BOEING NORTH BRIDGE:
LESSONS LEARNED IN ACCELERATED BRIDGE CONSTRUCTION

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ABSTRACT

The Boeing North Bridge is a multi-span girder bridge spanning the Cedar River in Renton, Washington. All aircraft assembled in the Boeing Renton factory get towed over the bridge in order to access Renton Field where the aircraft undergo final inspections before taking-off from the Renton Airport. The design and construction schedule for the bridge was accelerated in order to meet Boeing's increased production rate and plans for production of the new 737MAX. In response to the accelerated schedule and its impacts on timing of construction activities around environmental work windows and the winter construction season, the new bridge was designed utilizing precast columns, precast crossbeams, and full-depth precast deck panels. This paper summarizes decisions made by the design team to use prefabricated bridge elements along with their perceived advantages. These decisions are then contrasted with the construction methods the Contractor elected to follow along with explanations as to why the methods were elected.

Keywords: Accelerated Bridge Construction, Precast Bridges, Lessons Learned, Bridges

INTRODUCTION

The Boeing North Bridge is a multi-span girder bridge spanning the Cedar River in Renton, Washington. All aircraft assembled in the Boeing Renton factory get towed over the bridge in order to access Renton Field where the aircraft undergo final inspections before taking-off from the Renton Airport. The design and construction schedule for the bridge was accelerated in order to meet Boeing's increased production rate and plans for production of the new 737MAX. In response to the accelerated schedule and its impacts on timing of construction activities around environmental work windows and the winter construction season, the new bridge was designed utilizing precast columns, precast crossbeams, and full-depth precast deck panels. This paper summarizes decisions made by the design team to use prefabricated bridge elements along with their perceived advantages. These decisions are then contrasted with the construction methods the Contractor elected to follow along with explanations as to why the methods were elected.

PROJECT OVERVIEW

TEAM

The owner of the bridge is the Boeing Company. The Boeing Company hired BergerABAM as the prime consultant to design the replacement bridge under a design-bid-build contract. The winning contractor was Atkinson Construction with Concrete Technology Corporation as a subcontractor to fabricate the precast bridge components.

LOCATION

The project is located in the State of Washington in the City of Renton, just south of Seattle. More specifically, the project is located within the Boeing Company facilities located at the south end of Lake Washington (Fig. 1).

Fig. 1 Vicinity Map

PURPOSE

The existing bridge and approach aprons were constructed in 1969 and 1940 respectively. The existing bridge is a 3 span post-tensioned flat slab bridge supported on pipe piles filled with concrete and rebar. The aprons are flat reinforced concrete slabs supported on H-piles that sit on top of wood piles. The existing bridge is seismically deficient and poses large economic risk to Boeing if the bridge were to be rendered unusable.

DESIGN SCHEDULE

Below are notable times of the actual design schedule:

Notice-to-proceed on design:	August 9, 2012
Permit documents sent in for review:	December 19, 2012
Advertisement date:	February 5, 2013
Notice-to-proceed on construction: (in-water work starting June 1, 2013)	May 2013

BRIDGE DETAILS

OVERALL LAYOUT

The bridge is a three span structure totaling 245-ft in length measured from back-to-back of pavement seat. The end spans are each 55'-6" long, and the main span is 134-feet long. The bridge has a 48-ft wide travel way, and is 50-feet in width measured out-to-out (Fig. 2).

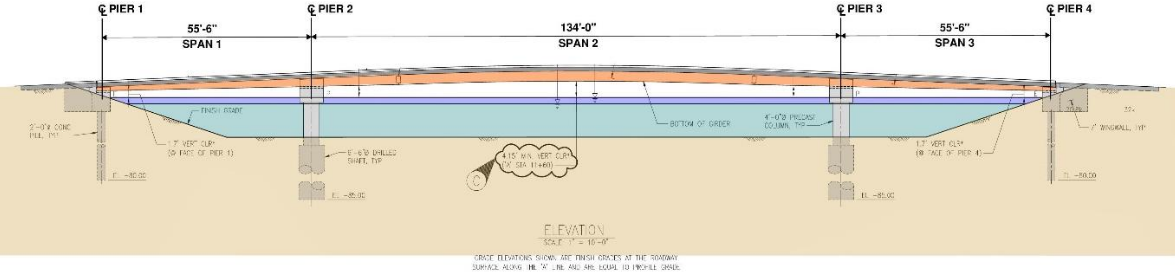


Fig. 2 Bridge Elevation

SUPERSTRUCTURE DETAILS

The bridge superstructure is made up of ten variable depth steel plate girders spaced at 5-feet on-center. The steel plate girders consist of 3-segments; two end segments and one drop-in segment. The end segments run continuous from the end pier out to approximately 20-feet beyond the centerline of the intermediate piers into the main span. The drop-in segment splices the end segments together to form one continuous girder. All the girder depth variation occurs in the girder end segments. The depth of the girders vary from 1’-0” at the end piers to 2’-6” at the splice location with the drop-in segment.

The steel plate girders are made composite with full depth precast deck panels that span transversely between steel plate girders. The precast deck panels are 8-feet wide and have a thickness of 10-inches. The full depth precast deck panels were designed as one-way slabs spanning transversely between girder center lines. The primary deck panel reinforcing is in the transverse direction (ie. perpendicular to the girder centerlines). The reinforcing in the longitudinal direction was considered distribution steel. With the bridge being a 3-span continuous structure, the deck panels will be required to carry tensile demands near Piers 2 and 3 due to superimposed dead loads and live loads. Longitudinal post-tensioning was added to maintain compression across the panel joints. See Fig. 3 for a typical panel detail.

