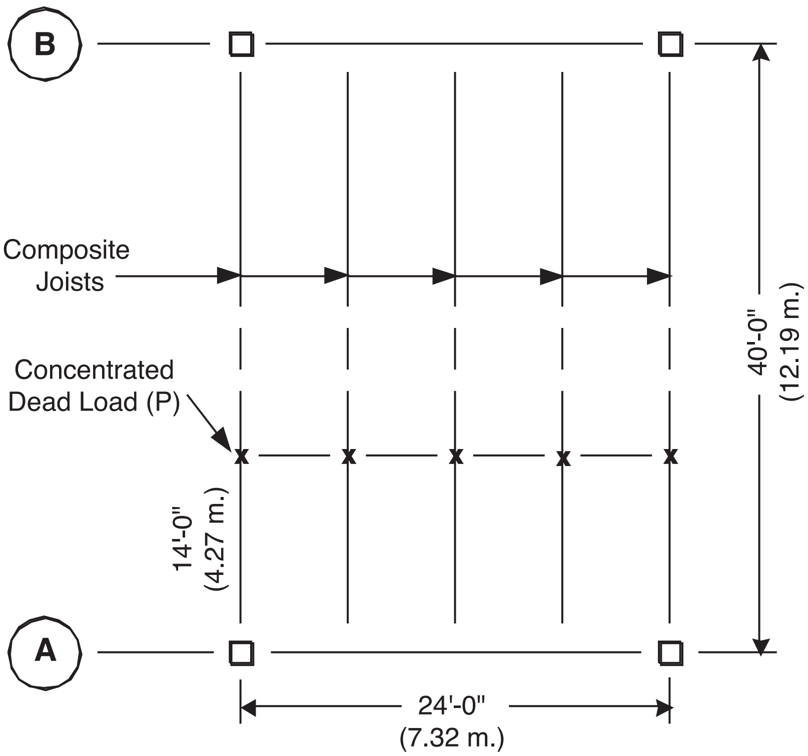
Composite Joist Design Example 2
Special Loadings

The purpose of this example is to demonstrate that the Composite Steel Joist Weight Tables and Bridging Tables may also be used for special loadings.

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



Joist Geometry:

1)	Depth	26 in.	(660 mm)
2)	Span	40 ft.	(12.19 m)
3)	Adjacent Member Spacing (left)	6 ft.	(1.83 m)
4)	Adjacent Member Spacing (right)	6 ft.	(1.83 m)

Concrete and Deck:

1)	Type of Floor Deck	B Comp Floor Deck	
2)	Depth of Floor Deck	2 in.	(51 mm)
3)	Slab Thickness Above Deck	2.5 in.	(64 mm)
4)	Concrete Unit Weight	145 pcf	(2324 kg/m^3)
5)	Concrete Compressive Strength	4 ksi	(27.6 MPa)

COMPOSITE JOIST DESIGN EXAMPLE 2
SPECIAL LOADINGS

Nominal Loads:

1) Non-composite Construction Dead Load

a) Concrete	44	psf	(2.11 kPa)
b) Joist and Bridging (estimated)	4	psf	(0.19 kPa)
c) Deck	2	psf	(0.10 kPa)
d) TOTAL	50	psf	(2.40 kPa)
	= 300	plf	(4.37 kN/m)

2) [1]Construction Live Load

a) During Concrete Placement	0	psf	(0.00 kPa)
	= 0	plf	(0.00 kN/m)

3) Composite Dead Load

a) Fixed Partitions	20	psf	(0.96 kPa)
b) Mechanical	5	psf	(0.24 kPa)
c) Electrical	2	psf	(0.10 kPa)
d) Fireproofing	2	psf	(0.10 kPa)
e) Floor Covering and Ceiling	16	psf	(0.76 kPa)
f) Miscellaneous Dead Loads	0	psf	(0.00 kPa)
g) TOTAL	45	psf	(2.16 kPa)
	= 270	plf	(3.94 kN/m)

