



Roof Design with Special Profile Joists

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Webinar Description

Steel joists and Joist Girders can be used to construct more than just flat roofs. This session will provide designers with details and design guidance for using Special Profile Steel Joists in these situations. Direction will be provided for designing and detailing Special Profile Steel Joists, particularly in pitched roofs, curved roofs, and hip roof framing. We will also examine best practices when using Special Profile Steel Joists.

Learning Objectives

1. Identify the unique considerations for designing and specifying steel joists and Joist Girders with pitched chords, including hip roof framing.
2. Identify the unique considerations for designing and specifying steel joists and Joist Girders with radiused chords.
3. Describe the factors that impact special profile steel joists and Joist Girders.
4. Summarize the general concerns with using special profile steel joists and Joist Girders.

Roof Design with Special Profile Joists

- Standards SJI Shapes
- Sloped Seats
- Pitched Top Chords
- Joists in a Hip Roof
- Special Profile Joists

Specialty Shapes

What makes them special?

Not a standard shape

Standard SJI Shapes

K: 10" – 30" deep, up to 60' long

LH: 18" – 48" deep, up to 96' long

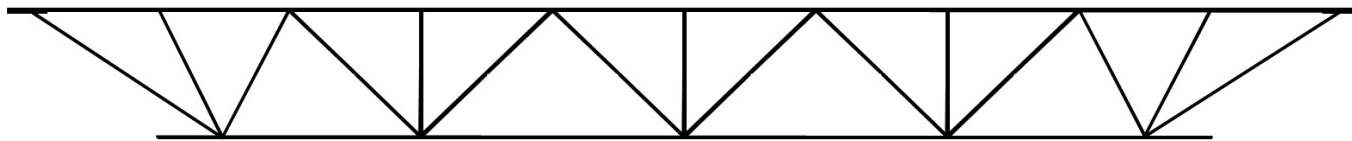
DLH: 52" – 120" deep, up to 240' long

Joist Girders:

20" – 120" deep, up to 120' long

Standard SJI Shapes

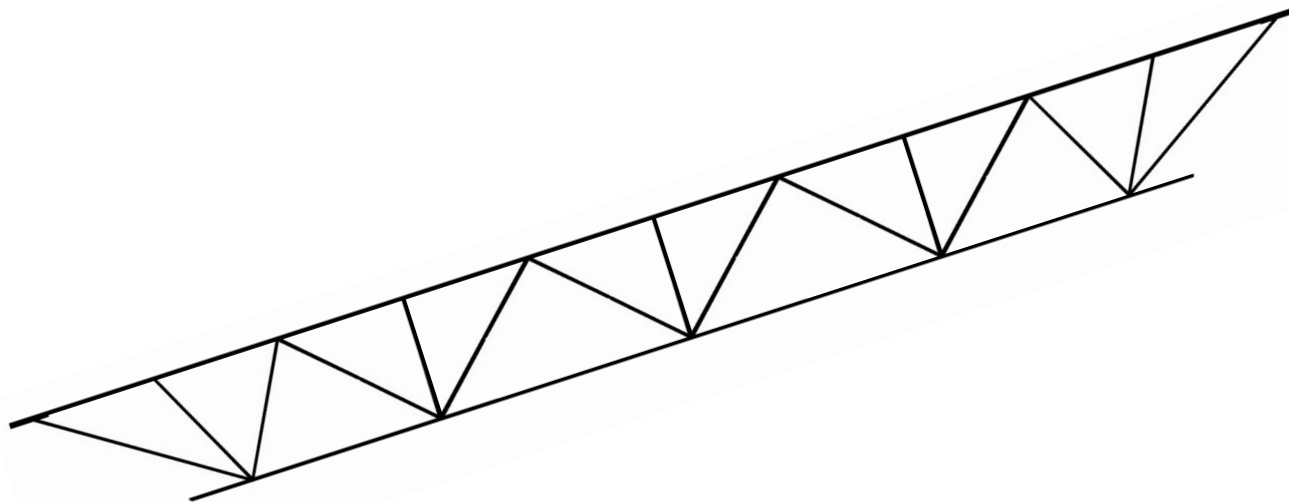
Most common is parallel chord



Used in floors and flat roofs

Standard SJI Shapes

Most common is parallel chord



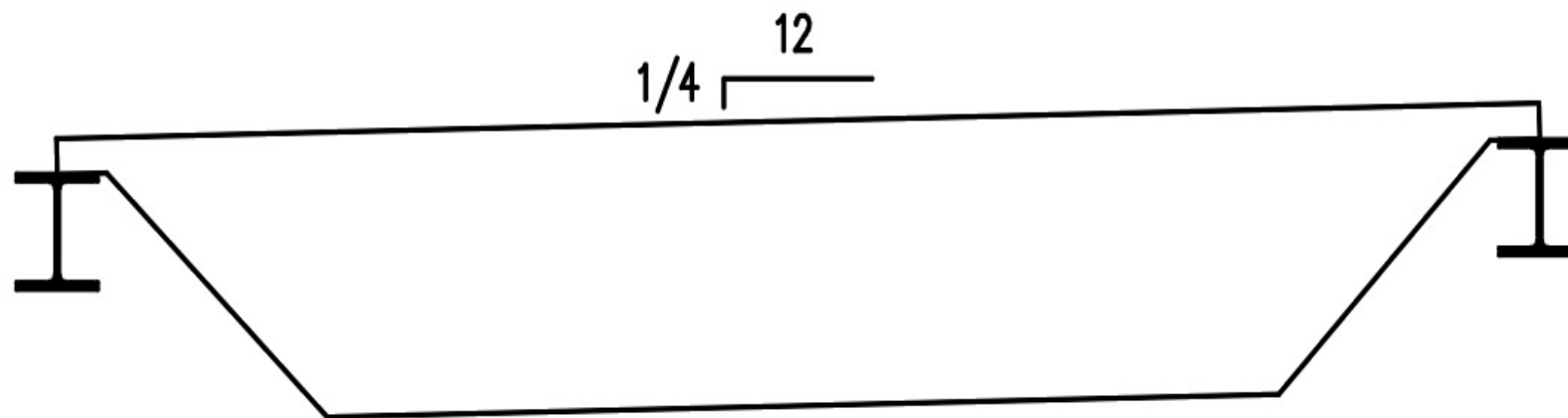
Also used in sloped roofs
with low and high supports

Sloped Seats

Where steel joists or Joist Girders are sloped, the end bearing, or seats, may also be sloped

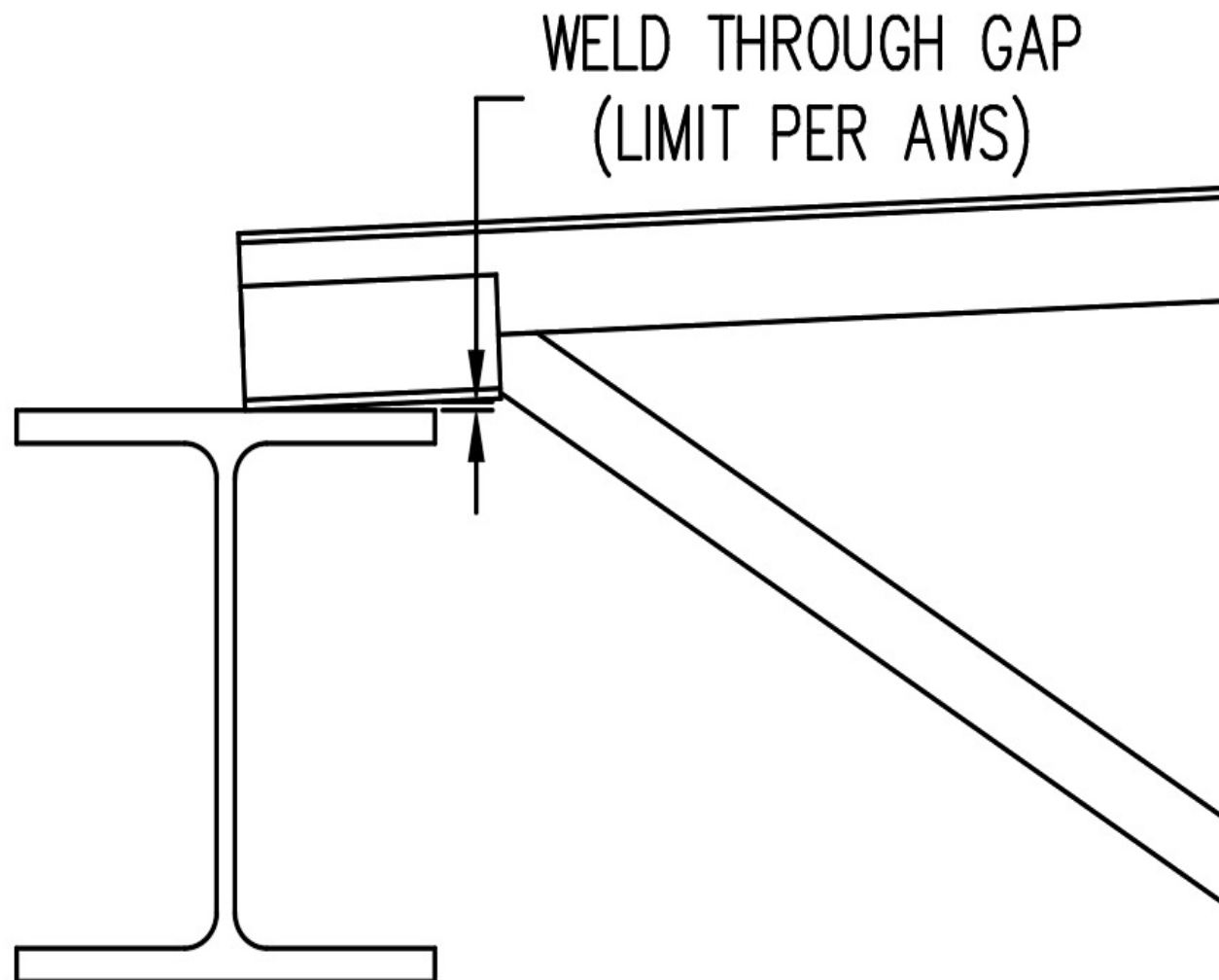
For K-Series Joists, seats are permitted to not be beveled for slopes of 1/4 inch or less per foot

Sloped Seats



JOIST SEATS NOT SLOPED

Sloped Seats



Sloped Seats



Sloped Seats

When sloped seats are required, the seat depths shall be adjusted to maintain standard height at the shallow end of the sloped seat

SJI publishes these requirements in:

Table 2.2-2 and 2.2-3

Sloped Seats

TABLE 2.2-2

**SLOPED SEAT REQUIREMENTS FOR SLOPES 3/8":12 AND GREATER
K-SERIES OPEN WEB STEEL JOISTS**



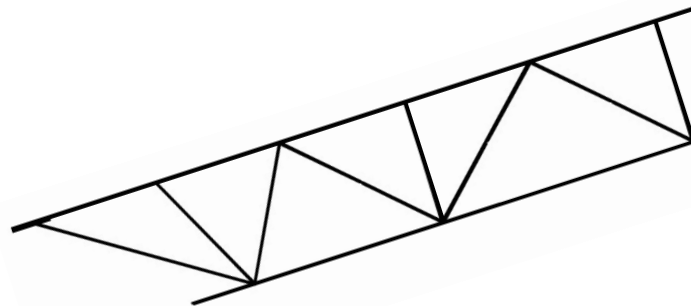
TABLE 2.2-3

**SLOPED SEAT REQUIREMENTS FOR SLOPES 3/8":12 AND GREATER
LH- AND DLH-SERIES OPEN WEB STEEL JOISTS**



Sloped Seats

Most common is parallel chord



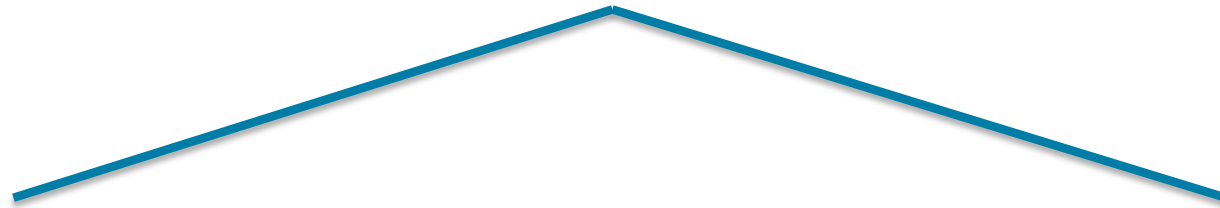
**SLOPED SEAT
REQUIREMENTS
(SJI CODE OF
STANDARD PRACTICE)**

**SLOPED SEAT REQUIREMENTS FOR SLOPES 3/8":12 AND GREATER
LH- AND DLH-SERIES OPEN WEB STEEL JOISTS**

LOW END W/OUT TOP CHORD EXTENSIONS	HIGH END W/OUT TOP CHORD EXTENSIONS	SLOPE "X" : 12	MINIMUM HIGH END SEAT DEPTH "d"
		3/8	6
		1/2	6
		1	6 1/2
		1 1/2	6 1/2
		2	7
		2 1/2	7
		3	7 1/2
LOW END W/ TOP CHORD EXTENSIONS	HIGH END W/ TOP CHORD EXTENSIONS	3 1/2	7 1/2
		4	8
		4 1/2	8 1/2
		5	8 1/2
		5 1/2	9
		6	9 1/2
		SEE NOTE (2) FOR SLOPE RATES GREATER THAN 6:12	

Specialty Shapes

Pitched Chords



Arched (Curved) Chords



Pitched Top Chords

Four standard types of joists with pitched top chords:

Double Pitch



TOP CHORD PITCHED TWO WAYS, UNDERSLUNG

Single Pitch



TOP CHORD PITCHED ONE WAY, UNDERSLUNG



TOP CHORD PITCHED TWO WAYS, SQUARE ENDS



TOP CHORD PITCHED ONE WAY, SQUARE ENDS

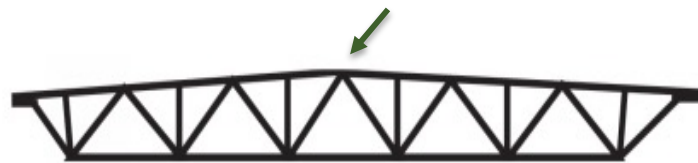
*Web systems shown are examples,
and vary by manufacturer*

Pitched Top Chords

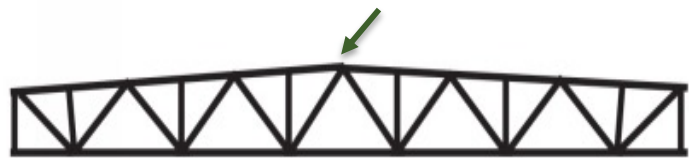
Specifying a joist with a Double Pitched top chord

What depth is used to specify the joist?

Double Pitch



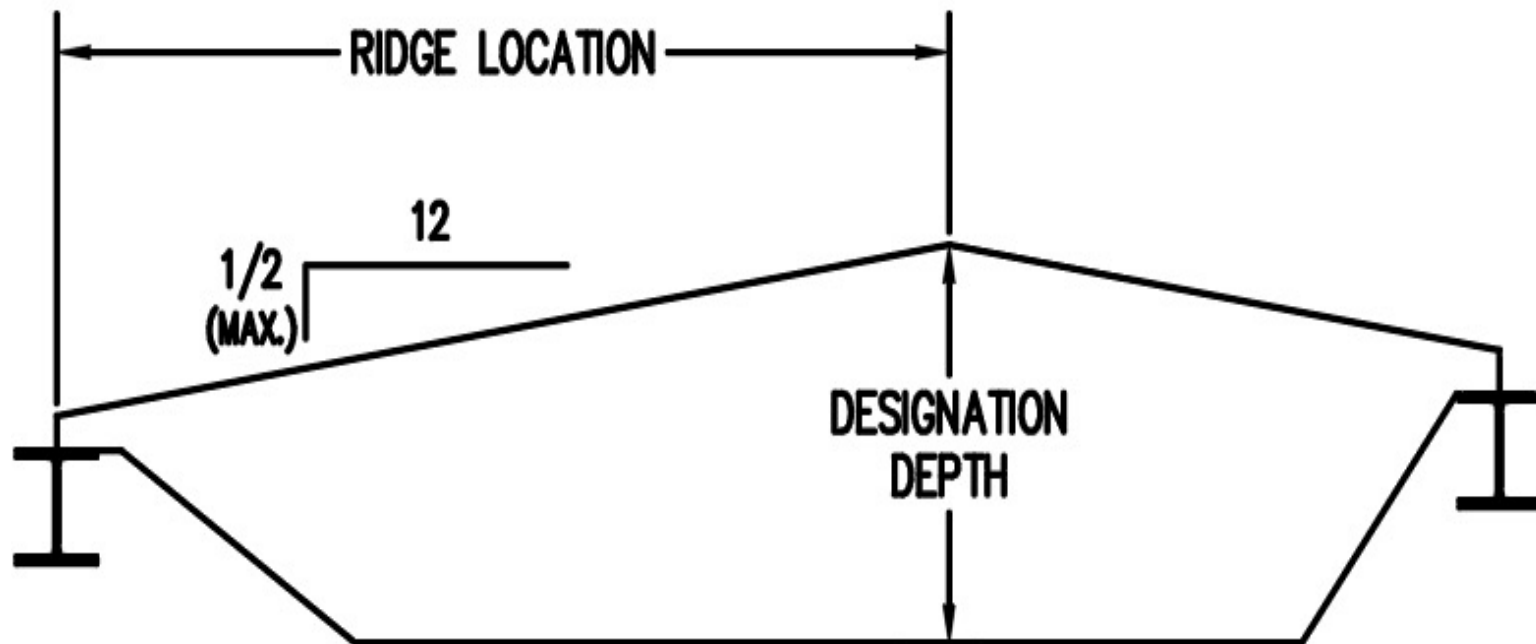
TOP CHORD PITCHED TWO WAYS, UNDERSLUNG



TOP CHORD PITCHED TWO WAYS, SQUARE ENDS

Double pitch joist designation depth is at the ridge.

