Recommended Structural Construction Document Language for Welded Wire Reinforcement

For any modern construction project it is imperative that the contract documents upon which the construction is to be based are prepared with sufficiently thorough annotative and illustrative information, as it is these documents that ultimately guide the contractor's on-site building efforts.

A properly-conceived set of structural contract drawings typically contains a compilation of over-arching descriptive directives and guidelines known as "General Notes" that provide clarity to the contractor as it relates to the structural design intent. General Notes are the ground rules for the usage and implementation of various construction materials, assemblies, and procedures.

With this in mind, the Wire Reinforcement Institute recommends consideration of the following framework language for welded wire reinforcement (WWR) utilization in cast-in-place concrete building projects. While every design firm maintains its own set of standards, templates, and practice procedures, the content presented below serves as an example of language that is not only descriptive from a designer's perspective but also easily understood and actionable by the WWR detailing professionals ultimately tasked with generating WWR submittals that are intended to be in general conformance with the project design intent.

To provide color and context in this technical article, each individual General Note below (capitalized bold lettering) is accompanied by descriptive commentary (blue lettering).

1. **WELDED WIRE REINFORCEMENT SHALL CONFORM TO ASTM A1064 WITH A MAXIMUM YIELD STRENGTH (f_y) EQUAL TO 80,000 PSI.**

WRI Commentary:

The design professional of record is responsible for defining the benchmarks by which construction materials and products are measured. While a directive related to ASTM conformancy may seem like an obvious and innocuous statement, the absence of such a requirement for WWR to be produced in accordance with a broadly-accepted ASTM material specification will result in the possibility that welded reinforcement could be fabricated using unregulated and untraceable materials and methods.

The importance of WWR conformance with the ASTM A1064 specification cannot be overstated, as the specification establishes clear-cut requirements for the following production and certification attributes:

A. Product Terminology
B. Purchaser-defined ordering information
C. Minimum pre-weld and post-weld mechanical properties
D. Type and interval/frequency of testing, including sampling procedures
E. Dimensions and permissible geometric variations
F. Rules for rejection and re-test
G. Standard of certification
H. Standardized packaging and marking

It is noteworthy that all WRI producer members manufacture WWR in strict accordance with the ASTM A1064 specification.

2. DEFORMED WELDED WIRE REINFORCEMENT AND PLAIN WELDED WIRE REINFORCEMENT ARE PERMITTED FOR USE WHERE DIRECTLY SPECIFIED ON THE CONTRACT DOCUMENTS AND AS A MATERIAL SUBSTITUTION FOR SPECIFIED REINFORCING BARS (REBAR). WHERE WELDED WIRE REINFORCEMENT IS TO BE UTILIZED AS A SUBSTITUTION, ADDITIONAL REQUIREMENTS APPLY AS NOTED BELOW.

WRI Commentary:

The designer should provide clarification on the types of WWR being used in the specified design. Both deformed and plain WWR are readily available from manufacturers, though the former is significantly more common for structural usage in building applications.

Where the designer - in addition to directly specifying WWR – also allows for WWR as a substitution for rebar, this permission should be clearly stated so that the contractor and reinforcement detailer are made aware of potential additional WWR usages on the project beyond those for which WWR has already been directly specified. Naturally, when WWR is allowed as a substitution, the designer should provide guidance on the extent to which the substitution effort can take place. This guidance manifests in a brief sub-set (items A through E) of provisions like those shown below.

A. WWR EQUAL-AREA SUBSTITUTIONS: A WWR SUBSTITUTION IN WHICH THE ORIGINALLY SPECIFIED CROSS-SECTIONAL AREA OF REINFORCEMENT (A_s; A_s PER FOOT) IS MAINTAINED SHALL BE PERMITTED FOR ALL APPLICATIONS EXCEPT…

WRI Commentary:

Equal-area substitutions are perhaps the most intuitive form of rebar replacement, as the originally-specified rebar steel areas are simply superseded by the same steel areas in WWR form. The designer should clarify if there are any applications for which this type of substitution is not permitted, as this provides necessary guidance to the contractor and reinforcement detailer regarding the extent of the substitution.

B. WWR EQUAL-STRENGTH SUBSTITUTIONS: A WWR SUBSTITUTION IN WHICH THE ORIGINALLY SPECIFIED UNIT STRENGTH OF REINFORCEMENT (A_s x f_y; A_s x f_y PER FOOT) IS MAINTAINED SHALL BE PERMITTED FOR ALL APPLICATIONS EXCEPT…

WRI Commentary:

Equal-strength substitutions are an extremely popular form of rebar replacement, as there are considerable cost savings that arise when substituting a smaller cross-sectional area of high-strength WWR for a larger cross-sectional area of reinforcing bars in order to achieve design strengths identical to those associated with the original configuration.

In allowing an equal-strength substitution, the designer must clarify if there are applications for which this type of substitution is not permitted. This is especially important for structural usage in which the calculated magnitude of element deformation / deflection is increased due to the effect of a smaller cross-sectional area of steel.

C. SUBSTITUTED WWR WIRE SPACING SHALL NOT EXCEED ORIGINALLY-SPECIFIED SPACING FOR REBAR.

WRI Commentary:

Under no circumstances should a substituted WWR solution used in lieu of an originally-specified rebar configuration be characterized by wire spacing exceeding the original spacing of rebar, unless the designer has explicitly allowed for such an adjustment.

