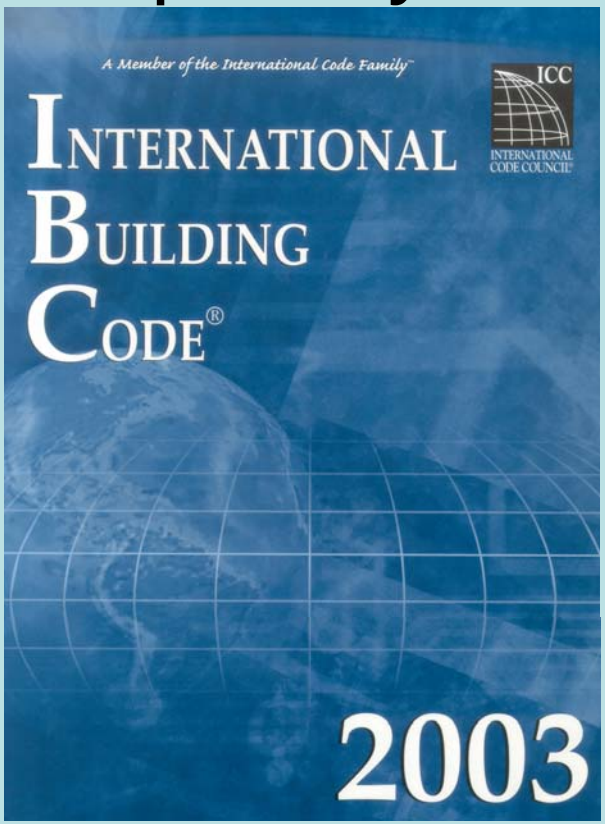
Ce 479 Fall 06

Steel Joists- Introduction

Joists and Joist Girders

Design of Open Web Joists/Girders

- Adopted by the IBC 2003



SECTION 2206
STEEL JOISTS

2206.1 General. The design, manufacturing and use of open web steel joists and joist girders shall be in accordance with one of the following Steel Joist Institute specifications:

1. *Standard Specifications for Open Web Steel Joists, K Series.*
2. *Standard Specifications for Longspan Steel Joists, LH Series and Deep Longspan Steel Joists, DLH Series.*
3. *Standard Specifications for Joist Girders.*

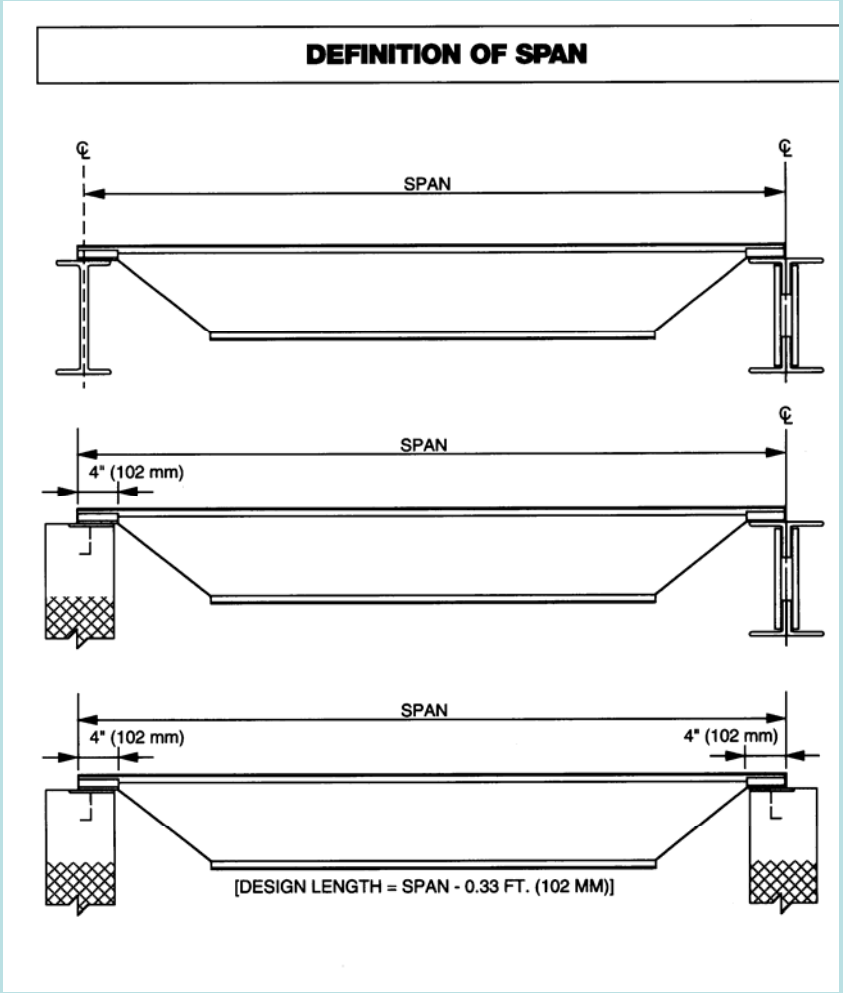
Where required, the seismic design of buildings shall be in accordance with the additional provisions of Section 2205.2 or 2211.

