

STANDARD SPECIFICATION FOR OPEN WEB STEEL JOISTS, K-SERIES

Adopted by the Steel Joist Institute November 4, 1985
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SECTION 1. SCOPE AND DEFINITIONS

1.1 SCOPE

The *Standard Specification for Open Web Steel Joists, K-Series*, hereafter referred to as the Specification, covers the design, manufacture, application, and erection stability and handling of Open Web Steel Joists **K-Series** in buildings or other structures, where other structures are defined as those structures designed, manufactured, and erected in a manner similar to buildings. **K-Series** joists shall be designed using Allowable Stress Design (ASD) or Load and Resistance Factor Design (LRFD) in accordance with this Specification. Steel joists shall be erected in accordance with the Occupational Safety and Health Administration (OSHA), U.S. Department of Labor, Code of Federal Regulations 29CFR Part 1926 Safety Standards for Steel Erection, Section 1926.757 Open Web Steel Joists. The KCS joists; Joist Substitutes, **K-Series**; and Top Chord Extensions and Extended Ends, **K-Series** are included as part of this Specification.

This Specification includes Sections 1 through 6.

1.2 DEFINITION

The term "Open Web Steel Joists **K-Series**", as used herein, refers to open web, load-carrying members utilizing hot-rolled or cold-formed steel, including cold-formed steel whose yield strength has been attained by cold working, suitable for the direct support of floors and roof slabs or deck.

The **K-Series** Joists have been standardized in depths from 10 inches (254 mm) through 30 inches (762 mm), for spans up through 60 feet (18288 mm). The maximum total safe uniformly distributed load-carrying capacity of a **K-Series** Joist is 550 plf (8.02 kN/m) in ASD or 825 plf (12.03 kN/m) in LRFD.

The **K-Series** standard joist designations are determined by their nominal depth, followed by the letter "**K**", and then by the chord size designation assigned. The chord size designations range from 01 to 12. Therefore, as a performance based specification, the **K-Series** standard joist designations listed in the following Standard Load Tables shall support the uniformly distributed loads as provided in the appropriate tables:

Standard LRFD Load Table Open Web Steel Joists, **K-Series** – U.S. Customary Units
Standard ASD Load Table Open Web Steel Joists, **K-Series** – U.S. Customary Units

And the following Standard Load Tables published electronically at www.steeljoist.org/loadtables

Standard LRFD Load Table Open Web Steel Joists, **K-Series** – S.I. Units
Standard ASD Load Table Open Web Steel Joists, **K-Series** – S.I. Units

Two standard types of **K-Series** Joists are designed and manufactured. These types are underslung (top chord bearing) or square-ended (bottom chord bearing), with parallel chords.



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A **KCS** Joist shall be designed in accordance with this Specification based on an envelope of moment and shear capacity, rather than uniform load capacity, to support uniform plus concentrated loads or other non-uniform loads. The **KCS** Joists have been standardized in depths from 10 inches (254 mm) through 30 inches (762 mm), for spans up through 60 feet (18288 mm). The maximum total safe uniformly distributed load-carrying capacity of a **KCS** Joist is 550 plf (8.02 kN/m) in ASD or 825 plf (12.03 kN/m) in LRFD.

The **KCS** Joists standard designations are determined by their nominal depth, followed by the letters “**KCS**”, and then by the chord size designation assigned. The chord size designations range from 1 to 5. Therefore, as a performance based specification, the **KCS** Joists standard designations listed in the following Standard Load Tables shall provide the moment capacity and shear capacity as listed in the appropriate tables:

Standard LRFD Load Table for **KCS** Open Web Steel Joists – U.S. Customary Units
Standard ASD Load Table for **KCS** Open Web Steel Joists – U.S. Customary Units

And the following Standard Load Tables published electronically at www.steeljoist.org/loadtables

Standard LRFD Load Table for **KCS** Open Web Steel Joists – S.I. Units
Standard ASD Load Table for **KCS** Open Web Steel Joists – S.I. Units

A Joist Substitute, **K-Series**, shall be designed in accordance with this Specification to support uniform loads when the span is less than 10 feet (3048 mm) where an open web configuration becomes impractical. The Joist Substitutes, **K-Series** have been standardized as 2.5 inch (64 mm) deep sections for spans up through 10'-0" (3048 mm). The maximum total safe uniformly distributed load-carrying capacity of a Joist Substitute is 550 plf (8.02 kN/m) in ASD or 825 plf (12.03 kN/m) in LRFD.

The Joist Substitutes, **K-Series** standard designations are determined by their nominal depth, i.e. **2.5**, followed by the letter “**K**” and then by the chord size designation assigned. The chord size designations range from 1 to 3. Therefore, as a performance based specification, the Joist Substitutes, **K-Series** standard designations listed in the following Load Tables shall support the uniformly distributed loads as provided in the appropriate tables:

LRFD Simple Span Load Table for 2.5 Inch **K-Series** Joist Substitutes – U.S. Customary Units
ASD Simple Span Load Table for 2.5 Inch **K-Series** Joist Substitutes – U.S. Customary Units

LRFD Outriggers Load Table for 2.5 Inch **K-Series** Joist Substitutes – U.S. Customary Units
ASD Outriggers Load Table for 2.5 Inch **K-Series** Joist Substitutes – U.S. Customary Units

And the following Load Tables published electronically at www.steeljoist.org/loadtables

LRFD Simple Span Load Table for 64 mm **K-Series** Joist Substitutes – S.I. Units
ASD Simple Span Load Table for 64 mm **K-Series** Joist Substitutes – S.I. Units

LRFD Outriggers Load Table for 64 mm **K-Series** Joist Substitutes – S.I. Units
ASD Outriggers Load Table for 64 mm **K-Series** Joist Substitutes – S.I. Units

A Top Chord Extension or Extended End, **K-Series**, shall be a joist accessory that shall be designed in accordance with this Specification to support uniform loads when one or both ends of an underslung joist needs to be cantilevered beyond its bearing seat. The Top Chord Extensions and Extended Ends, **K-Series** have been standardized as an “**S**” Type (top chord angles extended only) and an “**R**” Type (top chord and bearing seat angles extended), respectively. The maximum total safe uniformly distributed load-carrying capacity of either an “**R**” or “**S**” Type extension is 550 plf (8.02 kN/m) in ASD or 825 plf (12.03 kN/m) in LRFD.

Standard designations for the “**S**” Type range from S1 to S12 for spans from 0'-6" to 4'-6" (152 to 1372 mm). Standard designations for the “**R**” Type range from R1 to R12 for spans from 0'-6" to 6'-0" (152 to 1829 mm). Therefore, as a performance based specification, the “**S**” Type Top Chord Extensions and “**R**” Type Extended Ends listed in the following Standard Load Tables shall support the uniformly distributed loads as provided in the appropriate tables:

LRFD Top Chord Extension Load Table (S Type) – U.S. Customary Units
ASD Top Chord Extension Load Table (S Type) – U.S. Customary Units



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LRFD Top Chord Extension Load Table (R Type) – U.S. Customary Units
ASD Top Chord Extension Load Table (R Type) – U.S. Customary Units

And the following Standard Load Tables published electronically at www.steeljoist.org/loadtables

LRFD Top Chord Extension Load Table (S Type) – S.I. Units
ASD Top Chord Extension Load Table (S Type) – S.I. Units
LRFD Top Chord Extension Load Table (R Type) – S.I. Units
ASD Top Chord Extension Load Table (R Type) – S.I. Units

1.3 STRUCTURAL DESIGN DRAWINGS AND SPECIFICATIONS

The design drawings and specifications shall meet the requirements in the *Code of Standard Practice for Steel Joists and Joist Girders*, except for deviations specifically identified in the design drawings and/or specifications.

