

Analysis of Geotechnical and Consolidation Characteristics: A Case Study of UET, Kala Shah Kaku Campus, Lahore, Pakistan

Sadia Sohail, N. Aadil, and M. S. Khan

Abstract—Assessing the geotechnical parameters helps in improving the soil settlement which usually causes damage to the civil structure. In this study, geotechnical investigations at UET, Kala Shah Kaku Campas (KSK), Lahore site are carried out for undisturbed samples at depths of 2 ft, 3 ft, 4 ft and 5 ft. in order to soil classification and assess the consolidation parameters on undisturbed and disturbed/remolded samples.

Results indicate that the soil grade from top layer of silty clay (CL-ML) to lean clay (CL) from 3ft to 5ft depth. The natural moisture content is very low and the plastic limit varies from 20 to 23. The liquidity index shows that the soil of the study area is of semisolid or solid state. Void ratio varies from 0.70 to 0.96 for undisturbed samples and 0.60 to 0.90 for disturbed samples. Specific gravity and Bulk density range from 2.68 to 2.69 and 14.0 to 16.0 kN/m² respectively. The over consolidation ratio (OCR) values up to 5ft depth are in the range of 4.1 to 7.0.

It is found that compressibility characteristics decrease with depth. The coefficient of primary and secondary consolidation decreases with increase in applied pressure and tends to be more or less constant at high pressures.

Index Terms—Compressibility, Consolidation Parameters, Geotechnical Parameters, Soil Classification, Soil Settlement

I. INTRODUCTION

Settlement of the subsoil causes damage to the structures due to stability problems which needs to address before planning any engineering project [1]. Consolidation characteristics of a soil depend mainly on the clay contents and plasticity index. Settlement potential of soil increases with increase of these values. However, higher values of these characteristics are not desirable for use of such soil under foundations and roads etc. Efforts are made to reduce the settlement potential of such soils. The purpose of this research work was to determine the effect of sand mixing on the consolidation characteristics of Kala Shah Kaku clay.

The construction and development of new engineering structures; industrial buildings, roads, bridges, and office blocks together is being planned at KSK, Lahore (Fig. 1) as an extension programme of UET and other academic institutions. In this study, geotechnical investigations are carried out for undisturbed samples to determine consolidation characteristics of cohesive soil present in the

study area. Soil classification and consolidation assessment tests were performed on undisturbed and disturbed/remolded samples in order to observe the effect of depth on consolidation characteristics.

II. METHODOLOGY

Undisturbed block samples at 2ft, 3ft, 4ft and 5ft depths and sand for mixing with the clay were collected, sealed, marked and stored until the time of testing from the location area as shown in Fig. 1. Basic soil classification tests and Oedometer test were performed on undisturbed and disturbed/remolded samples. All tests were performed according to ASTM standards [2].

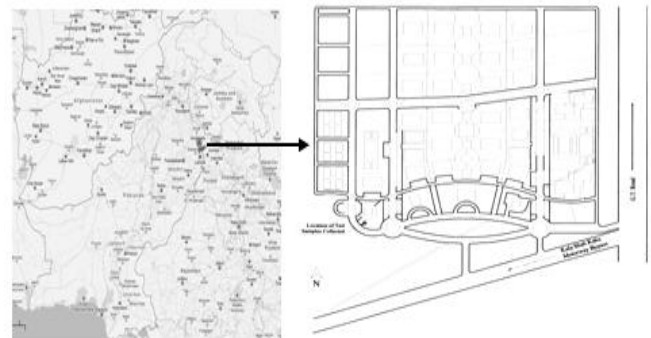


Fig. 1. Location map of study area

III. RESULTS

The determination of index properties is an important adjunct to consolidation test. Tests were performed to measure Specific Gravity (Gs), Atterberg limits, Particle size distribution and Hydrometer test. The determined parameters as shown in Table I will be used for both soil classification and assessing the consolidation characteristics. Top layer is cohesive soil consisting of silty clay/silt/sandy silt (CL-ML/M/ML) and its thickness varies from about three feet (3 ft) to twenty feet (20 ft). The upper stratum is followed by non-cohesive soil comprising of sand having variable amount of silt. The bottom stratum extends to the maximum investigated depth of 50 ft [3].

