Study on thermal insulation behavior of scrap tire materials for their use in cold region civil engineering applications

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1. Introduction: It is estimated that 88% of 104.3 millions of scrap tires generated in Japan for 2004 are reused and/or recycled [1]. However, the overall share recorded for material recycling items is limited to 17%. With the aim of increasing the share of scrap tires in material recycling sector, a research project has been initiated by our group to explore the possibility of their use as geomaterials in civil engineering applications [2, 3]. It is reported that scrap tires possess various properties e.g., lighter, resilient, water-proof, insulating, durable, etc., and such properties are recognized as beneficial to many civil engineering projects [4]. The present research is aimed to explore the thermal insulation behavior of scrap tire shreds for their use in cold region civil engineering applications. A field trial on the use of tire shreds as insulation for paved roads published elsewhere demonstrates that the use of tire shreds and tire shred/soil mixtures could improve the performance of paved roads in seasonally cold regions [5].

2. Experimental Procedure: For highlighting the differences, if any, in the properties of thermal insulation of scrap tire shreds and gravel, simple laboratory experiments on the thermal conductivity behavior of scrap tire derived rubber grains and sand are performed. For this purpose, a Thermal Conductivity Meter is used which is meant for measuring thermal conductivity of materials in sheet to blanket/plate forms with thickness below 10mm. Due to such instrumental limitations, only finely grained materials namely, Toyoura and Sohma sand, and almost similarly distributed (see Fig.1) scrap tire derived fine grained rubber materials are selected in this study for evaluating relative thermal conductivity behavior. A rectangular frame is made to form a blanket shaped test piece from selected material which is then sandwiched between known-conductivity reference plates and sensor, sequentially, for measuring thermal conductivity (Fig.2). Five observations are made for each kind of material. In order to study the in-situ performance of scrap tires on thermal insulation aspects, an instrumented test section is constructed at Hokkaido using scrap tire shreds as test specimen. A very similarly designed control section using gravel is also constructed side by side for comparative study. A number of sensors are embedded at various locations during construction for reading temperature over time which are recorded in the data-logger placed in a control unit.

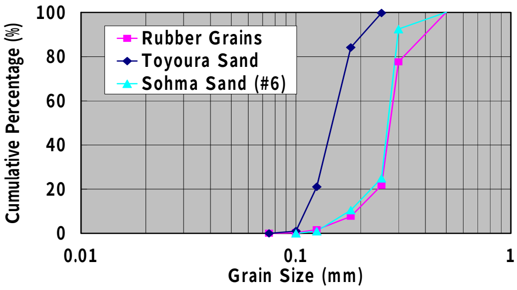

Fig.1 Grain size distribution curves.

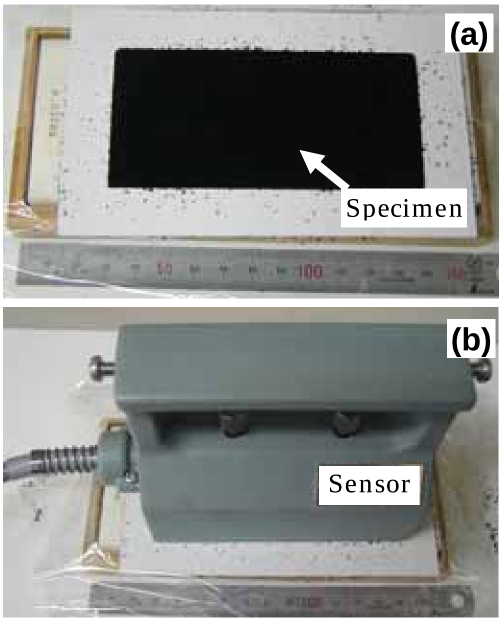

Fig.2 Thermal conductivity test; (a) rubber grain blanket (b) measurement in progress.

3. Results and Discussion: Results of thermal conductivity of finely grained rubber material and sand are shown in Fig.3. As may be seen, thermal conductivity of sand is 3 ~ 4 times higher than rubber materials. Therefore, it would be logical to say that the thermal insulation behavior

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of tire rubber material is superior than sand. Though the tests performed here are only relative in nature, and also the materials selected presently are far from representative-size as compared to generally used gravel and/or other equivalent materials, one may argue at this point that the use of scrap tire shreds could be beneficial for mitigating frost penetration phenomena in the cold region civil engineering structures. It is reported that scrap tire shreds could improve the performance of frost-susceptible soil structure not only due to its superior thermal insulation behavior but also due to its free draining criteria [5].

