NEW MILLENNIUM
BUILDING SYSTEMS

SPECIAL PROFILE STEEL JOISTS
GABLE JOISTS
BOWSTRING JOISTS
SCISSOR JOISTS
ARCH JOISTS

5

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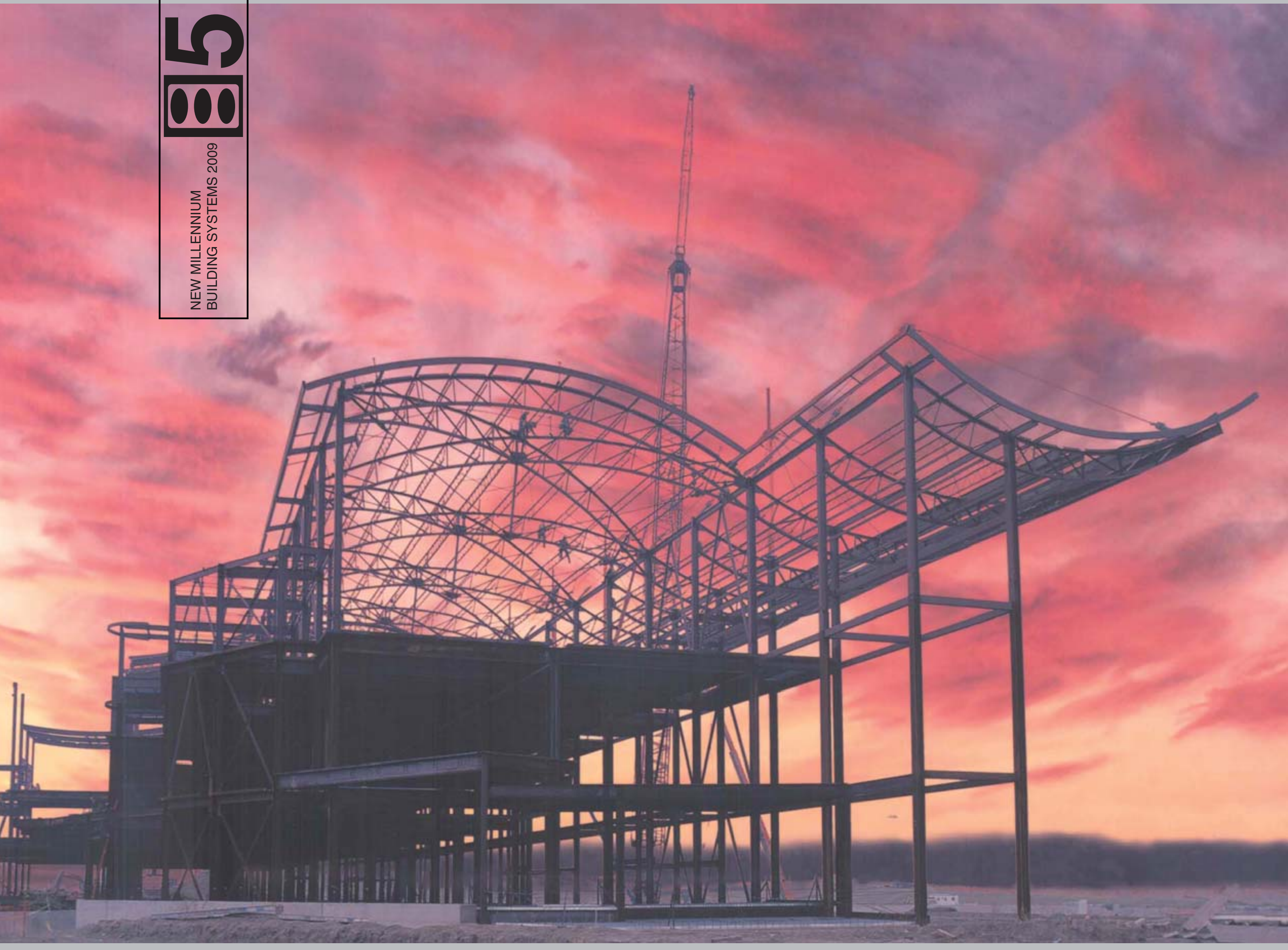

SPECIAL PROFILE STEEL JOIST CATALOG

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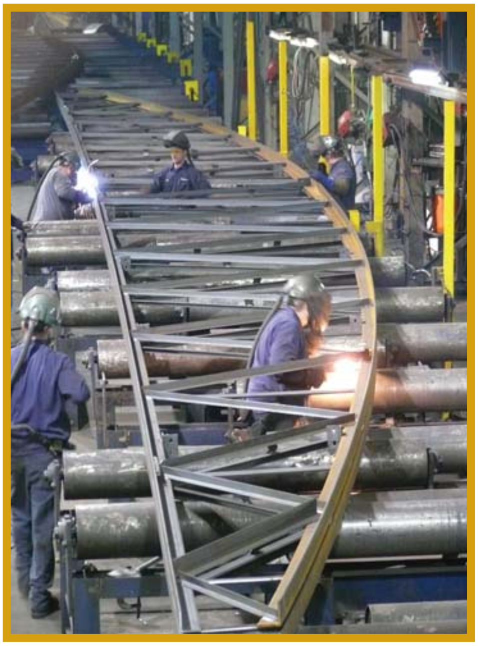

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NEW MILLENNIUM BUILDING SYSTEMS FACILITIES

New Millennium Building Systems (NMBS) is a wholly owned subsidiary of Steel Dynamics, Inc., manufacturing a complete range of joist and deck products. NMBS is a member of both the Steel Joist Institute and the Steel Deck Institute. NMBS joist products approved by the Steel Joist Institute for manufacture include K, LH, DLH Series joists and Joist Girders, designed and manufactured in accordance with the specifications of the Steel Joist Institute.

NMBS can also produce Special Profile Steel Joists, SP-Series, designed and manufactured in accordance with the Specifications in this catalog.

To locate the NMBS service representative in your immediate area, please call or visit www.newmill.com.

Locations:

Butler, Indiana
(260) 868-6000

Salem, Virginia
(540) 389-0211

Fallon, Nevada
(888) 643-1577

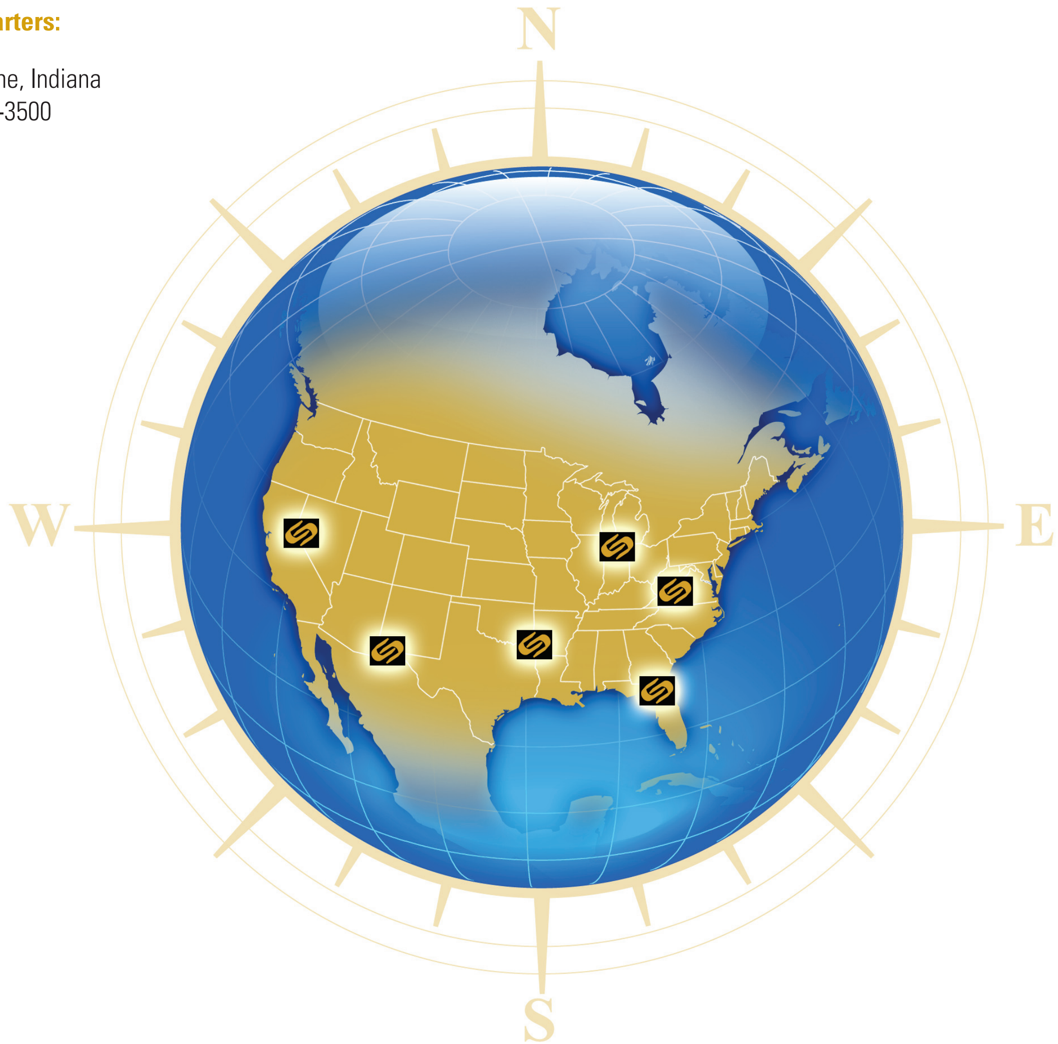
Lake City, Florida
(386) 466-1300

Hope, Arkansas
(800) 643-1577

Juarez, Mexico
(915) 298-5050

Headquarters:

Fort Wayne, Indiana
(260) 969-3500



NEW MILLENNIUM
BUILDING SYSTEMS

SPECIAL PROFILE STEEL JOISTS, SP-SERIES

INTRODUCTION & PURPOSE

The Steel Joist Institute (SJI) was organized in 1928 to standardize industry practices among competing companies. As its inception was prior to the computerized designs and manufacturing equipment available today, the information published was simple and limited in scope. Since then, the SJI has provided a collective source of information for architects and engineers specifying open web steel joists. The efficiency and ease of erection increased the use and performance scope of open web steel joists throughout the construction industry. As design and manufacturing technology has improved, so has the industry's ability to provide higher strength materials, more complex design methods, special geometries, and seemingly limitless uses of open web steel joists. Throughout these changes, the Steel Joist Institute's *Standard Specifications and Load Tables* have evolved to take advantage of the advancements.

ADVANTAGES OF SP-SERIES

- Special profiles provide distinctive architectural effects.
- Arch and Scissor profiles provide increased bottom chord clearance.
- Bowstring and Arch joists provide higher slope with increased drainage to the roof surface near eaves.

ADDITIONAL RESOURCES

Please contact New Millennium Building Systems with any questions about SP-Series joists. Also visit www.newmill.com for contact information and more special profile information.

The purpose of this publication is to standardize the design and specification of special profile open web steel joists. This publication provides detailed design and background information not previously published for architects and engineers. New Millennium Building System's Special Profile Steel Joists, SP-Series, give professionals the creative freedom to specify special profile steel joists with the confidence of a design specification written with this purpose in mind.

The tables contained in this publication consist of four common profiles, Gable, Bowstring, Scissor, and Arch. Each profile's weight table contains roughly 10,000 joist designs for a total of nearly 40,000 presented in this publication. Each design adheres to the specification contained in this publication. The tables also contain bridging information, bearing seat depth requirements, and other important design information.

For industry information, details, and definitions in the current *OSHA Steel Erection Standard Part §1926* refer to www.newmill.com and the appendix in the current NMBS standard catalog for Steel Joists, Joist Girders, and Steel Deck.

QUALITY ASSURANCE

JOIST CERTIFICATIONS

- NMBS is a member of the Steel Joist Institute, fully certified to manufacture K-Series, LH-Series, DLH-Series, and Joist Girder Series products.
- All NMBS welders are certified in accordance with the American Welding Society AWS D1.1 and AWS D1.3.
- The Indiana facility is certified in accordance with the requirements of the current IBC / Michigan Building Code, Chapter 17, Section 1705, Paragraph 2.2.
- The Florida facility is certified in accordance with the requirements of the current Miami-Dade County, Florida Building Code, Article IV, Chapter 8. The Florida facility is also certified in accordance with the requirements of the Houston, Texas Building Code, Section 1704.2.2.

SHIPPING CONSIDERATIONS

NMBS has the capability to engineer and produce projects of the highest complexity throughout the United States. Each of our facilities has the capacity to manufacture Special Profile Joists, SP-Series, with quality above and beyond standard steel joists. When project demands are out of the ordinary, NMBS SP-Series joists will meet your expectations.

- What are the site conditions where the joists are being erected? Is routing a concern due to the planned or finalized dimensions of the SP-Series joists? Is access to the site constrained? Physical changes to the profile dimensions to minimize delivery costs may be considered. Changes to the site access may be necessary to accommodate some profiles.

- Can the SP-Series joists be shipped and erected in one piece or do they need to be field-spliced? If joists are exceptionally long, deep, or are to be erected inside an existing building, splicing the joists in the field may simplify the installation process. These considerations should be identified and settled before bid to eliminate the possibility of unexpected expenses.

- Some states have restrictions on when over-length or over-width material may travel and what types of escorts and route surveys are required. Therefore, it is important that delivery schedules are coordinated with NMBS well in advance of delivery.

- It is essential to coordinate material delivery schedules prior to shipping to ensure the erection crew has the proper equipment and is ready to unload when the truck arrives. NMBS engineering is available to provide joist's and bundle weights.

- Sufficient time should be allowed for safe unloading. Special Profile Joists, SP-Series, are more time consuming to unload and need careful handling to prevent accidents or damage to the joists. NMBS can coordinate each delivery to ensure sufficient time to unload and prepare for the next truck.

SPECIAL PROFILE STEEL JOISTS, SP-SERIES

AVAILABILITY

There are an endless number of possibilities for joist profiles, loadings, and applications. In order to make this catalog a more useful and focused publication, four distinct profiles were identified and made the focus. The four profiles are: Gable, Bowstring, Scissor, and Arch. Most SP-Series joists are either one of these four types, a variation of one type, or a combination of one or more types. When specifying SP-Series joists, communication between the specifying professional and NMBS is key to success.

