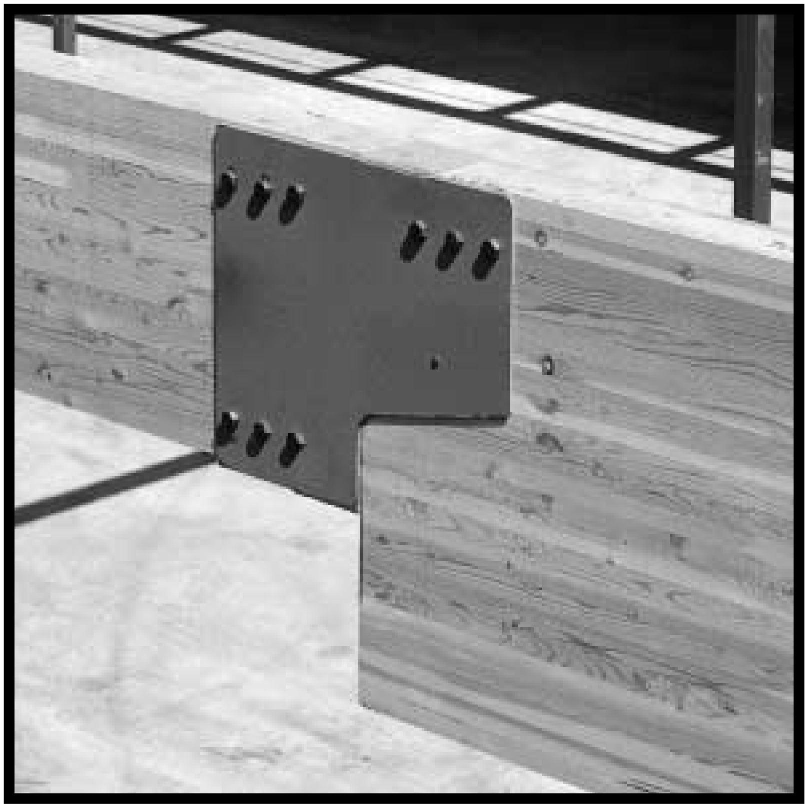
ENGINEERED WOOD SYSTEMS
APA EWS

TECHNICAL NOTE



GLULAM CONNECTION DETAILS

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Introduction

Proper connection details are important to the structural performance and serviceability of any timber-framed structure. While this is true for solid sawn as well as glued laminated (glulam) timbers, the larger sizes and longer spans made possible with glulam components make the proper detailing of connections even more critical. Careful consideration of moisture-related expansion and contraction characteristics of wood is essential in detailing glulam connections to prevent inducing tension perpendicular-to-grain stresses. Connections must be designed to transfer design loads to and from the structural glulam member without causing localized stress concentrations which may initiate failure at the connection.

It's also important to design connections to isolate all wood members from potential sources of excessive moisture. In addition to accentuating any connection problems related to expansion or contraction of the wood due to moisture cycling, equilibrium moisture content in excess of approximately 20 percent may promote the growth of decay-causing organisms in untreated wood.

Structural Effects of Shrinkage and Improper Detailing

Wood expands and contracts as a result of changes in its internal moisture content. While expansion in the direction parallel to grain in a wood member is minimal, dimensional change in the direction perpendicular to grain can be significant and must be considered in connection design and detailing. A 24-inch-deep beam can decrease in depth through shrinkage by approximately 1/8 inch as it changes from 12 to 8 percent in equilibrium moisture content. In designing connections for glulam members it is important to design and detail the connection such that the member's shrinkage is not restrained. If restrained, shrinkage of the beam can cause tension perpendicular-to-grain stresses to develop in the member at the connection. If these stresses exceed the capacity of the member, they may cause the glulam to split parallel to the grain. Once a tension-splitting failure has occurred in a member, its shear and bending capacity are greatly reduced.

In addition to the moisture-induced tension perpendicular-to-grain failures discussed above, similar failures can result from a number of different incorrect connection design details. Improper beam notching, eccentric (out of plane) loading of truss connections and loading beams from the tension side can induce internal moments and tension perpendicular-to-grain stresses.

Effects of Moisture Accumulation

As most connections occur at the ends of beams where the wood end-grain is exposed, it is critical that these connections be designed to prevent moisture accumulation. This can usually be accomplished by detailing drain holes or slots in box-type connectors and by maintaining a gap of at least 1/2 inch between the wood and concrete or masonry construction. Because most connections require the exposure of end grain due to fastener penetration, even those connections that occur away from beam ends must be considered potential decay locations. Field studies have shown that any metal connectors or parts of connectors that are placed in the "cold zone" of the building (that area outside of the building insulation envelope) can become condensation points for ambient moisture. This moisture has ready access to the inside of the beam through fasteners and exposed end grain. A few examples of these kinds of fasteners are saddle-type hangers, cantilever beam hinges and beam-to-column connectors.

Connection Examples

The following pages contain figures that illustrate various connection types. These illustrations show correct connection details along with examples of common incorrect details and a discussion of the failures that may occur due to the incorrect detailing. While the figures are not all inclusive, they are provided as a tool to illustrate the principles discussed in the preceding section. Reviewing the examples with these principles in mind will enable the designer to more easily detail proper connections.

While the details in this Technical Note address serviceability concerns associated with glulam connection detailing, it is important to emphasize that all connection details must effectively transfer the design loads imposed on the structure and that all designs be in accordance with accepted engineering practice. There are a number of manufacturers of pre-engineered metal connectors which have been specifically designed for use in glulam framing and it is recommended that these connectors be used whenever possible.

Summary

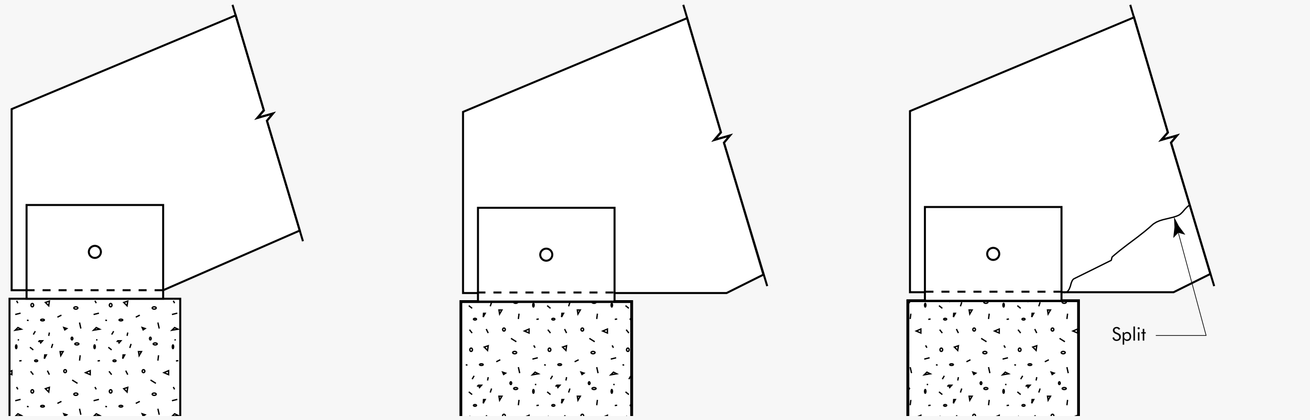
The details in this publication have been provided to illustrate both the correct and incorrect manner to make a connection involving glued laminated timbers. These details emphasize seven basic principles which, if followed, will lead to efficient, durable and structurally sound connections. These principles are:

1. Transfer loads in compression bearing whenever possible.
2. Allow for dimensional changes in the glulam due to potential in-service moisture cycling.
3. Avoid the use of details which induce tension perpendicular-to-grain stresses in the member.
4. Avoid moisture entrapment at connections.
5. Do not place the glulam in direct contact with masonry or concrete.
6. Avoid eccentricity in joint details.
7. Minimize exposure of end grain.

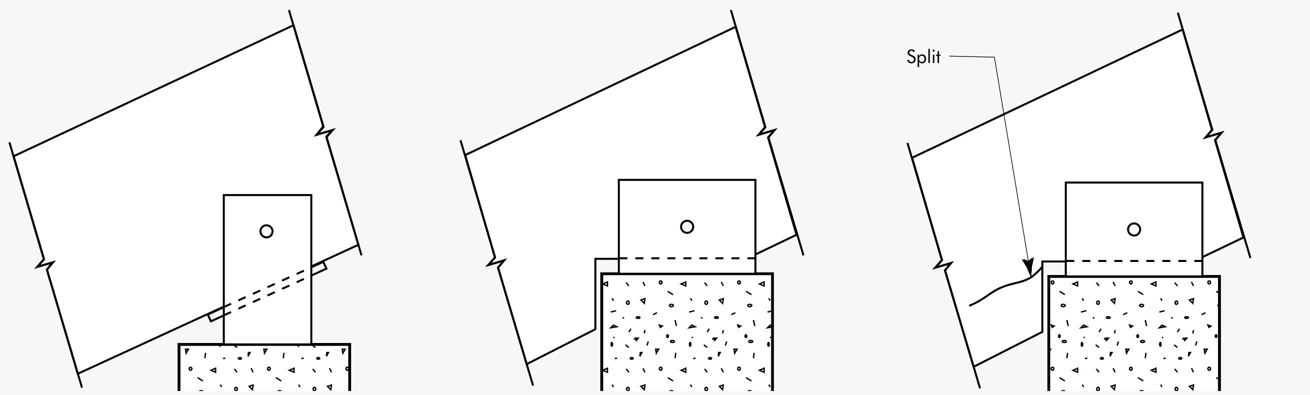
FIGURE 1

BEAM-TO-BEARING CONNECTIONS

Correct	Incorrect	Discussion



Similar to notching at beam ends. Splitting may result from rapid drying due to exposed end grain which may, in turn, induce tension perpendicular-to-grain stresses and reduce shear strength.

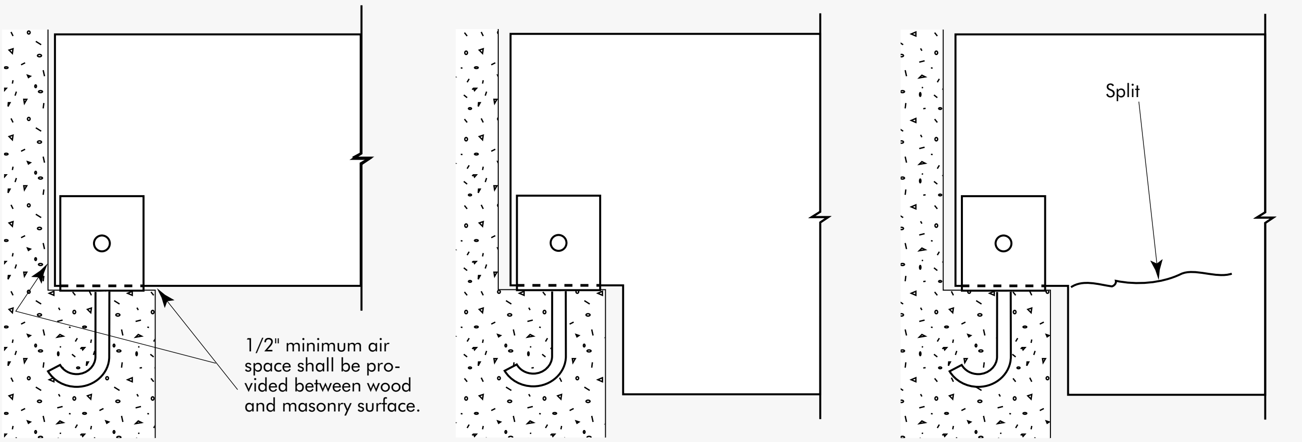


Similar to notching at beam ends. Can cause splitting at inside corner due to shear stress concentrations and induced tension perpendicular-to-grain stresses.

