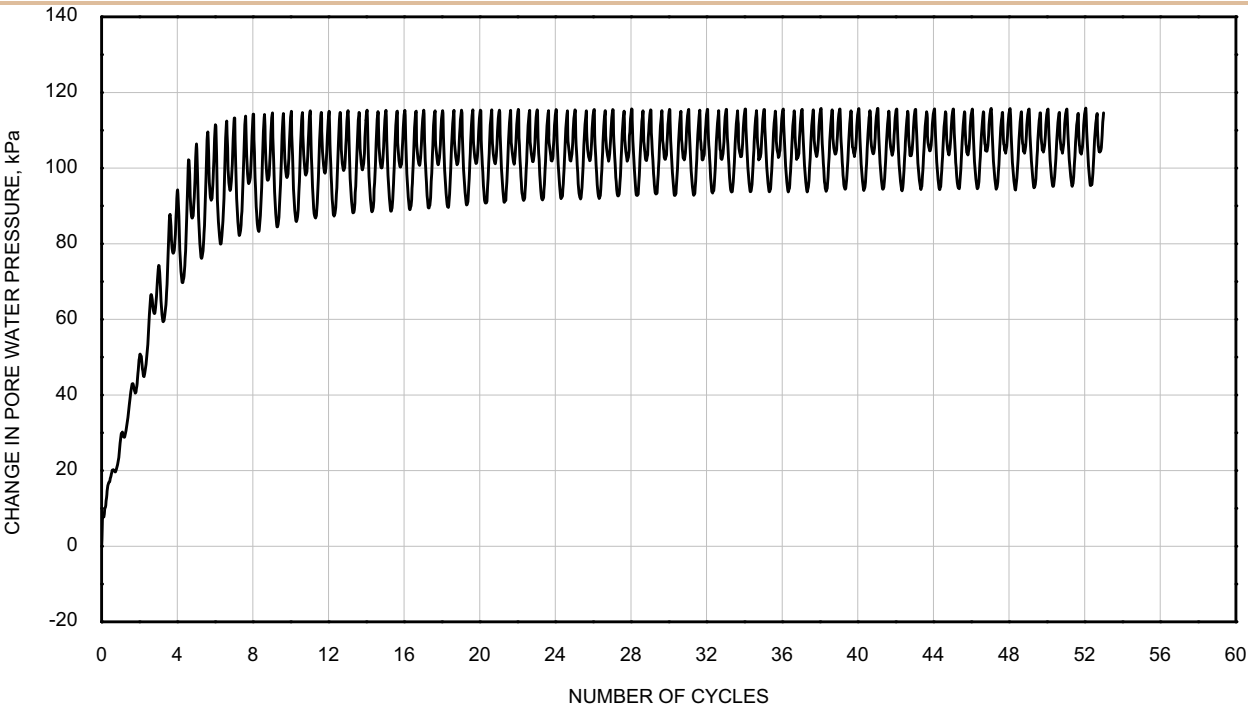
Filename: J11056 \ BH-07_06A_CSS2.OPJ

Date:

Date:

Checked by:

Approved by:



$\sigma'_{vc(max)}$	: 120 kPa	Borehole	: BH_07
σ'_{vc}	: 120 kPa	Sample	: 6WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 12.64
Nominal τ_{cy}	: 22 kPa	Test No	: CSS2
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



Drawn by: PR Date: 15/07/2011

Template Issue: 2

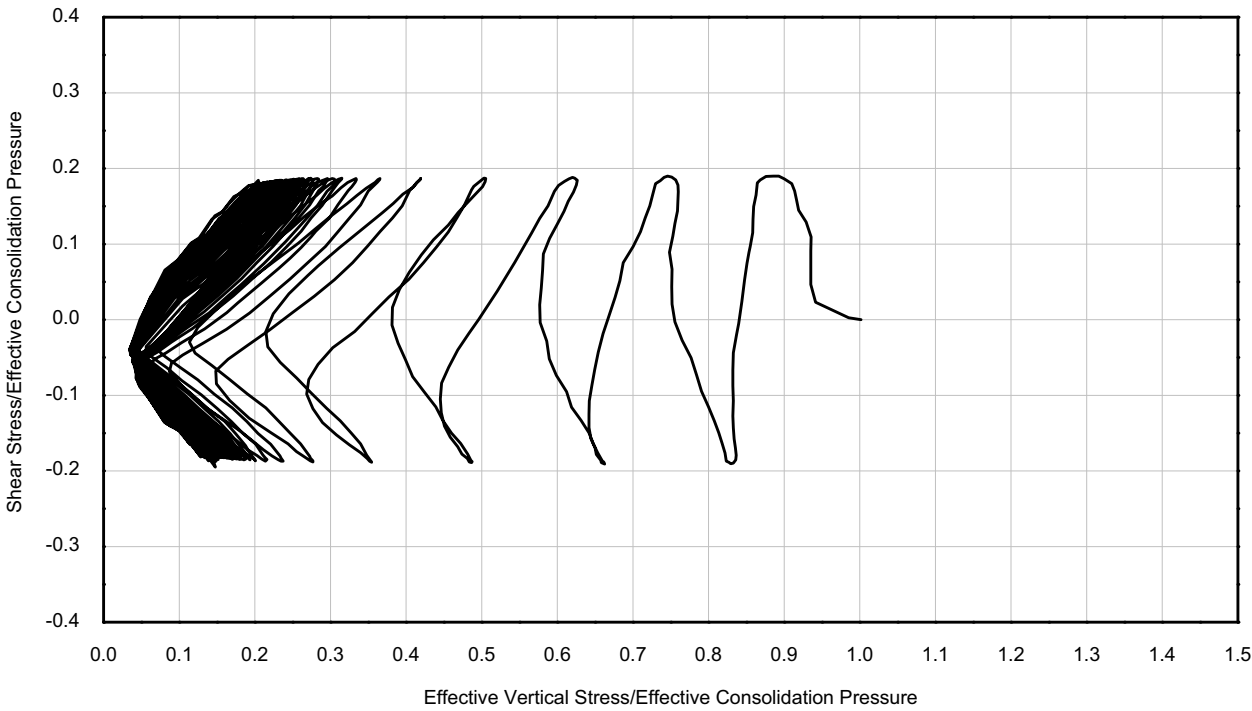
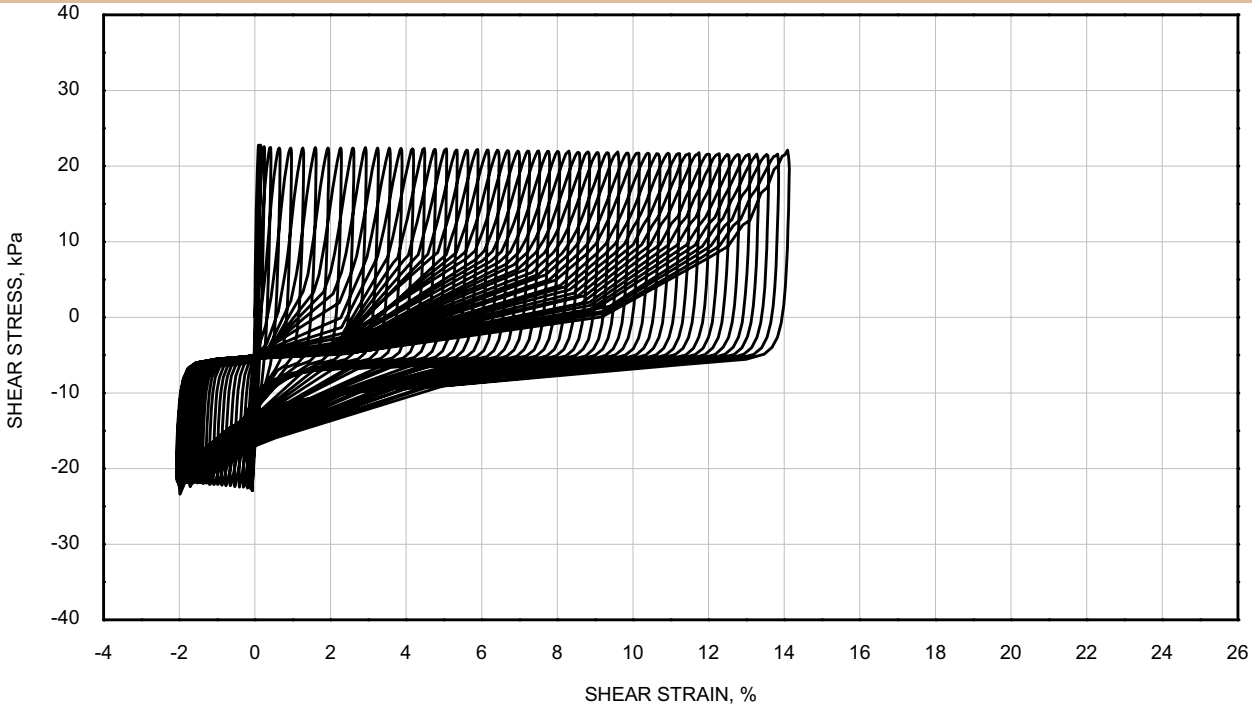
Filename: J11056\BH-07_06A_CSS2.OPJ

Date:

Date:

Checked by:

Approved by:



$\sigma'_{vc \text{ (max)}}$	: 120 kPa	Borehole	: BH_07
σ'_{vc}	: 120 kPa	Sample	: 6WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 12.64
Nominal τ_{cy}	: 22 kPa	Test No	: CSS2
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



Date: 13/06/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CSS / BH-07_12A_CSS3.XLS

VISUAL DESCRIPTION

GENERAL

Date test started	07/06/2011
Type of sample	Undisturbed
Specimen orientation	Vertical

INITIAL

Diameter	(mm)	49.9
Length	(mm)	19.2
Moisture content	(%)	21.4
Bulk density	(Mg/m ³)	2.05
Dry density	(Mg/m ³)	1.69
Voids ratio		0.601
Degree of saturation	(%)	96
Torvane	(kPa)	-
Pocket penetrometer	(kPa)	290

TESTING PROCEDURES USED

Specimen Set-up	Fugro in house procedure
Consolidation	Fugro in house procedure
Shearing	Fugro in house procedure

Note: Fugro testing procedures are available on request

Borehole	BH_07
Sample	12WaxA
Depth (m)	23.08
Test Number	CSS3

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST

Date: 21/06/2011

Checked by: PH

Date:
Approved by:

Date: 13/06/2011

Drawn by: PR

Template Issue: 2

Date: 21/06/2011

Checked by: PH

Filename: J11056 / CSS / BH-07_12A_CSS3.XLS

Date:

Approved by:

CONSOLIDATION σ_{vc}'		
σ_{vc}'	(kPa)	220
Vertical strain	(%)	2.57
Volumetric strain	(%)	2.57
Bulk density	(Mg/m ³)	2.08
Dry density	(Mg/m ³)	1.73

CYCLIC LOADING STAGE		
Reference shear stress	(kPa)	100
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	40
Frequency	(Hz)	0.10
Cycles at failure	(N)	267
Average shear strain @ N	(%)	-0.30
Cyclic shear strain @ N	(%)	8.34
Change in pore pressure @ N	(kPa)	205

SHEARING		
At peak shear stress		
Shear stress	(kPa)	312
Shear strain	(%)	28.99
Change in pore pressure	(kPa)	-191
Rate of strain	(%/hr)	3.4

Borehole	BH_07
Sample	12WaxA
Depth (m)	23.08
Test Number	CSS3

SUMMARY OF CONSOLIDATED CONSTANT VOLUME CSS TEST

Date: 13/06/2011

Drawn by: PR

Template Issue: 2

Date: 21/06/2011

Checked by: PH

Filename: J11056 / CSS / BH-07_12A_CSS3.XLS

Date:

Approved by:

SPECIMEN PHOTOGRAPH



Borehole	BH_07
Sample	12WaxA
Depth (m)	23.08
Test Number	CSS3

SUMMARY OF
CONSOLIDATED CONSTANT VOLUME CSS TEST



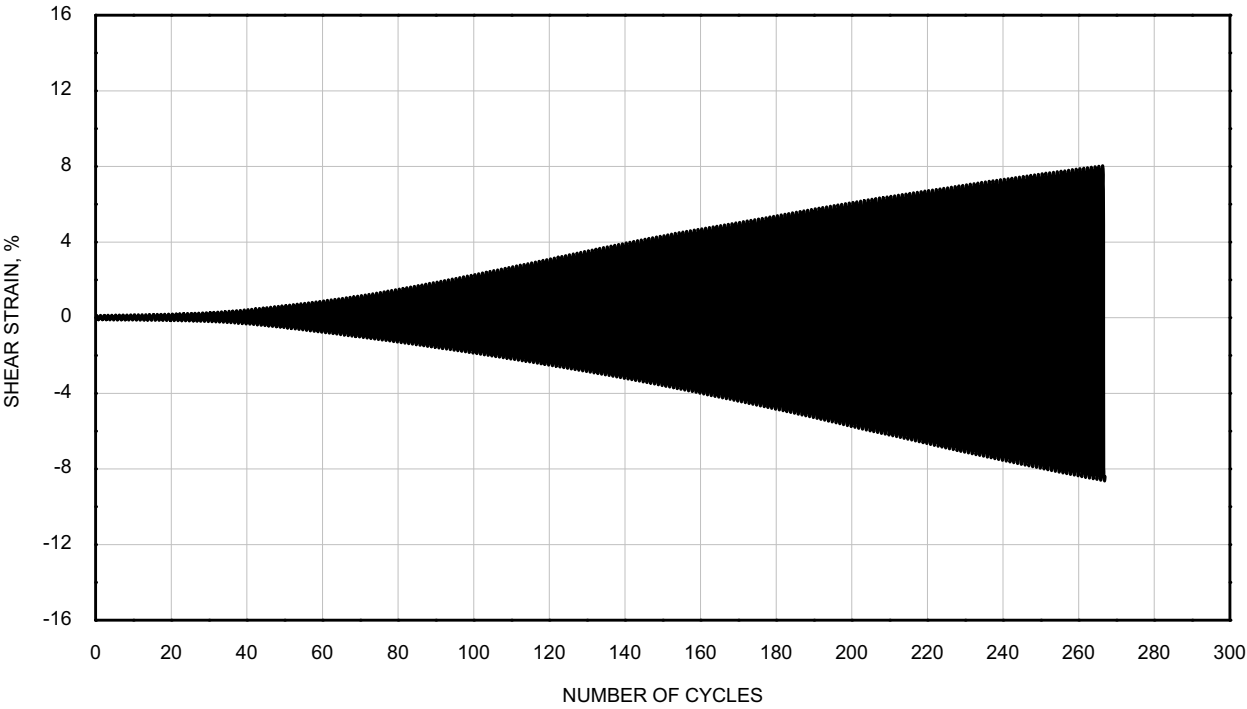
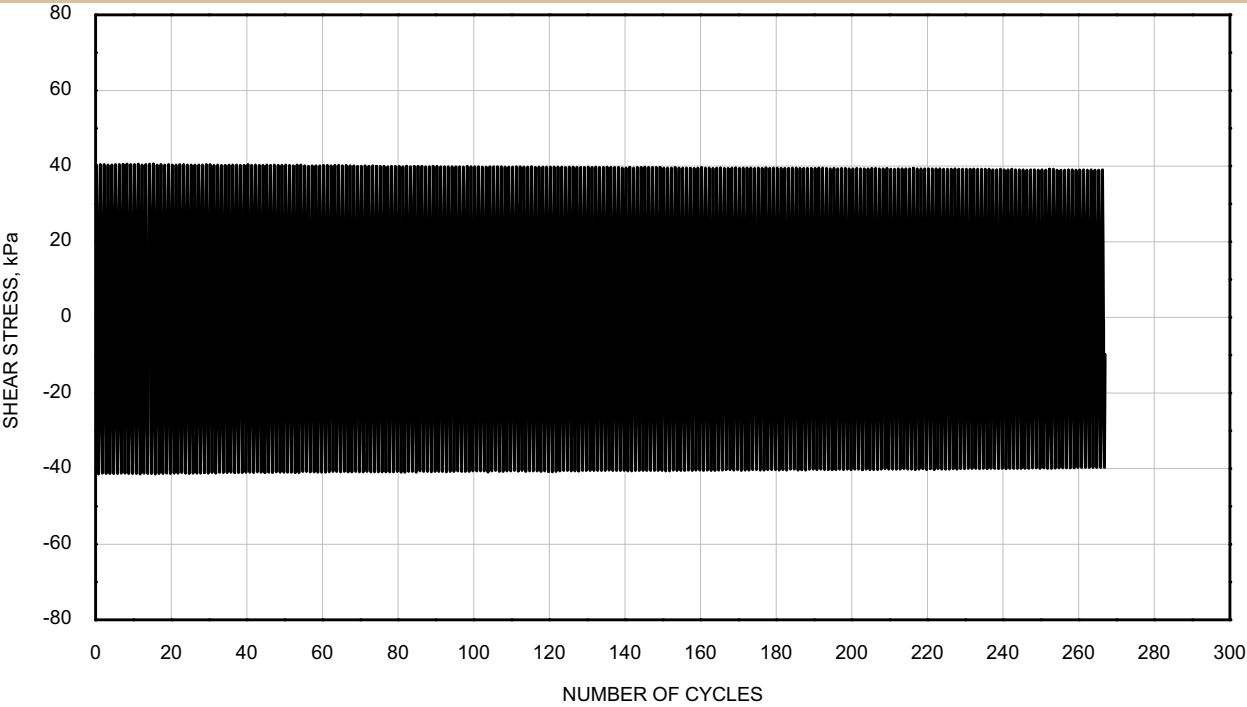
Date: 13/06/2011
Drawn by: PR

Template Issue: 2

Filename: J11056 \ BH-07_12A_CSS3.OPJ

Date:
Checked by:

Date:
Approved by:



$\sigma'_{vc(max)}$	: 220 kPa	Borehole	: BH_07
σ'_{vc}	: 220 kPa	Sample	: 12WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 23.08
Nominal τ_{cy}	: 40 kPa	Test No	: CSS3
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



Drawn by: PR Date: 13/06/2011

Template Issue: 2

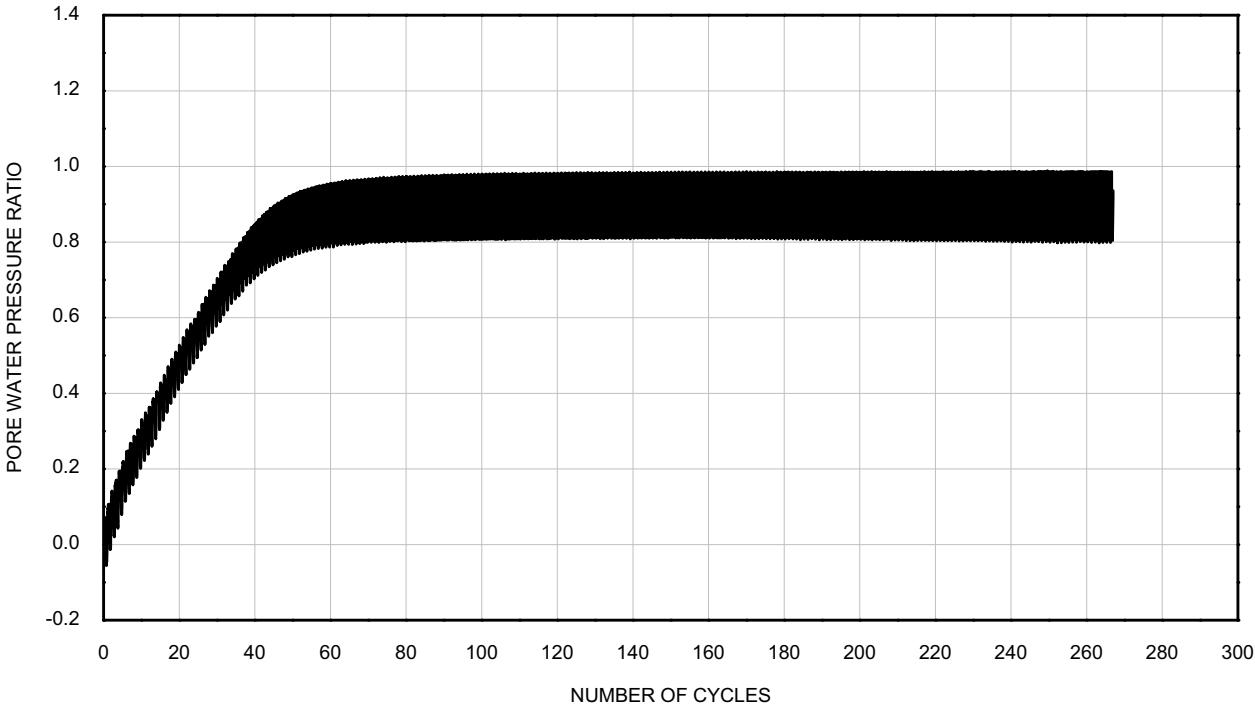
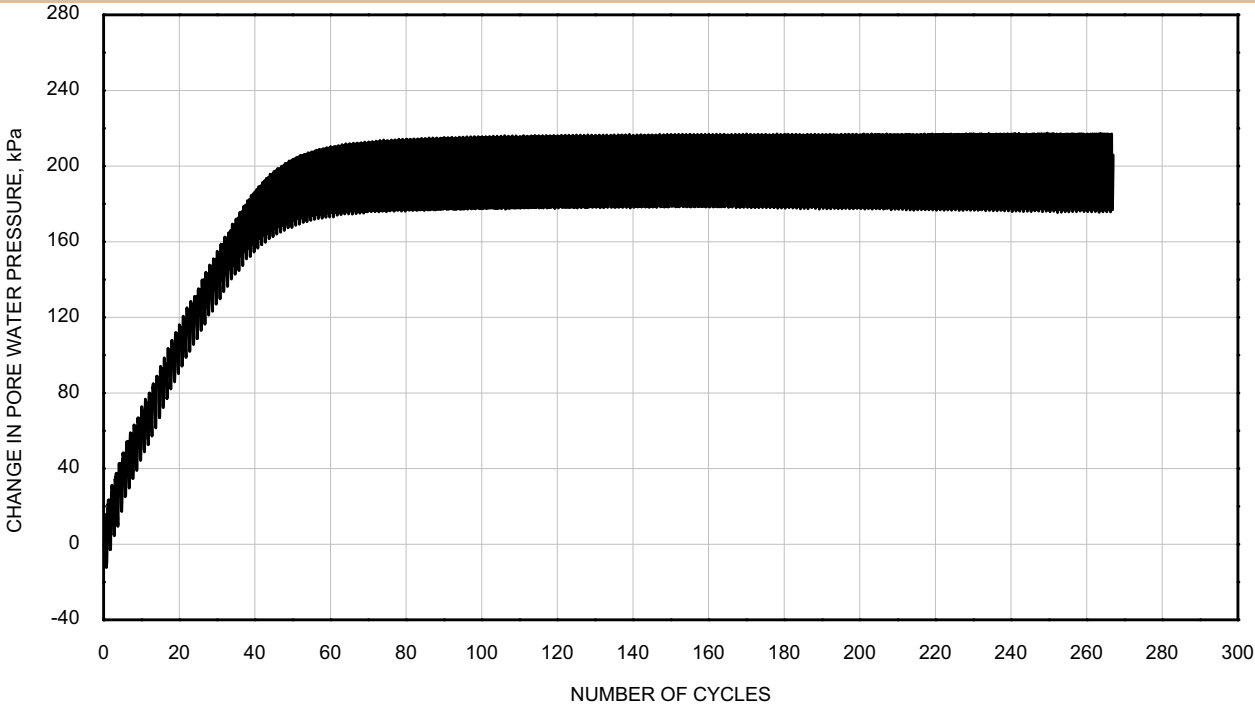
Filename: J11056 \ BH-07_12A_CSS3.OPJ

Date:

Date:

Checked by:

Approved by:



$\sigma'_{vc(max)}$	: 220 kPa	Borehole	: BH_07
σ'_{vc}	: 220 kPa	Sample	: 12WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 23.08
Nominal τ_{cy}	: 40 kPa	Test No	: CSS3
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE



Drawn by: PR Date: 13/06/2011

Template Issue: 2

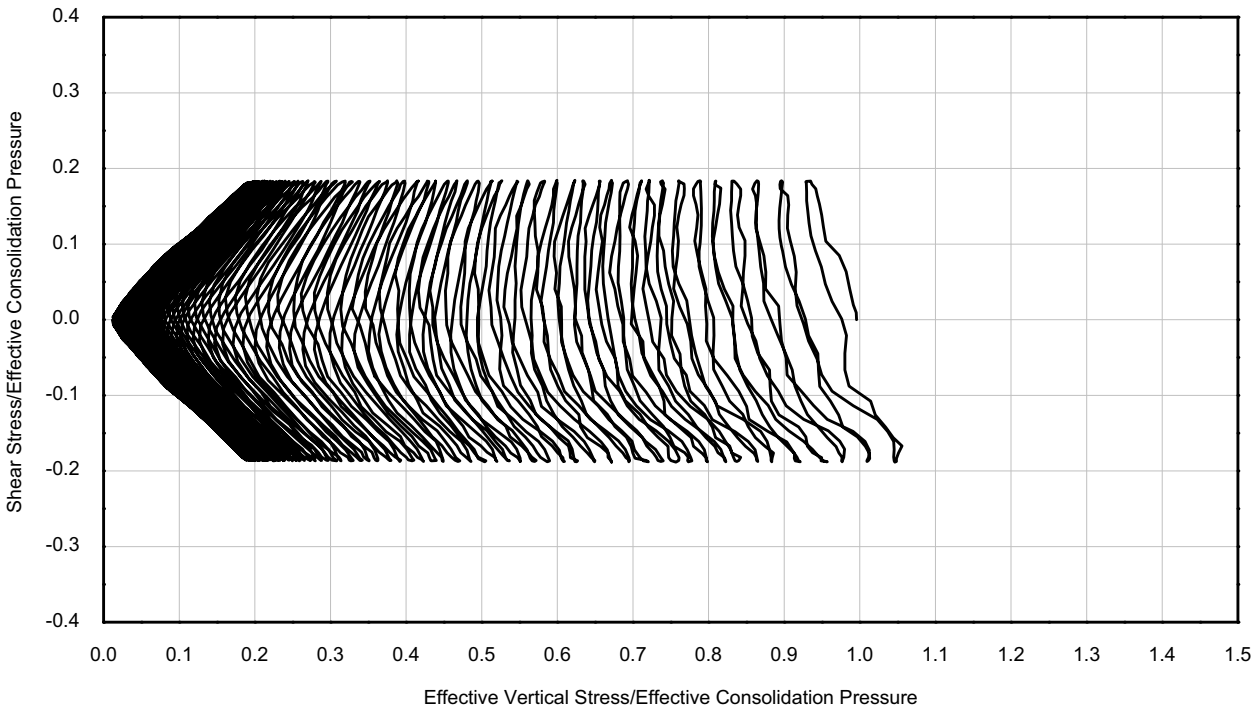
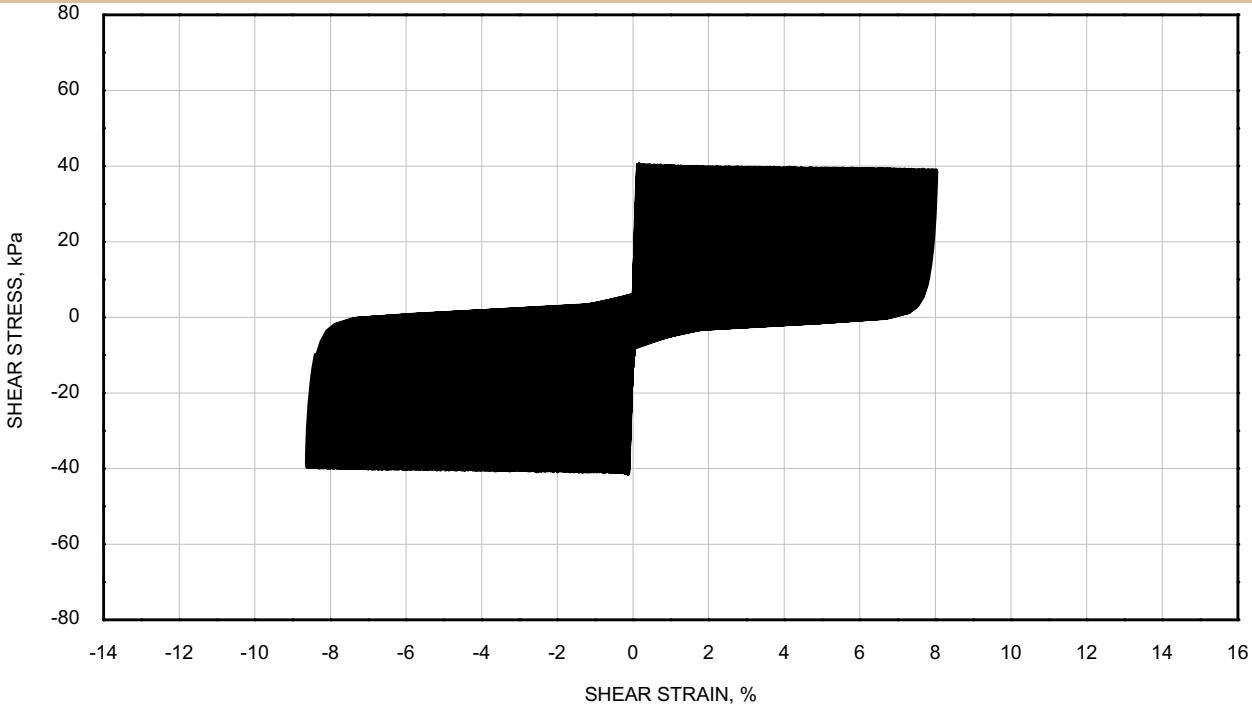
Filename: J11056\BH-07_12A_CSS3.OPJ

Date:

Date:

Checked by:

Approved by:



$\sigma'_{vc} \text{ (max)}$	: 220 kPa	Borehole	: BH_07
σ'_{vc}	: 220 kPa	Sample	: 12WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 23.08
Nominal τ_{cy}	: 40 kPa	Test No	: CSS3
Frequency	: 0.10 Hz		

CONSOLIDATED CONSTANT VOLUME CYCLIC DSS TEST
CYCLIC LOADING STAGE

Date: 19/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-13_04A_CTX1.XLS

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION

Very stiff dark olive grey slightly sandy CLAY with pockets, partings and layers of light olive grey silty fine sand and some black staining.

GENERAL

Date test started	10/06/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL

Diameter	(mm)	73.3
Length	(mm)	140.5
Moisture content	(%)	26
Bulk density	(Mg/m ³)	1.86
Dry density	(Mg/m ³)	1.48
Voids ratio		0.807
Degree of saturation	(%)	87

SATURATION

Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	35
Pore pressure on completion	(kPa)	524
Cell pressure on completion	(kPa)	577
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
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Fugro testing procedure L-T-023 Clause 5.2.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Cycling	Fugro testing procedure
Note: Fugro testing procedures are available on request	

Borehole	BH_13
Sample	4WaxA
Depth (m)	7.86
Test number	CTX1

SUMMARY OF ANISOTROPICALLY CONSOLIDATED UNDRAINED CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

Date: 19/07/2011

Drawn by: PR

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	577
Back pressure	(kPa)	500
Effective cell pressure	(kPa)	77
Pore pressure on completion	(kPa)	500
Pore pressure dissipation	(%)	100
Moisture content	(%)	27
Bulk density	(Mg/m ³)	1.89
Dry density	(Mg/m ³)	1.48
Voids ratio		0.801
Degree of saturation	(%)	91

* Initial test conditions given to the lab were incorrect, hence isotropic consolidation carried out to the lower pressure

Template Issue: 2

Filename: J11056 / CTXL / BH-13_04A_CTX1.XLS

CONSOLIDATION : ANISOTROPIC		
Cell pressure	(kPa)	639
Back pressure	(kPa)	500
Axial pressure	(kPa)	577
Effective cell pressure	(kPa)	139
Effective axial pressure	(kPa)	77
Pore pressure after consol	(kPa)	500
Moisture content	(%)	26
Bulk density	(Mg/m ³)	1.90
Dry density	(Mg/m ³)	1.50
Voids ratio		0.779
Degree of saturation	(%)	91
Volumetric strain	(%)	1.54
Axial strain	(%)	-0.46

Date:

Date:

Checked by:

Approved by:

Borehole	BH_13
Sample	4WaxA
Depth (m)	7.86
Test number	CTX1

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 19/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-13_04A_CTX1.XLS

SHEARING		
Initial pore pressure	(kPa)	574
Initial effective cell pressure	(kPa)	65
Rate of strain	(%/hour)	4.40
Initial deviator stress	(kPa)	0
At peak deviator stress		
Corrected deviator stress	(kPa)	258
Membrane correction applied	(kPa)	0.6
Drain correction applied	(kPa)	0
Axial strain	(%)	5.72
Excess pore pressure	(kPa)	130
Major principal effective stress	(kPa)	267
Minor principal effective stress	(kPa)	9
Principal effective stress ratio		28.41
e 50	(%)	1.02
Secant modulus at e 50	(kPa)	17013
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	243
Membrane correction applied	(kPa)	0.5
Drain correction applied	(kPa)	0
Axial strain	(%)	4.44
Excess pore pressure	(kPa)	139
Major principal effective stress	(kPa)	243
Minor principal effective stress	(kPa)	0
Principal effective stress ratio		93404.97
e 50	(%)	0.95
Secant modulus at e 50	(kPa)	17597

CYCLIC LOADING STAGE		
Reference stress	(kPa)	130
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	53
Frequency	(Hz)	0.1
Cycles at failure	(N)	1500
Average shear strain @ N	(%)	0.44
Cyclic shear strain @ N	(%)	0.73
Change in pore pressure @ N	(kPa)	59

Date:

Date:

Checked by:

Approved by:

Borehole	BH_13
Sample	4WaxA
Depth (m)	7.86
Test number	CTX1

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 19/07/2011
Drawn by: PR
Template Issue: 2
Filename: J11056 / CTXL / BH-13_04A_CTX1.XLS
Date:
Date:
Checked by:
Approved by:

SPECIMEN PHOTOGRAPHS



Borehole	BH_13
Sample	4WaxA
Depth (m)	7.86
Test number	CTX1

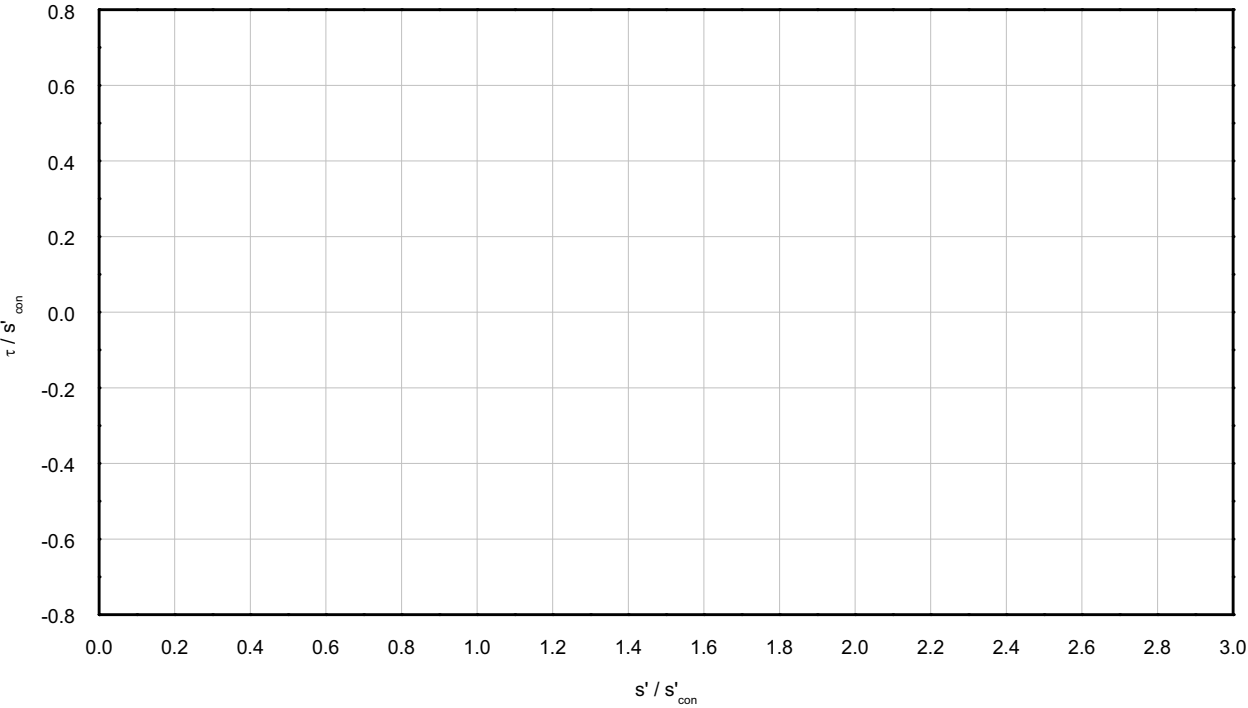
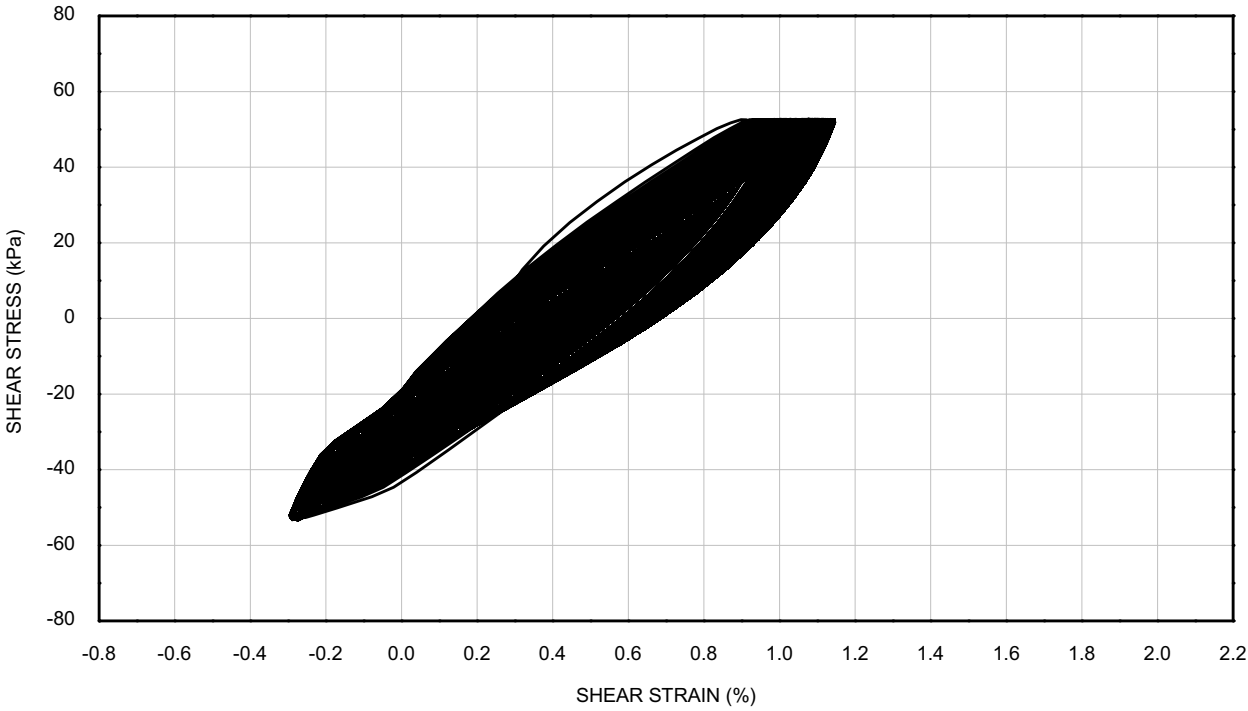
SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



Drawn by: PR
Date: 19/07/2011

Template Issue: 3

File Name : J11056 / BH-13_04A_CTX1.OPJ



Checked by:
Date:

Approved by:
Date:

σ'_{rc}	: 139 kPa	Borehole	: BH_13
σ'_{vc}	: 77 kPa	Sample	: 4WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.86
Nominal τ_{cy}	: 53 kPa	Test No	: CTX1
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



Drawn by: PR
Date: 19/07/2011

Template Issue: 3

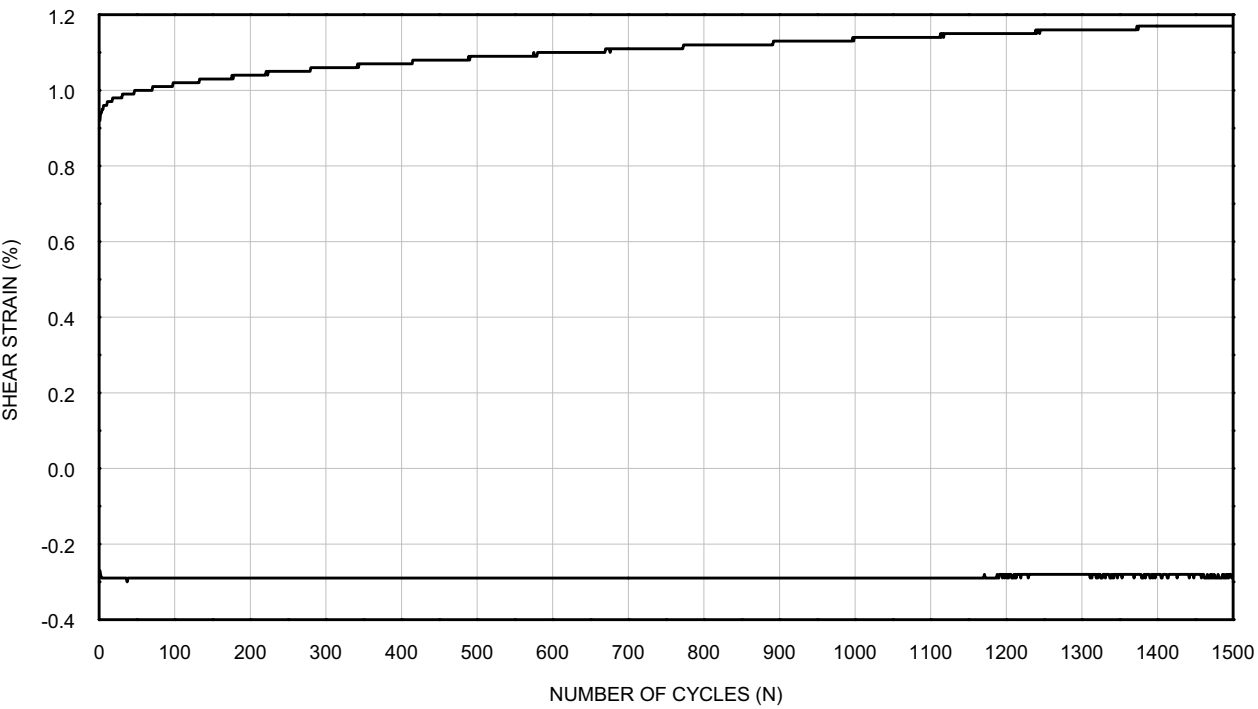
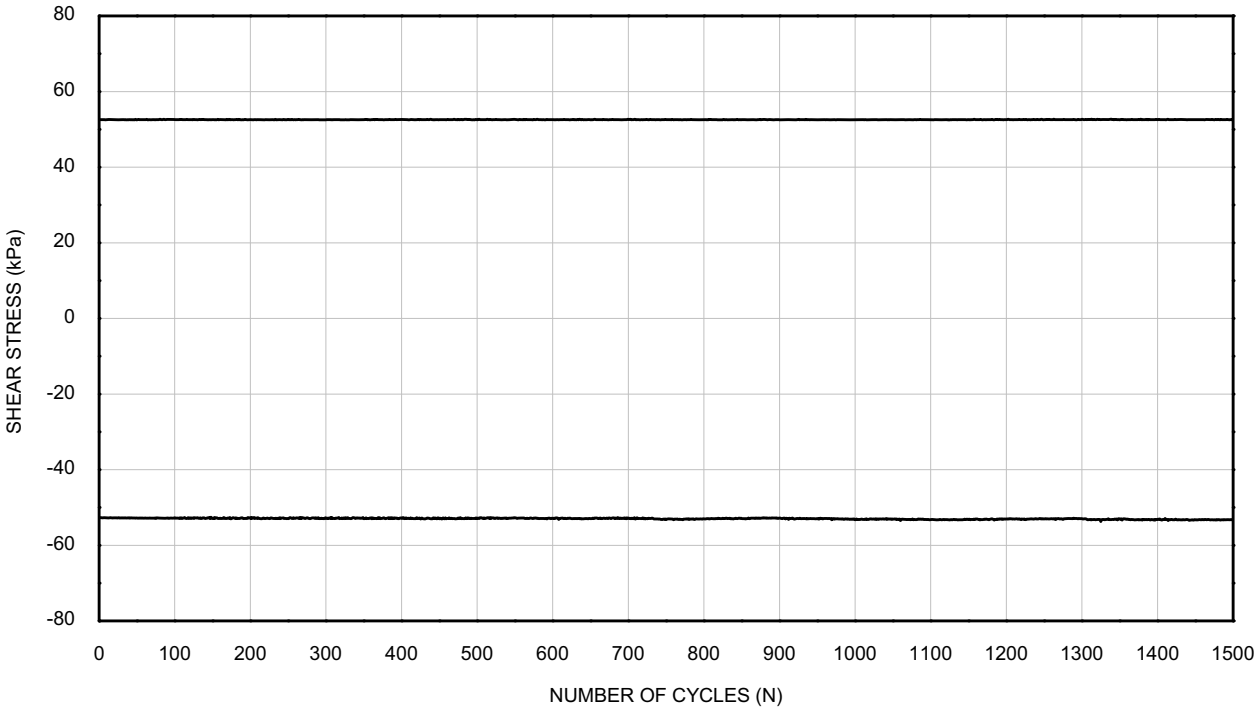
File Name : J11056 / BH-13_04A_CTX1.OPJ

Date:

Date:

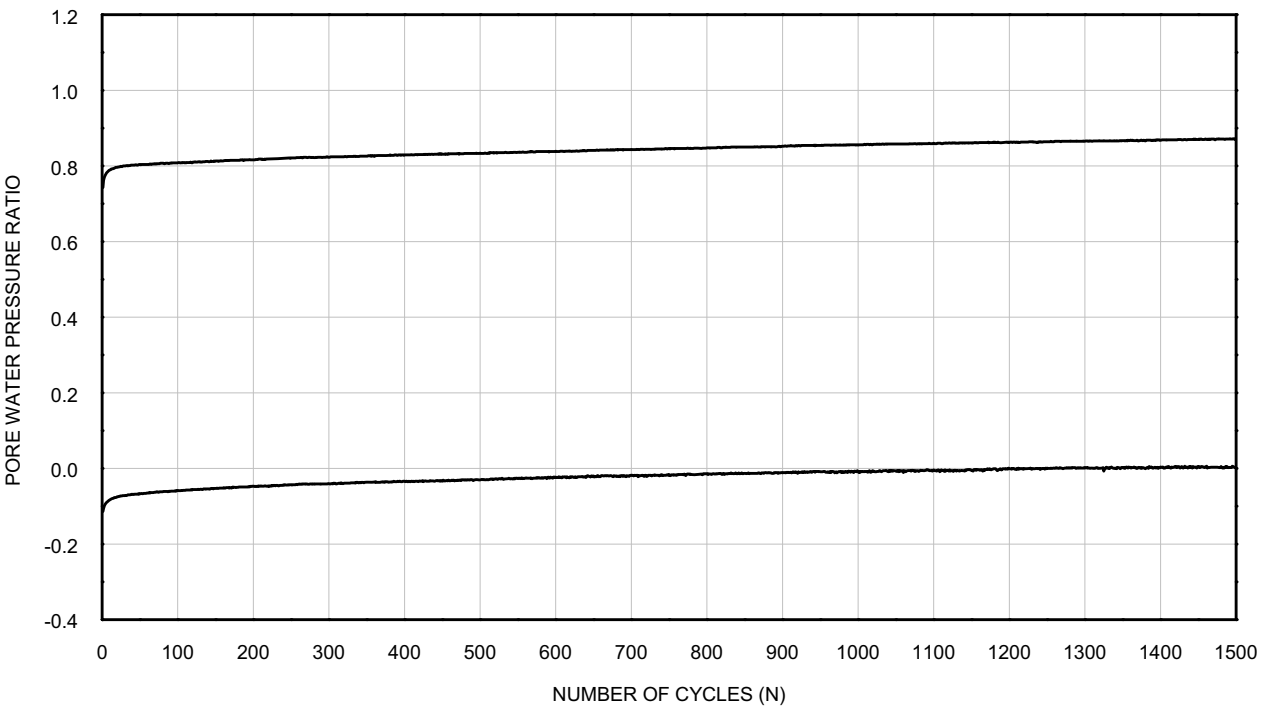
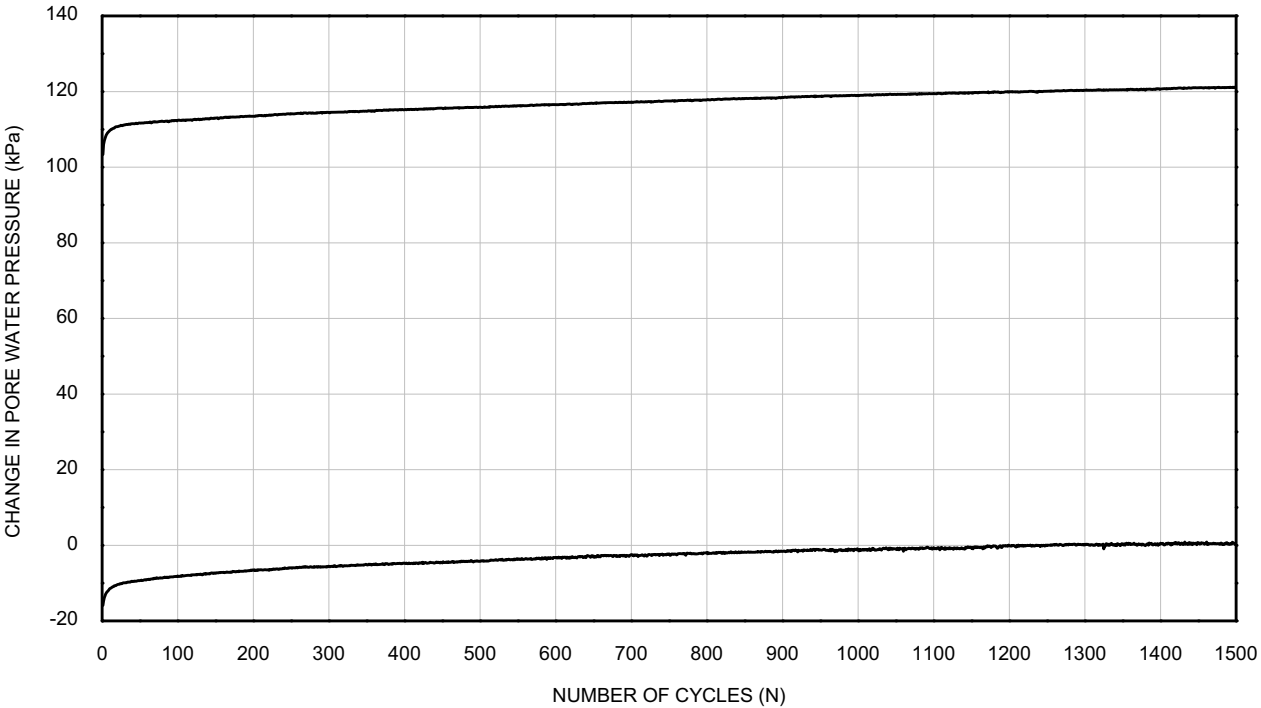
Checked by:

Approved by:



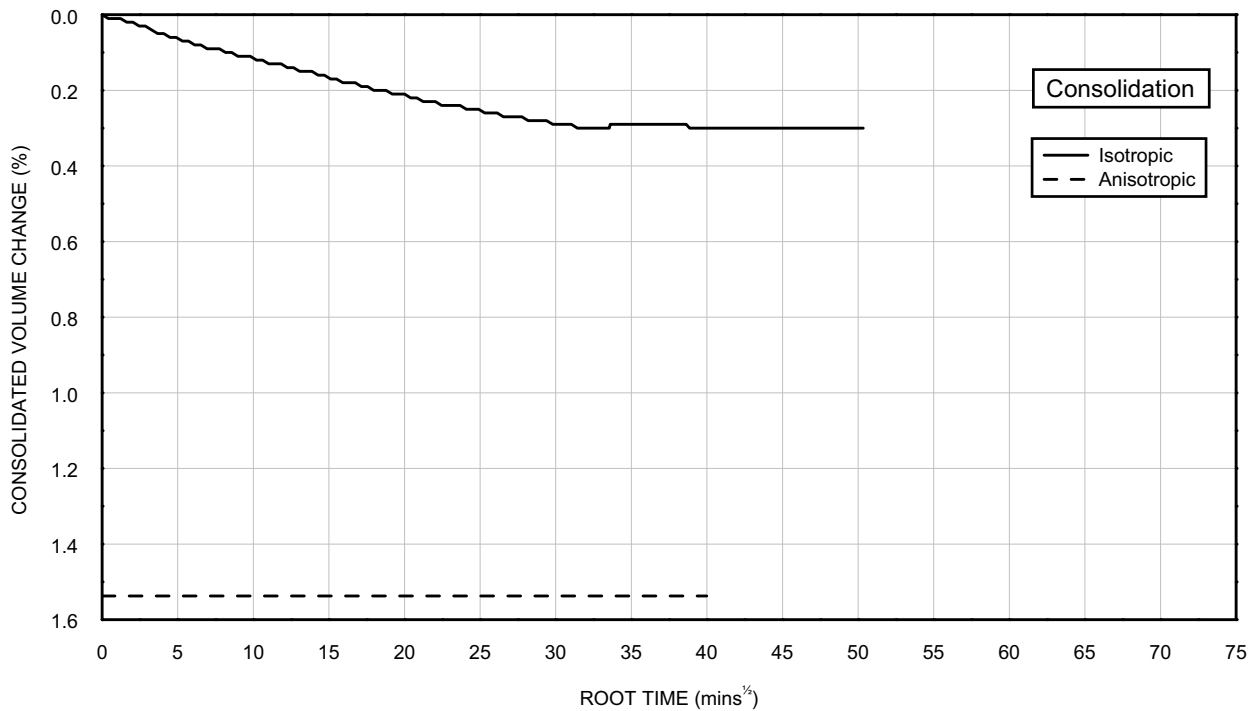
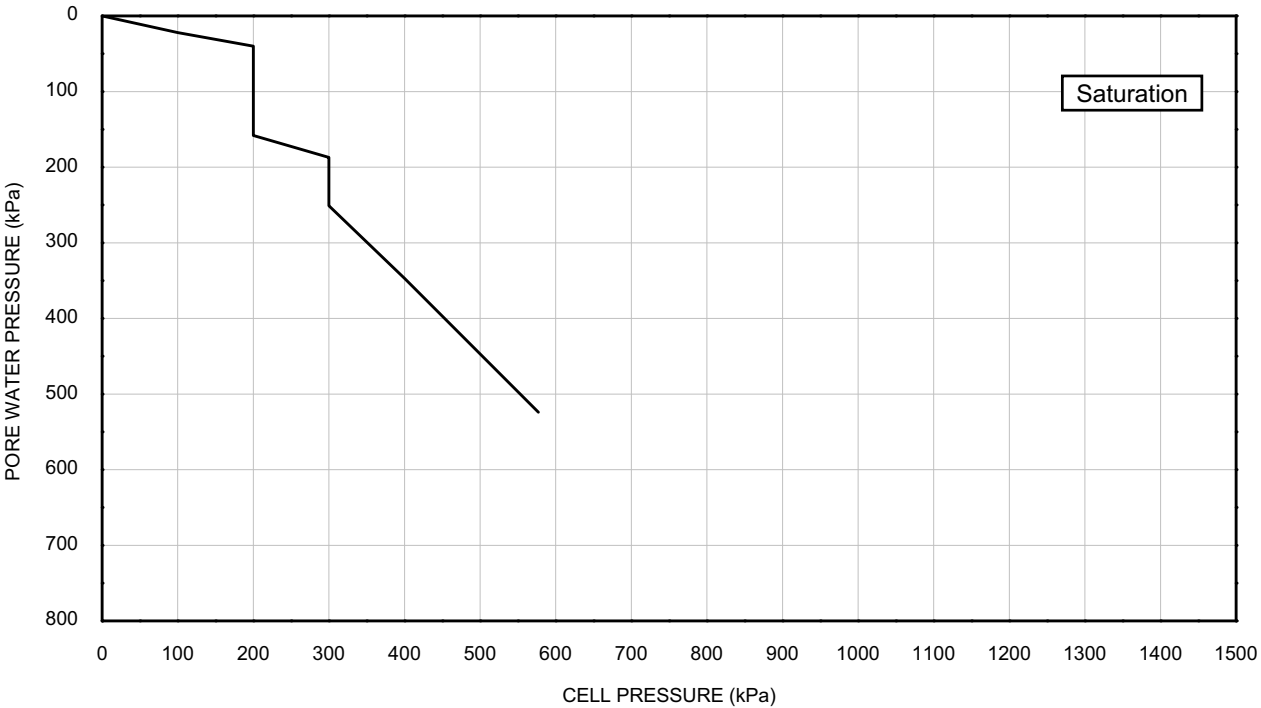
σ_{rc}'	: 139 kPa	Borehole	: BH_13
σ_{vc}'	: 77 kPa	Sample	: 4WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.86
Nominal τ_{cy}	: 53 kPa	Test No	: CTX1
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



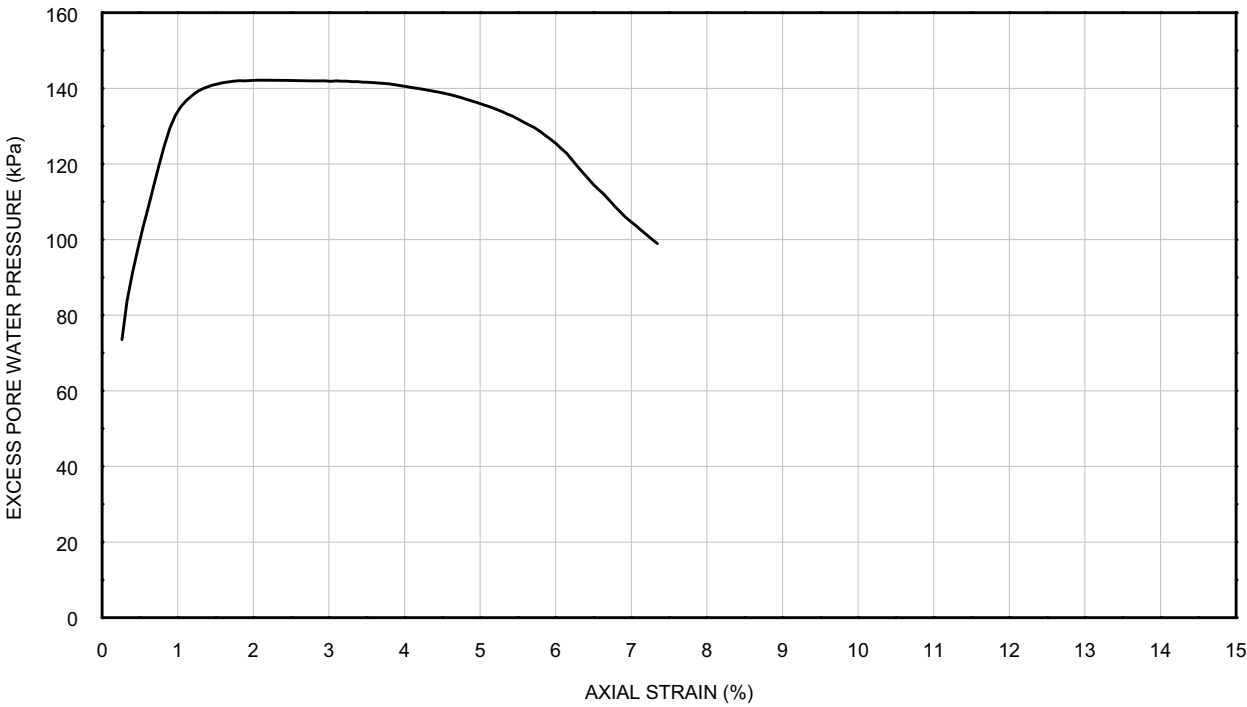
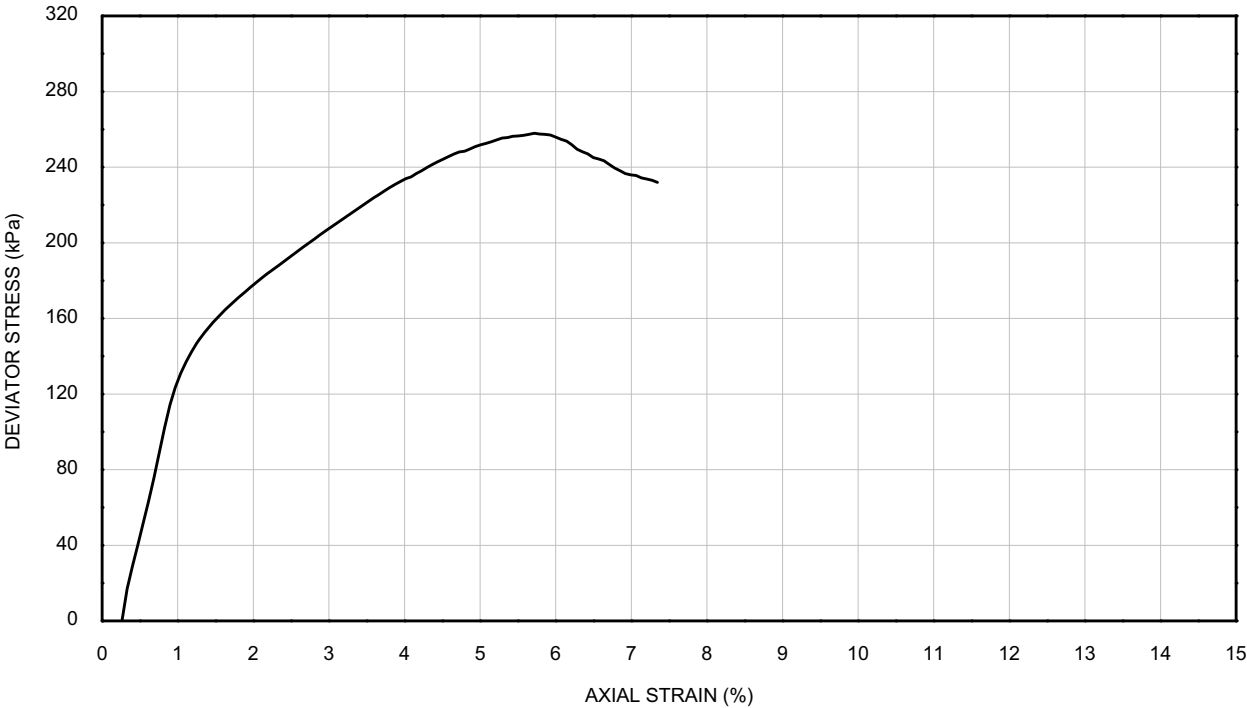
σ_{rc}'	: 139 kPa	Borehole	: BH_13
σ_{vc}'	: 77 kPa	Sample	: 4WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.86
Nominal τ_{cy}	: 53 kPa	Test No	: CTX1
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



σ'_{rc}	: 139 kPa	Borehole	: BH_13
σ'_{vc}	: 77 kPa	Sample	: 4WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.86
Nominal τ_{cy}	: 53 kPa	Test No	: CTX1
Frequency	: 0.1 Hz		