Design of Open Web Joists/Girders

- Standardized pre-engineered lightweight trusses
  - Usually span the roof/floor in the long direction of the framing.
  - Closely spaced to support roof and floor steel decks.
  - Types:
    - K and KCS
    - LH and DLH
    - SLH

Design of Open Web Joists/Girders

- K and KCS Types:
  - K Series - Pages 9-13 of Vulcraft Catalog
  - KCS Series – Pages 14-17
  - Specifications K-Series – Pages 22-30
  - Depths (d) from 8- 30 inches
  - Spans up to 24d
  - Simply supported to carry uniform loads- K series. KCS can handle concentrated loads as well
  - End depth 2.5”



Design of Open Web Joists/Girders

- LH and DLH – Long Span Series
  - LH Pages 43-46
  - Depths (d) 18-48 inches
  - Spans 24d
  - DLH Pages 47-48
  - Depths (d) 52-72 inches
  - End depth 5 inches
- Standard Specifications for LH and DLH Pages 54-62

Design of Open Web Joists/Girders

- SLH – Super Long Span Series
  - SLH Pages 63 - 67
  - Depths (d) 80 – 120 inches
  - Spans 24d
  - End depth 5 inches
- Standard Specifications for SLH - Pages 68- 73

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K and KCS Steel Joists

STANDARD LOAD TABLE
FOR OPEN WEB STEEL JOISTS, K-SERIES

Based on a Maximum Allowable Tensile Stress of 30 ksi
Adopted by the Steel Joist Institute November 4, 1985;
Revised to May 1, 2000 – Effective August 1, 2002

The black figures in the following table give the TOTAL safe uniformly distributed load-carrying capacities, in pounds per linear foot, of K-Series Steel Joists. The weight of DEAD loads, including the joists, must be deducted to determine the LIVE load-carrying capacities of the joists. Sloped parallel-chord joists shall use span as defined by the length along the slope.

The figures shown in RED in this load table are the LIVE loads per linear foot of joist which will produce an approximate deflection of 1/360 of the span. LIVE loads which will produce a deflection of 1/240 of the span may be obtained by multiplying the figures in RED by 1.5. In no case shall the TOTAL load capacity of the joists be exceeded.

The approximate joist weights per linear foot shown in these tables do not include accessories.

The approximate moment of inertia of the joist, in inches^4 is;

$I_j = 26.767(W_{LL})(L^3)(10^{-6})$, where W_{LL} = RED figure in the Load Table and L = (Span - .33) in feet.

For the proper handling of concentrated and/or varying loads, see Section 5.5 in the Recommended Code of Standard Practice for Steel Joists and Joist Girders.

