USING TOE-NAILED CONNECTIONS TO ATTACH TRUSSES AT BEARING LOCATIONS

GENERAL

☑ Metal Plate Connected Wood Trusses are typically designed to bear directly on top of a wall or beam, or to frame into the side of a Girder Truss. In many instances, a toe-nailed connection can be used to attach the Truss to the support. As with any Connection, the toe-nailing shall be capable of resisting and transferring the applicable loads.

FACTORS AFFECTING THE STRENGTH OF A TOE-NAILED CONNECTION

☑ The resistance provided by a toe-nailed connection is governed by the following factors:

1. Proper Installation

To get the most out of a toe-nailed connection, it is important to toe-nail correctly. Figure B8-1 illustrates proper toe-nailing of a truss to the wood top plates of a bearing wall. The dimensions shown are only meant to serve as an approximate guide. Toe-nailing through a metal connector plate of a truss does not adversely affect the uplift capacity of the Connection provided the truss plate and lumber are not damaged during installation.

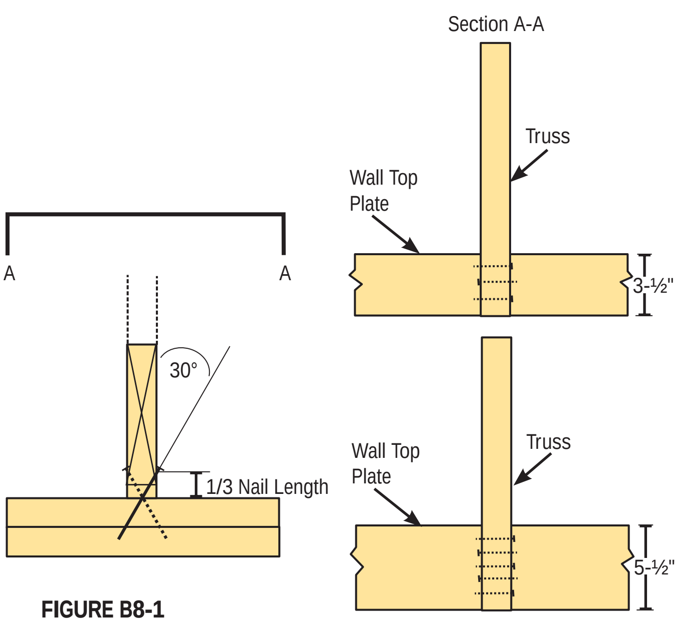


FIGURE B8-1

2. Species of Lumber

The species of wood that the nail is driven into also affects the amount of resistance provided by a toe-nailed connection. More specifically, nail resistance to withdrawal and lateral forces is directly related to the specific gravity (SG) of the wood. For example, a toe-nailed connection into Southern Pine (SG = 0.55) will provide greater resistance than the same Connection into Spruce-Pine-Fir (SG = 0.42).

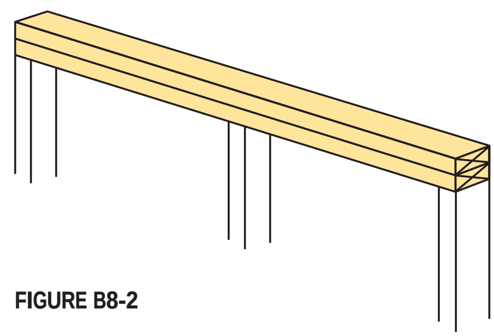


FIGURE B8-2

3. Length of Penetration

The withdrawal and lateral resistance provided by a nail depends, in part, on the length of penetration into the wood member. The greater the penetration, the greater the resistance.

4. Type of Nail

The type of nail used in a toe-nailed connection also influences capacity. The larger the diameter of the nail shank, the greater the resistance to withdrawal and lateral loads. For this reason, common wire nails provide greater resistance than the same size (i.e., penny-weight) of box, sinker or gun nails. The type of nail shank will also influence nail holding capacity. Deformed shank (i.e., ring- or screw-shank) typically provide greater withdrawal resistance than smooth shank nails.

