INFLUENCE OF INITIAL CONDITIONS ON UNDRAINED RESPONSE OF SOFT CLAYS

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ABSTRACT: Soft soils are found along east and west coast of Kerala. They exhibit unusual engineering properties like high natural water content, high compressibility, low permeability and low shear strength. Availability of land for the development of commercial, housing, industrial and transportation, infrastructure etc. are getting scarce nowadays. This necessitated the use of land, which has weak strata, wherein the geotechnical engineers are challenged by the presence of different problematic soils with varied engineering characteristics. Not much work has been done to understand the behaviour of these soils. Hence it is necessary to study the geotechnical behaviour of such soils including the effect of various parameters. As far as Kerala is considered soft clays are predominant in Kuttanad and greater parts of Cochin. Research works carried on Kuttanad clay and Cochin marine clay mainly focused on compaction, compressibility and UCC strength. Clayey soils are impervious and do not permit drainage of water. There will be a cumulative buildup of pore water leading to increase in pore water pressure and reduction in shear strength, finally leading to increase in settlement and deformation. Not much works have been done on laboratory modelling of the soft clays of Kerala and its behaviour under the influence of varying parameters. Soil properties vary from point to point due to the variations of field parameters The objective of this paper is to investigate the effect of various parameters influencing undrained behaviour of Kuttanad clay. Confining stress and density were studied. For this purpose consolidated undrained triaxial test were performed with pore pressure measurements. Typical deviator stress-strain graphs , pore pressure versus strain graphs and stress paths were drawn for all the tests conducted.

KEYWORDS: density, confining stress, deviator stress, pore pressure

1 .INTRODUCTION

Soft clay is defined as a disturbed cohesive soil whose water content is higher than its liquid limit; such materials display extremely low yield stresses and represent difficult construction conditions. Soft clay deposits are widespread, and they present special problems. By definition, soft clays are of high natural water content, low shear strength, high compressibility, low permeability and low shear strength, and many are sensitive, in that their strength is reduced by disturbances. Foundation failures in soft clay are comparatively common, and surface loading, e.g. in the form of embankments, inevitably results in large settlements. The present study aims to investigate on the parameters influencing undrained behaviour of soft clay under triaxial loading conditions. Not much works have been done on laboratory modelling of the soft clays of Kerala and its behaviour under the influence of varying parameters. Soil properties vary from point to point due to the variations of field soil parameters. So it is highly essential to study the behaviour of clay under varying parameters. Kuttanad clays are dark brown coloured medium sensitive alluvial deposits spread over the Kuttanad region in the state of Kerala in India. The dominant mineral constituents in this clay are kaolinite and illite (Ayyar 1971). These clays are characterized by high compressibility, low shear strength and high percentage of organic matter, which are unfavourable from the geotechnical Engineering point of view. A large number of embankment failures and foundation failures have been reported in this soil due to its poor shear strength and compressibility characteristics. It is proposed to make an attempt on such clay soils to investigate on the undrained behaviour of soils prior to improvement by adopting suitable measures

2. LITERATURE REVIEW

Sharanya K and Muttharam (2013) [5] carried out studies to determine the effect of consolidation stress on strength of lime stabilized soils. The various laboratory tests such as vane shear, unconfined compressive strength and triaxial tests were conducted. It was found that the undrained cohesion and the angle of internal friction are increases with increase in lime content and curing periods. However for a given lime content and curing period, the undrained cohesion is increases with an increase in consolidation stress and angle of internal friction decreases with an increase in consolidation stress. Ajanta Sachan and Dayakar Penumadu (2014)[1] studied the influence of confining pressure on clay specimens with dispersed and flocculated micro-fabric. In this research the normally consolidated kaolin clay shows its dilative nature during shearing for dispersed micro-fabric and contractive nature for flocculated micro-fabric. The dispersed micro-fabric showed relatively sudden failure response at low strain levels followed by significant softening when compared to flocculated micro-fabric due to its volume change behaviour. Assem A Elsayed and Christopher W Swan (2010)[2] introduced a new preparation technique, termed volume control (VC), which attempts to achieve a pre-determined, pre-shear relative density (Drc) for granular soil samples used in triaxial tests. Korichi S. et al. (2013) [4] studied the effects of compression on porous texture of clay powder. Application of uniaxial pressing pressures (31.84 at 127.38 MPa) of powder clay produces materials with increased density and reduction of porosity. Victoria Caridad et al. (2014)[6] conducted experimental measurements of thermal conductivity (λ) and the density (ρ) of several clay pastes used in pelotherapy (peloids). A clear correlation was established between the density and the thermal conductivity of the peloids.

