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Introducing ANSI/TPI 1-2002: Cq: What Does It Mean to You? by WTCA Staff

Is Confirmed Quality in Your Future?

The implementation of the revised National Design Standard for Metal Plate Connected Wood Truss Construction (ANSI/TPI 1-2002) into your business and truss design software brings a unique opportunity to re-examine the critical link between truss design and truss performance. That critical link is known as Quality Control (QC), or more specifically, an In-Plant Quality Control process, which ANSI/TPI 1 refers to as "a manufacturing quality assurance procedure."

WHAT EXACTLY IS Cq?

What does QC have to do with Cq? Do I really need to know what it is, or can I just let the truss technician/truss designer worry about it? Let's take a closer look at Cq and what it really means inside the truss plant, and to you, the component manufacturer.

ANSI/TPI 1-2002 defines Cq as the "Quality Control Factor." To put it in more friendly terms, let's call Cq "Confirmed Quality." The term Confirmed Quality suggests that a certain ownership is attached to it: "Yes, my plant is taking steps to confirm its quality." The same is true with Cq. Cq is a factor that the component manufacturer will set, based on your plant's capabilities and your expectations, to control the plating tolerances that your truss design software will use to design the trusses you build. Basically, with the addition of Cq, the truss design software recognizes that the truss production environment is not a laboratory under constant conditions. The production environment needs varying tolerances for plating to meet varying needs. Let's look first at the Standard and its Commentary to learn how Cq will help you confirm acceptable quality of the products you are manufacturing.

First, here is some useful discussion on Cq itself as provided in the Commentary to ANSI/TPI 1-2002 Chapter 6: Materials and General Design Considerations:

WHERE DO WE GO FROM HERE?

Where you stand with respect to the new quality standard? You'll have to collect data from your in-plant QC process to find out. Is a Cq of 1.0 a better fit than a Cq of 1.25 in your plant? Only accurate data will tell you. Are your efforts to cull in the pick yard or at the saw paying off? Data will tell us. Is your attention to QC on the table giving you fewer plate placement problems? What does the data say? Is it possible to adjust your manufacturing approach to ensure that there were no knots, wane, holes or rolled teeth in the plate contact area and then modify the Cq factor to not only account for defects under the plate but for plate positioning as well? We are currently working on addressing this issue to provide as much quality control process flexibility as we can for those manufacturers that can show that they have far less than the 25 percent built-in defects in the plate area. With good data, you can certainly make a compelling and persuasive argument that the Cq of 1.0 is too conservative. Have you taken the data collection steps needed to really know the quality level in your plant? In the near future, our goal is to allow those that have good data collection to take the best advantage of that fact.

"The quality control factor (Cq) is a new adjustment factor that was added to accommodate changes in the 2002 edition pertaining to quality in the manufacture of metal plate connected wood trusses. It applies to plate lateral resistance design values to effectively calibrate the amount of built-in quality tolerance used in the design of plates for lateral resistance. Plate lateral resistance design per the 2002 edition incorporates a new reduction, through the addition of a 0.8 factor, on plate lateral resistance values in order to account for quality imperfections in the plating area that are considered to be inherent to the manufacturing process. The quality control factor may, under certain cases, be used to offset this reduction and potentially utilize the full lateral resistance design capacity of the plates. The conditions of use on the quality control factor are specified in Section 6.4.11.2 and 6.4.11.3."

Here is the explanation on Cq's conditions of use per Section 6.4.11.2.

"Because the quality control factor is an adjustment factor that addresses a manufacturing quality issue, and not an engineering design issue, the value of the quality control factor to be used in the truss design, which will link the design to the manufacturing needs, is appropriately specified by the Truss Manufacturer rather than the Truss Designer (see Section 2.4.2). As in the case of all other adjustment factors, however, there are provisions governing the Truss Manufacturer's value of Cq. The Truss Manufacturer's value of Cq should provide enough built-in quality tolerance as necessary to demonstrate an acceptable level of quality as defined by Chapter 3. Thus, Section 2.4.2 states that the Truss Manufacturer's value of Cq shall be based on evidence of conformance with Chapter 3. Where special conditions are not met…this value of Cq is limited to 1.00 for wide-face plating and 1.11 for narrow face plating, such as 4x2 floor trusses. Where mitigating circumstances allow for an increased Cq value, the maximum Cq value permitted is 1.25, because this results in the original full lateral resistance design values (i.e., before the application of the 0.8 factor), which shall not be exceeded."

