Glulam Connection Details

CONSTRUCTION GUIDE

CONTENTS

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 a 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% may promote the growth of decay-causing organisms in untreated wood.

This guide from APA illustrates a variety of connections that are common in timber-frame construction.

DESIGNING AND DETAILING CONNECTIONS FOR SHRINKAGE

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%-8% 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's 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 Construction Guide 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 must be in accordance with accepted engineering practice. There are a number of manufacturers of pre-engineered metal connectors that have been specifically designed for use in glulam framing, and it is recommended that these connectors be used whenever possible.

In some instances, it may be necessary to use a concealed or semi-concealed connection to achieve a given architectural detail. For a beam-to-beam or beam-to-column connection, the use of a concealed kerf plate has proven to be an excellent solution to create this type of detail. Either steel pins or countersunk bolts can be used for the supported beam connection.

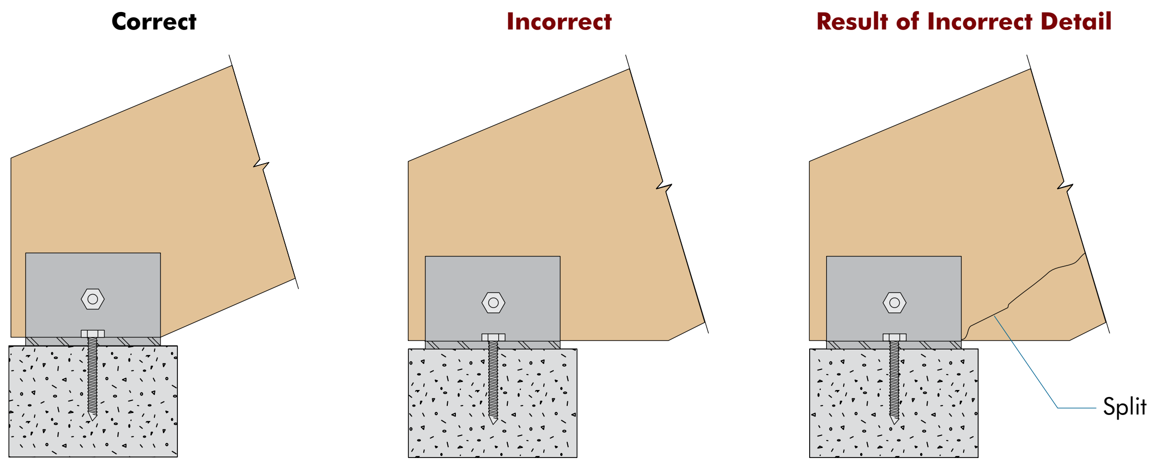
SUMMARY

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 glulam due to potential in-service moisture cycling.
3. Avoid the use of details that induce tension perpendicular-to-grain stresses in a member.
4. Avoid moisture entrapment at connections.
5. Do not place glulam in direct contact with masonry or concrete.
6. Avoid eccentricity in joint details.
7. Minimize exposure of end grain.

FIGURE 1A

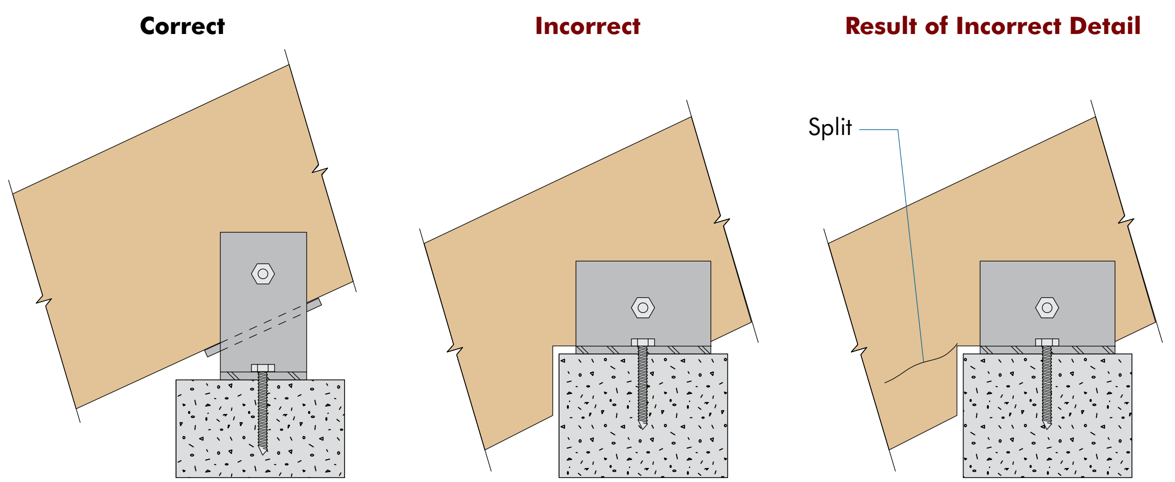
BEAM-TO-BEARING CONNECTION



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.

FIGURE 1B

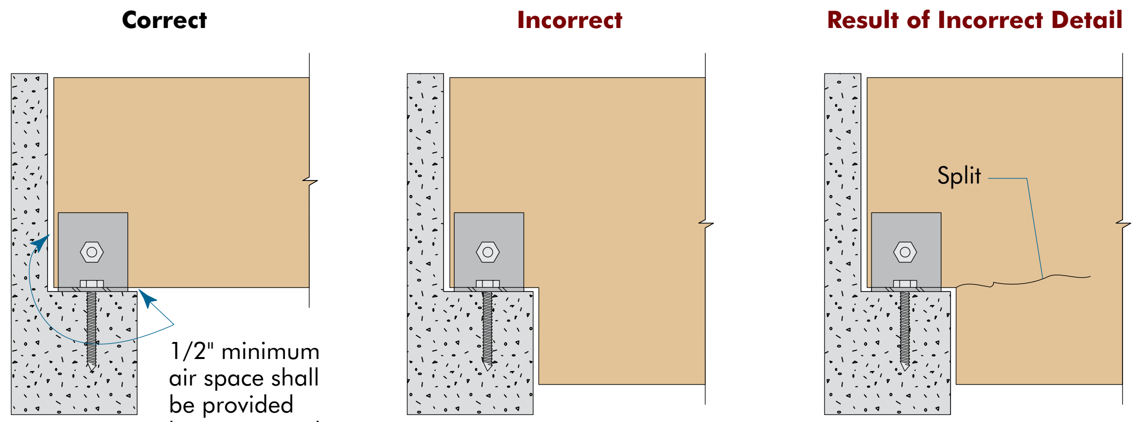
BEAM-TO-BEARING CONNECTION



This detail can cause splitting at inside corner due to shear stress concentrations and induced tension perpendicular-to-grain stresses.

