LGSEA

Newsletter for the

Light Gauge Steel Engineers Association

Spring 2002

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Upcoming Events

Pacific Coast Builders Conference — June 26-28
San Francisco, CA
Info: (916) 325-9300
www.PCBC.com

Construction Specifications Institute — Exhibit: June 27-29; Conv.: June 27-30
Las Vegas, NV
Info: 1-800-689-2900
www.csinet.org

LGSEA Committee Meetings — June 29
Las Vegas, NV
Info: (202) 263-4488
www.LGSEA.com

METALCON — Oct 1-3
Rosemont, IL
Info.: (617) 965-0055
www.metalcon@psmj.com

SEMINARS: Practical Design of Cold-Formed Steel Structures 2002

Phoenix, AZ	Aug 1
Los Angeles	Aug 2
AISI Specification - Aug 3	
San Francisco, CA	Aug 5
Seattle, WA	Aug 6
Chicago, IL	Sep 30
Atlanta, GA	Dec 4
Charlotte, NC	Dec 5
Orlando, FL	Dec 6

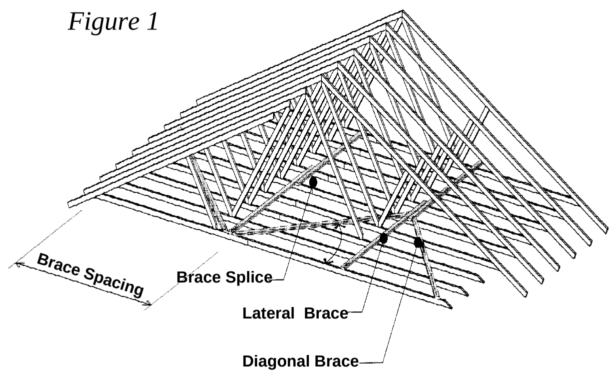
Info: (202) 263-4488
- A registration form can be downloaded from www.LGSEA.com -

Design Guidelines for Bracing of Steel Trusses

by Bill Babich, P. E., Alpine Engineered Products, Haines City, FL
Don Allen, P. E., Starzer Brady Fagan Associates, Atlanta, GA

Bracing of trusses and truss systems can be complex, and is ignored by design professionals. Many of today's engineers rely on component manufacturers to give guidance on bracing of truss systems, both steel and wood. The LGSEA, as well as the Steel Truss and Component Association (STCA) and American Iron and Steel Institute (AISI), have some resources available giving some general guidelines. However, the engineer of record is ultimately responsible for the design of the structure, and therefore needs to confirm that bracing design has been adequately addressed.

Figure 1



Why is Bracing Required?

There are several reasons for truss bracing in a roof or floor structure. During construction, before all of the components of a truss system are in place, bracing acts to hold members upright, straight, and in place. This "temporary bracing" typically may not be the responsibility of the structural engineer. However, contractor clients may hire the engineer or component manufacturer to design this temporary bracing, since it can be very costly and dangerous if improperly addressed.

Truss bracing also acts to transfer loads to other parts of the structure that can better resist these loads. Often, a single truss or truss member cannot take certain

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Evaluation Services to be Combined

The International Code Council (ICC) has announced plans to consolidate the evaluation services offered by or on behalf of the Building Officials and Code Administrators International, Inc. (BOCA), International Conference of Building Officials (ICBO), Southern Building Code Congress International (SBCCI), and National Evaluation Service, Inc. (NES). By January 1, 2003, in conjunction with the planned consolidation of the model code organizations (BOCA, ICBO, and SBCCI) as the ICC, the evaluation services that are currently offered separately by BOCA, ICBO-ES, SBCCI PST&ES, and NES will be combined into a single program.

This "one evaluation" concept is in line with the one-code interests of code enforcement officials and the building industry, and also creates opportunities for testing laboratories, quality assurance agencies and building technologies to receive national acceptance. This may also prove beneficial to steel framing, where new technologies are introduced as the industry grows, and established products are adapted for new markets.

