



## Rapid Bridge Replacement Techniques: Summary

The destruction of the World Trade Center buildings in September of 2001 exposed the vulnerability of domestic structures and facilities to terrorist attack. A review of terrorist targets in recent years indicates that major transportation infrastructure is high on terrorists' list. Because of this, state transportation agencies initiated efforts to investigate and develop methods to minimize traffic disruption and lessen the impact of terrorist attack and other extreme events on the country's critical transportation infrastructure. This process can be divided into three parts. One, lessen the probability of

attack on any given asset by improving security around the asset and making the asset less accessible. Two, improve the asset's survivability, should an attack occur, by strengthening the asset's critical components by retrofit or during initial design and construction. Three, lessen the impact of an attack through rapid recovery operations by advanced planning and preparation, which includes the identification and development of emergency response procedures and rapid repair or replacement techniques. This project focuses on the latter of these for the nation's bridges following any extreme event including ve-

hicle or barge impact, fire, and forces of nature, not just a terrorist attack.

### What We Did...

As a TxDOT-led transportation pooled-fund project, this effort obtained funding support from 9 states. The primary focus of the project was to identify rapid bridge replacement and repair techniques that could be used during recovery operations following a terrorist attack or other extreme event to minimize traffic disruption and lessen the impact on the surrounding community. This was accomplished



Figure 1. May 2002 Barge Impact with I-40 Webbers Fall Bridge (Provided by Oklahoma DOT)



by an extensive review of the literature, individual contacts, and site visits that utilized civilian and military resources. Applicable rapid bridge replacement and repair techniques were divided into six categories: superstructure, bridge deck, substructure, member/element repair, floating bridges, and construction/contractor techniques.

This project also sought to identify lessons learned from recovery operations of previous extreme events. This was accomplished by conducting in-depth studies on three diverse cases; they include the May 1998 fire incident associated with the I-95 Chester Creek Bridge in Pennsylvania, the May 2002 barge impact incident associated with the I-40 Webbers Falls Bridge in Oklahoma (shown in Figure 1), and the October 1997 fire incident associated with the New York State Thruway Bridge in Yonkers, New York. In addition, 23 additional extreme events were identified and included as short summaries to provide further resources.

This project also addressed two secondary issues. First, it sought to evaluate the

effectiveness of incentive/disincentive (I/D) clauses in construction contracts associated with rapid bridge replacement and repair projects. Second, it sought to provide guidance on the importance of advanced planning and preparation as applied to improving a DOT's response to any extreme bridge event (natural, accidental, or terrorist-planned).

### What We Found...

1. There is no "silver bullet" that is applicable to the rapid repair of all bridges following an extreme event. The "best" repair or replacement procedure will have to be determined on a case-by-case basis once a specific scenario is defined for a given asset.
2. Rapid replacement of critical bridge assets can be divided into three stages: pre-event planning, post-event temporary traffic, and post-event permanent repair or replacement. All three categories are important to an integrated total recovery operation.
3. The effective use of temporary repairs, elements, or structures is dependent on the short-term availability of materials and components, which could affect state DOTs

by requiring them to pre-purchase and stockpile some materials and components in preparation for an extreme event.

4. Over the last ten years, a significant and successful engineering effort has focused on the rapid replacement and repair of bridges to minimize the impact of construction on the driving public. Many of these materials and techniques are adaptable to unplanned events if temporary traffic can be re-established at some reasonable level to permit time for the planning, coordination, and prefabrication of components to occur.

5. Two dominant manufacturers of commercially available modular panel truss bridges were identified; Acrow Corporation of America (shown in Figure 2) and Mabey Bridge and Shore, Inc. This type of bridge is composed of a number of modular units and members that are bolted or pinned together in various configurations to accommodate different span lengths, roadway widths, and load applications.

6. Several rapidly placed bridges developed for or by the U. S. military were identified and considered during this project, but they tend to require specialty equipment for installation or have less adaptability with



**Figure 2.** Acrow Temporary Truss Panel Bridge and Supports (Provided by Acrow Corp.)



respect to geometric configurations and load applications.

7. A large number of applicable rapid bridge deck repair and replacement materials and techniques were identified and summarized. Their applicability is dependent on the type and extent of damage to the existing bridge deck.

8. A large number of applicable guidelines and products addressing shoring were identified and summarized along with a large number of prefabricated substructure applications. The one advantage that truss panel bridges hold over other products is that their components can also be used in shoring applications.

9. Three dominant member/element strengthening or repair techniques were identified and included in this report: epoxy injection of concrete members, fiber reinforced polymer strengthening or repairs of concrete members, and heat straightening of steel members. These techniques are well established with a large amount of technical guidance and contact information available.