The key points to note thus far are:

- Cq is a quality adjustment factor for the component manufacturer to set.
- Different values of Cq will provide different levels of tolerance to allow for detrimental lumber characteristics or rolled/partially imbedded teeth inside the plate contact areas. These user set tolerances will help your product meet acceptable levels of quality.
- The expected "default" value of Cq is 1.00 for 2x_ trusses, and 1.11 for 4x/3x_ trusses. These values will determine the maximum level of tolerance in the plating area that is allowable in meeting the minimum structural quality standards.

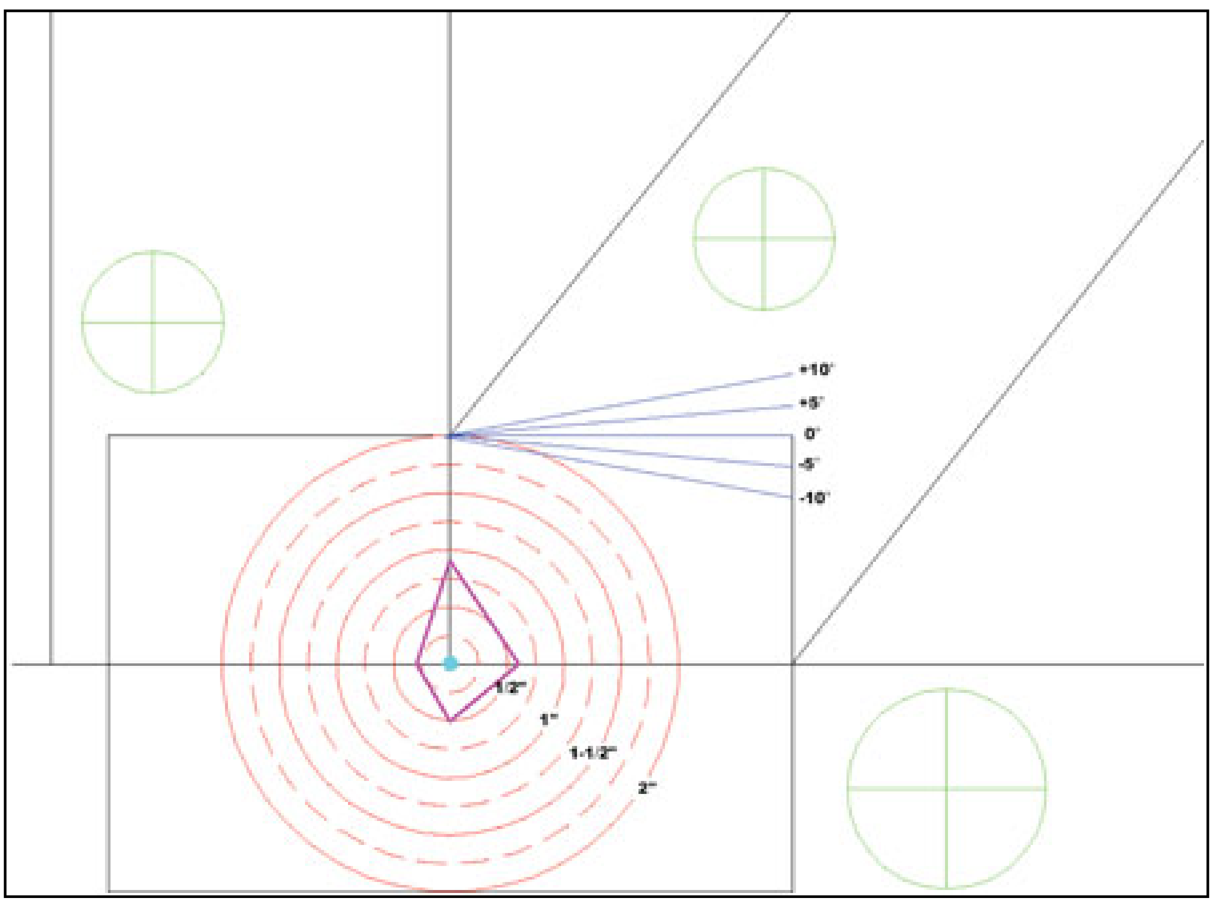
Next you'll see another benefit in using the "default values" of Cq mentioned above. Not only will these values give you additional tolerances for manufacturing inaccuracies, but they will also allow you to use a new, and quicker, method of joint inspection to assess and confirm the quality of a joint. This new method is called the Plate Placement Method (PPM), which is described in the Commentary to Chapter 3 as follows:

"The PPM is introduced in the 2002 edition as a new method for assessing truss joint quality, in which plate placement is used as a primary indicator of acceptable quality. This differs from quality assessment in the 1995 edition, which required inspection of the plate on a tooth-by-tooth basis, for each wood member contact area, rather than by plate positioning alone. The

purpose of any quality assurance protocol is to consistently manufacture a product that will structurally perform as intended by its design. The PPM provides a quick means to visually inspect a plate's position, rotation, embedment, and member-to-member joint gaps, while ensuring that any joint within these criteria sufficiently meets the truss design requirements. The faster approach afforded by the PPM is possible because of a related design provision that introduces a degree of conservatism into the design phase to account for quality imperfections in the plate contact area…"

Here is how it works:

- A Cq value of 1.00 is required to use the PPM for the design and inspection of plates embedded into the wide face and equates to a 20 percent reduction of plate tooth holding design values, or 25 percent more connector teeth than the absolute minimum number of teeth required to carry the design loads.
- A Cq value of 1.11 is required to use the PPM for the design and inspection of plates embedded into the narrow face of the lumber and equates to an 11 percent reduction of plate tooth holding design values, or about 12 percent more connector teeth than the absolute minimum number of teeth required to carry the design loads.
- Using increasingly greater values of Cq than the above equates to smaller and smaller tolerances built into the design and requires a change in the inspection procedure, until the maximum allowed Cq value of 1.25 results in no reduction to plate tooth holding values.
- Additionally, a maximum plate rotation of +/- ten degrees is accounted for in the design, unless a smaller rotational tolerance is specified.



Based on the discussion above, you think that the PPM increased plate sizes by 25 percent. As PPM was developed, this was a big concern and was determined not to be true because plate manufacturer analysis performed on the new QC program suggests that most component manufacturers already provide 25 percent more teeth than the minimum required. For instance, perhaps the minimum plate size that could be used on a joint is 2.15x4.23. Since all you have in inventory is a 3x5 plate, this 3x5 plate has 1.65 times more plate area than is required and probably will give you a great amount of PPM flexibility. Inventory on hand, handling and related design factors that you use when you design your trusses all increase plate sizes. The PPM takes advantage of that.

A preliminary analysis was completed by Mike Magid, P.E., of Robbins Engineering, using 172 different residential truss types for a total of 361 trusses; 129 commercial truss types for a total of 1076 trusses; nine agricultural truss types for a total of nine trusses; 234 multi-family truss types for a total of 619 trusses; and 123 4x2 truss types for a total of 534 trusses. The total increase in cost, based on the WTCA Financial Performance Survey, where truss plates are four percent of the cost of a truss, was 0.16 percent (less than two tenths of one percent). This means that on a truss that costs $50.00, the increased plate cost will be $0.08.

You will also note that there is a distinction between wide-face plates and narrow-face plates. According to the Commentary, here's why:

"The reason for specifying a smaller quality tolerance, or less conservatism, for narrow-face plating than for wide-face plating is due primarily to the ease of accurate positioning with narrow-face plating. Secondly, there is a greater propensity to limit quality inaccuracies in the narrow-face plating area during manufacturing. Since there is considerably less wood contact area available for plating in the narrow dimension, lumber characteristics such as lumber wane will be monitored more closely and will generally not be used within the plating area."