3. EXPERIMENTAL PROGRAMME

Clay sample selected for the present study was collected from Champakkulam (Kuttanad region) from 2 m and 3 m depth as per the procedure described in IS:2132 (Part 2) -1986. Water table was very close to ground surface at the time of sampling. The soil sample was brought to the laboratory without any loss of water content and it was stored under humid condition. Disturbed samples were also collected. Soil samples were tested for Atterberg limit’s and grain size distribution characteristics. Specific gravity was calculated from known values of shrinkage limit. Grain size analysis was done by hydrometer method. The weight of wet sample which will contain 50 g dry soil is estimated based on water content. All the tests were conducted according to IS code procedures. The index properties determined are shown in Table 1.

Table 1. Index and Strength Properties

Property	**Value**
Index property	
Natural water content (%)	130
Specific gravity	2.53
Liquid Limit (%)	135
Plastic Limit (%)	55
Shrinkage Limit (%)	25
Plasticity Index	79
Clay size (%)	50
Strength property	
Maximum dry density (kN/m^3)	14
Optimum moisture content (%)	31
UCS, kPa (At w_c=60%)	15.2
Organic content (%)	12

4. TRIAXIAL COMPRESSION

Among all the shear tests, triaxial compression is more preferable for accurate research work. There is a complete control over the drainage conditions. Among the different drainage conditions consolidated undrained test conditions are suitable for pore pressure measurements. The test setup comprised of a standard triaxial test apparatus with facilities for measuring pore water pressure. A proving ring of 2.5 kN capacity was calibrated and was used for measuring axial loads. A dial gauge of 0.01mm sensitivity was used to measure the axial displacements. It contains pressure control system to control the cell and back pressure applications. Electronic kit device is attached to monitor the displacement as well as axial loads applied to the sample. Cylindrical specimens were prepared in the mould of 38 mm dia. and 76 mm long at the various densities of 12, 13 and 14 kN/m$^{3.}$Samples air dried to 60% water content was used for the convenience of sample preparation. Samples were saturated by immersion method. For each specimens tested back pressure is increased in steps and corresponding increase in pore pressure is noted to check B parameter for saturation (B approximately 0.96). Specimens were tested under consolidated undrained condition and subjected to confining pressures of 50,100 and 150 kPa. After application of each confining stress, axial load is applied.

5. RESULTS AND DISCUSSION

5.1. Effect of Density

The effect of densities on undrained response in terms of stress-strain relations and pore pressure variations at particular confining pressure of 50, 100, and 150 kPa are shown in Figures 1 to 3 respectively. The figures 1 to 3 are indicating that the deviator stresses are increasing with increase in the density irrespective of all pressures. The increase of deviator stress is due to decrease of pore water pressure with increase in the density. The effective stress paths of samples confined at the pressures of 50, 100, and 150 kPa is shown in Figure 4. It illustrated that the clay samples moulded at low densities possesses high contraction behaviour and exhibit less resistance to shear loads when to compared to that at high densities irrespective of all confining pressures. It also observed that the reduction in mean effective normal stress is increasing with decrease in density of clay samples

