International Journal of Engineering Research and General Science Volume 6, Issue 2, March-April, 2018
ISSN 2091-2730

*T*OTAL CONSOLIDATION SETTLEMENT OF A LOCAL SOIL IN THE FIELD CONDITION (LABORATORY INVESTIGATION)

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Abstract— Estimating consolidation settlement, and the rates at which they will occur, plays an important part in many civil engineering projects. Accurate predictions of settlement magnitudes require accurate evaluations of soil properties and pre consolidation pressure. Accurate predictions of settlement rates require improved methods to take into account important factors such as variations in 'cv' within clay layers, nonlinear stress-strain behavior, and non uniform strain profile effects, and research to develop an improved model of soil compressibility that can determine the accurate value of total consolidation settlement of soil in the field condition. This study also tries to develop a model of soil layer and to determine accurate value of total settlement. A laboratory investigation on consolidation settlement has been done. For this purpose a soil bed was made in a model tank and consolidated by applying some pressure. The determination of total settlement by making model of soil bed and doing direct loading on soil for consolidation is an approach to predict accurate total settlement of a soil.
Keywords: Consolidation settlement, Atterberg's limit constants, Clay Soil, Field Condition, Laboratory Investigation.

Introduction:
In this research determination of general soil properties of the local soil along with estimation of settlement of soil layered in the field condition. For this purpose fabrication and preparation of the laboratory set up of soil similar to a field condition, loading on the soil sample and determination of settlement with time.

Fabrication of the laboratory set up:
Two square boxes of 18' X 18' and 24' X 24' have been fabricated. All the boxes are made by fiber with appropriate shape. In each box, there are one out let in one face at a height of two inches from bottom are also made. This out let is used for flow of water from the box. One iron clamp for each small box is made for prevention of lateral expansion of the soil under the box. Similarly two iron clamps are used for bigger boxes for prevention of lateral expansion. In each small box at a height of 12 inches from bottom, there is one small circular hole in each face. Similarly in bigger boxes, the holes are made at the height of 16 inches. There is a scale, on each of the face of the all boxes from the bottom side of the boxes for the purpose of measurement of settlement of the soil layer.

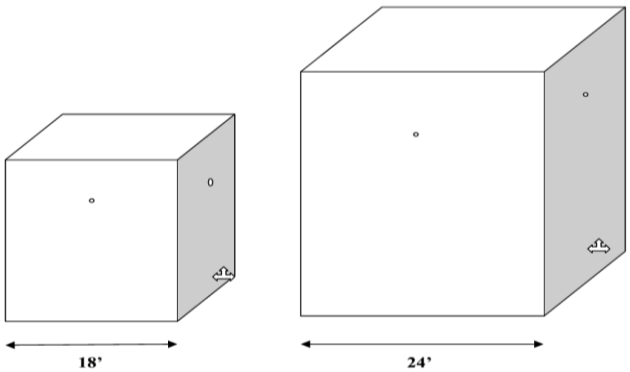

Fig. 1. Fabricated Smaller and Bigger Boxes.

Arrangement and Preparation of the soil (clay) sample:
The soil sample was collected from a pond in Balrampur village near IIT Kharagpur. The soil was cut from bottom of the pond. The 30 bags of soil were brought from that pond. The soil was mixed with organic fossils and undesirable matters. So it has been put in the

water tank and then it has been washed in water. All the undesirable materials with soil were removed by sieving the soil with a sieve. In this way obtained fresh soil sample is taken in a big tank. Soil water suspension with water content sufficiently more than the liquid limit of soil and natural water content were kept up to desired height for some time.

Determination of soil properties:

A. Determination of water content of the soil sample:

The water content of the soil sample just taken from the pond is determined by the oven dry method in the laboratory. For that small quantity of soil sample was taken in two cans and put in the electric oven for 24 hours for being dry. After 24 hours soil was weighed and water content of the sample has been determined. The water content of the sample was **65.45%.** This is the natural water content of the sample. Similarly when the clay was being put in the boxes again the water content of the respective clay of individual box has been taken.

B. Determination of Atterberg's limits constants:

For determining Atterber's limits constant the sample is prepared as accordance with BIS code 2720 part 1. Soil is first dried in the sun and later by oven between the temperatures 105^0c to 110^0c after that it has been powdered by using hammer. When soil is almost converted to dust, it is sieved by the 425 micron sieve. The Liquid limit of prepared soil sample is determined by the Mechanical method. Plastic limit is also determined by the BIS code 2720 part 5 methods. In the last shrinkage limit is determine by BIS 2720 part 6 methods. By using these methods the obtained data are as follow.

