



SIN BEAM TECHNICAL GUIDE

US EDITION

Corrugated Web Steel Beam

October, 2022



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1 GENERAL

1.1 Description of SIN Beam

The SIN beam is a corrugated web welded I-shaped steel beam with a corrugated steel web welded to flat steel flanges.

SIN Beams may be used as flexural members such as roof or floor beams, as components subjected to axial loads such as columns, or as combined bending and axial members such as in moment frames or wind columns. The optimal application for the SIN beam is as an alternative to a rolled or welded wide flange shape or a joist or joist girder section with a depth between 12 in. and 70 in. (300 mm and 1800 mm).

Traditionally the shear strength of a thin web steel beam has been governed by web buckling. Web stiffeners can be used to avoid web buckling but are costly to install. The sinusoidal shape of the SIN beam web prevents such buckling, eliminating the need for web stiffeners, and allowing the web steel material to reach its shear yield strength.

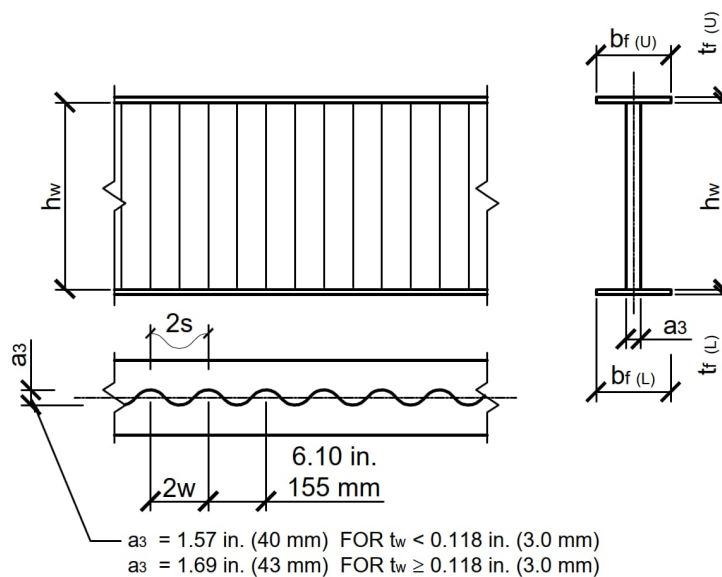


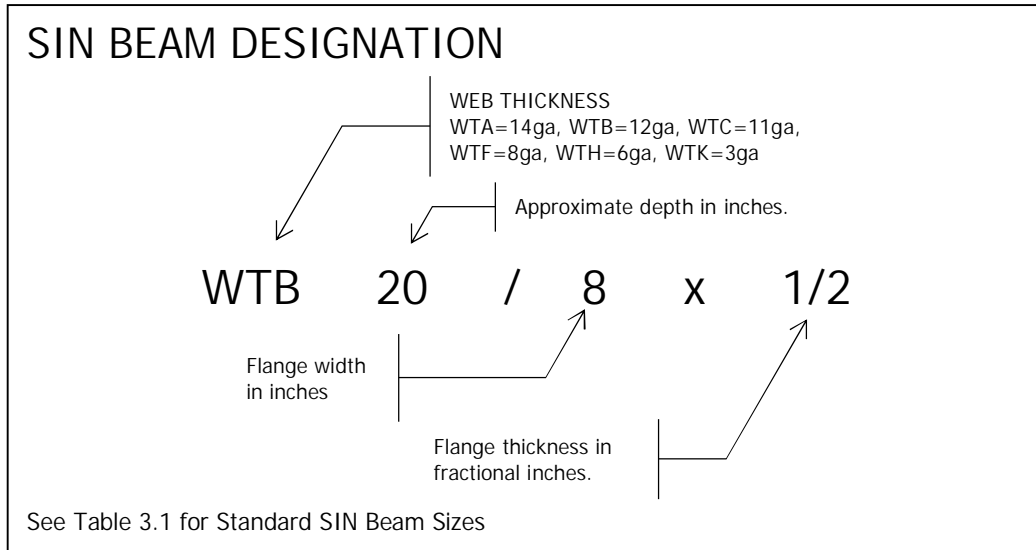
Figure 1: Corrugated Web Steel Beam

1.1.1 Designation:

The standard designation for a parallel flange SIN beam is:

WT [web_thickness] [web_height] / [flange_width] x [flange_thickness]

Example: WTB 20 / 8 x 1/2



1.2 Basis for Calculations

The strength of the SIN beam in bending, axial and shear forces is described in detail in Section 2 of this guide. The bending and axial strength of the SIN beam is based on the design requirements provided in ANSI/AISC 360-16 (A360) "Specification for Structural Steel Buildings" [1]. The web of the SIN beam is made of cold-formed steel and therefore the shear strength is established based on ANSI/AISI S100-16 (S100) "North American Specification for the Design of Cold-Formed Steel Structural Members" [2].

Due to the sinusoidal shape, the web has a negligible contribution to the axial strength of the SIN beam flanges. The axial forces in the beam (due to axial load or a bending moment couple) are carried solely by the SIN beam flanges. The corrugated web resists the beam shear forces and stabilizes the flanges. As such the SIN beam behaves similar to a truss or joist, where the axial and bending forces are carried by the chords (flanges) and the shear forces are carried by the web diagonals (corrugated web).

The SIN beam strength has been confirmed by a number of experimental results and expert opinions, some of which are included in Section 5 of this guide.

1.3 Product Range

Standard SIN beam members are composed of a uniform height, corrugated steel web and two flat steel flanges of equal size. Other configurations, including different top and bottom flanges or tapered webs, are also available. SIN beam sections can be manufactured in lengths between 13 ft (3.96 m) and 50 ft (15.2 m). The standard configurations and designations are described in this section and listed in table 3.1.

1.3.1 Beam Components

1.3.1.1 Web

The SIN beam web is manufactured from steel coil material which is cold-formed into the corrugated shape. The standard coil widths used to manufacture SIN beam webs are between 13 in. (333 mm) and 60 in. (1500 mm). These coils are available in thicknesses ranging from 0.0748 in. (1.90 mm) to 0.239 in. (6.07 mm).

Standard coils can be used to create the following standard web heights:

- 13 = 13.1 in. (333 mm)
- 20 = 19.7 in. (500 mm)
- 24 = 24.0 in. (610 mm)
- 30 = 29.5 in. (750 mm)
- 36 = 35.4 in. (900 mm)
- 40 = 39.4 in. (1000 mm)
- 48 = 48.0 in. (1219 mm)
- 60 = 59.1 in. (1500 mm)

The web thicknesses and associated designations are as follows:

- A : 0.0748 in. [14 ga] (1.90 mm)
- B : 0.105 in. [12 ga] (2.66 mm)
- C : 0.120 in. [11 ga] (3.04 mm)
- F : 0.164 in. [8 ga] (4.17 mm)
- H : 0.194 in. [6 ga] (4.93 mm)
- K : 0.239 in. [3 ga] (6.07 mm)

The corrugated web follows a sinusoidal shape with a wave length of 6.10 in. (155 mm) and an amplitude of 1.57 in. (40 mm) for web thicknesses less than 0.118 in. (3 mm) or 1.69 in. (43 mm) for web thicknesses greater than 0.118 in. (3 mm), see Figure 1. The web is continuously fillet welded to both beam flanges by robotic welding equipment, on one side of the web.

1.3.1.2 Flange

The flanges are fabricated of flat stock material or de-stressed coil material with thickness ranging from ¼ in. (6.35 mm) to 1½ in. (38.1 mm) and in widths between 5 in. (127 mm) and 17.7 in. (450 mm). For all standard size SIN beams the ratio of the flange width to thickness is such that the beam is

considered compact (C) or non-compact (NC) as per A360, Table 3.3a and 3.3b indicate the section classification. A list of standard sizes is included in Table 3.1 of this guide.

Due to the availability of materials flanges $\frac{3}{4}$ in. (19.1 mm) and thicker and longer than 40 ft (12.2 m) will be spliced with full penetration welds.

1.4 Material

The standard material for both flange and web steel is ASTM A572 Gr 50. Other steel grades can also be used but would be considered a special order and would require longer procurement times, minimum order quantities and premium pricing. SIN beam members are fabricated to the tolerances given in ASTM A6 for rolled or welded wide flange steel shapes.

1.5 Welding

All welding is AWS D.1 & D1.3 compliant and done by procedures approved by the American Welding Society (AWS). Welding procedures are included in part 5 of this guide. The corrugated web is welded to the flanges using a continuous fillet weld on one side of the web.

1.6 Corrosion Protection / Painting

SIN beam members are available in any of the following conditions:

- Raw Steel – if special coatings including fireproofing are to be applied.
- Shop Primer
- Hot-Dip Galvanized

1.7 List of Symbols / Abbreviations

a_3	amplitude of the SIN beam web corrugation (see 1.1)
A_g	gross area of beam flanges
A_v	shear area
$A_{v, \text{eff}}$	effective shear area, adjusted to account for the corrugated profile of the web, is used for shear deflection calculations
A360	ANSI/AISC 360-16 Specification for Structural Steel Buildings
$b_{f (U) \text{ or } (L)}$	width of the SIN beam flange (Upper or Lower)
C_w	warping torsional constant
d	overall depth of a SIN beam member
E	Young's Modulus (For A360 $E = 29,000$ ksi; for S100 $E = 29,500$ ksi)
ENC	EN 1993-1-5:2006 European code for plated steel elements
F_y	specified minimum steel yield stress
G	shear Modulus (For A360 $G = 11,200$ ksi; for S100 $G = 11,300$ ksi)

h_w	height of the SIN beam web (i.e. between the flanges)
I_x, I_y	moment of inertial about the strong axis / weak axis
J	St. Venant torsional constant
L_p	longest unbraced length where the beam will reach its full moment strength
M/D	mass over heated perimeter (kg / m / m) per UL
M_n	nominal flexural strength
P_n	nominal axial strength
r_x, r_y	radius of gyration with respect to the strong / weak axis
s	unfolded length of half of a single wave of the SIN beam corrugation
S100	ANSI S100-16 North American specification for the design of cold-formed steel structural members
S_x, S_y	elastic section modulus about the strong axis / weak axis
t_r (U) or (L)	thickness of the SIN beam flange (upper or lower)
t_w	SIN beam web thickness
$t_{w, eff}$	SIN beam effective web thickness, adjusted to account for the corrugated profile of the web, is used for weight and shear deflection calculations
UL	Underwriters Laboratory
V_n	nominal shear strength
w	length of half of a single wave of the SIN beam corrugation
w/d	weight over heated perimeter (lb / ft / in.) per UL
WTA, WTB, WTC, WTF, WTH, WTK	– SIN Beam web thickness designation (see 1.3.1.1)
Ω_b	ASD safety factor for flexure = 1.67
Ω_c	ASD safety factor for compression = 1.67
Ω_v	ASD safety factor for shear = 2.0
ϕ_b	LRFD resistance factor for flexure = 0.9
ϕ_c	LRFD resistance factor for compression = 0.9
ϕ_v	LRFD resistance factor for shear = 0.8
ν	Poisson's ratio = 0.3
$\chi_{c,l}, \chi_{c,g}$	reduction factor for local and global buckling

1.8 Referenced Standards

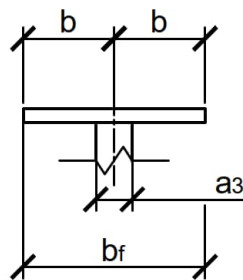
- [1] ANSI/AISC 360-16 – Specification for Structural Steel Buildings
- [2] ANSI/AISI S100-16 – North American Specification for the Design of Cold-Formed Steel Structural Members
- [3] EN-1993-1-5:2006 – Eurocode 3 – Design of steel structures – Part 1-5: Plated Structural Elements
- [4] Omer W. Blodgett, “Design of Welded Structures” 1966

2 TECHNICAL SECTION

2.1 Flexural Strength

The SIN beam flexural strength can be calculated based on the formula given in Section F5 of A360. Due to the nature of the corrugated beam web, the web material has an insignificant contribution to the flexural strength of the member and is ignored.

The limiting width to thickness ratio for the SIN beam compression flange is determined based on Table B4.1b Case 11 of A360. Based on this the thin web, k_c value is taken as 0.35 for all SIN beam members. The width b is taken as $b = \frac{1}{2}b_f$.



Standard SIN beam section properties and flexural strength are given Section 3 of this guide.

2.1.1 Deflection Calculations

Because of the thin and deep web of the SIN beam member, shear deformations will be larger than for conventional rolled wide flange shapes and should be considered for accurate deflection calculations. The beam shear area for each web height and thickness is included in Section 3, and can be used to calculate the shear deformation of the SIN beam.

For common beam sizes (i.e. less than 36.0 in. (914 mm) in depth) and typical beam spans, the shear deflection typically increase the deflection by 5 to 15%. Shear deformation increases linearly with beam length while flexural deformation increases rapidly as a third power to beam length. Therefore, shear deformations are most significant for beams with low span to depth ratios.

In section 2.6 of Blodgett [4] there is an expression for the calculation of shear deformation of steel beams. Shear deflection is related to the beam loading, span, shear area and modulus of elasticity. Equations are presented for shear deformation due to uniform or point loads on simply supported and cantilever sections. The shear deformation can be added to the beam flexural deformation to determine the total beam deflection. A shear deflection calculation based on Blodgett's formula has been included in the example problem in Section 1 of this guide.

2.2 Shear Strength

Since the SIN beam web material is made of cold-formed steel, the shear design of the beam is based on S100. The governing shear design criteria in Section G of S100 is based on the web material being uniform thickness and not of a corrugated geometric shape. Therefore, in the case of the SIN Beam, a

direct shear strength calculation cannot be made based on Section G2.1 of S100. However, Section A1.2(c) does permit the use of a “Rational Engineering Analysis” based on appropriate theory and engineering judgment.

2.2.1 Shear Strength – Rational Engineering Analysis

A shear strength design method for corrugated beam webs has been developed in Europe in the 1990s based on theory/research and extensive testing. This design expression has been adopted by the European Code ENC [3] and is contained in Annex D, a copy of which is included in section 5 of this guide. Given the well-established history in Europe, the method was adopted as the Rational Engineering Analysis as per Section A1.2(c) of S100 for the SIN beam. In addition, confirmatory tests were carried out to verify the accuracy of the method. As well, for LRFD the resistance factor is 0.80 and the safety factor for ASD is 2.00.

2.2.2 Annex D of ENC [3]

Annex D provides expressions for the shear design of corrugated web beams which accounts for yielding, local buckling, or global buckling of a corrugated web. The basic nominal shear expression of Annex D is:

$$V_n = \chi_c \frac{f_y}{\gamma_{M1} \sqrt{3}} h_w t_w$$

χ_c is the lesser of the local or global buckling coefficient $\chi_{c,l}$ or $\chi_{c,g}$

γ_{M1} is the partial factor equal to 1.0 (the appropriate LRFD or ASD factor will be applied per S100)

$\frac{f_y}{\sqrt{3}} = 0.577 f_y$ as per von Mises yield theory which is similar to the $0.6F_y$ used in A360 and S100

$h_w t_w = A_w$ is the area of the web

In the European code material resistance factors are left up to each country and not included in the code formula.

Local Buckling

$$\chi_{c,l} = \frac{1.15}{0.9 + \bar{\lambda}_{c,l}} \leq 1.0$$

$$\bar{\lambda}_{c,l} = \sqrt{\frac{F_y}{\tau_{cr,l} \cdot \sqrt{3}}}$$

$$\tau_{cr,l} = \left(5.34 + \frac{a_3 S}{h_w t_w} \right) \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{t_w}{s} \right)^2$$

a_3 - Web amplitude

S - unfolded length of one half wave

E - Young's modulus

ν – Poisson's Ratio

Global Buckling

$$\chi_{c,g} = \frac{1.5}{0.5 + \bar{\lambda}_{c,g}^2} \leq 1.0$$

$$\bar{\lambda}_{c,g} = \sqrt{\frac{F_y}{\tau_{cr,g} \cdot \sqrt{3}}}$$

$$\tau_{cr,g} = \frac{32.4}{t_w h_w^2} \sqrt[4]{D_x D_z^3}$$

$$D_x = \frac{E t^3}{12(1-\nu^2)} \frac{w}{s}$$

$$D_z = \frac{E I_z}{w}$$

w - length of one half wave

I_z - second moment of area of one corrugation of length w

2.2.3 Shear Strength – Load Testing

Steelcon has conducted shear load testing, in accordance with Section K of S100 for a selection of SIN beam members to ensure the accuracy of the design method in ENC [3] Annex D. A report by Dr. R.M. Schuster of the shear load testing is included in Section 5 of this guide. The SIN Beam shear load testing has shown that the shear expression is conservative, as can be observed from the conclusion of the test report.

2.3 Axial Strength

The axial strength of a SIN beam section can be determined by formula in A360 sections E3, E4, & E7. Similar to the flexural resistance the axial resistance is provided solely by the steel area of the flanges (neglecting any contribution of the web).

The limiting width to thickness ratio for the SIN beam flanges is determined based on Table B4.1a Case 2 of A360 since the thin web k_c value is taken as 0.35 for all SIN beam members. The width b is taken as $b = \frac{1}{2} b_f$. Some SIN beam flanges are considered slender per Table B4.1a, for these members the axial strength is calculated per Section E7, the table for axial strength in Section 3 of this guide indicates if the member is slender (S) or non-slender (NS).

2.4 Detailed Calculation

Below is a detailed member strength calculation for flexure, shear and axial strength of a SIN beam member. Equation and Section references from A360 or S100 are in (italics).

2.4.1 Input

$$F_y = 50 \text{ ksi} \quad \mu = 0.3 \quad \phi_b = 0.9 \quad \phi_c = 0.9 \quad \phi_v = 0.8$$

$$E = 29,000 \text{ ksi} \quad G = 11,170 \text{ ksi} \quad \Omega_b = 1.67 \quad \Omega_c = 1.67 \quad \Omega_v = 2.00$$

SIN Beam Size WTC 20 / 8 x ½

Web Properties $h_w = 19.68 \text{ in.} \quad t_w = 0.1196 \text{ in.} \quad a_3 = 1.69 \text{ in.} \quad w = 3.05 \text{ in.}$

Flange Properties $b_f = 8 \text{ in.} \quad t_f = ½ \text{ in.}$

Unbraced Length

$L_b = 10 \text{ ft}$ Bending Lateral-Torsional Buckling

$L_c = 20 \text{ ft}$ Compression Flexural Buckling

$L_{cz} = 20 \text{ ft}$ Compression Torsional Buckling

2.4.2 A360 Flexural Strength (Section F5)

2.4.2.1 Compression Flange Yielding

$R_{pg} = 1.0$ – The web has no contribution to the flexural strength $a_w = 0$

$$I_x = 2 \left(\frac{1}{12} b_f t_f^3 + b_f t_f \left(\frac{1}{2} h_w + \frac{1}{2} t_f \right)^2 \right) = 2 \left(\frac{1}{12} 8 \times 0.5^3 + 8 \times 0.5 \left(\frac{1}{2} 19.68 + \frac{1}{2} 0.5 \right)^2 \right) = 815 \text{ in}^4$$

$$S_{xc} = \frac{I_x}{\frac{1}{2}(t_f + h_w + t_f)} = \frac{815}{\frac{1}{2}(0.5 + 19.7 + 0.5)} = 78.8 \text{ in}^3 \quad I_x \text{ and } S_x \text{ are based on the flanges only}$$

$$M_n = R_{pg} F_y S_{xc} = 1.0 \times 50 \times 78.8 = 328 \text{ kip-ft} \quad - (F5-1)$$

2.4.2.2 Lateral-Torsional Buckling

$$r_t = \frac{b_f}{\sqrt{12(1 + \frac{1}{6} a_w)}} = \frac{8}{\sqrt{12}} = 2.31 \text{ in.} \quad - (F4-11) \quad a_w = 0$$

$$L_p = 1.1 \times r_t \sqrt{\frac{E}{F_y}} = 1.1 \times 2.31 \sqrt{\frac{29,000}{50}} = 61.2 \text{ in.} \quad - (F4-7)$$

$$L_r = \pi \times r_t \sqrt{\frac{E}{0.7 \times F_y}} = 3.14 \times 2.31 \sqrt{\frac{29,000}{0.7 \times 50}} = 209 \text{ in.} \quad - (F5-5)$$

$$C_b = 1.0$$

$L_b = 10 \text{ ft} = 120 \text{ in.}$ $L_p < L_b < L_r$ therefore F_{cr} is based on (F5-3)

$$F_{cr} = C_b \left(F_y - 0.3 \times F_y \frac{L_b - L_p}{L_r - L_p} \right) = 1.0 \left(50 - 0.3 \times 50 \frac{120 - 61.2}{209 - 61.2} \right) = 44.0 \text{ ksi} < 50 \text{ ksi} \quad - (F5-3)$$

$$M_n = R_{pg} F_{cr} S_{xc} = 1.0 (44.0) (78.8) = 289 \text{ kip-ft} \quad - (F5-2)$$

2.4.2.3 Compression Flange Local Buckling

$$\lambda_p = 0.38 \sqrt{\frac{E}{F_y}} = 0.38 \sqrt{\frac{29,000}{50}} = 9.15 \quad - \text{(Table B4.1b – Case 11)}$$

$$k_c = 0.35$$

$$F_L = 0.7F_y = 0.7(50) = 35 \text{ ksi} \quad - \text{Since } S_{xt} = S_{xc}$$

$$\lambda_r = 0.95 \sqrt{\frac{k_c E}{F_L}} = 0.95 \sqrt{\frac{0.35 \times 29,000}{35}} = 16.2 \quad - \text{(Table B4.1b – Case 11)}$$

$$\lambda = \frac{b_f}{2 t_f} = \frac{8}{2 \times 0.5} = 8 \quad \lambda < \lambda_p \text{ Therefore } F_{cr} = F_y$$

$$M_n = R_{pg} F_{cr} S_{xc} = 1.0(50)(78.8) = 328 \text{ kip-ft} \quad - \text{(F5-7)}$$

2.4.2.4 Tension Flange Yielding

Does not apply as $S_{xt} = S_{xc}$

2.4.2.5 Flexural Strength

Nominal Flexural Strength is the minimum of the values for Compression Flange Yielding (F5-1), Lateral-Torsional Buckling (F5-2) and Compression Flange Buckling (F5-7)

$$M_n = 289 \text{ kip-ft}$$

Design Flexural Strength (LRFD)

$$\phi_b M_n = 0.9(289) = 260 \text{ kip-ft} \quad (\text{see Table 3.3b})$$

Allowable Flexural Strength (ASD)

$$\frac{M_n}{\Omega_b} = \frac{289}{1.67} = 173 \text{ kip-ft} \quad (\text{see Table 3.3a})$$

2.4.3 S100 Shear Strength

Based on Rational Engineering Analysis, S100 Section A1.2(c), and ENC [4] (Annex D)

$$V_n = \chi_c \frac{F_y}{\sqrt{3}} h_w t_w$$

$$s = \frac{1}{2} \int_0^{2w} \sqrt{1 + \left(\frac{a_3 \pi}{2w} \times \sin \left(\frac{2\pi x}{2w} \right) \right)^2} dx = \frac{1}{2} \int_0^{2 \times 3.05} \sqrt{1 + \left(\frac{1.69 \pi}{2 \times 3.05} \times \sin \left(\frac{2 \pi x}{2 \times 3.05} \right) \right)^2} dx = 3.57 \text{ in.}$$

2.4.3.1 Local Buckling Coefficients

$$\tau_{cr,1} = \left(5.34 + \frac{a_3 s}{h_w t_w} \right) \frac{\pi^2 E}{12(1-\mu^2)} \left(\frac{t_w}{s} \right)^2 = \left(5.34 + \frac{1.69 \times 3.57}{19.7 \times 0.120} \right) \frac{\pi^2 29,500}{12(1-0.3^2)} \left(\frac{0.120}{3.57} \right)^2 = 237 \text{ ksi}$$

$$\lambda_{c,1} = \sqrt{\frac{F_y}{\tau_{cr,1} \sqrt{3}}} = \sqrt{\frac{50}{237 \sqrt{3}}} = 0.349$$

$$\chi_{c,l} = \frac{1.15}{0.9 + \lambda_{c,l}} = \frac{1.15}{0.9 + 0.349} = 0.921$$

2.4.3.2 Global Buckling Coefficients

$$I_z = \frac{1}{2} \int_0^{2w} \left(\frac{1}{12} t_w^3 + t_w \left(\frac{a_3}{2} \sin\left(\frac{2\pi x}{2w}\right) \right)^2 \right) dx$$

$$= \frac{1}{2} \int_0^{2 \times 3.05} \left(\frac{1}{12} 0.1196^3 + 0.1196 \left(\frac{1.69}{2} \sin\left(\frac{2\pi x}{2 \times 3.05}\right) \right)^2 \right) dx = 0.131 \text{ in}^4$$

$$D_z = \frac{EI_z}{w} = \frac{29,500 \times 0.131}{3.05} = 1270 \text{ kip-in.}$$

$$D_x = \frac{E t_w^3}{12(1-\mu^2)} \frac{w}{s} = \frac{29,500 \times 0.1196^3}{12(1-0.3^2)} \times \frac{3.05}{3.57} = 3.95 \text{ kip-in}$$

$$\tau_{cr,g} = \frac{32.4}{t_w \times h_w^2} \times \sqrt[4]{D_x \times D_z^3} = \frac{32.4}{0.1196 \times 19.68^2} \times \sqrt[4]{3.95 \times 1270^3} = 209 \text{ ksi}$$

$$\lambda_{c,g} = \sqrt{\frac{F_y}{\tau_{cr,g} \sqrt{3}}} = \sqrt{\frac{50}{209 \sqrt{3}}} = 0.371$$

$$\chi_{c,g} = \frac{1.5}{0.5 + \lambda_{c,g}^2} = \frac{1.5}{0.5 + 0.371^2} = 2.35 \text{ but } \chi_{c,g} \leq 1.0 \therefore \chi_{c,g} = 1.0$$

χ_c is the minimum of $\chi_{c,l}$ for Local Buckling and $\chi_{c,g}$ for Global Buckling $\therefore \chi_c = 0.921$

2.4.3.3 Shear Strength

$$V_n = \chi_c \frac{F_y}{\sqrt{3}} h_w t_w = 0.921 \frac{50}{\sqrt{3}} 19.68 \times 0.1196 = 62.6 \text{ kip}$$

Design Shear Strength (LRFD)

$$\phi_v V_n = 0.8(62.6) = 50.1 \text{ kip} \quad (\text{see Table 3.4b})$$

Allowable Shear Strength (ASD)

$$\frac{V_n}{\Omega_v} = \frac{62.6}{2.0} = 31.3 \text{ kip} \quad (\text{see Table 3.4a})$$

2.4.4 A360 Axial Strength (*Section E3, E4, E7*)

$$k_c = 0.35$$

$$\lambda_r = 0.64 \sqrt{\frac{k_c E}{F_y}} = 0.64 \sqrt{\frac{0.35 \times 29,000}{50}} = 9.12 \quad - (\text{Table B4.1a} - \text{Case 2})$$

$$\lambda = \frac{0.5 b_f}{t_f} = \frac{0.5 \times 8}{0.5} = 8 \quad - \text{As } \lambda < \lambda_r \text{ this section is non-slender and section E3 and E4 apply}$$

$$d = h_w + 2 \times t_f = 19.7 + 2 \times 0.5 = 20.7 \text{ in.}$$

$$A = 2 \times b_f \times t_f = 2 \times 8 \times 0.5 = 8 \text{ in}^2$$

$$I_x = 2 \left(\frac{1}{12} b_f t_f^3 + b_f t_f \left(\frac{1}{2} h_w + \frac{1}{2} t_f \right)^2 \right) = 2 \left(\frac{1}{12} 8 \times 0.5^3 + 8 \times 0.5 \left(\frac{1}{2} 19.68 + \frac{1}{2} 0.5 \right)^2 \right) = 815 \text{ in}^4$$

$$I_y = \frac{1}{12} b_f^3 d - \frac{1}{12} b_f^3 h_w = \frac{1}{12} 8^3 \times 20.7 - \frac{1}{12} 8^3 \times 19.7 = 42.7 \text{ in}^4$$

$$r_x = \sqrt{\frac{I_x}{A}} = \sqrt{\frac{815}{8}} = 10.1 \text{ in.} \quad r_y = \sqrt{\frac{I_y}{A}} = \sqrt{\frac{42.7}{8}} = 2.31 \text{ in.} \quad r_x/r_y = 10.1/2.31 = 4.37$$

$$J = \frac{2 \times b_f \times t_f^3}{3} = \frac{2 \times 8 \times 0.5^3}{3} = 0.667 \text{ in}^4$$

$$C_w = \frac{(d-t_f)^2 \times b_f^3 \times t_f}{24} = \frac{(20.7-0.5)^2 \times 8^3 \times 0.5}{24} = 4350 \text{ in}^6$$

2.4.4.1 Flexural Buckling – Section E3

$$F_e = \frac{\pi^2 E}{\left(\frac{L_c}{r_y}\right)^2} = \frac{\pi^2 29,000}{\left(\frac{240}{2.31}\right)^2} = 26.5 \text{ ksi} \quad \frac{F_y}{F_e} = \frac{50}{26.5} = 1.89 \leq 2.25$$

$$F_{cr} = \left(0.658 \frac{F_y}{F_e} \right) F_y = \left(0.658 \frac{50}{26.5} \right) 50 = 22.7 \text{ ksi} \quad (E3-2)$$

$$P_n = F_{cr} \times A_g = 22.7 \times 8 = 182 \text{ kip}$$

2.4.4.2 Torsional Buckling – Section E4

$$F_e = \left(\frac{\pi^2 E \times C_w}{L_{cz}^2} + G \times J \right) \frac{1}{I_x + I_y} = \left(\frac{\pi^2 29,000 \times 4350}{240^2} + 11,200 \times 0.667 \right) \frac{1}{815 + 42.7} = 33.9 \text{ ksi} \quad (E4-2)$$

$$\frac{F_y}{F_e} = \frac{50}{33.9} = 1.47 \leq 2.25$$

$$F_{cr} = \left(0.658 \frac{F_y}{F_e} \right) F_y = \left(0.658 \frac{50}{33.9} \right) 50 = 27.0 \text{ ksi} \quad (E3-2)$$

$$P_n = F_{cr}(A_g) = 27.0(8) = 216 \text{ kip}$$

2.4.4.3 Axial Strength

Nominal Axial Strength is the minimum value of Flexural Buckling (E3) and Torsional Buckling (E4)

$$P_n = 182 \text{ kip}$$

Design Axial Strength

$$\phi_c P_n = 0.9(182) = 163 \text{ kip} \quad (\text{see Table 3.5b})$$

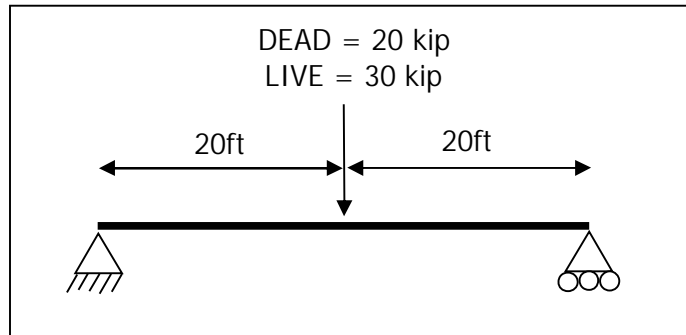
Allowable Axial Strength

$$\frac{P_n}{\Omega_c} = \frac{182}{1.67} = 109 \text{ kip} \quad (\text{see Table 3.5a})$$

2.5 Sample Problem

This sample problem is intended as a quick introduction to using the design tables contained in this guide. This beam will be designed using the LRFD strength design approach. For a typical SIN beam design there are 3 independent parameters to determine, web height, web thickness and flange size. Flexural strength and flexural deflection are related to the web height and flange size, and shear strength and shear deflection are related to the web height and web thickness.

2.5.1 Input Parameters



A 40 ft long simply supported beam is loaded at mid span with a 20 kip dead and 30 kip live load. The beam is laterally restrained at the supports and at mid span. Design the beam that is less than 36 in. in depth to resist the applied loads and to have a live load deflection of less than $L/360$.

