Introduction to the New ASD/LRFD Unified Specifications for the Design of K-Series Joists, LH- and DLH-Series Joists and Joist Girders

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SJI Presentation Outline

- **Background and Development**
- **42nd Edition Catalog Highlights**
  - 2005 SJI Unified Specifications
    - Tension
    - Compression
    - Bending
    - Similarities and Differences with the 2005 AISC Specification for Structural Steel Buildings
  - 2005 Code of Standard Practice
- **The 2006 International Building Code**
- **Practical Usage – A Design Example**

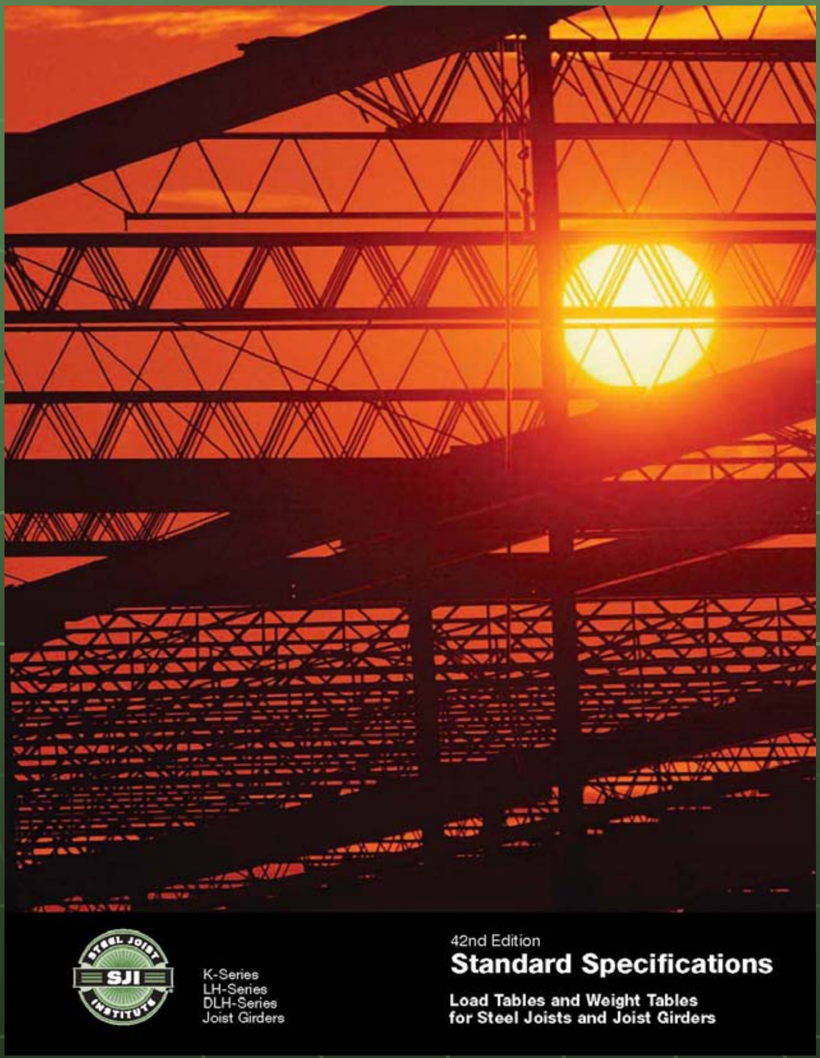
Background and Development

- The Steel Joist Institute was founded in 1928 and produced it's first Catalog and Specifications in 1932.
- The 2005 Catalog is the 42nd Edition, the last being published in 2002.
- The K-Series, LH- and DLH-Series and Joist Girder Specifications are ANSI accredited and have already been approved by the ICC for the 2006 International Building Code.

Background and Development

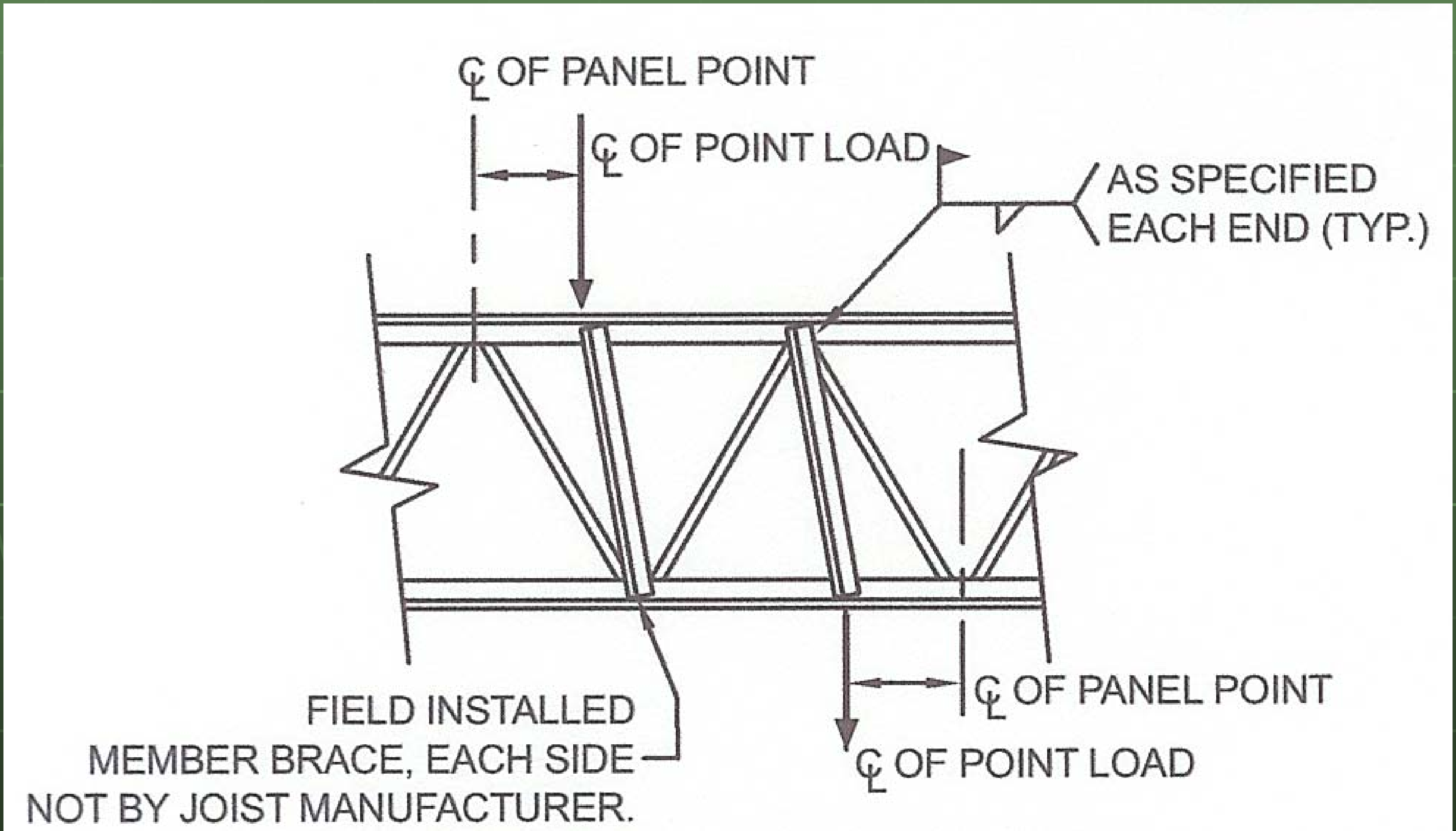
- The Steel Joist Institute developed, but never published, an **LRFD** Specification.
- After learning that AISC planned a dual specification for both **ASD** and **LRFD**, SJI decided that it would be appropriate to do the same for joists.
- The goal is to make the use of joists convenient for the Specifying Professional who is using either design method.

2005 SJI 42nd Edition Catalog

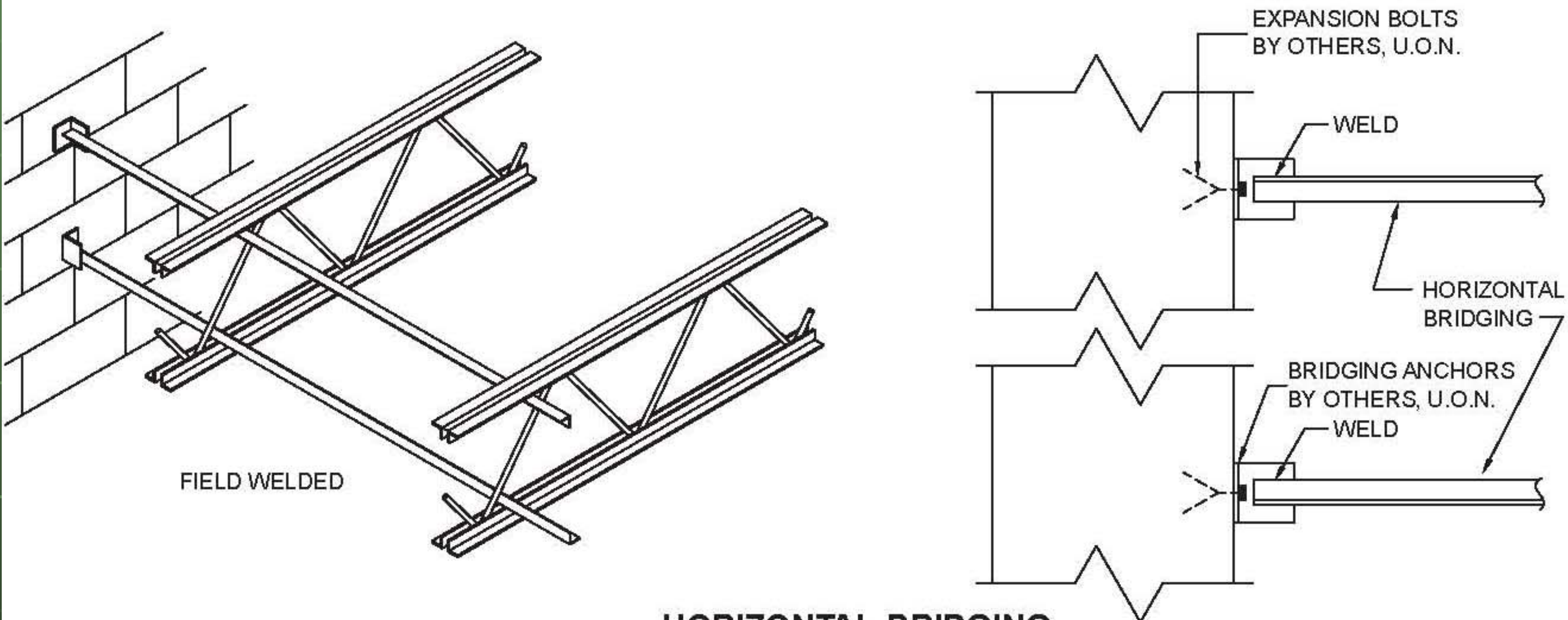


- **Steel Joist Institute**
  - History, Policy, Membership, Publications, Introduction
- **Accessories and Details**
- **K-Series Standard Specifications**
  - K-Series Load Tables
  - KCS Joists
- **LH- and DLH-Series Standard Specifications**
  - LH- and DLH-Series Load Tables
- **Joist Girders Standard Specifications**
  - Joist Girder Weight Tables
- **Referenced Specifications, Codes and Standards**
- **Code of Standard Practice for Steel Joists and Joist Girders**
- **Glossary**
- **Appendices**
  - A) Joist Substitutes, K-Series
  - B) TCXs and Extended Ends, K-Series
  - C) Economy Tables, K-Series
  - D) Fire-Resistance Ratings with Steel Joists
  - E) OSHA Safety Standards for Steel Erection

Accessories and Details: Added Members



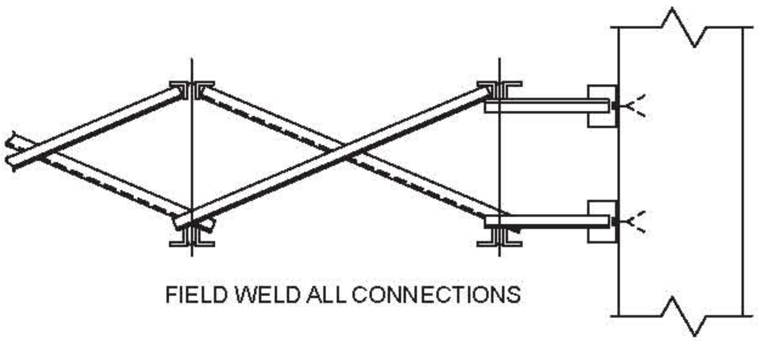
Accessories and Details: K-Series Joists Selected Bridging Details



HORIZONTAL BRIDGING
SEE SJI SPECIFICATIONS

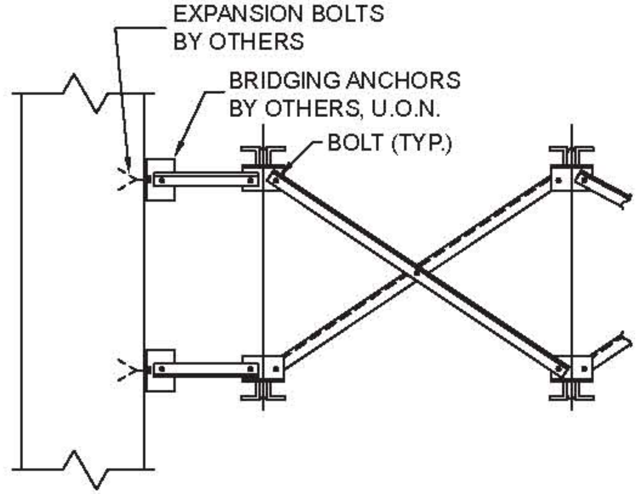
NOTE: DO NOT WELD BRIDGING TO JOIST WEB MEMBERS.
DO NOT HANG ANY MECHANICAL, ELECTRICAL, ETC. FROM BRIDGING.