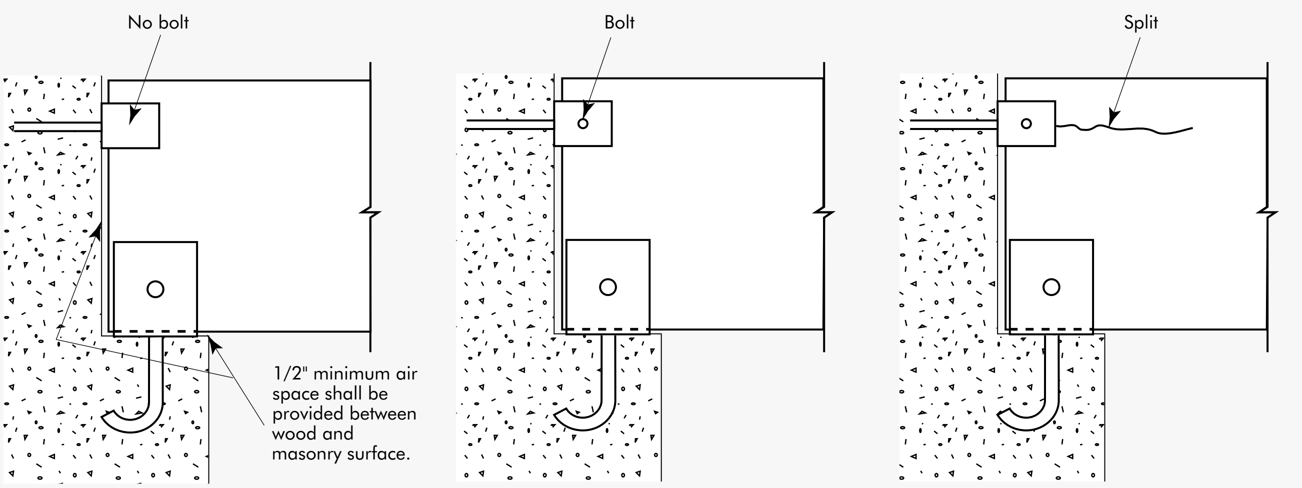
FIGURE 2

BEAM-TO-BEARING CONNECTIONS

Correct	Incorrect	Discussion



Notching at ends of beam can cause splitting at inside corner due to shear stress concentrations and induced tension perpendicular-to-grain stresses. A notch at the end of a glulam beam should **never** exceed 1/10 of beam depth and should be checked by the notched-beam formulas.

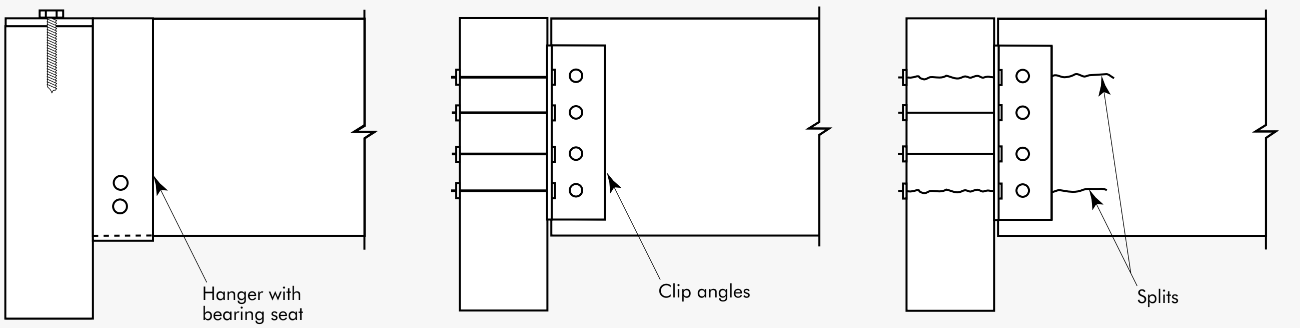


When beam is attached at the base as well as at the lateral restraint clip at the top, shrinkage of the beam can cause splitting at the top connection as loads are transferred from the bearing seat to the bolt. Splitting can also occur at this location if top restraint doesn't allow the beam end to rotate as the beam deflects under load.

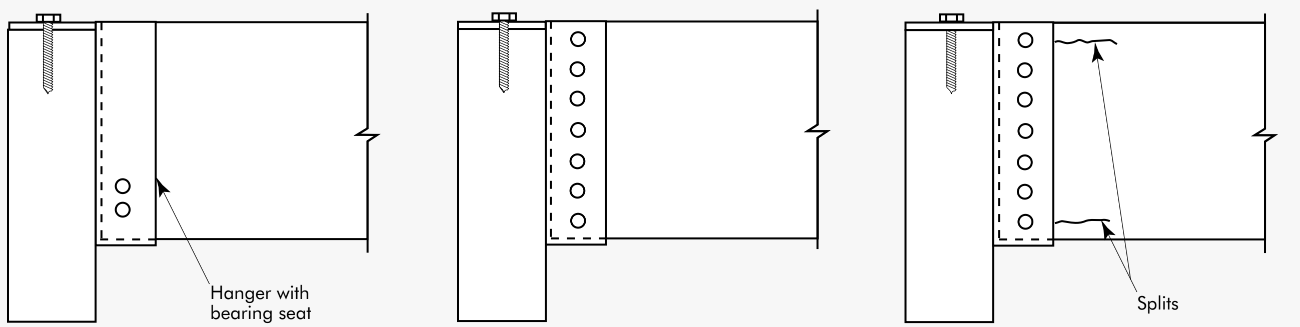
FIGURE 3

BEAM-TO-BEAM CONNECTION

Correct	Incorrect	Discussion



Clip angles with long rows of fasteners can cause splits to form in **both** beam and girder shown above due to tension perpendicular-to-grain stresses induced at the bolts due to beam shrinkage. Use a hanger with bearing seat as shown.

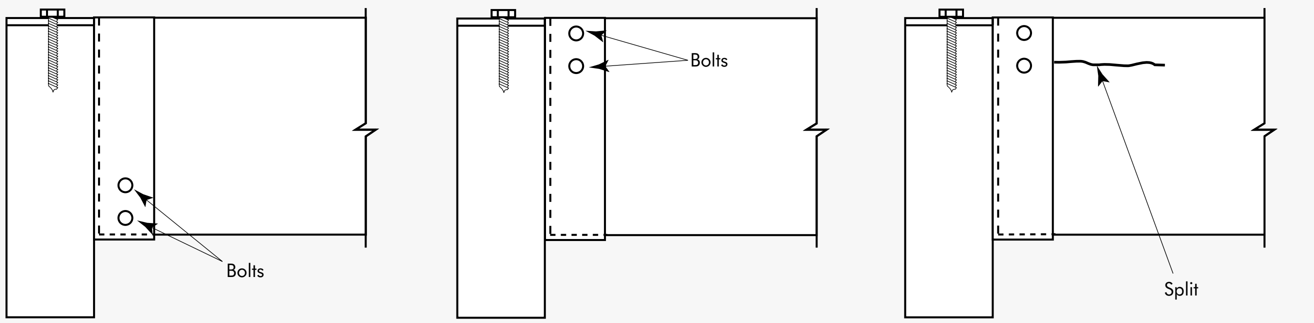


Side plates on saddle hanger with long rows of fasteners can cause splits to form in beam as shown due to beam shrinkage lifting beam off of bearing plate and transferring the loads to the bolts.

