WIRE REINFORCEMENT INSTITUTE®

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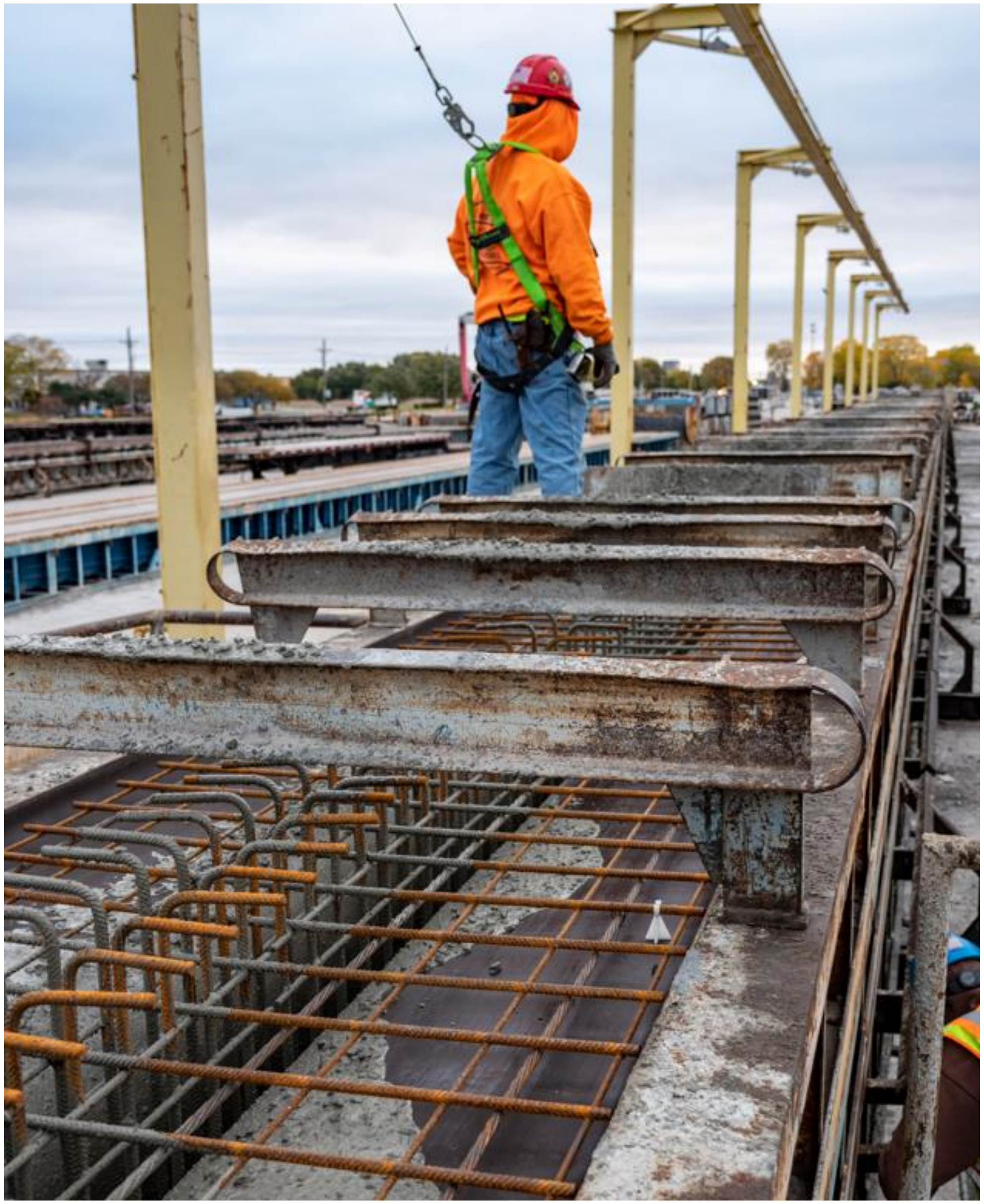
Technical Blog



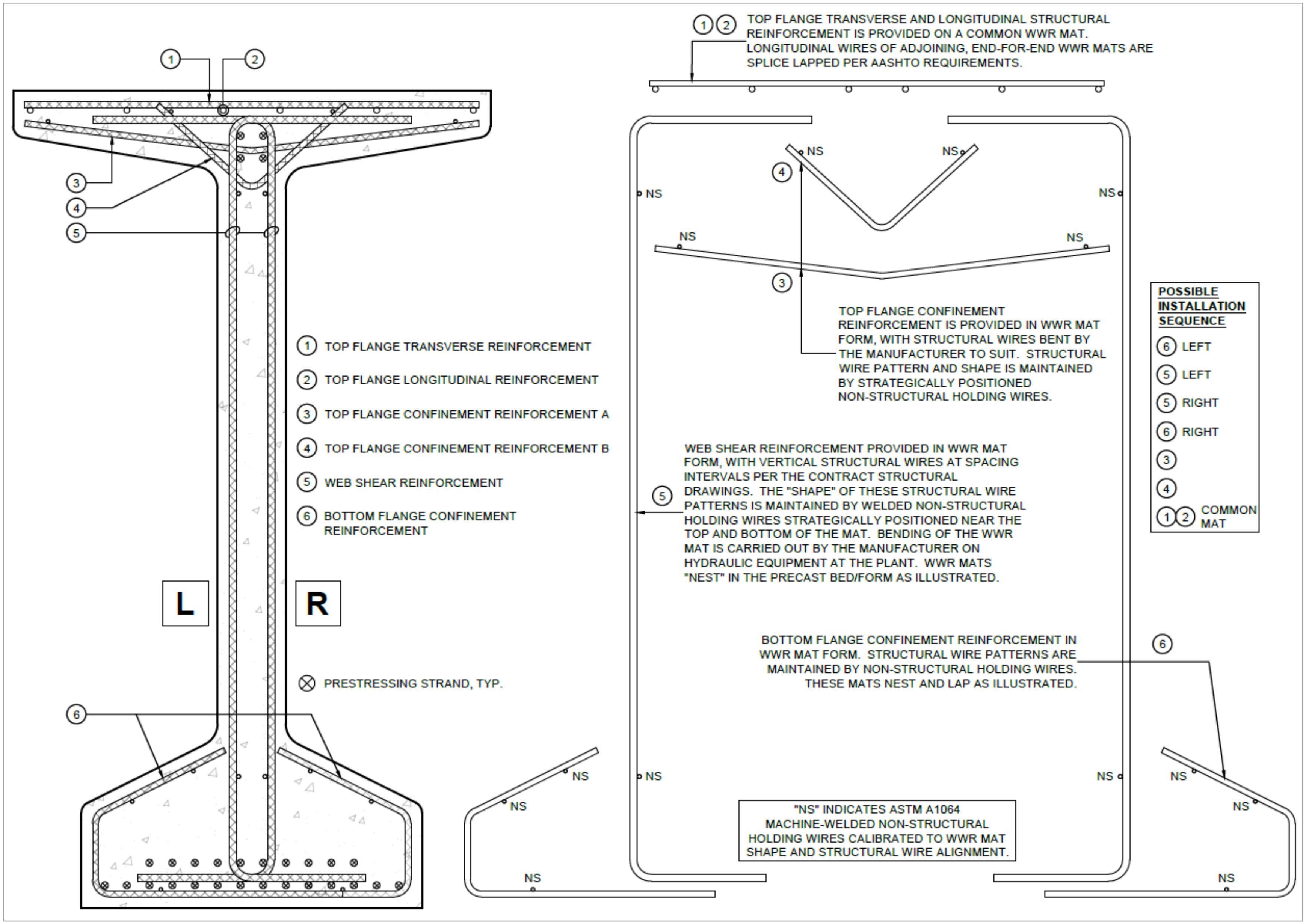
Welded Wire Reinforcement Usage in Highway Bridge Girders

The use of welded wire reinforcement (WWR) in precast prestressed bridge girders are common across numerous state transportation agencies, supported by the fact that WWR features heavily in the AASHTO LRFD Bridge Design Specifications as an accepted structural reinforcement. Among a multitude of roadway-related uses, the precast prestressed bridge girder (beam) is perhaps one of the best illustrations of how well-suited WWR is for the design and construction of large precast structural elements.

