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Knowledge Is Power

Introducing a New Quality Standard by Kirk Grundahl, P.E. & Steve Cramer, P.E.

The development of improved truss quality control (QC) began at a May 5, 2000 meeting of the following WTCA component manufacturer representatives: Roger Gibbs, Mary Pat Keller, Michael Ruede, Barry Dixon, Keith Kinser, Jim Irvin, Stan Sias, Jack Dermer, Stephen Yoder, Dwight Hikel, Steve Batchelor, Sid Ketchum, Pat McGowan, Glenn McClendon, Tom Nomeland, Scott Arquilla, Eric Lundquist, Jerry Vulgaris, Jack Parker, Kris Alberti, Tony Alberti, Don Groom, Louis Daviau, Lidge Johnson, Kendall Hoyd, Bob Becht, Rip Rogers, Merle Nett, Simon Evans, Dick Rotto and Dave Scott.

It was decided, based on the QC data that we had at our disposal, that it was of the utmost importance for our industry to better understand truss quality and the resulting finished product structural performance. This group recommended, and the Board of Directors approved, allocating funds to proceed with testing a significant number of trusses for the purpose of gathering information to provide a benchmark to evaluate the existing industry quality standard.

On February 15 and 16, 2001 a working group met that included Professor Steve Cramer, P.E. and Bert Hall of the University of Wisconsin-Madison; Steve Cabler, P.E. of MiTek; Dave Brakeman, P.E. of Alpine; Dave Gromala, P.E. of Weyerhaeuser; Kelly Gutting of TPI; and Ryan Dexter and Kirk Grundahl, P.E. of WTCA. Charlie Goehring of TPI was able to attend the second day of the meeting. This group was charged with taking all of the test data that WTCA had developed from its tests completed in June 2000 and January 2001, digesting it and determining the direction that our industry should take with QC. The group was also responsible for submitting a QC standard draft to the project committee working on the rewrite of ANSI/TPI 1-1995.

CLICK ON IMAGES FOR LARGER VIEW

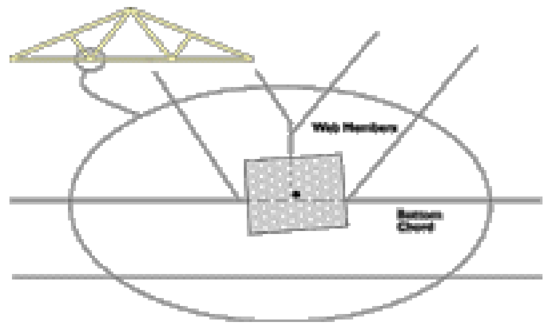

FIGURE 1: JOINT SELECTED FOR INSPECTION. THE BLACK DOT IDENTIFIES THE CENTER OF THE PLATE.

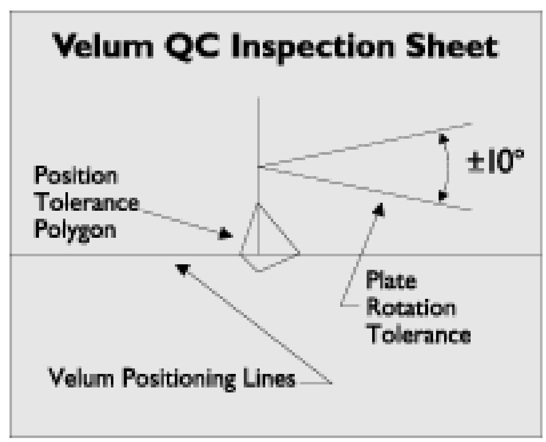

FIGURE 2: JOINT QC DETAIL FOR INSPECTION ON A VELUM SHEET.

