Large scale footing tests for evaluating vertical earth pressure distribution of shredded scrap tire geomaterials

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1. Introduction:

Number of scrap tires in Japan is estimated to 106 million in 2006 [1] which constitutes a large quantity of solid waste. While 88% of the annually produced scrap tires are reused and/or recycled, the share in material recycling sector is constituted only by 15%. Therefore, many efforts to recycle scrap tires have been made to increase the share of material recycling of scrap tires [2, 3]. In-line, a research project has been initiated to explore the earth pressure reduction potentiality of scrap tire shreds for their use as lightweight fill materials. A comparative model test evaluation has shown that lateral earth pressure exerted by tire rubber grains is lower than sand [4]. The present research is aimed to evaluate vertical earth pressure distributions of scrap tire shreds with and without top sand cover layer by conducting footing tests using a large-scale soil box in laboratory. A report published elsewhere demonstrates that the use of tire shreds as backfill could improve the performance of retaining structures [5].

2. Experimental Procedure: Large scale footing tests were carried out to evaluate vertical earth pressure distribution of scrap tire shreds in laboratory. A soil box with specifications of 2000x1000x1000mm was used for preparing the test specimens. Tire shreds layer with a compacted layer thickness of 200mm was first prepared upon laying and compacting tire shreds in the soil box. In a very similar fashion, subsequent layers of tire shreds were placed to prepare the 800mm thick specimen for testing as shown in Fig.1. As may be seen, scrap tire shreds used are mainly non-spherical types, and contain steel, textile cords embedded inside the rubber as it was in the tire. Size of scrap tire shreds used in the test specimen ranges from 20-70mm, and are quite uniformly graded. Bulk density of tire shreds specimen in the soil box was 6.5kN/m^3 (material density: 12.5 kN/m^3 approximately). Further tests were also carried out on tire shreds specimen covered with sand (No.3 Keisha) on the top. It is essential to mention that nonwoven geotextiles were laid on tire shreds before placing sand cover layer on it. Two variations of cover sand layer thickness, viz., 100 and 200mm were used for footing tests. As schematically shown in Fig.2, a number of pressure transducers were used for measuring pressures exerted at the various base points due to loading applied on a footing plate of size 500x250mm placed on top of the specimen. For testing, an incremental loading profile is followed which is applied on the footing plate by a loading system attached with the soil box. Arrangements were also made to measure the displacements of footing plate during loading.

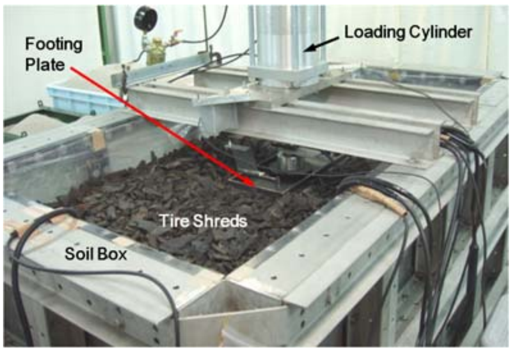

Fig.1 Large scale soil box used.

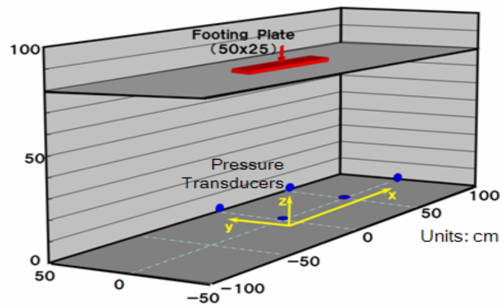

Fig.2 Positions of pressure transducers.

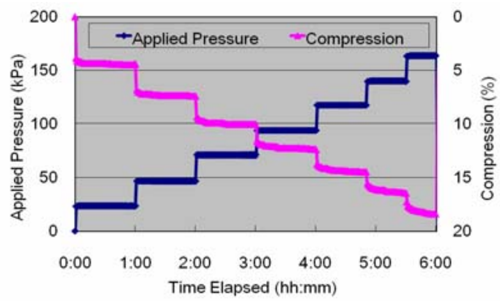

Fig.3 Applied pressure and compression levels.

3. Results and Discussion: A typical case of loading profile applied, and consequently specimen compression occurred (displacement in the footing plate) during testing of tire shreds specimen are shown in Fig.3. It is essential to mention that irrespective of specimen type under testing in the soil box, all pressure transducers were always calibrated to zero before loading profile applied on the footing plate.

