EFFECT OF SAND CONTENT ON CYCLIC SWELL-SHRINK BEHAVIOR OF COMPACTED EXPANSIVE SOIL

Sabari Ramesh* and Dr. T.Thyagaraj*
*Department of Civil Engineering, Indian Institute of Technology, Madras, India
Phone number: +91-9539377590, Email ID: sabarirameshjuly2@gmail.com

GEO-CONGRESS 2020
Minneapolis, Minnesota | February 25-28
Paper ID: 0280_0408_000069

INTRODUCTION

- Due to climatic variations, in arid and semi-arid regions, the expansive soils undergo large changes in water content up to the active zone depth -thus resulting in cyclic wetting and drying (W-D) of these soils
- During dry seasons, the loss of moisture from this zone results in an increase in matric suction and the decrease in the thickness of diffuse double layers, thereby causing the shrinkage of soils and during wet seasons, swelling of soils occurs due to decrease in matric suction and increase in diffuse double layer thickness
- Swelling of expansive soils causes lifting up of lightly loaded structures and formation of cracks in walls of buildings and underground pipe lines whereas shrinkage results in the formation of desiccation cracks
- Compacted expansive soils, provided as liners and covers for landfills are prone to both swelling and shrinkage. Desiccation cracks formed in the liners and covers due to continuous W-D cycles have significant influence on their hydraulic performance.
- Effect of sand fraction on compacted expansive soils during W-D cycles was least addressed in the literature

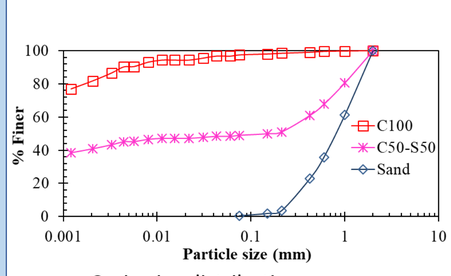
The role of sand fraction on cyclic swell-shrink behavior of compacted expansive soil is studied

- By conducting cyclic swell-shrink tests on compacted expansive soil and expansive soil amended with sand specimens by subjecting it to five W-D cycles
- By performing image analysis studies on digital camera images of specimens after 1st, 2nd and 5th drying cycles to study the effect of sand content on desiccation crack formation

MATERIALS AND METHODS

Soils

- 2 mm passing expansive soil (C100)
- 2 mm passing river sand (S100)
- Clay-sand mixture (C50-S50)- 50% expansive soil + 50% sand



Grain size distribution curves

Basic properties of soils

Property	C100	S100	C50-S50
Liquid limit (%)	87	NP	67
Plastic limit (%)	32	NP	26
Plasticity index (%)	55	NP	41
Specific gravity	2.71	2.65	2.68
Fines (%)	97	0.5	49
Soil type	CH	SP	SC
Optimum moisture content (%)	28	-	17
Maximum dry unit weight (kN/m³)	13.1	-	16.8

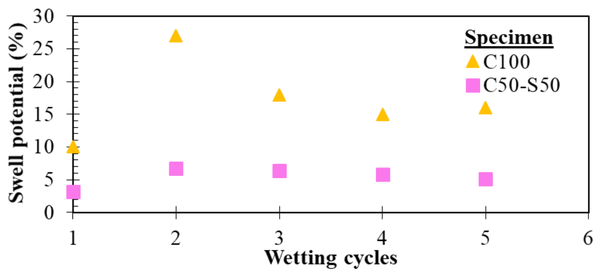
Cyclic swell-shrink tests

- Specimen size - 75 mm × 20 mm
- Surcharge load - 12.5 KN/m²
- Inundating fluid - distilled water
- Drying temperature - 40 ±5 º C (up to shrinkage limit)