Pitched Top Chords



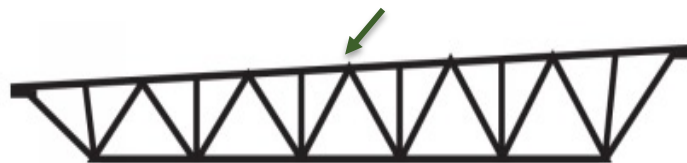
DOUBLE PITCH JOIST

Pitched Top Chords

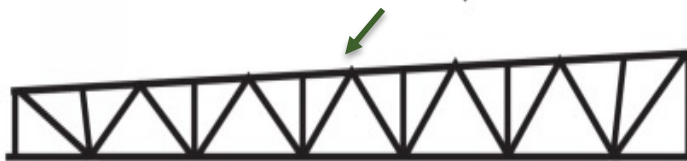
Specifying a joist with a Single Pitched top chord

What is the joist depth?

Single Pitch



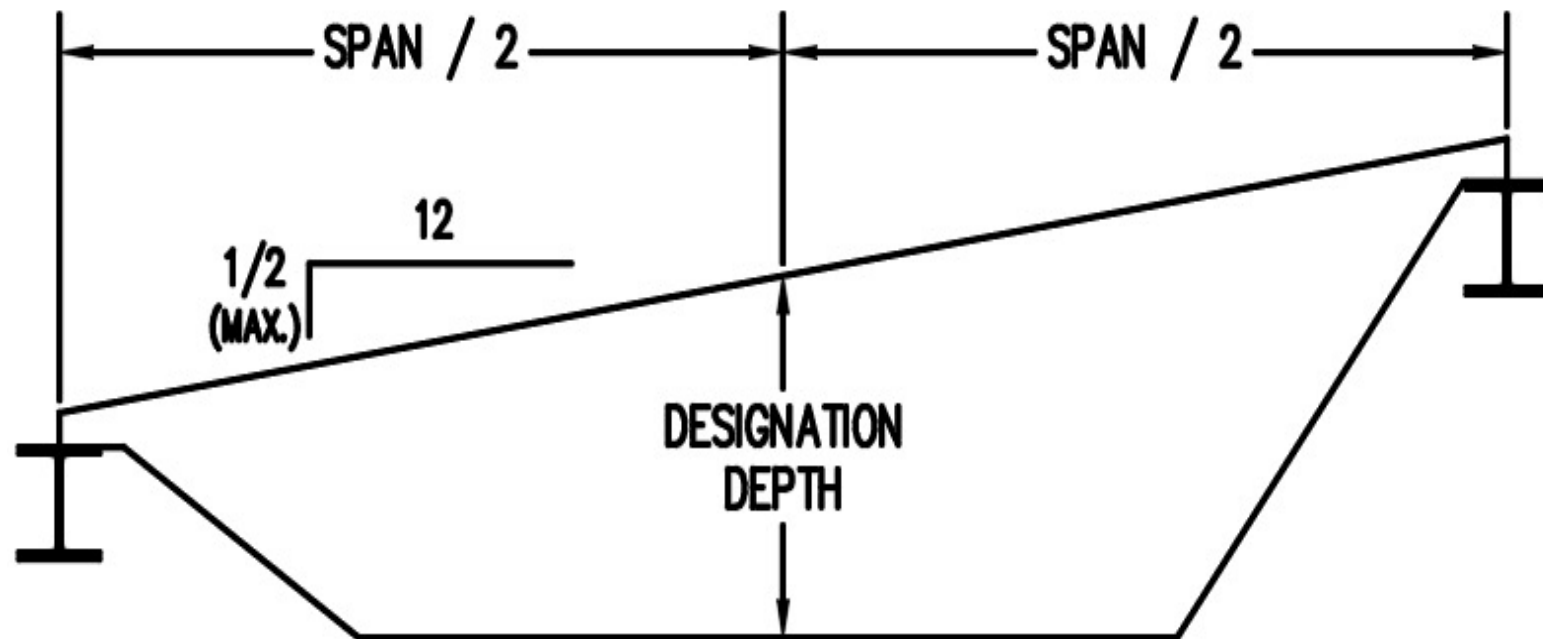
TOP CHORD PITCHED ONE WAY, UNDERSLUNG



TOP CHORD PITCHED ONE WAY, SQUARE ENDS

Single pitch joist designation depth is at mid-span.

Pitched Top Chords



SINGLE PITCH JOIST

Pitched Top Chords

It is critical that structural drawings provide all necessary dimensions and joists depths.

Special requirements for web-layouts must be specified as well.

Pitched Top Chords

A note about SJI designations

STANDARD LOAD TABLE FOR OPEN WEB STEEL JOISTS, K-SERIES												
Based on a 50 ksi Maximum Yield Strength - Loads Shown In Pounds Per Linear Foot (plf)												
Joist Designation	28K6	28K7	28K8	28K9	28K10	28K12	30K7	30K8	30K9	30K10	30K11	30K12
Depth (In.)	28	28	28	28	28	28	30	30	30	30	30	30
Approx. Wt. (lbs./ft.)	8.9	9.2	9.8	10.5	11.8	14.5	9.6	10.0	10.6	11.9	13.3	15.0
Span (ft.)												
↓												
27	550 550	550 550	550 550	550 550	550 550	550 550						
28	548 541	550 543	550 543	550 543	550 543	550 543						
29	511 486	550 522	550 522	550 522	550 522	550 522	550 550	550 550	550 550	550 550	550 550	550 550
30	477 439	531 486	550 500	550 500	550 500	550 500	550 543	550 543	550 543	550 543	550 543	550 543

“The Load Table applies to joists with either parallel chords or pitched top chords. Joists can have a top chord pitch up to 1/2 inch per foot. If the pitch exceeds this limit, the Load Table does **not** apply.”

Pitched Top Chords

Design Example:

100' span & 10' spacing

Top chord sloped at 1/2 : 12

Bottom chord flat (Architectural requirement)

End Depths = 31" & 81"

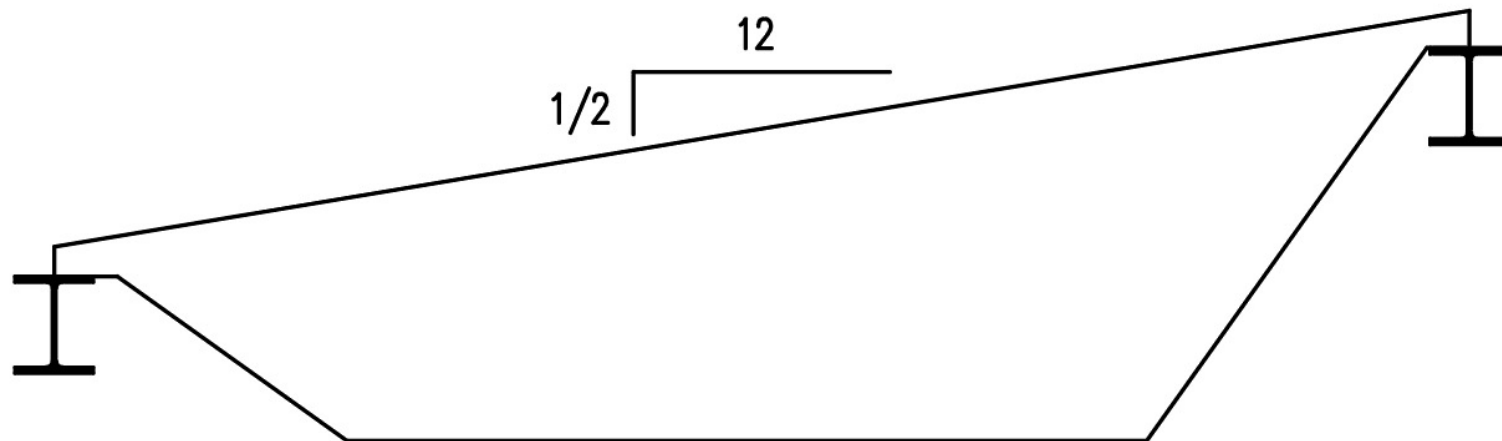
Mid-Span Depth = 56" ← DESIGNATION DEPTH

Total Load = 40 psf

Pitched Top Chords

Design Example:

Designate a **Single Pitch** DLH-Series joist



SINGLE PITCH JOIST

Pitched Top Chords

Design Example:

40 psf @ 10' Spacing = 400 plf Total Load

			<67	67-97	98	99	100
56DLH11	26	56	421	28200	288 169	283 163	277 158
56DLH12	30	56	484	32400	331 184	324 178	318 173
56DLH13	34	56	586	39240	401 223	394 216	386 209
56DLH14	39	56	662	44360	453 249	444 242	435 234
56DLH15	42	56	756	50680	518 281	508 272	499 264
56DLH16	46	56	816	54680	559 313	548 304	537 294

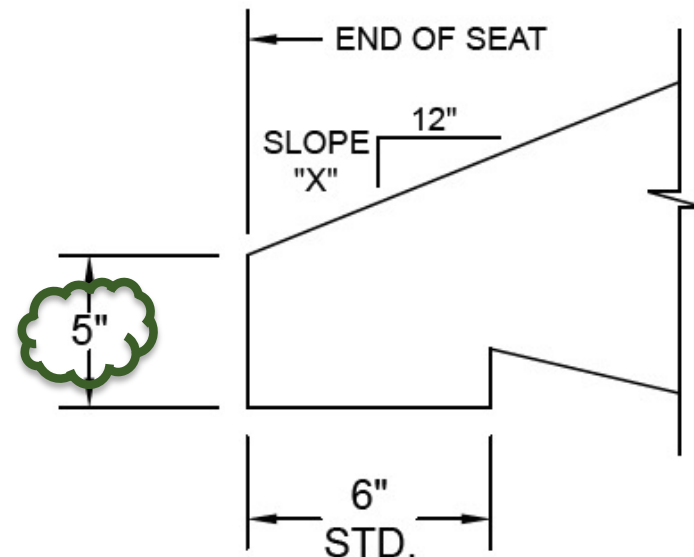
Select 56DLH14: 435 plf > 400 plf

Pitched Top Chords

Design Example:

Check seat depths - Top chord sloped at 1/2 : 12

Low End = 5" minimum



Pitched Top Chords

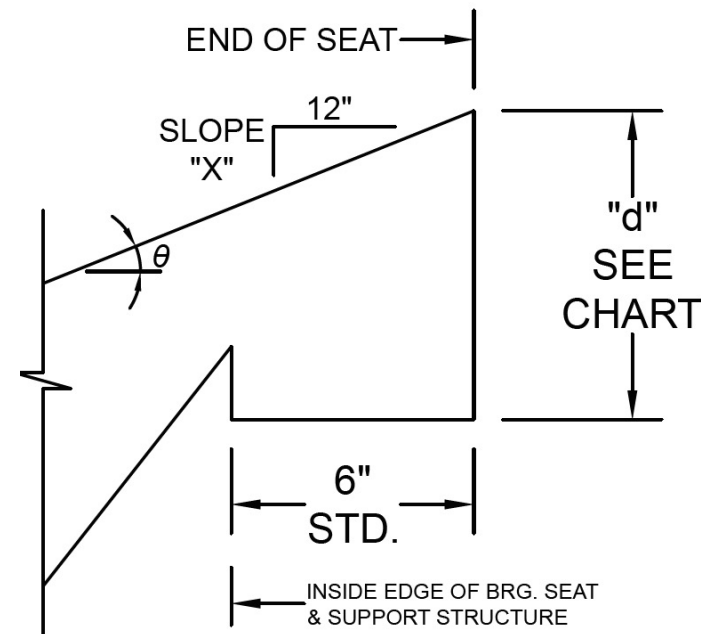
Design Example:

Check seat depths - Top chord sloped at 1/2 : 12

Low End = 5" minimum

High End = 6" minimum

SLOPE "X" : 12	MINIMUM HIGH END SEAT DEPTH "d"
3/8	6
1/2	6
1	6 1/2
1 1/2	6 1/2



Pitched Top Chords

Design Example:

Check seat depths - Top chord sloped at $1/2 : 12$

Low End = 5" minimum

High End = 6" minimum

Specify 6" Seat Depth at both ends for consistency

Pitched Top Chords

SUMMARY

Design Example:

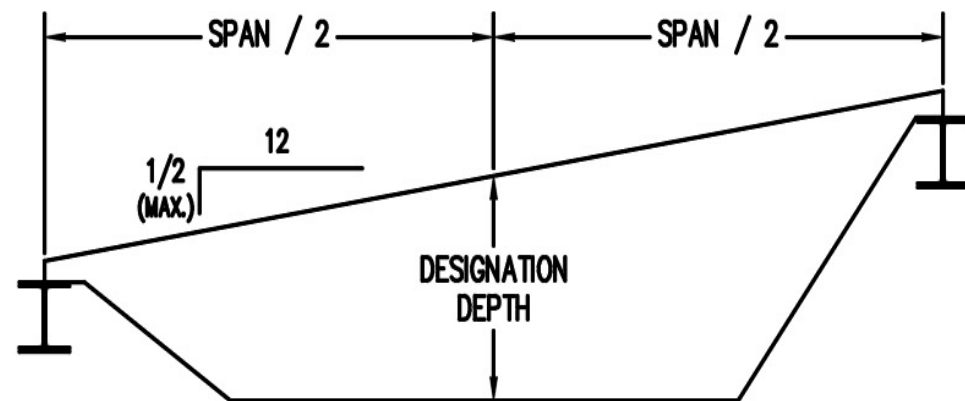
56DLH14 spanning 100' @ 10' O.C.

Top Chord Single Pitch, Underslung, TC Slope = 1/2 : 12

Mid-Span: 56"

Shallow End: 31"

Deep End: 81"



SINGLE PITCH JOIST

6" Deep Seats at both ends

Pitched Top Chords

What if the top chord slope is greater than 1/2 : 12?

