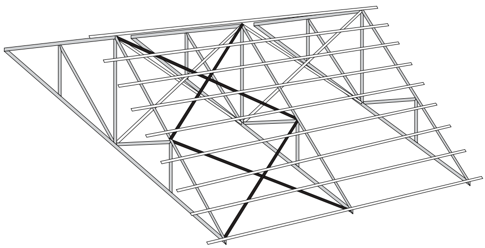
Commentary for Permanent Bracing of Metal Plate Connected Wood Trusses



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Reviewed by the
Engineering Review Committee
of the Wood Truss Council of America

and the

Technical Advisory Committee
of the Truss Plate Institute

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INTRODUCTION

Building Designers and Contractors recognize the design versatility and economies of Metal Plate Connected Wood Trusses (MPCWT). From its beginning in the early 1950's, the use of MPCWT has increased to the point of being the dominant roof framing method in the residential market and continues penetration into commercial, institutional, and agricultural markets. An important contribution to the growth of the use of trusses has been the early use of computer analysis, material optimization and the design efficiencies of wood trusses by the truss industry. MPCWT are offered to the marketplace as individual engineered wood components to be incorporated into a complete structural system by the Building Designer.

This commentary is intended to give guidelines to the Building Designer in defining those parts of the structure that, under present industry practice, will be designed by the Truss Designer and those parts that will be designed by the Building Designer. The Building Designer must determine and use the proper design criteria when applying the information provided within this Commentary.

DEFINITIONS

Architect: The registered architect responsible for all or part of the design of the Building Structural System and/or who produces structural drawings which are included in the Building Structural System Design Documents.

Building Structural System: The completed combination of structural elements, connections and systems, which serve to support the Building's self weight, and all applicable live and environmental loads.

Building Designer: The individual or organization responsible for the overall design of the Building Structural System in accordance with all Legal Requirements, and with respect to compliance of applicable state architectural and engineering registration laws. The Building Designer may be an Architect, the Engineer of Record, a registered building designer, the owner or the Contractor.

Building Structural System Design Documents: The architectural drawings, structural drawings, and any other drawings, specifications, and addenda which set forth the overall structural design of the Building Structural System and which are issued by the Building Designer. These documents should contain complete detailed information on the wood truss structural system, including framing plan, section details, truss profiles or configurations, connections, tie-downs, and permanent bracing requirements, for contractor and supplier bidding purposes.

Contractor: The individual or organization responsible for constructing the building in accordance with all Legal Requirements, the Building Structural System Design Documents and the Truss Submittals. 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, and installation of the Trusses.

Engineer of Record: The registered engineer responsible for the design of the Building Structural System and/or who may produce structural drawings included in the Building Structural System Design Documents. The Engineer of Record is one who is legally eligible to seal the structural drawings contained within the Building Structural System Design Documents. This seal acknowledges that he/she has performed or supervised the analysis, design, and document preparation of the Building's Structural System, and has knowledge of the requirements for the load carrying Building Structural System.

Legal Requirements: The applicable provisions of all statutes, laws, rules, regulations, ordinances, codes or orders of any governmental authority of the United States of America, any state, and any political subdivision or quasi-governmental authority of any of the same, including but not limited to departments, commissions, boards, bureaus, agencies, counties, municipalities, provinces, and other instrumentalities.

Truss: An individual metal plate connected wood structural element manufactured by the Truss Manufacturer and supplied to the Contractor.

Truss Designer: The individual or organization responsible for the design of metal plate connected wood trusses, and with respect to compliance of applicable state architectural and engineering registration laws. The Truss Designer may be a registered engineer and accordingly may be referred to as a Truss Design Engineer or design engineer.

Truss Design Drawing: The graphic depiction of an individual Truss prepared by the Truss Designer.

Truss Manufacturer: An individual or organization regularly engaged in the manufacturing of Trusses.

Truss Placement Plan: The drawing identifying the location assumed for each Truss based on the Truss Manufacturer's interpretation of the Building Structural System Design Documents. The Truss Placement Plan will reflect a truss identifying mark and perhaps other products and structural elements supplied by the Truss Manufacturer so that they may be more easily identified by the Contractor during field erection.

Truss Submittals: Those Truss Design Drawings and the Truss Placement Plan, if required by the contract, submitted to the owner, Building Designer and Contractor for their review and approval.

SCOPE

The purpose of this document is to provide guidelines for Building Designers to use in designing and specifying the permanent bracing for metal plate connected wood truss systems. The emphasis for bracing wood trusses is always on the application of triangulation, perpendicular to the plane of the trusses, which will hold every truss component in its proper position to create a structurally stable roof or floor truss system.

This document is written in general terms only and does not include specific bracing member and connection design. Lateral forces due to wind or seismic loads must be considered separately by the Building Designer. This document is not intended to take the place of any building code. It is up to the Building Designer to decide how the Building Structural System will function and how the wood truss components will be incorporated within this system.

GENERAL PROCEDURE

Before trusses can be analyzed, certain basic design considerations must be decided. Usually, the character of the floor/roof covering, the truss span, and the geometrical shape (profile) of the trusses are fixed by architectural requirements. The span and spacing of trusses are also usually established by the architectural location, in plan, of the supporting columns, beams, girders, and/or load bearing walls. The location of the building site and its exposure will fix the amount

of snow and wind loads or seismic loading which must be considered in the overall design of the Building Structural System. Design loads are usually based upon local building code requirements or ANSI/ASCE 7-95, *Minimum Design Loads for Buildings and Other Structures* (1).

<u>Roof or Floor Loads</u>: The loads which must be considered by the Building Designer in the design of a roof or floor truss system usually consist of, but are not limited to the following:

a. The weight of the deck materials and coverings, including the anticipation of future layers of coverings, such as replacing existing floor or roofing material with heavier floor or roofing material.

b. The weights of purlins, bracing and other framing.

c. The weight of the truss itself.

d. Ceiling loads, insulation.

e. Special loads, such as suspended loads, concentrated loads, sprinkler piping, HVAC or other mechanical equipment.

f. Maximum expected roof and floor live loads, including anticipated live load changes due to potential changes in occupancy.

g. Maximum and minimum expected snow loads, including drifting.

h. Maximum expected wind loads, including distinct zone loadings, and any transfer loadings required by the structural wind analysis, where applicable.

i. Maximum expected seismic loads, and any transfer loadings required by the structural seismic analysis, where applicable.

<u>Architect and/or Engineer of Record - Building Designer</u>: Metal plate connected wood trusses are required by all major model building codes to be designed and manufactured in accordance with ANSI/TPI 1, *National Design Standard for Metal Plate Connected Wood Truss Construction* (2), a national consensus standard published by the Truss Plate Institute (TPI) and approved by the American National Standards Institute (ANSI). Section 2.2 of ANSI/TPI 1-1995 provides the definition of Building Designer that is virtually identical to the one included at the beginning of this document (Note: The definitions set forth in this Commentary have been submitted for adoption into ANSI/TPI 1-2000). In addition, ANSI/TPI 1 also states:

8.1.5.1 The Building Designer shall make provisions for bearings, cross and lateral bracing, bracing to transfer truss member buckling forces to the structure, and bracing to resist wind, seismic or other horizontal loadings.

8.1.5.2 Connections between two or more [wood] members, all of which are designed or specified by the Truss Designer, shall be designed or specified by the Truss Designer. Connections between two or more [wood] members, one or more of which are not designed or specified by the Truss Designer, shall be designed or specified by the Building Designer. **See Figure 1 on page 4.**

2.2.1 The Building Designer shall specify the following:

a. Design loads as described above.

b. Truss profile [shape] and intended support locations.

c. Temperature and moisture environment for the intended use.

d. Any special requirements to be considered in the truss design.

2.2.2 ...the Building Designer shall provide for the following in the design and detailing of the building:

a. Truss deflections.

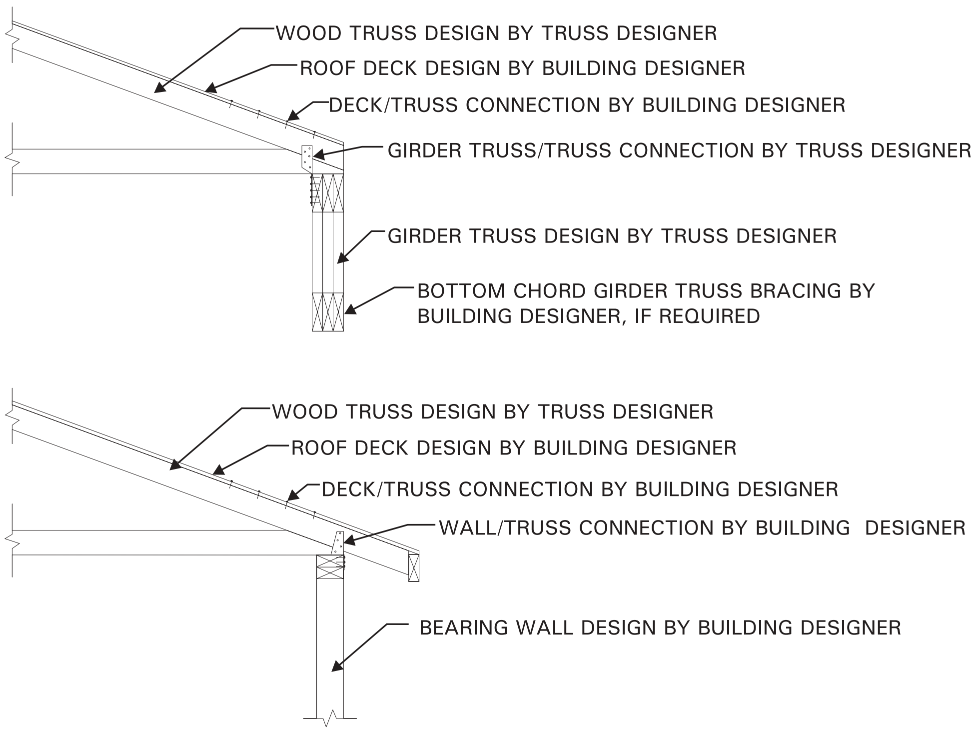
b. Truss movement due to moisture and temperature change.

c. Truss supports and anchorage accommodating horizontal, vertical or other reactions or displacements.

d. Permanent truss bracing to resist wind, seismic and any other lateral forces acting perpendicular to the plane of the truss.

e. Permanent lateral bracing as specified by the Truss Designer, to prevent buckling of individual truss members due to design loads.

