ROLLING THE NE 8TH STREET BRIDGE – BELLEVUE, WASHINGTON

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BIOGRAPHY

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SUMMARY

An innovative construction scheme kept all traffic lanes open during replacement of the Northeast 8th Street Bridge across Interstate 405 in Bellevue, Washington. Half of the new superstructure was built on a temporary substructure next to the existing bridge and used as a detour route for eastbound traffic. The rest of the replacement bridge was built using staged demolition and construction so that the westbound lanes remained open.

During one Friday night, the two-span superstructure was rolled from its temporary piers to its permanent new abutments and center pier. During the rest of the weekend, approach roadways were paved and permanent bridge bearings installed so that the bridge opened in time for the Monday morning commute.

To maximize span lengths, minimize superstructure depth and encroachment on the freeway below, and to minimize the weight of the superstructure for the rolling operation, a steel girder superstructure was the only feasible solution for the replacement bridge.

ROLLING THE NORTHEAST 8TH STREET BRIDGE
BELLEVUE, WASHINGTON

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INTRODUCTION

The City of Bellevue, Washington's fifth largest city, is located on the east side of the Seattle metropolitan area. Major office buildings and large retail centers are part of the City's downtown core, and the daily workforce is estimated at 121,000. Interstate 405 (I-405) is the major regional north/south arterial through the area. In Bellevue, Northeast 8th Street is the main east/west arterial and crosses over I-405. The full clover leaf interchange with collector distributor roads at Northeast 8th Street / I-405 serves as the primary access route between I-405 and the City's downtown business district. Weekday traffic averages more than 150,000 vehicles per day through the interchange.

The *Access Downtown Project*, as completed, improves transportation infrastructure in and around downtown Bellevue. Partners in the project are Sound Transit (a regional transportation agency that involves three Puget Sound counties), the City of Bellevue, the Washington State Department of Transportation, the King County Department of Transportation's Metro Transit Division, the Federal Highway Administration, and the State Transportation Improvement Board. Key components of the multi-interchange *Access Downtown Project* include:

- Replacing the bridge at the Northeast 8th Street / I-405 Interchange.
- Rebuilding the bridge at the Northeast 4th Street / I-405 Interchange, located approximately 1,400 feet south of the Northeast 8th Street / I-405 Interchange.
- Constructing a new interchange at Northeast 6th and I-405, located midway between Northeast 4th and 6th Streets. At Northeast 6th Street, a new Texas Tee spans the southbound lanes of I-405 to the median between the northbound and southbound lanes. The legs of the Tee are northbound and southbound direct access ramps for transit and carpools to and from I-405. To accommodate the new direct access ramps, both the Northeast 8th and Northeast 4th Street Interchanges had to be reconfigured.

Because of the need to avoid significant traffic disruption in this busy area, replacing the Northeast 8th Street bridge over I-405 required a unique approach to construction. A four-stage construction sequence kept traffic lanes open during bridge replacement and allowed a two-span superstructure to be rolled into place over a matter of hours on a weekend. Except for the one night of the bridge roll, Northeast 8th Street was never fully closed and closures along I-405 were minimized.

EXISTING AND NEW STRUCTURES

The original Northeast 8th Street bridge was constructed in 1959 and widened in 1973. The structure crossed eight lanes of I-405 and on/off ramps with six spans of precast concrete girders and a cast-in-place concrete deck. Cast-in-place concrete abutments and multi-column bents with slant-leg exterior columns on spread footings supported the superstructure. Total length of the bridge was 293 feet and total width was 103 feet.

Span lengths ranged from 44 to 57 feet. Three eastbound and three westbound traffic lanes with sidewalks on each side were carried by the bridge.

To make space for the new direct access connector ramps at Northeast 6th Street, realigned I-405 traffic lanes, and future widening of I-405, the new bridge was limited to two spans and the abutments were relocated further east and west. Total bridge length was increased to 328 feet. The bridge profile had to be raised approximately 3.3 feet to achieve sufficient vertical clearance over the new direct connector ramps at Northeast 6th Street. To accommodate heavy traffic on Northeast 8th Street, a lane in each direction was added, thereby increasing the width of the bridge to 120 feet.