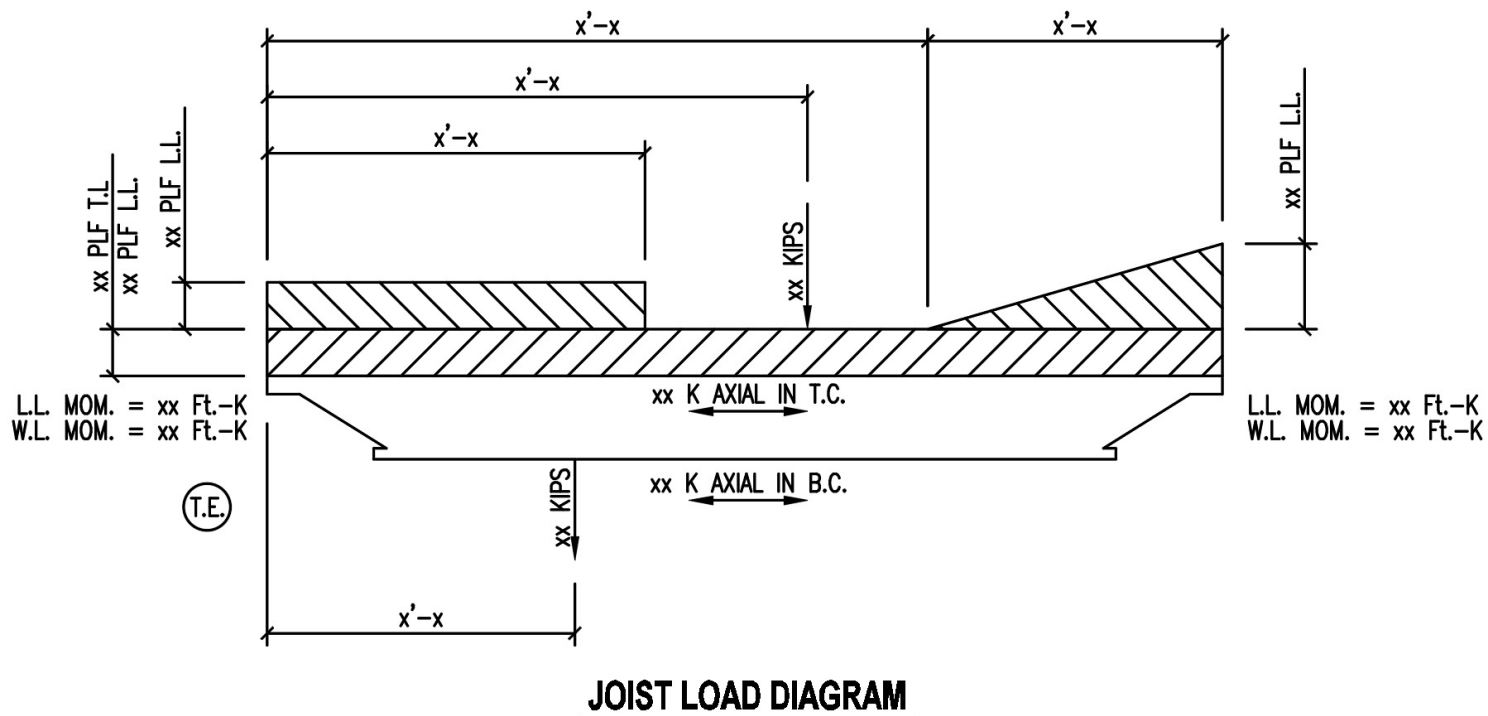
Instead of an SJI designation,
use a '**LOAD / LOAD**' designation

STANDARD WEIGHT TABLE FOR LOAD/LOAD LH-SERIES JOISTS																							
Based on a 50 ksi Maximum Yield Strength																							
Joist Span [ft]	Joist Depth [in]	Total Uniformly Distributed Joist Load in Pounds per Linear Foot																					
		LRFD	750	900	1050	1200	1350	1500	1650	1800	1950	2100	2250	2400	2550	2700	2850	3000	3150	3300	3450	3600	
		ASD	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
14	14	Wt.	7.3	7.6	8.1	8.8	9.4	10.6	11.3	12.0	12.3	12.4	13.4	14.2	15.4	15.6	16.0	17.1	17.6	18.8	19.2	19.4	
		w360	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400	
		Ix	71	73	77	80	83	96	98	108	108	114	122	131	137	144	149	161	168	174	182	182	
		Pbrg	266	293	332	373	421	484	520	563	563	563	608	658	726	726	726	797	797	891	891	891	
16	14	Wt.	6.9	7.4	7.5	8.4	9.3	9.9	10.9	11.9	12.5	13.4	14.0	15.0	15.8	16.2	17.4	18.1	19.4	19.5	21.3	21.5	
		w360	500	600	700	800	900	1000	1100	1200	1286	1395	1462	1586	1622	1717	1821	1894	2007	2032	2190	2218	
		Ix	67	71	71	81	92	97	107	119	125	133	142	153	158	164	176	181	197	197	215	215	
		Pbrg	247	281	284	327	366	418	479	512	549	595	595	643	696	696	768	768	842	842	941	941	
	16	16	Wt.	7.0	7.0	7.6	7.9	8.8	9.3	9.9	11.2	11.6	12.5	13.2	13.6	14.1	15.0	16.1	16.5	17.8	17.8	18.2	19.3
			w360	500	600	700	800	900	1000	1100	1200	1300	1400	1500	1600	1700	1800	1900	2000	2100	2200	2300	2400
			Ix	89	89	94	97	112	117	129	143	152	162	170	177	183	196	211	220	235	235	243	252
			Pbrg	228	228	259	286	324	363	385	441	472	506	548	548	548	592	641	641	708	708	708	776

Pitched Top Chords

What if the top chord slope is greater than 1/2 : 12?

You may also label the joists as “SP” and provide a complete load diagram.



Pitched Top Chords

Design Example:

60' span

Top chord sloped at 3 : 12

Double-pitched, bottom chord bearing



Pitched Top Chords

Design Example:

Depth at Ridge € 102" ← DESIGNATION DEPTH

Joists at 6' O.C.

LL = 20 psf DL = 20 psf

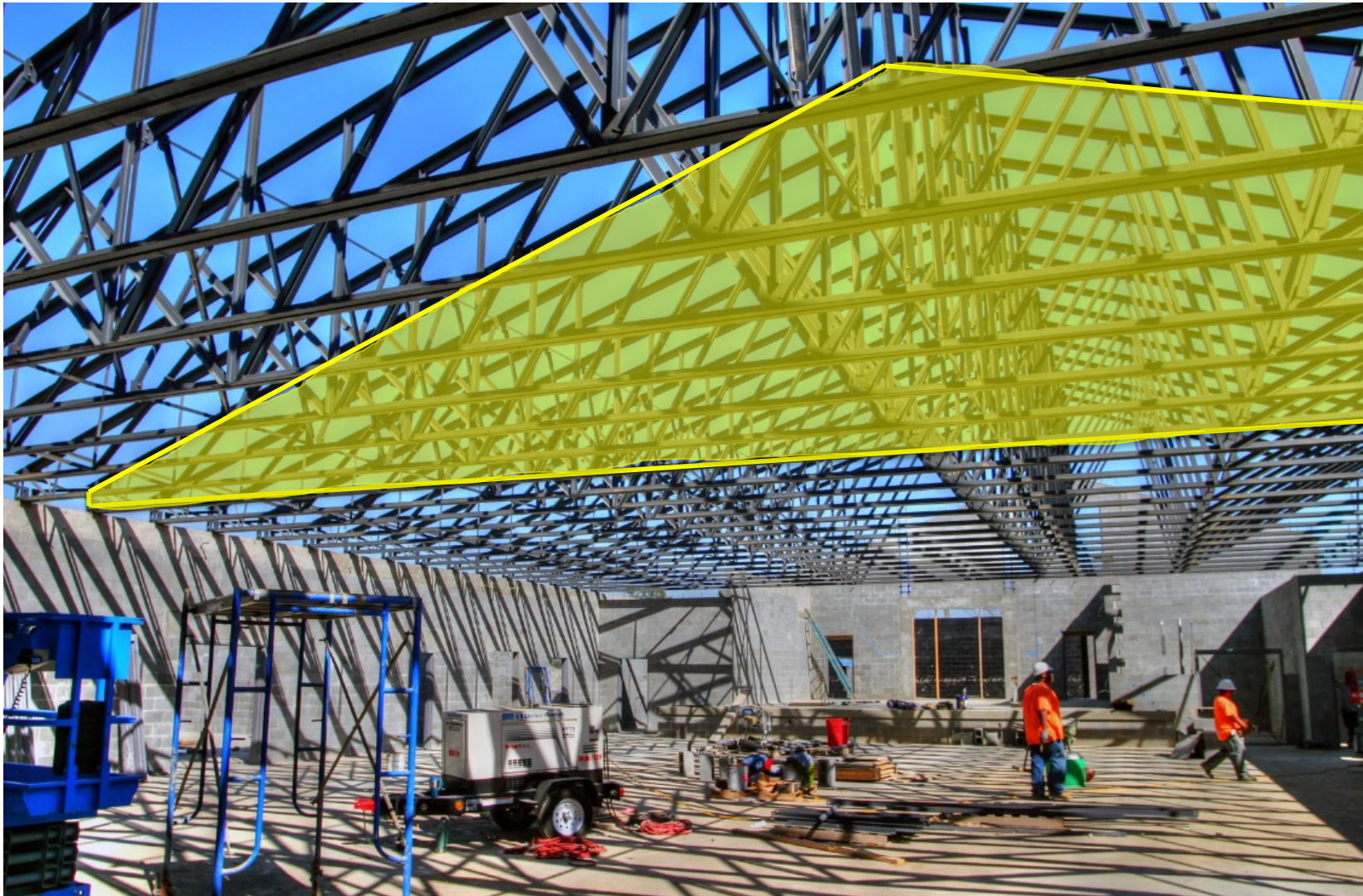
102DLH240/120

Depth at Ends = 12"

Pitched Top Chords



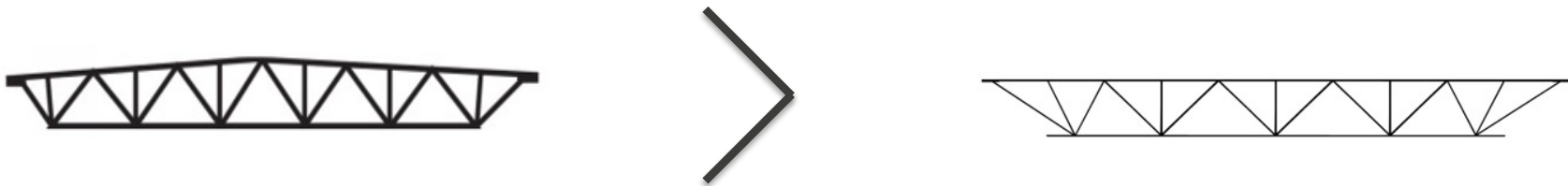
Pitched Top Chords



Pitched Top Chords

Bridging

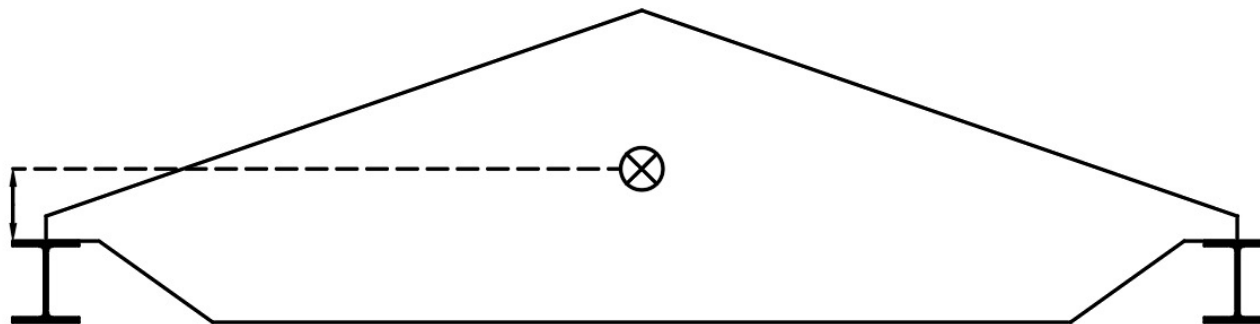
Whether a standard SJI designation or a Load/Load designation is used, the number of bridging rows needed is often greater than a standard, parallel-chord joist.



Pitched Top Chords

Bridging

If the joist center of gravity is above the supports, **bolted erection bridging** will be required for stability during erection.

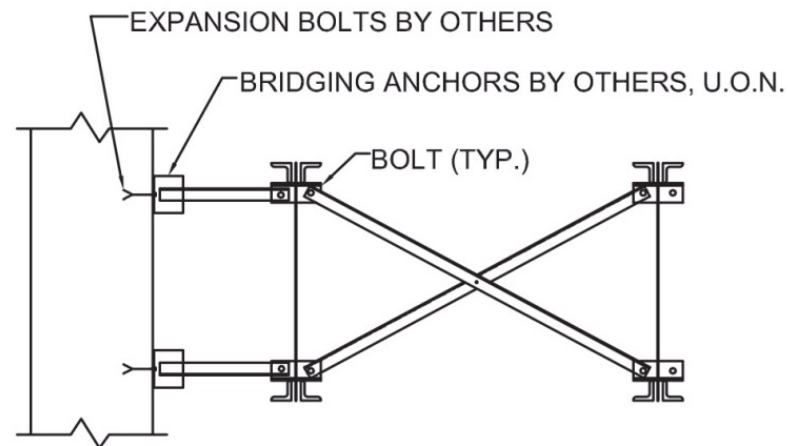


HIGH CENTER OF GRAVITY

Pitched Top Chords

Bridging

Based on the overall profile, all rows may need to be **bolted erection bridging**.



BOLTED CROSS BRIDGING

(a) HORIZONTAL BRIDGING UNITS SHALL BE USED IN THE SPACE ADJACENT TO THE WALL TO ALLOW FOR PROPER DEFLECTION OF THE JOIST NEAREST THE WALL.

(b) FOR REQUIRED BOLT SIZE REFER TO BRIDGING TABLE.

NOTE: CLIP CONFIGURATION MAY VARY FROM THAT SHOWN.

Pitched Top Chords

Bridging

The method of terminating bridging should receive special attention, and requires clear communication.

In many cases, the best approach is to terminate bridging between the last two joists in lieu of attaching to the main structure.

Pitched Top Chords

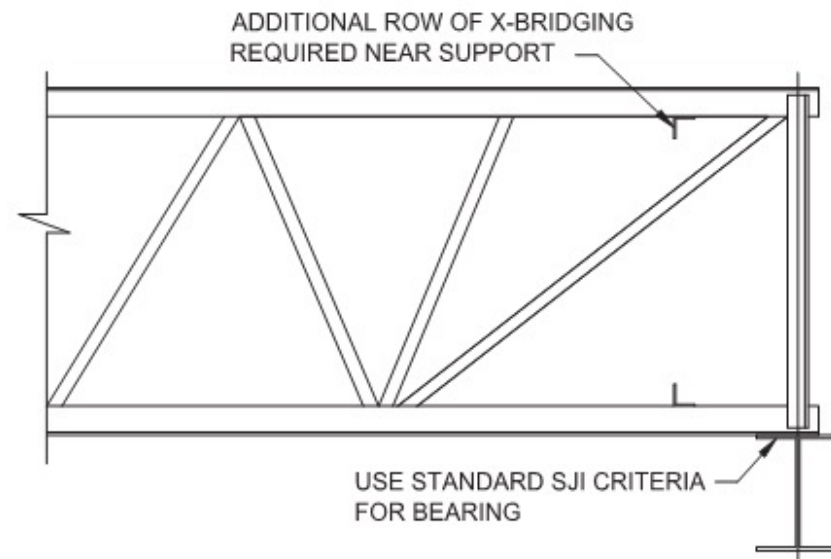
Bridging

When the joist spacing is less than $0.7 \times$ Joist Depth, bolted horizontal bridging shall be used in addition to diagonal bridging.

LH AND DLH SERIES JOISTS HORIZONTAL PLUS DIAGONAL BRIDGING REQUIREMENTS		
JOIST DEPTH	MINIMUM JOIST SPACE FOR DIAGONAL ONLY BRIDGING ($0.70 \times$ DEPTH)*	HORIZONTAL AND DIAGONAL MINIMUM ANGLE SIZE REQUIRED FOR JOIST SPACING < ($0.70 \times$ DEPTH) AND JOIST SPANS > 60'-0" (18.3 m)
in. (mm)	ft.-in. (mm)	in. (mm)
52" (1321)	3'- 0" (914)	1" x 1" x 7/64" (25 x 3)
56" (1422)	3'- 3" (990)	1" x 1" x 7/64" (25 x 3)
60" (1524)	3'- 6" (1066)	1" x 1" x 7/64" (25 x 3)
64" (1626)	3'- 8" (1117)	1¼" x 1¼" x 7/64" (32 x 3)
68" (1727)	3'-11" (1193)	1¼" x 1¼" x 7/64" (32 x 3)

Pitched Top Chords

Bridging



SQUARE ENDED, BOTTOM BEARING

“Whenever joists are bottom chord bearing, diagonal cross bridging must be installed from joist to joist at or near the bearing location to provide additional lateral erection stability.”

