4.1 General Requirements

Practicing engineers are likely familiar with the steps necessary to effectively communicate a design’s reinforcement needs in terms of deformed reinforcing bars (rebar) on their structural contract documents. Generally, the delivery of this information comes in the form of “typical” and “project-specific” content.

Information unchanged from one project to the next ("TYPICAL"): 

![Typical reinforcement details](image)

*Figure 4-1: Typical reinforcement details*
BAR LAP SCHEDULE

<table>
<thead>
<tr>
<th>BAR SIZE</th>
<th>CMU WALLS</th>
<th>CAST-IN-PLACE CONCRETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>#4</td>
<td>28”</td>
<td>24”</td>
</tr>
<tr>
<td>#5</td>
<td>36”</td>
<td>28”</td>
</tr>
<tr>
<td>#6</td>
<td>42”</td>
<td>36”</td>
</tr>
<tr>
<td>#8</td>
<td>52”</td>
<td>50”</td>
</tr>
</tbody>
</table>

NOTES:
1. LAP SPlice LENGTHS SHOWN FOR REINFORCED CMU WALLS SHALL BE USED FOR BOTH VERTICAL AND HORIZONTAL REINFORCEMENT.
2. LAP SPlice LENGTHS SHOWN FOR REINFORCED CONCRETE SHALL APPLY TO ALL REINFORCEMENT FOR CAST-IN-PLACE CONCRETE SLABS, WALLS, AND FOUNDATIONS.

Figure 4-2: Typical splice and reinforcement schedules

C. REINFORCING STEEL
1. REINFORCING STEEL SHALL CONFORM TO ASTM A615, GRADE 60. LAP 30 X BAR DIAMETERS AT THE SPLICES UNLESS OTHERWISE NOTED ON THE DRAWINGS OR IN THE PROJECT SPECIFICATIONS. LAP CONTINUOUS WALL FOOTING BARS INTO SPREAD FOOTINGS 24” MINIMUM.
2. ALL REINFORCING STEEL SHALL BE SECURELY TIED AND ANCHORED IN PLACE TO PREVENT DISLOCATION DURING THE PLACING OPERATION.
3. REINFORCING STEEL SHALL BE CLEAN OF MUD, DEBRIS, LOOSE RUST, CEMENT GROUT, OR ANY OTHER MATERIAL WHICH MAY INHIBIT BOND BETWEEN THE STEEL AND CONCRETE.

Figure 4-3: General notes covering reinforcement material and usage requirements

Information that varies from one project to the next (“PROJECT-SPECIFIC”):

Figure 4-4: Project-specific reinforced concrete detail
What degree of effort, then, is expected of the design professional as it relates to effective specification of welded deformed wire reinforcement? Just how much change in the conventional design and detailing routine, if any, will a consulting engineer be willing to take on without feeling encumbered?

There are two primary methods by which welded wire reinforcement can be incorporated into structural contract documents: by Direct Specification or as a Pre-Approved Equal.
4.2 Welded Wire Reinforcement Information by Direct Specification

Direct Specification is exactly as it sounds - welded wire reinforcement information is specified directly and explicitly on the contract drawings by the design professional.

As was discussed in Chapter 1 of *The Guide*, there is a threshold for welded wire information definition beyond which an engineer wouldn’t be expected to operate. The following basic “design” attributes would be the responsibility of the design professional to define:

- Wire yield strength
- Wire size
- Wire spacing
- Wire orientation (bent geometry, positioning within the concrete element, etc.)
- Wire lap splice requirements

In effect, all remaining manufacturing attributes related to the manufactured WWR mat width and length would be deferred to the downstream WWR detailer. The result, again as shown in Chapter 1, is intuitive:

**Figure 4-8: Cantilever Retaining Wall Section with WWR directly specified**
Slab-on-ground reinforcement applications continue to be excellent examples of directly-specified welded wire reinforcement, with only very simple definitions required for effective implementation.

