IOSR Journal of Engineering (IOSRJEN) **www.iosrjen.org**
ISSN (e): 2250-3021, ISSN (p): 2278-8719
Vol. 09, Issue 1 (January. 2019), ||V (II) || PP 09-13

Affect of a In-Situ Parameters in Explaining Collapsible Behaviour of Red Soils

K. Saroja Rani[1], P.V.V.Satyanarayana[2], G.Mounika[3]
[1](Ph.D Research Scholar, CIVIL Engineering, Andhra University, INDIA)
[2](PROFESSOR, CIVIL Engineering, Andhra University, INDIA)
[2](Pg Student, CIVIL Engineering, Andhra University, INDIA)
Corresponding Author: K. Saroja Rani

Abstract: Red Soils are problematic soils in nature that decrease of capillary tension and loss of particle contact and decreasing volume on saturation. This volume decrease causes change of soil's structure and finally causes considerable settlement. The impact of development induced changes in soil structure changes the engineering performance which are moisture sensitive.

In the present study an attempt is made with 10 red soils for various geotechnical characteristics to relate the collapsibility of these soils by considering parameters like water content dry density, saturation moisture content, void ratio and porosity etc., and the degree of collapsibility of these soils are explained with existing models.

Key words: Problematic soils, Moisture sensitive, Geotechnical characteristics, Parameters.

Date of Submission: 26-12-2018 Date of acceptance: 10-01-2019

I. INTRODUCTION

Collapsible soils are open saturated soils that collapse suddenly when wetted under loading. Collapse is induced by reduction in volume which causes differential settlement of buildings, foundation failures and damage to public facilities and infrastructures, which inundate huge loss of money. These soils need to have focused on understanding the existence, description, classification, structural bond that influence the collapse of soils. The above behavior features can be affectively connected with the parameters like particle type (size, percentage and Atterberg limits), dry density, moisture content, degree of saturation which makes them collapsible. In The present investigation 10 no of red soils have been tested for geotechnical characterization at various compacted conditions and these verified with respect to the existing models like Denisov's.(1951); Feda. (1966); Gibbs and Holland. (1960) etc.

Exciting methods of Estimation of Collapsible Potential:

3.2.1 Denisov's (1951):

Uses the coefficient of subsidence for identifying collapsible behavior.

Denisov's coefficient of subsidence (k) = void ratio at liquid limit / natural void ratio = $\frac{e_l}{e_n}$

Where e_n = Void ratio at remolded water content corresponding to their dry densities.

If, K= 0.5 – 0.75: highly collapsible K= 1.0: non collapsible loam K= 1.5 – 2.0: non collapsible soil;

3.2.2 Clevenger (1956):

Proposed the criterion for collapsibility in terms of dry unit weight, if the dry density is less than 12.6 KN/m^3, then the soil is liable to undergo significant settlement and if the dry density is larger than (14.1kN/m^3), soils are capable of supporting the assigned loads.

3.2.3 Gibbs (1961):

Proposed a measure of collapse potential, which is displayed in graphical form, it is the ratio of the water content at fully saturation to the liquid limit.

Collapsible ratio (R) = $\frac{w_{sat}}{w_L}$

R < 1 (Non – collapsible soils); R > 1 (Collapsible soils);

3.2.4 Handy (1973):

- Clay content of less than 16 percent had a high probability for collapse;
- Clay content of between 16 and 24 percent were probably collapsible;
- Clay content between 25 and 32 percent had a probability of collapse of less than 50 percent;
- Clay content which exceeded 32 percent was non-collapsible.

Soils in which the ratio of liquid limit to saturation moisture content was less than unity were collapsible, while if it was greater than unity they were safe.

II. MATERIALS, TESTS & RESULTS:

To study the geotechnical characterization of red soils in Visakhapatnam region, the soil samples were collected at a depth of 1.0 – 1.5m from the ground level and the collected samples were dried and subjected for geotechnical characteristics such as grain size distribution, plasticity, compaction and strength as per IS 2720.

