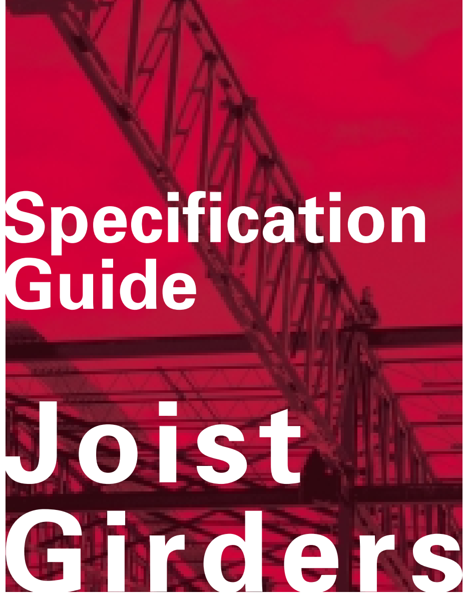


Specification Guide

Joist Girders

CANAM

Joists and Steel Deck

A division of Canam Group

TABLE OF CONTENTS

1. GENERAL

1.1 FORWARD

The present catalogue was developed to assist engineers in the specification of Canam joist girders.

It includes the advantages of using joist girders, the principles guiding their use in a building, as well as standard connections. The catalogue is also a selection tool for choosing the most economical joist girder depth.

The information presented in this catalogue was prepared according to recognized engineering principles and is for general use. Although every effort has been made to ensure that the information in this catalogue is correct and complete, it is possible that errors or oversights may have occurred. Canam reserves the right to change, revise or withdraw any product or procedure without notice.

1.2 DESCRIPTION OF A CANAM JOIST GIRDER

1.2.1 DEFINITION

A Canam joist girder is a primary structural component of a building. Generally, it supports floor or roof joists in simple span conditions, or other secondary elements (purlins, wood trusses, etc.) evenly spaced along the length of the joist girder. The loads applied to a spandrel joist girder come from one side, while on an inside bay the loads are applied on either side of the joist girder.

GIRTS AND JOIST GIRDERS ROOF SYSTEM (DECK PLANT, BOUCHERVILLE)

JOISTS AND JOIST GIRDERS ROOF SYSTEM (DISTRIBUTION CENTER, SPOKANE)

1.2.2 COMPONENTS OF A CANAM JOIST GIRDER

An open web joist girder, or commonly known as a Canam joist girder, is composed of a top chord and a bottom chord which are usually parallel to each other. These chords are held in place using vertical and diagonal web members. In conventional construction, a joist girder rests on a column and the bottom chord is held in place horizontally by a stabilizing plate.

The standard main components are (see Figure 1):

1. **Top and bottom chords:** two angles back-to-back with a gap varying between *25 mm (1 in.)* and *75 mm (3 in.)*,
2. **Diagonals:** U-shaped channels or two angles back-to-back,
3. **Verticals:** U-shaped channels, boxed angles or HSS,
4. **Shoes:** two angles back-to-back.

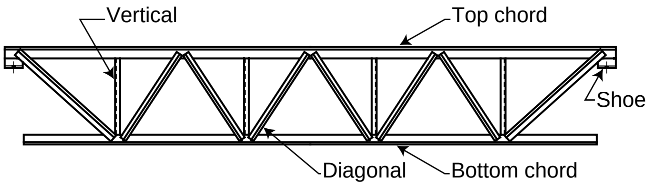


Figure 1
Components of a Canam joist girder

1.3 ADVANTAGES OF CANAM JOIST GIRDERS

The use of open web joist girders is widespread in North America, mostly in the United States, for roof construction of commercial and industrial buildings. The joist girders are advantageous compared with conventional load bearing systems composed of beams with a W profile. The illustration in Figure 2 provides the various options for supporting systems when designing a steel building.

Economical factors associated with the specification of Canam joist girders include the following:

1. The steel used in joist girders has a yield strength higher than steel used in beams (*380 MPa* or *55 ksi* vs *350 MPa* or *50 ksi* for shaped or welded beams).
2. Better cost control for material purchases (angles) on the Canadian market compared with importing the beam sections.
3. Open web joist girders are lighter than the full web beams of the same depth.
4. The joist girders can be used to facilitate the installation of ventilation ducts and plumbing as compared to a beam as shown in Figure 3.
5. The speed and ease of site erection improves jobsite co-ordination.

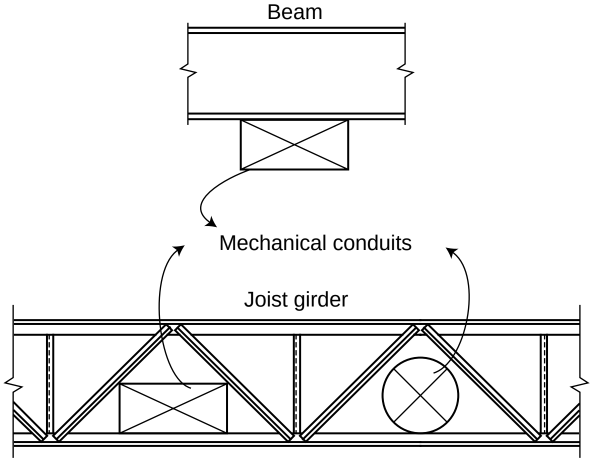


Figure 3
Passage of mechanical conduits

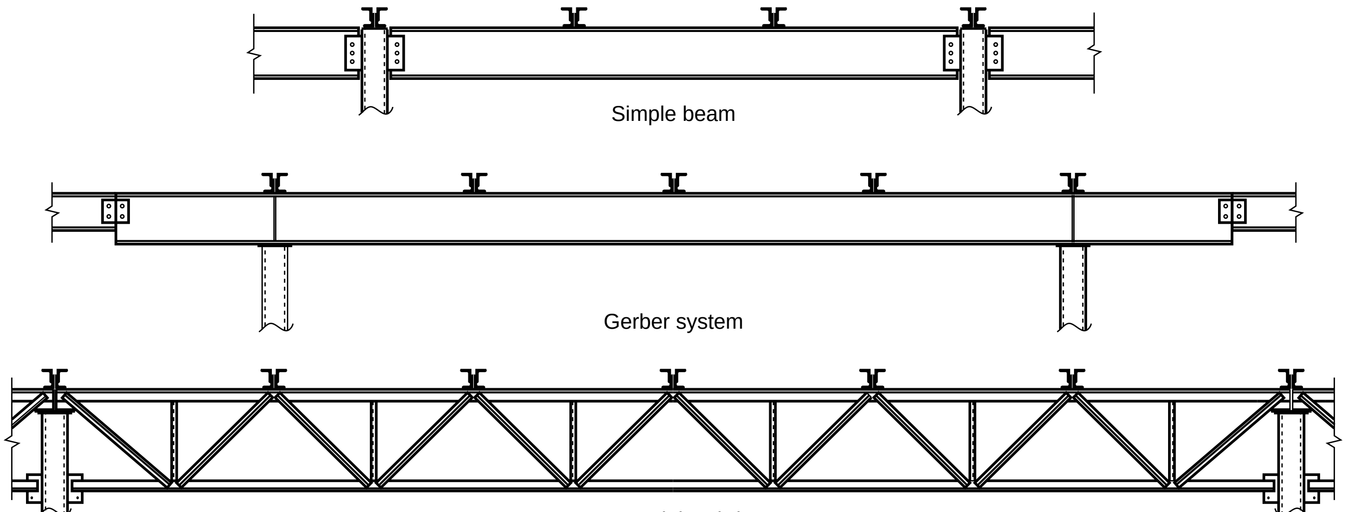


Figure 2
Carrying system


PASSAGE OF A VENTILATION DUCT (LOBLAW'S)

If a larger opening is required, a diagonal member can be removed if the top and bottom chord are reinforced.


OPENING REINFORCEMENT (ING CANADA)

The building designer must consider the following to ensure the economical use of joist girders:

1. **Longer spans** of joist girders are preferred as this reduces the number of columns inside a building.
2. **Greater depths** reduce the size of the top and bottom chords for increased weight savings.
3. **Bay arrangement** should be repetitive since designing and fabricating many identical pieces will reduce production costs.
4. **Regular joist spacing** must be maintained by the building designer by lining up the joists on either side of the joist girders.
5. **Rectangular bays** are recommended, in a roof or floor system using joist girders and joists, where the longest dimension corresponds to the joist span, while the shortest dimension corresponds to the joist girder span. An optimal rectangular bay would typically have a ratio of joist span to joist girder span of approximately *1.5* (see Figure 4).
6. **Bearing shoes** are used for economical joist girder to column connection, usually *190 mm (7.5 in.)* deep, bolted to the top of the column or on a bearing bracket on the web or the flange of the column.

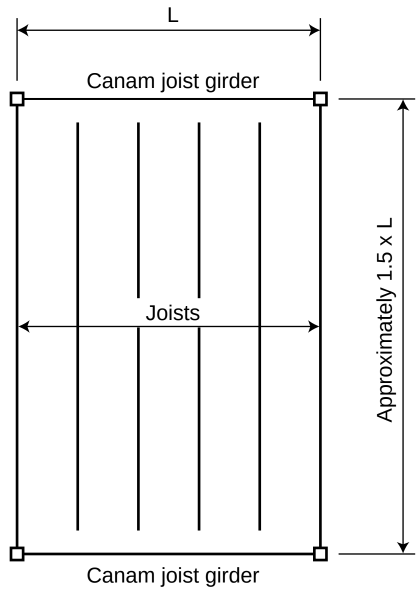


Figure 4
Optimal rectangular bay


JOIST GIRDER SITTING ON A BRACKET CONNECTED TO THE WEB OF A COLUMN (ING CANADA)

2. Design Standards

2.1 Engineering Standards

Joist girder design is based on the latest issue of the design standards:

- CAN/CSA-S16, Limit States Design of Steel Structures

  Specifically, section 15 of Standard S16-01 deals with "conventional" joist girders as opposed to composite joist girders.

  Canam joist girders are analyzed according to the simplified method (Clause 15.1.1). All the panel points of top and bottom chords are considered as pins, the effective length factors are equal to one and no secondary moment is calculated due to deflections of the joist girder.
- CAN/CSA-S136, North American Specification for the Design of Cold-Formed Steel Structural Members.

2.2 Joist Girder to Column Connections

2.2.1 BEARING REACTION

This section is intended to present to the building designer possible positions of the joist girder on the column. Consider the following three types of connections: bearing on top of the column, bearing on a bracket facing the column, and bearing facing the column but with a reaction at the center. For the first two types, the impact of connecting one or two joist girders to the column is also presented.

The building designer must consider these special conditions when designing the column.

2.2.1.1 BEARING ON TOP OF THE COLUMN

A bearing on top of the column is the most economical solution. Sufficient shoe depth (usually *190 mm* or *7.5 in.*) allows a reaction close to the center of the column. However, the slope of the end diagonal of the joist girder along with the width of the column may move the position of the reaction away from the center of the column.

In general, the reaction of the joist girder occurs at the center or to the outside of the centerline of the shoe (see Figure 5).

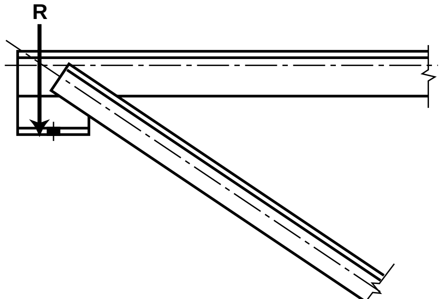


Figure 5
Joist girder reaction

Even if there is only one joist girder bearing on top of the column, an extension of the shoe to completely cover the column does not guarantee that the reaction will be located at the center of the column (see Figure 6). As previously mentioned, the physical limitations may restrict design.

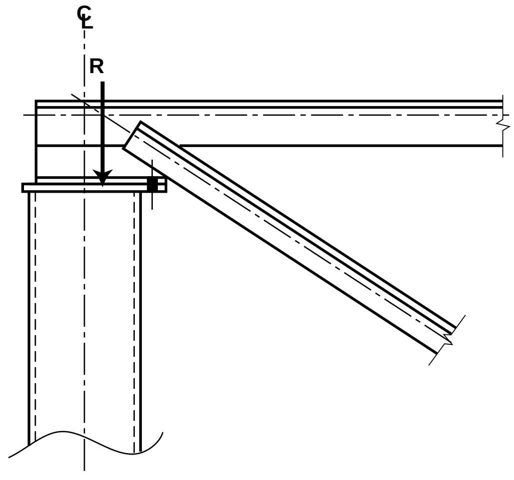


Figure 6
Joist girder reaction on top of the column

When two joist girders are bearing on top of a column (Figure 7), their reactions are produced closer to the exterior faces of the column. Unbalanced reactions caused by varying bay dimensions, different bay loads, or by unbalanced loading conditions, as prescribed in the *National Building Code of Canada*, may cause bending stress in the column.

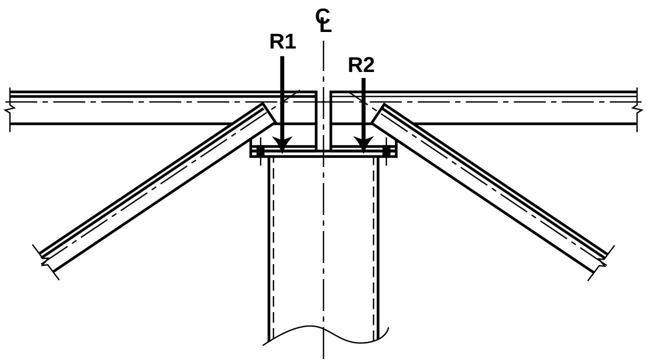


Figure 7
Reactions of two joist girders on top of the column

2.2.1.2 BEARING FACING THE COLUMN

When the joist girder bearing is facing the column, a bending moment is induced in the column. However, a bracket bearing (Figure 8) is more economical for the fabrication of the joist girder compared to other bearing connections presented in Figures 9 and 10.

