I-90 EASTON BRIDGE REPAIR

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ABSTRACT

Precast concrete girders were used to replace a bridge span over eastbound I-90 that was severely damaged by an over-sized truck load near the city of Easton, Washington. The damaged span was to be replaced under an emergency contract that required the bridge to be operational in 45 days. WSDOT met that challenge using non-standard precast prestressed deck bulb tee girders, which made the accelerated construction possible and limited temperature-sensitive construction in the freezing and snowy mountain region. The bridge design and construction moved rapidly within the short time frame using in-place production tools. Working directly with the precast concrete industry, the bridge design office streamlined the fabrication and construction schedule of the replacement span.

Keywords: Accelerated Construction, Creative/Innovative Solutions and Structures, Repair and Rehabilitation

INTRODUCTION

Over-height trailer loads frequently strike the underside of highway overpasses, often causing damage. On October 31, 2007 an unusually stout trailer load smashed into a concrete overpass on I-90 causing irreparable damage and requiring an emergency repair. This paper explains 1) the problem of the damaged bridge span, 2) the emergency replacement solution using deck bulb tee girders, and 3) key points that made the fast-paced project a success.

The subject bridge carries a local road over I-90, one of the main east-west routes through the state of Washington. The interchange is one of two I-90 access and crossing points for the citizens of the nearby city of Easton. Figure 1 shows a vicinity map of the project site, which lies in the central part of the state on the east side of the Cascade Mountain Range.

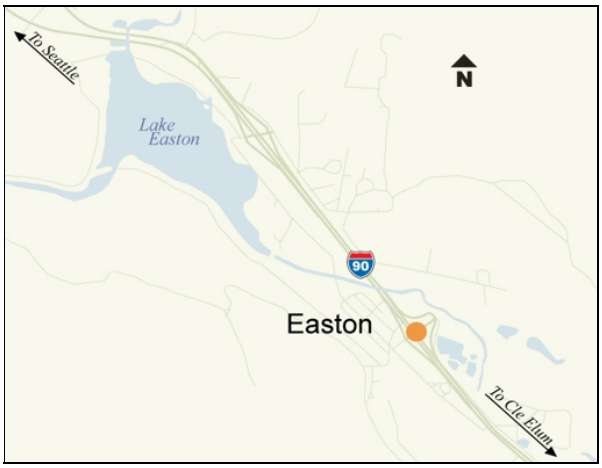

Fig. 1 Vicinity Map

Built in 1959, the bridge consists of a series of five 50 ft simply-supported spans. Each span is comprised of precast pretensioned concrete girders with a cast-in-place concrete deck. Figure 2 shows the bridge before it was damaged.

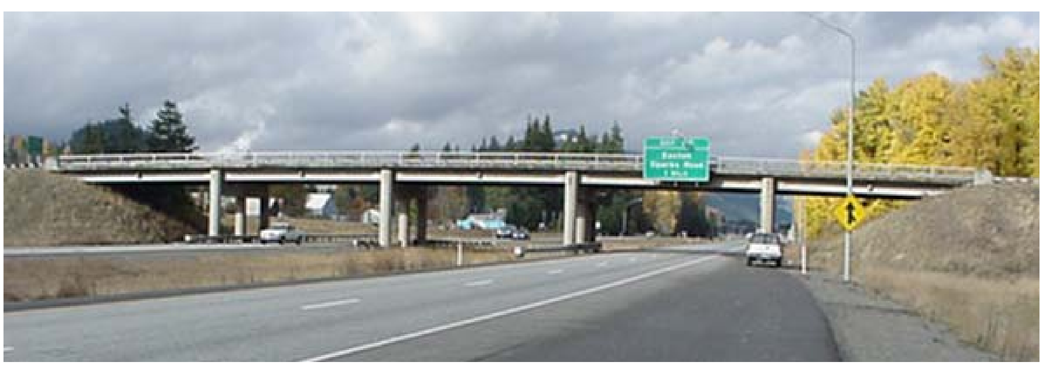

Fig. 2 Easton Bridge Prior to Damage

THE PROBLEM – BRIDGE SPAN DAMAGED BEYOND REPAIR

The bridge was damaged beyond repair by an over-height load, and the damaged portion of the bridge was subsequently demolished. The bridge needed to be repaired and put back in service quickly for the use of the nearby residents.

COLLISION

The collision occurred at 4:35 AM on October 31, 2007. A truck traveling at more than 60 mph smashed into the bridge with a large diameter pipe secured to the trailer (see Figure 3). It punched through the bottom flanges and webs of the girders at midspan across the entire bridge. The collision was so loud that a resident from the nearby city of Easton claimed to have heard it. Fortunately no one was injured during the accident.