Based on Atterberg limits as plotted on the Casagrande's plasticity chart (Fig. 2), the data points above Casagrande's A-line and the soil in hatched zone is classified as CL-ML [4].

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The authors are with the Department of Geological Engineering, University of Engineering & Technology, Lahore-54890, Pakistan.

TABLE I: SOIL CLASSIFICATION PARAMETERS WITH BASIC SOIL PROPERTIES. LL, PL, PI, AND LI INDICATE LIQUID LIMIT, PLASTIC LIMIT, PLASTICITY INDEX AND LIQUIDITY INDEX.

Sample	Depth [ft (m)]	Natural M.C (%)	Sp. Gravity (Gs)	Grain Size Analysis			Atterberg Limits				Soil C'fication	Initial Void Ratio	Initial Bulk Density	Initial Degree of Saturation
				Gravel (%)	Sand (%)	Silt & Clay (%)	LL (%)	PL (%)	PI (%)	LI (%)				
1	2 (0.6)	1.01	2.69	0	3	97	27	20	7	-2.7	CL-ML	0.91	14	3.02
2	3 (0.9)	1.28	2.68	0	5	95	28	22	6	-3.5	CL-ML	0.71	15.6	4.83
3	4 (1.2)	1.4	2.69	0	7	93	34	23	11	-1.9	CL	0.76	15.2	4.93
4	5 (1.5)	16	2.69	1	5	94	29	21	8	-0.6	CL	0.94	15.8	46.12

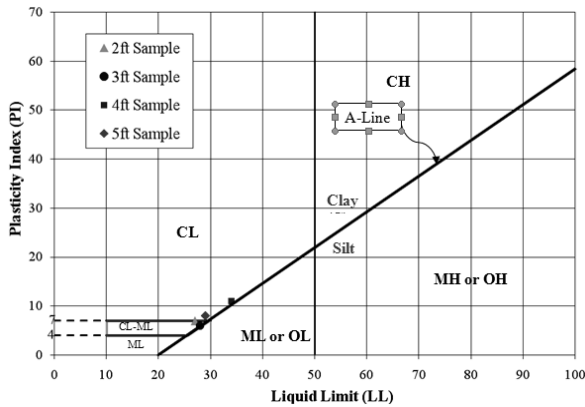


Fig. 2. Atterberg Limits on casagrande plasticity chart

IV. DISCUSSION

The results of consolidation tests are plotted from Fig. 4 to 15 which is discussed below.

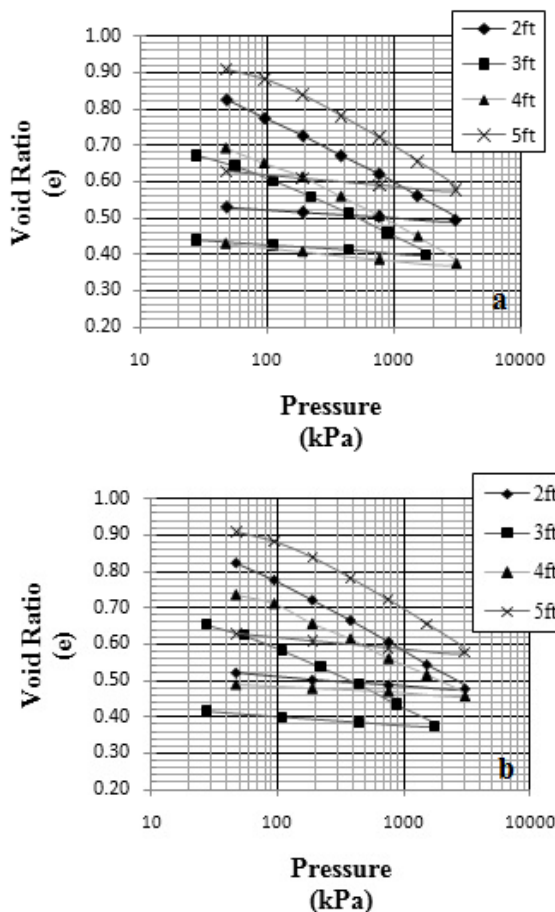


Fig. 3 (a & b): Void Ratio- log Pressure Curves for Un-disturbed and Disturbed Samples