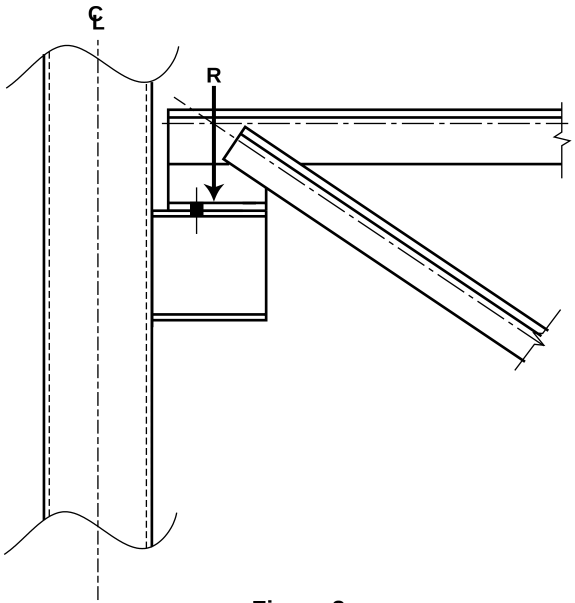


Figure 8
Joist girder sitting on a column bracket

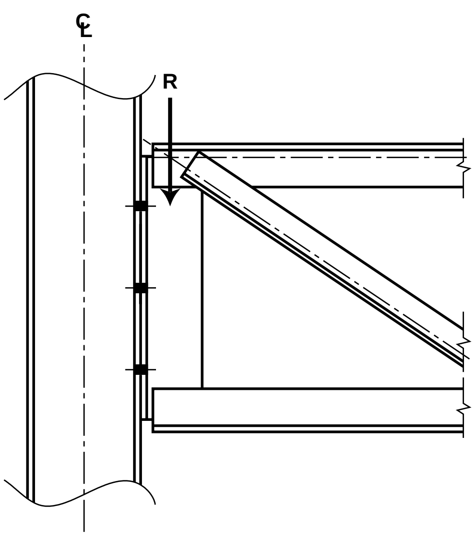


Figure 9
Web girder connection - Model 1

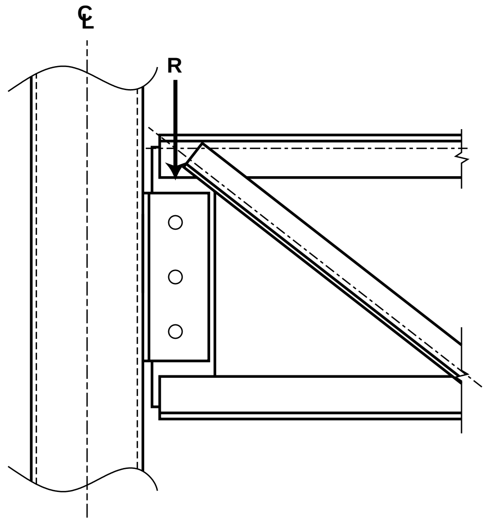


Figure 10
Web girder connection - Model 2

As mentioned in section 2.2.1.1, even if two joist girders are bearing on either side of the column (see Figure 11), unbalanced reactions may cause bending stress in the column, similar to beams framing from both sides.

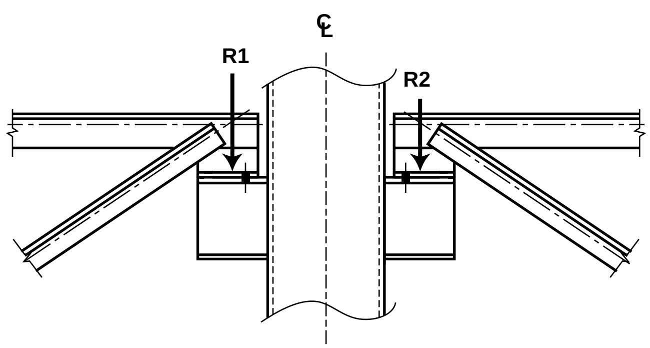


Figure 11
Bearing facing the column on either sides

The design engineer must consider the eccentricity of the position of the reaction of the joist girder in designing the column.

2.2.1.3 BEARING FACING THE COLUMN WITH CENTER REACTION

Although designing a column is made easier by considering that the reaction of the joist is not eccentric in relation to the column axis, the design and fabrication of eccentric connections is more complex. Consequently, the cost of a joist girder increases with this type of connection (see Figure 12).

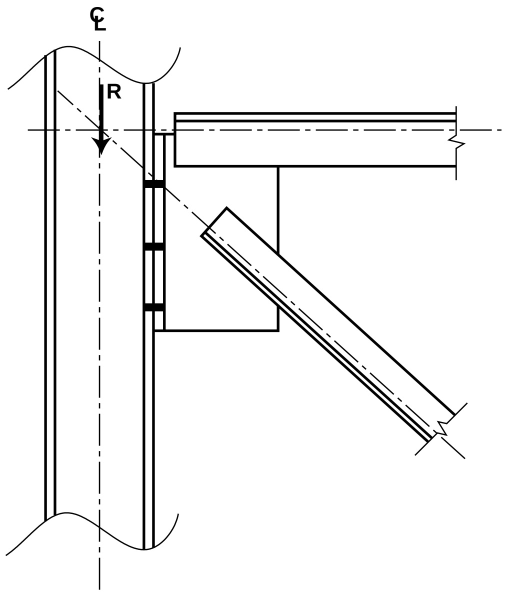


Figure 12
Bearing facing the column with center reaction

It is recommended to specify joist girders with a shoe under the top chord (see Figures 6, 7, 8 and 11) and to allow for the eccentricity of the joist girder reaction when designing the column.

2.2.2 TRANSFER OF AXIAL LOADS

Wind and seismic loads are usually transferred by the roof diaphragm to the axes of the vertical bracing system (Figure 13). The seismic loads transferred have a cumulative effect along these axes. The building design engineer specifies these loads on the plans and specifications.

The building designer may consider a lateral factored capacity of *4,5 kN (1 000 lb)* for the joist seats for the transfer of the deck shear forces to the girder top chord. Adding shear connectors between the joists on the girder increases the capacity to transfer diaphragm shear forces.

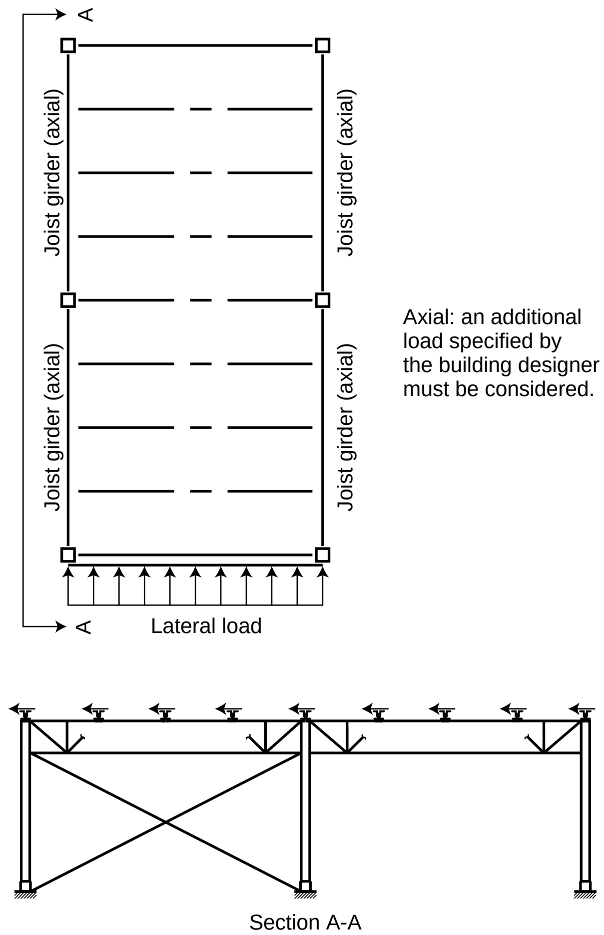


Figure 13
Transfer of axial loads

Depending on the specifications of the building designer, axial loads between two joist girders may be transferred to the top chord as follows:

- By angles placed under the top chord of the joist girders (Figure 14);
- By a transfer plate placed on the top of the top chord (Figure 15);
- By a transfer plate placed between the two angles of the top chord of the joist girders (Figure 16);
- Without a transfer piece using the capacity of the joist girder shoes (Figure 17).

Suggested use of these transfer options are prioritized as follows:

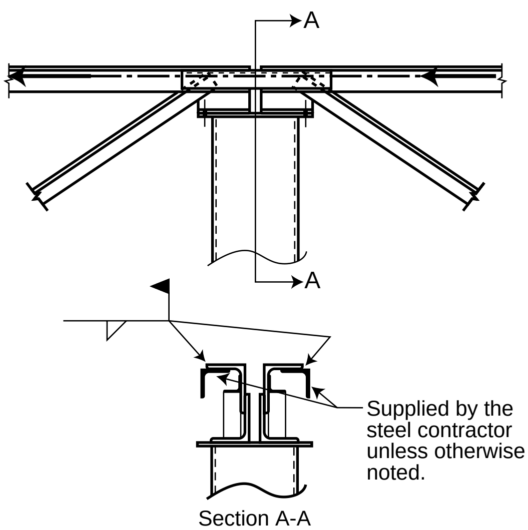


Figure 14
Transfer of an axial load by two angles placed under the top chord
Suggestion #1

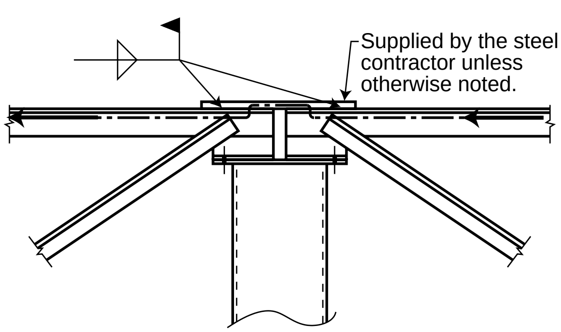


Figure 15
Transfer of an axial load by a plate placed on the top of the top chord
Suggestion #2

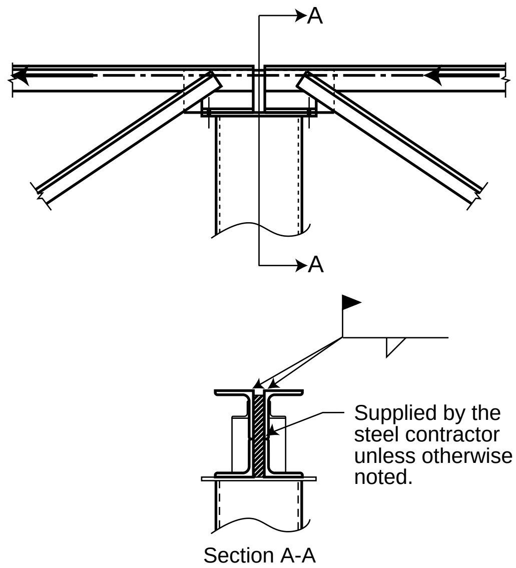


Figure 16
Transfer of an axial load by a plate placed between the angles of the top chord
Suggestion #3

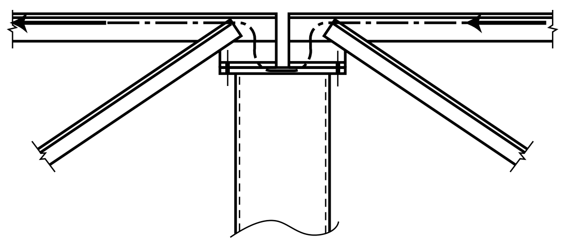


Figure 17
Transfer of an axial load using the shoes
Suggestion #4

Although not illustrated in Figure 17, the transfer of an axial load by the base of the shoe, usually requires bracing of the first panel of the top chord.

In the case where a joist girder has adjacent bracing as illustrated in Figure 13 on page 9, the effect is represented by an axial load applied to the bottom chord (Figure 18).

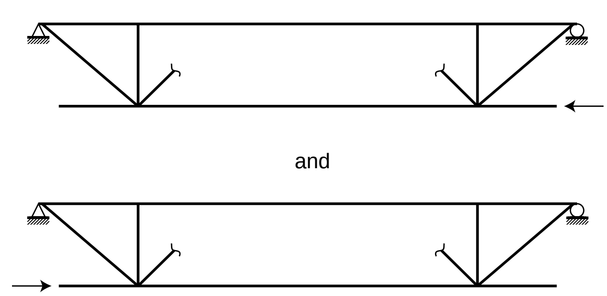


Figure 18
Transfer of an axial load at the bottom chord

2.2.3 END MOMENTS

2.2.3.1 GRAVITATIONAL MOMENTS

The use of a joist girder in a rigid frame relieves the top chord and carries the compression loads to the bottom chord (Figure 19).

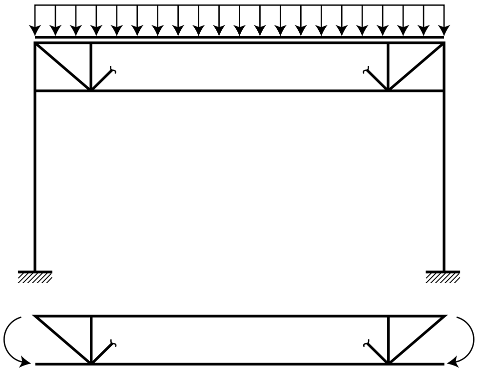


Figure 19
Gravitational moments

End moments, as specified by the building designer on the plans and specifications, result in the analysis of a frame with defined moments of inertia. It is recommended that the building designer specifies minimum and maximum limits of inertia to ensure that the frame is designed according to the analysis model. The moment of inertia of the joist girder may be estimated using the equation below in either metric or imperial.