Often during high-load bridge collisions in the state of Washington the load falls off the truck trailer after striking the first or second girder. In this case however the pipe section sliced through all six girder bottom flanges and webs, and the pipe remained attached to the truck and undamaged by the impact.

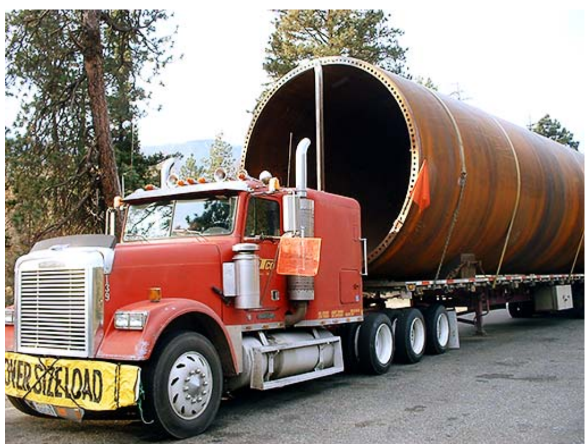

Fig. 3 Oversized Load After Impact

The bridge span was damaged beyond repair as shown in Figure 4. The photo shows spalled concrete with large pieces sitting on I-90. Exposed and broken prestressing strands can also be seen hanging from the bridge. Figure 5 is another view of the damage, in which the radial curvature of the pipe can be seen in the broken girders. Washington State Department of Transportation (WSDOT) engineers from the Bridge Preservation Office arrived on the scene quickly and determined that the bridge should remain closed to traffic and that the girders could not be repaired.

Fig. 4 Bridge Damage

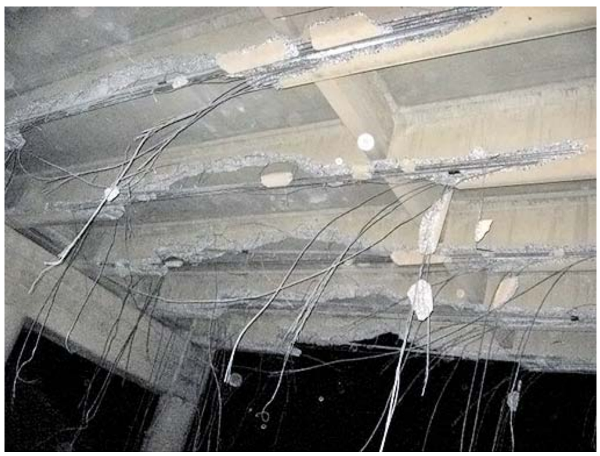

Fig. 5 Pipe Curvature Seen in Damaged Bridge Girders

DEMOLITION

After the decision was made to remove the span, the local WSDOT construction office signed an emergency contract with R.W. Rhine of Tacoma, WA. Within 24 hours of the initial accident the demolition was complete and the eastbound lanes of I-90 were open to traffic.

Since the bridge consisted of simple spans with a deck expansion joint at each pier, the demolition work was relatively straight forward. Two specialized hydraulic excavators were used to demolish the bridge (see Figure 6). One machine used a cutting tool and the other used a punching attachment. The demolition proceeded through the night, and the remaining concrete at the adjacent piers and diaphragms were undamaged in the process. Figure 7 shows the bridge after demolition with eastbound I-90 open to traffic.