Table 1 Atterber's limits constant

Liquid limit of the soil	(W_L)	43%
Plastic Limit of the soil	(W_P)	21%
Shrinkage limit of soil	(W_s)	17%
Plasticity index	(I_p)	22%

From the Plasticity chart the soil sample is **Inorganic clays of low to medium plasticity (CL).**

C. Determination of specific gravity of the soil:

The specific gravity of the soil sample is determined by the IS 2720 part 3: section – 1:1980 or density bottle method. The specific gravity of the soil **G = 2.43.**

D. Determination of organic content of the soil:

The organic content of the soil sample is determined by the IS 2720 part 22: 1976. The percentage organic content in the soil is found 12.23 %. This data shows that the soil has low organic contents hence the soil have greater compatibility characteristics. It means it has high co-efficient of compression.

Table 2 Properties of Clay

Parameters	Value	Relevant IS codes
Classification	CL	IS : 1498-1970
Specific Gravity	2.43	IS:2720 (Part III)-1980
Liquid Limit	43%	IS:2720 (Part V)-1985
Plastic Limit	21%	IS:2720 (Part V)-1985
Plasticity Index	22%	IS:2720 (Part V)-1985
Shrinkage Limit	17%	IS:2720 (Part VI)-1982
Organic content	12%	IS:2720 (Part XXII)-1972

Preparation of Laboratory set up with the soil similar to field condition:

A. Process of preparation of soil layer

For the preparation of experimental set up similar to field condition following procedure has been done.

- The prepared soil sample is poured in to the box very slowly to a fixed height.
- The box was leaved for 15 days for squeezing out of the water from the soil and to settle the soil layer by self weight.
- After 15 days gravels were put on the soil layer slowly and uniformly, each day 3 inches heights, until the box is filled fully by gravel.
- The out let of the box is being closed after putting the gravel and each day the settlement of the soil layer is noted due to weight of gravel.
- After 20 days the settlement of the soil layer was become almost constant and some water is raised in gravel zone.
- Now for full saturation of the soil, the water is added very slowly from the top and uniformly up to the height of a hole in the box.
- Thus in this way a model of saturated soil layer under the layer of a gravel has been prepared in two tank which is ready for consolidation test.

Fig. 2. Model of soil sample prepared for consolidation test

B. Loading on the soil layer and settlement of the soil layer with time:

After completion of settlement under the self weight and gravel surcharge weight the external loads were placed for one dimensional consolidation of soil layer in single drainage condition. Before loading some water was added from the top to the boxes for keeping the soil fully saturated. Then the upper Portion of the gravel was leveled by the leveling device. A square iron plate had been put in the middle of the box. On this plate the concentric weights are loaded for the settlement purpose. Upon concentric loads a dial gauge of least count of 0.01mm is set for measuring settlement (Fig. 3 & Fig. 4). After just applying the load the settlement has been noted in the interval of 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours and 24 hours. Then every day at a fixed time the settlement of clay has been noted up to when the settlement of clay becomes almost constant.

Table 3 Loading detail of the soil layer

Box	Weight W (kg)	Area of plate A_S (m^2)	Load P (kN/m^2)	Ht. of clay H_t (cm)
Smaller box	94.107	0.052	17.648	17.46
Bigger box	88.220	0.041	21.270	25.72

Fig. 3. Loading on the smaller box model

Fig. 4. Loading on the bigger box model

Settlement data of soil layer in the boxes:

After just applying the load on the soil, settlement was noted in the interval of 30 minutes, 1 hour, 2 hours, 4 hours, 6 hours and 24 hours. Then every day at a fixed time the settlement of soil was noted up to when the settlement of clay becomes almost constant. The settlement data of the soil of smaller box and bigger box are shown in the table 4 and table 5 respectively.

