STANDARD SPECIFICATION
SPECIAL PROFILE STEEL JOISTS, SP-SERIES
NEW MILLENNIUM BUILDING SYSTEMS

SECTION 900. SCOPE

This specification covers the design, manufacture and use of **Special Profile Steel Joists, SP-Series**. Load and Resistance Factor Design (LRFD) and Allowable Strength Design (ASD) are included in this specification.

SECTION 901. DEFINITION

The term **"Special Profile Steel Joists, SP-Series"** as used herein, refers to open web, load-carrying members utilizing hot-rolled or cold-formed steel, including cold-formed steel whose yield strength has been attained by cold working. SP-Series steel joists are suitable for the direct support of roof decks in buildings.

The design of SP-Series joists' chord and web sections shall be based on a yield strength of at least 36 ksi (250 MPa), but not greater than 50 ksi (345 MPa). Steel used for SP-Series joist chord or web sections shall have a minimum yield strength determined in accordance with one of the procedures specified in Section 902.2, which is equal to the yield strength assumed in the design. SP-Series joists shall be designed in accordance with these specifications to support the loads specified in the joist designation.

The term "Yield Strength" as used herein shall designate the yield level of a material as determined by the applicable method outlined in paragraph 13.1 "Yield Point," and in paragraph 13.2 "Yield Strength," of ASTM A370, *Standard Test Methods and Definitions for Mechanical Testing of Steel Products*, or as specified in Section 902.2 of this specification.

SECTION 902. MATERIALS

902.1 STEEL

The steel used in the manufacture of chord and web sections shall conform to one of the following ASTM specifications:

- Carbon Structural Steel, ASTM A36/A36M
- High-Strength Low-Alloy Structural Steel, ASTM A242/A242M
- High-Strength Carbon-Manganese Steel of Structural Quality, ASTM A529/A529M, Grade 50
- High-Strength Low-Alloy Columbium-Vanadium Structural Steel, ASTM A572/A572M, Grade 42 and 50
- High-Strength Low-Alloy Structural Steel with 50 ksi (345 MPa) Minimum Yield Point to 4 inches (100 mm) thick, ASTM A588/A588M
- Steel, Sheet and Strip, High-Strength, Low-Alloy, Hot-Rolled and Cold-Rolled, with Improved Corrosion Resistance, ASTM A606
- Steel, Sheet, Cold-Rolled, Carbon, Structural, High Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, ASTM A1008/A1008M
- Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength, ASTM A1011/A1011M

or shall be of suitable quality ordered or produced to other than the listed specifications, provided that such material in the state used for final assembly and manufacture is weldable and is proven by tests performed by the producer or manufacturer to have the properties specified in Section 902.2.

902.2 MECHANICAL PROPERTIES

The yield strength used as a basis for the design stresses prescribed in Section 903 shall be either 36 ksi (250 MPa) or 50 ksi (345 MPa). Evidence that the steel furnished meets or exceeds the design yield strength shall, if requested, be provided in the form of an affidavit or by witnessed or certified test reports.

For material used without consideration of increase in yield strength resulting from cold forming, the specimens shall be taken from as-rolled material. In the case of material, the mechanical properties of which conform to the requirements of one of the listed specifications, the test specimens and procedures shall conform to those of such specifications and to ASTM A370.

In the case of material, the mechanical properties of which do not conform to the requirements of one of the listed specifications, the test specimens and procedures shall conform to the applicable requirements of ASTM A370, and the specimens shall exhibit a yield strength equal to or exceeding the design yield strength and an elongation of not less than (a) 20 percent in 2 inches (51 mm) for sheet and strip, or (b) 18 percent in 8 inches (203 mm) for plates, shapes, and bars with adjustments for thickness for plates, shapes, and bars as prescribed in ASTM A36/A36M, A242/A242M, A529/A529M, A572/A572M, A588/A588M, whichever specification is applicable on the basis of design yield strength.

The number of tests shall be as prescribed in ASTM A6/A6M for plates, shapes, and bars; and ASTM A606, A1008/A1008M and A1011/A1011M for sheet and strip.

If as-formed strength is utilized, the test reports shall show the results of tests performed on full section specimens in accordance with the provisions of the *AISI North American Specifications for the Design of Cold-Formed Steel Structural Members*. They shall also indicate compliance with these provisions and with the following additional requirements:

a) The yield strength calculated from the test data shall equal or exceed the design yield strength.

b) Where tension tests are made for acceptance and control purposes, the tensile strength shall be at least 6 percent greater than the yield strength of the section.

c) Where compression tests are used for acceptance and control purposes, the specimen shall withstand a gross shortening of 2 percent of its original length without cracking. The length of the specimen shall be not greater than 20 times the least radius of gyration.

d) If any test specimen fails to pass the requirements of the subparagraphs (a), (b), or (c) above, as applicable, two retests shall be made of specimens from the same lot. Failure of one of the retest specimens to meet such requirements shall be the cause for rejection of the lot represented by the specimens.

902.3 WELDING ELECTRODES

The following electrodes shall be used for arc welding:

a) For connected members both having a specified minimum yield strength greater than 36 ksi (250 MPa):

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

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

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

or any of those listed in Section 902.3(a)

Other welding methods, providing equivalent strength as demonstrated by tests, may be used.

902.4 PAINT

The standard shop paint is intended to protect the steel for only a short period of exposure in ordinary atmospheric conditions and shall be considered an impermanent and provisional coating. When specified, the standard shop paint shall conform to one of the following:

a) Steel Structures Painting Council Specification, SSPC No. 15

b) Shall be a shop paint which meets the minimum performance requirements of the above listed specification

SECTION 903. DESIGN AND MANUFACTURE

903.1 METHOD

SP-Series joists shall be designed in accordance with these specifications as simply supported, uniformly loaded trusses supporting a roof deck so constructed as to brace the top chord of the joists against lateral buckling. All joists are designed as pinned at one end and roller bearing on the opposite end to prevent horizontal thrust to the supporting structure. The end fixity conditions of Scissor and Arch joists require special consideration from the specifying professional regarding end anchorage conditions. (See Sections 904.1 and 904.7)

Where any applicable design feature is not specifically covered herein, the design shall be in accordance with the following specifications:

a) Where the steel used consists of hot-rolled shapes, bars or plates, use the *American Institute of Steel Construction, Specification for Structural Steel Buildings.*

b) For members that are cold-formed from sheet or strip steel, use the *American Iron and Steel Institute, North American Specification for the Design of Cold-Formed Steel Structural Members.*

Design Basis:

Designs shall be made according to the provisions in this Specification for either Load and Resistance Factor Design (LRFD) or for Allowable Strength Design (ASD).

