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Geotechnical and Geological Characterization of a Quick Clay Site at Flotten,Trondheim

Konjit Paulos Gella

Geotechnics and Geohazards
Submission date: July 2017
Supervisor: Steinar Nordal, IBM

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Spring 2017

MSc Thesis

TBA4900 – Geotechnical Engineering

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BACKGROUND

Norwegian Geotechnical Test Sites (NGTS) is an infrastructure project funded by the Norwegian Research Council in cooperation with partners NGI, the Norwegian Public Road Administration, SINTEF, UNIS and NTNU. The project shall establish five sites with soil types sand, silt, clay, quick clay and permafrost and prepare them for testing over a period of 20 years.

The preparation for a site includes screening of soil conditions, layering and ground water, and further make ready infrastructure for future use of the site.

Flotten is a farmland and the site is about 1 km from where the Tiller quick clay slide took place in March 1816. The area is dominated by clays and quick clays and is within the quick clay zones 221 – 223 in Trondheim.

Until today, another quick clay research site at Tiller is used. This old site is in the quick clay zone 227, called Kvenildstrøa, and is located about 2 km south-west from the new site at Flotten. Both sites are in the same geological sediment and are expected to be fairly comparable.

SCOPE

The scope of the MSc work is to perform an investigation of a continuous soil profile at the Flotten site with thorough study of the geotechnical properties and an evaluation of the results in view of the geological history of the area.

The investigation shall include extended index and soil characterization testing together with consolidation and triaxial testing for stiffness, stress history and strength parameters.

The soil in the upper part of the site is non-sensitive. This material shall also be included in the study.

The results will be used as part of the documentation of the NGTS project.

The report should be written in the form of an article for publication.

NTNU spring 2017
A. Emdal
Arnfinn Emdal

Advisor

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Abstract:
This work presents the geotechnical and geological characterization of a quick clay site at Flotten which is one of NTNU's research sites in Trondheim, Norway. To characterize the material, number of laboratory tests were carried out in the geotechnical laboratory. These are index tests (such as water content, density measurement, grain size distributions, atterberg limits, salinity, falling cone test and unconfined compression), oedometer and triaxial tests. The deposit in the area is over-consolidated above about 8m and normally consolidated below that depth. Over-consolidated modulus of about, Moc=5Mpa, modulus in normally consolidated range, Mnc=3Mpa, and modulus number, m=18.2, on average. The deposit is composed of a fraction of clay of 50% to 78% and silt 22% to 50% except the top layer,2m to 2.4m, which is a fine sand. An average water content and bulk density of about 45% and 1.79g/cm^3 respectively and plasticity index ranged from 9% to 41.57%. The undrained shear strength increases with depth and is about 45kpa to 60kpa. The overall study shows that the property of the material in the area is consistent with correlations for Norwegian clays.

Keywords:

1. Quick clay
2. Laboratory testing

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Table of contents

ABSTRACT

This work presents the geotechnical and geological characterization of a quick clay site at Flotten which is one of NTNU's research sites in Trondheim, Norway. To characterize the material, number of laboratory tests were carried out in the geotechnical laboratory. These are index tests (such as water content, density measurement, grain size distributions, atterberg limits, salinity, falling cone test and unconfined compression), oedometer and triaxial tests. The deposit in the area is over-consolidated above about 8m and normally consolidated below that depth. Over-consolidated modulus of about, Moc=5Mpa, modulus in normally consolidated range, Mnc=3Mpa, and modulus number, m=18.2, on average. The deposit is composed of a fraction of clay of 50% to 78% and silt 22% to 50% except the top layer,2m to 2.4m, which is a fine sand. An average water content and bulk density of about 45% and 1.79g/cm^3 respectively and plasticity index ranged from 9% to 41.57%. The undrained shear strength increases with depth and is about 45kpa to 60kpa. The overall study shows that the property of the material in the area is consistent with correlations for Norwegian clays.

1.Introduction

Salt-leached marine clay which was deposited in sea by an inland glacier has high sensitivity. A sensitive or quick clay in its solid, undisturbed state has a shear strength but so unstable when it is subjected to sufficient stress. The deposit found in Norway, Sweden, Finland, Canada and North America and has been a fundamental cause for many deadly landslides. Landslides in quick clay at Byneset(2012), Kattmarka(2009), and Lyngen(2010) were some of current slide incidents in Trondheim(Emdal et al.,2012). The slide at Tiller (1816) is close to the test site at Flotten.

Flotten is a quick clay site underlying NTNU's research site in Trondheim area. Laboratory investigations were carried out for characterization of the material on test site. Oedometer and triaxial tests were done to find out engineering properties of the material, whereas routine tests for classification and to find out engineering properties which will be put in use with oedometer and triaxial test results. The material will be classified according to standard Norwegian practice(NGF,1982) based on lab test results and correlations for Norwegian clays such as Janbu (1985) and Lunne et al. (1997a) will be used to characterize the soil at Flotten.

The overall objective of this work is to provide useful references to engineers working on similar soil type.

2. Engineering geology

2.1 Geological settings

The general quaternary geological map of Trondheim area and the detailed quaternary geological map of the site are shown on fig.1(a) and (b) respectively. The marine limit was about +170m above the current sea level (Reite et al.,1999). Inland glacier,10600 years ago, poured out deposits in the sea water. Glacial deposits are shown on map(fig.1a) and are represented with orange and light blue colors. The light blue colored glacial deposit consists of clay and covers larger area in Trondheim. Nidelva at different times sprang out sand (alluvial deposit) in the sea water. Alluvial deposits are shown on map with a yellow color. Thin moraine, light green color on map, and weathered material, violet color, dominate occupants over Trondheim area. The one which is represented on map by a brown color is Peat and bog (Reite et al.,1999).

Flotten test site(fig.1b) is located on thick marine clay deposit which is an old sea floor and is +123m above the current sea level. It is surrounded by alluvial deposits to the east and peat and bog to the south-west direction. There is an eroded marine deposit which is represented by a dark blue color near to the river Nidelva to the east (Reite et al., 1999). The test site is located on an old sea floor and it may suggest that the deposit is normally consolidated assuming that the site has not been eroded so far.

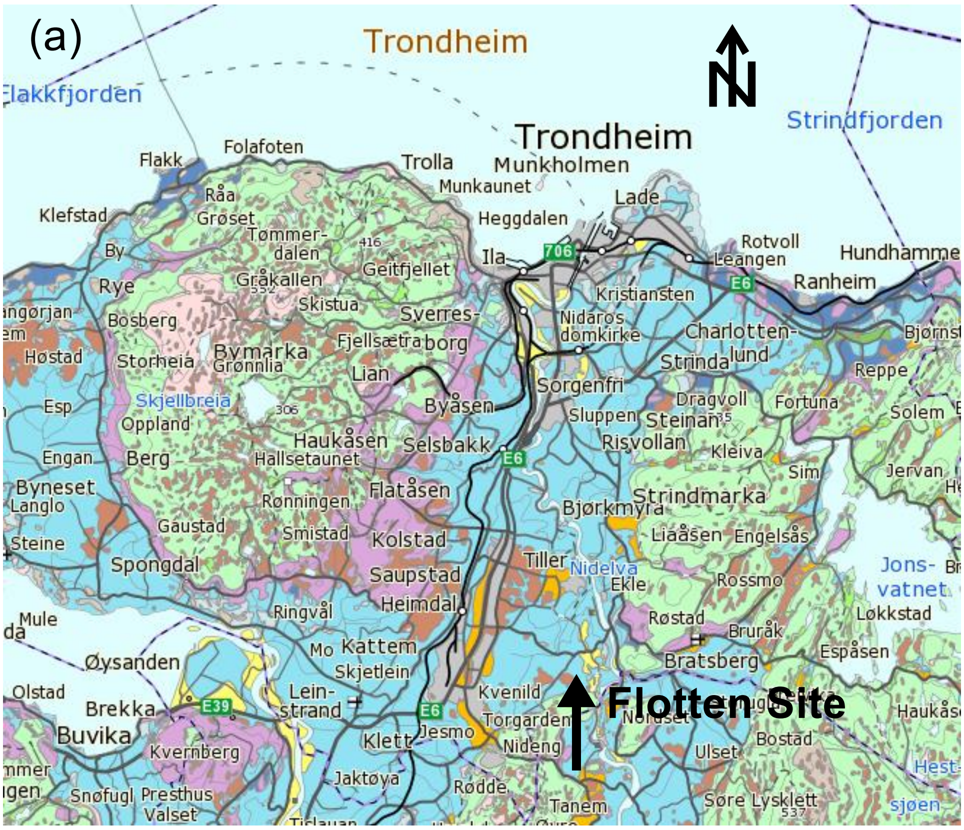
2.2 Stress history

The geological history of the area suggests that there has been only a normal sedimentation in the sea by the action of glacier and the nearby river Nidelva. The stress history of the area is due to variation in ground water. It is currently located at 1.5m below the actual ground surface.

Fig.3(a) and (b) show the preconsolidation pressure(P’c) and overconsolidation ratio(OCR) with depth calculated from an oedometer test result. According to Janbu,1970, P’c is a vertical effective stress where constrained modulus(M) and coefficient of consolidation(C_v) become minimum in a plot of M-σ'm and C_v- σ'm. As it can be seen on fig.3a values of P’c above about 8m show the material is overconsolidated and those below 8m fit with an in-situ effective vertical stress(σ'_{vo}) line and are normally consolidated.

Overconsolidation ratio (fig.3b) decreases linearly in an overconsolidation zone from OCR=6 at 3.5m to OCR=2 at 8m. In the normally consolidated zone, OCR= 1 and it is constant all the way down to 18.5m.

An overview of samples used for lab testing from bored hole-1 are shown in table-1.



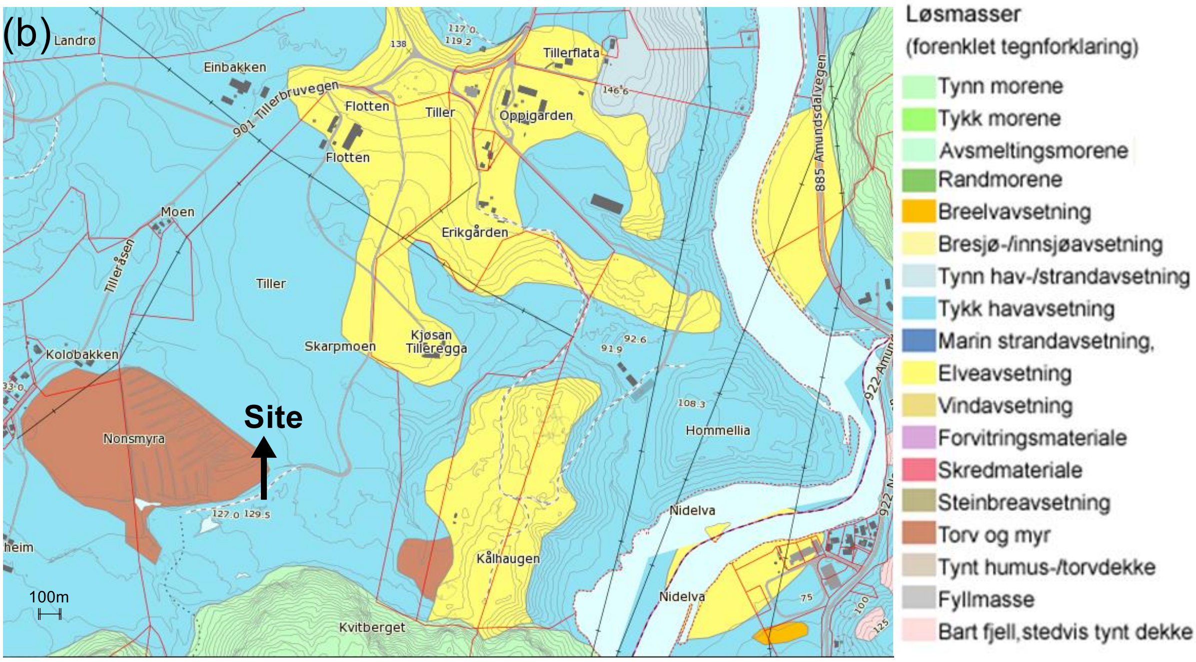


Fig.1 Quaternary geological map. (a) general map of Trondheim area (b) detailed map of Flotten site. (www.ngu.no)

Fig.2 View of Flotten site from South

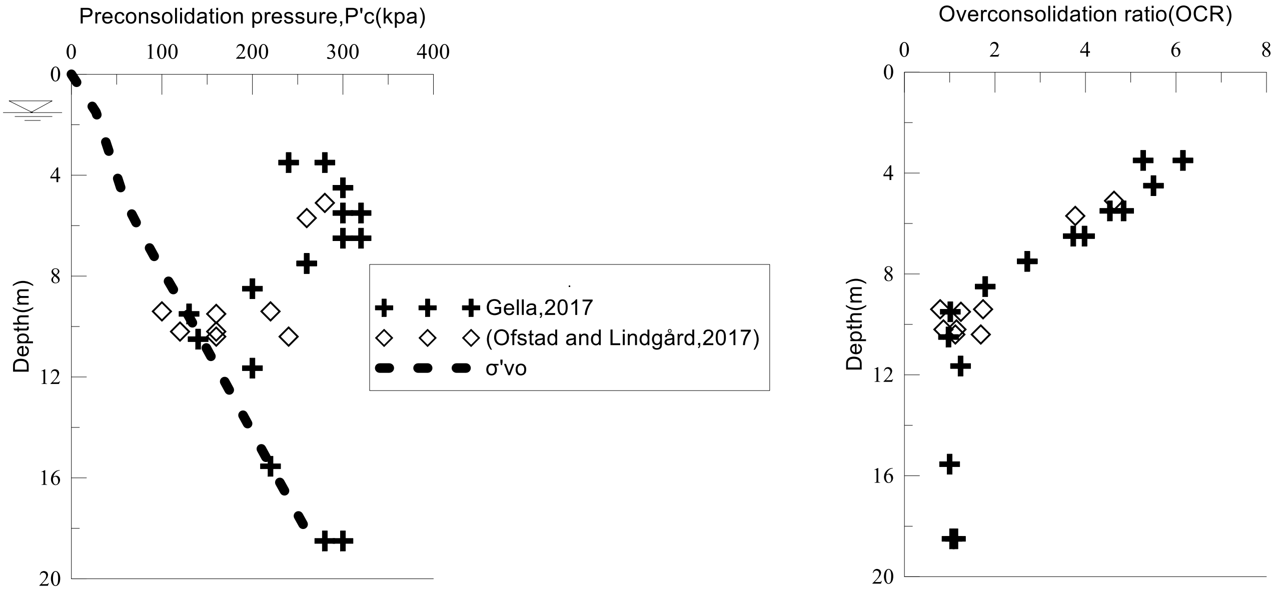


Fig.3 (a) Preconsolidation pressure(P’c) versus depth

(b) Overconsolidation ratio(OCR) versus depth

Table 1 Overview of samples used for lab testing (54mm steel sampler).

