REPORT

Mounting of Clay samples into triaxial test cell in the field

EFFECT OF VARIOUS STORAGE TIMES FOR A BLOCK SAMPLE. EXPERIENCES WITH SAMPLE TUBES COATED WITH A LOW FRICTION POLYMER AND A NEW PISTON SAMPLER, ALL ON ONSØY CLAY

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Summary

This report contains the results of four CAUC triaxial tests, two being performed on block samples and two on 72 mm tube samples. The tests were all performed on plastic clay from Onsøy.

The purpose with the block samples was to see if there is any significant improvement in sample quality whether the sample is mounted into the triaxial in the field compared to when it is transported to the laboratory and mounted into the triaxial cell several days later. However, no improvement was observed in sample quality for the test on the sample being mounted in the field.

One of the two tube samples was sampled with the ordinary NGI 72 mm piston sampler, but the sample tube was smeared on the inside and the outside with a low friction polymer. However, again, no improvement in sample quality.

The other tube (72 mm) sample was sampled with a new piston sampler for a remote operated drilling system (Santos et al, 2015). However, during removal of the sample tube from the sampler a suction was created that spoiled the sample so no conclusion can be drawn regarding this sampler in this case.

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1 Introduction

Laboratory tests on undisturbed clay samples reported by Bjerrum (1973), La Rochelle et al. (1976), Amundsen and Thakur (2017) show that strength and stiffness tend to decrease with increasing storage time (storage time being the length of the time period from sampling in the field until testing in the laboratory.) The tendency for decrease in strength and stiffness seems to increase with decreasing plasticity.

On 13. January 2017 Jean-Sebastian L'Heureux wrote a mail where he referred to the following NGI reports:

20130672-01-R – NIFS – N-6.4.3 – Effekt av lagringstid på prøvekvalitet
20140382-01 R - NIFS – N.6.4.4 Effekt av lagringstid på prøvekvalitet: Studie av 54 mm prøver fra Onsøy.

These reports showed relatively small change in properties due to storage time for the Onsøy clay. However, in the same mail he also reports about cases within SP8 in 2016 where an increase was found in strength for block samples compared to strength for 72 mm tube samples of 10-50 %, also in cases where the difference in the $\Delta e/e_i$-value is relatively small.

2 Sampling

An overview of the various borings made in the Onsøy test area north of Panco road 22 in the years 2009 to 2017 is given in Figure 1. The tests described in the present report were performed on block and tube samples taken in May 2017.

2.1 Block samples

The block samples were taken from boring Block 6 from the following depths:

Block sample 1: Depth 2.34 – 2.74 m Sample length: 40 cm
Block sample 2: Depth 2.74 – 3.14 m Sample length: 40 cm
Block sample 3: Depth 4.74 – 5.14 m Sample length: 40 cm
Block sample 4: Depth 5.09 – 5.44 m Sample length: 35 cm
Block sample 5: Depth 5.49 – 5.84 m Sample length: 35 cm

The block samples were, except for the uppermost 2.3 m, and in the depth interval from 3.14 to 4.74, taken continuously all the way from the top. The "gaps" between the block samples listed above come from samples that were discarded.

Immediately after retrieval of block sample No. 4 the top 4 cm of the sample was cut away and discarded. The next 17 cm (i.e. floor A), was divided into two equal pieces, one of those was divided into two new equal pieces, one piece being trimmed to a diameter of about 72 mm and a height of about 141 mm and mounted into a triaxial cell.

The piston through the top of the cell, with no load on top of it, was then brought into contact with the top cap (sitting on the top of the specimen.) and locked in this position. The cell was then filled with water and a cell pressure of about 20 kPa applied when the cell was still close to the borehole. The cell was now brought to the soil laboratory at NGI in about 2 hours. No suction was applied to the filter disks at this stage.

The initial negative pore pressure in the specimen, before applying any cell pressure, is believed to be about 10 kPa. After application of a cell pressure of 20 kPa the effective stresses on the specimen should gradually increase from about 10 to about 20 kPa.

The remaining parts of block sample 4, together with block samples 1, 2 and 3 were then sealed in clingfilm and aluminium foil and placed in plastic containers in the usual way and brought to NGI the same evening as block sample 4 was brought to NGI. Block sample 5 was sampled, sealed and brought to NGI the next day.

2.2 Tube samples

None of the tube samples were mounted into the triaxial cell in the field. The purpose with these samples was to try new equipment and procedures for tube sampling. The sample tubes had no inside clearance. The angle of the cutting edge was about 5 degrees and the wall thickness close to the cutting edge was up to about 0.3 mm.

72 mm tube samples, from borehole BH72-08gammel, and BH72-08ny, were taken close to boring Block 6 (the one with the block samples) see Figure 1. One tube was taken from each of these holes from depth 5.0 to 5.8 m, i.e. about the same depth as block sample No. 4.

The tube from hole BH72-08gammel was smeared on the inside and the outside with a low friction polymer. The sample from hole BH72-08ny was taken with a new piston sampler for a remote operating drilling system as described by Santos et al (2015) who also give test results obtained with this samples. The main advantages with this sampler compared to the traditional fixed piston samplers are as follows:

1) The use of an inner rod to control the position of the piston is avoided.
2) The cutting of the sample during the sampling operation can be done very fast without the risk of compressing the sample due to overdriving.

However, during removal of the sample tube from the sampler a suction was created that disturbed the sample substantionally.

3 Testing procedures

The CAUC triaxial tests were performed as follows:

- No paper filter side drains were used.

- The filter disks were flushed with salt water at a cell pressure of 20 kPa and no load (i.e. no load on hanger) on top of the piston.
- The next day the cell pressure was increased so that the effective horizontal stress became equal to σ_{HO}', then the deviator load was increased in about 6 steps so that the effective vertical stress became equal to σ_{vo}'.
- The next day a back pressure equal to 294 kPa was applied.
- After another day the B-value was measured and undrained shearing started with a rate of vertical strain equal to 0.7 % pr. hour.

4 Test results on plastic clay from Onsøy

4.1 General

The test results are given in Table 1 and in Figures 1 to 5.

Colums 2, 3 and 4 in Table 1 give "boring No.", "sample No." and "part No." respectively. For block samples, the letter in "part No." gives the "floor" from which the triaxial test specimen is trimmed. "Floor A" is the top floor. Each "floor" is devided into four equal quadrants and numbered from 1 to 4. The test numbers, the "old ones" given in column 5, start with T1 for the very first triaxial test specimen from the block sample and continues until the very last specimen from the same block sample. The "new" test numbers in column 1, continue from block sample to block sample, i.e. they are not set equal to 1 for each new block sample.

4.2 Effect of length of storage time for a block sample

Test No. 40x (1. Line in Table 1) was performed on a specimen that was mounted in to the triaxial cell in the field so that the storage time (i.e. time period from sampling the field until mounting the specimen into the triaxial cell) became only about 1 hour. The companion test, is the one with test No. 41x, and storage time 168 hours, 2. line in Table 1. The undrained shear strength for the test with short storage time is seen to be 17.6 kPa while the strength for the test with long storage time is slightly higher, i.e. 18.0 kPa. This is opposite of what was found by Bjerrum (1973), La Rochelle et al. (1976) and Amundsen and Thakur (2017) who all found that tests on specimens with short storage time gave significantly higher strength than tests with longer storage time. A possible reason for this may be that the tests reported in this report were performed on specimens with significantly higher plasticity index.

