Complex Sloping Steel Roof Issues

SEAC/RMSCA Steel Liaison Committee

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Original Participating Members of the Committee

Dave Henley, *P.E., Vulcraft*
Tim Hickish, *P.E., Jirsa Hedrick & Associates, Inc*
Robert Leberer, *P.E., S.E., Anderson & Hastings Consulting Engineers, Inc*
Patrick McManus, *S.E., Puma Steel*
Justin Mitchell, *P.E., LPR Construction Co.*
Derek Pedersen, *P.E., JVA Consulting Engineers*
John Quinn, *Zimkor LLC*
Brent Ross, *Zimkor LLC*
Tom Skinner, *P.E., JVA Consulting Engineers*
Bryan Starr, *P.E., S.E., S. A. Miro, Inc*
Tad Toler, *Cobalt of Colorado*
Maynard Trostel, *P.E., Puma Steel*
Jules Van de Paas, *P.E., S.E., Computerized Structural Design*
Scott Van Deren, *Mountain Steel & Supply Co.*
David Weaver, *Zimmerman Metals, Inc.*
Bruce Wolfe, *P.E., Structural Consultants (Chair)*
Bill Zimmerman, *P.E. Zimkor LLC*

Members of Revision Team

Maryann Davis, *P.E., Drake Williams Steel*
Dave Henley, *P.E., Vulcraft*

Introduction

Steel roof framing construction can present challenges that do not occur with flat roofs, and become increasingly complex as slopes increase beyond ¼" per foot. Mountain projects almost always fall into this type of construction. Non-repetitive framing, vaulted framing, connections and deck support must be clearly defined in the Design Documents for the construction team since conditions are almost always atypical. The General Contractor, Detailer, Fabricator and Erector may be faced with incomplete Design Documents and left to guess about the design intent. This paper addresses important considerations for inclusion in the Design Documents for complex sloped steel roof construction.

This paper has been assembled in a question-and-answer format by members of the committee who are in the trenches daily.

Topics & Contributors

1. Dimensioning of Design Drawings – Justin Mitchell/ Tad Toler.
2. Defining Framing Conditions with Sections and Details – Bryan Starr/ Rob Leberer
3. Required Deck Support and Design – Tom Skinner/ Derek Pedersen/ Maynard Trostel/ Patrick McManus
4. Open Web Steel Joists – Dave Henley
5. Steel Connections – David Weaver
6. Snow Guards & Tie-offs – Tim Hickisch
7. Specification & Design Drawing Conflicts – Scott Van Deren

Topics

1. **Dimensioning of Design Drawings**
   A. What are work points and where should they be established on a complex sloping roof?
      1) A work point can be defined as a reference point on the Design Drawings. Work points are commonly the intersections of the centerlines of beams, girders, columns, and braces. Work points shown in plan must have a corresponding elevation.
      2) Think of a sloped roof as a series of geometric deck planes sitting atop the steel structure. Each endpoint of the polygonal deck plane will require a horizontal location in plan. If the polygonal deck planes represent the bottom of deck (B.O.D.), we have established the work points required to lay out the supporting steel frame. See Figure 1.1 – Deck Plane Plan View. It is much easier to work with B.O.D. than top of steel (T.O.S.) elevations.
      3) On complex sloping roof framing, the work points should be established at the intersections of the framing centerlines in plan and the bottom of the deck planes at ridges, perimeter framing, and transitioning slopes in the roof planes. See Figure 1.2 – Sloped Roof Plan View. Properly established work points that include B.O.D. elevations will define the limits of the architectural envelope into which the steel framing must fit and allow the steel detailer to accurately detail all the individual members of the sloped roof system.

   B. Should work points be provided on the Structural Drawings or is it sufficient to provide only the roof slope and B.O.D. for each member?
      1) The Structural Drawings for complex sloping roofs should have clearly identified work points on the plans, which will allow the steel detailer to layout the geometric properties of the roof. Roof slope is not recommended for detailing due to likely insufficient precision but if given should be stated as approximate for understanding general geometry only (add +/-).

   C. What issues should be taken into consideration when dimensioning sloped roof framing plans?
      1) It is the responsibility of the design team to provide the dimensions and work point elevations for the roof framing plans on the Design Drawings that have been accurately coordinated with Architectural Drawings.
      2) It is critical that all roof framing members be dimensioned in plan with offsets from grid lines.
      3) Secondary dimensions should also be coordinated, and their locations must be accurately shown in the Design Drawings for such items as mechanical penetrations, tie-off davits, roof access hatches, snow fences, etc.

   D. What is the critical information that needs to be provided on the Design Drawings regarding B.O.D. elevations, roof slopes, work points, etc. without providing too much information?
      1) There is a greater chance of inadvertent conflicts to arise if too much dimensional information is provided on the Structural Drawings. The provision of critical information in the Design Drawings will greatly increase the likelihood of accurate shop and erection drawings.
      2) Provide either the horizontal position of the starting and ending work points of sloped members along with the B.O.D. elevation at the work points <u>or</u> the horizontal position of the starting work points. Also, if a dimension along a slope is critical, then it needs to be defined. Too often indicated slopes and elevations are in conflict. Do not provide both. This suggested approach will allow the detailer to fill in the blanks between the defined work points. The common use of well-defined work points at key roof transitions by the Structural Engineer, Detailer and General Contractor will allow for simplified review and coordination.

E. How should deck bearing (B.O.D.) elevations be defined?
   1) Provide accurate deck bearing (B.O.D.) elevations and details at all high, low and transition points of ridges, valleys and eaves along with horizontal plan dimensions. The details must clearly define transition relationships and accurate elevations of supporting framing members such as columns, ridge beams, and valley beams. T.O.S. can then be determined by the steel detailer.

F. The roof plan drawing can become cluttered with information making it extremely difficult to understand roof slopes and elevations on 2D Plan drawings. Is there a simple way to display the basic information for the detailer?
   1) Yes; provide a separate, organized plan with only elevations and work points. Do not show member sizes, details, etc., on this plan.

G. Is there a way to help the Steel Detailer visualize roof slopes and accurate locations of framing in complicated areas such as dormers and areas of multiple slope changes?
   1) Yes; provide 3D isometric views of both "big picture" and localized areas to help the Detailer visualize the framing. This level of information is needed to avoid resubmittals and additional charges for undefined work.

H. What if 3D isometric views are only representative and they do not accurately match the Design Drawings?
   1) Information that is representative only should be noted as such so that the Steel Detailer knows which information controls.

I. What are some key issues to consider for <u>erection</u> of dormers and vaulted framing?
   1) During design, detailing, and fabrication…" think like the erector."
   2) Pre-assembly consideration input is needed from the Erector including connection details & locations, and erection sequence of framing. Pre-assembly of dormers, A-frames, spires, etc. are preferred by the Erector. See Figure 1.3. 3-D/Isometric diagrams provided on the Design Drawings can help the Erector visualize the construction. Keep in mind ease of accessibility when choosing connection details & locations for these pre-assemblies. For example, simple bearing plate connections from the protruding columns below can be advantageous. See Figure 1.4. Extended shear tab plates, which are often used for sloped roof connections are not desired at each end of an A-frame due to a concern about temporary stability during erection. In this case, beam end plates or column bearing plates are preferred. Also, it is important to keep connection elevations & connection types consistent for ease of erecting the pre-assembly. See Figures 1.4 & 1.5.
   3) Where possible, avoid HSS or channel framing. Their profiles are extremely difficult to traverse during erection and can present difficulty for attachment of temporary safety tie-offs. See Figure 1.6.
   4) Keep the number of framing members for a sloped roof to a minimum. Sloped roofs are labor and cost intensive, so the fewer framing members the better.
   5) Allow for structural tolerances in the architectural details since the structure will not be perfect for trades following the steel erection. Special attention should be given for tolerances in the structural details since trades following the steel erection may have tighter tolerance requirement.

