

# THE NEW 2005 UNIFIED STEEL JOIST SPECIFICATIONS



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## Abstract:

The Steel Joist Institute has introduced new specifications for K-Series joists, LH- and DLH-Series joists and Joist Girders that allow the Specifying Professional to utilize joists as part of either an allowable strength design (ASD) or a load and resistance factor (LRFD) design. In addition, the SJI has revised its code of standard practice. The desire of the SJI is that all practicing engineers know the current methods and conventions to be used in selecting joists and providing loading information to the joist supplier. A common design example will be evaluated using ASD and LRFD that will cover various loading conditions involving not only uniformly distributed loads, but concentrated loads and axial loads. Bridging requirements for this design example will also be reviewed.

# THE NEW 2005 UNIFIED STEEL JOIST SPECIFICATIONS

Tim Holtermann, PE, SE and Perry S. Green, PhD

## INTRODUCTION

The Steel Joist Institute (SJI) is the governing body for joist manufacturers who produce, on a continuing basis, joists of the K-, LH- and DLH-Series and/or Joist Girders conforming to the Institute's Specifications and Load Tables. These manufacturers have also fulfilled the requirements for membership as described in the 42<sup>nd</sup> Edition of the **Standard Specifications Load Tables & Weight Tables for Steel Joists and Joist Girders** that will be subsequently referred to as the Catalog. Since the inception of the Steel Joist Institute in 1928 and the issuance of the first Catalog in 1932, open web steel joists have often been found to be the most economical and efficient solution for framing systems to support floor and roof panels between main supporting beams, girders, Joist Girders, trusses and walls in a wide variety of building structures. Steel joists are easy to use and provide a great deal of flexibility in their use for many different loading conditions, spans, shapes or other special situations.

This paper describes the changes that have been made in the design process for steel joists and Joist Girders and how these changes will impact the Specifying Professional (Structural Engineer of Record). Discussion will highlight the changes that have been made to the Specifications and Load Tables, Code of Standard Practice (COSP), and Catalog. When appropriate, examples will be used to demonstrate the effects that the changes will make on the way a SER specifies a steel joist or Joist Girder.

## BACKGROUND AND DEVELOPMENT

One of the main objects of the Institute as described in its Bylaws is "to develop, establish and maintain standards for the design, manufacture and erection of steel joists ..." This has been faithfully carried out throughout the years by the SJI's Engineering Practice Committee (EPC). As such, in 2002 immediately following the committee's work for the 41<sup>st</sup> Edition Catalog, the EPC began work on the next revision of the **Standard Specifications Load Tables & Weight Tables for Steel Joists and Joist Girders**. The approach that was decided for the K-Series, LH- and DLH-Series and Joist Girder Specifications would be to provide them in both Load and Resistance Factor Design (LRFD) and Allowable Stress Design (ASD) to give the Specifying Professional a choice of design methodologies. The committee felt that this approach was both necessary and appropriate as it paralleled what was happening with the American Institute of Steel Construction's Structural Steel Building Specification (AISC 2005) and had already taken place with the American Iron and Steel Institute's AISI Standard, North American Specification for the Design of Cold-Formed Steel Structural Members (AISI 2002).

The Steel Joist Institute's K-Series, LH- and DLH-Series and Joist Girder Specifications were submitted to, and approved by, the American National Standards Institute (ANSI) for the first time in 2002, and this process has continued for the 2005 Catalog. One of the major reasons for acquiring ANSI certification is to help expedite the acceptance of the SJI's steel joist and Joist Girder specifications into the model building codes. The International Code Council's 2006 International Building Code (IBC 2006) has already approved and incorporated the latest SJI specifications. Therefore, these latest specifications will automatically come into use as individual states adopt this latest IBC building code. It should also be noted that continued ANSI approval of the latest SJI specifications is in concert with the steps taken by both the AISC and AISI for their most recent steel specifications.

The EPC, early on in the new specifications development process, recognized that all the current joist series have to be maintained. As will be described in more detail later, for example, an ASD 18K5 has the same ultimate load-carrying capacity as a LRFD 18K5 which has the same ultimate load-carrying capacity as a current 18K5 joist from the 2002 Catalog. This same philosophy was applied to the new LH- and DLH-Series Joist Specifications and the new Joist Girder Specifications.

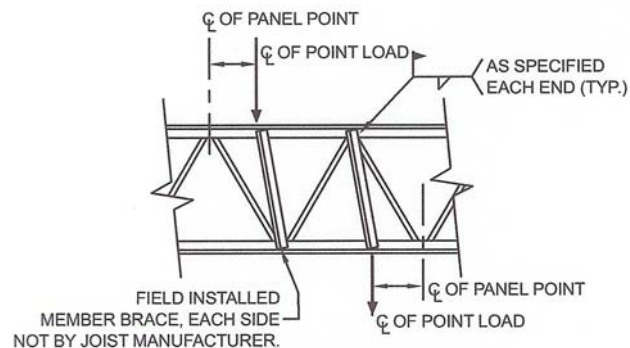
## 42<sup>nd</sup> EDITION CATALOG HIGHLIGHTS

The 42<sup>nd</sup> Edition of the Catalog has been reorganized for ease of use and contains several major updates relating to 1) Accessories and Details; 2) U.L. Fire Resistance Ratings with Steel Joists; and 3) Expanded Design Guide Weight Tables for Joist Girders. The Catalog now contains a concise list of Referenced Specifications, Codes and Standards, a Glossary of common steel joist and Joist Girder terminology and five Appendices labeled A through E, where,

- Appendix A – Joist Substitutes, K-Series
- Appendix B – Top Chord Extensions and Extended Ends, K-Series
- Appendix C – Economy Tables, K-Series
- Appendix D – Fire-Resistance Ratings with Steel Joists
- Appendix E – OSHA Safety Standards for Steel Erection Part 1926.757 – Open Web Steel Joists