METRIC $I = 1\,596\, M_f D$

where I = Moment of inertia of the joist girder *(mm⁴)*
M_f = Factored bending moment *(kN•m)*
D = Depth of joist girder *(mm)*

Note: M_f may be calculated by considering a uniform load applied to the joist girder.

$$M_f = \frac{(1.25DL + 1.5LL) \times l \times L^2}{8}$$

where DL = Dead load *(kPa)*
LL = Live load *(kPa)*
l = Tributary width of joist girder *(m)*
L = Joist girder span *(m)*

IMPERIAL $I = 0.132\, M_f D$

where I = Moment of inertia of the joist girder *(in⁴)*
M_f = Factored bending moment *(kips-ft.)*
D = Depth of joist girder *(in.)*

Note: M_f may be calculated using a uniform loading applied to the joist girder.

$$M_f = \frac{(1.25DL + 1.5LL) \times l \times L^2}{8{,}000}$$

where DL = Dead load *(psf)*
LL = Live load *(psf)*
l = Tributary width of joist girder *(ft.)*
L = Joist girder span *(ft.)*

2.2.3.2 WIND MOMENTS

Horizontal wind loads on a joist girder in a rigid frame may cause alternating moments as shown in Figure 20. Consequently, the joist girder will be analyzed with opposite moments.

Example: Case #1 *- 20 kN•m and + 20 kN•m*
Case #2 *+ 20 kN•m and - 20 kN•m*

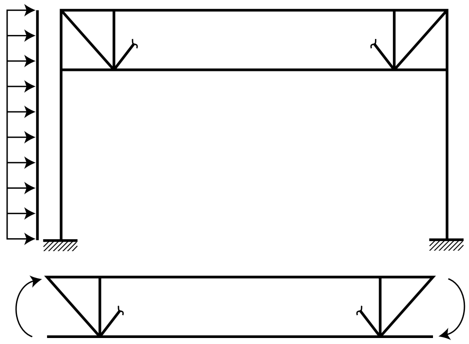


Figure 20
Wind moments

2.2.3.3 JOIST GIRDER ANALYSIS AND DESIGN

The erection plans, supplied by Canam, usually instruct the erector to fasten the bottom chord after all of the dead loads have been applied. In this way, the joist girder follows the condition for simple span condition under dead loads. **In the case of end gravity moments, Canam will assume that they are caused only by the live load, unless otherwise specified by the building designer.**

When end moments are specified, the joist girder shall first be designed to support loads on simple span condition. Then according to the combination of defined loads in the codes, different loading scenarios can be generated during analysis of the joist girder. Each element shall be designed for worst-case conditions, whether simple span or with end moments.

In addition to providing the end moment values applicable to the joist girder, the building designer must pay special attention to ensure that the end connections develop the moments for which the building was designed.

As in the case of the transfer of axial loads, the loads generated by an end moment are transferred to the top chord by the shoe or by a transfer plate placed on top of the top chord or between the two top chord angles.

The end moment transferred to the joist girder can divide into forces in opposite directions (couple) applied to the top and bottom chords.

For a connection with a transfer plate, the couple is calculated as follows (see Figure 21):

$$T_f = C_f = \frac{M_f}{d_e}$$

where $T_f = C_f$ = Axial force *(kN or kips)*
M_f = Factored moment connection *(kN•m or kips-ft.)*
d_e = Effective joist girder depth *(m or ft.)*

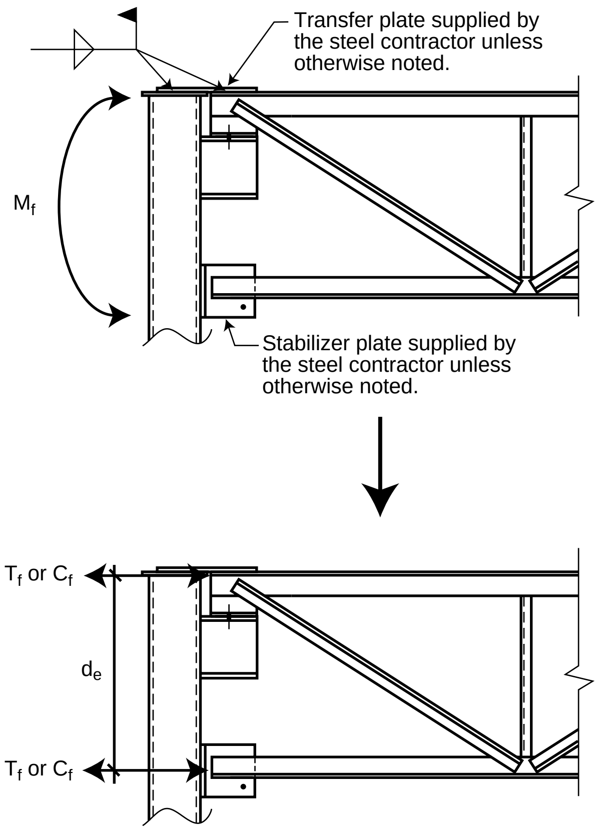


Figure 21
Transfer of the loads via a transfer plate

For a connection where the loads are carried by the shoe base, the axial force increases due to a shorter moment arm (see Figure 22).

$$T_f = C_f = \frac{M_f}{d_e}$$

where $T_f = C_f$ = Axial force *(kN or kips)*
M_f = Factored moment connection *(kN•m or kips-ft.)*
d_e = Effective joist girder depth *(m or ft.)*

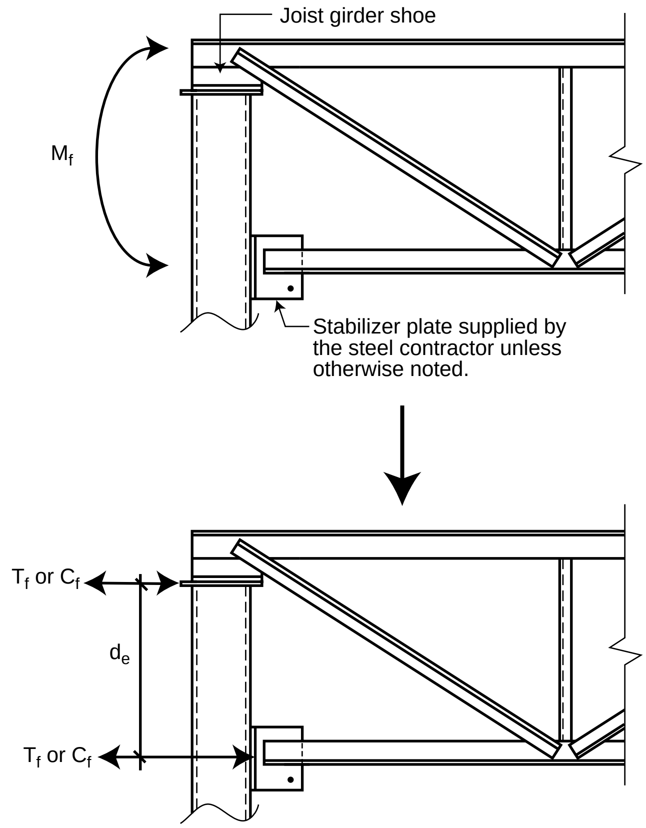


Figure 22
Transfer of the loads by the shoe base

Since the loads transferred by the base of the shoe create significant eccentricity, normally the first panel must be reinforced by the joist girder engineer (Figure 23).

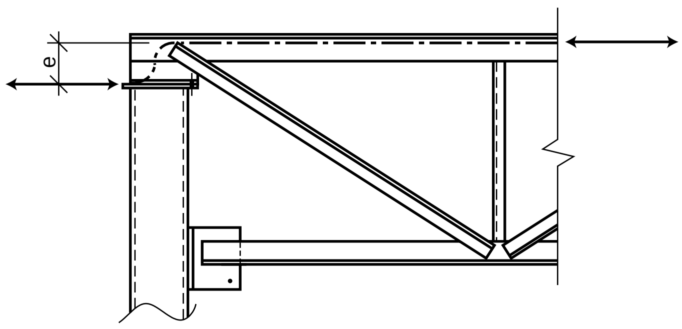
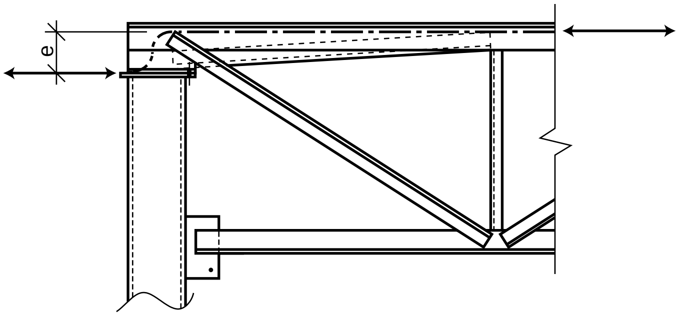
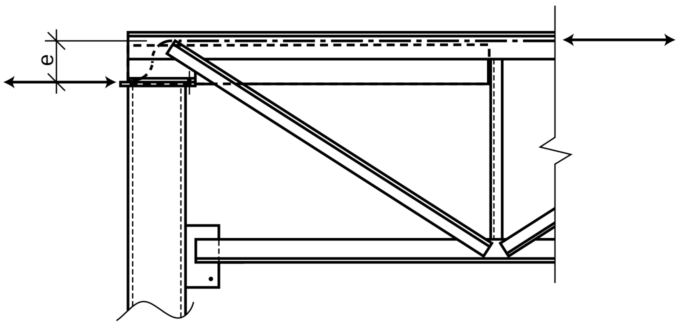


Figure 23
Vertical eccentricity at bearing due to the axial load

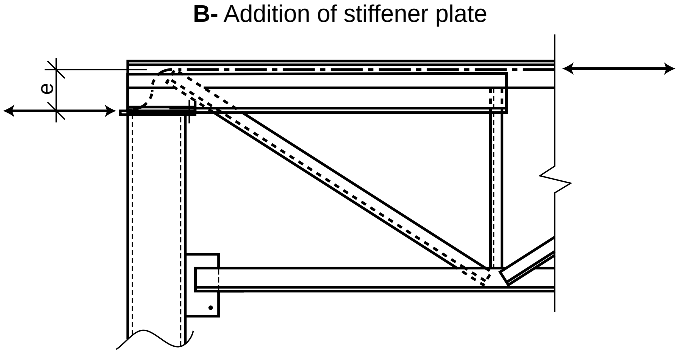
Different types of reinforcement of the first panel are presented below in Figure 24.



A- Addition of a strut



B- Addition of stiffener plate



C- Shoe extension

Figure 24
Different types of reinforcement of the first panel

Most of the connections to the bottom chord of Canam joist girders use an angle welded to the column and a tie joist plate shop welded to the joist girder. However, this type of connection, as shown in Figure 25, is no longer recommended.

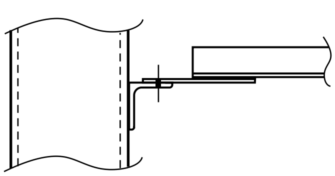


Figure 25
Connection at bottom chord
with a tie joist plate

A connection with a stabilizer plate is more simple and gives the same lateral stability.

The steel contractor usually supplies the steel plate on the column at the location of the bottom chord of the joist girder. The plate is inserted between the vertical flanges of the bottom chord angles. A plate should have a thickness of *22 mm* (*7/8 in.*) or *25 mm* (*1 in.*). A hole in the stabilizer plate allows the column to be plumbed with guy wires. The transfer of forces from the column to the bottom chord is achieved by welding the angles of the bottom chord to the plate, as indicated in Figure 26.

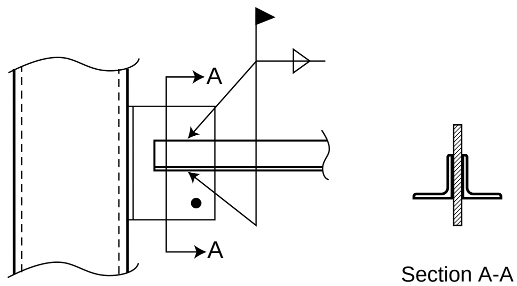


Figure 26
Connection at bottom chord
with a stabilizer plate

2.3 Unbalanced Loads

As with a steel supporting beam, the Canam joist girder can have an unbalanced load on its longitudinal axis. Joists distributed on either side of the joist girder may be at different lengths or the loads they support may vary (see Figure 27). This situation causes torsional stress in the joist girder, which will be considered by the joist girder designer (Canam). Therefore the designer could specify larger chords and web members for the joist girder and add additional knee braces between the bottom chord of the joist girders and the joists bearing on them.

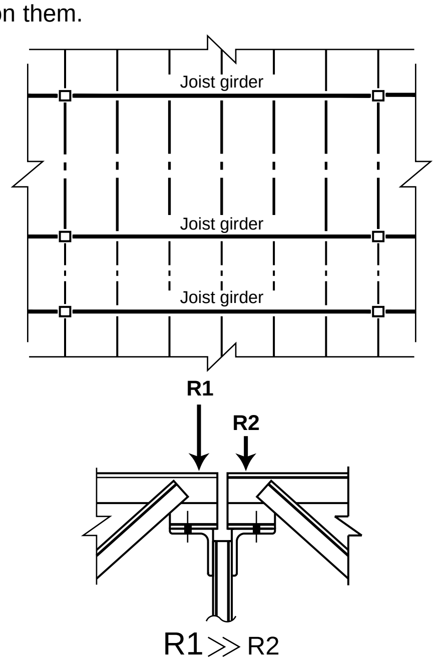


Figure 27
Unbalanced loading

However, to avoid unbalanced loads, the joists must be staggered on each side of the Canam joist girder as illustrated in Figure 28:

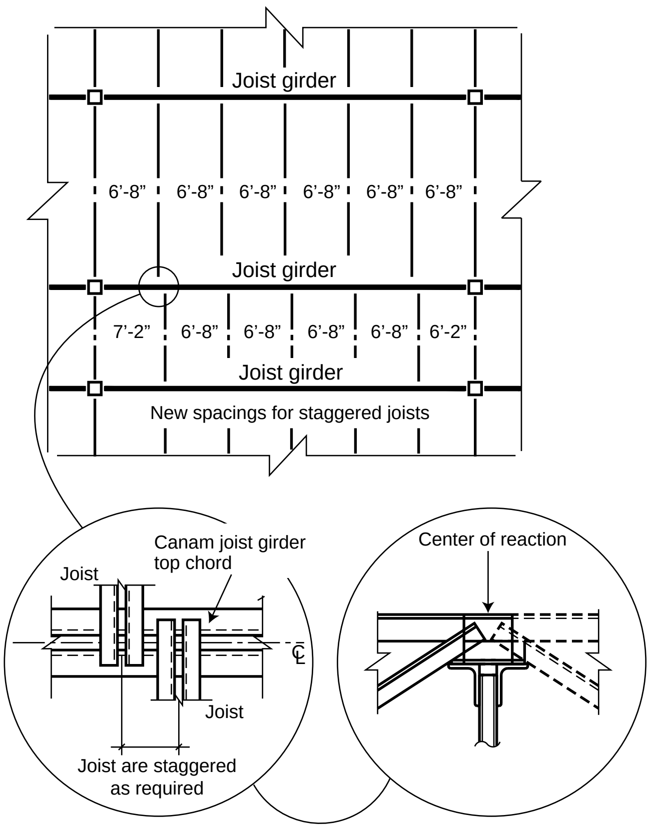


Figure 28
Staggered joists

The offsetting of joists bearing on the joist girder will be considered by Canam during the design stage.