☑ When installing toe-nails, use care to avoid splitting the wood. The Building Designer typically provides nail spacing and minimum end and edge distances. In lieu of such guidance, a well accepted rule is to limit the total number of toe-nails to three (total, including both sides) for full bearing on a 2x4 top plate (i.e., 3-1/2") and five (total, including both sides) for full bearing on a 2x6 top plate (i.e., 5-1/2") (see Figure B8-1). When using toe-nails to attach the top or bottom chord of a truss to the side of a Girder Truss or wood beam, the number of nails used is generally limited to a maximum of three toe-nails for 2x4 chords and four toe-nails for 2x6 chords.

- The National Design Specification® (NDS®) for Wood Construction provides the engineering basis for toe-nail and slant-nail connections when used to resist withdrawal and lateral loads. The design values included in this document were developed using the provisions of the 2005 edition of NDS®.

TOE-NAILING USED WITH BOTTOM BEARING APPLICATIONS

- Trusses designed to bear directly on top of a structural wood support are often attached by toe-nailing the truss chord to the support. Toe-nailing used in this type of application is typically required to resist uplift and lateral forces.

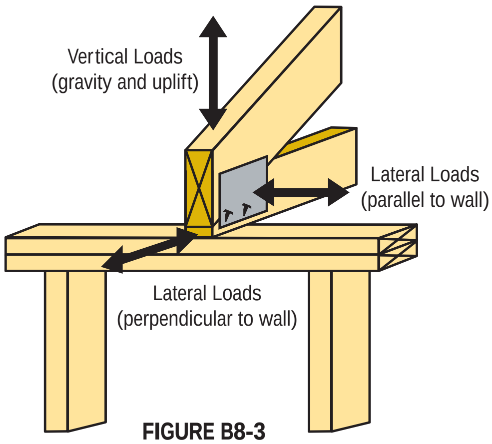


FIGURE B8-3

- Wind loads acting on a truss, as well as certain multi-span truss applications supporting gravity loads, can produce uplift reactions at truss bearing locations. The magnitudes of these uplift reactions are typically provided on the Truss Design Drawing (TDD).

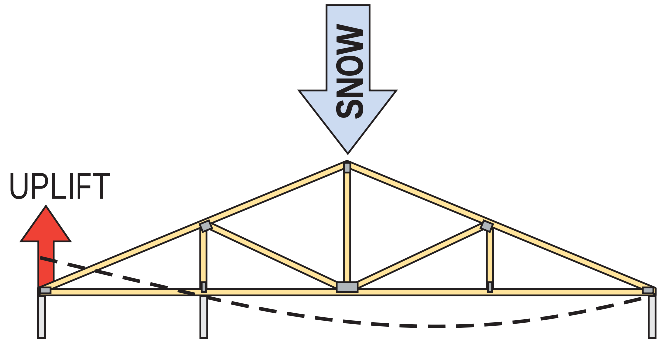


FIGURE B8-4

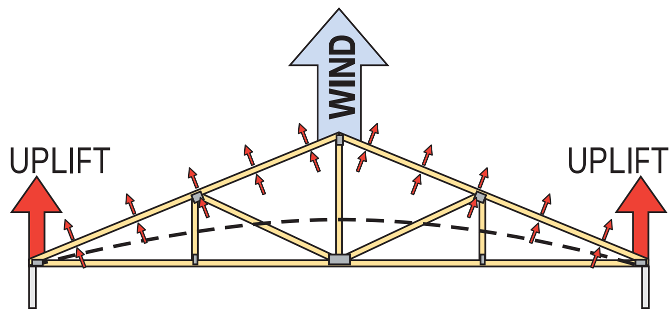
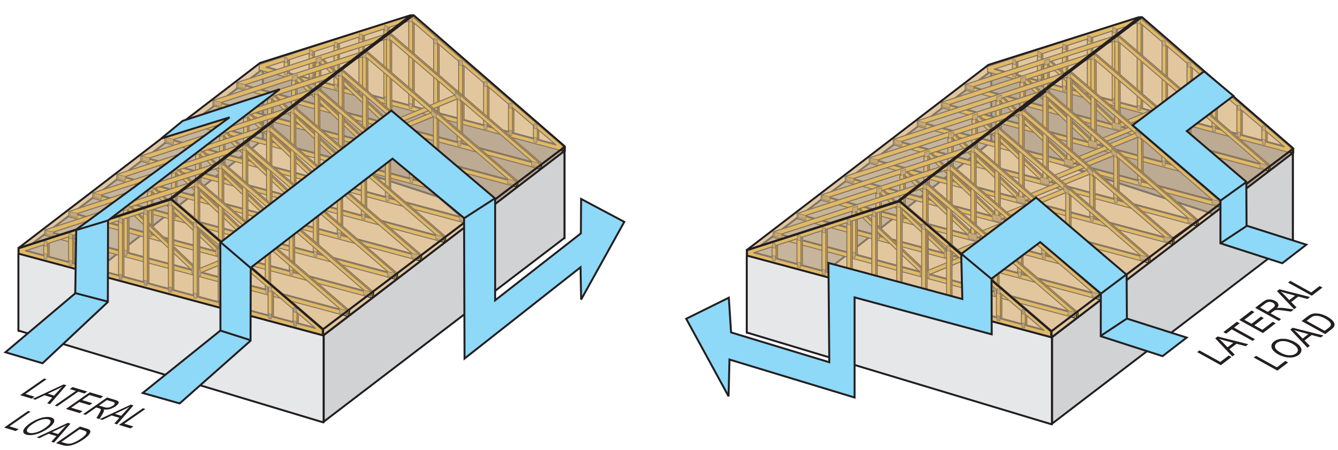