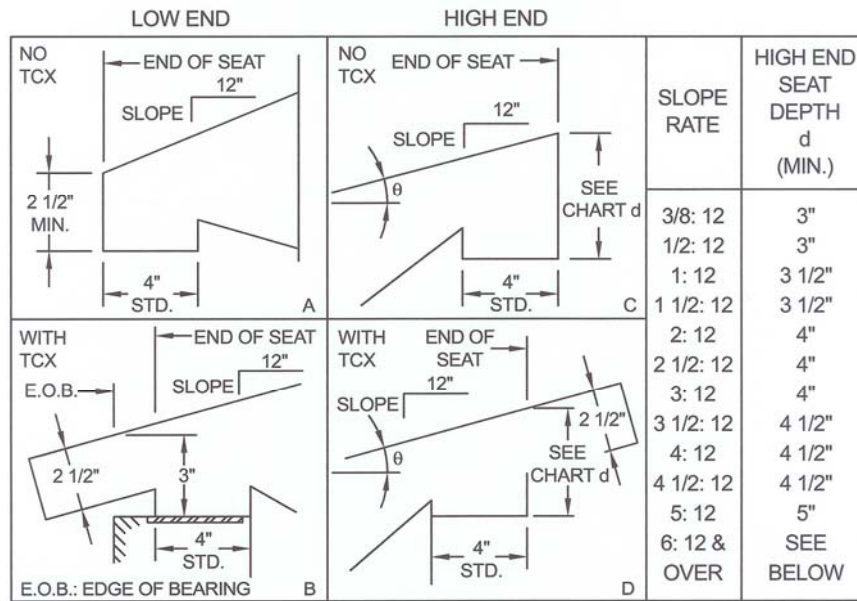
The revisions made to the K-Series, LH- and DLH-Series and Joist Girder Specifications and the Code of Standard Practice (COSP) will be described separately.

Prior to this Catalog being published, information related to most joist accessories and details was only found in the various publications produced by several of the SJI member companies. If a particular member company did not produce their own catalog (containing all the SJI Specifications and COSP) then information related to accessories and details would not have been readily available to the Specifying Professional. In an effort to alleviate this situation the EPC decided that it would add a new section to the Catalog providing essential information on the most commonly used accessories and details used by engineers. The information contained in this section addresses Added Members, Bridging Details and Sloped Seat Requirements for both K-Series and LH- and DLH-Series joists and Approximate Duct Opening Sizes. Figure 1 is a generic detail of a field installed added member required to prevent bending induced in a joist chord due to the placement of a concentrated load that is not located at a panel point.



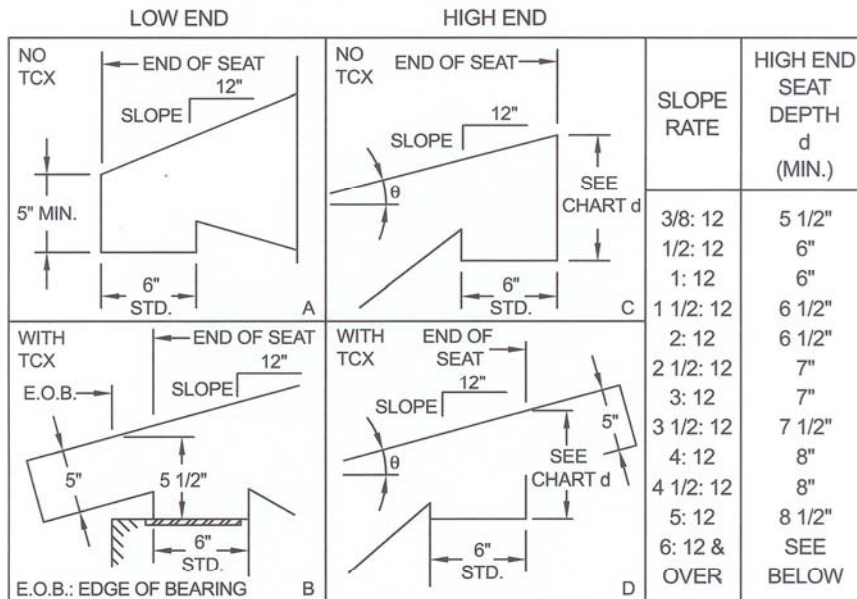
*Figure 1 Typical Joist Reinforcement at Concentrated Loads*

Figure 2 was developed from a consensus of the member companies represented on the EPC. Figures 2A and 2B give the minimum sloped seat requirements for K-Series and LH- and DLH-Series joists, respectively based on slopes ranging from 3/8 : 12 to 5 : 12. The notes accompanying each figure provide an equation that can be used by the Specifying Professional to calculate the minimum sloped seat depth when a roof slope is greater than 6 : 12. In all cases the Engineer of Record must ensure that a minimum clearance is provided at the Edge of Bearing (EOB) of the low end of the joist when a top chord extension is used.



NOTES:

- (1) Depths shown are the minimums required for manufacturing of sloped bearing seats. Depths may vary depending on actual bearing conditions.
- (2)  $d = 1/2 + 2.5 / \cos \theta + 4 \tan \theta$
- (3) Clearance must be checked at outer edge of support as shown in Detail B. Increase bearing depth as required to permit passage of 2 1/2" deep extension.
- (4) If extension depth greater than 2 1/2" is required (see Details B and D) increase bearing depths accordingly.
- (5) If slope is 1/4: 12 or less, sloped seats are not required.



Notes:

- (1) Depths shown are the minimums required for manufacturing of sloped seats.
- (2)  $d = 1/2 + 5 / \cos \theta + 6 \tan \theta$
- (3) Clearance must be checked at outer edge of support as shown in Detail B. Increase bearing depth as required to permit passage of 5" deep extension.
- (4) If extension depth greater than 5" is required (see Details B and D) increase bearing depths accordingly.
- (5) Add 2 1/2" to seat depth at 18 and 19 chord section numbers. Consult manufacturer for information when TCX's are present.