2.5.2 Strength Check

LRFD Factored Load Effects

$$\text{Factored point load } P_f = 1.2 \text{ DL} + 1.6 \text{ LL} = 1.2(20) + 1.6(30) = \underline{72 \text{ kip}}$$

$$\text{Factored mid-span moment } M_f = \frac{1}{4} P_f L = \frac{1}{4} 72 \times 40 = \underline{720 \text{ kip-ft}}$$

$$\text{Factored shear load } V_f = \frac{1}{2} P_f = \frac{1}{2} 72 = \underline{36 \text{ kip}}$$

To have the final beam size be less than 36 in. in depth we will use a WT_ 30 SIN beam which has a 29.5 in. tall web. The flange size and web thickness can be selected such that the design flexural strength and design shear strength exceed the factored load effects.

The flange size can be selected based on Table 3.3b. The LRFD design flexural strength of a WT_ 30 / 10 x 1 is 814 kip-ft for an unbraced length of 20 ft.

The web thickness can be selected based on Table 3.4b. The LRFD design shear strength of a WTB 30 is 62.3 kip

Therefore a WTB 30 / 10 x 1 is structurally sufficient to resist the design loads

2.5.3 Deflection Check

The Live Load deflection limit is $L/360 = 40(12)/360 = \underline{1.33 \text{ in.}}$

2.5.3.1 Flexural Deflection

From Table 3.2a the strong axis moment of inertia for a WT_ 30 / 10 x 1 is $I_x = 4660 \text{ in}^4$

$$\Delta_f = \frac{P L^3}{48 E I_x} = \frac{30 \times 480^3}{48 \times 29,000 \times 4660} = \underline{0.511 \text{ in.}}$$

2.5.3.2 Shear Deflection

From "Design of Welded Structures" by O.W. Blodgett [4] the shear deflection is calculated as

$$\Delta_v = \frac{P L \alpha}{4 A_v E_s}, \text{ in Blodgett's nomenclature } E_s \text{ is the Shear modulus } G$$

α is a form factor for an I or box beam $\alpha = \frac{A}{8 I_x t_w} (b_f d^2 - b_f h_w^2 + t_w h_w^2)$ most of these physical properties for a WTB 30 / 10 x 1 can be found in Table 3.2, the web effective shear area A_v can be found in Table 3.4c

$$\alpha = \frac{3.62}{8 \times 4660 \times 0.105} (10 \times 31.5^2 - 10 \times 29.5^2 + 0.105 \times 29.5^2) = \underline{1.21}$$

$$\Delta_v = \frac{30 \times 480 \times 1.21}{4 \times 3.62 \times 11300} = \underline{0.106 \text{ in.}}$$

2.5.3.3 Total Deflection

The total beam deflection is the summation of the flexural plus the shear deflection of the beam.

$$\Delta = \Delta_f + \Delta_v = 0.511 + 0.106 = 0.617 \text{ in.} < L/360 = \underline{1.33 \text{ in.}}$$

2.5.4 Results Summary

The SIN beam that satisfies the design criteria is therefore a WTB 30 / 10 x 1

Per Table 3.2a the overall depth is 31.5 in.

Per Table 3.3b the design flexural strength is 814 kip-ft

Per Table 3.4b the design shear strength is 62.3 kip

The resulting total deflection is 0.617 in.

3 TABLES

Table 3.1 – Common SIN Beam Sizes

Table 3.1a – Web Thickness

Table 3.1b – Web Depth

Table 3.1c – Flange Size

Table 3.1d – Equivalent Web Thickness

Table 3.2 – SIN Beam Section Properties

Table 3.2a – Section Properties

Table 3.2b – Continued Section Properties

Table 3.3 – SIN Beam Flexural Strength

Table 3.3a – Allowable Flexural Strength (ASD)

Table 3.3b – Design Flexural Strength (LRFD)

Table 3.4 – SIN Beam Shear Strength

Table 3.4a – Allowable Shear Strength (ASD)

Table 3.4b – Design Shear Strength (LRFD)

Table 3.4c – SIN Beam Shear Properties

Table 3.5 – SIN Beam Flexural Strength

Table 3.3a – Allowable Flexural Strength (ASD)

Table 3.3b – Design Flexural Strength (LRFD)

Table 3.6 – SIN Beam w/d and M/D ratio for Fire Proofing of Beam members

Table Notes

- Table 3.3 • NC, C indicates if the section is Non-Compact or Compact in Flexure per A360 Table B4.1b Case 11
- Table 3.5 • NS, S indicates if the section is Non-Slender or Slender in Axial Compression per A360 Table B4.1a Case 2
- Table 3.6 • Per current UL / ULC listings all SIN beam webs must have a minimum thickness of 0.120 in. (3.04 mm) which is a WTC or heavier, thinner webs are shown in grey italics
 - Per the BXUV Guide the minimum w/d ratio is 0.37, smaller values are shown in red
 - Per the BXUVC Guide the minimum M/D ratio is 23, smaller values are shown in red
 - These values are for UL / ULC Beam design formula and exclude the top of the top flange in the perimeter calculation
 - There are currently no UL / ULC designs for SIN members used as column sections

Common SIN Beam Sizes

Table 3.1

Web Thickness Table 3.1a

Designation	Web Thickness t_w		
	(in.)	(mm)	(ga)
WTA	0.0747	1.90	14
WTB	0.105	2.66	12
WTC	0.120	3.04	11
WTF	0.164	4.18	8
WTH	0.194	4.94	6
WTK	0.239	6.07	3

Web Depth Table 3.1b

Designation	Web Depth h_w	
	(in.)	(mm)
13	13.1	333
20	19.7	500
24	24.0	610
30	29.5	750
36	35.4	900
40	39.4	1000
48	48.0	1219
60	59.1	1500

Flange Size Table 3.1c

b_f (in.)	t_f (in.)	b_f (mm)	t_f (mm)
6	1/4	152	6.35
6	5/16	152	7.94
6	3/8	152	9.53
7	3/8	178	9.53
6	1/2	152	12.7
7	1/2	178	12.7
8	1/2	203	12.7
6	3/4	152	19.1
8	5/8	203	15.9
8	3/4	203	19.1
10	3/4	254	19.1
8	1	203	25.4
12	3/4	305	19.1
10	1	254	25.4
11	1	279	25.4
12	1	305	25.4
10	1 1/4	254	31.8
13	1	330	25.4
14	1	356	25.4
12	1 1/4	305	31.8
16	1	406	25.4
14	1 1/4	356	31.8
16	1 1/4	406	31.8

Equiv Web Thickness Table 3.1d

Designation	Equiv. Web Thickn. t_w	
	(in.)	(mm)
WTA	0.0873	2.22
WTB	0.122	3.11
WTC	0.140	3.55
WTF	0.192	4.88
WTH	0.227	5.77
WTK	0.280	7.10

Equivalent web thickness accounts for corrugated shape and is used for weight and shear deflection calculations

SIN Beam Section Properties

Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_13									
5x1/4	13.6	13.1	5.00	0.250	2.50	0.112	5.21	16.4	2.08
6x1/4	13.6	13.1	6.00	0.250	3.00	0.134	9.00	19.7	3.00
6x5/16	13.7	13.1	6.00	0.313	3.75	0.169	11.3	24.6	3.75
6x3/8	13.9	13.1	6.00	0.375	4.50	0.205	13.5	29.5	4.50
7x3/8	13.9	13.1	7.00	0.375	5.25	0.239	21.4	34.4	6.13
6x1/2	14.1	13.1	6.00	0.500	6.00	0.278	18.0	39.4	6.00
7x1/2	14.1	13.1	7.00	0.500	7.00	0.324	28.6	46.0	8.17
8x1/2	14.1	13.1	8.00	0.500	8.00	0.371	42.7	52.5	10.7
6x3/4	14.6	13.1	6.00	0.750	9.00	0.433	27.0	59.2	9.00
8x5/8	14.4	13.1	8.00	0.625	10.0	0.472	53.3	65.7	13.3
8x3/4	14.6	13.1	8.00	0.750	12.0	0.577	64.0	79.0	16.0
10x3/4	14.6	13.1	10.0	0.750	15.0	0.721	125	98.7	25.0
8x1	15.1	13.1	8.00	1.00	16.0	0.798	85.3	106	21.3
12x3/4	14.6	13.1	12.0	0.750	18.0	0.865	216	118	36.0
10x1	15.1	13.1	10.0	1.00	20.0	0.997	167	132	33.3
11x1	15.1	13.1	11.0	1.00	22.0	1.10	222	145	40.3
12x1	15.1	13.1	12.0	1.00	24.0	1.20	288	158	48.0
10x1 1/4	15.6	13.1	10.0	1.25	25.0	1.29	208	166	41.7
13x1	15.1	13.1	13.0	1.00	26.0	1.30	366	172	56.3
14x1	15.1	13.1	14.0	1.00	28.0	1.40	457	185	65.3
12x1 1/4	15.6	13.1	12.0	1.25	30.0	1.55	360	199	60.0
16x1	15.1	13.1	16.0	1.00	32.0	1.60	683	211	85.3
14x1 1/4	15.6	13.1	14.0	1.25	35.0	1.81	572	232	81.7
16x1 1/4	15.6	13.1	16.0	1.25	40.0	2.07	853	265	107
17.7x1 1/4	15.6	13.1	17.7	1.25	44.3	2.29	1160	293	131

SIN Beam Section Properties (cont.)

Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_13										
5x1/4	6.68	1.44	0.232	0.0521	12.4	14.0	14.7	17.1	18.6	21.0
6x1/4	6.68	1.73	0.402	0.0625	14.1	15.7	16.4	18.8	20.3	22.7
6x5/16	6.71	1.73	0.507	0.122	16.7	18.2	19.0	21.3	22.9	25.2
6x3/8	6.74	1.73	0.614	0.211	19.2	20.8	21.5	23.9	25.4	27.8
7x3/8	6.74	2.02	0.975	0.246	21.8	23.3	24.1	26.4	28.0	30.3
6x1/2	6.81	1.73	0.834	0.500	24.3	25.9	26.7	29.0	30.5	32.9
7x1/2	6.81	2.02	1.32	0.583	27.7	29.3	30.1	32.4	34.0	36.3
8x1/2	6.81	2.31	1.98	0.667	31.1	32.7	33.5	35.8	37.4	39.7
6x3/4	6.93	1.73	1.30	1.69	34.5	36.1	36.9	39.2	40.8	43.1
8x5/8	6.87	2.31	2.52	1.30	37.9	39.5	40.3	42.6	44.2	46.5
8x3/4	6.93	2.31	3.07	2.25	44.7	46.3	47.1	49.4	51.0	53.3
10x3/4	6.93	2.89	6.00	2.81	54.9	56.5	57.3	59.6	61.2	63.5
8x1	7.06	2.31	4.25	5.33	58.3	59.9	60.7	63.0	64.6	66.9
12x3/4	6.93	3.46	10.4	3.38	65.1	66.7	67.5	69.8	71.4	73.7
10x1	7.06	2.89	8.30	6.67	72.0	73.5	74.3	76.6	78.2	80.5
11x1	7.06	3.18	11.0	7.33	78.8	80.3	81.1	83.4	85.0	87.3
12x1	7.06	3.46	14.3	8.00	85.6	87.1	87.9	90.2	91.8	94.1
10x1 1/4	7.19	2.89	10.7	13.0	89.0	90.5	91.3	93.6	95.2	97.5
13x1	7.06	3.75	18.2	8.67	92.4	93.9	94.7	97.0	98.6	101
14x1	7.06	4.04	22.8	9.33	99.2	101	102	104	105	108
12x1 1/4	7.19	3.46	18.6	15.6	106	108	108	111	112	115
16x1	7.06	4.62	34.0	10.7	113	114	115	117	119	121
14x1 1/4	7.19	4.04	29.5	18.2	123	125	125	128	129	132
16x1 1/4	7.19	4.62	44.0	20.8	140	142	142	145	146	149
17.7x1 1/4	7.19	5.11	59.7	23.1	155	156	157	159	161	163

SIN Beam Section Properties

Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_20									
5x1/4	20.2	19.7	5.00	0.250	2.50	0.248	5.21	24.6	2.08
6x1/4	20.2	19.7	6.00	0.250	3.00	0.298	9.00	29.5	3.00
6x5/16	20.3	19.7	6.00	0.313	3.75	0.375	11.3	36.9	3.75
6x3/8	20.4	19.7	6.00	0.375	4.50	0.453	13.5	44.3	4.50
7x3/8	20.4	19.7	7.00	0.375	5.25	0.528	21.4	51.7	6.13
6x1/2	20.7	19.7	6.00	0.500	6.00	0.611	18.0	59.1	6.00
7x1/2	20.7	19.7	7.00	0.500	7.00	0.713	28.6	69.0	8.17
8x1/2	20.7	19.7	8.00	0.500	8.00	0.815	42.7	78.8	10.7
6x3/4	21.2	19.7	6.00	0.750	9.00	0.940	27.0	88.7	9.00
8x5/8	20.9	19.7	8.00	0.625	10.0	1.03	53.3	98.5	13.3
8x3/4	21.2	19.7	8.00	0.750	12.0	1.25	64.0	118	16.0
10x3/4	21.2	19.7	10.0	0.750	15.0	1.57	125	148	25.0
8x1	21.7	19.7	8.00	1.00	16.0	1.71	85.3	158	21.3
12x3/4	21.2	19.7	12.0	0.750	18.0	1.88	216	177	36.0
10x1	21.7	19.7	10.0	1.00	20.0	2.14	167	197	33.3
11x1	21.7	19.7	11.0	1.00	22.0	2.36	222	217	40.3
12x1	21.7	19.7	12.0	1.00	24.0	2.57	288	237	48.0
10x1 1/4	22.2	19.7	10.0	1.25	25.0	2.74	208	247	41.7
13x1	21.7	19.7	13.0	1.00	26.0	2.78	366	257	56.3
14x1	21.7	19.7	14.0	1.00	28.0	3.00	457	276	65.3
12x1 1/4	22.2	19.7	12.0	1.25	30.0	3.29	360	297	60.0
16x1	21.7	19.7	16.0	1.00	32.0	3.43	683	316	85.3
14x1 1/4	22.2	19.7	14.0	1.25	35.0	3.84	572	346	81.7
16x1 1/4	22.2	19.7	16.0	1.25	40.0	4.39	853	396	107
17.7x1 1/4	22.2	19.7	17.7	1.25	44.3	4.86	1160	438	131

SIN Beam Section Properties (cont.)

Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_20										
5x1/4	9.97	1.44	0.517	0.0521	14.4	16.7	17.9	21.4	23.7	27.2
6x1/4	9.97	1.73	0.894	0.0625	16.1	18.4	19.6	23.1	25.4	28.9
6x5/16	10.0	1.73	1.12	0.122	18.6	21.0	22.1	25.6	28.0	31.5
6x3/8	10.0	1.73	1.36	0.211	21.2	23.5	24.7	28.2	30.5	34.0
7x3/8	10.0	2.02	2.16	0.246	23.7	26.1	27.2	30.7	33.1	36.6
6x1/2	10.1	1.73	1.83	0.500	26.3	28.6	29.8	33.3	35.6	39.1
7x1/2	10.1	2.02	2.91	0.583	29.7	32.0	33.2	36.7	39.0	42.5
8x1/2	10.1	2.31	4.35	0.667	33.1	35.4	36.6	40.1	42.4	45.9
6x3/4	10.2	1.73	2.82	1.69	36.5	38.8	40.0	43.5	45.8	49.3
8x5/8	10.2	2.31	5.50	1.30	39.9	42.2	43.4	46.9	49.2	52.8
8x3/4	10.2	2.31	6.68	2.25	46.7	49.0	50.2	53.7	56.0	59.6
10x3/4	10.2	2.89	13.0	2.81	56.9	59.2	60.4	63.9	66.3	69.8
8x1	10.3	2.31	9.13	5.33	60.3	62.6	63.8	67.3	69.7	73.2
12x3/4	10.2	3.46	22.5	3.38	67.1	69.4	70.6	74.1	76.5	80.0
10x1	10.3	2.89	17.8	6.67	73.9	76.2	77.4	80.9	83.3	86.8
11x1	10.3	3.18	23.7	7.33	80.7	83.1	84.2	87.7	90.1	93.6
12x1	10.3	3.46	30.8	8.00	87.5	89.9	91.0	94.5	96.9	100
10x1 1/4	10.5	2.89	22.8	13.0	90.9	93.3	94.4	97.9	100	104
13x1	10.3	3.75	39.2	8.67	94.3	96.7	97.8	101	104	107
14x1	10.3	4.04	48.9	9.33	101	103	105	108	110	114
12x1 1/4	10.5	3.46	39.4	15.6	108	110	111	115	117	121
16x1	10.3	4.62	73.0	10.7	115	117	118	122	124	128
14x1 1/4	10.5	4.04	62.6	18.2	125	127	128	132	134	138
16x1 1/4	10.5	4.62	93.5	20.8	142	144	145	149	151	155
17.7x1 1/4	10.5	5.11	127	23.1	157	159	160	164	166	169

SIN Beam Section Properties

Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_24									
5x1/4	24.5	24.0	5.00	0.250	2.50	0.368	5.21	30.0	2.08
6x1/4	24.5	24.0	6.00	0.250	3.00	0.442	9.00	36.0	3.00
6x5/16	24.6	24.0	6.00	0.313	3.75	0.555	11.3	45.0	3.75
6x3/8	24.8	24.0	6.00	0.375	4.50	0.669	13.5	54.1	4.50
7x3/8	24.8	24.0	7.00	0.375	5.25	0.781	21.4	63.1	6.13
6x1/2	25.0	24.0	6.00	0.500	6.00	0.902	18.0	72.1	6.00
7x1/2	25.0	24.0	7.00	0.500	7.00	1.05	28.6	84.1	8.17
8x1/2	25.0	24.0	8.00	0.500	8.00	1.20	42.7	96.1	10.7
6x3/4	25.5	24.0	6.00	0.750	9.00	1.38	27.0	108	9.00
8x5/8	25.3	24.0	8.00	0.625	10.0	1.52	53.3	120	13.3
8x3/4	25.5	24.0	8.00	0.750	12.0	1.84	64.0	144	16.0
10x3/4	25.5	24.0	10.0	0.750	15.0	2.30	125	180	25.0
8x1	26.0	24.0	8.00	1.00	16.0	2.50	85.3	193	21.3
12x3/4	25.5	24.0	12.0	0.750	18.0	2.76	216	216	36.0
10x1	26.0	24.0	10.0	1.00	20.0	3.13	167	241	33.3
11x1	26.0	24.0	11.0	1.00	22.0	3.44	222	265	40.3
12x1	26.0	24.0	12.0	1.00	24.0	3.76	288	289	48.0
10x1 1/4	26.5	24.0	10.0	1.25	25.0	3.99	208	301	41.7
13x1	26.0	24.0	13.0	1.00	26.0	4.07	366	313	56.3
14x1	26.0	24.0	14.0	1.00	28.0	4.38	457	337	65.3
12x1 1/4	26.5	24.0	12.0	1.25	30.0	4.79	360	361	60.0
16x1	26.0	24.0	16.0	1.00	32.0	5.01	683	385	85.3
14x1 1/4	26.5	24.0	14.0	1.25	35.0	5.59	572	422	81.7
16x1 1/4	26.5	24.0	16.0	1.25	40.0	6.39	853	482	107
17.7x1 1/4	26.5	24.0	17.7	1.25	44.3	7.07	1160	534	131

SIN Beam Section Properties (cont.)

Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_24										
5x1/4	12.1	1.44	0.767	0.0521	15.6	18.5	19.9	24.2	27.1	31.3
6x1/4	12.1	1.73	1.32	0.0625	17.3	20.2	21.6	25.9	28.8	33.0
6x5/16	12.2	1.73	1.66	0.122	19.9	22.8	24.2	28.5	31.3	35.6
6x3/8	12.2	1.73	2.01	0.211	22.4	25.3	26.7	31.0	33.9	38.2
7x3/8	12.2	2.02	3.19	0.246	25.0	27.9	29.3	33.6	36.4	40.7
6x1/2	12.3	1.73	2.70	0.500	27.6	30.4	31.8	36.1	39.0	43.3
7x1/2	12.3	2.02	4.29	0.583	31.0	33.8	35.2	39.5	42.4	46.7
8x1/2	12.3	2.31	6.41	0.667	34.4	37.2	38.6	42.9	45.8	50.1
6x3/4	12.4	1.73	4.14	1.69	37.8	40.6	42.1	46.3	49.2	53.5
8x5/8	12.3	2.31	8.10	1.30	41.2	44.0	45.5	49.7	52.6	56.9
8x3/4	12.4	2.31	9.81	2.25	48.0	50.8	52.3	56.5	59.4	63.7
10x3/4	12.4	2.89	19.2	2.81	58.2	61.0	62.5	66.7	69.6	73.9
8x1	12.5	2.31	13.4	5.33	61.6	64.4	65.9	70.1	73.0	77.3
12x3/4	12.4	3.46	33.1	3.38	68.4	71.2	72.7	77.0	79.8	84.1
10x1	12.5	2.89	26.1	6.67	75.2	78.0	79.5	83.8	86.6	90.9
11x1	12.5	3.18	34.7	7.33	82.0	84.9	86.3	90.6	93.4	97.7
12x1	12.5	3.46	45.1	8.00	88.8	91.7	93.1	97.4	100	105
10x1 1/4	12.6	2.89	33.2	13.0	92.2	95.1	96.5	101	104	108
13x1	12.5	3.75	57.3	8.67	95.6	98.5	99.9	104	107	111
14x1	12.5	4.04	71.5	9.33	102	105	107	111	114	118
12x1 1/4	12.6	3.46	57.5	15.6	109	112	114	118	121	125
16x1	12.5	4.62	107	10.7	116	119	120	125	127	132
14x1 1/4	12.6	4.04	91.2	18.2	126	129	131	135	138	142
16x1 1/4	12.6	4.62	136	20.8	143	146	148	152	155	159
17.7x1 1/4	12.6	5.11	185	23.1	158	161	162	166	169	174

SIN Beam Section Properties

Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_30									
5x1/4	30.0	29.5	5.00	0.250	2.50	0.554	5.21	36.9	2.08
6x1/4	30.0	29.5	6.00	0.250	3.00	0.665	9.00	44.3	3.00
6x5/16	30.2	29.5	6.00	0.313	3.75	0.835	11.3	55.4	3.75
6x3/8	30.3	29.5	6.00	0.375	4.50	1.01	13.5	66.5	4.50
7x3/8	30.3	29.5	7.00	0.375	5.25	1.17	21.4	77.5	6.13
6x1/2	30.5	29.5	6.00	0.500	6.00	1.35	18.0	88.6	6.00
7x1/2	30.5	29.5	7.00	0.500	7.00	1.58	28.6	103	8.17
8x1/2	30.5	29.5	8.00	0.500	8.00	1.80	42.7	118	10.7
6x3/4	31.0	29.5	6.00	0.750	9.00	2.06	27.0	133	9.00
8x5/8	30.8	29.5	8.00	0.625	10.0	2.27	53.3	148	13.3
8x3/4	31.0	29.5	8.00	0.750	12.0	2.75	64.0	177	16.0
10x3/4	31.0	29.5	10.0	0.750	15.0	3.44	125	222	25.0
8x1	31.5	29.5	8.00	1.00	16.0	3.73	85.3	237	21.3
12x3/4	31.0	29.5	12.0	0.750	18.0	4.13	216	266	36.0
10x1	31.5	29.5	10.0	1.00	20.0	4.66	167	296	33.3
11x1	31.5	29.5	11.0	1.00	22.0	5.13	222	325	40.3
12x1	31.5	29.5	12.0	1.00	24.0	5.59	288	355	48.0
10x1 1/4	32.0	29.5	10.0	1.25	25.0	5.92	208	370	41.7
13x1	31.5	29.5	13.0	1.00	26.0	6.06	366	384	56.3
14x1	31.5	29.5	14.0	1.00	28.0	6.53	457	414	65.3
12x1 1/4	32.0	29.5	12.0	1.25	30.0	7.11	360	444	60.0
16x1	31.5	29.5	16.0	1.00	32.0	7.46	683	473	85.3
14x1 1/4	32.0	29.5	14.0	1.25	35.0	8.29	572	518	81.7
16x1 1/4	32.0	29.5	16.0	1.25	40.0	9.48	853	592	107
17.7x1 1/4	32.0	29.5	17.7	1.25	44.3	10.5	1160	655	131

SIN Beam Section Properties (cont.)

Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_30										
5x1/4	14.9	1.44	1.15	0.0521	17.3	20.8	22.6	27.8	31.3	36.6
6x1/4	14.9	1.73	2.00	0.0625	19.0	22.5	24.3	29.5	33.0	38.3
6x5/16	14.9	1.73	2.50	0.122	21.5	25.0	26.8	32.1	35.6	40.8
6x3/8	15.0	1.73	3.02	0.211	24.1	27.6	29.4	34.6	38.1	43.4
7x3/8	15.0	2.02	4.79	0.246	26.6	30.2	31.9	37.2	40.7	45.9
6x1/2	15.0	1.73	4.06	0.500	29.2	32.7	34.5	39.7	43.2	48.5
7x1/2	15.0	2.02	6.44	0.583	32.6	36.1	37.9	43.1	46.6	51.9
8x1/2	15.0	2.31	9.62	0.667	36.0	39.5	41.3	46.5	50.0	55.3
6x3/4	15.1	1.73	6.19	1.69	39.4	42.9	44.7	49.9	53.4	58.7
8x5/8	15.1	2.31	12.1	1.30	42.8	46.3	48.1	53.3	56.8	62.1
8x3/4	15.1	2.31	14.7	2.25	49.6	53.1	54.9	60.1	63.7	68.9
10x3/4	15.1	2.89	28.6	2.81	59.8	63.3	65.1	70.4	73.9	79.1
8x1	15.3	2.31	19.9	5.33	63.2	66.7	68.5	73.8	77.3	82.5
12x3/4	15.1	3.46	49.5	3.38	70.0	73.5	75.3	80.6	84.1	89.3
10x1	15.3	2.89	38.8	6.67	76.8	80.3	82.1	87.4	90.9	96.1
11x1	15.3	3.18	51.7	7.33	83.6	87.1	88.9	94.2	97.7	103
12x1	15.3	3.46	67.1	8.00	90.4	94.0	95.7	101	104	110
10x1 1/4	15.4	2.89	49.3	13.0	93.8	97.4	99.1	104	108	113
13x1	15.3	3.75	85.3	8.67	97.2	101	103	108	111	117
14x1	15.3	4.04	107	9.33	104	108	109	115	118	123
12x1 1/4	15.4	3.46	85.3	15.6	111	114	116	121	125	130
16x1	15.3	4.62	159	10.7	118	121	123	128	132	137
14x1 1/4	15.4	4.04	135	18.2	128	131	133	138	142	147
16x1 1/4	15.4	4.62	202	20.8	145	148	150	155	159	164
17.7x1 1/4	15.4	5.11	274	23.1	159	163	165	170	174	179

SIN Beam Section Properties

Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_36									
5x1/4	35.9	35.4	5.00	0.250	2.50	0.796	5.21	44.3	2.08
6x1/4	35.9	35.4	6.00	0.250	3.00	0.955	9.00	53.2	3.00
6x5/16	36.1	35.4	6.00	0.313	3.75	1.20	11.3	66.4	3.75
6x3/8	36.2	35.4	6.00	0.375	4.50	1.44	13.5	79.7	4.50
7x3/8	36.2	35.4	7.00	0.375	5.25	1.68	21.4	93.0	6.13
6x1/2	36.4	35.4	6.00	0.500	6.00	1.94	18.0	106	6.00
7x1/2	36.4	35.4	7.00	0.500	7.00	2.26	28.6	124	8.17
8x1/2	36.4	35.4	8.00	0.500	8.00	2.58	42.7	142	10.7
6x3/4	36.9	35.4	6.00	0.750	9.00	2.95	27.0	160	9.00
8x5/8	36.7	35.4	8.00	0.625	10.0	3.25	53.3	177	13.3
8x3/4	36.9	35.4	8.00	0.750	12.0	3.93	64.0	213	16.0
10x3/4	36.9	35.4	10.0	0.750	15.0	4.91	125	266	25.0
8x1	37.4	35.4	8.00	1.00	16.0	5.31	85.3	284	21.3
12x3/4	36.9	35.4	12.0	0.750	18.0	5.89	216	319	36.0
10x1	37.4	35.4	10.0	1.00	20.0	6.64	167	355	33.3
11x1	37.4	35.4	11.0	1.00	22.0	7.30	222	390	40.3
12x1	37.4	35.4	12.0	1.00	24.0	7.97	288	426	48.0
10x1 1/4	37.9	35.4	10.0	1.25	25.0	8.41	208	444	41.7
13x1	37.4	35.4	13.0	1.00	26.0	8.63	366	461	56.3
14x1	37.4	35.4	14.0	1.00	28.0	9.29	457	497	65.3
12x1 1/4	37.9	35.4	12.0	1.25	30.0	10.1	360	532	60.0
16x1	37.4	35.4	16.0	1.00	32.0	10.6	683	567	85.3
14x1 1/4	37.9	35.4	14.0	1.25	35.0	11.8	572	621	81.7
16x1 1/4	37.9	35.4	16.0	1.25	40.0	13.5	853	710	107
17.7x1 1/4	37.9	35.4	17.7	1.25	44.3	14.9	1160	786	131

SIN Beam Section Properties (cont.)

Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_36										
5x1/4	17.8	1.44	1.66	0.0521	19.0	23.3	25.4	31.7	35.9	42.2
6x1/4	17.8	1.73	2.86	0.0625	20.7	25.0	27.1	33.4	37.6	43.9
6x5/16	17.9	1.73	3.59	0.122	23.3	27.5	29.6	35.9	40.1	46.5
6x3/8	17.9	1.73	4.33	0.211	25.8	30.1	32.2	38.5	42.7	49.0
7x3/8	17.9	2.02	6.87	0.246	28.4	32.6	34.7	41.0	45.3	51.6
6x1/2	18.0	1.73	5.81	0.500	30.9	35.2	37.3	43.6	47.8	54.1
7x1/2	18.0	2.02	9.23	0.583	34.3	38.6	40.7	47.0	51.2	57.5
8x1/2	18.0	2.31	13.8	0.667	37.8	42.0	44.1	50.4	54.6	60.9
6x3/4	18.1	1.73	8.84	1.69	41.2	45.4	47.5	53.8	58.0	64.3
8x5/8	18.0	2.31	17.3	1.30	44.6	48.8	50.9	57.2	61.4	67.7
8x3/4	18.1	2.31	20.9	2.25	51.4	55.6	57.7	64.0	68.2	74.5
10x3/4	18.1	2.89	40.9	2.81	61.6	65.8	67.9	74.2	78.4	84.7
8x1	18.2	2.31	28.3	5.33	65.0	69.2	71.3	77.6	81.8	88.1
12x3/4	18.1	3.46	70.7	3.38	71.8	76.0	78.1	84.4	88.6	95.0
10x1	18.2	2.89	55.3	6.67	78.6	82.8	84.9	91.2	95.4	102
11x1	18.2	3.18	73.6	7.33	85.4	89.6	91.7	98.0	102	109
12x1	18.2	3.46	95.6	8.00	92.2	96.4	98.5	105	109	115
10x1 1/4	18.3	2.89	70.1	13.0	95.6	99.8	102	108	112	119
13x1	18.2	3.75	122	8.67	99.0	103	105	112	116	122
14x1	18.2	4.04	152	9.33	106	110	112	118	123	129
12x1 1/4	18.3	3.46	121	15.6	113	117	119	125	129	136
16x1	18.2	4.62	227	10.7	119	124	126	132	136	143
14x1 1/4	18.3	4.04	192	18.2	130	134	136	142	146	153
16x1 1/4	18.3	4.62	287	20.8	147	151	153	159	163	170
17.7x1 1/4	18.3	5.11	390	23.1	161	165	168	174	178	184

SIN Beam Section Properties

Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_40									
5x1/4	39.9	39.4	5.00	0.250	2.50	0.981	5.21	49.2	2.08
6x1/4	39.9	39.4	6.00	0.250	3.00	1.18	9.00	59.1	3.00
6x5/16	40.0	39.4	6.00	0.313	3.75	1.48	11.3	73.8	3.75
6x3/8	40.1	39.4	6.00	0.375	4.50	1.78	13.5	88.6	4.50
7x3/8	40.1	39.4	7.00	0.375	5.25	2.07	21.4	103	6.13
6x1/2	40.4	39.4	6.00	0.500	6.00	2.38	18.0	118	6.00
7x1/2	40.4	39.4	7.00	0.500	7.00	2.78	28.6	138	8.17
8x1/2	40.4	39.4	8.00	0.500	8.00	3.18	42.7	158	10.7
6x3/4	40.9	39.4	6.00	0.750	9.00	3.62	27.0	177	9.00
8x5/8	40.6	39.4	8.00	0.625	10.0	4.00	53.3	197	13.3
8x3/4	40.9	39.4	8.00	0.750	12.0	4.83	64.0	236	16.0
10x3/4	40.9	39.4	10.0	0.750	15.0	6.04	125	295	25.0
8x1	41.4	39.4	8.00	1.00	16.0	6.52	85.3	315	21.3
12x3/4	40.9	39.4	12.0	0.750	18.0	7.24	216	354	36.0
10x1	41.4	39.4	10.0	1.00	20.0	8.15	167	394	33.3
11x1	41.4	39.4	11.0	1.00	22.0	8.97	222	433	40.3
12x1	41.4	39.4	12.0	1.00	24.0	9.78	288	473	48.0
10x1 1/4	41.9	39.4	10.0	1.25	25.0	10.3	208	493	41.7
13x1	41.4	39.4	13.0	1.00	26.0	10.6	366	512	56.3
14x1	41.4	39.4	14.0	1.00	28.0	11.4	457	552	65.3
12x1 1/4	41.9	39.4	12.0	1.25	30.0	12.4	360	591	60.0
16x1	41.4	39.4	16.0	1.00	32.0	13.0	683	630	85.3
14x1 1/4	41.9	39.4	14.0	1.25	35.0	14.4	572	690	81.7
16x1 1/4	41.9	39.4	16.0	1.25	40.0	16.5	853	788	107
17.7x1 1/4	41.9	39.4	17.7	1.25	44.3	18.3	1160	873	131

SIN Beam Section Properties (cont.)

Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_40										
5x1/4	19.8	1.44	2.04	0.0521	20.2	24.9	27.2	34.3	38.9	46.0
6x1/4	19.8	1.73	3.53	0.0625	21.9	26.6	28.9	36.0	40.6	47.7
6x5/16	19.8	1.73	4.43	0.122	24.5	29.1	31.5	38.5	43.2	50.2
6x3/8	19.9	1.73	5.33	0.211	27.0	31.7	34.0	41.1	45.7	52.8
7x3/8	19.9	2.02	8.47	0.246	29.6	34.2	36.6	43.6	48.3	55.3
6x1/2	19.9	1.73	7.15	0.500	32.1	36.8	39.1	46.2	50.8	57.9
7x1/2	19.9	2.02	11.4	0.583	35.5	40.2	42.5	49.6	54.2	61.3
8x1/2	19.9	2.31	17.0	0.667	38.9	43.6	46.0	53.0	57.7	64.7
6x3/4	20.1	1.73	10.9	1.69	42.3	47.0	49.4	56.4	61.1	68.1
8x5/8	20.0	2.31	21.3	1.30	45.7	50.4	52.8	59.8	64.5	71.5
8x3/4	20.1	2.31	25.8	2.25	52.5	57.2	59.6	66.6	71.3	78.3
10x3/4	20.1	2.89	50.3	2.81	62.7	67.4	69.8	76.8	81.5	88.5
8x1	20.2	2.31	34.8	5.33	66.1	70.8	73.2	80.2	84.9	91.9
12x3/4	20.1	3.46	86.9	3.38	72.9	77.6	80.0	87.0	91.7	98.7
10x1	20.2	2.89	67.9	6.67	79.8	84.4	86.8	93.8	98.5	106
11x1	20.2	3.18	90.4	7.33	86.6	91.2	93.6	101	105	112
12x1	20.2	3.46	117	8.00	93.4	98.0	100	107	112	119
10x1 1/4	20.3	2.89	85.9	13.0	96.8	101	104	111	115	123
13x1	20.2	3.75	149	8.67	100	105	107	114	119	126
14x1	20.2	4.04	186	9.33	107	112	114	121	126	133
12x1 1/4	20.3	3.46	148	15.6	114	118	121	128	133	140
16x1	20.2	4.62	278	10.7	121	125	128	135	139	146
14x1 1/4	20.3	4.04	236	18.2	131	135	138	145	150	157
16x1 1/4	20.3	4.62	352	20.8	148	152	155	162	167	174
17.7x1 1/4	20.3	5.11	478	23.1	162	167	169	176	181	188

SIN Beam Section Properties

Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_48									
5x1/4	48.5	48.0	5.00	0.250	2.50	1.45	5.21	60.0	2.08
6x1/4	48.5	48.0	6.00	0.250	3.00	1.75	9.00	72.0	3.00
6x5/16	48.6	48.0	6.00	0.313	3.75	2.19	11.3	90.0	3.75
6x3/8	48.7	48.0	6.00	0.375	4.50	2.63	13.5	108	4.50
7x3/8	48.7	48.0	7.00	0.375	5.25	3.07	21.4	126	6.13
6x1/2	49.0	48.0	6.00	0.500	6.00	3.53	18.0	144	6.00
7x1/2	49.0	48.0	7.00	0.500	7.00	4.12	28.6	168	8.17
8x1/2	49.0	48.0	8.00	0.500	8.00	4.70	42.7	192	10.7
6x3/4	49.5	48.0	6.00	0.750	9.00	5.35	27.0	216	9.00
8x5/8	49.2	48.0	8.00	0.625	10.0	5.91	53.3	240	13.3
8x3/4	49.5	48.0	8.00	0.750	12.0	7.13	64.0	288	16.0
10x3/4	49.5	48.0	10.0	0.750	15.0	8.91	125	360	25.0
8x1	50.0	48.0	8.00	1.00	16.0	9.60	85.3	384	21.3
12x3/4	49.5	48.0	12.0	0.750	18.0	10.7	216	432	36.0
10x1	50.0	48.0	10.0	1.00	20.0	12.0	167	480	33.3
11x1	50.0	48.0	11.0	1.00	22.0	13.2	222	528	40.3
12x1	50.0	48.0	12.0	1.00	24.0	14.4	288	576	48.0
10x1 1/4	50.5	48.0	10.0	1.25	25.0	15.2	208	600	41.7
13x1	50.0	48.0	13.0	1.00	26.0	15.6	366	624	56.3
14x1	50.0	48.0	14.0	1.00	28.0	16.8	457	672	65.3
12x1 1/4	50.5	48.0	12.0	1.25	30.0	18.2	360	721	60.0
16x1	50.0	48.0	16.0	1.00	32.0	19.2	683	768	85.3
14x1 1/4	50.5	48.0	14.0	1.25	35.0	21.2	572	841	81.7
16x1 1/4	50.5	48.0	16.0	1.25	40.0	24.3	853	961	107
17.7x1 1/4	50.5	48.0	17.7	1.25	44.3	26.9	1160	1060	131

SIN Beam Section Properties (cont.)

Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_48										
5x1/4	24.1	1.44	3.03	0.0521	22.8	28.5	31.3	39.9	45.6	54.2
6x1/4	24.1	1.73	5.24	0.0625	24.5	30.2	33.0	41.6	47.3	55.9
6x5/16	24.2	1.73	6.56	0.122	27.0	32.7	35.6	44.1	49.9	58.4
6x3/8	24.2	1.73	7.90	0.211	29.6	35.3	38.1	46.7	52.4	61.0
7x3/8	24.2	2.02	12.5	0.246	32.1	37.8	40.7	49.2	55.0	63.5
6x1/2	24.2	1.73	10.6	0.500	34.7	40.4	43.2	51.8	57.5	66.1
7x1/2	24.2	2.02	16.8	0.583	38.1	43.8	46.7	55.2	60.9	69.5
8x1/2	24.2	2.31	25.1	0.667	41.5	47.2	50.1	58.6	64.3	72.9
6x3/4	24.4	1.73	16.0	1.69	44.9	50.6	53.5	62.0	67.7	76.3
8x5/8	24.3	2.31	31.5	1.30	48.3	54.0	56.9	65.4	71.1	79.7
8x3/4	24.4	2.31	38.0	2.25	55.1	60.8	63.7	72.2	77.9	86.5
10x3/4	24.4	2.89	74.2	2.81	65.3	71.0	73.9	82.4	88.1	96.7
8x1	24.5	2.31	51.2	5.33	68.7	74.4	77.3	85.8	91.5	100
12x3/4	24.4	3.46	128	3.38	75.5	81.2	84.1	92.6	98.3	107
10x1	24.5	2.89	100	6.67	82.3	88.0	90.9	99.4	105	114
11x1	24.5	3.18	133	7.33	89.1	94.8	97.7	106	112	121
12x1	24.5	3.46	173	8.00	95.9	102	104	113	119	127
10x1 1/4	24.6	2.89	126	13.0	99.3	105	108	116	122	131
13x1	24.5	3.75	220	8.67	103	108	111	120	126	134
14x1	24.5	4.04	274	9.33	110	115	118	127	132	141
12x1 1/4	24.6	3.46	218	15.6	116	122	125	133	139	148
16x1	24.5	4.62	410	10.7	123	129	132	140	146	155
14x1 1/4	24.6	4.04	347	18.2	133	139	142	150	156	165
16x1 1/4	24.6	4.62	517	20.8	150	156	159	167	173	182
17.7x1 1/4	24.6	5.11	702	23.1	165	171	174	182	188	196

SIN Beam Section Properties Table 3.2a

Designation	Overall Depth d (in.)	Web Height h _w (in.)	Flange Width b _f (in.)	Flange Thickn. t _f (in.)	Area A _g (in ²)	Moment of Inertia		Section Modulus	
						I _x x10 ³ (in ⁴)	I _y (in ⁴)	S _x (in ³)	S _y (in ³)
WT_60									
5x1/4	59.6	59.1	5.00	0.250	2.50	2.20	5.21	73.8	2.08
6x1/4	59.6	59.1	6.00	0.250	3.00	2.64	9.00	88.6	3.00
6x5/16	59.7	59.1	6.00	0.313	3.75	3.30	11.3	111	3.75
6x3/8	59.8	59.1	6.00	0.375	4.50	3.97	13.5	133	4.50
7x3/8	59.8	59.1	7.00	0.375	5.25	4.64	21.4	155	6.13
6x1/2	60.1	59.1	6.00	0.500	6.00	5.32	18.0	177	6.00
7x1/2	60.1	59.1	7.00	0.500	7.00	6.21	28.6	207	8.17
8x1/2	60.1	59.1	8.00	0.500	8.00	7.09	42.7	236	10.7
6x3/4	60.6	59.1	6.00	0.750	9.00	8.05	27.0	266	9.00
8x5/8	60.3	59.1	8.00	0.625	10.0	8.90	53.3	295	13.3
8x3/4	60.6	59.1	8.00	0.750	12.0	10.7	64.0	354	16.0
10x3/4	60.6	59.1	10.0	0.750	15.0	13.4	125	443	25.0
8x1	61.1	59.1	8.00	1.00	16.0	14.4	85.3	473	21.3
12x3/4	60.6	59.1	12.0	0.750	18.0	16.1	216	532	36.0
10x1	61.1	59.1	10.0	1.00	20.0	18.0	167	591	33.3
11x1	61.1	59.1	11.0	1.00	22.0	19.8	222	650	40.3
12x1	61.1	59.1	12.0	1.00	24.0	21.6	288	709	48.0
10x1 1/4	61.6	59.1	10.0	1.25	25.0	22.7	208	739	41.7
13x1	61.1	59.1	13.0	1.00	26.0	23.4	366	768	56.3
14x1	61.1	59.1	14.0	1.00	28.0	25.2	457	827	65.3
12x1 1/4	61.6	59.1	12.0	1.25	30.0	27.3	360	886	60.0
16x1	61.1	59.1	16.0	1.00	32.0	28.9	683	945	85.3
14x1 1/4	61.6	59.1	14.0	1.25	35.0	31.8	572	1030	81.7
16x1 1/4	61.6	59.1	16.0	1.25	40.0	36.4	853	1180	107
17.7x1 1/4	61.6	59.1	17.7	1.25	44.3	40.3	1160	1310	131

SIN Beam Section Properties (cont.) Table 3.2b

Designation	Radius of Gyration		Warping Const C _w x10 ³ (in ⁶)	Torsion Const J (in ⁴)	Section Weight (lb / ft)					
	r _x (in.)	r _y (in.)			WTA	WTB	WTC	WTF	WTH	WTK
WT_60										
5x1/4	29.7	1.44	4.58	0.0521	26.1	33.1	36.6	47.1	54.2	64.7
6x1/4	29.7	1.73	7.91	0.0625	27.8	34.8	38.3	48.8	55.9	66.4
6x5/16	29.7	1.73	9.91	0.122	30.3	37.3	40.9	51.4	58.4	68.9
6x3/8	29.7	1.73	11.9	0.211	32.9	39.9	43.4	53.9	61.0	71.5
7x3/8	29.7	2.02	18.9	0.246	35.4	42.4	46.0	56.5	63.5	74.0
6x1/2	29.8	1.73	16.0	0.500	38.0	45.0	48.5	59.0	66.1	76.6
7x1/2	29.8	2.02	25.3	0.583	41.4	48.4	51.9	62.4	69.5	80.0
8x1/2	29.8	2.31	37.8	0.667	44.8	51.8	55.3	65.8	72.9	83.4
6x3/4	29.9	1.73	24.1	1.69	48.2	55.2	58.7	69.2	76.3	86.8
8x5/8	29.8	2.31	47.5	1.30	51.6	58.6	62.1	72.6	79.7	90.2
8x3/4	29.9	2.31	57.2	2.25	58.4	65.4	68.9	79.5	86.5	97.0
10x3/4	29.9	2.89	112	2.81	68.6	75.6	79.1	89.7	96.7	107
8x1	30.0	2.31	76.9	5.33	72.0	79.0	82.5	93.1	100	111
12x3/4	29.9	3.46	193	3.38	78.8	85.8	89.3	99.9	107	117
10x1	30.0	2.89	150	6.67	85.6	92.6	96.2	107	114	124
11x1	30.0	3.18	200	7.33	92.4	99.4	103	113	121	131
12x1	30.0	3.46	260	8.00	99.2	106	110	120	127	138
10x1 1/4	30.2	2.89	189	13.0	103	110	113	124	131	141
13x1	30.0	3.75	330	8.67	106	113	117	127	134	145
14x1	30.0	4.04	412	9.33	113	120	123	134	141	151
12x1 1/4	30.2	3.46	327	15.6	120	127	130	141	148	158
16x1	30.0	4.62	616	10.7	126	133	137	148	155	165
14x1 1/4	30.2	4.04	520	18.2	137	144	147	158	165	175
16x1 1/4	30.2	4.62	776	20.8	154	161	164	175	182	192
17.7x1 1/4	30.2	5.11	1050	23.1	168	175	179	189	196	207

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L_p (ft)	Allowable Flexural Strength M_n/Ω_b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_13													
5x1/4	NC	3.19	39.4	38.0	30.0	15.1	8.47	5.42	3.76	2.77	2.12	1.67	1.36
6x1/4	NC	3.82	43.1	47.2	39.2	26.0	14.6	9.37	6.50	4.78	3.66	2.89	2.34
6x5/16	NC	3.82	60.2	59.0	49.1	32.5	18.3	11.7	8.13	5.98	4.57	3.61	2.93
6x3/8	C	3.82	73.7	70.9	58.9	39.0	22.0	14.1	9.76	7.17	5.49	4.34	3.51
7x3/8	NC	4.46	85.3	84.7	72.7	60.7	34.9	22.3	15.5	11.4	8.72	6.89	5.58
6x1/2	C	3.82	98.3	94.5	78.6	52.1	29.3	18.8	13.0	9.57	7.33	5.79	4.69
7x1/2	C	4.46	115	113	97.0	81.0	46.5	29.8	20.7	15.2	11.6	9.19	7.45
8x1/2	C	5.10	131	131	115	99.4	69.5	44.5	30.9	22.7	17.4	13.7	11.1
6x3/4	C	3.82	148	142	118	78.3	44.1	28.2	19.6	14.4	11.0	8.70	7.05
8x5/8	C	5.10	164	164	144	124	86.9	55.6	38.6	28.4	21.7	17.2	13.9
8x3/4	C	5.10	197	197	173	149	104	66.8	46.4	34.1	26.1	20.6	16.7
10x3/4	C	6.37	246	246	229	205	181	131	90.7	66.6	51.0	40.3	32.6
8x1	C	5.10	263	263	232	200	140	89.4	62.1	45.6	34.9	27.6	22.3
12x3/4	C	7.65	296	296	284	260	236	212	157	115	88.1	69.6	56.4
10x1	C	6.37	329	329	306	274	242	175	121	89.1	68.2	53.9	43.6
11x1	C	7.01	362	362	343	311	279	232	161	119	90.7	71.7	58.1
12x1	C	7.65	395	395	380	348	316	284	209	154	118	93.1	75.4
10x1 1/4	C	6.37	413	413	384	344	303	219	152	112	85.5	67.6	54.7
13x1	C	8.28	428	428	417	385	353	321	266	196	150	118	95.9
14x1	C	8.92	461	461	454	422	390	358	326	244	187	148	120
12x1 1/4	C	7.65	496	496	477	436	396	356	263	193	148	117	94.6
16x1	C	10.2	527	527	527	496	464	432	400	365	279	221	179
14x1 1/4	C	8.92	578	578	570	529	489	449	408	306	235	185	150
16x1 1/4	C	10.2	661	661	661	622	582	542	501	458	350	277	224
17.7x1 1/4	C	11.3	732	732	732	702	662	621	581	541	476	376	304

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L_p (ft)	Allowable Flexural Strength M_n/Ω_b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_20													
5x1/4	NC	3.19	59.2	57.1	45.1	22.6	12.7	8.14	5.65	4.15	3.18	2.51	2.03
6x1/4	NC	3.82	64.7	70.9	58.9	39.1	22.0	14.1	9.76	7.17	5.49	4.34	3.52
6x5/16	NC	3.82	90.4	88.6	73.6	48.8	27.5	17.6	12.2	8.97	6.87	5.43	4.39
6x3/8	C	3.82	111	106	88.4	58.6	33.0	21.1	14.6	10.8	8.24	6.51	5.27
7x3/8	NC	4.46	128	127	109	91.1	52.3	33.5	23.3	17.1	13.1	10.3	8.37
6x1/2	C	3.82	147	142	118	78.2	44.0	28.1	19.5	14.4	11.0	8.68	7.03
7x1/2	C	4.46	172	169	145	122	69.8	44.7	31.0	22.8	17.5	13.8	11.2
8x1/2	C	5.10	197	197	173	149	104	66.7	46.3	34.0	26.1	20.6	16.7
6x3/4	C	3.82	221	213	177	117	66.0	42.2	29.3	21.6	16.5	13.0	10.6
8x5/8	C	5.10	246	246	216	187	130	83.4	57.9	42.6	32.6	25.7	20.9
8x3/4	C	5.10	295	295	260	224	156	100	69.5	51.1	39.1	30.9	25.0
10x3/4	C	6.37	369	369	343	307	271	196	136	99.8	76.4	60.4	48.9
8x1	C	5.10	394	394	347	299	209	134	92.8	68.2	52.2	41.3	33.4
12x3/4	C	7.65	443	443	426	390	354	318	235	172	132	104	84.5
10x1	C	6.37	493	493	458	410	362	261	181	133	102	80.6	65.3
11x1	C	7.01	542	542	513	465	417	348	241	177	136	107	86.9
12x1	C	7.65	591	591	569	521	473	424	313	230	176	139	113
10x1 1/4	C	6.37	617	617	573	513	453	327	227	167	128	101	81.7
13x1	C	8.28	640	640	624	576	528	480	398	293	224	177	143
14x1	C	8.92	690	690	679	631	583	535	487	366	280	221	179
12x1 1/4	C	7.65	740	740	712	652	592	531	392	288	221	174	141
16x1	C	10.2	788	788	788	742	694	646	598	546	418	330	267
14x1 1/4	C	8.92	864	864	851	790	730	670	610	458	350	277	224
16x1 1/4	C	10.2	987	987	987	929	869	809	749	683	523	413	335
17.7x1 1/4	C	11.3	1090	1090	1090	1050	988	928	868	808	710	561	455

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L_p (ft)	Allowable Flexural Strength M_n/Ω_b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_24													
5x1/4	NC	3.19	72.2	69.6	55.0	27.6	15.5	9.93	6.89	5.06	3.88	3.06	2.48
6x1/4	NC	3.82	79.0	86.5	71.8	47.6	26.8	17.2	11.9	8.75	6.70	5.29	4.29
6x5/16	NC	3.82	110	108	89.8	59.6	33.5	21.4	14.9	10.9	8.38	6.62	5.36
6x3/8	C	3.82	135	130	108	71.5	40.2	25.7	17.9	13.1	10.1	7.94	6.43
7x3/8	NC	4.46	156	155	133	111	63.8	40.9	28.4	20.8	16.0	12.6	10.2
6x1/2	C	3.82	180	173	144	95.3	53.6	34.3	23.8	17.5	13.4	10.6	8.58
7x1/2	C	4.46	210	207	177	148	85.2	54.5	37.8	27.8	21.3	16.8	13.6
8x1/2	C	5.10	240	240	211	182	127	81.3	56.5	41.5	31.8	25.1	20.3
6x3/4	C	3.82	270	260	216	143	80.5	51.5	35.8	26.3	20.1	15.9	12.9
8x5/8	C	5.10	300	300	264	227	159	102	70.6	51.9	39.7	31.4	25.4
8x3/4	C	5.10	360	360	317	273	191	122	84.8	62.3	47.7	37.7	30.5
10x3/4	C	6.37	450	450	418	374	330	238	166	122	93.2	73.6	59.6
8x1	C	5.10	480	480	423	364	255	163	113	83.1	63.7	50.3	40.7
12x3/4	C	7.65	540	540	519	475	432	388	286	210	161	127	103
10x1	C	6.37	600	600	558	499	441	318	221	162	124	98.2	79.6
11x1	C	7.01	661	661	626	567	508	424	294	216	165	131	106
12x1	C	7.65	721	721	693	634	576	517	382	281	215	170	137
10x1 1/4	C	6.37	751	751	698	625	552	398	277	203	156	123	99.6
13x1	C	8.28	781	781	761	702	643	585	486	357	273	216	175
14x1	C	8.92	841	841	828	769	711	652	594	446	341	270	218
12x1 1/4	C	7.65	902	902	867	794	721	647	478	351	269	212	172
16x1	C	10.2	961	961	961	905	846	787	729	665	509	402	326
14x1 1/4	C	8.92	1050	1050	1040	963	890	816	743	558	427	337	273
16x1 1/4	C	10.2	1200	1200	1200	1130	1060	985	912	832	637	504	408
17.7x1 1/4	C	11.3	1330	1330	1330	1280	1200	1130	1060	984	865	684	554

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L_p (ft)	Allowable Flexural Strength M_n/Ω_b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_30													
5x1/4	NC	3.19	88.8	85.6	67.6	33.9	19.1	12.2	8.47	6.23	4.77	3.77	3.05
6x1/4	NC	3.82	97.1	106	88.3	58.6	33.0	21.1	14.6	10.8	8.24	6.51	5.27
6x5/16	NC	3.82	136	133	110	73.2	41.2	26.4	18.3	13.4	10.3	8.14	6.59
6x3/8	C	3.82	166	159	133	87.9	49.4	31.6	22.0	16.1	12.4	9.76	7.91
7x3/8	NC	4.46	192	191	164	137	78.5	50.2	34.9	25.6	19.6	15.5	12.6
6x1/2	C	3.82	221	213	177	117	65.9	42.2	29.3	21.5	16.5	13.0	10.5
7x1/2	C	4.46	258	254	218	182	105	67.0	46.5	34.2	26.2	20.7	16.7
8x1/2	C	5.10	295	295	260	224	156	100	69.4	51.0	39.1	30.9	25.0
6x3/4	C	3.82	332	319	265	176	98.9	63.3	44.0	32.3	24.7	19.5	15.8
8x5/8	C	5.10	369	369	325	280	195	125	86.8	63.8	48.8	38.6	31.3
8x3/4	C	5.10	442	442	390	336	234	150	104	76.6	58.6	46.3	37.5
10x3/4	C	6.37	553	553	514	460	406	293	204	150	114	90.5	73.3
8x1	C	5.10	590	590	520	448	313	200	139	102	78.2	61.8	50.1
12x3/4	C	7.65	664	664	638	584	530	476	352	258	198	156	127
10x1	C	6.37	738	738	686	614	542	391	272	200	153	121	97.8
11x1	C	7.01	812	812	769	697	625	520	361	266	203	161	130
12x1	C	7.65	885	885	851	780	708	636	469	345	264	209	169
10x1 1/4	C	6.37	923	923	858	768	678	489	340	250	191	151	122
13x1	C	8.28	959	959	934	862	791	719	597	438	336	265	215
14x1	C	8.92	1030	1030	1020	945	873	802	730	547	419	331	268
12x1 1/4	C	7.65	1110	1110	1070	975	885	795	587	431	330	261	211
16x1	C	10.2	1180	1180	1180	1110	1040	967	895	817	626	494	400
14x1 1/4	C	8.92	1290	1290	1270	1180	1090	1000	913	685	524	414	336
16x1 1/4	C	10.2	1480	1480	1480	1390	1300	1210	1120	1020	783	618	501
17.7x1 1/4	C	11.3	1640	1640	1640	1570	1480	1390	1300	1210	1060	840	680

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L_p (ft)	Allowable Flexural Strength M_n/Ω_b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_36													
5x1/4	NC	3.19	107	103	81.1	40.7	22.9	14.6	10.2	7.47	5.72	4.52	3.66
6x1/4	NC	3.82	116	128	106	70.3	39.5	25.3	17.6	12.9	9.88	7.81	6.33
6x5/16	NC	3.82	163	159	132	87.9	49.4	31.6	22.0	16.1	12.4	9.76	7.91
6x3/8	C	3.82	199	191	159	105	59.3	38.0	26.4	19.4	14.8	11.7	9.49
7x3/8	NC	4.46	230	229	196	164	94.2	60.3	41.9	30.8	23.5	18.6	15.1
6x1/2	C	3.82	265	255	212	141	79.1	50.6	35.2	25.8	19.8	15.6	12.7
7x1/2	C	4.46	310	305	262	219	126	80.4	55.8	41.0	31.4	24.8	20.1
8x1/2	C	5.10	354	354	311	268	187	120	83.3	61.2	46.9	37.0	30.0
6x3/4	C	3.82	398	383	318	211	119	76.0	52.7	38.8	29.7	23.4	19.0
8x5/8	C	5.10	442	442	389	335	234	150	104	76.5	58.6	46.3	37.5
8x3/4	C	5.10	531	531	467	403	281	180	125	91.9	70.3	55.6	45.0
10x3/4	C	6.37	663	663	616	552	487	352	244	179	137	109	87.9
8x1	C	5.10	708	708	623	537	375	240	167	123	93.8	74.1	60.0
12x3/4	C	7.65	796	796	766	701	636	572	422	310	237	188	152
10x1	C	6.37	885	885	822	736	650	469	326	239	183	145	117
11x1	C	7.01	973	973	922	836	749	624	434	319	244	193	156
12x1	C	7.65	1060	1060	1020	935	849	762	563	414	317	250	203
10x1 1/4	C	6.37	1110	1110	1030	921	813	587	407	299	229	181	147
13x1	C	8.28	1150	1150	1120	1030	948	862	716	526	403	318	258
14x1	C	8.92	1240	1240	1220	1130	1050	961	875	657	503	397	322
12x1 1/4	C	7.65	1330	1330	1280	1170	1060	954	704	517	396	313	253
16x1	C	10.2	1420	1420	1420	1330	1250	1160	1070	980	750	593	480
14x1 1/4	C	8.92	1550	1550	1530	1420	1310	1200	1090	821	629	497	402
16x1 1/4	C	10.2	1770	1770	1770	1670	1560	1450	1340	1230	939	742	601
17.7x1 1/4	C	11.3	1960	1960	1960	1880	1770	1660	1560	1450	1270	1010	816

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L _p (ft)	Allowable Flexural Strength M _n /Ω _b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_40													
5x1/4	NC	3.19	118	114	90.2	45.2	25.4	16.3	11.3	8.30	6.36	5.02	4.07
6x1/4	NC	3.82	129	142	118	78.1	43.9	28.1	19.5	14.3	11.0	8.68	7.03
6x5/16	NC	3.82	181	177	147	97.6	54.9	35.1	24.4	17.9	13.7	10.8	8.79
6x3/8	C	3.82	221	213	177	117	65.9	42.2	29.3	21.5	16.5	13.0	10.5
7x3/8	NC	4.46	256	254	218	182	105	67.0	46.5	34.2	26.2	20.7	16.7
6x1/2	C	3.82	295	283	236	156	87.9	56.2	39.1	28.7	22.0	17.4	14.1
7x1/2	C	4.46	344	339	291	243	140	89.3	62.0	45.6	34.9	27.6	22.3
8x1/2	C	5.10	393	393	346	298	208	133	92.6	68.0	52.1	41.1	33.3
6x3/4	C	3.82	442	425	353	234	132	84.4	58.6	43.1	33.0	26.0	21.1
8x5/8	C	5.10	491	491	433	373	260	167	116	85.0	65.1	51.4	41.7
8x3/4	C	5.10	590	590	519	447	313	200	139	102	78.1	61.7	50.0
10x3/4	C	6.37	737	737	685	613	541	391	271	199	153	121	97.7
8x1	C	5.10	786	786	692	597	417	267	185	136	104	82.3	66.7
12x3/4	C	7.65	884	884	851	779	707	635	469	344	264	208	169
10x1	C	6.37	983	983	914	818	722	521	362	266	204	161	130
11x1	C	7.01	1080	1080	1020	928	832	694	482	354	271	214	173
12x1	C	7.65	1180	1180	1130	1040	943	847	625	459	352	278	225
10x1 1/4	C	6.37	1230	1230	1140	1020	903	652	453	332	255	201	163
13x1	C	8.28	1280	1280	1250	1150	1050	958	795	584	447	353	286
14x1	C	8.92	1380	1380	1360	1260	1160	1070	972	730	559	441	357
12x1 1/4	C	7.65	1480	1480	1420	1300	1180	1060	782	574	440	348	282
16x1	C	10.2	1570	1570	1570	1480	1380	1290	1190	1090	834	659	534
14x1 1/4	C	8.92	1720	1720	1700	1580	1460	1340	1220	912	698	552	447
16x1 1/4	C	10.2	1970	1970	1970	1850	1730	1610	1490	1360	1040	824	667
17.7x1 1/4	C	11.3	2180	2180	2180	2090	1970	1850	1730	1610	1420	1120	906

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L_p (ft)	Allowable Flexural Strength M_n/Ω_b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_48													
5x1/4	NC	3.19	144	139	110	55.1	31.0	19.8	13.8	10.1	7.75	6.12	4.96
6x1/4	NC	3.82	158	173	144	95.2	53.6	34.3	23.8	17.5	13.4	10.6	8.57
6x5/16	NC	3.82	220	216	179	119	66.9	42.8	29.8	21.9	16.7	13.2	10.7
6x3/8	C	3.82	269	259	215	143	80.3	51.4	35.7	26.2	20.1	15.9	12.9
7x3/8	NC	4.46	312	310	266	222	128	81.6	56.7	41.7	31.9	25.2	20.4
6x1/2	C	3.82	359	346	287	190	107	68.6	47.6	35.0	26.8	21.2	17.1
7x1/2	C	4.46	419	413	354	296	170	109	75.6	55.5	42.5	33.6	27.2
8x1/2	C	5.10	479	479	422	363	254	162	113	82.9	63.5	50.2	40.6
6x3/4	C	3.82	539	518	431	286	161	103	71.4	52.5	40.2	31.7	25.7
8x5/8	C	5.10	599	599	527	454	317	203	141	104	79.4	62.7	50.8
8x3/4	C	5.10	719	719	633	545	381	244	169	124	95.2	75.2	60.9
10x3/4	C	6.37	898	898	835	747	660	476	331	243	186	147	119
8x1	C	5.10	958	958	844	727	508	325	226	166	127	100	81.3
12x3/4	C	7.65	1080	1080	1040	949	862	774	571	420	321	254	206
10x1	C	6.37	1200	1200	1110	996	880	635	441	324	248	196	159
11x1	C	7.01	1320	1320	1250	1130	1010	845	587	431	330	261	211
12x1	C	7.65	1440	1440	1380	1270	1150	1030	762	560	429	339	274
10x1 1/4	C	6.37	1500	1500	1390	1250	1100	794	551	405	310	245	199
13x1	C	8.28	1560	1560	1520	1400	1280	1170	969	712	545	431	349
14x1	C	8.92	1680	1680	1650	1540	1420	1300	1180	889	681	538	436
12x1 1/4	C	7.65	1800	1800	1730	1580	1440	1290	953	700	536	423	343
16x1	C	10.2	1920	1920	1920	1800	1690	1570	1450	1330	1020	803	650
14x1 1/4	C	8.92	2100	2100	2070	1920	1770	1630	1480	1110	851	672	545
16x1 1/4	C	10.2	2400	2400	2400	2260	2110	1960	1820	1660	1270	1000	813
17.7x1 1/4	C	11.3	2650	2650	2650	2550	2400	2250	2110	1960	1720	1360	1100