FIGURE B8-5

- Wind and seismic forces acting on the building produce lateral loads that are often transferred at the truss bearing locations. The magnitude and direction of these wind and seismic loads are to be provided by the Building Designer.

Example of lateral load paths through the roof of a building



Lateral load applied to end wall

Lateral load applied to side wall

FIGURE B8-6

HOW MUCH UPLIFT AND LATERAL RESISTANCE CAN TOE-NAILING PROVIDE?

Table B8-1 provides the uplift and lateral load capacities of toe-nailed connections consisting of three, four or five nails for various types of nails and species of wood. The table assumes the nails are installed a distance of either L/3 (i.e., length of nail divided by 3) or 1-1/8" from the top surface of the plate (support) (Figure B8-1, page 63). The values listed are for normal load duration and are permitted to be multiplied by the load duration factor (Table B8-2, page 66) appropriate for the specific application.

Example: A truss manufactured with SPF chords and webs bears on top of a bearing wall with double 2x6 SPF top plates. The TDD for this truss indicates a maximum uplift reaction due to wind of 225 pounds. From the columns marked "Uplift Capacity" in Table B8-1, a toe-nailed connection of either 5-16d 0.131" diameter nails (i.e., 150 x 1.6 = 240 lbs > 225), 5-16d Box nails (i.e., 155 x 1.6 = 248 lbs > 225), or 5-12d Common nails (i.e., 155 x 1.6 = 248 lbs > 225) would be required to resist this uplift, using a load duration factor of 1.6 for wind.

The calculated lateral resistance capacity of each of these toe-nailed connections can be determined from the righthand side of Table B8-1. The connections consisting of 5-16d (0.131x3.5") nails can resist a lateral load due to wind of 340 x 1.6 = 544 lbs at a load duration factor of 1.6. Similarly a connection using 5-16d Box nails can resist approximately 584 lbs and a connection with 5-12d Common nails can resist approximately 664 lbs.

Note: Uplift and lateral loads can occur simultaneously and the capacity of toe-nailed connections should be evaluated under this combined loading. It is best to have the Building Designer evaluate the load transfer path and the truss to bearing connection to determine what is required.

TABLE B8-1 Nominal Uplift and Lateral Capacity per Toe-Nail Joint Connection into Double Top Plate of Wall[1,2,3,6,7]

