STANDARD SPECIFICATION
FOR CJ-SERIES COMPOSITE STEEL JOISTS

CJ-Series Adopted by the Steel Joist Institute May 10, 2006
Revised to May 18, 2010, Effective December 31, 2010
Revised to November 9, 2015; Effective August 1, 2016

SECTION 1.
SCOPE AND DEFINITIONS

1.1 SCOPE

The *Standard Specification for* **CJ**-*Series Composite Steel Joists,* hereafter referred to as the Specification, covers the design, manufacture, application, and erection stability and handling of **CJ**-Series Composite Steel Joists in buildings or other structures, where other structures are defined as those structures designed, manufactured, and erected in a manner similar to buildings. **CJ**-Series joists shall be designed using Load and Resistance Factor Design (LRFD) in accordance with this Specification.

1.2 OTHER REGULATIONS

CJ-Series joists shall be erected in accordance with the Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Safety Standards for Steel Erection, Subpart R – Steel Erection. The erection of **CJ**-Series joists shall be in accordance with the requirements of Section 1926.757, Open Web Steel Joists.

1.3 APPLICATION

This Specification includes Section 1 through Section 8. The user notes shall not be part of the Specification.

> **User Note**: User notes are intended to provide practical guidance in the use and application of this Specification.

1.4 DEFINITIONS

The following terms shall, for the purposes of this Specification, have the meanings shown in this Section. Where terms are not defined in this Section, those terms shall have their ordinary accepted meanings in the context in which it applies.

CJ-Series shall be open web, parallel chord, load-carrying steel members utilizing hot-rolled or cold-formed steel, including cold-formed steel whose yield strength has been attained by cold working. Shear connection between the top chord and overlying concrete slab allows the steel joist and slab to act together as an integral unit after the concrete has adequately cured.

The **CJ-**Series joist standard designation is determined by its nominal depth in inches (mm), the letters “**CJ**”, followed by the total uniform composite load, uniform composite live load, and finally the uniform composite dead load. Composite Steel Joists shall be designed in accordance with this Specification to support the loads defined by the specifying professional.

> **User Note**: **CJ-**Series joists are suitable for the direct support of one-way floors and roof slabs or decks. **CJ-**Series joists have parallel chords and are standardized in depths from 10 inches (254 mm) through 96 inches (2438 mm), for spans through 120 feet (36.58 m).

Two standard types of **CJ-**Series joists are designed and manufactured. These types are underslung (top chord bearing) or square-ended (bottom chord bearing).

The **CJ-**Series joists have bearing depths that range from 2½ inches (64 mm) to 7½ inches (191 mm).

1.5 STRUCTURAL DESIGN DRAWINGS AND SPECIFICATIONS

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

SECTION 2.
REFERENCED SPECIFICATIONS, CODES AND STANDARDS

2.1 REFERENCES

The standards listed below shall be considered part of the requirements of this Specification. Where conflicts occur between this Specification and a referenced standard, the provisions of this Specification shall take precedence unless otherwise so stated. This section lists the standards that are referenced in this Specification. The standards are listed in alphabetical order by name of the standards developer organization, with the specific standard designation, title and date of each referenced standard below.

ACI International (ACI), Farmington Hills, MI

ACI 318-14, *Building Code Requirements for Structural Concrete and Commentary*

ACI 318M-14, *Metric Building Code Requirements for Structural Concrete and Commentary*

American Institute of Steel Construction, Inc. (AISC), Chicago, IL

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

American Iron and Steel Institute (AISI), Washington, DC

ANSI/AISI S100-2012 *North American Specification for the Design of Cold-Formed Steel Structural Members*

American Society of Civil Engineers (ASCE), Reston, VA

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

American Society of Testing and Materials, ASTM International (ASTM), West Conshohocken, PA

ASTM A6/A6M-14, *Standard Specification for General Requirements for Rolled Structural Steel Bars, Plates, Shapes, and Sheet Piling*

ASTM A36/A36M-14, *Standard Specification for Carbon Structural Steel*

ASTM A242/242M-13, *Standard Specification for High-Strength Low-Alloy Structural Steel*

ASTM A307-14, *Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength*

ASTM A325-14 *Standard Specification for Structural Bolts, Steel, Heat Treated, 120/105 ksi Minimum Tensile Strength*

ASTM A325M-14 *Standard Specification for Structural Bolts, Steel, Heat Treated 830 MPa Minimum Tensile Strength (Metric)*

ASTM A370-14, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*

ASTM A500/A500M-13, *Standard Specification for Cold-Formed Welded and Seamless Carbon Steel Structural Tubing in Rounds and Shapes*

ASTM A501/A501M-14 *Standard Specification for Hot-Formed Welded and Seamless Carbon Steel Structural Tubing*

ASTM A529/A529M-14, *Standard Specification for High-Strength Carbon-Manganese Steel of Structural Quality*

ASTM A572/A572M-15, *Standard Specification for High-Strength Low-Alloy Columbium-Vanadium Structural Steel*

ASTM A588/A588M-15, *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-09a, *Standard Specification for Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Atmospheric Corrosion Resistance*

ASTM A992/A992M-11 (2015), *Standard Specification for Structural Steel Shapes*

ASTM A1008/A1008M-15, *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-14, *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*

ASTM A1065/A1065M-15 *Standard Specification for Cold-Formed Electric-Fusion (ARC) Welded High-Strength Low Alloy Structural Tubing in Shapes with 50 ksi (345 MPA) Minimum Yield Point*

ASTM A1085-13 *Standard Specification for Cold-Formed Welded Carbon Steel Hollow Structural Sections (HSS)*

American Welding Society (AWS), Miami, FL

AWS A5.1/A5.1M-2012, *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:2011, *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:2010, *Specification for Low Alloy Steel Electrodes for Flux Cored Arc Welding*

AWS D1.1/D1.1M:2015, *Structural Welding Code - Steel*

AWS D1.3/D1.3M:2008, *Structural Welding Code Sheet Steel*

Steel Deck Institute (SDI), Glenshaw, PA

ANSI/SDI C-2011, Standard for Composite Steel Floor Deck - Slabs

ANSI/SDI NC-2010, Standard for Non-Composite Steel Floor Deck

Steel Joist Institute (SJI), Florence, SC

ANSI/SJI 100-2015, *Standard Specification for K-Series, LH-Series, and DLH-Series Open Web Steel Joists and for Joist Girders*

User Note: The following references provide additional practical guidance in the use and application of this Specification:

Code of Federal Regulations (CFR), Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Safety Standards for Steel Erection; Subpart R – Steel Erection; January 18, 2001, Washington, D.C

Steel Joist Institute (SJI), Florence, SC

ANSI/SJI-CJ COSP-2015, *Code of Standard Practice for Composite Steel Joists*

Technical Digest No. 3 (2018), *Structural Design of Steel Joist Roofs to Resist Ponding Loads*

Technical Digest No. 5 (2015), *Vibration of Steel Joist-Concrete Slab Floors*

Technical Digest No. 6 (2012), *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*

The Society for Protective Coatings (SSPC), Pittsburgh, PA

SSPC 08-02 Steel Structures Painting Manual – Volume 2 – Systems and Specifications, 2011 Edition

SSPC Paint 15 Steel Joist Shop Primer/Metal Building Primer (Includes 2004 Revisions) 05/01/1999

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Curry, Jamison Hyde (1988), *Full Scale Tests on Two Long-Span Composite Open-Web Steel Joists,* Master's Thesis, Department of Civil and Mineral Engineering Institute of Technology, University of Minnesota, MN.

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Samuelson, David (2004) SJI Updates – *Expanded Load Tables for Noncomposite Joists/Joist Girders and Development of New Composite Joist Series*, North American Steel Construction Conference, Long Beach, CA, March 24-27.

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SECTION 3.
MATERIALS

3.1 STEEL CHORD AND WEB MEMBERS

The steel used in the manufacture of **CJ-**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

EXCEPTION: Steel used in the manufacture of **CJ-**Series joists shall be permitted to be of suitable quality ordered or produced to other than the listed ASTM specifications, provided that such material in the state used for final assembly and manufacture is weldable and is proven by tests performed by the producer or manufacturer to have properties, in accordance with Section 3.2.

3.2 MECHANICAL PROPERTIES

3.2.1 Minimum Yield Strength: Steel used for **CJ-**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.

User Note: The term "Yield Strength" as used herein designates 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 Section 3.2.3.

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 such material, the mechanical properties of which conform to the requirements of one of the listed ASTM specifications in Section 3.1, the test specimens and procedures shall conform to those of the applicable ASTM specification and to ASTM A370.

3.2.2 Other Materials: For materials where the mechanical properties do not conform to the requirements of one of the ASTM specifications listed in Section 3.1, these materials shall conform to the following requirements:

a) The specimens shall comply with ASTM A370.

b) The specimens shall exhibit a yield strength equal to or exceeding the design yield strength.

c) The specimens shall have an elongation of not less than 20 percent in 2 inches (51 mm) for sheet strip, or 18 percent in 8 inches (203 mm) for plates, shapes and bars with adjustments for thickness for plates, shapes and bars as prescribed in either ASTM A36/A36M, A242/A242M, A500/A500M, A529/A529M, A572/A572M, A588/A588M, or A992/A992M, whichever ASTM specification is applicable, on the basis of design yield strength.

d) The number of tests for (a), (b), and (c) above 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.

3.2.3 As-Formed Strength: If as-formed strength is utilized for cold-formed steel members, the test reports shall show the results performed on full section specimens in accordance with the provisions of AISI S100. The test reports shall also indicate compliance 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 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 WELDING ELECTRODES

3.3.1 Welding Electrodes: The welding electrodes used for arc welding shall be in accordance with the following:

a) For connected members both having a specified minimum yield strength greater than 36 ksi (250 MPa), one of the following electrodes shall be used:

AWS A5.1: E70XX
AWS A5.5: E70XX-X
AWS A5.17: F7XX–EXXX, F7XX–ECXXX flux electrode combination
AWS A5.18: ER70S-X, E70C-XC, E70C-XM
AWS A5.20: E7XT-X, E7XT-XM
AWS A5.23: F7XX–EXXX-XX, F7XX–ECXXX-XX
AWS A5.28: ER70S-XXX, E70C-XXX
AWS A5.29: E7XTX-X, E7XTX-XM

b) For connected members both having a specified minimum yield strength of 36 ksi (250 MPa) or one having a specified minimum yield strength of 36 ksi (250 MPa), and the other having a specified minimum yield strength greater than 36 ksi (250 MPa), one of the following electrodes shall be used:

AWS A5.1:	E60XX
AWS A5.17:	F6XX-EXXX, F6XX-ECXXX flux electrode combination
AWS A5.20:	E6XT-X, E6XT-XM
AWS A5.29:	E6XTX-X, E6XTX-XM

or any of those listed in Section 3.3.1(a).

3.3.2 Other Welding Methods: Other welding methods, providing equivalent strength as demonstrated by tests, shall be permitted to be used.

3.4 PAINT

CJ-Series joists shall be provided unpainted to facilitate installation of welded shear studs, unless otherwise specified.

When specified, the standard shop paint shall be considered an impermanent and provisional coating and shall conform to one of the following:

a) The Society for Protective Coatings, SSPC Paint Specification No. 15.

b) Or, shall be a shop paint which meets the minimum performance requirements of SSPC Paint Specification No. 15.

> **User Note**: The standard shop paint is intended to protect the steel for only a short period of exposure in ordinary atmospheric conditions. It is usually considered preferable to leave **CJ-**Series joists unpainted due to concerns that paint may potentially hinder the installation of welded shear studs to the joist top chord.

SECTION 4.
DESIGN AND MANUFACTURE

4.1 METHOD

CJ-Series joist design shall be based on achieving the nominal flexural strength of the composite member and is designed as a one-way, composite joist system that meets the following criteria:

a) Members are simply-supported and are not considered part of a designated lateral force resisting system, such as a braced frame or moment frame.

b) Horizontal shear connection is achieved using welded steel stud anchors, except as provided in Section 8.

CJ-Series 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 steel 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, AISC 360.

b) For members which are cold-formed from sheet or strip steel, AISI S100.

4.1.1 Design Basis: **CJ-**Series joist designs shall be in accordance with the provisions in this Specification using Load and Resistance Factor Design (LRFD) as specified by the specifying professional for the project.

4.1.2 Loads, Forces and Load Combinations: The loads and forces used for the **CJ-**Series joist design shall be calculated by the specifying professional in accordance with the applicable building code and specified and provided on the structural drawings.

For nominal concentrated loads, which have been accounted for in the specified uniform loads, the addition of chord bending moments or an added shop or field web member due to these nominal concentrated loads shall not be required provided that the sum of the concentrated loads within a chord panel does not exceed 100 pounds and the attachments are concentric to the chord. When exact dimensional locations for concentrated loads which do not meet the above criteria are provided by the specifying professional, the **CJ-**Series joist shall be designed for the loads and load locations provided without the need for additional field applied web members at the specified locations.

The load combinations shall be specified by the specifying professional on the structural drawings in accordance with the applicable building code. In the absence of an applicable building code, the load combinations shall be those stipulated in SEI/ASCE 7 Section 2.3 for Load and Resistance Factor Design.

At a minimum, the required stress for LRFD designs shall be computed for the factored loads based on the factors and load combinations as follows:

a) Non-composite

$$1.4D_c \qquad (4.1\text{-}1)$$

$$1.2D_c + 1.6L_c \qquad (4.1\text{-}2)$$

Where:

D_c = construction dead load due to weight of the joist, the metal decking, and the fresh concrete, lb/ft^2 (kPa)

L_c = construction live load due to the work crews and the construction equipment, lb/ft^2 (kPa)

b) Composite

$$1.4D \qquad (4.1\text{-}3)$$

$$1.2D + 1.6\ (L, \text{ or } L_r, \text{ or } S, \text{ or } R) \qquad (4.1\text{-}4)$$

Where:

D = dead load due to the weight of the structural elements and the permanent features of the structure, lb/ft^2 (kPa)

L = live load due to occupancy and movable equipment, lb/ft^2 (kPa)

L_r = roof live load, lb/ft^2 (kPa)

S = snow load, lb/ft^2 (kPa)

R = load due to initial rainwater or ice exclusive of the ponding contribution, lb/ft^2 (kPa)

4.2 DESIGN STRESSES

4.2.1 Design Using Load and Resistance Factor Design (LRFD): **CJ-**Series 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, ksi (MPa)
F_y = specified minimum yield stress, ksi (MPa)
E = modulus of elasticity of steel, ksi (MPa)

4.2.2 Stresses: The calculation of design stress for chords shall be based on a yield strength, F_y, of the material used in manufacturing equal to 50 ksi (345 MPa). The calculation of design stress for all other joist elements 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) nor greater than 50 ksi (345 MPa). Yield strengths greater than 50 ksi shall not be used for the design of any members.

4.2.2.1 Tension: $\phi_t = 0.90$ (LRFD)

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

4.2.2.2 Compression: $\phi_c = 0.90$ (LRFD)

$$\text{Design Stress} = 0.9F_{cr} \tag{4.2-2}$$

Where:

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

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

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

$$F_{cr} = 0.877F_e \tag{4.2-4}$$

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

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

In the above equations, ℓ is the length, k is the effective length factor, and r is the corresponding radius of gyration of the member as defined in Section 4.3. E is equal to 29,000 ksi (200,000 MPa).

User Note: ℓ should be taken as the distance in inches (mm) between panel points for the chord members and web members.

For hot-rolled sections and cold-formed angles, the form factor, Q, shall be taken as the full reduction factor for slender compression members as determined in accordance with AISC 360-10.

Where a compression web member, either a hot-rolled section or a cold-formed angle, is a crimped-end angle member intersecting at the first bottom chord panel point, then Q shall be determined as follows:

$$Q = [5.25/(w/t)] + t \leq 1.0 \tag{4.2-6a}$$

Where:

w = angle leg length, inches

t = angle leg thickness, inches

or,

$$Q = [5.25/(w/t)] + (t/25.4) \leq 1.0 \tag{4.2-6b}$$

Where:

w = angle leg length, mm

t = angle leg thickness, mm

For all other cold-formed sections the method of calculating the nominal compression strength shall be in accordance with AISI S100.

4.2.2.3 Bending: $\phi_b = 0.90$ (LRFD)

Bending calculations shall be based on the elastic section modulus.

