Precast Bridge Deck Solutions for Rapid Rehabilitation of a Truss Bridge

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Figure 1-Bridge Elevation

ABSTRACT:

The Washington State DOT’s Bridge and Structures Office replaced the deck on the Lewis and Clark Bridge using precast concrete panels and self-propelled modular transporters (SPMT) in October of 2002. This historic bridge constructed in 1930, spans across the Columbia River between Longview, Washington and Rainier, Oregon. Joseph B. Strauss, who designed the Golden Gate Bridge, was also the principal designer of this bridge. The bridge has a main 2,720-foot through-truss, a 927-foot long deck-truss on the Oregon side, and a 168-foot long deck-truss coupled with a 1,507 foot long rolled-beam approach on the Washington side. During construction the bridge could be closed to traffic only from 9:30 P.M. to 5:30 A.M. Night closures were limited to 120 days and single-lane closures were limited to 200 days. Precast, lightweight concrete deck panels were used to replace the existing deck on the trusses and for widening the existing deck on the rolled beam approach spans. A total of 103 precast panels were used with a constant width of 36 feet and lengths varying from 25 to 45 feet. The rolled-beam spans utilized 46 precast panels with a constant width of 4 feet and variable lengths of 58 to 70 feet. This paper discusses the design, construction, and lifting operations involved in replacing the existing bridge deck. The engineer’s estimate for the total cost of this project was $27 million.

KEYWORDS: Precast deck panels, lightweight concrete, self-propelled modular transporters.

History and Condition Of Bridge:

The Lewis and Clark Bridge was constructed by the private Longview Bridge Company and opened to traffic as a toll bridge in 1930. This historic bridge spanning the Columbia River between Longview, Washington and Rainer, Oregon was designed by Joseph A. Strauss who also designed the Golden Gate Bridge. The Washington State Toll Bridge Authority purchased the bridge in 1947 and the Washington State Department of Transportation (WSDOT) took over maintenance functions in 1948. Tolls were removed in 1965. The bridge consists of a main 2,720-foot main through-truss, a 927-foot long deck-truss approach on the Oregon side, and a 168-foot long deck-truss coupled with a 1,507 foot long, rolled-beam approach on the Washington side. A 30-year preservation plan completed in 1991 by WSDOT detailed nearly $30 million in maintenance work to keep the bridge structurally sound. The overall condition of the bridge was characterized as fair to poor. The most immediate needs were replacing the deck on the through and deck trusses and widening the existing deck on the Washington and Oregon approaches. Seismic retrofit of the existing expansion bearings and painting both approaches were also recommended. The existing floor beams were in fair condition, but many of them had a section loss of 5 % to 25% in the top flanges. It was decided that the floor beams did not require rehabilitation. They could be cleaned, painted, and reused provided a stress reduction could be achieved with a new deck system. State and local governments agreed that rehabilitating the bridge was more practical and financially feasible than building a new bridge.

Both WSDOT and the Oregon Department of Transportation met with the local business community and the general public to get input on traffic restrictions for the project. Based on their feedback, the bridge would close to vehicular traffic for deck-truss deck panel removal and replacement for 8 hours at night from 9.30 P.M. to 5.30 A.M. A total of 103 precast deck panels with a constant width of 36 feet with lengths varying from 25 to 45 feet were to be placed on the trusses. For widening the Washington approach and the Oregon approach 48 precast deck panels with a constant width of 4 feet with lengths varying from 58 to 70 feet were required. The widening of the approaches was accomplished using single lane closures. To perform the overall work the Contractor was limited to 120 days of night closures and 200 days of single lane closures. To test the equipment and procedure for placement of the first deck panel, the Contractor was allowed one weekend closure. In addition, the Contractor was allowed two weekend closures to place a concrete overlay on the approaches and to retrofit the bearings.

The engineer’s estimate for this project was $27 million. Although WSDOT designed the deck replacement utilizing a rail and crane system, the contractor developed an alternate system using self-propelled modular transporters. This highly efficient scheme enabled the contractor to save resources and time allowing him to bid the job at $17 million. The contract also provided incentives for early completion and penalties for late completion of the project.

