

Identification of Expansive Soils and Improving Geotechnical Properties Using Gypsum and Sand

Dr. Jagdish Prasad¹, Dr. D.G.M. Purohit², Dr. Sunil Sharma³

Assistant Director, Directorate of Technical Education, Jodhpur, Rajasthan, India¹

Professor, Department of Civil Engg., M.B.M. Engg. College, JNVU Jodhpur, Rajasthan, India²

Professor & Head of Department of Civil Engg., M.B.M. Engg. College, JNVU Jodhpur, Rajasthan, India³

ABSTRACT: The National codes of practice do not give characterization and classification of expansive soils. Expansive soils have distributed very widely over almost all geographical locations in the world, causing distress to the structures founded on them and discomfort to the users. A simple user-friendly approach based on the free swell ratio, defined as the ratio of the sediment volume of soil in distilled water to that in carbon tetra-chloride or kerosene, is formulated considering the compatibility of the results with oedometer free swell tests and the soil clay mineralogy. A statistical illustrations are provided which clearly indicate that while the assessment of soil expansively based on index properties is an over estimation, there is a consistency in the classifications based on oedometer test results and the proposed approach. The problems associated with expansive soil are related to bearing capacity and cracking, breaking up of pavements, and various other building foundation problems. Such soils are common in Australia, India and South Africa.

The present paper is a study of the identification of expansive soils and improving geotechnical properties using available Gypsum and dune sand with respect to various locations of western Rajasthan. In this location Gypsum and Dune Sand are easily available, so that the effect of gypsum and addition of dune sand on swelling pressure is studied and it is found that swelling pressure decreases with addition of dune sand and gypsum. Effect of dry density and molding water content is also studied. The multiple suggestions are given to overcome the swelling pressure of expansive soils by different method of soil stabilisation technique including using CNS materials, addition of lime, cement, gypsum and dune sand etc.

KEYWORDS: Expansive Soils, Illite, Kaolinite, Montmorillonite, Swelling Pressure, Gypsum, Dry Density.

I. INTRODUCTION

A soil classification is a systematic method of categorizing soils into various groups and subgroups according to their probable engineering behaviour but without detailed descriptions. Most of the earlier classification systems were based on grain size distribution e.g. MIT classification and soil texture e.g. textural classification. The introductions of Atterberg's limits have given new classification systems.

It is possible to trace many soil classification systems such as the Casagrande unified soil classification system, the American Association of State Highway and Transportation officials system, the pedologic soil classification system, Federal Aviation Agency system, US public roads administration system and the textural classification system. Present time, the USCS and the AASHTO system are in use in civil engineering practice.

The USCS was originally developed by Casagrande and was later modified by the US Bureau of Reclamation (USBR) and the US Army Corps of Engineers, to enhance its applicability to many more fields. Many national standard codes of practice such as ASTM designation D2487-93, BS 5930 and IS1498 follow this modified version of the USCS as it stands or with slight modification. Both systems, namely modified USCS and AASHTO, base their classification of soils for engineering purposes on particle size characteristics, liquid limit (w_L) and plasticity index (I_p) of soils. The sub

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

grouping of coarse-grained soils is done with the help of parameters such as uniformity coefficient (Cu) and coefficient of curvature (Cc) to account for the gradation of soils. The sub grouping of fine-grained soils is entirely based on a plasticity chart i.e. Ip plotted against w_L. In addition, some codes of practice give some useful criteria that need to be followed to obtain a rough estimation of soil characteristics such as angularity of coarse-grained soils, moisture content, consistency, cementation, dry strength, plasticity, dilatancy, toughness, organic content e.g. ASTM designation D2488-93, IS 1498. However, apart from IS 1498 these systems do not have the criteria to assess the expansiveness of the soil. Expansive or swelling clay are soils which volume change from change in soil moisture in Foundation materials due to highly plastic clays and clay shales that often contain

colloidal clay minerals such as the Montmorillonite. Soils that exhibit large volume changes from dry to wet state usually possess a considerable percentage of Montmorillonite. Since expansive soils have a tendency to change their volume to a large extent, they cause heavy distress to engineering constructions works. The lightweight structures are severely affected due to high swelling pressure exerted by these soils. Such type of large scale distress, due to expansive shrinking nature of expansive soil, can be prevented by either obstructing the soil movement and reducing the swelling pressure of soil or making the structure sufficiently resistant to damage from soil movement.

In Western Rajasthan, India previously it seems that only dune sand is present up to great depth or there is some sand stone etc. However, during construction of Indira Gandhi Nahar Project, it was observed that Bentonite is present below the dune sand or at depth when Canal is in cutting. This causes swelling pressure i.e. volume change and hence there are various cracks development in the Lining of Canal. It is also in Military quarter of Pokran in Jaisalmer district, Government Industrial Training Institute and Polytechnic College Barmer in Barmer district, Panchayat Bhawan in Jaitaran in Pali district, Primary School in Bhopalgarh in Jodhpur district, old house in Kolayat in Bikaner district have effected by presence of bentonite which is similar property of expansive soils or Black cotton soils. It is in swelling pressure due to swelling soil is present. Many researchers have Experiment on Expansive soils such as Jones & Holtz (1973), Holts and Gibbs, Chen (1975), Sridharan and Prakash and Mathur (1995).

