PUTTING RESEARCH TO WORK

BRIEF

Decision support system guides response to damaged bridges

Collisions and severe weather may leave highway bridges with impact damage, fire damage, fatigue cracking or scour that structurally impair these spans. According to the NCHRP, vehicle collisions inflict damage on about 200 prestressed concrete bridges annually, 80 percent of these caused by over-height trucks. A Texas DOT study found that on all types of bridges in that state, collisions increased at a rate of 50 incidents per year between 1987 and 1992, and 14 percent of structures were seriously damaged.

What's the problem?

When accidents involve structures, emergency personnel call in transportation officials to assess damage and determine the need for road closures. In 2005 a backhoe/excavator struck the Mason Street Bridge in Green Bay, resulting in extensive damage to several concrete girders. The debris scattered the roadway and struck another vehicle behind the truck. Traffic was closed temporarily until transportation officials cleared the roadway debris and determined the bridge was still structurally sound.

WisDOT representatives called to crash scenes are not always bridge engineers or inspectors. A decision support system consisting of data on bridges, past incidents and maintenance history could expedite reopening of roadways, when appropriate, by transportation officials.

Research objectives

The primary objective of the study was to build upon the Phase I study, which collected data from 16 bridges in a Bridge Incident Response Database (BIRD), by developing a DSS linkable to BIRD that would assist transportation officials responding to bridge incidents. Specific objectives were to develop an easily used Bridge Emergency Expert System (BEES) based upon expert knowledge from Wisconsin case histories, and to merge BIRD with BEES.

Methodology

LITERATURE REVIEW Researchers executed this work by reviewing both bridge management systems and DSSs in use around the country as well as in Canada and Europe. Investigators then consulted WisDOT's Highway Structures Information System to identify bridge types, and the WisDOT Emergency Traffic Control and Scene Management Guidelines to identify and prioritize DSS goals and incident classifications. The team also reviewed national and state crash studies and reports to identify the types of damage to which bridges like those in Wisconsin may be subject.

PROTOTYPE DEVELOPMENT AND TESTING The research team then worked with two commercial open-source software packages to develop the WisDOT system:

- Python, an object-oriented programming language.
- CLIPS, an expert system development program.

The team drew on Wisconsin bridge data, reports from bridge incidents and civil engineering principles to create rules and facts written as if-then expressions in a forward-chain process. Python and CLIPS were employed to develop the user interface and to implement the rules and facts. The research team developed and tested suggestions from the prototype BEES against the recommendations implemented in nine bridge case histories from BIRD.

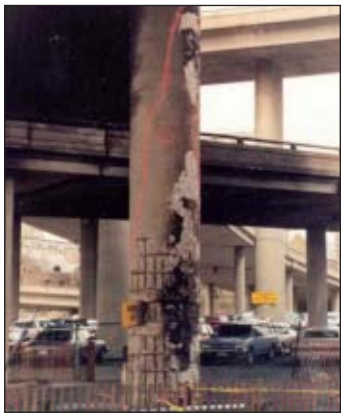
Results

Researchers found that none of the bridge management systems in use around the world could be considered fully developed; all would need some improvement in terms of inspection modules, data processing or effective expert systems.

Investigator

"Based on our previous research, we developed a new decision support system that can assist WisDOT personnel in assessing bridge condition and road closure needs in cases of bridge emergencies."

–Al Ghorbanpoor
University of Wisconsin–Milwaukee
algh@uwm.edu



Fire damage like this from a 1992 gasoline truck explosion at the Marquette Interchange can cause alarming damage that may be structurally significant.

Researchers checked the software's recommendations against action taken with these severely damaged steel girders on County Road M over WIS 60 near Watertown. Officials closed the bridge and had girders replaced, a recommendation echoed by BEES.

Project Manager

"A database of incidents and how we've responded to them can be really important in helping bridge inspectors assess emergency situations."

–Travis McDaniel
WisDOT Bureau of Structures
travis.mcdaniel@dot.wi.gov

Investigators used BIRD, Python and CLIPS to create a BEES that is simple to use as well as, rapid and effective as a tool for assisting transportation officials responding to emergency incidents. Its primary standards for recommendations are the safety of the traveling public and incident responders, and the integrity of the structure.

Because most bridges in Wisconsin are concrete or steel, and the most common emergency incidents result from impact and fire, BEES classifies emergencies on the basis of the material type for damaged bridge elements, the type of incident and the level of damage to the structure. Users define damage as minor, moderate or severe based on visual evidence and then categorize the damage into one of five groups:

- Concrete superstructures damaged by impact.
- Concrete substructures damaged by impact.
- Concrete superstructures damaged by fire.
- Concrete substructures damaged by fire.
- Steel superstructures damaged by impact.

Tests of BEES were used to improve outcomes it delivered. Investigators found close correlation between BEES' recommendations and previous WisDOT responses to bridge incidents. Diversions of BEES from past decisions reflected the system's more conservative approach, calling for additional analysis, testing and evaluation.

Incidents outside the BEES/BIRD knowledge base are addressed by recommendations in the system. BEES and BIRD are expandable; updates to existing case histories as well as new bridge case histories can be added to the database and will expand the BEES capability.

Implementation

BEES will help transportation representatives who respond to bridge incidents make quick decisions. It will not replace the judgment and action of experts and experienced engineers but will help provide efficient, suitable responses to emergencies. The system can be updated and expanded by WisDOT personnel to include more bridge case histories.

This brief summarizes Project 0092-04-15, "Bridge Integrated Analysis and Decision Support—Phase II," produced through the Wisconsin Highway Research Program for the Wisconsin Department of Transportation Research Program, 4802 Sheboygan Ave., Madison, WI 53707.

Daniel Yeh, WisDOT Research and Communication Services

Brief prepared by
CTC & Associates LLC
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