OTHER Cq VALUES

What about other values of Cq? We have centered our discussion thus far around the benefits of using the default values of Cq defined as 1.00 (wide-face plating) and 1.11 (narrow-face plating). But earlier we said component manufacturing will set Cq based on the plant's capabilities because the truss plant and production environment has varying needs for varying tolerances. The Commentary states the following about Cq:

"...In recognition of differing manufacturing practices and quality assurance needs, the conservatism introduced into the joint design procedures has been accounted for by the addition of a new adjustment factor, the quality control factor (Cq), which can be used to offset the reduction in tooth holding values."

We also learned earlier that Cq values greater than 1.00 and 1.11 (up to 1.25) result in less and less tolerance in the plating area to account for manufacturing inaccuracies (ineffective teeth). Nevertheless, the Commentary recognizes the following:

"There may be cases where the added conservatism provided through the use of the lower Cq factors (i.e., 1.00 and 1.11) is not as advantageous from a manufacturing standpoint. This might be the case if a Truss Manufacturer has procedures specifically in place to avoid loss of effective teeth in the plate area due to teeth flattening or lumber characteristics; for example, trimming lumber to ensure no knots or wane are contained within the ends of the lumber where plates can be placed, and closely monitoring roller press operations such that teeth are not flattened. If such procedures are in place and can be shown to be effective, then a plant may elect to reduce or remove the extra level of conservatism through the use of greater Cq values…this would require the use of more detailed inspections per the Tooth Count Method provided in the Annex to Chapter 3. This case is covered in Section 3.2.4.2, but it is not intended to be used unless a Truss Manufacturer can justify it through proven compliance with the quality standard, even without the extra level of conservatism built into the plates, and using the inspection procedures in the Annex."

Notice the reference to the Tooth Count Method (TCM); this method of inspection, in contrast to the PPM, involves counting effective teeth. This method must be used with these "other" values of Cq (greater than 1.00 and 1.11), and may be used anytime if desired. Counting teeth is also used as a final check of a joint's effectiveness if the criterion of the PPM is not met.

Let's say you are encouraged by the PMM and the extra tolerance provided by the default Cq values to help confirm quality of your products, but you can't help but think there will occasionally be certain joints that simply won't plate if there is this "extra" tolerance built in. Does this mean you should forget the idea of using the default values of Cq all together to avoid this from happening? No. Fortunately, the standard addresses this case for you as well. Here's how:

"Where the Truss Manufacturer's value of Cq is less than the maximum value of 1.25, this section permits a pragmatic increase of the Cq factor by the Truss Designer for design purposes, on a joint-by-joint basis. While a 0.80 reduction factor was incorporated into the lateral resistance design procedures in order to provide for quality imperfections in the plating area that reduce the lateral resistance capacity of a plate, it is clear that with this reduction and in the absence of any such imperfections, a plate would have reserve capacity that was neglected in the design. It is furthermore recognized that there may be especially high-stressed joints, in which neglecting some of the plate's capacity will not allow the design to work. Since this is not practical, the Truss Designer is permitted to increase the Truss Manufacturer's value of Cq, in order to utilize up to the full design capacity of the plate, when necessary from a design standpoint. This implies that the plating area and plate location for that joint becomes more critical, and an assessment of the plate using the Tooth Count Method in Annex A3 is required to assure that the plate has the capacity assumed in the design. Thus, Section 6.4.11.3 requires the truss design drawing to indicate this."

CONFIRMED QUALITY

For the component manufacturer, this is a streamlined quality control procedure, greatly improved over the ANSI/TPI 1-1995 procedure. It also means that you will want to carefully review (with your plate supplier) the other plating options within your design software such as handling considerations, minimum bite or any other plating protocols. This would also be a good time to review your inventoried plate sizes and adjust as necessary to minimize incremental size increases when implementing the PPM of inspections under the 2002 standard.

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