2.4 Lateral Stability

The lateral stability of joist girders is ensured by the following as shown in Figure 29:

- On the top chord, by the joists that are fastened with welds or with bolts.
- On the bottom chord, by connected knee braces, or by the bottom chord of the joists connected to the bottom chord of the joist girder.

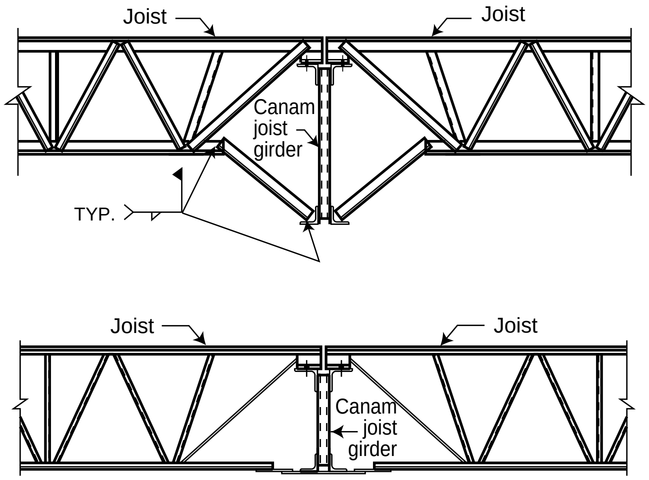


Figure 29
Lateral stability of a joist girder

For the spacing of the knee braces, clause 15.2.6 of the CAN/CSA Standard S16-01, specifies that the maximum slenderness ratio (L/r) compression chord (bottom chord) is limited to 240.

The capacity in compression out of plane of the bottom chord may also determine the spacing of the knee braces.

According to Clause 9.2.5 of CAN/CSA Standard S16-01, by simplified analysis the knee braces must be designed using compression forces of 0.02 times the factored compression force on the bottom chord of the joist girder. If the bottom chord of the joist girder is under tension only, the knee brace must only respect a slenderness criteria of 200.

2.5 Deflection and Camber

2.5.1 DEFLECTION

As stipulated in clause 15.2.7 of the CAN/CSA Standard S16-01, the deflection of the joist girder is calculated based on the axial deflection of members.

Appendix D of the CAN/CSA Standard S16-01 provides the maximum recommended values for deflections of specified design live and wind loads. The maximum values recommended in table D1 for vertical deflection of a roof or a floor vary between $1/180$ to $1/360$ of the span.

Clause D1 of Appendix D, states that the designer should, in some cases, consider the dead loads when establishing the deflection criteria. For example, non-permanent partitions, which are classified by the *National Building Code of Canada* as dead loads, should be part of the loading considered if they are likely to be applied to the structure after the completion of finishes susceptible to cracking.

2.5.2 CAMBER

Camber is specified by the building designer on the plans and specifications. Unless otherwise indicated by the designer, the standards are applied as stated in Clause 6.2.2.1 of the CAN/CSA Standard S16-01 and the joist girders are cambered to compensate for the deflection due to the dead load. Joist girders with a span of *25 m (82 ft.)* or more are cambered for the dead load plus one half of the service load.

In some cases, camber must be restricted for joist girders adjacent to non-flexible walls.

2.6 Vibration

The increased use of longer spans and lighter floor systems has resulted in the need to address the problem of floor vibration.

As demonstrated in the vibration section of the joist catalogue, the floor vibration characteristics improve more by increasing the thickness of the slab than by increasing the joist and joist girder (non-composite) moments of inertia.

The building designer, by controlling the main parameters affecting floor vibration characteristics, can specify the joists and joist girders to meet an acceptable annoyance threshold and find an economical solution. The joist and joist girder manufacturer shall then respect the minimum moment of inertia required by the building designer.

2.7 Load Reduction According to Tributary Area

Although a joist girder may have a tributary area that is much larger than that of a joist, a reduction of the live load allowed by the *National Building Code of Canada* in Clause 4.1.6.9 is very limited. In fact, no reduction is permitted for a live load due to snow or an assembly area designed for a live load less than *4.8 kPa (100 psf)*. The reduction is applicable for a specific use and a minimal surface area (Ref. NBC 1995, Clauses 4.1.6.9.2 and 4.1.6.9.3).

Joists and Joists Girders System (CSA)

3. Standard Details

3.1 Connections

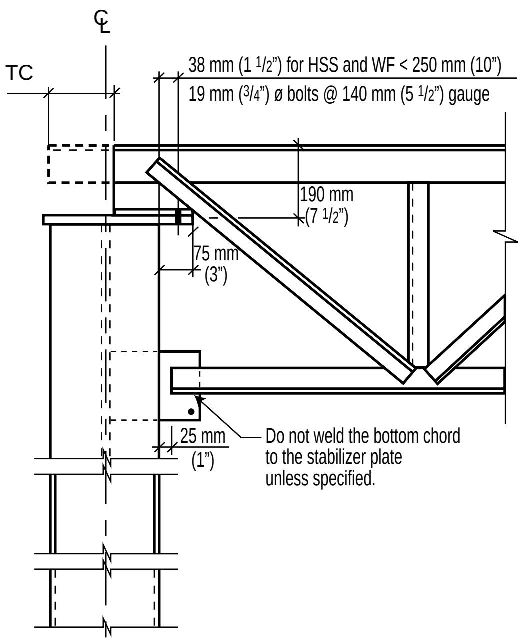
3.1.1 STANDARD CONNECTIONS

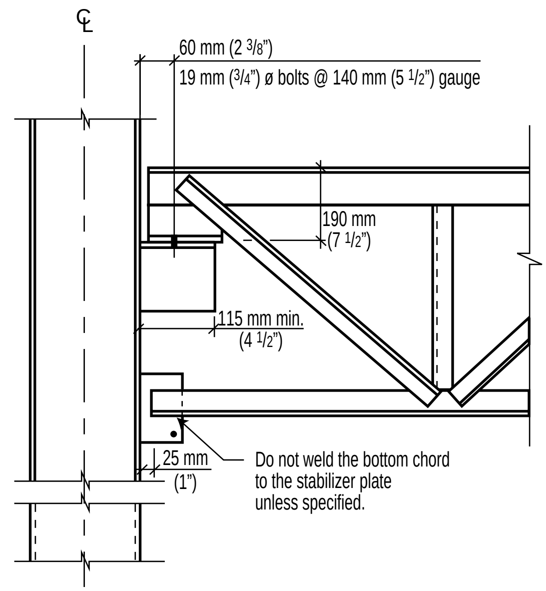
Standard connections of Canam joist girders are presented below. The illustrations show attachments on columns that are not the responsibility of Canam.

The use of Canam standards is strongly recommended for the following reasons:

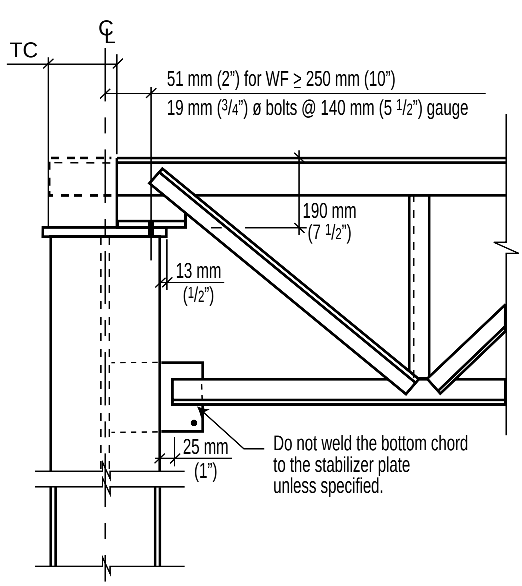
- Standardization of the fabrication details;
- Faster verification of the plans;
- Minimal risk of error.

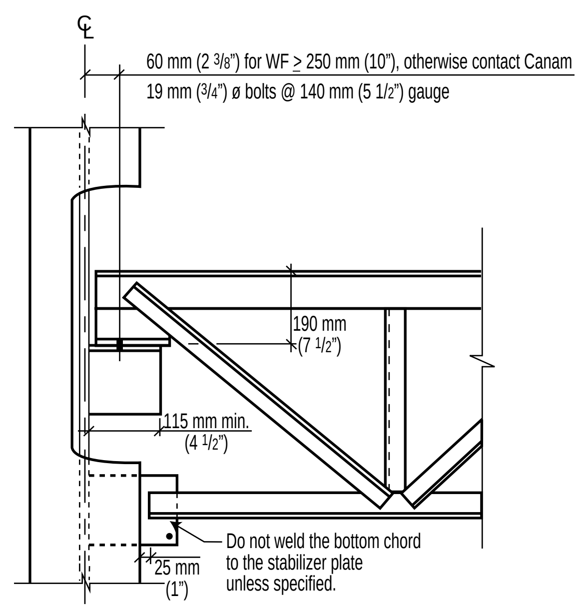
Specific customer connection details can be utilized according to the forces and geometries of each project. As mentioned on page 13, the connection of the bottom chord with a tie joist plate (see Figure 25) is no longer recommended.





NOTE: Hole positions are given with respect to the face of the column.





NOTE: Hole positions are given with respect to the center of the column.

3.1.2 SPECIAL ASSEMBLY CONDITIONS

Special assembly conditions do not necessarily limit the use of joist girders in a building.

The following examples illustrate some of these conditions.

3.1.2.1 JOIST GIRDER TO PERIMETER COLUMN CONNECTION

In Figure 30, the joist girder connects to the perimeter column using adjacent bracing to beams on either side of the joist girder. The detail allows for concentric connections.

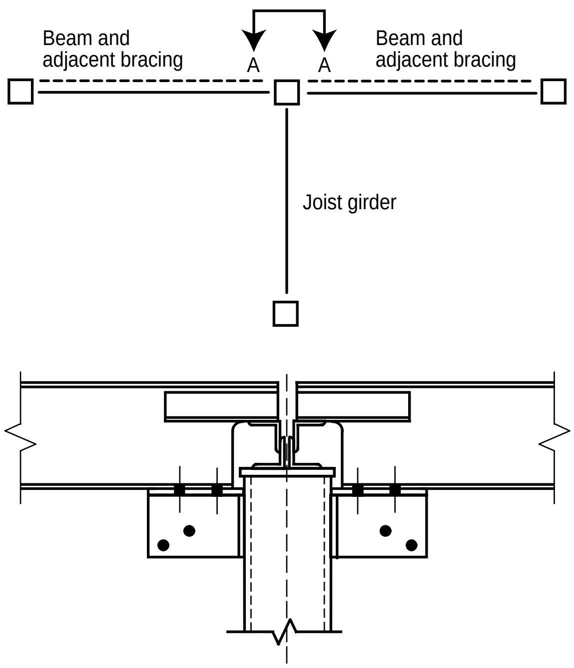


Figure 30
Assembly with a joist girder bearing on top of the column

According to the importance of the forces induced by gravity loads and the forces in the braces, the column could extend up to the top of the perimeter beams. The joist girder would then have a bearing facing the column as shown below in Figure 31.

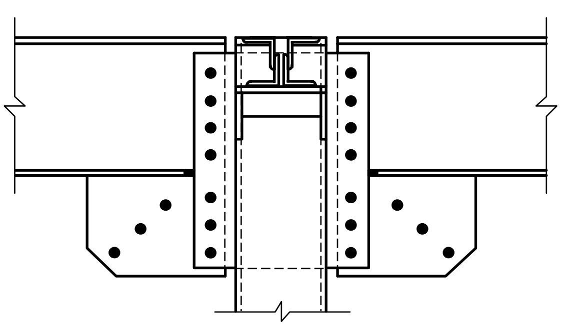


Figure 31
Assembly with a joist girder bearing on the face of the column

3.1.2.2 PERIMETER JOIST GIRDER TO HSS COLUMN CONNECTION

In Figure 32, the joist girder connects to a perimeter column using adjacent bracing to a beam on the opposite side. For this type of connection, a through plate connection allows the beam and the bracing to be connected to the column supporting the joist girder. The continuity of axial forces from the joist girder to the bearing is ensured by using suggestion #2 or #4 presented on page 10 (see Figures 15 and 17).

