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Prediction of FSI Value by using Hyperbola Method

Shirisha Galiguti, P. Arti Sudam

Abstract*: Expansive soils are problematic soils due to their swelling nature, pose a major threat to most of the civil engineering structures. So, in order to avoid damage of structures free swell index test is conducted before the structure is built. In this paper an attempt has been made, to predict the free swell index of different expansive soils before 24 hours by using Hyperbola method. Samples are collected from 4 different areas from Telangana region. Free swell index test is conducted and the sediments in distilled water are noted by taking readings at particular time intervals depending on rate of fall of sediments for different soils. By considering initial sediment values from the obtained values, final value is predicted by using Hyperbola method. FSI is calculated by considering the predicted sediment value in distilled water to the sediment value in kerosene. Thus it is observed that predicted values and the final values in 24 hours are almost similar and hence it can be concluded that by using Hyperbola method we can terminate the experiments before the equilibrium is attained.

***Keywords: - Hyperbola, Montmorillonite, Shrinkage, Swelling*.**

I. INTRODUCTION

Soil extension is because of enhancement in soil volume because of saturation. The soil formation, which subjected towards deformation, is considered by the presence of lattice particles that might undergo swelling because of increase in the content of water. Lattice particles comprises of the fine-grained soils that consists highly expansive minerals such as montmorillonite which absorbs more amount of water and other minerals illite, kaolinite and chlorite has lesss intake of water compared to montmorillonite. So the soils which has montmorillonite mineral has more swelling compared to other soils. The soils containing predominately montmorillonite causes soil to swell and shrink on wetting and drying. As a result of this there will be huge damage to the civil engineering structures. To avoid this problem swelling tests are conducted before construction of any structure. Depending upon the result obtained from swell test the soil is treated and construction is done accordingly. Free swell ratio test is one the user friendly test which can be adopted in the field for characterizing expansive soil and identifying mineralogical composition **Sridharan et al., [5]**. Free swell-ratio is one of the simple method and which do not require highly sophisticated instruments likes X-ray diffraction techniques **Prakash et al., [3]**.

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* Correspondence Author
Shirisha Galiguti*, Department of Civil Engineering, VNRVJIET, Hyderabad-90, Telangana, India.
P Arti sudam, Assistant Prof, Department of Civil Engineering, VNRVJIET, Hyderabad-90, Telangana, India

Modified free swell index and free swell ratio is conducted and analyzed to pore fluid chemistry mineral composition and clay content **Wojcik et al., [7]**. Swelling pressure of soil is controlled by adding gypsum and sand dune **Jagadish et al.,** [2]. The swelling properties of expansive soils is determined based on parameters like free swell index, swell pressure and swell potential **Radhakrishnan et al., [4]**. Coefficient of consolidation is determined by predicting the rate of settlement by using Hyperbola method **Shukla et al.,** [6].

II. METHODOLOGY

In the contemporary study free swell index of different soils is carried out. The samples of soil are gathered from different areas of Telangana. Sample 1 is collected from Sangareddy, sample 2 is collected from Mangur, sample 3 is collected from Kamareddy and sample 4 is collected from suryapet. For the soil samples index properties are calculated and soils are classified accordingly. Free swell index test is conducted by taking 10g of oven dried sample passing through 425µm sieve were placed in each of the two 100ml graduated measuring jars. Distilled water in one of the jar and kerosene in other is added to make the initial volume of solid liquid suspension **IS 2720 [1]**. Soil samples are added in both the measuring jars and solid-liquid suspensions were thoroughly mixed, slowly the soil particles starts to settle down. The rate of fall of particles at particular time interval is noted by using stop watch and values are noted at every time interval until 24 hours. Similarly, same procedure is repeated for other soil samples and values are noted accordingly. Different time intervals are adopted for different type of soils depending on rate of fall of soils particles. By considering initial sediment value in distilled water, final sediment value is predicted using Hyperbola method and free swell index value is calculated. Thus before 24 hrs. free swell index value can be predicted and test can be terminated before equilibrium has attained.

