Earth Reinforcement, Ochiai, Yasufuku & Omine (eds) © 1996 Balkema, Rotterdam. ISBN 90 5410 833 9

Infiltration tests on reinforced clay wall and test embankment

Ching-Chuan Huang & Bor-Nan Huang
National Cheng Kung University, Tainan, Taiwan

ABSTRACT: Infiltration tests are performed both on geosynthetic-reinforced clay walls and a test embankment to investigate the permeability of compacted clay and the stability of reinforced clay walls under heavy rainfall condition. Various soil pre-processing and compaction methods are introduced on low plasticity Alluvial clays for the construction of the walls and test embankment. Outward displacements of wall facings between 5 and 10mm are measured during 50 days of water infiltration on the entire top surface of the reinforced walls. Some consistent test results are also obtained in the infiltration test performed on the top of test embankment using single-ring tube method.

1 INTRODUCTION

The use of non-chemically treated clays as the backfill of reinforced wall is a worth challenging topic nowadays in terms of cost saving and environment protection. A pioneer study on this topic has been conducted by Tatsuoka and Yamauchi (1986). A long-term observation on the behavior of steep reinforced clay embankment has also been reported by Itoh et al.(1994). However, clayey soil has yet been accepted as the backfill material in major construction projects due to the soil-water related problems.

As a preliminary study on the employment of clay as the backfill of reinforced soil retaining system, Huang et al. (1996a, b) constructed 2.77 meter high reinforced clay walls using an Alluvial clay containing more than 90% of fine particles. The clay was compacted with a light tamping rammer weighted 0.64kN under small lift and careful water spreading controls. Monitoring on the behavior of the reinforced clay walls during and after the completion of the wall has been reported elsewhere (Huang, 1996a, b). A test embankment is also constructed using similar soil, yet more practical pre-processing and soil compaction methods. Infiltration tests were conducted on the crest of reinforced walls and test embankment. The soil preparation, the construction of the test embankment, and some infiltration test results are reported herewith.

2 TEST ARRANGEMENT AND RESULTS

A 2.77m high, 6m wide and 3m long reinforced embankment were constructed at the campus of National Cheng Kung University in Tainan City, Taiwan. Two vertical reinforced walls (NCKU walls) were constructed as side faces of this test embankment as shown in Fig. 1. Backfill for the NCKU walls is an Alluvial clay classified as CL according to the Unified Soil Classification System. A woven-nonwoven composite geotextile and a PVC-coated polyester fiber geogrid were used for the right-side wall (R-wall) and the left-side wall (L-wall), respectively. Detailed descriptions on the design, construction and the instrumentation of NCKU walls is reported elsewhere (Huang, 1996a, b).

An infiltration test on the crest of the NCKU walls was carried out on the entire top surface of NCKU walls. An approximately constant water height of 100mm was maintained during 50 days. The outward displacements of the facing for the reinforced walls during the test are shown in Figs. 2(a) and 2(b). It is seen that maximum outward displacements were obtained at the topmost locations near the crest of the walls. During 50 days of continuous water infiltration, outward displacements of the facing ranged between 5 and 10mm were measured. These values are even larger than those occurred during first 330 days of monitoring in which some heavy rainfalls occurred and a uniform surcharge of 6.8kN/m^2 was applied. Although the boundary condition introduced by the