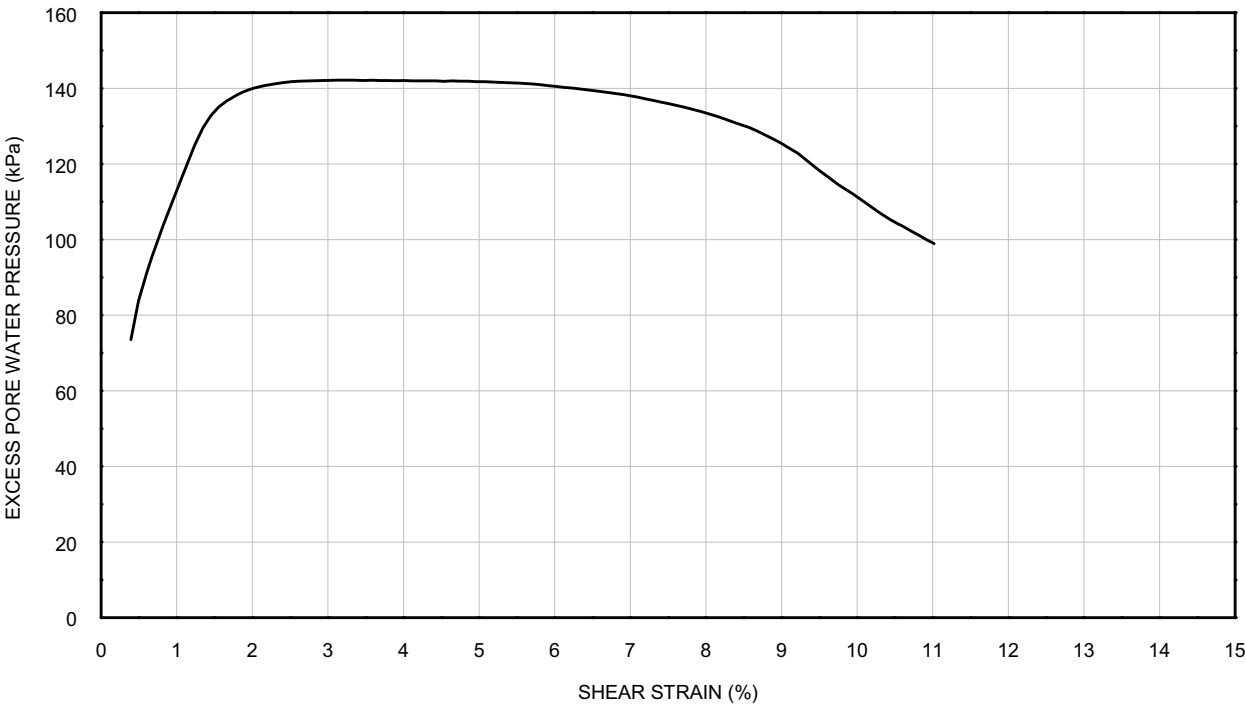
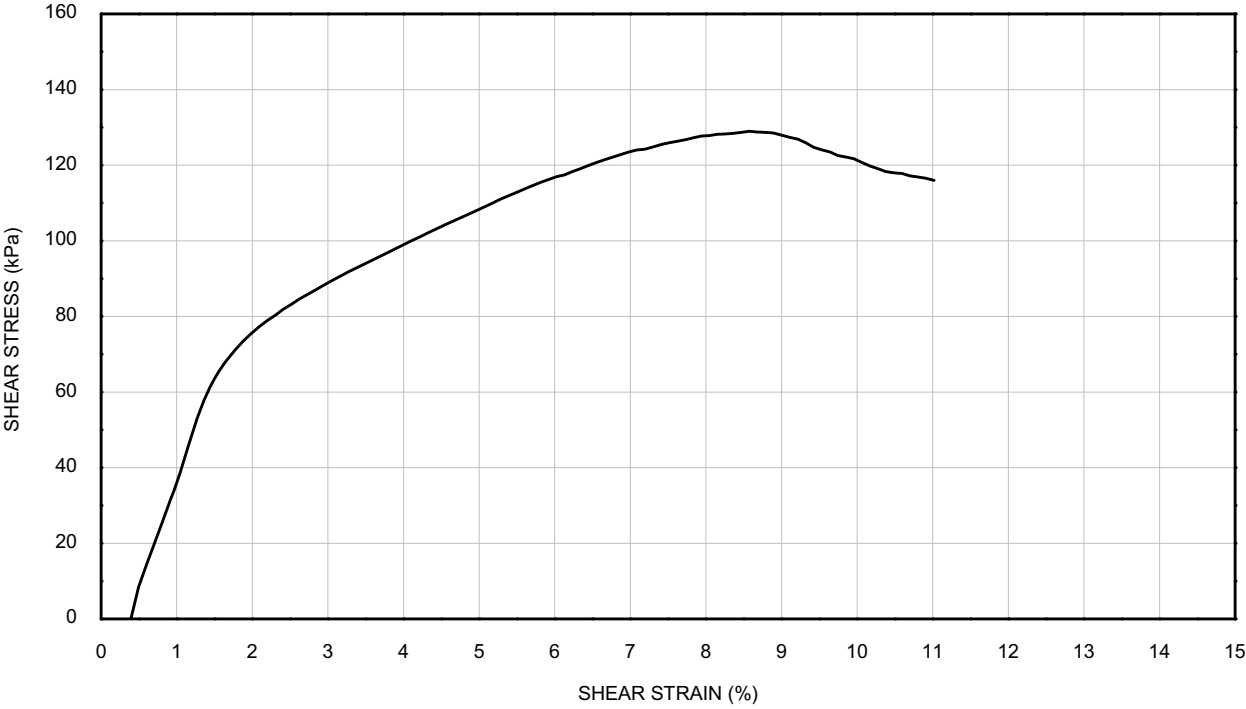
CYCLIC TRIAXIAL TEST
SATURATION AND CONSOLIDATION



σ'_{rc}	: 139 kPa	Borehole	: BH_13
σ'_{vc}	: 77 kPa	Sample	: 4WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.86
Nominal τ_{cy}	: 53 kPa	Test No	: CTX1
Frequency	: 0.1 Hz		

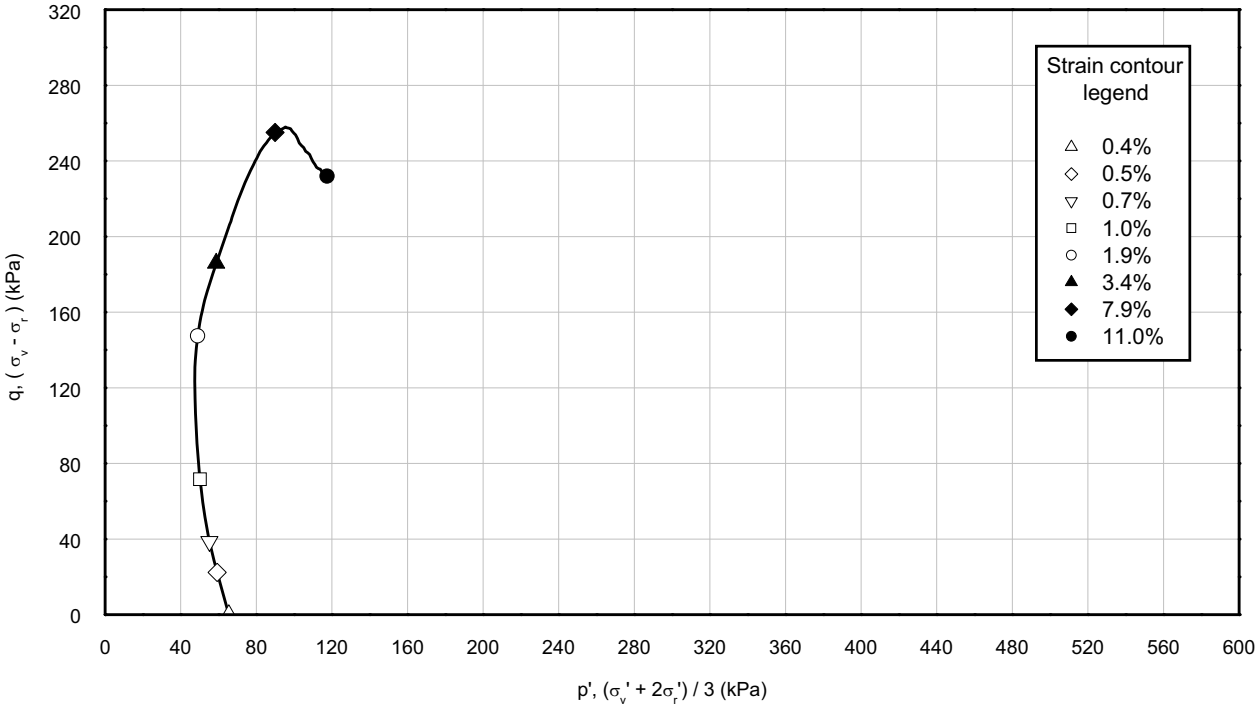
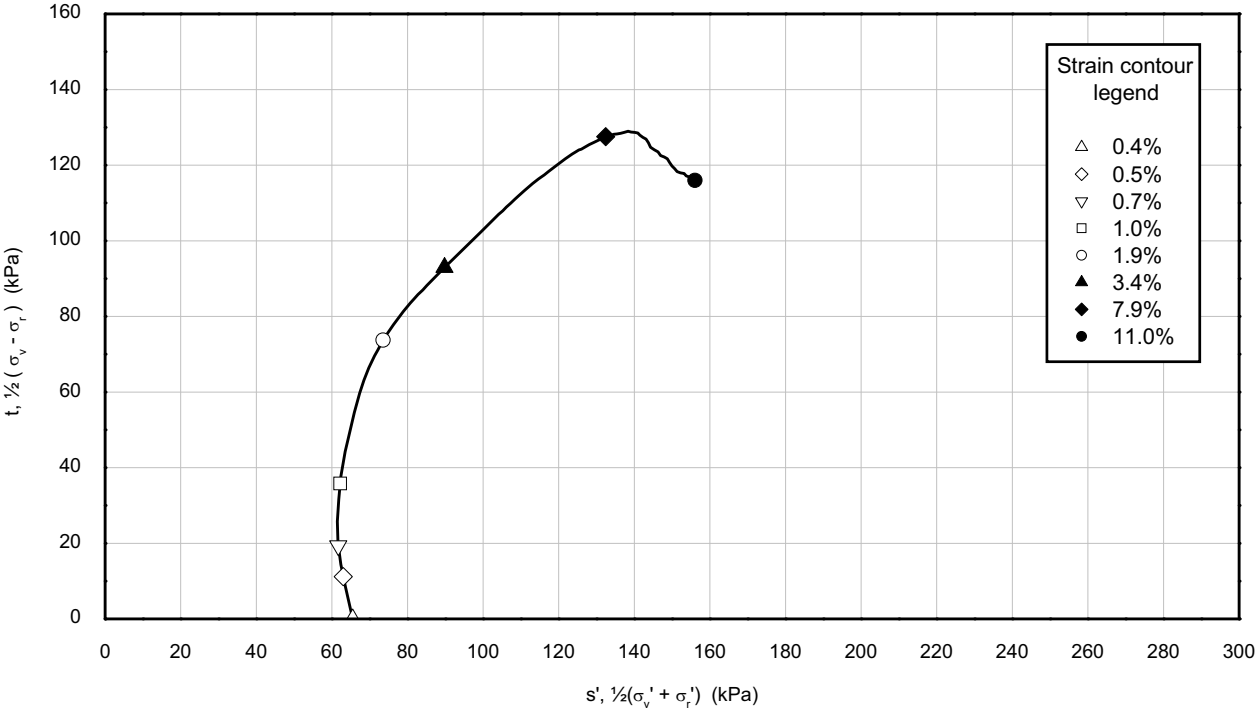
**CYCLIC TRIAXIAL TEST
POST CYCLIC STATIC LOADING STAGE**

Checked by: Date: Approved by: Date: Template Issue: 3 File Name : J11056 / BH-13_04A_CTX1.OPJ Date: 19/07/2011 Drawn by: PR



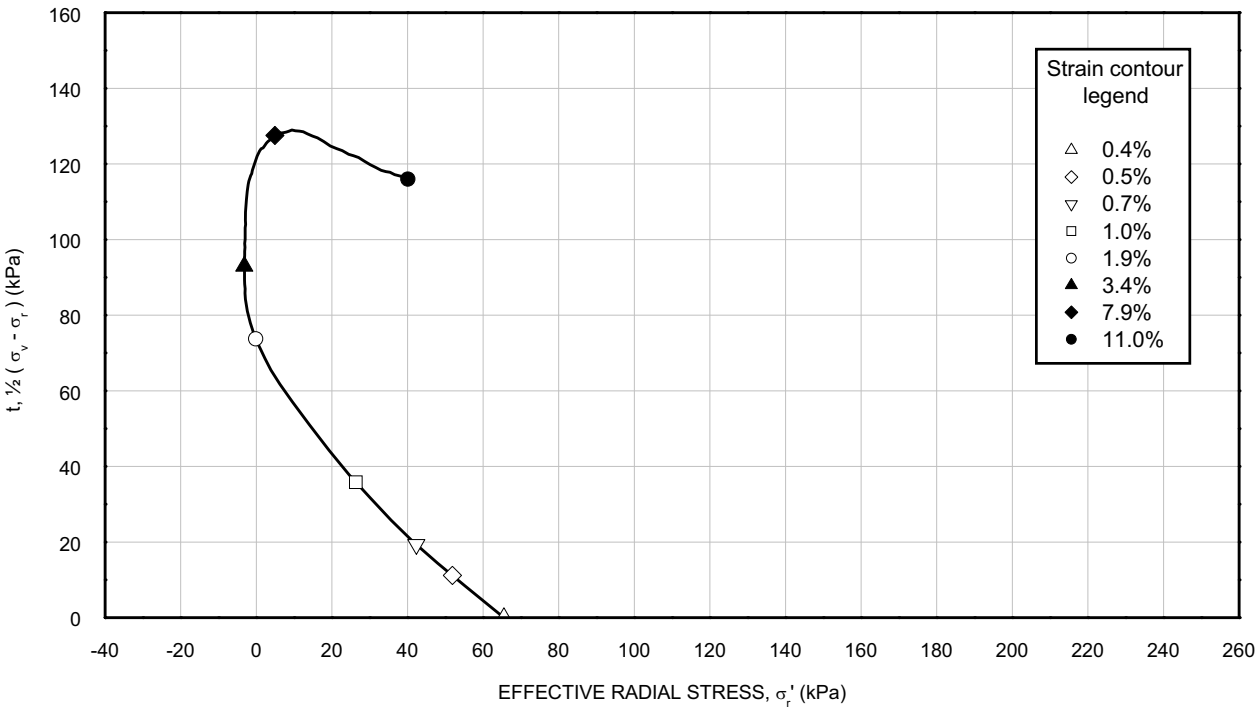
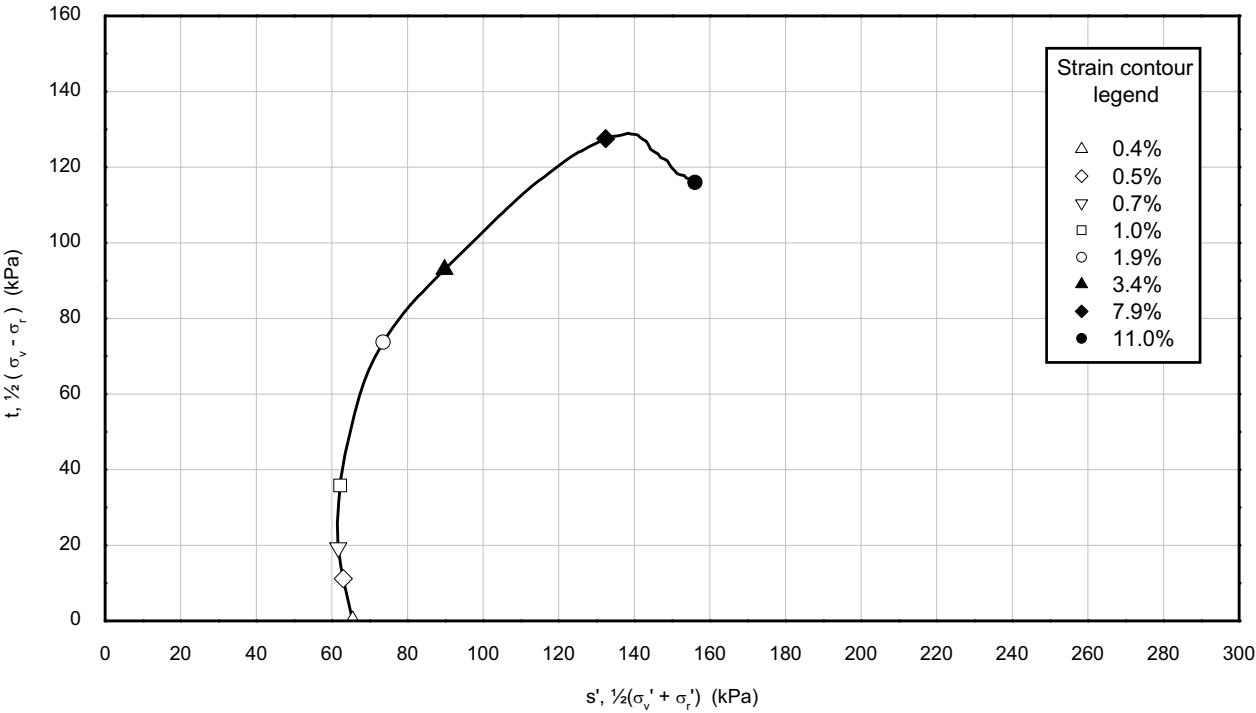
σ'_{rc}	: 139 kPa	Borehole	: BH_13
σ'_{vc}	: 77 kPa	Sample	: 4WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.86
Nominal τ_{cy}	: 53 kPa	Test No	: CTX1
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
POST CYCLIC STATIC LOADING STAGE



σ_{rc}'	: 139 kPa	Borehole	: BH_13
σ_{vc}'	: 77 kPa	Sample	: 4WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 7.86
Nominal τ_{cy}	: 53 kPa	Test No	: CTX1
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
POST CYCLIC STATIC LOADING STAGE



Checked by: Date: Approved by: Date:

σ_{rc}'	: 139 kPa
σ_{vc}'	: 77 kPa
Nominal τ_{av}	: 0 kPa
Nominal τ_{cy}	: 53 kPa
Frequency	: 0.1 Hz

Borehole	: BH_13
Sample	: 4WaxA
Depth (m)	: 7.86
Test No	: CTX1

CYCLIC TRIAXIAL TEST
POST CYCLIC STATIC LOADING STAGE

Date: 19/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-13_07A_CTX2.XLS

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION

Very stiff very dark grey slightly sandy CLAY with pockets and partings of light grey silty fine sand.

GENERAL

Date test started	22/06/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL

Diameter	(mm)	70.4
Length	(mm)	142.0
Moisture content	(%)	28
Bulk density	(Mg/m ³)	1.93
Dry density	(Mg/m ³)	1.51
Voids ratio		0.791
Degree of saturation	(%)	97

SATURATION

Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	10
Pore pressure on completion	(kPa)	513
Cell pressure on completion	(kPa)	558
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 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Fugro testing procedure L-T-023 Clause 5.2.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Cycling	Fugro testing procedure
Note: Fugro testing procedures are available on request	

Borehole	BH_13
Sample	7WaxA
Depth (m)	13.66
Test number	CTX2

SUMMARY OF ANISOTROPICALLY CONSOLIDATED UNDRAINED CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

Date: 19/07/2011

Drawn by: PR

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	558
Back pressure	(kPa)	300
Effective cell pressure	(kPa)	258
Pore pressure on completion	(kPa)	300
Pore pressure dissipation	(%)	100
Moisture content	(%)	23
Bulk density	(Mg/m ³)	1.93
Dry density	(Mg/m ³)	1.57
Voids ratio		0.720
Degree of saturation	(%)	86

Template Issue: 2
 Filename: J11056 / CTXL / BH-13_07A_CTX2.XLS

CONSOLIDATION : ANISOTROPIC		
Cell pressure	(kPa)	558
Back pressure	(kPa)	300
Axial pressure	(kPa)	433
Effective cell pressure	(kPa)	258
Effective axial pressure	(kPa)	133
Pore pressure after consol	(kPa)	300
Moisture content	(%)	23
Bulk density	(Mg/m ³)	1.93
Dry density	(Mg/m ³)	1.57
Voids ratio		0.716
Degree of saturation	(%)	86
Volumetric strain	(%)	4.23
Axial strain	(%)	0.70

Date:

Date:

Checked by:

Approved by:

Borehole	BH_13
Sample	7WaxA
Depth (m)	13.66
Test number	CTX2

**SUMMARY OF
 ANISOTROPICALLY CONSOLIDATED UNDRAINED
 CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 19/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-13_07A_CTX2.XLS

SHEARING		
Initial pore pressure	(kPa)	-
Initial effective cell pressure	(kPa)	-
Rate of strain	(%/hour)	-
Initial deviator stress	(kPa)	-
At peak deviator stress		
Corrected deviator stress	(kPa)	-
Membrane correction applied	(kPa)	-
Drain correction applied	(kPa)	-
Axial strain	(%)	-
Excess pore pressure	(kPa)	-
Major principal effective stress	(kPa)	-
Minor principal effective stress	(kPa)	-
Principal effective stress ratio		-
e 50	(%)	-
Secant modulus at e 50	(kPa)	-
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	-
Membrane correction applied	(kPa)	-
Drain correction applied	(kPa)	-
Axial strain	(%)	-
Excess pore pressure	(kPa)	-
Major principal effective stress	(kPa)	-
Minor principal effective stress	(kPa)	-
Principal effective stress ratio		-
e 50	(%)	-
Secant modulus at e 50	(kPa)	-

CYCLIC LOADING STAGE		
Reference shear stress	(kPa)	300
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	124
Frequency	(Hz)	0.1
Cycles at failure	(N)	110
Average shear strain @ N	(%)	-5.52
Cyclic shear strain @ N	(%)	15.38
Change in pore pressure @ N	(kPa)	109

Date:

Date:

Checked by:

Approved by:

Borehole	BH_13
Sample	7WaxA
Depth (m)	13.66
Test number	CTX2

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**



Date: 19/07/2011
Drawn by: PR
Template Issue: 2
Filename: J11056 / CTXL / BH-13_07A_CTX2.XLS
Date:
Date:
Checked by:
Approved by:

SPECIMEN PHOTOGRAPHS	
Specimen photograph was not possible due to power failure post test.	

Borehole	BH_13
Sample	7WaxA
Depth (m)	13.66
Test number	CTX2

SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN

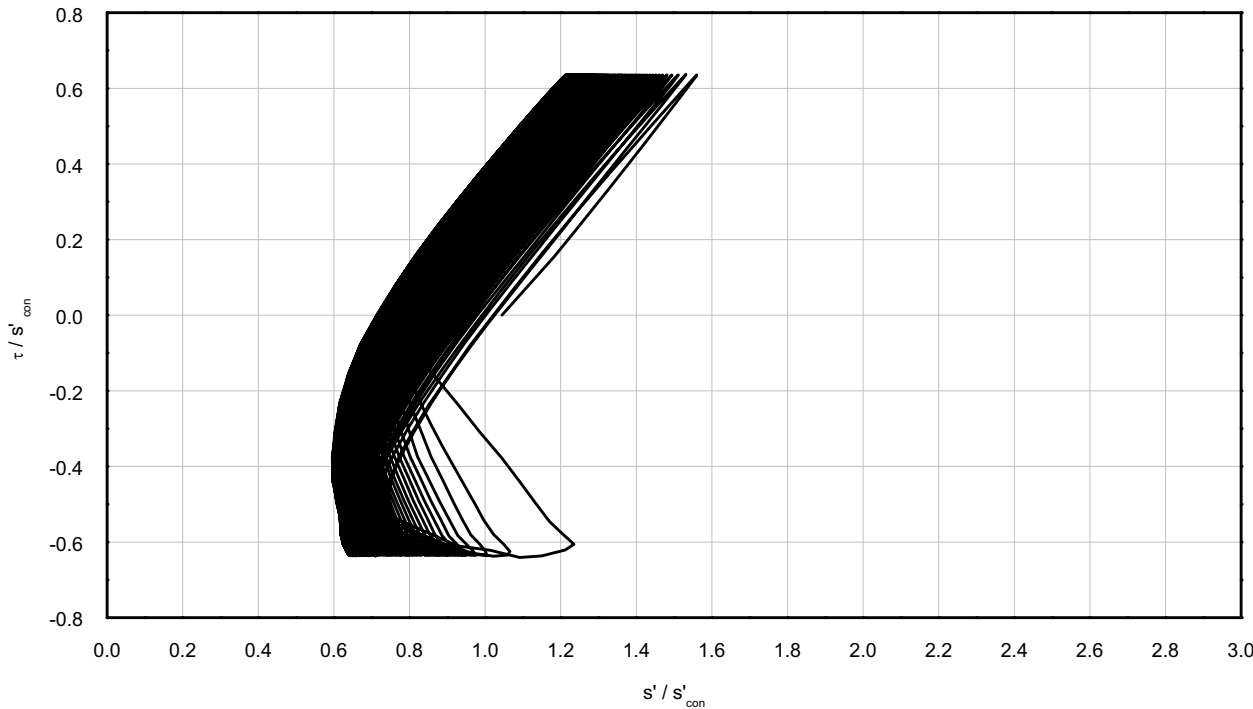
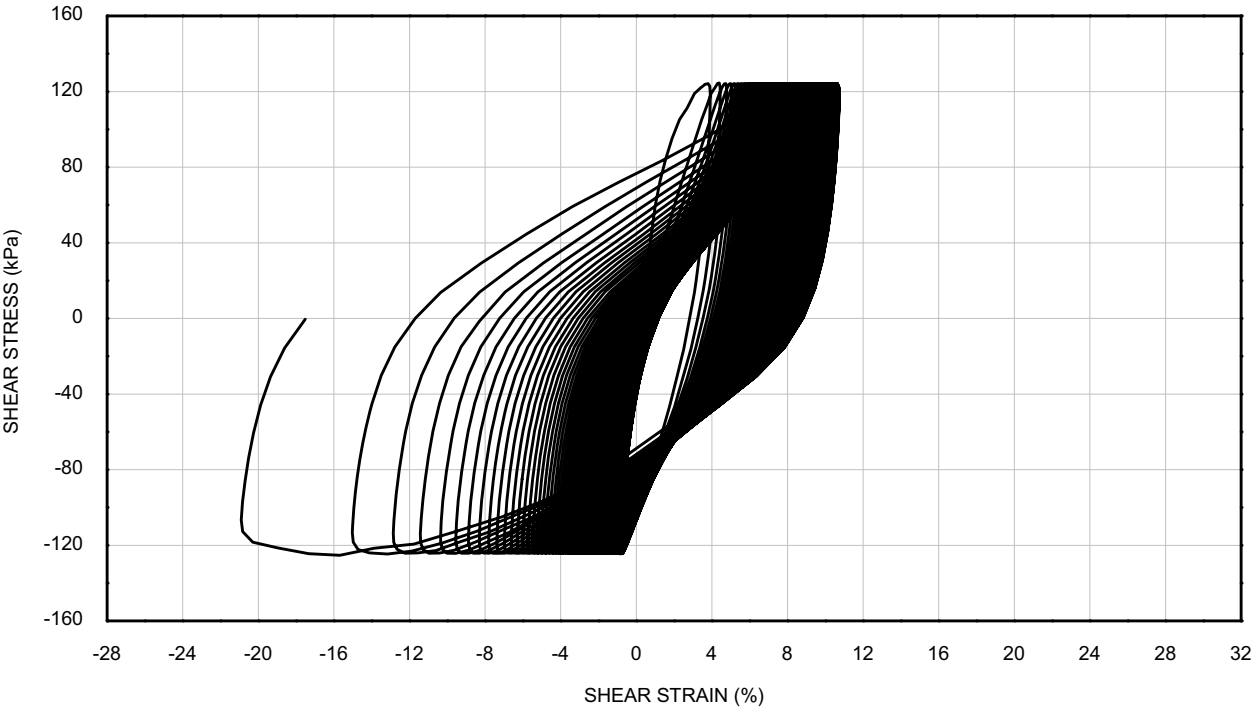
Drawn by: PR
Date: 19/07/2011

Template Issue: 3

File Name : J11056 / BH-13_07A_CTX2.OPJ

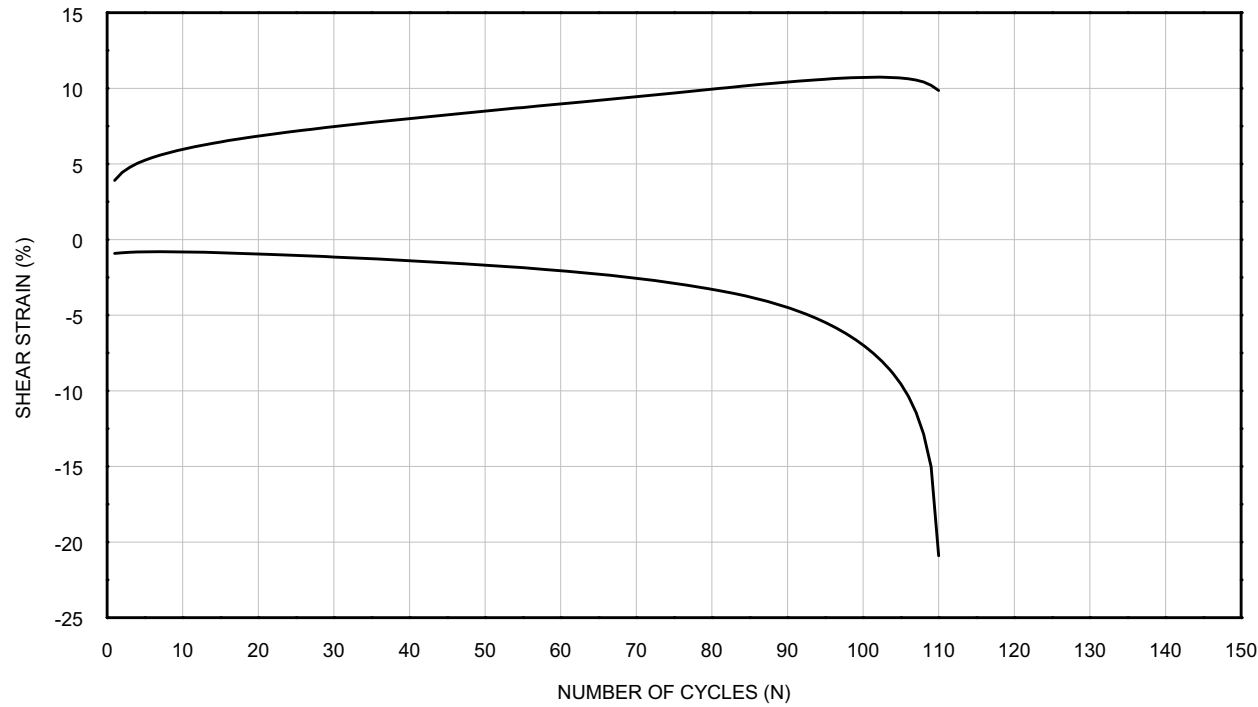
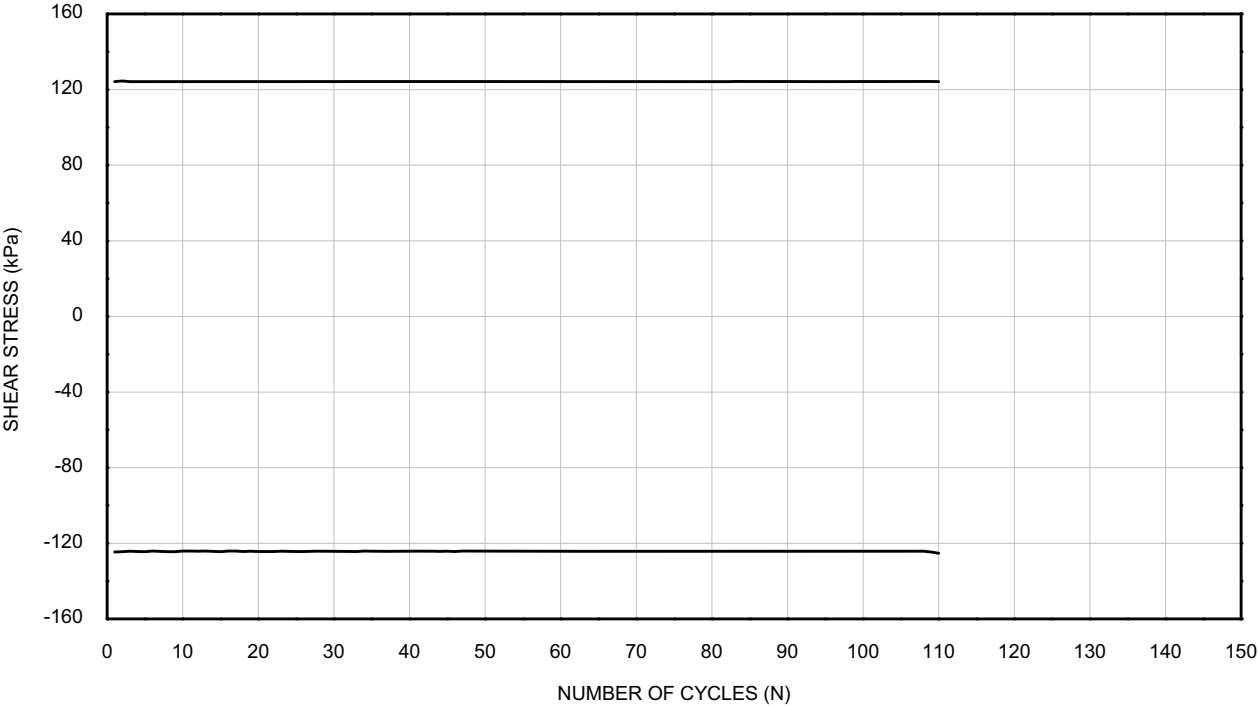
Checked by:
Date:

Approved by:
Date:



σ'_{rc}	: 258 kPa	Borehole	: BH_13
σ'_{vc}	: 133 kPa	Sample	: 7WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 13.66
Nominal τ_{cy}	: 124 kPa	Test No	: CTX2
Frequency	: 0.1 Hz		

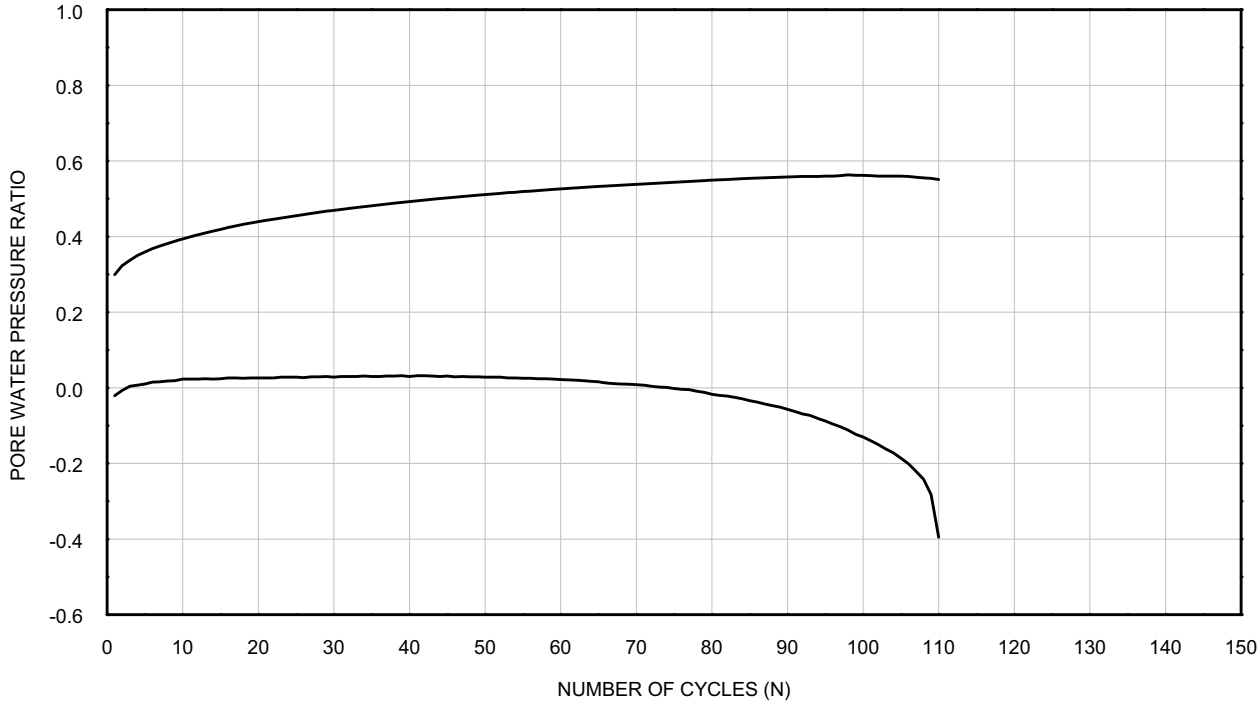
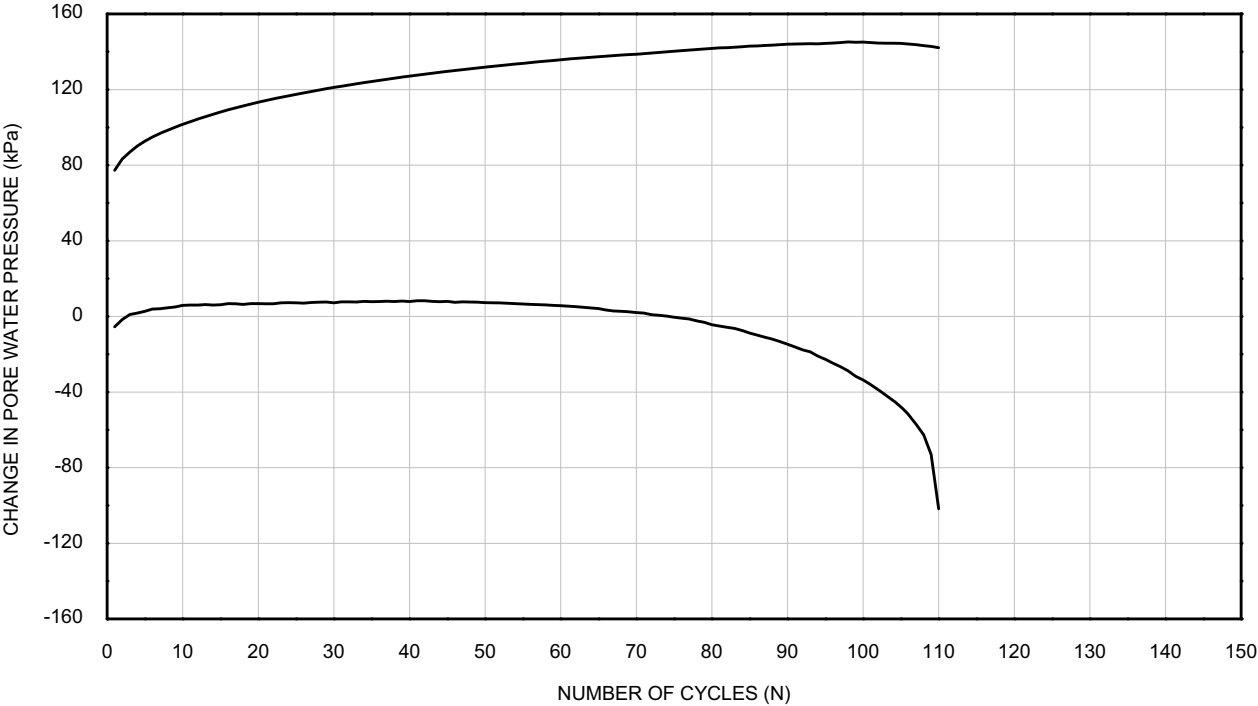
CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



σ_{rc}'	: 258 kPa	Borehole	: BH_13
σ_{vc}'	: 133 kPa	Sample	: 7WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 13.66
Nominal τ_{cy}	: 124 kPa	Test No	: CTX2
Frequency	: 0.1 Hz		

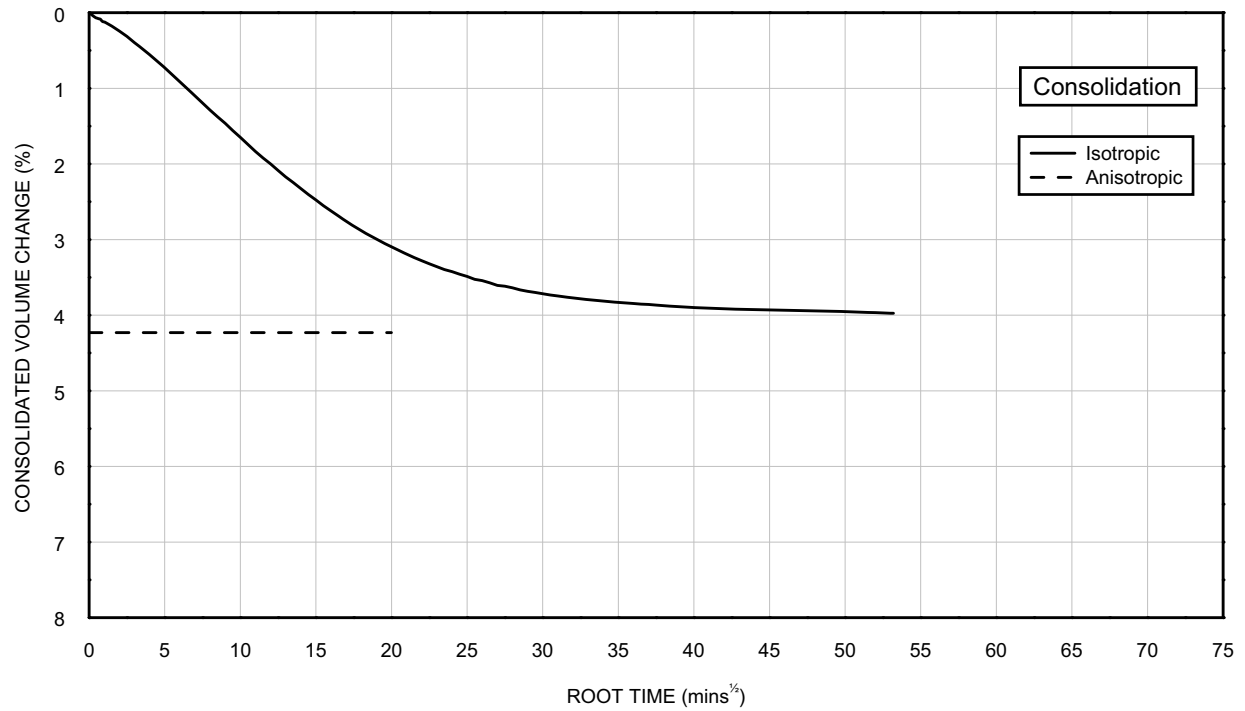
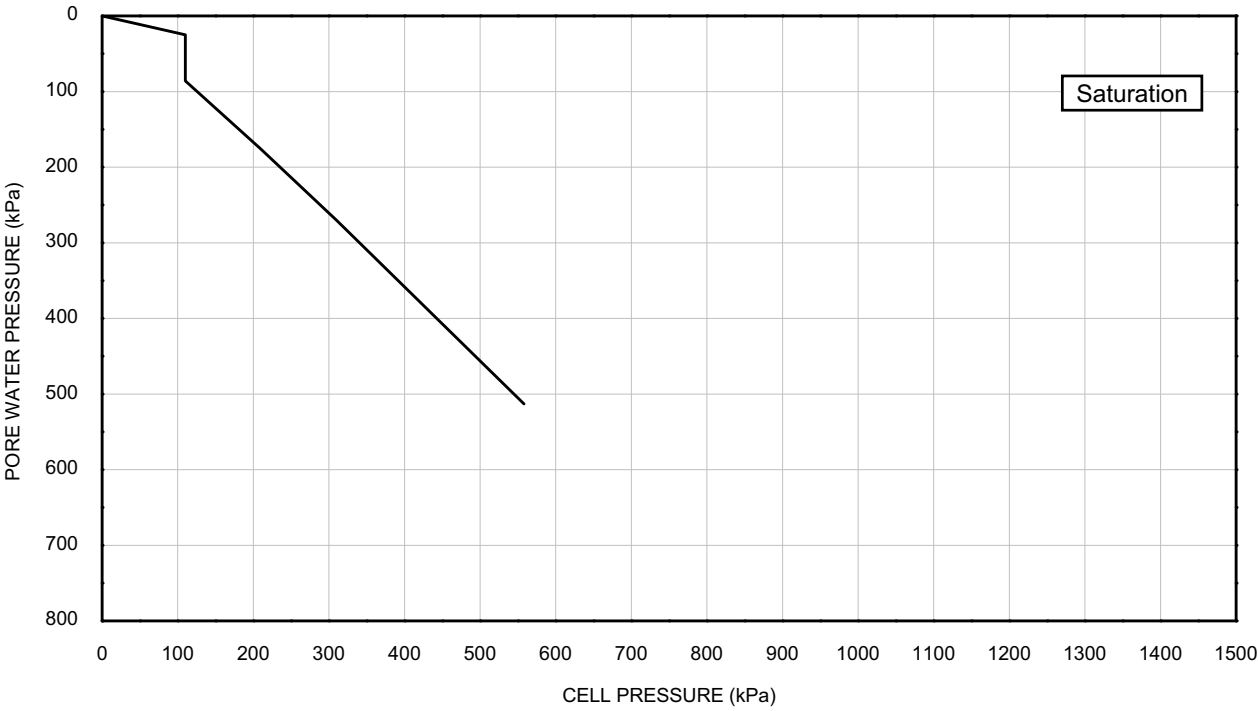
CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE

Checked by: Date: Approved by: Date: Template Issue: 3 File Name : J11056 / BH-13_07A_CTX2.OPJ Drawn by: PR Date: 19/07/2011



σ'_{rc}	: 258 kPa	Borehole	: BH_13
σ'_{vc}	: 133 kPa	Sample	: 7WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 13.66
Nominal τ_{cy}	: 124 kPa	Test No	: CTX2
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



σ_{rc}'	: 258 kPa	Borehole	: BH_13
σ_{vc}'	: 133 kPa	Sample	: 7WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 13.66
Nominal τ_{cy}	: 124 kPa	Test No	: CTX2
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
SATURATION AND CONSOLIDATION

Template Issue: 3
File Name : J11056 / BH-13_07A_CTX2.OPJ
Date: 19/07/2011
Drawn by: PR
Checked by: Date:
Approved by: Date:

Date: 19/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-13_23B_CTX3.XLS

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION	
Very stiff dark brown sandy CLAY with pockets of light grey fine sand.	

GENERAL	
Date test started	23/6/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL		
Diameter	(mm)	70.4
Length	(mm)	142.4
Moisture content	(%)	16
Bulk density	(Mg/m ³)	2.07
Dry density	(Mg/m ³)	1.79
Voids ratio		0.507
Degree of saturation	(%)	83

SATURATION		
Pressure increments applied	(kPa)	100
Differential pressure used	(kPa)	N/A
Pore pressure on completion	(kPa)	867
Cell pressure on completion	(kPa)	1365
B value achieved		0.93

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Fugro testing procedure L-T-023 Clause 5.2.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Cycling	Fugro testing procedure
Note: Fugro testing procedures are available on request	

Borehole	BH_13
Sample	23WaxB
Depth (m)	39.25
Test number	CTX3

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 19/07/2011

Drawn by: PR

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	1365
Back pressure	(kPa)	800
Effective cell pressure	(kPa)	565
Pore pressure on completion	(kPa)	800
Pore pressure dissipation	(%)	100
Moisture content	(%)	16
Bulk density	(Mg/m ³)	2.07
Dry density	(Mg/m ³)	1.80
Voids ratio		0.503
Degree of saturation	(%)	83

Template Issue: 2
 Filename: J11056 / CTXL / BH-13_23B_CTX3.XLS

CONSOLIDATION : ANISOTROPIC		
Cell pressure	(kPa)	1365
Back pressure	(kPa)	800
Axial pressure	(kPa)	1161
Effective cell pressure	(kPa)	565
Effective axial pressure	(kPa)	361
Pore pressure after consol	(kPa)	800
Moisture content	(%)	16
Bulk density	(Mg/m ³)	2.07
Dry density	(Mg/m ³)	1.80
Voids ratio		0.503
Degree of saturation	(%)	83
Volumetric strain	(%)	0.24
Axial strain	(%)	-0.26

Date:

Date:

Checked by:

Approved by:

Borehole	BH_13
Sample	23WaxB
Depth (m)	39.25
Test number	CTX3

**SUMMARY OF
 ANISOTROPICALLY CONSOLIDATED UNDRAINED
 CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 19/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-13_23B_CTX3.XLS

SHEARING		
Initial pore pressure	(kPa)	-
Initial effective cell pressure	(kPa)	-
Rate of strain	(%/hour)	-
Initial deviator stress	(kPa)	-
At peak deviator stress		
Corrected deviator stress	(kPa)	-
Membrane correction applied	(kPa)	-
Drain correction applied	(kPa)	-
Axial strain	(%)	-
Excess pore pressure	(kPa)	-
Major principal effective stress	(kPa)	-
Minor principal effective stress	(kPa)	-
Principal effective stress ratio		-
e 50	(%)	-
Secant modulus at e 50	(kPa)	-
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	-
Membrane correction applied	(kPa)	-
Drain correction applied	(kPa)	-
Axial strain	(%)	-
Excess pore pressure	(kPa)	-
Major principal effective stress	(kPa)	-
Minor principal effective stress	(kPa)	-
Principal effective stress ratio		-
e 50	(%)	-
Secant modulus at e 50	(kPa)	-

CYCLIC LOADING STAGE		
Reference shear stress	(kPa)	380
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	152
Frequency	(Hz)	0.1
Cycles at failure	(N)	457
Average shear strain @ N	(%)	-7.65
Cyclic shear strain @ N	(%)	15.07
Change in pore pressure @ N	(kPa)	308

Date:

Date:

Checked by:

Approved by:

Borehole	BH_13
Sample	23WaxB
Depth (m)	39.25
Test number	CTX3

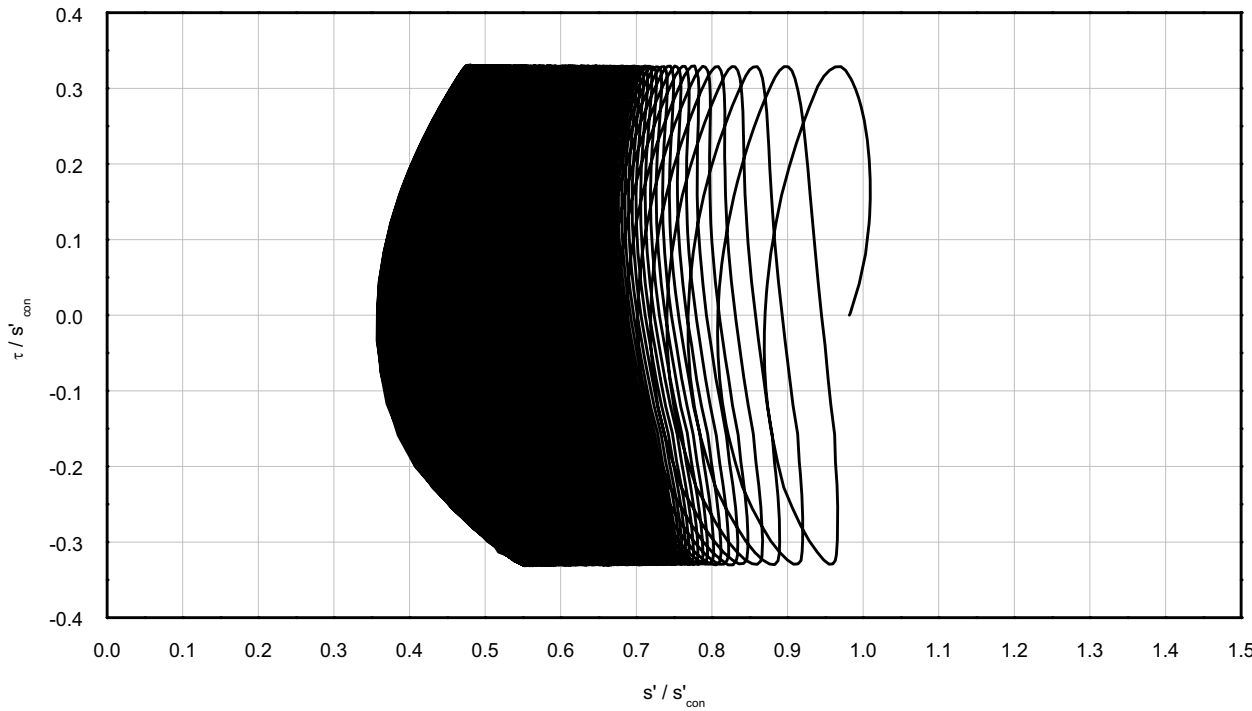
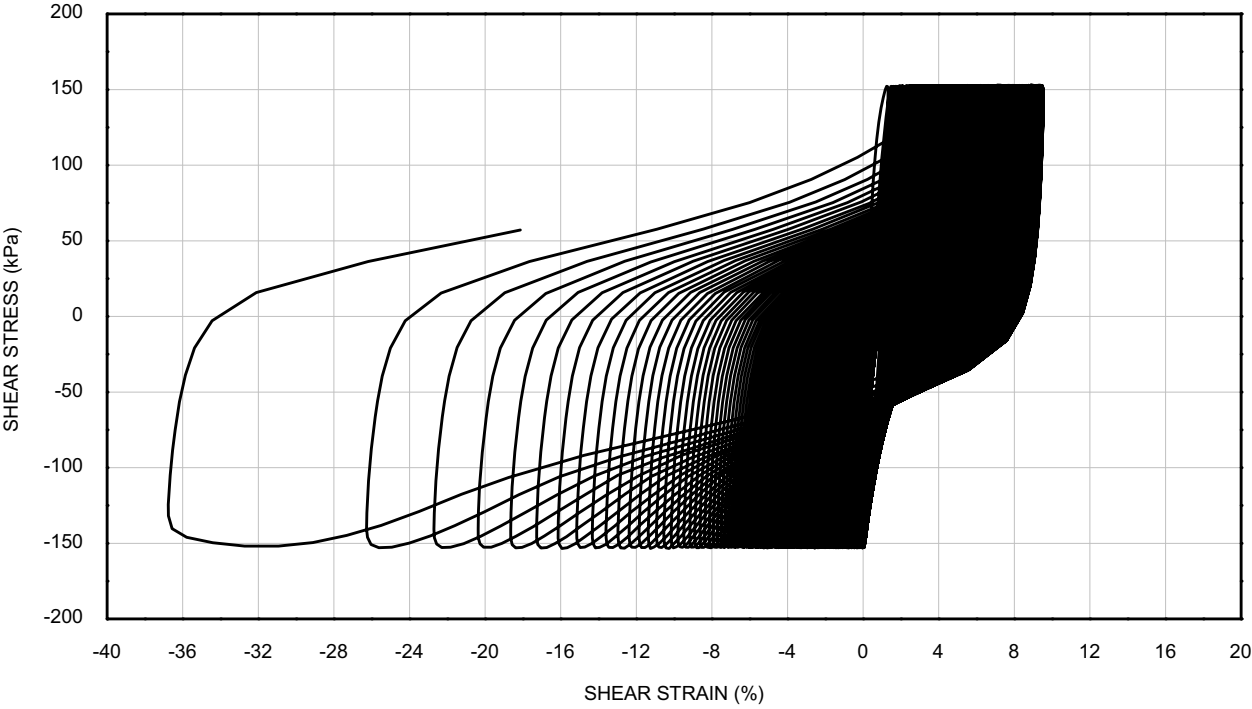
**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Checked by: Date: Template Issue: 2 Drawn by: PR Date: 19/07/2011 Filename: J11056 / CTXL / BH-13_23B_CTX3.XLS



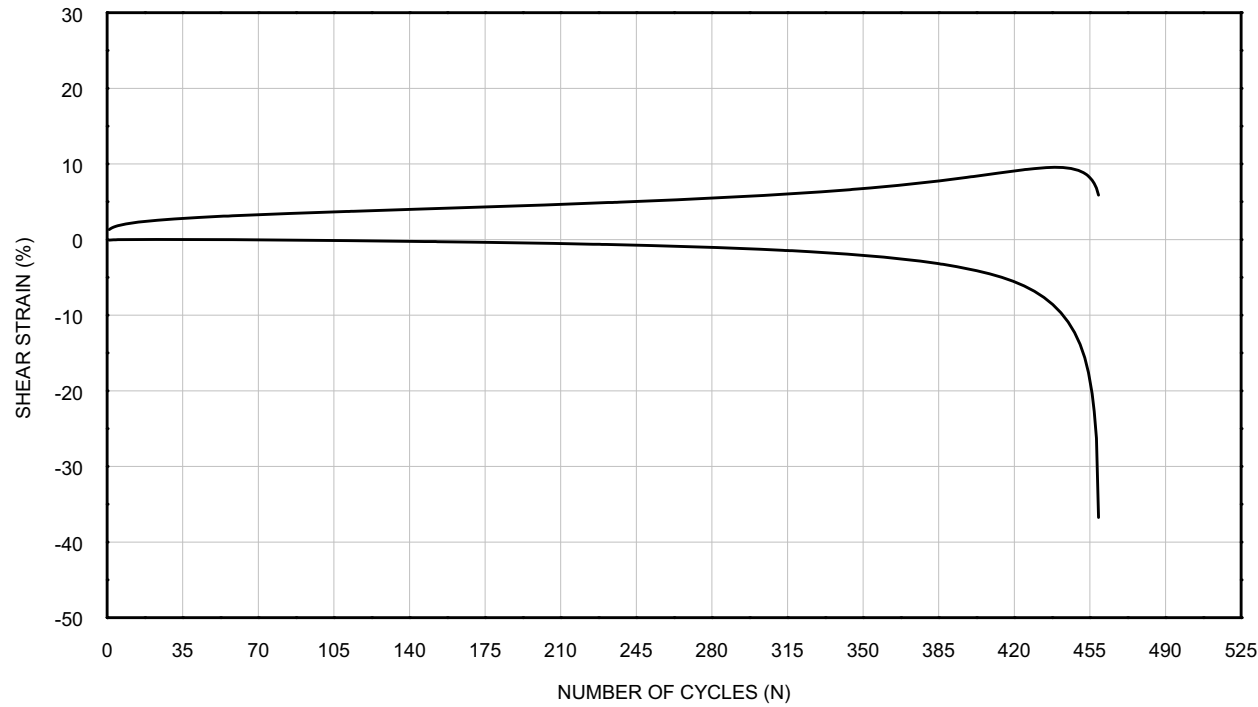
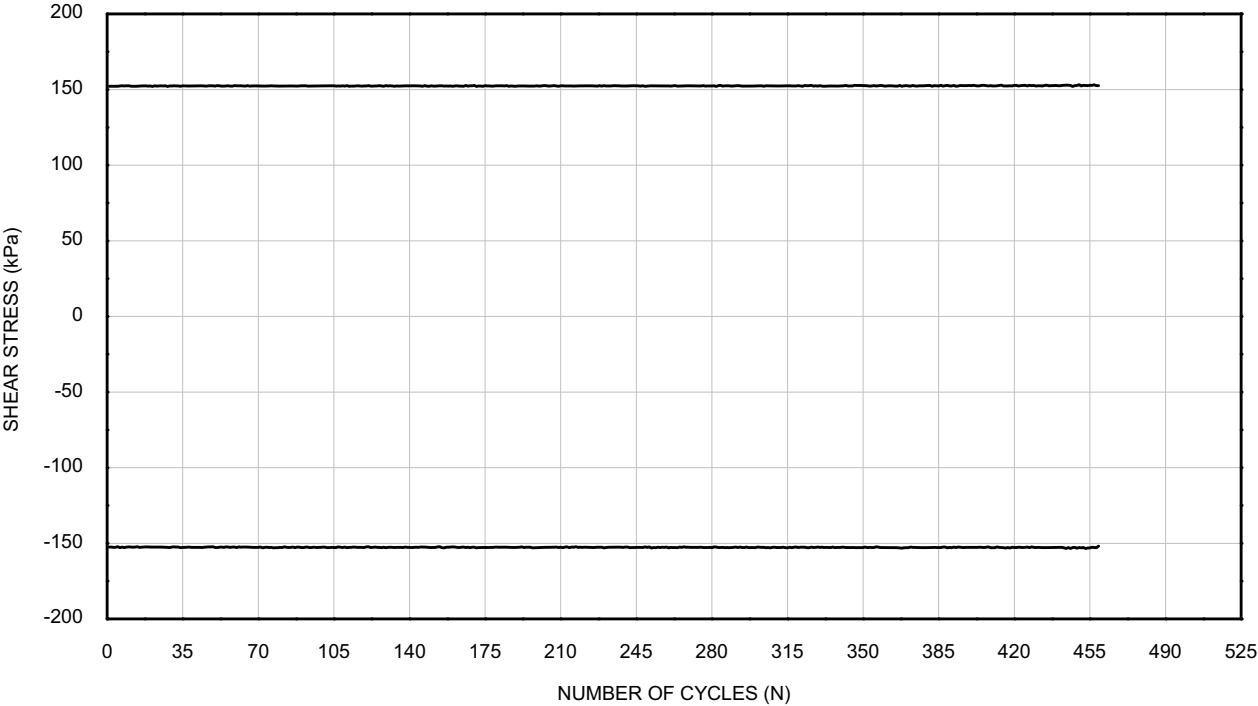
Borehole	BH_13
Sample	23WaxB
Depth (m)	39.25
Test number	CTX3

SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



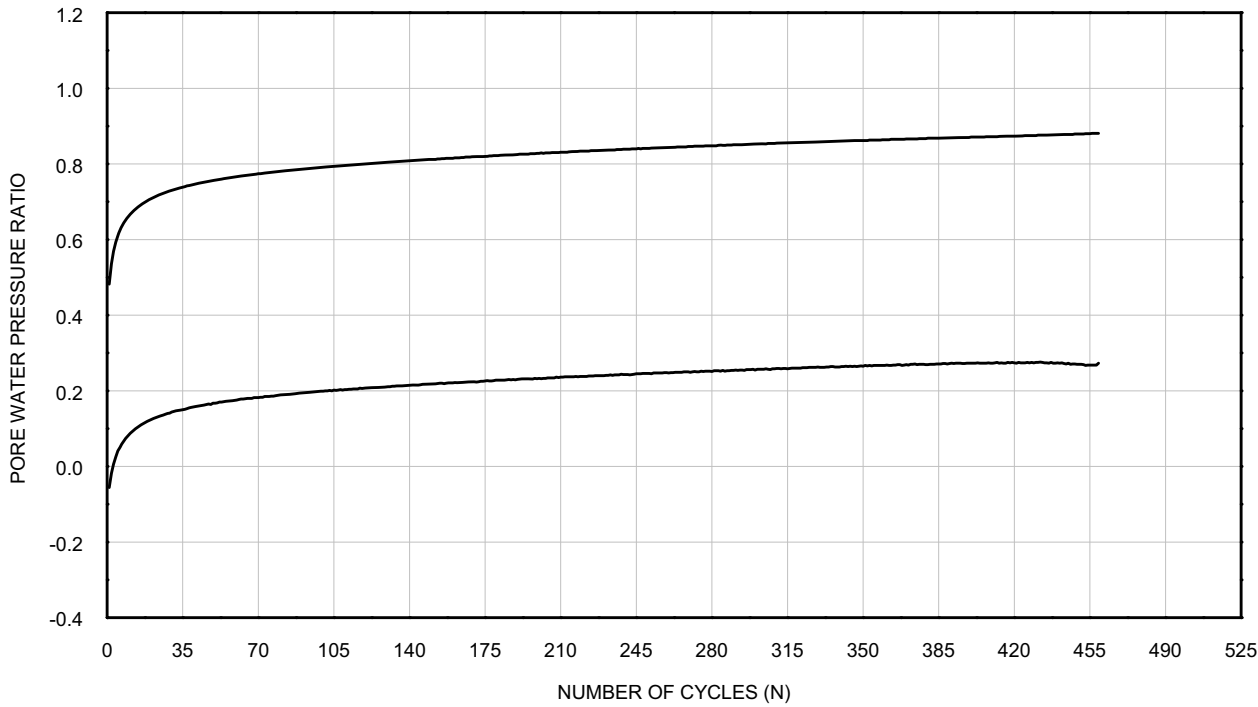
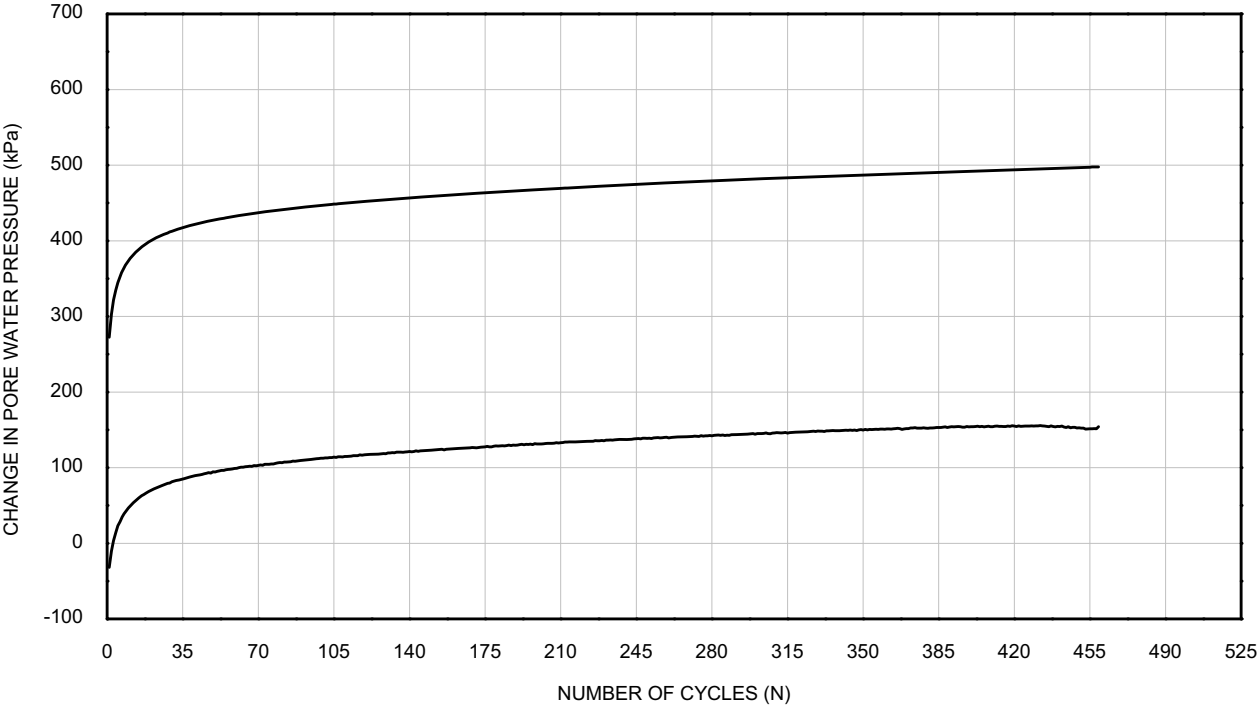
σ'_{rc}	: 565 kPa	Borehole	: BH_13
σ'_{vc}	: 361 kPa	Sample	: 23WaxB
Nominal τ_{av}	: 0 kPa	Depth (m)	: 39.25
Nominal τ_{cy}	: 152 kPa	Test No	: CTX3
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



σ_{rc}'	: 565 kPa	Borehole	: BH_13
σ_{vc}'	: 361 kPa	Sample	: 23WaxB
Nominal τ_{av}	: 0 kPa	Depth (m)	: 39.25
Nominal τ_{cy}	: 152 kPa	Test No	: CTX3
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



σ'_{rc}	: 565 kPa	Borehole	: BH_13
σ'_{vc}	: 361 kPa	Sample	: 23WaxB
Nominal τ_{av}	: 0 kPa	Depth (m)	: 39.25
Nominal τ_{cy}	: 152 kPa	Test No	: CTX3
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE



Drawn by: PR
Date: 23/06/2011

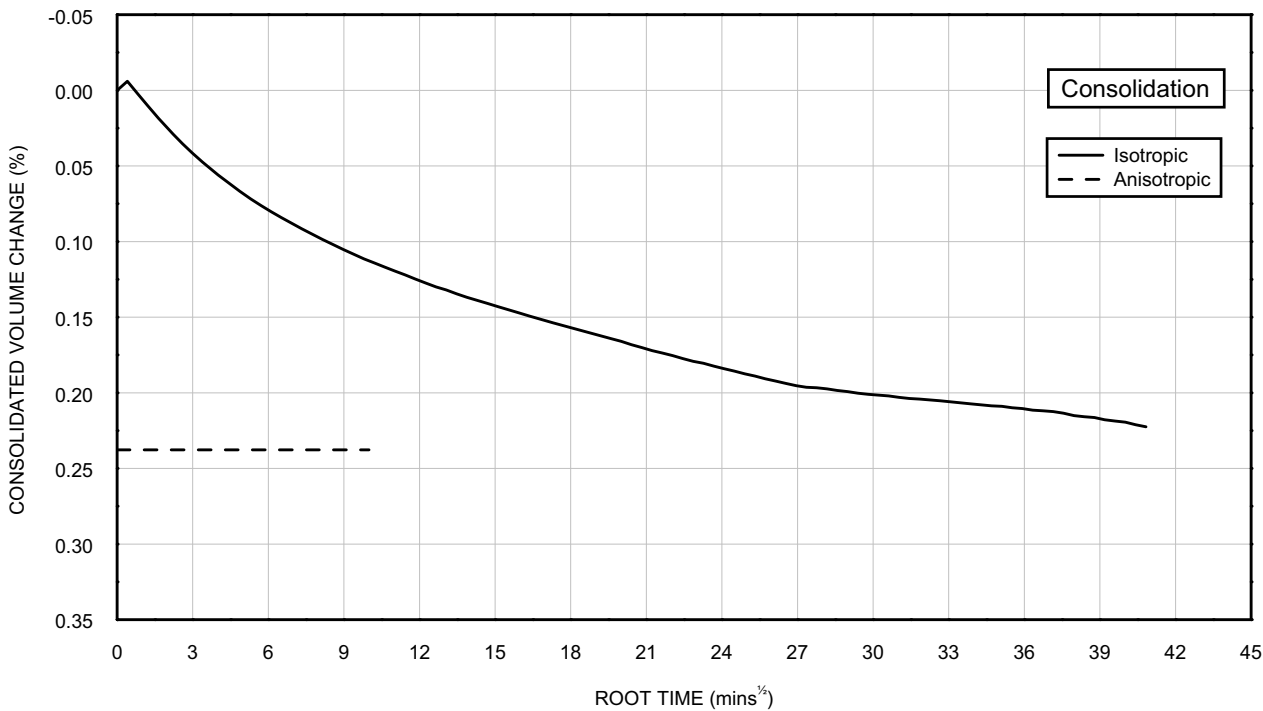
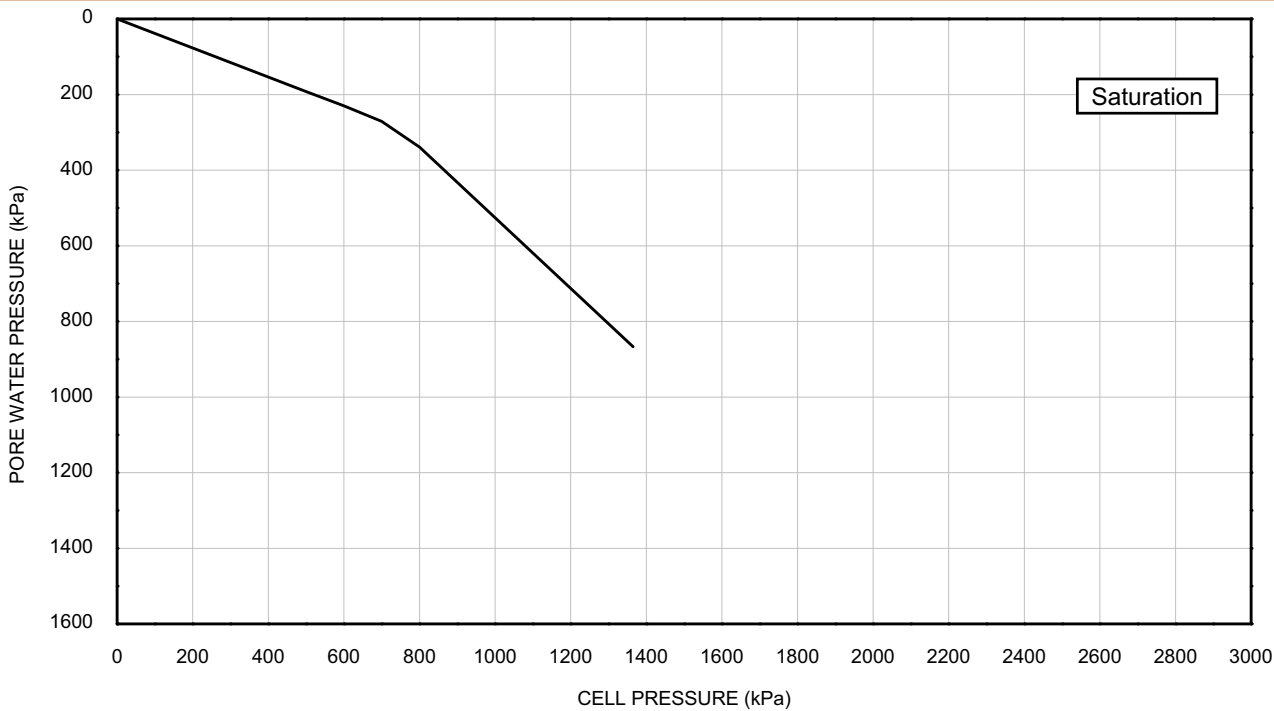
Template Issue: 3

File Name : J11056 / BH-13_23B_CTX3.OPJ

Checked by:

Date:

Approved by:



σ'_{rc}	: 565 kPa	Borehole	: BH_13
σ'_{vc}	: 361 kPa	Sample	: 23WaxB
Nominal τ_{av}	: 0 kPa	Depth (m)	: 39.25
Nominal τ_{cy}	: 152 kPa	Test No	: CTX3
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
SATURATION AND CONSOLIDATION

Date: 22/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-16_15A_CTX5.XLS

Date:

Date:

Checked by:

Approved by:

VISUAL DESCRIPTION	
Very stiff dark brown silty CLAY.	