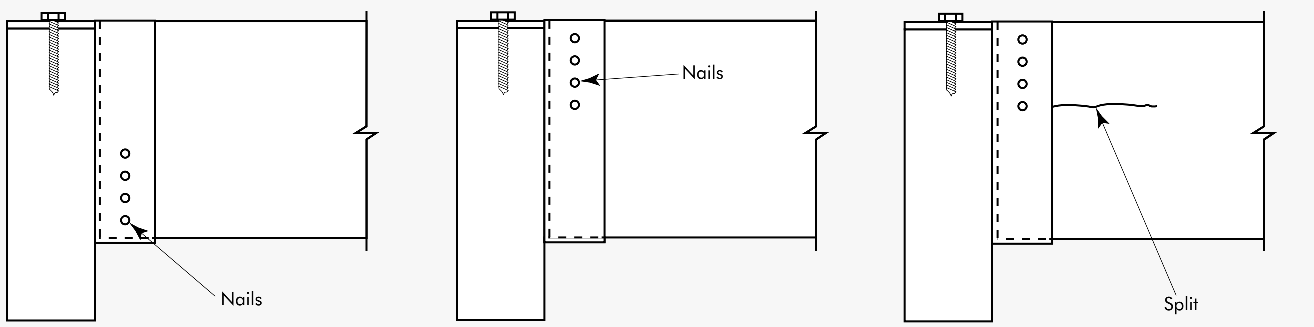
FIGURE 4

BEAM-TO-BEAM CONNECTION

Correct	Incorrect	Discussion



Shrinkage of supported beam causes bearing load to transfer from beam saddle to bolts. This can cause splitting of beam.

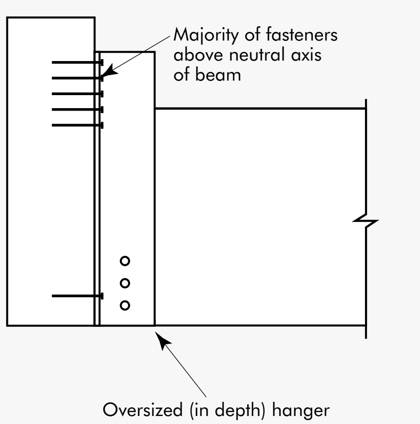


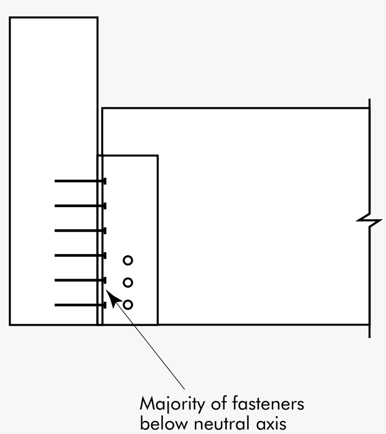
Shrinkage of supported beam causes bearing load to transfer from beam saddle to nail group. This can cause splitting of beam.

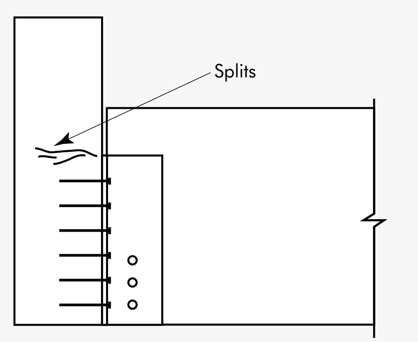
FIGURE 5

BEAM-TO-BEAM CONNECTION

Correct	Incorrect	Discussion





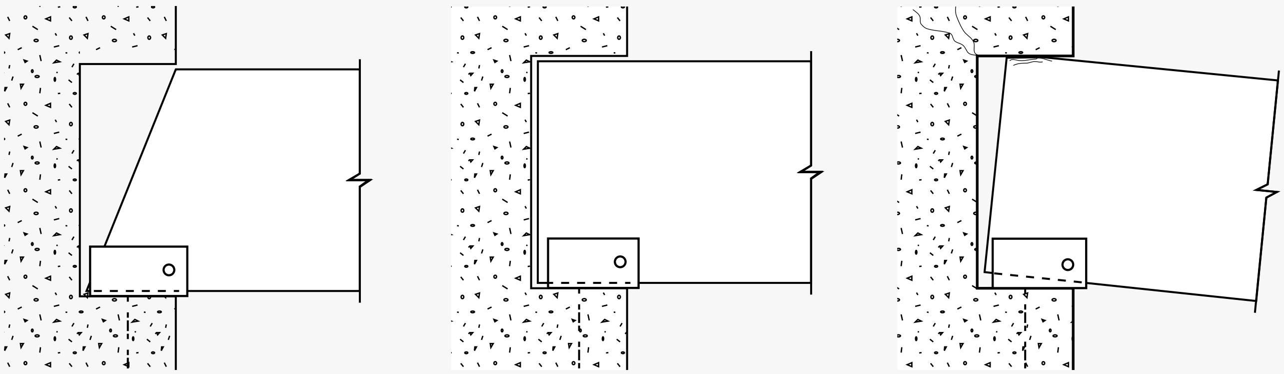


Application of load via fasteners below the neutral axis can cause a tension-perpendicular-to-grain failure in the beam. Location of majority of fasteners above neutral axis or use of top-mounted hanger will minimize the possibility of splitting of the beam. Note that when face-mounted hangers are used, oversized (in depth) hangers may be required to place majority of fasteners above neutral axis.

FIGURE 6

BEAM-TO-BEARING CONNECTION – FIRE CUT

Correct | **Incorrect** | **Discussion**

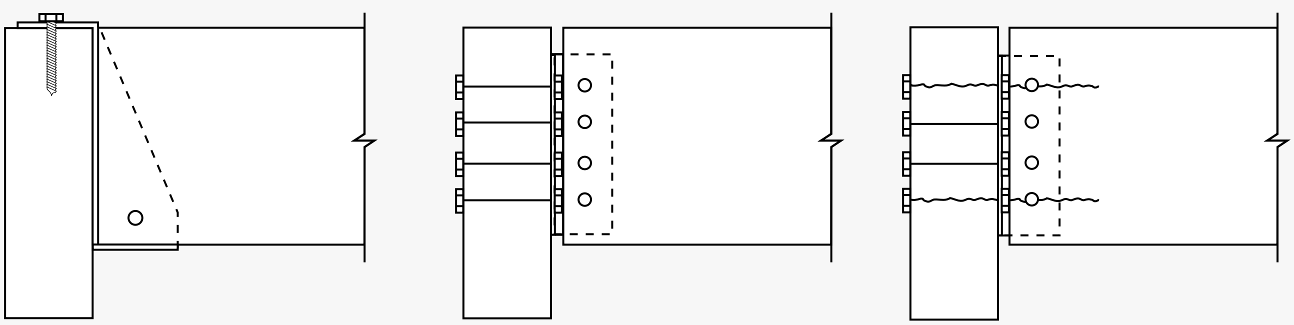


Deflection of square end-cut beams during a fire can cause structural damage to bearing wall. While such a failure is unlikely due to the excellent performance of heavy timber construction during fires, such detailing is prudent.