Pitched Top Chords

Rules of Thumb

For **Square Ends** (Bottom Chord Bearing):

Minimum joist end depth = **12"**

Pitched Top Chords

Rules of Thumb

For **Square Ends**:



Pitched Top Chords

Rules of Thumb

For Square Ends (Bottom Chord Bearing):

Minimum joist end depth = 12"

For **Underslung**:

Minimum bearing elevation to bottom chord = 12"

That is, Minimum joist end depth = Seat Depth + 12"

Pitched Top Chords

Rules of Thumb

For **Underslung**:



Pitched Top Chords



Pitched Top Chords

A note about SJI designations

STANDARD LOAD TABLE FOR LONGSPAN STEEL JOISTS, LH-SERIES																				
Based on a 50 ksi Maximum Yield Strength - Loads Shown In Pounds Per Linear Foot (plf)																				
Joist Designation	Approx. Wt in Lbs. Per Linear Ft. (Joists only)	Depth in inches	Max Load (plf) < 22	SAFE LOAD* in Lbs. Between	SPAN IN FEET															
					22-25	26	27	28	29	30	31	32	33	34	35	36				
18LH02	10	18	553	12160	468 313	442 284	418 259	391 234	367 212	345 193	324 175	306 160	289 147	273 135	259 124					
18LH03	11	18	613	13480	521 348	493 317	467 289	438 262	409 236	382 213	359 194	337 177	317 161	299 148	283 136					
18LH04	12	18	714	15700	604 403	571 367	535 329	500 296	469 266	440 242	413 219	388 200	365 182	344 167	325 153					
18LH05	15	18	806	17740	684 454	648 414	614 378	581 345	543 311	508 282	476 256	448 233	421 212	397 195	375 179					
18LH06	15	18	954	20980	809 526	749 469	696 419	648 377	605 340	566 307	531 280	499 254	470 232	443 212	418 195					
18LH07	17	18	990	21780	840 553	809 513	780 476	726 428	678 386	635 349	595 317	559 288	526 264	496 241	469 222					

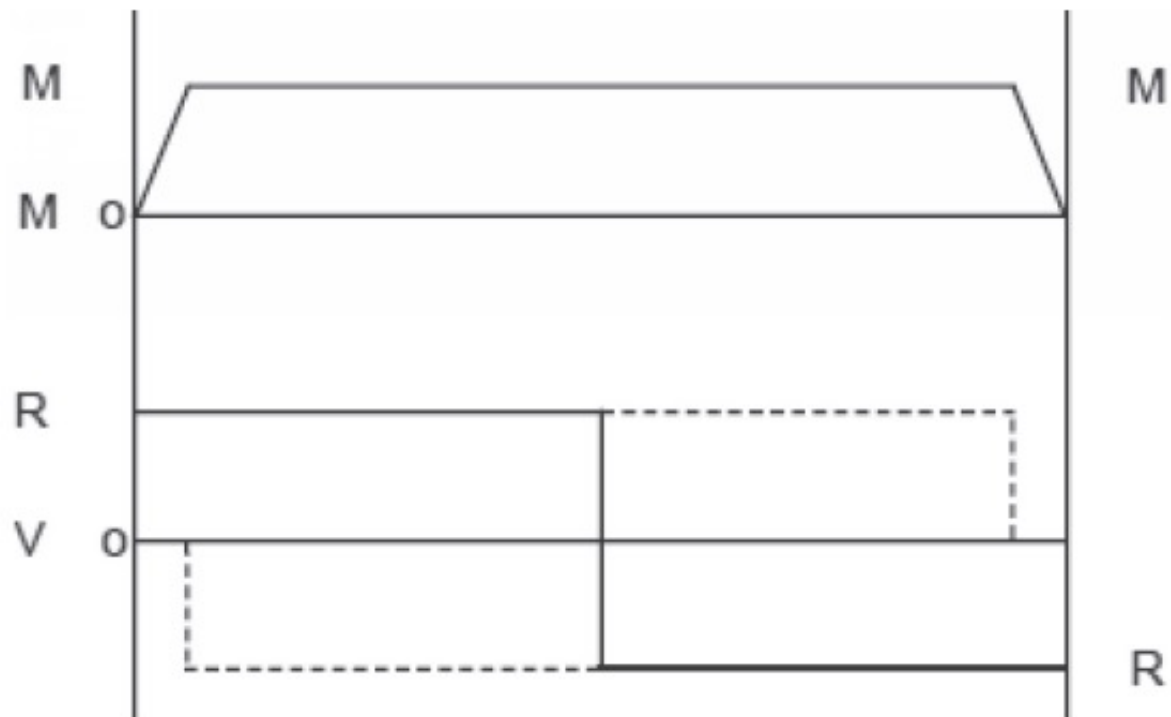
“The Load Table applies to joists with either parallel chords or pitched top chords. Joists can have a top chord pitch up to 1/2 inch per foot. If the pitch exceeds this limit, the Load Table does not apply.”

Pitched Top Chords

A note about SJI designations...

KCS Joists

Shear and Moment Envelopes



Pitched Top Chords

A note about SJI designations...

KCS Joists

STANDARD LOAD TABLE FOR KCS OPEN WEB STEEL JOISTS							
Based on a 50 ksi Maximum Yield Strength							
JOIST DESIGNATION	DEPTH (in.)	MOMENT CAPACITY (k-in.)	SHEAR CAPACITY* (lbs)	APPROX. WEIGHT** (lbs/ft.)	GROSS MOMENT OF INERTIA (in. ⁴)	ERECTION STABILITY BRIDGING REQ'D (ft.)	BRIDGING TABLE SECTION NUMBER
10KCS1	10	172	2000	6.0	29	NA	1
10KCS2	10	225	2500	7.5	37	NA	1
10KCS3	10	296	3000	10.0	47	NA	1
12KCS1	12	209	2400	6.0	43	NA	3
12KCS2	12	274	3000	8.0	55	NA	5
12KCS3	12	362	3500	10.0	71	NA	5
14KCS1	14	247	2900	6.5	59	NA	4
14KCS2	14	324	3400	8.0	77	NA	6
14KCS3	14	428	3900	10.0	99	NA	6

Pitched Top Chords

What about maximum joist depths?

Standard SJI designations range up to 120" deep

Most SJI manufacturers can go beyond 120"

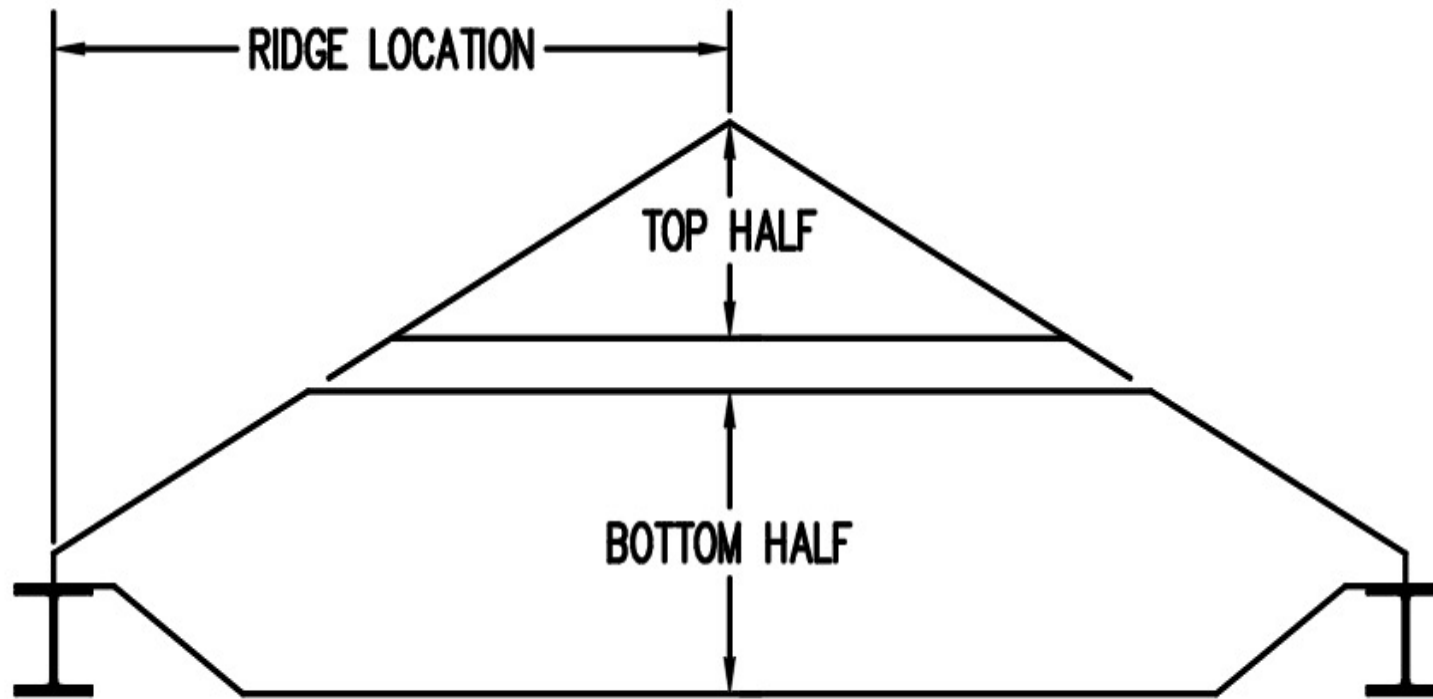
However, limits are dependent on a number of factors:

Individual shop capacity

Job site access

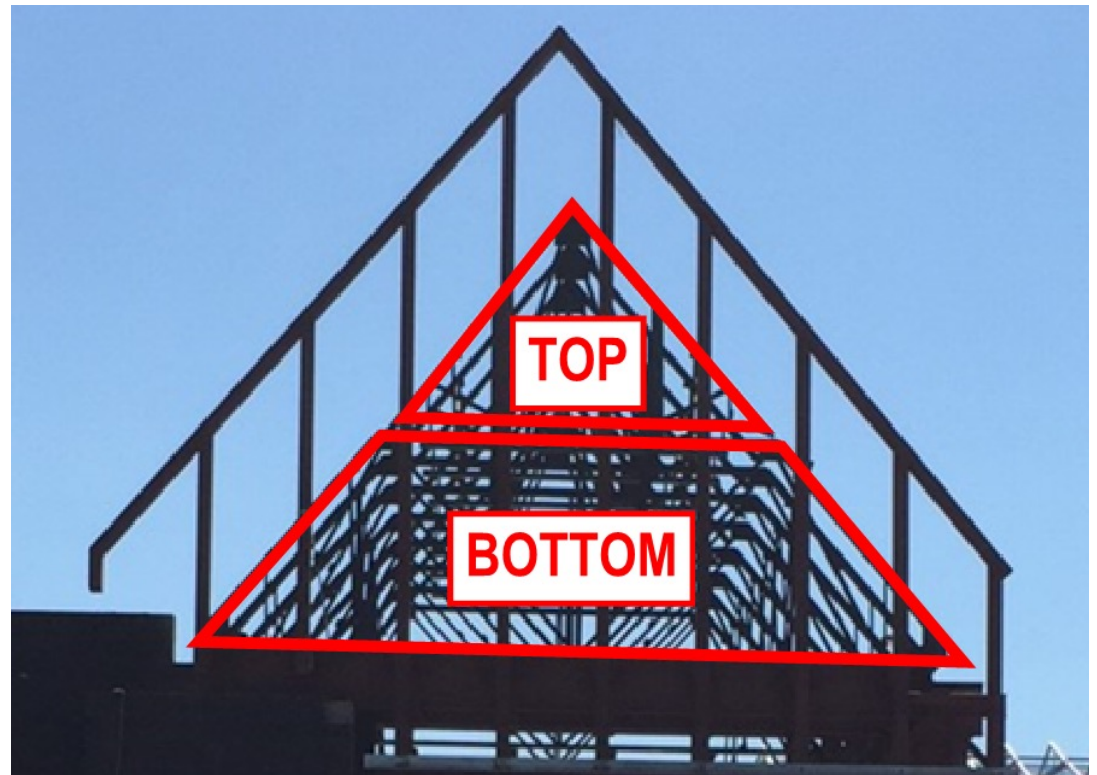
Shipping limitations

Pitched Top Chords



"PIGGY BACK" GABLE JOIST

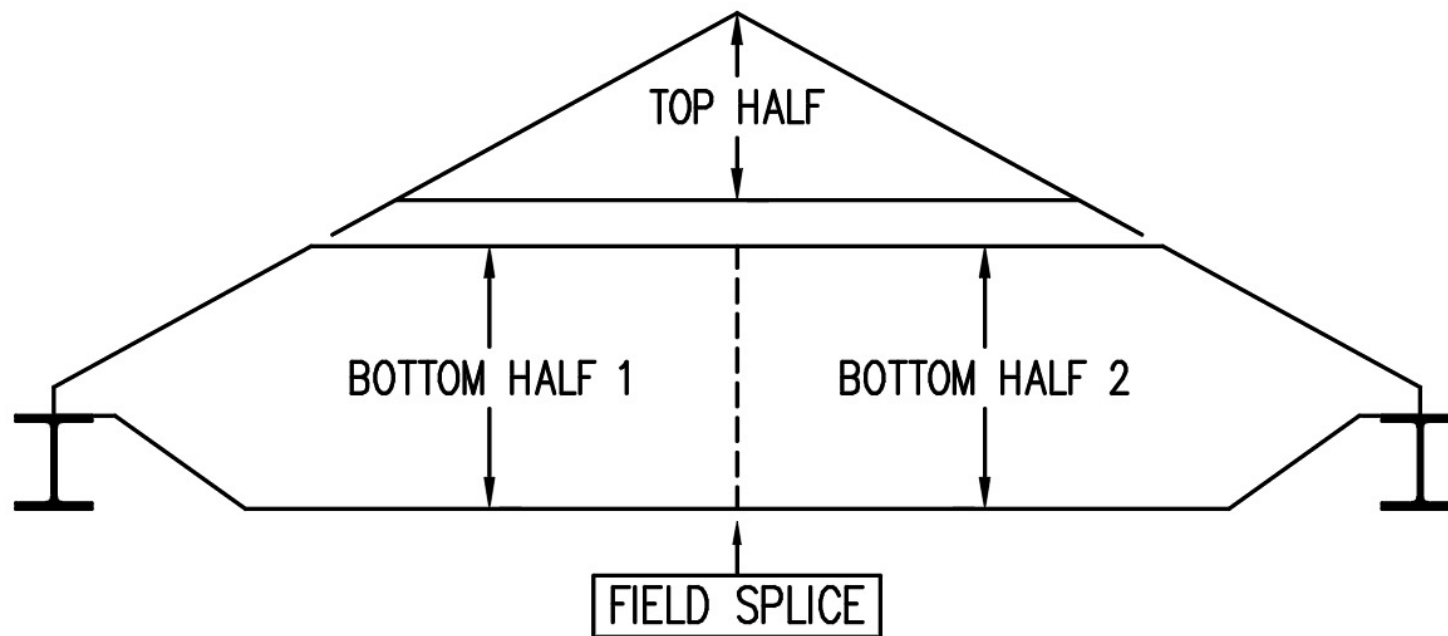
Pitched Top Chords



Pitched Top Chords



Pitched Top Chords



"PIGGY BACK" GABLE JOIST

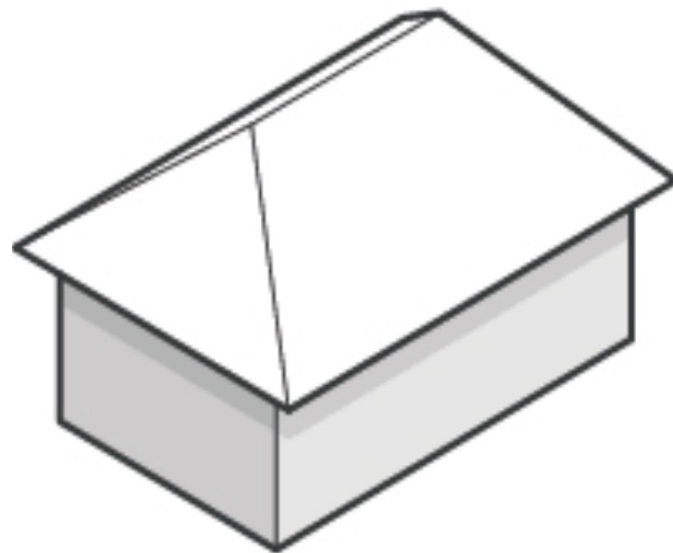
Polling Question #1

What is the maximum allowable top chord pitch of an SJI Designation joist?