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Truss Bracing

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loads by themselves; the bracing helps redistribute the load over multiple trusses or to stiffer supports. For individual truss members, if the axial load is too high for a given Kl/r, weak axis bracing can reduce the effective length and increase member capacity. Bottom chord bracing, even in conditions where the bottom chord remains in tension, can help increase truss web member capacity. If the bottom chord is left unbraced, axial compression in web members can produce a horizontal force at the bottom chord, especially with back-to-back (offset) web members. If this force is not braced, the effective K value for the compression web could be considered to be as much as 2, which may greatly reduce this member's load carrying capacity. Bottom chord bracing is also required where wind uplift loads create bottom chord axial compression. Although this may not be the governing load condition, even small amounts of axial compression can result in failure of long, unbraced members. A good rule of thumb is to follow the bracing requirements found in the LGSEA Technical Note *"Field Installation Guide for Cold-Formed Steel Trusses"* or brace the truss chords at each panel point.

Ways to accomplish truss bracing

There are two general categories of bracing: Temporary bracing and permanent bracing.

Temporary bracing is covered in LGSEA Tech Note 551d: *Design Guide for Construction Bracing of Cold-Formed Steel Trusses*. This is the bracing placed in the trusses at the time of truss erection. Temporary bracing can double as permanent bracing, because it is often left in the structure and not removed. It may also be used to facilitate erection, such as the different stresses placed on trusses and truss components during lifting or staging. Often, several trusses or even an entire section of roof or floor may be braced together and lifted in place. Temporary bracing may be used to help accomplish this. The LGSEA *Field Installation Guide – Trusses* also gives some guidance on temporary bracing configuration and location.

Permanent bracing is covered in LGSEA Tech Note 551e: *Design Guide for Permanent Bracing of Cold-Formed Steel Trusses*. This is bracing that is required to stay in the truss system for the duration of the life of the structure. Permanent bracing helps resist the long and short-term loading and load combinations specified in the building codes.

Sheathing is an important component of the roof truss permanent bracing system. It is typically attached directly to the top of the top chord members, and is sometimes used as part of the roof or floor diaphragm. Sheathing or decking may be considered as individual member bracing, if the top chord members are relatively shallow.

Occasionally, sheathing is not attached directly to the truss members. Often, "Z" or "F" (furring) members are used where sheathing cannot span the distance between trusses. These furring members may be designed as bracing members. The designer must include both the bending loads induced by the sheathing, as well as the axial loads from the member brace force. With piggyback trusses or overbuilt trusses or rafters, some portions of the top chord are not immediately adjacent to the roof deck or sheathing. Nonetheless, these chord members may experience high axial loads. The designer must ensure that sheathing, furring, or other members are used below piggyback trusses and below overbuilt rafters, or design their truss top chords with longer unbraced lengths in these areas.

How to Brace Truss Systems

Entire manuals and chapters have been written on truss system bracing; here is a summary of some of the truss bracing options available to the designer. LGSEA Technical Note 551g, due out Fall 2002, provides additional guidance, equations, and a method for designing system bracing. The following is an overview of the factors that need to be taken into consideration.

Lateral Braces are braces between

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Truss Bracing

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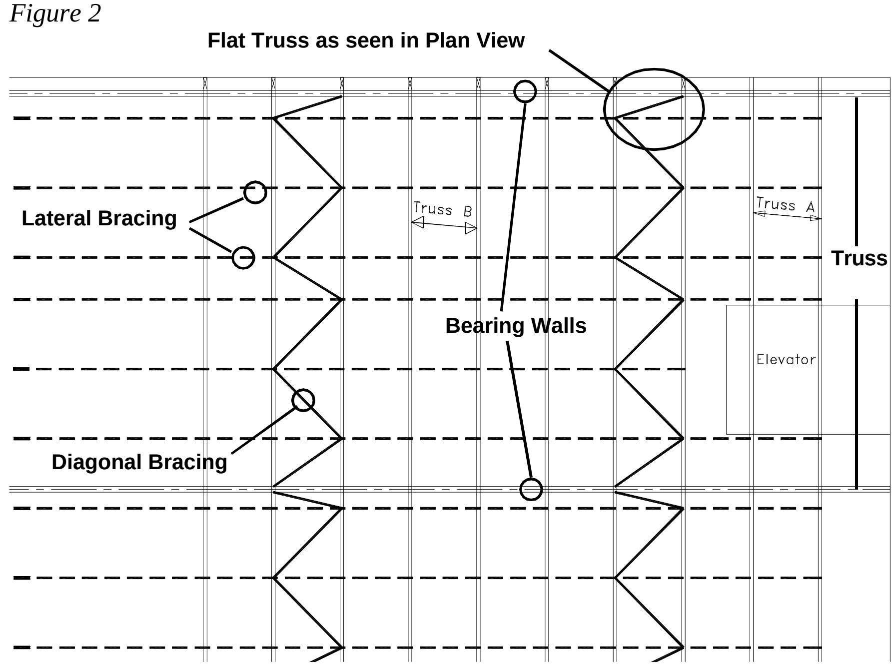
chords or webs of adjacent trusses. These are typically perpendicular to the plane of the chord or web, and with C-shaped, angle, or tube shaped web members, can be attached directly to the flanges of adjacent truss members. Lining up the truss webs can make the bracing installer's job much easier.

