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The Effect of Initial Moisture Content on the Swelling Characteristics of Expansive Soils

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ABSTRACT

Expansive soils are prone to swell or shrink with the change of moisture content. They swell or increase in their volume when they imbibe water and shrink or reduce in their volume on evaporation of water. The swell and shrinkage characteristics of the expansive soil causes change in volume of expansive soil which poses many problems before the geotechnical engineers. When a structure is founded on the expansive soils, they swell and put an uplift pressure on the foundation causing damage to the structure. When these expansive soil are used in embankments or water retaining structures, the swell and shrinkage characteristics of the expansive soil causes the cracks in the structures which lead to the failure of structures. The swelling of expansive soil depends upon a lot of factors like type of clay minerals, amount of clay and initial moisture content of soil, density of the soil etc. In the present study, the effect of initial moisture content on the swelling characteristics of expansive soil is studied using the Clay-Bentonite mix. The initial moisture content of soil-bentonite mix. is varied as 10%, 20%, 25%, 30%, 35% and 40 % and the swelling characteristics of soil-bentonite mix. is determined.

I. INTRODUCTION

Expansive soils are prone to swell or shrink with the change of moisture content. They swell or increase in their volume when they imbibe water and shrink or reduce in their volume on evaporation of water (Chen 1988). The swell and shrinkage characteristics of the expansive soil causes change in volume of expansive soil which poses many problems before the geotechnical engineers. When a structure is founded on the expansive soils, they swell and put an uplift pressure on the foundation causing damage to the structure. When these expansive soil are used in embankments or water retaining structures, the swell and shrinkage characteristics of the expansive soil causes the cracks in the structures which lead to the failure of structures. The swelling of expansive soil the depends upon a lot of factors like type of clay minerals, amount of clay and initial moisture content of soil, density of the soil etc. Expansive soil is found in many parts of India which includes Gujarat, Maharashtra, Karnataka and Madhya Pradesh on the Deccan lava plateau and the Malwa Plateau, but their characters are different as per the clay mineralogy. The soil map of India is shown in Figure 1. A vast majority of expansive soils are montmorillonite-rich clays, over consolidated clays and shales (Nelson and Miller, 1992, Pillappa, 2005). Generally, the chemical composition of the expansive soil constitutes SiO_2, $Al2O_3$, TiO_2, Fe_2O_3, MnO, CaO, K_2O and Na_2O. The values of these compounds vary according to the type of clay minerals present in soil viz. kaolinite, illite and montmorillonite.

II. METHODOLOGY OF STUDY

In the present study, 6 nos. samples of clayey soil passing 425 micron IS sieve were mixed with bentonite to study the effect of moisture content on the swelling characteristics of expansive soil. The engineering properties of soil and bentonoite is given in Table 1. The bentonite was mixed with soil in the proportion of 10%, 20%, 25%, 30%, 35% and 40%. All the soil samples are remolded and tested for swelling pressure tests by varying the initial moisture content of samples as 10%, 20%, 25%, 30%, 35% and 40 %. The density of all each set of soil samples was kept constant and the soil samples were allowed to expand under submerged conditions in consolidation cell. The one dimensional consolidation apparatus was used to determine the swelling in thickness and swelling pressure exerted by the expansive soils. The test was conducted as per IS 2720-Part-15. The diameter of each

sample was 60 mm and height of soil sample was 20 mm. The density of each set of soil samples was kept constant and the moisture content is varied as 10%, 20%, 25%, 30%, 35% and 40 %.

