International Journal For Technological Research In Engineering
Volume 7, Issue 4, December-2019 *ISSN (Online): 2347 - 4718*

COMPOSITION OF SOFT CLAYEY SOILS AND THEIR STRESS ANALYSIS UNDER DIFFERENT CONDITIONS

Rameez Rafiq[1], Er. Nasir Ali[2], Er. Abhishek[3]
[1]Research Scholar, Geotechnical Engineering, GGG1, Dinarpur (Ambala)
[2]Assistant Professor, Geotechnical Engineering, GGGI, Dinarpur (Ambala)
[3]H.O.D, Geotechnical Engineering, GGGI, Dinarpur (Ambala)

Abstract: Construction of civil engineering structures on soft clayey grounds requires engineers to consider the consolidation behavior of these deposits. Because of the natural viscosity of clayey soils, their consolidation is majorly effected by vertical stress and also due to organic content. Due to more and more constructions being aimed at in highly populated urban areas, there is a growing need for construction of buildings and geotechnical structures on soft clayey surfaces, that usually produce prominent creep deformation. Despite a vast research work being done associated to the secondary consolidation behavior of a natural clay materials, there are still many questions about this phenomenon.
Keywords: soft clay, consolidation, creep, viscosity.

I. INTRODUCTION

Increasing population and dire shortage of land area has caused its reclamation in many of the developed countries. For the ease of sea transport, many big cities worldwide are located on clayey deposits around coastal areas, hence large number of structures are constructed on soft soils. For all the civil engineering projects related to soft clayey deposits, engineers of necessity have to contemplate the consolidation behaviors of a deposit. Consolidation generally is a phenomenon by which a soil mass decreases in volume by squeezing out pore water by means of slow dissipation of the excess hydrostatic pressure due to an imposed total stress. As per Karl Terzaghi's theory, "consolidation is a process which is characterized by reduction in water content of the saturated soils without the replacement of water by air." Terzaghi shown the consolidation process in a clay soil subjected to loading is analogous to the behavior of the spring – piston model. Springs represent soil skeleton. Spring surrounded by water represents saturated soil. Perforations in a piston are analogous to the voids which provide permeability to soil. As the stress is withdrawn from the consolidated soil, it rebounds, restoring some of its volume it had lost in the consolidation process. On stress being applied again, the soil will consolidate again but now along the recompression curve, represented by the recompression index. The soil with its load removed is referred as over-consolidated, while highest stress to have acted upon it is referred to as the pre-consolidation stress.

1.2 Need and Scope:

The importance of secondary consolidation is predominant for highly plastic soils. Fundamental understanding of the compressibility of soil with a wide range of plasticity index is essential for developing theories of consolidation data for any foundation project. An assessment of the behavior of secondary compression index Ca with time is urgently wanted. Determination of the primary compression index (Cc) and secondary compression index (Ca) of soils with wide margin of plasticity indices (Ip) may help in this regard.

1.3 Literature Review:

Hanna (1950) carried out research at Fouad I University, Cairo. The calculated and the theoretical settlements, according to the results from consolidation tests were relatively very close; but numerically, theoretical settlements in many buildings were 3–4 times the observed values. Mesri (1973) investigated considerable importance of secondary or delayed compression and noted that coefficient of secondary compression is the powerful tool to explain the secondary compression. Mineral composition and physicochemical environment have significant influences on the co-efficient of secondary compression. Sridharan and Jayadeva (1982) explained that the compressibility of the pure clay soils under external loading not only relies on the negative charges and the crystallite structures of clayey minerals but it also relies on the ion concentrations, temperature , dielectric constants and cation valency of the pore fluid. Barbour and Fredlund (1989) stressed on smectite behavior of clay, which is significantly controlled by pore liquid composition. The interactions of clay soil with pore fluid cause changes in volume and shear strength by ion diffusion under constant external stresses. Sridharan and Prakash (1998) proposed estimation of secondary settlement based on secondary compression factor ($m = \Delta \log e / \Delta \log t$) is more realistic for soil which exhibit non-linear secondary compression behavior. Muntohar (2003) carried out laboratory one-dimensional consolidation tests and stressed on the swelling and compressibility characteristics of soil–bentonite mixtures. The swelling and compressibility characteristics generally increase with increase in bentonite percentage in bentonite, kaolinite and sand mixtures. Bhattacharya and Basack (2011) suggested Installation of prefabricated vertical drains, followed by preloading that accelerates the consolidation of soft soil having low hydraulic conductivity and low shear strength thereby reducing the time period.