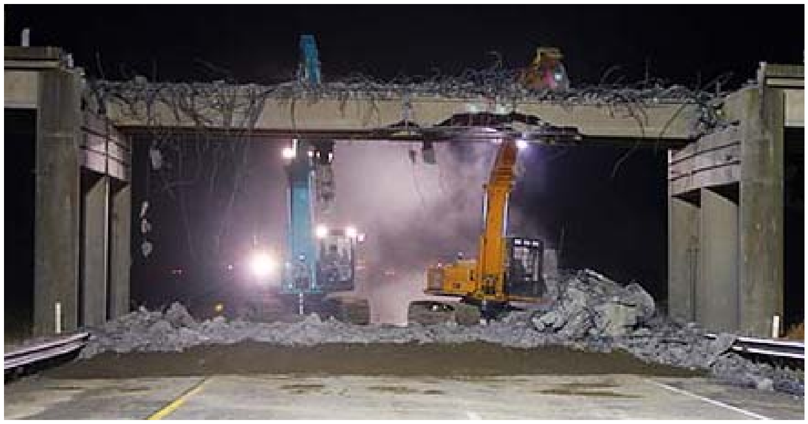

Fig. 6 Demolition

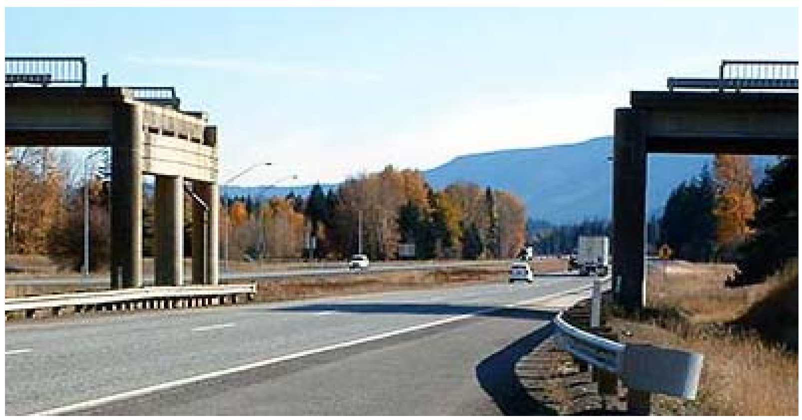

Fig. 7 After Demolition

EMERGENCY ANNOUNCEMENT

The downed span posed a problem for Easton residents. Access to I-90 was limited, and local traffic was required to make a major detour to cross the interstate. The detour caused particular difficulty for school buses.

Washington State's Secretary of Transportation, Paula Hammond, publicly challenged WSDOT engineers to "get creative – get this bridge replaced as quickly and effectively as possible."[1] This announcement immediately turned the project into an accelerated bridge construction project. As a result, WSDOT made the commitment to reopen the bridge by the ambitious date of December 15, 2007, only 45 days after the collision. The challenge ultimately extended beyond engineers to the contractor and fabricator. All groups involved worked together to meet the challenge.

PROJECT OVERVIEW

The following overview provides a snapshot of some of the key dates throughout the bridge span replacement project near the end of 2007.[1]

- Oct. 31 Collision Occurred
- Nov 1 Span Removed, Eastbound I-90 Opened to Traffic
- Nov 12 Girder Construction Began in Tacoma
- Nov 14-17 I-90 Lanes Restricted Due to Prep Work
- Nov 15 Community Open House Held at Easton Community School
- Nov 27 Girder Installation Began on Bridge
- Dec 6 Concrete Diaphragm Placement Began
- Dec 11 Concrete Sidewalk Placement Began
- Dec 13-14 Salvaged Bridge Rail Re-installed
- Dec 15 Bridge Opened to Traffic

THE SOLUTION – PRETENSIONED GIRDERS, EMERGENCY CONTRACTS

To expedite the replacement, the decision was made to replace the span with prestressed deck bulb tee girders using unique emergency contracts. Once construction began, adverse weather made it even more difficult to complete the span by the target date.

WSDOT DECK BULB TEE GIRDERS

Precast girders were an easy choice for this project, since the remaining adjacent spans were made of precast girders. Precast concrete was also chosen because no girder falsework was required over I-90 and it is a common bridge type in Washington State. Precast girders were particularly beneficial for the Easton Bridge because they enabled speedy construction and required minimal temperature-sensitive installation work.

The prestressed deck bulb tee girder was chosen as the main structural solution. This girder has a wide, thick top flange and is placed so that the top flanges of adjacent girders touch each other. A cross section of one of the Easton Bridge girders can be seen in Figure 8. The top flange acts as the deck so that no additional transverse decking is required. The flange tips are connected using both 1) discretely spaced welded ties and 2) a continuous grouted keyway. Both connection systems extend the full length of the girders.

Fig. 8 Deck Bulb Tee Girder

Deck bulb tee superstructures of this design are not for use on large ADT roadways. High traffic volumes damage the longitudinal joints at the girder flange tips. Typically, this type of girder is used only for non-highway roads because of its durability limitations. However, WSDOT engineers decided to use this type of bridge system because the road crossing over I-90 had a low ADT (431 in 2007), the design speeds were low (25 mph), and it was an emergency project.

Although an asphaltic overlay is normally placed over the top of the girder top flanges to smooth out the riding surface, no overlay was used on this bridge. This was done to reduce the amount of temperature-sensitive work required during the cold-weather season. The top surface of the girder top flange was the actual riding surface. A metal-combed finish, as required by state specifications for concrete bridge decks, was therefore provided on the tops of the girders in the fabrication shop.

