RESEARCH ADMINISTRATION
Bureau of Field Services
Michigan Department of Transportation

Research Spotlight

Updated Bridge Design System endures as a unique, powerful tool for MDOT's Design Division

MDOT engineers rely on custom software called the Bridge Design System (BDS) to perform a wide array of bridge design functions, allowing for the top-down design of bridges in a single package. Developed by MDOT engineers beginning in 1956 and enhanced and updated over the years, it is a uniquely valuable tool that fits the Design Division's business processes and outperforms off-the-shelf systems. Researchers undertook a major modernization of the BDS source code and updated its documentation, developing a new user manual and technical reference guide. The result is a robust, efficient bridge design tool that MDOT can continue to use for years to come.

Project Information

REPORT NAME: Bridge Design System Analysis and Modernization

START DATE: November 2013

REPORT DATE: September 2016

RESEARCH REPORT NUMBER: RC-1642

TOTAL COST: $561,176

COST SHARING: 20% MDOT, 80% FHWA through the SPR, Part II, Program

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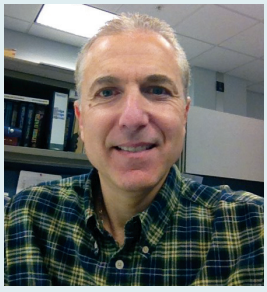

Problem

MDOT is unique among departments of transportation in using bridge design software that is custom-built by its employees to precisely match its Design Division's business processes. The BDS is a powerful solution that has grown over the years to include a wide array of bridge design functions. Bridge designers input a number of variables regarding a bridge's basic structure and type, and the software uses design equations from state and national specifications to output design details like the dimensions and layout of the bridge's deck, beams, piers, abutments and other elements.

With the modernization of its source code and updated software documentation, MDOT's unique Bridge Design System software will continue to be a robust and flexible bridge design tool for years to come. Above, project intern Drew Roberts, an engineering student at Michigan Technological University, gives a sense of the project's scale: The updated documentation would be more than 4,000 pages if printed out.

(continued)

"The Bridge Design System is a unique tool that is very valuable to MDOT. It allows us to perform a number of different design functions with one package. This project was vital to making sure that it continues to be a powerful solution for MDOT's Design Division."

Sam Guerrazzi, P.E.
Project Manager

Because of the software's age and the fact that the code was written over a number of years, portions of the BDS source code were not current with today's software standards. It was written in multiple versions of the programming language Fortran, and it contained proprietary functions restricting the code to one compiler (a tool that converts source code to create an executable program). MDOT needed to update its bridge design software.

Approach

MDOT explored other software options, but determined that replacing the BDS would require multiple off-the-shelf products that are not as customizable, integrated and powerful as BDS. MDOT decided to modernize the BDS code to be compatible with the latest Fortran standards and compilers, and to update the software documentation (user manual and technical reference guides). After six decades, the documentation had not kept up with the growth of the code to more than 43,000 lines, and the MDOT staff who were most knowledgeable about the program's architecture and design had retired.

MDOT worked with the Center for Technology & Training at Michigan Technological University to conduct an analysis of the BDS code and graphical user interface, update the software documentation, and begin to modernize the code.

Research

The researchers began by mapping out the software's architecture, processes and functionality using flow charts and other diagrams. They then separated the program into multiple modules in order to work efficiently with its large code base. They identified the most critical bridge design equations in the BDS and cross-checked them against current bridge design specifications from MDOT and the American Association of State Highway and Transportation Officials (AASHTO). The team developed an automatic testing suite that runs hundreds of bridge designs at once and compares the results from the old code to the new code to identify the impact of changes in the software. Finally, they evaluated the existing BDS user manual and archived documentation.

In the process of examining the BDS code, the researchers identified obsolete and deprecated programming language components and proprietary language extensions, which enabled them to modernize the code so that it will run on any compiler. They also documented each BDS module with a description of its functions and engineering design processes. Finally, they updated the user manual to reflect the current state of the BDS.

Results

The researchers produced two comprehensive documents. The *BDS Reference Guide* is a HTML-based compilation intended for structural engineers and software engineers. The guide's *Engineering Technical Reference* includes worksheets that compare BDS design equations to AASHTO specifications, and its *Software Technical Reference* includes logic diagrams detailing the relationships between BDS modules. The *BDS User's Manual* provides step-by-step explanations of the fields where users enter data on the software's 13 design input tabs. The manual also gives an overview of the graphical user interface and chronicles the history, scope and limitations of the BDS.

The researchers also provided a software risk assessment detailing the results of their forensic investigation of the BDS and outlining the major code-based and institutional risks to the long-term viability of the BDS.

Value

The BDS plays a pivotal role in MDOT's bridge design processes. This project ensures that MDOT can efficiently maintain and enhance the BDS code so it continues to be a viable bridge design solution for years to come. Michigan Technological University's Center for Technology & Training will continue to work with MDOT to support the BDS, including updating its graphical user interface and accommodating new types of bridge elements and changing AASHTO specifications.

Research Administration

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