2. Defining Framing Conditions with Sections and Details

Sections and details are essential. They are an effective and necessary way to illustrate construction concepts including bearing conditions, overhangs, deck support plates, bent members, framing relationships, connections, and more. In the case of complex sloped steel roofs, the use of effective details becomes especially important.

A. General Typical Details – When are they appropriate?

1) It is a common practice to include a sheet or two of general *typical* details in the Structural Design Drawings. In the case of complex sloped steel roofs, these details can be effectively used to illustrate connections, deck attachments and additional material necessary for deck support or framing around openings etc., that are *typically* required in the construction of the framing system.
2) There can be a tendency for the Structural Engineer to rely too much on *typical* details and notes in conveying the requirements of the project to the General Contractor. Information included in general *typical* details should be limited to general information that is common to broad portions of the scope of a project. They should be noted as such and that specific details have precedence.

B. Specific Details **–** When are they required?

1) The AISC Code of Standard Practice, (AISC 303-16), states "The structural design documents shall clearly show or note the work that is to be performed…," and when discussing particular details, (bracing, stiffeners etc.), it states, "[they] shall be shown in sufficient detail in the structural design documents issued for bidding so that the quantity, detailing and fabrication requirements for these items can be readily understood."
2) Specific details should be used to provide supplementary information that cannot be reasonably understood in the plans or typical details. This often includes relationships between elements, or variations such as different roof slopes, deck depths, span directions, skews, overhangs, etc., that occur at specific locations. For complicated sloping steel roof framing, the design professionals should investigate framing conditions at all locations in determining where specific details are required. This usually involves considering or sketching many more details than will ultimately appear on the Structural Design Drawings. This process can also help to uncover conditions that require revisions to member sizes or depths to accommodate connections. If a BIM model is created for the project, it can be used to coordinate conflicts, determine the need for details, and develop them.

C. Referencing "similar" Specific Details – When is it appropriate?

1) The practice of referencing "similar" details at alternate locations that are not identical is not unusual. However, the references often do not clearly identify the corresponding variations or similarities. In addition, there can be a tendency to over-reference the same detail as "similar" at too many locations on the plans, leading to conflicts and ambiguities.
2) If a "similar" detail is referenced, the differences should be clearly indicated. Referencing the same detail at multiple locations, that have multiple variables, should be avoided. There is a limit to the conveyance of accurate information by referencing "similar" details. It should be noted that the reader may not be able to understand the intent of the design professional regarding similar details. The Structural Engineer should look very, very hard at the

appropriateness of referencing “similar” and “typical” details at each specific location during the preparation of the Structural Design Drawings.

3. Required Deck Support & Design

A. What should be considered for proper design and detailing of support of roof deck on sloped steel roofs?

1) The roof deck needs to be continuously supported with appropriately spaced supports and along its edges for the transfer of gravity and lateral loads to the supporting structure.
2) Often sloped roofs cause snow drifting and/or sliding conditions that increase gravity loads on the deck.
    a. Consider locally decreasing the spacing of deck supports at drifting and/or sliding areas. Alternatively, select a stronger deck section if additional supports would increase costs and complexity beyond that of heavier deck.
3) Triangular sections of deck near hips and valley construction can often place the roof deck into single or two span conditions when the typical roof deck has been selected by the designer based on two or three span conditions, respectively.
    a. Add intermediate supports to reduce the span length and increase the number of spans. Alternatively, select a stronger deck that can support the loads under the local one or two span condition.
4) Hip, valley, and ridge beams should be dropped to prevent their top flanges from interfering with the plane of the roof deck. An additional support element, such as a continuous bent plate, added to the tops of the beams will support the deck and transfer deck forces to the beam. See Figures 3.1 and 3.2 for an example of a continuous bent plate welded along a dropped hip beam.
    a. The dimension that the beams must be dropped varies with the width of the flange, the slope of the roof and the location of the beam as a hip, valley or ridge.
    b. Load transfer of deck forces at bearing/shear walls can be achieved with a continuous bent plate beneath the deck that is welded to a series of embed plates cast into the top or side of the wall. The designer should consider varying tolerances between materials.
    c. Convergence points of multiple planes of roof decks may require a unique support element to offer a large enough support area for the deck as well as make the deck connections achievable. At hips and valleys, be aware that the deck will be cut in the field. The cut will probably be made perpendicular to the plane of the deck, not beveled. Due to this, make sure there are generous bearing lengths for the deck. Increase beam flange widths or bent plate dimensions if necessary. On sloped roofs with steel bar joists, the beams are dropped an additional amount to accommodate the joist bearing depths. Additional detailing consideration may be required to support the deck between joists. The deck support can be a special bent plate attached to the top of the beam between joists or it could be a continuous bent plate that spans from top of joist to top of joist to provide continuous support to the angle cut deck edge.
5) AWS limits puddle welding of deck on sloped roofs to a maximum of 15 degrees (approx. < 3/12) without special qualification. Mechanical fasteners should be specified instead. Keep in mind the requirements of this type of connection when selecting the roof deck and the deck support. AWS does allow the Structural Engineer to modify the requirements of the code if it is incorporated into the Design Drawings. Some Erectors have used low hydrogen

electrodes that harden quickly with successful results on steep roofs. Welds may need to be pre-qualified.

6) Cold Formed framing is a common support option on sections of complex sloping roofs. This can be the main roof supports or overfaming, crickets, etc. Deck attachment should not be made with welds due to the probable slope and the minimal thickness of the framing. Mechanical attachments should be used. If diaphragm shear is a design consideration, use a cold formed framing diaphragm shear table or tool to find the capacity because screw tilting can reduce the capacity below common diaphragm shear values when support framing is less than $^{1}/_{8}$" thick.
7) Often pitched roofs have eaves or roofs that overhang the exterior walls. Structural elements that fit within the depth of the eaves may be required at corners of the roof where two eaves meet to prevent a soft corner. Structural eaves can be supported by cantilevered joist/beam ends that support a structural sub-fascia member at the edge of the eave, which in turn cantilevers to the corner of the roof.
8) Roof planes on projects with steep roofs will sometimes carry past or through one or two levels of floor framing.
    a. Keep in mind the sequencing of the erection of the floor and roof elements. Detailing that facilitates a logical erection sequence may require additional elements.
    b. Detail these areas to provide a clear load path for gravity and diaphragm forces to transfer from the roof or floor decks to the supporting elements.
9) Dormer framing that is over framed instead of incorporated into the main roof structure may require secondary elements between the roof joists / beams that can support and transfer gravity and lateral loads from the dormer. Consider adding an element spanning between the roof joists or beams under the intersection of the dormer and main roof deck for deck support.
10) Arched dormer framing presents unique design challenges.
    a. The curved valley at a curved dormer interface with a flat main roof must be considered in providing valley support members. See figure 6.3, attached.
    b. The deck should be oriented perpendicular to the curve of the dormer such that the deck is field curved in the weak direction.
11) Diaphragm shears may be transferred through minor axis bending of the beam and through their connections to the supporting ridge or valley member. The designer needs to ensure that these members have the capacity to transfer the loads in this manner. Sloped joist seats have no capacity to transfer these "rollover" forces. Provide an alternate load path.
12) Often projects with sloped roofs also feature stone wall veneer that is supported on lower roof elements. Roof deck has a limited capacity to directly support the weight of the veneer.
    a. Place HSS or steel channel members within the deck flutes spanning to the adjacent deck supports for reinforcement to support the base of the veneer. Alternatively, run the stone or masonry through the roof deck plane to steel member supports below. Make proper connections of the deck to the support and wall.
13) Wherever possible, frame the roof to allow the roof deck to span perpendicular to the roof slope. This adds to cost effectiveness of roof deck construction and provides safety for the Erector and the trades that follow.
14) There may be times where roof decks of different depth are used on the same project. An example would be where an overbuilt area utilizes 1½" deck for short spans between light gage trusses or at an arched dormer and the deck for the main roof has longer spans and is framed with a 3" deep deck. Where these decks meet, the top of the decks may need to align