Free swell index

It is a standard model which is specified by the Bureau of Indian standards (IS: 2720, 1977). 10gm of oven dried passing through 425µm sieve is placed in 100ml of graduated measuring jar comprising distilled water to that in kerosene. After an equilibrium period of 24hrs the swell potential of the soil is calculated utilizing FSI.

$$FSI\ (\%) = \frac{(V_d - V_k)}{V_d} * 100 \qquad (1)$$

Where, V_d is the sediment volume in distilled water, V_k is sediment volume in kerosene

Hyperbola Model

(Shukla et al., 2009) explained the model theory and its computation process. This model detects that Terzaghi U-T association is in rectangular-hyperbola for an extensive of T-range. Therefore, if T & U were plotted as T/U vs. T, then the curve is attained approximately as U=60% and there could be straight-line for 60% ≤ U ≤ 90% (Fig. 1). The process of cv determination is in the following way: Attain values of heave (s) and time (t) from standard test at an equivalent time periods; plotting the graph among t/v vs t; recognize initial part of straight line in t/s vs t plot; evaluate intercept-c and slope-m values; and lastly, calculate cv value (Shukla et al., 2009).

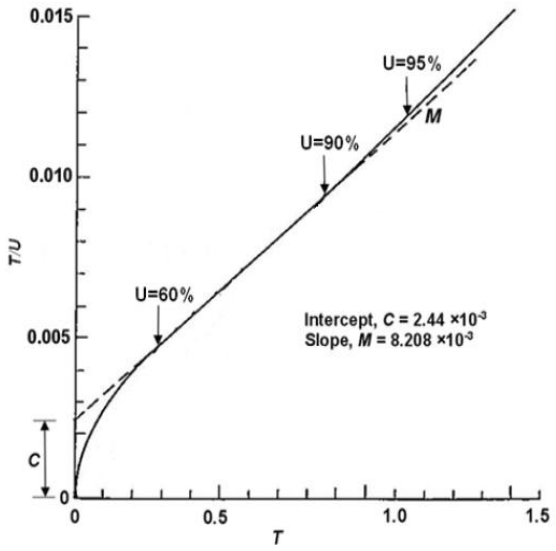

Fig .1 Theoretical T/U versus T relationship from (Shukla et al., 2009)

Soil Classification

The soil samples from different regions of Telangana are brought and examined in the laboratory for classifying the type of soil. By using "Casagrande liquid limit device" the liquid limit of each soil is known. On the basis of liquid limit (W_L) Plasticity index (I_P) is calculated and the obtained results are provided in ISSCS to aid classification and are shown in below Table 1.

