Updated Steel Joist Applications & Capabilities for Floor Systems

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Polling Question

- New requirement to earn PDH credits
- Two questions will be asked during the duration of today's presentation
- The question will appear within the polling section of your GoToWebinar Control Panel to respond

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Webinar Description

Steel joists provide an economical and efficient structural framing option for constructing steel deck supported concrete floor systems. This webinar discusses the usage of K, LH, DLH, and CJ-Series joists in concrete floors and suggests typical span / depth ratios for each type of steel joist.

Open web steel joists permit the easy passage of plumbing, electrical, and HVAC without having to cut special web openings. For large HVAC ducts, the joist manufacturer can design special Vierendeel openings within the webs of the steel joists.

This webinar will introduce the Steel Joist Institute's (SJI's) Floor Bay Tool to assist in making economical comparisons with varying joist types, joist spacings, joist depths, and joist spans.

Various types of joist seats will be discussed along with potential applications where each type of seat may be particularly advantageous. The SJI new "Expanded" LH -Series tables provide more options for typical heavier floor loads. This webinar will briefly describe these new tables and outline associated benefits. Vibration behavior of steel joist supported concrete floors can be accurately predicted in the design phase. Resources available to assist with floor vibration calculations will be discussed.

Learning Objectives

- Be able to readily pick the best steel joist product type for any span and loading and how to display this product on structural drawings.
- Know how to address vibrational issues in the design of steel joists in floor applications.
- Understand the capabilities and limitations of current structural software related to floor joists.
- Know how to apply beneficial standard SJI camber when calculating deflections on steel joists.

Why Use Open Web Steel Joists?

- Easy passage of plumbing, electrical, and HVAC through web openings
  - Decreased floor-to-floor height as HVAC through rather than under
  - Increased member depth allows less weight per sq. ft.
- Plenty of strength for wider spacing
  - Expanded LH Standard Load Tables
  - Composite options with CJ-Series Joist
  - Fewer members to install and fire-proof
- Excellent vibration characteristics
  - Wider joist spacing
  - Bottom chord can be customized to yield desired a/g%
- Powerful Design Tools
  - SJI Floor Bay Analysis Tool
  - Various commercial software available

Advantages of Steel Floor Joists

- Wide joist spacing of 4 – 12 feet reduces number of joists to be erected and fireproofed.
- Less variations in camber as the joists are fabricated in carefully controlled rigging tables.
- Results in more level finished floors with reduced concrete surface grinding required.
- Faster steel delivery as no mill order scheduling required. Steel joists are fabricated utilizing readily available hot-rolled angles.
- No need to coordinate web opening penetrations which are never known until the end of the project. Simply run pipes, electrical, small HVAC thru the joist open webs.

Open Web Steel Joist Options

- K-Series Joists
  - Depth: 10” thru 30”
  - Spans: thru 60 feet
  - Max Span/Depth Ratio: 24
- LH-Series Joists
  - Depth: 18” thru 48”
  - Spans: thru 96 feet
  - Max Span/Depth Ratio: 24
- DLH-Series Joists
  - Depth: 52” thru 120”
  - Spans: thru 240 feet
  - Max Span/Depth Ratio: 24
- CJ-Series Composite Joists
  - Depth: 10” thru 96”
  - Spans: thru 120 feet
  - Max Span/Depth Ratio: 30

Open Web Steel Joist Floor Applications

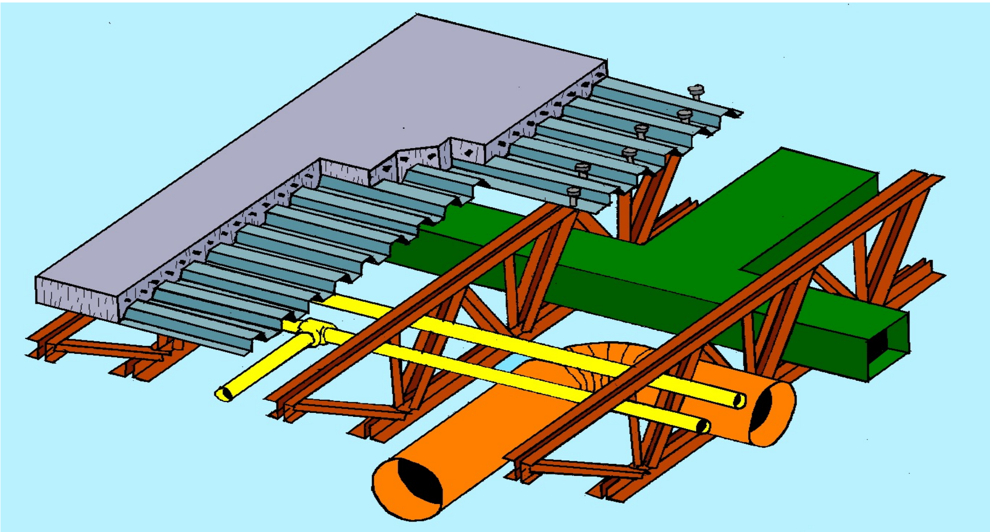
- K-Series Joists
  - Limited to 550 plf or less
  - Floor joist spacing <= 4’
  - Primarily used in conjunction with form decks, OSB, plywood on floors and standard bearing seats
- LH-Series Joists
  - Expanded Loading up to nearly 3000 plf vs 1207 plf previously
  - Floor spacing generally over 4’, 20’ to 50’ spans
  - Used in conjunction with form decks, composite decks (1.5,2,3)
- DLH-Series Joists
  - Not used for floor applications as a general rule
- CJ-Series Composite Joists
  - TC thickness governed by stud diameter on shorter spans
  - Spans: thru 120 feet
  - As spacing, loading and spans increase, CJs are “best option”

Optimal Floor Joist Spacings

- For K , LH-, DLH-, and CJ- Series joists, space joists at 4’ minimum with typical spacings of 4’ – 12’ on centers
- Fewer joists to erect
- Fewer joists to fireproof
- Larger joist members make them easier to fireproof
- For CJ-Series joists, larger joist top chord members facilitate shear stud installation
- Combined cost of the joists and composite steel deck are reduced at wider joist spacings
- Improved floor vibration properties at wider joist spacings
- Reduced rows of joist bridging at wider spacings given the larger joist top chords

Mechanical Ducts, Plumbing and Electrical

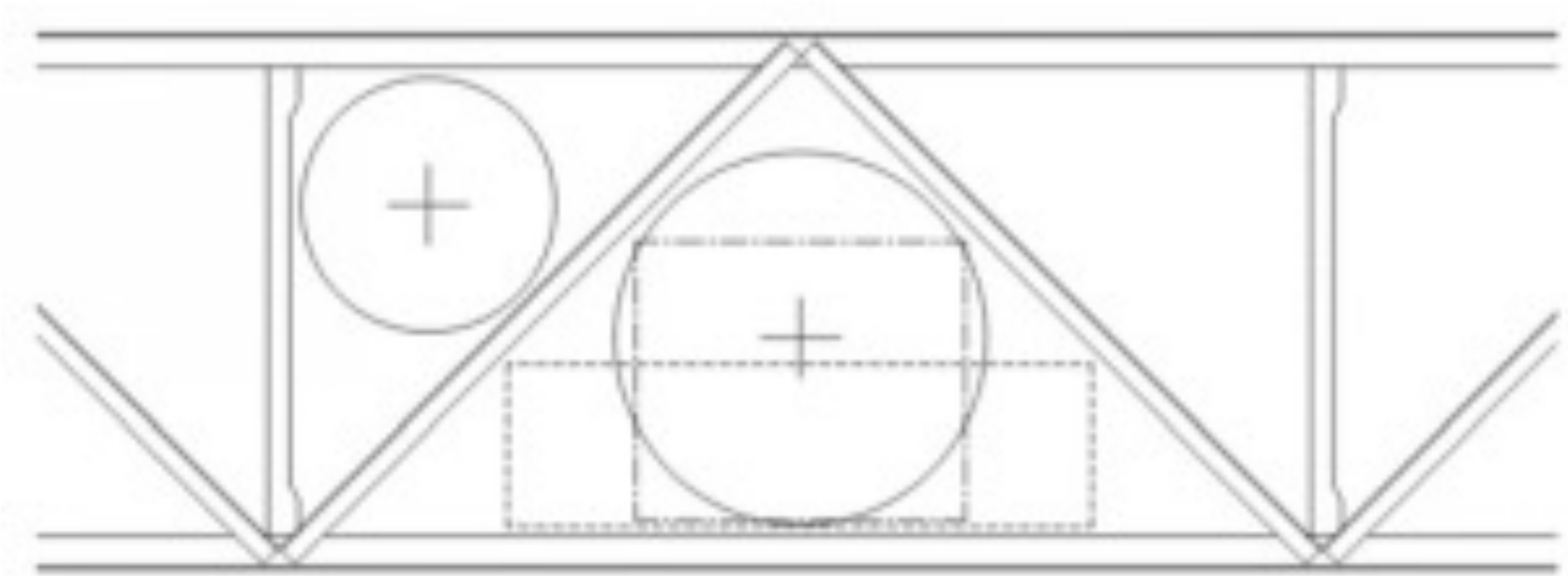
- Mechanical ducts and piping (MEP) can be run through the open webs of joists instead of running beneath the joist bottom chord.
- Increase joist depth for greater strength and stiffness while simultaneously reducing floor to floor height



HVAC Ducts and Plumbing thru CJ-Series Open Web System

Mechanical Ducts, Plumbing and Electrical

- Ideally, ducts run through the standard web panel configurations for optimal efficiency.
- Circular, square or rectangular ducts
- The Specifying Professional must indicate on the structural drawings the size and location of any duct opening that is to pass through joists



Duct Opening Sizes

Joist Depth (inches)	Panel length (inches)	Round (inches)	Square (inches)	Rectangle (inches)
10	19*	5	4	3x7
12	19*	6	5	4x7
14	19*	7	6	5x7
16	19*	8	6	6x7
18	24*	9	7	6x9
20	24*	10	8	6x11
22	24*	10	9	7x11
24	24*	12	10	7x13
18	48	10	8	6x18
20	48	10	8	7x18
22	48	10	9	8x18
24	48	12	10	8x19
26	48	15	12	9x19
28	48	16	13	10x18
30	48	17	14	11x19
32	64	20	16	11x25
36	72	24	18	13x29
40	80	26	22	14x32
44	88	28	23	17x36
48	96	32	26	19x40

- * Indicates tables based on bent rod web configuration
- For Deeper LH and DLH-Series joists, consult manufacturer

Expansion of LH Load Tables

There are four primary components to the LH-Series expansion:

- Increase the load carrying capacity of existing LH-Series joist designations at shorter spans.
- Increase the range of available LH-Series designations (chord numbers) to provide increased load carrying capacity.
- Rearrange the format of the LH-Series Load Tables, to be similar to the K-Series.
- Associated changes to related Specification tables, mainly for labeling purposes.

Previous LH-Series Load Table

The previous LH-Series Load Tables established a maximum ASD load carrying capacity of 1207 plf.

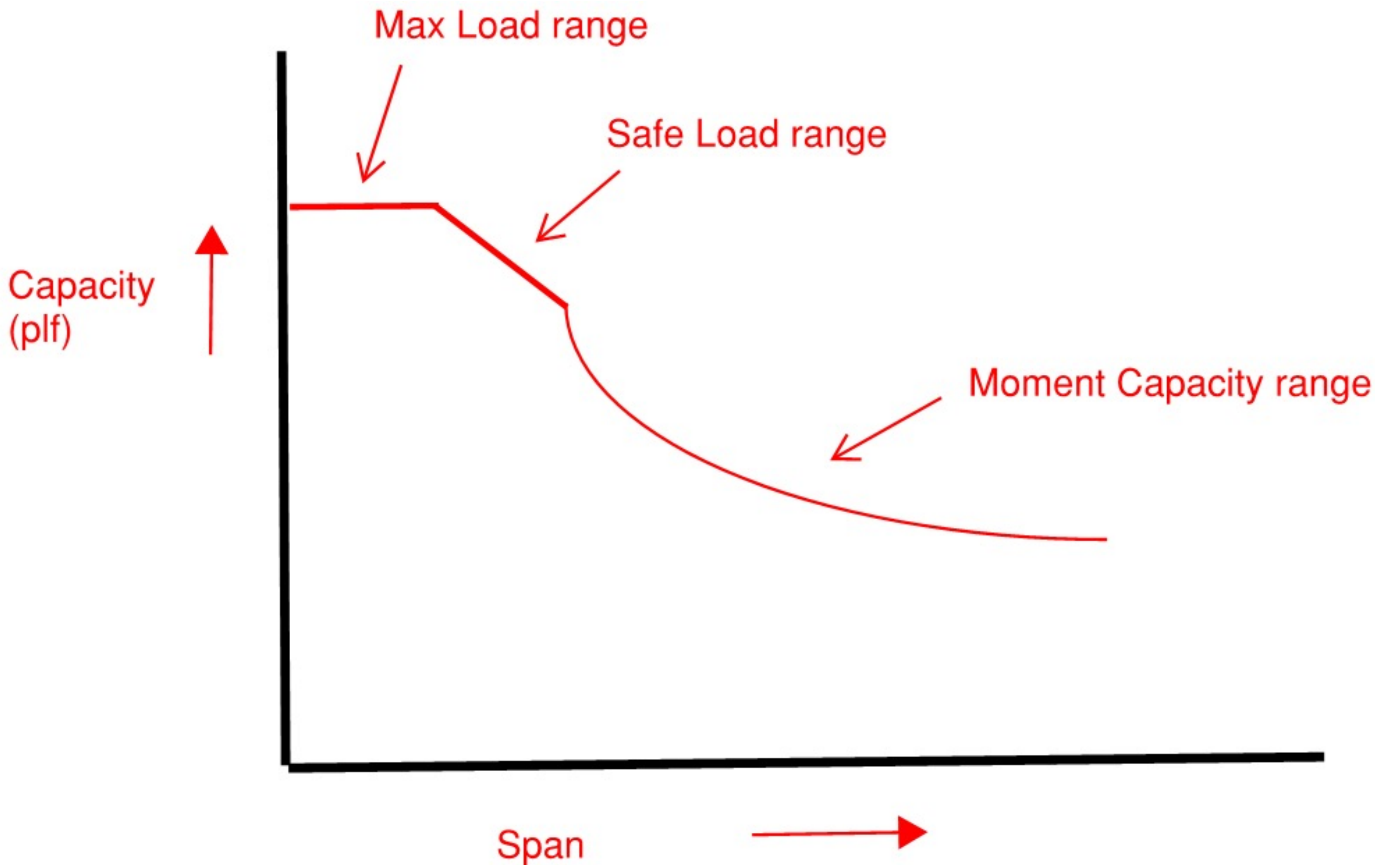
The Safe Load and Max Load columns imposed arbitrary limits on the load carrying capacity at shorter spans.

Joist Designation	Approx. Wt in Lbs. Per Linear Ft. (Joists only)	Depth in inches	Max Load (plf)	SAFE LOAD* in Lbs. Between
			< 22	**22-25**
18LH02	10	18	553	12160
18LH03	11	18	613	13480
18LH04	12	18	714	15700
18LH05	15	18	806	17740
18LH06	15	18	954	20980
18LH07	17	18	990	21780
18LH08	19	18	1032	22700
18LH09	21	18	1105	24320
			< 23	**23-25**
20LH02	10	20	498	11460
20LH03	11	20	529	12160
20LH04	12	20	648	14900
20LH05	14	20	697	16020
20LH06	15	20	930	21380
20LH07	17	20	991	22800
20LH08	19	20	1023	23520
20LH09	21	20	1119	25740
20LH10	23	20	1207	27760

Previous LH Load Tables – Three areas

Joist Designation	Approx. Wt in Lbs. Per Linear Ft. (Joists Only)	Depth in inches	Max Load (plf) < 48	SAFELOAD* in Lbs. Between 48-59	60-65	66	67	68	69	70
40LH08	16	40	348	16680	16680	254 150	247 144	241 138	234 132	228 127
40LH09	21	40	457	21920	21920	332 196	323 188	315 180	306 173	298 166
40LH10	21	40	503	24120	24120	367 216	357 207	347 198	338 190	329 183
40LH11	22	40	549	26340	26340	399 234	388 224	378 215	368 207	358 198
40LH12	25	40	668	32060	32060	486 285	472 273	459 261	447 251	435 241
40LH13	30	40	788	37800	37800	573 334	557 320	542 307	528 295	514 283
40LH14	35	40	900	43220	43220	656 383	638 367	620 351	603 336	587 323
40LH15	36	40	1007	48340	48340	734 427	712 408	691 390	671 373	652 357
40LH16	42	40	1110	53280	53280	808 469	796 455	784 441	772 428	761 416

LH Load Tables – Previous load ranges



Expansion of LH Load Tables

The SJI sees a growing need for higher load carrying capacities for floor joists.

There are a number of advantages to the use of floor joists with wider joist spacings:

- Fewer pieces to handle and erect.
- Better vibration performance with thicker slab and more damping mass per joist.
- Where spray applied fire proofing is required, fewer joists means reduced costs.

“Old School”: floor joists at 2 feet to 3 feet on center

Current Practice: floor joist spacing at 4 feet to 12 feet on center

Expansion of LH Load Tables

- The new tables start with a span (in feet) equal to the joist depth (in inches), with capacities listed for each successive one foot increment of span.
- The Safe Load and Max Load have been eliminated.
- The load carrying capacities are limited by a maximum chord size as well as an arbitrary ASD limit of 3000 plf.
- The format is now similar to K-Series, with designations in columns and spans in rows.
- New columns and chord numbers have been added.
- Note: DLH-Series Load Table format and values are unchanged.