Fig. 3 (a&b) indicates the stress-strain behavior of the collected samples from KSK Campus, Lahore for disturbed and un-disturbed samples. Analysis shows that the void ratio for 4ft undisturbed sample range from 0.37 to 0.76 and for disturbed sample it is from 0.46 to 0.76. Initial void ratio for the 5ft undisturbed sample is the highest value compared with other samples which 0.936.

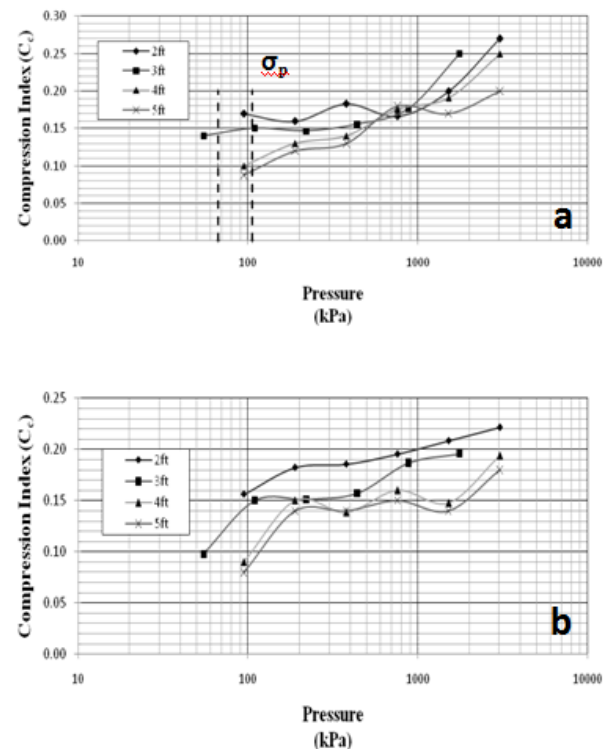


Fig. 4 (a & b): Compression Index-log Pressure Relationship for Un-disturbed and Disturbed Samples

Fig. 4 (a & b) indicate the variation of compression index (C_c) with log pressure for un-disturbed and disturbed samples. This shows that C_c value generally increases with pressure increases. Similar findings have been reported by [5, 6, 7, 8]. The C_c values also decrease with depth indicating less potential of settlement with increase in depth.

Fig. 5 (a & b) show the curves of coefficient of compressibility (a_v) with pressure for un-disturbed and disturbed samples respectively. It can be seen that the value of a_v decreases with increase in applied pressure. The values of a_v are in scattered formation at initial pressures and converge closer to each other as applied pressure increases. This indicates that all soil samples have been compacted to a similar stiff structure and would behave in the same way under higher load. It is also observed that value of a_v decreases with depth.