The new bridge superstructure consists of built-up steel I-girders with a composite concrete deck. Each of the two spans is 164 feet long. Girders have a constant 60-inch deep web and are spaced at 11 feet 4 inches. The abutments and four-column center pier are reinforced concrete on spread footings.

New steel girder superstructures were selected for both the Northeast 8th bridge replacement and the new Northeast 6th high occupancy vehicle (HOV) direct access bridges to maximize span length while minimizing superstructure depth and weight. Although precast concrete girders are typically the first choice for cost-effective roadway bridges in the Pacific Northwest, they result in relatively deeper superstructures, and fitting the new Northeast 6th Street bridge and ramps into the corridor demanded that all structures be as shallow as possible. A cast-in-place concrete box girder structure as shallow as the steel girder superstructure was considered; however, the falsework required to construct it would have restricted truck traffic on I-405 (tall trucks would need to detour off the freeway to avoid the construction site). The unique construction staging required to maintain traffic on Northeast 8th during bridge reconstruction made constructing as light a structure as possible desirable. Half of the structure was to be rolled into its final location up a 2-percent cross slope. A lighter structure allowed the use of smaller jacking equipment and resulted in less severe loading on the temporary substructures.

CONSTRUCTION STAGING

During the preliminary planning stages, designers grappled with the problem of replacing the structure while maintaining traffic capacity on Northeast 8th Street. A 12-month loss of Northeast 8th Street was expected under a complete demolition / replacement scenario. Conventional staged construction with half of the bridge removed and replaced at a time was estimated to result in 18 months of restricted access and reduced capacity. Both schemes were unacceptable to the City because of the potential to cripple eastbound and westbound traffic and negatively impact business operations in Bellevue.

To keep all six lanes of Northeast 8th Street open to traffic, a construction sequence borrowed from the railroad industry was devised. First, before beginning demolition of the existing bridge, the south half of the new bridge superstructure was constructed on temporary piers adjacent to the existing bridge. The three eastbound lanes of Northeast 8th Street were diverted to this new half-bridge for most of the remaining construction. In the parlance of the railroad, this is known as a “shoofly,” that is, a detour route adjacent to the existing route. After the eastbound traffic was shifted to the new half-bridge, conventional staged bridge construction was used for demolition and reconstruction of the existing bridge, thereby maintaining the three westbound lanes of traffic. After the new north half-bridge and the permanent south half piers were completed, the new south half-superstructure was rolled onto the new, permanent south substructure. Finally, a closure pour connected the two half-superstructures. Construction staging was as follows:

- **Stage 1**: Build the permanent south half of the new bridge superstructure on temporary piers immediately south of the existing bridge. Shift eastbound Northeast 8th Street traffic onto the new south half-bridge and shift westbound lanes onto the existing south half-bridge.

- **Stage 2**: Demolish the north half of the existing bridge and build the new north half-bridge in approximately the same location. Shift westbound traffic onto the new north half-bridge.
- **Stage 3**: Demolish the remaining section of the existing bridge (south half). Construct the south half of the permanent abutments and center pier (see Figure 1).
- **Stage 4**: Jack the new south-half superstructure off its temporary piers and set on rollers. Roll the superstructure 64 feet north to its permanent location (see Figure 2). Shift eastbound traffic onto the south half-bridge. Construct the deck closure pour between the north and south half superstructures.

Using this construction staging, full closure of Northeast 8th Street was limited to one weekend when the south half-superstructure was rolled. Partial closures of Northeast 8th Street were limited to non-peak hours, nights, and selected weekends for construction of roadway approaches to the Northeast 8th Street bridge for the "traffic shifts." Full closures and lane and ramp closures on I-405 were limited to nighttime operations and several weekend windows (for traffic shifts and bridge relocation), except for three specific periods for construction operations.