SECTION 2. REFERENCED SPECIFICATIONS, CODES AND STANDARDS

2.1 REFERENCES

American Institute of Steel Construction, Inc. (AISC)

ANSI/AISC 360-10 *Specification for Structural Steel Buildings*

American Iron and Steel Institute (AISI)

ANSI/AISI S100-2007 *North American Specification for Design of Cold-Formed Steel Structural Members*

ANSI/AISI S100-07/S1-09, *Supplement No. 1 to the North American Specification for the Design of Cold-Formed Steel Structural Members*, 2007 Edition

ANSI/AISI S100-07/S2-10, *Supplement No. 2 to the North American Specification for the Design of Cold-Formed Steel Structural Members*, 2007 Edition

American Society of Testing and Materials, ASTM International (ASTM)

ASTM A6/A6M-09, Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling

ASTM A36/A36M-08, Standard Specification for Carbon Structural Steel

ASTM A242/242M-04 (2009), Standard Specification for High-Strength Low-Alloy Structural Steel

ASTM A307-07b, Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength

ASTM A325/325M-09, Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi [830 MPa] Minimum Tensile Strength

ASTM A370-09ae1, Standard Test Methods and Definitions for Mechanical Testing of Steel Products

ASTM A500/A500M-07, Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes

ASTM A529/A529M-05, Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality



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ASTM A572/A572M-07, Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel
ASTM A588/A588M-05, Standard Specification for High-Strength Low-Alloy Structural Steel, up to 50 ksi [345 MPa] Minimum Yield Point, with Atmospheric Corrosion Resistance
ASTM A606/A606M-09, Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance
ASTM A992/A992M-06a, Standard Specification for Structural Steel Shapes
ASTM A1008/A1008M-09, Standard Specification for Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable
ASTM A1011/A1011M-09a, Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength

American Welding Society (AWS)

AWS A5.1/A5.1M-2004, Specification for Carbon Steel Electrodes for Shielded Metal Arc Welding
AWS A5.5/A5.5M:2006, Specification for Low-Alloy Steel Electrodes for Shielded Metal Arc Welding
AWS A5.17/A5.17M-97:R2007, Specification for Carbon Steel Electrodes and Fluxes for Submerged Arc Welding
AWS A5.18/A5.18M:2005, Specification for Carbon Steel Electrodes and Rods for Gas Shielded Arc Welding
AWS A5.20/A5.20M:2005, Specification for Carbon Steel Electrodes for Flux Cored Arc Welding
AWS A5.23/A5.23M:2007, Specification for Low-Alloy Steel Electrodes and Fluxes for Submerged Arc Welding
AWS A5.28/A5.28M:2005, Specification for Low-Alloy Steel Electrodes and Rods for Gas Shielded Arc Welding
AWS A5.29/A5.29M:2005, Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding

2.1 OTHER REFERENCES

The following are non-ANSI Standards documents and as such, are provided solely as sources of commentary or additional information related to topics in this Specification.

American Society of Civil Engineers (ASCE)

SEI/ASCE 7-10 *Minimum Design Loads for Buildings and Other Structures*

Federal Register, Department of Labor, Occupational Safety and Health Administration (2001), 29 CFR Part 1926 Safety Standards for Steel Erection; Final Rule, §1926.757 Open Web Steel Joists - January 18, 2001, Washington, D.C.

Steel Joist Institute (SJI)

SJI-COSP-2010, *Code of Standard Practice for Steel Joists and Joist Girders*
Technical Digest No. 3 (2007), *Structural Design of Steel Joist Roofs to Resist Ponding Loads*
Technical Digest No. 5 (1988), *Vibration of Steel Joist-Concrete Slab Floors*
Technical Digest No. 6 (2011), *Structural Design of Steel Joist Roofs to Resist Uplift Loads*
Technical Digest No. 8 (2008), *Welding of Open Web Steel Joists and Joist Girders*
Technical Digest No. 9 (2008), *Handling and Erection of Steel Joists and Joist Girders*
Technical Digest No. 10 (2003), *Design of Fire Resistive Assemblies with Steel Joists*
Technical Digest No. 11 (2007), *Design of Lateral Load Resisting Frames Using Steel Joists and Joist Girders*
Technical Digest No. 12 (2007), *Evaluation and Modification of Open-web Steel Joists and Joist Girders*



Steel Structures Painting Council (SSPC) (2000), *Steel Structures Painting Manual, Volume 2, Systems and Specifications*, Paint Specification No. 15, Steel Joist Shop Primer, May 1, 1999, Pittsburgh, PA.

SECTION 3. MATERIALS

3.1 STEEL

The steel used in the manufacture of **K-Series Joists** shall conform to one of the following ASTM Specifications:

- Carbon Structural Steel, ASTM A36/A36M.
- High-Strength Low-Alloy Structural Steel, ASTM A242/A242M.
- Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes, ASTM A500/A500M.
- High-Strength Carbon-Manganese Steel of Structural Quality, ASTM A529/A529M.
- High-Strength Low-Alloy Columbium-Vanadium Structural Steel, ASTM A572/A572M.
- High-Strength Low-Alloy Structural Steel up to 50 ksi [345 MPa] Minimum Yield Point with Atmospheric Corrosion Resistance, ASTM A588/A588M.
- Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance, ASTM A606/A606M.
- Structural Steel Shapes, ASTM A992/A992M.
- Steel, Sheet, Cold-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, Solution Hardened, and Bake Hardenable, ASTM A1008/A1008M.
- Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra High Strength, ASTM A1011/A1011M.

or shall be of suitable quality ordered or produced to other than the listed specifications, provided that such material in the state used for final assembly and manufacture is weldable and is proved by tests performed by the producer or manufacturer to have the properties specified in Section 3.2.

3.2 MECHANICAL PROPERTIES

Steel used for **K-Series Joists** shall have a minimum yield strength determined in accordance with one of the procedures specified in this section, which is equal to the yield strength* assumed in the design.

*The term "Yield Strength" as used herein shall designate the yield level of a material as determined by the applicable method outlined in paragraph 13.1 "Yield Point", and in paragraph 13.2 "Yield Strength", of ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*, or as specified in paragraph 3.2 of this specification.

Evidence that the steel furnished meets or exceeds the design yield strength shall, if requested, be provided in the form of an affidavit or by witnessed or certified test reports.

For material used without consideration of increase in yield strength resulting from cold forming, the specimens shall be taken from as-rolled material. In the case of material, the mechanical properties of which conform to the requirements of one of the listed specifications, the test specimens and procedures shall conform to those of such specifications and to ASTM A370.



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In the case of material, the mechanical properties of which do not conform to the requirements of one of the listed specifications, the test specimens and procedures shall conform to the applicable requirements of ASTM A370, and the specimens shall exhibit a yield strength equal to or exceeding the design yield strength and an elongation of not less than (a) 20 percent in 2 inches (51 millimeters) for sheet and strip, or (b) 18 percent in 8 inches (203 millimeters) for plates, shapes and bars with adjustments for thickness for plates, shapes and bars as prescribed in ASTM A36/A36M, A242/A242M, A500/A500M, A529/A529M, A572/A572M, A588/A588M, A992/A992M whichever specification is applicable, on the basis of design yield strength.

The number of tests shall be as prescribed in ASTM A6/A6M for plates, shapes, and bars; and ASTM A606/A606M, A1008/A1008M and A1011/A1011M for sheet and strip.

If as-formed strength is utilized, the test reports shall show the results of tests performed on full section specimens in accordance with the provisions of the AISI North American Specifications for the Design of Cold-Formed Steel Structural Members. They shall also indicate compliance with these provisions and with the following additional requirements:

- a) The yield strength calculated from the test data shall equal or exceed the design yield strength.
- b) Where tension tests are made for acceptance and control purposes, the tensile strength shall be at least 8 percent greater than the yield strength of the section.
- c) Where compression tests are used for acceptance and control purposes, the specimen shall withstand a gross shortening of 2 percent of its original length without cracking. The length of the specimen shall be not greater than 20 times the least radius of gyration.
- d) If any test specimen fails to pass the requirements of the subparagraphs (a), (b), or (c) above, as applicable, two retests shall be made of specimens from the same lot. Failure of one of the retest specimens to meet such requirements shall be the cause for rejection of the lot represented by the specimens.

3.3 PAINT

The standard shop paint is intended to protect the steel for only a short period of exposure in ordinary atmospheric conditions and shall be considered an impermanent and provisional coating.

When specified, the standard shop paint shall conform to one of the following:

- a) Steel Structures Painting Council Specification, SSPC No. 15.
- b) Or, shall be a shop paint which meets the minimum performance requirements of the above listed specification.