Expansion of LH Load Tables

	STANDARD LOAD TABLE/OPEN WEB STEEL JOISTS, LH-SERIES																	
	Based on a 50 ksi Maximum Yield Strength - Loads Shown In Pounds Per Linerar Foot (plf)																	
Joist Designation	40LH08	40LH09	40LH10	40LH11	40LH12	40LH13	40LH14	40LH15	40LH16	40LH17	40LH18	40LH19	40LH20	40LH21	40LH22	40LH23	40LH24	40LH25
Depth (in.)	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40	40
Approx. Wt. (lbs./ft.)	16	21	21	22	25	30	35	36	42	51	56	64	81	93	100	121	127	148
Span (ft.) ↓																		
40	519	705	839	879	1068	1297	1480	1655	1963	2377	2685							
	519	705	839	879	1068	1297	1480	1655	1963	2377	2685							
41	504	682	810	850	1032	1251	1427	1597	1891	2290	2586							
	504	682	810	850	1032	1251	1427	1597	1891	2290	2586							
42	490	660	783	821	997	1207	1377	1540	1822	2206	2492	2912						
	490	660	783	821	997	1207	1377	1540	1822	2206	2492	2874						
43	475	640	757	794	964	1165	1329	1487	1756	2127	2403	2802						
	475	640	757	794	964	1165	1329	1487	1756	2106	2403	2677						
61	290	378	433	457	555	659	752	842	980	1171	1341	1524	1915	2119	2355	2597	2819	
	190	249	274	297	361	424	486	542	595	732	837	931	1163	1289	1464	1599	1736	
62	283	368	419	445	540	641	731	818	952	1133	1303	1475	1853	2058	2279	2521	2728	
	181	237	261	283	344	403	462	516	566	697	797	886	1107	1227	1394	1523	1653	
63	276	358	406	433	526	623	711	796	925	1097	1267	1428	1795	1999	2207	2447	2642	
	173	226	249	269	328	384	441	491	540	664	760	845	1055	1169	1328	1451	1575	
64	269	349	394	421	512	606	692	774	900	1063	1230	1384	1739	1943	2138	2377	2560	
	165	215	237	257	313	366	420	469	515	634	724	805	1006	1115	1267	1383	1502	
65	262	340	382	410	498	590	673	753	875	1031	1192	1341	1685	1883	2073	2309	2481	2937
	157	205	226	245	298	350	401	447	491	605	691	769	960	1064	1209	1320	1434	1671
66	254	332	367	399	486	573	656	734	808	999	1156	1301	1634	1826	2010	2245	2406	2849
	150	196	216	234	285	334	383	427	469	577	660	734	917	1016	1154	1261	1369	1596

Expansion of LH Load Tables

Joist Depth (inches)	Maximum Chord Number	
	Prior	New
18	9	20
20	10	20
24	11	21
28	13	23
32	15	24
36	15	25
40	16	25
44	17	25
48	17	25

Expansion of LH Load Tables

Joist Depth	Maximum Chord Number Current	New
18	09	20
20	10	20
24	11	21
28	13	23
32	15	24
36	15	25
40	16	25
44	17	25
48	17	25

Expansion of LH Load Tables

K, LH, and DLH SERIES JOISTS MAXIMUM JOIST SPACING FOR DIAGONAL BRIDGING[1]								
JOIST DEPTH	BRIDGING ANGLE SIZE – (EQUAL LEG ANGLE)[2]							
	1 x 7/64 (25 x 3 mm) r = 0.20" (5.08 mm)	1-1/4 x 7/64 (32 x 3 mm) r = 0.25" (6.35 mm)	1-1/2 x 7/64 (38 x 3 mm) r = 0.30" (7.62 mm)	1-3/4 x 7/64 (45 x 3 mm) r = 0.35" (8.89 mm)	2 x 1/8 (50 x 3 mm) r = 0.40" (10.16 mm)	2 ½ x 5/32 (64x 4 mm) r=0.50" (12.70 mm)	3 x 3/16 (76 x 5 mm) r = 0.60" (15.24 mm)	3 ½ x 1/4 (89 x 6 mm) r = 0.70" (17.78 mm)
in. (mm)	ft.-in. (mm)	ft.-in. (mm)	ft.-in. (mm)	ft.-in. (mm)	ft.-in. (mm)	ft.-in. (mm)	ft.-in. (mm)	ft.-in. (mm)
12" (305)	6'-7" (2007)	8'-3" (2514)	9'-11"(3022)	11'-7" (3530)	13'-3" (4038)	16'-7" (5055)	19'-11"(6070)	23'-3" (7086)
14" (356)	6'-6" (1981)	8'-3" (2514)	9'-11"(3022)	11'-7" (3530)	13'-3" (4038)	16'-7" (5055)	19'-11"(6070)	23'-3" (7086)
16" (406)	6'-6" (1981)	8'-2" (2489)	9'-10"(2997)	11'-7" (3530)	13'-3" (4038)	16'-7" (5055)	19'-11"(6070)	23'-3" (7086)
18" (457)	6'-6" (1981)	8'-2" (2489)	9'-10"(2997)	11'-6" (3505)	13'-3" (4038)	16'-7" (5055)	19'-11"(6070)	23'-3" (7086)
20" (508)	6'-5" (1955)	8'-2" (2489)	9'-10"(2997)	11'-6" (3505)	13'-2" (4013)	16'-7" (5055)	19'-11"(6070)	23'-3" (7086)
22" (559)	6'-4" (1930)	8'-1" (2463)	9'-10"(2997)	11'-6" (3505)	13'-2" (4013)	16'-6" (5029)	19'-11"(6070)	23'-3" (7086)
24" (610)	6'-4" (1930)	8'-1" (2463)	9'-9" (2971)	11'-5" (3479)	13'-2" (4013)	16'-6" (5029)	19'-10"(6045)	23'-3" (7086)
26" (660)	6'-3" (1905)	8'-0" (2438)	9'-9" (2971)	11'-5" (3479)	13'-1" (3987)	16'-6" (5029)	19'-10"(6045)	23'-2" (7061)
28" (711)	6'-3" (1905)	8'-0" (2438)	9'-8" (2946)	11'-5" (3479)	13'-1" (3987)	16'-6" (5029)	19'-10"(6045)	23'-2" (7061)
30" (762)	6'-2" (1879)	7'-11"(2413)	9'-8" (2946)	11'-4" (3454)	13'-1" (3987)	16'-5" (5004)	19'-10"(6045)	23'-2" (7061)
32" (813)	6'-1" (1854)	7'-10"(2387)	9'-7" (2921)	11'-4" (3454)	13'-0" (3962)	16'-5" (5004)	19'-9" (6020)	23'-2" (7061)
36" (914)	5'-11"(1803)	7'-9" (2362)	9'-6" (2895)	11'-3" (3429)	12'-11"(3973)	16'-4" (4979)	19'-9" (6020)	23'-1" (7035)
40" (1016)	5'-9" (1753)	7'-7" (2311)	9'-5" (2870)	11'-2" (3403)	12'-10"(3911)	16'-4" (4979)	19'-8" (5994)	23'-1" (7035)
44" (1118)	5'-6" (1676)	7'-5" (2260)	9'-3" (2819)	11'-0" (3352)	12'-9" (3886)	16'-3" (4953)	19'-7" (5969)	23'-0" (7010)
48" (1219)	5'-4" (1626)	7'-3" (2209)	9'-2" (2794)	10'-11"(3327)	12'-8" (3860)	16'-2" (4928)	19'-7" (5969)	22'-11"(6985)
52" (1321)	5'-0" (1524)	7'-1" (2159)	9'-0" (2743)	10'-10" (3302)	12'-7" (3835)	16'-1" (4902)	19'-6" (5943)	22'-11"(6985)
56" (1422)	4'-9" (1448)	6'-10"(2083)	8'-10"(2692)	10'-8" (3251)	12'-5" (3784)	16'-0" (4877)	19'-5" (5918)	22'-10"(6960)
60" (1524)	4'-4" (1321)	6'-8" (2032)	8'-7" (2616)	10'-6" (3200)	12'-4" (3759)	15'-10"(4826)	19'-4" (5893)	22'-9" (6935)
64" (1626)	**	6'-4" (1931)	8 -5" (2565)	10'-4" (3149)	12'-2" (3708)	15'-9" (4801)	19'-3" (5867)	22'-8" (6909)
68" (1727)	**	6'-1" (1854)	8'-2" (2489)	10'-2" (3098)	12'-0" (3657)	15'-8" (4775)	19'-2" (5842)	22'-7" (6884)
72" (1829)	**	5'-9" (1753)	8'-0" (2438)	10'-0" (3048)	11'-10"(3606)	15'-6" (4724)	19'-1" (5816)	22'-6" (6858)
80" (2032)	**	5'-0" (1524)	7'-5" (2260)	9'-6" (2895)	11'-6" (3505)	15'-3" (4648)	18'-10"(5740)	22'-4" (6808)
88" (2235)		**	6'-9" (2058)	9'-0" (2743)	11'-1" (3378)	14'-11"(4546)	18'-7" (5664)	22'-1" (6731)
96" (2438)		**	6'-0" (1829)	8'-5" (2565)	10'-8" (3251)	14'-7" (4445)	18'-4" (5588)	21'-11"(6680)
104" (2642)			**	7'-9" (2362)	10'-1" (3073)	14'-2" (4318)	18'-0" (5486)	21'-8" (6604)
112" (2845)			**	7'-0" (2134)	9'-6" (2895)	13'-9" (4191)	17'-8" (5385)	21'-4" (6503)
120" (3048)				**	8'-9" (2667)	13'-4" (4064)	17'-3" (5258)	21'-1" (6426)

INTERPOLATION BELOW THE MINIMUM VALUES SHOWN IS NOT ALLOWED.

(1) SEE TABLE 2.7-4 FOR MINIMUM JOIST SPACE FOR DIAGONAL ONLY BRIDGING.

(2) In the shaded range of the Table, for LH23, 24 and 25, compressive strength requirements may control, reducing the maximum joist spacing shown. Either select a larger bridging angle size (outside of the shaded area) or check compression strength (Ref. Section 2.7(c)) for LH23, 24, and 25.

(2) In the shaded range of the Table, for LH23, 24 and 25, compressive strength requirements may control, reducing the maximum joist spacing shown. Either select a larger bridging angle size (outside of the shaded area) or check compression strength (Ref. Section 2.7(c)) for LH23, 24, and 25.

Expansion of LH Load Tables

A couple of notes added to the LH Load Tables Preamble:

- User Note: For floor joists, the RED figures may control the joist selection, and for longer spans consideration shall be given to the effects of camber on slab thickness. If a deeper joist designation cannot be used, CJ-Series composite joists may also be considered to take advantage of increased stiffness available due to composite action.
- For spans shorter than the first span listed in the Load Table, the capacity shall be equal to that of the shortest listed span.

Expansion of LH Load Tables

Most of the changes to existing Specification Tables are just an editorial change to add "LH" to the range of larger chord numbers. For example:

TABLE 5.4-2

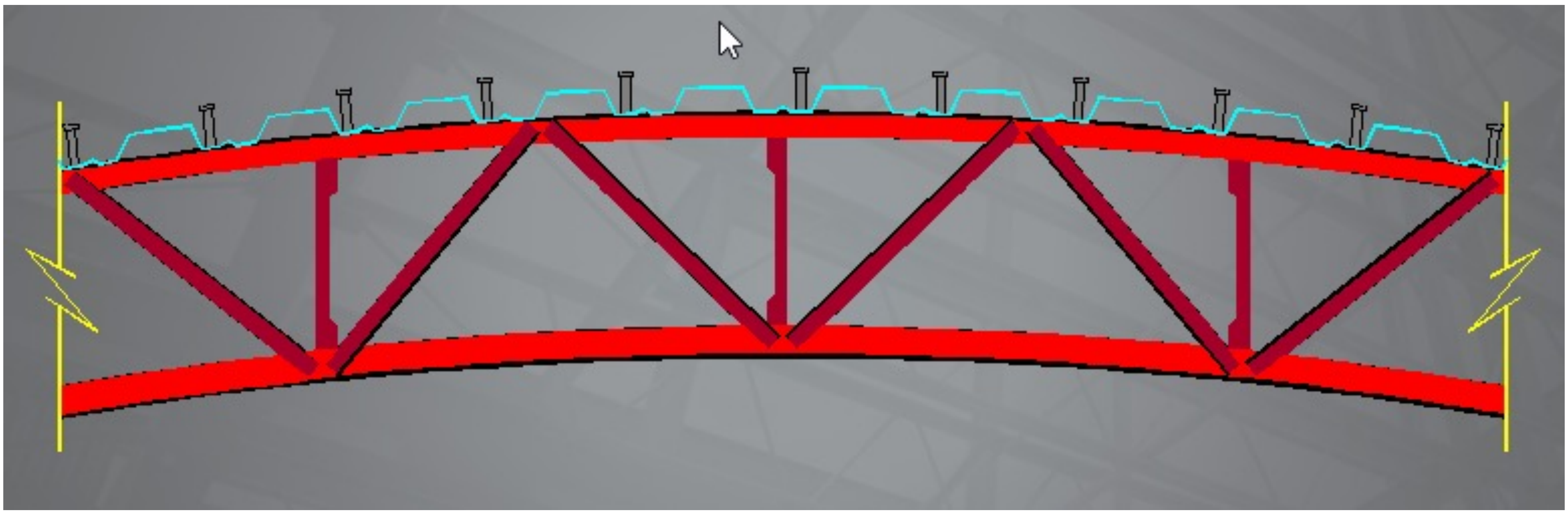
JOIST SECTION NUMBER[1]	MINIMUM BEARING PLATE WIDTH
K1-12, LH02-06	7" (178 mm)
LH07-17, DLH10-17, JG	9" (229 mm)
LH/DLH18-25, JG[2]	14" (356 mm)

However, Table 2.7-3, the chart of maximum joist spacing for diagonal bridging, required a check of capacity for the bridging forces related to the new chord numbers.

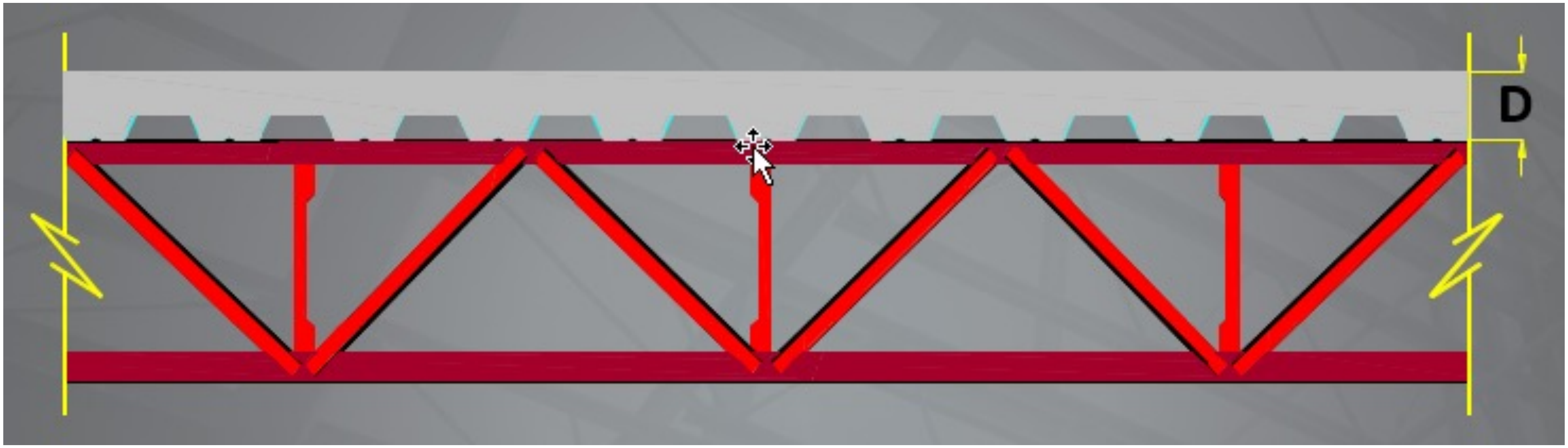
Expansion of LH Load Tables

- Expansion of previous tables allows for fairly easy updates to commercial software, with simple table replacements
- SJI Floor Bay Analysis Tool has been updated to include the expanded LH-Series Load Tables
- RISAFloor has yet to add the Expanded LH-Series Load Tables to their software, although CJ-Series is now in software.
- RAM has the expanded LH-Series Load Tables in latest software release along with deflection calculations with camber considered. No CJ-Series joists as of now.

Joist Camber – Length based per SJI Standard Specification Table 4.6-1



Joist Camber – used to offset DL deflections



- Concrete placed to a constant thickness
- Simple Pinned – Pinned End Restraint

SJI Standard Specification for K-Series, LH-Series, and DLH-Series Open Web Joists and for Joist Girders

- 4.6 CAMBER
  - Steel Joists and Joist Girders 100’-0” or less **shall** have a manufactured camber in accordance with Table 4.6-1
- Table 4.6-1 Approximate Camber for joist length =
  - 20-0 is 1/4”
  - 30-0 is 3/8”
  - 40-0 is 5/8”
  - 50-0 is 1”
  - 60-0 is 1 ½ “
- Camber will be built into joists so consider the camber when addressing serviceability requirements.

IBC Floor Deflection Requirements

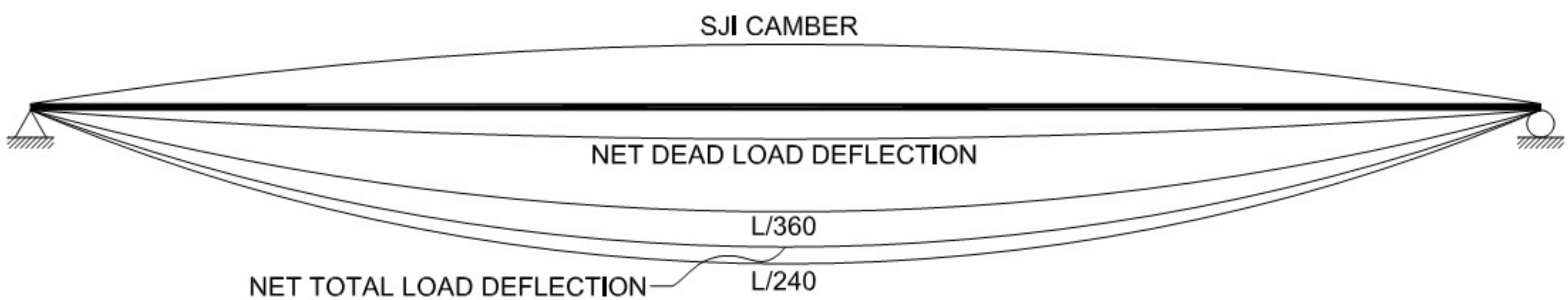
IBC Table 1604.3

CONSTRUCTION	L or L_r	S or W[f]	$D + L$[d, g]
Roof members:[e]			
Supporting plaster or stucco ceiling	$l/360$	$l/360$	$l/240$
Supporting nonplaster ceiling	$l/240$	$l/240$	$l/180$
Not supporting ceiling	$l/180$	$l/180$	$l/120$
Floor members	$l/360$	—	$l/240$

- Responsibility of EOR to specify deflection requirements.
- 2018 IBC Table 1604.3 suggests "D + L" limit
- Footnote d: "The deflection limit for the D + L load combinations only applies to the deflection due to the creep component of long-term dead load deflection plus the short-term live load deflection."
- Footnote g: "For steel structural members, the deflection due to creep component of long-term dead load shall be permitted to be taken as zero."

IBC Floor Deflection Requirements

- Live Load deflection requirements stricter than total load requirements.
- Total load deflection will not govern the design.
- IBC has no total load deflection requirements for steel members.
- Net DL deflection = Camber – DL deflection
- Net total load deflection = Camber – (DL + LL Deflections)



Deflection Comments

- If not using SJI standard designations, be clear on contract structural drawings where you want to control the TL deflection from:
  - Cambered Position
  - Horizontal datum as if camber was not there
- Recommend that when TL deflection criteria is being sought, use "net total load deflection" from the horizontal datum so that beneficial effect of camber is realized and chord sizes on joists are not increased and result in more expensive joists.
- By specifying standard SJI joists, the EOR should have already considered deflection and camber and no additional deflection criteria is necessary on the drawings. Standard joists have a total load capacity and stiffness defined in the SJI load tables.

Using the Expanded Load Tables

- 4-0 ceiling to next floor height
- W2 deck, 20 gage with 3” cover = 5” total slab
- 48” - (7” ceiling, lights + 5” slab) = 36“ max joist depth
- Joists spaced at 8-0 o.c., spanning 40-0
- DL incl joist = 65 psf, LL = 67.5 psf (80 psf reduced)
- DL, plf = 8*65 = 520 plf; LL, plf = 8*67.5 = 540 plf
- TL = 520 + 540 = 1060 plf
- LL deflection <= L/360 = (40*12)/360 = 1.33”
- Enter SJI load tables for 36 inch deep joist where the TL capacity >=1060 and load to cause L/360 deflection >=540 plf

Need TL>= 1060 plf, load for L/360 defl>=540plf

Joist Designation	36LH07	36LH08	36LH09	36LH10	36LH11	36LH12	36LH13
Depth (in.)	36	36	36	36	36	36	36
Approx. Wt. (lbs./ft.)	16	18	21	21	23	25	30
Span (ft.)							
36	582 582	668 668	851 851	1006 1006	1064 1064	1273 1273	1533 1533
37	562 562	644 644	820 820	967 967	1022 1022	1224 1224	1471 1471
38	543 543	620 620	780 780	929 929	983 983	1177 1177	1412 1412
39	525 525	598 598	762 762	894 894	946 946	1132 1132	1357 1357
40	508 508	576 576	735 735	860 839	910 910	1090 1088	1304 1275

Need TL>= 1060 plf, load for L/360 defl>=540plf

- 36LH12 good for 1090 plf TL, load for L/360 = 1088 plf
- TL demand/capacity ratio = 1060/1090 = .97
- Joist wt. per sq. ft = 25/8 = 3.13 psf
- SJI standard camber for 40' = 5/8" = .625"
- L/360 deflection = (40 ft*12"/ft)/360 = 1.33"
- DL deflection = 520/1088*1.33" = .64"
- Camber and DL deflection are a close match, flat joist under full DL.
- LL deflection = 540/1088*1.33" = .66" = L/727
- TL deflection = .64" + .66" = 1.30" = L/369
- Net TL deflection (TL defl – camber) = 1.30" - .625" = .675" = L/711