State transportation departments incorporate WWR into standard bridge beam drawings and specifications either by direct, detailed illustration or by reference as a permitted substitution for the originally-detailed mild reinforcing bars. Where WWR is not directly referenced, the state agencies are generally agreeable to consideration of a WWR alternative provided there is communicated preference on the part of the precaster and designer alike.

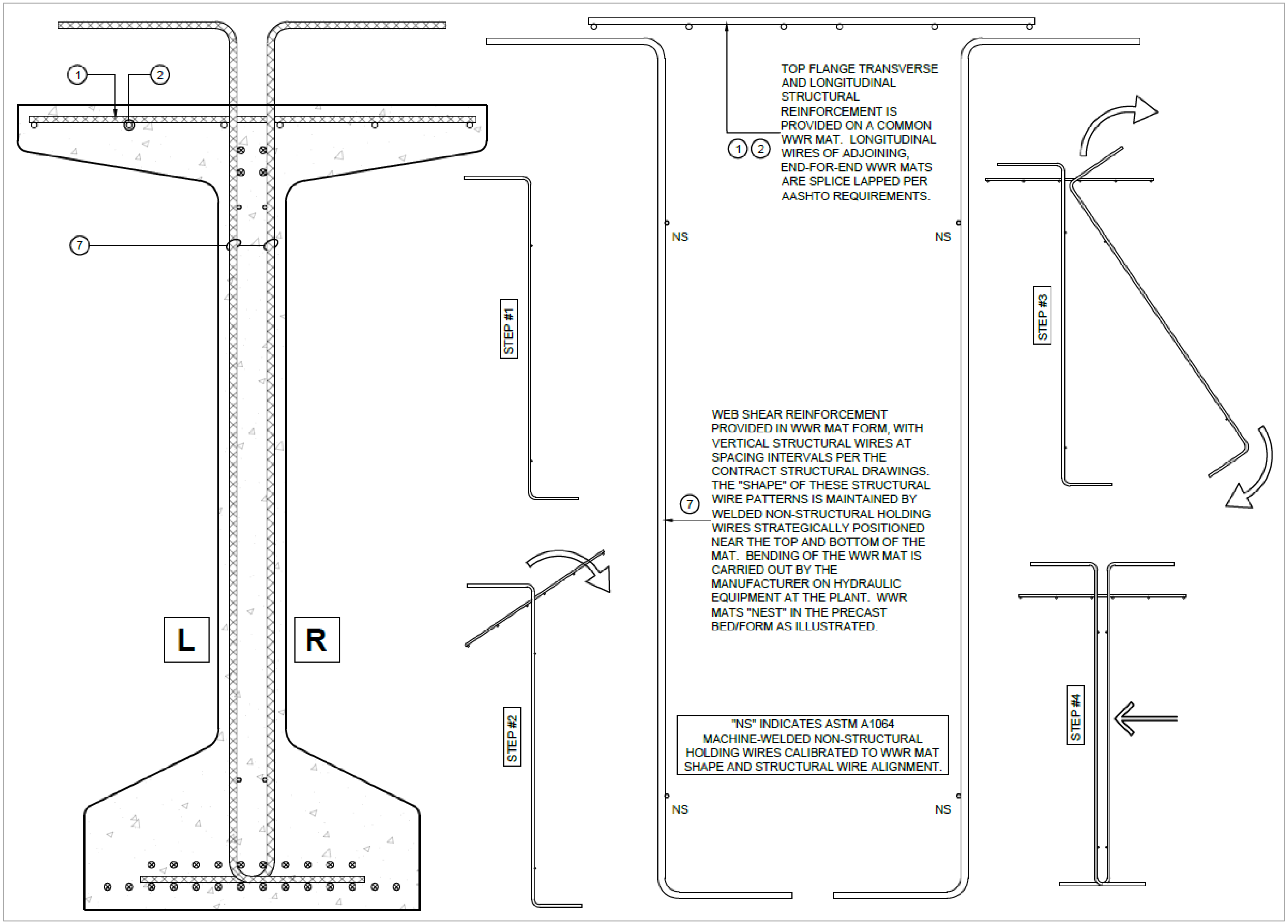
The benefit of utilizing WWR is really brought to bear on the precasting yard, where the time and labor required to install WWR mats is often a fraction of that required to install individual hand-ties reinforcing bars.

While all state transportation departments tend to approach the use of WWR differently, generally speaking, the material can be substituted for rebar in all components of the bridge girder: top flange, stem, and bottom flange.

