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Effects of Stress Relief and Reconsolidation on Shear Characteristics of Reconstituted Over-consolidated Dhaka Clay

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Introduction

The behaviour of the ground and foundations are analysed usually on the basis of soil parameters obtained from laboratory test on the sampled soil since stresses, deformations and boundary conditions can be more readily and precisely controlled and observed in the laboratory. However, the inherent problem with a sampled soil is that it gets disturbed during sampling process. Sampling introduces two major difficulties, both associated with the disturbance that a sample experiences before being transported to the laboratory where it is tested. Firstly, mechanical disturbance is caused due to deep penetration of sampler into the clay. This produces shear distortion and subsequent compression of clay close to the inside wall of the sampler. The second source of disturbance is caused as a result of stress relief due to removal of the sample from the ground to zero total stress state in the laboratory. This disturbance is termed as stress relief or "perfect" sampling disturbance. The first source of disturbance is directly associated with sampler design and can be controlled to certain extent. Disturbance due to stress relief, however, is unavoidable even though its effects may be different depending on the depth of sampling and soil properties and present states. A number of researchers have investigated the effects of stress relief on the undrained shear characteristics of clays (Skempton and Sowa, 1963; Ladd and Lambe, 1963; Noorany and Seed, 1965; Adams and Radakrishna, 1971; Kirkpatrick and Khan, 1984; Hight et

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TABLE 1 : Summary of the Effects of "Perfect" Sampling Disturbance on Some Engineering Properties of Normally Consolidated and Over-consolidated Clays

Soil	IndexValues	OCR	Ratioof s_u	Ratioof e_p	Ratioof E_i	Ratioof E_{50}	Ratioof A_p	Reference
Weald Clay	LL = 46 PI = 24	1.0 2.0 14.0	0.98 1.03 1.08	1.29 0.88 -	- - -	- - -	- - -	Skempton andSowa (1963)
Soft Clay	LL = 88 PI = 45	1.0	0.95	1.05	0.9	-	-	Noorany andSeed (1965)
Boston Blue Clay	LL = 33 PI = 15	1.0	0.93	2.5	-	-	-	Ladd andVarallyay (1965)
Kaolin	PI = 30	1.0	0.44	2.75	0.76	-	-	Kirkpatrick andKhan (1984)
Illite	PI = 40	1.0	0.58	3.50	0.78	-	-	
North Sea Clay	LL = 32 PI = 17	1.0 7.4	0.72 0.96	8.00 1.00	1.19 0.47	- -	- -	Hight et al. (1985)
Kaolin	PI = 30	2.0	0.54	1.75	0.46	-	-	Kirkpatirick et al.(1986)
Illite	PI = 40	2.7	0.62	2.50	0.52	-	-	
Illite	PI = 40	5.0	0.86	1.10	0.94	-	-	
Patengha Clay	LL = 44 PI = 18	1.0	0.87	1.32	1.40	-	0.32	Siddique andFarooq (1996)
Kumira Clay	LL = 57 PI = 33	1.0	0.93	1.24	1.47	-	0.17	
Banskhali Clay	LL = 34 PI = 10	1.0	0.89	1.27	1.06	1.10	0.54	Bashar et al. (1997)
Anwara Clay	LL = 40 PI = 16	1.0	0.92	1.21	1.08	1.07	0.50	
Chandan-Aish Clay	LL = 45 PI = 20	1.0	0.96	1.17	1.09	1.08	0.44	
Dhaka Clay	LL = 45 PI = 23	1.0	0.97	1.16	1.67	1.40	0.36	Siddique andSarker (1998)

al., 1985; Kirkpatrick et al., 1986; Graham and Lau, 1988, Siddique and Farooq, 1996; Bashar et al., 1997; Siddique and Sarker, 1998). A summary of the effects of stress relief on some engineering properties of few regional soils is presented in Table 1. All the clays studied were prepared reconstituted samples in laboratory. In Table 1, all ratios refer to results from "in situ" sample. It can be seen from Table 1 that, in general, the effects include reduction in undrained shear strength and an increase in strain at peak deviator stress. Majority of the previous works have concentrated only on the effects of stress relief disturbance on the engineering properties of the clays. Attention should also be directed towards the reconsolidation techniques for minimizing the effects of stress relief. Kirkpatrick et al., 1986, investigated various reconsolidation procedures on over-consolidated clays to reduce perfect sampling disturbance effects. Siddique and Farooq (1996), Siddique et al. (1997) and Siddique and Sarker (1998) examined a number of reconsolidation techniques for a few regional normally consolidated soils in Bangladesh.