for the roofing, resulting in varying bottom of deck elevation. It is generally better to keep the B.O.D. at the same elevation and add a bent plate transition or rigid insulation on top of the shallower deck to even out the roofing surface.

4. Open Web Steel Joists

A. Is it better for the joists to span parallel or perpendicular to the slope?

1) It is better when the joist framing is parallel to the slope, especially if the slope is steep, (greater than 2:12). The forces along the plane of the roof can then be transferred into the joists along their longitudinal axis. Joist manufacturers have the capability to design the joists for vertical loading even though the joist is not level. Remember to use the sloped length of the joist to select joist type from the load table.
2) Steel joists do not have the capacity to resist loads perpendicular to their weak axis. So, if joists are framed perpendicular to the slope:
   a. The Design Drawings must show other means to resist gravity forces along the plane of the roof. The deck, added bracing, or other means will be required to resist load components along the roof plane. Standard joist bridging should not be used to resist these loads.
   b. The joists should be canted (tilted) normal to the roof plane, or a detail needs to be added showing a bent plate added to the joist top chord for deck bearing.
   c. For canted joists, additional and/or heavier bridging may be required to keep the joists straight and out of plumb during erection and during service life.
   d. For canted joists, vertical loads, such as rigging, cannot be applied to the top or bottom chords since this will twist the chord and the entire joist.
3) Spanning the joists parallel to the slope allows the deck ribs to be horizontal giving the erector an easier and safer work surface (see 3.A.12 above).

B. Can joists bear directly on hip beams?

1) No; provide level bearing surfaces for steel joists using bent plates or provide bearing surfaces that slope parallel with the joists.

C. What is the "roll-over" capacity of a sloped joist bearing?

Roll over capacity of steel joists is significantly affected when a sloped bearing is used, particularly where the bearing depth is increased. Assume there is no "roll over" capacity and use a bent plate, blocking, or other means to transfer the shear from the deck to the structure.

D. What is the difference between a "Pitched" joist and a "Sloped" joist?

"Pitched" joists are defined as joists with non-parallel chords as opposed to "sloped" joists that have parallel chords and sloped bearings. See figure 4.1.

E. How do you specify a pitched joist?

1) Double pitched joist depths are typically specified for roofs with ridges perpendicular to the joist span. The depth is specified at the ridge.
2) Single pitched joist depths are typically specified using the required depth at mid-span. However, other means to specify the joist profile may be better. Actual or theoretical depths at the ends or grids can sometimes be used to be more specific.

3) If a standard designation is specified, the uniform load capacity shall be determined from the SJI load tables for that standard, whether the joist has parallel chords or is of a pitched chord configuration.
4) Do not specify pitched KCS joists.

F. Should standard joist camber be used for sloped roofs?
1) Steel joists are typically provided with a standard camber. Standard camber should always be used unless there is a compelling reason to change it. Changing or eliminating the camber in joists from the standard is expensive.
2) Double pitched joists with chords sloped more than 1" per foot are not typically cambered. Camber may leave the elevation at the ridge of a double pitched joist higher than expected. If elevations are critical at the ridge of the joist, allow for or change the camber.
3) A mixture of non-cambered roof beams with long cambered joists will create deck erection difficulties.
4) Cambering primary members such as joist girders in combination with steeply sloped joists bearing on them will create joist length problems. Joist lengths are not normally determined accounting for the camber of the supporting member. The designer should strongly consider no camber.
5) Deflections of primary members at the high end of joists in steep roofs will create horizontal deflections and thrusts that need to be considered.
   a. As the structure is loaded, the exterior walls will deflect outward. This phenomenon must be considered if the wall must remain plumb.

G. What are the bearing depth considerations for sloped joists?
1) Use Figure 4.2 or equations in the joist catalog for sloped joist bearings.
2) Bearing depths must be kept consistent. Increase adjacent shallower bearing depths to match bearings with deeper requirements.
3) When bearing on top of a wall or beam, the bearing depth at the high end of the joist must allow:
   a. The top chord must clear the inside edge of the masonry wall or beam flange edges.
   b. The bearing depth must allow clearance for the intersection of the web and top chord centroids over the bearing surface.
4) At the joist low end:
   a. Any extension must also clear the far edge of the beam flange or wall. For normal loading, a beginning rule of thumb is that the extension depth will need to be approximately the same depth in inches as the extension is long in feet. Coordinate with a joist manufacturer in advance for long or heavily loaded extensions.
   b. In addition to the vertical clearance needed for the extension, adequate vertical depth must be provided for the fabrication of the sloped joist bearing under the top chord or extension.

5. Steel Connections

Forethought and a little value engineering up front can reduce the overall project cost and shorten the schedule. For example, while the use of the lightest beams as required by design will save money in material, the resulting increases in connection costs may exceed the material savings. See Figure 5.1 for an example showing a shallow rafter which resulted in some expensive connections.

A. What considerations for connections should be made when sizing members?

1) Flange widths should be considered when sizing supporting members. Wide supporting members result in large copes in the sloping supported members. Large copes decrease the strength of the sloping member and often require web doubler or web extension plates.
2) The choice of a shallow size for a sloping member will increase the complexity of its connection. Generally, sloping members should not be shallower than a W12. See figure 5.2.
   a. Coped W8 and W10 sections often do not have adequate strength for the required connections. They often fail bending/buckling limit states.
   b. W8 and W10 sections often require web extensions in order to meet minimum bolt requirements. This is especially true when the slope of the beam decreases its effective depth at the connection.
3) It is often more cost effective to choose a heavier beam with a thicker web than to use the lightest beam possible. This is because copes on sloped beams often require the removal of both flanges or significant portions of the web at its connections. If the web is not thick enough, then web doubler plates are required.
4) Avoid use of “column sections” as beam members as they have reduced “T” dimensions that further limit available connection depth

B. How should roof connection requirements be specified in the Design Drawings?
1) Specifying roof connection loading criteria based on member capacity is inappropriate and may require excessive capacity that is not attainable or practical. The members most affected are often short or governed by deflection or uplift conditions, thus requiring the connection capacity to be substantially higher than necessary. This requirement often results in unnecessary and costly web doubler or web extension plates. This problem can be avoided by either showing connection details in the Design Drawings or showing the actual end reaction loads. While these issues are present in flat roofs, sloped roofs exacerbate these issues substantially.