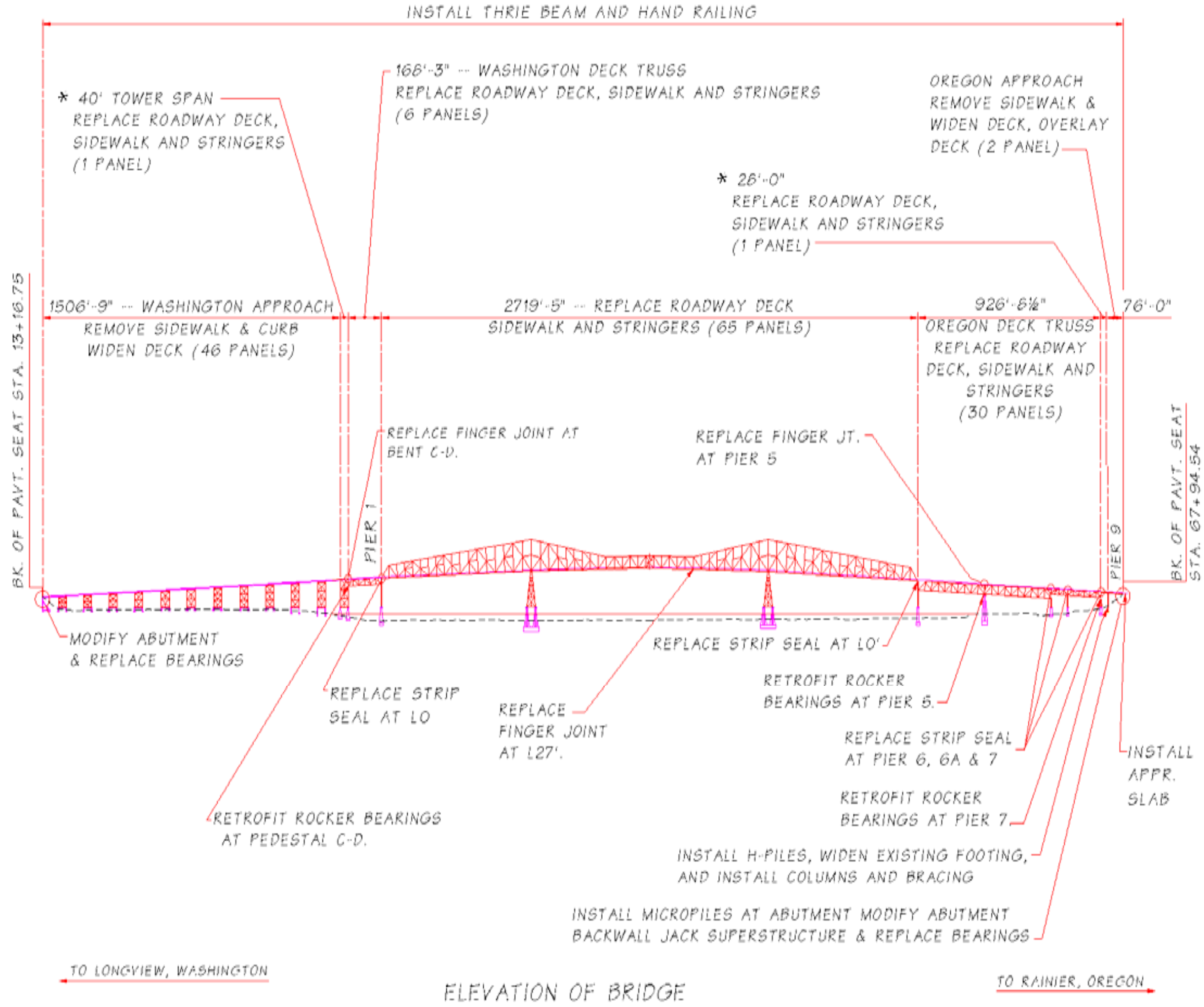

INSTALL THRIE BEAM AND HAND RAILING
* 40' TOWER SPAN
REPLACE ROADWAY DECK,
SIDEWALK AND STRINGERS
(1 PANEL)
168'-3" -- WASHINGTON DECK TRUSS
REPLACE ROADWAY DECK, SIDEWALK AND STRINGERS
(6 PANELS)
OREGON APPROACH
REMOVE SIDEWALK &
WIDEN DECK, OVERLAY
DECK (2 PANEL)
* 28'-0"
REPLACE ROADWAY DECK,
SIDEWALK AND STRINGERS
(1 PANEL)
BK. OF PAVT. SEAT STA. 13+16.75
1506'-9" -- WASHINGTON APPROACH
REMOVE SIDEWALK & CURB
WIDEN DECK (46 PANELS)
2719'-5" -- REPLACE ROADWAY DECK
SIDEWALK AND STRINGERS (65 PANELS)
926'-8½"
OREGON DECK TRUSS
REPLACE ROADWAY
DECK, SIDEWALK AND
STRINGERS
(30 PANELS)
76'-0"
REPLACE FINGER JOINT AT
BENT C-D.
REPLACE FINGER JT.
AT PIER 5
PIER 1
PIER 9
BK. OF PAVT. SEAT
STA. 67+94.54
MODIFY ABUTMENT
& REPLACE BEARINGS
REPLACE STRIP SEAL AT L0'
REPLACE STRIP
SEAL AT L0
REPLACE
FINGER JOINT
AT L27'.
RETROFIT ROCKER
BEARINGS AT PIER 5.
REPLACE STRIP SEAL
AT PIER 6, 6A & 7
INSTALL
APPR.
SLAB
RETROFIT ROCKER BEARINGS
AT PEDESTAL C-D.
RETROFIT ROCKER
BEARINGS AT PIER 7
INSTALL H-PILES, WIDEN EXISTING FOOTING,
AND INSTALL COLUMNS AND BRACING
INSTALL MICROPILES AT ABUTMENT MODIFY ABUTMENT
BACKWALL JACK SUPERSTRUCTURE & REPLACE BEARINGS
TO LONGVIEW, WASHINGTON
ELEVATION OF BRIDGE
TO RAINIER, OREGON