Load Combinations:

LRFD:

When load combinations are not specified to NMBS, the required stress shall be computed for the factored loads based on the factors and load combinations as follows:

1.4D
1.2D + 1.6 (L, or L_r, or S, or R)

ASD:

When load combinations are not specified to NMBS, the required stress shall be computed based on the load combinations as follows:

D
D + (L, or L_r, or S, or R)

Where:

D = dead load due to the weight of the structural elements and the permanent features of the structure
L = live load due to occupancy and movable equipment
L_r = roof live load
S = snow load
R = load due to initial rainwater or ice exclusive of the ponding contribution

The current *ASCE 7, Minimum Design Loads for Buildings and Other Structures* shall be used for LRFD and ASD load combinations. This provision pertains exclusively to the combination of loads and does not imply that NMBS generate or verify load development for SP-Series.

903.2 DESIGN AND ALLOWABLE STRESSES

Design Using Load and Resistance Factor Design (LRFD)

Joists shall have their components so proportioned that the required stresses, f_u, shall not exceed ΦF_n where,

f_u = required stress ksi (MPa)
F_n = nominal stress ksi (MPa)
Φ = resistance factor
ΦF_n = design stress ksi (MPa)

Design Using Allowable Strength Design (ASD)

Joists shall have their components so proportioned that the required stresses, f, shall not exceed F_n/Ω where,

f_u = required stress ksi (MPa)
F_n = nominal stress ksi (MPa)
Ω = safety factor
F_n/Ω = allowable stress ksi (MPa)

Stresses:

(a) Tension: $\Phi_t = 0.90$ (LRFD), $\Omega_t = 1.67$ (ASD)

For chords: $F_y = 50$ ksi (345 MPa)
For webs: $F_y = 50$ ksi (345 MPa) or $F_y = 36$ ksi (250 MPa)

Design Stress $= 0.9F_y$ (LRFD) (903.2-1)
Allowable Stress $= 0.6F_y$ (ASD) (903.2-2)

(b) Compression: $\Phi_c = 0.90$ (LRFD), $\Omega_c = 1.67$ (ASD)

For members with $\frac{K\ell}{r} \le 4.71\sqrt{\frac{E}{QF_y}}$

$$F_{cr} = Q\left[0.658^{\left(QF_y/F_e\right)}\right]F_y \qquad (903.2\text{-}3)$$

For members with $\frac{K\ell}{r} > 4.71\sqrt{\frac{E}{QF_y}}$

$$F_{cr} = 0.877F_e \qquad (903.2\text{-}4)$$

F_e = Elastic buckling stress determined in accordance with Equation 903.2-5

$$F_e = \frac{\pi^2 E}{\left(K\ell/r\right)^2} \qquad (903.2\text{-}5)$$

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

Design Stress $= 0.9F_{cr}$ (LRFD) (903.2-6)
Allowable Stress $= 0.6F_{cr}$ (ASD) (903.2-7)

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

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

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

(c) Bending: $\Phi_b = 0.90$ (LRFD), $\Omega_b = 1.67$ (ASD)

Bending calculations are to be based on using the elastic section modulus.

For chords and web members other than solid rounds:
$F_y = 50$ ksi (345 MPa)

Design Stress $= 0.9F_y$ (LRFD) (903.2-8)
Allowable Stress $= 0.6F_y$ (ASD) (903.2-9)

For web members of solid round cross section:
$F_y = 50$ ksi (345 MPa) or $F_y = 36$ ksi (250 MPa)

Design Stress $= 1.45F_y$ (LRFD) (903.2-10)
Allowable Stress $= 0.95F_y$ (ASD) (903.2-11)

For bearing plates:
F_y = 50 ksi (345 MPa) or F_y = 36 ksi (250 MPa)

Design Stress = $1.35F_y$ (LRFD) (903.2-12)
Allowable Stress = $0.90F_y$ (ASD) (903.2-13)

(d) Weld Strength:

Shear at throat of fillet welds:

Nominal Shear Stress = $F_{nw} = 0.6F_{exx}$ (903.2-14)

LRFD: $\Phi_w = 0.75$

Design Shear Strength =
$\Phi R_n = \Phi_w F_{nw} A = 0.45F_{exx} A$ (903.2-15)

ASD: $\Omega_w = 2.0$

Allowable Shear Strength =
$R_n/\Omega_w = F_{nw}A/\Omega_w = 0.3F_{exx} A$ (903.2-16)

Where A = effective throat area

Made with E70 series electrodes or F7XX-EXXX flux-electrode combinations.

F_{exx} = 70 ksi (483 MPa)

Made with E60 series electrodes or F6XX-EXXX flux-electrode combinations.

F_{exx} = 60 ksi (414 MPa)

Tension or compression on groove or butt welds shall be the same as those specified for the connected material.

Divergence Stress: The design of chords formed into arcs through cold rolling shall include a divergence stress in the design. A secondary moment in the chord resulting from the divergence of the actual member from the node-to-node linear design element shall be accounted for in the design.

For chords rolled to a radius, the secondary moment stress shall be equal to:

$$\sigma_{divergence} = \frac{P_r \cdot c}{I_x} \cdot \left(R - \sqrt{R^2 - \frac{d^2}{4}} \right) \quad (903.2\text{-}17)$$

P_r = axial force required in the member

c = distance from neutral axis to the extreme fiber results in two stress values for asymmetric sections such as double angles

I_x = moment of inertia about axis perpendicular to radius of divergence

R = radius of divergence from neutral axis. Usually the radius of cold rolling for Bowstring or Arch Joists

d = straight-line distance from node to node

903.3 MAXIMUM SLENDERNESS RATIOS

The slenderness ratios, 1.0 ℓ/r and 1.0 ℓs/r of members as a whole or any component part shall not exceed the values given in Table 903.3-1, Parts A.

The effective slenderness ratio, Kℓ/r to be used in calculating the nominal stresses F_{cr} and F_e, is the largest value as determined from Table 903.3-1, Parts B and C. See P.N. Chod and T.V. Galambos, *Compression Chords Without Fillers in Longspan Steel Joists, Research Report No. 36,* June 1975 Structural Division, Civil Engineering Department, Washington University, St. Louis, Mo.

In compression members when fillers or ties are used, they shall be spaced so that the ℓ_s/r_z ratio of each component does not exceed the governing ℓ/r ratio of the member as a whole.

The terms used in Table 903.3-1 are defined as follows:

ℓ = length center-to-center of panel points, except ℓ = 36 inches (914 mm) for calculating ℓ/r_y of top chord member.
ℓ_s = maximum length center-to-center between panel point and filler (tie), or between adjacent fillers (ties).
r_x = member radius of gyration in the plane of the joist.
r_y = member radius of gyration out of the plane of the joist.
r_z = least radius of gyration of a member component.