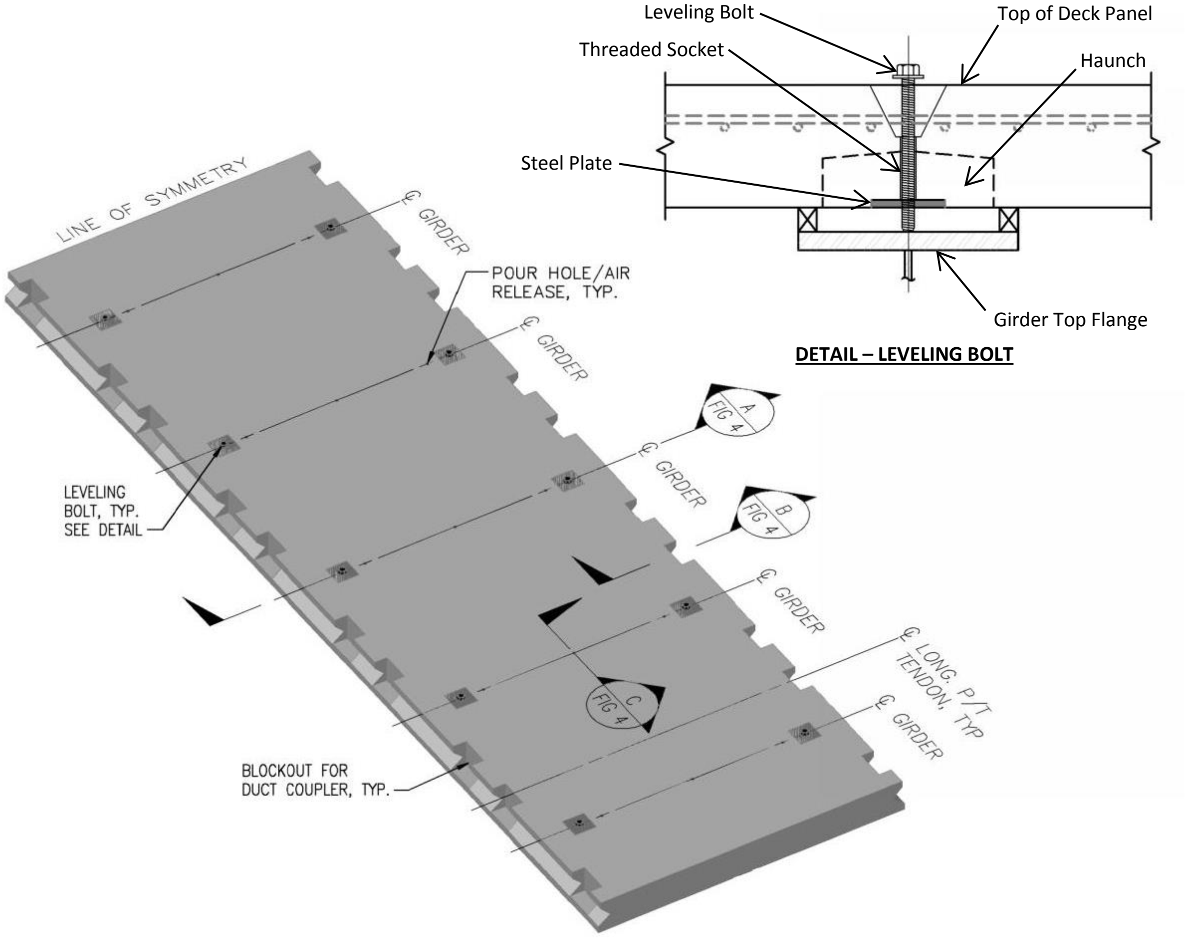
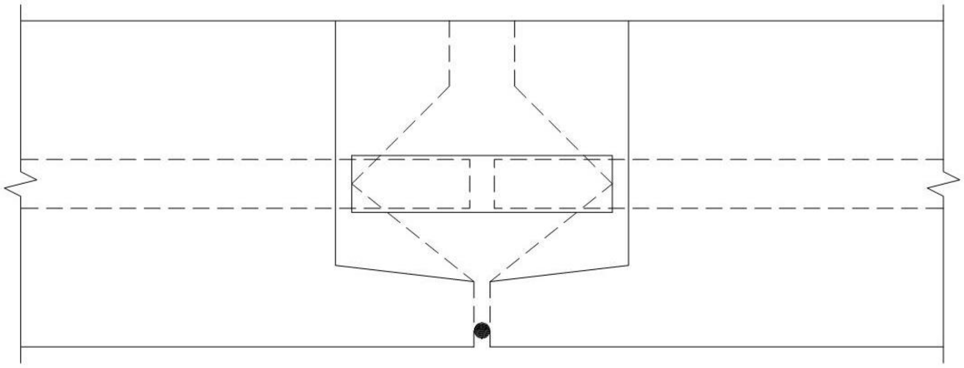


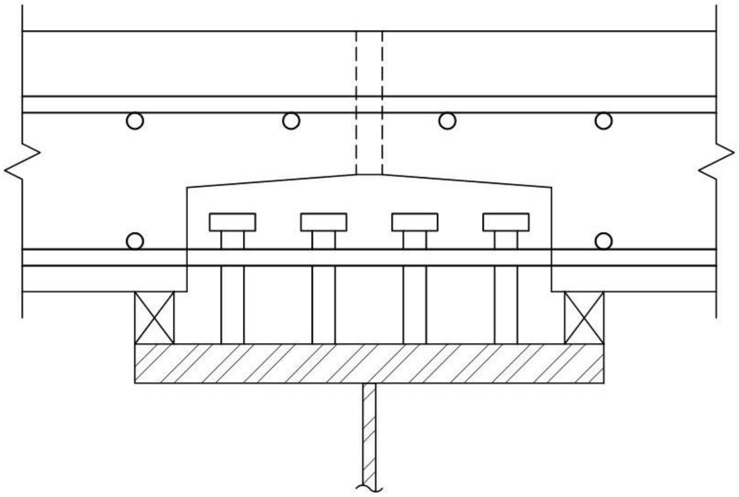
Fig. 3 – Typical Full Depth Precast Deck Panel

The deck panels have full width transverse grouted shear keys between panels, and a continuous longitudinal joint over each girder line (Fig. 4). The continuous longitudinal joint allowed for the girder shear studs to stick up beyond the panel bottom mat reinforcing steel.

LONG. SECTION @ GIRDER
SCALE: NTS
A
FIG 3



SECTION @ PANEL JOINT
SCALE: NTS
B
FIG 3



TRANS. SECTION @ GIRDER
SCALE: NTS
C
FIG 3

Fig. 4 - Required Panel Joints

Each panel has twenty leveling bolts in order to provide a means to adjust the elevation of the top of the precast deck panel, see Fig. 3. The leveling bolts also provided a means to properly distribute the panel weight to each girder line.

The deck panels were erected starting from the middle of the bridge and then worked back towards the ends of the bridge. The center two panels were grouted prior to post-tensioning the deck panels. All other panels were grouted after post-tensioning in order to not induce stress into the steel girders.

SUBSTRUCTURE DETAILS

The substructure consists of four piers. There are two end piers (ie. Piers 1 and 4), and then there are two intermediate piers (ie. Piers 2 and 3). The end piers are outside the limits of the ordinary high water and consist of conventional cast-in-place pile caps supported by 24" diameter concrete filled steel pipe piles.

The intermediate piers are located within the wetted perimeter of the ordinary high water mark of the Cedar River and are 2-column bents with partially precast crossbeams, precast columns, and cast-in-place drilled shafts, see Fig. 5. The water depth at the pier is approximately 8.49-feet based on a planned dredge elevation of 7.00-feet. The drilled shafts extend below the mudline approximately 150-feet. The crossbeams are elevated approximately 0.10-feet above the ordinary high water elevation, however, will be partially submerged during the 100-year flood event.