This paper presents further investigation into effects of stress relief disturbance on the undrained stress-strain-strength, stiffness and pore pressure characteristics of reconstituted over-consolidated (OCR values of 2 and 10) Dhaka clays. Attempt has also been directed to examine different reconsolidation techniques, both isotropic and anisotropic, in order to minimize the effects of stress relief disturbance.

Soil Used

Reddish brown Dhaka clay collected from Rupnagor Housing Project, Mirpur-11, Dhaka was used in this investigation. Soil sampling was carried out according to the procedure outlined in ASTM D420-87. Approximately 1 m by 1 m area was excavated to a depth of 1.5 m to 2 m. Disturbed samples were collected from the bottom of the borrow pit through excavation by hand shovels. The index properties and classification of the clay are according to Unified Soil Classification System (USCS) and listed in Table 2.

TABLE 2 : Index Properties and Classification of the Dhaka Clay

Specific Gravity G_s	Liquid Limit (LL) %	Plasticity Index (PI) %	Sand Size Fractions %	Silt Size Fractions %	Clay Size Fractions %	Activity	Unified Soil Classification System
2.69	47	26	7	66	27	0.81	CL

Geological Condition

The Bengal Basin has been formed by sediments washed down from adjacent highlands such as Himalayas, where the slopes are steep. The major part of this land building process has been due to sediments carried by the Ganges and the Brahmaputra rivers. From the studies of Morgan and McIntire (1959), geologically the land of Bangladesh can be broadly classified as recent alluvium and older Pleistocene sediments.

The city of Dhaka stands on the southern part of Madhupur Garh, which is formed by older Pleistocene sediments. The Pleistocene sediments are flood plain deposits of earlier Ganges and Brahmaputra. They occur in several extensive areas above the level of present flood plains. There are also indications of differential of these Pleistocene deposits. The Dhaka city is at an elevation 6 to 8 meters above mean sea level. In general, top layer, which extends up to a depth of to 6 to 7.5 meters, is a mixture of silt and clay. Deposits of sand and gravels occur at relatively deeper horizons with a sequence of finer material at top and coarser material downward. The consistency of top layer for the Dhaka clay is medium to stiff and the soil is over-consolidated, the level of over-consolidation ratio varies from 1 to 15. A detailed description of soil profile over Dhaka clay has been provided by Eusufzai (1967) while Ameen (1985) and Kamaluddin have (1990) reported the geotechnical properties of reconstituted over-consolidated Dhaka clay.

Preparation of Reconstituted Sample

Reconstituted soils are those, which are prepared by breaking down natural soils, sieving by no. 40 sieve, mixing them as slurry and consolidating them. The major advantages of using data from reconstituted soils are that the ambiguous and substantial effects of sample inhomogeneity can be eliminated, while the essential history and composition of in-situ soils can be represented. Jardine (1985) discussed the difficulties of implementing detailed investigations of general stress-strain and strength properties using intact samples and it was found that the most comprehensive studies invariably employed reconstituted soil. The pattern of behaviour for the over-consolidated Dhaka clay discussed in the following articles will be taken to represent that of young or unaged sample where on post-depositional processes have operated.

Reconstituted samples of Dhaka clay were prepared in the laboratory by one-dimensional K_0-consolidation of a uniform slurry of the clay in a cylindrical consolidation cell of 260 mm diameter and 305 mm in height. The slurry had water content of approximately 1.5 times the liquid limit of the soil. A consolidation pressure of 150 kN/m^2 was used so as to get clay of firm consistency. A soil cake of about 125 to 150 mm thickness was produced in about nine to ten days at the end of primary consolidation.

Equipment and Instrumentation

For the determination of undrained shear properties of the samples, a strain controlled triaxial apparatus together with volume change and pore pressure measuring devices were used. Soil lathe was used to trim the sample to the required dimensions. The cell had the facility of drainage through both top and bottom of the sample. Cell pressure was applied using a standard pressure gauge of operating of 0 to 1700 kN/m^2. Backpressure was applied using dashpot and control cylinder system. For measuring axial deformation, a dial gauge with a resolution of 0.0254 mm was used. Mercury pore pressure null indicator was used to monitor pore pressure. A burette system (Bishop and Donald 1961) was used for measuring volume change during consolidation.