**Figure 4-9: Excerpt showing directly specified WWR**

**Figure 4-10: Typical detail related to directly specified WWR**

* WWR MAT SHORT OVERHANG = 6"
** WWR MAT LONG OVERHANG = 12" = LAP SPlice
In directly specifying welded deformed wire reinforcement, it is important for the language and composition of typical reinforcement details, typical splice and reinforcement schedules, and general notes to be expanded to include appropriate reference to welded wire reinforcement. This is essentially a one-time adjustment that would need to be made by the design professional of record, with modification to “typical” information that is from that moment forward intended to remain unchanged on subsequent projects. Likewise, “project-specific” information would require specific acknowledgement of intended WWR usage as well.

The primary benefit of Direct Specification of welded deformed wire reinforcement is realized by those engineers who wish to have explicit, illustrated control over very specific usages of WWR on the project. In taking this approach, the engineer is actually absorbing quite a bit of the detailing-related burden that would otherwise be expected of the downstream welded wire reinforcement detailer.

The primary drawback of Direct Specification of welded deformed wire reinforcement, other than the additional time spent in preparation of WWR content and detailing by the design professional, is the unintentional restriction placed on the contractor for an application that might be better suited for loose, individual reinforcing bars. The irony here is that the same exact drawback scenario exists – and is likely even more prevalent in the construction industry as a whole - when a design professional of record explicitly defines loose individual reinforcing bars for a structural application that could very well yield significant favorable field placement and labor savings if it were permitted to be installed using WWR.

It should be understood that Direct Specification will still require downstream involvement of a WWR detailer, as it is the detailer who will take the design professional's specified wire sizes, spacings, and orientations and transform this information into mat configurations that will actually be produced on the equipment in the plant. As was alluded to in Section 1.3 of Chapter 1, project design professionals are discouraged from explicitly defining “turnkey” welded deformed wire reinforcement mat styles unless they themselves are intimately familiar with the producing manufacturer’s capabilities and capacities.

4.3 Welded Wire Reinforcement Specified as a Pre-Approved Equal

The creation of buildings and related structures in the built environment requires the close collaboration of design and construction professionals. Design and construction are two very distinct disciplines, the marriage of which is inextricably linked to a project’s successful completion. Nowhere is this more apparent than with today’s fast-based, design-build type project delivery method, where it is critical for all of the moving parts of the design-build team to operate in step.

The specification of welded deformed wire reinforcement as a Pre-Approved Equal is a manifestation of the value of collaboration. The EOR has a very specific design intent needing to be achieved on a project, while the contractor seeks to deploy the optimum use of time and resources on the jobsite to transform that design intent into built elements. Mild reinforcement for reinforced concrete structures essentially comes in two forms: deformed bar and deformed wire, each of which effectively receives equal treatment in the eyes of the ACI 318-19 Standard as it relates to alignment with modern reinforced concrete design methodologies. As such, the engineer is in a unique position to deploy both types of reinforcement, while affording the contractor the necessary oversight related to the means and methods of executing the installation.

Specifying welded deformed wire reinforcement as a Pre-Approved Equal requires very little effort on the part of the design professional of record. This effort comes in the form of a one-time modification to a project’s general notes section, wherein permissive language (and/or exclusive language) related to the use of WWR on the project is introduced. All other mild reinforcement content that is presented in terms of rebar is permitted – and encouraged - to remain unchanged. This allows for the engineer to continue on with longstanding, familiar design routines without compromise to productivity, while building flexibility into the contract documents that relates directly to constructability and construction schedule using appropriate mild reinforcement.
The following figures provide examples of “pre-approved equal” language that can be easily implemented.

**MILD REINFORCING STEEL**

1. TYPICAL DEFORMED REINFORCING BARS (REBAR) SHALL CONFORM TO ASTM A615, GRADE 80. BARS SHALL BE LAPPED IN ACCORDANCE WITH THE REBAR LAP SCHEDULE UNLESS OTHERWISE EXPLICITLY DETAILED.

2. LONGITUDINAL REINFORCEMENT IN SPECIAL MOMENT FRAME BEAMS AND COLUMNS, AND VERTICAL AND HORIZONTAL REINFORCEMENT IN SPECIAL STRUCTURAL (SHEAR) WALLS SHALL BE ASTM A706 GRADE 60 OR GRADE 80 AS NOTE. TENSILE AND ELONGATION PROPERTIES SHALL BE CONFIRMED THROUGH MILL REPORT DOCUMENTATION PROVIDED AS PART OF THE PROJECT REINFORCEMENT SUBMITTAL.