4.3 Effect of coating the sample tube with a low friction polymer

Test No. 42x (3. Line in Table 1) was performed on a 72 mm tube sample where the sample cylinder had been coated with a low friction polymer both on the inside and on the outside. However, in spite of that the specimen for this test was taken at slightly higher depth than the specimen from the block sample, the strength is about 20 % lower than for the block samples. The strength is also about 8 % lower than for an ordinary tube sample from this place.

A comparison of the stress-strain curves in Figure 2 (block sample, test T40x) with the stress-strain curve in Fig. 6 (tube sample, test T42x with polymer) show that test T42x is a typically disturbed specimen, the shear stress at very low strains (e.g. 0,5-1.0 % axial strain) being considerably lower than for the block sample and significantly higher than for the block sample at large strains (e.g. at about 10 % axial strain). If the low strain shear strength for T42x is corrected for sample disturbance as suggested by Berre et al (2007), the shear strength will increase from 14.4 to 15.5 kPa. However, if a 3:1 line is used up from the consolidation stresses instead of a vertical line, the corrected shear strength will be 17.1 kPa, but Berre et al (2007) recommend to use a vertical line if OCR≤2 (In this case OCR is equal to about 1.5 for block samples). The value for the test on the block sample (T40x) is 17.6 kPa.

If the shear stress at 10 % axial strain for T42x is corrected by the large strain correction suggested by Berre et al (2007), the shear stress at 10 % axial strain will decrease from 11.4 to about 9.90 kPa, the value for the block sample being 9.2 kPa, so in this case the large strain correction appear to be better than the small strain one.

4.4 Experience with a new piston sampler for a remote drilling system

This sampler is described by Santos et al. (2015) who also give test results obtained with this sampler. Test results obtained with this sampler are also given by Lunne and Kåsin (2013). A comparison of test results obtained with this sampler with tests on block samples appear to be quite promising. However, the sampling in Onsøy described in the present report for the new sampler was not successful because an unexpected suction was created when removing the piston from the top of the sample tube. This suction disturbed the sample significantly. There was also an accident during the testing in the laboratory, therefore no results are given in Table 1 for this test.

5 Recommendations for further work

5.1 Mounting of block samples in the field

The fact that the strength was slightly lower for the specimen mounted in the field compared to the one mounted later in the laboratory indicate that these tests perhaps should be repeated, since this is opposite of what was expected, Carrying the triaxial cell with the specimen mounted in it from the borehole to the place where the transportation car was parked might have given some disturbance of the specimen, which might have been avoided if the whole block had been carried to the place where the car was parked before doing the mounting operation.

5.2 Tube samples

A modified version of the new piston sampler where the piston can be removed from the top of the sample tube without creating any suction, should be tried as soon as possible.

6 Acknowledgements

- Sampling in the field was done by Martin Lian Akerholt, Pål Kristian Karstensen and Svein Evenrud
- The triaxial tests were performed by Helge Rolandsgard, Geir Sandbækken and Toralv Berre
- The figures in the report were made by Tim Gregory, Morten A. Sjursen and Thomas Vestgården
- The typewriting of the report, with several rounds of corrections, was done by Siv Anneli F. Haugenes

7 List of symbols

CAUC	triaxial test on a specimen consolidated anisotropically to the in situ effective stresses and then sheared undrained in compression
D_i	initial diameter of specimen
$\Delta e/e_i$	change in pore volume relative to the initial pore volume when consolidating a specimen to the in situ (i.e. present) effective stresses
H_i	initial height of specimen
OCR	ratio between apparent preconsolidation stress and in situ effective vertical stress
σ_{vo}'	vertical effective stress in situ (present vertical stress in the ground)
σ_{ho}'	horizontal effective stress in situ (present horizontal stress in the ground)
w_i	initial water content of specimen
w_f	final water content of specimen
ε_a	axial strain
ε_{ac}	axial strain at end of consolidation to σ_{vo}'
$\acute{\varepsilon}_a$	rate of axial strain
ε_{vol}	volumetric strain
$\varepsilon_{ol.c}$	volumetric strain at end of consolidation to σ_{vo}'
σ_a	axial total stress
σ_a'	axial effective stress
σ_{ac}'	value of σ_a' at end of consolidation to σ_{vo}'
σ_r	radial total stress
σ_r'	radial effective stress
σ_{rc}'	value of σ_r' at end of consolidation to σ_{vo}'
ρ_s	density of solid particles
s_u	undrained shear strength
$(s_u)_r$	undrained shear strength of remoulded material
S_{ri}	initial degree of water saturation of specimen
u	excess pore pressure during undrained shearing

8 List of references

Amundsen, H.A. and Thakur, V. (2017). Effects of storage on 54 mm piston samples of soft sensitive clay. Proceedings of the 19th International Conference on Soil Mechanics and Geotechnical Engineering, Seoul 2017.

Berre, T., Lunne, T., Andersen, K.H., Strandvik, S. and Sjursen, M. (2007). Potential improvements of design parameters by taking samples of soft marine Norwegian clays. Canadian Geotechnical Journal **44**: 698-716 (2007).

Bjerrum, L. (1973). Problems of soil mechanics and construction on soft clay. Tate-of-the-Art report to Session IV. In Proceedings of the 8th International Conference on Soil Mechanics and Foundation engineering, Moscow, 1973. (Also published in Norwegian Geotechnical Institute, Publication 100.)