4) Composite Live Load

a) Live Load ([2]Reduced as Applicable)	100	psf	(4.79 kPa)
b) Moveable Partitions	0	psf	(0.00 kPa)
c) TOTAL	100	psf	(4.79 kPa)
	= 600	plf	(8.75 kN/m)

5) Total Factored Non-composite Dead Load, 1.2 x (1d)
= 60 psf (2.87 kPa) or 360 plf (5.25 kN/m)

6) Total Factored Composite Dead Load, 1.2 x (3g)
= 54 psf (2.58 kPa) or 324 plf (4.72 kN/m)

7) Total Factored Composite Live Load, 1.6 x (4c)
= 160 psf (7.66 kPa) or 960 plf (14.00 kN/m)

8) Total Factored Composite Design Load, (5) + (6) + (7)
(Concentrated dead load not included)
= 274 psf (13.11 kPa) or 1644 plf (23.97 kN/m)

Additional Concentrated Dead Load, **P**, at Top Chord = 7.0 kips (31.1 kN)

Total Factored Composite Dead Load, 1.2 x 7.0 = **8.4 kips (37.3 kN)**

NOTES:

[1]When estimating construction live loading on a composite steel joist it is suggested that the construction live loading be adjusted for tributary area. No construction live load has been assumed in this example.

[2]Floor live load may be reduced as applicable per ASCE 7-05, Section 4.8. No live load reduction has been taken in this example.

Camber and Deflection (unfactored load):

1. Loads to Camber For:

a)	Percent of Non-composite DL	(1d) x 100%	=	50 psf	(2.40 kPa)
b)	Percent of Composite DL	(3g) x 50%	=	22.5 psf	(1.08 kPa)
c)	Percent of Composite LL	(4c) x 20%	=	20 psf	(0.96 kPa)

2. Maximum Allowable Live Load Deflection, Span/360

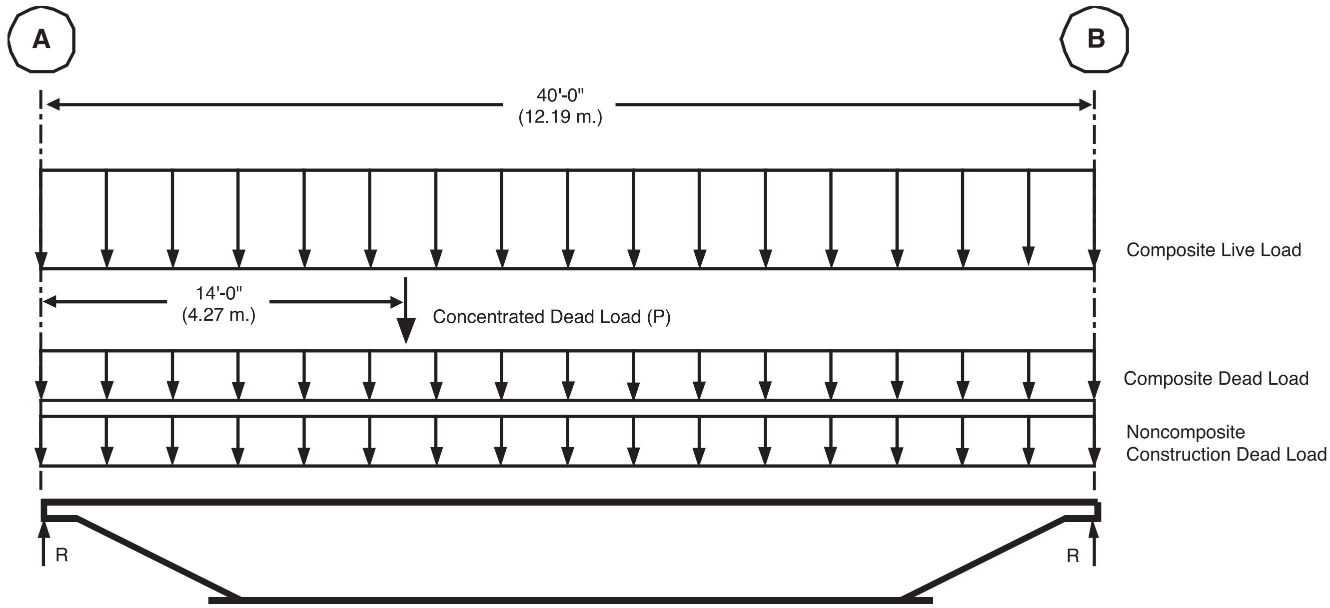
   = (40 x 12/360) = 1.33 in. (34 mm)

