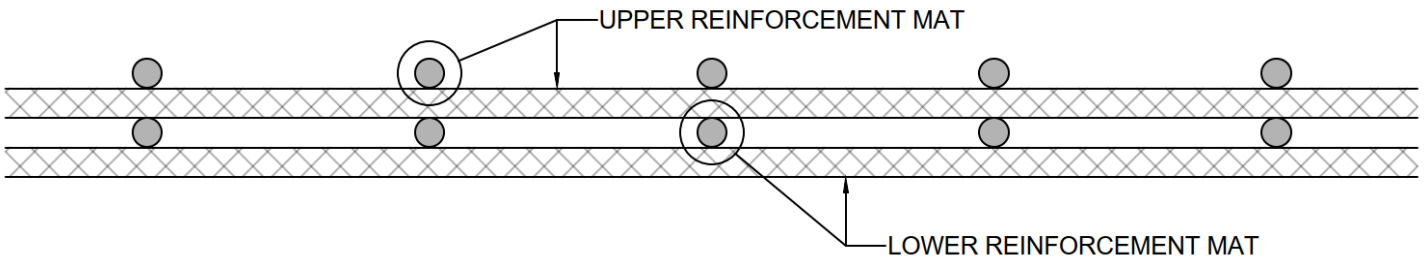
Stacked WWR Mats

For structures designed per ACI 318, is it acceptable to "contact-stack" WWR mats – one directly on top of another (i.e., without horizontal stagger) – for the purpose of achieving the specified cross-sectional area of steel within a concrete slab or wall?

The WRI fairly frequently receives some form of the question above. It describes a scenario in which lighter gauge WWR mats are available, and the contractor seeks to economize the reinforcement package by deploying multiple stacked layers of these smaller wires in lieu of utilizing a single WWR mat comprised of larger wires.

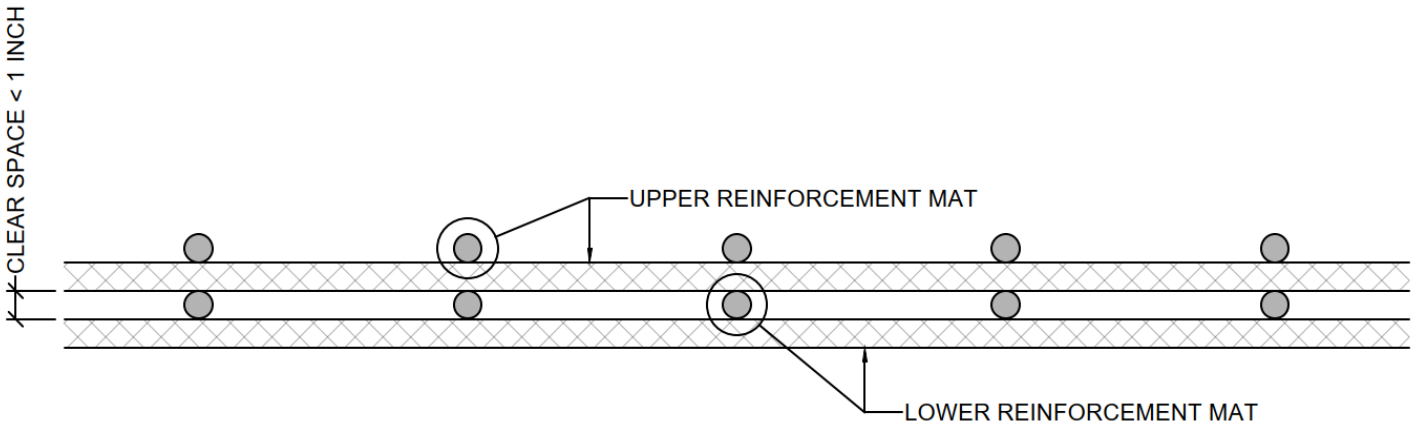
Illustratively, contact-stacked WWR appears as shown below:



The most apparent limitation to directly stacked WWR mats can be found in ACI 318 Section 25.2.2, which states:

> *For parallel nonprestressed reinforcement placed in two or more horizontal layers, reinforcement in the upper layers shall be placed directly above reinforcement in the bottom layer with a clear spacing between layers of at least 1 inch.*

This seemingly makes the direct stacking of WWR a non-starter, as the wire diameters utilized in the production of WWR are typically on the order of 5/8" maximum, falling well short of the 1" that would be required to implicitly satisfy the 1" minimum for clear spacing between layers:

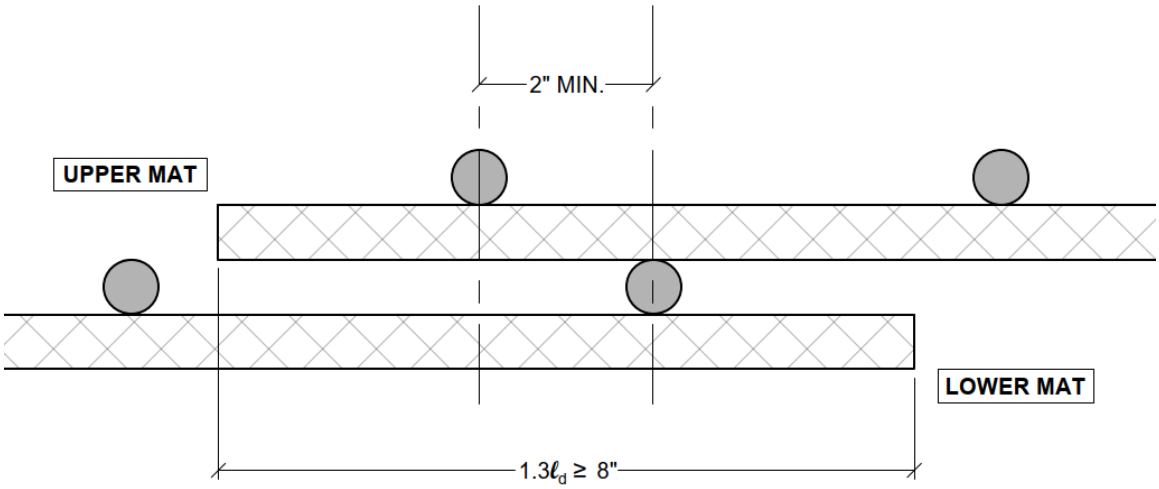


Note, too, that trying a different angle – say, categorizing the stacked WWR mats as "bundled bars" – appears to fall short of the spirit of the design standard, and

seemingly ends up being a non-starter given that, per Section 25.6.1.2, bundled reinforcement must actually be enclosed within transverse reinforcement (ties, hoops, stirrups, etc.). The likelihood that "enclosing" transverse reinforcement[1] is present in a slab or wall utilizing smaller diameter WWR is extremely low, and such a configuration would itself likely create a plethora of placement challenges that would almost certainly negate whatever benefit was expected to be derived from the use of WWR in the first place.

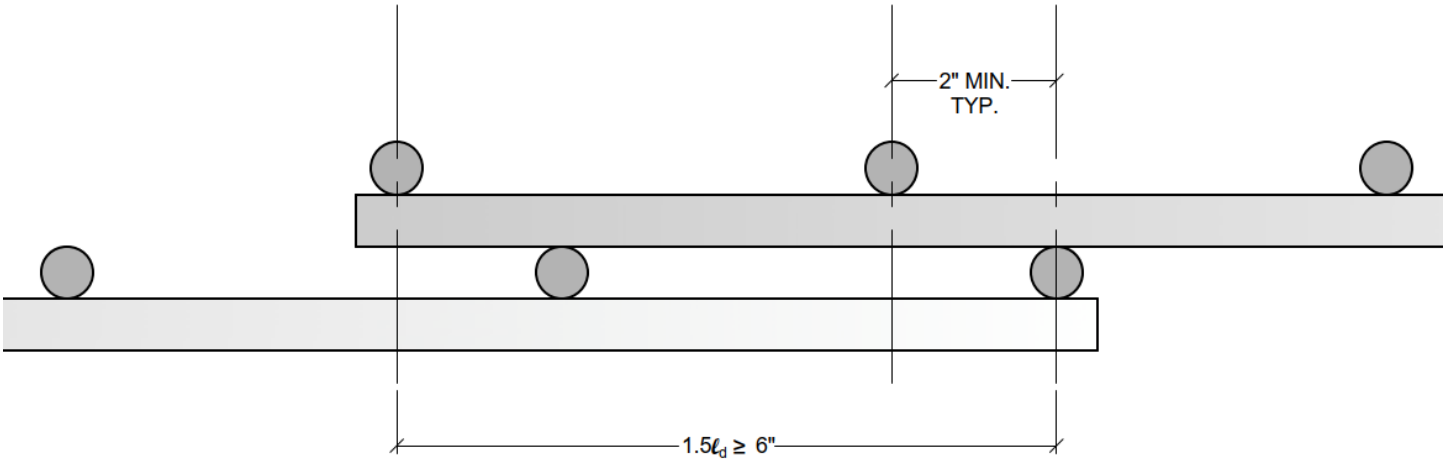
With the above explanations in mind, it would seem that the answer to the original question is a categorical "**NO**". However, elsewhere in the ACI 318 standard there are prescriptions that show instances of contact staggered WWR mats. These sections are illustrated as follows.