Depth (m)	Average density of sample cylinder ($\rho_{avg.}$) (g/cm^3)	Sampling date	Opening of the sample
2-2.8	1.96	17.02.17	20.02.17
3-3.8	1.92	17.02.17	27.02.17
4-4.8	1.86	23.02.17	06.03.17
5-5.8	1.81	23.02.17	16.03.17
6-6.8	1.81	23.03.17	27.03.17
7-7.8	1.85	23.03.17	03.04.17
8-8.8	1.83	07.04.17	10.04.17
9-9.8	1.83	07.04.17	18.04.17
10-10.8	1.86	26.04.17	27.04.17
11-11.8	1.88	26.04.17	01.05.17
15-15.8	1.92	23.05.17	24.0517
18-18.8	1.91	23.05.17	27.05.17

3. Material Composition

3.1 Grain size distribution

Particle size distribution curves to samples from different depths are shown on fig.1a. By a visual inspection, during laboratory investigation, it was confirmed that the top 15cm of the soil sample from 2m to 3m depth is pure sand and the next 25cm is sand which partially mixed with clay and the rest of the sample is clay. Some plant fibers and very thin fine sand layering's were also observed in clay samples. The deposit in the area is dominated by 50% to 78% by mass of clay and 22% to 50% of silt except the top 40cm layer which is composed of fine sand. Clay content with depth is shown on fig.1b. The clay content is about 69% on average and there is a tendency of decreasing with depth below about 11m which is 55% on average. Based on particle size distributions, the material <0.002mm diameter is >30% and the material is classified as clay(NGF,1982).

3.2 Pore water chemistry

Values for salt content in pore water are shown on fig.4c and an average salt content of about 0.65g/l. They are consistent in non-sensitive and quick clay zones.

4. Index parameters

4.1 Water content and degree of saturation

Values of water content(w) are shown on fig.5a. The average water content is about 45% and tends to decrease with depth below 10m. The groundwater water is at 1.5m below the original ground surface and the material below 1.5m are fully saturated (Sr=100%). The ground water distribution with depth is shown on fig.6b

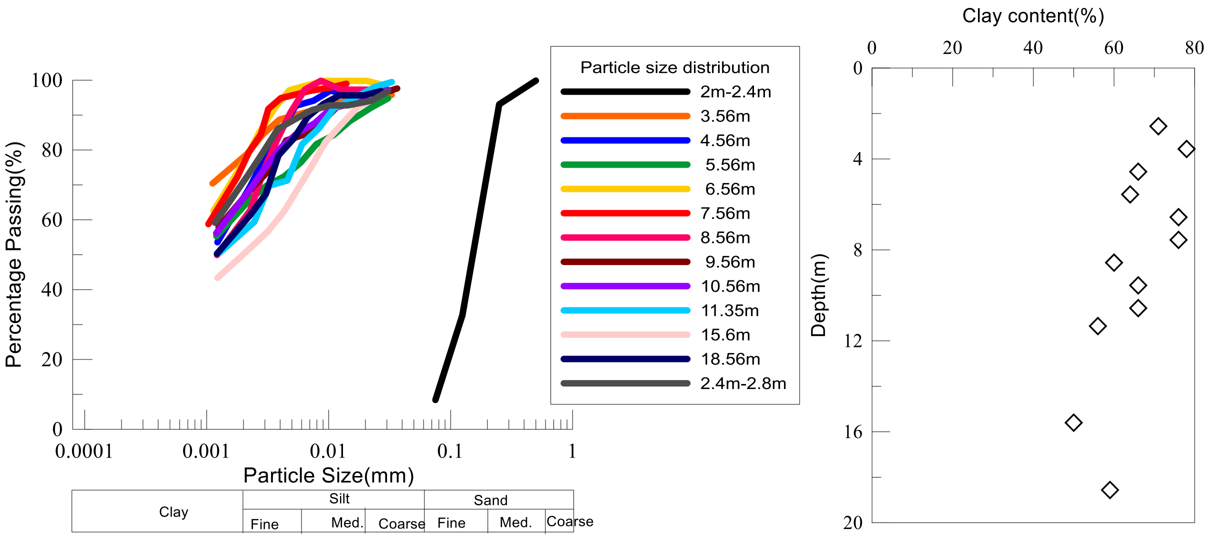


Fig.4 (a) Particle size distribution curves (b) Clay content versus depth

4.2 Atterberg limits

Plasticity index(I_p) is defined as liquid limit(w_L) minus plastic limit(w_p) i.e. $Ip=W_L-Wp$. Plasticity index of the material with depth is presented on fig.8a. As it is seen on fig., the plasticity ranged from 9% to 41.57%. According to Norwegian standard(NGF,1982), the material is classified as low plasticity for $I_p< 10$, medium plasticity between $10<I_p<20$ and high plasticity for $I_p >20$. Values on an A-line plasticity chart (fig.9) lie above A-line in the zones of CL, CI and CH which are called clay of low, medium, and high plasticity respectively. The type of material(clay) is consistent with the result found by particle size distributions.

4.3 Density and Void ratio

On fig.5b, values of bulk density versus depth are plotted. The bulk density is 1.79g/cm3 on average and is consistent with depth. This indicates that the mineral makeup and degree of compaction of the material is uniform throughout the bored hole. In-situ void ratio(e_o) of the material is about 1.38 on average which is within the range,0.6 to 1.5, for a Norwegian clay(Janbu,1970).

4.4 Liquidity index

Liquidity index(I_L) is used for scaling the in-situ moisture content to liquid and plastic limits. It is defined as:

$$I_L=(w-w_p)/I_p$$

where: w= water content
w_p= plasticity limit
I_p= plasticity index
I_L= liquidity index

As it is shown on fig.5b, the material which is from 2m to about 7.5m depth has an average liquidity index of about 1.1 and tends to increase with depth below 7.5m which is about 1.9 on average. This confirms that the material above 7.5m is stiffer than the one underneath and correspond to the no-sensitive and quick clay zones respectively, see fig.7(a) and (b) in section 5.2.

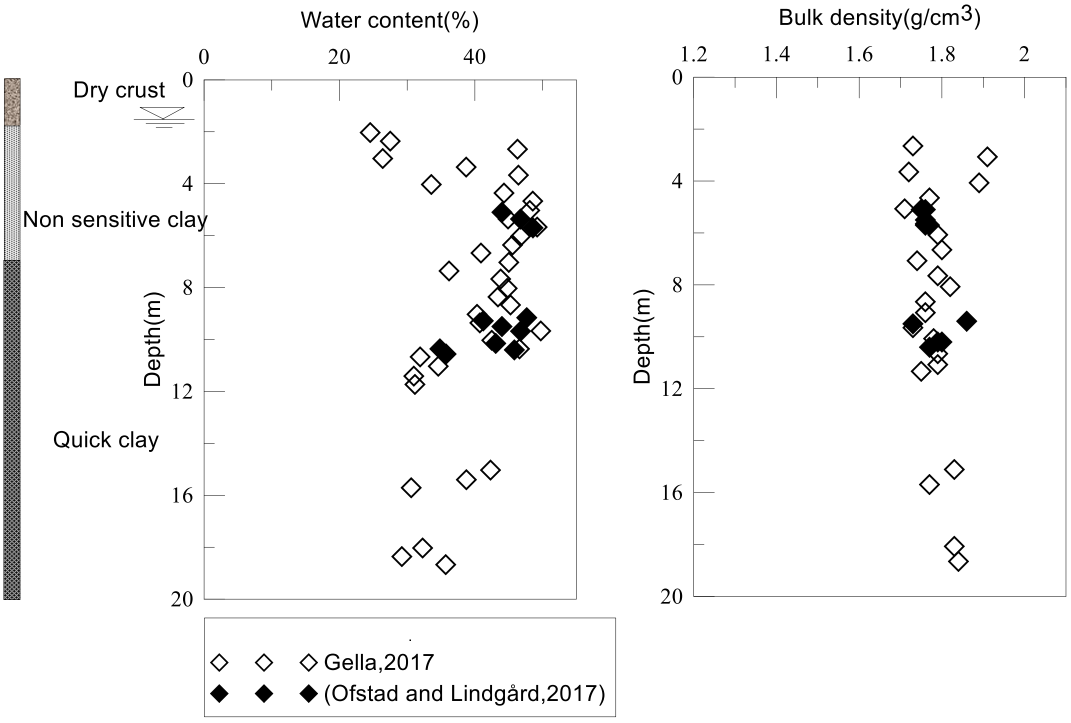


Fig.5 (a) Water content versus depth (b) Bulk density versus depth

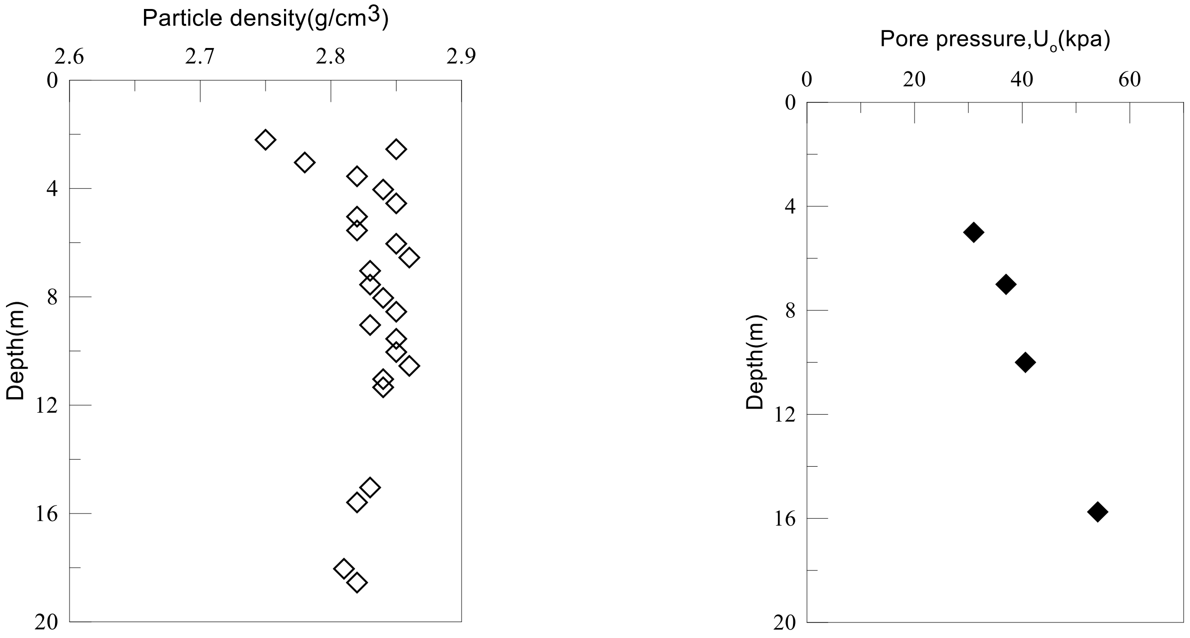


Fig.6 (a) Particle density versus depth

(b) In situ pore pressure(uₒ) distribution with depth (Ofstad and Lindgård,2017)

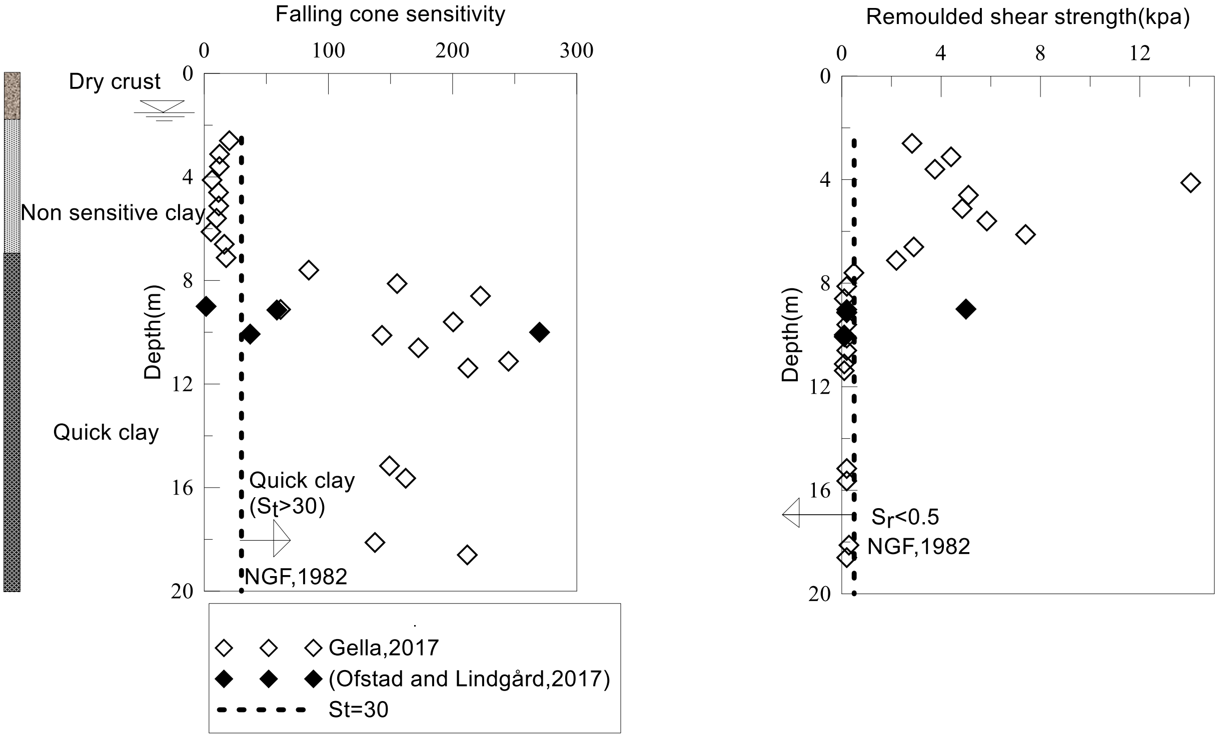
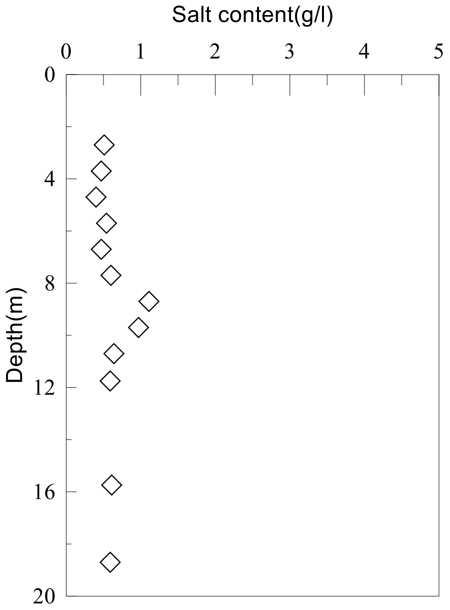


Fig.7 (a) Sensitivity versus depth

(b) Remoulded shear strength versus depth



(c) Salt content of pore water versus depth

5. Structure

5.1 Cementation

A combined index property which is called a degree of colloidal activity offers a valuable additional information to a quantitative measure of the effect of clay constituents on basic clay properties(skempton,1953). The degree of colloidal activity is expressed as:

Activity= plasticity index(Ip)/ clay fraction
Where: clay fraction is a fraction finer than 0.002mm diameter.