1.1 Soil Expansivity:

Bentonite soils are found extensively in western Rajasthan . The presence of bentonite soils greatly affects the construction activities in many parts of Bikaner, Jaisalmer, Barmer, Jodhpur, Nagaur, Pali and Jalore district of Rajasthan. More and more bentonite soil regions are being discovered each year with an increase in the amount of constructional activities, particularly in the underdeveloped nations. These soils are characterized by the presence of a large proportion of highly active clay minerals of the Montmorillonite group which are responsible for the pronounced volume change capability of the soils. A number of soils such as volcanic ash soils and diatomaceous earth cannot be grouped by using the existing classification system only; however, their distribution is restricted to certain areas. Unlike these, the expansive soils are distributed geographically very widely, covering large areas. Hence, identification and classification of such soils is essential.

Many criteria are available to identify and characterize bentonite / expansive soils, such as Liquid Limit (Table: 1), Plasticity Index (Table:2), Shrinkage Limit, Shrinkage Index, Free Swell Index, Activity and percent of Free Swell (Table:3).

Table: 1 Soil Expansivity Predictions by Liquid Limit

| Degree of Expansion | Liquid Limit (%) | |
|---------------------|------------------|---------|
| | Chen | IS 1498 |
| Low | <30 | 20-35 |
| Medium | 30-40 | 35-50 |
| High | 40-60 | 50-70 |
| Very High | >60 | 70-90 |

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

Table: 2 Soil Expansivity Predictions by Plastic Limit

| Degree of Expansion | Plastic Limit (%) | | |
|---------------------|-------------------|-------|---------|
| | Holtz and Gibbs | Chen | IS 1498 |
| Low | <20 | 0-15 | <12 |
| Medium | 12-20 | 10-35 | 12-23 |
| High | 20-35 | 20-55 | 23-32 |
| Very High | >35 | >35 | >32 |

Table: 3 Soil Expansivity Prediction by other Measures

| Degree of Expansion | Colloid Content (% minus 0.001 mm) | Shrinkage Limit (%) | Shrinkage Index (%) | Free Swell Index (%) | Expansion in Oedometer as per Holts and Gibbs (%) | Expansion in Oedometer as per Seed et al (%) |
|---------------------|------------------------------------|---------------------|---------------------|----------------------|---|--|
| Low | <17 | >13 | <15 | <50 | <10 | 0-1.5 |
| Medium | 12-27 | 8-18 | 15-30 | 50-100 | 10-20 | 1.5-5.0 |
| High | 18-37 | 6-12 | 30-60 | 100-200 | 20-30 | 5-25 |
| Very High | >27 | <10 | >60 | >200 | >30 | >25 |

From Dry to Saturated condition Under a Surcharge of 7 kPa.

From Compacted Saturated condition under a Surcharge of 7 kPa.

Chen observed that there was no conclusive evidence of the correlation between swelling potential and shrinkage limit. Sridharan and Prakash have also shown that the shrinkage limit can not be satisfactorily used to predict the swell potential of a soil and that the mechanisms governing the shrinkage and swellings are entirely different. Holtz and Gibbs proposed the percent free swell test. It consists of pouring slowly 10 cm³ of oven dried soil (passing a 425 mm sieve) into a 100 cm³ measuring jar filled with distilled water and noting the volume of the soil after it comes to rest at the bottom of the jar. The free swell is then reported as the increase in the volume of the soil expressed as a percentage of the initial volume. The major drawback of this method, which is crude, is that measuring 10 cm³ of soil is not that easy and the procedure therefore introduces personal judgment as one more factor. It is normal to quantify 10 cm³ as the volume occupied by 10 g of soil. This does not account for variations of density. IS 1498 gives a criterion to predict the Expansivity of soils, based on the free swell index

$$FSI = \left(\frac{V_d - V_k}{V_k} \right) \times 100$$

Where V_d is the sediment volume of 10 g of oven dried soil passing a 425 mm sieve placed in a 100 ml graduated measuring jar containing distilled water, and V_k is the sediment volume of 10 g of oven dried soil passing a 425 mm sieve placed in a 100 ml graduated measuring jar containing kerosene.

However, this method gives negative free swell indices for Kaolinite-rich soils and may underestimate the Expansivity of Montmorillonitic soils, if the soils contain a significant amount of Kaolinite clay material. To eliminate this difficulty, Sridharan et al. have defined the modified free swell index (MFSI) as the ratio of equilibrium sediment volume (V_d) after 10 g of oven dried soil is mixed thoroughly with the distilled water to form a soil water suspension of 100 ml initial volume in a 100 ml measuring jar and allowed to settle, to the dry weight of the soil. Thus

$$MFSI = \frac{V_d}{10}$$

Sridharan et al. have observed that the sediment volume occupied by unit weight of dry soil in distilled water together with that in carbon tetrachloride provides useful information about the soil Expansivity and nature of the soil type-expansive/non-expansive/combination of both (Table 4).

