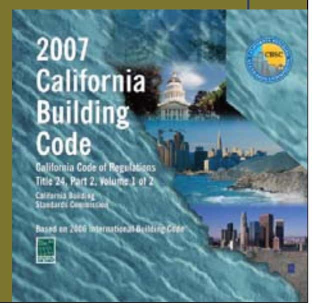
2007 California Building Code's New Referenced Standard: TPI 1 - 2002



Outline

- **Overview:**
  - **Structure**
- **Issues:**
  - **QC**
  - **Materials & Design**

The implementation of quality standards in TPI 1-2002 has received a great deal of attention, but there are a number of other significant changes that impact the truss manufacturer's bottom line. The following is an outline of the topics that will be covered in this section:

1. Just to set the playing field, one needs to be aware that the structure of TPI 1-2002 has changed significantly from TPI 1-1995 – both the standard and the commentary & appendices.
2. Then we will cover some of the issues that have come about because of specific changes - regarding quality control, as well as materials & design.

The current national design standard that governs metal plate connected wood truss construction is ANSI/TPI 1-2002.

•It is an update to ANSI/TPI 1-1995. This update includes a complete rewrite of the quality criteria for the manufacture of metal plate connected wood trusses as well as other significant changes.

In addition to the TPI 1 standard you should have a copy of the TPI 1-2002 Commentary & Appendices and a current version of the Errata to TPI 1, both of which are available for download from the TPI website.

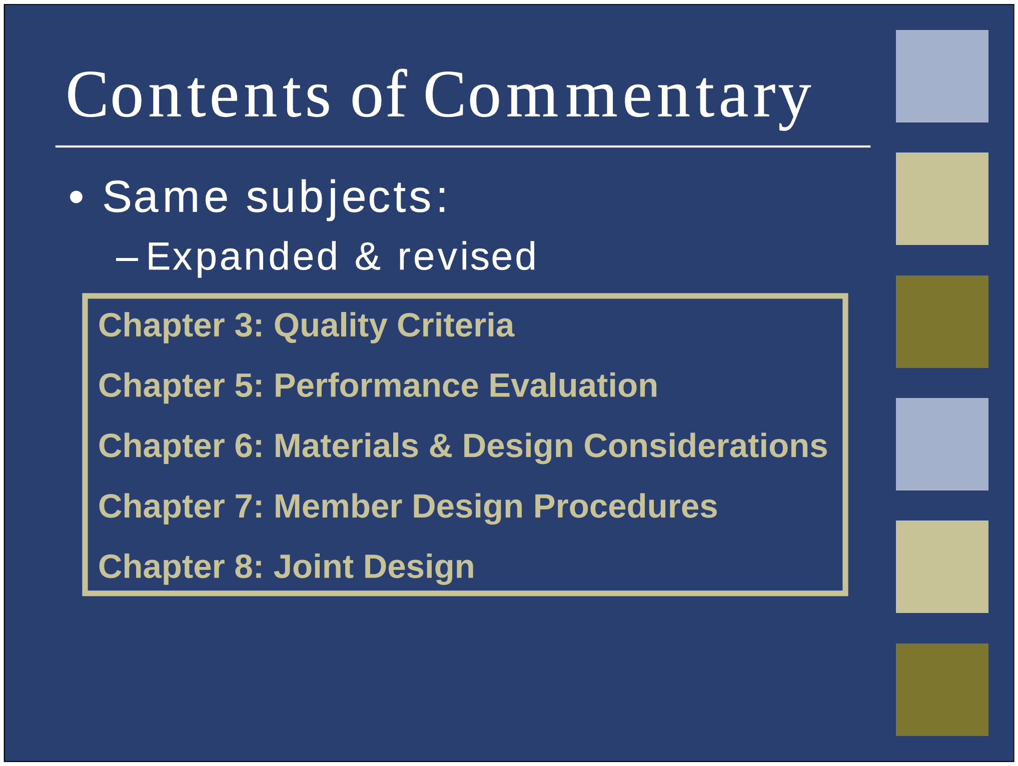
Contents of Standard

Chapter	TPI 1- 2002	TPI 1-1995
1	General	1
2	Design Responsibilities	2
3	Quality Criteria	4
4	Plate Manufacturing	6
5	Performance Evaluation of Connections	7
6	Materials & Design Considerations	3,9
7	Member Design Procedures	10,12,13,14
8	Plate Joint Design	11

Commentary on Permanent Truss Bracing – Appendix C

For those familiar with TPI 1-1995, TPI 1-2002 has been restructured, updated, and contains enhanced information. Many critical references have been relocated.

1. The number of chapters or sections has been reduced from 14 to 8.
2. Quality Criteria is now in chapter 3.
3. Loading is now covered in chapter 6.
4. Installation & bracing information in section 5 has been moved to Appendix C.
5. A number of sections related to member design have been combined in chapter 7. And section 8 has basically been eliminated, since the content is now covered elsewhere.



The commentary subjects are basically the same in TPI 1-2002 and 1995.

1. However, a great deal of the content has been expanded and revised because the standard has changed in most of the areas listed.

Outline

- **Overview:**
  - **Structure**
- **Issues:**
  - **QC**
  - **Materials & Design**

Now we will look at some of the issues that have come about because of specific changes – in the light of actual implementation: especially regarding quality control and materials & design issues.

