III - B 290 Model and field tests on Geosynthetic reinforced clay embankments

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INTRODUCTION:

In actual construction, geosynthetic reinforced soil embankment/slopes have continued to demonstrate excellent performance characteristics and experience with reinforcing action of geosynthetics with granular backfill, in particular, (Huang et al, 1994) exhibit many advantages over the conventional ones. However, the performance of reinforced soil structures with locally available materials and under various geometric and loading conditions has not been investigated in details. In this paper results of laboratory model tests on clay embankment vis-à-vis characteristic response of field prototype embankment are discussed. The aim of these tests program has been to assess the feasibility of using locally available Kanto loam as backfill materials. Tests results reveal that reinforcing action of geosynthetics when used with clay can be improved with a thin granular mat in between. The prototype embankment with three layers of geosynthetic was found stable and showed higher footing load with larger settlement.

MODEL TEST:

A model box made of acrylic plates was fabricated in the laboratory in order to prepare a model embankment as per dimensions shown in Fig. 1. The slope adopted is relatively steep which is in consideration to the reinforcement effect on the embankment stability. Kanto loam (G=2.68, w_l=93.9%, w_p=65.2%, $\gamma_{d\ max}$=0.86g/cm^3, OMC=59%) was used for the embankment. Since reinforcing actions of geosynthetics are more pronounced with granular soil, standard Toyora sand ($\gamma_{d\ max}$=1.64g/cm^3, $\gamma_{d\ min}$=1.33g/cm^3, G=2.64, D_{10}=0.16mm) was used as thin granular mat. In order to have a characteristic response a separate tests on reinforced sand embankment has been conducted. While preparing the model embankment all precautions were taken to ensure about the homogeneity and uniform density. The clay was compacted at OMC and for the sand density of 1.42g/cm^3 was maintained. Special arrangement was made to maintain the steep sand slope with minimum effect on the results. Latex membrane were used on both side walls to have a record of displacement pattern. Two types of geotextiles (Nonwoven type: wide width tensile strength = 1600 Kgf/m at 100% strain; Nonwoven composite type: wide width tensile strength = 5300 Kgf/m at 7% strain @ 20%/minute, 2800 Kgf/m @1%/minute) were used. Three layers of geotextile extending to full width of the embankment were used leaving both ends free. In order to characterize the sandwich effect, 1cm thick Toyora sand was placed covering the composite geotextile (Fig. 1). A rigid footing of 5cm wide was placed at the top of the embankment and it was connected with loading ram with the facility of strain controlled data acquisition system.

With the model arrangement as above 6 tests have been performed and they are shown as load-settlement plot in Fig.2. Punching type failure took place in unreinforced clay model. Large area of the underlying soil was affected resulting in deep cracks and eventual minimum horizontal displacement of the top soil. Under such condition the bearing capacity of Kanto loam was about 1.16Kgf/cm^2. Unreinforced Toyora sand showed higher load capacity and increases monotonically with the footing displacement. With the use of nonwoven geotextile the footing settled more initially and it showed marginal increase in load bearing capacity at large settlement. Even with relatively stronger composite not much improvement was noticed in Kanto loam. However, the effect of composite with thin granular mat was quite significant.

FIELD TEST:

Keeping in view of the difficulty of extrapolating the small scale model tests results for design purposes a series of field tests have been performed at the Mitsui Petrochemical Industry campus. The details of the tests setup along with pore pressure measurement devices (P1, P2,..), displacement transducers (D1, D2, ..) and geotextile strain measurement devices (G1, G2, ..), etc. are shown in Fig. 3. Due to the space limitations only two tests performed respectively on unreinforced Kanto loam and reinforced one are presented in Fig. 4. Same nonwoven type geotextile were used in the field test. These tests were carried out immediately after the preparation of the embankment. Stepped loading was applied till failure. In case of the unreinforced clay the footing settled enormously and the collapse load of 52kPa was recorded at 125mm settlement. Such behaviour in the large scale test is quite different from the small scale tests already reported. Some of the factors responsible are, size effect of footing, stress path, loading method, strength and stiffness of reinforcement materials, etc. Test on reinforced embankment shows that the footing settled more initially due to pore pressure dissipation. However, it carried much higher load before collapse. Thus use of geotextile inside the clay embankment has increased the load carrying capacity and also ensure stability of the embankment at higher settlement. Some more tests with composite geotextiles and onsite-consolidation of the clay are in progress.