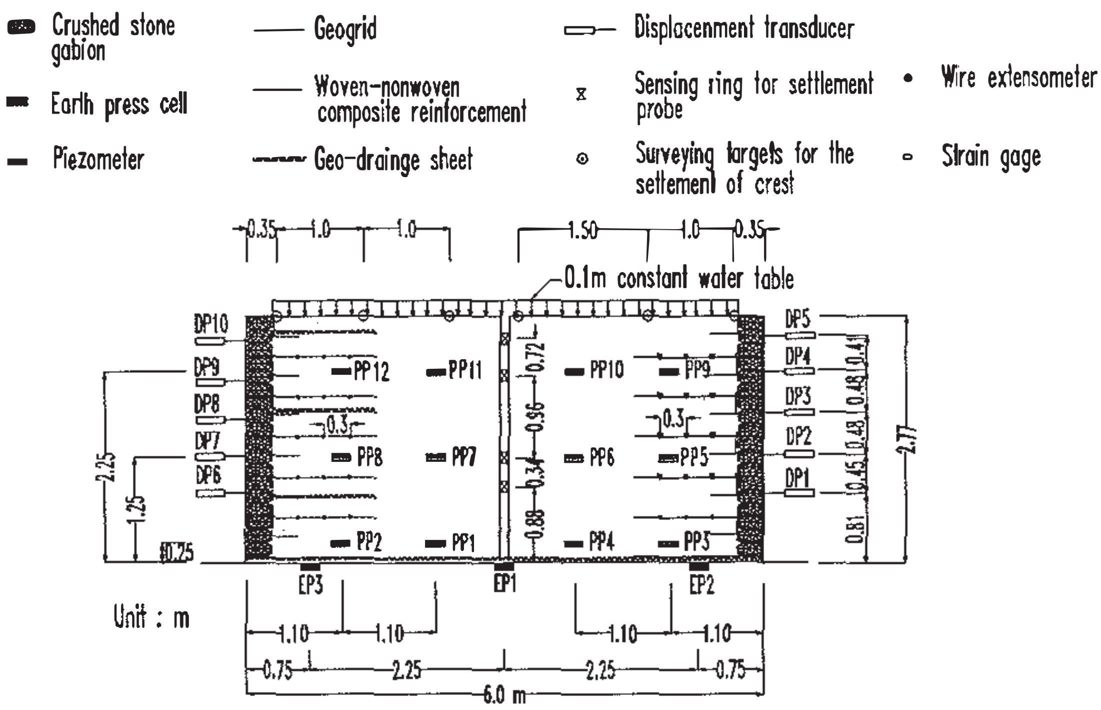

Fig. 1 A schematic view of NCKU reinforced clay walls

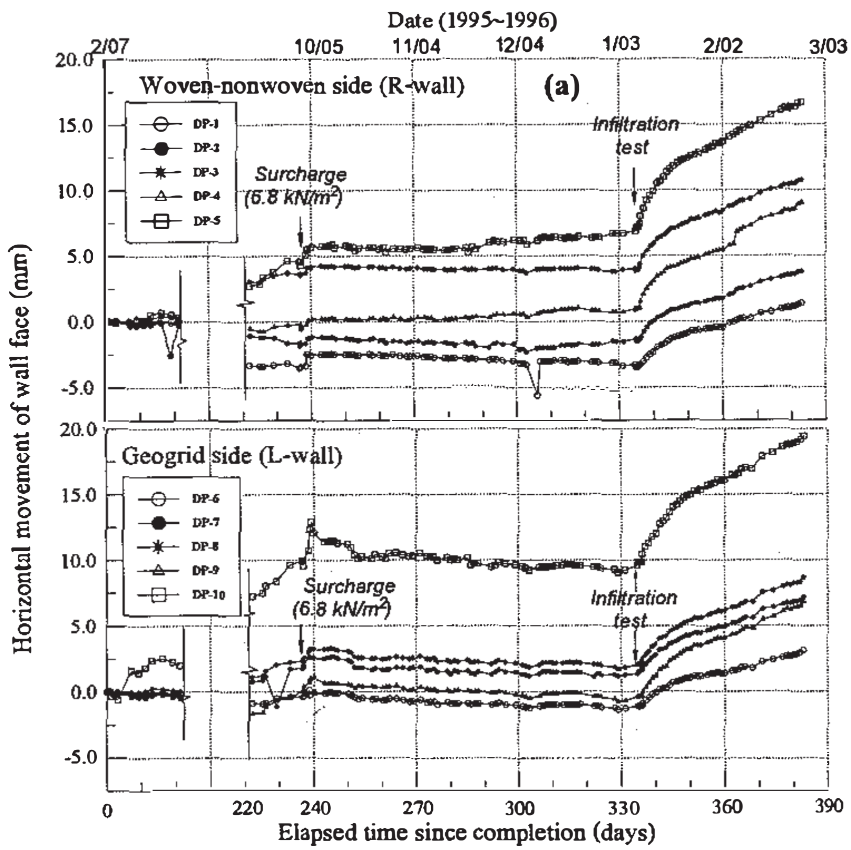

Fig. 2 Outward displacements of facing vs. time relations for
(a) R-wall,and (b) L-wall