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

$$\text{Design Stress} = \phi_b F_n = 0.9F_y \qquad (4.2\text{-}7)$$

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

$$\text{Design Stress} = \phi_b F_n = 1.45F_y \qquad (4.2\text{-}8)$$

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

$$\text{Design Stress} = \phi_b F_n = 1.35F_y \qquad (4.2\text{-}9)$$

4.2.2.4 Weld Strength: $\phi_w = 0.75$ (LRFD)

Shear at throat of fillet welds, flare bevel groove welds, partial joint penetration groove welds, and plug/slot welds shall be determined as follows:

$$\text{Nominal Shear Stress} = F_{nw} = 0.6F_{exx} \qquad (4.2\text{-}10)$$

$$\text{Design Shear Strength} = \phi R_n = \phi_w F_{nw} A = 0.45F_{exx} A_w \text{ (LRFD)} \qquad (4.2\text{-}11)$$

Where:

F_{exx} is determined as follows:

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

E60 series electrodes or F6XX-EXXX flux-electrode combinations $F_{exx} = 60$ 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 (in.) and web diameter, D (in.), where:

$$T = 0.12D + 0.11 \text{ (in.)} \qquad (4.2\text{-}12a)$$

or,

For flare bevel groove welds, the effective weld area is based on a weld throat width, T (mm) and web diameter, D (mm), where:

$$T = 0.12D + 2.8 \text{ (mm)} \qquad (4.2\text{-}12b)$$

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 AISC 360.

User Note: For more on plugs/slot welds see Steel Joist Institute 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 where the stress is normal to the weld axis) shall be equal to the base metal strength:

$\phi_t = \phi_c = 0.90$ (LRFD)

Design Stress = $0.9\ F_y$ (4.2-13)

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, Part A.

4.3.1 Effective Slenderness Ratios: 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, Part B and Part C, and modified where required with Equation 4.3-1.

4.3.2 Compression Members: In compression members where 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 shall be defined as follows:

- ℓ = length center-to-center of panel points, except ℓ = 36 inches (914 mm) for calculating ℓ/r_y of the top chord member for **CJ-**Series joists, 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 about the horizontal axis of the **CJ-**Series joist, in. (mm)
- r_y = member radius of gyration about the vertical axis of the **CJ-**Series joist, in. (mm)
- r_z = least radius of gyration of a member component, in. (mm)

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

4.3.3 Tension Members: Tension web members shall be those web members subject to tension axial loads under gravity loading, and which shall be permitted to be subject to compressive axial loads under alternate loading conditions.

User Note: An example of a non-gravity alternate loading condition is net uplift.

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

4.3.5 Built-Up Web Members: For built-up web members composed of two interconnected shapes, where $\ell_s/r_z > 40$, a modified slenderness ratio $\left(\frac{k\ell}{r_y}\right)_m$ shall replace $\frac{k\ell}{r_y}$ in Equations 4.2-3, 4.2-4, and 4.2-5, where:

$$\left(\frac{k\ell}{r_y}\right)_m = \sqrt{\left(\frac{k\ell}{r_y}\right)^2 + \left(\frac{k_i\ell_s}{r_z}\right)^2} \qquad (4.3\text{-}1)$$

Where:

k_i = 0.50 for angles back-to-back
= 0.75 for channels back-to-back

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 for CJ-Series joists, $k\ell/r$, to determine F_{cr} where k is:**				
1.	Two shapes with fillers or ties	0.75	0.94	---	1.0
2.	Two shapes without fillers or ties	---	---	0.75	---
3.	Single component members	0.75	0.94	---	---
C.	**For bending, the effective slenderness ratio, $k\ell/r$, to determine F'_e where k is:**				
		0.75	---	---	---
II.	**TOP CHORD END 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.**				
B.	**The effective slenderness ratio for CJ-Series joists, $k\ell/r$, to determine F_{cr} where k is:**				
1.	Two shapes with fillers or ties	1.0	0.94	---	1.0
2.	Two shapes 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.	**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 240.**				
B.	**For members subject to compression, the effective slenderness ratio for CJ-Series joists, $k\ell/r$, to determine F_{cr} where k is:**				
1.	Two shapes with fillers or ties	0.9	0.94	---	1.0
2.	Two shapes without fillers or ties	---	---	0.9	---
3.	Single component members	0.9	0.94	---	---
C.	**For bending, the effective slenderness ratio, $k\ell/r$, to determine F'_e where k is:**				
		0.9	---	---	---
IV.	**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 for a tension member or 200 for a compression member.**				
B.	**For members subject to compression, the effective slenderness ratio for CJ-Series joists, $k\ell/r$, to determine F_{cr} where k is:**				
1.	Two shapes with fillers or ties	0.75	1.0	---	1.0
2.	Two shapes without fillers or ties	---	---	1.0	---
3.	Single component members	0.75	0.9*	---	---
	* For end tension web members subject to compression, k shall equal 0.80				

4.4 MEMBERS

4.4.1 Chord Members

4.4.1.1 Non-composite Design

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

The top chord shall resist the construction loads, at which time the joist behaves non-compositely. An analysis shall be made using an effective depth of the joist to determine the member forces due to construction loads. The effective depth for a non-composite joist shall be considered the vertical distance between the centroids of the top and bottom chord members.

The minimum horizontal flat leg width and minimum thickness of the top chord shall be as specified in Table 4.4-1.

TABLE 4.4-1
MINIMUM TOP CHORD SIZES FOR INSTALLING WELDED SHEAR STUDS

Shear Stud Diameter, in. (mm)	Minimum Horizontal Flat Leg Width, in. (mm)	Minimum Leg Thickness, in. (mm)
0.375 (10)	1.50 (38)	0.125 (3.2)
0.500 (13)	1.75 (44)	0.167 (4.2)
0.625 (16)	2.00 (51)	0.209 (5.3)
0.750 (19)	2.50 (64)	0.250 (6.3)

The top chord shall be designed as a continuous member subject to combined axial and bending stresses. It shall be so proportioned that for LRFD:

At the panel point:

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

At the mid panel:

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

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

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

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

Where:

f_{au} = P_u/A = required compressive stress using LRFD load combinations, ksi (MPa)
P_u = required axial strength using LRFD load combinations, kips (N)
A = area of the top chord, in.^{2} (mm^2)
f_{bu} = M_u/S = required bending stress at the location under consideration using LRFD load combinations, 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 $k\ell/r$ as defined in Section 4.3

C_m = 1 - 0.3 $f_{au}/\phi_c F'_e$ for end panels
C_m = 1 - 0.4 $f_{au}/\phi_c F'_e$ for interior panels
Q = form factor defined in Section 4.2.2.2
ϕ_c = resistance factor for compression = 0.90
ϕ_b = resistance factor for flexure = 0.90
F_y = specified minimum yield strength, ksi (MPa)
F'_e = $\dfrac{\pi^2 E}{(k\ell/r_x)^2}$, ksi (MPa),

where ℓ is the length, k is the effective length factor, and r_x is the corresponding radius of gyration of the member as defined in Section 4.3

E = modulus of elasticity, 29,000 ksi (200,000 MPa)

The joist top chord shall be considered as laterally braced by the floor slab or roof deck provided the requirements of Section 5.9.5 are met.

The top chord and bottom chord shall be designed such that at each joint complies with Equation 4.4-4:

$$f_{vmod} \leq \phi_v F_n \qquad \text{(LRFD, } \phi_v = 1.00\text{)} \qquad (4.4\text{-}4)$$

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 = $(\frac{1}{2})\sqrt{f_t^2+4f_v^2}$
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, f_{vmod}, where a round bar web member is continuous through a joint. The minimum required shear of Section 4.4.2 (25 percent of the maximum end reaction) shall not be required when evaluating Equation 4.4-4.

4.4.1.2 Composite Design

The distance between the centroid of the tension bottom chord and the centroid of the concrete compression block, d_e, shall be computed using a concrete stress of $0.85f'_c$ and an effective concrete width, b_e, taken as the sum of the effective widths for each side of the joist centerline, each of which shall be the least value of the following:

a) one-eighth of the joist span, center-to-center of supports;
b) one-half the distance to the center-line of the adjacent joist;
c) the distance to the edge of the slab.

$$a = A_b F_y /(0.85\, f'_c\, b_e) \leq t_c, \text{ in. (mm)} \qquad (4.4\text{-}5)$$

$$d_e = d_j - y_{bc} + h_{deck} + t_c - a/2, \text{ in. (mm)} \qquad (4.4\text{-}6)$$

Where:

- a = depth of concrete compressive stress block, in. (mm)
- A_b = cross-sectional area of **CJ**-Series steel joist bottom chord, in.^{2} (mm^2)
- b_e = effective width of concrete slab over the joist, in. (mm)
- d_j = **CJ**-Series steel joist depth, in. (mm)
- f'_c = specified compressive strength of concrete, ksi (MPa)
- F_y = specified minimum yield stress of **CJ-** Series joist bottom chord, ksi (MPa)
- h_{deck} = height of metal deck, in. (mm)
- t_c = thickness of concrete slab above the metal deck, in. (mm)
- y_{bc} = vertical distance to centroidal axis of bottom chord measured from the bottom of the bottom chord, in. (mm)

When the metal deck ribs are perpendicular to the **CJ-**Series joists, the concrete below the top of the metal deck shall be neglected when determining section properties and in calculating the concrete compressive stress block.

The first top chord end panel member shall be designed for the full factored load requirements as a non-composite member per Section 4.4.1.1.

$$M_u \le \phi M_n \quad (4.4\text{-}7)$$

Where:

- ϕM_n = minimum design flexural strength of composite section as determined from Equations 4.4-8, 4.4-9, 4.4-10, and 4.4-11, kip-in. (N-mm)
- M_u = required flexural strength determined from applied factored loads, kip-in. (N-mm)

The design flexural strength of the composite section, ϕM_n, shall be computed as the least value of the following limit states:

a) Bottom Chord Tensile Yielding: $\phi_t = 0.90$ $\quad \phi M_n = \phi_t A_b F_y d_e$ (4.4-8)

b) Bottom Chord Tensile Rupture: $\phi_{tr} = 0.75$ $\quad \phi M_n = \phi_{tr} A_n F_u d_e$ (4.4-9)

c) Concrete Crushing: $\phi_{cc} = 0.85$ $\quad \phi M_n = \phi_{cc} 0.85 f'_c b_e t_c d_e$ (4.4-10)

d) Shear Connector Strength: $\phi_{stud} = 0.90$ $\quad \phi M_n = \phi_{stud} N Q_n d_e$ (4.4-11)

Where:

- A_b = cross-sectional area of **CJ-**Series joist bottom chord, in.^{2} (mm^2)
- A_n = net cross-sectional area of the **CJ-**Series joist bottom chord, in.^{2} (mm^2)
- b_e = effective width of concrete slab over the **CJ-**Series joist, in. (mm)
- d_e = vertical distance from the centroid of **CJ-**Series joist bottom chord to the centroid of resistance of the concrete in compression, in.(mm)
- F_u = tensile strength of the **CJ-**Series joist bottom chord, ksi (MPa)
- F_y = specified minimum yield stress of **CJ-**Series joist bottom chord, ksi (MPa)
- N = number of shear studs between the point of maximum moment and zero moment
- Q_n = shear capacity of a single shear stud, kips (kN)
- t_c = minimum thickness of the concrete slab above the top of the metal deck, in. (mm)

Where composite flexural strength is governed by the strength of shear connection as provided by Equation 4.4-11, the strength of shear connection, NQ_n, shall be no less than 50 percent of the bottom chord yield strength.

4.4.2 Web Members

The vertical shears to be used in the design of the web members shall be determined by including all loads, i.e. from the controlling load combination from Section 4.1.2, but such vertical shears shall be not less than the following:

a) 25 percent of the maximum end reaction from the design load combinations;
b) Tension web members controlled by (a) shall be designed for a compressive force resulting from a factored shear value of:

$$V_{c\,min} = \frac{(1.6w_L)L}{8} \qquad (4.4\text{-}12)$$

Where:

w_L = non-factored live load due to occupancy and moveable equipment, plf (kN/m)

L = design length for the **CJ-**Series joist as defined in Table 5.2-1, where design length = Span – 0.33 ft. (Span (m) – 0.102 m)

$V_{c\,min}$ = minimum factored compressive design shear in tension web members, lbs (kN)

4.4.2.1 Redundant Web Member: Interior vertical web members used in modified Warren type web systems shall be designed to resist the gravity loads supported by the member plus 2.0 percent of the composite bottom chord axial force.

Redundant web members in end panels shall be designed to resist the gravity loads supported by the member plus an additional load of ½ of 1.0 percent of the top chord axial force.

4.4.2.2 Single Component Web Member: In those cases where a single component web member is attached to the outside of the stem of a tee or double angle chord or any other orientation of a single web member which creates an out-of-plane moment, the web member design shall account for the stresses due to eccentricity.

4.4.2.2.1 Uncrimped Single Angle Web Member

For 1 inch (25 mm) uncrimped single angle web members where one leg is placed flat against one chord member in the gap, the resulting eccentricities and the effects in loading shall be considered in the design. A minimum of 50 percent of the required weld shall be deposited to each chord angle.

For angles subjected to tension loading, combined axial and bending stresses shall be proportioned in accordance with Equation 4.4-1.

For angles subjected to compression loading, the following requirements shall be met:

at the panel point, combined axial and bending stresses shall be proportioned in accordance with Equation 4.4-1.

at the mid length, the strength shall meet Equations 4.4-2 or 4.4-3, and 4.4-13:

$$\frac{f_{au}}{\phi_c F_{crz}} \leq 1.0 \qquad (4.4\text{-}13)$$

Where:

f_{au} = P_u/A = required tensile or compressive stress, ksi (MPa)

P_u = required axial strength using LRFD load combinations, kips (N)

A = area of the uncrimped angle web, in.^{2}, (mm^2)

f_{bu} = M_u/S = required bending stress, ksi (MPa)

M_u = required flexural strength = $0.5P_u\left(\frac{\text{chord gap}}{2} - \bar{y}\right)$, kip-in. (N-mm)

S = elastic section modulus, in.^{3} (mm^3)

F_{cr} = F_{crx}, ksi (MPa)

F_{crx} = nominal axial compressive stress in ksi (MPa) based on $k\ell/r_x$,
where ℓ is the length, k is the effective length factor, and r_x is the corresponding radius of gyration of the member as defined in Section 4.3

F_{crz} = nominal axial compressive stress in ksi (MPa) based on $k\ell/r_z$
where k = 1.0

C_m = 1.0

F_y = specified minimum yield strength, ksi (MPa)

F'_e = $\dfrac{\pi^2 E}{(k\ell/r_x)^2}$, ksi (MPa)

Q = form factor defined in Section 4.2.2.2

Alternate methods of design shall be permitted provided they provide strength equal to or greater than those given. Alternate design procedures shall be submitted to the Steel Joist Institute's consulting engineer for approval.

4.4.3 Fillers and Ties

Fillers or ties added on chord or web compression members shall be designed and connected for a force equal to two percent of the required member axial force.

4.4.4 Joist Extensions

CJ-Series joist extensions shall be designated as one of three extension types, as follows: top chord extensions (TCX), extended ends, or full depth cantilevers.

Design criteria for **CJ-**Series joist extensions shall be specified using one of the following methods:

(1) A **CJ-**Series joist top chord extension (TCX), extended end, or full depth cantilevered end shall be designed for the load based on the design length and designation of the specified **CJ-**Series 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 **CJ**-Series joist 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 applicable load combinations.

Any deflection requirements or limits due to the accompanying loads and load combinations on the **CJ-**Series 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 **CJ-**Series joist base span and the extension.

The joist manufacturer shall consider the effects of **CJ-**Series joist extension loading on the base span of the steel joist. This shall include 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 steel joist chord and web axial forces. The joist extension shall support all end loads without relying on any composite action.

Required bracing of extensions shall be clearly indicated on the structural drawings.

Design of concrete reinforcing steel in the negative moment region shall be the responsibility of the specifying professional.

4.5 CONNECTIONS

4.5.1 Methods

Member connections and splices shall be made by attaching the members to one another by arc or resistance welding or other accredited methods in accordance with the following:

a) CJ-Series joist arc welded joints shall be in accordance with the American Welding Society, “Structural Welding Code-Steel”, D1.1, and/or the “Structural Welding Code Sheet Steel”, D1.3 with the following eight modified acceptance criteria as permitted by AWS D1.1 Clause 6.8:

1. Undercut shall not exceed 1/16 inch (2 mm) for welds oriented parallel to the principal stress.

User Note: The typical diagonal web member connection to one leg of a chord angle is considered to be parallel to the principal stress.

