EMERGENCY REPLACEMENT OF BRIDGES

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ABSTRACT

The travelling public's safety is Texas Department of Transportation's highest priority. The number of bridges damaged over the past five years in Texas highlights an urgent need to develop emergency response plans to counteract the possible consequences of accidents. This paper's objective is to identify strategies and technologies that can quickly restore highway bridges in the event that they are damaged.

There are three bridges in Abilene, Texas, which were damaged by accidents and replaced by an emergency replacement contract. The first bridge is in Nolan County, at U.S. 84 overpass at interstate IH 20 near Roscoe. It was hit by an 18-wheeler, crashed on the concrete barrier, and damaged the overpass. The bridge was replaced by emergency contract and reopened to traffic in September, 2013. The second incident happened in Scurry County near U. S. Highway 180 overpass. A truck carrying an oversized load damaged this bridge. The third bridge is located in Howard County at interstate IH 20 from FM 2599 to Highway 176. The pier columns in the bridge were hit by an 18-wheeler and caused a collapse.

By studying the design and contracting procedures in these three projects, the project team sought to identify the issues involved and evaluated the procedures undertaken in those situations. Emergency replacement of any structure involves many steps and requires various personnel to make technical and management decisions in a very short period of time.

OBJECTIVE:

The objective of this paper is to identify strategies and technologies to quickly restore highway bridges, in the event that they are damaged by extreme events or accidents. This paper presents three bridge cases in Abilene, Texas and lessons learned from the incidents. In this paper the team is going to identify and synthesize current practices that comprise the state of practice related to expedited procurement procedures and discuss the procedures that have been used successfully on these emergency replacement projects. This paper also describes effective procedures for delivering emergency projects and managing the increased contractual risks that involved in those situations. The amount of money spent on these case study projects range from $1,564,000 to $2,709,930 for overpass bridge replacement. In the past ten years there were number of natural and man-made catastrophes that resulted in the loss of a major portion of bridge to the national highway network. The sudden major collapse in 2007 of the Interstate 35W Bridge in Minnesota and destruction caused by the 2005 Hurricane Katrina to the Gulf Coast and Interstate 10 were major emergency situations. Even though high profile emergency projects are well known to the travelling public, the more common situation is the loss of a culvert on a country road or a freeway overpass damaged and closed due to a traffic accident. These kinds of local emergency cases sometimes are not published, but are critical to the travelling public in the area, require the same restoration and involve expedited procurement procedures to save public life and property. Nonetheless the Departments of Transportation across the nation have been able to restore structures with both large and small emergency incidents to the highway network service through an ongoing process[1]. The main purpose of this paper is to collect, analyze and publish the collective experience of TxDOT personnel with the emergency projects in Abilene, Texas.

DEFINITIONS:

This paper uses a number of procurement terms in a precise sense. It is important for the reader to understand the specific definitions of each terms used in this paper.

Emergency projects: A project initiated as the result of some unexpected circumstance that affected the capacity/and/or level of service of a given transportation facility (road, bridge, tunnel, etc.) to the point where the respondent believed it to be great enough to warrant special treatment in the procurement phase.

Qualifications Based Selection (QBS): A procurement method where the consultant or contractor is selected on a basis of qualification alone with no price factors. Price is negotiated with the best qualified competitor.

Sole Source: A procurement method where the agency is authorized to award directly to the consultant/contractor of its choice without competition.

Typical Project: A project delivered using procedures considered by the respondent to be normal.

Alternative Technical Concepts (ATC): A procedure where the designers and/or contractors are asked to furnish alternative design solutions for features of work designated by the agency in its DB Request for Proposals (RFP)

Construction Manager/General Contractor (CMGC): A project delivery method where the contractor is selected during design and furnishes preconstruction services

Design-Build (DB): The system of contracting under which one entity performs both architecture/engineering and construction under a single contract with the owner.

Best Bid (BB): This is one type of selection of contractor based on time to complete the project, estimate and experience of the contractor.