SECTION 4. DESIGN AND MANUFACTURE

4.1 METHOD

Joists shall be designed in accordance with this specification as simply-supported, trusses supporting a floor or roof deck so constructed as to brace the top chord of the joists against lateral buckling. Where any applicable design feature is not specifically covered herein, the design shall be in accordance with the following specifications:

- a) Where the steel used consists of hot-rolled shapes, bars or plates use the American Institute of Steel Construction, *Specification for Structural Steel Buildings*.
- b) For members which are cold-formed from sheet or strip steel, use the American Iron and Steel Institute, *North American Specification for the Design of Cold-Formed Steel Structural Members*.



Design Basis:

Steel joist designs shall be in accordance with the provisions in this Standard Specification using Load and Resistance Factor Design (LRFD) or Allowable Strength Design (ASD) as specified by the **specifying professional** for the project.

Loads, Forces and Load Combinations:

The loads and forces used for the steel joist design shall be calculated by the **specifying professional** in accordance with the applicable building code and specified and provided on the contract drawings.

The load combinations shall be specified by the **specifying professional** on the contract drawings in accordance with the applicable building code or, in the absence of a building code, the load combinations shall be those stipulated in SEI/ASCE 7. For LRFD designs, the load combinations in SEI/ASCE 7, Section 2.3 apply. For ASD designs, the load combinations in SEI/ASCE 7, Section 2.4 apply.

4.2 DESIGN AND ALLOWABLE STRESSES

Design Using Load and Resistance Factor Design (LRFD)

Joists shall have their components so proportioned that the required stresses, f_u , shall not exceed ϕF_n where

- f_u = required stress ksi (MPa)
- F_n = nominal stress ksi (MPa)
- ϕ = resistance factor
- ϕF_n = design stress

Design Using Allowable Strength Design (ASD)

Joists shall have their components so proportioned that the required stresses, f , shall not exceed F_n / Ω where

- f = required stress ksi (MPa)
- F_n = nominal stress ksi (MPa)
- Ω = safety factor
- F_n / Ω = allowable stress

Stresses:

For Chords: The calculation of design or allowable stress shall be based on a yield strength, F_y , of the material used in manufacturing equal to 50 ksi (345 MPa).

For all other joist elements: The calculation of design or allowable stress shall be based on a yield strength, F_y , of the material used in manufacturing, but shall not be less than 36 ksi (250 MPa) or greater than 50 ksi (345 MPa).

Note: Yield strengths greater than 50 ksi shall not be used for the design of any joist members.

(a) Tension: $\phi_t = 0.90$ (LRFD), $\Omega_t = 1.67$ (ASD)

$$\text{Design Stress} = 0.9F_y \text{ (LRFD)} \tag{4.2-1}$$

$$\text{Allowable Stress} = 0.6F_y \text{ (ASD)} \tag{4.2-2}$$

(b) Compression: $\phi_c = 0.90$ (LRFD), $\Omega_c = 1.67$ (ASD)

$$\text{Design Stress} = 0.9F_{cr} \text{ (LRFD)} \tag{4.2-3}$$

$$\text{Allowable Stress} = 0.6F_{cr} \text{ (ASD)} \tag{4.2-4}$$



For members with

$$k\ell/r \leq 4.71\sqrt{E/QF_y}$$

$$F_{cr} = Q \left[0.658 \left(\frac{QF_y}{F_e} \right) \right] F_y \quad (4.2-5)$$

For members with

$$k\ell/r > 4.71\sqrt{E/QF_y}$$

$$F_{cr} = 0.877F_e \quad (4.2-6)$$

Where: F_e = Elastic buckling stress determined in accordance with Equation 4.2-7

$$F_e = \frac{\pi^2 E}{\left(\frac{k\ell}{r} \right)^2} \quad (4.2-7)$$

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 a compression or tension web member, 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).

For hot-rolled sections and cold formed angles, Q is the full reduction factor for slender compression members as defined in the AISC *Specification for Structural Steel Buildings* except that when the first primary compression web member is a crimped-end angle member, whether hot-rolled or cold formed:

$$Q = [5.25/(w/t)] + t \leq 1.0 \quad (4.2-8)$$

Where: w = angle leg length, inches
 t = angle leg thickness, inches

or,

$$Q = [5.25/(w/t)] + (t/25.4) \leq 1.0 \quad (4.2-9)$$

Where: w = angle leg length, millimeters
 t = angle leg thickness, millimeters

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



(c) Bending: $\phi_b = 0.90$ (LRFD), $\Omega_b = 1.67$ (ASD)

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

For chords and web members other than solid rounds: $F_n = F_y$

$$\text{Design Stress} = \phi_b F_n = 0.9F_y \quad (\text{LRFD}) \quad (4.2-10)$$

$$\text{Allowable Stress} = F_n/\Omega_b = 0.6F_y \quad (\text{ASD}) \quad (4.2-11)$$

For web members of solid round cross section: $F_n = 1.6 F_y$

$$\text{Design Stress} = \phi_b F_n = 1.45F_y \quad (\text{LRFD}) \quad (4.2-12)$$

$$\text{Allowable Stress} = F_n/\Omega_b = 0.95F_y \quad (\text{ASD}) \quad (4.2-13)$$

For bearing plates used in joist seats: $F_n = 1.5 F_y$

$$\text{Design Stress} = \phi_b F_n = 1.35F_y \quad (\text{LRFD}) \quad (4.2-14)$$

$$\text{Allowable Stress} = F_n/\Omega_b = 0.90F_y \quad (\text{ASD}) \quad (4.2-15)$$

(d) Weld Strength:

Shear at throat of fillet welds, flare bevel groove welds, partial joint penetration groove welds, and plug/slot welds:

$$\text{Nominal Shear Stress} = F_{nw} = 0.6F_{\text{exx}} \quad (4.2-16)$$

LRFD: $\phi_w = 0.75$

$$\text{Design Shear Strength} = \phi R_n = \phi_w F_{nw} A = 0.45F_{\text{exx}} A_w \quad (4.2-17)$$

ASD: $\Omega_w = 2.0$

$$\text{Allowable Shear Strength} = R_n/\Omega_w = F_{nw} A/\Omega_w = 0.3F_{\text{exx}} A_w \quad (4.2-18)$$

Made with E70 series electrodes or F7XX-EXXX flux-electrode combinations $F_{\text{exx}} = 70$ ksi (483 MPa)

Made with E60 series electrodes or F6XX-EXXX flux-electrode combinations $F_{\text{exx}} = 60$ ksi (414 MPa)

A_w = effective throat area, where:

For fillet welds, A_w = effective throat area, (other design methods demonstrated to provide sufficient strength by testing shall be permitted to be used);

For flare bevel groove welds, the effective weld area is based on a weld throat width, T , where:

$$T \text{ (inches)} = 0.12D + 0.11 \quad (4.2-19)$$

Where: D = web diameter, inches

or,

$$T \text{ (mm)} = 0.12D + 2.8 \quad (4.2-20)$$

Where: D = web diameter, mm

For plug/slot welds, A_w = cross-sectional area of the hole or slot in the plane of the faying surface provided that the hole or slot meets the requirements of the American Institute of Steel Construction *Specification for Structural Steel Buildings* (and as described in SJI Technical Digest No. 8, "Welding of Open-Web Steel Joists and Joist Girders").



Strength of resistance welds and complete-joint-penetration groove or butt welds in tension or compression (only when the stress is normal to the weld axis) is equal to the base metal strength:

$$\phi_t = \phi_c = 0.90 \text{ (LRFD)} \quad \Omega_t = \Omega_c = 1.67 \text{ (ASD)}$$

$$\text{Design Stress} = 0.9F_y \text{ (LRFD)} \tag{4.2-21}$$

$$\text{Allowable Stress} = 0.6F_y \text{ (ASD)} \tag{4.2-22}$$

4.3 MAXIMUM SLENDERNESS RATIOS

The slenderness ratios, $1.0 \ell/r$ and $1.0 \ell_s/r$ of members as a whole or any component part shall not exceed the values given in Table 4.3-1, Parts A.

The effective slenderness ratio, $k\ell/r$ to be used in calculating the nominal stresses, F_{cr} and F'_e , is the largest value as determined from Table 4.3-1, Parts B and C.