2. Discontinuities outside of the weld design length shall be permitted provided no cracks exist and undercut does not exceed the limits of item 1.

User Note: The weld design length is the minimum weld length needed for the connection force and weld thickness. Portions of the actual weld length with imperfections or discontinuities such as porosity or lack of a full profile are not included when comparing the actual weld length to the weld design length.

3. One unrepaired arc strike shall be permitted per joint provided it does not result in other unacceptable defects.

User Note: Minor arc strikes do not reduce the strength of AWS Group II materials (refer to Van Malssen, 1984).

4. The effective throat for flare bevel groove welds shall be calculated in accordance with equation 4.2-12.

User Note: The effective weld throat used by the SJI with round bars is based on SJI research and is more conservative than AWS D1.1 for GMAW for round bars in excess of 9/16” (14 mm). See Steel Joist Institute Technical Digest 8 - Welding of Open Web Steel Joists and Joist Girders.

5. Tack welds that are discontinuous from other welds shall meet the criteria for undercut, but shall be exempt from all other acceptance criteria.

User Note: Joist manufacturers use tack welds in the assembly process, and so long as they do not diminish the strength of the base metal and are not incorporated into the final weld for strength, they are not required to meet other inspection criteria.

6. The weld profile shall be considered acceptable provided neither the weld leg nor the weld throat is undersized less than AWS D1.1 limits within the weld design length.

7. For material with thickness less than 1/8”, AWS D1.1 or D1.3 shall be considered appropriate.

User Note: AWS D1.1 does not address thicknesses less than 1/8” for hot rolled material and AWS D1.3 does not address hot rolled material, thus SJI has extended the ranges to include these material thicknesses.

8. A ratio of stud diameter to top chord thickness of up to 3.0 shall be permitted.

User Note: See section 4.5.4 Shear Studs for reduction in stud capacity for ratios between 2.7 and 3.0.

b) CJ-Series joist resistance welded joints shall follow a preproduction validation procedure and a production checking procedure and shall meet the strength requirements of this Specification.

User Note: Spot, flash or upset resistance welds should have a written welding procedure qualification record and a systematic quality plan. For further information, see Steel Joist Institute Technical Digest 8 - Welding of Open Web Steel Joists and Joist Girders.

c) Welded Connections for Crimped-End Angle Web Members

1) 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 an end return of no less than two times the nominal weld size.

d) Welding Program

1) The manufacturer's welders shall be qualified in accordance with either AWS D1.1 or AWS D1.3 for the applicable weld type, position, and material.

2) Manufacturers shall have a program for establishing weld procedures and operator qualification, and for weld sampling and testing. Each manufacturing facility shall have trained inspectors, and an engineer responsible for all welding procedures.

e) Weld Inspection by Outside Agencies (See Section 5.14)

1) The agency shall arrange for visual inspection to determine that welds meet the acceptance standards of Section 4.5.1.

User Note: Ultrasonic, X-ray, and magnetic particle testing are inappropriate for joists due to the configurations of the components and welds.

4.5.2 Strength

4.5.2.1 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.

4.5.2.2 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 a nominal tensile strength 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" shall be defined as the minimum required area such that the required stress will be less than the design (LRFD) stress.

User Note: For more information on welding, see Steel Joist Institute Technical Digest 8 - Welding of Open Web Steel Joists and Joist Girders.

4.5.3 Field Splices

Field Splices shall be designed by the manufacturer and shall be either bolted or welded. Splices shall be designed for the member force, but not less than 50 percent of the member strength.

4.5.4 Shear Studs

Shear studs, after installation, shall extend not less than 1½ in. (38 mm) above the top of the steel deck and there shall be at least ½ in. (13 mm) of concrete cover above the top of the installed studs.

For studs in 1.5 in. (38 mm), 2 in. (51 mm), or 3 in. (76 mm) deep decks with $d_{stud}/t_{top\,chord} \le 2.7$:

$$Q_n = \text{Min}\left[0.5A_{stud}\sqrt{f'_c E_c}\ ,\ R_p R_g A_{stud} F_{u\,stud}\right] \text{ (kips)} \quad (4.5\text{-}1a)$$

$$Q_n = \text{Min}\left[0.5A_{stud}\sqrt{f'_c E_c}\ ,\ \left(R_p R_g A_{stud} F_{u\,stud}/1000\right)\right] \text{ (kN)} \quad (4.5\text{-}1b)$$

For studs in 1.5 in. (38 mm), 2 in. (51 mm), or 3 in. (76 mm) deep decks with $2.7 < d_{stud}/t_{top\,chord} \le 3.0$:

$$Q_n = \text{Min}\left[0.5A_{stud}\sqrt{f'_c E_c}\ ,\ R_p R_g A_{stud} F_{u\,stud} - 1.5\left(\frac{d_{stud}}{t_{top\,chord}} - 2.7\right)\right] \text{(kips)} \quad (4.5\text{-}2a)$$

$$Q_n = \text{Min}\left[0.5A_{stud}\sqrt{f'_c E_c}\ ,\ \left(R_p R_g A_{stud} F_{u\,stud}/1000\right) - 6.67\left(\frac{d_{stud}}{t_{top\,chord}} - 2.7\right)\right] \text{(kN)} \quad (4.5\text{-}2b)$$

Where:

A_{stud} = cross-sectional area of shear stud, in.^{2} (mm^2)
d_{stud} = diameter of shear stud, in. (mm)
E_c = modulus of elasticity of the concrete, ksi (MPa)
f'_c = specified compressive strength of concrete, ksi (MPa)
$F_{u\,stud}$ = minimum tensile strength of stud, 65 ksi (450 MPa)
Q_n = shear capacity of a single shear stud, kips (kN)
R_p = shear stud coefficient from Table 4.5-1
R_g = 1.00 for one stud per rib or staggered position studs
= 0.85 for two studs per rib side-by-side
= 0.70 for three studs per rib side-by-side
$t_{top\,chord}$ = thickness of top chord horizontal leg or flange, in. (mm)

TABLE 4.5-1
VALUES FOR R_p

Metal Deck Height	**$Wr_{@\ mid\text{-}height}$**	**Diameter Stud**			
		3/8 in. (10 mm)	**1/2 in. (13 mm)**	**5/8 in. (16 mm)**	**3/4 in. (19 mm)**
1 in. (25 mm)	1.9 in. (48 mm)	0.55	0.55	0.50	0.45
1.5 in. (38 mm)	2.1 in. (53 mm)	0.55	0.50	0.45	0.40
1.5 in. (38 mm) Inverted	3.9 in. (99 mm)	0.85	0.60	0.60	0.60
2 in. (51 mm)	6 in. (152 mm)	---	0.55	0.50	0.45
3 in. (76 mm)	6 in. (152 mm)	---	0.50	0.50	0.50

Notes: $Wr_{@\ mid\text{-}height}$ = Average metal deck rib width of deck rib containing the shear stud.
The deck is assumed to be oriented perpendicular to the joists.

4.5.5 Eccentricity

Members connected at a joint shall have their center of gravity lines meet at a point, where practical. Ends of **CJ-**Series joists shall be proportioned to resist bending produced by eccentricity at the support.

For a single component web member, the eccentricity shall be permitted to be neglected where it does not exceed the lesser of three-quarters of the overall dimension of the chord or 2 inches (51 mm). This eccentricity, measured in the plane of the joist, 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 in accordance with Figure 4.5-1.

For a web member composed of at least two shapes, the eccentricity on either side of the neutral axis of chord members, measured in the plane of the **CJ-**Series joist at the joint work point, shall be permitted to be neglected where the web intersection point does not exceed one and one-half times the distance between the neutral axis and the back of the chord in accordance with Figure 4.5-2.

If these limits are exceeded, provision shall be made for the stresses due to eccentricity.

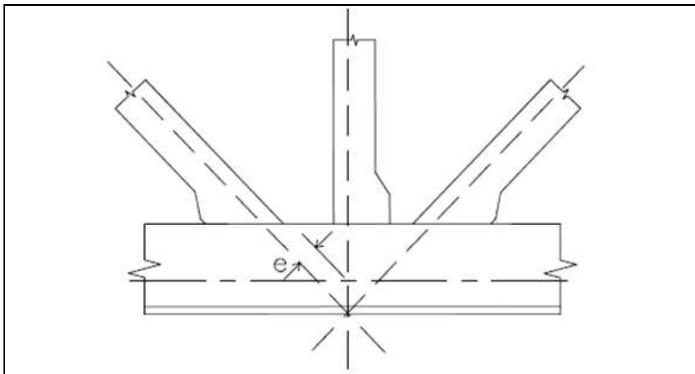


Figure 4.5-1

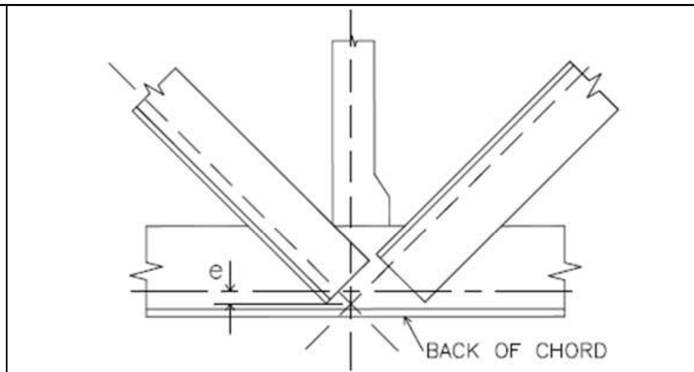


Figure 4.5-2

4.6 CAMBER

CJ-Series joists shall be cambered. The approximate camber shall be based on the deflection associated with 100 percent of the non-composite unfactored dead load plus any additional loads defined by the specifying professional.

> **User Note**: The specifying professional shall give consideration to coordinating this approximate camber with adjacent framing.

4.7 VERIFICATION OF DESIGN AND MANUFACTURE

> **User Note:** This Section is included as part of this Specification since the verification of design and manufacture is a requirement of any Steel Joist Institute member company in order to be in compliance with this Specification. This Section applies only to a Steel Joist Institute member manufacturer.

4.7.1 Design Calculations

Companies manufacturing any **CJ-**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 this Specification. Design data shall be submitted in detail and in the format specified by the Steel Joist Institute.

4.7.2 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 Section 4.1 through Section 4.5, provides the theoretical strength of critical members. Such tests shall be evaluated considering the actual yield strength of the members of the test **CJ-**Series joists.

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

4.7.3 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 **CJ-**Series joists that connections will meet the provision of Section 4.5.2. Chord and web members shall be permitted to be reinforced for such tests.

4.7.4 In-Plant Inspections

Each manufacturer shall verify their ability to manufacture **CJ-**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 shall not represent a guarantee of the quality of any specific **CJ-**Series joists; this responsibility shall lie fully and solely with the individual manufacturer.

SECTION 5.
APPLICATION

5.1 USAGE

5.1.1 Scope: This Specification shall apply to any type of structure where floors or roofs are to be supported directly by **CJ-**Series joists installed as hereinafter specified. Where **CJ-**Series joists are used other than on simple spans under uniformly distributed loading for **CJ-**Series joists, as prescribed in Section 4.1, they shall be designed to limit the required stresses to those listed in Section 4.2. The magnitude and location of all loads and forces to be considered in the **CJ-**Series joist design shall be provided on the structural drawings.

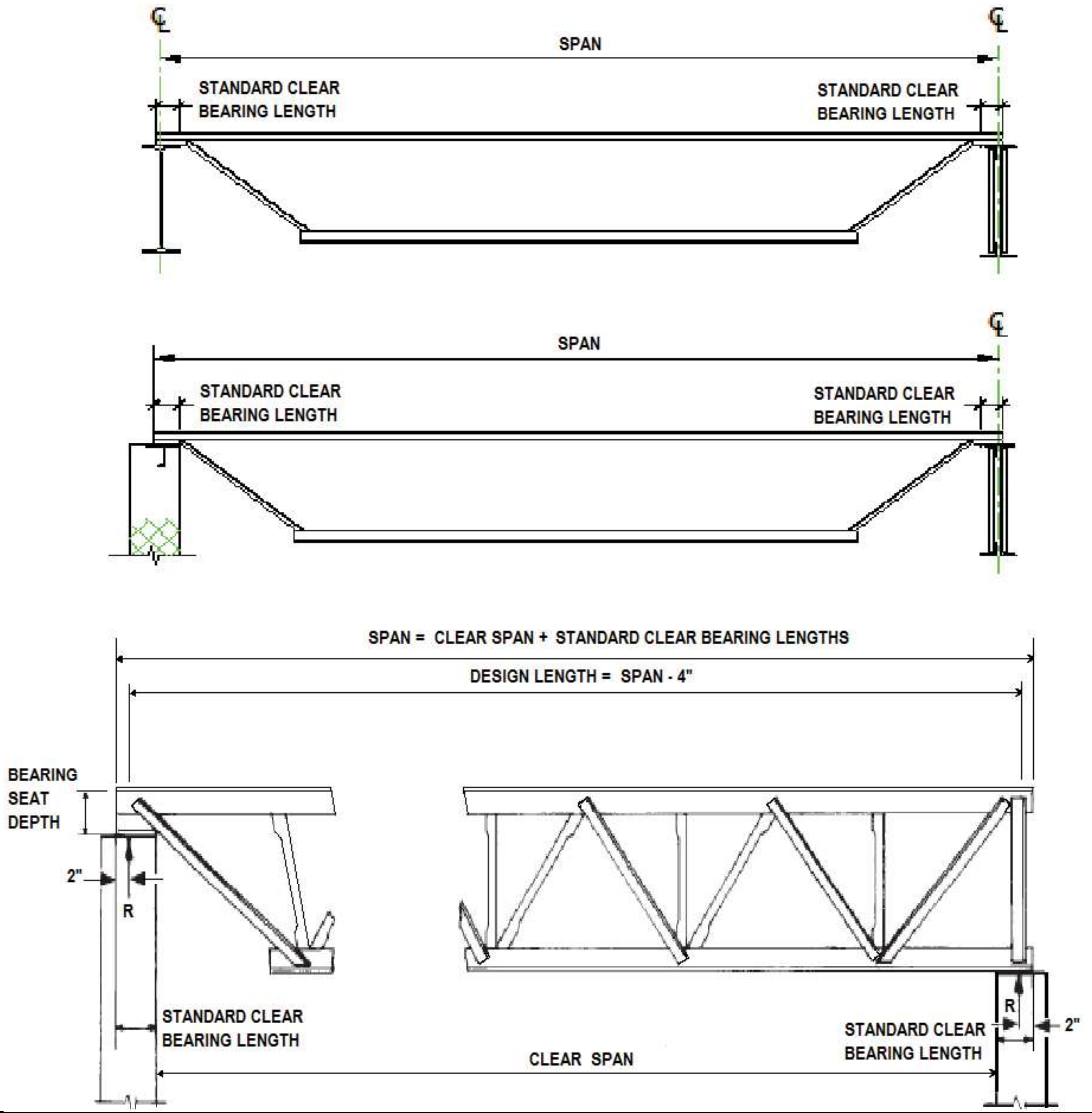
5.1.2 Continuous Frame Action: Where a rigid connection of the bottom chord is to be made to a column or other structural support, the **CJ-**Series steel joist is then no longer simply-supported, and the system shall be investigated for continuous frame action by the specifying professional. The specifying 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.

> **User Note**: For further reference concerning continuous frame action and their connections, refer to Steel Joist Institute Technical Digest No. 11, "Design of Lateral Load Resisting Frames Using Steel Joists and Joist Girders".

5.2 SPAN

The span of a **CJ-**Series joist shall not be less than 12 times nor exceed 30 times the depth. Design length shall equal the span minus 4 inches (102 mm) as shown in Figure 5.2-1 "Definition of Span".



NOTES:

1) DESIGN LENGTH = SPAN – 4"

2) MINIMUM BEARING LENGTHS SHALL MEET THE REQUIREMENTS OF SECTION 5.4; BEARING LENGTHS SHOWN MAY VARY BETWEEN STANDARD CLEAR BEARING AND MINIMUM BEARING LENGTH.