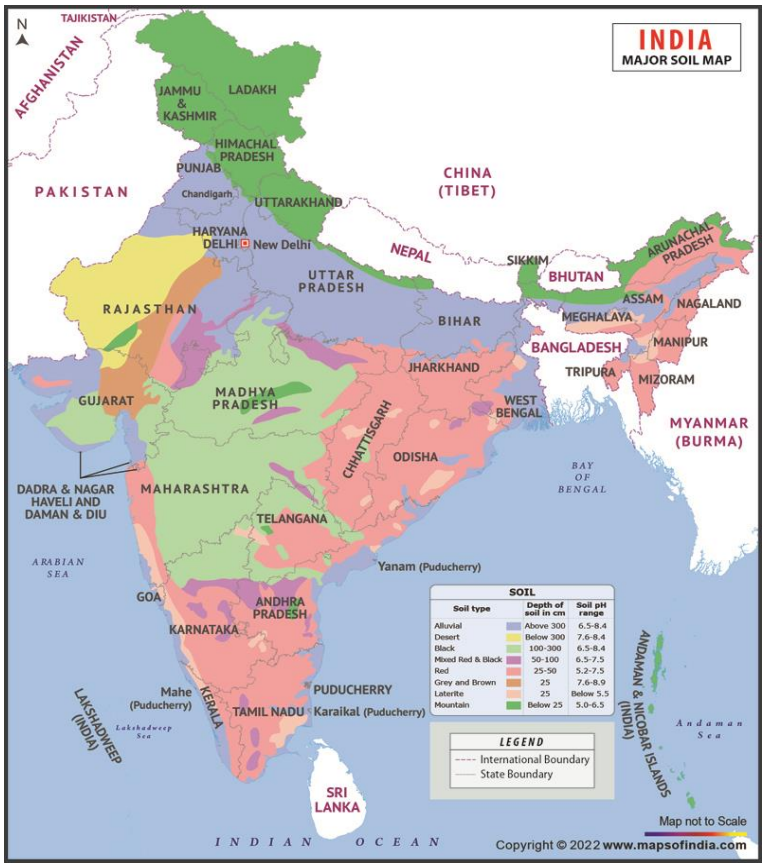

Figure 1: Soil map of India

III. RESULTS AND DISCUSSIONS

a. Swelling in Volume

It was observed that for each set of soil samples, the maximum swelling in volume occurs when the initial moisture content was 10% and minimum swelling in volume occurs at 40% initial moisture content. The swelling in volume of soil samples decreases with the increase of moisture content. The swelling in volume of the soil samples increases as the bentonite content in the soil increases. The maximum swelling in volume 16.3 % was observed at the bentonite content 40 % and moisture content 10%. The minimum swelling in volume 0.90 % was observed at bentonite content of 10 % and moisture content 40 %. The values of minimum and maximum swelling in volume of different set of soil samples with bentnite content 10%, 20%, 25%, 30%, 35% and 40 % is given in Table-2 and the swelling in volume at different moisture content 10%, 20%, 25%, 30%, 35% and 40 % of each set of soil is presented in Figure 2.

Table 1: Properties of Materials used for the Study

Material	Clay	Silt	Fine sand	Medium Sand	Coarse sand	Liquid Limit	Plastic Limit	Plasticity Index
Soil	53.8	44.1	2.1	0.0	0.0	63.8	28.8	35.0
Bentonite	84.3	14.2	1.2	0.3	0.0	452.0	41.0	411.0

Table-2: Relation between Initial Moisture Content Vs. Swelling Characteristics

Soil Composition	Swelling in Volume, %		Swelling Pressure, kg/cm^2	
	Minimum	Minimum	Minimum	Maximum
Soil+10% Bentonite	0.90	7.13	0.30	0.80
Soil+20% Bentonite	1.22	9.04	0.35	1.10

Soil+25% Bentonite	1.77	11.02	0.45	1.60
Soil+30% Bentonite	2.72	12.42	0.60	2.10
Soil+35% Bentonite	3.52	13.93	0.70	2.60
Soil+40% Bentonite	4.28	16.31	0.80	2.90

b. Swelling Pressure

It was observed that for each set of soil samples, the maximum swelling pressure occurs when the initial moisture content was 10% and minimum swelling pressure occurs when the initial moisture content 40%. The swelling pressure of the soil samples increases with the increase of bentonite content. The maximum swelling pressure 2.90 kg/cm^2 was observed at 40 % bentonite content and 10 % moisture content. The minimum swelling pressure 0.30 kg/cm^2 was observed at 10 % bentonite content and 40 % moisture content. The values of minimum and maximum swelling pressure of different set of soil samples with bentonite content 10%, 20%, 25%, 30%, 35% and 40 % is given in Table-2 and the swelling pressure at different moisture content 10%, 20%, 25%, 30%, 35% and 40 % of each set of soil is presented in Figure 3.