FIGURE 1
ILLUSTRATION OF ANSI/TPI 1-1995 SECTION 8.1.5.2



The Building Designer is legally responsible for the overall design of the Building Structural System. The previously indicated design loads must be identified and shown in proper position by the Building Designer on the Building Structural System Design Documents.

It is obvious that the Truss Designer must have access to proper information as shown on the Building Structural System Design Documents in order to competently prepare the Truss Design Drawings. It is also obvious that the Truss Designer is not in a position to know how the Building Designer intended to analyze and transfer the loads due to (a) the effect of vertical or lateral loadings of the truss system(s) on the building, or (b) the effect of vertical and lateral loadings of the building on the truss system(s). The interrelationship of the loads and the transfer of these loads between the truss system(s) and the building, including permanent bracing and connections, is the responsibility of the Building Designer.

Neither the Truss Manufacturer, nor the Truss Designer accepts responsibility for the design of the Building Structural System. Responsibilities for the parties involved are restricted to those as defined in WTCA 1, *Standard Responsibilities in the Design Process Involving Metal Plate Connected Wood Trusses* (3), ANSI/TPI 1, or as defined in this document, regardless of the background of the individual obtaining the building permit.

The Building Designer may choose to do the truss analysis as part of his/her work product, for which complete detailed truss design, fabrication and connection information will be shown in the Building Structural System Design Documents. Alternately, the Building Designer may delegate the truss component design to others either directly or through the Building Structural System Design Documents. The individual or organization who assumes the design of the Trusses is the Truss Designer. The Truss Designer's responsibility is restricted to the design of the wood truss components only, which are to be incorporated into the truss system(s) by the Building Designer.

Approval of Truss Submittals: The Truss Submittals are usually developed by the Truss Manufacturer after contracts are awarded and project work has begun. The Truss Submittals include the Truss Design Drawings for each individual truss and, if required by the contract, the Truss Placement Plan(s). The Truss Design Drawings contain information to enable building designers, owners, and contractors to review and verify that the trusses to be manufactured conform to the requirements and intent of the Building Structural System Design Documents.

The Truss Placement Plan is an ancillary document that is intended to assist contractors in correctly locating individual trusses for the building. The Truss Placement Plan is prepared by the Truss Manufacturer and is based on the Truss Manufacturer's interpretation of the Building Structural System Design Documents. The Truss Placement Plan contains no structural information and requires no engineering knowledge and calculations. It is not an engineered drawing and is not intended to replace the Building Structural System Design Documents; it is only a guide for installation. As such, the Truss Placement Plan should not receive an engineer's seal. Refer to the document titled, *WTCA's Recommended Policy for Review of Engineered Component Product Placement Plans for Construction Projects in which a Professional Building Designer is Required* (4), for additional information pertaining to Truss Placement Plans.

The Truss Submittals are provided to the Contractor for approval of the quantities, shapes and dimensions. The Contractor then forwards the Truss Submittals to the Building Designer for approval of the truss shapes, design loads, deflection restrictions, and layout conditions. It is at this point that the Building Designer either accepts, revises or rejects the Truss Submittals for their overall compliance with the intent of the Building Structural System Design Documents. It is also at this point that the Contractor either accepts or revises any dimensional changes or Truss Placement Plan changes that may have occurred during the progress of the project.

The Building Designer should review **all** notes and specifications on the Truss Submittals and verify that all conditions of the Building Structural System Design Documents will be met. Any questions the Building Designer has concerning the Truss Submittals should be directed to the Truss Designer at this time.

Truss Installation: Once the approved Truss Submittals have been received by the Truss Manufacturer, production and delivery schedules may be determined and the procedure for installing the trusses may be planned by the Contractor. Several publications including HIB-91 Booklet, *Commentary and Recommendations for Handling, Installing and Bracing Metal Plate Connected Wood Trusses* (5); HIB-91 Summary Sheet (6); *Job Site Warning Poster* (7); or HIB-98PF, *Recommendations for Handling, Installing & Temporary Bracing Metal Plate Connected Wood Trusses Used in Post-Frame Construction* (8); are readily available and may be included

with the Truss Submittals as supplementary information. Contractors should use the information and recommendations provided in these documents to ensure the overall safety of the workers as well as to protect property from damage. Temporary bracing, as recommended in HIB-91, the Job Site Warning Poster, or HIB-98PF should be used during installation to hold the trusses true to line and plumb and to prevent a toppling (“dominoing”) failure of the trusses. **The authors are unaware of any occurrence of an erection accident where HIB-91 recommendations were properly followed.**

Most of the major building codes recognize HIB-91 as an acceptable method of installation for many Truss installation applications. The document is not intended, however, to supersede the Building Designer’s specific installation method for a particular project. It is obvious that if some of the temporary bracing can be left in place as permanent bracing, economies will result.

TRUSS BRACING

PERMANENT BRACING PER ANSI/TPI 1

ANSI/TPI 1 provides a very basic discussion concerning the importance of permanent bracing in assuring long-term truss and building performance. Permanent bracing considerations with respect to trusses are subdivided into three components: top chord plane, bottom chord plane and web member plane. It is the responsibility of the Building Designer to design and detail the permanent bracing and the required connections for each of the three components discussed.

Web Member Plane: Permanent bracing in the web member plane holds the trusses in a vertical position and maintains proper truss spacing. In addition, certain web members may require bracing in order to adequately resist the compressive stresses developed under the specified design conditions.

Web members requiring bracing will be specified by the Truss Designer on the individual Truss Design Drawings. Continuous lateral bracing can be used to shorten the buckling length of the identified compression webs in adjacent identical trusses. The approximate location of this bracing on the braced web member is indicated on the Truss Design Drawings. The Building Designer is responsible for determining the size, grade and connection of this bracing to the web member, as well as the means of stabilizing this bracing so as to prevent the simultaneous lateral movement of the braced webs in the same direction. This can generally be accomplished by properly anchoring the lateral bracing to an end wall designed to resist these lateral loads, connecting the lateral bracing into the roof diaphragm, adding permanent diagonal bracing on the side opposite the lateral bracing (i.e. cross bracing) in the plane of the web members, adding structurally rated sheathing, or by other equivalent means.

The buckling capacity of a web member can also be enhanced by adding a scab, “T,” “L,” or “U” brace. **See Figure 4 on page 9**. This type of bracing is generally used when dissimilar trusses are located next to each other. When this occurs, the braced compression webs often do not line up, making continuous lateral bracing very difficult if not impossible to install. Since this type of bracing is specific to an individual truss, the size and type of brace, as well as the connection to the web, will be specified by the Truss Designer.

Truss Members in Compression: The capacity of truss members in compression decreases as their unbraced length increases. The typical Truss Design Drawing shows the location of web member bracing only, since the chords are assumed to be braced by properly designed roof or ceiling diaphragms. When this is not the case, the maximum allowed brace spacing will be shown on the Truss Design Drawing.

Truss Members in Tension: Some truss web members in tension require lateral bracing simply because their slenderness ratio, L/d, is excessive (as described in ANSI/TPI 1). For wind uplift loadings that exceed gravity loads, member forces become reversed. Under these conditions, members that are normally in tension under gravity load conditions are placed in compression and may require the addition of bracing to ensure that they are capable of sustaining the design compression stress. The Truss Design Drawings will indicate the location(s) where additional bracing is needed based on the worst case design condition as provided by the Building Designer.

Special Conditions: The axial forces in some chord and web members of cantilevered and multiple span trusses may change from tension to compression under certain loading conditions. In the absence of a diaphragm, the Truss Designer must provide the approximate location of the bracing for the chords in these conditions on the individual Truss Design Drawings.

The Building Designer and Contractor must be aware that changes in loading, spacing, layout, etc., may affect not only the individual truss designs but also the bracing requirements. The Truss Designer must be informed of any changes to, or deviations from, the original information shown on the Truss Design Drawings so the trusses can be re-designed and approved, as necessary.

TRUSS SYSTEM BRACING

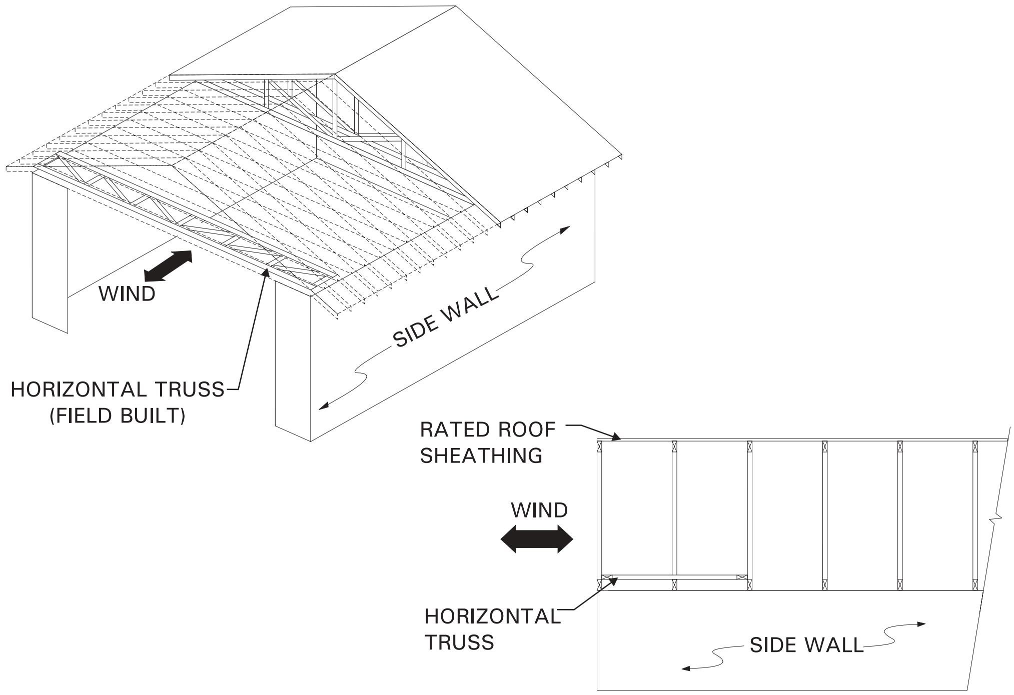
Lateral Stability Bracing: The lateral rigidity of the entire truss system is an important consideration during and after installation and is one that is too often neglected. *The theory of bracing for any truss system is to apply sufficient bracing at right angles to the plane of the truss to hold every member in the position assumed for it in the design.* Overall permanent bracing is essential to the proper performance of any truss system regardless of the material used.