TABLE 903.3-1

MAXIMUM AND EFFECTIVE SLENDERNESS RATIOS

	$k\ell/r_x$	$k\ell/r_y$	$k\ell/r_z$	$k\ell_s/r_z$
I TOP CHORD INTERIOR PANEL				
A. The slenderness ratios, $1.0\ell/r$ and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 90.				
B. The effective slenderness ratio, $k\ell/r$, to determine F_{cr} where k is:				
1. With fillers or ties	0.75	1.0	---	1.0
2. Without fillers or ties	---	---	0.75	---
3. Single component members	0.75	1.0	---	---
C. The effective slenderness ratio, $k\ell/r$, to determine F_e where k is:				
1. With fillers or ties	0.75	---	---	---
2. Without fillers or ties	0.75	---	---	---
3. Single component members	0.75	---	---	---
II TOP CHORD END PANEL				
A. The slenderness ratios, $1.0\ell/r$ and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 120.				
B. The effective slenderness ratio, $k\ell/r$, to determine F_{cr} where k is:				
1. With fillers or ties	1.0	1.0	---	1.0
2. Without fillers or ties	---	---	1.0	---
3. Single component members	1.0	1.0	---	---
C. The effective sl enderness ratio, $k\ell/r$, to determine F_e where k is:				
1. With fillers or ties	1.0	---	---	---
2. Without fillers or ties	1.0	---	---	---
3. Single component members	1.0	---	---	---
III TENSION MEMBERS – CHORDS AND WEBS				
A. The slenderness ratios, $1.0\ell/r$ and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 240.				
IV COMPRESSION MEMBERS				
A. The slenderness ratios, 1.0 and $1.0\ell_s/r$, of members as a whole or any component part shall not exceed 200.				
B. The effective slenderness ratio, $k\ell/r$, to determine F_{cr} where k is:				
1. With fillers or ties	0.75	1.0	---	1.0
2. Without fillers or ties	---	---	1.0	---
3. Single component members	0.75*	1.0	---	---

* If moment-resistant weld groups are not used at the ends of a crimped, first primary compression web member, then $1.2\ell/r_x$ must be used.

903.4 MEMBERS

(a) Chords

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

Bottom chords that are rolled for arched chord joist shall be designed to include divergence stress per Equation 903.2-17, in combination with tension forces.

For **LRFD**: $f_{au} + \sigma_{div} \le 0.9 F_y$ (903.4-1)

For **ASD**: $f_a + \sigma_{div} \le 0.6 F_y$ (903.4-2)

The radius of gyration of the top chord about its vertical axis shall not be less than ℓ/120 where ℓ is the spacing in inches (mm) between lines of bridging as specified in Section 904.5(d).

The top chord shall be considered as stayed laterally by the roof deck provided the requirements of Section 904.9(c) of this specification are met.

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

For **LRFD**:

at the panel point: $f_{au} + f_{bu} \le 0.9 F_y$ (903.4-3)

at the mid panel:

for $\frac{f_{au}}{\phi_c F_{cr}} \ge 0.2$,

$$\left(\frac{f_{au}}{\phi_c F_{cr}}\right) + \frac{8}{9}\left[\frac{C_m\left(f_{bu} + \sigma_{div}\right)}{\left[1 - \left(\frac{f_{au}}{\phi_c F_e}\right)\right] Q \phi_b F_y}\right] \le 1.0 \qquad (903.4\text{-}4)$$

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

$$\left(\frac{f_{au}}{2\phi_c F_{cr}}\right) + \left[\frac{C_m\left(f_{bu} + \sigma_{div}\right)}{\left[1 - \left(\frac{f_{au}}{\phi_c F_e}\right)\right] Q \phi_b F_y}\right] \le 1.0 \qquad (903.4\text{-}5)$$

f_{au} = P_u/A, required compressive stress, ksi (MPa)
P_u = required axial strength using LRFD load combinations, kips (N)
f_{bu} = M_u/S, required bending stress at the location under consideration, ksi (MPa)
σ_{div} = divergence stress applied where applicable as defined in Equation 903.2-17
M_u = required flexural strength using LRFD load combinations, kip-in (N-mm)
S = elastic section modulus, in^3 (mm^3)
F_{cr} = nominal axial compressive stress based on ℓ/r as defined in Section 903.2(b), ksi (MPa)
C_m = 1 - 0.3 $f_{au}/\Phi F_e$ for end panels
C_m = 1 - 0.4 $f_{au}/\Phi F_e$ for interior panels
F_y = specified minimum yield strength, ksi (MPa)

$$F_e = \frac{\pi^2 E}{(k\ell / r_x)^2}, \text{ ksi (MPa)}$$

Where ℓ is the panel length, in inches (mm), as defined in Section 903.2(b), and r_x is the radius of gyration about the axis bending.

Q = form factor defined in Section 903.2(b)
A = area of the top chord, $in.^2$ (mm^2)

For **ASD**:

at the panel point: $f_a + f_b \le 0.6 F_y$ (903.4-6)

at the mid panel:

for $\frac{f_a}{F_a} \ge 0.2$,

$$\left(\frac{f_a}{F_a}\right) + \frac{8}{9}\left[\frac{C_m\left(f_b + \sigma_{div}\right)}{\left[1 - \left(\frac{1.67 f_a}{F_e}\right)\right] Q F_b}\right] \le 1.0 \qquad (903.4\text{-}7)$$

for $\frac{f_a}{F_a} < 0.2$,

$$\left(\frac{f_a}{2F_a}\right) + \left[\frac{C_m\left(f_b + \sigma_{div}\right)}{\left[1 - \left(\frac{1.67 f_a}{F_e}\right)\right] Q F_b}\right] \le 1.0 \qquad (903.4\text{-}8)$$

f_a = P/A, required compressive stress, ksi (MPa)
P = required axial strength using ASD load combinations, kips (N)
f_b = M/S, required bending stress at the location under consideration, ksi (MPa)
σ_{div} = divergence stress applied where applicable as defined in Equation 903.2-17
M = required flexural strength using ASD load combinations, kip-in (N-mm)
S = elastic Section Modulus, in^3 (mm^3)
F_a = allowable axial compressive stress based on ℓ/r as defined in Section 903.2(b), ksi (MPa)

F_b = 0.6 F_y, allowable bending stress, ksi (MPa)
C_m = 1 - 0.5 f_a/F_e for end panels
C_m = 1 - 0.67 f_a/F_e for interior panels

(b) Web

The vertical shears to be used in the design of the web members shall be determined from full uniform loading, but such vertical shears shall be not less than 25 percent of the end reaction.

Interior vertical web members used in modified Warren-type web systems shall be designed to resist the gravity loads supported by the member plus an additional axial load of 1/2 of 1 percent of the top chord axial force.

(c) Eccentricity

Members connected at a joint shall have their center-of-gravity lines meet at a point, if practical. Eccentricity on either side of the neutral axis of chord members may be neglected when it does not exceed the distance between the neutral axis and the back of the chord. Otherwise, provision shall be made for the stresses due to eccentricity. Ends of joists shall be proportioned to resist bending produced by eccentricity at the support.

(d) Extended Ends

Extended top chords or full depth cantilever ends require the special attention and coordination between the specifying professional and NMBS. The magnitude and location of the loads to be supported, deflection requirements, and proper bracing shall be clearly indicated in the contract documents and joist erection plans.