Table 4 Settlement of soil in smaller box

No. of Days	Dial Reading R (mm)	Difference from initial (mm)	Cumulative difference (mm)
1	4.90	0.00	0.00
2	3.05	1.85	1.85
3	2.40	0.65	2.5
4	1.86	0.54	3.04
5	1.33	0.53	3.57
6	0.92	0.41	3.98
7	0.76	0.16	4.14

8	0.58	0.18	4.32
9	0.44	0.14	4.46
10	0.32	0.12	4.58
20	-0.27	0.59	5.17
30	-0.69	0.42	5.59
40	-1.06	0.37	5.96
50	-1.32	0.26	6.12
60	-1.51	0.19	6.41
70	-1.68	0.17	6.58
80	-1.83	0.15	6.73
90	-1.95	0.12	6.85
100	-2.05	0.10	6.95

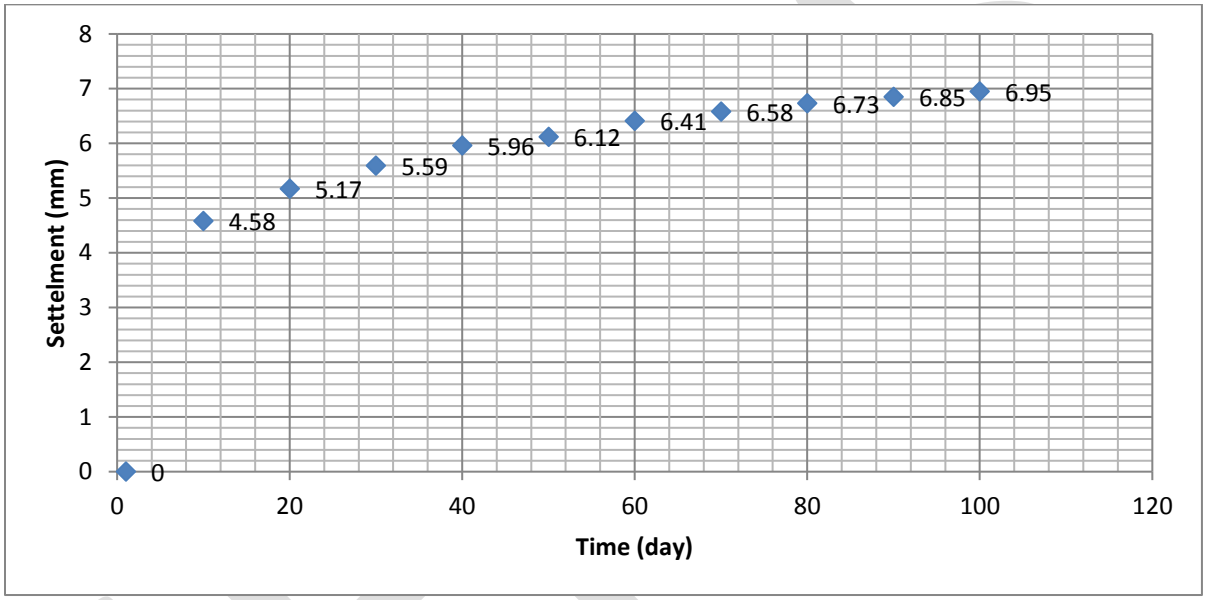

Fig. 5. Settlement in smaller box

Table 5 Settlement of soil in bigger box

No. of Days	Dial Reading R (mm)	Difference from initial (mm)	Cumulative difference (mm)
1	18.45	0.00	0.00
2	17.73	0.72	0.72
3	17.11	0.62	1.34
4	16.55	0.56	1.90
5	16.04	0.51	2.41
6	15.56	0.48	2.89
7	15.13	0.43	3.32
8	14.72	0.41	3.73
9	14.31	0.39	4.12
10	13.92	0.38	4.50
15	12.38	1.54	6.04
20	11.23	1.15	7.19
30	10.50	0.73	7.92
40	10.04	0.46	8.38
50	9.63	0.41	8.79

60	9.31	0.32	9.11
70	9.08	0.23	9.34
80	8.77	0.18	9.52
90	8.66	0.11	9.63
100	8.58	0.08	9.71