The material at Flotten is classified as less active(inactive) clay with an activity (Ip/clay fraction) less than 0.75(Janbu,1970). Inactive colloidal activity is a characteristic of marine clay which leached out its salt content of post deposition. The composition of commonly occurring inactive clay minerals such as quartz, calcite, mica, and kaolinite are ground for weakening intermolecular bond in a clay(skempton,1953).

5.2 Sensitivity

Sensitivity values are plotted in the fig.7a. The deposit is highly sensitive below about 7.5m in the quick clay zone where sensitivity(St) is greater than 30 and the remoulded shear(fig.7b) strength(Sur) is less than 0.5kpa(NGF,1982). Salt content and mineral compositions of the material is almost consistent with depth, in non-sensitive and quick clay zones, regardless of the sensitivity of the clay. Water content values also remain unchanged both in non-sensitive and quick clay zones but there is a slight tendency of decreasing with depth below 10.5m.

6. Engineering properties

6.1 Oedometer tests

Constant rate of strain(CRS) oedometer test results are plotted in the form of mean effective stress (σ'_m) versus axial strain (ε), constrained modulus(M) and consolidation coefficient(C_v) on fig.10 to 15

$$\sigma'_m=\sigma-u_o$$

$$u_o=2u_b/3$$

$$M=d\sigma'_m/d\varepsilon$$

$$C_v= (d\sigma/dt)*[Ho(1-\varepsilon)]^2*(1/2u_b)$$

where: u_o= mean pore pressure
u_b= pore pressure at the sample base
H_o= initial test height(20mm)

Quick clay samples are generally difficult to handle them carefully without being disturbed. In an oedometer test, highly sensitive clay samples flood out of an oedometer ring when they are consolidated to sufficient vertical stress(fig.29(a) to (e)). For that reason, stress-strain curves which are produced from the test results will become flat as if samples are disturbed. On the other hand, the corresponding graph of constrained modulus versus stress will become close to linear and it will be difficult to find out preconsolidation stress from the diagram.

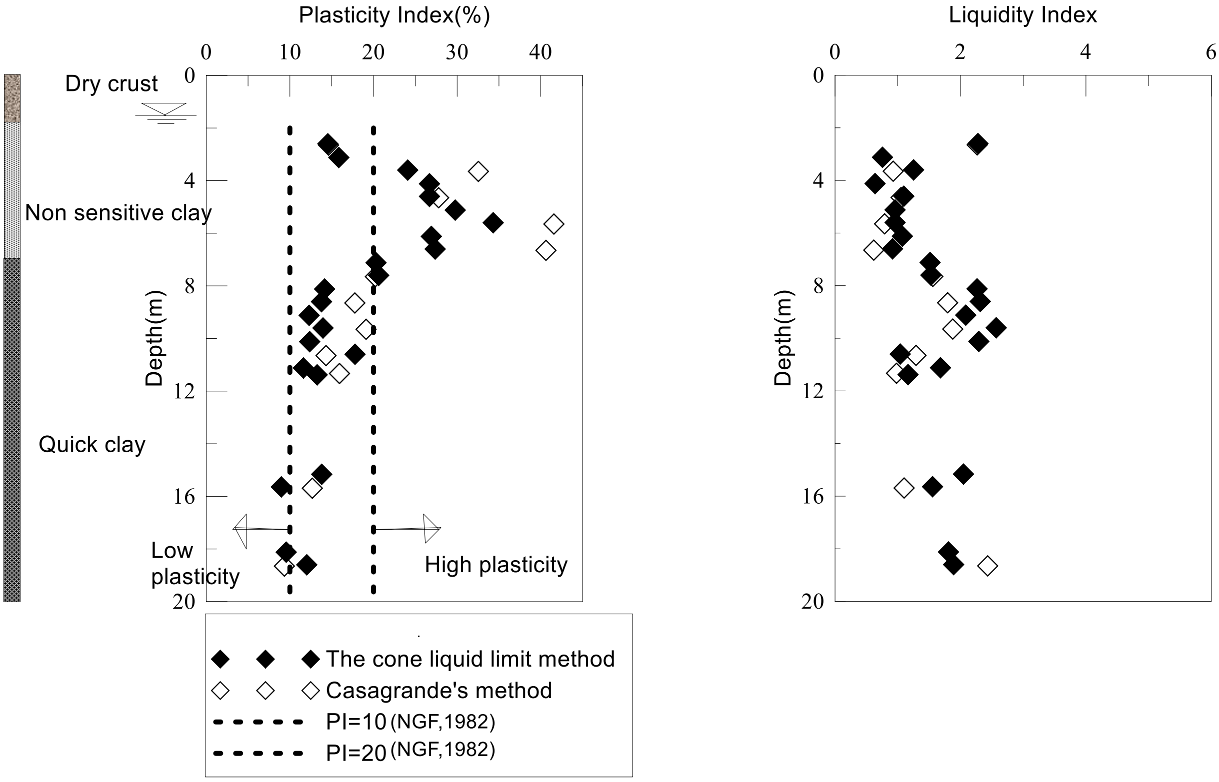


Fig.8 (a) Plasticity index versus depth

(b) Liquidity index versus depth

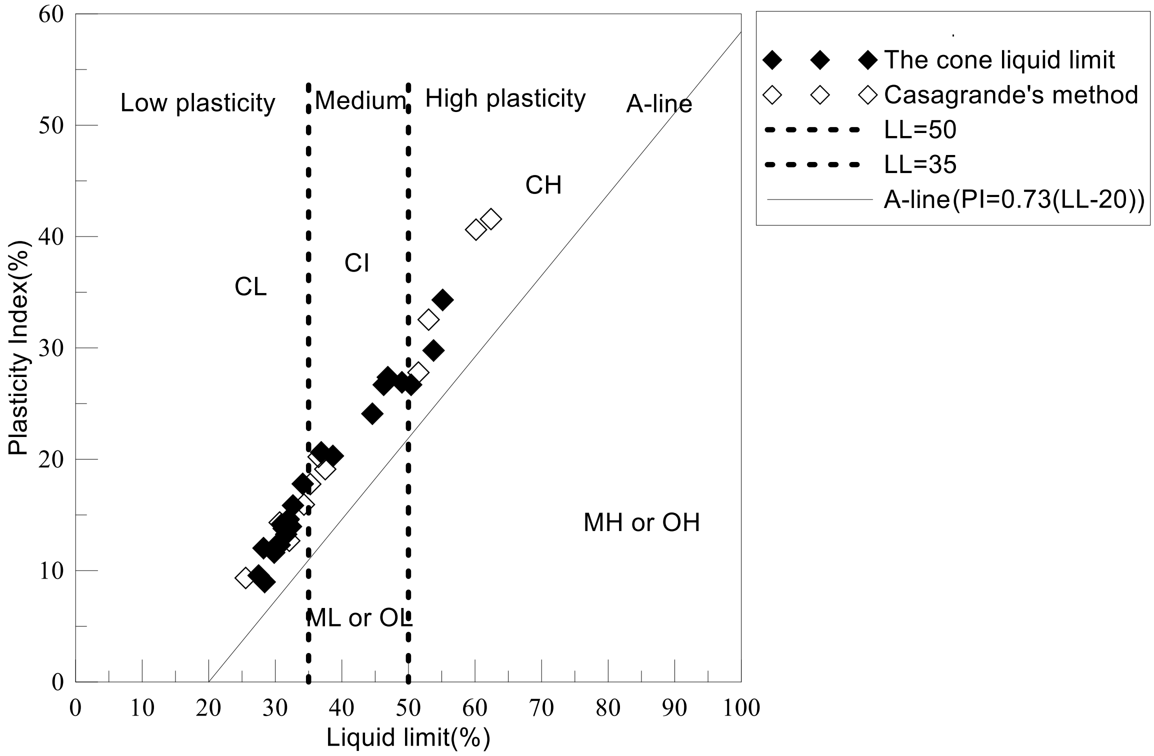


Fig.9 A-line plasticity chart for classification of cohesive soil

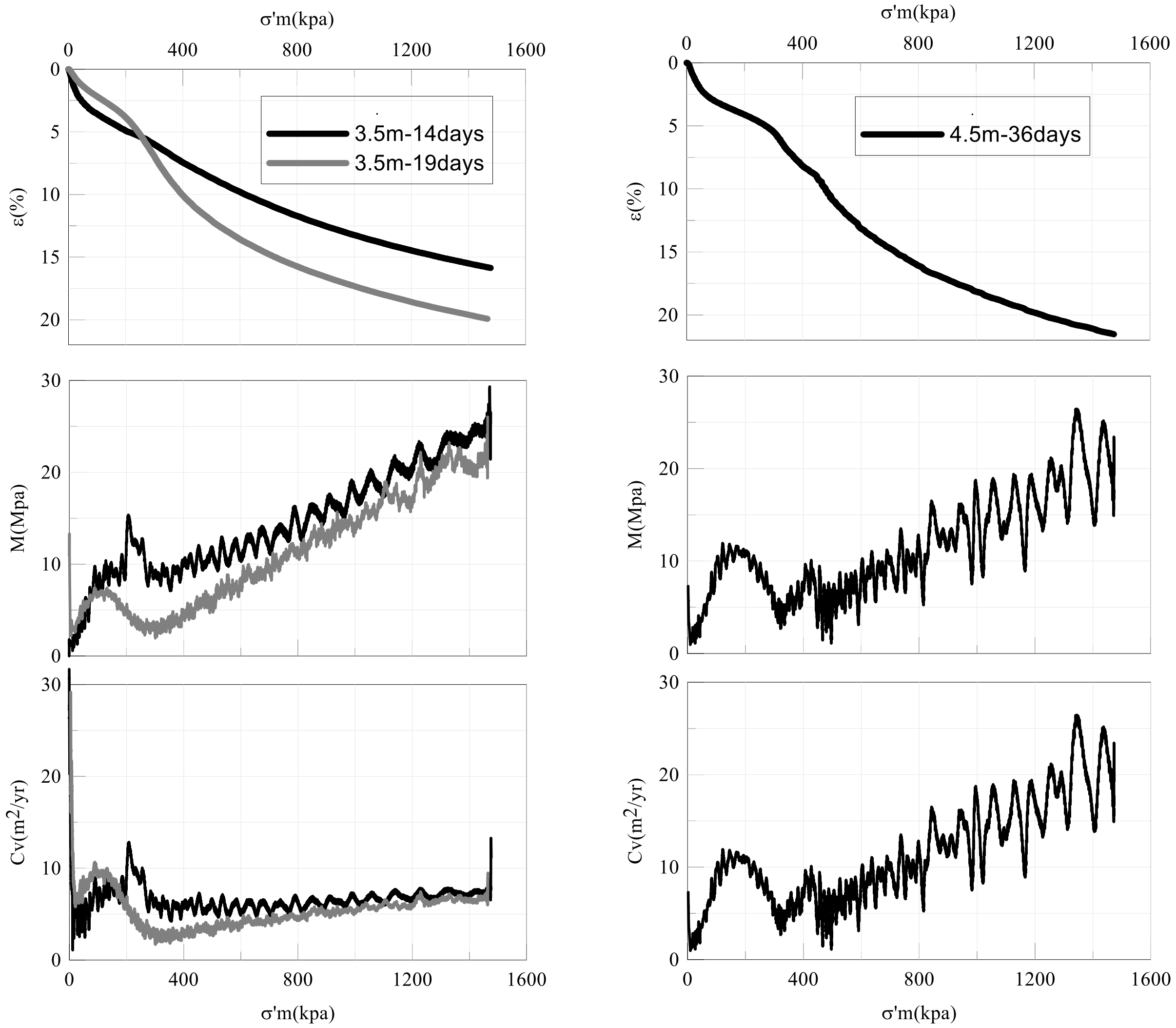


Fig.10 (a) CRS test from 3.5m depth

(b) CRS test from 4.5m depth

6.1.1 Constrained modulus(M)

Values of overconsolidated modulus (Moc) and modulus(Mnc) at preconsolidation stress(P'c) versus depth are plotted on fig.16(a) and (b) below. There is no tendency of varying with depth but of course, Moc values are larger on top zone. Moc of about 5Mpa and Mnc=3Mpa on average are estimated from the graph.

6.1.2 Compressibility in the normally consolidated range

Modulus number(m) which is the slope of M versus σ'm curve in a normally consolidated range versus depth is plotted on fig.16c. As it is shown on the figure, values lie within the range (m=10 and m=21) suggested for a Norwegian clay(Janbu,1985) for an average water content of about 45%. There is no significant variation in the trend with depth and about 18.5 on average.