Quality Control (QC)

- Chapter 3
  - *Trusses shall meet the minimum manufacturing quality requirements specified in this chapter, so that design assumptions are met.*

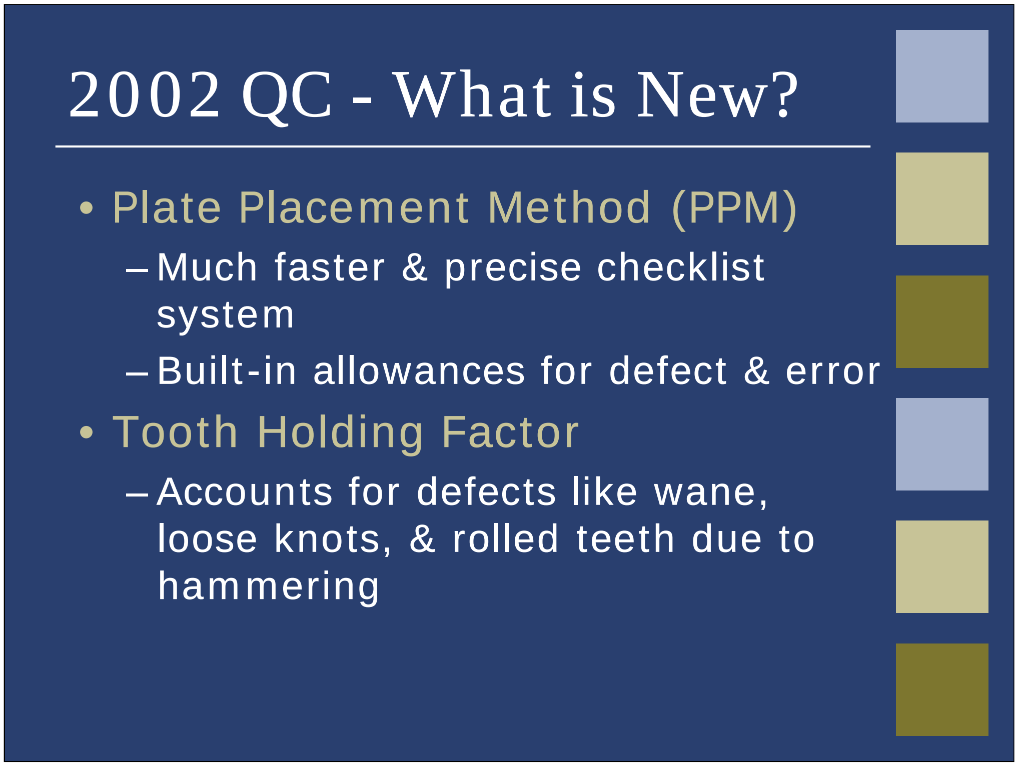
If you are designing to TPI 1-2002, any one or any combination of factors could be involved in making some truss designs less expensive and others more expensive than under TPI 1-1995. The QC requirements are only one of many revisions.

QC Overview

- 1995 *did not reflect* what was going on in the real world, 2002 will:
  - Recognize tolerances *actually occurring* in truss plants
  - Make *allowances for wood defects* by reducing tooth holding strength values in the design
  - Take plate placement into account for *each* joint during the design process

TPI 1-1995 *did not reflect* what was going on in the real world.

1. TPI 1-2002 will recognize things like member gaps, placement, rotation
2. And make allowances for them. Going into a 1995 inspection, it assumed all lumber was 100% good for plating. So you would have no wane, no rolled teeth and it was hard to get inspections to pass on a regular basis.
3. The engineering software analyzes each joint to see how complex it is.

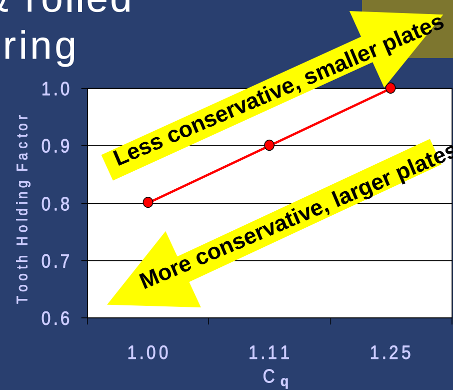


Basically for PPM if you do not pass the quicker check you count teeth as plan B

1. This is also a new factor.

2002 QC - What is New?

- Quality Control Factor (C_q)
  - Accounts for defects like wane, loose knots, & rolled teeth due to hammering
  - PPM Roof C_q = 1.0
  - PPM Floor C_q = 1.11
  - TCM: C_q = 1.25

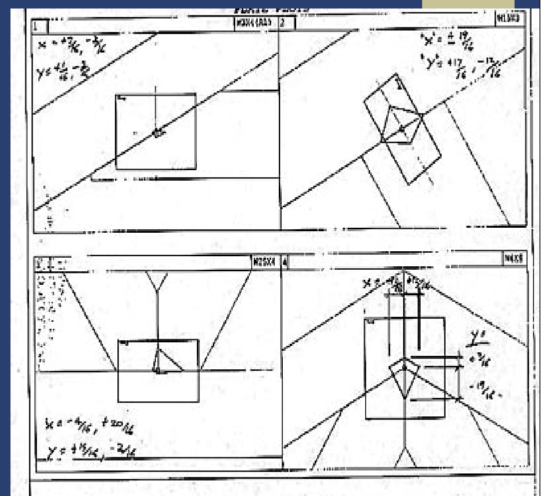


The Cq is the factor in the design equations that accounts for the defect

- This shows that as you lower the tooth holding factor or the ability of the teeth to grab the lumber to take into account defects, your Cq lowers and this results in larger plates. On the flip side, when you have less defects your tooth holding factor will be higher, your Cq will be larger and you will be able to go with smaller plates.

