COMPARISON OF CONSTANT VOLUME AND CONSOLIDOMETER METHOD FOR SWELLING POTENTIAL OF DIFFERENT EXPANSIVE SOIL PLACED AT DIFFERENT DRY DENSITY AND INITIAL WATER CONTENT

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Abstract: Expansive or swelling soils exist in many parts of the world. Such common soils in Australia, India and South Africa Show excessive volume changes with increase in water content. Results of this volume increase expansive soil apply pressure to the structures located or buried in these regions. In this paper comparison of swelling behaviour of expansive clay is investigate using Constant Volume and Consolidometer method. The tests will be carried out on a number of samples obtained from different part of Saurashtra region Rajkot, Bhavnagar, Jamnagar, Amreli. The remoulded samples are prepared having different initial dry densities with different initial water contents used to study the effect of these variable parameters on the swelling pressure. It is observed that swell pressures increase with increasing initial dry density and they decrease with increasing initial water content.

Index Terms: Expansive Soils, Swelling Pressure, Dry Density, Moulding Water Content.

1. Introduction

Some of the partially saturated clayey soil are very sensitive to variation in water content and show excessive volume changes, such soils are classified as expansive soil and exist on many part of the world. Many places of India, Africa, Australia, Israel, and South America are covered with such soil. Expansive soils are worldwide problem faced by civil engineer. It is extended nearly one-fifth of our country, chiefly in the states of Maharashtra, Gujarat, Madhya Pradesh, Uttar Pradesh, Rajasthan, Karnataka, Andhra Pradesh and Tamil Naidu. Expansive soils also call black cotton soil.

The swelling phenomena is considered as one of the most serious challenge which the foundation engineer faces, because of the potential danger of unpredictable upward movements of structures founded on such soils. Any structure located on expansive clay may be subjected to large magnitudes of pressures due to development of swelling pressure when moisture content of clay increases. When moisture content of clay decreases settlement, problem create in structure due to differential settlement structure became damage. We can reduce economical loss by evaluating swelling characteristic of soil before starting the construction of important structure. Considerable amount of work has already been done in understanding the behavior of expansive soils. The parent materials associated with expansive soils are either basic igneous rocks or sedimentary rocks. Basic igneous rocks, it is formed by decomposition of feldspar and pyroxene and in sedimentary rocks, it is a constituent of rock itself in any case most expansive soils are rich in montmorillonite clay mineral.

2. Experimental Methodology

The purpose of this experimental study is to measure swelling potential of clayey soil and to investigate the pressure induced. And also investigate the effects of initial water content and initial dry density on swelling.

The constant volume swell (CVS) tests and Consolidometer swell tests are carried out. To investigate the effects of initial water content and initial dry density, a wide range of water content and densities are used for the tests program.

2.1 Material Investigated

The clayey soil samples used in these studies are collect from different part of Saurashtra region Jamnagar (Sample No-1), Bhavnagar (Sample No-2), Amreli (Sample No-3), Rajkot (Sample No-4). The soil sample is plastic clay. The soil is classified as CH soil according to Unified Soil Classification System. Index properties is shown in Table 1.

Table 1: Index Properties Clayey of Soils

Sr. No	Properties of soils	Jam nagar	Bhav nagar	Amreli	Rajkot
1	Liquid limit (%), LL	77	74	58	53
2	Plastic limit (%), PL	26	25	22	25
3	Plasticity index , PI	51	49	36	28
4	% Free swell test	150	140	100	75
5	Specific gravity, GS	2.57	2.6	2.61	2.63
6	% of Gravel	01	03	01	00
7	% of Sand	20	28	14	36
8	% of Silt and Clay	79	66	85	64
9	% of Clay	44	43	34	28
10	% of Silt	35	26	51	36
11	Shrinkage limits SL	20	19	16.50	18.5
12	O.M.C.%	23.26	23.26	20.70	17.17
13	M.D.D gm./cc, γd	1.41	1.5	1.58	1.7
14	Activity IP/C%	1.15	1.13	1.07	1.0
15	Type of soil	CH	CH	CH	CH

2.2 Constant Volume Method

Total 36 No. of consolidation swell tests were carried out on four types soils-CH at various dry density and water content, to study swelling behaviour of expansive soils, 9 no of tests at 90 %, 95%, and 100% of M.D.D and water content 5 %, 10 %, O.M.C are carried out for four types soil.