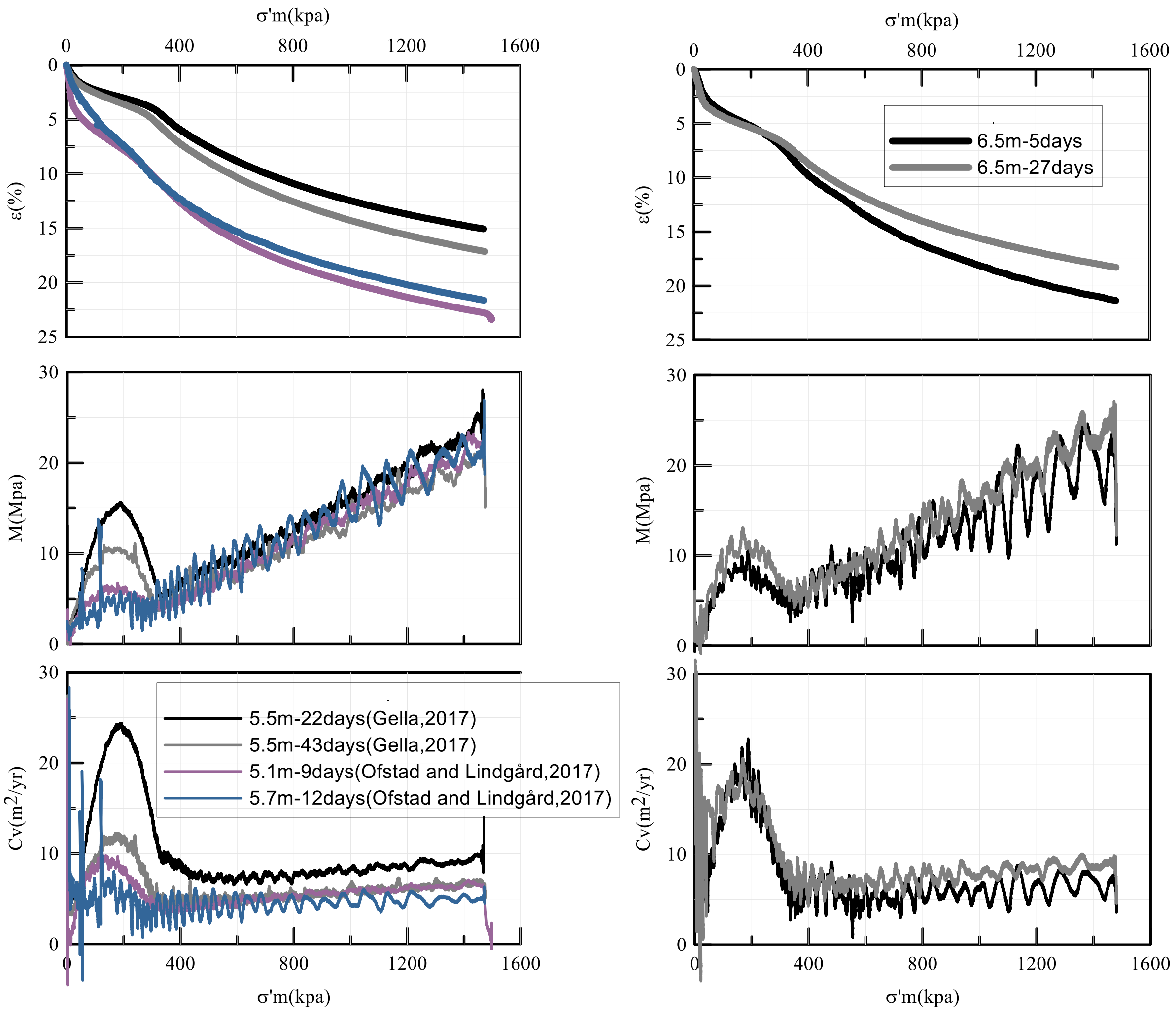


Fig.11 (a) CRS tests from 5.1m to 5.7m (b) CRS tests from 6.5

6.1.3 Coefficient of consolidation

Coefficient of consolidation values are shown on fig.17(a) and (b). Minimum and maximum limits for a coefficient of consolidation in normally consolidated range for an average water content of about 45% are C_{vn}=3.3 and C_{vn}=7.4(Janbu,1985) respectively and are shown with dotted line on the figure. Values lie within the range suggested and C_{vn}=4m^2/yr on average. And coefficient of consolidation in an overconsolidated range is about C_{vo}=8m^2/yr on average.

6.2 Triaxial tests

Isotropically consolidated undrained(CIUc) and anisotropically consolidated undrained(CAUc) triaxial tests are shown in the form of axial strain(ε) versus shear stress(τ=(σ'1-σ'3)/2) and pore pressure and mean stress(p'=(σ'1+2σ'3)/3) versus shear stress(q=σ'1-σ'3). The triaxial tests are plotted on fig18 to 23.

The assumed in-situ pore water pressure distribution for finding effective vertical stresses only for triaxial consolidation phase of triaxial test samples from (3m to 12m) are shown in table-2.

At that point, the in-situ water pressure was known at 5m which was about 30kpa and estimated to raise up hydrostatically to

2m(0kpa). From these known data points, I assumed the ground water level at 12m to be 100kpa.

Finally, the measure in-situ water pressure was borrowed from my fellow students Ofstad and Lindgård,2017. The distribution is shown on fig.6b. This in-situ water pressure distribution was considered for triaxial consolidation of samples from (15m to 15.8m) and (18m to 18.8m) and to all other in-situ pore water pressure related calculations.

6.2.1 Undrained shear strength

Undrained shear strength(Su) values from triaxial tests are plotted on fig.26(a) and (b). In an isotropically consolidated undrained(CIUc) triaxial tests soil samples were consolidated back to an in-situ effective mean stress, P'o= 1/3(σ'1+2σ'3), while K_0=0.7 was considered for consolidation during anisotropically consolidated undrained(CAUc) triaxial tests.

According to Ladd and Foot (1974), normalized undrained shear strength from triaxial test samples which were consolidated in lab to an in-situ stress before shearing can be related to overconsolidation ratio(OCR) as:

$$(S_u/\sigma'_v)_{oc} = OCR^{0.8}(S_u/\sigma'_v)_{nc}$$

S_u/σ'_v is about 0.3 in the quick clay zone and corresponds to OCR=1. This shows that OCR compares very well with the result of oedometer test in quick clay zone which is normally consolidated.

6.2.2 Drained shear strength

Drained shear strength parameters, friction angle(φ') and cohesion(C') can be calculated from plots of triaxial tests in the form of shear stress(q) versus effective mean stress(P')(fig.18 to 23). Inclination of a failure line(M) on q-p' plot:

$$M=6\sin\varphi/(3-\sin\varphi)$$

Values of friction angle and cohesion are tabulated in Table 3.

Table 2 Assumed in-situ pore water pressure distribution

Depth(m)	Pore pressure(kpa)
2	0
3	10
4	20
5	30
6	40
7	50
8	60
9	70
10	80
11	90
12	100

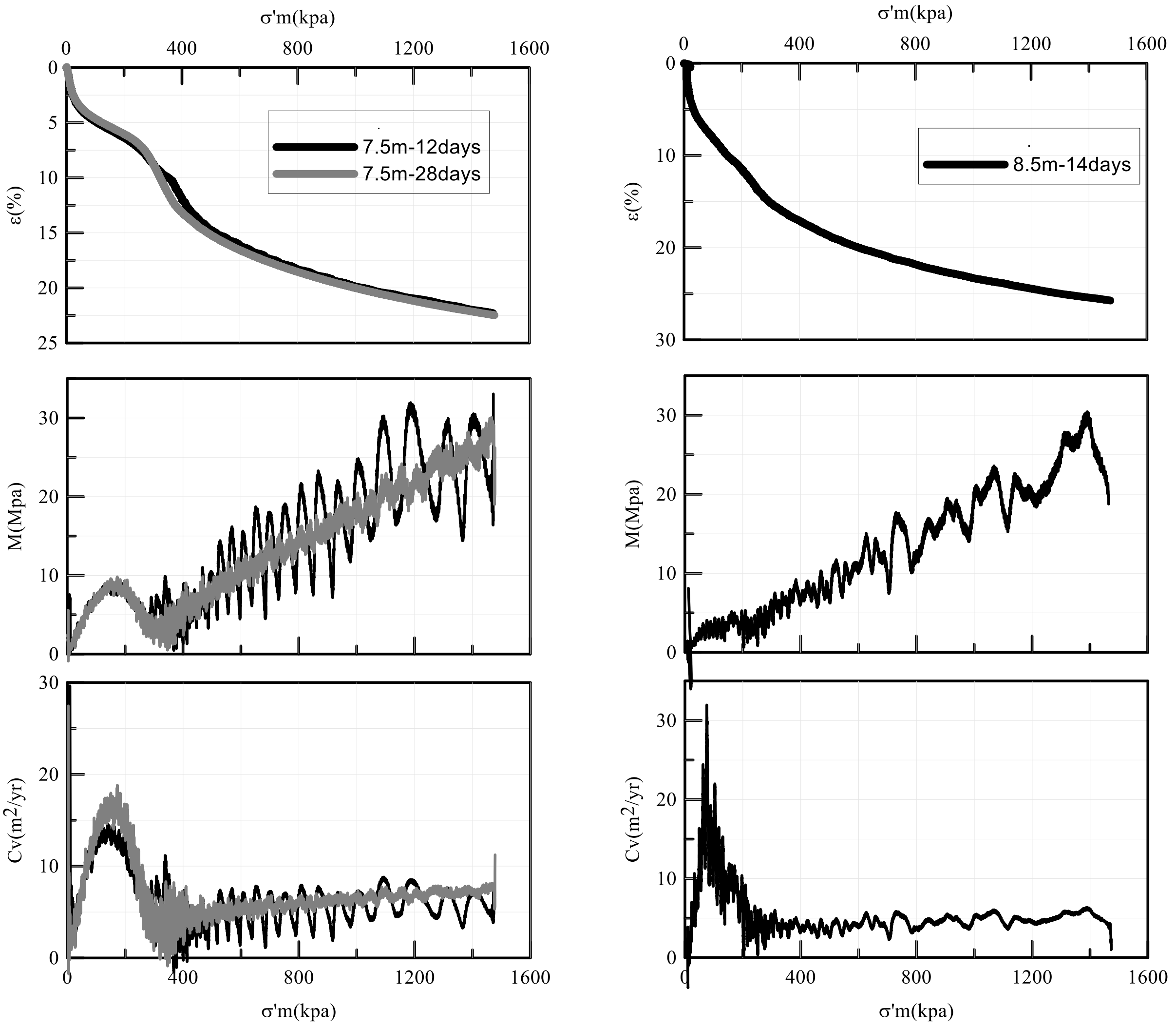


Fig.12 (a) CRS tests from 7.5m (b) CRS test from 8.5m

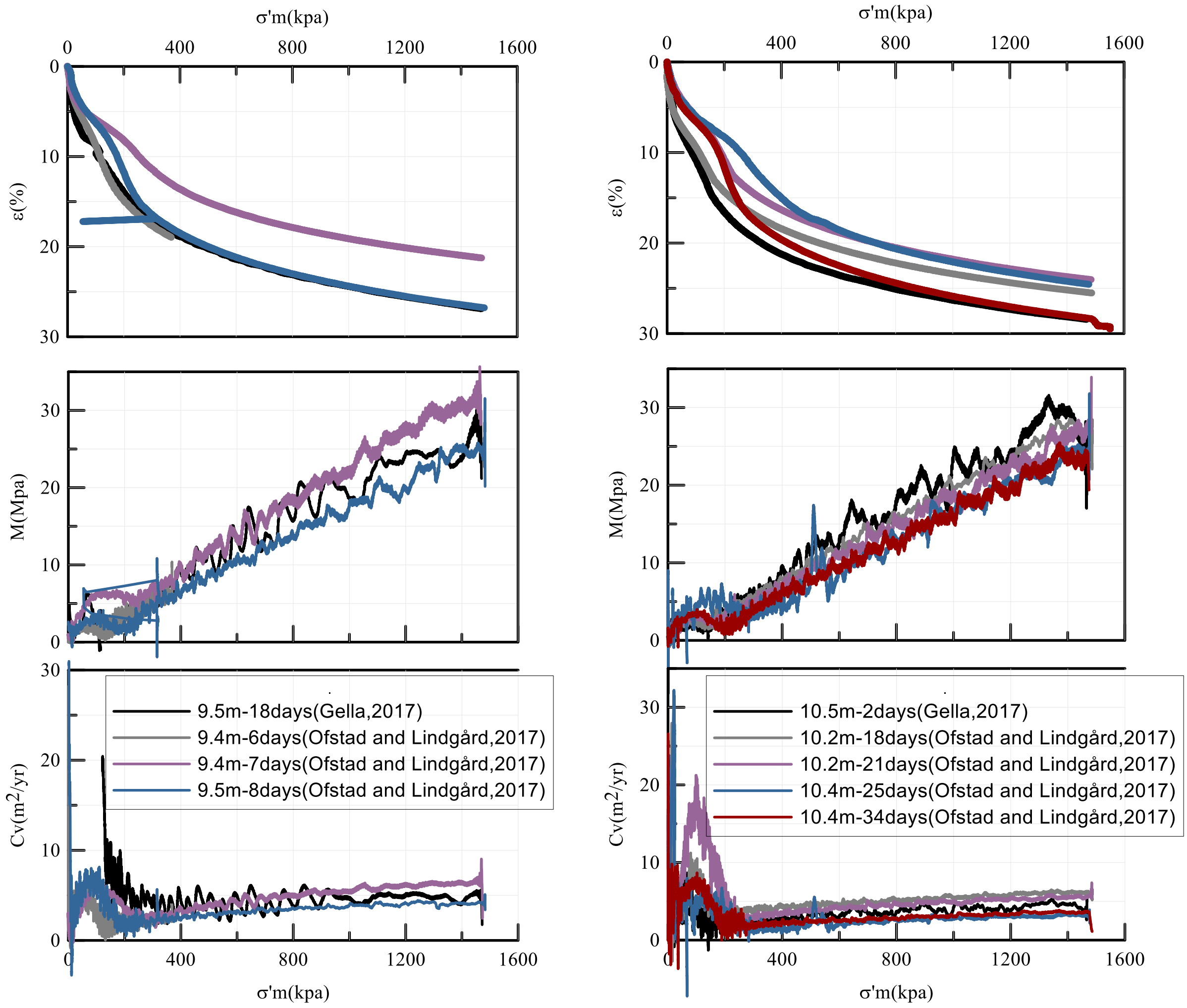


Fig.13 (a) CRS tests from 9.4m and 9.5m (b) CRS tests from 10.2m,10.4m and 10.5m

Table 3 Drained shear strength parameters

Depth,m	Friction angle,φ’(degree)	Cohesion,C’ (kpa)
3-3.8	39	0
4-4.8	33.9	5.4
5-5.8	33.1	5.2
6-6.8	31.1	7.2
7-7.8	31.5	6.7
8-8.8	21.3	9.7
9-9.8	28.3	6.5
10-10.8	28.7	6.6
11-11.8	23.4	13
15-15.8	21.2	19.4
18-18.8	26.6	14