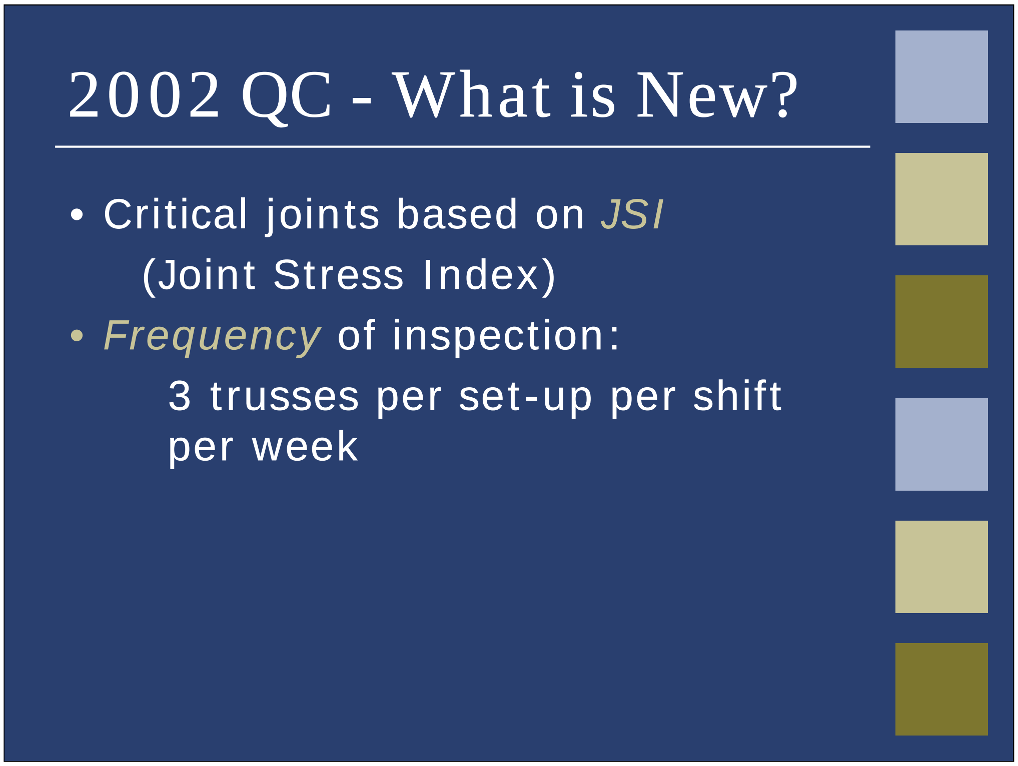
2002 QC - What is New?

- *Joint QC Details* for critical joints



Courtesy of Dave Brakeman- Alpine Engineered Products

1) Joint QC Detail Bullet:
2) A graphical detail of a truss joint that shows positioning tolerance polygons calculated by the software for sample joints selected for inspection.



For example, a JSI over .8 for PPM would mean a critical joint.

- 1995 never required an inspection frequency.

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STRUCTURAL BUILDING COMPONENTS MAGAZINE
September/October 2004

WTCA Update
www.woodtruss.com

Best Practices for Converting from ANSI/TPI 1-1995 to ANSI/TPI 1-2002 by WTCA Staff

Got the conversion blues? Review these best practices and learn how to compare apples to apples!

The intent of this article is to assist Truss Manufacturers in understanding the changes that take place to lumber and plate inventory during the conversion of truss designs to the 2002 design standard. This article will also address the differences between the 1995 (Figure 1) and 2002 (Figure 2) standards.


FIGURE 1


FIGURE 2

WTCA recommends the following steps as an aid in understanding how this change affects your business and inventory:

WHEN COMPARING DESIGNS, USE A PURE APPLES TO APPLES COMPARISON

It is very important to use the following concepts:

- Identical design
- Identical loading
- Identical plate and lumber inventory
- Identical procedure for designing the truss (i.e., optimizing)
- Identical lumber prices
- Identical plate prices
- Identical plate rotation checks

By making these checks, you will have a proper comparison of the effects of the change. You will be able to make more educated decisions on how best to manage this change, so that it has the most positive effect on your business.

RUN A SAMPLING PLAN ON YOUR BASE SETS OF JOBS

In-Plant WTCA QC

IN-PLANT WTCA QC Certification FAQ

Ryan Dexter, WTCA QC Program Manager
Listed below are Frequently Asked Questions (FAQs)
about **In-Plant WTCA QC** and **In-Plant WTCA QC** certification.

1. What is IN-PLANT WTCA QC?

In-Plant WTCA QC is a program that helps Truss Manufacturers monitor the quality of trusses they manufacture. This in-plant program consists of two main parts: 1) inspections procedures and 2) software for storing the results to see trends over time.

Inspections

There are five different inspections:

- a) **Preliminary Truss Inspection:** Verifies that the lumber and truss dimensions correspond to the design.
- b) **Plate Placement Method:** Verifies that the plate is placed within a certain placement tolerance specific for each joint.
- c) **Tooth Count Method:** Verifies that the number of teeth required to be in members is actually present. Checks that are similar to the Plate Placement Method are made on plate embedment, member-to-member gaps, and lumber defects.
- d) **Lumber Inspection:** The quality of lumber (including dimensions, moisture content and defects) is documented when each shipment arrives at the plant.
- e) **Truss Dimensions:** Available such that truss plants could track additional truss dimensions not outlined in ANSI/TPI 1-2002.

Software

The data from the completed inspections is entered into the **In-Plant WTCA QC** software, which is basically a database program created using Microsoft Access™. Storage of the data allows users to see their performance over time in graphs, and to find out more detailed information on performance by crew, truss type, etc.