GENERAL	
Date test started	11/07/2011
Type of sample	Undisturbed
Specimen orientation	Vertical
Type of drains fitted	Radial & one end

INITIAL	
Diameter (mm)	72.6
Length (mm)	139.7
Moisture content (%)	20
Bulk density (Mg/m ³)	2.09
Dry density (Mg/m ³)	1.75
Voids ratio	0.541
Degree of saturation (%)	97

SATURATION	
Pressure increments applied (kPa)	100
Differential pressure used (kPa)	N/A
Pore pressure on completion (kPa)	695
Cell pressure on completion (kPa)	1088
B value achieved	0.90

TESTING PROCEDURES USED	
Specimen Set-up	BS 1377: Part 8: 1990 Clause 4
Saturation	BS 1377: Part 8: 1990: Clause 5.4
Consolidation - Isotropic	BS 1377: Part 8: 1990 Clause 6
Consolidation - Anisotropic	Fugro testing procedure L-T-023 Clause 5.2.6
Shearing	BS 1377: Part 8: 1990 Clause 7
Cycling	Fugro testing procedure
Note: Fugro testing procedures are available on request	

Borehole	BH_16
Sample	15WaxA
Depth (m)	31.08
Test number	CTX5

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 22/07/2011

Drawn by: PR

CONSOLIDATION : ISOTROPIC		
Cell pressure	(kPa)	1088
Back pressure	(kPa)	600
Effective cell pressure	(kPa)	488
Pore pressure on completion	(kPa)	600
Pore pressure dissipation	(%)	100
Moisture content	(%)	19
Bulk density	(Mg/m ³)	2.10
Dry density	(Mg/m ³)	1.77
Voids ratio		0.529
Degree of saturation	(%)	97

Template Issue: 2

Filename: J11056 / CTXL / BH-16_15A_CTX5.XLS

CONSOLIDATION : ANISOTROPIC		
Cell pressure	(kPa)	1088
Back pressure	(kPa)	600
Axial pressure	(kPa)	852
Effective cell pressure	(kPa)	488
Effective axial pressure	(kPa)	252
Pore pressure after consol	(kPa)	600
Moisture content	(%)	19
Bulk density	(Mg/m ³)	2.10
Dry density	(Mg/m ³)	1.76
Voids ratio		0.532
Degree of saturation	(%)	97
Volumetric strain	(%)	0.61
Axial strain	(%)	-0.42

Date:

Date:

Checked by:

Approved by:

Borehole	BH_16
Sample	15WaxA
Depth (m)	31.08
Test number	CTX5

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

Date: 22/07/2011

Drawn by: PR

Template Issue: 2

Filename: J11056 / CTXL / BH-16_15A_CTX5.XLS

SHEARING		
Initial pore pressure	(kPa)	-
Initial effective cell pressure	(kPa)	-
Rate of strain	(%/hour)	-
Initial deviator stress	(kPa)	-
At peak deviator stress		
Corrected deviator stress	(kPa)	-
Membrane correction applied	(kPa)	-
Drain correction applied	(kPa)	-
Axial strain	(%)	-
Excess pore pressure	(kPa)	-
Major principal effective stress	(kPa)	-
Minor principal effective stress	(kPa)	-
Principal effective stress ratio		-
e 50	(%)	-
Secant modulus at e 50	(kPa)	-
At peak principal effective stress ratio		
Corrected deviator stress	(kPa)	-
Membrane correction applied	(kPa)	-
Drain correction applied	(kPa)	-
Axial strain	(%)	-
Excess pore pressure	(kPa)	-
Major principal effective stress	(kPa)	-
Minor principal effective stress	(kPa)	-
Principal effective stress ratio		-
e 50	(%)	-
Secant modulus at e 50	(kPa)	-

CYCLIC LOADING STAGE		
Reference shear stress	(kPa)	520
Nominal τ_{av}	(kPa)	0
Nominal τ_{cy}	(kPa)	208
Frequency	(Hz)	0.1
Cycles at failure	(N)	183
Average shear strain @ N	(%)	-12.02
Cyclic shear strain @ N	(%)	13.51
Change in pore pressure @ N	(kPa)	180

Date:

Date:

Checked by:

Approved by:

Borehole	BH_16
Sample	15WaxA
Depth (m)	31.08
Test number	CTX5

**SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN**

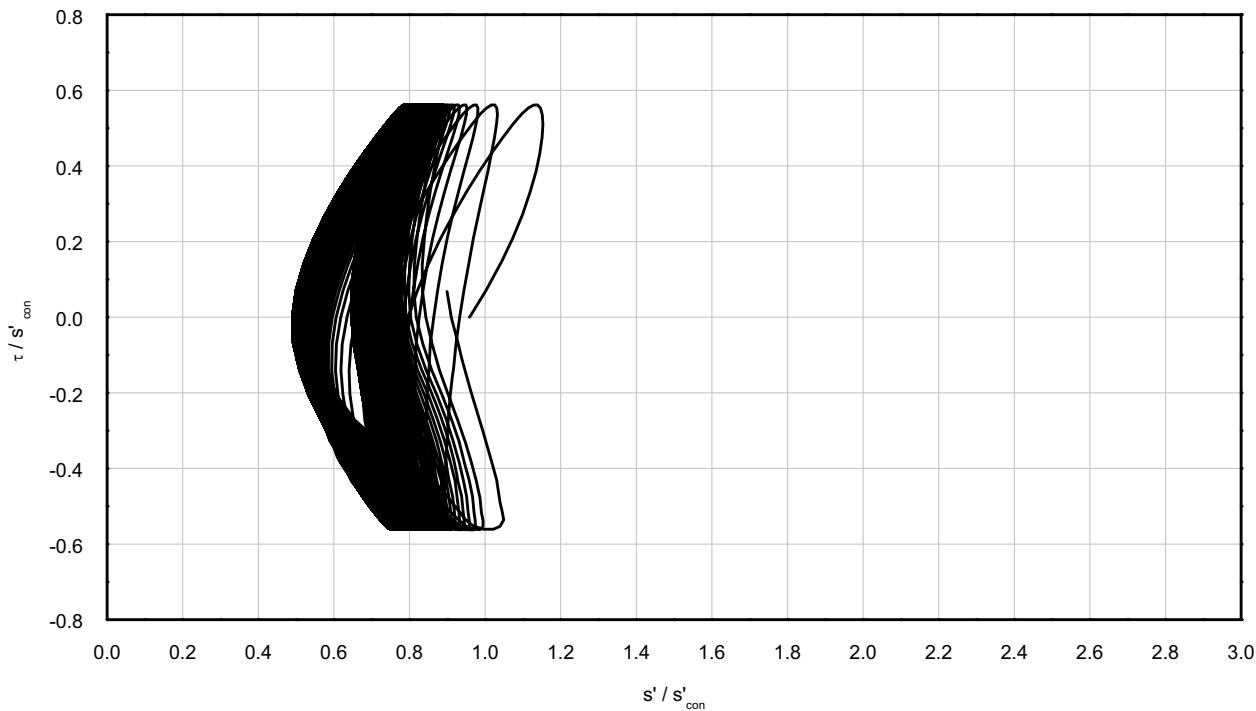
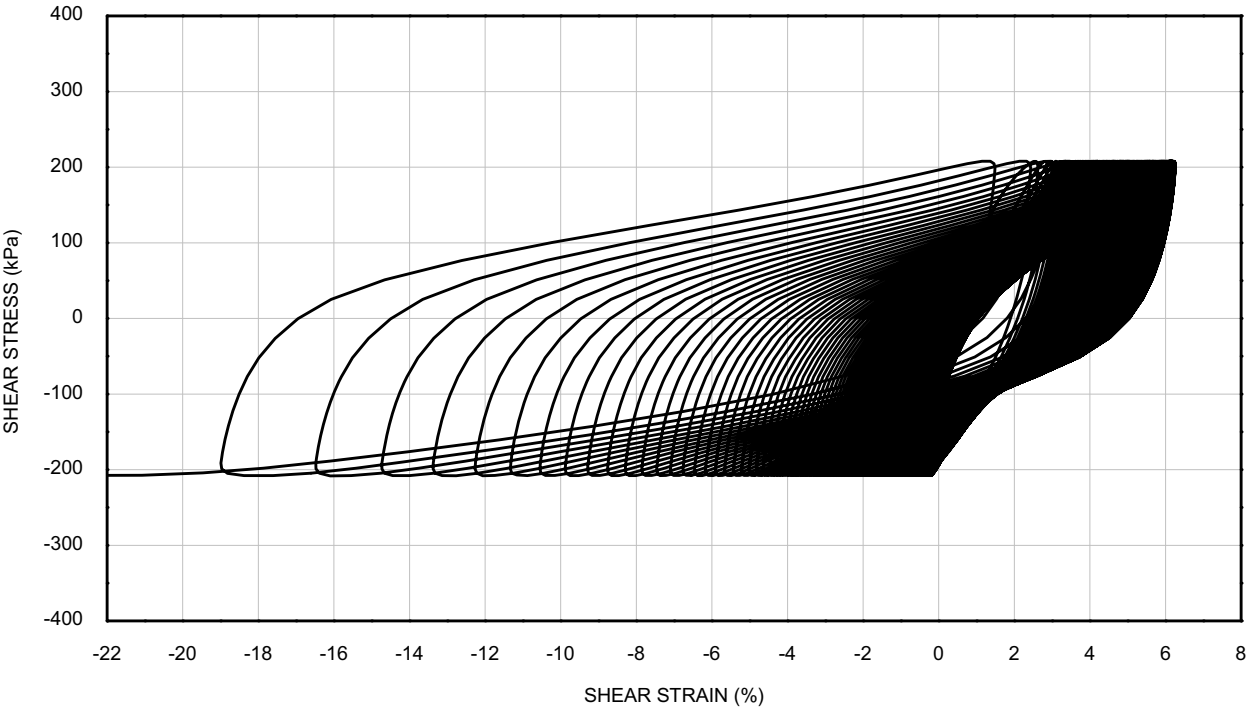
Date: 22/07/2011
Drawn by: PR
Template Issue: 2
Filename: J11056 / CTXL / BH-16_15A_CTX5.XLS
Checked by:
Approved by:

SPECIMEN PHOTOGRAPHS



Borehole	BH_16
Sample	15WaxA
Depth (m)	31.08
Test number	CTX5

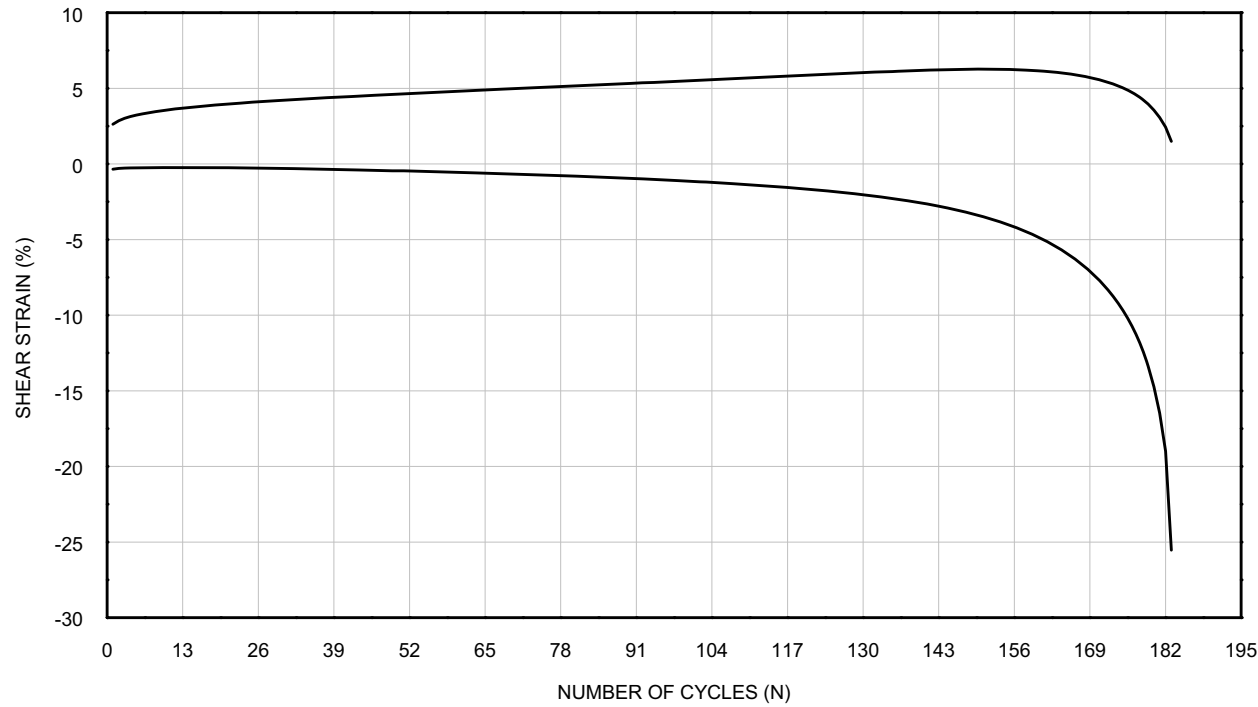
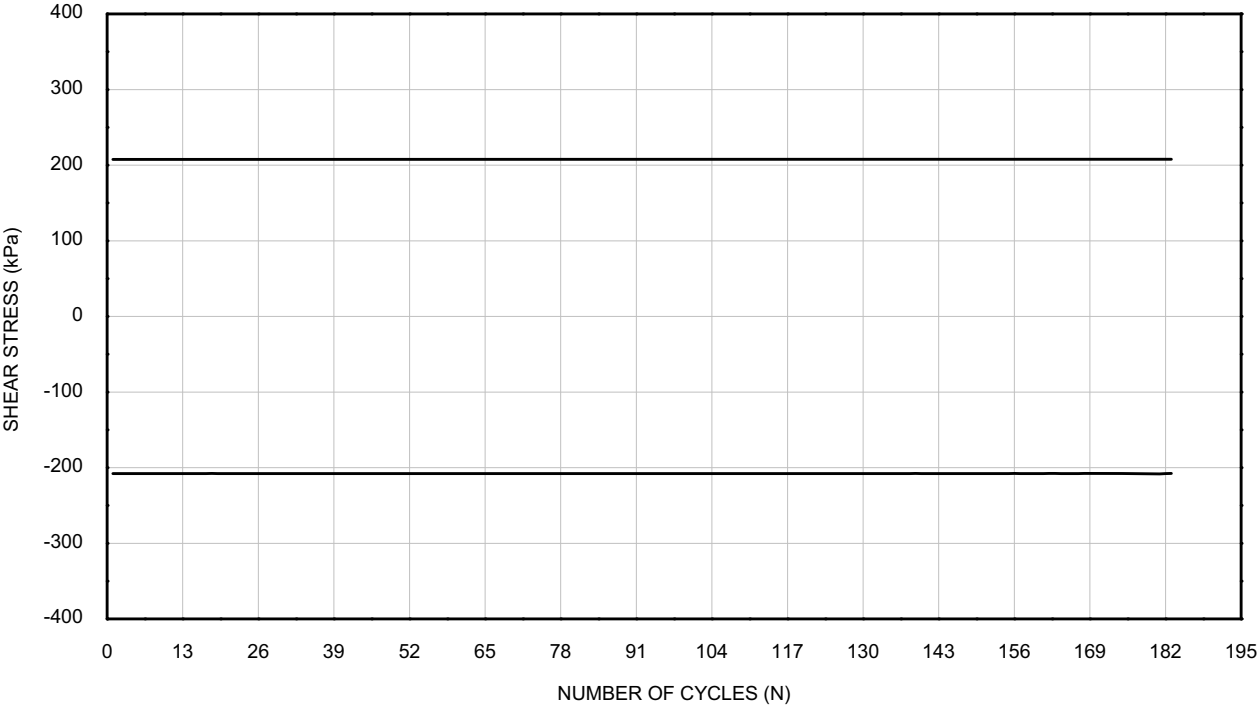
SUMMARY OF
ANISOTROPICALLY CONSOLIDATED UNDRAINED
CYCLIC TRIAXIAL COMPRESSION TEST : SINGLE SPECIMEN



σ'_{rc}	: 488 kPa	Borehole	: BH_16
σ'_{vc}	: 252 kPa	Sample	: 15WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 31.08
Nominal τ_{cy}	: 208 kPa	Test No	: CTX5
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE

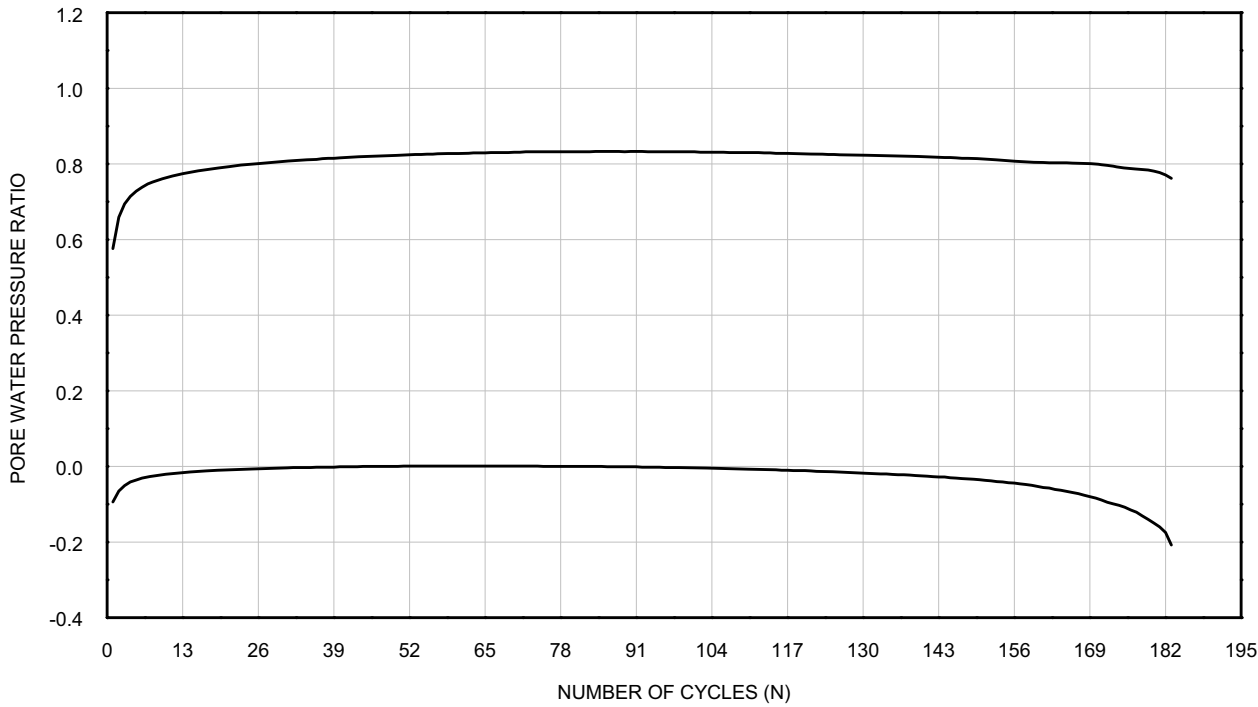
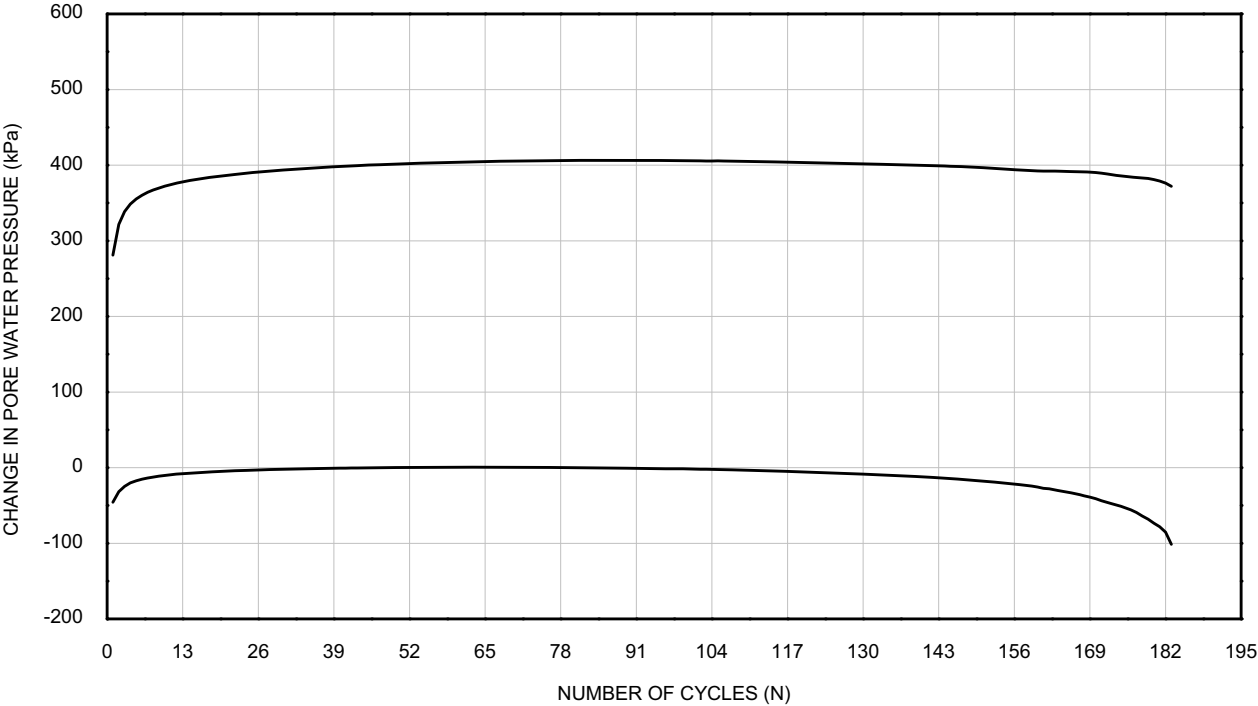
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σ_{rc}'	: 488 kPa	Borehole	: BH_16
σ_{vc}'	: 252 kPa	Sample	: 15WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 31.08
Nominal τ_{cy}	: 208 kPa	Test No	: CTX5
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE

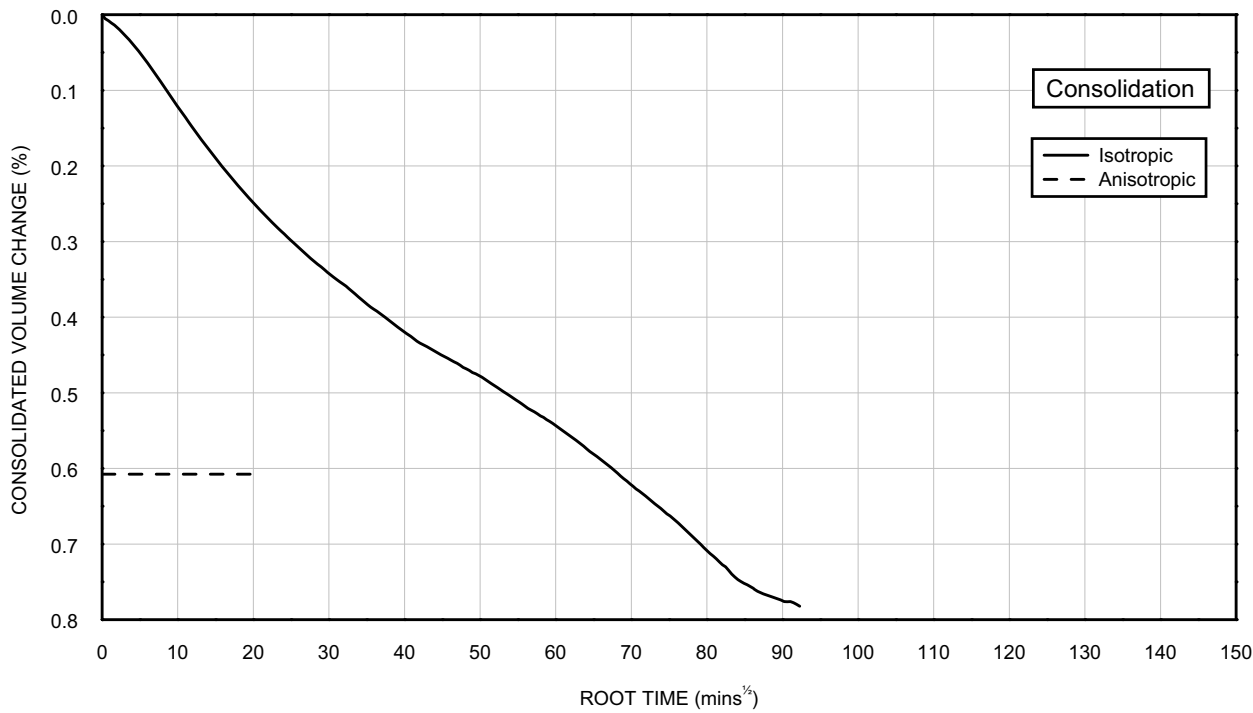
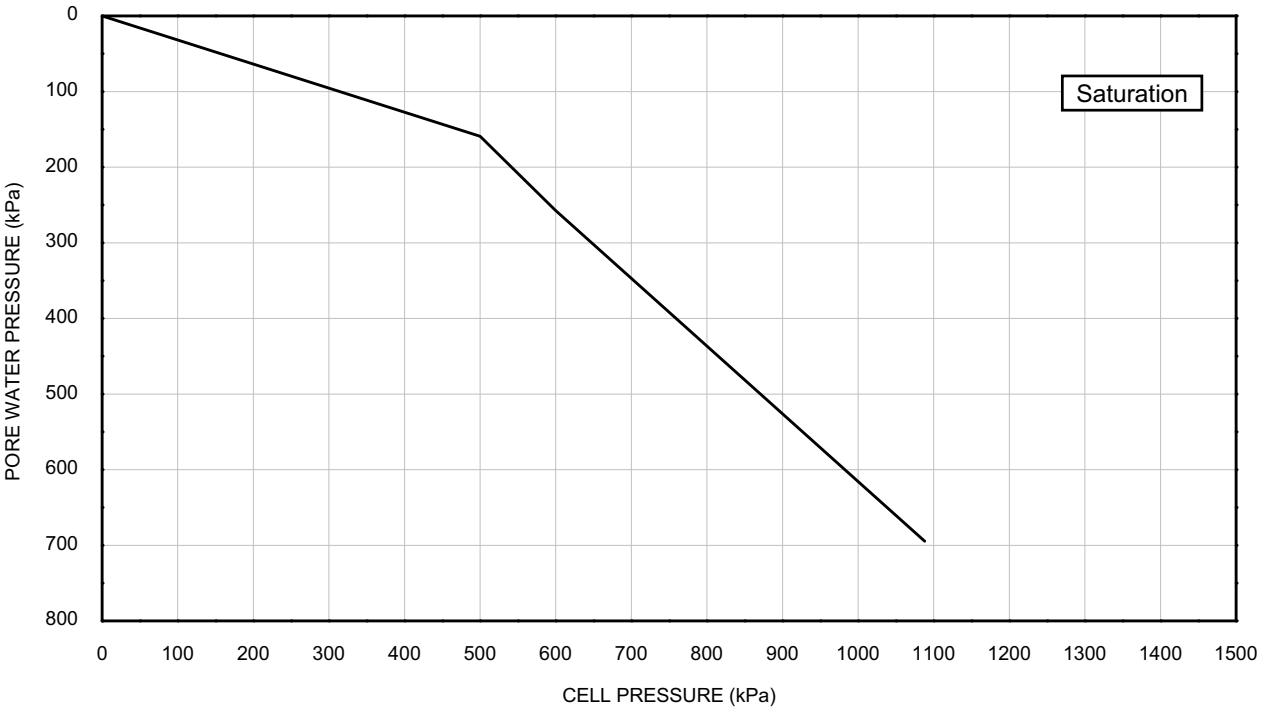
Template Issue: 3
File Name : J11056 / BH-16_15A_CTX5.OPJ
Date: 22/07/2011
Drawn by: PR
Checked by: Date:
Approved by: Date:



σ'_{rc}	: 488 kPa	Borehole	: BH_16
σ'_{vc}	: 252 kPa	Sample	: 15WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 31.08
Nominal τ_{cy}	: 208 kPa	Test No	: CTX5
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
CYCLIC LOADING STAGE

Checked by: Date: Approved by: Date: Template Issue: 3 File Name : J11056 / BH-16_15A_CTX5.OPJ Drawn by: PR Date: 22/07/2011



σ'_{rc}	: 488 kPa	Borehole	: BH_16
σ'_{vc}	: 252 kPa	Sample	: 15WaxA
Nominal τ_{av}	: 0 kPa	Depth (m)	: 31.08
Nominal τ_{cy}	: 208 kPa	Test No	: CTX5
Frequency	: 0.1 Hz		

CYCLIC TRIAXIAL TEST
SATURATION AND CONSOLIDATION

Template Issue: 3
File Name : J11056 / BH-16_15A_CTX5.OPJ
Date: 22/07/2011
Drawn by: PR
Checked by: Date:
Approved by: Date:

SECTION B.9

ROCK TESTING

B.9	ROCK TESTING	1
B.9.1	SUMMARY	1
B.9.2	SATURATED MOISTURE CONTENT	1
B.9.3	BULK AND DRY DENSITY DETERMINATION	1
B.9.4	POINT LOAD TEST	1
B.9.5	DISCUSSION OF RESULTS	1

B.9 ROCK TESTING

B.9.1 SUMMARY

A series of rock classification and stress tests were performed on selected samples from the Rampion Wind Farm site and are presented at the end of this section.

B.9.2 SATURATED MOISTURE CONTENT

Two (2) saturated moisture content determination tests were performed on selected chalk samples from BH_07. Results have been summarised and are presented on Plate B.9-1.

B.9.3 BULK AND DRY DENSITY DETERMINATION

Seven (7) bulk density measurements were performed on samples taken from borehole BH_07. These have been summarised on Plates B.9-2 and present dry density, bulk density, water content and lithological descriptions of the samples taken. The results show good agreement with one another and are thought to accurately represent the in-situ conditions of the chalk.

B.9.4 POINT LOAD TEST

Two (2) point load tests were performed on selected samples from BH_07 to determine the point load index, $I_{s(50)}$, of the chalk bedrock based on the procedure given by Ulusay and Hudson (2007) Part 2. Tests were performed on rock core samples in both axial and diametric set-up and are considered representative of the rocks compressive strength.

B.9.5 DISCUSSION OF RESULTS

The $I_{s(50)}$ of the two samples tested was 0.3 MPa for 21WAXA and 0.9 MPa for 23WAXA using a equivalent uniaxial compressive strength (UCS) conversion factor of 7 after Johnston (1991). The results are summarised on Plate B.9-1. The results of the dry density determination and saturated moisture content determination are presented on Plates B.9-2 and B.9-3.

POINT LOAD TESTS

LIST OF PLATES – SECTION B.9

Description	Plate
Summary of Saturated Moisture Content Test Results	B.9-1
Summary of Chalk Classification Test Results	B.9-2
Summary of Point Load Test Results	B.9-3

SUMMARY OF CHALK CLASSIFICATION TESTS

BS : 1377 Parts 2 & 4 : 1990

Hole	Sample no	Type	Depth	Bulk Density (Mg/m ³)	Moisture Content (%)	Dry Density (Mg/m ³)	Saturation Moisture Content (%)	Chalk Crushing Value	Retained on 10mm sieve (%)	Description
BH07	3WAX C	C	7.70	2.03		1.62	25			White CHALK
BH07	21WAXA	C	32.06	1.97		1.54	28			White CHALK

SUMMARY OF CLASSIFICATION TESTS ISRM 2007											
BH No.	Sample No.	Type	Depth (m)	Bulk Density (kg/m³)	Water Content (%)	Dry Density (kg/m³)	Saturation Moisture Content (%)	Porosity (%)		Slake Durability (%)	Lithology
BH07	2WAXB	C	4.35	1.80	30	1.39					White CHALK
BH07	3WAXC	C	7.70	2.03		1.62	25				White CHALK
BH07	6WAXB	C	12.84	2.10	25	1.69					White CHALK
BH07	7WAXA	C	15.55	1.99	28	1.56					White CHALK
BH07	11WAXA	C	21.07	1.97	26	1.56					White CHALK
BH_07	13WAXA	C	23.62	2.02	25	1.63					White CHALK
BH_07	21WAXA	C	32.06	1.97		1.54	28				White CHALK
Type of Test: d - diametral, a - axial, b - block, l - irregular lump Moisture Condition: A - air dried, S - saturated, AR - as received											

Plate B.9-3

SECTION B.10

CONE PENETRATION TESTING (CPT)

B.10	CONE PENETRATION TESTING	1
B.10.1	SUMMARY	1
B.10.2	TEST RESULTS	2
B.10.3	DISCUSSION OF RESULTS	3

B.10 CONE PENETRATION TESTING

B.10.1 SUMMARY

A total of 188 successful downhole piezocone penetration tests (CPTU) were performed from the M/V Fugro Saltire. Cone penetrometer tests (CPTs) were performed using Fugro's WISON[®] MK III system. The penetration force for the test is provided by the Fugro's SEACLAM[®] seabed reaction frame, which was ballasted to provide a submerged weight of the order of 10 tonnes. Details of these systems are presented in Section C.2. A total of six CPTs were performed from the M/V Willendeavour using the Roson Seabed Penetrometer system.

A summary of test numbers, depth ranges, and cones used for the tests is presented in Table B.4-1.

Table B.10.1: Summary of Cones Used

Location	CPT Number	Depth Range [m BSF]	Cones Used
Performed from the M/V Fugro Saltire			
BH_02	1 to 8	0.0 to 22.2	F5CKEW2/V-1955
	9	23.5 to 25.0	F8CKE/V-1551
	10	25.0 to 25.8	F5CKEW2/V-1955
	11 to 15	27.0 to 35.5	F8CKE/V-1551
	16	36.0 to 36.6	F5CKEW2/V-1955
	17 to 18	38.0 to 40.6	F8CKE/V-1551
	19	43.0 to 45.9	F5CKEW2/V-1955
BH_04	1 to 4	0.0 to 6.7	F5CKEW2/V-1356
	5 to 14	8.0 to 17.6	F8CKE/V-1738
	15 to 19	18.0 to 21.2	F8CKE/V-1551
	20 to 29	26.9 to 46.8	F5CKEW2/V-1356
BH_06	1 to 17	0.0 to 46.6	F5CKEW2/V-1356
BH_07	1 to 6	0.0 to 17.3	F5CKEW2/V-1356
	7	17.5 to 19.2	F5CKEW2/V-1877
	8 to 23	21.5 to 45.0	F5CKEW2/V-1955
BH_13	1 to 9	0.0 to 19.6	F5CKEW2/V-1314
	10 to 26	21.0 to 38.9	F8CKE/V-1680
	27	41.0 to 43.9	F5CKEW2/V-1314
BH_14	1 to 10	0.0 to 38.1	F5CKEW2/V-1314
	11 to 23	38.5 to 49.6	F8CKE/V-1680
BH_16	1 to 19	0.0 to 36.2	F5CKEW2/V-1314
	20 to 23	36.5 to 40.7	F8CKE/V-1698
	24 to 26	42.0 to 45.9	F8CKE/V-1680
BH_17	1 to 8	0.0 to 29.7	F5CKEW2/V-1314
	9 to 20	31.0 to 40.7	F8CKE/V-1680
	21 to 24	42.5 to 44.5	F5CKEW2/V-1314
Performed from the M/V Willendeavour			
CPT_03	1	0.0 to 5.2	F5CKE2HAW2/B P10 170
CPT_18C	1	0.0 to 3.2	F5CKE2HAW2/B P10 170
CPT_19C	1	0.0 to 1.0	F5CKE2HAW2/B P10 170
CPT_19Ca	1	0.0 to 1.2	F5CKE2HAW2/B P10 170

Table B.10.2: Summary of Cones Used Cont.

Location	CPT Number	Depth Range [m BSF]	Cones Used
CPT_20C	1	0.0 to 3.2	F5CKE2HAW2/B P10 170
CPT_21C	1	0.0 to 3.0	F5CKE2HAW2/B P10 170

Notes:

BSF = Below seafloor

Cones with a projected area of 10 cm² and a 5 tonne capacity were used for the testing, with pore pressure measurements being made on the cone shoulder. Corresponding α and β values for these cones are 0.75 and 1.0, respectively. In harder soils, cones with a projected area of 5 cm² and an 8 tonne capacity were used, with corresponding α and β values of 0.5 and 1.0, respectively. No pore pressure measurements are recorded with this type of cone and only basic parameters are presented. A summary of CPT abbreviations and definitions is presented below.

B.10.2 TEST RESULTS

B.10.2.1 General

The results of the piezocone penetration tests are presented at the end of this section. Two types of plot are presented for each test:

- (i) The first type of plot presents the measured data obtained during the test, e.g. cone resistance, cone sleeve friction and excess pore-water pressure.
- (ii) The second type of plot presents parameters derived from the measured data, e.g. total cone resistance, excess pore-water pressure ratio and friction ratio.

B.10.2.2 Results

The following data are presented at each test location:

- (i) Cone resistance, q_c ;
- (ii) Cone sleeve friction, f_s ;
- (iii) Total cone resistance, q_t ;
- (iv) Pore-water pressure, u ;
- (v) Pore-water pressure ratio, B_q ;
- (vi) Friction ratio, R_f .

An explanation of common CPT abbreviations is presented below:

q_c	=	Measured cone resistance.
f_s	=	Measured sleeve friction.
d	=	Depth below seafloor at start of test.
α	=	The ratio of the area of the cone shaft to the area of the cone face.
β	=	The ratio of the excess pore-water pressure acting on the cone shoulder to that acting at the sensor location.
u_o	=	The theoretical hydrostatic water pressure relative to seafloor acting at the elevation of the cone face.
du	=	The pore-water pressure in excess of the theoretical hydrostatic pore-water pressure relative to seafloor.
p_o	=	The total overburden pressure relative to seafloor.
f_s	=	The measured cone sleeve friction.
γ_w	=	The unit weight of sea water.

Total cone resistance (q_t) is the measured cone resistance corrected for the effects of cone shape and pore-pressure distribution around the cone tip. The formula used to calculate q_t is given below:

$$q_t = q_c + \alpha \cdot \gamma_w \cdot d + (1-\alpha) \cdot (u_o + \beta du)$$

Net cone resistance (q_{net}) is defined as total cone resistance (q_t) minus the total overburden pressure relative to seafloor (p_o). The formula used to calculate q_{net} is given below:

$$q_{net} = q_c + \alpha \cdot \gamma_w \cdot d + (1-\alpha) \cdot (u_o + \beta du) - p_o$$

Excess pore-water pressure ratio is the ratio of the measured excess pore-water pressure to the net cone resistance. The formula used to calculate B_q is given below:

$$B_q = (du/q_{net})$$

Friction ratio is the ratio of the measured cone sleeve friction to the measured cone resistance and is normally expressed as a percentage. The formula used to calculate R_f is given below:

$$R_f = (f_s/q_c) \times 100\%$$

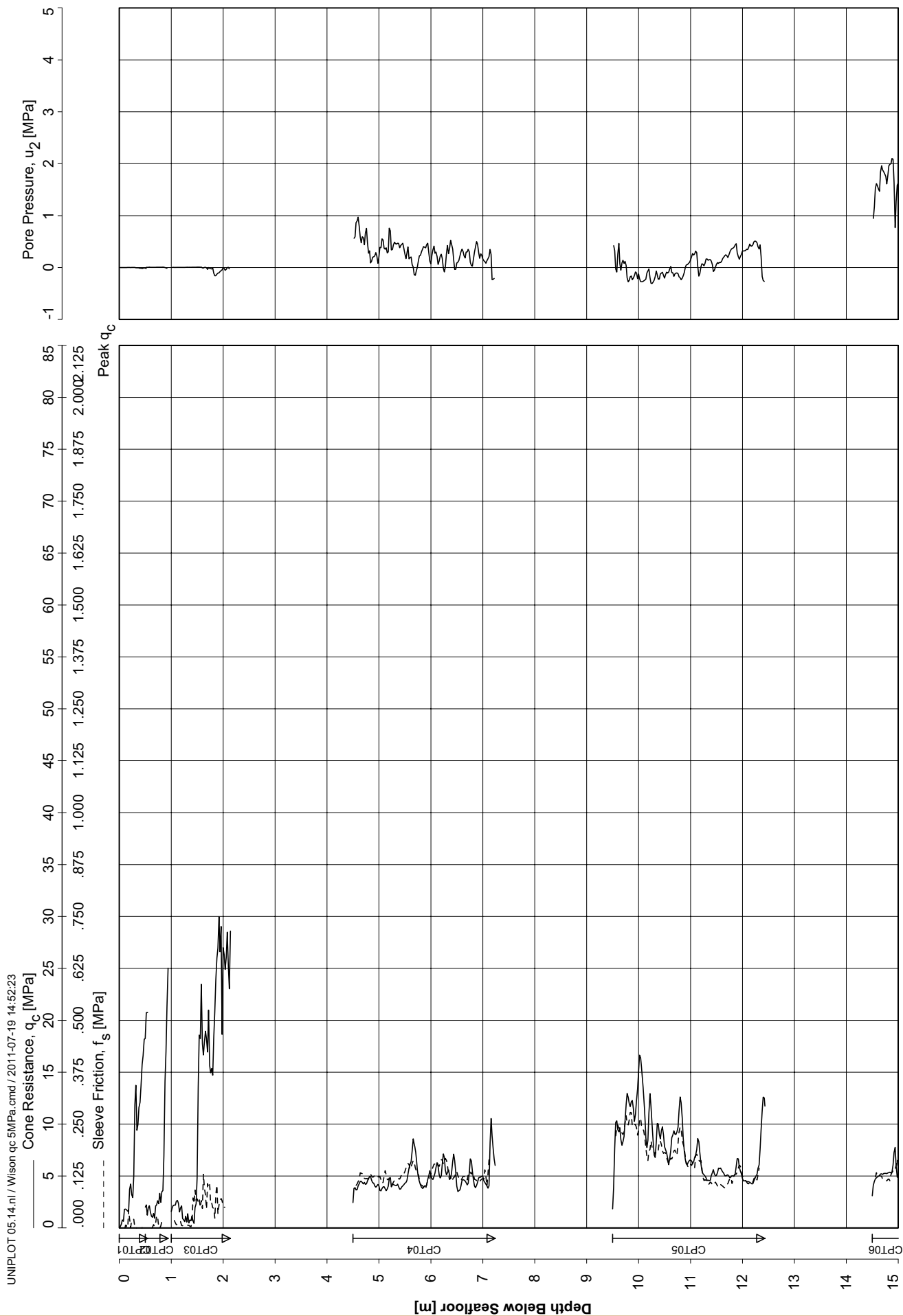
B.10.3 DISCUSSION OF RESULTS

The results are believed to adequately represent the soil conditions and the N_{kt} range of 15 to 20 shows good correlation with UU testing performed offshore.

CPT TESTS

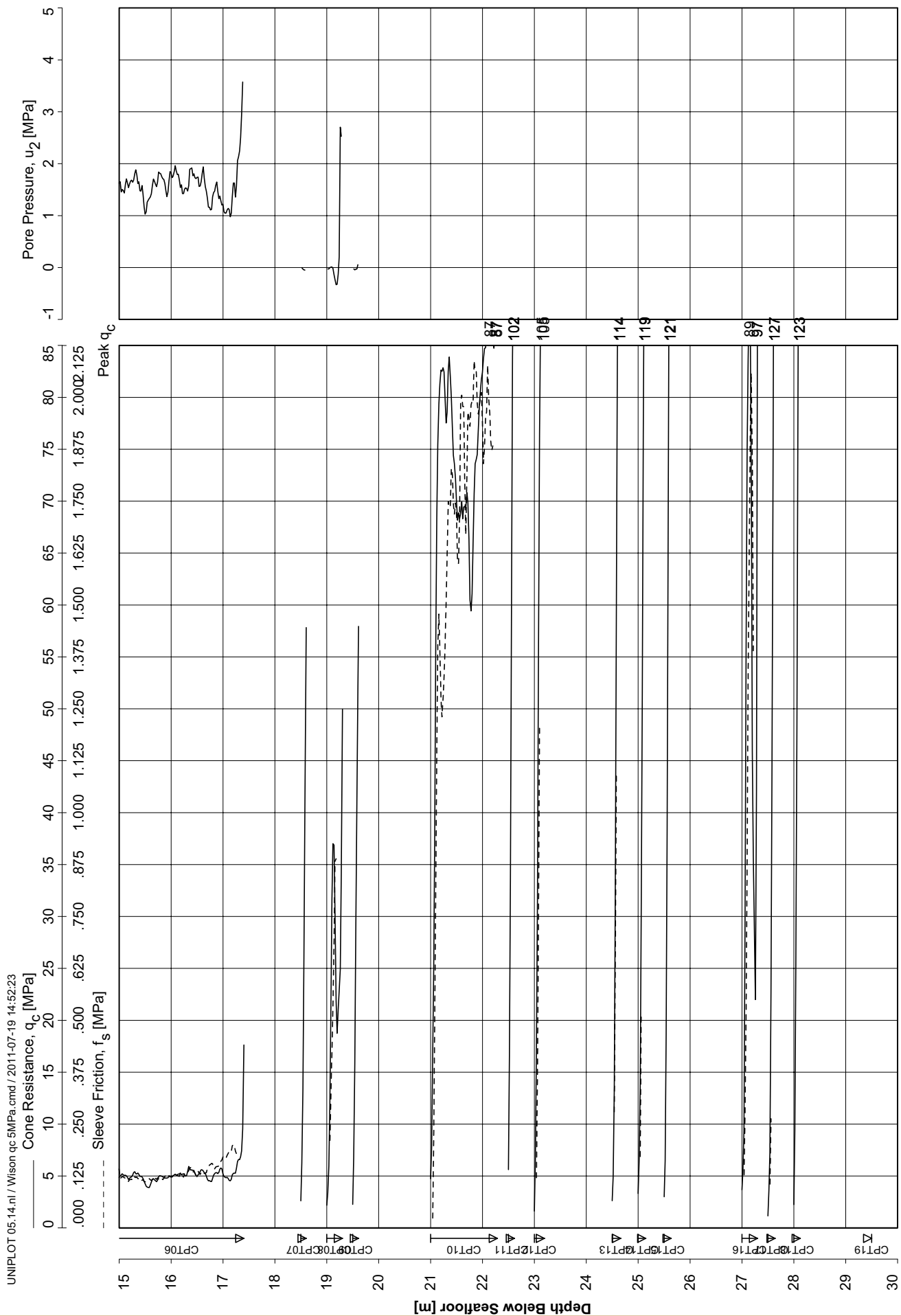
LIST OF PLATES – SECTION B.10

Description	Plate
BH_13 - q_c , f_s , and u_2	B.10-1 to B.10-3
BH_13 - q_n , q_t , B_q and R_f	B.10-4 to B.10-6
BH_14 - q_c , f_s , and u_2	B.10-7 to B.10-10
BH_14 - q_n , q_t , B_q and R_f	B.10-11 to B.10-14
BH_02 - q_c , f_s , and u_2	B.10-15 to B.10-18
BH_02 - q_n , q_t , B_q and R_f	B.10-19 to B.10-22
BH_04 - q_c , f_s , and u_2	B.10-23 to B.10-26
BH_04 - q_n , q_t , B_q and R_f	B.10-27 to B.10-30
BH_06 - q_c , f_s , and u_2	B.10-31 to B.10-34
BH_06 - q_n , q_t , B_q and R_f	B.10-35 to B.10-36
BH_07 - q_c , f_s , and u_2	B.10-37 to B.10-41
BH_07 - q_n , q_t , B_q and R_f	B.10-42 to B.10-45
BH_16 - q_c , f_s , and u_2	B.10-45 to B.10-48
BH_16 - q_n , q_t , B_q and R_f	B.10-49 to B.10-52
BH_17 - q_c , f_s , and u_2	B.10-53 to B.10-55
BH_17 - q_n , q_t , B_q and R_f	B.10-56 to B.10-58



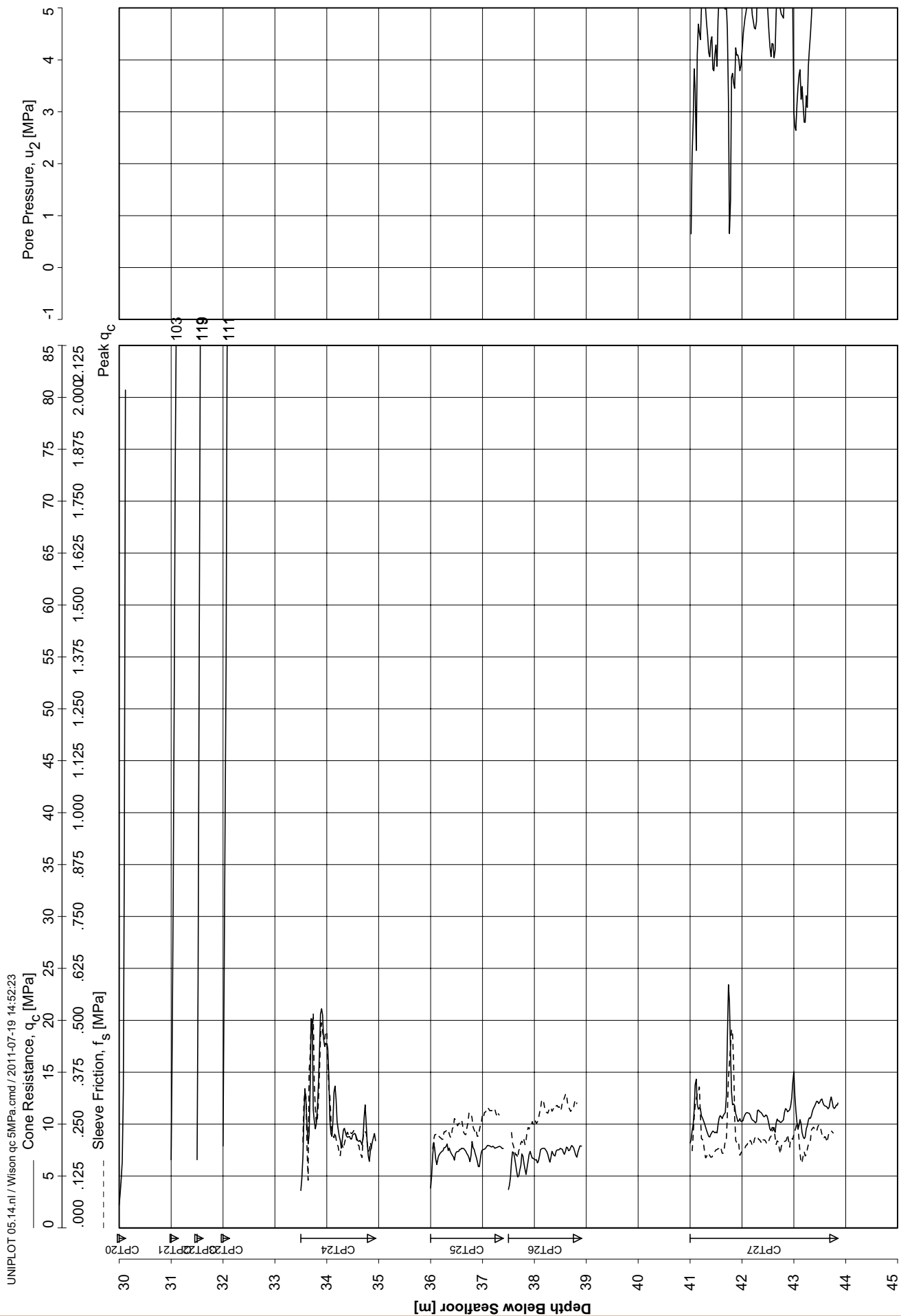
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BH_13
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 29-Mar-2011
Water Depth [m] : 18.5
Coordinates [m] : E687654 N5618494



