The effects of sandwich earth structure on reduction of clogging in geosynthetics

University of Tsukuba, Chandan Ghosh
Ibaraki University, Fellow, Kazuya Yasuhara

Abstract: This paper reports an experimental investigation on the performance of a geocomposite drain layer embedded within Kanto loam slurry that undergoes consolidation. Five possible arrangements of the drain layer were investigated in which in-plane flow capacities were checked at every stage of consolidation. Both in-plane and cross plane flow capacities of the extracted drain specimens have been measured. Thin sand mat worked well as a protective blanket against clogging. Hybrid systems showed excellent drainage abilities with almost zero clogging. A design chart consisting of transmissivity and permittivity ratios has been prepared.

Introduction: Soft soil is not suitable for use in earthworks, because of its high compressibility, low friction, excess pore water pressure, creep settlement, and related weaknesses typical with non-granular soils. However, there are situations where use of such problematic soils is unavoidable due to economic and other factors. High strength permeable geotextiles offer possible solutions under these conditions. Giroud (1983) gave a theoretical explanation for the use of geosynthetics to accelerate soil consolidation. In general, non-woven geotextiles are permeable and compressible materials. As the thickness of the geotextile reduces under stress so does its coefficient of permeability and pore dimensions (Gardoni and Palmeira 2002). The work described in this paper involves the development of an effective non-clogging drain system from a combination of geosynthetic materials and granular materials. Such a drainage system fabricated from geosynthetics would have a number of advantages compared to a conventional granular soil-based system, that is:

- desirable properties can be optimized by design and controlled during manufacture and these products can be readily delivered to the site for implementation;
- drainage functions can be combined with other functions such as reinforcement and soil retention, and
- the synthetic geotextile surfaces are rough enough to have frictional interaction with granular soil. However, this interaction is not obvious when fine-grained soils are used. A combination of thin sand mat and high strength geocomposite may suffice to meet the need for anti-clogging and increased stability (Yasuhara et al. 2002).

Experiments performed: Details of the experimental set-up, selected geocomposite and geotechnical properties of Kanto loam are given in Ghosh and Yasuhara (2004). A geocomposite specimen (120 mm-length X 50 mm-wide) was placed within Kanto loam slurry. Five possible arrangements were made; 1. A thin sand mat inside the soil, 2. A geocomposite layer inside the soil, 3. Thin sand mat at the top of the geocomposite layer, 4. Thin sand mat on both sides of geocomposite layer, and 5. Thin sand mat covered by two geocomposite layers. The schematic of the experimental set-up and drain layer arrangements are shown in Fig. 1.