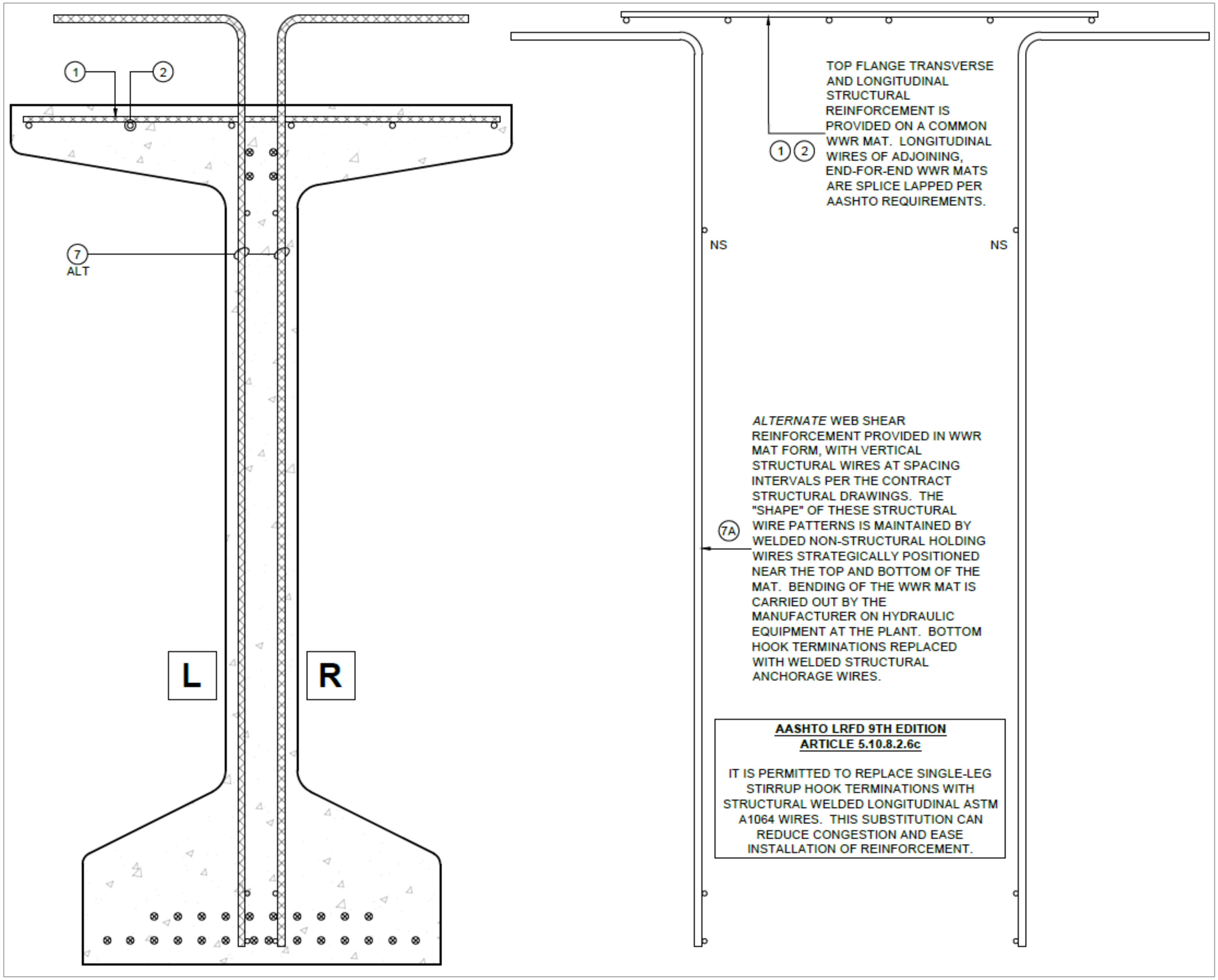


The diagrams shown in this blog are taken from the WRI's illustrative tool "Anatomy of a Bridge Girder", available for free download on the website.

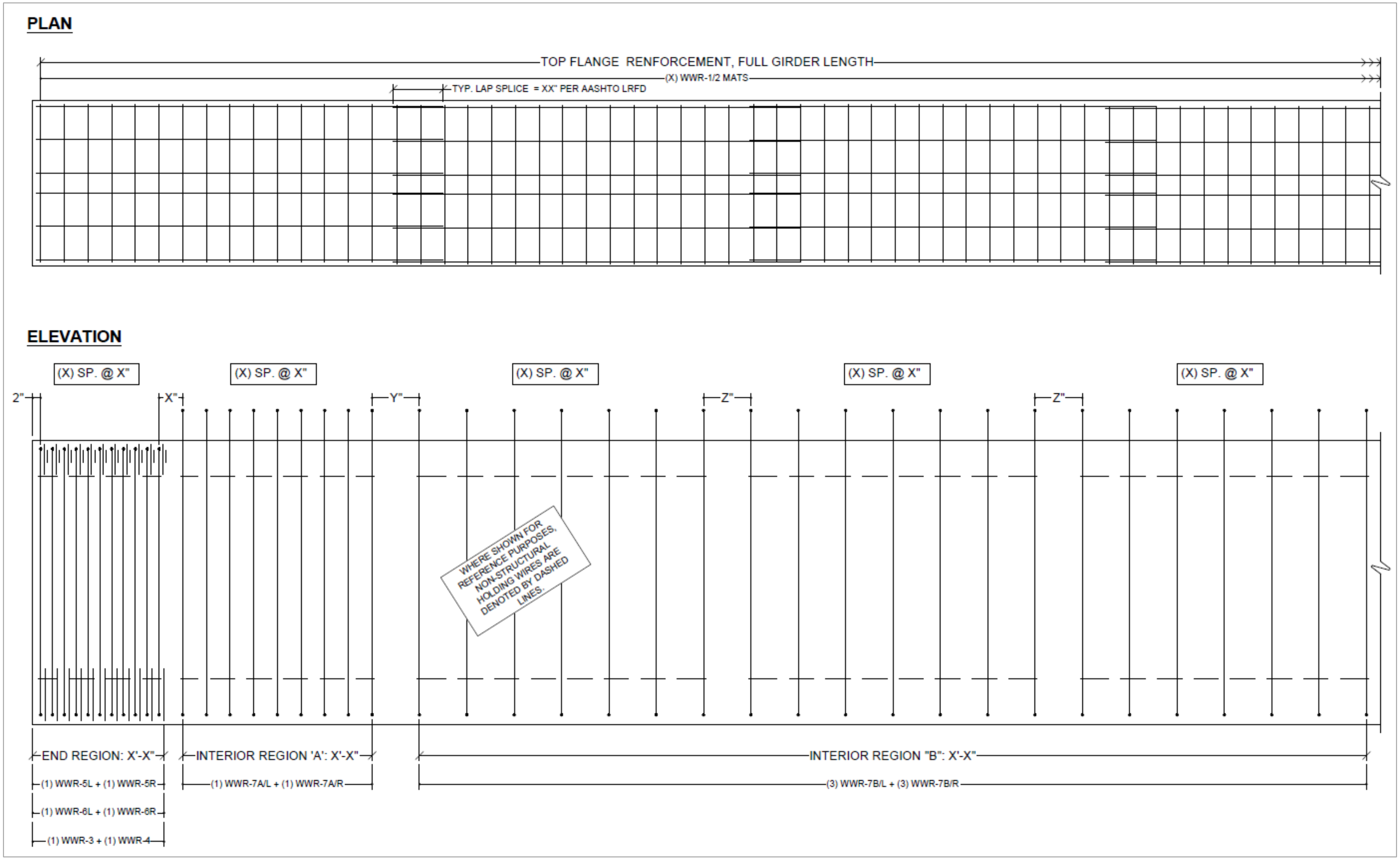
The illustrations above show the various reinforcement components that are commonly provided in the form of welded wire reinforcement mats, including top flange components, stem (web) reinforcement for shear resistance, and bottom flange components.