Diagonal Braces are braces placed between lateral braces, in the same plane, and between chords and webs of trusses. Diagonal braces may also be termed as X-bracing or cross bracing, because of their appearance within the structure. As seen in plan, diagonal braces act as a sort of "flat truss," transferring loads from the lateral braces to adjacent walls or adjacent drag struts. Individual chords of adjacent trusses may become a part of this diagonal brace flat truss system. If this is the case, these trusses must be designed for the added bracing loads, as well as the typical load combinations from applied loads.

Layout for Diagonal Bracing (plan view)

Figure 2



Bridging is a brace between the top chord of one truss to the bottom chord of an adjacent truss. Bridging may also extend from a location of web bracing to a roof or ceiling diaphragm (shown in LGSEA Technical Note 551e as Figure 2). Truss bracing is also shown in isometric view in Figure 1.

Blocking may be a part of the truss bracing system, but more likely may be used to transfer lateral diaphragm loads from the sheathing or roof deck down to the shear wall or drag strut below. Blocking may be accomplished using diagonal straps (Figure 3a), using a brake shape (Figure 3b), or using an actual truss (Figure 3c) to transfer these loads.

Sway braces are diagonal braces installed to avoid truss tipping. These are typically temporary construction bracing; follow the guidelines of Technical Note 551d and *"Field Installation Guide for Cold-Formed Steel Trusses."*

Design of the individual braces can be daunting and complex. However, using some simple guidelines can greatly ease the task. Tech Note 551e states, "The design should be performed using a minimum of 2 percent of the full member axial forces. There are some other sources (listed in sidebar or table) that give varying other data for brace force design. It is the responsibility of the designer which source to use and what assumptions are made about the rigidity of supports and of the system. Tech Note 551e gives an excellent example of brace design.

Design Responsibility

An issue that is still often hotly debated is the question of who designs the bracing, and who is ultimately responsible. As

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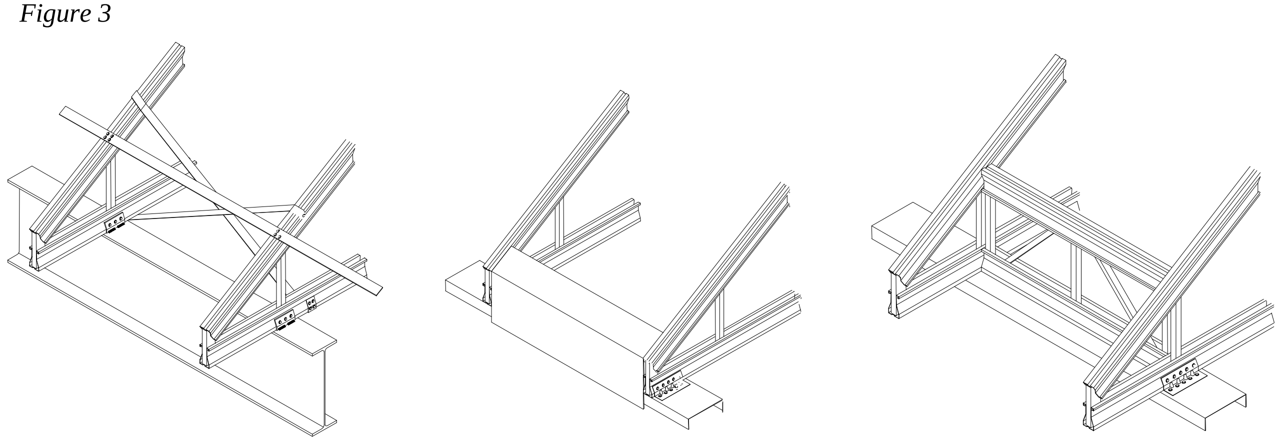
Figure 3



3a. Flat straps on beam **3b. Cold-formed steel brake shape** **3c. Truss as blocking**

TECHNICAL EXCHANGE

The Light Gauge Steel Engineers Association needs you and your experience. Please mail or fax your opinions, questions, and design details that are relevant to the cold-formed steel industry (fax to Dean Peyton at (253) 941-9939). Upon editorial review, your submission may be printed in the Technical Exchange Section of this Newsletter.