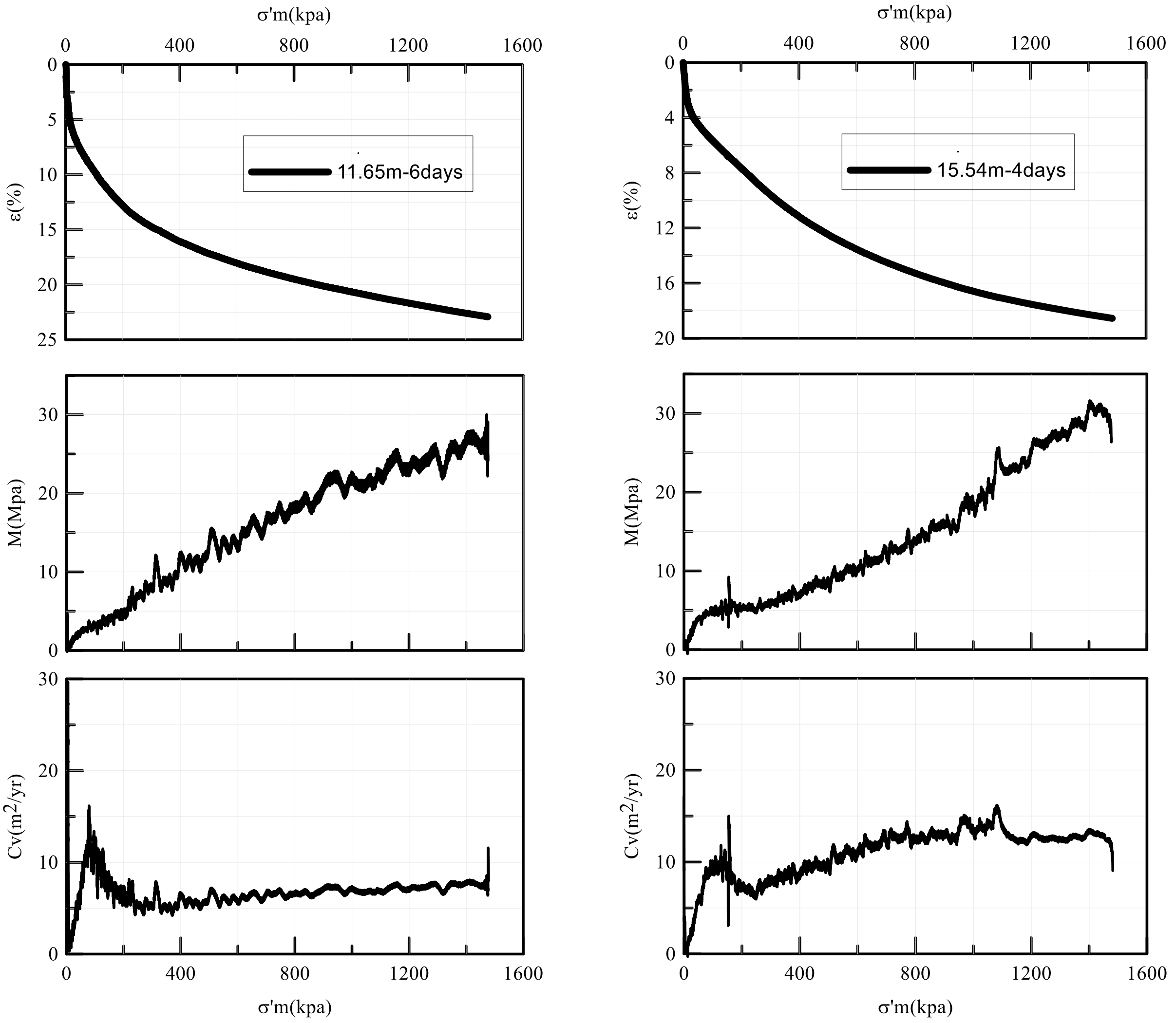


Fig.14 (a)CRS tests from 11.65m (b) CRS tests from 15.54m

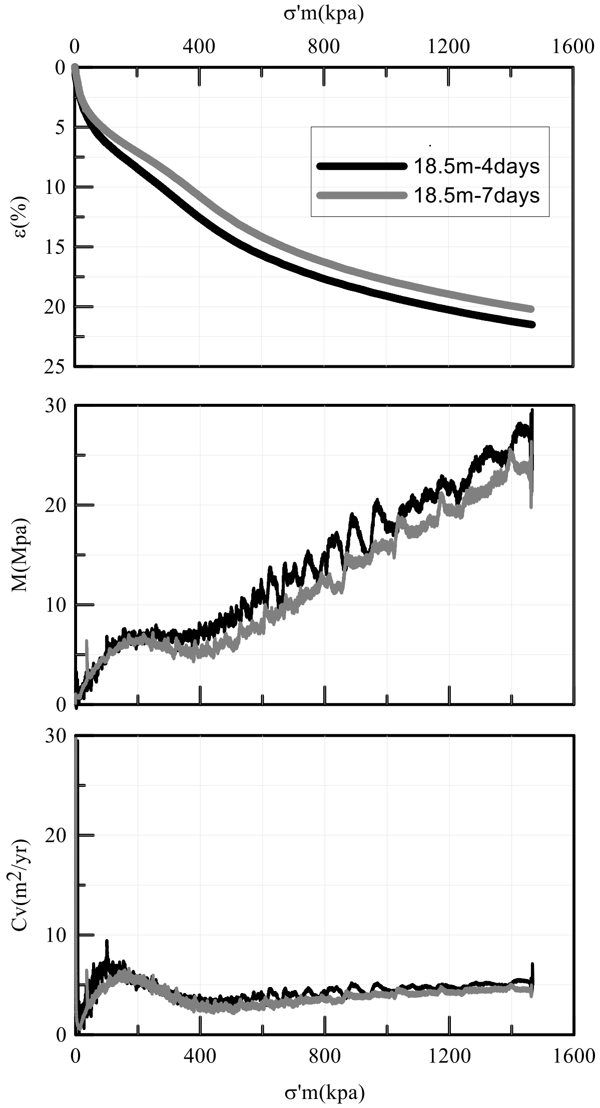


Fig.15 CRS tests from 18.5m

6.2.3 Comparison between triaxial test strength(CAUc) with CPTU strength

Field testing was not the intension of this work but CPTU test results were borrowed just to compare the derived strength from CPTU to CAUc triaxial test strength. CPTU test results are shown on fig.25. Corrected cone resistance(q_t) increases with depth from 0.78Mpa at 1m to 2.6Mpa at 19.5m and does not tend to shift sideways until 19.5m depth is reached. The material is homogeneous between 3m and 19.5m, which is clay. Above 3m, there seems to be sand on top of clay which is clearly seen on generated pore water pressure(u_2) diagram. Values of sleeve friction(f_s) start decreasing in between 7m to 7.5m which is where the non-sensitive clay zone shifts to quick clay.

Undrained shear strength(s_u) from CPTU test can be derived in the form of generated pore water pressure(u_2) correlating to pore pressure factor($N_{\Delta u}$)(Lunne et al.,1997b)

$N_{\Delta u}=(u_2-u_o)/s_u$

where: u_o= in situ pore water pressure

$N_{\Delta u}$ =bearing capacity factor(Karlslud et al., 2005)

$N_{\Delta u} = 6.9-4\log OCR+0.07(I_p)$ [for St<15]

$N_{\Delta u} = 9.8-4.5\log OCR$ [for St>15]

I_p =plasticity index in %

St=sensitivity

OCR=overconsolidation ratio

Su can also be correlated with corrected cone resistance(q_t)(Lunne et al.,1997b) as:

$N_{kt}=(q_t-\sigma_{vo})/s_u$

where: σ_{vo} =total vertical overburden pressure

N_{kt} = bearing capacity factor(Karlslud et al.,2005)

$N_{kt} = 7.8+2.5\log OCR+0.082I_p$ [for St<15]

$N_{kt} = 8.5+2.5\log OCR$ [for St>15]

Undrained shear strength from CPTU and CAUc tests are shown on fig.26b. Su of CPTU test which was derived in terms of $N_{\Delta u}$ correlates very well with Su of CAUc.

6.3 Undrained shear strength from Index tests

Fig.24(a) and (b) show undrained shear strength from fall cone test and unconfined compression tests respectively. As it is seen on the fig.24(a) and (b), values are crossing 0.3σ'$_{vo}$ line at about 7.5m and is the depth where the quick clay zone starts. Minimum value is attained at this point and then increasing slowly with depth. It is also the point where state of stress of the material changes from overconsolidated to normally consolidated. Values of which laid above 0.3σ'$_{vo}$ line represent overconsolidated material and those below are normally consolidated (Ladd and Foott,1974)

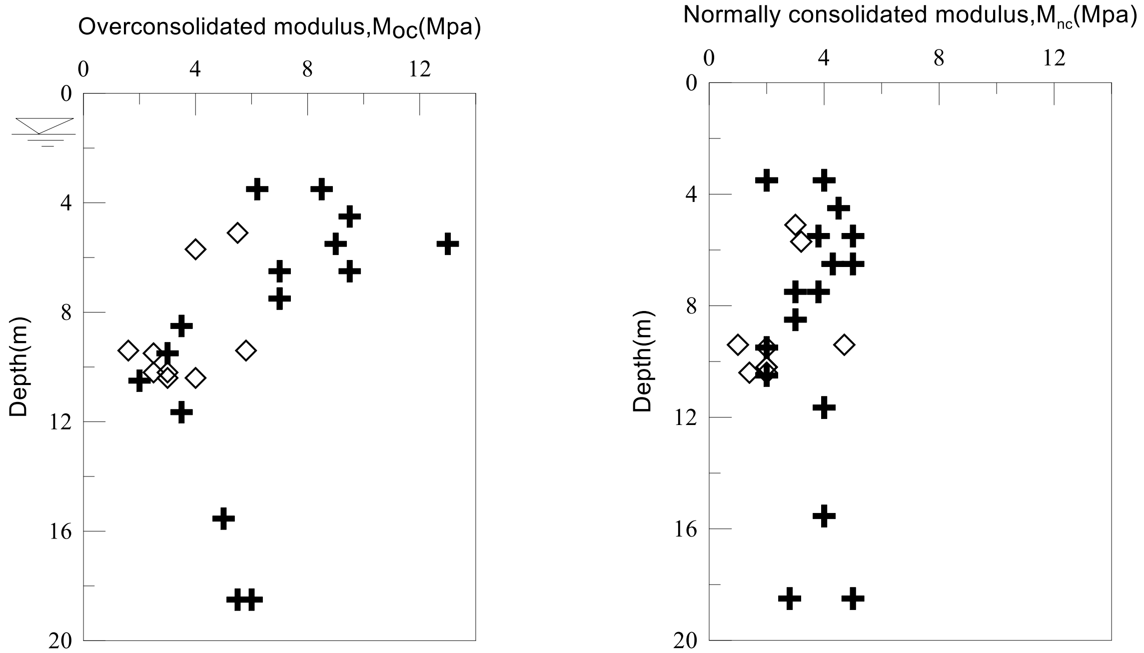
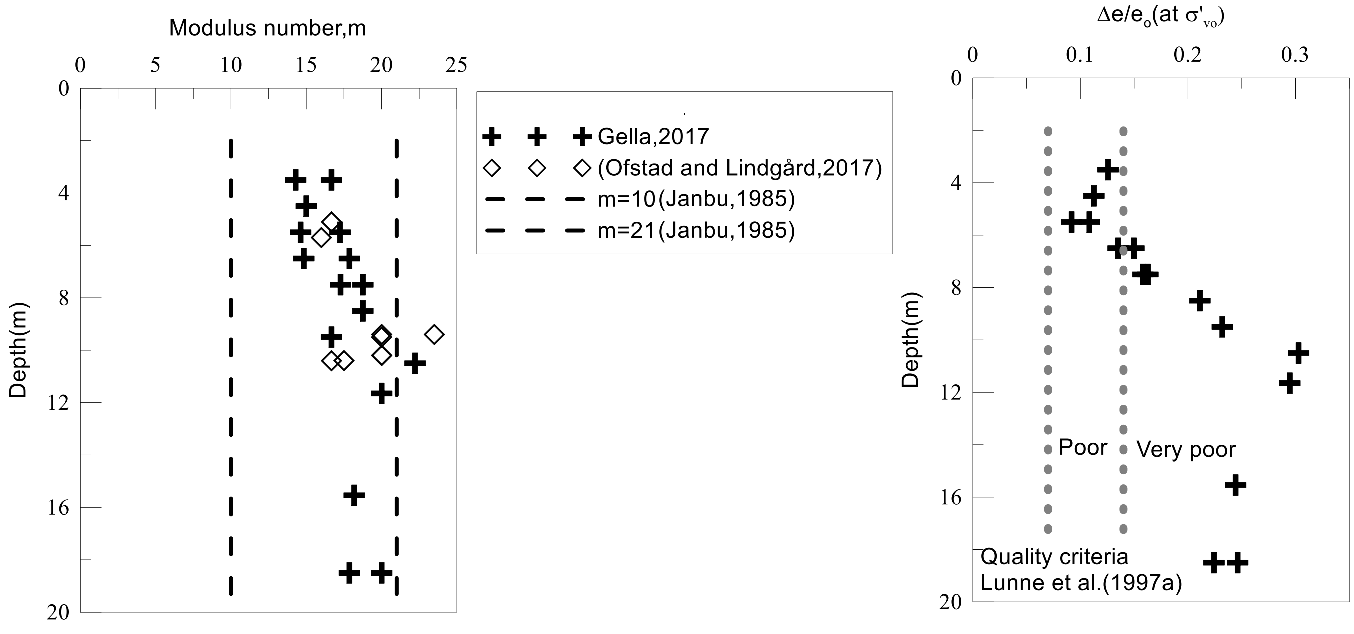