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

Table: 4 Soil Expansivity Classification Based on MFSI

| MFSI (Cm ³ /gm) | Sediment Volume in Carbon Tetra Chlorides (Cm ³ /gm) | Clay Type | Soil Expansivity |
|--------------------------------|--|--------------------------------------|------------------|
| <1.5 | 1.10-3.00 | Non Swelling | Negligible |
| 1.5 -2.0 | >1.1 and <MFSI | Mixture of swelling and Non Swelling | Low |
| 1.5-2.0 | ≤1.1 | Swelling | Moderate |
| 2.0-4.0 | ≤1.1 | Swelling | High |
| >4.0 | ≤1.1 | Swelling | Very High |

From Dry to Saturated condition Under a Surcharge of 7 kPa.

From Compacted, Saturated condition Under a Surcharge of 7 kPa.

The predictive capability of the MFSI is evident from the following statistical illustrations. About 32 soils from various parts of India, 16 of them Kaolinitic (25% ≤ wL ≤ 100%) and the remaining 16 Montmorillonitic (47% ≤ wL ≤ 124%), were considered for the analysis. These soils are placed on the plasticity chart. It can be noted that both the Kaolinitic and Montmorillonitic soils lie above and below the A-line. Hence, nothing can be inferred regarding their expansive nature just by their position on the plasticity chart.

1.1.1 Analysis - Phase 1:

In the first phase of analysis, 18 soils (nine Kaolinitic and nine Montmorillonitic) are considered. The degree of Expansivity of these soils has been assessed based on their liquid limit,⁶ plasticity index, activity, percentages swell in the oedometer test and MFSI according to Table 4. Winterkorn and Fang and Chen suggest that the most useful and reliable assessment of swelling capabilities for expansive soils can be obtained from conventional oedometer tests. According to USBR, the criterion for expansiveness of a soil is the total volume change of a soil from air dry to a saturated condition under a surcharge of 7 kPa, in an oedometer. Hence, the results obtained from oedometer swell tests conducted on air dry soils assessed as per Table 3 are taken as are reference point.

Figure 1 shows the comparison of such an assessment for Kaolinitic soils. While the oedometer tests assign a low degree of Expansivity for those soils true to their Mineralogy (note that Kaolinite is a non-expansive clay mineral), the criteria based on liquid limit, plasticity index and activity show a large percentage of the non-expansive soils to have a low to very high degree of Expansivity. Plasticity index, activity and liquid limit predict a high to very high degree of Expansivity in about 55.5, 66.6 and 77.8% of cases respectively. However, the evaluations based on the MFSI given in Table 4 are in better agreement with those from the oedometer tests.

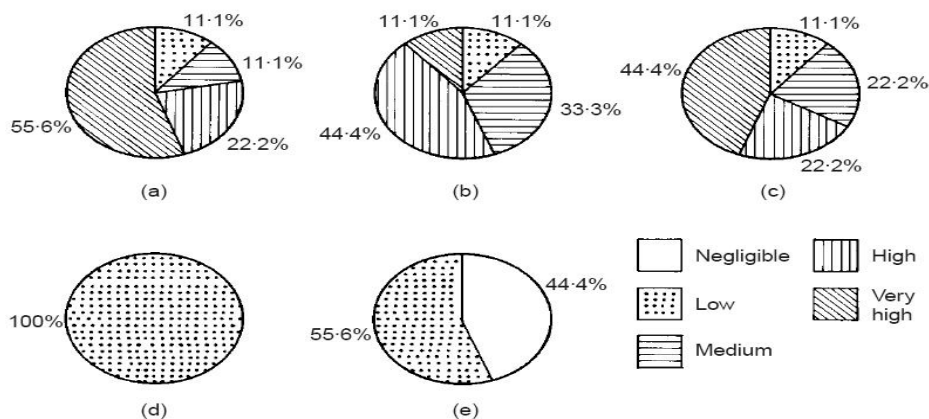


Fig.: 1. Prediction of soil Expansivity of Kaolinitic Soils by: (a) Liquid Limit; (b) Plasticity Index; (c) Activity (d) Oedometer Test and (e) MFSI

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

Fig.: 2 illustrates the comparison of the evaluation of the degree of Expansivity of Montmorillonitic soils by the different criteria .It can be noted that liquid limit, plasticity index and activity greatly overestimated the soil Expansivity in comparison with those observed in oedometer tests. As Chen quotes, while it may be true that a high-swelling soil will manifest a high index property, the converse need not be true. On the other hand, the predictions of soil Expansivity based on the proposed MFSI are again quite satisfactory.

Table: 5 Proposed Expansive Soil Classifications

| Oedometer Expansion (%) | Free Swell Ratio | Clay type | Soil Expansivity |
|-------------------------|------------------|--------------------------------------|------------------|
| <1 | <1.0 | Non Swelling | Negligible |
| 1-5 | 1.0-1.5 | Mixture of swelling and Non Swelling | Low |
| 5-15 | 1.5-2.0 | Swelling | Moderate |
| 15-25 | 2.0-4.0 | Swelling | High |
| >25 | >4.0 | Swelling | Very High |

From air dry to Saturated condition Under a Surcharge of 7 kPa.