Suggested Design of Cold-Formed Steel Clip Angles for Tension

By John C. Lyons, P.E., Walter P. Moore and Associates
Rahim A. Zadeh, P.E., Unimast Incorporated

Cold-formed steel clip angles are commonly used to attach members such as trusses, studs and kickers to supporting structures. In addition to carrying shear load, these connectors often are required to carry tension loads. The most common fasteners for clip angles are powder actuated fasteners, self-drilling screws, masonry screws or small diameter expansion anchors. Determining the tension capacity of such a connection requires a careful examination of the behavior of the connection.

There are four modes of failure for a clip angle in tension:
1. Excessive Deformation of the clip angle.
2. Yielding of the clip angle in bending.
3. Pull-out Failure of the Fasteners.
4. Pull-over of the steel sheet over the heads of the fasteners.

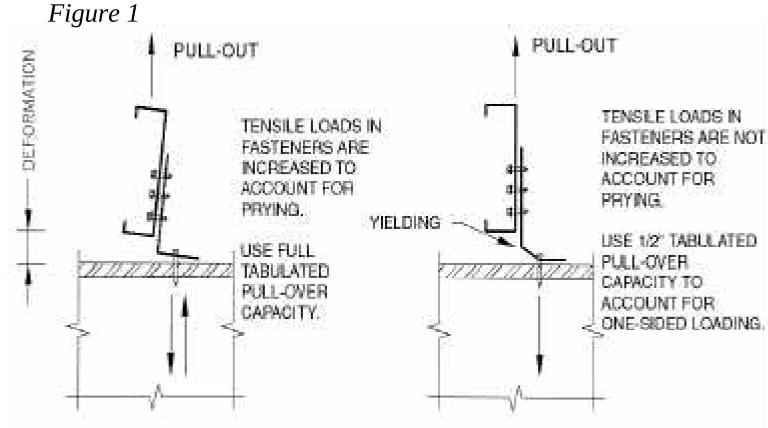
The first two failure modes are relatively straightforward. The others depend upon the how the clip angle deforms under load and re-distributes forces within the connection. The degree of angle flexibility results in two different failure mechanisms.

In the "prying case" the clip angle is stiffer than the unfolding case. The clip will tend to rotate as a unit about the edge of the clip angle as shown in Figure 1, causing the tensile forces in the fastener and the surrounding sheet to be magnified. Full pull-over resistance would be mobilized around the full perimeter of the fastener head.

In the "unfolding case", the clip angle is more flexible. The clip will tend to unfold at the corner, in which case there would be no magnified fastener forces due to prying. The load at the head of the fastener, however, would be resisted on one side only. Therefore only half of the sheet pull-over capacity may be used.