Fig.16 (a) Moc versus depth

(b) Mnc(at P'c) versus depth



(c)modulus number(m) versus depth

(d)Δe/e$_o$ at σ'$_{vo}$ versus depth

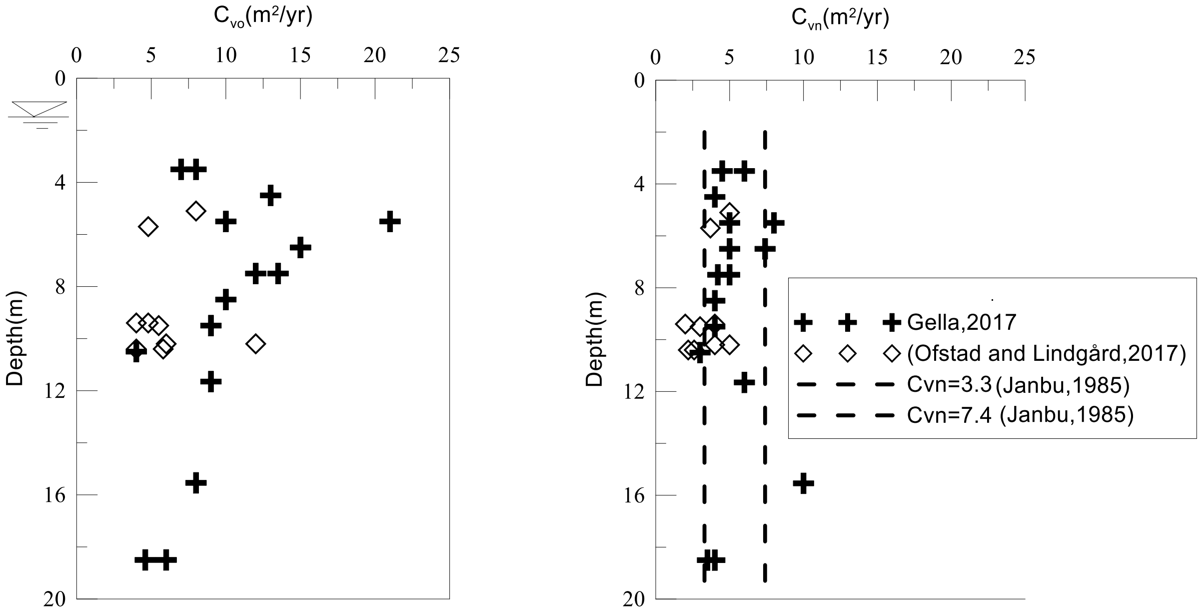


Fig.17 (a) C_{vo}versus depth (b) C_{vn} versus depth

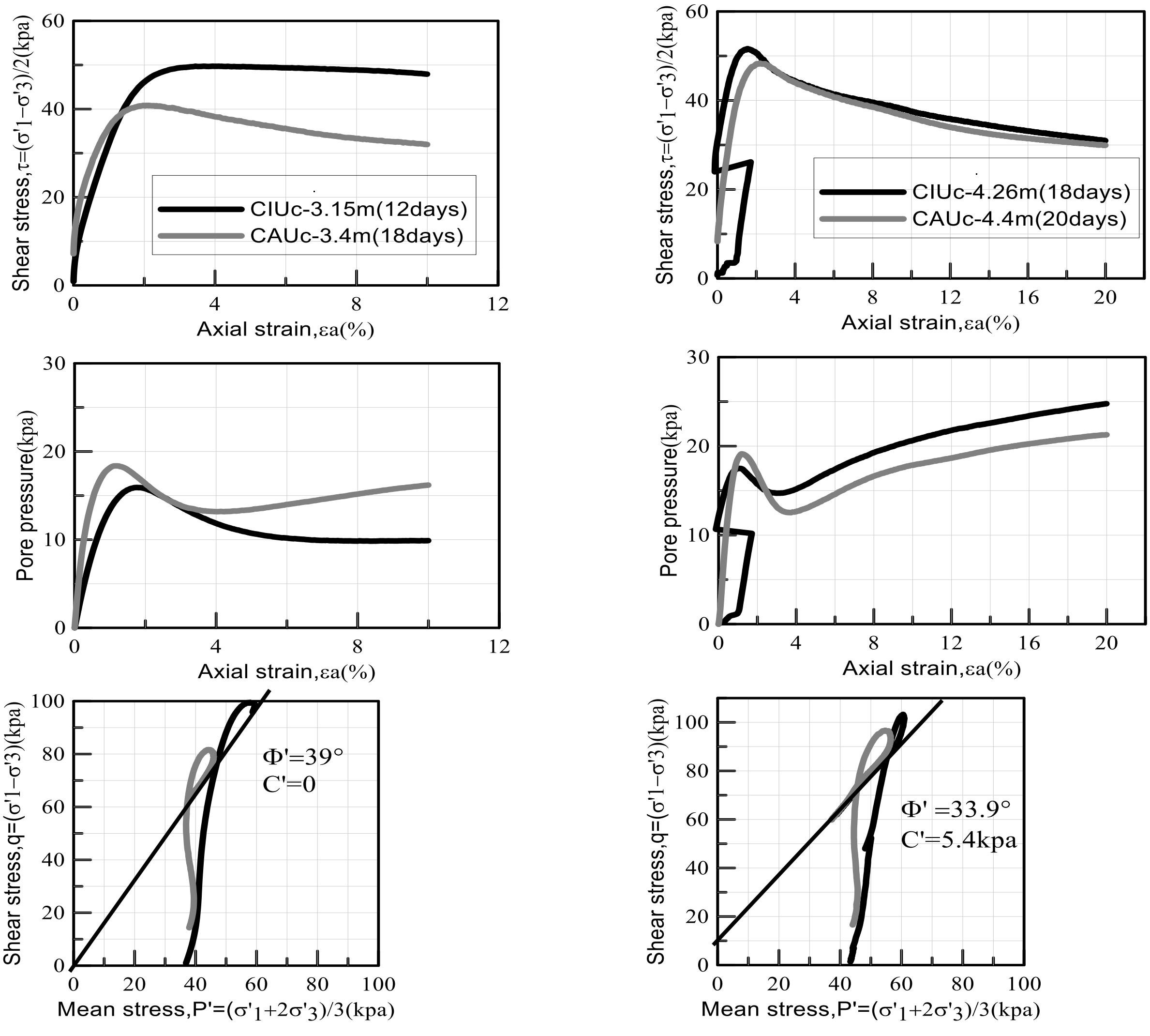


Fig.18 (a)CIUC and CAUC triaxial tests from 3.15m and 3.4m (b) CIUC and CAUC triaxial tests from 4.26m and 4.4m

Note: During shearing phase of CIUc triaxial test from 4.26m something went wrong with the system and stopped at axial vertical strain of ε=1.71%. Then the problem was solved and made it run again where it had stopped. As it can be seen on fig.18b, the vertical loading cell started running almost where it had stopped but axial strain started from negative value back to the beginning.

