Welded Wire Reinforcement: A Primer for the Bridge Designer, Part 2

by Paul Aubee, Artisan Structural PLLC

In part 1 of this two-part series, published in the Winter 2022 issue of *ASPIRE®*, we discussed welded wire reinforcement (WWR) manufacture, material characteristics and benefits, design compatibility, and use in bridge elements. This article shifts the focus to the implementation of WWR in contract drawings and the critical role played by the manufacturer's WWR detailing staff in preparing shop and placement submittals for engineer and contractor reviews.

Specification Options

The extent to which WWR is included as a structural reinforcement option in bridge elements is a function of state agency acceptance. Just as each state's department of transportation (DOT) establishes and maintains its own unique set of roadway and bridge design and detailing standards, the degree to which WWR is included in those standards varies as well.

Generally speaking, for bridge girders, WWR is largely used as steel reinforcement in the form of vertical stem, top flange, and bottom flange confinement applications. The inclusion of WWR in the American Association of State Highway and Transportation Officials' bridge design and construction specifications[1,2] as mild steel reinforcement for use in flexural, shear, torsional, and axial sectional strength calculations will generally be enough to allow a state to authorize use of the material.

With state acceptance, the use of WWR is typically deployed by one of two methods. The first and perhaps most common approach is for the DOT's standard drawings or specifications to allow WWR as a preapproved substitution for reinforcing bars that are typically detailed as the "default solution." Example language could be, "WWR may be substituted for reinforcing bars." In some cases, such as with the Texas DOT,[3] the area of WWR for some bars may be reduced in proportion to the increase in reinforcement yield strength over 60 ksi. However, WWR yield strength is limited to 75 ksi in the AASHTO specifications. Different states may have different limits.

When the state's standard specifications or drawings allow WWR as a preapproved substitution, both the designer and the contractor have the latitude to use WWR on a case-by-case basis to suit project-specific design challenges and site and schedule logistics, without altering the basic reinforcing bar detailing. A key attribute of this solution is that the WWR manufacturer is afforded the flexibility of using combinations of welded wire size and spacing (and sometimes strength) that are acceptable as long as a structurally equivalent design is achieved, considering the cross-sectional area and, when allowed, the increased yield strength of the wire reinforcement.

The second approach is for WWR to be directly specified in the standard drawing, with explicit details showing the required WWR size, spacing, and geometry. This is the approach used by the Florida DOT,[4] which typically has two sheets showing standard reinforcement details for each girder size. One sheet presents reinforcing bar details and the second has the alternate WWR details. Similar to the previously mentioned preapproved substitution method, the direct specification method uses WWR as an alternative to the default reinforcing bar arrangement. The difference between this approach and the preapproved substitution method is that the alternate standard detail approach is less flexible because the wire size, spacing, and positioning are specified in the alternate girder details.

It is worth noting that some state DOTs may not use either of the aforementioned acceptance methods, and will instead present standard details with no reference to WWR usage. In these situations, the designer can initiate communication with the state agency to seek a project-specific (or application-specific) approval. The material's acceptance throughout AASHTO standards would be the most obvious basis for such a request, but the argument for WWR usage can be strengthened by presenting examples of previously completed projects in which WWR was successfully implemented. It is the author's experience that the strongest cases made are typically those in which the designer collaborates with both a contractor and manufacturer to present a holistic view of a proposed WWR option for a project. This is an upfront effort that can yield significant downstream benefit.

The Role of the WWR Manufacturer

Regardless of the method used by a state to incorporate WWR into its bridge design standards, the WWR manufacturer is tasked with producing a project-specific reinforcement submittal package that conforms to the state DOT's requirements while accurately capturing a specific project's material placement and quantity demands.

To be clear, WWR use in cast-in-place or precast concrete bridge girders is not a commodity pursuit. There is no construction material distributor in the supply chain, which is different than some building applications where standard rectangular WWR mats may be specified.

Manufacturers employ technical staffs who are tasked with generating submittal packages for project-specific WWR use. These technical staff members have the appropriate level of familiarity with the governing design and detailing standards, and they are able to generate WWR information that aligns with the manufacturer's own production capabilities. To that end, each WWR submittal contains WWR mat geometries, quantities, and placement requirements specific to a given project.

