Experimental Study On Shrinkage Behaviour Of Clay

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ABSTRACT

An important aspect of the expansive soil mass is the volume reduction or shrinkage exhibited by the soil mass on drying. This aspect appears to be inadequately investigated in the available literature. This paper includes investigations on the shrink behaviour of soil and attempt is made to propose appropriate parameter characterizing shrinkability of soil on lines of the "Limiting Unit Swell Potential". The aim of the research is to study shrinkage behaviour or the rate at which volume decrease takes place when a given soil at different initial water content shrink till it assume fully shrunken dry state. Extensive laboratory investigations were carried out on five soil materials, at different initial water contents, possessing different swelling characteristics and a simple rational approach is developed for estimating the vertical movement of soil during shrinkage.

Keywords

Limiting Unit Swell Potential(PSu)0, Limiting Unit Shrink Potential,$(Spu)_0$

1. INTRODUCTION

The main environmental cause of volume changes exhibited by fine grained soil (with appreciable percentage of Montmorillonite type of clay particles) is the change in water content. On increasing the water content, fine grained soil swells and the decrease in water content causes shrinkage. The volume of soil at any stage of water content can better be represented by specific volume of soil mass having unit mass or weight of soil particle (1gm) at any stage of water content and thus the specific volume has unit like cubic cm per gram (cm^3/gm). This is the most convenient parameter for characterizing the volume change for different water contents.

For specifying more realistically the volume change characteristics during swelling the 'Limiting Unit Swell Potential' parameter was proposed by Golait and Khanzode (1995), and Golait and Wakhare (1998). It essentially signifies the volumetric strain exhibited by soil due to unit percentage increase in water content.

In this paper, a new parameter is developed for characterizing shrinkability of soil on lines of the "Limiting Unit Swell Potential".

2. LABORTARY INVESTIGATIONS

2.1 Material used:

BLACK COTTON SOIL: - The soil used for the investigations was collected from a black cotton soil deposit in Nagpur area.

BENTONITE: - Commercial Bentonite available in the local market was used for mixing with native B.C. soil to enhance swelling characteristic.

GRAY CLAY:- Gray clay is used in preparation of soil samples of low expansivity.

2.2 Soil Mixes for Laboratory Investigation

In order to develop the parameter for characterizing shrinkability of soil with different swell-shrink capacity, the soil mixes of different swellability characteristics are considered with soil particles less than 75 micron size.

In actual cases of natural soil the finer active fraction (F) may also possesses the swellability characteristics of different magnitude which depends on the type and amount of clay minerals, fineness of clay particle etc. In order to incorporate these varying swellability characteristics of finer fraction the artificial prepared material was used. It consists of mixture of -75µ local BC soil, commercial Bentonite and Gray clay.

Considering the varying degree of expansivity of finer fraction (F) various mixes were prepared by adding different percentage of Bentonite and Gray clay as shown in table 1. In this way finer fraction (F) material with 30% Bentonite and 70% of 75µ BC soil fraction is considered as fine active fraction with largest swellability, where as finer fraction (F) containing 100%, 75 µ Gray clay is considered to have least swellability.

Table 1. Composition of Sample Mixes

Sr. No.	Designation	Soil Mixes
1	A	BCS+30% BENTONITE
2	B	BCS+15% BENTONITE
3	C	100% BCS
4	D	BCS+30%GRAY CLAY
5.	E	100% GRAY CLAY

2.3 Sample Preparation

The soil sample BCS and Gray Clay was collected from a site. Then it was kept for air drying for 24 hours. After 24 hours it

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was soaked with water to form slurry and the slurry was sieved through 75 µ. Then the slurry passing through 75 µ was kept steady for 1 to 2 days in the tub. The water from the tub was removed by siphoning. The wet soil was oven dried at 105°C. Then it was pulverized with help of mallet. The pulverized soil was then sieved through 1 mm. sieve. The soil sample thus obtained was stored for further use.

Commercial and pure Bentonite available in local market was used for preparing finer fraction (F). Individual samples were prepared by considering weights of different material as indicated in table no 1.

On above mentioned five samples of soils volume change behaviour test (Shrinkage Test) were performed.

3. PARAMETERS Calculated

From the investigation the following values for all soils are calculated

SHRINKAGE TEST

- Initial water content (w_i)
- Initial dry unit weight (γ_{di})
- Water content on shrinkage limit (w_s)
- Initial specific volume (v_i)
- Specific volume on full drying (v_d) (cm^3/gm)

The evaluated values of 'Limiting Unit Shrink Potential' are given in table 2. The evaluated values which are considered inconsistent are highlighted by *.

4. CHARACTERISTICS OF VOLUME CHANGE ON SHRINKING

The samples of all soils at different initial water content were allowed to freely shrink till fully dry state. The volume change (reduction) of soil during this process is proposed to be characterized by a parameter with the similar logic as used in characterizing the volume change during swelling. Hence by applying the same logic used in defining 'Limiting Unit Swell Potential' $(Psu)_0$, a parameter termed as 'Limiting Unit Shrink Potential' $(S_{Pu})_0$ can be expressed as volumetric strain (during shrinking) due to unit percent reduction in water content.

Thus,

$$\frac{\left(\frac{\Delta V}{V}\right)}{\Delta w} \qquad \text{--------} \quad 1$$

where,

$(\Delta V/V)$ = Volumetric strain (%)

Δw = Reduction in water content (%)

It is to be noted that volume of any wet fine grained soil reduces up to only its shrinkage limit on reduction in water content. During further water content reduction below shrinkage limit the volume of the soil mass remains constant till it attains fully dry state at zero water content. Considering this fact the water content change from initial water content till water content nearer to shrinkage limit needs to be considered in evaluating $(S_{Pu})_0$. With this consideration, $(S_{Pu})_0$ can be expressed as,

$$\frac{\left(\frac{\Delta V}{V}\right)}{(w_i - w_s)} \qquad 2$$

The data on specific volumes of soil at initial state and at fully shrunken dry state can be utilized to get the percent volumetric strain (reduction) as under

$$\frac{\Delta V}{V} = \frac{V_i - V_d}{V_d}$$

Thus, the 'Limiting Unit Shrink Potential' can be expressed as

$$(S_{Pu})_0 = \frac{V_i - V_d}{V_d \Delta w}$$

The values of $(S_{Pu})_0$ so calculated for all the cases are shown in table 3. It is seen that these values in some cases appears to be inconsistent which might be due to some procedural errors in finding initial specific volume.

Table 3. $(Spu)_0$, values of Sample A, B, C, D and E.

Soil	w_i	$(Spu)_0$	Avg $(Spu)_0$
A	35.870	1.648*	1.899
	30.476	1.926	
	19.380	1.872	
B	23.793	1.946	2.000
	21.326	2.054	
	16.825	1.011*	
C	26.250	1.677	1.925
	24.121	2.274*	
	18.902	2.182	
D	30.172	1.859	1.735
	22.059	1.61	
E	24.286	0.677	0.883
	20.00	1.117	
	17.47	0.857	
	15.217	1.399*	

* indicate inconsistent values therefore neglected

5. CONCLUSION

Analysis of the results of laboratory investigations carried out on expansive soil led to the following broad conclusions:

- A newly proposed parameter 'unit shrink potential' appropriately characterizes the shrinking behavior of expansive soil.
- This 'unit shrink potential' have important relevance in predicting cyclic volumetric changes exhibited by any natural or manmade soil mass.
- Shrinkage behaviour or the rate at which volume decrease takes place when a given soil at initial water content shrink till it assume fully shrunken dry state.

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