		Uplift Capacity (lbs) with Common Species[5]					Lateral Resistance Capacity (lbs) with Common Species[4]				
Nail Type & Size	No. of Toe-Nails	Load Duration Factor = 1.0									
		SP (SG = 0.55)	DF-L (SG = 0.50)	HF (SG = 0.43)	SPF (SG = 0.42)	SPF(s) (SG = 0.36)	SP (SG = 0.55)	DF-L (SG = 0.50)	HF (SG = 0.43)	SPF (SG = 0.42)	SPF(s) (SG = 0.36)
16d (0.131x3.5")	3	174	138	96	90	60	264	243	210	204	180
	4	232	184	128	120	80	352	324	280	272	240
	5	290	230	160	150	100	440	405	350	340	300
12d (0.120x3.25")	3	147	114	78	75	51	222	204	177	171	150
	4	196	152	104	100	68	296	272	236	228	200
	5	245	190	130	125	85	370	240	295	285	250
10d (0.120x3.0")	3	126	99	69	66	45	222	204	177	171	150
	4	168	132	92	88	60	296	272	236	228	200
	5	210	165	115	110	75	370	240	295	285	250
10d (0.131x3.0")	3	138	108	75	72	48	264	243	210	204	180
	4	184	144	100	96	64	352	324	280	272	240
	5	230	180	125	120	80	440	405	350	340	300
16d Box (0.135x3.5")	3	180	141	99	93	63	282	258	222	219	189
	4	240	188	132	128	84	376	344	296	292	252
	5	300	235	165	155	105	470	430	370	365	315
10d Box (0.128x3.0")	3	135	108	72	69	48	252	231	201	195	171
	4	180	144	96	92	64	336	308	268	260	228
	5	225	180	120	115	80	420	385	335	325	285
8d Box (0.113x2.5")	3	84	66	45	42	30	198	180	156	153	132
	4	112	88	60	56	40	264	240	208	204	176
	5	140	110	75	70	50	330	300	260	255	220
16d Common (0.162x3.5")	3	216	171	117	111	75	384	351	304	297	261
	4	288	228	156	148	100	512	468	404	396	348
	5	360	285	195	185	125	640	585	505	495	435
12d Common (0.148x3.25")	3	180	141	96	93	63	321	294	255	249	216
	4	240	188	128	124	84	428	392	340	332	288
	5	300	235	160	155	105	535	490	425	415	360
10d Common (0.148x3.0")	3	156	123	84	81	54	321	294	255	249	216
	4	208	164	112	108	72	428	392	340	332	288
	5	260	205	140	135	90	535	490	425	415	360
8d Common (0.131x2.5")	3	99	78	54	51	33	243	222	192	186	165
	4	132	104	72	68	44	324	296	256	248	220
	5	165	130	90	85	55	405	370	320	310	275

Footnotes:

1. The capacities in this Table are for Normal load duration and assume moisture, temperature and end grain factor of 1.0. Refer to NDS® if other adjustments are required.
2. For nail types and sizes not shown here consult a design professional.
3. Nominal uplift and lateral resistance capacities are based on wood species of the top plate, where SP = Southern Pine, DF-L = Douglas Fir-Larch, HF = Hem-Fir, SPF = Spruce-Pine-Fir, and SPF(s) = Spruce-Pine-Fir (South).
4. If the truss bottom chord and wall plate are different species use the species with the lowest specific gravity to determine the lateral load capacity of the fastener.
5. Nominal uplift capacities assume full penetration of the toe-nail into the top plate. Double 2x_ plates are required for nail lengths greater than 2.69".
6. Apply fire retardant treated lumber adjustment factors per manufacturer's specifications.
7. Per NDS®, edge distances, end distances and spacing shall be sufficient to prevent the splitting of the wood.

Note: Trusses are intended to carry loads applied parallel to their plane (i.e., depth) and not perpendicular to it. The lateral load transfer through the truss as depicted in Figure B8-7 occurs unless blocking or some other means is provided that will transfer this load directly between the roof sheathing and top plate of the wall. The truss industry places the following general limits on this load transfer through the truss:

> Trusses shall be permitted to transfer load between diaphragms and supporting shear walls, provided that the distance between the diaphragm and the shear wall does not exceed 6", the trusses are spaced no greater than 24" on center, and the horizontal load transfer between the diaphragm and the shear wall does not exceed 50 plf.

LOAD DURATION FACTOR, C_D (FOR CONNECTIONS)

TABLE B8-2 Load Duration Factor, C_D (for connections)

LOAD DURATION	C_D	TYPICAL DESIGN LOAD
Permanent	0.9	Dead Loads
10 Years (Normal)	1.0	Floor Live Loads
2 Months	1.15	Snow Loads
7 Days	1.25	Construction Loads
10 Minutes/Impact	1.33/1.6*	Wind/Earthquake

*Check with local code.