Accessories and Details: LH- and DLH-Series Joists Selected Bridging Details



WELDED CROSS BRIDGING
SEE SJI SPECIFICATIONS

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

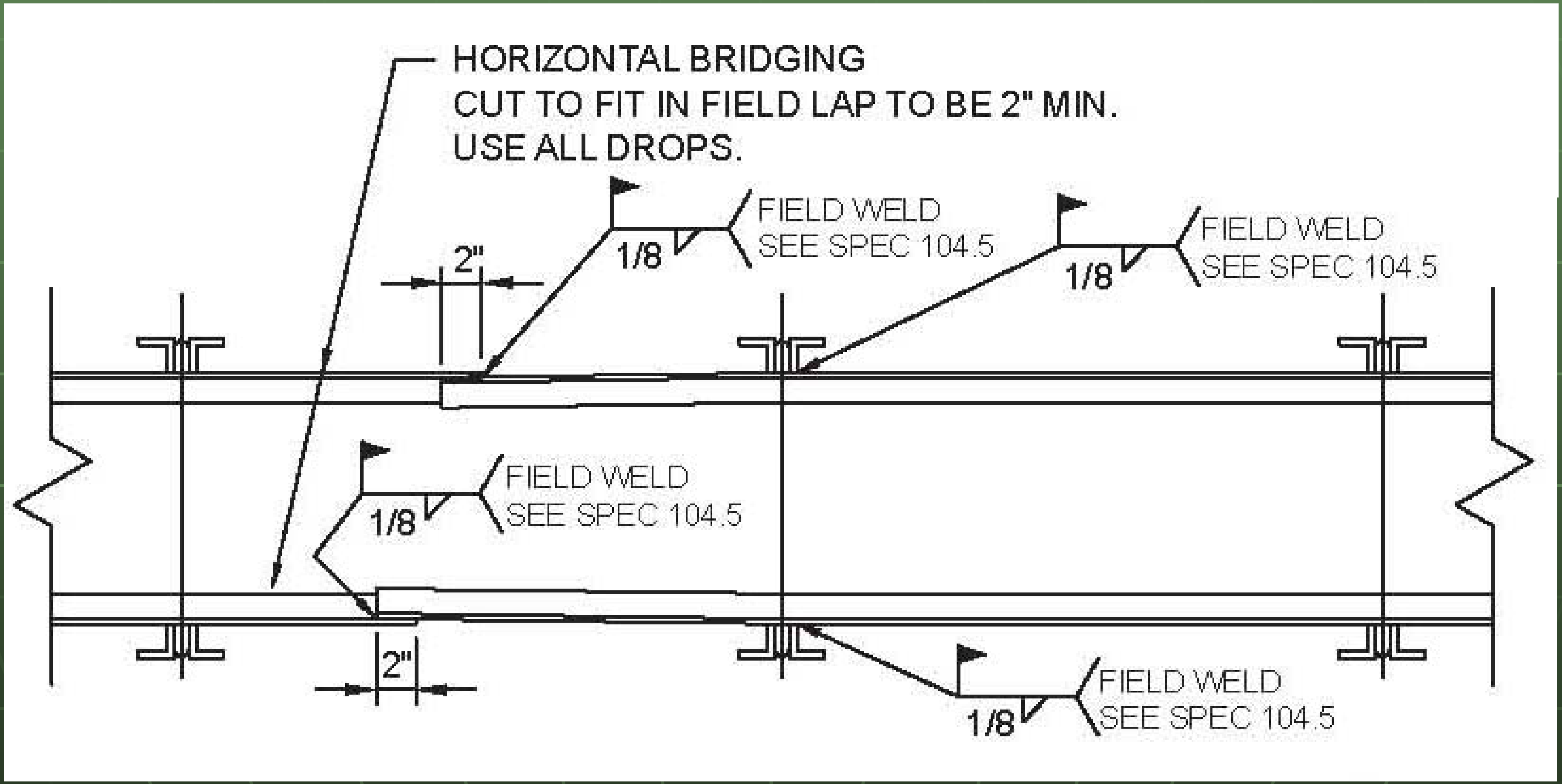


BOLTED CROSS BRIDGING
SEE SJI SPECIFICATIONS

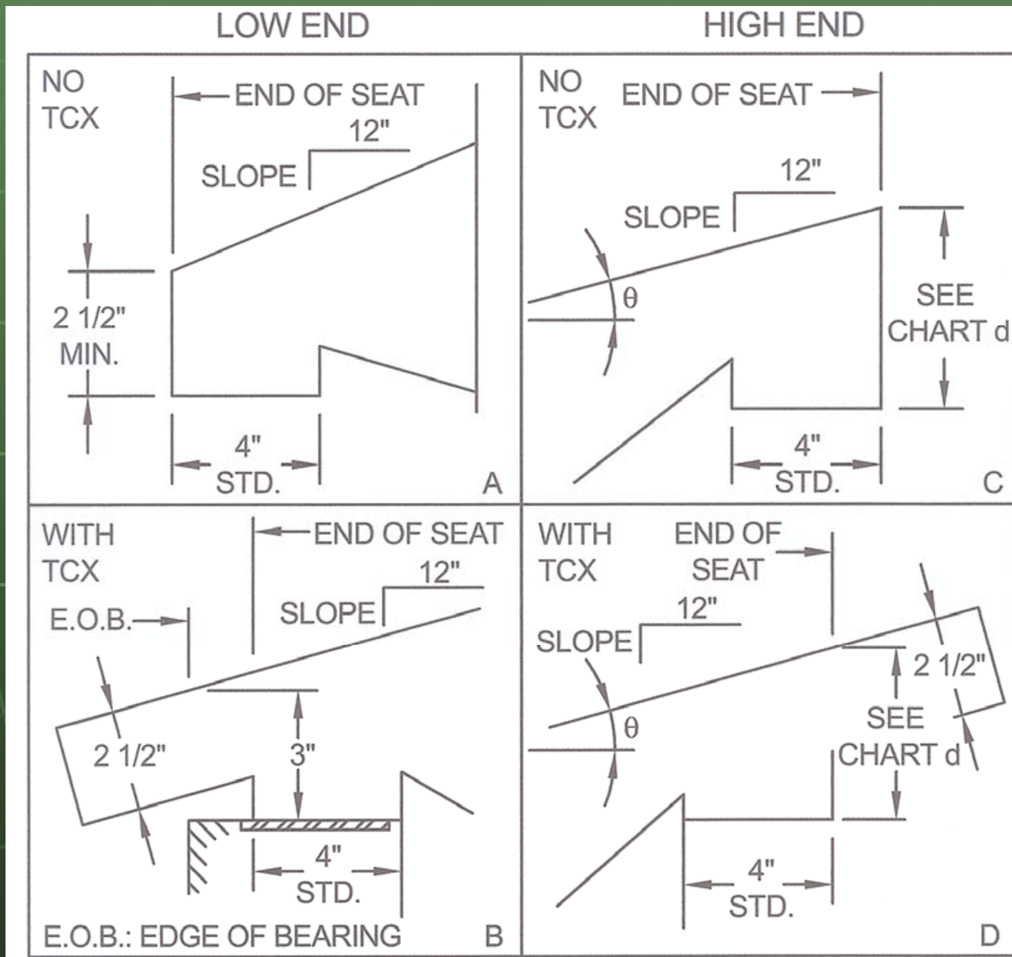
(a) HORIZONTAL BRIDGING UNITS SHALL BE USED IN THE SPACE ADJACENT TO THE WALL TO ALLOW FOR PROPER DEFLECTION OF THE JOIST NEAREST THE WALL.

(b) FOR REQUIRED BOLT SIZE REFER TO BRIDGING TABLE. NOTE: CLIP CONFIGURATION MAY VARY FROM THAT SHOWN.

Accessories and Details: LH- and DLH-Series Joists Selected Bridging Details

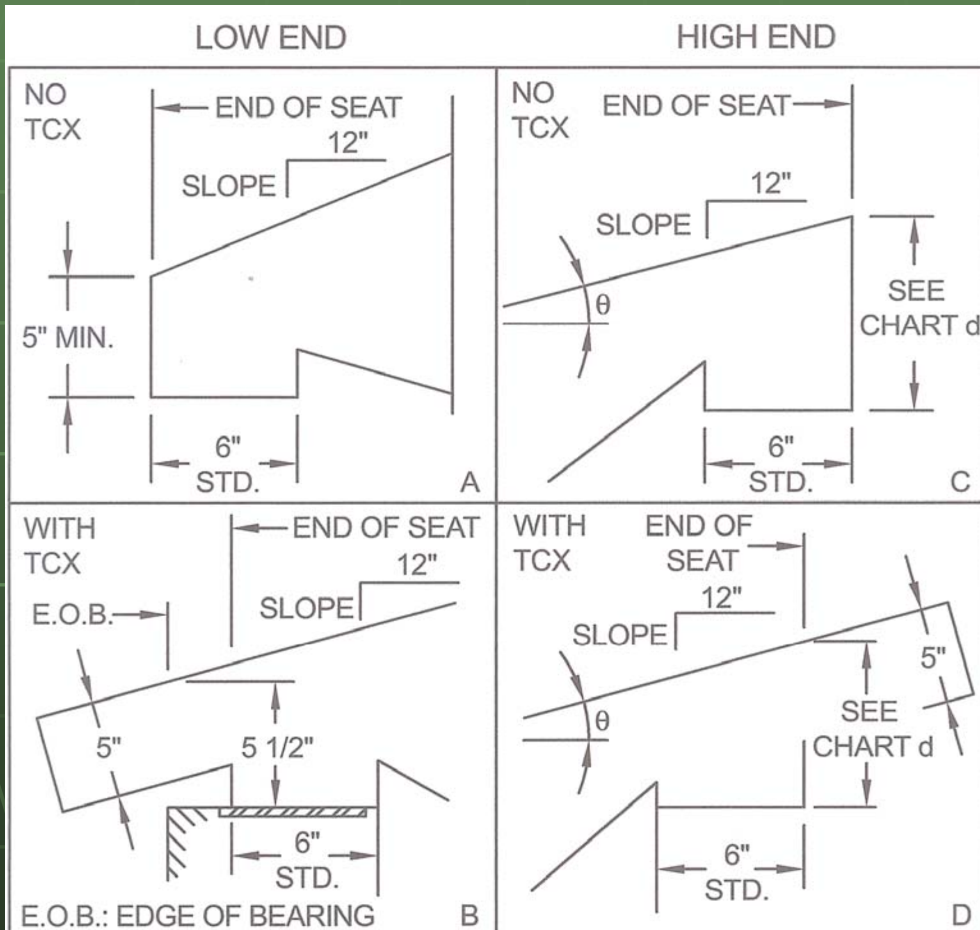


Accessories and Details:
K-Series Joists Sloped Seats



SLOPE RATE	HIGH END SEAT DEPTH d (MIN.)
3/8: 12	3"
1/2: 12	3"
1: 12	3 1/2"
1 1/2: 12	3 1/2"
2: 12	4"
2 1/2: 12	4"
3: 12	4"
3 1/2: 12	4 1/2"
4: 12	4 1/2"
4 1/2: 12	4 1/2"
5: 12	5"
6: 12 & OVER	SEE BELOW

Accessories and Details:
LH- and DLH-Series Sloped Seats



SLOPE RATE	HIGH END SEAT DEPTH d (MIN.)
3/8: 12	5 1/2"
1/2: 12	6"
1: 12	6"
1 1/2: 12	6 1/2"
2: 12	6 1/2"
2 1/2: 12	7"
3: 12	7"
3 1/2: 12	7 1/2"
4: 12	8"
4 1/2: 12	8"
5: 12	8 1/2"
6: 12 & OVER	SEE BELOW

Accessories and Details: Approximate Duct Opening Sizes

JOIST DEPTH	ROUND	SQUARE	RECTANGLE
8 INCHES	5 INCHES	4x4 INCHES	3x6 INCHES
10 INCHES	5 INCHES	4x4 INCHES	3x7 INCHES
12 INCHES	7 INCHES	5x5 INCHES	3x8 INCHES
14 INCHES	8 INCHES	6x6 INCHES	5x9 INCHES
16 INCHES	8 INCHES	6x6 INCHES	5x9 INCHES
18 INCHES	9 INCHES	7x7 INCHES	5x9 INCHES
20 INCHES	10 INCHES	8x8 INCHES	6x11 INCHES
22 INCHES	10 INCHES	9x9 INCHES	7x11 INCHES
24 INCHES	12 INCHES	10x10 INCHES	7x13 INCHES
26 INCHES	15 INCHES*	12x12 INCHES*	9x18 INCHES*
28 INCHES	16 INCHES*	13x13 INCHES*	9x18 INCHES*
30 INCHES	17 INCHES*	14x14 INCHES*	10x18 INCHES*

SPECIFYING PROFESSIONAL MUST INDICATE ON STRUCTURAL DRAWINGS SIZE AND LOCATION OF ANY DUCT THAT IS TO PASS THRU JOIST. THIS DOES NOT INCLUDE ANY FIREPROOFING ATTACHED TO JOIST. FOR DEEPER **LH-** AND **DLH-**SERIES JOISTS, CONSULT MANUFACTURER.