Types of Test Samples

"In Situ" Samples

The soil cake prepared by K_o-consolidation was extruded from the consolidation cell. The cake was sliced by the wire knife into small blocks and samples of nominal dimensions of 38 mm diameter by 76 mm high was prepared by trimming a block sample using piano wire, a soil lathe and a split mould. These samples were consolidated under K_o-conditions (K_o = 0.50) in the triaxial cell to its in situ vertical effective stress, σ'_{vc} (i.e., 150 kN/m^2). The maximum vertical effective stress of 150 kN/m^2 was reduced to 75 kN/m^2 and 15 kN/m^2 to prepare samples of OCR values of 2 and 10, respectively. A backpressure of 270 kN/m^2 was used during K_o-consolidation and swelling of the samples. The moisture content for samples of OCR values 2 and 10 were 28.5 ± 0.5% and 30 ± 0.5% respectively and the respective values of bulk density were 19 ± 0.2 kN/m^3 and 18.2 ± 0.3 kN/m^3 respectively. These samples have been termed as "in situ" samples. The "in situ" samples prepared from Dhaka clay for OCR values 2 and 10 have been designated OCR_2-I and OCR_{10}-I respectively.

"Perfect" Samples

These types of samples were prepared from respective "in situ" samples in the triaxial cell. The in situ shear stress, i.e., deviator stress of the "in situ" sample was first released from its in situ anisotropic stress condition. At this stage, the sample was subjected to an all-round isotropic stress (i.e., cell pressure). The cell pressure was then reduced to zero and thereby the sample was subjected to zero total stress. This sample has been termed as "perfect" sample, which has been obtained by the complete relief of the total in situ stresses. The "perfect" samples prepared from Dhaka clay for OCR values 2 and 10 have been designated OCR_2-P and OCR_{10}-P respectively.

Laboratory Testing Programme

The test programme consisted of carrying out the following three types of tests:

Firstly, undrained triaxial compression test on the two "in situ" samples was performed in order to determine the reference undisturbed behaviour of the clay. In this test, after the completion of K_o-consolidation and swelling, the sample was sheared in compression under undrained condition a deformation rate of 0.020 mm/min.

Secondly, unconsolidated undrained triaxial compression test was carried out on the two "perfect" samples. In this test, soon after simulation of the relief of the respective total in situ stress, the sample was subjected to total isotropic stress (i.e., all-round cell pressure) equal to respective in situ effective vertical stress under undrained condition. When the pore water pressure became steady, the sample was then sheared in compression under undrained condition at a deformation rate of 0.020 mm/min.

Finally, undrained triaxial compression tests, were conducted on two reconsolidated "perfect" samples. In these, after completion of reconsolidation, the samples were sheared at a deformation rate of 0.020 mm/min in compression under undrained condition.

Results and Discussions

Effect of Stress Relief Disturbance

Changes in effective stress paths

A comparison of the effective stress paths in $s'-t'$ [$s' = (\sigma'_a + \sigma'_r)/2$, $t' = (\sigma'_a - \sigma'_r)/2$] space for "in situ" and "perfect" samples (which simulated total stress relief) is presented in Fig.1. It can be seen from Fig.1 that for the "in situ" samples, initially s' slightly increases with the increase in t' and then it reduces with the further increase in t' as failure approaches. For the "perfect" samples, however, s' increases with the increase in t' for the major stage of undrained shearing and then it decreases as failure approached. Complete relief of total stresses, therefore produced appreciably different effective stress path for the "perfect" samples. It can also be seen from Fig.1 that the nature of the effective stress paths of the over-consolidated "in situ" and "perfect" samples, are similar. Marked

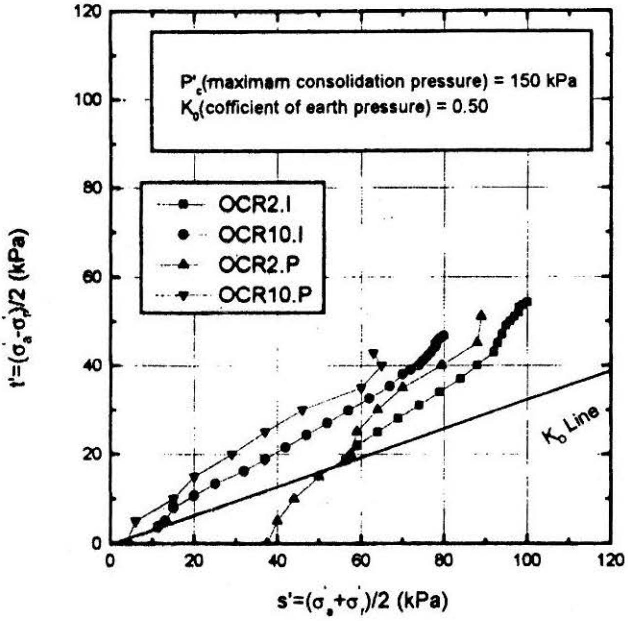

FIGURE 1 : Comparison of Effective Stress Paths for "In-Situ" and "Perfect" Samples of Overconsolidated Dhaka Clay