Image analysis

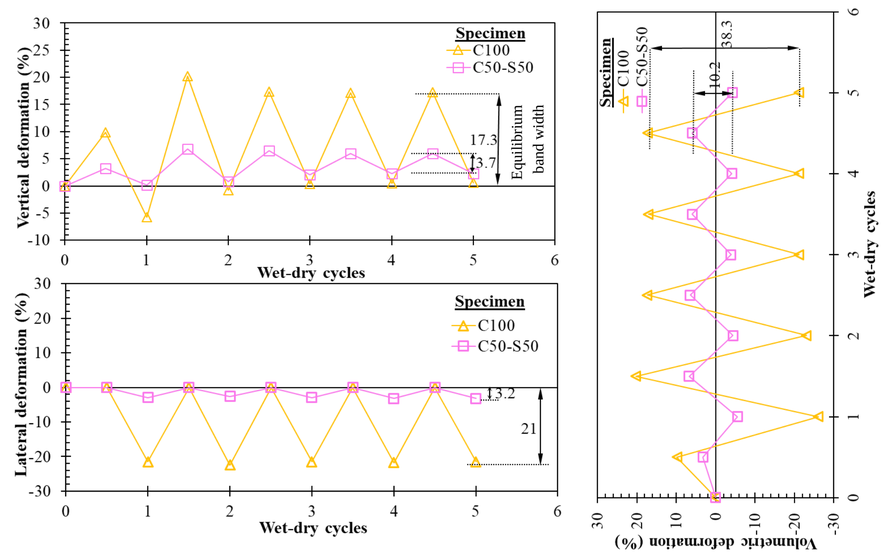
- Captured images – top and bottom surface images (1st, 2nd and 5th cycle)
- Image processing software – ImageJ Fiji
- RGB images → grayscale images → filtering and thresholding → binary images
- In binary images- black color represents solids and white color represents voids- thus aids in the identification of crack formation

RESULTS AND DISCUSSIONS



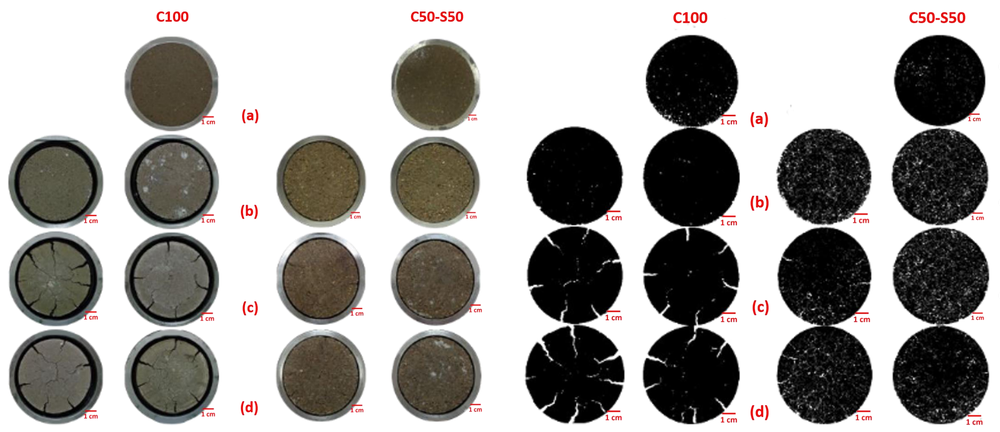
Comparison of swell potential during different wetting cycles of expansive clay and clay-sand mixture

- For all the cycles, C100 specimen exhibited higher swell potential
- Swell potential becomes almost constant after 3rd cycle for both C100 and C50-S50 specimens
- Addition of sand resulted in lower swell potential owing to the reduction in clay content, intervoid swelling and encapsulation offered by sand particles



Comparison of vertical , lateral and volumetric deformation during W-D cycles of C100 and C50-S50 specimens

- An equilibrium bandwidth was observed for both specimens after 2nd cycle
- Vertical, lateral and volumetric deformations of C50-S50 specimen were comparatively much lower than the C100 specimen
- Addition of sand reduced the overall deformation of compacted expansive soils during swell-shrink cycles



Digital camera and binary Top and Bottom surface images of C100 and C50-S50 specimens: (a) as compacted state (b) after 1st drying cycle (c) after 2nd drying cycle (d) after 5th drying cycle

- Sand played a major role in preventing the formation of cracks
- C50-S50 specimen exhibited only surface cracks
- In depth cracks and larger volume of cracks were noticed in C100 specimen

CONCLUSIONS

- During all W-D cycles, the sand amended specimen showed a reduction in swell potential owing to their reduced water holding capacity
- The vertical, lateral and volumetric deformations decreased for C50-S50 specimens during W-D cycles when compared to the deformations of C100 specimen
- The amount of shrinkage and cracks formed were less in C50-S50 specimen, displaying the capability of sand to arrest the shrinkage and crack formation
- Image analyses revealed that mostly the surface cracks were observed in C50-S50 specimen and the volume of cracks formed were lesser compared to C100 specimen
- These results have implications for the possible use of clay-sand mixtures in geotechnical and geoenvironmental applications such as base liners and covers for landfills which are vulnerable to high fluctuations in water content