3) PARALLEL CHORD CJ-SERIES JOISTS INSTALLED TO A SLOPE GREATER THAN ½ INCH PER FOOT SHALL USE A SPAN DEFINED BY THE LENGTH ALONG THE SLOPE.

Figure 5.2-1 Definition of Span (U.S. Customary Units)

5.3 DEPTH

CJ-Series joists shall have parallel chords. The composite joist designation depth or nominal depth shall be the vertical distance from the top of the steel top chord to the bottom of the bottom chord.

5.4 END SUPPORTS

Consideration of the reactions, vertical and lateral, shall be taken by the specifying professional in the design of the steel support, or the steel bearing plate on masonry or concrete. The standard location of the end reaction shall be 2 inches (51 mm) from the end of the span (exclusive of extensions) at each end of the **CJ-**Series joist as shown in Figure 5.2-1 "Definition of Span".

The standard **CJ-**Series joist bearing seat depth, clear bearing length, minimum bearing plate width and minimum bearing length on steel is provided in Table 5.4-1.

TABLE 5.4-1

GENERAL DESCRIPTION OF CJ-SERIES JOIST TOP CHORD	STANDARD BEARING SEAT DEPTH	STANDARD CLEAR BEARING LENGTH	MINIMUM BEARING PLATE WIDTH	MINIMUM BEARING LENGTH ON STEEL
Where round web end bars are used and the top chord vertical angle leg is less than or equal to 2"	2½" (64 mm)	4" (102 mm)	6" (178 mm)	2½" (64 mm)
Where the top chord vertical angle leg is greater than 2", but less than $3^1/_2$"	5" (127 mm)	6" (152 mm)	9" (229 mm)	4" (102 mm)
Where the top chord vertical angle leg is greater than or equal to $3^1/_2$"	7½" (191 mm)	6" (152 mm)	14" (356 mm)	6" (152 mm)

If the specifying professional requires the end reaction to be located at a distance from the face of support more than the standard clear bearing length values shown in Table 5.4-1 minus 2 in. (51 mm), the structural drawings shall indicate the required special location of the end reaction. The **CJ-**Series joist seat depth shall be increased proportionately.

5.4.1 Masonry and Concrete

5.4.1.1 Scope: **CJ-**Series joists supported by masonry or concrete shall bear on steel bearing plates and shall be designed as steel bearing. 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 bearing plate and the masonry or concrete.

The ends of **CJ-**Series joists shall extend over the masonry or concrete support as shown in Figure 5.2-1 and be anchored to a steel bearing plate.

The steel bearing plate shall be located not more than ½ inch (13 mm) from the face of the wall. If the steel bearing plate is located more than ½ inch (13 mm) from the face of the wall, or the minimum bearing over the masonry or concrete support cannot be provided as given in Table 5.4-1, special consideration shall be given to the design of the steel bearing plate and the masonry or concrete by the specifying professional.

The steel bearing plate is to be designed by the specifying professional and shall be furnished by other than the joist manufacturer.

5.4.1.2 Anchorage: **CJ-**Series joists shall be anchored to the steel bearing plate per Section 5.7.

5.4.1.3 Composite Joist Bearing Seat

For 2½” ≤ Seat Depth < 5”:

a) The ends of **CJ-**Series joists shall extend a distance of not less than 4 inches (102 mm) over the masonry or concrete support and be anchored to the steel bearing plate.
b) The width of the plate perpendicular to the span of the **CJ-**Series joist shall be not less than 6 inches (152 mm).
c) The **CJ-**Series joist shall bear a minimum of 2½ inches (64 mm) on the steel bearing plate.

For 5” ≤ Seat Depth < 7½”:

a) The ends of **CJ-**Series joists shall extend a distance of not less than 6 inches (152 mm) over the masonry or concrete support and be anchored to the steel bearing plate.
b) The width of the plate perpendicular to the span of the **CJ-**Series joist shall be not less than 9 inches (229 mm).
c) The **CJ-**Series joist shall bear a minimum of 4 inches (102 mm) on the steel bearing plate.

For Seat Depth ≥ 7½”:

a) The ends of **CJ-**Series joists shall extend a distance of not less than 6 inches (152 mm) over the masonry or concrete support and be anchored to the steel bearing plate.
b) The width of the plate perpendicular to the span of the **CJ-**Series joist shall be not less than 14 inches (356 mm).
c) The **CJ-**Series joist shall bear a minimum of 6 inches (152 mm) on the steel bearing plate.

5.4.2 Steel

5.4.2.1 Scope: **CJ-**Series joists supported directly by steel supporting members shall be designed as steel bearing.

> **User Note:** 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.

5.4.2.2 Anchorage: **CJ-**Series joists shall be anchored to steel supporting members per Section 5.7.

5.4.2.3 CJ-Series Joist Bearing Seat

For 2½" ≤ Seat Depth < 5": The ends of **CJ-**Series joists shall extend a distance of not less than 2½ inches (64 mm) over the steel supports.

For 5" ≤ Seat Depth < 7½": The ends of **CJ-**Series joists shall extend a distance of not less than 4 inches (102 mm) over the steel supports.

For Seat Depth ≥ 7½": The ends of **CJ-**Series joists shall extend a distance of not less than 6 inches (152 mm) over the steel supports.

Where deemed necessary to butt opposite joists over a narrow steel support with bearing less than that noted above, special ends shall be specified, and such ends shall have positive attachment to the support, either by bolting or welding.

5.5 BRIDGING OR BRACING

CJ-Series joist top and bottom chord bridging shall be required and shall consist of one or both of either horizontal or diagonal bridging.

> **User Note:** See Section 5.12 for bridging or bracing required for uplift forces.

5.5.1 Horizontal Bridging

Horizontal bridging lines shall consist of continuous horizontal steel members. The ℓ/r ratio 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.

5.5.2 Diagonal Bridging

Diagonal bridging lines shall consist of cross-bracing with an ℓ/r ratio of not more than 200, where ℓ is the distance in inches (mm) 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 (mm) between connections at the point of intersection of the bridging members and the connections to the chords of the **CJ-**Series steel joists.

5.5.2.1 Diagonal Erection Bridging

> **User Note**: **CJ-**Series joists exhibit varying degrees of stability dependent upon the span, depth, member sizes, self-weight and other parameters. Bolted diagonal Erection Bridging which must be installed prior to releasing hoisting cables may be required.

Where required, bolted diagonal Erection Bridging shall be provided in accordance with the following:

a) For **CJ-**Series joist spans up through and including 60 feet (18.3 m) in length, welded horizontal bridging shall be permitted to be used except where the row of bridging nearest the center is required to be bolted diagonal Erection Bridging as indicated on the joist manufacturer's joist placement plans.

The stability of the **CJ-**Series joist and the need for Erection Bridging shall be determined using Equation 5.5-1.

Erection Bridging is required if,

$$\frac{w_u}{w_{actual}} \leq 1.00 \tag{5.5-1}$$

Where:

w_{actual} = **CJ-**Series joist self-weight, plf (kN/m)

w_u = ultimate lateral buckling load, $w_u = \frac{W \cdot 12}{L}$ plf $w_u = \frac{W}{L}$ (kN/m)

$$W = \frac{-b + \sqrt{b^2 - 4 \cdot a \cdot c}}{2 \cdot a}$$

$$a = \left(\frac{\pi^2 + 3}{24}\right)^2$$

$$b = P \cdot \frac{\pi^2 + 3}{12} \cdot \frac{\pi^2 + 4}{16} - \frac{\pi^4 \cdot E \cdot I_y}{2 \cdot (k \cdot L)^3} \cdot \left[\beta_x \cdot \left(\frac{\pi^2 - 3}{24}\right) - \frac{y_o}{2}\right]$$

$$c = (P)^2 \left(\frac{\pi^2 + 4}{16}\right)^2 - \frac{\pi^4 \cdot E \cdot I_y}{2 \cdot (k \cdot L)^3} \cdot \left[P \cdot \left(\beta_x \cdot \frac{\pi^2 - 4}{16} - a_e\right) + \frac{\pi^4 \cdot E \cdot C_w}{2 \cdot (k \cdot L)^3} + \frac{\pi^2 \cdot G \cdot J}{2 \cdot k \cdot L}\right]$$

A_b = area of non-composite joist bottom chord, in.^{2} (mm^2)

A_t = area of non-composite joist top chord, in.^{2} (mm^2)

C_w = warping constant $C_w = \frac{d_e^{\,2} \cdot I_{yb} \cdot I_{yt}}{I_y}$

E = modulus of elasticity = 29,000,000 psi (200,000 MPa)

G = shear modulus, psi (MPa) $G = 0.385E$

I_x = non-composite joist moment of inertia about x-axis, in.^{4} (mm^4) $I_x = A_t y^2 + A_b (d_e - y)^2$

I_y = joist moment of inertia about y-axis, in.^{4} (mm^4) $I_y = I_{yt} + I_{yb}$

I_{yb} = bottom chord moment of inertia about y-axis, in.^{4} (mm^4)

I_{yt} = top chord moment of inertia about y-axis, in.^{4} (mm^4)

J = St. Venant torsion constant, in.^{4} (mm^4) $J = \frac{1}{3}\left(A_t \cdot t_t^{\,2} + A_b \cdot t_b^{\,2}\right)$

L = joist span, in. (mm)

P = factored weight of erector = 1.2 x (assumed weight of 250 lbs.) = 300 lbs (1334 N)

a_e = vertical location of load P from shear center (locate at non-composite joist center of gravity), in. (mm), where $a_e = y_o$

β_x = cross-sectional parameter $\beta_x = \frac{1}{I_x}\left[A_b \cdot \left(d_e - y\right)^3 - A_t \cdot y^3\right] - 2 \cdot y_o$

d_e = non-composite joist effective depth, in.(mm) $d_e = d - y_t - y_b$

k = effective length factor = 0.85

t_b = thickness of bottom chord, in. (mm)

t_t = thickness of top chord, in. (mm)

y = distance from centroid of top chord to centroid of cross section, in. (mm) $y = \frac{A_b \cdot d_e}{A_t + A_b}$

y_o = distance from centroid of cross section to shear center, in. (mm) $y_o = -y + \frac{I_{yb} \cdot d_e}{I_y}$

y_t = neutral axis of non-composite joist top chord, in. (mm)

y_b = neutral axis of non-composite joist bottom chord, in. (mm)

b) For joist spans over 60 feet (18.3 meters) all rows of bridging shall be diagonal bridging with bolted connections at the chords and intersections as indicated on the joist manufacturer's joist placement plans. Where the **CJ-**Series joist spacing is less than 0.70 x joist depth, bolted horizontal bridging shall be used in addition to bolted diagonal Erection Bridging.

c) The bolted diagonal Erection Bridging determined by Section 5.5.2 shall be considered a minimum. This bolted diagonal Erection Bridging shall be indicated on the joist manufacturer's joist placement plans.

5.5.3 Quantity and Spacing of Bridging

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

$$\ell_{brmax} = \left(100 + 0.67\, d_j + 40 \frac{d_j}{L}\right) r_y \text{, in.} \quad (5.5\text{-}2a)$$

$$\ell_{brmax} = \left(100 + 0.026\, d_j + 0.48 \frac{d_j}{L}\right) r_y \text{, mm} \quad (5.5\text{-}2b)$$

or,

$$\ell_{brmax} = 170\ r_y \quad (5.5\text{-}3)$$

Where:

d_j = **CJ-**Series joist depth, in. (mm)

L = **CJ-**Series joist span length, ft. (m)

r_y = radius of gyration of the top chord about the vertical axis of the joist cross section, in. (mm)

5.5.3.2 Number of Rows: The number of rows of bottom chord bridging, including bridging required per Section 5.12, shall not be less than the number of top chord rows. Rows of bottom chord bridging shall be 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.

5.5.4 Sizing of Bridging

Horizontal and diagonal bridging shall be capable of resisting the nominal unfactored horizontal compressive force, P_{br} given in Equation 5.5-4.

$$P_{br} = 0.0025\, n\, A_t\, F_{construction}\text{, kips (N)} \quad (5.5\text{-}4)$$

Where:

n = 8 for horizontal bridging

n = 2 for diagonal bridging

A_t = cross-sectional area of joist top chord, in.^{2} (mm^2)

$F_{construction}$ = assumed ultimate stress in top chord to resist construction loads, determined in accordance with the following:

$$F_{construction} = \frac{\pi^2 E}{\left(\frac{0.9\,\ell_{brmax}}{r_y}\right)^2} \geq 12.2\text{ ksi} \quad (5.5\text{-}5a)$$

$$F_{construction} = \frac{\pi^2 E}{\left(\frac{0.9\,\ell_{brmax}}{r_y}\right)^2} \geq 84.1\text{ MPa} \quad (5.5\text{-}5b)$$

Where:

E = modulus of elasticity = 29,000 ksi (200,000 MPa)

and $\frac{\ell_{brmax}}{r_y}$ is determined from Equations 5.5-2 or 5.5-3

5.5.5 Connections

Connections to the **CJ-**Series joist chords shall be made by welding or mechanical means and shall be capable of resisting the unfactored or nominal horizontal force, P_{br}, of Equation 5.5-4 but not less than 700 pounds (3114 N).

5.5.6 Bottom Chord Bearing CJ-Series Joists

Where bottom chord bearing **CJ-**Series 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.

5.6 INSTALLATION OF BRIDGING

Bridging shall be provided to support the top chord of **CJ-**Series joists during installation of the metal decking prior to the attachment of the deck to the top chord. All bridging and bridging anchors shall be completely installed before construction loads are placed on the **CJ-**Series joists. Bridging shall support the top and bottom chords against lateral movement during the construction period and shall hold the **CJ-**Series 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.

5.7 BEARING SEAT ATTACHMENTS

5.7.1 Masonry and Concrete

Ends of **CJ-**Series steel joists resting on steel bearing plates on masonry or structural concrete shall be attached as defined by the following criteria:

For 2½" ≤ Seat Depth < 5": With a minimum of two 1/8 inch (3 mm) fillet welds 2 inches (51 mm) long, or with two ½ inch (13 mm) ASTM A307 bolts, or with the equivalent.

For Seat Depth ≥ 5": With a minimum of two ¼ inch (6 mm) fillet welds 2 inches (51 mm) long, or with two 3/4 inch (19 mm) ASTM A307 bolts or the equivalent.

5.7.2 Steel

Ends of **CJ-**Series joists resting on steel supports shall be attached as defined by the following criteria:

For 2½" ≤ Seat Depth < 5": With a minimum of two 1/8 inch (3 mm) fillet welds 2 inches (51 mm) long, or with two ½ inch (13 mm) ASTM A307 bolts, or with the equivalent.

For Seat Depth ≥ 5": With a minimum of two ¼ inch (6 mm) fillet welds 2 inches (51 mm) long, or with two 3/4 inch (19 mm) ASTM A307 bolts, or with the equivalent.

When **CJ**-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.

5.7.3 Uplift

Where uplift forces are a design consideration, **CJ-**Series joists used in roof applications shall be anchored to resist such forces and shall meet the requirements of Section 5.12.

5.8 JOIST SPACING

CJ-Series joists shall be spaced so that the loading on each joist does not exceed the design load (LRFD).

5.9 DECKS

5.9.1 Material

Floor deck shall consist of steel deck or other suitable material capable of supporting the required load at the specified **CJ-**Series joist spacing.

5.9.2 Thickness

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

5.9.3 Centering

Centering for cast-in-place slabs shall be permitted to be a suitable material capable of supporting the slab at the designated **CJ-**Series joist spacing.

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

5.9.4 Bearing

Slabs or decks shall bear uniformly along the top chords of the **CJ-**Series joists.

5.9.5 Attachments

The decking shall be attached per Steel Deck Institute requirements prior to placing construction loads on the **CJ-**Series joists. The spacing of attachments along the **CJ-**Series joist top chord shall not exceed 36 inches (914 mm).

5.10 DEFLECTION

The deflection due to the design 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, or 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 **CJ-**Series steel joists.

> **User Note**: For further information on vibration, refer to Steel Joist Institute Technical Digest 5, “Vibration of Steel Joist-Concrete Slab Floors".

5.11 PONDING

The ponding investigation shall be performed by the specifying professional.

> **User Note**: For further reference, refer to Steel Joist Institute Technical Digest 3, “Structural Design of Steel Joist Roofs to Resist Ponding Loads” and AISC 360.