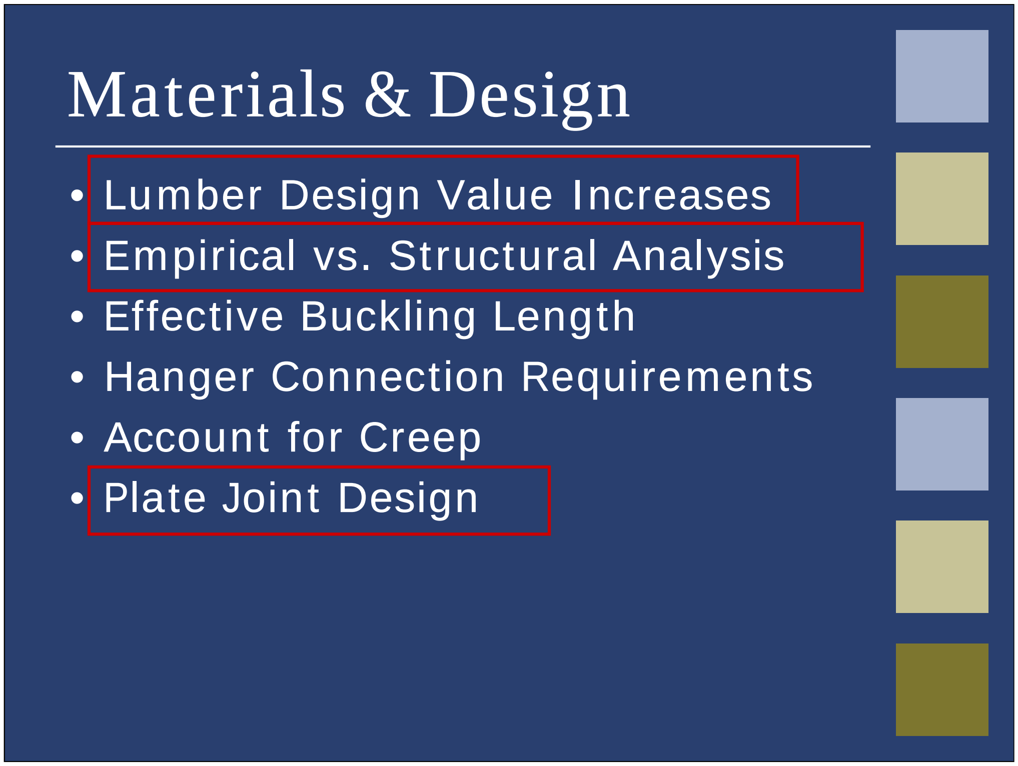
2. Why was In-Plant WTCA QC developed?

WTCA developed this program at the request of its members, who wanted a way to monitor the quality of their manufacturing process. **IN-PLANT WTCA QC** allows users to create detailed charts and reports, so they can get a clear sense for what is happening with their quality. WTCA members also had concerns that the inspection procedures being used by inspection agencies were not always consistent. Thus, WTCA created this program to be very objective, with little room for variation between inspectors.

3. What is the intent of the IN-PLANT WTCA QC program?

The intent of the program is to provide an objective, quantifiable method of assessing a truss manufacturer's conformance to the TPI 1 Quality Standard. This standard is what the ANSI consensus process created and was approved as the quality requirements for all truss manufacturers in this country. In addition, the ANSI/TPI 1 standard is referenced by the International Building Code (IBC). WTCA's role in this is to provide a method to accurately assess conformance to the ANSI/TPI 1 quality standard. WTCA used the quality records gathered over time to create a database of information that was used

WOOD TRUSS COUNCIL OF AMERICA

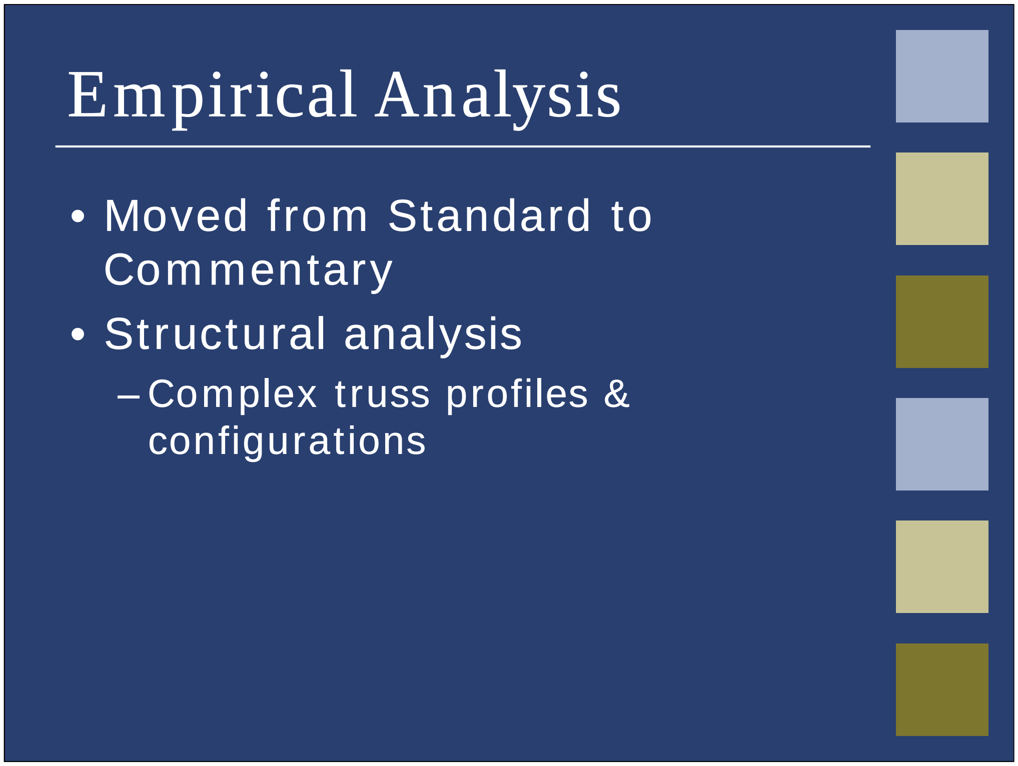


In regard to materials & design there are a number of changes that may have an effect on the cost of a truss:

1. New Repetitive Member Increases will most likely have the most dramatic impact.
2. Changing to a more exact structural analysis rather than Empirical Analysis will have the largest impact on the design of trusses with large chords, like Agricultural trusses.
3. Effective Buckling Length used for web member out-of-plane buckling has been modified.
4. Changes have been made to the hanger connections requirements.
5. The requirement to account for creep in total load deflection calculations has been added.
6. And, in plate joint design a factor has been introduced into the calculation of lateral resistance of truss joints, a new procedure has been introduced to account for the effects of moments, and an additional limitation has been added to the net section check

Increases to Lumber Design Values

- Increases for repetitive member assemblies (6.4.2)
  - 10% increases to compression and tensile allowable stresses
- Specific Gravity Increases (5.2.9.3)
- Removed stipulations on the buckling stiffness factor (6.4.4)
  - Increase E for some 4x2 longer spans
- Special Cases- dry lumber design stresses for green lumber (6.4.12)



The empirical methodology has been moved from the mandatory Standard to the non-mandatory Commentary. For those of you who enjoyed Level II, Section 3, Design Principles, this change only affects the calculation of moments for top and bottom chords – which was three slides in that presentation. These moment calculations now are done within the design software using a more complex methodology.