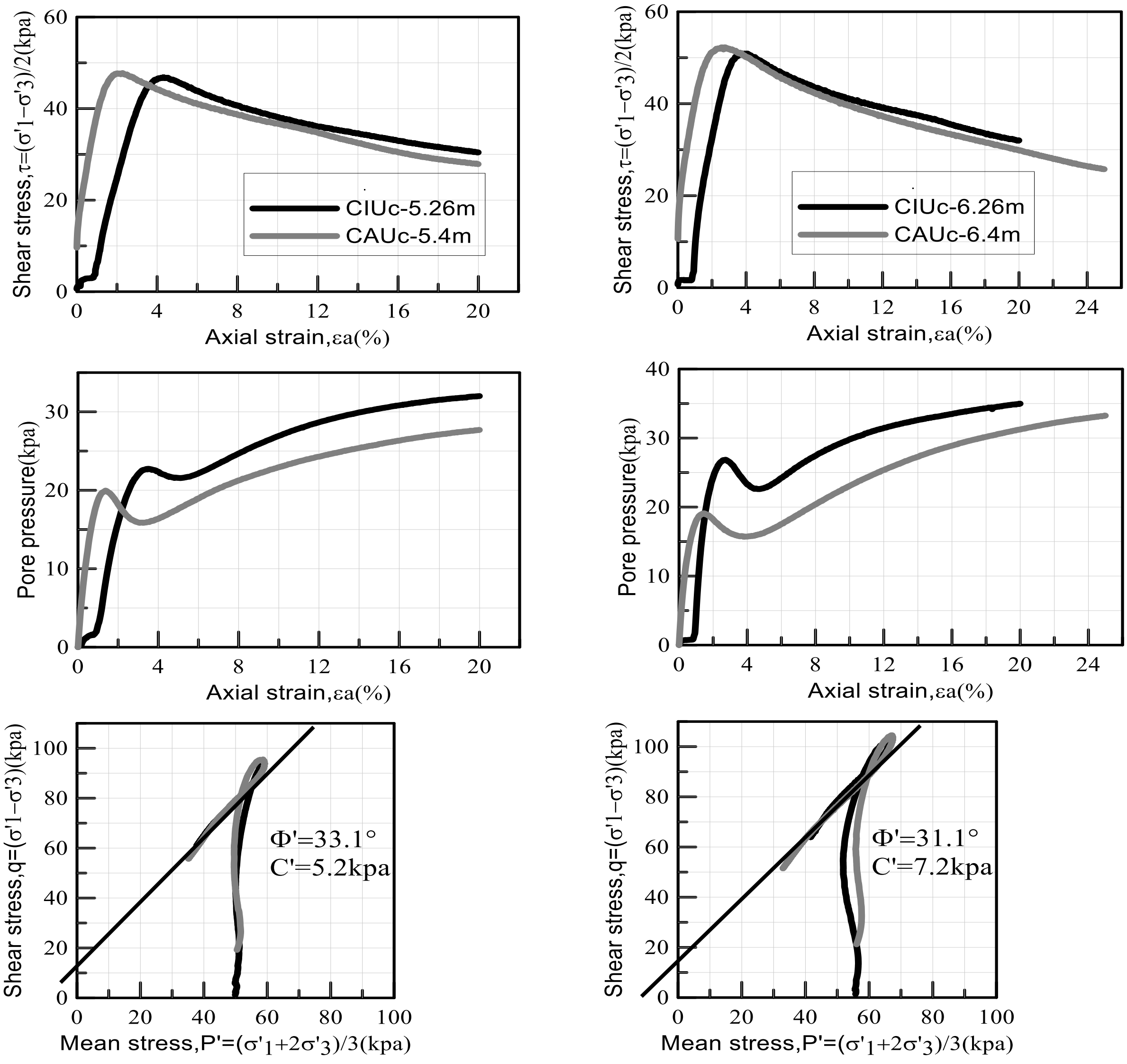


Fig.19 (a)CIUC and CAUC triaxial tests from 5.26m and 5.4m

(b) CIUC and CAUC triaxial tests from 6.26m and 6.4m

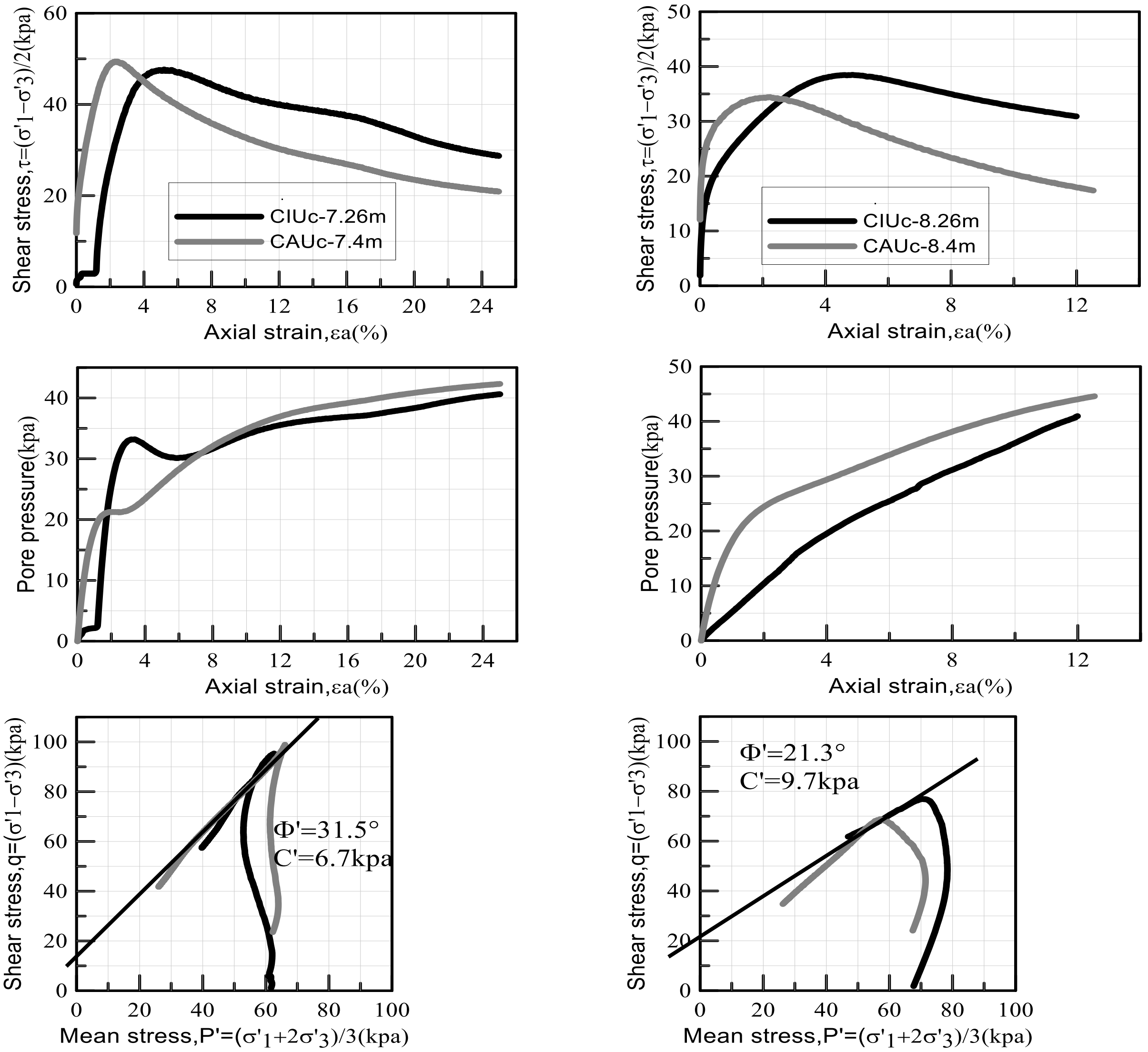


Fig.20 (a)CIUC and CAUC triaxial tests from 7.26m and 7.4m

(b) CIUC and CAUC triaxial tests from 8.26m and 8.4m

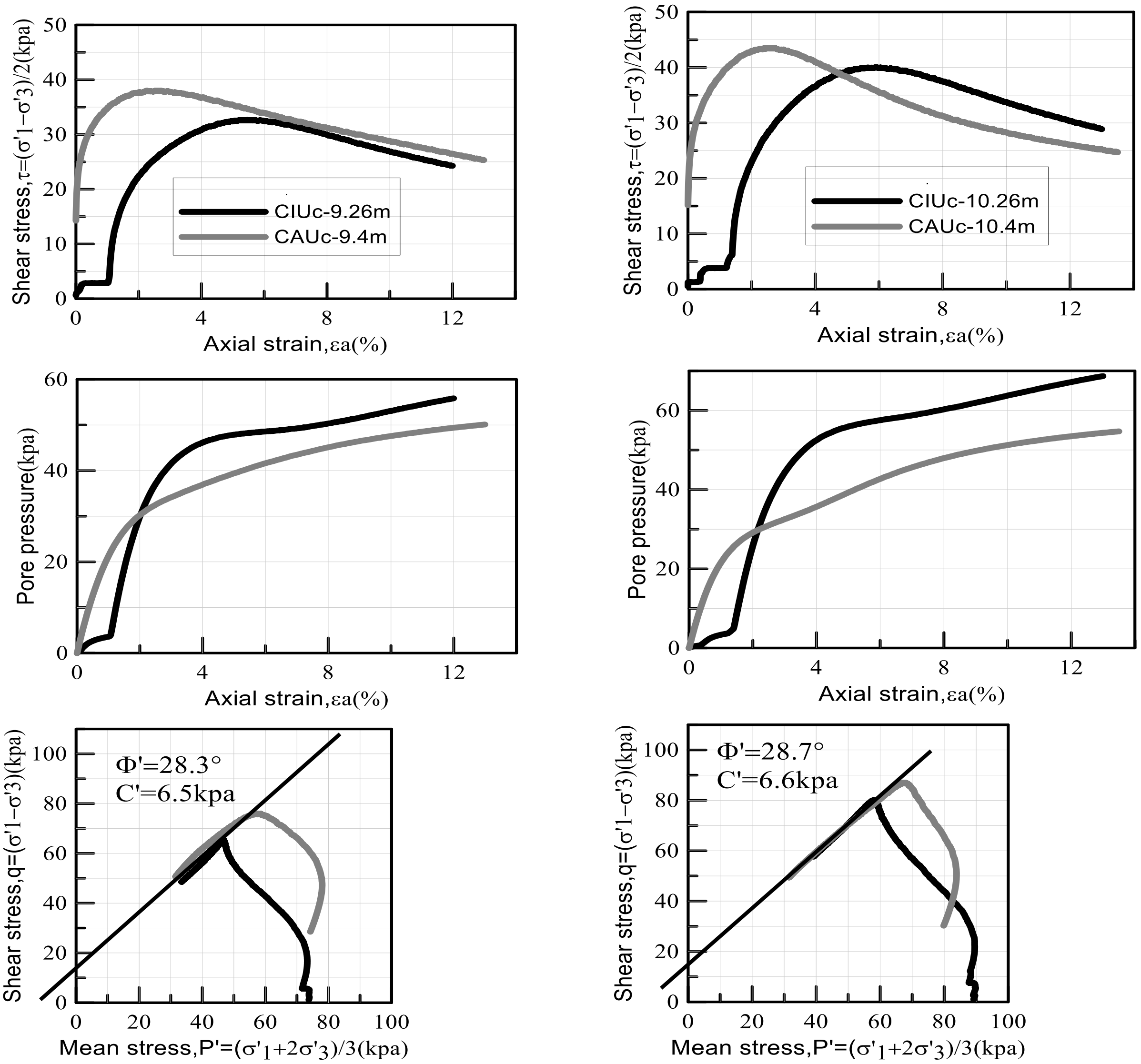


Fig.21 (a)CIUC and CAUC triaxial tests from 9.26m and 9.4m

(b) CIUC and CAUC triaxial tests from 10.26m and 10.4m

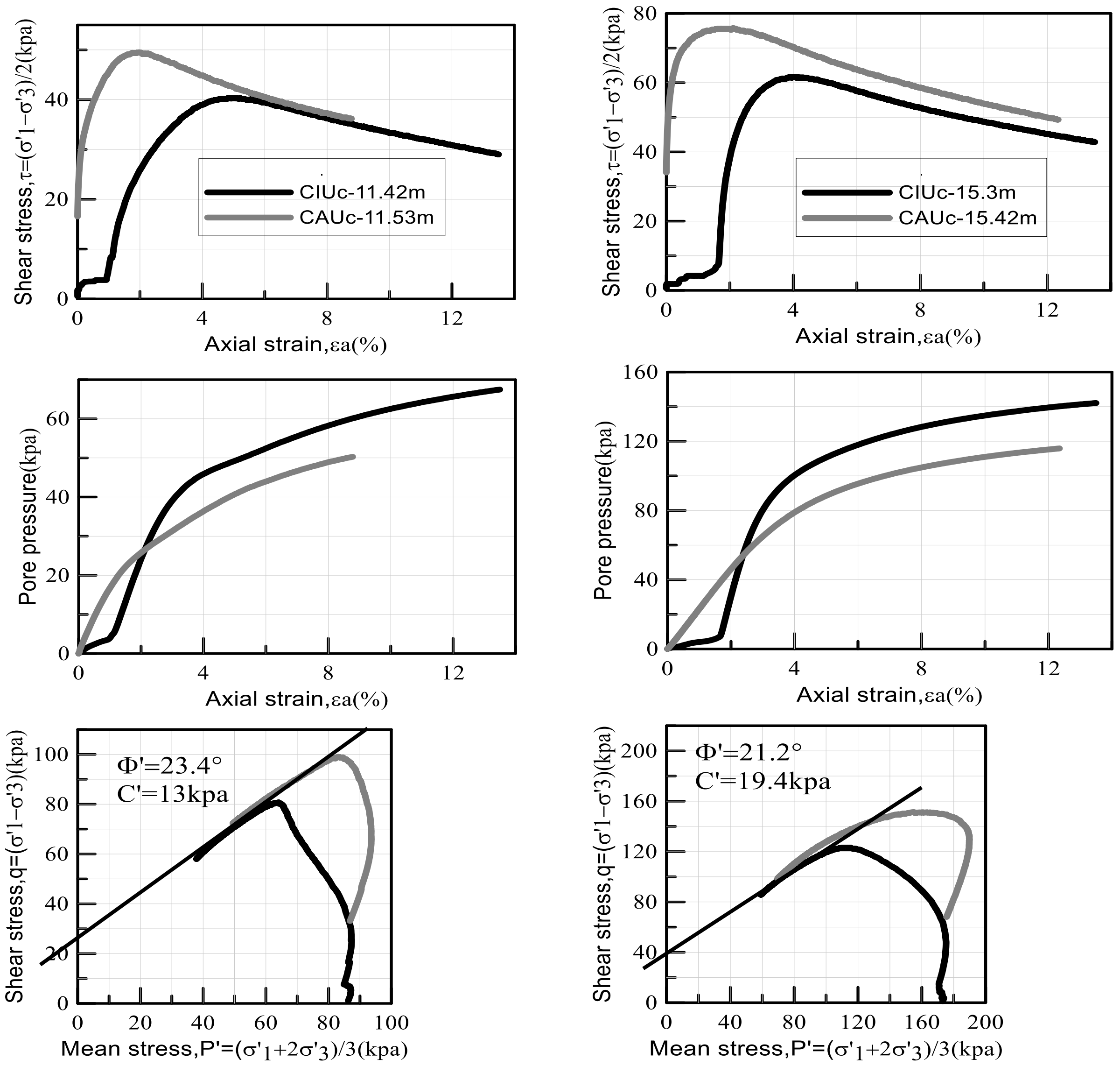


Fig.22 (a)CIUC and CAUC triaxial tests 11.42m and 11.53m

(b) CIUC and CAUC triaxial from tests from 15.3m and 15.42m

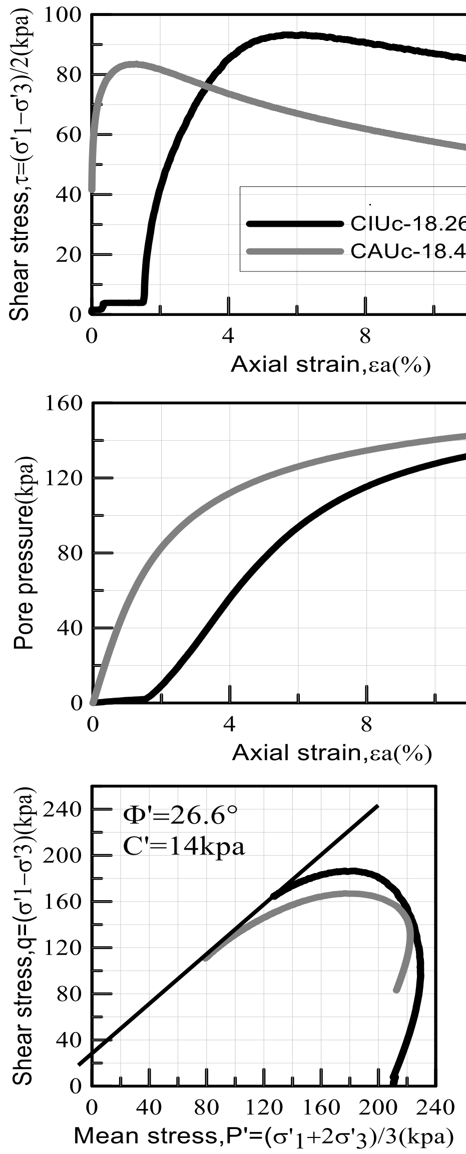


Fig.23 (a)CIUC and CAUC triaxial tests from 18.26m and 18.4m

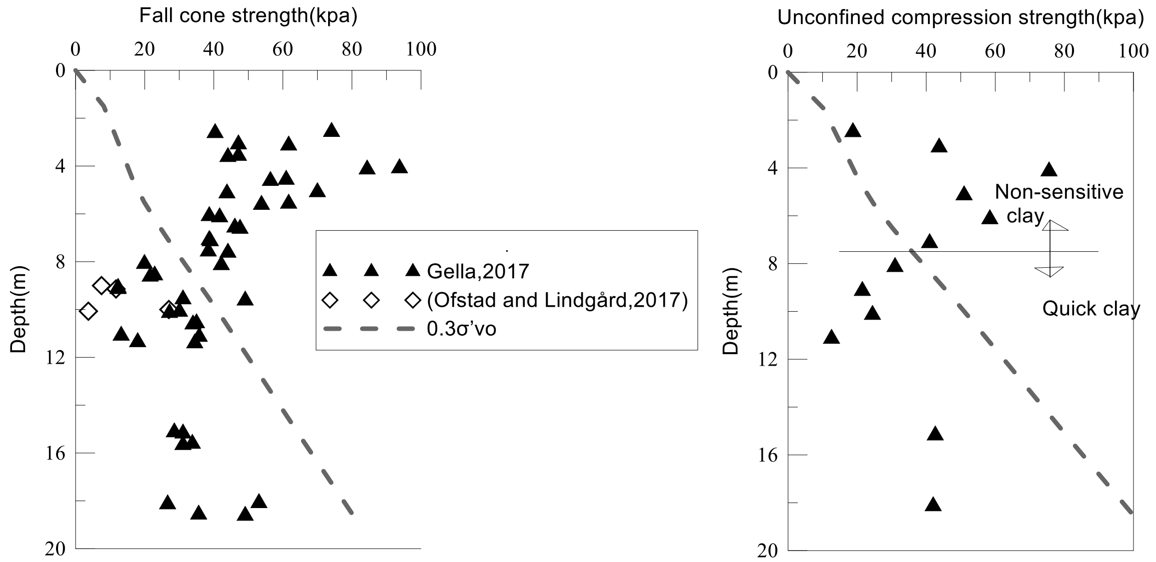


Fig.24 (a) Fall cone strength (b) Unconfined compression strength

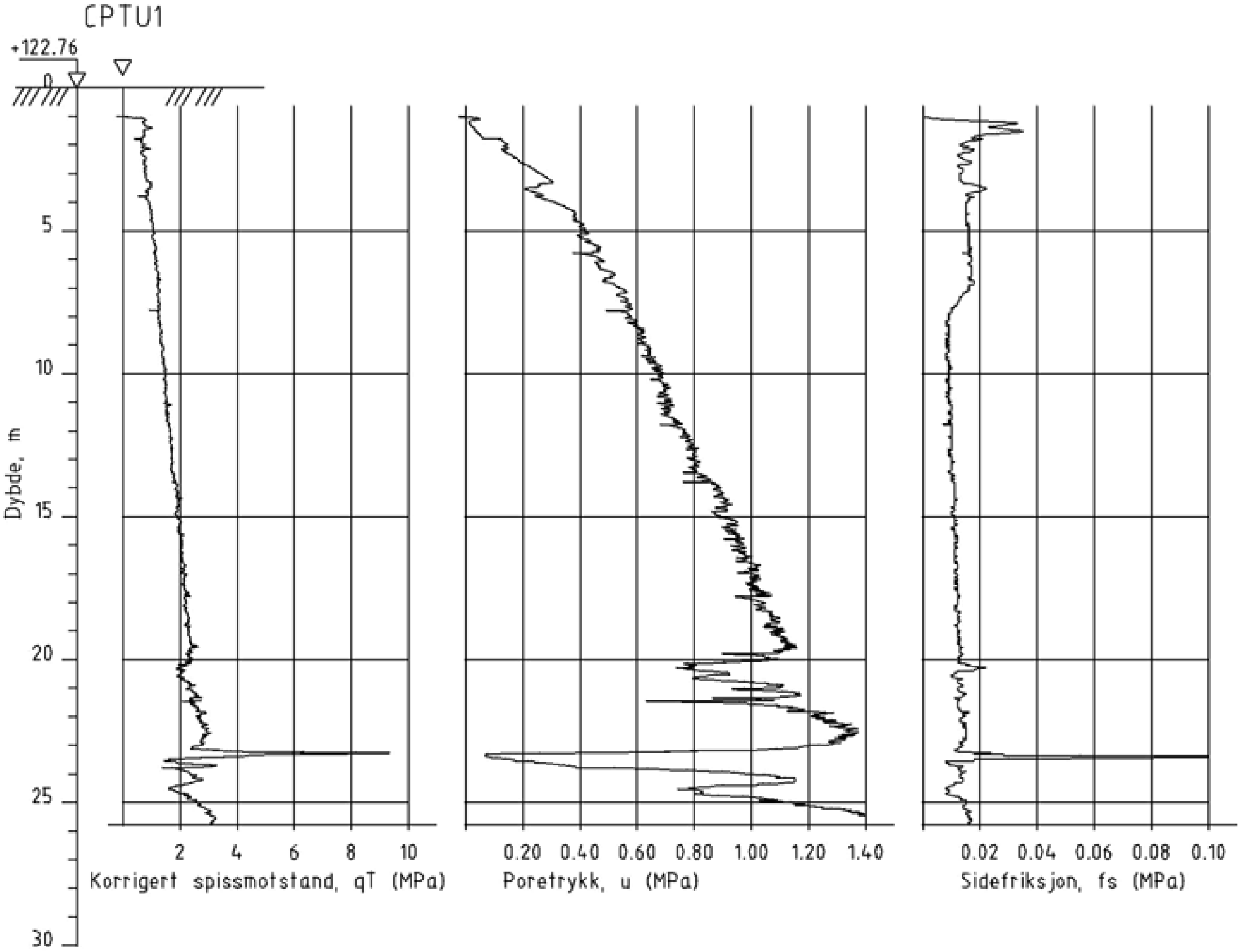


Fig.25 Cone penetration test with pore pressure measurements(CPTU) (Ofstad and Lindgård,2017)