5.12 UPLIFT

Where uplift forces due to wind are a design requirement, these forces shall be indicated on the structural drawings in terms of net uplift in pounds per square foot (Pascals). When these forces are specified, they shall be considered in the design of **CJ-**Series steel joists, and required bridging or bracing. A single line of bottom chord bridging shall be provided near the first bottom chord panel points wherever uplift due to wind forces is a design consideration.

> **User Note**: For further reference, refer to Steel Joist Institute Technical Digest 6, “Structural Design of Steel Joist Roofs to Resist Uplift Loads”.

5.13 DIAPHRAGMS AND COLLECTORS

Where diaphragm collector forces due to wind or seismic forces are a design requirement, these nominal (unfactored) forces shall be indicated on the structural drawings. The structural drawings shall also indicate the Seismic Design Category, and the Seismic Force Resisting System type, and applicable seismic design coefficients. When this data is specified, joist collectors or chords in horizontal diaphragm systems, shall be designed in conformance with the provisions of Section 4 through Section 6. End connections and splices in **CJ-**Series steel joists incorporated into Seismic Force Resisting System (SFRS) as horizontal diaphragms as collectors or chords shall adhere to the requirements stipulated by the applicable building code.

5.14 INSPECTION

CJ-Series joists shall be inspected by the manufacturer before shipment to verify compliance of materials and workmanship with the requirements of this Specification.

> **User Note:** If the purchaser requires an inspection of the **CJ-**Series joists by someone other than the manufacturer's own inspectors, they shall be permitted to reserve the right to do so in their "Invitation to Bid" or the accompanying "Job Specifications". Arrangements shall be made with the manufacturer for such inspection of the **CJ-**Series joists at the manufacturing facility by the purchaser's inspectors at purchaser's expense.

SECTION 6
ERECTION STABILITY AND HANDLING

As a minimum, erection stability and handling of **CJ-**Series steel joists shall meet the requirements of this Section 6.

> **User Note**: Additional requirements for erection of **CJ-**Series steel joists can be found in Steel Joist Institute Technical Digest 9, "Handling and Erection of Steel Joists and Joist Girders".

6.1 STABILITY REQUIREMENTS

> **User Note**: It is not recommended that an erector climb on unbridged joists, extreme caution shall be exercised since unbridged joists exhibit some degree of instability under the erector's weight.

a) In steel framing, where **CJ-** Series joists are utilized at column lines, the **CJ-**Series joists shall be field-bolted at the column. Before hoisting cables are released and before an employee is allowed on the **CJ-**Series joists the following conditions shall be met:

1) The seat at each end of the **CJ-**Series joists is attached in accordance with Section 5.7. Where a bolted seat connection is used for erection purposes, as a minimum, the bolts shall be snug tightened. The snug tight condition shall be defined as the tightness that exists where 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) Where stabilizer plates are required the **CJ-**Series joists bottom chord shall engage the stabilizer plate.

During the construction period, the contractor shall provide means for the adequate distribution of loads so that the carrying capacity of any **CJ-**Series joist is not exceeded.

b) Before an employee is allowed on the **CJ-**Series joist both ends of **CJ-**Series joist at columns shall be attached to its supports. For all other **CJ-**Series joists a minimum of one end shall be attached before the employee is allowed on the **CJ-**Series joist. The attachment shall be in accordance with Section 5.7.

Where a bolted seat connection is used for erection purposes, as a minimum, the bolts shall be snug tightened. The snug tight condition shall be defined as the tightness that exists where 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.

c) On **CJ-**Series joists that do not require Erection Bridging as determined by Section 5.5.2.1 or as shown on the joist placement plans, only one employee shall be allowed on the **CJ-**Series joist until all bridging is installed and anchored.

d) Where the span of the **CJ-**Series joist is such that one row of Erection Bridging nearest the midspan is required in accordance with Section 5.5.2.1 or as indicated on the joist placement plans, the following shall apply:

1) Hoisting cables shall not be released until this bolted diagonal Erection Bridging row is installed and anchored, unless an alternate method of stabilizing the joist has been provided; and
2) No more than one employee shall be allowed on these spans until all other bridging is installed and anchored.

e) Where the span of the **CJ-**Series steel joist exceeds 60'-0" (18228 mm and is less than or equal to 100'-0" (30175 mm), the following shall apply:

1) All rows of bridging shall be bolted diagonal bridging; and
2) Hoisting cables shall not be released until the two rows of bolted diagonal Erection Bridging nearest the third points of the **CJ-**Series joist are installed and anchored; and
3) No more than two employees shall be allowed on these spans until all other bridging is installed and anchored.

f) Where the span of the **CJ-**Series joist exceeds 100'-0" (30175 mm), the following shall apply:

1) All rows of bridging shall be bolted diagonal bridging; and
2) Hoisting cables shall not be released until all rows of bolted diagonal Erection Bridging is installed and anchored; and
3) No more than two employees shall be allowed on these spans until all other bridging is installed and anchored.

g) Where permanent bridging terminus points cannot be used during erection, additional temporary bridging terminus points shall be required to provide lateral stability.

h) In the case of bottom chord bearing **CJ-**Series joists, the ends of the **CJ-**Series joist shall be restrained laterally per Section 5.5.6 before releasing the hoisting cables.

i) After the **CJ-**Series joist is straightened and plumbed, and all bridging is completely installed and anchored, the ends of the **CJ-**Series joists shall be fully connected to the supports in accordance with Section 5.7.

6.2 LANDING AND PLACING LOADS

a) Except as stated in Section 6.2(d), no "construction loads" shall be allowed on the **CJ-**Series joists until all bridging is installed and anchored, and all joist bearing ends are attached.

User Note: For the definition of "construction load" see Code of Federal Regulations (CFR), Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Safety Standards for Steel Erection; Subpart R – Steel Erection, §1926.751 Definitions; January 18, 2001, Washington, D.C.

b) During the construction period, loads placed on the **CJ-**Series joists shall be distributed so as not to exceed the capacity of the **CJ-**Series joists.

c) The weight of a bundle of **CJ-**Series steel bridging shall not exceed a total of 1000 pounds (454 kilograms). The bundle of joist bridging shall be placed on a minimum of three **CJ-**Series 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.

d) No bundle of metal deck shall be placed on **CJ-**Series joists until all bridging has been installed and anchored and all joist bearing ends attached, unless the following conditions are met:

1) 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;
2) The bundle of metal decking is placed on a minimum of three **CJ-**Series joists;
3) The **CJ-**Series joists supporting the bundle of metal decking are attached at both ends;
4) At least one row of bridging is installed and anchored;
5) The total weight of the metal decking does not exceed 4000 pounds (1816 kilograms); and
6) The edge of the bundle of metal decking is placed within 1 foot (0.30 meters) of the bearing surface of the **CJ-**Series joist end.

User Note: For the definition of "qualified person" see Code of Federal Regulations (CFR), Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Safety Standards for Steel Erection; Subpart R – Steel Erection, §1926.751 Definitions; January 18, 2001, Washington, D.C.

f) The edge of the construction load shall be placed within 1 foot (0.30 meters) of the bearing surface of the **CJ-**Series joist end.

6.3 FIELD WELDING

All field welding shall be performed in accordance with the structural drawings. Field welding shall not damage the **CJ-**Series joists.

On cold-formed steel 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.

6.4 HANDLING

Particular attention shall be considered for the handling and erection of **CJ-**Series joists. Damage to the **CJ-**Series joists and accessories shall be avoided. Hoisting cables shall be attached at panel point locations and those locations shall be selected to minimize erection stresses.

Each **CJ-**Series steel joist shall be adequately braced laterally before any loads are applied. If lateral support is provided by bridging, the bridging lines as defined in Section 6.1(c), 6.1(d), 6.1(e), and 6.1(f) shall be anchored to prevent lateral movement.

6.5 FALL ARREST SYSTEMS

CJ-Series 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".

User Note: For the definition of "qualified person" see Code of Federal Regulations (CFR), Occupational Safety and Health Administration (OSHA), 29 CFR Part 1926, Safety Standards for Steel Erection; Subpart R – Steel Erection, §1926.751 Definitions; January 18, 2001, Washington, D.C.

SECTION 7
SHEAR CONNECTOR PLACEMENT AND WELDING

a) Shear connectors required on each side of the point of maximum positive or negative bending moment, shall be distributed uniformly between that point and the adjacent points of zero moment, unless otherwise specified. However, the number of shear connectors placed between any concentrated load and the nearest point of zero moment shall be sufficient to develop the maximum moment required at the concentrated load point.

b) Studs shall be alternately placed on each chord angle section for double angle top chords. When constructability does not allow this to occur, stud placement shall be limited as follows:

    1) No more than three studs shall be placed consecutively on any one chord angle, and
    2) No more than 60 percent of the total number of studs shall be placed on any one chord angle.

    Studs shall have a minimum of ½ inch (13 mm) concrete cover over the head of each stud (see Section 4.5.4).

c) The minimum center-to-center spacing of stud connectors shall be six stud diameters along the longitudinal axis of the supporting **CJ-**Series joist, except that within the ribs of formed metal decks oriented perpendicular to the **CJ-**Series joists, the minimum center-to-center spacing shall be four stud diameters in any direction.

d) The distance measured along the longitudinal axis of the **CJ-**Series joist from the free edge of the concrete slab to the first stud shall not be less than the deck height plus four stud diameters.

e) The spacing of stud shear connectors along the length of the supporting **CJ-**Series joist shall not exceed eight times the slab depth or 36 inches (914 mm).

f) To resist uplift, the metal deck shall be anchored to all supporting members at a spacing not to exceed 18 inches (460 mm). Such anchorage shall be provided by stud connectors, a combination of stud connectors and arc spot (puddle) welds, or other devices.

SECTION 8
SPECIAL CASES

When a method of shear transfer is used other than headed shear studs for developing composite joist behavior, the strength of shear connectors and details of composite construction shall be established by a test program that has been submitted to and accepted by the SJI.

NOTES

RESPONSIBILITY OF THE SPECIFYING PROFESSIONAL

SJI member companies have developed computer programs to provide composite steel joist designs quickly and efficiently. To do this, some basic information must be provided to the manufacturer. The following list summarizes the needed information from the Specifying Professional:

1) **Joist Depth**
   The joist depth must be provided in inches (mm). This depth includes the steel joist portion only, not the deck slab.

2) **Joist Span**
   The joist span must be given in feet (mm). The span is from the centerline of the supporting joist girder (structural steel) to the centerline of the opposite supporting joist girder (structural steel). In the case of masonry and/or concrete walls, span is measured from the inside face of walls plus 8 inches (203 mm). For more information on span see the Standard Specifications for Composite Steel Joists, CJ-Series, Figure 5.2-1.

3) **Adjacent Member Spacing**
   The distance in feet (mm) to the adjacent member or to the edge of the slab (if an exterior joist) must be provided.

4) **Type of Floor Deck**
   Review each deck manufacturer's deck load capacity and deflection characteristics and specify the deck depth, profile, and thickness to meet the building design.

5) **Concrete Unit Weight**
   The unit weight in pcf (kg/m^3) must be indicated.

6) **Concrete Compressive Strength**
   The 28 day specified compressive strength of concrete in ksi (MPa) must be provided.

7) **Slab Thickness above Floor Deck**
   The actual slab thickness in inches (mm) above the top of the deck must be indicated.

8) **Composite Design Loads**
   The loads which must be specified are as follows:
   a) Noncomposite DL:
      Concrete, joists, deck, bridging, and any other non-composite dead loads.
   b) Construction LL:
      A suggested minimum construction live load calculation can be found in the COSP for Composite Steel Joists, SJI Composite Joist Floor Design Parameters Checklist.
   c) Composite DL:
      Partitions, mechanical, electrical, fireproofing, floor covering, ceilings, and other composite dead loads.
   d) Composite LL:
      Reduced design live loads may be specified if applicable.

   Note: The Specifying Professional shall provide the nominal loads and load combinations as stipulated by the applicable code under which the structure is designed.

9) **Camber**
   The load to be used to calculate the camber must be specified.

The "Composite Joist Floor Design Parameters Checklist" that can be found in the **Code of Standard Practice for Composite Steel Joists**, includes a form for filling in the above information.

Composite steel joists have some limitations that the Specifying Professional must be aware of. These include:
   a) Parallel top and bottom chords.
   b) The minimum and maximum deck heights are 1 inch (25 mm) and 3 inches (76 mm), respectively.
   c) The minimum slab thickness above the top of the deck must be 2 inches (51 mm).
   d) Shear studs must have at least 1/2 inch (13 mm) of concrete cover.
   e) The concrete shall be placed to provide a constant thickness along the entire span.

Provisions for field inspection of projects involving composite steel joists shall be made by the Specifying Professional. This inspection shall include, as a minimum, verifying the concrete strength, concrete thickness, and shear stud attachment and placement. For more information on shear stud placement and welding see the Standard Specifications for Composite Steel Joists, CJ-Series, Section 106.

This inspection will not be provided by SJI member manufacturers.

NON-COMPOSITE AND COMPOSITE EFFECTIVE MOMENTS OF INERTIA

$$I_{chords} = I_{tc} + I_{bc} + \frac{d_e^2 (A_{tc}\ A_{bc})}{(A_{tc} + A_{bc})}$$

Where,

A_{tc} = Area of the top chord (in.^{2})

A_{bc} = Area of the bottom chord (in.^{2})

I_{tc} = Moment of inertia of the top chord about the top chord x-x axis (in.^{4})

I_{bc} = Moment of inertia of the bottom chord about the bottom chord x-x axis (in.^{4})

d_e = Effective depth for the steel joist (in.)

Web Type	C_r	L / D
Single or Double Angle Web Members	$0.90\,(1 - e^{-0.28\,(L/D)})^{2.8}$	$6 \le L/D \le 24$
Continuous Round Rod Web Members	$0.721 + 0.00725\,(L/D)$	$10 \le L/D \le 24$

Where,

L = Span length (in.)

D = Nominal depth of steel joist (in.)

The non-composite moment of inertia of the joist can be determined as follows,

$$I_{non-comp\ eff} = C_r I_{chords}$$

and the composite effective moment of inertia of the joist can be determined as follows,

$$I_{eff} = \frac{1}{\dfrac{\gamma}{I_{chords}} + \dfrac{1}{I_{composite}}}$$

Where,

$$\gamma = \frac{1}{C_r} - 1$$

$I_{composite}$ = Transformed moment of inertia using the actual joist chord areas (in.^{4})

References:

Barry Band Jr. and Tom Murray, “Vibration Characteristics of Joist and Joist Girder Members”, Virginia Polytechnic Institute and State University, Report No. CE / VPI-ST 96 / 07, July 1996

AISC Steel Design Guide 11, “Floor Vibrations Due to Human Activity”, Tom Murray, David Allen, and Eric Ungar, 1997

CODE OF STANDARD PRACTICE

FOR CJ-SERIES COMPOSITE STEEL JOISTS

Adopted by the Steel Joist Institute May 10, 2006
Revised to May 18, 2010 - Effective December 31, 2010
Revised to November 9, 2015 – Effective August 1, 2016

SECTION 1.
GENERAL

1.1 SCOPE

The practices and customs set forth herein are in accordance with good engineering practice, tend to ensure safety in composite steel construction, and are standard within the industry. There shall be no conflict between this code and any legal building regulation. This code shall only supplement and amplify such laws. Unless specific provisions to the contrary are made in a contract for the purchase of composite steel joists, this code is understood to govern the interpretation of such a contract.

1.2 APPLICATION

This Code of Standard Practice is to govern as a standard unless otherwise covered in the *specifying professional's* plans and specifications.

1.3 DEFINITIONS

Add-Load. A single vertical concentrated load that occurs at any one panel point along the joist chord. This load is in addition to any other gravity loads specified.

Bend-Check Load. A vertical concentrated load used to design the joist chord for the additional bending stresses resulting from this load being applied at any location between the joist panel points. This load shall already be accounted for in the specified joist designation load, uniform load, or Add-load and is used only for the additional bending check in the chord and does not contribute to the overall axial forces within the joist. An ideal use of this is for incidental loads which have already been accounted for in the design loading but may induce additional bending stress due to this load occurring at any location along the chord.

Buyer. The entity that has agreed to purchase *material* from the manufacturer and has also agreed to the terms of sale.

Erector. The entity that is responsible for the safe and proper erection of the materials in accordance with all applicable codes and regulations.

Material. Composite steel joists and accessories as provided by the *seller*.