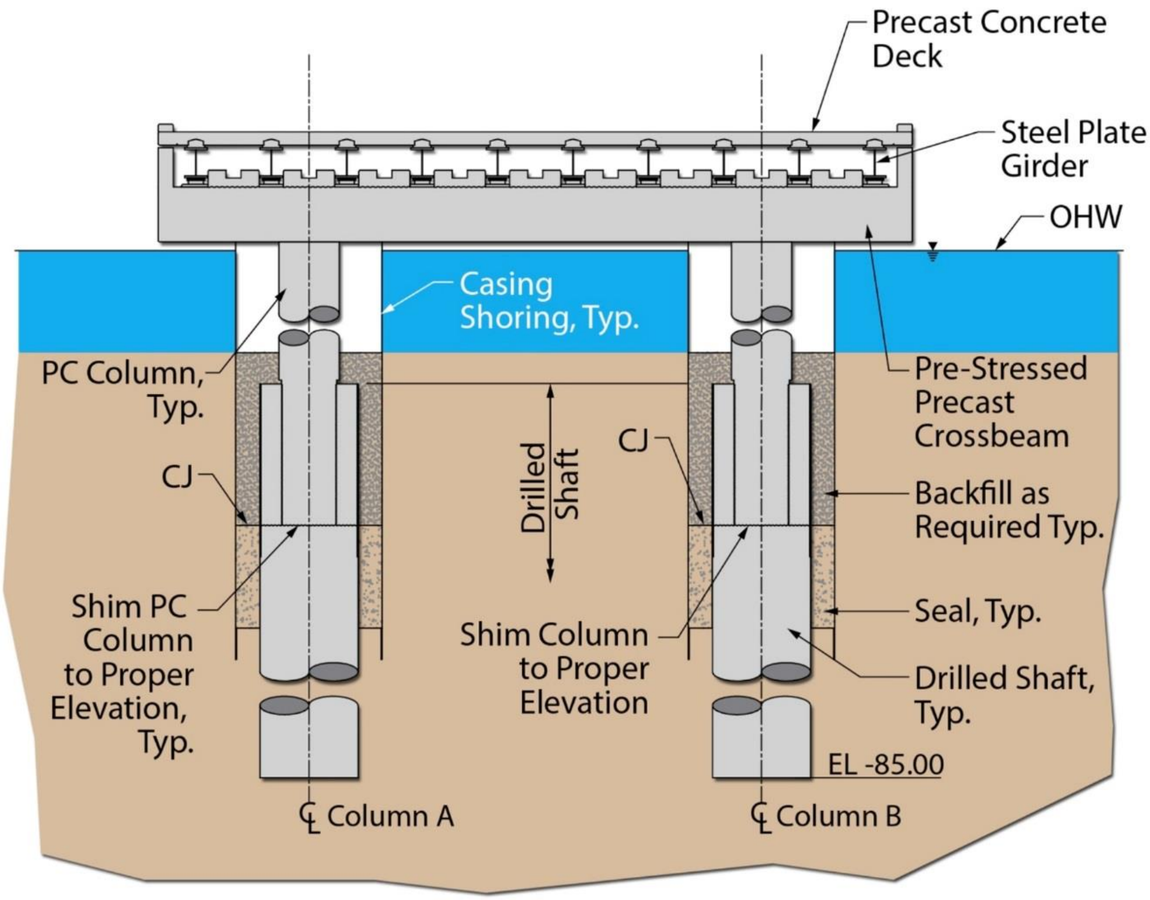
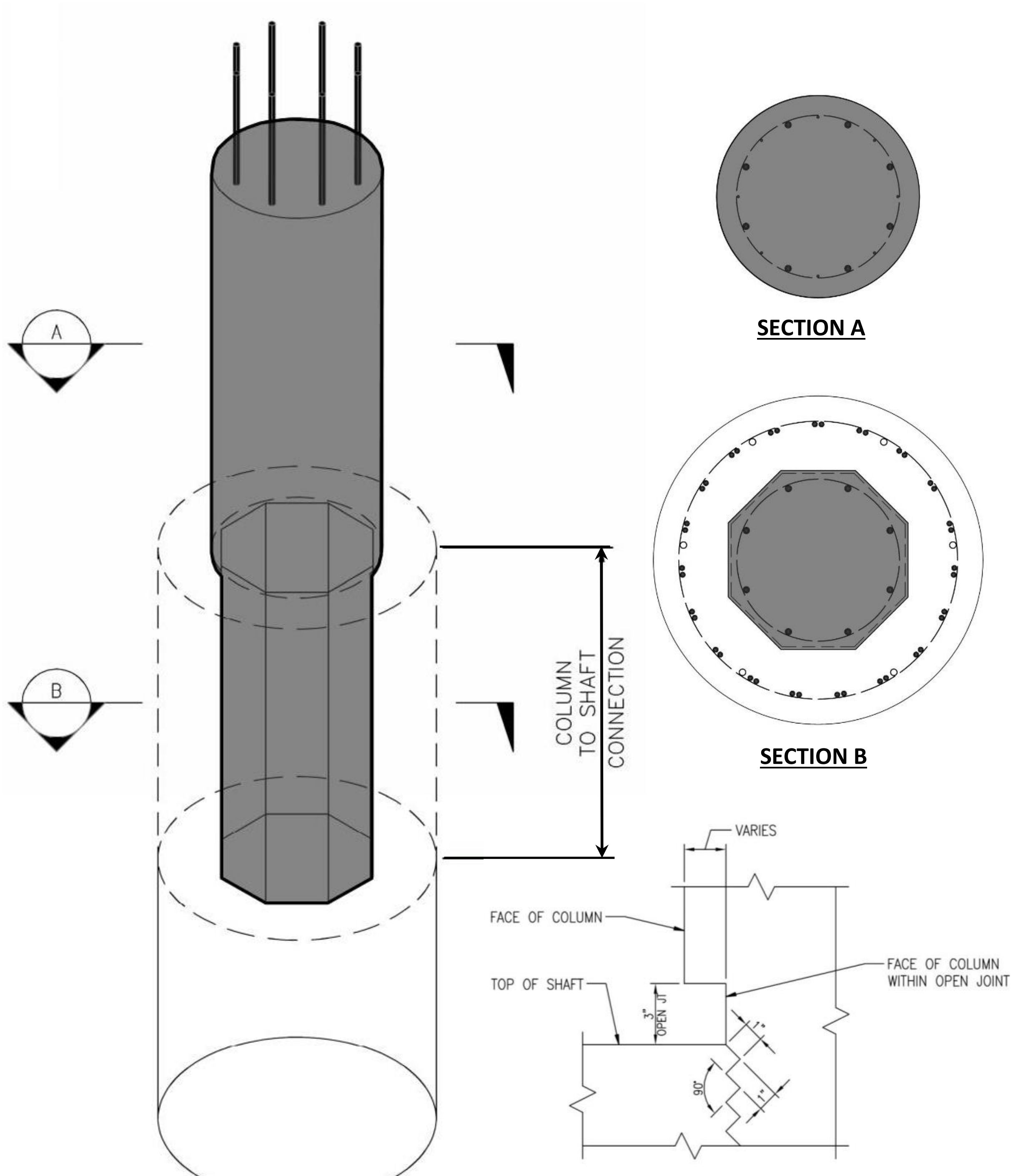


Fig. 5 – Elevation of Intermediate Pier

The columns are 4-ft in diameter and are founded on 6’-6” diameter drilled shafts. The column clear height is 10.59-feet, however, the length of the precast member is 19.59-feet with the lower 9-feet of the column being cast into the drilled shaft. The portion of the column that gets cast into the shaft is octagonal in shape with 1” sawtooth grooves continuous over its length and on each face, see Fig. 6.