Figure 2 Sloped Seat Requirements for Slopes 3/8 : 12 and Greater;  
 A) K-Series Open Web Steel Joists; and B) LH- and DLH-Series Steel Joists

The current range of the SJI Joist Girders as shown in the **Design Guide Weight Table for Joist Girders** is as follows: Maximum span is 60 feet; Maximum depth is 72 inches; and Maximum unfactored panel point load is 20 kips (i.e. ASD). The EPC felt that these maximum conditions placed on the design of standard SJI Joist Girders were overly restrictive and have been working to expand the length and depth range as well as increase the panel point loading. The committee recognized that joist loadings are getting heavier, joist spacings are getting wider and in the near future the SJI will be issuing its first composite joist specification, designated the CJ-Series so it was imperative that the Weight Tables be revised to accommodate these changes. The 2005 SJI Specification limits on Joist Girders will be as follows: Maximum span is 120 feet; Maximum depth is 120 inches; and the Maximum unfactored panel point load is 56 kips. The revised **Design Guide Weight Table for Joist Girders** is based on a maximum chord angle size of 6 x 6 x 3/4 that is available to all joist manufacturers. The committee also realized that there may be some joist manufacturers that will be able to utilize up to an 8 x 8 chord angle, but that any design with this angle will be considered a non-standard SJI product.

The Joist Girder weight tables are only provided as a design aid for the structural engineer to help provide an approximate value for the Joist Girder self-weight. Therefore, the weight tables do not cover every combination of span, panel point spacing and kip loading. The Specifying Professional should be able to interpolate between values in the tables when a Joist Girder falls within any of the “gaps” in the weight tables.

The last major item that was revised in the Catalog was the Underwriter’s Laboratory Fire-Resistance Ratings with Steel Joists which has now been moved to Appendix D. The appendix covers Roof-Ceiling Assemblies and Floor-Ceiling Assemblies with both Membrane Protection and Spray-Applied Fire Resistive Materials. All the tables are presented by hourly rating in a Restrained Assembly condition as defined by UL. Only those UL Numbers that refer to currently manufactured joists are included in the tables. This means that any UL Number that specifically called out or illustrated a steel joist with a round rod bottom chord has been removed since no joist manufacturer currently produces that type of K-Series joist.

The EPC felt that there has been much confusion in the past regarding the specification of a UL Fire Resistance Assembly and subsequently the design of the joists required to meet that UL Number. Therefore the following clarifications have been provided in the Appendix. Whenever a UL Fire Resistance Assembly is being utilized, the Specifying Professional shall indicate the UL Number on the structural contract drawings. In addition, the Specifying Professional shall evaluate the applicability of the following conditions set by UL from their specific testing protocols:

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

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

### Specification Highlights

The major effort faced by the SJI's Engineering Practice Committee was to be able to provide a smooth transition between steel joist and Joist Girder design using Allowable Stress Design and having an alternate design methodology for Load and Resistance Factor Design that would, in effect, produce the same joist whether ASD or LRFD was used. Since 1994 the SJI has offered a conversion method for use with LRFD and in 2000 a *Guide for Specifying Joists with Load and Resistance Factor Design* (SJI 2000) was published that contained LRFD design examples, LRFD Load Tables for K-Series, KCS, LH-Series, DLH-Series and LRFD Weight Tables for Joist Girders. The *Guide* stated, "The Steel Joist Institute is currently developing an LRFD design specification for our products. At some point in the future, the joist industry as a whole will uniformly switch our internal design programs from the current ASD specifications to a new LRFD specification."

When the American Institute of Steel Construction decided that its *Specification for the Design of Steel Buildings* (AISC 2005) was to be a combined Allowable Strength Design and Load and Resistance Factor Design specification, SJI's EPC decided that it would be in the best interest of the joist industry to follow the same direction as AISC. The committee began working on unified specifications for the K-Series, LH- and DLH-Series and Joist Girders. The most important results of the EPC's efforts are contained in Section 4. Design and Manufacture from the OPEN WEB STEEL JOISTS, K-SERIES Specification, Section 103. Design and Manufacture from the LONGSPAN AND DEEP LONGSPAN STEEL JOISTS, LH- AND DLH-SERIES Specification and Section 1003. Design and Manufacture from the JOIST GIRDERS Specification.

The Specifying Professional can now choose to design the steel joists and Joist Girders using ASD or LRFD. Since each of the joist series have similar language, the new K-Series Specification will be used to describe the changes that were made in more detail. Therefore, once the decision is made as to which design methodology is to be used then the appropriate parts of Subsections 4.1 Method, 4.2 Design and Allowable Stresses, and 4.4 Members need to be applied to the joist design. Only two basic Load combinations are given:

LRFD     1.4D  
          1.2D + 1.6 (L, or L<sub>r</sub>, or S, or R)

ASD       D  
          D + (L, or L<sub>r</sub>, or S, or R)

Otherwise, when special loads are specified and the Specifying Professional does not provide the load combinations, the provisions of ASCE 7 *Minimum Design Loads for Buildings and Other Structures* (ASCE 2002) shall be used for LRFD and ASD load combinations.

It is the responsibility of the Specifying Professional to provide all the required loads and load combinations to the joist manufacturer and that the design code (e.g. IBC 2006) being used is specified on the contract drawings. The load and load combinations need to be clearly identified as factored (LRFD) or unfactored (ASD) and can be shown in a joist or Joist Girder load schedule or load diagram. It should be noted that the current IBC 2003 offers two different load combinations for use with ASD design, Basic Load Combinations (Section 1605.3.1) and

Alternate Basic Load Combinations (Section 1605.3.2). Identifying which code section was used for the overall building structure will ensure that the joists and Joist Girders will be designed to the same load combinations. If a different set of load combinations is required, they should be specified on the contract drawings. It is also important for the Specifying Professional to provide net uplift values where the joist manufacturer needs to consider uplift in the joist or Joist Girder design. If the uplift forces shown on the contract drawings are displayed as gross uplift, the joist manufacturer may conservatively design for the full force without deducting any dead load, or will need to verify a net uplift value. Many contract drawings do not show the dead loads used in design, and even if they do, it is the solely the Specifying Professional's decision to consider some of the dead load as collateral and not be deducted from the gross uplift. When earthquake loads are a design consideration, the joist manufacturer will use different load combinations for  $E$  or  $E_m$  loads, so the contract drawings need to make a clear distinction between these two types of loads. If axial loads or moments are also a design consideration, these need to be clearly identified along with their applicable load combinations.