SP-Series joists are available with either underslung or square ends. Due to the limitations of depth and span inherent in special profiles, it is recommended that the owner's representative contact NMBS early in the design stage. Considerable cost savings may be recognized by addressing design and shipping issues early in the design process. SP-Series joists may require horizontal or vertical field splicing involving installation cost at the job site. To ensure a fair and accurate bidding process, these issues should be identified and resolved prior to bid. Design calculations prepared by a professional engineer registered in the state of manufacture are available for NMBS SP-Series joists.

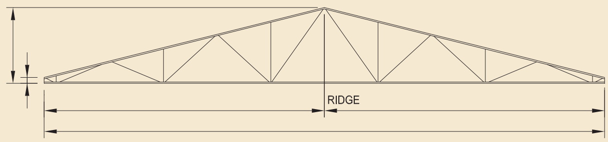
Experienced NMBS design personnel equipped with sophisticated design software are on staff to help with the design of SP-Series joists or joist girders. In a matter of minutes, NMBS can design a SP-Series joist and e-mail a STAAD or AutoCAD file at no charge. This preliminary design can give you the head start that you need to gain a competitive edge.

GEOMETRY

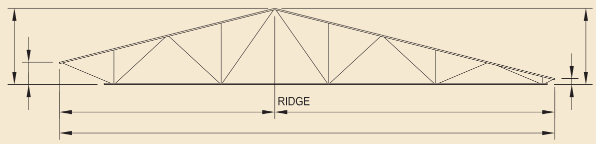
The dimensions shown on the SP-Series profile diagrams to the right and in the following page should be clearly shown and noted in the construction documents. Web layouts in SP-Series joists vary greatly depending on geometry and loading. Special web layouts may be specified on the contract documents for architectural needs or compatibility (e.g. duct clearances). Unless specifically noted or requested, NMBS will provide an economical web geometry that meets the requirements of this specification and those contained in the contract documents. When special web layouts are required, they should be clearly shown and noted in the contract documents.

The old adage "deeper is cheaper" is true when considering SP-Series joists. It is also usually more cost effective to specify fewer joists, with increased spacing, and therefore heavier, compared to more numerous, lighter joists at narrower spacing.

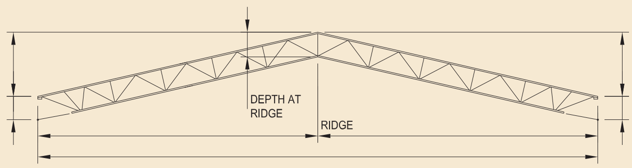
All SP-Series joists are provided with no camber unless otherwise specified in the contract documents.



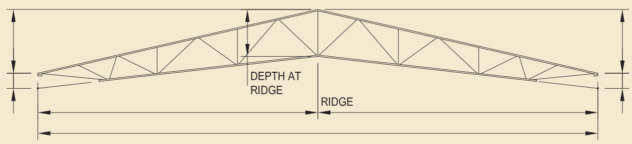
GABLE



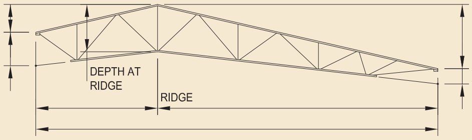
OFFSET GABLE



SCISSOR

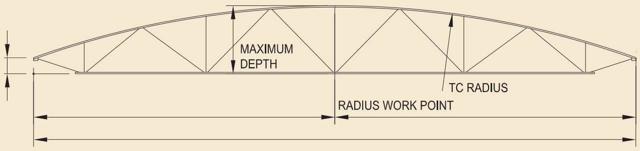


COMPOUND SCISSOR

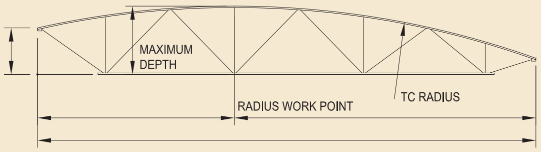


OFFSET COMPOUND SCISSOR

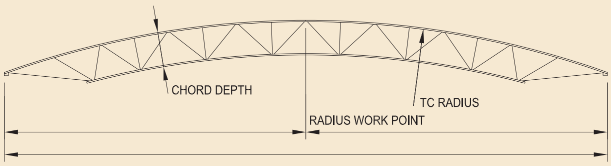
SPECIAL PROFILE STEEL JOISTS, SP-SERIES



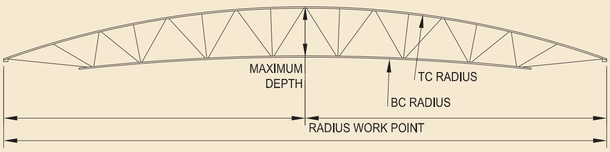
BOWSTRING



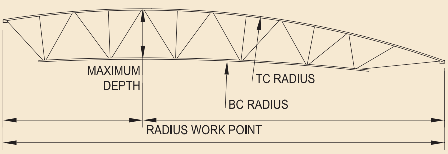
OFFSET BOWSTRING



ARCH



COMPOUND ARCH



OFFSET COMPOUND ARCH

DESIGN

The specifying professional has several things to consider when specifying SP-Series joists. The specifying professional is responsible for providing all loads for which the joist or joist girder must be designed. NMBS can help identify and suggest areas for review and value engineering on SP-Series joists to insure proper load development, analysis, and structural design for any project.

WIND LOADS

Design of structures to resist wind load in combination with other loads is required by every building code. Wind load alone creates both lateral forces and uplift forces on a structure. The lateral forces and uplift forces on a structure must be resisted by the primary and secondary roof support members. Both types of forces may or may not involve roof deck, standard joists, joist girders, or SP-Series joists provided by NMBS.

The lateral wind moment or lateral forces are best provided to NMBS in terms of "Wind Moment" in units of foot-kips or "Wind Axial Load" in units of kips. As end moments and axial forces act in combination with other loads, (e.g. uniform gravity and continuity moments), coordination between the specifying professional and NMBS is crucial to ensure that the building code specified combinations are properly applied. Clear instructions on the contract documents and, better still, contact with NMBS during the design process is advised.

Uplift is best provided to NMBS in terms of "Net Uplift" in units of pounds per square foot and shown on a plan uplift layout. These loads are then applied to the affected members according to the tributary area. Uplift design may also involve additional rows of bridging or joist girder bottom chord braces beyond those required for normal erection stability.

On sloped roofs, wind load acting on the roof will create inward pressure on the windward side of the roof that is additive to normal gravity loading and outward pressure on the leeward side that opposes the normal gravity loading. Both loading conditions have effects on the resulting member forces and subsequent design. The specifying professional is reminded to clearly communicate such loads to NMBS.

GRAVITY LOADS

Design of structures to resist gravity snow load, dead load, and live load in combination with other loads is required by every building code.

When joists are part of the lateral force resisting system, they may also resist axial loads, end moments, or perform

SPECIAL PROFILE STEEL JOISTS, SP-SERIES

other structural requirements as determined by the design professional.

The uniform snow load in combination with the dead load (including estimated self-weight) is best provided to NMBS as part of the SP-Series designation in units of pounds per linear foot. Refer to the design examples on pages 13 through 19 for further explanation. There are also several abbreviated examples on pages 96 through 99.