* FOR ROD WEB CONFIGURATION THESE WILL BE REDUCED, CONSULT MANUFACTURER.

Joist Girders

- **2002 SJI Joist Girder Specification limitations on standard product:**
  1. Maximum span = 60 feet
  2. Maximum depth = 72 inches
  3. Maximum panel point load = 20 kips

     Allowable Strength Design **(ASD)**

Joist Girders

- **2005 SJI Joist Girder Specification limitations on standard product:**
  1. Maximum span = 120 feet
  2. Maximum depth = 120 inches
  3. Maximum panel point load = 56 kips

     Allowable Strength Design **(ASD)**

     Maximum panel point load = 84 kips

     Load and Resistance Factor Design **(LRFD)**

Joist Girders

- **Joist Girder Weight Tables**
  - Maximum chord angle size is 6 x 6 x ¾

    Applicable to all joist manufacturers
  - Some joist manufacturers will be able to go up to a 8 x 8 chord angle, but that will be a non-standard SJI product

Joist Girders

- **Joist Girder Weight Tables**
  - The weight table can not cover every combination of span, panel spacing and kip loading
  - A Joist Girder can be made to fit within any of the “gaps” in the weight table
  - Remember that the weight table is provided as a design aid for the structural engineer to help provide an approximate value for the Joist Girder self weight

2005 SJI Unified Specifications

- New, unified specifications for the K-Series, LH- and DLH-Series and Joist Girders similar to AISC and AISI allowing an **ASD** or **LRFD** approach to joist design have been developed.
- The end product for the Specifying Professional or structural engineer remains the same; there will be no noticeable changes in the appearance of a fabricated joist and there are no new series or designations.

2005 SJI Unified Specifications

- The equations for computing compression, tension, and bending capacity closely follow the new AISC equations.
- In keeping with SJI history, the specification is written in terms of "stresses" rather than "forces".
- The combined interaction equations more closely resemble previous SJI Specifications than AISC, but have been modified with a primary goal of consistent results between **ASD** and **LRFD**.

2005 SJI Unified Specifications

- Key Features
  - **Load combinations are better defined**
  - **Combined interaction equations are set up to produce identical results for a given designation using either an ASD or LRFD design approach**
  - **Two Load Tables are provided for each joist series, one with ASD loads and one with LRFD factored loads**

2005 SJI Unified Specifications

- Using the New Unified Specifications
  - **Contract drawings need to clearly show if the project is ASD or LRFD**
  - **For special loads, contract drawings need to define any load combinations if other than those given in ASCE 7**
  - **An ASD or LRFD joist or Joist Girder of the same designation will be identical, but the choice of ASD or LRFD may affect which designation is selected**
  - **LRFD projects will need to show all design loads as already factored**

Load Combinations

- Only two basic load combinations are given:

  LRFD **1.4D**

  1.2D + 1.6 (L, or Lr, or S, or R)

  ASD **D**

  D + (L, or Lr, or S, or R)

- When special loads are specified and the Specifying Professional does not provide the load combinations, the provisions of ASCE 7 *Minimum Design Loads for Buildings and Other Structures* shall be used for **LRFD** and **ASD** load combinations.

Design and Allowable Stresses

- The following **LRFD** Resistance Factors (φ) and **ASD** Safety Factors (Ω) are defined for determining tension, compression and bending stresses:
  - **Tension** $\varphi_t = 0.90$ $\Omega_t = 1.67$
  - **Compression** $\varphi_c = 0.90$ $\Omega_c = 1.67$
  - **Bending** $\varphi_b = 0.90$ $\Omega_b = 1.67$

Design and Allowable Stresses

Section 4.2(a) Tension

For Chords: F_y = 50 ksi (345 MPa)

For Webs: F_y = 50 ksi (345 MPa) or
F_y = 36 ksi (250 MPa)

Design Stress = $0.9F_y$ (LRFD) (4.2-1)

Allowable Stress = $0.6F_y$ (ASD) (4.2-2)

Design and Allowable Stresses

Section 4.2(b) Compression

For members with $\ell/r \leq 4.71\sqrt{E/QF_y}$

$$F_{cr} = Q\left[0.658^{\left(QF_y/F_e\right)}\right]F_y \qquad \textbf{(4.2-3)}$$

For members with $\ell/r > 4.71\sqrt{E/QF_y}$

$$F_{cr} = 0.877F_e \qquad \textbf{(4.2-4)}$$

Where F_e = Elastic buckling stress determined in accordance with Equation 4.2-5

Design and Allowable Stresses

Section 4.2(b) Compression (cont'd)

$$F_e = \frac{\pi^2 E}{\left(\ell / r\right)^2} \qquad (4.2\text{-}5)$$

Where ℓ is the panel length, in inches (mm), as defined in Section 4.2(b) and r_x is the radius of gyration about the axis of bending.

For hot-rolled sections, "Q" is the full reduction factor for slender compression elements.

Design Stress $= 0.9F_{cr}$ (LRFD) (4.2-6)

Allowable Stress $= 0.6F_{cr}$ (ASD) (4.2-7)

Design and Allowable Stresses

Section 4.2(b) Compression (cont'd)

In the above equations, ℓ is taken as the distance in inches (millimeters) between panel points for the chord members and the appropriate length for web members, and *r* is the corresponding least radius of gyration of the member or any component thereof. *E* is equal to 29,000 ksi (200,000 MPa).

Use 1.2 ℓ / r_x for a crimped, first primary compression web member when a moment-resistant weld group is not used for this member; where r_x = member radius of gyration in the plane of the joist.

For cold-formed sections the method of calculating the nominal column strength is given in the AISI, *North American Specification for the Design of Cold-Formed Steel Structural Members*.

Design and Allowable Stresses

Section 4.2(b) Compression (cont'd)

2005 AISC Specification

E7. MEMBERS WITH SLENDER ELEMENTS

For cross section composed of only unstiffened slender elements, $Q = Q_s$ ($Q_a = 1.0$). For cross sections composed of only stiffened slender elements, $Q = Q_a$ ($Q_s = 1.0$). For cross sections composed of both stiffened and unstiffened slender elements, $Q = Q_sQ_a$.

Slender Unstiffened Elements Q_s

Table B4.1 Limiting Width-Thickness Ratios for Compression Elements Unstiffened Elements

Case 5: Uniform compression in legs of single angles, legs of double angles with separators, and all other unstiffened elements

E7-1(c) For single angles:

$$Q_s = 1.0 \qquad \text{when } \frac{b}{t} \le 0.45\sqrt{\frac{E}{F_y}} \qquad (E7-10)$$

$$Q_s = 1.34 - 0.76\left(\frac{b}{t}\right)\sqrt{\frac{F_y}{E}} \qquad \text{when } 0.45\sqrt{\frac{E}{F_y}} < \frac{b}{t} < 0.91\sqrt{\frac{E}{F_y}} \qquad (E7-11)$$

$$Q_s = \frac{0.53E}{F_y\left(\frac{b}{t}\right)^2} \qquad \text{when } \frac{b}{t} \ge 91\sqrt{\frac{E}{F_y}} \qquad (E7-12)$$

Design and Allowable Stresses

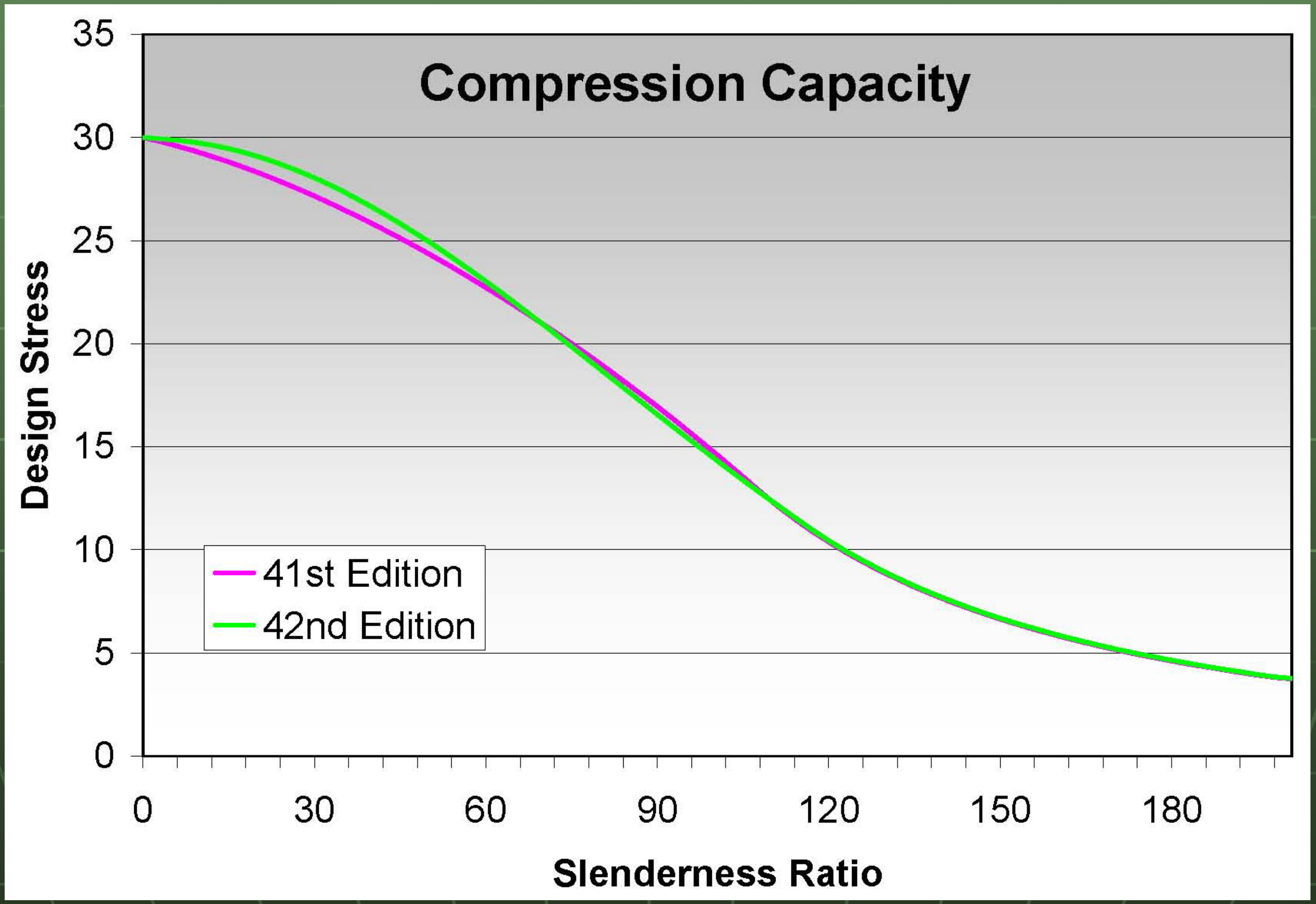
The allowable compression stress is given by the following formulas in AISC-ASD 9th Edition

$$F_a = \frac{\left[1 - \frac{(Kl/r)^2}{2C_c^{\,2}}\right]F_y}{\frac{5}{3} + \frac{3(Kl/r)}{8C_c} - \frac{(Kl/r)^3}{8C_c^{\,3}}} \qquad (E2-1)$$

$$\text{where } C_c = \sqrt{\frac{2\pi^2 E}{F_y}}$$

$$F_a = \frac{12\pi^2 E}{23(Kl/r)^2} \qquad (E2-2)$$

Design and Allowable Stresses



Design and Allowable Stresses

Section 4.2(c) Bending

Bending calculations are to be based on using the elastic section modulus.

For chords and web members other than solid rounds:

F_y = 50 ksi (345 MPa)

Design Stress = $0.9F_y$ (LRFD) (4.2-8)

Allowable Stress = $0.6F_y$ (ASD) (4.2-9)

For web members of solid round cross-section:

F_y = 50 ksi (345 MPa) or F_y = 36 ksi (250 MPa)

Design Stress = $1.45F_y$ (LRFD) (4.2-10)

Allowable Stress = $0.95F_y$ (ASD) (4.2-11)

Design and Allowable Stresses

Section 4.2(c) Bending (cont'd)

For bearing plates:

F_y = 50 ksi (345 MPa) or F_y = 36 ksi (250 MPa)

Design Stress = $1.35F_y$ (LRFD) (4.2-12)

Allowable Stress = $0.90F_y$ (ASD) (4.2-13)

Design and Allowable Stresses

Section 4.4

- The combined interaction equations have been modified to take advantage of the "8/9" factor now allowed by AISC on the bending part of the interaction.
- The constants in the "moment magnification" parts of the equations were carefully constructed to produce the same interaction result for equal **ASD** or **LRFD** Required Stresses.