FIGURE 7

BEAM-TO-BEAM CONNECTIONS – SEMI-CONCEALED USING FISH PLATES

Correct | **Incorrect** | **Discussion**

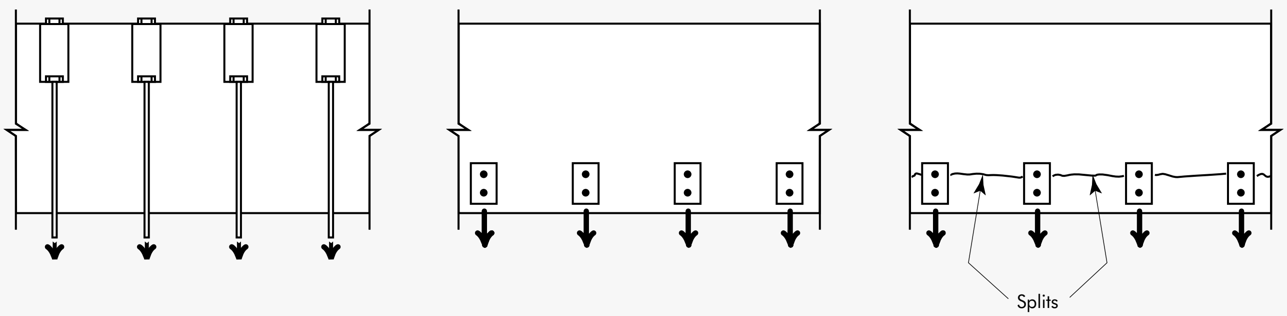


Concealed fish plate with long row of fasteners can cause splits to form in **both** beam and girder as shown above. Use a fish plate with bearing seat as shown to the left.

FIGURE 8

HEAVY CONCENTRATED LOADS SUSPENDED FROM BEAM

Correct	Incorrect	Discussion



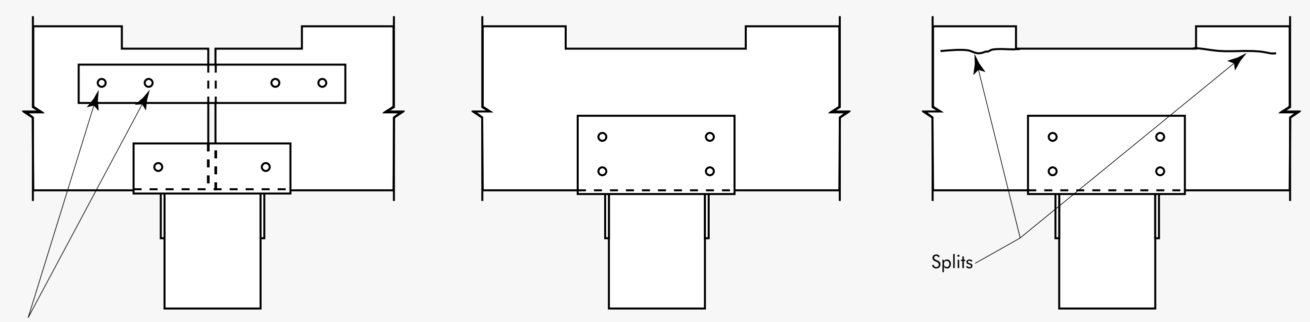
Heavy concentrated loads such as heating and air conditioning units, crane rails or main framing members suspended from the bottom of beams induce tension perpendicular-to-grain stresses and may cause splits as shown.

This is not intended to apply to light loads such as from 2x – joists attached to the main beam with light gauge nail-on metal hangers.

FIGURE 9

NOTCH IN BEAM OVER COLUMN

Correct	Incorrect	Discussion



Shown with no slotted holes for use as a tension tie. Design must insure no excessive rotation of beams under load.

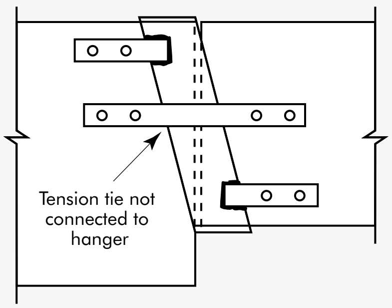
If used as a lateral support plate only, slotted holes may be used with no further restrictions on beam rotation required.

A notch in the top of a continuous beam over a center support occurs in the tension zone of the beam, greatly reducing its capacity. Design as two simply supported beams if top notch is required.

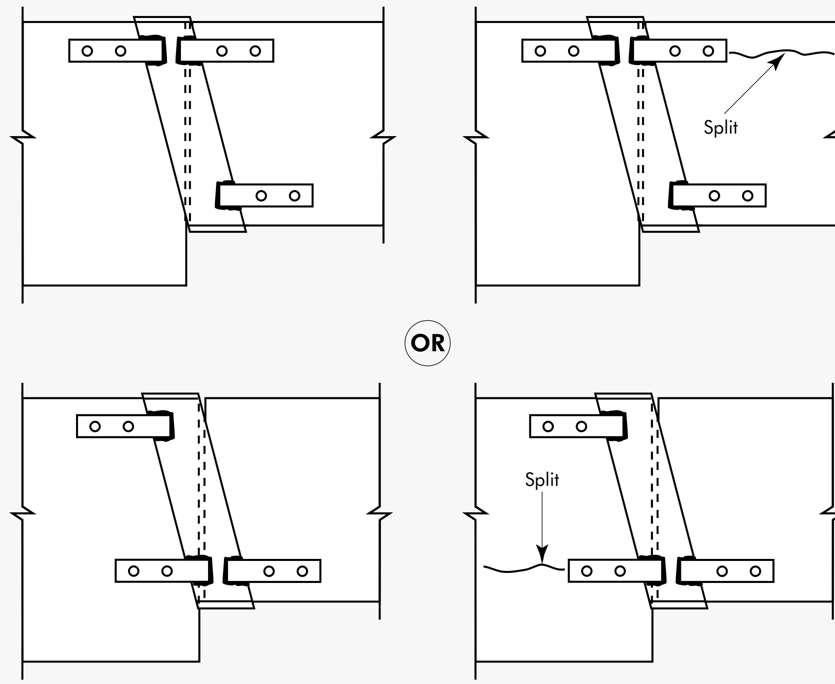
FIGURE 10

CANTILEVER BEAM CONNECTION – INDEPENDENT TENSION TIE

Correct	Incorrect	Discussion



The relative vertical positioning of the side tabs shown in this detail is very important to minimize the possibility of splitting along the axis of these tabs due to beam shrinkage.