Figure-2

Design and Construction Methodology:

Full width deck panels

The existing lightweight deck in the through and deck truss sections had a unit weight of 120 pcf and was supported by six stringers spanning between floor beams as shown in Figure 3. Due to section loss experienced by the floor beam flanges, it was prudent to reduce the dead load stresses in these floor beams. With an allowable construction window of only 8 hours, WSDOT designed a twin longitudinal girder system spanning between the existing floor beams. The longitudinal girders were connected by a series of intermediate transverse stringers as shown in Figure 4. This floor system not only reduced the dead load stresses on the floor beams by 40 percent, but also reduced the number of connections to the floor beam from six to two, thereby saving valuable installation time. The weight of new deck panels was approximately 5 percent lower than the existing deck panels. The precast concrete full-width deck panels were designed to sit on preinstalled beam seats. The seats consisted of two channels (C 15x33.9) attached to the floor beam and a wide flange (W16x100) attached to the channels as shown in Figure 5. Although the plans called for shop drilling the holes in the beam seat for attachment to the longitudinal girders, the contractor proposed and received approval for, field drilling the holes in the beam seats for better fit of the deck panels. The contractor surveyed each panel location the day before and prepared the required shims prior to each nightly panel installation. After panel installation, the longitudinal beams were attached to the existing floor beam stiffeners by plates as shown in Figure 5. A backer rod and silicone sealant was used to fill the 1 inch joint between adjacent panels. Minor variations of the beam seat were used at the finger joint locations and on the Oregon and Washington approaches. The replacement lightweight precast deck panels had a preinstalled 1-inch thick latex modified concrete overlay to provide long-term durability. . After a short initial learning curve, deck panels were installed efficiently at the rate of 1 panel per night.

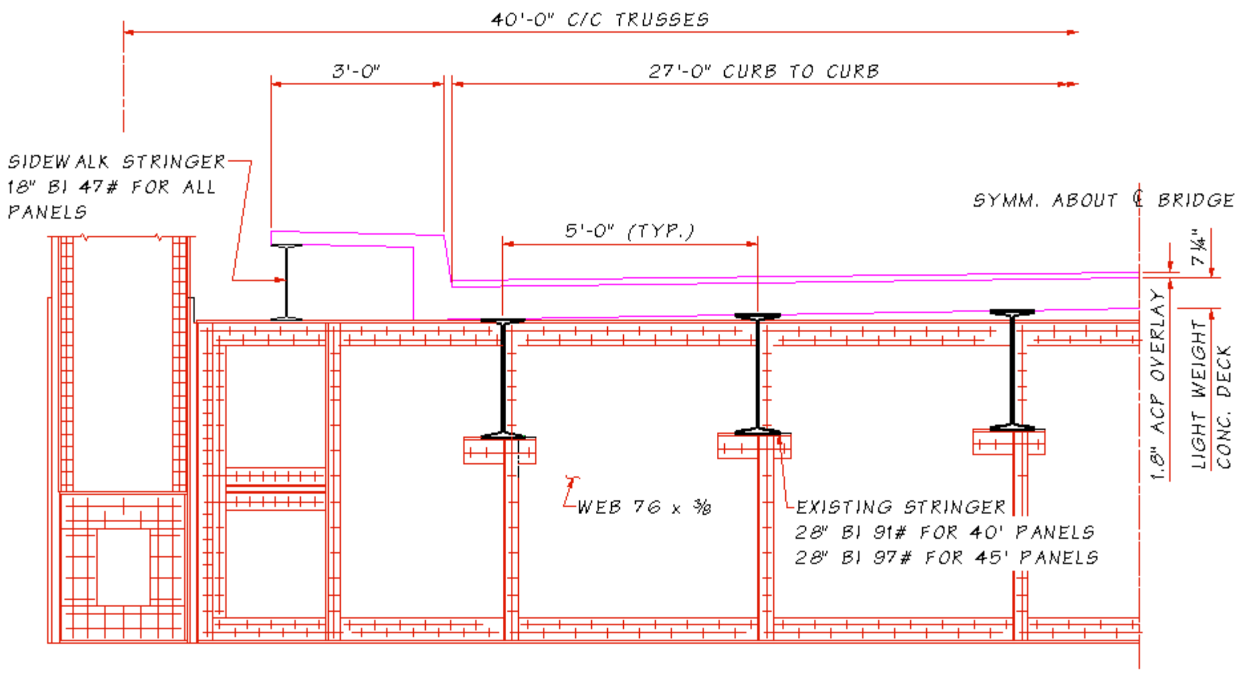
Table 1 below shows the concrete mix proportions for the lightweight concrete deck