Design and Allowable Stresses

Section 4.4 Members

When the panel length exceeds 24 inches, the top chord shall be designed as a continuous member subject to combined axial and bending stresses and shall be so proportioned that:

For LRFD:

At the panel point:

$$f_{au} + f_{bu} \leq 0.9 F_y \qquad \textbf{(4.4-1)}$$

Design and Allowable Stresses

For LRFD:

At the mid panel:

For, $\dfrac{f_{au}}{\phi_c F_{cr}} \geq 0.2$

$$\frac{f_{au}}{\phi_c F_{cr}} + \frac{8}{9}\left[\frac{C_m f_{bu}}{\left[1-\left(\dfrac{f_{au}}{\phi_c F_e}\right)\right] Q\phi_b F_y}\right] \leq 1.0 \qquad \textbf{(4.4-2)}$$

For, $\dfrac{f_{au}}{\phi_c F_{cr}} < 0.2$

$$\left(\frac{f_{au}}{2\phi_c F_{cr}}\right) + \left[\frac{C_m f_{bu}}{\left[1-\left(\dfrac{f_{au}}{\phi_c F_e}\right)\right] Q\phi_b F_y}\right] \leq 1.0 \qquad \textbf{(4.4-3)}$$

Design and Allowable Stresses

Where:

F_{au} = P_u/A = Required compressive stress, ksi (MPa)

P = Required axial strength using LRFD load combinations, kips (N)

F_{bu} = M_u/S = Required bending stress at the location under consideration, ksi (MPa)

M_u = Required flexural strength using LRFD load combinations, kip-in. (N-mm)

S = Elastic Section Modulus, $in.^3$ (mm^3)

F_{cr} = Nominal axial compressive stress in ksi (MPa) based on ℓ/r as defined in Section 4.2(b)

C_m = $1 - 0.3\ f_{au}/\varphi F_e$ for end panels

C_m = $1 - 0.4\ f_{au}/\varphi F_e$ for interior panels

F_y = Specified minimum yield strength, ksi (MPa)

Q = Form factor defined in Section 4.2(b)

A = Area of the top chord, in.2 (mm^2)

Design and Allowable Stresses

Section 4.4 Members (cont'd)

For ASD:

At the panel point:

$$f_a + f_b \leq 0.6\,F_y \qquad \textbf{(4.4-4)}$$

Design and Allowable Stresses

For ASD:

At the mid panel:

For, $\frac{f_a}{F_a} \geq 0.2$

$$\frac{f_a}{F_a} + \frac{8}{9}\left[\frac{C_m f_b}{\left[1 - \left(\frac{1.67 f_a}{F_e}\right)\right] Q F_b}\right] \leq 1.0 \qquad \textbf{(4.4-5)}$$

For, $\frac{f_a}{F_a} < 0.2$

$$\left(\frac{f_a}{2F_a}\right) + \left[\frac{C_m f_b}{\left[1 - \left(\frac{1.67 f_a}{F_e}\right)\right] Q F_b}\right] \leq 1.0 \qquad \textbf{(4.4-6)}$$

Design and Allowable Stresses

Where:

f_a = P/A = Required compressive stress, ksi (MPa)

P = Required axial strength using ASD load combinations, kips (N)

f_b = M/S = Required bending stress at the location under consideration, ksi (MPa)

M = Required flexural strength using ASD load combinations, k-in. (N-mm)

S = Elastic Section Modulus, in.^{3} (mm^3)

F_a = Allowable axial compressive stress based on ℓ/r as defined in Section 4.2(b), ksi (MPa)

F_b = Allowable bending stress; $0.6F_y$, ksi (MPa)

C_m = $1 - 0.50\ f_a/F_e$ for end panels

C_m = $1 - 0.67\ f_a/F_e$ for interior panels

Design and Allowable Stresses

- Within a discontinuous panel point, the effects of combined shear and axial stress are considered.
- For double angle chord members, only the area of the vertical legs is used in computing the shear stress.

Design and Allowable Stresses

Node shear:

For LRFD: $1/2\sqrt{(f_t)^2 + 4(f_v)^2} \leq 0.6F_y$ (SJI – 1)

For ASD: $1/2\sqrt{(f_t)^2 + 4(f_v)^2} \leq 0.4F_y$ (SJI – 2)

Design and Allowable Stresses

- For Joist Girders, a check is made for bearing capacity of the outstanding leg of a double angle top chord in combination with axial compression.

- The allowable bearing end reaction (P_p) at each chord angle is computed and compared against ½ the girder panel point load.

Design and Allowable Stresses

$$P_p = \frac{t^2 F_y}{2(b-K)}\left[g + 5.66(b-K)\right] \qquad (SJI-3)$$

Allowable reaction is lesser of:

For LRFD: $0.9P_p$ and $0.9P_p\left[1.6 - \frac{f_a}{0.9QF_y}\right]$ $(SJI-4)$

For ASD: $0.6P_p$ and $0.6P_p\left[1.6 - \frac{f_a}{0.6QF_y}\right]$ $(SJI-5)$

Design and Allowable Stresses

- An allowance is made for eccentricity at the supports by limiting the top chord end panel and the end web member to 90 percent of the Design Stress or Allowed Stress.

Code of Standard Practice Highlights

- Document renamed, *Recommended* removed from title
- Three sections revised; modified and edited
  - Section 2. Joists and Accessories
  - Section 5. Estimating
  - Section 6. Plans and Specifications

Plans and Specifications

- Plans Furnished by Buyer

  The Buyer shall furnish the Seller plans and specifications as prepared by the *Specifying Professional* showing all material requirements and steel joist and/or steel joist girder designations, the layout of walls, columns, beams, girders and other supports, as well as floor and roof openings and partitions correctly dimensioned. The live loads to be used, the wind uplift if any, the weights of partitions and the location and amount of any special loads, such as monorails, fans, blowers, tanks, etc., shall be indicated. The elevation of finished floors, roofs, and bearings shall be shown with due consideration taken for the effects of dead load deflections.

  (a) Loads
  (b) Connections
  (c) Special Considerations

Loads

- The Steel Joist Institute does not presume to establish the loading requirements for which structures are designed.
- The Steel Joist Institute Load Tables are based on uniform loading conditions and are valid for use in selecting joist sizes for gravity loads that can be expressed in terms of "pounds per linear foot" (kiloNewtons per Meter) of joist. The Steel Joist Institute Joist Girder Weight Tables are based on uniformly spaced panel point loading conditions and are valid for use in selecting Joist Girder sizes for gravity conditions that can be expressed in kips (kiloNewtons) per panel point on the Joist Girder.
- The *Specifying Professional* shall provide the nominal loads and load combinations as stipulated by the applicable code under which the structure is designed and shall provide the design basis (ASD or LRFD).

Loads

- The *Specifying Professional* shall calculate and provide the magnitude and location of ALL JOIST and JOIST GIRDER LOADS. This includes all special loads (drift loads, mechanical units, net uplift, axial loads, moments, structural bracing loads, or other applied loads) which are to be incorporated into the joist or Joist Girder design. For Joist Girders, reactions from supported members shall be clearly denoted as point loads on the Joist Girder. When necessary to clearly convey the information, a Load Diagram or Load Schedule shall be provided.

- The *Specifying Professional* shall give due consideration to:
  1. Ponded rain water
  2. Accumulation of snow
  3. Wind forces
  4. Seismic forces

Loads

- Where the LRFD method is being used, the joist manufacturer should be provided with total design loads on the contract drawings that are already factored.
- This is important since the proportions of dead and live load are not always given (For example, a Joist Girder designation).

Loads

- **Replace the "K" at the end of Joist Girder designations with "F" to denote factored loads.**

  48G10N12K for **ASD**

  48G10N18F for **LRFD**

- **For wind uplift, the NET uplift is requested; i.e., the result of the appropriate load combination involving "D" and "W".**

Concentrated Loads

- Where concentrated loads occur, the magnitude and location of these concentrated loads shall be shown on the structural drawings when, in the opinion of the *Specifying Professional*, they may require consideration by the joist manufacturer.
- The *Specifying Professional* shall use one of the following options that allows the:
  - Estimator to price the joists.
  - Joist manufacturer to design the joists properly.
  - Owner to obtain the most economical joists.

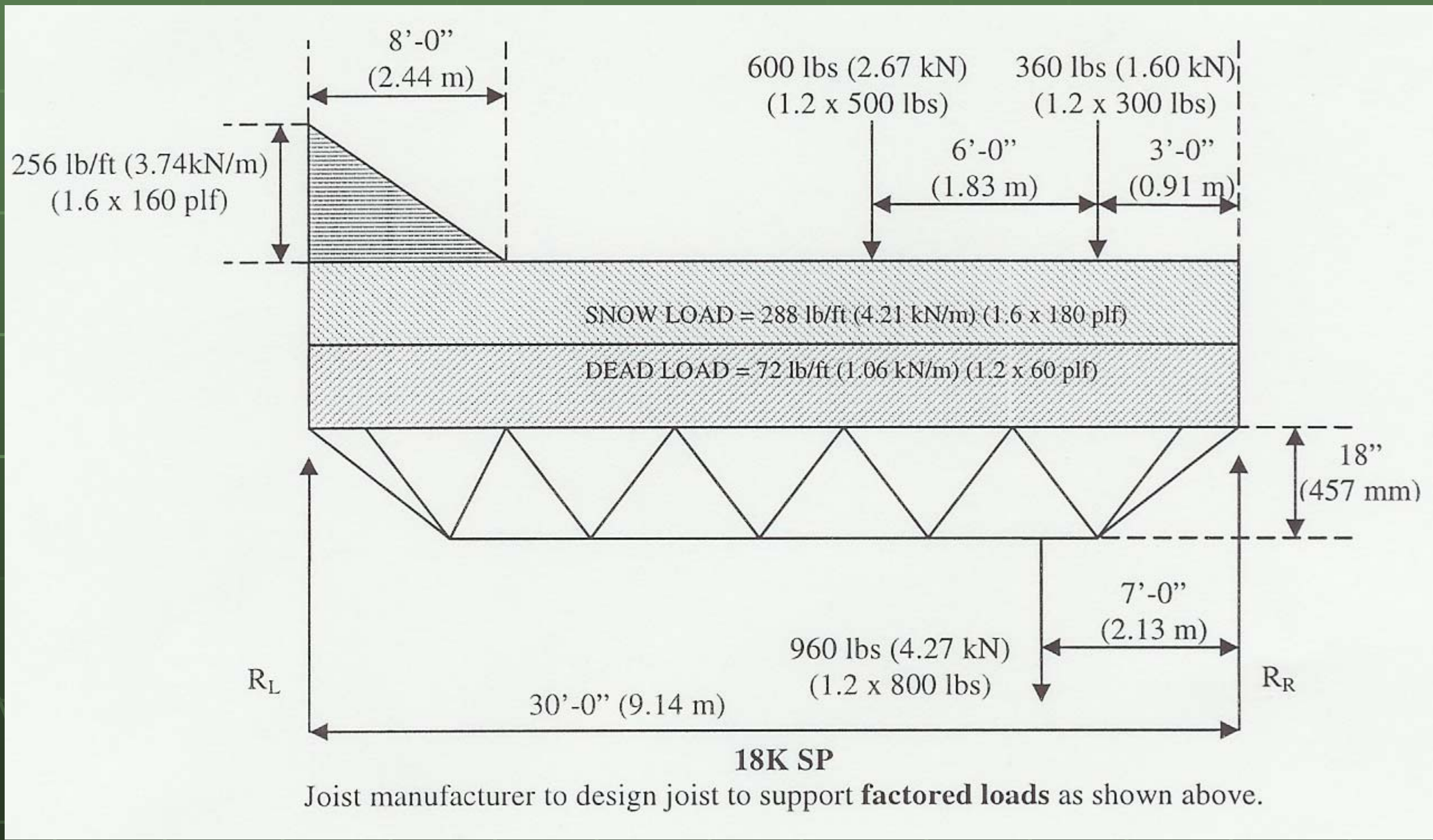
OPTION 1: Select a Standard SJI joist for the UDL and provide the load and location of any additional loads.

OPTION 2: Select a KCS joist using moment and end reaction.

OPTION 3: Specify a SPECIAL joist with load diagrams.