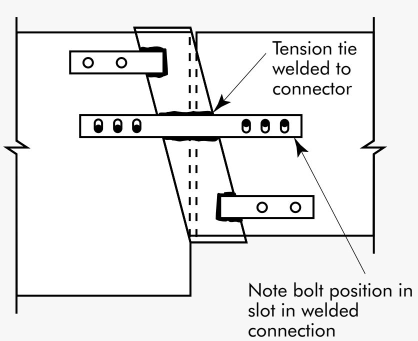


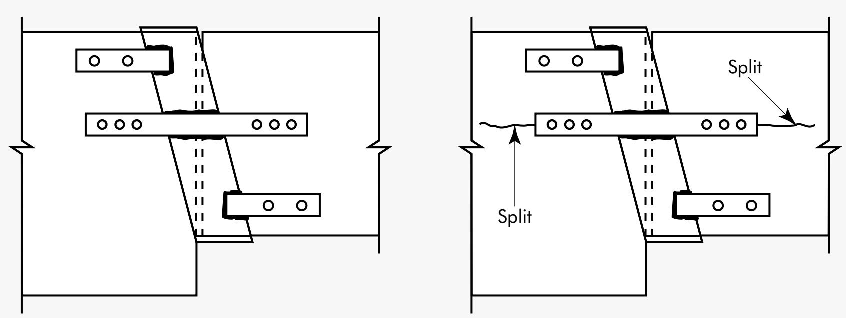
An integral tension-tie connection can cause tension perpendicular-to-grain stress to develop due to beam shrinkage. This can happen regardless of the location of the integral tension tie connector. If a tension connection is required, a separate connector may be used as shown in the figure to the left. This tie is not welded to the beam hanger.

FIGURE 11

CANTILEVER BEAM CONNECTION – WELDED TIE TENSION

Correct	Incorrect	Discussion



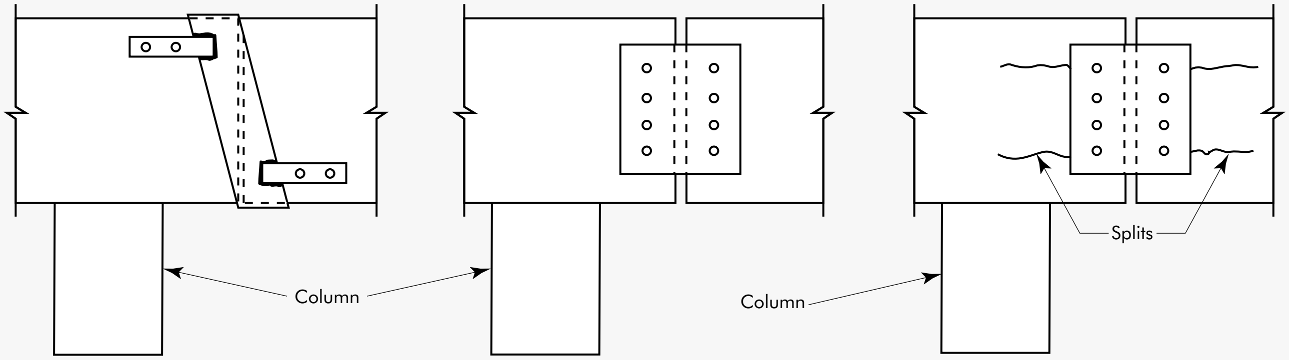


An integral tension tie can be used if holes in tie are vertically slotted and tie attachment bolts are placed as shown to allow motion of bolt in slot due to shrinkage of timber elements. If movement is not allowed at this location, tension perpendicular-to-grain stresses may develop in both members and cause splitting.

FIGURE 12

CANTILEVER BEAM CONNECTION – NO TENSION TIE

Correct | **Incorrect** | **Discussion**

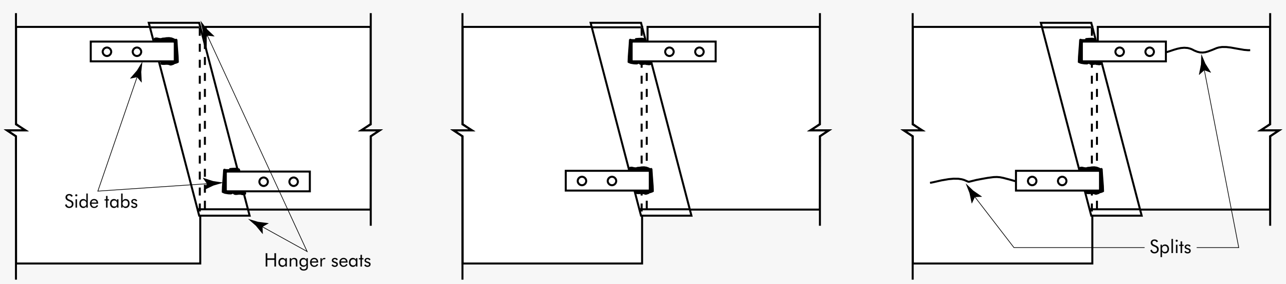


Deep splice plates applied to both sides can cause splitting of both members if members shrink. Sideplates resist this shrinkage and may induce tension perpendicular-to-grain stresses which may in turn cause splits.

FIGURE 13

CANTILEVER BEAM CONNECTION – NO TENSION TIE

Correct | **Incorrect** | **Discussion**

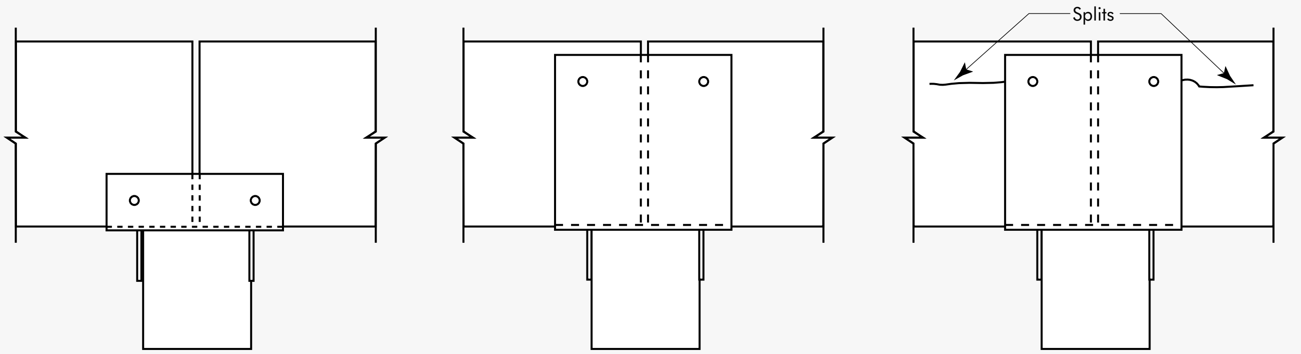


With side tabs inverted, glulam beam shrinkage shifts load from hanger seats to side tabs. This is likely to induce tension perpendicular-to-grain stresses which can lead to the development of splits and beam failure.