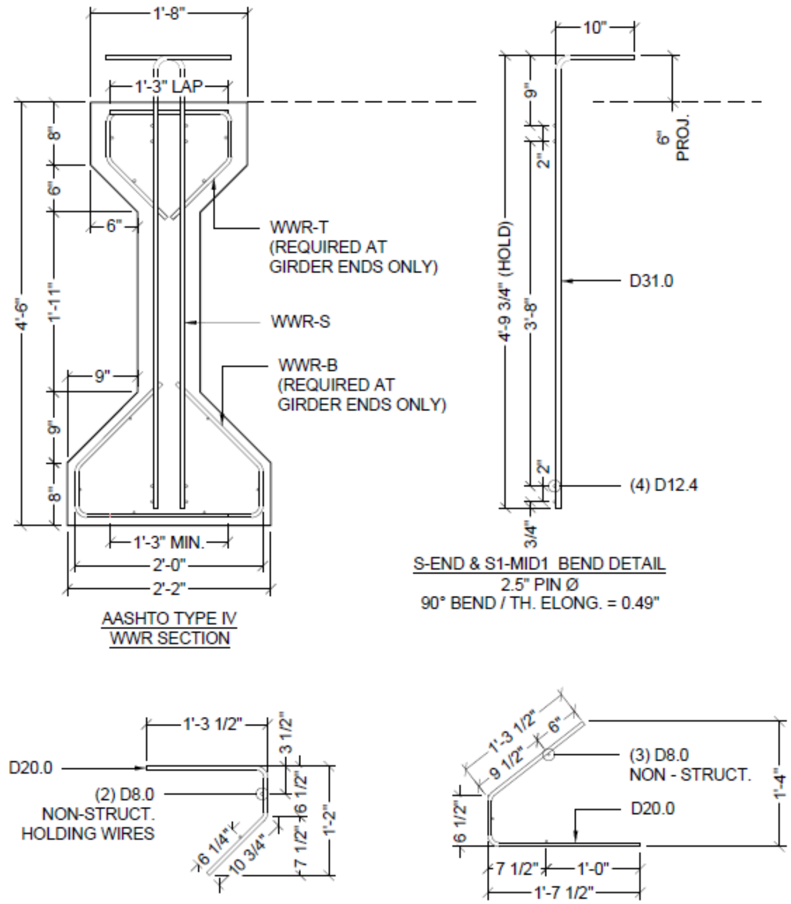
The diagram above shows a variation of the shear reinforcement mats shown to extend out of the top flange for future embedment into the cast-in-place concrete deck. A potential sequencing of mat installation is also provided. Note that both ends of the shear reinforcement mats terminate in standard 90-degree hooks.



An alternative to hooked terminations is the use of structural anchor wires, shown here at the bottom of the shear reinforcement mats and permitted in design as outlined in AASHTO LRFD Bridge Design Specifications Article 5.10.8.2.6c. The elimination of hooked terminations frees up space in the girder form, in turn simplifying and expediting the placement of other elements. While the anchor wire termination is shown here in the flange, bottom flange, similar curtailment has been used in the top flanges of bridge giders with successful results.



The illustrations above are example views of plan and elevation layouts of WWR mats in the top flange stem, and bottom flange. Note how a series of WWR mats is used to achieve the designer's specified distribution of reinforcement. These plan and elevation views would be accompanied by section views wherein the specific geometry of the individual WWR mats themselves is presented to the reviewer. With section, plan, and elevation views combined, a complete and highly-detailed picture of the WWR is provided to precasters, contractors, engineers of record, and transportation agencies in a manner that is highly intuitive and easily reviewable.



AASHTO TYPE IV
WWR SECTION

S-END & S1-MID1 BEND DETAIL
2.5" PIN Ø
90° BEND / TH. ELONG. = 0.49"

WWR-T BEND DETAIL
2" PIN Ø (TYP)
TH. ELONG. = 0.40" (90° BEND)
TH. ELONG. = 0.20" (45° BEND)

WWR-B BEND DETAIL
2" PIN Ø (TYP)
TH. ELONG. = 0.40" (90° BEND)
TH. ELONG. = 0.23" (52° BEND)

SUMMARY OF WELDED WIRE REINFORCEMENT:

S-END(L):	V1xV2	D12.4xD31.0	48"(+0.75",+17.75")	x	7'-2"(1",1")	2/BEAM = 36
S-END(R):	V1xV3	D12.4xD31.0	48"(+0.75",+17.75")	x	7'-2"(1",1")	2/BEAM = 36
S-MID:	V1x21	D12.4xD31.0	48"(+0.75",+17.75")	x	19'-5"(1",1")	SEE TABLE = 142
B1-LEFT:	V4xV5	D8.0xD20.0	22"(+6",+12")	x	6'-6"(1",1")	2/BEAM = 36
B1-RIGTH:	V4xV6	D8.0xD20.0	22"(+6",+12")	x	6'-6"(1",1")	2/BEAM = 36
B2-LEFT:	V4xV7	D8.0xD20.0	22"(+6",+12")	x	5'-8"(1",1")	2/BEAM = 18
B2-RIGTH:	V4xV8	D8.0xD20.0	22"(+6",+12")	x	5'-8"(1",1")	2/BEAM = 18
T1-LEFT:	7xV5	D8.0xD20.0	7"(+6.25",18")	x	6'-6"(1",1")	2/BEAM = 36
T1-RIGTH:	7xV6	D8.0xD20.0	7"(+6.25",18")	x	6'-6"(1",1")	2/BEAM = 36
T2-LEFT:	7xV7	D8.0xD20.0	7"(+6.25",18")	x	5'-8"(1",1")	2/BEAM = 18
T2-RIGTH:	7xV8	D8.0xD20.0	7"(+6.25",18")	x	5'-8"(1",1")	2/BEAM = 18

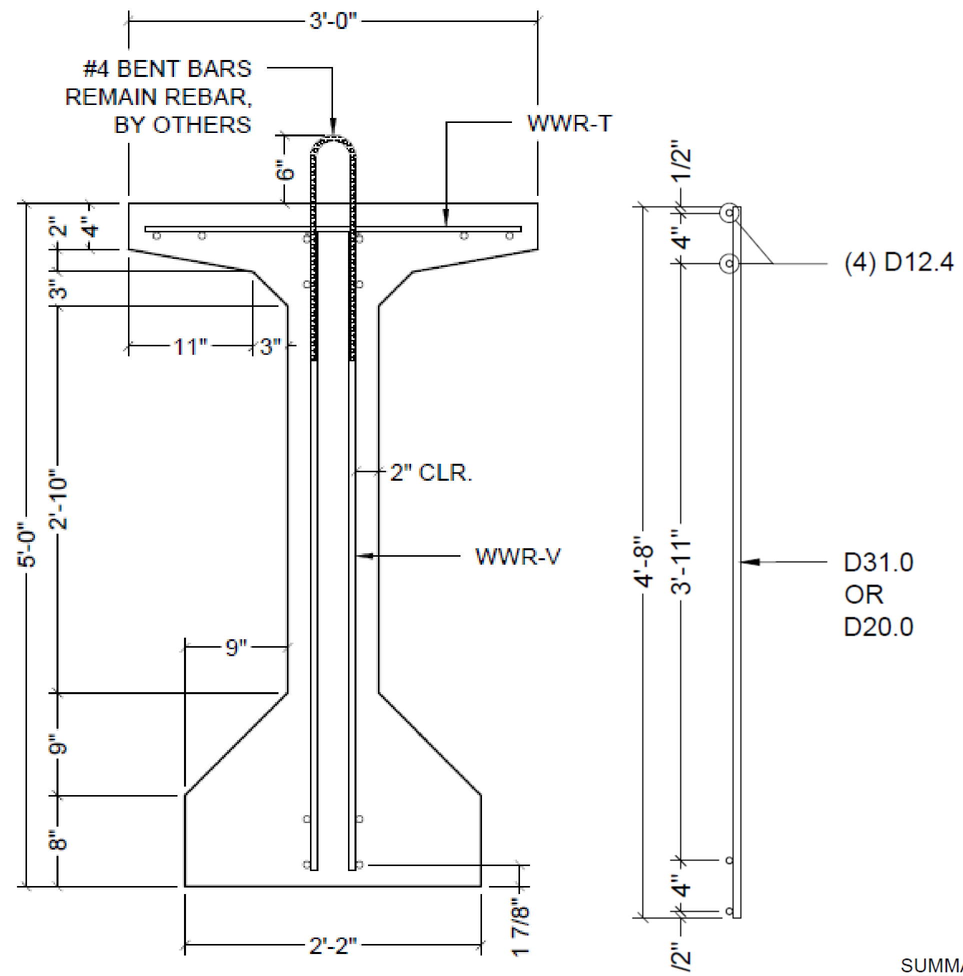
V1 = 0.75"oh - 2" - 44" - 2" - 17.75"oh
V2 = 1"oh - 12" - 4@18" - 1"oh
V3 = 1"oh - 4@18" - 12" - 1"oh
V4 = 6"oh - 12" - 10" - 12"oh
V5 = 1"oh - 4" - 12@6" - 1"oh
V6 = 1"oh - 12@6" - 4" - 1"oh
V7 = 1"oh - 3@6" - 6@8" - 1"oh
V8 = 1"oh - 6@8" - 3@6" - 1"oh