In compression members when fillers or ties are used, they shall be spaced so that the ℓ_s/r_z ratio of each component does not exceed the governing ℓ/r ratio of the member as a whole. The terms used in Table 4.3-1 are defined as follows:

- ℓ = length center-to-center of panel points, except $\ell = 36$ inches (914 millimeters) for calculating ℓ/r_y of top chord member, in. (mm) or the appropriate length for a compression or tension web member, in. (mm).
- ℓ_s = maximum length center-to-center between panel point and filler (tie), or between adjacent fillers (ties), in. (mm).
- r_x = member radius of gyration in the plane of the joist, in. (mm).
- r_y = member radius of gyration out of the plane of the joist, in. (mm).
- r_z = least radius of gyration of a member component, in. (mm).

Compression web members are those web members subject to compressive axial loads under gravity loading.

Tension web members are those web members subject to tension axial loads under gravity loading, and which may be subject to compressive axial loads under alternate loading conditions, such as net uplift.

For top chords, the end panel(s) are the panels between the bearing seat and the first primary interior panel point comprised of at least two intersecting web members.



**TABLE 4.3-1
MAXIMUM AND EFFECTIVE SLENDERNESS RATIOS**

Description		$k\ell/r_x$	$K\ell/r_y$	$k\ell/r_z$	$k\ell_s/r_z$
I TOP CHORD INTERIOR PANELS					
	A. The slenderness ratios, $1.0\ell/r$ and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 90.				
	B. The effective slenderness ratio, $k\ell/r$, to determine F_{cr} where k is:				
	1. With fillers or ties	1.0	0.94	---	1.0
	2. Without fillers or ties	---	---	1.0	---
	3. Single component members	1.0	0.94	---	---
	C. For bending, the effective slenderness ratio, $k\ell/r$, to determine F'_e where k is:	1.0	---	---	---
II TOP CHORD END PANELS, ALL BOTTOM CHORD PANELS					
	A. The slenderness ratios, $1.0\ell/r$ and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 120 for Top Chords, or 240 for Bottom Chords.				
	B. The effective slenderness ratio, $k\ell/r$, to determine F_{cr} where k is:				
	1. With fillers or ties	1.0	0.94	---	1.0
	2. Without fillers or ties	---	---	1.0	---
	3. Single component members	1.0	0.94	---	---
	C. For bending, the effective slenderness ratio, $k\ell/r$, to determine F'_e where k is:	1.0	---	---	---
III TENSION WEB MEMBERS					
	A. The slenderness ratios, $1.0\ell/r$ and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 240.				
	B. For end web members subject to compression, the effective slenderness ratio, $k\ell/r$, to determine F_{cr} where k is:				
	1. With fillers or ties	1.0	1.0	---	1.0
	2. Without fillers or ties	---	---	1.0	---
	3. Single component members	0.8	0.8	---	---
IV COMPRESSION WEB MEMBERS					
	A. The slenderness ratios, $1.0\ell/r$ and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 200.				
	B. The effective slenderness ratio, $k\ell/r$, to determine F_{cr} where k is:				
	1. With fillers or ties	1.0	1.0	---	1.0
	2. Without fillers or ties	---	---	1.0	---
	3. Single component members	1.0	1.0	---	---



4.4 MEMBERS

(a) Chords

The bottom chord shall be designed as an axially loaded tension member.

The radius of gyration of the top chord about its vertical axis shall not be less than:

$$r_y \geq \ell_{br} / \left(124 + 0.67 d_j + 28 \frac{d_j}{L} \right), \text{ in.} \quad (4.4-1a)$$

$$r_y \geq \ell_{br} / \left(124 + 0.026 d_j + 0.34 \frac{d_j}{L} \right), \text{ mm} \quad (4.4-1b)$$

or,

$$r_y \geq \ell_{br} / 170 \quad (4.4-2)$$

Where:

d_j is the steel joist depth, in. (mm)

L is the design length for the joist, ft. (m)

r_y is the out-of-plane radius of gyration of the top chord, in. (mm)

ℓ_{br} is the spacing in inches (millimeters) between lines of bridging as specified in Section 5.4(c).

The top chord shall be considered as stayed laterally by the floor slab or roof deck when attachments are in accordance with the requirements of Section 5.8(e) of these specifications.

The top chord shall be designed for only axial compressive stress when the panel length, ℓ , does not exceed 24 inches (609 mm). When the panel length exceeds 24 inches (609 mm), 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:

$$f_{au} + f_{bu} \leq 0.9F_y \quad (4.4-3)$$

at the mid panel:

$$\text{for, } \frac{f_{au}}{\phi_c F_{cr}} \geq 0.2,$$

$$\frac{f_{au}}{\phi_c F_{cr}} + \frac{8}{9} \left[\frac{C_m f_{bu}}{\left[1 - \left(\frac{f_{au}}{\phi_c F'_e} \right) \right] Q \phi_b F_y} \right] \leq 1.0 \quad (4.4-4)$$



for, $\frac{f_{au}}{\phi_c F_{cr}} < 0.2$,

$$\left(\frac{f_{au}}{2\phi_c F_{cr}} \right) + \left[\frac{C_m f_{bu}}{\left[1 - \left(\frac{f_{au}}{\phi_c F'_e} \right) \right] Q \phi_b F_y} \right] \leq 1.0 \quad (4.4-5)$$

- f_{au} = P_u/A = Required compressive stress, ksi (MPa)
- P_u = 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 (mm³)
- F_{cr} = Nominal axial compressive stress in ksi (MPa) based on ℓ/r as defined in Section 4.2(b),
- C_m = $1 - 0.3 f_{au}/\phi F'_e$ for end panels
- C_m = $1 - 0.4 f_{au}/\phi F'_e$ for interior panels
- F_y = Specified minimum yield strength, ksi (MPa)
- $F'_e = \frac{\pi^2 E}{(\mathbf{K}\ell/r_x)^2}$, ksi (MPa)

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

- Q = Form factor defined in Section 4.2(b)
- A = Area of the top chord, in.² (mm²)

For **ASD**:

at the panel point:

$$f_a + f_b \leq 0.6F_y \quad (4.4-6)$$

at the mid panel:

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

$$\frac{f_a}{F_a} + \frac{8}{9} \left[\frac{C_m f_b}{\left[1 - \left(\frac{1.67f_a}{F'_e} \right) \right] Q F_b} \right] \leq 1.0 \quad (4.4-7)$$



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

$$\left(\frac{f_a}{2F_a} \right) + \left[\frac{C_m f_b}{\left[1 - \left(\frac{1.67 f_a}{F'_e} \right) \right] Q F_b} \right] \leq 1.0 \quad (4.4-8)$$

- 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)
- 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

The top chord and bottom chord shall be designed such that at each joint:

$$f_{vmod} \leq \phi_v f_n \quad (\text{LRFD, } \phi = 1.00) \quad (4.4-9)$$

$$f_{vmod} \leq f_n / \Omega_v \quad (\text{ASD, } \Omega = 1.50) \quad (4.4-10)$$

Where:

- f_n = nominal shear stress = $0.6F_y$, ksi (MPa)
- f_t = axial stress = P/A, ksi (MPa)
- f_v = shear stress = V/bt, ksi (MPa)
- f_{vmod} = modified shear stress = $\left(\frac{1}{2} (f_t^2 + 4f_v^2) \right)^{1/2}$
- b = length of vertical part(s) of cross section, in. (mm)
- t = thickness of vertical part(s) of cross section, in. (mm)

It shall not be necessary to design the top chord and bottom chord for the modified shear stress when a round bar web member is continuous through a joint. The minimum required shear Section 4.4(b) (25 percent of the end reaction) shall not be required when evaluating Equation 4.4-9 or 4.4-10.

KCS Joist chords shall be designed for a flat positive bending moment envelope where the moment capacity is constant at all interior panels. The top chord end panel(s) is designed for an axial load based on the force in the first tension web resulting from the specified shear. A uniform load of 550 plf (8020 N/m) in ASD or 825 plf (12030 N/m) in LRFD shall be used to check bending in the end panel(s).

(b) Web

The vertical shears to be used in the design of the web members shall be determined from full uniform loading, but such vertical shears shall be not less than 25 percent of the end reaction. Due consideration shall be given to the effect of eccentricity. The effect of combined axial compression and bending shall be investigated using the provisions of Section 4.4(a), letting $C_m = 0.4$ when bending due to eccentricity produces reversed curvature.