Owner. The entity that is identified as such in the contract documents.

Placement Plans. Drawings that are prepared depicting the interpretation of the contract document's requirements for the *material* to be supplied by the *seller*. These floor or roof plans are approved by the *specifying professional*, *buyer* or *owner* for conformance with the design requirements. The *seller* uses the information contained on these drawings for final *material* design. A unique piece mark number is typically shown for the individual placement of the composite steel joists and accessories along with sections that describe the end bearing conditions and minimum attachment required so that *material* is placed in the proper location in the field.

Seller. A company certified by the Steel Joist Institute engaged in the manufacture and distribution of composite steel joists and accessories.

Specifying Professional. The licensed professional who is responsible for sealing the building contract documents, indicating that he or she has performed or supervised the analysis, design and document preparation for the structure and has knowledge of the load-carrying structural system.

Structural Drawings. The graphic or pictorial portions of the contract documents showing the design, location and dimensions of the work. These documents generally include plans, elevations, sections, details, connections, all loads, schedules, diagrams and notes.

1.4 DESIGN

In the absence of ordinances or specifications to the contrary, all designs prepared by the *specifying professional* shall be in accordance with the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption.

1.5 RESPONSIBILITY FOR DESIGN AND ERECTION

When *material* requirements are specified, the *seller* shall assume no responsibility other than to furnish the items listed in Section 5.2(a). When *material* requirements are not specified, the *seller* shall furnish the items listed in Section 5.2(a) in accordance with Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption, and this code. Pertinent design information shall be provided to the *seller* as stipulated in Section 6.1. The *seller* shall identify *material* by showing size, type, and load. In no case shall the *seller* assume any responsibility for the erection of the items furnished.

1.6 PERFORMANCE TESTS FOR CJ-SERIES STEEL JOIST CONSTRUCTION

When a performance test on a composite steel joist is required, the following criteria shall be used:

a) The performance test load shall be the maximum factored uniformly distributed composite design load for the selected composite steel joist.

b) Composite steel joist self-weight and the weight of all test materials shall be included in the calculation of applied performance test loading as appropriate for the composite steel joist during testing.

c) Loading shall be uniformly distributed across the full length of the composite steel joist top chord, and the load application shall maintain uniform distribution throughout the test. At any stage during the application of the test loading, the test load shall not be distributed in such a manner as to result in any composite steel joist component being subjected to a larger proportion of force than intended by the composite joist design.

d) At a minimum, a panel test assembly shall be comprised of a pair of composite steel joists with bridging, top deck, steel headed stud anchors and concrete slab applied as used. The concrete shall be allowed adequate cure time as determined by the *specifying professional* (typically 28 days) prior to testing. The deck attachments and bridging shall be installed per the approved joist and deck *placement plans*. All bottom chord horizontal bridging rows shall be terminated by bracing back to the top chord of the adjacent composite steel joist or by a lateral restraint system which does not inhibit the vertical deflection of the panel test assembly.

e) The performance test loading shall be applied at a rate of no greater than 25 plf per minute and shall be sustained for no less than 15 minutes. After the maximum test load has been removed for a minimum of 10 minutes, the remaining vertical displacement at midspan shall not exceed 20% of the vertical midspan deflection sustained under the full performance test load.

f) All costs associated with such testing shall be borne by the purchaser.

g) Composite steel joists that have been designed and manufactured and have satisfied the above performance test criteria shall be considered to satisfy the intent of the Standard Specification for Composite Steel Joists, **CJ**-Series, and shall be considered acceptable for use in construction. No further proof of strength of individual composite steel joist components or connections is required.

SECTION 2.
COMPOSITE JOISTS AND ACCESSORIES

2.1 COMPOSITE STEEL JOISTS

Composite steel joists shall carry the loads and meet the requirements of the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption.

CJ-Series joists are furnished with parallel chords only, and with minimum standard end bearing depth of 2½ inches (64 mm). **CJ**-Series joists shall be permitted to be furnished with either underslung or square ends.

2.2 COMPOSITE STEEL JOIST LOCATION AND SPACING

The maximum composite steel joist spacing shall be in accordance with the requirements of Section 5.8, Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption.

Where side walls, wall beams or tie beams are capable of supporting the floor slab or roof deck, the first adjacent composite steel joists should be placed one full space from these members. **CJ**-Series joists are provided with camber. These composite steel joists may have a significant difference in elevation with respect to the adjacent structure because of this camber. This difference in elevation shall be given consideration when locating the first composite steel joist adjacent to a side wall, wall beam or tie beam.

Where partition walls are supported by parallel floor composite steel joists, there shall be at least one composite steel joist provided under each such partition, and more than one such composite steel joist shall be provided if necessary to safely support the weight of such partition and the adjacent floor. When partitions occur perpendicular to the composite steel joists, they shall be treated as concentrated loads on the supporting composite steel joists.

2.3 EXTENSIONS ON COMPOSITE STEEL JOISTS

Extensions on composite steel joists shall be specified and designed in accordance with the requirements of the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption.

The magnitude and location of the loads to be supported, deflection requirements, and proper bracing of composite steel joist Top Chord Extensions (S Type), Extended Ends (R Type) or full depth cantilever ends as defined in Steel Joist Institute Standard Specification for K-Series, LH-Series, and DLH-Series Open Web Steel Joists and for Joist Girders, SJI 100-2015 (or of latest adoption) shall be clearly indicated on the structural drawings.

Extended composite steel joist ends shall be stipulated to act non-compositely. In the absence of a load diagram, the extended top chord shall be designed for the uniformly distributed load.

2.4 CEILING EXTENSIONS

Ceiling extensions shall be furnished to support ceilings that are to be attached directly to the bottom of the composite steel joists. They are not furnished for the support of suspended ceilings. The ceiling extension shall be either an extended bottom chord element or a loose unit, whichever is standard with the manufacturer, and shall be of sufficient strength to properly support any specified ceiling loads.

2.5 BRIDGING AND BRIDGING ANCHORS

a) Bridging standard with the manufacturer and complying with the applicable Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption shall be used for bridging all joists furnished by the manufacturer. Positive anchorage shall be provided at the ends of each bridging row at both top and bottom chords.

b) For the **CJ**-Series joists, horizontal bridging is recommended for spans up to and including 60 feet (18.3 m) except where bolted diagonal bridging is required. Refer to Section 5.5 in the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption for erection stability requirements.

   CJ-Series joists, exceeding 60 feet (18.3 m) in length shall have bolted diagonal bridging for all rows.

   Refer to OSHA *Safety Standards for Steel Erection, 29 CFR 1926.757 – Open Web Steel Joists* for erection stability requirements.

   > **Note**: The requirements as per OSHA apply for composite steel joists since, during erection, a composite steel joist is like any SJI steel joist. Only after the concrete has cured, does the joist become composite.

   Horizontal bridging shall consist of continuous horizontal steel members. The ℓ/r ratio for horizontal bridging shall not exceed 300. Table 2.5-1 provides the maximum nominal (unfactored) horizontal bridging force, P_{br}, for various combinations of joist spacing and bridging angle size.

c) Diagonal cross bridging consisting of angles or other shapes connected to the top and bottom chords of **CJ**-Series joists shall be used when required by the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption.

   Diagonal bridging, when used, shall have an ℓ/r ratio not exceeding 200.

   When the bridging members are connected at their point of intersection, the material sizes listed in Table 2.5-2 and Table 2.5-3 meet the requirements of the composite steel joist specification.

   For **CJ**-Series joists, where the joist spacing is less than 70 percent of the joist depth, bolted horizontal bridging shall be provided in addition to the diagonal bridging, as shown in Table 2.5-3.

d) When bolted diagonal erection bridging is required, the following shall apply:

   1. The bridging shall be indicated on the joist placement plans.
   2. The joist placement plans shall be the exclusive indicator for the proper placement of this bridging.
   3. Shop installed bridging clips, or functional equivalents, shall be provided where the bridging bolts to the composite steel joist.
   4. When two pieces of bridging are attached to the composite steel joist by a common bolt, the nut that secures the first piece of bridging shall not be removed from the bolt for the attachment of the second piece.
   5. Bridging attachments shall not protrude above the top chord of the composite steel joist.

TABLE 2.5-1

MAXIMUM NOMINAL (UNFACTORED) BRIDGING FORCE (P_{br}) FOR HORIZONTAL BRIDGING (lbs)							
JOIST	BRIDGING ANGLE SIZE (EQUAL LEG ANGLE)						
SPACING (ft.-in.)	1 x 7/64 r = 0.20"	1¼ x 7/64 r = 0.25"	1½ x7/64 r = 0.30"	1¾ x 7/64 r = 0.35"	2 x 1/8 r = 0.40"	2½ x 5/32 r = 0.50"	3 x 3/16 r = 0.60"
2'-0"	2150	3960	5600				
2'-6"	1370	2730	4410	5910			
3'-0"	950	1890	3290	4850			
3'-6"	700	1390	2420	3840	6180		
4'-0"	530	1060	1850	2960	5030		
4'-6"	420	840	1460	2340	4000		
5'-0"	340	680	1180	1890	3240		
5'-6"	-	560	980	1560	2670		
6'-0"	-	470	820	1310	2250	5490	
6'-6"	-	-	700	1120	1910	4680	
7'-0"	-	-	600	960	1650	4030	
7'-6"	-	-	520	840	1440	3510	
8'-0"	-	-	-	740	1260	3090	
8'-6"	-	-	-	650	1120	2740	5680
9'-0"	-	-	-	-	1000	2440	5060
9'-6"	-	-	-	-	890	2190	4540
10'-0"	-	-	-	-	810	1970	4100
10'-6"	-	-	-	-	-	1790	3720
11'-0"	-	-	-	-	-	1630	3390
11'-6"	-	-	-	-	-	1490	3100
12'-0"	-	-	-	-	-	1370	2850

TABLE 2.5-2

CJ SERIES JOISTS
MAXIMUM JOIST SPACING FOR DIAGONAL BRIDGING

JOIST DEPTH	BRIDGING ANGLE SIZE – (EQUAL LEG ANGLE)							
	1 x 7/64 (25 x 3 mm) **r = 0.20"** (5.08 mm)	**1-1/4 x 7/64** (32 x 3 mm) **r = 0.25"** (6.35 mm)	**1-1/2 x 7/64** (38 x 3 mm) **r = 0.30"** (7.62 mm)	**1-3/4 x 7/64** (45 x 3 mm) **r = 0.35"** (8.89 mm)	**2 x 1/8** (50 x 3 mm) **r = 0.40"** (10.16 mm)	**2 ½ x 5/32** (64x 4 mm) **r=0.50"** (12.70 mm)	**3 x 3/16** (76 x 5 mm) **r = 0.60"** (15.24 mm)	**3 ½ x 1/4** (89 x 6 mm) **r = 0.70"** (17.78 mm)
in. (mm)	**ft.-in. (mm)**	**ft.-in. (mm)**	**ft.-in. (mm)**	**ft.-in. (mm)**	**ft.-in. (mm)**	**ft.-in. (mm)**	**ft.-in. (mm)**	**ft.-in. (mm)**
12" (305)	6'-7" (2007)	8'-3" (2514)	9'-11"(3022)	11'-7" (3530)	13'-3"(4038)	16'-7"(5055)	19'-11"(6070)	23'-3"(7086)
14" (356)	6'-6" (1981)	8'-3" (2514)	9'-11"(3022)	11'-7" (3530)	13'-3"(4038)	16'-7"(5055)	19'-11"(6070)	23'-3"(7086)
16" (406)	6'-6" (1981)	8'-2" (2489)	9'-10"(2997)	11'-7" (3530)	13'-3"(4038)	16'-7"(5055)	19'-11"(6070)	23'-3"(7086)
18" (457)	6'-6" (1981)	8'-2" (2489)	9'-10"(2997)	11'-6" (3505)	13'-3"(4038)	16'-7"(5055)	19'-11"(6070)	23'-3"(7086)
20" (508)	6'-5" (1955)	8'-2" (2489)	9'-10"(2997)	11'-6" (3505)	13'-2"(4013)	16'-7"(5055)	19'-11"(6070)	23'-3"(7086)
22" (559)	6'-4" (1930)	8'-1" (2463)	9'-10"(2997)	11'-6" (3505)	13'-2"(4013)	16'-6"(5029)	19'-11"(6070)	23'-3"(7086)
24" (610)	6'-4" (1930)	8'-1" (2463)	9'-9" (2971)	11'-5" (3479)	13'-2"(4013)	16'-6"(5029)	19'-10"(6045)	23'-3"(7086)
26" (660)	6'-3" (1905)	8'-0" (2438)	9'-9" (2971)	11'-5" (3479)	13'-1"(3987)	16'-6"(5029)	19'-10"(6045)	23'-2"(7061)
28" (711)	6'-3" (1905)	8'-0" (2438)	9'-8" (2946)	11'-5" (3479)	13'-1"(3987)	16'-6"(5029)	19'-10"(6045)	23'-2"(7061)
30" (762)	6'-2" (1879)	7'-11 (2413)	9'-8" (2946)	11'-4" (3454)	13'-1"(3987)	16'-5"(5004)	19'-10"(6045)	23'-2"(7061)
32" (813)	6'-1" (1854)	7'-10"(2387)	9'-7" (2921)	11'-4" (3454)	13'-0" (3962)	16'-5"(5004)	19'-9"(6020)	23'-2"(7061)
36" (914)	5'-11"(1803)	7'-9" (2362)	9'-6" (2895)	11'-3" (3429)	12'-11"(3937)	16'-4"(4979)	19'-9"(6020)	23'-1"(7035)
40" (1016)	5'-9"(1753)	7'-7" (2311)	9'-5" (2870)	11'-2" (3403)	12'-10"(3911)	16'-4"(4979)	19'-8"(5994)	23'-1"(7035)
44" (1118)	5'-6"(1676)	7'-5" (2260)	9'-3" (2819)	11'-0" (3352)	12'-9" (3886)	16'-3"(4953)	19'-7"(5969)	23'-0"(7010)
48" (1219)	5'-4"(1626)	7'-3" (2209)	9'-2" (2794)	10'-11"(3327)	12'-8" (3860)	16'-2"(4928)	19'-7"(5969)	22'-11"(6985)
52" (1321)	5'-0"(1524)	7'-1"(2159)	9'-0" (2743)	10'-10" (3302)	12'-7" (3835)	16'-1"(4902)	19'-6"(5943)	22'-11"(6985)
56" (1422)	4'-9"(1448)	6'-10"(2083)	8'-10"(2692)	10'-8" (3251)	12'-5" (3784)	16'-0"(4877)	19'-5"(5918)	22'-10"(6960)
60" (1524)	4'-4"(1321)	6'-8"(2032)	8'-7" (2616)	10'-6" (3200)	12'-4" (3759)	15'-10"(4826)	19'-4"(5893)	22'-9"(6935)
64" (1626)	**	6'-4"(1931)	8 -5" (2565)	10'-4" (3149)	12'-2" (3708)	15'-9" (4801)	19'-3"(5867)	22'-8"(6909)
68" (1727)	**	6'-1"(1854)	8'-2" (2489)	10'-2" (3098)	12'-0" (3657)	15'-8" (4775)	19'-2"(5842)	22'-7"(6884)
72" (1829)	**	5'-9"(1753)	8'-0" (2438)	10'-0" (3048)	11'-10"(3606)	15'-6" (4724)	19'-1" (5816)	22'-6" (6858)
80" (2032)	**	5'-0"(1524)	7'-5"(2260)	9'-6" (2895)	11'-6" (3505)	15'-3" (4648)	18'-10"(5740)	22'-4" (6808)
88" (2235)		**	6'-9"(2058)	9'-0" (2743)	11'-1" (3378)	14'-11"(4546)	18'-7" (5664)	22'-1" (6731)
96" (2438)		**	6'-0"(1829)	8'-5" (2565)	10'-8"(3251)	14'-7" (4445)	18'-4" (5588)	21'-11"(6680)
104" (2642)			**	7'-9" (2362)	10'-1"(3073)	14'-2" (4318)	18'-0" (5486)	21'-8" (6604)
112" (2845)			**	7'-0" (2134)	9'-6"(2895)	13'-9" (4191)	17'-8" (5385)	21'-4" (6503)
120" (3048)				**	8'-9"(2667)	13'-4"(4064)	17'-3" (5258)	21'-1" (6426)

**INTERPOLATION BELOW THE MINIMUM VALUES SHOWN IS NOT ALLOWED.
SEE TABLE 2.5-3 FOR MINIMUM JOIST SPACE FOR DIAGONAL ONLY BRIDGING.