Figure 1 *– The Northeast 8th Street bridge prior to rolling the south half-bridge into its permanent position. Eastbound traffic jogs to the right to cross over I-405 on the south half-bridge. Westbound traffic travels straight across I-405 on the new north half-bridge. The permanent south abutments and center pier are in the gap between the south half and north half superstructures.*

ROLLING THE BRIDGE

Rollers have been used to move superstructures in the past; however, significant new challenges involving weight and geometry were required for this project. The superstructure to be moved consisted of a 61-foot wide deck slab composite with six steel girders. Total weight of the half-superstructure was 4,400 kips. The ultimate Northeast 8th Street roadway cross-section has a 2-percent crown at the roadway centerline, so the temporary and permanent pier cap beams were sloped to match and the superstructure was rolled up the 2-percent grade.

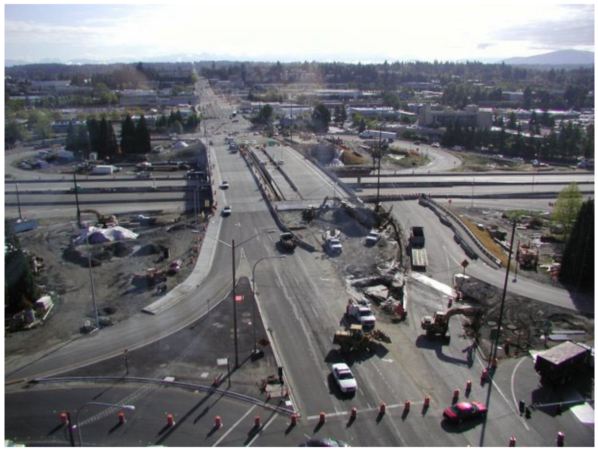

Figure 2 *– The new Northeast 8th Street bridge with the south half-bridge rolled into its permanent location. The temporary approach roadway that no longer connects to the relocated bridge is at right.*

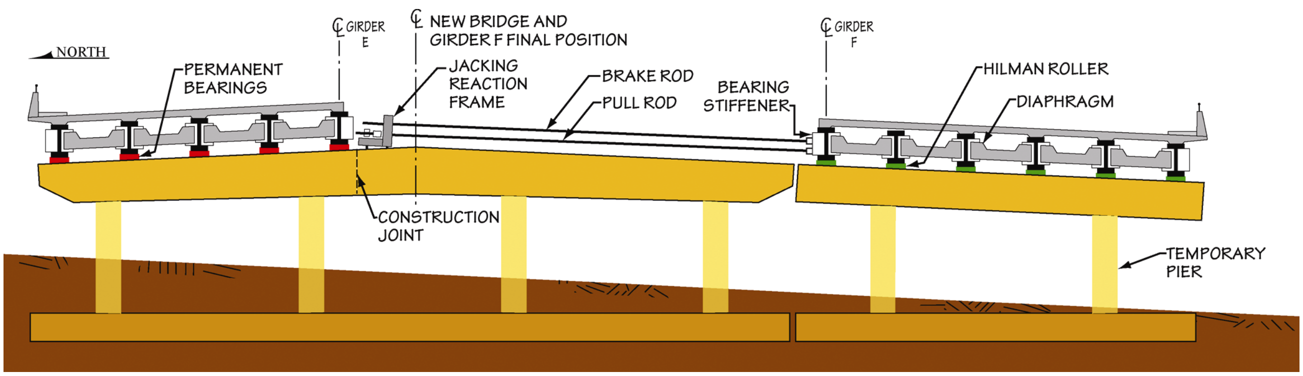

Figure 3 *– A schematic of the system for bridge jacking and rolling, with the south half-superstructure shown on the temporary pier before rolling it.*

Figure 3 illustrates the system used to "roll" the bridge. System components included the reaction frames mounted on the permanent crossbeam and abutment seats, and high-strength rods (Grade 150 ksi). One end of the high strength rods was connected with a simple bracket to the bearing stiffener of Girder "F" of the half-superstructure to be relocated (see Figure 4). After the rolling operation was completed, this girder was positioned at the finished bridge centerline. At the other end, the upper backup rods were locked off by a nut against a bearing plate welded to the reaction frame. The lower pull rods passed through the reaction frame and were locked off against a jacking beam with a similar bearing plate and nut. The reaction frame fit in the space between the non-moving north Girder E and final position of Girder F. Horizontally-mounted jacks acting against the jacking frame and jacking beam were used to incrementally move the bridge superstructure transversely.