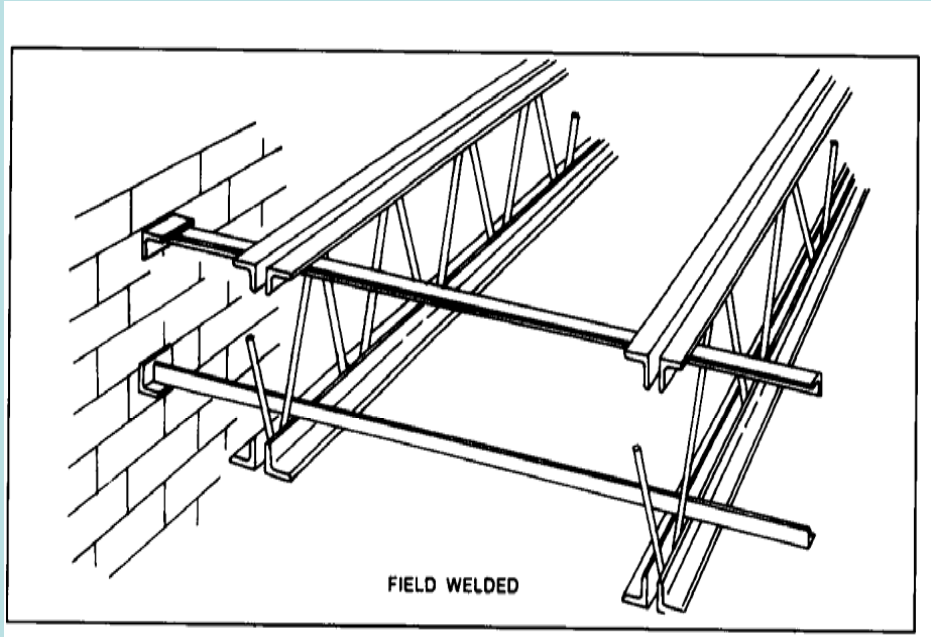
Where the joist span exceeds the unshaded area of the load table, the row of bridging nearest the mid-span shall be diagonal bridging with bolted connections at the chords and intersections.

STANDARD LOAD TABLE/OPEN WEB STEEL JOISTS, K-SERIES
Based on a Maximum Allowable Tensile Stress of 30 ksi

Joist Designation	8K1	10K1	12K1	12K3	12K5	14K1	14K3	14K4	14K6	16K2	16K3	16K4	16K5	16K6	16K7	16K9
Depth (in.)	8	10	12	12	12	14	14	14	14	16	16	16	16	16	16	16
Approx. Wt (lbs./ft.)	5.1	5.0	5.0	5.7	7.1	5.2	6.0	6.7	7.7	5.5	6.3	7.0	7.5	8.1	8.6	10.0
Span (ft.) ▼																
8	550 550															
9	550 550															
10	550 480	550 550														
11	532 377	550 542														
12	444 288	550 455	550 550	550 550	550 550											
13	377 225	479 363	550 510	550 510	550 510											
14	324 179	412 289	500 425	550 463	550 463	550 550	550 550	550 550	550 550							
15	281 145	358 234	434 344	543 428	550 434	511 475	550 507	550 507	550 507							
16	246	313	380	476	550	448	550	550	550	550	550	550	550	550	550	550

Need for Bridging – Lateral Bracing of Joists

1. Align joists during construction
2. Provide joist stability during construction
3. Provide bracing to the bottom chord in the event of wind uplift
4. Brace laterally the top chord of the joist until the permanent deck is attached



HORIZONTAL BRIDGING
SEE SJI SPECIFICATION 5.5 AND 6.

NOTE: DO NOT WELD BRIDGING TO JOIST WEB MEMBERS.
DO NOT HANG ANY MECHANICAL, ELECTRICAL, ETC. FROM BRIDGING.