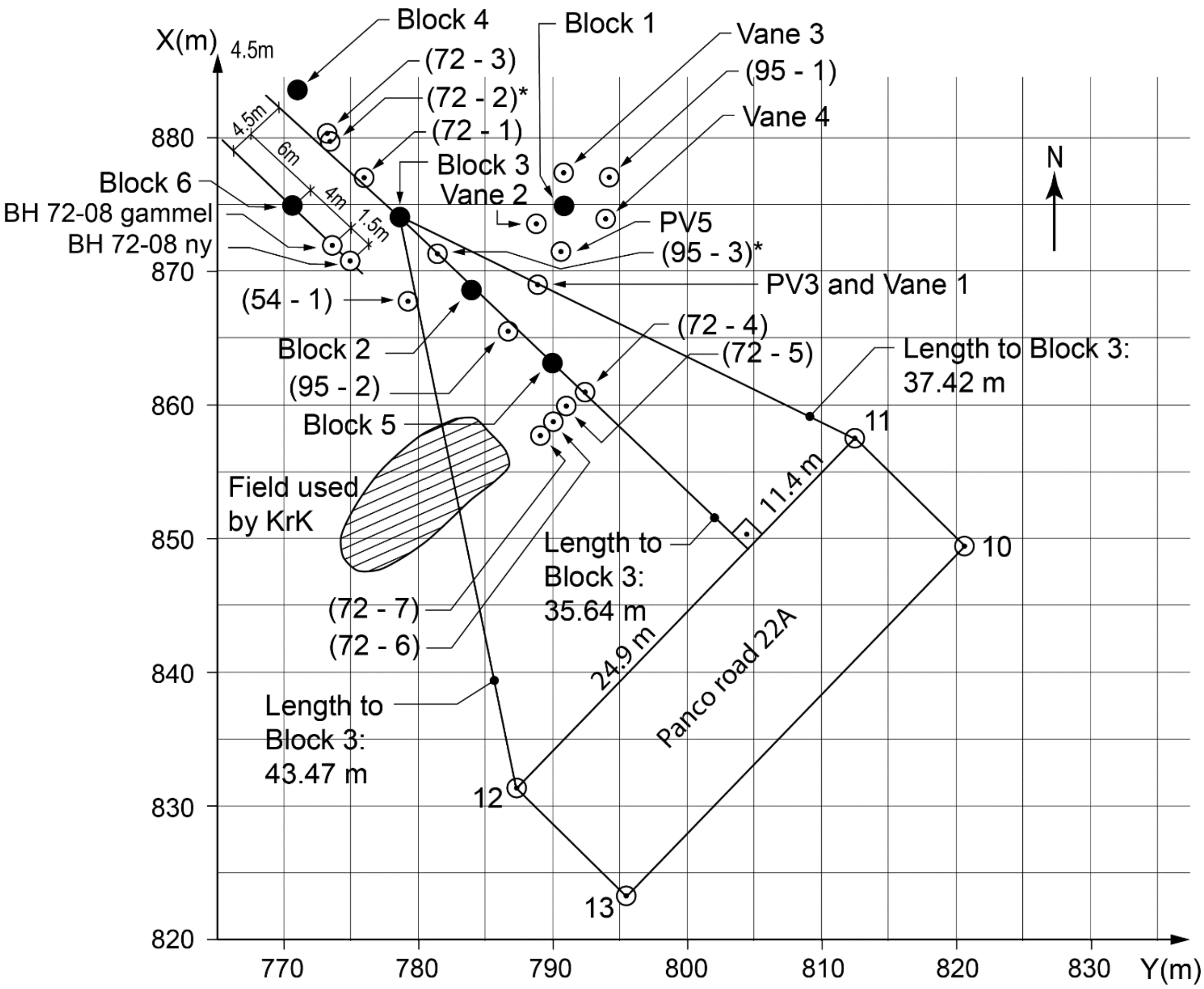
La Rochelle, P., Darrailh, J., Roy, M. and Tavenas, F.A., (1976). Effect of Storage and Reconsolidation on the Properties of Champlain Clays. *Soil Specimen Preparation for Laboratory Testing, ASTM STP 599.* American Society for Testing and Materials, 126-146.

Lunne, T. and Kåsin, K. (2013). Test of new ROV-drill piston sampler at Onsøy Evaluation of sample quality. NGI Report 20130471-01-R, 10. July 2013, Draft.

Santos, R.S., Alexander, M., Barwise, A., Walta, A., Solhjell, E. and Lunne, T. (2015). A new piston sampler for a remotely operated drilling system. Frontiers in Offshore Geotechnics III – Meyer (Ed.). 2015 Taylor & Francis Group, London, ISBN: 978-1-138-02848-7.

Table 1 Testing procedures and results of triaxial tests on Onsøy clay

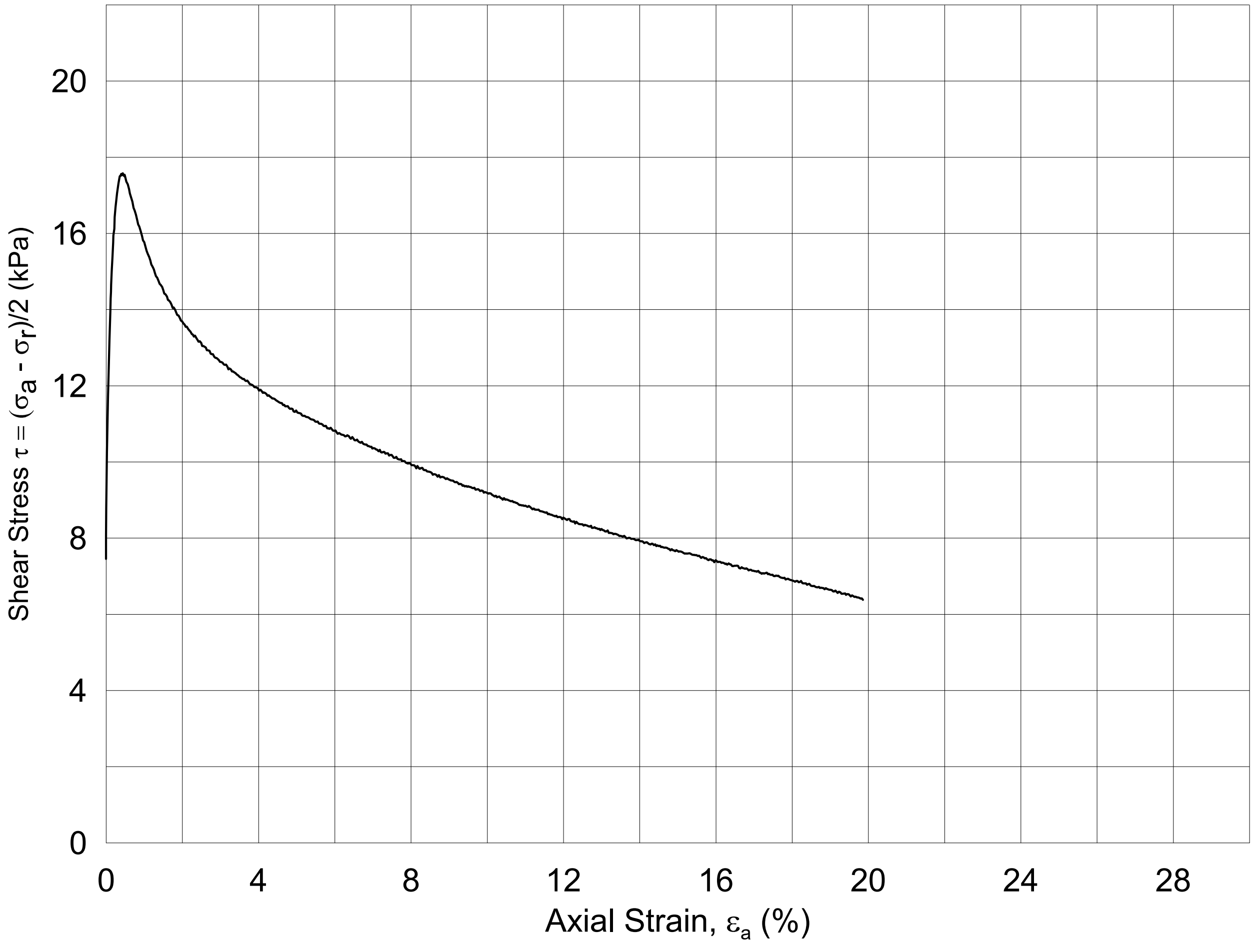
									Initial data						Data at consolidation to σ_{vo}'								Data at failure, i.e at $(\sigma_a+\sigma_r)$max, for CAUC test					
Test[1)] No. "New"	Boring No.	Sample No.	Part No.	Test No. [1)] "Old"	Type of tube	Depth (m)	σ_{vo}' (kPa)	Type of test	H_i (mm)	D_i (mm)	w_i (%)	S_{ri} (%)	ρ_s (g/cm³)	Salt cont. (g/l)	σ_{ac}' (kPa)	σ_{rc}' (kPa)	ε_{ac} (%)	$\varepsilon_{vol.c}$ (%)	$\Delta e/e_i$	Cat. w.r.t samp. dist.	OCR	Storage time (hrs)	$\dot{\varepsilon}_a$ (%/hr)	$\frac{\sigma_a-\sigma_r}{2}$ (kPa)	$\frac{\sigma_a-\sigma_r}{2\sigma_{ac}'}$	$\frac{\sigma_a'+\sigma_r'}{2}$ (kPa)	u (kPa)	ε_a (%)
T40x	Block 6	4	A1	T1	Block	5.22	36.9	CAUC	141.7	71.6	64.5	98.0	2.784	23.5	37.0	22.2	0.63	0.76	0.012	1	1.5	1	0.70	17.6	0.48	31.5	8.2	0.42
T41x	Block 6	4	A2	T2	Block	5.22	36.9	CAUC	141.2	71.7	66.0	98.4	2.784	23.5	37.0	22.2	0.66	0.51	0.008	1	1.5	168	0.70	18.0	0.49	31.7	8.5	0.60
T42x	BH72-08gammel	1	-	-	Tube 72 mm	5.40	38.0	CAUC	140.9	72.0	65.9	99.8	2.784	23.5	38.2	23.0	1.42	2.60	0.04	2	1.5	>24	0.70	14.4	0.38	27.8	9.6	0.95
T43x	BH72-08ny	1	-	-	Tube 72 mm	Not calculated, sample quality too bad due to accidents in the field and later in the laboratory.																						

