RAPID CONSTRUCTION MEETING THE CHALLENGES OF URBAN ENVIRONMENTS

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ABSTRACT

This paper describes two recent bridge projects designed by the Washington State Department of Transportation (WSDOT) that utilized rapid construction techniques to meet the challenges in urban environments. The first bridge used precast, prestressed, spliced, trapezoidal concrete tub girders with precast, stay-in-place deck panels and a cast-in-place concrete topping. The composite girders were post-tensioned for superimposed dead load and live load. This 325-foot long bridge, over a major interstate freeway, was completed in ten months. WSDOT also completed the design for the Lewis and Clark Bridge deck replacement project. This historic bridge built in 1930, spans the Columbia River between Longview, Washington and Rainier, Oregon. The bridge consists of a 2,720 feet long main through-truss section, a 927-foot long deck truss section on the Oregon side, and a 168-foot long deck truss and a 1,507-foot long, 12 span rolled-beam section on the Washington side. The bridge could be closed to traffic only from 9:30 P.M. to 5:30 A.M. Night closures were limited to 120 and single-lane closures to 200 days. WSDOT replaced the existing concrete deck on the main through-truss and deck trusses, and widened the existing deck on the rolled beam spans using precast concrete deck panels. A total of 103 precast panels with a constant width of 36 feet and lengths varying from 25 to 45 feet were placed on the trusses.

SOUTH 38th STREET BRIDGE

When the 38th Street Bridge in Tacoma, Washington needed replacement, the Washington State Department of Transportation faced challenges common to urban bridge construction. It had to minimize traffic disruptions and reduce construction time. Located close to a major shopping center, retailers near the bridge were concerned about the loss of business during the holiday shopping season. To alleviate the retailers' concerns WSDOT agreed to withhold construction until after the first of the year and complete the project before the next holiday season. By choosing precast concrete elements WSDOT was able to remove and replace the existing bridge in under 10 months. Precast concrete also allowed WSDOT to meet the local corridor theme aesthetic requirements.

As part of a larger project to widen the interstate through Tacoma, the existing 4-span, 228 foot bridge could not span the

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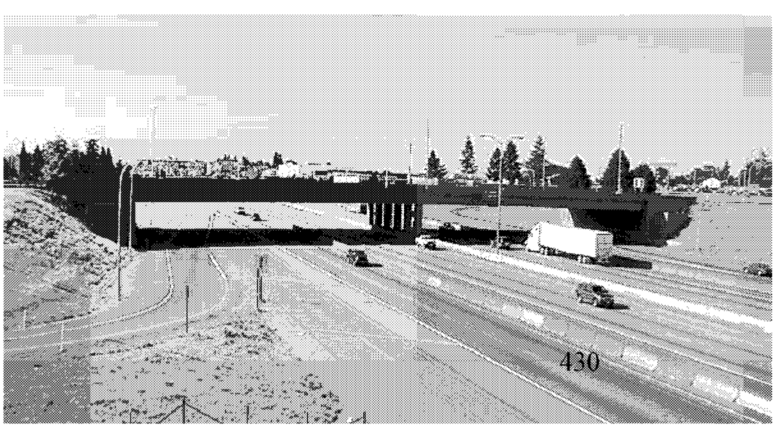
planned freeway widening and was substandard for the busy local retail traffic. The new 2-span, 325 feet long and 106 feet wide bridge was designed to carry additional lanes over the interstate and allowed future freeway widening. Instead of staging the project, WSDOT along with the city decided to completely remove the existing bridge in order to complete the project as quickly as possible.

One of the main construction challenges faced was to minimize traffic disruptions to the interstate, the main North-South corridor through the city. Because of heavy traffic volumes, most of the temporary traffic revisions were limited to nighttime closures. In order to construct the bridge within traffic limitations and meet the vertical clearance requirements WSDOT chose precast trapezoidal tub girders for the main spans. The 6 feet deep tubs varied in length from 41 feet to 57 feet. In all, the superstructure consisted of 6 lines of girders with 3 precast tubs per span for a total of 36 girders. The footings, walls and columns were constructed first followed by backfilling the intermediate pier. Temporary falsework for supporting the precast segments was then erected in the median of the freeway and at locations with minimum impact the traffic lanes on the interstate freeway. Tub girders were placed on the temporary falsework and the bottom slab between them at span closure locations was cast. Next girder stops and end diaphragms were cast locking all the girders in place. To eliminate the need for deck falsework, stay-in-place precast deck panels were used. The 8 feet 3 inches wide by 4 feet long deck panels were 3-1/2 inches thick and pretensioned with 7/16-inch diameter strands. Since the need to construct and remove deck forms was eliminated, lane closures on the interstate were greatly reduced and all 766 precast panels were placed within a week of limited nighttime closures. After placement, the panels were adjusted for camber by leveling screws. The remaining 4 inches of deck was then cast in place. The crossbeam, webs at span closure locations and the intermediate diaphragms were cast next. The composite tub girders were then post tensioned, followed by removal of the temporary falsework. The final steps involved casting the traffic barrier and installing the pedestrian railing.