1.4 Experimental Investigation:

Material used in this study are Na bentonite and Ca bentonite that are commercially available
in market, along with silt.

1.5 Material Characterization:

1.5.1 Atterberg limits:

Atterberg limits were determined as per IS: 2720-Part 5 (1985) and the results are tabulated below.

Soil	Liquid limit (*wl* %)	Plastic limit (*wp* %)	Plasticity Index (*Ip* %)
Na- Bentonite	407	42	365
Ca- Bentonite	140	61	79
Silt	27	22	5

1.5.2 Special gravity: The specific gravity of Na- bentonite and Ca-bentonite, silt were determined as per IS: 2720-Part 3 (1980) and their values were found to be 2.7, 2.67 and 2.6 respectively.

1.6 Apparatus Used:

The mineral composition of bentonite is obtained by using X-ray diffraction method. According to Bragg's law, the XRD identifies the minerals based on the relationship between the angle of incidence of X-rays (θ) to the c-axis spacing (d). A Philips automated powder diffractometer was used for XRD analysis in this study. Consolidation test under varied load and plasticity indices is done by using a one-dimensional consolidometer or oedometer.

1.6.1 X-ray diffraction method (EDX):

Fine grained bentonite power and silt of 1.5 g was kept in oven drying for 2 hours and allowed to cool in room temperature. Then, sample is filled in the sample holder of diffractometer and the XRD pattern is obtained by scanning over angles between 5° to 90°, 2θ at 5°/min. In the step mode, a 0.05° - 2θ step for 2 s was given. Results are analyzed using X-pert High Score software. From the results of XRD analysis mineral composition such as Illite, Kaolinite, Montmorillonite, Muscovite are found in Na bentonite sample. Similarly, the analyses were carried out for Ca bentonite and silty soil and the mineral composition were determined.

1.6.2 One-dimensional consolidometer Test:

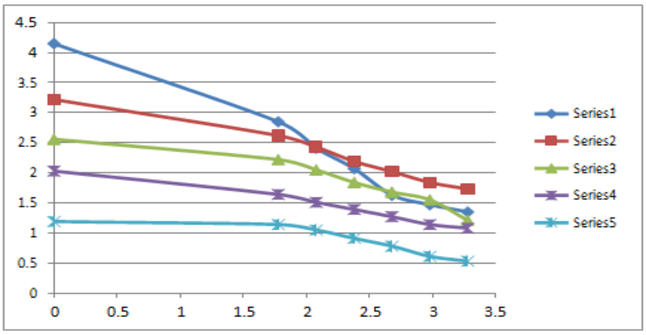
One-dimensional consolidation testing method was first given by Terzaghi in 1925. The test is carried out using a consolidometer or (oedometer). Figure 3.14 represents a one dimensional consolidometer or oedometer. The soil specimen is kept in a metal ring having two porous stones, one is at top of the said specimen and another one at the bottom of it. The load is imposed by a lever arm, and compression is read through t h e dial gauge. The specimen remains under water during the coarse of test. Every load increment is normally kept for atleast 24 hours. Following that the load is doubled and the compression measurement is done and continued.

1.6.2.1 Test procedure:

One-Dimensional consolidation test was done in in conformity with ASTM D2435/ (ASTM, 1999). Standard fixed ring type consolidometer was used with ring diameter 75mm and 25mm height to perform the experiment. The soil specimen was kept inside the metal ring having a porous stone at the top and bottom. All specimens were tested at moisture content of extracted soil sample. Utmost care was taken to prevent air entrapment in soil specimens remolded in the rings. The specimen was kept under water throughout the test. The load to the specimen was exerted through a lever arm, and the compression of the specimen was measured by a dial gauge. The deformation of the soil sample was noted from the dial gauge starting from 0 s, 30 s, 1 min, 1.5 min, 2 min, 4 min, 6 min, 8 min, 10 min, 15 min, 30 min, 60 min, 90 min, 120 min, 150 min, and 1440 min. The load was usually doubled every 24 h (i.e. incremental loading of 60, 120, 240, 480, 960, 1920 kPa were applied).