Design-Bid-Build (DBB): The traditional project delivery approach where the owner commissions a designer to prepare drawings and specifications under a design services contract, and separately contracts for construction, by engaging a contractor through competitive bidding or negotiation.

EMERGENCY PROCUREMENT PROJECT CASE STUDY DETAILS

The following sections explain the details of each case study project.

WB IH20 UNDERPASS AT EB US84 IN NOLAN COUNTY

The EB US 84 bridge over WB IH 20 in Nolan County was struck by a tractor-trailer on Thursday, September 27th 2012. The truck lost control, swerved off the roadway and hit the bridge bent causing severe damage to two of the three columns. The remaining column was also damaged at the bent cap to column connection. The continuous steel I beam superstructure and deck also suffered damage due to the loss of support from the bent that was impacted. The damage to the bridge forced the immediate closure of both IH 20 WB and US 84 EB.

An emergency contract was executed with a contractor early Friday September 28th 2012 morning to erect shoring under the bridge so that WB IH 20 could be re-opened. TxDOT Bridge

Division was on site Friday to perform a preliminary structural evaluation. The contractor was able to complete the shoring by 3:00AM Saturday morning and one lane of WB IH 20 was opened at 9:30AM. The one lane configuration for WB IH 20 was necessary due to the proximity of the shore towers to the main lanes. The US 84 EB Bridge remained closed.

Figure 1 Overview of Damaged Bridge at US 84 over IH 20 in Nolan county

The existing bridge was a 195 ft., 3-span structure (60.00'-75.00'-60.00'). The superstructure consisted of continuous steel I beam unit, which rested on bents skewed at 54.8 degrees. The existing bent that was damaged had columns in close proximity to the underlying roadway shoulder.

The replacement bridge follows the same alignment as the existing bridge, but the vertical profile was slightly raised. The reason for the bridge replacement was because a bent adjacent to the roadway was hit, therefore, in the new bridge geometry the substructure was moved further away from the underlying roadway. The new bridge substructure consists of only two abutments supporting a 130 ft. prestressed concrete Tx46 girder span. The west abutment is 30 ft. from the existing west bent and the east abutment is 35 ft. from the existing east bent.

Both replacement bridge abutments are oriented with the same bearing, but have varying skews of 52.83 degrees and 56.73 degrees since the bridge geometry relies on a horizontal curve. The abutments have tightly spaced drilled shaft foundations because they also support a retaining wall that wraps around both ends of the bridge. Figure 2 shows the two abutments with different skew angle and support retaining wall.

Figure 2 New single span bridge structure under construction

Figure 3 New Retaining wall wraps around the abutment

Figure 4 Completed Bridge Structure –WB IH 20 Underpass at EB US 83

TABLE 1. US 180 UNDERPASS BRIDGE REPLACEMENT TIMELINE

Date	Event	Remarks
September 27, 2012	Accident occurs	
September 28, 2012	Emergency demolition contract awarded	TxDOT generates different feasible options around the existing bridge
September 28, 2012	Contractor installs temporary shoring	Gibson & Associates, Inc.
February 1, 2013	WB IH 20 Underpass contract advertised	
February 14, 2013	WB IH 20 Underpass contract awarded	Contract amount $1,564,229.50 J. H. Strain & Sons, Inc.
March 11, 2013	WB IH 20 Underpass construction started	
October 11, 2013	WB IH 20 Underpass Completion date	

US 180 OVERPASS AT US 84 IN SNYDER COUNTY

The U.S. Highway 180 overpass at U.S. Highway 84 in Snyder was damaged Tuesday February 6th, 2013 by an 18-wheel truck carrying an oversize load, according to the Texas Department of Public Safety. No one was injured in the wreck, which occurred when an 18-wheeler carrying a rock crusher attempted to pass underneath the bridge. The truck, which is permitted to travel at 14 feet in height, attempted to pass beneath a bridge marked at a height of 14 feet 5 inches. The over-weight equipment pulled and damaged the exterior steel girder. This caused damage to the bridge deck partially. This incident happened three months after the accident of the Nolan county bridge, which was under construction.