Aesthetics was a major concern during design. A corridor theme was developed to provide design guidance and ensure consistency throughout the corridor for various structures to follow. The preferred structure type was the box girder for its graceful horizontal appearance and shallow depth. As the first bridge in the corridor, would set the tone of the structures to follow. Precast tub girders provided the desired box girder appearance and profile, but without the time consuming and disruptive falsework required for a cast-in-place box.



Precast concrete enabled WSDOT to uphold a commitment to the city, local neighborhoods, and retailers to reopen the bridge within 10 months. The bridge also significantly reduced traffic congestion on 38th St. and provided for the future expansion of the interstate. Precast concrete ensured that the traveling public would have a functional, durable, and aesthetically pleasing bridge for years to come.

LEWIS & CLARK BRIDGE

Precast Bridge Deck Solutions For Rapid Rehabilitation Of A Truss Bridge

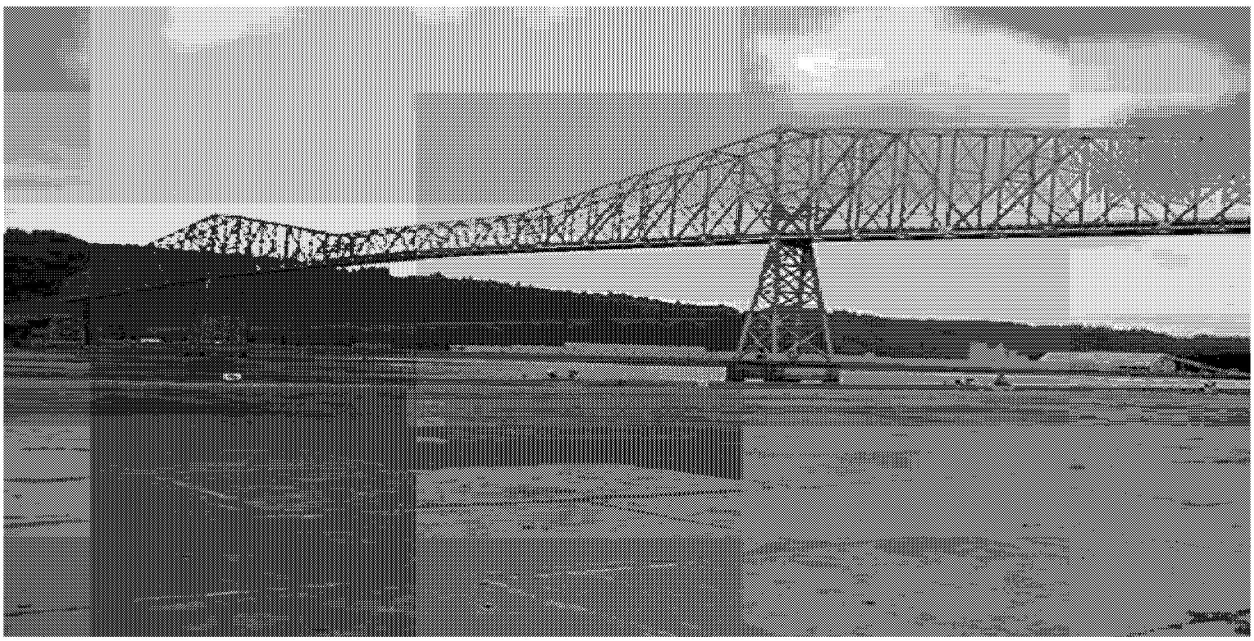
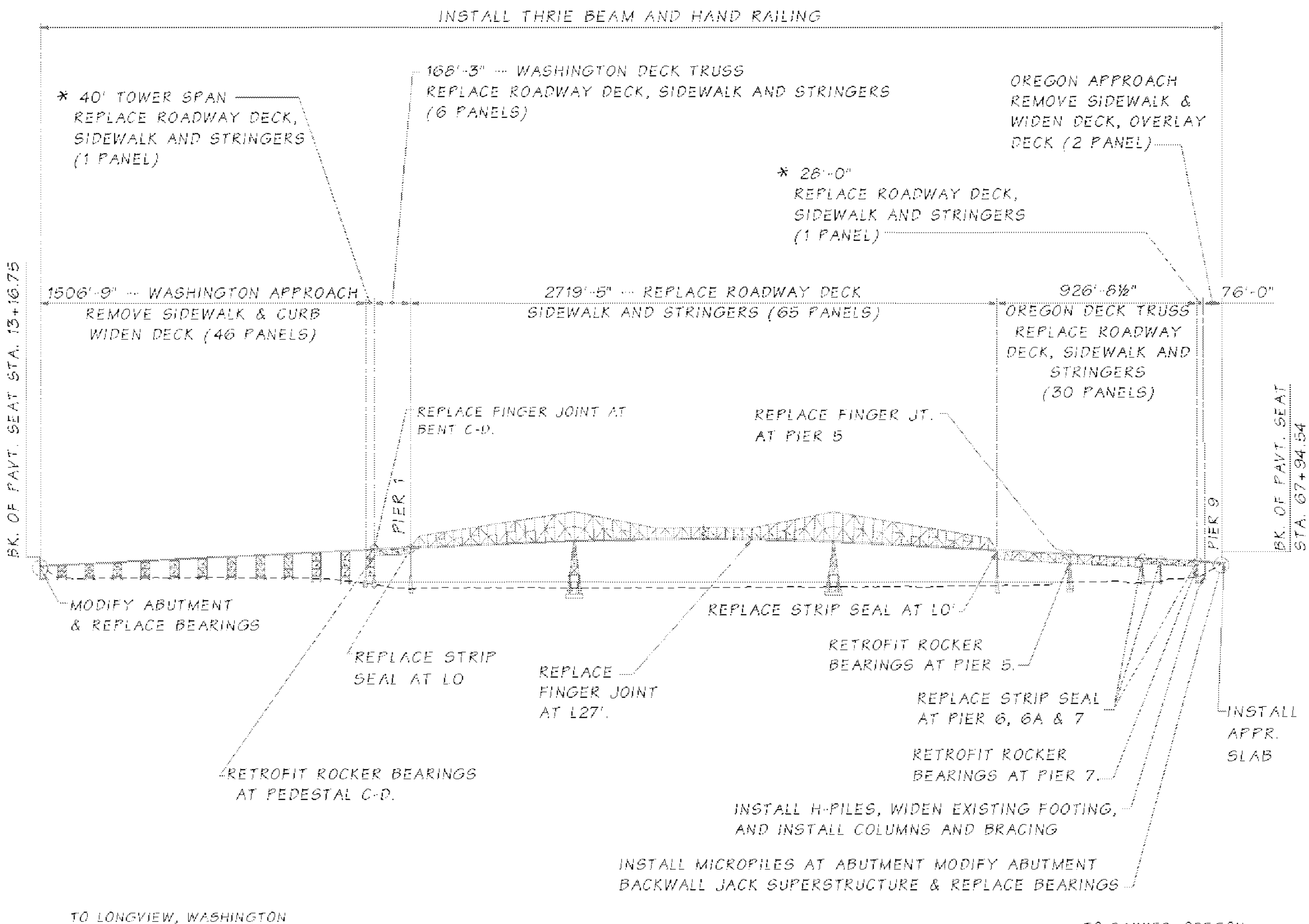