Interior vertical web members used in modified Warren type web systems shall be designed to resist the gravity loads supported by the member plus an additional axial load of $\frac{1}{2}$ of 1.0 percent of the top chord axial force.

KCS Joist web forces shall be determined based on a flat shear envelope. All webs shall be designed for a vertical shear equal to the specified shear capacity. In addition, all webs shall be designed for 100 percent stress reversal except for the first tension web which will remain in tension under all simple span gravity loads.

(c) Joist Extensions

Joist extensions are defined as one of three types, top chord extensions (TCX), extended ends, or full depth cantilevers.

Design criteria for joist extensions shall be specified using one of the following methods:

- (1) A Top chord extension (TCX), extended end, or full depth cantilevered end shall be designed for the load from the Standard Load Tables based on the design length and designation of the specified joist. In the absence of other design information, the joist manufacturer shall design the joist extension for this loading as a default.
- (2) A loading diagram shall be provided for the top chord extension, extended end, or full depth cantilevered end. The diagram shall include the magnitude and location of the loads to be supported, as well as the appropriate load combinations.
- (3) Joist extensions shall be specified using extension designations found in the Top Chord Extension Load Table (S Type) for TCXs or the Top Chord Extension Load Table (R Type) for extended ends.

Any deflection requirements or limits due to the accompanying loads and load combinations on the joist extension shall be provided by the **specifying professional**, regardless of the method used to specify the extension. Unless otherwise specified, the joist manufacturer shall check the extension for the specified deflection limit under uniform live load acting simultaneously on both the joist base span and the extension.

The joist manufacturer shall consider the effects of joist extension loading on the base span of the joist. This includes carrying the design bending moment due to the loading on the extension into the top chord end panel(s), and the effect on the overall joist chord and web axial forces. In the case of a K-Series Standard Type 'R' Extended End or 'S' TCX, the design bending moment is defined as the tabulated extension section modulus (S) multiplied by the appropriate allowable (ASD) or design (LRFD) flexural stress.

Bracing of joist extensions shall be clearly indicated on the structural drawings.

4.5 CONNECTIONS

(a) Methods

Joist connections and splices shall be made by attaching the members to one another by arc or resistance welding or other accredited methods.

(1) Welded Connections

- a) Selected welds shall be inspected visually by the manufacturer. Prior to this inspection, weld slag shall be removed.
- b) Cracks are not acceptable and shall be repaired.
- c) Thorough fusion shall exist between weld and base metal for the required design length of the weld; such fusion shall be verified by visual inspection.
- d) Unfilled weld craters shall not be included in the design length of the weld.
- e) Undercut shall not exceed 1/16 inch (2 mm) for welds oriented parallel to the principal stress.



- f) The sum of surface (piping) porosity diameters shall not exceed 1/16 inch (2 mm) in any 1 inch (25 mm) of design weld length.
- g) Weld spatter that does not interfere with paint coverage is acceptable.

(2) Welded Connections for Crimped-End Angle Web Members

The connection of each end of a crimped angle web member to each side of the chord shall consist of a weld group made of more than a single line of weld. The design weld length shall include, at minimum, an end return of two times the nominal weld size.

(3) Welding Program

Manufacturers shall have a program for establishing weld procedures and operator qualification, and for weld sampling and testing. (See Technical Digest 8 - Welding of Open Web Steel Joists and Joist Girders.)

(4) Weld Inspection by Outside Agencies (See Section 5.12 of this specification)

The agency shall arrange for visual inspection to determine that welds meet the acceptance standards of Section 4.5(a)(1) above. Ultrasonic, X-Ray, and magnetic particle testing are inappropriate for joists due to the configurations of the components and welds.

(b) Strength

- (1) Joint Connections - Joint connections shall develop the maximum force due to any of the design loads, but not less than 50 percent of the strength of the member in tension or compression, whichever force is the controlling factor in the selection of the member.
- (2) Shop Splices - Shop splices shall be permitted to occur at any point in chord or web members. Splices shall be designed for the member force, but not less than 50 percent of the member strength. All component parts comprising the cross section of the chord or web member (including reinforcing plates, rods, etc.) at the point of the splice, shall develop an ultimate tensile force of at least 1.2 times the product of the yield strength and the full design area of the chord or web. The "full design area" is the minimum required area such that the required stress will be less than the design (LRFD) or allowable (ASD) stress.

(c) Eccentricity

Members connected at a joint shall have their centroidal axes meet at a point whenever possible. Between joist ends where the eccentricity of a web member is less than 3/4 of the over-all dimension, measured in the plane of the web, of the largest member connected, the additional bending stress from this eccentricity shall be permitted to be neglected in the joist design. Otherwise, due consideration shall be given to the effect of eccentricity. The eccentricity of any web member shall be the perpendicular distance from the centroidal axis of that web member to the point on the centroidal axis of the chord which is vertically above or below the intersection of the centroidal axis of the web member(s) forming the joint. Joist ends shall be proportioned to resist bending produced by eccentricity at the support.



4.6 CAMBER

Joists shall have approximate camber in accordance with the following:

TABLE 4.6-1

<u>Top Chord Length</u>		<u>Approximate Camber</u>	
20'-0"	(6096 mm)	1/4"	(6 mm)
30'-0"	(9144 mm)	3/8"	(10 mm)
40'-0"	(12192 mm)	5/8"	(16 mm)
50'-0"	(15240 mm)	1"	(25 mm)
60'-0"	(18288 mm)	1 1/2"	(38 mm)

The **specifying professional** shall give consideration to coordinating joist camber with adjacent framing.

4.7 VERIFICATION OF DESIGN AND MANUFACTURE

(a) Design Calculations

Companies manufacturing **K-Series Joists** shall submit design data to the Steel Joist Institute (or an independent agency approved by the Steel Joist Institute) for verification of compliance with the SJI Specifications. Design data shall be submitted in detail and in the format specified by the Institute.

(b) Tests of Chord and Web Members

Each manufacturer shall, at the time of design review by the Steel Joist Institute, verify by tests that the design, in accordance with Sections 4.1 through 4.5 of this specification, will provide the theoretical strength of critical members. Such tests shall be evaluated considering the actual yield strength of the members of the test joists.

Material tests for determining mechanical properties of component members shall be conducted.

(c) Tests of Joints and Connections

Each manufacturer shall, at the time of design review by the Steel Joist Institute, verify by shear tests on representative joints of typical joists that connections will meet the provision of Section 4.5(b). Chord and web members shall be permitted to be reinforced for such tests.

(d) In-Plant Inspections

Each manufacturer shall verify their ability to manufacture **K-Series Joists** through periodic In-Plant Inspections. Inspections shall be performed by an independent agency approved by the Steel Joist Institute. The frequency, manner of inspection, and manner of reporting shall be determined by the Steel Joist Institute. The plant inspections are not a guarantee of the quality of any specific joists; this responsibility lies fully and solely with the individual manufacturer.



SECTION 5. APPLICATION

5.1 USAGE

This specification shall apply to any type of structure where floors and roofs are to be supported directly by steel joists installed as hereinafter specified. Where joists are used other than on simple spans under uniformly distributed loading as prescribed in Section 4.1, they shall be investigated and modified when necessary to limit the required stresses to those listed in Section 4.2.

When a rigid connection of the bottom chord is to be made to a column or other structural support, the joist is then no longer simply supported, and the system shall be investigated for continuous frame action by the **specifying professional**. The magnitude and location of all loads and forces shall be provided on the structural drawings. The **specifying professional** shall design the supporting structure, including the design of columns, connections, and moment plates*. This design shall account for the stresses caused by lateral forces and the stresses due to connecting the bottom chord to the column or other structural support.

The designed detail of a rigid type connection and moment plates shall be shown on the structural drawings by the **specifying professional**. The moment plates shall be furnished by other than the joist manufacturer.

*For further reference, refer to Steel Joist Institute Technical Digest 11, "Design of Lateral Load Resisting Frames Using Steel Joists and Joist Girders."

5.2 SPAN

The span of a joist shall not exceed 24 times its depth.