Figure 1: Constant Volume test set- up

2.2.1 Preparation of specimen

1) First of all, volume of the consolidation ring is determined.
2) 90%, 95%, 100% of maximum dry density obtained from standard Procter test is multiplied with volume of the consolidation ring to obtain the soil to be taken for testing.
3) The oven dried soil was mixed with water and it was rubbed thoroughly until a uniform colour is obtained.
4) The wet soil is now compacted in the consolidation ring itself in such a way that it occupies all the space in the ring.

2.2.2 Procedure

The initial reading of the proving ring shall be noted. The swelling of the specimen with increasing volume shall be obtained in the strain measuring load gauge. To keep the specimen at constant volume, the platen shall be so adjusted that the dial gauge always shows the original reading. This adjustment shall be done at every 0.1 mm of swell or earlier. The duration of test some as Consolidometer test. The assembly shall then be dismantled and the soil specimen extracted from the specimen ring to determine final moisture content in accordance IS-2720(Part II).

2.2.3 Calculation

The difference between the final and initial dial readings of the proving ring gives total load in terms of division which when multiplied by the calibration factor gives the total load. This when divided by the cross-sectional area of the soil specimen gives the swell pressure expressed in kN/m^2 (kgf/cm^2).

Swelling pressure in = ((Final dial reading-Initial dial reading)/ Area of the specimen) × Calibration factor of proving ring.

2.3 Consolidometer Method

Total 36 No. of consolidation swell tests were carried out on four types soils-CH at various dry density and water content, to study swelling behavior of expansive soils, 9 no of tests at 90 %, 95%, and 100% of M.D.D and water content 5 %, 10 %, O.M.C are carried out for four types soil.

Fig 2: Consolidation test set up-I

2.3.1 Procedure

The free swell readings shown by the dial gauge under the seating load of 5 kN/m2 (0.05 kgf/ cm) shall be recorded at different time intervals 0, 0.25, 0.5, 1, 2, 4, 8, 12, 16, 20, 24, 36, 48, 60, 72, 96, 120, and144 hours. Total readings noted at total elapsed time since starting shown therein. The dial gauge readings shall be taken till equilibrium is reached. This is ensured by making a plot of swelling dial reading versus time in hours, which plot becomes asymptotic with abscissa (time scale). The equilibrium swelling is normally reached over a period of 6 to 7 days in general for all expansive soils.

The swollen sample shall then be subjected to consolidation under different pressures 0.05 to 0.1 kg /cm2, 0.1 to 0.25 kg /cm2, 0.25 to, 0.5 kg /cm20.5 to 1.0 kg /cm21 to 2 kg /cm2, 2 to 4 kg /cm2 compression dial readings shall be recorded till the dial readings attain a steady state for each load applied over the specimen. The consolidation loads shall be applied till the specimen attains its original volume.

2.3.2 Calculations

Plotted with elapsed time as abscissa and swelling dial reading as ordinates on natural scale. A smooth curve shall be drawn joining these points. If the curve so drawn becomes asymptotic with the abscissa, the swelling has reached its maximum and hence the swelling phase shall be stopped, and the consolidation phase shall be started. A plot of change in thickness of expanded specimen as ordinates and consolidation pressure applied as abscissa in semi logarithmic scale shall be made. The swelling pressure exerted by the soil specimen under zero swelling condition shall be obtained by interpolation and expressed in kN/m^2 (kgf/cm^2).

3. Results and Discussion

3.1 Calculation of Constant volume Method

The difference between the final and initial dial readings of the proving ring gives total load in terms of division which when multiplied by the calibration factor gives the total load. This when divided by the cross-sectional area of the soil specimen gives the swell pressure expressed in kN/m^2 (kgf/cm^2).

Swelling pressure in = ((Final dial reading-Initial dial reading)/ Area of the specimen) × Calibration factor of proving ring.