The span replacement was designed so that an overlay could be placed across the surface of the entire bridge if desired in the future. Load rating calculations for the existing girders were performed to ensure that the existing spans could safely receive the additional overlay material.

PARTNERING WITH INDUSTRY

The Washington State Department of Transportation partnered with industry to meet the challenge to quickly replace the span. Three main partnerships were integral to the project's success:

- WSDOT and Rhine – Demo Contractor
- WSDOT and Concrete Technology Corporation (CTC) – Girder Supplier
- WSDOT and Max J. Kuney Company – General Contractor

Because of the need for rapid span replacement, the typical design-bid-build contract was inadequate. In this case the contract between WSDOT and the general contractor was signed before the design was completed. Kuney was to construct the span by force account. Technically the plans and specifications were not part of the contract documents. Instead, the WSDOT construction office gave whatever portions of the bridge design plans they wanted built to Kuney, and Kuney was expected to build according to those plans.

CONSTRUCTION CHALLENGES

Since the construction occurred from the end of November to the middle of December, adverse weather caused delay and difficulties for the construction of the replacement span. The bridge is located in the eastern part of the Cascade Mountain Range, which is a stormy region in winter. The weather during this project was snowy and cold, causing work to progress more slowly than anticipated. Concrete and grout work in the cold weather required that local areas be heated. Figure 9 shows an example of heating enclosures at one of the piers for the placement of bearing grout pads.


Fig. 9 Cold Weather Protection for Grout Pad Placement

Shipping the precast girders over the I-90 mountain pass was also made difficult by the weather. By law no oversize loads are allowed over the pass during traction advisories. The loaded girder delivery trucks were held over at one point for this reason before being able to cross the pass.

Another unforeseen schedule challenge resulted from flooding of Interstate 5 nearly 100 miles away. Portions of the Easton Bridge construction work, such as placement of the diaphragm concrete, required the I-90 eastbound traffic to be moved to the off-ramps. During the I-90 closures, a section of I-5 flooded, prohibiting traffic from accessing the major north-south corridor for western Washington. Southbound I-5 traffic was redirected across eastbound I-90, then down south, and finally back west to I-5. This detour increased traffic volume, making it impossible to shift traffic across the ramps. The excess traffic associated with the I-5 closure caused a two-day delay in the project. Between the adverse weather and the increased traffic, it was difficult to find a window of opportunity to perform the work that necessitated the closing of eastbound I-90.

KEY FACTORS THAT EXPEDITED CONSTRUCTION

WSDOT wanted to show the public a success story in the Easton Bridge project that would demonstrate the agency's abilities and build confidence in the work its people do. Fortunately the project was a genuine success. There were several key factors that expedited the construction project itself and allowed the design to be streamlined and delivered quickly.

CONSTRUCTION SUCCESS FACTORS

Two key construction-related success factors were 1) the efforts of the demolition, fabrication, and general contractor, and 2) the use of deck bulb tee girders.

WSDOT had several industry partners that were vital to the project's success. R.W. Rhine was the first partnership. Rhine demolished the span and reopened the I-90 eastbound lanes to traffic less than 24 hours after the collision – a very quick completion time.

WSDOT partnered with Concrete Technology Corporation (CTC) for the fabrication of the prestressed concrete girders. CTC was busy with production of other scheduled customer needs but accommodated the Easton Bridge girders on another production line. CTC communicated to WSDOT their limitations for the girders on the available casting bed, and the bridge designers worked around those limitations.

The WSDOT Bridge Design Office has a unique relationship with the precasters in the region. Communication between the state and the fabricators has been welcomed from and initiated by both sides. This communication has evolved into a partnership in which both sides of the industry meet regularly and work to find mutually beneficial solutions.

WSDOT partnered with Max J. Kuney as the general contractor. The WSDOT construction office worked out construction problems quickly with Kuney and paid for individual work items by force-account.

The general contractor's depth of experience proved valuable in dealing with the schedule challenges posed by the project. One example of the contractor's ingenuity was the use of high-early strength concrete for the girder diaphragms. The design plans required diaphragm concrete to reach 4000 psi before concrete trucks could drive on the bridge to place sidewalk concrete. The contractor used a special mix that could reach 4000 psi in five days, enabling the project to be completed on time.

Pretensioned precast concrete was another key element that expedited construction. The deck bulb tee girders reduced the temperature-sensitive work required in the cold weather and enabled accelerated bridge construction. The girders in the completed span can be seen in Figure 10.