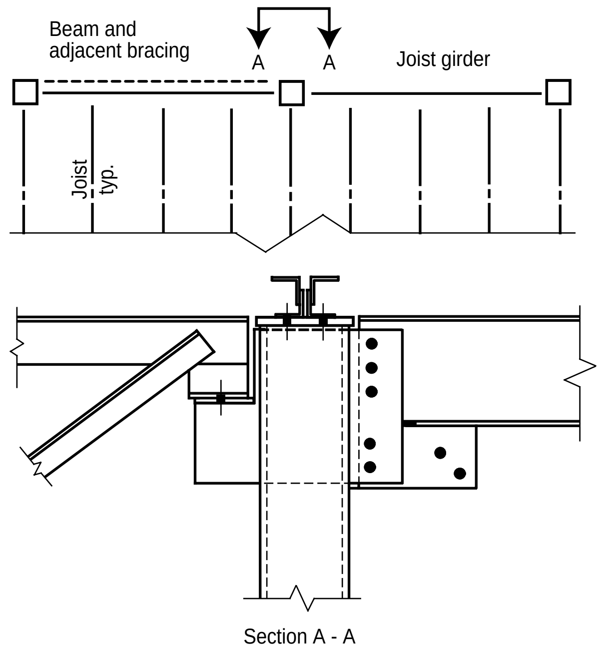


Figure 32
Assembly with a through plate connection

3.1.2.3 BEAM TO JOIST GIRDER CONNECTION

The joist girder is a bearing member that can be adapted to different connection conditions. One or more conventional web members can be replaced by adapted members to facilitate the connection to the members. For the following condition in Figure 33, the beam can be notched and bear on the top of the joist girder, or it can be connected to the web members. Note that there are other ways of connecting a beam to a joist girder.

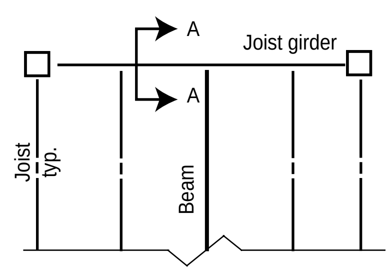
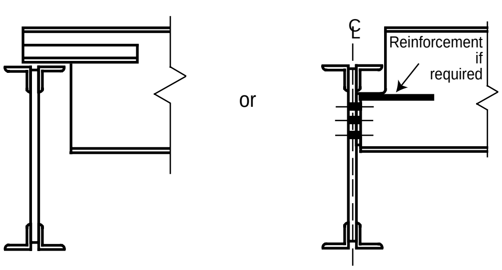


Figure 33
Beam connection to a joist girder

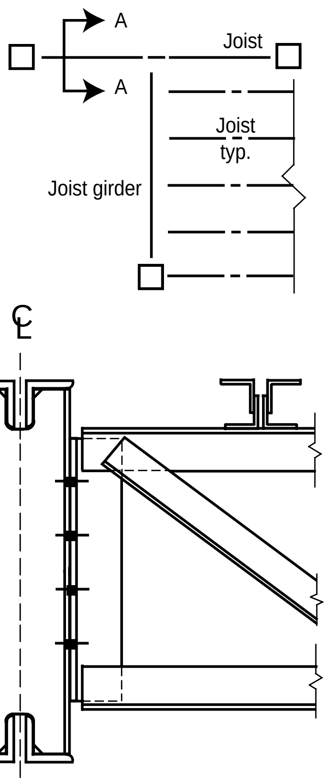


Section A - A

Figure 33 (continued)
Beam connection to a joist girder

3.1.2.4 JOIST GIRDER TO JOIST CONNECTION

The conventional joist web member is replaced by a "W" section used to connect the joist girder to the joist as shown in Figure 34.



Section A - A

Figure 34
Joist girder connection to the joist web member

3.2 Geometry

Joist girder geometry refers to the web profile system. Standard geometry types are presented in Figure 35. The "Modified Warren" geometry is the most commonly used as it is often more economical than the other two types.

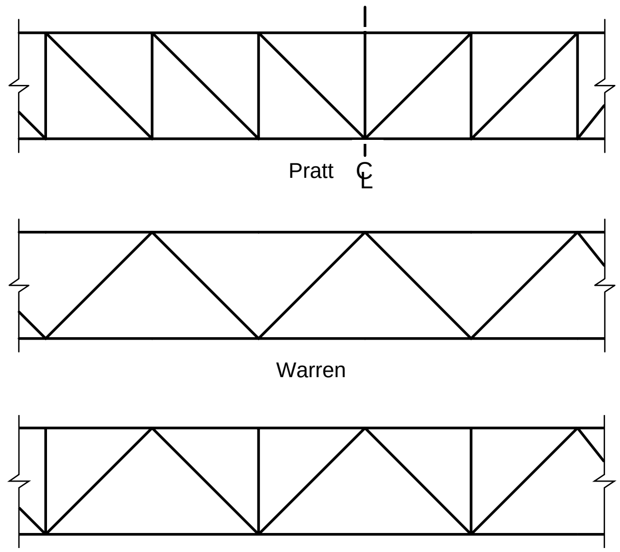


Figure 35
Standard joist girder geometries

Since joists are usually evenly spaced, the joist girder can combine two types of geometry as shown in Figure 36 where a "Warren" type is combined with a "Modified Warren" geometry.

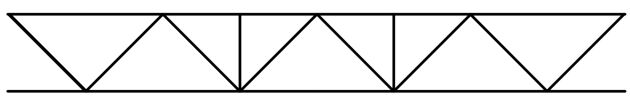


Figure 36
Combined geometries

The panel points of a joist girder are usually located where joists are bearing. Depending on the joist spacing, the Canam design engineer can add intermediate panel points to design the optimum joist girder for the loading conditions and the span.

The different panel point configurations presented in Figures 37 to 39 inclusive can be specified by the building designer for architectural purposes or large duct openings.

Type G: The panel points where the joists are bearing correspond to the intersection of the two diagonals at the top chord.

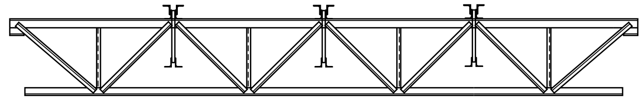


Figure 37
Type G configuration

Type VG: The panel points where the joists are bearing correspond to the position of the secondary web members (verticals) on the top chord.

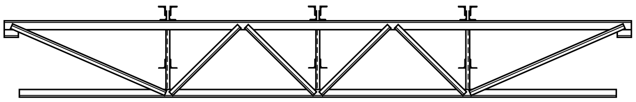


Figure 38
Type VG configuration

Type BG: The panel points where the joists are bearing correspond to the position of the secondary web members (verticals) and the intersection of the two diagonals at the top chord.

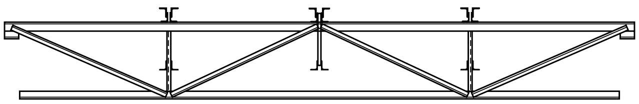


Figure 39
Type BG configuration

3.3 Shapes

The shape of the joist girder depends on it's use and the roof system required by the owner. The standard shape (Figure 40) has a uniform depth while the most common non-standard shapes have one or two slopes (Figure 41).

Figure 40
Standard shape

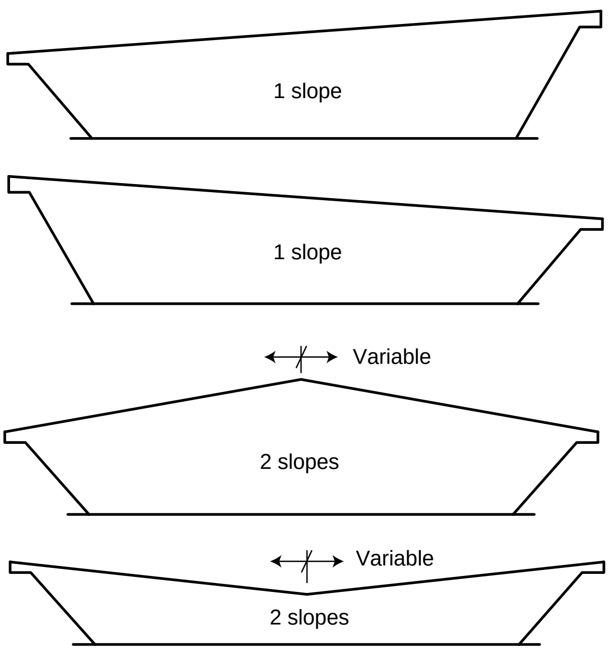


Figure 41
Non-standard shapes

3.4 Minimum Bearing

Joist girder shoes are at least *150 mm (6 in.)* long given the sizeable vertical forces to transfer between the top chord and the bearing support.

3.4.1 BEARING ON CONCRETE OR MASONRY WALL

The building designer shall allow for a bearing plate for the joist girder. The plate shall be in accordance with CSA S304.1 Standard if used for a masonry wall and A23.3 Standard if used on concrete. The plate shall have minimum dimensions in length and width to ensure a minimum bearing for the joist girder of *150 mm (6 in.)* and to allow the horizontal legs of the seat to be welded to the bearing plate.

3.4.2 BEARING ON STEEL

The joist girder shall be extended on the steel support to respect the minimum bearing of *100 mm (4 in.)*. The building designer must ensure that the type of connection and bearing support used respect this criteria.

3.5 Knee Braces

See Figures 42, 43 and 44 for typical knee braces from joist girders to open web joists.

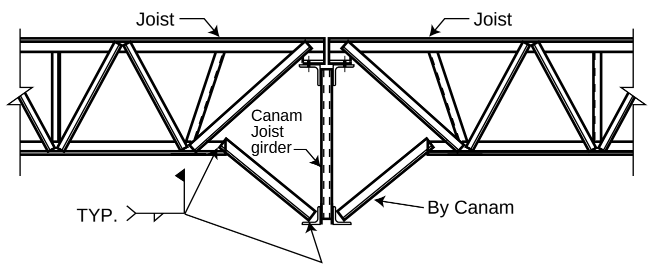


Figure 42
Knee braces - Detail 1

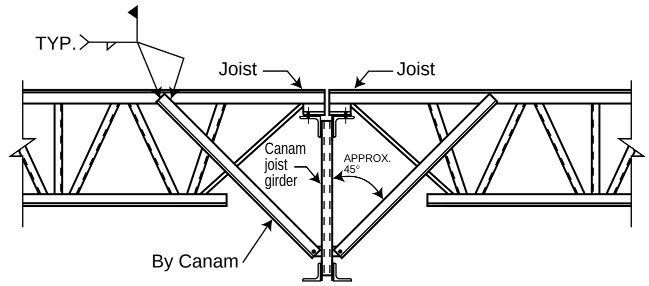


Figure 43
Knee braces - Detail 2

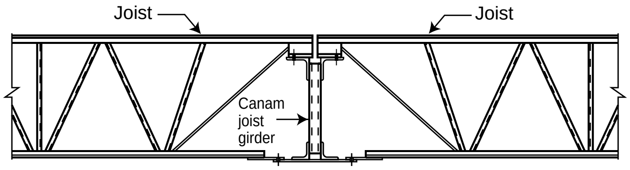


Figure 44
Knee braces - Detail 3

3.6 Extensions

Extended top chords only (Figure 45) or full depth girders extended as cantilevers and bearing on the bottom chord (Figure 46) require special attention by the building designer.

The magnitude and location of the design loads, the deflection limitations and the lateral support must be clearly indicated on the structural drawings for various applicable load cases.

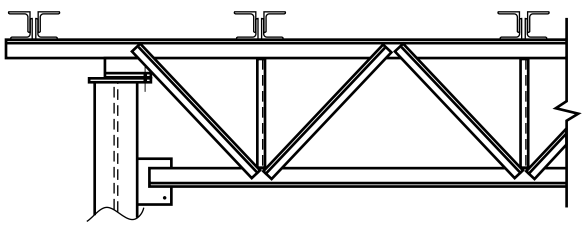


Figure 45
Extended top chord only

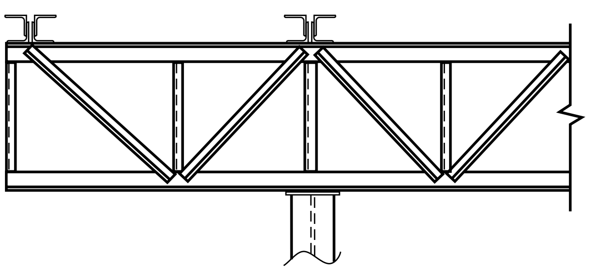


Figure 46
Bearing on the bottom chord

3.7 Joist Girder Identification

Joist girders are identified by piece marks on the Canam erection drawings, ie. G1, G2, G3, etc. Identical Canam joist girders have the same piece mark. Piece marks are indicated on the drawing near one end of the joist girder as illustrated in Figure 47.

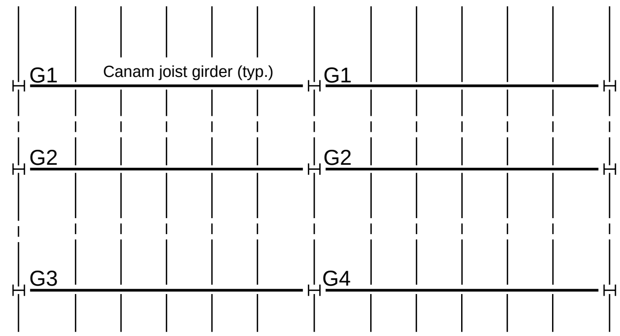


Figure 47
Identification of joist girders

At the plant, a metal identification tag is attached to one end of the joist girder indicating the piece mark, project and other related information (see Figure 48).

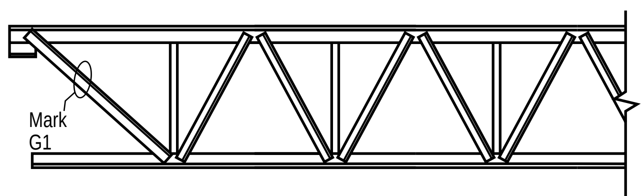
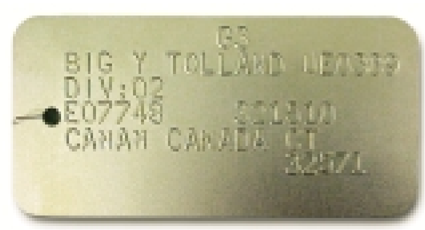


Figure 48
Metal tag location

It is essential that the joist girder be erected so that the metal tag is on the same side as the piece mark indicated on the erection drawing.