DETOUR TRAFFIC

Due to the two consequent accidents the eastbound traffic was detoured from US 84 twice between Snyder and Sweetwater. The east bound US 84 traffic was remained detoured to west bound IH 20, where it could continue east near Roscoe.

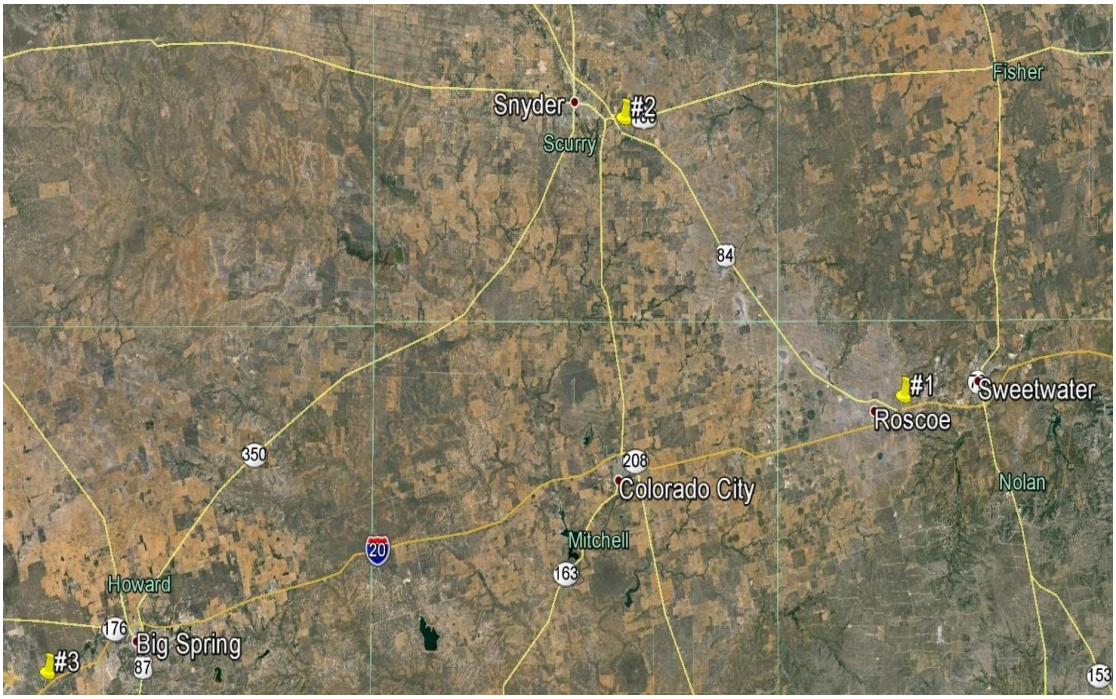

Figure 5 Aerial Map showing all three Bridge Location

Figure 6 Damaged Bridge – US 180 Overpass at US 84 in Snyder County

Figure 7 Steel Girder Damaged by the 18 Wheeler Truck

Figure 8 Damaged Bridge Concrete Deck

Figure 9 Damaged Bridge (Under view)

The overall length of the original bridge was 240.00', consisting of 4-spans (50.00, 70.00', 70.00', 50.00'). The existing super structure was a steel continuous beam unit and the interior bents were rectangular bents with three columns. The vertical clearance was the main criteria for the design of the new bridge and the designer tried to use shallow beam for the superstructure and raise the existing road profile. The replacement bridge has an overall length of 240.00', with same four spans configuration (50.00'-70.00'-70.00'-50.00') as the existing bridge. The superstructure of the new bridge consists of Prestressed Concrete X-Box beams, which are box beams that have been modified to allow for maximum span length and performance with a spread framing system.