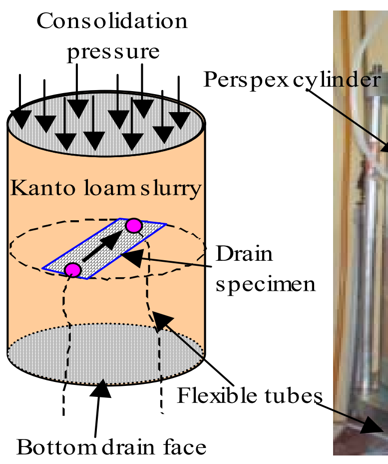


Fig.1a) Schematic of experiment with drain specimen

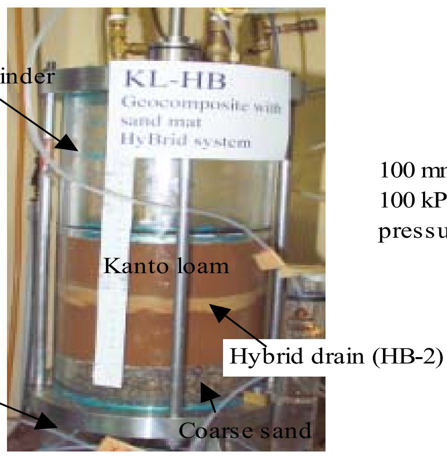


Fig.1b) View of experimental set-up with hybrid system inside

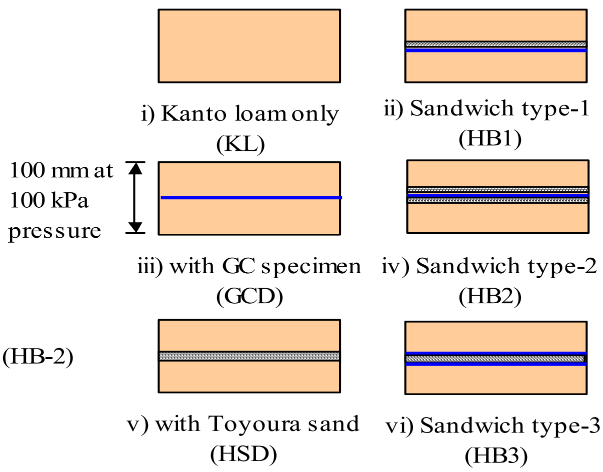


Fig. 1c) Arrangement of drain layer within Kanto loam

Discussion of test results: Changes in the transmissivity of various drain systems are described in Fig. 2a for Kanto loam. Significant reduction (Fauri and Fabian 1987, Chai and Miura 2002) in the transmissivity occurred for geocomposite drains. Transmissivity in the non-clog drain specimen was obtained by conducting in-plane flow in an apparatus developed for this purpose. There was not much changes in the rate of reduction for hybrid drains and horizontal sand drain (HSD). Out of three hybrid systems, HB2 showed excellent flow capacity. The apparent difference in the transmissivity of HB2 and non-clog drain layer could be due to; 1. boundary and interface effect, 2. thickness of the geocomposite drain layer and thin sand mat.

Keywords: Geocomposite, Sandwich mat, Hybrid system, Clogging potential, Kanto loam, Transmissivity, Permittivity
Contact: PIN 305-8573, Visiting Researcher, Institute of Engineering Mechanics, University of Tsukuba, Japan

In order to highlight the relative performances of the GC drain and hybrid drain systems a new term, **"clogging potential",** has been defined and depicted in Fig. 2b. Qualitatively if clogging potential of a drain system is high, it means that particular drain is more susceptible to clogging in the field condition. In the present context it is also important to specify clogging potential with increasing confining pressure. It was evidently observed that the clogging potential of the hybrid drain layer was lower than the same found with the GC drain layer. Interestingly clogging potential of the hybrid drain reduces with the increase in consolidation pressure. This means hybrid drains become more efficient at increasing confining pressure. In contrast the clogging potential of the GC drain is higher than the same for hybrid drain and its efficiency reduced with the increase in confining pressure (Fig. 2b). After consolidation test the drain specimen was extracted and flow capacity in its plane and x-direction were measured. Equivalent confining pressure was applied during flow test. Fig. 3a presents a design chart explaining the effect of sandwich system under confining pressure. As explained in Fig. 2a, transmissivity reduces with increasing pressure. The rate of reduction in the confining pressure was higher than the same for hybrid drains. Thin sand mat prevented clogging (Fig. 3b), which is reflected in the flow capacity of the exhumed drain specimen.

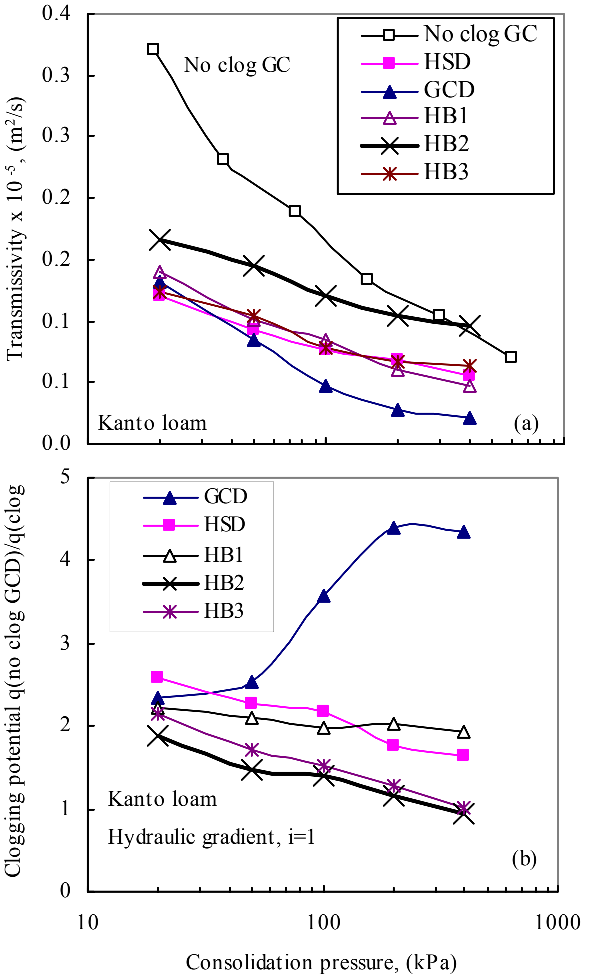
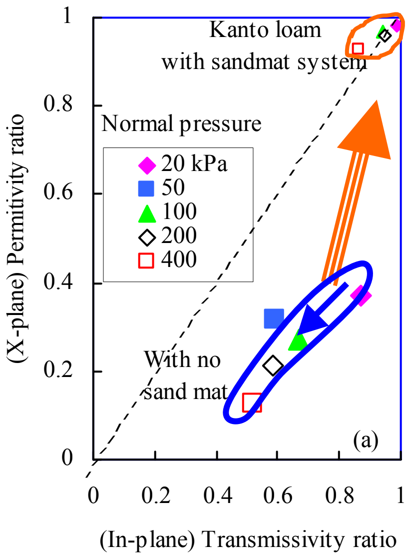