4. Joist Girder Depth Selection

Selecting a joist girder can be done using graphs #1 to #4 inclusive on pages 23 to 26 inclusive. The horizontal axis gives the factored moment of the joist girder, while the vertical axis indicates the joist girder weight. The various lines indicate different joist girder depths. The building designer must calculate the factored moment of the joist girder in order to use the graphs.

To select the depth, it is unnecessary to calculate the bending moment from the concentrated loads of the joists bearing on the joist girder. Considering an equivalent uniform load is sufficiently accurate. When designing the joist girders, the Canam designer will consider the actual loadings, as well as other forces and special conditions, if applicable.

Unless advised otherwise, Canam will consider that the weight of the joist girders is included in the loads specified in the documents and on the drawings.

The two following examples explain how to select the depth of a joist girder.

4.1 Examples *IMPERIAL*

4.1.1 EXAMPLE #1 - COMPARISONS

For the building conditions below, use one or two intermediate columns on the two longest exterior walls as shown in Figure 49. Evaluate the impact of the weight of joist girders G1 and G2.

Uniform dead load (DL): *20 psf*

Uniform live load (LL): *55 psf*

Maximum allowable deflection under the service load: *L/240*

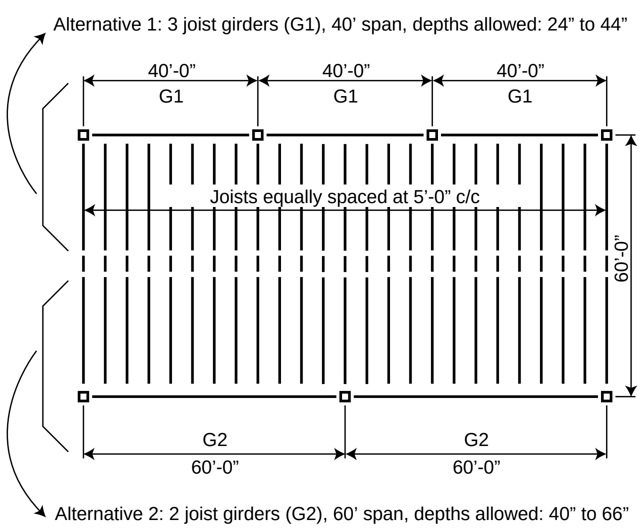


Figure 49
Example #1

Solution

The total moment of the joist girder can be calculated as follows:

$$M_f = \frac{(1.25\ DL + 1.5\ LL) \text{ x } Girder\ tributary\ width \text{ x } Girder\ span^2}{8{,}000}$$

The two joist girder lengths to be used are *40'* and *60'*. The tributary width of the joist girder is *30'* (one-half the length of the joists).

$$M_{f\ alt\ 1} = \frac{(1.25 \text{ x } 20 + 1.5 \text{ x } 55) \text{ x } 30 \text{ x } 40^2}{8{,}000} = 645\ kips\text{-}ft.$$

$$M_{f\ alt\ 2} = \frac{(1.25 \text{ x } 20 + 1.5 \text{ x } 55) \text{ x } 30 \text{ x } 60^2}{8{,}000} = 1{,}450\ kips\text{-}ft.$$

From the table on page 25, select the weight of the joist girders for the different depths permitted. Then calculate the unit weight of the joist girders and the total weight for each alternative. The results are presented below in Table 1.

	UNIT WEIGHT				TOTAL WEIGHT	
	(plf)		(lbs)		(lbs)	
Depth	**Alt. 1**	**Alt. 2**	**Alt. 1**	**Alt. 2**	**Alt. 1**	**Alt. 2**
24"	68		2,720		**8,160**	
28"	60		2,400		**7,200**	
32"	49		1,960		**5,880**	
36"	45		1,800		**5,400**	
40"	42	90	1,680	5,400	**5,040**	**10,800**
44"	40	84	1,600	5,040	**4,800**	**10,080**
48"		79		4,740		**9,480**
54"		74		4,440		**8,880**
60"		68		4,080		**8,160**
66"		64		3,840		**7,680**

Note: Alternative 1: 3 joist girders; Alternative 2: 2 joist girders

Table 1
Joist girder weights

For both alternatives, the greater the depth of the joist girder, the less it weighs. In addition, alternative 1 requires three joist girders but the total weight is generally less than that of alternative 2. However, in making a choice, the building designer should also consider the cost of the intermediate columns (including the foundations) on the overall building costs.

Alternatives 1 and 2 can be verified to see if the maximum deflection under the service load is respected in the worst case scenario for a depth of *24 in.* (alternative 1) and a depth of *40 in.* (alternative 2).

$$I_{alt\ 1} = 0.132\ M_f\ D = 0.132 \times 645 \times 24 = 2{,}043\ in^4$$

$$I_{alt\ 2} = 0.132\ M_f\ D = 0.132 \times 1{,}450 \times 40 = 7{,}656\ in^4$$

The joist girder deflection can be estimated by using the deflection equation of a simple beam, increased by *10%* to include the elongation of web members.

$$\Delta = 1.10 \left(\frac{5 W_L L^4}{384\ EI} \right)$$

By integrating the above formula of inertia and by simplifying the equation for deflection, we obtain:

$$\Delta = \left(\frac{W_L L^4}{154{,}667\ M_f\ D} \right)$$

$$\Delta_{alt\ 1} = \frac{55 \times 30 \times 40^4}{154{,}667 \times 645 \times 24} = 1.76\ in. < 2.0\ in.\ (40 \times 12/240) \qquad OK$$

$$\Delta_{alt\ 2} = \frac{55 \times 30 \times 60^4}{154{,}667 \times 1{,}450 \times 40} = 2.38\ in. < 3.0\ in.\ (60 \times 12/240) \qquad OK$$

4.1.2 EXAMPLE #2 - SPECIAL LOADING

Evaluate the weight of the joist girder for the conditions below and Figure 50.

Uniform dead load:	*15 psf*
Uniform live load:	*45 psf*
Maximal deflection allowed under live load:	*L/240*
Concentrated (P.L.) dead load:	*5 kips*
live load:	*10 kips*

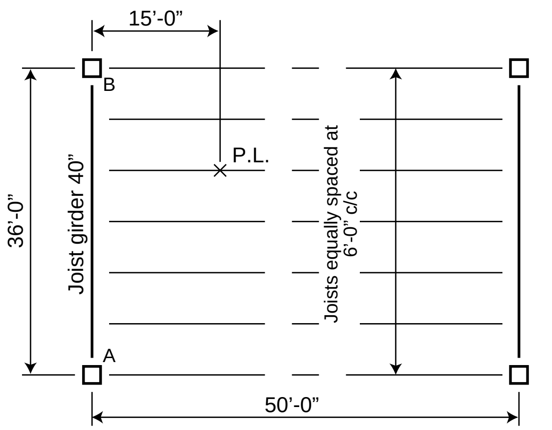


Figure 50
Example #2

Solution

Contrary to the previous example, the maximum moment of the joist girder does not occur at mid-span. Therefore the maximum moment must be located first. Then it's value is calculated and the unit weight *(plf)* of the joist girder is selected from the vertical axis.

1. Calculate the loading on the joist girder:

a) uniformly distributed loads

$$W_f = (1.25 \times 15 + 1.5 \times 45) \times 25 = 2{,}156\ plf$$

b) concentrated loads

$$P_f = \frac{(1.25 \times 5 + 1.5 \times 10) \times 35}{50} = 14.9\ kips = 14{,}875\ lbs$$

2. Locate the maximum moment:

The maximum moment is produced at the location where shear is zero. Starting from point A,

$$R_A = \frac{2{,}156 \times 36}{2} + \frac{14{,}875 \times 24}{36} = 48{,}725\ lbs$$

$$L_{VO} = \frac{48{,}725}{2{,}156} = 22.6\ ft.$$

3. Calculate the maximum moment and determine the weight of the joist girder:

$$M_{fmax} = 2{,}156 \times 22.6 \times \frac{(36 - 22.6)}{2} + 14{,}875 \times 12 \times \frac{22.6}{36} = 438{,}520\ lb\text{-}ft. = 438.5\ kips\text{-}ft.$$

A moment of *438.5 kips-ft* and a depth of *40 in.* results in a joist girder with a weight of approximately *30 plf* or *1,080 lbs* total.

4. Verify the maximum deflection criteria under the service load:

$$I = 0.132\ M_f\ D = 0.132 \times 438.5 \times 40 = 2{,}315\ in^4$$

$$\Delta = 1.10 \left[\frac{5 W_L \times L^4}{384\ EI} + \frac{P_L \times a \times L_{vo}}{6\ EI\ L} (L^2 - a^2 - L_{vo}^2) \right]$$

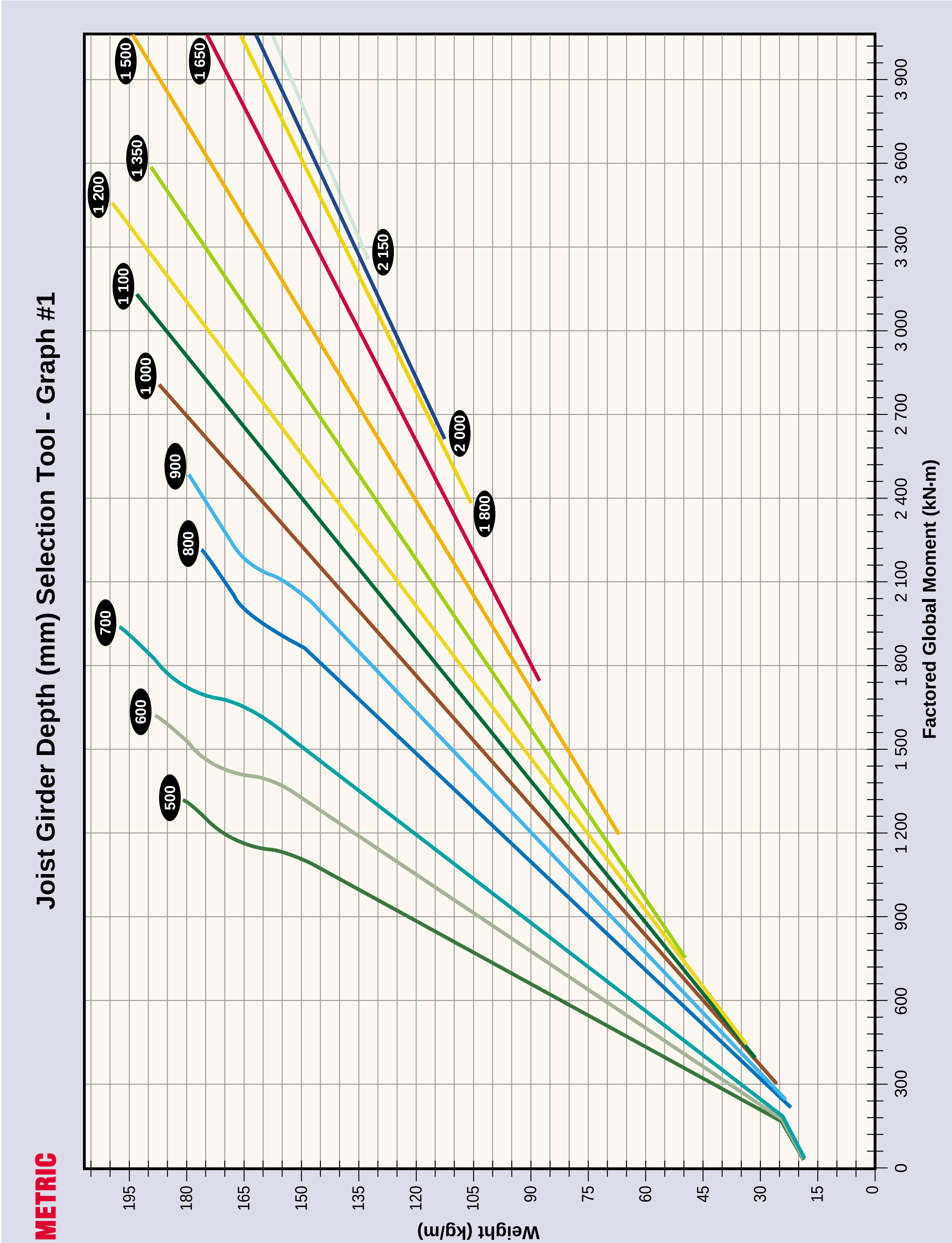
$$= 1.10 \left[\frac{5 \times 45 \times 25 \times 36^4}{384 \times 29 \times 10^6 \times 2{,}315} \times 12^3 + \frac{10 \times 35}{50} \times \frac{12 \times 22.6\ (36^2 - 12^2 - 22.6^2)}{6 \times 29{,}000 \times 2{,}315 \times 36} \times 12^3 \right]$$