The Building Designer is required to design for stability of the overall building. Wood structures, like other structural systems, must be designed to resist all lateral forces acting along the length and across the width of the building as caused by wind or seismic loads.

In conventional construction, wind loads acting perpendicular to the end walls and gable ends will cause lateral forces acting along the length of the building. Resistance to these forces may be provided through a properly designed ceiling diaphragm, or may require the design of bracing in the plane of the truss bottom chords, to transfer the forces into the side walls. A truss oriented horizontally, as shown in **Figure 2 on page 8**, is one means of effectively accomplishing this task. Alternatively, diagonal bracing may be designed at specified spacings across the width of the building to transfer these forces from the end wall to the roof/floor diaphragm and from there into the side walls. **See Figure 3 on page 9.**

Wind loads acting perpendicular to the side walls will cause lateral forces acting across the width of the building. These lateral loads are usually designed to be transferred through the stiffness of the roof/ceiling/floor diaphragm into the end walls, or into interior shear walls, portal frames or partitions. The choice of how to resist these lateral forces is the responsibility of the Building Designer.

FIGURE 2
FIELD BUILT HORIZONTAL TRUSS TO TRANSFER WIND LOAD TO BUILDING SIDE WALLS

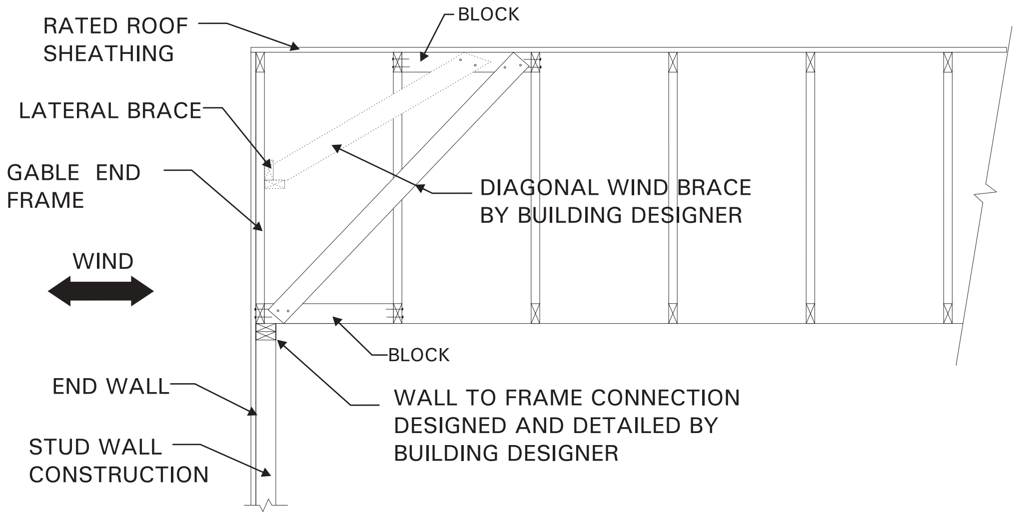


SPECIAL CONDITIONS

Gable End Braces: Lateral forces from wind and seismic loads acting against the end walls and gable ends of a building must be safely transferred into the floor and/or roof diaphragms, which transfer this load to the side walls and then to the foundation. As discussed in an earlier section, this may require the design of a bracing system in the plane of the bottom chord of the trusses at both ends of the building. Alternately, diagonal braces may be designed at intervals along the gabled end to direct wind forces from the top of the wall to the roof diaphragm.

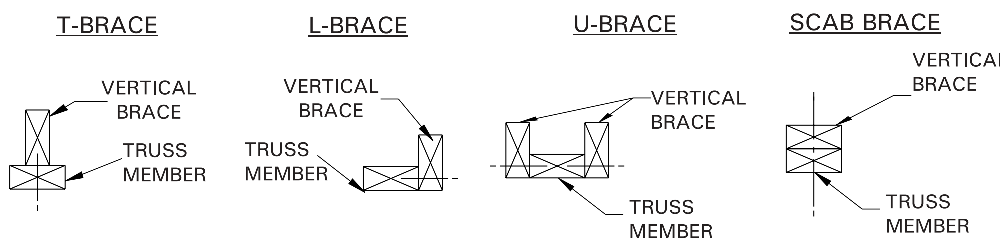
Metal plate connected gable end frames are often used directly above the end walls of a building to save the Contractor the time and expense of having to field frame the end wall to match the roof slope. Gable end frames are typically built with uniformly spaced vertical webs and are designed to transfer roof loads (gravity and/or uplift) directly into the wall, or some other continuous load bearing support running the entire length of the bottom chord. The web member bracing shown on the Truss Design Drawings for these frames is required to prevent column buckling of the web members due to these axially applied gravity loads. In high wind regions, the bracing may also serve the role of a moment resisting element. The Building Designer must incorporate the gable end frame into the wall design for this purpose. Lateral shear forces from the roof diaphragm are assumed to be resisted by the wall sheathing and transferred via this sheathing into the end wall below. Reinforcement may also be required for the vertical web members to resist bending due to the lateral loads applied perpendicular to the face of the gable end frame. Diagonal bracing, attached near the mid-depth or third-points of the vertical webs, works well for this application. **See Figure 3 on page 9**.

FIGURE 3
GABLE END BRACE



The stiffness of the vertical gable end truss webs can also be increased by attaching an additional piece (or pieces) of dimension lumber parallel to the length of the web. The additional piece(s) can be attached to the wide face of the web (i.e. "scab" brace) or to the narrow face, resulting in a cross section that looks like a "T," "L," or "U." **See Figure 4 below.** Actual bracing requirements will vary due to the magnitude of the load, the building height, web lumber grade/species/on-center spacing/height and other variables, making it imperative for the Building Designer to determine the bracing and attachment requirements for each specific job.

FIGURE 4
INDIVIDUAL
TRUSS MEMBER
BRACING/REINFORCING



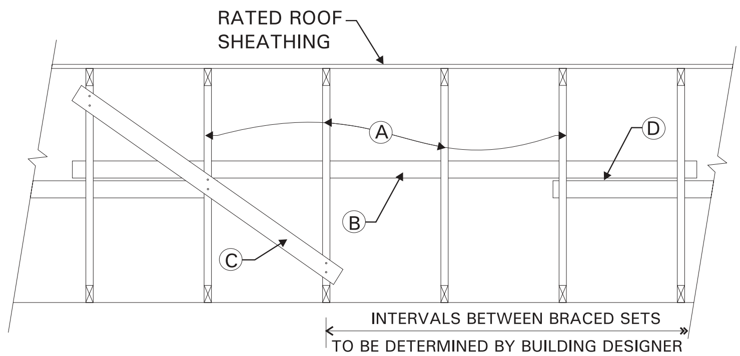
Diagonal Braces: Other considerations by the Building Designer for the overall performance of the building must be the design and connections of bracing to hold every truss member (chords and webs) in the position assumed for it in the truss design. One means of accomplishing this is to use diagonal bracing to further stabilize those truss members which are identified on the Truss Design Drawings as requiring lateral bracing at specific locations. The intent is to prevent those members from simultaneously buckling together in the same direction.

A diagonal member applied at 45°± in the compression member plane and attached to the side opposite the lateral braces will serve to stabilize the members. The typical rule is to apply diagonal bracing intermittently to those members on which lateral bracing at mid-length or third points is specified by the Truss Designer. These diagonals may be positioned at both ends of the building (or both ends of a braced set of similar trusses), and should be repeated along the length of the building at intervals to be determined by the Building Designer. **See Figure 5 on page 10.**

> **NOTE**: Exact diagonal member sizes and connections may be designed by the Building Designer to resist the cumulative brace force of 2% of the axial force in the braced member times the number of members to be braced. In most cases, nail capacity at the braced points will determine the number of compression

members that can be held in place by a single diagonal member, and thus the spacing between diagonals is determined. A description of this procedure is detailed in the publication titled DSB-89, *Recommended Design Specification for Temporary Bracing of Metal Plate Connected Wood Trusses* (9).

FIGURE 5
DIAGONAL BRACING TO STABILIZE TRUSS COMPRESSION MEMBERS



Ⓐ COMPRESSION WEB MEMBER IN ADJACENT SIMILAR WOOD TRUSSES

Ⓑ CONTINUOUS LATERAL BRACING PER TRUSS DESIGN DRAWING TO REDUCE BUCKLING LENGTH OF WEB MEMBER. LOCATION BY TRUSS DESIGNER. DESIGNED AND DETAILED BY BUILDING DESIGNER.

Ⓒ DIAGONAL BRACE ATTACHED TO SIDE OF WEB OPPOSITE THE LATERAL BRACE. PREVENTS ALL WEB MEMBERS FROM BUCKLING SIMULTANEOUSLY IN THE SAME DIRECTION.