5.3 END SUPPORTS

(a) Masonry and Concrete

A K-Series Joist end supported by masonry or concrete shall bear on steel bearing plates and shall be designed as steel bearing. Due consideration of the end reactions and all other vertical or lateral forces shall be taken by the **specifying professional** in the design of the steel bearing plate and the masonry or concrete. The ends of K-Series Joists shall extend a distance of not less than 4 inches (102 mm) over the masonry or concrete support unless it is deemed necessary to bear less than 4 inches (102 mm) over the support. Special consideration shall then be given to the design of the steel bearing plate and the masonry or concrete by the **specifying professional**. K-Series Joists shall be anchored to the steel bearing plate and shall bear a minimum of 2 1/2 inches (64 mm) on the plate.

The steel bearing plate shall be located not more than 1/2 inch (13 mm) from the face of the wall, otherwise special consideration shall then be given to the design of the steel bearing plate and the masonry or concrete by the **specifying professional**. When the **specifying professional** requires the joist reaction to occur at or near the centerline of the wall or other support, then a note shall be placed on the contract drawings specifying this requirement and the specified bearing seat depth shall be increased accordingly. If the joist reaction is to occur more than 2 1/2 inches (64 mm) from the face of the wall or other support, the minimum seat depth shall be 2 1/2 inches (64 mm) plus a dimension equal to the distance the joist reaction is to occur beyond 2 1/2 inches (64 mm).

The steel bearing plate shall not be less than 6 inches (152 mm) wide perpendicular to the length of the joist. The plate is to be designed by the **specifying professional** and shall be furnished by other than the joist manufacturer.



(b) Steel

Due consideration of the end reactions and all other vertical and lateral forces shall be taken by the **specifying professional** in the design of the steel support. The ends of **K-Series Joists** shall extend a distance of not less than 2 ½ inches (64 millimeters) over the steel supports.

5.4 BRIDGING

Top and bottom chord bridging is required and shall consist of one or both of the following types.

(a) Horizontal

Horizontal bridging shall consist of continuous horizontal steel members. The ratio of unbraced length to least radius of gyration, ℓ/r , of the bridging member shall not exceed 300, where ℓ is the distance in inches (mm) between attachments, and r is the least radius of gyration of the bridging member.

(b) Diagonal

Diagonal bridging shall consist of cross-bracing with a ℓ/r ratio of not more than 200, where ℓ is the distance in inches (millimeters) between connections and r is the least radius of gyration of the bracing member. Where cross-bracing members are connected at their point of intersection, the ℓ distance shall be taken as the distance in inches (millimeters) between connections at the point of intersection of the bracing members and the connections to the chord of the joists.

(c) Quantity and Spacing

Bridging shall be properly spaced and anchored to support the decking and the employees prior to the attachment of the deck to the top chord. The maximum spacing of lines of bridging, ℓ_{brmax} shall be the lesser of,

$$\ell_{brmax} = \left(124 + 0.67 d_j + 28 \frac{d_j}{L} \right) r_y, \text{ in.} \tag{5.4-1a}$$

$$\ell_{brmax} = \left(124 + 0.026 d_j + 0.34 \frac{d_j}{L} \right) r_y, \text{ mm} \tag{5.4-1b}$$

or,
$$\ell_{brmax} = 170 r_y \tag{5.4-2}$$

Where:

d_j is the steel joist depth, in. (mm)

L is the Joist Span length, ft. (m)

r_y is the out-of-plane radius of gyration of the top chord, in. (mm)

The number of rows of top chord bridging shall not be less than as shown in Bridging Tables 5.4-1 and 5.4-2 and the spacing shall meet the requirements of Equations 5.4-1 and 5.4-2. The number of rows of bottom chord bridging, including bridging required per Section 5.11, shall not be less than the number of top chord rows. Rows of bottom chord bridging are permitted to be spaced independently of rows of top chord bridging. The spacing of rows of bottom chord bridging shall meet the slenderness requirement of Section 4.3 and any specified strength requirements.



TABLE 5.4-1

U.S. CUSTOMARY UNITS					
NUMBER OF ROWS OF TOP CHORD BRIDGING**					
Refer to the K-Series Load Table and Specification Section 6 for required bolted diagonal bridging.					
Distances are Joist Span lengths in feet – See “Definition of Span” preceding Load Tables.					
Section Number*	Joist Depth	One Row	Two Rows	Three Rows	Four Rows
#1	All	Up thru 17	Over 17 thru 26	Over 26 thru 28	
#2	All	Up thru 21	Over 21 thru 30	Over 30 thru 32	
#3	All	Up thru 18	Over 18 thru 26	Over 26 thru 40	
#4	All	Up thru 20	Over 20 thru 30	Over 30 thru 41	Over 41 thru 48
#5	12K to 24K	Up thru 20	Over 20 thru 30	Over 30 thru 42	Over 42 thru 48
	26K	Up thru 28	Over 28 thru 41	Over 41 thru 52	
#6	14K to 24K	Up thru 20	Over 20 thru 31	Over 31 thru 42	Over 42 thru 48
	26K & 28K	UP thru 28	Over 28 thru 41	Over 41 thru 54	Over 54 thru 56
#7	16K to 24K	Up thru 23	Over 23 thru 34	Over 34 thru 48	
	26K to 30K	Up thru 29	Over 29 thru 44	Over 44 thru 60	
#8	24K	Up thru 25	Over 25 thru 39	Over 39 thru 48	
	26K to 30K	Up thru 29	Over 29 thru 44	Over 44 thru 60	
#9	16K to 24K	Up thru 22	Over 22 thru 34	Over 34 thru 48	
	26K to 30K	Up thru 29	Over 29 thru 44	Over 44 thru 60	
#10	18K to 24K	Up thru 22	Over 22 thru 38	Over 38 thru 48	
	26K to 30K	Up thru 29	Over 29 thru 48	Over 48 thru 60	
#11	22K	Up thru 24	Over 24 thru 39	Over 39 thru 44	
	30K	Up thru 34	Over 34 thru 49	Over 49 thru 60	
#12	24K	Up thru 25	Over 25 thru 43	Over 43 thru 48	
	26K to 30K	Up thru 29	Over 29 thru 47	Over 47 thru 60	

*Last digit(s) of joist designation shown in Load Table

**See Section 5.11 for additional bridging required for uplift design.



TABLE 5.4-2

METRIC UNITS					
NUMBER OF ROWS OF TOP CHORD BRIDGING**					
Refer to the K-Series Load Table and Specification Section 6 for required bolted diagonal bridging. Distances are Joist Span lengths in mm – See “Definition of Span” preceding Load Tables.					
Section Number*	Joist Depth	One Row	Two Rows	Three Rows	Four Rows
#1	All	Up thru 5182	Over 5182 thru 7925	Over 7925 thru 8534	
#2	All	Up thru 6401	Over 6401 thru 9144	Over 9144 thru 9754	
#3	All	Up thru 5486	Over 5486 thru 7925	Over 7925 thru 12192	
#4	All	Up thru 6096	Over 6096 thru 9144	Over 9144 thru 12497	Over 12497 thru 14630
#5	12K to 24K	Up thru 6096	Over 6096 thru 9144	Over 9144 thru 12802	Over 12802 thru 14630
	26K	Up thru 8534	Over 8534 thru 12497	Over 12497 thru 15850	
#6	14K to 24K	Up thru 6096	Over 6096 thru 9449	Over 9449 thru 12802	Over 12802 thru 14630
	26K & 28K	Up thru 8534	Over 8534 thru 12497	Over 12497 thru 16459	Over 16459 thru 17069
#7	16K to 24K	Up thru 7010	Over 7010 thru 10363	Over 10363 thru 14630	
	26K to 30K	Up thru 8839	Over 8839 thru 13411	Over 13411 thru 18288	
#8	24K	Up thru 7620	Over 7620 thru 11887	Over 11887 thru 14630	
	26K to 30K	Up thru 8839	Over 8839 thru 13411	Over 13411 thru 18288	
#9	16K to 24K	Up thru 6706	Over 6706 thru 10363	Over 10363 thru 14630	
	26K to 30K	Up thru 8839	Over 8839 thru 13411	Over 13411 thru 18288	
#10	18K to 24K	Up thru 6706	Over 6706 thru 11582	Over 11582 thru 14630	
	26K to 30K	Up thru 8839	Over 8839 thru 14630	Over 14630 thru 18288	
#11	22K	Up thru 7315	Over 7315 thru 11887	Over 11887 thru 13411	
	30K	Up thru 10363	Over 10363 thru 14935	Over 14935 thru 18288	
#12	24K	Up thru 7620	Over 7620 thru 13106	Over 13106 thru 14630	
	26K to 30K	UP thru 8839	Over 8839 thru 14326	Over 14326 thru 18288	

