D201

Study on the Mechanical Properties of Soil-bentonite Mixtures Amended with Slag Cement

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1 Introduction

Soil-bentonite (SB) is widely applied in vertical cutoff walls for preventing migration of contaminants to the aquifer, owing to extremely low hydraulic conductivity and high deformability (Takai, A. et al., 2016). However, SB exhibits relatively low shear strength, and the effectiveness will be influenced by statistic loads or in situations of dynamic loads, as shown in **Fig. 1**. To enhance certain mechanical properties (e.g., strength and stiffness) of SB, cementitious additives like Ordinary Portland Cement (OPC) is often used with high content (10% to 20%). However, the interaction between bentonite slurry and cement lead to the flocculation and dissolution of bentonite, as a result significantly undermine the stability and swelling properties of bentonite.

In efforts to enhance the mechanical performance and maintain the swelling properties of soil-bentonite mixtures, Slag Cement, as one type of eco-friendly additive, was utilized in this study to investigate the effects of slag cement on the mechanical properties of soil-bentonite mixtures amended with relatively low content ratio of slag cement (1% to 3%).

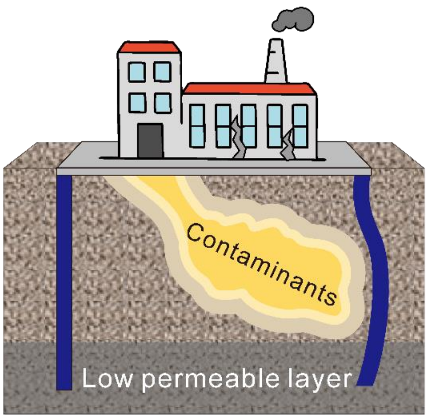

Fig. 1. Deformation in SB vertical cutoff wall.

2 Materials and methods

Decomposed granite soil was selected as the host soil. The bentonite used was sodium bentonite and the Slag Cement was taken as the cement additive. The dry density of the decomposed granite soil, sodium bentonite and slag cement are 2.73, 2.60 and 3.04 g/cm^3, respectively. The mixing ratios and test conditions of these specimens are summarized in **Table 1**.

Table. 1 Summary of test conditions.

	Bentonite slurry (L/m^3)	Bentonite powder (kg/m^3)	Effective confining pressure (kPa)	Curing time (D)
SB	350	97.5	40, 80, 160	0
SB-C25				7, 28
SB-C50				
SB-C75				

The preparation process of SB and amended SB (SB-C) specimens is shown in **Fig. 2**.

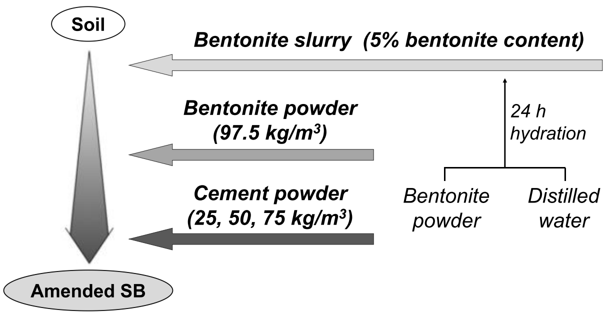

Fig. 2. Specimen preparation process.

Consolidated undrained (CU) triaxial tests as per ASTM D4767-11 (ASTM International, 2020) were conducted in this research to monitor the specimens subjected to triaxial loading. The structure of the triaxial test apparatus has been shown in **Fig. 3**.

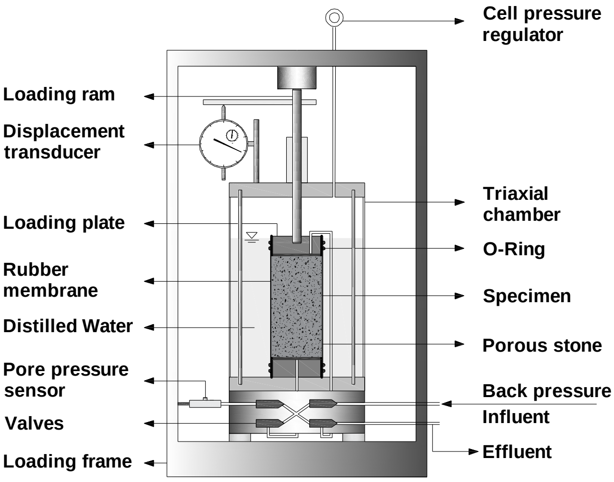

Fig. 3. Schematic of CU triaxial test apparatus.