The following LRFD Resistance Factors ( $\phi$ ) and ASD Safety Factors ( $\Omega$ ) are defined for determining tension, compression and bending stresses:

Tension	$\phi_t = 0.90$	$\Omega_t = 1.67$
Compression	$\phi_c = 0.90$	$\Omega_c = 1.67$
Bending	$\phi_b = 0.90$	$\Omega_b = 1.67$

The equations in Section 4.2 Design and Allowable Stresses are used to calculate the design stresses (LRFD) or the allowable stresses (ASD) in tension, compression and bending for chords and webs. For (b) Compression:

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

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

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

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

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

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

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

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

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

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

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

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

Section 4.4 Members addresses the design of chords, webs and extended ends. The specification states that when the panel length exceeds 24 inches, the top chord shall be designed as a continuous member subject to combined axial and bending stresses and shall be so proportioned that:

For **LRFD**:

$$\text{at the panel point:} \quad f_{au} + f_{bu} \leq 0.9 F_y \quad (4.4-1)$$

at the mid panel:

$$\text{for,} \quad \frac{f_{au}}{\phi_c F_{cr}} \geq 0.2, \quad \frac{f_{au}}{\phi_c F_{cr}} + \frac{8}{9} \left[ \frac{C_m f_{bu}}{\left[ 1 - \left( \frac{f_{au}}{\phi_c F_e} \right) \right] Q \phi_b F_y} \right] \leq 1.0 \quad (4.4-2)$$

$$\text{for,} \quad \frac{f_{au}}{\phi_c F_{cr}} < 0.2, \quad \left( \frac{f_{au}}{2\phi_c F_{cr}} \right) + \left[ \frac{C_m f_{bu}}{\left[ 1 - \left( \frac{f_{au}}{\phi_c F_e} \right) \right] Q \phi_b F_y} \right] \leq 1.0 \quad (4.4-3)$$

- $f_{au}$  =  $P_u/A$  = Required compressive stress, ksi (MPa)  
 $P_u$  = Required axial strength using LRFD load combinations, kips (N)  
 $f_{bu}$  =  $M_u/S$  = Required bending stress at the location under consideration, ksi (MPa)  
 $M_u$  = Required flexural strength using LRFD load combinations, kip-in. (N-mm)  
 $S$  = Elastic Section Modulus, in.<sup>3</sup> (mm<sup>3</sup>)  
 $F_{cr}$  = Nominal axial compressive stress in ksi (MPa) based on  $\ell/r$  as defined in Section 4.2(b)  
 $C_m$  = 1 - 0.3  $f_{au}/\phi F_e$  for end panels  
 $C_m$  = 1 - 0.4  $f_{au}/\phi F_e$  for interior panels  
 $F_y$  = Specified minimum yield strength, ksi (MPa)  
 $F_e = \frac{\pi^2 E}{(\ell / r_x)^2}$ , ksi (MPa)  
 Where  $\ell$  is the panel length, in inches (millimeters), as defined in Section 4.2(b) and  $r_x$  is the radius of gyration about the axis of bending  
 $Q$  = Form factor defined in Section 4.2(b)  
 $A$  = Area of the top chord, in.<sup>2</sup> (mm<sup>2</sup>)

For **ASD**:

$$\text{at the panel point:} \quad f_a + f_b \leq 0.6 F_y \quad (4.4-4)$$

at the mid panel:

$$\text{for} \quad \frac{f_a}{F_a} \geq 0.2, \quad \frac{f_a}{F_a} + \frac{8}{9} \left[ \frac{C_m f_b}{\left[ 1 - \left( \frac{1.67 f_a}{F_e} \right) \right] Q F_b} \right] \leq 1.0 \quad (4.4-5)$$



$$\text{for } \frac{f_a}{F_a} < 0.2, \quad \left( \frac{f_a}{2F_a} \right) + \left[ \frac{C_m f_b}{1 - \left( \frac{1.67 f_a}{F_e} \right)} \right] QF_b \leq 1.0 \quad (4.4-6)$$

- $f_a$  =  $P/A$  = Required compressive stress, ksi (MPa)  
 $P$  = Required axial strength using ASD load combinations, kips (N)  
 $f_b$  =  $M/S$  = Required bending stress at the location under consideration, ksi (MPa)  
 $M$  = Required flexural strength using ASD load combinations, k-in. (N-mm)  
 $S$  = Elastic Section Modulus, in.<sup>3</sup> (mm<sup>3</sup>)  
 $F_a$  = Allowable axial compressive stress based on  $\ell/r$  as defined in Section 4.2(b), ksi (MPa)  
 $F_b$  = Allowable bending stress;  $0.6F_y$ , ksi (MPa)  
 $C_m$  =  $1 - 0.50 f_a/F_e$  for end panels  
 $C_m$  =  $1 - 0.67 f_a/F_e$  for interior panels

The SJI's unified specifications are still stress based whereas the new AISC specification (AISC 2005) is force based so Allowable Stress Design, ASD, is now Allowable Strength Design, ASD. For the practicing structural engineer specifying steel joists and Joist Girders nothing technical was actually changed. The equations that the joist manufacturers will use to analyze and design the joist and Joist Girder members will have changed, but the assumptions and principles that govern the design of the joists and Joist Girders have not changed.