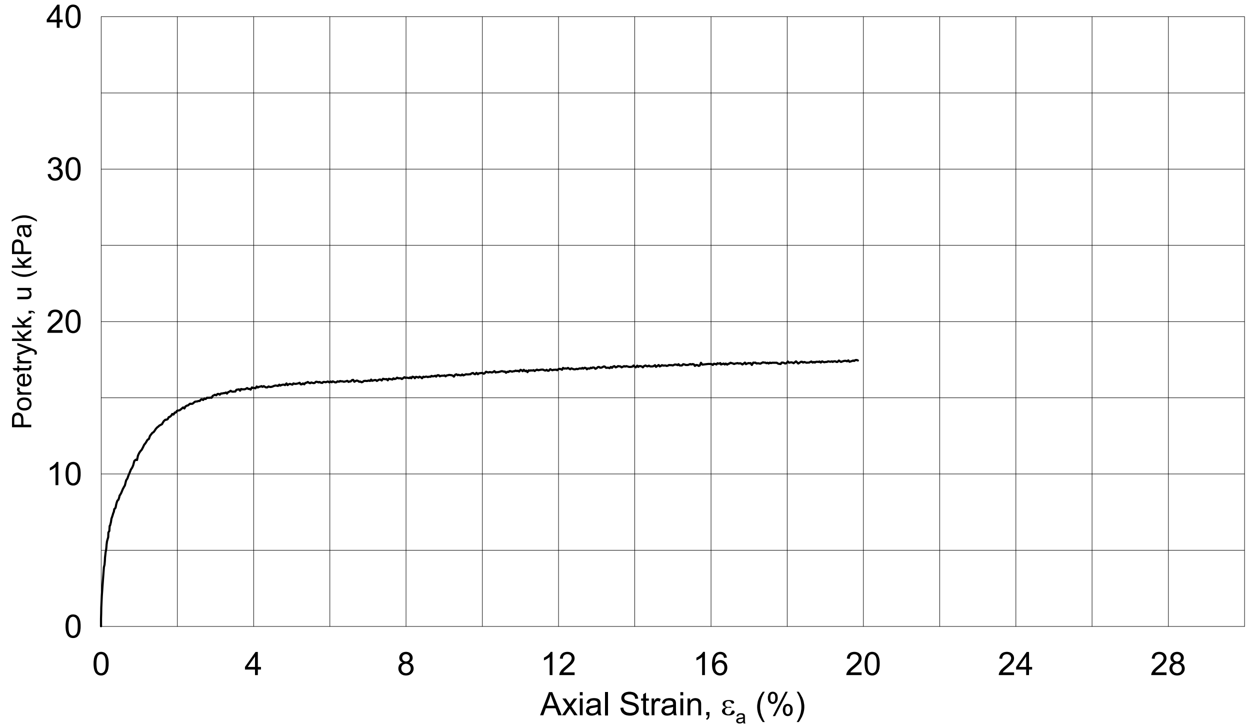


Note:	No samples were taken from holes (95 - 3)* and (72 - 2)*. Only pre-boring through the weathered crust was done for these holes. "PV" means pocket vane.

Key: ⊙ Tube samples (95, 72 and 54 mm)
● Block samples

Mounting of clay samples into triaxial test cell in the field	Document no. 20170166-01-R	
Positions of borings north of Panco road at Onsøy, later than about 2008	Figure no. 1	
	Date 2017-10-18	Drawn by TBe/TG
Scale 1:500	NGI	