Other SJI standard joist potential choices

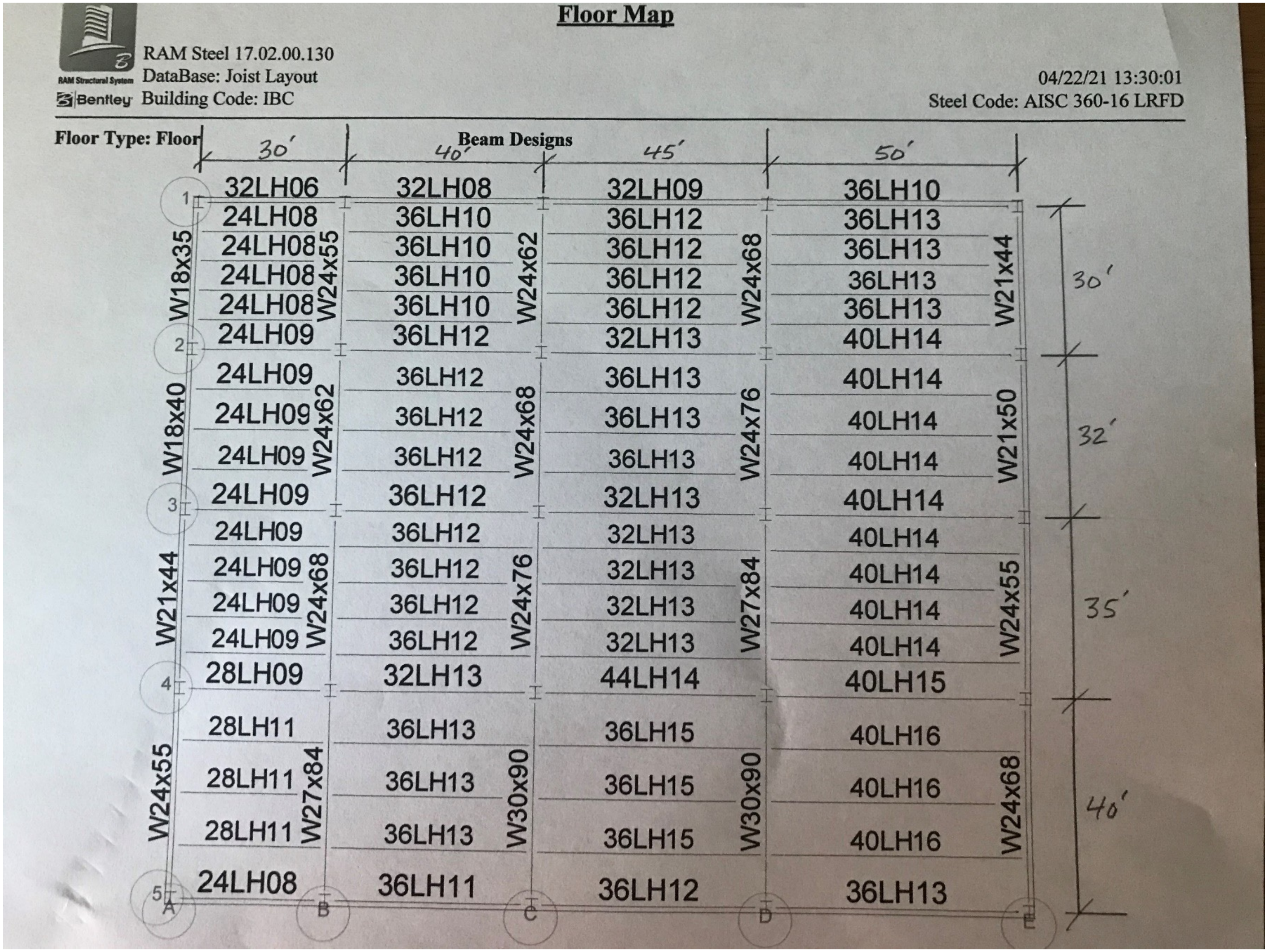
Joist span =	40	feet	=	480	inches		
SJI camber =	0.625	inches					
Total load =	1060	plf					
Live load =	540	plf	L/360	=	1.33	inches	

SJI joist designation	Joist Weight psf	Joist TL capacity plf	Joist plf for L/360 defl	Joist TL Demand/ Capacity Ratio	Defl Live Load span /	Defl Total Load span /	Defl Net Total Load span /
40LH12	3.13	1068	1068	0.99	712	363	687
36LH12	3.13	1090	1088	0.97	725	370	712
32LH12	3.75	1073	883	0.99	589	300	492
28LH13	3.75	1108	659	0.96	439	224	316
24LH13	4.00	1078	588	0.98	392	200	270
20LH16	5.63	1127	515	0.94	343	175	226
20LH17	6.88	1286	586	0.82	391	199	269

Non-composite joist suggestions

- Deeper is cheaper due to reduction in chord weight
- Deeper is stiffer and less likely to have deflection issues and will also generally help with vibration.
- SJI tables give the engineer the total load capacity in plf and load in plf that would cause L/360 deflection
- Simple ratios of loads to deflections will yield quick deflection results
- Don’t forget about the beneficial and free benefit of standard SJI camber in helping offset dead load deflections.

Ram Joist Design Results for sample floor



RAM Joist Output – top portion

Standard Joist Selection

RAM Structural System
Bentley

RAM Steel 17.02.00.130
DataBase: April DM design
Building Code: IBC

04/22/21 15:30:02

Floor Type: Floor 1 **Beam Number = 96**

SPAN INFORMATION (ft): I-End (105.00,54.00) J-End (150.00,54.00)

Joist Size (Optimum) = 36LH13
Total Beam Length (ft) = 45.00

LINE LOADS (k/ft):

Load	Dist	DL	LL	Red%	Type	PartL
1	0.000	0.414	0.000	---	NonR	0.000
	45.000	0.414	0.000			0.000
2	0.000	0.120	0.640	19.1%	Red	0.000
	45.000	0.120	0.640			0.000
3	0.000	0.000	0.000	---	NonR	0.000
	45.000	0.000	0.000			0.000

Maximum Total Unif. Load at any location (lbs/ft) : 1051.5
Maximum Allowable Total Unif. Load at any location (lbs/ft) : 1533.0

Listed Uniform Capacities (lbs/ft)
Total for Strength: 1078.0
L/360 for Deflection: 893.0

Allowable Stress Ratio: 1.00
Deflection Interaction Limit: 1.00

RAM Joist Output – bottom portion

Listed Uniform Capacities (lbs/ft)

Total for Strength:	1078.0
L/360 for Deflection:	893.0

Allowable Stress Ratio: 1.00
Deflection Interaction Limit: 1.00

	Design Loads	Allowable Loads (lbs/ft)	Ratio
Dead:	533.7		
Live:	517.8	893.0	
Total:	1051.5	1078.0	0.98

MOMENTS:

Span	Cond	Moment kip-ft	@ ft
Center	Max +	266.2	22.5

REACTIONS (kips):

	Left	**Right**
DL reaction	12.01	12.01
Max +LL reaction	11.65	11.65
Max +total reaction	23.66	23.66

DEFLECTIONS: (SJI Standard Camber = 7/8)

							Ratio
Dead load (in)	= 0.896	L/D	=	602			
Live load (in)	= 0.870	L/D	=	621	>	360	0.58
Total load (in)	= 1.766	L/D	=	306			
Net Total load (in)	= 0.891	L/D	=	606	>	240	0.40

Fire Resistance Ratings
45th Edition SJI Catalog

APPENDIX A

FIRE-RESISTANCE RATINGS WITH STEEL JOISTS

The Underwriters Laboratories (U.L.) Fire Resistance Directory lists hundreds of assemblies and their fire resistance ratings. The Specifying Professional can choose between numerous Floor-Ceiling and Roof-Ceiling assemblies that include steel joists and Joist Girders.

As a convenience, a selected number of assemblies are listed on the following pages. In addition, the Steel Joist Institute's Technical Digest #10 "Design of Fire Resistive Assemblies with Steel Joists" has a complete listing of steel joist assemblies and additional information about fire ratings. However, the listing that follows and the Technical Digest are intended as a guide only, and the Specifying Professional must refer to the current U.L. Fire Resistance Directory for complete design requirements.

Fire Resistance Ratings

- Joist designations specified on the structural contract drawings shall not be less than the minimum size for that assembly. The assembly may also require a minimum bridging size that may be larger than required by the SJI Specifications for the particular designation and joist spacing.
- Some assemblies stipulate minimum size materials or minimum cross sectional areas for individual joist and Joist Girder components. It is the responsibility of the Specifying Professional to show all special requirements on the contract drawings.
- Note that the maximum joist spacing shown for Floor-Ceiling Assemblies may be increased from the spacing listed in the U.L. Fire Resistance Directory to a maximum of 48 inches on center, provided the floor slab meets the structural requirements and the spacing of hanger wires supporting the ceiling is not increased.
- Some assemblies stipulate an allowable maximum joist design stress level less than the 30 ksi (207 MPa) used in the joist and Joist Girder specifications.
  - It is the responsibility of the Specifying Professional to apply the proper stress level reductions (when applicable) when selecting joists and/or Joist Girders.
  - This is accomplished by prorating the joist and/or Joist Girder capacities.
  - To adjust the stress level of joists or Joist Girders, multiply the design load by the ratio of the joist design stress to the required maximum [e.g. 30/26 (207/179), 30/24 (207/165), 30/22 (207/152)], and then using this increased load, select a joist or Joist Girder from the load and/or weight tables.

Fire Resistance Ratings

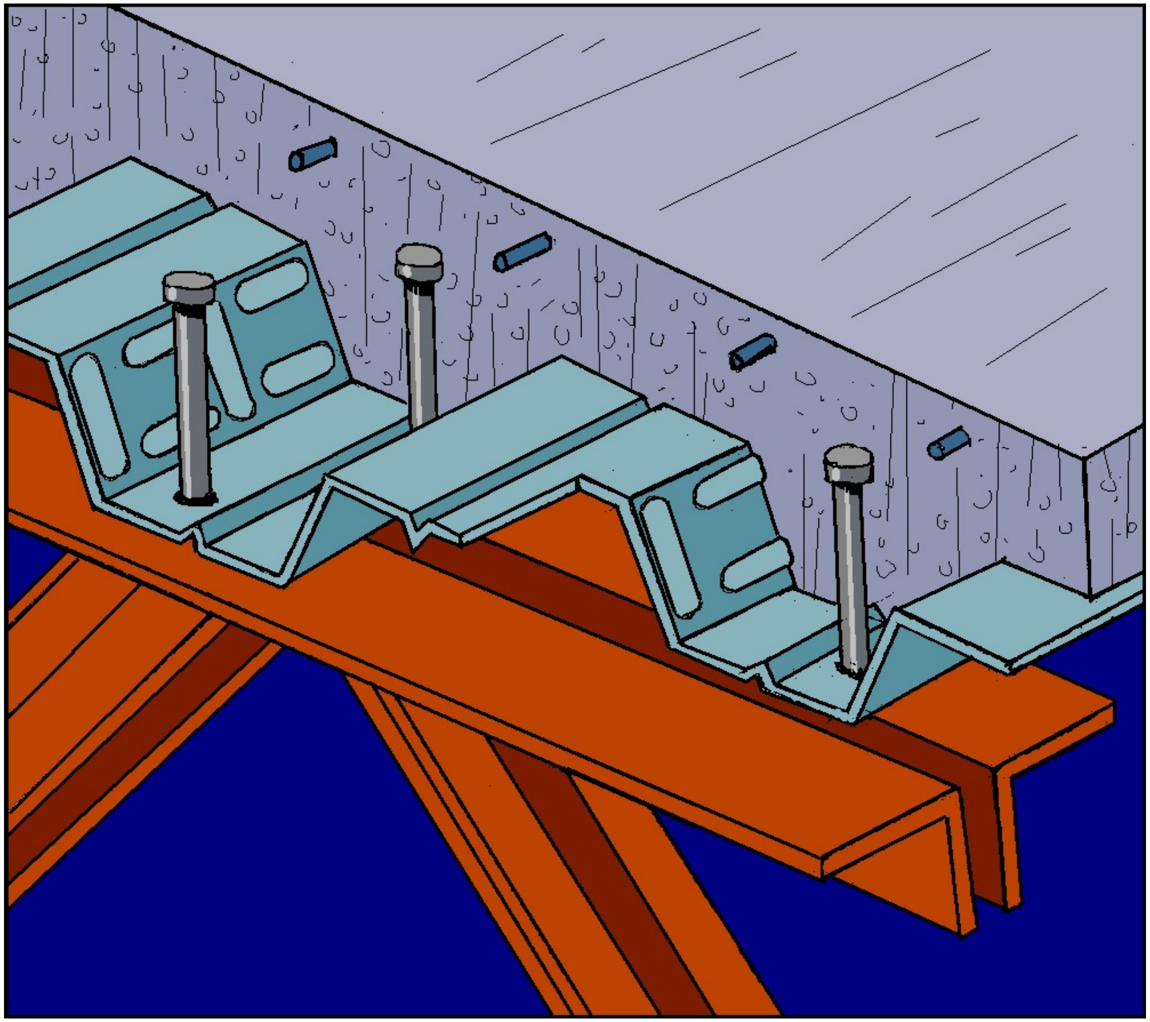
- Some U.L. Roof-Ceiling Assemblies using direct applied protection limit the spacing of the joists for certain types and gages of metal decking – refer to the U.L. Fire Resistance Directory for this information.
- Where fire protective materials are to be applied directly to the steel joists or Joist Girders, it is often desired to have the joist furnished as unpainted. The Specifying Professional should indicate on the structural contract drawings if the joists or Joist Girders are to be painted or not.
- Certain older U.L. fire rated assemblies may refer to joist series that predate the K-series joists. Where one of these assemblies is selected, refer to the U.L Fire Resistance Directory for special provisions for substituting a K-Series joist in lieu of an S-, J-, and/or H-Series joist.

Polling Question #1

Which of the following are benefits of using open web steel joists in floor design?

A) Easy passage of MEP chase through web openings
B) Plenty of strength for wider joist spacing
C) Excellent vibration characteristics
D) Powerful design tools
E) All of the above

SJI CJ-Series Composite Steel Joists



SJI CJ-Series Composite Steel Joists

SJI CJ-Series Composite Steel Joists

- System utilizes open-web steel joists.
- Members are simply-supported and are generally not considered part of the lateral load-resisting system.
- Concrete slab is attached to the joist top chord, acting as the compression chord element.
- Horizontal shear transfer is achieved by field –welding shear studs through the metal deck to the joist top chord and thus providing direct bearing of embedments within the concrete slab.

Advantages of CJ-Series Composite Steel Joists

- Composite steel joists are more efficient allowing a reduction in the joist weight for any given joist depth. For a 50 foot span, weight savings of 30 - 50% vs composite wide flange beams.
- Live load deflections are significantly reduced.
- Efficient erection of the CJ-Series joist system.

Designation for CJ-Series Composite Steel Joists

30 CJ 2188 / 1168 / 420

30	CJ	2188	1168	420
Steel Joist Depth (in.)	Composite Joist Series	[1]Total Factored Composite Design Load (plf)	Total Factored Composite Live Load (plf)	Total Factored Composite Dead Load (plf)

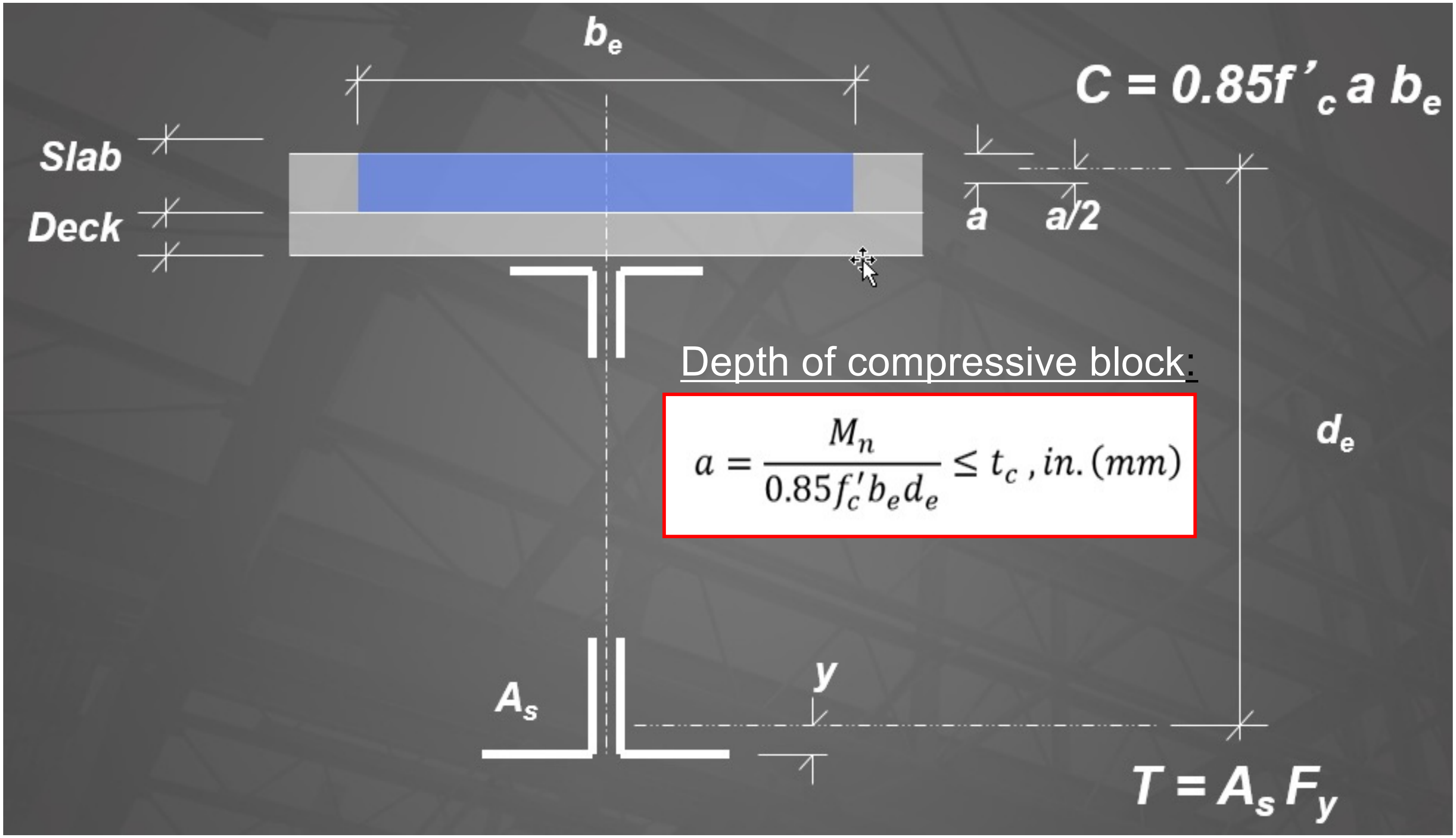
- [1]Total Factored Composite Design Load = Total Factored Composite Live Load + Total Factored Composite Dead Load + Total Factored Noncomposite Dead Load.
- See the "SJI Composite Joist Floor Design Parameter Checklist" for form to assist organizing loading information.
- See also SJI CJ COSP-2015, Section 6.6.1, Design Input required for Composite Steel Joists.

Composite Steel Joist Design

- Top chord designed for compressive forces from non-composite dead load plus construction live load followed by a total composite load case check.
- Bottom chord designed for tension forces from composite dead and live loads.
- Webs designed to carry total vertical shear.
- Shear connectors applied to fully develop the bottom chord yield strength.
- Concrete slab analyzed using the transformed area concept.
- Deflection under composite loads analyzed using composite moment of inertia.

Virginia Polytechnic Institute and State University, Blacksburg, VA

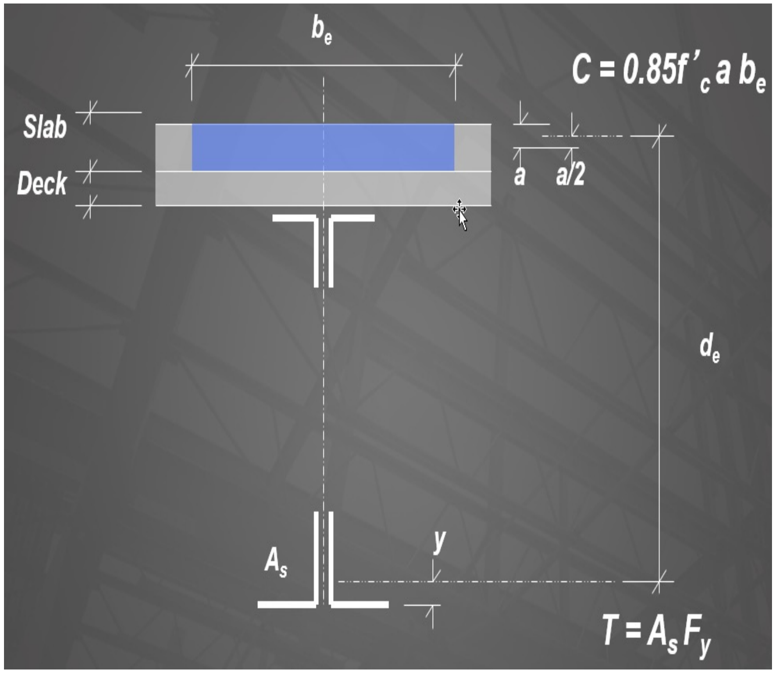
Composite Design Moment Capacity



$$a = \frac{M_n}{0.85 f_c' b_e d_e} \le t_c\text{, in. (mm)}$$

Composite Steel Joist Design

- The distance "d_e" between the centroid of the tension bottom chord and the centroid of the concrete compression block, shall be computed using a concrete stress of $0.85f'_c$ and an effective concrete width, b_e.