FIGURE 1- BRIDGE

History and Condition Of Bridge:
The existing 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 of Golden Gate Bridge fame. The bridge consists of a 2,720-foot long main through truss section, a 927-foot long deck truss section on the Oregon side, and a 168-foot long deck truss and a 1,507-foot long 12 span rolled beam section on the Washington side. See Figure 2 for details.

A 30-year preservation plan completed in 1991 by WSDOT detailed nearly $30 million in work to keep the bridge structurally sound. The overall condition of the bridge was characterized as fair to poor. The most immediate needs were the deck replacement on the through and deck trusses, and for widening the existing deck on the Washington approaches and a portion of the Oregon approach. Seismic retrofit of the existing expansion bearings, painting and other remedial work on both approaches constitute a majority of the other work that was recommended. The existing floor beams were in fair condition with many of them having a section loss of 5 % to 25% on the top flanges. It was decided that the floor beams except from being cleaned and painted did not require rehabilitation, 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 as opposed to building a new bridge.

Both WSDOT and the Oregon Department Of Transportation (ODOT) met with the local business community and the general public to get input on traffic control restrictions for the project. Based on this feedback, the project was set up to close the bridge to vehicular traffic to accommodate the through and deck truss deck panel removal and replacement within 8 hours from 9.30 P.M. to 5.30 A.M. A total of 103 precast deck panels with a constant width of 36 feet and lengths varying from 25 to 45 feet were placed on the trusses. For the widening of the Washington approach and a span of the Oregon approach 48 precast deck panels with a constant width of 4 feet and variable lengths of 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 8-hour night closures and 200 days of single lane closures. For placement of the first deck panel the Contractor was allowed a weekend closure to test both equipment and procedure for the replacement of the full-width deck panels. In addition, the Contractor was allowed two weekend closures to place a concrete overlay on the approaches and complete a bearing retrofit.



