SUMMARY OF CONTRIBUTIONS OF THE DISSERTATION

PhD candidate : NGUYEN THANH TU Fellows code: 1828002
Major : Civil Engineering Major code: 9580201
Dissertation title : IMPROVEMENT METHODS TO REINFORCE RIVERBED SILTY SOIL USING GEOTEXTILE - CEMENT - SAND CUSHION
Supervisor one : Dr MGUYEN MINH DUC
Supervisor two : Dr TRAN VAN TIENG

Summary of theoretical and academic contribution of the dissertation:

Using silty soil that was dredged from riverbeds to replace sand for road basements is considered an alternative with many advantages. However, the riverbed soil is soft, with low shear resistance, a high void ratio, weak permeability, and high swelling and bearing capacity loss when saturated. Geotextile, sand cushion, and cement methods are introduced to strengthen soil due to their popularity and effectiveness. The laboratory experiments, including the California Bearing Ratio (*CBR*), a triaxial compression test, a one-dimensional consolidation test with a modified oedometer apparatus, and a modified direct shear test, were conducted to investigate the swelling, *CBR* value, shear strength, and consolidation of reinforced soil. Then, evaluating the applicability of these methods to reinforce the dredged soil from the Cai Lon River would be carried out.

With the high permeability, geotextile accelerated the soil expansion process, and the swell decreased. In addition, the *CBR* values increased dramatically, especially for the saturated samples. Similarly, the shear strength of the unsaturated sample reinforced with three geo-layers rose to approximately 1.6 times that of the unreinforced soil and about 2.1 times that of the saturated case due to the interaction between soil and geotextiles. In the saturated samples, the pore water pressure increased when the displacement was small before rapidly decreasing when slippage between the geotextile and the soil occurred. In addition, consolidation results indicated that the reinforced sample consolidated 1–2 times faster than the unreinforced sample of the same height.

The one-dimensional consolidation tests of reinforced soil were also performed. In this test, the height of the specimen must be significant. Thus, side friction between the soil and the ring must be considered. A modified odometer apparatus was introduced to measure the friction force between the soil and the ring. The results indicated that friction pressure increased as the ratio of diameter to height (*D/H*) decreased. When the *D/H* ratio was less than 2.5, the effect of friction was significant and reduced the compression pressure by up to 20% at the end of consolidation (*EOP*). Based on the Taylor method, an analytical method for predicting the stress loss and coefficient of variation of the void ratio, *COV,* along soil sample depth at *EOP* was proposed. The results indicated that the void ratio increased with depth, and if the *D/H* ratio exceeded 2.5, the *COV* would be less than 1.2%.

When reinforced with sand cushions, the swelling and the dried unit weight reduction decreased with increasing sand cushion thickness. In addition, the *CBR* value was effectively increased for saturated clay rather than unsaturated samples. In the *UU* triaxial compression test, the shear resistance of the reinforced soil in the unsaturated condition increased as the horizontal pressure increased. The shear strength of unsaturated samples with a 20-mm-thick sand cushion increased approximately 1.9 times compared to that of unreinforced samples and about 3.3 times for the saturated case. Specifically, the pore water pressure in the saturated samples increased when the strain was small, and then the pore water pressure decreased. In addition, the consolidation results indicated that the reinforced sample consolidates between 3.5 and 5 times faster than the unreinforced sample.

As a binder, cement reduced the swelling of riverbed clay by 1.77 to 2.5 times when the cement ratio increased from 3 to 10%. In the case of a 28-day saturation curing, the *CBR* value of the soil cement mixture increased from 1.7 to 3.8 times that of the soil. In the *UU* triaxial compression test, the shear strength of soil cement increased in both unsaturated and saturated samples. The increase in strength of the soil cement was due to the hydration and pozzolanic processes, which resulted in a change in particle composition. In the case of 10% cement, the percentage of sand granules doubled after 28 days. Brittle failure and an increase in shear resistance and interface shear were also observed by the direct shear test of soil cement and the modified shear test of soil cement and steel. The peak shear strength and residual shear resistance of cement soil increased to 2.4 and 1.8 times those of clay, respectively. In the case of the interface shear strength of cement and steel, the maximal and residual shear resistance of cement-metal soils were 1.55 and 1.40 times greater than soil-steel, respectively. Then, a formula was proposed for estimating shear resistance over 28 days and predicting the shear strength of the soil-cement mixture at 28 days based on the water content and cement weight.

In summary, the results indicated that the methods of reinforcing riverbed soil with geotextile, sand cushion, and cement are effective. Based on the results, compared to these methods, the cement method had the most effectiveness. Soil cement mixtures can be used as backfill material for roads with car traffic, whereas geotextile and sand cushions can be used for roads with car-free traffic.

The results of laboratory experiments will be the basic theories to improve the riverbed soil for the road embankment. The results showed that these methods satisfied the Vietnamese standard. Thus, these results will be the fundamental theory for further field research when considering the field conditions, such as material, cost, construction methods, machines, etc.

Hồ Chí Minh city, 28/11/2023

PhD candidate

Nguyen Thanh Tu