Bridging

K – Series Bridging

MAXIMUM JOIST SPACING FOR HORIZONTAL BRIDGING							
	BRIDGING MATERIAL SIZE						
	Round Rod	Equal Leg Angles					
SECTION NUMBER**	1/2"DIA (13mm) r = .13"	1 x 7/64 (25mm x 3mm) r = .25"	1-1/4 x 7/64 (32mm x 3mm) r = .25"	1-1/2 x7/64 (38mm x 3mm) r = .30"	1-3/4 x 7/64 (45mm x 3mm) r = .35"	2x 1/8 (51mm x 3mm) r = .40"	2-1/2 x 5/32 (64mm x 4mm) r = .50"
1 thru 9	3'-3" (991mm)	5'-0" (1524mm)	6'-3" (1905mm)	7'-6" (2286mm)	8'-7" (2616mm)	10'-0" (3048mm)	12'-6" (3810mm)
10	3'-0" (914mm)	4'-8" (1422mm)	6'-3" (1905mm)	7'-6" (2286mm)	8'-7" (2616mm)	10'-0" (3048mm)	12'-6" (3810mm)
11 and 12	2'-7" (787mm)	4'-0" (1219mm)	5'-8" (1727mm)	7'-6" (2286mm)	8'-7" (2616mm)	10'-0" (3048mm)	12'-6" (3810mm)

*SECTION NUMBER REFERS TO THE LAST DIGITS OF JOIST DESIGNATION. CONNECTION TO JOIST MUST RESIST 700 POUNDS (3114 N)

MAXIMUM JOIST SPACING FOR DIAGONAL BRIDGING				
	BRIDGING ANGLE SIZE-EQUAL LEG ANGLES			
JOIST DEPTH	1 x 7/64 (25mm x 3mm) r = .20"	1 1/4 X7/64 (32mm x 3mm) r = .25"	1 1/2 X 7/64 (38mm x 3mm) r = .30"	1 3/4 x 7/64 (45mm x 3mm) r = .35"
12	6'-6" (1981mm)	8'-3" (2514mm)	9'-11" (3022mm)	11'-7" (3530mm)
14	6'-6" (1981mm)	8'-3" (2514mm)	9'-11" (3022mm)	11'-7" (3530mm)
16	6'-6" (1981mm)	8'-2" (2489mm)	9'-10" (2997mm)	11'-6" (3505mm)
18	6'-6" (1981mm)	8'-2" (2489mm)	9'-10" (2997mm)	11'-6" (3505mm)
20	6'-5" (1955mm)	8'-2" (2489mm)	9'-10" (2997mm)	11'-6" (3505mm)
22	6'-4" (1930mm)	8'-1" (2463mm)	9'-10" (2997mm)	11'-6" (3505mm)
24	6'-4" (1930mm)	8'-1" (2463mm)	9'-9" (2971mm)	11'-5" (3479mm)
26	6'-3" (1905mm)	8'-0" (2438mm)	9'-9" (2971mm)	11'-5" (3479mm)
28	6'-2" (1879mm)	8'-0" (2438mm)	9'-8" (2946mm)	11'-5" (3479mm)
30	6'-2" (1879mm)	7'-11" (2413mm)	9'-8" (2946mm)	11'-4" (3454mm)

K-series--all sections numbers use A307 bolt 3/8" (9mm) diameter.

See page 27 for number of rows of bridging required.

BRIDGING FOR STANDING SEAM ROOF SYSTEMS:

Generally, standing seam roof systems will not adequately brace the top chords of the joists with standard SJI bridging. We therefore, recommend that when a standing seam roof system is specified, the design professional specifically state that the joist manufacturer is to check the bridging requirements and provide bridging as required to adequately brace the top chord against lateral movement under full loading conditions.

UPLIFT BRIDGING:

Where uplift forces due to wind are a design requirement, these forces must be indicated on the structural drawings in terms of **net** uplift in pounds per square foot or pounds per linear foot. When these loads are specified, they must be considered in the design of joists and bridging. As a minimum, a single line of bottom chord bridging must be provided near the first bottom chord panel point, at each end of the joist, whenever uplift is a design consideration.*

*See Section 5.11 of the specifications.

K – Series Rows of Bridging

NUMBER OF ROWS OF BRIDGING**

Refer to the K-Series Load Table and Specification Section 6. for required bolted diagonal bridging.
Distances are Joist Span lengths - See "Definition of Span" on page 30.

