Project Summary

Texas Department of Transportation

0-5517: Beneficial Use of Scrap Tire Bales in Highway Projects

Background

The need for suitable construction material and for the proper disposal of scrap tires has led the Texas Department of Transportation to use readily available scrap tires as an alternative fill material for highway structures. Tire bales have recently emerged as a fill material because bale structures can potentially require a significant amount of whole scrap tires (only whole tires are used to create the bales), which results in the ease of constructing the tire bale structures as compared to traditional tire shred-soil mixtures. Even with the significant interest in using tire bales as a fill material, the lack of material properties and cost evaluation data, as well as the fear of potential combustion within tire structures, has hindered the use of tire bales as a viable alternative. The overall objectives of this research were to define and measure tire bale properties needed for design, and to develop specifications for the construction and use of tire bales in highway structures.

What the Researchers Did

A research plan was developed that consisted of a series of laboratory and field testing programs to determine the mechanical and index properties of the tires bales. The testing programs were completed using innovative and large-scale testing setups constructed specifically for this research. Each testing setup took into account the large size and weight of the tire bales. Numerous design considerations, including the effects of soil infill and moisture on the tire bale behavior, were modeled with the testing setups to determine the mechanical properties of the tire bales needed for current and future designs. The laboratory and field testing of tire bales included long term conditions of the bales, in which the behavior of the bales after wire breakage was observed.

In addition, a comprehensive literature review was conducted to determine the environmental impacts of the tire bales in soil structures, including groundwater contamination and the potential for exothermic reactions leading to combustion of the tire bale structure. Results from the testing program were then used in an analytical study to determine the stability of current and proposed scrap tire bale projects to ensure adequate factors of safety. A cost benefit analysis was coupled with the analytical study to illustrate both the economical and mechanical advantages of reusing scrap tire bales in highway structures as compared to other designs and construction materials.

Research Performed by:

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What They Found

The unit weight of the tire bales was defined in a different manner, as compared to values reported in the literature, so that the effects of soil infill and tire bale submergence could now be taken into account. For the tire bales tested in the field, expansion deformations measured after wire breakage indicated a significant expansion of the bales parallel to the direction of the confining wires. The expansion pressure needed to retain the bale shape after wire breakage was found to be approximately 200 psf.

The shear resistance along the tire bale interface, which is commonly assumed to be the weakest plane, was determined for a tire bale-tire bale contact and for a tire bale-soil layer contact. The interface shearing resistance was found to decrease with the presence of water, indicating the importance of considering water on the structure stability. It was also found that the strength of the tire bale-soil interface was significantly less than that of a soil only mass. Bale stamping tests, used to determine the interface contact area, provided evidence that the irregular and non-uniform contact along the tire bale-soil interface caused the reduction in strength due to the definition of stress along the interface.

Compression testing on different tire bale structures (stacking arrangements of two or three tire bales) illustrated the importance of the tire bale interface on the deformation of a tire bale structure. For all ranges of normal loads tested, approximately 50% of the deformation occurred along the tire bale interface. Testing conducted for unconfined and confined conditions resulted in the calculation of the tire bale stiffness and Poisson's Ratio. Long term sustained loading tests provided evidence that creep deformations within the tire bale structure are comparable to those measured for soils and geosynthetics.

What This Means

Results from this testing program can be directly used in the design and construction of future tire bale highway structures. Testing and design data is now available for all design considerations, including short and long term aspects of tire bale behavior. The cost benefit analysis indicated numerous advantages of using tire bales as opposed to tire shreds, as well as compared to other remediation and construction methodologies. Specifications were compiled from lessons learned from the literature review and testing program for use by the Texas Department of Transportation for the construction of tire bale structures, as well as for the manufacturing of tire bales.

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