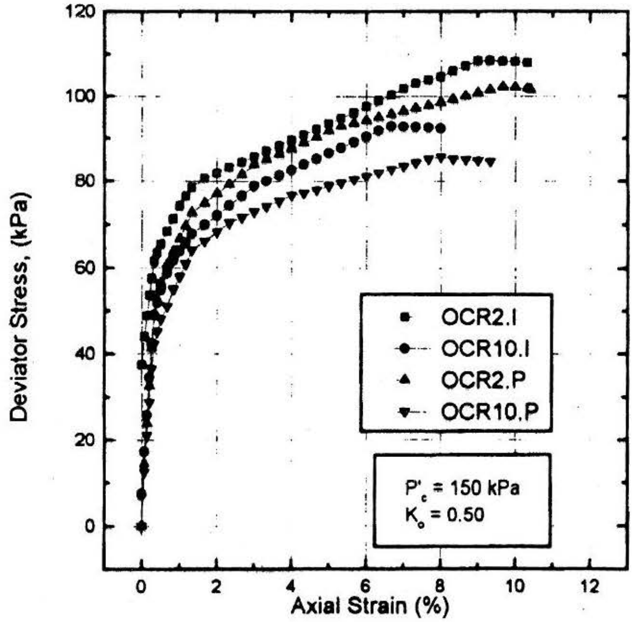

FIGURE 2 : Deviator Stress vs. Axial Strain (%) Plot for "In Situ" and "Perfect" Samples of Overconsolidated Dhaka Clay

difference in the effective stress paths between the normally consolidated "in situ" and "perfect" samples have also been reported by several investigators (Skempton and Sowa, 1963; Ladd and Lambe, 1963; Atkinson and Kubba, 1981; Hight et al., 1985; Siddique and Farooq, 1996; Bashar et al., 1997; Siddique and Sarker, 1998).

Changes in stress-strain-strength and stiffness properties

Figure 2 shows the deviator stress versus axial strain plots for "in situ" and "perfect" samples. From the stress-strain data, the undrained strength (s_u), initial tangent modulus (E_i), secant modulus at half the peak deviator stress (E_{50}) and axial strain at peak deviator stress (ε_p) have been determined for both the "in situ" and "perfect" samples. A comparison the undrained shear parameters of the "in situ" and "perfect" samples is presented in Table 3. It can be seen from Table 3 that because of the relief of total stress undrained strength of the over-consolidated Dhaka clay decreased by about 6% and 8% for "perfect" samples of OCR values 2 and 10, respectively. Value of ε_p however increased by about 9% and 21% for "perfect" samples of OCR values 2 and 10 respectively. Reduction in undrained strength due to stress relief has been found for other normally consolidated clays by a number of researchers (Skempton and Sowa, 1963; Noorany and Seed 1965; Ladd and Varallyay, 1965; Atkinson and Kubba, 1981; Kirkpatrick and Khan, 1984; Hight et al., 1985; Graham et al., 1987, Siddique and Farooq, 1996; Bashar et al. 1997). Ladd and Varallyay (1965), Kirpatrick and Khan (1984), Graham et al. (1987), Siddique and Farooq (1996) and Bashar et al. (1997) also observed considerable increase in ε_p due to stress relief for reconstituted normally consolidated clays. Reduction in s_u and increase in ε_p due to stress relief has been also found by Hight et al. (1985) and Kirkpatrick et. al. (1986) for reconstituted over-consolidated clays.

