In-situ performance of scrap tire shreds in thermal insulation of cold region civil engineering structures

○Ashoke K Karmokar, Member, Bridgestone Corporation
Hideo Takeichi, Member, Bridgestone Corporation
Hidea Ego, Non-member, Mukawa Town Hobetsu Office
Kazuya Yasuhara, Member, Ibaraki University

1. Introduction:

Number of scrap tires in Japan is estimated to 104 million in 2005 [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 by only 15%. Therefore, many efforts to recycle scrap tires have been made to increase the share of material recycling of scrap tires. In-line, a research project has been initiated to explore the thermal insulation behavior of scrap tire shreds for their use in cold region civil engineering applications. A comparative laboratory evaluation has shown that thermal insulation behavior of tire rubber powder is superior than sand [2]. The present research is aimed to explore in-situ performance of scrap tire shreds in thermal insulation of cold region agricultural waterway system. A report 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 [3].

2. Experimental Procedure:

2.1 Problem:

Due to geographical position, Hokkaido faces severe cold spell every year, and civil engineering projects in such a cold region need special measures because the frost-susceptible soil shows different characteristics in the course of seasonal cycles. An example of the problem that occurred on a large-scale agricultural waterway system at Niwa area of Mukawa cho (formerly, Hobetsu-cho), Hokkaido, due to frost-heave phenomena could be seen in Fig.1. Upon the reach of winter in the areas, under-ground water (also water from the surrounding soil) gathers/siphons up at or near the surface soil and get freeze which in turn increases the soil volume. This fact may cause an increase of lateral and/or upward pressure acting on the concrete trenches. Depending on the severity of soil freezing phenomenon, the level of destabilizing forces acting on the trenches may be high enough that the trenches may be tilted, lifted up or incurred cracks in the body.

Fig.1 Agricultural waterway system.

2.2 Measure:

Such a popping up problem is common whenever frost-susceptible soils mix with freezing water, and remedy is to replace the frost-susceptible soil by gravel or equivalent material which does not contain water, and also the pores are to be large enough for free draining of water. However, the soil in Hokkaido is mainly mudstone and/or peat type, and consequently, availability of gravel is not abundant which pushes unit cost of gravel in the higher side. Therefore, finding replacement for technically equivalent or better materials than gravel, further which has economical advantages is preferred for newly planned geotechnical/civil engineering projects. Recently, scrap tire shreds are found to be an alternative to gravel for thermal insulation applications because of its beneficial engineering properties viz., insulation, permeable, water proof, durable, etc. [3].


Fig.2 Overhauling process in progress.

Key Words: tire recycle, scrap tire shreds, thermal insulation.
Addresses: Ashoke K. Karmokar and Hideo Takeichi, Bridgestone Corporation, 3-1-1 Ogawahigashi cho, Kodaira shi, Tokyo 187-8531, Japan, E-mails: *karmokar.ashoke@bridgestone.co.jp and takeic-h@bridgestone.co.jp*; Hideya Ego, Mukawa Town Hobetsu Branch Office, 2 Hobetsu, Mukawa cho, Yufutsu gun, Hokkaido 054-0211, E-mail: *hideya_ego@town.mukawa.lg.jp*; Kazuya Yasuhara, Ibaraki University, 4-12-1 Nakanarusawa, Hitachi shi, Ibaraki 316-8511, E mail: *yasuhara@mx.ibaraki.ac.jp*

2.3 Overhauling Plan:

Due to severity of the damages incurred on the pre-cast concrete trenches, a part of the waterway system mentioned before had been planned to be overhauled. As may be seen in Fig.2, replacement of damaged pre-cast concrete trenches is in progress with the new "V" type trenches. In order to study the in-situ performance of scrap tires on thermal insulation aspects, an instrumented test section was constructed using scrap tire shreds as backfill of newly installed concrete trenches. A very similarly designed control section using gravel backfill was also selected side by side for comparative study. A cross sectional view of the test/control sections are shown in Fig.3. Scrap tire shreds used for backfill are shown in Fig.4. Size of scrap tire shreds ranges from 20-70mm, and are quite uniformly graded.

