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TRANSPORTATION POOLED FUND PROGRAM

TECHNICAL SUMMARY

Questions?
Contact research.dot@state.mn.us.

Technical Liaison:
Thomas Burnham, MnDOT
Tom.Burnham@state.mn.us

Principal Investigator:
Lev Khazanovich, University of Pittsburgh

PARTICIPATING STATES:
GA, IA, KS, MI, MN, MO, NC, OK

This overlay at a site in Michigan shows corner damage and midslab longitudinal cracking.

DEPARTMENT OF TRANSPORTATION
OFFICE OF RESEARCH & INNOVATION

Pooling Our Resources: New Design Tools for Concrete Overlays

In a six-year pooled fund study led by MnDOT, researchers developed a sophisticated method for designing concrete overlays with asphalt or geotextile interlayers. The new design procedure and desktop software allow designers to consider a variety of factors to optimize concrete overlay designs.

What Was the Need?

Soon over 50% of MnDOT's concrete paving projects will be concrete overlays of existing pavement. Current concrete overlay design procedures are based on older empirical procedures designed for concrete pavement on granular bases. Though these procedures are suitable, they tend to result in very conservative and thick overlay designs.

Recent advances in mechanistic-empirical design procedures, primarily the American Association of State Highway and Transportation Officials (AASHTO) Mechanistic-Empirical Pavement Design Guide (MEPDG), helped optimize standard concrete pavement designs. But the MEPDG does not fully recognize unique aspects of concrete overlays, particularly stress-reducing interlayers.

The introduction of fabric interlayers heightens the need to understand interlayer effects on concrete overlay design and performance. MnDOT and other state departments of transportation (DOTs) recognized the need for a revised design procedure for concrete overlays with an interlayer.

What Was Our Goal?

Starting in 2012, MnDOT led an eight-state pooled fund research project to develop a rational mechanistic-empirical design procedure for concrete overlays with an interlayer. The new procedure would create longer lasting and more economical overlay designs, and would provide guidance for selecting the most appropriate interlayer for given site conditions.

What Did We Do?

The research team began with a literature review of design approaches and performance of unbonded concrete overlays in participating and nonparticipating pooled fund states. Researchers visited sites in Michigan and Minnesota to evaluate unbonded concrete overlay performance and gather samples from pre-overlay concrete pavements with existing asphalt overlays that would become an interlayer.

In the laboratory, researchers examined sample beams that were collected in the field and cast in the lab. Geotextile fabric interlayers were placed on laboratory beams, and overlays were cast before testing for interlayer deflection, friction between overlay and interlayer, performance of interlayer in preventing reflective cracking, and bond strength at interlayer interfaces.

Based on observations and test results, researchers developed finite element models that reflected the behavior of concrete overlay layers, as well as new fatigue cracking and faulting models. The team developed guidelines for determining optimal design and materials of interlayers.

What Did We Learn?

Results significantly increase understanding and characterization of interlayers in unbonded concrete overlays. Researchers determined that unbonded overlays perform

continued

"This project was quite innovative. Nobody had examined concrete overlay design to this level, and the focus on interlayers was really a breakthrough. It should be widely adopted, but time will tell."

—Thomas Burnham,
Senior Road Research Engineer, MnDOT Office of Materials and Road Research

"The Mechanistic-Empirical Pavement Design Guide is very robust for new pavements, but we found some problems with overlay design and have at least begun to resolve those issues."

—Lev Khazanovich,
Professor, University of Pittsburgh Department of Civil and Environmental Engineering

Produced by CTC & Associates for:
Minnesota Department
of Transportation
Office of Research & Innovation
MS 330, First Floor
395 John Ireland Blvd.
St. Paul, MN 55155-1899
651-366-3780
www.mndot.gov/research

MnDOT led a multistate pooled fund study to develop a new design procedure for unbonded concrete overlays, improving in many ways upon existing national guidance.

very well for 20 or more years, and that interlayers and drainage significantly affect performance. Designs should consider failure modes, particularly joint faulting and transverse and longitudinal cracking at midslab and in the wheel path. Models developed in the study encourage a focus on mitigating interlayer erosion, as well as selecting slab sizes that reduce failures.

Asphalt-based interlayers need to be erosion-resistant, of adequate thickness—1 inch or thicker—and must balance density, permeability and strength requirements with compaction and the stress that occurs under wheel paths. Limited performance data on geotextile fabric interlayers suggest they work well and provide adequate drainage. Joint sealing and effective drainage design can ensure water will not be trapped in the interlayer.

Adequate interlayers and subgrades clear of voids will ensure that cracks at joints and damage in the underlying pavement will not reflect into overlays, and that overlays will not interlock with old pavement at fault sites. Pre-overlay repair is needed only for severely damaged areas.

Investigators calibrated the new mechanistic-empirical design procedure, known as UNOLDesign, with test data and incorporated cracking and faulting prediction into the design outputs. The design procedure and desktop software allow designers to consider traffic volume, joint spacing, overlay dowel diameters, shoulder type, existing pavement thickness and stiffness, interlayer type, mix design, reliability levels and other factors in a process that optimizes the design of unbonded concrete overlays constructed on existing concrete and composite pavements.

What's Next?

The research team plans to create a website to host the new procedure and associated supporting documentation. MnDOT, Missouri DOT and Michigan DOT are expected to adopt a version of the new procedures, and pooled fund participants hope that many more state transportation agencies and AASHTO will eventually adopt the approach.

Geotextile fabric interlayers and field performance will require more evaluation, particularly in terms of drainage and water retention. Further study may increase flexibility in panel design sizes and widths, and may evaluate the use of fibers in concrete as an alternative to dowel bars.

This Technical Summary pertains to Report 2020-08, "Development of an Improved Design Procedure for Unbonded Concrete Overlays," published February 2020 for Transportation Pooled Fund Study 5(269). The full report can be accessed at mndot.gov/research/reports/2020/202008.pdf. *Information about the pooled fund project can be found at* pooledfund.org/Details/Study/498.