On steep sloped or curved roof profiles more complex load combinations must be considered. Depending on the slope, snow drift may be a consideration or live load reduction may be permitted. Unbalanced loading may also create critical stresses. Coordination between the specifying professional and NMBS becomes crucial to ensure that code specified combinations are properly applied. Clear instructions in the contract documents and, better still, personal contact with NMBS during the design process is advised.

While it is not the purview of this document to dictate design loads, there are several items that must be drawn to the specifying professional's attention to ensure SP-Series joist designs are consistent with applicable building codes and specifications. Building codes vary in minimum load and load combination requirements. Model codes, such as the latest *International Building Code (IBC)* and the widely referenced *ASCE/SEI 7 Minimum Design Loads for Buildings and Other Structures*, contain complex sections dictating the application of loads to all components of buildings and other structures. Attention is drawn to the fact that the application of loads to sloping, curved, and pitched roofs that utilize SP-Series joists must be concerned with loads on horizontal and vertical projections, windward and leeward wind and snow loads, uniform and drifting snow, unbalanced loading, and myriad other possible loads specific to the geometry, geographic location, and structural functions explicit to the SP-Series joist design requirements.

The intent of the weight tables in this publication is to provide the specifying professional approximate weights, bridging requirements, seat depths, and other design information when appropriate for special profile joists. This information is to serve as a basis for comparison of alternative designs and value engineering purposes. The weight tables were generated based on various uniform loadings on a select array of Special Profile Joists, SP-Series, geometries. In using the weight tables, the specifying professional must use sound judgment in relating actual loading conditions to a comparable equivalent uniform load.

Design information should be clearly shown in the contract documents by the specifying professional. Load diagrams should convey load combinations, uniform load and unbalanced load requirements in addition to the total, live, and net uplift specified by the designation. Concentrated load values and locations should also be shown and noted by type and by applicable load case where appropriate.

See Section 906 – HOW TO SPECIFY SPECIAL PROFILE JOISTS

SPECIAL PROFILE STEEL JOISTS, SP-SERIES

FIRE RATINGS

NMBS SP-Series joists are made entirely of steel and are non-combustible. They qualify in roof construction for some uses in construction types that the model building codes identify as Type IA, IB, IIA, IIB, IIIA and IIIB. Specifying professionals should consult applicable local codes for details and other requirements for the entire roof system.

FABRICATION & DELIVERY

NMBS production facilities have been specifically designed and equipped to produce SP-Series joists. This allows NMBS to maintain the high quality our customers expect and provide cost advantages through state-of-the-art design and manufacturing facilities.

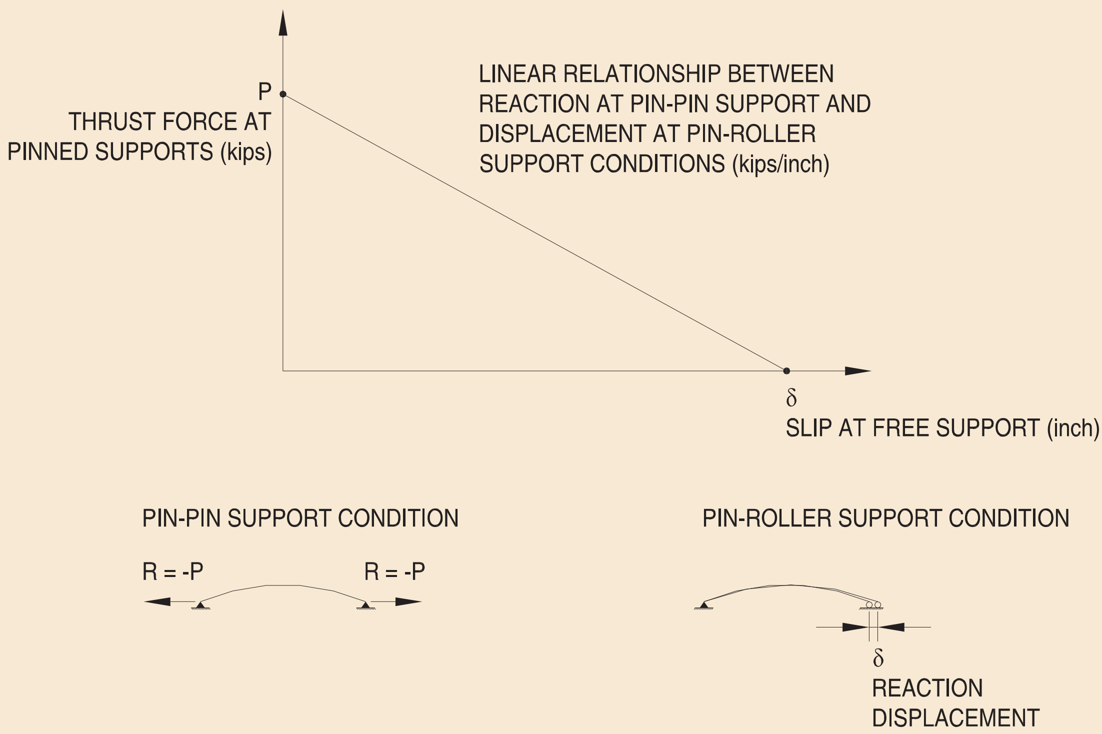
SP-SERIES DESIGN

HORIZONTAL REACTIONS

The behavior of some SP-Series profiles, such as Scissor or Arch, may cause a horizontal reaction to be applied to the supporting structure. When joists with upwardly curved or sloped bottom chords deflect under load, they either displace at the bearing points or induce a horizontal thrust force at the supports. The magnitude of the thrust force imparted to the support is a function of the stiffness of the joist, the stiffness of the support, and the attachment conditions. The chart below shows the linear interactive relationship between the two theoretical conditions.

From a design standpoint, one option is to provide a slip connection at one end, which eliminates the bearing restraint and the resulting horizontal thrust force (pin-roller condition). This option eliminates the possibility for the joist to transmit chord axial forces to the supporting structure at the slip-bearing end. For this condition, the specifying professional should coordinate the allowable horizontal deflection at the bearing with NMBS. Diaphragm forces collected into the joist chords must transfer through the pinned end of the joist seat. Consequently, joist anchorage must be designed for both the windward and leeward forces. The pin and roller anchorage conditions necessary for this approach must be intentionally designed and detailed by the specifying professional and clearly indicated in the contract documents. To facilitate proper design for this condition and to be certain that code specified requirements are properly satisfied, coordination between the specifying professional and NMBS is crucial.

A second design option is to design the end anchorage supports as fixed at each end (pin-pin condition). This design option may decrease the weight of the joist. However, the horizontal thrust at the end anchorage of the joist can be quite large and the resisting structure or tie must be designed by the specifying professional for the thrust force. Once the joist end attachment has been made, the combined horizontal stiffness of both the supporting structure and the joist must be large enough to develop the required horizontal thrust at the joist end anchorage. The required stiffness can be generated by means of a braced frame, a tension tie, or some other structural mechanism. Once again, clear instructions in the contract documents and, better still, personal contact with a NMBS design engineer during the quote and design process is imperative for successful SP-Series joist design.