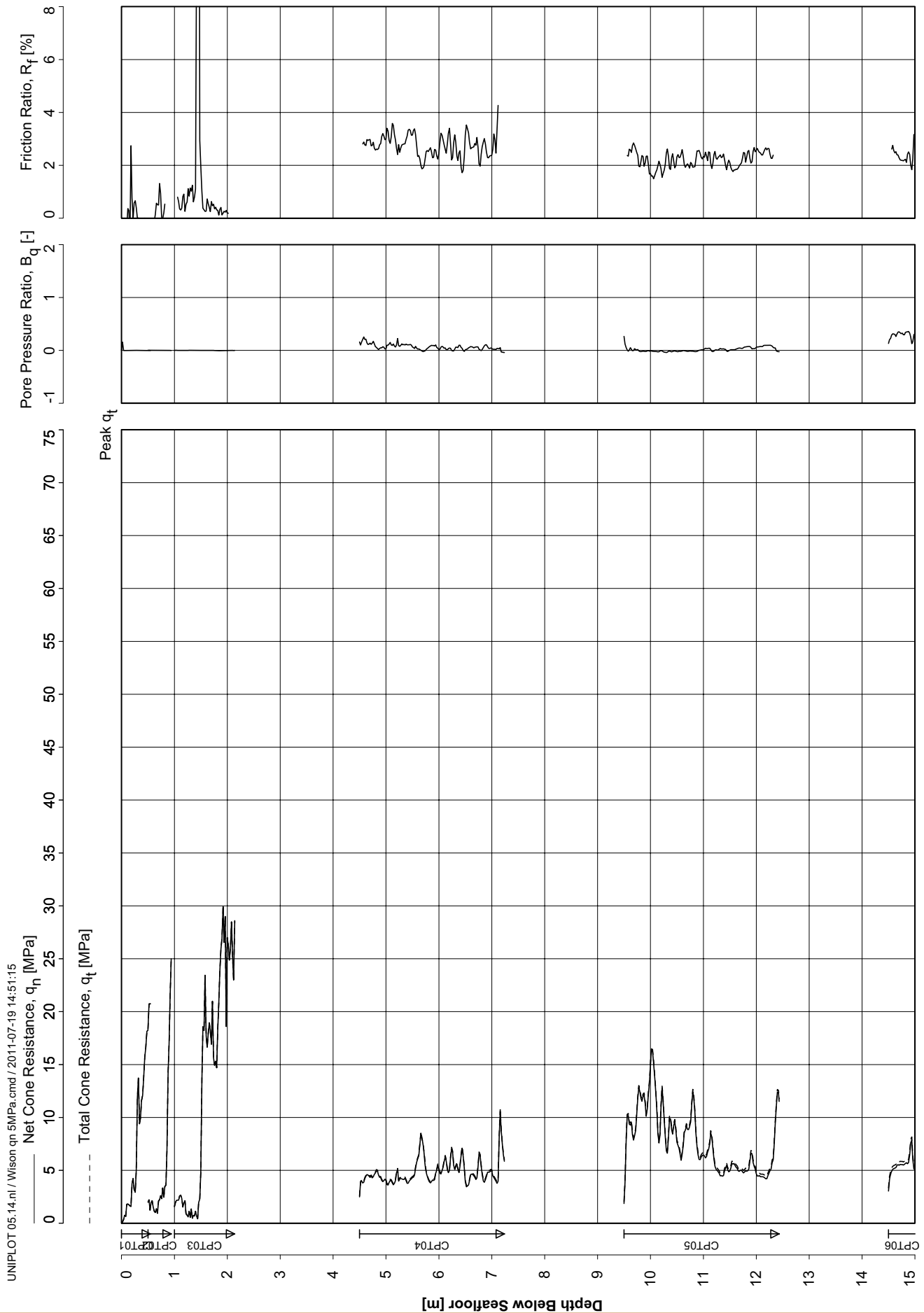
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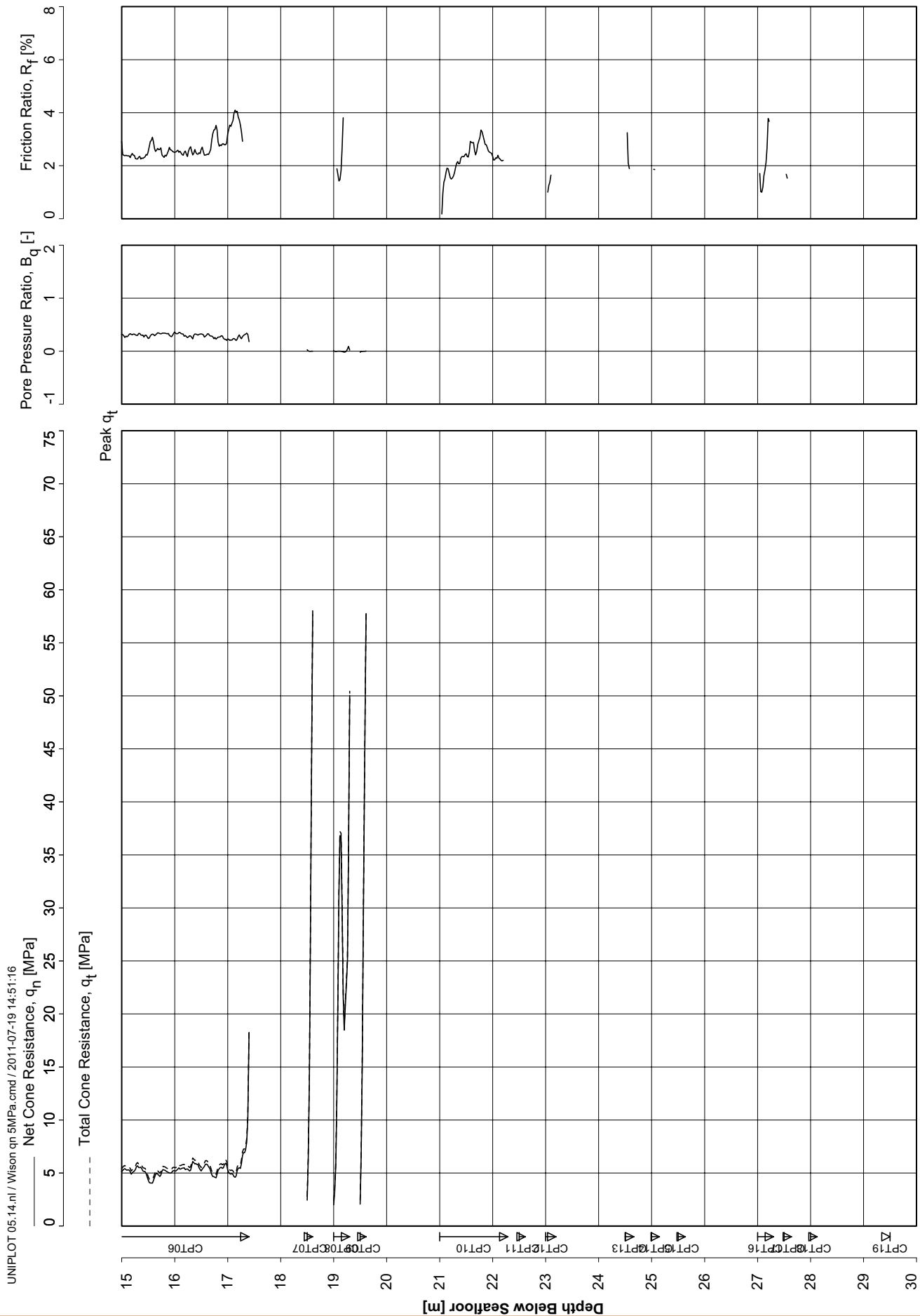
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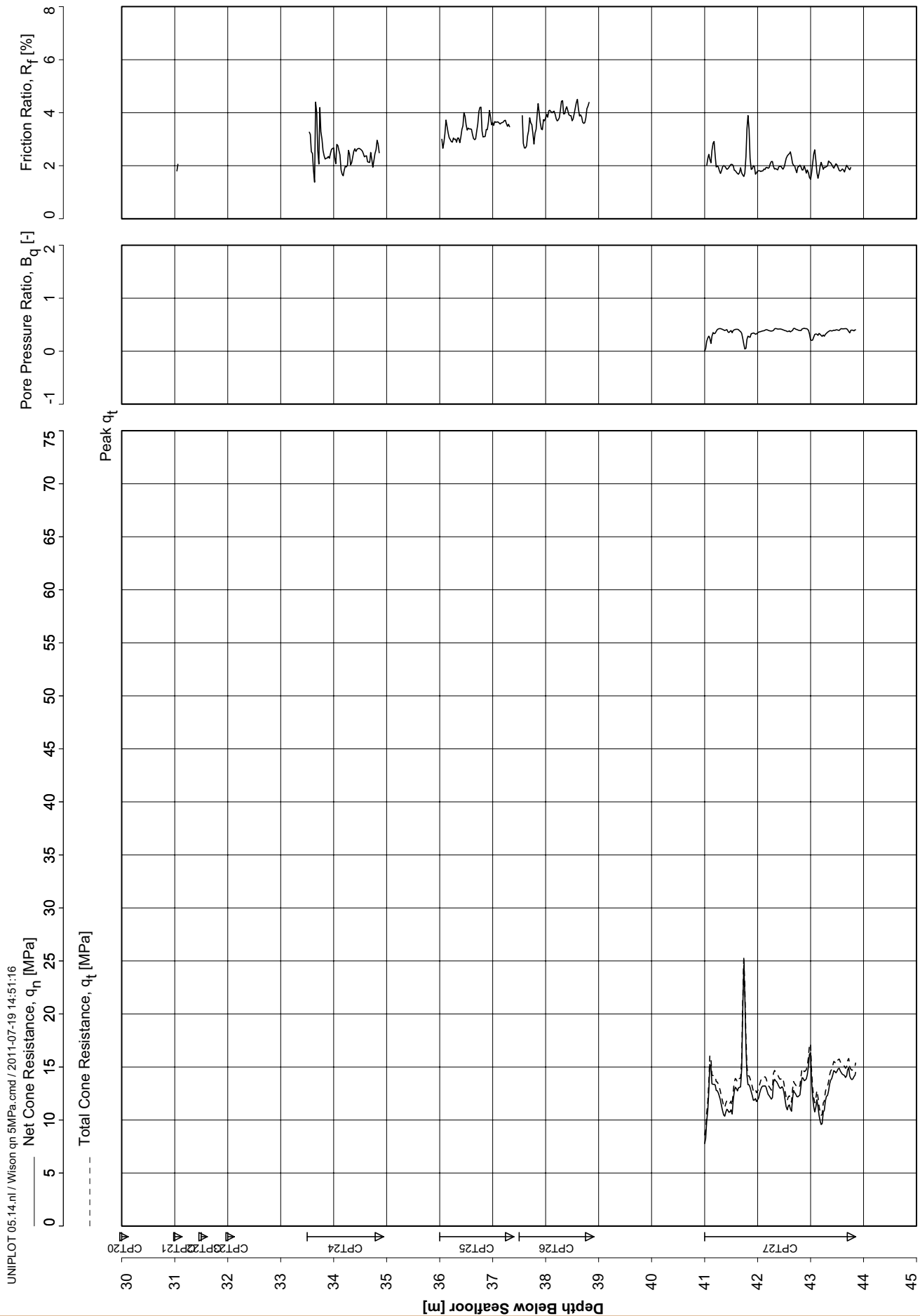
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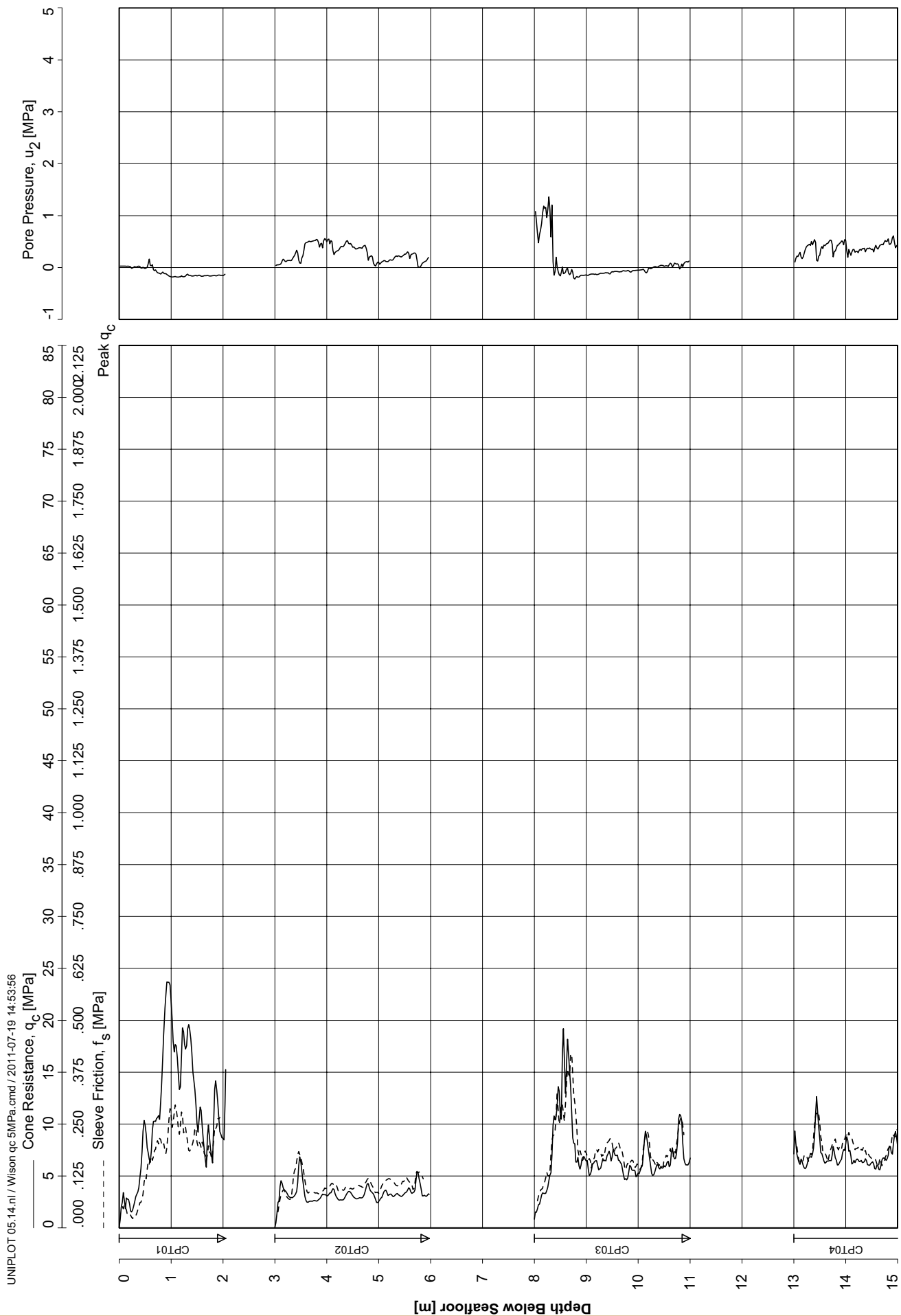
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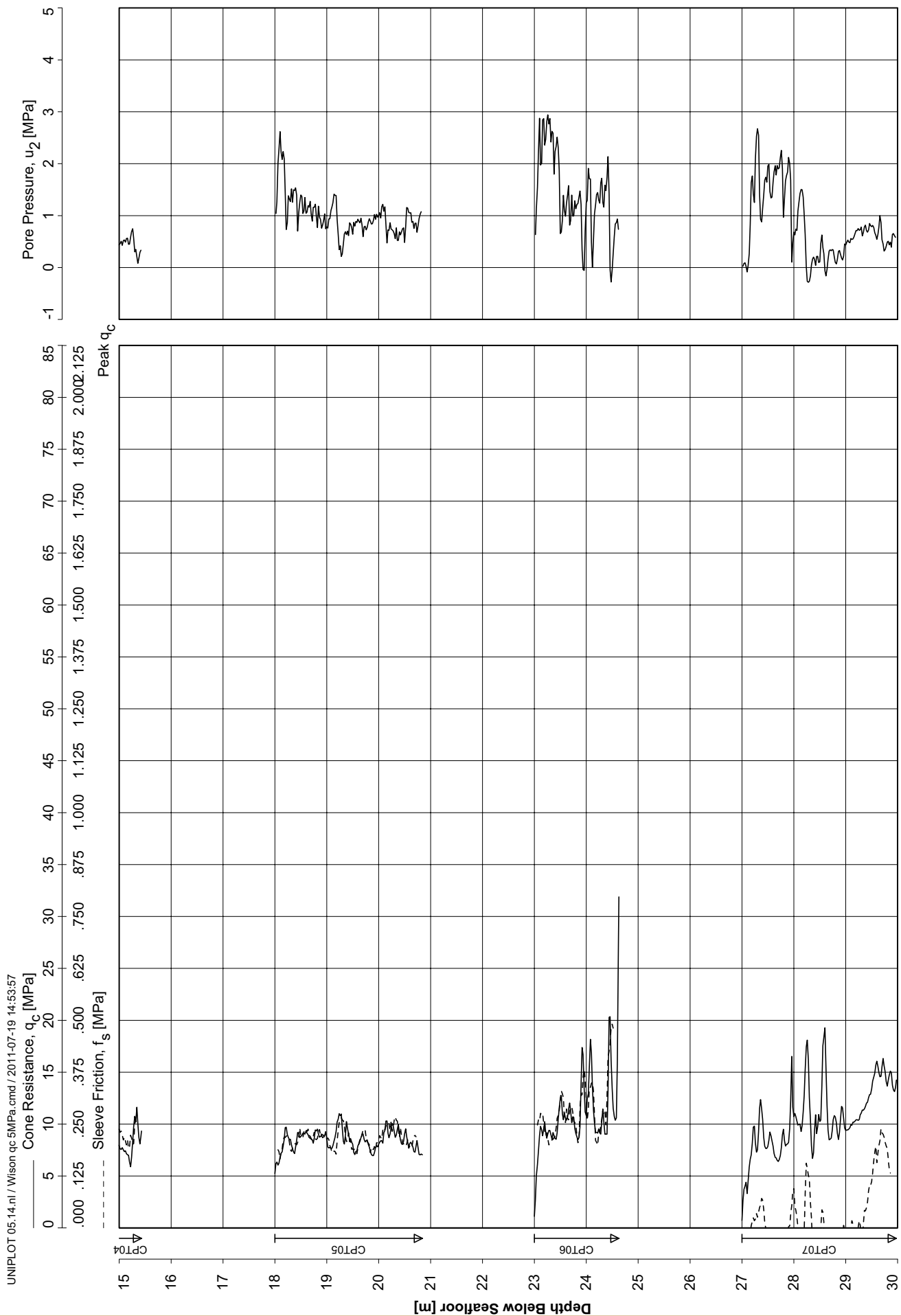
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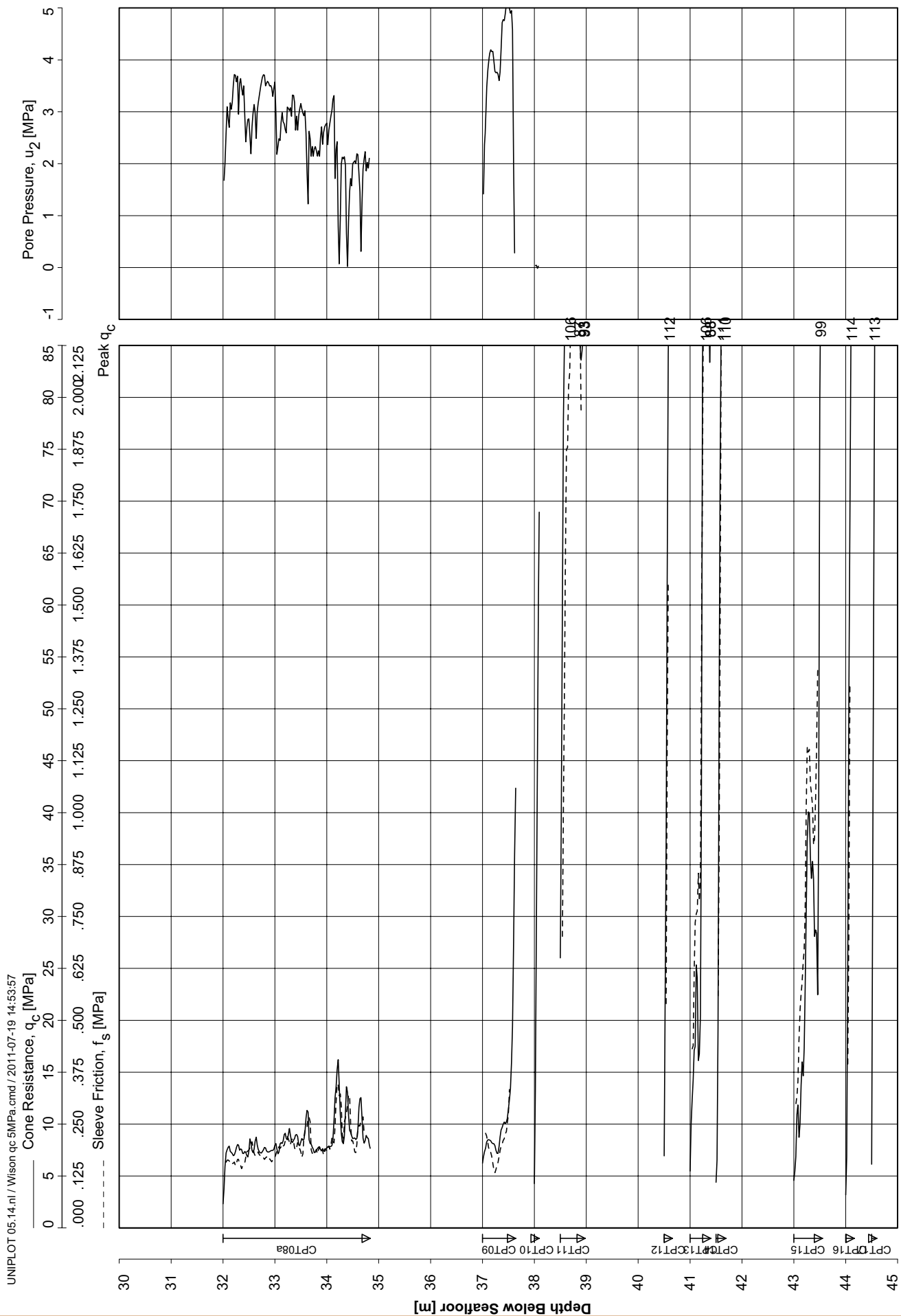
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Coordinates [m] : E686487 N5617486



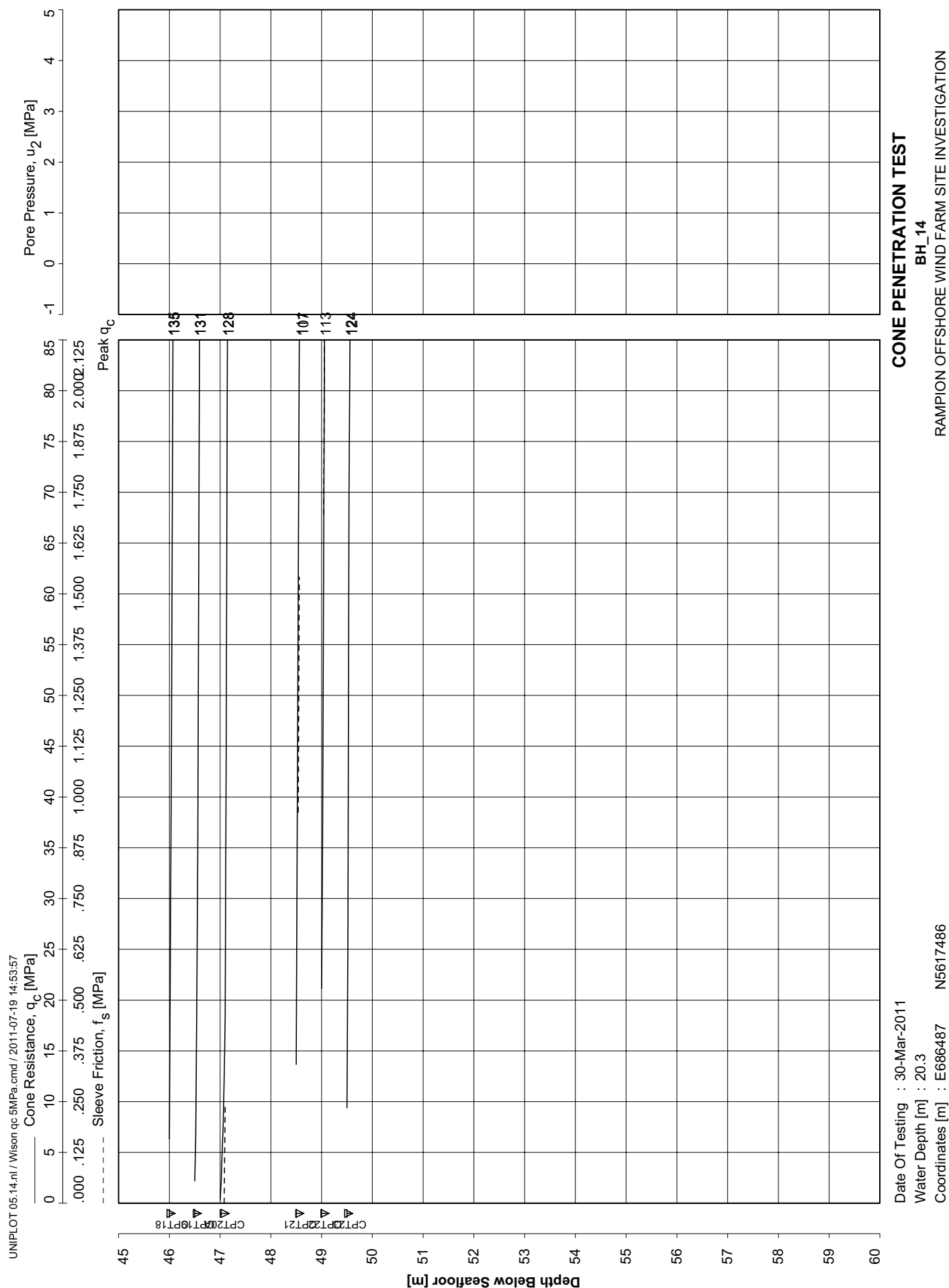
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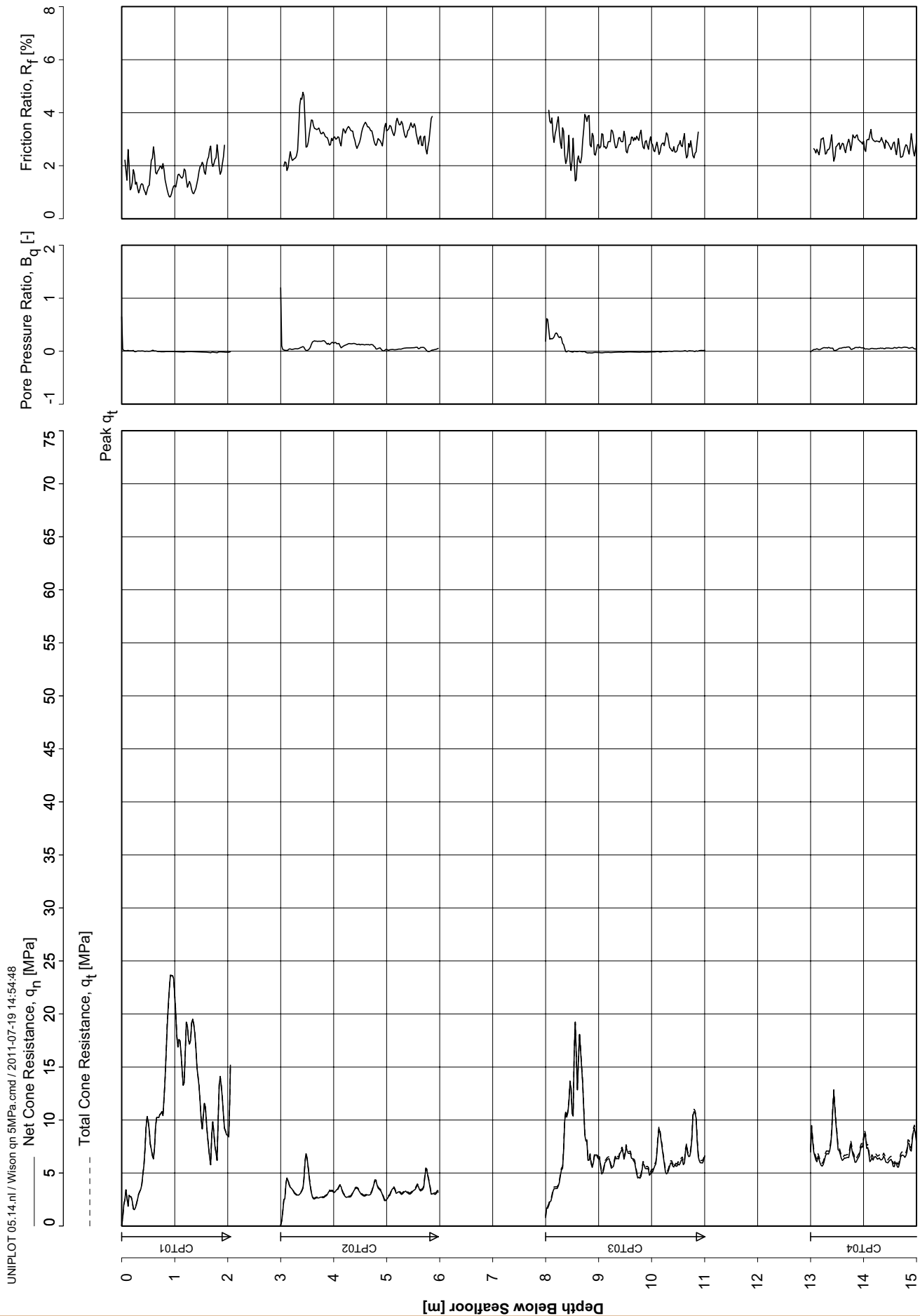
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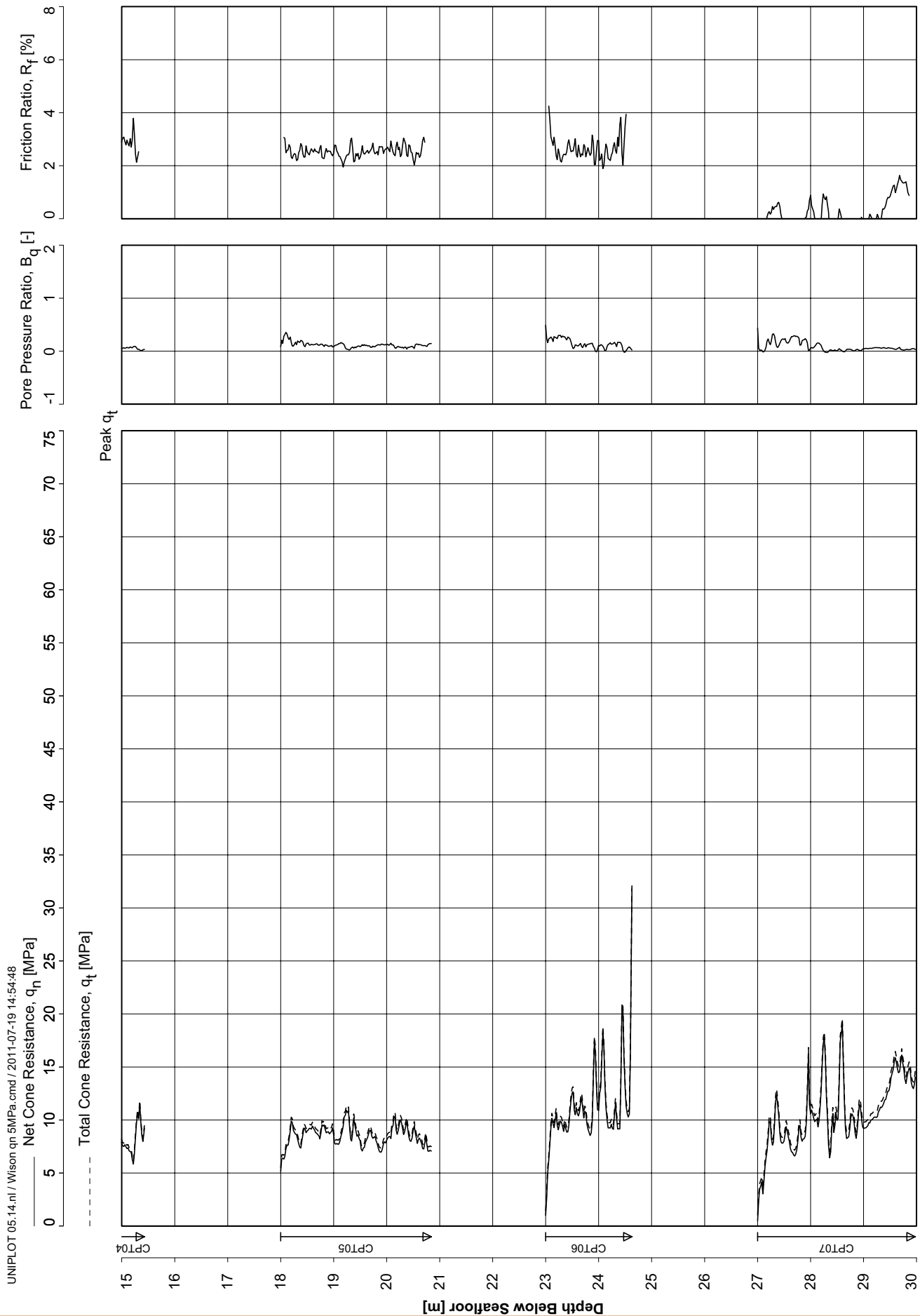
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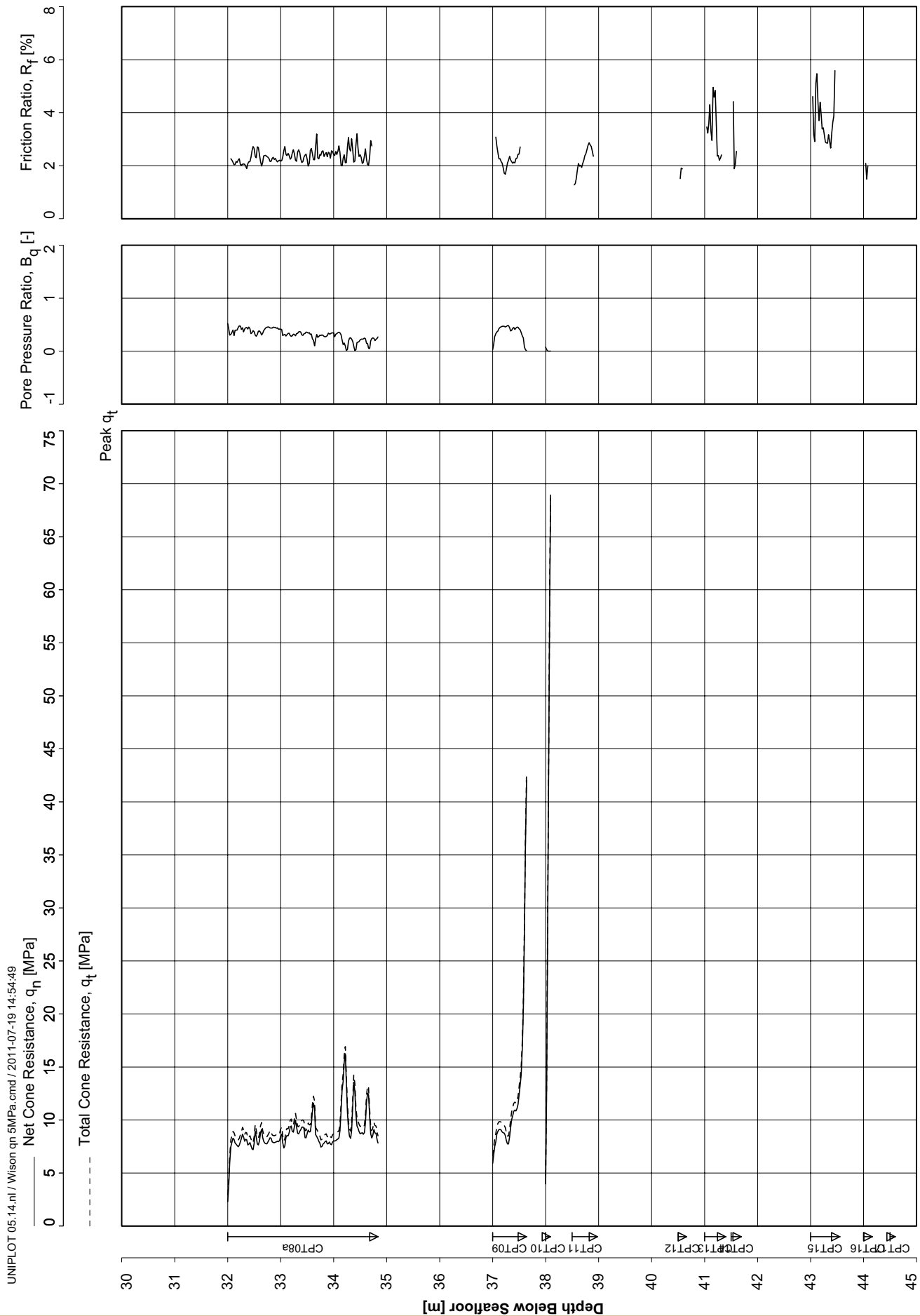
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Coordinates [m] : E686487 N5617486



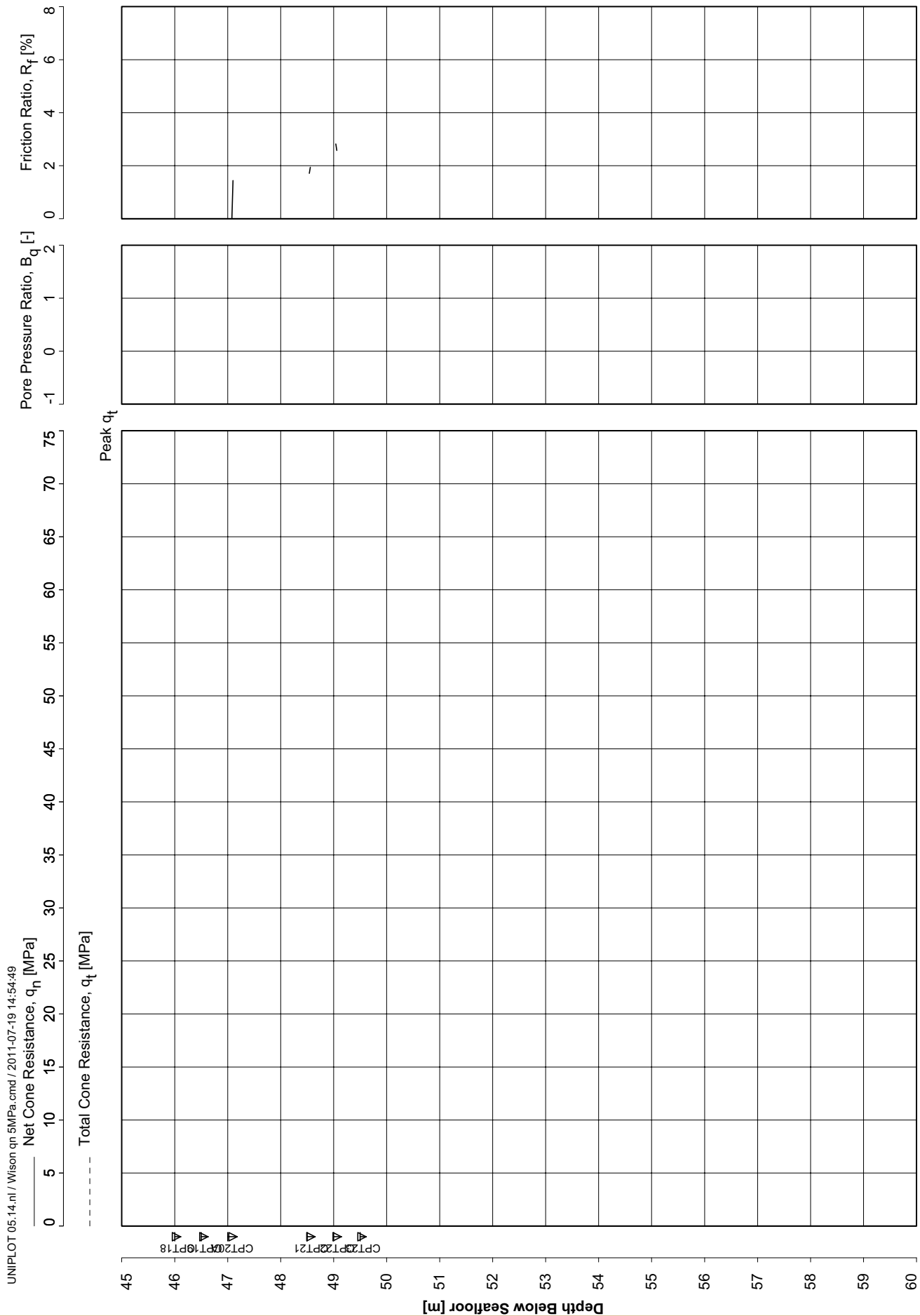
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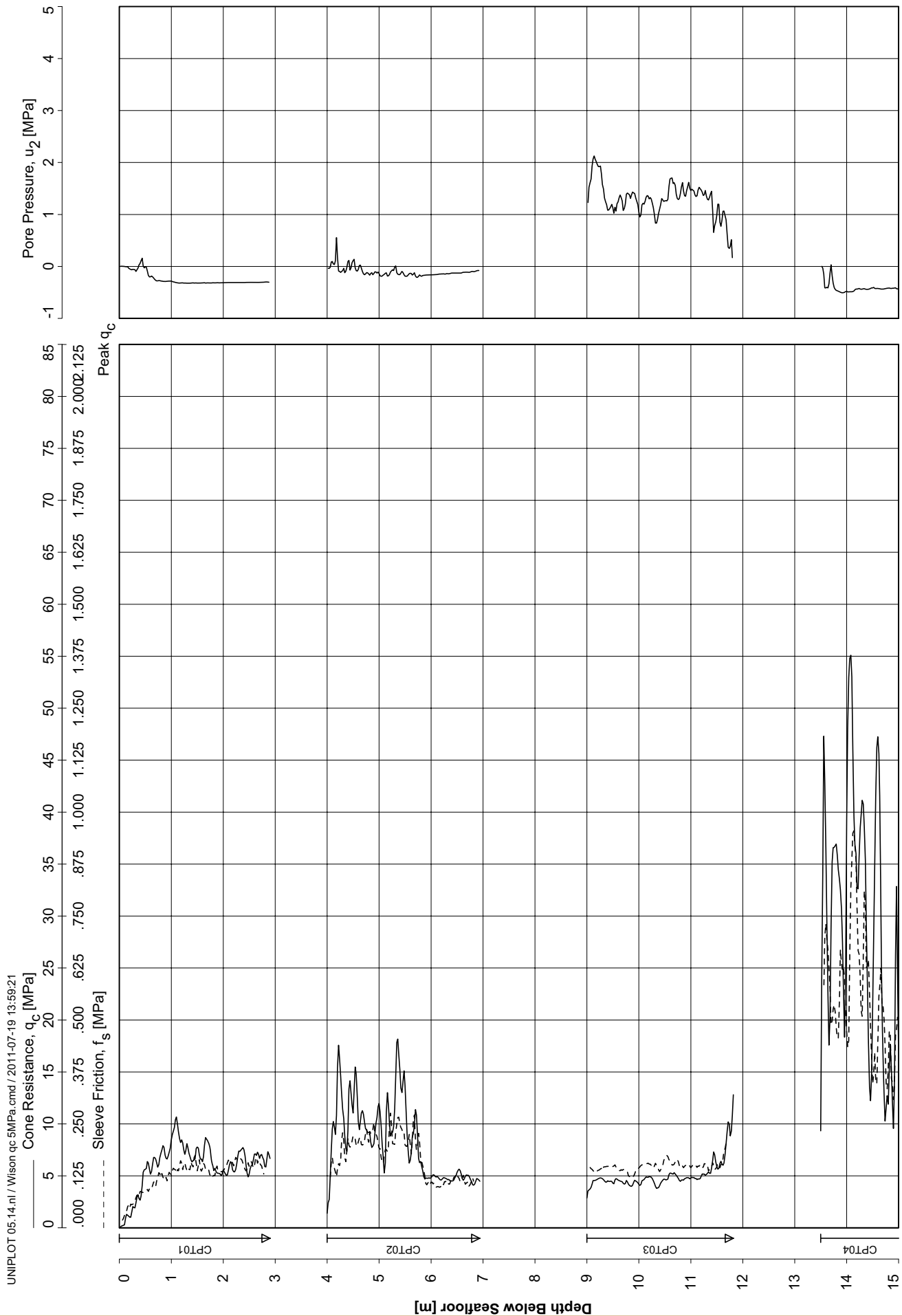
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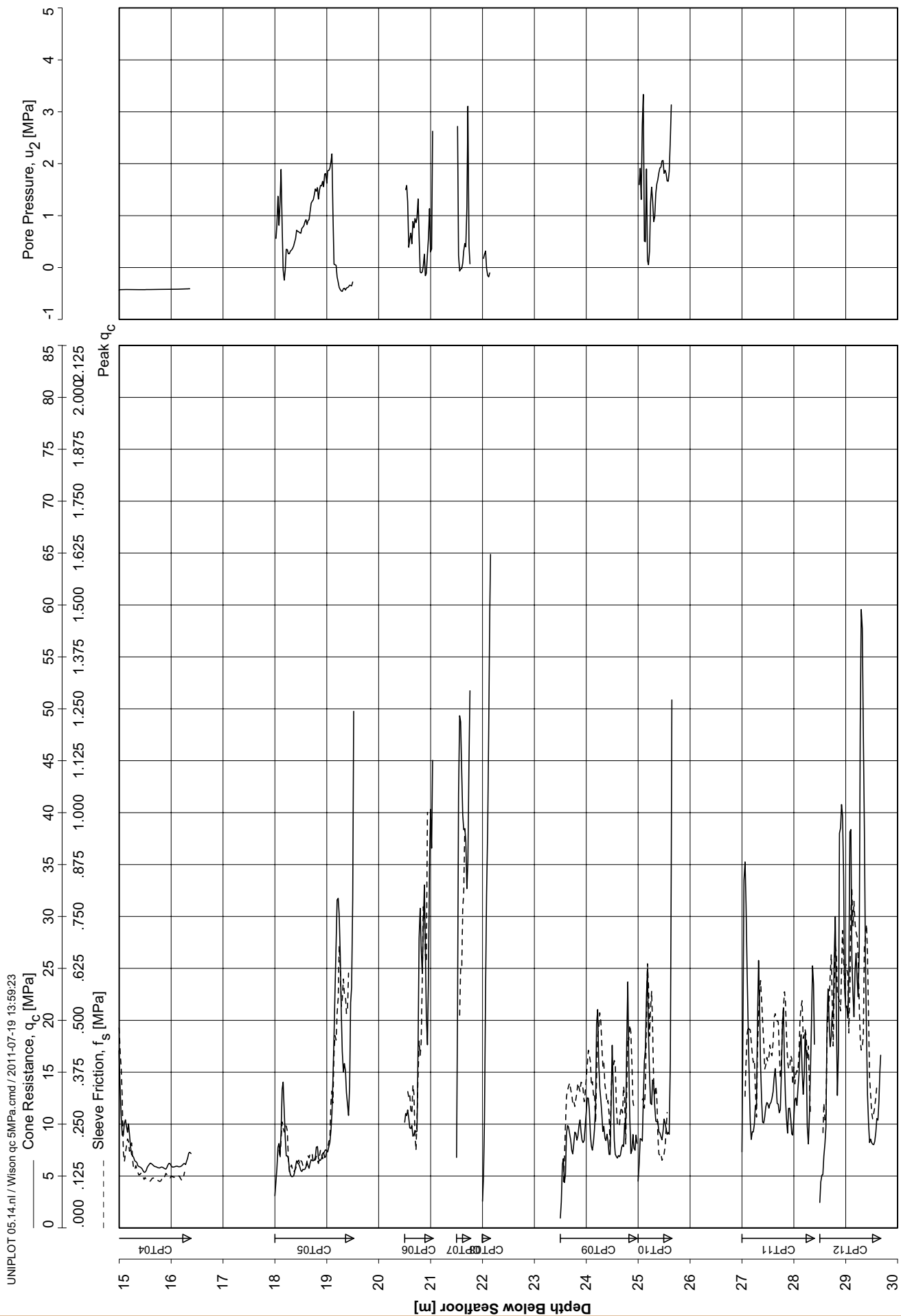
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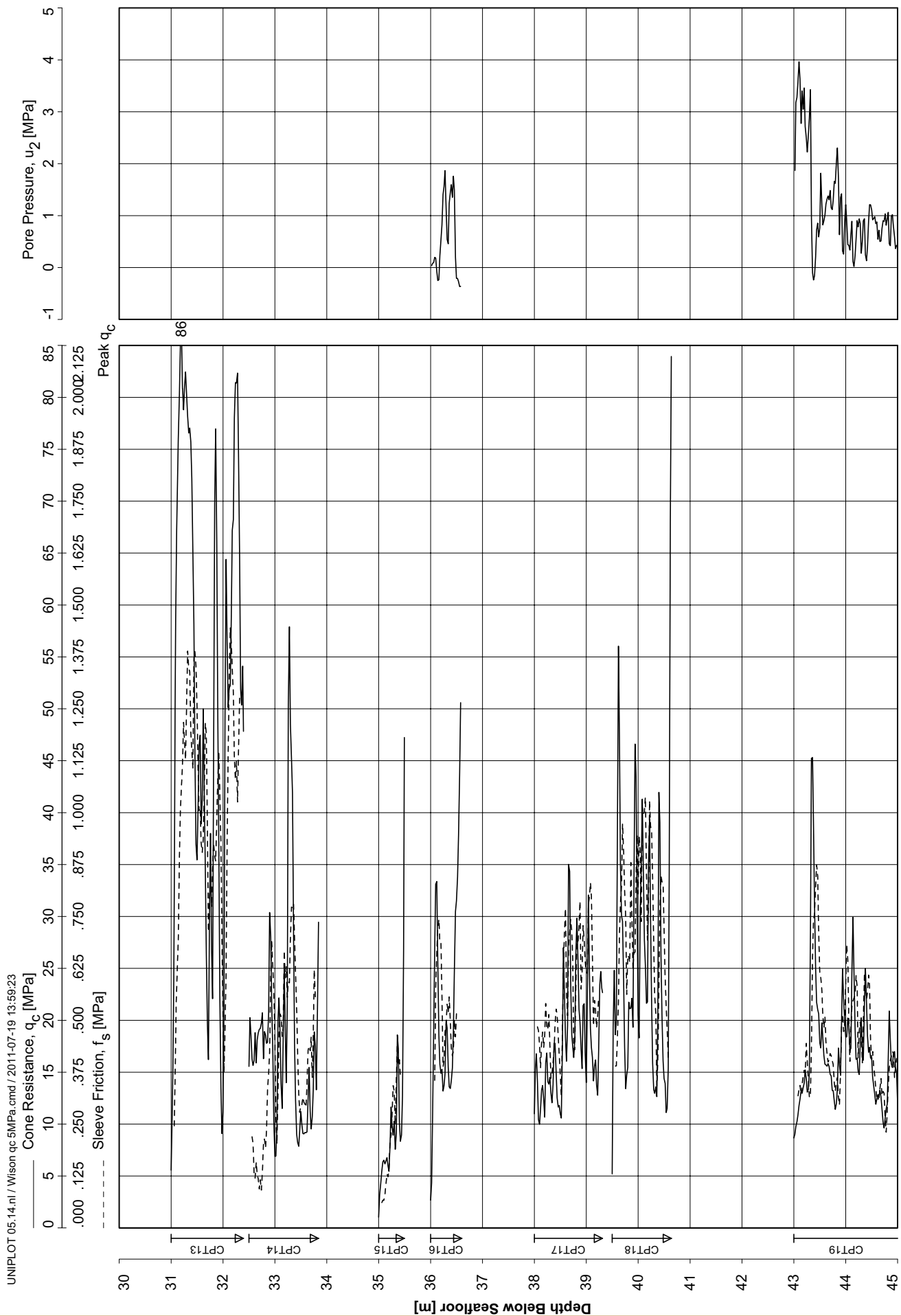
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RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 04-Apr-2011
Water Depth [m] : 35.4
Coordinates [m] : E691041.4 N561364.2



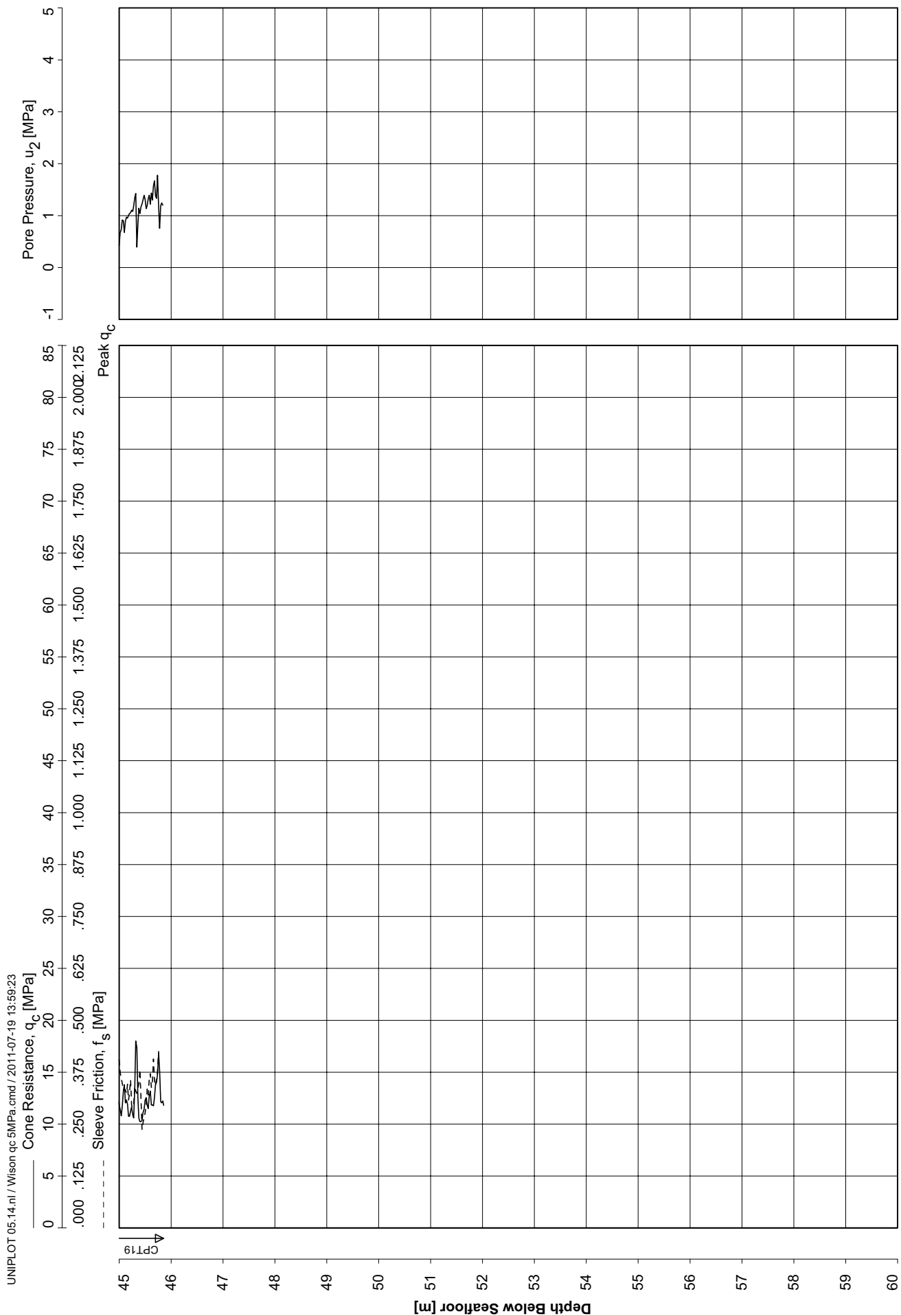
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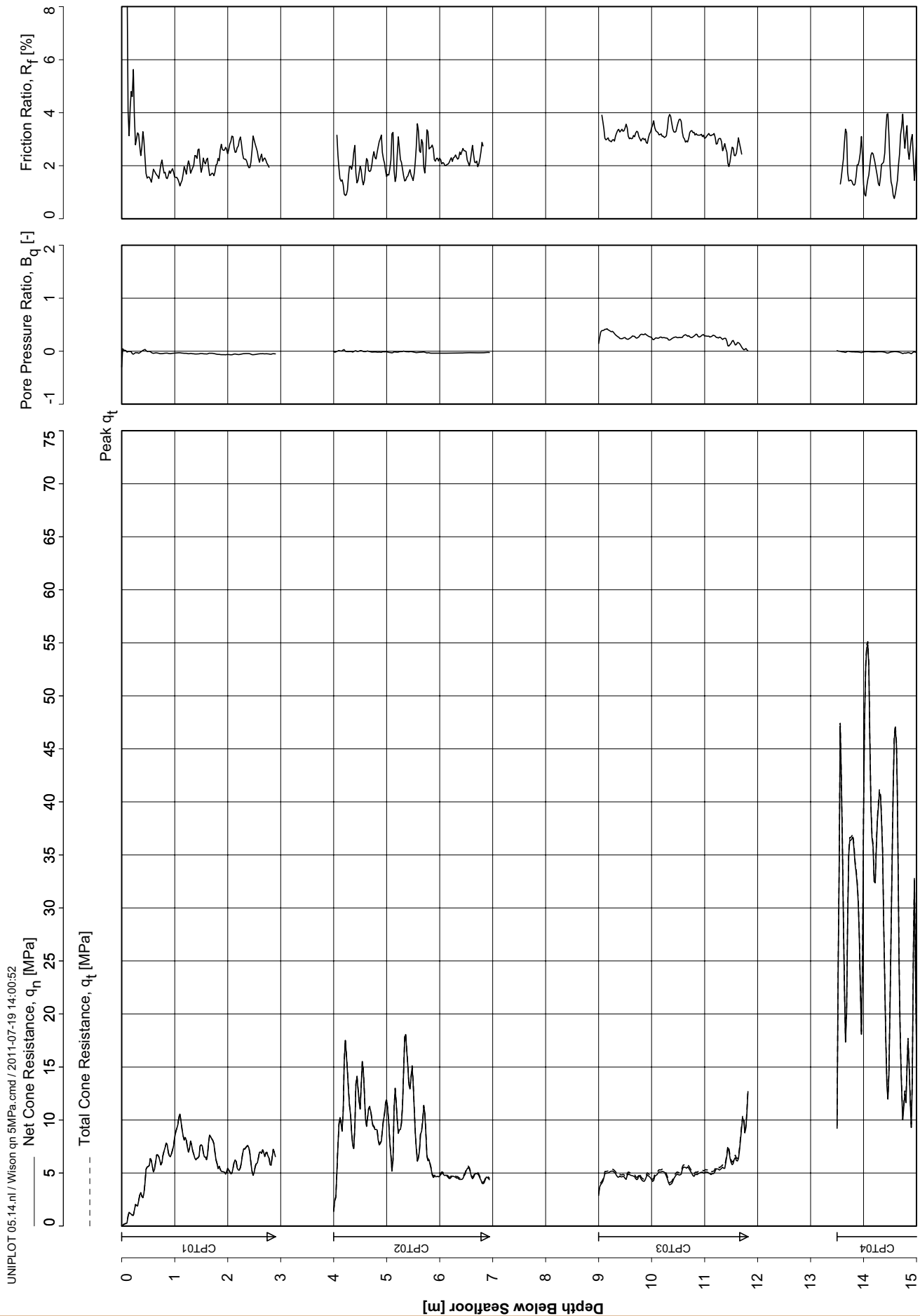
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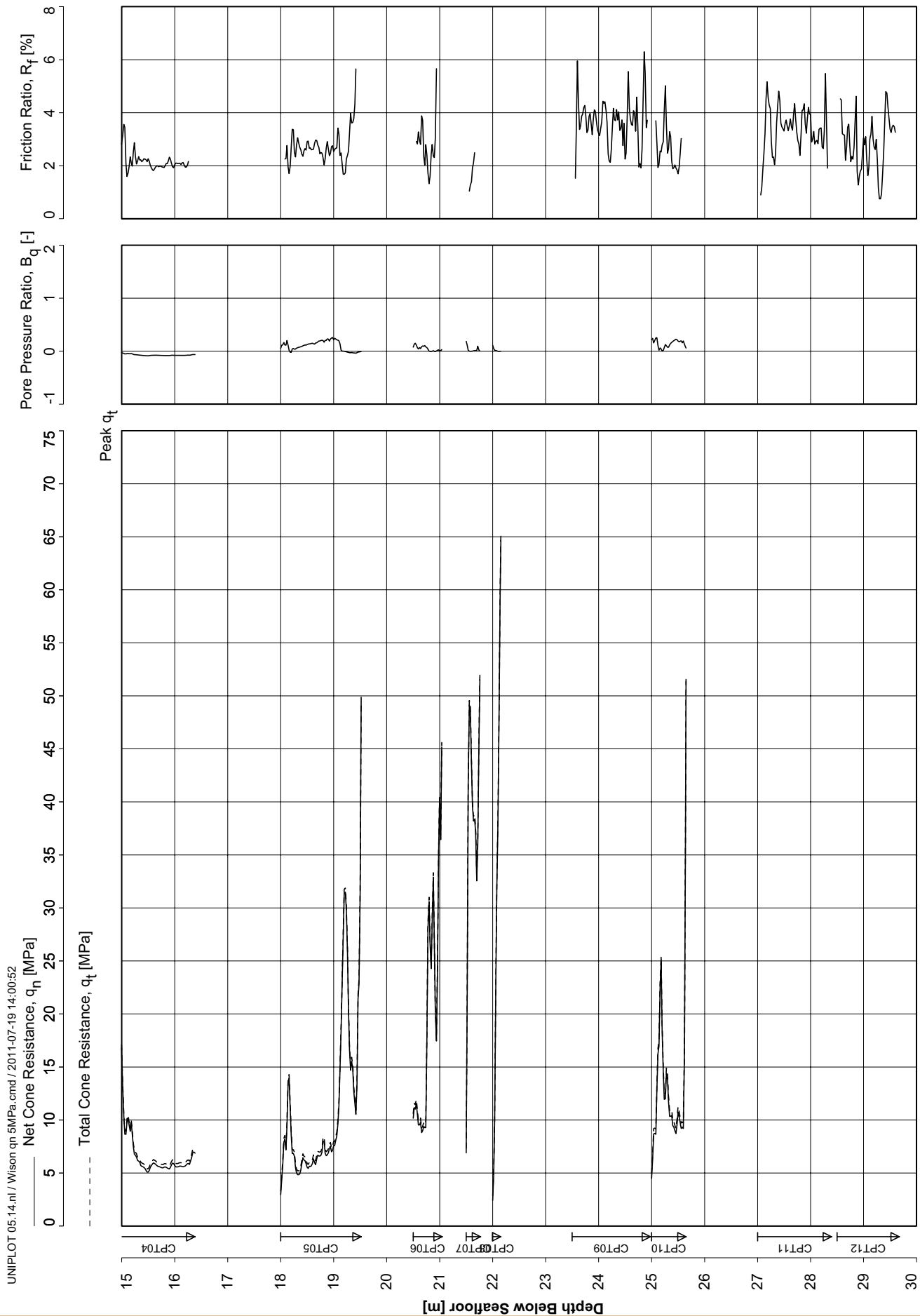
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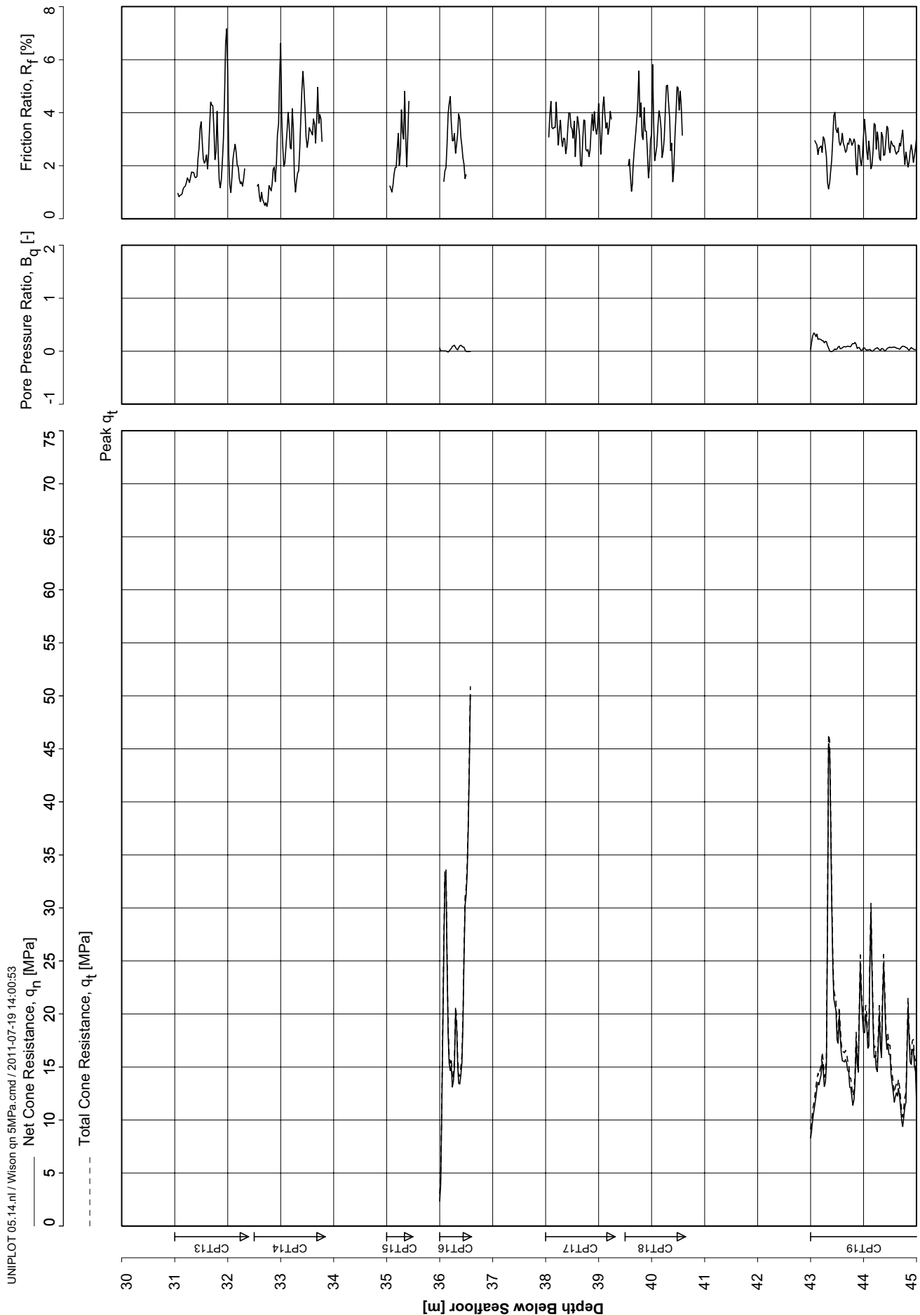
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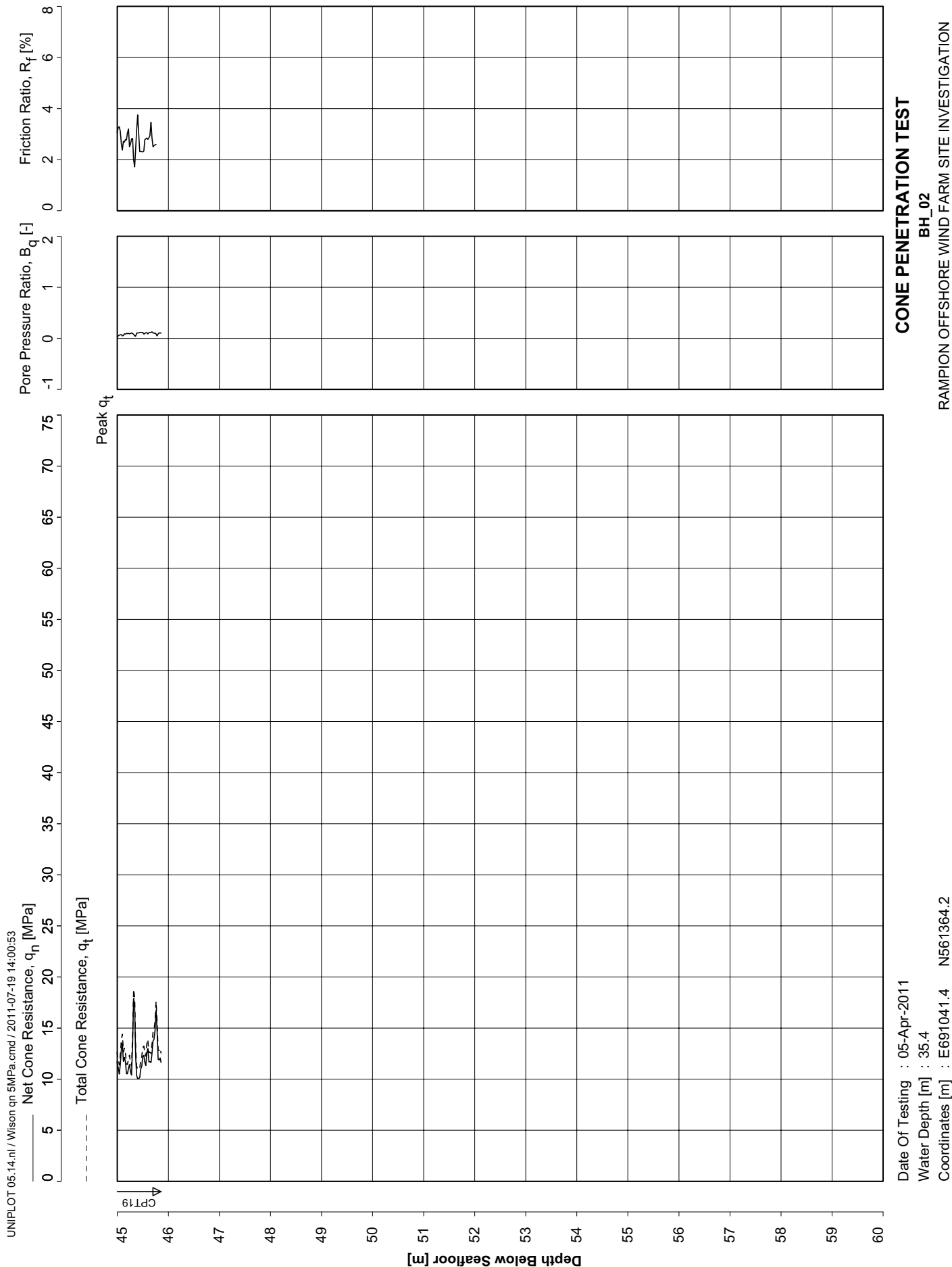
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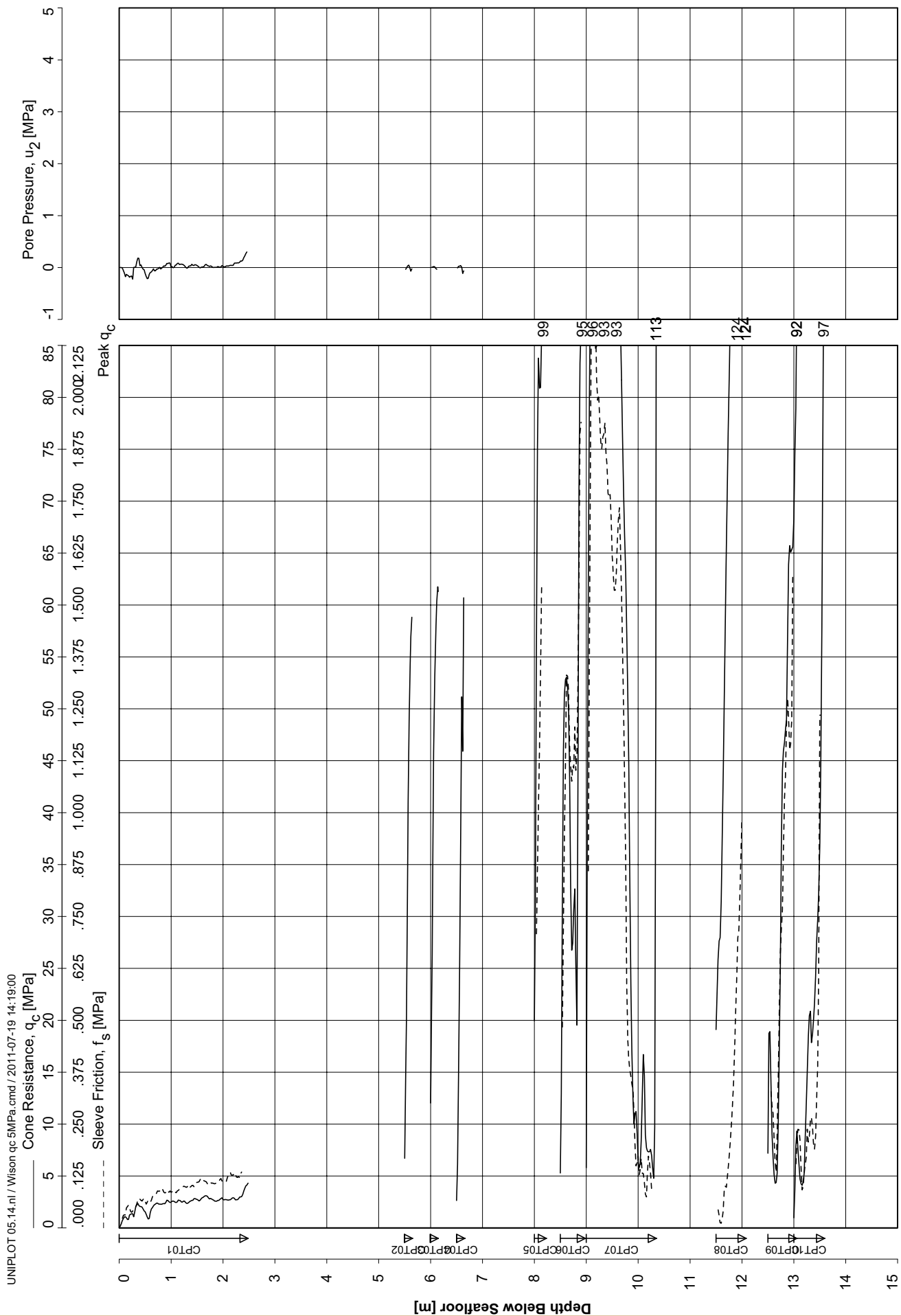
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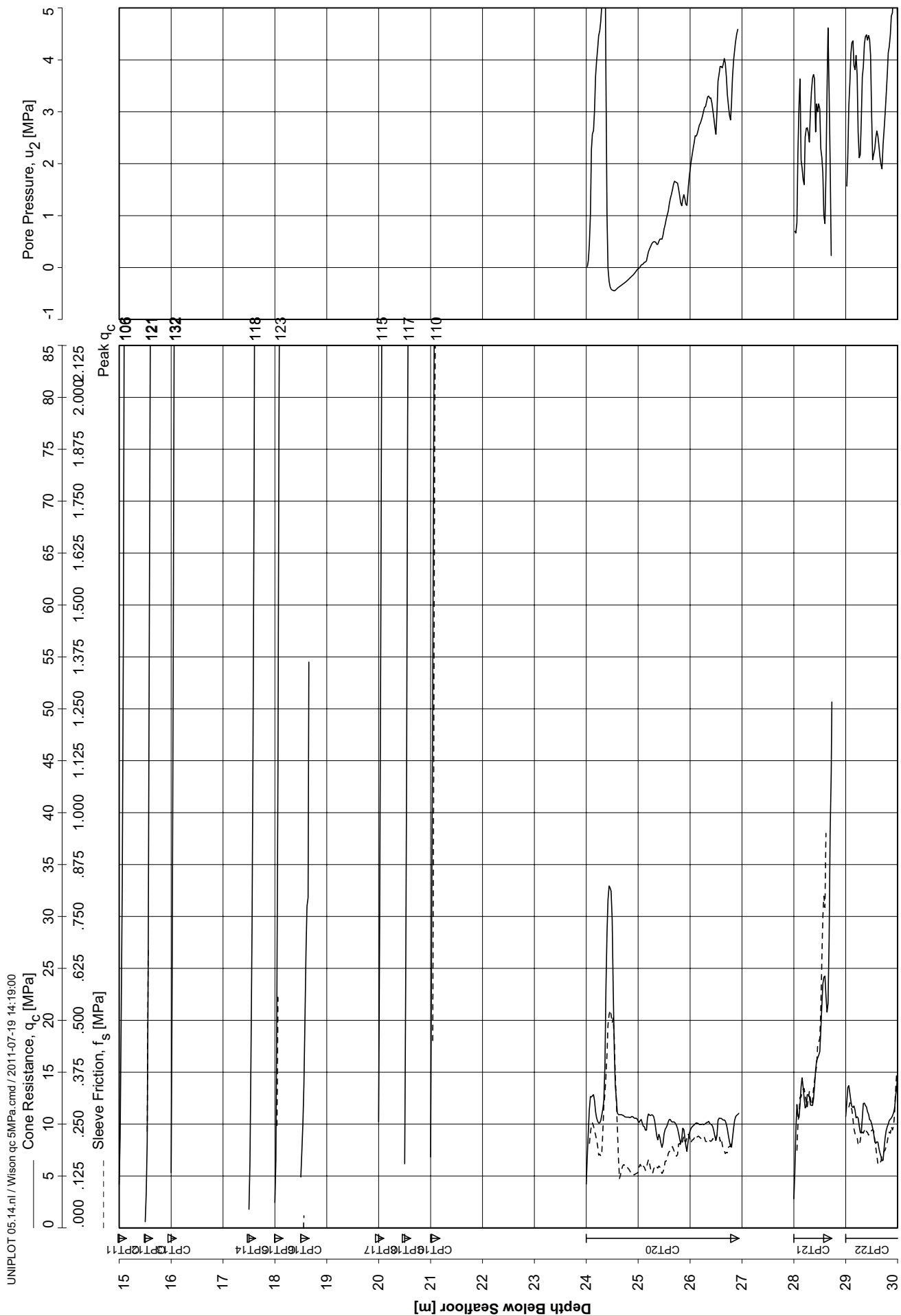
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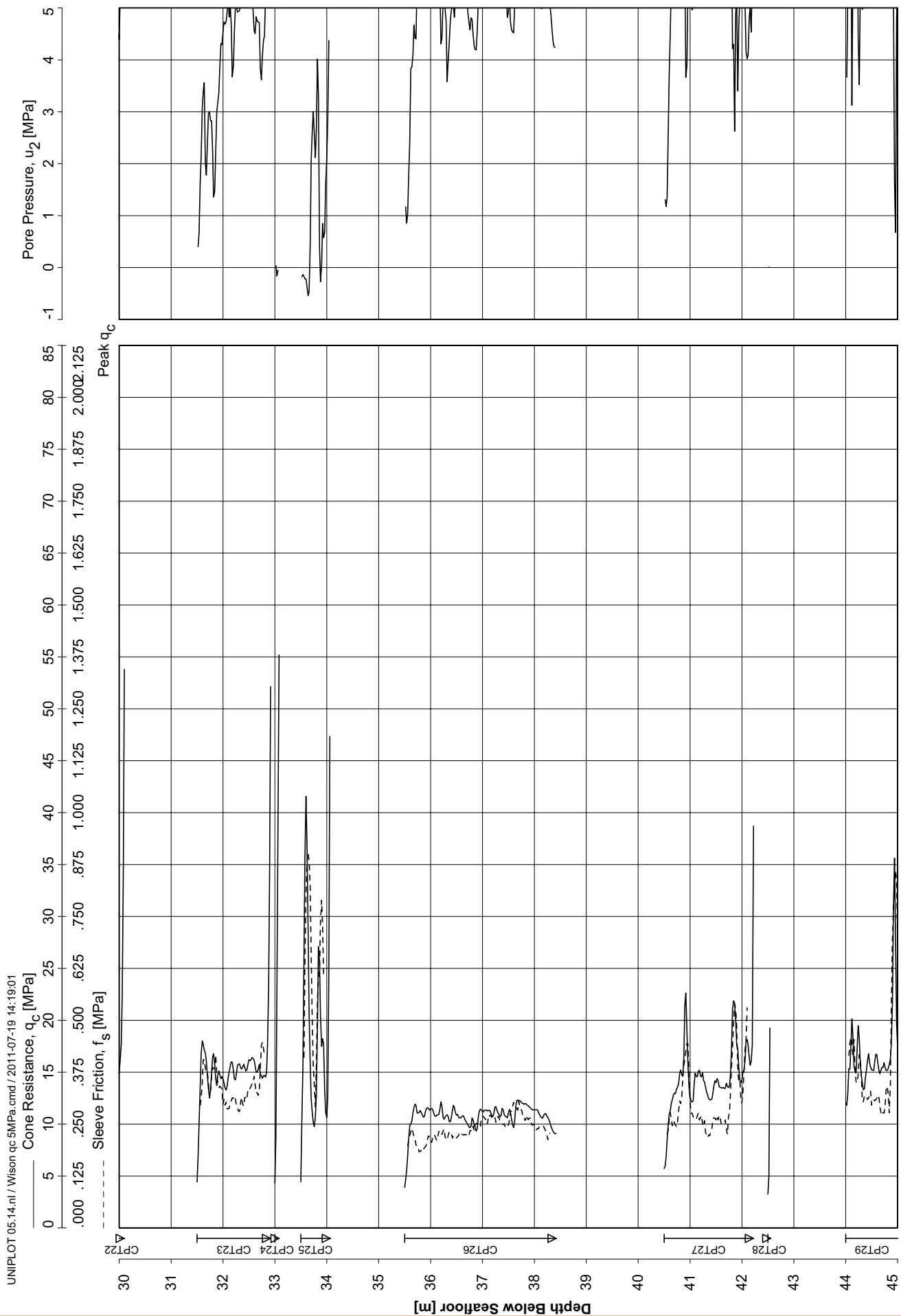