SIN Beam Allowable Flexural Strength (ASD)

Table 3.3a

Designation	L_p (ft)	Allowable Flexural Strength M_n/Ω_b (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_60													
5x1/4	NC	3.19	178	171	135	67.8	38.1	24.4	16.9	12.5	9.53	7.53	6.10
6x1/4	NC	3.82	194	213	177	117	65.9	42.2	29.3	21.5	16.5	13.0	10.5
6x5/16	NC	3.82	271	266	221	146	82.4	52.7	36.6	26.9	20.6	16.3	13.2
6x3/8	C	3.82	332	319	265	176	98.8	63.3	43.9	32.3	24.7	19.5	15.8
7x3/8	NC	4.46	384	381	327	273	157	100	69.8	51.3	39.2	31.0	25.1
6x1/2	C	3.82	442	425	353	234	132	84.4	58.6	43.0	33.0	26.0	21.1
7x1/2	C	4.46	516	508	436	364	209	134	93.0	68.3	52.3	41.3	33.5
8x1/2	C	5.10	589	589	519	447	312	200	139	102	78.1	61.7	50.0
6x3/4	C	3.82	663	638	530	352	198	127	87.9	64.6	49.4	39.1	31.6
8x5/8	C	5.10	737	737	649	559	391	250	174	128	97.6	77.1	62.5
8x3/4	C	5.10	884	884	779	671	469	300	208	153	117	92.6	75.0
10x3/4	C	6.37	1110	1110	1030	919	812	586	407	299	229	181	146
8x1	C	5.10	1180	1180	1040	895	625	400	278	204	156	123	100
12x3/4	C	7.65	1330	1330	1280	1170	1060	952	703	517	395	312	253
10x1	C	6.37	1470	1470	1370	1230	1080	781	543	399	305	241	195
11x1	C	7.01	1620	1620	1540	1390	1250	1040	722	531	406	321	260
12x1	C	7.65	1770	1770	1700	1560	1410	1270	938	689	527	417	338
10x1 1/4	C	6.37	1840	1840	1710	1530	1350	977	678	498	382	301	244
13x1	C	8.28	1920	1920	1870	1720	1580	1440	1190	876	670	530	429
14x1	C	8.92	2060	2060	2030	1890	1750	1600	1460	1090	837	662	536
12x1 1/4	C	7.65	2210	2210	2130	1950	1770	1590	1170	861	659	521	422
16x1	C	10.2	2360	2360	2360	2220	2080	1930	1790	1630	1250	988	800
14x1 1/4	C	8.92	2580	2580	2540	2360	2180	2000	1820	1370	1050	827	670
16x1 1/4	C	10.2	2950	2950	2950	2780	2600	2420	2240	2040	1560	1230	1000
17.7x1 1/4	C	11.3	3260	3260	3260	3130	2950	2770	2590	2410	2120	1680	1360

Notes:

NC, C indicates if the section is Non-Compact or Compact in Flexure per A360 Table B4.1b Case 11

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_13													
5x1/4	NC	3.19	59.3	57.1	45.1	22.6	12.7	8.15	5.66	4.16	3.18	2.51	2.04
6x1/4	NC	3.82	64.8	71.0	59.0	39.1	22.0	14.1	9.78	7.18	5.50	4.35	3.52
6x5/16	NC	3.82	90.5	88.7	73.7	48.9	27.5	17.6	12.2	8.98	6.88	5.43	4.40
6x3/8	C	3.82	111	106	88.5	58.7	33.0	21.1	14.7	10.8	8.25	6.52	5.28
7x3/8	NC	4.46	128	127	109	91.3	52.4	33.6	23.3	17.1	13.1	10.4	8.39
6x1/2	C	3.82	148	142	118	78.3	44.1	28.2	19.6	14.4	11.0	8.70	7.05
7x1/2	C	4.46	172	170	146	122	70.0	44.8	31.1	22.8	17.5	13.8	11.2
8x1/2	C	5.10	197	197	173	149	104	66.8	46.4	34.1	26.1	20.6	16.7
6x3/4	C	3.82	222	214	178	118	66.2	42.4	29.4	21.6	16.6	13.1	10.6
8x5/8	C	5.10	246	246	217	187	131	83.6	58.1	42.7	32.7	25.8	20.9
8x3/4	C	5.10	296	296	261	225	157	100	69.8	51.3	39.2	31.0	25.1
10x3/4	C	6.37	370	370	344	308	272	196	136	100	76.6	60.6	49.1
8x1	C	5.10	396	396	349	300	210	134	93.3	68.5	52.5	41.5	33.6
12x3/4	C	7.65	444	444	427	391	355	319	235	173	132	105	84.8
10x1	C	6.37	495	495	460	412	363	262	182	134	102	81.0	65.6
11x1	C	7.01	544	544	516	467	419	349	242	178	136	108	87.3
12x1	C	7.65	594	594	571	523	475	426	315	231	177	140	113
10x1 1/4	C	6.37	621	621	577	516	456	329	229	168	129	102	82.3
13x1	C	8.28	643	643	627	579	530	482	400	294	225	178	144
14x1	C	8.92	693	693	683	634	586	538	489	367	281	222	180
12x1 1/4	C	7.65	745	745	716	656	595	535	395	290	222	175	142
16x1	C	10.2	792	792	792	746	697	649	601	548	420	332	269
14x1 1/4	C	8.92	869	869	856	796	735	674	614	461	353	279	226
16x1 1/4	C	10.2	993	993	993	935	875	814	753	688	526	416	337
17.7x1 1/4	C	11.3	1100	1100	1100	1050	994	934	873	813	715	565	457

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_20													
5x1/4	NC	3.19	88.9	85.8	67.8	34.0	19.1	12.2	8.49	6.24	4.78	3.77	3.06
6x1/4	NC	3.82	97.3	107	88.5	58.7	33.0	21.1	14.7	10.8	8.25	6.52	5.28
6x5/16	NC	3.82	136	133	111	73.4	41.3	26.4	18.3	13.5	10.3	8.15	6.60
6x3/8	C	3.82	166	160	133	88.1	49.5	31.7	22.0	16.2	12.4	9.79	7.93
7x3/8	NC	4.46	192	191	164	137	78.7	50.3	35.0	25.7	19.7	15.5	12.6
6x1/2	C	3.82	222	213	177	117	66.1	42.3	29.4	21.6	16.5	13.1	10.6
7x1/2	C	4.46	259	255	219	183	105	67.2	46.6	34.3	26.2	20.7	16.8
8x1/2	C	5.10	296	296	260	224	157	100	69.6	51.1	39.2	30.9	25.1
6x3/4	C	3.82	333	320	266	176	99.2	63.5	44.1	32.4	24.8	19.6	15.9
8x5/8	C	5.10	370	370	325	280	196	125	87.1	64.0	49.0	38.7	31.3
8x3/4	C	5.10	444	444	391	337	235	151	105	76.8	58.8	46.5	37.6
10x3/4	C	6.37	555	555	515	461	407	294	204	150	115	90.7	73.5
8x1	C	5.10	592	592	522	449	314	201	140	103	78.5	62.0	50.2
12x3/4	C	7.65	666	666	640	586	532	478	353	259	198	157	127
10x1	C	6.37	740	740	688	616	544	392	273	200	153	121	98.1
11x1	C	7.01	815	815	771	699	627	522	363	267	204	161	131
12x1	C	7.65	889	889	855	782	710	638	471	346	265	209	170
10x1 1/4	C	6.37	927	927	862	771	681	491	341	251	192	152	123
13x1	C	8.28	963	963	938	866	793	721	599	440	337	266	216
14x1	C	8.92	1040	1040	1020	949	877	804	732	549	421	332	269
12x1 1/4	C	7.65	1110	1110	1070	980	889	799	590	433	332	262	212
16x1	C	10.2	1180	1180	1180	1120	1040	971	899	820	628	496	402
14x1 1/4	C	8.92	1300	1300	1280	1190	1100	1010	917	688	527	416	337
16x1 1/4	C	10.2	1480	1480	1480	1400	1310	1220	1130	1030	786	621	503
17.7x1 1/4	C	11.3	1640	1640	1640	1580	1490	1390	1300	1210	1070	843	683

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_24													
5x1/4	NC	3.19	109	105	82.7	41.4	23.3	14.9	10.4	7.61	5.83	4.60	3.73
6x1/4	NC	3.82	119	130	108	71.6	40.3	25.8	17.9	13.2	10.1	7.96	6.45
6x5/16	NC	3.82	166	162	135	89.5	50.4	32.2	22.4	16.4	12.6	9.95	8.06
6x3/8	C	3.82	203	195	162	107	60.4	38.7	26.9	19.7	15.1	11.9	9.67
7x3/8	NC	4.46	235	233	200	167	96.0	61.4	42.7	31.3	24.0	19.0	15.4
6x1/2	C	3.82	270	260	216	143	80.6	51.6	35.8	26.3	20.1	15.9	12.9
7x1/2	C	4.46	315	311	267	223	128	81.9	56.9	41.8	32.0	25.3	20.5
8x1/2	C	5.10	360	360	317	273	191	122	84.9	62.4	47.8	37.7	30.6
6x3/4	C	3.82	406	390	324	215	121	77.4	53.8	39.5	30.2	23.9	19.4
8x5/8	C	5.10	451	451	397	342	239	153	106	78.0	59.7	47.2	38.2
8x3/4	C	5.10	541	541	476	410	287	184	127	93.6	71.7	56.6	45.9
10x3/4	C	6.37	676	676	628	562	497	358	249	183	140	111	89.6
8x1	C	5.10	722	722	636	548	383	245	170	125	95.7	75.6	61.2
12x3/4	C	7.65	812	812	780	715	649	583	430	316	242	191	155
10x1	C	6.37	903	903	839	751	663	478	332	244	187	148	120
11x1	C	7.01	993	993	940	852	764	637	442	325	249	197	159
12x1	C	7.65	1080	1080	1040	954	866	778	574	422	323	255	207
10x1 1/4	C	6.37	1130	1130	1050	939	829	599	416	305	234	185	150
13x1	C	8.28	1170	1170	1140	1060	967	879	730	536	411	324	263
14x1	C	8.92	1260	1260	1240	1160	1070	981	892	670	513	405	328
12x1 1/4	C	7.65	1360	1360	1300	1190	1080	973	718	528	404	319	259
16x1	C	10.2	1440	1440	1440	1360	1270	1180	1100	1000	765	605	490
14x1 1/4	C	8.92	1580	1580	1560	1450	1340	1230	1120	838	642	507	411
16x1 1/4	C	10.2	1810	1810	1810	1700	1590	1480	1370	1250	958	757	613
17.7x1 1/4	C	11.3	2000	2000	2000	1920	1810	1700	1590	1480	1300	1030	832

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_30													
5x1/4	NC	3.19	133	129	102	51.0	28.7	18.3	12.7	9.36	7.16	5.66	4.59
6x1/4	NC	3.82	146	160	133	88.0	49.5	31.7	22.0	16.2	12.4	9.78	7.92
6x5/16	NC	3.82	204	200	166	110	61.9	39.6	27.5	20.2	15.5	12.2	9.91
6x3/8	C	3.82	249	240	199	132	74.3	47.5	33.0	24.3	18.6	14.7	11.9
7x3/8	NC	4.46	288	286	246	205	118	75.5	52.4	38.5	29.5	23.3	18.9
6x1/2	C	3.82	332	320	266	176	99.1	63.4	44.0	32.4	24.8	19.6	15.9
7x1/2	C	4.46	388	382	328	274	157	101	69.9	51.4	39.3	31.1	25.2
8x1/2	C	5.10	443	443	390	336	235	150	104	76.7	58.7	46.4	37.6
6x3/4	C	3.82	499	480	399	264	149	95.2	66.1	48.5	37.2	29.4	23.8
8x5/8	C	5.10	554	554	488	420	294	188	130	95.9	73.4	58.0	47.0
8x3/4	C	5.10	665	665	585	504	352	226	157	115	88.1	69.6	56.4
10x3/4	C	6.37	831	831	772	691	610	441	306	225	172	136	110
8x1	C	5.10	887	887	781	673	470	301	209	154	118	92.9	75.2
12x3/4	C	7.65	997	997	959	878	797	716	529	388	297	235	190
10x1	C	6.37	1110	1110	1030	922	814	588	408	300	230	181	147
11x1	C	7.01	1220	1220	1160	1050	939	782	543	399	306	241	196
12x1	C	7.65	1330	1330	1280	1170	1060	955	705	518	397	313	254
10x1 1/4	C	6.37	1390	1390	1290	1150	1020	735	511	375	287	227	184
13x1	C	8.28	1440	1440	1400	1300	1190	1080	897	659	504	399	323
14x1	C	8.92	1550	1550	1530	1420	1310	1200	1100	823	630	498	403
12x1 1/4	C	7.65	1660	1660	1600	1470	1330	1200	882	648	496	392	318
16x1	C	10.2	1770	1770	1770	1670	1560	1450	1350	1230	940	743	602
14x1 1/4	C	8.92	1940	1940	1910	1780	1640	1510	1370	1030	788	623	504
16x1 1/4	C	10.2	2220	2220	2220	2090	1950	1820	1680	1540	1180	929	753
17.7x1 1/4	C	11.3	2460	2460	2460	2360	2220	2090	1950	1820	1600	1260	1020

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_36													
5x1/4	NC	3.19	160	154	122	61.1	34.4	22.0	15.3	11.2	8.60	6.79	5.50
6x1/4	NC	3.82	175	192	159	106	59.4	38.0	26.4	19.4	14.9	11.7	9.51
6x5/16	NC	3.82	244	240	199	132	74.3	47.5	33.0	24.3	18.6	14.7	11.9
6x3/8	C	3.82	299	288	239	158	89.1	57.1	39.6	29.1	22.3	17.6	14.3
7x3/8	NC	4.46	346	344	295	246	142	90.6	62.9	46.2	35.4	28.0	22.7
6x1/2	C	3.82	399	383	319	211	119	76.1	52.8	38.8	29.7	23.5	19.0
7x1/2	C	4.46	465	458	393	329	189	121	83.9	61.6	47.2	37.3	30.2
8x1/2	C	5.10	532	532	468	403	282	180	125	92.0	70.4	55.7	45.1
6x3/4	C	3.82	598	575	478	317	178	114	79.3	58.2	44.6	35.2	28.5
8x5/8	C	5.10	665	665	585	504	352	225	157	115	88.1	69.6	56.4
8x3/4	C	5.10	798	798	702	605	423	271	188	138	106	83.5	67.6
10x3/4	C	6.37	997	997	927	829	732	529	367	270	206	163	132
8x1	C	5.10	1060	1060	937	807	564	361	251	184	141	111	90.2
12x3/4	C	7.65	1200	1200	1150	1050	956	859	634	466	357	282	228
10x1	C	6.37	1330	1330	1240	1110	977	705	490	360	275	218	176
11x1	C	7.01	1460	1460	1390	1260	1130	938	652	479	367	290	235
12x1	C	7.65	1600	1600	1540	1410	1280	1150	846	622	476	376	305
10x1 1/4	C	6.37	1660	1660	1550	1380	1220	882	612	450	344	272	220
13x1	C	8.28	1730	1730	1680	1550	1430	1300	1080	790	605	478	387
14x1	C	8.92	1860	1860	1830	1700	1570	1450	1320	987	756	597	484
12x1 1/4	C	7.65	2000	2000	1920	1760	1600	1430	1060	777	595	470	381
16x1	C	10.2	2130	2130	2130	2000	1870	1740	1610	1470	1130	891	722
14x1 1/4	C	8.92	2330	2330	2290	2130	1970	1810	1650	1230	945	747	605
16x1 1/4	C	10.2	2660	2660	2660	2510	2340	2180	2020	1840	1410	1110	903
17.7x1 1/4	C	11.3	2950	2950	2950	2830	2660	2500	2340	2180	1920	1510	1230

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_40													
5x1/4	NC	3.19	178	172	136	67.9	38.2	24.5	17.0	12.5	9.55	7.55	6.11
6x1/4	NC	3.82	195	213	177	117	66.0	42.3	29.3	21.6	16.5	13.0	10.6
6x5/16	NC	3.82	272	266	221	147	82.5	52.8	36.7	27.0	20.6	16.3	13.2
6x3/8	C	3.82	332	320	266	176	99.1	63.4	44.0	32.3	24.8	19.6	15.8
7x3/8	NC	4.46	385	382	328	274	157	101	69.9	51.4	39.3	31.1	25.2
6x1/2	C	3.82	443	426	354	235	132	84.5	58.7	43.1	33.0	26.1	21.1
7x1/2	C	4.46	517	509	437	365	210	134	93.2	68.5	52.4	41.4	33.6
8x1/2	C	5.10	591	591	520	448	313	200	139	102	78.3	61.8	50.1
6x3/4	C	3.82	665	639	531	352	198	127	88.1	64.7	49.5	39.1	31.7
8x5/8	C	5.10	738	738	650	560	391	250	174	128	97.8	77.3	62.6
8x3/4	C	5.10	886	886	780	672	470	301	209	153	117	92.8	75.2
10x3/4	C	6.37	1110	1110	1030	921	813	587	408	300	229	181	147
8x1	C	5.10	1180	1180	1040	897	627	401	278	205	157	124	100
12x3/4	C	7.65	1330	1330	1280	1170	1060	954	705	518	396	313	254
10x1	C	6.37	1480	1480	1370	1230	1080	783	544	400	306	242	196
11x1	C	7.01	1630	1630	1540	1400	1250	1040	724	532	407	322	261
12x1	C	7.65	1770	1770	1710	1560	1420	1270	940	690	529	418	338
10x1 1/4	C	6.37	1850	1850	1720	1540	1360	979	680	500	383	302	245
13x1	C	8.28	1920	1920	1870	1730	1580	1440	1190	878	672	531	430
14x1	C	8.92	2070	2070	2040	1890	1750	1610	1460	1100	839	663	537
12x1 1/4	C	7.65	2220	2220	2130	1950	1770	1590	1180	863	661	522	423
16x1	C	10.2	2360	2360	2360	2230	2080	1940	1790	1640	1250	990	802
14x1 1/4	C	8.92	2590	2590	2550	2370	2190	2010	1830	1370	1050	829	672
16x1 1/4	C	10.2	2960	2960	2960	2780	2600	2420	2240	2050	1570	1240	1000
17.7x1 1/4	C	11.3	3270	3270	3270	3140	2960	2780	2600	2420	2130	1680	1360

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_48													
5x1/4	NC	3.19	217	209	165	82.8	46.6	29.8	20.7	15.2	11.6	9.20	7.45
6x1/4	NC	3.82	237	260	216	143	80.5	51.5	35.8	26.3	20.1	15.9	12.9
6x5/16	NC	3.82	331	325	270	179	101	64.4	44.7	32.9	25.2	19.9	16.1
6x3/8	C	3.82	405	389	324	215	121	77.3	53.7	39.4	30.2	23.8	19.3
7x3/8	NC	4.46	469	465	400	334	192	123	85.2	62.6	47.9	37.9	30.7
6x1/2	C	3.82	540	519	432	286	161	103	71.6	52.6	40.2	31.8	25.8
7x1/2	C	4.46	630	621	533	445	256	164	114	83.5	63.9	50.5	40.9
8x1/2	C	5.10	720	720	634	546	382	244	170	125	95.4	75.4	61.1
6x3/4	C	3.82	810	779	647	429	242	155	107	78.9	60.4	47.7	38.6
8x5/8	C	5.10	900	900	792	683	477	305	212	156	119	94.2	76.3
8x3/4	C	5.10	1080	1080	951	819	573	366	254	187	143	113	91.6
10x3/4	C	6.37	1350	1350	1250	1120	991	716	497	365	280	221	179
8x1	C	5.10	1440	1440	1270	1090	764	489	339	249	191	151	122
12x3/4	C	7.65	1620	1620	1560	1430	1290	1160	859	631	483	382	309
10x1	C	6.37	1800	1800	1670	1500	1320	954	663	487	373	295	239
11x1	C	7.01	1980	1980	1880	1700	1520	1270	882	648	496	392	318
12x1	C	7.65	2160	2160	2080	1900	1730	1550	1150	841	644	509	412
10x1 1/4	C	6.37	2250	2250	2090	1870	1650	1190	829	609	466	368	298
13x1	C	8.28	2340	2340	2280	2110	1930	1750	1460	1070	819	647	524
14x1	C	8.92	2520	2520	2480	2310	2130	1960	1780	1340	1020	808	655
12x1 1/4	C	7.65	2700	2700	2600	2380	2160	1940	1430	1050	806	636	516
16x1	C	10.2	2880	2880	2880	2710	2540	2360	2190	1990	1530	1210	977
14x1 1/4	C	8.92	3150	3150	3100	2890	2670	2450	2230	1670	1280	1010	819
16x1 1/4	C	10.2	3600	3600	3600	3390	3170	2950	2730	2490	1910	1510	1220
17.7x1 1/4	C	11.3	3990	3990	3990	3830	3610	3390	3170	2950	2590	2050	1660

SIN Beam Design Flexural Strength (LRFD)

Table 3.3b

Designation	L_p (ft)	Design Flexural Strength $\phi_b M_n$ (kip-ft)											
		Unbraced Length (ft)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_60													
5x1/4	NC	3.19	267	257	203	102	57.3	36.7	25.5	18.7	14.3	11.3	9.17
6x1/4	NC	3.82	292	319	265	176	99.0	63.4	44.0	32.3	24.8	19.6	15.8
6x5/16	NC	3.82	407	399	332	220	124	79.2	55.0	40.4	31.0	24.5	19.8
6x3/8	C	3.82	498	479	398	264	149	95.1	66.0	48.5	37.1	29.3	23.8
7x3/8	NC	4.46	577	573	492	411	236	151	105	77.0	59.0	46.6	37.7
6x1/2	C	3.82	664	639	531	352	198	127	88.0	64.7	49.5	39.1	31.7
7x1/2	C	4.46	775	764	656	548	315	201	140	103	78.6	62.1	50.3
8x1/2	C	5.10	886	886	780	672	470	301	209	153	117	92.8	75.1
6x3/4	C	3.82	997	959	797	528	297	190	132	97.0	74.3	58.7	47.5
8x5/8	C	5.10	1110	1110	975	840	587	376	261	192	147	116	93.9
8x3/4	C	5.10	1330	1330	1170	1010	704	451	313	230	176	139	113
10x3/4	C	6.37	1660	1660	1540	1380	1220	881	611	449	344	272	220
8x1	C	5.10	1770	1770	1560	1340	939	601	418	307	235	186	150
12x3/4	C	7.65	1990	1990	1920	1760	1590	1430	1060	776	594	470	380
10x1	C	6.37	2220	2220	2060	1840	1630	1170	815	599	459	362	294
11x1	C	7.01	2440	2440	2310	2090	1880	1560	1090	797	611	482	391
12x1	C	7.65	2660	2660	2560	2340	2120	1910	1410	1040	793	626	507
10x1 1/4	C	6.37	2770	2770	2570	2300	2030	1470	1020	749	573	453	367
13x1	C	8.28	2880	2880	2810	2590	2370	2160	1790	1320	1010	796	645
14x1	C	8.92	3100	3100	3050	2840	2620	2410	2190	1640	1260	994	806
12x1 1/4	C	7.65	3320	3320	3200	2930	2660	2390	1760	1290	991	783	634
16x1	C	10.2	3540	3540	3540	3340	3120	2900	2690	2450	1880	1480	1200
14x1 1/4	C	8.92	3880	3880	3820	3550	3280	3010	2740	2060	1570	1240	1010
16x1 1/4	C	10.2	4430	4430	4430	4170	3900	3630	3360	3070	2350	1860	1500
17.7x1 1/4	C	11.3	4910	4910	4910	4710	4440	4170	3900	3630	3190	2520	2040

Notes:

NC, C indicates if the section is Non-Compact or Compact in Flexure per A360 Table B4.1b Case 11

SIN Beam Allowable Shear Strength (ASD)

Table 3.4a

	Web Ht h_w (in.)	Allowable Shear Strength V_n/Ω_v (kip)					
		WTA	WTB	WTC	WTF	WTH	WTK
Web Thick. t_w (in.)		0.0747	0.105	0.120	0.164	0.194	0.239
WT_13	13.1	11.9	18.0	21.2	31.1	36.8	45.2
WT_20	19.7	17.2	26.4	31.2	46.0	55.2	67.9
WT_24	24.0	20.7	32.0	37.8	55.8	67.4	82.9
WT_30	29.5	25.1	38.9	46.0	68.2	82.8	102
WT_36	35.4	29.8	46.4	54.9	81.6	99.4	122
WT_40	39.4	33.0	51.4	60.8	90.4	110	136
WT_48	48.0	39.8	62.3	73.8	110	135	166
WT_60	59.1	42.0	67.0	86.8	134	165	204

SIN Beam Design Shear Strength (LRFD)

Table 3.4b

	Web Ht h_w (in.)	Design Shear Strength $\phi_v V_n$ (kip)					
		WTA	WTB	WTC	WTF	WTH	WTK
Web Thick. t_w (in.)		0.0747	0.105	0.120	0.164	0.194	0.239
WT_13	13.1	19.0	28.8	34.0	49.7	58.8	72.4
WT_20	19.7	27.5	42.3	49.9	73.5	88.3	109
WT_24	24.0	33.2	51.1	60.4	89.3	108	133
WT_30	29.5	40.2	62.3	73.6	109	132	163
WT_36	35.4	47.7	74.2	87.8	130	159	196
WT_40	39.4	52.8	82.2	97.3	145	177	217
WT_48	48.0	63.7	99.6	118	176	215	265
WT_60	59.1	67.2	107	139	214	265	326

SIN Beam Shear Properties

Table 3.4c

	Web Ht h_w (in.)	Effective Shear Area $A_{v,eff}$ (in ²)					
		WTA	WTB	WTC	WTF	WTH	WTK
Eff. Thick. $t_{w,eff}$ (in.)		0.0873	0.123	0.140	0.192	0.227	0.279
WT_13	13.1	1.14	1.61	1.84	2.51	2.97	3.66
WT_20	19.7	1.72	2.42	2.76	3.78	4.47	5.50
WT_24	24.0	2.10	2.95	3.37	4.60	5.44	6.71
WT_30	29.5	2.58	3.62	4.14	5.66	6.69	8.24
WT_36	35.4	3.09	4.35	4.97	6.79	8.03	9.89
WT_40	39.4	3.44	4.84	5.53	7.55	8.94	11.0
WT_48	48.0	4.19	5.89	6.73	9.20	10.9	13.4
WT_60	59.1	5.16	7.25	8.29	11.3	13.4	16.5

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_13													
5x1/4	S	4.63	71.2	64.9	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	3.86	76.2	71.7	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	3.88	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	3.89	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	3.34	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	3.93	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	3.37	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	2.95	240	227	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	4.00	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	2.97	299	284	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	3.00	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	2.40	449	434	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	3.06	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	2.00	539	525	491	442	379	311	245	184	141	111	90.2
10x1	NS	2.45	599	579	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	2.22	659	640	593	521	434	343	257	189	145	114	92.6
12x1	NS	2.04	719	701	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	2.49	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	1.88	778	761	722	658	577	488	397	312	239	189	153
14x1	NS	1.75	838	822	782	725	648	560	469	381	298	236	191
12x1 1/4	NS	2.08	898	877	823	737	632	519	408	307	235	186	150
16x1	NS	1.53	958	942	902	855	786	704	614	523	435	352	285
14x1 1/4	NS	1.78	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	1.56	1200	1180	1130	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	1.41	1330	1310	1260	1210	1130	1030	923	810	696	587	484

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_20													
5x1/4	S	6.91	71.2	64.9	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	5.75	76.2	71.8	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	5.77	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	5.79	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	4.96	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	5.83	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	5.00	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	4.37	240	228	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	5.90	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	4.40	299	285	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	4.43	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	3.54	449	434	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	4.48	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	2.95	539	526	492	442	379	311	245	184	141	111	90.2
10x1	NS	3.58	599	580	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	3.26	659	641	593	521	434	343	257	189	145	114	92.6
12x1	NS	2.99	719	702	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	3.63	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	2.76	778	763	722	658	577	488	397	312	239	189	153
14x1	NS	2.56	838	823	784	725	648	560	469	381	298	236	191
12x1 1/4	NS	3.02	898	878	823	737	632	519	408	307	235	186	150
16x1	NS	2.24	958	944	907	856	786	704	614	523	435	352	285
14x1 1/4	NS	2.59	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	2.27	1200	1180	1140	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	2.05	1330	1310	1270	1210	1130	1030	923	810	696	587	484

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_24													
5x1/4	S	8.41	71.2	64.9	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	7.01	76.2	71.8	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	7.02	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	7.04	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	6.04	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	7.08	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	6.07	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	5.31	240	228	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	7.15	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	5.34	299	285	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	5.36	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	4.29	449	435	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	5.42	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	3.58	539	526	493	442	379	311	245	184	141	111	90.2
10x1	NS	4.33	599	580	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	3.94	659	641	593	521	434	343	257	189	145	114	92.6
12x1	NS	3.61	719	702	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	4.38	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	3.33	778	763	722	658	577	488	397	312	239	189	153
14x1	NS	3.10	838	824	785	725	648	560	469	381	298	236	191
12x1 1/4	NS	3.65	898	878	823	737	632	519	408	307	235	186	150
16x1	NS	2.71	958	945	909	857	786	704	614	523	435	352	285
14x1 1/4	NS	3.13	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	2.74	1200	1180	1140	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	2.47	1330	1310	1270	1210	1130	1030	923	810	696	587	484

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_30													
5x1/4	S	10.3	71.2	64.9	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	8.60	76.2	71.8	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	8.61	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	8.63	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	7.40	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	8.67	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	7.43	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	6.50	240	228	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	8.74	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	6.53	299	285	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	6.56	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	5.24	449	435	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	6.61	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	4.37	539	527	493	442	379	311	245	184	141	111	90.2
10x1	NS	5.29	599	580	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	4.81	659	641	593	521	434	343	257	189	145	114	92.6
12x1	NS	4.41	719	702	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	5.33	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	4.07	778	763	722	658	577	488	397	312	239	189	153
14x1	NS	3.78	838	824	785	725	648	560	469	381	298	236	191
12x1 1/4	NS	4.44	898	878	823	737	632	519	408	307	235	186	150
16x1	NS	3.31	958	945	910	857	786	704	614	523	435	352	285
14x1 1/4	NS	3.81	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	3.33	1200	1180	1140	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	3.01	1330	1310	1270	1210	1130	1030	923	810	696	587	484

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_36													
5x1/4	S	12.4	71.2	64.9	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	10.3	76.2	71.8	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	10.3	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	10.3	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	8.86	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	10.4	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	8.89	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	7.78	240	228	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	10.4	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	7.81	299	285	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	7.83	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	6.27	449	435	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	7.89	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	5.22	539	527	493	442	379	311	245	184	141	111	90.2
10x1	NS	6.31	599	580	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	5.74	659	641	593	521	434	343	257	189	145	114	92.6
12x1	NS	5.26	719	703	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	6.35	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	4.85	778	764	722	658	577	488	397	312	239	189	153
14x1	NS	4.51	838	824	785	725	648	560	469	381	298	236	191
12x1 1/4	NS	5.3	898	878	823	737	632	519	408	307	235	186	150
16x1	NS	3.94	958	946	910	857	786	704	614	523	435	352	285
14x1 1/4	NS	4.54	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	3.97	1200	1180	1140	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	3.59	1330	1310	1270	1210	1130	1030	923	810	696	587	484

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_40													
5x1/4	S	13.7	71.2	64.9	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	11.4	76.2	71.8	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	11.5	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	11.5	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	9.83	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	11.5	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	9.87	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	8.63	240	228	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	11.6	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	8.66	299	285	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	8.69	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	6.95	449	435	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	8.74	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	5.79	539	527	493	442	379	311	245	184	141	111	90.2
10x1	NS	6.99	599	580	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	6.36	659	641	593	521	434	343	257	189	145	114	92.6
12x1	NS	5.83	719	703	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	7.04	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	5.38	778	764	722	658	577	488	397	312	239	189	153
14x1	NS	5	838	824	785	725	648	560	469	381	298	236	191
12x1 1/4	NS	5.86	898	878	823	737	632	519	408	307	235	186	150
16x1	NS	4.37	958	946	911	857	786	704	614	523	435	352	285
14x1 1/4	NS	5.03	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	4.4	1200	1180	1140	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	3.97	1330	1310	1270	1210	1130	1030	923	810	696	587	484

