PUTTING RESEARCH TO WORK
BRIEF

Quantifying the Benefits of Geogrids for More Durable Pavements

In the past 25 years there has been a steady increase in the use of geosynthetics to improve road foundations. Geosynthetics are any of several durable polymeric materials designed for use in soils: for example, to separate layers of soil and aggregate, provide reinforcement or added strength, or facilitate drainage and filtration. Two common geosynthetic materials are geotextiles, or polymer-based fabrics; and geogrids, polymers formed into open, grid-like configurations.

Geogrids placed between the subgrade and base course extend the service lives of roads by improving underlying layer stiffness and load distribution, and by decreasing pavement rutting, cracking and other physical deterioration. Use of geogrids can also reduce the cost of construction by decreasing the necessary thickness of the base course, meaning fewer loads of coarse aggregate need to be hauled to the construction site.

What's the Problem?

In spite of the benefits of geogrids, their effects on the stress-strain relationships in the pavement system have not yet been fully quantified. As WisDOT moves toward a mechanistic-empirical approach to pavement design, research was needed to evaluate how the stiffness and other properties of pavement structures change with depth, particularly in the vicinity of a geogrid layer.

Further, because traditional resilient modulus tests cannot easily be used in the field to measure the stiffness of granular soils surrounding a geogrid, researchers needed to develop a new method for evaluating soil stiffness.

Research Objectives

The purpose of this study was to examine the effects of a geogrid reinforcing layer on the structure and stiffness of base courses and subgrade soils. Determining how the properties of these materials and soils vary with their distance from the geogrid will allow engineers to establish the optimum geogrid position and base course thickness for enhancing the life and durability of pavement systems.

Methodology

Researchers used two methods to determine the interaction between base course materials and geogrid reinforcement—the first using seismic measurements of wave propagation and the second involving the measurement of soil particle rotation. Both methods employed micro-electronic mechanical systems, or MEMS—very small accelerometers that are sensitive to soil particle accelerations caused by the vibration of elastic waves. MEMS can also be used to measure the rotational deformation or shearing in materials by determining the vertical and horizontal contributions of gravitational acceleration.

Researchers used wave propagation tests to determine the correlation between the seismic properties and resilient modulus values of various soils commonly used in road construction. One of these tests involved compacting soil in a 5-gallon bucket and placing two MEMS accelerometers on either side of a load plate, about 10 millimeters below the surface of the soil. Researchers then tapped the side of the bucket with a rubber hammer, and recorded the travel time of the wave under the plate and between the accelerometers—with faster travel times corresponding to a higher resilient modulus. These tests established correlations between seismic modulus and resilient modulus, allowing researchers to use more convenient seismic methods to analyze changes in soil stiffness with variation in the soil's proximity to the geogrid.

Researchers then monitored the influence of the geogrid on soil particle rotation in order to assign a "zone of influence," a measurement of how far a geogrid's impact extends into the surrounding soil, as determined by increases in the soil's resilient modulus. Researchers tested two geogrids that had

Investigator

"We knew that geogrids stiffen aggregates, but we didn't know by how much. This study provides us with the quantification we need for the mechanistic-empirical design of pavements."

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"This study will allow WisDOT to increase its use of geogrids when appropriate, improving pavement durability and reducing construction costs."

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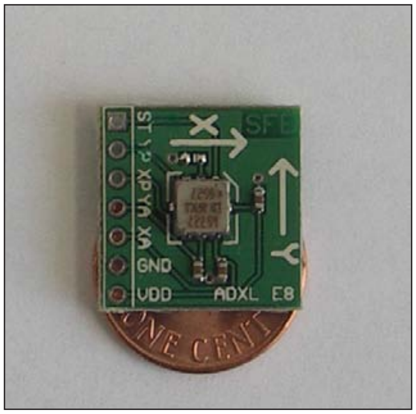

Very small accelerometers (left) can be used to measure wave propagations in granular materials, which provide a useful measure of improved stiffness of soils surrounding geogrid material (right) placed during construction.

flexural stiffness values of 250,000 mg-cm, and a stiffer geogrid that had a flexural stiffness value of 750,000 mg-cm.

Results

Elastic wave test results indicated that the geogrid stiffened soil around it by a minimum factor of 1.3 (for geogrids placed 75 millimeters from the surface), ranging to a maximum of 2.6 (for geogrids at 100 millimeters depth).

Rotation tests showed a zone of influence no more than 50 millimeters on both sides of the geogrid reinforcement, depending on the position of the geogrid, with a geogrid at 100 millimeters depth being the most effective in laterally constraining subsurface materials and distributing shear stresses vertically over the depth of the pavement system.

While the stiffer geogrid (flexural stiffness of 750,000 mg-cm) increased the stiffness of nearby soil, the other geogrids (flexural stiffness of 250,000 mg-cm) did not, according to both rotation and wave velocity results.

Benefits

This study provides WisDOT with the mechanistic-empirical information that engineers need to determine the most effective position of geogrids and the required thickness of the base course materials surrounding them. Further, the bucket test developed during this study is a new method for quick and small-scale field measurements of the stiffness of granular soils, which cannot be measured easily using traditional resilient modulus tests.

Implementation and Further Research

The zone of influence and recommended geogrid depth identified by this study vary from those assumed in current WisDOT foundation design. Consequently, department engineers plan to analyze this study's results and attempt to correlate them with data from the department's previous highway design and construction experiences.

This brief summarizes Project 0092-07-05, "Development of Testing Methods to Determine Interaction of Geogrid-Reinforced Granular Material for Mechanistic Pavement Analysis," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

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