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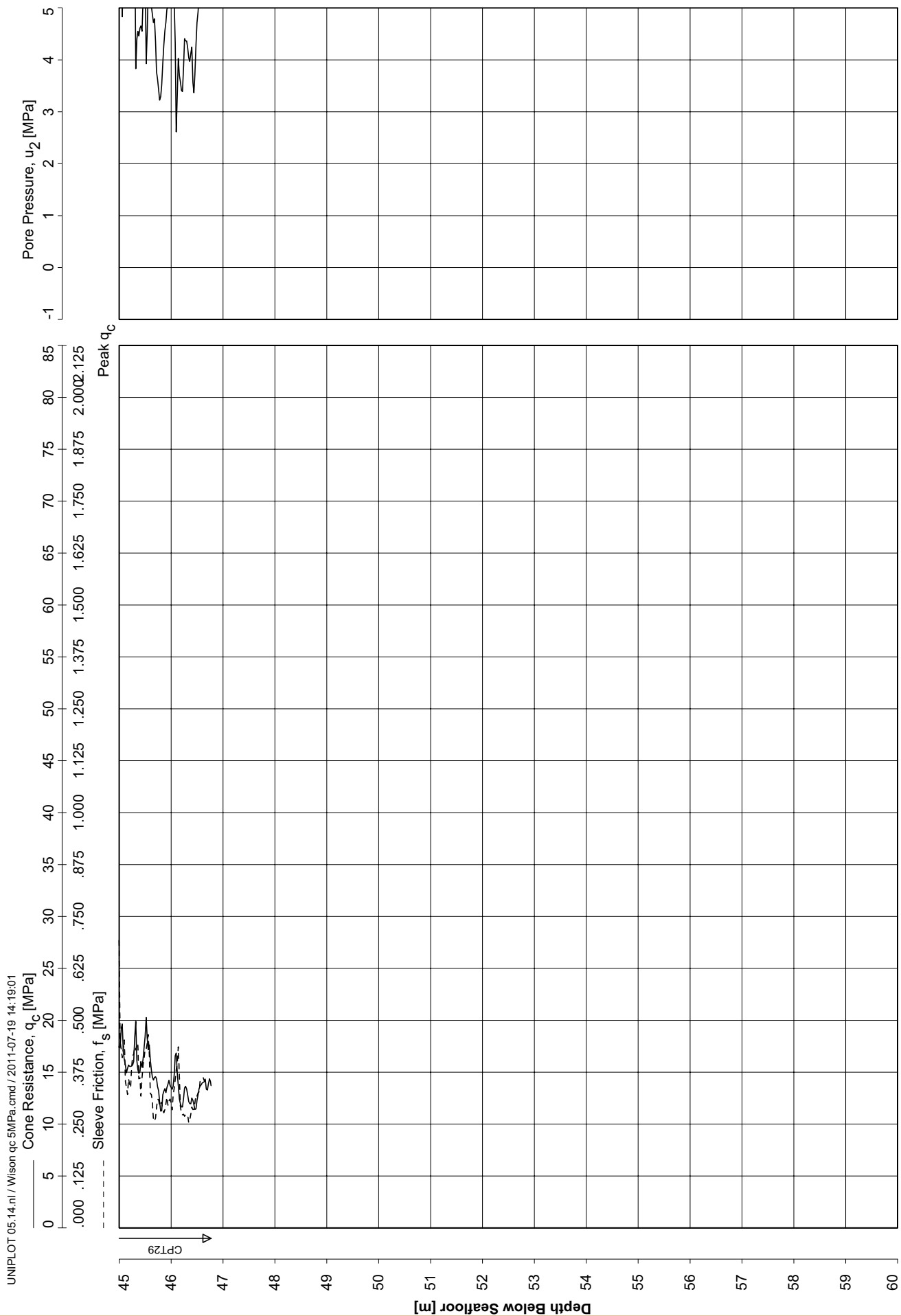
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Water Depth [m] : 24.8
Coordinates [m] : E695137 N5618678

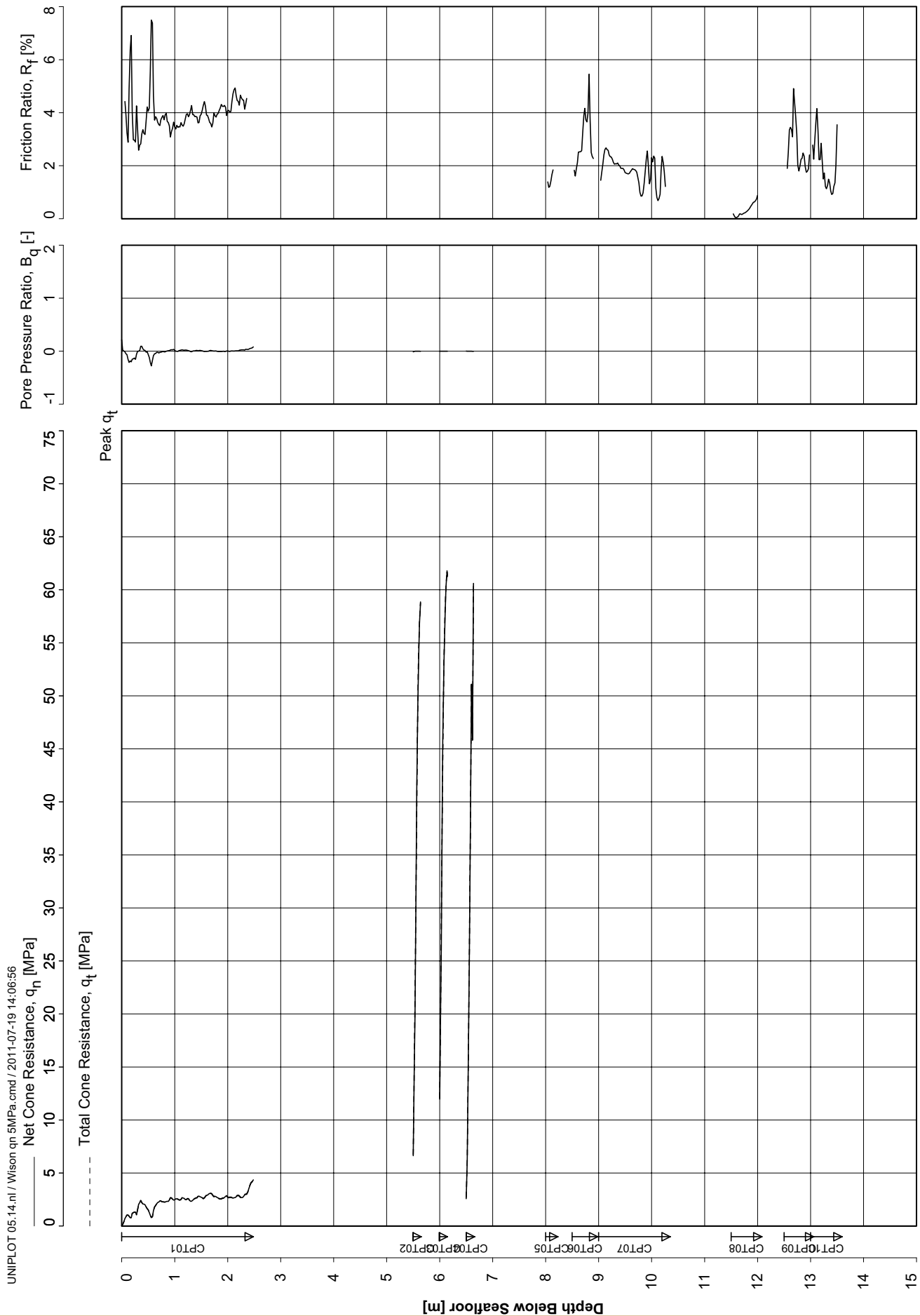




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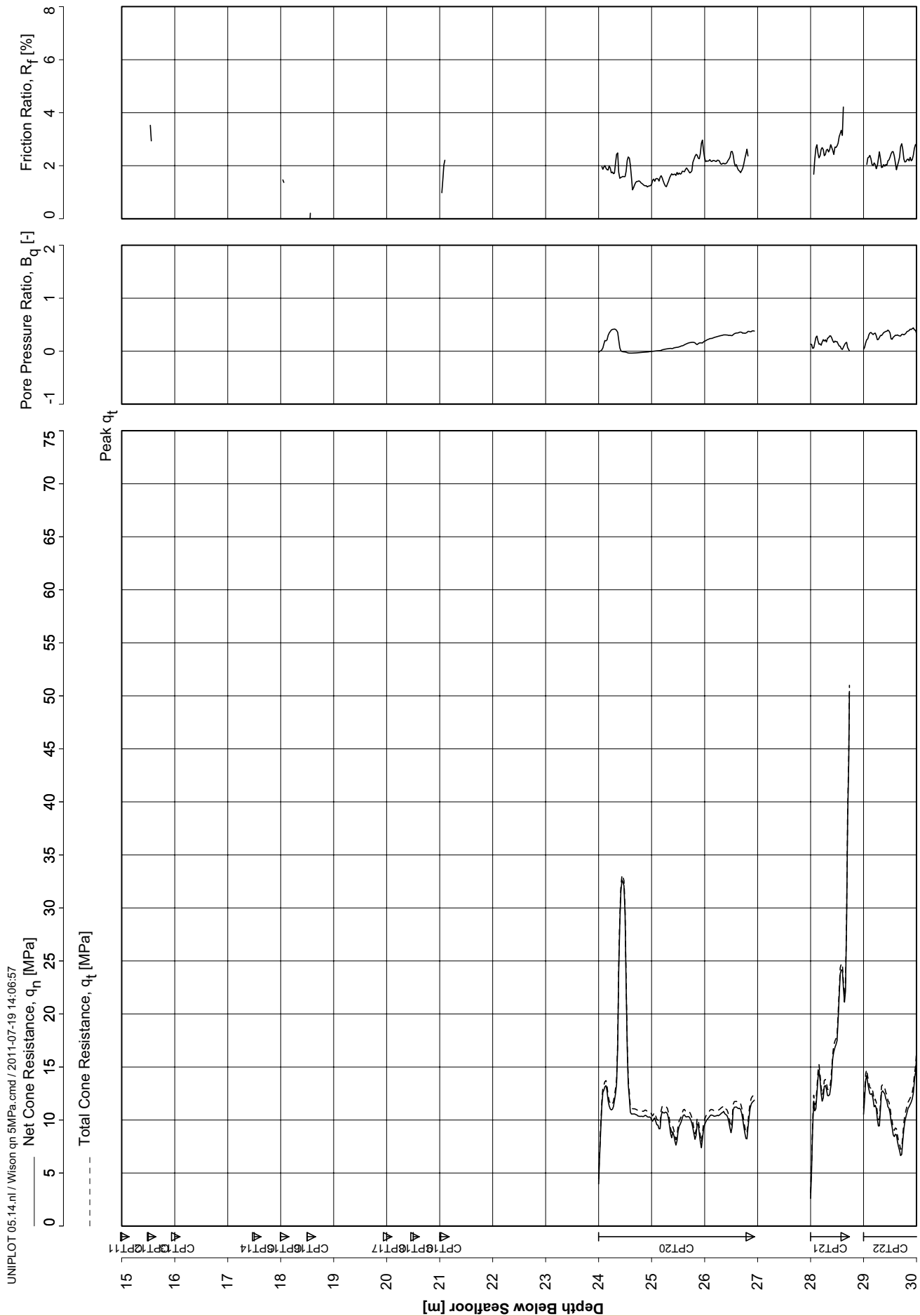
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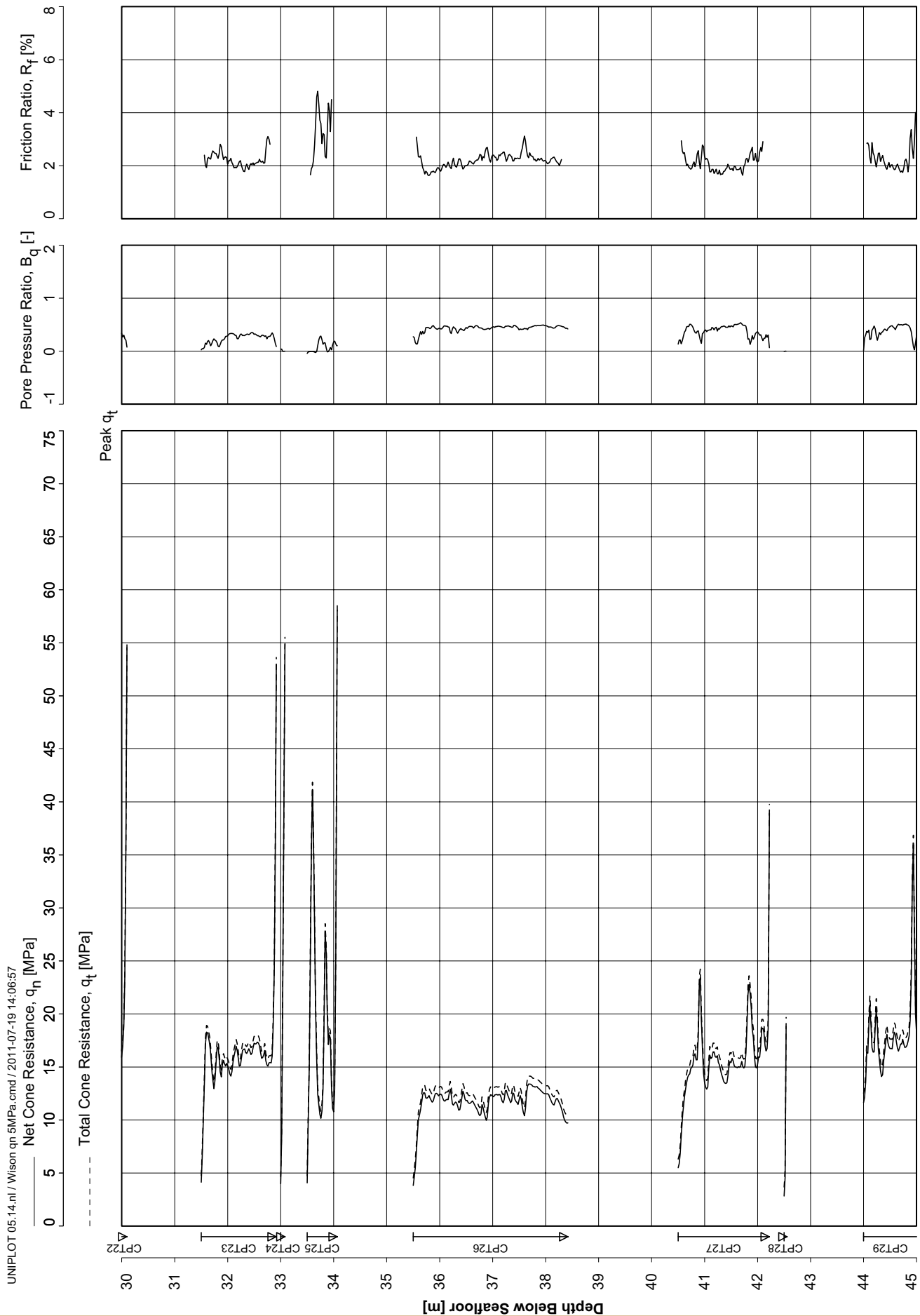
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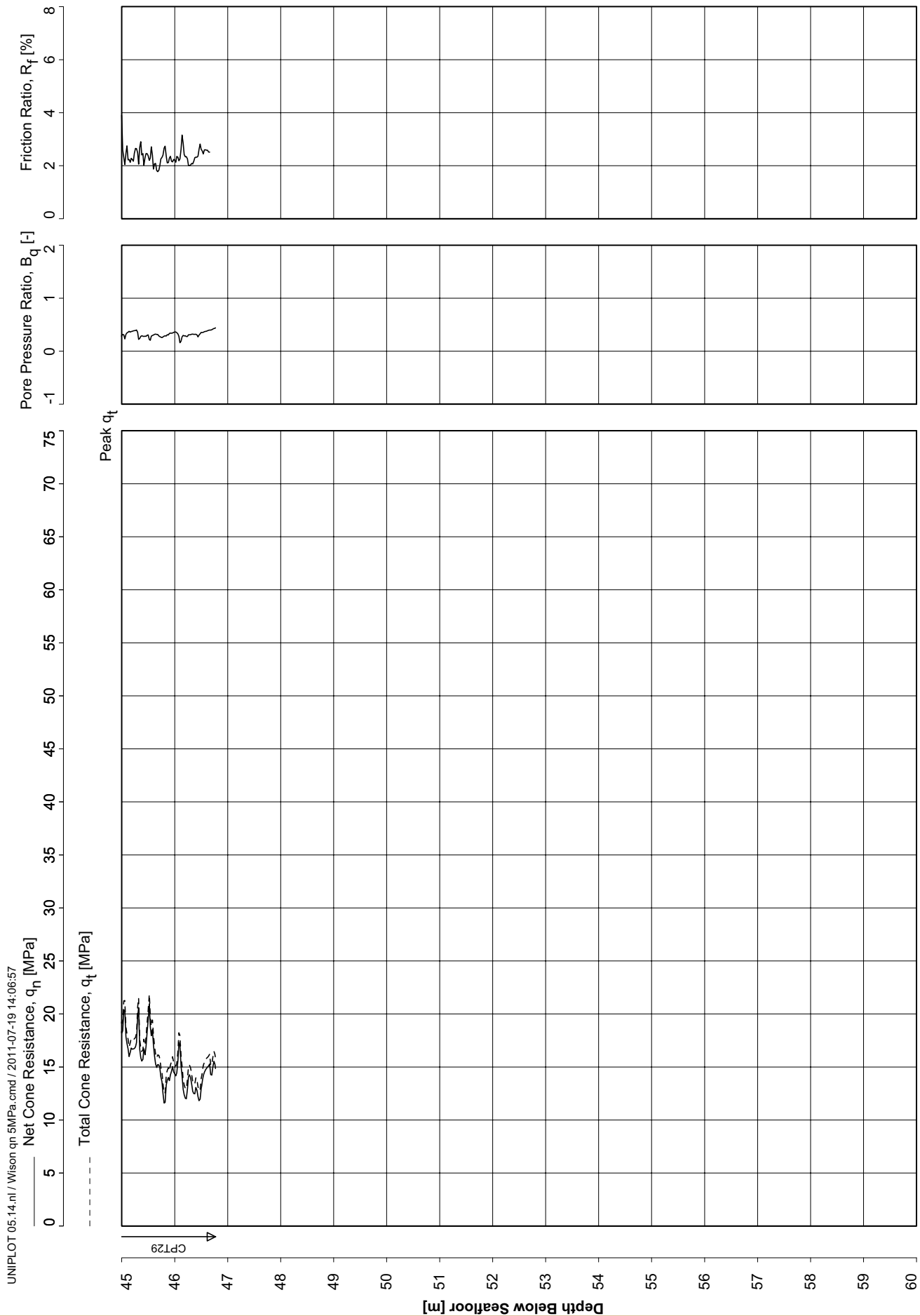
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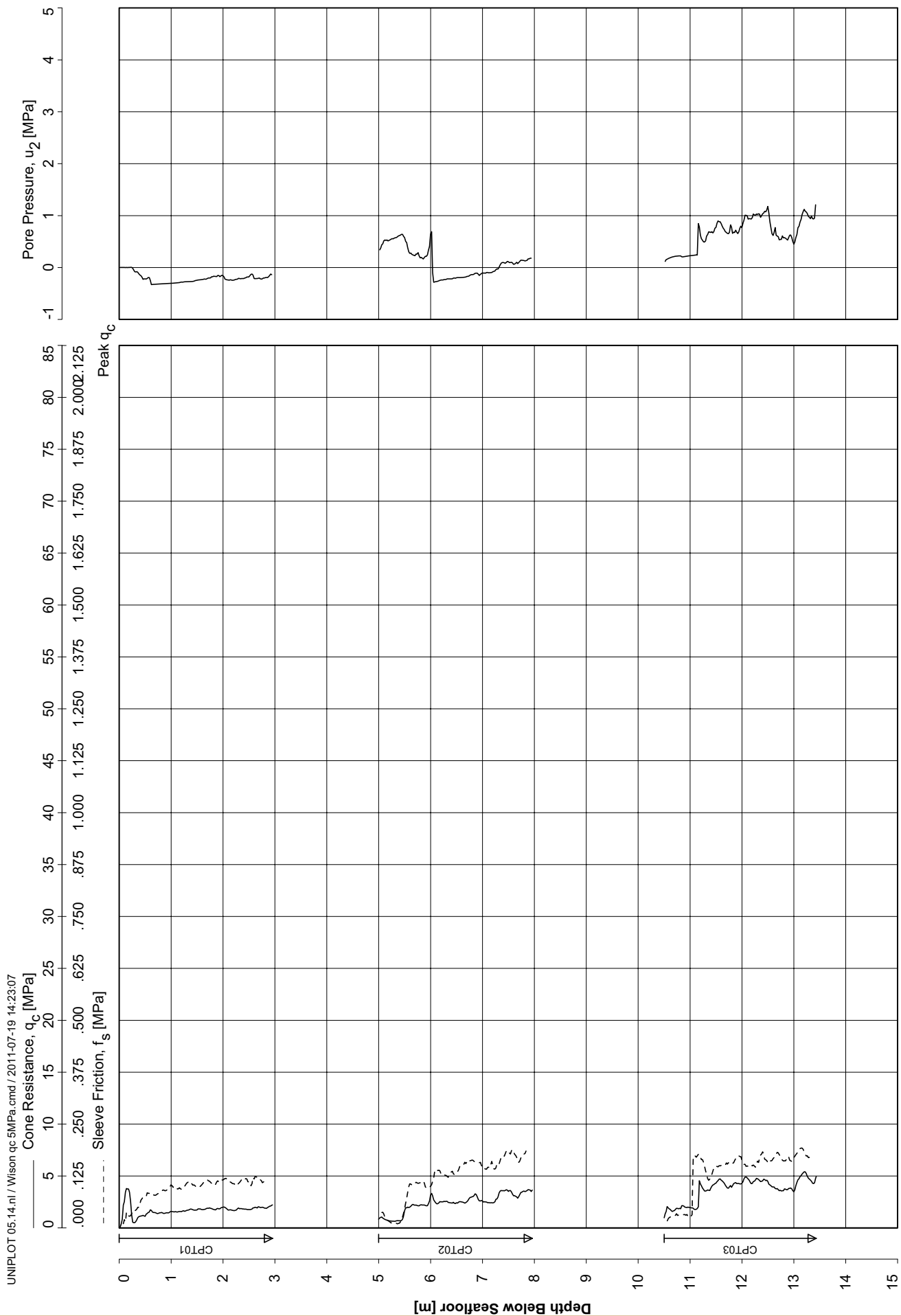
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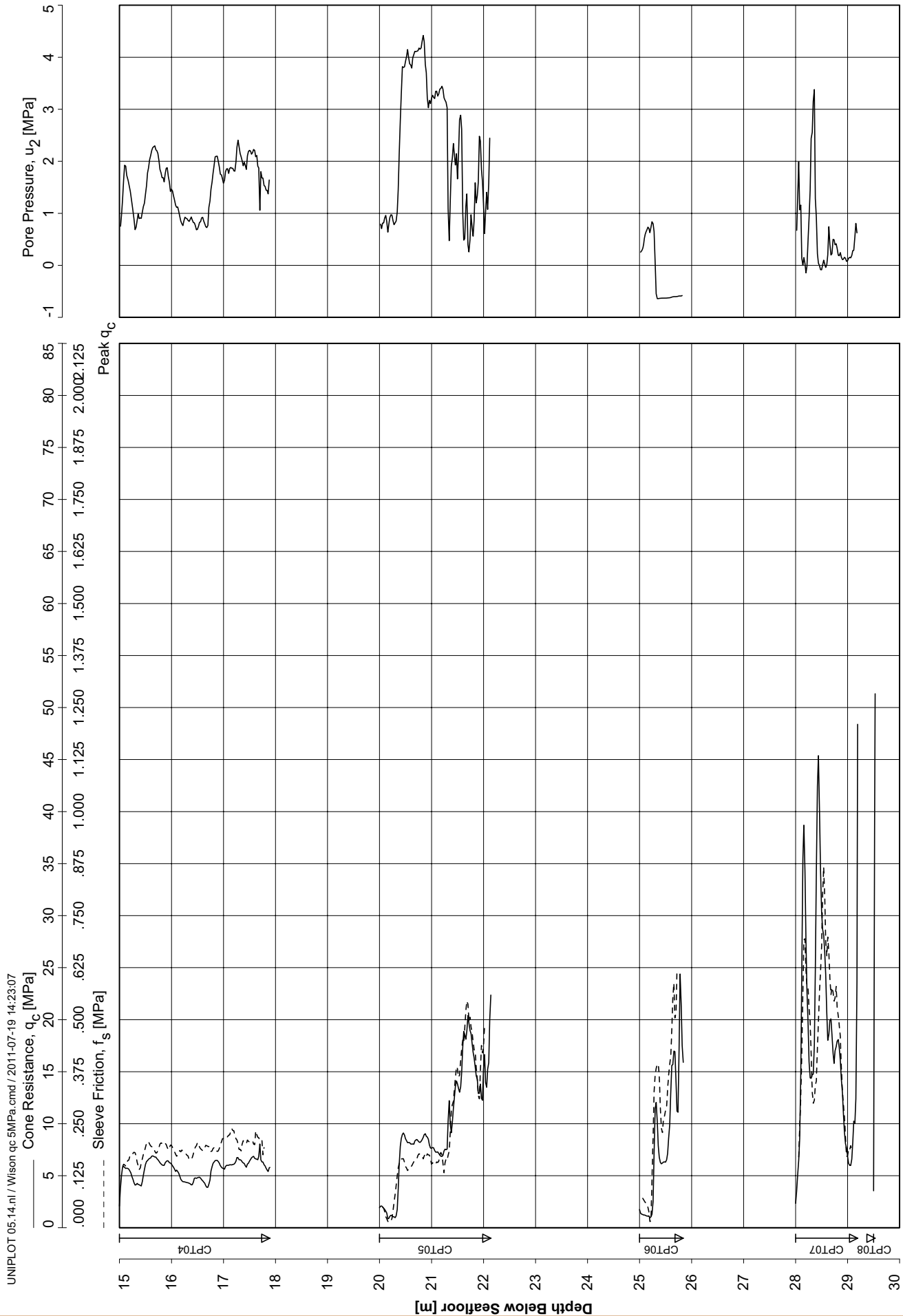
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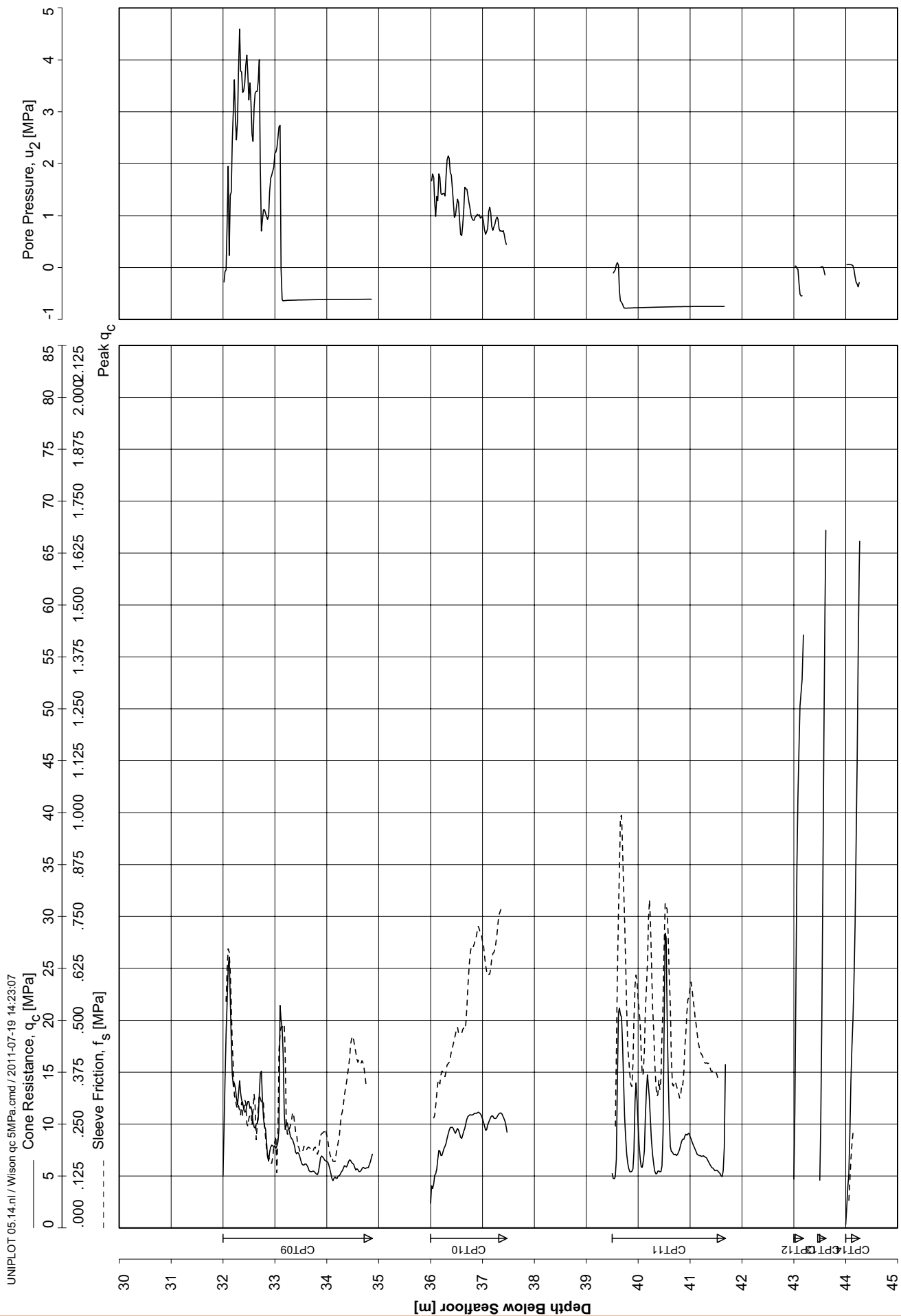
CONE PENETRATION TEST
BH_06
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 02-Apr-2011
Water Depth [m] : 25.3
Coordinates [m] : E703417 N5618398



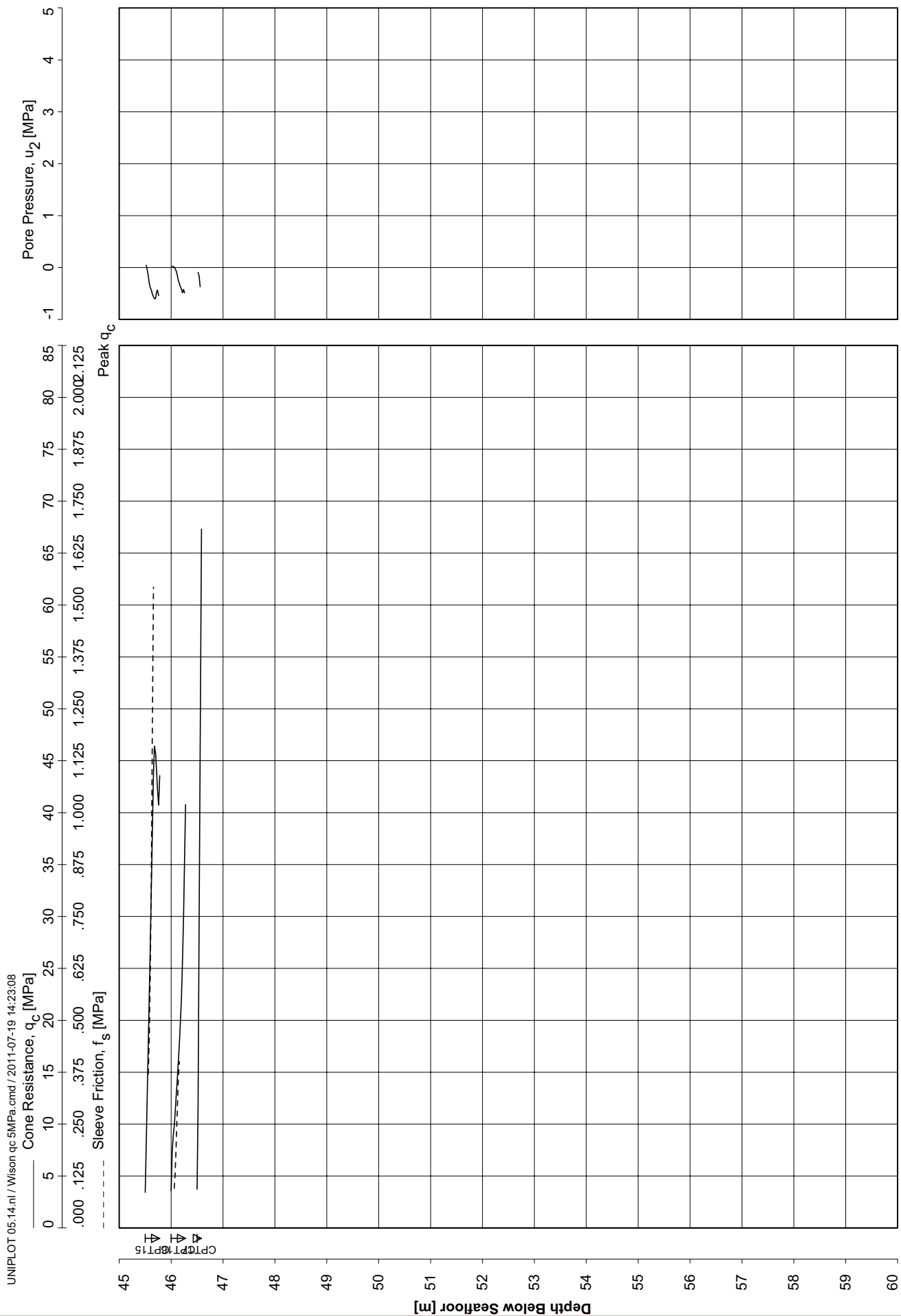
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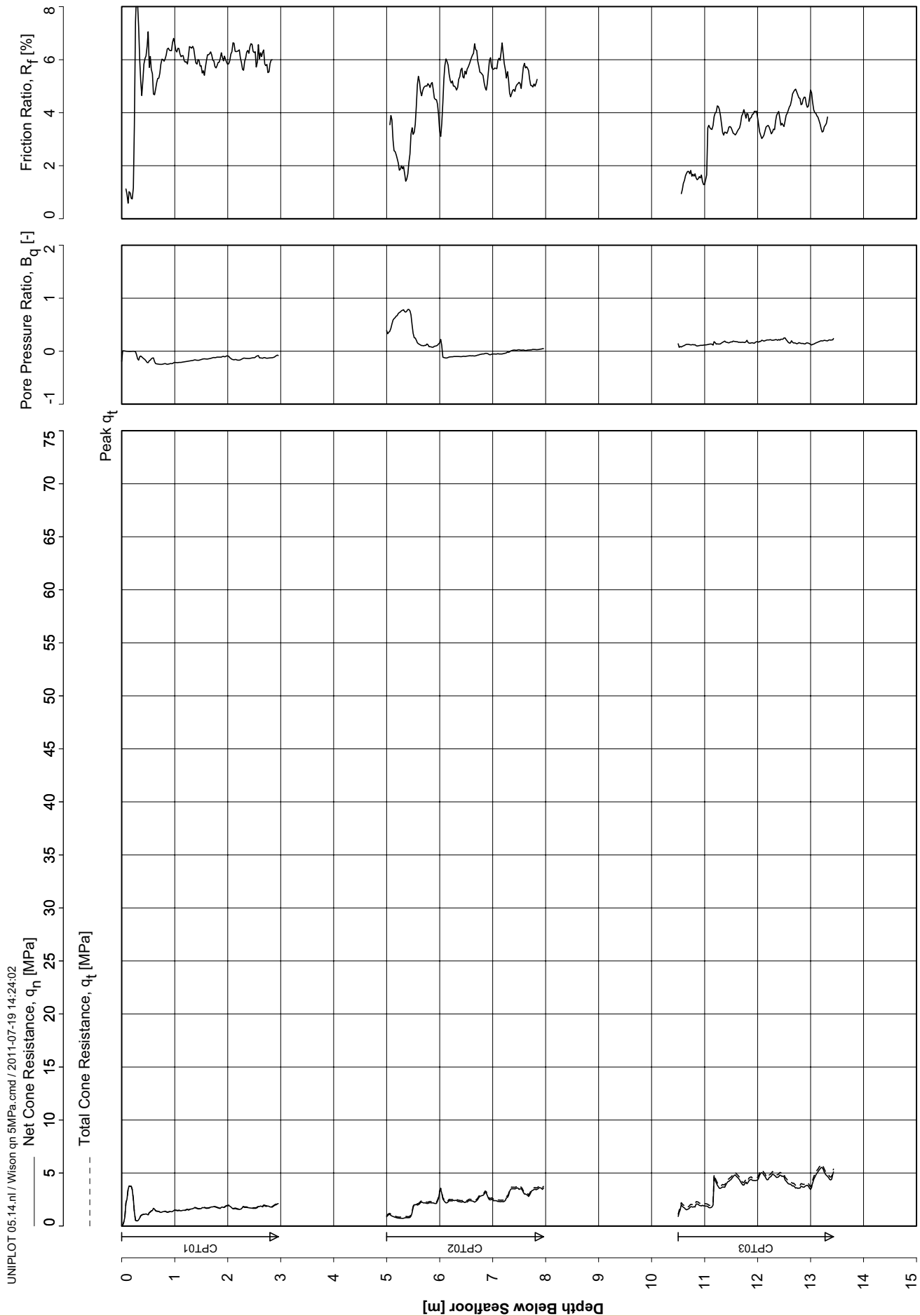
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RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

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Coordinates [m] : E703417 N5618398



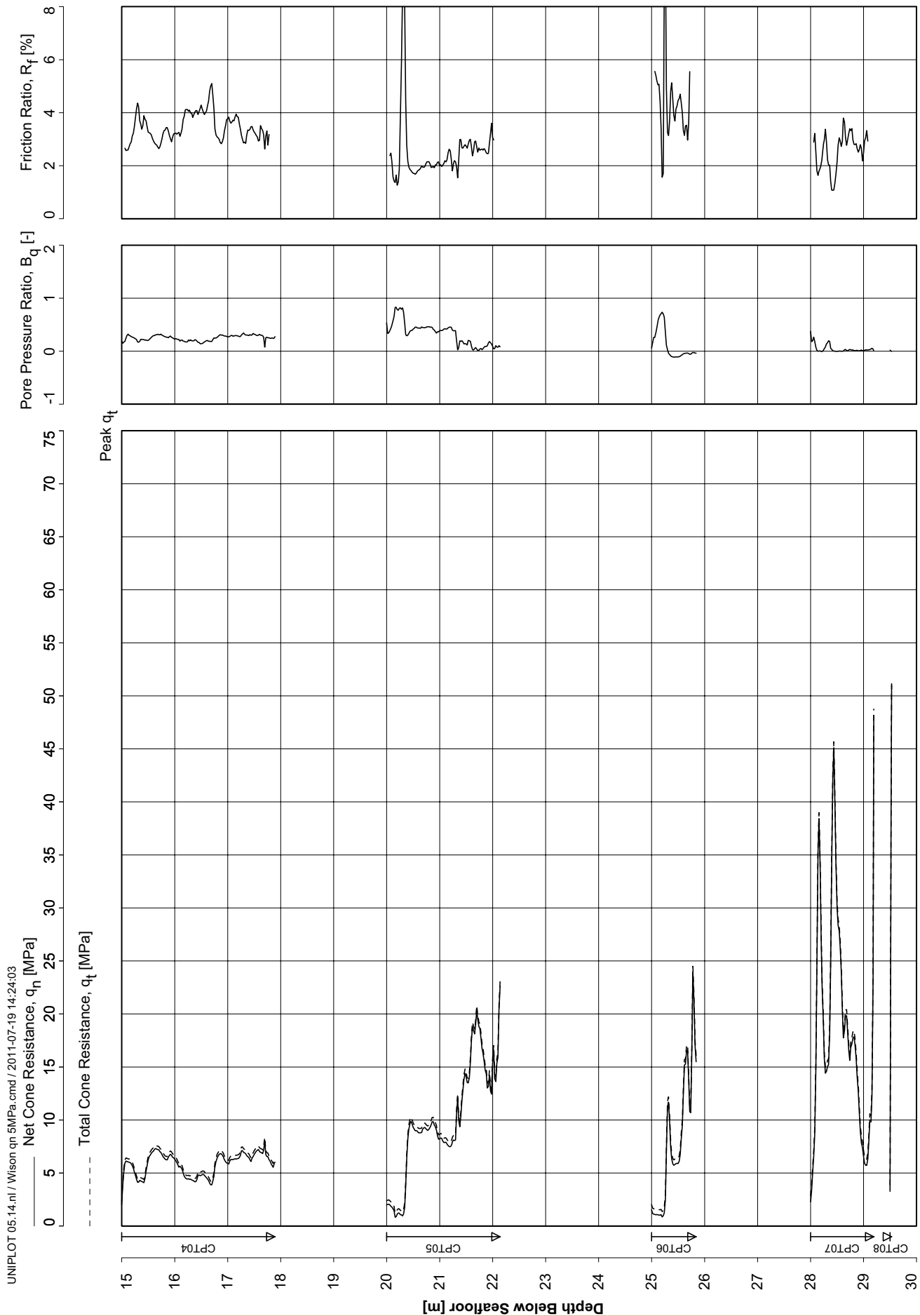
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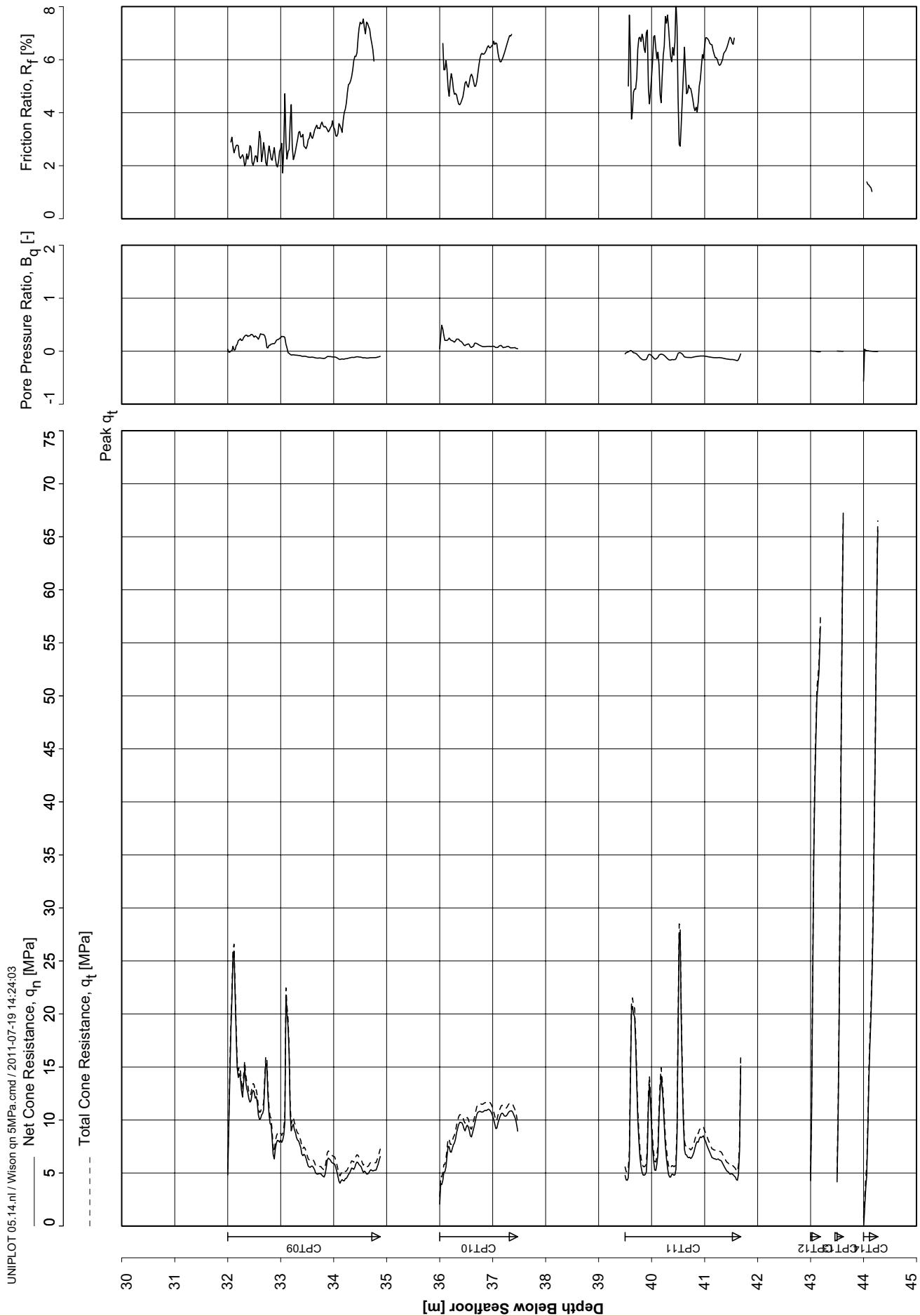
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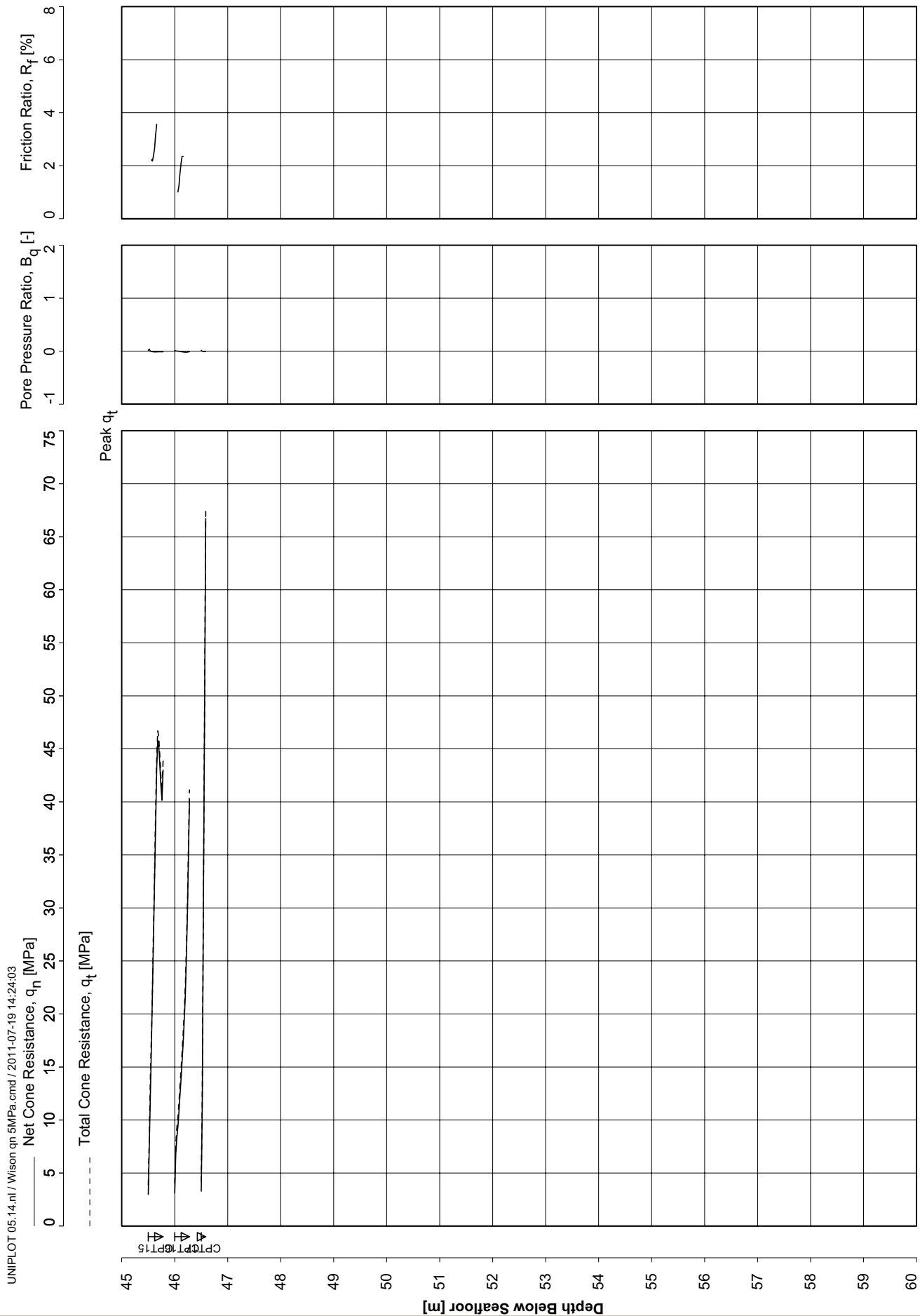
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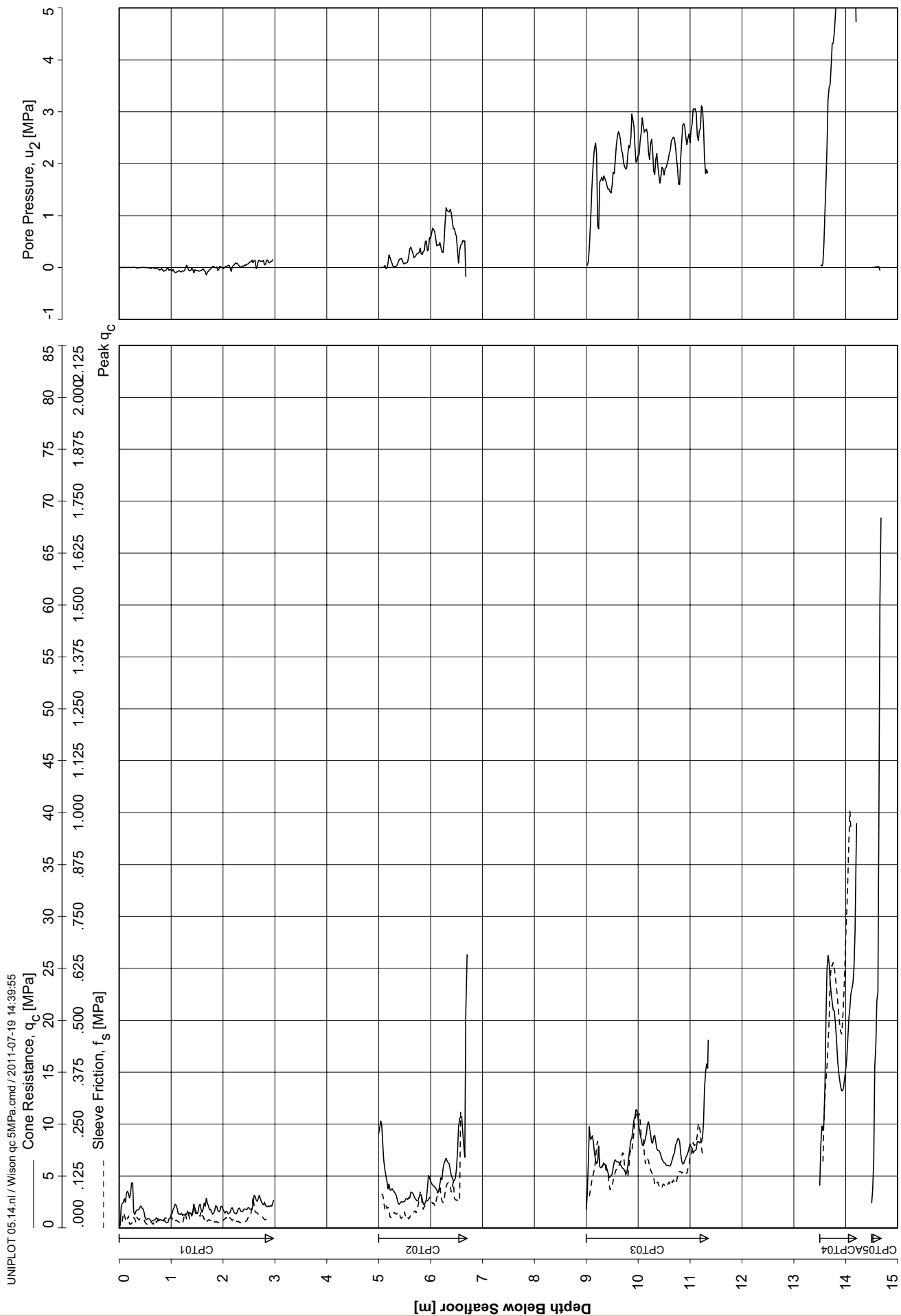
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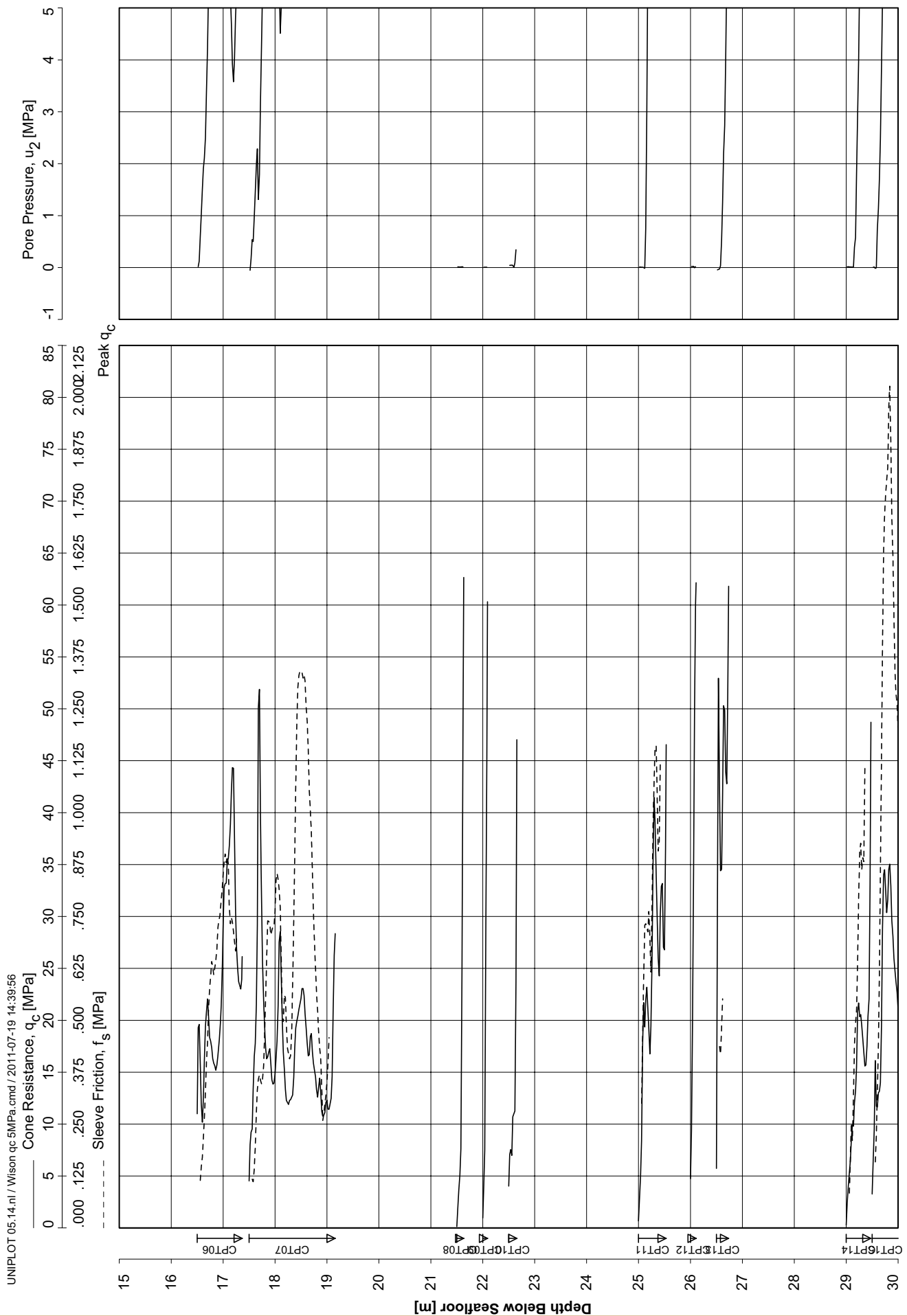
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Coordinates [m] : E703417 N5618398





