ROLE OF ATTERBERG LIMITS ON TIME RATE SETTLEMENT OF ALLUVIAL DEPOSITS

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Summary

The rate of soil consolidation depends on the soil permeability, the thickness and drainage path. A soil with low permeability will take longer time to drain the initial excess pore water and settlement proceeds at slower rate. To obtain the time rate settlement, it is required to find out coefficient of consolidation. Generally coefficient of consolidation is determined by one dimensional consolidation test. Consolidation test is relatively costly and takes a very long time to perform in the laboratory. In this paper attempt is made to obtain coefficient of consolidation using soil plasticity characteristics for alluvial deposits. The author has used numbers of data sets of South Gujarat region to suggest new correlations to obtain time rate settlement from soil plasticity characteristics.

Keywords: Alluvial Deposits, Coefficient of Consolidation, Soil Compressibility, Soil Plasticity.

Introduction

The rate at which settlement of a soil layer takes place is essential from a design consideration. This can be determined using coefficient of consolidation (C_V). To obtain coefficient of consolidation it is usual to conduct a routine one-dimensional consolidation test. The various time fitting curves are available to evaluate coefficient of consolidation. This is time consuming process. Shridharan and Nagaraj (2004) suggest that curve fitting procedures available in the literature are not completely satisfactory in evaluating coefficient of consolidation and hence large variation is obtained in the evaluated values by different procedures. Generally square root time fitting or Log time fitting curves are used for evaluation of coefficient of consolidation. The rate of settlement is directly related to the rate of excess pore pressure dissipation. Coefficient of consolidation is useful in the determination of the time required for a finite percentage of consolidation to occur. The coefficient of consolidation generally decreases as the liquid limit of soil increases. The range of variation of coefficient of consolidation for given liquid limit is very high. Coefficient of consolidation varies with both level of stress and degree of consolidation. For practical site settlement calculations it is usual to measure coefficient of consolidation relative to loading range applicable on site, and then assume this value to be constant except very low values. The present study is carried out in order to obtain a possible correlation between coefficient of consolidation and Atterberg limits.

Review on Methods for Determination of Coefficient of Consolidation

Yenumula (1995) proposed a method to predict the compression (σ) versus time (t) behavior of the clayey soil by measuring the compression values of soil specimen at two times intervals in oedometer test. Ausillio and Conte (1999) deals with the one dimensional consolidation of unsaturated soils due to the application of external loads and equation is derived to predict the rate of settlement of shallow foundation with time. Fox (1999) presented a graphical solution charts for 1 D consolidation of single homogeneous layer of consolidated clay under a surcharge load. Shridharan et al (1998) suggested that results obtained from rectangular hyperbola method generally lies between those obtained from the Taylor and Casagrande methods. Mesri et al (1999) suggested that the inflection point method required only visual identification of inflection point on comparison verses log time curve. The values of coefficient of consolidation by simple inflection method are quite similar to those from the Casagranded method. Shridharan et al (1999) proposed a rapid method of consolidation testing. In this method, the next load increment is applied as soon as necessary time required to identify the

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percent consolidation is reached and evaluated the coefficient of consolidation by one of the popular curve-fitting procedures such as square root time fitting or Log time fitting method. Analytical solutions and solution charts relating the degree of consolidation U to the dimensionless time factor T for the finite strain one dimensional consolidation of saturated soil layers with both one way and two way drainage are developed by Morris (2002). Analytical closed form solution is obtained for vertical consolidation considering the variation in compressibility and permeability Lekha (2003). Parameter C_C/M representing the nonlinearity in compressibility and permeability behavior is identified and found to play a significant role in deciding the rate of the consolidation process by Lekha (2003). Seah et al (2004) presented the coefficient of consolidation in the horizontal direction determined from the laboratory and the field through testing, along with analysis from settlement measurement of embankment constructed with prefabricated vertical drained at the Suvaranabhumi Airport site in Bangkok. Singh (2005) shows exact analytical solutions for the one-dimensional transient consolidation settlement of clay under triangular loading of pore pressure. Using these solutions, two new methods, a 'diagnostic curve' method and 'peak derivative' method are developed for simultaneous estimation of coefficient of consolidation and final consolidation settlement. Singh (2007) proposed two new diagnostic curve methods, which do not requires the implicit determination of initial or final dial gauge readings for primary settlement, for identification of the consolidation coefficient.

Sub Soil Characteristics of Alluvial Deposits of Study Area

The subsoil characteristics of Surat city situated in south Gujarat region of Gujarat state in India and surroundings are studied. The study area is divided in the different zones of Surat and Surat urban development authorities (SUDA).The soil in most of the zones are stratified alluvial deposits under the alternate floods and tides. The city is subjected to frequent floods. The laboratory results of soil samples of different zones and different locations are studied. The depth of soil is about 3 m to 7 m for different locations representing the maximum stress zone for shallow foundations. The average range of soil properties are shown for alluvial deposits of Surat and surroundings in Table -1.