*Section Number	One Row	Two Rows	Three Rows	Four Rows	Five Rows
#1	Up thru 16'	Over 16' thru 24'	Over 24' thru 28'		
#2	Up thru 17'	Over 17' thru 25'	Over 25' thru 32'		
#3	Up thru 18'	Over 18 thru 28'	Over 28' thru 38'	Over 38' thru 40'	
#4	Up thru 19'	Over 19' thru 28'	Over 28' thru 38'	Over 38' thru 48'	
#5	Up thru 19'	Over 19' thru 29'	Over 29' thru 39'	Over 39' thru 50'	Over 50' thru 52'
#6	Up thru 19	Over 19' thru 29'	Over 29' thru 39'	Over 39' thru 51'	Over 51' thru 56'
#7	Up thru 20'	Over 20' thru 33'	Over 33' thru 45'	Over 45' thru 58'	Over 58' thru 60'
#8	Up thru 20'	Over 20' thru 33'	Over 33' thru 45'	Over 45' thru 58'	Over 58' thru 60'
#9	Up thru 20'	Over 20' thru 33'	Over 33' thru 46'	Over 46' thru 59'	Over 59' thru 60'
#10	Up thru 20'	Over 20' thru 37'	Over 37' thru 51'	Over 51' thru 60'	
#11	Up thru 20'	Over 20' thru 38'	Over 38' thru 53'	Over 53' thru 60'	
#12	Up thru 20'	Over 20' thru 39'	Over 39' thru 53'	Over 53' thru 60'	

* Last digit(s) of joist designation shown in Load Table
** See Section 5.11 for additional bridging required for uplift design.

Example K-series Joist

- Select a K-series joist to span 30 ft an allowable dead plus live load of 215 plf (live load is 150 plf). The joists are placed on 4-ft centers. Using Standard Load Table (page 11) select a 20K3. Note that span is clear span + 8 in. (see Page 30). Also from Economical Joist Guide (page 107). Note that for LH joists etc tables are for clear span + 8 inches same as the EJG (page 107).

Joist Designation	18K3	18K4	18K5	18K6	18K7	18K9	18K10	20K3	20K4	20K5	20K6
Depth (In.)	18	18	18	18	18	18	18	20	20	20	20
Approx. Wt. (lbs./ft.)	6.6	7.2	7.7	8.5	9	10.2	11.7	6.7	7.6	8.2	8.9
Span (ft.) ↓											
18	550 550	550 550	550 550	550 550	550 550	550 550	550 550				
19	514 494	550 523	550 523	550 523	550 523	550 523	550 523				
20	463 423	550 490	550 490	550 490	550 490	550 490	550 490	517 517	550 550	550 550	550 550
21	420 364	506 426	550 460	550 460	550 460	550 460	550 460	468 453	550 520	550 520	550 520
22	382 316	460 370	518 414	550 438	550 438	550 438	550 438	426 393	514 461	550 490	550 490
23	349 276	420 323	473 362	516 393	550 418	550 418	550 418	389 344	469 402	529 451	550 468
24	320 242	385 284	434 318	473 345	526 382	550 396	550 396	357 302	430 353	485 396	528 430
25	294 214	355 250	400 281	435 305	485 337	550 377	550 377	329 266	396 312	446 350	486 380
26	272 190	328 222	369 249	402 271	448 299	538 354	550 361	304 236	366 277	412 310	449 337
27	252 169	303 198	342 222	372 241	415 267	498 315	550 347	281 211	339 247	382 277	416 301
28	234 151	282 177	318 199	346 216	385 239	463 282	548 331	261 189	315 221	355 248	386 269
29	218 136	263 159	296 179	322 194	359 215	431 254	511 298	243 170	293 199	330 223	360 242
30	203 123	245 144	276 161	301 175	335 194	402 229	477 269	227 153	274 179	308 201	336 218

Example K-Series

- Select bridging: (3) represents the chord size. From Table on Page 27, 3 rows of bridging are required

NUMBER OF ROWS OF BRIDGING**

Refer to the K-Series Load Table and Specification Section 6. for required bolted diagonal bridging.
Distances are Joist Span lengths - See "Definition of Span" on page 30.