BEAM ID	# Sp. @ 21"	# S2-MID MATS
A1	18	8
A2	19	8
A3	19	8
A4	20	8
A5	21	8
A6	22	8
B1	18	8
B2	19	8
B3	20	8
B4	21	8
B5	21	8
B6	22	8
C1	17	6
C2	18	8
C3	19	8
C4	20	8
C5	22	8
C6	23	8

The illustrations above are excerpts from a bridge beam project completed by a WRI producer member. These illustrations show the section/mat view of the WWR solution. Typically, the WWR detailer will reproduce the actual bridge beam cross-sectional shape and show it populated with the accompanying WWR mat reinforcements in order to give a review of the spatial frame of reference for WWR within the section. With the beam section provided as a reference point, individual dimensioned mat diagrams are furnished that show WWR composition (wire size, spacing, outside dimensioning, and bend characteristics). As an accompaniment to the WWR mat diagrams, a summary list of the WWR mat “styles” is provided, along with project-specific quantities of each mat style. All of this information is important to the reviewer in order to assess general conformance with the design intent and constructability, but it is equally important for the in-house plant personnel responsible for fabricating the material.

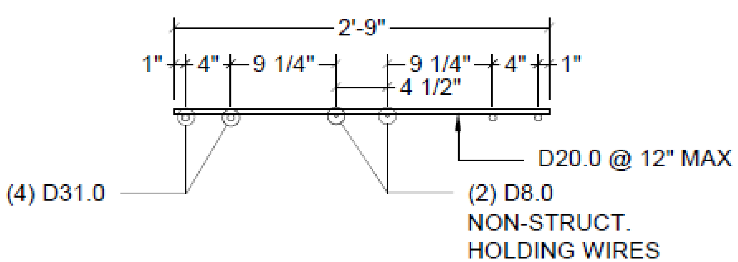
Like the previous illustrations, here we have another WRI producer member project with similar formatting. A beam cross-sectional view is shown along with the individual WWR mat geometries, styles, and quantities.

Notice how on this project, however, because epoxy-coated reinforcement was required at the beam ends to extend from inside the bridge beam up to the space above the beam in which cast-in-place deck concrete is to be poured, individual reinforcing bars are implemented as supplemental reinforcement. While WWR mats are very commonly epoxy-coated, it is extremely rare for reinforcement pieces only to be partially coated. In this case, because only the projecting reinforcement element requires epoxy coating, the primary stem WWR remains uncoated and simply laps with epoxy-coated rebar “hairpins”. This solution maintains the time and labor savings of WWR without compromising the corrosion-resistant performance expected in the end regions of the beam’s top flange projecting reinforcement.