ELEVATION OF BRIDGE

FIGURE-2

Design and Construction Methodology:

A) 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. Because of the section loss suffered by the floor beam flanges, and the desire to retain these steel members in the rehabilitated structure, it was decided to reduce the dead load stresses in these floor beams as much as possible. This, coupled with an allowable construction window of only 8 hours necessitated the use of a twin longitudinal girder system spanning between the existing floor beams. The longitudinal girders, in turn, were connected by a series of intermediate transverse stringers as shown in Figure 4. This precast deck panel 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 only about 5 percent lower than the removed deck section. The precast full-width deck panel was 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. Though the plans called for shop drilling the holes in the beam seat for attachment to the longitudinal girders, the contractor proposed, and received approval, to field drill the holes in the beam seats for better fit of the deck panel. After installation of the panel, the longitudinal beams were attached to the existing floor beam stiffeners by plates as shown on Figure 5. 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 for the deck. For the most part the Contractor did not have any problems installing the deck panels in the 8-hour closure period. 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.
H_2O/Cement Ratio	0.40
Slump	4 +/- 1"
Unit weight	119 pcf

TABLE 1

B) <u>Partial width deck panel</u>

To match the new roadway cross-section on the trusses, the approaches with the rolled beam spans were widened on both sides of the roadway deck with precast 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 old and new deck a 1½ inch rapid set latex modified concrete overlay was placed during a weekend closure.