*Section Number	One Row	Two Rows	Three Rows	Four Rows	Five Rows
#1	Up thru 16'	Over 16' thru 24'	Over 24' thru 28'		
#2	Up thru 17'	Over 17' thru 25'	Over 25' thru 32'		
#3	Up thru 18'	Over 18 thru 26'	Over 26' thru 38'	Over 38' thru 40'	
#4	Up thru 19'	Over 19' thru 28'	Over 28' thru 38'	Over 38' thru 48'	
#5	Up thru 19'	Over 19' thru 29'	Over 29' thru 39'	Over 39' thru 50'	Over 50' thru 52'
#6	Up thru 19	Over 19' thru 29'	Over 29' thru 39'	Over 39' thru 51'	Over 51' thru 56'
#7	Up thru 20'	Over 20' thru 33'	Over 33' thru 45'	Over 45' thru 58'	Over 58' thru 60'
#8	Up thru 20'	Over 20' thru 33'	Over 33' thru 45'	Over 45' thru 58'	Over 58' thru 60'
#9	Up thru 20'	Over 20' thru 33'	Over 33' thru 46'	Over 46' thru 59'	Over 59' thru 60'
#10	Up thru 20'	Over 20' thru 37'	Over 37' thru 51'	Over 51' thru 60'	
#11	Up thru 20'	Over 20' thru 38'	Over 38' thru 53'	Over 53' thru 60'	
#12	Up thru 20'	Over 20' thru 39'	Over 39' thru 53'	Over 53' thru 60'	

* Last digit(s) of joist designation shown in Load Table
** See Section 5.11 for additional bridging required for uplift design.

Example K-Series

- Select bridging with table on page 9: three rows of bracing results in a 30/4 = 7’- 6” spacing of bridging for 3 section number, using horizontal bridging for a joist spacing of 4-ft requires equal leg angles 1 x 7/64

MAXIMUM JOIST SPACING FOR HORIZONTAL BRIDGING

	BRIDGING MATERIAL SIZE						
	Round Rod	Equal Leg Angles					
SECTION NUMBER**	1/2"DIA (13mm) r = .13"	1 x 7/64 (25mm x 3mm) r = .25"	1-1/4 x 7/64 (32mm x 3mm) r = .25"	1-1/2 x7/64 (38mm x 3mm) r = .30"	1-3/4 x 7/64 (45mm x 3mm) r = .35"	2x 1/8 (51mm x 3mm) r = .40"	2-1/2 x 5/32 (64mm x 4mm) r = .50"
1 thru 9	3'-3" (991mm)	5'-0" (1524mm)	6'-3" (1905mm)	7'-6" (2286mm)	8'-7" (2616mm)	10'-0" (3048mm)	12'-6" (3810mm)
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11 and 12	2'-7" (787mm)	4'-0" (1219mm)	5'-8" (1727mm)	7'-6" (2286mm)	8'-7" (2616mm)	10'-0" (3048mm)	12'-6" (3810mm)

*SECTION NUMBER REFERS TO THE LAST DIGITS OF JOIST DESIGNATION, CONNECTION TO JOIST MUST RESIST 700 POUNDS (3114 N)