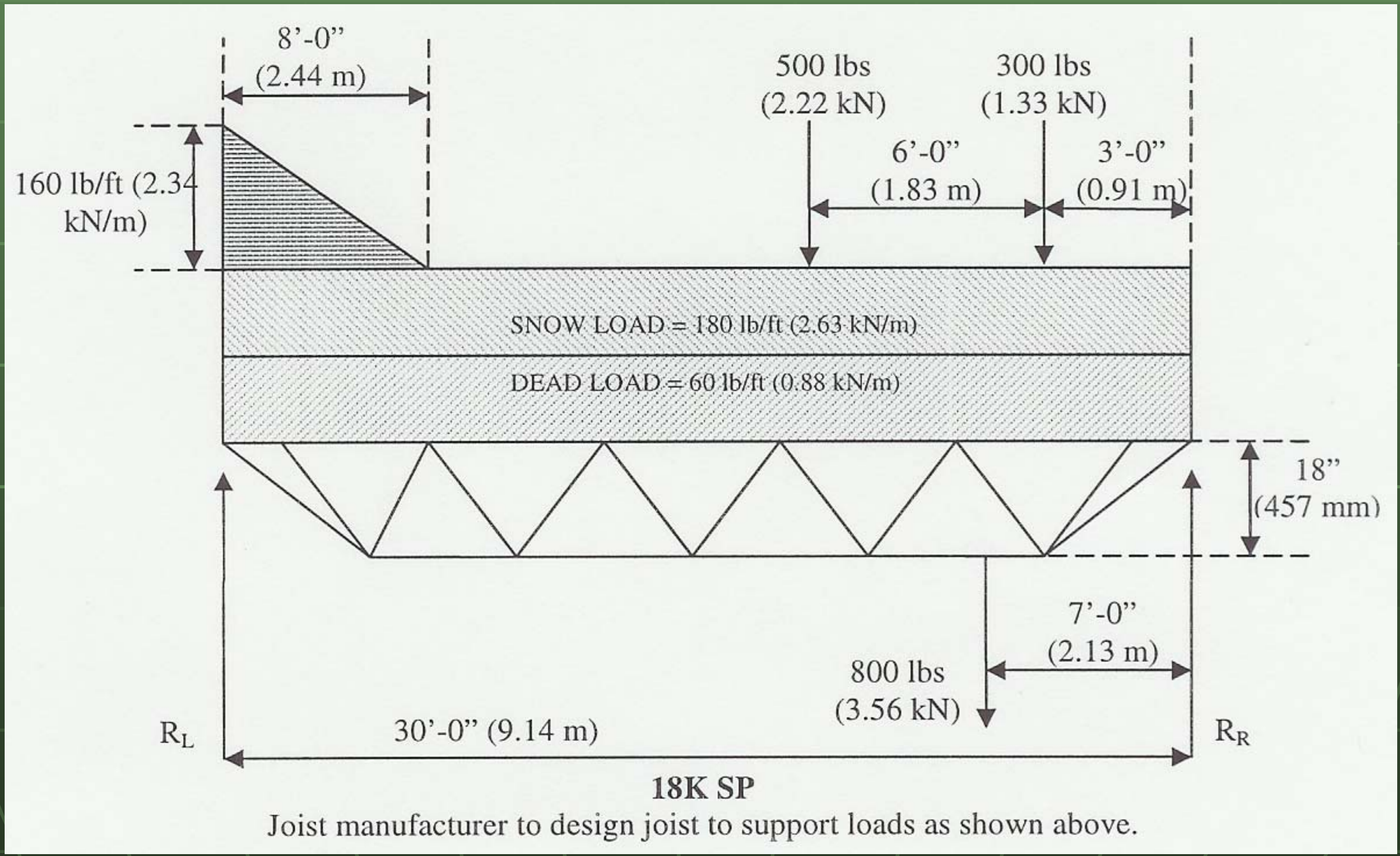
Concentrated Loads

LRFD Load Diagram per ASCE 7 2.3.2 (3): 1.2D + 1.6S



Concentrated Loads

ASD Load Diagram per ASCE 7 2.4.1 (3): D + S



Concentrated Loads

- The load combinations previously shown are for the referenced examples only.
- It is not to be presumed that the joist designer is responsible for the applicable building code load combinations.
- If the loading criteria are too complex to adequately communicate in a simple load diagram, then the specifying professional shall provide a load schedule showing the specified design loads, load categories, and required load combinations with applicable load factors (i.e. for ASD or LRFD).

2003 International Building Code

- **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 SJI 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**

2006 International Building Code

- 2206.1 General.
- 2206.2 Design.
- 2206.3 Calculations.
- 2206.4 Steel Joist Drawings.
- 2206.5 Certification.

2006 International Building Code

- IBC Code Revision Background
- Compromise between SJI and NCSEA

An agreement was worked out between the two parties and IBC that initiated with a concern that steel joist details could fall outside the direct supervision of either the EOR or Specialty Engineer

2006 International Building Code

- **2206.2 Design.**

  This section outlines the responsibility of the Registered Design Professional and what needs to be shown on the contract drawings.

  1. **Special loads**
  2. **Special considerations**
  3. **Deflection criteria for non-SJI standard joists**

2006 International Building Code

- **2206.3 Calculations.**

  This section describes that the RDP may request sealed calculations from the joist manufacturer's registered design professional. In addition to the standard calculation package(s) the following shall be included:

  1. **Non-SJI standard bridging details**
  2. **Connection details for: Non-SJI standard connections; field splices; and joist headers**

2006 International Building Code

- **2206.4 Steel Joist Drawings.**

  This section shows the products as specified in the contract drawings.

  These drawings <u>will not</u> be sealed.

2006 International Building Code

- **2206.4 Steel Joist Drawings.**

  Joist Placement Plans

  1. **Listing of all applicable loads**
  2. **Profiles for non-standard joist and joist girder configurations**
  3. **Connection requirements**
  4. **Deflection criteria for non-SJI standard joists**
  5. **Size, location and connections for all bridging**
  6. **Joist headers**

2006 International Building Code

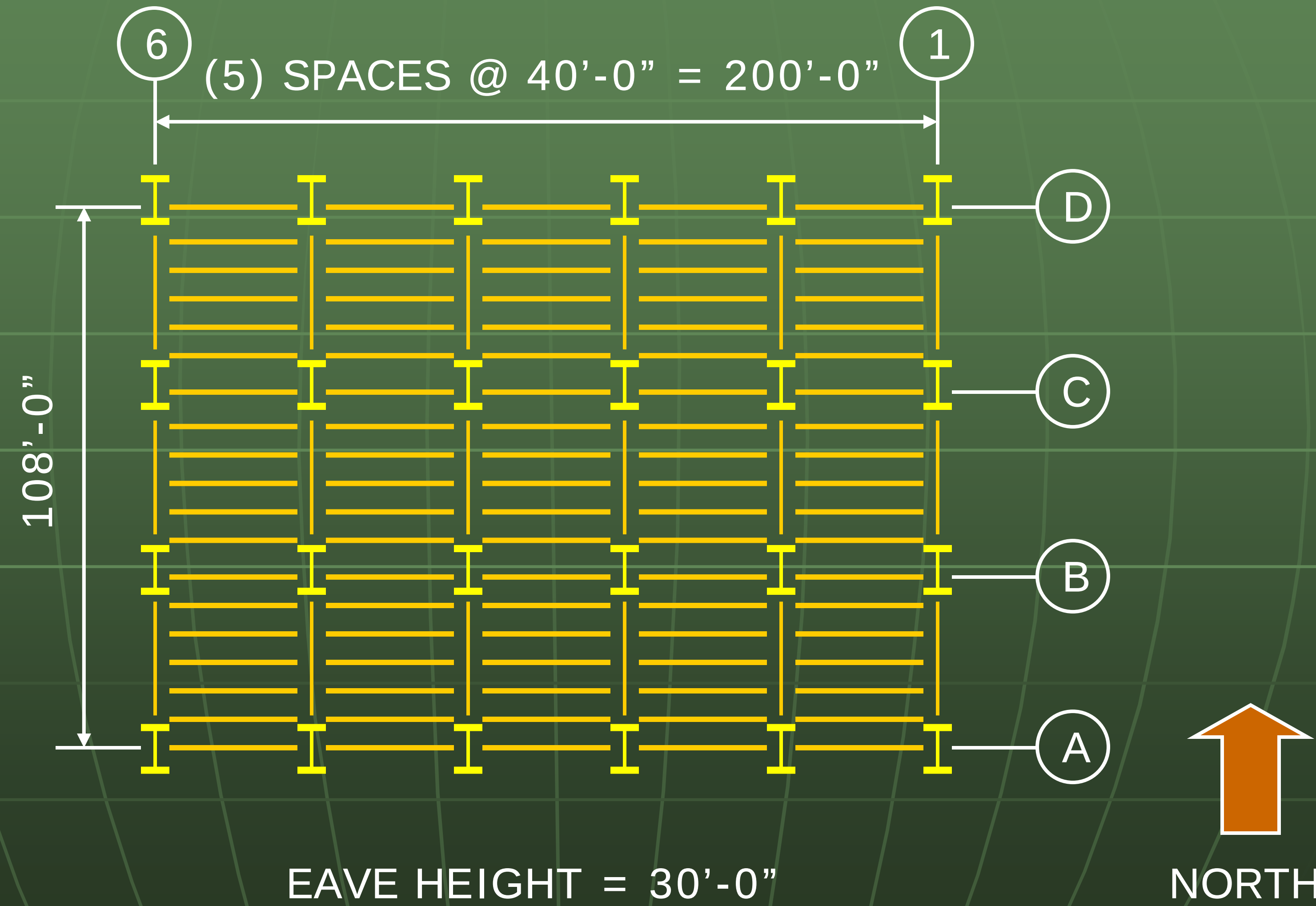
- **2206.5 Certification.**

  The joist manufacturer shall issue a Certificate of Compliance to the SJI Specifications and contract documents at the completion of fabrication.

Practical Usage – A Design Example

- **The joist manufacturer needs to know:**
  - Is the structural design, and therefore the joist design, **ASD** or **LRFD**?
  - What is the applicable model building code?
  - Are there special loads that require load combinations other than those of ASCE 7?

Overall Building Layout



Design Example using ASD and LRFD

Consider a typical interior bay of a building with the following design parameters:

- **Joist span = 40 ft.**
- **Joist Girder span = 36 ft.**
- **Joist spacing 6’ – 0” on centers**

Design Example using ASD and LRFD

Required Loads or Load Combinations to be Provided from the Engineer of Record Include:

Dead Load, Live Load, Rain Load,

Snow Load, Wind Load, Seismic Load, Other Loads, etc.

These Loads can be Uniformly Distributed Loads, Other Types of Distributed Loads or Concentrated Loads, and depending on the Design Methodology selected, need to be either unfactored or factored.

Self Weight of Joists and Joist Girders

When specifying joists, always include the self weight of joists and bridging.

When specifying joist girders, it is normal that the self weight of the girders is included in the specified loads. When this is not the case, the design drawings must clearly note that self weight is not included and the manufacturer must add self weight.

Design Example using ASD and LRFD

Design Parameters for St. Louis, MO

Building Eave Height, h = 30 ft.

