PUTTING RESEARCH TO WORK

BRIEF

Improving Subgrades with Byproducts and Geosynthetics

Sixty percent of Wisconsin's topsoil is composed of soft silts and clay, soils in which road-building crews and equipment can get mired and which can make roadbed preparation difficult, time-consuming, and therefore expensive. At times, crews must remove soft subgrade soils and replace them with 2 to 3 feet of breaker run aggregate or other granular material.

This granular material may include inexpensive industrial byproducts, like foundry sand, foundry slag and bottom ash from coal combustion. Other alternatives for builders are fabrics (geotextiles) and perforated sheets (geogrids) made from manmade materials, referred to as geosynthetics. These materials can be quickly and inexpensively laid over soft soil and covered with aggregate, potentially reducing the volume of aggregate needed—which saves money as well as preserving a diminishing natural resource.

What's the Problem?

Though designers and contractors have been using industrial byproducts and geosynthetics for several years, WisDOT engineers have lacked numeric values for how much each material may improve a given subgrade. Perhaps even more significant, engineers also possess little quantifiable data on how these improved subgrades may affect the performance and durability of the pavements they support.

If granular materials, industrial byproducts and geosynthetics were found to work in quantifiable and predictable ways, engineers could routinely design subgrades and even pavements that account for the benefits of these materials. Engineers know these materials can increase subgrade and pavement durability and performance, as well as reduce the expense and resource depletion entailed in using aggregate, but need to find methods to quantify these benefits.

Research Objectives and Methodology

This group of four studies sought to collect data on granular materials, industrial byproducts, and geosynthetics in both subgrades and pavement structures. Primary goals included:

- Determine working platform and highway structure support sufficiency of subgrades enhanced with geogrids and geotextiles (0092-45-15).
- Determine working platform and highway structure stability of subgrades enhanced with various industrial byproducts and geosynthetics (0092-45-18).
- Determine equivalencies of soft subgrades as working platforms when enhanced with different granular materials, industrial byproducts or geosynthetics to those enhanced by conventional use of aggregate (0092-00-12).
- Determine the structural value of working platforms enhanced with granular materials, byproducts or geosynthetics in flexible pavement structures. For geosynthetics-enhanced platforms, develop design coefficients that can be used in assigning structural numbers to pavement system layers in order to quantify the benefit to pavement structures (0092-03-12).

To meet these objectives, researchers constructed test sections of geogrids and geotextiles (0092-45-15); and tested different configurations of soft subgrade enhancement, evaluating their performance with pavement deflection testing over five years (0092-45-18). They also tested large-scale models of enhanced subgrades, and models of geosynthetics used with breaker run and granular backfill (0092-00-12). Finally, they used large-scale models to develop design inputs for enhanced subgrades, and developed design coefficients for pavement structures built on enhanced subgrades (0092-03-12).

Results

Clearly, geosynthetics and industrial byproducts will help WisDOT reduce its reliance on natural

Investigator

"The higher layer coefficient of geosynthetics means we can use them to enhance subgrades while using less aggre gate—saving both money and time."

–Tuncer Edil
University of Wisconsin–Madison
edil@engr.wisc.edu

Investigator

"Use of recycled industrial by-products provides cost savings but also contributes to sustainability."

–Craig Benson
UW–Madison
benson@
engr.wisc.edu

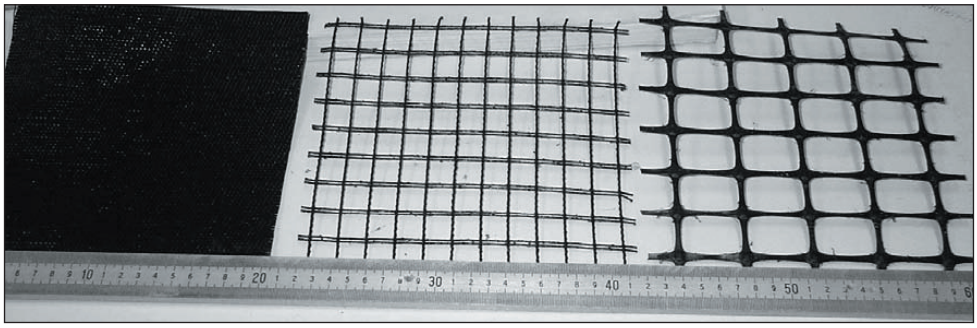
Geotechnics TOC Chair

"These studies demonstrate how several materi als can enhance subgrades. Now we need to put these materials into regular use."