MAXIMUM JOIST SPACING FOR DIAGONAL BRIDGING

JOIST DEPTH	BRIDGING ANGLE SIZE-EQUAL LEG ANGLES			
	1 x 7/64 (25mm x 3mm) r = .20"	1 1/4 X7/64 (32mm x 3mm) r = .25"	1 1/2 X 7/64 (38mm x 3mm) r = .30"	1 3/4 x 7/64 (45mm x 3mm) r = .35"
12	6'-6" (1981mm)	8'-3" (2514mm)	9'-11" (3022mm)	11'-7" (3530mm)
14	6'-6" (1981mm)	8'-3" (2514mm)	9'-11" (3022mm)	11'-7" (3530mm)
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18	6'-6" (1981mm)	8'-2" (2489mm)	9'-10" (2997mm)	11'-6" (3505mm)
20	6'-5" (1955mm)	8'-2" (2489mm)	9'-10" (2997mm)	11'-6" (3505mm)
22	6'-4" (1930mm)	8'-1" (2463mm)	9'-10" (2997mm)	11'-6" (3505mm)
24	6'-4" (1930mm)	8'-1" (2463mm)	9'-9" (2971mm)	11'-5" (3479mm)
26	6'-3" (1905mm)	8'-0" (2438mm)	9'-9" (2971mm)	11'-5" (3479mm)
28	6'-2" (1879mm)	8'-0" (2438mm)	9'-8" (2946mm)	11'-5" (3479mm)
30	6'-2" (1879mm)	7'-11" (2413mm)	9'-8" (2946mm)	11'-4" (3454mm)

K-series--all sections numbers use A307 bolt 3/8" (9mm) diameter.
See page 27 for number of rows of bridging required.

BRIDGING FOR STANDING SEAM ROOF SYSTEMS:

Generally, standing seam roof systems will not adequately brace the top chords of the joists with standard SJI bridging. We therefore, recommend that when a standing seam roof system is specified, the design professional specifically state that the joist manufacturer is to check the bridging requirements and provide bridging as required to adequately brace the top chord against lateral movement under full loading conditions.

UPLIFT BRIDGING:

Where uplift forces due to wind are a design requirement, these forces must be indicated on the structural drawings in terms of **net** uplift in pounds per square foot or pounds per linear foot. When these loads are specified, they must be considered in the design of joists and bridging. As a minimum, a single line of bottom chord bridging must be provided near the first bottom chord panel point, at each end of the joist, whenever uplift is a design consideration.*

*See Section 5.11 of the specifications.

Concentrated Loads

- Approaches:
  1. Use a special joist designed for the uniform load and the concentrated load. This requires submittal of loading diagram to manufacturer
  2. Use a heavier standard joist designed to resist the uniform load and the concentrated load, i.e. a joist that is capable of handling the shear and moment diagram for the applied loads
  3. Use a KCS joist

Concentrated Loads

- Approach 2:
  a) Calculate the moment and shear diagram due to combined loads
  b) Find “equivalent uniform load” that results in the maximum moment, and the “equivalent uniform load” that would result in an allowable shear diagram that is an envelope to the shear diagram due to the actual loads
  c) Using the larger of the two “equivalent uniform loads” select a standard joist
  d) The location of zero shear must be within 1-ft of the joist midspan to prevent reversal of stress on the truss diagonals with respect to original design. Otherwise either approach 1 or 3 must be followed.

Example of Joist Design Under Concentrated Loads

- A joist will be used on a 36 ft simply supported span to carry a service distributed load of 200 plf and a concentrated load of 600 lbs located at 6 ft from the left support. The joist are spaced on 6 ft centers.
  1. Use a standard joist designed to carry the distributed and the concentrated loads. Use the Economical Joist Guide
  2. Use a KCS joist

Economical Joist Guide

ECONOMICAL JOIST GUIDE

Combined K, VS, LH & DLH Series Load Table

The following table is an economy guide with the Joists listed in sequence of increasing relative cost. That is, the most economical joist for given length is listed first. The economies were based on production costs and do not include bridging requirements or erection costs.

HOW TO USE THE ECONOMICAL JOIST GUIDE: The specifying professional simply turns to the length required and proceeds down the allowable loads column until the first joist type in the list that will carry the required load is found. (However, additional bridging due to erection stability requirements should be taken into consideration.) This will then be the most economical joist type for the combination of length and required load. The approximate weight per foot of the joist is listed to the right of the live load.