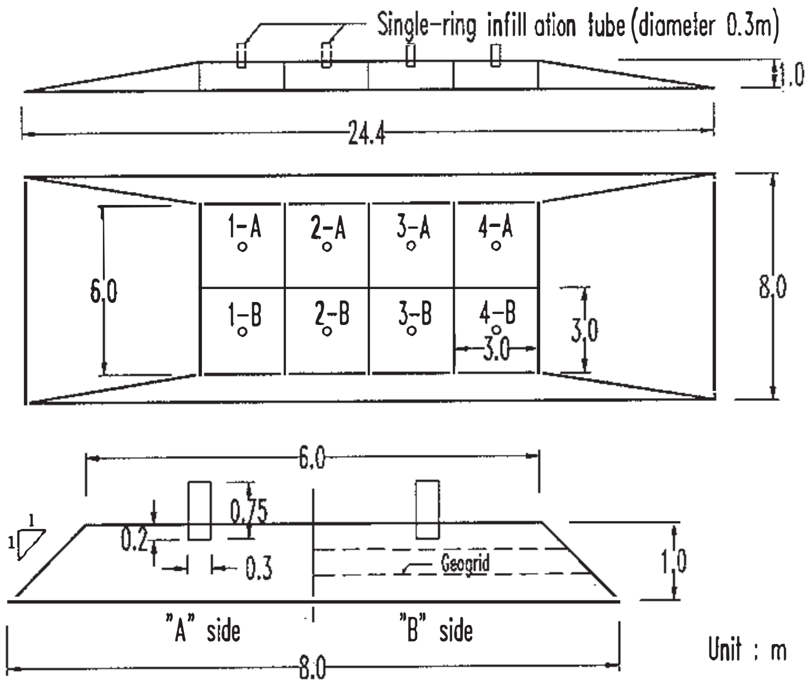

Fig.3 Configuration of the test clay embankment

test is much more critical than what is expected in the practice, the result revealed the importance of a well-functioned drainage system for reinforced clay wall in order to fulfill a higher performance requirement.

A 24m long, 8m wide and 1.0m high test embankment was constructed at a port construction site about 20km from the campus of NCKU using an alluvial clay similar to that used for the NCKU reinforced walls (Fig. 3). Prior to the construction, compaction tests following the procedure in ASTM D698-91 were performed to obtained the compaction curves for the clay. Different clod size distributions were intentionally employed to study the effect of clod size of clay to the compaction curves. Fig.4 shows that the result of compaction was influenced by the size of clay chunk to some degree. Sample 1 demonstrates the standard soil sample preparation procedure. Larger clod sizes were introduced for samples 2 and 3. It is seen that the samples with larger clod size have larger dry densities. However, it is considered that the size and distribution of the macro voids within the compacted clay mass may play a more important role than the dry density especially when the infiltration of water is concerned. Saturated alluvial clay with natural water content of about 22.5% was air-dried on-site for about 47 days. During the air-drying process, the soil was stirred by

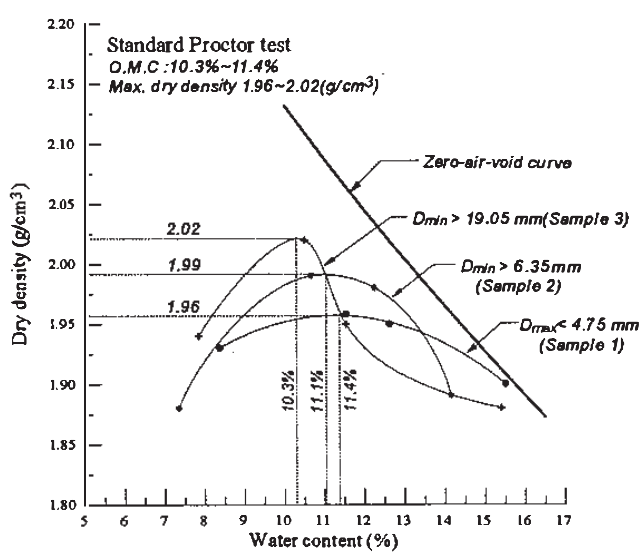

Fig. 4 Compaction curves using standard efforts

using a back hoe for 3 times to expose the soil thoroughly. Photo 1(a) and (b) show a comparison between the original and the ready-for-use states. The ready-for-use clay has typical clod size distributions as shown in Fig. 5, and the water contents between 7 and 9%. Soil was dumped and layered by a shovel to form a layer of soil approximately 100mm thick followed by a manual water spreading using plastic bowls. These process was repeated for 5 times to