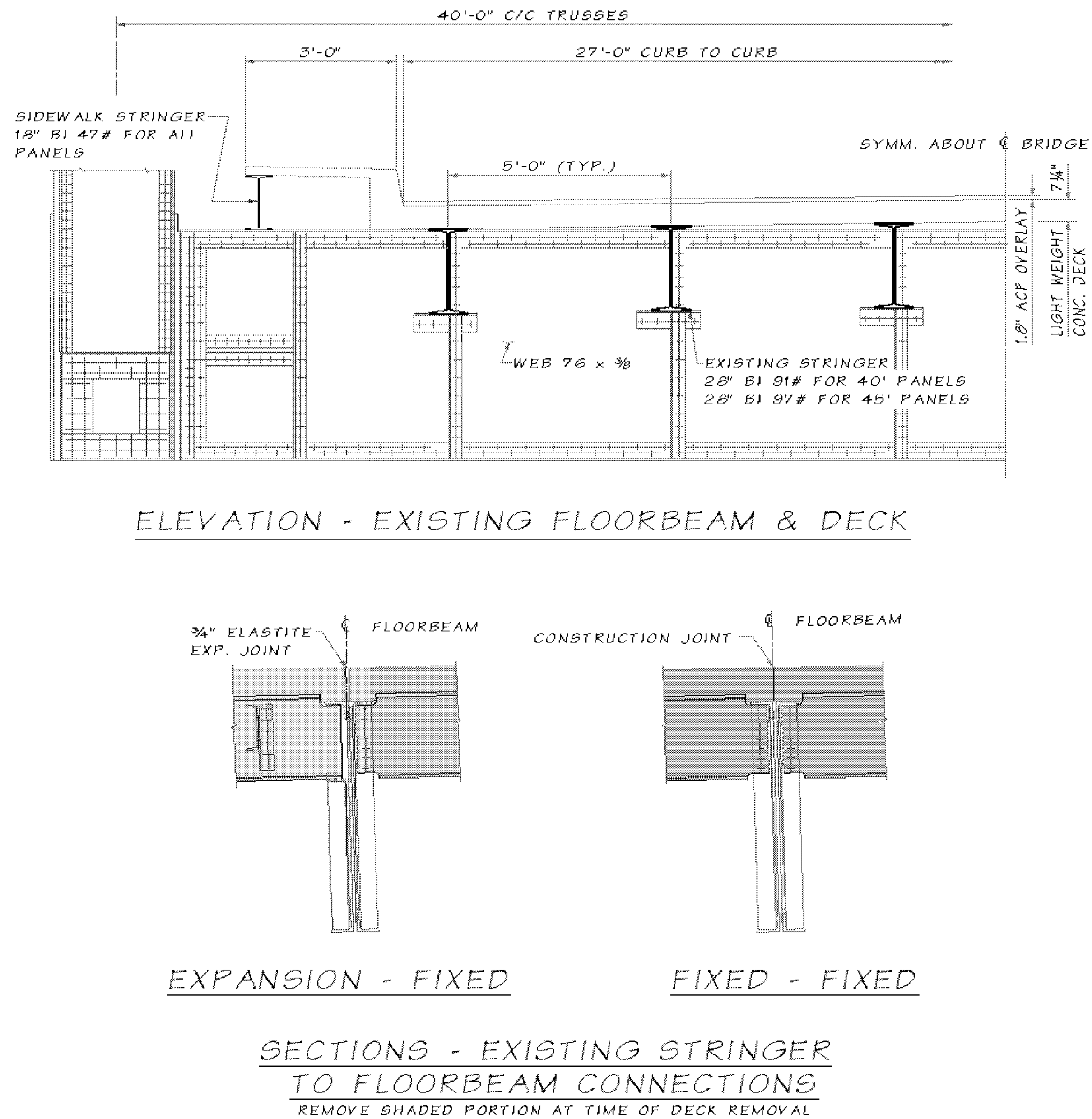


FIGURE 3

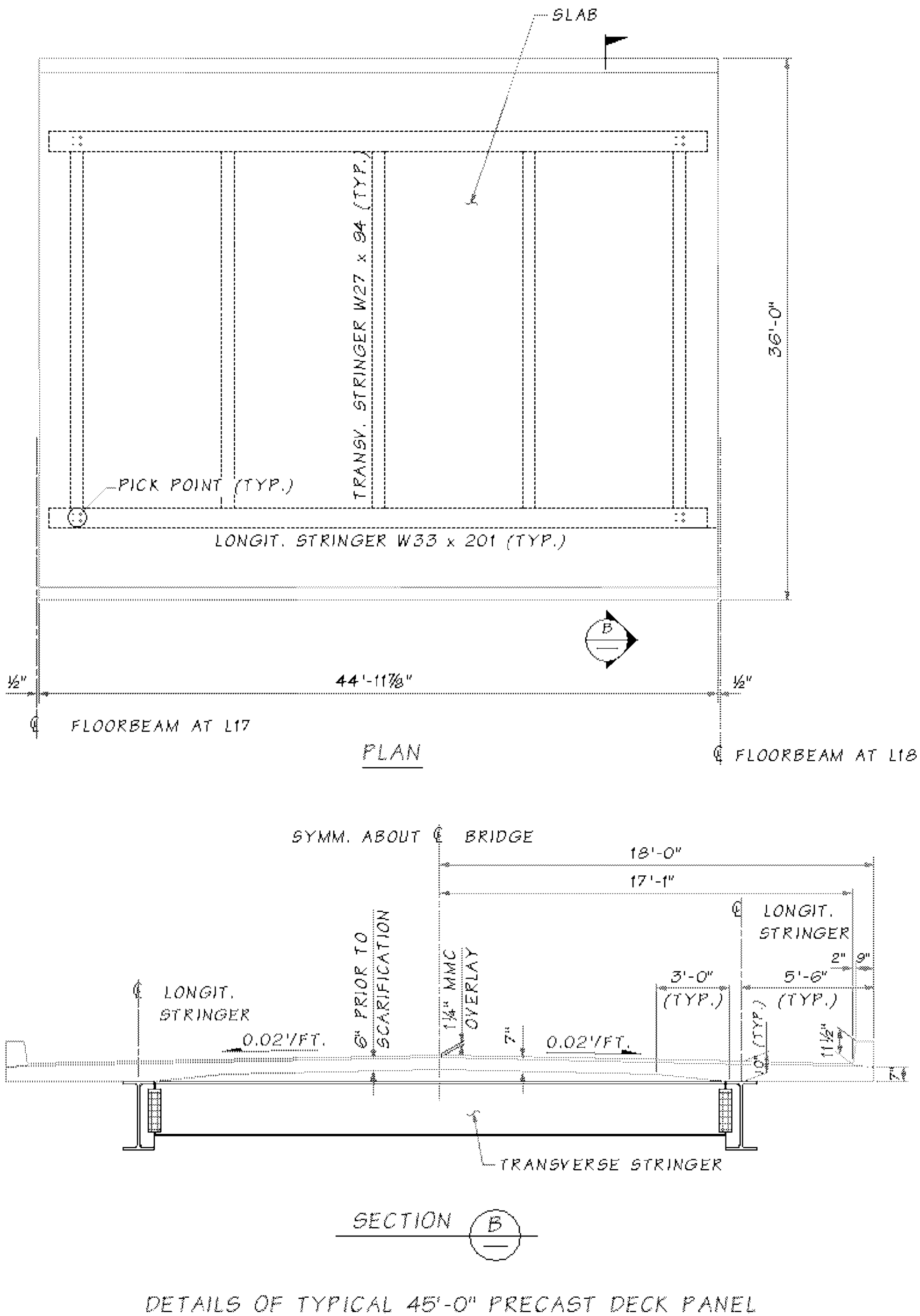

SLAB
TRANSV. STRINGER W27 x 94 (TYP.)
36'-0"
PICK POINT (TYP.)
LONGIT. STRINGER W33 x 201 (TYP.)
B
½"
44'-11⅞"
½"
℄ FLOORBEAM AT L17
PLAN
℄ FLOORBEAM AT L18
SYMM. ABOUT ℄ BRIDGE
18'-0"
17'-1"
℄ LONGIT. STRINGER
2"
9"
3'-0" (TYP.)
5'-6" (TYP.)
℄ LONGIT. STRINGER
6" PRIOR TO SCARIFICATION
1¼" MMC OVERLAY
7"
0.02'/FT.
0.02'/FT.
11½"
TRANSVERSE STRINGER
SECTION B
DETAILS OF TYPICAL 45'-0" PRECAST DECK PANEL