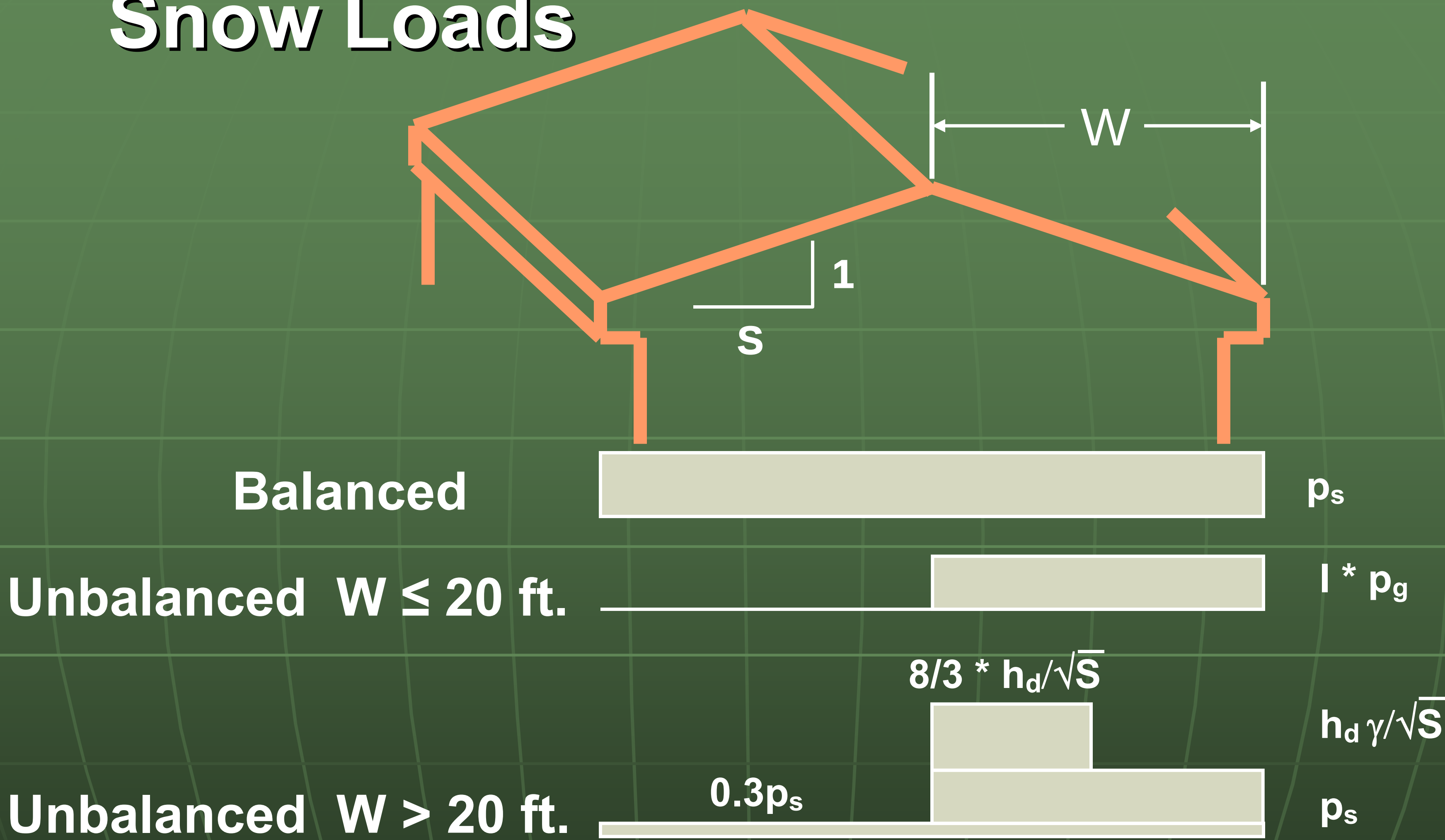
Building Importance Factor, I = 1.0

Basic Wind Speed, V = 90 mph

Building Exposure Category B, K_{zt} = 1.0

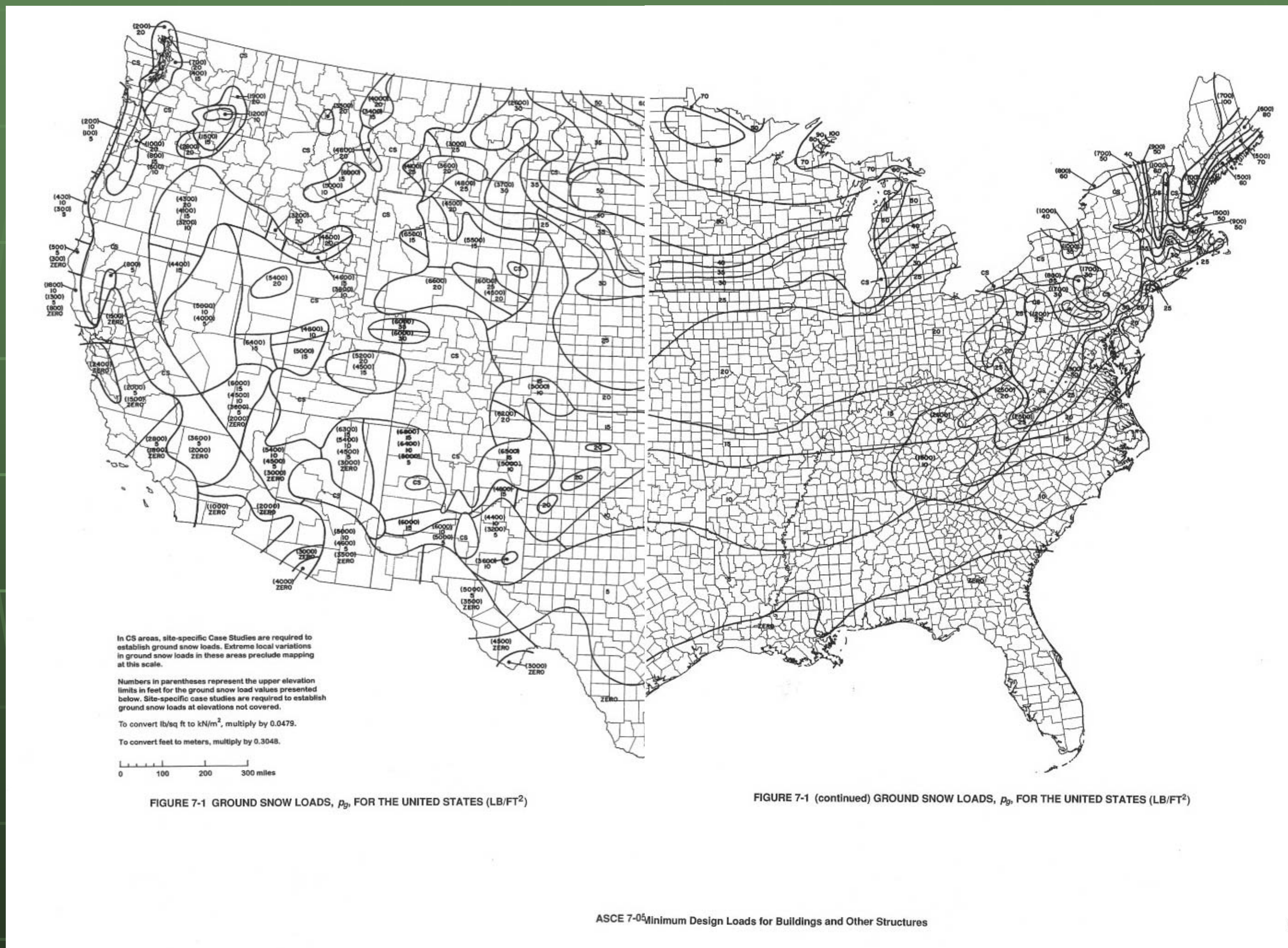
Roof Slope = 1/4 : 12 (low slope)

Snow Loads

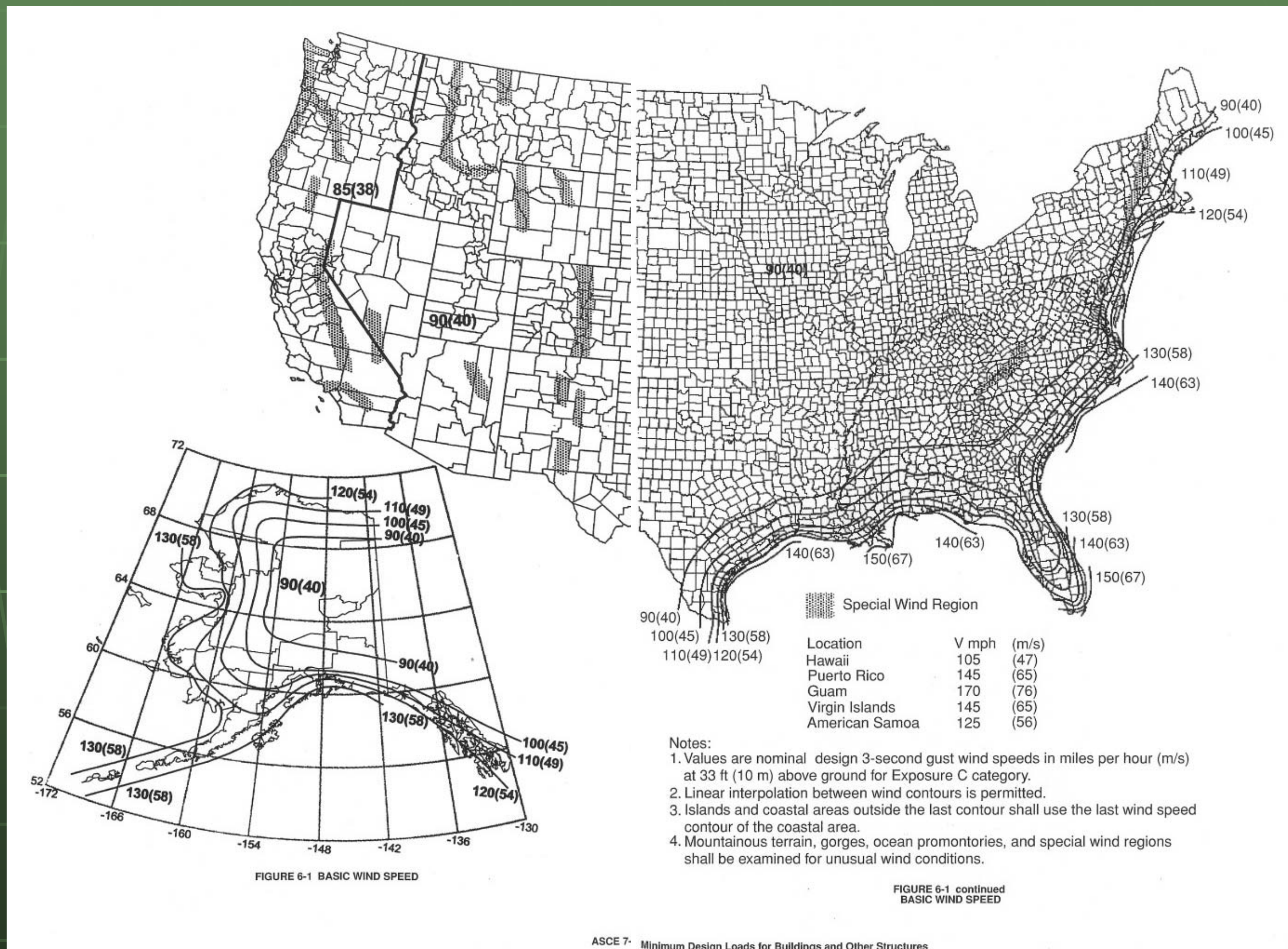


Note: Unbalanced loads need not be considered for θ > 70° or for θ < larger of 2.38° and 70/W + 0.5

Snow Load Map



Wind Load Map



Design Example using ASD and LRFD

Design Dead Load = 22 psf

Roof Live Load L_r = 20 psf

Snow Load p_g = 20 psf; p_s = 20 psf

Per ASCE 7-05, Section 7.10 add 5 psf rain-on-snow surcharge,

Design Snow Load = 20 psf + 5 psf = 25 psf

Per ASCE 7-05, Figure 6.3 Components and Cladding, Zone 1 (Interior Bay), Effective Wind Area > 100 sf, Net Design Wind Pressure,

p_{net30} = 4.7 psf, -13.3 psf

Wind Loads: Uplift

When wind uplift is a design consideration, it should be specified as <u>net</u> uplift on the joists and Joist Girders.

The Engineer of Record knows the design dead load and if there are collateral dead loads that should not be deducted from the gross uplift.

Joists are considered components and cladding.

The joist tributary width need not be less than one-third the joist span.

Wind Loads: Uplift

Joist Girders can be considered part of the main wind force-resisting system, although it is common to simply apply the joist uplift end reactions.

Joist Girder tension webs must be designed to resist , in compression, 25 percent of their axial force.

Hence, uplift loads on a Joist Girder of less than 25 percent of the gravity loads have minimal or no effect on the girder design.

Design Example using ASD and LRFD

Other Design Considerations

The interior bay has a hanging catwalk that is attached to the bottom chords of two joists at three panel point locations (600 lbs each, unfactored).

One joist of the interior bay has a 15^K top chord axial load due to seismic.

No Live Load Reduction has been taken.

Basic Load Combinations

- IBC 1605.2.1 Load and Resistance Factor Design

Basic load combinations. Where strength or load and resistance factor design is used, structures and portions thereof shall resist the most critical effects resulting from the following combinations of factored loads:

Basic Load Combinations

$1.4D$	(Eqn 16-1)
$1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$	(Eqn 16-2)
$1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (f_1L \text{ or } 0.8W)$	(Eqn 16-3)
$1.2D + 1.6W + f_1L + 0.5(L_r \text{ or } S \text{ or } R)$	(Eqn 16-4)
$1.2D + 1.0E + f_1L + f_2S$	(Eqn 16-5)
$0.9D + 1.6W$	(Eqn 16-6)
$0.9D + 1.0E$	(Eqn 16-7)

Basic Load Combinations

f_1 = 1.0 for floors in places of public assembly, for live loads in excess of 100 psf and for parking garage live load, and

= 0.5 for other live loads

f_2 = 0.7 for roof configurations (such as saw tooth) that do not shed snow off the structure, and

= 0.2 for other roof configurations

Exception: Where other factored load combinations are specifically required by the provisions of this code, such combinations shall take precedence.

Basic Load Combinations

- IBC 1605.3.1 Allowable Stress Design

Basic load combinations. Where allowable stress design (working stress design), as permitted by this code, is used, structures and portions thereof shall resist the most critical effects resulting from the following combinations of loads:

Basic Load Combinations

D	(Eqn 16-8)
$D + L$	(Eqn 16-9)
$D + (L_r \text{ or } S \text{ or } R)$	(Eqn 16-10)
$D + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$	(Eqn 16-11)
$D + (W \text{ or } 0.7E)$	(Eqn 16-12)
$D + 0.75((W \text{ or } 0.7E) + L + (L_r \text{ or } S \text{ or } R))$	(Eqn 16-13)
$0.6D + W$	(Eqn 16-14)
$0.6D + 0.7E$	(Eqn 16-15)

Basic Load Combinations

Exceptions:

1. Crane hook loads need not be combined with roof live load or with more than three-fourths of the snow load or one-half of the wind load.
2. Flat roof snow loads of 30 psf or less need not be combined with seismic loads. Where flat roof snow loads exceed 30 psf, 20 percent shall be combined with seismic loads.

Basic Load Combinations

- IBC 1605.3.1.1 Stress increases.

  Increases in allowable stresses specified in the appropriate material chapter or the referenced standards shall not be used with the load combinations of Section 1605.3.1, except that a duration of load increase shall be permitted in accordance with Chapter 23 WOOD.

- IBC 1605.3.1.2 Other loads.

Basic Load Combinations

- IBC 1605.3.2 Alternate Basic Load Combinations

In lieu of the basic load combinations specified in Section 1605.3.1, structures and portions thereof shall be permitted to be designed for the most critical effects resulting from the following combinations. When using these alternate basic load combinations that include wind or seismic loads, allowable stresses are permitted to be increased or load combinations reduced, where permitted by the material section of this code or referenced standard. Where wind loads are calculated in accordance with Section 1609.6 or ASCE 7, the coefficient ω in the following formulas shall be taken as 1.3. For other wind loads ω shall be take as 1.0.

Alternate Basic Load Combinations

$D + L + (L_r \text{ or } S \text{ or } R)$	(Eqn 16-16)
$D + L + (\omega W)$	(Eqn 16-17)
$D + L + \omega W + S / 2$	(Eqn 16-18)
$D + L + S + \omega W / 2$	(Eqn 16-19)
$D + L + S + E / 1.4$	(Eqn 16-20)
$0.9D + E / 1.4$	(Eqn 16-21)

The same exceptions apply to these Alternate Basic Load Combinations as apply to the Basic Load Combinations using allowable stress design.