$$= 1.10\ [0.63 + 0.15]$$

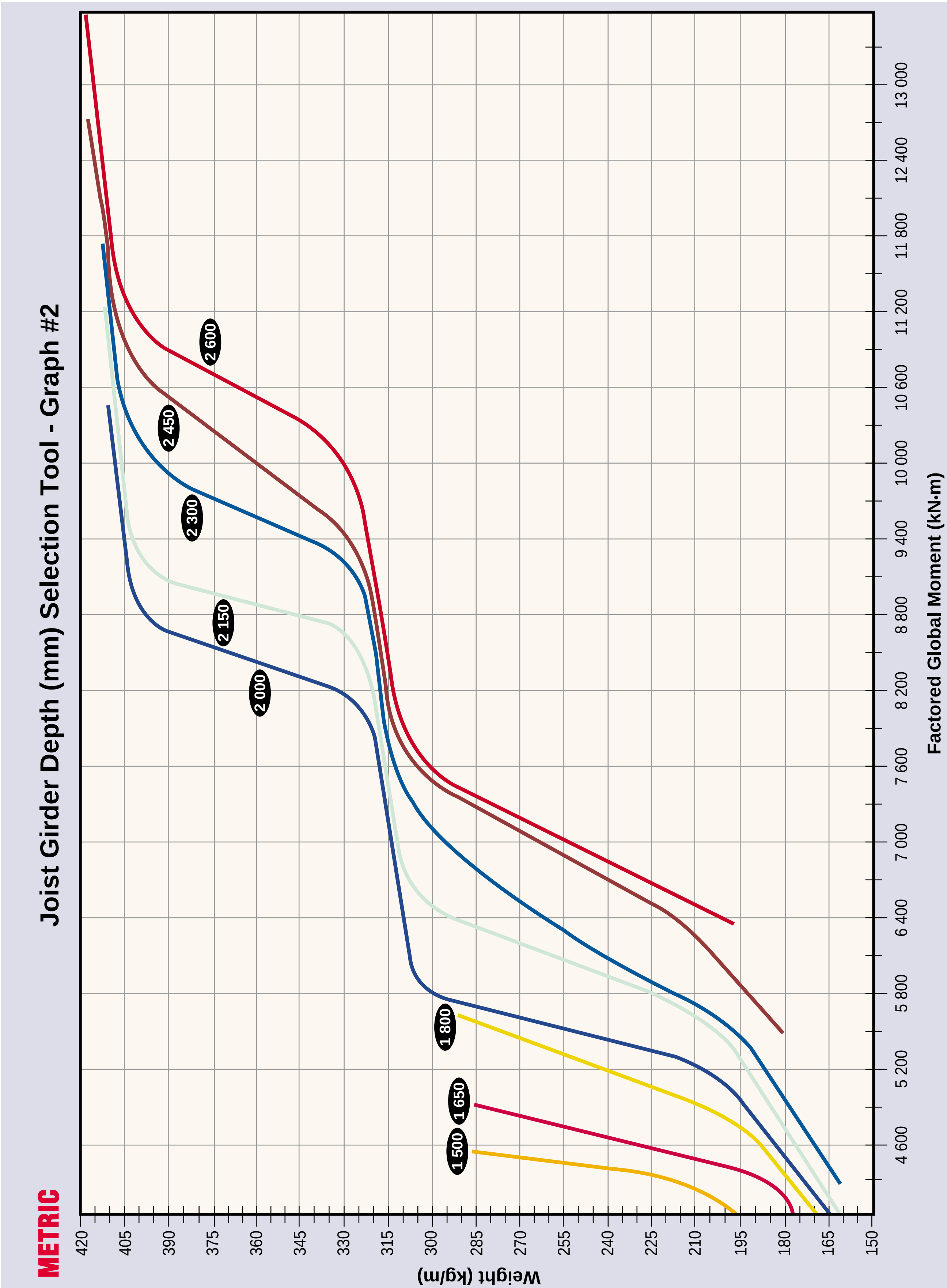
$$= 0.86\ in. < 1.8\ in.\ (36 \times 12/240) \qquad OK$$

Note: Calculations for Example #2 can be simplified by adding separately the maximum moments under the uniform and concentrated loads. A value of *468.3 kips-ft.* is then obtained which corresponds to a weight of *32 plf*.

4.2 Graphs


METRIC
Joist Girder Depth (mm) Selection Tool - Graph #1
Weight (kg/m)
Factored Global Moment (kN·m)
0
15
30
45
60
75
90
105
120
135
150
165
180
195
0
300
600
900
1 200
1 500
1 800
2 100
2 400
2 700
3 000
3 300
3 600
3 900
500
600
700
800
900
1 000
1 100
1 200
1 350
1 500
1 650
1 800
2 000
2 150

JOIST GIRDER DEPTH SELECTION



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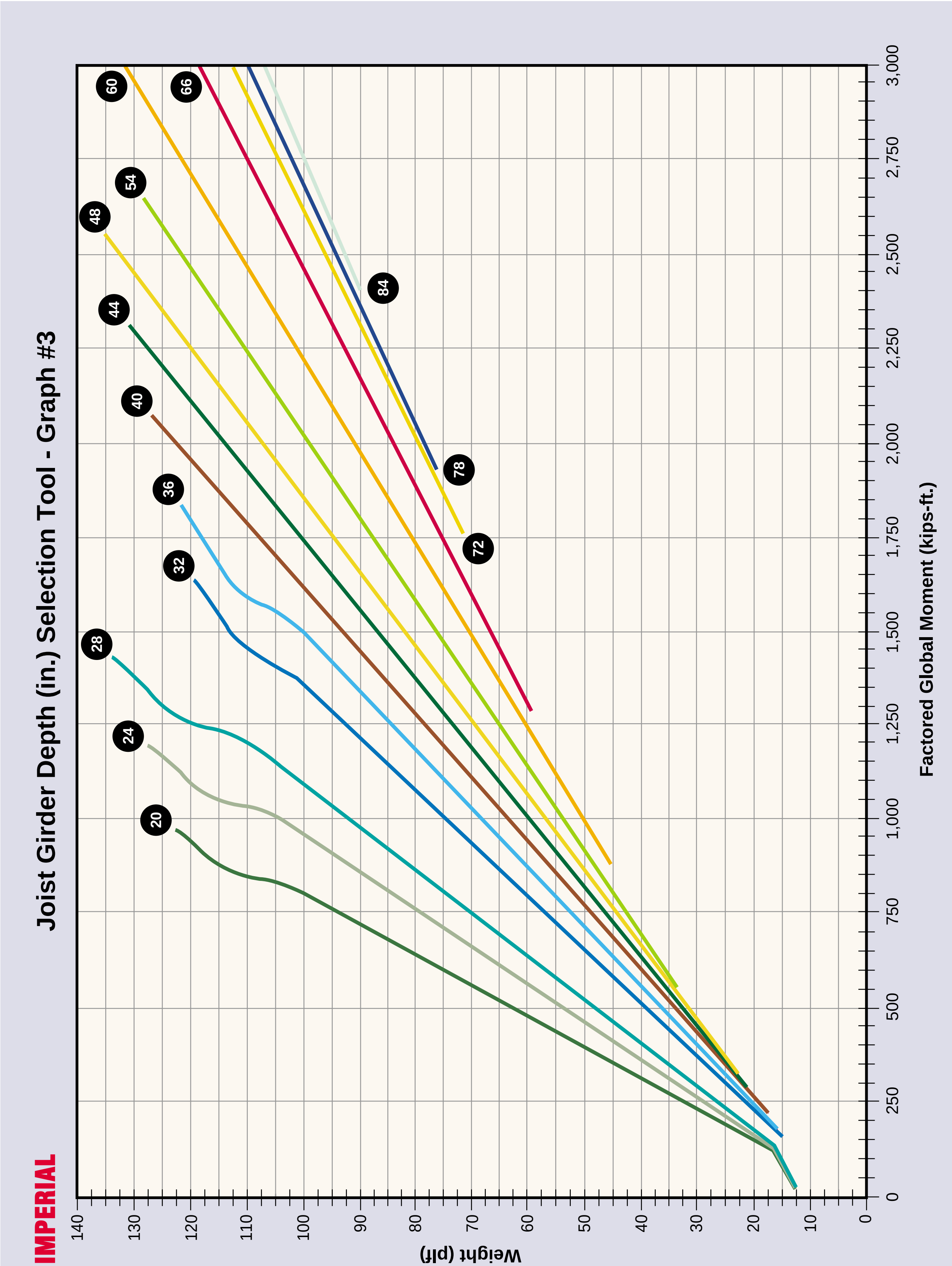
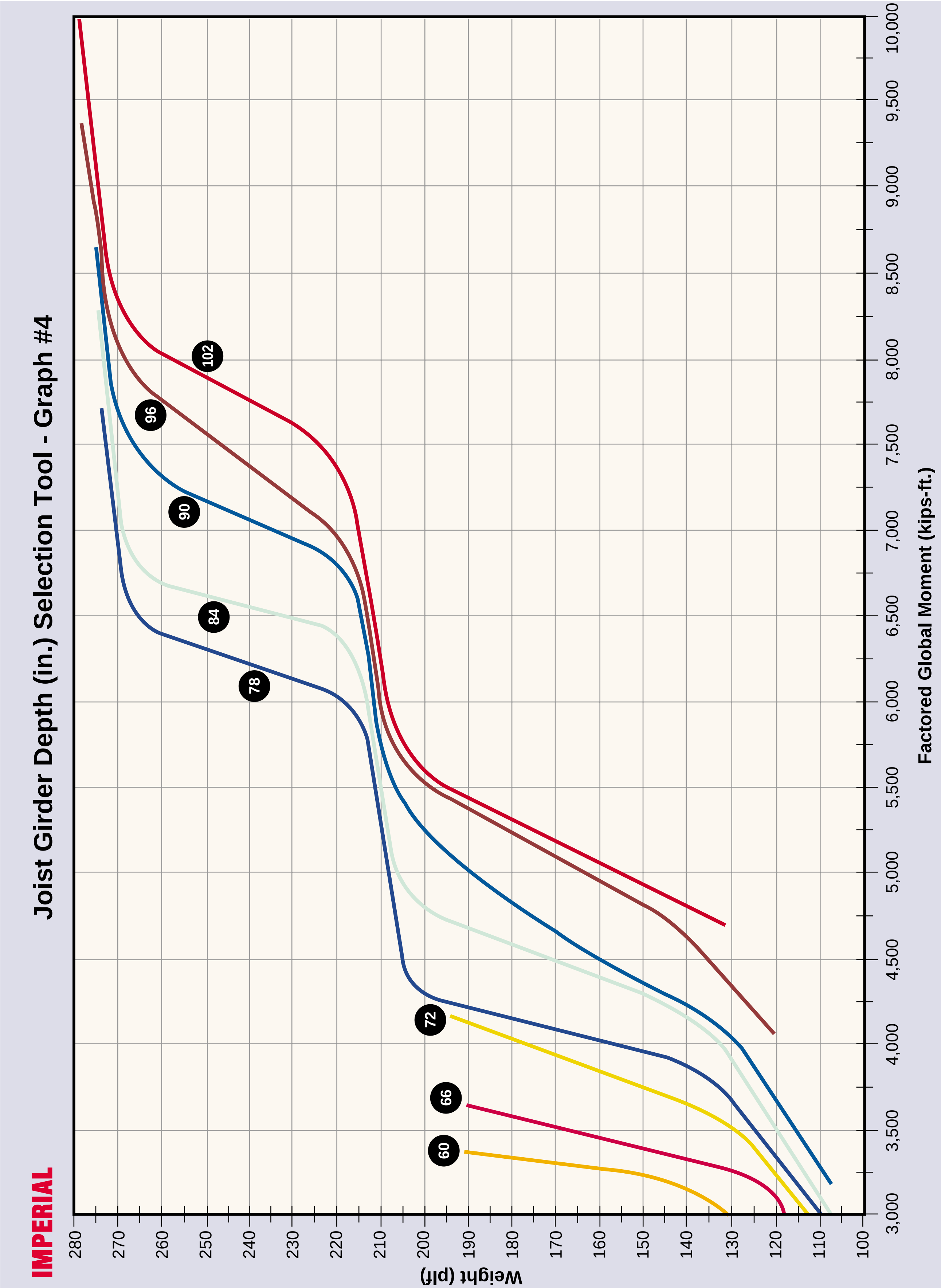

IMPERIAL
Joist Girder Depth (in.) Selection Tool - Graph #3
Weight (plf)
Factored Global Moment (kips-ft.)
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
0
250
500
750
1,000
1,250
1,500
1,750
2,000
2,250
2,500
2,750
3,000
20
24
28
32
36
40
44
48
54
60
66
72
78
84



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5. Joist Girder Specifications

5.1 Information Required from the Building Designer

The building designer using joist girders shall consider the following, and provide all the required information in the specification documents and on the drawings:

- The **loads** that are carried by the joist girders can be specified by area *(kPa or psf)*, or calculated as point loads *(kN or lbs)* by the building designer. For special loading conditions, a loading diagram is recommended.
- The building engineer shall indicate the possible live **load reduction** of a floor.
- The **horizontal forces,** applied to the joist girders and the steel joists that will affect the building's lateral stability, shall be indicated on the drawing for consideration by Canam in designing the joist girders.
- The building designer shall indicate **special conditions**, such as net uplift or fixed ends, that will produce compression forces in the bottom chord for consideration by Canam in determining chord size or number of knee braces required for stability of that chord.
- The **depth** of the joist girders must be specified.
- The connection of joist girders to the columns is economical if a **bearing shoe** is used, usually *190 mm (7.5 in.)* deep, bolted to the top of the column or on a bearing bracket on the web or the flange of the column. This bracket is designed by the building designer to safely support the reaction.
- Joist girder bearing must be large enough to allow a **minimum bearing length** on steel *(100 mm or 4 in.)* and concrete *(150 mm or 6 in.)*.
- The **maximum deflection** under the live loads and (if required) the total load must be given.
- All **special cambers** (if applicable) to be specified.
- Minimum and maximum **inertias** must be given to ensure that they follow the analysis model for a rigid frame or the vibration calculations made by the building designer.
- The type of **geometry** ("Pratt", "Warren" or "Modified Warren") and the **panel point configuration** (G, BG or VG), if required, is to be specified by the building designer. Otherwise, Canam will use the most economical geometry and panel point configuration.

Notes: No perforating or cutting of the joist girders shall be performed without the authorization of the building designer.

All loads or forces specified on the plans and specifications are considered unfactored unless otherwise indicated.

Joists and Joist Girders System (ING Canada)

6. Handling, Fabrication and Erection

6.1 General

Special precautions must be taken during the handling of the joist girders. Care must be taken to avoid damage during transport, unloading, site storage and erection. Dropping of joist girders shall not be permitted.

The joist girders should only carry the weight of the joists until they all have been connected as specified. The Canam joists sitting on top of the joist girder are usually bolted to the top chord by bolts supplied by Canam.

Joists Bolted to a Joist Girder (Boa-Franc, Québec)

During the construction period, the contractor shall adequately distribute the concentrated loads in order not to exceed the load capacity of any joist.

Canam joist girders are usually fastened to the columns using two *19 mm (3/4")* bolts.