Table 3 also shows that because of disturbance due to stress relief, the initial tangent modulus (E_i) and secant modulus at half the peak deviator stress (E_{50}) increased. Compared with the "in situ" samples of the Dhaka

TABLE 3 : Comparison of Undrained Shear Properties of "Perfect" and "In-Situ" Samples of Over-consolidated Dhaka Clays

Sample Designation	S_u (kN/m^2)	ε_p (%)	E_i (kN/m^2)	E_{50} (kN/m^2)	A_p
OCR_2-P	51.0	9.8	28970	24120	0.039
OCR_2-I	54.2	9.0	26530	21750	0.19
OCR_{10}-P	42.8	8.1	23920	20830	0.036
OCR_{10}-I	46.6	6.7	22230	18950	0.13

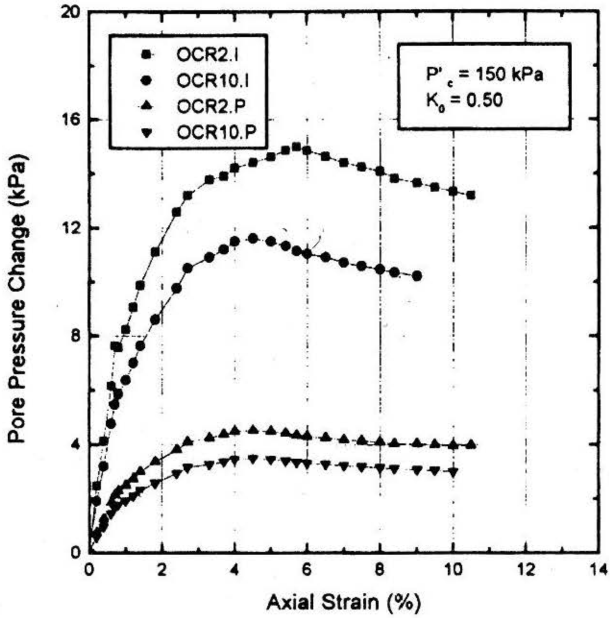

FIGURE 3 : Pore Pressure Change vs. Axial Strain (%) Plot for "In-Situ" and "Perfect" Samples of Overconsolidated Dhaka Clay

clay, the values E_i increased by approximately 9% and 7.5% and E50 increased by approximately 11% and 10% for "perfect" samples of OCR values 2 and 10 respectively. Hight et al. (1985) and Kirkpatrick et al. (1986) found decrease in stiffness of over-consolidated clays while Bashar et al. (1997) and Siddique and Sarker (1998) found increase in stiffness of normally consolidated clays due to disturbance caused by stress relief.

Changes in pore pressure response

Figure 3 shows a comparison of the changes in pore pressure during shearing between the "in situ" and "perfect" samples. It can be seen from Fig. 3 that compared with the "in situ" sample, the changes in pore pressure for the "perfect" sample is considerably less. From Fig. 3 it appears that for both "in situ" and "perfect" samples at small strains (up to 2.5%), the pore pressure increases rapidly with the increase in deviator stress and then pore pressure remains fairly with the increase in axial strain. Skempton's pore pressure parameters A at peak deviator stress (A_p) were determined for the "in situ" and "perfect" samples which are shown in Table 3. It can also be seen from Table 3 that the value of A_p of about 79% and 72% less than that of the "in situ" samples for "perfect" samples of OCR values 2 and 10, respectively. Significant reduction in A_p due to stress relief for reconstituted normally consolidated clays has also been reported by other investigators

(Siddique and Farooq, 1996; Bashar et al. 1997 and Siddique and Sarker, 1998).

Assessment of Reconsolidation Techniques of "Perfect" Sample

It is possible to reduce the effects of perfect sampling disturbance on the undrained behaviour of clays by reconsolidating the sample to a more appropriate stress level prior to shearing. The following several adopted reconsolidation procedures for minimising the sampling disturbance effects are presented:

Isotropic reconsolidation

In this technique a hydrostatic consolidation stress equal to effective stress (σ'_{vc}) of the "in situ" (i. e. 75 kN/m^2 and 15 kN/m^2 for OCR values of 2 and 10 respectively) has been applied to reconsolidate the "perfect" samples. A backpressure of 270 kN/m^2 has been used during isotropic consolidation of the "perfect" samples.

Anisotropic reconsolidation using Bjerrum (1973) procedure

Samples were reconsolidated under K_o-consolidation to vertical effective stresses equal to 1.0 times the effective initial vertical stress (σ'_{vc}) of the "in situ" sample. A backpressure of 270 kN/m^2 has been used during K_o-consolidation of the samples.