Photo 1(a) Original state of Alluvial clay used

Photo 1(b) A view of air-dried clay

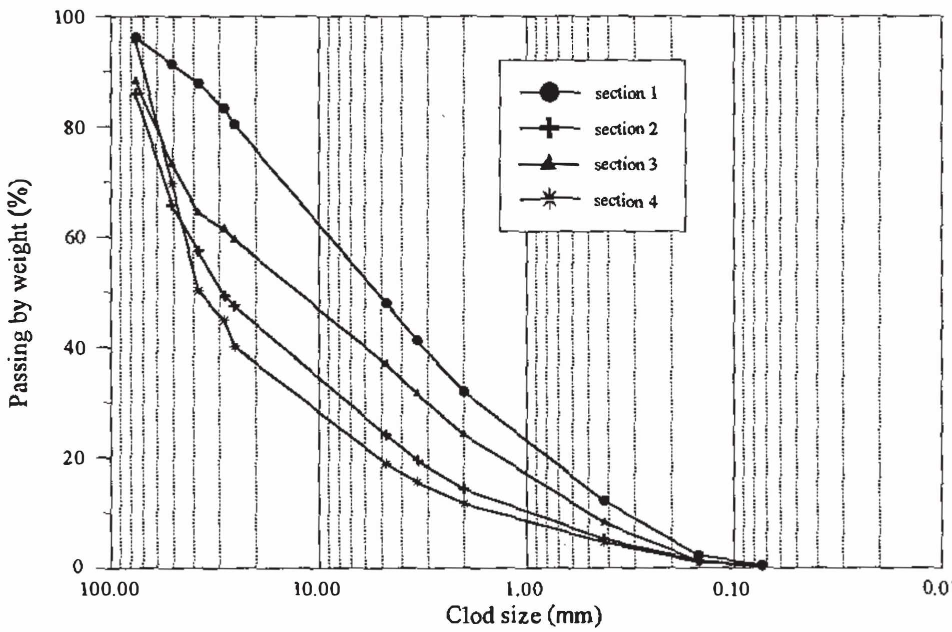

Fig. 5 Clod size distribution of the ready-for-use clay

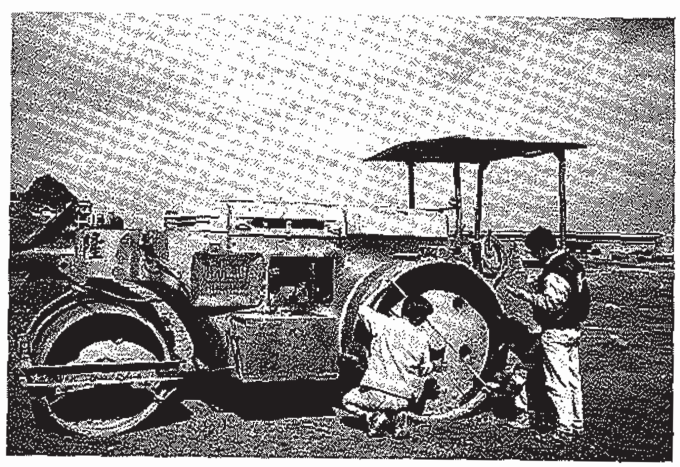

Photo 2 Steel wheel compactor

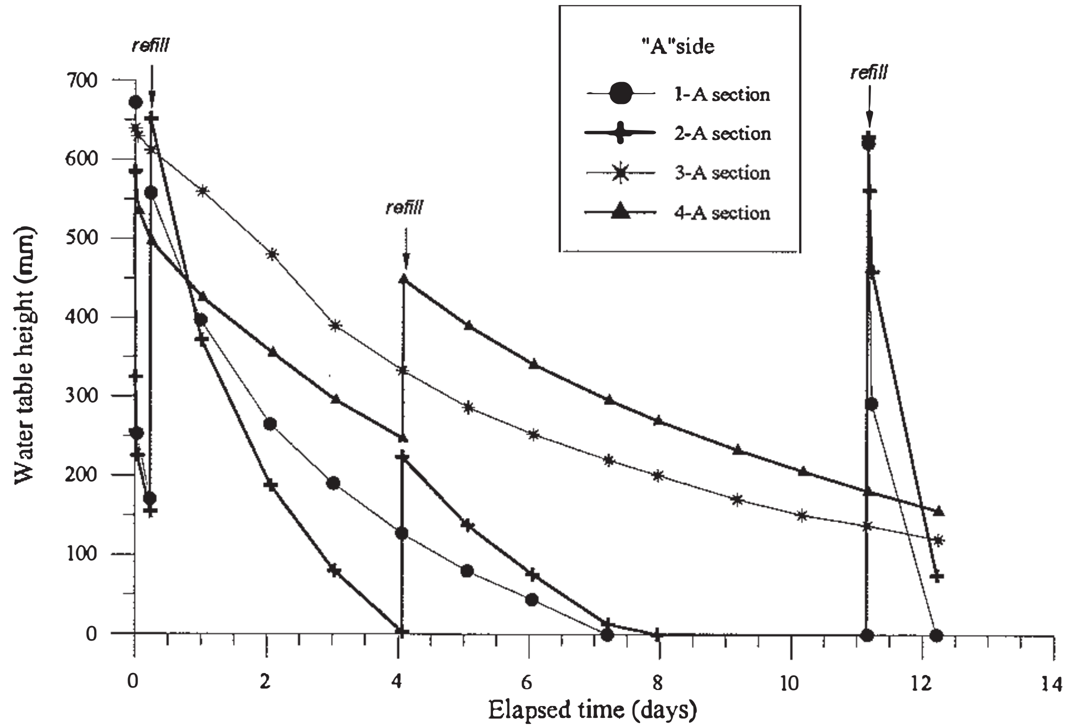

Fig. 6(a) Water table height vs. time relations for non-reinforcement sections of embankment (A side)