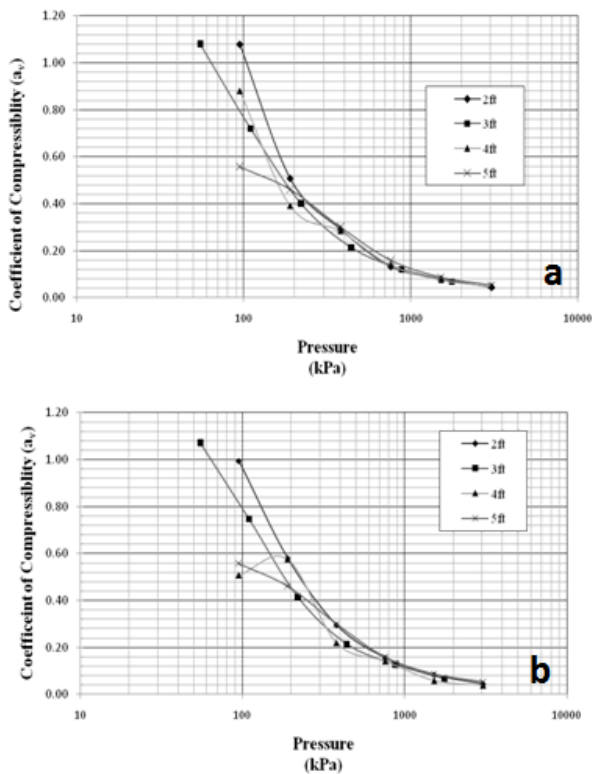


Fig. 5 (a & b): The curves of coefficient of compressibility (a_v) with pressure.

Fig. 6 (a & b) show the relationship of coefficient of volume compressibility with pressure (m_v - $\log \sigma_v$ curves) for un-disturbed and disturbed soil samples respectively. The discussion on the results is the same as stated for coefficient of compressibility above. Similar findings have been found by [9].

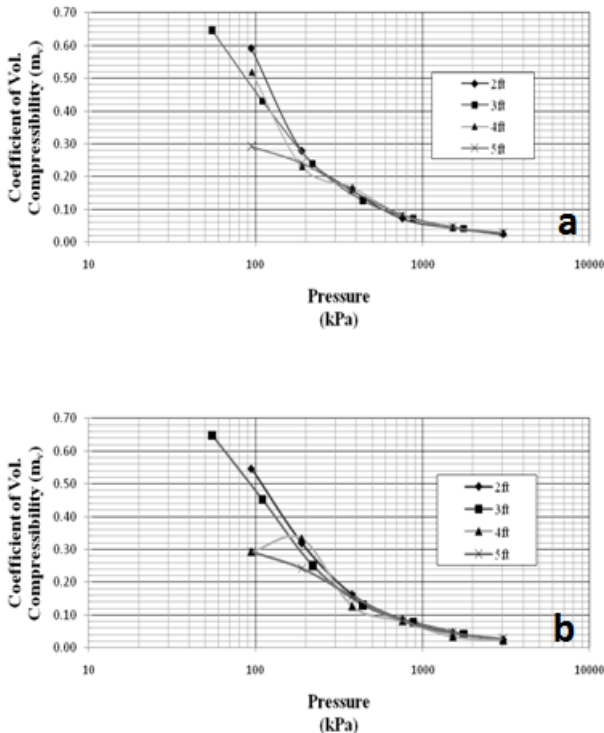


Fig. 6 (a & b): The relationship of coefficient of volume compressibility with pressure

Fig. 7 (a & b) indicate the variation of the coefficient of

primary consolidation with pressure on log scale for un-disturbed and disturbed samples. For un-disturbed samples it is seen that the values of C_v decreases with increase in applied pressure and tends to be more or less constant at higher pressure. The values of C_a for undisturbed and disturbed soil samples are plotted against pressure in Fig. 8 (a & b). No definite conclusions can be drawn about the variation of C_a with depth, however, the values of C_a tend to increase and decrease with increase in pressure. Similar results have been reported by [10, 7, 8].