903.5 CONNECTIONS

(a) Methods

Joist connections and splices shall be made by attaching the members to one another by arc or resistance welding or other accredited methods.

(1) Welded Connections
a) Selected welds shall be inspected visually by the manufacturer. Prior to this inspection, weld slag shall be removed.
b) Cracks are not acceptable and shall be repaired.
c) Thorough fusion shall exist between weld and base metal for the required design length of the weld; such fusion shall be verified by visual inspection.
d) Unfilled weld craters shall not be included in the design length of the weld.
e) Undercut shall not exceed 1/16 inch (2 mm) for welds oriented parallel to the principal stress.
f) The sum of surface (piping) porosity diameters shall not exceed 1/16 inch (2 mm) in any 1 inch (25 mm) of design weld length.
g) Weld spatter that does not interfere with paint coverage is acceptable.

(2) Welding Program

NMBS shall have a program for establishing weld procedures and operator qualification, and for weld sampling and testing. (Refer to Steel Joist Institute *Technical Digest #8, Welding of Open Web Steel Joists*.)

(3) Weld Inspection by Outside Agencies (See Section 904.13 of this specification).

The agency shall arrange for visual inspection to determine that welds meet the acceptance standards of Section 903.5(a)(1). Ultrasonic, X-ray, and magnetic particle testing are inappropriate for joists due to the configurations of the components and welds.

(b) Strength

(1) Joint Connections shall develop the maximum force due to any of the design loads, but not less than 50 percent of the strength of the member in tension or compression, whichever force is the controlling factor in the selection of the member.

(2) Shop Splices may occur at any point in chord or web members. Splices shall be designed for the member force but not less than 50 percent of the member strength. Members containing a butt weld splice shall develop an ultimate tensile force of at least 2 x 0.6 F_y times the full design area of the chord or web. The term "member" shall be defined as all component parts comprising the chord or web, at the point of splice.

(c) Field Splices

Field Splices shall be designed by NMBS in accordance with the AISC *Steel Construction Manual*. Splices shall be designed for the member forces, but not less than 50 percent of the member strength.

Top chord splices may be designed as "compression only" when the joist is not subject to an in-service net uplift. Most all joists are subject to negative bending moment during hoisting at erection and "compression only" splices shall be designed for these tension forces.

903.6 CAMBER

SP-Series joists are furnished with no camber. NMBS can provide special camber as required by the contract documents. The specifying professional shall give consideration to coordinating joist elevation with adjacent framing. Technical performance requirements shall be coordinated between NMBS and the specifying professional.

903.7 VERIFICATION OF DESIGN & MANUFACTURE

(a) Design Calculations

Design calculations prepared by a professional engineer registered in the state of the NMBS manufacturing plant are available for NMBS SP-Series joists upon request.

SECTION 904. APPLICATION

904.1 USAGE

This specification shall apply to any type of structure where roof decks are to be supported directly by SP-Series joists installed as hereinafter specified. Where SP-Series joists are used other than on simple spans under uniformly distributed loading as prescribed in Section 903.1, they shall be investigated and modified if necessary to limit the required stresses to those listed in Section 903.2.

CAUTION: If a rigid connection of the bottom chord is to be made to the column or other support, it shall be made only after the application of the dead loads. The joist is then no longer simply supported, and the system must be investigated for continuous frame action by the specifying professional.

The designed detail of a rigid-type connection and moment plates shall be shown in the contract documents and on the structural drawings by the specifying professional. The moment plates shall be furnished by other than NMBS.

904.2 SPAN

The term "span" as used herein is defined as shown on the diagram at the right. On beams, the span is to the center line of the supporting steel and on a wall, span is defined as 6" (152 mm) over the support. In each case, the vertical location of the point for determining span is at the top of the joist top chord.

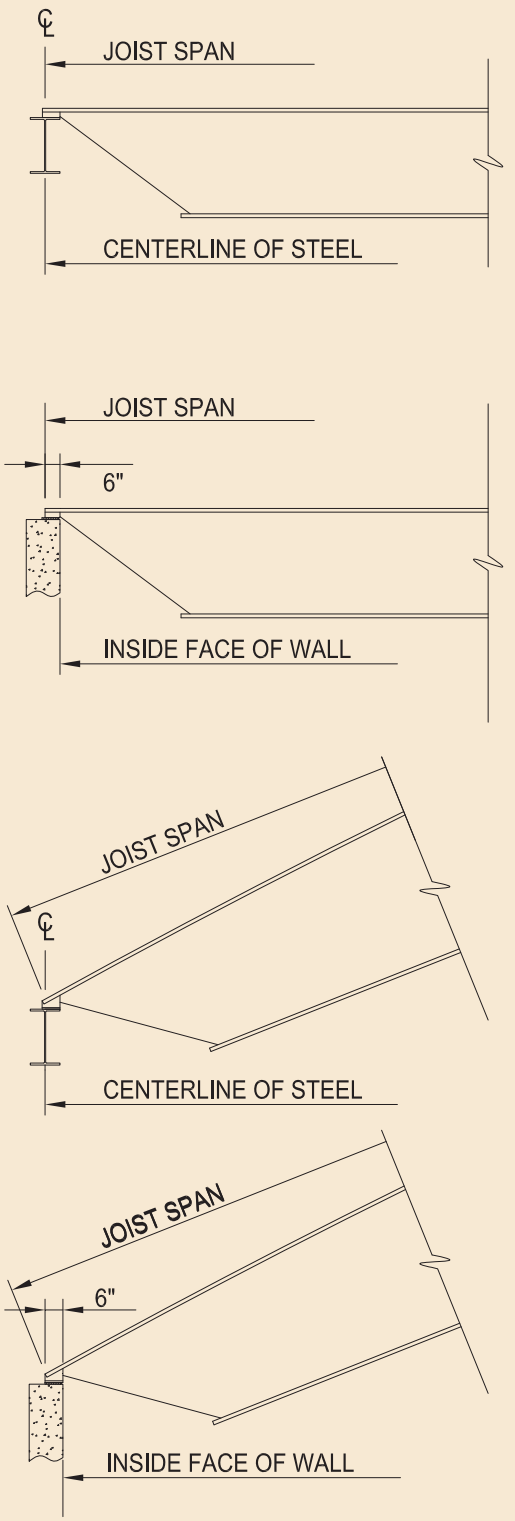
When the bearing points of a SP-Series joist are at different elevations, the span of the joist shall be determined by the length along the slope.

In all cases, the design length of the joist is equal to the span less 4" (102 mm).

904.3 DEPTH

The nominal depth as specified in the designation of SP-Series joists shall be the maximum depth of the joist as measured between the top and bottom chords. When joist geometry consists of parallel chords, (e.g. Scissor or Arch), the measurement shall be made perpendicular to the top and bottom chord. If a profile not conforming to one of the four types or variations in this catalog is used, the nominal depth shall be measured perpendicular to a chord tangent, at a discontinuous panel point, (i.e. top or bottom chord ridge), or at the greatest nominal depth along the span. In any case, dimensions to be used in design shall be as specified in the contract documents.