The replacement bridge used the same alignment but the vertical profile was higher than the existing bridge in order to maintain a vertical clearance of 17'-6". Since the XB20 box beams in the new bridge have considerably less section depth than the existing steel beams, there is an increase in vertical clearance. Using precast concrete beams reduced the material delivery time, but increased the bridge dead load. The station of interior bents and abutments, located in the main lanes remain unchanged. Two additional drilled shafts were added, one in between each existing drilled shaft, which were designed to carry the additional load of the new bent caps and super structure. The existing columns were removed to 2'-0" minimum below existing grade. The reinforcing steel of the existing drilled shafts were cleaned and extended into new column. The new Grade 60 reinforcement steel from the columns was connected to the existing bars by welding or mechanical couplers per Item 440, under "Reinforcing Steel" specifications[3]. A sealed armor joint was used at each abutment.

Table 2 shows the timeline of the bridge replacement process. Figure 10 shows the completed bridge structure.

TABLE 2. US 180 UNDERPASS BRIDGE REPLACEMENT TIMELINE

Date	Event	Remarks
February 6, 2013	Accident occurs	
February 8, 2013	Emergency demolition contract awarded	TxDOT generates different feasible options around the existing bridge
February 14, 2013	Contractor demolishes	J.H. Strain & Sons, Inc. $185,945
May 28, 2013	US 180 Underpass contract advertised	Contractors notified
June 6, 2013	US 180 Underpass contract awarded	Contract amount $2,709,930.20 Gilvin-Terrill, LTD
June 17, 2013	US 180 Underpass	

	construction started	
October 20, 2013	US 180 Underpass Completion date	

- Issued sole source contracts to immediately begin demolition and address the immediate danger of US 180 bridge collapse with temporary shoring.
- Implemented an aggressive BB procurement process based on time to complete the project and estimate
- Prequalified contractors are invited to bid on emergency contract.
- The district personnel contacted the contractors directly and provided the PS&E set for the project.
- Arranged bid opening so a contract award could be made immediately after bid opening.

Figure 10 Completed Bridge Structure – US 184 Underpass at US 84 in Snyder County.

Figure 11 Completed Bridge Structure with T 223 Rail (Vertical Clearance 18.0')

IH 20 UNDERPASS AT FM 2599 IN HOWARD COUNTY

On November 6th 2013, an 18-wheeler lost control and struck the columns of an interior bent of the IH 20 Underpass at FM 2599, causing a partial collapse of the bridge. Since the bridge crosses an interstate highway, rapid replacement was necessary. While the original and new designs were both fairly conventional, there were some design considerations that helped facilitate a speedy and effective replacement of the damaged structure.

Figure 12 Westbound IH-20 Bridge Hit by 18-wheeler truck in Howard County

Figure 13 Overview of Damaged Bridge – IH 20 Underpass at FM 2599

Figure 14 Partial Collapse of Columns of Interior Bent

Figure 15 Damaged Columns Struck by 18-wheeler truck

The original bridge was a 305.00', 6-span structure (37.50'-50.00'-65.00'-65.00'-50.00'-37.50'). The end spans and frontage road spans were designed with Type B Prestressed Concrete Beams. The two center spans crossing over the IH 20 mainlanes were designed with Type C Prestressed Concrete Beams. The replacement bridge is a 330.00' structure, with four spans (50.00'-115.00'-115.00'-50.00'). The superstructure of the new bridge consists of Prestressed Concrete X-Beams, which are box beams that have been modified to allow for maximum span length and performance with spread framing.

The replacement bridge used the same alignment and vertical profile of the damaged bridge. Since the XB40 beams in the new bridge have the same section depth as the Type C beams used over the IH 20 mainlanes in the old structure, there is no loss of vertical clearance. The station of the central bent, located in the median between the IH 20 mainlanes, remained unchanged. There was no difficulty in missing the existing bent foundations, because the replacement bridge is wider than the original bridge (34'-0" and 29'-2", respectively).

The original bridge had six spans, with additional interior bents between the frontage roads and the mainlanes. By using XB40 Prestressed Concrete X-Beams in the new bridge, the designer was able to span a mainlane and a frontage road in each direction (115 ft.), thus eliminating two interior bents. This is cost effective, and also shortens construction time. Figure 15 shows the construction of new bridge with four spans.

Lastly, the replacement bridge is 25 ft. longer than the original. This ensures that the existing abutment pilings won't be in the way of the new abutment drilled shafts.