C. While designing connections what considerations should be made for access.
1) Shop weld access is often limited when multiple connections share a common work point. This can be alleviated by building out the connection with cover plate, HSS or WT near the flange edges of the supporting beam.
2) Field bolt access is often limited in skewed connections, particularly where multiple connections share a common work point. One solution is to push the line of bolts further out from the supporting member, however large eccentricities will result. Another solution is to build out the connection by placing a cover plate, HSS, or WT near the flanges of the supporting beam.

D. What are the considerations when designing moment connections for cantilevered members?
1) Weld access, thickness of material being welded to, backer bars, and field conditions should all be considered when designing moment connections at cantilevers.
2) The designer should account for the slope of beam and supporting members where they differ.

6. Snow Guards & Tie-offs

A. Snow retention systems are an additional consideration that applies to sloped roofs and not flat roofs. While they are beyond the scope of this paper, the design team is encouraged to consider their existence during design.

B. Who designs the snow guards on a building?
   1) If the snow guards are not pre-manufactured, where they are attached to the roof shingles or to the ribs of the metal roof, then the Engineer of Record should design and provide details for the snow guards. Some pre-manufactured snow guards may require structural support below their attachment to the roof.

C. What design loads should be used to size and detail snow guards?
   1) What is written on this issue is not very specific. ASCE 7-16, "Minimum Design Loads for Buildings and Other Structures", has only one paragraph on this subject

      Snow guards are needed on some roofs to prevent roof damage and eliminate hazards associated with sliding snow (Ref. C7-60). When Snow guards are added to a sloping roof, snow loads on the roof can be expected to increase. Thus, it may be necessary to strengthen a roof before adding snow guards. When designing a roof that will likely need snow guards in the future, it may be appropriated to use the "all other surfaces" curves in Fig. 7.2, not the "unobstructed surfaces" curves.

D. Structural design assumptions for the design and support of snow guards vary widely. Reasonable assumptions would be:
   1) Assume zero friction between the roof and the snow.
   2) Do not reduce snow loads for the roof slope.
   3) Use the larger unbalanced snow loads indicated in ASCE 7-16.
   4) Single guards near the eaves shall be designed for the trapezoidal volume of snow above it and the ends of the guard should be sized for a larger proportion of snow than the rest. See Figure 6.1.

E. Where should snow guards be placed?
   1) Typically, they should be placed no less than 12" upslope from the inside face of wall below to mitigate ice damming. See Figure 6.1

F. The Architect says that some areas of the roof will require snow guards, but they are not designed yet. Can I just add some notes to the structural drawings to cover pricing for these guards?
   1) No. Snow guard construction and complexity can vary significantly. Primitive ones in the Alps just use a log tied to the roof. See Figure 6.2, photo 1. Pad-style snow guards are individual guards typically attached to the roofing material, either mechanically to the shingles or with an adhesive to the metal roofing. They are installed in a grid pattern to create a large area where snow is supported. See Figure 6.2, photo 2. Lastly, there are pipe-style snow guards that are secured to the roof to create a fence barrier. This last one typically performs the best. Choices are either pre-manufactured or custom designs. See Figure 6.2, photo 3 for a custom design. While the log design is not typically used in Colorado, the pad type can be included in the roofing specification. Pipe style guards usually require secondary structural members for support. Since custom designs will have a significant impact on the project cost and coordination of additional structural member supports, it is important that the Architect clarify the type of snow guards desired early in the design phase.

G. Do you have to consider longitudinal thermal effects of pipe-style snow guards?

1) Yes; long horizontal sections of exposed pipe will undergo thermal expansion and contraction, which could result in damage to the roof attachment. With this scenario, positive slip joints must be provided. Pre-manufactured pipe styles typically include details to allow for this movement.

H. Will snow guards always support all the snow above them?
   1) No; snow can accumulate and drift to a point that requires the snow to be removed.

Conclusions

Complex sloping steel roof construction by its very nature requires much more thought and job specific details than a typical project with a ¼" per foot roof slope. Without the needed project-specific information, the General Contractor, Steel Detailer, Fabricator and Erector are faced with guessing about the requirements. Guessing often leads to field coordination problems and additional costs. The EOR is encouraged to provide the suggested information in this paper and to be consistent with the AISC COSP.