$$I_P = 0.73(W_L-20) \qquad (2)$$

Where, W_L =liquid limit

Note

Equilibrium sediment volume in distilled water = s

Time = T

Soil sample 1

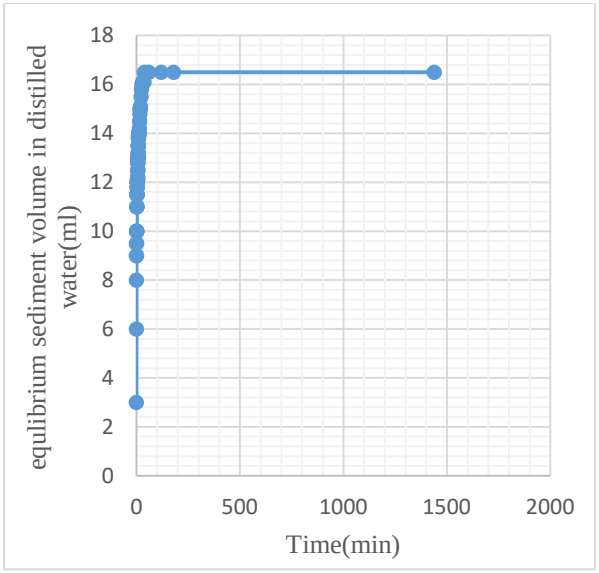

Fig. 2 Time (min) versus sediment volume (ml) in distilled water

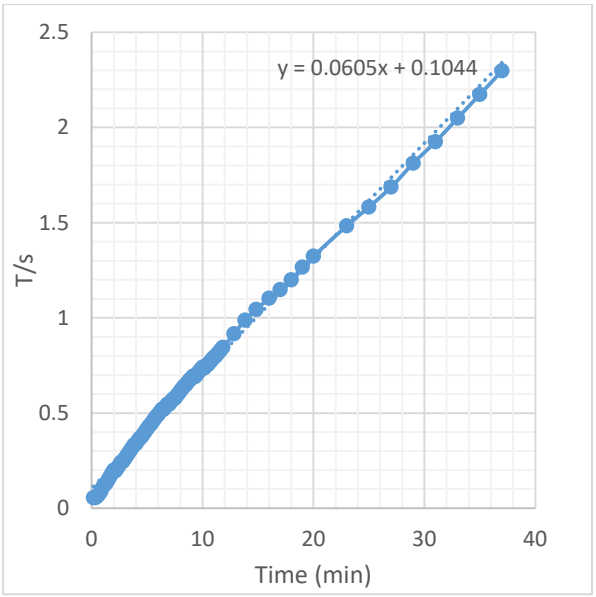

Fig. 3 Hyperbolic plot

In Fig. 2 Plot shows the equilibrium sediment value in distilled water is measured till 24 hours, at particular time interval the final value is attained. Fig. 3 by considering initial values Hyperbolic plot is drawn and the final sediment value is predicted at a time interval of 37 min. Thus by using eq (1). FSI value is calculated by considering the predicted sediment volume in distilled water.

Soil Sample 2

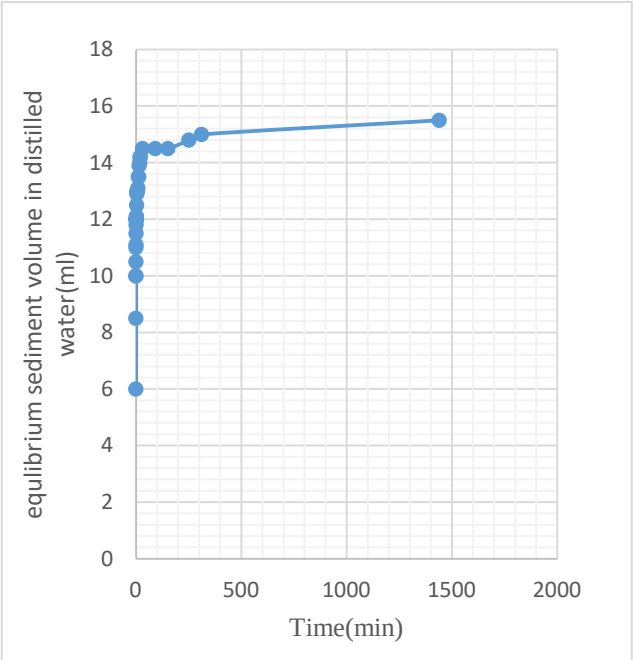

Fig. 4 Time (min) versus equilibrium sediment volume in distilled water (ml)

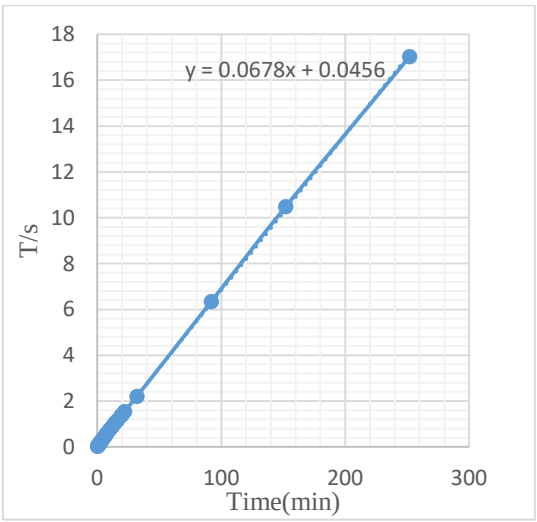

Fig. 5 Hyperbolic plot

Fig. 4 Graph is plotted by taking the values till the equilibrium point and FSI value is calculated by using eq (1) as shown in Table (2). Fig. 5 shows a Hyperbolic plot in which the sediment value is predicted by considering a duration of 6hrs and FSI value is calculated using eq (1). Shown in Table(1)

