FEM Analysis of California Bearing Ratio (CBR) Test with Cemented Sand

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Abstract: In this study, finite element analysis was used to predict the CBR tests, based on modulus and strength parameters obtained from unconfined compression tests for 3% cemented sand. The cemented sand was modeled using linear elastic-perfectly plastic constitutive relationship with Mohr-Coulomb failure criteria. The ratio of predicted to measured CBR values varied from 0.69 to 1.07.

1 Introduction

In the past decade researchers have conducted extensive laboratory and field-testing to establish correlations between CBR and other tests for a variety of soil types. Sawangsuriya and Edil (2005) used DCP, Soil Stiffness Gauge and CBR for evaluating the stiffness and strength of pavement materials, and they developed equations to correlate these test methods to pavement and subgrade modulus using the results of various researchers. Livneh and Ishai (1988) developed correlations between Vane test, SPT, Plate Bearing Test and CBR based on field testing carried out in three airport construction on silty subgrade. Another research about CBR was carried out by Guney et al. (2005) to investigate the geoenvironmental behavior of foundry sand amended mixtures which is used for highway subbases. These tremendous researches indicate the importance and capability of CBR as an in-situ and laboratory test.

Numerical studies are also important to gain a better understanding and verify the experimental studies (Ismail 2005). In this study, PLAXIS software was used to verify the CBR values obtained from laboratory the tests.

2 Objective

The objective of this study was to use finite element method to model the CBR test with cemented sand.

3 Finite Element Model Analyses

The basic CBR test involves applying load to a small piston at a rate of 0.05 in per minute and recording the total load at penetrations ranging from 0.025 in. up to 0.300 in. Generally, the load at 0.1 inch penetration is used to compute the CBR value. The CBR value is defined as the ratio of the stress on piston at 0.1 inch penetration to that of the standard unit load for well graded crushed stone.

A commercially available geotechnical finite element program (PLAXIS) was used to develop the FEM analyses. A 15 node, triangular elements were used in the axisymmetric analysis. The cemented sand was modeled as elastic – perfectly plastic material, with Mohr-Coulomb failure criteria. Table 1 summaries the parameters used in the analysis.

The model used to simulate the cemented sand behavior, required six input parameters-initial elastic modulus (E), Poisson's ratio (υ) , cohesion (c), friction angle (φ), dilatancy angle (ψ) and unit weight (ρ). Simulations were performed with keeping constant the friction angle and dilatancy angle, respectively at 38^o and 5^o, while varying elastic modulus (E) and cohesion (c) based on unconfined compression test results.

4 Results

Finite element modeling of CBR test was done in two phases. In the first phase, a surcharge weight of 5 lbs was applied to the cemented sand which simulates an intensity of loading equal to the weight of the base material (ASTM D 1883). In the second phase the surcharge weight was kept constant and total prescribed displacement of 0.3 in. with 0.025 in. increments was given to the piston. The CBR value was predicted at prescribed displacement of 0.1 in of the piston and compared with the laboratory test results for 3% cemented sand (Fig. 1)

Table 1. Properties of cemented sand modeled (PLAXIS) and tested.

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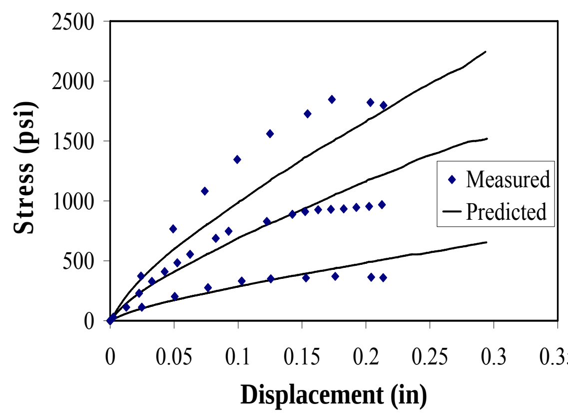

Figure 1. Measured and predicted (FEM) CBR values.

5 Conclusion

FEM was used to model the CBR test with 3% cemented sand (linearly elastic and perfectly plastic with Mohr-Coulomb yielding criteria) and the ratio of predicted to measured CBR value varied from 0.69 to 1.07.

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7. References

Guney, Y., Aydilek, A. H., Demirkan M. M. (2005). “Geoenvironmental behavior of foundry sand amended mixtures for highway subbases.” Waste Manag. 2005 Aug 16; 16111882

Ismail, M.A. (2005). “Performance of cement-stabilized retaining walls.” Canadian Geotechnical Journal, Vol 42(3), 876-891

Livneh, M., and Ishai, I. (1988). ”The Relationship Between In Situ CBR Test and the Various Penetration Tests”. Proc. First Int. Conf. on Penetration Testing, Orlando, Fl, pp. 445-452.

Sawangsuriya, A. and Edil, T. B. (2005). “Evaluating stiffness and strength of pavement materials.” Proc. Inst. Civ. Eng., Geotech. Eng.: 217-230