ASD Load Combinations

D = 22 psf

D + S = 22 + 25 = 47 psf

D + W = 22 +4.7 = 27 psf

D + 0.75(W + S) = 22 + 0.75(4.7 + 25) = 44 psf

0.6D + W = 0.6(22) + (-13.3) = -0.1 psf

Therefore, essentially No Net Uplift Pressure

Roof Framing Plan Interior Bay using ASD

ASD Selections:

Controlling Load Combination = D + S

Joist capacity ≥ 6 ft. (47 psf) = 282 plf

Select 24K9 from Load Table

Joist Girder capacity

40 ft. (282 plf) = 11.3^{K} per PP + self weight

Self weight = 36 ft. ($0.039^{K}/_{ft.}$) /6 = 0.234^{K} per PP

Select 36G6N11.6K from Weight Table

Roof Framing Plan Interior Bay using ASD

Select

ASD

STANDARD LOAD [illegible] OPEN WEB STEEL JOISTS, K-SERIES
Based on a 50 ksi Maximum [illegible] Yield Strength - Loads Shown in Pounds per Linear Foot (plf)

Joist Designation	24K4	24K5	24K6	24K7	[illegible]	24K9	[illegible]	24K12	26K5	26K6	26K7	26K8	26K9	26K10	26K12
Depth (In.)	24	24	24	24	24	24	24	24	26	26	26	26	26	26	26
Approx. Wt. (lbs./ft.)	8.4	9.3	9.7	10.1	[illegible]	[illegible]	13.1	16.0	9.8	10.6	10.9	12.1	12.2	13.8	16.6
Span (ft.) ↓															
24	520 516	550 544	550 544	[illegible] 544	550 544	[illegible]	550 544	550 544							
25	479 456	540 511	[illegible]	550 520	550 520	[illegible]	550 520	550 520							
26	442 405	499 [illegible]	543 493	550 499	550 499	[illegible]	550 499	550 499	542 535	550 541	550 541	550 541	550 541	550 541	550 541
27	410 361	462 404	503 439	550 479	550 479	[illegible]	550 479	550 479	502 477	547 519	550 522	550 522	550 522	550 522	550 522
38	205 128	231 143	252 156	281 172	310 189	[illegible]	401 240	461 275	251 169	274 184	305 204	337 223	367 241	436 284	461 299
39	195 118	219 132	239 144	266 159	294 [illegible]	[illegible]	380 [illegible]	449 261	238 156	260 170	289 188	320 206	348 223	413 262	449 283
40	185 109	208 122	227 133	253 148	[illegible]	304 175	[illegible]	438 247	227 145	247 157	275 174	304 191	331 207	393 243	438 269
[illegible]	176 101	198 114	216 124	241 137	[illegible] 150	[illegible] 162	[illegible] 191	427 235	215 134	235 146	262 162	289 177	315 192	374 225	427 256
42	168	189	206	229	253	276	327	417	205	224	249	275	300	356	417

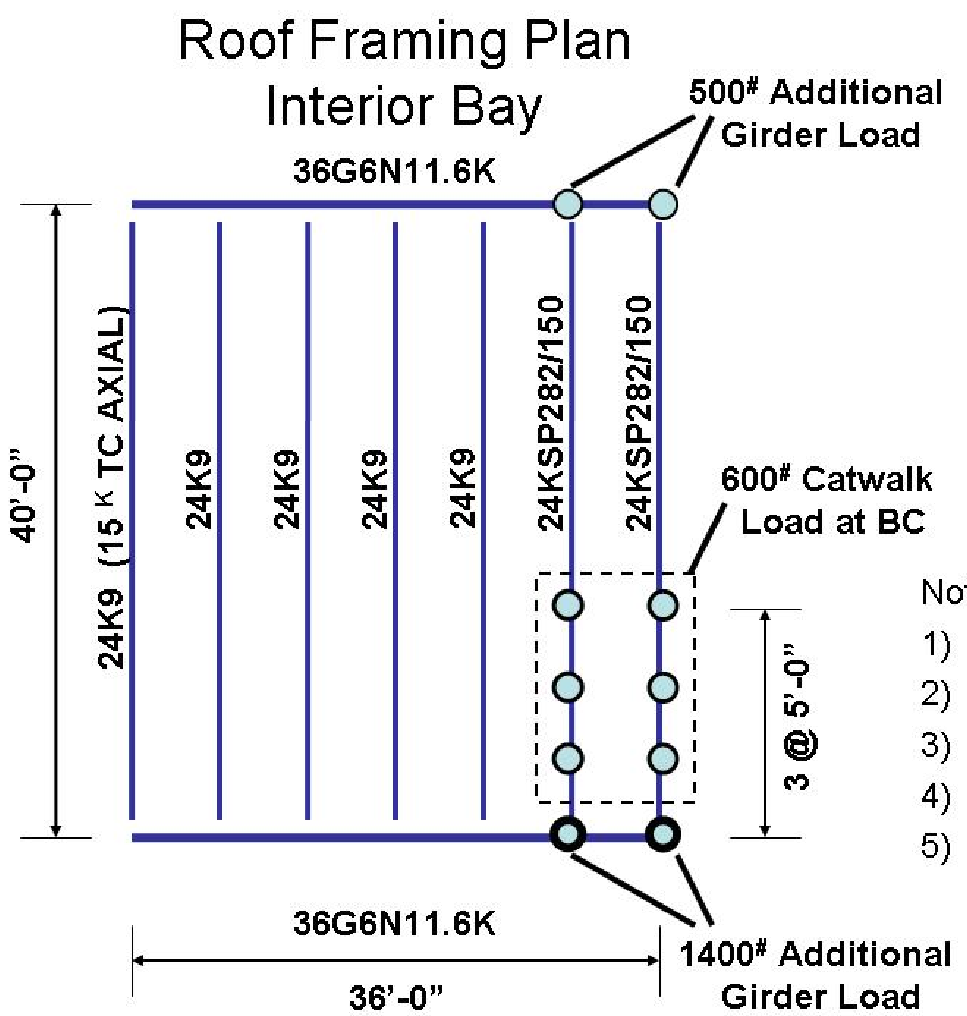
Roof Framing Plan Interior Bay using ASD

Select

ASD

GIRDER SPAN (ft.)	JOIST SPACES (ft.)	GIRDER DEPTH (in.)	JOIST GIRDER WEIGHT – POUNDS PER LINEAR FOOT																	
			LOAD ON EACH PANEL POINT – KIPS																	
			4	6	8	10	12	14	16	18	20	24	28	32	36	40	44	48	52	56
35	4N@ 8.75	28	16	19	23	27	31	36	41	46	52	60	74	79	94	100	111	117	137	138
		32	15	18	21	24	28	33	37	39	45	53	60	73	80	92	100	106	112	127
		36	15	16	20	[illegible]	27	30	33	37	41	561	55	62	74	83	94	97	107	113
		40	15	16	17	21	26	27	30	37	38	46	52	61	64	75	90	95	96	108
	5N@ 7.00	28	15	20	26	32	37	43	52	57	59	73	86	100	109	126	136			
		32	15	18	24	29	34	37	45	50	53	66	75	88	100	102	112	128	138	
		36	16	17	23	27	29	35	40	46	48	62	68	77	90	100	104	115	131	133
		40	16	17	22	25	27	33	37	43	47	56	63	70	80	95	102	107	115	125
	6N@ 5.83	28	17	24	30	37	44	52	58	65	73	93	103	115	134					
		[illegible]	16	21	27	[illegible]	[illegible]	46	53	57	65	79	96	100	117	139	140			
		36	16	20	25	31	36	41	48	54	58	70	81	99	102	113	121	142	144	
		[illegible]	16	20	24	[illegible]	[illegible]	38	44	49	55	64	77	84	101	104	115	123	145	146
	7N@ 5.00	28	19	27	34	43	52	59	66	74	86	101	115	135						
		32	17	24	30	39	47	53	61	67	75	97	103	118	137					
		36	17	23	28	35	42	48	55	62	69	82	99	105	120	141	144			
		40	17	22	27	32	39	44	50	55	63	73	86	102	107	118	133	147		
	8N@ 4.38	28	21	30	39	48	59	69	78	94	98	115	136							
		32	20	27	36	42	53	61	69	79	88	101	118	138						
		36	19	26	32	39	48	55	62	71	77	99	109	121	141					
		40	18	24	30	37	44	54	60	65	73	86	102	113	127	147	149			
38	4N@ 9.50	32	16	19	21	26	31	34	39	43	48	58	67	74	87	100	101	111	127	138
		36	15	17	21	24	28	33	35	39	44	53	60	74	75	93	97	106	112	123
		40	15	16	20	23	27	30	34	37	41	51	55	62	74	83	94	98	107	109
		44	16	16	20	22	26	28	30	35	38	46	52	58	65	75	90	95	95	108
	5N@ 7.60	32	15	20	25	31	36	42	46	52	59	70	86	96	101	111	126	137		
		36	16	20	24	28	33	38	45	47	53	64	74	89	98	103	112	129	138	
		40	16	20	23	26	31	35	40	46	48	59	70	78	91	101	105	113	117	134
		44	17	20	22	25	30	33	39	41	48	56	63	75	80	93	102	107	111	118
	6N@ 6.33	[illegible]	17	24	30	[illegible]	[illegible]	49	55	62	70	86	98	105	125	136				
		36	16	21	27	33	39	47	50	57	61	75	89	100	107	118	141	142		
		[illegible]	16	21	25	[illegible]	[illegible]	40	48	55	59	71	82	99	102	109	121	143	142	
		44	17	20	24	29	33	38	44	49	55	64	77	84	102	104	115	123	145	147

Roof Framing Plan Interior Bay using ASD



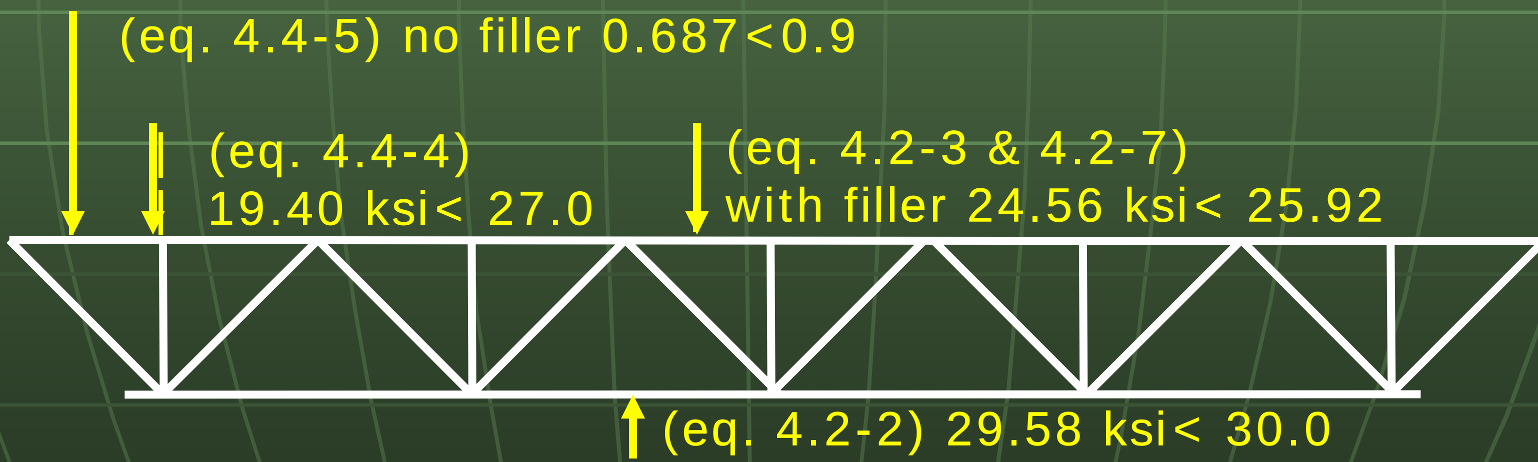
Notes:

1) ASD Design
2) IBC 2006
3) All loads are unfactored
4) No net uplift
5) Bridging per SJI

24K9 Joist Design using ASD

TC = 2 L's 2 x 2 x .166, Q=0.960

BC = 2 L's 1.75 x 1.75 x .155



LRFD Load Combinations

1.4D = 1.4(22) = 31 psf

1.2D + 0.5S = 1.2(22) + 0.5(25) = 39 psf

1.2D + 1.6S + 0.8W =

1.2(22) + 1.6(25) + 0.8(4.7) = 70 psf

1.2D + 1.6W + 0.5S =

1.2(22) + 1.6(4.7) + 0.5(25) = 46 psf

1.2D + f_2S = 1.2(22) + 0.2(25) = 31 psf

0.9D + 1.6W = 0.9(22) + 1.6(-13.3) = -1.5 psf

Therefore, use a Net Wind Uplift Pressure of 2 psf

Roof Framing Plan Interior Bay using LRFD

LRFD Selections:

Controlling Load Combination = 1.2D + 1.6S +0.8W

Joist capacity ≥ 6 ft. (70 psf) = 420 plf

Select 24K8 from Load Table

Joist Girder capacity

40 ft. (420 plf) = 16.8^K + 1.2 (self weight)