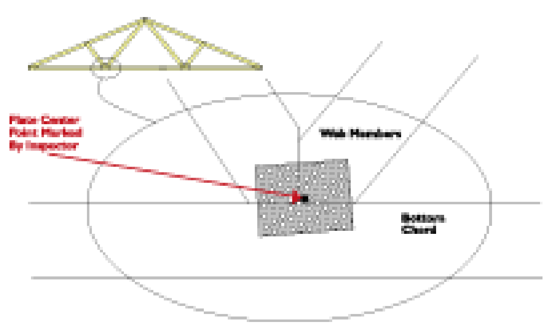

FIGURE 3

The data indicated that changing the way we undertake QC in our industry was advisable and that the overall goal for this project should be to develop an in-plant QC program that:

- Is quick to do in a typical truss plant.
- Is easy to understand and implement by plant personnel.
- Provides us with the assurance that, even when we are doing QC quickly, the result will be the expected, code-mandated structural performance of the trusses that are produced.
- Keeps costs in line, yet recognizes that each of the three parameters above causes the application of truss plates at a joint to be more conservative than a more intensive QC program would require.
- Keeps the in-plant QC inspector as its frame of reference, so that understandability and ease of implementation are assured.

HOW IS IT GOING TO WORK?

A key change in the approach from the existing ANSI/TPI 1-1995 quality standard is the creation of a new inspection procedure called the Plate Placement Method (PPM) of inspection. This procedure has at its core the creation of a plate placement tolerance polygon that is printed onto a template, which is called the Joint QC Detail. All truss design software providers will program into their software the ability to provide this detail. As an example of how the standard will be applied, consider the joint selected for inspection in Figure 1.

A Joint QC Detail will be transferred to an 8-½" x 11" sheet of velum. As shown in Figure 2, this velum QC detail will provide at a minimum:

- lines that allow the inspector to align the velum sheet on the joint,
- the plate position tolerance polygon, and
- angled reference lines that define the maximum allowable rotation for the primary axis of the plate.

The tolerance polygon, as depicted in Figure 2, defines a region on the truss within which the center of the plate must be positioned. The maximum allowable plate rotation will be defined with a rotational tolerance range

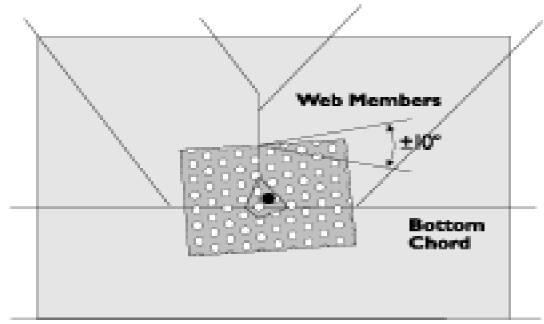

FIGURE 4: VELUM JOINT QC DETAIL INSPECTION SHEET POSITIONED OVER THE TRUSS JOINT FOR INSPECTION.

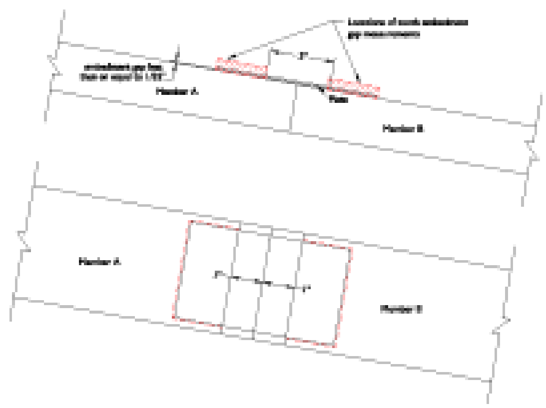

FIGURE 5

"WTCA's role in the QC process from my perspective boils down to three words: Pioneering, Persistent, and Team Players.

Pioneering: WTCA had the vision to initiate research that seeks resolution of manufacturing issues AND structural performance issues in one comprehensive approach. This combined-issue approach provides a foundation for further competitive improvements for the truss industry in years to come.

Persistent: The vision and goals of this research presented by WTCA were essentially constant from day one. Research projects sometimes fail because the sponsor changes the agenda, and pressures constantly change the goals and interpretation of the research. WTCA persisted through the research, the standard development process and communications with industry with one vision. From a researcher perspective this was that in all but special situations will be ±10-degrees.