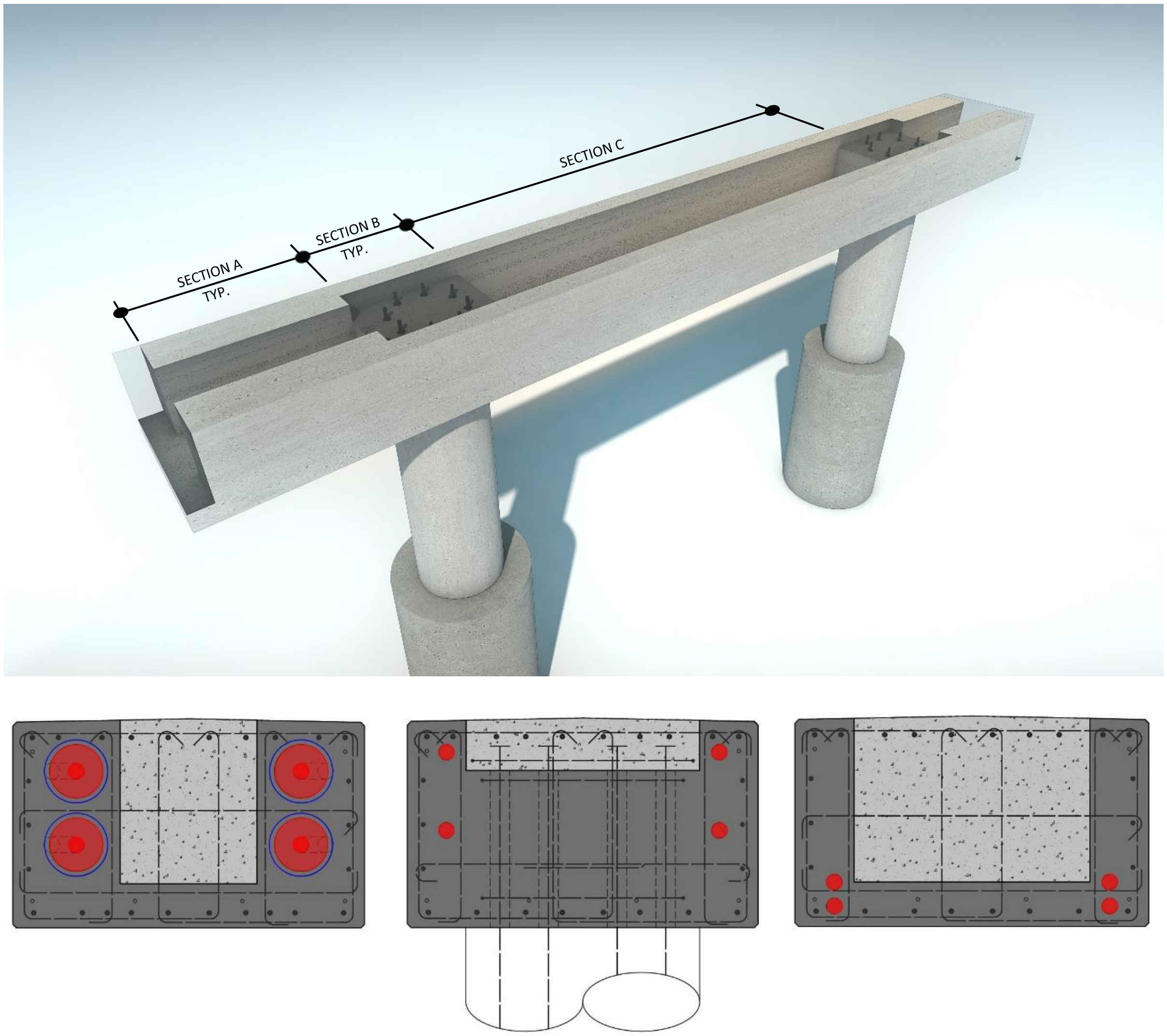
SECTION A

SECTION B

SAWTOOTH DETAIL

Fig. 6 – Precast Column Details

The intermediate pier crossbeam is partially precast. The crossbeams are precast U-shaped tubs filled with cast-in-place concrete, and then post-tensioned. The precast portion is U-shaped and is represented by the dark grey coloring in Fig. 7. The precast portion is 3.5-feet tall and is 6-feet wide. The thickness of the walls and bottom slab varies. The walls are typically 1-foot thick, however, are 1’-10” thick at the ends of the crossbeam in order to house the post-tensioning anchors. The bottom slab is typically 9-inches thick, however, is 2’-7” thick at the column locations in order to facilitate construction of the column connection. The cast-in-place in-fill is shown in light grey in Fig. 7. The overall crossbeam length is 50-feet and the pick weight of the precast section was approximately 42 tons.



SECTION A SECTION B SECTION C

Fig. 7 – Partially Precast Crossbeams

The bridge bent configuration selected utilized precast column-to-crossbeam and column-to-shaft connection details developed as part of the Highways for Life program[1,5]. However, the precast crossbeam on the Boeing North Bridge project is tub shaped, in-lieu of rectangular, with a cast-in-place infill in order to minimize pick weight, and the bottom-of-column connection is made to a cast-in-place drilled shaft in-lieu of a cast-in-place spread footing.

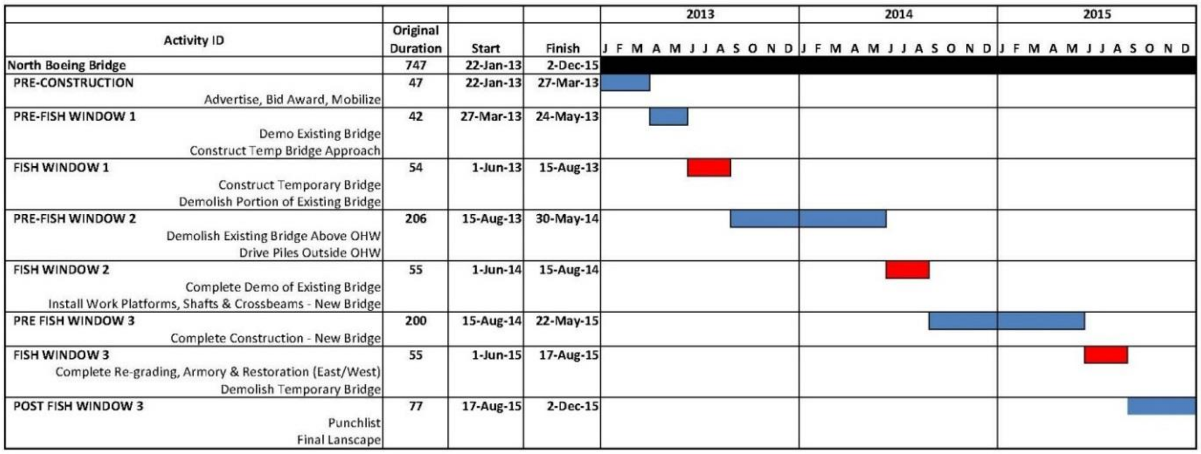
ANTICIPATED CONSTRUCTION SCHEDULE/METHODS

GENERAL

In a typical design-bid-build environment, the Engineer typically figures out “a way” to construct the project, not necessarily “the way” to build a project. That said, it is essential for the Engineer to identify the critical construction constraints so that the contractor can adequately bid the job. On the Boeing North Bridge project there were numerous project site constraints that significantly impacted construction schedule and methods.

