WIRE REINFORCEMENT INSTITUTE®

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Technical Blog

ACI 318-19 -- Section 20.2.1.7.3: Prescriptive Maximum Wire Spacing

The current wording of ACI 318-19 Section 20.2.1.7.3 indicates that for welded deformed wire reinforcement (WDWR) used in applications other than stirrups, the maximum spacing of welded intersections in the direction of calculated stress shall not exceed 16 inches.

This is a curious restriction on WDWR. Here's why.

ACI 318-19 acknowledges treatment of WDWR in a manner identical to individual loose deformed bars and deformed wires when welded intersections are either absent or are not intentionally-positioned for tensile development or curtailment.

ACI 318-19 Sections 25.4.6.4 and 25.5.3.1.1 outline the common scenario in which the absence of intentionally-positioned welded intersections in turn requires calculation of welded deformed wire reinforcement development length and lap splice length, respectively, to be based on the same equations that are used for individual (loose, non-welded) deformed bars and deformed wires. In essence, these ACI 318 provisions direct the designer to disregard any contribution a welded intersection might make to bond and development, and have the designer instead base these attributes on the deformed wire surface's contribution alone.

Per ACI 318-19 Section 25.4.6.2, for welded deformed wire reinforcement, l_d shall be calculated from 25.4.2.2 (simplified equation) or 25.4.2.3 ("all-factors" equation), multiplied by the welded deformed wire reinforcement factor ψ_w from 25.4.6.3 or 25.4.6.4.

$$l_d = \left[\frac{3}{40} \times \frac{f_y}{\lambda\sqrt{f'_c}} \times \frac{\psi_t \psi_e \psi_s \psi_g}{\left(\frac{c_b + K_{tr}}{d_b}\right)}\right] d_b \times \psi_w$$

This is ACI 318-19 Section 24.4.2.3, Equation 25.4.2.3a "all factors". It is more precise than those from Section 25.4.2.2. This equation is used to calculate development length for deformed bar, deformed wire, and welded deformed wire reinforcement.

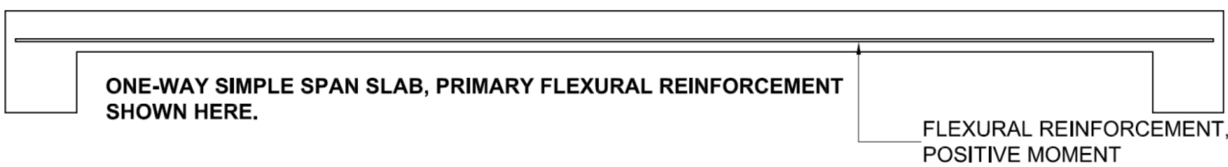
This factor applies to welded deformed wire reinforcement and acknowledges the bond contribution made by the presence of welded crosswires, mathematically reducing the development length dimension accordingly.

The factor is simply assumed to equal 1.0 if the crosswire positioning within the l_d region does not satisfy 25.4.6.3, or if there are no crosswires in the region at all.

The same philosophy that is illustrated above for development length also applies to calculation of WWR tension lap splices in Section 25.5.3; i.e., if there does not exist a specific orientation and relationship of welded crosswires within the tension lap region of two separate WWR mats, the calculation of tension lap splice length simply defaults to that outlined in Section 25.5.2 for deformed bar and deformed wire.

The takeaway here is that tensile development and tensile continuity of welded deformed wire reinforcement is still achievable even in those instances where welded crosswires are physically absent from critical regions, with equations set up to intuitively disregard welded intersection contribution entirely. Yet, even in those instances where ACI 318-19 explicitly allows for development length and tension lap splice of welded deformed wire reinforcement to “default” to the same behavior as loose deformed reinforcing bars or loose deformed wires, Section 20.2.1.7.3 as written still seems to impose a need for the presence of prescriptively-spaced crosswires.

The curious, almost arbitrary nature of ACI 318-19 Section 20.2.1.7.3 can be explained further through illustrations below. Refer to the following one-way simple span slab “excerpt”, with reinforcement schemes presented in six (6) different configurations (A through F). In all cases, the reinforcement parallel to span is shown while the perpendicular reinforcement (running into the page) is annotated but not explicitly detailed. In light of ACI 318 acceptance of A through D, one has to wonder what the justification is for non-compliance of configurations E and F.