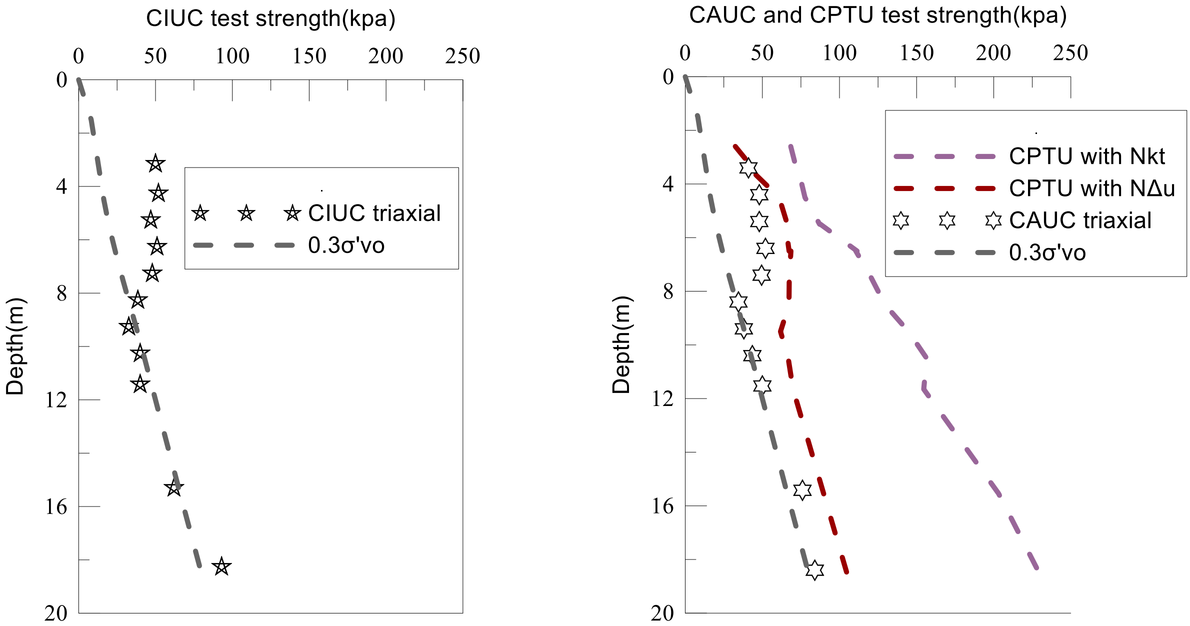


Fig.26 (a) Undrained shear strength from CIUc tests

(b) Undrained shear strength from CAUc and CPTU tests

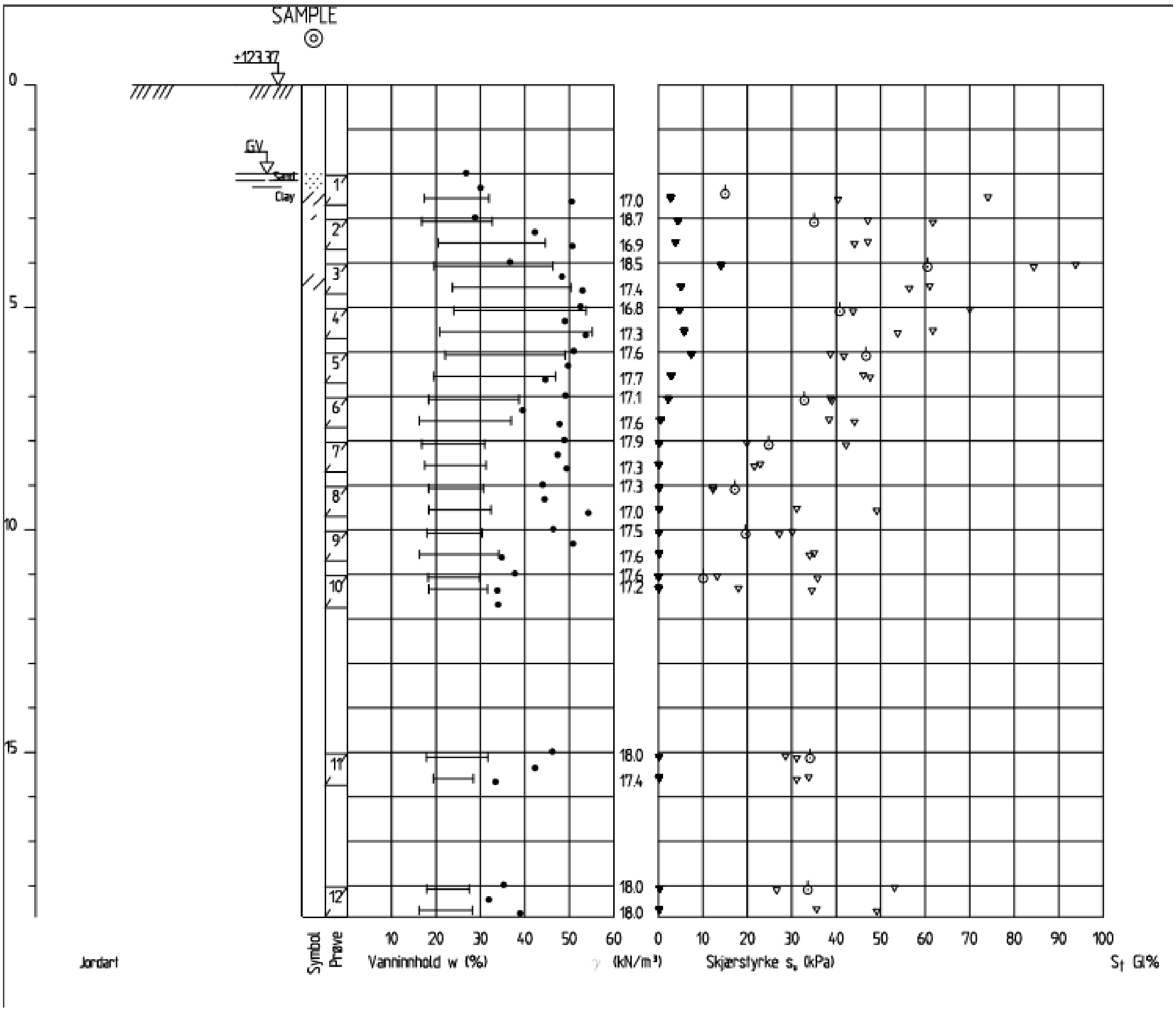


Fig.27 Boring-1 rutine test

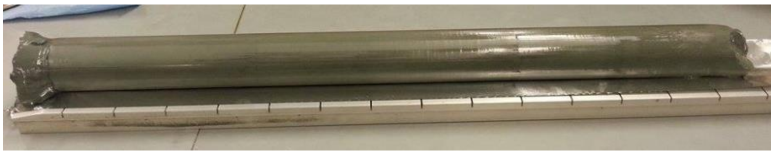
(a)

(b)

(c)

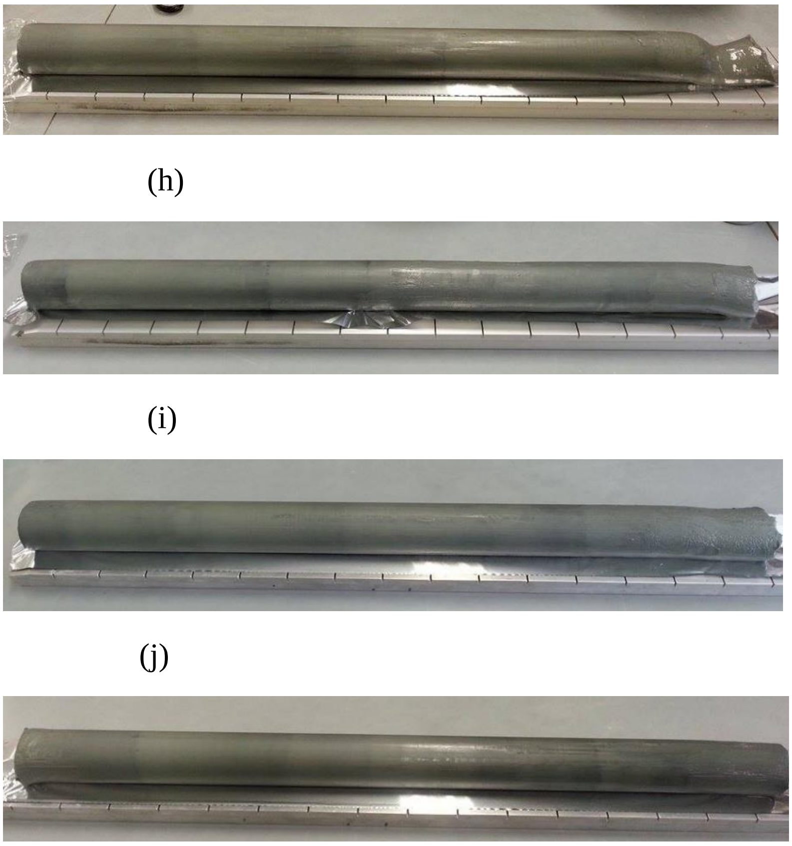
(d)

(e)



(f)

(g)



(h)

(i)

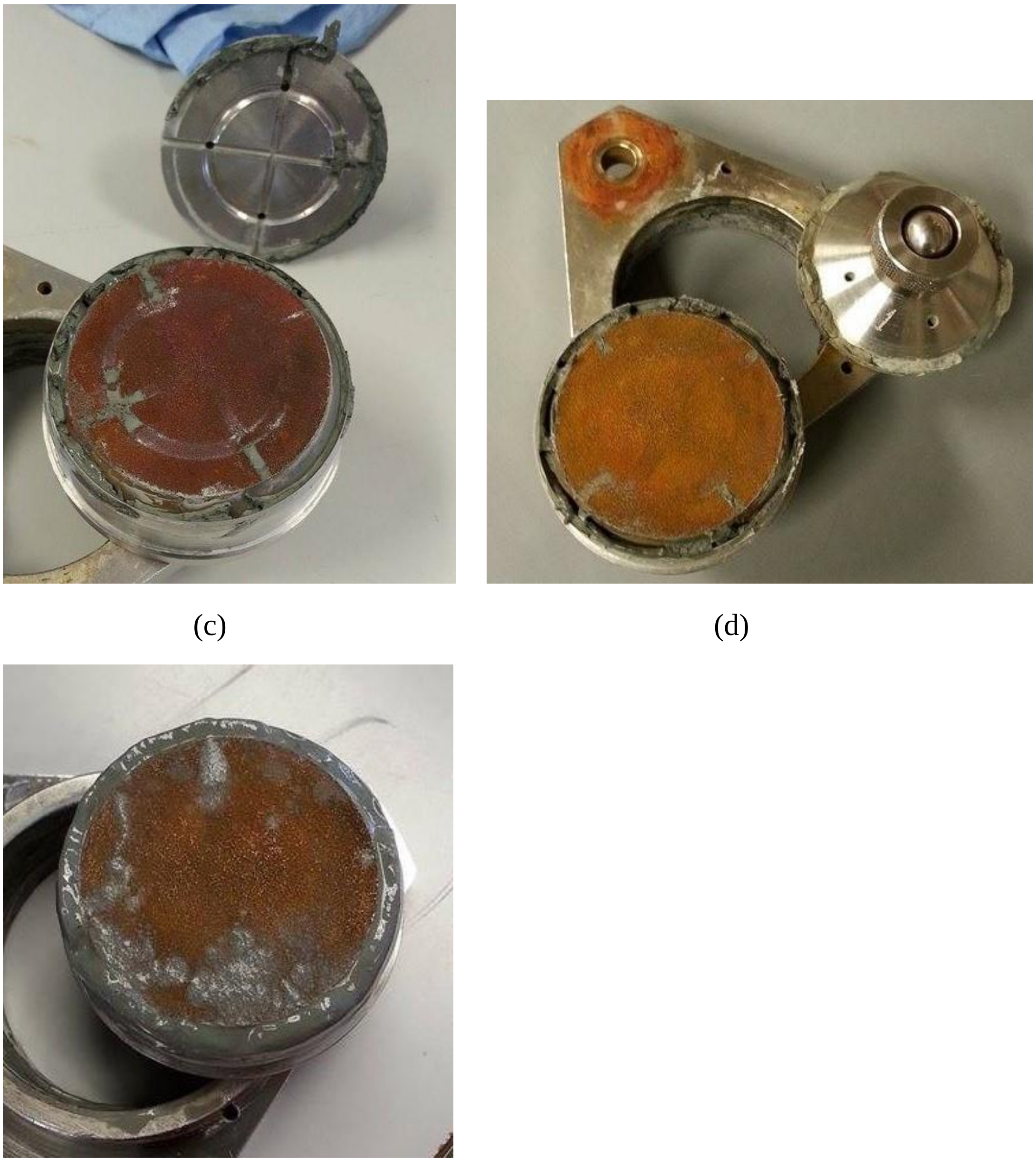
(j)

(k)

Fig.28 An overview of soil samples from each depth (a)2m-2.8m (b) 3m-3.8m (c) 4m-4.8m (d) 6m-6.8m (e) 7m-7.8m (f) 8m-8.8m (g) 9m-9.8m (h) 10m-10.8m (i)11m-11.8m (j) 15m-15.8m (k) 18m-18.8m

(a)

(b)



(c)

(d)

(e)

Fig.29 An overview of oedometer test samples after testing from (a) 7.5m(12days) (b)7.5m(28days) (c) 8.5m (d) 9.5m (e) 11.65m.

7. Conclusion

1. Test results of Flotten clay is like Norwegian quick clay.

2. The clay at Flotten is homogeneous that the mineral makeup is consistent with depth.

3. The clay on the test site is overconsolidated in zone above about 7.5m and normally consolidated underneath which correspond to the non-sensitive and quick clay zones respectively.

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