Effective Depth of composite Joist:

$$d_e = d_j - y_{bc} + h_{deck} + t_c - \frac{a}{2}, in. (mm)$$

- "b_e" shall be taken as the sum of the effective widths for each side of the joist centerline, each of which shall be the lowest value of the following:
  1. One-eighth of the joist span, center-to-center of supports;
  2. One-half the distance to the centerline of the adjacent joist;
  3. The distance to the edge of the slab.

Minimum Top Chord Sizes for Installing Welded Shear Studs

Shear Stud Diameter, in.	Minimum Horizontal Flat Leg Width, in.	Minimum Leg Thickness, in.
0.375	1.50	0.125
0.500	1.75	0.167
0.625	2.00	0.209
0.750	2.50	0.250

Painting of CJ-Series Joists

- Normal shop practice is to provide composite joists unpainted.
- Paint hinders installation of welded shear studs.
- In some cases, CJ-Series joists have been provided with just the top chord unpainted.

Welded Shear Stud Installation

- Mark location of top chord with chalk line.
- Note the two blue chalk lines photo indicating where the center of each joist top chord leg is located.

- Deck must be tight against top chord.
- AISC requires $\left[\frac{d_{stud}}{t_{top\ chord}}\right] \leq 2.5$
- SJI testing supports $\left[\frac{d_{stud}}{t_{top\ chord}}\right] \leq 3.0$ but with a reduction in the stud capacity

Welded Shear Stud Installation

- "Strong" side preferable for shear studs but SJI has conservatively assumed studs will be installed in the "Weak" position
- ¾" diameter shear studs were being installed at a rate of 220 studs/ hour to the CJ-Series joists.
- Stud installation rate is very equivalent to the stud installation rate for WF beams.

Welded Shear Stud Installation

- Studs shall be alternately placed on each chord angle section for double angle top chords.

- When constructability does not allow this to occur, stud placement shall be limited as follows:

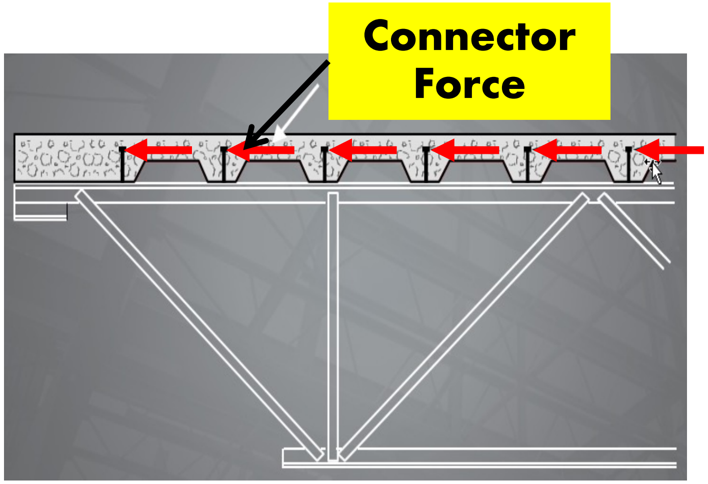
  - No more than three studs shall be placed consecutively on any one chord angle.

  - No more than 60% of the total number of studs shall be placed on any one chord angle.

Shear Stud Strength

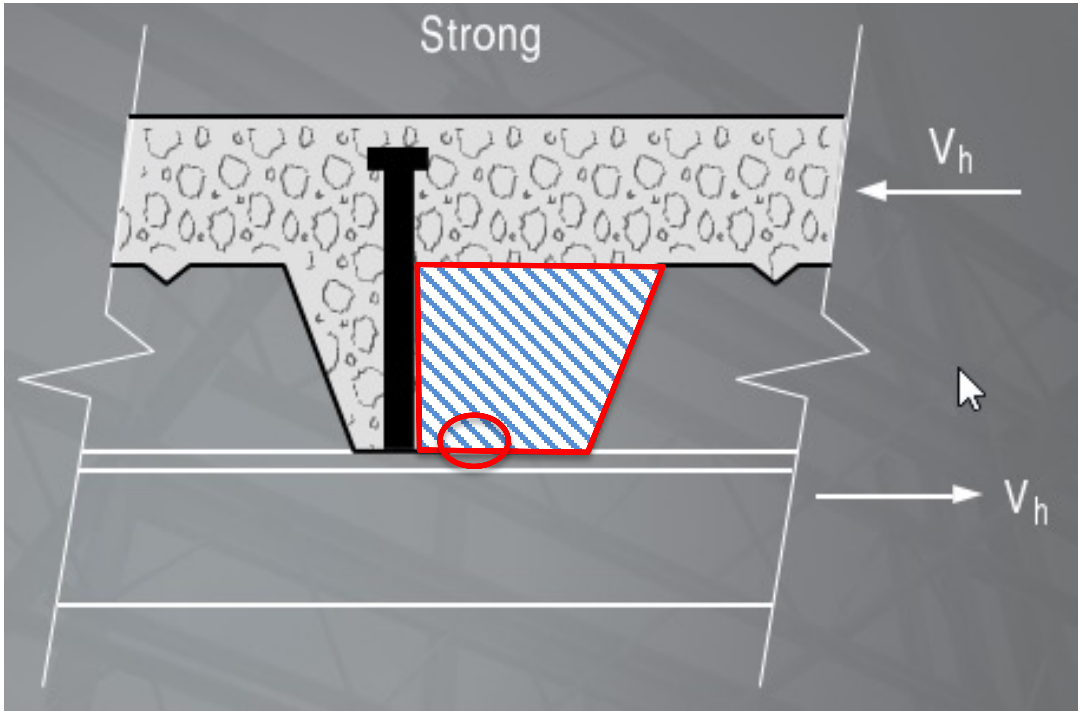
- When a composite joist is loaded, the concrete slab wants to slip relative to the joist top chord toward each end of the joist.

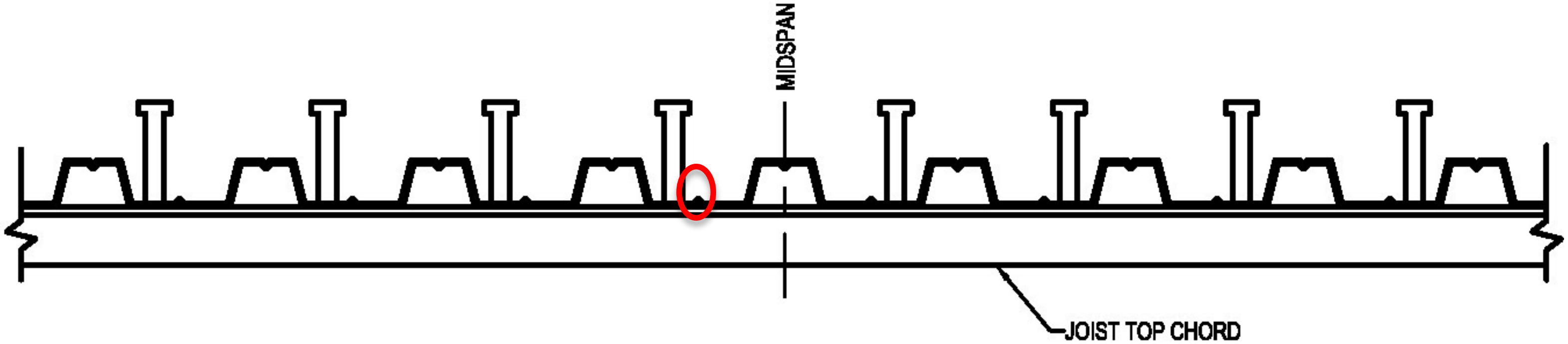
- The shear studs are attached to the joist top chord and hence acts to limit the slip of the concrete over the joist top chord.



- Shear stud located near the left joist support following a full scale load test. Note how the shear stud is bent to the left by the concrete slab moving from right to left.

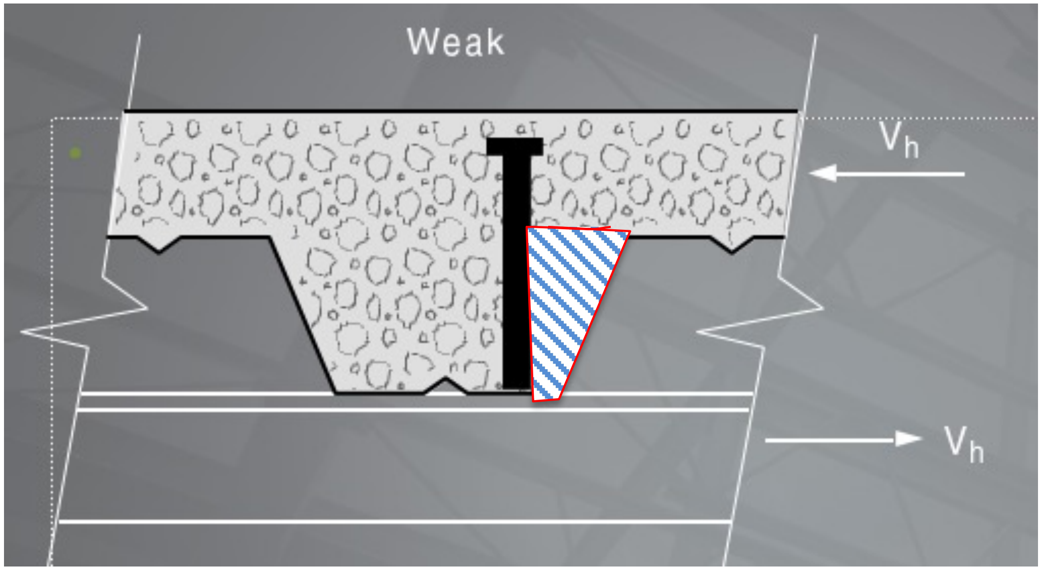
Shear Stud Layout in "Strong" Position

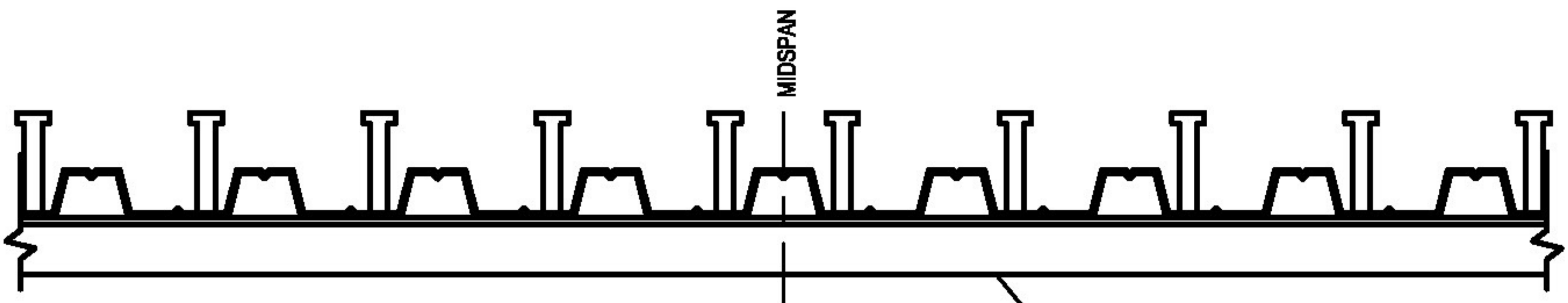




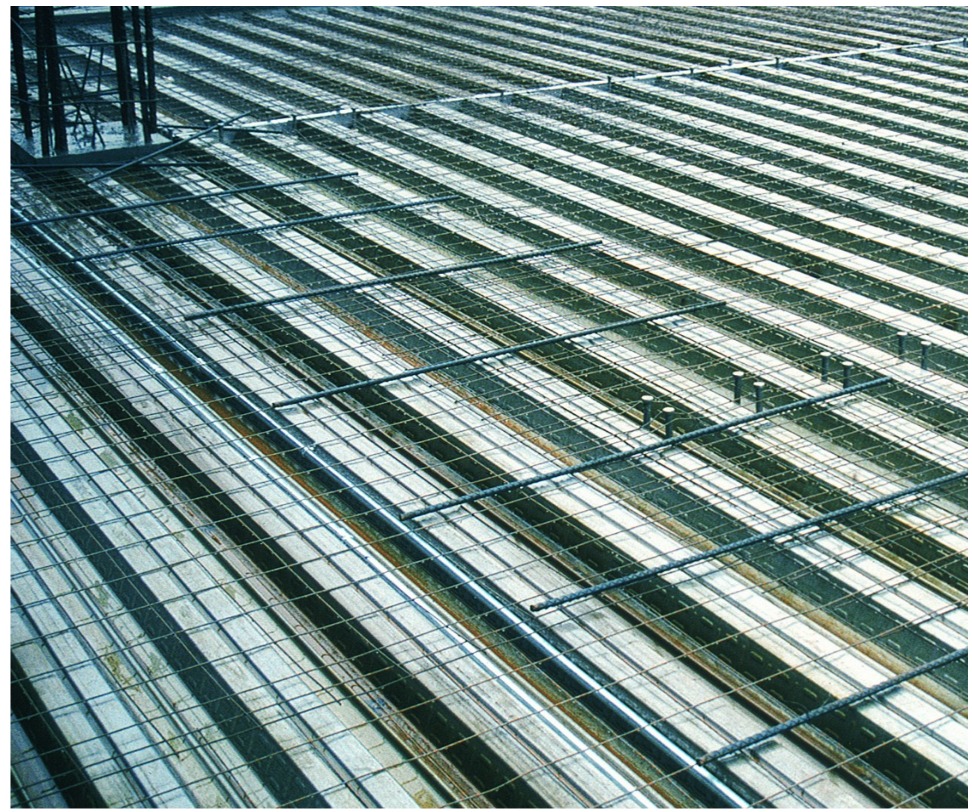
Shear Stud Layout in "Weak" Position

SJI always assumes studs in "Weak" position





Placement of Steel Reinforcement



Composite Joist Camber

- When do you want the floor flat?
- Option 1: Camber only for full non-composite dead load
- Option 2: Camber for full non-composite dead load + 50% composite dead load + 25% composite live load

Placement of Concrete

Optimal CJ-Series Joist Spacings

- Space the CJ-Series out 6’ – 12’ on center
- Fewer joists to erect
- Fewer joists to fireproof
- Larger joist members make them easier to fireproof
- Larger joist top chord members facilitate shear stud installation
- Combined cost of the CJ-Series joists and composite steel deck are reduced at wider joist spacings

SJI Floor Bay Analysis Tool

Floor Bay Analysis

(SJI Load Tables / SDI Specification and Floor Deck Design Manual)

Project Name:	SJI Floor Bay Example		
Project Number:	2020xyz		
Engineer:	XYZ	Date:	11/4/2020

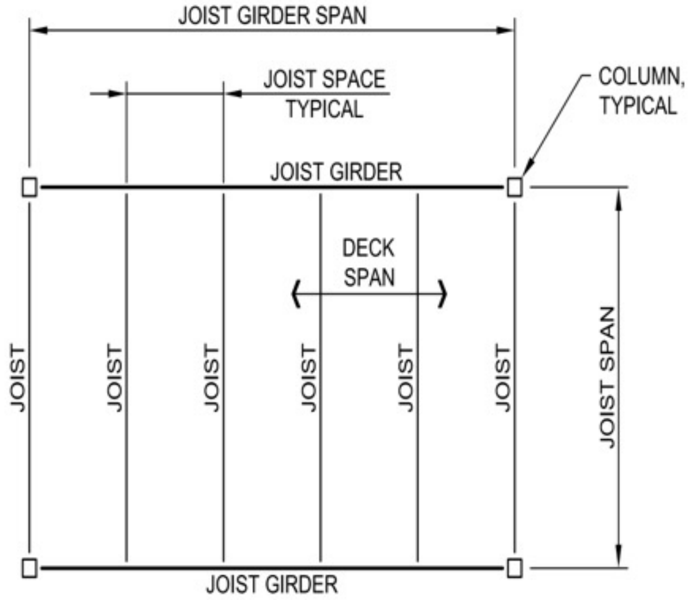
Design Methodology **LRFD** **OK** LRFD - Load and Resistance Factor Design, ASD - Allowable Strength Design

TYPICAL INTERIOR BAY LAYOUT

Bay Width / Joist Span	40.0	ft.
Bay Length / Joist Girder (JG) Span	30.0	ft.

JOIST DESIGN CRITERIA

Comp. or Non-Comp.	Non-Comp	
Steel Yield Stress	50	ksi



SJI Floor Bay Analysis Tool

CLEAR INPUT

NOMINAL FLOOR LIVE LOADS

Live Load	300	psf
Moveable Partitions	0	psf
Total Live Load	300	psf
Live Load Reduction	Y	(Y or N)

Live loads that exceed 100 psf are not reducible.

NOMINAL FLOOR DEAD LOADS

Deck & Concrete Slab	39	psf
Joists & Bridging	8.25	psf
Joist Girders	4.63	psf
Partitions	0	psf
Mechanical & Electrical	3	psf
Fireproofing	2	psf
Floor Covering	2	psf
Ceilings	2	psf
Other Deck Load	1	psf
Total Dead Load	61.87	psf

DECK & CONCRETE SLAB DESIGN CRITERIA

Deck Profile & Gage	1.5 - 22 Gage		OK
Is Deck Galvanized?	Y	(Y or N)	OK
Comp. or Non-Comp.	Comp.		OK
Reinforcement	6x6-W1.4xW1.4		OK
NW or LW Concrete	NW		
Total Slab Depth	4	in.	
Construction Live Load	20	psf	
Joist Spaces per Bay	5		

DEPTH DATA

Joist Min Depth: Default	20	in.
Joist Min Depth: Manual		in.
Joist Max Depth: Default	40	in.
Joist Max Depth: Manual		in.
JG Min Depth: Default	20	in.
JG Min Depth: Manual		in.
JG Max Depth: Default	36	in.
JG Max Depth: Manual		in.

Minimum depths are span/24 for non-composite joists & Joist Girders.

DEFLECTION CRITERIA

Deck - Concrete Weight	Min: Span/180 or 0.75 in.		0.40	in.
Joist - Live Load	Span /	360	1.33	in.
JG - Live Load	Span /	360	1.00	in.

Loads considered are unfactored nominal loads.

X-BRIDGING

Minimize X-Bridging for Spans ≤ 60 ft. | N | (Y or N)

If "Y", the lightest joist without x-bridging is selected, if it's adequate.

SJI Floor Bay Analysis Tool

DECK AND CONCRETE SLAB SUMMARY (Superimposed Loads)

Deck Profile & Gage	Total Slab Depth & Conc Type	Deck Span ft.	Max Deck Span * ft.	Required Load psf	Available Load psf	Deck Weight psf	Conc Weight Deflection Allowable in.	Conc Weight Deflection Actual in.
1.5 - 22 Gage	4 in. NW	6.00	6.34	533	564	1.78	0.40	0.13

* Maximum Deck Construction Span (Three Span) per SDI — Available Load: **OK** — Actual deflection: **OK**

JOIST SUMMARY (Total Loads)

Joist Designation	Joist Spacing ft.	Required Load lb / ft	Available Load lb / ft	Joist Weight lb / ft	Allowable Deflection in.	Live Load Deflection in.
36LH17	6.00	3293	3424	49.0	1.33	1.14
			OK			**OK**

BRIDGING SUMMARY

X-Bridging Req'd (Y or N)	Number of rows X-Bridging	Length of X-Bridging ft.	Weight of X-Bridging plf	H-Bridging Req'd (Y or N)	Number of rows H-Bridging	Length of H-Bridging ft.	Weight of H-Bridging plf	
N	0	0.00	0.00	Y	1	60.00	1.65	**OK**

JOIST GIRDER SUMMARY (Total Panel Point Loads)

Joist Girder Depth in.	Joist Spaces	Required Load kips	Load Used to Estimate Wt. kips	Joist Girder Weight lb / ft	Allowable Deflection in.	Live Load Deflection in.
36	5	133.1	135.0	185	1.00	0.67
JG Designation: 36G5N133.1F			**OK**			**OK**

SJI Floor Bay Analysis Tool

WEIGHT CHECK - ESTIMATED VS ACTUAL

Joists & Bridging		Joist Girders	
Estimated psf	Actual psf	Estimated psf	Actual psf
8.25	8.25	4.63	4.63
OK	UPDATE	**OK**	UPDATE

WEIGHT RESULTS

Reinforce-ment Weight	Deck Weight	K-Joist, LH ≤ 60' Weight	DLH-Joist, LH > 60' Weight	X-Bridging Weight	H-Bridging Weight	Joist Girder Weight	
0.19	1.78	8.17	0.00	0.00	0.08	4.63	psf
0.11	1.07	4.90	0.00	0.00	0.05	2.78	tons / bay

SJI Floor Bay Analysis Tool

COST DATA

CLEAR COSTS

Item	Purchase $ / Unit	Purchase Unit	Installation $ / Unit	Installation Unit
Normal Weight Concrete	85	cubic yards	260	100 sf
Light Weight Concrete	115			
6x6-W1.4xW1.4	37	100 sf	20	100 sf
6x6-W2.1xW2.1	44			
6x6-W2.9xW2.9	53			
6x6-W4.0xW4.0	63			
6x6-W6.0xW6.0	81			
4x4-W2.9xW2.9	63			
4x4-W4.0xW4.0	81			
4x4-W6.0xW6.0	105			
Rebar	900	ton	900	ton
Deck	1700		70	100 sf
K or LH-Joists ≤ 60'	2000		200	piece
LH-Joists > 60', DLH-Joists, Joist Girders	1800		250	piece
3/8" Studs	1.10	piece	1.00	piece
1/2" Studs	1.20		1.00	
5/8" Studs	1.50		1.00	
3/4" Studs	1.40		1.00	
X-Bridging	1700	ton	3.50	foot
H-Bridging	1500		2.00	foot

Consult with general contractor / joist manufacturer / erector for cost data.