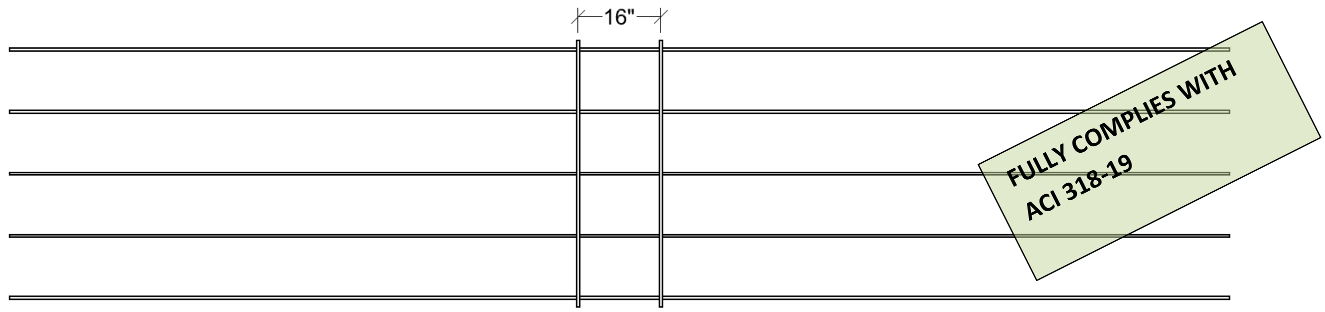


A

PRIMARY FLEXURE: FIVE (5) #5 DEFORMED BARS @ 12" ON CENTER
SHRINKAGE/TEMPERATURE IN ORTHOGONAL DIRECTION: REBAR, NOT SHOWN

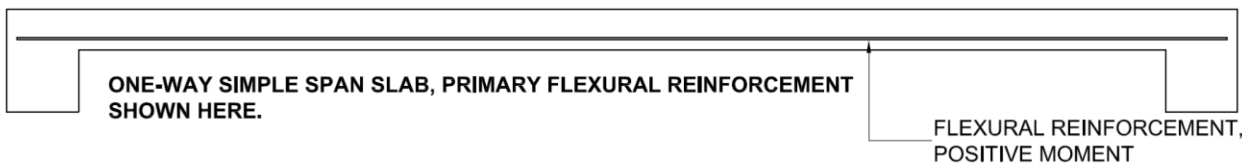
B

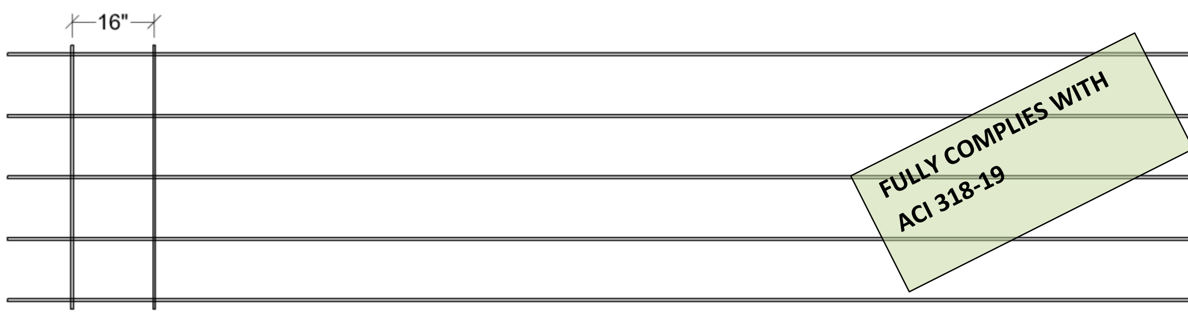
PRIMARY FLEXURE: FIVE (5) D31 DEFORMED WIRES @ 12" ON CENTER
SHRINKAGE/TEMPERATURE IN ORTHOGONAL DIRECTION: DEFORMED WIRES, NOT SHOWN