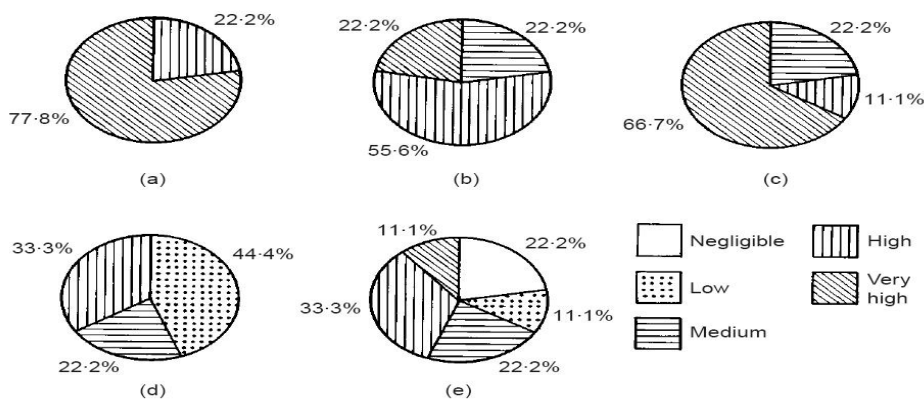


Fig.:2 Prediction of soil Expansivity of Montmorillonitic Soils by: (a) Liquid Limit; (b) Plasticity Index; (c) Activity; (d) Oedometer Test; and (e) MFSI

It is not untimely to mention that the mechanisms controlling the liquid limit of Kaolinitic and Montmorillonitic soils are entirely different from each other. While the liquid limit of a Kaolinitic soil is controlled by the particle arrangement and the inter particle attractive forces, that of a Montmorillonitic soil is controlled by the double layer thickness. Hence, higher liquid limits do not necessarily mean expansive Montmorillonitic soils. This is the reason why the liquid limit and the related index properties, without any consideration of clay mineralogy, cannot satisfactorily indicate the soil Expansivity. Instead, they may give an altogether different and wrong picture.

It has been observed that there are instances wherein the values of sediment volumes, obtained from free swell tests, in water and carbon tetrachloride do not fall into any of the categories listed in Table 5, thus resulting in ambiguity. This limitation can be avoided by the use of the ratio of equilibrium sediment volume of 10 g oven dried soil passing a 425 mm sieve in distilled water to that in carbon tetrachloride, which is defined herein as 'free swell ratio', while dealing with the Indian black cotton soils, the expansion predictions by the oedometer test proposed by Holtz and Gibbs are slightly underestimated. With this experience, considering the clay mineralogy of the soils, the Sridharan propose a criterion for classifying the soils based on their expansive nature as shown in Table: 5.

Figure 3 indicates the statistical predictions of soil Expansivity of 18 soils, considered in the first phase of the analysis, by the proposed classification based on expansion from oedometer tests and free swell ratio. It can be observed that the

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

predictions based on the two methods proposed match very well and also that the predictions based on the proposed free swell ratio (i.e. Fig. 3) are in line with those from the consideration of Table: 4 (i.e. Figs 1 and 2).

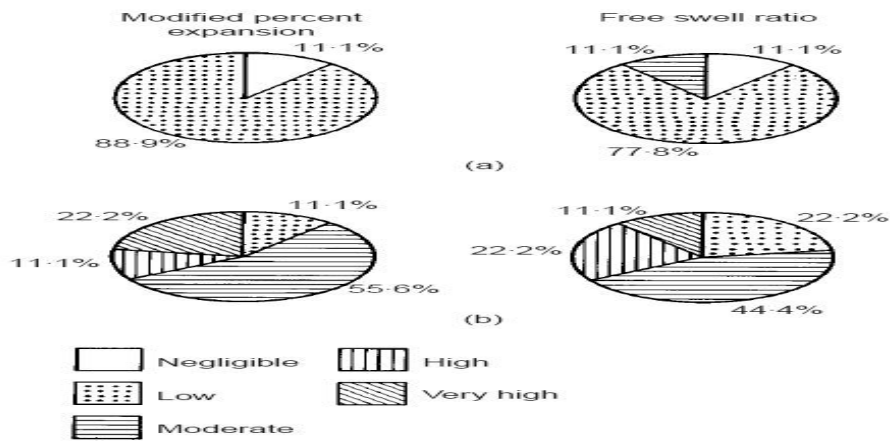


Fig.: 3. Prediction of soil Expansivity by proposed Oedometer per cent Expansion and Free Swell Ratio Criteria for: (a) Kaolinitic Soils; and (b) Montmorillonitic soils

1.1.2 Analysis - Phase 2:

Seed et al. have also proposed an Expansivity classification based on percent swelling potential observed by compacted soils at maximum dry density and optimum moisture content conditions, under a surcharge of 7 kPa (Table: 3). In order to prove the enhanced capability of the proposed free swell ratio in classifying the soils, the second phase of analysis is done as follows.

Fourteen soils, seven Kaolinitic and seven Montmorillonitic, compacted at standard Proctor's maximum dry density and optimum moisture conditions, were allowed to swell under a surcharge of 7 kPa. Using the criteria of Seed et al. and that based on the proposed free swell ratio, the 14 soils are classified with respect to their expansive nature; the results are shown in Fig. 4. A very good correlation is observed between the predictions from two entirely different testing procedures which indicate the acceptability of the free swell ratio for predicting the soil Expansivity.