In order to investigate the in-situ performance of tire shreds in thermal insulation application e.g., frost-penetration phenomena in the cold region, an instrumented test section is constructed at Hokkaido. A highway drainage system stretched over 100m long trench is constructed using large-sized pre-cast concrete troughs. One side of the concrete troughs is backfilled with tire shreds while the other side is backfilled with gravel in a very similar fashion for having control section in this study. Width of backfill (insulation) layer is about 500mm. A cross-sectional view of the constructed trench is shown in Fig.4. Scrap tire shreds and gravel used in the backfills are shown in Fig.5. Tire shreds are uniformly graded (size range: 20-60mm) as compared to gravel which is conventionally used for this purpose.

A number of sensors are embedded within backfill as well as in neighboring soil during construction for measuring temperature. Fig.6 (inset) shows the sensor positions which are in fact mirror imaged for comparative study. A few of the typical temperature distributions in tire shred test section are shown in Fig.6 along with their counter positions in gravel section. As evident, all the temperatures recorded in backfill and neighboring soil are above 0°C despite a local minimum atmospheric temperature of -20°C. Distributions of temperature in tire shred section are found to be higher than those of in control section which may indicate the effectiveness of scrap tire shreds for mitigating frost penetration phenomena in cold region civil engineering structures. To be in the conservative side, it may be said that performance of scrap tire shreds is equal, if not better, to gravel.

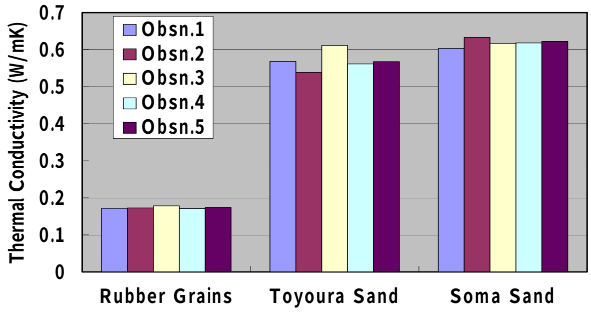

Fig.3 Relative values of thermal conductivity.

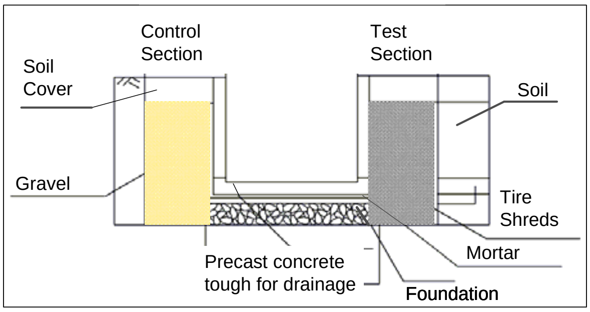

Fig.4 Cross-sectional view of control/test sections

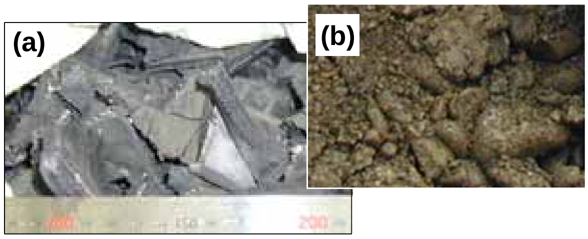

Fig.5 Materials used (a) tire shreds (b) gravel

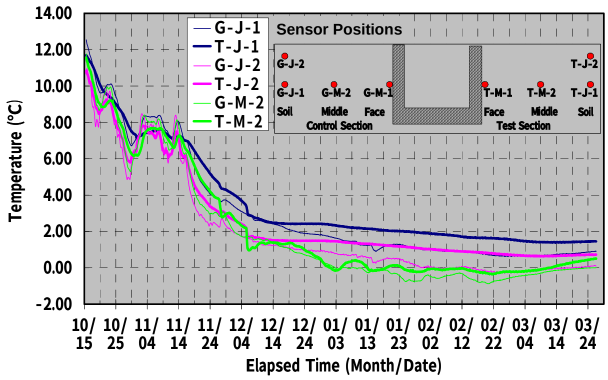

Fig.6 Temperature distribution at control/test section.

4. Summary: The present study is aimed at addressing the thermal insulation behavior of scrap tire rubber materials for their use in cold region civil engineering applications. In this direction, preliminary laboratory studies are performed for evaluating relative thermal conductivity of scrap tire derived fine rubber grain materials over common sand, followed by a study in in-situ conditions. Scrap tire shreds is found to be acting better as insulation barrier over a control section, and consequently, it may be said that scrap tire shreds may effectively be used in mitigating frost penetration phenomena.

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