TYPICAL WWR SECTION

WWR-V DETAIL

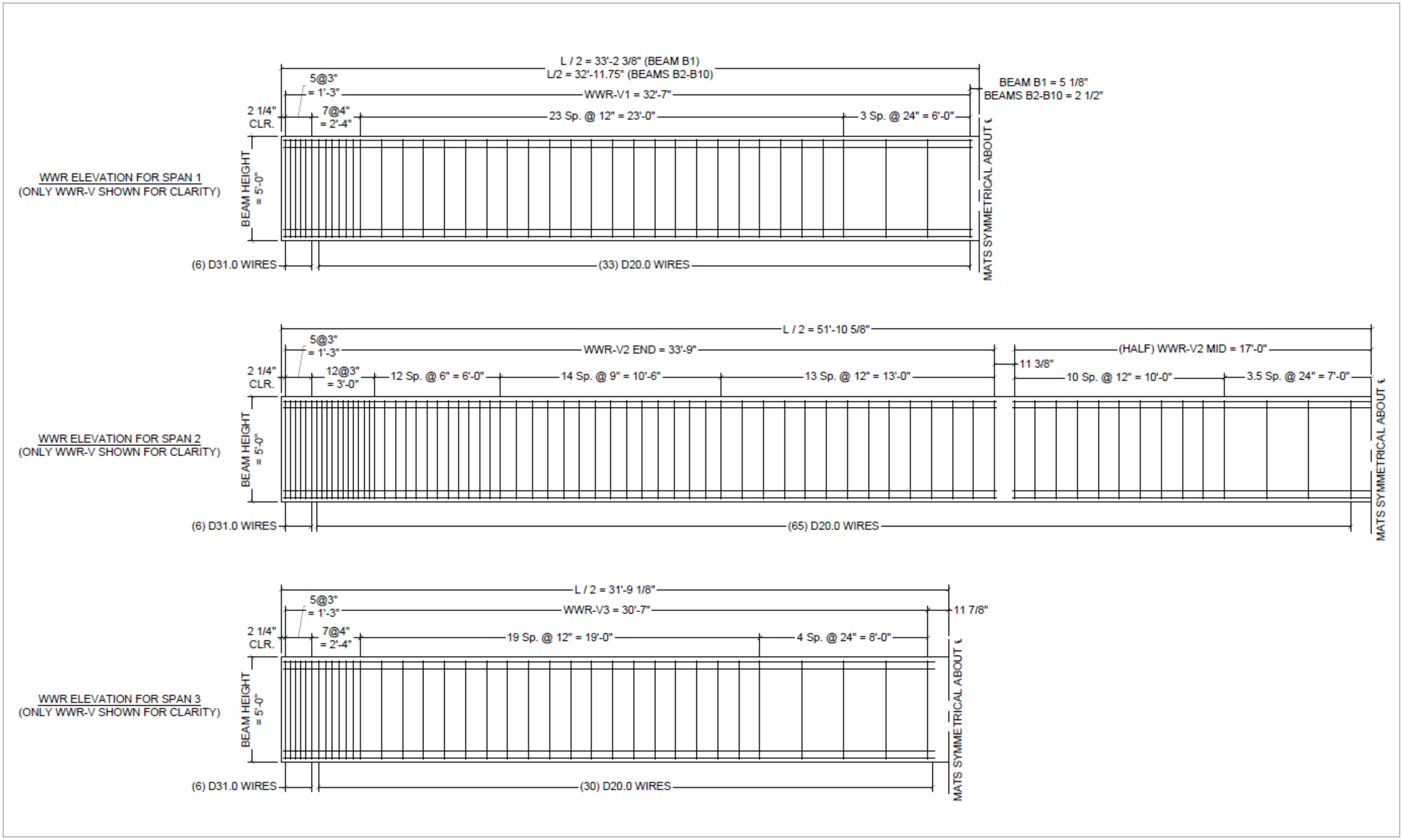


WWR-T DETAIL

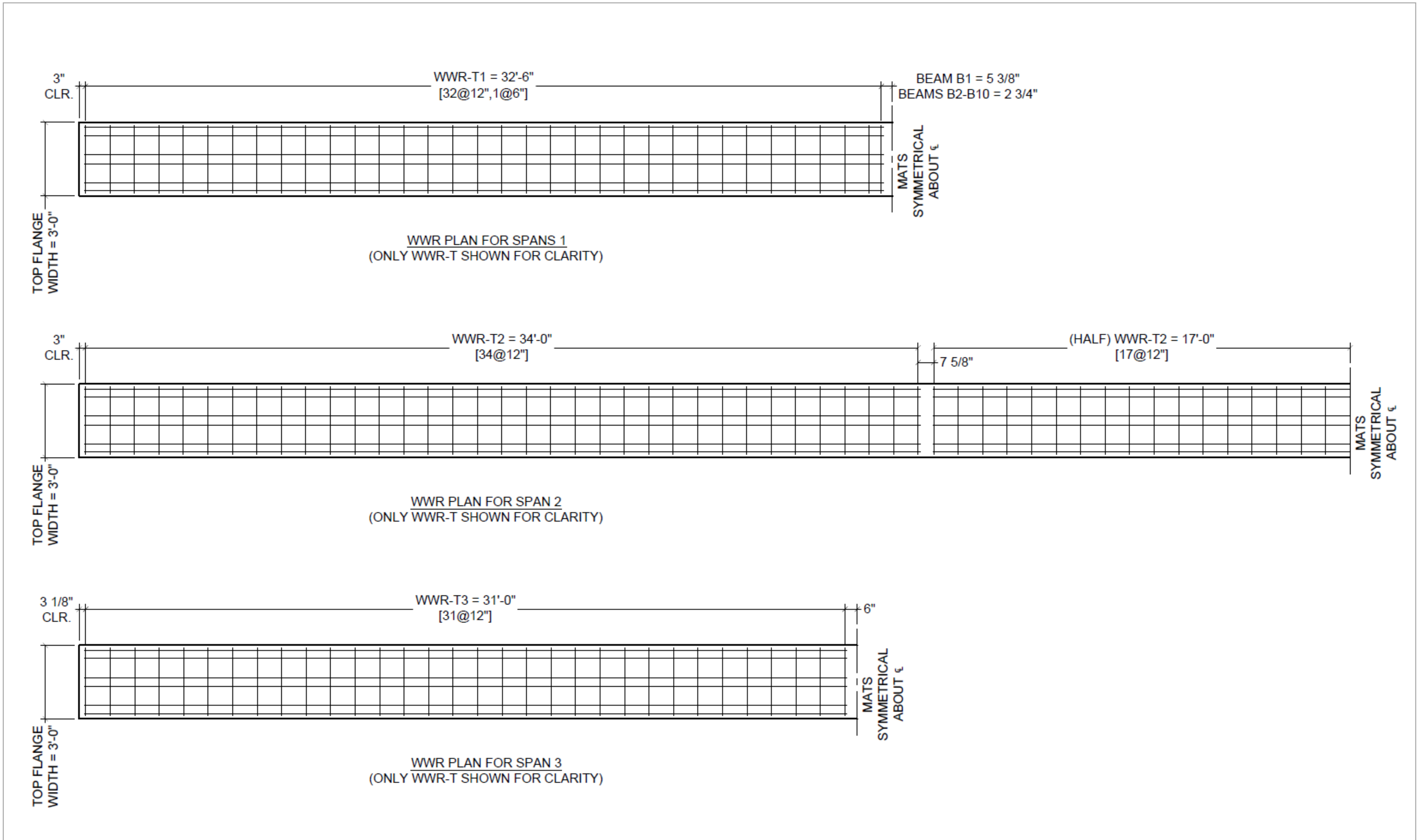
SUMMARY OF WELDED WIRE REINFORCEMENT:

WWR-V1:	V1xV2	D12.4xD31.0/D20.0	55"(+0.5",+0.5")	x	32'-9"(1",1")	4/BEAM = 40 REQ'D
WWR-V2 END:	V1xV3	D12.4xD31.0/D20.0	55"(+0.5",+0.5")	x	33'-11"(1",1")	4/BEAM = 40 REQ'D
WWR-V2 MID:	V1xV4	D12.4xD20.0	55"(+0.5",+0.5")	x	34'-2"(1",1")	2/BEAM = 20 REQ'D
WWR-V3:	V1xV5	D12.4xD31.0/D20.0	55"(+0.5",+0.5")	x	30'-9"(1",1")	4/BEAM = 40 REQ'D
WWR-T1:	V6xV7	D31.0/D8.0xD20.0	31"(+1",+1")	x	32'-8"(1",1")	2/BEAM = 20 REQ'D
WWR-T2:	V6x12	D31.0/D8.0xD20.0	31"(+1",+1")	x	34'-2"(1",1")	3/BEAM = 30 REQ'D
WWR-T3:	V6x12	D31.0/D8.0xD20.0	31"(+1",+1")	x	31'-2"(1",1")	2/BEAM = 20 REQ'D