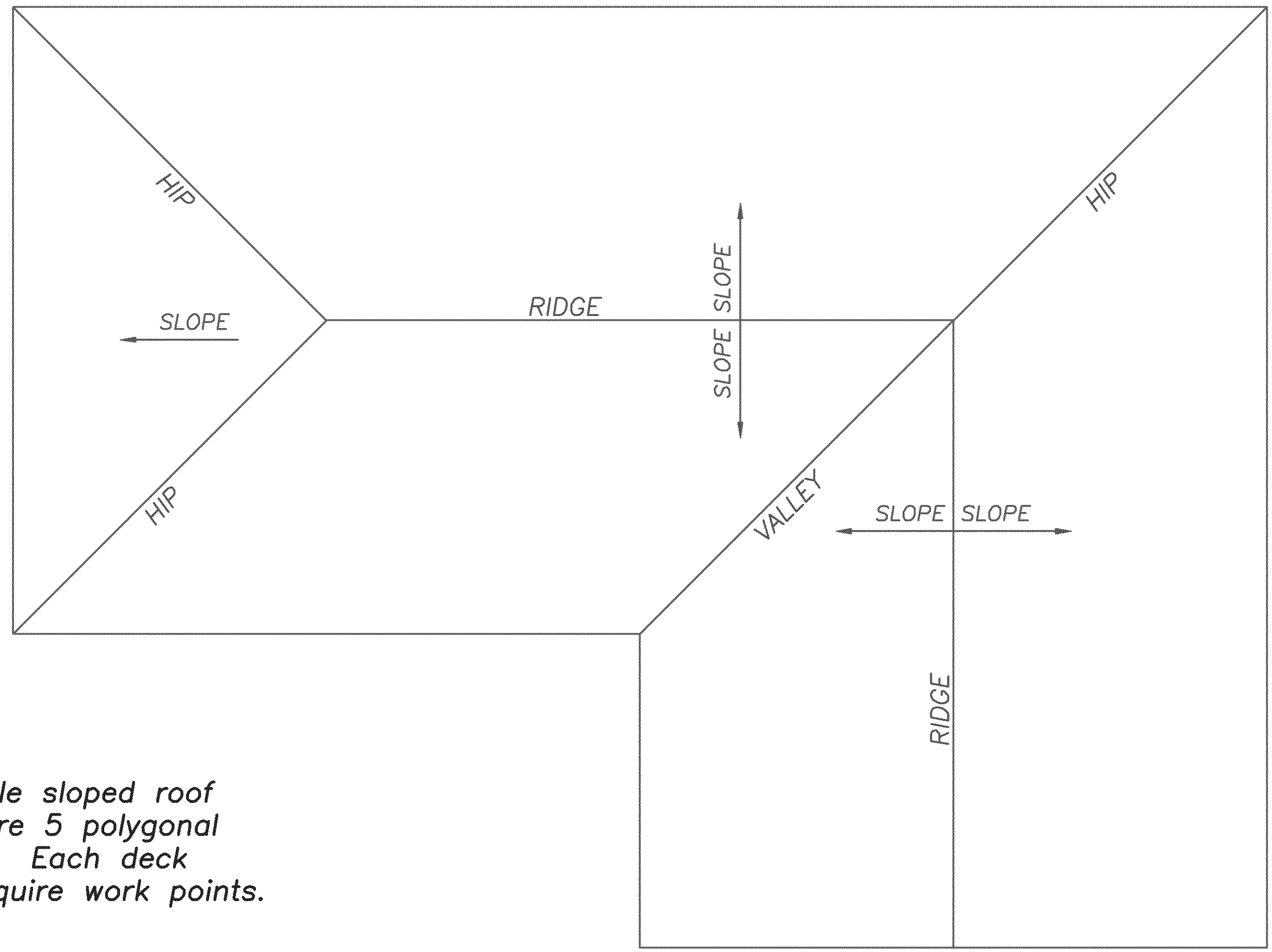


FIGURE 1.1
In this sample sloped roof plan there are 5 polygonal deck planes. Each deck plane will require work points.

DECK PLANE PLAN VIEW

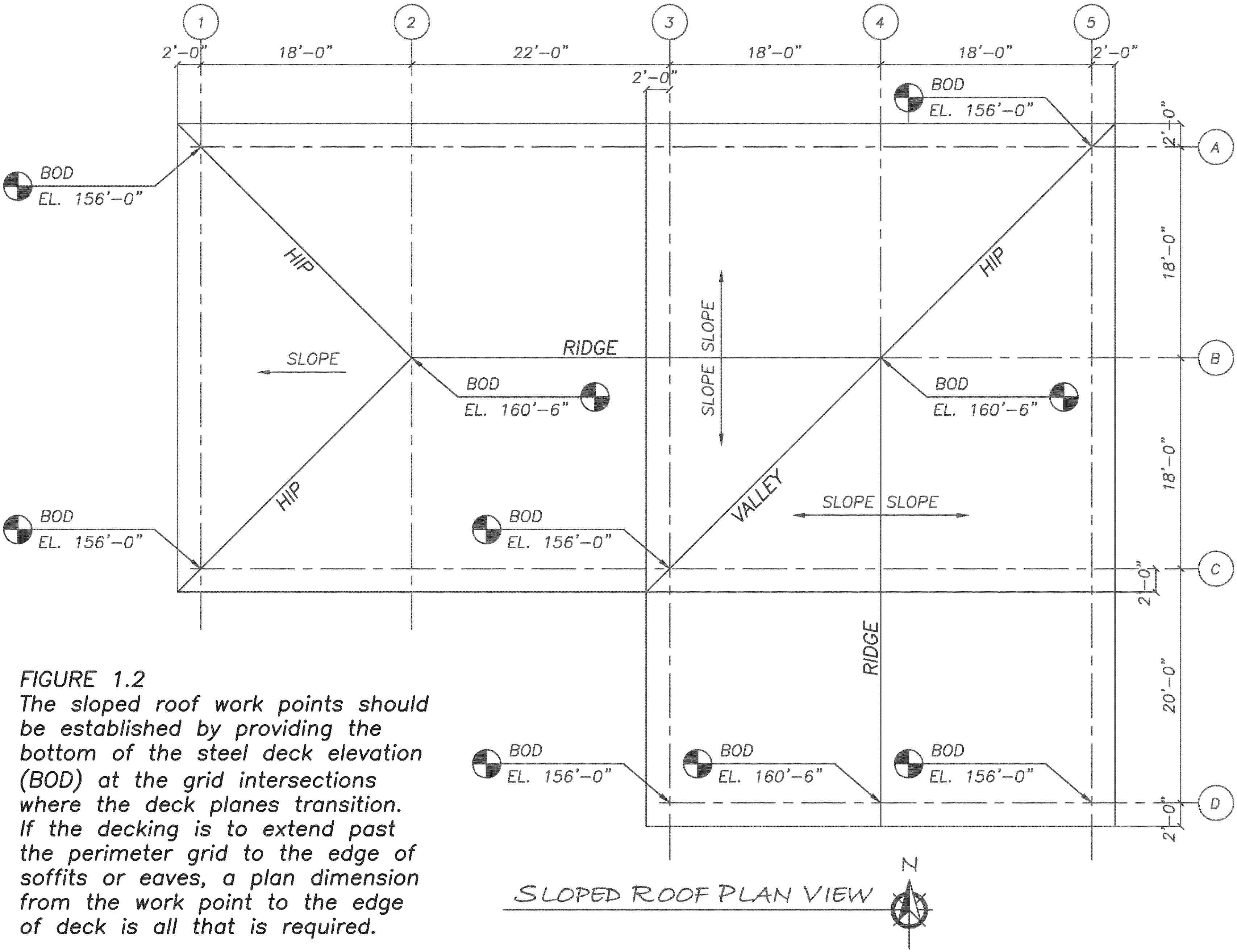


FIGURE 1.2
The sloped roof work points should be established by providing the bottom of the steel deck elevation (BOD) at the grid intersections where the deck planes transition. If the decking is to extend past the perimeter grid to the edge of soffits or eaves, a plan dimension from the work point to the edge of deck is all that is required.

Figure 1.3

Depicting successful ground assembly & erection of steep sloped spire including completed deck & clock mount framing.