SP-Series joists may have various chord configurations and may have bearing conditions that cause the excessive pitch in the chords. The design of the joist in all cases shall be comprehensive to meet all SP-Series design requirements set forth in the contract documents.



WHEN SP-SERIES JOISTS BEAR AT DIFFERENT ELEVATIONS, JOIST SPAN IS DEFINED ALONG THE SLOPE. USE THE CENTERLINE OF BEAM FOR STEEL AND 6" OF BEARING ON MASONRY.

904.4 END SUPPORTS

(a) Masonry and Concrete

SP-Series joists supported by masonry or concrete are to bear on steel bearing plates and shall be designed as steel bearing. Due consideration of the end reactions and all other vertical or lateral forces shall be taken by the specifying professional in the design of the steel bearing plate and the masonry or concrete. The ends of SP-Series joists shall extend a distance of not less than 6 inches (152 mm) over the masonry or concrete support and be anchored to the steel bearing plate. The plate shall be located not more than 1/2 inch (13 mm) from the face of the wall and shall not be less than 9 inches (229 mm) wide perpendicular to the length of the joist. The plate is to be designed by the specifying professional and shall be furnished by other than NMBS.

Where it is deemed necessary to bear less than 6 inches (152 mm) over the masonry or concrete support, special consideration is to be given to the design of the steel bearing plate and the masonry or concrete by the specifying professional. The joists must bear a minimum of 4 inches (102 mm) on the steel bearing plate.

(b) Steel

Due consideration of the end reactions and all other vertical and lateral forces shall be taken by the specifying professional in the design of the steel support. The ends of SP-Series joists shall extend a distance of not less than 4 inches (102 mm) over the steel supports.

904.5 BRIDGING

Top and bottom chord bridging is required and shall consist of one or both of the following types.

(a) Horizontal

Horizontal bridging shall consist of continuous horizontal steel members with a ℓ/r ratio of the bridging member of not more than 300, where ℓ is the distance in inches (mm) between attachments and r is the least radius of gyration of the bridging member.

(b) Diagonal

Diagonal bridging shall consist of cross-bracing with a ℓ/r ratio of not more than 200, where ℓ is the distance in inches (mm) between connections and r is the least radius of gyration of the bridging member. Where cross-bracing members are connected at their point of intersection, the ℓ distance shall be taken as the distance in inches (mm) between connections at the point of intersection of the bridging members and the connections to the chord of the joists.

(c) Bridging Types

For spans less than or equal to 20 feet (6.096 m), welded horizontal bridging may be used. If the joist center of gravity is above the supports, the row of bridging nearest the center is required to be bolted diagonal bridging.

For spans more than 20 feet (6.096 m) all rows shall be bolted diagonal bridging. Where the joist spacing is less than 2/3 times the joist depth at the bridging row, both bolted diagonal bridging and bolted horizontal bridging shall be used.

(d) Quantity and Spacing

The maximum spacing of lines of bridging shall not exceed the values in Table 904.5-1.

TABLE 904.5-1

BRIDGING SPACING AND FORCES		
TOP CHORD LEG SIZE	**MAXIMUM BRIDGING SPACING**	**NOMINAL FORCE REQUIRED**
< 2″	10′-6″	500 lbs.
2″	12′-6″	500 lbs.
2½″	14′-6″	600 lbs.
3″	16′-6″	800 lbs.
3½″	18′-6″	1050 lbs.
4″	20′-6″	1700 lbs.
5″	24′-6″	2150 lbs.
6″ x 6″ x 0.500″	24′-6″	3250 lbs.
6″ x 6″ x 0.625″	24′-6″	4150 lbs.
6″ x 6″ x 0.75″	24′-6″	4950 lbs.
Nominal bracing force is unfactored. 8″ chords – contact NMBS		

(e) Connections

Connections to the chords of the steel joists shall be made by positive mechanical means or by welding, and capable of resisting a horizontal force not less than that specified in Table 904.5-1.

(f) Bottom Chord Bearing Joists

Where bottom chord bearing joists are utilized, a row of diagonal bridging shall be provided near the support(s). This bridging shall be installed and anchored before hoisting cables are released.

904.6 INSTALLATION OF BRIDGING

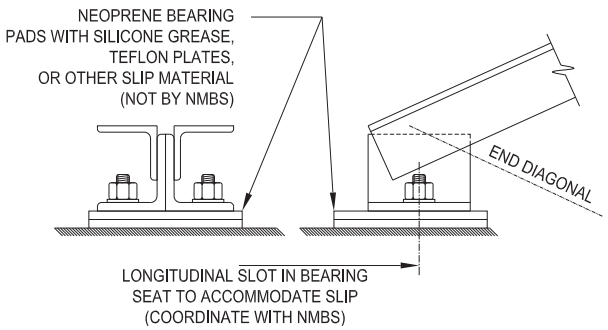
Bridging shall support the top and bottom chords against lateral movement during the construction period and shall hold the steel joists in the approximate position as shown on the joist placement plans.

The ends of all bridging lines terminating at walls or beams shall be anchored to resist the nominal force shown in Table 904.5-1.

904.7 BEARING SEAT ATTACHMENT

CAUTION: Scissor and Arch joists with fixed anchorage conditions may induce a horizontal thrust to the supporting structure. The specifying professional shall give consideration to this thrust at the fixed ends of the joist. Alternatively, roller (slip) end supports result in lateral displacement of the reaction at the roller (slip) end of the joist. Anchorage conditions must be investigated by the specifying professional and the design of the supporting structure shall accommodate appropriate anchorage conditions.

For applicable conditions, horizontal thrust force to be resisted by the joist or allowable lateral slip at the support and design details of end anchorage conditions shall be clearly indicated by the specifying professional on the contract documents.



(a) Masonry and Concrete

Ends of SP-Series joists resting on steel bearing plates on masonry or structural concrete shall be attached thereto with a minimum of two 1/4 inch (6 mm) fillet welds 2 inches (51 mm) long, or with two 3/4 inch (19 mm) ASTM A307 bolts (minimum), or the equivalent.

(b) Steel

Ends of SP-Series joists resting on steel supports shall be attached thereto with a minimum of two 1/4 inch (6 mm) fillet welds 2 inches (51 mm) long, or with two 3/4 inch (19 mm) ASTM A307 bolts (minimum), or the equivalent. When SP-Series joists are used to provide lateral stability to the supporting member, the final connection shall be made by welding or as designated by the specifying professional.

(c) Uplift

Where uplift forces are a design consideration, SP-Series joists shall be anchored to resist such forces (Refer to Section 904.12 Uplift).

904.8 JOIST SPACING

Joists shall be spaced so that the loading on each joist does not exceed the design load (LRFD or ASD) for the particular joist as designated in the contract documents.