Soil sample 3

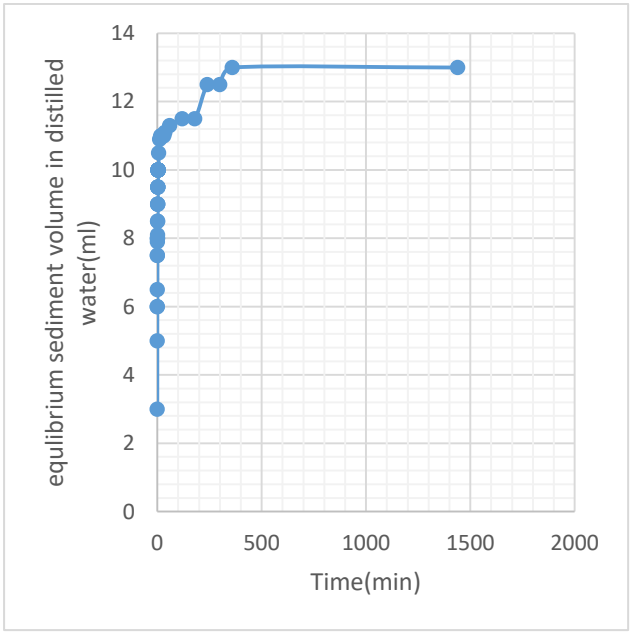

Fig. 6 Time (min) versus Sediment volume in distilled water (ml)

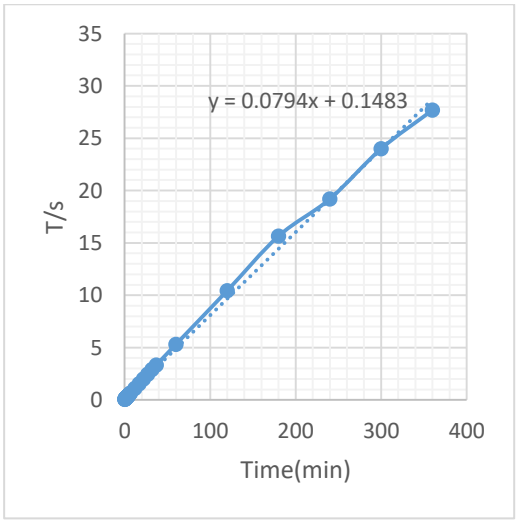

Fig. 7 Hyperbolic plot

Fig. 6 Graph is plotted by taking the values till the equilibrium point and FSI value is calculated by using eq (1) as shown in Table (2). Fig. 7 shows a Hyperbolic plot in which the sediment value is predicted by considering a duration of 4hrs. 20 mins and FSI value is calculated using eq (1). Shown in Table (3).

Soil sample 4

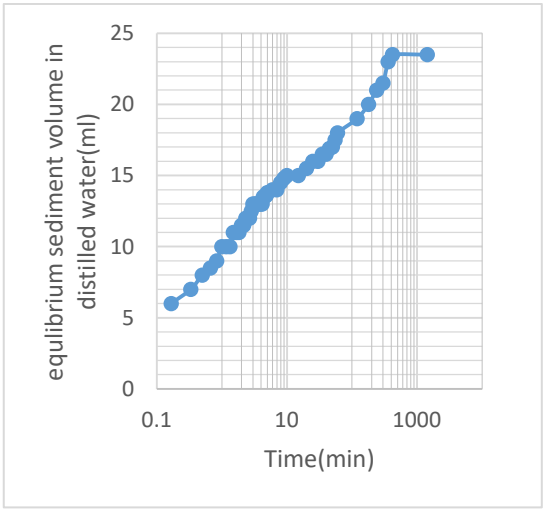

Fig. 8 Time (min) versus equilibrium sediment volume in distilled water (ml)