LOAD ADJUSTMENT FACTORS

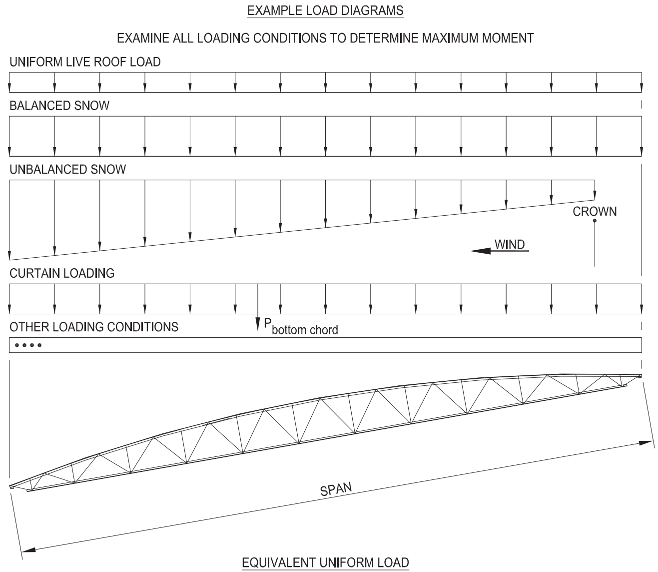
The SP-Series Weight Tables were generated using a uniform distributed load on a horizontal span. Therefore, the uniform loads specified in the SP-Series joist designations should be calculated as distributed normal to the span. Loads in design development are generally defined as horizontal or vertical. When the SP-Series joists' span is sloping, or when the top chord is pitched or curved, one or more adjustment factors are needed to convert actual loads, w_a, to the designation loads, w_d, used in the SP-Series designations.

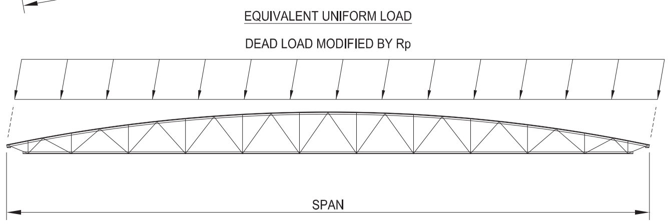
The first of these adjustment factors, R_p, is the Profile Projection Ratio and accounts for the difference between the actual chord length and the straight line length along the span. The Profile Projection Ratio comes in two varieties, R_{pp} and R_{pr}, for pitched chords and radius chords respectively. The purpose of the Profile Projection Ratio is to account for dead loads uniformly distributed on the actual length of the joist top chord, which will always be longer than the span length for SP-Series joists. Calculating and applying the R_p ratio enables the specifying professional to easily determine the equivalent uniform load projected normal to the span.

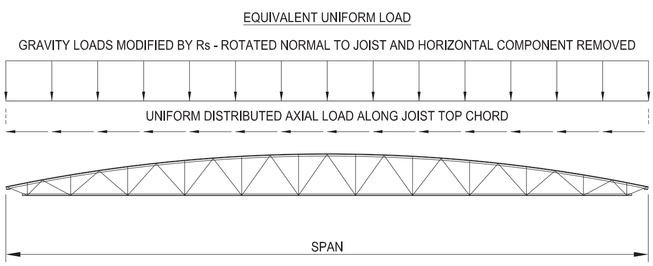
The second adjustment factor, R_s, is the Slope Projection Ratio and accounts for the difference in the horizontal span length and the joist span as defined in Section 904.2 on page 91. R_s is independent of the profile shape and should be calculated when the joist span is sloped. As seen on the right, applying R_s isolates the component of the uniform load normal to the span of the joist. The longitudinal component of this load translates into a uniform distributed axial load along the top chord of the joist. Load resulting from a slope as high as 4:12 has a negligible effect on the chords or webs. The chord size is generally governed by the maximum moment at the center, thus the axial load accumulated toward the low end of the joist does not govern over the chord force at the center of the joist.

The load adjustment factors R_p and R_s are independent of one another and must be applied to the design loads in order to accurately determine an equivalent uniform total gravity load. Figures to the right show the general theory for determining the uniform load with which to enter the joist tables. Design examples may be found on pages 13 through 19.

In order to convert uniform distributed loads generated in design development to uniform loads tabulated in the SP-Series Weight Tables, the specifying professional must first determine the maximum moment from all applicable load cases. The maximum moment will generally be the best determination for the chord sizes of the joist design since the top and bottom chords are the key factors in determining joist weight.







Once the maximum moment is determined, the next step is to find the equivalent total uniform load ($W_{eqM\text{-}TL}$) that would cause this maximum moment. While this method does assume that the maximum uniform moment occurs at the mid-span of the joist, it is accurate for determining a joist self-weight, bearing seat heights, and bridging requirements. NMBS engineering staff is available to assist with your specific design needs.

After determining the equivalent uniform moment, the next and final step is to adjust the uniform loads with R_s. Once the load is adjusted, the geometry and designation may be referenced in the SP-Series Weight Tables. The tables contain the uniform self-weight, bearing seat depth, bridging requirements, and horizontal deflection requirements when applicable.

SP-SERIES DESIGN

Profile Projection Ratio for Gable or Scissor Joists, R_{pp} = Ratio of the pitched length of the joist top chord to the length of span defined in Section 904.2. Because the length of the dead load supported by the pitched joist chord is longer than the span, the roof Dead Load, D, must be increased by the ratio of these values. Note that only dead loads in the pitched part of the roof need adjusted by R_{pp}. Dead loads defined in the horizontal plane (e.g. ceiling tiles) should not be adjusted. The roof Live Load, L_r, and Snow Load, S, which are defined on the horizontal projection are also not affected.

Gable or Scissor joists:

$$R_{pp} = \frac{\sqrt{Pitch^2 + 144}}{12}$$

Pitch = Rise per 12" of the top chord

Profile Projection Ratio for Arch or Bowstring Joists, R_{pr} = Ratio of the arched length of the joist top chord to the length of span defined in Section 904.2. Because the length of the dead load supported by the arched joist chord is longer than the span, the roof Dead Load, D, must be increased by the ratio of these values. Note that only dead loads in the arched part of the roof need adjusted by R_{pr}. Dead loads defined in the horizontal plane (e.g. ceiling tiles) should not be adjusted. The roof Live Load, L_r, and Snow Load, S, which are defined on the horizontal projection are also not affected.

Arch or Bowstring joists:

$$R_{pr} = \left(\frac{2 \cdot Radius \cdot \pi}{Span \cdot 180°}\right) \cdot Sin^{-1}\left(\frac{Span}{2 \cdot Radius}\right)$$

Radius = Curve of the top chord and span is defined in Section 904.2 (Span & Radius in feet)

Slope Projection Ratio, R_S = Ratio of span defined on the slope to the horizontal projection of the span. As code specifies, the roof Live Load, L_r, and roof Snow Load, S, are defined on the horizontal projection. Thus, when the joist span is defined along the slope, these loads must be decreased in the same proportion that the span increases as compared to the horizontal projection. R_S is independent of the joist profile and should be calculated whenever the joist span is sloped. For a horizontal span, R_S = 1.