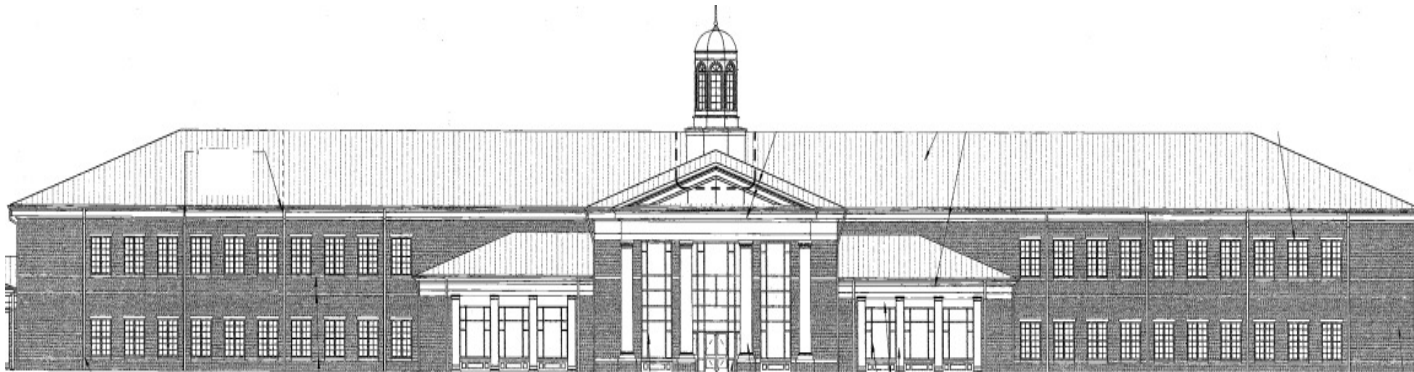
- A. Top chord pitch not allowed on SJI Designations
- B. $1/4 : 12$
- C. $1/2 : 12$
- D. There is no limit

Joists in a Hip Roof

- Joists can also be used for greater sloped hip roofs
- This is common in schools, particularly over gymnasiums and auditoriums



Joists in a Hip Roof



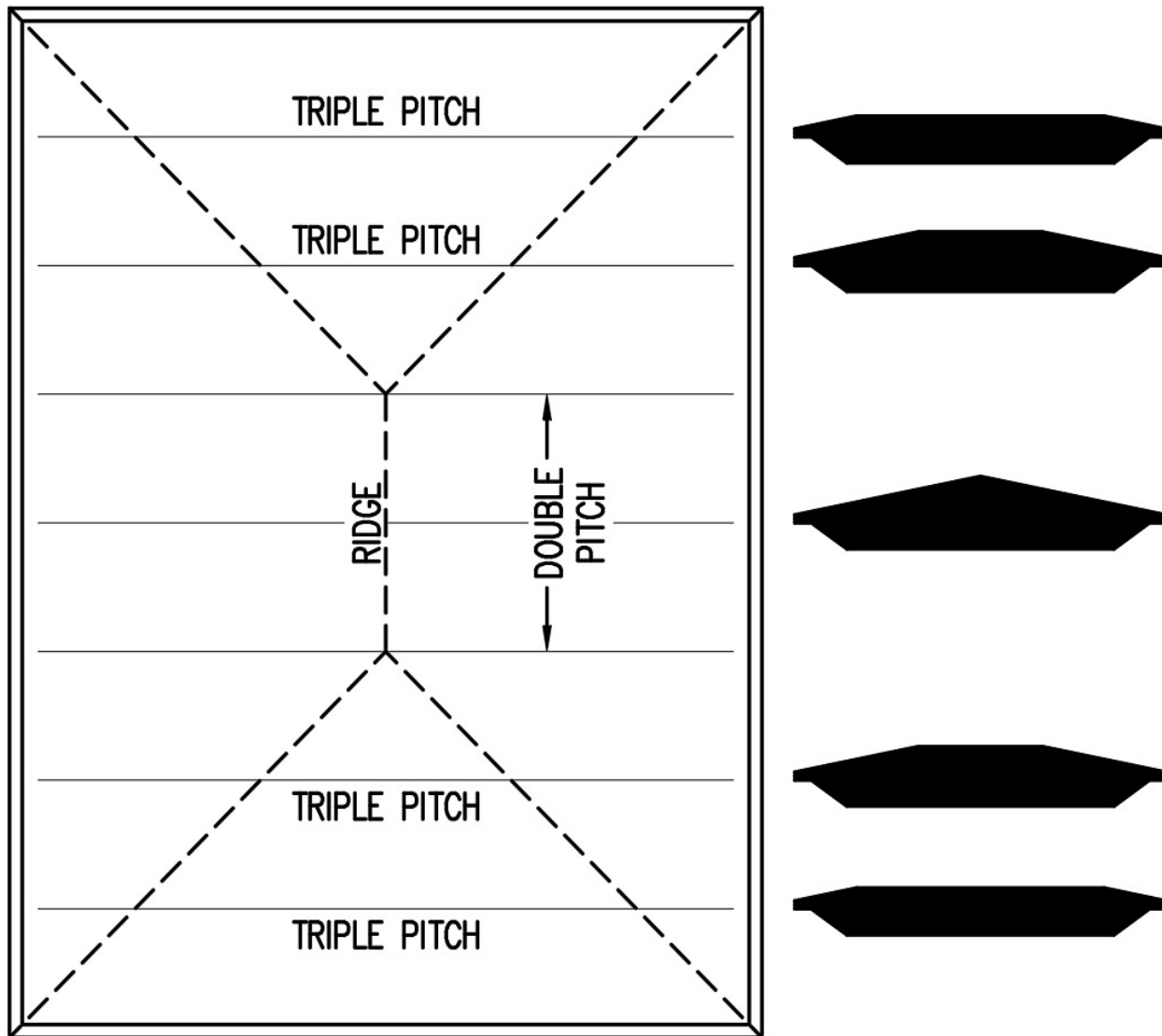
Steel Joists used for 4:12 Hip Roof on School

Joists in a Hip Roof

Using Steel Joists in a hip roof can be an economical option

This is most commonly done using **Double** and **Triple Pitch** Steel Joists

Joists in a Hip Roof



Pitched Top Chords

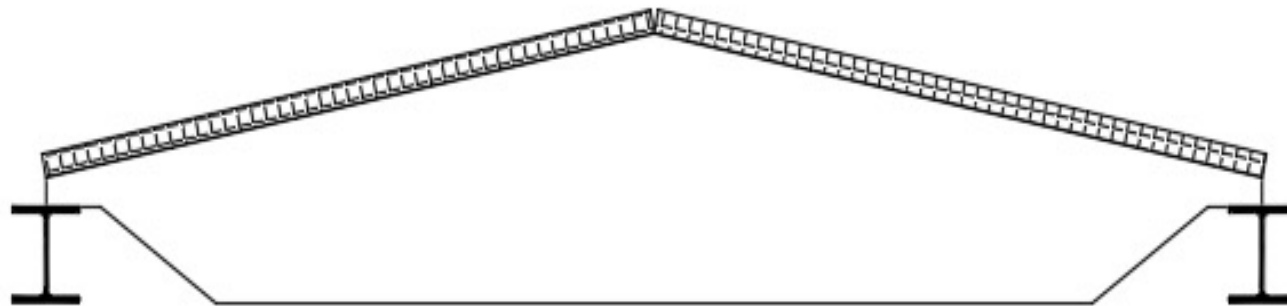


Joists in a Hip Roof

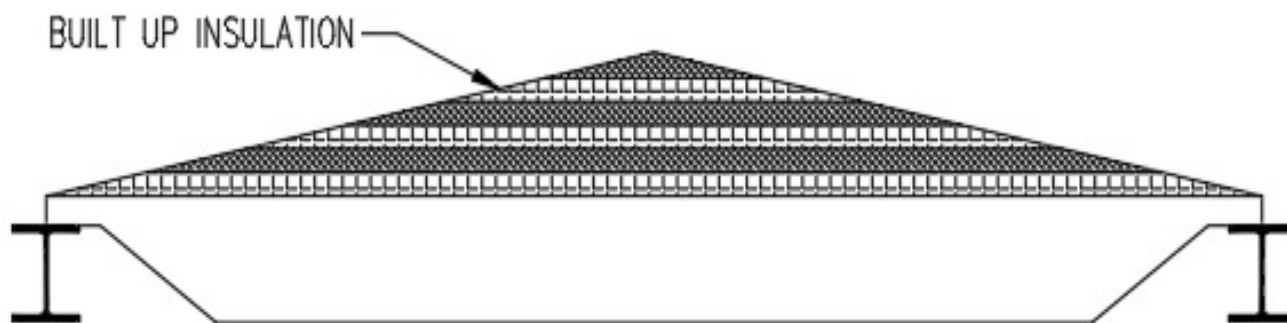
This method can be used with low slope, such as often done for drainage

When the building shape is simple, this can be more economical than building up insulation

Joists in a Hip Roof

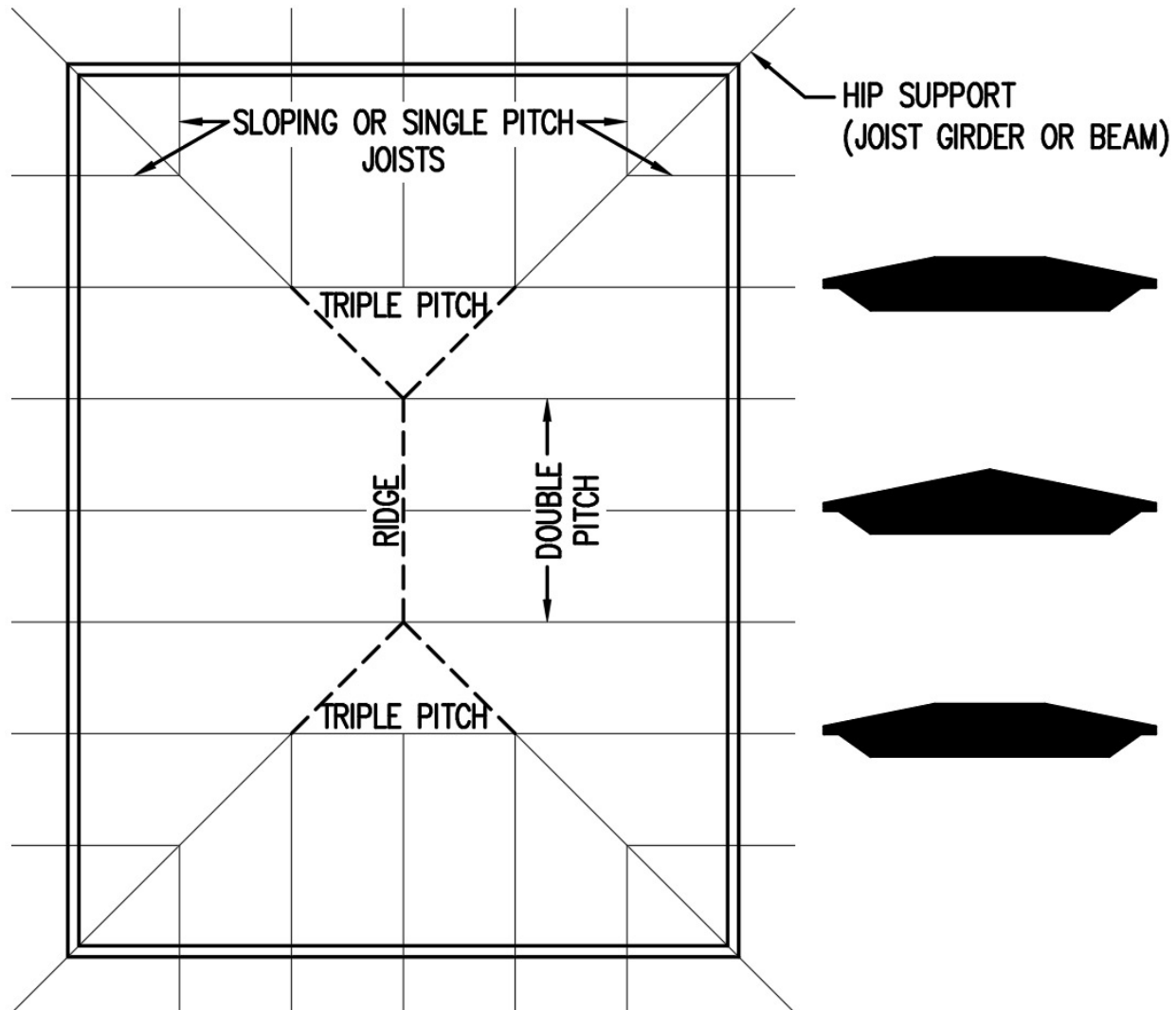


PITCHED TOP CHORD



FLAT TOP CHORD

Joists in a Hip Roof

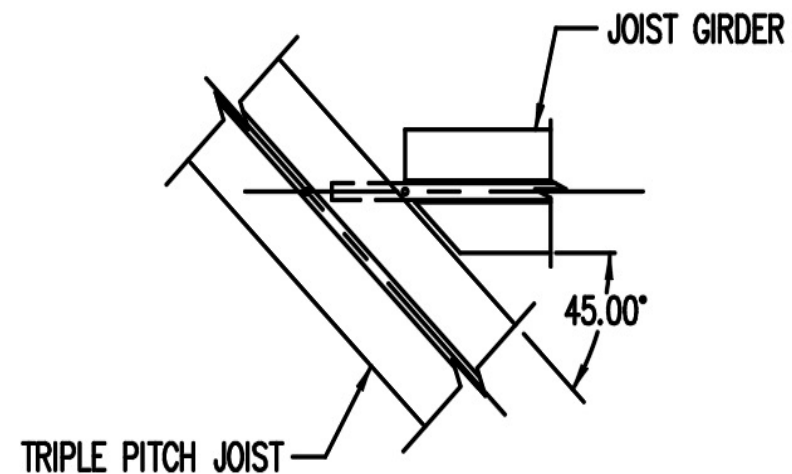
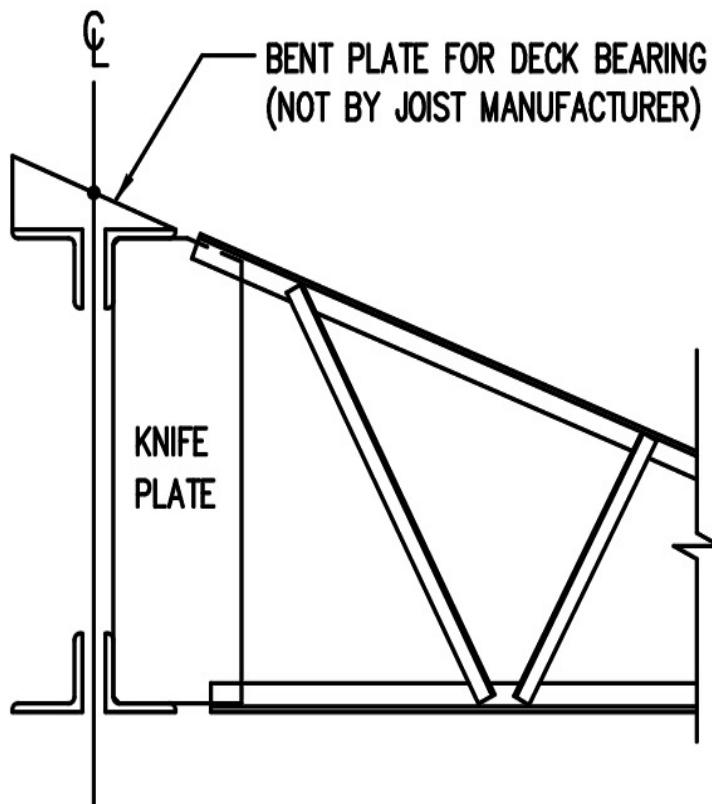


Joists in a Hip Roof

- When roof overhangs are needed, Steel Joists can be turned 90 degrees at building ends
- These bear on a **Hip Support** member, which can be a Joist Girder or Beam
- Top chord extensions create the overhang