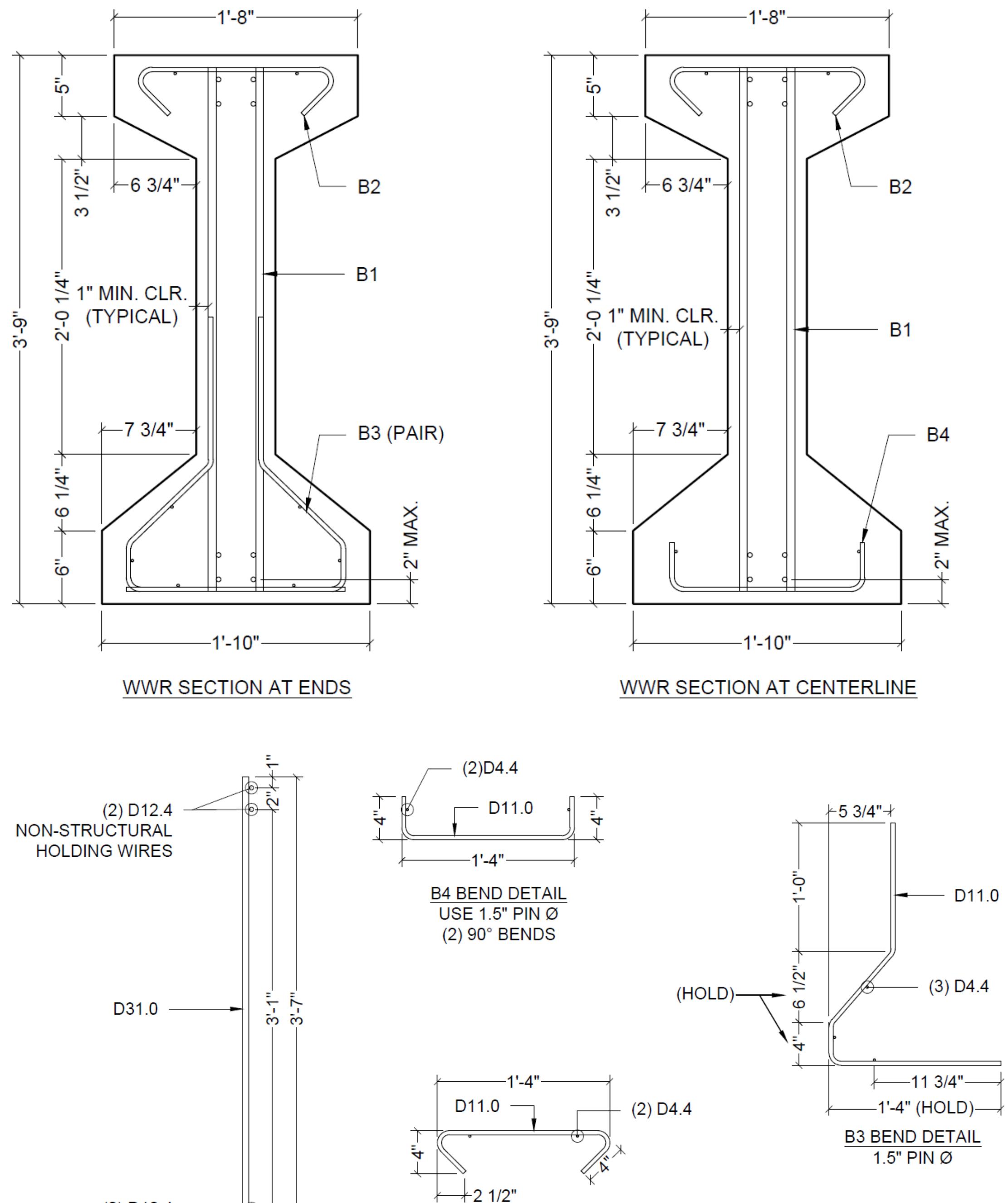
V1 = 0.5"oh - 4" - 47" - 4" - 0.5"oh
V2 = 1"oh(D31) - 5@3"(D31) - 7@4"(D20) - 23@12"(D20) - 3@24"(D20) - 1"oh
V3 = 1"oh(D31) - 5@3"(D31) - 12@3"(D20) - 12@6"(D20) - 14@9"(D20) - 13@12"(D20) - 1"oh
V4 = 1"oh - 10@12" - 7@24" - 10@12" - 1"oh
V5 = 1"oh(D31) - 5@3"(D31) - 7@4"(D20) - 19@12"(D20) - 4@24"(D20) - 1"oh
V6 = 1"oh(D31) - 4"(D31) - 9.25"(D8) - 4.5"(D8) - 9.25"(D31) - 4"(D31) - 1"oh
V7 = 1"oh - 32@12" - 6" - 1"oh



Shown above are the elevation view accompaniments to the beam reinforcement shown on page 7. Notice the high level of dimensional detailing and annotations indicating extents of the particular WWR mat placements within the beam stem.


3"
CLR.
WWR-T1 = 32'-6"
[32@12",1@6"]
BEAM B1 = 5 3/8"
BEAMS B2-B10 = 2 3/4"
MATS SYMMETRICAL ABOUT ℄
TOP FLANGE WIDTH = 3'-0"
WWR PLAN FOR SPANS 1
(ONLY WWR-T SHOWN FOR CLARITY)
3"
CLR.
WWR-T2 = 34'-0"
[34@12"]
7 5/8"
(HALF) WWR-T2 = 17'-0"
[17@12"]
MATS SYMMETRICAL ABOUT ℄
TOP FLANGE WIDTH = 3'-0"
WWR PLAN FOR SPAN 2
(ONLY WWR-T SHOWN FOR CLARITY)
3 1/8"
CLR.
WWR-T3 = 31'-0"
[31@12"]
6"
MATS SYMMETRICAL ABOUT ℄
TOP FLANGE WIDTH = 3'-0"
WWR PLAN FOR SPAN 3
(ONLY WWR-T SHOWN FOR CLARITY)

Shown above are the plan view accompaniments to the beam reinforcement shown on page 7. Notice the high level of dimensional detailing and annotations indicating extents of the particular WWR mat placements within the beam top flange.



SUMMARY OF WELDED WIRE REINFORCEMENT:

B1 END/MID1: V1xV2 D12.4xD31.0 41"(+1",+1") x 13'-0"(1",1") 72 REQ'D
B1 MID2: V1x18 D12.4xD31.0 41"(+1",+1") x 15'-2"(1",1") 72 REQ'D

B2 END/MID1: 10xV2 D4.4xD11.0 10"(+7",+7") x 13'-0"(1",1") 36 REQ'D
B2 MID2: 10x18 D4.4xD11.0 10"(+7",+7") x 15'-2"(1",1") 36 REQ'D

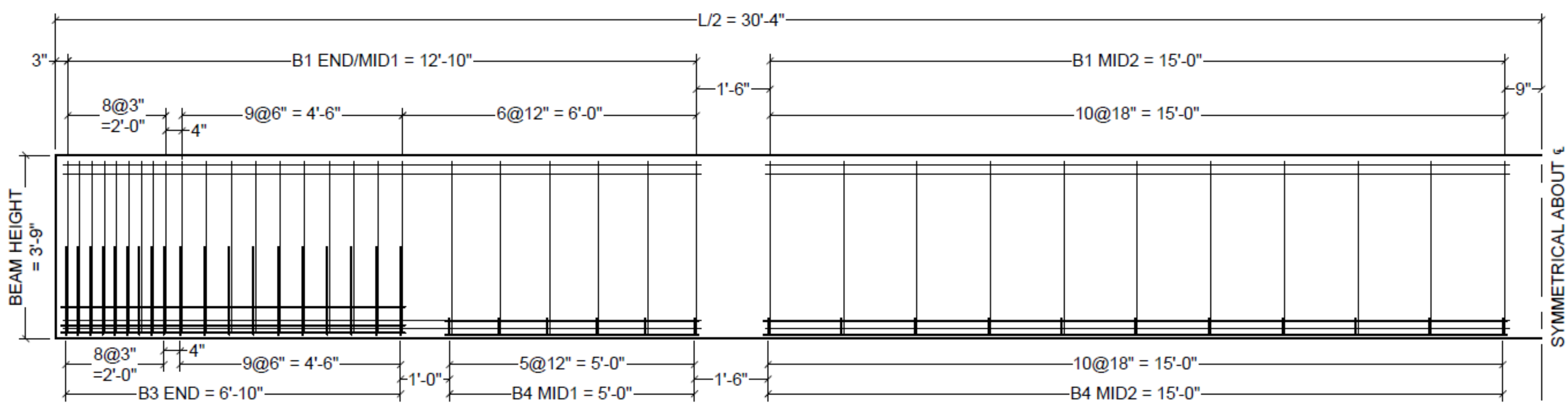
B3 END-L: 6xV3 D4.4xD11.0 12"(+16",+11.75") x 7'-0"(1",1") 36 REQ'D
B3 END-R: 6xV4 D4.4xD11.0 12"(+16",+11.75") x 7'-0"(1",1") 36 REQ'D

B4 MID1: 20x12 D4.4xD11.0 20"(+1.25",+1.25") x 5'-2"(1",1") 36 REQ'D
B4 MID2: 20x18 D4.4xD11.0 20"(+1.25",+1.25") x 15'-2"(1",1") 36 REQ'D

V1 = 1"oh - 2" - 37" - 2" - 1"oh
V2 = 1"oh - 8@3" - 4" - 9@6" - 6@12" - 1"oh
V3 = 1"oh - 8@3" - 4" - 9@6" - 1"oh
V4 = 1"oh - 9@6" - 4" - 8@3" - 1"oh

Another beam project is illustrated here with the characteristic beam view, WWR mat view, and WWR mat style summaries presented for the reviewer.

