TECHNOLOGY NEWS
Iowa's Local Technical Assistance Program (LTAP): providing transportation technology transfer for Iowa's cities and counties

September–October 2003

Acronyms in this issue

AASHTO	American Association of State Highway and Transportation Officials
CTRE	Center for Transportation Research and Education
FHWA	Federal Highway Administration
Iowa DOT	Iowa Department of Transportation
ISU	Iowa State University
LTAP	Local Technical Assistance Program
MUTCD	Manual on Uniform Traffic Control Devices

Build better pavements: stabilize the subgrade

UNSTABLE SUBGRADE is the number-one cause of pavement failure. Although stabilizing subgrade soils may increase up-front construction time and cost, the extra expense will generally be recovered—and more—over the pavement's lifetime.

What is "stable" soil?
Stable subgrades are those that can support loads. Soil *quality* and *uniformity* contribute to its stability.

Some soil types naturally provide better drainage and support beneath pavements than other soils; they are considered to be more stable. "Loam or clay loam of glacial till origin or clean sand is typically desired," according to David Heer, assistant soils design engineer and former earthwork field engineer at the Iowa DOT.

Other types of soil cause differential movements that can lead to dips or cracks in pavements. Such "unstable" soil types generally include those with a high volume of expansive clay minerals or silt, organic material, or water.

In addition to being composed of stable soil that provides good drainage and support, a critical characteristic of a stable subgrade is *uniformity*. That is, subgrades are generally stable if they are composed primarily of one type (and grade) of soil and uniformly compacted at optimum water content.

The problem with a subgrade composed of different soil types and/or gradations, according to Dale Harrington, CTRE's associate director for pavements, is that "different materials absorb water differently. So, they have different densities and, consequently, they expand and contract at different rates."

With varying densities and rates of expansion/contraction, different soils in the subgrade provide different levels of support under the pavement slab. Different levels of support can cause the slab to settle and/or break up. A subgrade composed of uniform materials provides a more uniform level of support under the slab.

Harrington emphasizes, "It isn't only the quality of the soil that counts, but the fact that the quality—whether excellent or fair—is the same throughout the subgrade. Uniform, stable soil is the key."

He adds, "Iowa has many different kinds of soils, and this has to be considered in pavement design and construction planning." In fact, it's not unusual in Iowa to find several kinds of soil along one roadway construction site. Agencies generally have to work with whatever kinds of soil are naturally present, using engineering techniques to improve, or stabilize, them.

PAVEMENTS . . . continued on page 2

In Iowa, fly ash can be a cost-effective additive for stabilizing soils.

Preparation of this newsletter was financed through LTAP, a nationwide effort financed jointly in Iowa by the FHWA and the Iowa DOT. Iowa's LTAP is housed and administered at ISU's Center for Transportation Research and Education (CTRE).

The mission of Iowa's LTAP: To foster a safe, efficient, environmentally sound tranportation system by improving skills and knowledge of local transportation providers through training, technical assistance, and technology transfer, thus improving the quality of life for Iowans.

Subscriptions to *Technology News* are free. We welcome readers' comments, questions, and suggestions. To subscribe, or to obtain permission to reprint articles, contact the editor.

ISU Research Park
2901 S. Loop Drive, Suite 3100
Ames, Iowa 50010-8632
Telephone: 515-294-8103
Fax: 515-294-0467
www.ctre.iastate.edu/

Stephen J. Andrle
Director of CTRE
andrle@iastate.edu

Duane Smith
Director of Iowa LTAP
desmith@iastate.edu

Marcia Brink
Editor
mbrink@iastate.edu

Tom McDonald
Safety Circuit Rider
tmcdonal@iastate.edu

Lori Wildeman
Program Coordinator
lwild@iastate.edu

Michele Regenold
Brett Hansen
Contributing Writers

PAVEMENTS . . . ***continued from page 1***

This involves, primarily, making the subgrade material more uniform. As much as possible, it also involves developing a subgrade composed of stable soils. One way to achieve both objectives is to remove and replace some of the soil.