TABLE1: GEOTECHNICAL PROPERTIES OF RED SOILS (SM-SC) OF VISAKHAPATNAM REGION:

Property	Values
Gradation Properties	
Gravel (%)	0
Sand (%)	74 – 84
Fines (%)	16 – 26
Silt (%)	10 – 16
Clay (%)	4 – 12
Specific Gravity (G)	2.65 – 2.66
Index Properties	
Liquid Limit (%) (W_L)	22 – 26
Plastic Limit (%) (W_P)	17 – 19
Plasticity Index (I_p)	5 – 7
IS Classification	SM – SC
Compaction Characteristics	
Optimum Moisture Content (OMC %)	9.0 - 10.4
Maximum dry density (MDD g/cc)	1.75 – 1.80
Strength Parameters At OMC & MDD	
C (t/m^2)	1.2 – 1.7
Φ (Degrees)	26 – 29
Strength Parameters At Saturated Condition	
C_s (t/m^2)	0.5 – 0.9
Φ_s (Degrees)	20 – 23
CBR%	5.0 – 5.5

- Grain size distribution analysis shows that red soils are dominated by sand particles of ranging from 74 - 84% and fines in the range of 16 - 26% out of which silt particles are in the range of 10 – 16% and clay particles are in the range of 4 – 12%.
- It is identified that liquid limit is in the range of 22 - 26%, and Plasticity Index is in the range of 5 - 7. Based on the grain size distribution and consistency these are classified under SM-SC group (IS: 1498-1970). Low compressibility and low plasticity is due to less quantity of clay fractions in these soils.
- The maximum dry densities are in the range of 1.75 g/cc – 1.80 g/cc where as OMC values are in the range of 9.0% - 10.4%.These compaction characteristics are due to interaction between sand and fines in the soil masses.
- High shear strength value in terms cohesion (c) as 1.7 t/m^2 and angle of shearing resistance (φ) as 29^o at OMC condition and considerable decrease of these values to 0.9 t/m^2 and 23^o upon saturation. The decrease in strength is due to loss of contact of particles by softening of clay particles at contact levels.

3.3 Parameters considered in explaining collapsible behavior:

To know the collapsible behavior of red soil in Vishakhapatnam region the following parameters are considered at their remolded conditions are water content, void ratio, porosity and degree of saturation etc. Ten number of red soils of SM-SC nature were considered and these subjected to remolded conditions and their corresponding dry densities, water content, void ratio, porosity and degree of saturation are computed and are shown below:

Table: 2 Variation of water content with dry density

Υ_d (g/cc)→	1.4-1.5	1.5-1.6	1.6-1.7	1.7-1.8
Soils↓	**Water Content ↓**			
SM-SC-I	4.3	5.2	8.5	10.0
SM-SC-II	4.8	5.5	8.4	10.3
SM-SC-III	4.0	5.4	7.9	9.8
SM-SC-IV	4.0	5.5	8.2	9.8
SM-SC-V	3.9	6.8	8.7	10.0
SM-SC-VI	4.5	6.3	8.4	9.4
SM-SC-VII	4.0	5.2	7.8	9.0
SM-SC-VIII	4.3	8.4	10.3	13.7
SM-SC-IX	4.5	7.6	8.4	11.2
SM-SC-X	4.2	6.4	8.7	10.4
Range	3.9-4.8	5.2-8.4	7.9-10.3	9.0-13.7

