Swell–Consolidation Characteristics of Artificial Sand Clay Mixes

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ABSTRACT

Expansive soils are highly problematic because they undergo detrimental volumetric changes corresponding changes in moisture regime. They swell when they absorb water and shrink when water evaporates from them. As a result, civil engineering infrastructure is severely cracked. Of various innovative foundation techniques, chemical stabilization and blending expansive clay with non-expansive material have also been found to have met with success. This paper presents swell-consolidation behaviour of artificially prepared sand-expansive clay mixtures, wherein fine sand was used in the blends at different contents. The fines content in the expansive clay was also varied. Swell potential, swelling pressure, compression index and coefficient of volume compressibility were studied.

1. INTRODUCTION

Expansive soils swell on absorption of water during monsoon and shrink on evaporation of water in summer (Chen, 1988). As a result, the swell-shrink behaviour of expansive soils, lightly loaded civil engineering structures founded in them are severely damaged. Many foundation techniques were suggested for counteracting this problem, which include sand cushion technique (Satyanarayana, 1966), underreamed piles (Sharma et al. 1978) and granular pile-anchors (Phanikumar, 1997). Bellied piers, lime-slurry pressure injection and geomembranes as moisture barriers are also among the innovative techniques in practice (Chen, 1988). Stabilization of expansive soils with various additives including fly ash, lime, cement and calcium chloride (Hunter, 1988; Phanikumar and Sharma, 2004) has also met with considerable success.

This paper presents results of laboratory tests performed on artificially prepared expansive soil-sand mixtures. Swell potential, swelling pressure, compression index, compressibility and volume compressibility were determined.

2. EXPERIMENTAL INVESTIGATION

Test Materials

Remoulded expansive clay and fine sand were the test materials used in the investigation. The soil, collected from Amalapuram, Andhra Pradesh, is a highly swelling soil with an FSI of 250%. It was a CH soil as per USCS classification as its LL and PI were 100% and 27% respectively. Fine sand, used as the blend material, had the particle size between 0.075 mm and 0.425 mm.

Preparation of Test Specimens and Test Procedure

Oven-dry soil passing 425 µm and 75 µm sieve was used for the preparation of the test specimens. Fine sand content was varied as 0%, 10%, 20% and 30% by dry weight of the expansive soil.

Tests Conducted and Variables Used

1-D swell-consolidation tests were conducted on the sand-clay blends by free swell method. Swell potential, swelling pressure, compression index and coefficient of compressibility were determined. The dry unit weight of the expansive soil was kept constant at 12 kN/m$^3$. Oven-dry soil passing 425 µm and 75 µm sieve was used for the preparation of the test specimens. Fine sand content was varied as 0%, 10%, 20% and 30% by dry weight of the expansive soil.

Preparation of Test Specimens and Test Procedure

Oven-dry soil passing 425 µm sieve and 75 µm sieve was weighed corresponding to the prefixed dry unit weight of 12 kN/m$^3$ based on the volume of the consolidometer ring (dia = 60 mm and height = 20 mm). Fine sand was also weighed according to its content in the blend and mixed with the expansive soil thoroughly. The blend was statically compacted into the consolidometer ring in four layers, each layer having a thickness of 5 mm. The compacted blend specimen was sandwiched between two filter papers and porous discs.

The consolidometer was arranged in position and loading hanger was placed upon the specimen.
load of 5 kPa was applied on the specimen. Swelling was allowed in the blend by free swell method and monitored continuously. When equilibrium heave was reached, compressive load increments of 10 kPa, 20 kPa, 40 kPa, 80 kPa, 160 kPa and 320 kPa were applied on the specimen to bring it to its initial void ratio. Equilibrium heave was understood to have reached when there was no further movement in the dial gauge. At the end of consolidation, the sample was removed and water content determined.

3. DISCUSSION OF TEST RESULTS

Figure 1 shows the e – log p curves of expansive clay (425 µm) and sand blends for varying sand content (0%, 10%, 20% and 30%).

Equilibrium void ratio at the end of the process of swelling was different for different specimens having varying sand content, as swelling was controlled by adding sand content. Swell potential (S%) is the ratio of increase in thickness (upon inundation) to the original thickness, expressed as a percentage. Fig 2 shows the variation of swell potential with sand content.

As the sand content in the blends increased from 0% to 30%, S% decreased by 71% and 50% respectively for 425 µm and 75 µm fractions. Swelling pressure (p_s), which is defined as the pressure required to bring back a completely swollen soil specimen to its initial void ratio, can be obtained from the e-log p curves as the pressure corresponding to the initial void ratio. Swelling pressure of clay-sand blends having a sand content of 0%, 10%, 20% and 30% were found to be respectively equal to 230 kpa, 150 kpa, 110 kpa and 75 kpa when the fines content in the blend was passing through 425 µm sieve. Figure 3 shows the variation of swelling pressure with sand content for fines passing both 425 µm and 75 µm sieves. Coefficient of volume compressibility decreased by 30% and compression index decreased by 50% in the case of blend having 425 µm fraction.

4. CONCLUSIONS

As the sand content in the blends increased from 0% to 30%, swell potential decreased by 71% and 50% and swelling pressure decreased by 67% and 57% respectively for 425 µm and 75 µm fractions. Coefficient of volume compressibility reduced by 30% and compression index decreased by 50% as the sand content increased from 0% to 30% in the case of 425 µm fraction.

REFERENCES