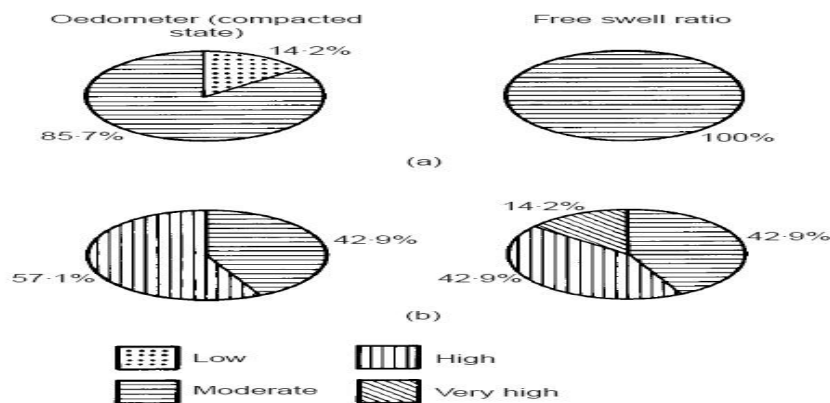


Fig.: 4 Prediction of soil Expansivity of soils from the data of soils compacted at optimum conditions and from Free Swell Ratio for: (a) Kaolinitic soils; and (b) Montmorillonitic Soils

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

The determination of sediment volume of highly expansive soils in distilled water can be problematic, as such soils take a prohibitively long time to settle. This difficulty can be overcome by using 0.025% NaCl solution instead of distilled water, which reduces the settling time markedly without affecting the final equilibrium sediment volume. It has been observed that the soils have taken about 24-216 h to reach equilibrium in water depending upon the type of soil. However, the same soils took about 4-24 h to reach the equilibrium in 0.025% NaCl solution. Likewise, kerosene is a more easily available, cheaper non-polar liquid which is relatively less volatile and carbon tetrachloride. The equilibrium sediment volumes obtained in these two liquids are almost the same, with a maximum error of $\pm 5\%$. Hence, use of kerosene instead of carbon tetrachloride is suggested, owing to its greater accessibility.

II. PROPERTIES OF BENTONITE SOIL

Due to the presence of imbalance electrical charge and cation exchange capacity produced by sodium-based Montmorillonite the Bentonite soil swells. Replacing the sodium ions by inorganic compounds, which may produce such type of cation having less ion exchange capacity and also form a balanced electrical charge in soil structure, can reduce this expansion. Replacement of monovalent sodium by calcium ions may lead to a marked reduction in diffuse double layer thickness leading to decrease in liquid limit, plastic limits and swelling pressure. Keeping this aspect in view, an attempt has been made to study the alteration brought out by dune sand and gypsum mixture. Therefore, tests have been conducted on Bentonite soil, obtained from different parts of Rajasthan, mixed with different percentage of dune sand and gypsum to study the effects of mixtures on swelling pressures of expansive soils. Also effect of molding water content and variation of densities are studied in view of change in swelling pressure. Few soil samples from various parts of Rajasthan were analyzed and various properties of these soils such as liquid limit, plastic limit, plasticity index, shrinkage limit, Grain size distribution, Unconfined compressive strength, shear properties and free swell index were analyzed in laboratory as per various IS (Indian Standards) codes. These are listed as Table: 6.

Table: 6 Properties of Various Bentonite Soils

| Sl. no. | Properties | Locations of Swelling Soil under Case Study | | | | |
|---------|--|---|--------------------|----------------------|-----------------|-------------------|
| | | Barmer (Sheo) | Jaisalmer (Pokran) | Jodhpur (Bhopalgarh) | Pali (Jaitaran) | Bikaner (Kolayat) |
| 1. | Liquid Limit (%) | 180.0 | 95.0 | 115.0 | 90.0 | 95.0 |
| 2. | Plastic Limit (%) | 44.0 | 42.0 | 48.0 | 42.0 | 38.0 |
| 3. | Plasticity Index | 136.0 | 53.0 | 67.0 | 48.0 | 57.0 |
| 4. | Shrinkage Limit (%) | 16.3 | 24.7 | 21.2 | 18.0 | 21.0 |
| 5. | Sand % | 3.0 | 2.5 | 5.8 | 8.5 | 8.0 |
| 6. | % Passing 75 Micro Sieve | 99.0 | 94.0 | 91.0 | 89.0 | 94.0 |
| 7. | Silt (%) | 27.0 | 71.0 | 45.0 | 35.0 | 46.0 |
| 8. | Clay (%) | 71.0 | 25.0 | 65.0 | 32.0 | 44.0 |
| 9. | Specific Gravity | 2.60 | 2.68 | 2.67 | 2.69 | 2.68 |
| 10. | Unconfined Compressive Strength (kN/m ²) | 174.6 | 118.5 | 124.5 | 126.8 | 94.5 |
| 11. | Cohesion C _u (kN/m ²) | 74.5 | 52.5 | 58.4 | 56.9 | 42.6 |
| 12. | Angle of Internal Friction | 21.4 | 25.6 | 22.5 | 22.4 | 28.7 |
| 13. | Free Swell Index | 710% | 195% | 105% | 86% | 128% |
| 14. | Soil Group | CH | CH | CH | CH | CH |