The in-plant inspector will put a black mark on the exact center of the truss plate of the joint to be inspected as shown in Figure 3.

The positioning of the velum sheet for this joint is accomplished with lines on the Joint QC Detail, which parallel the top of the bottom chord and the intersection of the webs. The velum will be laid over the joint to align the positioning lines with the actual lumber edges as shown in Figure 4. If the center of the plate is inside the tolerance polygon, and any plate rotation falls within the ±10-degree rotation tolerance range, then the joint passes the basic positioning requirements (also shown in Figure 4).

The inspector will then inspect all wood-member to wood-member joint gaps at the edges of the plate for that particular joint. The inspector will check that the gaps that exist are less than 1/8" (except for floor truss chord splices where it is less than 1/16").

invaluable.
Team Players: After the research vision was set, WTCA worked side by side with the academic research team providing help in crucial areas without dictating research approaches or attempting to influence outcomes. WTCA played a primary role in bringing different parties to the table to both complete the research and to propose an industry-wide consensus standard."
—Professor Steve Cramer, P.E., UW–Madison

"WTCA's vision for a new QC standard has led the way in developing a standard that is technically sound and provides truss manufacturers with the tools to produce component products that will perform structurally. Without WTCA's leadership, this cooperative industry effort would not have been possible."
—Dave Brakeman, Alpine Engineered Products

The next check will be a visual inspection for any lumber characteristics (e.g. loose knots, holes, wane, flattened teeth, etc.) in the plate area of the joint being inspected. No more than 20 percent (10 percent for floor trusses) of the teeth in a plate contact area can be found in these types of lumber characteristics. This again is a visual check and pictorial guidelines for what constitutes 20 percent of the plate area will be found in the standard.

Finally, the inspector checks for plate embedment of the joint with a gauge set at 1/32" plus the thickness of the plate, around the perimeter of the plate as shown in Figure 5.

The PPM joint inspection process is far more simple than that required by the current ANSI/TPI 1-1995 Standard. Now, not all joints on a truss will need to be inspected. Our testing determined that there were some joints that were unlikely to influence truss failure if they were anywhere close to being properly plated. The testing further suggested that all joints with a Joint Stress Index (JSI) of 0.80 when using the PPM of inspection should be inspected, and all joints with a JSI of 0.65 when using the TCM inspection process (the Tooth Count Method, or TCM process, is described below). The difference is to ensure that the same joints will be inspected for each method. The JSI is the largest ratio of applied design force to allowable design force, a concept similar to the commonly used Combined Stress Index (CSI) used for wood members. The JSI values will be printed on the inspector's truss design drawing.

Therefore, this process continues until both sides of all joints with a JSI greater than 0.80 are inspected. By inspecting only critical joints and using the velum approach, our experience indicates that the inspection process for an individual truss should now take less than fifteen minutes to complete for most common truss types. The final checks are the overall checks made to ensure that all joints are plated, the lumber is the proper grade and species, and the truss length and height are within tolerance.

WHAT HAS CHANGED FROM THE EXISTING ANSI/TPI QUALITY STANDARD?

Following are the key changes that have been made to the existing ANSI/TPI Quality Standard. All of the changes have been arrived at through the unanimous consensus of the **TPI Technical Advisory Committee (TAC),** UW–Madison, WTCA staff and TPI staff.