C

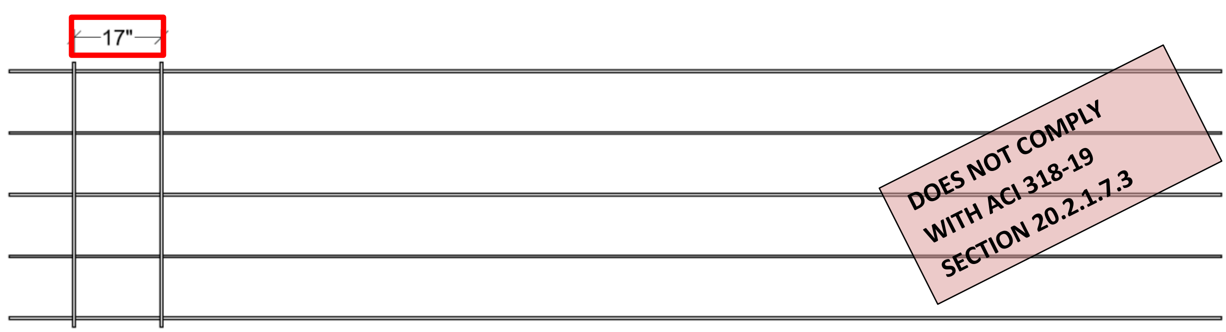
PRIMARY FLEXURE: WELDED DEFORMED WIRE REINFORCEMENT WITH (5) D31
SHRINKAGE/TEMPERATURE IN ORTHOGONAL DIRECTION: SEPARATE WWR MAT, NOT SHOWN





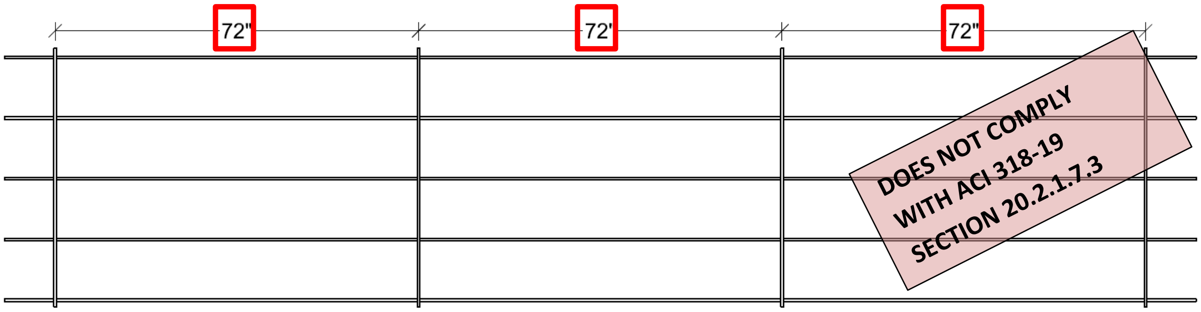
D

PRIMARY FLEXURE: WELDED DEFORMED WIRE REINFORCEMENT WITH (5) D31
SHRINKAGE/TEMPERATURE IN ORTHOGONAL DIRECTION: SEPARATE WWR MAT, NOT SHOWN



E

PRIMARY FLEXURE: WELDED DEFORMED WIRE REINFORCEMENT WITH (5) D31
SHRINKAGE/TEMPERATURE IN ORTHOGONAL DIRECTION: SEPARATE WWR MAT, NOT SHOWN



F

PRIMARY FLEXURE: WELDED DEFORMED WIRE REINFORCEMENT WITH (5) D31
SHRINKAGE/TEMPERATURE IN ORTHOGONAL DIRECTION: SEPARATE WWR MAT, NOT SHOWN

In today's evolving concrete construction environment, WDWR's usage is characterized by the need for customization and flexibility: its implementation must be sophisticated enough to acknowledge the spatial variability of the structural system itself. Thanks to significant advances in welding machine automation and process refinements, as well as the presence of more savvy designers and detailers on staff with the manufacturers, welded deformed wire reinforcement mats are often configured with variable-spaced wires and wire sizes, and it is not uncommon for separate "uni-directional" mats (design-specific reinforcement in one direction, with widely-spaced "non-structural" wires welded in the other direction) to be utilized to better satisfy considerations such as engineer-mandated alignments of lap splices and contractor-mandated sequence requirements.

For more information on WWR, refer to www.wirereinforcementinstitute.org.