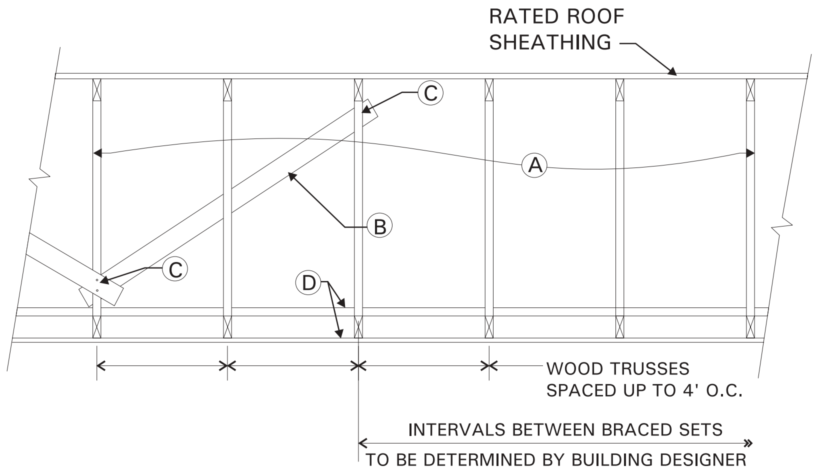
Ⓓ OVERLAP CONTINUOUS LATERAL BRACING (CLB) AT LEAST 2 FEET. DESIGN OF CLB SPLICE CONNECTION BY BUILDING DESIGNER.

Sway Bracing: In some cases, individual wood truss designs will be such that lateral bracing is NOT required to reduce the buckling length of web members. Top chords may be stabilized by rated sheathing and bottom chords braced by lateral bracing at specified spacing, usually ten feet (i.e. $L/d = 80$, where $L = 120$ in. and $d_{min.} = 1.5$in.). If none of the web members require bracing, triangulation to stabilize the web members may not be required. **The truss system, however, may be able to sway one way or the other due to wind against the end truss or due to the cumulative effect of any out-of-plumb erection tolerance.**

Under these conditions, diagonal bracing may be used to provide lateral rigidity to the entire roof system. Sway bracing serves to stiffen the roof system, thereby preventing excessive stresses due to a possible movement or displacement of the trusses. This bracing, if continuous, also serves to distribute gravity loads between trusses of varying stiffness, similar to the action of strongback bridging between floor trusses. Permanent sway bracing between wood roof trusses is usually in the discretion of the Building Designer based upon his/her knowledge and experience.

Trusses requiring little or no lateral bracing for web members, which would normally require the addition of permanent diagonal bracing as described in the **Diagonal Bracing** section above, should be braced by sway bracing extending from the roof to the ceiling, in planes at right angles to the trusses. **See Figures 6a on page 11 and 6b on page 12.**

FIGURE 6a
TYPICAL SWAY BRACING FOR TRUSS SPACINGS UP TO 4 FEET O.C.



(A) VERTICAL WEB MEMBERS (PREFERRED) IN ADJACENT SIMILAR WOOD TRUSSES.

(B) DIAGONAL MEMBERS FOR SWAY BRACING (CONTINUOUS, IF USED AS BRIDGING). LOCATE AS CLOSE TO CONTINUOUS BOTTOM CHORD BRACING, (D), AS POSSIBLE.

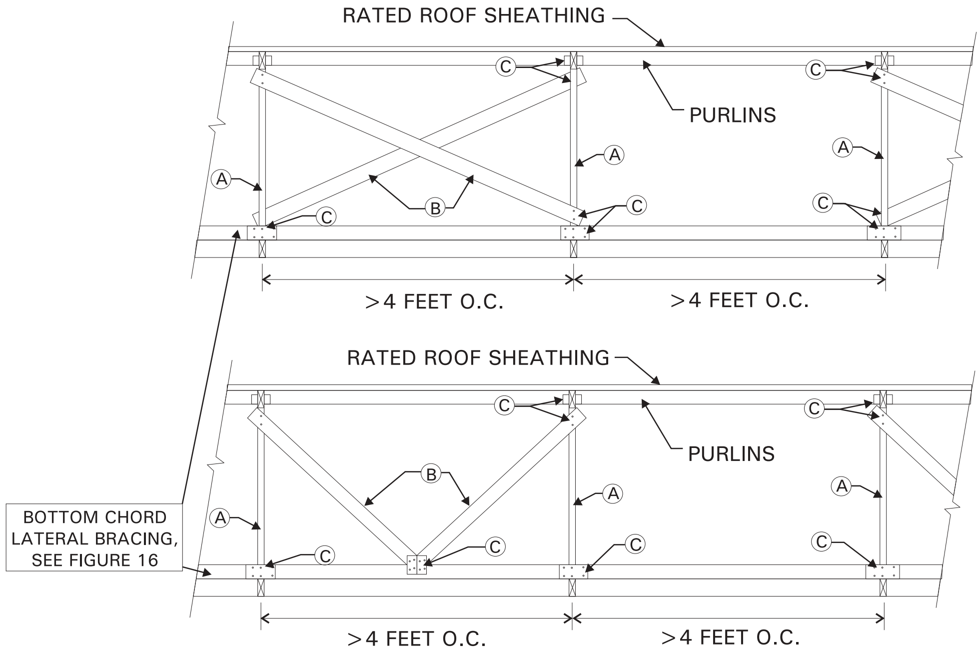
(C) CONNECTIONS DESIGNED AND DETAILED BY THE BUILDING DESIGNER.

(D) CONTINUOUS BOTTOM CHORD LATERAL BRACING OR CONTINUOUS CEILING DIAPHRAGM DESIGNED BY THE BUILDING DESIGNER.

There is no set rule for sway bracing. However, it should be fairly obvious that such bracing should be located at panel points (but not necessarily every panel point) and attached diagonally (45° ±) by nailing to every crossed member — preferably along vertical web members.

For truss spacings up to four feet on center, diagonal bracing may simply be nailed directly to the web members, **see Figure 6a above**. For truss spacings greater than four feet, stronger connections and possibly larger sway bracing members are required, **see Figure 6b on page 12.** Truss Designers and Building Designers should consider these options when determining the configuration of the trusses so that sway bracing, if required by the Building Designer, will be able to be most easily installed.

**FIGURE 6b
TYPICAL SWAY BRACING FOR TRUSS SPACINGS GREATER THAN 4 FEET**



A VERTICAL WEB MEMBERS (PREFERRED) IN ADJACENT SIMILAR WOOD TRUSSES

B DIAGONAL MEMBERS FOR SWAY BRACING. INTERVALS TO BE DETERMINED BY BUILDING DESIGNER (CONTINUOUS, IF USED AS BRIDGING). LOCATE NEAR BOTTOM CHORD LATERAL BRACING.

C CONNECTIONS FOR PURLINS TO TRUSS AND BRACING TO TRUSS DESIGNED AND DETAILED BY THE BUILDING DESIGNER.

Top Chord Bracing - Multi-piece Truss: Long span or high pitch trusses are often too large to be manufactured, shipped and erected in one piece. The Building Designer or Truss Designer may choose to design trusses in two or more pieces to be assembled at the jobsite. A supporting (carrying) truss that is topped with a smaller, supported (cap) truss carried directly on top of the supporting truss is often referred to as a piggyback truss assembly.

The top chord of the supporting truss will require some type of lateral restraint to prevent the top chord from buckling out from under the supported truss. This is most often accomplished with 4x2 dimension lumber continuous lateral bracing (CLB). The Truss Design Drawing provided by the Truss Designer will show:

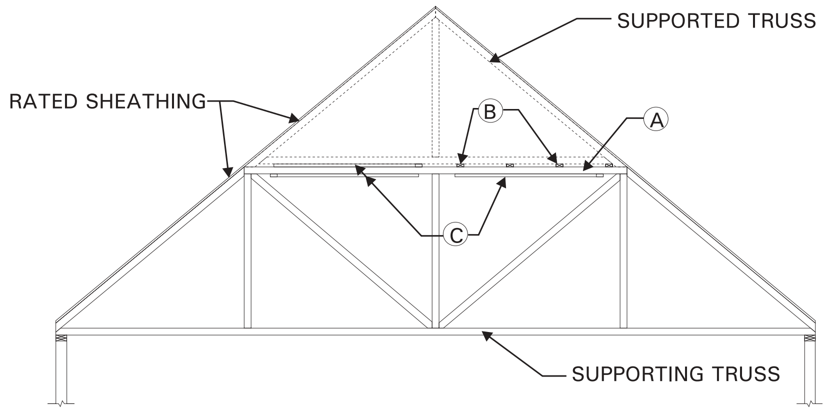
- The required spacing of the CLB.
- The assumed thickness of the bracing.
- The minimum connection requirements between the cap and the supporting truss or bracing.

It is imperative that the Building Designer review this information and ensure that all potential loading conditions have been included.

The Building Designer must design and detail the bracing needed to stabilize the top chords of the supporting trusses. Restraint can be provided by securely anchoring the lateral bracing to end walls designed to resist the lateral loading from the bracing, connecting the lateral bracing into the roof diaphragm, adding diagonal bracing at intervals along the length of the building (**See Figure 7 on page 13**), adding structurally rated sheathing, or some other equivalent means.

The Truss Designer must be notified, prior to truss manufacture, if the spacing and thickness of the bracing between the supported and supporting trusses will be different than what he/she has assumed on the Truss Design Drawing. Discrepancies may require dimensional adjustments to the supported truss and result in load distributions to the supporting truss that are inconsistent with the original design.

FIGURE 7
PIGGYBACK TOP CHORD BRACING



Ⓐ SUPPORTING TRUSS TOP CHORD - REQUIRES LATERAL SUPPORT

Ⓑ LATERAL BRACING AT SPACING SPECIFIED BY TRUSS DESIGNER.

Ⓒ RESTRAINT CAN BE PROVIDED BY:
-SECURELY ANCHORING THE LATERAL BRACING TO END WALLS DESIGNED TO RESIST THE LATERAL LOADING.
-DIAGONAL BRACING AT INTERVALS ALONG THE LENGTH OF THE BUILDING
-STRUCTURALLY RATED SHEATHING APPLIED DIRECTLY TO THE TOP CHORD OF THE SUPPORTING TRUSS.
-CONNECTING THE LATERAL BRACING INTO THE ROOF DIAPHRAGM
-OR SOME OTHER EQUIVALENT MEANS
THE DESIGN AND DETAILING OF THIS RESTRAINT IS TO BE DETERMINED BY THE BUILDING DESIGNER.