Table 2: Test Results of Constant volume Method

	90% of MDD	**95% of MDD**	**100% of MDD**
Jamnagar	Swell pre. kg/cm^2	Swell pre. kg/cm^2	Swell pre. kg/cm^2
OMC	0.65	0.7	0.75
10%	0.7	0.75	0.8
5%	0.75	0.8	0.95
Bhavnagar			
OMC	0.6	0.65	0.75
10%	0.6	0.7	0.75
5%	0.7	0.8	0.9
Amreli			
OMC	0.2	0.4	0.45
10%	0.35	0.55	0.6
5%	0.35	0.55	0.6
Rajkot			
OMC	0.2	0.25	0.35
10%	0.25	0.35	0.4
5%	0.35	0.45	0.52

3.2 Calculation of Consolidation test

Graph Plotted with elapsed time as abscissa and swelling dial reading as ordinates on natural scale. A smooth curve shall be drawn joining these points. If the curve so drawn becomes asymptotic with the abscissa, the swelling has reached its maximum and hence the swelling phase shall be stopped, and the consolidation phase shall be started. A plot of change in thickness of expanded specimen as ordinates and consolidation pressure applied as abscissa in semi logarithmic scale shall be made. The swelling pressure exerted by the soil specimen under zero swelling condition shall be obtained by interpolation and expressed in kN/m^2 (kgf/cm^2).

Table 3: Test Results of Consolidometer Method

	90% of MDD	95% of MDD	100% of MDD
Jamnagar	Swell pre. kg/cm2	Swell pre. kg/cm2	Swell pre. kg/cm2
OMC	0.65	0.7	0.79
10 %	0.78	0.78	0.87
5 %	0.78	0.84	0.98
Bhavnagar			
OMC	0.64	0.6	0.78
10 %	0.69	0.75	0.83
5 %	0.75	0.83	0.95
Amreli			
OMC	0.39	0.45	0.5
10 %	0.4	0.48	0.55
5 %	0.43	0.5	0.63
Rajkot			
OMC	0.27	0.32	0.36
10 %	0.32	0.4	0.43
5 %	0.37	0.49	0.53

3.3 Effect of Initial Water Content

Swelling mechanism depends on the amount of water absorbed by the soil mass. As the initial water content increases, for specimens having the same dry unit weight, the initial degree of saturation will also increase and the affinity of soil to absorb water will decrease. It follows that the amount of water absorbed for complete saturation will become smaller, and consequently the amount of swelling will decrease as the initial water content increases. As the absorbed water is decreased for the same initial dry density the inter particle forces developed during swelling will become smaller. This in turn will be resulted in smaller swell pressures.

Swelling pressure decreases as the initial water content increases in both method Constant volume and Consolidometer for all soil types which are used in this study.

Fig 3 show relationship between swelling pressure and initial water content for different initial dry densities for constant volume method and sample No. 4 Rajkot.
Fig 4 show relationship between swelling pressure and initial water content for different initial dry densities for Consolidometer method and sample No. 4 Rajkot.

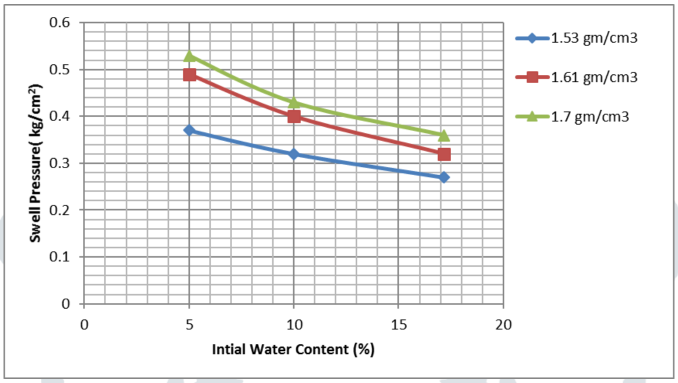

Fig 3: Relationship between the swelling pressure and the initial water content for different initial dry densities by CVT

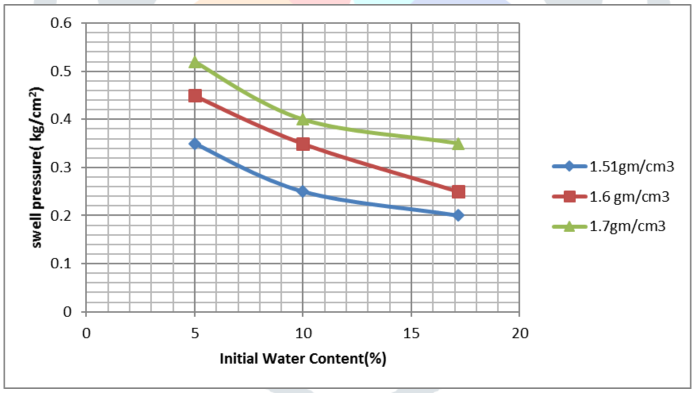

Fig 4: Relationship between the swelling pressure and the initial water content for different initial dry densities by Consolidometer.