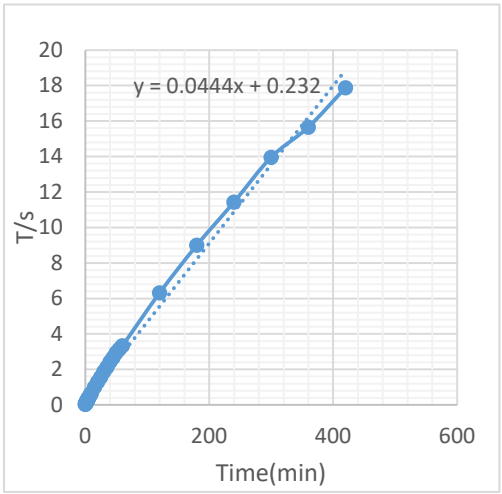

Fig. 9 Hyperbolic plot

Fig. 8 Graph is plotted by taking the values till the equilibrium point and FSI value is calculated by using eq (1) as shown in Table 2. Fig. 9 shows a Hyperbolic plot in which the sediment value is predicted by considering a duration of 7 hrs. and FSI value is calculated using eq (1). Shown in Table (3)

III. Results and discussions

Table 1 Properties of soil samples and its results

Sl. no	Soil samples	Specific Gravity (G)	Plastic limit (W_p %)	Liquid limit (W_L %)	Soil Classification
1.	Soil sample 1	2.69	43	115.8	CH
2.	Soil sample 2	2.68	30	101	CH
3.	Soil sample 3	2.52	31	57	CH
4.	Soil sample 4	2.57	51	72	MH

Soil samples collected from different locations are classified based on the liquid limit values obtained by using eq (2). The soil samples 1, 2 and 3 classified are highly expansive in nature. Thus, from the above results obtained, soil samples can be used for conducting free swell index test.

Table 2 Free swell index for 24hrs readings

Sl.No	Soil samples	Sediment volume in distilled water (V_d) (ml)	Sediment volume in kerosene (V_K) (ml)	FSI (%)
1.	Soil sample 1	16.5	9	83.3
2.	Soil sample 2	15.5	10	55
3.	Soil sample 3	13	9	44.4
4.	Soil sample 4	23.5	11	113.6

The above tabulated results are obtained after the equilibrium point has attained. By considering the V_d and V_k values free swell index is calculated for 24 hours readings. The swelling nature is more for soil sample 4 and least for soil sample 3.

Table 3 Estimated free swell value by prediction of Hyperbola method

S.No	Soils	Equilibrium sediment value predicted by using Hyperbola method (ml)	Time taken for prediction of final value using Hyperbola method	Sediment volume in kerosene (V_d) (ml)	FSI (%)
1.	Soil sample 1	16.6	37 min	9	84.4
2.	Soil sample 2	14.7	4hrs. 20min	10	47
3.	Soil sample 3	12.5	6hrs	9	38.8
4.	Soil sample 4	22.5	7hrs	11	104

Free swell index values are calculated by considering the predicted sediment values in distilled water using Hyperbola method, and the time taken for the predicting the value are given in Table 3.

IV. CONCLUSION

An analysis is done to predict the free swell value by using Hyperbola method before the equilibrium has attained. Generally it requires 24 hours to know the free swell value of a particular soil by using free swell index test. In this paper an attempt has been made to predict the free swell index of different expansive soils before 24 hours by using Hyperbola method. Samples are collected from 4 different areas from Telangana region. Free swell index test is conducted by taking readings at particular time intervals depending on rate of fall of sediments for different soils. By considering initial values from the obtained values final value is predicted by plotting using Hyperbola method and free swell index is calculated. From the obtained results, it is observed that predicted values and the final values in 24 hours are almost similar and hence it can be concluded that by using and Hyperbola method we can terminate the experiments before the equilibrium point is attained.

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AUTHORS PROFILE

Shirisha Galiguti, Post Graduate student, M. Tech Geotechnical Engineering, Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad-90,TS.

P. Arti Sudam, Assistant Prof, Department of Civil Engineering, published 5 national and 1 international conference publication journals. VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad-90,TS.