FIGURE 4

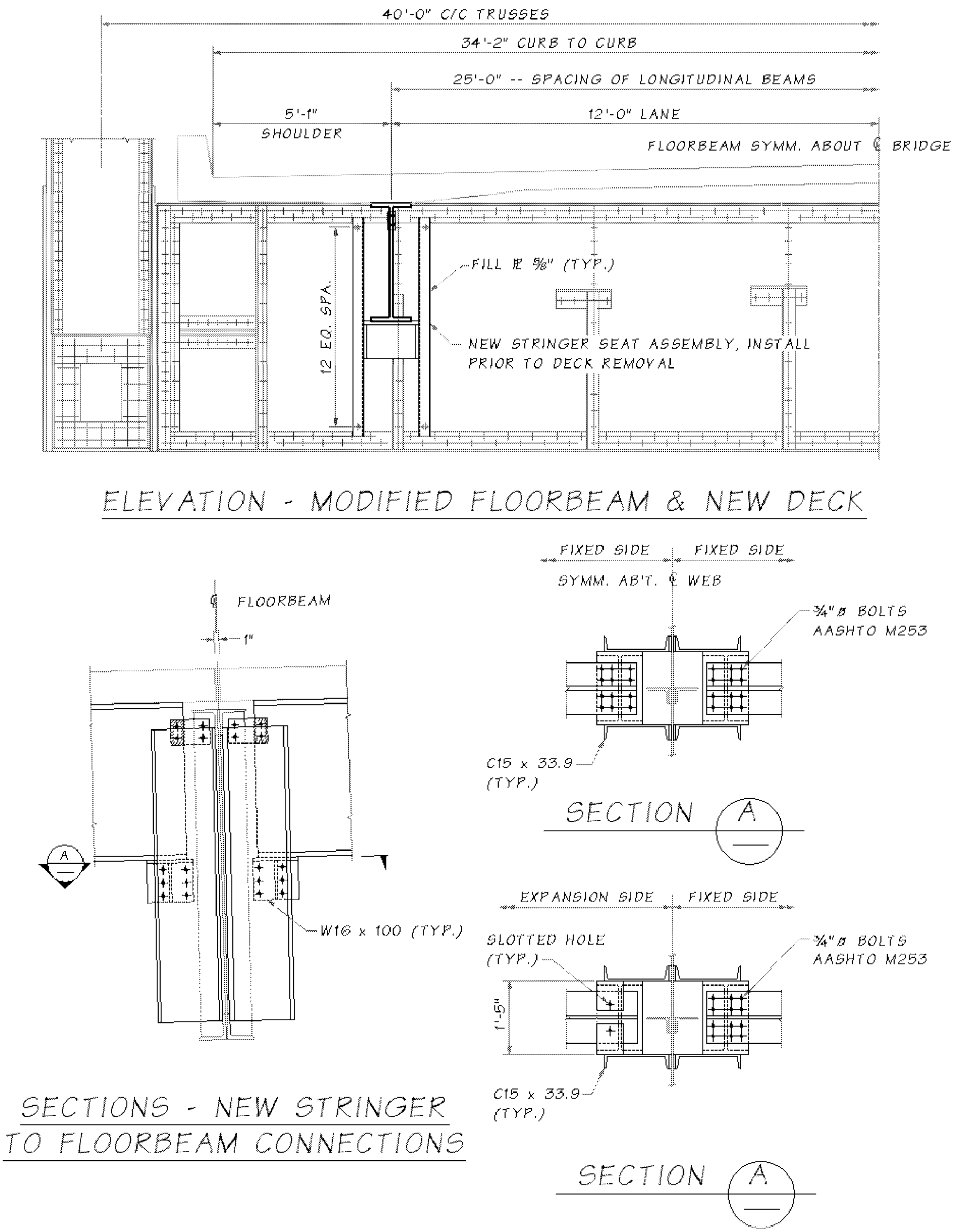

40'-0" C/C TRUSSES
34'-2" CURB TO CURB
25'-0" -- SPACING OF LONGITUDINAL BEAMS
5'-1"
SHOULDER
12'-0" LANE
FLOORBEAM SYMM. ABOUT ℄ BRIDGE
FILL ℙ 5⁄8" (TYP.)
12 EQ. SPA.
NEW STRINGER SEAT ASSEMBLY, INSTALL PRIOR TO DECK REMOVAL
ELEVATION - MODIFIED FLOORBEAM & NEW DECK
FIXED SIDE
FIXED SIDE
SYMM. AB'T. ℄ WEB
3⁄4"ø BOLTS AASHTO M253
C15 x 33.9 (TYP.)
SECTION A
℄ FLOORBEAM
1"
A
W16 x 100 (TYP.)
SECTIONS - NEW STRINGER TO FLOORBEAM CONNECTIONS
EXPANSION SIDE
FIXED SIDE
SLOTTED HOLE (TYP.)
3⁄4"ø BOLTS AASHTO M253
1'-5"
C15 x 33.9 (TYP.)
SECTION A