- *Uninterrupted Production* – To the Boeing Company, production is king. On average, one or two 737 aircraft cross the bridge daily, which required daily demobilization of construction activities/equipment.
- *Renton Municipal Airport* – The project is directly adjacent to the Renton Municipal Airport and located within the “object free area”, which meant that construction activities would be impacted by runway operations (this was a function of the height of construction activities above the bridge deck).
- *Vertical Profile* – The combination of the runway of the Renton Municipal Airport being located immediately off the end of the bridge, the topography around the site being flat, the 100-year flood elevation being near the top of the river bank, and a grade restriction of 4-percent maximum, minimized the available structure depth.
- *Environmental* – The Cedar River is salmon bearing and is considered environmentally sensitive. The in-water work window (also called the fish window), was limited to 2 ½ months (June to mid-August).
- *Geology* - The soils in the site are poor and subject to liquefaction which lead to deep foundations, which meant cranes with large booms would be required during construction. The boom heights would violate the object height threshold within the “object free area”. The Contractor would need to coordinate with the airport to find allowable work times/windows.
- *Production Schedule* - The bridge had to be completed prior to start of Boeing’s planned production date for the new 737 MAX aircraft.
- *Noise Restrictions* – The contract posed a number of noise restrictions and mitigation strategies as a result of the number of nearby residents.
- *Underground Obstructions* – Construction required extensive in-water demolition of the existing 1940’s apron and 1969 bridge. The Engineer had some of the original design drawings, but not all of them, and so there wasn’t a great understanding of what underground obstructions existed at the site.

Working around all the site constraints led to a complicated schedule with construction stretching over three in-water work windows, see Fig. 8.



Activity ID	Original Duration	Start	Finish
North Boeing Bridge	747	22-Jan-13	2-Dec-15
PRE-CONSTRUCTION Advertise, Bid Award, Mobilize	47	22-Jan-13	27-Mar-13
PRE-FISH WINDOW 1 Demo Existing Bridge Construct Temp Bridge Approach	42	27-Mar-13	24-May-13
FISH WINDOW 1 Construct Temporary Bridge Demolish Portion of Existing Bridge	54	1-Jun-13	15-Aug-13
PRE-FISH WINDOW 2 Demolish Existing Bridge Above OHW Drive Piles Outside OHW	206	15-Aug-13	30-May-14
FISH WINDOW 2 Complete Demo of Existing Bridge Install Work Platforms, Shafts & Crossbeams - New Bridge	55	1-Jun-14	15-Aug-14
PRE FISH WINDOW 3 Complete Construction - New Bridge	200	15-Aug-14	22-May-15
FISH WINDOW 3 Complete Re-grading, Armory & Restoration (East/West) Demolish Temporary Bridge	55	1-Jun-15	17-Aug-15
POST FISH WINDOW 3 Punchlist Final Lanscape	77	17-Aug-15	2-Dec-15

Fig. 8 Anticipated Construction Sequence

The use of accelerated bridge construction methods was pivotal in reducing construction time and allowed some potential for float in the in-water work window schedule. Particularly the critical second fish window which contained the major tasks of demolishing the existing bridge, restoring and armoring the embankment, and installation of the shafts, columns, and crossbeam. The major work activities needed to be accomplished before, during, or after each fish window is defined in the following subsections, and shown pictorially in Fig. 9 to Fig. 14.

PRE-FISH WINDOW No. 1

1. Demolish a portion of existing apron above/outside of ordinary high water (OHW)
2. Construct a portion of the temporary work bridge approach
3. Drive temporary work bridge piling outside of OHW (East side only)

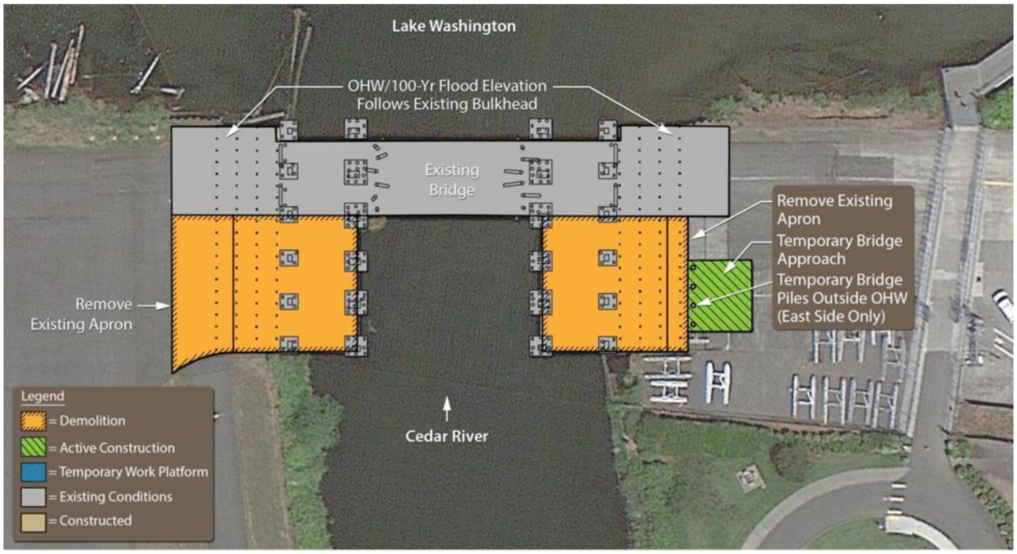


Fig. 9 Pre-Fish Window No. 1 Construction

FISH WINDOW No. 1

1. Demolish the remainder of the existing apron and a portion of existing structure foundations within the footprint of the new permanent bridge.
2. Construct temporary bridge.
3. Prepare temporary bridge approaches.
4. Demolish existing east side bridge apron.
5. Grade channel within the new bridge footprint.
6. Construct east side temporary work platform.
7. Construct Pier 3 reaction piles.
8. Construct temporary support piles for existing bridge removal.