### Code of Standard Practice Highlights

The Engineering Practice Committee made several changes to the **Code of Standard Practice for Steel Joists and Joist Girders**. First, the word "Recommended" has been removed from the title of this document. It was felt that it should be more than a recommendation to the engineering community. The Code of Standard Practice or COSP should be the document that is referenced in all contract documents along with the Standard Specifications. The topics in Section 2. Joists and Accessories have been modified and edited to be more consistent with what is found in the plans. Subsection 2.2 Joist Location and Spacing has been added though it was previously Subsection 5.3. Section 5. Estimating now only has two Subsections: 5.1 Plans for Bidding and 5.2 Scope of Estimate. Section 6. Plans and Specifications has been revised. Subsection 6.1 Plans Furnished by Buyer now contains extensive information on loads, connections and special considerations that was not part of the COSP previously. The new language reads,

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

#### (a) Loads –

The Steel Joist Institute does not presume to establish the loading requirements for which structures are designed.

The Steel Joist Institute Load Tables are based on uniform loading conditions and are valid for use in selecting joist sizes for gravity loads that can be expressed in terms of "pounds per linear foot" (kiloNewtons per Meter) of joist. The Steel Joist Institute Joist Girder Weight Tables are based on uniformly spaced panel point loading conditions and are valid for use in selecting Joist Girder sizes for gravity conditions that can be expressed in kips (kiloNewtons) per panel point on the Joist Girder.

The **specifying professional** shall provide the nominal loads and load combinations as stipulated by the applicable code under which the structure is designed and shall provide the design basis (ASD or LRFD).

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

The **specifying professional** shall give due consideration to the following loads and load effects:

1. Ponded rain water.
2. Accumulation of snow in the vicinity of obstructions such as penthouses, signs, parapets, adjacent buildings, etc.
3. Wind.
4. Type and magnitude of end moments and/or axial forces at the joist and Joist Girder end supports shall be shown on the structural drawings. For moment resisting joists or Joist Girders 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 or Joist Girder top chord and the column.

Avoid resolving joist or Joist Girder end moments and axial forces through the 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 shall be designed by the **specifying professional**. The joist designer shall furnish the **specifying professional** with the joist detail information if requested.

The nominal loads, as determined by the **specifying professional**, shall not be less than that specified in the applicable building codes.

Where concentrated loads occur, the magnitude and location of these concentrated loads shall be shown on the **structural drawings** when, in the opinion of the **specifying professional**, they may require consideration by the joist manufacturer.

The **specifying professional** shall use one of the following options that allows the:

- Estimator to price the joists.
- Joist manufacturer to design the joists properly.
- Owner to obtain the most economical joists.

**Option 1:** Select a Standard Steel Joist Institute joist for the uniform design loading and provide the load and location of any additional loads on the structural plan with a note "Joist manufacturer shall design joists for additional loads as shown". This option works well for a few added loads per joist with known locations.

**Option 2:** Select a KCS joist using moment and end reaction. This option works well for concentrated loads for which exact locations are not known or for multiple loading. See examples and limitations on the pages accompanying the KCS Joist Load Table.

- a) Determine the maximum moment
- b) Determine the maximum end reaction (shear)
- c) Select the required KCS joist that provides the required moment and end reaction (shear).

**Option 3:** Specify a SPECIAL joist with load diagrams. This option is preferred when the joist includes loading that cannot clearly be denoted on the structural drawings.

- a) Provide a load diagram to clearly define ALL loads
- b) Place the designation ( i.e. 18K SP or 18LHSP ) under the load diagram with the following note: "Joist manufacturer to design joist to support loads as shown above."

CAUTION: The **specifying professional** shall compare the equivalent uniform loads derived from the maximum moment and shear to the uniform loads tabulated in the **K-Series Load Table**. An equivalent unfactored uniform load in excess of 550 plf (8020 N/m) or a maximum unfactored end reaction exceeding 9200 lbs. (40.9 kN) indicate that the **specifying professional** shall consider using additional joists to reduce the loading or use an **LH-Series Joist** and make provisions for 5 inch (127 mm) deep bearing seats.

**SPECIAL LOADING:** Please note the load combinations shown are for referenced examples only and it is not to be presumed that the joist designer is responsible for the applicable building code load combinations. If the loading criteria are too complex to adequately communicate in a simple load diagram, then the specifying professional shall provide a load schedule showing the specified design loads, load categories, and required load combinations with applicable load factors.

#### **(b) Connections –**

Minimum End Anchorage for simple span gravity loading shall be in accordance with Steel Joist Institute Standard Specifications Load Tables & Weight Tables Section 5.6 for **K-Series**, Section 104.4 for **LH** and **DLH-Series**, and Section 1004.6 for Joist Girders. The **specifying professional** is responsible for the design of the joist and Joist Girder connection when it is subject to any loads other than simple span gravity loading including uplift and lateral loads. The **specifying professional** is also responsible for bridging termination connections. The contract documents must clearly illustrate these connections.

#### **(c) Special Considerations**

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

- a) Profiles for non-standard joist and joist girder configurations (Standard joist and joist girder configurations are as indicated in the Steel Joist Institute Standard Specifications Load Tables & Weight Tables)
- b) Oversized or other non-standard web openings
- c) Extended Ends
- d) Deflection criteria for live and total loads for non-SJI standard joists
- e) Non-SJI standard bridging

Figures 3 and 4 illustrate the use of load diagrams for a given LRFD load combination,  $1.2 D + 1.6 S$ , and the same ASD load combination,  $D + S$ , in accordance with ASCE 7.