NOTE: INFORM THE TRUSS DESIGNER IF SPACING AND/OR THICKNESS OF BRACING BETWEEN THE SUPPORTED AND SUPPORTING TRUSS IS DIFFERENT THAN WHAT HAS BEEN ASSUMED ON THE TRUSS DESIGN DRAWING.

Chord Extensions and Fillers: Some trusses used in complex roof designs have extended chords and filler, shop or field applied to the truss chords, for the purpose of accomplishing a certain architectural profile. When this occurs, the distinction between chords and webs may not be immediately obvious. This occurs in conditions such as clerestory trusses **Figure 8a on page 14**, top chord fillers, **Figure 8b on page 14** or bottom chord fillers **Figure 9 on page 15.** For these conditions, it is assumed by the truss designer that the "exposed" top and bottom chord will be braced as indicated on the truss design drawing. Any additional bracing will be specified on the member needing permanent bracing.

FIGURE 8a
BRACING FOR TOP CHORD EXTENSION OF A CLERESTORY TRUSS

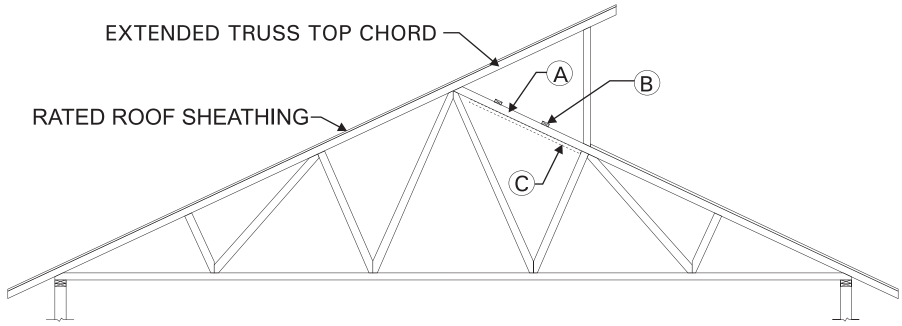
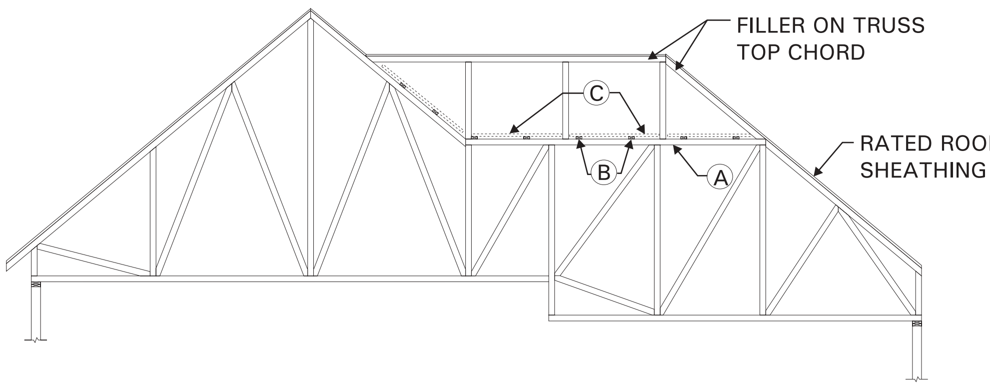


FIGURE 8b
BRACING FOR TOP CHORD SUPPORTING FILLER

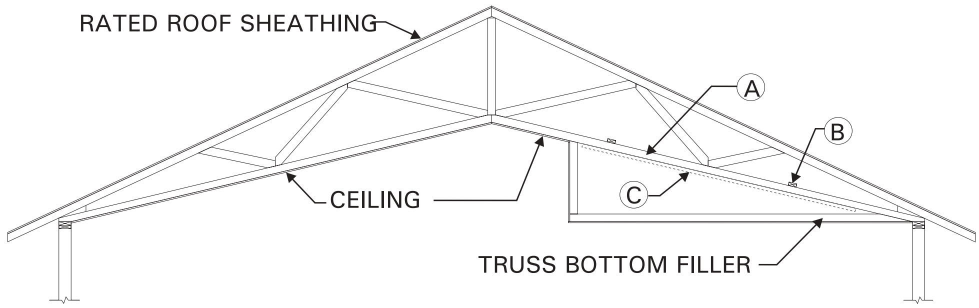


(A) TRUSS TOP CHORD - REQUIRES LATERAL SUPPORT.

(B) LATERAL BRACING AT SPACING SPECIFIED BY TRUSS DESIGNER.

(C) RESTRAINT CAN BE PROVIDED BY:
-SECURELY ANCHORING THE LATERAL BRACING TO END WALLS DESIGNED TO RESIST THE LATERAL LOADING.
-DIAGONAL BRACING AT INTERVALS ALONG THE LENGTH OF THE BUILDING.
-STRUCTURALLY RATED SHEATHING APPLIED TO THE TRUSS TOP CHORD
-CONNECTING THE LATERAL BRACING INTO THE ROOF DIAPHRAGM
-OR SOME OTHER EQUIVALENT MEANS
THE DESIGN AND DETAILING OF THIS RESTRAINT IS TO BE DETERMINED BY THE BUILDING DESIGNER.

**FIGURE 9
BRACING FOR
BOTTOM CHORD
SUPPORTING FILLER**



(A) TRUSS BOTTOM CHORD - REQUIRES LATERAL SUPPORT

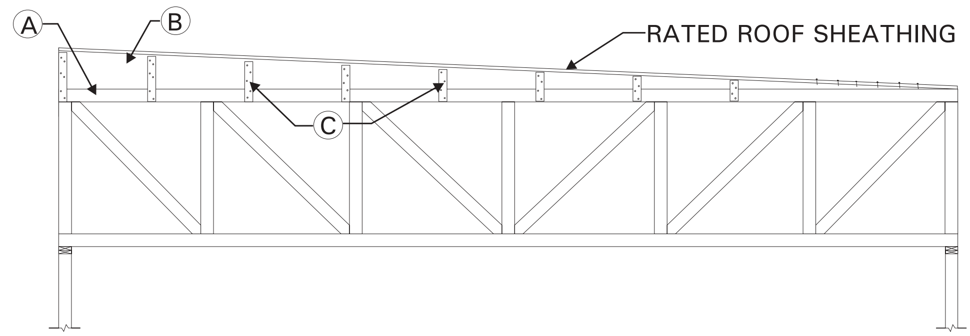
(B) LATERAL BRACING DESIGNED AND DETAILED BY BUILDING DESIGNER AT SPACING SPECIFIED BY TRUSS DESIGNER.

(C) RESTRAINT CAN BE PROVIDED BY:
-SECURELY ANCHORING THE LATERAL BRACING TO END WALLS DESIGNED TO RESIST THE LATERAL LOADING.
-ADDING DIAGONAL BRACING AT INTERVALS ALONG THE LENGTH OF THE BUILDING
-STRUCTURALLY RATED SHEATHING APPLIED DIRECTLY TO THE TRUE BOTTOM CHORD.
-CONNECTING THE LATERAL BRACING INTO THE ROOF DIAPHRAGM
-OR SOME OTHER EQUIVALENT MEANS
THE DESIGN AND DETAILING OF THIS RESTRAINT IS TO BE DETERMINED BY THE BUILDING DESIGNER.

FIGURE 9 - BRACING FOR BOTTOM CHORD SUPPORTING FILLER

Roof slope is sometimes provided by fastening a sloping filler strip, ripped from a 2x_ member, to the top chords of parallel chord trusses. The roof sheathing is attached to the top of the filler strip. This detail is often used when the trusses span perpendicular to the roof slope, but may also be used to provide special drainage requirements at localized areas. Depending on the thickness, orientation and attachment of the filler strip to the truss, additional restraint may be required to keep the top chord of the truss from buckling laterally under the filler strip. This is most often accomplished by using metal clips or lumber blocking. **See Figure 10 on page 16**. The Truss Designer will provide the approximate spacing for the required restraint, while the Building Designer must design and detail the type of restraint to use.

FIGURE 10
TOP CHORD BRACING FOR TRUSSES WITH FILLER STRIPS



Ⓐ TRUE TRUSS TOP CHORD - REQUIRES LATERAL SUPPORT

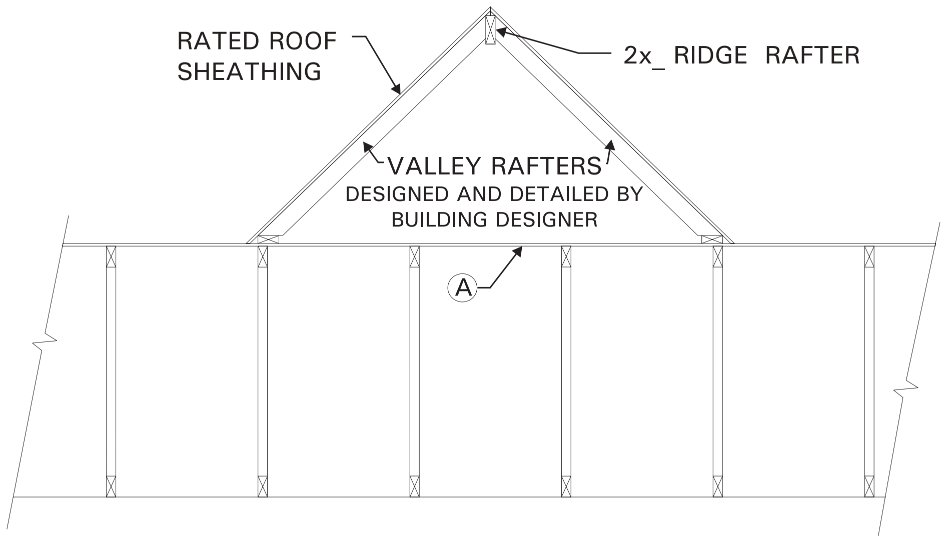
Ⓑ SLOPING FILLER STRIP BY BUILDING DESIGNER

Ⓒ METAL CLIPS OR WOOD BLOCKING, NAILED TO FILLER STRIP AND TOP CHORD TO MAINTAIN VERTICAL ALIGNMENT AND PREVENT LATERAL BUCKLING. DESIGNED AND DETAILED BY BUILDING DESIGNER AT SPACING SPECIFIED BY TRUSS DESIGNER.