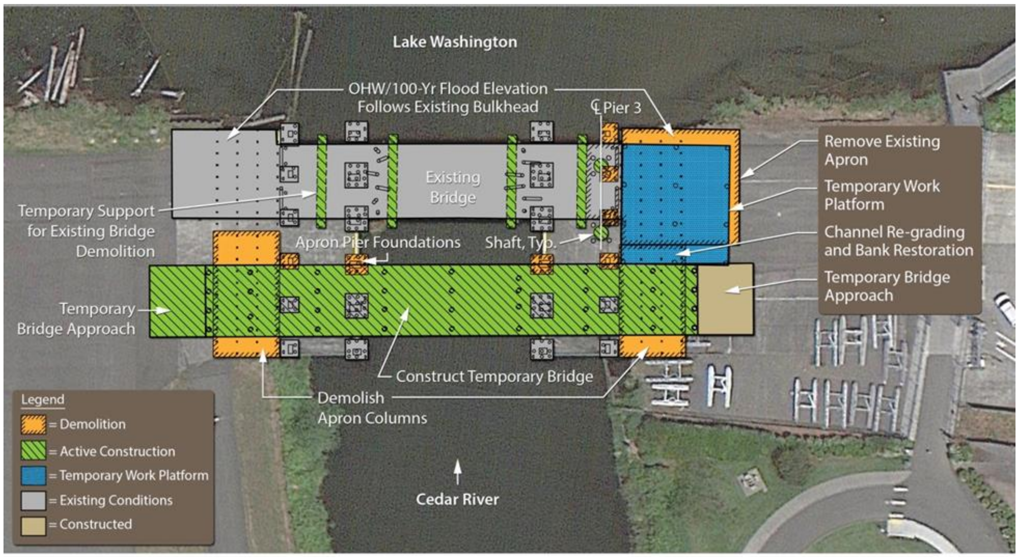


Fig. 10 Fish Window No. 1 Construction

PRE-FISH WINDOW No. 2

1. Demolish portions of existing bridge above OHW.
2. Drive Pier 1 and Pier 4 piles.

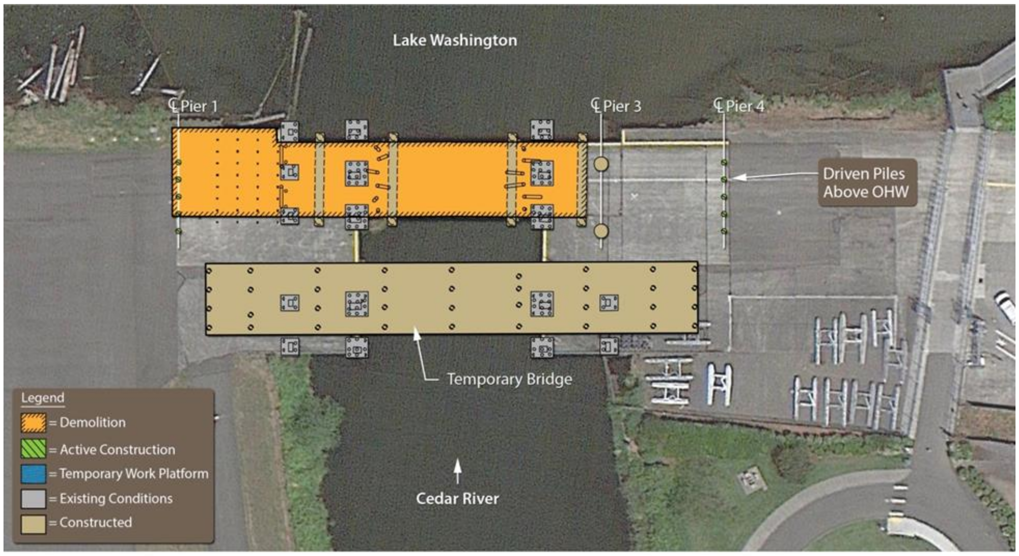


Fig. 11 Pre-Fish Window No. 2 Construction

FISH WINDOW No. 2

1. Demolish remainder of existing bridge.
2. Build temporary work platform for installation of Pier 2 drilled shafts.
3. Install Piers 2 and 3 drilled shafts (remove reaction piles).
4. Install Piers 2 and 3 columns and crossbeams.
5. Remove temporary work platforms.
6. Complete channel grading.

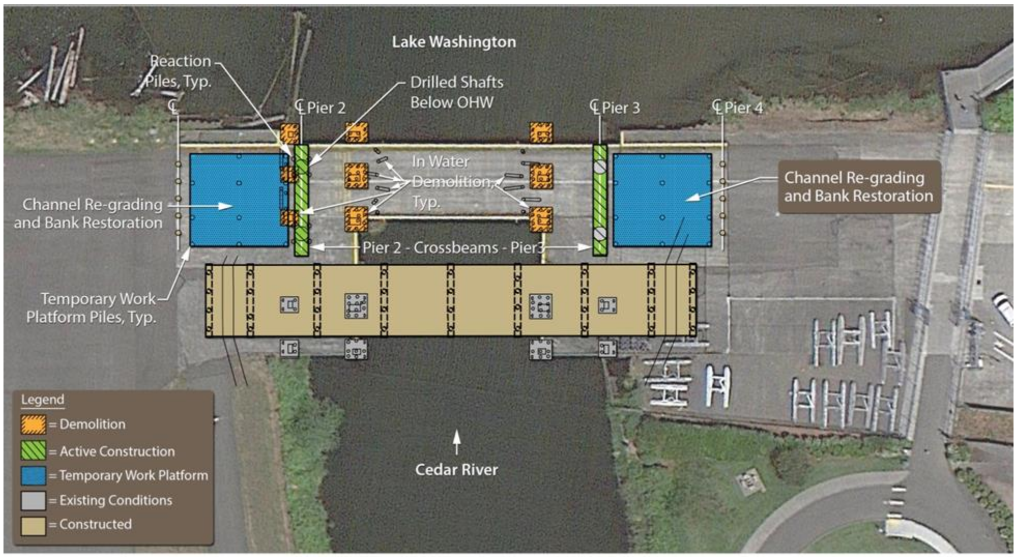


Fig. 12 Fish Window No. 2 Construction

PRE-FISH WINDOW No. 3

1. Complete bridge construction (erect girders, set full depth precast deck panels, etc).
2. Commission the bridge by December 2015.