FIGURE 1C

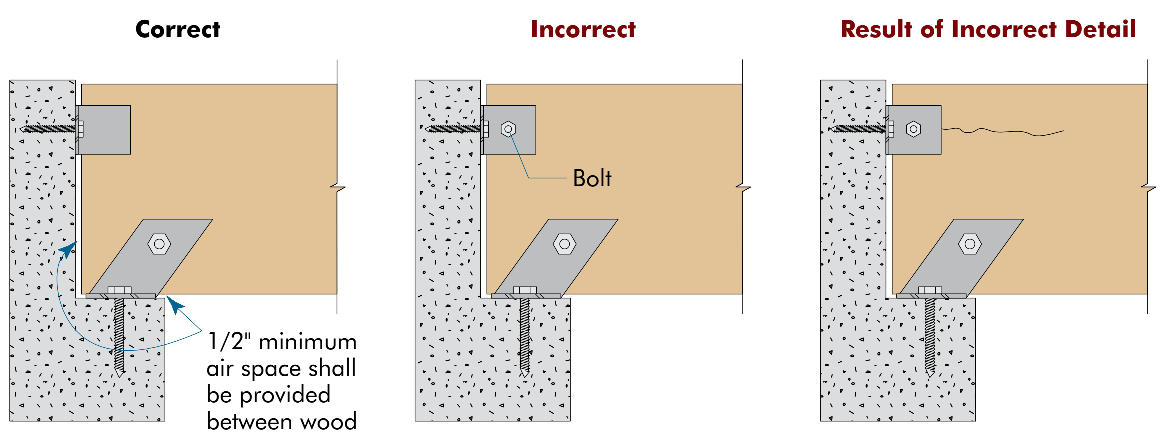
BEAM-TO-BEARING CONNECTION



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 the lesser of 1/10 of beam depth or 3" and should be checked by the notched-beam formulas in the National Design Specification for Wood Construction (NDS).

FIGURE 1D

BEAM-TO-BEARING CONNECTION



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 2A

BEAM-TO-BEARING—POCKET DETAILS

Correct | **Incorrect** | **Result of Incorrect Detail**

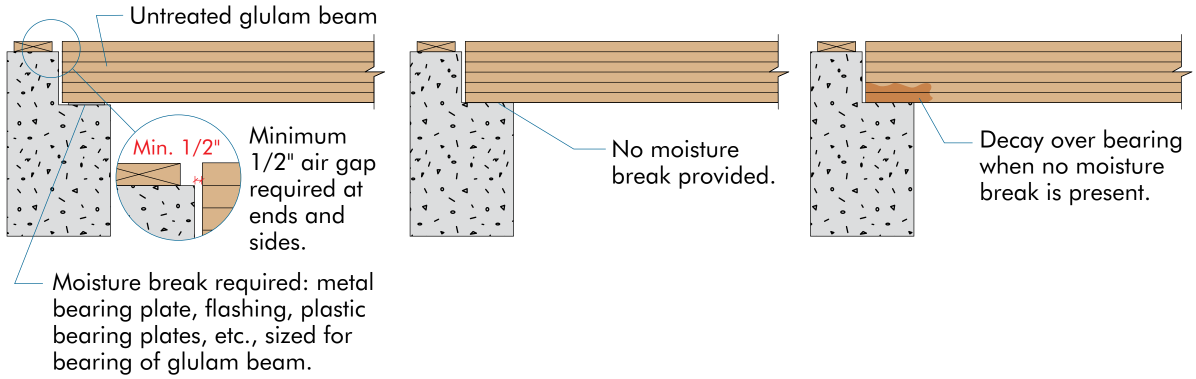


FIGURE 2B

BEAM-TO-BEARING—POCKET DETAILS (when uplift resistance is required)

Correct | **Incorrect** | **Result of Incorrect Detail**

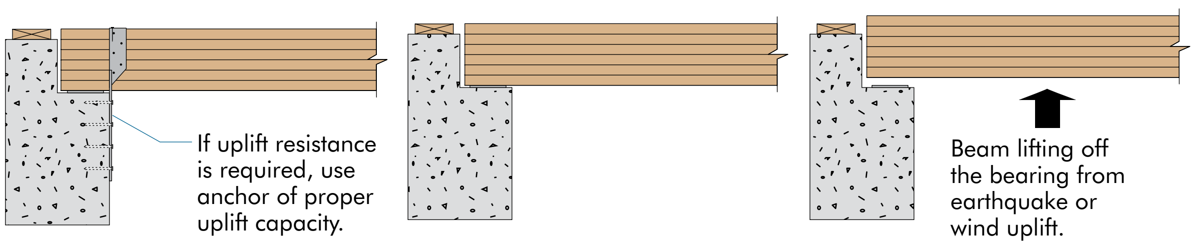
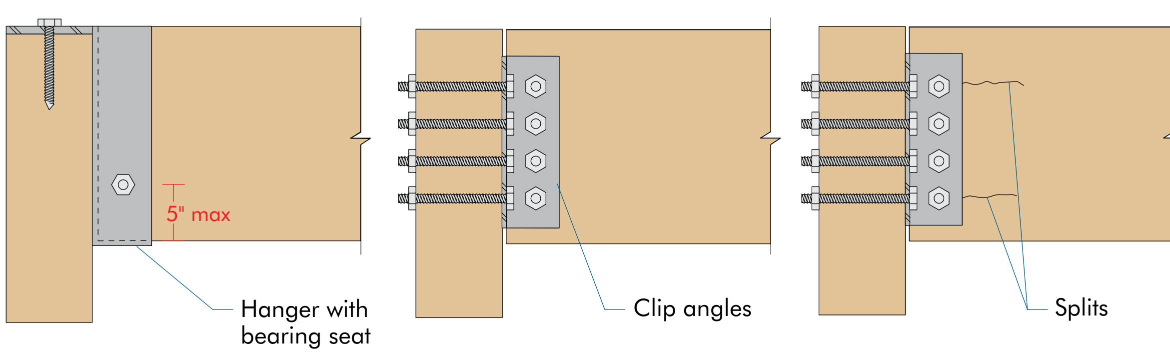


FIGURE 3A

BEAM-TO-BEAM CONNECTION

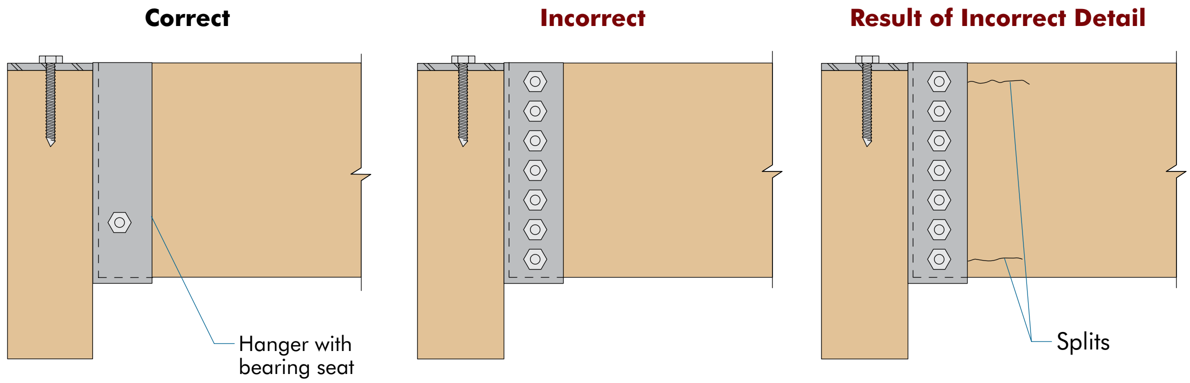
Correct | **Incorrect** | **Result of Incorrect Detail**



Clip angles with long rows of fasteners can cause splits to form in the suspended beam, as 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.