Clip Angle Failure Modes

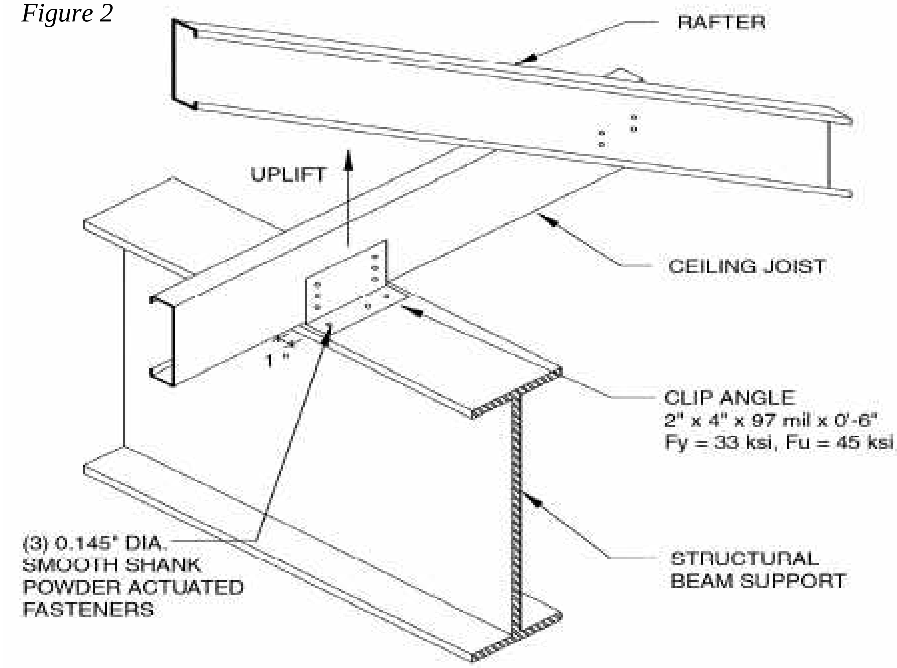
Figure 1



Prying-Action Case **Unfolding Case**

Example - Clip Angle in Uplift

Figure 2



Note that the tensile capacity of fastener attached clip angles is relatively small. If greater capacity is required, there are several tips to increase capacity:
1. Place fasteners close to the angle bend. Doing so minimizes the bending length of the angle. However, because screw-guns and powder actuated tools require a minimum entering clearance, it may not be practical to install fasteners closer

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Clip Angle Design

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than 1" from the angle bend.

2. Use larger-head fasteners (1/2" max., per AISI, Sec. E4.4.2). Doing so reduces the bending length and increases the pull-over strength. Some powder-actuated fasteners have integral washers.
3. Use fasteners with high tensile capacity. Although smooth-shank powder actuated fasteners are more commonly used, knurled shank fasteners provide greater tensile capacity. Self-drilling screws provide superior capacity and can drill though up to ½" of structural steel plate.
4. Use a proprietary clips. Some manufacturers produce clips with stiffeners that provide greater resistance to unfolding. Prying failure of the fasteners should still be checked.
5. Welding along the angle bend produces the greatest capacity by transferring load directly into the support. ❒

Example*

Given: 2" x 4" x 97 mil clip angle, 6" long, shown in figure 2.

Design Thickness, t = 0.1017, F_y=50 ksi, F_u=65 ksi.

Fastener – (3) - 0.145" Dia. Smooth Shank Powder Actuated Fasteners into ¼" flange steel beam.

Fastener head diameter, dw = 0.3"

Fastener pattern as shown.

- Clip Angle Vertical Leg, L = 6"
- Horizontal Leg, B = 2"
- Eccentricity from bend, e = 1"
- Bending Length, BL = e – ½(dw) = 1 – ½(0.3) = 0.85"
- Factor of Safety, FS = 3.0 per AISI Specification

Moment of inertia of sheet $I = (L)(t^3) / 12 = (6)(0.1017)^3 / 12 = 0.000526$ in ^{4}

Section Modulus of sheet, $S_x = (L)(t^2) / 6 = (6)(0.1017)^2 / 6 = 0.0103$ in^3

Deflection Limit = 1/8" (per standard industry practice)

Allowable fastener tension Pat= 125#/fastener (ICBO tested values as tabulated in LGSEA Technical Note 562)

Full pull-over capacity of steel sheet, $P_{apo} = [1.5(t)(dw)(F_u)]/FS = [1.5(0.1017)(0.3)(65000)] / 3$ = 992 # per fastener (based on AISI specification, equation E4.4.2.1)

Find: Minimum Allowable tension load of connection (T).

<u>Step 1)</u> Check Maximum Deformation

T1 = [(Deflection Limit)(3)(E)(I)]/(BL^3) = [(1/8)(3)(29500)(0.000526)]/(0.85^3) = **9474#**

<u>Step 2)</u> Check Bending of Angle

Moment Capacity of horizontal leg, $M_{all} = (0.6)(F_y)(S_{xx}) = 0.6(50)(0.0103)=0.310$ kip-in

T2 = M_{all}/BL =0.310/0.85=**365#**

<u>Step 3)</u> Check Fasteners for Prying Case

Reduction of fastener capacity due to prying, RF = (B-e)/B = (2-1)/2 =0.5

Check Fastener, T3a = 3(P_{at})RF = 3(125)(0.5) = **188#**

Check Pull-over, T3b = 3(P_{apo})RF = 3(992)(0.5) = **1487#**

<u>Step 4)</u> Check Fasteners for Unfolding Case

Check Fastener, T4a = 3(P_{at}) = 3(125) = **375#**

Check Pull-over on one side, T4b = 3(P_{apo})(0.5) = 3(992)(0.5) = **1487#**

Solution – Prying case fastener failure controlled.