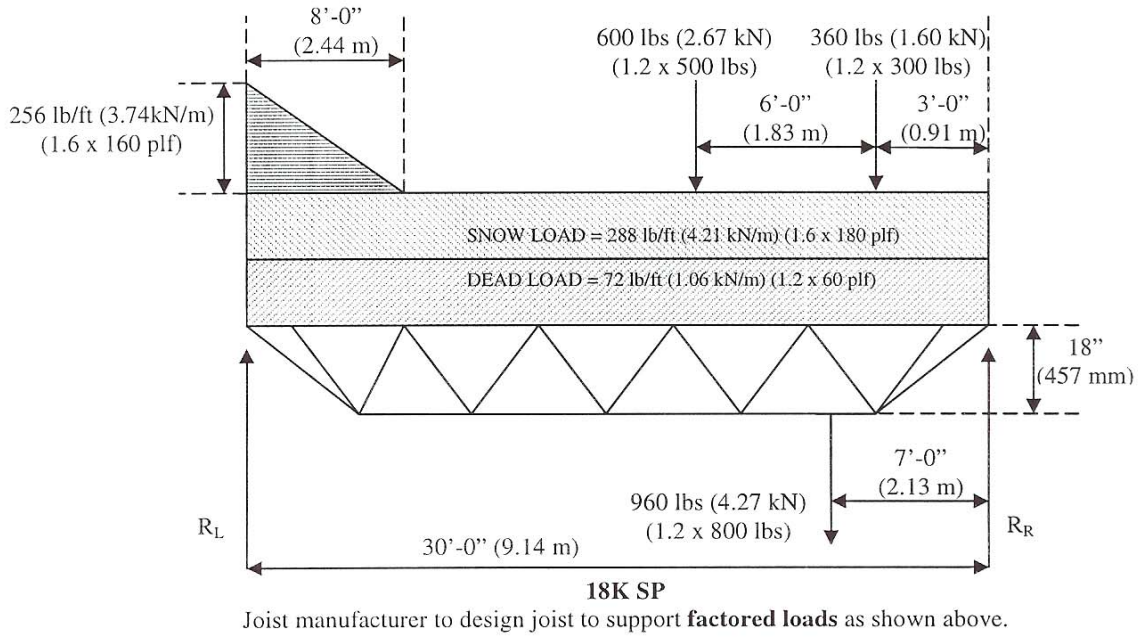


Figure 3 LRFD Example U.S. Customary Units (Metric Units), Load Diagram per ASCE 7 2.3.2(3)  $1.2D + 1.6S$

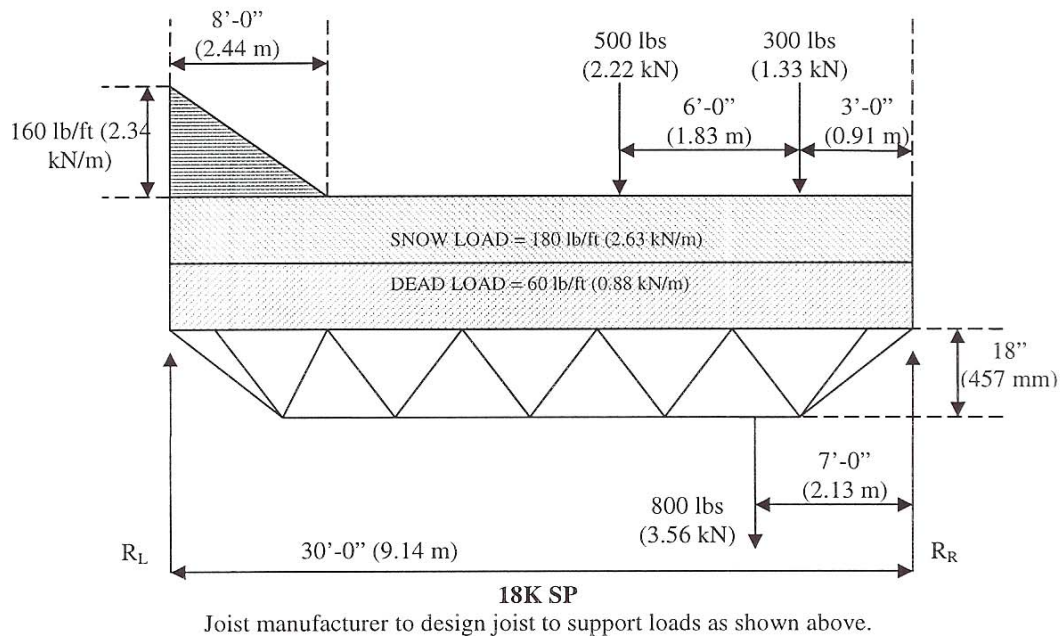


Figure 4 ASD Example U.S. Customary Units (Metric Units), Load Diagram per ASCE 7 2.4.1(3)  $D + S$

## THE INTERNATIONAL BUILDING CODE

The 2003 International Building Code (ICC 2003) in CHAPTER 22 STEEL, SECTION 2206 STEEL JOISTS carried the following language for the use of steel joist and Joist Girder products,

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

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

This was the extent that steel joists and Joist Girders were addressed by the IBC.

It was felt by many practicing structural engineers as well as building officials that the language contained in the IBC 2003 needed to be revised and updated to more accurately reflect what a joist manufacturer acting as a specialty steel fabricator or supplier as well as a Specialty Joist Engineer was responsible for as part of the contract documents. Between 2002 and 2005 numerous meetings and hearings were attended by Building Code Officials (ICC), members of the National Council of Structural Engineers Association (NCSEA) and the Steel Joist Institute (SJI). In October 2005 the final hearings took place with an amendment to the code being approved for inclusion in the IBC 2006 that contained compromise language between all parties. It is hoped that this new language will ensure that the responsibilities of the SJE and the SEOR will be clearly met.