FIGURE 3B

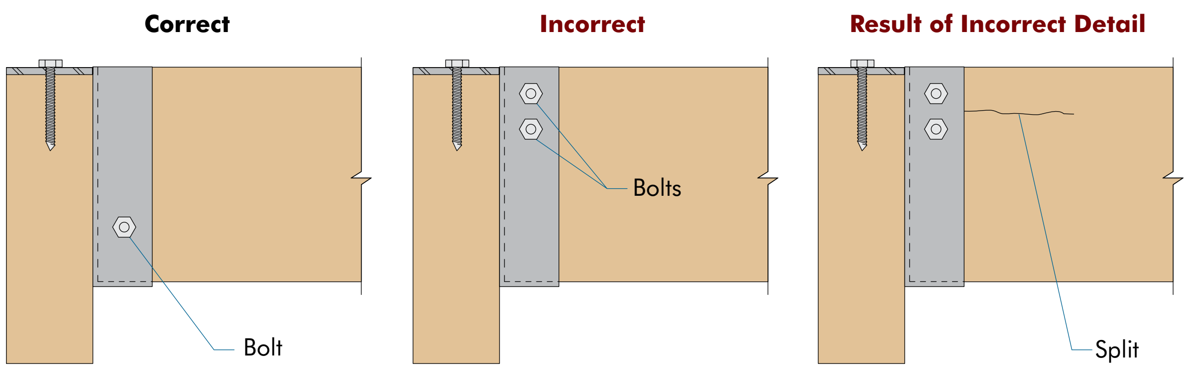
BEAM-TO-BEAM CONNECTION



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 3C

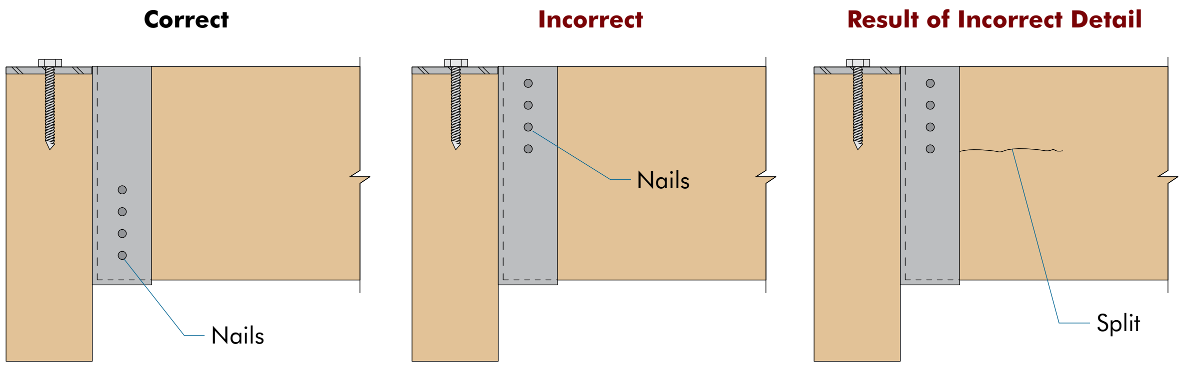
BEAM-TO-BEAM CONNECTION



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

FIGURE 3D

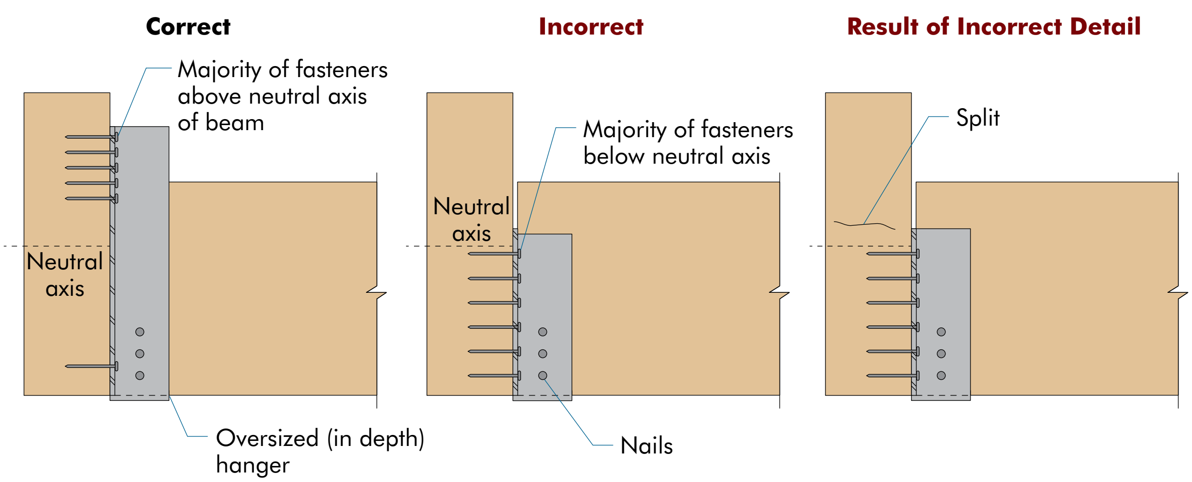
BEAM-TO-BEAM CONNECTION



Shrinkage of supported beam causes bearing load to transfer from beam saddle to nail group. Even with nails, there is potential for splitting of beam.