Lateral load transfer between the roof diaphragm and supporting wall is through the heel of the truss unless some other means is provided to transfer this load directly between the roof sheathing and the wall plate.

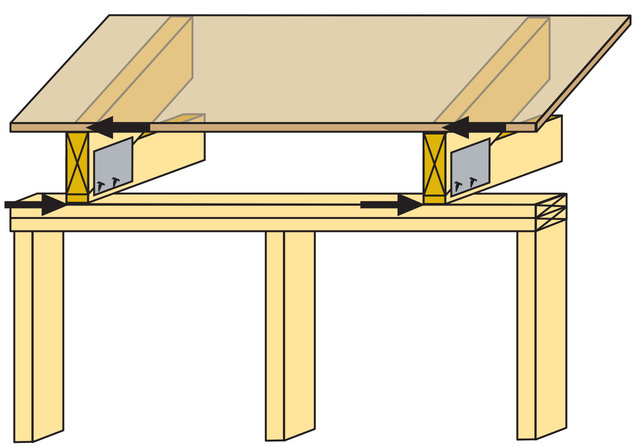


FIGURE B8-7

TOE-NAILING USED TO ATTACH JACK TRUSSES TO A GIRDER

- ☑ Toe-nailing is often used to attach corner and end jack trusses to Girder Trusses. The relatively short spans and light end reactions associated with typical jack truss applications makes toe-nailing an efficient and effective attachment method.

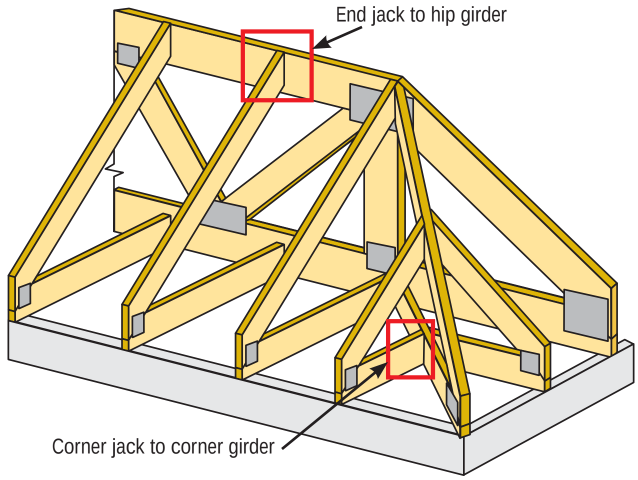


FIGURE B8-8 Open Jack Hip Framing

- ☑ Table B8-3, page 67, provides the nominal lateral design capacity of toe-nailed connections consisting of two-, three-, and four-nails for various types of nails and species of wood. The capacities listed are for toe-nailed connections attaching the top and bottom chords of a 2x_ end jack truss to a single or multiple 2x_ hip Girder Truss (Figure B8-9, page 67) or for the toe-nailed connections attaching the top and bottom chords of a 2x_ corner jack truss to a corner Girder Truss that intersect at angles from 30° to 60° (Figure B8-10, page 67).

  Note: The nails for these connections are assumed to be installed at either L/3 (i.e., length of nail divided by 3) or 1-1/8" from the end of the jack truss (Figures B8-9 and 10, page 67). Also, the connection between the corner jack and corner girder assumes that the nails are driven normal to the face of the jack into the girder as depicted in (Figure B8-10, page 67).

- ☑ To reduce the chance of splitting, rafter connections such as those depicted here are typically limited to a maximum of three toe-nails for 2x4 chords and four toe-nails for 2x6 chords.