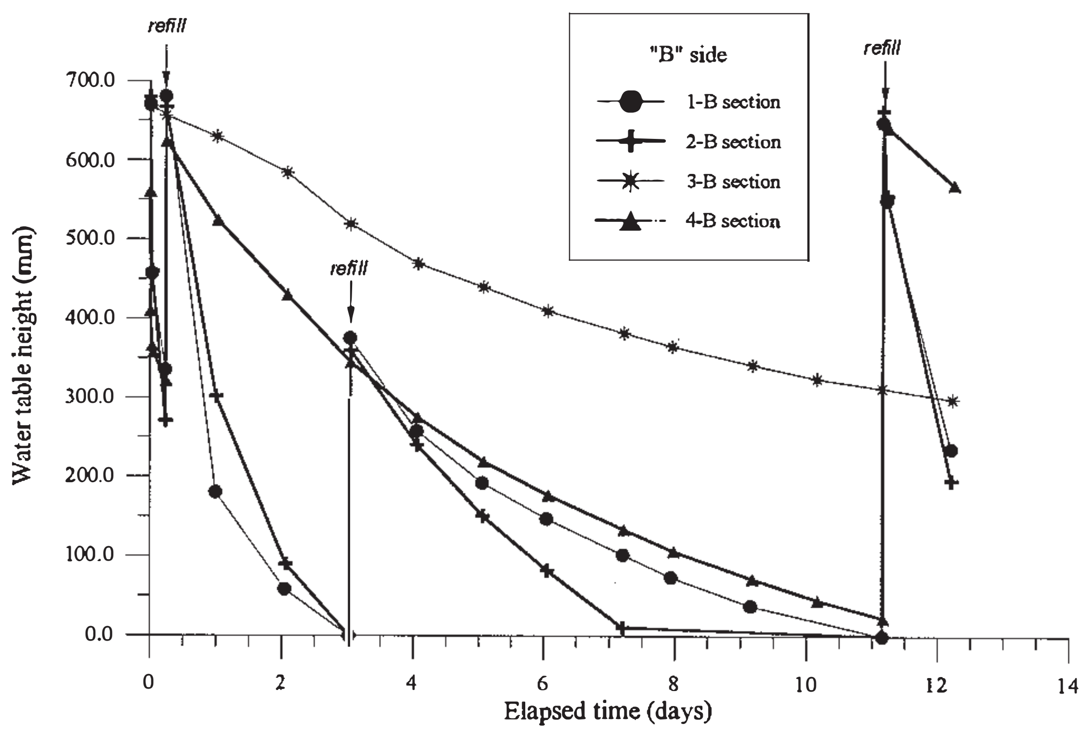

Fig. 6(a) Water table height vs. time relations for non-reinforcement sections of embankment (B side) form a lift height about 40cm for compaction. Compaction effort was provided by a steel wheel roller (Photo 2) weighted 24 kN for the front , and 60.8kN for the reel wheels, respectively. It was shown that 5 passes of roller produced 92% of compaction based on the compaction curve for sample 1 as shown in Fig. 4. Field compaction with 5 passes of roller was then used throughout the construction. The test embankment was divided into eight sections. Sections 1-A and 1-B simulate 3% dry-side compaction; sections 2-A, 2-B, 4-A, 4-B simulate the optimum water content compaction; sections 3-A and 3-B simulate 3% wet-side compaction. The sections denoted by "A" presents the cases without placing reinforcement sheets, while those denoted by "B" present the cases with geogrid sheets placed on the top of each soil lift. Infiltration test and block sampling were carried out immediately after the completion of the test embankment. Fig. 3 schematically shows the infiltration test arrangement. The records of water head drop in the 300mmϕ plastic tubes for various sections of the embankment during the test are presented in Figs. 6(a) and (b). It is clear that the clay compacted at the dry-side (sections 1-A and 1-B) demonstrated the highest infiltration rate, while those at wet-side (section 3-A and 3-B) demonstrated the lowest one. The sections for optimum water content showed equivalent or slightly small infiltration rates than those for dry-side. Comparing the curves for 3-A and 3-B, it is seen that geogrid may have some impact on the enhancement of compaction and reduction of permeability of compacted clay in these cases.

Dismantling of the NCKU walls and the test embankment is to be performed in the near future to investigate the distribution of the water content and the engineering properties of the compacted clayey backfills.

3 CONCLUSIONS

