Design Responsibilities for Metal-Plate-Connected Wood Truss Building Construction

By Frank Woeste, P.E., Ph.D. and Don Bender, P.E., Ph.D.

ANSI/TPI 1-2007 will be the referenced standard for metal-plate-connected (MPC) wood trusses in the new 2009 *International Residential Code*® (IRC) and *International Building Code*® (IBC). In Chapter 2 of ANSI/TPI 1-2007, the responsibilities in the design and application of MPC wood trusses have been defined for the Owner, Registered Design Professional (RDP), Contractor, Truss Designer, and Truss Manufacturer. While some responsibilities defined by the new ANSI/TPI 1-2007 standard overlap responsibilities defined by previous editions of ANSI/TPI 1, the new Chapter 2, *Standard Responsibilities in the Design and Application of MPC Wood Trusses*, addresses additional issues and information valuable to all parties involved in MPC wood truss construction.

This article reviews important content of ANSI/TPI 1-2007 with respect to responsibilities when metal-plate-connected trusses are utilized, and provides discussion and background on several topics in Sections 2.3 of the standard on Owner and RDP design responsibilities. The discussion presented should be viewed only as a starting point for learning the responsibilities of the RDP when utilizing MPC wood trusses – all RDPs are strongly encouraged to purchase a complete copy of ANSI/TPI 1-2007 standard for study and familiarity. Copies are available at the TPI website: **www.tpinst.org/publication-tpi1.html#TPI12007**.

New Format Clarifies Responsibilities

Early versions of Chapter 2 of ANSI/TPI 1, such as 2002, did not differentiate between cases involving MPC truss applications where the building code and other legal requirements required the work of an RDP verses cases when an RDP was not mandated by the building code and other legal requirements. The format of the new 2007 standard has two sections that define responsibilities when an RDP is mandated (Section 2.3) and when an RDP is not mandated (Section 2.4). This distinction is valuable because, in some past construction cases, all of the necessary steps for a successful truss design and installation were not executed by all parties involved. The remainder of this article is limited to discussion of Section 2.3 of ANSI/TPI1. However, Plan Reviewers and jurisdictions are encouraged to carefully review all sections of Chapter 2, as the code enforcement community can help educate and enforce applicable provisions of their codes and the referenced MPC truss standard.

Responsibilities where the Legal Requirements Mandate a Registered Design Professional for Buildings (Section 2.3 of ANSI/TPI 1)

In preparation for specifying MPC wood trusses, every section of Chapter 2 and ANSI/TPI 1-2007 standard should be carefully studied by the RDP. In preparing this article, we assumed that the RDP will view a complete copy of Chapter 2 for a full understanding. Specific sections selected for discussion are cited by paragraph and subparagraph numbers.

Under Section **2.3.1 Requirements of the Owner**, we note three sections that can help prevent truss erection accidents, and in some cases improve in-service truss performance. Over the past two decades, industry safety documents recommended that for truss spans over 60 feet, the Contractor should "See a registered professional engineer" for temporary bracing information. In many cases, Erection Contractors failed to follow the advice, and some accidents and performance problems stemmed from inadequate temporary and permanent bracing. The new ANSI/TPI 1 standard now requires action by the Owner and RDP as given in the following paragraphs:

2.3.1.6 Long Span Truss Requirements.

2.3.1.6.1 Restraint/Bracing Design.
In all cases where a Truss clear span is 60 feet (18m) or greater, the Owner shall contract with any Registered Design Professional for the design of the Temporary Installation Restraint/Bracing and the Permanent Individual Truss Member Restraint and Diagonal Bracing.

2.3.1.6.2 Special Inspection
In all cases where a Truss clear span is 60 feet (18m) or greater, the Owner shall contract with any Registered Design Professional to provide special inspections to assure that the Temporary Installation Restraint/Bracing and the Permanent Individual Truss Member Restraint and Diagonal Bracing are installed properly."

The importance of these new paragraphs to truss safety and reliability cannot be overstated. When executed by the Owner and RDP, these provisions for long span trusses should be effective in preventing truss erection accidents and ensuring in-service truss performance.

Section **2.3.2.4 Required Information in the Construction Documents** is to be executed by the RDP. It contains a list of subjects from (a) to (h) with numbered subsections. Our comments follow on some subjects and subsection numbers:

2.3.2.4 (c) – The RDP is also required to specify the allowable bearing stresses for the bearing material. In the past, required truss bearing length was calculated using the bearing allowable stress for the truss lumber species or species group. This change was necessary because it is common for the top wall plate to have a lower bearing value than the bearing value of the truss lumber. For example, 2x_ No.2 Southern Pine has a tabulated perpendicular-to-grain bearing value, $F_{c\perp}$, of 565 psi whereas Spruce-Pine-Fir (SPF) has a tabulated $F_{c\perp}$ value of 425 psi. (SPF-South has a perpendicular-to-grain bearing value of 335 psi.) With the added information from the RDP, the Truss Design Engineer can calculate the required bearing length using the lower $F_{c\perp}$ value for the truss bearing chord and bearing support location.