FIGURE 5

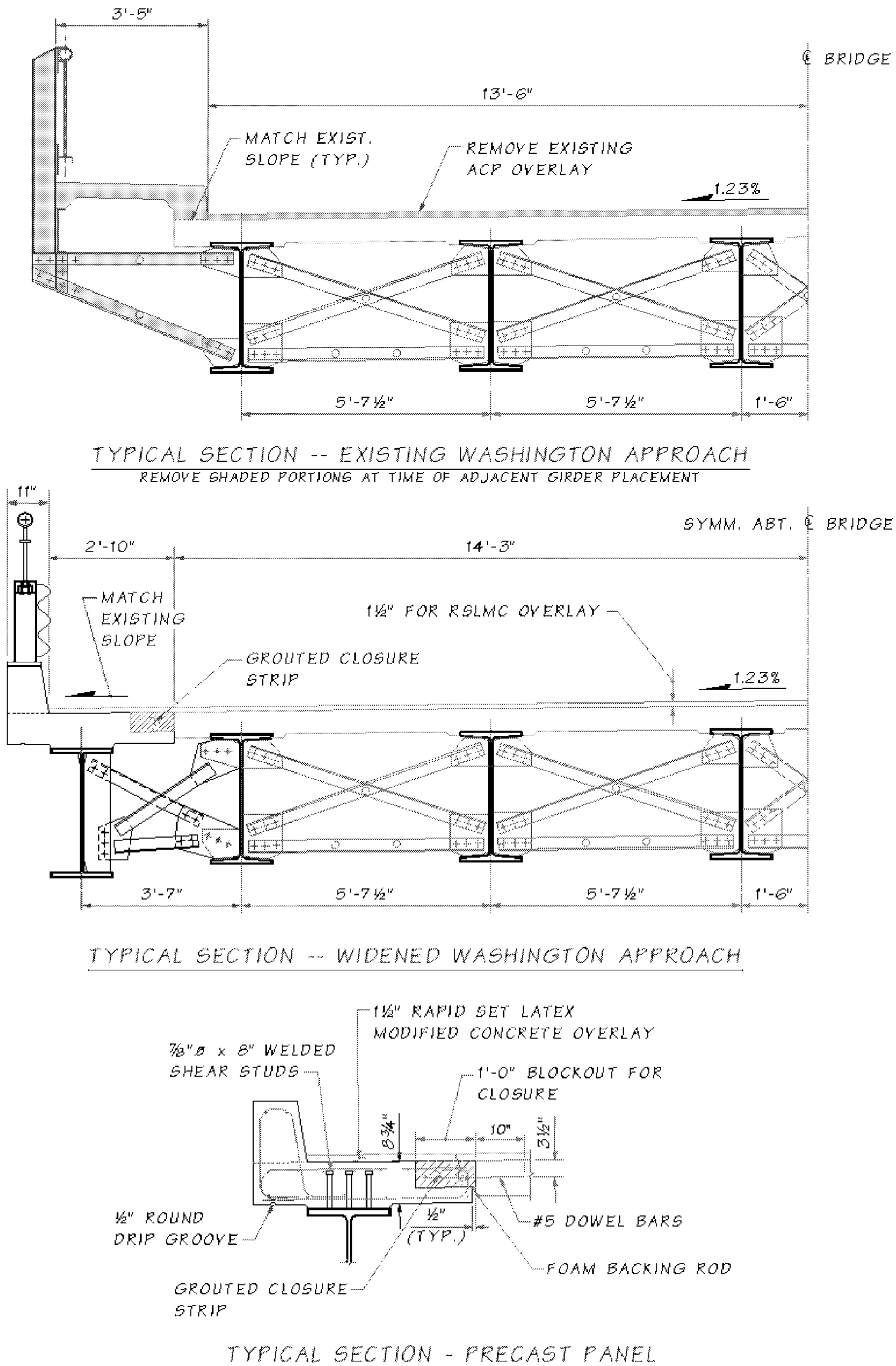

3'-5"
℄ BRIDGE
13'-6"
MATCH EXIST. SLOPE (TYP.)
REMOVE EXISTING ACP OVERLAY
1.23%
5'-7½"
5'-7½"
1'-6"
TYPICAL SECTION -- EXISTING WASHINGTON APPROACH
REMOVE SHADED PORTIONS AT TIME OF ADJACENT GIRDER PLACEMENT
11"
SYMM. ABT. ℄ BRIDGE
2'-10"
14'-3"
MATCH EXISTING SLOPE
1½" FOR RSLMC OVERLAY
GROUTED CLOSURE 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