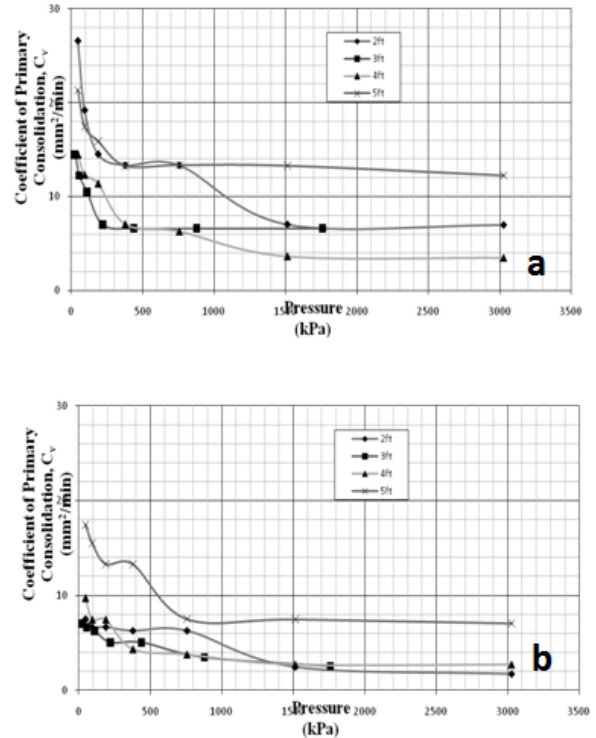


Fig. 7 (a & b): Variation of the coefficient of primary consolidation with pressure on log scale

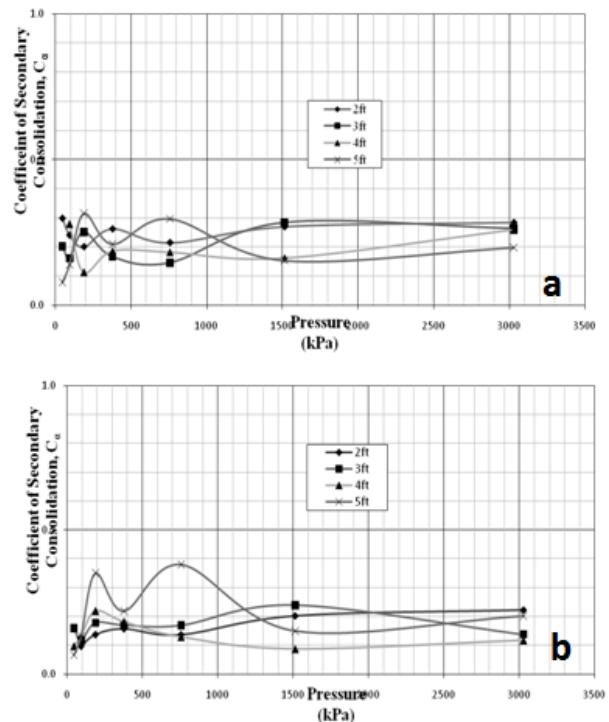


Fig. 8 (a & b): The relationship between Coefficient of Secondary Consolidation with Pressure for Un-disturbed and Disturbed Samples

V. CONCLUSIONS

On the basis of above data and its interpretation, the following conclusions are drawn;

- 1) The soil of the study area is classified as silty clay (CL-ML) up to 5ft depth with 3% to 7% sand. The natural moisture content to 4ft depth is very low and becomes 16% at 5ft and below.
- 2) The plastic limit of all the samples varies from 20 to 23 and the liquidity index shows that soil is in semisolid or solid state. Void ratio varies from 0.70 to 0.96 for undisturbed samples and 0.60 to 0.90 for disturbed samples.
- 3) The values of C_c have no definite trend with pressure, however it decreases with depth. For pressure range of 100 kPa to 200 kPa, the values of C_c vary between 0.07 to 0.18 respectively.
- 4) The values of a_v and m_v decrease with increase in applied pressure and depth. They are in scattered formation at initial pressure and converge closer to each other as applied pressure increases. For pressure range of 100 kPa to 200 kPa, the values of m_v vary between 0.23 to 0.65 and a_v vary between 0.39 to 1.08 respectively.
- 5) The coefficient of primary consolidation C_v , decreases with increase in applied pressure and tends to be more or less constant at higher pressures. Also, the values of C_v decreases with depth. The values of primary consolidation, C_v varies between 1.71 to 26.62.
- 6) The coefficient of secondary consolidation C_α , first increases with increase in applied pressure and tends to be more or less constant at higher pressures. No definite conclusion can be drawn about the variation of C_α with depth.

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