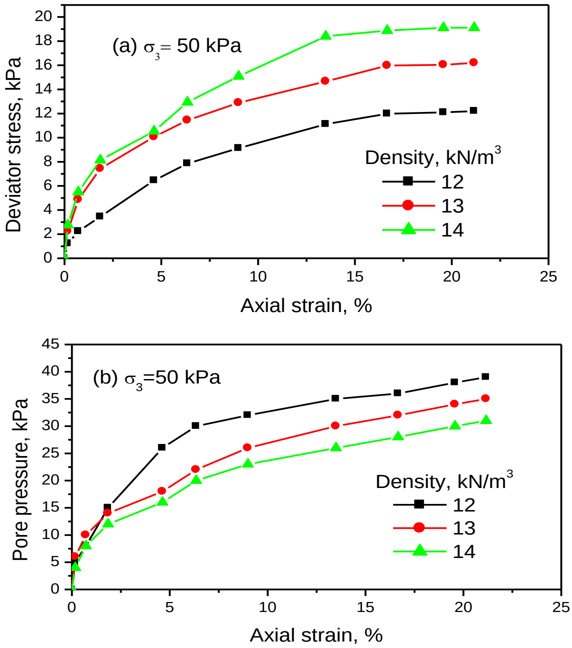

Fig.1 Effect of density on (a) stress-strain relations and (b) pore pressure variation of Kuttanad clay sample (σ3=50 kPa)

5.2. Effect of Confining Stress.

The effect of confining pressure is to be expressed in terms of normalized stress ratios as the test samples are subjected to different pressures. The deviator stress ratios are increasing with decrease in the confining pressure irrespective of density. The deviator stress ratio is defined as ratio of deviator stress to applied confining stress. The increase of deviator stress ratio is due to decrease of pore water pressure with decrease the confining pressure. The increase of deviator stress ratio is due to decrease of pore water pressure with decrease in the confining pressure of sample.

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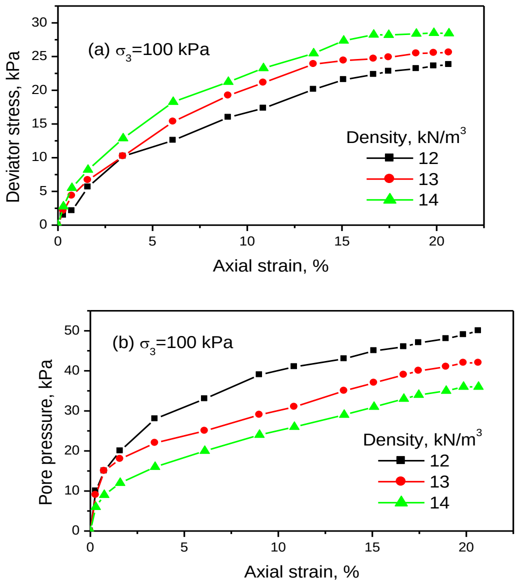

Fig. 2 Effect of density on (a) stress-strain relations and (b) pore pressure variation of Kuttanad clay sample (σ3=100 kPa)

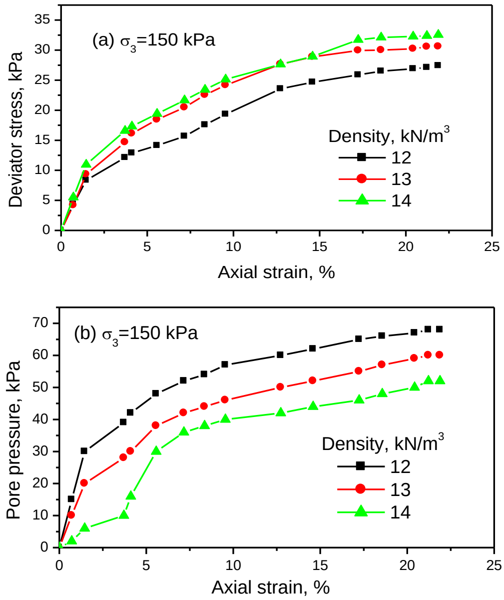

Fig. 3 Effect of density on (a) stress-strain relations and (b) pore pressure variation of Kuttanad clay sample (σ3=150 kPa)

It indicates that the samples confined at low pressures are more resistant to static shear stress ratios (static liquefaction).