Valley Framing Bracing: Framing over roof trusses to form dormers and valleys requires special attention in order to ensure the trusses beneath this framing are adequately designed and braced. Conventionally "stick" framed dormers and valleys can potentially cause problems in that the loads may not be uniformly distributed from the over-framing to the trusses below. In addition, if the roof sheathing does not extend beneath the over-framing, the top chords of the supporting trusses will not be laterally supported and may buckle out-of-plane. Manufactured valley trusses with verticals and bottom chords practically eliminate these concerns.

Valley framing should distribute loads to the trusses below in a manner consistent with the design loading specified on the individual Truss Design Drawings. Lateral support must also be provided at the intervals indicated on the Truss Design Drawings by adding continuous lateral bracing or by continuation of the roof sheathing over the trusses beneath the valley framing. Supported framing that causes load distributions other than those specified on the individual Truss Design Drawing will require re-evaluation. The Building Designer must specify how this framing is to be constructed, installed and supported, and verify the "as-built" conditions match those provided in the Truss Design Drawing. **See Figure 11 on page 17.**

FIGURE 11
SITE BUILT VALLEY FRAMING BRACING

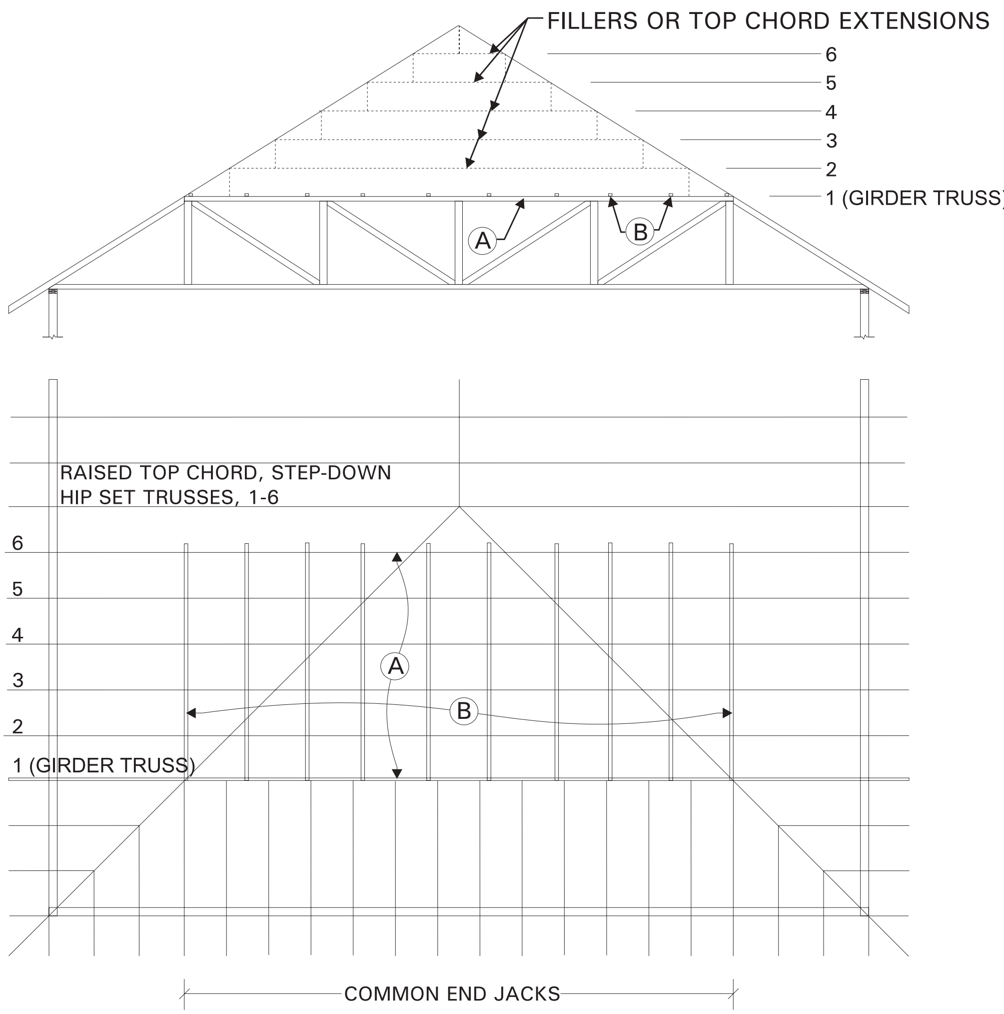


Ⓐ TOP CHORDS OF VALLEY SUPPORT TRUSSES MUST BE LATERALLY BRACED BY CONTINUOUS RATED SHEATHING OR BY OTHER STABILIZING BRACING DESIGNED AND DETAILED BY BUILDING DESIGNER AT INTERVALS SPECIFIED BY THE TRUSS DESIGNER.

BUILDING DESIGNER MUST SPECIFY THE MAGNITUDE AND LOADING DISTRIBUTION OF THE VALLEY FRAMING TO THE SUPPORT TRUSSES.

Hip Truss Bracing: The top chords of hip trusses, under certain framing applications, may be located well below the roof diaphragm requiring additional bracing for lateral support. **See Figure 12 on page 18.** The Truss Designer will specify the approximate locations of the required top chord lateral bracing on the individual Truss Design Drawings. The Building Designer must determine the connection, grade and size of this lateral bracing and the means by which this bracing is to be tied to the Building Structural System. This is most often accomplished by connecting the lateral bracing to a properly braced girder truss, but may also be accomplished by adding diagonal, T, L, or scab bracing to the top chords of the hip trusses.

FIGURE 12
HIP SET WITH TOP CHORD EXTENSION OR FILLERS



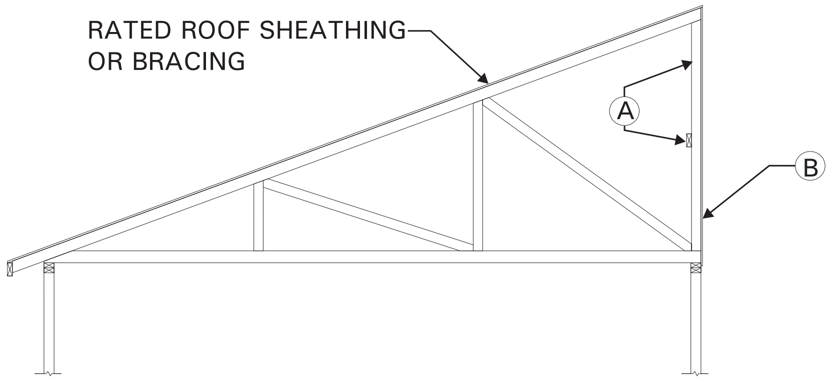
(A) TOP CHORDS - REQUIRE LATERAL SUPPORT

(B) LATERAL BRACING DESIGNED AND DETAILED BY BUILDING DESIGNER AT SPACING SPECIFIED BY TRUSS DESIGNER.

NOTE: EXTENSIONS AND FILLERS MUST DISTRIBUTE LOADS TO THE TRUSSES BELOW IN A MANNER CONSISTENT WITH THE DESIGN LOADING SPECIFIED ON THE TRUSS DESIGN DRAWINGS.

<u>Mono Pitch Triangular Trusses</u>: If the end vertical member of a mono pitch triangular truss is exposed to lateral loading, the member must be sized by the Truss Designer to resist the combined bending and axial forces present under lateral and gravity load conditions. The Building Designer is responsible for specifying whether or not the end vertical members are exposed to lateral loads, and what these load requirements are. The same would also be true for vertical members of a truss that are “dropped” through the chord (i.e. extended above or below the truss profile). If bracing for these members is required, its location must be indicated on the Truss Design Drawings by the Truss Designer. Rated sheathing should be designed and detailed by the Building Designer to be installed as sheathing to the outside of the vertical end members to provide lateral support for these members and lateral stability for the mono pitch truss set. **See Figure 13 on page 19.**

FIGURE 13
MONO PITCH TRUSS END BRACING



(A) LATERAL LOAD REQUIREMENTS FOR EXPOSED END MEMBER TO BE SPECIFIED BY BUILDING DESIGNER. LOCATION OF LATERAL BRACING TO PREVENT WEB BUCKLING, IF REQUIRED, BY TRUSS DESIGNER.