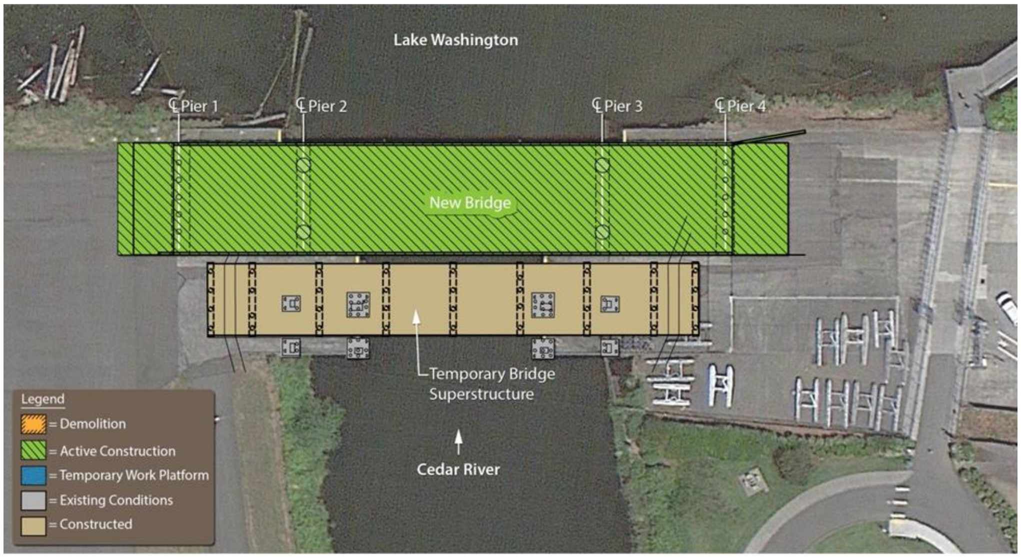


Fig. 13 Pre-Fish Window No. 3 Construction

FISH WINDOW No. 3

1. Demolish temporary bridge and complete channel and embankment restoration.

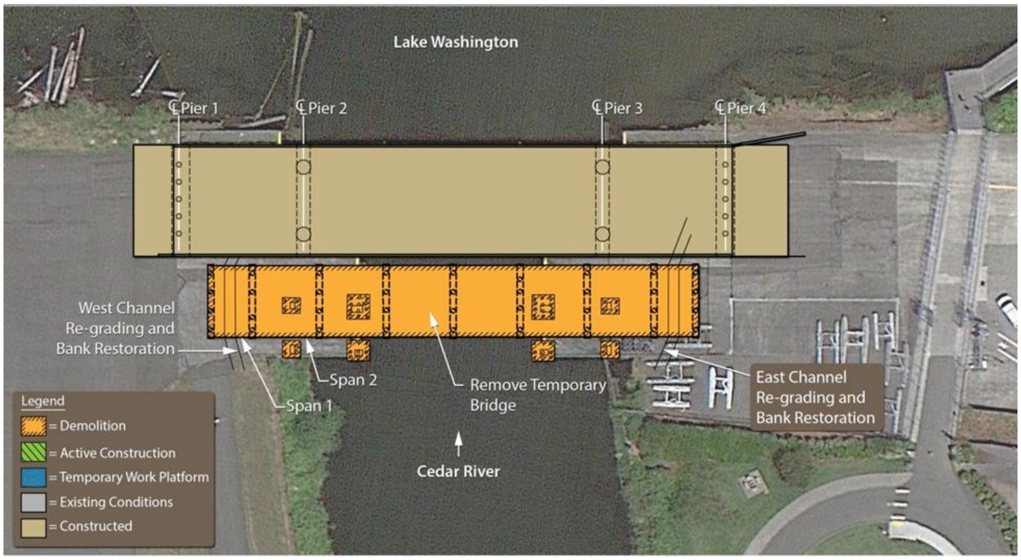


Fig. 14 Fish Window No. 3 Construction

PERCEIVED ACCELERATED BRIDGE CONSTRUCTION ADVANTAGES

The primary benefits of using accelerated bridge construction methods is to save on-site construction time. Conventional cast-in-place construction methods take longer and also increase the risk of schedule delays. The Boeing North Bridge project replaces an existing bridge structure that does not meet the needs of The Boeing Company facility. All aircraft that are assembled in the Boeing Renton facility are towed across the bridge to the Renton Airport for pre-flight activities before departing. Boeing accelerated both the design and construction schedules for the new bridge in order to meet their plans for production of the new 737MAX. The risks of schedule delay were seen as being very costly to Boeing's production plans. In response, the new bridge was designed using precast columns, crossbeams, and full-depth precast deck panels. The advantages of each is described in the below sub-sections.

PRECAST COLUMNS AND CROSSBEAMS

Utilizing precast columns and crossbeams minimized the amount of in-water work time and meant that the work could be completed within the allotted fish window. It was estimated that the use of precast columns and crossbeams would save approximately 10-20 work days compared to conventional cast-in-place construction methods.

A further advantage of using precast columns and crossbeams was related to the low profile of the bridge. If the crossbeams were cast-in-place, the formwork would have been below the ordinary high water elevation. Thus, the use of the partially precast crossbeam was preferred environmentally since the amount of cast-in-place concrete over the river was minimized.

FULL-DEPTH PRECAST DECK PANELS

Full-depth precast deck panels were used to accelerate construction due to the schedule benefits over a conventional cast-in-place concrete bridge deck system, saving significant time associated with forming, casting, and curing a cast-in-place bridge deck. The construction schedule for a conventional cast-in-place deck depends on weather. The bridge deck was scheduled to be cast in late fall/early winter, which is Western Washington's wettest and stormiest season. It was estimated that the full depth precast deck panel system could be constructed within two to three construction weeks. This includes time required for post-tensioning, grouting, and closure pours. The equivalent cast-in-place concrete bridge deck was estimated to take approximately 2 months considering the time of year and weather.

ACTUAL CONSTRUCTION SCHEDULE/METHODS

The actual construction schedule deviated from the anticipated schedule determined in design from the on-set of construction. Permits did not come through in time to allow for any significant construction to occur above/outside the ordinary high water extents prior to the first fish window. In addition, there were complications with construction of the temporary bridge foundations, with the airport requiring the majority of work to be conducted at nights, which reduced efficiency.

The anticipated schedule had the temporary bridge being commissioned, part of existing bridge demolished, and two of the four drilled shafts for the permanent bridge completed by the end of the first fish window (mid-August 2014). In actuality, the temporary bridge was not commissioned until February of 2014. No drilled shaft operations took place since mobilizing the drilled shaft sub-contractor twice was not seen as cost effective.

After the temporary bridge was commissioned, the center span of the existing bridge was demolished. The construction of the Pier 1 and 4 (abutments) was accelerated and completed in March 2014. Otherwise, construction of the abutments would have had to wait until after the second fish window. This change allowed for earlier setting of the girders and therefore earlier setting and grouting of the full depth precast deck panels.

The Contractor was able to adjust the environmental permits to allow for construction of large cofferdams (dewatered) to contain the demolition, channel re-grading, shaft construction, column construction, and the crossbeam construction. This allowed the contractor to work in the dry and opened the door to use falsework to construct the Piers 2 and 3 crossbeams. Because of this, the contractor submitted a change request to use cast-in-place construction methods for the column and crossbeam as a no-cost-change to the Owner. The presented perceived benefits to the Owner included:

1. **Safety Concerns**: The Contractor presented the setting of the precast crossbeams as one of their major safety concerns on the project. Their concern was that the precast crossbeams are heavy and require the use of a large crane. To set the precast crossbeam into the exact location and have the vertical column rebar align with the ducts in the crossbeam required personnel to work in close proximity to the overhead load. Cast-in-place operations would keep personnel further away.

2. **Quality Concerns:** The Contractor raised quality concerns with the use of the prefabricated substructure elements. Their concerns included the following:

   a. Grouting: The prefabricated elements as-detailed require grouted ducts and joints. With cast-in-place construction operations, the connections would be constructed monolithically without the need for grout.
   b. Number of Joints: The prefabricated elements require more joints than if cast-in-place methods were used. The sawtooth “socket” joint detail at the base of the column within the column-to-shaft connection limits could be replaced

with a single construction joint at the top of the shaft; the column-to-crossbeam connection, which requires grouting the column-to-crossbeam interface and grouting the vertical column reinforcing steel into corrugated ducts located within the crossbeam, could be simplified by eliminating the need for grouting or corrugated ducts; the additional concrete placed inside the precast crossbeam could be replaced with one monolithic concrete pour.

c. <u>Tolerance</u> - Setting the precast crossbeam over the precast column vertical rebar (within the ducts in the crossbeam) required little room for error.