CONE PENETRATION TEST
BH_07
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 03-Apr-2011
Water Depth [m] : 28.4
Coordinates [m] : E707817 N5617107



CONE PENETRATION TEST

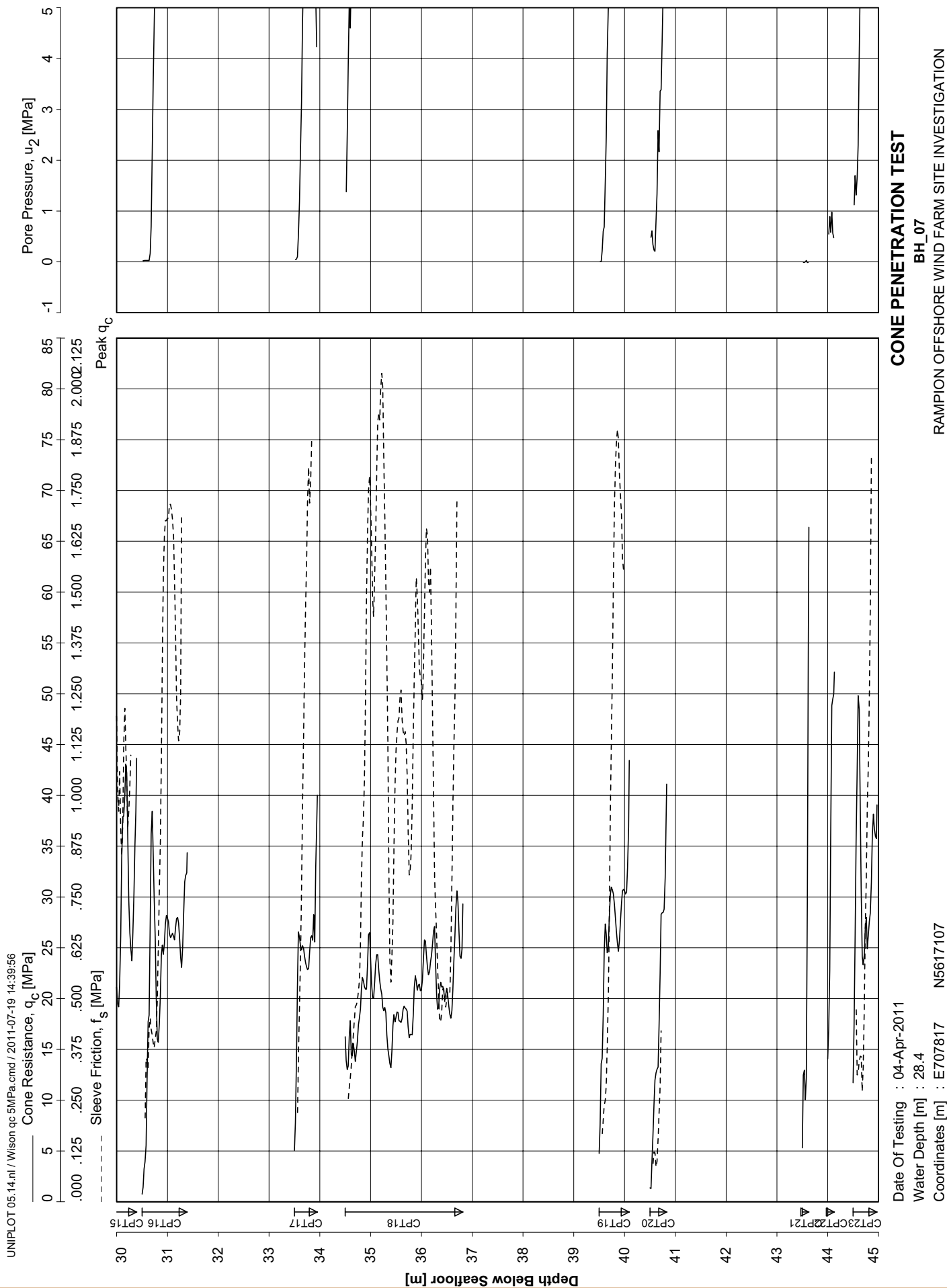
BH_07

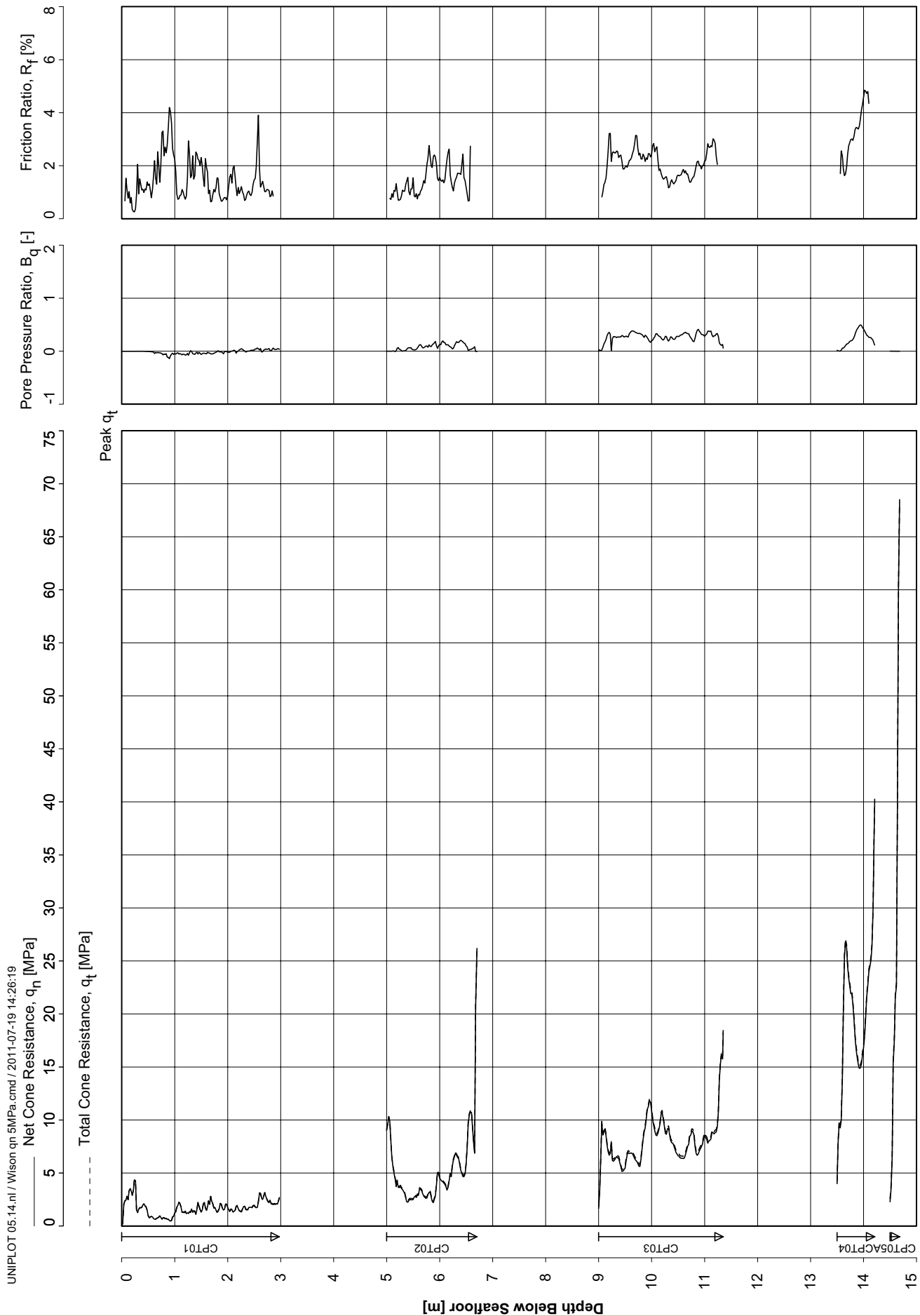
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 03-Apr-2011

Water Depth [m] : 28.4

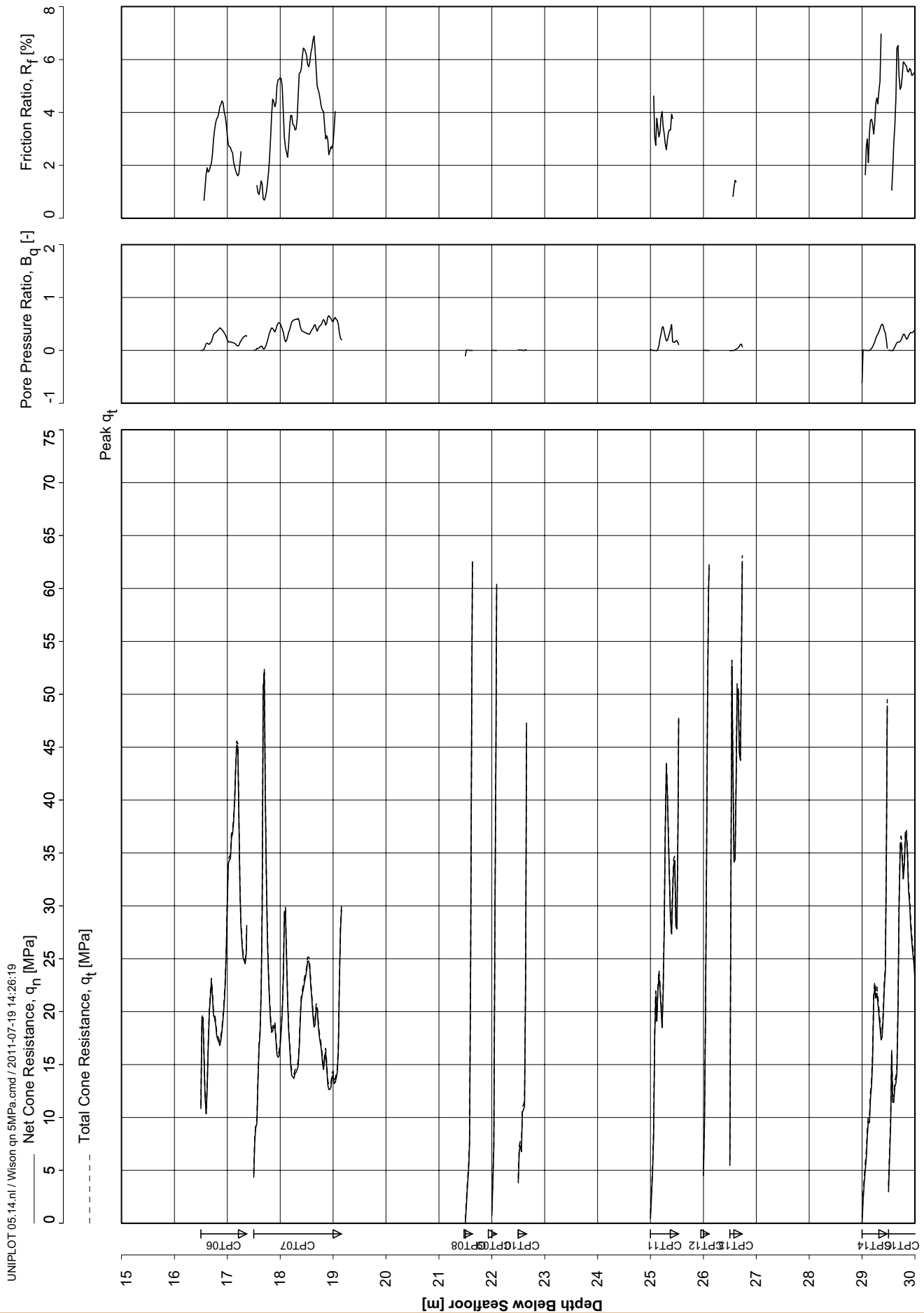
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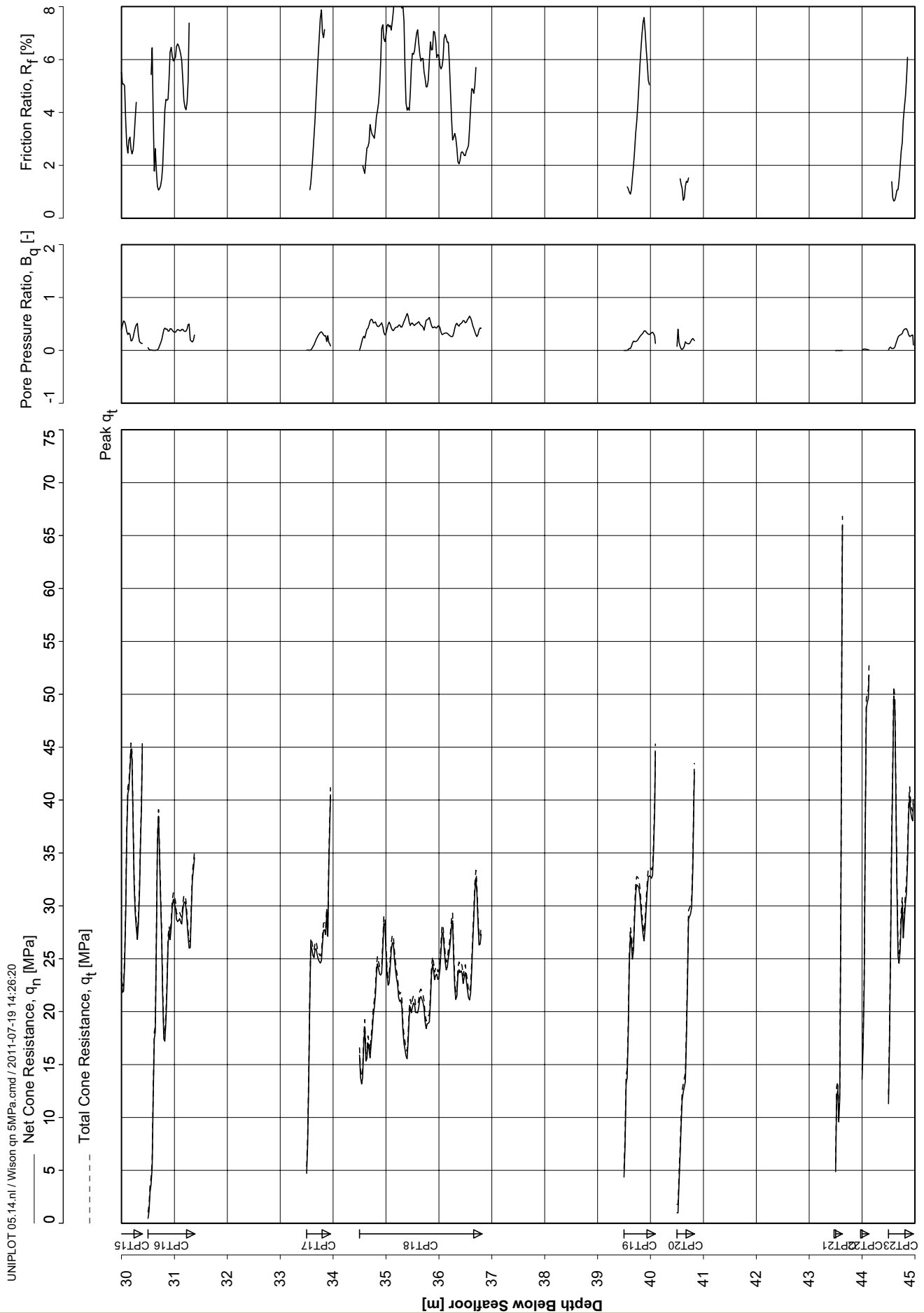
CONE PENETRATION TEST
BH_07
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 03-Apr-2011
Water Depth [m] : 28.4
Coordinates [m] : E707817 N5617107



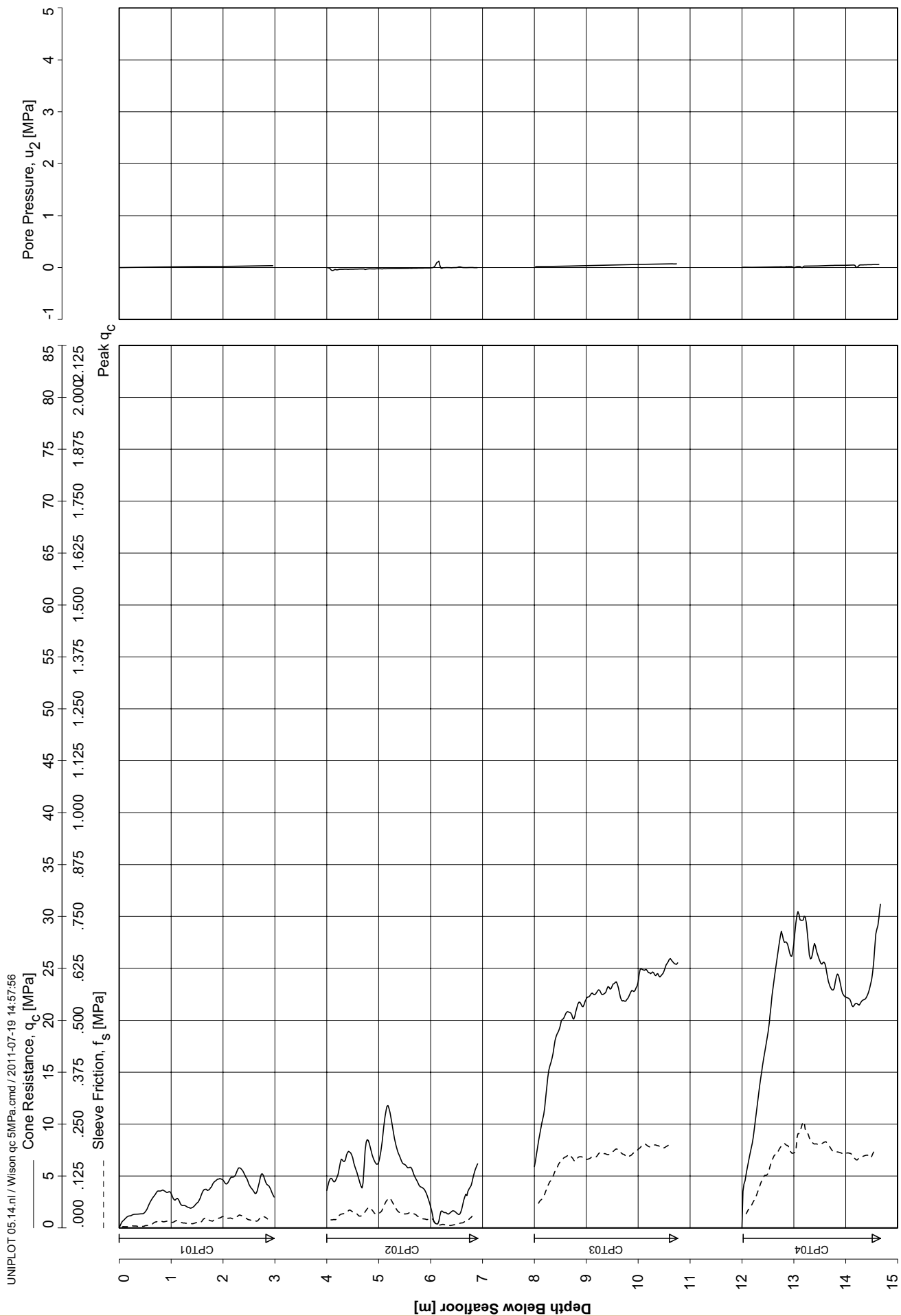
CONE PENETRATION TEST
BH_07
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 03-Apr-2011
Water Depth [m] : 28.4
Coordinates [m] : E707817 N5617107



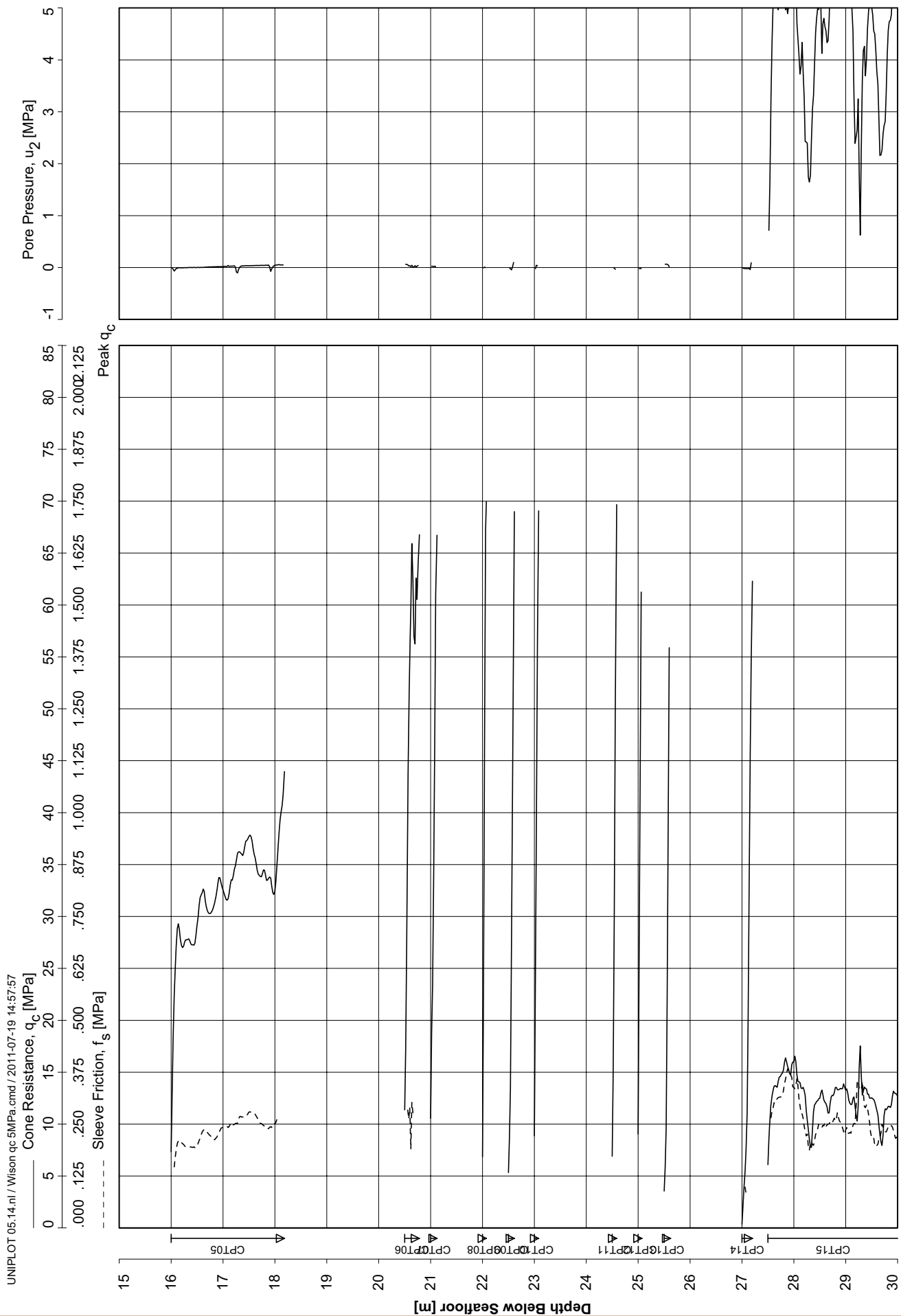
CONE PENETRATION TEST
BH_07
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 04-Apr-2011
Water Depth [m] : 28.4
Coordinates [m] : E707817 N5617107



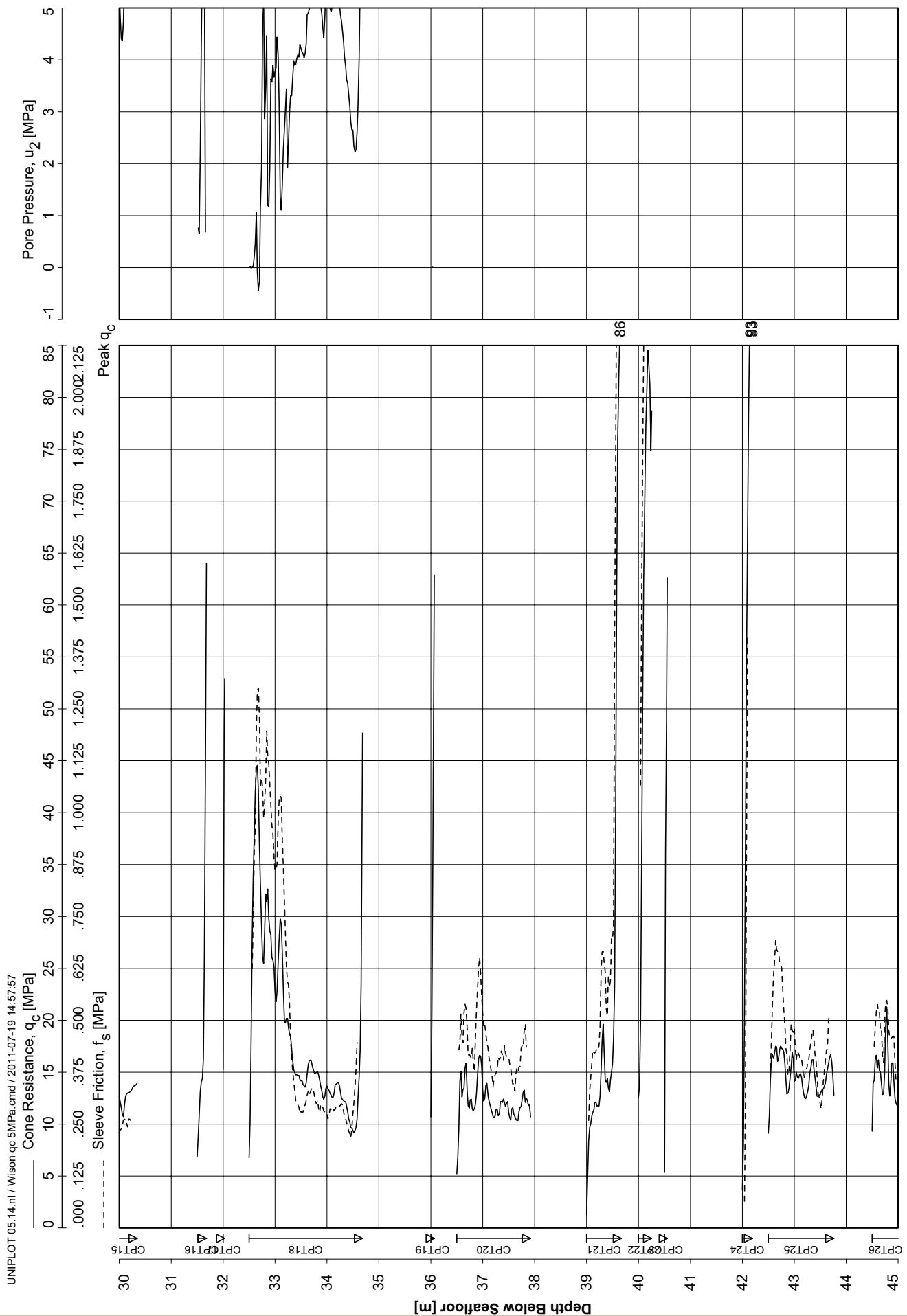
CONE PENETRATION TEST
BH_16
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 31-Mar-2011
Water Depth [m] : 44.9
Coordinates [m] : E696851 N5613444



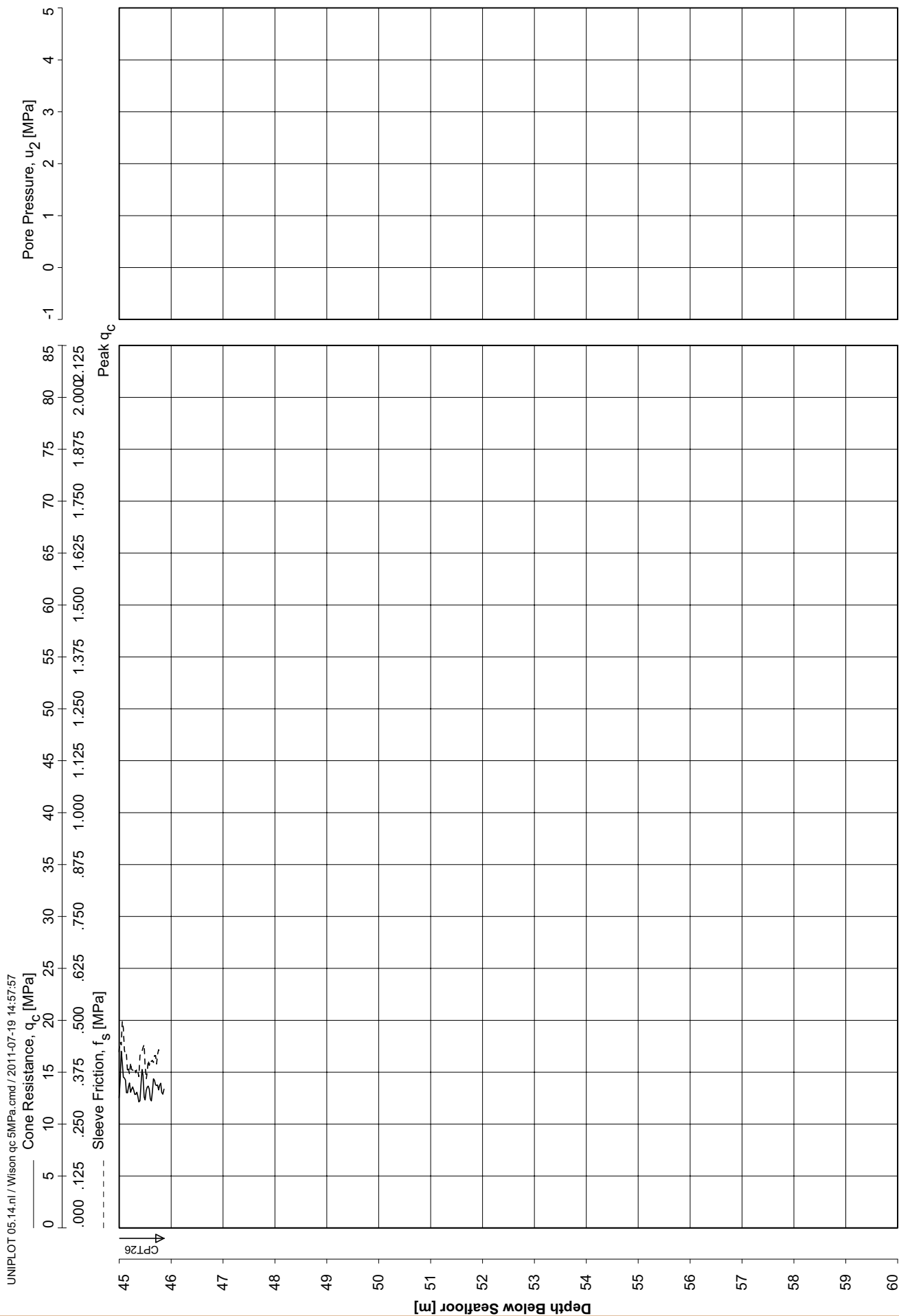
CONE PENETRATION TEST
BH_16
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 31-Mar-2011
Water Depth [m] : 44.9
Coordinates [m] : E696851 N5613444



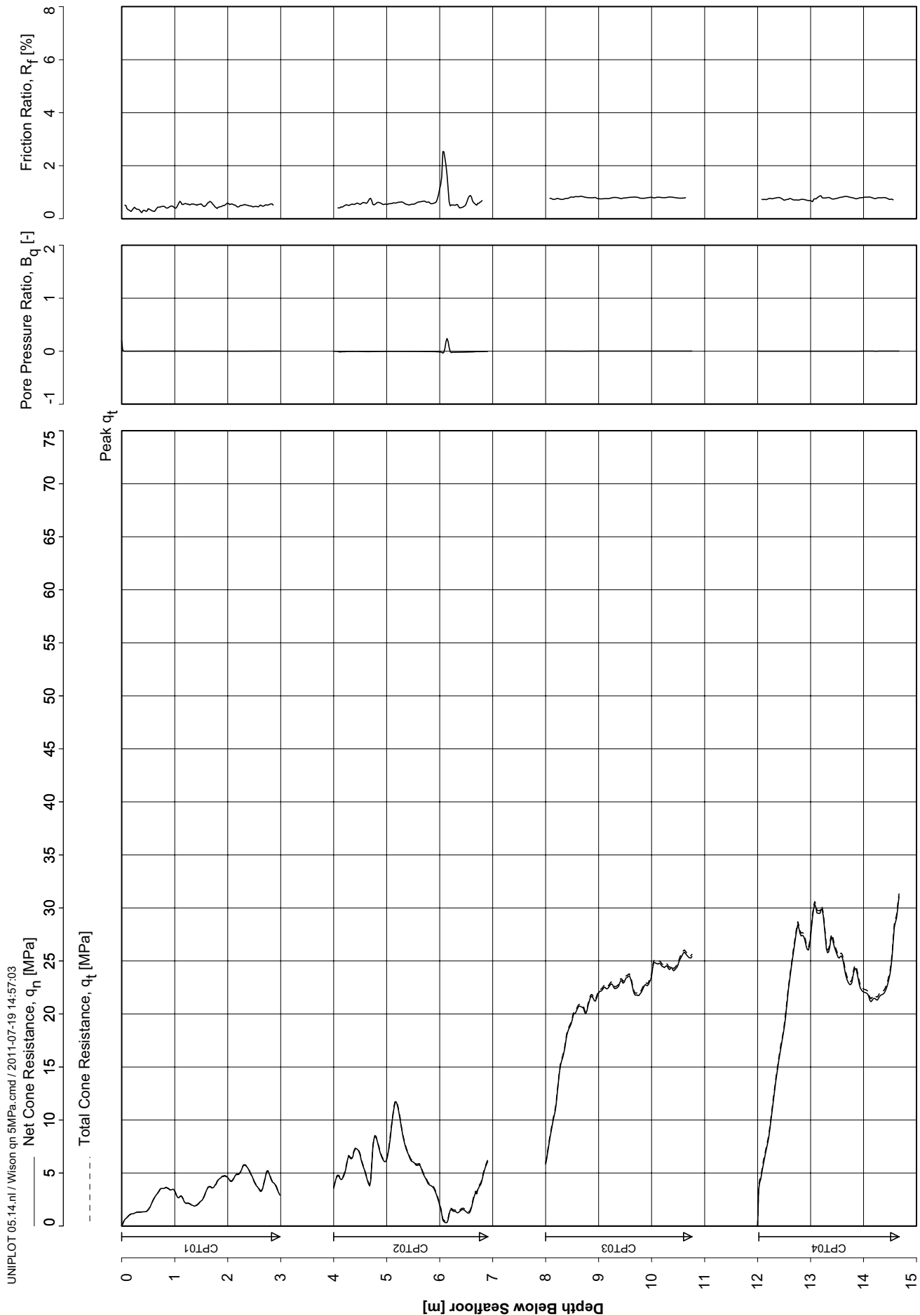
CONE PENETRATION TEST
BH_16
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 01-Apr-2011
Water Depth [m] : 44.9
Coordinates [m] : E696851 N5613444



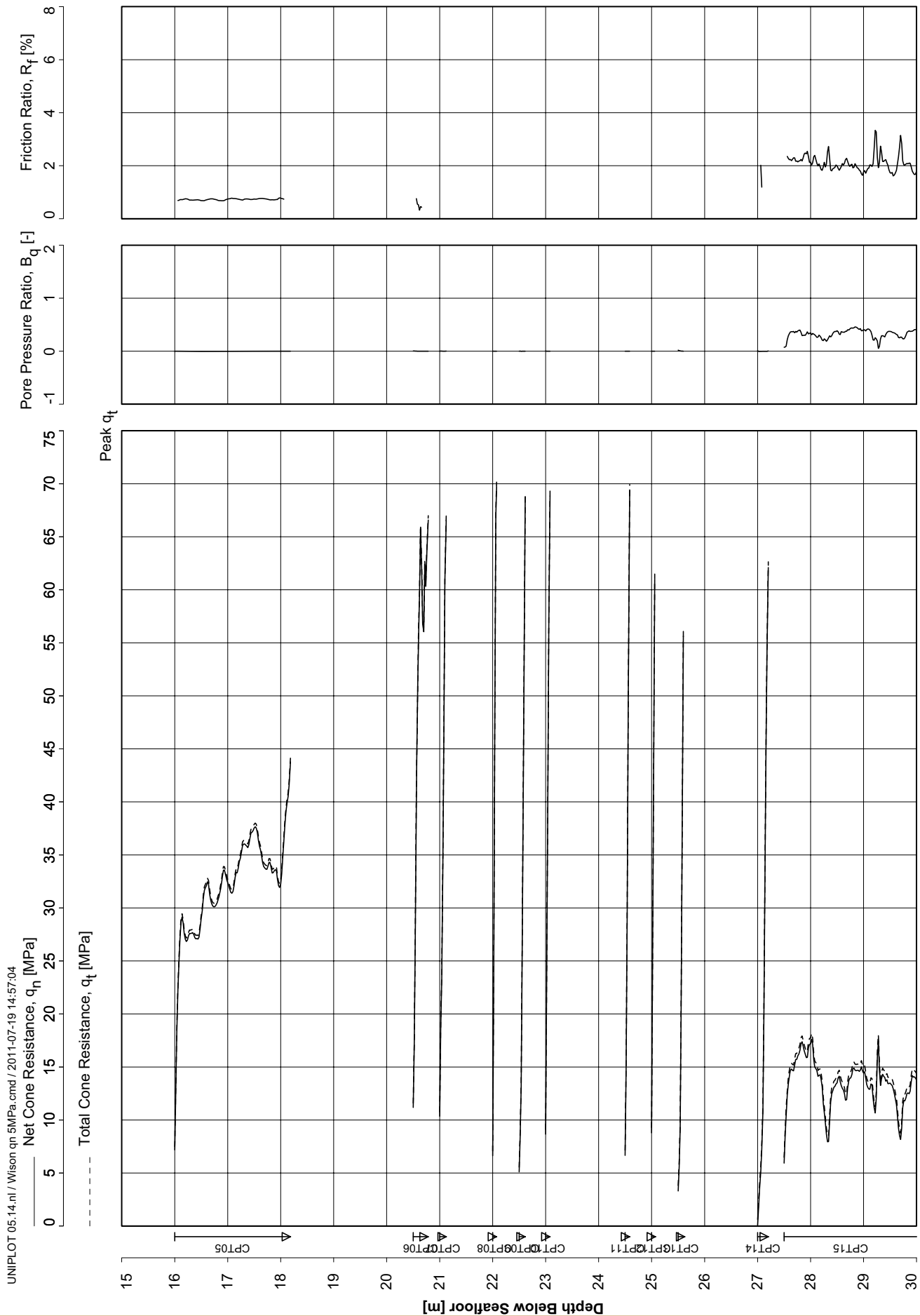
CONE PENETRATION TEST
BH_16
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 01-Apr-2011
Water Depth [m] : 44.9
Coordinates [m] : E696851 N5613444



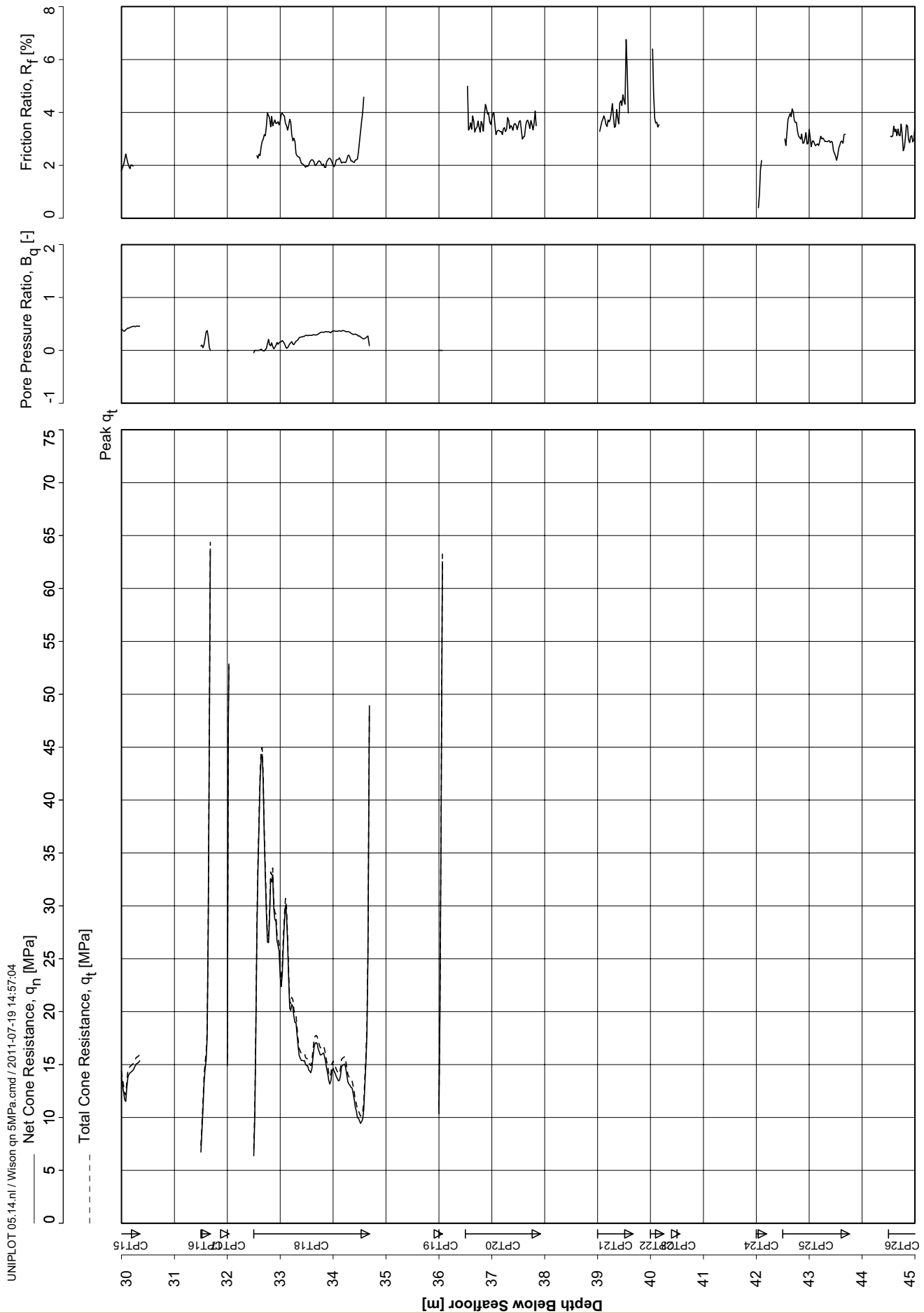
CONE PENETRATION TEST
BH_16
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 31-Mar-2011
Water Depth [m] : 44.9
Coordinates [m] : E696851 N5613444



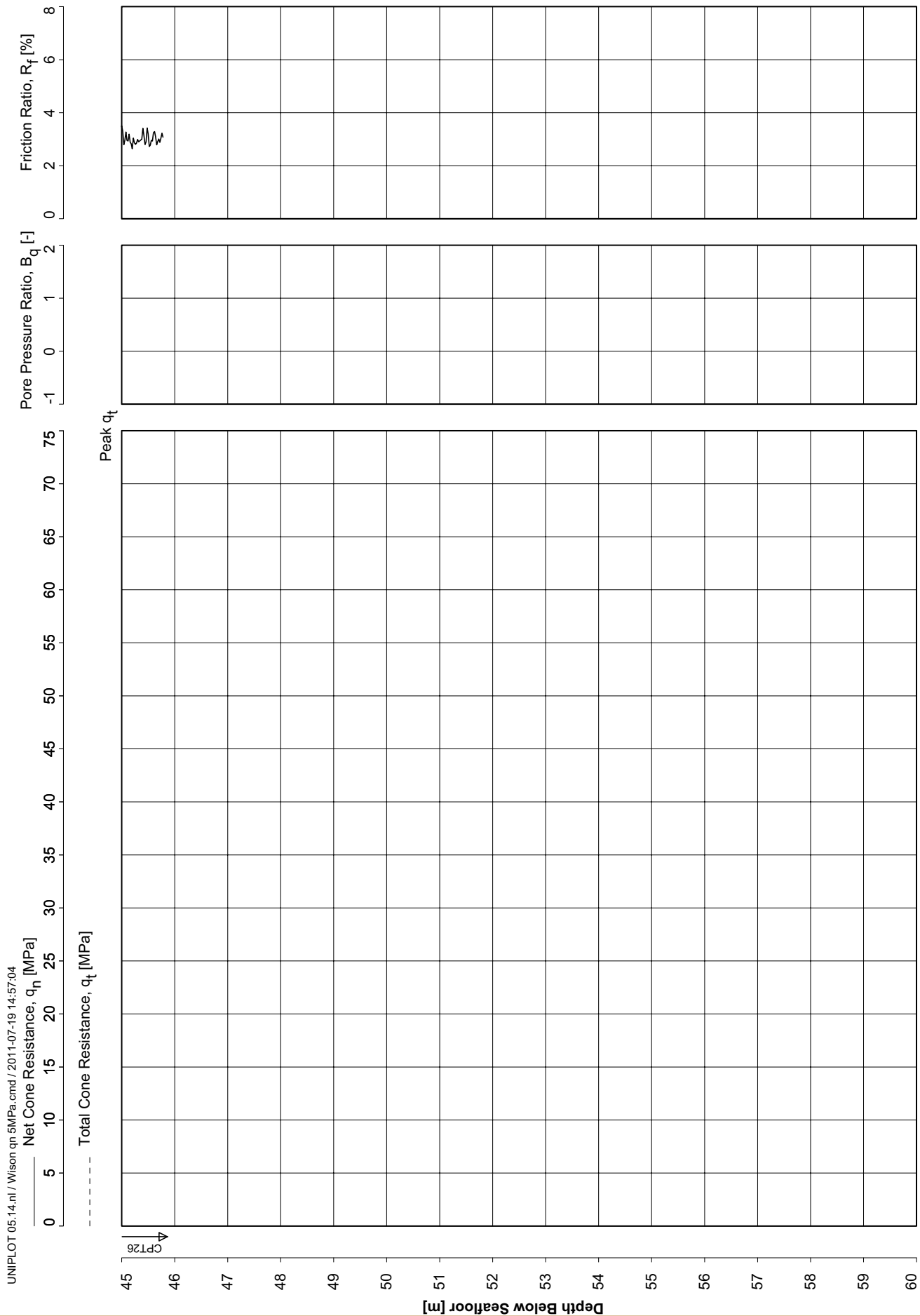
CONE PENETRATION TEST
BH_16
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

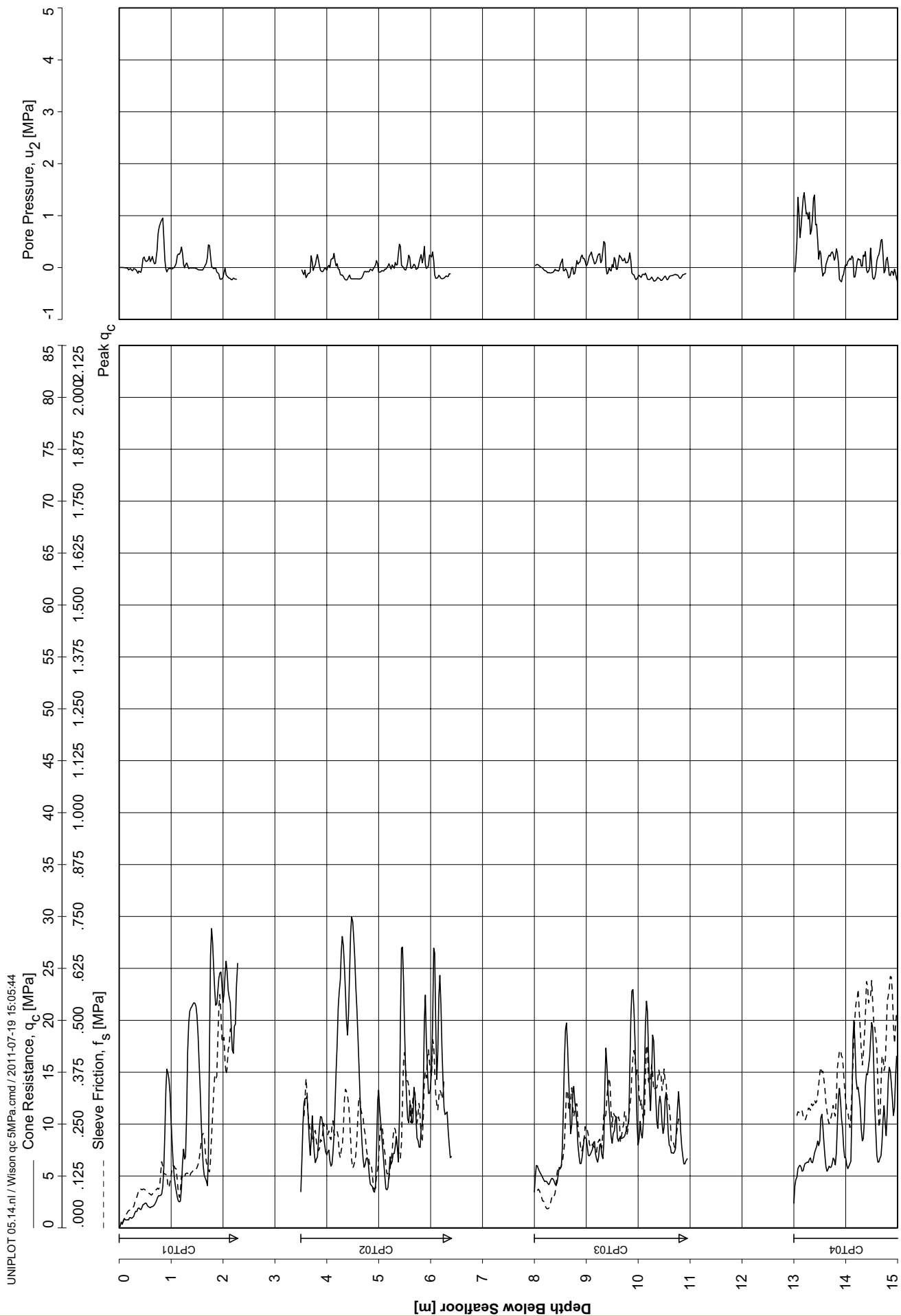
Date Of Testing : 31-Mar-2011
Water Depth [m] : 44.9
Coordinates [m] : E696851 N5613444



CONE PENETRATION TEST
BH_16
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

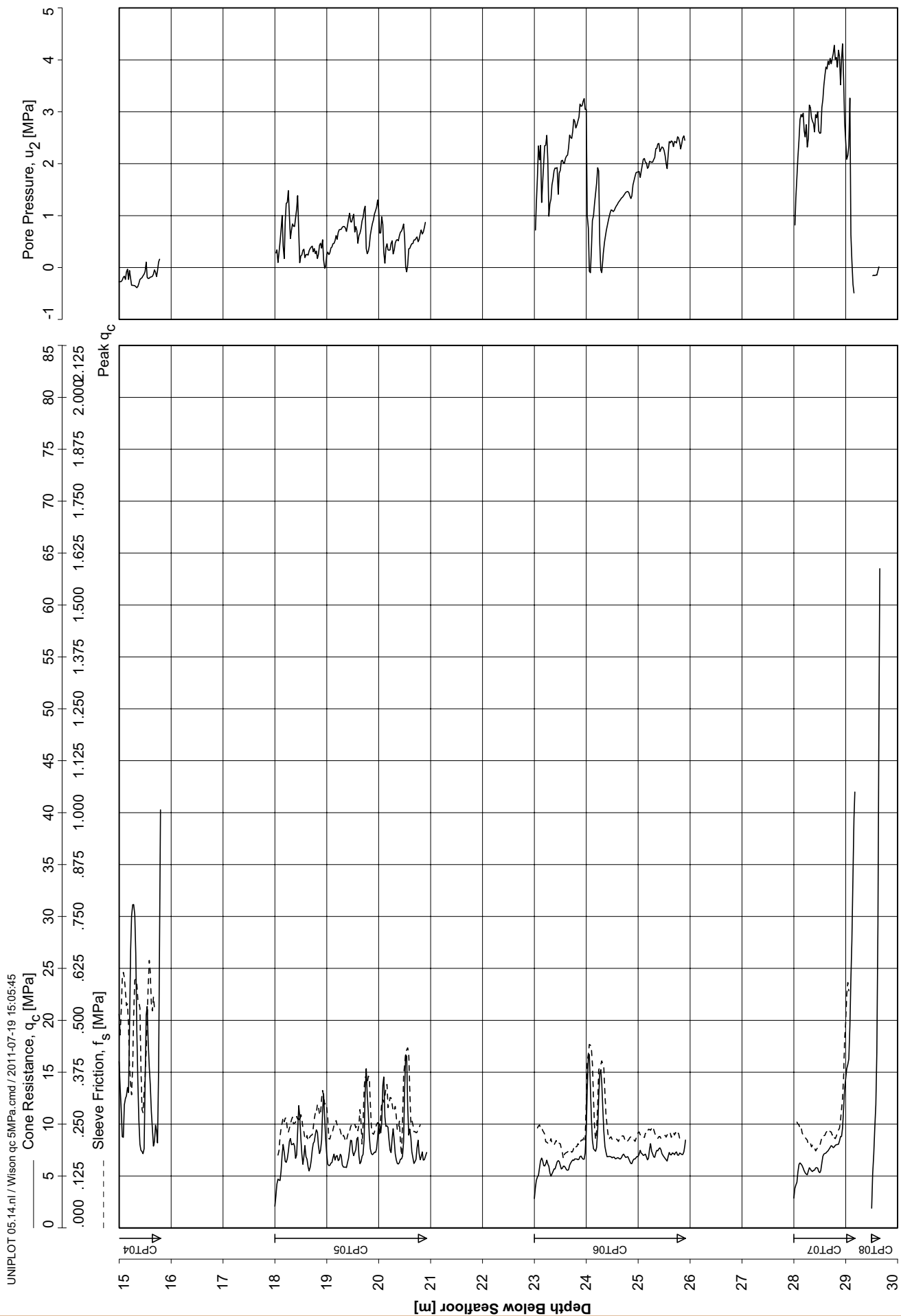
Date Of Testing : 01-Apr-2011
Water Depth [m] : 44.9
Coordinates [m] : E696851 N5613444





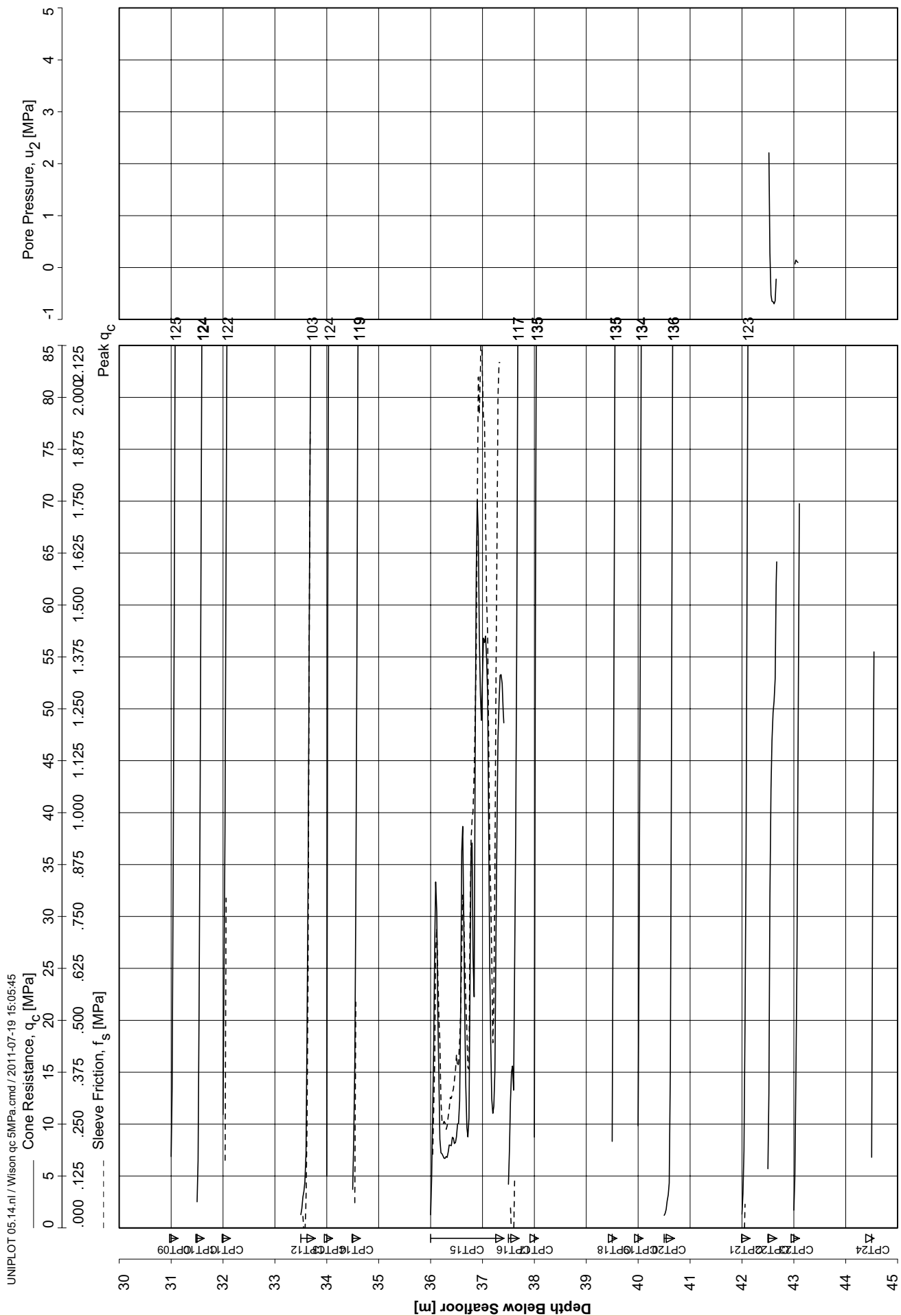
CONE PENETRATION TEST
BH_17
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 30-Mar-2011
Water Depth [m] : 27.0
Coordinates [m] : E690153 N5615571



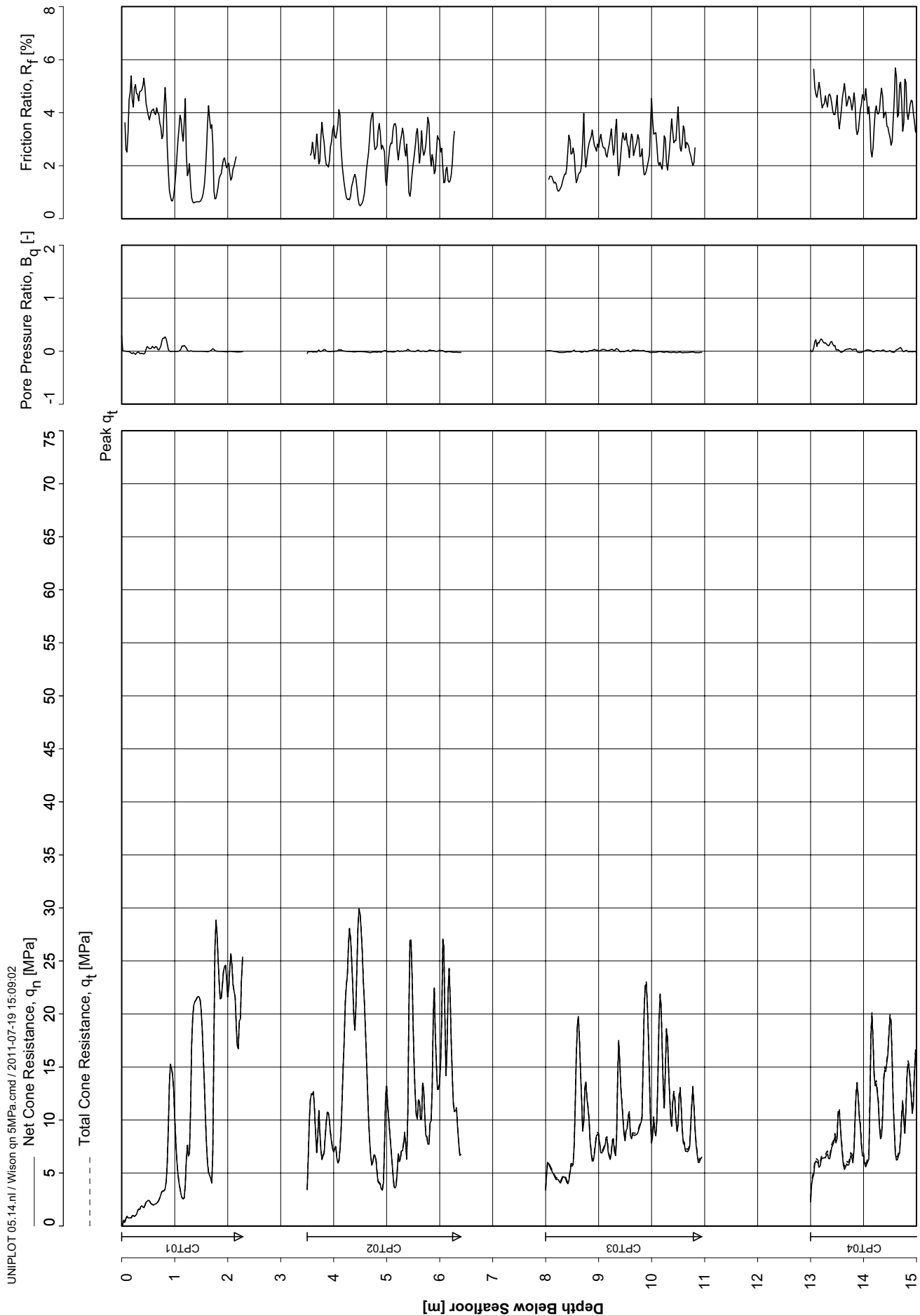
CONE PENETRATION TEST
BH_17
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 30-Mar-2011
Water Depth [m] : 27.0
Coordinates [m] : E690153 N5615571