Anisotropic reconsolidation using SHANSEP (Ladd and Foott, 1974) procedures

In this technique, the "perfect" samples were reconsolidated anisotropically under K_o-condition to vertical effective stresses equal to 1.5 and 2.5 times the effective vertical stress (s'_{vc}) of the "in situ" sample. A backpressure of 270 kN/m^2 has been used during K_o-consolidation of the "perfect" samples. The normalized deviator stress versus axial strain plots of the reconsolidated "perfect" samples for OCR values of 2 and 10 are presented in Figs.4 and 5, respectively. The pore pressure parameter, A versus axial strain plots of the reconsolidated "perfect" samples for OCR values of 2 and 10 are presented in Figs.6 and 7, respectively. In each of these figures, the corresponding of "in situ" sample is also shown for comparison with of reconsolidated "perfect" samples. Undrained shear strength, s_u, initial tangent stiffness, E_i, secant stiffness at half the peak deviator stress, E_{50} and pore pressure parameter at peak deviator stress, A_p have been determined from the stress-strain and pore pressure data.

A comparison of normalized soil parameters is presented in Table 4. It

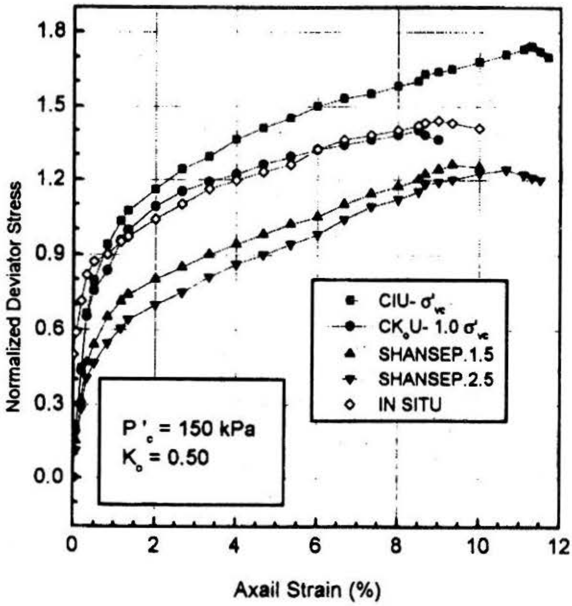

FIGURE 4 : Normalized Deviator Stress vs. Axial Strain (%) Plots for "In-Situ" and "Perfect" Samples of Overconsolidated Dhaka Clay for OCR = 2

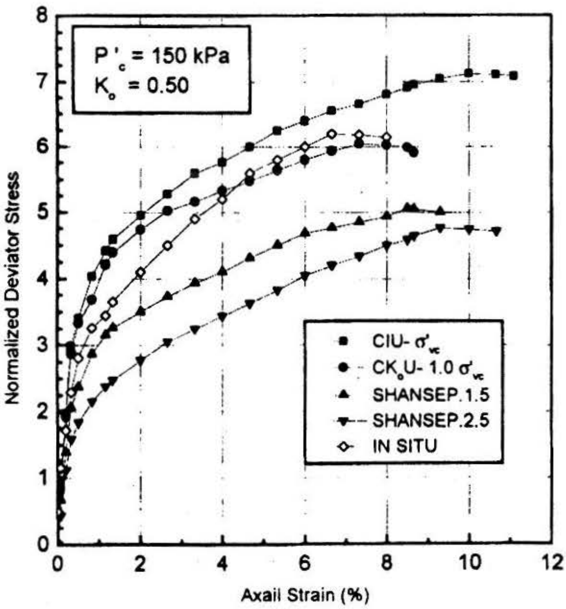

FIGURE 5 : Normalized Deviator Stress vs. Axial Strain (%) Plots for "In-Situ" and "Perfect" Samples of Overconsolidated Dhaka Clay for OCR = 10

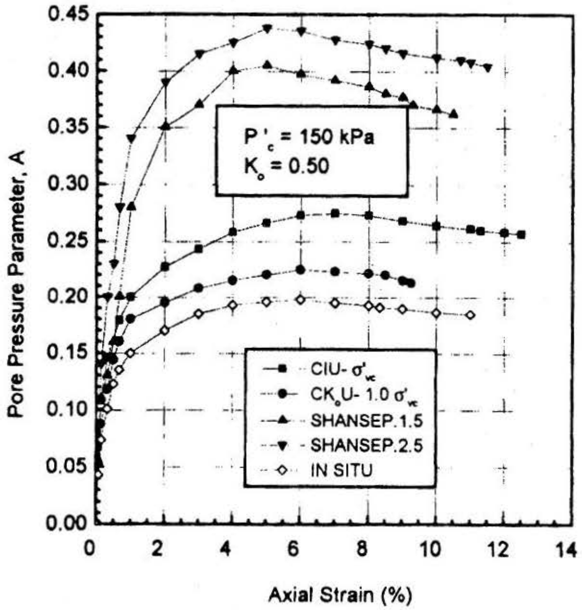

FIGURE 6 : Pore Pressure Parameter vs. Axial Strain Plot for "In-Situ" and Reconsolidated "Perfect" Samples of OCR = 2