*Last digit(s) of joist designation shown in Load Table

**See Section 5.11 for additional bridging required for uplift design.



(d) Sizing of Bridging

Horizontal and diagonal bridging shall be capable of resisting the nominal unfactored horizontal compressive force, P_{br} given in Equation 5.4-3.

$$P_{br} = 0.0025 n A_t F_{\text{construction}}, \text{ lbs (N)} \quad (5.4-3)$$

Where:

$n = 8$ for horizontal bridging

$n = 2$ for diagonal bridging

A_t = cross sectional area of joist top chord, in.² (mm²)

$F_{\text{construction}}$ = assumed ultimate stress in top chord to resist construction loads

$$F_{\text{construction}} = \left(\frac{\pi^2 E}{\left(\frac{0.9 \ell_{brmax}}{r_y} \right)^2} \right) \geq 12.2 \text{ksi} \quad (5.4-4a)$$

$$F_{\text{construction}} = \left(\frac{\pi^2 E}{\left(\frac{0.9 \ell_{brmax}}{r_y} \right)^2} \right) \geq 84.1 \text{MPa} \quad (5.4-4b)$$

Where: E = Modulus of Elasticity of steel = 29,000 ksi (200,000 MPa) and $\frac{\ell_{brmax}}{r_y}$ is determined from

Equations 5.4-1a, 5.4-1b or 5.4-2

The bridging nominal unfactored horizontal compressive forces, P_{br} , are summarized in Table 5.4-3.

TABLE 5.4-3

*Section Number	Horizontal $P_{br} (n=8)$		Diagonal $P_{br} (n=2)$	
	lbs	(N)	lbs	(N)
#1 thru #8	340	(1512)	85	(378)
#9, #10	450	(2002)	113	(503)
#11, #12	560	(2491)	140	(623)
*Last digit(s) of joist designation shown in Load Table				



(e) Connections

Attachments to the joist chords shall be made by welding or mechanical means and shall be capable of resisting the nominal (unfactored) horizontal force, P_{br} , of Equation 5.4-3, but not less 700 pounds (3114 N).

(f) Bottom Chord Bearing Joists

Where bottom chord bearing joists are utilized, a row of diagonal bridging shall be provided near the support(s). This bridging shall be installed and anchored before the hoisting cable(s) is released.

5.5 INSTALLATION OF BRIDGING

Bridging shall support the top and bottom chords against lateral movement during the construction period and shall hold the steel joists in the approximate position as shown on the joist placement plans.

The ends of all bridging lines terminating at walls or beams shall be anchored thereto.

5.6 BEARING SEAT ATTACHMENTS

(a) Masonry and Concrete

Ends of **K-Series** Joists resting on steel bearing plates on masonry or structural concrete shall be attached thereto with a minimum of two 1/8 inch (3 mm) fillet welds 2 inches (51 mm) long, or with two 1/2 inch (13 mm) ASTM - A307 bolts, or the equivalent.

(b) Steel

Ends of **K-Series** Joists resting on steel supports shall be attached thereto with a minimum of two 1/8 inch (3 mm) fillet welds 2 inches (51 mm) long, or with two 1/2 inch (13 mm) ASTM – A307 bolts, or the equivalent. When **K-Series** Joists are used to provide lateral stability to the supporting member, the final connection shall be made by welding or as designated by the **specifying professional**.

(c) Uplift

Where uplift forces are a design consideration, roof joists shall be anchored to resist such forces (Refer to Section 5.11 Uplift).

5.7 JOIST SPACING

Joists shall be spaced so that the loading on each joist does not exceed the design load (LRFD or ASD) for the particular joist designation and span as shown in the applicable load tables.

5.8 FLOOR AND ROOF DECKS

(a) Material

Floor and roof decks shall be permitted to consist of cast-in-place or pre-cast concrete or gypsum, formed steel, wood, or other suitable material capable of supporting the required load at the specified joist spacing.



(b) Thickness

Cast-in-place slabs shall be not less than 2 inches (51 mm) thick.

(c) Centering

Centering for cast-in-place slabs shall be permitted to be ribbed metal lath, corrugated steel sheets, paper-backed welded wire fabric, removable centering or any other suitable material capable of supporting the slab at the designated joist spacing.

Centering shall not cause lateral displacement or damage to the top chord of joists during installation or removal of the centering or placing of the concrete.

(d) Bearing

Slabs or decks shall bear uniformly along the top chords of the joists.

(e) Attachments

The spacing for slab or deck attachments along the joist top chord shall not exceed 36 inches (914 mm), and shall be capable of resisting a nominal (unfactored) lateral force of not less than 300 pounds (1335 N), i.e., 100 plf (1.46 kN/m).

(f) Wood Nailers

Where wood nailers are used, such nailers in conjunction with deck or slab shall be attached to the top chords of the joists in conformance with Section 5.8(e).

(g) Joist With Standing Seam Roofing or Laterally Unbraced Top Chords

When the roof system does not provide lateral stability for the joists in accordance with Section 5.8 (e), (i.e. as may be the case with standing seam roofs or extended skylights and openings) sufficient stability shall be provided to brace the joists laterally under the full design load. The compression chord shall resist the chord axial design force in the plane of the joist (i.e., x-x axis buckling) and out of the plane of the joist (i.e., y-y axis buckling). In any case where the attachment requirement of Section 5.8(e) is not achieved, out-of-plane strength shall be achieved by adjusting the bridging spacing and/or increasing the compression chord area and the y-axis radius of gyration. The effective slenderness ratio in the y-direction equals $0.94 L/r_y$; where L is the bridging spacing in inches (millimeters). The maximum bridging spacing shall not exceed that specified in Section 5.4(c).

Horizontal bridging members attached to the compression chords and their anchorages shall be designed for a compressive axial force of $0.001nP + 0.004 P\sqrt{n} \geq 0.0025nP$, where n is the number of joists between end anchors and P is the chord design force in kips (Newtons). The attachment force between the horizontal bridging member and the compression chord shall be 0.01P. Horizontal bridging attached to the tension chords shall be proportioned so that the slenderness ratio between attachments does not exceed 300. Diagonal bridging shall be proportioned so that the slenderness ratio between attachments does not exceed 200.



5.9 DEFLECTION

The deflection due to the design nominal live load shall not exceed the following:

Floors: 1/360 of span.

Roofs: 1/360 of span where a plaster ceiling is attached or suspended.
1/240 of span for all other cases.

The **specifying professional** shall give consideration to the effects of deflection and vibration* in the selection of joists.

*For further reference, refer to Steel Joist Institute Technical Digest 5, "Vibration of Steel Joist-Concrete Slab Floors" and the Institute's Computer Vibration Program.

5.10 PONDING

The ponding investigation shall be performed by the **specifying professional**.

*For further reference, refer to Steel Joist Institute Technical Digest 3, "Structural Design of Steel Joist Roofs to Resist Ponding Loads" and the AISC Specification for Structural Steel Buildings.

5.11 UPLIFT

Where uplift forces due to wind are a design requirement, these forces shall be indicated on the contract drawings in terms of NET uplift in pounds per square foot (Pascals). The contract documents shall indicate if the net uplift is based upon LRFD or ASD. When these forces are specified, they shall be considered in the design of joists and/or bridging. A single line of **bottom chord** bridging shall be provided near the first bottom chord panel points whenever uplift due to wind forces is a design consideration.

*For further reference, refer to Steel Joist Institute Technical Digest 6, "Structural Design of Steel Joist Roofs to Resist Uplift Loads".

5.12 INSPECTION

Joists shall be inspected by the manufacturer before shipment to verify compliance of materials and workmanship with the requirements of these specifications. If the purchaser wishes an inspection of the steel joists by someone other than the manufacturer's own inspectors, he shall be permitted to reserve the right to do so in his "Invitation to Bid" or the accompanying "Job Specifications".