Swelling soil of Sheo in Barmer district, Pokran in Jaisalmer district, Bhopalgarh in Jodhpur district, Jaitaran in Pali district and Kolayat in Bikaner district were tested at different densities and various Swelling Pressure obtained is presented in Table: 7.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

Table: 7 Swelling Pressure (kN/m²) of Bentonite Soils at Various Densities

| Sl. no. | Density (gm/cm ³) | Locations of Swelling Soil under Case Study | | | | |
|---------|-------------------------------|---|--------------------|----------------------|-----------------|-------------------|
| | | Barmer (Sheo) | Jaisalmer (Pokran) | Jodhpur (Bhopalgarh) | Pali (Jaitaran) | Bikaner (Kolayat) |
| 1. | 1.45 | 186.0 | 045.5 | 040.5 | 35.0 | 25.5 |
| 2. | 1.55 | 275.0 | 065.5 | 058.5 | 42.5 | 38.5 |
| 3. | 1.65 | 345.0 | 095.0 | 85.0 | 82.5 | 75.5 |
| 4. | 1.75 | 398.0 | 125.5 | 115.5 | 90.05 | 75.5 |
| 5. | 1.85 | 415.0 | 150.5 | 135.5 | 114.5 | 85.2 |
| 6. | 1.95 | 475.0 | 180.0 | 165.5 | 126.5 | 105.5 |

The effect of Molding Water Content on swelling pressure of Bentonite Soils was investigated in the laboratory and the results obtained are listed in Table: 8.

Table: 8 Effect of Molding Water Content on Bentonite Soils

| Dry Density (gm/cc) | Molding Water Content | Swelling Pressure (kN/m ²) | | | | |
|---------------------|-----------------------|--|--------------------|----------------------|-----------------|-------------------|
| | | Location | | | | |
| | | Barmer (Sheo) | Jaisalmer (Pokran) | Jodhpur (Bhopalgarh) | Pali (Jaitaran) | Bikaner (Kolayat) |
| 1.65 | 4% | 305.0 | 85.5 | 81.5 | 80.5 | 65.5 |
| 1.65 | 8% | 295.50 | 68.5 | 90.5 | 78.4 | 58.6 |
| 1.65 | 12% | 265.0 | 62.5 | 85.5 | 74.5 | 52.4 |
| 1.65 | 16% | 245.0 | 57.5 | 78.5 | 71.6 | 46.8 |
| 1.65 | 20% | --- | 35.5 | 71.5 | 70.4 | 42.5 |

After addition of Gypsum to the Bentonite Soils of Barmer, percentage reduction in swelling pressure of soil at various Densities is presented in Figure: 5.

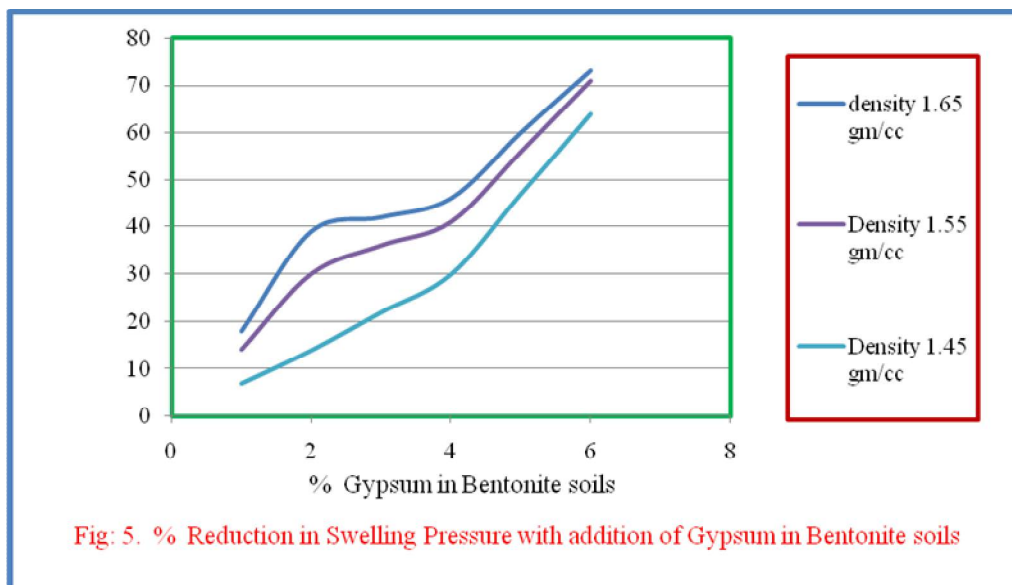


Fig: 5. % Reduction in Swelling Pressure with addition of Gypsum in Bentonite soils