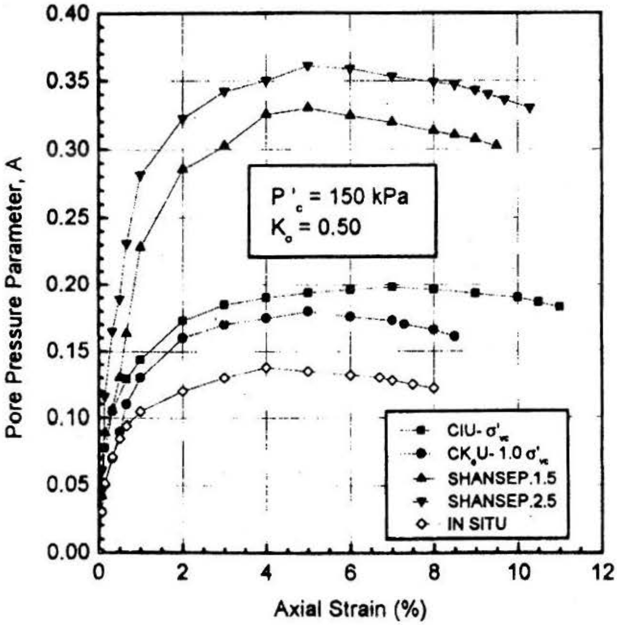

FIGURE 7 : Pore Pressure Parameter vs. Axial Strain Plot for "In-Situ" and Reconsolidated "Perfect" Samples of OCR = 10

TABLE 4 : Comparison of Undrained Shear Characteristics of Reconsolidated "Perfect" and "In Situ"Samples of Overconsolidated Dhaka Clay.

Test Type	Sample Designation	S_u/σ'_{vc}	ε_p (%)	E_i/σ'_{vc}	E_{50}/σ'_{vc}	A_p
Isotropic Reconsolidation Procedure	OCR_2-P	0.87	11.3	567.2	400.5	0.26
	OCR_{10}-P	3.56	10.0	2216.0	1557.6	0.19
Bjerrum Reconsolidation Procedure	OCR_2-P	0.70	9.3	332.6	274.2	0.22
	OCR_{10}-P	3.02	7.3	1298.6	1095.0	0.17
SHANSEP-1.5 Reconsolidation Procedure	OCR_2-P	0.63	9.5	269.2	236.7	0.37
	OCR_{10}-P	2.53	8.5	1032.2	944.0	0.31
SHANSEP-2.5 Reconsolidation Procedure	OCR_2-P	0.62	10.7	215.3	189.4	0.41
	OCR_{10}-P	2.38	9.3	790.8	729.7	0.34
"In Situ" Sample	OCR_2-I	0.72	9.0	353.8	290.0	0.19
	OCR_{10}-I	3.10	6.7	1482.0	1263.0	0.13

can be seen from Table 4 that isotropic reconsolidation of "perfect" samples have the effect of grossly overestimation of strength and stiffness ratios, strains and pore pressure parameters of the "in situ" sample. It can be seen from Table 4 that s_u, ε_p, E_i, E_{50} and A_p increased by 20.8%, 25.5%, 60.3%, 37.9% and 36.8% respectively due to isotropic reconsolidation of "perfect" samples for OCR values of 2. It can also be seen from Table 4 that s_u, ε_p, E_i, E_{50} and A_p increased by 14.8%, 49.2%, 49.5%, 23.3% and 46.1% respectively due to isotropic reconsolidation of "perfect" samples for OCR values of 10. Same effects have been reported by Kirkpatrick et al. (1986) due to isotropic reconsolidation of over-consolidated "perfect" samples. Also, same effects have been reported by Kirkpatrick and Khan (1984), Graham et al. (1987), Siddique and Faroque (1996) and Siddique and Sarker (1998) due to isotropic reconsolidation of normally consolidated "perfect" samples.