Joists in a Hip Roof

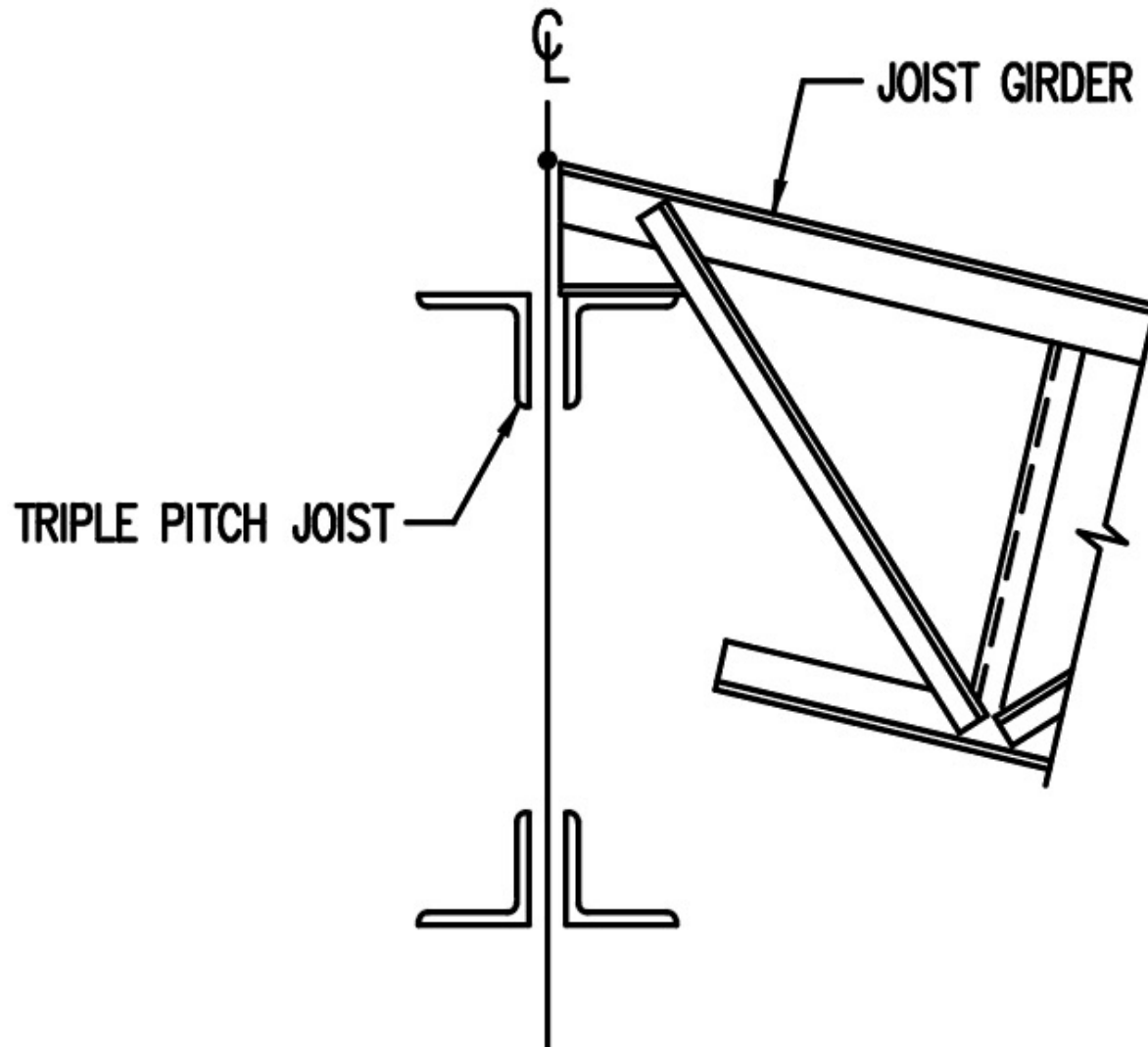
- Coordination is required at connection of **Hip Support** member to **Triple Pitch Joist**



Joists in a Hip Roof

- A simpler solution is to bear the **Hip Support** member on top of the **Triple Pitch Joist**
- Contact your preferred local Joist Manufacturer to discuss connection details and preferences

Joists in a Hip Roof

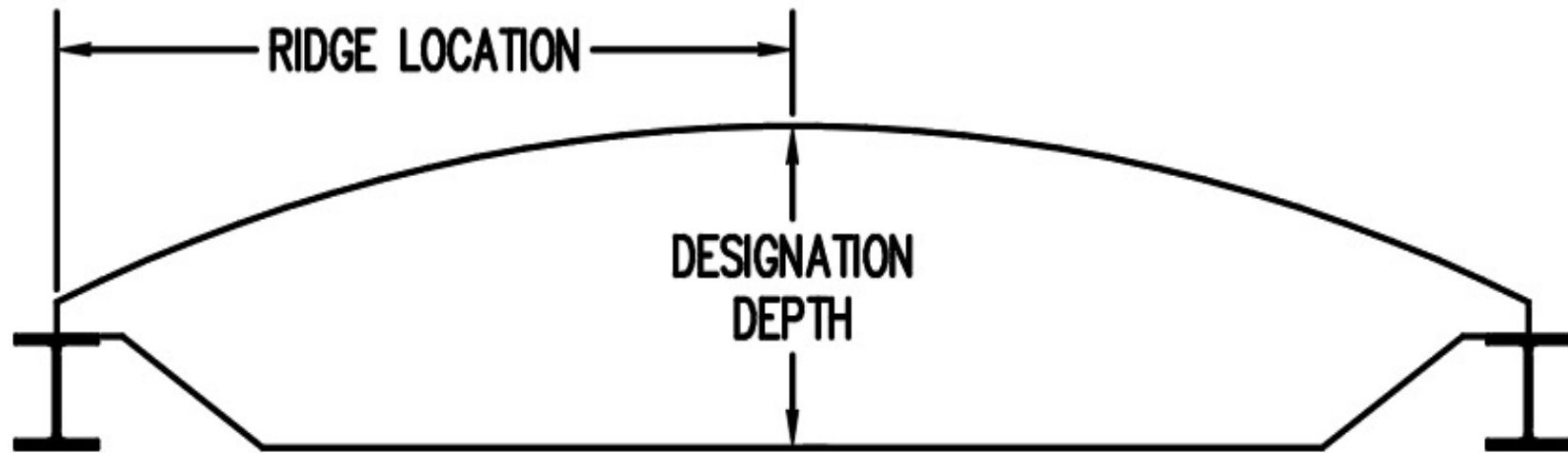


Special Profile Joists

There are four generally accepted Special Profiles:

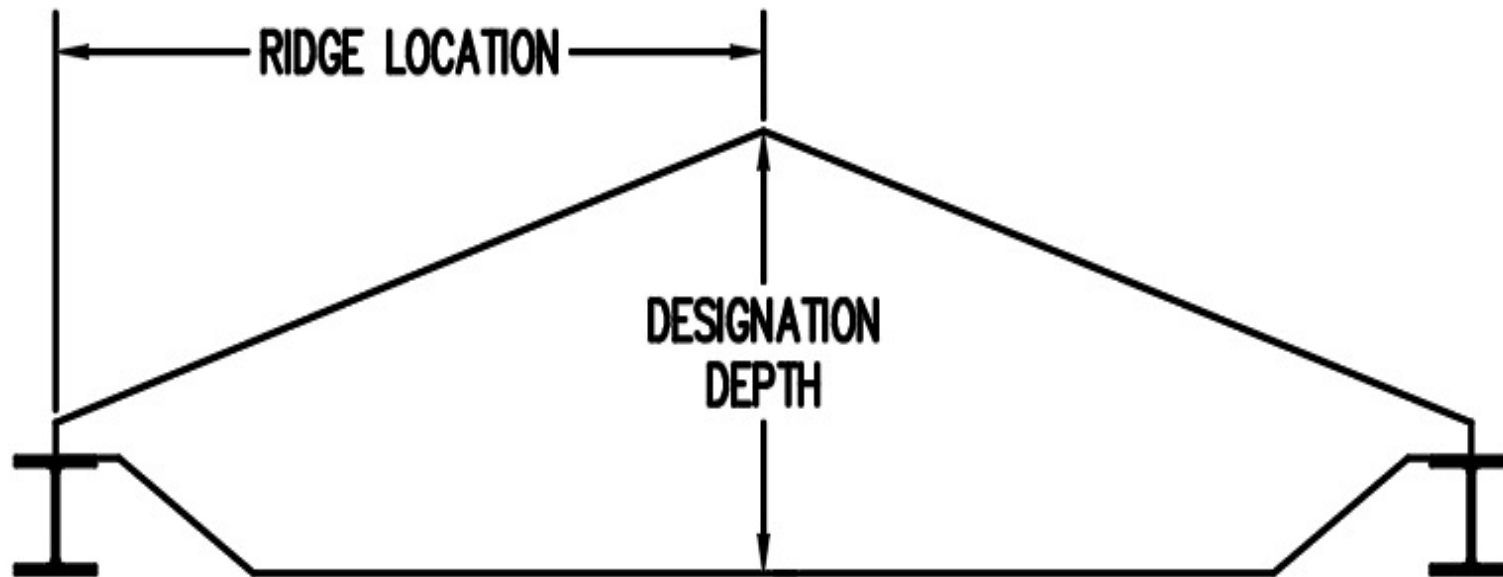
- Bowstring
- Arch
- Gable
- Scissor

Special Profile Joists



BOWSTRING JOIST

Special Profile Joists

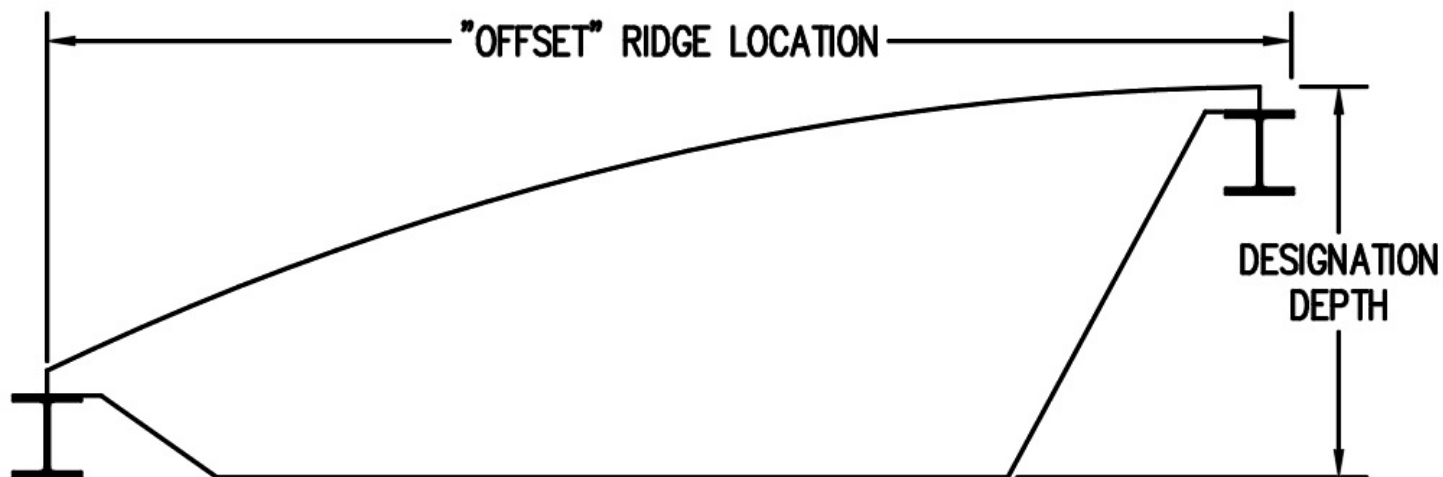
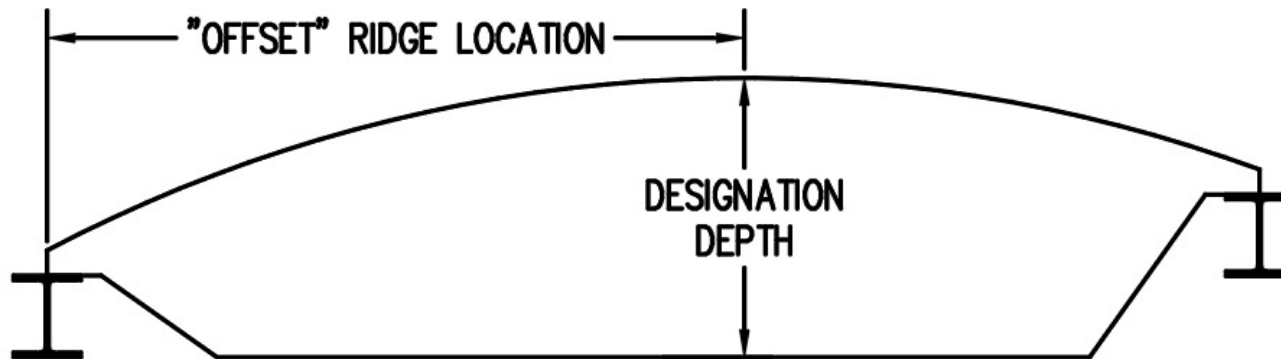


GABLE JOIST

Special Profile Joists



Special Profile Joists



OFFSET RIDGE BOWSTRING JOIST

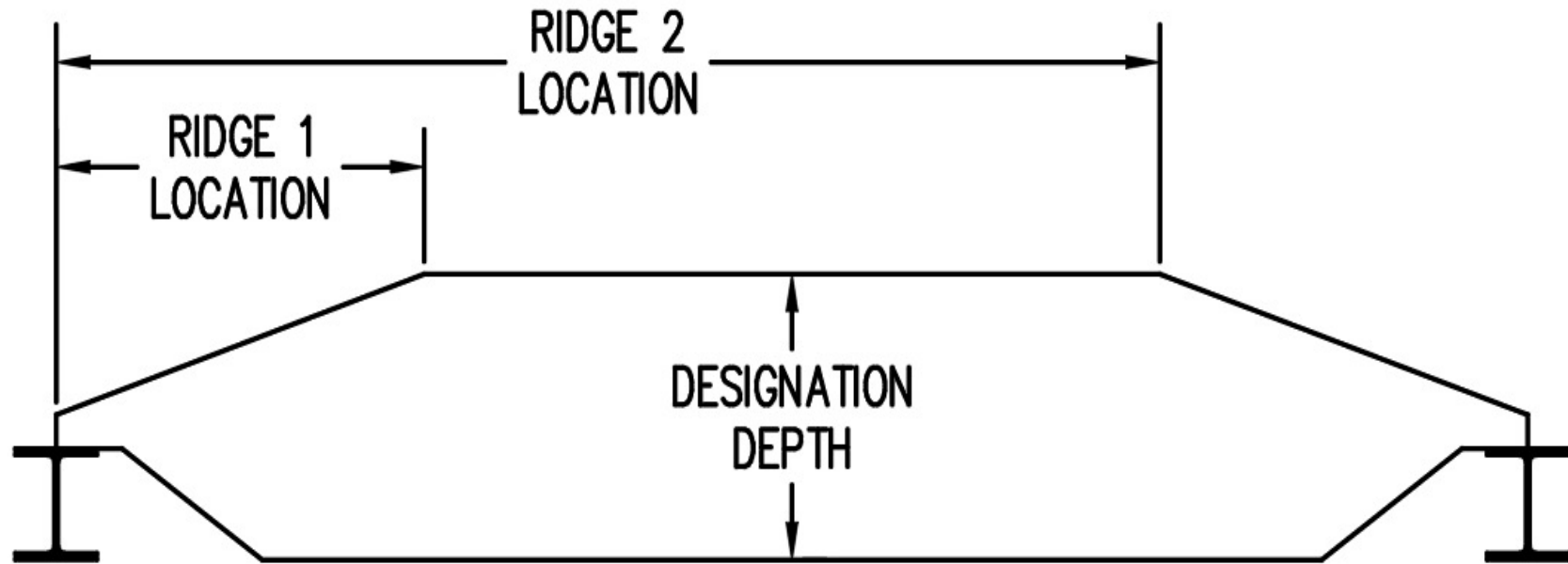
Pitched Top Chords

Many Joist Manufacturers can provide more than two pitched chords

Most common is **Triple Pitch**

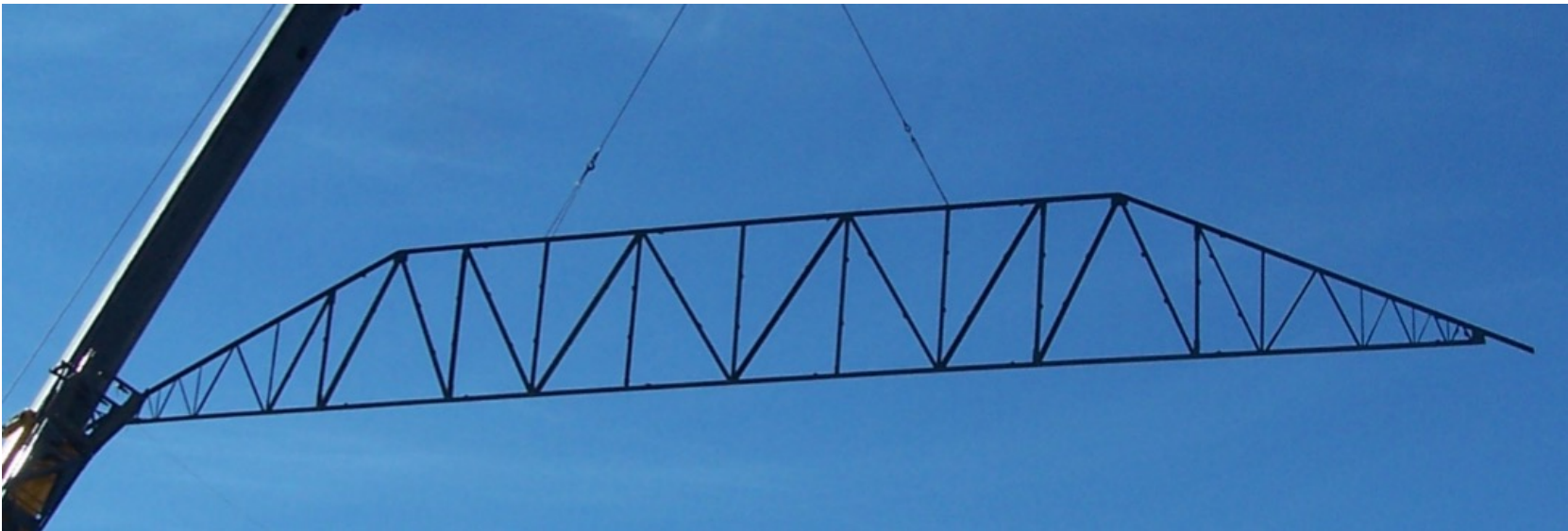
Contact your preferred local Joist Manufacturer to discuss their capabilities