Dato/rev.: 2014-12-23/01

Mounting of Clay Samples into Triaxial Test Cell in the Field

Document No. 20170166-01-R

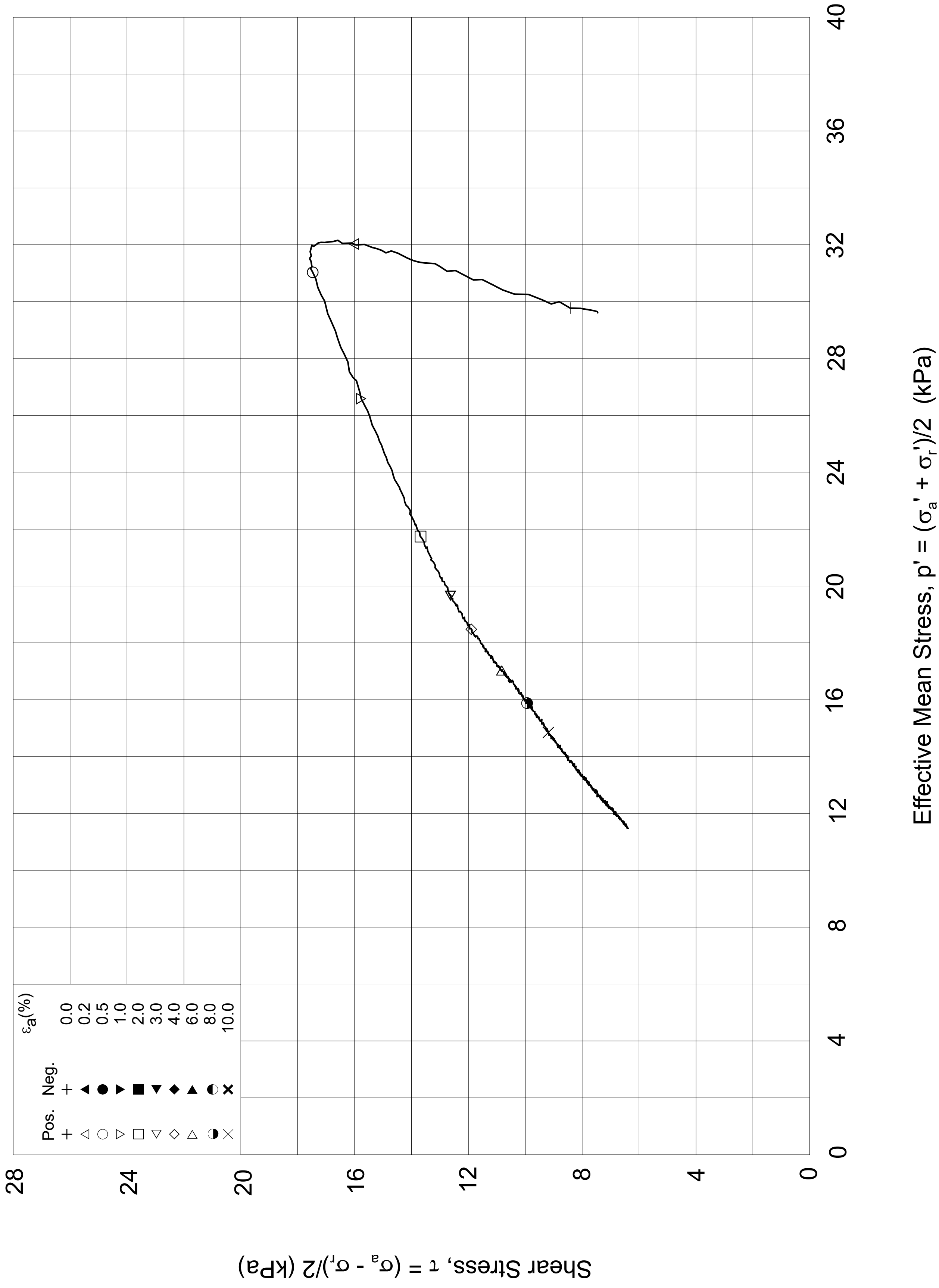
Figure No. 2

Triaxial test: **CAUC**

Boring:	**Blokk6**	Depth =	**5.22**	m	Consolidation stresses				
Tube:	**4**	po' =	**36.9**	kPa	(kPa)	max.	min.	final	
Part:	**A1**	w_i =	**65.3**	%	σ_{ac}' =	-	-	**37.0**	
Test:	**T40X**	w_c =	**64.5**	%	σ_{rc}' =	-	-	**22.2**	

Date	Drawn by/checked
2017-10-20	ThV / GS

Blokk6-10-A1-T40X.Plot1.grf



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Mounting of Clay Samples into Triaxial Test Cell in the Field