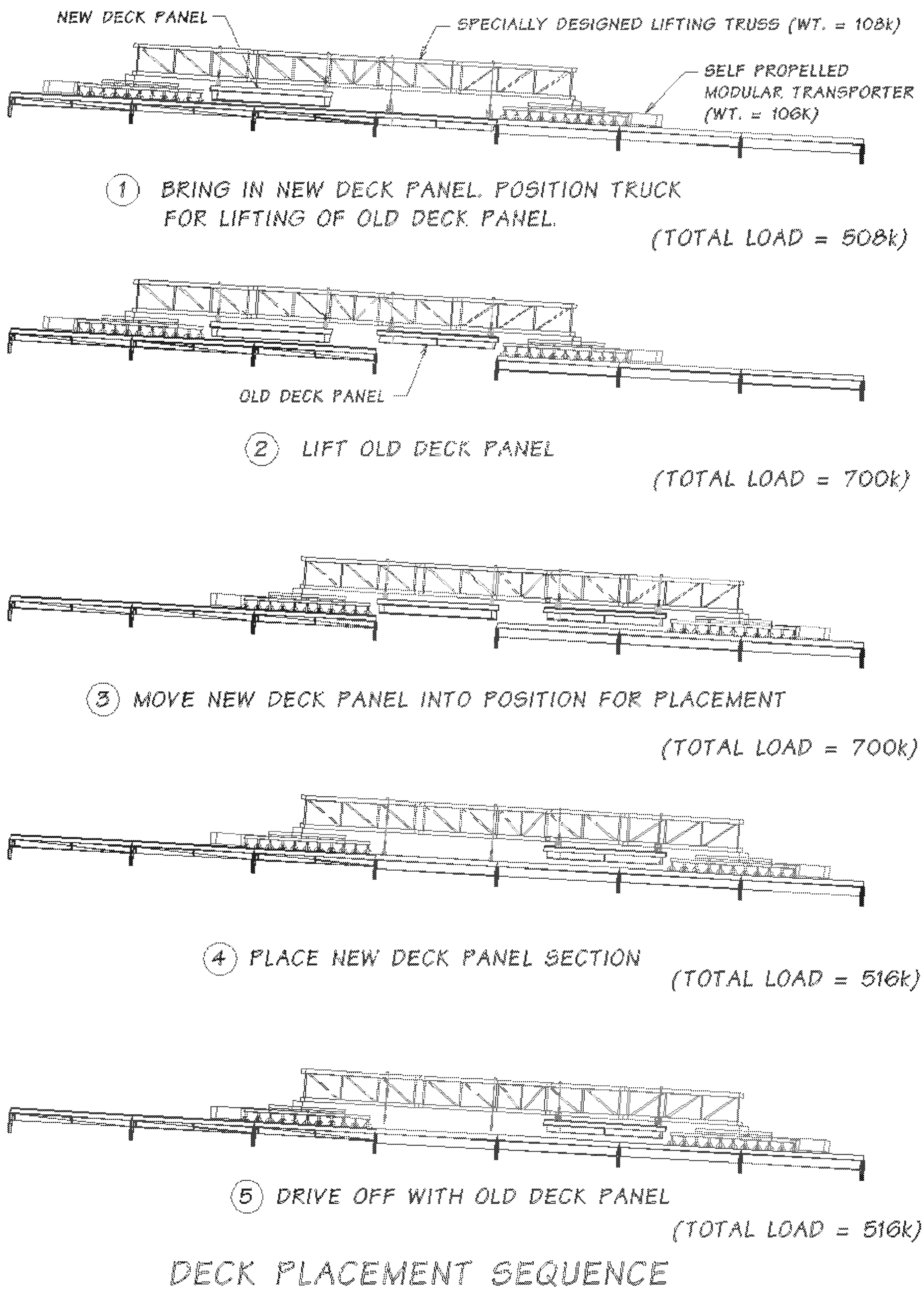
FIGURE 6

Lifting Operations: The contract plans had an Engineer's suggested method for replacement of the deck panels for both the through-truss and deck trusses. For the through-truss, it consisted of a crane rail system attached to it. For the deck trusses, a special lifting frame with a crane rail system attached to it was designed. The contactor proposed an alternate system, which utilized 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 operations associated with the replacement of the deck panels were designed and executed by the subcontractor MAMMOET USA, INC; Rosharon, Texas. The lifting system consisted of two self-propelled modular trailers with a specially designed lifting truss spanning the trailers. Air hoists were used to remove the old deck panel and lower the new pre-cast deck panel into place. Figure 7 shows the trailers and the lifting truss and the sequence of operations involved in removing and replacing the deck panel. 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.

TABLE 2

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**



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

Conclusions: The precast concrete deck panel system showed that rapid replacement of the deck in truss bridges and widening of the deck in the rolled beam spans is possible, without closing down the bridge for more than 8 hours at night. The impact to the businesses community and the general public was minimal when considering the magnitude of the project. It may be appropriate to use this concept for rehabilitation of other truss bridges subjected to similar traffic and time constraints. The bridge deck will be monitored to gauge its durability. Total cost for the project was $27 million.

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TABLE 3 – CONVERSION FACTORS

ENGLISH UNITS	SI UNITS
1 inch	25.4 mm
1 foot	0.3048 m
1 oz	0.2780 N
1 lb	4.4482 N
1 kip	4448.2 N
1 cy	0.7646 m^3