Reinforcement spacing is a function of several design considerations, not the least of which are code-prescribed maximum spacings that are embedded within design procedures that represent a certain type of expected concrete element behavior.

D. **SUBSTITUTED WWR SHALL BE CONFIGURED SO AS NOT TO REDUCE THE CLEAR COVER DIMENSION OR THE EFFECTIVE REINFORCEMENT DEPTH "d" ASSOCIATED WITH ORIGINALLY-SPECIFIED REBAR.**

WRI Commentary:

Similar to the previous substitution provision, it is important that reinforcement placement within the concrete cross-section not be altered, as this can result in a change to calculated structural capacities and expected durability.

E. **FOR BEAM AND SLAB LONGITUDINAL REINFORCEMENT, WWR SUBSTITUTED IN PLACE OF ORIGINALLY-SPECIFIED REBAR SHALL MAINTAIN THE HOOKED REBAR TERMINATION'S GEOMETRY.**

WRI Commentary:

While WWR is frequently used in beam U-stirrup applications reliant upon welded anchorage wires in lieu of hooked terminations (ACI 318-19 Section 25.7.1.4), there is no ACI provision that allows for WWR anchorage wires to be used as a flexural curtailment in lieu of hooks for longitudinal reinforcement in beams and slabs. As such, where WWR is permitted by the designer to be substituted for flexural reinforcement with hooked ends, these same hooked ends must be maintained on the WWR mats used in the replacement.

3. **WWR TENSION LAP SPLICE LENGTHS SHALL BE NOT LESS THAN THOSE VALUES SHOWN IN SCHEDULE XX-SX.XX**

WRI Commentary:

The designer should provide on the drawing set a schedule outlining minimum tension lap splice lengths, no different than what is done for rebar.

Worth noting is that if the designer is specifying deformed WWR, and is not relying on any contribution from welded wire intersections in the calculated reduction of tension development lengths and tension lap splice lengths, the same calculation routine used for loose deformed rebar is used to calculate these attributes for deformed WWR as well, and in turn, the same lap splice schedule that already exists for rebar could be used for WWR.

The derivation of WWR development lengths and lap splice lengths for use in populating a schedule is made considerably more convenient if one utilizes WRI's ACI 318 Lap Splice Calculator, a free web-based application found on its website:

https://wirereinforcementinstitute.org/technical-resources/calculators-and-tools/lap-splice-calculator

Finally, in the event that a WWR substitution is being made, the designer-of-record could potentially bypass the need for a WWR lap splice schedule altogether and instead rely on the WWR detailer's submittal package to provide the necessary calculations and information related to the derivation of the lap splice lengths.

4. THE USE OF ONE-WAY WWR MATS COMPRISED OF STRUCTURAL WIRES IN ONE DIRECTION HELD IN PLACE BY NON-STRUCTURAL "HOLDING WIRES" IN THE ORTHOGONAL DIRECTION IS PERMITTED. WWR DETAILER SHALL BE RESPONSIBLE FOR APPROPRIATE SIZE AND PATTERN OF HOLDING WIRES, AND SHALL CONFIGURE THE WWR MATS SUCH THAT HOLDING WIRES DO NOT CREATE INTERFERENCE WITH STRUCTURAL ELEMENTS AND OTHER ITEMS EMBEDDED IN CONCRETE. WHERE ONE-WAY MATS ARE UTILIZED IN BOTH PRIMARY REINFORCEMENT DIRECTIONS, THE MATS SHALL BE NESTED TO ENSURE THAT HOLDING WIRES DO NOT INTERFERE WITH THE INTENDED PLANE OF STRUCTURAL WIRES WITHIN THE MEMBER DEPTH.

WRI Commentary:

There are instances where the use of one-way (uni-directional) WWR mats is necessary to achieve complex reinforcement layouts and / or challenging layout geometries. A few examples of applications for which one-way mats are an appropriate solution are listed below:

- Two-way slab reinforcement with column strip and middle strip zones in both orthogonal directions, combined with a need to preclude lap splices from regions of high tensile stress.
- Spread footings with plan widths exceeding those widths that can commonly be achieved by WWR welding machines and/or conventional roadway transport.
- One-way post-tensioned elevated slabs in which a minimum area of bonded deformed longitudinal reinforcement must be provided in the direction parallel with the unbonded flexural tendons.

The proper use of very basic guidance language on contract documents will pave the way for smooth implementation of WWR into any project.

The WWR community, comprised of production, engineering, and detailing professionals, is well-versed in efficiently adapting the WWR structural product for use in cast-in-place concrete building applications. In addition to the project's contractors (and in turn the project's bottom-line), it is the WWR professional who most benefits from targeted WWR-related General Notes, as the notes help define the WWR playing field and allow for efficient and expedient derivation of project-specific WWR solutions.

For more information visit www.wirereinforcementinstitute.org.

References:

1. ACI Committee 318, "Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19)," American Concrete Institute, Farmington Hills, MI, 2019 (Reapproved 2022)

2. "Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete (ASTM A1064/A1064M-22)", ASTM International, West Conshohocken, PA, 2022.