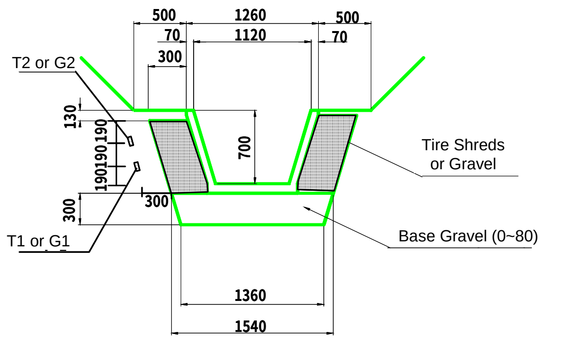

Fig.3 Cross-sectional view of control/test sections.

Fig.4 Scrap tire shreds used for backfill.

3. Results and Discussion:

As far as field construction is concerned, scrap tire shreds were found favorable over conventional gravel. Absence of dusts at the field and lightweight nature of tire shreds (less than half of the gravel) are found helpful in material handling and constructional works at the site.

A number of sensors are embedded at the neighboring ground soil for reading temperatures over time which are recorded in the data-logger. Fig.5 shows the sensor positions which are in fact mirror imaged in both test and control sections for comparative study. The trends of temperature distributions in the respective sections are shown in Fig.6 along with the recorded on-site atmospheric temperature. As evident, minimum atmospheric temperature recorded at the site was about -20°C. However, neighboring ground soil temperatures were about 0°C throughout. Temperatures of ground soil behind tire shreds are found about 1~2°C higher than those of gravel side during the core winter spell. This difference could be the indicative of the effectiveness of insulation property of tire shreds over gravel backfill. In a general term, it may be said that scrap tire shreds could improve the performance of frost-susceptible soil structure not only due to its superior thermal insulation behavior but also may be due to its good free draining criteria.

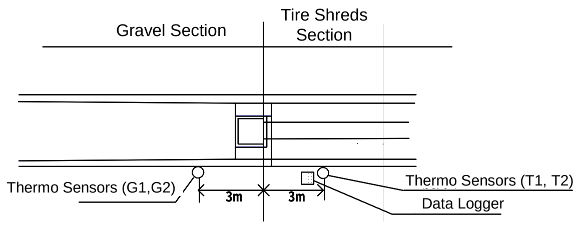

Fig.5 Sensor positions at the test/control sections.

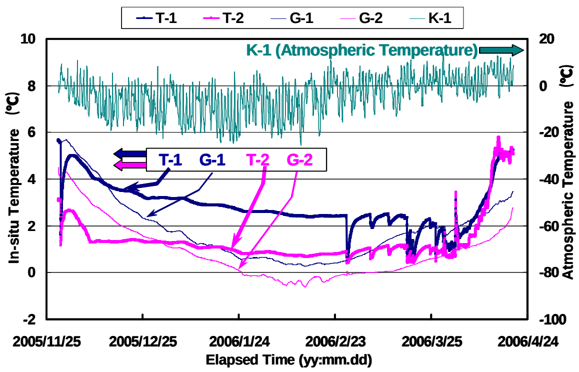

Fig.6 Temperature distribution at respective section.

4. Summary: The present study is aimed to explore the thermal insulation behavior of scrap tire rubber materials for their use in cold region civil engineering applications. Scrap tire shreds are found to perform better as insulation barrier over a control section using gravel. Based on the merits of constructability, and considerations on other technical aspects associated with the tire shreds materials, it may be said that the use of scrap tire shreds in frost-heave measuring applications are quite effective over conventionally used gravel.

References:

1. JATMA/JTRA, "Tyre Recycling Handbook," Japan Automobile Tire Manufacturers Association & Japan Tire Recycle Association, Tokyo 105-0001, Japan, 2005.
2. Karmokar, A.K., Takeichi, H., Kawaida, M., Kato., Y., Moki, H. and Yasuhara, K., "Study on thermal insulation behavior of scrap tire materials for their use in cold region civil engineering applications," *Proc. 60th Annual Meeting, Japan Soc. Civil Engineers, Japan*, pp.851-852, 2006.
3. Lawrence, B., Humphrey, D.N., Chen, L.H., "Field trial of tire shreds as insulation for paved roads," Proc. Intl. Conf. on Cold Region Engineering: Putting research into Practice, J.E. Zufelt (Ed.), ASCE, pp.428-439, 1999.