1. The structural analysis approach recognized by TPI 1-2002 is one in which the truss members are designed to resist forces and bending moments that are determined using a matrix analysis or other accepted structural analysis method that more accurately models the forces in the truss.
2. This change has been driven by the growing complexity of truss profiles and configurations
3. And the difficulty in determining critical bending moments
4. And buckling lengths.

Plate Joint Design

- 8.4.3.1 Lateral resistance
- 8.8 Combined Flexural & Axial Loading
  - section for effect of moment
  - lateral resistance for effect of moment
- 8.9.2 Net Section Check

There are quite a number of changes in Chapter 8, Metal Connector Plate Joint Design:

1. A factor has been introduced into the calculation of lateral resistance of truss joints,
2. New provisions have been added for designing steel plate section for effect of moment . . .And designing plate lateral resistance for effect of moment.
3. And an additional limitation has been added to the net section check to account for "chunk-out" failure.

Lateral Resistance

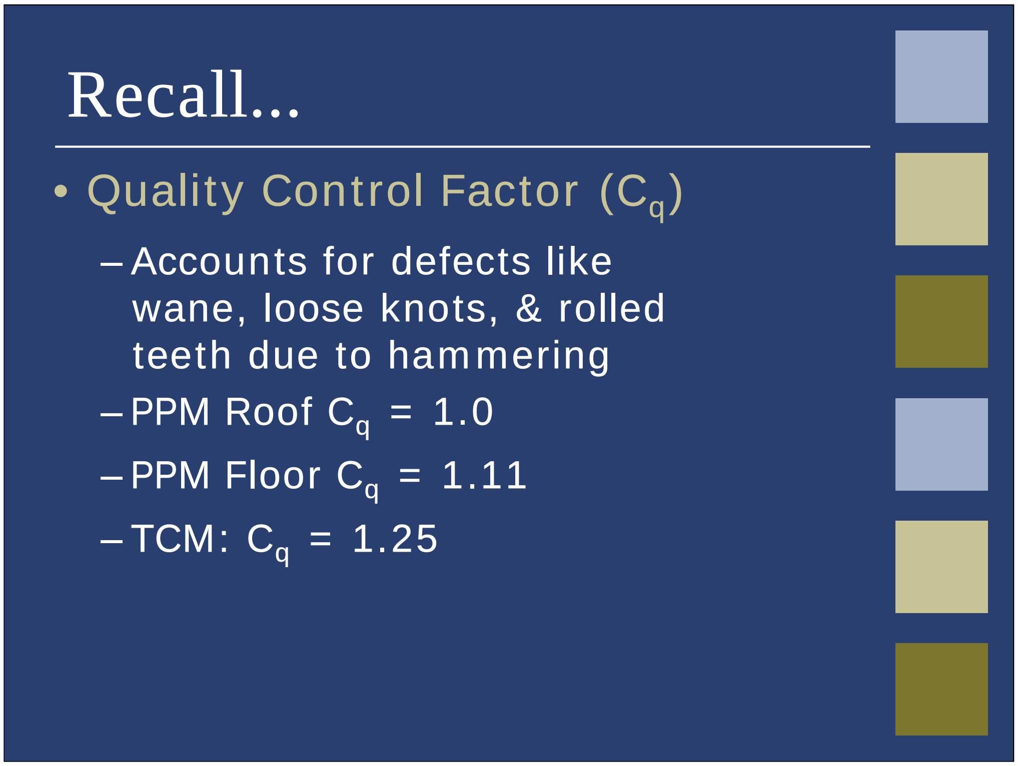
- 8.4.3.1

  $$A_p = P/0.8V_{LR}'$$

- Naturally occurring lumber characteristics or flattened teeth
- Quality Control Factor (6.4.11)
  - C_q = 1.00 $\rightarrow (0.8)(1.00)V_{LR} \rightarrow 0.8\ V_{LR}$
  - C_q = 1.11 $\rightarrow (0.8)(1.11)V_{LR} \rightarrow 0.9\ V_{LR}$
  - C_q = 1.25 $\rightarrow (0.8)(1.25)V_{LR} \rightarrow V_{LR}$

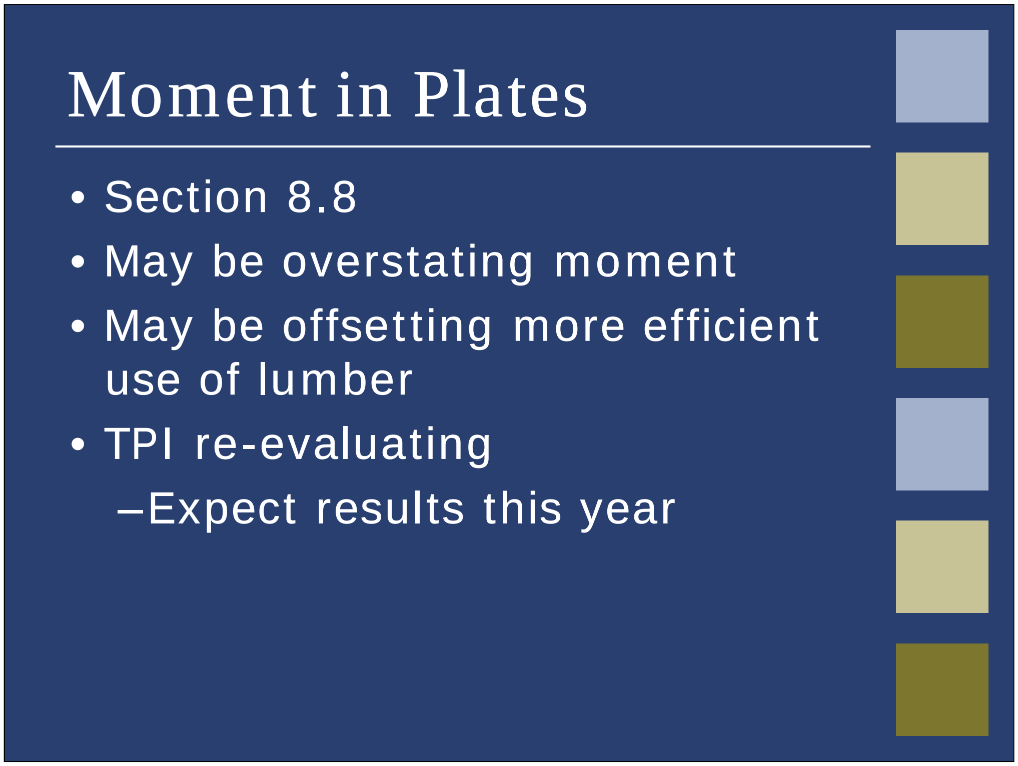
Section 8.4.3.1 introduces a new factor applied to the lateral resistance design value, V_{LR}.