FIGURE 3E

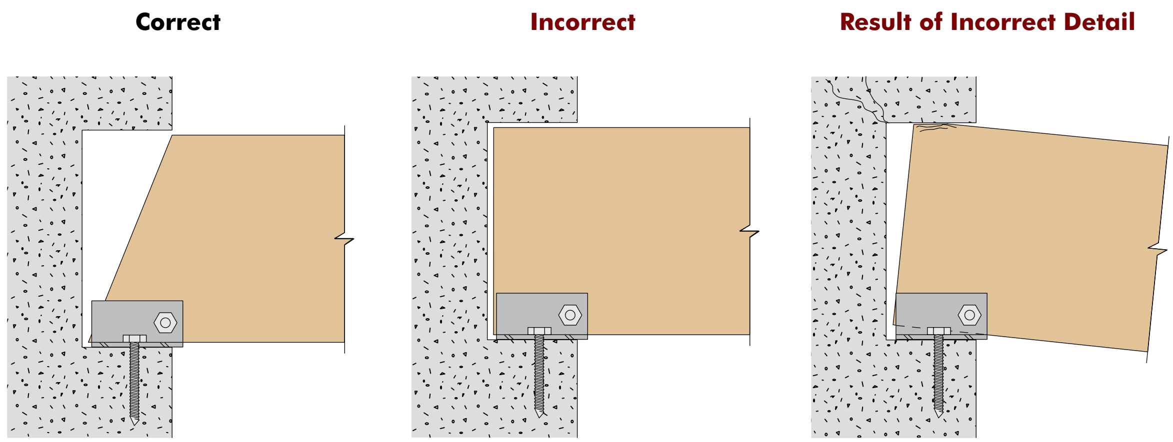
BEAM-TO-BEAM CONNECTION



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 4

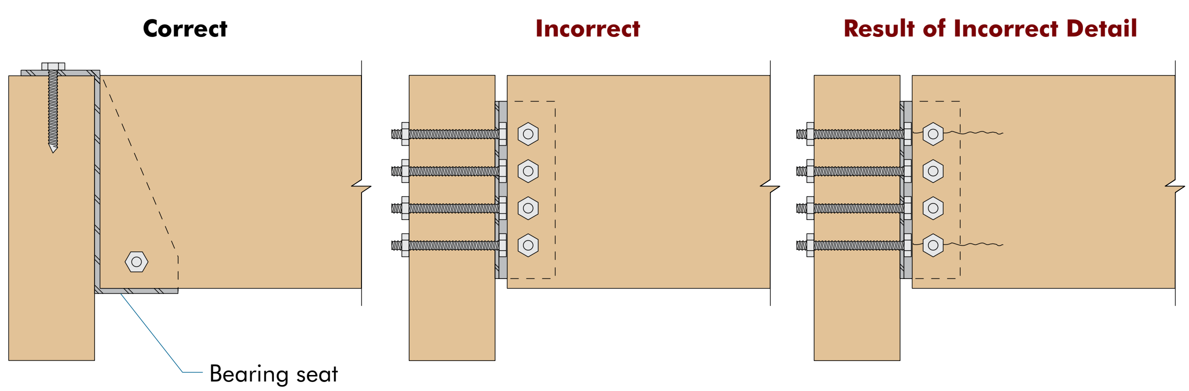
BEAM-TO-BEARING CONNECTION—SLOPED END CUT



Deflection of square end-cut beams can cause structural damage to bearing wall and the beam. One way to prevent this is to slope cut the end of the beam.

FIGURE 5

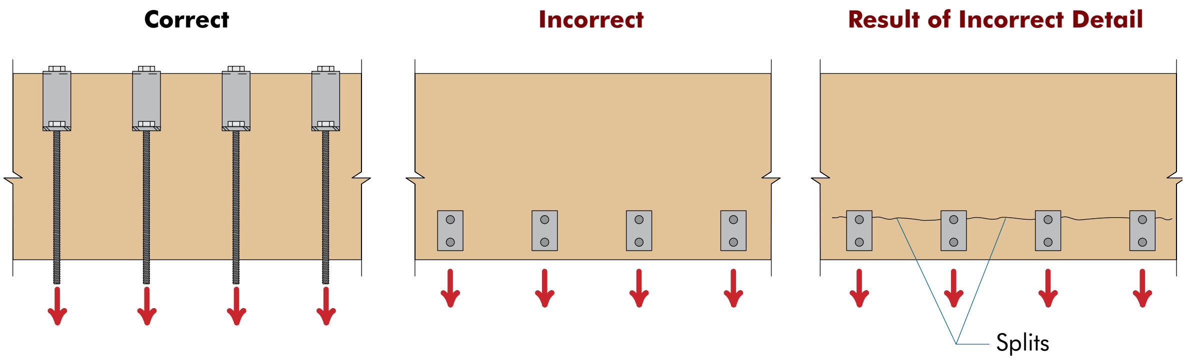
BEAM-TO-BEAM CONNECTION USING CONCEALED PLATES



Concealed plate with long row of fasteners can cause splits to form in suspended beam, as shown above. Use a concealed plate with bearing seat.

FIGURE 6

HEAVY CONCENTRATED LOADS SUSPENDED FROM BEAM

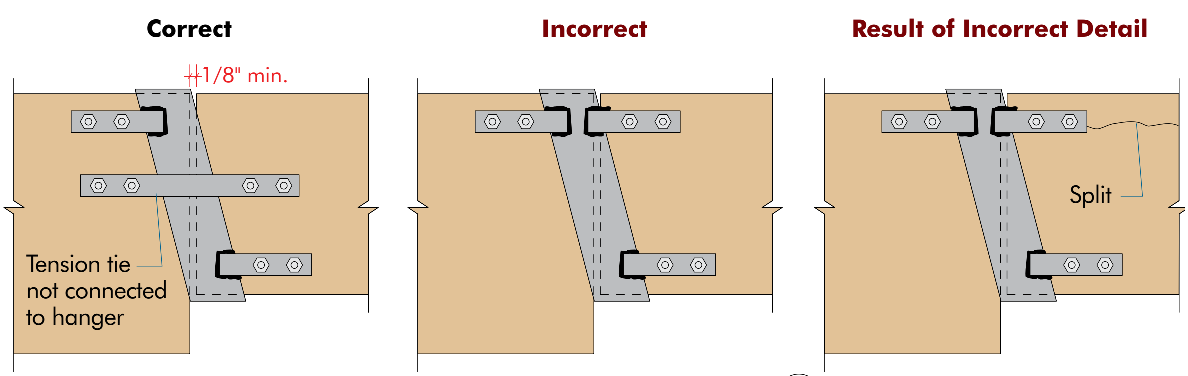


Heavy concentrated loads, such as heating and air conditioning units, crane rails or main framing members suspended from the bottom of beams induce tension perpendicular-to-grain stresses and may cause splits as shown.

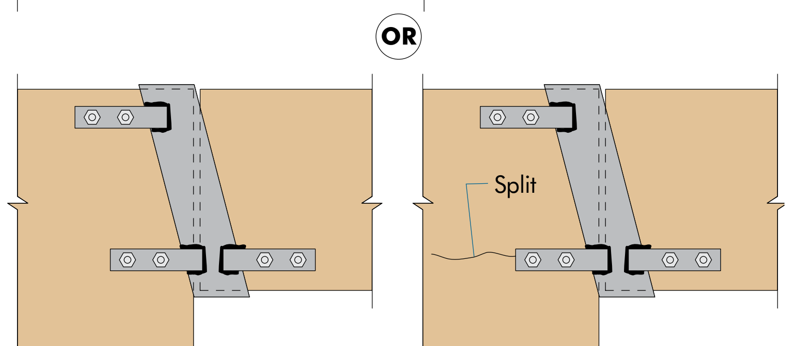
This is not intended to apply to light loads, such as from 2x joists attached to the main beam with light gauge nail-on metal hangers.