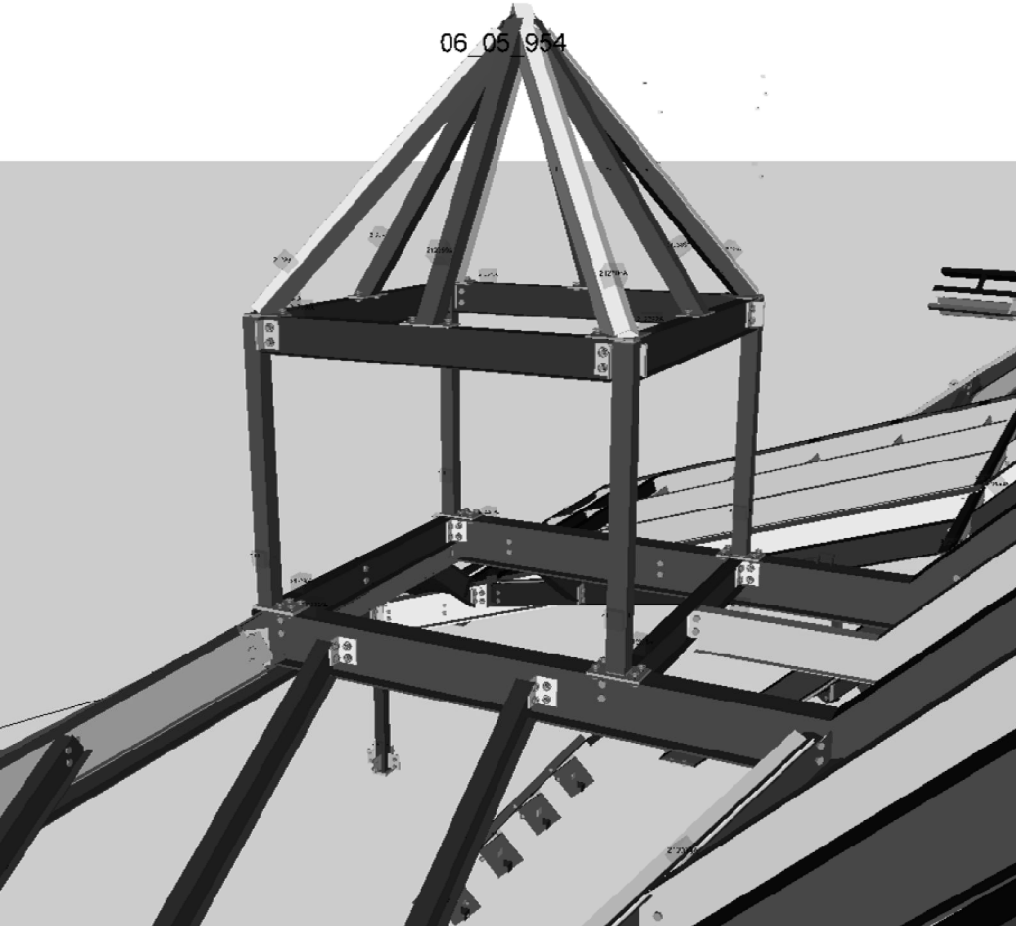


Figure 1.4

Illustrating simple bearing plate connections and consistent elevations & types of connections including good access that allow for pre-assembly and ease of erection of sloped steel roofs.

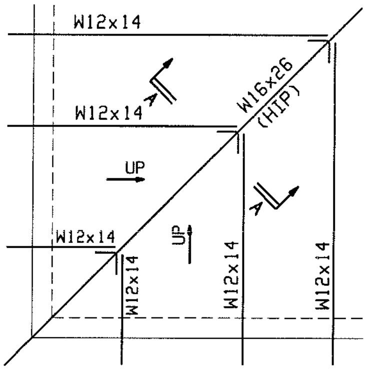
Figure 1.5

Depicting simple bearing plate connections and consistent elevations & types of connections including good access that allow for pre-assembly and ease of erection of sloped steel roofs.

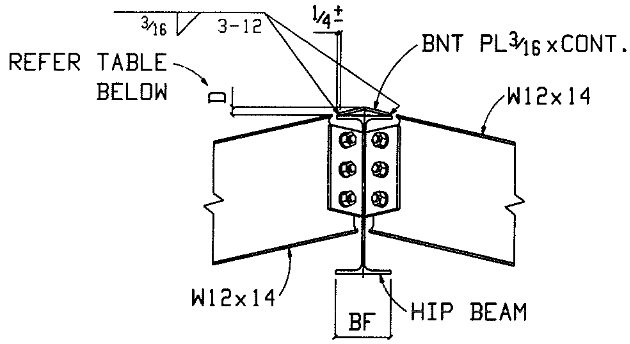
Figure 1.6

Portraying extreme difficulty in traversing channel framing on sloped steel roofs.

FIGURE 3.1

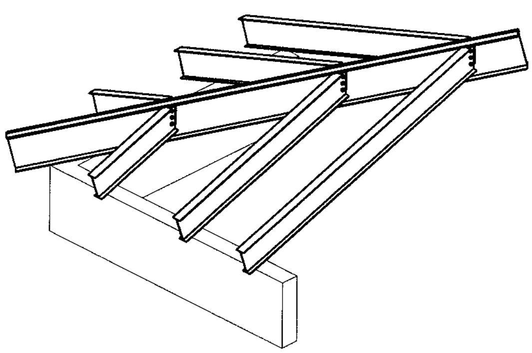


HIP BEAM FRAMING PLAN



SECTION A-A

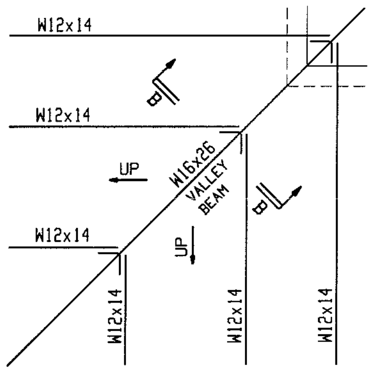
ROOF SLOPE	HIP DROP, D				
	BF=4	BF=5 1/2	BF=7	BF=9	BF=12
2:12	3/8	1/2	9/16	11/16	7/8
3:12	1/2	5/8	3/4	15/16	1 3/16
4:12	5/8	3/4	15/16	1 3/16	1 1/2
5:12	11/16	7/8	1 1/8	1 3/8	1 13/16
6:12	3/4	1	1 1/4	1 5/8	2 1/8
7:12	7/8	1 1/8	1 7/16	1 13/16	2 3/8
8:12	15/16	1 1/4	1 9/16	2	2 5/8
9:12	1	1 3/8	1 3/4	2 3/16	2 7/8
10:12	1 1/8	1 1/2	1 7/8	2 3/8	3 1/8
11:12	1 3/16	1 9/16	2	2 1/2	3 5/16
12:12	1 1/4	1 11/16	2 1/16	2 11/16	3 9/16