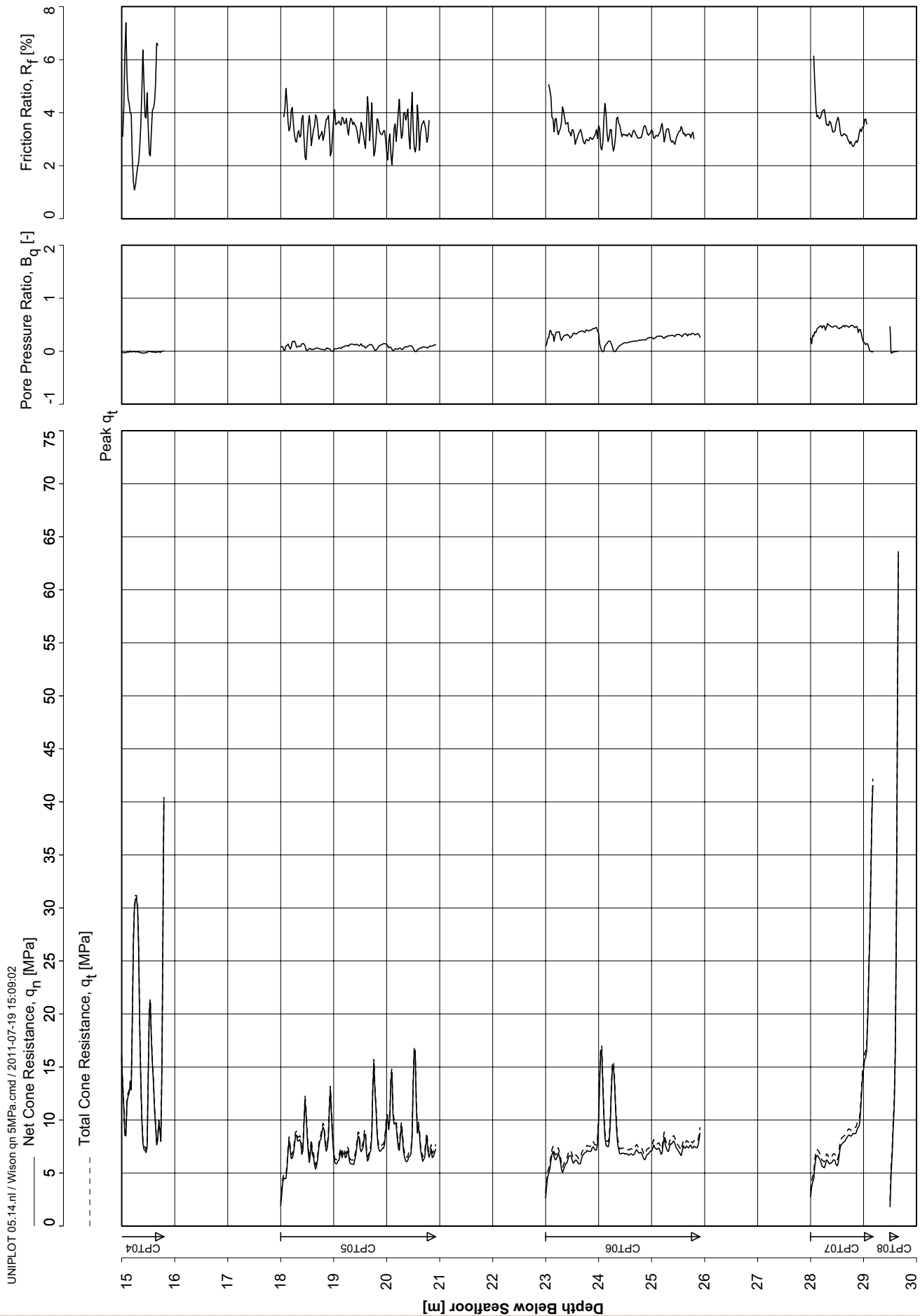
CONE PENETRATION TEST
BH_17
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 31-Mar-2011
Water Depth [m] : 27.0
Coordinates [m] : E690153 N5615571



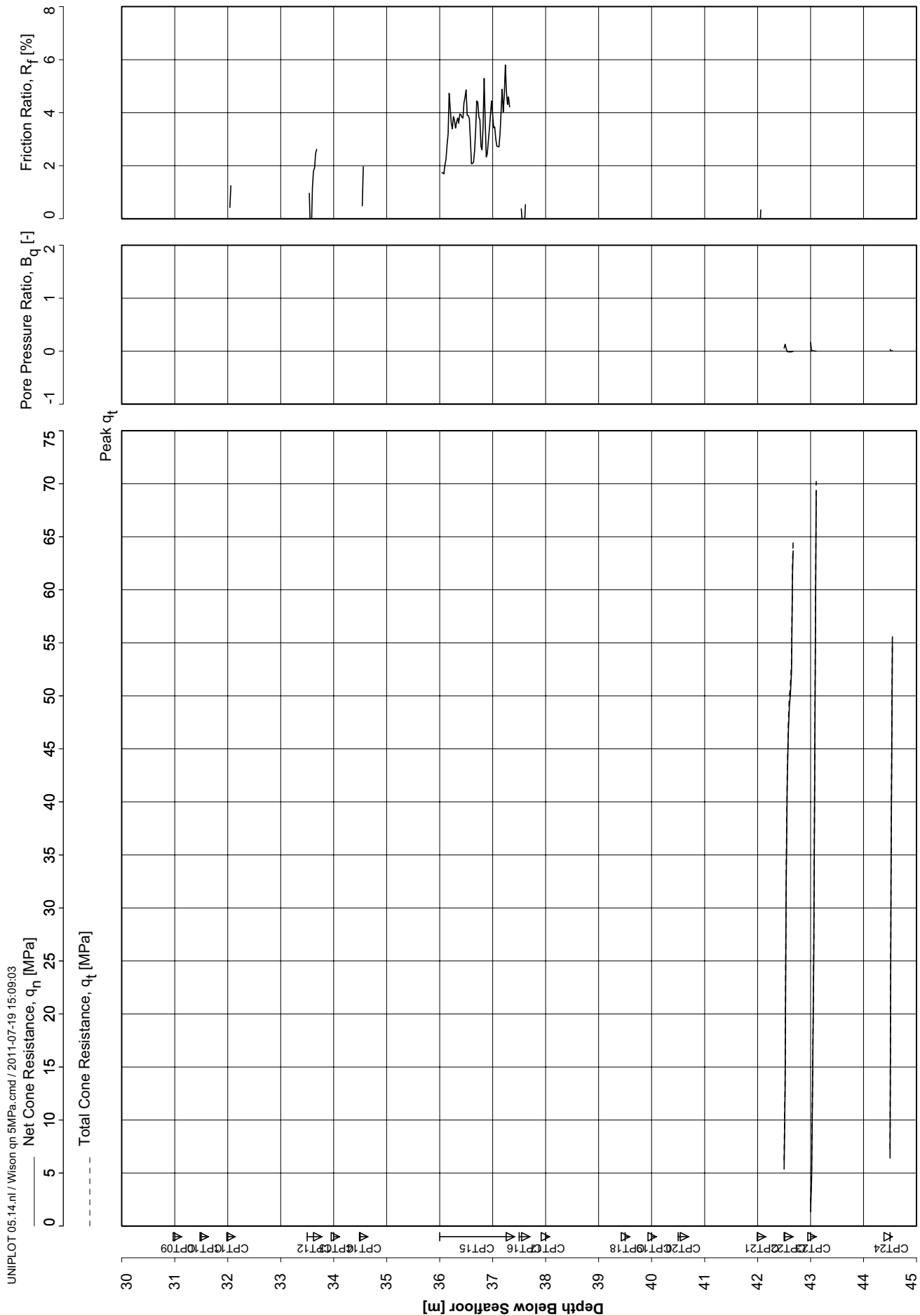
CONE PENETRATION TEST
BH_17
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 30-Mar-2011
Water Depth [m] : 27.0
Coordinates [m] : E690153 N5615571



CONE PENETRATION TEST
BH_17
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 30-Mar-2011
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CONE PENETRATION TEST
BH_17
RAMPION OFFSHORE WIND FARM SITE INVESTIGATION

Date Of Testing : 31-Mar-2011
Water Depth [m] : 27.0
Coordinates [m] : E690153 N5615571

SECTION B.11

DESCRIPTION OF LABORATORY TESTS AND PROCEDURES

LABORATORY METHOD STATEMENTS	NUMBER
CLASSIFICATION TESTS	
CODES OF PRACTICE AND ACCREDITATION	L-M-000
MOISTURE CONTENT	L-M-001
BULK AND DRY DENSITY	L-M-002
ATTERBERG LIMITS (CONE PENETROMETER)	L-M-003a
PARTICLE DENSITY (PYKNOMETER)	L-M-006a
MINIMUM AND MAXIMUM DENSITY	L-M-007
PARTICLE SIZE DISTRIBUTION	L-M-009
TORVANE	L-M-011
LAB VANE	L-M-012
POCKET PENETROMETER	L-M-015
CHEMICAL TESTING	L-M-021
CONSOLIDATION AND PERMEABILITY TESTS	
INCREMENTAL OEDOMETER	L-M-108
TOTAL STRESS SHEAR TESTS AND ROCK STRENGTH	
SHEARBOX	L-M-201
RING SHEAR – ICP	L-M-203
UNCONSOLIDATED UNDRAINED TRIAXIAL	L-M-205
POINT LOAD TESTS	L-M-206
EFFECTIVE STRESS AND ADVANCED TESTS	
ISOTROPICALLY CONSOLIDATED TRIAXIAL – UNDISTURBED	L-M-301
ISOTROPICALLY CONSOLIDATED TRIAXIAL – DISTURBED	L-M-301a
ANISOTROPICALLY CONSOLIDATED TRIAXIAL – UNDISTURBED	L-M-302
CYCLIC TRIAXIAL – STRESS CONTROLLED	L-M-306
DIRECT SIMPLE SHEAR	L-M-307
CYCLIC SIMPLE SHEAR – STRESS CONTROLLED	L-M-308

B.11 DESCRIPTION OF LABORATORY TESTS AND PROCEDURES

CODES OF PRACTICE AND ACCREDITATION

CODES OF PRACTICE

Unless otherwise stated the tests are performed following the methods outlined in the appropriate part of the British Standard Code of Practice "Methods of Test for Soils for Civil Engineering Purposes" 1377 (1990).

During testing the soils are described both from visual examination and, where other results are available, following the recommendations of the British Standard Code of Practice BS 5930 (1999) "Site Investigation".

The limits of consistency for predominantly cohesive (fine-grained) soils are based on BS 5930, and are presented in Table 1.

Table 1. Consistency Limits – Cohesive Soils

Consistency	Unconsolidated undrained shear strength [kPa]
Very soft	0-20
Soft	20-40
Firm	40-75
Stiff	75-150
Very stiff	150-300
Hard	300-600
Very hard	greater than 600

It should be noted that the term 'Very hard' has been introduced by Fugro GeoConsulting Limited in order to provide a complete range of consistency limits for the soils found offshore.

The relative density limits adopted in predominantly cohesionless (sand) soils are based on the ranges recommended by Lambe and Whitman (1969), and are presented in Table 2.

Table 2. Consistency Limits – Cohesionless Soils

Consistency	Relative density [%]
Very loose	0-15
Loose	15-35
Medium dense	35-65
Dense	65-85
Very dense	85-100

ACCREDITATION

Fugro GeoConsulting Limited's Wallingford laboratory is accredited by the 'United Kingdom Accreditation Service' (UKAS) for the performance of a range of laboratory testing. The tests Fugro GeoConsulting Limited are accredited to perform are detailed on the 'UKAS' Schedule (UKAS Testing Laboratory No. 0919) as displayed on the UKAS web site.

REFERENCES

[BS 1377, 1990. *Methods of Test for Soils for Civil Engineering Purposes*. London: British Standards Institution.](#)

[BS 5930, 1999. *Code of Practice for Site Investigations*. London: British Standards Institution.](#)

LAMBE, T.W. and WHITMAN, R.V., 1969. *Soil Mechanics*. New York: John Wiley and Sons Inc.

MOISTURE CONTENT DETERMINATION

GENERAL

The water (moisture) content is defined as the ratio of the weight of water to the weight of dry soil. Water content determinations are normally performed in accordance with the procedures of BS 1377 (1990). A brief outline of the test procedure is presented here.

This method is essentially the same as CEN/ISO TS17892-1:2004.

TEST PROCEDURE

The moisture content is determined by weighing a suitable quantity of wet soil. The soil is then dried in an oven, typically for a period of at least 16 hours, at a temperature of 105 to 110°C. Some soils, especially those containing eg gypsum or calcite, are dried at lower temperatures to constant weight in order to avoid errors due to loss of water of crystallisation, or cementation of the sample if it is to be used subsequently in another test.

The resulting dry soil is re-weighed in order to obtain the weight of water lost from the sample. The moisture content, as defined above, is then determined.

PRESENTATION OF RESULTS

Individual results are presented in tabular form and may also be presented graphically. Unless agreed otherwise with the customer, the result is presented as a percentage to the nearest 0.1% below 10%, and to the nearest 1% above.

If the sample has been dried at a temperature other than 105 to 110°C this fact is also reported.

ACCURACY OF MEASUREMENTS

Temperature $\pm 1^{\circ} \text{C}$
Weight $\pm 0.01 \text{ g}$

REFERENCE

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 2, Section 3.

BULK AND DRY DENSITY DETERMINATION

GENERAL

Bulk density is defined as the mass of soil per unit volume and is normally expressed in units of Megagrammes per cubic metre (Mg/m^3). Dry density is defined as the mass of dry soil per unit volume.

Bulk and Dry Density determinations are performed in accordance with the procedures of BS 1377 (1990). A brief outline of the test procedure is presented here.

This method is essentially the same as CEN/ISO TS17892-2:2004 (Linear Measurement Method).

TEST PROCEDURE

The bulk density of a sample is determined by weighing a known volume of wet soil. A regular shaped specimen, usually a right-cylinder, is carefully prepared and its dimensions (e.g. length and diameter) measured in several locations. These measurements are averaged, then used to calculate the volume (i.e. simply $\pi d^2 h / 4$ in the case of a cylinder).

In very soft samples that tend to slump under their own weight, a mould may be used to constrain the specimen: the internal dimensions of the mould are substituted for the measured dimensions of the test specimen in the volume calculation.

The dry density is determined by determining the water content of the soil according to method L-M-001. The measured bulk density from above is then corrected for the contribution from water to obtain the dry density.

PRESENTATION OF RESULTS

Individual results are presented in a tabular form.

Results may be converted to and presented as unit weights by multiplying the bulk or dry density value by the acceleration due to gravity (i.e. 9.81 m/s^2 in the UK) with the resulting values being expressed in kN/m^3 .

ACCURACY OF MEASUREMENTS

Dimensions	$\pm 0.01 \text{ mm}$
Temperature	$\pm 1^\circ \text{ C}$
Weight	$\pm 0.01 \text{ g}$

REFERENCE

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 2, Section 7.

ATTERBERG LIMITS DETERMINATION USING CONE PENETROMETER METHOD FOR LIQUID LIMIT ASSESSMENT

GENERAL

Atterberg Limits tests are performed to determine the liquid and plastic limits, and hence the plasticity index of a cohesive soil. Definitions of liquid and plastic limit are presented below. The tests are performed in accordance with the procedures of BS 1377 (1990) on the soil fraction passing a 425 μm sieve. A brief outline of the test procedure is presented below.

This method is essentially the same as CEN/ISO TS17892-12:2004.

Note that we also routinely run liquid limit tests using the "Casagrande" method and currently hold both BS and ASTM Casagrande equipment (the equipment required of the two standards is different).

TEST PROCEDURE

- (i) **Liquid Limit** – The 'Cone Penetrometer Apparatus' is a variant of the Fall Cone and consists of a cone with a smooth polished surface and angle of $30^\circ \pm 1^\circ$. The weight of the cone, together with its associated shaft is $80 \text{ g} \pm 0.1 \text{ g}$. A support assembly with an automatic cone release mechanism and cone height adjustment mechanism is used to hold the cone vertically. The angle and weight of the cone are calibrated at regular intervals, and the sharpness of the cone tip is checked daily.

Distilled water is added and thoroughly mixed with the soil to be tested to produce a homogeneous paste. The paste is then placed in a cup with a diameter of at least 55 mm and a depth of at least 40 mm. The surface of the soil is smoothed off level and parallel to the base. The support assembly is used to position the tip of the cone so that it is just touching the top surface of the soil, and the automatic tripping mechanism is released. The cone is allowed to penetrate into the soil for a period of $5 (\pm 1) \text{ s}$, then the cone is locked off to stop further movement and the penetration is recorded. The cup is refilled and the test repeated. The two recorded penetrations need to be within 0.5 mm of each other, otherwise a third test is performed. If the three test vary by more than 1 mm the test is repeated.

A sample of soil from the cup is removed and its water content is determined according to L-M-001.

Further tests are conducted, at varying water contents, in order to produce a series of cone penetrations (usually 4) in the range 15 mm to 25 mm. The resulting cone penetrations are plotted versus the water content of the test specimens. The Liquid Limit (W_L) is read off the graph, being the water content at which the line of best fit through the test points crosses 20 mm penetration.

- (ii) **Plastic Limit** – The plastic limit is determined by allowing a portion of approximately twenty grammes of the soil used for the liquid limit test to dry partially. When the soil has dried sufficiently to be workable by hand, it is kneaded into a ball until cracks appear on the surface.

The soil is then rolled into threads approximately three millimetres in diameter using even pressure. If the threads remain intact at 3 mm diameter, the specimen is rolled back into a ball

and kneaded some more in order that heat from the hands dries it a little more each time. The thread rolling is then repeated.

Once both longitudinal and radial cracks appear in the 3 mm threads, the crumbled soil fragments are placed into weighed tins and are dried according to L-M-001. Care needs to be taken to ensure that the cracking is only occurring as the threads reduce to 3 mm diameter: If the cracking appears while the threads are significantly the larger, the sample is already too dry. The accuracy of this test is highly dependent on the skill and experience of the person performing it.

The Plastic Limit (W_P) is defined as the moisture content at which the threads of soil three millimetres in diameter crumble.

- (iii) **Plasticity Index** – The Plasticity Index (I_P) is equal to the value of the liquid limit minus that of the plastic limit (i.e. $I_P = W_L - W_P$).

PRESENTATION OF RESULTS

Result of Atterberg Limits determinations are presented both in tabular form, reported as water contents to the nearest 1%, and plotted on a BS 5930 "Plasticity Chart".

ACCURACY OF MEASUREMENTS

Weight ± 0.01 g

REFERENCE

BS1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 2, Sections 4 and 5.

PARTICLE DENSITY DETERMINATION SMALL PYKNOMETER METHOD

GENERAL

The particle density of fine grained soils and sands is normally evaluated according to BS 1377 (1990) by the small pyknometer method. A brief outline of this method is presented below.

This method is essentially the same as CEN/ISO TS17892-3:2004.

TEST PROCEDURE

A dry sample weighing between ten and twenty grams is placed in a calibrated 50 ml pyknometer (density bottle) bottle of known weight and volume, and weighed. The pyknometer is partially filled with de-aired distilled water and placed in a vacuum desiccator until all the air has been evacuated from the soil. Considerable care is taken to completely remove air, the presence of which will give a false-low result. The presence of organic material in the sample is also likely to lead to a false-low result and some samples therefore may need pre-treatment. The pyknometer is then completely filled with de-aired distilled water, the stopper is placed in the bottle and the whole arrangement is weighed.

The volume of the solids equals the difference between the calibrated volume of the density bottle and the volume of water required to fill the bottle with the sample present. Due allowance is made in this calculation for the accurate density of water as a function of its temperature.

Two particle density determinations are carried out on each sample and the reported result is taken as the average of these provided the two results are within 0.03 Mg/m³ of each other.

PRESENTATION OF RESULTS

Test results are presented in tabular form showing the average particle density value in Mg/m³.

ACCURACY OF MEASUREMENTS

Weight ± 0.001 g

REFERENCE

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 2, Section 8.

MAXIMUM AND MINIMUM DENSITY DETERMINATION

GENERAL

Maximum and minimum density tests are performed on cohesionless (coarse-grained) soils. If the relative density of the soil is known or can be estimated, e.g. from in-situ cone penetration tests, then the maximum and minimum dry density may be used to estimate the in-situ dry density of the soil. The determination is normally performed before direct shear or triaxial tests, allowing test specimens to be reconstituted to a best estimate of the in-situ conditions.

Testing is normally performed to BS 1377 (1990) Part 4: other methods are available.

A scaled version of the electric vibrating hammer method may be performed, in a 100 cm³ mould, to determine the maximum density of sands when limited sample is available (<500 g). This variant of the method is fully calibrated, using standard Leighton Buzzard sand, to the required acceptance criteria of the full sized method described in BS 1377 (1990) Part 4, Paragraph 3.7.3.2.

TEST PROCEDURE

- (i) **Minimum Density** – A dry sample is gently poured into a mould of known volume and mass. The mould containing the sample is then weighed and the weight of soil calculated. This process is repeated at least three times: the lowest value is taken as the result.
- (ii) **Maximum Density** – The maximum dry density is obtained by compacting soil that has been passed through a 4 mm sieve into a calibrated cylindrical mould at a range of moisture contents.

The dry sample is thoroughly mixed with water to produce a soil with about 6% moisture content, and is then compacted into a weighed mould fitted with an extension collar in three equal layers using a vibrating hammer for a period of 5 seconds per layer. If the sand is fine, sand may be lost through the annular gap between the wall of the mould and the hammer. In this case, a disc of polythene is used on top of each layer to act as a barrier to loss, although this must be removed before the next layer of sand is added.

Once all three layers are compacted, the extension collar is removed and the compacted sand is struck off level with the top of the mould. The filled mould is weighed and the bulk density of the sample is calculated. A representative portion of soil is removed for water content determination according to method statement L-M-001.

The test is repeated at four further moisture contents, typically 8%, 10%, 12% and 14%. Additional test points at higher water contents may be required for samples with significant shell content.

Care is taken not to re-use specimens of samples where particle crushing may occur under the influence of the compaction effort from the vibrating hammer.

The resulting dry densities are plotted as a function of the water content, a smooth curve is plotted through the points and the resulting maximum dry density and corresponding water content read off.

PRESENTATION OF RESULTS

The test results are presented in tabular form with minimum and maximum dry densities presented to the nearest 0.01 Mg/m³ and the optimum water content to the nearest 0.1% below 10% and to the nearest 1% above.

ACCURACY OF MEASUREMENTS

Dimensions	± 0.01 mm
Weight	± 0.01 g

REFERENCES

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 4.

PARTICLE SIZE DISTRIBUTION

GENERAL

Particle size distribution tests are normally performed in accordance with the procedures of BS 1377 (1990). A brief outline of the test procedures is presented below.

This method is essentially the same as CEN/ISO TS17892-4:2004.

TEST PROCEDURE

(i) Dry Sieving

Dry sieving is normally performed on clean soils containing only a small proportion of fine-grained soil. The soil specimen is dried in a thermostatically controlled oven to constant weight before being placed in a mortar and tamped using a rubber pestle, to ensure soil particles are not binding together. The soil is then passed through standard calibrated ISO sieves, usually using a mechanical shaker. Care is taken to ensure that each sieve is not overloaded with sample, and that sieving is complete.

The mass of dry soil retained on each sieve is determined.

(ii) Wet Sieving

Wet sieving is normally performed on soil samples with any appreciable proportion of fine-grained soils and is the preferred method for most soils. Prior to determination of the particle size distribution, a weighed quantity of soil is dispersed with a solution of sodium hexametaphosphate before being washed through a 63 micron sieve. The use of alternative dispersants may be required for certain samples.

Care is taken during the wet sieving and washing processes to ensure, as far as possible, that fragile solids such as chalk gravel and pelloidal clays are not destroyed.

The percentage by weight of the various particle sizes in excess of 63 microns is then determined by dry sieving as above. The percentage of fines is determined by difference.

(iii) Sedimentation

The distribution of particle sizes smaller than 63 microns is determined by sedimentation using either the hydrometer or the pipette method. In both methods the soil sample is suspended in a solution of 33g/L sodium hexametaphosphate in water. The amount of soil remaining in the soil/water suspension is determined at various times and related to soil particle size by means of Stoke's Law.

Unless agreed to the contrary with the client, a sedimentation test is always performed on mixed soils containing more than 15% fines.

PRESENTATION OF RESULTS

Particle size distribution, expressed in terms of percentage of soil by weight passing a particular sieve size, is presented for individual tests in graphical format.

ACCURACY OF MEASUREMENTS

Weight ± 0.01 g for dry/wet sieving
 ± 0.001 g for sedimentation

REFERENCE

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 2, Section 9.

TORVANE TEST

GENERAL

The torvane test is used to obtain a basic estimate of the undrained shear strength of the soil. The test and equipment are described by Head (1982). A brief outline of the test procedure is presented here.

TEST PROCEDURE

The torvane is a small hand-operated device consisting of a metal disc with thin radial vanes projecting from one face. The disc is pressed against a flat surface of the soil until the vanes are fully embedded. It is then rotated through a torsion spring until the soil enclosed within the vanes is sheared from the sample. The device is calibrated to indicate the shear strength of the soil from the rotation of the torsion spring. Several vane sizes are available in order to increase the undrained strength range of the instrument. Generally the results are presented as an average of three readings.

PRESENTATION OF RESULTS

Individual test results are tabulated on laboratory test summary sheets and may also be presented graphically.

ACCURACY OF MEASUREMENTS

Values are presented for indication only

REFERENCE

HEAD, K., 1982. *Manual of Soil Laboratory Testing, Vol. 2: Permeability, Shear Strength and Compressibility Tests*. London and Plymouth: Pentech Press.

LABORATORY VANE TEST

GENERAL

The laboratory vane is used to estimate the undrained shear strength of relatively soft cohesive soils. The test is performed in accordance with the procedures of BS 1377 (1990). A brief outline of the procedure is presented here.

TEST PROCEDURE

An undisturbed sample, normally contained in a sample tube, is secured by clamping under the vane apparatus. A small cruciform vane with a height to diameter ratio of one is lowered mechanically into the soil until the vane is fully embedded. The vane is then rotated by hand, at a constant rate of nominally 0.1° per second, until the soil enclosed within the vanes is sheared from the sample. Rotation is resisted by means of a calibrated spring and measured on a circular vernier gauge.

The undrained shear strength is obtained by multiplying the spring rotation by a factor appropriate to the vane size and spring stiffness. Several vane sizes are available in order to increase the undrained strength range of the instrument.

PRESENTATION OF RESULTS

Individual test results are tabulated on laboratory test summary sheets and may also be presented graphically.

ACCURACY OF MEASUREMENTS

Typically $\pm 10\%$ of presented value

REFERENCES

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 7, Section 3.

HEAD, K., 1982. *Manual of Soil Laboratory Testing, Vol. 2: Permeability, Shear Strength and Compressibility Tests*. London and Plymouth: Pentech Press.

POCKET PENETROMETER TEST

GENERAL

The pocket penetrometer test is used to obtain a basic estimate of the undrained shear strength of the soil. The test and equipment are described by Head (1992). A brief outline of the test procedure is presented here.

TEST PROCEDURE

A small cylindrical metal rod is slowly pressed into the soil through a spring until it is embedded to a predetermined distance. This hand-operated device is calibrated to allow the undrained shear strength of the soil to be calculated by reading off a scale that measures the compression of the spring and multiplying by an appropriate factor which depends on the diameter of the cylindrical metal rod. The range of the instrument may be increased by attaching cylindrical rods of various diameters to the basic penetrometer. Generally the results are presented as an average of three readings.

PRESENTATION OF RESULTS

Individual test results are tabulated on laboratory test summary sheets and may also be presented graphically.

ACCURACY OF MEASUREMENTS

Values are presented for indication only

REFERENCE

HEAD, K., 1982. *Manual of Soil Laboratory Testing, Vol. 2: Permeability, Shear Strength and Compressibility Tests*. London and Plymouth: Pentech Press.

CHEMICAL TESTING

GENERAL

Chemical testing may be required to determine the amount of chemical substances, including organic matter, in samples of soil in order to assist in, for example, the design of structures and pipelines to resist chemical attack and corrosion.

Testing is generally performed in accordance with BS 1377 (1990) Part 3 methods as described below. Other methods are also in use for determinands not covered by BS 1377.

Many of these tests are subcontracted to a specialist chemical testing laboratory holding appropriate ISO 17025 certification, as they have the necessary training and safety and environmental regimes required to handle hazardous chemical reagents.

TEST PROCEDURES

- (i) **Organic matter** – Samples are tested according to BS 1377 (1990), Part 3, Clause 4. Samples are dried at 50° C, weighed, ignited in a muffle furnace at 440° ($\pm 25^\circ$) C, then weighed again. The mass that is lost as a proportion of the dry mass is deemed to be the organic content.
- (ii) **Total sulphate content of soil** – Samples are tested according to BS 1377 (1990), Part 3, Clause 5. The dried soil is extracted with a 10% solution of hydrochloric acid. The extract is adjusted to slightly alkaline pH with ammonia, then barium chloride solution is added to precipitate the sulphate. The barium sulphate precipitate is collected by filtration, and is washed, dried and weighed. The mass of barium sulphate recovered is used to calculate the sulphate content of the original soil.
- (iii) **Water-soluble sulphate content of soil** – Samples are tested according to BS 1377 (1990), Part 3, Clause 5. Dry soil is extracted with distilled water (2:1 soil to water ratio by weight) with agitation for at least 16 hours. The resulting soil suspension is filtered and then treated as above for the total sulphate content.

The solubility of calcium sulphate in water is limited at neutral pH and soils with levels above approximately 2,500 mg/kg sulphate (0.25%) will give a false-low result. The soil to water extraction ratio may need to be increased in these cases.

Unless agreed to the contrary with the customer, a water-soluble sulphate test is always performed if a total sulphate test above shows more than 0.5% acid soluble sulphate.

- (iv) **pH Value** – Samples are tested according to BS 1377 (1990), Part 3, Clause 9. The soil sample (30 ± 0.1 g) is extracted with 75 mL of distilled water and the pH of the resulting suspension is measured with a calibrated pH meter.
- (v) **Carbonate content** – Samples are tested according to BS 1377 (1990), Part 3, Clause 6. The soil sample is extracted with 1M hydrochloric acid, liberating carbonate as CO₂. The amount of hydrochloric acid remaining after reaction is complete is determined by titrating 25 ml of the supernatant solution with 1M sodium hydroxide solution with indicator, to neutral pH. The quantity

of HCl consumed in the reaction with the carbonate is used to determine the amount of carbonate present.

- (vi) **Chloride content** – Samples are tested according to BS 1377 (1990), Part 3, Clause 7. For the water soluble content, soil samples are extracted with a volume of water equal to twice the mass of the soil. The extract is filtered and acidified with a small amount of nitric acid. Standardised silver nitrate solution is then added to precipitate the chloride as its silver salt. The amount of unprecipitated silver remaining in solution is then determined by titration.

An acid-soluble version of the test is also available, with the initial extraction being with nitric acid instead of water.

- (vii) **Soil pore water salinity** – Samples are tested to an in-house procedure based on ASTM D4542-07. Either pore water is squeezed out of the wet soil in a press, or the salt is extracted by producing a slurry with distilled water in a high-speed, high-shear blender. The resulting extract is allowed to settle or is filtered to produce a small quantity of clear solution. The dissolved solids content of the clear solution is determined using a digital refractometer calibrated for salt (sodium chloride) concentration.

Note that strictly, both extraction methods will result in the measurement of the total dissolved solids content, but for samples from saline environments it is often assumed that the total dissolved solids comprise solely sodium chloride.

- (viii) **Other** – Samples may be tested for a wide range of other chemical parameters, too numerous to mention individually here. The identity of the determinand, and the identity of the test method and its required performance (e.g. limit of detection) will be agreed in advance with the customer.

PRESENTATION OF RESULTS

The results are presented in tabular form in percent, g/kg or mg/kg of dry soil.

REFERENCE

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 3.

ONE DIMENSIONAL INCREMENTAL OEDOMETER TEST

GENERAL

Incremental oedometer tests are typically used to infer the stress history and time dependent one dimensional consolidation behaviour of the soil. The test is carried out on a specimen, prepared in a consolidation ring with a minimum specimen diameter to height ratio of 2.5. Tests are performed in accordance with the procedures defined in BS 1377 (1990), Part 5. Tests may also be undertaken in accordance with the equipment specifications and test procedures given in ASTM D 2435-04.

The following is a brief outline of the procedures employed for incremental oedometer tests on undisturbed soil specimens.

TEST PROCEDURE

- (i) **Specimen Preparation** – The sample is extruded from the sample tube and carefully trimmed into a specimen consolidation ring of 38, 50 or 72 mm diameter, depending on the sample size and the maximum loading increment required for the test. A moisture content determination is carried out on a portion of soil trimmings representative of the specimen to be tested.

The specimen is mounted on saturated porous filter stones in the oedometer cell. For stiff clay specimens the filter stones used are initially dry in order to prevent any change in water content and swelling of the specimen during assembly of the apparatus.

- (ii) **Consolidation loading/unloading** – Following apparatus assembly specimen behaviour is constantly monitored during the first hour of the test in order to identify and prevent any tendency of the specimen to swell. The vertical load is then applied according to the specified loading schedule. Readings of vertical deformation and time are recorded automatically via a computer logging system. Each stress increment, or decrement, is maintained for a period of 24 hours or until the end of primary consolidation has been effectively established.

Strengthened loading frames are available which, in combination with 38 mm specimens, allow vertical loads up to 38 MPa to be applied to the specimen. Where excessive deformation of soft soil specimens at minimum load increments is of concern, lightweight top-caps are used to enable seating loads of ~1 kPa to be applied.

- (iii) **Measurement of swelling pressure** – Where determination of the pressure required to prevent swelling of a clay specimen after inundation is required as part of an incremental oedometer test, the procedures given in BS 1377 (1990) Part 5, Clause 4.3 are employed.
- (iv) **Measurement of swelling and compression during unloading** – Where determination of the swelling properties of a clay specimen during unloading is required as part of an incremental oedometer test, the procedures given in BS 1377 (1990) Part 5, Clause 4.4 are employed.

PRESENTATION OF RESULTS

The test data is processed using in-house developed templates and results are presented in accordance with the recommendations given in BS 1377 (1990) Part 6. This includes derivation of all

parameters including: coefficient of vertical consolidation and constrained modulus. The following results may be presented, depending on project requirements:

Initial specimen dimensions (mm)

Initial moisture content (%) and bulk and dry densities (Mg/m^3).

Graph of vertical effective stress (kPa, log scale) versus voids ratio

Graph of vertical effective stress (kPa, log scale) versus coefficient of consolidation (m^2/year)

Where provision of the estimated pre-consolidation stress is required as part of the result presentation, this may be estimated using the methods of Casagrande (1936), Becker (1987), Janbu (1969) or Akai (1960).

Data may also be reported and presented in compliance with ASTM D 2435-04.

ACCURACY OF MEASUREMENTS

Vertical stress	$\pm 1 \text{ kPa}$
Deformation	$\pm 0.01 \text{ mm}$
Time	$\pm 0.5 \text{ s}$
Weight	$\pm 0.01 \text{ g}$
Dimensions	$\pm 0.01 \text{ mm}$

REFERENCES

ASTM Standard D2435-04, 2004. *Standard Test Method for One-Dimensional Consolidation Properties of Soils Using Incremental Loading*. ASTM International, West Conshohocken, PA, DOI: 10.1520/ D2435-04.

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 5, Sections 3 and 4.

DIRECT SHEAR (SHEAR BOX) TEST

GENERAL

Direct shear tests are typically undertaken to estimate the angle of shearing resistance of a cohesionless sample. The test is carried out on a specimen, prepared in a shear box with a minimum square dimension of 60 mm. Tests are performed in accordance with the procedures in BS 1377 (1990), Part 7.

The following is a brief outline of the procedures employed for direct shear tests on re-compacted soil specimens.

TEST PROCEDURE

- (i) **Specimen Preparation** – The shear box apparatus is assembled and the soil to be tested is placed in the shear box mould, with internal dimensions of 60 mm by 60 mm, and compacted, in 3 layers, to a specified dry density at optimum moisture content. A porous stone and loading plate are placed on top of the specimen
- (ii) **Consolidation Stage** – Following apparatus assembly an initial reading of vertical deformation is taken before a normal stress is applied to the top of the specimen via a load hanger and lever arm arrangement. Readings of vertical deformation and time are recorded automatically via a computer logging system and consolidation is continued until the end of primary consolidation has been effectively established.
- (iii) **Shearing Stage** – On completion of the consolidation stage the proving ring and deformation gauges, measuring horizontal and vertical displacement, are zeroed. The specimen is then sheared, by displacing the top half of the shear box relative to the bottom half, at a rate of displacement selected to prevent generation of excess pore pressures within the specimen during shearing. During the test, readings of horizontal displacement, horizontal load and vertical displacement are recorded. The shear stage is typically terminated when the relative horizontal displacement reaches 10 mm.

On completion of the first shear stage, the specimen is removed from the shear box and the unit weight and moisture content are determined. Two further tests are then performed according to the procedures outlined above, at the same dry density, but with increased normal stresses in order to provide sufficient data to evaluate a failure envelope for the soil.

- (iv) **Residual Shearing Stage (cohesive samples)** – Following development of the peak shearing stress it is possible to infer a residual shearing stress across a pre-determined shear plane in the soil specimen. The initial shearing stage is terminated after development of peak shearing stress and the top half of the shear box is manually displaced, relative to the bottom half, to the horizontal limit of the apparatus before being returned to its initial position prior to shearing. This reversal process is repeated up to 4 times to establish the shear plane across the specimen. The specimen is then sheared under control, following the same procedures as outlined above for the initial shearing stage. The residual shear stage is typically terminated when the relative horizontal displacement reaches 10 mm.

PRESENTATION OF RESULTS

The test data is processed using in-house developed templates and results are presented in accordance with the recommendations given in BS 1377 (1990) Part 7. The following results may be presented, depending on project requirements:

Initial moisture content (%) and bulk and dry densities (Mg/m^3).

Graph of shear stress (kPa) versus horizontal displacement (mm)

Graph of vertical deformation (mm) versus horizontal displacement (mm)

Graph of maximum shear stress (kPa) versus normal stress (kPa)

ACCURACY OF MEASUREMENTS

Dimensions	$\pm 0.01 \text{ mm}$
Displacement	$\pm 0.01 \text{ mm}$
Load	$\pm 1 \text{ N}$
Time	$\pm 0.5 \text{ s}$
Weight	$\pm 0.01 \text{ g}$

REFERENCES

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 7, Section 4.

HEAD, K., 1994. *Manual of Soil Laboratory Testing, Volume 2: Permeability, Shear Strength and Compressibility*. London and Plymouth: Pentech Press.

RING SHEAR TEST - IMPERIAL COLLEGE PILE CAPACITY EVALUATION METHOD

GENERAL

Ring shear tests are performed on remoulded or reconstituted soils to infer the residual angle of friction on a soil-steel interface. The test is performed in general accordance the procedures given in BS1377 (1990), Part 7, but with modifications to provide the data necessary for input into the Imperial College pile capacity method (Jardine et al. 2005).

The following is a brief outline of the procedures employed for incremental oedometer tests on remoulded soil specimens.

TEST PROCEDURE

All tests are performed on a soil/steel annular interface. The steel interface is shot-blasted so that it is representative of offshore piles, i.e. a centreline average roughness of approximately 1×10^{-5} m.

- (i) **Specimen Preparation** – The ring shear apparatus is assembled and the soil to be tested is remoulded by hand at natural moisture content. If a cohesive sample contains a significant “coarse” fraction (soil particles larger in size than $425 \mu\text{m}$) then this fraction is removed prior to remoulding.

If the soil is too hard to remould by hand, then the samples is reconstituted at the estimated in situ water content.

If the sample is in a soft state such that it is estimated that large settlements may occur during consolidation, then the sample is air dried to the estimated in situ water content or to a state allowing a reliable test to be performed.

The test specimen is then remoulded into the annulus of the ring shear apparatus in at least two layers by thumb pressure and levelled across the upper surface using a suitably calibrated straight edge.

- (ii) **Initial Consolidation Stage** – Following apparatus assembly an initial reading of vertical deformation is taken before a normal stress is applied to the top of the specimen via a load hanger and lever arm arrangement. The normal stress applied is selected as to be representative of the in-situ horizontal effective stress at specimen depth. Readings of vertical deformation and time are recorded automatically via a computer logging system and consolidation is continued until the end of primary consolidation has been effectively established. If the vertical strain during consolidation is observed to exceed 15% the test is ceased and the specimen allowed a suitable period of air drying prior to a repeat test being performed.
- (iii) **Fast Shearing Stage** – On completion of the consolidation stage the load cells and deformation gauges are zeroed. The specimen is then sheared at a rate equivalent to an installation rate of 400 mm/min, followed by 50mm/min, up to a relative displacement of at least one metre. This rate is probably slower than the actual rate that the piles may be installed, but comparative studies have shown that the final measured residual friction angles are relatively unaffected. Generally three or four stop/starts, with rest periods of the order of three to four minutes, are included during this stage to simulate gaps in driving. Readings of shear displacement, applied

load and vertical displacement are recorded automatically via a computer logging system throughout the fast shear stage.

- (iv) **Final Consolidation Stage** – On completion of the first shear stage the specimen is allowed to recover for a period of 24 hours to allow for dissipation of excess pore water pressures. The specimen is then reconsolidated under a second normal stress, representative of the equalised lateral stress acting on a pile wall after driving. Readings of vertical deformation and time are recorded automatically via a computer logging system and consolidation is continued until the end of primary consolidation has been effectively established.
- (v) **Residual Shearing Stage** – Following consolidation the specimen is sheared at a slow rate of nominally 0.018 mm/min until ultimate residual (steady state) conditions are established. Readings of readings of shear displacement, applied load and vertical displacement are recorded automatically via a computer logging system throughout the residual shear stage.

PRESENTATION OF DATA

The test data is processed using in-house developed templates and the results of ring shear test are presented in graphical form. The following results may be presented, depending on project requirements:

Graph of displacement (mm) versus stress ratio for fast shearing

Graph of displacement (mm) versus angle of friction (°) for fast shearing

Graph of displacement (mm) versus stress ratio for slow shearing

Graph of displacement (mm) versus angle of friction (°) for slow shearing

ACCURACY OF MEASUREMENTS

Vertical stress	± 1 kPa
Deformation	± 0.1 mm
Time	± 1 s
Weight	± 0.01 g

REFERENCES

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 7, Section 6.

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

UNCONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST

GENERAL

Unconsolidated undrained triaxial compression tests are carried out on undisturbed samples to determine the undrained shear strength.

Remoulded undrained triaxial compression tests are carried out to determine the remoulded shear strength of samples and are normally carried out in conjunction with undisturbed tests to provide a measure of soil sensitivity.

Samples are tested with a height to diameter ratio of approximately 2:1 in accordance with the procedures of BS 1377 (1990). A brief outline of the procedure is presented here.

TEST PROCEDURE

(i) Sample Preparation

Remoulded Sample – The sample is broken down at natural moisture content to provide the mass of soil needed to give the required density in a mould of known volume. A base plate is placed in the bottom of the mould and the soil is compacted into the mould in three equal layers using a tamping tool or, if necessary, an electrically operated vibrating hammer.

Undisturbed Sample – The sample is extruded from the sample tube and carefully trimmed to a specimen height to diameter ratio of approximately 2:1.

Both Remoulded and Undisturbed Specimens – The specimen is weighed and carefully measured to determine the bulk density. A moisture content determination is carried out on a portion of soil trimmings representative of the specimen to be tested. The trimmed specimen is placed on the base pedestal of the triaxial apparatus and a lightly greased top cap is placed on top of the specimen. The specimen is enclosed within a rubber membrane that is sealed with rubber 'O' rings to prevent the ingress of water into the specimen during testing.

(ii) **Shearing Stage** – The triaxial cell is assembled and filled with water. A suitable confining pressure is applied to the cell and the load measurement is zeroed before the piston is brought into contact with the top cap. The initial load reading is recorded and the displacement measurement is zeroed. The sample is sheared at a rate of strain equivalent to two per cent per minute with measurements of displacement and load being recorded at intervals equivalent to 0.5 per cent axial strain. The test is terminated when an axial strain of 20% has been reached.

(iii) **End of Test** – On completion of the shearing stage the confining pressure is reduced to atmospheric pressure, the water drained and the specimen removed from the cell. After sketching the failure shape, the specimen is weighed and placed in a thermostatically controlled oven, typically for a period of 24 hours, at a temperature of 105-110° C. This procedure enables the moisture content, wet density and dry density to be determined.

PRESENTATION OF RESULTS

The test data is processed using in-house developed software that incorporates an allowance for the effect of the membrane on the stress-strain behaviour of the specimen. The following results are presented in the report.

Initial sample dimensions (mm)

Initial moisture content (%)

Bulk and dry density (Mg/m³)

Cell pressure (kPa)

Undrained shear strength (kPa)

Failure shape of sample.

Graph of axial strain (%) versus deviator stress or shear stress (kPa)

where:

$$\text{deviator stress} = (\sigma_a - \sigma_r)$$

$$\text{shear stress} = 0.5 \times (\sigma_a - \sigma_r)$$

and

$$\sigma_a = \text{total axial stress}$$

$$\sigma_r = \text{total radial stress}$$

ACCURACY OF MEASUREMENTS

Moisture content and dry density determinations are presented in accordance with the accuracies stated in the relevant procedures.

Dimensions ± 0.01 mm

Displacement ± 0.01 mm

Load: 100 kN ring ± 4 N; 50 kN ring ± 2 N; 10 kN ring ± 1 N; Load cell ± 1 N

Cell pressure ± 5 kPa

REFERENCE

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 7, Section 8.

POINT LOAD STRENGTH TEST

GENERAL

Uniaxial compressive strength tests are typically performed on core specimens. Where possible, specimens are tested at the full sampled diameter. The test is undertaken to measure the point load strength index and, where required, the strength anisotropy index of the specimen and is mainly intended for strength classification and characterisation of intact rock. The tests are performed based on the procedures given by Ulusay and Hudson (2007) Part 2.

The following is a brief outline of the procedure employed for point load strength tests on core samples of intact rock.

TEST PROCEDURE

- (i) **Diametral test** – Core specimens with a sample to diameter ratio greater than 1.0 are suitable for the diametral test. The specimen is measured carefully and the length and diameter recorded.

The specimen is mounted in the point load apparatus and the platens closed along the core diameter. The distance from the platen to the nearest free edge is measured and recorded. The load is steadily increased until failure occurs. If fracture of the specimen occurs along a single loading point, the test is considered invalid.

- (ii) **Axial test** – Core specimens with a sample to diameter ratio between 0.3 and 1.0 are suitable for the axial test. The specimen is measured carefully and the length and diameter recorded.

The specimen is mounted in the point load apparatus and the platens closed such that they form a line which is perpendicular to the core end faces. The distance between the platen contact points and the specimen width perpendicular to loading are measured and recorded. The load is steadily increased until failure occurs. If fracture of the specimen occurs along a single loading point, the test is considered invalid.

PRESENTATION OF RESULTS

The test data is interpreted and corrected for size in accordance with the procedures given by Ulusay and Hudson (2007) Part 2. The following results may be presented, depending on project requirements:

Tabulated test data, including specimen dimensions and test measurements, the uncorrected and corrected point load strengths and information related to the direction of specimen loading.

ACCURACY OF MEASUREMENTS

Load	± 5% maximum load
Weight	± 0.01 g

Dimensions ± 0.01 mm

REFERENCES

ULUSAY, R. and HUDSON, J.A., 2007. *The Complete ISRM Suggested Methods for Rock Characterisation, Testing Monitoring: 1974-2006*. ISRM Turkish National Group.

ULUSAY, R. and HUDSON, J.A., 2007. *Suggested Methods for Determining the Uniaxial Compressive Strength and Deformability of Rock Materials*. ISRM Turkish National Group.

ISOTROPICALLY CONSOLIDATED TRIAXIAL COMPRESSION TEST- UNDISTURBED SAMPLE

GENERAL

Isotropically consolidated triaxial compression tests with pore-water pressure measurements are performed on undisturbed cohesive specimens with a height to diameter ratio of approximately 2:1. Where possible, specimens are tested at full size. Shearing may be performed under drained or undrained conditions. The tests are performed in accordance with the procedures of BS 1377 (1990).

The following is a brief outline of the procedure employed for isotropically consolidated triaxial tests on undisturbed soil specimens.

Pre-test triaxial cell checks, including flushing of the drainage and pore pressure measurement systems, are undertaken in accordance with Fugro GeoConsulting Testing Procedure L-T-023.

TEST PROCEDURE

- (i) **Specimen Preparation** – The sample is extruded from the sample tube and carefully trimmed to a specimen height to diameter ratio of approximately 2:1. The specimen is weighed and measured to determine the bulk density. A moisture content determination is carried out on a portion of soil trimmings representative of the specimen to be tested; this allows an estimate to be made of the initial air-voids in the specimen.

After placing filter paper on the ends of the trimmed specimen, the soil is placed on a saturated porous stone mounted on the base pedestal of the triaxial cell. A similar stone is placed on the top of the specimen beneath a lightly greased top cap. Filter paper drainage strips are placed around the circumference of the specimen before enclosing the soil within a rubber membrane that is sealed with rubber 'O' rings to prevent the ingress of water into the specimen during testing.

- (ii) **Saturation Stage** – The triaxial cell is assembled and filled with de-aired water from a header tank. An initial pore-water pressure reading is taken and an increment of cell pressure is applied, whilst noting the corresponding increase in pore-water pressure measured in the specimen. If the increase in pore-water pressure is less than 0.95 of the increase in cell pressure a further increase in cell pressure is applied and the initial process repeated. Where it is not possible to fully saturate the specimen under constant moisture content, the procedures outlined in Fugro GeoConsulting Testing Procedure L-T-023 for saturation under back pressure are applied. For the purposes of the test the specimen is considered saturated when a B value of at least 0.95 is achieved. Pore-water pressure is normally measured at the base of the specimen and drainage/back pressure is applied to the top of the specimen.

The volume change of the specimen during back pressure saturation is calculated as the water inflow less the initial estimated air-voids, since the water which flows into the air-voids is assumed not to change the volume of the specimen.

- (iii) **Isotropic Consolidation Stage** – The specimen is generally isotropically consolidated to stress conditions equivalent to either the effective overburden pressure (p_0'), the effective overburden plus an estimate of foundation surcharge ($p_0' + \Delta p$), or to an estimate of the in-situ mean effective stress (σ_m') defined as:

$$\sigma_m' = \frac{1}{3}(p_0' + 2K_0 p_0')$$

where:

K_0	=	Coefficient of lateral earth pressure
p_0'	=	Effective overburden pressure
Δp	=	Estimated additional vertical stress due to foundation loading

The required effective stress is applied to the specimen via the cell pressure, with a minimum back pressure of 300 kPa being applied to maintain specimen saturation. An initial reading is taken on the volume change indicator and the drainage line is opened to the drained face (top) of the specimen. Readings of volume change and time are recorded automatically via a computer logging system. Pore pressure dissipation is measured at the undrained face (base) of the specimen. Consolidation is continued until the measured pore-water pressure is equal to the applied back pressure and a minimum of an overnight period has been allowed following the end of primary consolidation.

At the end of the consolidation stage the consolidated cross sectional area and length of the specimen are calculated based on the volume changes during the saturation and consolidation phases.

- (iv) **Shearing Stage (Single-Stage Tests)** – On completion of the consolidation stage the drainage system is either closed for undrained shearing, or left open for drained shearing. The load cell is brought into contact with the top cap on the specimen and the displacement transducer is zeroed. A compressive deviator stress is then applied to the specimen, at a constant axial strain rate, via the loading ram. The specimen is sheared at an appropriate strain rate, in the range 0.001 – 10 %/hour. In an undrained test the selected rate allows an equalised pore-water pressure response throughout the specimen. In a drained test the rate is selected to prevent generation of excess pore pressures within the specimen during shearing.

Measurements of load, pore-water pressure, volume change (drained test) and displacement are recorded automatically throughout the test via the computer logging system. Manual checks are also made by technicians. The test is normally terminated when an axial strain of 20% has been reached.

- (v) **Shearing Stage (Multi-Stage Tests)** – The procedure adopted for multi-stage tests is generally similar to the procedure given for single-stage tests, except that for all shear stages except the final shearing stage, the stage is terminated when the peak shear stress ratio has been achieved. After the intermediate shearing stages, the deviator stress is reduced to zero and the specimen is isotropically consolidated to the next specified consolidation stress in the same manner as outlined in section (iii). On completion of this consolidation stage, the next shear stage is performed as outlined above. During the final shearing stage the test is normally continued until an axial strain of 20% has been reached.
- (vi) **End of Test** – On completion of the shearing stage the confining pressure is reduced to atmospheric pressure and the cell fluid is drained. The specimen is removed from the cell and a sketch of the failure shape is made. The specimen is then photographed, split and described and weighed and dried so that the final moisture content and bulk and dry densities may be determined. Any unusual specimen conditions potentially affecting interpretation of the test data are carefully noted.

PRESENTATION OF RESULTS

The test data is processed using in-house developed software that incorporates an allowance for the effect of the membrane and filter drainage strips on the stress-strain behaviour of the specimen. The following results may be presented, depending on project requirements:

Initial specimen dimensions (mm)

Initial moisture content (%) and bulk and dry densities (Mg/m^3)

Graph of cell pressure (kPa) versus pore water pressure (kPa) during saturation

Graph of root time ($\text{mins}^{0.5}$) versus consolidated volume change (%) during consolidation

Graph of axial strain (%) versus shear stress (kPa) or deviator stress (kPa) during shearing

Graph of axial strain (%) versus excess pore water pressure (kPa) during undrained shearing

Graph of axial strain (%) versus volume change (%) during drained shearing

Graph of p' (kPa) versus q (kPa) or s' (kPa) versus t (kPa)

Graph of σ_r' (kPa) versus shear stress (kPa)

where:

σ_v'	=	effective axial stress
σ_r'	=	effective radial stress
q	=	deviator stress = $(\sigma_v' - \sigma_r')$
t	=	shear stress = $0.5(\sigma_v' - \sigma_r')$
p'	=	effective mean normal stress (triaxial) = $\frac{1}{3}(\sigma_v' + 2\sigma_r')$
s'	=	effective mean normal stress (plane-strain) = $0.5(\sigma_v' + \sigma_r')$

ACCURACY OF MEASUREMENTS

Moisture content and dry density determinations are presented in accordance with the accuracies stated in the relevant procedures.

Pore water pressure	± 1 kPa
Displacement	± 0.01 mm
Load	± 1.0 N
Volume change	± 0.05 ml
Weight	± 0.01 g
Dimensions	± 0.01 mm

REFERENCES

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 8, Sections 1 to 7.

BISHOP, A. W. and HENKEL, D.S. *The Measurement of Soil Properties in the Triaxial Test*. Second Edition, Arnold.

HEAD, K. *Manual of Soil Laboratory Testing Volume 3*. London and Plymouth: Pentech Press.

ISOTROPICALLY CONSOLIDATED TRIAXIAL COMPRESSION TEST- RECONSTITUTED SAMPLE

GENERAL

Isotropically consolidated triaxial compression tests with pore-water pressure measurements are performed on reconstituted cohesionless specimens with a height to diameter ratio of approximately 2:1. Shearing may be performed under drained or undrained conditions. The tests are performed in general accordance with the procedures of BS 1377 (1990).

The following is a brief outline of the procedure employed for isotropically consolidated triaxial tests on re-compacted soil specimens.

Pre-test triaxial cell checks, including flushing of the drainage and pore pressure measurement systems, are undertaken in accordance with Fugro GeoConsulting Testing Procedure L-T-023.

TEST PROCEDURE

- (i) **Specimen Preparation** – The specimen is reconstituted by compaction in a mould, to a specified density, using the general method proposed by Ladd (1978). This procedure is described in detail in Fugro GeoConsulting Testing Procedure L-T-023. Typically the soil is tamped into the mould in eight layers. The initial layers are compacted to a lower relative density than the target density in order to account for the additional compaction caused by subsequent layers, and so achieve a final uniform dry density across the whole specimen. The specimen is weighed and measured to determine the bulk density. A moisture content determination is carried out on a portion of soil representative of the specimen to be tested; this allows an estimate to be made of the initial air-voids in the specimen.

The specimen is then placed on a saturated porous stone mounted on the base pedestal of the triaxial cell. A similar stone is placed on the top of the specimen beneath a lightly greased top cap before enclosing the soil within a rubber membrane which is sealed with rubber O rings to prevent the ingress of water into the specimen during testing.

Where reconstitution of sand samples by pluviation is required, the procedures for specimen preparation and mounting are described in detail in Fugro GeoConsulting Testing Procedure L-T-046.

- (ii) **Saturation Stage** – The triaxial cell is assembled and filled with de-aired water from a header tank. Specimens are initially flushed with carbon dioxide in order to displace oxygen from the void spaces (carbon dioxide dissolves more readily than oxygen in water). Flushing pressures and durations depend on specimen characteristics. Typically, medium dense to dense clean sand specimens are flushed at 30 kPa and very dense or silty sand specimens at up to 80 kPa. Flushing generally takes place over a period of approximately half an hour.

An initial pore-water pressure reading is taken and an increment of cell pressure is applied, whilst noting the corresponding increase in pore-water pressure measured in the specimen. If the increase in pore-water pressure is less than 0.95 of the increase in cell pressure the specimen is allowed to take in water under back pressure, with an effective stress of 5 kPa, before a further increment of cell pressure is applied. This process is repeated until the ratio of the increase of pore-water pressure to the increase of cell pressure is greater than 0.95. At this point the

specimen is considered to be saturated. Pore-water pressure is normally measured at the base of the specimen and drainage/back pressure is applied to the top of the specimen.

The volume change of the specimen during the saturation phase is calculated as the water inflow less the initial estimated air-voids, since the water which flows into the air-voids is assumed not to change the volume of the specimen.

- (iii) **Isotropic Consolidation Stage** – The specimen is generally isotropically consolidated to stress conditions equivalent to either the effective overburden pressure (p_0'), the effective overburden plus an estimate of foundation surcharge ($p_0' + \Delta p$), or to an estimate of the in-situ mean effective stress (σ_m') defined as:

$$\sigma_m' = \frac{1}{3}(p_0' + 2K_0 p_0')$$

where:

K_0	=	Coefficient of lateral earth pressure
p_0'	=	Effective overburden pressure
Δp	=	Estimated additional vertical stress due to foundation loading

The required effective stress is applied to the specimen via the cell pressure, with a minimum back pressure of 300 kPa being applied to maintain specimen saturation. An initial reading is taken on the volume change indicator and the drainage line is opened to the drained face (top) of the specimen. Readings of volume change and time are recorded automatically via a computer logging system. Pore pressure dissipation is measured at the undrained face (base) of the specimen. Consolidation is continued until the measured pore-water pressure is equal to the applied back pressure and a minimum of an overnight period has been allowed following the end of primary consolidation.

At the end of the consolidation stage the consolidated cross sectional area and length of the specimen are calculated based on the volume changes during the saturation and consolidation phases.

- (iv) **Shearing stage** – On completion of the consolidation stage the drainage system is either closed for undrained shearing, or left open for drained shearing. The load cell is brought into contact with the top cap on the specimen and the displacement transducer is zeroed. A compressive deviator stress is then applied to the specimen, at a constant axial strain rate, via the loading ram. The specimen is sheared at an appropriate strain rate, in the range 0.001 – 10 %/hour. In an undrained test the selected rate allows an equalised pore-water pressure response throughout the specimen. In a drained test the rate is selected to prevent generation of excess pore pressures within the specimen during shearing.

Measurements of load, pore-water pressure, volume change (drained test) and displacement are recorded automatically throughout the test via the computer logging system. Manual checks are also made by technicians. The test is normally terminated when an axial strain of 20% has been reached.

- (v) **End of Test** – On completion of the shearing stage the confining pressure is reduced to atmospheric pressure and the cell fluid is drained. A sketch of the failure shape is generally made before the specimen is removed from the cell. Any unusual specimen conditions potentially affecting interpretation of the test data are carefully noted.

PRESENTATION OF RESULTS

The test data is processed using in-house developed software that incorporates an allowance for the effect of the membrane on the stress-strain behaviour of the specimen. The following results may be presented, depending on project requirements:

Initial specimen dimensions (mm)

Initial moisture content (%) and bulk and dry densities (Mg/m^3).

Graph of cell pressure (kPa) versus pore water pressure (kPa) during saturation.

Graph of root time ($\text{mins}^{0.5}$) versus consolidated volume change (%) during consolidation

Graph of axial strain (%) versus shear stress (kPa) or deviator stress (kPa) during shearing

Graph of axial strain (%) versus excess pore water pressure (kPa) during undrained shearing

Graph of axial strain (%) versus volume change (%) during drained shearing

Graph of p' (kPa) versus q (kPa) or s' (kPa) versus t (kPa)

Graph of σ_r' (kPa) versus shear stress (kPa)

where:

σ_v'	=	effective axial stress
σ_r'	=	effective radial stress
q	=	deviator stress = $(\sigma_v' - \sigma_r')$
t	=	shear stress = $0.5(\sigma_v' - \sigma_r')$
p'	=	effective mean normal stress (triaxial) = $\frac{1}{3}(\sigma_v' + 2\sigma_r')$
s'	=	effective mean normal stress (plane-strain) = $0.5(\sigma_v' + \sigma_r')$

ACCURACY OF MEASUREMENTS

Moisture content and dry density determinations are presented in accordance with the accuracies stated in the relevant procedures.

Pore water pressure	± 1 kPa
Displacement	± 0.01 mm
Load	± 1.0 N
Volume change	± 0.05 ml
Weight	± 0.01 g
Dimensions	± 0.01 mm

REFERENCES

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 8, Sections 1 to 7.

BISHOP, A. W. and HENKEL, D.S. *The Measurement of Soil Properties in the Triaxial Test*. Second Edition, Arnold.

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ANISOTROPICALLY CONSOLIDATED TRIAXIAL COMPRESSION OR EXTENSION TEST – UNDISTURBED SAMPLE

GENERAL

Anisotropically consolidated triaxial tests with pore-water pressure measurement are typically performed on undisturbed specimens with a height to diameter ratio of approximately 2:1. Where possible, specimens are tested at full size. Shearing may be performed under drained or undrained conditions. The tests are performed based on the procedures of BS 1377 (1990) Part 8, modified to conform to the requirements of CEN ISO/TS 17892-9:2004.

The following is a brief outline of the procedures employed for anisotropically consolidated triaxial tests on undisturbed soil specimens.

Pre-test triaxial cell checks, including flushing of the drainage and pore pressure measurement systems, are undertaken in accordance with Fugro GeoConsulting Testing Procedure L-T-023.

TEST PROCEDURE

- (i) **Specimen Preparation** – The sample is extruded from the sample tube and carefully trimmed to a specimen height to diameter ratio of approximately 2:1. The specimen is weighed and measured to determine the bulk density. A moisture content determination is carried out on a portion of soil trimmings representative of the specimen to be tested; this allows an estimate to be made of the initial air-voids in the specimen.

After placing filter paper on the ends of the trimmed specimen, the soil is placed on a saturated porous stone mounted on the base pedestal of the triaxial cell. A similar stone is placed on the top of the specimen beneath a lightly greased top cap. Where required, filter paper drainage strips are placed around the circumference of the specimen before enclosing the soil within a rubber membrane that is sealed with rubber 'O' rings to prevent the ingress of water into the specimen during testing.

Where determination of shear wave velocities using Bender Elements are required, the modified procedures for mounting of the specimen within the triaxial cell are given in Fugro GeoConsulting Test Method L-M-305.

Where measurement of axial and/or radial strain using local transducers is required, these are mounted on the test specimen according to the procedures described in Fugro GeoConsulting Test Method L-M-304.

The triaxial cell wall is lowered around the specimen on to the base of the triaxial cell and locked in position. The externally mounted LVDT, used to measure axial displacement during consolidation and shear is connected to the loading ram. The loading ram is then connected to the specimen top cap via a threaded connection while the load cell output is monitored to ensure minimal vertical stress is applied to the specimen. The top of the loading ram is connected to the vertical actuator which then maintains zero vertical stress on the specimen. The cell is then filled with de-aired water from a header tank.

- (ii) **Saturation Stage** – After assembly of the cell an initial pore-water pressure reading is taken and an increment of cell pressure is applied, whilst noting the corresponding increase in pore-water pressure measured in the specimen. If the increase in pore-water pressure is less than 0.95 of the increase in cell pressure a further increase in cell pressure is applied and the initial process repeated. Where it is not possible to fully saturate the specimen under constant moisture content, the procedures outlined in Fugro GeoConsulting Testing Procedure L-T-023 for saturation under back pressure are applied. For the purposes of the test the specimen is considered saturated when a B value of at least 0.95 is achieved.

Pore-water pressure is typically measured at the base of the specimen and drainage/back pressure is applied to the top of the specimen. The zero deviator stress condition applied during cell assembly is maintained throughout the saturation stage of the test.

The volume change of the specimen during back pressure saturation phase is calculated as the water inflow less the initial estimated air-voids, since the water which flows into the air-voids is assumed not to change the volume of the specimen.

NOTE: Consolidation

The consolidation procedures given below relate to the typically adopted procedure of isotropically consolidating the specimen to the required radial effective stress before applying axial stress increments to achieve the required effective stress ratio.