FIGURE 7

CANTILEVER BEAM CONNECTION—INDEPENDENT TENSION TIE



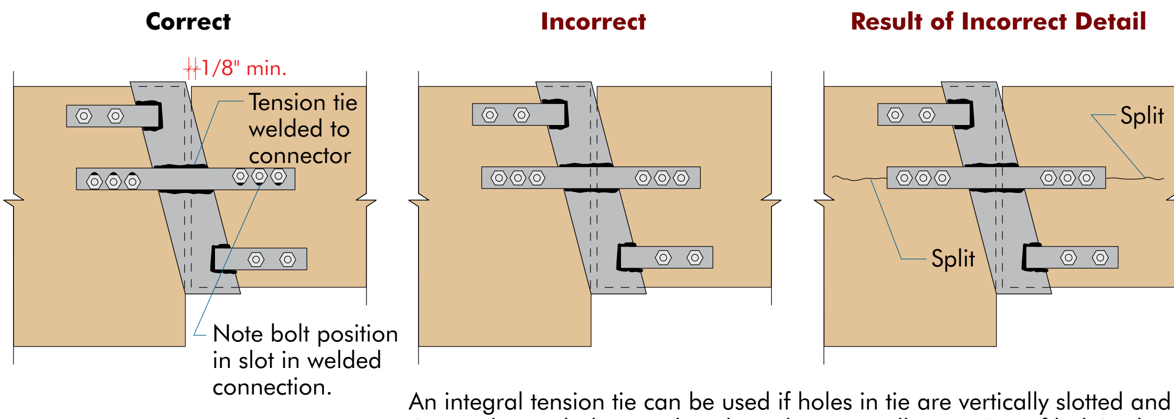
The relative vertical positioning of the side tabs shown in this detail is very important to minimize the possibility of splitting along the axis of these tabs due to beam shrinkage.



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 upper left figure. This tie is not welded to the beam hanger.

