Hydraulic barrier performance of fiber-reinforced cement treated clay

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1. INTRODUCTION

In coastal landfill sites, the liner system for waste containment is a important component to avoid the contamination of the surrounding environment. Thus, it is necessary to maintain its hydraulic barrier performance in the long term under the field conditions. Hybrid clay barrier (HCB) is a fiber-reinforced geomaterial developed for the barrier material in the containment system and has a feature to improve toughness of brittle cement treated clay (CTC) by inclusion of polymeric fibers. HCB consists of a) dredged slurry with its water content of 150 to 250 % (approximately twice of its liquid limit), b) hardening agent or cement of 50 to 100 kg/m^3 and c) polymeric fibers, e.g. polyvinyl alcohol (PVA) fiber of approximately 1 % per unit volume of slurry. Fiber reinforcement is employed to restrain local failure and resultantly development of failure surface due to the tensile forces induced by the fibers. Accordingly, HCB is expected to keep its hydraulic barrier performance when it was subjected to large deformation caused by earthquake motions and settlements of the soft foundation ground. In this study, to clarify the mechanical and hydraulic barrier performances of HCB, three different laboratory tests were conducted as follows,

Test-1: Hydraulic barrier performance of fiber-reinforced cement treated clay subjected to large deformation
Test-2: Deformability and hydraulic performance of the fiber-reinforced cement treated clay subjected to cyclic loading,
Test-3: Interface transimissivity between fiber reinforced cement treated clay and geomembrane sheet

2. EXPERIMENT

Each test procedures were as follows; Test-1: To clarify quantitatively the hydraulic barrier performance in relation to strain and stress levels, a series of hydraulic conductivity tests were conducted on the specimens that had suffered from relatively large strains in triaxial compression states, Test-2: To clarify the seismic performance, cyclic triaxial tests with various stress ratios (0.02 to 0.8) were performed at a constant frequency (0.1Hz) and a number of cycles (11 times). Then, falling head hydraulic conductivity tests were conducted for the specimens subjected to cyclic loading, Test-3: To clarify the interface transimissivity between HCB and a geomembrane, sheet a series of hydraulic conductivity tests were conducted on the specimens to which a few pieces of geomembrane sheet were inserted.

3. RESULTS AND DISCUSSIONS

The outlines of the testing results are as follows:

Test-1: As shown in Figure 1 which indicates the relationship between the deviator stress ($(\sigma_1 - \sigma_3)_{max}$), axial strain ($\varepsilon_h$) and hydraulic conductivity (k), hydraulic conductivity values of HCB significantly increased when the axial strain changed from 2% to 5%. However, they mostly remained in the range lower than 1.0×10^{-6}cm/s even when the axial strains were more than 10%. In the cases with the confining pressures of 0 and 50 kN/m^2, fiber reinforcement was so effective that the hydraulic conductivity of HCB was lower than that of the cement treated clay under a certain deviator stress condition.

Test-2: Only 0.25% of shear strain was accumulated in both HCB and cement treated clay even for the maximum stress ratio. The shear modulus of rigidity and equivalent damping ratio of the HCB were similar to those of the cement treated clay within the observed strain range. Even the HCB subjected to the maximum shear deformation maintained its hydraulic conductivity, $1.0\text{x}10^{-9}$ m/s, which is lower than the target value of $1.0\text{x}10^{-8}$ m/s, regulated in the Japanese domestic structural code of the lining system for the landfill.

Test-3: The interface transimissivity between HCB and geomembrane was $\theta_t = 3.9 \sim 5.9 \text{ x } 10^{-12}$ m^2/s, which is sufficiently low to employ the HCB for the anchorage component of the geomembrane liner in the coastal landfill.

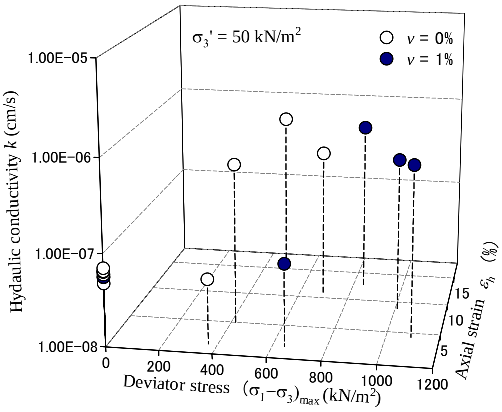

Figure 1. $(\sigma_1 - \sigma_3)_{max}$ vs. ε_h vs. k relation

4. CONCLUSIONS

Under the condition that a relatively low confining pressure (normally 5 to 10 m in depth) acts on the liner system, as observed in the coastal landfill, the hydraulic conductivity of HCB was much lower than the regulated value ($1.0\text{x}10^{-8}$ m/s) in the Japanese domestic structural code of the lining system for the landfill, due to the restraining effects of local failures, even when it is subjected to large deformation or cyclic loading, which is caused by earthquake, wave and tidal actions, and settlement of underlying seabed in field condition.