0-6037: Alternatives to Asphalt Concrete Pavement Subbase for Concrete Pavement

Background

TxDOT has become increasingly aware of the rising cost associated with the use of asphalt concrete bond breakers to meet the Federal Highway Administration (FHWA) requirement of using a permanently stabilized, nonerodable subbase layer below concrete pavement. The main issue associated with this research is whether less expensive alternatives can be configured for acceptable subbase construction.

Subbase layers have certain functions that need to be fulfilled in order to assure adequate pavement performance. The assessment of each of these functions (e.g., resistance to erosion) relative to different alternatives is key to understanding the capability of those alternatives to perform adequately. In this respect, this project was poised to examine the design assumptions leading to design recommendations for long-lasting subbase layers based upon test methods and design guidelines.

What the Researchers Did

Many pavement sections in Texas were sampled and investigated to identify factors associated with subbase performance using a number of techniques including visual survey, nondestructive testing (FWD), and ground penetrating radar as well as coring and destructive dynamic cone penetrometer testing. Researchers assembled a list of alternative subbase types and materials based on the evaluation of field performance and other functional factors.

Researchers proposed a new test method as well as a mechanistic-empirical model to evaluate the sustainability of subbase material with respect to erodibility as determined by using the Hamburg wheel-tracking device. This test method measures subbase erosion under pressures imparted by a loaded concrete layer. Results qualify a subbase under wet conditions relative to the magnitude of the shear stress creating the erosive action. Researchers explained summarized test devices, procedures, and results for application in mechanistic design processes. A proposed erosion model was validated by comparing erosion predictions to erosion results.

Several computer program analyses assessed the effects of friction and stiffness of subbase relative to crack spacing, crack width, steel stress, and punchout as well as deflections and stresses by curling for long-term performance predictions. Guidelines and a design assistant sheet were developed in this project to help achieve the economical and sustainable design of a concrete pavement subbase layer considering many design factors.

Research Performed by:

Texas Transportation Institute (TTI),
The Texas A&M University System

Center for Multidisciplinary Research in Transportation (TechMRT),
Texas Tech University

Center for Transportation Research (CTR),
The University of Texas at Austin

Research Supervisor:
Andrew J. Wimsatt, TTI

Researchers:
Youn su Jung, TTI
Dan G. Zollinger, TTI
Moon Won, TechMRT
Byoung Hooi Cho, CTR

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What They Found

In the field study, untreated flexible bases have not performed well over the years, particularly where moisture-sensitive subgrades are present, while most cement-treated bases have performed well particularly when used with an asphalt concrete interlayer due to its high resistance to erosion. Accordingly, experience with the use of cement-treated bases has been good, and recyclable materials (recycled asphalt and recycled concrete) show promise at least economically.

The new lab test method and model for subbase erosion prediction provides a significant advantage over other approaches in terms of the translation of laboratory-derived erosion rates to performance in the field. Moreover, this approach allows for testing of a core sample from the field as well as laboratory-compacted samples in a relatively short period of time while providing a wide range of applicability to all types of subbase or subgrade materials.

Three types of materials (conventional aggregate, recycled concrete, and reclaimed asphalt pavement) treated by various cement contents were tested and evaluated by different stress levels and number of loads. As expected, more weight loss developed as shear stress and loading number increased; however, the rate of weight loss dropped off to some extent at higher stress levels and loading numbers. The 2 percent cement treatment for stabilized subbase materials did not reduce the erosion rate significantly, but treatment with 4 percent cement did reduce the erosion compared with untreated samples.

On the basis of the finite element analysis, the nighttime nonlinear temperature gradient condition led to a critical curling stress condition in concrete slab. Therefore, the critical temperature input should be the nighttime nonlinear case and the stress responses in the concrete layer should be evaluated when selecting alternative subbase materials.

What This Means

The subbase design for rigid pavements should take into account many interacting materials, slab characteristics, and environmental conditions since, it is the heart of sustainability of a concrete pavement system. Factors to be considered in order to address the full extent of subbase-related distress include:

- general material factors such as material type, strength, and erodability,
- design factors such as thickness, interlayer frictional, and traffic conditions, and
- sustainability issues such as constructability.

In design, the erosion rate should be weighted over dry and wet performance periods in light of calibration for local conditions and performance to represent such factors as frequency of joint sealing maintenance, changes in drainage conditions, and annual precipitation. The calibration coefficients based on field and lab performance can be applied to the erosion prediction model for estimation of future maintenance and pavement repairs.

For More Information:

0-6037-1 Subbase and Subgrade Performance Investigation for Concrete Pavement

Research Engineer - German Claros, TxDOT, 512-416-4730
Project Director - Ralph Browne, TxDOT, 817-399-4301
Research Supervisor - Andrew J. Wimsatt, TTI, 979-862-4597

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keyword: research

Texas Department of Transportation
Research and Technology Implementation Office
P.O. Box 5080
Austin, Texas 78763-5080
512-416-4730