Arrangements shall be made with the manufacturer for such inspection of the joists at the manufacturing shop by the purchaser's inspectors at purchaser's expense.

5.13 PARALLEL CHORD SLOPED JOISTS

The span of a parallel chord sloped joist shall be defined by the length along the slope. Minimum depth, load-carrying capacity, and bridging requirements shall be determined by the sloped definition of span. The Standard Load Table capacity shall be the component normal to the joist.



**SECTION 6.
ERECTION STABILITY AND
HANDLING***

When it is necessary for the erector to climb on the joists, extreme caution shall be exercised since unbridged joists may exhibit some degree of instability under the erector's weight.

(a) Stability Requirements

- 1) Before an employee is allowed on the steel joist: BOTH ends of joists at columns (or joists designated as column joists) shall be attached to its supports. For all other joists a minimum of one end shall be attached before the employee is allowed on the joist. The attachment shall be in accordance with Section 5.6 - End Anchorage.

When a bolted seat connection is used for erection purposes, as a minimum, the bolts shall be snug tightened. The snug tight condition is defined as the tightness that exists when all plies of a joint are in firm contact. This shall be attained by a few impacts of an impact wrench or the full effort of an employee using an ordinary spud wrench.

- 2) On steel joists that do not require erection bridging as shown by the unshaded area of the Load Tables, only one employee shall be allowed on the steel joist unless all bridging is installed and anchored.
- 3) Where the span of the steel joist is within the red shaded area of the Load Table, the following shall apply:
 - a) The row of bridging nearest the mid span of the steel joists shall be bolted diagonal erection bridging; and
 - b) Hoisting cables shall not be released until this bolted diagonal erection bridging is installed and anchored, unless an alternate method of stabilizing the joist has been provided; and
 - c) No more than one employee shall be allowed on these spans until all other bridging is installed and anchored.
- 4) When permanent bridging terminus points cannot be used during erection, additional temporary bridging terminus points are required to provide stability.
- 5) In the case of bottom chord bearing joists, the ends of the joist shall be restrained laterally per Section 5.4(f).
- 6) After the joist is straightened and plumbed, and all bridging is completely installed and anchored, the ends of the joists shall be fully connected to the supports in accordance with Section 5.6 - End Anchorage.

(b) Landing and Placing Loads

- 1) Except as stated in paragraphs 6(b)(3) and 6(b)(4) of this section, no "construction loads"⁽¹⁾ shall be allowed on the steel joists until all bridging is installed and anchored, and all joist bearing ends are attached.
- 2) During the construction period, loads placed on the steel joists shall be distributed so as not to exceed the capacity of the steel joists.
- 3) The weight of a bundle of joist bridging shall not exceed a total of 1000 pounds (454 kilograms). The bundle of joist bridging shall be placed on a minimum of 3 steel joists that are secured at one end. The edge of the bridging bundle shall be positioned within 1 foot (0.30 m) of the secured end.



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- 4) No bundle of deck shall be placed on steel joists until all bridging has been installed and anchored and all joist bearing ends attached, unless the following conditions are met:
 - a) The contractor has first determined from a qualified person and documented in a site-specific erection plan that the structure or portion of the structure is capable of supporting the load;
 - b) The bundle of decking is placed on a minimum of 3 steel joists;
 - c) The joists supporting the bundle of decking are attached at both ends;
 - d) At least one row of bridging is installed and anchored;
 - e) The total weight of the decking does not exceed 4000 pounds (1816 kilograms); and
 - f) The edge of the decking shall be placed within 1 foot (0.30 meters) of the bearing surface of the joist end.
- 5) The edge of the construction load shall be placed within 1 foot (.30 meters) of the bearing surface of the joist end.

(c) Field Welding

- 1) All field welding shall be performed in accordance with the contract documents. Field welding shall not damage the joists.
- 2) On cold-formed members whose yield strength has been attained by cold working, and whose as-formed strength is used in the design, the total length of weld at any one point shall not exceed 50 percent of the overall developed width of the cold-formed section.

(d) Handling

Care shall be exercised at all times to avoid damage to the joists and accessories.

(e) Fall Arrest Systems

Steel joists shall not be used as anchorage points for a fall arrest system unless written direction to do so is obtained from a "qualified person" ⁽²⁾.

*For a thorough coverage of this topic, refer to SJI Technical Digest 9, "Handling and Erection of Steel Joists and Joist Girders."

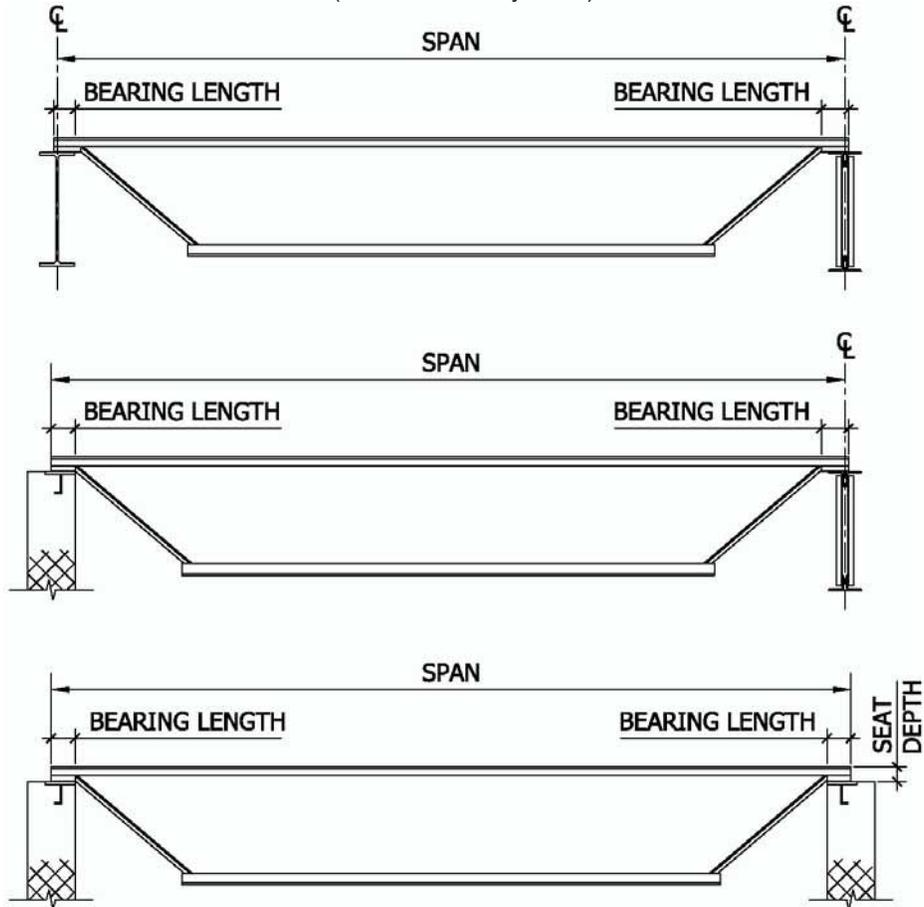
⁽¹⁾ See Federal Register, Department of Labor, Occupational Safety and Health Administration (2001), 29 CFR Part 1926 Safety Standards for Steel Erection; Final Rule, §1926.757 Open Web Steel Joists - January 18, 2001, Washington, D.C. for definition of "construction load".

⁽²⁾ See Federal Register, Department of Labor, Occupational Safety and Health Administration (2001), 29 CFR Part 1926 Safety Standards for Steel Erection; Final Rule, §1926.757 Open Web Steel Joists - January 18, 2001, Washington, D.C. for definition of "qualified person".



DEFINITION OF SPAN

(U. S. Customary Units)



- NOTES:**
- 1) DESIGN LENGTH = SPAN - 0.33 FT.**
 - 2) BEARING LENGTH FOR STEEL SUPPORTS SHALL NOT BE LESS THAN 2½ INCHES ; FOR MASONRY AND CONCRETE NOT LESS THAN 4 INCHES.**
 - 3) PARALLEL CHORD JOISTS INSTALLED TO A SLOPE GREATER THAN ½ INCH PER FOOT SHALL USE SPAN DEFINED BY THE LENGTH ALONG THE SLOPE.**