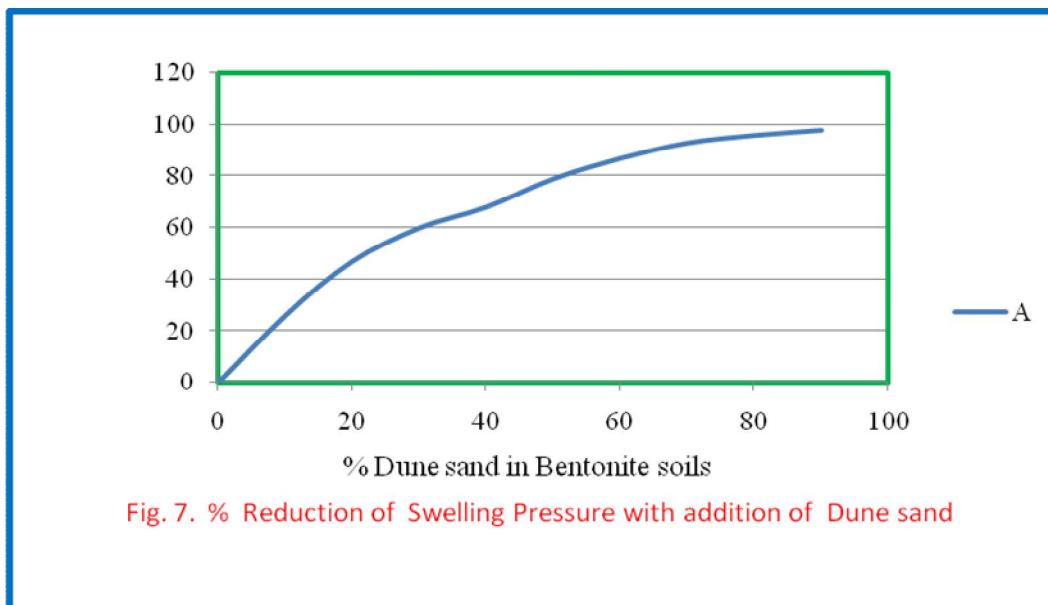
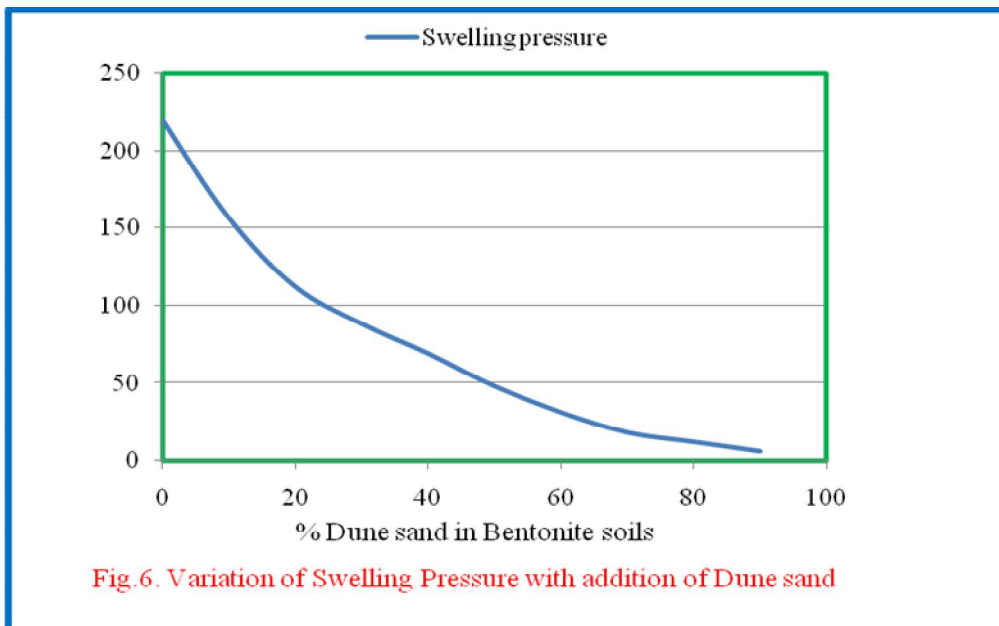
International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

The variation of swelling pressure and reduction in % swell of Bentonite after addition of Dune Sand at different percentages is shown in Figure 6 and Figure 7.



International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

III. RESULTS AND DISCUSSIONS

The numbers of soil samples obtained were tested to determine the swelling pressure at different density and different molding water content. The Table 7 and 8 shows that significant effect of swelling pressure with the change of Dry Density of the soil. Swelling pressure was increased from 186.0 to 475.0 kN/m², 45.5 to 180.0 kN/m², 40.5 to 165.5 kN/m², 35.0

to 126.5 kN/m² and 25.5 to 105.5 kN/m² when Density was increased from 1.45 to 1.95 g/cc for Sheo, Pokran , Bhopalgarh , Jaitaran and Kolayat were tested soil respectively. Similarly tests were conducted on Dry Density 1.65 g/cc and different molding water content, it was observed that due to increase in molding water content, the swelling pressure is reduced as 305.0 to 245.0 kN/m², 85.5 to 35.5 kN/m², 81.5 to 71.5 kN/m², 80.5 to 70.4 kN/m² and 65.5 to 42.5 kN/m² when molding water content changed from 0% to 20%. The difference of swelling pressure is high at initial level. As the initial water content increase for various soil specimens having the same dry unit weight, the initial degree of saturation will also increase and the affinity of the soil to absorb water will decrease.