904.9 ROOF DECKS

(a) Material

Roof decks may consist of gypsum, formed steel, wood, or other suitable material capable of supporting the required load at the specified joist spacing.

(b) Bearing

Decks shall bear uniformly along the top chords of the joists.

(c) Attachments

The spacing of attachments along the joist top chord shall not exceed 36 inches (914 mm). Such attachments of the deck to the top chord of joists shall be capable of resisting the forces given in Table 904.9-1.

TABLE 904.9-1

DECK ATTACHMENT FORCES	
TOP CHORD LEG	**NOMINAL FORCE REQUIRED**
≤2″	100 PLF
2½″	150 PLF
3″	200 PLF
3½″	250 PLF
4″	400 PLF
5″	500 PLF
6″ x 6″ x 0.500″	600 PLF
6″ x 6″ x 0.625″	750 PLF
6″ x 6″ x 0.75″	850 PLF
Nominal bracing force is unfactored. 8″ chords – contact NMBS	

(d) Wood Nailers

Where wood nailers are used, such nailers in conjunction with deck shall be firmly attached to the top chords of the joists in conformance with Section 904.9(c).

904.10 DEFLECTION

The deflection due to the design live or snow load shall not exceed the following:

Roofs:

- 1/360 of span where a plaster ceiling is attached or suspended
- 1/240 of span for all other cases

The specifying professional shall give consideration to the effects of deflection.

904.11 PONDING

The ponding investigation shall be performed by the specifying professional. Refer to Steel Joist Institute *Technical Digest #3, Structural Design of Steel Joist Roofs to Resist Ponding Loads* and AISC *Steel Construction Manual*.

904.12 UPLIFT

Where uplift forces due to wind are a design requirement, these forces must be indicated in the contract documents in terms of NET uplift in pounds per square foot (Pascals). The contract documents shall indicate if the net uplift is based upon LRFD or ASD. When these forces are specified, they must be considered in the design of joists and/or bridging. A single line of **bottom chord** bridging must be provided near the first bottom chord panel points whenever uplift due to wind forces is a design consideration. Refer to Steel Joist Institute *Technical Digest #6, Structural Design of Steel Joist Roofs to Resist Uplift Loads*.

904.13 INSPECTION

Joists shall be inspected by NMBS before shipment to verify compliance of materials and workmanship with the requirements of these specifications. If the buyer wishes an inspection of the steel joists by someone other than NMBS, they may reserve the right to do so in their "Invitation to Bid" or the accompanying "Job Specifications."

Arrangements shall be made with NMBS for such inspection of the joists at the manufacturing facility by the buyer's inspectors at buyer's expense.

SECTION 905. ERECTION STABILITY AND HANDLING

905.1 STABILITY

When it is necessary for the erector to climb on the SP-Series joists, extreme caution must be exercised since unbridged joists may exhibit some degree of instability under the erector's weight. The degree of instability increases for geometries common with SP-Series joists due to their higher center-of-gravity.

(a) Stability Requirements

(1) Before an employee is allowed on the SP-Series joists: BOTH ends of joists at columns (or joists designated as column joists) shall be attached to its supports. For all other joists a minimum of one end shall be attached before the employee is allowed on the joist. The attachment shall be in accordance with Section 904.7.

When a bolted seat connection is used for erection purposes, as a minimum, the bolts must be snug tightened. The snug tight condition is defined as the tightness that exists when all plies of a joint are in firm contact. This may be attained by a few impacts of an impact wrench or the full effort of an employee using an ordinary spud wrench.

(2) For SP-Series joists with spans less than or equal to 20 feet (6.096 mm) that are permitted to have horizontal bridging per the restrictions of Section 904.5.(c), only one employee shall be allowed on the joists unless all bridging is installed and anchored.

(3) For SP-Series joists with spans more than 20 feet (6.096m), the following shall apply:

a) All rows of bridging shall be bolted diagonal bridging. Where the joist spacing is less than 2/3 times the joist depth at the bridging row, both bolted diagonal bridging and bolted horizontal bridging shall be used.

b) Hoisting cables shall not be released until all bolted bridging is installed and anchored, unless an alternate method of stabilizing the joist has been provided.

c) No more than one employee shall be allowed on these spans until all bridging is installed and anchored.

(4) When permanent bridging terminus points cannot be used during erection, additional temporary bridging terminus points are required to provide lateral stability.

(5) In the case of bottom chord bearing joists, the ends of the joist must be restrained laterally per Section 904.5(f) before releasing the hoisting cables.

(6) After the joist is straightened and plumbed, and all bridging is completely installed and anchored, the ends of the joists shall be fully connected to the supports in accordance with Section 904.7.

(b) Landing and Placing Loads

(1) Except as stated in paragraph 905(b)(3) of this section, no "construction loads"[1] are allowed on the SP-Series joists until all bridging is installed and anchored, and all joist bearing seats are attached.

(2) During the construction period, loads placed on the SP-Series joists shall be distributed so as not to exceed the capacity of the joists.

(3) The weight of a bundle of joist bridging shall not exceed a total of 1000 pounds (454 kilograms). The bundle of joist bridging shall be placed on a minimum of three steel joists that are secured at one end. The edge of the bridging bundle shall be positioned within 1 foot (0.30 m) of the secured end.

(4) No bundle of deck may be placed on SP-Series joists until all bridging has been installed and anchored and all joist bearing ends attached, unless the following conditions are met:

a) The contractor has first determined from a "qualified person"[2] and documented in a site specific erection plan that the structure or portion of the structure is capable of supporting the load.

b) The bundle of decking is placed on a minimum of three steel joists.

c) The joists supporting the bundle of decking are attached at both ends.

d) All rows of bridging are installed and anchored.

e) The total weight of the decking does not exceed 4000 pounds (1816 kilograms).

f) The edge of the bundle of decking shall be placed within one foot (0.30 m) of the bearing surface of the joist end.

(5) The edge of the construction load shall be placed within one foot (0.30 m) of the bearing surface of the joist end.

[1] A copy of the *OSHA Steel Erection Standard §1926.757, Open Web Steel Joists*, is included at www.newmill.com for reference. Construction loads are defined therein for joist purposes as "any load other than the weight of the employee(s), the joists and the bridging."

[2] A copy of the *OSHA Steel Erection Standard §1926.757, Open Web Steel Joists*, may be found at www.newmill.com for reference. Qualified person is defined therein as "one who, by possession of a recognized degree, certificate, or professional standing, or who by extensive knowledge, training, and experience, has successfully demonstrated the ability to solve or resolve problems relating to the subject matter, the work, or the project."

(c) Field Welding

(1) All field welding shall be performed in accordance with the contract documents. Field welding shall not damage the joists.

(2) On cold-formed members whose yield strength has been attained by cold working, and whose as-formed strength is used in the design, the total length of weld at any one point shall not exceed 50 percent of the overall developed width of the cold-formed section.