SJI Floor Bay Analysis Tool

COST RESULTS

Concrete		Reinforcement		Deck		
Purchase	Installation	Purchase	Installation	Purchase	Installation	
$0.81	$2.60	$0.37	$0.20	$1.51	$0.70	$ / sf
$970	$3,120	$444	$240	$1,816	$840	$ / bay

Joists		Studs		Bridging		Joist Girders		
Purchase	Installation	Purchase	Installation	Purchase	Installation	Purchase	Installation	
$8.17	$0.83	$0.00	$0.00	$0.06	$0.10	$4.16	$0.21	$ / sf
$9,800	$1,000	$0	$0	$74	$120	$4,995	$250	$ / bay

FINAL TOTALS

Cost			
Purchase	Installation	Total	
$15.08	$4.64	$19.72	$ / sf
$18,099	$5,570	$23,669	$ / bay

Concrete Volume cu yd/bay
11.4

Reinf Weight	Steel Weight (w/o Reinf)	
0.19	14.65	psf
0.11	8.79	tons / bay

OK

Design is acceptable and within the limits of this program.

SJI Floor Bay Analysis Tool

RUN DATA

Design Methodology	LRFD
Joist Span, ft.	40.0
Joist Girder Span, ft.	30.0
Deck Profile & Gage	1.5 - 22 Gage
Tot. Slab Depth & Type	4 in. NW Comp.
Reinforcement	6x6-W1.4xW1.4
Deck Span, ft.	6.00
X-Bridging Rows	0
H-Bridging Rows	1
Joist Size	36LH17
Studs/bay & Diameter	0
Joist Seat Depth, in.	5
Joist Girder Size	36G5N133.1F
Concrete, cu yd/bay *	11.4
Reinf Weight, psf	0.19
Stl Wt (w/o Reinf), psf	14.65
Total Cost, $ / sf	$19.72

COPY TO TABLE

CLEAR TABLE

SJI Floor Bay Analysis Tool

RUN COMPARISONS

	Run 1	Run 2	Run 3	Run 4
Design Methodology	LRFD			
Joist Span, ft.	40.0			
Joist Girder Span, ft.	30.0			
Deck Profile & Gage	1.5 - 22 Gage			
Tot. Slab Depth & Type	4 in. NW Comp.			
Reinforcement	6x6-W1.4xW1.4			
Deck Span, ft.	6.00			
X-Bridging Rows	0			
H-Bridging Rows	1			
Joist Size	36LH17			
Studs/bay & Diameter	0			
Joist Seat Depth, in.	5			
Joist Girder Size	36G5N133.1F			
Concrete, cu yd/bay *	11.4			
Reinf Weight, psf	0.19			
Stl Wt (w/o Reinf), psf	14.65			
Total Cost, $ / sf	$19.72			

* Concrete volumes are based on SDI's conservative slab weight estimates. The volumes are not precise.

SJI Floor Bay Analysis Tool

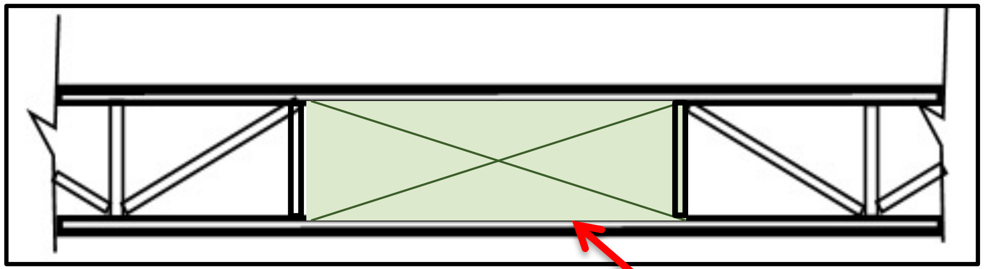
RUN COMPARISONS

	Run 1	Run 2	Run 3	Run 4
Design Methodology	LRFD	LRFD	LRFD	
Joist Span, ft.	40.0	40.0	40.0	
Joist Girder Span, ft.	30.0	30.0	30.0	
Deck Profile & Gage	1.5 - 22 Gage	1.5 - 22 Gage	1.5 - 22 Gage	
Tot. Slab Depth & Type	4 in. NW Comp.	4 in. NW Comp.	4 in. NW Comp.	
Reinforcement	6x6-W1.4xW1.4	6x6-W1.4xW1.4	6x6-W1.4xW1.4	
Deck Span, ft.	6.00	6.00	6.00	
X-Bridging Rows	0	0	0	
H-Bridging Rows	1	1	1	
Joist Size	36LH17	32LH18	32CJ3278/2880/72	
Studs/bay & Diameter	0	0	(250) 3/4" Studs	
Joist Seat Depth, in.	5	7.5	5	
Joist Girder Size	36G5N133.1F	36G5N133.4F	36G5N132.5F	
Concrete, cu yd/bay *	11.4	11.4	11.4	
Reinf Weight, psf	0.19	0.19	0.19	
Stl Wt (w/o Reinf), psf	14.65	15.87	12.55	
Total Cost, $ / sf	$19.72	$20.92	$18.13	

* Concrete volumes are based on SDI's conservative slab weight estimates. The volumes are not precise.

Rectangular Vierendeel Openings

- Specially designed panel configurations and web openings can be provided to accommodate MEP.



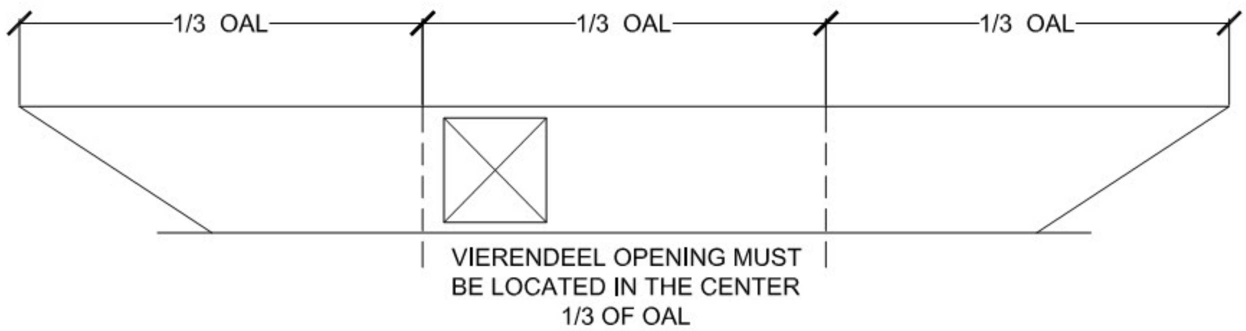
Rectangular Vierendeel Opening at Joist Mid-Span

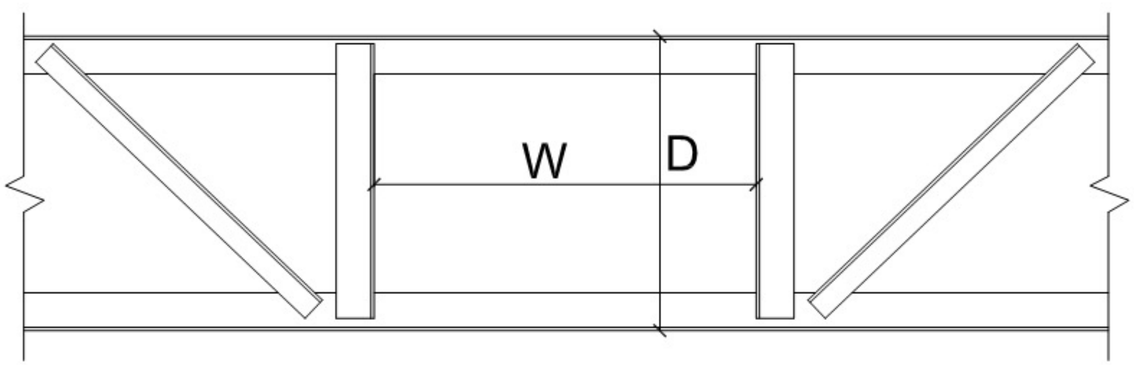
Rectangular Vierendeel Openings

- Design Considerations for Joist Manufacturer
  - Chord design must account for bending moments developed in transferring shear across an opening without diagonal web members. This commonly requires larger chords or chord reinforcing.
  - The vertical webs at each edge of the opening may be designed as pinned-end members or as moment-frame members. If designed as moment frame members, these webs will likely also be reinforced and will likely require special moment connections to the chord members.
  - Partial span loading effects on member forces in the region around the opening must be considered.
  - To avoid interference from bridging and bridging clips, bridging lines should be located outside the openings. This may increase the number of bridging rows to adequately brace the joist.

Rectangular Vierendeel Openings

- Must be located in center third of the joist
- Maximum opening width is twice the depth



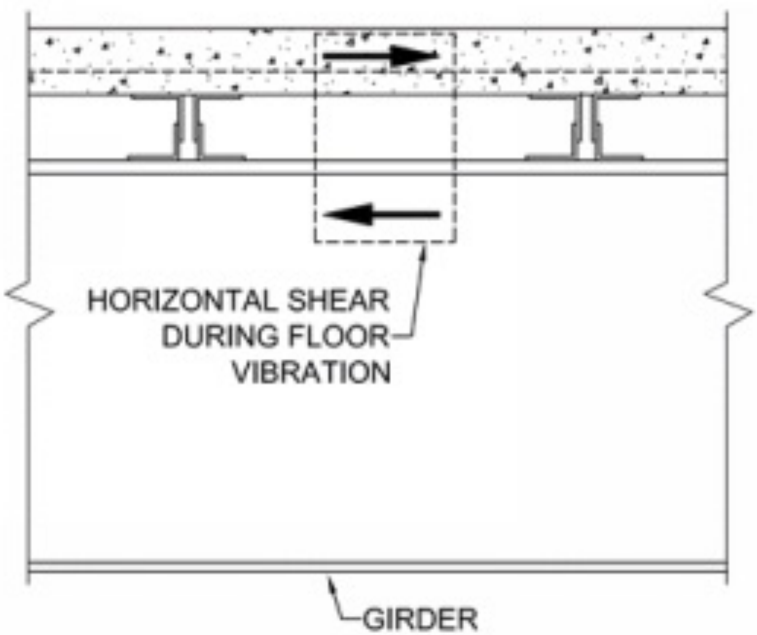


MAXIMUM VIERENDEEL OPENING: W = 2 x D

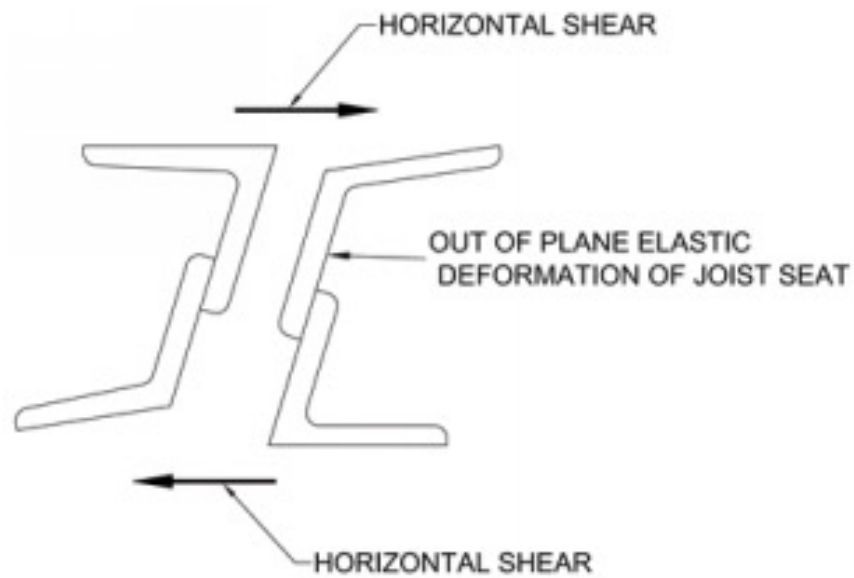
Rectangular Vierendeel Openings

- Guidelines for Specifying Professional
  - Maximum Opening Depth: Subtract 6” to 12” from the joist depth to account for increased chord sizes
  - Maximum Opening Width: 2 x Joist Depth (narrower is better)
  - Specified minimum opening must account for insulation, spray applied fire proofing, etc., as applicable
  - Locate openings in the center third of joist span
  - Multiple openings within a single joist should be avoided. If required, a minimum space of twice the joist depth must be maintained between openings to allow transfer of shear forces