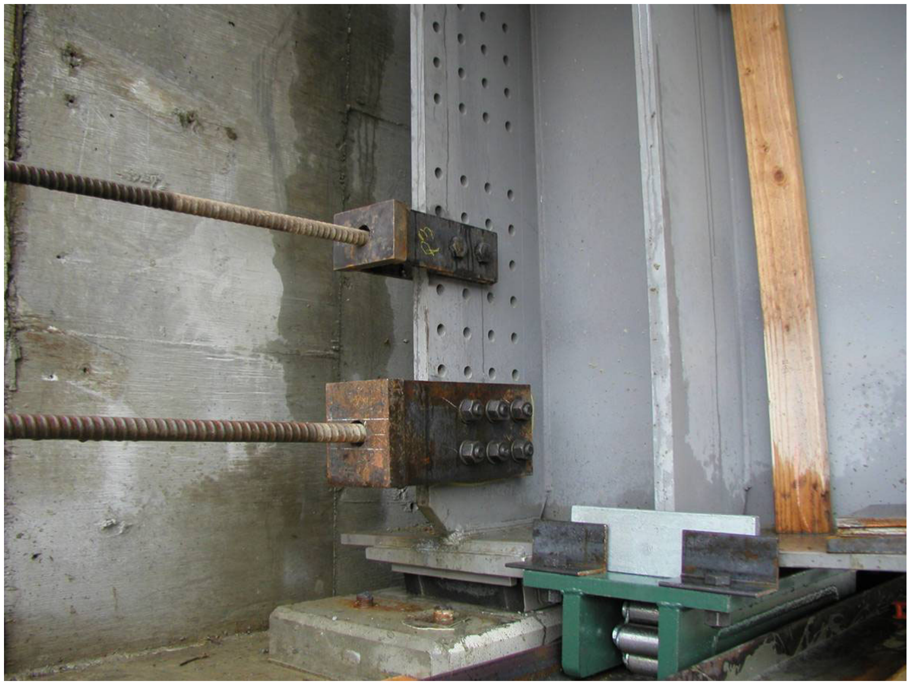

Figure 4 *– Connection of the high strength rods to the south half-bridge at a girder end. A Hilman Roller supports the girder at a jacking stiffener.*

