FEBRUARY 2025

Developing prefabricated concrete rail barriers for bridges can shorten the time needed to reconstruct a deficient or obsolete bridge.

RESEARCH SOLUTIONS

Evaluating the use of prefabricated concrete bridge rails

Accelerated bridge construction (ABC) replaces structurally deficient bridges with less disruption to the traveling public than traditional construction techniques. To ensure new bridges are built or existing bridges are rehabilitated or replaced efficiently, prefabricated concrete bridge railings are needed to complement existing prefabricated components used in ABC bridges. In this project, investigators evaluated the performance of a prefabricated concrete barrier that included full-scale crash testing the new bridge railing with a 22,000-pound, single-unit truck impacting at the AASHTO MASH Test Level 4 (TL-4). Successful crash test results supported the future use of prefabricated concrete bridge barrier segments as part of ABC projects.

THE NEED

A high percentage of bridges throughout the United States are structurally deficient. To ensure safe travel and a high level of service, state departments of transportation (DOTs) may reconstruct bridges with prefabricated components. Currently, cast-in-place barriers are used with the prefabricated components, but this practice is time-consuming and more disruptive to traffic. Precast concrete bridge rails are needed to accelerate bridge construction.

Building upon current knowledge, investigators developed a precast concrete barrier that can be installed quickly. They evaluated the safety performance of the prefabricated barrier segments attached to reinforced concrete decks using computer simulations and full-scale crash testing.

RESEARCH APPROACH

Initially, two barrier-to-deck connections were evaluated to understand the load distribution and connection performance. One barrier

(continued)

"The precast concrete barrier developed and tested in this project offers an efficiently made bridge barrier rail that can be used on accelerated bridge construction projects."

– JAMES HAUBER,
Iowa DOT Bridges and Structures Chief Structural Engineer

option uses inclined reinforcing bars to promote durability and repairability, but has a higher initial cost. The other barrier option uses U-shaped reinforcing bars to connect the precast barriers to the bridge deck. This option is durable and cost-effective, but replacement costs will be higher. After testing the performance of both barriers, investigators selected the barrier with inclined reinforcing bars for further testing.

Next, two variations of the barrier design were evaluated with LS-DYNA software:

- Single-slope barrier with a 10.9-degree slope from the vertical inclined bar.
- Near-vertical barrier with a 3.0-degree slope from the vertical inclined bar.

Investigators selected the refined single-slope barrier configuration for full-scale crash testing because of its prevalence among state DOTs. Investigators then conducted full-crash testing of this barrier using a 22,200-pound, single-unit truck that impacted the barrier at a speed of 55.4 mph and an angle of 14.7 degrees.

Full-scale crash testing results were compared to precrash simulation results to make improvements to precrash simulation testing.

WHAT IOWA LEARNED

The precast single-slope concrete barrier performed satisfactorily in the full-scale crash testing. All safety performance criteria were within acceptable limits. The barrier successfully contained and redirected the single-unit truck, with the vehicle exiting the system at an angle of approximately 0 degrees. The truck leaned over the barrier, but it did not show any indication of possible rollover during or after the test.

The truck exhibited minimal damage from the crash with limited concrete gouges. The barrier exhibited only hairline cracks near the impact region and along the top of the barrier. Neither detached fragments nor debris from the crash penetrated the occupant compartment or posed potential hazards to other traffic, pedestrians, or work zone staff.

In earlier phases of testing, the near-vertical barrier outperformed the single-slope barrier. Full-crash testing of the near-vertical barrier is needed to confirm the earlier results.

PUTTING IT TO WORK

The findings of this project will inform guidance for improving deck engagement and reinforcement strategies in bridge design. Specifically, the results will be used to refine design procedures in AASHTO's *Load and Resistance Factor Design (LRFD) Bridge Design Specifications*. Additionally, Iowa DOT will consider using the single-slope precast rail barrier as part of future ABC projects.

ABOUT THIS PROJECT

PROJECT NAME: Evaluation and Full-Scale Testing of Concrete Prefabricated Bridge Rails

Final Report

PROJECT FUNDING PROGRAM:
Evaluation and Full-Scale Testing of Concrete Prefabricated Bridge Rails, an eight-state collaborative research effort

PROJECT NUMBER: TPF-5(367)

REPORT DATE: July 2024

PROJECT CHAMPION:
James Hauber, P.E.
Bridges and Structures Chief Structural Engineer
Iowa DOT
james.hauber@iowadot.us
515-239-1393

PROJECT MANAGER:
Khyle Clute, P.E.
SPR Research and Pooled Fund Programs Manager
Iowa DOT
khyle.clute@iowadot.us
515-239-1646

PRINCIPAL INVESTIGATOR:
Ronald Faller, Ph.D., P.E.
University of Nebraska
rfaller1@unl.edu
402-472-6864

IOWA DOT RESEARCH:
iowadot.gov/research
ideas.iowadot.gov