ACI Placement Tolerance for Welded Wire Reinforcement

Engineers and contractors are imperfect beings. The holistic process of carrying out a design and then constructing it to a satisfactory level of conformance is wrought with technical, logistical, and spatial complications and challenges.

If the built environment is being carried out by imperfect minds and hands, then the resulting construction product itself is bound to be imperfect as well. The level of acceptable imperfection must be managed and restricted, however, otherwise the absence of consistent control will yield grossly non-conforming construction that – if even buildable in the first place – would have a higher likelihood of poor and/or unpredictable performance.

In short: building stuff can be difficult.

The method by which we establish the ground rules for "acceptable imperfection" is in the definition of tolerances.

ACI 117 is a detailed specification for tolerances associated with concrete construction. It defines "tolerance" as *the permitted deviation from a specified dimension, location, or quantity*. It goes on to define "deviation" as *a departure from an established point, line, or surface; measured normal (perpendicular) to the reference line or surface*, with additional definitions for "deviation from plane", "deviation from horizontal", and "deviation from vertical" combining to further identify positional limitations.

The expectation, then, is that a design will be carried out based on an established and sufficiently illustrated and annonated relationship of material positions and geometries (typically on a set of sealed contract documents issued by the design professional), and the subsequent construction of that design is deemed adequate provided those material positions and geometries are put together within the range of specified tolerable deviation.

From ACI 117's commentary:

> ***No structure is exactly level, plumb, straight, and true. Tolerances are a means to establish permissible variation in dimension and location, giving both the designer and the contractor limits within which the work is to be performed. They are the means by which the designer conveys to the contractor the performance expectations upon which the design is based or that the project requires. Such specified tolerances should reflect design assumptions and project needs, being neither overly restrictive nor lenient.***
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> ***Necessity rather than desirability should be the basis of selecting tolerances.***

It is worth noting that ACI 117 Sections 1.1.1 and 1.1.2 state the following as an overarching condition of use:

> **1.1.1 This specification designates standard tolerances for concrete construction.**
>
> **1.1.2 The indicated tolerances govern unless otherwise specified.**

As it relates to reinforcement location within a concrete element, then, ACI 117 provides detailed information on placement tolerance for nonprestressed reinforcement as follows:

Condition	Tolerance
When concrete member depth (or thickness) is 4 inches or less	±1/4 inch
When concrete member depth (or thickness) is over 4 inches and not over 12 inches	±3/8 inch
When concrete member depth (or thickness) is over 12 inches	±1/2 inch

The above plus-minus ranges would be referenced from the point, line, or surface that defines the design positioning of the reinforcement as illustrated and annotated by the engineer on the contract documents. It is noteworthy that these tolerances are not tied to a particular size/diameter of a piece of reinforcement; the singular governing variable is member geometry.

ACI 117 goes on to provide information on **concrete cover tolerances measured perpendicular to the concrete surface**:

Condition	Tolerance
When member depth (or thickness) is 12 inches or less	-3/8 inch
When member depth (or thickness) is over 12 inches	-1/2 inch
Reduction in cover shall not exceed one-third the specified concrete cover. Reduction in cover to formed soffits shall not exceed one-quarter inche.	

The above reductions in clear cover would be referenced from the clear cover dimension that is illustrated and annotated by the engineer on the contract documents. Again, it is noteworthy that these tolerances are not tied to a particular size/diameter of a piece of reinforcement; the singular governing variable is member geometry.

Lastly, ACI 117 defines an **acceptable vertical deviation for slab-on-ground reinforcement.**

Application	Vertical Deviation
Slab-on-ground reinforcement	±3/4 inch

It is noteworthy that this permissible range of deviation is not tied to a particular size/diameter of a piece of reinforcement, but instead is a constant value independent of all other attributes.

All told, ACI 117 does a fine job in establishing the ground rules for permissible deviation in the placement of nonprestressed reinforcement within concrete.

But wait.