(d) Handling

Particular attention should be paid to the erection of SP-Series joists. Care shall be exercised at all times to avoid damage to the joists and accessories.

Each joist shall be adequately braced laterally before any loads are applied. If lateral support is provided by bridging, the bridging lines, as defined in Section 905.1(a)(2) and 905.1(a)(3), must be anchored to prevent lateral movement.

(e) Fall Arrest Systems

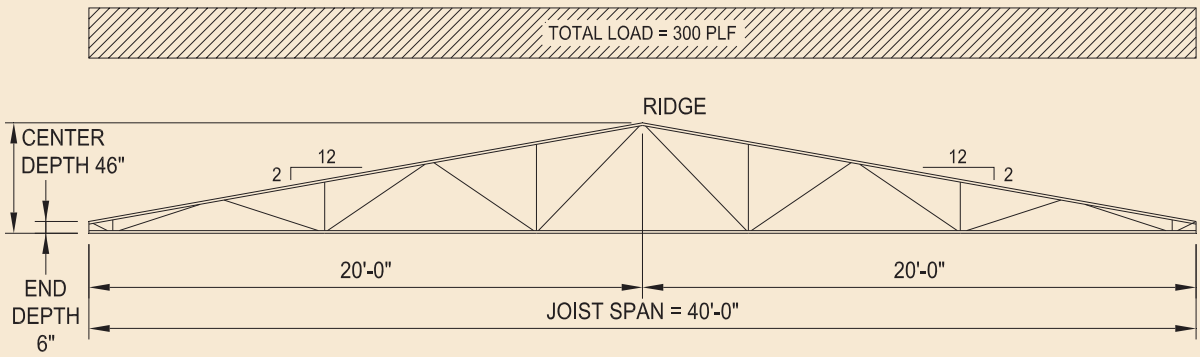
SP-Series joists shall not be used as anchorage points for a fall arrest system unless written direction to do so is obtained from a "qualified person."[2]

SECTION 906.
HOW TO SPECIFY SPECIAL PROFILE JOISTS

The following abbreviated design examples demonstrate the selection of an SP-Series joist from the Weight Tables given all necessary geometry and loading information. The information found in the SP-Series Weight Tables includes the uniform self-weight of the joist as well as bridging and seat-depth requirements. For Scissor (SPSC) and Arch (SPAC) Joists, the table will note if the horizontal deflection is greater than 2". This allowance is for a pin-roller bearing anchorage condition. The horizontal deflection, or slip, is at the roller end.

906.1 GABLE EXAMPLE

ALL TABLES ARE BASED ON ASD



GABLE JOIST (SPGB)

From the above diagram, the following information is used to enter the Gable Joists (SPGB) Tables on page 20.

Span: 40'-0" Center Depth: 46" End Depth: 6" Top Chord Pitch: 2" / foot

Total Load: 300 plf — Total Load is the result of worst-case equivalent uniform load, $W_{eqM\text{-}TL}$, based on investigation of all load cases.

Live Load: 120 plf — SP-Series tables are based on a 0.75 Live to Total Load ratio (300 x 0.75 = 225 plf) and check for a Live Load deflection not to exceed L/240, or 40' x 12 / 240 = 2" maximum deflection for 225 plf. The Live Load in this example, 120 plf, is less than 75 percent of the total load, 225 plf, therefore deflection is within limits.

Uplift Load: 160 plf — Net Uplift is not shown in the above diagram but is called out in the contract documents in the NET UPLIFT plan.

Joist Designation: 46 SPGB 300 / 120 / 160

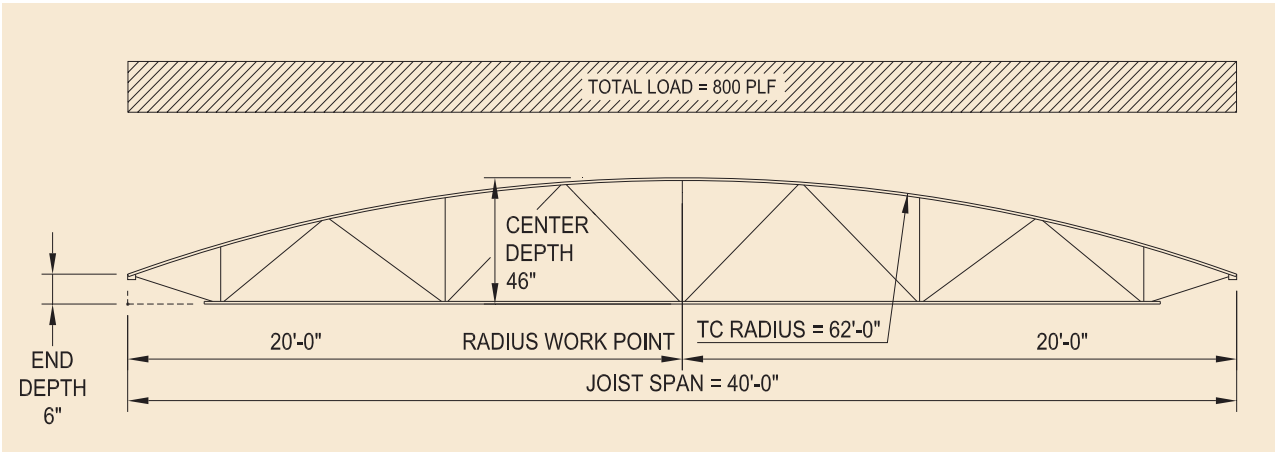
From the information above, the correct geometry is found on page 24.

From the table:	Joist Self-Weight:	8 PLF
	Bridging Required:	3 Rows of Bolted X-Bridging
	Seat Depth:	5" Deep Seats

Bridging and seat depth information should be noted in the contract documents and reflected in the section details.

906.2 BOWSTRING EXAMPLE

ALL TABLES ARE BASED ON ASD



BOWSTRING JOIST (SPBW)

From the above diagram, the following information is used to enter the Bowstring Joists (SPBW) Tables on page 36.

Span: 40'-0" Center Depth: 46" End Depth: 6" Top Chord Radius: 62'-0"

Total Load: 800 plf — Total Load is the result of worst-case equivalent uniform load, $W_{eqM\text{-}TL}$, based on investigation of all load cases.

Live Load: 400 plf — SP-Series tables are based on a 0.75 Live to Total Load ratio (800 x 0.75 = 600 plf) and check for a Live Load deflection not to exceed L/240, or 40' x 12 / 240 = 2" maximum deflection for 600 plf. The Live Load in this example, 400 plf, is less than 75 percent of the total load, 600 plf, therefore deflection is within limits.

Uplift Load: 220 plf — Net Uplift is not shown in the above diagram but is called out in the contract documents in the NET UPLIFT plan.

