Paradigm Shift in Earthquake Induced Geohazards Mitigation

– Emergence of Nondilatant Geomaterials -

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INTRODUCTION

Many sustainable construction techniques using materials derived from scrap tires have been developed in Japan. Scrap tire derived materials (such as granulated rubber, tire chips, tire shreds, etc) are emerging geomaterials, which have gradually made their presence felt in the Geotechnical construction because of their multifaceted ground improving characteristics, one of which is the nondilatancy. Researches on applications of tire chips as ground improving geomaterials have seen a tremendous progress in Japan and throughout the world [1]. Especially various techniques have been developed in Japan as countermeasures against earthquake induced geohazards. They can be categorized into three groups: 1) Ground improvement by full replacement, 2) Foundation Improvement using base isolation layer, and 3) Tire chips drain for dissipating the excess pore water pressure. Whatever techniques are adopted in practice, it is very important to know three very important characteristics of such materials: 1) earthquake resistant characteristics (including the dilatancy) 2) the interfacial behavior at the boundaries of tire chips, soils and the structures involved and 3) liquefaction behavior of tire chips mixed sandy soils. In this paper, the potentials of tire chips as earthquake hazards preventive material are evaluated.

EVALUATION PROCESS

Evaluations were based on a series of laboratory testing of pure tire chips (both small size and large size) and tire chips mixed sand, which are described here. Firstly the characteristics of tire chips under cyclic loading are evaluated through the results from direct shear testing and triaxial testing on larger size tire chips. Also, the liquefaction potentials of the tire chips (smaller size) and tire chips mixed sandy soils are evaluated based on the results from undrained cyclic triaxial testing. This paper then discusses some non-destructive testing methods such as X-ray scanning techniques and Particle Image Velocimetry (PIV) analysis to evaluate the internal structure and deformation mechanism of tire chips. Direct shear testing procedures are described, in which the deformation behavior of sand as well as layers of sand and tire chips were examined. Finally, a series of tri-axial testing program of tire chips-sand mixtures are described through which the deformation characteristics of tire chips and tire chips mixed sandy soils were examined. The following section summarizes some of the important conclusions derived from each of those testing program.

**SUMMARY AND CONCLUSIONS**

Large-scale cyclic direct shear testing

Energy absorbing capacity is an intrinsic property of tire chips, which can be exploited to use in application such as vibration absorbing cushion [2]. Based on the results from direct shear testing using large size tire chips, it was found that the energy absorbed by specimens using pure tire chips is more than twice that of the specimens of tire chips mixed sand. However, specimens using tire chips mixed sand can absorb more than thrice that of the specimen using pure sand. Shear modulus of tire chips increases when mixed with sand.

Large-scale cyclic triaxial testing

Based on the results from triaxial testing using large size tire chips, it was found that as compared to the conventional geomaterials, degradation of the equivalent shear modulus of tire chips is significantly less with increasing shear strain. Damping ratio also shows only a mild increase (less than 5%) with increasing shear strain. Though not significant, density was found to be affected by the grain size.

Undrained cyclic triaxial testing

Cyclic undrained triaxial tests on small size tire chips and tire chips mixed sand revealed that pure tire chips have very small stiffness and displacements are easily generated during cyclic shear loading, resulting in visco-elastic stress-strain relation. Moreover, excess pore water pressure is not generated during cyclic loading and liquefaction does not occur. For specimens with sand fraction less than 0.5, liquefaction was not clearly observed. Tire chips appear to control the build-up of excess pore water pressure through its negative dilatancy.

Non destructive testing method

Non destructive testing methods confirmed that under direct shearing (static load), shear stress of tire chips is small and increases monotonically compared to that of sand, and there is no peak stress for such material. X-ray scanning revealed that tire chips does not exhibit any dilatancy. PIV analyses indicate that the phenomenon of strain localization does not occur in tire chips, and therefore, tire chips could have a tremendous potential for applications in various geotechnical projects.

**REFERENCES**

[1] Hazarika, H. and Yasuhara, K. (2007). Scrap Tire Derived Geomaterials - Opportunities and Challenges -, Taylor & Francis, London, UK.

[2] Hazarika, H., Kohama, E., and Sugano, T. (2008). Underwater Shake Table Tests on Waterfront Structures Protected with Tire chips Cushion, Journal of Geotechnical and Environmental Engineering, ASCE, 134(12), 1706-1719.