In CU tests, saturated specimens (B value > 0.9) were consolidated under different isotropic effective confining pressures (i.e., σ_3 = 40, 80 and 160 kPa) and sheared at an axial strain rate of 0.05 mm/min until reaching approximately 15% axial strain.

3 Results

After the triaxial test, the stress strain relationship of 7 and 28 D specimens were achieved. **Fig. 4** plots the stress strain relationship of SB-C25 28 D specimens. In **Fig. 4**, the yellow points represent the failure of each specimen, as according to ASTM D4767-11.

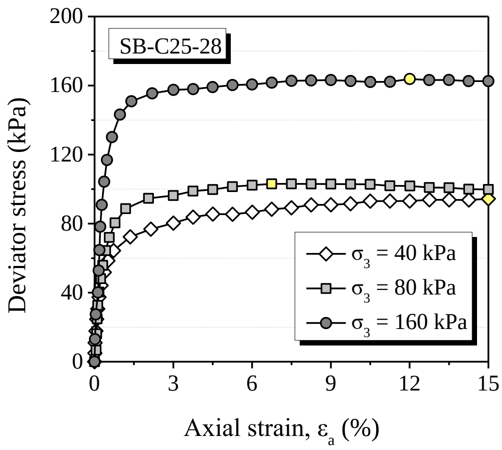

Fig. 4. Deviator stress-strain relationship curve.

Based on the stress strain relationship, we plotted the effective stress path and strength envelope of each specimen, as shown in **Fig. 5**. The effective strength parameters cohesive coefficient c'(kPa) and effective internal friction angle φ'(kPa) were calculated.

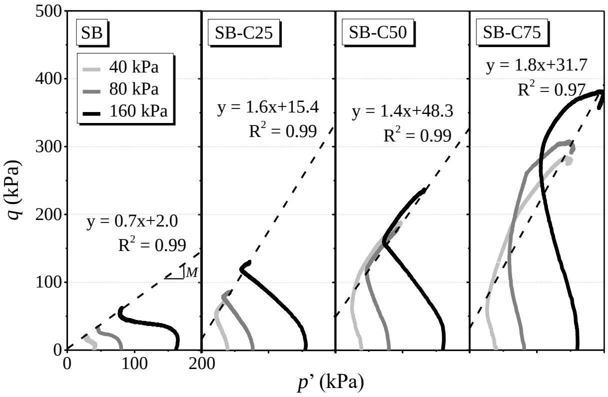

Fig. 5. Effective stress path and strength envelope.

To evaluate the deformation mode, the results of Young's modulus E_0 (defined at the initial stable point) and secant modulus E_{50} (defined at 50% of the peak strength) are illustrated in **Fig. 6**. It is observed that the moduli (E_0, E_{50}) increase with the augment of cement addition. When comparing the E_0 to E_{50}, the E_{50} is less than 50% of E_0 in all instances. It is noteworthy that this value does not align with that of typical elastic material, which tends to be significantly higher. It is also indicated the propensity for plastic deformation.

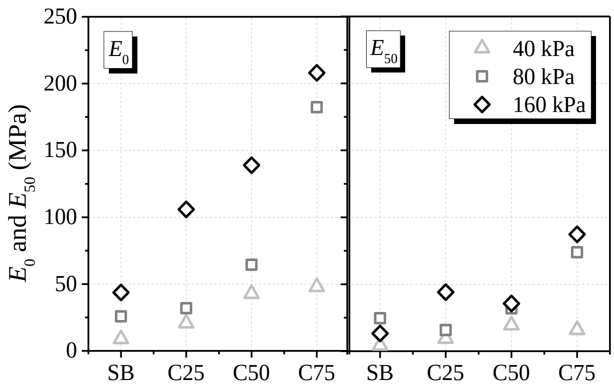

Fig. 6. Young's modulus E_0 and secant modulus E_{50}.

References

ASTM D4767-11 (2020), Standard Test Method for Consolidated Undrained Triaxial Compression Test for Cohesive Soils, ASTM International, West Conshohocken, PA, the United States.

Takai, A., Inui, T., Katsumi T. (2016) Evaluating the hydraulic barrier performance of soil-bentonite cutoff walls using the piezocone penetration test, Soils and Foundations. 56(2): 277-290.