Where requested, the specimen may be consolidated by combined incremental variation of both axial stress and cell pressure to a specified value of K_0 . In such cases the adopted regime of stress increments is calculated in a similar manner to that outlined in Fugro GeoConsulting Testing Procedure L-T-023 Section 5.3.6 and submitted to the project engineer or client for approval prior to commencement of testing.

- (iii) **Isotropic Consolidation Stage** – The specimen is typically isotropically consolidated to the required radial effective stress.

The required effective stress is applied to the specimen via the cell pressure, with a minimum back pressure of 300 kPa being used to maintain specimen saturation. An initial reading is taken on the volume change indicator and the drainage line is opened to the drained face (top) of the specimen. Readings of volume change and time are recorded automatically via a computer logging system. Pore-water pressure dissipation is recorded on the undrained face (base) of the specimen. Consolidation is continued until the measured pore-water pressure is equal to the applied back pressure and a minimum of an overnight period has been allowed following the end of primary consolidation.

The zero deviator stress condition applied during cell assembly and saturation is maintained throughout the consolidation stage of the test.

- (iv) **Anisotropic Consolidation Stage** – The anisotropic phase of consolidation is accomplished by applying an additional axial load to the specimen via the loading ram. The applied load, which may be compressive or tensile depending on the estimated orientation of the major and minor principal stresses, is implemented in one or more stages based on the magnitude of the final required deviatoric stress. Anisotropic consolidation is undertaken in accordance with Fugro GeoConsulting Testing Procedure L-T-023 Section 5.3.6.

The additional axial load is applied under drained conditions (i.e. with the specimen drainage line open). Readings of pore water pressure, volume change and time are logged automatically via a computer logging system. Time is allowed for the dissipation of excess pore pressure within the specimen and consolidation is considered to be complete when the pore-water pressure is equal to the back pressure and the measured volume change is less than 0.02 %/hour. This procedure is repeated for subsequent anisotropic loading stages until the required effective stress state is achieved. The final axial load increment is typically maintained for a period of at least 24 hours. The new dimensions of the specimen are calculated at the start of each anisotropic loading increment to ensure that the correct load is applied to the specimen to achieve the desired axial stress.

Following anisotropic consolidation the final consolidated cross sectional area and length of the specimen are calculated based on the volume changes during the saturation and isotropic and anisotropic consolidation phases.

- (v) **Shearing Stage** – On completion of the final anisotropic consolidation stage the drainage system is either closed for undrained shearing, or left open for drained shearing. A compressive or tensile deviator stress is then applied to the specimen, at a constant axial strain rate, via the loading ram. The specimen is sheared at an appropriate strain rate, in the range 0.001 – 10 %/hour. In an undrained test the selected rate allows an equalised pore-water pressure response throughout the specimen. In a drained test the rate is selected to prevent generation of excess pore pressures within the specimen during shearing.

Measurements of load, pore-water pressure, volume change (drained test) and displacement are recorded automatically throughout the test via the logging system. Manual checks are also made by technicians. The test is normally terminated when an axial strain of 20% has been reached.

- (vi) **End of Test** – On completion of the shearing stage the confining pressure is reduced to atmospheric pressure and the cell fluid is drained. The specimen is removed from the cell and a sketch of the failure shape is made. The specimen is then photographed, split and described and weighed and dried so that the final moisture content and bulk and dry densities may be determined. Any unusual specimen conditions potentially affecting interpretation of the test data are carefully noted.

PRESENTATION OF RESULTS

The test data is processed using in-house developed software that incorporates an allowance for the effect of the membrane and filter drainage strips on the stress-strain behaviour of the specimen. The following results may be presented, depending on project requirements:

Initial specimen dimensions (mm)

Initial moisture content (%) and bulk and dry densities (Mg/m^3)

Graph of cell pressure (kPa) versus pore-water pressure (kPa) during saturation

Graph of root time ($\text{mins}^{0.5}$) versus consolidated volume change (%) during consolidation

Graph of axial strain (%) versus deviator stress (kPa) during shearing

Graph of axial strain (%) versus excess pore-water pressure (kPa) during undrained shearing

Graph of axial strain (%) versus volume change (%) during drained shearing

Graph of p' (kPa) versus q (kPa) or s' (kPa) versus t (kPa)

Graph of σ_r' (kPa) versus shear stress (kPa)

where:

σ_v'	=	effective axial stress
σ_r'	=	effective radial stress
q	=	deviator stress = $(\sigma_v' - \sigma_r')$
t	=	shear stress = $0.5(\sigma_v' - \sigma_r')$
p'	=	effective mean normal stress (triaxial) = $\frac{1}{3}(\sigma_v' + 2\sigma_r')$
s'	=	effective mean normal stress (plane-strain) = $0.5(\sigma_v' + \sigma_r')$

ACCURACY OF MEASUREMENTS

Moisture content and dry density determinations are presented in accordance with the accuracies stated in the relevant procedures.

Pore-water pressure	± 1 kPa
Displacement	± 0.01 mm
Load	± 1.0 N
Volume change	± 0.05 ml
Weight	± 0.01 g
Dimensions	± 0.01 mm

REFERENCES

BS 1377, 1990. British Standard Methods of Test for Soils for Civil Engineering Purposes, Part 8, Sections 1 to 7.

BISHOP, A. W. and HENKEL, D.S. *The Measurement of Soil Properties in the Triaxial Test*. Second Edition, Arnold.

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CONSOLIDATED CYCLIC TRIAXIAL TEST (STRESS CONTROLLED)

GENERAL

Consolidated cyclic triaxial tests with pore water pressure measurement are typically performed on specimens with a height to diameter ratio of approximately 2:1. Where possible, specimens are tested at full size. The test is undertaken to investigate the effect of cyclic loading on the shear behaviour of the soil. Cyclic loading may be applied under drained or undrained conditions. Tests are performed to an in-house method, based closely on the procedures given in ASTM D3999-91 and ASTM D5311-92.

The specimen set-up and testing procedures are essentially similar to the static triaxial test, except that the axial or radial stress is applied cyclically, generally at a frequency of between 0.1 and 1.0 Hertz. Typically, the number of cycles to failure is determined for a selected combination of average and cyclic shear stresses.

The following is a brief outline of the procedures employed for stress controlled consolidated cyclic triaxial tests on undisturbed or re-compacted soil specimens.

Pre-test triaxial cell checks, including flushing of the drainage and pore pressure measurement systems, are undertaken in accordance with Fugro GeoConsulting Testing Procedure L-T-023.

TEST PROCEDURE

- (i) **Specimen Preparation, Saturation and Consolidation** – For an anisotropically consolidated cyclic triaxial test the specimen is mounted, saturated and consolidated as for a standard consolidated triaxial test, according to the procedures given in Fugro GeoConsulting Test Method L-M-302 (for an undisturbed specimen) or L-M-302a (for a reconstituted specimen). For an isotropically consolidated cyclic triaxial test the same procedures are followed, except that no anisotropic consolidation stage is required.

Where measurement of axial and/or radial strain using local transducers is required, these are mounted on the test specimen according to the procedures described in Fugro GeoConsulting Test Method L-M-304.

- (ii) **Cyclic Pre-Shearing Stage (drained)** – Where cyclic pre-shearing of a reconstituted specimen is required to model densification under small magnitude cyclic loading, this is applied to the specimen after completion of the consolidation stage. The drainage lines are left open and a small cyclic shear stress (τ_{cy}) is applied to the specimen for up to 200 loading cycles. Measurements of load, volume change and axial displacement are recorded automatically throughout pre-shearing via the logging system.
- (iii) **Cyclic Loading Stage (undrained)** – On completion of the consolidation (or pre-shearing) stage, the drainage lines are closed and a combination of initial average shear stress (τ_{av}) and cyclic shear stress (τ_{cy}) is applied to the specimen. These stresses are defined in relation to stress controlled cyclic triaxial testing in Figure 1.

Where required, a static axial stress (τ_{av}) is applied to the specimen prior to the application of cyclic stress. This average axial stress is applied undrained and left to equalise for a period of

time representative of the in-situ loading conditions (nominally 1 hour), as defined by Andersen et al. (1988).

A sinusoidal cyclic axial stress (τ_{cy}) of specified amplitude is then applied to the specimen around the mean τ_{av} value, as shown in Figure 1. The cyclic loading is normally applied at a frequency of 0.1 Hz (a load period of 10 seconds) unless otherwise specified. Frequencies ranging from 0.01 to 2 Hz are available (load periods from 100 to 0.2 seconds). The cyclic stress amplitude may be specified directly or given as the ratio of cyclic axial stress to a reference undrained shear strength as determined from a static undrained triaxial test on an adjacent soil specimen.

Measurements of load, pore-water pressure and displacement are recorded automatically throughout the test via the logging system. Cyclic loading is typically ceased when one of several agreed criteria are reached. These are defined, in relation to stress controlled cyclic triaxial testing, in Figure 2.

- (iv) **Undrained Shearing** – Following termination of the cyclic loading stage the specimen may be sheared statically to determine the post-cyclic undrained shear strength as indicated in Figure 1. The cyclic stage is stopped at the initial shear stress (τ_0) and the specimen is sheared at an appropriate strain rate, in the range 0.001 – 10 %/hour, such as to allow an equalised pore-water pressure response throughout the specimen.

Measurements of load, pore-water pressure, volume change (drained test) and displacement are recorded automatically throughout the test via the logging system. Manual checks are also made by technicians. The test is normally terminated when an axial strain of 20% has been reached.

- (v) **End of Test** – On completion of the cyclic loading or shearing stage (where required) the confining pressure is reduced to atmospheric pressure and the cell fluid is drained. The specimen is removed from the cell and a sketch of the failure shape is made. The specimen is then photographed, split and described and weighed and dried so that the final moisture content and bulk and dry densities may be determined. Any unusual specimen conditions potentially affecting interpretation of the test data are carefully noted.

DEFINITIONS

The initial shear stress after consolidation (τ_0), is defined as:

$$\tau_0 = \frac{\sigma'_{ac} - \sigma'_{rc}}{2} \quad (1)$$

where, σ'_{ac} and σ'_{rc} are the axial and radial effective consolidation stresses, respectively.

The average shear stress (τ_a) is the value about which the cyclic shear stress is applied and is defined as:

$$\tau_a = \tau_0 + \Delta\tau_a \quad (2)$$

where, $\Delta\tau_a$ is the undrained static increase in shear stress applied to the specimen prior to the application of cyclic stress.

The cyclic shear stress (τ_{cy}) is defined as one half of the amplitude of the change in shear stress over one load cycle.

The maximum shear stress during cycling (τ_{max}) is defined as:

$$\tau_{max} = \tau_a + \tau_{cv} \quad (3)$$

The minimum shear stress during cycling (τ_{min}) is defined as:

$$\tau_{min} = \tau_a - \tau_{cv} \quad (4)$$

PRESENTATION OF RESULTS

The test data is processed using in-house developed software in general accordance with the specifications given in ASTM D3999-91 and ASTM D5311-92. The following results may be presented, depending on project requirements:

Consolidation Phase:

Graph of root time ($\text{mins}^{0.5}$) versus consolidated volume change (%)

Cyclic Shearing Phase:

Graph of number of loading cycles (N) versus deviator stress (kPa)

Graph of number of loading cycles (N) versus pore-water pressure ratio (%)

Graph of number of loading cycles (N) versus excess pore-water pressure (kPa)

Graph of number of loading cycles (N) versus axial strain (%)

Graph of axial strain (%) versus deviator stress (kPa)

Graph of p' (kPa) versus q (kPa) or s' (kPa) versus t (kPa)

Graph of σ_r' (kPa) versus shear stress (kPa)

Post-Cyclic Static Shearing Phase:

Graph of axial strain (%) versus deviator stress (kPa)

Graph of axial strain (%) versus excess pore-water pressure (kPa)

Graph of p' (kPa) versus q (kPa) or s' (kPa) versus t (kPa)

where:

σ_v'	=	effective axial stress
σ_r'	=	effective radial stress
q	=	deviator stress = $(\sigma_v' - \sigma_r')$
t	=	shear stress = $0.5(\sigma_v' - \sigma_r')$

$$\begin{aligned} p' &= \text{effective mean normal stress (triaxial)} = \frac{1}{3}(\sigma_v' + 2\sigma_r') \\ s' &= \text{effective mean normal stress (plane-strain)} = 0.5(\sigma_v' + \sigma_r') \end{aligned}$$

ACCURACY OF MEASUREMENTS

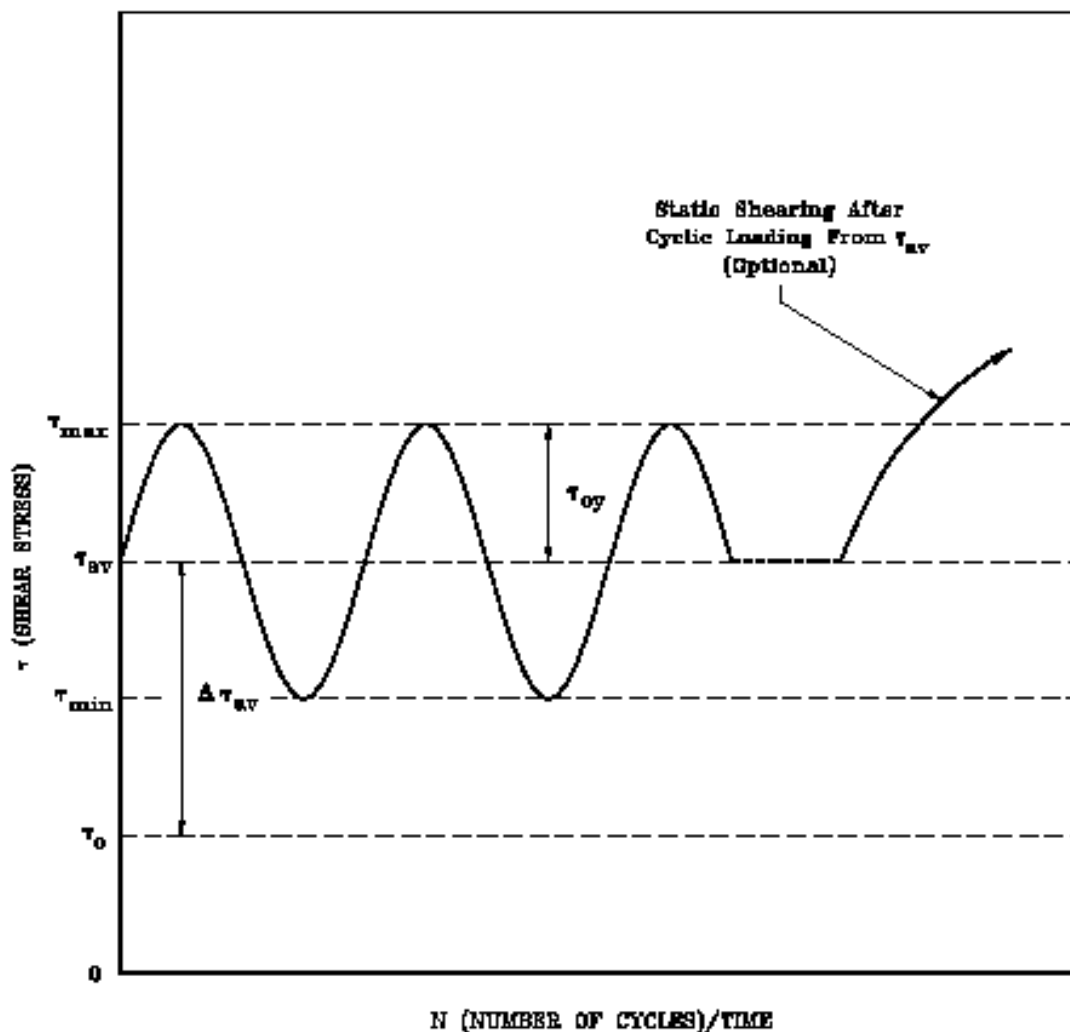
Pore-water pressure	± 1 kPa
Displacement	± 0.01 mm
Load	± 1.0 N
Volume change	± 0.05 ml
Weight	± 0.01 g
Dimensions	± 0.01 mm
Time	± 0.5 s

REFERENCES

ANDERSEN, K.H., KLEVEN, A. and HEIEN, D., 1988. Cyclic soil data for design of gravity structures. *American Society of Civil Engineers, Proceedings*, **114** (5), May 1988, pp. 517-539.

ASTM D3999-91, 2003. *Standard Test Method for the Determination of the Modulus and Damping Properties of Soils Using the Cyclic Triaxial Apparatus*. ASTM International, West Conshohocken, PA, DOI: 10.1520/ D3999-91.

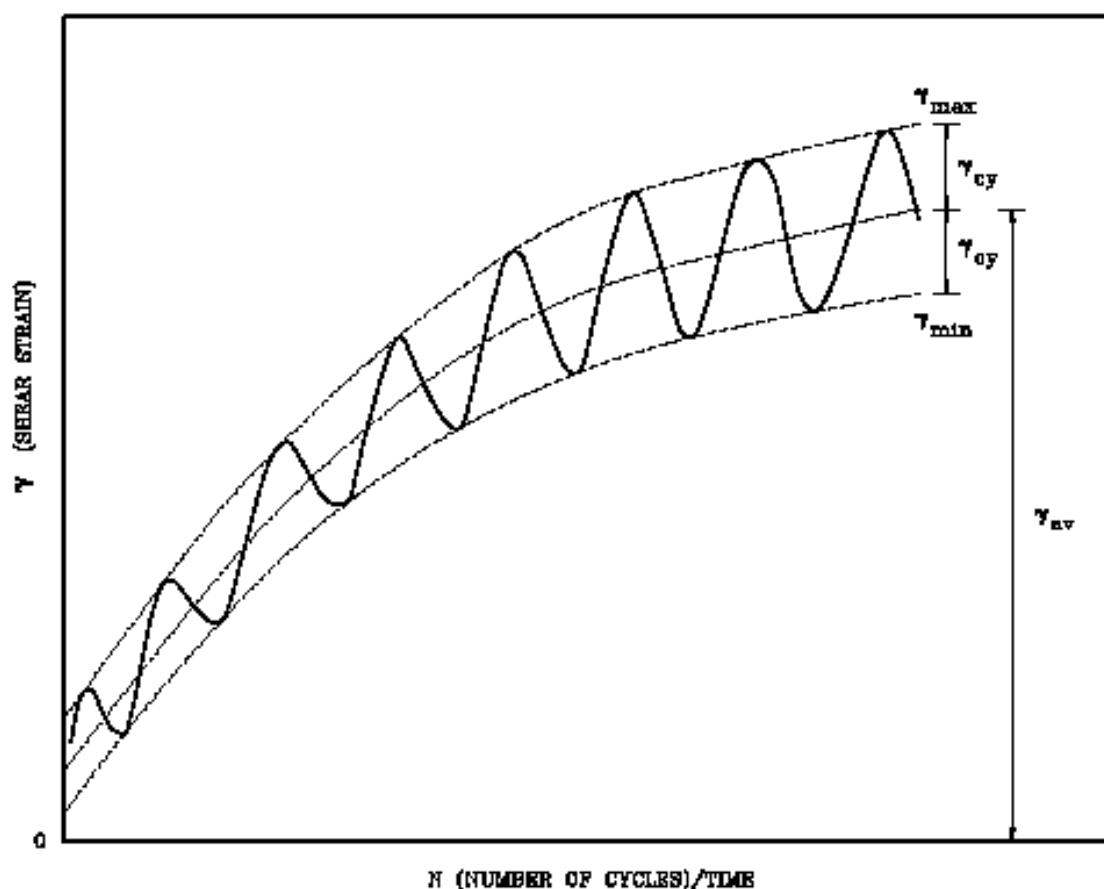
ASTM D5311-92, 2004. *Standard Test Method for Load Controlled Cyclic Triaxial Strength of Soil*. ASTM International, West Conshohocken, PA, DOI: 10.1520/ D5311-92.



Definitions of Terms :-

- τ_{max} = Maximum Shear Stress During Cycling
- τ_{av} = Average Shear Stress During Cycling
- τ_{min} = Minimum Shear Stress During Cycling
- τ_0 = Initial Shear Stress After Consolidation (Triaxial Tests)
- τ_{cy} = Cyclic Shear Stress
- $\Delta\tau_{av} = \tau_{av} - \tau_0$

Figure 1. Definition of Terms for Cyclic Triaxial Testing



Tests are Normally Stopped When :-

For Clay Soils

- i) The Cyclic Shear Strain Amplitude Exceeds 15% ie: $\gamma_{cy} = \frac{\gamma_{max} - \gamma_{min}}{2} > 15\%$
- ii) The Average Shear Strain Amplitude Exceeds 15% ie: $\gamma_{av} = \frac{\gamma_{max} + \gamma_{min}}{2} > 15\%$
- iii) 1500 Cycles of Shearing Have Been Applied
- iv) The Applied Shear Stress Ratio Cannot be Maintained to Within 10% of the Prescribed Ratio

For Sand Soils

- i) The Cyclic Shear Strain Amplitude Exceeds 3.75% ie: $\gamma_{cy} = \frac{\gamma_{max} - \gamma_{min}}{2} > 3.75\%$
- ii) The Average Shear Strain Amplitude Exceeds 3.75% ie: $\gamma_{av} = \frac{\gamma_{max} + \gamma_{min}}{2} > 3.75\%$
- iii) The Pore-Water Pressure Generated During the Test Effectively Reaches the Vertical Consolidation Pressure, σ_{vd}
- iv) 1500 Cycles of Shearing Have Been Applied
- v) The Applied Shear Stress Ratio Cannot be Maintained to Within 10% of the Prescribed Ratio

Figure 2. Definitions of Failure for Cyclic Triaxial Testing

DIRECT SIMPLE SHEAR TEST

GENERAL

Consolidated direct simple shear (DSS) tests are typically undertaken on specimens prepared to dimensions of approximately 19 mm height and 67 mm internal diameter. The test is intended to simulate plane strain conditions in which radial deformation is prevented during the test but the specimen is allowed to deform in simple shear. Shearing may be performed under constant volume or constant vertical stress conditions. Tests are performed to an in-house method, based closely on the procedures given in ASTM D6528-07, with modifications recommended by the Norwegian Geotechnical Institute.

The constant volume condition is equivalent to the undrained condition for saturated specimens. This condition is achieved by continuous adjustment of the vertical stress acting on the horizontal surface during shearing, so that the height of the specimen remains constant. It has been suggested that the change in vertical stress during shearing can be equated to the change in pore water pressure in a truly undrained test (Bjerrum and Landva, 1966).

The following is a brief outline of the procedures employed for DSS tests on undisturbed and re-compacted soil specimens.

TEST PROCEDURE

- (i) **Specimen Preparation – Cohesive Specimens** – The undisturbed specimen is extruded directly into a purpose built cutting ring with an internal diameter of either 50 or 67 mm and a height of 19 mm. The specimen is then transferred to the base platen of the simple shear system, sealed in a circular membrane and surrounded by a stack of rigid, low friction rings. The upper loading platen of the system is then lowered into contact with the top of the specimen and a small vertical seating stress is applied. The membrane is sealed top and bottom with rubber O-rings.

Cohesionless Specimens – The specimen is prepared to a specified relative density at a known optimum moisture content using the Ladd Undercompaction technique (Ladd, 1978). The soil is compacted, in three or five layers, into a specially designed mould to give a specimen of the required relative density. The specimen is then transferred, together with membrane and confining rings, into the simple shear device. The upper loading platen of the system is then lowered into contact with the top of the specimen and a small vertical seating stress is applied. The membrane is then sealed top and bottom with rubber O-rings.

Both the base and upper loading platens of the simple shear device incorporate a porous disc to allow drainage from the specimen. A selection of disc interface profiles is available, based on soil type, to ensure full transfer of shear stress to the specimen during shearing. For testing of hard cohesive specimens, skirted platens may also be used to prevent interface slippage; this is avoided where possible due to the large strain non-uniformity introduced to the specimen during shearing.

- (ii) **Consolidation** – The specimen is typically consolidated under a vertical stress equivalent to the estimated maximum in-situ pre-consolidation pressure (p_c') and then unloaded to the estimated in-situ effective overburden pressure (p_0'). For a normally consolidated specimen these pressures are equal and no unloading stage is required. During initial loading, the specimen and porous

discs are inundated with water at a specified stress increment, sufficient to prevent swelling of the specimen.

During consolidation and unloading (if required) readings of specimen height change and time are recorded automatically via a computer logging system to enable the post-consolidation specimen density to be calculated. Consolidation is continued until a sufficient period (depending on soil type) has been allowed following the end of primary consolidation. The minimum period required is determined according to ASTM D6528-07.

- (iii) **Undrained Shearing** – On completion of consolidation and unloading (if required), the platen drainage lines are closed and a horizontal shear stress is applied to the specimen at a constant shear strain rate via the base loading platen. Specimens may typically be sheared at a rate of strain of between two and ten per cent per hour, depending on project requirements, although a shear strain rate of 3 %/hour is generally taken as standard. The test is normally terminated at a shear strain of 30%.

In order to simulate undrained conditions, vertical movement of the top platen is prevented during shear in order to keep the specimen volume constant throughout the test. Changes in pore-water pressure are then inferred from the normal stress required to maintain the specimen at constant volume. It should be noted that there is no provision for controlling drainage or measuring pore-water pressure during the test and that back pressure cannot be applied to the specimen.

- (iv) **Drained Shearing** – Drained shearing is performed, under constant vertical stress, by allowing vertical movement of the top platen and by shearing the specimen at a constant rate of shear strain sufficient to allow full dissipation of excess pore water pressure generated within the specimen during shear. Shear strain rates are calculated according to the recommendations given in ASTM D6528-07. The test is normally terminated at a shear strain of 30%.

PRESENTATION OF RESULTS

The test data is processed using in-house developed software and results are presented in accordance with ASTM D6528-07. The following results may be presented, depending on project requirements:

Graph of root time ($\text{mins}^{0.5}$) versus vertical strain (%) during consolidation
Graph of shear strain (%) versus horizontal shear stress (kPa)
Graph of shear strain (%) versus excess pore-water pressure (kPa) for an undrained test
Graph of shear strain (%) versus vertical strain (%) for a drained test
Graph of effective vertical stress (kPa) versus horizontal shear stress (kPa)
Graph of shear strain (%) versus secant shear modulus (MPa)

ACCURACY OF MEASUREMENTS

Load	$\pm 1.0 \text{ N}$
Horizontal stress	$\pm 1 \text{ kPa}$
Vertical stress	$\pm 1 \text{ kPa}$
Deformation	$\pm 0.01 \text{ mm}$
Time	$\pm 0.5 \text{ s}$

Weight	± 0.01 g
Dimensions	± 0.01 mm
Time	± 0.5 s

REFERENCES

ASTM D6528-07, 2007. *Standard Test Method for Consolidated Undrained Direct Simple Shear Testing of Cohesive Soils*. ASTM International, West Conshohocken, PA, DOI: 10.1520/ D6528-07.

BJERRUM, I. and LANDVA, A., 1966. Direct simple shear tests on a Norwegian quick clay. *Geotechnique*, **16** (1), pp. 1-20.

LADD, R. S., 1978. Preparing test specimens using undercompaction. *Geochemical Testing Journal*, GTJODJ, **1** (1), pp. 16-23.

CYCLIC DIRECT SIMPLE SHEAR TEST (STRESS CONTROLLED)

GENERAL

Consolidated cyclic direct simple shear (CSS) tests are typically undertaken on specimens prepared to dimensions of approximately 19 mm height and 67 mm internal diameter. The test is performed to investigate the effect of cyclic loading on the simple shear behaviour of the soil, where plane strain conditions are simulated. Cyclic shearing may be performed under constant volume or constant vertical stress conditions. Tests are performed to an in-house method, based closely on the procedures given in ASTM D6528-07, with modifications recommended by the Norwegian Geotechnical Institute.

The constant volume condition is equivalent to the undrained condition for saturated specimens. This condition is achieved by continuous adjustment of the vertical stress acting on the horizontal surface during shearing, so that the height of the specimen remains constant. It has been suggested that the change in vertical stress during shearing can be equated to the change in pore water pressure in a truly undrained test (Bjerrum and Landva, 1966).

The specimen set-up and testing procedures are essentially similar to the static direct simple shear test, except the horizontal loading is applied cyclically, generally at a frequency of between 0.1 and 1.0 Hertz. Typically, the number of cycles to failure is determined for a selected combination of average and cyclic shear stresses.

The following is a brief outline of the procedures employed for stress controlled cyclic simple shear tests on undisturbed and re-compacted soil specimens.

TEST PROCEDURE

- (i) **Specimen Preparation – Cohesive Specimens** – The undisturbed specimen is extruded directly into a purpose built cutting ring with an internal diameter of either 50 or 67 mm and a height of 19 mm. The specimen is then transferred to the base platen of the simple shear system, sealed in a circular membrane and surrounded by a stack of rigid, low friction rings. The upper loading platen of the system is then lowered into contact with the top of the specimen and a small vertical seating stress is applied. The membrane is sealed top and bottom with rubber O-rings.

Cohesionless Specimens – The specimen is prepared to a specified relative density at a known optimum moisture content using the Ladd Undercompaction technique (Ladd, 1978). The soil is compacted, in three or five layers, into a specially designed mould to give a specimen of the required relative density. The specimen is then transferred, together with membrane and confining rings, into the simple shear device. The upper loading platen of the system is then lowered into contact with the top of the specimen and a small vertical seating stress is applied. The membrane is then sealed top and bottom with rubber O-rings.

Both the base and upper loading platens of the simple shear device incorporate a porous disc to allow drainage from the specimen. A selection of disc interface profiles is available, based on soil type, to ensure full transfer of shear stress to the specimen during shearing. For testing of hard cohesive specimens, skirted platens may also be used to prevent interface slippage; this is

avoided where possible due to the large strain non-uniformity introduced to the specimen during shearing.

- (ii) **Consolidation** – The specimen is typically consolidated under a vertical stress equivalent to the estimated maximum in-situ pre-consolidation pressure (p_c') and then unloaded to the estimated in-situ effective overburden pressure (p_0'). For a normally consolidated specimen these pressures are equal and no unloading stage is required. During initial loading, the specimen and porous discs are inundated with water at a specified stress increment, sufficient to prevent swelling of the specimen.

During consolidation and unloading (if required) readings of specimen height change and time are recorded automatically via a computer logging system to enable the post-consolidation specimen density to be calculated. Consolidation is continued until a sufficient period (depending on soil type) has been allowed following the end of primary consolidation. The minimum period required is determined according to ASTM D6528-07.

- (iii) **Cyclic Loading** – On completion of consolidation and unloading (if required), the platen drainage lines are closed and a combination of initial average shear stress (τ_{av}) and cyclic shear stress (τ_{cy}) is applied to the specimen. These stresses are defined in relation to stress controlled cyclic simple shear testing in Figure 1.

Where required, a static shear stress (τ_{av}) is applied to the specimen prior to the application of cyclic stress. This average shear stress is applied undrained and left to equalise for a period of time representative of the in-situ loading conditions (nominally 1 hour), as defined by Andersen et al. (1988).

A sinusoidal cyclic shear stress (τ_{cy}) of specified amplitude is then applied to the specimen around the mean τ_{av} value, as shown in Figure 1. The cyclic loading is normally applied at a frequency of 0.1 Hz (a load period of 10 seconds) unless otherwise specified. Frequencies ranging from 0.01 to 2 Hz (load periods from 100 to 0.5 seconds) are available. The cyclic stress amplitude may be specified directly or given as the ratio of cyclic shear stress to a reference undrained shear strength as determined from a static simple shear test on an adjacent soil specimen.

In order to simulate undrained conditions, vertical movement of the top platen is prevented during shear in order to keep the specimen volume constant throughout the test. Changes in pore-water pressure are then inferred from the normal stress required to maintain the specimen at constant volume. It should be noted that there is no provision for controlling drainage or measuring pore-water pressure during the test and that back pressure cannot be applied to the specimen.

Cyclic loading is typically ceased when one of several agreed criteria are reached. These are defined, in relation to stress controlled cyclic triaxial testing, in Figure 2.

- (iv) **Undrained Shearing** – Following termination of the cyclic loading stage the specimen may be sheared statically to failure to determine the post-cyclic undrained shear strength as indicated in Figure 1. A horizontal shear stress is applied to the specimen at a constant shear strain rate via the base loading platen. Specimens may typically be sheared at a rate of strain of between two and ten per cent per hour, depending on project requirements, although a shear strain rate of 3 %/hour is generally taken as standard. The test is normally terminated at a shear strain of 30%.

DEFINITIONS

The average shear stress (τ_a) is the value about which the cyclic shear stress is applied and is defined as:

$$\tau_a = \tau_0 + \Delta\tau_a \quad (1)$$

where, $\Delta\tau_a$ is the undrained static increase in shear stress applied to the specimen prior to the application of cyclic stress.

The cyclic shear stress (τ_{cy}) is defined as one half of the amplitude of the change in shear stress over one load cycle.

The maximum shear stress during cycling (τ_{max}) is defined as:

$$\tau_{max} = \tau_a + \tau_{cv} \quad (2)$$

The minimum shear stress during cycling (τ_{min}) is defined as:

$$\tau_{min} = \tau_a - \tau_{cv} \quad (3)$$

PRESENTATION OF RESULTS

The test data is processed using in-house developed software. The following results may be presented, depending on project requirements:

Consolidation Phase:

Graph of root time ($\text{mins}^{0.5}$) versus vertical strain (%) during consolidation

Cyclic Shearing Phase:

Graph of number of loading cycles (N) versus horizontal shear stress (kPa)

Graph of number of loading cycles (N) versus pore-water pressure ratio (%)

Graph of number of loading cycles (N) versus excess pore-water pressure (kPa)

Graph of number of loading cycles (N) versus shear strain (%)

Graph of effective vertical stress (kPa) versus horizontal shear stress (kPa)

Graph of shear strain (%) versus horizontal shear stress (kPa)

Post-Cyclic Static Shearing Phase:

Graph of shear strain (%) versus horizontal shear stress (kPa)

Graph of shear strain (%) versus excess pore-water pressure (kPa)

Graph of effective vertical stress (kPa) versus horizontal shear stress (kPa)

ACCURACY OF MEASUREMENTS

Load	± 1.0 N
Horizontal stress	± 1 kPa
Vertical stress	± 1 kPa
Deformation	± 0.01 mm
Time	± 0.5 s
Weight	± 0.01 g
Dimensions	± 0.01 mm
Time	± 0.5 s

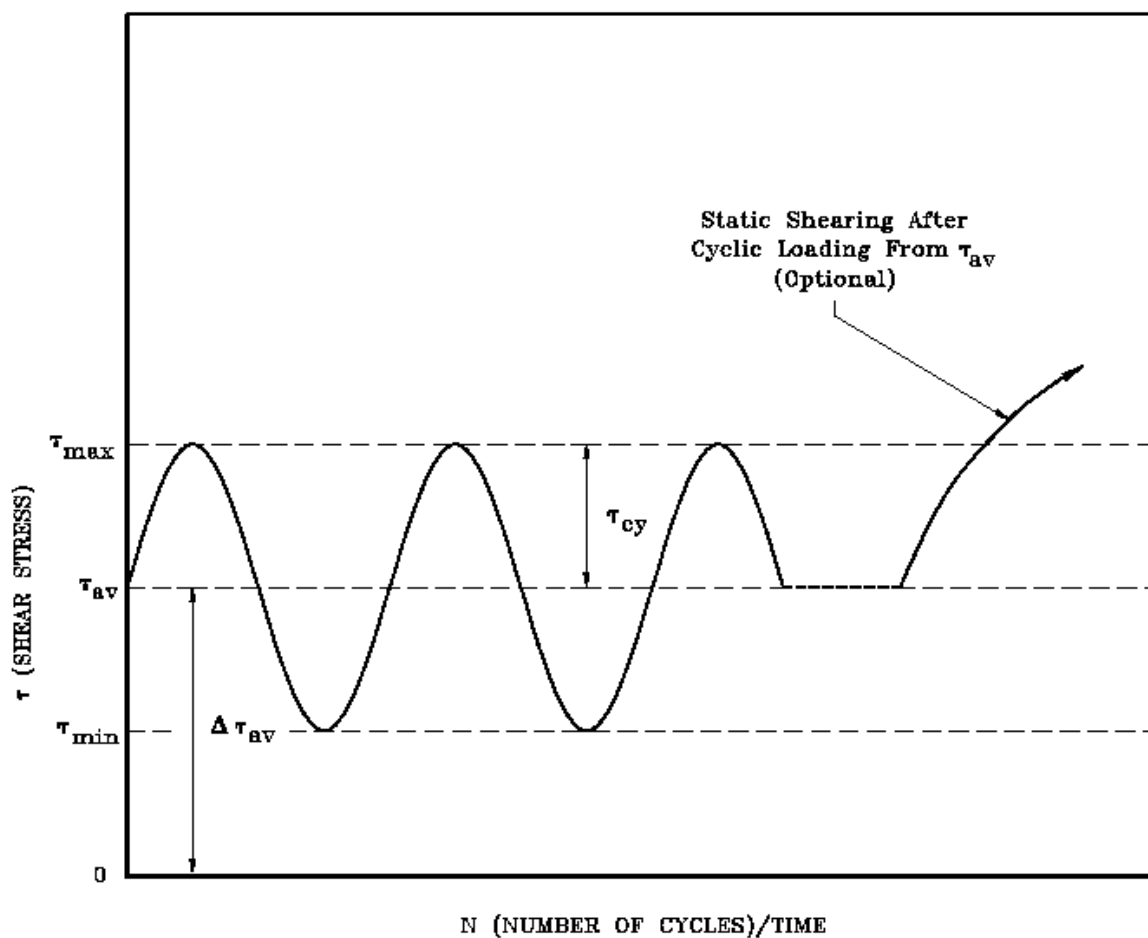
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LADD, R. S., 1978. Preparing test specimens using undercompaction. *Geochemical Testing Journal*, GTJODJ, **1** (1), pp. 16-23.



Definitions of Terms :-

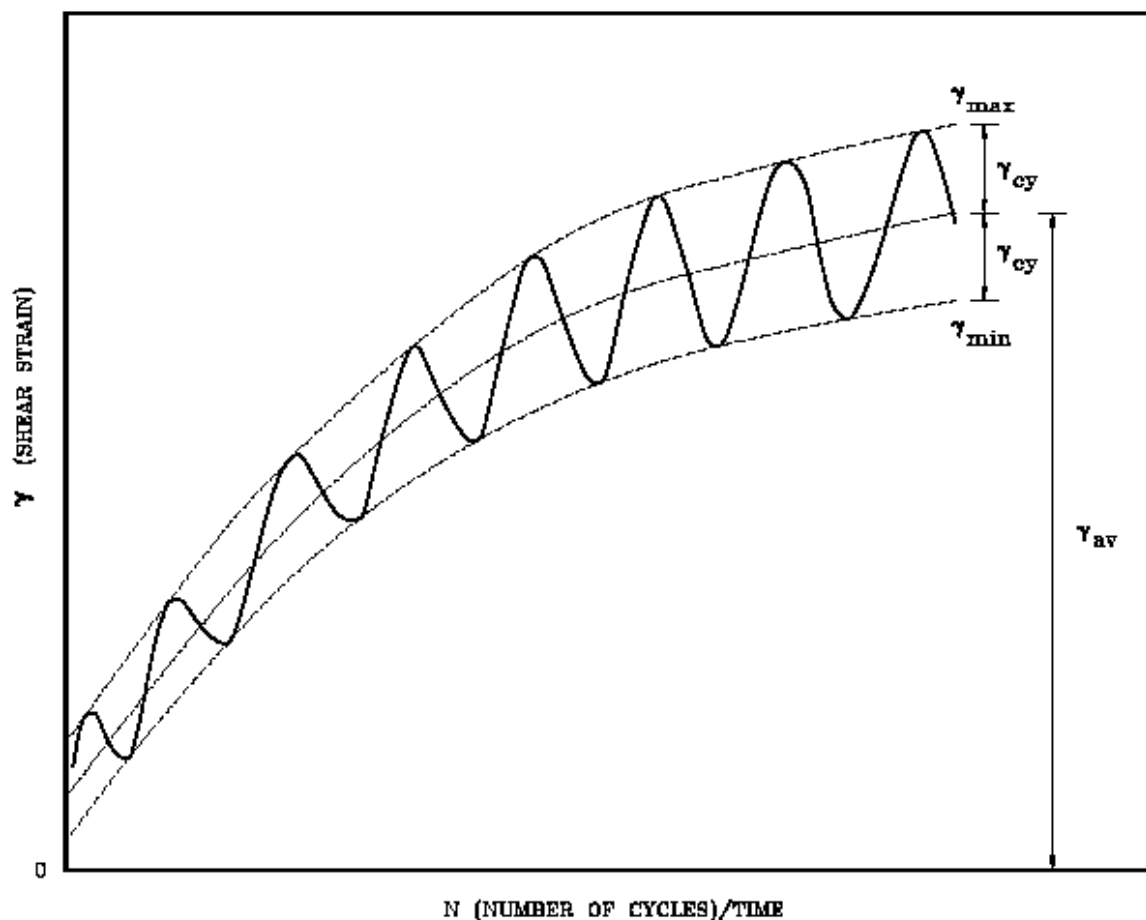
τ_{max} = Maximum Shear Stress During Cycling

τ_{av} = Average Shear Stress During Cycling

τ_{min} = Minimum Shear Stress During Cycling

τ_{cy} = Cyclic Shear Stress

Figure 1. Definition of Terms for Cyclic Testing



Tests are Normally Stopped When :-

For Clay Soils

- i) The Cyclic Shear Strain Amplitude Exceeds 15% ie: $\gamma_{cy} = \frac{\gamma_{max} - \gamma_{min}}{2} > 15\%$
- ii) The Average Shear Strain Amplitude Exceeds 15% ie: $\gamma_{av} = \frac{\gamma_{max} + \gamma_{min}}{2} > 15\%$
- iii) 1500 Cycles of Shearing Have Been Applied

For Sand Soils

- i) The Cyclic Shear Strain Amplitude Exceeds 3.75% ie: $\gamma_{cy} = \frac{\gamma_{max} - \gamma_{min}}{2} > 3.75\%$
- ii) The Average Shear Strain Amplitude Exceeds 3.75% ie: $\gamma_{av} = \frac{\gamma_{max} + \gamma_{min}}{2} > 3.75\%$
- iii) The Pore-Water Pressure Generated During the Test Effectively Reaches the Vertical Consolidation Pressure, σ_{vc}'
- iv) 1500 Cycles of Shearing Have Been Applied

Figure 2. Definitions of Failure for Cyclic Testing

SECTION B.12

LIST OF SYMBOLS AND CLASSIFICATION SYSTEM USED

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B.12 LIST OF SYMBOLS AND CLASSIFICATION SYSTEM USED

B.12.1 LIST OF SYMBOLS AND TERMS

a	=	attraction (in terms of effective stress) (Use List Style)
A_f	=	Skempton's pore-water pressure parameter at failure
B	=	Skempton's pore-pressure parameter
BSF	=	below seafloor
(CC)	=	core catcher 'tulip' used in sample tube
c'	=	cohesion (in terms of effective stress)
c_v	=	coefficient of consolidation
CAUc	=	anisotropically consolidated undrained triaxial compression test
CAUe	=	anisotropically consolidated undrained triaxial extension test
CIU	=	isotropically consolidated undrained triaxial test
CPT	=	cone penetration test
CRS	=	constant rate of strain 'oedometer' test
D	=	Janbu's 'D' parameter
D_r	=	relative density
DSS	=	static direct simple shear test
CSS	=	cyclic direct simple shear test
E_d	=	drained elastic modulus
E_u	=	undrained elastic modulus
E_{50}	=	secant elastic modulus (measured at half the deviator stress at failure)
e	=	voids ratio
e_o	=	initial voids ratio
FC	=	fall cone
G	=	shear modulus
I_p	=	plasticity index = $w_L - w_p$
k	=	coefficient of permeability
L & F	=	Ladd et al. (1977)
LI	=	liquidity index
LL	=	liquid limit
LV	=	labvane
M	=	constrained modulus (one-dimensional consolidation)
m	=	Janbu (1985) deformation parameter
m_v	=	coefficient of compressibility
M & K	=	Mayne and Kulhawy (1982)
MC	=	moisture content

n	=	porosity
N	=	number of cycles
N _F	=	number of cycles to failure
N _{kt}	=	cone factor (q_{net}/s_u)
OCR	=	overconsolidation ratio (p_c'/p_o')
OED	=	incremental oedometer test
K _o	=	coefficient of earth pressure at rest
P72	=	Piston sample in sample tube of 72mm internal diameter
PD	=	particle density
PI	=	plasticity index
PL	=	plastic limit
PP	=	pocket penetrometer
PSD	=	particle size distribution
p'	=	$(\sigma_1' + 2K_o \sigma_3')/3$
p _o '	=	effective overburden pressure in situ
Δp	=	$p_c' - p_o'$
p _c '	=	vertical effective pre-consolidation pressure in situ
p _r '	=	reference stress for Janbu (1985) approach to settlement calculation
q	=	$(\sigma_1' - \sigma_3')$
s'	=	$(\sigma_1' + \sigma_3')/2$
SD	=	standard deviation
S & N	=	Skempton and Northey (1952)
S _r	=	degree of saturation
s _u	=	undrained shear strength
s _{ua}	=	undrained shear strength from CAUc test
s _{ud}	=	undrained shear strength from DSS test
s _{uu}	=	undrained shear strength from UU test
s _{up}	=	undrained shear strength from CAUe test
s _{u(pp)}	=	undrained shear strength from pocket penetrometer test
s _{u(R)}	=	remoulded shear strength
(TW)	=	Thick walled shelby tube
t	=	$(\sigma_1 - \sigma_3)/2$
TV	=	torvane
UU	=	unconsolidated undrained triaxial compression test
u	=	pore-water pressure
u _f	=	pore-water pressure at failure
u _N	=	pore-water pressure after N cycles
W72	=	WIP sample in sample tube of 72mm internal diameter

W_{50}	=	WIP sample in sample tube of 50mm internal diameter
w	=	water content
w_i	=	initial water content
w_f	=	final water content
w_L	=	liquid limit
w_p	=	plastic limit
$\Delta\sigma_1$	=	change in major principal stress, σ_{ε_1}
$\Delta\sigma_2$	=	change in minor principal stress, σ_2
$\Delta\sigma_3$	=	change in minor principal stress, σ_3
$\Delta\sigma_d$	=	change in deviator stress ($\Delta\sigma_a - \Delta\sigma_r$)
$\Delta\sigma_r$	=	change in total radial stress
$\Delta\sigma_r'$	=	change in effective radial stress
$\Delta\sigma_m'$	=	change in mean effective stress
$\Delta\sigma_v$	=	change in total vertical stress
$\Delta\sigma_v'$	=	change in effective vertical stress
Δu	=	change in pore-water pressure
Δu_f	=	change in pore-water pressure at failure
ε_{50}	=	vertical strain at half the maximum deviator stress
ε_v	=	vertical strain
ε_{vc}	=	vertical strain after consolidation
ε_{vf}	=	vertical strain at failure
ε_{vol}	=	volumetric strain
$\tan \phi$	=	internal friction
$\tan \rho$	=	mobilised internal friction
β	=	ratio of pore-water pressure generation in cyclic test relative to number of cycles and confining pressure.
β	=	pore-water pressure correction factor (CPTu)
ϕ_u	=	undrained friction angle
ϕ_d	=	drained friction angle
ϕ'	=	effective friction angle
ϕ_{cv}	=	friction angle at constant volume
ϕ_{res}	=	ultimate friction angle at large strain
γ_w	=	unit weight of water
γ_{av}	=	average cyclic shear strain
γ_{cy}	=	cyclic shear strain
γ_f	=	shear strain at failure
γ'	=	effective unit weight of soil
γ_d	=	unit dry weight of soil

γ_{dmin}	=	minimum dry unit weight of soil
γ_{dmax}	=	maximum dry unit weight of soil
γ_N	=	cyclic shear strain after N cycles
γ_s	=	unit weight of solid particles
ρ	=	density of soil
ρ_s	=	density of solid particles
σ_1'	=	effective major principal stress
σ_3'	=	effective minor principal stress
σ_c'	=	effective consolidation pressure (isotropic)
σ_r'	=	radial effective stress
σ_{rc}'	=	radial effective consolidation stress
σ_v'	=	vertical effective stress
σ_{vc}'	=	vertical effective consolidation stress
σ_{oct}'	=	octahedral stress
τ	=	shear stress
τ_{av}	=	average shear stress during cyclic test
τ_{cy}	=	cyclic shear stress
τ_{res}	=	residual horizontal shear stress at large strain
#	=	test performed offshore

B.12.2 SOIL CLASSIFICATION SYSTEM

The limits of consistency that have been adopted for the predominantly cohesive soils are based on BS 5930 (1999), and are presented in Table B.12-1. Note that an additional range for "Very Hard" soils is included to cover the full range of strength of soils.

Table B.12-1: Ranges of Shear Strength for Soil Description

Consistency	Shear Strength [kPa]
Very soft	0 – 20
Soft	20 – 40
Firm	40 – 75
Stiff	75 – 150
Very Stiff	150 – 300
Hard	300 – 600
Very Hard	Greater than 600

The limits of consistency adopted in sand soils are based on the ranges presented in Table B.12-2 (Lambe and Whitman, 1969).

Table B.12-2: Ranges of Relative Density for Soil Description

Consistency	Relative Density [%]
Very Loose	0 – 15
Loose	15 – 35
Medium Dense	35 – 65
Dense	65 – 85
Very Dense	85 – 100

B.12.3 CHALK CLASSIFICATION SYSTEM

The limits of consistency that have been adopted for the rock core samples are based on CIRIA C574 (2002) for structureless and structured chalk.

If the samples are a mixture of a fine chalk soil matrix and chalk clasts they are determined to be structureless (Grade D) and are described by the content of fine soil shown in Table B.12-3. The chalk clasts were then further described according to on BS 5930 and EN ISO 14689-1 methods Table B.12-4.

Table B.12-3: Fine Soil Behaviour for Structureless Chalk Description

% of Fine Soil	Description
< 35 %	Clast Dominated (Dc)
> 35 %	Matrix Dominated (Dm)

Table B.12-4: Rock Material Strength (BS 5930) and BS EN 14689-1

Description	Field Identification
Extremely Weak	Gravel-sized lumps may be crushed between finger and thumb. Can be indented by finger nail
Very Weak	Crumbles under firm hammer blows, can be peeled by knife
Weak	Can be peeled with difficulty, hammer makes shallow indents
Medium Strong	Cannot be peeled with knife, rock can be broken by a single hammer blow
Strong	When resting on a solid surface, rock can be broken by hammer blows
Very Strong	Requires many hammer blows to break specimen
Extremely Strong	Rock rings on hammer blows. Only broken by sledge hammer

If there is visible structure within the chalk (Grades A, B and C) the samples are described by assessing the intact dry density, the discontinuity aperture and discontinuity spacing shown in Tables B.12-5 to B.12-7 respectively.

Table B.12-5: Intact Dry Density Ranges for Structured Chalk Description

Field Identification	Density Scale	Density Range [Mg/m ³]
30-40 mm thick fragments crush by finger pressure and remould to putty	Low density	<1.55
30-40 mm thick fragments break with both hands: will not crush with finger pressure	Medium density	1.55 – 1.70
Cannot break 30-40 mm thick fragments in two: difficult to break slabs < 10 mm thick and corners/edges of lumps	High density	1.70 – 1.95
Unable to break by hand: 100 mm diameter lump held in hand broken by single hammer blow	Very high density	>1.95

Table B.12-6: Discontinuity Aperture Ranges for Structured Chalk Description

Typical Discontinuity Aperture [mm]	Grade
No infill	A
Infilled < 3	B
Infilled > 3	C

Table B.12-7: Discontinuity Spacing Ranges for Structured Chalk Description

Typical Discontinuity Spacing [mm]	Suffix
> 600	1
> 200 – < 600	2
> 60 – < 200	3
> 20 – < 60	4
< 20	5

SECTION B.13

REFERENCES

B.13 REFERENCES

1

B.13 REFERENCES

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SECTION B.14

GUIDELINES ON USE OF REPORT

B.14 GUIDELINES ON USE OF REPORT

1

B.14 GUIDELINES ON USE OF REPORT

This report and the assessment carried out in connection with the report (together the "Services") were compiled and carried out by Fugro GeoConsulting Limited ("FGCLTD") for E.ON Climate and Renewables (the "Client") in accordance with the terms of a contract between FGCLTD and the Client. The Services were performed by FGCLTD 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 FGCLTD 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 FGCLTD and the Client.

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It is FGCLTD'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 FGCLTD's review and advice shall be at the Client's sole and own risk. Should FGCLTD be requested, and FGCLTD agree, to review the report after the date hereof, FGCLTD shall be entitled to additional payment at the then existing rates or such other terms as may be agreed between FGCLTD and the Client.

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B.15 LABORATORY AND IN-SITU DATA REPORT FROM FUGRO ALLUVIAL LIMITED (FAOL)

B.15.1 SUMMARY

This report contains factual data focusing on the data gathered from the M/V Willendeavour during the Rampion offshore wind farm site investigation.

RAMPION OFFSHORE WINDFARM ENGLISH CHANNEL, UK

Survey Period: 06 April – 08 April 2011

Report Number: 110515-1 (01)

Volume 1 of 1: Geotechnical Laboratory and In-Situ Data

Prepared for: EON Climate and
Renewable UK
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Client Reference:

1	Draft	JO	AMP	AMP	21/06/11
Rev.	Description	Prepared	Checked	Approved	Date

**GEOTECHNICAL REPORT
GEOTECHNICAL LABORATORY AND IN-SITU DATA
RAMPION OFFSHORE WINDFARM
ENGLISH CHANNEL, UK**

Ultimate Client	EON Climate and Renewable UK Developments Limited
Client Address	Westwood Way Westwood Business Park Coventry CV4 8LG UK
Fugro Report No.	110515-1
Volume	1 of 1
Digital Report Image	Fugro can only be held responsible for hand-signed paper copies of this document.
Confidentiality	Report distribution is restricted to project participants approved by the Client

Abstract:

A geotechnical site investigation was performed by Fugro Alluvial Offshore Limited to provide soils data for the Rampion Windfarm.

This report presents;

An overview of the site investigation

In-Situ test data

Geotechnical Logs

Laboratory Test Results

Report Issue No.	Date	Report Status	Checked	Approved
1	21/06/2011	DRAFT	<i>[Signature]</i>	<i>[Signature]</i>

Our ref: 110515-1 (01)

Date: 21th June 2011

EON Climate and Renewable UK Developments Limited
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UK

Dear Sir(s)

GEOTECHNICAL REPORT

RAMPION WINDFARM

SHALLOW SAMPLING (VIBROCORING), CONTINUOUS PCPT

This report presents data from a geotechnical investigation for the Rampion Windfarm. The report was prepared in accordance with the contract and subsequent communication. Reporting for this project was performed by Fugro Alluvial Offshore Ltd. (FAOL).

The principal team members for report preparation were Mr Adrian Pearce (Geotechnical Manager) and Mr James Oakes (Geologist).

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

Yours faithfully



Adrian Pearce
FAOL Geotechnical Manager

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REPORTING STRUCTURE

RAMPION WINDFARM

SHALLOW SAMPLING (VIBROCORING), CONTINUOUS PCPT

Laboratory & In-situ data

Report No: 110515-1

Date: 21/06/2011

Issue No. 01

Status: Draft

SUMMARY

MAIN TEXT

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APPENDICES

1 Description of Methods and Practices

REPORT ISSUE CONTROL

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Note: The Fugro Alluvial Offshore Limited report number and report issue number are given on the bottom left of each page. For example Fugro Alluvial Offshore Limited Report No. 012345-1 (01) indicates the Fugro Alluvial Offshore Limited report number is 012345-1 and the issue number is (01).

QUALITY ASSURANCE RECORD

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Notes:

The personnel stated above were responsible for checking and approving this report. The PDF document file held in Fugro's archive represents Fugro's formal deliverable to the Client.

SUMMARY

Background

Fugro Alluvial Offshore Limited was contracted by EON to perform a geotechnical investigation for the Rampion Wind Farm. This comprised of 5 Vibrocores (VC) and 5 Peizo Cone Penetration Tests (PCPT).

Mobilisation of the "Willendeavour" was on the 5th April 2011.

The CPT phase of the project was completed on the 7th April 2011.

The vibrocoreing phase of the project was completed 8th April 2011.

1. INTRODUCTION

1.1 General Project Description

Fugro Alluvial Offshore Limited (FAOL) was contracted by EON to perform a geotechnical investigation for the Rampion Windfarm. This comprised of 6 Vibrocores (VC), including retests at 5 locations and 6 Piezo Cone Penetration Tests (PCPT), including retests at 5 locations.

The work was performed from the vessel "Willendeavour" from 6th April to 8th April 2011 in accordance with instructions received from EON.

The scope of onshore laboratory testing performed was as agreed between FAOL and EON. All laboratory testing was carried out by FAOL with the exception of the UU triaxial tests, UCS tests and chemical tests.

1.2 Contractual Arrangements

FAOL were contracted by EON Climate and Renewable UK Developments Limited.

FAOL was to provide a suitable vessel equipped with navigation and deployment facilities suitable for safe and effective operation of the investigation equipment.

Fugro Survey Limited (FSLTD) provided positioning services.

Fugro Engineering Services (FES) were subcontracted by FAOL to perform UU triaxial and UCS testing on selected soil samples.

Severn Trent Laboratories Limited (STL) were subcontracted by FAOL to perform chemical testing on selected soil samples.

1.3 Purpose and Scope of Report

The site investigation was performed to provide soils information that would assist in the geotechnical investigation associated with the survey. The scope of this report is to present the following information:

- a. Geotechnical logs and descriptions of the soil strata
- b. Details of the onshore laboratory testing that has been performed
- c. Results of the laboratory testing performed

1.4 Use of Report

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

Fugro understands that this report will be used for the purpose described in this "Introduction" section. That purpose was a significant factor in determining the scope and level of the services, and the geotechnical data were acquired to support this purpose. If the purpose for which the report is used or the Client's proposed development or activity change, this report may no longer be valid. Results herein must not be used for another purpose unless their suitability to the alternate use has been verified.

2. STUDY OVERVIEW

2.1 Data Sources

The investigation comprised 6 vibrocore samples at a total of 5 locations, 6 PCPT's at 5 locations.

Fieldwork performance is presented on the following pages and Section D. Where re-tests or samples were performed, this is indicated by a lower case alphabetic suffix after the location number. Tests with an uppercase suffix were planned and were not re-tests.

2.2 Positioning and Water Depth

A tabulated summary of PCPT and VC co-ordinates are presented in Section D of this report.

Target co-ordinates for all PCPT and VC locations were specified by EON Climate and Renewable UK Developments Limited prior to the investigation. The co-ordinates presented in this report are the actual location co-ordinates recorded by the FSLTD surveyors.

Co-ordinates for all locations are expressed using the UTM projection, WGS84 Datum, WGS84 Spheroid, with a Central Meridian of 3° West.

Water depths are presented as reduced to LAT.

The user of presented geodetic information must consider the accuracy of measurements, particularly where use may differ from original intentions. For example, the water depth measurements serve to establish sample and test depths below seafloor.

Table 2.1: Summary of PCPT and Vibrocore Performance

Re-tests are indicated by a lower case alphabetic suffix attached to the location number.

PCPT SUMMARY							
CPT No.	Date	Time UTC+1	Actual Coordinates		Water Depth (m) (LAT)	Penetration (m)	Stop Criteria
			UTM				
			Eastings (m)	Northings (m)			
CPT_21C	07/04/2011	11:08	691334	5630921	5.60	3.04	D
CPT_18C	07/04/2011	11:48	690325	5629207	6.80	3.19	D
CPT_19C	07/04/2011	12:37	692784	5626333	13.40	1.00	C
CPT_19Ca	07/04/2011	12:43	692788	5626330	13.90	1.16	C
CPT_20C	07/04/2011	13:17	691332	5624079	16.10	3.21	D
CPT_3	07/04/2011	14:14	692327	5617602	29.30	5.17	D
Stop Criteria: D=Depth achieved, E=Excess thrust, C=Cone inclination, L=cone end Load, F=sleeve Friction, T=frame Tilt, O=Other							

VC SUMMARY							
VC No.	Date	Time UTC+1	Actual Coordinates		Water Depth (m) LAT	Penetration (m)	Recovery (m)
			UTM				
			Eastings (m)	Northings (m)			
VC03	07/04/2011	15:53	692328	5617602	30.40	6.20	5.35
VC20C	07/04/2011	16:41	691333	5624080	17.80	3.17	1.86
VC21C	08/04/2011	11:09	691333	5630919	4.30	3.96	3.49
VC18C	08/04/2011	11:35	690327	5629206	6.90	3.39	2.39
VC19C	08/04/2011	12:14	692786	5626332	12.50	4.00	3.78
VC20C-B	08/04/2011	12:52	691333	5624081	15.30	1.95	1.34

2.3 Sampling and In-Situ Testing

2.3.1 Vibrocore

Sampling operations during the fieldwork were performed using FAOL's 6m High Performance Vibro Corer (HPVC) deployed using the vessels HIAB and winch system.

The penetration of the core was measured using a digital penetrometer, which comprised a cable that was attached to the vibrating pot with a digital encoder wheel affixed to the stationary lifting head of the HPVC. As the core barrel penetrated the soil the cable would reel out producing a graphical digital read out upon the HPVC operators screen. The penetration at each location is summarised in Table 2.1

Immediately after recovery, the cores were cut into 1m sections, and a description of the exposed ends was made. Where appropriate, a strength assessment of cohesive soils was made using a Pocket Penetrometer and a Torvane.

The sections of core were sealed using plastic caps and adhesive PVC tape, and were stored vertically orientated in a core transport crate located on deck.

On completion of the survey the samples were forwarded to FAOL's geotechnical soil laboratory in Great Yarmouth, United Kingdom for further description and analysis.

Soil conditions observed at each geotechnical location are presented individually on sample logs in section A. A total of 6 vibrocore tests including a single retest (VC 20Ca was attempted but failed due to mechanical difficulties with the HPVC and as a result retest VC 20Cb performed) were performed at the 5 specified locations.

2.3.2 In-Situ Testing

The PCPT data were acquired using an FAOL two module ROSON system, which was equipped with Fugro cones and data acquisition system. The ROSON system uses piezocones with a projected surface area of 10 cm², with the pore water pressure measured at the cone shoulder. The available thrust was of the order of 8 tonnes.

A total of 6 piezocone penetration tests (PCPTs) including a single retest were performed at the 5 specified locations.

2.3.3 Quality of Data

In general, the results are considered to be of good quality and are representative of the soils tested. Further details of the CPTs, including data plots, are presented in section B.

2.4 Laboratory Testing

2.4.1 Summary

A summary of the laboratory tests performed is presented in Table 2.3. Details of the laboratory testing methods that have been used are presented in Appendix 1.

The scope of onshore laboratory testing performed was as agreed between FAOL and EON.

Laboratory testing was predominantly performed by FAOL, with some testing being carried out by Fugro Engineering Services (FES) and Severn Trent Laboratories (STL).

Laboratory testing was divided as follows.

Table 2.2: Summary of Soil Testing Laboratories Use

Laboratory Tests Performed	Laboratory Responsible
Logging, classification tests and thermal conductivity	FAOL
UU Triaxial and UCS	FES
Chemical tests	STL

All soils have been described in accordance with Fugro Soil classification procedure 5091DT-RPT-02-R4.

This document states: 'It has been agreed that the soil classification systems of all Fugro geotechnical groups will conform to either BS 5930 or ASTM D 2487. This document encompasses both procedures, and presents specific additions to each system that will enable the naming conventions to be as similar as possible throughout Fugro. For description and classification of calcareous soils, the system outlined by Clark and Walker (1977) is integrated with both systems.

Soil descriptions for this report are based upon BS5930:1999.

Table 2.3: Summary of Laboratory Testing

TEST TYPE	Number of Tests
Natural Moisture Content Determination	41
Bulk and Dry Density Determination	22
Density of Intact Core	38
Torvane	11
Pocket Penetrometer	15
Atterberg Limit Test	5
Particle Size Distribution Test – Wet Sieving	7
Particle Size Distribution Test – Hydrometer sedimentation	5
U.U. Triaxial	4
Unconfined Compression	2
Organic Content	1
Total Sulphate	2
Sulphate (2:1) Water Extract	2
pH Value	2

Note: The number of test in some cases, exceed the numbers in the agreed schedule. The results of all valid tests have been reported.

2.4.2 Project Specific Details

The primary objectives of the laboratory testing programme were to provide soils data. As a consequence, tests were performed to classify the soils in each soil layer, including determination of water content, bulk density, particle size distribution, and atterberg limits.

Further details of the laboratory testing that were performed are presented in Section C and standard laboratory method statements are presented in Appendix 1.

3. REFERENCES

BS1377 (1990) British Standard Methods of Test for Soils for Civil Engineering Purposes, British Standards Institution, London

FJG Report No. 5033ST-RPT-02-R4 (2006). Soil Classification Procedure Fugro Engineering Group

BS5930 (1999): Code of Practice for Site Investigation, British Standards Institution, London.

JAMIOŁKOWSKI, M., GHIONNA, V, N, AND LANCELLOTTA, R. (1988). New correlations of penetration tests for design practice. International Symposium on Penetration testing ISOPT-1. Orlando, USA. Proc., Vol 1, pp. 263-296.