Table -1: Subsoil characteristics of alluvial soils of study area

Soil Properties	Typical Range
Liquid Limit (w_L)	30 – 60
Plastic Limit (w_p)	20 – 30
Plasticity Index (I_p)	15 – 30
Void Ratio (e_0)	0.6 – 0.9
Dry unit weight kN/m^3 (γ_d)	14 – 16
Water Content (w)	15 – 30
Porosity (n_0) %	40 – 46
Fines %	60 - 90
Clay %	20 – 30
Silt %	40 – 60
Compression Index (C_c)	0.15 – 0.30
Compression Ratio ($C_{c'}$)	0.12 – 0.18
Soil Classification	Low to High Compressible Fine Grained Soil

Coefficient of Consolidation From Liquid Limit of Soils

In the present study coefficient of consolidation is correlated with liquid limit and plasticity index of soil. It is observed that C_v for alluvial soil of south Gujarat region are better correlation coefficient with plasticity index than liquid limit. The correlation of C_v with liquid limit is also quite satisfactory. New empirical correlations are derived using soil liquid limit and plasticity index for determining coefficient of consolidation of alluvial soil using test data of loading range up to 400 kN/m^2.

Using test data of coefficient of consolidation with liquid limit of soil new correlation is derived for alluvial deposits of south Gujarat region in India as shown in Fig. 1. Comparison of predicted and measured datasets of coefficient of consolidation with liquid limit of soil is shown in Fig. 2.

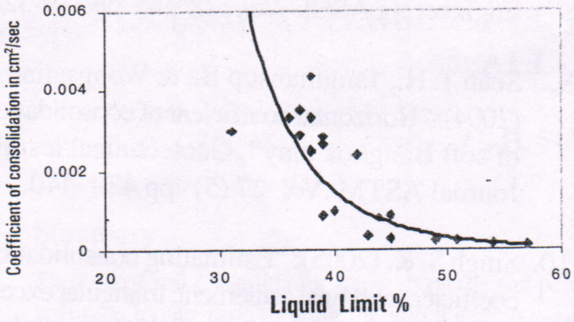

Fig. 1 Coefficient of consolidation from Liquid limit of soil

$C_v = 10^8 \ (W_{L})^{-6.7591}$ .... (1) in cm^2/sec

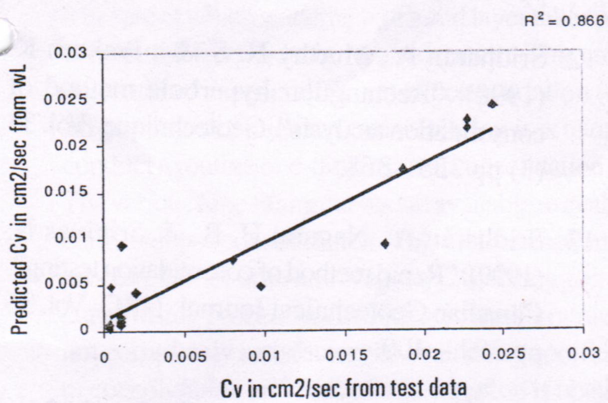

Fig. 2 Coefficient of consolidation from Liquid limit of soil

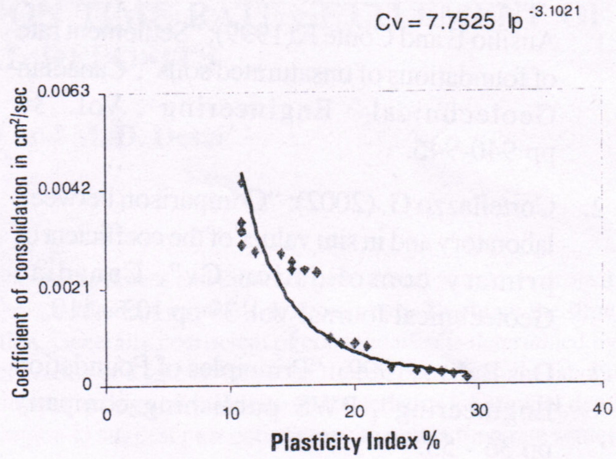

Fig. 3 Coefficient of consolidation from Plasticity Index

$C_v = 7.7525 \ (I_p)^{-3.1021}$ in cm^2/sec............ (3)