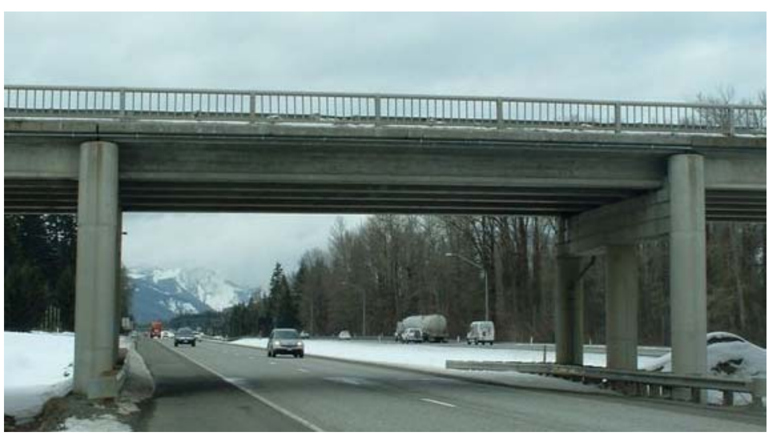

Figure 10 Completed Span Replacement

DESIGN SUCCESS FACTORS

An accelerated design schedule was required to reopen the bridge as quickly as possible. The designer of record was assigned the work on November 6, 2007, and the draft framing plan and girders were completed the following day. Girder design plan sheets were signed just before the girder shop plans were approved on November 13th, the two efforts having occurred nearly simultaneously. The complete plan set was signed and delivered on November 21st. What enabled the expedited design was: a detailed design schedule, in-place production tools, prioritization of effort around the construction schedule, experienced detailing and checking, timely site data, open communication, and a minimal plan sheet count.

One of the most important efforts that paved the way for a successful accelerated design occurred near the beginning of the project in a joint effort between the WSDOT Bridge Design Office and the girder fabricator, CTC. The two parties developed a design concept and a detailed design and fabrication schedule. The schedule became the framework for the design/fabrication effort. The schedule was outlined down to the day the contractor could ship the girders, and it helped keep all involved on the same page.

Design tools already in place allowed the engineers to quickly design the girders. The girder design computer program PGSuper™ helped engineers meet the difficult design schedule and was versatile enough to handle the non-standard girder cross section. PGSuper™ was already an integral part of the overall prestressed girder design process in Washington State. Many design assumptions had already been worked out between the precasters and the Bridge Design Office and incorporated into the computer program. Also, standard girder and diaphragm details were in the WSDOT Bridge Design Manual for this type of girder, making sheet production a matter of modifying the standard sheets for the specific situation.

The designers prioritized their efforts around the scheduling needs of the fabricator and contractor. The girder sheets were the first priority because fabrication was on the critical path. Prioritizing design work was made easier by the original schedule created by the Bridge Design Office and CTC. After starting work on the scheduled items, upcoming work pushed the design forward.

An experienced plan sheet detailer and an experienced checker were assigned to the project, which sped up sheet production. The detailer was able to draw much of the information in the plan sheets with minimal direction from the design engineer. Frequent engineering checks also moved production forward.

The Bridge Design Office received the requested site data in a timely fashion. Survey of the existing bridge deck profile was completed prior to demolition. More detailed survey requests were later made via email, and the bridge designer went to the site to discuss the requests so that both surveyor and engineer were in agreement.

Another important ingredient in the speedy design was free and open communication between all parties involved. For example, the designer frequently emailed “for information only” progress plan sheets to the contractor, and helpful, timely feedback was returned. This allowed the design to be tailored to the contractor’s preferences.

Since demolition had already occurred, no bridge demolition plans needed to be created. This was one less work item to capture in the design sheets, helping the design move forward quickly.

Under such a demanding schedule, WSDOT’s contractors, the proper design scheme, and a concerted design and construction effort enabled the success of this high profile project.

CONCLUSION

The overpass over I-90 was damaged beyond repair on October 31, 2007. Despite several challenges to the construction schedule, the damaged bridge span was replaced and opened to traffic 45 days later on December 15, 2007. The success of the accelerated bridge construction project was due to: the use of precast prestressed deck bulb tee concrete girders; key industry partners in demolition, fabrication, and construction; and a concerted and properly coordinated design effort. The span replacement project was a genuine success story for WSDOT.

REFERENCES

1. “I-90 - Easton Bridge Repair - Complete December 2007”. Washington State Department of Transportation website. Retrieved May 2009 from Completed Projects web page. http://www.wsdot.wa.gov/projects/i90/eastonbridge/ Copyright WSDOT 2009.