3. WELDED DEFORMED WIRE REINFORCEMENT SHALL CONFORM TO ASTM A1064 GRADE 80 AND SHALL BE PROVIDED IN SHEET FORM. REINFORCEMENT SHEETS SHALL BE MANUFACTURED WITH OVERHANG LENGTHS SUFFICIENT TO ACHIEVE A LAP SPLICE LENGTH EQUAL TO THE GREATER OF 12 INCHES OR THE LAP SPLICE DIMENSION SHOWN IN THE REBAR LAP SCHEDULE FOR BAR OF EQUAL (OR GREATER) DIAMETER AND GRADE, UNLESS OTHERWISE NOTED. SHEETS AND ASSOCIATED LAP REGIONS SHALL BE INSTALLED COPLANAR SO AS TO NOT "STACK".

4. WELDED DEFORMED WIRE REINFORCEMENT OF EQUAL AREA, EQUAL OR LESSER SPACING, AND IDENTICAL CURTAILMENT (HOOKS AND LAP SPLICES) IS PERMITTED AS A SUBSTITUTION FOR DEFORMED REINFORCING BARS, EXCEPT IN THE FOLLOWING STRUCTURAL APPLICATIONS:
   
   A. LONGITUDINAL STEEL IN SPECIAL MOMENT FRAMES
   
   B. VERTICAL AND HORIZONTAL STEEL IN SPECIAL STRUCTURAL WALLS

*Figure 4-11: General Notes excerpt showing WWR permissive language and specific exclusions. Note that this engineer is calling for identical curtailment of WWR, which essentially disallows reliance on welded intersections for structural purposes.*

1. MILD STEEL REINFORCING BARS SPECIFIED ON THESE STRUCTURAL CONTRACT DRAWINGS ARE PERMITTED TO BE REPLACED BY ASTM A1064 WELDED DEFORMED WIRE REINFORCEMENT (WWR) IN ALL APPLICATIONS, WITH THE FOLLOWING EXCEPTIONS:
   
   A. SPECIAL MOMENT FRAME LONGITUDINAL REINFORCEMENT
   
   B. SPECIAL STRUCTURAL WALL VERTICAL REINFORCEMENT
   
   C. COUPLING BEAM DIAGONAL REINFORCEMENT

2. WWR SUBSTITUTIONS SHALL NOT ALTER THE REINFORCEMENT UNIT CROSS-SECTIONAL AREA, SPACING, AND POSITIONING AS PRESENTED IN THE STRUCTURAL CONTRACT DRAWINGS, UNLESS APPROVED IN WRITING BY THE STRUCTURAL ENGINEER OF RECORD.

3. FABRICATOR DETAILING SHALL REFLECT POSITIONING OF STRUCTURAL (AND NON-STRUCTURAL) WIRES THAT BEST MINIMIZES INTERFERENCE WITH OTHER STRUCTURAL COMPONENTS.

*Figure 4-12: WWR permissive language and specific exclusions suitable for incorporation into project General Notes*
Specifying WWR as a Pre-Approved Equal defers all manufacturing geometries and attributes to the WWR detailer residing downstream of the actual structural design process. This results in minimal disruption to the designer’s daily rebar-based structural design routines and affords the contractor the real-time advantage of choice between equivalent mild reinforcement solutions to best suit desired site installation duration and labor savings.

Specifying WWR as a Pre-Approved Equal is generally considered to be a superior method of WWR implementation when compared to Direct Specification, and is made possible by – and maximizes the leveraging of - the presence of the highly qualified engineers and technical personnel who provide the downstream WWR detailing service itself, without compromising the original structural design intent.

### 4.4 The Role of the Welded Wire Reinforcement Detailer

Both of the previously described methods of specifying welded wire reinforcement require the downstream involvement of welded wire reinforcement detailers. These detailers are most commonly employed directly by the manufacturing companies, though there do exist independent welded wire reinforcement broker-detailers who work in concert with the manufacturer to generate the reinforcement package for the project.