Material	**Quantity (per cyd)**
Portland Cement	600 lb.
Fly Ash	80 lb.
Fine Aggregate	1158 lb.
Coarse Aggregate	1114 lb.
Total Water	270 lb.
Air Entrainment (Daravair)	3.2 oz.
Water Reducer (WRDA 64)	34 oz.
Water/Cement Ratio	0.40
Slump	4 +/- 1”
Unit weight	119 pcf

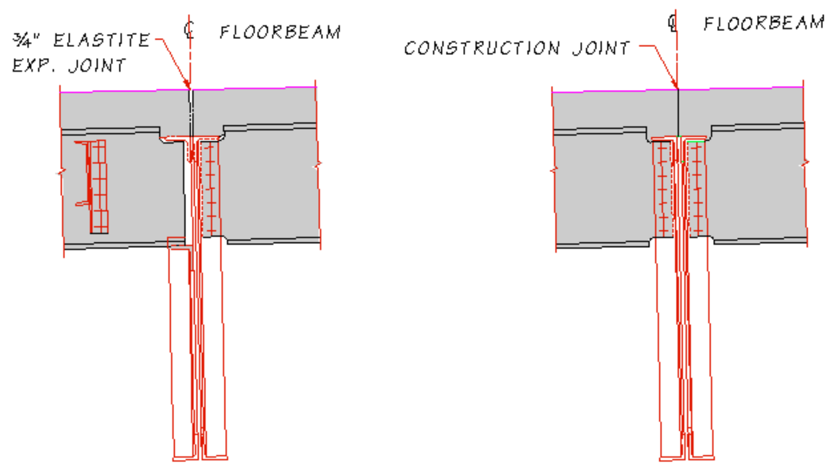
Table 1

B) Partial width deck panel

To match the new roadway cross-section on the trusses, the approaches with the rolled-beam spans were widened on both sides with precast concrete slab sections. These sections were placed directly on the widened crossbeams using single lane closures. See Figure 6 for details of the precast sections. To smooth the transition between the old and the new deck a 1 inch rapid set micro-silica modified concrete overlay was placed during a weekend closure.