Joist Designation: 46 SPBW 800 / 400 / 220

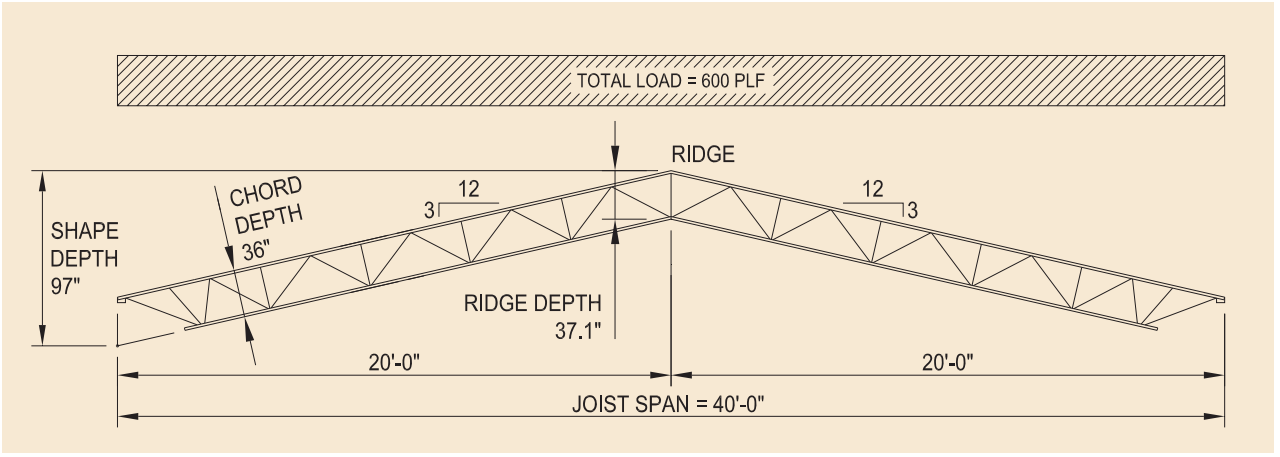
From the information above, the correct geometry is found on page 40.

From the table:	Joist Self-Weight:	17 PLF
	Bridging Required:	3 Rows of Bolted X-Bridging
	Seat Depth:	5" Deep Seats

Bridging and seat depth information should be noted in the contract documents and reflected in the section details.

906.3 SCISSOR EXAMPLE

ALL TABLES ARE BASED ON ASD



SCISSOR JOIST (SPSC)

From the above diagram, the following information is used to enter the Scissor Joists (SPSC) Tables on page 52.

Span: 40'-0" Chord Depth: 36" Shape Depth: 97" Top Chord Pitch: 3" / foot
Ridge Depth: 37.1"

Total Load: 600 plf — Total Load is the result of worst-case equivalent uniform load, $W_{eqM\text{-}TL}$, based on investigation of all load cases.

Live Load: 370 plf — SP-Series tables are based on a 0.75 Live to Total Load ratio (600 x 0.75 = 450 plf) and check for a Live Load deflection not to exceed L/240, or 40' x 12 / 240 = 2" maximum deflection for 450 plf. The Live Load in this example, 370 plf, is less than 75 percent of the total load, 450 plf, therefore deflection is within limits.

Uplift Load: 110 plf — Net Uplift is not shown in the above diagram but is called out in the contract documents in the NET UPLIFT plan.

Joist Designation: 36 SPSC 600 / 370 / 110

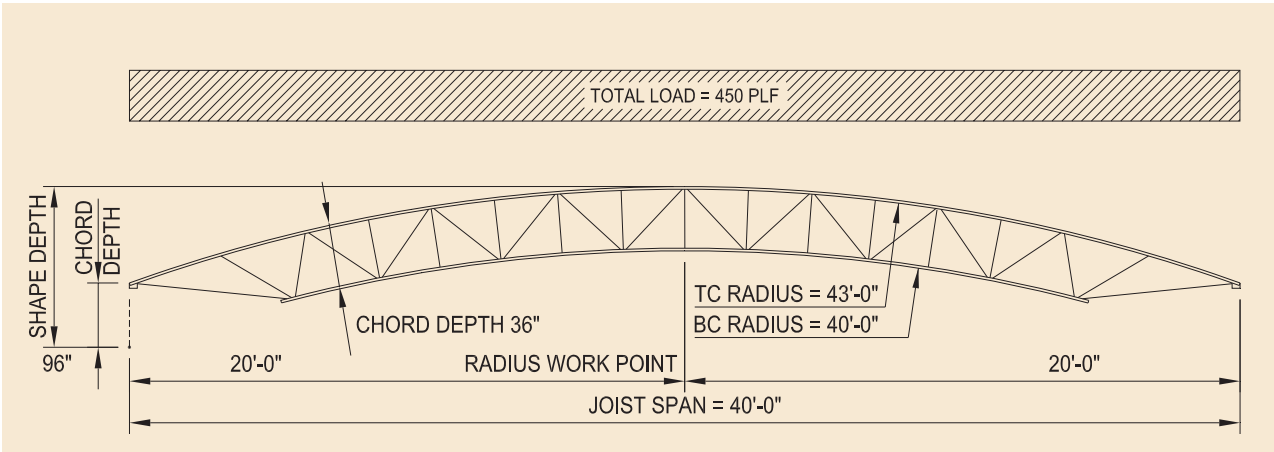
From the information above, the correct geometry is found on page 56.

From the table:	Joist Self-Weight:	18 PLF
	Bridging Required:	2 Rows of Bolted X-Bridging
	Seat Depth:	5 Deep Seats
	Horizontal Deflection:	≤2"; as the note for δ_X>2 is not shown in the cell

Bridging and seat depth information should be noted in the contract documents and reflected in the section details.

906.4 ARCH EXAMPLE

ALL TABLES ARE BASED ON ASD



ARCH JOIST (SPAC)

From the above diagram, the following information is used to enter the Arch Joists (SPAC) Tables on page 68.

Span: 40'-0" Chord Depth: 36" Shape Depth: 96" Top Chord Radius: 43'-0"

Total Load: 450 plf — Total Load is the result of worst-case equivalent uniform load, $W_{eqM\text{-}TL}$, based on investigation of all load cases.

Live Load: 315 plf — SP-Series tables are based on a 0.75 Live to Total Load ratio (450 x 0.75 = 338 plf) and check for a Live Load deflection not to exceed L/240, or 40' x 12 / 240 = 2" maximum deflection for 338 plf. The Live Load in this example, 315 plf, is less than 75 percent of the total load, 338 plf, therefore deflection is within limits.

Uplift Load: 200 plf — Net Uplift is not shown in the above diagram but is called out in the contract documents in the NET UPLIFT plan.

Joist Designation: 36 SPAC 450 / 315 / 200

From the information above, the correct geometry is found on page 72.

From the table:	Joist Self-Weight:	17 PLF
	Bridging Required:	2 Rows of Bolted X-Bridging
	Seat Depth:	5 Deep Seats
	Horizontal Deflection:	≤2"; as the note for x>2 is not shown in the cell

Bridging and seat depth information should be noted in the contract documents and reflected in the section details.