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_48													
5x1/4	S	16.7	71.2	64.9	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	13.9	76.2	71.8	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	13.9	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	14.0	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	12.0	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	14.0	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	12.0	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	10.5	240	228	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	14.1	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	10.5	299	285	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	10.6	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	8.4	449	435	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	10.6	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	7.0	539	527	493	442	379	311	245	184	141	111	90.2
10x1	NS	8.5	599	580	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	7.7	659	642	593	521	434	343	257	189	145	114	92.6
12x1	NS	7.1	719	703	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	8.5	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	6.5	778	764	722	658	577	488	397	312	239	189	153
14x1	NS	6.1	838	825	786	725	648	560	469	381	298	236	191
12x1 1/4	NS	7.1	898	879	823	737	632	519	408	307	235	186	150
16x1	NS	5.3	958	946	911	857	786	704	614	523	435	352	285
14x1 1/4	NS	6.1	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	5.3	1200	1180	1140	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	4.8	1330	1310	1270	1210	1130	1030	923	810	696	587	484

SIN Beam Allowable Axial Strength (ASD)

Table 3.5a

Designation	r_x/r_y	Allowable Axial Strength P_n / Ω_c (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_60													
5x1/4	S	20.5	71.2	65.0	45.2	24.2	13.6	8.70	6.04	4.44	3.40	2.68	2.17
6x1/4	S	17.1	76.2	71.8	59.9	40.8	23.5	15.0	10.4	7.67	5.87	4.64	3.76
6x5/16	S	17.1	109	102	79.0	51.0	29.4	18.8	13.0	9.59	7.34	5.80	4.70
6x3/8	NS	17.2	135	123	94.9	61.2	35.2	22.5	15.7	11.5	8.81	6.96	5.64
7x3/8	S	14.7	155	147	121	88.0	55.9	35.8	24.9	18.3	14.0	11.1	8.95
6x1/2	NS	17.2	180	165	126	81.6	47.0	30.1	20.9	15.3	11.7	9.28	7.52
7x1/2	NS	14.7	210	196	162	117	74.6	47.7	33.2	24.4	18.6	14.7	11.9
8x1/2	NS	12.9	240	228	197	154	109	71.3	49.5	36.4	27.8	22.0	17.8
6x3/4	NS	17.3	269	247	190	122	70.5	45.1	31.3	23.0	17.6	13.9	11.3
8x5/8	NS	12.9	299	285	246	192	136	89.1	61.9	45.4	34.8	27.5	22.3
8x3/4	NS	12.9	359	342	295	230	163	107	74.2	54.5	41.8	33.0	26.7
10x3/4	NS	10.4	449	435	396	338	271	204	145	107	81.5	64.4	52.2
8x1	NS	13	479	456	393	307	217	143	99.0	72.7	55.7	44.0	35.6
12x3/4	NS	8.63	539	527	493	442	379	311	245	184	141	111	90.2
10x1	NS	10.4	599	580	528	451	361	272	193	142	109	85.9	69.6
11x1	NS	9.46	659	642	593	521	434	343	257	189	145	114	92.6
12x1	NS	8.67	719	703	658	590	506	415	326	245	188	148	120
10x1 1/4	NS	10.4	749	725	660	563	452	340	242	178	136	107	87.0
13x1	NS	8	778	764	722	658	577	488	397	312	239	189	153
14x1	NS	7.43	838	825	786	725	648	560	469	381	298	236	191
12x1 1/4	NS	8.7	898	879	823	737	632	519	408	307	235	186	150
16x1	NS	6.5	958	946	911	857	786	704	614	523	435	352	285
14x1 1/4	NS	7.46	1050	1030	982	906	810	700	587	476	373	295	239
16x1 1/4	NS	6.53	1200	1180	1140	1070	983	880	768	654	544	440	356
17.7x1 1/4	NS	5.9	1330	1310	1270	1210	1130	1030	923	810	696	587	484

Notes:

NS, S indicates if the section is Non-Slender or Slender in Axial Compression per A360 Table B4.1a Case 2

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_13													
5x1/4	S	4.63	107	97.5	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	3.86	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	3.88	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	3.89	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	3.34	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	3.93	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	3.37	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	2.95	360	342	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	4.00	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	2.97	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	3.00	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	2.40	675	652	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	3.06	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	2.00	810	789	738	665	570	468	368	277	212	167	136
10x1	NS	2.45	900	871	793	677	543	409	291	213	163	129	105
11x1	NS	2.22	990	962	892	783	652	515	387	284	218	172	139
12x1	NS	2.04	1080	1050	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	2.49	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	1.88	1170	1140	1080	989	868	733	597	468	359	284	230
14x1	NS	1.75	1260	1230	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	2.08	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	1.53	1440	1420	1360	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	1.78	1570	1540	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	1.56	1800	1770	1700	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	1.41	1990	1960	1900	1820	1700	1550	1390	1220	1050	882	727

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_20													
5x1/4	S	6.91	107	97.6	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	5.75	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	5.77	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	5.79	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	4.96	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	5.83	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	5.00	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	4.37	360	342	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	5.90	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	4.40	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	4.43	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	3.54	675	653	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	4.48	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	2.95	810	791	740	665	570	468	368	277	212	167	136
10x1	NS	3.58	900	871	793	677	543	409	291	213	163	129	105
11x1	NS	3.26	990	963	892	783	652	515	387	284	218	172	139
12x1	NS	2.99	1080	1050	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	3.63	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	2.76	1170	1150	1090	989	868	733	597	468	359	284	230
14x1	NS	2.56	1260	1240	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	3.02	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	2.24	1440	1420	1360	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	2.59	1570	1550	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	2.27	1800	1770	1710	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	2.05	1990	1970	1900	1820	1700	1550	1390	1220	1050	882	727

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_24													
5x1/4	S	8.41	107	97.6	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	7.01	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	7.02	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	7.04	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	6.04	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	7.08	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	6.07	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	5.31	360	342	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	7.15	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	5.34	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	5.36	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	4.29	675	653	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	5.42	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	3.58	810	791	741	665	570	468	368	277	212	167	136
10x1	NS	4.33	900	872	793	677	543	409	291	213	163	129	105
11x1	NS	3.94	990	964	892	783	652	515	387	284	218	172	139
12x1	NS	3.61	1080	1060	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	4.38	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	3.33	1170	1150	1090	989	868	733	597	468	359	284	230
14x1	NS	3.10	1260	1240	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	3.65	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	2.71	1440	1420	1370	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	3.13	1570	1550	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	2.74	1800	1780	1710	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	2.47	1990	1970	1910	1820	1700	1550	1390	1220	1050	882	727

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_30													
5x1/4	S	10.3	107	97.6	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	8.60	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	8.61	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	8.63	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	7.40	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	8.67	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	7.43	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	6.50	360	342	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	8.74	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	6.53	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	6.56	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	5.24	675	654	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	6.61	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	4.37	810	792	741	665	570	468	368	277	212	167	136
10x1	NS	5.29	900	872	793	677	543	409	291	213	163	129	105
11x1	NS	4.81	990	964	892	783	652	515	387	284	218	172	139
12x1	NS	4.41	1080	1060	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	5.33	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	4.07	1170	1150	1090	989	868	733	597	468	359	284	230
14x1	NS	3.78	1260	1240	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	4.44	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	3.31	1440	1420	1370	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	3.81	1570	1550	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	3.33	1800	1780	1710	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	3.01	1990	1970	1910	1820	1700	1550	1390	1220	1050	882	727

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_36													
5x1/4	S	12.4	107	97.6	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	10.3	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	10.3	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	10.3	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	8.86	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	10.4	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	8.89	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	7.78	360	342	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	10.4	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	7.81	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	7.83	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	6.27	675	654	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	7.89	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	5.22	810	792	741	665	570	468	368	277	212	167	136
10x1	NS	6.31	900	872	793	677	543	409	291	213	163	129	105
11x1	NS	5.74	990	964	892	783	652	515	387	284	218	172	139
12x1	NS	5.26	1080	1060	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	6.35	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	4.85	1170	1150	1090	989	868	733	597	468	359	284	230
14x1	NS	4.51	1260	1240	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	5.3	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	3.94	1440	1420	1370	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	4.54	1570	1550	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	3.97	1800	1780	1710	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	3.59	1990	1970	1910	1820	1700	1550	1390	1220	1050	882	727

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_40													
5x1/4	S	13.7	107	97.6	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	11.4	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	11.5	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	11.5	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	9.83	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	11.5	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	9.87	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	8.63	360	343	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	11.6	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	8.66	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	8.69	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	6.95	675	654	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	8.74	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	5.79	810	792	741	665	570	468	368	277	212	167	136
10x1	NS	6.99	900	872	793	677	543	409	291	213	163	129	105
11x1	NS	6.36	990	964	892	783	652	515	387	284	218	172	139
12x1	NS	5.83	1080	1060	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	7.04	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	5.38	1170	1150	1090	989	868	733	597	468	359	284	230
14x1	NS	5	1260	1240	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	5.86	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	4.37	1440	1420	1370	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	5.03	1570	1550	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	4.4	1800	1780	1710	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	3.97	1990	1970	1910	1820	1700	1550	1390	1220	1050	882	727

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_48													
5x1/4	S	16.7	107	97.6	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	13.9	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	13.9	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	14.0	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	12.0	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	14.0	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	12.0	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	10.5	360	343	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	14.1	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	10.5	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	10.6	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	8.4	675	654	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	10.6	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	7.0	810	792	742	665	570	468	368	277	212	167	136
10x1	NS	8.5	900	872	793	677	543	409	291	213	163	129	105
11x1	NS	7.7	990	964	892	783	652	515	387	284	218	172	139
12x1	NS	7.1	1080	1060	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	8.5	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	6.5	1170	1150	1090	989	868	733	597	468	359	284	230
14x1	NS	6.1	1260	1240	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	7.1	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	5.3	1440	1420	1370	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	6.1	1570	1550	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	5.3	1800	1780	1710	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	4.8	1990	1970	1910	1820	1700	1550	1390	1220	1050	882	727

SIN Beam Design Axial Strength (LRFD)

Table 3.5b

Designation	r_x/r_y	Design Axial Strength $\phi_c P_n$ (kip)											
		Effective Length L_c (ft) (with respect to the least radius of gyration r_y)											
		0	5	10	15	20	25	30	35	40	45	50	
WT_60													
5x1/4	S	20.5	107	97.6	67.9	36.3	20.4	13.1	9.08	6.67	5.11	4.04	3.27
6x1/4	S	17.1	115	108	90.0	61.3	35.3	22.6	15.7	11.5	8.82	6.97	5.65
6x5/16	S	17.1	164	154	119	76.6	44.1	28.2	19.6	14.4	11.0	8.72	7.06
6x3/8	NS	17.2	202	185	143	91.9	52.9	33.9	23.5	17.3	13.2	10.5	8.47
7x3/8	S	14.7	233	221	183	132	84.1	53.8	37.4	27.5	21.0	16.6	13.5
6x1/2	NS	17.2	270	247	190	123	70.6	45.2	31.4	23.1	17.6	13.9	11.3
7x1/2	NS	14.7	315	295	243	176	112	71.7	49.8	36.6	28.0	22.1	17.9
8x1/2	NS	12.9	360	343	296	231	163	107	74.4	54.6	41.8	33.1	26.8
6x3/4	NS	17.3	405	371	285	184	106	67.8	47.1	34.6	26.5	20.9	16.9
8x5/8	NS	12.9	450	428	369	289	204	134	93.0	68.3	52.3	41.3	33.5
8x3/4	NS	12.9	540	514	443	346	245	161	112	82.0	62.8	49.6	40.2
10x3/4	NS	10.4	675	654	595	508	407	306	218	160	123	96.8	78.4
8x1	NS	13	720	685	591	462	327	214	149	109	83.7	66.1	53.5
12x3/4	NS	8.63	810	792	742	665	570	468	368	277	212	167	136
10x1	NS	10.4	900	872	793	677	543	409	291	213	163	129	105
11x1	NS	9.46	990	964	892	783	652	515	387	284	218	172	139
12x1	NS	8.67	1080	1060	989	887	760	624	490	369	282	223	181
10x1 1/4	NS	10.4	1120	1090	991	847	679	511	363	267	204	161	131
13x1	NS	8	1170	1150	1090	989	868	733	597	468	359	284	230
14x1	NS	7.43	1260	1240	1180	1090	974	842	705	572	448	354	287
12x1 1/4	NS	8.7	1350	1320	1240	1110	950	780	613	461	353	279	226
16x1	NS	6.5	1440	1420	1370	1290	1180	1060	924	787	654	529	428
14x1 1/4	NS	7.46	1570	1550	1480	1360	1220	1050	882	715	561	443	359
16x1 1/4	NS	6.53	1800	1780	1710	1610	1480	1320	1150	983	817	661	535
17.7x1 1/4	NS	5.9	1990	1970	1910	1820	1700	1550	1390	1220	1050	882	727

Notes:

NS, S indicates if the section is Non-Slender or Slender in Axial Compression per A360 Table B4.1a Case 2

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter) (lb / ft / in)						Beam M/D Ratio (top of top flange excluded) (kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
	WT_13											
5x1/4	0.267	0.301	0.318	0.369	0.403	0.454	15.7	17.7	18.7	21.7	23.7	26.7
6x1/4	0.285	0.317	0.333	0.381	0.413	0.461	16.7	18.6	19.6	22.4	24.2	27.1
6x5/16	0.335	0.367	0.383	0.430	0.462	0.510	19.7	21.5	22.5	25.2	27.1	29.9
6x3/8	0.384	0.416	0.432	0.479	0.511	0.559	22.5	24.4	25.4	28.1	30.0	32.8
7x3/8	0.411	0.440	0.456	0.501	0.531	0.576	24.1	25.8	26.8	29.4	31.2	33.8
6x1/2	0.481	0.513	0.529	0.576	0.608	0.655	28.2	30.1	31.1	33.8	35.7	38.5
7x1/2	0.518	0.548	0.563	0.607	0.637	0.682	30.4	32.2	33.1	35.6	37.4	40.0
8x1/2	0.551	0.579	0.593	0.636	0.664	0.707	32.4	34.0	34.8	37.3	39.0	41.5
6x3/4	0.670	0.701	0.717	0.764	0.795	0.842	39.3	41.2	42.1	44.9	46.7	49.4
8x5/8	0.665	0.693	0.707	0.750	0.778	0.820	39.0	40.7	41.5	44.0	45.7	48.1
8x3/4	0.778	0.806	0.820	0.862	0.890	0.932	45.7	47.3	48.1	50.6	52.3	54.7
10x3/4	0.865	0.891	0.903	0.941	0.967	1.01	50.8	52.3	53.0	55.2	56.8	59.3
8x1	0.997	1.02	1.04	1.08	1.11	1.15	58.5	59.9	61.1	63.4	65.2	67.5
12x3/4	0.937	0.961	0.972	1.01	1.03	1.07	55.0	56.4	57.1	59.3	60.5	62.8
10x1	1.12	1.14	1.15	1.19	1.22	1.25	65.8	66.9	67.5	69.9	71.6	73.4
11x1	1.17	1.19	1.20	1.24	1.26	1.30	68.7	69.9	70.5	72.8	74.0	76.3
12x1	1.21	1.24	1.25	1.28	1.31	1.34	71.0	72.8	73.4	75.2	76.9	78.7
10x1 1/4	1.36	1.38	1.40	1.43	1.46	1.50	79.8	81.0	82.2	84.0	85.7	88.1
13x1	1.26	1.28	1.29	1.32	1.35	1.38	74.0	75.2	75.7	77.5	79.3	81.0
14x1	1.30	1.32	1.33	1.36	1.38	1.41	76.3	77.5	78.1	79.8	81.0	82.8
12x1 1/4	1.48	1.51	1.52	1.55	1.57	1.61	86.9	88.7	89.2	91.0	92.2	94.5
16x1	1.37	1.39	1.40	1.43	1.45	1.48	80.4	81.6	82.2	84.0	85.1	86.9
14x1 1/4	1.59	1.61	1.62	1.65	1.67	1.70	93.4	94.5	95.1	96.9	98.0	99.8
16x1 1/4	1.68	1.70	1.71	1.74	1.76	1.79	98.6	99.8	100	102	103	105
17.7x1 1/4	1.74	1.76	1.77	1.80	1.82	1.85	102	103	104	106	107	109

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter) (lb / ft / in)						Beam M/D Ratio (top of top flange excluded) (kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
	WT_20											
5x1/4	0.232	0.270	0.289	0.347	0.385	0.442	13.6	15.9	17.0	20.4	22.6	26.0
6x1/4	0.248	0.284	0.302	0.357	0.393	0.448	14.6	16.7	17.7	21.0	23.1	26.3
6x5/16	0.286	0.322	0.340	0.395	0.431	0.486	16.8	18.9	20.0	23.2	25.3	28.5
6x3/8	0.324	0.360	0.378	0.432	0.469	0.523	19.0	21.1	22.2	25.4	27.5	30.7
7x3/8	0.347	0.381	0.399	0.451	0.485	0.538	20.4	22.4	23.4	26.5	28.5	31.6
6x1/2	0.399	0.435	0.453	0.507	0.543	0.597	23.4	25.5	26.6	29.8	31.9	35.1
7x1/2	0.431	0.465	0.482	0.534	0.569	0.621	25.3	27.3	28.3	31.4	33.4	36.5
8x1/2	0.460	0.493	0.510	0.559	0.592	0.642	27.0	28.9	29.9	32.8	34.8	37.7
6x3/4	0.545	0.581	0.599	0.652	0.688	0.742	32.0	34.1	35.2	38.3	40.4	43.6
8x5/8	0.551	0.584	0.600	0.650	0.683	0.732	32.4	34.3	35.2	38.2	40.1	43.0
8x3/4	0.641	0.673	0.690	0.739	0.772	0.821	37.6	39.5	40.5	43.4	45.3	48.2
10x3/4	0.721	0.752	0.767	0.812	0.843	0.888	42.3	44.2	45.0	47.7	49.5	52.1
8x1	0.816	0.849	0.865	0.913	0.946	0.995	47.9	49.8	50.8	53.6	55.5	58.4
12x3/4	0.791	0.819	0.833	0.875	0.903	0.946	46.4	48.1	48.9	51.4	53.0	55.5
10x1	0.925	0.955	0.970	1.02	1.05	1.09	54.3	56.1	57.0	59.9	61.6	64.0
11x1	0.974	1.00	1.02	1.06	1.09	1.13	57.2	58.7	59.9	62.2	64.0	66.3
12x1	1.02	1.05	1.06	1.10	1.13	1.17	59.9	61.6	62.2	64.6	66.3	68.7
10x1 1/4	1.12	1.15	1.17	1.21	1.24	1.29	65.8	67.5	68.7	71.0	72.8	75.7
13x1	1.06	1.09	1.10	1.14	1.17	1.21	62.2	64.0	64.6	66.9	68.7	71.0
14x1	1.10	1.13	1.14	1.18	1.21	1.25	64.6	66.3	66.9	69.3	71.0	73.4
12x1 1/4	1.24	1.27	1.28	1.33	1.35	1.40	72.8	74.6	75.2	78.1	79.3	82.2
16x1	1.17	1.20	1.21	1.25	1.27	1.31	68.7	70.5	71.0	73.4	74.6	76.9
14x1 1/4	1.35	1.37	1.38	1.42	1.45	1.49	79.3	80.4	81.0	83.4	85.1	87.5
16x1 1/4	1.44	1.46	1.47	1.51	1.53	1.57	84.5	85.7	86.3	88.7	89.8	92.2
17.7x1 1/4	1.51	1.53	1.54	1.58	1.60	1.63	88.7	89.8	90.4	92.8	93.9	95.7

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter) (lb / ft / in)						Beam M/D Ratio (top of top flange excluded) (kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
	WT_24											
5x1/4	0.217	0.257	0.277	0.337	0.377	0.437	12.7	15.1	16.3	19.8	22.1	25.7
6x1/4	0.231	0.270	0.289	0.346	0.385	0.443	13.6	15.9	17.0	20.3	22.6	26.0
6x5/16	0.264	0.303	0.322	0.379	0.418	0.475	15.5	17.8	18.9	22.3	24.5	27.9
6x3/8	0.297	0.335	0.355	0.412	0.450	0.508	17.4	19.7	20.8	24.2	26.4	29.8
7x3/8	0.318	0.355	0.374	0.429	0.465	0.521	18.7	20.8	22.0	25.2	27.3	30.6
6x1/2	0.363	0.400	0.419	0.476	0.514	0.572	21.3	23.5	24.6	27.9	30.2	33.6
7x1/2	0.392	0.428	0.447	0.501	0.538	0.593	23.0	25.1	26.2	29.4	31.6	34.8
8x1/2	0.419	0.454	0.472	0.525	0.560	0.613	24.6	26.7	27.7	30.8	32.9	36.0
6x3/4	0.490	0.528	0.547	0.603	0.641	0.697	28.8	31.0	32.1	35.4	37.6	40.9
8x5/8	0.499	0.534	0.552	0.604	0.639	0.692	29.3	31.4	32.4	35.5	37.5	40.6
8x3/4	0.578	0.613	0.630	0.683	0.718	0.770	33.9	36.0	37.0	40.1	42.2	45.2
10x3/4	0.654	0.686	0.703	0.751	0.784	0.833	38.4	40.3	41.3	44.1	46.0	48.9
8x1	0.733	0.768	0.785	0.837	0.872	0.924	43.0	45.1	46.1	49.1	51.2	54.3
12x3/4	0.720	0.750	0.766	0.812	0.842	0.888	42.3	44.0	45.0	47.7	49.4	52.1
10x1	0.835	0.868	0.884	0.933	0.965	1.01	49.0	51.0	51.9	54.8	56.7	59.3
11x1	0.882	0.913	0.929	0.976	1.01	1.05	51.8	53.6	54.5	57.3	59.3	61.6
12x1	0.925	0.955	0.971	1.02	1.05	1.09	54.3	56.1	57.0	59.9	61.6	64.0
10x1 1/4	1.01	1.05	1.06	1.11	1.14	1.19	59.3	61.6	62.2	65.2	66.9	69.9
13x1	0.966	0.995	1.01	1.05	1.08	1.13	56.7	58.4	59.3	61.6	63.4	66.3
14x1	1.00	1.03	1.05	1.09	1.12	1.16	58.7	60.5	61.6	64.0	65.8	68.1
12x1 1/4	1.13	1.16	1.17	1.22	1.25	1.29	66.3	68.1	68.7	71.6	73.4	75.7
16x1	1.07	1.10	1.11	1.16	1.18	1.22	62.8	64.6	65.2	68.1	69.3	71.6
14x1 1/4	1.23	1.25	1.27	1.31	1.34	1.38	72.2	73.4	74.6	76.9	78.7	81.0
16x1 1/4	1.31	1.34	1.35	1.40	1.42	1.46	76.9	78.7	79.3	82.2	83.4	85.7
17.7x1 1/4	1.38	1.41	1.42	1.46	1.49	1.52	81.0	82.8	83.4	85.7	87.5	89.2

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter) (lb / ft / in)						Beam M/D Ratio (top of top flange excluded) (kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
	WT_30											
5x1/4	0.204	0.245	0.266	0.328	0.370	0.433	12.0	14.4	15.6	19.3	21.7	25.4
6x1/4	0.216	0.256	0.276	0.337	0.377	0.437	12.7	15.0	16.2	19.8	22.1	25.7
6x5/16	0.244	0.284	0.304	0.365	0.405	0.465	14.3	16.7	17.8	21.4	23.8	27.3
6x3/8	0.273	0.312	0.333	0.393	0.433	0.493	16.0	18.3	19.6	23.1	25.4	28.9
7x3/8	0.291	0.330	0.350	0.408	0.446	0.505	17.1	19.4	20.5	24.0	26.2	29.6
6x1/2	0.328	0.368	0.388	0.448	0.488	0.548	19.3	21.6	22.8	26.3	28.7	32.2
7x1/2	0.355	0.393	0.413	0.470	0.509	0.567	20.8	23.1	24.2	27.6	29.9	33.3
8x1/2	0.379	0.417	0.435	0.491	0.529	0.585	22.3	24.5	25.5	28.8	31.1	34.3
6x3/4	0.438	0.478	0.497	0.557	0.596	0.656	25.7	28.1	29.2	32.7	35.0	38.5
8x5/8	0.449	0.486	0.504	0.560	0.597	0.653	26.4	28.5	29.6	32.9	35.1	38.3
8x3/4	0.517	0.554	0.573	0.628	0.666	0.721	30.4	32.5	33.6	36.9	39.1	42.3
10x3/4	0.587	0.622	0.639	0.692	0.727	0.779	34.5	36.5	37.5	40.6	42.7	45.7
8x1	0.653	0.689	0.708	0.763	0.799	0.855	38.3	40.5	41.6	44.8	46.9	50.2
12x3/4	0.649	0.682	0.699	0.748	0.781	0.831	38.1	40.0	41.0	43.9	45.9	48.8
10x1	0.747	0.781	0.799	0.851	0.885	0.937	43.9	45.9	46.9	50.0	52.0	55.0
11x1	0.790	0.823	0.840	0.891	0.925	0.975	46.4	48.3	49.3	52.3	54.3	57.2
12x1	0.831	0.863	0.880	0.929	0.962	1.01	48.8	50.7	51.7	54.5	56.5	59.3
10x1 1/4	0.903	0.938	0.955	1.01	1.04	1.09	53.0	55.1	56.1	59.3	61.1	64.0
13x1	0.869	0.901	0.917	0.965	0.997	1.04	51.0	52.9	53.8	56.7	58.5	61.1
14x1	0.906	0.937	0.952	0.999	1.03	1.08	53.2	55.0	55.9	58.7	60.5	63.4
12x1 1/4	1.01	1.04	1.06	1.11	1.14	1.19	59.3	61.1	62.2	65.2	66.9	69.9
16x1	0.973	1.00	1.02	1.06	1.09	1.14	57.1	58.7	59.9	62.2	64.0	66.9
14x1 1/4	1.10	1.13	1.15	1.20	1.23	1.27	64.6	66.3	67.5	70.5	72.2	74.6
16x1 1/4	1.19	1.22	1.23	1.28	1.31	1.35	69.9	71.6	72.2	75.2	76.9	79.3
17.7x1 1/4	1.26	1.28	1.30	1.34	1.37	1.41	74.0	75.2	76.3	78.7	80.4	82.8

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter) (lb / ft / in)						Beam M/D Ratio (top of top flange excluded) (kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
	WT_36											
5x1/4	0.193	0.236	0.257	0.322	0.365	0.429	11.3	13.9	15.1	18.9	21.4	25.2
6x1/4	0.204	0.246	0.266	0.329	0.371	0.433	12.0	14.4	15.6	19.3	21.8	25.4
6x5/16	0.228	0.270	0.291	0.353	0.395	0.457	13.4	15.9	17.1	20.7	23.2	26.8
6x3/8	0.253	0.294	0.315	0.377	0.419	0.481	14.9	17.3	18.5	22.1	24.6	28.2
7x3/8	0.270	0.310	0.330	0.391	0.431	0.492	15.9	18.2	19.4	23.0	25.3	28.9
6x1/2	0.301	0.343	0.363	0.425	0.467	0.529	17.7	20.1	21.3	25.0	27.4	31.1
7x1/2	0.325	0.365	0.385	0.445	0.486	0.546	19.1	21.4	22.6	26.1	28.5	32.1
8x1/2	0.347	0.386	0.406	0.464	0.504	0.562	20.4	22.7	23.8	27.2	29.6	33.0
6x3/4	0.397	0.438	0.458	0.520	0.561	0.622	23.3	25.7	26.9	30.5	32.9	36.5
8x5/8	0.408	0.447	0.466	0.525	0.564	0.622	24.0	26.2	27.4	30.8	33.1	36.5
8x3/4	0.468	0.507	0.526	0.584	0.623	0.682	27.5	29.8	30.9	34.3	36.6	40.0
10x3/4	0.532	0.569	0.587	0.642	0.679	0.735	31.2	33.4	34.5	37.7	39.9	43.2
8x1	0.587	0.625	0.645	0.702	0.741	0.799	34.5	36.7	37.9	41.2	43.5	46.9
12x3/4	0.590	0.625	0.642	0.695	0.730	0.782	34.6	36.7	37.7	40.8	42.9	45.9
10x1	0.673	0.710	0.728	0.783	0.820	0.874	39.5	41.7	42.7	46.0	48.1	51.3
11x1	0.713	0.749	0.767	0.820	0.856	0.909	41.9	44.0	45.0	48.1	50.3	53.4
12x1	0.751	0.786	0.804	0.856	0.891	0.943	44.1	46.1	47.2	50.3	52.3	55.4
10x1 1/4	0.812	0.849	0.867	0.921	0.957	1.01	47.7	49.8	50.9	54.1	56.2	59.3
13x1	0.788	0.822	0.839	0.889	0.924	0.975	46.3	48.3	49.3	52.2	54.3	57.2
14x1	0.822	0.855	0.872	0.922	0.955	1.00	48.3	50.2	51.2	54.1	56.1	58.7
12x1 1/4	0.910	0.945	0.962	1.01	1.05	1.10	53.4	55.5	56.5	59.3	61.6	64.6
16x1	0.887	0.918	0.934	0.982	1.01	1.06	52.1	53.9	54.8	57.7	59.3	62.2
14x1 1/4	0.999	1.03	1.05	1.10	1.13	1.18	58.7	60.5	61.6	64.6	66.3	69.3
16x1 1/4	1.08	1.11	1.13	1.18	1.21	1.25	63.4	65.2	66.3	69.3	71.0	73.4
17.7x1 1/4	1.14	1.18	1.19	1.24	1.27	1.31	66.9	69.3	69.9	72.8	74.6	76.9

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter) (lb / ft / in)						Beam M/D Ratio (top of top flange excluded) (kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
	WT_40											
5x1/4	0.187	0.231	0.253	0.318	0.362	0.427	11.0	13.6	14.9	18.7	21.3	25.1
6x1/4	0.198	0.240	0.261	0.325	0.367	0.431	11.6	14.1	15.3	19.1	21.5	25.3
6x5/16	0.220	0.262	0.284	0.347	0.389	0.453	12.9	15.4	16.7	20.4	22.8	26.6
6x3/8	0.242	0.285	0.306	0.369	0.411	0.475	14.2	16.7	18.0	21.7	24.1	27.9
7x3/8	0.258	0.300	0.320	0.382	0.423	0.485	15.1	17.6	18.8	22.4	24.8	28.5
6x1/2	0.287	0.329	0.350	0.413	0.455	0.519	16.9	19.3	20.5	24.2	26.7	30.5
7x1/2	0.309	0.350	0.371	0.432	0.473	0.535	18.1	20.5	21.8	25.4	27.8	31.4
8x1/2	0.330	0.370	0.390	0.450	0.490	0.550	19.4	21.7	22.9	26.4	28.8	32.3
6x3/4	0.375	0.417	0.438	0.500	0.542	0.605	22.0	24.5	25.7	29.4	31.8	35.5
8x5/8	0.386	0.426	0.446	0.506	0.546	0.605	22.7	25.0	26.2	29.7	32.1	35.5
8x3/4	0.442	0.481	0.501	0.561	0.601	0.660	26.0	28.2	29.4	32.9	35.3	38.8
10x3/4	0.502	0.540	0.559	0.616	0.654	0.710	29.5	31.7	32.8	36.2	38.4	41.7
8x1	0.552	0.591	0.611	0.670	0.709	0.769	32.4	34.7	35.9	39.3	41.6	45.1
12x3/4	0.557	0.593	0.611	0.666	0.702	0.756	32.7	34.8	35.9	39.1	41.2	44.4
10x1	0.633	0.671	0.690	0.746	0.784	0.840	37.2	39.4	40.5	43.8	46.0	49.3
11x1	0.672	0.708	0.727	0.782	0.818	0.874	39.5	41.6	42.7	45.9	48.0	51.3
12x1	0.708	0.744	0.762	0.815	0.851	0.905	41.6	43.7	44.7	47.9	50.0	53.1
10x1 1/4	0.763	0.800	0.819	0.875	0.912	0.968	44.8	47.0	48.1	51.4	53.5	56.8
13x1	0.743	0.778	0.795	0.848	0.883	0.936	43.6	45.7	46.7	49.8	51.8	55.0
14x1	0.776	0.810	0.827	0.879	0.913	0.965	45.6	47.6	48.6	51.6	53.6	56.7
12x1 1/4	0.856	0.892	0.910	0.963	0.999	1.05	50.3	52.4	53.4	56.5	58.7	61.6
16x1	0.838	0.871	0.887	0.937	0.970	1.02	49.2	51.1	52.1	55.0	57.0	59.9
14x1 1/4	0.942	0.976	0.993	1.04	1.08	1.13	55.3	57.3	58.3	61.1	63.4	66.3
16x1 1/4	1.02	1.05	1.07	1.12	1.15	1.20	59.9	61.6	62.8	65.8	67.5	70.5
17.7x1 1/4	1.08	1.11	1.13	1.18	1.21	1.26	63.4	65.2	66.3	69.3	71.0	74.0