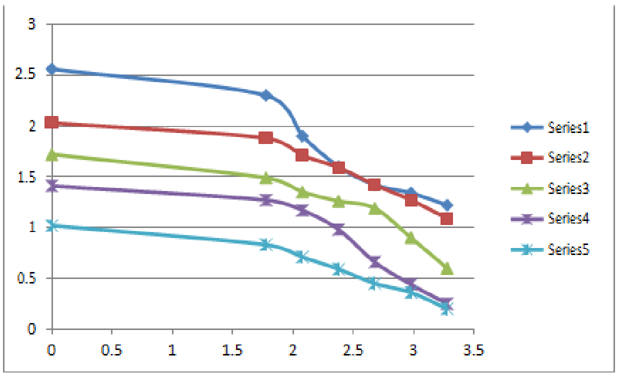
1.7 Result:

Various tests were carried out on ten different type of clays based on their plasticity, prepared by having different proportions of silt mixed in commercially obtainable sodium and calcium bentonite to aquire representative samples of various plasticity indices. As one dimensional consolidation tests were done for each of these soil samples at different vertical effective stresses. Dial gauge readings corresponding to each incremental loading were noted down. The primary compression index (C_c) was calculated from the slope of e versus log σ' curve and the secondary compression index(C_a) was obtained from the slope of settlement versus time plot (δ-log t).



Series: 1-IP=98 2-IP=75 3-IP=42 4-IP=20 5-IP=14.

Figure 4.1 e - $log\ \sigma^{l}$ curves for the consolidation test conducted for soil with Na bentonite mixed with silt.



Series : 1-IP=51 2-IP=40 3-IP=29 4-IP=18 5-IP=10.

Figure 4.2 e - $log\ \sigma^{l}$ curves for the consolidation test conducted for soil with Ca bentonite mixed with silt

II. CONCLUSION AND FUTURE SCOPE

Tests reported in this thesis suggest primary compression index (Cc) increase with increase in the plasticity of the soil. Also a correlation was made between primary compression index (Ca) and plasticity index (Ip). The equation so developed can be considered to be reasonably accurate for consolidation problem. Secondary compression index (Ca) decreases with rise in stress range but the case is opposite with increase in plasticity index. Based on the outcome of this investigation following future works may be suggested:

- More investigation is required to establish correlation between primary compression index (Cc) and secondary compression index (C_a) with permeability (*k*), coefficient of consolidation (*Cv*), coefficient of volume compressibility (*mv*).
- Tests may be conducted to study different minerals, pore fluid present in soft soil and their effect on primary and secondary consolidation.
- Tests may be conducted at low and elevated temperature.

REFERENCES

[1] Hanna, W. S. (1950). “Settlement studies in Egypt.” Geotechnique; 2(1), 33-45.
[2] Mesri, G. (1973). “Coefficient of Secondary Compression,” J. of the soil mech. and found. Div; 99(1), pp. 124-128.
[3] Jain, S.K; and Nanda, A. (2010). “Nature of the Secondary Compression in Soil.”
[4] Ind. Geotech. Conf; IGS Mumbai Chapter & IIT Bombay, 1121-1124.
[5] Lambe, T. W., and R. V. Whitman. (1969). "Soil Mechanics.” New York: Wiley.
[6] Indian Standard. IS: 2720 (Part 5) –1985 –Method of test for soils (Part 5 - Determination of liquid and plastic limit).
[7] Indian Standard. IS: 2720 (Part 5) –1985 –Method of test for soils (Part 5 - Determination of liquid and plastic limit).
[8] Sheeran, D. E., and Krizek, R.J. (1971). “Preparation of homogeneous soil samples by slurry consolidation.” J. Materials; 6(2), 356.