3. Maximum Deflection, Span/240

   = (40 x 12/240) = 2.00 in. (51 mm)

Determine joist weight per foot, quantity and size of shear studs, and the number of bridging rows required for the following conditions.

Solution



COMPOSITE JOIST DESIGN EXAMPLE 2
SPECIAL LOADINGS

1. Calculate factored loads for one joist as per the provisions for Load and Resistance Factor Design (LRFD)

a) Uniformly Distributed Loads

w_f = (60 psf + 54 psf + 160 psf) x 6 ft. = 1644 plf (23.97 kN/m)

b) Concentrated Load

P_f = 8.4 kips x 1000 = 8400 lbs (37.3kN)

2. Calculate maximum moment and its position along the joist

The point of maximum moment is the point of zero shear.

Calculate this point, L_0, as follows:

R_A = 1644 plf x 40 ft./2 + 8400 lbs x (40 – 14)/40 = 38,340 lbs (170.4 kN)

L_0 = (38,340 lbs – 8400 lbs)/1644 plf = 18.2 ft. (5.55 m)

Thus the maximum moment is:

M_f = 1644 plf x 18.2 ft. x (40 ft. – 18.2 ft.)/2 + 8400 lbs x 14 ft./ x (40 –18.2)/40

= 390,229 ft.- lbs (528.9kN - m)

3. Calculate maximum end reaction

R_A = 38,340 lbs (170.4kN) from previous calculation

4. Calculate equivalent load due to maximum moment

w_{eM} = 8 x 390,229 ft. – lbs/40 ft.^{2} = 1951 plf (28.45 kN/m)

5. Calculate equivalent load due to maximum end reaction

w_{eR} = 2 x 38,340 lbs/40 ft. = 1917 plf (27.95 kN/m)

6. Determine equivalent load

w_e = Maximum of w_{eM} and w_{eR} = 1951 plf (28.45 kN/m)

7. Select composite joist from the appropriate Composite Joist Weight Table and bridging from appropriate Composite Joist Bridging Table

JOIST SELECTION:

The proper joist shall be selected from the **Design Guide LRFD Weight Table for Composite Steel Joists, CJ-Series – Normal Weight Concrete** for a joist with a 40 foot (12.19 m) span, depth of 26 inches (660 mm), normal weight concrete and a total factored composite design load of 1951 plf (28.45 kN/m) and composite live load of 960 plf (14.00 kN/m).

Choose the column in the table that is equal to or greater than the calculated total safe factored uniformly distributed load and for the corresponding joist depth. The joist spacing, **Js** in the column selected should be less than or equal to the actual spacing of the joists. However, should the joist spacing be less than the **Js** value chosen, then the concrete capacity would need to be checked, since it would likely have a lower **W360** value and a lower total load carrying capacity. The **SJI Composite Joist Floor Design Parameters Checklist** found in the **Code of Standard Practice for Composite Steel Joists** needs to be filled out. This information should be forwarded to a Steel Joist Institute member company requesting that a composite joist design be checked.

In this example choose the column headed by total factored load of 2000 plf (29.16 kN/m) and the 26 inch (660 mm) joist depth row.