The IBC 2006 will now contain five sections. Section 2206.1 General remains unchanged and four new sections are added to the code. The language in these new sections is as follows:

2206.2 Design. The Registered Design Professional shall indicate on the construction documents the steel joist and/or steel joist girder designations from the specifications listed in Section 2206.1 and shall indicate the requirements for joist and joist girder design, layout, end supports, anchorage, non-SJI standard bridging, bridging termination connections and bearing connection design to resist uplift and lateral loads. These documents shall indicate special requirements as follows:

1. Special loads including:
  - a) Concentrated loads,
  - b) Non-uniform loads,
  - c) Net uplift loads,
  - d) Axial loads,
  - e) End moments, and,
  - f) Connection forces
2. Special considerations including:
  - a) Profiles for non-standard joist and joist girder configurations (Standard joist and joist girder configurations are as indicated in the SJI catalog).
  - b) Oversized or other non-standard web openings, and,
  - c) Extended ends
3. Deflection criteria for live and total loads for non-SJI standard joists

2206.3 Calculations. The steel joist and joist girder manufacturer shall design the steel joists and/or steel joist girders in accordance with the current Steel Joist Institute Specifications and Load Tables to support the load requirements of Section 2206.2. The Registered Design Professional may require submission of the steel joist and joist girder calculations as prepared by a registered design professional responsible for the product design. If requested by the Registered Design Professional, the 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:

1. Non-SJI standard bridging details (e.g. for cantilevered conditions, net uplift, etc.)
2. Connection details for:
  - a) Non-SJI standard connections (e.g. flush framed or framed connections)
  - b) Field splices, and
  - c) Joist headers

2206.4 Steel Joist Drawings. Steel joist placement plans shall be provided to show the steel joist products as specified on the construction documents and are to be utilized for field installation in accordance with specific project requirements as stated in Section 2206.2. Steel placement plans shall include, at a minimum, the following:

1. Listing of all applicable loads as stated in Section 2206.2 and used in the design of the steel joists and joist girders as specified in the construction documents,
2. Profiles for non-standard joist and joist girder configurations (Standard joist and joist girder configurations are as indicated in the SJI Catalog)
3. Connection requirements for:
  - a) Joist supports,
  - b) Joist girder supports,
  - c) Field splices, and,
  - d) Bridging attachments
4. Deflection criteria for live and total loads for non-SJI standard joists
5. Size, location, and connections for all bridging
6. Joist headers

Steel joist placement plans do not require the seal and signature of the joist manufacturer's registered design professional.

2206.5 Certification. At completion of fabrication, the steel joist manufacturer shall submit a certificate of compliance per Section 1704.2.2 and stating that work was performed in accordance with approved construction documents and with Steel Joist Institute Standard Specifications.

### **PRACTICAL USAGE**

With the Specification now allowing the choice of two different design methods, it becomes critically important that a few key pieces of information be communicated from the Specifying Professional to the joist manufacturer on every project. This can be accomplished with general notes on the structural contract drawings.

First and foremost, the structural contract drawings need to indicate if the structural design, and therefore the joist design, is to be ASD or LRFD. For a simple job with only standard K-, LH-, or DLH-Series joists, the design method will not matter in terms of the joist design. However, as soon as any additional loading conditions (such as net uplift), special joist designations, or any Joist Girders are involved, the joist manufacturer will need to know which design method to follow.

Secondly, the structural contract drawings should indicate the applicable model building code. While the joist manufacturer is not responsible for building code interpretation, the reference to a specific code will provide

direction for load combinations that may be required beyond those in the SJI Specification. The Specifying Professional can and should also provide the specific load combinations to be used in the event of unusual or complex loading conditions.

Thirdly, where the LRFD method is being used, it is recommended that all design loads given on the contract drawings for the joist manufacturer be displayed as factored loads. This is a critical coordination item, as a misunderstanding about whether the loads have already been factored or not can result in a potentially unsafe, or overly conservative, design. The current practice for many additional joist and Joist Girder loads is to specify only the total magnitude of the load, and not the specific dead and live load components of the load. In some cases the nature of the load, and hence the appropriate load factor to use, would be obvious to the joist manufacturer. But, there are many cases where a point load may be a combination of dead and live load components. The reaction from an outrigger is one such example. Joist Girders are similar in that the designation provides only a total load and not the portions that are dead and live load. For this reason it is requested that the contract drawings provide all point loads as factored loads, and that the drawings provide notation to that effect.

A suggested convention for LRFD Joist Girder designations is to replace the “K” at the end of the designation (which represents “kips”) with the letter “F” to indicate the kip loading has already been factored. Hence, 48G10N12K would be an ASD girder designation, while 48G10N18F would be an LRFD girder designation.

A design example, in both ASD and LRFD, follows, to demonstrate the contract drawing conventions outlined above, and the use of the new Specification.

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

Joist span = 40 feet	DL = 25 psf
Girder span = 36 feet	LL = 25 psf
Joist spacing 6'-0" on centers	Gross Uplift = 20 psf

ASD selections:

Joist capacity  $\geq 6$  ft. (50 psf) = 300 plf  
Therefore, select 24K9  
Joist Girder 40 ft. (300 plf) = 12<sup>K</sup> + self weight  
Therefore, select 36G6N12.3K

LRFD selections:

Joist capacity  $\geq 6$  ft.  $[1.2(25) + 1.6(25)] = 420$  plf  
Therefore, select 24K8  
Joist Girder 40 ft. (420 plf) = 16.8<sup>K</sup> + self weight  
Therefore, select 36G6N17.1F

Figure 5 shows the typical bay with the use of ASD and Figure 6 shows the typical bay with LRFD. Note the following with regard to each of these figures:

- The framing plan notes clearly indicate the design method, the applicable model code, the net wind uplift pressure, and if the loads are factored or unfactored.
- For the ASD example, the required joist capacity falls between designations 24K8 and 24K9, so a 24K9 was selected to provide the required capacity. There would be no visible difference between an ASD and an LRFD 24K9 joist. However, in this example the ratio of live to dead load is such that the factored LRFD load allows the selection of a 24K8 instead of a 24K9. The use of the LRFD method may create some economies like this whenever the ratio of live load to dead load is significantly less than 3 to 1.
- In this bay, there are two special joists to support a hanging catwalk. These have been designated with a “load/span” format, as shown in the figures. In Figure 6, with LRFD, the total load used in the special joist designation has been factored. The live load is an unfactored service load, used only for the deflection check.

