PUTTING RESEARCH TO WORK

BRIEF

Cost-Effectiveness of Open Graded Base Course with Doweled and Nondoweled Transverse Joints

A standard concrete pavement in Wisconsin stands on a dense graded, aggregate base course. The pavement may be 9 inches or 10 inches thick, and the base course 6 inches. Designers expect these structures to last 20 to 30 years. Typically damage over the life of a pavement accumulates and causes surface roughness for drivers; many pavements will require rehabilitation or resurfacing in 20 years, and potentially subsequent maintenance to maximize service life.

What's the Problem?

Most of the damage to concrete pavement results from poor drainage, which can lead to increased freeze-thaw damage, and when combined with heavy loading can contribute to cracking, spalling and surface damage that causes driver discomfort from increased roughness of the roadway. Open graded base courses compact less tightly than dense graded courses and consequently drain better.

Many designs with OGBC call for stabilizing the upper portion of the OGBC with asphalt or cement. If these methods can reduce drainage problems and offer enough support to improve the service lives of concrete pavements and delay rehabilitation or replacement needs, OGBC may prove a more cost-effective way to deliver excellent concrete pavements to Wisconsin drivers. However, it can cost nearly an additional $100,000 per mile to use OGBC, so its life-cycle cost and performance must be carefully considered.

Research Objectives

This study aimed to investigate the performance of 20-year-old concrete pavements, both doweled and nondoweled, in three areas of Wisconsin:

- US 18/151 in Iowa and Dane counties: 17 sections of pavement. Constructed in 1988 with 9-inch portland cement concrete and a mixture of sealed and unsealed transverse joints, the Iowa County sections were nondoweled and the Dane County sections were doweled. Sections featured seven unique design factors and five pavement bases over 4-inch drainage pipes.
- WIS 29 in Brown County: four test sections. Built in 1988 with 10 inches of PCC over a 4-inch permeable base, all over a 4-inch dense graded base with 6-inch drainage pipes, these sections featured both sealed and unsealed joints at doweled and nondoweled seams.
- US 151 in Columbia and Dane counties: four sections. These sections of 10-inch PCC were constructed in 1991 over five bases and 6-inch drainage pipes.

The sites offered five pavement base types: dense graded base, asphalt-stabilized permeable base, cement-stabilized permeable base and untreated permeable bases in two aggregate gradation sizes. Researchers aimed to compare these sections in terms of subgrade support, drainability, load transfer, joint sealant and overall performance.

Methodology

Researchers evaluated pavement surface condition, load response, faulting, permeability and water drainage through the base material using methods that included:

- Automated and manual pavement condition surveys.
- Pavement Distress Index and International Roughness Index data, some of which was gathered via semiautomated electronic surveys.
- Falling weight deflectometer testing.

Investigator

"Both the dense and open graded doweled sections have performed well in terms of distresses and ride. Soil conditions and added cost of open graded base must be considered during design selection."

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Researchers investigated the permeability of open graded bases using water flow meters, as shown here on US 18/151.

- Pavement condition evaluation for transverse faulting via semiautomated electronic surveys and via manual surveys for slab breakup, distressed joints and cracks, joint crack filling, patching, surface distress, transverse faulting, and longitudinal joint distress and distortion.

Researchers also performed life-cycle cost analysis of pavements over select bases.

Results

Though permeable bases offer performance benefits, over a 20-year period the benefit of OGBC does not appear to justify the increased cost. However, in areas in which repair and rehabilitation after 20 years may not be viable, such as in large, urban settings in which traffic disruption causes inconvenience, use of stabilized OGBC may be cost-effective.

Of the OGBC types evaluated, asphalt-stabilized bases performed best. Key findings included the following:

- On US 18/151, for doweled unsealed pavement, base differences had little impact on performance, and sealant did not generally improve ride.
- On US 18/151, asphalt-stabilized bases had no slab breakup or surface distress, but featured more severe joint distress and cracking. Nondoweled sections over asphalt-stabilized base and interchannel drains outperformed other nondoweled sections.
- On WIS 29, sealed doweled pavement outperformed sealed nondoweled, but unsealed nondoweled outperformed unsealed doweled.
- On US 151, fine graded permeable base offered the smoothest ride of the permeable sections. Asphalt-stabilized base produced the roughest ride.
- Permeability varied little with doweling or sealing.
- More efficient load transfer was observed for doweled sections relative to nondoweled. Base type and sealant impacted slab support ratios.

Life-cycle cost analysis found dense graded base the least costly of the base configurations. Untreated OGBC and asphalt-stabilized were more expensive based on life-cycle cost by 13 percent and 28 percent, respectively.

What's Next?

A webinar, which can be viewed at http://www.whrp.org/research-areas/rigid/rigid_0092-09-03_closeout_webinar.html, presented findings from this study on June 16, 2010. Its results favor WisDOT's current practice of using dense graded bases beneath doweled concrete pavement. Higher volume Interstates may warrant evaluation of OGBC versus dense graded bases.

This brief summarizes Project 0092-09-03, "Performance Evaluation of Open Graded Base Course with Doweled and Nondoweled Transverse Joints on USH 18/151, STH 29 and USH 151," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, P.O. Box 7915, Madison, WI 53707.

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"Having a stabilized base course does provide a better base in the long run, but it is very costly. We saw slightly better performance, but we didn't see enough difference over 20 years to justify the additional cost."

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