In contrast to isotropic reconsolidation, it can be seen from Table 4 that reconsolidation using SHANSEP procedures (i.e., K_o-consolidation to $1.5\,\sigma'_{vc}$ and $2.5\,\sigma'_{vc}$) considerably underestimated strength and stiffness ratios, and overestimated the values of ε_p and A_p of the "in situ" sample. This indicates that K_o-reconsolidation of the "perfect" samples beyond in situ stresses did not recover the properties of the "in situ" sample. These results are also in agreement with those for normally consolidated clays, reported by

Bashar et al. (1997). The results of K_0-reconsolidation of the "perfect" sample using SHANSEP procedures may not be applicable to normally consolidated Dhaka clay samples, reported by Siddique and Sarker (1998). This may be attributed to progressive destructing of the clay due to large volumetric strains occurred during reconsolidation. Destructing has also been observed in natural and reconstituted clays during reconsolidation using SHANSEP procedures (Burland, 1990; Clayton et al., 1992).

In contrast to isotropic and SHANSEP reconsolidation, it can be seen from Table 4 that reconsolidation using Bjerrum procedure considerably underestimated strength and stiffness ratios and overestimated the values of ε_p and A_p but all of them more closely to the "in situ" sample. It appears that for both OCR-values of Dhaka clay, Bjerrum reconsolidation procedure produced better agreement with the respective "in situ" samples than those of the samples reconsolidated using Isotropic and SHANSEP reconsolidation procedures. Siddique et al. (1997) also reported that reconsolidation using Bjerrum procedure produced the best estimate of the "in situ" samples for normally consolidated coastal soils of Bangladesh.

Conclusions

Effects of stress relief disturbance on undrained stress-strain-strength, stiffness and pore pressure characteristics of reconstituted over-consolidated Dhaka clay have been investigated, which are more practical problems. From the aforementioned effects, the main findings and conclusions are as follows:

a. The nature of the effective stress paths of the over-consolidated "in situ" and "perfect" samples, however were similar.

b. Disturbance due to perfect sampling led to reduction in the values of s_u while the values of E_i, E_{50} and ε_p increased as compared with "in situ" samples.

c. Compared with "in situ" samples, the pore pressure changes of the "perfect" samples were very small, resulting in much lower values of A_p for the "perfect" samples.

The conclusions relating to the influence of reconsolidation in "perfect" samples of over-consolidated Dhaka clay having OCR values of 2 and 10, are summarised below:

a. Isotropic reconsolidation ($CIU-1.0\sigma'_{vc}$) had the effect of gross overestimation of s_u, ε_p, E_i, E_{50} and A_p of "perfect" samples for both the OCR values as compared with those of "in situ" samples.

b. In contrast to isotropic reconsolidation, for both OCR values, the undrained shear strength ratio (s_u/σ'_{vc}) and stiffness ratios (E_i/σ'_{vc} and E_{50}/σ'_{vc}) of "perfect" samples reconsolidated using Bjerrum ($CK_0U-1.0\sigma'_{vc}$) and SHANSEP ($-1.5\sigma'_{vc}$ and $-2.5\sigma'_{vc}$) procedures were, in general, less.

c. Both the Bjerrum and SHANSEP reconsolidation procedures provided a lower bound values of s_u/σ'_{vc}, E_i/σ'_{vc} and E_{50}/σ'_{vc}, and an upper bound the value of ε_p and A_p for "perfect" samples than those of the "in situ" samples for both OCR values.

d. The undrained behaviours of "Perfect" samples reconsolidated using Bjerrum procedure agreed more closely with those of "in situ" samples for both over-consolidated Dhaka clay.

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Notation

A	=	Skempton's pore pressure parameter
A_p	=	Skempton's pressure parameter A at peak deviator stress
S_u	=	undrained shear strength
E_i	=	initial tangent modulus
E_{50}	=	secant modulus at half of the peak deviator stress
K_o	=	coefficient of earth pressure at rest
LL	=	liquid limit
OCR	=	Over-consolidation Ratio
PI	=	plasticity index
s'	=	$(\sigma'_a + \sigma'_r)/2$
SHANSEP	=	stress history and normalized soil engineering properties
t'	=	$(\sigma'_a - \sigma'_r)/2$
ε_p	=	axial strain at peak deviator stress
σ'_a	=	axial effective stress
σ'_r	=	radial effective stress
σ'_{vc}	=	vertical effective stress at the end of K_o-consolidation