Allowable load = **188#**

* *This design example addresses only the vertical components of truss reactions. Often, sizeable horizontal loads accompany any truss uplift in high wind conditions. Designers must consider this when designing clips.*

AISI Releases New Cold-Formed Steel Design Guide

The American Iron and Steel Institute (AISI) has released a new design guide to assist practicing structural engineers in the design of CFSF systems.

The 2002 Cold-Formed Steel Framing Design (CFSF) Guide, by author Thomas W. J. Trestain (P.E.), reviews basic CFSF structural principles along with a number of detailed design examples covering wind loaded and axial-load-bearing stud walls and joists.

The author's focus in producing the Guide is to demonstrate to practicing structural engineers "..that there is nothing mysterious about cold-formed steel design. The same basic structural design principles that work with every other building material will also work with cold-formed steel framing."

The examples are based on the 1996 edition of the AISI Specification for the Design of Cold-Formed Steel Structural Members. The examples, using a universal designator system for CFSF members, show how to translate the information currently available in CFSF manufacturers' literature into complete structural systems.

Design Guide examples include:

- Wind-Bearing Infill Wall With Screwed Connections and a Sheathed Design Approach
- Wind-Bearing Infill Wall with Welded Connections and an Unsheathed Design Approach
- Wind-Bearing Wall with Strip Windows
- CFSF Floor and Axial Load-Bearing Stud Wall ❒

Interior Non-Structural 30-mil Framed Walls

The Steel Stud Manufacturers Association has just published a new Technical Note that provides additional information on wall height limits for interior, non-structural walls framed with 30-mil steel. The 30 mil thickness is recognized in certain geographic regions as the old 20ga. drywall stud. The report (Tech Note No. 4) is based on information generated by SSMA-funded tests conducted at Oregon State University. The results complement testing previously conducted on 18 mil to 68 mil thicknesses sponsored by SSMA and the Gypsum Assoc. that are included in ASTM A754 and SSMA's Product Technical Catalog. SSMA Industry Technical Note No.4 is available on the SSMA Web Site (www.ssma.com) for free down loading. ❒

Evaluation Services

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The task force also emphasized that a future ICC program must recognize evaluation reports issued by the participating services through the end of the existing term, allowing report holders to choose when they want to transition to the new ICC evaluation program. ❒

LGSEA Elects Board and Officers

The Light Gauge Steel Engineers Association announces its' Board of Directors and Officers for the 2002-2003 term:

Professional Directors

Randy Daudet, S.E., *LGSEA President*
Dietrich Design Group, Hammond, IN

Don Allen, P.E., *LGSEA Vice President*
Starzer Brady Fagan Associates, Atlanta, GA

Pat Ford, P.E.
Matsen-Ford Design, Pewaukee, WI

Howard Lau, P.E.
Shigemura, Lau, Sakanashi, Higuchi & Associates, Honolulu, HI

Dean Peyton, P.E.
Anderson-Peyton Structural Engineers, Federal Way, WA

Affiliate Directors

Ken Vought
Lafayette, CA

Rahim Zadeh, P.E.
Unimast Incorporated, McDonough, GA

Truss Bracing

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building designer, the architect and engineer of record are responsible to see that the bracing is designed and installed properly. However, the appendix to the AISI truss design guide, as well as Tech Note 551f *Specifying Cold-Formed Steel Roof and Floor Trusses* and AISI's *Standard for Cold-Formed Steel Framing – Truss Design* spell out at least part of the responsibilities of the owner, building designer, and truss designer. All of the above references specify that the building designer is responsible for the permanent truss bracing, and that the truss designer is responsible for defining the locations of required permanent truss member bracing.

There are some truss and truss system fabricators that also sell products intended to brace trusses and truss members. These manufacturers are more likely to provide truss system design because they can specify and sell their own bracing products. This does not mean that their design is any better or worse than other designs; but it may be more efficient to get them involved in the bracing design process. Some engineers (building designers) will include statements in their specifications that spell out bracing design responsibilities. Contractors and truss designers bidding on these documents must carefully read these requirements, to ensure that everyone is clear about who does what before bids are issued. The wording of the structural general notes, as well as the specifications, must be consistent and clear on bracing issues. Although it is the responsibility of the specialty engineer to ensure the that truss elements will not fail, ultimately it is still the building designer's responsibility to review the design and ensure it is compatible with the other elements of the structure.