DETOUR TRAFFIC

Due to the collapse of the bridge, the westbound IH-20 traffic continued to be detoured to SH 176 and into Martin County until the debris was removed. TxDOT had a contractor at the site of the incident and debris removal started as soon as possible. TxDOT officials assessed the situation at IH 20 and FM 2599 and decided to expedite the contract procurement process.

Figure 16 New Bridge Under Construction- IH 20 Underpass at FM 2599 in Howard County

Figure 17 New Bridge with Four Spans

TABLE 3. FM 2599 BRIDGE REPLACEMENT TIMELINE

Date	Event	Remarks
November 6, 2013	Accident occurs	
November 7, 2013	Emergency demolition contract awarded	TxDOT generates different feasible options around the existing bridge
November 6-7, 2013	Contractor installs temporary shoring	Gibson & Associates, Inc.
November 8, 2013	FM 2599 contract advertised	Contractors notified
January 14, 2014	FM 2599 contract awarded	Contract amount $2,094,360.80 J.H. Strain & Sons, Inc.
January 20, 2014	FM 2599 construction started	
Est. June 30, 2014	FM 2599 Completion date	

BEST BID

Best Bid basis is the type of selection of contractor based on time to complete the project, estimate and experience of the contractor.

Prequalified contractors, from a list that is supplied by TxDOT Bridge Division, were invited to bid on these emergency contracts. Then the best contractor was selected and the work was awarded on best bid basis. The TxDOT district personnel contact the contractors directly and furnish them the PS&E set for the project.

This project was let as an invitation-only bid. List of prequalified contractors who work in the area were invited to bid on the emergency contract. Eventually, only five contractors submitted bids. There was a pre-bid conference at the project site as well as a mandatory small business outreach meeting. The project was advertised with $50,000 per day incentive/disincentive clause capped at a $1 million maximum. The contract time was set up for 150 calendar days with an internal milestone of 130 calendar days for opening the bridge to traffic. The contract set a construction completion deadline of re-opening FM 2599 on June 30, 2014.

FM 2599 BRIDGE COLLAPSE SUMMARY

The following is a list of the major tools used to expedite the emergency replacement of the FM 2599 bridge:

- Issued sole source contracts to immediately begin demolition and address the immediate danger of FM 2599 bridge collapse with temporary shoring.
- Implemented an aggressive DBB procurement process based on limited competition among a select group of contractors with known experience.
- Arranged bid opening so a contract award could be made immediately after bid opening.
- Incentivized the emergency construction contract to minimize the construction period.
- Massed agency personnel in three shifts of field engineers and conducted construction submittal review and approval on site.

PREQUALIFICATION REQUIREMENTS FOR EMERGENCY CONTRACT AWARDS

Prequalification in its simplest form is an assessment of financial responsibility, which often mirrors what factors to look for in making underwriting decisions relating to the issuance of bonds for public works projects. It also includes some other factors such as the ability to

demonstrate performance of a certain type of work. Whether by prequalification or other methods, public owners are increasingly exploring ways to include non-price factors, both qualitative and quantitative, in the procurement process to motivate contractors not only to improve their performance during construction, but equally as important, to build value into the end product of construction. Figure 16 shows the general model for a bridge replacement.