Table:3 Variation of void ratio and porosity with dry density

Υ_d (g/cc)→	1.4-1.5	1.5-1.6	1.6-1.7	1.7-1.8	1.4-1.5	1.5-1.6	1.6-1.7	1.7-1.8
Soils↓	**Void Ratio↓**				**Porosity↓**			
SM-SC-I	0.80	0.75	0.54	0.50	44.40	42.90	35.10	33.30
SM-SC-II	0.79	0.72	0.65	0.47	44.20	41.90	39.80	38.00
SM-SC-III	0.84	0.78	0.63	0.50	45.70	43.80	36.98	33.30
SM-SC-IV	0.85	0.77	0.62	0.50	45.90	43.50	37.21	33.80
SM-SC-V	0.79	0.71	0.58	0.49	44.13	41.52	36.70	32.88
SM-SC-VI	0.74	0.68	0.65	0.51	42.52	40.47	39.39	33.77
SM-SC-VII	0.74	0.68	0.62	0.52	42.52	40.47	38.27	34.21
SM-SC-VIII	0.79	0.69	0.58	0.49	44.13	40.82	36.90	32.88
SM-SC-IX	0.81	0.70	0.60	0.48	43.12	41.52	38.20	33.85
SM-SC-X	0.75	0.69	0.58	0.48	42.85	40.82	36.70	32.43
Range	0.74-0.85	0.68-0.78	0.54-0.65	0.47-0.50	42.52-45.90	40.47-43.80	36.70-39.80	32.43-38.00

Table: 4 Variation of saturation water content and degree of saturation with dry density

Υ_d (g/cc)→	1.4-1.5	1.5-1.6	1.6-1.7	1.7-1.8	1.4-1.5	1.5-1.6	1.6-1.7	1.7-1.8
Soils↓	**Saturation Water Content↓**				**Degree of Saturation↓**			
SM-SC-I	30.07	28.2	20.30	18.80	14.30	18.50	41.90	53.20
SM-SC-II	29.70	27.10	24.40	17.70	16.20	20.30	34.40	58.30
SM-SC-III	31.70	29.40	21.58	18.90	12.60	18.40	35.56	51.94
SM-SC-IV	31.59	28.95	22.56	18.80	12.50	19.00	36.42	52.14
SM-SC-V	29.69	26.69	21.80	18.42	13.13	25.47	39.90	54.20
SM-SC-VI	27.82	25.56	24.43	19.17	16.17	24.64	34.37	49.02
SM-SC-VII	27.90	25.66	22.64	19.62	14.32	20.26	33.33	45.86
SM-SC-VIII	29.69	25.93	23.42	18.42	14.47	32.38	35.20	55.91
SM-SC-IX	28.82	26.78	22.51	18.20	12.50	27.89	37.20	58.20
SM-SC-X	28.19	25.93	21.80	18.04	14.89	24.67	39.90	57.63
Range	27.82-31.70	25.56-29.40	20.30-24.40	17.70-19.62	12.50-16.20	18.40-32.38	33.33-41.90	45.86-58.30

Table:5 Variation of Denisov's coefficient with dry density

Υ_d (g/cc)→	1.4-1.5	1.5-1.6	1.6-1.7	1.7-1.8
Soils↓	**Denisov's coefficient of subsidence↓**			
SM-SC-I	0.80	0.85	1.19	1.28
SM-SC-II	0.85	0.93	1.03	1.43
SM-SC-III	0.73	0.78	0.95	1.22
SM-SC-IV	0.75	0.83	0.93	1.28
SM-SC-V	0.80	0.89	1.10	1.30

SM-SC-VI	0.82	0.90	0.94	1.12
SM-SC-VII	0.78	0.86	0.94	1.12
SM-SC-VIII	0.84	0.93	0.97	1.36
SM-SC-IX	0.81	0.89	0.98	1.20
SM-SC-X	0.92	1.00	1.19	1.44
Range	0.73-0.92	0.78-1.00	0.94-1.19	1.12-1.44

Table:6 Variation of Gibbs Ratio with dry density

Υ_d (g/cc)→	**1.4-1.5**	**1.5-1.6**	**1.6-1.7**	**1.7-1.8**
Soils↓	**Gibbs Collapsible ratio↓**			
SM-SC-I	1.25	1.18	0.85	0.78
SM-SC-II	1.19	1.08	0.98	0.71
SM-SC-III	1.38	1.28	0.82	0.69
SM-SC-IV	1.33	1.21	0.78	0.69
SM-SC-V	1.23	1.11	0.90	0.76
SM-SC-VI	1.20	1.11	1.06	0.83
SM-SC-VII	1.26	1.16	1.02	0.89
SM-SC-VIII	1.18	1.04	0.95	0.74
SM-SC-IX	1.15	1.08	0.92	0.78
SM-SC-X	1.08	0.99	0.84	0.69
Range	1.18-1.38	0.99-1.28	0.82-1.06	0.69-0.89