1. A_p is the minimum required metal connector plate contact area for each member, the total area for one face.
2. The reduction is intended to account for locations in the plate contact area that have naturally occurring lumber characteristics, such as knots, wane, etc., which reduce the effectiveness of the plate teeth.
3. If the manufacturing process removes or reduces the probability that this reduction factor is necessary, the Quality Control Factor C_q, as applicable to lateral resistance design values, has been introduced. (see section 6.4.11 for more information).
4. For example, if a C_q of 1.0 is used, the lateral resistance factor remains at 0.8 (20%).
5. If a C_q of 1.11 is used, the lateral resistance factor is reduced to 0.9 (10%).
6. If the maximum Cq of 1.25 is used, the lateral resistance factor is eliminated.



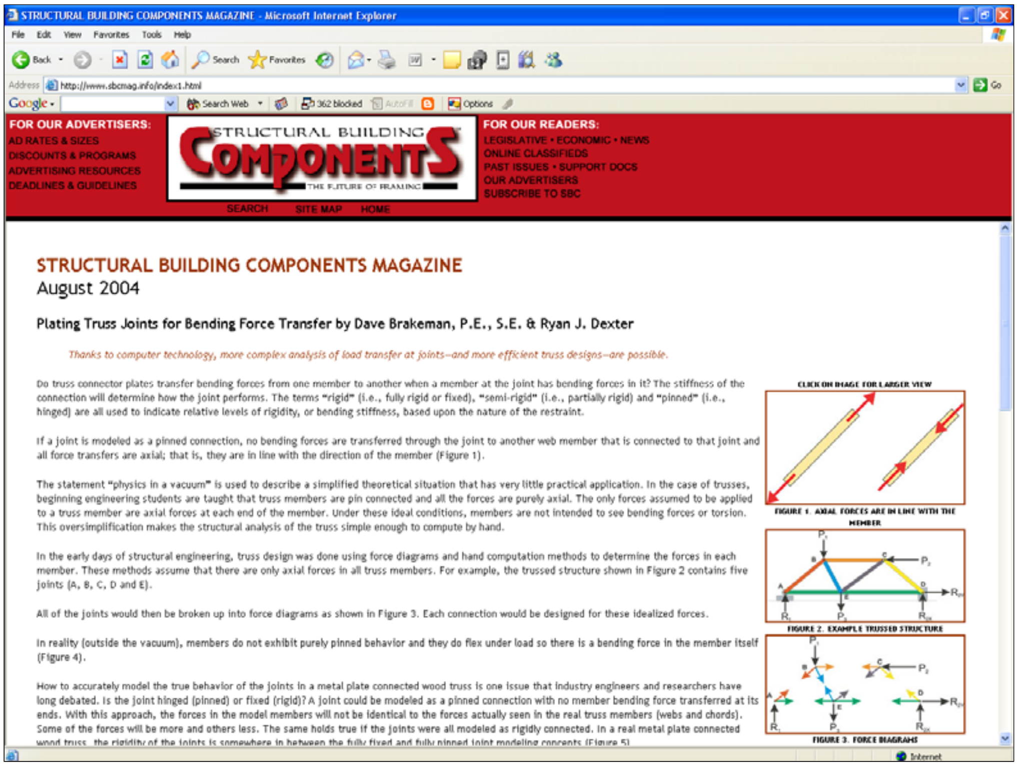
The Cq is the factor in the design equations that accounts for the defect

- This shows that as you lower the tooth holding factor or the ability of the teeth to grab the lumber to take into account defects, your Cq lowers and this results in larger plates. On the flip side, when you have less defects your tooth holding factor will be higher, your Cq will be larger and you will be able to go with smaller plates.



The design to account for moment in metal connector plates was revised in TPI 1-2002.

1. Plate increases are controlled by moment in a significant number of cases. The new method may be overstating the amount of moment that must be dealt with in combination with compression.
2. This plate increase, when or if it occurs, may be offsetting the greater efficiency in the use of lumber introduced in TPI 1-2002.
3. This is currently under evaluation by TPI and an interim methodology may be developed to address this issue.



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August 2004

Plating Truss Joints for Bending Force Transfer by Dave Brakeman, P.E., S.E. & Ryan J. Dexter

Thanks to computer technology, more complex analysis of load transfer at joints—and more efficient truss designs—are possible.

Do truss connector plates transfer bending forces from one member to another when a member at the joint has bending forces in it? The stiffness of the connection will determine how the joint performs. The terms "rigid" (i.e., fully rigid or fixed), "semi-rigid" (i.e., partially rigid) and "pinned" (i.e., hinged) are all used to indicate relative levels of rigidity, or bending stiffness, based upon the nature of the restraint.