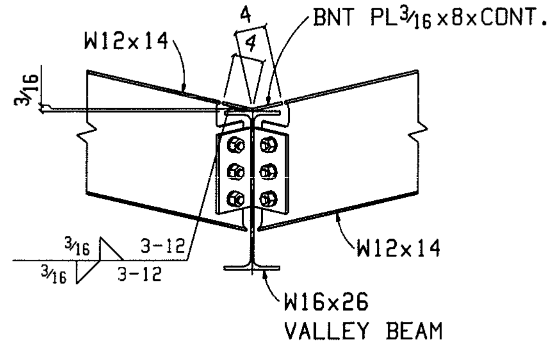
HIP BEAM ISOMETRIC

FOR DETAILING PURPOSES ONLY

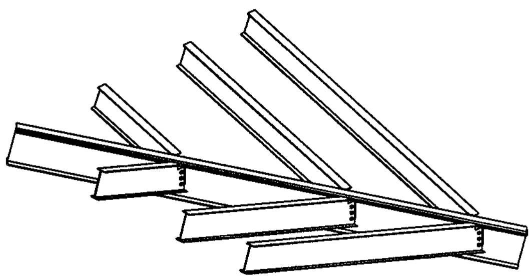
FIGURE 3.2



VALLEY BEAM FRAMING PLAN



SECTION B-B

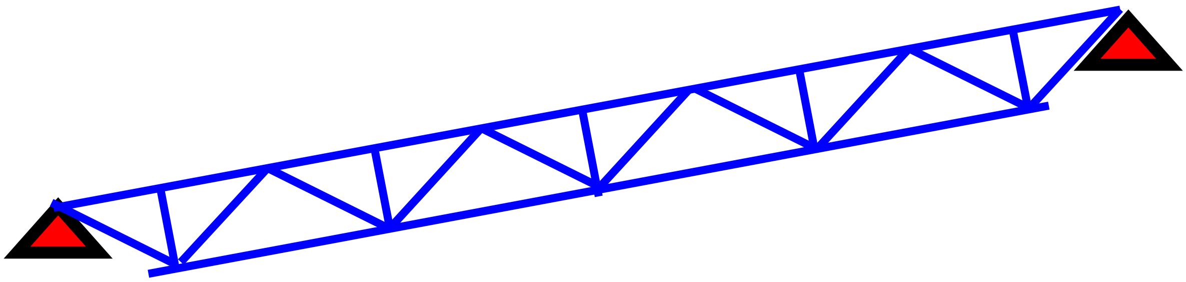


VALLEY BEAM ISOMETRIC

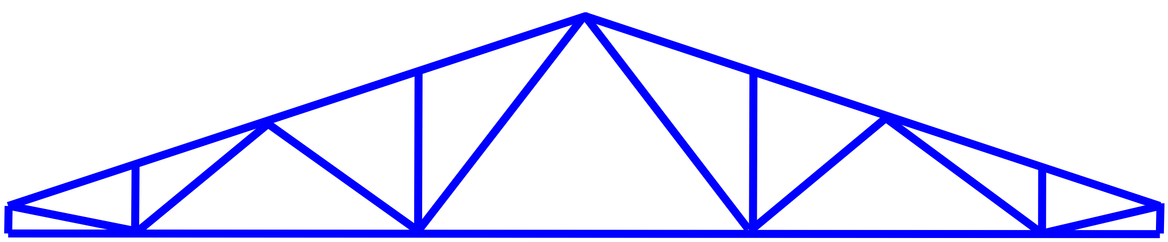
FOR DETAILING PURPOSES ONLY

Figure 4.1

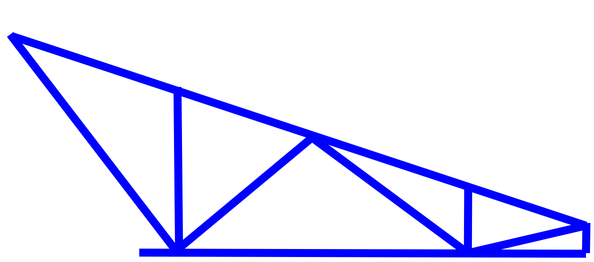
Sloped



Pitched



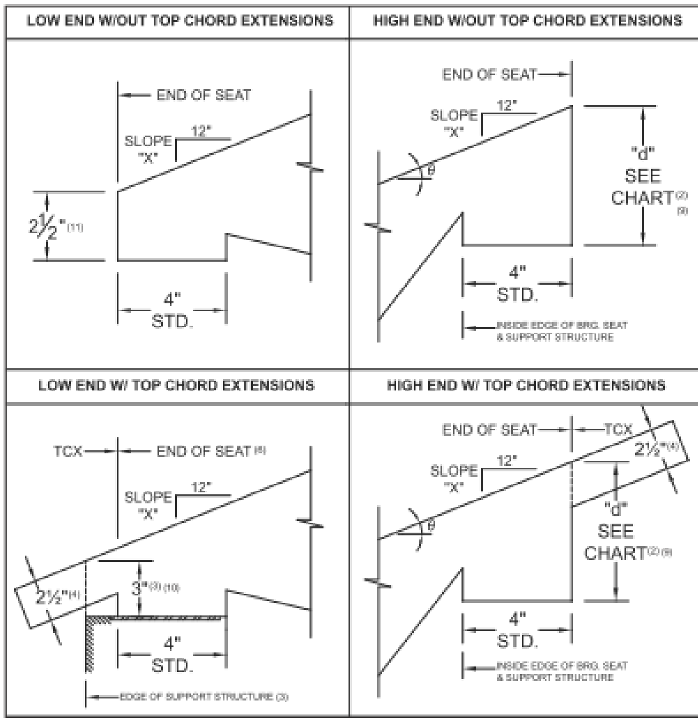
Double Pitched



Single Pitched

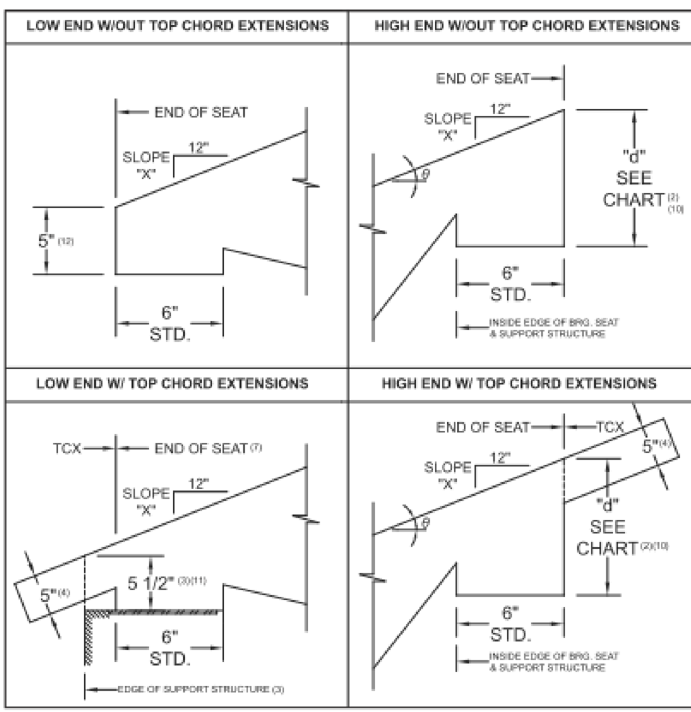
Figure 4.2

SLOPED SEAT REQUIREMENTS FOR SLOPES 3/8":12 AND GREATER
K-SERIES OPEN WEB STEEL JOISTS
(VARIES FROM SJI CODE OF STANDARD PRACTICE)



SLOPE "X":12	MINIMUM HIGH END SEAT DEPTH "d" SJI STANDARD	MINIMUM HIGH END SEAT DEPTH "d" VULCRAFT RECOMMENDED FOR SPECIAL CONDITIONS (8)
3/8	3 1/2	5"
1/2	3 1/2	5"
1	3 1/2	5"
1 1/2	4	5 1/2"
2	4	5 1/2"
2 1/2	4	5 1/2"
3	4 1/2	6"
3 1/2	4 1/2	6"
4	4 1/2	6"
4 1/2	5	6 1/2"
5	5	6 1/2"
5 1/2	5 1/2	7"
6	5 1/2	7"
> 6:12	SEE NOTE (2)	SEE NOTE (9)

SLOPED SEAT REQUIREMENTS FOR SLOPES 3/8":12 AND GREATER
LH- AND DLH-SERIES OPEN WEB STEEL JOISTS
(VARIES FROM SJI CODE OF STANDARD PRACTICE)



SLOPE "X":12	MINIMUM HIGH END SEAT DEPTH "d" SJI STANDARD	MINIMUM HIGH END SEAT DEPTH "d" VULCRAFT RECOMMENDED FOR SPECIAL CONDITIONS (9)
3/8	6	7 1/2"
1/2	6	7 1/2"
1	6 1/2	8"
1 1/2	6 1/2	8"
2	7	8 1/2"
2 1/2	7	8 1/2"
3	7 1/2	9"
3 1/2	7 1/2	9"
4	8	9 1/2"
4 1/2	8 1/2	10"
5	8 1/2	10"
5 1/2	9	10 1/2"
6	9 1/2	11"
> 6:12	SEE NOTE (2)	SEE NOTE (10)