Manufacturers’ WWR detailers are required to be familiar with ACI, AASHTO, and ASTM Standards and Specifications that are relevant to structural design, structural reinforcement layout and geometry, and material manufacture. As such, it is extremely common (if not implicitly required by the manufacturer) for the welded wire reinforcing detailer him/herself (or the detailing department’s manager) to be a licensed Professional Engineer (PE).
WWR detailers must have the ability to quickly and efficiently review full sets of structural contract documents for the purpose of preparing welded wire reinforcement submittal packages for review and approval during a project’s construction administration phase. Submittal packages are not unlike those commonly prepared for loose rebar, though are comparatively far more illustrative given the nature of prefabricated mats of reinforcement versus individual loose bars.

Welded wire reinforcement submittals must include reinforcement material properties, layout and placement plans, reinforcement details, mat piece-marks, and mat quantities. For a project on which the design professional has deployed the Pre-Approved Equal method of specifying WWR, the submittal will also include reinforcement substitution information. This substitution information is necessary to show with full transparency the WWR solution selected to conform with the engineer’s contract documents as a replacement for the base design that was presented in terms of loose reinforcing bars. Refer to Figure 4-14 for an example of substitution information submitted to show equivalent WWR used as a replacement for originally detailed reinforcing bars. Chapters 5 through 10 show in greater detail excerpts of the formatting and content of welded wire reinforcement shop drawing submittals.

The welded wire reinforcement detailer will work closely with the contractor (and relevant subcontractors) to ensure timely submittal of the reinforcement package for review. It is increasingly common for the welded wire reinforcement package and loose rebar package to be presented as part of a common submittal to help streamline the review process and to ensure that the project’s full reinforcement requirements are duly addressed, minimizing the likelihood of unintentional omissions.
### Figure 4-14: Substitution information for WWR as a Pre-Approved Equal.

In this example, an isolated spread footing was defined on the structural contract documents to be reinforcement with rebar, but the engineer’s pre-approval language allows for the substitution indicated to be made. The burden is on the welded wire reinforcement detailing professional to present proposed substitutions in a clear and concise manner to facilitate the design professional’s review for conformance with original design intent.

<table>
<thead>
<tr>
<th>Footing</th>
<th>Specified Reinforcement</th>
<th>Total Reinforcement Area (in²)</th>
<th>Hooked Termination</th>
<th>Approximate Bar Spacing Based on Edge Cover (in)</th>
<th>Nominal Rebar Tensile Strength (kips) N_s = A_s x f_y</th>
<th>WWR ID Utilized</th>
</tr>
</thead>
<tbody>
<tr>
<td>F80</td>
<td>(7) #6 EW B</td>
<td>3.08</td>
<td>N</td>
<td>15</td>
<td>246.4</td>
<td>WWR-F80</td>
</tr>
<tr>
<td></td>
<td>(0) EWT</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**WWR Substitution – f_y = 80 ksi**

<table>
<thead>
<tr>
<th>WWR ID</th>
<th>Mat Type</th>
<th>Mats Per Footing</th>
<th>Wires in X/Y Directions (For uni-directional mats, Y-Dir non-structural wires)</th>
<th>Average Wire Spacing (in)</th>
<th>Reinforcement Area Provided, X/Y (in²)</th>
<th>Nominal Tensile Strength Provided N_s = A_s x f_y (kips)</th>
</tr>
</thead>
<tbody>
<tr>
<td>WWR-F80</td>
<td>B</td>
<td>1</td>
<td>(11) D28.0/ (11) D28.0</td>
<td>9</td>
<td>3.08/3.08</td>
<td>246.4</td>
</tr>
</tbody>
</table>

**Mat Type:**
- **Uni-directional** - structural wires in the primary direction; minimal non-structural holding wires at wide intervals in secondary direction, positioned to maintain mat shape.
- **Bi-directional** - structural reinforcement in both orthogonal directions fabricated on a common WWR mat