For additional information on bracing design and design responsibility, the following references are available:

Standard for Cold-Formed Steel Framing – Truss Design, American Iron and Steel Institute Committee on Framing Standards, 2000. e-mail: kbielat@steel.org.

LGSEA Technical Notes on Cold-Formed Steel Framing, No.s 551f, 551e, 552g, and 551d. E-mail: LGSEA@aol.com

Field Installation Guide for Cold-Formed Steel Roof Trusses, Light Gauge Steel Engineers Association. E-mail: LGSEA@aol.com

Design Guide for Cold-Formed Steel Trusses (Publication RG-9518) American Iron and Steel Institute, 1995. www.steel.org

Specification Guide for Cold-Formed Steel Trusses and Components, Steel Truss and Component Association, E-mail: stca@steeltruss.org.

Jobsite Warning Poster for Cold-Formed Steel Trusses and Components Steel Truss and Component Association, E-mail: stca@steeltruss.org. ❒

More Reading on Brace Force Design

The following citations are meant only to be guide to the designer. The use of any of these procedures is the responsibility of the designer.

"Lateral bracing forces on beams and columns" by William Zuk, Journal of the Engineering Mechanics Division of ASCE, Vol. 82, No. EM 3, July 1956. One immovable brace at mid-height is 0.53% of P; Continuous immovable brace all along the column's height is 0.63% of P; One elastic lateral support at mid-height is 2% of P; Continuous elastic support all along the column's height is 1.8% of P.

"Compendium of Design Office Problems" by the Committee on Design of Steel Building Structures of the Committee on Metals, Structural Division, Journal of Structural Engineering, Vol. 118, No. 12, December 1992. On a question-answer type presentation, the paper recommends the lateral brace for a truss to be designed for 0.006 times the axial force in the compression chord at that location, and the connection of the lateral brace and chord to be designed for 0.012 times the average compression force in adjacent panels. If two or more trusses are braced by a single bracing system, then the 0.006 and 0.012 factors should be applied to the sum of the chord forces in all the panels.

"Simple solutions to stability problems in the design office" by Shankar Nair, Proceedings of the 1988 National Steel Construction Conference, AISC, Miami, FL, June 9-11, 1988. For a column braced by a floor, with assumptions of 0.002" for out-of-plumbness and 0.002" for relative horizontal movement of adjacent floors, the author calculates the brace force required as 0.006 times the axial force in the column below the floor.

"Lateral stability of welded light trusses" by John Hribar and William P. Laughlin, Journal of the Structural Division Proceedings of ASCE, March 1968.

"Stability and bracing of parallel chord wood trusses" by Robert J. Hoyle Jr. and Harold C. Sorenson, Forest Products Journal. Based of tests conducted on parallel chord trusses with bottom chord laterally supported and unsupported; 0.3% to 1.5% when BC laterally supported; 3.2% to 5% when BC laterally unsupported.

"Conceptual Model for Temporary Bracing of MPC wood trusses" by C.R. Underwood and F.E. Woeste, Practice Periodical on Structural Design and Construction, February, 2000. Conceptual explanation is given on how temporary bracing works; a list of industry references is given to aid the designer.

"Permanent bracing design for MPC wood roof truss webs and chords" by Catherine Underwood, Frank Woeste, J. Daniel Dolan, and Siegfried M. Holzer, Forest Products Journal, Vol. 51, No. 7/8. Deals with multiple braces on multiple members; SAP analysis of analog models; 2.3% for one web with one CLB; 2.8% for one web with two CLB's ("Net"); 3.1% for chord with purlins ("Net"); Forces are cumulative.

STCA Develops Jobsite Warning Poster

The "do's" and "don'ts" of steel truss erection and bracing details for builders is now available in a large 11" x 17" poster format. Published by the Steel Truss & Component Association (STCA), the Jobsite Warning Poster provides clear illustrations instructing builders on the proper techniques for unloading, storing, lifting, erecting and bracing steel trusses.

STCA's Jobsite Warning Poster is based on material from the Light Gauge Steel Engineers Association, the Truss Plate Institute and the Wood Truss Council of America, and represents an important element in a company's safety management program. For more information or to order,contact the STCA at stca@steeltruss.org, visit the web site at www.steeltruss.org or (608) 268-1031.❒

Light Gauge Steel Engineers Association

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