Table:7 Variation of Feda with dry density

Υ_d (g/cc)→	**1.4-1.5**	**1.5-1.6**	**1.6-1.7**	**1.7-1.8**
Soils↓	**Feda ↓**			
SM-SC-I	2.21	1.82	0.26	-0.05
SM-SC-II	1.77	1.35	0.90	-0.22
SM-SC-III	2.75	2.27	0.78	0.17
SM-SC-IV	2.46	1.90	0.82	0.08
SM-SC-V	1.95	1.44	0.63	0.07
SM-SC-VI	1.80	1.42	1.23	0.36
SM-SC-VII	2.18	1.73	1.28	0.52
SM-SC-VIII	1.67	1.13	1.10	0.06
SM-SC-IX	1.98	1.20	0.98	0.48
SM-SC-X	1.31	0.99	0.40	-0.13
Range	1.31-2.75	0.99-2.27	0.26-1.28	0.52- -0.22

III. DISCUSSIONS

Based on the test results the degree of collapsible behavior is explained as follows:

Soils compacted at densities in between 1.4g/cc – 1.5g/cc.

- Red soils compacted at very low water contents of 3.9 – 4.8% have exhibited void ratios as 0.85 – 0.74 and their corresponding porosities are 42.52 – 45.90% and saturation water contents are 27.82 - 31.70%. At these compacted dry densities and water contents these soils attained degree of saturation in the range of 12.50 – 16.20%. At these densities the Denisov's coefficient of subsidence (k) is in the range of 0.73 – 0.92, exhibited high collapsibility to moderate collapsibility. At these densities Gibb's collapsible ratio (R) is in the range 1.18- 1.38, which are greater than 1, show high potential for collapsibility. At these densities Fedas K_L is in the range 1.31 – 2.75, which are greater than 0.85, shows collapsibility.

Soils compacted at densities in between 1.5g/cc – 1.6 g/cc.

- Red soils compacted at very low water contents 5.2 – 8.4 %, have exhibited void ratios as 0.78 – 0.68 and their corresponding porosities are 40.47-43.80 % and saturation water contents are 25.56-29.40. At these compacted dry densities and water contents these soils attained degree of saturation in the range of 18.40 – 32.38 %. At these densities the Denisov's coefficient of subsidence (k) is in the range of 0.78 – 1.00, which is in the range of 0.75 – 1.5, exhibited moderate collapse. At these densities Gibb's collapsible ratio (R) is in the range 0.99 –1.28, which are greater than 1, show high potential for collapsibility. At these densities Fedas K_L is in the range 0.99 – 2.27, which are greater than 0.85, shows collapsible.

Soils compacted at densities in between 1.6g/cc – 1.7 g/cc.

- Red soils compacted at very low water contents 7.9–10.3 %, exhibited void ratio as 0.65 – 0.54 and their corresponding porosities are 36.70 – 39.80% and saturation water contents are 20.30-24.40. At these compacted dry densities and water content these soils attained degree of saturation in the range of 33.33 – 41.90 %. At these densities the Denisov's coefficient of subsidence (k) is in the range of 0.94 – 1.19, which is in the range of 0.75 – 1.5 exhibited moderate collapse. At these densities Gibb's collapsible ratio (R) is in the range 0.82 – 1.06, which are less than 1, show free from collapsibility. At these densities Fedas K_L is in the range 0.26-1.28, which is greater than 0.85, which shows moderate collapsible.

Soils compacted at densities in between 1.7g/cc – 1.8 g/cc.

