2018-17TS
Published June 2018

DEPARTMENT OF TRANSPORTATION

RESEARCH SERVICES & LIBRARY

IMPLEMENTATION SUMMARY

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PROJECT COST:
$24,000

In-house software helps MnDOT engineers design high-performing, cost-effective concrete pavements before road crews build them.

Putting Research into Practice: Upgrading MnPAVE-Rigid Design Software

What Was the Need?

MnDOT developed its own pavement design software, MnPAVE-Rigid, in 2014 that incorporated the methodology of the American Association of State Highway and Transportation Officials (AASHTO) Mechanistic–Empirical Pavement Design Guide (MEPDG). Minnesota's pavement designers use MnPAVE to apply AASHTO's most sophisticated design principles for both rigid and flexible pavement, focusing on mechanical properties of the pavement and prevention of early cracking and other distress.

MnDOT has upgraded its software for concrete pavement design. MnPAVE-Rigid 2.0 is easier to use and allows designers to select from more options for aggregate base types and thicknesses, and incorporate specific traffic values.

AASHTO's mechanistic–empirical (M–E) design methods entail hundreds of inputs, each a mechanical parameter, a measure of site-specific characteristics or a design goal. To simplify the input selection process, AASHTO's M–E design software offers various input levels to reduce the data gathering and input burden. The most basic level uses default values for most of the inputs based on national averages, but still requires dozens of inputs for the number of pavement layers, traffic expectations, climate and other features.

MnPAVE-Rigid for concrete pavement design reduced that number of inputs to nine, operating like a module of AASHTO's M–E software. MnPAVE-Rigid inputs work with a set of default values for jointed plain concrete selected by the MnDOT Office of Materials and Road Research in 2014, as described in the MnPAVE-Rigid 1.0 report.

Since implementing MnPAVE-Rigid 1.0, MnDOT has gathered feedback from users about their experience with the software. In the current project, MnDOT wanted to address this feedback, and expand and improve the original software by exploring additional options with some of the default parameters for concrete pavements.

What Was Our Goal?

The goal of this project was to update MnPAVE-Rigid 1.0 by expanding the range of inputs for traffic, subgrade type, base type and thickness, and to make the user interface more accessible.

What Did We Implement?

MnPAVE-Rigid 2.0 allows users to enter 11 inputs, including inputs related to specific traffic levels and aggregate base types; calculate the new design thickness; and print a project report that summarizes the inputs and the recommended thickness. The upgraded software is more user-friendly, and MnDOT can maintain or make future upgrades to the source code.

How Did We Do It?

Researchers met with the Technical Advisory Panel and reviewed the list of software improvements requested by pavement designers and the MnDOT Office of Materials and Road Research.

Because every change to an input affects a large number of default input variables, investigators ran over 21,000 simulations to analyze the impact of changes made to inputs for

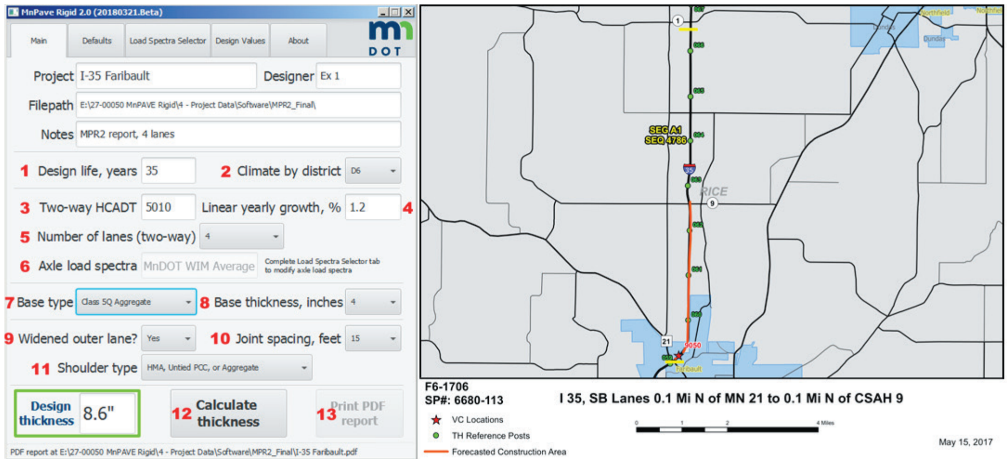
continued

"In the original software, we only allowed one aggregate base thickness and one aggregate type. MnPAVE-Rigid 2.0 allows two base thicknesses and three base types."

—Tim Andersen,
Pavement Design Engineer, MnDOT Office of Materials and Road Research

"Many states ignored the challenge of adopting AASHTO M–E or they bought an AASHTO software license. MnDOT used its accumulated knowledge of AASHTO M–E and Minnesota conditions to build MnPAVE-Rigid, and so can account for its M–E design results firsthand."

—Derek Tompkins,
Principal Civil Engineer, American Engineering Testing, Inc.



MnDOT engineers use sophisticated and complex M–E pavement design methods from MnPAVE-Rigid 2.0 software to design durable, high-performing concrete pavements.

base type, base thickness, subgrade type and traffic level. The research team also modified the traffic input calculator to allow designers to enter traffic values from MnDOT's weigh-in-motion and traffic counting data. The calculator runs input traffic data in software simulations and assigns the input an appropriate axle value for design.

MnPAVE-Rigid 1.0 ran designs based on Class 5 aggregate base over a subgrade like clay loam. Other aggregate types were added to simulations to determine how the software responds to these changes. Investigation also explored the addition of subgrade material options in design simulations.

The code developer modified elements of the advanced inputs tab and PDF report generation features to improve performance for software users, and rebuilt the software in JavaScript 2.0 code, including an installer for use with Windows software.

What Was the Impact?

MnPAVE-Rigid 2.0 is more user-friendly. Its tabs better match designer needs, and the software offers a design report PDF file for export. Instead of selecting from limited options for traffic volumes (default, normal and heavy), users can now input traffic data that the software will categorize. Designers can input Class 5 aggregate, Class 5Q (a higher quality aggregate with fewer fines) and open graded aggregate (no fines). Users can also choose 4-inch or 12-inch aggregate base thicknesses. An additional subgrade option was not included, as simulations indicated a sand subgrade input did not discernibly impact structural thickness outputs.

The AASHTO M–E software is expensive, and agencies that use it have to work closely with consultants to receive training and to explore or modify the code. MnDOT owns and manages the source code for MnPAVE-Rigid 2.0, can keep it secure, and can continue to change and upgrade it internally for Windows and Linux platforms.

What's Next?

MnDOT designers around the state are reviewing the software, but it is essentially already in use. After full review, the Office of Materials and Road Research will post a link to the program on its website. Presentations about the software upgrades will be made at meetings for materials and soils engineers through the fall of 2018.

This Implementation Summary pertains to Report 2018-17, "MnPAVE-Rigid 2.0," published May 2018. The full report can be accessed at mndot.gov/research/reports/2018/201817.pdf.

Produced by CTC & Associates for:
Minnesota Department of Transportation
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