ELEVATION - EXISTING FLOORBEAM & DECK



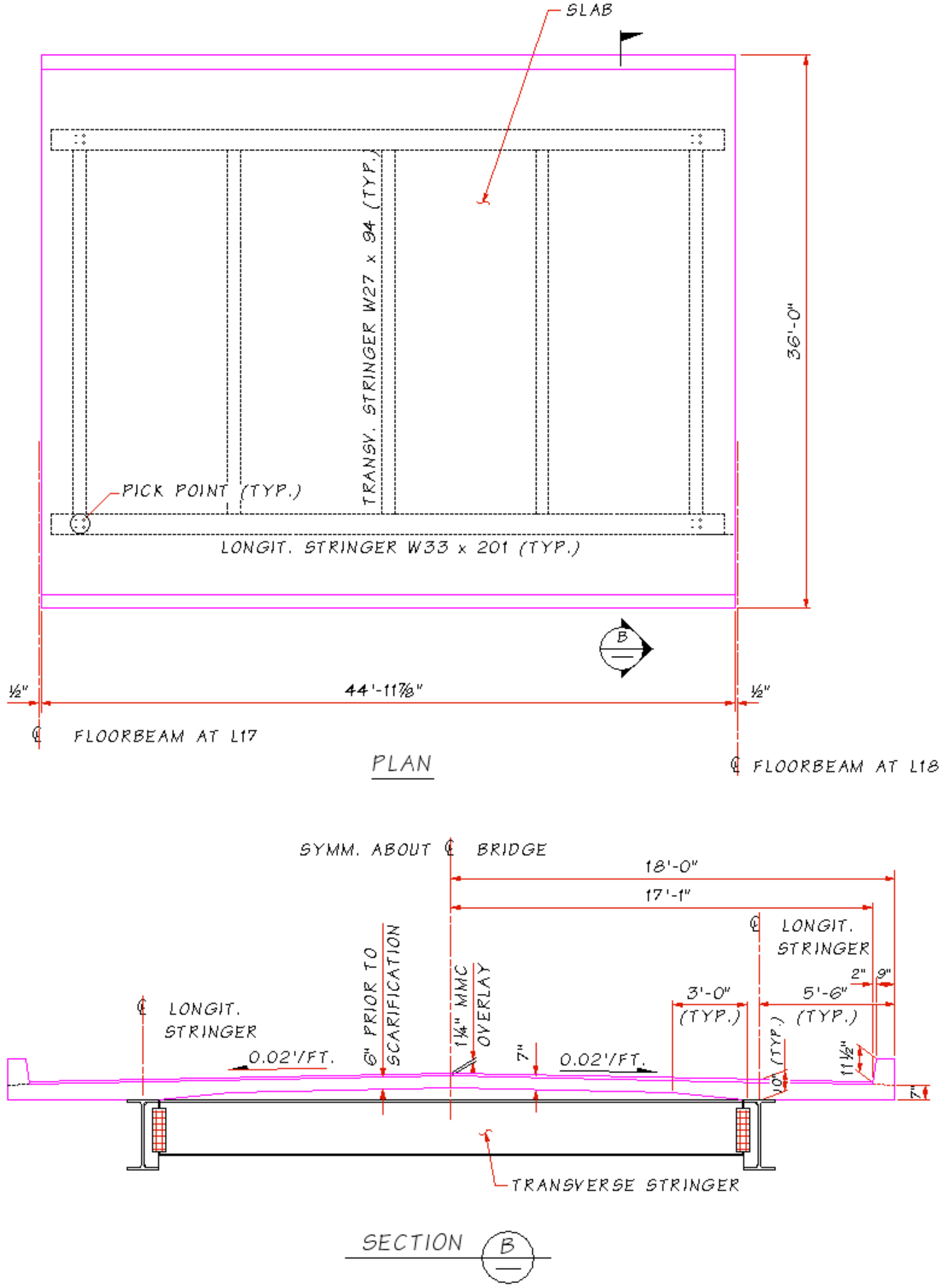
EXPANSION - FIXED

FIXED - FIXED

SECTIONS - EXISTING STRINGER TO FLOORBEAM CONNECTIONS

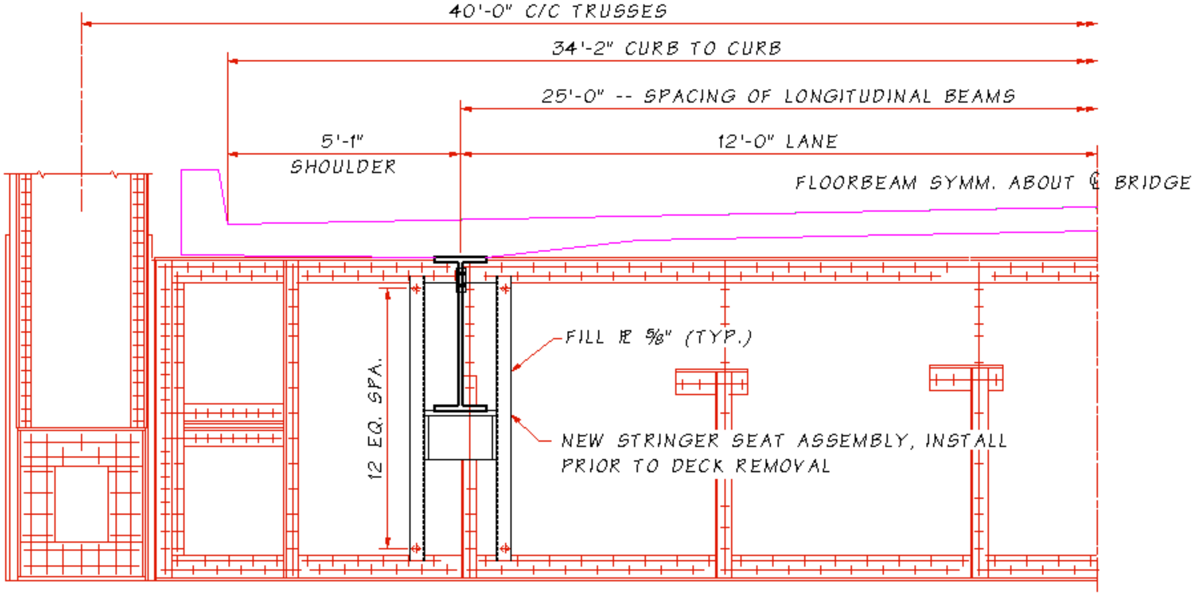
REMOVE SHADED PORTION AT TIME OF DECK REMOVAL

Figure 3

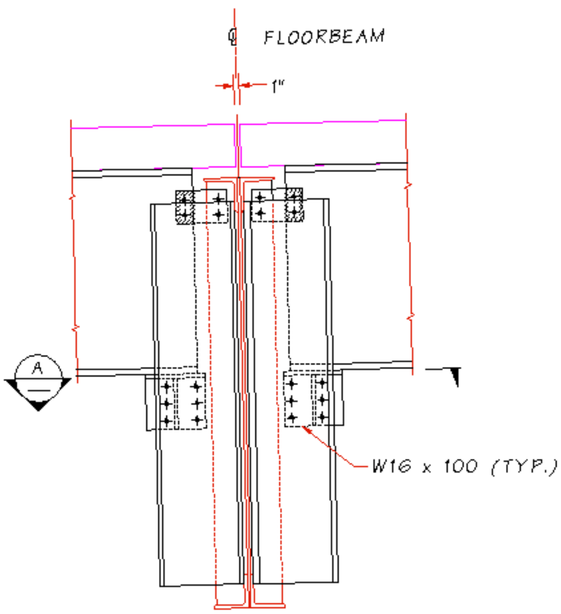


DETAILS OF TYPICAL 45'-0" PRECAST DECK PANEL

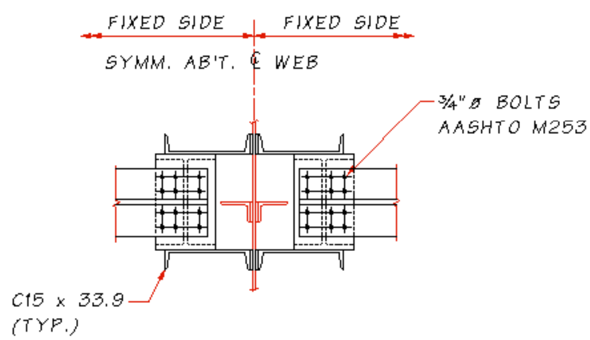
Figure 4



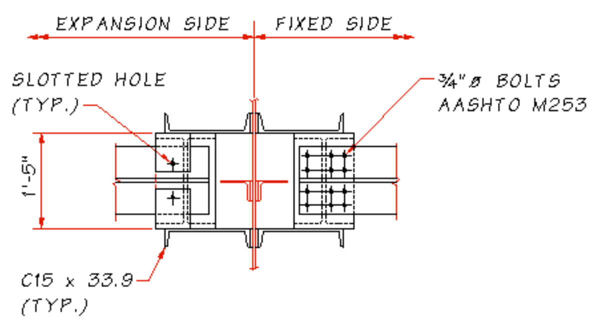
ELEVATION - MODIFIED FLOORBEAM & NEW DECK



SECTIONS - NEW STRINGER TO FLOORBEAM CONNECTIONS



SECTION A



SECTION A

Figure 5

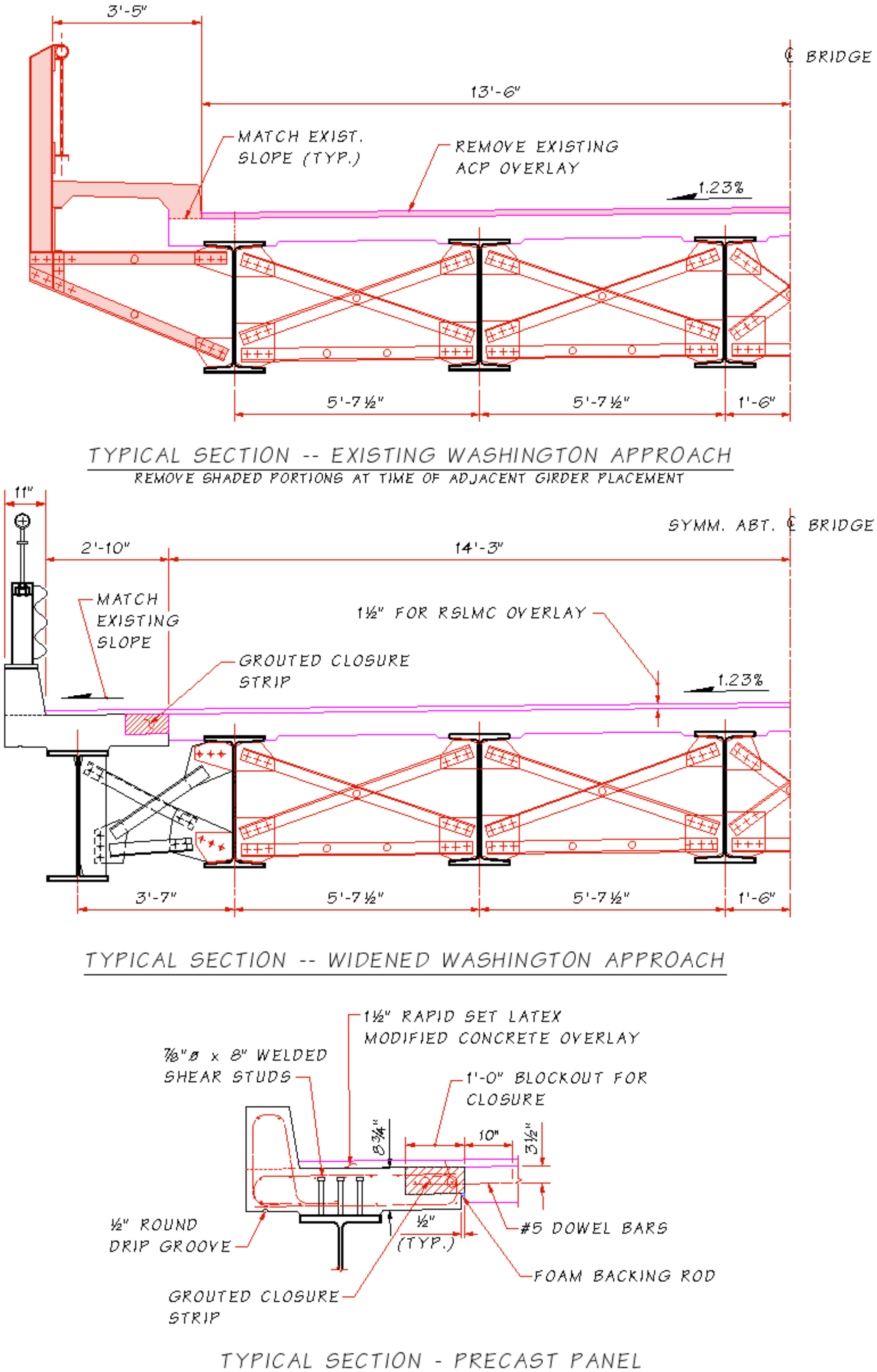

3'-5"
℄ BRIDGE
13'-6"
MATCH EXIST. SLOPE (TYP.)
REMOVE EXISTING ACP OVERLAY
1.23%
5'-7½"
5'-7½"
1'-6"
TYPICAL SECTION -- EXISTING WASHINGTON APPROACH
REMOVE SHADED PORTIONS AT TIME OF ADJACENT GIRDER PLACEMENT
11"
SYMM. ABT. ℄ BRIDGE