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Figure No. 3

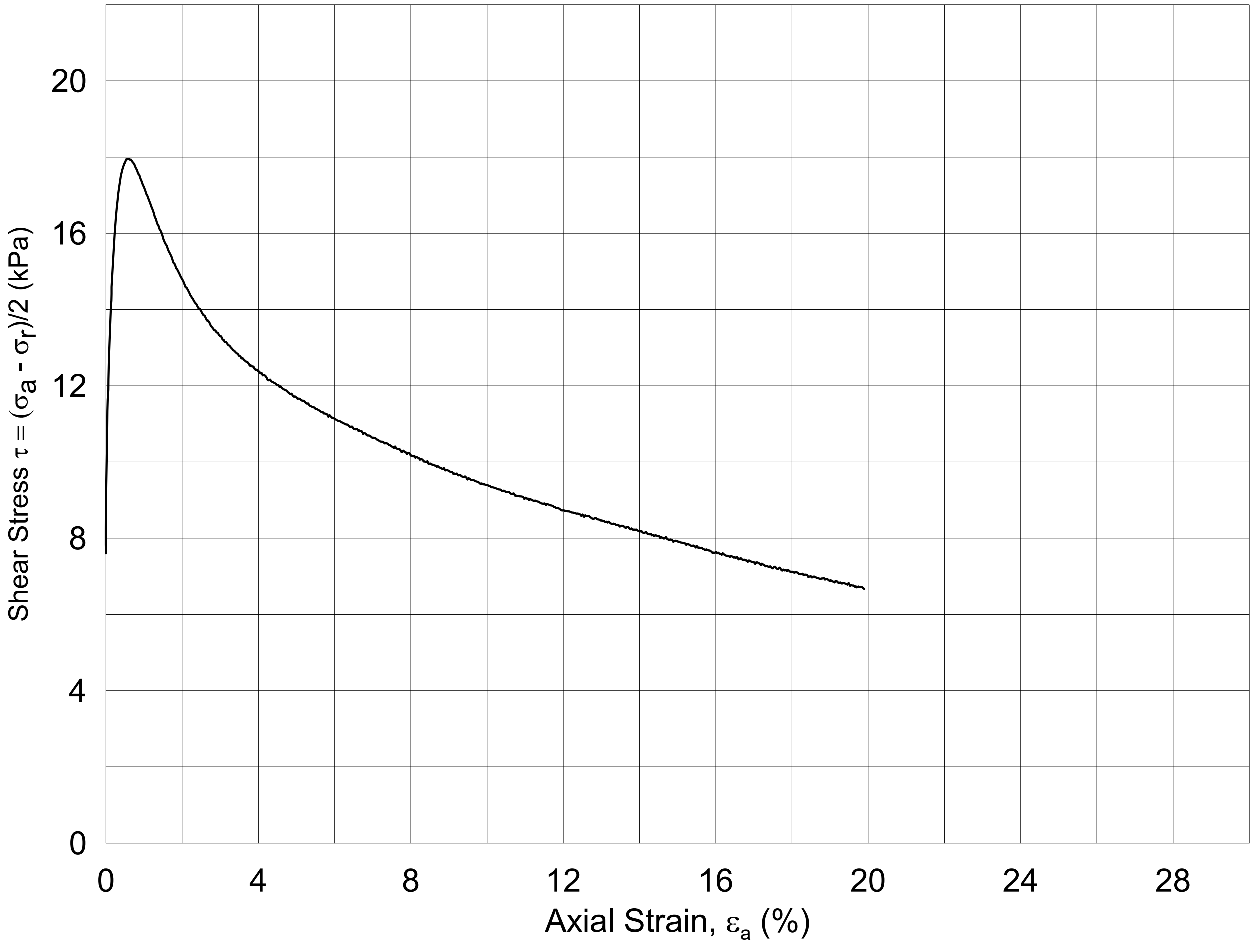
Triaxial test: **CAUC**

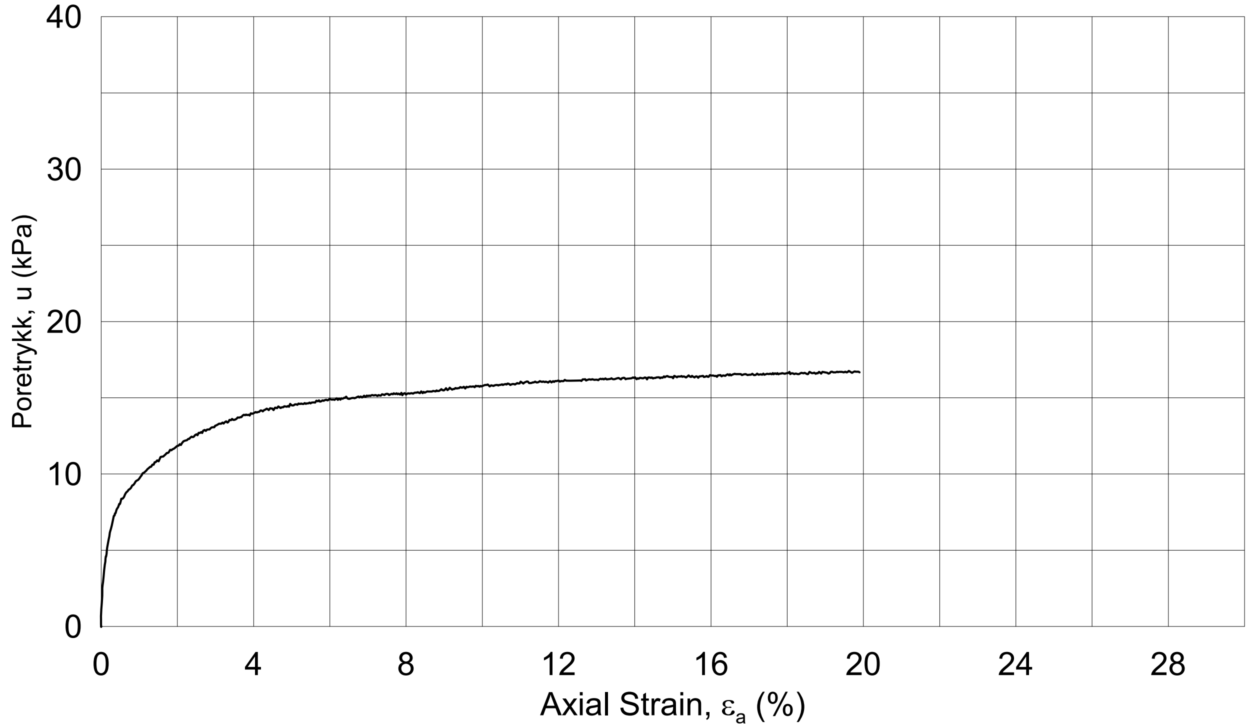
Boring:	**Blokk6**	Depth =	**5.22**	m	Consolidation stresses			
Tube:	**4**	po' =	**36.9**	kPa	(kPa)	max.	min.	final
Part:	**A1**	w_i =	**65.3**	%	σ_{ac}' =	-	-	**37.0**
Test:	**T40X**	w_c =	**64.5**	%	σ_{rc}' =	-	-	**22.2**

Date 2017-10-20

Drawn by/checked ThV / GS

Blokk6-10-A1-T40X.Plot2.grf





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Mounting of Clay Samples into Triaxial Test Cell in the Field

Document No. 20170166-01-R

Figure No. 4

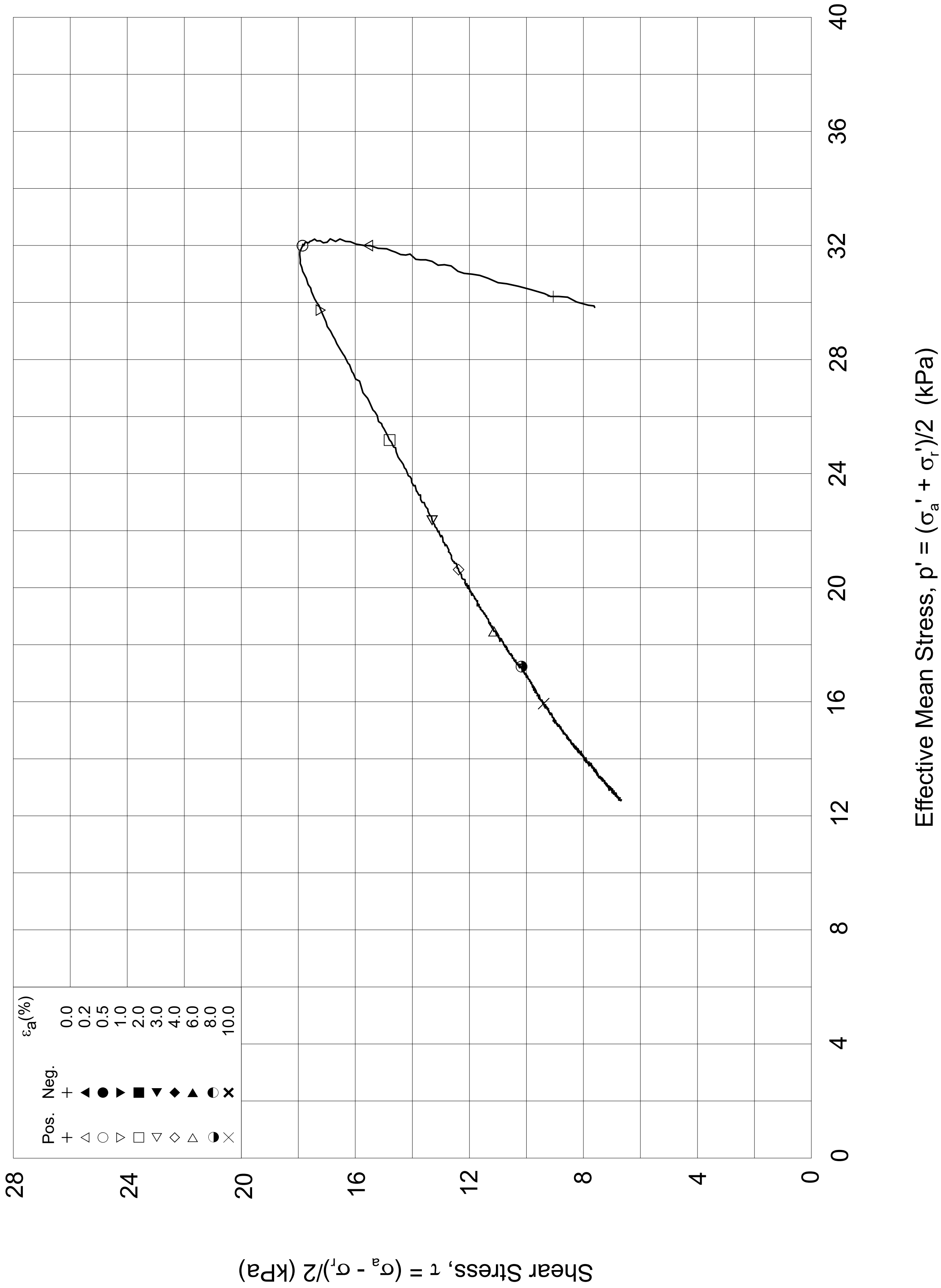
Date 2017-10-20

Drawn by/checked ThV / GS

Triaxial test: **CAUC**

Boring:	**Blokk6**	Depth =	**5.22**	m	Consolidation stresses					
Tube:	**4**	po' =	**36.9**	kPa	(kPa)	max.	min.	final		
Part:	**A2**	w_i =	**66.0**	%	σ_{ac}' =	-	-	**37.0**		
Test:	**T41X**	w_c =	**65.5**	%	σ_{rc}' =	-	-	**22.2**		