Key Words: tire recycle, scrap tire shreds, vertical earth pressure.
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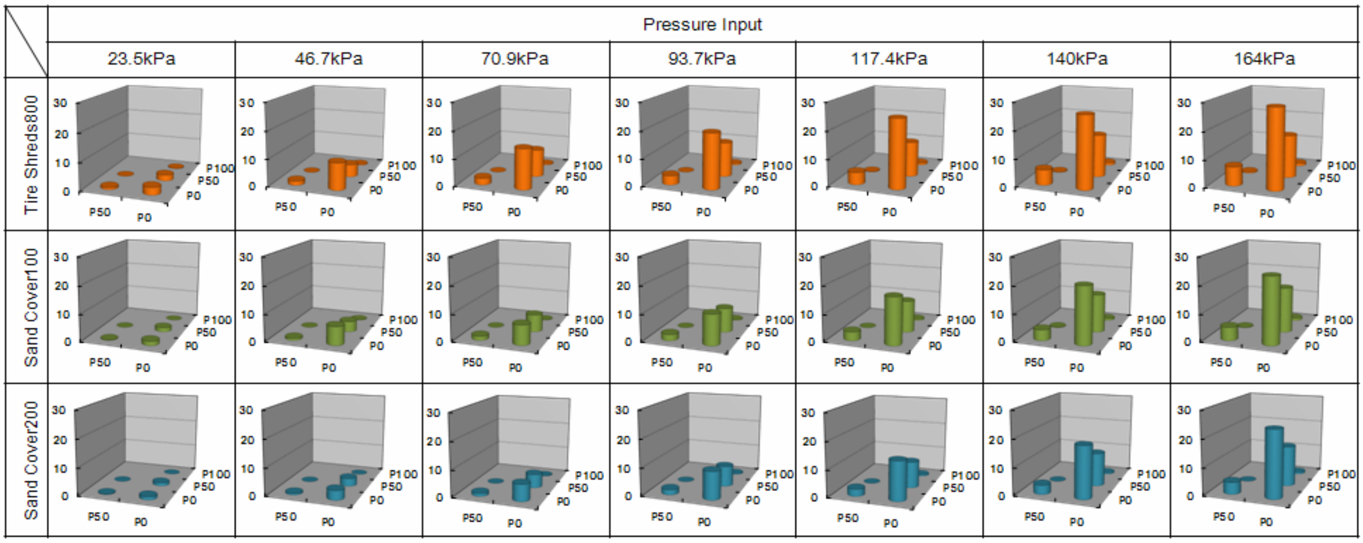

Fig.4 Pressure distributions for different levels of loading (levels on vertical axis are pressures in kPa).

Pressure distributions obtained for different specimens tested are shown in Fig.4. For any given input loading level, pressure levels for Tire Shreds800 specimen show higher values compared to specimens covered with sand. It may be believed apparently that the pressure levels exerted for sand covered specimens under a given input loading assume lower values due to increased distance of loading point because of in-between sand layer placement. Figure 5 compares a typical case of equal level of pressures exerted at point P(0,0,0) for Tire Shreds800 (at 70kPa) and Sand Cover200 (at 117 kPa) specimens. As may be seen, pressures at other points are also very similarly distributed which in other words mean that the possibility of lateral earth pressure reduction potentiality of these two cases are same though a higher footing load (surcharge) is applied to the Sand Cover200 specimen. From the measured levels of footing plate displacements, compressions of tire shreds layer for each cases are calculated which are shown in Fig.6. As evident, compression of tire shreds layer decreases with the placement of top sand cover, and it may be due to the pre-consolidation of tire shreds layer owing to sand weight placed on the top. For a similar pressure distribution profile, therefore, sand covered tire shreds specimen performs better by exerting less compression in the structure.

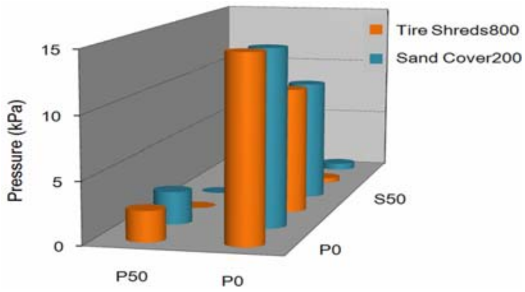

Fig.5 Pressure levels for Tire Shreds800 *at 70 kPa and* Sand Cover200 *at 117kPa.*

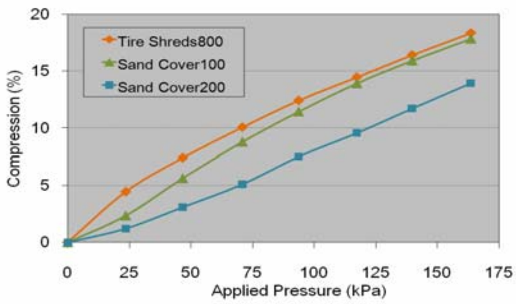

Fig.6 Compressions of tire shreds layers.

4. Summary: With the aim of increasing the use of scrap tires in civil engineering applications, various studies to evaluate the geotechnical engineering properties of tire shreds have been initiated. The present study is aimed to evaluate vertical earth pressure distribution of scrap tire shreds with and without top soil cover by conducting footing tests in laboratory using a large sized soil box for exploring their use as lightweight fill/backfill materials. Scrap tire shreds is found to perform better in terms of lower earth pressure levels exerted due to footing load (surcharge) when soil cover is placed on top. Compression exerted in the tire shreds layer also decreased notably due to top soil, which in fact may act as material weight helping to pre-load the tire shreds below. Based on the merits of better performance, and the considerations of other technical aspects associated with tire shreds, it may be said that the use of scrap tire shreds with soil cover is structurally beneficial for their use as lightweight fill materials.

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