TABLE 2.5-3

CJ-SERIES JOISTS HORIZONTAL PLUS DIAGONAL BRIDGING REQUIREMENTS		
JOIST DEPTH	**MINIMUM JOIST SPACE FOR DIAGONAL ONLY BRIDGING (0.70 x DEPTH)***	**HORIZONTAL AND DIAGONAL MINIMUM ANGLE SIZE REQUIRED** FOR JOIST SPACING < (0.70 X DEPTH) AND JOIST SPANS > 60'-0" (18.3 m)
in. (mm)	**ft.-in. (mm)**	**in. (mm)**
52" (1321)	3'- 0" (914)	1" x 1" x 7/64" (25 x 3)
56" (1422)	3'- 3" (990)	1" x 1" x 7/64" (25 x 3)
60" (1524)	3'- 6" (1066)	1" x 1" x 7/64" (25 x 3)
64" (1626)	3'- 8" (1117)	1¼" x 1¼" x 7/64" (32 x 3)
68" (1727)	3'-11" (1193)	1¼" x 1¼" x 7/64" (32 x 3)
72" (1829)	4'- 2" (1270)	1¼" x 1¼" x 7/64" (32 x 3)
80" (2032)	4'- 8" (1422)	1¼" x 1¼" x 7/64" (32 x 3)
88" (2235)	5'- 1" (1549)	1 ½" x 1 ½" x 7/64" (38 x 3)
96" (2438)	5'- 7" (1702)	1 ½" x 1 ½" x 7/64" (38 x 3)
104" (2642)	6'- 0" (1829)	1 ¾" x 1 ¾" x 7/64" (44 x 3)
112" (2845)	6'- 6" (1981)	1 ¾" x 1 ¾" x 7/64" (44 x 3)
120" (3048)	7'- 0" (2134)	2" x 2" x1/8" (51 x 3)

* NOTE: WHEN THE JOIST SPACING IS LESS THAN 0.70 x JOIST DEPTH, BOLTED HORIZONTAL BRIDGING SHALL BE USED IN ADDITION TO DIAGONAL BRIDGING.

2.6 CAMBERING

a) Manufacturing Tolerances

The camber tolerance for **CJ**-Series joists, as shown in Table 2.6, shall be -0 in. (0 mm), +1/4 in. (6 mm) or -0 in., + L / 1600 [where L = top chord length, in. (mm)] whichever is greater. Negative camber is not permitted.

TABLE 2.6
Camber Tolerances

TOP CHORD LENGTH feet (mm)	TOLERANCE - or + inches (mm)
20 (6,096)	-0, +1/4 (6)
30 (9,144)	-0, +1.4 (6)
40 (12,192)	-0, +1/4 (6)
50 (15,240)	-0, +3/8 (9)
60 (18,288)	-0, +1/2 (12)
70 (21,336)	-0, +1/2 (12)
80 (24,384)	-0, +5/8 (16)
90 (27,432)	-0, +5/8 (16)
100 (30,480)	-0, +3/4 (19)
110 (33,528)	-0, +7/8 (22)
120 (36,576)	-0, +7/8 (22)

b) Camber Design

It is standard practice that **CJ**-Series joists are furnished with sufficient camber for 100 percent of the non-composite dead load (joist, bridging, deck, and concrete slab). Joist bearings act as pinned / pinned-end connections with negligible end rotation restraint provided. Hence one shall obtain 100 percent (100%) of the predicted non-composite joist deflection when the full non-composite dead load has been placed on the composite steel joist. With the composite steel joist cambered for 100 percent (100%) of the non-composite dead load and the floor slab placed to a uniform thickness as suggested in Section 9, Concrete Placement, the floor shall be approximately level after the concrete has been placed.

Should the *specifying professional* strive to achieve a level floor after the composite dead and live loads are placed on the floor, joist camber can be specified on the "Required Design Parameters", see Appendix A. It is typical that the actual composite dead and live loads supported by the composite steel joist are less than the full design composite dead and live loads.

c) Shop Inspection

When a check is to be made of the camber of a **CJ**-Series joist, the composite steel joist shall be carefully laid on its side with the joist intermittently supported prior to measuring the camber. With the joist lying on its side, the joist shall be in an unstressed condition at which time the amount of camber provided can be accurately determined.

Joists having measured camber outside of the camber tolerances shown in Table 2.6 shall have their camber adjusted by the joist manufacturer. At the option of the joist manufacturer, the composite steel joists shall be permitted to be rebuilt with the corrected camber.

2.7 STEEL HEADED STUD ANCHORS

The joist manufacturer shall indicate the size, quantity and layout of steel headed stud anchors required on the stud installation drawings. Purchasing of the steel headed stud anchors and ferrules, rental of stud welding equipment, installation of steel headed stud anchors and field testing of the studs is the responsibility of the shear stud installer.

2.8 CONNECTIONS

The adequacy of the end anchorage connection (bolted or welded) between the CJ-Series joist bearing seat and the supporting structure is the responsibility of the *specifying professional*. The contract documents shall clearly illustrate the end anchorage connection. Forces to be considered include end moments, axial loads, and diaphragm boundaries. Particular attention is required where there is net uplift.

SECTION 3.
MATERIALS

3.1 STEEL

The steel used in the manufacture of composite steel joists shall comply with the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption.

3.2 PAINT

CJ-Series joists shall be provided unpainted to facilitate installation of welded steel headed stud anchors, unless otherwise specified, as paint may potentially hinder the installation of welded steel headed stud anchors to the joist top chord.

If the project specifications require joist shop paint, the joist manufacturer shall not be responsible for field preparation of the top chord required for welded stud installation.

It is also understood that the typical shop applied paint used to coat steel joists is a dip applied, air dried paint. The paint is intended to be an impermanent and provisional coating which shall protect the steel for only a short period of exposure in ordinary atmospheric conditions.

Since most steel joists are painted using a standard dip coating, the coating shall be permitted to not be uniform and shall be permitted to include drips, runs, and sags. Compatibility of any coating including fire protective coatings applied over the standard shop paint shall be the responsibility of the specifier and/or painting contractor.

The shop applied paint may require field touch-up/repair as a result of, but not limited to, the following:

1. Abrasions from: Bundling, banding, loading and unloading, chains, dunnage during shipping, cables and chains during erection, bridging, installation, and other handling at the jobsite.
   Note: Rusting should be expected at any abrasion.
2. Dirt.
3. Diesel smoke.
4. Road salt.
5. Weather conditions during storage.

The joist manufacturer shall not be responsible for the condition of the paint if it is not properly protected after delivery.

SECTION 4.
INSPECTION

Inspection of composite steel joists at the joist manufacturer's plant shall be in accordance with Section 5.14 of the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption.

Provisions for field inspection of projects involving composite steel joists shall be made by the *specifying professional*. This field inspection shall include verifying the concrete strength, concrete thickness and placement of the steel headed stud anchors. For more information on stud placement see Section 7 of the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption. This field inspection shall not be provided by SJI member manufacturers.

SECTION 5.
ESTIMATING

5.1 PLANS FOR BIDDING

Plans to serve as the basis for bids shall show the character of the work with sufficient clarity to permit making an accurate estimate and shall show the following:

- Designation and location of *materials* (see Sections 5.2 (a) and 6.1.1), including any special design or configuration requirements
- Locations and elevations of all steel and concrete supporting members and bearing walls
- Composite steel joist depth
- Composite steel joist span
- Distance, each side of the joist centerline, to adjacent joists or other supporting members
- Type and depth of floor deck
- Concrete unit weight
- Concrete compressive strength
- Total depth of concrete slab
- Loads and their locations as defined in Section 6.1.1
- Location and length of joist extended ends
- Location and size of all openings in floors and roofs
- Location of all partitions
- Composite steel joists requiring extended bottom chords
- Deflection limitation
- No paint on the joist. Refer to Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ**-Series, of latest adoption, Section 3.4 Paint

5.2 SCOPE OF ESTIMATE

a) Unless otherwise specified, the following items shall be included in the estimate, and requirements shall be determined as outlined in Section 6.1.

- Composite Steel Joists
- Joist Extensions
- Ceiling Extensions
- Extended bottom chord used as strut
- Bridging and bridging anchors

b) The following items shall not be included in the estimate but may be quoted and identified by the joist manufacturer as separate items:

- Headers for Composite Steel Joists, **CJ**-Series
- Shear connectors and/or ferrules
- Centering material and attachments
- Miscellaneous framing between joists for openings at ducts, dumbwaiters, ventilators, skylights, etc.
- Loose individual or continuous bearing plates and bolts or anchors for such plates
- Erection bolts for composite steel joist end anchorage
- Horizontal bracing in the plane of the top and bottom chords from joist to joist or joist to structural framing and walls
- Moment plates
- Special joist configuration or bridging layouts for ductwork or sprinkler systems
- Bridging anchors and anchorage

SECTION 6.
PLANS AND SPECIFICATIONS

6.1 PLANS FURNISHED BY BUYER

The *buyer* shall furnish the *seller* plans and specifications as prepared by the *specifying professional* showing all material requirements and composite steel joist designations.

6.1.1 Design Input Required for Composite Steel Joists

The following basic information shall be provided by the *specifying professional*:

a) Joist Depth

The joist depth includes the steel joist portion only, not the deck or concrete slab, in. (mm).

b) Composite Steel Joist Layout

The joist plans shall show the layout of the composite steel joists, walls, columns, beams, girders and other supports, as well as floor and roof openings and any partitions. The joist manufacturer shall determine the required composite steel joist span to be fabricated based on this information.

c) Finished Floor, Roof, and Bearing Elevations

The elevation of finished floors, roofs, and bearings shall be shown with due consideration taken for the effects of dead load deflection.

d) Adjacent Member Spacing

This is the distance to the adjacent member or to the edge of the slab (if an exterior joist), feet (m).

e) Type of Floor Deck

Review each manufacturer's deck capacity for load capacity and deflection characteristics and specify the deck depth, profile and thickness to meet the building design.

f) Concrete Unit Weight, lb/ft.^{3} (kg/m^3).

g) Concrete Compressive Strength

28 day specified compressive strength of concrete, ksi (MPa).

h) Slab Thickness above the Top Ribs of the Deck, in. (mm).

i) Loads

The Steel Joist Institute does not presume to establish the loading requirements for which structures are designed. The *specifying professional* shall provide the nominal loads and load combinations as stipulated by the applicable code under which the structure is designed. At the present time the **CJ**-Series joists are stipulated to be designed utilizing an LRFD design basis.

The *specifying professional* shall calculate and provide the magnitude and location of all joist loads including those described below. When necessary to clearly convey information, a Load Diagram or Load Schedule shall be provided.

1. Non-composite DL, lb/ft.^{2} (kPa) - Concrete, joists, deck, bridging, and any other non-composite dead loads.
2. Construction LL, lb/ft.^{2} (kPa) – It is suggested that construction live load be determined considering the tributary area for each composite steel joist. See Appendix A.
3. Composite DL, lb/ft.^{2} (kPa) - Partitions, mechanical, electrical, fireproofing, floor covering, ceilings, and other composite dead loads. The magnitude and location of composite dead loads shall be clearly dimensioned.
4. Composite LL, lb/ft.^{2} (kPa) - Reduced design live loads shall be permitted to be specified if applicable.

j) Special Loads

The *specifying professional* shall be responsible for determining the applicable building code load combinations. If the loading criteria are too complex to be adequately communicated 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.

The *specifying professional* shall show on the structural drawings and give due consideration to the following special loads and load effects:

1. Snow drift loads including the accumulation of snow in the vicinity of obstructions such as penthouses, signs, parapets, adjacent buildings, etc.
2. Axial loads at the joist end supports.
3. Type and magnitude of end moments. For moment resisting joists framing near the end of a column, due consideration shall be given to extend the column length to allow a plate type connection between the top of the joist top chord and the column. Whenever possible, avoid resolving joist end moment forces through the joist bearing seat connection. A note shall be provided on the structural drawings stating that all moment resisting joists shall have all dead loads applied to the joist before the bottom chord struts are welded to the supporting connection whenever the moments provided do not include dead load. The top and bottom chord moment connection details and reinforcing steel placed in the concrete slab to resist negative flexural moments shall be designed by the *specifying professional*. The joist designer shall furnish the *specifying professional* with the joist detail information if requested.
4. Structural bracing loads.
5. Ponded rain water.
6. Wind loads - When composite steel joists are utilized in roof applications, the magnitude and location of all wind uplift loads shall be clearly shown.
7. Concentrated loads from mechanical units, fans, blowers, tanks, monorails, etc. - 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 shall require consideration by the joist manufacturer. For nominal concentrated loads, which have been accounted for in the specified uniform design loads, a "strut" to transfer the load to a panel point on the opposite chord shall not be required provided that the sum of the concentrated loads within a chord panel does not exceed 100 pounds (445 N) and the attachments are concentric to the chord. When exact dimensional locations for concentrated loads which do not meet the above criteria are provided by the *specifying professional,* the joist shall be designed for the loads and load locations provided without the need for additional field applied web members at the specified locations.

k) Camber

CJ-Series steel joists, unless otherwise specified, are cambered, in. (mm), for 100 percent (100%) of the non-composite weight of joist, bridging, deck and concrete slab. Additional camber to accommodate for actual sustained composite dead and live loads and concrete shrinkage/creep shall be identified by the *specifying professional.*

6.1.2 Required Design Parameters

A form is provided in Appendix A for filling in the required design information listed in Section 6.1.1(a), Sections 6.1.1(d) through 6.1.1(i), and Section 6.1.1(k).

6.1.3 Composite Steel Joist Limitations

The *specifying professional* must be aware of some of the limitations that have been placed on composite steel joists. These include:

- The maximum deck depth is 3 inches (76 mm)
- The minimum slab thickness above the top of the deck shall be 2 inches (51 mm)

- When steel headed stud anchors are utilized, they shall have at least 1/2 inch (13 mm) of concrete cover
- The concrete shall be placed to provide a constant thickness along the entire span

6.1.4 Connections

Minimum end anchorage for simple span gravity loading shall be in accordance with Section 5.7 of the Steel Joist Institute Standard Specification for Composite Steel Joists, **CJ-**Series, of latest adoption. The end anchorage of a composite steel joist is the connection of the joist bearing seat to the support.

The adequacy of the end anchorage connection (bolted or welded) between the composite steel joist bearing seat and the supporting structure is the responsibility of the *specifying professional*. The contract documents shall clearly illustrate the end anchorage connection.

When the end anchorage is welded, it is recommended that the *specifying professional* consider a smaller fillet weld thickness in conjunction with a longer weld length.

The *specifying professional* is responsible for bridging termination connections. The contract documents shall clearly illustrate these termination connections.

The Joist Manufacturer is responsible for the design of the bearing seats of composite steel joists for the loads designated by the *specifying professional* in the contract documents.

6.1.5 Special Considerations

The *specifying professional* shall indicate on the construction documents special considerations including:

a) Oversized or other non-standard web openings
b) Extended ends
c) Non-SJI standard bridging

6.2 PLANS FURNISHED BY SELLER

The *seller* shall furnish the *buyer* with composite steel joist placement plans to show the *material* as specified in the construction documents and are to be utilized for field installation in accordance with specific project requirements as stated in Section 6.1. Composite steel joist placement plans shall include, at a minimum, the following:

a) Listing of all applicable loads as stated in Section 6.1 and used in the design of the composite steel joists as specified in the construction documents
b) Connection requirements for:
    - Joist supports
    - Field splices
    - Bridging attachments
c) Deflection criteria for live load and total load
d) Shear stud installation plans showing:
    - Size, quantity and location of all shear connectors to be installed on the composite steel joists
    - Design camber for each composite steel joist or reference to a table giving the design camber for each composite steel joist
e) Size, location, and connections for all bridging
f) Joist headers

All *material* shall be identified with its mark which also appears on the Bill of Materials. Composite steel joist placement plans do not require the seal and signature of the joist manufacturer's registered design professional.

6.3 DISCREPANCIES

The *specifying professional's* bid plans and specifications shall be stipulated to be correct in the absence of written notice from the *buyer* to the contrary. When the *buyer* furnishes plans that do not agree with the Architect's bid plans, such detailed plans shall be considered as a written notice of change of plans. However, it shall be the *buyer's* responsibility to advise the *seller* of those changes which affect the composite steel joists.