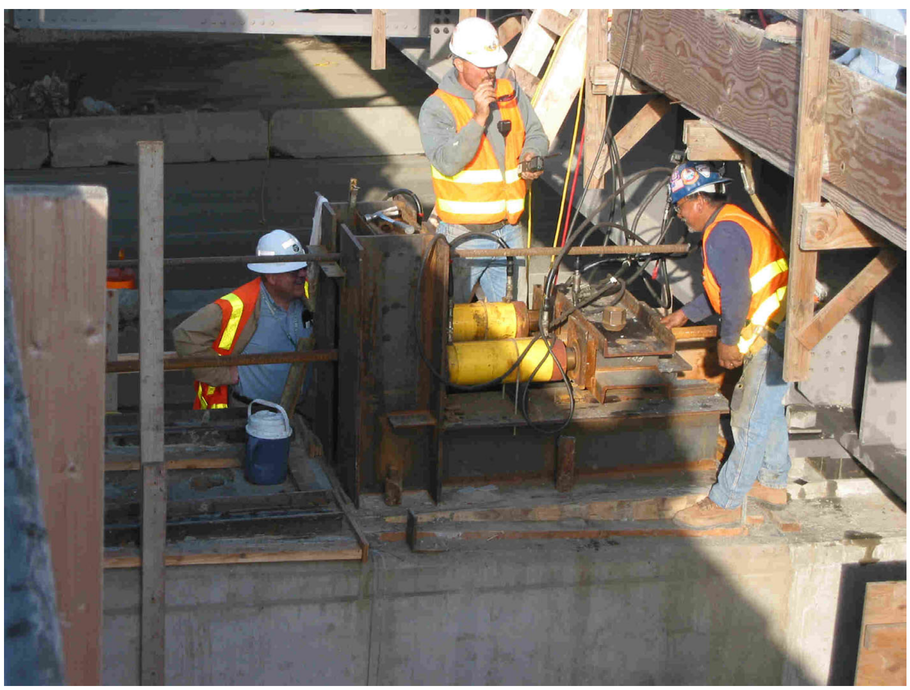

Figure 5 *– Bridge rolling: The worker at far right manually tightens the nut that locks the pull rod to the jacking beam. The two jacks bear against the L-shaped, steel reaction frame, thereby pushing the jacking beam and pulling the bridge structure as the jacks extend.*

Figure 5 shows one of the reaction frames, partially extended jacks, jack beam, and rods at the center pier. Each jacking cycle consisted of pressurizing the jacks so the jack pistons extended their 12-inch stroke. This simultaneously pushed the jacking beam and pulled the lower rods and bridge superstructure the same distance. With the jacks fully extended, the nut at the upper brake rod was hand-tightened against the bearing plate at the reaction frame. Next, the pressure in the jack was released and the jack piston retracted. With the south half-superstructure held in place by the upper brake rod, the jacking beam was repositioned against the jack. Then the nut for the lower pull rod was hand-tightened against the bearing plate of the jacking beam to set up for the next jacking cycle. Periodically, the ends of the high-strength rods were cut off because they would otherwise run into Girder E of the north half-superstructure.

Pull rods consisted of a single 1-1/4 inch-diameter rod at each abutment and a 1-3/4-inch rod at the center pier. Brake rods were 1-inch diameter at the abutments and 1-1/4 inches at the center pier. Allowing for a maximum of 5-percent friction in the rollers and the 2-percent cross-slope, estimated pull loads were 57 kips at each abutment and 191 kips at the center pier.

Hilman Rollers supported each girder at the center pier and abutments during the rolling operations (see Figure 6). The rollers were set in tracks consisting of channel beams mounted on the top of the center pier and abutment seats. Hydraulic jacks under the steel diaphragms between the girders lifted the superstructure approximately 1/4-inch so the temporary bearings on the temporary substructure could be removed and the rollers and shims installed.

Figure 6 *– With the bridge lifted by hydraulic jacks, a roller is aligned under the girder.*

RESULTS

Over the weekend of September 19, 2003, the south half-bridge was relocated onto its permanent substructure. Starting Friday evening, Northeast 8th Street was closed to traffic and I-405 traffic was routed around the bridge via the existing on/off ramps. Rolling the bridge took 10 hours and by late morning on Saturday, I-405 and westbound Northeast 8th traffic lanes were re-opened. During the rest of the weekend, permanent bridge bearings were installed and the eastbound approaches to the bridge were graded, paved, and striped in time for the early Monday morning commute.

Reconstruction of the Northeast 8th Street bridge required 19 months:

- 7 months to complete the south half-bridge on temporary substructure
- 10-1/2 months to build the north half-bridge and permanent south half-substructure
- 1-1/2 months to complete the deck closure pour, install permanent bridge bearings and deck expansion joints, and to mount metal pedestrian railings on the concrete traffic barriers

The challenge of limiting the impact of major construction on the traveling public was successfully met by using a carefully designed and executed construction staging sequence. Close collaboration between all parties during design and construction and a high-visibility campaign to inform the public about upcoming closures resulted in a project completed within budget, on schedule. The choice of a steel girder superstructure facilitated the roadway geometry required by the closely spaced interchanges without detouring trucks off I-405 during construction, and minimized the weight of the bridge for rolling into place. The successful implementation of the Northeast 8th Street bridge replacement project resulted in minimal traffic disruption. It also raised the image of the Northwest's transportation industry by demonstrating its ability to deliver a major project with a minimal inconvenience to the traveling public.

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