2.3.2.4 (g) – This paragraph requires the RDP to design the permanent truss bracing for the roof or floor truss system with needed connections to the building for a completed load path. In the past, this requirement has not always been met by the RDP. A sample of problem areas are truss webs not laterally braced as required by the truss design drawings, truss web lateral bracing not restrained by needed diagonal bracing in the plane of the webs, compression top chords under valley sets not laterally braced, compression top chords insufficiently braced by purlins without adequate sheathing stiffness and strength, and the compression top chord of the supporting truss of a piggyback truss system not laterally braced/restrained. For calculating lateral bracing forces for compression webs or chords with one or more continuous lateral brace, the reader is referred to Underwood et al. (2001).

Regarding **2.3.2.4, (h) Criteria related to serviceability issues**, subsection (2) addresses dead and live loads and associated "creep deflection" for flat roofs (meaning slope of 1:48) subject to ponding action. The subject of creep deflection for wood beams and truss components is both important and difficult to predict. Section 7.6.1 of Chapter 7 requires time dependent or creep deflection to be included in the total deflection calculation for MPC trusses. The creep factors given, 1.5 for dry lumber and 2.0 for green or wet service conditions, match the equation for solid-sawn lumber in the ANSI/AF&PA NDS-2005 and may not be adequate for a truss with metal-plate-connected joints.

The first step in evaluating the protection afforded by the 7.6.1 total deflection equation is to realize that some snow loads in northern climates and other roof loads can be "sustained." Some floor live loads can also be "sustained." For example, a large piano rested primarily on two floor trusses is technically a "live load", however, with respect to creep deflection it most likely acts as a "sustained load" and its contribution to total deflection should be considered in design specifications. While long term studies of parallel chord MPC roof trusses have not been reported in the literature, a long term deflection study of 4x2 floor trusses was conducted by Percival and Suddarth (1989) and it provides valuable data on the performance of 4x2 floor trusses over a 10-year test period.

The ANSI/TPI 1-2007 *Commentary & Appendices* provides discussion and recommendations on the creep deflection issue. After some discussion of research on the subject, the ANSI/TPI 1-2007 Commentary *recommends* a *minimum* creep factor adjustment for a total dead load of 25 psf or greater:

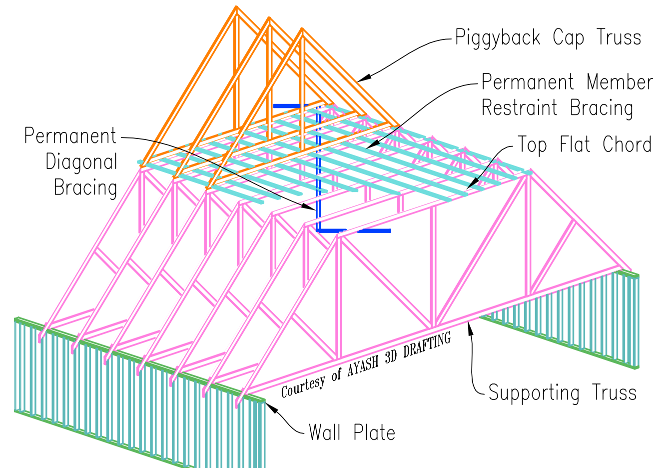
> *For floor truss applications with a total dead load of 25 psf or greater where the Registered Design Professional for the Building or the Building Designer does not specify adjustment factors for serviceability issues (per Sections 2.3.2.4(h)(5) or Section 2.4.2.4(h)(5), respectively), a creep factor, K_{cr}, of 2.0 is recommended as a minimum adjustment in lieu of the 1.5 factor for season lumber used in dry conditions.*

It should be noted that the use of 2.0 versus 1.5 is a recommendation only. Without a specification by the RDP, a higher creep factor may not be used, or is not required, in a floor truss design. Assuming the RDP determines that a specific load is "sustained" to the extent it is likely to produce significant creep deflection and selects a creep factor greater than 1.5, the "sustained load" should be added to the technical "dead load" specification so that the specified creep factor can be applied to the total of the sustained load and dead load.