If a joint is modeled as a pinned connection, no bending forces are transferred through the joint to another web member that is connected to that joint and all force transfers are axial; that is, they are in line with the direction of the member (Figure 1).

The statement "physics in a vacuum" is used to describe a simplified theoretical situation that has very little practical application. In the case of trusses, beginning engineering students are taught that truss members are pin connected and all the forces are purely axial. The only forces assumed to be applied to a truss member are axial forces at each end of the member. Under these ideal conditions, members are not intended to see bending forces or torsion. This oversimplification makes the structural analysis of the truss simple enough to compute by hand.

In the early days of structural engineering, truss design was done using force diagrams and hand computation methods to determine the forces in each member. These methods assume that there are only axial forces in all truss members. For example, the trussed structure shown in Figure 2 contains five joints (A, B, C, D and E).

All of the joints would then be broken up into force diagrams as shown in Figure 3. Each connection would be designed for these idealized forces.

In reality (outside the vacuum), members do not exhibit purely pinned behavior and they do flex under load so there is a bending force in the member itself (Figure 4).

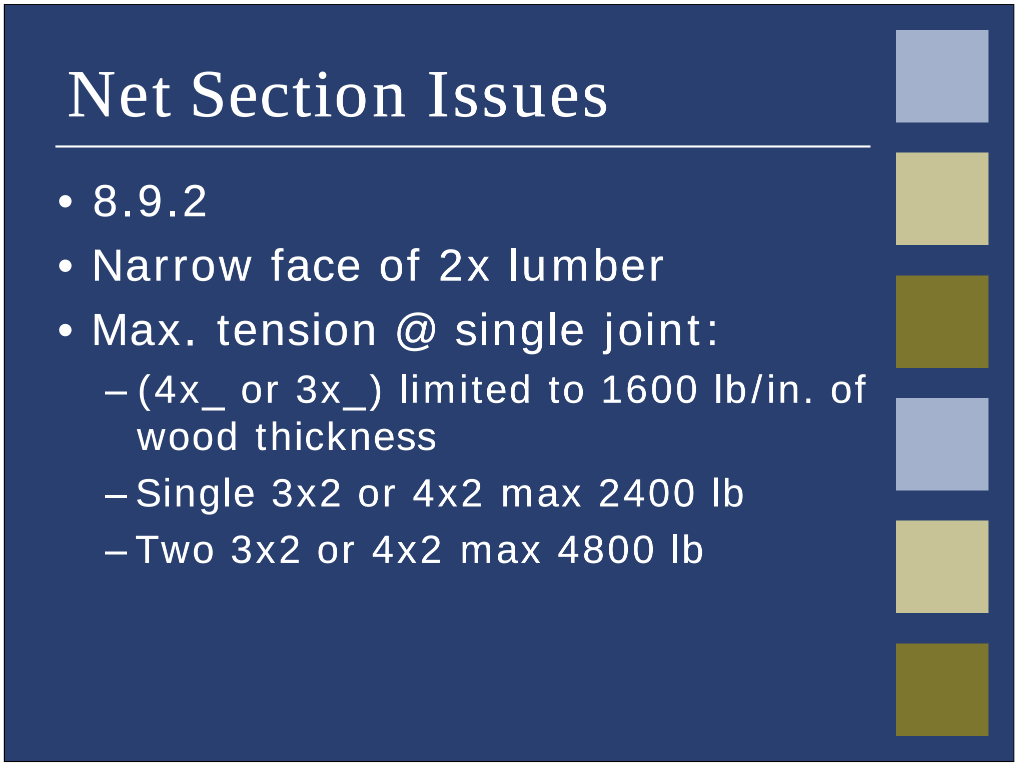
How to accurately model the true behavior of the joints in a metal plate connected wood truss is one issue that industry engineers and researchers have long debated. Is the joint hinged (pinned) or fixed (rigid)? A joint could be modeled as a pinned connection with no member bending force transferred at its ends. With this approach, the forces in the model members will not be identical to the forces actually seen in the real truss members (webs and chords). Some of the forces will be more and others less. The same holds true if the joints were all modeled as rigidly connected. In a real metal plate connected wood truss, the rigidity of the joints is somewhere in between the fully fixed and fully pinned joint modeling concepts (Figure 5)