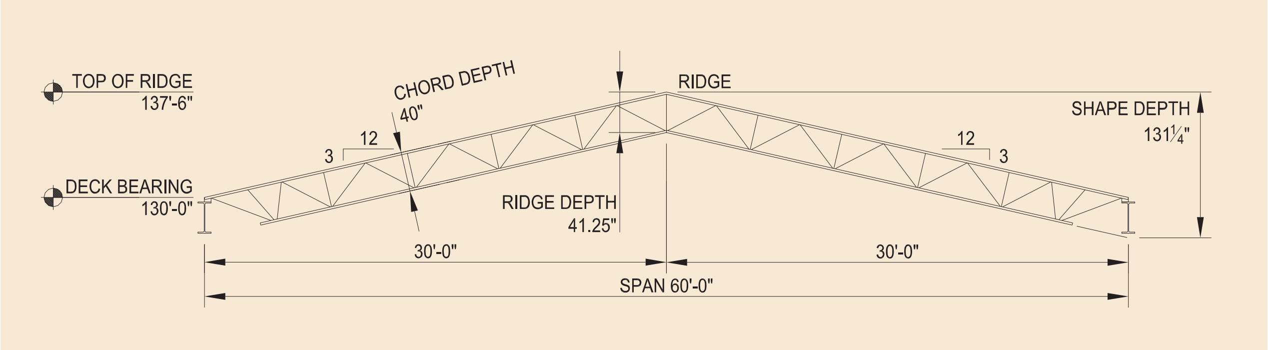
$$R_s = \frac{\sqrt{Rise^2 + Run^2}}{Run}$$

Rise = Difference in elevation between the top of the joist chord at each bearing location

Run = Horizontal projection of span

SCISSOR JOIST DESIGN EXAMPLE

The following example will determine the self-weight of an SP-Series, Scissor joist (SPSC). For the design examples, only the snow load development is illustrated. All load combinations should be fully investigated by the specifying professional.



Design Criteria:

Design Code: *IBC 2006* and *ASCE 7-05*
Project Location: Grand Rapids, Mich.
Load Combinations: ASD
Building Class: II
Importance Factor: I = 1.0

Joist Span = 60'-0" (center to center of steel supports)
Joist Spacing = 9'-0"
Roof Pitch = 3:12
Exposure C

Loading:

Roof Dead Load (D) = 25 psf — includes estimate for joist self-weight
Roof Live Load (L_r) = 20 psf — not reducible
Net Uplift (UL) = 70 plf — calculations not shown

Snow Load:

Ground Snow: p_g = 35 psf
C_e = 1.0 C_t = 1.0 C_s = 1.0

Flat Roof Snow: $p_f = 0.7\ C_e\ Ct\ I\ p_g$ = 24.5 psf
Sloped Roof Snow: $p_s = C_s p_f$ = 24.5 psf

The first step is to adjust the dead load by the Profile Projection Ratio, R_{pp}.

$$R_{pp} = \frac{\sqrt{Pitch^2 + 144}}{12} = \frac{\sqrt{3^2 + 144}}{12} = 1.031$$

The uniform Dead Load, D, is 25 psf x R_{pp} x joist spacing = 25 psf x 1.031 x 9'-0" c-c = 232 plf.

The uniform roof Live Load, L_r, is 20 psf x joist spacing = 20 psf x 9'-0" c-c = 180 plf.

The uniform roof Snow Load, S, = 24.5 psf x joist spacing = 24.5 psf x 9'-0" c-c = 221 plf.

The uniform sloped roof Snow Load, S, = 24.5 psf governs, as it exceeds the 20 psf live load.

Thus, the resulting uniform Total Load, TL = D + (L_r or S) = 232 plf + 221 plf = 453 plf.

SP-SERIES DESIGN

The next step is to determine the equivalent total uniform load, W_{eq}, that results in a shear or moment equal to the shear or moment for the worst-case loading conditions. For this example, refer to *ASCE 7-05* Section 2.4.1 load case 3: D + (L_r or S).

For the uniform Snow Load case the uniform Total Load, TL = 453 plf.

$W_{eqV\text{-}TL} = W_{eqM\text{-}TL} = 453$ plf

For the Live Load deflection check $W_{eq\delta\text{-}LL} = 221$ plf

For unbalanced Snow Load case per *ASCE 7-05* Section 7.6.1:

Windward side:

Uniform Snow Load = 0.3*p_s = 7.35 psf

Leeward side:

Uniform Snow Load full width leeward = p_s = 24.5 psf

Plus rectangular Snow Load surcharge = h_d x $\gamma/\sqrt{S}$

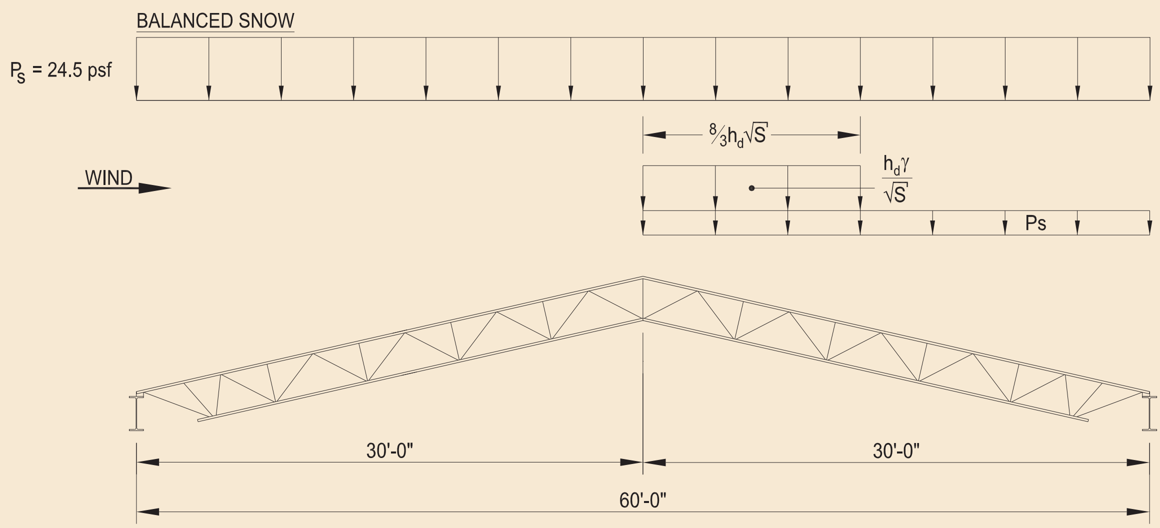
Where $h_d = 0.43 \times \sqrt[3]{l_u} \times \sqrt[4]{(p_g+10)} - 1.5 = 1.96$

$\gamma = 0.13 \times p_g + 14 = 18.55$ S = .25 $l_u = 60 / 2 = 30$

Rectangular Snow Load surcharge = 1.96 x 18.55 / 0.5 = 72.72 psf

Width of surcharge from ridge = (8 / 3) x $\sqrt{S}$ x h_d

Width of surcharge from ridge = (8 / 3) x 0.5 x 1.96 = 2.613’



The unbalanced Snow Load case at a span of 60’ results in a maximum shear and moment with equivalent uniform loads:

V_{ub} = 12.825 kips	$W_{eqv\text{-}TL} = 2 \times V_{ub} / L$	= 427 plf.
M_{ub} = 181.425 kip-ft.	$W_{eqm\text{-}TL} = 8 \times M_{ub} / L^2$	= 403 plf

For determining uniform Total Load to use for the SP-Series Weight Table, it is suggested that the designer use the W_{eq} based on the maximum moment, since the chords for a joist comprise most of the joist self-weight. This will give a close approximation to the actual weight and the number of bridging rows for cost comparisons and estimating. Entering the tables, the uniform Total Load of W_{eq} = 453 plf should be used and should be rounded up to 500 plf to select the proper joist from the SPSC Weight Table. The specifying professional is reminded to provide specific load diagrams for actual contract documents for NMBS, as all load cases must be checked for accurate quoting and for actual final design. In some cases, the unbalanced Snow Load may govern the final web, weld, and top chord end panel design.