Blokk6-10-A2-T41X.Plot1.grf



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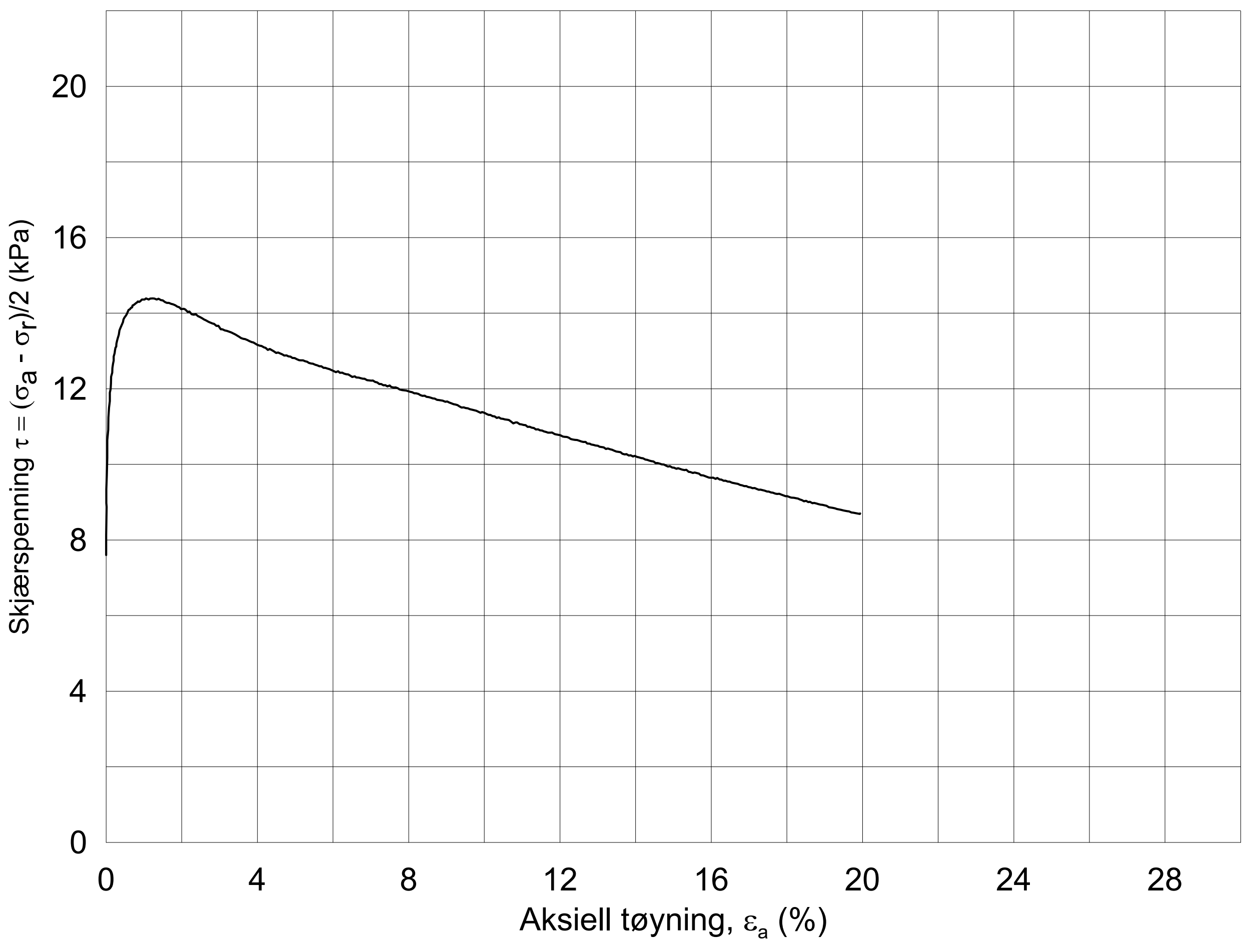
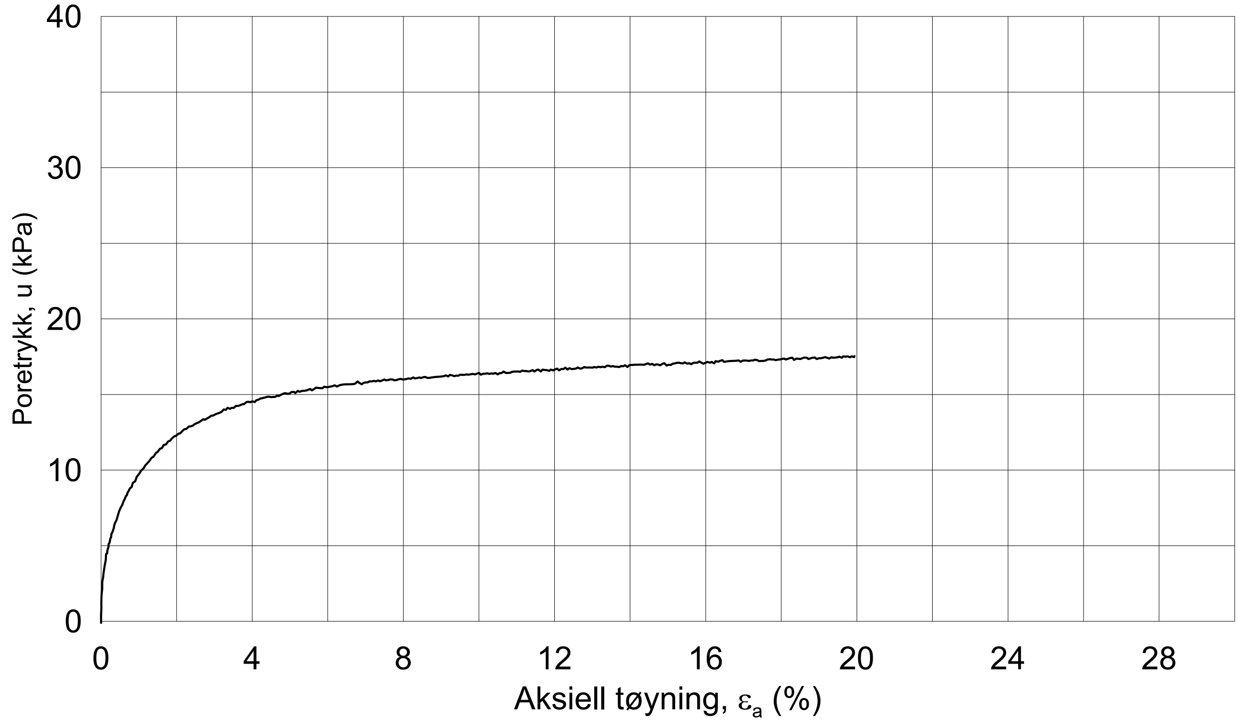
Mounting of Clay Samples into Triaxial Test Cell in the Field						Document No. 20170166
Triaxial test: **CAUC**						Figure No. 5
Boring: **Blokk6**	Depth = **5.22** m	Consolidation stresses				Date 2017-10-20
Tube: **4**	po' = **36.9** kPa	(kPa)	max.	min.	final	Drawn by/checked ThV / GS
Part: **A2**	w_i = **66.0** %	σ_{ac}' =	-	-	**37.0**	NGI
Test: **T41X**	w_c = **65.5** %	σ_{rc}' =	-	-	**22.2**	