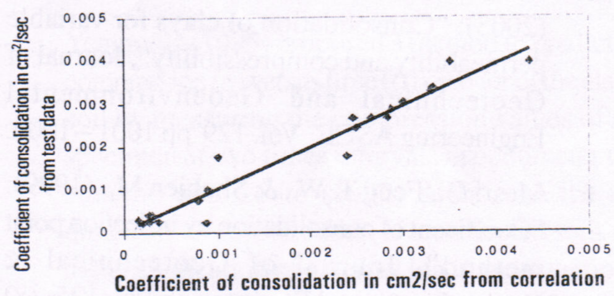

Fig. 4 Comparison of coefficient of consolidation from Plasticity Index and test results

Coefficient of Consolidation From Plasticity Index of Soils

Using test data of coefficient of consolidation with plasticity index a new correlation is derived Fig. 3. Fig. 4 shows comparison of coefficient of consolidation with plasticity index using test data and correlation. This correlation of plasticity index is verified with test data. It is observed that correlation coefficient obtained by using soil plasticity index is having better correlation coefficient ($R^2 = 0.9484$) as compared to liquid limit of soils.

Conclusion

New correlations for coefficient of consolidation of alluvial deposits for given range of subsoil characteristics are derived with plasticity characteristics with higher value of correlation coefficient. It is observed that Cv for alluvial soil of south Gujarat region are giving higher value of correlation coefficient with plasticity index in compare to liquid limit. The correlation of Cv with liquid limit is also quite satisfactory.

$$C_V = 10^8 \ (w_{L})^{-6.7591} \quad \text{in } cm^2/sec$$

$$C_V = 7.7525 \ (I_p)^{-3.1021} \quad \text{in } cm^2/sec$$

References

1. Ausilio E and Conte E (1999): "Settlement rate of foundations of unsaturated soils", Canadian Geotechnical Engineering Vol. 36 pp 940-946.
2. Cortellazzo G. (2002): "Comparison between laboratory and in situ values of the coefficient of primary consolidation Cv", Canadian Geotechnical Journal Vol. 39 pp 103 – 110.
3. Das B. M., (1999): "Principles of Foundation Engineering", PWS publishing company pp 36 - 55.
4. Fox P. J., (1999): "Solution charts for finite strain consolidation of normally consolidated clays". Journal of Geotechnical and Geoenvironmental Engineering Vol. 125 (10) ASCE pp 847 – 867.
5. Lekha K. R., Krishnaswami N. R. & Basak P. (2003): "Consolidation of clays for variable permeability and compressibility", Journal of Geotechnical and Geoenvironmental Engineering ASCE Vol. 129 pp 1001 – 1009.
6. Mesri G., Feng T. W., & Shahien M., (1999): "Coefficent of consolidation by inflection point method". Journal of Geotechnical & Geoenvironmental Engineering Vol. 125 (8) pp 716-718.
7. Moriwak Seah T. H., Tangthansup B., & Wongsatian P. (2004): "Horizontal coefficient of consolidation of soft Bangkok clay", Geotechnical testing Journal ASTM . Vol. 27(5) pp 430 -440.
8. Morris P. H. (2002): "Analytical solution of liner finite-strain one dimensional consolidation", Journal of Geotechnical & Geoenvironmental Engineering ASCE Vol.128 (4) pp 319-326.
9. Seah T. H., Tangthansup B., & Wongsatian P. (2004): "Horizontal coefficient of consolidation of soft Bangkok clay", Geotechnical testing Journal ASTM .Vol. 27 (5) pp 430 -440.
10. Singh S. K. (2005): "Estimating consolidation coefficient and final settlement; triangular excess pore-water pressure", Journal of Geotechnical and Geoenvironmental Engineering ASCE Vol. 131 pp 1050 – 1055.
11. Singh S. K. (2007):"Diagnostic curve methods for consolidation coefficient". International Journal of Geomechanics ASCE Vol. 7 (1), pp 75 – 79.
12. Sridharan A., Murthy N. S. & Prakash K. (1998): "Rectangular hyperbola method of consolidation analysis". Geotechnique Vol. 37 (3) pp 355 - 368.
13. Sridharan A., Nagaraj H. B., & Srinivas N. (1999): "Rapid method of consolidation testing". Canadian Geotechnical Journal NRC Vol. 36 pp 392 – 400.
14. Sridharan, A., Nagaraj H. B. (2004): "Coefficient of consolidation and its correlation with index properties of remoulded soil", Geotechnical testing Journal ASTM Vol. 27 (5) pp 1-6
15. Yenumula. Prasad V. S. N. & Rao S. N. (1995): "A new two point method of obtaining C_V from a consolidation test", Canadian Geotechnical Journal NRC Vol. 32 pp 741 - 746.

It you wait for an opportunity, you may have to wait till eternity.
Begin where you are and with what you have.

- Dada J. P. Vaswani