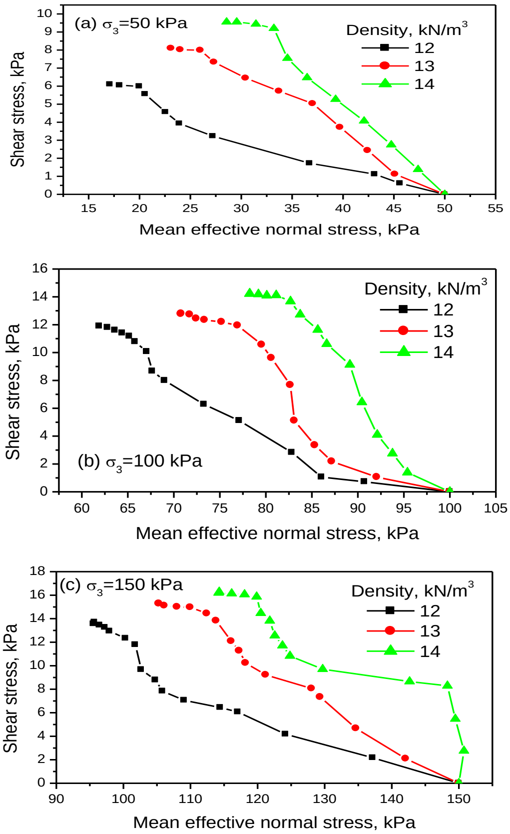

Fig. 4 Effect of density on stress paths of samples at confining pressures of (a) 50 kPa, (b) 100 kPa and (c) 150 kPa

6. CONCLUSIONS

Peak deviator stresses at failure strain level are increasing with increase in the density of samples, but the pore pressures decreases with increase in the densities irrespective of all confining pressures surrounded by the sample. Clay samples moulded at low densities possess high contraction behaviour and exhibit less resistance to shear loads when to compared at high densities irrespective of all confining pressures. The reduction in mean effective normal stress is increasing with decrease in the density of clay samples. Effect of confining pressure is to be expressed in terms of normalised stress ratios due to the test samples are subjected to different pressures. Peak deviator stress ratios are decreasing with increase in the confining pressures, but the pore pressures increases with increase in pressures irrespective of all density of samples. In contrary, the peak deviator stresses are increasing with increase in the confining pressures

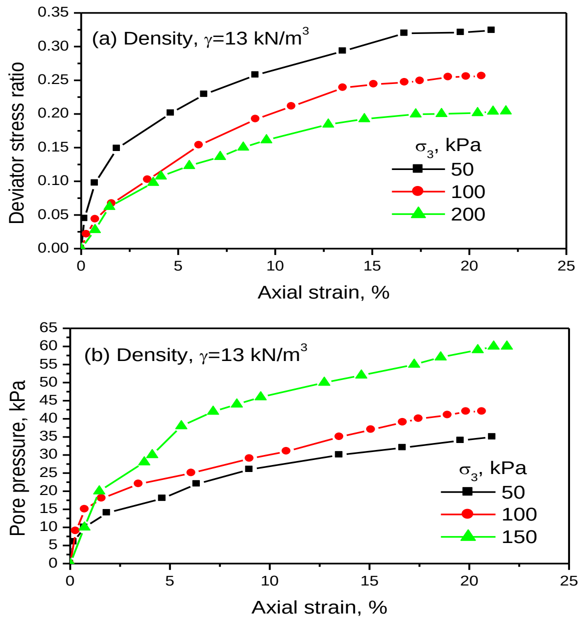

Fig 5. Effect of confining pressure on (a) stress ratio-strain relations, and (b) pore pressure variation of Kuttanad clay sample at the density of 13 kN/m^3

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