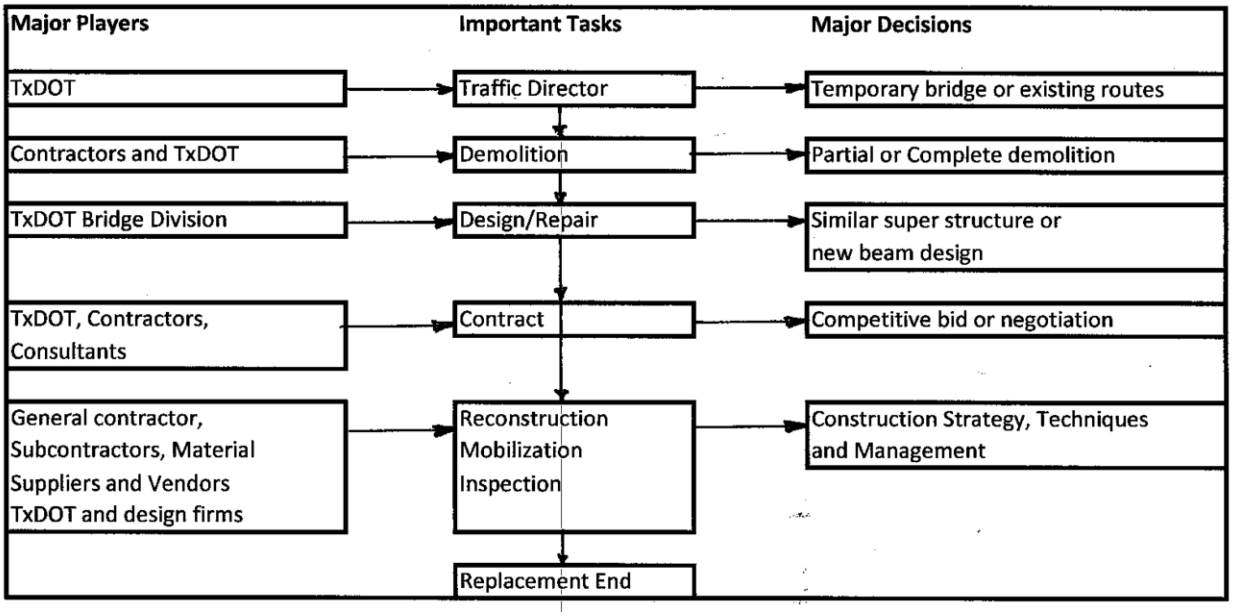

Figure 16 General Model for Emergency Bridge Replacement[2]

LESSONS LEARNED

There were many important factors contributing to the successes of the three emergency bridge replacement projects. The research team reviewed literature including design and construction information, talked to the people involved in the repair of the bridge via telephone. In all three cases, a quick response to the incident was the key to mitigate the losses and reduce the inconvenience to the travelling public. The immediate actions taken by TxDOT personnel included:

- The stabilization of the remaining structure to prevent further damage to property and safety of the travelling public.
- The removal of debris
- The detour the traffic route to prevent further damage and ensure public safety

- These primary initial steps needed to take place immediately following the incident to protect the travelling public.

CONCLUSIONS

In all three bridge replacement process, TxDOT expedited and used their resources from existing new design and construction procedures. The main tasks in the bridge replacement include traffic route detour, demolition, in-house roadway and bridge design, contracting and reconstruction. At each stage of the construction process, most of the critical decisions were made by the state DOT official without any delays. Maintaining and developing a list of prequalified contractors for emergency replacement procedures is an effective way to expedite the process based on contract agreements between TxDOT and the consultant/contractors. This will give an efficient and cost effective solution to state DOT's. The quality and qualifications for the personnel and consulting firms that are involved in designing and building an emergency bridge replacement project is more important than the administrative planning processed, since time is a constraint in an emergency. Designating the authority to deem a situation as an emergency project and to waive routine contracting constraints helps to achieve a quick response and decrease the overall impact to the public. In order to avoid contract disputes, established contracting methods and procedures must be used to speed up the contract negotiation process. Fast response to the incidents was the main factor to mitigate the losses and enhance the public safety. The cooperation among the different parties, such as TxDOT, contractors, and material suppliers accelerated the replacement project. TXDOT reviewed and approved shop drawings in a short time frame and this expedited the construction process. The roadway and bridge design for the three replacement bridge projects were performed in-house by TxDOT designers in a short period of time. The major challenges of any replacement project are communication and coordination among the people involved in the replacement process. The qualifications of the firms that will design and build an emergency project are more important than the administrative planning procedures, since time is an important factor in an emergency. Selective procedures for a design-bid-build, design-build, and construction supervisor/general contractor list can be developed to accelerate the procurement of design and construction assets in response to a major emergency situation.

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