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter) (lb / ft / in)						Beam M/D Ratio (top of top flange excluded) (kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
	WT_48											
5x1/4	0.178	0.222	0.245	0.312	0.357	0.424	10.5	13.0	14.4	18.3	21.0	24.9
6x1/4	0.187	0.230	0.252	0.318	0.362	0.427	11.0	13.5	14.8	18.7	21.3	25.1
6x5/16	0.206	0.249	0.271	0.337	0.380	0.446	12.1	14.6	15.9	19.8	22.3	26.2
6x3/8	0.225	0.268	0.290	0.355	0.399	0.465	13.2	15.7	17.0	20.8	23.4	27.3
7x3/8	0.239	0.281	0.303	0.367	0.409	0.473	14.0	16.5	17.8	21.5	24.0	27.8
6x1/2	0.263	0.306	0.328	0.393	0.436	0.502	15.4	18.0	19.3	23.1	25.6	29.5
7x1/2	0.282	0.324	0.346	0.409	0.452	0.516	16.6	19.0	20.3	24.0	26.5	30.3
8x1/2	0.300	0.342	0.363	0.425	0.467	0.529	17.6	20.1	21.3	25.0	27.4	31.1
6x3/4	0.337	0.380	0.402	0.467	0.510	0.575	19.8	22.3	23.6	27.4	29.9	33.8
8x5/8	0.349	0.390	0.411	0.473	0.514	0.576	20.5	22.9	24.1	27.8	30.2	33.8
8x3/4	0.396	0.437	0.458	0.520	0.561	0.623	23.3	25.7	26.9	30.5	32.9	36.6
10x3/4	0.450	0.490	0.510	0.569	0.609	0.668	26.4	28.8	29.9	33.4	35.8	39.2
8x1	0.491	0.532	0.552	0.614	0.655	0.716	28.8	31.2	32.4	36.0	38.5	42.0
12x3/4	0.500	0.538	0.557	0.614	0.652	0.709	29.4	31.6	32.7	36.0	38.3	41.6
10x1	0.564	0.603	0.623	0.682	0.721	0.780	33.1	35.4	36.6	40.0	42.3	45.8
11x1	0.598	0.636	0.656	0.714	0.752	0.810	35.1	37.3	38.5	41.9	44.2	47.6
12x1	0.631	0.669	0.688	0.744	0.782	0.839	37.0	39.3	40.4	43.7	45.9	49.3
10x1 1/4	0.675	0.715	0.734	0.793	0.832	0.891	39.6	42.0	43.1	46.6	48.8	52.3
13x1	0.663	0.700	0.718	0.774	0.811	0.867	38.9	41.1	42.2	45.4	47.6	50.9
14x1	0.693	0.729	0.748	0.802	0.839	0.893	40.7	42.8	43.9	47.1	49.3	52.4
12x1 1/4	0.760	0.798	0.817	0.873	0.911	0.967	44.6	46.9	48.0	51.3	53.5	56.8
16x1	0.751	0.786	0.803	0.856	0.891	0.944	44.1	46.1	47.1	50.3	52.3	55.4
14x1 1/4	0.838	0.875	0.893	0.947	0.983	1.04	49.2	51.4	52.4	55.6	57.7	61.1
16x1 1/4	0.911	0.946	0.963	1.02	1.05	1.10	53.5	55.5	56.5	59.9	61.6	64.6
17.7x1 1/4	0.969	1.00	1.02	1.07	1.10	1.16	56.9	58.7	59.9	62.8	64.6	68.1

SIN Beam w/d and M/D ratio for Fire Proofing

Table 3.6

Designation	Beam w/d Ratio (top of top flange excluded in heated perimeter)						Beam M/D Ratio (top of top flange excluded)					
	(lb / ft / in)						(kg / m / m)					
	WTA	WTB	WTC	WTF	WTH	WTK	WTA	WTB	WTC	WTF	WTH	WTK
WT_60												
5x1/4	0.169	0.215	0.238	0.307	0.352	0.421	9.92	12.6	14.0	18.0	20.7	24.7
6x1/4	0.177	0.222	0.244	0.312	0.356	0.424	10.4	13.0	14.3	18.3	20.9	24.9
6x5/16	0.193	0.238	0.260	0.327	0.372	0.439	11.3	14.0	15.3	19.2	21.8	25.8
6x3/8	0.209	0.253	0.276	0.343	0.388	0.455	12.3	14.9	16.2	20.1	22.8	26.7
7x3/8	0.221	0.265	0.287	0.352	0.396	0.462	13.0	15.6	16.9	20.7	23.3	27.1
6x1/2	0.240	0.285	0.307	0.374	0.419	0.486	14.1	16.7	18.0	22.0	24.6	28.5
7x1/2	0.257	0.301	0.323	0.388	0.432	0.498	15.1	17.7	19.0	22.8	25.4	29.2
8x1/2	0.273	0.316	0.338	0.402	0.445	0.510	16.0	18.6	19.8	23.6	26.1	29.9
6x3/4	0.303	0.347	0.370	0.436	0.481	0.547	17.8	20.4	21.7	25.6	28.2	32.1
8x5/8	0.314	0.357	0.378	0.442	0.485	0.550	18.4	21.0	22.2	26.0	28.5	32.3
8x3/4	0.354	0.397	0.418	0.482	0.525	0.589	20.8	23.3	24.5	28.3	30.8	34.6
10x3/4	0.401	0.443	0.463	0.525	0.566	0.628	23.5	26.0	27.2	30.8	33.2	36.9
8x1	0.434	0.476	0.498	0.561	0.604	0.668	25.5	27.9	29.2	32.9	35.5	39.2
12x3/4	0.445	0.485	0.505	0.565	0.605	0.665	26.1	28.5	29.6	33.2	35.5	39.0
10x1	0.498	0.539	0.560	0.621	0.662	0.724	29.2	31.6	32.9	36.5	38.9	42.5
11x1	0.528	0.569	0.589	0.649	0.690	0.750	31.0	33.4	34.6	38.1	40.5	44.0
12x1	0.558	0.597	0.617	0.677	0.717	0.776	32.8	35.1	36.2	39.7	42.1	45.6
10x1 1/4	0.593	0.634	0.655	0.716	0.757	0.818	34.8	37.2	38.5	42.0	44.4	48.0
13x1	0.586	0.625	0.645	0.703	0.742	0.801	34.4	36.7	37.9	41.3	43.6	47.0
14x1	0.613	0.652	0.671	0.729	0.767	0.825	36.0	38.3	39.4	42.8	45.0	48.4
12x1 1/4	0.669	0.708	0.728	0.787	0.827	0.886	39.3	41.6	42.7	46.2	48.6	52.0
16x1	0.666	0.703	0.722	0.777	0.815	0.871	39.1	41.3	42.4	45.6	47.9	51.1
14x1 1/4	0.739	0.777	0.796	0.854	0.892	0.949	43.4	45.6	46.7	50.1	52.4	55.7
16x1 1/4	0.805	0.842	0.860	0.916	0.953	1.01	47.3	49.4	50.5	53.8	56.0	59.3
17.7x1 1/4	0.858	0.894	0.912	0.967	1.00	1.06	50.4	52.5	53.5	56.8	58.7	62.2

Notes:

Per current UL / ULC listings all SIN beam webs must have a minimum thickness of 0.120 in. (3.04 mm) which is a WTC or heavier, thinner webs are shown in grey italics

Per the BXUV Guide the minimum w/d ratio is 0.37, smaller values are shown in red

Per the BXUVC Guide the minimum M/D ratio is 23, smaller values are shown in red

4 SAMPLE DETAILS

Shear Connections

- SK-1.01 – Shear Connection Angle – No Axial Loads
- SK-1.02 – Shear Connection T Plate – No Axial Loads
- SK-1.03 – Shear Connection T Plate – With Axial Loads
- SK-1.04 – SIN Beam to SIN Beam Shear Connection

Moment Connections

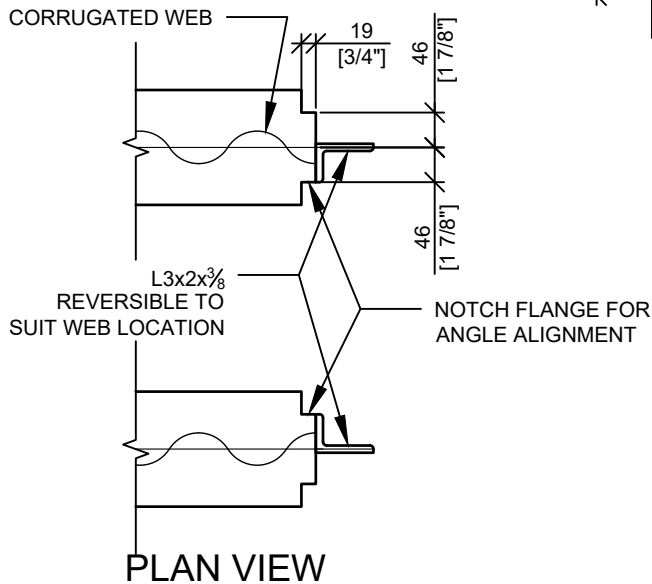
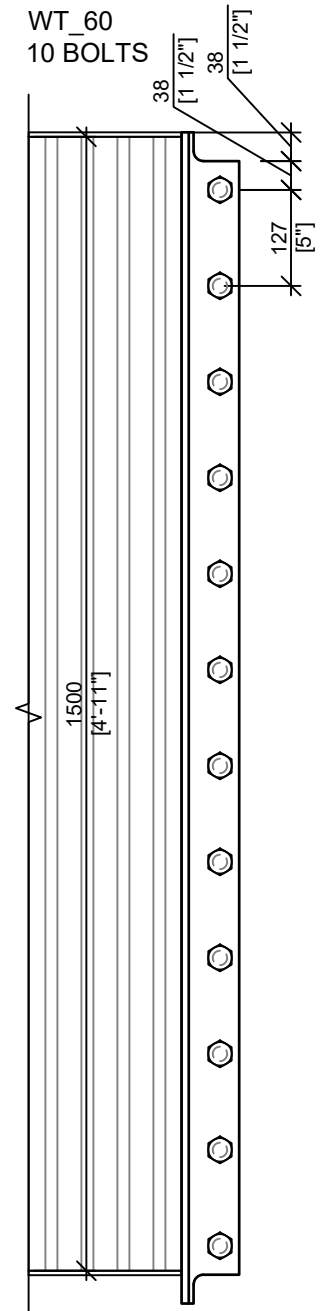
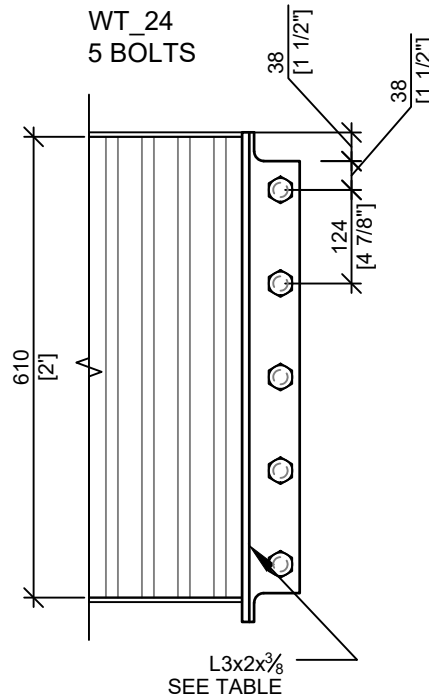
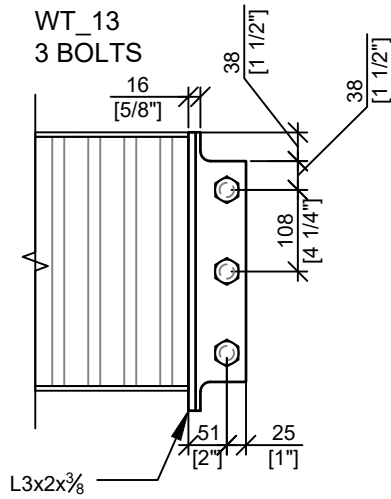
- SK-2.01 – SIN Beam to SIN Beam Moment Connection
- SK-2.02 – SIN Beam Splice

These pages are intended as sample / common SIN beam connection details only. For every project the connections must be designed and reviewed by a qualified engineer to suit the project specific requirements.

PROJECT: SIN BEAM
DATE: 2022-06-08

TITLE: SHEAR CONNECTION
ANGLE - NO AXIAL LOAD

SHEET: SK-1.01



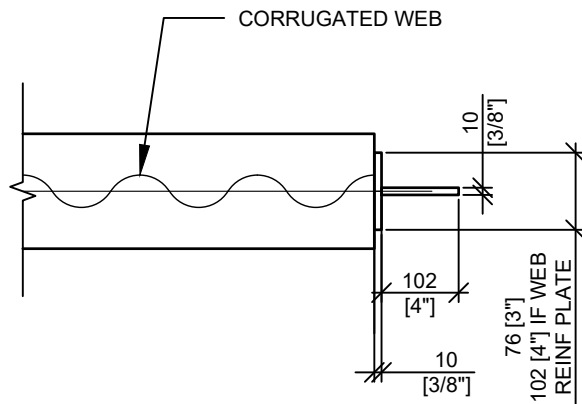
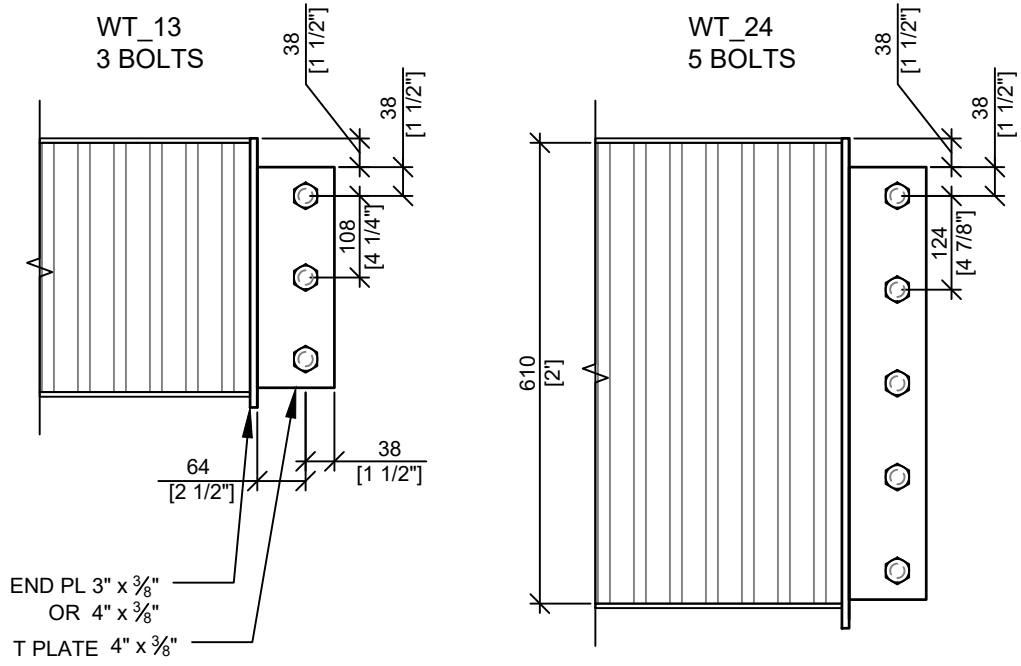
NUMBER OF BOLTS

SIN SIZE	WEB DEPTH		# BOLTS	BOLT SPACING	ANGLE LENGTH
	(mm)	(in)			
13	333	13.1	3	4 1/4"	1'-2 1/2"
20	500	19.7	4	5"	1'-9"
24	610	24.0	5	4 7/8"	2'-1 1/2"
30	750	29.5	6	5"	2'-7"
36	900	35.4	7	5 1/8"	3'-0 3/4"
40	1000	39.4	8	5"	3'-5"
48	1219	48.0	10	4 7/8"	4'-1 7/8"
60	1500	59.1	12	5"	5'-1"

PROJECT: SIN BEAM
DATE: 2022-06-08

TITLE: SHEAR CONNECTION
T PLATE - NO AXIAL LOAD

SHEET: SK-1.02

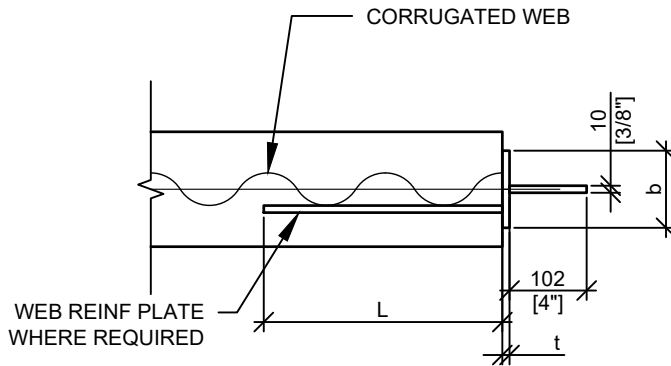
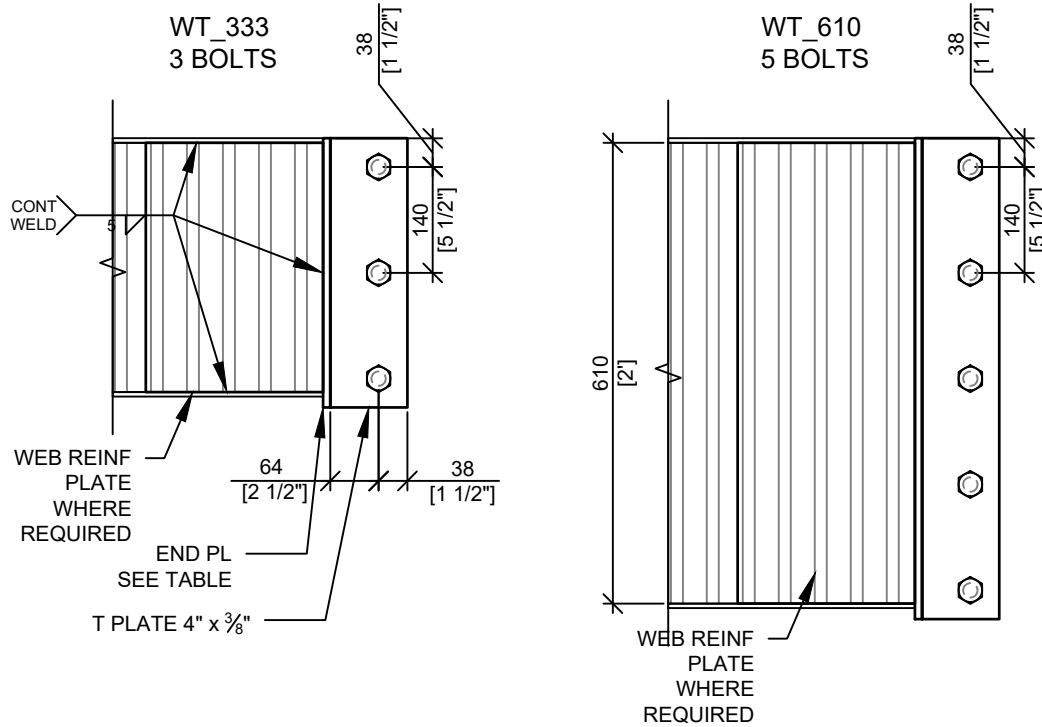


PLAN VIEW

PROJECT: SIN BEAM
DATE: 2022-06-08

TITLE: SHEAR CONNECTION
WITH SIN BEAM AXIAL LOAD

SHEET: SK-1.03



PLAN VIEW

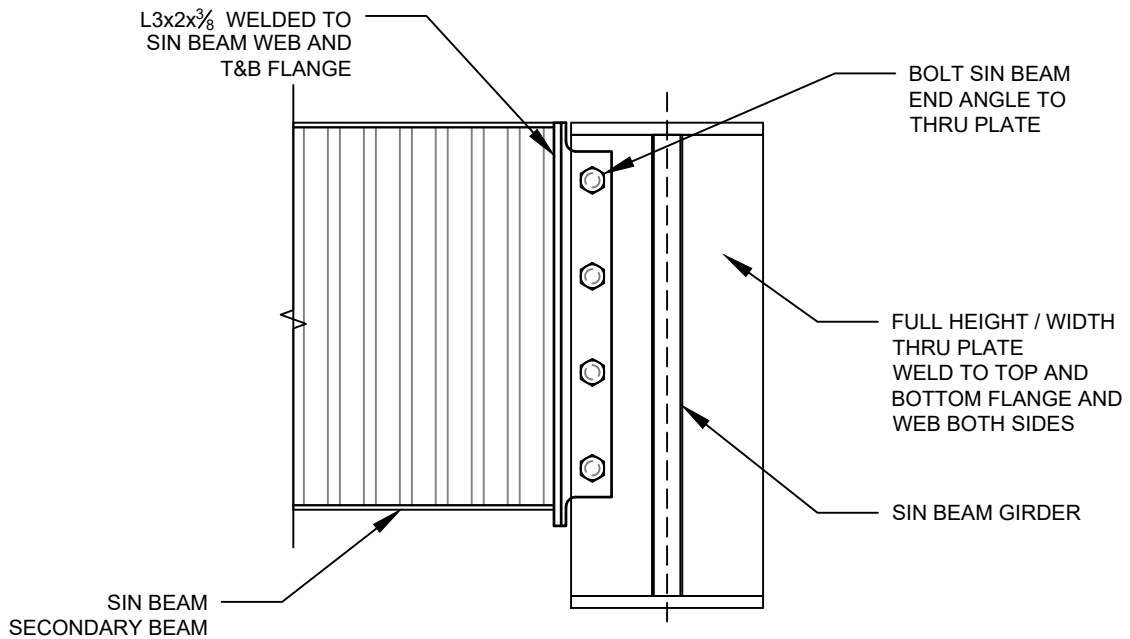
MIN NUMBER OF BOLTS			
SIN SIZE	SIN BEAM DEPTH		# BOLTS MINIMUM
	(mm)	(in)	
			19mm (3/4") Ø
13	333	13.1	3
20	500	19.7	4
24	610	24.0	5
30	750	29.5	6
36	900	35.4	7
40	1000	39.4	8
48	1219	48.0	10
60	1500	59.1	12

FD SHEAR / AXIAL CONNECTIONS			
	b (in)	t (in)	WEB REINF PLATE
FD1	3	3/8"	NO
FD2	4	3/8"	YES
FD3	4	1/2"	YES
FD4	4	5/8"	YES

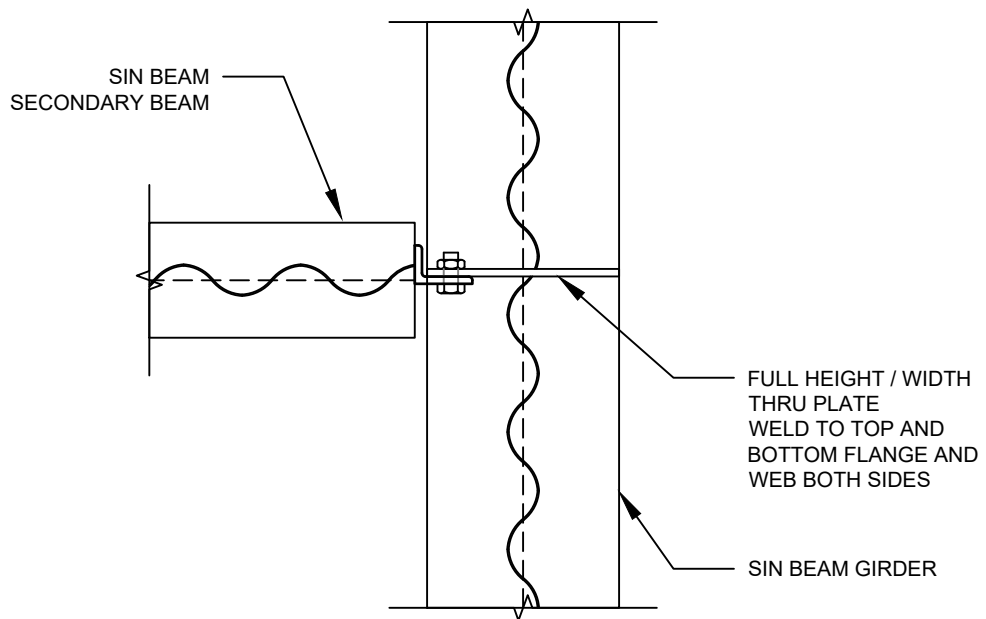
PROJECT: SIN BEAM
DATE: 2022-06-08

TITLE: SIN BEAM TO SIN BEAM SHEAR CONNECTION

SHEET: SK-1.04



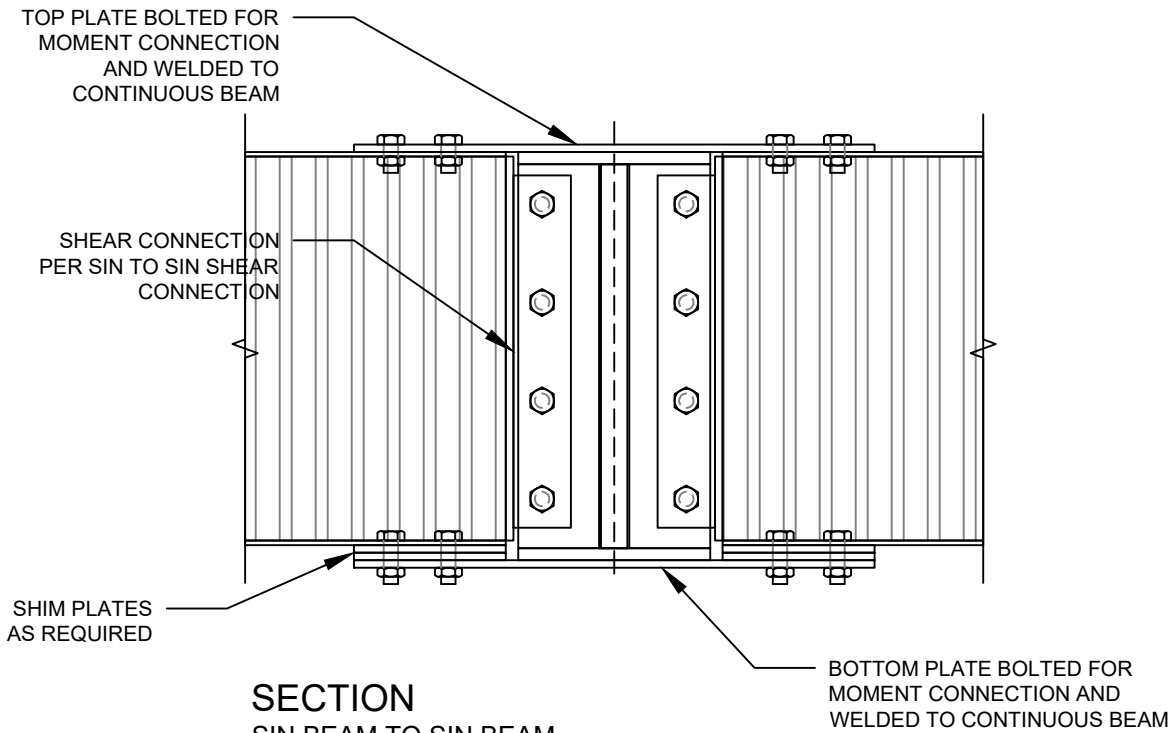
SECTION
SIN BEAM TO SIN BEAM SHEAR CONNECTION



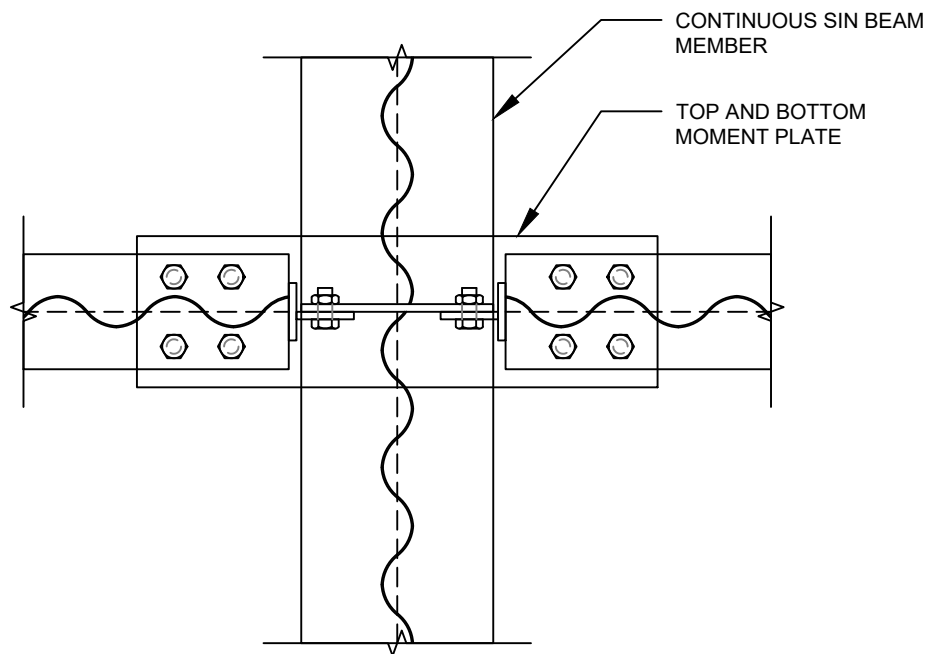
PLAN
SIN BEAM TO SIN BEAM SHEAR CONNECTION

FOR NUMBER OF BOLTS REFER TO SIN BEAM TO HSS COLUMN BOLTING TABLE USING THE DEPTH OF THE SECONDARY BEAM

PROJECT: SIN BEAM TITLE: SIN BEAM TO SIN BEAM MOMENT CONNECTION SHEET: SK-2.01
 DATE: 2022-06-08



SECTION
SIN BEAM TO SIN BEAM
MOMENT CONNECTION



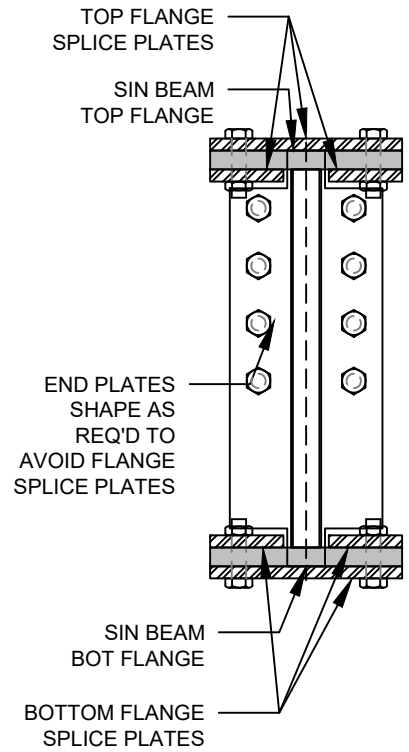
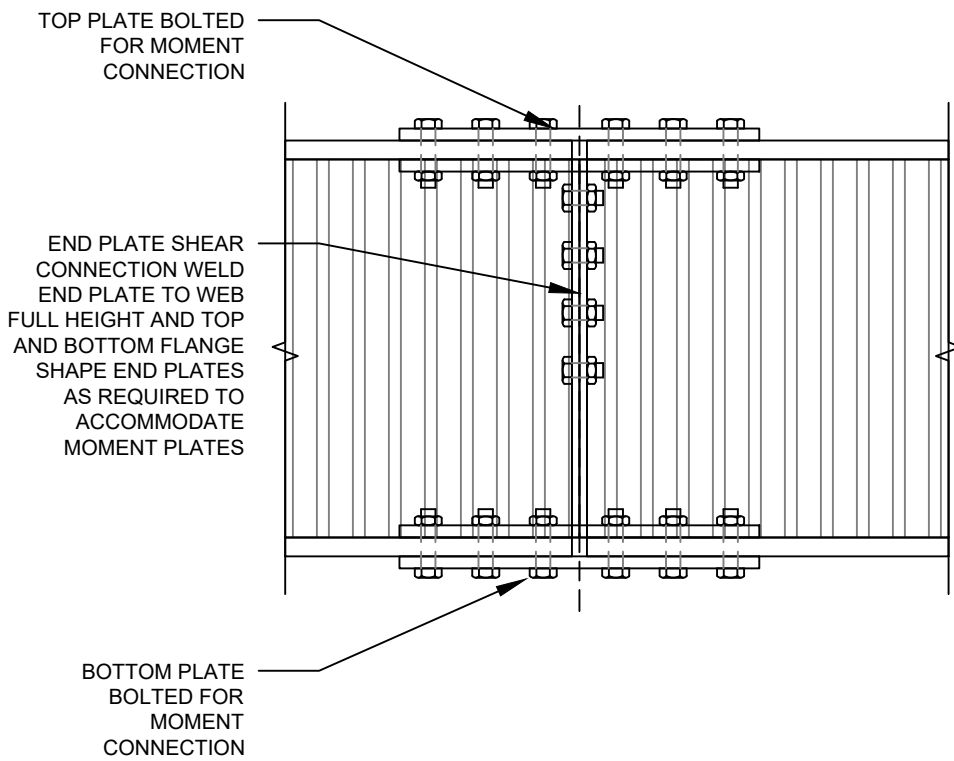
PLAN
SIN BEAM TO SIN BEAM
MOMENT CONNECTION