- Red soils compacted at very low water contents 9.0 – 13.7 %, exhibited void ratio 0.50 – 0.47 and their corresponding porosities are 32.43-38.00% and saturation water contents are 17.70-24.40. At these compacted dry densities and water content these soils attained degree of saturation in the range of 45.86 – 58.60%. At these densities the Denisov's coefficient of subsidence (k) is in the range of 1.12 – 1.44, which is in the range of 0.75 – 1.5 exhibited moderate collapse. At these densities Gibb's collapsible ratio (R) is in the range 0.69-0.89, which are less than 1, show free from collapsibility. At these densities Feda (K_L) is in the range 0.52- -0.22, which are less than 0.85, shows non-collapsible.

From the analysis it is identified that soils at very low water content (3.9-4.8%) posses' low dry densities (1.4-1.5g/cc), which are in dry state with honey-comb structure having high air voids and porosity. At this state the soils are deficient in moisture to become saturate, upon saturation these air voids are replaced with water and loss of clay particles and inherent oxides due to softening of the soils etc., results in decrease of volume soils leads to collapsibility.

As dry densities nearing to MDD decreases void ratio and increasing degree of saturation hence the particle to particle contact is increasing and arrangement of particles into closed packing has been taking place. This phenomenon decreases the degree of collapsibility. Therefore high dry densities maintain high degree of saturation leads to very less volume reduction on saturation results the soils are free from collapsibility. This phenomenon accepts with the models of Denisov's (1951), Clevenger (1956), Gibbs (1961), and Handy (1973).

IV. CONCLUSION

By observing results from the consistency, grain size distribution and compaction test and index parameters at various compacted conditions the following conclusions have drawn.

- Collapsibility occurs at very low percentages of clay contents and low dry densities (less than 1.5 – 1.6 g/cc), low moisture contents (3.9-4.8%) and low liquid limits (less than 25%) and porosity greater than 40%, high void ratios etc.
- Red soils at dry densities nearing to maximum dry densities (1.7-1.8 g/cc) exhibited high degree of saturation, and less void ratios are free from collapsibility.

REFERENCES

[1]. Feda, J., 1966, "Structural Stability of Subsiding Loess from Praha dejvice", *Engineering Geology*, Vol. 1, pp. 201–219.

[2]. Gibbs, H. J., Bara, J. P., 1967, "Stability Problems of Collapsing Soil", *Journal of Soil Mechanics and Foundation Engineering*, Vol. 93, pp. 577–594.

[3]. Handy, R. L., 1973, "Collapsible Loess in Iowa", *Soil Science Society of America Journal*, Vol. 37, No. 2, pp. 281–284.

[4]. IS 2720: Part 13:1986 Methods of Test for Soils – Part 13 Direct shear test.

[5]. IS 2720: Part 16:1986 Methods of Test for Soils – Part 16 Laboratory Determination of CBR.

[6]. IS 2720: Part 17:1986 Methods of Test for Soils – Part 17 Laboratory Determination of permeability.

[7]. IS 2720: Part 3: Sec 2 :1980 Methods of Test for Soils – Part III: Determination of Specific Gravity – Section 2 : Fine, Medium and Coarse Grained Soils.

[8]. IS 2720: Part 4:1985 Methods of Test for Soils – Part 4 Grain Size Analysis.

[9]. IS 2720: Part 8:1986 Methods of Test for Soils – Part 8 Laboratory Determination of Water Content – Dry Density relation using Heavy Compaction.

[10]. Priklonski, V.A., 1952, "*Gruntoredenia-Vtoraid chest. Gosgeolzdat*", Moscow, U.S.S.R.

[11]. S.P. Clemence, A.O. Finbarr, Design considerations for collapsible soils, Journal of the Geotechnical Engineering Division, ASCE 107 (3) (1981) 305–317.

K. Saroja Rani. "Affect of a In-Situ Parameters in Explaining Collapsible Behaviour of Red Soils." IOSR Journal of Engineering (IOSRJEN), vol. 09, no. 01, 2019, pp. 09-13.