FIGURE 8

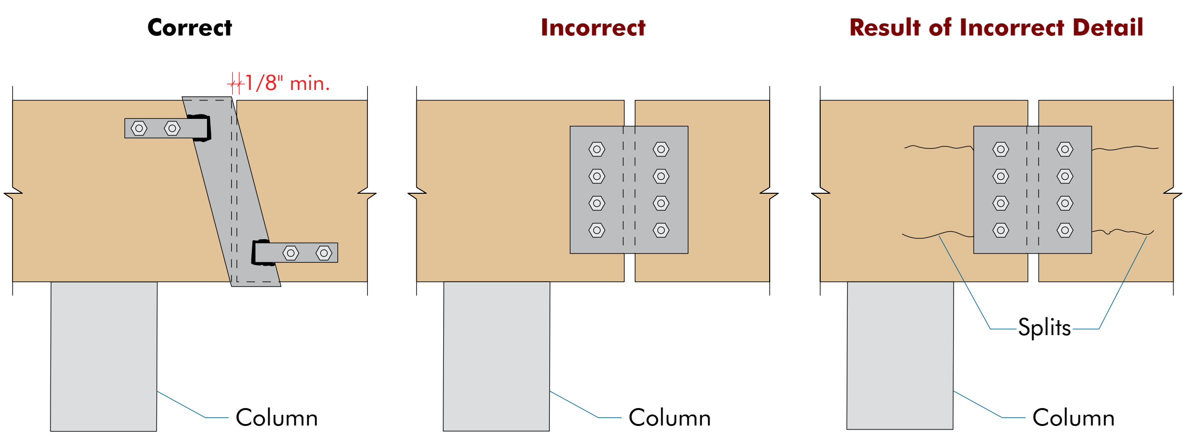
CANTILEVER BEAM CONNECTION—WELDED TENSION TIE



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 9A

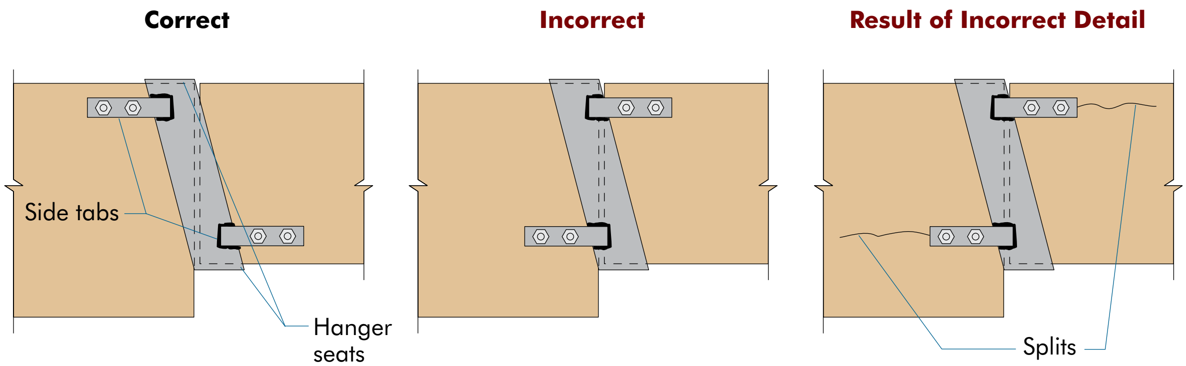
CANTILEVER BEAM CONNECTION—NO TENSION TIE



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

FIGURE 9B

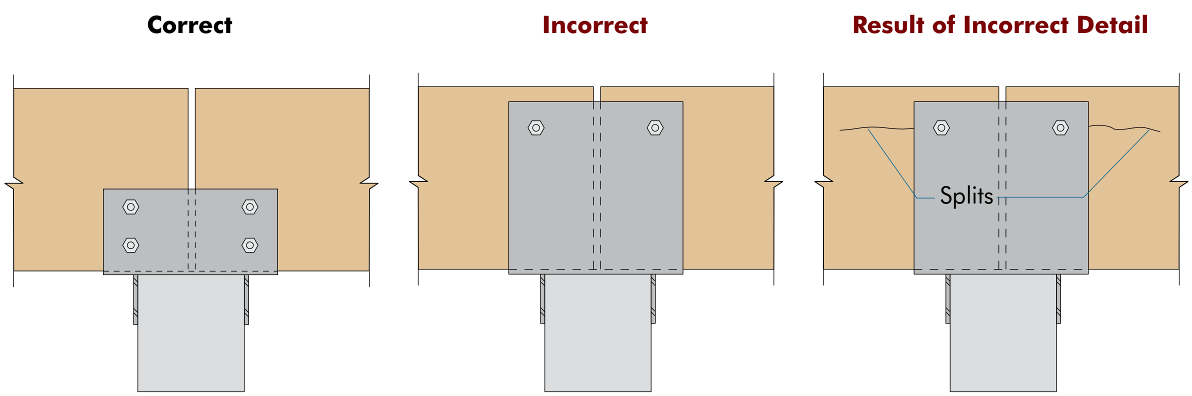
CANTILEVER BEAM CONNECTION—NO TENSION TIE



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 10A

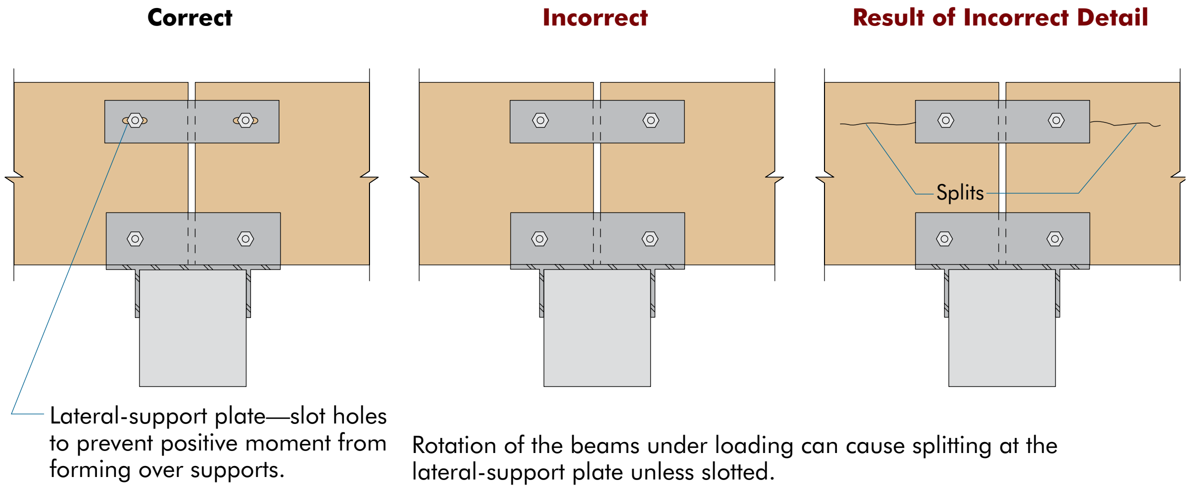
BEAM-TO-COLUMN—U-BRACKET—WOOD OR PIPE COLUMN



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.

FIGURE 10B

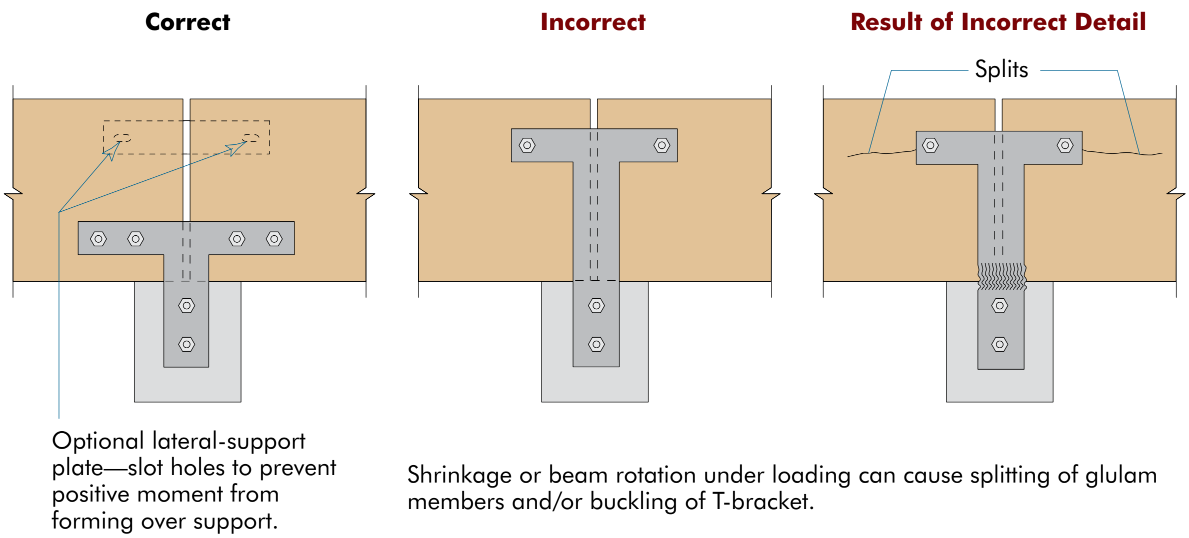
BEAM-TO-COLUMN—U-BRACKET—WOOD OR PIPE COLUMN



Rotation of the beams under loading can cause splitting at the lateral-support plate unless slotted.

FIGURE 11

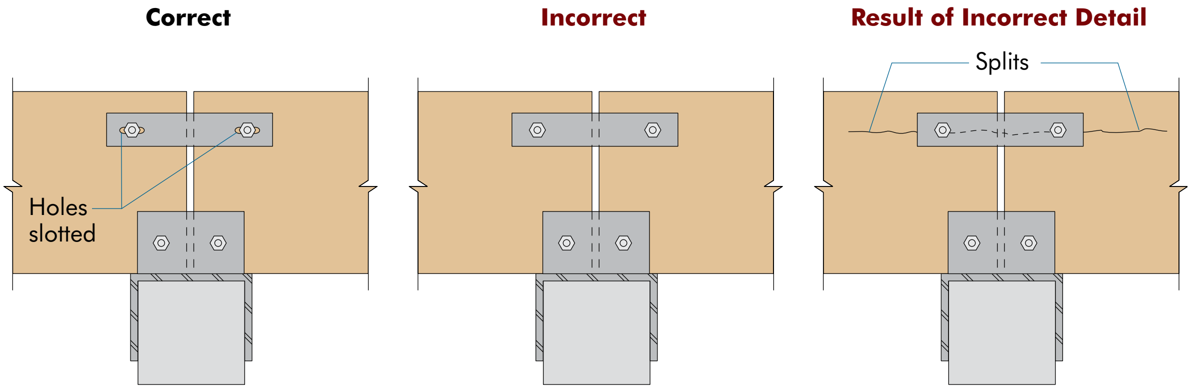
BEAM-TO-COLUMN—T-BRACKET



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

FIGURE 12

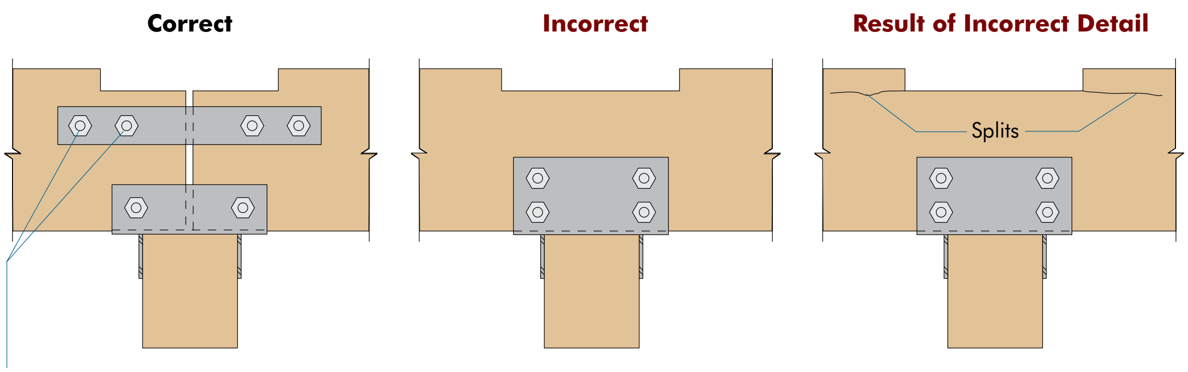
BEAM-TO-COLUMN—WITH TOP LATERAL SUPPORT PLATE



