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# Methods for Removing Concrete Decks from Bridge Girders, TR-647

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**Abstract**
With ever tightening budgets and limitations of demolition equipment, states are looking for cost-effective, reliable, and sustainable methods for removing concrete decks from bridges. The goal of this research was to explore such methods. The research team conducted qualitative studies through a literature review, interviews, surveys, and workshops and performed small-scale trials and push-out tests (shear strength evaluations). Interviews with bridge owners and contractors indicated that concrete deck replacement was more economical than replacing an entire superstructure under the assumption that the salvaged superstructure has adequate remaining service life and capacity. Surveys and workshops provided insight into advantages and disadvantages of deck removal methods, information that was used to guide testing. Small-scale trials explored three promising deck removal methods: hydrodemolition, chemical splitting, and peeling.

**Keywords**
Bridge decks, Bridges, Concrete, Girders, Girder bridges, Steel bridges, TR-647

**Disciplines**
Civil Engineering

**Comments**
The related 73-page full report, under the same title, can be found at: http://lib.dr.iastate.edu/intrans_reports/

# Methods for Removing Concrete Decks from Bridge Girders

tech transfer summary

**With ever tightening budgets and limitations of demolition equipment, states are looking for cost-effective, reliable, and sustainable methods for removing concrete decks from bridge girders.**

## Background

Although bridges are typically designed to last for 75 years (AWS 2012), bridge decks deteriorate at a faster rate (Flowers et al. 2010). Full-depth replacement of bridge decks that can be performed without replacing the bridge superstructures and substructures is one way of cost-effectively extending bridge service life.

## Problem Statement

Current deck removal methods, such as saw cutting, jackhammering, and blasting, often damage the bridge superstructure. Sometimes a lack of information on the as-built geometry increases the possibility of damaging portions of the existing superstructure, thereby increasing the cost of deck replacement and slowing construction progress.

Also, noise, vibration, dust, and falling materials associated with traditional deck removal techniques are environmental and public safety concerns. Consequently, bridge owners and contractors need economic, efficient, and reliable methods for concrete deck removal that do not damage existing superstructure elements.

## Research Objective

The overall goal of this research was to identify more efficient and reliable methods for concrete deck removal that preserve bridge superstructures and substructures.

## Research Methodology

- Review literature about removing concrete decks from concrete and steel girders including state-of-the-art and state-of-the practice for the following:
  - Deck removal methods and equipment
  - Steel girder damage and repair
- Interview bridge owners and contractors to determine cost-effective replacement alternatives
- Survey state departments of transportation (DOTs) to assess their experience with deck removal methods and identify current deck removal practices
- Conduct meetings with Iowa and Nebraska bridge owners and contractors to discuss deck removal methods for both steel and concrete girders
- Conduct small-scale trials on promising deck removal methods on steel girder bridges
- Evaluate the performance of various shear connectors with partial concrete removal

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**RESEARCH PROJECT TITLE**
Methods for Removing Concrete Decks from Bridge Girders

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The Bridge Engineering Center (BEC) is part of the Institute for Transportation (InTrans) at Iowa State University. The mission of the BEC is to conduct research on bridge technologies to help bridge designers/owners design, build, and maintain long-lasting bridges.



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## Research Description

Researchers at Iowa State University (ISU) conducted three semi-structured telephone interviews to explore the cost of bridge replacement alternatives with a Midwest DOT estimator and two bridge contractors. Because there was limited literature available on current deck removal practices, the ISU research team also conducted a survey and a workshop to investigate the state-of-the-art deck removal practices on steel girder bridges.

A parallel study of deck removal methods for concrete girder bridges was undertaken at the University of Nebraska-Lincoln (UNL). The UNL research team also conducted a survey and a workshop for deck removal methods on concrete girders.

These surveys and workshops were designed to determine methods that state DOTs currently accept and to develop ideas for methods worth further exploration. The ISU research team then conducted two experimental studies.

Small-scale trials of three promising deck removal methods—hydrodemolition, chemical splitting, and peeling—which were identified through the surveys and workshops, were conducted to evaluate their effectiveness.

*Hydrodemolition trial (Dang 2013)*

*Second peeling test (2 shear studs) (Dahlberg 2014)*

These methods have not been widely or often used to remove bridge decks, but were thought to have the potential to change and have a positive impact on the state-of-the-practice for bridge deck removal.

Push-out lab tests were also conducted, at ISU's Structural Engineering Research Laboratory, to evaluate the shear strength of shear connectors when variable amounts of concrete are removed from around various types of connectors: stud shear, channel, and angle-plus-bar. In short, this evaluation sought to answer the question as to whether it is necessary to remove 100% of the concrete during a deck replacement.