It shows that the swelling properties are directly related to the amount of water present in the soil. Since only a certain amount of water can be accepted by the mass, it is evident that swell potential is dependent on the initial moisture content (Parcher, James, 1965). Seed and Chan, (1961) also confirm this conclusions in their investigations of compacted clays. They stated "that soil samples compacted dry of optimum exhibit higher swelling characteristics and swell to higher water contents than do samples of the same density compacted wet of optimum." They indicated that this may be due to the different soil structure present in the soil on the dry of optimum and wet of optimum. It has been investigated that compacted clays soil when compacted dry of optimum moisture content are likely to have a flocculated structure (Figure 5) while soils compacted wet of optimum moisture content tend to have a dispersed structure (Figure 4). The structure play important role in the swelling mechanisms of clayey soil which depends upon the initial moisture content at which the soil is compacted.

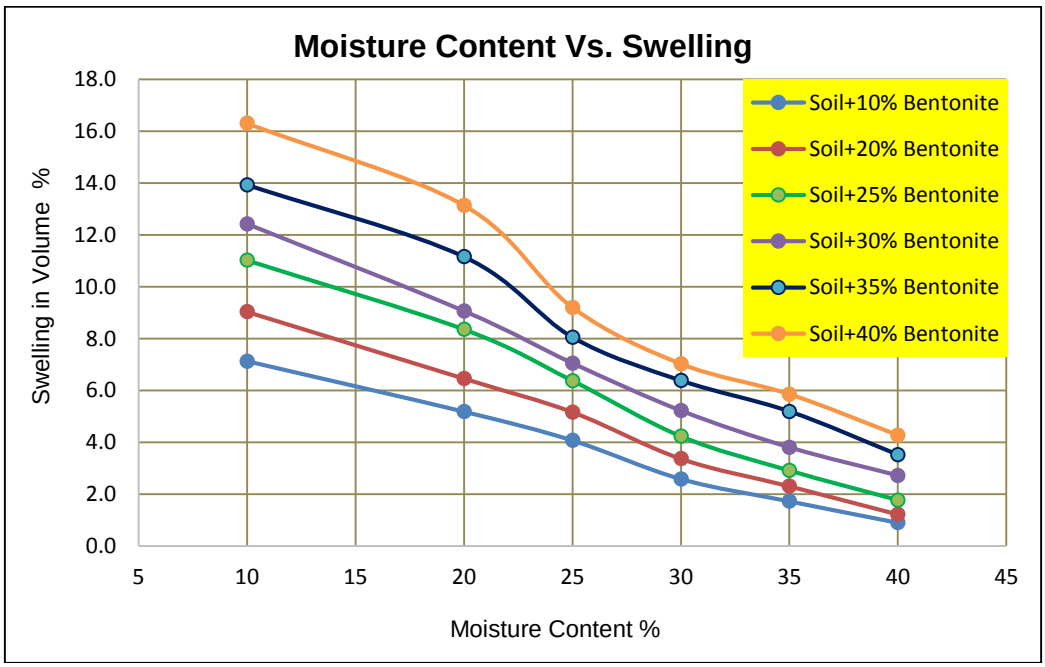

Figure 2: Effect of Initial Moisture Content on Swelling of Soil