Pitched Top Chords



TRIPLE PITCH JOIST

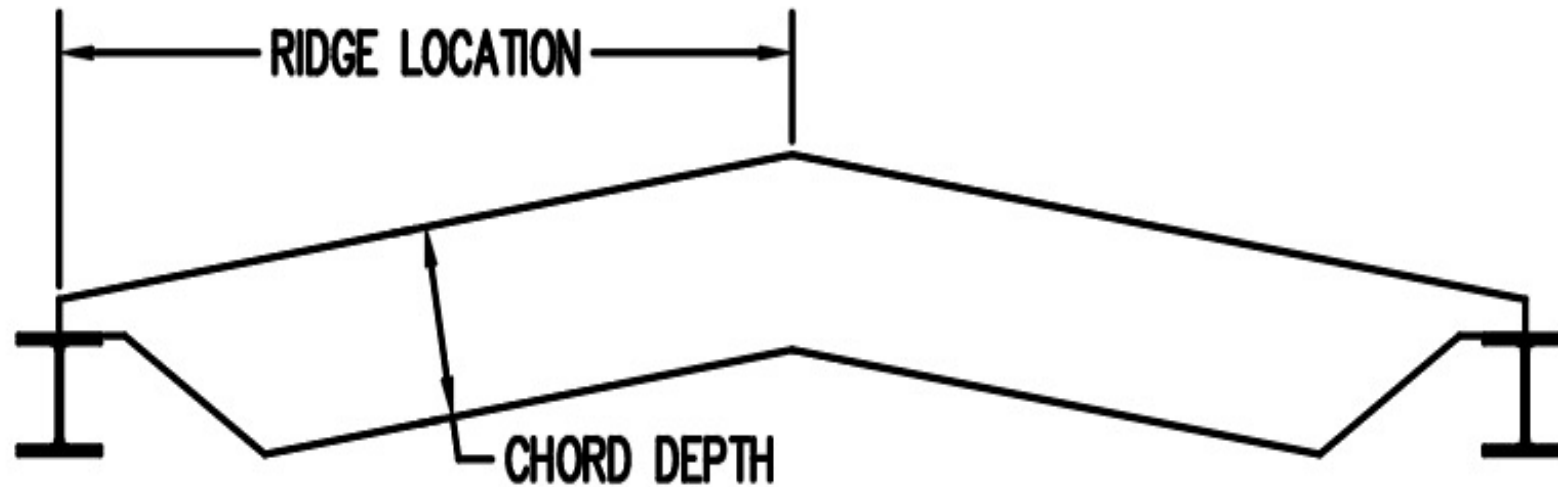
Pitched Top Chords



Special Profile Joists

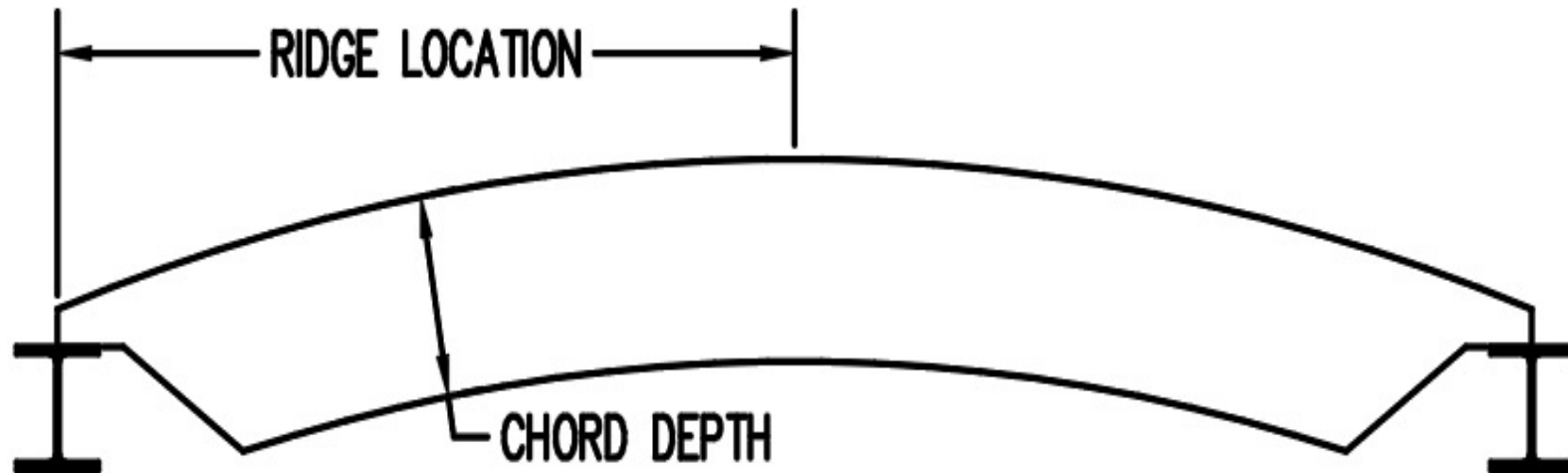


Special Profile Joists



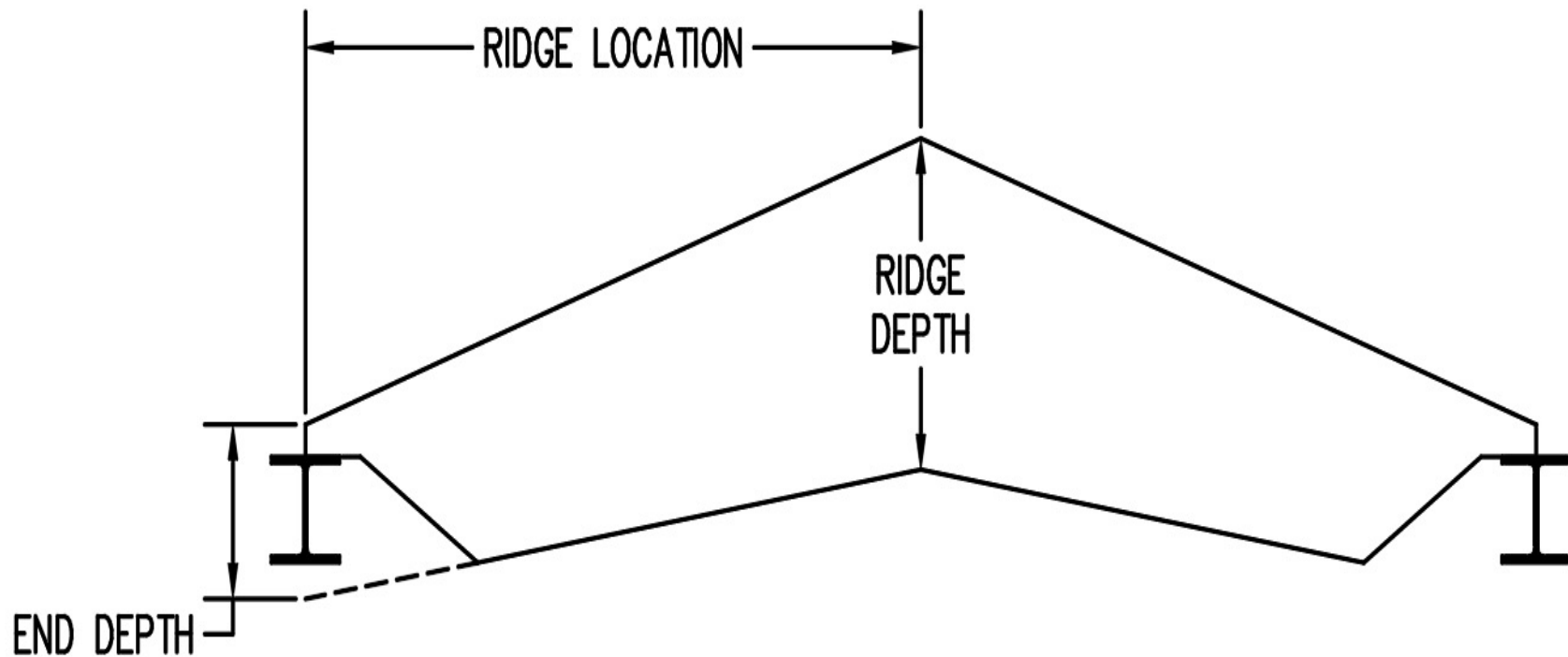
SCISSOR JOIST

Special Profile Joists



ARCH JOIST

Special Profile Joists



COMPOUND SCISSOR JOIST

Special Profile Joists

Of Special Profile Joists, **Gable Joists** are typically the most cost effective to manufacture

Scissor or Arch Joists should only be used if the additional clearance is needed below the joist, often for aesthetic reasons

Special Profile Joists

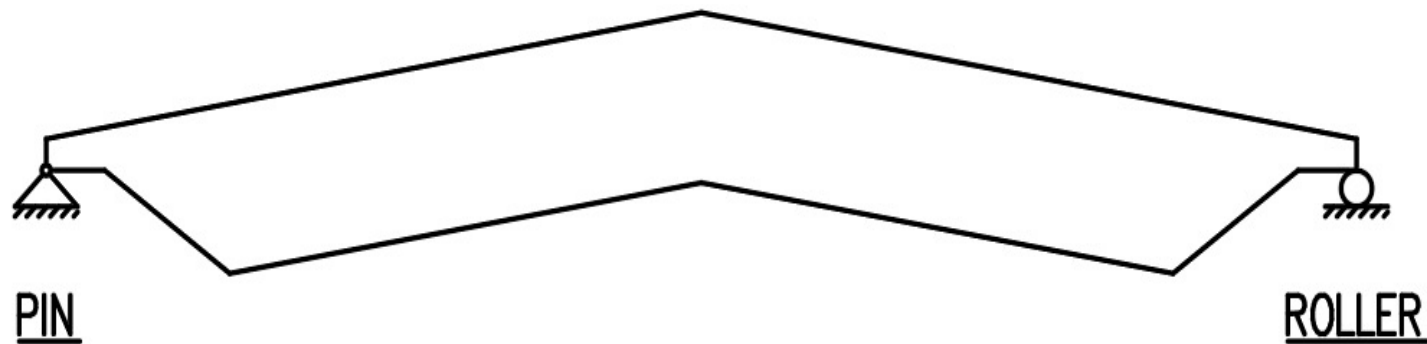
When using Scissor or Arch Joists, there is a...



Special Profile Joists

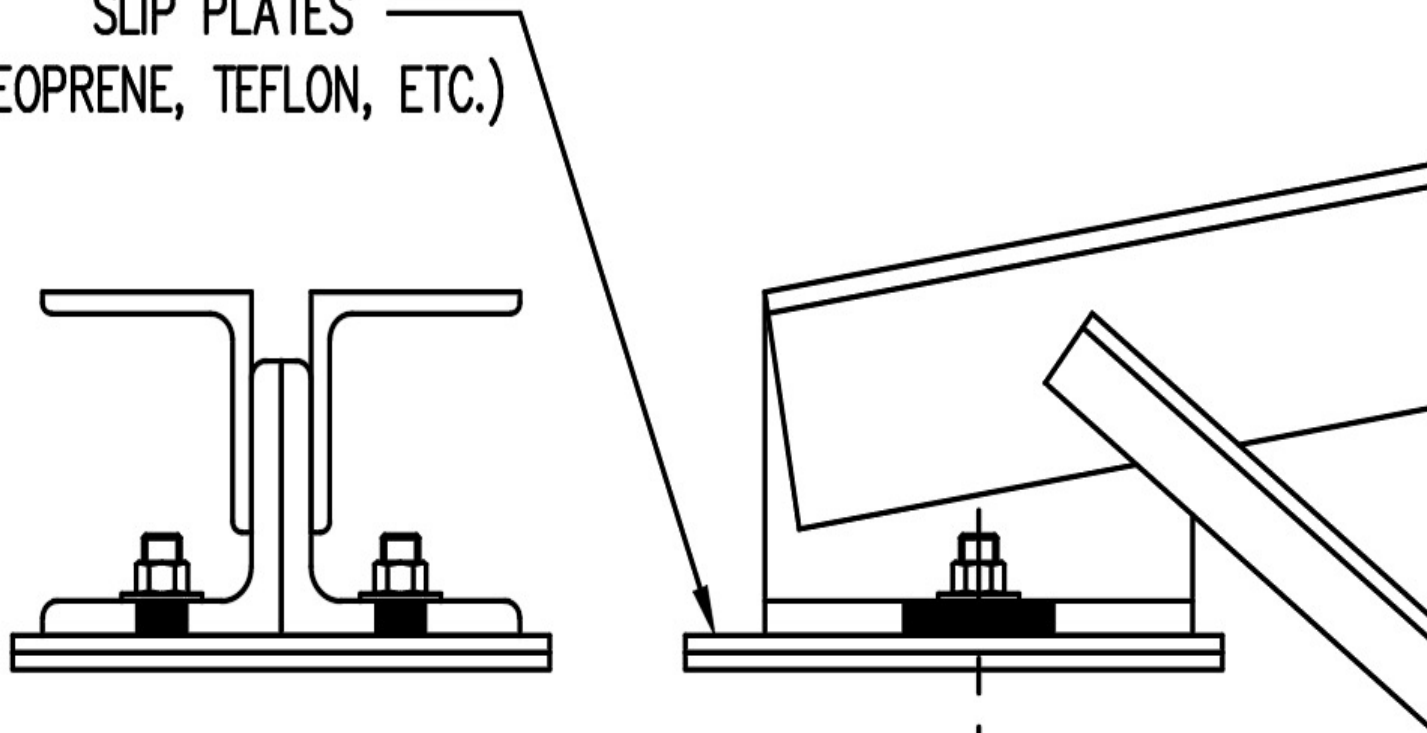
Scissor and Arch Joists may create a horizontal reaction on the structure

To remove this **thrust force**, a slip connection should be used at one end (roller support)



Special Profile Joists

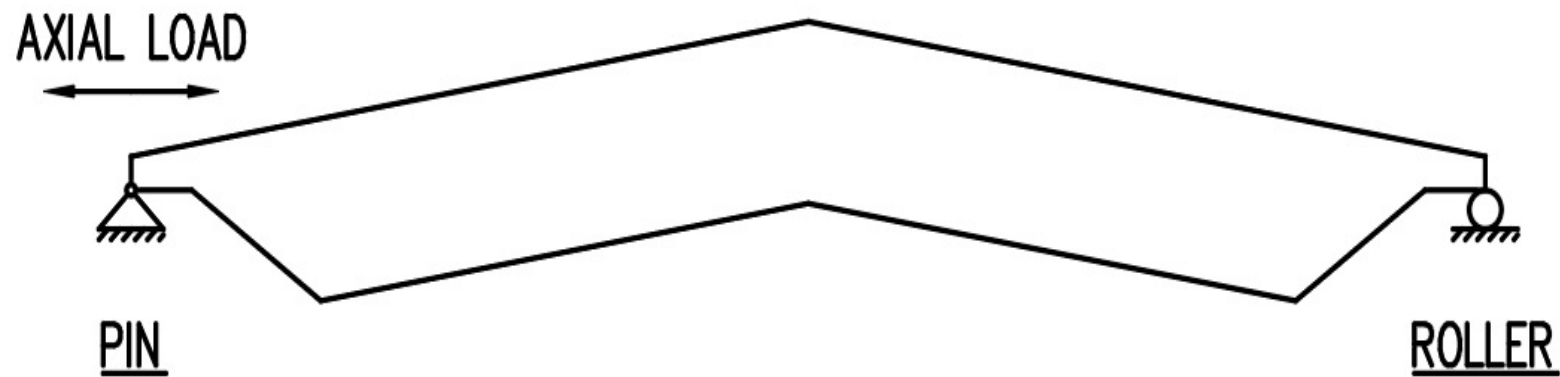
SLIP PLATES
(NEOPRENE, TEFLON, ETC.)