3.4 Effect of Initial Dry Density

Swelling pressure in both method Constant volume and Consolidometer results of inter particle forces developed during swelling as a result of water absorption. As density increases, volume of voids decreased, water particle has smaller volume to move. During Water absorption in to soil media water practical has to apply more force to the surrounding soil particles to achieve the complete saturation for higher initial dry densities. The swelling pressure increases as the initial dry density increases for all soil types which are used in this study.
Figure 5 shows relationship between the swelling pressure and the initial dry density for different initial water contents and constant volume method used for sample No. 4 Rajkot.
The swelling pressure increases as the initial dry density increases.
Figure 6 shows relationship between the swelling pressure and the initial dry density for different initial water contents and Consolidometer method used for sample No. 4 Rajkot.

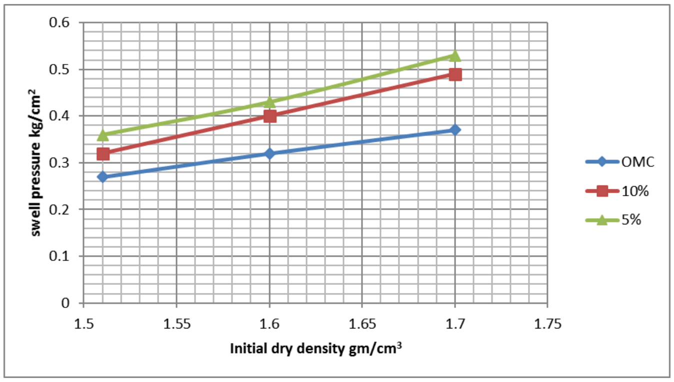

Figure 5: Relationship between the vertical swelling pressure and the initial dry density for different initial water contents. (constant volume method) sample No 4

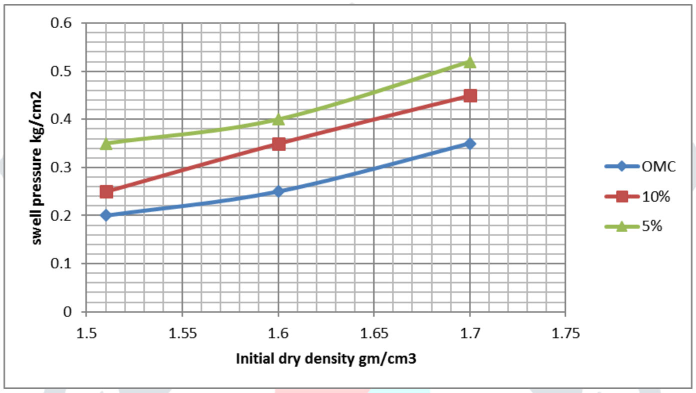

Figure 6: Relationship between the vertical swelling pressure and the initial dry density for different initial water contents. (Consolidometer method) sample No.4

3.5 Discussion of Test Results

During constant volume swell tests and Consolidometer swell tests it has been found that both initial dry density and initial water contents effect on swelling pressure. Swell pressure is function of density. Detailed discussions of test results will be presented in the proceeding sections.

4 Conclusion

The work aimed at investigating the effect of in-situ dry density and in-situ moisture content on swelling potential of expansive soils obtained from location Jamnagar, Bhavnagar, Amreli, Rajkot. The following observations are made.

- It was observed that significant effect of swelling pressure with the change of dry density and water content of the soil.
- With increased dry density, swelling pressure increases for all soil types. With decrease initial water content, swelling pressure increases for all soil types.
- The result of swelling pressure obtained by constant volume method and Consolidometer method and it is observed that in case of constant volume method swell pressure 1% to 5% greater than Consolidometer method but difference between both very small result obtained are reliable.

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