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

FIGURE 13

NOTCH IN BEAM OVER COLUMN



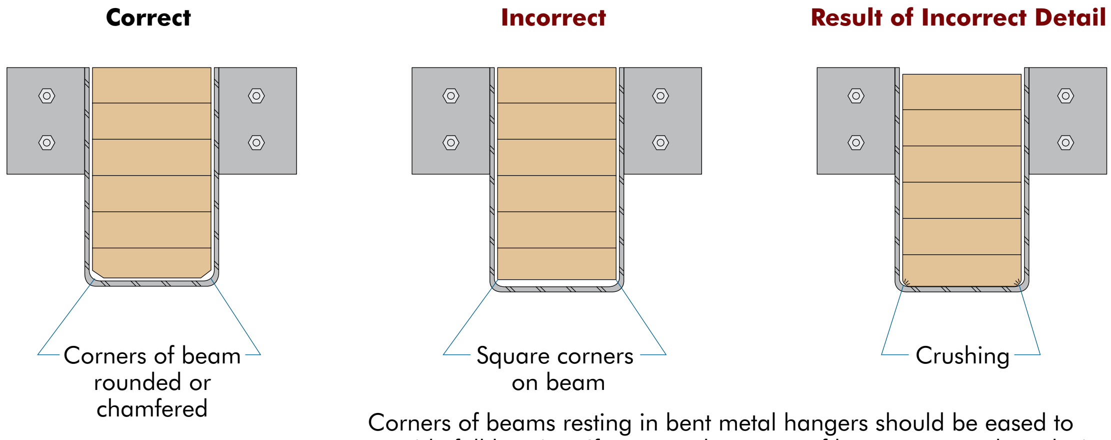
Shown with no slotted holes for use as a tension tie. Design must ensure no excessive rotation of beams under load.

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 14

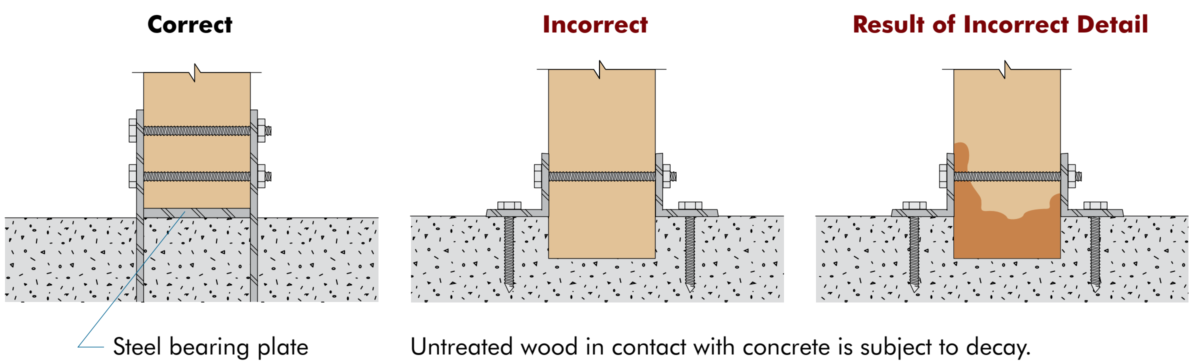
BEAM IN BENT HANGER



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 15

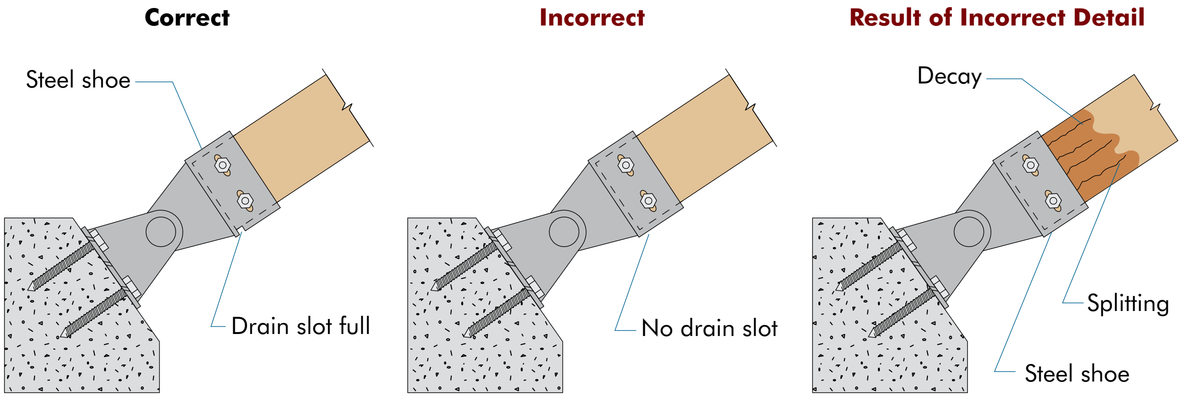
WOOD COLUMN TO CONCRETE BASE



Untreated wood in contact with concrete is subject to decay.