TABLE B8-3 Nominal Lateral Capacity per Toe-Nail Joint Connection for Attaching Jack Trusses to Girders[1,2,3,4,5,6,7]

Nail Type & Size (Dia. & Length)	Number of Toe-Nails per Connection	Capacities for Truss Chord Species (lbs)				
		Load Duration Factor = 1.0				
		SP	DF-L	HF	SPF	SPF(s)
		G = 0.55	G = 0.5	G = 0.43	G = 0.42	G = 0.36
16d (0.131" x 3.5")	2	158	140	114	110	92
	3	237	210	171	165	138
	4	316	280	228	220	184
12d (0.120" x 3.25")	2	138	120	98	94	78
	3	207	180	147	141	117
	4	276	240	196	188	156
10d (0.120" x 3.0")	2	130	116	94	92	76
	3	195	174	141	138	114
	4	260	232	188	184	152
10d (0.131" x 3.0")	2	142	130	108	106	90
	3	213	195	162	159	135
	4	284	260	216	212	180
16d Box (0.135" x 3.5")	2	166	146	120	116	96
	3	249	219	180	174	144
	4	332	292	240	232	192
10d Box (0.128" x 3.0")	2	138	126	104	102	86
	3	207	189	156	153	129
	4	276	252	208	204	172
16d Common (0.162" x 3.5")	2	214	188	156	152	128
	3	321	282	234	228	192
	4	428	376	312	304	256
12d Common (0.148" x 3.25")	2	182	160	132	128	108
	3	273	240	198	192	162
	4	364	320	264	256	216
10d Common (0.148" x 3.0")	2	152	140	120	116	94
	3	228	210	180	174	141
	4	304	280	240	232	188

Footnotes:

1. Nominal lateral design capacities have been adjusted by the toe-nail factor and represent normal load duration values. To determine the adjusted lateral design values, multiply the table values by all other applicable adjustment factors provided in NDS®.
2. Nominal lateral capacities are based on framing conditions depicted in Figures B8-9 and 10.
3. Nominal lateral capacities are for a single-shear connection with both members of the same species. If the two members are of different species, use the species with the lowest specific gravity to determine the lateral load capacity of the fastener.
4. Species designation is: SP = Southern Pine, DF-L = Douglas Fir-Larch, HF = Hem-Fir, SPF = Spruce-Pine-Fir and SPF(s) = Spruce-Pine-Fir (South).
5. Nominal lateral capacities assume the side member and main member are both 1-½" thick.
6. Apply fire retardant treated lumber adjustment factors per manufacturer's specifications.
7. For nail capacities not shown here, consult a design professional.

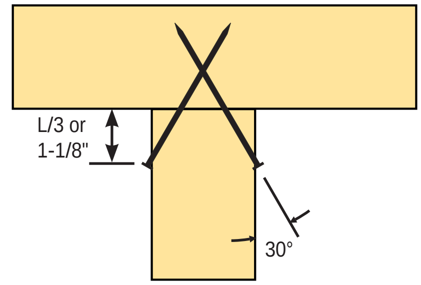


FIGURE B8-9 End jack to hip girder

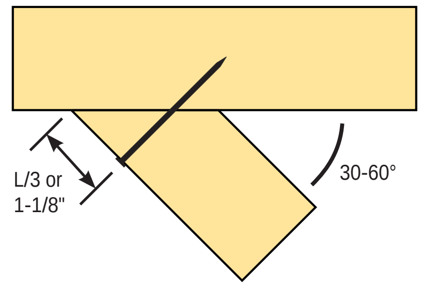


FIGURE B8-10 Corner jack to corner girder

OTHER TYPES OF UPLIFT CONNECTIONS

If the truss reactions due to the design loads are greater than the capacity of the toe-nailed connection, it will be necessary to use a different type of connection. Options include a screwed connection, designed in accordance with the applicable provisions of NDS®, a metal anchor, strap, tie or hanger connection, such as the ones shown below. Please refer to the hardware manufacturer's literature for uplift and lateral load capacities of the hardware, the fastener schedules, and specific requirements for locating the connector.