Field welding shall not cause damage to joist girders, nor to the steel supporting members.

A connection allowing longitudinal movement of the end of the bottom chord of the joist girder is recommended during erection in order to provide lateral stability and to prevent overturning. A stabilizing plate for the bottom chord must be supplied for each column that supports a Canam joist girder. The stabilizing plate shall be supplied by the steel contractor.

If a rigid connection is required on the bottom chord, it must be made after all of the dead loads have been applied, unless noted otherwise.

6.2 Manufacturing Tolerances

The following Figure 51 illustrates many of the manufacturing tolerances.

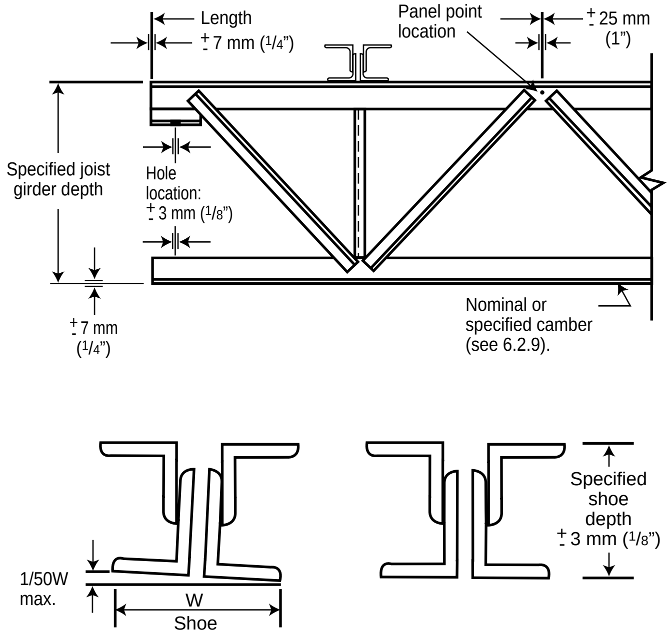

Figure 51
Manufacturing tolerances

6.2.1

Manufacturing tolerances on the specified depth of the joist girder shall be *± 7 mm (1/4")*.

6.2.2

The maximum deviation from the design location of a panel point measured along the length of a chord must not exceed *25 mm (1 in.)*.

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6.2.3

The maximum deviation from the design location of a panel point measured perpendicularly to the longitudinal axis of the chord and in the plane of the joist girder, shall not exceed the extreme outside of the top or bottom chord.

6.2.4

The connections of web members to chords shall not deviate laterally more than *3 mm (1/8")* from that assumed in the design.

6.2.5

As illustrated in Figure 52, the maximum sweep of a joist girder, or any portion of the joist girder, upon completion of manufacture shall be equal to *1/500* of the length on which the sweep is measured.

6.2.6

The maximum tilt of bearing shoes shall be *1/50*, measured from a plane perpendicular to the plane of the web and parallel to the longitudinal axis of the joist girder, as shown in Figure 51 previously.

6.2.7

The tolerance on the specified shoe depth for the supporting elements shall be ± *3 mm (1/8")*.

6.2.8

The tolerance on the specified length of the joist girder must be ± *7 mm (1/4")*. The connection holes for the joist girders must not vary from the detailed location by more than *3 mm (1/8")*.

6.2.9

The tolerance on the nominal or specified camber must be as follows:

METRIC

$$\pm\left(6+\frac{L}{4\,000}\right) \quad \text{where } L = \text{span (mm)}$$

IMPERIAL

$$\pm\left(0.24+\frac{L}{4{,}000}\right) \quad \text{where } L = \text{span (in.)}$$

6.3 Erection Tolerances

The following figure illustrates several erection tolerances that apply to Canam joist girders:

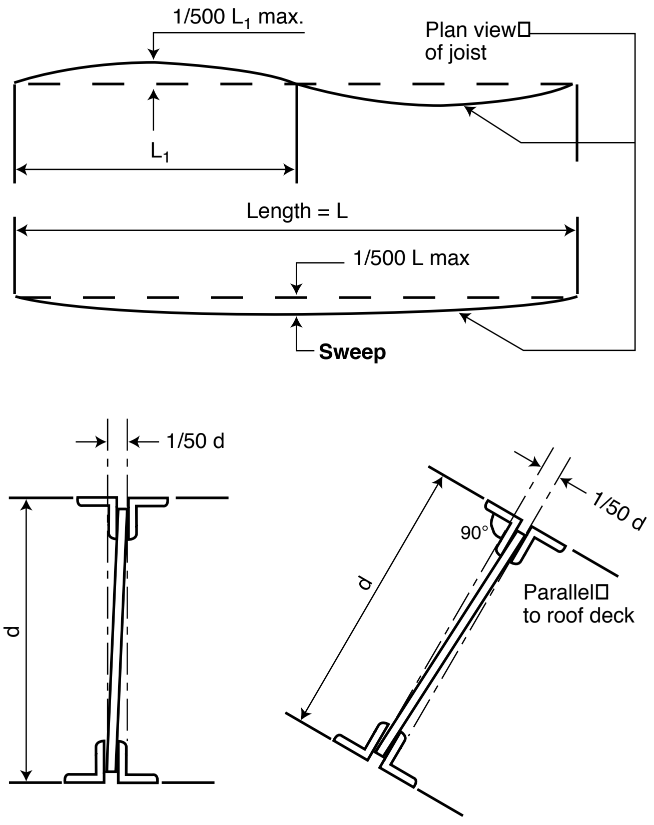

Figure 52
Joist girder erection tolerances

6.3.1

The maximum sweep of a joist girder or a portion of the length of a joist girder upon completion of erection shall not exceed the limit given in Clause 6.2.5 and shall be in accordance with the general requirements of Clause 29 of the S16-01 Standard.

6.3.2

All members shall be free from twists and excessive bends.

6.3.3

The maximum difference in the position of the trusses with respect to the erection drawings must not exceed *15 mm (5/8")*.

6.3.4

The difference between the bottom chord and the top chord, measured perpendicularly to the truss web, must not exceed *1/50* of the depth of the truss.

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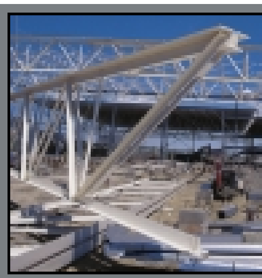

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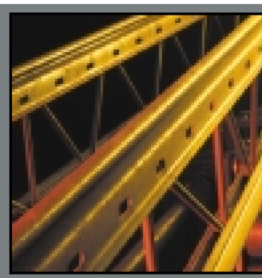

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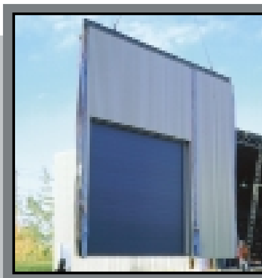

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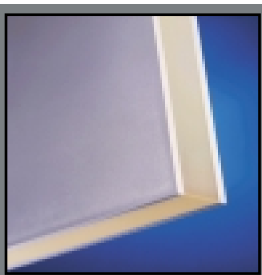

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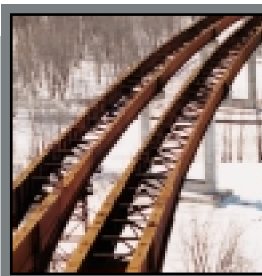

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PUBLICATIONS

- JOIST CATALOG
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TECHNICAL QUESTIONS

JOISTS:	joist@canam.ws
STEEL DECK:	steeldeck@canam.ws
GIRTS:	coldformed@canam.ws
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Canada
Management, Sales Offices and Plants

Quebec, Head Office

11505, 1re Avenue, bureau 500
Ville de Saint-Georges (Québec) G5Y 7X3
Telephone: (418) 228-8031
Toll-free: 1-877-499-6049
Fax: (418) 227-5424

Head Office, Plant and Sales Office
ISO 9001:2000, SJI, AISC, CWB(1)
115, boulevard Canam Nord
Saint-Gédéon, Beauce (Québec) G0M 1T0
Telephone: (418) 582-3331
Toll-free: 1-888-849-5910
Fax: (418) 582-3381

Plant - ISO 9001:2000, CWB(1)
200, boulevard Industriel
Boucherville (Québec) J4B 2X4
Telephone: (450) 641-2820
Toll-free: 1-800-463-1582
Fax: (450) 641-3132

Plant and Sales Office
ISO 9001:2000, AISC, CWB, CISC(1)
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Laval (Québec) H7S 1J9
Telephone: (514) 337-8031
Toll-free: 1-800-361-3966
Fax: (450) 663-5800

Plant
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St-Joseph-de-Beauce (Québec) G0S 2V0
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Alberta
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Fax: (506) 857-3253

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Toll-free: 1-800-361-0203
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United States
Plants

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Head Office and Plant - SJI, AISC(1)
4010 Clay Street, P.O. Box C-285
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Toll-free: 1-800-638-4293
Fax: (301) 874-5685

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Sales Offices

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Fax (561) 540-2571

Illinois
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Telephone: (630) 427-1003
Fax: (630) 427-9046

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Fax: (765) 883-1138

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Lafayette, Indiana 47909
Telephone: (765) 471-7300
Fax: (765) 471-7303

Kansas
14521 West 86th Terrace
Lenexa, Kansas 66215
Telephone: (913) 384-9809
Fax: (913) 384-9816

Maryland
P.O. Box 296
Phoenix, Maryland 21131-0296
Telephone: (410) 472-4327
Fax (410) 472-4827

Massachusetts
50 Eastman Street
Easton, Massachusetts 02334-1245
Telephone: (508) 238-4500
Fax: (508) 238-8253

Minnesota
14481 Fairway Drive
Eden Prairie, Minnesota 55344
Telephone: (952) 475-9165
Fax: (952) 475-2710

New York
139 Hawthorne Way
Chittenango, New York 13037-1010
Telephone: (315) 687-5870
Fax: (315) 687-3701

Ohio
30 Hill Road South
Pickerington, Ohio 43147
Telephone: (614) 920-0949
Fax: (614) 920-0937

Oregon
2081 Holcomb Springs Road
Gold Hill, Oregon 97525
Telephone: (541) 855-9057
Fax: (541) 855-2027

Pennsylvania
3280 St. Andrews Drive
Chambersburg, Pennsylvania 17201
Telephone: (717) 263-7432
Fax: (717) 263-7542

1012 Hampstead Road
Wynnewood, Pennsylvania 19096
Telephone: (610) 896-4790
Fax: (610) 896-4815

Texas
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Fax: (210) 495-0141

Virginia
11008 Blake Lane
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Fax: (540) 439-1476

Washington
240 N.W. Gilman Blvd., Suite G
Issaquah, Washington 98027
Telephone: (425) 392-2935
Fax: (425) 392-3149

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Mexico
Canam Romsa
Plants

Monterrey, NL
Head Office,
Plant and Sales Office - SJI(1)
Carretera Monterrey-Laredo km. 22.450
Cienega de Flores, Nuevo León, México
C.P. 65550
Telephone:
(52 81) 82 62 26 26 = 826CANAM
(52 81) 82 62 26 00
Fax: (52 81) 82 62 26 19
(52 81) 82 62 26 39

Canam Juarez

Ciudad Juárez, Chih.
SJI, IAS(1)
Carretera Panamericana #9920
Colonia Puento Alto
Ciudad Juárez, Chihuahua
México 32695
Telephone: (52 65) 66 29 09 38
Fax: (52 65) 66 33 13 48

Sales Offices

Chihuahua, Chih.
Calle Cipres #1317
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Chihuahua, Chih., México
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Fax: (52 61) 44 82 18 92

Mexico D.F.
Homero 203
Despacho 602, Piso 6
Col. Chapultepec Morelos, México D.F.
CP 11560
Telephone: (011 52) 55-5536-2520
Fax: (011 52) 55-5536-2520

New Mexico
2085 Futury Dr.
Sunland Park
New Mexico 88063
Telephone: (505) 589-1310
Fax: (505) 589-1816

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Plant and Sales Office, Canada

ISO 9001:2000, AISC, CWB(1)
1445, rue du Grand Tronc
Québec (Québec) G1N 4G1
Telephone: (418) 683-2561
Toll-free: 1-877-304-2561
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Sales Office, United States

Maryland
4010 Clay Street, P.O. Box C-285
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Business Offices

Quebec, Canada
270, chemin Du Tremblay
Boucherville (Québec) J4B 5X9
Telephone: (450) 641-4000
Toll-free: 1-866-506-4000
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Brasov, Roumania
Alexandru Ion Lepadatu no 4
Brasov 500446, Roumania
Telephone: (40 268) 31 43 73
Fax: (40 268) 32 78 63

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GN 37/B, Sector V
Salt Lake, Kolkata
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Telephone: (91 33) 23 57 58 65
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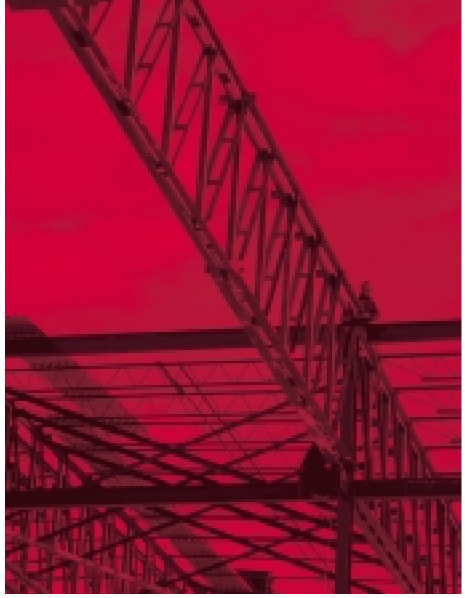

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CANAM
Joists and Steel Deck

Saint-Gédéon
115, boulevard Canam Nord
Saint-Gédéon, Beauce (Québec)
Canada G0M 1T0
Telephone: (418) 582-3331
Toll Free: 1 888-849-5910
Fax: (418) 582-3381

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