6.4 APPROVAL

When composite steel joist placement plans are furnished by the *seller*, they are submitted to the *buyer* and *owner* for examination and approval. The *seller* allows a maximum of fourteen (14) calendar days in their schedule for the return of placement plans noted with the *owner's* and customer's approval, or approval subject to corrections as noted. The *seller* makes the corrections, furnishes corrected prints for field use to the *owner*/customer and is released by the *owner*/customer to start composite steel joist manufacture.

Approval by the *owner*/customer of the composite steel joist placement plans, sections, notes and joist schedule prepared by the *seller* indicates that the *seller* has correctly interpreted the contract requirements and is released by the *owner*/customer to start composite steel joist manufacture. This approval constitutes the *owner's*/customer's acceptance of all responsibility for the design adequacy of any detail configuration of joist support conditions shown by the *seller* as part of the preparation of these placement plans.

Approval does not relieve the *seller* of the responsibility for accuracy of detail dimensions on the plans, nor the general fit-up of composite steel joists to be placed in the field.

6.5 CHANGES

When any changes in plans are made by the *buyer* (or the *buyer's* representative) either prior to or after approval of detailed plans, or when any *material* is required and was not shown on the plans used as the basis of the bid, the cost of such changes and/or extra *material* shall be paid by the *buyer* at a price to be agreed upon between *buyer* and *seller*.

6.6 CALCULATIONS

The *seller* shall design the composite steel joists in accordance with the Steel Joist Institute Standard Specifications, **CJ**-Series, of latest adoption, to support the load requirements of Section 6.1. The *specifying professional* may require submission of the composite steel joist calculations as prepared by a registered design professional responsible for the product design. If requested by the *specifying professional*, the composite steel joist manufacturer shall submit design calculations with a cover letter bearing the seal and signature of the joist manufacturer's registered design professional. In addition to standard calculations under this seal and signature, submittal of the following shall be included:

a) Non-SJI standard bridging details (e.g. for cantilevered conditions, net uplift)

b) Connection details for:

- Non-SJI standard connections (e.g., flush framed or framed connections)
- Field splices
- Joist headers

c) Shear stud requirements

SECTION 7.
HANDLING AND ERECTION

The *buyer* and *erector* shall comply with the requirements of the Steel Joist Institute Standard Specifications for Composite Steel Joists, **CJ**-Series, of latest adoption in the handling and erection of *material*.

> **Note**: For additional coverage of this topic, refer to the Steel Joist Institute's Technical Digest 9, "Handling and Erection of Steel Joists and Joist Girders".

The *buyer* and/or *erector* shall check all *materials* on arrival at job site and promptly report to the *seller* any discrepancies and/or damages.

When composite steel joists cannot be delivered as a single piece, they shall be permitted to be delivered in two or more pieces therefore requiring the pieces to be spliced together in the field. The manufacturer's instructions shall be followed to assure matching pieces are joined, proper bolts are used, and any required bolt tensioning is incorporated.

All composite steel joists shall be handled by methods which avoid damage to any part of the joist. This may require the use of spreader bars, multiple hoisting cables, or multiple cranes as necessary to safely handle the joist. Hoisting cables shall be attached at panel points and shall be at panel point locations selected to minimize erection stresses.

The current OSHA Safety and Health Regulations for Construction, 29 CFR Part 1926, Subpart R - Steel Erection, refers to certain joists at or near columns to be designed with sufficient strength to allow one employee to release the hoisting cable without the need for erection bridging. This Standard shall not be interpreted that any composite steel joist at or near a column line is safe to support an employee without bridging installed. Many limitations exist that prevent these joists from being designed to safely allow an employee on an un-bridged joist. Because of these limitations these joists shall be erected by incorporating erection methods ensuring joist stability and either:

1) Installing bridging or otherwise stabilizing the composite steel joist prior to releasing the hoisting cable, or
2) Releasing the hoisting cable without having a worker on the composite steel joist.

A composite steel joist shall not be placed on any support structure unless such structure is stabilized. When composite steel joists are landed on a structure, they shall be secured to prevent unintentional displacement prior to installation.

A bridging terminus point shall be established before joist bridging is installed.

Composite steel joists shall not be used as anchorage points for a fall arrest system unless written directions to do so is obtained from a "qualified person" (for definition of "qualified person" see Code of Federal Regulations (CFR) 29 Part 1926 Safety and Health Regulations for Construction, Subpart R, Steel Erection, §1926.751 Definitions, January 18, 2001).

No modification that affects the strength of a composite steel joist shall be made without the written approval of the Engineer of Record.

The *seller* shall not be responsible for improper fit of *material* due to inaccurate construction work.

SECTION 8.
INSTALLATION AND INSPECTION OF STEEL HEADED STUD ANCHORS

8.1 INSTALLATION

a) Locate steel headed stud anchors, hereafter referred to as shear studs, on composite steel joists per details shown on the manufacturer's shear stud placement drawings and as outlined in any shear stud layout tables. Start laying out shear studs from each end of the joist and working toward the center. Alternate installation of the shear studs from one top chord angle to the other. Note minimum concrete longitudinal edge distance for shear studs on ends of joists as shown on placement drawings.

b) All shear studs shall be welded through the steel deck after the deck has been placed on the joists. Welding voltage, current, time, and gun settings for lift and plunge shall be set at optimum settings for the particular size of shear studs and range of joist top chord thicknesses, based on recommendations of the shear stud manufacturer and automatic shear stud welding equipment manufacturer, or both. The shear stud installer should consult AWS C5.4, *Recommended Practices for Stud Welding*, for technique guidance. All welding shall comply with AWS D1.1, Structural Welding Code - Steel, Section 7, *Stud Welding,* with the exception that a ratio of stud diameter to top chord thickness of up to 3.0 shall be permitted.

> **Note**: The shear capacity of a single shear stud is determined from the requirements of the Steel Joist Institute Standard Specifications for Composite Steel Joists, **CJ**-Series, of latest adoption Section 4.5.4, Shear Studs where the shear stud coefficient, R_p, is based more closely on the research conducted for composite behavior than used by AISC 360.

c) Each shear stud shall be provided with the appropriate ceramic ferrule (arc shield) designated by the shear stud manufacturer as designed for weld through deck application. Ferrules shall be stored in a moisture free environment and kept dry during installation.

d) Prior to welding shear studs, the top surface of the joist top chords shall be clean, unpainted and free of heavy rust, dirt, sand, oil, grease, water, or other foreign substances. The surfaces of the deck prior to stud welding shall be free of heavy rust or mill scale, moisture, dirt, sand, or other construction related waste materials.

e) Prior to welding, the steel deck shall rest tightly against the top chord of the composite steel joist.

f) Shear studs shall not be welded through more than one thickness of 16 gage deck or two thicknesses of 18 gage deck or lighter. Total galvanizing thickness on one thickness or two thicknesses of deck shall not exceed 1.25 oz. per square foot total for both sides of the deck.

g) Welding of shear studs shall not be done when the base metal is below 0°F (-18°C) or when the surface is wet or exposed to falling rain or snow. When the base metal temperature is between 0°F (-18°C) and 32°F (0°C), welding shall be permitted to only be done with appropriate set up, pre-production testing and inspection procedures as outlined in AWS D1.1 Structural Welding Code - Steel, Section 7.5, *Technique*.

h) Qualification of the stud application procedure used to weld shear studs through metal deck is outlined in AWS D1.1, Structural Welding Code –Steel, Section 7.6 *Stud Application Qualification Requirements*. This document requires that a minimum of ten (10) shear studs shall be welded using the decking and base material representative of the conditions to be used during construction. The ten (10) studs shall then be successfully tensile or bend tested. A document recording the details and settings including the weld set up used for this test shall be prepared prior to beginning of any production shear stud welding. A copy of the Application Qualification Test Data shall be furnished to the Engineer of Record as outlined in AWS D1.1, Structural Welding Code- Steel, Section 7.6.7 *Application Qualification Test Data*. At the beginning of each day's or shift's production, Pre-production testing in accordance with AWS D1.1 Structural Welding Code - Steel, Section 7.7 *Production Control* shall be performed on the first two shear studs that are welded.

8.2 INSPECTION

a) The welding of shear studs requires special inspection. The *owner*, or the *specifying professional*, acting as *owner's* agent, shall employ one or more special inspectors who shall provide inspections of the shear stud welds on a continual and timely basis. The special inspector's duties include verifying welder's qualifications, welding preparation, welding procedures and conformance of materials. Unless otherwise specified in the contract documents, the stud installer shall be responsible for application qualification tests, pre-production tests and removal of the ferrule from each weld for inspection purposes.

b) To ensure proper welds, bend test a minimum of 1 out of every 100 shear studs production welded, by either striking the shear stud with a hammer or placing a pipe or other hollow device over the shear stud and manually or mechanically bending the shear stud 15° from its original axis. Shear studs shall be bent along the longitudinal axis of the joist toward the nearest end of the joist. If failure occurs in the weld zone, a minimum of two adjacent shear studs shall be satisfactorily bend tested. The special inspector, where conditions warrant, shall be permitted to select a reasonable number of additional shear studs to be subjected to a 15° bend test.

c) If in the judgment of the *specifying professional*, shear studs welded during the progress of the work are not in accordance with AWS D1.1, Structural Welding Code - Steel, Section 7, *Stud Welding* requirements, as indicated by inspection and testing, corrective action shall be required of the shear stud installer. At the shear stud installer's expense, the shear stud installer shall make the set-up changes necessary to ensure that shear studs subsequently welded meet code requirements.

d) The shear stud installer shall certify to the *specifying professional* that the shear studs were installed in accordance with the requirements of AWS D1.1, Structural Welding Code - Steel, Section 7, *Stud Welding.*

SECTION 9.
CONCRETE PLACEMENT

Even if the joist camber is specified to theoretically provide a flat floor surface after placing of the concrete is completed, special consideration must be given relative to concrete placement.

It is recommended that ACI 302.1R-15, Guide to Concrete Floor and Slab Construction be utilized for establishing the requirements needed for successful construction of suspended slabs. This starts with establishing responsibilities in the contract documents to address (not all-inclusive) class of floor, reinforcement, when required, and construction tolerances that include floor flatness and levelness requirements, including how and when these need to be measured.

The levelness of suspended slabs on composite steel joists depends on the accuracy of formwork and strike-off once the concrete slab is placed, but is also influenced by the type of structural system being utilized as each type of structural frame behaves somewhat differently. The concrete contractor needs to recognize these differences and plan the work accordingly.

Regardless of the structural system and whether the concrete placement will be done shored or unshored, it is imperative that the concrete slab be placed at a constant thickness across the entire length of the composite steel joist. The main reasons for this include the following:

- Full concrete slab thickness shall be provided along the entire composite steel joist span to carry the composite steel joist compressive loads
- A full thickness slab is necessary to provide required fire protection.
- Sufficient concrete cover shall be provided over the steel headed stud anchors.
- The potential for over runs in concrete placing volume shall be greatly reduced.
- Deflections of the composite steel joist under the non-composite loading can be more accurately predicted vs. with a variable thickness slab.

Concrete construction joints should ideally be located between joists. When a construction joint is located closer than 12 in. (305 mm) from the longitudinal centerline of any given composite steel joist, it is the responsibility of the *specifying professional* to determine whether extra transverse steel reinforcing needs to be provided to assure that the composite properties of the supporting member with steel headed stud anchors has not been affected.

SECTION 10.
BUSINESS RELATIONS

10.1 PRESENTATION OF PROPOSALS

All proposals for furnishing *material* shall be made on a Sales Contract Form. After acceptance by the *buyer*, these proposals shall be approved or executed by a qualified official of the *seller*. Upon such approval the proposal becomes a contract.

10.2 ACCEPTANCE OF PROPOSALS

All proposals are intended for prompt acceptance and are subject to change without notice.

10.3 BILLING

Contracts on a lump sum basis are to be billed proportionately as shipments are made.

10.4 PAYMENT

Payments shall be made in full on each invoice without retention.

10.5 ARBITRATION

All business controversies which cannot be settled by direct negotiations between *buyer* and *seller* shall be submitted to arbitration. Both parties shall sign a submission to arbitration and if possible agree upon an arbitrator. If they are unable to agree, each shall appoint an arbitrator and these two shall appoint a third arbitrator. The expenses of the arbitration shall be divided equally between the parties, unless otherwise provided for in the agreements to submit to arbitration. The arbitrators shall pass final judgement upon all questions, both of law and fact, and their findings shall be conclusive.

APPENDIX A.
REQUIRED DESIGN PARAMETERS
(Nominal Uniform Loads)

Date ____________________ **Project** ____

Joist Geometry:

1)	Depth	___________ in. (mm)		
2)	Span	___________ ft. (m)		
3)	Adjacent Member Spacing (left)	___________ ft. (m)		
4)	Adjacent Member Spacing (right)	___________ ft. (m)		

Concrete and Deck:

1)	Type of Floor Deck			
2)	Depth of Floor Deck	___________ in. (mm)		
3)	Slab Thickness above Deck	___________ in. (mm)		
4)	Concrete Unit Weight	___________ pcf (kg/m^3)		
5)	Concrete Compressive Strength	___________ ksi (MPa)		

Nominal Loads:

1) Non-composite Construction Dead Load

a)	Concrete	___________ psf (kPa)	
b)	Joist and Bridging	___________ psf (kPa)	
c)	Deck	___________ psf (kPa)	
d)	**Total**	___________ psf (kPa)	___________ plf (kN/m)

2) [1]Construction Live Load

a)	During Concrete Placement	___________ psf (kPa)	___________ plf (kN/m)

3) Composite Dead Load

a)	Fixed Partitions	___________ psf (kPa)	
b)	Mechanical	___________ psf (kPa)	
c)	Electrical	___________ psf (kPa)	
d)	Fireproofing	___________ psf (kPa)	
e)	Floor Covering and Ceiling	___________ psf (kPa)	
f)	Miscellaneous Dead Loads	___________ psf (kPa)	
g)	**Total**	___________ psf (kPa)	___________ plf (kN/m)

4) Composite Live Load

a)	Live Load (Reduced as Applicable)	___________ psf (kPa)	
b)	Moveable Partitions	___________ psf (kPa)	
c)	**Total**	___________ psf (kPa)	___________ plf (kN/m)

5) Total Factored Non-composite Dead Load, 1.2 x (1d)

__________ psf (kPa) __________ plf (kN/m)

6) Total Factored Composite Dead Load, 1.2 x (3g)

__________ psf (kPa) __________ plf (kN/m)

7) Total Factored Composite Live Load, 1.6 x (4c)

__________ psf (kPa) __________ plf (kN/m)

8) Total Factored Composite Design Load, (5) + (6) +(7)

__________ psf (kPa) __________ plf (kN/m)

9) Joist Designation: ____CJ________/________/________
dd (8) (7) (6) dd = joist depth

Camber and Deflection (unfactored load):

1) Loads to Camber for:

a) Non-composite Dead Load, (1d) x __________ % (typically 100%)
b) Composite Dead Load, (3g) x __________ % (typically 0 – 50%)
c) Composite Live Load, (4c) x __________ % (typically 0 – 25%)

2) Maximum Allowable Live Load Deflection Span / _______
3) Maximum Deflection __________ in. (mm)

[1]When estimating construction live loading on a composite steel joist it is suggested that the construction live loading be adjusted for tributary area as shown below:

For English units

$L_c = 20R_1$ where $12 \le L_c \le 20$, lb/ft.^{2} (Eq. A1-1)

$R_1 = 1$ for $A_t \le 200$ ft.^{2}

$R_1 = 1.2 - 0.001A_t$ for 200 ft.$^2 < A_t <$ 600 ft.^{2}

$R_1 = 0.6$ for $A_t \ge 600$ ft.^{2}

Where:

L_c = Construction live load

A_t = Tributary floor area over one joist supporting the construction live load, ft.^{2} (m^2)

For Metric units

$L_c = 0.96R_1$ where $0.58 \le L_c \le 0.96$, kN/m^2 (Eq. A1-2)

$R_1 = 1$ for $A_t \le 18.58$ m^2

$R_1 = 1.2 - 0.01076A_t$ for 18.58 m$^2 < A_t <$ 55.74 m^2

$R_1 = 0.6$ for $A_t \ge 55.74$ m^2