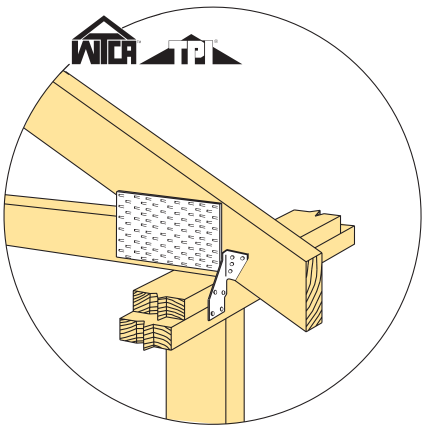


FIGURE B8-11

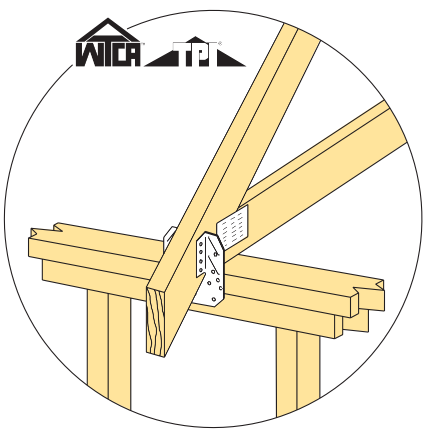


FIGURE B8-12

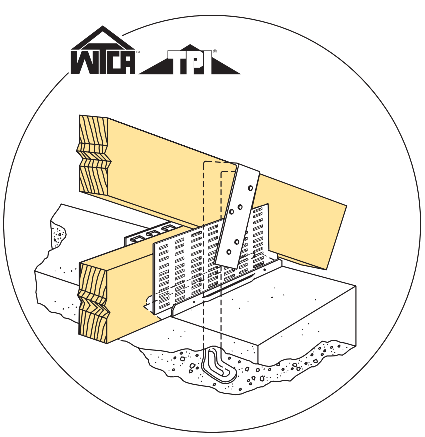


FIGURE B8-13

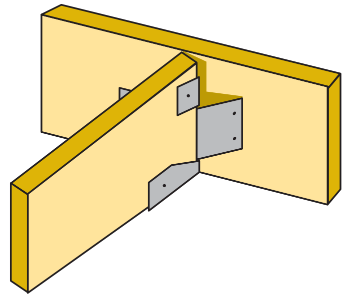


FIGURE B8-14

☑ Some building codes specify connection requirements between the truss and the bearing surface. It is imperative that the installer be familiar with the requirements that apply for each job.

Non-Bearing Wall Considerations

Attachments to non-bearing interior walls must allow for a Floating Connection to prevent the occurance of partition separation.

⊘ Do not shim.

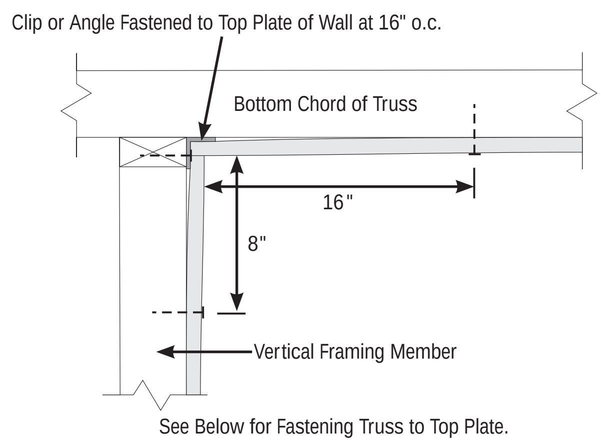


FIGURE B8-15 Floating Gypsum Corner (Truss Perpendicular to Wall)

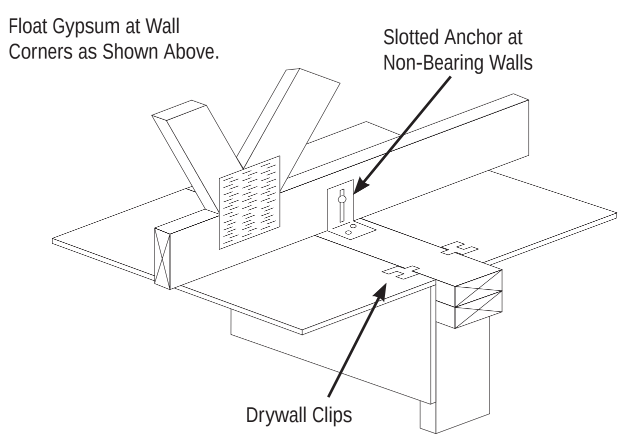


FIGURE B8-16 Use of Drywall Clips and Slotted Anchor on Non-Bearing Wall