## Interview, Survey, and Workshop Key Findings

- Survey respondents from the 50 state DOTs indicated that the top three most commonly used deck removal methods were saw cutting, use of percussive tools, and hydrodemolition
- Sawing, use of percussive tools (e.g., jackhammers and rig-mounted breakers), and hydrodemolition are three commonly used deck removal methods identified through interviews, surveys, and workshops
- Damage caused by deck removal methods and equipment is not considered in cost estimates or other decisions because the damage is typically minimal
- Hydrodemolition has the unique advantage that it does not damage steel girders
- Contractors usually have equipment that can be used for peeling
- Grinding, welding, heat-straightening, and flange build-up or replacement are currently used to repair damaged superstructures
- 10 of the 28 state DOTs responding to the project survey reported that they specify deck removal methods and equipment in special provisions
- Removing bridge decks takes about the same amount of time as removing entire superstructures when bridges are over waterways
- Bridge deck removal takes longer and is more delicate work than removing the entire superstructure or bridge
- Concrete deck replacement is more economical than replacing the entire superstructure under the assumption that salvaged superstructures have adequate remaining service life and capacity

## Small-Scale Trial Key Findings

- Hydrodemolition is well suited for both partial and full-depth concrete removal
- Hydrodemolition did not damage the steel elements in the trial, which validated the survey results
- Hydrodemolition consumes a large quantity of water and produces wastewater, slurries, and debris

- Hydrodemolition might be cost prohibitive, depending on the cost of water sources, wastewater treatment, and disposal
- Chemical splitting was found to not be an effective deck removal method
- Peeling is a simple, economical deck removal method

## Shear Strength Evaluation Key Findings

- The shear strength of the stud shear connector is insensitive to the quantity of concrete removed
- The shear strength of the channel connector is sensitive to the amount of concrete removed
- Some difference in the shear strength of the angle-plus-bar connector was observed in a lower percentage of concrete removed

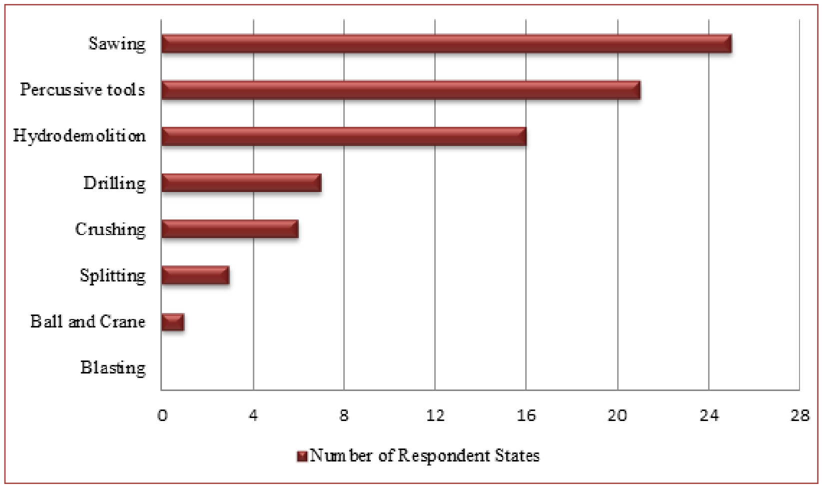
## Implementation Readiness

Interviews with bridge owners and contractors indicated that concrete deck replacement was more economical than replacing the entire superstructure under the assumption that the salvaged superstructure has adequate remaining service life and capacity.

This research confirmed that hydrodemolition has a unique advantage in that it does not damage steel girders and is well suited to both partial and full-depth removals. The pressure-controlled demolition protects the steel girders, shear connectors, and reinforcing steel from unintended damage and the method produces no dust and induces no vibration.

However, while hydrodemolition yields a high-quality deck removal, the method has several drawbacks. Hydrodemolition produces at least an equal amount of wastewater, which needs to be contained and treated, which can be cost prohibitive. The power unit is noisy (range of 90 to 100 dB). And, shadowing might occur when steel elements shield the concrete beneath them.

Chemical splitting produces no noise, dust, or vibration, but even in the best cases requires a long time to break the concrete deck and needs a method to catch falling materials. In this study, chemical splitting did not sufficiently break the reinforcing concrete, so it was not found to be an effective deck removal method.




*Currently allowed deck removal methods for steel I-girders*

With peeling, this research found that contractors usually have the required equipment  and that peeling may offer contractors advantages such as high production rate, low cost, and simplified operation. In addition, peeling did not damage steel elements in the small-scale trial.

However, with peeling, concrete on top of steel girders and around shear connectors may need additional removals by using other methods such as jackhammering. Peeling also yields dust, noise, and falling materials. Large loads generated during the peeling process might cause undesirable vibrations or deformations. And, safety, structural adequacy, and stability are other concerns with peeling equipment working on bridges.

Finally, the push-out tests validated that removing all concrete around shear connectors may not, in some cases, be necessary from a shear strength perspective.

## Implementation Benefits

The results of this study address two of the United States Department of Transportation (U.S. DOT) strategic goals: state of good repair and environmental sustainability (U.S. DOT 2012). Successful implementation of cost-effective deck removal methods maintains a state of good repair of the US transportation system. Efficient deck removal methods enhance a timely bridge deck replacement and avoid undesirable public inconvenience, travel delay, and economic hardship. These methods can preserve the superstructure resulting in improving the environmental sustainability of the US transportation system.

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