Stabilizing with select backfill or special backfill
First, "select" soil—the best (i.e., most stable) material found during the exploration of a site—is typically excavated from roadcuts or borrow sites and reserved for the final two feet of fill placed beneath the pavement structure.

If loam or clay loam, clean sand, or other stable soils aren't available for select fill, or if an agency simply wants to provide additional support, "special" backfill may be placed on top of the subgrade.

Special backfill is a uniform mixture of crushed concrete or crushed limestone, or a mixture of gravel, sand, and soil (with or without crushed stone), that meets specific gradation requirements. Recycled asphalt pavement (RAP) is reclaimed hot-mix asphalt pavement that is processed to meet Iowa DOT special backfill requirements. (See Article 2102.04 and Section 4132 of the DOT Standard Specifications for material requirements for special backfill.)

Because of the expense associated with applying special backfill, "the depth is normally limited to eight to twelve inches," according to Harrington.

A layer of polymer geosynthetic called geogrid may be used as a foundation for special backfill. Geogrid acts as an underlying tension reinforcement to prevent failure at the base of special backfill. And a course of fairly rigid fill material, sometimes cement- or asphalt-treated, may be placed on the special backfill to provide a stable platform for the concrete pavement slab.

Stabilizing with additives
Another way to stabilize subgrades is with additives. Through chemical reactions with the soil, these additives can alter soil characteristics in ways that improve its stability. Lime, fly ash, and portland cement are the most common stabilizing additives.

Lime. Lime is an effective stabilizing agent for a variety of soils. Either quicklime or hydrated lime, in both high calcium and dolomitic types, is an especially effective stabilizer of granular materials and clays because it reduces soil plasticity and increases compressive strength through chemical reactions.

In fact, using lime "may easily triple or quadruple" the strength of clay soils, according to Dr. Robert Parsons, assistant professor of civil engineering at the University of Kansas. "In some instances, strength has improved by an order of 10 or more."

The National Lime Association recommends that when mixing lime with soils, the moisture content should be five percent above optimum during mixing to promote the necessary chemical reactions.

Portland cement. When added to soil, portland cement hardens the mixture through hydration of the cement.

Portland cement can be used for a variety of soils. However, well graded, sandy, and gravelly materials with 10 to 35 percent fines have the best reaction. Soils with little or no fines and clay soils normally require a greater proportion of cement.

Fly ash. Fly ash, a byproduct of coal burning, is commonly used to improve the uniformity of subgrade materials. Self-cementing Class C fly ash is used for subgrade treatment, according to Iowa DOT specifications.

Typically, fly ash is incorporated into soil at rates of 5 to 20 percent to form a low-grade concrete; the soil is the aggregate and fly ash is the cement, according to Heer. Sometimes, partially hydrated fly ash is applied as a crushed product in the upper pavement support layer.

Because fly ash is plentiful in parts of Iowa near coal-burning plants, it can be a cost-effective additive for stabilizing soils. Stabilizing subgrades with fly ash is also an environmentally sound recycling practice.

No stabilization "formula"
When it comes to stabilizing subgrades, there is no single solution. Because of the diversity of soils in Iowa, each project must be analyzed and treated on a case-by-case basis. The result will be smoother, stronger pavements; less traffic congestion due to road maintenance and rehabilitation; and dollars saved over the pavement's lifetime.

For more information
For general information about soil and subgrade stabilization, contact David White, assistant professor of civil engineering at ISU specializing in geotechnical engineering, 515-294-1463, djwhite@iastate.edu.

For information on stabilization additives, contact the National Lime Association, 703-243-5463, www.lime.org; the American Coal Ash Association, 703-317-2400, www.acaa-usa.org; or the Portland Cement Association, 847-966-6200, www.Cement.org.

For related publications, contact Jim Hogan, library coordinator, 515-294-9481, hoganj@iastate.edu. •