- The catwalk load is an example of a load that probably has both a dead and live component. So the Specifying Professional applies the appropriate load factors to those components, and simply presents the total catwalk loads, already factored
- The girder designation in Figure 5, ASD, has the unfactored kip load and ends with the letter “K”. The girder designation in Figure 6, LRFD, has a factored kip load, and ends with the letter “F”. In both cases, the specified girder kip loading includes an allowance for the Joist Girder self weight in addition to the joist reactions.
- The special joists create additional loads on the supporting Joist Girders. These loads are shown in the figures at the joist bearing locations where they apply, and in the case of LRFD, the loads have already been factored.
- There is a seismic top chord axial load noted for one joist in each figure. The load is the same in each figure because the LRFD load factor is 1.0. For the ASD example, the IBC code allows the use of a 0.7 factor in certain combinations, but this factor has not been used in the example. The reason for this is that the controlling load case for a top chord axial load will typically involve the dead, live, and seismic loads. The joist manufacturer will utilize the load reduction allowed by IBC of 0.75 for two transient loads. But IBC does not allow the use of the 0.7 factor with E when using this load reduction.
- In each figure, the net wind uplift is provided. For these examples, the IBC load combinations of  $0.6D + W$  for ASD, and  $0.9D + 1.6W$  for LRFD were utilized to arrive at the net uplift. The Specifying Professional should provide the net uplift because for standard designation joists, the design dead load may not be given. Also, it is the Specifying Professional’s judgment if there is a significant portion of the dead load that should be considered as a collateral load, and hence, a more conservative load combination than IBC should be utilized.

Note that for these examples the net wind uplift load is relatively light. The SJI Specification requires that where net uplift is a design consideration, a row of bottom chord bridging is required adjacent to the first bottom chord panel points at each end. However, this does not necessarily mean that the bottom chord requires two rows in addition to the number of top chord rows. Nor is it required that the top and bottom chord horizontal bridging rows align. So for these design examples, the SJI Specification requirements can be met with a bridging configuration as shown in Figure 7. This would be determined by the joist manufacturer, and be shown on their placing plan.

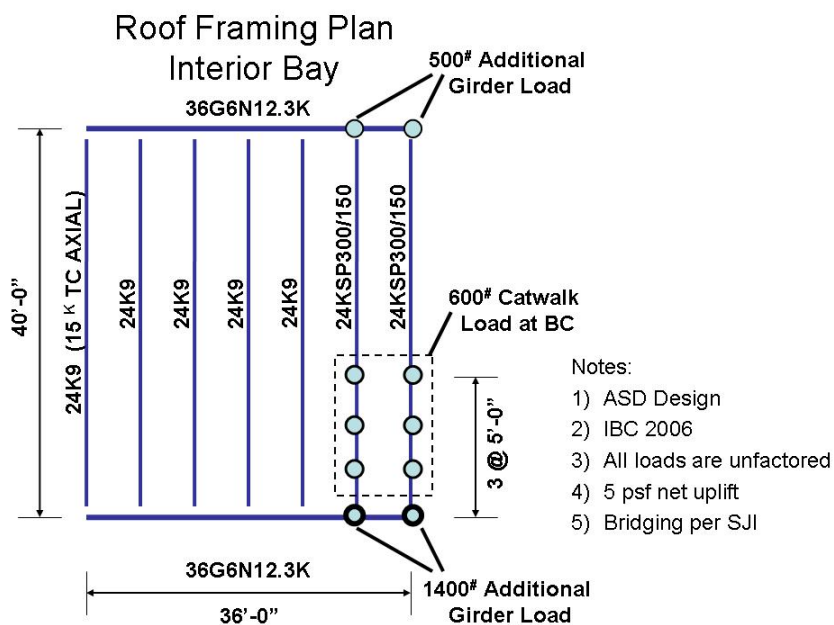
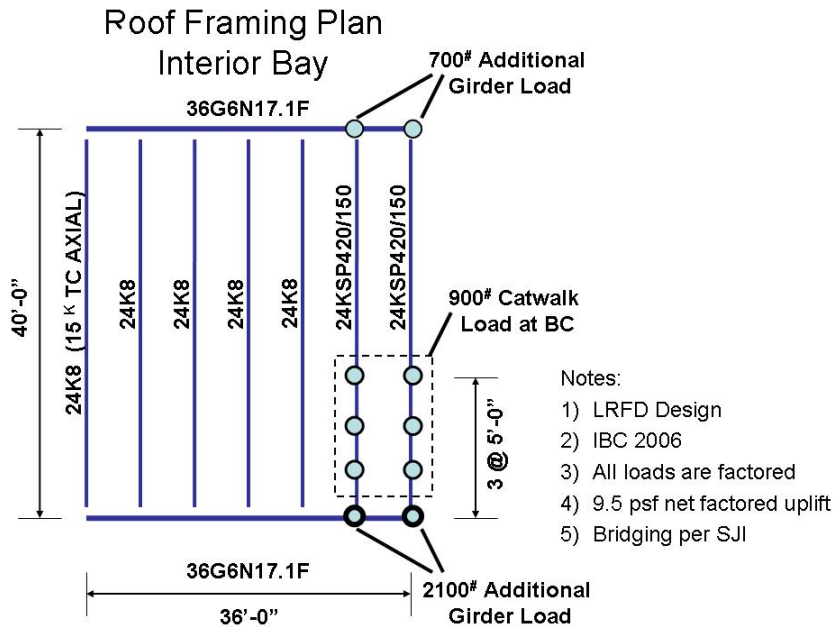
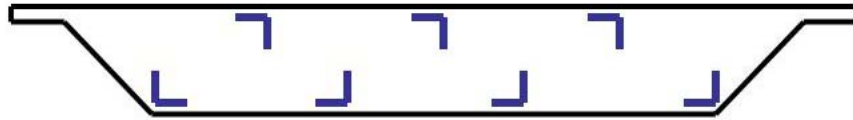


Figure 5 Roof Framing Plan Design using ASD





*Figure 6 Roof Framing Plan using LRFD*



*Figure 7 Bridging Layout*

## REFERENCES

- American Institute of Steel Construction, Inc. (AISC) (2005), *Specification for Structural Steel Buildings*, Chicago, IL.
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