Since the span of this joist is horizontal, there is no adjustment needed to account for the sloped span.

$$R_s = \frac{\sqrt{Rise^2 + Run^2}}{Run}$$

Rise = 0 and Run = 12 therefore R_S = 1.0

The next step is to determine the actual joist depth to be specified. In this example, the top of joist is at 130'-0" + 7'-6"=137'-6". The bottom of the joist is at 134'-0¾". This gives a ridge depth of 3'-5¼" or 41.25" and a chord depth of 40". Generally speaking, greater depths will yield lighter and usually most economical designs. An easy way to remember this is; 'deeper is cheaper.'

To determine the estimated self-weight in plf, estimated number of bridging rows, and the minimum seat depth, enter the Scissor Joist (SPSC) Weight Table at the 60' span (page 58), 40" parallel chord depth, slope of 3:12 for a total uniform load of 500 plf and find the estimated self-weight of 27 plf. Also note that the joist profile requires three rows of bridging and has a minimum seat depth of 5". Also note that for a pin-roller support, the horizontal deflection at the roller end of the joist is less than 2 inches since the table does not mark the weight listed as having $\delta_X > 2$".

The tabulated joist weight in the weight table is also based on limiting the joist live load deflection to L/240 based on a live load not to exceed the tabulated total load 500 plf x 0.75 = 375 plf, which is greater than the 221 plf determined in the design example.

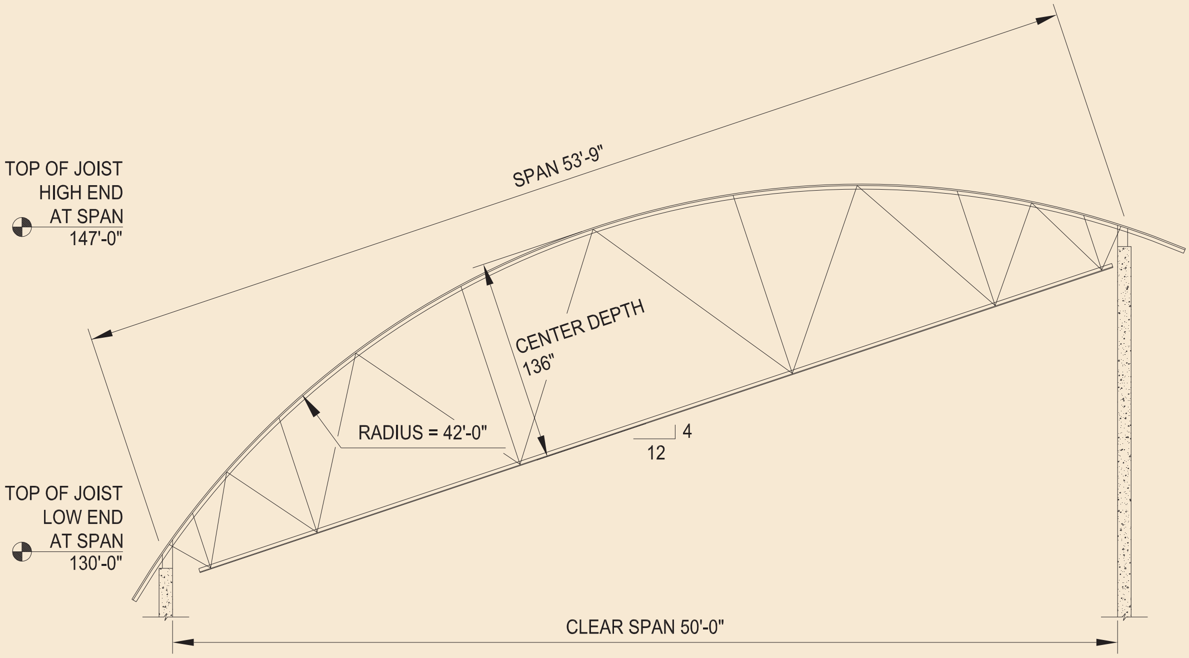
The resulting SP-Series designation is: 40 SPSC 453 / 221 / 70: Span = 60'-0"; Top Chord Pitch = 3 on 12.

This example investigates only the basic calculation for a snow load example. All loading conditions, combinations, and compliance with local building code requirements should be fully investigated by the specifying professional. Specific loads and load combinations shall be furnished to NMBS by the specifying professional in the form of the uniform load designation and/or load diagrams for accurate quoting and for actual final design.

SP-SERIES DESIGN

BOWSTRING JOIST DESIGN EXAMPLE

The following example will determine the self-weight of an SP-Series, Bowstring joist (SPBW). For the design examples, only the snow load development is illustrated. All load combinations should be fully investigated by the specifying professional.



Design Criteria:

Design Code: *IBC 2006* and *ASCE 7-05*	Clear Span	= 50'-0"
Project Location: Grand Rapids, Mich.	Joist Span	= 53'-9" on Slope
Load combinations: ASD	Joist Spacing	= 6'-0"
Building Class: II	Exposure C	
Importance Factor I = 1.0		

Loading:

Roof Dead Load (D)	= 20 psf	Includes estimate for joist self-weight
Roof Live Load (L_r)	= 20 psf	Not reducible
Roof Net Uplift (UL)	= 70 plf	Calculations not shown

Snow Load

Ground Snow	p_g = 35 psf		
C_e = 1.0	C_t = 1.0	C_s = 1.0
Flat Roof Snow	$p_f = 0.7\ C_e\ C_t\ I\ p_g$	= 24.5 psf
Sloped Roof Snow	$p_s = C_s\ p_f$	= 24.5 psf

The first step is to adjust the dead load, D, by the Profile Projection Ratio, R_{pr}.

$$R_{pr} = \left(\frac{2 \cdot Radius \cdot \pi}{Span \cdot 180°}\right) \cdot Sin^{-1}\left(\frac{Span}{2 \cdot Radius}\right) = \left(\frac{2 \cdot 42 \cdot \pi}{53.75 \cdot 180°}\right) \cdot Sin^{-1}\left(\frac{53.75}{2 \cdot 42}\right) = 1.085$$

The adjusted Dead Load is D x R_{pr} x joist spacing = 20 psf x 1.085 x 6'-0" c-c = 131 plf.

The uniform roof Live Load L_r x joist spacing = 20 psf x 6'-0" c-c = 120 plf.

The uniform roof Snow Load is S x joist spacing = 24.5 psf x 6'-0" c-c = 147 plf.

The uniform sloped roof Snow Load, S, = 24.5 psf governs, as it exceeds the 20 psf live load.

The resulting uniform Total Load, TL = D + (L_r or S) = 131 plf + 147 plf = 278 plf.