FIGURE 16

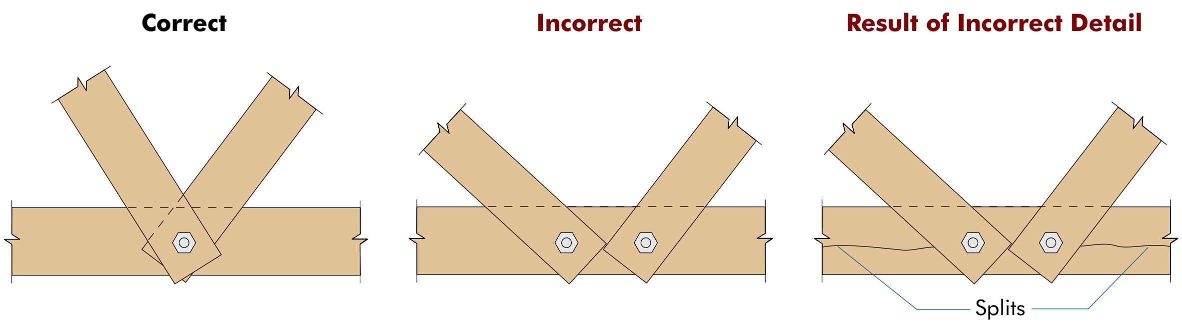
GLULAM ARCH TO FOUNDATION



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 17A

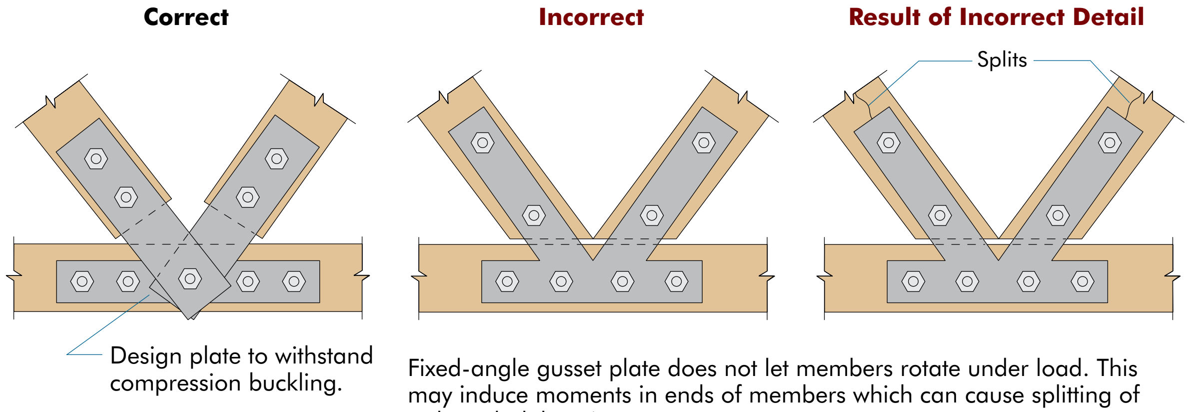
TRUSS CONNECTORS



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.

FIGURE 17B

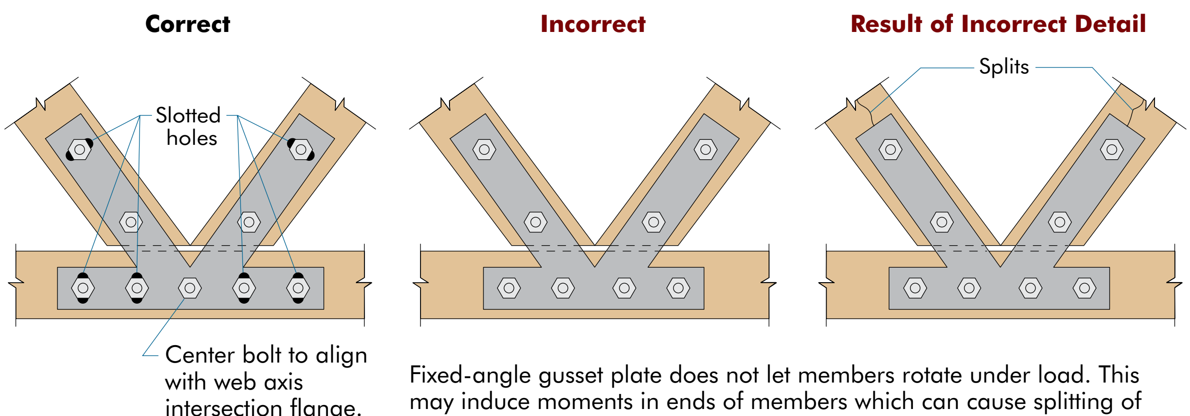
TRUSS CONNECTORS



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.

FIGURE 17C

TRUSS CONNECTORS

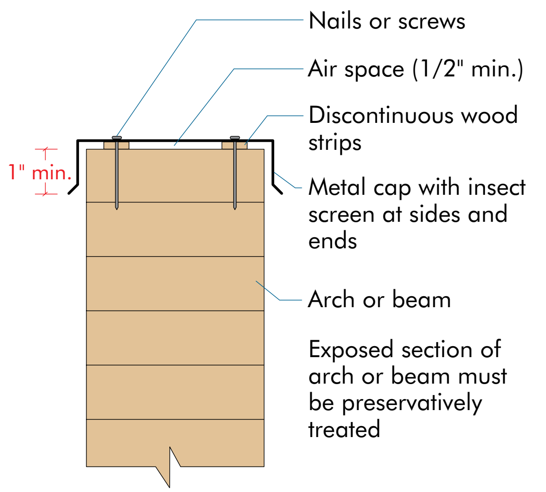


Fixed-angle gusset plate does not let members rotate under load. This may induce moments in ends of members which can cause splitting of webs at bolt locations.

Recommended use of metal caps to protect glulam beams directly exposed to the elements from moisture intrusion.

FIGURE 18A

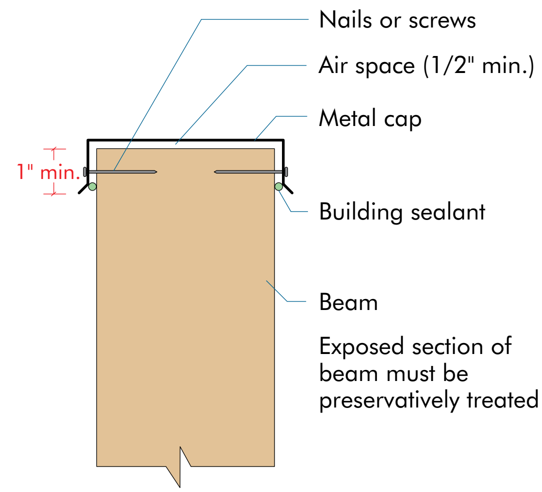
TOP CAP FOR HORIZONTAL OR SLOPED MEMBERS



END VIEW

FIGURE 18B

END CAP FOR EXPOSED BEAMS OR VERTICAL MEMBERS



TOP VIEW (BEAMS) OR SIDE VIEW (VERTICAL MEMBERS)

ABOUT APA

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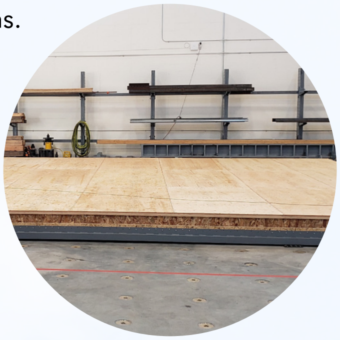
APA – The Engineered Wood Association is a nonprofit trade association of and for structural wood panel, glulam timber, wood I-joist, structural composite lumber, cross-laminated timber and other engineered wood product manufacturers. Based in Tacoma, Washington, APA represents approximately 175 mills throughout North America, ranging from small, independently owned and operated companies to large integrated corporations.



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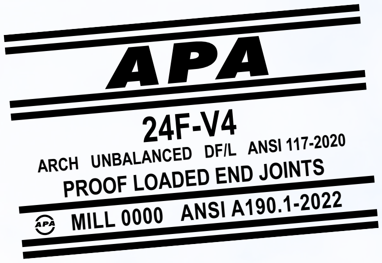

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