Factored self weight = 1.2 (36 ft.)($0.039^K/_{ft.}$) /6

= 0.281^K per PP

Select 36G6N17.1F from Weight Table

Roof Framing Plan Interior Bay using LRFD

Select

LRFD

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	24K4	24K5	24K6	24K7	24K8	24K9	24K10	24K12	26K5	26K6	26K7	26K8	26K9	26K10	26K12
Depth (In.)	24	24	24	24	24	24	24	24	26	26	26	26	26	26	26
Approx. Wt. (lbs./ft.)	8.4	9.3	9.7	[illegible]	[illegible]	12.0	13.1	16.0	9.8	10.6	10.9	12.1	12.2	13.8	16.6
Span (ft.) ↓															
24	780 516	825 544	[illegible] 544	825 544	[illegible]	825 544	825 544	825 544							
25	718 456	810 [illegible]	825 520	825 520	[illegible]	825 520	825 520	825 520							
26	663 405	[illegible] 453	814 493	825 499	[illegible]	825 499	825 499	825 499	813 535	825 541	825 541	825 541	825 541	825 541	825 541
27	615 [illegible]	693 404	754 439	825 479	[illegible]	825 479	825 479	825 479	753 477	820 519	825 522	825 522	825 522	825 522	825 522
38	307 128	346 143	378 156	421 172	[illegible]	507 204	601 240	691 275	376 169	411 184	457 204	505 223	550 241	654 284	691 299
39	292 118	328 132	358 144	399 [illegible]	[illegible]	480 [illegible]	570 222	673 261	357 156	390 170	433 188	480 206	522 223	619 262	673 283
40	277 109	312 122	340 133	[illegible]	420 161	[illegible]	541 206	657 247	340 145	370 157	412 174	456 191	496 207	589 243	657 269
[illegible]	264 101	297 114	324 124	361 137	[illegible] 150	[illegible] 162	516 191	640 235	322 134	352 146	393 162	433 177	472 192	561 225	640 256
42	252 94	283 106	309 115	343 127	379 139	414 151	490 177	625 224	307 125	336 136	373 150	412 164	450 178	534 210	625 244

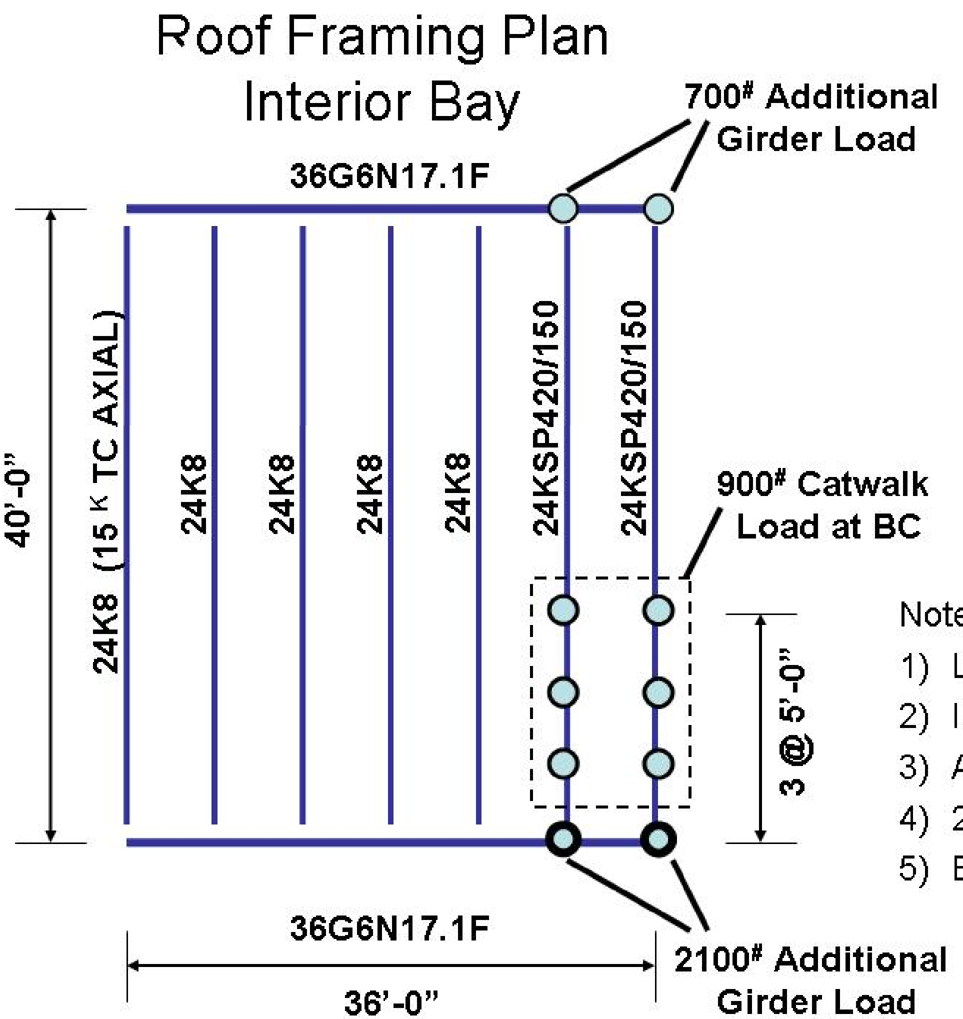
Roof Framing Plan Interior Bay using LRFD

Select

LRFD

GIRDER SPAN (ft.)	JOIST SPACES (ft.)	GIRDER DEPTH (in.)	JOIST GIRDER WEIGHT – POUNDS PER LINEAR FOOT / FACTORED LOAD ON EACH PANEL POINT – KIPS																	
			6.0	9.0	12.0	15.0	18.0	21.0	24.0	27.0	30.0	36.0	42.0	48.0	54.0	60.0	66.0	72.0	78.0	84.0
35	4N@ 8.75	28	16	19	23	27	31	36	41	46	52	60	74	79	94	100	111	117	137	138
		32	15	18	[illegible]	24	28	33	37	39	45	53	60	73	80	92	100	106	112	127
		36	15	16	20	[illegible]	27	30	33	37	41	561	55	62	74	83	94	97	107	113
		40	[illegible]	16	17	21	26	27	30	37	38	46	52	61	64	75	90	95	96	108
	5N@ 7.00	28	15	20	26	32	37	43	52	57	59	73	86	100	109	126	136			
		32	15	18	24	29	34	37	45	50	53	66	75	88	100	102	112	128	138	
		36	16	17	23	27	29	35	40	46	48	62	68	77	90	100	104	115	131	133
		40	16	17	22	25	27	33	37	43	47	56	63	70	80	95	102	107	115	125
	6N@ 5.83	28	17	24	30	37	44	52	58	65	73	93	103	115	134					
		32	16	21	27	[illegible]	[illegible]	46	53	57	65	79	96	100	117	139	140			
		36	16	20	25	31	36	41	48	54	58	70	81	99	102	113	121	142	144	
		[illegible]	16	20	24	[illegible]	[illegible]	38	44	49	55	64	77	84	101	104	115	123	145	146
	7N@ 5.00	28	19	27	34	43	52	59	66	74	86	101	115	135						
		32	17	24	30	39	47	53	61	67	75	97	103	118	137					
		36	17	23	28	35	42	48	55	62	69	82	99	105	120	141	144			
		40	17	22	27	32	39	44	50	55	63	73	86	102	107	118	133	147		
	8N@ 4.38	28	21	30	39	48	59	69	78	94	98	115	136							
		32	20	27	36	42	53	61	69	79	88	101	118	138						
		36	19	26	32	39	48	55	62	71	77	99	109	121	141					
		40	18	24	30	37	44	54	60	65	73	86	102	113	127	147	149			
38	4N@ 9.50	32	16	19	21	26	31	34	39	43	48	58	67	74	87	100	101	111	127	138
		36	15	17	21	24	28	33	35	39	44	53	60	74	75	93	97	106	112	123
		40	15	16	20	23	27	30	34	37	41	51	55	62	74	83	94	98	107	109
		44	16	16	20	22	26	28	30	35	38	46	52	58	65	75	90	95	95	108
	5N@ 7.60	32	15	20	25	31	36	42	46	52	59	70	86	96	101	111	126	137		
		36	16	20	24	28	33	38	45	47	53	64	74	89	98	103	112	129	138	
		40	16	20	23	26	31	35	40	46	48	59	70	78	91	101	105	113	117	134
		44	17	20	22	25	30	33	39	41	48	56	63	75	80	93	102	107	111	118
	6N@ 6.33	32	17	24	30	35	41	49	55	62	70	86	98	105	125	136				
		36	16	21	27	33	39	47	50	57	61	75	89	100	107	118	141	142		
		[illegible]	16	21	25	[illegible]	[illegible]	40	48	55	59	71	82	99	102	109	121	143	142	
		44	17	20	24	29	33	38	44	49	55	64	77	84	102	104	115	123	145	147

Roof Framing Plan Interior Bay using LRFD

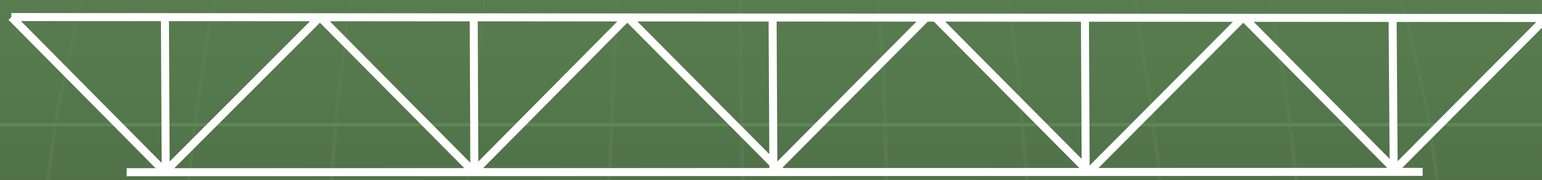


Notes:

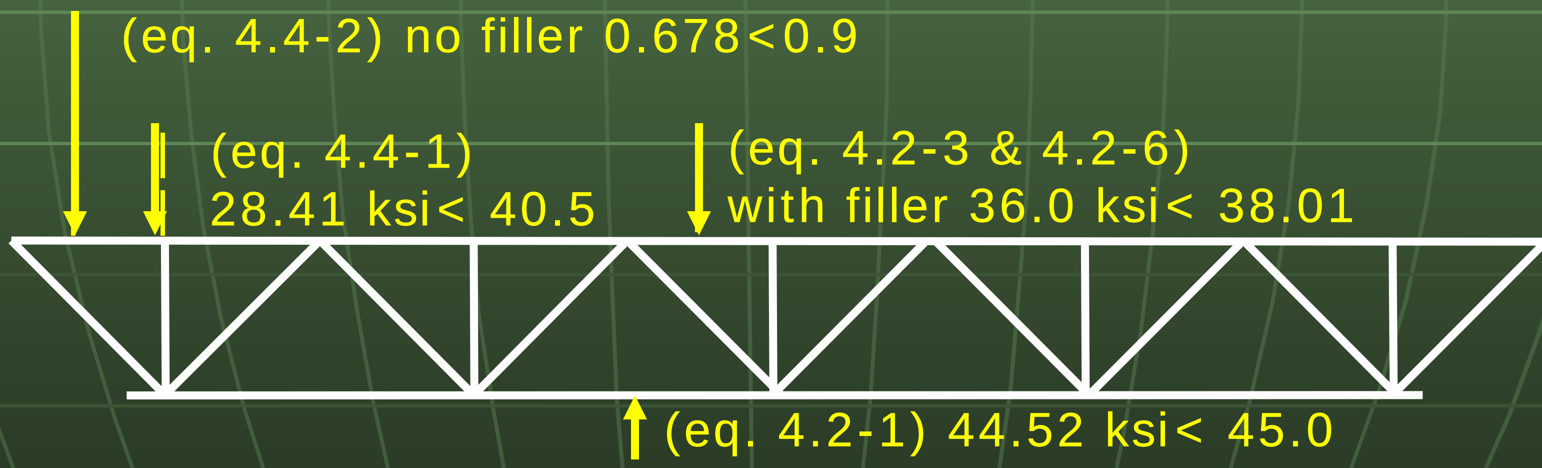
1) LRFD Design
2) IBC 2006
3) All loads are factored
4) 2.0 psf net factored uplift
5) Bridging per SJI

24K8 Joist Design using LRFD

TC = 2 L's 2 x 2 x .156, Q=0.935



BC = 2 L's 1.75 x 1.75 x .143



New Developments in Steel Joists and Joist Girders

- **Non-composite Floor Joists**
  - Wider Spacings
  - Heavier Loads
- **Composite Floor Joists – New SJI Joist CJ-Series to be Introduced**

SJI Technical Digest Update

- TD No. 3 Structural Design of Steel Joist Roofs to Resist Ponding Loads (2006)
- TD No. 5 Vibration of Steel Joist – Concrete Slab Floors (1988)
- TD No. 6 Structural Design of Steel Joist Roofs to Resist Uplift Loads (2006)
- TD No. 8 Welding of Open Web Steel Joists (1983)
- TD No. 9 Handling and Erection of Steel Joists and Joist Girders (2006)
- TD No. 10 Design of Fire Resistive Assemblies with Steel Joists (2003)
- TD No. 11 Design of Joist Girder Frames (1999)
- TD No. 12 Evaluation and Modification of Existing Steel Joists (NEW)

2006 SJI Educational Seminars

Specifying and Designing with Steel Joists and Joist Girders

Chelmsford, MA   May 23, 2006

Oakbrook, IL   July 17, 2006

St. Louis, MO September 19, 2006

Salt Lake City, UT   October 16, 2006

Greensboro, NC   November 15, 2006

Any Questions?

SJI Website: http://www.steeljoist.org