IV. SUGGESTED REMEDIES FOR BENTONITE SOILS

The bentonite soils causes due to its expansive and shrink nature with water cracks are formed in Buildings, Canal Lining, Road Pavement, Embankment etc., the various suggestions to overcome the problem is as under:-

1. Provide CNS-MCM technique published by Dr. Katti (1972, 1979). It is a great problem now a day to locate the CNS-MCM material at nearby site and hence it is very costly some times to transport the natural CNS material. Some percentage of clay, sand and the existing swelling soil may be used as CNS-MCM material. Provide under-reamed piled foundation. Provide slotted footing so that this may reduce the Swelling Pressure.
2. Addition of Gypsum will reduce the Swelling Pressure. Limit the Foundation depth if Expansive Soil is at some depth so that distance between Foundation and Expansive Soil will be more and as the distance is more there are less chances of cracks in Building. Take effective measures to maintain Moisture Equilibrium in Foundation soil. Add Dune Sand in the existing Swelling Soil to reduce the Swelling Pressure.
3. Provide Chemical stablisation by Calcium carbide, Sodium chloride, Phosphoric acid, Sodium Silicate etc.
4. Vertical and Horizontal Moisture Barriers are to be placed around the perimeter of the Structures/ Building. They efficiently reduce the variations in Water Content and differential Heave.

V. CONCLUSIONS

The previously described analysis has clearly indicated that the index properties such as Liquid limit, Plasticity limit, Plasticity index, Shrinkage limit and related parameters cannot satisfactorily predict the Soil Expansivity. They do not consider the effect of Clay Mineralogy. The Free Swell Ratio approach, in addition to predicting the soil Expansivity more realistically and satisfactorily, gives additional information about the nature of the Clay Mineralogy of Soils. The Free Swell Index test discussed in this Research Paper involves a very simple, user-friendly testing procedure, requiring negligible instrumental sophistication. . As the sediment volumes in the non-polar liquids carbon tetrachloride and kerosene are almost equal, the applicability of the test can be further enhanced by using commonly available kerosene in place of carbon tetra chloride. It was felt that the inclusion of such a simple test to evaluate the expansive nature of the soils in standard codes of practice of various National Organizations would be useful.

Bentonite soils are present in various parts of western Rajasthan. Swelling pressures, liquid limit, plastic limit, shrinkage limit etc. are different at each site and there is no correlation of properties of each site. Swelling Pressure increases with increase in Dry Density and decreases with increase in Molding Water Content. Swelling Pressure also decreases due to addition of Gypsum and Dune Sand. Various remedial measures are presented in the Research Paper to overcome the problem of Swelling Pressure.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

Visit: www.ijirset.com

Vol. 6, Issue 10, October 2017

ACKNOWLEDGEMENT

The author is grateful to **Dr. D.G.M. Purohit**, Professor, Department of Civil Engineering and **Dr. Sunil Sharma** Professor and Head of Department of Civil Engineering, M.B.M. Engineering College, J.N.V. University Jodhpur, Rajasthan, India research guide for his keen interest, sincere and valuable guidance, moral support and encouragement and timely suggestion were useful in the preparation of my this paper. Finally a word of thanks is in store especially for Dear Most **Mrs. Indu Bala Chaudhary** and **Mr. Mohit Inaniyan**.

REFERENCES

1. ASTM, Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System).ASTM Designation D2487-93. Annual Book of ASTM standards, 1995, West Conshohocken, 4.08.
2. Bureau of Indian Standards, Indian Standard, Classification and Identification of Soils for General Engineering Purposes. BIS, New Delhi, 1970, (Reaffirmed 1987), IS 1498.
3. Bureau of Indian Standards, Indian Standards Method of Test for Soils. BIS, New Delhi, 1977, IS 2720: Part 40.
4. Chen F. H. Foundations on Expansive Soils .Elsevier, Amsterdam, 1975.
5. Holtz W. G. and Gibbs H. J., Engg. Properties of expansive clays. Transactions of ASCE, 1956, 121, 641-663.
6. Katti, R.K. (1979) "Search for Solutions to Problems in Black Cotton Soils". IG Journal, L.G.S. Vol. 9, No. 1
7. Sridharan A, Rao S. M. and Murthy N. S., Liquid limit of Kaolinitic soils. Geo tech., 1988, 38, No. 2, 191-198.
8. Seed H. B., Woodward R. J. and Lundgren R. Prediction of swelling potential for compacted clays. Journal of the Soil Mechanics and Foundations Division, ASCE, 1962, 88, No. SM3, 53-87.
9. Sridharan A. and Rao S. M. A Scientific basis for the use of Index tests in Identification of Expansive soils. Geotechnical Testing Journal, ASTM, 1988, 11, No. 3, 208-212.
10. Sridharan A., Rao S. M. and Joshi S. Classification of Expansive soils by Sediment volume method. Geotechnical Testing Journal, ASTM, 1990, 13, No. 4, 375-380.
11. Sridharan A. and Prakash K. Classification Procedures for Expansive soils, Proc. Instn. Civ. Eng Geo tech. Engg, 2000, 143, Oct., 235-240.
12. Mathur, A.K. (1995) "Study of Gypsum on the Swelling Pressure Characteristics of Bentonite," M.E. Thesis, J. N.V. University, Jodhpur
13. Singh S.P. and Pani A. (2014) , Investigated evaluation of lime stabilised fly ash as a highway material , International Journal of Environmental Research and Department, volume 4, Number4,pp282-286.
14. Punmia B.C. (2011), Soil Mechanics and Foundation Engineering. 16th Edition, New Delhi.