If we look closely at ACI 117's commentary section R2.2:

> ***Tolerances for fabrication, placement, and lap splices for welded wire reinforcement are not covered by ACI 117 and, if required, should be specified by the Specifier.***

Note that the ACI 117 *Mandatory Requirements Checklist* goes on to say that "Tolerances for fabrication, placement, and lap splices for welded wire reinforcement must be specified by the Specifier." Based on this information, the specification of welded wire reinforcement (WWR) tolerances shall be by the Specifier, and are not found in ACI 117.

For the fabrication aspect of WWR, ASTM A1064 contains all the required attributes relevant to defining the acceptable envelope of manufacturing control for the product. As such, it is understandable that WWR is excluded from ACI 117 given it is a prefabricated assembly as opposed to a discrete piece of reinforcement.

In contrast, that WWR is altogether excluded from ACI 117 as it relates to placement is perplexing (especially for those WWR wire sizes that are equal to or greater than reinforcing bar sizes that are implicitly covered by ACI 117). The default, then, is simply this:

The Specifier is responsible for defining WWR placement tolerances.

The concept of responsibility deferral to the Specifier is neither foreign nor unprecedented. In fact, we only need to go as far as the previously cited ACI 117 Section 1.1.2 to see that, even for "standard" tolerances that are conveniently compiled in ACI 117, there is a concise acknowledgment that the Specifier can overrule the stated tolerances (i.e., *"the indicated tolerances govern unless otherwise specified"*).

So theoretically, it is always the Specifier's call in the end. For reinforcing bars, if a Specifier wants to default to ACI 117, then the framework is clearly there for them to do so. Otherwise, depending on project and application-specificity, alternative tolerances for rebar could be defined by the Specifier, and these tolerances could either be more stringent or lenient than those defaults that are outlined in ACI 117. This fact is acknowledged and expanded upon within ACI 117's commentary:

> *As the title "Specifications for Tolerances for Concrete Construction and Materials (ACI 117)" implies, the tolerances given are standard or usual tolerances that apply to various types and uses of concrete construction. They are based on normal needs and common construction techniques and practices. Specified tolerances at variance with the standard values can cause both increases and decreases in the cost of construction.*
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> *Economic feasibility – The specified degree of accuracy has a direct impact on the cost of production and the construction method. In general, the higher degree of construction accuracy required, the higher the construction cost, and the lower the degree of construction accuracy, the higher the cost of required repairs.*
>
> *Construction techniques – The feasibility of a tolerance depends on available craftsmanship, technology, materials, and project management.*

The above commentary is of course not a mandate or directive, but rather is presented by ACI for informational purposes. We know that ACI 117 excludes WWR from its purview, but the above commentary language related to tolerance variance relative to "standard" values affecting cost of construction, as well as varying degrees of construction accuracy also being correlating to construction cost, could all be reasonably interpreted as universally accurate for both rebar and WWR.

For a Specifier utilizing WWR in their design, tolerances should be selected that are appropriate for and compatible with the achievement of their design intent, as tolerances in general are – according to ACI 117 – *"the means by which the designer conveys to the contractor the performance expectations upon which the design is based or that the project requires".*

It is noteworthy that, currently, the most prevalent talking points related to placement tolerance for WWR seem to revolve around prescriptions that are found in ACI 301-20 "Specification for Concrete Construction". ACI 301 contains the following mandates, originally included starting with ACI 301-16:

3.3.2.5(a)
Welded wire reinforcement in slabs on composite steel deck and slabs-on-ground

"Place reinforcement as indicated in Contract Documents. If reinforcement less than W4.0 or D4.0 is specified, the continuous support spacing shall not exceed 12 in."

3.3.2.5(b)
Welded wire reinforcement in elevated formed slabs, slabs on noncomposite steel deck, and members not covered in 3.3.2.5(a)

"Place and support reinforcement before concrete placement to maintain location within tolerances indicated for nonprestressed reinforcement in ACI 117. If reinforcement less than W4.0 or D4.0 is specified, the continuous support spacing shall not exceed 12 in. perpendicular to the direction of span."