**Bending:** None

**Material:** ASTM A1064, 80 ksi yield strength

**NOTES:**
1. See placement drawings for detailed WWR mat description, geometry, and arrangement in the structure.
2. Field trimming of mats is not permitted.
4.5 Welded Wire Reinforcement as a Non-Proprietary Finished Product

Welded wire reinforcement is a non-proprietary, manufactured product in the same sense that a reinforcing bar or a hot-rolled structural steel beam is. It is required to be produced to satisfy the requirements of the ASTM A1064 Standard Specification, analogous to rebar’s required conformance with ASTM A615 or ASTM A706, or a structural steel beam’s conformance to ASTM A992. Welded deformed wire reinforcement is referenced explicitly and expansively throughout longstanding industry design standards (ACI 318, AASHTO LRFD Bridge Specification, AREMA, etc.), wherein it is defined as a mild reinforcement for structural concrete. There is no International Code Council Evaluation Service (ICC-ES) report for welded wire reinforcement, as a third-party evaluation of this type would not only be redundant, but at its core unnecessary given the longstanding presence of welded deformed wire reinforcement in the aforementioned cornerstone design standards.

In the past there have been instances of confusion and misrepresentation on the part of jurisdictional authorities and plan review department entities as to what level of added certification might be required for use of welded wire reinforcement in lieu of reinforcing bars. The project’s design professional of record can allay these issues entirely by deploying one (or both) of the specification methods presented in this Guide. If the design professional her/himself is building welded deformed wire reinforcement into the project’s design vocabulary from the start, the plan approval process itself will flow seamlessly without the consternation and confusion that is often associated with other late-breaking “value engineering” proposals that are typically predicated on proprietary product replacements.

4.6 Deferred Submittals

Deferred submittals are elements or assemblies, defined and delegated by the design professional of record, to be designed, detailed, and submitted by a specialty designer, with the deferred submittal’s viability being confirmed by EOR approval after issuance of the building permit.

With welded wire reinforcement being specified by the design professional of record as an acceptable and intentional reinforcement for structural concrete, either by Direct Specification or as a Pre-Approved Equal on the structural contract documents themselves, the material is not considered a deferred submittal, even if – in the case of the latter - the extent of its utilization on a project may not be fully defined until after permit issuance.

It is important to understand that welded wire reinforcement is, in theory, not capable of being defined or deferred as a “standalone” or accessory structural element or assembly subject to independent design by others. It is quite literally an implicit component, the presence of which inside hardened concrete produces quantifiable reinforced structural concrete behavior. The EOR, by including welded deformed wire reinforcement as the base reinforcement or as a pre-approved equal reinforcement on the sealed structural contract documents, has acknowledged that the design he or she is presenting is predicated on its acceptability as a mild steel reinforcement, no different than an engineer allowing for either ASTM A615 or A706 reinforcing bars to be utilized in certain applications.

While welded wire reinforcement detailing personnel are commonly licensed as professional engineers, it would be erroneous and misguided to attempt to defer to them any of the project’s structural design responsibility, as the detailers themselves are not responsible for deriving the project-specific reinforced concrete design behaviors and interactions, nor are they in a position to make engineering judgments related to same. In contrast to design responsibility, the responsibility for material performance and compliance with ASTM standards is an entirely reasonable and expected demand of the manufacturer. Such a demand would be satisfied through the inclusion of manufacturer-certified mill report results and other material-specific verifications issued as part of the welded wire reinforcement submittal package. Likewise, the accuracy and applicability of reinforcement geometries and layouts are solely the responsibility of the welded wire reinforcement detailer in conjunction with the overseeing contractor.
The Guide uses design and detailing examples as the means by which WWR implementation is best illustrated.

The Direct Specification method is shown in Chapter 6 (Slab-on-Ground) and Chapter 9 (One-Way Post-Tensioned Parking Structure), while Chapter 5 (Shallow Foundations), Chapter 7 (Tilt-Up Wall Panel), Chapter 8 (Cantilever Retaining Wall), and Chapter 10 (Two-Way Mildly Reinforced Slab) utilize the Pre-Approved Equal approach to welded wire reinforcement specification.