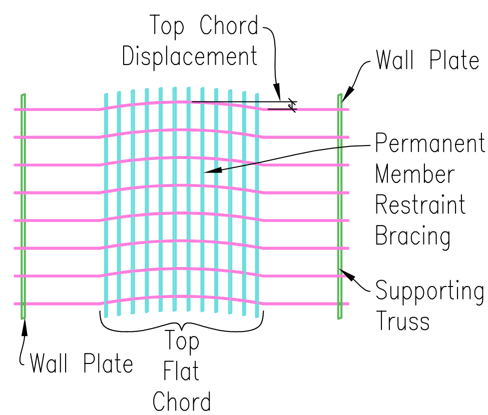
In the case of parallel chord roof trusses, the specification of a creep factor greater than 1.5 should be considered as the total dead plus sustained load can easily be greater than 25 psf. With respect to, stone ballast (even though it is not attached to the roof) and HVAC units, both are a sustained loading and will contribute to creep deflection of a truss.

Regarding **2.3.2.4, (h) Criteria related to serviceability issues**, subsection (5)(a) on strongback bridging, strongbacks in floor trusses are extremely effective in minimizing annoying floor vibrations. Research at Virginia Tech University on full-scale truss floors with 23/32-inch rated sheathing, glued and screwed, demonstrated that properly installed 2x6 strongbacks distributed 50-percent of an applied concentrated load to neighboring trusses. With the strongback installed, the *apparent* stiffness of the loaded truss was doubled thus raising the frequency of vibration to undetectable levels by an observer. Strongbacks are not required by the ANSI/TPI 1 standard; however, when specified by the RDP, Section **7.6.2.4 Strongbacking** applies to the installation. A good option to three nails cited in paragraph 7.6.2.4 (a) is the use of screws, such as the ¼-inch SDS screw by Simpson Strong-Tie®.

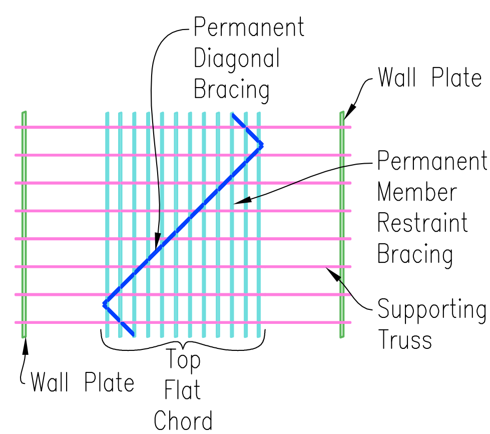
Subsection (5)(b) addresses design loads and creep deflection criteria for floor trusses supporting stone or ceramic tile finishes. Creep deflection, previously discussed, can be an issue with respect to the performance of floor trusses supporting stone or ceramic tile. In the advent of increased use of stone and ceramic tile, it is important for the dead and live design loads for the completed floor to be communicated to the affected parties through the Construction Documents. For a typical residential carpeted or hardwood finish floor, designers often use a 40-10-0-5 (top chord live, top chord dead, bottom chord live, bottom chord dead) load specification. The "carpeted floor" load specification may be woefully inadequate for some ceramic tile installation methods.



Piggyback top flat-chord bracing required by RDP.



A buckled flat-chord without diagonal bracing.



A flat-chord stabalized with permanent bracing.

To assess and specify an adequate top chord dead load for a ceramic tile installation, the RDP must first determine which "installation method" will be used for the tile installation which also determines the maximum truss spacing. This step may require coordination with the Building Designer and Tile Contractor. Industry recognized methods are contained in the 2008 TCA *Handbook for Ceramic Tile Installation* (**www.tileusa.com/publication_main.htm**).

The total weight or dead load of some typical installation methods are given in Table 1 of this publication: **www.iccsafe.org/news/bsj/1207_Wood%20Bits.pdf**.

The total weight of eight installation methods ranges from 5.7 to 29.3 psf. When the installation method weight is combined with the weight of the top chord and webs (about ½ total truss weight), the requisite subfloor, the *top chord dead load* will generally exceed 10 psf. Based on Table 2 for the case of solid-sawn joists with ceiling drywall, the total design dead load ranged from 15.4 psf to 39.4 psf.

In addition to the uniform load specification, concentrated loads may be present and should be included. The RDP should specify (as a minimum) the maximum permitted joist spacing, and the allowable live and dead load deflection limits for the truss design. The impact of creep deflection on ceramic tile installation performance should be considered by the RDP when specifying floor trusses. Please recall that the ANSI/TPI 1 Commentary recommends a *minimum* creep factor of 2.0 for dead total dead loads of 25 psf or greater.

Concluding Remarks

ANSI/TPI 1-2007 is a referenced standard in the 2009 IRC and IBC. Preparing yourself as an RDP for the implementation of ANSI/TPI 1-2007 before localities adopt the 2009 I-Codes may require substantial study. A review of page 3 of the 2007 Commentary is recommended to get a feel for the extent of non-editorial changes to Chapter 2 requirements on design responsibilities from the previous edition of ANSI/TPI 1 (2002). The 134-page Commentary and Appendices is available free on the web for review: **www.tpinst.org/TPI1-2007_Commentary-Appendices_web.pdf**.▪

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