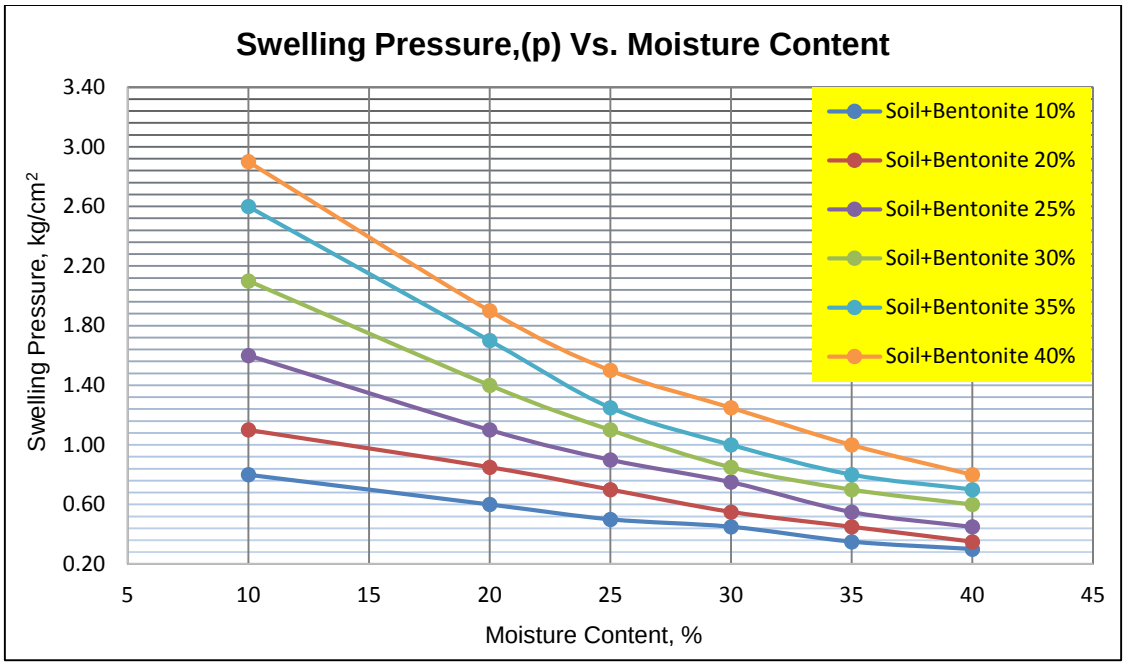

Figure 3: Effect of Initial Moisture Content on Swelling Pressure of Soil

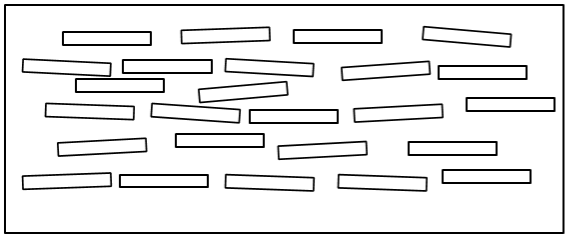

Figure 4: Dispersed Soil Structure

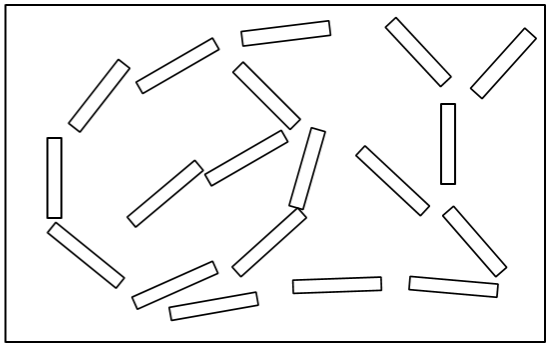

Figure 5: Flocculated Soil Structure

IV. CONCLUSIONS

Based upon the study carried out on the effect of initial moisture content on the swelling characteristics of the clayey soil, it is concluded that the swelling of the expansive or clayey soil not only depend upon the clayey mineralogy, clay content and density of the soil but also upto a great extent on the initial moisture content of the clayey soil. It is evident from the above study that as the initial moisture content of clayey soil increases, the swelling characteristics (swelling in volume and swelling pressure) decreases. Hence, while using the clayey soil in clay core in dams, embankments, canals etc., the soil should be compacted on wet side of the optimum to control the swelling on saturation. Further, to control the swelling of soil, suitable measures shall also be used to control the change in moisture content.

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