3. **Schedule Concerns:** The contractor submitted comparative schedules based on the use of prefabricated bridge elements (as designed) and then based on the use of cast-in-place construction. The two schedules showed the same construction duration (ie. 38 construction days) for the respective work activities. The major difference between the two methods (as noted by the contractor) was that the precast method required the use of a crane with a 120-ft boom height, whereas, the cast-in-place method did not. In addition to the added equipment costs, the boom height would impact to the Renton Municipal Airport operations, and thus, could only be used at night.

The engineer-of-record reviewed the Contractor's proposal with the Owner, and provided the Contractor with the following responses:

1. **Response to Safety Concerns:** The Contractor presented the setting of the precast crossbeams as one of their major safety concerns on the project. It was noted that safety should be at the forefront of every construction operation, and that the setting of the precast crossbeam should be no different than setting a conventional precast bridge girder. The weight of the precast tub crossbeam was approximately 85-kips, which is well within the range of a typical bridge girder. It was suggested that a good work plan be developed and that work platforms be built, or man-lifts used, so that field personnel can be located to the side of the overhead work versus directly under the crossbeam as it is placed.

   It was also argued that safety was being improved. The precast tub was formed and poured at-grade within the precast plant. This avoided potential issues with shoring failures and/or falling hazards during the forming, rebar placement, post-tensioning operations, and casting of concrete.

2. **Response to Quality Concerns:** The Contractor highlighted grouting, the quantity of joints, and tolerances, as their quality concerns with utilizing the prefabricated bridge elements. Quality is very important and prefabricated bridge elements have

long been considered higher in quality than cast-in-place concrete members. The curing of precast components is superior to that of cast-in-place concrete, the construction tolerance requirements are tighter for precast concrete, and precast components get inspected in the plant prior to arriving on-site. Responses to address the specific issues brought up by the Contractor are as follows:

- Construction Joints – Joints in the precast design were detailed to provide ample cover and corrosion protection. The construction joint at the top of shaft/bottom of column as proposed by the contractor is worse than the sawtooth construction joint from a corrosion standpoint. The location of the construction joints have been considered in the design and durability of the precast option.

- Tolerance – The drilled shafts can be out of position +/-8” without impact to column location. This is no different than with cast-in-place construction methods. The columns can be precisely set, including orientation of the longitudinal bars with use of surveying equipment and templates. The location and orientation of longitudinal reinforcement can be match-cast with the ducts in the crossbeam at the precast plant. The vertical column reinforcing consisted of #14 bars. Aligning the #14 bars (nominal diameter of 1.70”) in 4” diameter ducts provided tolerances within limits of standard practice.

- Grouting – The grouting of the ducts and joint between the column and crossbeam can have problems without good procedures and controls. A potential mockup of this procedure was recommended.

3. **Response to Schedule Concerns:** Review of the contractors schedule comparison revealed several opportunities for time savings utilizing prefabricated bridge elements:

- The Contractor was stacking cure times for grouting operations that could occur simultaneously. In addition, longer than required cure times were being assumed for the grout prior to moving onto the next construction activity.

- For the cast-in-place option, the cofferdams cannot be removed until after the crossbeams have been cured, forms stripped, shoring removed, and the final grading and embankment protection under the crossbeam has been completed. For the precast option, the final grading work can start as soon as the columns have been set and the column-to-shaft closure is cast and cured. There is better access for grading, compacting, and placement of rip-rap without the crossbeam in place.

- In case of schedule slip, the precast tub crossbeam section can be set, filled and cured outside of the fish window after the cofferdam is removed. This allows for additional float in schedule of approximately 10-20 days.

As noted earlier, one of the Contractor's expressed concerns with the prefabricated bridge elements was that a crane with a 120-ft long boom would be required, which would put them beyond the allowable height threshold of the airport, which meant that erection activities needed to occur at night. In response, it was noted that following cast-in-place construction methods would still require the use of a crane for multiple work activities, and if any of these work activities required boom lengths in excess of 25-feet, the work would have to be performed at night. The below list of provided potential construction activities requiring a crane with a boom of excess of 25-feet was provided to the Contractor:

- Lift and place column reinforcement cage.
- Lift and place column forms.
- Concrete pump truck boom for casting columns
- Lift shoring and scaffolding
- Lift and place crossbeam formwork
- Lift crossbeam components including reinforcement, ducts, and strands
- Concrete pump truck boom for casting crossbeam

Based on these responses, the Owner did not allow the Contractor to alter the design to utilize cast-in-place construction methods in-lieu of the prefabricated bridge elements detailed in the contract plans. The Contractor ultimately found ways to significantly shorten the schedule of the precast option, which was fortunate, since new soils information led to significantly deeper drilled shaft foundations, which squeezed the schedule and left no float within the fish window. The crossbeam construction had to be pushed to outside fish window, which was made possible by the use of prefabricated bridge elements.

SUMMARY/CONCLUSION

The Boeing North Bridge was designed utilizing prefabricated bridge elements in order to accelerate construction and meet the in-water work restrictions and Boeing's production plans for the new 737 MAX aircraft. The general contractor submitted a "no cost" change proposal to the Owner, opting to use conventional cast-in-place construction methods in-lieu of the prefabricated bridge elements. The Contractor sited concerns with safety, quality, and schedule. These concerns were addressed by the engineer-of-record and the Owner opted to not accept the Contractor's change proposal seeing the added schedule float created by the use of the prefabricated bridge elements as being valuable to the project.

From the general contractor's perspective, using prefabricated bridge elements required a certified PCI precast plant to fabricate the precast bridge elements, which put more work out of the general contractor's control, being subject to the costs and schedule limitations of the precaster. Without significant schedule impacts or cost savings, the general contractor would have preferred to self-perform the work. On future projects, depending on the details of the components being built, allowable space on-site, it may be beneficial for the designer to consider allowing the Contractor to precast the bridge components on-site.

In addition, the use of prefabricated bridge elements required the use of larger cranes than would have otherwise been needed if the bridge was cast-in-place, which had cost impacts, and in the case at hand, also required that the work be done at night due to work restrictions of the airport. In the case at hand, consideration of the required equipment to erect the prefabricated bridge elements had been considered, and it was determined that the Contractor would have had to perform a lot of the work at night even if they elected to use cast-in-place construction methods. That said, regardless of the work restrictions, the temporary works and equipment cost differentials between cast-in-place construction methods versus use of prefabricated bridge elements should always be considered.

The use of prefabricated substructure elements and full depth precast deck panels is relatively new to the construction industry in the Pacific Northwest. On future contracts utilizing non-standard prefabricated bridge elements, it may be worthwhile to require the Contractor, after the job has been awarded, to have a kick-off meeting to discuss planned methods of construction, tolerances, etc. This could help save the Contractor time and efforts planning their work.

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