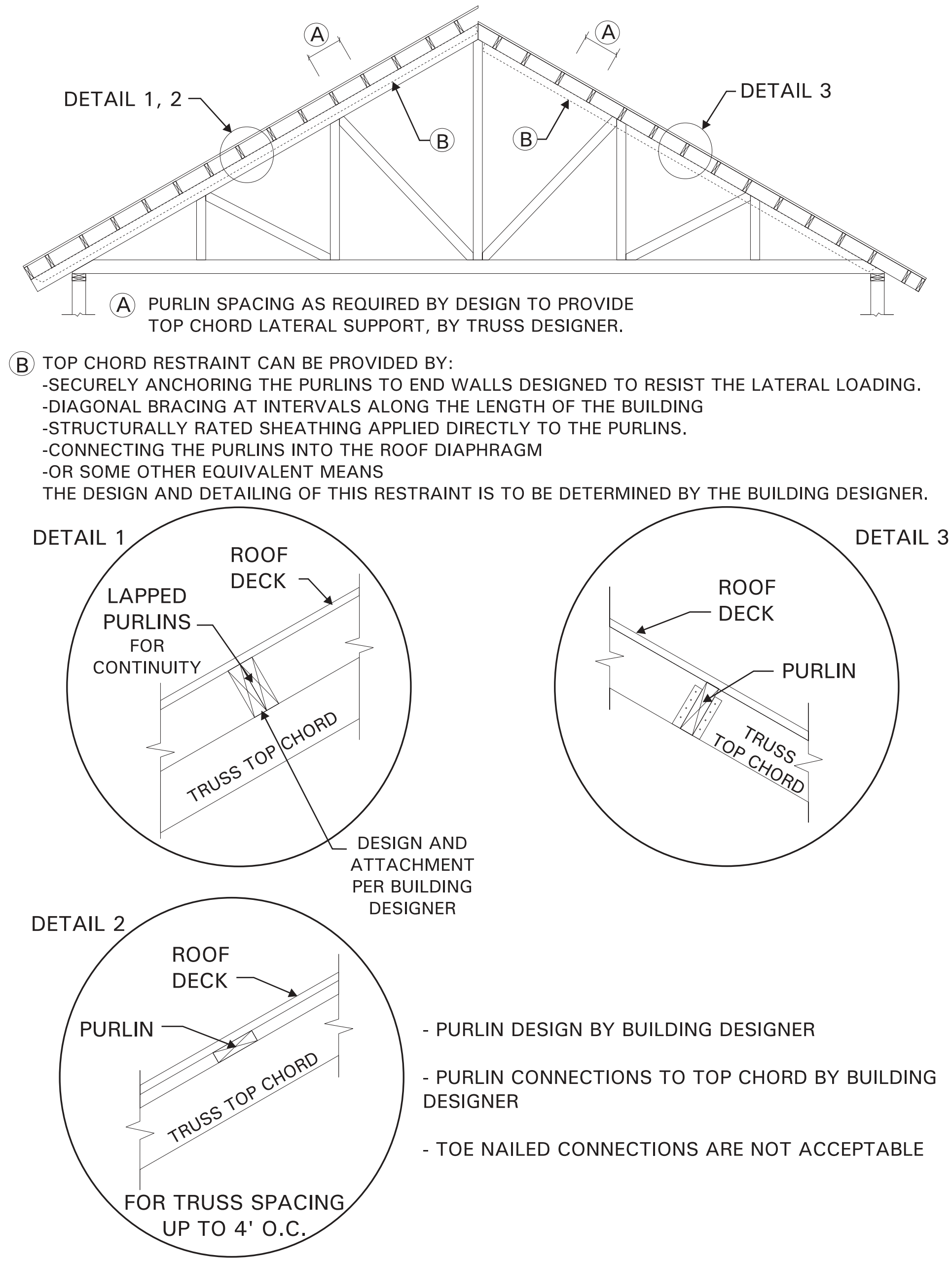
(B) RATED SHEATHING OR BRACING TO BE DESIGNED AND DETAILED BY BUILDING DESIGNER.

Top Chord Bracing by Purlins: Trusses may be designed for virtually any on-center spacing. In keeping with the availability of rated sheathing, 2 feet on-center spacing is usually standard. If wider truss spacing is desired, purlins are often used to span between the trusses and support the roof sheathing. For these types of applications, the purlins are also required to provide lateral stability to the top chord of the supporting trusses. Care must be taken to ensure the purlin spacing does not exceed the maximum allowable spacing for top chord lateral restraint as specified on the individual Truss Design Drawings. If the specified spacing is exceeded, the trusses will not perform as designed. It is imperative that the Building Designer and Truss Designer coordinate their efforts to ensure that the specified purlin spacing optimizes both the truss and building design.

The Building Designer must design the connections between the purlins and the top chords of the trusses to ensure the purlins will provide adequate lateral support. Toe nailing is generally not acceptable. For truss on-center spacings up to 4 feet, 4x2 purlins continuous over at least four trusses and spaced no farther apart than 2 feet, may be applied flatwise and connected to the top chord of each truss with the appropriate size and number of fasteners. Purlins over multiple ply trusses (e.g. girder trusses) must be attached to each ply with the appropriate size and number of fasteners.

For truss on-center spacings greater than 4 feet and purlin spacings greater than 2 feet, purlins should be placed with the depth of the member oriented vertically, and designed by the Building Designer as simple or multiple span members attached to the truss chords with special blocks, metal hangers, straps, or other equivalent means. **See Figure 14 on page 20.**

FIGURE 14
TOP CHORD BRACING
BY ROOF PURLINS



The roof deck must be capable of acting as a diaphragm to prevent purlins from buckling simultaneously in the same direction, unless the building designer has designed alternate permanent bracing for the top chord. Certain types of finish roofing may not be able to provide the necessary diaphragm action. In the absence of an adequate diaphragm, diagonal members may be required to be attached to the bottom of the purlins at both ends of the building, or at both ends of braced sets of similar trusses, and repeated along the length of the building at intervals to be determined by the Building Designer (per Section 5.3.1 of ANSI/TPI 1). **See Figure 15a and Figure 15b on page 21.**

FIGURE 15a
TOP CHORD BUCKLING WHERE LATORAL RESTRAINT IS ABSENT

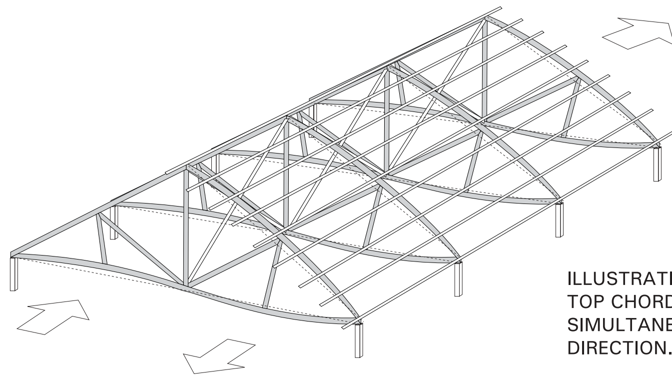
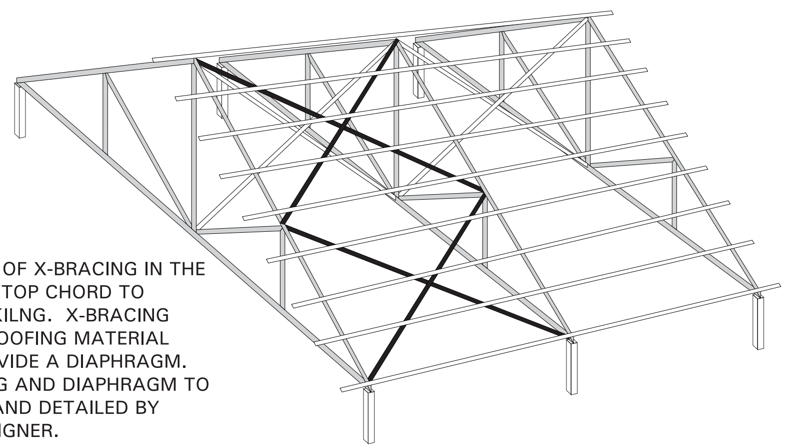


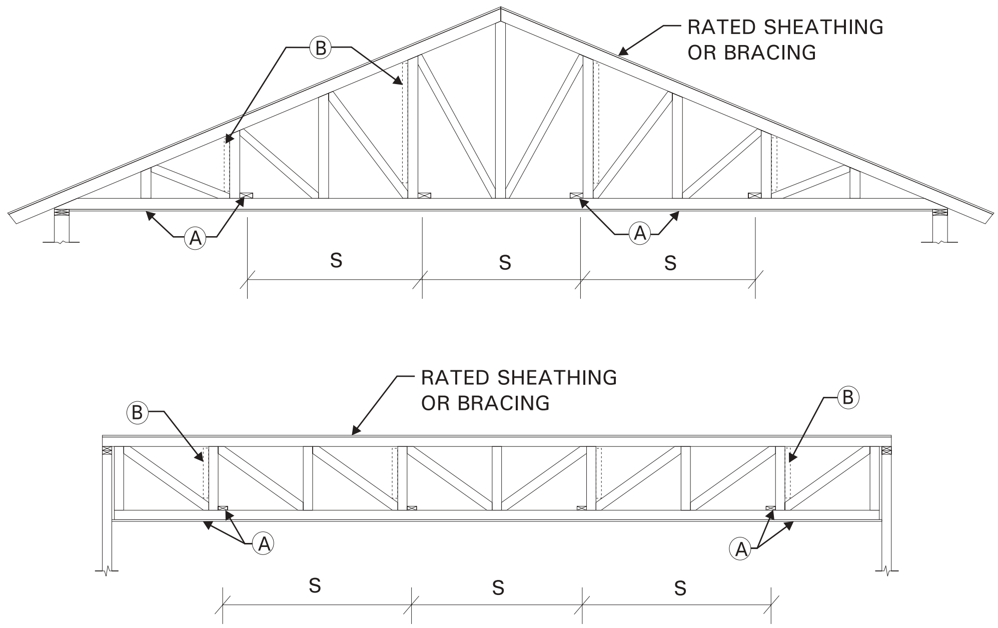
FIGURE 15b
TOP CHORD BRACING WITH ROOF PURLINS AND DIAGONAL BRACING



Knee Braces: In some buildings, particularly post-frame type structures, knee braces are used to brace the columns and reduce the effective buckling length. Knee braces can have a significant effect on the performance of the roof trusses and the Truss Designer must be advised of this requirement during the design process to ensure that the truss design takes into consideration the loads from the knee brace. Knee brace forces must be specified by the Building Designer and given to the Truss Designer. Knee braces must be designed and installed to act in the plane of the truss and must not produce lateral (out-of-plane) loads on the truss.

Bottom Chord Bracing: The bottom chords of trusses must be braced to ensure proper on-center spacing and to prevent lateral movement under certain service load conditions. This bracing will generally consist of a properly attached gypsum board ceiling or continuous lateral bracing properly restrained against lateral movement. It is the responsibility of the Building Designer to determine whether the material attached to the chord is sufficient to restrain lateral movement, or if additional bracing should be included. Lumber used for lateral bracing should be stress rated material of sufficient strength and stiffness to resist the chord buckling forces. The lateral bracing should be attached to the top of the bottom chord, at or near a panel point and spaced so that the L/d of the braced chords does not exceed 80 (i.e. 80x1.5" = 120" for nominal 2" lumber). **See Figure 16 on page 22.**

FIGURE 16
BOTTOM CHORD
BRACING FOR TRUSSES



SPACING, S, PER TRUSS DESIGNER
MAXIMUM, L/d = 80

Ⓐ BOTTOM CHORD OF TRUSS MUST BE BRACED BY A CEILING DIAPHRAGM OR LATERAL BRACING TO ENSURE PROPER ON CENTER SPACING AND TO PREVENT LATERAL BUCKLING. BRACING DESIGNED AND DETAILED BY BUILDING DESIGNER AT SPACING SPECIFIED BY TRUSS DESIGNER.