Observe how for these beam sections (not unlike those presented previously on page 7) the stem reinforcement relies entirely on structural anchor wires positioned at each end of the mat. These anchor wire replace hooked curtailments and are used to ensure that the vertical wires in the beam stem are properly developed / anchored to resist shear within the stem, which would typically manifest in the form of diagonal shear cracking. In effect, the vertical wires are the “stitches” that bridge across a region that would otherwise be susceptible to diagonal shear cracking, and the anchor wires located in the beam flanges are the elements preventing the stitches from slipping.



TYPICAL WWR ELEVATION
(B2 WIRES SPACED WITH B1;
NOT SHOWN FOR CLARITY)

Shown above is the elevation view accompaniment to the beam reinforcement shown on page 10. Notice that all WWR mats (B1, B2, B3, and B4) have been clearly identified in the elevation view, making for a simplified submittal-checking process and accelerated placement operation on the precasting yard.

The photographs that follow provide insight into the sequence of WWR installation for a typical precast-prestressed bridge beam.

STEP 1

One half of the bottom flange WWR mats are placed, allowing for the subsequent general placement of the prestressing strands therein.

STEP 2

With the prestressing strands in place, the balance of the bottom flange WWR mats are installed.

STEP 3

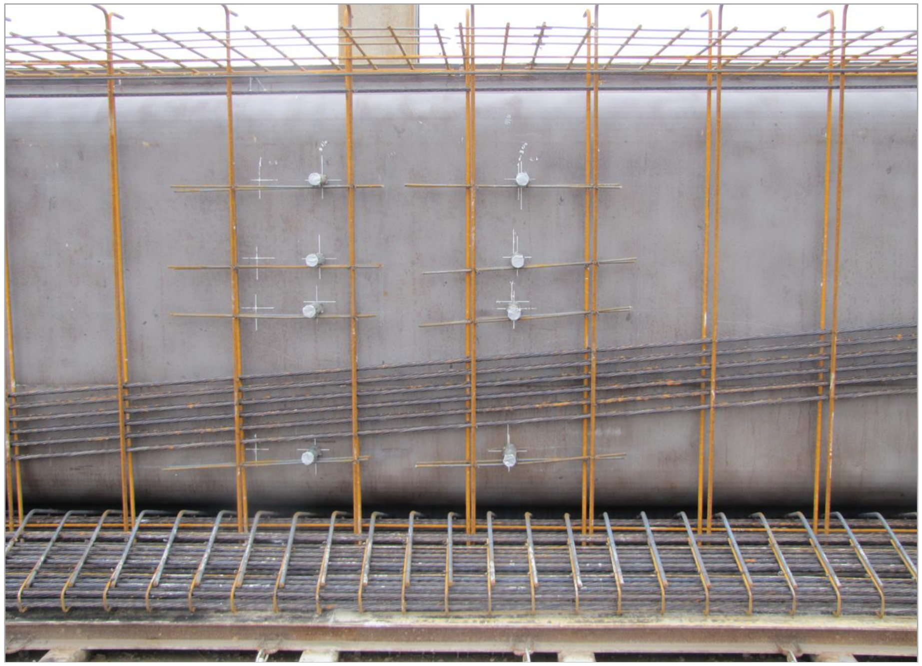
With the prestressing strands extended the length of the casting bed and the bottom flange WWR mat installation completed, WWR stem mats are “staged” at the top of the casting bed for subsequent placement.

STEP 4

Stem mats are installed. For this bridge beam, it can be observed that the end region stem mats do not have hooked extensions.

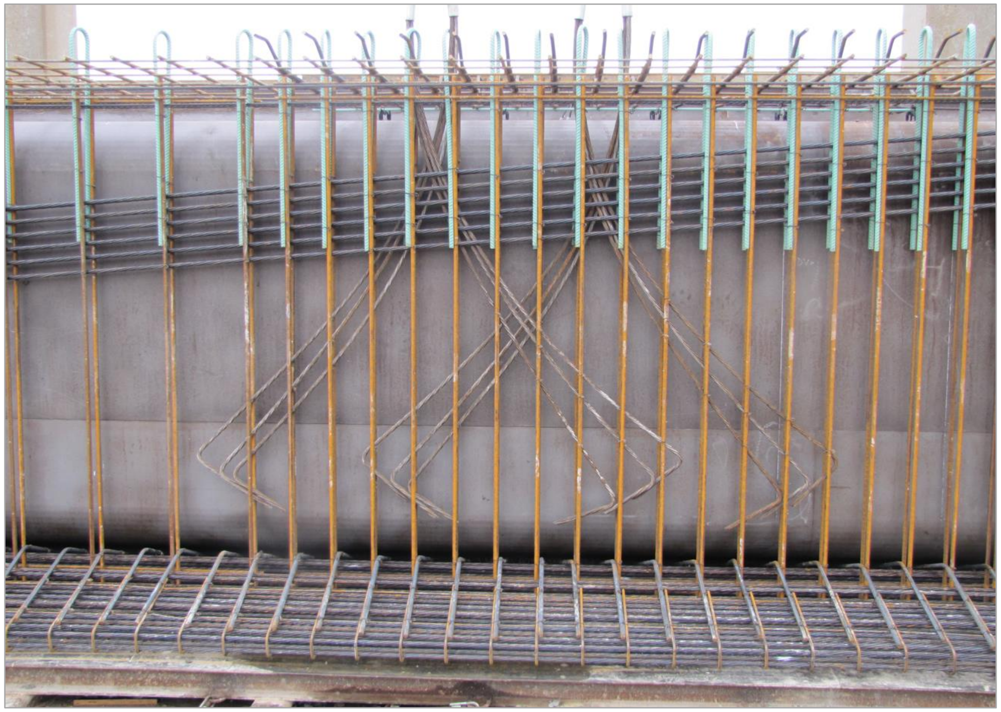
Note that the stem will receive two "curtains" of WWR mats, one curtain position in each face of the stem. In this stem, the first curtain is being placed.

A close-up view of placement of WWR stem mats



STEP 5a

Stem mat placement is completed, in turn allowing for the top flange mats to be positioned along the length of the casting bed. This photo shows interior region WWR stem mats, with hooked terminations that extend into the space above the beam top flange (but DO NOT require an epoxy coating). Also note that the prestressing strands have been aligned with the necessary deviation achieve their intended “design” profile.



STEP 5b

Stem mat placement is completed, in turn, allowing for the top flange mats to be positioned along the length of the casting bed. This photo shows end region WWR stem mats that do not extend above the beam top flange. Projecting supplemental rebar elements can be observed in the end region of the beam.

Also, note the design profile of the prestressing strand group as well as the installed lifting assemblies to be cast into the beam.

Completed installation of the WWR mats

The use of WWR mats as reinforcement in highway bridge girders is accepted by a multitude of state transportation agencies and provides a simplified and expedited solution for precasters seeking to maximize efficiency while conforming to the structural design intent.

For more information, visit www.wirereinforcementinstitute.org.

References:

1. "LRFD Bridge Design Specifications, 9th Edition", American Association of State Highway Transportation Officials, Washington, DC, 2020.