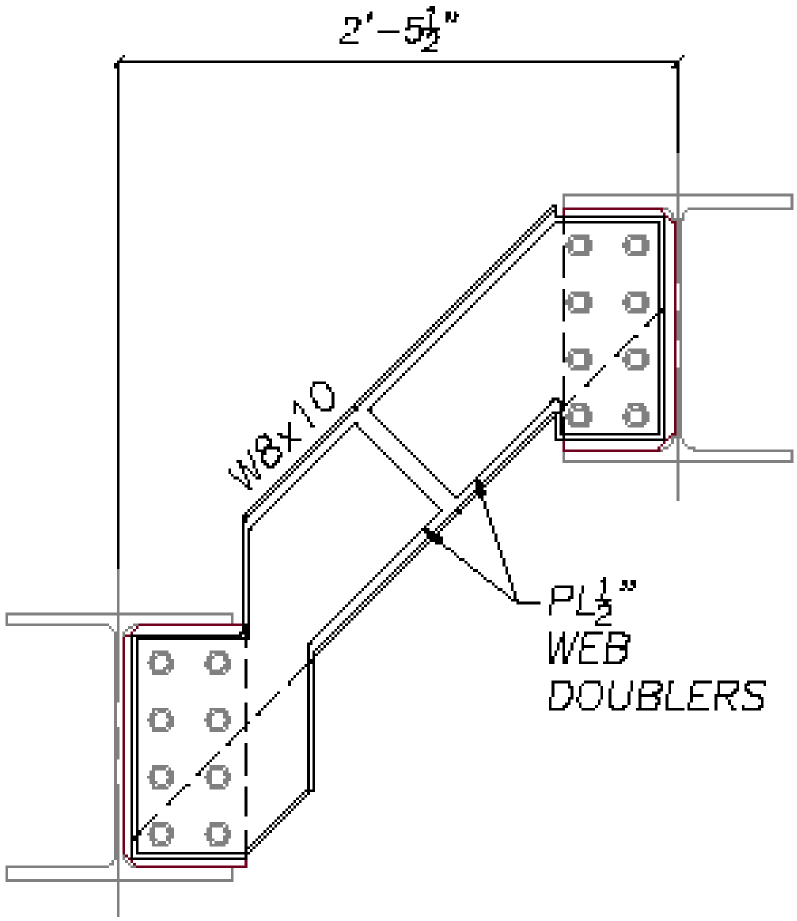


Figure 5.1

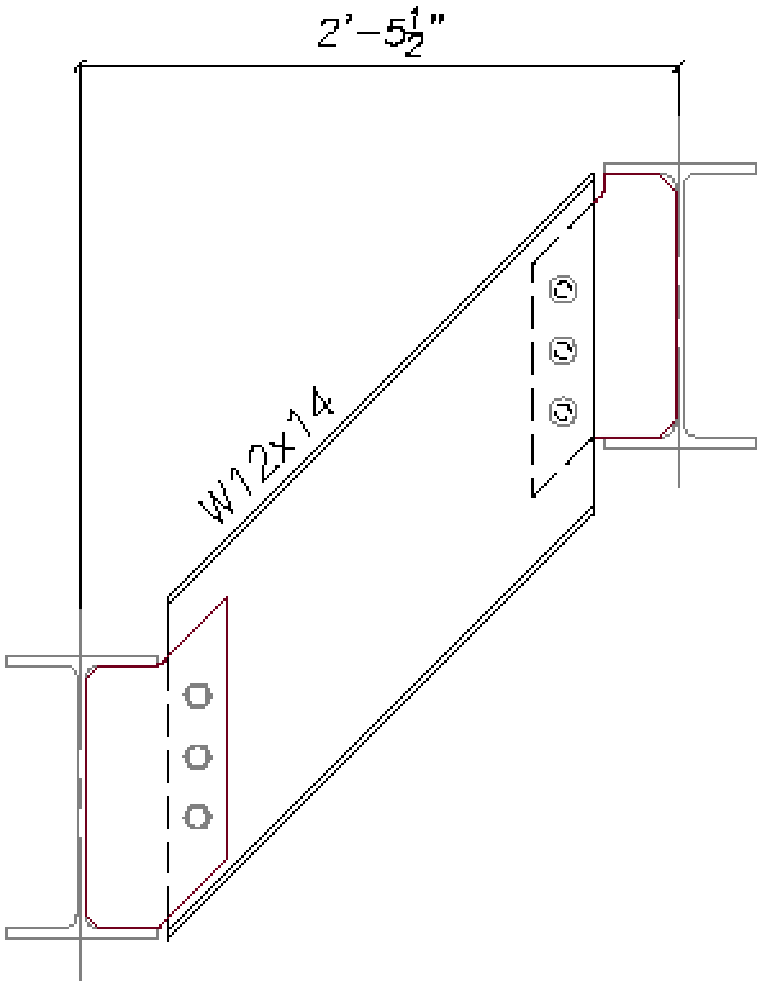
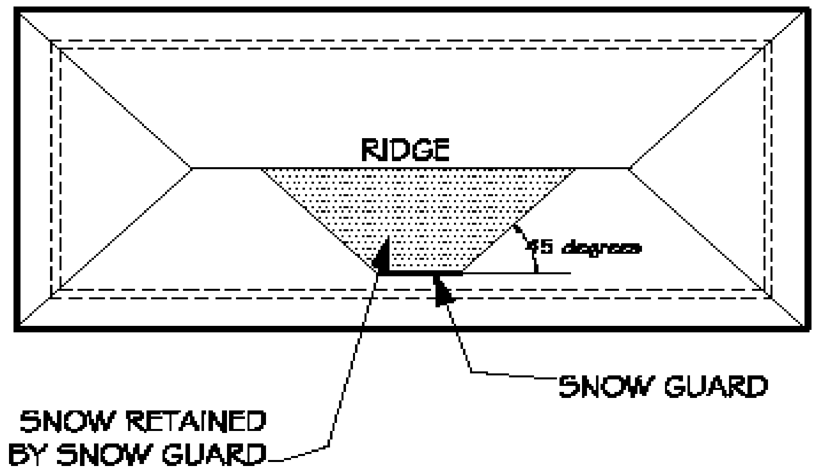
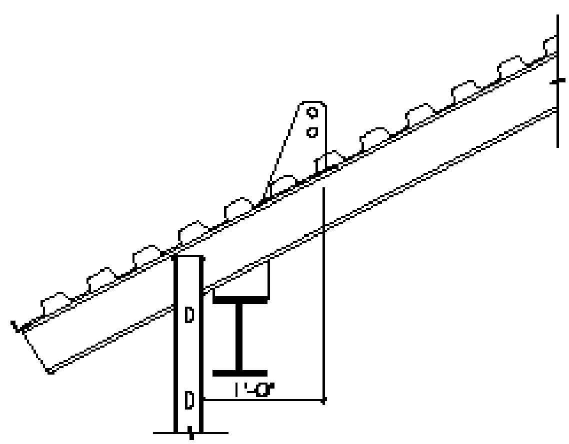


Figure 5.2

Figure 6.1



Trapezoidal Snow Load on Single Guard



Snow Guard Placed Away From Eave


log snow guard in Switzerland


pad style snow guards

Figure 6.2


custom pipe style snow guard

Figure 6.3