SIN BEAM MEMBERS SHOULD HAVE SAME WEB DEPTH, SHIM PLATES REQUIRED TO MAKE UP DIFFERENCE IN FLANGE THICKNESS

PROJECT: SIN BEAM
DATE: 2022-06-08

TITLE: SIN BEAM SPLICE DETAIL

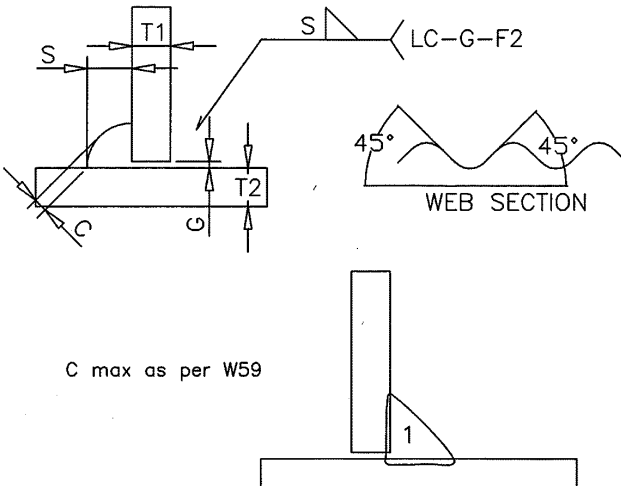

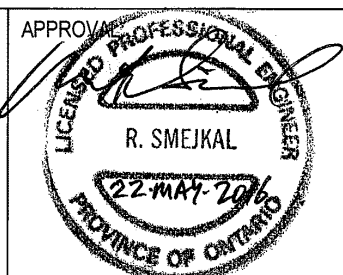
SHEET: SK-2.02



BEAM SPLICE
SIN BEAM SPLICE MOMENT CONNECTION

5 REFERENCES / CERTIFICATION

- 5.1 CWB Certification for Steelcon – SIN Beam Welding
- 5.2 European Code 1993-1-5:2005 Annex D Plate Girders with Corrugated Webs
- 5.3 Annex D – Commentary
- 5.4 Shear Load Testing Results - Professor R.M. Schuster – Dec 2021

STEELCON FABRICATION INC. 62 Progress Court Brampton, Ontario						DATE: August 18, 2015					
						Data Sheet No: LC-G-F2					
						WPS No: LC-GMAW					
						PQR #: 61AG1605021314					
						Date Qualified: May 2, 2016					
						Applicable Standards: CSA W47.1, W59 / AWS D1.3					
Base Material Designation AWS D1.3 – Table 1.2 Group I and II to CSA W59* Table 11-1 Group 1, 2, 3 CSA G40.21 44W, 50W						Filler Metal / Classification ISO 14341 / B-G 49A 3 C G6					
Process: GMAW automatic robot			Joint Details 								
Joint: FILLET tee											
Penetration: N / A											
Position: 2F to 45° SLOPE UP AND DOWN											
Root Opening: G = 0											
Effective Throat Thickness: ETT = 0.7 S											
Single or Multi-pass: SINGLE PASS											
Backing Material: NONE											
Root Prep. Sec. Side: N / A											
Peening: NONE											
Bead: STRINGER											
Shielding Gas/Flux: 85%Ar + 15%CO ₂											
Nozzle Size: 16 mm											
Gas Flow: 15 l / min – 35 CFH											
Transfer Mode: GLOBULAR / SPRAY											
Electrode Stickout: 16 to 20 mm											
Cleaning: BRUSHING / GRINDING											
Interpass Cleaning: N / A											
Preheating / Interpass Temp.: 10°C Min.											
Interpass Temperature max.: 250°C max											
Postweld Heat Treatment Temp.: NONE											
Time:											
WELD SIZE S mm inch		Web Ga.	Position	LAYER	PASS	EL. SIZE mm	CURRENT POLARITY	AMPS	WIRE SPEED m / min	VOLTS	ARC TRAVEL cm / min
3.7 0.150		14	2F	1	1	1.0	DCEP	110	8.0-8.2	19.0	55-59
			45° UP	1	1	1.0		100	4.7-4.8	19.0	55-59
			45° DOWN	1	1	1.0		185	8.8-9.0	19.0	55-59
4 5/32		12-11	2F	1	1	1.0		120	8.3-8.5	20.0	52-56
			45° UP	1	1	1.0		110	5.0-5.2	20.0	52-56
			45° DOWN	1	1	1.0		195	9.1-9.3	20.0	52-56
NOTES: Procedure for robot producing SIN beams; welded beam with thin gauge web formed to sinusoidal wave shape with max slope 45° Feeder varies parameters automatically for horizontal, uphill or downhill welding. Flange thickness range 6 – 32mm; *Any combination of equivalent AWS or ASTM steels is permitted.											
NOTES: 22-March-2016 revised; previous limit on material thickness not applicable to product. Procedure requires to join gauge webs to plate flanges. 29-March-2016 revised; remove 16ga. web material. Change in shielding gas. 22-May-2016 modified as per PQR# 61AG1605021314						SIGNED		 On the basis of PROCEDURE QUALIFICATION		APPROVAL 	
						NAME					
						TITLE					
						DATE					
12g-f2F-01											

prEN 1993-1-5 : 2005 (E)

Annex D [informative] – Plate girders with corrugated webs

D.1 General

(1) Annex D covers design rules for I-girders with trapezoidally or sinusoidally corrugated webs, see Figure D.1.

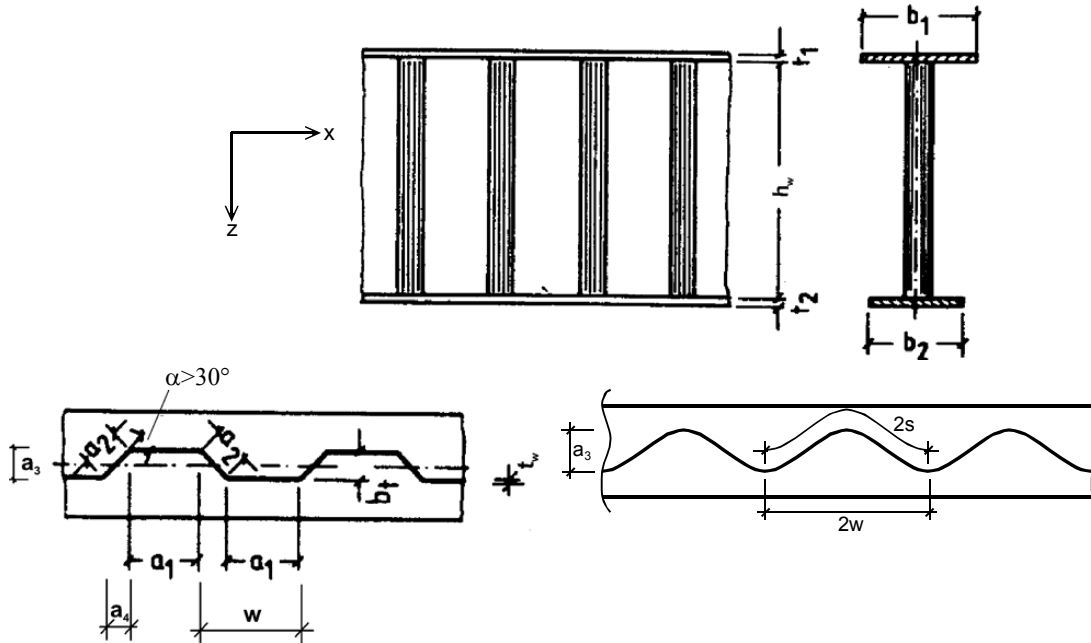


Figure D.1: Geometric notations

D.2 Ultimate limit state

D.2.1 Moment of resistance

(1) The moment of resistance M_{Rd} due to bending should be taken as the minimum of the following:

$$M_{Rd} = \min \left\{ \underbrace{\frac{b_2 t_2 f_{yw,r}}{\gamma_{M0}} \left(h_w + \frac{t_1 + t_2}{2} \right)}_{\text{tension flange}}, \underbrace{\frac{b_1 t_1 f_{yw,r}}{\gamma_{M0}} \left(h_w + \frac{t_1 + t_2}{2} \right)}_{\text{compression flange}}, \underbrace{\frac{b_1 t_1 \chi f_{yw}}{\gamma_{M1}} \left(h_w + \frac{t_1 + t_2}{2} \right)}_{\text{compression flange}} \right\} \quad (D.1)$$

where $f_{yw,r}$ is the value of yield stress reduced due to transverse moments in the flanges

$$f_{yw,r} = f_{yw} f_T$$

$$f_T = 1 - 0,4 \sqrt{\frac{\sigma_x(M_z)}{f_{yf}}} \sqrt{\frac{1}{\gamma_{M0}}}$$

$\sigma_x(M_z)$ is the stress due to the transverse moment in the flange

χ is the reduction factor for out of plane buckling according to 6.3 of EN 1993-1-1

NOTE 1 The transverse moment M_z results from the shear flow in flanges as indicated in Figure D.2.

NOTE 2 For sinusoidally corrugated webs f_T is 1,0.

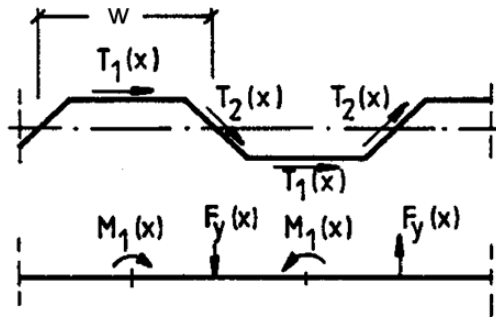


Figure D.2: Transverse moments M_z due to shear flow introduction into the flange

(2) The effective area of the compression flange should be determined from 4.4(1) and (2) using the larger value of the slenderness parameter $\bar{\lambda}_p$ defined in 4.4(2) and the buckling factor k_σ taken as:

$$a) \quad k_\sigma = 0,43 + \left(\frac{b}{a}\right)^2 \quad (D.2)$$

where b is the maximum width of the outstand from the toe of the weld to the free edge

$$a = a_1 + 2a_4$$

$$b) \quad k_\sigma = 0,60 \quad (D.3)$$

where $b = \frac{b_1}{2}$

D.2.2 Shear resistance

(1) The shear resistance V_{Rd} should be taken as:

$$V_{Rd} = \chi_c \frac{f_{yw}}{\gamma_{M1} \sqrt{3}} h_w t_w \quad (D.4)$$

where χ_c is the lesser of the values of reduction factors for local buckling $\chi_{c,\ell}$ and global buckling $\chi_{c,g}$ obtained from (2) and (3)

(2) The reduction factor $\chi_{c,\ell}$ for local buckling should be calculated from:

$$\chi_{c,\ell} = \frac{1,15}{0,9 + \bar{\lambda}_{c,\ell}} \leq 1,0 \quad (D.5)$$

where $\bar{\lambda}_{c,\ell} = \sqrt{\frac{f_y}{\tau_{cr,\ell} \sqrt{3}}}$ (D.6)

$$\tau_{cr,\ell} = 4,83 E \left[\frac{t_w}{a_{\max}} \right]^2 \quad (D.7)$$

a_{\max} should be taken as the greater of a_1 and a_2 .

prEN 1993-1-5 : 2005 (E)

For sinusoidally corrugated webs $\tau_{cr,t}$ may be obtained from

$$\tau_{cr,t} = \left(5,34 + \frac{a_3 s}{h_w t_w} \right) \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{t_w}{s} \right)^2 \quad (D.8)$$

where w length of one half wave, see Figure D.1,

s unfolded length of one half wave, see Figure D.1.

(3) The reduction factor $\chi_{c,g}$ for global buckling should be taken as

$$\chi_{c,g} = \frac{1,5}{0,5 + \bar{\lambda}_{c,g}^2} \leq 1,0 \quad (D.9)$$

where $\bar{\lambda}_{c,g} = \sqrt{\frac{f_y}{\tau_{cr,g} \sqrt{3}}}$ (D.10)

$$\tau_{cr,g} = \frac{32,4}{t_w h_w^2} \sqrt[4]{D_x D_z^3} \quad (D.11)$$

$$D_x = \frac{E t^3}{12(1-\nu^2)} \frac{w}{s}$$

$$D_z = \frac{E I_z}{w}$$

I_z second moment of area of one corrugation of length w , see Figure D.1

NOTE 1 s and I_z are related to the actual shape of the corrugation.

NOTE 2 Equation (D.11) is valid for plates that are assumed to be hinged at the edges.

D.2.3 Requirements for end stiffeners

(1) Bearing stiffeners should be designed according to section 9.

13 Annex D to EN 1993-1-5 – Plate girders with corrugated webs

Bernt Johansson, Division of Steel Structures, Luleå University of Technology

13.1 Background

This section will give background and justification of the design rules for girders with corrugated webs. The rules have been developed during the drafting of EN 1993-1-5 and the background has not been published. For this reason this section will be quite detailed giving the reasoning behind the choice of design rules for shear resistance.

Girders with corrugated webs are marketed as a product from specialised fabricators or as one-off structures. One example of the former is Ranabalken, which has been on the Swedish market for about 40 years [1]. Its main use is as roof girder. It has a web geometry that is fixed because of the production restraints. A vertical section through the web is shown in Figure 13.1. The thickness of the web is minimum 2 mm, which is governed by the welding procedure. The welding is single sided, which is important for the competitiveness. The maximum depth is 3 m.

In Austria the company Zeman & Co is producing similar beams named Sin-beam but with sinusoidally corrugated webs with the web geometry also shown in Figure 13.1. The web depth is limited to 1500 mm and the web thickness is from 2 to 3 mm. The web has single sided welds.

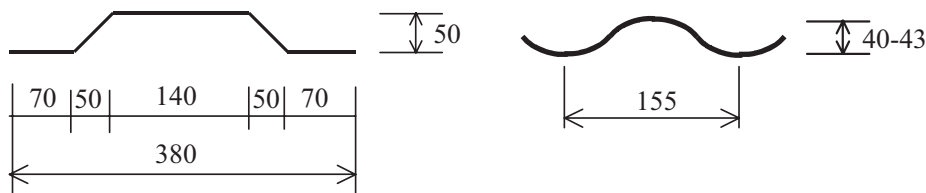


Figure 13.1: Geometry of web plate of Ranabalken, Sweden and Sin-beam, Austria

Corrugated webs have been used for bridges in several countries, including France, Germany and Japan. In France at least three composite bridges have been built of which one was doubly composite with box section. The corrugated steel web was provided with very small flanges, just enough for fixing the shear connectors. The concrete slabs were post-tensioned and when it is important that the steel flanges do not offer too much resistance to the imposed strains. A similar but larger bridge has been built at Altwipfergrund in Germany. It is a three span bridge built by cantilevering with a central span of 115 m and the depth varies from 2,8 m in the span to 6 m at the intermediate supports. The use of single sided welds is not recommended for bridges as it would cause problems with the corrosion protection and the fatigue resistance is not documented.

13.2 Bending moment resistance

As the web is corrugated it has no ability to sustain longitudinal stresses. The conventional assumption is to ignore its contribution to the bending moment resistance. This is the basis for the rules in D.2.1. For a simply supported girder supporting a uniformly distributed load the bending resistance is simply the smallest axial resistances of the flanges times the distance between the centroids of the flanges. This axial resistance may be influenced by lateral torsional buckling if the compression flange is not braced closely enough. Reference is given to the rules in 6.3 of EN 1993-1-1. There may be a positive influence of the corrugated web on the lateral buckling resistance compared to a flat web as the corrugation gives the web a substantial transverse bending stiffness. This should reduce the influence of cross sectional distortion but this influence has not been studied in detail and there is no basis for giving rules. There is also an increase in warping stiffness that may be utilized.

EN 1993-1-5,
D.2.1

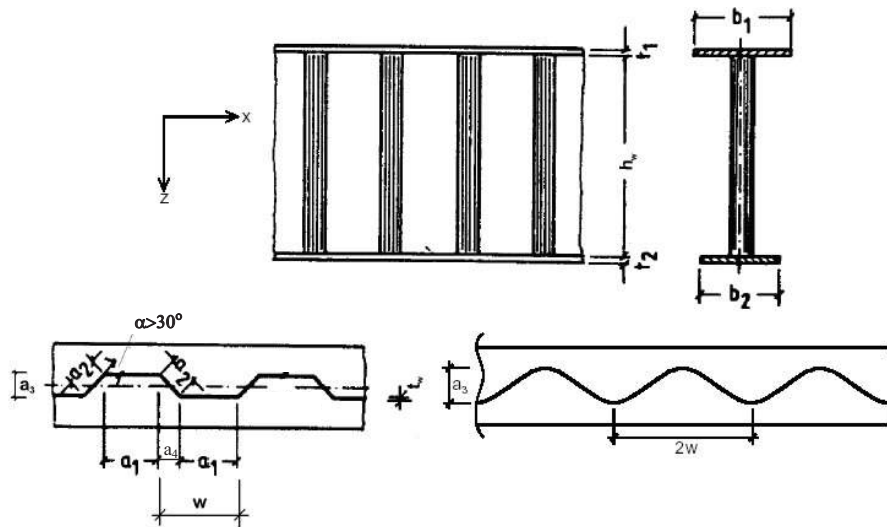


Figure 13.2: Geometry and notations for girders with corrugated webs

If there is a substantial shear force in the cross section of maximum bending moment there may be an influence of the flange axial resistance from lateral bending. Rules for this have been included in the German design rules [2]. A model for calculating these secondary bending moments is shown in Figure 13.3. The shear flow in the web will be constant V/h_w and its effect can be modelled as shown in the lower part of Figure 13.3. The maximum transverse bending moment $M_{z,max}$ occurs where the inclined part of the web intersects the centreline of the flange. It becomes:

$$M_{z,max} = \frac{Va_3}{4h_w}(2a_1 + a_4) \quad (13.1)$$

where V is the coexisting shear force and other notations are according to Figure 13.2.

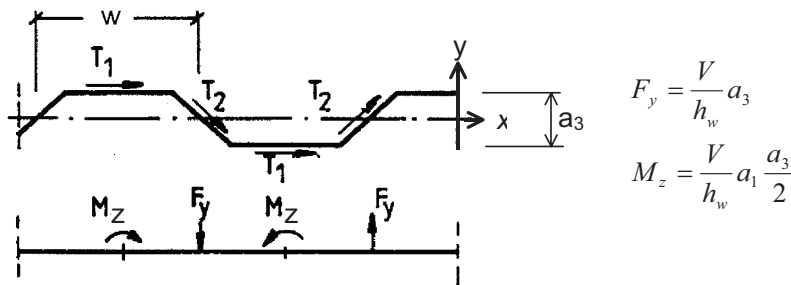


Figure 13.3: Action model for calculating secondary lateral bending moments in a flange caused by a corrugated web

In [2] the reduction of the bending resistance is expressed by the factor:

$$f_T = 1 - 0,4 \sqrt{\frac{6M_{z,max} \gamma_{M0}}{f_{yf} b_f^2 t_f}} \quad (13.2)$$

This reduction is not large and actually it has not been considered in the Austrian and Swedish design rules. From a theoretical point of view these bending moments are required for reasons of equilibrium. However, it is questionable how important they actually are in real life. They have been included just as a precaution but for sinusoidally corrugated webs the factor is put to 1,0.

In case yielding of the flange governs the bending resistance becomes:

$$M_{Rd} = \frac{f_{yf} f_T b_f t_f}{\gamma_{M0}} \left(h_w + \frac{t_1 + t_2}{2} \right) \quad (13.3)$$

where b_{fT} should be taken as the smaller of $b_1 t_1$ and $b_2 t_2$.

Local flange buckling is of importance for the bending resistance. It will obviously be influenced by the geometry of the web. The question is to define the flange outstand c to be used for calculating the slenderness. There is little information on this question in the literature. One of few published studies is by Johnson & Cafolla [3] who suggested that the average outstand could be used if:

$$\frac{(a_1 + a_4) a_3}{(a_1 + 2a_4) b_1} < 0,14 \quad (13.4)$$

where b_1 is the width of the compression flange and other notations are according to Figure 13.2. It is not stated what to do if this criterion is not fulfilled but presumably the idea is to use the larger outstand. The average outstand was defined as the average of the smaller and the larger outstand each calculated from free edge to the toe of the weld.

EN 1993-1-5,
D.2.1(2)

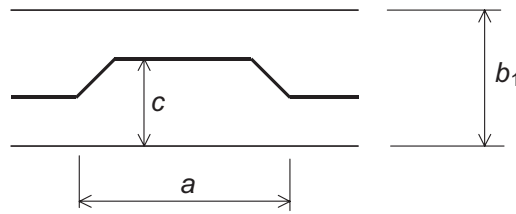


Figure 13.4: Notations for flange geometry

The design rules for Ranabalken states that the outstand should be taken as half the flange width minus 30 mm. This is actually smaller than the smallest outstand, which seems quite optimistic. The corresponding rule for the Sin-beam is half the flange width minus 11 mm.

The flange buckling may in general take place in two different modes. One possibility is a plate type buckling of the larger outstand and another is a torsional buckling where the flange rotates around the centreline of the web. General rules without restrictions on the geometry have to consider both possibilities. The first mode may be relevant for a long corrugation in combination with a narrow flange for which the larger outstand will govern the buckling. However, the flange will be supported by the inclined parts of the web. Assuming an equivalent rectangular plate supported along three edges a safe approximation of the relevant length should be $a = a_1 + 2a_4$, see Figure 13.2 and Figure 13.4. The buckling coefficient of such a plate assuming conservatively a hinged support along the web is approximately [4]:

$$k_{\sigma} = 0,43 + (c/a)^2 \quad (13.5)$$

with:

c = largest outstand from weld to free edge

$a = a_1 + 2a_4$

For a geometry with small corrugations compared to the flange width the flange will buckle in a mode of rotation around the centreline of the web. Then c is taken to $0,5b$. A corrugated web will however give a stronger restraint than a flat web. The buckling coefficient ranges from 0,43 for simple support to 1,3 for fixed. A solution for elastic rotational restraint is given in [4] but it is not easy to use. A simplification in form of a reasonably conservative value is instead suggested, which is also used in [2]:

$$k_{\sigma} = 0,60 \quad (13.6)$$

The rules for flange buckling in 4.4 (1) and (2) of EN 1993-1-5 are used with the buckling coefficients given above together with the relevant outstand c . In general, both (13.5) and (13.6) have to be checked and the most unfavourable case governs.

13.3 Shear resistance

EN 1993-1-5,
D.2.2

13.3.1 Introduction

The shear resistance of corrugated webs has attracted interest from many researchers. Accordingly, there are several proposals for the shear resistance e. g. Leiva [5], Lindner [6], Höglund [7] and Johnson & Cafolla [8]. These will be compared with 70 test results presented in Table 13.1. The formulae for the shear resistance actually used in EN 1993-1-5 were developed during the evaluation. This work was done in close co-operation with Professor Torsten Höglund of the Royal Institute of Technology, Stockholm. He was in charge of the corresponding rules in EN 1999-1-1, which are now harmonized with EN 1993-1-5.

Notations for the corrugated web are shown in Figure 13.2. For the sinusoidally corrugated web the measures a_3 and $2w$ are relevant and the developed length of one full wave is denoted $2s$. For the trapezoidal web the following relations and definitions apply.

$$a_2 = a_3 / \sin \alpha$$

$$a_4 = a_3 \cot \alpha$$

$$w = a_1 + a_4$$

$$s = a_1 + a_2$$

t_w = thickness of web

h_w = depth of web

$$a_{\max} = \max(a_1, a_2)$$

There are two shear buckling modes; one local governed by the largest flat panel and one global involving one or more corrugations. The critical stress for local buckling is taken as that for a long plate, which can be written as:

$$\tau_{cr,l} = 4,83 E \left[\frac{t_w}{a_{\max}} \right]^2 \quad (13.7)$$

For a sinusoidally corrugated web the local buckling is less likely to occur. A formula for critical shear stress for local buckling of webs with dimension as given in Figure 13.1 can be found in [19] and reads:

$$\tau_{cr,l} = \left(5,34 + \frac{a_3 s}{h_w t_w} \right) \frac{\pi^2 E}{12(1-\nu^2)} \left(\frac{t_w}{s} \right)^2 \quad (13.8)$$

This formula was developed for the type of corrugation used in an Austrian girder but it has turned out that the formula is not general enough and the formula may give large errors if the dimensions are different to those given in Figure 13.1. For this reason sinusoidally corrugated webs have to be designed by testing with regard to local shear buckling where dimensions other than those given in Figure 13.1 are used. There is also a possibility to calculate the critical shear stresses for local buckling with FEM and to use it in the design rules given here.

The critical stress for global buckling is given by [9]:

$$\tau_{cr,g} = \frac{32,4}{t_w h_w^2} \sqrt[4]{D_x D_z^3} \quad (13.9)$$

where:

$$D_x = \frac{Et_w^3}{12(1-\nu^2)} \frac{w}{s} = \frac{Et_w^3}{12(1-\nu^2)} \frac{a_1 + a_4}{a_1 + a_2} \quad (13.10)$$

$$D_z = \frac{EI_z}{w} = \frac{Et_w a_3^2}{12} \frac{3a_1 + a_2}{a_1 + a_4} \quad (13.11)$$

The first versions of the formulae (13.10) and (13.11) are relevant for sinusoidally corrugated webs where I_z is the second moment of area of one half wave. The second versions are relevant for trapezoidally corrugated webs.

Both critical stresses are valid for simply supported long plates. The global buckling stress is derived from orthotropic plate theory, see e. g. [9]. Some authors have defined D_x without the factor $(1-\nu^2)$ in the denominator. It is theoretically more correct to include it as in (13.10). In [9] there is also a solution for restrained rotation along the edge. For fully clamped edges the coefficient 32,4 in (13.9) increases to 60,4. This has been used for evaluating tests e. g. in [5] but it is hard to believe that this corresponds to the actual conditions at tests. The flanges are not likely to be rigid enough to provide a rotational restraint for such a stiff plate as a corrugated web. In this evaluation (13.9) will be used throughout.

Table 13.1: Data for test girders and test results (The shading shows the governing model and V_{R1} and V_{R2} are according to the EN 1993-1-5 as described in 13.3.6)

Test No	original	ref ⁹	h_w mm	t_w mm	f_{yw} MPa	α	a_1 mm	a_3 mm	V_u kN	χ_u	λ_1	λ_2	V_d/V_{R1}	V_d/V_{R2}
0	L1A	5	994	1,94	292	45	140	48	280	0,860	0,931	0,558	1,370	0,860
1	L1B	5	994	2,59	335	45	140	48	502	1,007	0,747	0,556	1,442	1,007
2	L2A	5	1445	1,94	282	45	140	50	337	0,737	0,915	0,774	1,164	0,737
3	L2B	5	1445	2,54	317	45	140	50	564	0,839	0,741	0,768	1,197	0,839
4	L3A	5	2005	2,01	280	45	140	48	450	0,690	0,880	1,092	1,068	0,778
5	L3B	5	2005	2,53	300	45	140	48	775	0,881	0,724	1,067	1,244	0,962
6	B1	10	600	2,1	341	45	140	50	208	0,837	0,929	0,347	1,332	0,837
7	B2	10	600	2,62	315	45	140	50	273	0,954	0,716	0,315	1,340	0,954
8	B3	10	600	2,62	317	45	140	50	246	0,854	0,718	0,316	1,202	0,854
9	B4b	10	600	2,11	364	45	140	50	217	0,815	0,956	0,358	1,315	0,815
10	M101	10	600	0,99	189	45	70	15	53	0,817	0,734	0,750	1,160	0,817
11	M102	10	800	0,99	190	45	70	15	79	0,908	0,736	1,003	1,292	0,912
12	M103	10	1000	0,95	213	45	70	15	84	0,718	0,812	1,342	1,069	1,101
13	M104	10	1200	0,99	189	45	70	15	101	0,778	0,734	1,501	1,106	1,428
14	L1	11	1000	2,1	410	30	106	50	380	0,764	0,772	0,616	1,110	0,764
15	L1	11	1000	3	450	30	106	50	610	0,782	0,566	0,590	0,996	0,782
16	L2	11	1498	2	376	30	106	50	600	0,921	0,776	0,894	1,343	0,921
17	L2	11	1498	3	402	30	106	50	905	0,867	0,535	0,836	1,081	0,867
18	1	12	850	2	355	33	102	56	275	0,788	0,731	0,459	1,118	0,788
19	2	12	850	2	349	38	91	56	265	0,773	0,642	0,466	1,036	0,773

⁹ ref = bibliographical reference where the test results can be found

Test No	original	ref ⁹	h_w mm	t_w mm	f_{yw} MPa	α	a_1 mm	a_3 mm	V_u kN	χ_u	λ_1	λ_2	V_u/V_{R1}	V_u/V_{R2}
20	V1/1	13	298	2,05	298	45	144	102	68	0,646	0,917	0,099	1,021	0,646
21	V1/2	13	298	2,1	283	45	144	102	70	0,684	0,872	0,096	1,054	0,684
22	V1/3	13	298	2	298	45	144	102	81	0,789	0,940	0,100	1,262	0,789
23	V2/3	13	600	3	279	45	144	102	235	0,810	0,606	0,175	1,060	0,810
24	CW3	8	440	3,26	284	45	250	45	171	0,726	0,976	0,218	1,184	0,726
25	CW4	8	440	2,97	222	45	250	45	154	0,918	0,947	0,198	1,475	0,918
26	CW5	8	440	2,97	222	45	250	63	141	0,841	0,947	0,156	1,350	0,841
27	I/5	14	1270	2	331	62	171	24	260	0,535	1,223	1,483	0,987	0,963
28	II/11	14	1270	2	225	62	171	24	220	0,666	0,974	1,267	1,085	0,935
29	121216A	15	305	0,64	676	45	38	25	50	0,656	1,165	0,583	1,177	0,656
30	121221A	15	305	0,63	665	55	42	33	46	0,623	1,298	0,501	1,190	0,623
31	121221B	15	305	0,78	665	55	42	33	73	0,798	1,048	0,475	1,352	0,798
32	121232A	15	305	0,64	665	63	50	51	41	0,546	1,741	0,391	1,255	0,546
33	121232B	15	305	0,78	641	63	50	51	61	0,692	1,403	0,365	1,386	0,692
34	121809A	15	305	0,71	572	50	20	14	63	0,880	0,509	0,829	1,078	0,880
35	121809C	15	305	0,63	669	50	20	14	55	0,740	0,620	0,924	0,978	0,740
36	121832B	15	305	0,92	562	63	50	51	53	0,581	1,113	0,328	1,018	0,581
37	122409A	15	305	0,71	586	50	20	14	58	0,791	0,515	0,839	0,973	0,791
38	122409C	15	305	0,66	621	50	20	14	58	0,803	0,570	0,880	1,026	0,803
39	122421A	15	305	0,68	621	55	42	33	43	0,578	1,162	0,475	1,036	0,578
40	122421B	15	305	0,78	638	55	42	33	61	0,695	1,027	0,466	1,165	0,695
41	122432B	15	305	0,78	634	63	50	51	49	0,562	1,395	0,363	1,122	0,562
42	181209A	15	457	0,56	689	50	20	14	81	0,795	0,708	1,446	1,111	1,373
43	181209C	15	457	0,61	592	50	20	14	89	0,933	0,602	1,312	1,219	1,382
44	181216C	15	457	0,76	679	45	38	25	119	0,873	0,984	0,839	1,430	0,873
45	181221A	15	457	0,61	578	55	42	33	62	0,666	1,250	0,706	1,244	0,666
46	181221B	15	457	0,76	606	55	42	33	98	0,806	1,027	0,684	1,350	0,806
47	181232A	15	457	0,6	552	63	50	51	52	0,594	1,692	0,542	1,340	0,594
48	181232B	15	457	0,75	602	63	50	51	80	0,671	1,414	0,535	1,349	0,671
49	181809A	15	457	0,61	618	50	20	14	82	0,823	0,615	1,341	1,085	1,262
50	181809C	15	457	0,62	559	50	20	14	78	0,852	0,576	1,270	1,093	1,200
51	181816A	15	457	0,63	592	45	38	25	75	0,761	1,108	0,821	1,329	0,761
52	181816C	15	457	0,74	614	45	38	25	96	0,800	0,961	0,803	1,294	0,800
53	181821A	15	457	0,63	552	55	42	33	56	0,610	1,182	0,684	1,104	0,610
54	181821B	15	457	0,74	596	55	42	33	93	0,798	1,046	0,683	1,351	0,798
55	181832A	15	457	0,61	689	63	50	51	53	0,477	1,859	0,603	1,145	0,477
56	181832B	15	457	0,75	580	63	50	51	79	0,687	1,388	0,525	1,368	0,687
57	241209A	15	610	0,62	606	50	20	14	71	0,536	0,599	1,765	0,699	1,292
58	241209C	15	610	0,63	621	50	20	14	79	0,573	0,597	1,780	0,746	1,400
59	241216A	15	610	0,63	592	45	38	25	76	0,578	1,108	1,096	1,009	0,656
60	241216B	15	610	0,79	587	45	38	25	133	0,813	0,880	1,032	1,259	0,848
61	241221A	15	610	0,61	610	55	42	33	77	0,587	1,284	0,968	1,114	0,587
62	241221B	15	610	0,76	639	55	42	33	127	0,742	1,055	0,938	1,261	0,742
63	241232A	15	610	0,62	673	63	50	51	69	0,469	1,808	0,792	1,104	0,469
64	241232B	15	610	0,76	584	63	50	51	101	0,645	1,374	0,701	1,276	0,645

Test	h_w	t_w	f_{yw}	α	a_1	a_3	V_u	χ_u	λ_1	λ_2	V_d/V_{R1}	V_d/V_{R2}
No original ref ⁹	mm	mm	MPa		mm	mm	kN					
65 Gauche	16	460	2	254	30,5	0	126 139	1,029	1,494	0,121	2,142	1,029
66 Droit	16	550	2	254	30,5	0	126 109	0,675	1,494	0,145	1,405	0,675
67 Sin 1	17	1502	2,1	225	2w=155	40	370	0,902	0,433	1,108	1,046	1,038
68 Sin 2	17	1501	2,1	225	2w=155	40	365	0,890	0,433	1,108	1,032	1,025
69 Sin 3	17	1505	2,1	225	2w=155	40	353	0,859	0,433	1,108	0,996	0,989

Slenderness parameters are defined by:

$$\lambda_i = \sqrt{\frac{f_{yw}}{\tau_{cri} \sqrt{3}}} \quad (13.12)$$

for $i = 1,2,3$ there 1 and 2 refers to equations (13.8) and (13.9) and 3 to equation (13.14) below.