CONCLUSIONS: Due to the several factors involved in the true depiction of real life behaviour of the reinforced clay structures, it is often difficult and time consuming for conducting large scale tests. However, small scale model tests help us understanding the qualitative response of such structures. It is demonstrated that composite geotextile with thin sand mat improves the load-settlement response of the embankment foundation.

REFERENCE:

Huang,C.C., Tatsuoka,F. and Sato, Y., (1994) Failure mechanism of reinforced sand slopes loaded with a footing, **Soils and Foundations**, Vol. 34, No. 2,pp. 27-40.

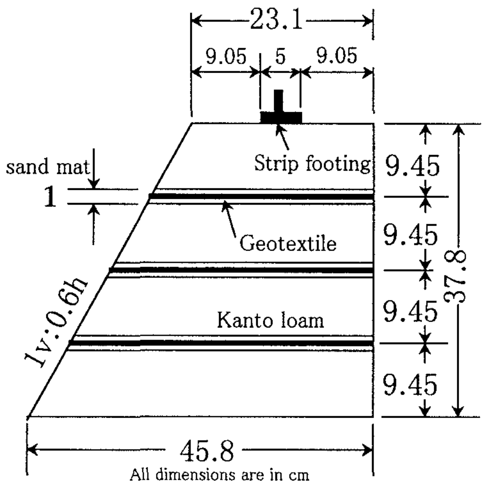

Fig. 1 Model embankment

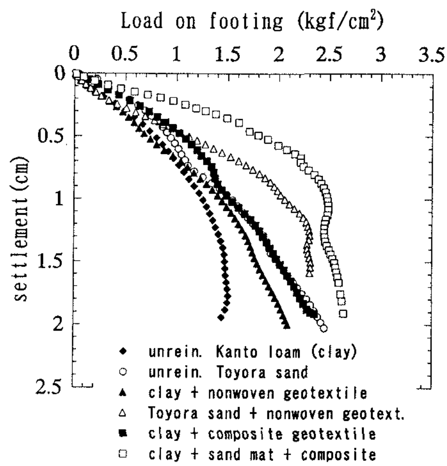

Fig. 2 Load-settlement plot of footing on model embankment

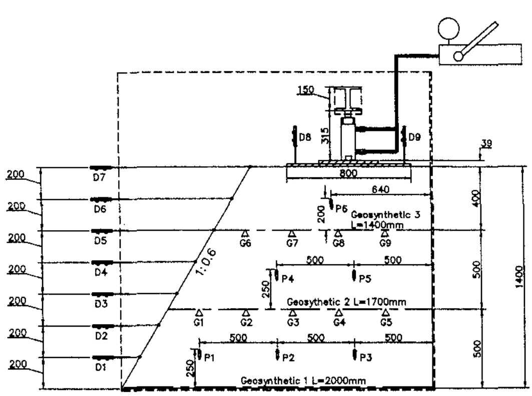

Fig. 3 Field test embankment

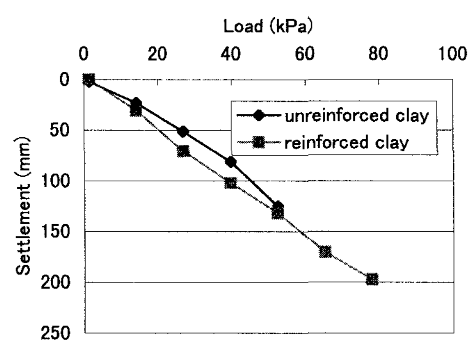

Fig. 4 Load-settlement plot of field test embankment