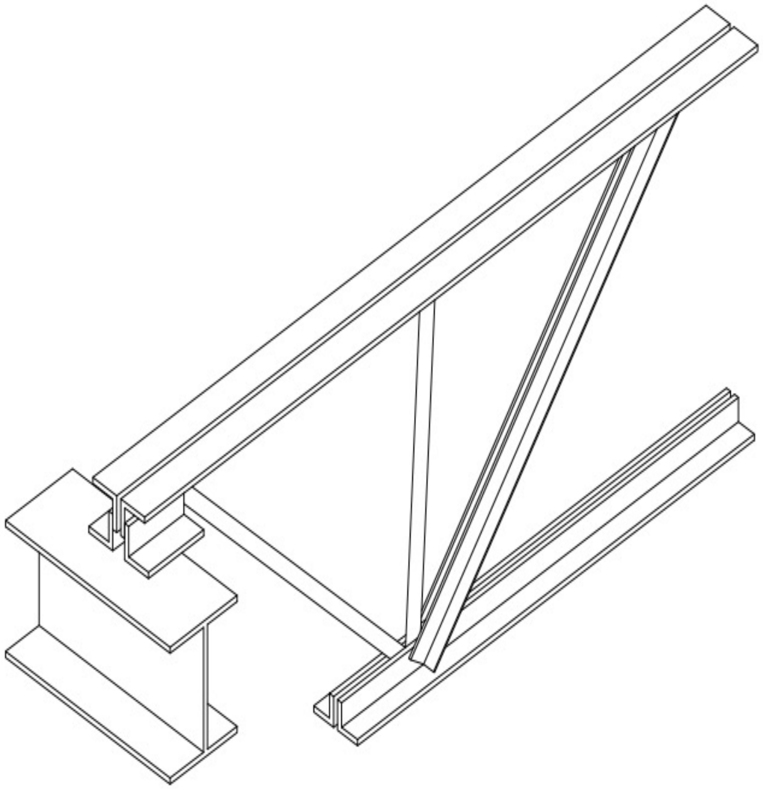
Lateral Deformation of "Standard" Seat



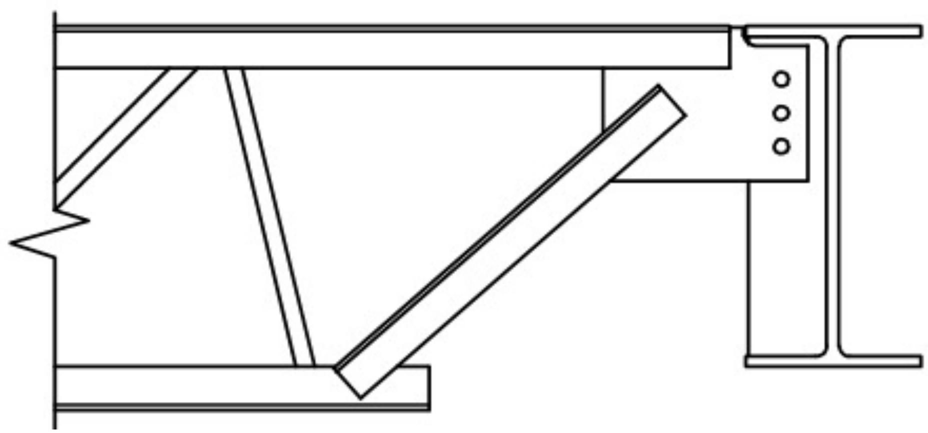
(a) Horizontal Shear Forces



CJ-Series Joist Seat Types



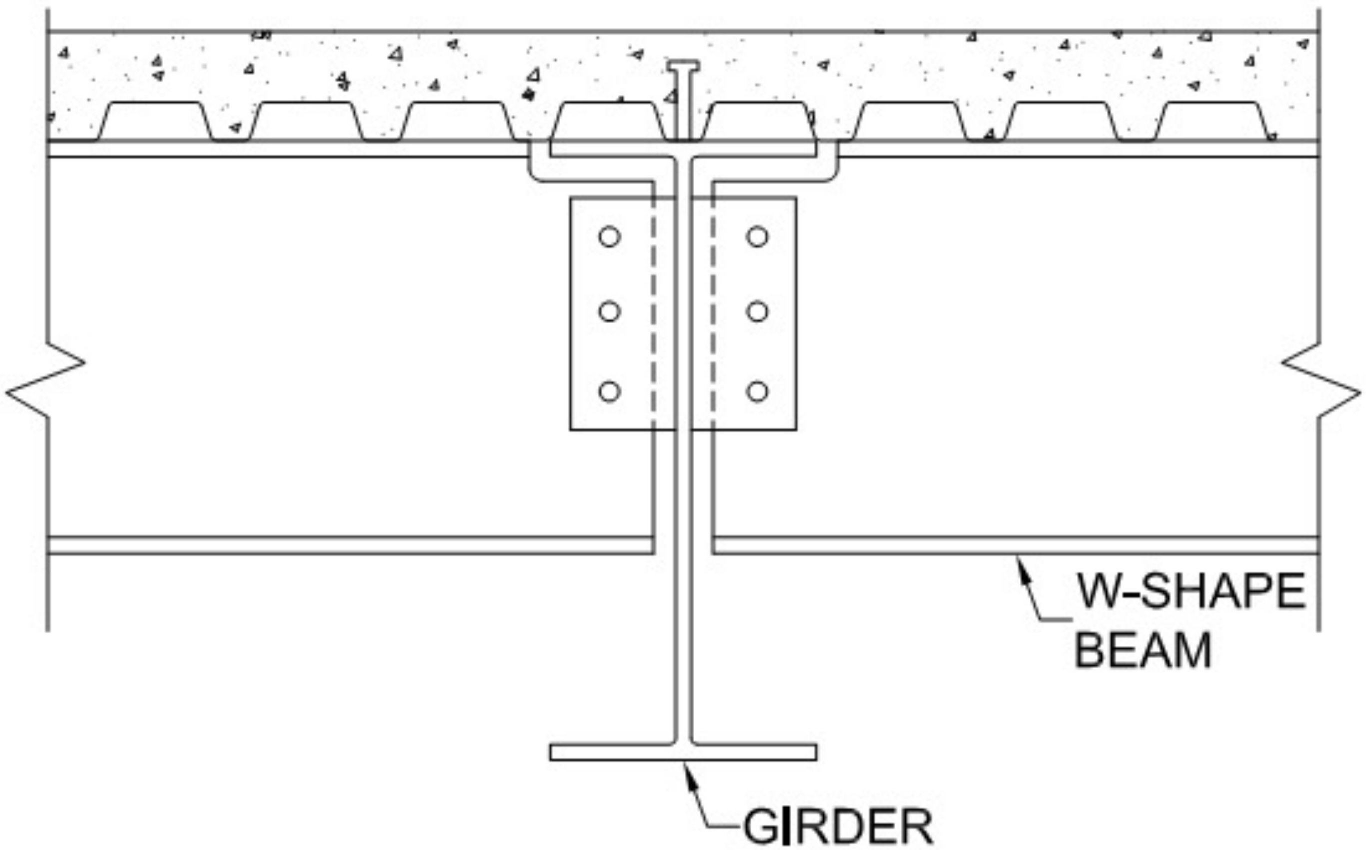
Standard Top Chord Bearing Seat



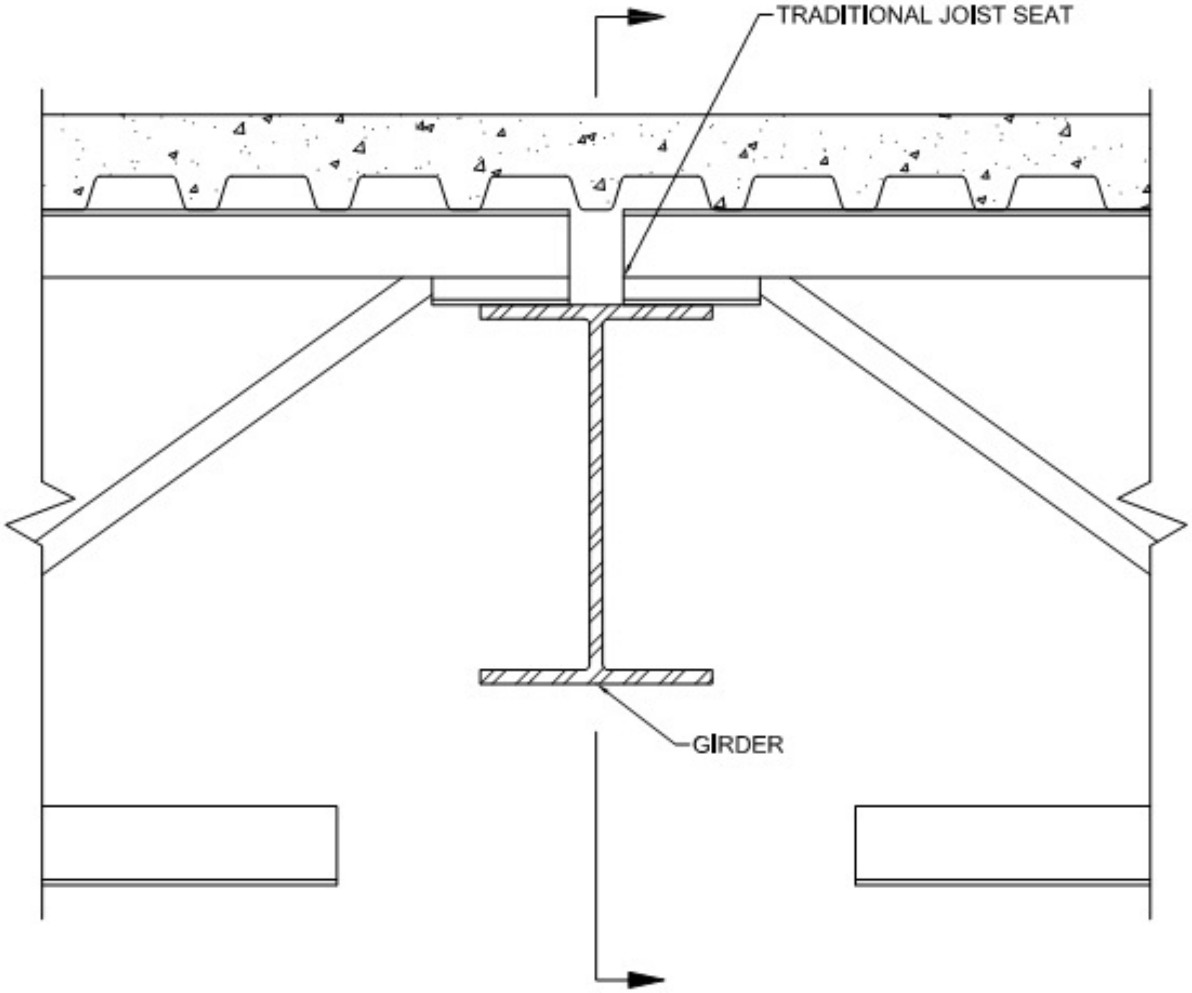
Flush Framed Top Chord Bolted Seat

In 2020, Over 90% of all fabricated CJ-Series joists have been fabricated with flush framed top chord bolted seats.

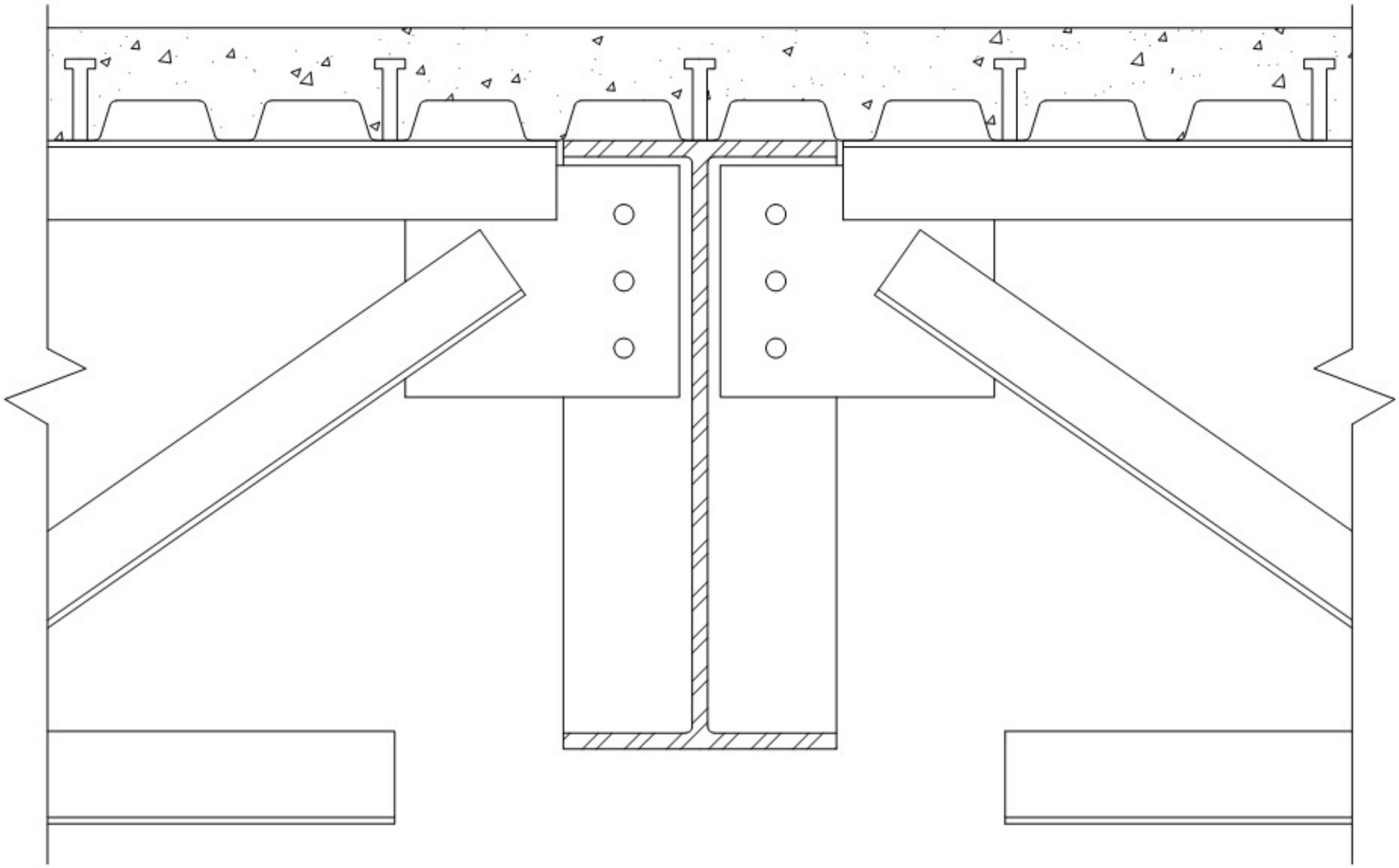
Typical Beam to WF Girder Connection



Typical Joist to WF Girder Connection



Flush Framed Top Chord Bolted Seat



Effect on Hot-rolled Girder Composite Moment of Inertia by Standard Joist Seats

- Joists (K, LH, DLH, and CJ –Series with standard 2.5 – 10” deep joist seats reduce the hot-rolled girder composite moment of inertia.

  For hot-rolled girders supporting a standard joist seat:

  $I_g = I_x + \frac{I_{comp} - I_x}{4}$ (AISC DG11, 2ND Ed. Eqn 3-11)

- For a hot-rolled girder supporting a beam:

  $I_g = I_{comp}$

  Where:

  I_x = Moment of inertia for steel hot-rolled girder

  I_{comp} = Fully composite moment of inertia for the slab & hot-rolled girder

Girder Effective Width

- For the girder panel mode, the effective width, except for the edge girders is:

$$B_g = C_g \left(\frac{D_j}{D_g}\right)^{\frac{1}{4}} L_g \leq \frac{2}{3} floor\ length \quad \text{(Eqn 4-4)}$$

$C_g = 1.6$ for girders supporting joists with joist standard seats

$C_g = 1.8$ for girders supporting beams connected to girder web

Floor Vibration - CJ-Series Composite Steel Joists with Flush Framed Top Chord Bolted Seats

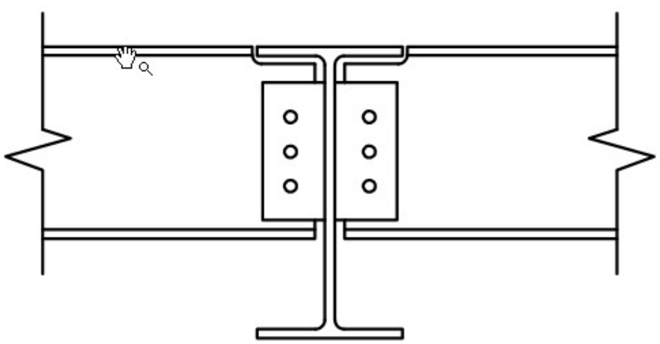
- Excellent floor vibration characteristics equivalent to wide flange beam construction

$$\frac{a_p}{g} = \frac{P_o e^{-0.35 f_n}}{\beta W} \le \frac{a_o}{g}$$

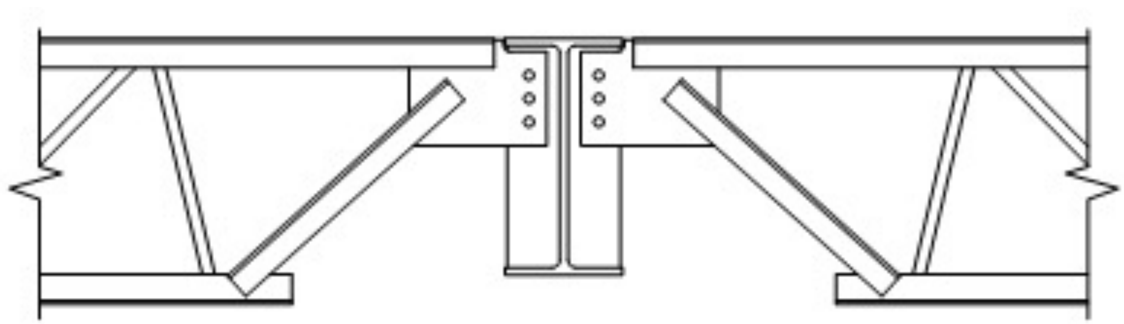
Eqn 2-6, AISC DG 11, 2nd Edition

- Wide flange beams and joists with flush framed top chord bolted connections, increase W by 50% to account for energy transfer across the girder into the adjacent bay

- Net effect is a reduction in the acceleration by at least 33% vs. joists with standard seats.



Web Shear Tab



Flush Framed Top Chord Bolted Connection

Joists with Flush Framed Connections to WF Girders or Joist Girders

- You can utilize $I_g = I_{comp}$
- You can utilize a larger C_g = 1.8 vs. 1.6
- You can increase W_j by 50% - The most positive significant impact of these three items.

What to Do When $\frac{a_p}{g} > 0.50\%$?

1) Increase mass of the floor

   a. Utilize flush framed top chord bolted joist seats - can increase effective floor panel mass by 50%

   b. Increase concrete floor thickness

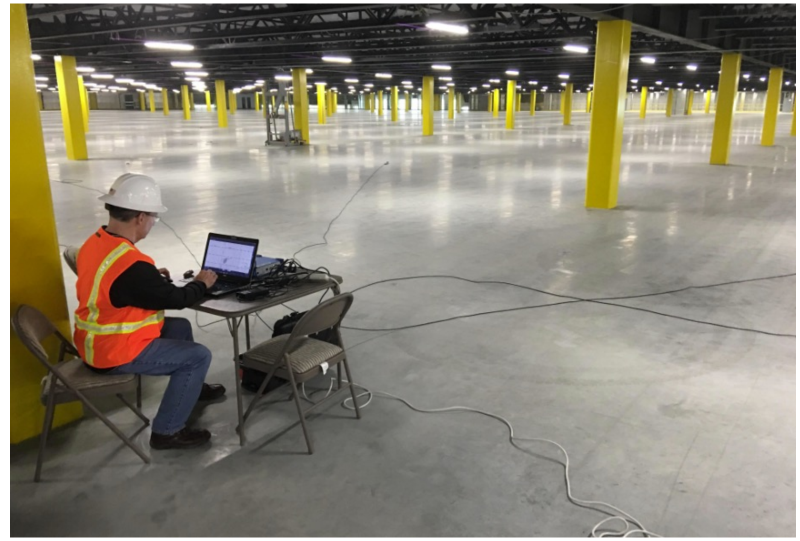
2) Increase stiffness of joist \ girder which ever has the lowest frequency, Typically the joists

   a. Increase joist \ Joist Girder depth

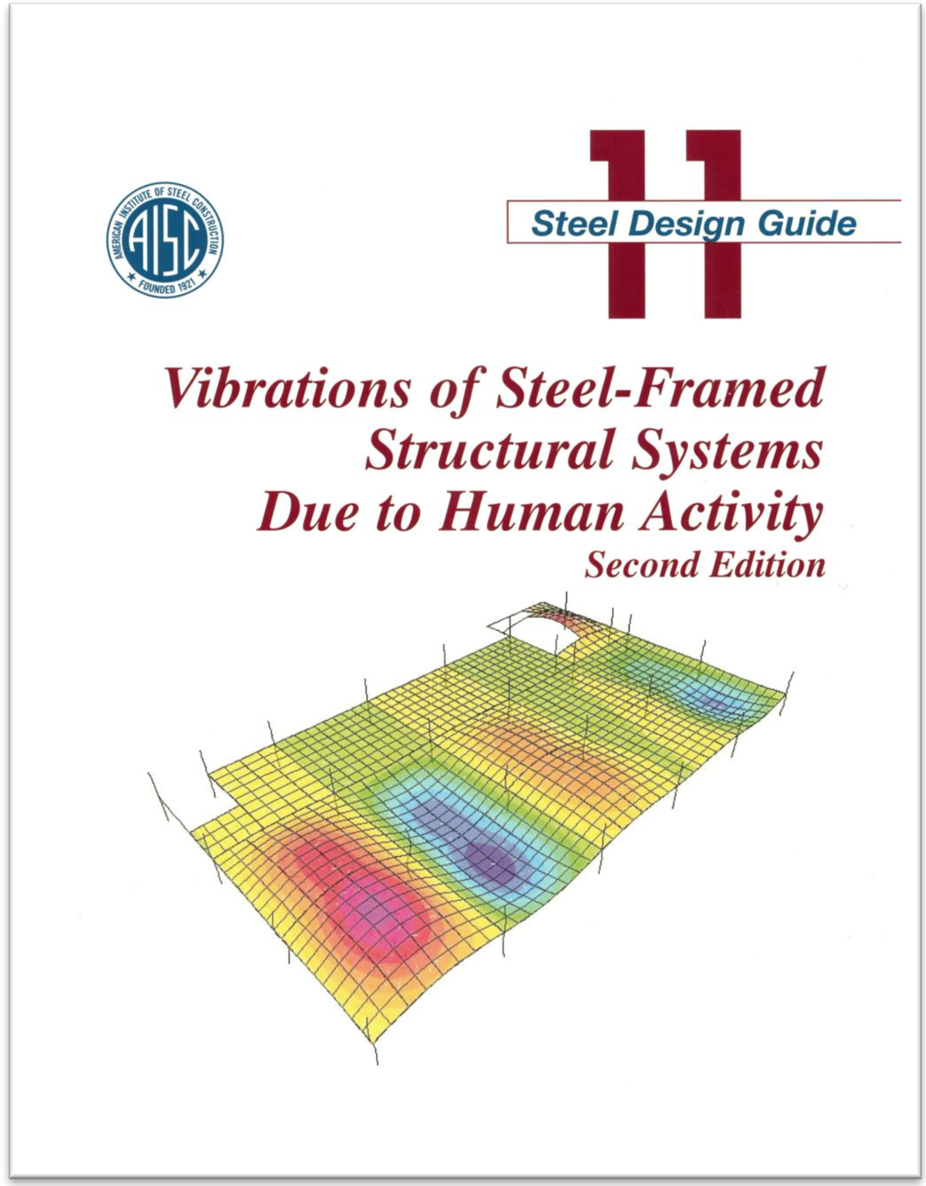
   b. Increase bottom chord section size

Floor Vibration of CJ-Series Joists with Flush Framed Top Chord Bolted Connections

- Dr. Brad Davis, University of Kentucky measuring floor vibration in a retail distribution center.
- CJ-Series joists measured were fabricated utilizing Vulcraft's flush framed top chord bolted connection.
- Excellent floor vibration behavior was noted.
- Vibration behavior was equivalent to that of wide flange beams framing into wide flange girders.
- Future release of FloorVibe 3.1 will handle joists with flush framed top chord bolted connections.