Bob Arndorfer
WisDOT Bureau of
Technical Services
robert.arndorfer@
dot.state.wi.us

Co-investigators:
Steve Maxwell, Woon-Hyung Kim, Burak Tanyu, Aykut Şenol, and Md Sazzad Bin-Shafique, UW–Madison

Brief prepared by
CTC & Associates LLC
ctcandassociates.com



Geosynthetics like punched-aperture geogrids, knitted geogrids and woven geotextiles (above, left to right) can reduce the amount of breaker run aggregate used to stabilize soft subgrades for highway construction work.

granular aggregates in subbase enhancement and, ultimately, in base courses for highway pavement structures. The four studies found enhancements effective in improving subgrade stability and strength. Key findings include:

- Geogrids and woven geotextiles provide adequate subbase support in test sections, although their benefit diminishes when used with thick layers of breaker run (0092-45-15).
- Over a five-year period, most soft subgrades enhanced with geosynthetics or industrial byproducts offered equal or greater stiffness to those enhanced with breaker run aggregate, and even subgrades enhanced with foundry sand perform adequately, as determined by deflection testing and back-calculated resilient modulus. Subgrade stabilized with fly ash performed exceptionally well (0092-45-18).

Researchers developed design charts that identify the thickness of alternative materials required to achieve the same total deflection as a working platform of breaker run. Design inputs were also developed for enhanced subgrades. The charts include:

- Thickness equivalents of industrial byproduct-enhanced subgrades to breaker run-enhanced subgrades. Subgrades enhanced with cementitious fly ash were found to achieve identical performance as those enhanced with breaker run at less thickness (0092-00-12).
- Thickness equivalents of subgrades enhanced with breaker run and Grade 2 granular fill, with and without geosynthetics. Each geosynthetic provides equivalent support at reduced granular material thickness (0092-00-12).
- Effective structural numbers and roadbed resilient modulus of subgrades enhanced with breaker run, Grade 2 granular fill, bottom ash, foundry slag, and foundry sand (0092-03-12).

Design values for various geosynthetics indicated that they offer increased structural coefficients (i.e., more strength for a given thickness) when compared to subgrades that were not enhanced by geosynthetics (0092-03-12).

Implementation and Further Research

These studies demonstrate that in subgrade working platforms, industrial byproducts can replace aggregate in stabilizing soft subgrades, and geosynthetics can help reduce the aggregate thickness required in pavement subbases. Research must still establish specific design values for most of these materials as they impact pavement structures, and with each material, values must be determined for full use in future mechanistic-empirical pavement design methods. WHRP has initiated an implementation project that will produce design values for use with alternative materials in pavement design.

Future research may address geosynthetics' potential to reduce the amount of aggregate used in subgrade enhancements and help define the performance characteristics of various geosynthetic materials.

This brief summarizes Projects 0092-45-15, "Effectiveness of Geosynthetics in Stabilizing Soft Subgrades;" 0092-45-18, "Field Performance of Subbases Constructed with Industrial Byproducts;" 0092-00-12, "Equivalency of Subgrade Reinforcement Methods;" and 0092-03-12, "Development of Methodology to Include Strength Contribution of Select Subgrade Materials in Pavement Structures;" produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research, Development & Technology Transfer Program, 4802 Sheboygan Ave., Madison, WI 53707.

Nina McLawhorn, Research Administrator