Fig. 2 (a) Transmissivity of various drains confined within Kanto loam, (b) Changes in the clogging potential of various drains with increasing consolidation pressure

Conclusions: Clogging potential of the hybrid drain system decreased with increasing confining pressure. This means hybrid drains become more efficient at increasing confining pressure. In contrast the clogging potential of the GC drain is higher than the same for hybrid drain and its efficiency reduces with the increase in confining pressure. Hybrid system investigated in this study proves to be a good drain medium with almost zero susceptibility to clogging. Moreover, frictional interaction at the interface of high strength geocomposite and granular mat ensures suitable application of this system for the stability enhancement of the reinforced earth structures with fine-grained soil as backfill. Thin sandmat was found effective in preventing clogging by Kanto loam.



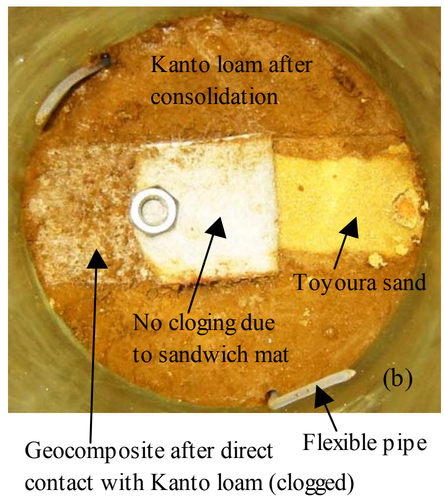


Fig. 3a Effect of sandwich mat on the in-plane and x-plane flow characteristics of drain layer
Fig. 3b Geocomposite (HB1) drain specimen after in-plane flow test during consolidation

References:

1. Chai, J.C. and Miura, N., 2002, Long term transmissivity of geotextiles confined in clay", *Proc. 7th International Conf. on Geotextiles*, Nice, France, pp. 155-158.
2. Fauri, A.B. and Fabian, K.J., 1987, "Laboratory determination of clay geotextile interaction", *Geotextiles and Geomembranes*, Vol. 6, No. 4, pp. 275-294.
3. Ghosh, C. and Yasuhara, K., 2004, "Clogging and flow characteristic of a geosynthetic drain confined in soils undergoing consolidation", *Geosynthetics International*, USA (to appear in Vol. 11, No. 1).
4. Gardoni, M. G. and Palmeira, E. M., 2002, "Microstructure and pore characteristics of synthetic filters under confinement" *Geotechnique,* Vol. 52, No. 6, pp. 405-418.
5. Giroud, J.P., 1983, "Geotextile Drainage layers for Soil Consolidation", *Civil Engineering for Practicing and Design Engineers,* Vol. 2, pp. 275-295.
6. Yasuhara, K., Hirao, K. and Tanabashi, Y., 2002, "Effects of sand mat on soft soil reinforcement using geosynthetics", *Proceedings of the International Symposium on Lowland Tech.,* ISLT 2002, Saga University, Japan, Vol. 1, pp.149-154.