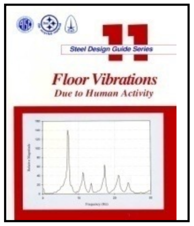

STEEL JOIST
SJI
INSTITUTE
TECHNICAL DIGEST 5
VIBRATION ANALYSIS OF STEEL JOIST CONCRETE FLOOR SYSTEMS
5


AMERICAN INSTITUTE OF STEEL CONSTRUCTION
AISC
FOUNDED 1921
11
Steel Design Guide
Vibrations of Steel-Framed Structural Systems Due to Human Activity
Second Edition

FloorVibe 3.0

FloorVibe 3.0

Software for Analyzing
Floors for Vibrations Criteria Based on
AISC/CISC Design Guide 11
SJI Technical Digest 5



SEI

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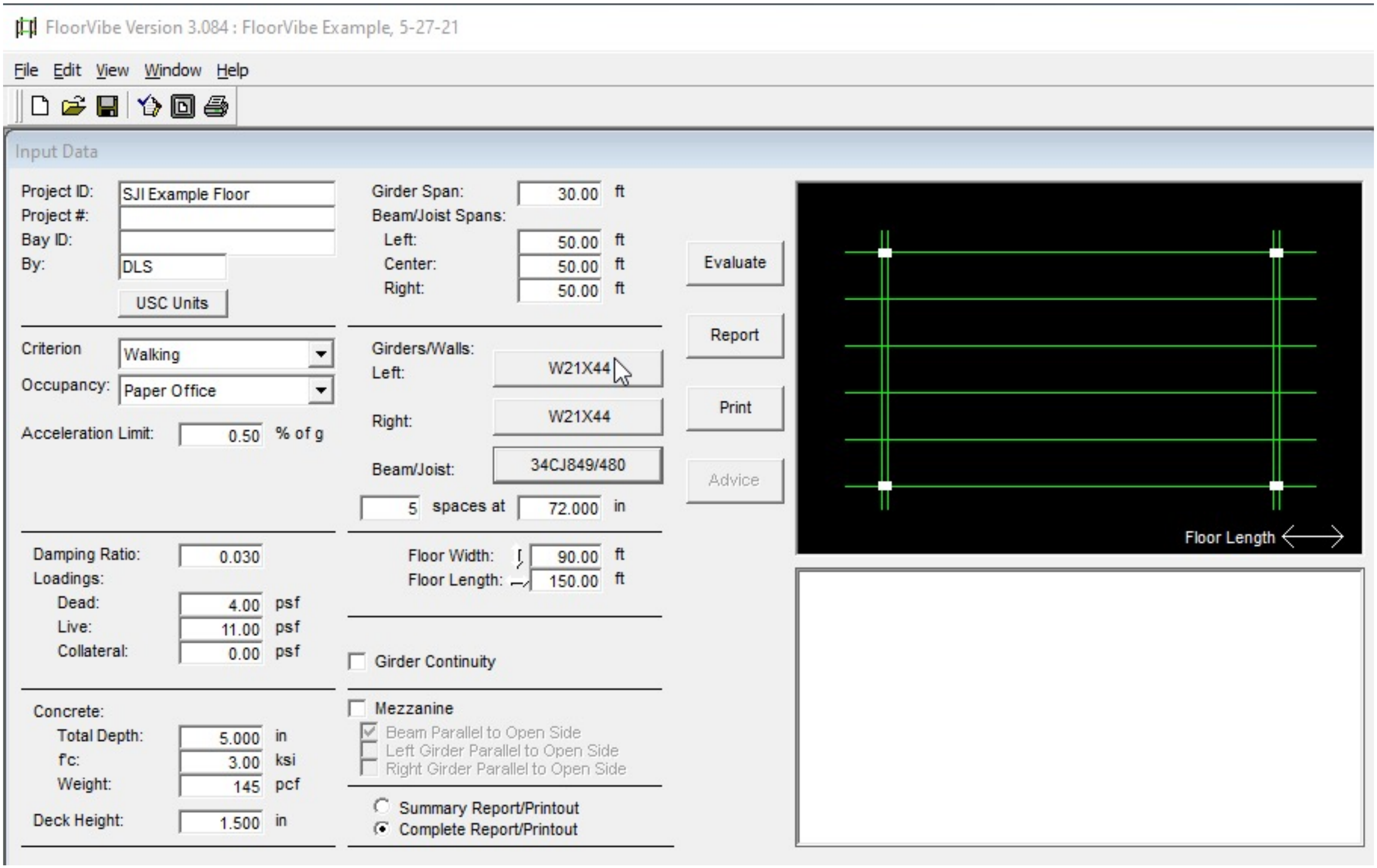
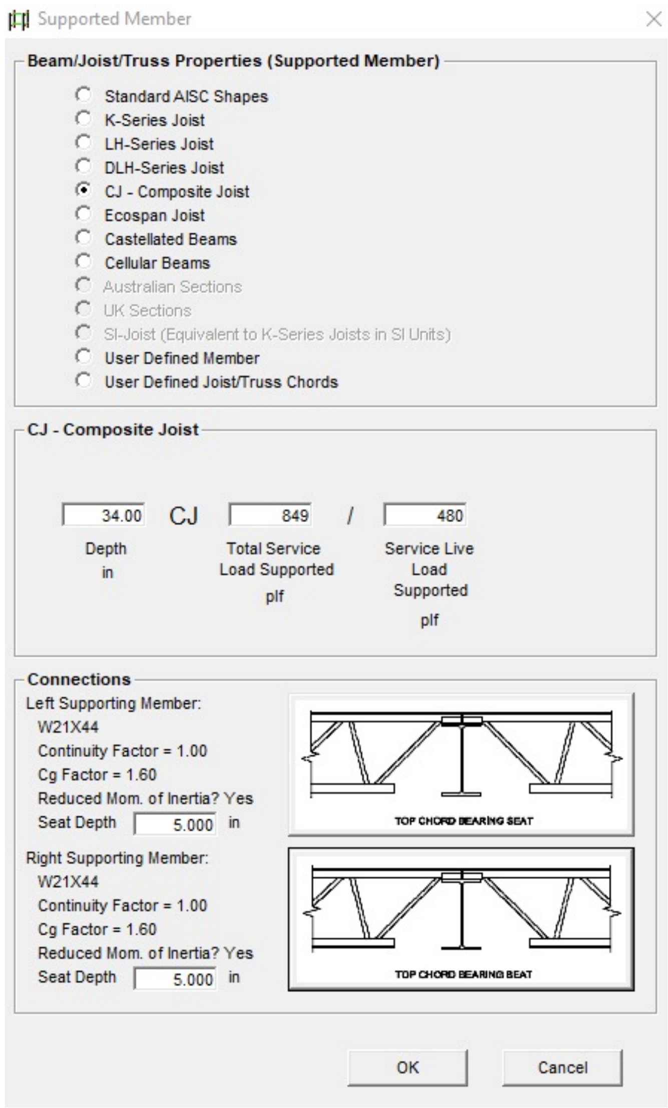
http://www.floorvibe.com

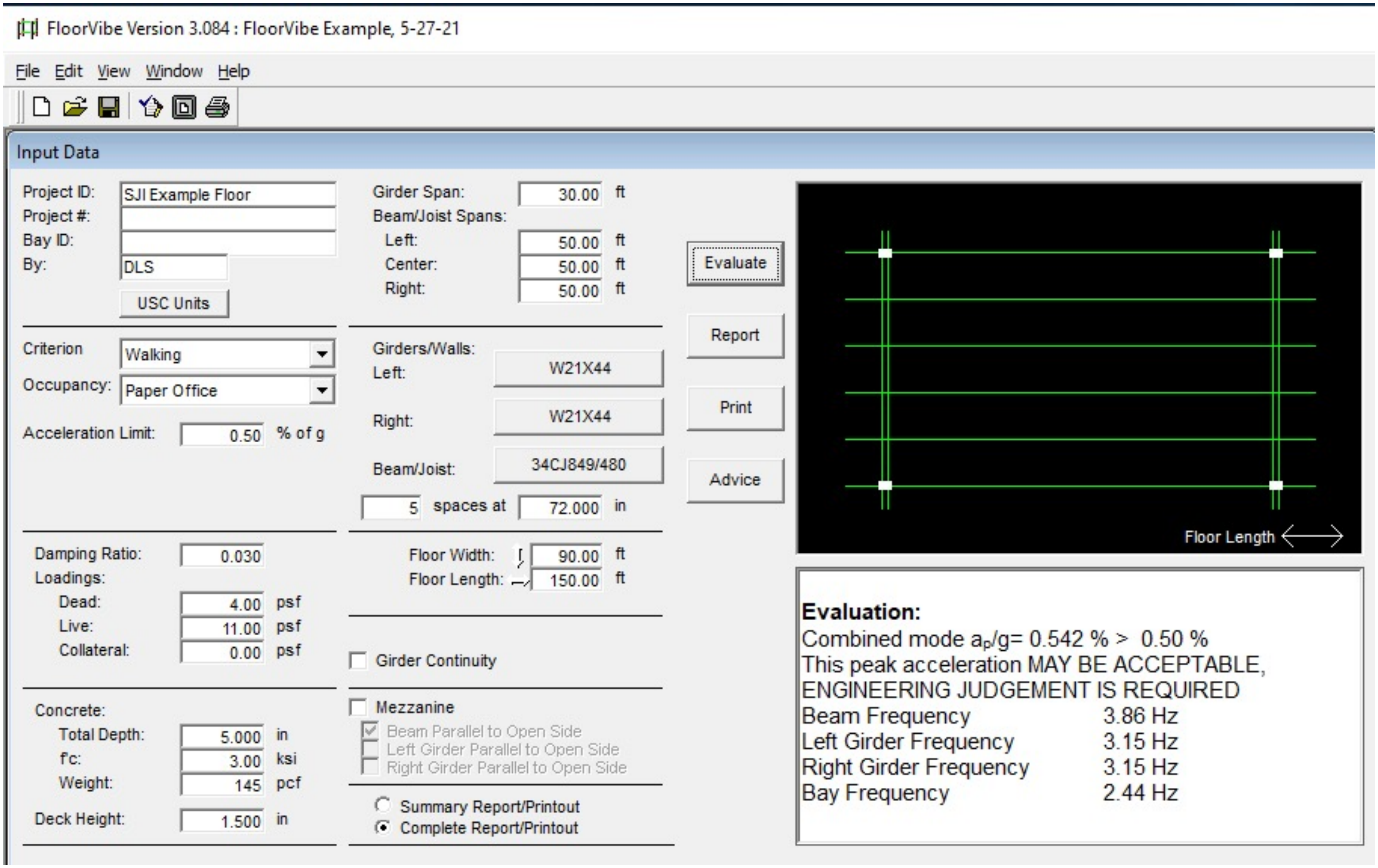
FloorVibe 3.084



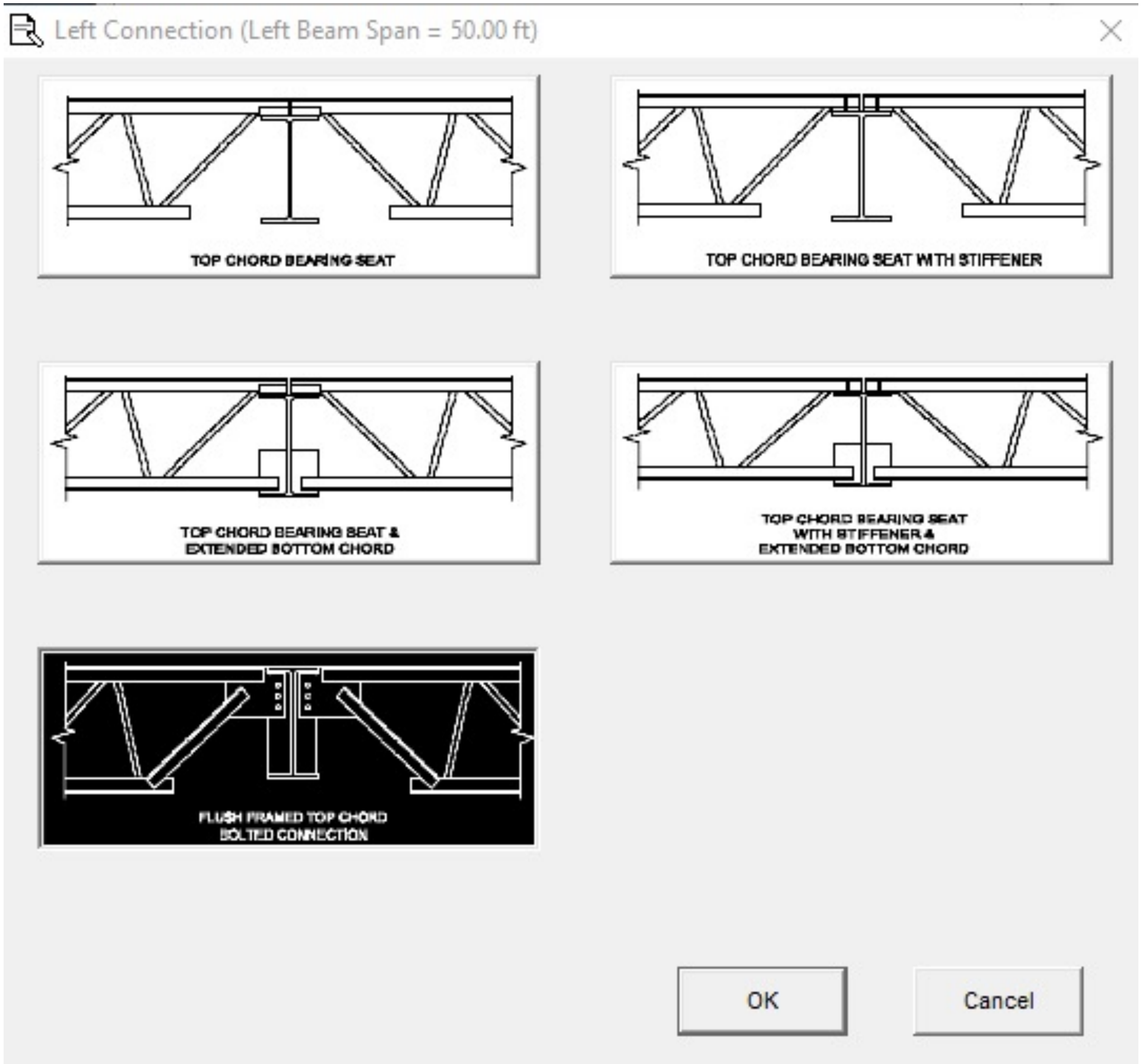
Standard Bearing Seats



Standard Bearing Seats: Ap / g = 0.54%



Check Flush Framed Top Chord Bolted Connection



Flush Framed Top Chord Bolted Connection – Both Ends of Joist

Supported Member

Beam/Joist/Truss Properties (Supported Member)

- ( ) Standard AISC Shapes
- ( ) K-Series Joist
- ( ) LH-Series Joist
- ( ) DLH-Series Joist
- (•) CJ - Composite Joist
- ( ) Ecospan Joist
- ( ) Castellated Beams
- ( ) Cellular Beams
- ( ) Australian Sections
- ( ) UK Sections
- ( ) SI-Joist (Equivalent to K-Series Joists in SI Units)
- ( ) User Defined Member
- ( ) User Defined Joist/Truss Chords

CJ - Composite Joist

34.00 CJ 849 / 480

Depth in | Total Service Load Supported plf | Service Live Load Supported plf

Connections

Left Supporting Member:

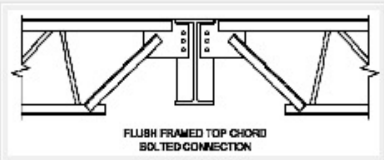
W21X44

Continuity Factor = 1.50

Cg Factor = 1.80

Reduced Mom. of Inertia? No

Seat Depth 0.000 in



Right Supporting Member:

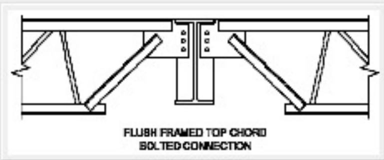
W21X44

Continuity Factor = 1.50

Cg Factor = 1.80

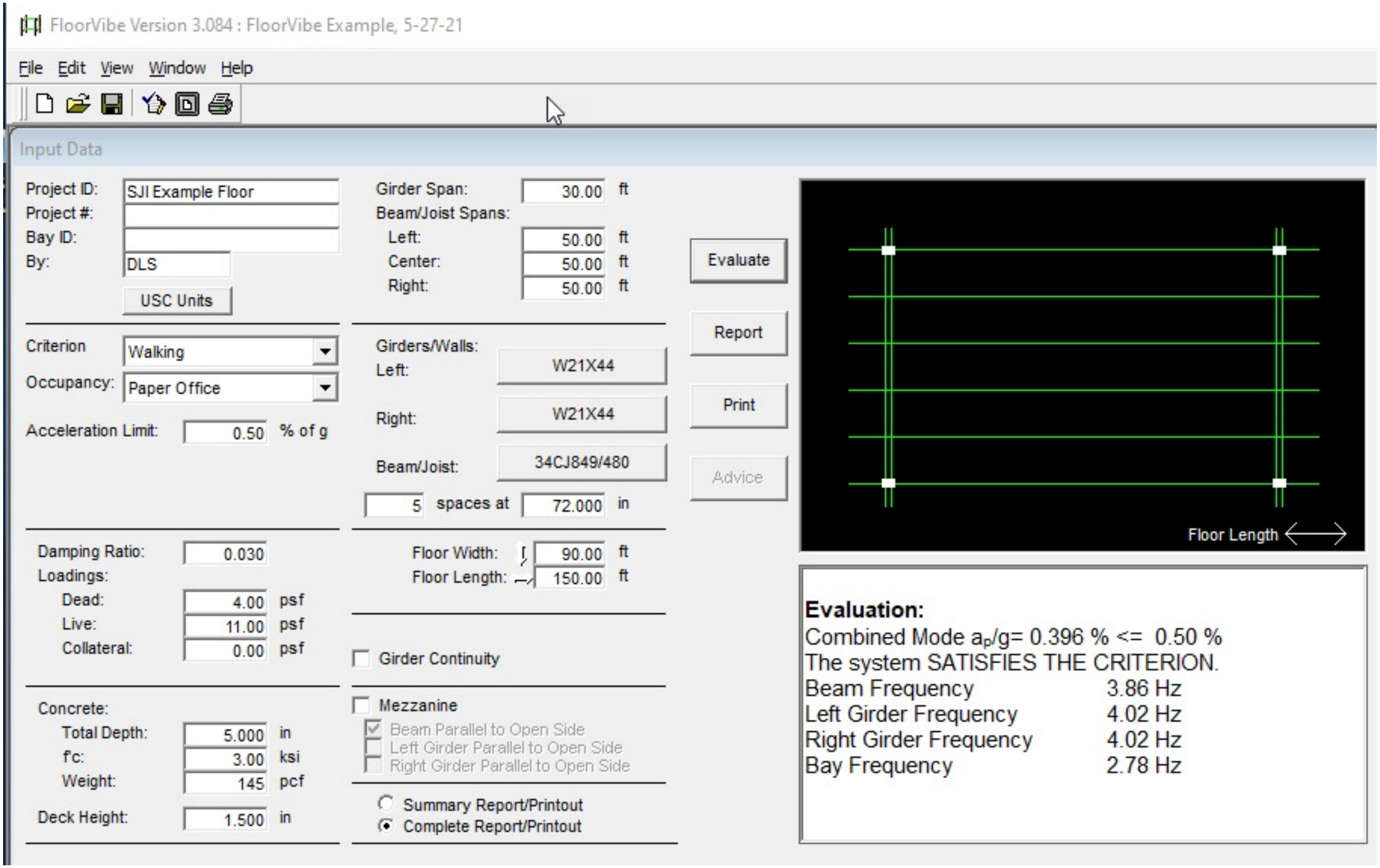
Reduced Mom. of Inertia? No

Seat Depth 0.000 in



OK Cancel

Flush Framed Connection: Ap/g = 0.396%



Kohl's Department Stores

More than 1,140 stores in U.S.

More than 650 stores with CJ-Series Composite Steel Joists

Fan Pier Parcel I, Boston, MA Office Building EOR: McNamara Salvia Structural Engineers, Boston, MA

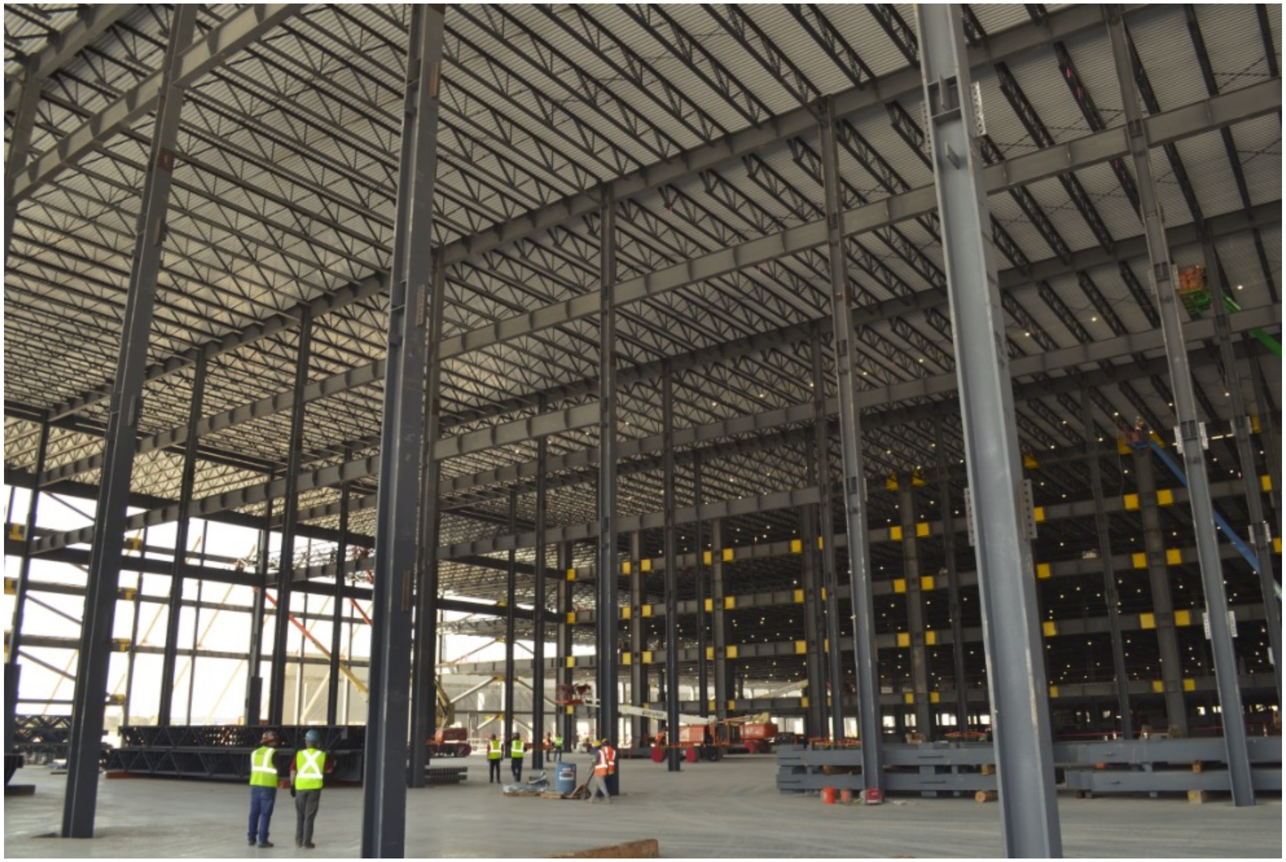
Fan Pier Parcel I, Boston, MA Office Building