FIGURE 14

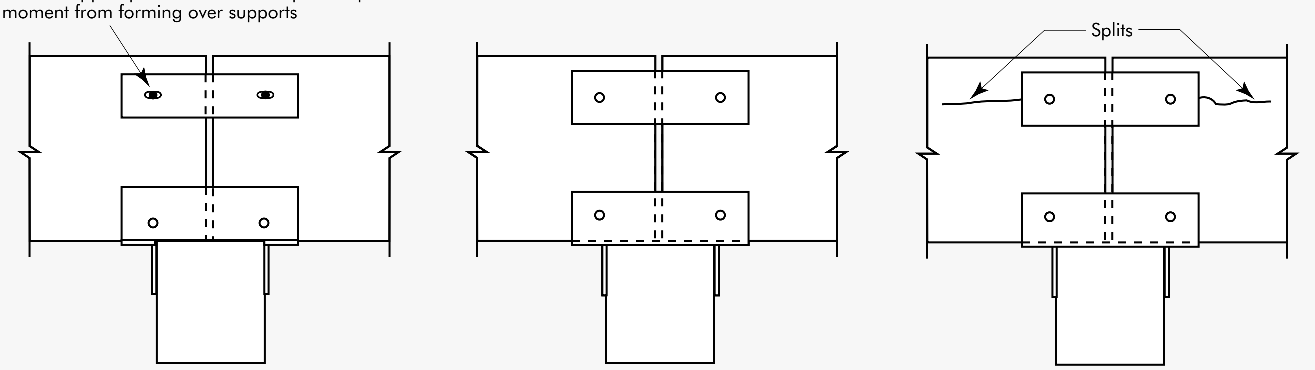
BEAM TO COLUMN – U-BRACKET– WOOD OR PIPE COLUMN

Correct	Incorrect	Discussion



If beam shrinks, bearing load may be transferred to bolts. This can cause splitting of beam. This detail also restrains beam rotation due to deflection under loading which can also cause splitting.

Lateral support plate – slot holes to prevent positive moment from forming over supports

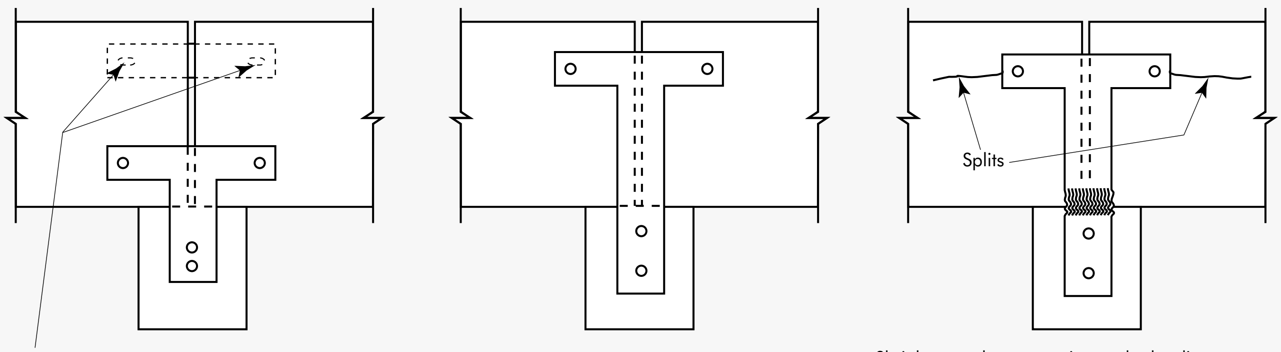


Rotation of the beams under loading can cause splitting at the tension tie plate unless slotted.

FIGURE 15

BEAM TO COLUMN – T-BRACKET

Correct	Incorrect	Discussion



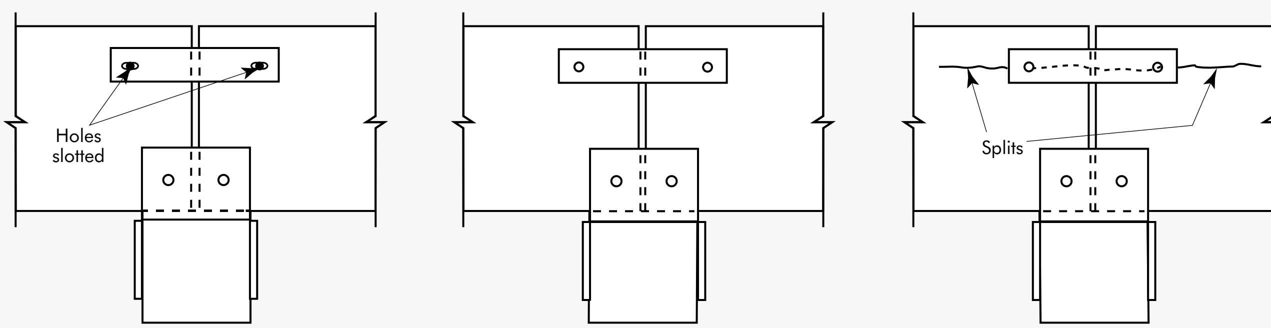
Optional lateral support plate – slot holes to prevent positive moment from forming over support.

Shrinkage or beam rotation under loading can cause splitting of the glulam members and/or buckling of T-bracket

FIGURE 16

BEAM TO COLUMN – WITH TOP LATERAL SUPPORT PLATE

Correct	Incorrect	Discussion

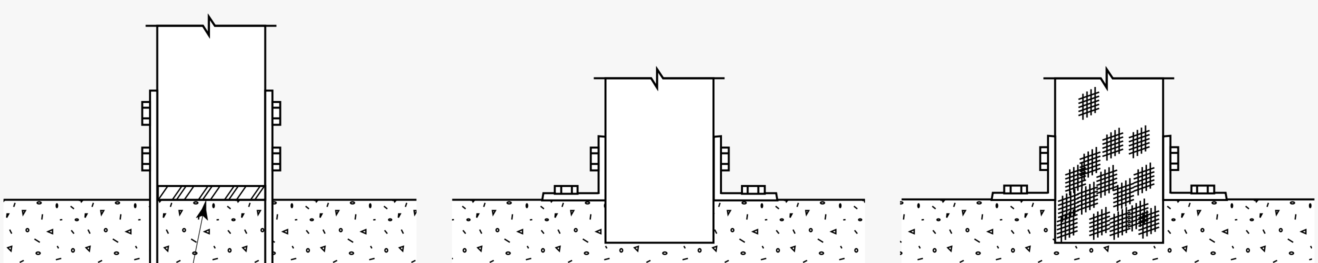


Splitting may occur due to beam rotation as beam deflects under load.