2'-10"
14'-3"
MATCH EXISTING SLOPE
1½" FOR RSLMC OVERLAY
GROUTED CLOSURE STRIP
1.23%
3'-7"
5'-7½"
5'-7½"
1'-6"
TYPICAL SECTION -- WIDENED WASHINGTON APPROACH
1½" RAPID SET LATEX MODIFIED CONCRETE OVERLAY
⅞"ø x 8" WELDED SHEAR STUDS
1'-0" BLOCKOUT FOR CLOSURE
8¾"
10"
3½"
½" ROUND DRIP GROOVE
½" (TYP.)
#5 DOWEL BARS
FOAM BACKING ROD
GROUTED CLOSURE STRIP
TYPICAL SECTION - PRECAST PANEL

Figure 6

Lifting Operations:

The contract plans detailed an engineer’s recommended method for replacement of the deck panels for both the through and deck trusses. The method consisted of a crane rail system. The contactor proposed an alternate system using SPMTs, a single system for replacement of the deck panels in both the deck and through trusses. The contractor’s method was found to be acceptable after careful review of the proposal, which included a detailed analysis of the existing structure for the heavy construction loads.

The lifting operation was designed and executed by the subcontractor MAMMOET USA, INC. The lifting system consisted of two self-propelled modular transporters with a specially designed lifting truss spanning between them. Air hoists were used to remove the old deck panels and lower the new precast deck panels into place. Figure 7 shows the trailers and the lifting truss and the sequence of operations involved in removing and replacing deck panels. Table 2 below shows the break down of the lifting loads. Figure 8 illustrates a fully constructed deck panel being readied for transportation to the site.

Component	**Load (kips)**
Lifting Truss	108
Self Propelled Modular Trailers	212
Old Deck Panel	192
New Deck Panel	184
Hydraulic Equipment Hoists And Miscellaneous.	4
Total	**700**