The manufacturer's detailing effort will vary depending on the method by which WWR is presented in the contract documents. If the state DOT allows WWR as a preapproved substitution, the WWR solution developed by the manufacturer might offer savings and efficiencies, as there is leeway to achieve the specifier's intended design by pulling from a broader range of wire size, spacing, and strength combinations. Deriving a reinforcement solution that satisfies the specifier's design intent and, at the same time, best leverages a manufacturer's inventory allocation and minimizes welding equipment changeover times is the real sweet spot for WWR. While direct specification is a viable and proven method for implementing WWR on bridge projects, the WWR as shown on the project drawings does not necessarily allow the manufacturer's detailer to select a solution favorable to in-house WWR fabrication capabilities. WWR manufacturers won't shy away from using what is explicitly specified in the plans, but there is some merit to a more general definition of reinforcement areas and spacing limits on design drawings to unlock some additional efficiency.

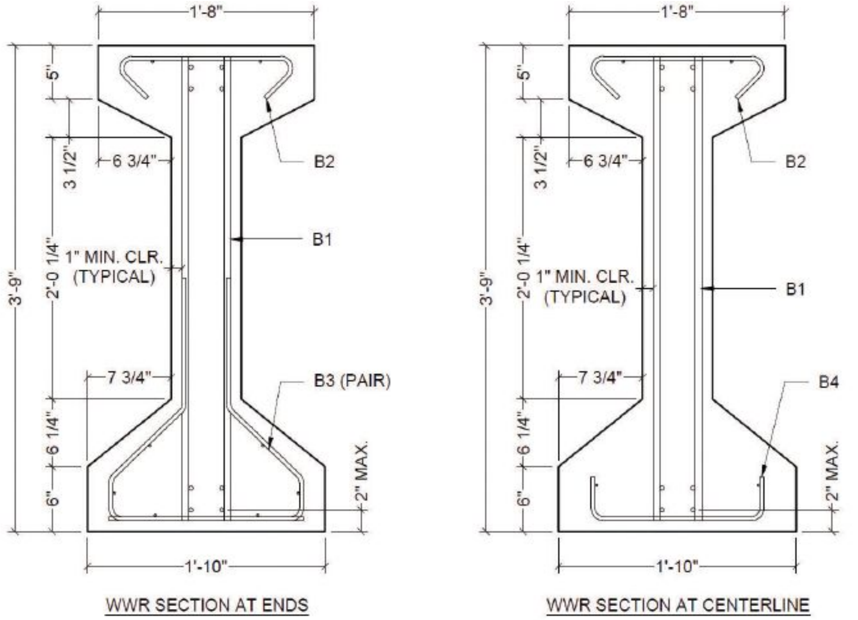

Figure 1. In a typical WWR submittal, there are two cross-section views—end and middle—for a given bridge girder. All Figures: The Wire Reinforcement Institute.

In the end, regardless of the method by which WWR is presented as an option on a bridge project, the Wire Reinforcement Institute's manufacturer members are staffed to produce detailed submittals that conform to the specifier's original design intent.

The Deliverable

A typical WWR submittal, which serves as the deliverable intended for the contractor's, girder producer's, and specifier's reviews and approvals, includes the following information:

- Beam section views—There are typically two cross-section views for a given bridge girder. The first view is cut through the end region of the beam, and the second view is cut through an intermediate or middle region of the beam. While these regions are often similar to each other when it comes to the reinforcement assembly that populates the beam cross section, the end sections are usually more heavily reinforced. Therefore, differences in configuration are best illustrated through separate cross-section views (**Fig. 1**).
- WWR mat diagrams—For the WWR mats that populate the aforementioned sections of the beam, diagrams are provided to show WWR sectional geometry, wire size, and bend arrangement, as applicable (**Fig. 2**).
- WWR mat summary—The mat summary outlines the WWR mat item description and quantity for the beam or beam project. The item description helps the reviewer spot-check sizes and spacings of the reinforcing wires, and it is critical for in-house use by the WWR manufacturer's workers on the plant floor who are tasked with actually producing the mats. The combination of item description and WWR mat diagram is mandatory for the production of WWR (**Fig. 3**).
- Beam elevation view—WWR mats shown in cross-section view and summarized in item descriptions with accompanying mat diagrams ultimately must be identified in an elevation view to show the girder producer the precise placement of mats in the forms or beds. Elevation views illustrate the distribution of mat types along the length of a given beam (**Fig. 4**).