LONG SLOTS IN JOIST
SEAT TO ALLOW FOR SLIP

Special Profile Joists

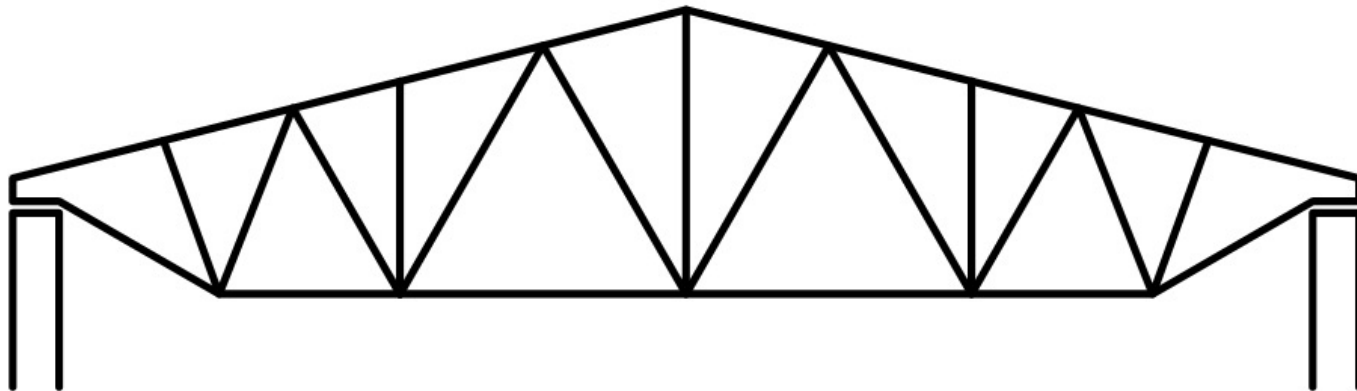
Note that diaphragm forces collected in the joist top chord must transfer through the pinned end of the joist



Special Profile Joists

Other Considerations...

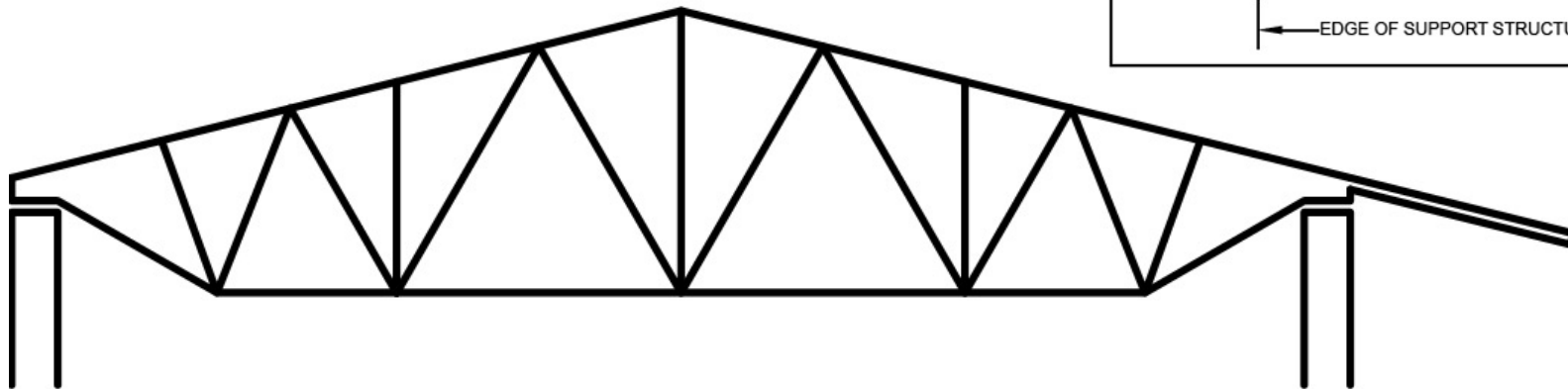
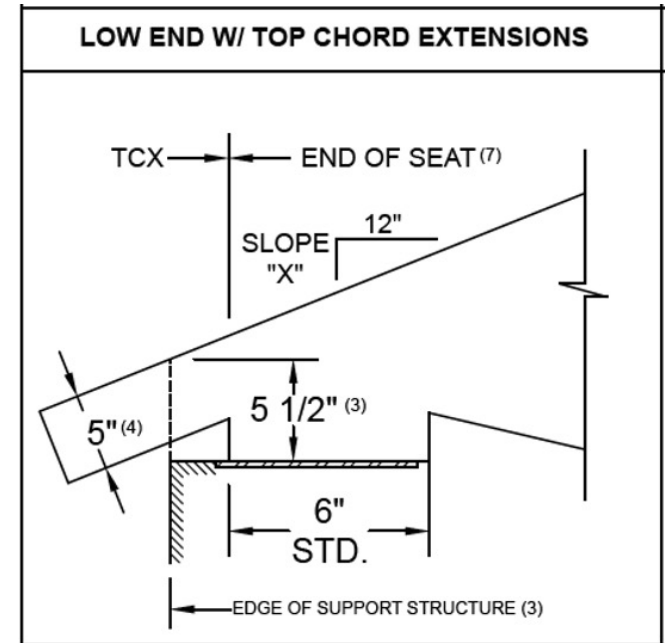
Top Chord Extensions / Cantilevers



Special Profile Joists

Other Considerations...

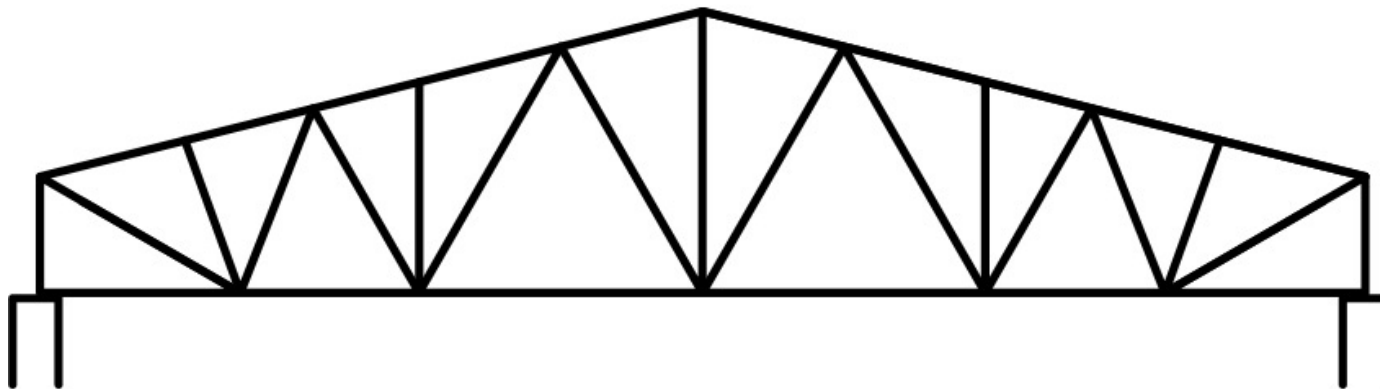
Top Chord Extensions / Cantilevers



Special Profile Joists

Other Considerations...

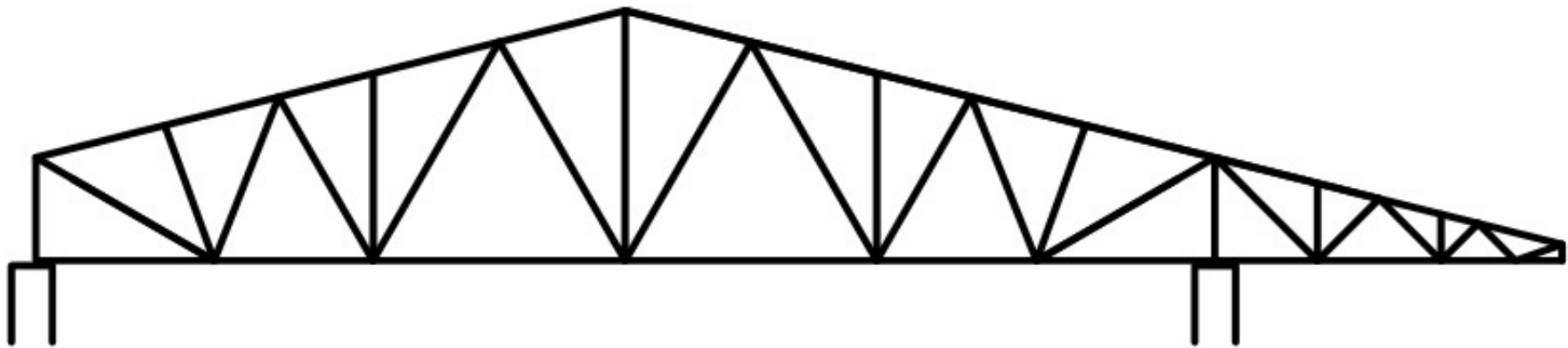
Top Chord Extensions / Cantilevers



Special Profile Joists

Other Considerations...

Top Chord Extensions / Cantilevers



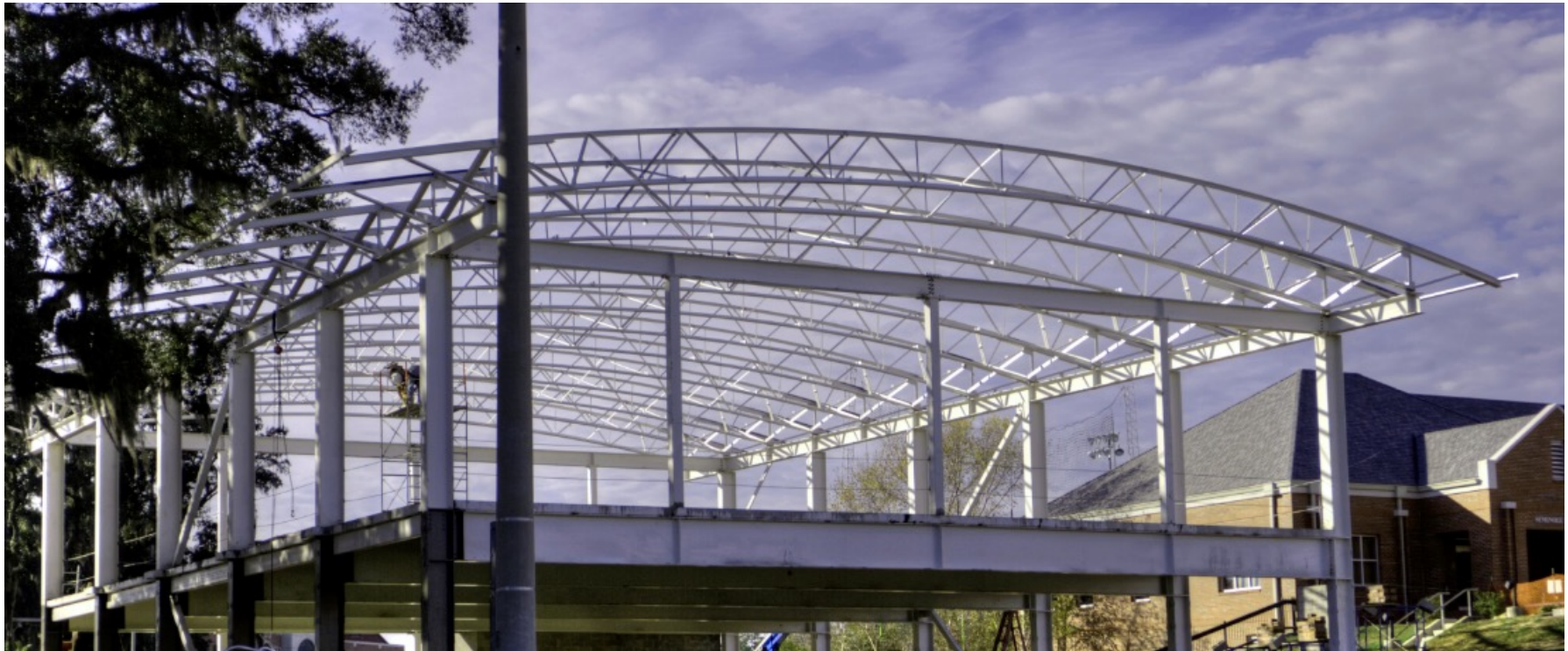
Special Profile Joists

Other Considerations...

Special Profiles Joists are typically fabricated with:

NO CAMBER

Special Profile Joists



Special Profile Joists

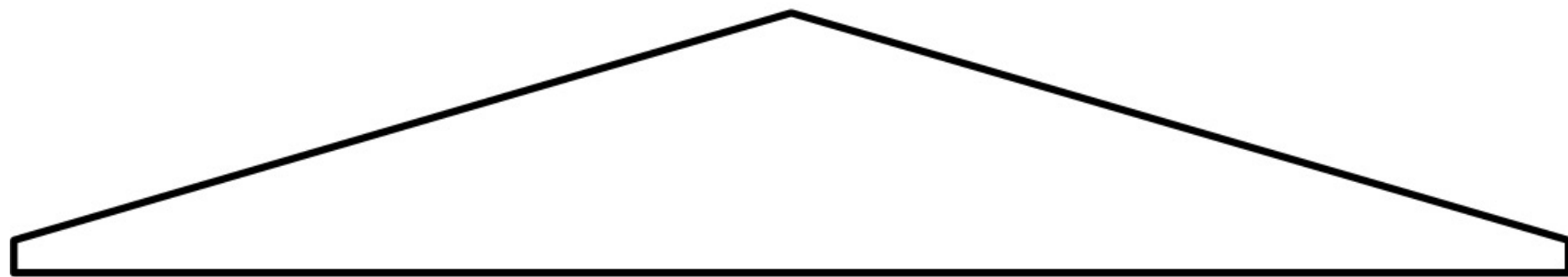


Special Profile Joists



Best Practices

- Optimize joist spacing



60' span 3 1/2 : 12 slope Depth at ridge = 120" Depth at end = 15"

Deep joists often have chords controlled by minimum sizes for handling, rather than load requirements

Consider using a 3" deep roof deck to allow greater joist spacing and better utilization of deep joist capacity.

Best Practices

- Clearly specify all geometric requirements of the joists on the contract documents.
- Use LOAD/LOAD designations when a design is beyond the standard SJI designation range. Where additional load requirements exist, provide a complete load diagram.

Best Practices

- Standard SJI camber may not be ideal for the project application. Consider the transition between areas with special profile joists and adjacent areas. Specify zero camber or specific camber requirements as needed.
- Specify the means of bridging termination. If needed, the joist manufacturer can provide termination bridging in the last space between joists, to avoid terminating at adjacent framing.

Best Practices

- Specify structural bracing in lieu of joist bridging when the bracing is intended to do more than provide lateral support to the joists under self-weight, weight of erectors, deck, bridging bundles, etc.
- Coordinate support boundary conditions with the joist manufacturer when specifying joists that exert a horizontal thrust at the support, such as arch or scissor joists.

Check Out Our Resources

SJI offers a number of resources including:

- Design tools
- Publications
- Live webinars
 - Our next live webinar will be on December 15, 2021 3:00 p.m. EST
 - Ethics, Laws and Regulations
- Webinars on demand
 - Our Webinars on Demand section offers 40+ pre-recorded webinars.
Earn PDHs today.

Polling Question #2

Special profile joists with pitched or curved bottom chords (scissor or arch) have what additional design requirement?

- A. The joist-to-joists spacing can not exceed the joist depth
- B. The joists can be erected without any bridging
- C. Supports must resist the horizontal thrust or movement
- D. The joists can only span up to 60'



Q&A SESSION



THANK YOU

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