- 17 stories of CJ-Series Composite Joists
- 30CJ, 45 – 59’ foot spans, 10 foot c/c joist spacing
- 6 ¼” light weight slab on 3” VLI composite deck
- LL = 100 psf
- 22” x 56” Vierendeel opening at mid-span
- Ieff = 7,500 in^4
- Joists flush with composite WF Girders
- Spray on fire proofing

Retail Distribution Centers

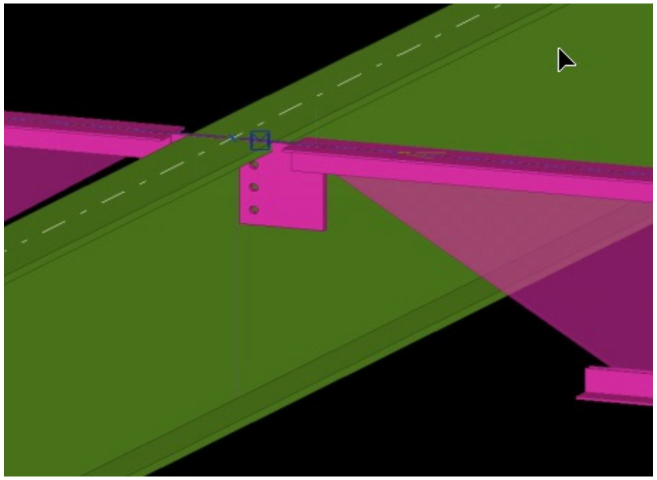
Retail Distribution Center

- Panelized roof joists installed first protecting work area from weather.
- Panelized CJ-Series joists lifted into place next on 5^{th}, 4^{th}, 3^{rd}, and 2^{nd} floors.
- Significant reduction in erection time and reduced erector fall hazards.
- CJ-Series joists have twice the performance with half the weight as WF beams



Extended Girder Shear Plates to Facilitate Panelized CJ-Series Joist Erection

Non-extended Girder Shear Plates & Flush Framed Top Chord Bolted Connection



On October 27th RISAFLOOR Version 15.0 released

RISAFloor

- Added Composite Joist Design per SJI Specification 200-2015
- Updated the SJI 42nd edition joist capacities for LH-, DLH- and SLH-series
- Updated the SJI 43RD / 44TH edition Safe Load capacities for the LH- and DLH - series

CJ Joist Weight vs. Alternatives

Span: 50 feet LL: 150 psf 6 ft o.c. Max LL Defl = L/360

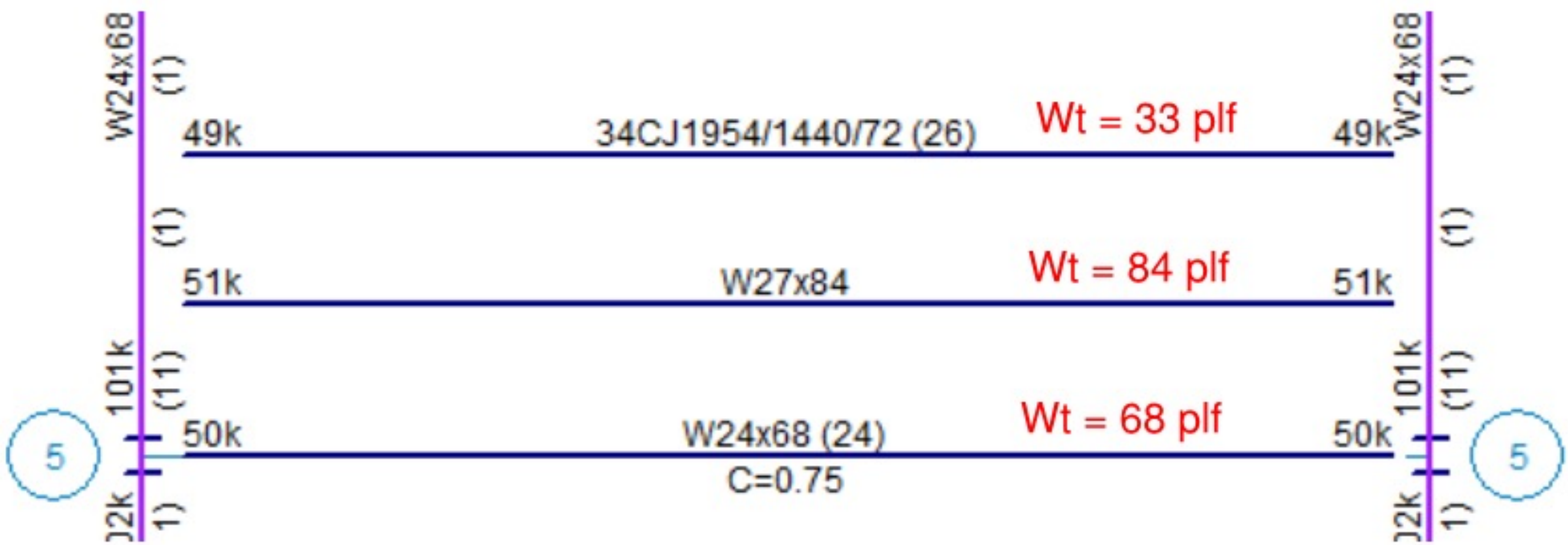
Design 1: 34CJ1980 / 1440/80 @ 33 plf

Design 2: Standard Non-composite Joists
Alternative 34LH 1980 / 1440 @48 plf

Design 3: Structural Steel Alternative
Composite W24 x 68

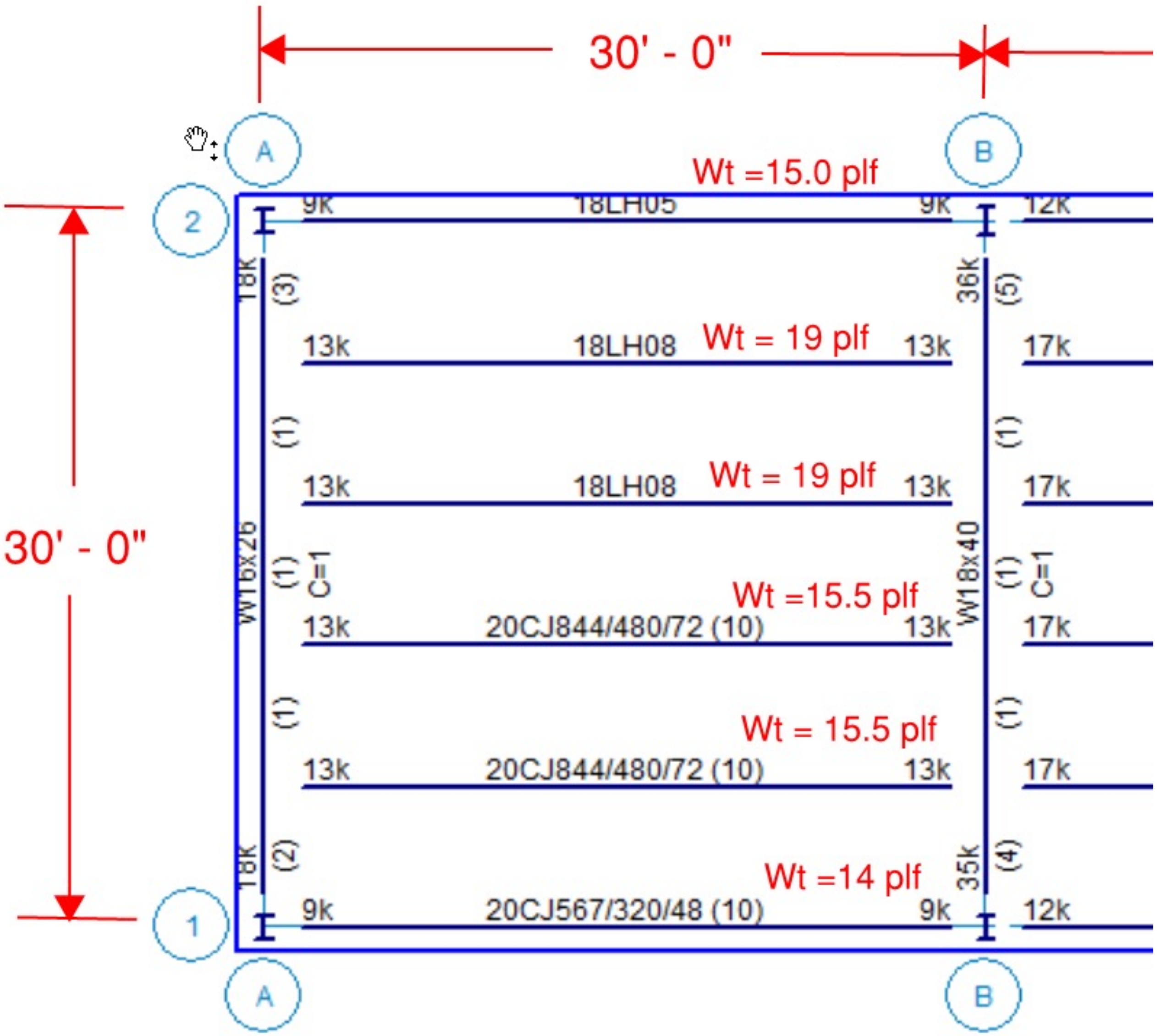
Design 4: Structural Steel Alternative
Non-composite W27x84

SJI CJ-Series Joists vs. Composite Wide Flange for 50' Span, LL = 150 psf, Max LL Defl = L/360



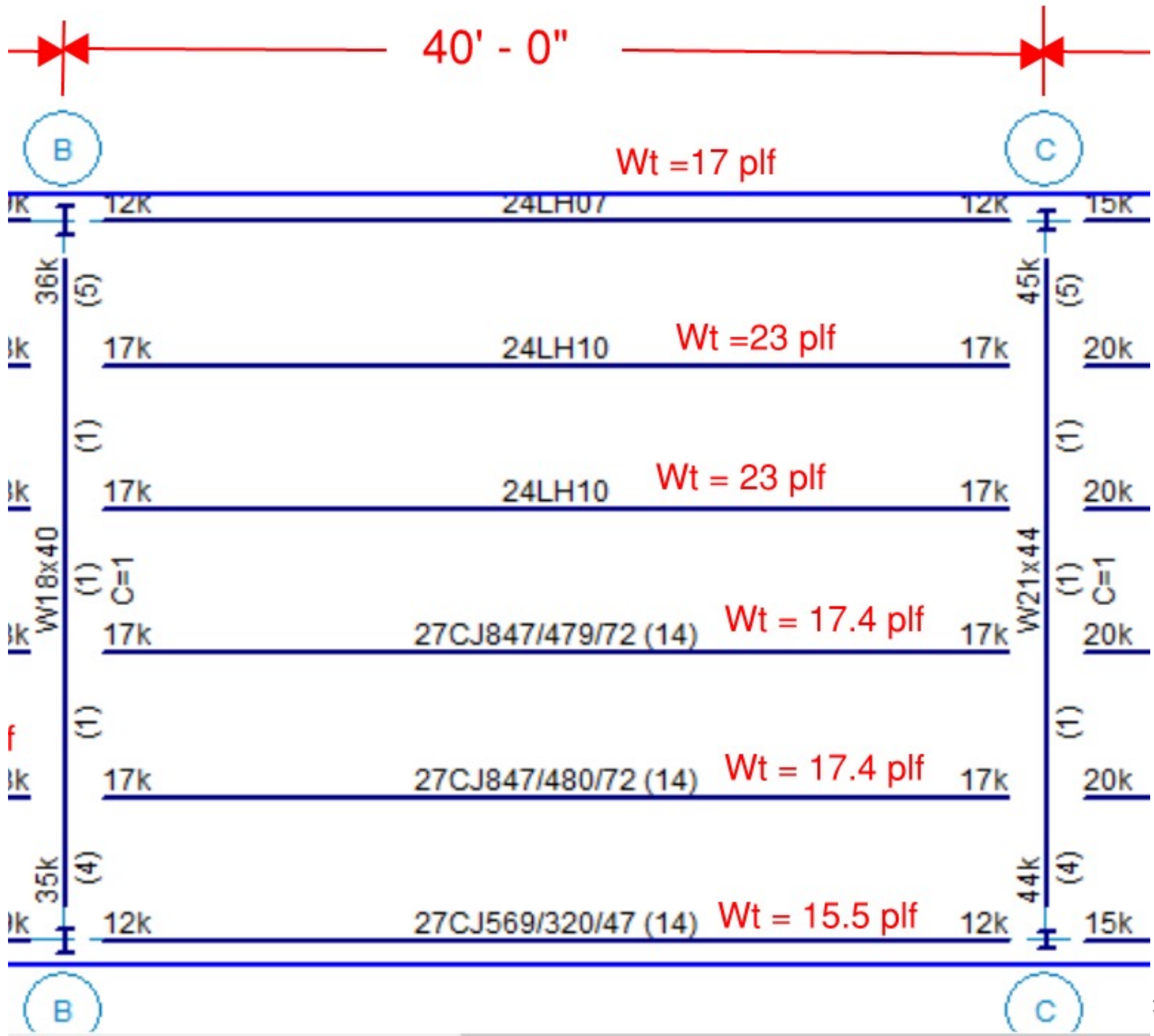
SJI LH-Series Joists vs. CJ-Series for 30’ Span, LL = 100 psf, Max LL Defl = L/360

CJ-Series 18.4% lighter than LH



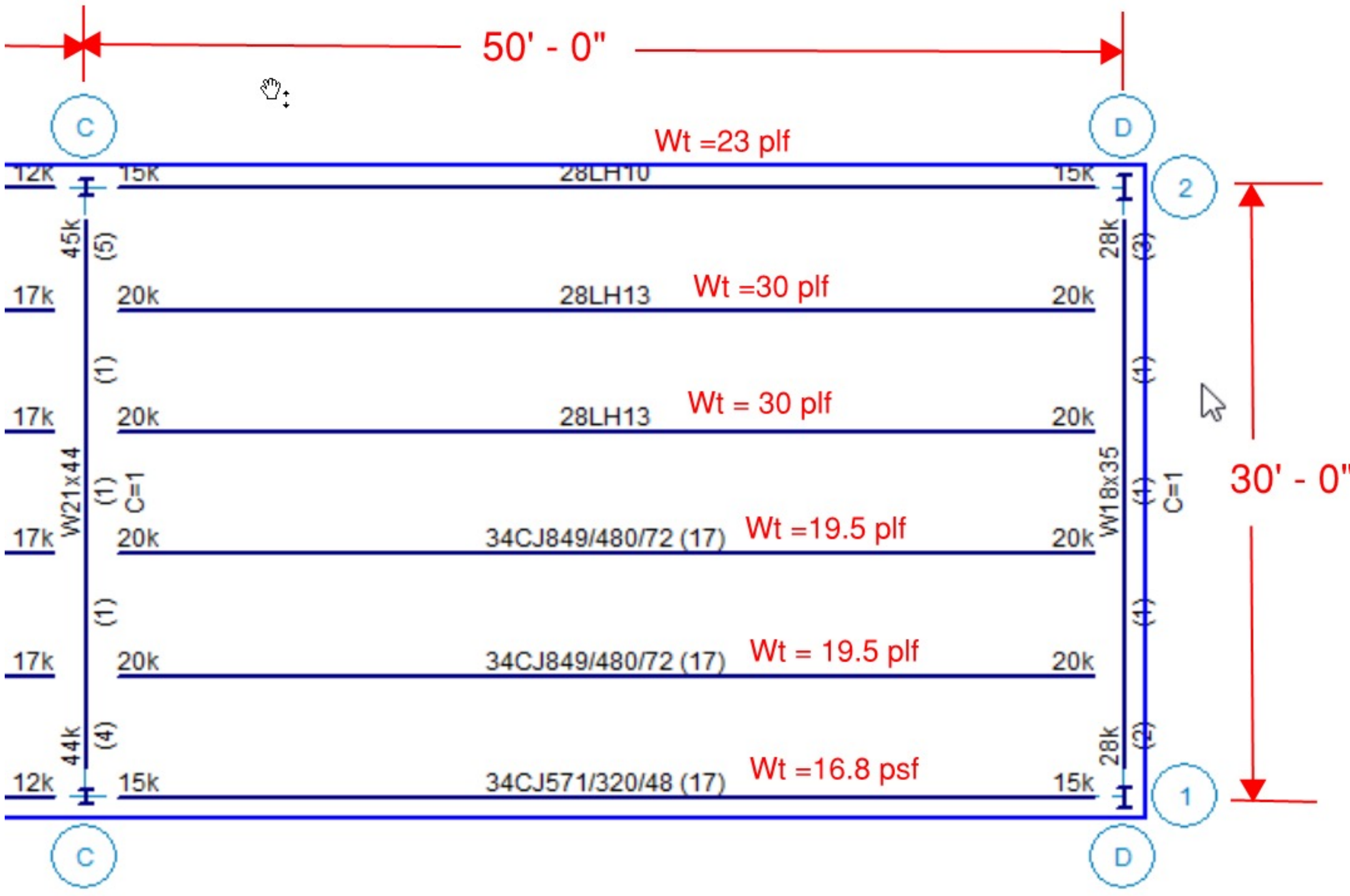
SJI LH-Series Joists vs. CJ-Series for 40' Span, LL = 100 psf, Max LL Defl = L/360

CJ-Series
24.3% lighter
than LH



SJI LH-Series Joists vs. CJ-Series for 50' Span, LL = 100 psf, Max LL Defl = L/360

CJ-Series 35% lighter than LH



Summary

- Steel joists provide an efficient and economical floor system.
- Flatter floors as joists are fabricated in special rigging tables.
- Floor to floor heights can be reduced when utilizing steel joists since mechanical systems can be routed through the open web steel joists.
- When utilizing steel joists large column free areas can be provided allowing increased flexibility for laying out floor plans.
- Reductions in structural steel framing weights varying from 30 – 50% have been achieved through the use of efficient composite steel joist designs with spans of 45- 50 feet.
- CJ-Series joists with flush framed top chord bolted connections frame flush with the top of the girders. Ease in making the girders composite easily reduces the girder weights by 20% vs. noncomposite girders.

Summary

- CJ-Series joists with flush framed top chord bolted connections provide vibration characteristics equivalent to wide flange beam framing.
- Flush framed top chord bolted joist connections have the potential to reduce concrete floor accelerations by a minimum of 33% versus joists with standard seats given the same depth of steel joist.
- For seismic regions being able to easily met floor vibration criteria without having to increase the concrete slab thickness is an enormous advantage.
- Quick delivery of SJI steel joists given no mill order lead times.
- For large projects, panelizing of steel can significantly reduce steel erection times and greatly improve erector safety.

Summary

- SJI'S *45TH Edition Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders*
- SJI's *2ND Edition, Standard Specifications for Composite Steel Joists, Weight Tables and Bridging Tables, Code of Standard Practice*

https://steeljoist.org/product-category/publications/free-downloads/

- SJI's Floor Bay Tool facilitates preparation of cost estimates for CJ-Series steel joist floor systems. https://steeljoist.org/product-category/design-tools/

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Phone No. (402) 318-8408

Check Out Our Resources

SJI offers a number of resources including:

- Design tools
- Publications
- Live webinars
- Webinars on demand
  - Our Webinars on Demand section offers 40+ pre-recorded webinars. Earn PDHs today.

Polling Question #2

Steel joists with flush framed top chord bolted connections provide which of the following benefits:

A) Potential to easily make the girders composite
B) Reduced floor plenum depth at the girders
C) Vibration characteristics equivalent to wide flange beams
D) Facilitates installation of panelized joists and deck
E) All the above

Polling Answers

Which of the following are benefits of using open web steel joists in floor design?

A. Easy passage of MEP chase through web openings
B. Plenty of strength for wider joist spacing
C. Excellent vibration characteristics
D. Powerful design tools
E. **All of the above**

Steel joists with flush framed top chord bolted connections provide which of the following benefits:

A. Potential to easily make the girders composite
B. Reduced floor plenum depth at the girders
C. Vibration characteristics equivalent to wide flange beams
D. Facilitates installation of panelized joists and deck
E. **All of the above**

Q&A SESSION

THANK YOU