Ⓑ DIAGONAL SWAY BRACING FOR STABILITY AND LOAD SHARING BETWEEN TRUSSES, AS NECESSARY, DESIGNED AND DETAILED BY BUILDING DESIGNER.

NOTE: LATERAL BRACING MAY BE PLACED FLATWISE FOR TRUSS SPACING UP TO 4 FEET.

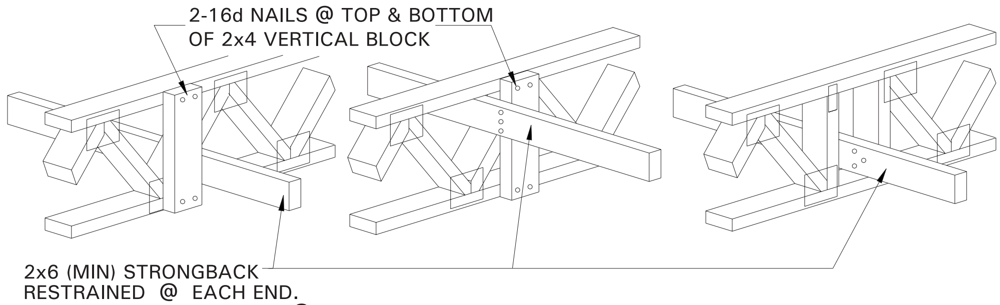
Trusses subject to load conditions that create compressive forces in the bottom chords require special consideration. Examples include cantilevered trusses, multiple bearing trusses, or trusses subject to uplift forces due to wind loads. Lateral bracing for these conditions should be designed by the Building Designer based on the compression force that exists in the chord under the specific loading condition.

All lateral bracing must be installed continuously between sets of similar trusses, and attached with no less than 2-16d nails per brace/truss connection. If diagonal bracing is required, it should be installed at about 45° to the lateral bracing, nailed to the side opposite the lateral bracing at both ends of the building, or both ends of similar truss sets, and at intervals determined by the Building Designer. Lateral and diagonal bracing between braced sets of dissimilar trusses must be adjusted to maintain lateral support between the dissimilar units.

<u>Floor Trusses</u>: Floor systems should be designed to carry all loads anticipated by the Building Designer, braced per the foregoing concepts and provide an acceptable level of serviceability with respect to vibration performance. This is often accomplished by limiting deflection of the structural components of the floor system to levels that are considerably stiffer than the minimums prescribed by the building code. Rows of continuous 2x_ strongbacks provide an additional

means of damping floor vibration within wood floor truss systems. **See Figure 17 below.** The performance requirements should be specified by the Building Designer in the Building Structural System Design Documents for use by the Truss Designer in the design of the individual floor truss components.

FIGURE 17
STRONGBACK DETAILS



SECURE WITH 3-16d NAILS @ EACH VERTICAL. LOCATE AS CLOSE TO BOTTOM CHORD AS POSSIBLE.

STRONGBACKS ARE RECOMMENDED TO MINIMIZE VIBRATION.

STRONGBACKS SPACED AT 10'–0" (MAX) ARE REQUIRED TO MAINTAIN CERTAIN FIRE ASSEMBLIES.

SUMMARY

The Truss Designer is responsible for indicating approximate bracing locations for individual truss members on the truss design drawing. The Building Designer is responsible for designing the permanent bracing and connections for the individual trusses and the truss structural system. This commentary is intended to aid the Building Designer in determining where and how to locate permanent bracing. Any bracing information shown on the individual Truss Design Drawings is for permanent lateral bracing of individual truss members only and is not the only bracing required for the roof or floor system.

In many instances bracing may be required on some individual truss members for more than one reason. It is the Building Designer's responsibility to determine which bracing requirement is most critical and to design the bracing and it's connections accordingly. The following suggestions are offered as a guide:

1. Up to 4 feet on-center truss spacing, all bracing members may be 2x_ stress rated material of sufficient strength and stiffness, connected with no less than 2-16d nails at every brace/ truss intersection. All continuous lateral braces should be lapped at least two feet for stiffness and continuity. The lapped joint should be attached with enough fasteners to sufficiently transfer the brace force through the joint.

2. For truss spacings greater than 4 feet on-center, bracing members and connections should be designed, sized and detailed by the Building Designer. Continuous lateral bracing members should overlap at least 2 feet to provide adequate contact area for connections and ensure stiffness and continuity.

3. Long lateral braces spanning between widely spaced trusses may exceed the allowable L/d ratio for compression members, and therefore may require stiffening with a scab, "T," "L," or "U" brace.

4. Parallel chord trusses used in floor applications should be specified by the Building Designer to have permanent, continuous rows of minimu 2x6 strongbacks between adjacent trusses, at spacings not to exceed 10 feet. Additional rows of strongbacks, together with deflection limits more restrictive than code allowed maximums provide a means of minimizing perceived floor vibration. The free ends of the trusses should be tied together with continuous 2x4 banding.

The provisions outlined in this document are based on the best information and engineering judgement that the truss industry has available to it at this time. Many of these recommendations are solely based on experience and judgement and should not be considered to be the absolute best approach to all permanent bracing needs of the building.

ILLUSTRATIVE EXAMPLE

An actual truss bracing problem is illustrated in **Figure 18 on page 25**. For permanent bracing design, the application of rated roof sheathing and end sheathing is assumed to be installed in accordance with local building code requirements. Since the trusses are spaced at 2 feet on center, no additional bracing is necessary at top chords or end members.

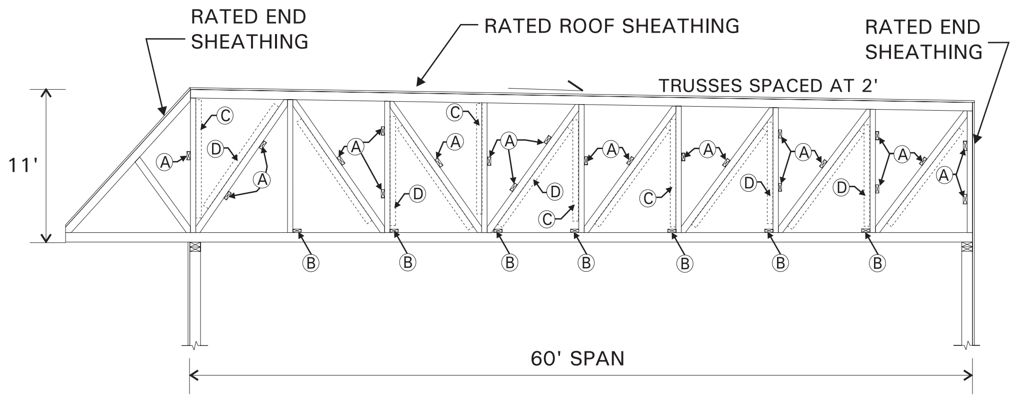
Ⓐ The Truss Design Drawing shows continuous lateral bracing required by design to reduce the buckling length of certain individual web members. Member axial forces for worst case design conditions are listed on the truss drawing for each truss member. Some web members require bracing at mid-length, others require bracing at one-third points, and still others do not require any bracing. For this example, the Building Designer has determined that additional bracing is required to prevent these members (when in compression) from buckling simultaneously, in the same direction (see below).

Ⓑ The Truss Design Drawing specifies bottom chord bracing at not more than ten foot on center. Since bottom chord panel lengths are approximately 7.5 feet, the Building Designer placed bottom chord lateral braces at each panel point. Trusses spaced four feet or less may have bottom chord bracing installed flatwise, continuous between similar trusses. Lap all lateral bracing at least two (2) feet (one truss spacing in this case).

Ⓒ& Ⓓ Diagonal bracing (45°±) is applied to the side opposite the mid-point and one-third-point braced web members to stabilize the lateral bracing and thereby prevent a series of these members in similar trusses from buckling simultaneously in the same direction. These diagonals need not be continuous. Spacing may be accurately determined by the Building Designer, using the 2% rule, found in DSB-89(9), beginning at one or both ends of the building or at one or both ends of similar truss types.

> **<u>NOTE</u>:** By observation, the Building Designer determined that, due to the large number of diagonally braced lateral braces throughout the width and length of the building, additional SWAY bracing would not be necessary.

FIGURE 18
ILLUSTRATIVE EXAMPLE



Ⓐ CONTINUOUS LATERAL BRACING TO REDUCE BUCKLING LENGTH OF WEBS BASED ON WORST CASE DESIGN CONDITIONS. APPROXIMATE LOCATION SPECIFIED ON TRUSS DESIGN DRAWINGS BY TRUSS DESIGNER. CONTINUOUS LATERAL BRACING MAY BE APPLIED TO EITHER SIDE OF THE WEB.

Ⓑ CONTINUOUS LATERAL BRACING ON BOTTOM CHORD AT PANEL POINTS, DESIGN AND DETAILING BY THE BUILDING DESIGNER.

Ⓒ DIAGONAL BRACES ON MID-BRACED WEB MEMBERS TO PREVENT MEMBERS FROM BUCKLING SIMULTANEOUSLY IN THE SAME DIRECTION. DESIGN, DETAILING AND SPACING OF DIAGONALS TO BE PROVIDED BY THE BUILDING DESIGNER.

Ⓓ DIAGONAL BRACES ON ONE-THIRD BRACED WEB MEMBERS TO PREVENT MEMBERS FROM BUCKLING SIMULTANEOUSLY IN THE SAME DIRECTION. DESIGN, DETAILING AND SPACING OF DIAGONALS TO BE PROVIDED BY THE BUILDING DESIGNER.

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