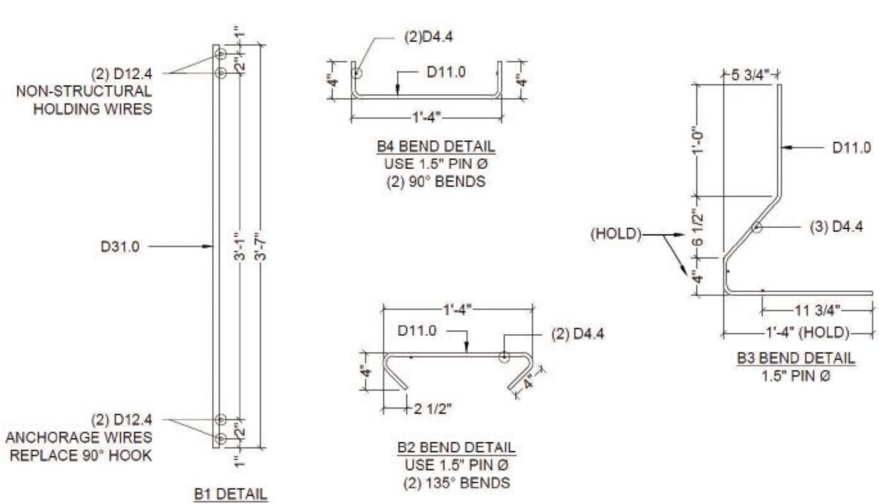

Figure 2. A mat diagram in a typical WWR submittal shows welded wire reinforcement sectional geometry, wire size, and bend arrangement.

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

Figure 3. The mat summary in a typical WWR submittal includes the welded wire reinforcement mat item descriptions and quantities for the beam or beam project.

- Manufacturer notes—The manufacturer will include a list of notes that is relevant to both the reviewing contractor and the specifier. These notes often reiterate the material's conformance with the AASHTO M 336M or ASTM A1064 standards for WWR,[5,6] describe the WWR material equivalency to the originally specified reinforcing bar (when applicable), and distinguish between the reinforcement items that were "converted" to WWR and those that remained in reinforcing bar form (**Fig. 5**).

Conclusion

To meet the increasing demand for construction efficiency in the face of skilled labor shortages, manufacturers continue to work alongside specifiers, contractors, and girder producers in an effort to derive WWR solutions tailor-made for concrete bridge applications. Both the specifier and manufacturer play central roles in the communication of WWR use in bridge beams and how that reinforcement is ultimately produced and placed to achieve a successful end result.

References

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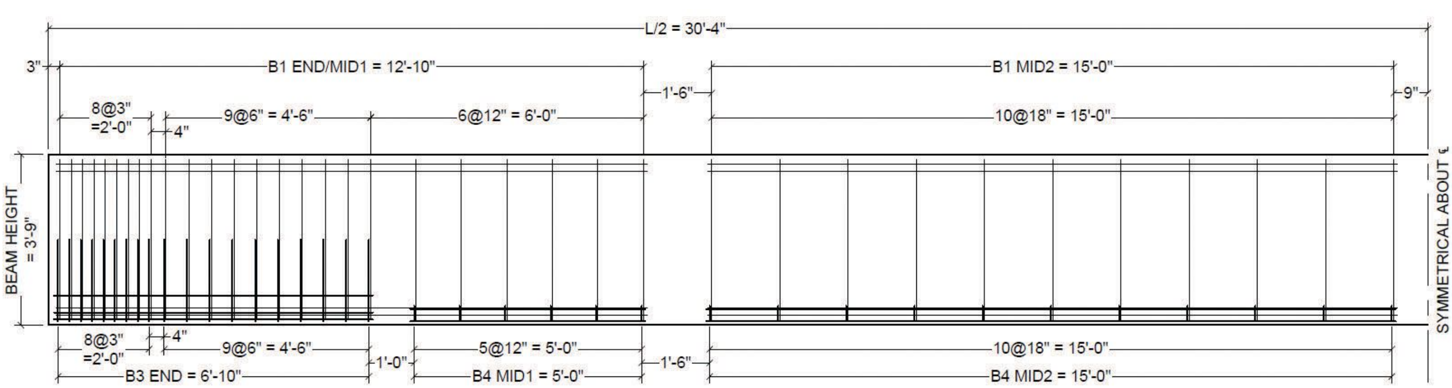

Figure 4. Beam elevation view in a typical WWR submittal showing the required placement of specified welded wire reinforcement mats.

NOTES:
- ALL MATERIAL CONFORMS TO ASTM A1064 FOR GRADE 70 DEFORMED WIRE.
- WELDED WIRE CONFIGURATIONS SHOWN ARE BASED ON EQUAL AREA CONVERSION FOR REBAR SHOWN IN DRAWINGS PROVIDED BY CUSTOMER.
- ONLY B1, B2, B3 AND B4 BARS WERE CONVERTED TO WELDED WIRE, ALL OTHER REINFORCEMENT REMAINS REBAR PROVIDED BY OTHERS.

Figure 5. The WWR manufacturer typically includes a list of notes that is relevant to both the reviewing contractor and the specifier.