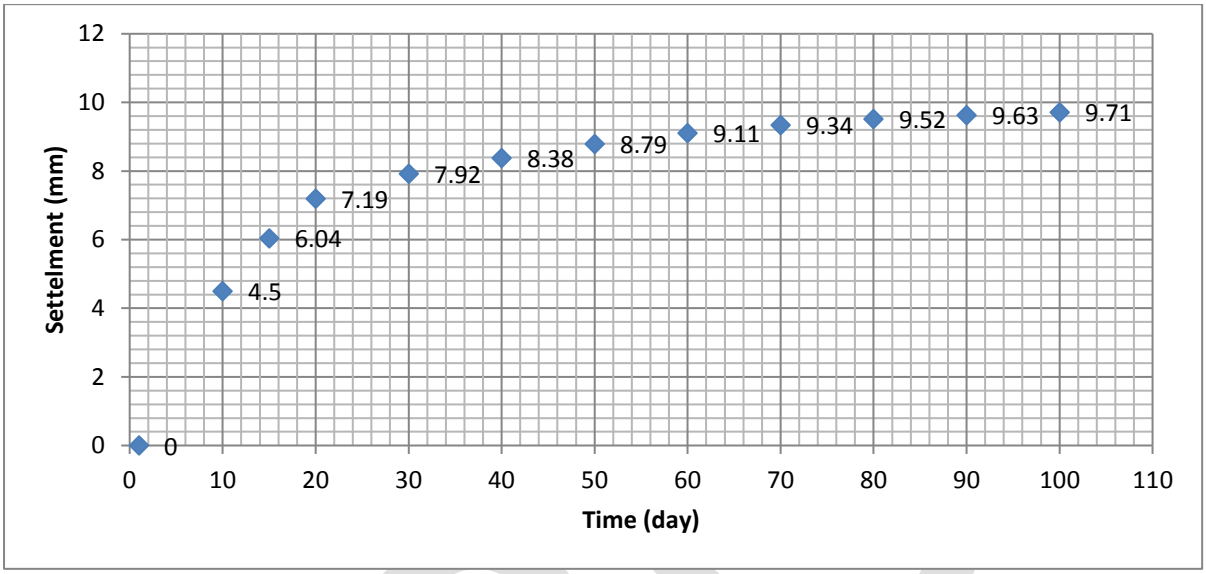

Fig. 6. Settelment in bigger box

Comparision of the data obtain:

On comparision of data obtained in table 4 and table 5, we can plot following graphs.

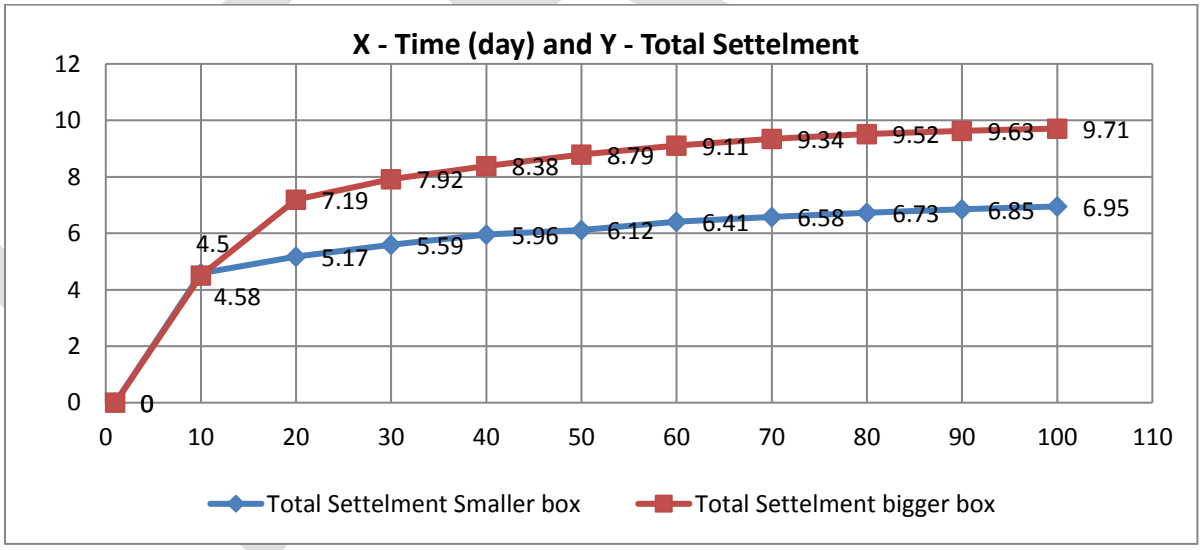

Fig 7 Comparative settlement in smaller and bigger boxes

Conclusions:

1. The settlement of clay soil in smaller box in 100 days is 6.95 mm
2. 70% of the total settlement of clay soil in smaller box in only 15 days.
3. The settlement of clay soil in bigger box in 100 days is 9.71 mm.
4. 75% of the total settlement of clay soil in bigger box in only 20 days.
5. At the 100 days the settlement of clay soil in both boxes stop or negligible.
6. Bigger box having 39.71 % more settlement than smaller box.

7. In First 10 day's settlement rate in both the boxes are approximately equal. After 10 days settlement rate increases in bigger box with respect to smaller box.
8. The settlement rate is more in first 10 days in both the boxes as compared to the other days.
9. This study ensures that this settlement data of soil by direct load settlement experiment in the laboratory can be used for designing of structure.

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