Wt = 24.0 plf (35.7 kg/m)

W360 = 1280 plf (18.66 kN/m) > 600 plf (8.75 kN/m)

N-ds = 40 – 5/8 in. (16 mm)

The joist spacing (6 ft.) in this example is less than the value in the table (7 ft.). Therefore, the concrete capacity should normally be checked and the **W360** value could be less than the tabulated value. However, the concrete slab compressive failure does not govern in general and as shown above, **W360** tabulated value far exceeds the required criterion. For the purpose of the example, it is assumed that the concrete slab capacity is OK.

Because of the presence of a concentrated load, spacing of the shear studs may vary over part of the member. The number of studs will be calculated between the point of zero moment and its adjacent point of concentrated load. The rest of the shear studs will be distributed between the point of maximum moment (L_0) and the point of concentrated load, also considering the maximum spacing of the shear studs.

For estimating purposes only, the total number of shear studs may be adjusted for special loadings as follows:

$$\text{Total number of shear studs} = \left(\frac{\text{Span x Quantity from Weight Table}}{2 \text{ x Min } (L_0, \text{ Span} - L_0)}\right)$$

For this example,

$$\text{Total number of shear studs} = \left(\frac{40 \text{ x } 40}{2 \text{ x Min } (18.2,\ 40 - 18.2)}\right) = 44.0$$

Therefore, use 44 studs.

BRIDGING AND NOMINAL HORIZONTAL TOP CHORD FORCE (Pbr) SELECTION:

From the **Design Guide LRFD Weight Table for Composite Steel Joists, CJ-Series – Normal Weight Concrete**, use the same column and row selection for the joist selection (2000 plf; 26 inch joist depth) and determine the number of rows and type of bridging:

For this example two rows of horizontal bridging **(2H)** are required.

For the bridging member size(s) and the nominal horizontal top chord force go to the **Design Guide LRFD Bridging Table for Composite Steel Joists, CJ-Series – Normal Weight Concrete** and choose the column at or nearest the actual joist spacing and the joist depth row based on the joist selection above (Note: This approach is conservative since the nominal horizontal top chord force, **Pbr** will be larger than the actual top chord force, but since the bridging size is also based on the length of bridging, the distance nearest the actual spacing of the joists needs to be considered to size the bridging. This is an estimate and the actual size of the bridging may change when the final design is performed by the joist manufacturer).

For this example the size of the bridging and the **Pbr** force can be selected for the 7 ft. spacing, because the joist spacing is less than the tabulated value for 2000 plf (29.16 kN/m). The bridging size is L1.5 x 1.5 x 0.138 and the nominal horizontal top chord force, **Pbr** is 750 lbs (Note: The nominal horizontal top chord force is used to determine the connection for the termination of the bridging row).

NON-COMPOSITE EFFECTIVE MOMENT of INERTIA SELECTION:

To determine the Non-composite Effective Moment of Inertia of the joist go to the **Design Guide LRFD Bridging Table for Composite Steel Joists, CJ-Series – Normal Weight Concrete** and choose the same column and row used in making the joist selection.

For this example, use the column labeled 2000 plf and the row labeled 26 inch joist depth.

$I_{non\text{-}comp\ eff}$ = 737 in.^{4} (3.07 x 10^8 mm^4)

Deflection:

$$\Delta_{\text{Non-composite DL}} = \frac{5(W_{\text{Non-composite DL}})(\text{Design Length})^4(1728)}{384 E_S\, I_{\text{non-comp eff}}}$$

Where:

Design Length	=	Span – 4 in. = 39.67 ft. (12.19 m)
E_S	=	Modulus of Elasticity of steel (psi)
$I_{\text{non-comp eff}}$	=	Moment of Inertia of Non-composite joist (in.^{4})

$$\Delta_{\text{Non-composite DL}} = \frac{5(300)(39.67)^4(1728)}{384(29{,}000{,}000)(737)} = 0.78 \text{ in. } (19.9 \text{ mm}) = L/614$$

$$\Delta_{\text{Composite DL}} = \frac{5(270)(39.67)^4(1728)}{384(29{,}000{,}000)(1910)} + \frac{(7000)(14)(18.2)(39.67^2 - 14^2 - 18.2^2)(1728)}{6(29{,}000{,}000)(1910)(39.67)}$$

$$\Delta_{\text{Composite DL}} = 0.27 \text{ in.} + 0.24 \text{ in.} = 0.52 \text{ in. } (13.1 \text{ mm}) = L/930$$

$$\Delta_{\text{Composite LL}} = \left[\frac{W_{\text{Composite LL}}}{W_{L/360}}\right]\left[\frac{L}{360}\right] = \left[\frac{600}{1299}\right]\left[\frac{(39.67)(12)}{360}\right] = 0.61 \text{ in. } (15.5 \text{ mm}) = L/786$$

$$\Delta_{\text{TL}} = \Delta_{\text{Non-composite DL}} + \Delta_{\text{Composite DL}} + \Delta_{\text{Composite LL}}$$

$$\Delta_{\text{TL}} = 0.78 \text{ in.} + 0.52 \text{ in.} + 0.61 \text{ in.} = 1.91 \text{ in. } (48.5 \text{ mm}) = L/251$$

Camber:

Camber joist for 100% x $\Delta_{\text{Non-composite DL}}$ + 50% x $\Delta_{\text{Composite DL}}$ + 20% x $\Delta_{\text{Composite LL}}$

Joist Camber = 1.0 x 0.78 in. + 0.50 x 0.52 in. + 0.20 x 0.61 in. = 1.16 in. (29.5 mm)

EFFECTIVE MOMENT of INERTIA SELECTION:

To determine the Effective Moment of Inertia of the joist go to the **Design Guide LRFD Weight Table for Composite Steel Joists, CJ-Series – Normal Weight Concrete** and choose the same column and row used in making the joist selection.

For this example, use the column labeled 2000 plf and the row labeled 26 inch joist depth.

I_{eff} = 1910 in.^{4} (7.95 x 10^8 mm^4)

The published value of **W360** takes into account the reductions in effective transformed moment of inertia associated with web deformations and interfacial slippage. Therefore, the above value of $\mathbf{I_{eff}}$, has been reduced to account for these behaviors. In deriving **W360**, an interfacial slippage factor of 1.05 was assumed.

Therefore, taking out this effect, $I_{e\ composite\ without\ slippage}$ can be given as:

$I_{e\ composite\ without\ slippage}$ = 1.05 I_{eff} = 1.05 (1910 in.^{4}) = 2006 in.^{4} (8.35 x 10^8 mm^4)

Design Summary:

The composite steel joist designation: **26CJ 1644/960/324 (660CJ 23.97/14.00/4.72 kN/m)**

26	CJ	1644	960	324
Depth (in.)	Composite Joist Series	Total Factored Composite Design Load (plf)	Total Factored Composite Live Load (plf)	Total Factored Composite Dead Load (plf)

Bridging: Use **2 rows of 2L's 1.5 x 1.5 x 0.138**

Joist weight = 24 plf (35.7 kg/m)

$\Delta_{Non\text{-}composite\ DL}$ = 0.78 in. (19.9 mm)

$\Delta_{Composite\ DL}$ = 0.52 in. (13.1 mm)

$\Delta_{Composite\ LL}$ = 0.61 in. (15.5 mm)

Camber = 1.16 in. (29.5 mm)

Quantity and Type of Shear Studs: Use 44 - 5/8 in. diameter studs

Duct Opening Available:

From the Approximate Duct Opening Sizes table located in the front portion of the catalog a 12 in. (305 mm) circular duct is permissible to pass through the web openings of a 26 in. deep composite steel joist.