Table 2

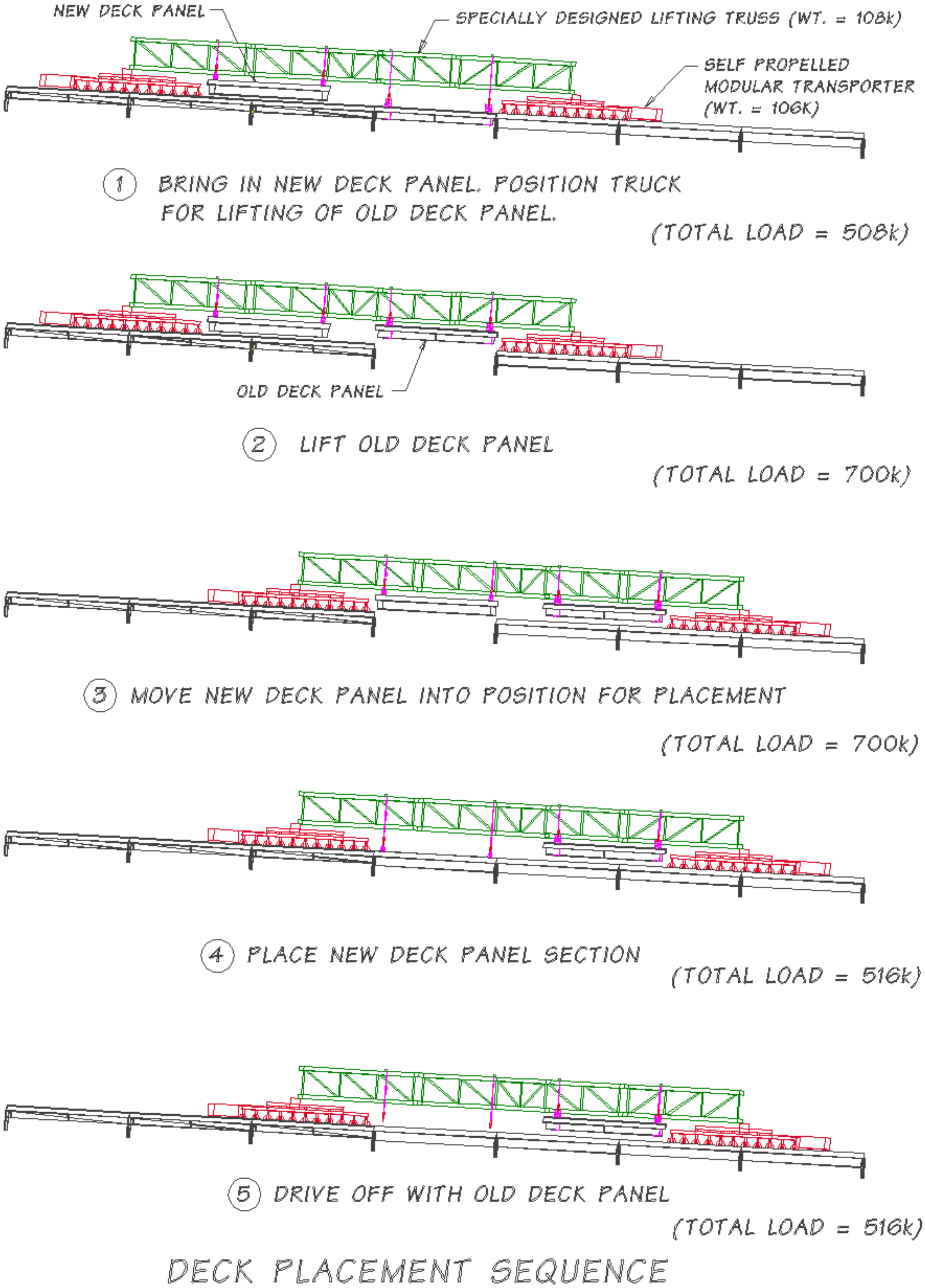

NEW DECK PANEL
SPECIALLY DESIGNED LIFTING TRUSS (WT. = 108k)
SELF PROPELLED
MODULAR TRANSPORTER
(WT. = 106K)
1 BRING IN NEW DECK PANEL. POSITION TRUCK
FOR LIFTING OF OLD DECK PANEL.
(TOTAL LOAD = 508k)
OLD DECK PANEL
2 LIFT OLD DECK PANEL
(TOTAL LOAD = 700k)
3 MOVE NEW DECK PANEL INTO POSITION FOR PLACEMENT
(TOTAL LOAD = 700k)
4 PLACE NEW DECK PANEL SECTION
(TOTAL LOAD = 516k)
5 DRIVE OFF WITH OLD DECK PANEL
(TOTAL LOAD = 516k)
DECK PLACEMENT SEQUENCE

Figure 7

Figure 8

<u>Conclusions</u>: The precast concrete deck panel system and the intelligent use of SPMTs demonstrated that deck replacement and widening of a major steel truss is possible without closing the bridge for more than 8 hours at night. Construction impact to the business community and the general public was minimal.

It may be appropriate to use this concept for rehabilitation of other truss bridges subjected to similar traffic and time constraints and WSDOT would consider using this technique again on future projects The bridge deck will be monitored to gauge the long-term durability of the deck.