FIGURE 17

WOOD COLUMN TO CONCRETE BASE

Correct	Incorrect	Discussion



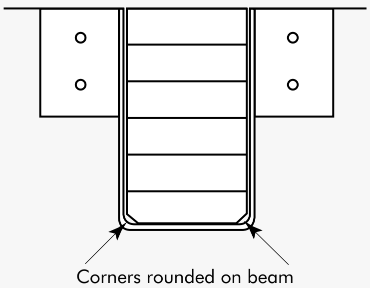
Steel bearing plate

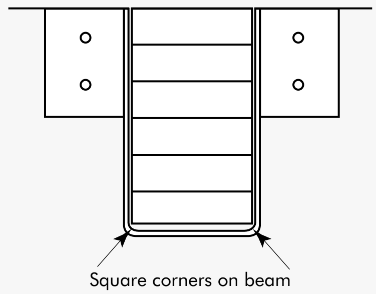
Untreated wood in contact with concrete is subject to decay.

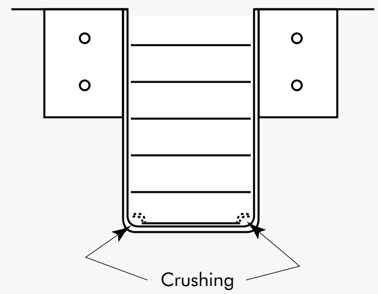
FIGURE 18

BEAM IN BENT HANGER

Correct	Incorrect	Discussion





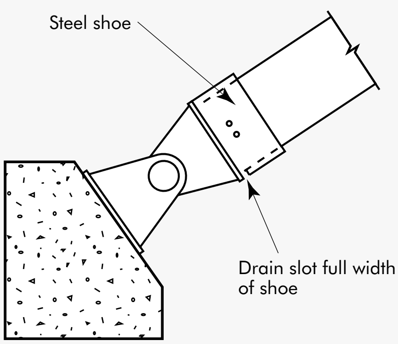


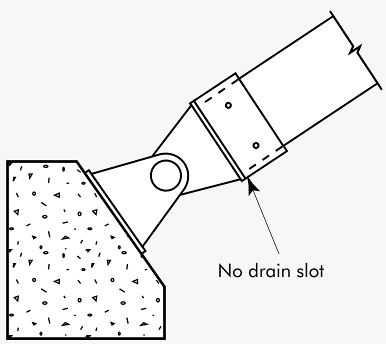
Corners of beams resting in bent metal hangers should be eased to provide full bearing. If not eased, corners of beam may crush, reducing bearing capacity of beam and possibly causing beam settlement.

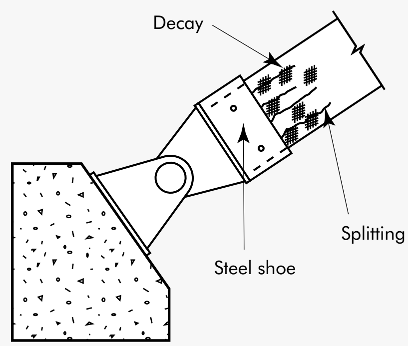
FIGURE 19

GLULAM ARCH TO FOUNDATION

Correct	Incorrect	Discussion





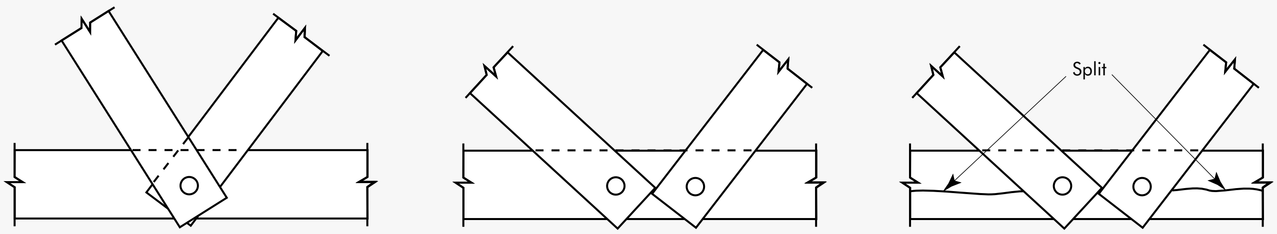


Steel arch shoe must be provided with drain slot to minimize moisture buildup which could result in decay. Interior bolts must be kept close together to prevent splitting if shrinkage occurs.

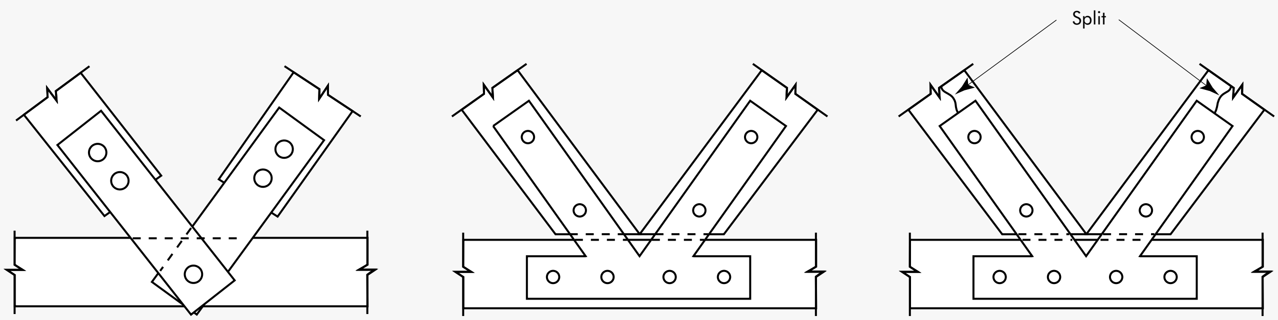
FIGURE 20

TRUSS CONNECTORS

Correct	Incorrect	Discussion



Longitudinal axes of all three members do not intersect. This can induce shear, moment and tension perpendicular-to-grain stresses. A combination of the above stresses may induce a failure at the joint.



Fixed-angle gusset plate does not let members rotate under load. This may induce moments in ends of members which can cause splitting of webs at bolt locations.

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