Despite ACI 301 containing language stating that location and placement tolerance of welded wire reinforcement must be specified (this is found in the ACI 301 Mandatory Requirements Checklist, and is consistent with ACI 117's deferral of these attributes to the Specifier), there is still a 12-inch support spacing prescription for WWR material smaller than W4.0 (or D4.0).

Effectively then, ACI 301 is actually enforcing a means & methods provision (a prescriptively defined 12-inch support spacing) regardless of whether or not the Specifier's tolerances for a particular design would ultimately require such a spacing to be utilized in order to achieve conforming construction. There are numerous lightly-reinforced concrete applications for which a 12-inch support spacing would be unnecessarily conservative, while there also exist applications for which a 12-inch support spacing would be justified. But ACI 301 does not allow for a distinction to be made between the two when WWR with wire sizes smaller than W4.0 (or D4.0) is specified.

At the very least, this prescription doesn't make much procedural sense, because on the one hand the Specifier is directed to define the tolerances compatible with their particular design, but on the other hand those tolerances in all cases for W4.0 (or D4.0) WWR are overridden by the 12-inch support spacing prescription. If this is true, the Specifier's tolerances in many instances would be meaningless.

The ACI 301 provisions in question remain a highly contentious topic related to WWR placement tolerance. It is WRI's position that definition of tolerances are the sole responsibility of the Specifier, and the subsequent means & methods deployed to achieve construction conforming to those tolerances are the responsibility of the contractor. Whether the resulting cost of that conforming construction is comparatively exorbitant or efficient when compared to "normal needs" is most certainly a consideration that needs to be made from one project to the next, but it is also beyond ACI's purview to govern. ACI 117 essentialy states as much in its commentary:

Necessity rather than desirability should be the basis of selecting tolerances.

With that said, if concerns do arise from time to time that are related to cost and construction "desirability", how might the matter be worked towards resolution by the design and construction team? ACI 117 again does a fine job of providing some general guidance on the topic, this time in its Notes to the Specifier (relevant section bolded below for clarity).

> *Tolerance values affect construction cost. Specific use of a tolerance item may warrant less or more stringent tolerances than contained in the specification. Identify in the Contract Documents any tolerances the Contractor is required to achieve, but are not addressed in ACI 117. Designate Exposed Concrete and Architectural Concrete in the Contract Documents. Coordinate tolerances for concrete construction and those of any materials that interface with, or attach to, the concrete structure. Specify concrete tolerances that are more or less stringent than those contained in this specification. Specification of more restrictive tolerances for specialized constructions, such as architectural concrete, often results in an increase in material cost and time of construction. The Specifier should specify dimensional tolerances considered essential to successful execution of the design. Success may require one or more of the individual tolerances to be more restrictive than those contained in ACI 117.* ***The preconstruction meeting provides an opportunity for the design/construction team to identify and resolve, before actual construction, any tolerance compatibility issues relative to concrete Work and materials with which concrete interfaces. Successful resolution of any questions will almost certainly require active participation of the Design Professional. Specify acceptance criteria in accordance with ACI 301 or equivalent.***

Engineers and contractors are not perfect, and building stuff will rarely if ever be a simple endeavor. Not surprisingly, then, solutions to challenges are best derived when the designer and builder actually have a dialogue to resolve project-specific concerns.

References:

1. ACI Committee 117, “Specification for Tolerances for Concrete Construction and Materials (ACI 117-10) and Commentary (ACI 117R-10)”, American Concrete Institute, Farmington Hills, MI, 2010 (Reapproved 2015)

2. ACI Committee 301, “Specifications for Concrete Construction (ACI 301-20)”, American Concrete Institute, Farmington Hills, MI, 2020

3. “Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete (ASTM A1064/A1064M-24)”, ASTM International, West Conshohocken, PA, 2022.