The next step is to determine the equivalent total uniform load, W_{eq}, that results in a shear or moment equal to the shear or moment for the worst-case loading conditions. For this example, refer to *ASCE 7-05* Section 2.4.1 load case 3: D + (L_r or S).

For the uniform Snow Load case the uniform Total Load, TL = 278 plf.

$W_{eqV\text{-}TL}$ = $W_{eqM\text{-}TL}$ = 278 plf.
For Live Load deflection check $W_{eqM\text{-}LL}$ = 147 plf.

For the unbalanced Snow Load case per *ASCE 7-05* Section 7.6.2.

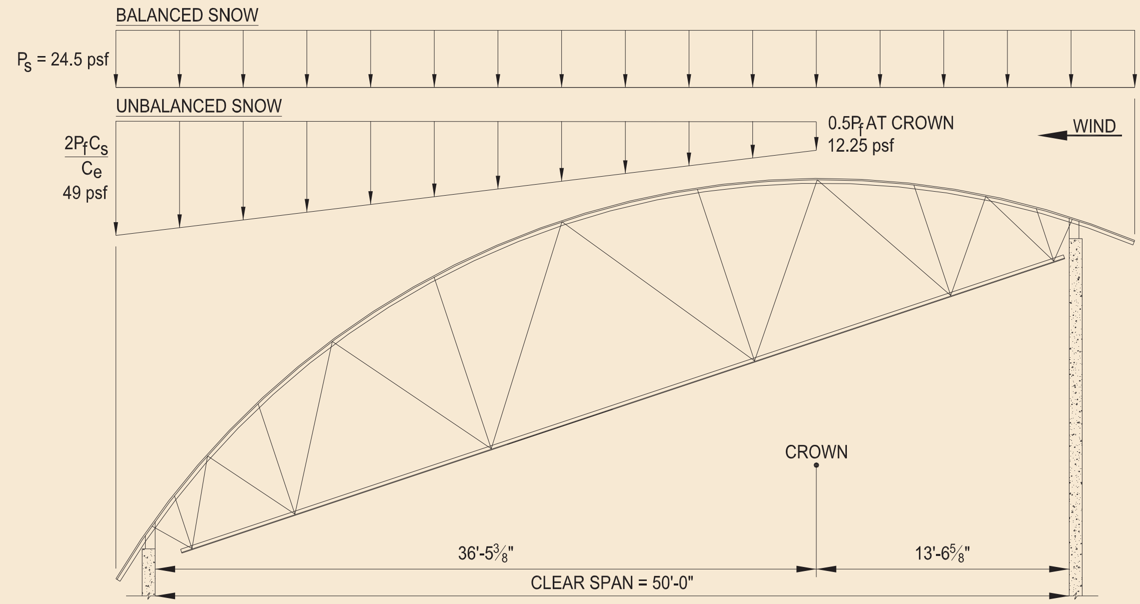
With the Bowstring sloped, the crown shifts towards the high end to 36'-5 3/8" from the inside face of wall. For simplicity, the equivalent uniform load is calculated by using a simple beam with the leeward unbalanced snow at the inside face of the wall and not at the eave or end of the extension. This is slightly conservative and has a negligible effect on the resulting maximum moment.

Windward Side:
No Snow Load per Figure 7.3 Case 1
With the slope at the eave < 30 degrees

Leeward Side:
Snow Load S = 2 x p_f x C_s / C_e = 49 psf at the eave
Snow Load S = S x Spacing = 49 psf x 6'-0" = 294 plf

Snow Load S = 0.5 x p_f = 12.25 psf at the crown
Snow Load S = S x Spacing = 12.25 psf x 6'-0" = 74 plf

SP-SERIES DESIGN



The unbalanced Snow Load case at a span of 51' results in a maximum shear and moment and equivalent uniform loads:

V_{ub} = 8.128 kips $W_{eqV\text{-}TL}$ = 2 x V_{ub} / L   = 319 plf.
M_{ub} = 86.78 kip-ft. $W_{eqM\text{-}TL}$ = 8 x M_{ub} / L^2 = 267 plf.

The next step is to adjust the maximum W_{eq} for TL to the sloped span to utilize the SP-Series Weight Table. Since this is a Bowstring joist with sloped bearings, the loads normal to the span must be determined. It is suggested that the designer use the W_{eq} based on the maximum moment, since the chords for a joist comprise most of the joist self-weight. This will give a close approximation to the actual weight and the number of bridging rows for cost comparisons and estimating.

$$R_s = \frac{\sqrt{Rise^2 + Run^2}}{Run}$$

Rise = 4 and Run = 12 therefore R_s = 1.054

Adjusted W_{eq} = W_{eq}/ R_s = 278 plf / 1.054 = 264 plf at the sloped span = 53'-9"

Adjusted W_{eqLL} = W_{eqLL} / R_s = 147 plf / 1.054 = 140 plf

Entering the tables, the uniform Total Load of W_{eq} = 264 plf should be used and should be rounded up to 300 plf to select the proper joist from the SPBW Weight Table. The specifying professional is reminded to provide specific load diagrams for actual contract documents for NMBS, as all load cases must be checked for accurate quoting and for actual final design. In some cases, the unbalanced Snow Load may govern the final web, weld, and top chord end panel design.

The actual joist depth is specified as 136" and the top chord radius is specified as 42'. To determine the estimated self-weight in plf, estimated number of bridging rows and the minimum seat depth at the 53.75 ft span, interpolation needs to be utilized, since the table only has information for 50 ft (page 41) and 60 ft (page 42) spans. The closest joist that fits the example joist profile for the 50 ft span weighs 27 plf at Center Depth = 136 in, Top Chord Radius = 42 ft and TL = 300 plf. The closest joist that fits the example joist profile for the 60 ft span weighs 33 plf at Center Depth = 148 in, Top Chord Radius = 50 ft and TL = 300 plf. This selection is chosen, since the resulting self-weight is slightly more conservative compared to choosing the joist at Center Depth = 132 in, Top Chord Radius = 50 ft and TL = 300 plf. Using linear interpolation, the self-weight of the example joist is:

$$\left[\frac{(53.75\text{ ft.} - 50\text{ ft.})}{(60\text{ ft.} - 50\text{ ft.})} \times (33\text{ plf} - 27\text{ plf})\right] + 27\text{ plf} \cong 29\text{ plf}$$

In addition, both selections for the 50 ft span and the 60 ft span show that a 5” minimum seat depth and four rows of X-bolted bridging are required. The same will hold true for the example joist profile. The table gives the minimum seat depth of 5” based on a flat span, which would require adjustment for slope and top chord extensions.

The tabulated joist weight in the Weight Table is also based on limiting the joist live load deflection to L/240 based on a live load not to exceed the tabulated total load 300 plf x 0.75 = 225 plf, which is greater than the 140 plf determined in the design example.

The resulting SP-Series designation is: 136 SPBW 264 / 140 / 70; Span = 53’-9”; Top Chord Radius = 42’.

This example investigates only the basic calculation for a snow load example. All loading conditions, combinations, and compliance with local building code requirements should be fully investigated by the specifying professional. Specific loads and load combinations shall be furnished to NMBS by the specifying professional in the form of the uniform load designation and/or load diagrams for accurate quoting and for final design.