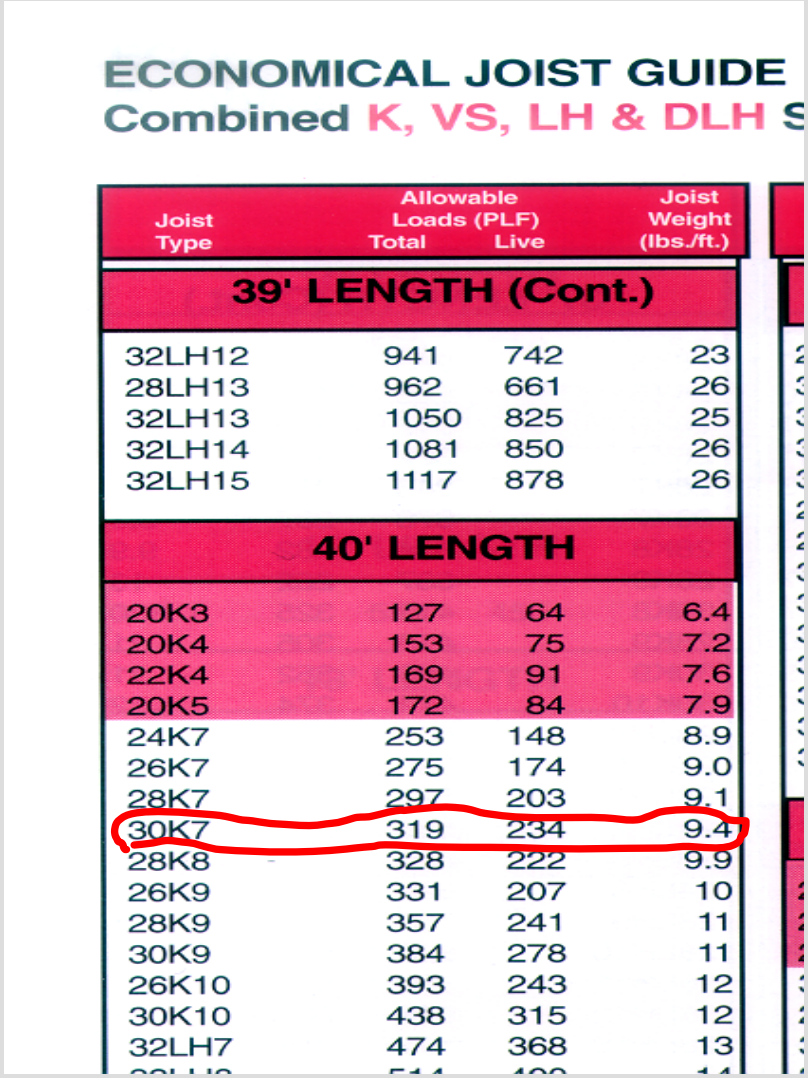
EXAMPLE: Given 40'-0" length and a required load of 300 plf. On page 110 of the table under 40', it is found that a 30K7 at 40'-" will carry 319 plf TL. (page 110)

The figures shown in red are the live loads per lineal foot of joist which will produce an approximate deflection of 1/360 of the length. If a deflection limitation of 1/240 is required multiply the figures in red by 1.5. In no case shall the total load capacity of the joist be exceeded.

NOTE: Length as used in the economical joist guide means: **clear span + 8" for K Series and clear span + 12" for LH and DLH Series joists.**

You will note that the tables have been shaded to match the load tables. This shading indicates when bolted cross bridging needs to be installed per the Steel Joist Institute specification for a particular joist series.

Economical Joist Guide



ECONOMICAL JOIST GUIDE
Combined K, VS, LH & DLH S

Joist Type	Allowable Loads (PLF) Total	Live	Joist Weight (lbs./ft.)
39' LENGTH (Cont.)			
32LH12	941	742	23
28LH13	962	661	26
32LH13	1050	825	25
32LH14	1081	850	26
32LH15	1117	878	26
40' LENGTH			
20K3	127	64	6.4
20K4	153	75	7.2
22K4	169	91	7.6
20K5	172	84	7.9
24K7	253	148	8.9
26K7	275	174	9.0
28K7	297	203	9.1
30K7	319	234	9.4
28K8	328	222	9.9
26K9	331	207	10
28K9	357	241	11
30K9	384	278	11
26K10	393	243	12
30K10	438	315	12
32LH7	474	368	13