CLICK ON IMAGE FOR LARGER VIEW

FIGURE 1. AXIAL FORCES ARE IN LINE WITH THE MEMBER

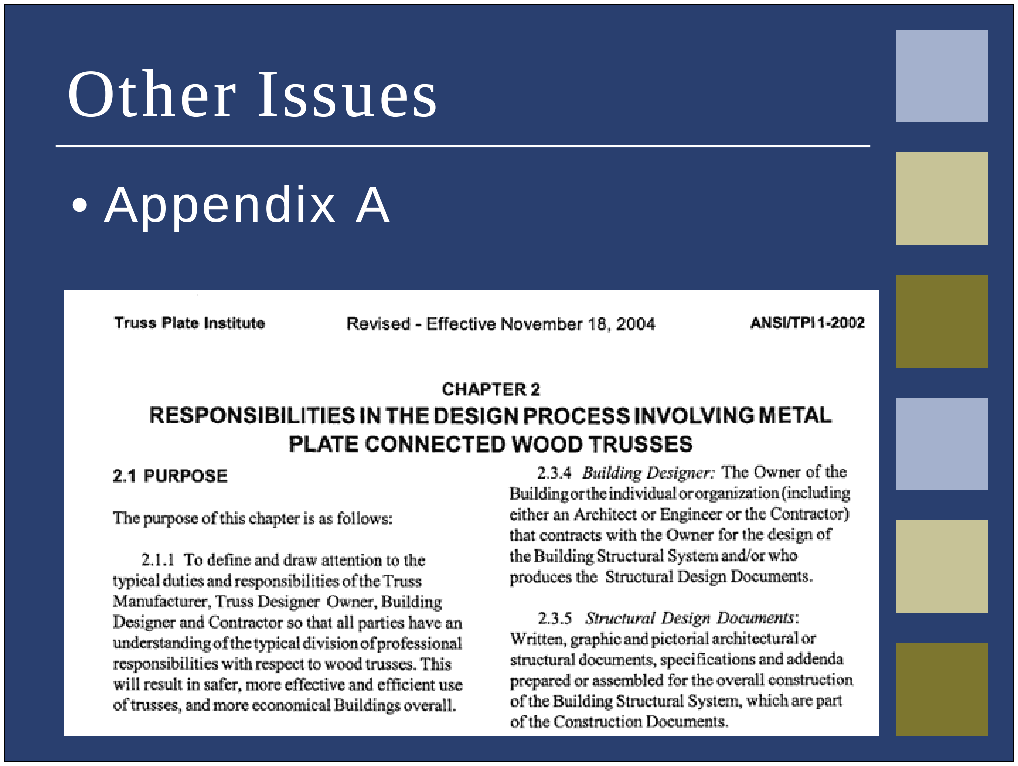
FIGURE 2. EXAMPLE TRUSSED STRUCTURE

FIGURE 3. FORCE DIAGRAMS



Section 8.9.2 has been added to the net section lumber check evaluation for a very specific condition:

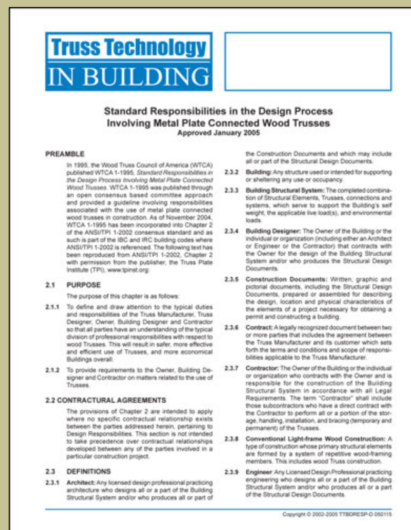
1. When plating on the narrow face of 2x lumber, testing has shown that there can be premature wood fractures if there happens to be a knot or grain deviation near the plate.
2. So the maximum tension at a single joint is now limited to 1600 pounds per inch of wood thickness:
3. For example: 2400 pounds for a single 3x2 or a 4x2,
4. And 4800 pounds for two 3x2s or two 4x2s



ANSI/TPI/WTCA 4 was included as an Appendix to TPI 1-2002.

1. Work has been completed to integrate it directly into Chapter 2 of TPI 1-2002.

TPI 1-2002 Chapter 2



Truss Technology IN BUILDING

Standard Responsibilities in the Design Process Involving Metal Plate Connected Wood Trusses
Approved January 2005

PREAMBLE

In 1995, the Wood Truss Council of America (WTCA) published WTCA 1-1995, *Standard Responsibilities in the Design Process Involving Metal Plate Connected Wood Trusses*. WTCA 1-1995 was published through an open consensus based committee approach and provided a guideline involving responsibilities associated with the use of metal plate connected wood trusses in construction. As of November 2004, WTCA 1-1995 has been incorporated into Chapter 2 of the ANSI/TPI 1-2002 consensus standard and as such is part of the IBC and IRC building codes where ANSI/TPI 1-2002 is referenced. The following text has been reproduced from ANSI/TPI 1-2002, Chapter 2 with permission from the publisher, the Truss Plate Institute (TPI), www.tpinst.org:

2.1 PURPOSE

The purpose of this chapter is as follows:

2.1.1 To define and draw attention to the typical duties and responsibilities of the Truss Manufacturer, Truss Designer, Owner, Building Designer and Contractor so that all parties have an understanding of the typical division of professional responsibilities with respect to wood Trusses. This will result in safer, more effective and efficient use of Trusses, and more economical Buildings overall.

2.1.2 To provide requirements to the Owner, Building Designer and Contractor on matters related to the use of Trusses.

2.2 CONTRACTURAL AGREEMENTS

The provisions of Chapter 2 are intended to apply where no specific contractual relationship exists between the parties addressed herein, pertaining to Design Responsibilities. This section is not intended to take precedence over contractual relationships developed between any of the parties involved in a particular construction project.

2.3 DEFINITIONS

2.3.1 **Architect:** Any licensed design professional practicing architecture who designs all or a part of the Building Structural System and/or who produces all or part of the Construction Documents and which may include all or part of the Structural Design Documents.

2.3.2 **Building:** Any structure used or intended for supporting or sheltering any use or occupancy.

2.3.3 **Building Structural System:** The completed combination of Structural Elements, Trusses, connections and systems, which serve to support the Building's self weight, the applicable live load(s), and environmental loads.

2.3.4 **Building Designer:** The Owner of the Building or the individual or organization (including either an Architect or Engineer or the Contractor) that contracts with the Owner for the design of the Building Structural System and/or who produces the Structural Design Documents.

2.3.5 **Construction Documents:** Written, graphic and pictorial documents, including the Structural Design Documents, prepared or assembled for describing the design, location and physical characteristics of the elements of a project necessary for obtaining a permit and constructing a building.

2.3.6 **Contract:** A legally recognized document between two or more parties that includes the agreement between the Truss Manufacturer and its customer which sets forth the terms and conditions and scope of responsibilities applicable to the Truss Manufacturer.

2.3.7 **Contractor:** The Owner of the Building or the individual or organization who contracts with the Owner and is responsible for the construction of the Building Structural System in accordance with all Legal Requirements. The term "Contractor" shall include those subcontractors who have a direct contract with the Contractor to perform all or a portion of the storage, handling, installation, and bracing (temporary and permanent) of the Trusses.

2.3.8 **Conventional Light-frame Wood Construction:** A type of construction whose primary structural elements are formed by a system of repetitive wood-framing members. This includes wood Truss construction.

2.3.9 **Engineer:** Any Licensed Design Professional practicing engineering who designs all or a part of the Building Structural System and/or who produces all or a part of the Structural Design Documents.

Questions