Section 25.5.3.1 – tension lap splice of welded deformed wire reinforcement



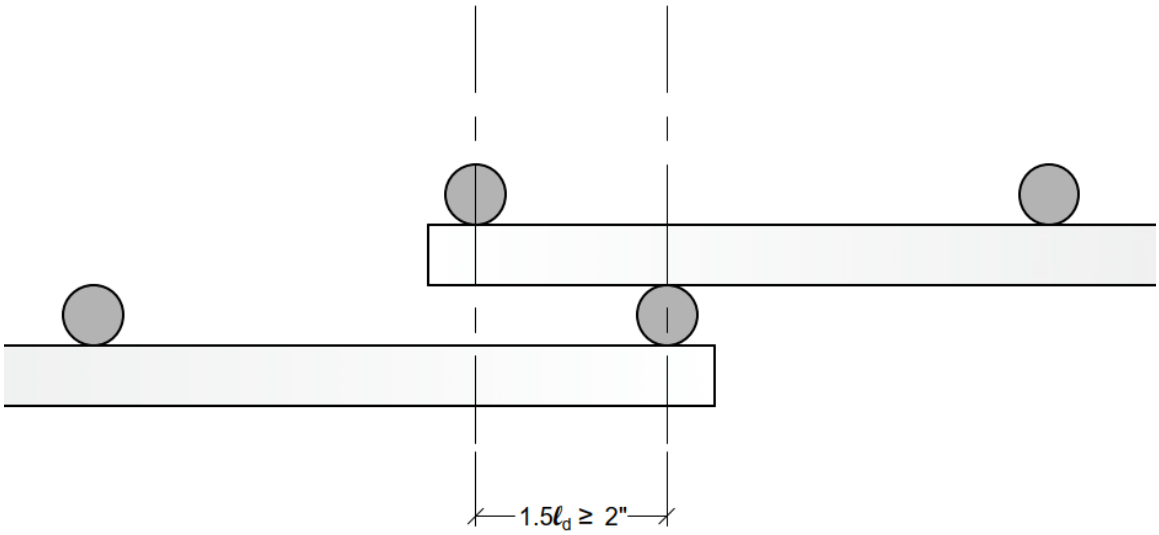
Section 25.5.4.1 – tension lap splice of welded plain wire reinforcement

$$\frac{A_{s,provided}}{A_{s,required}} < 2.0$$



Section 25.5.4.1 – tension lap splice of welded plain wire reinforcement

$$\frac{A_{s,provided}}{A_{s,required}} \geq 2.0$$



ACI 318 commentary R25.5.4.1 provides some context for the above illustrated 2" minimum stagger, stating in part that *"the 2 in. additional lap required is to provide adequate overlap of the cross wires and to provide space for satisfactoy consolidation of the concrete between the cross wires."*

One might argue, then, that if contact staggered reinforcement is permitted in a region as critical as a lap splice location – where an overlap of two physically discontinuous pieces of reinforcement is required to re-establish continuity of the effect of said reinforcement – then a stagger in reinforcement in a non-splice region may not be detrimental to overall performance.

Confusion on the part of the specifier is understandable, as ACI 318 seems to contain provisions that – while apparently intended to describe separate conditions (multilayer reinforcement positioning versus WWR lap splice positioning) – unavoidably conflict given that the two scenarios are not mutually exclusive.

It is WRI's opinion that instances exist in which wholesale stagger of contacting WWR mats would be acceptable, meaning that, from WRI's perspective, the answer to the original question is less of a "**NO**" and more of a "**YES, depending on the scenario**". The deciding factor is as it typically always is: left to the engineering judgment of the specifier. ACI 318 reinforces this general notion in its Section 1.3.2 and accompanying commentary R1.3.2:

Section 1.3.2
This Code does not address all design considerations.

Commentary R1.3.2
The minimum requirements in this Code do not replace sound professional judgment or the licensed design professional's knowledge of the specific factors surrounding a project, its design, the project site, and other specific or unusual circumstances to the project.

In the event that a specifier does allow for the use of stacked WWR mats, there are of course design attributes that must be validated. For example, the stacking of WWR mats inherently changes the depth at which the effect of the cumulative reinforcement is felt within the concrete section, as there is a literal shifting of a portion of the reinforcement off of its original position. The larger the wire size, the more pronounced the change to the cumulative reinforcement's effective position that is used in design calculations.

Other considerations include – but are not limited to - reinforcement spacing, reinforcement orientation within the concrete element (vertical versus horizontal), and concrete mix attributes. For example, a slab application with contact staggered mats of 12x12 D8.0/D8.0 using a high strength concrete mix design characterized by smaller aggregate sizes may require a different design (and construction) lens than a slab with 4x4 D20.0/D20.0 and a lower strength / larger aggregate concrete mix design.

The specifier's determination of the suitability of contact staggered WWR mats should be carried out on a case-by-case basis.

For more information visit www.wirereinforcementinstitute.org.

Footnotes:

1. *While WWR is unique in that it is commonly manufactured with welded intersections at which a quantified weld shear resistance can be calculated, the presence of these "structural" welds does not formally constitute confinement or lateral support in the sense that a transverse stirrup or tie would. Can these welds be relied upon to behave as a measure of anchorage or curtailment? Most certainly. But their presence alone does not create the same effect as the physical presence of "enclosing" transverse reinforcement.*

References:

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