- As described above, a new method of inspection has been created called the Plate Placement Method (PPM). This is a graphical approach that shows positioning tolerances calculated by the truss designer for any particular joint of a truss selected for truss inspection. The testing undertaken by WTCA showed that monitoring plate placement is the fastest way of controlling truss joint quality.
- Testing showed that to enhance the speed of the inspection process over the requirement of counting teeth in the existing ANSI/TPI Quality Standard, the new plate placement method of inspection requires that a factor of 0.8 be multiplied by the plate's lateral resistance (tooth holding) design values. This means that plate sizes may increase to account for the ability to quickly assess lumber characteristics (e.g. loose knots, holes, wane, flattened teeth, etc.) in the plate area. The PPM method will require that each joint is subject to a visual inspection to ensure lumber characteristics take no more than 20 percent of the plate contact area for each member connected.
- In special circumstances, a more detailed and time-consuming QC process called the Tooth Count Method (TCM) will be required and, as its name implies, requires the counting of teeth. The TCM, however, is an improved version of the QC methods that are currently found in the ANSI/TPI Quality Standard.
- As described above, we have simplified the plate rotation tolerances from the existing ANSI/TPI Quality Standard. The new standard uses a plate rotation tolerance of ±10 degrees. This rotation limit will be placed on the Joint QC Detail.
- We have simplified the gap tolerances from the existing ANSI/TPI Quality Standard. Wood-member to wood-member gap requirements are now:
  - 1/8" for all joints except floor truss chord splices.
  - 1/16" maximum gap for floor truss chord splices.
  - These gap tolerances apply to all points of member to member contact as shown on the truss design drawing. This also covers the use of round-cut webs (e.g. Turbo-webs) and square-cut webs.
- As discussed above, only joints with a Joint Stress Index (JSI) of 0.80 when using the PPM inspection process (and a JSI of 0.65 when using the TCM inspection process) need to be inspected. However, truss manufacturers should note that these inspection criteria pertain only to the minimum joint inspection requirements for the audit that verifies in-plant QC processes. These inspection guidelines do not suggest that the in-plant QC process can ignore joints without high stress levels. The in-plant QC process must still be in place to monitor overall quality issues.
- For internal plant auditing purposes, the group defined that, at a minimum, three trusses per week, per set-up location, per shift shall be inspected and recorded.

The next bulleted paragraph is a new concept that is very hard to explain concisely in an article and is much better discussed. We are introducing this concept to provide background for our readers. For those responsible for implementing this new standard, keep this article handy and we guarantee that this concept will quickly become clear.

- The group has introduced a new concept called the Quality Control Factor (C_q), which applies to plate lateral resistance values only. The value of this factor for the PPM method is 1.00 for all roof trusses and 1.11 for all floor trusses. In special circumstances, the C_q factor provides a means to reduce the conservatism introduced in the new standard. However, in all cases where the C_q is not the standard, 1.00 or 1.11 as described above, a higher level of QC, using the Tooth Count Method, will be required. There will be two primary cases when the value for C_q will be higher than 1.00 or 1.11:
  - In special situations when the joint cannot be plated using the PPM method. Then the Cq will be increased until the joint can be plated or a limiting value of 1.25 is reached and the TCM inspection process will be used for that joint.
  - There may be cases when a truss manufacturer desires to take actions within his/her operations that reduce the likelihood of lumber characteristics occurring in the plate area to such a low level that the C_q can be raised to a value of up to 1.25. In these cases, the TCM inspection process must be used. It is important to note that if a C_q higher than 1.0 or 1.11 is used, justification needs to be provided that actions have been taken to assure that there will not be characteristics in the plate area that would reduce the strength of the finished product to below what would be expected if a truss was tested to failure.

WHAT IS IT GOING TO COST?

Given the fact that the PPM method is a little more conservative in approach, one of the concerns was how the increased plate sizes will effect costs for the typical truss manufacturer in our industry. 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 different commercial truss types for a total of 1076 trusses; nine different agricultural truss types for a total of nine trusses; 234 different multifamily truss types for a total of 619 trusses; and 123 different 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 4 percent of the cost of a truss, was 0.16 percent (less than two tenths of one percent). This means that on a typical truss that costs $50.00, the increased plate cost will be $0.08.

CONCLUSIONS

Everyone involved in this project realizes now that we are coming to a close on the redraft of the standard and understands how difficult it was to produce a standard that properly weighs the competing demands of efficient production and structural quality. We have done our level best to provide a QC approach that meets these demands.We have taken a huge first step forward with our industry quality standard and can bank on even more significant refinements and improvements for our industry in the forthcoming years.

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