Infiltration test on the crest of the rap-around, vertical facing, NCKU clay walls using 100mm constant water head is performed. It is shown that a long-term percolation of water on the crest has some impact of the stability of the reinforced wall. A maximum outward deformation of the wall facing for about 10mm was measured during 50 days of testing. A test embankment is constructed using clay with maximum clod size of 100mm and a 84.8kN weight steel wheel roller. Infiltration test is conducted on various sections of the test embankment using single-ring tubes under falling water head condition. Test results shows fairly good relationship between the water content of clay during compaction and the permeability of compacted clay. Seepage analyses for unsaturated soil is now undergoing. The final target is to evaluate the feasibility of using clay as the backfill of reinforced wall from the point view of soil-water interaction.

ACKNOWLEDGMENT

This research is financially supported by the National Science Council, Taiwan, R.O.C. under the contract No.NSC 85-2611-E-006-031. The authors appreciate the support from the fishery department of Kaoshiung prefectural office, the Construction department of Chye-Dinq municipal office, the Dah-Donq Construction Company, Ltd., and the Taiwan Fisheries Consultants, Inc.. Assistance from Mr. Tsai, S.R., Mr. Ri, A.L., and Mr. Jou, Y.C., graduate students at Civil Engineering Department, Cheng Kung University is also acknowledged.

REFERENCES

Tatsuoka, F. and Yamauchi, H. (1986) "A reinforcing method for steep clay slopes using a non-woven geotextile." Geotextiles and Geomembranes, Vol.4, pp. 241-268.

Itoh, M, Shirasawa, A. Itoh & Kumagai, K. (1994) "Well documented case study of a reinforced soil wall." Fifth Int. Conf. on Geotextiles, Geomembranes and Related Products, Singapore, September, 1994. pp. 255-258.

Huang, C.C., Huang, B.N, Menq, F.Y., and Tsai, S.R. (1996a) "Infiltration test on full-scale reinforced clay walls", Proc. 3rd Int. Sympo. on Environmental Geotechnology, June 10-12, 1996, San Diego, CA, U.S.A.

Huang, C.C. and Huang, B.N. (1996b) "Design and construction of full-scale reinforced clay wall." submitted to Soils and Foundations for possible publication.

ASTM D698-91: Test Method for Laboratory compaction characteristics of soil using standard effort", 1994 Annual Book of ASTM Standards, Vol. 04. 08.