Values for the slenderness parameters λ_1 and λ_2 for the test girders are given in Table 13.1. The characteristic shear resistance is represented by:

$$V_R = \chi \frac{f_{yw}}{\sqrt{3}} h_w t_w \quad (13.13)$$

where χ is the minimum of the reduction values χ_i determined for λ_1 and λ_2 .

The ultimate shear resistance V_u in the tests can be transformed to the non-dimensional parameter χ_u by equation (13.13) and it is also given in Table 13.1.

The parameters defined above are general and will be used throughout the analysis. The features of the different models will now be described briefly and evaluated.

13.3.2 Model according to Leiva [5]

Leiva does not fully develop a design model but his main concern is the interaction between local and global buckling, which is based on observations from tests. His idea is to consider this interaction by defining a combined critical stress τ_{cr3} as:

$$\frac{1}{\tau_{cr3}^n} = \frac{1}{\tau_{cr1}^n} + \frac{1}{\tau_{cr2}^n} \quad (13.14)$$

Leiva discussed only in case $n=1$ but the equation has been written more general for later use. He also considered yielding as a limit for the component critical stresses in an attempt to make a design formula. The idea of Leiva will not be evaluated but it will form the basis for a model that will be presented later called "Combined model".

13.3.3 Model according to Lindner [6]

Lindner made an evaluation of test results 0 to 23 in Table 13.1. He discussed different options for taking the interaction between local and global buckling into account, including using (13.14) with $n=2$. His conclusions were however that the

interaction could be taken into account implicitly by correcting λ_2 . Lindner's model has been introduced in German recommendations [2]. The reduction factor for the resistance:

$$\chi_{i,L} = \frac{0.588}{\lambda_i} \quad (13.15)$$

is used for both local and global buckling. λ_1 is as defined in (13.12) but λ_2 is changed according to:

$$\lambda_2 = \sqrt{\frac{2f_y}{\tau_{cr2}\sqrt{3}}} \text{ if } 0.5 < \tau_{cr1}/\tau_{cr2} < 2 \quad (13.16)$$

The model has been evaluated with results shown in Figure 13.5 and in Table 13.2 where χ_L is the smallest of χ_{1L} and χ_{2L} according to (13.15). The right hand diagram in Figure 13.5 shows that the model has a slight bias with respect to λ_2 . It is an under-prediction of the resistance that increases with the slenderness for global buckling. Further the model includes discontinuities in the prediction because of the stepwise correction in (13.15).

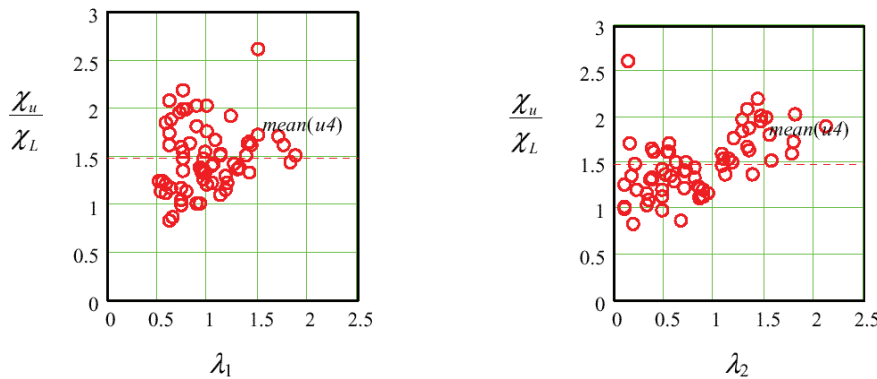


Figure 13.5: Test over prediction as function of λ_1 and λ_2 according to Lindner's model

13.3.4 Model according to Johnson [8]

The model according to Johnson involves three separate checks; one for local buckling, one for global buckling and one for combined local and global buckling. The check for local buckling is done with the post-buckling resistance predicted by:

$$\chi_{1J} = \frac{0,84}{\lambda_1} < 1,0 \quad (13.17)$$

For the global buckling the critical stress (13.9) is used but with a coefficient 36 instead of 32,4 and without $(1-\nu^2)$ in the denominator of D_x which gives more or less the same results. The design strength is taken as 0,5 times the critical stress, which includes a partial safety factor of 1,1. Considering these differences the characteristic reduction factor becomes:

$$\chi_{2J} = \frac{0,61}{\lambda_2^2} \tag{13.18}$$

if λ_2 is defined by (13.12) and (13.9).

Finally, the interaction between local and global buckling is considered with the critical stress τ_{cr3} according to (13.14) with $n=1$. The resistance is taken as the critical stress with a reduction factor $0,67 \times 1,1$, which leads to the reduction factor:

$$\chi_{3J} = \frac{0,74}{\lambda_3^2} \tag{13.19}$$

where λ_3 is defined by (13.12) and (13.14) with $n=1$.

The evaluation is shown in Figure 13.6 and Table 13.2. χ_J is taken as the lowest value from the three separate checks. The right hand diagram depicting the combined check shows a clear bias for under-prediction for high slenderness values, which is caused by the use of reduced critical stresses as design strength. The scatter in the quotient test over prediction shown in Table 13.2 is also fairly high.

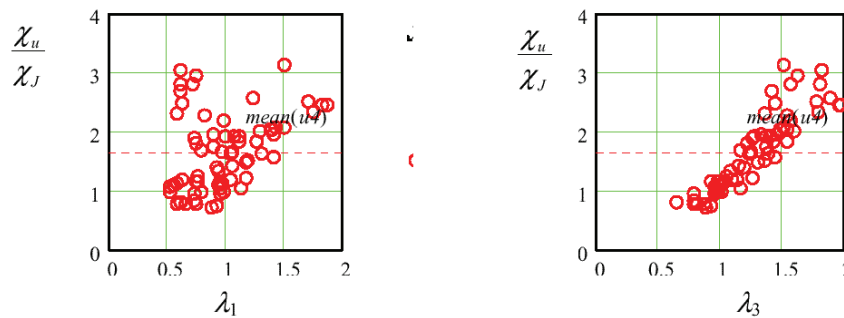


Figure 13.6: Test over prediction as function of λ_1 and λ_3 according to Johnson’s model

13.3.5 Combined model

The basic idea of this model was to define the resistance by a single reduction factor. A reduced critical stress will be defined by (13.14) in order to take the interaction between local and global buckling into account. This critical stress is used to calculate the slenderness parameter λ_3 from (13.12). It is used in combination with the strength function:

$$\chi_c = \frac{1,2}{0,9 + \lambda_3} < 1,0 \tag{13.20}$$

The results for $n=2$ are shown in Table 13.2 and in Figure 13.7. Also $n=4$ has been checked and the result is quite similar considering the statistical parameters. Both alternatives represent a quite weak interaction and the interaction becomes weaker the higher value of n is used. It can be seen that this model improves the prediction. However, the model is symmetrical in the influence of local and global buckling. It could be expected on theoretical grounds that the post-critical resistance is more pronounced for local buckling than for global. In the latter case

it is questionable if there is any at all. On the other hand the influence of imperfections in the range of medium slenderness can be expected to be smaller than for local buckling. This became clear when the tests with sinusoidally corrugated webs were included in the comparisons, which was done quite late in the work. This reasoning led to the model described in the next section.

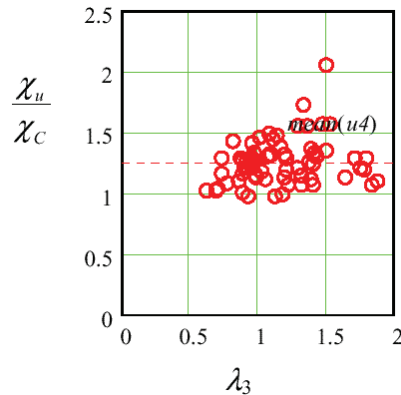


Figure 13.7: Test over prediction as function of λ_3 according to model Combined check, $n=2$

13.3.6 Model according to EN 1993-1-5

The model is based on the one proposed by Höglund [7]. It has two separate checks, one for local and one for global buckling. It has been modified in [18] and further modification has been done here as will be discussed below. The reduction factors for local and global buckling, respectively, is given by:

$$\chi_{1,EN} = \frac{1.15}{0.9 + \lambda_1} < 1.0 \quad (13.21)$$

$$\chi_{2,EN} = \frac{1.5}{0.5 + \lambda_2^2} \leq 1.0 \quad (13.22)$$

The reasoning behind the two checks is that the local buckling is expected to show a post-critical strength, which should not be present in the global buckling. This is reflected by λ_1 appearing linear and λ_2 is squared in the reduction factor. In [18] the reduction factor for local buckling has no plateau but the global buckling has the same reduction factor as (13.17). There is however one more difference. The restraint from the flanges to the global buckling is included in [18] and an increase of the buckling coefficient to 40 is suggested if a certain stiffness criterion is met. The predictions were compared with the test results in Table 13.1 and also with some tests on aluminium girders. The prediction is marginally better than the one using (13.21) and (13.22). The idea of increasing the global buckling coefficient has also been discussed by Leiva and it may very well be true. It has however not been included in the model in EN 1993-1-5 for simplicity and as an additional safety measure. The reduction factors (13.21) and (13.22) are shown in Figure 13.9 together with the Euler curve and the von Karman curve.

There are no test results that make it possible to evaluate the length of the plateau length for local buckling. Equation (13.21) has a plateau until $\lambda_1 = 0.25$, which is

very small compared to other buckling problems. For instance the design rules for flat webs give $\lambda = 0.83$ for the plateau length with $\eta = 1$. This question will remain unsettled until further experiments are available. It is believed that (13.21) is conservative enough.

The evaluation results are found in Figure 13.8 and Table 13.2. The notation χ_{EN} is the minimum of (13.21) and (13.22). The prediction is quite good with all the results between 1 and 1,5, except for test 65, which stick out in all the evaluations.

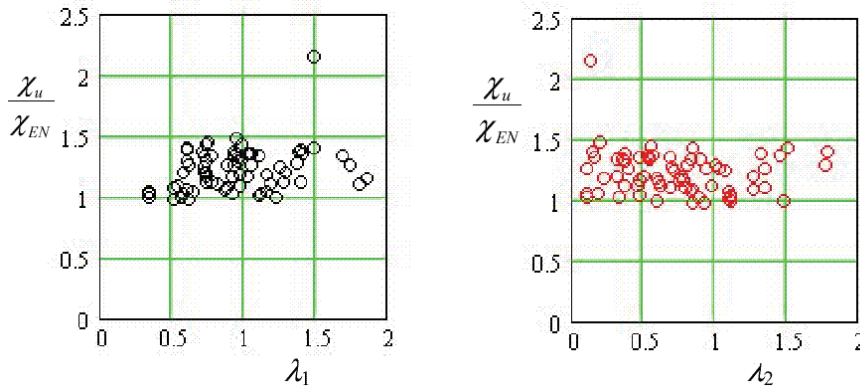


Figure 13.8: Test over prediction according to the model in EN 1993-1-5

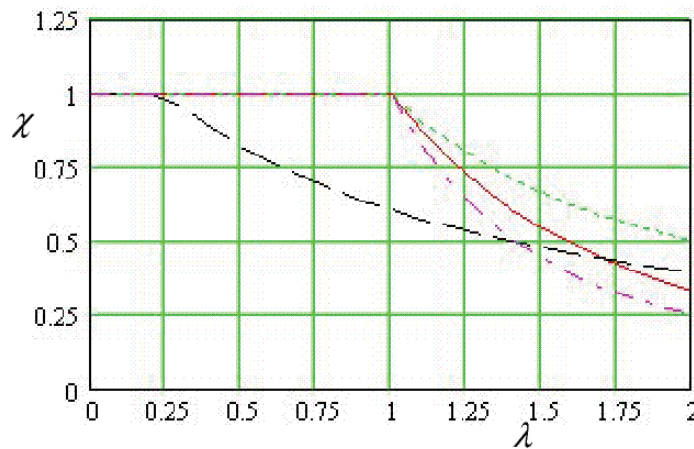


Figure 13.9: Reduction factors according to EN 1993-1-5; global buckling solid and local buckling dashed. As reference the Euler curve $1/\lambda^2$ is shown as dash-dots and the von Karman curve $1/\lambda$ as dots

Figure 13.10 shows the test results for which local buckling is supposed to govern and Figure 13.11 there global buckling is supposed to govern. The predictions gives almost the same statistical characteristics, mean 1,22 and 1,23 with coefficient of variation 0,15 and 0,14 for local and global buckling, respectively.

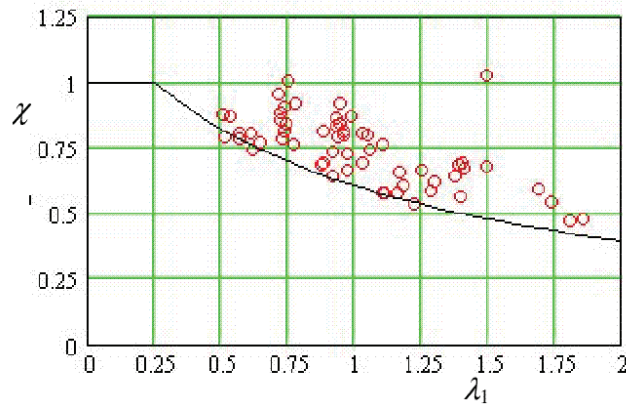


Figure 13.10: Reduction factor for local buckling together with 59 test results where local buckling is supposed to govern

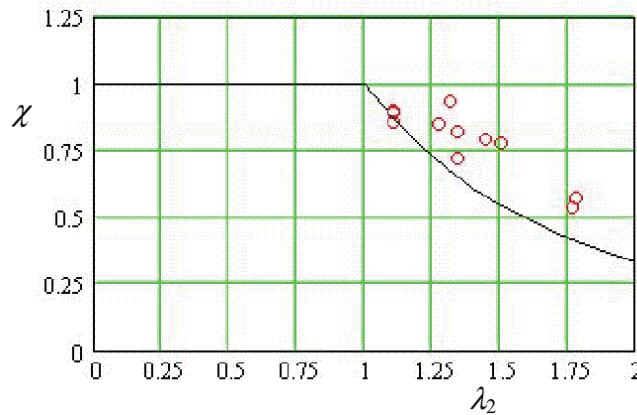


Figure 13.11: Reduction factor for global buckling together with 11 test result where global buckling is supposed to govern

Table 13.2: Evaluation of design models showing mean value, standard deviation and coefficient of variation of the quotient

$\chi_{ul} / \chi_{prediction}$

Model	Lindner	Johnson	Combined n=2	EN1993-1-5
Mean	1.48	1.62	1.26	1.22
Stand dev	0.34	0.65	0.19	0.18
Coeff of var	0.23	0.39	0.15	0.15

13.3.7 Discussion

The test data base is quite large and covers a range of parameters for instance:

$$190 < f_y < 690 \text{ Mpa}$$

$$140 < h_w/t_w < 1200$$

$$30^\circ < \alpha < 63^\circ$$

Most of the tests are normal I-girders tested in three or four point bending. The exceptions are test 27 and 28, which were racking tests on container walls with an unsymmetrical corrugation. The report included one more shear test that has been discarded because the web was not continuously welded. Test 65 and 66 had a triangular corrugation (α_1 in Figure 13.2 equal to zero) and the girder had flanges of cold-formed channels. Test 65 showed a very high resistance compared to prediction, which to some extent may have been influenced by the flanges carrying some shear. However, it is not the whole truth as test 66 does not stick out. The tests by Hamilton [15] included four more tests with the remark “support induced failure”, which are not included in Table 13.1.

The normal procedure for dealing with buckling problems is to use the critical stress for defining a slenderness parameter as in (13.12) and to find a reduction factor that depends on this slenderness parameter. In all the models studied here a post critical strength is recognized for the local buckling. It is however less pronounced than for a flat web. This is likely to be so because the folds of the web are less efficient in supporting tension fields than the flanges of a girder with a flat web. One question is how small the angle α between adjacent panels can be made before the fold becomes insufficient as a support for the panels. The smallest angle in the tests is 30° . This has been taken as lower limit until further evidence is available.

The next question is interaction between the two buckling modes. This has been considered by most of the authors except Höglund. His reasoning is that the interaction, if any, is so weak that two separate checks are sufficient. The evaluation in Table 13.2 supports this opinion as the EN 1993-1-5 model based on Höglund’s ideas, shows the lowest scatter. The suggestion of Lindner to increase the slenderness parameter for global buckling if the critical stresses for local and global buckling are close to each other is hard to justify and it creates an unnatural discontinuity. Using (13.14) for defining a reduced critical stress would give a continuous procedure that gives the highest interaction when the two critical stresses are equal. This seems intuitively reasonable. It will however be symmetrical in τ_{cr1} and τ_{cr2} , which is not likely to be true as indicated in the discussion in 13.3.5. Because of this theoretical objection and that the prediction of the test results is as good with the separate checks this was chosen.

For some low value of the slenderness the shear yield resistance of the web should be reached. The test results do not indicate at which slenderness this will be safely met. From Figure 13.10 it can be seen that the lowest slenderness there local failure was governing is $\lambda_1=0.5$. Judging from experiences of other plate buckling phenomena (13.21) will be very safe with $\lambda_1 = 0.25$ for reaching the yield resistance as discussed in 13.3.6.

The design model presented in EN 1993-1-5 has been shown to be a step forward compared to other existing or possible design models. It is certainly not the final

answer to the question of shear resistance of corrugated webs and future research will hopefully improve the model.

13.4 Patch loading

No rules for patch loading resistance are given in EN 1993-1-5. The rules for flat webs may be used but this is in most cases quite conservative, especially if the loaded length is larger than one half corrugation w . The patch loading resistance has been studied by several authors [10], [20], [21]. The results have however not been collated and merged into a design model. In [1] the design rule for patch loading includes only a check of the yield resistance. For sinusoidally corrugated webs for the patch loading resistance has been studied in [22] and [23].

13.5 References

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SHEAR TESTING OF THE SIN BEAM

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Report No. STC 12-13-21

INTRODUCTION

The SIN Beam

The SIN Beam is a unique steel structural member with a cold formed steel corrugated steel web element welded to two hot-rolled steel flange plates, resulting in a typical wide flange type section. The only difference being that the web is not a linear equal thickness steel plate but a sinusoidal corrugated cold formed steel section. SIN Beams can be used as flexural members such as roof or floor beams, as compression members such as columns, or as members subjected to combined bending and axial loading such as in moment frames. Shown in Figure 1 is a schematic diagram of the SIN Beam section that is manufactured by Steelcon Fabrication Inc. (Steelcon) in Brampton, Ontario.

Corrugated web steel beams have been researched since the 1960's and have been used in Europe for over 30 years. In fact, Annex D (Plate Girders with Corrugated Webs) of Euro Code EN1993-1-5:2006 (Steel Plated Structural Elements) [1] contains structural design information for such members. The SIN Beam is made using the same equipment and processes that ZEMAN of Austria has been using in Europe for the past 20 years.

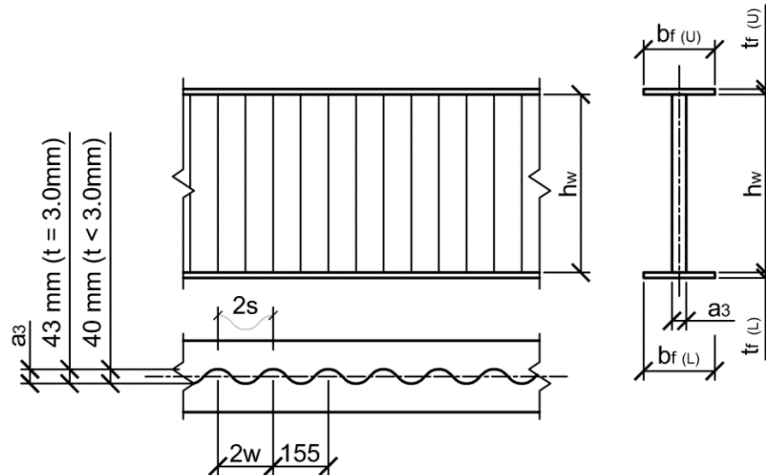


Figure 1 – Schematic Diagram of SIN Beam Section

Governing American Standards

Since the SIN Beam is made of two different steel materials, 1) flanges that are hot-rolled steel plates, ANSI/AISC 360-16 [2] applies and 2) AISI S100-16 [3] is the Standard that applies for the cold formed steel corrugated web section. In the case of the shear resistance of the SIN Beam, a direct calculation cannot be made based on Chapter G of AISI S100-16 [3], however, Section A1.2

does permit the use of a “*Rational Engineering Analysis*” based on appropriate theory and engineering judgement.

Objective

The primary objective of this report was to establish an appropriate rational engineering analysis for the shear resistance of the SIN Beam and to substantiate this analysis with verification testing.

SHEAR RESISTANCE ANALYSIS

Since Euro Code EN1993-1-5:2006 [1] contains a proven analysis for the shear strength of corrugated steel web members, it was chosen herein as the most appropriate Rational Analysis available in the design Code literature. The nominal shear strength is computed as follows. As can be observed, the theoretical base of this Equation is von Mises yield theory with a shear buckling coefficient relating to the corrugated web of the member.

$$V_n = \chi_c \frac{1}{\sqrt{3}} F_y A_w; \quad \chi_c = \min(\chi_{c,l}, \chi_{c,g})$$

The value of χ_c is taken as the lesser value of Local or Global buckling $\chi_{c,l}$ or $\chi_{c,g}$.

Local Buckling

$$\chi_{c,l} = \frac{1.15}{0.9 + \bar{\lambda}_{c,l}} \leq 1.0$$

$$\bar{\lambda}_{c,l} = \sqrt{\frac{F_y}{\tau_{cr,l} \sqrt{3}}}$$

$$\tau_{cr,l} = \left\{ 5.34 + \frac{a_3 s}{h_w t_w} \right\} \frac{\pi^2 E}{12(1 - \mu^2)} \left(\frac{t_w}{s} \right)^2$$

Global Buckling

$$\chi_{c,g} = \frac{1.5}{0.5 + (\bar{\lambda}_{c,g})^2} \leq 1.0$$

$$\bar{\lambda}_{c,g} = \sqrt{\frac{F_y}{\tau_{cr,g} \sqrt{3}}}$$

$$\tau_{cr,g} = \frac{32.4}{t_w (h_w)^2} \sqrt[4]{D_x (D_z)^3}$$

$$D_x = \frac{E t_w^3}{12(1 - \mu^2)} \frac{w}{s}$$

$$D_z = \frac{EI_z}{w}$$

Where,

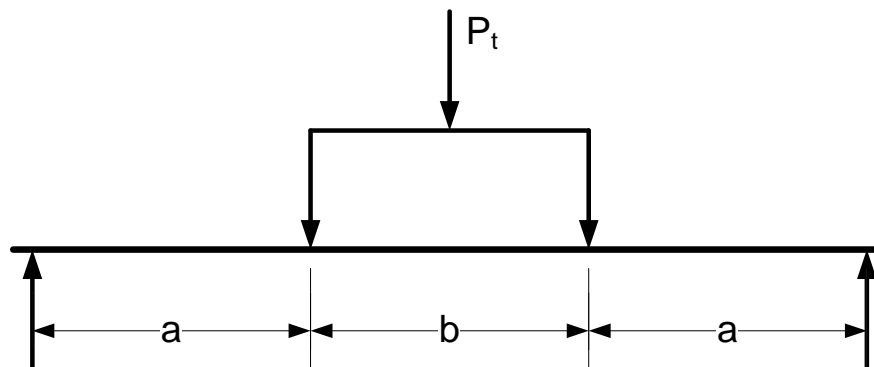
- F_y - yield stress of corrugated web
- a_3 - amplitude of corrugated web
- s - unfolded length of one half corrugation wave
- E - modulus of elasticity of corrugated web
- μ - poisson's ratio = 0.30
- h_w - clear web height of corrugated web
- t_w - web thickness of corrugated web
- w - length of one half corrugation wave

These buckling coefficients have been developed for steel beams with either trapezoidal or sinusoidal corrugated web configurations. Available research indicates that these coefficients are conservative when applied to steel beams with sinusoidal/corrugated webs such as with the SIN Beam [4], [5]. Extensive testing has been done in Europe to verify the design approach for shear that is contained in Euro Code EN1993-1-5:2006 [1], however, the Steelcon company decided to also carry out such shear tests on the SIN Beam product manufactured in its Canadian Brampton Ontario facility.

SHEAR TESTING

General

Steelcon retained “exp Brampton Laboratory” (eBL) to carry out the shear tests of the SIN Beam. Since eBL did not have a structural test frame in their facility with the required capacity, it was decided that Steelcon erect such a test frame in their facility to carry out these tests. All test specimens were fabricated/assembled in the Steelcon plant and actual testing/supervision was performed by the eBL staff. Shown in Figure 2 is a schematic diagram of the shear test set up, where $a = 5$ ft and $b = 4$ ft.



CELL 1

CELL 2

Figure 2 - Schematic Diagram of Shear Test Set up

Three shear tests were carried out in each case for the SIN WTB500/178x16 and the SIN WTA1000/178x10 beams. Two load cells were used to apply the load, CELL 1 and CELL 2. Shown in Figure 3 is a typical shear failure, which I personally witnessed.



Figure 3 – Typical Shear Failure

TEST RESULTS AND COMPARISONS

The test data from Reference 6 is contained in Appendix A of this report. More specifically, Table A1 contains the mechanical properties of the steel. Summarized in Table A2 are the shear test results and the respective calculated values with comparisons. The lesser load of load CELL 1 and load CELL 2 was used as the test shear value, V_t . As can be observed from Table A2, the average shear test ratio, V_t/V_n , in each case is equal to or greater than 1. This indicates that the shear prediction method selected from Reference 1 is an appropriate Rational Analysis method. The calculated nominal shear strengths are presented in Tables B1 and B2 of Appendix B.

CONCLUSIONS

Based on the information presented herein, the EN1993-1-5:2006 [1] design method satisfies the requirements of AISI S100-16 [3] and can be used for computing the nominal shear strength, V_n , of

the SIN Beam. The available shear strength, V_a , can then be computed as follows using either design method:

ASD

$$V_a = V_n/\Omega; \quad \Omega = 2.00$$

LRFD

$$V_a = \phi V_n; \quad \phi = 0.80$$

where $\Omega = 2.00$ and $\phi = 0.80$ are given in Section A1.2(c) [3].

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APPENDIX A
Table A1 – Mechanical Properties [6]

Test Type	t (in.)	F _y (ksi)	F _u (ksi)	% Elong.
SIN WTB500/178x16	0.100	56.5	70.9	27.5
SIN WTA1000/178x10	0.0750	60.7	70.9	27.2

Table A2 – Test Data and Comparisons [6]

SPECIMEN	CELL 1 (lb)	CELL 2 (lb)	V _t		V _n (kip)	V _t /V _n	t (in.)	F _y (ksi)
			(lb)	(kip)				
SIN WTB500/178X16								
SB1-A	64,900	69,000	64,900	64.9			0.100	56.5
SB1-B	75,830	71,067	71,067	71.1				
SB1-C	75,972	70,149	70,149	70.1				
			Average	68.7	55.5	1.24		
SIN WTA1000/178X10								
SB4-A	81,529	77,664	77,664	77.7			0.075	60.7
SB4-B	86,964	82,407	82,407	82.4				
SB4-C	80,974	79,806	79,806	79.8				
			Average	80.0	78.6	1.02		

V_t = Test shear strength taken as the lowest of Cell 1 and Cell 2.

V_n = Nominal calculated shear strength.

APPENDIX B

Table B1 – SIN WTB500/178x16

IMPERIAL UNITS - INPUT DATA AND DETAILED CALCULATIONS - IMPERIAL UNITS
 * STEELCON SIN BEAM *

INPUT DATA

HWB= 19.7IN TWB= 0.100IN BFL= 7.01IN TFL= 0.630IN A3= 1.57IN
 S= 3.50IN W= 3.05IN FYWB= 56.5KSI EWB= 29500.KSI IZ= 0.0992IN4

CALCULATED VALUES

TCRL= 176.8KSI LAMCL= 0.429 XCL= 0.865 DZ= 959.3K-IN DX= 2.352K-IN
 TCRG= 178.5KSI LAMCG= 0.427 XCG= 1.000 XC= 0.865

VN= 55.5KIP

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Table B2 – SIN WTA1000/178x10

IMPERIAL UNITS - INPUT DATA AND DETAILED CALCULATIONS - IMPERIAL UNITS
 * STEELCON SIN BEAM *

INPUT DATA

HWB= 39.4IN TWB= 0.075IN BFL= 7.01IN TFL= 0.394IN A3= 1.57IN
 S= 3.50IN W= 3.05IN FYWB= 60.7KSI EWB= 31200.KSI IZ= 0.0709IN4

CALCULATED VALUES

TCRL= 93.1KSI LAMCL= 0.613 XCL= 0.760 DZ= 724.7K-IN DX= 1.050K-IN
 TCRG= 39.4KSI LAMCG= 0.943 XCG= 1.000 XC= 0.760

VN= 78.6KIP

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