Blokk6-10-A2-T41X.Plot2.grf





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Mounting of Clay Samples into Triaxial Test Cell in the Field

Dokument nr. 20170166-01-R

Treaksial forsøk: **CAUA**

Figur nr. 6

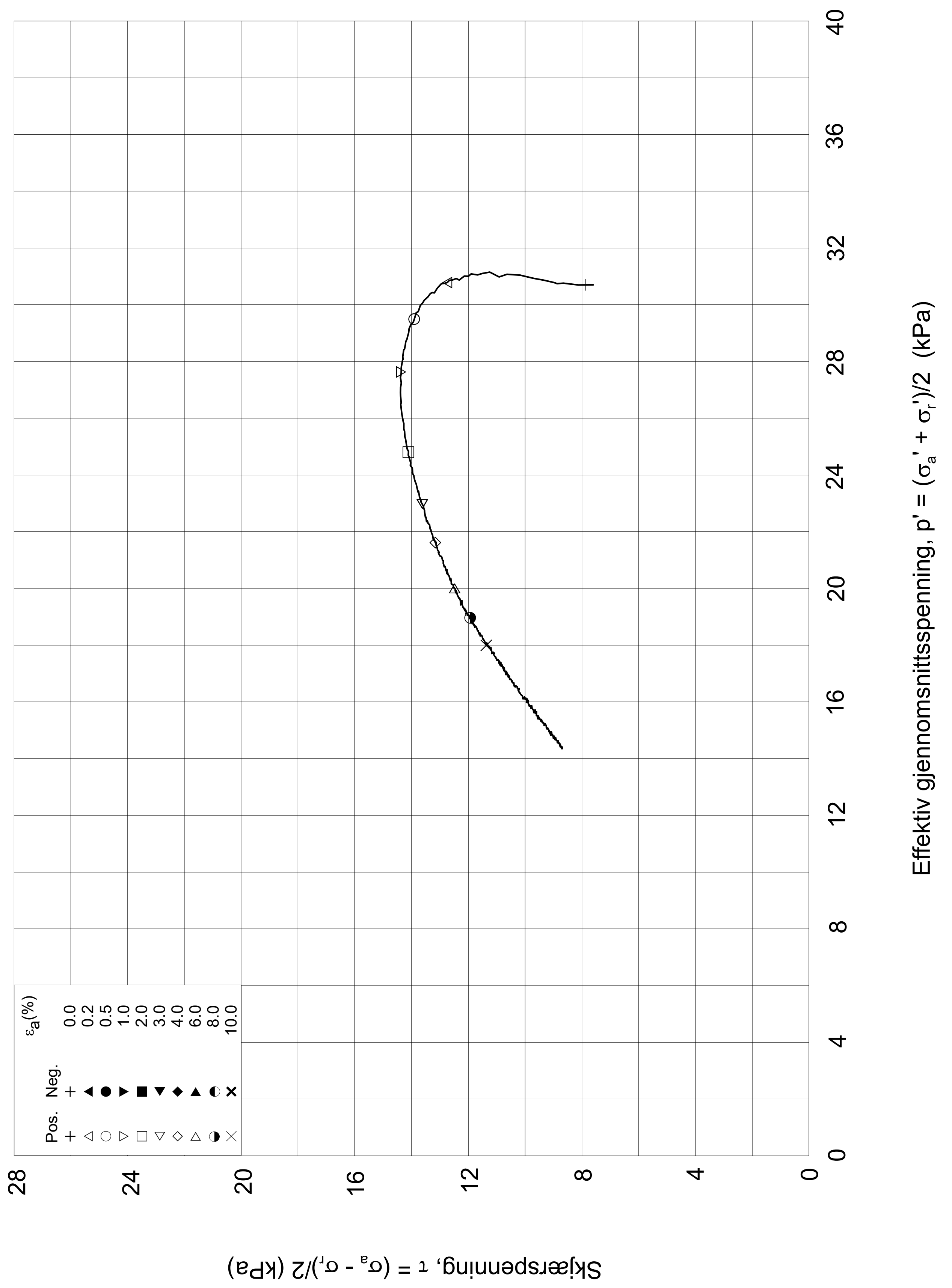
Boring:	**BH72-08gammel**	Dybde	=	**5.40**	m	Konsolidering-spenninger				
Sylinder:	**1**	po'	=	**38.0**	kPa	(kPa)		maks.	min.	endelig
Del:	**A**	w_i	=	**65.9**	%	σ_{ac}'	=	-	-	**38.2**
Test:	**42X**	w_c	=	**63.3**	%	σ_{rc}'	=	-	-	**23.0**

Dato 2017-09-21

Tegnet av / kontr. ThV / GS

NGI

BH72-08gammel-1-A-1.Plot1.grf



Dato/Rev.: 2014-12-23/02

Mounting of Clay Samples into Triaxial Test Cell in the Field

Treaksial forsøk: **CAUA**								Dokument nr. 20170166-01-R
								Figur nr. 7
Boring: **BH72-08gammel**	Dybde = **5.40** m		Konsolidering-spenninger					Dato 2017-09-21 / Tegnet av / kontr. ThV / GS
Sylinder: **1**	po' = **38.0** kPa		(kPa)	maks.	min.	endelig		
Del: **A**	w_i = **65.9** %		σ_{ac}' =	-	-	**38.2**		
Test: **42X**	w_c = **63.3** %		σ_{rc}' =	-	-	**23.0**		

BH72-08gammel-1-A-1.Plot2.grf

Kontroll- og referanseside/ Review and reference page

Dokumentinformasjon/*Document information*		
Dokumenttittel/*Document title* Effect of various storage times for a block sample. Experiences with sample tubes coated with a low friction polymer and a new piston sampler, all on Onsøy clay		**Dokumentnr./*Document no.*** 20170166-01-R
Dokumenttype/*Type of document* Rapport / Report	**Distribusjon/*Distribution*** Begrenset/Limited	**Dato/*Date*** 2017-11-08 **Rev.nr.&dato/Rev.no.&date** 0
Oppdragsgiver/*Client* Norges forskningsråd		
Emneord/*Keywords* CAUC, triaxial tests, storage time, new piston sampler		

Stedfesting/*Geographical information*	
Land, fylke/*Country* Norway, Fredrikstad	**Havområde/*Offshore area***
Kommune/*Municipality*	**Feltnavn/*Field name***
Sted/*Location* Onsøy	**Sted/*Location***
Kartblad/*Map*	**Felt, blokknr./*Field, Block No.***
UTM-koordinater/*UTM-coordinates* **Zone: East: North:**	

Dokumentkontroll/*Document control*
Kvalitetssikring i henhold til/*Quality assurance according to NS-EN ISO9001*

Rev/ *Rev.*	**Revisjonsgrunnlag/*Reason for revision***	**Egenkontroll av/ *Self review by:***	**Sidemanns-kontroll av/ *Colleague review by:***	**Uavhengig kontroll av/ *Independent review by:***	**Tverrfaglig kontroll av/ *Inter-disciplinary review by:***
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