10. Three modified construction work schedules (24-hour, 12-hour, and nighttime only) were found to be commonly associated with and effectively used during rapid or restricted bridge replacement construction projects. Issues that should be considered during selection of the appropriate work schedule include: 1) increases in construction costs associated with accelerated schedules or non-normal work hours; 2) decreases in user and state DOT costs associated with shorter out-of-service periods; 3) changes in costs and problems associated with inspections, problem solving, and material deliveries during typical off-duty hours; and 4) loss of worker productivity, quality control, and safety during non-standard work hours.

11. The use of the Maturity Method for estimating concrete strength was found to be effective in the acceleration of construction schedules. This method uses a temperature-time value of in-situ concrete to predict the concrete's strength and typically permits shorter form removal and non-loading periods.

12. Staged construction was found to be effective in several rapid bridge replacement projects identified and summarized during this research project. Staged construction

can use temporary bridges or portions of existing bridges to maintain an acceptable volume of reduced traffic flow during bridge repair or replacement work.

13. Selective waiving of standard construction specifications shortened bridge replacement schedules in several examples identified during this project. However, they should only be waived when justified by sound engineering judgment.

14. Incentive/disincentive (I/D) clauses in construction contracts provide positive effects on construction schedules. By far, the majority of cases identified that implemented I/D clauses finished ahead of schedule. I/D clauses are typically reserved for projects where user costs are high and the impact on the driving public is severe. Several references were identified that provide guidance on project selection and setting of I/D monetary and time limits.

15. A partnering attitude and a commitment of resources from all parties involved (state DOT, design firm, contractor, material suppliers, and the like) are critical to the successful completion of any rapid bridge replacement project. Several cases addressed in this report demonstrate truly amazing results when this combination of attitude and commitment was maintained throughout the projects' recovery operations and construction processes.

16. The A+B bidding technique has been shown to be an effective tool in shortening certain types of construction contracts. The "A" component provides the cost of the project, and the "B" component provides the time schedule required to execute the work. This technique encourages contractors to be more active and creative in the scheduling and management of a project. Guidance for use of the A+B bidding technique is provided in the report.

17. Advanced preparations prior to an extreme event will yield positive results during recovery operations in which a damaged asset is returned to full operational capacity. Advanced preparations include: 1) development of Emergency Response Plans for identified critical assets, 2) development and training of Emergency Response Teams at the state and local levels, and 3) acquisition and pre-positioning of

generic, adaptable and/or reusable bridges or bridge components.

## The Researchers Recommend . . .

The researchers' recommendations include the following:

1. An Emergency Response Plan (ERP) for all identified critical bridges in the state should be developed. The development of the ERP is the pre-event planning that will speed up the overall bridge recovery operation and minimize the impact on the driving public. It should include names and contact information for local and state agencies, key DOT personnel, and local contractors and material suppliers. It should also contain pre-developed plans that address response procedures, temporary detours and traffic, and debris management.

2. Consideration should be given to the pre-purchasing, pre-positioning, and stockpiling of materials and bridge components that can be used for the temporary or permanent replacement of each bridge. This includes items like truss panel bridges, shoring, and steel wide-flange I-beam sections. Selected materials need to be versatile, adaptable, and/or reusable.

3. Implementation of the stockpiling concept also requires the development of an Emergency Response Team who is familiar with and trained in the proper use of the stockpiled materials to maximize the effectiveness of the concept. In addition, the development and training of an Emergency Response Team will allow for the more efficient usage of the wide range of materials and techniques that were identified and discussed in this report and that are available in industry.



### *For More Details...*

The research is documented in the following reports:

Report No. 0-4568-1

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To obtain copies of the reports, contact the Center for Transportation Research Library at (512) 232-3126, [ctrlib@uts.cc.utexas.edu](mailto:ctrlib@uts.cc.utexas.edu).

### **TXDOT IMPLEMENTATION STATUS December 2004**

The TxDOT Bridge Division currently has several rapid bridge replacement initiatives underway. The results from this research project are being implemented on a trial basis on a bridge replacement project for FM 774 Dry Creek Bridge in Refugio County. Although the Dry Creek bridge replacement project is not the result of an extreme event, implementation of the rapid replacement techniques identified during the course of research project 0-4568 can be further refined through normal bridge replacement projects. This implementation effort will provide valuable experience and increased knowledge in a critical area that will be useful for responding to future bridge replacement challenges, planned or unplanned.

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### **Your Involvement Is Welcome...**

This research was performed in cooperation with the Texas Department of Transportation and the U.S. Department of Transportation, Federal Highway Administration. The contents of this report reflect the views of the authors, who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the official view or policies of the FHWA or TxDOT. This report does not constitute a standard, specification, or regulation, nor is it intended for construction, bidding, or permit purposes. Trade names were used solely for information and not for product endorsement.

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