



Special Profile Steel Joists

- 40,000+ Engineered Design Specifications
- Gable, Bowstring, Scissor, and Arch Joist Profiles
- Nationwide Engineering and Manufacturing

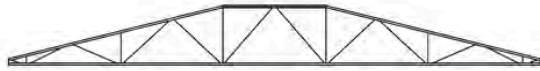


NEW MILLENNIUM
BUILDING SYSTEMS

Flexible to the Finish



GABLE



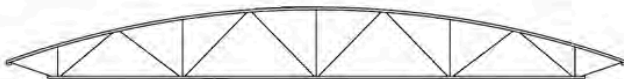
FLAT TOP GABLE



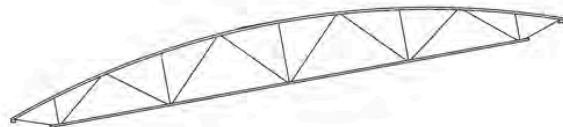
SCISSOR



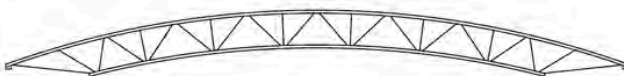
COMPOUND SCISSOR



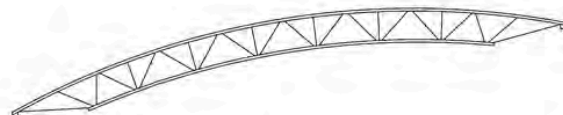
BOWSTRING



SLOPED BOWSTRING



ARCH



SLOPED ARCH

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LIABILITY STATEMENT

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Uplift your design ideas

40,000 ways to change the shape of architecture.

This catalog was developed in response to the growing demand for new structural design ideas and innovative rooflines that are only possible using “special profile” steel joists.

To meet the aspirations of both architects and engineers, we have vastly expanded the previous range of published weight table specifications for the four basic special joist profiles: gable, bowstring, scissor, and arch. This development has eased the way for the evaluation and specification of many thousands more combinations of steel joist profiles that were heretofore not practically supported by the specification tables.

With this catalog as your guide and our engineering teams at your service, you now have access to the following:

- Over 40,000 engineering design specifications across four basic profiles
- Engineers can now more feasibly and practically specify unique steel architecture
- Tables include bridging information, bearing seat depth and other key information
- Online joist specification “tools” make specification even easier and faster
- Online tools are available as mobile apps for Android and iOS devices



As more architects have learned about the design flexibility of gable, scissor, bowstring and arch joist profiles, they have used variations and even combinations of these profiles to uplift distinctive building designs.



Shipping Considerations

Delivery coordination of your project.

We ship special profile steel joists to all regions of the country and are always mindful of related considerations, such as trailering length and erection site constraints. We will collaborate on these important considerations to further assure the cost-minimized success of the project.

- Coordination on 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 can provide joist weights and bundle weights to assist in this planning.
- Coordination on erection site access and joist routing on site are often based on joist size and length, including whether profile dimensions must be modified in advance to minimize delivery costs. Related considerations include whether the joists can be shipped and erected in one piece or shipped in shorter sections for field splicing.
- Coordination extends to roadway considerations and meeting any state requirements regarding over-length or over-width material, types of escorts and route surveys.
- Sufficient time should be allowed for safe unloading. Special profile joists can take more time to unload than standard steel joists, due to their often-unusual shapes and dimensions.
- The safe erection of steel joists is guided by the OSHA Steel Erection Standard Part §1926. This information is published in our Steel Joists and Joist Girders catalog.



Hundreds of steel building projects feature special profile steel joists. New Millennium can deliver anywhere in the country.



Together, let's build a better steel experience.

New Millennium's competitive advantage is flexibility.

As our customers nationwide have discovered, we engineer winning relationships, success stories that continue to build America.

Our uniquely flexible engineering and manufacturing business model enables us to take the project owner's point of view: delivering higher total-project performance, for less total-project cost. You can count on us for the experience, products, services, and nationwide locations that will build your business...



- Value engineered total-project cost management
- Flexible approach to steel joist and metal decking supply
- Experienced developers of special profile steel joists
- Leading, most experienced providers of BIM/IPD projects
- Nationwide locations for local supply and support

QUALITY ASSURANCE

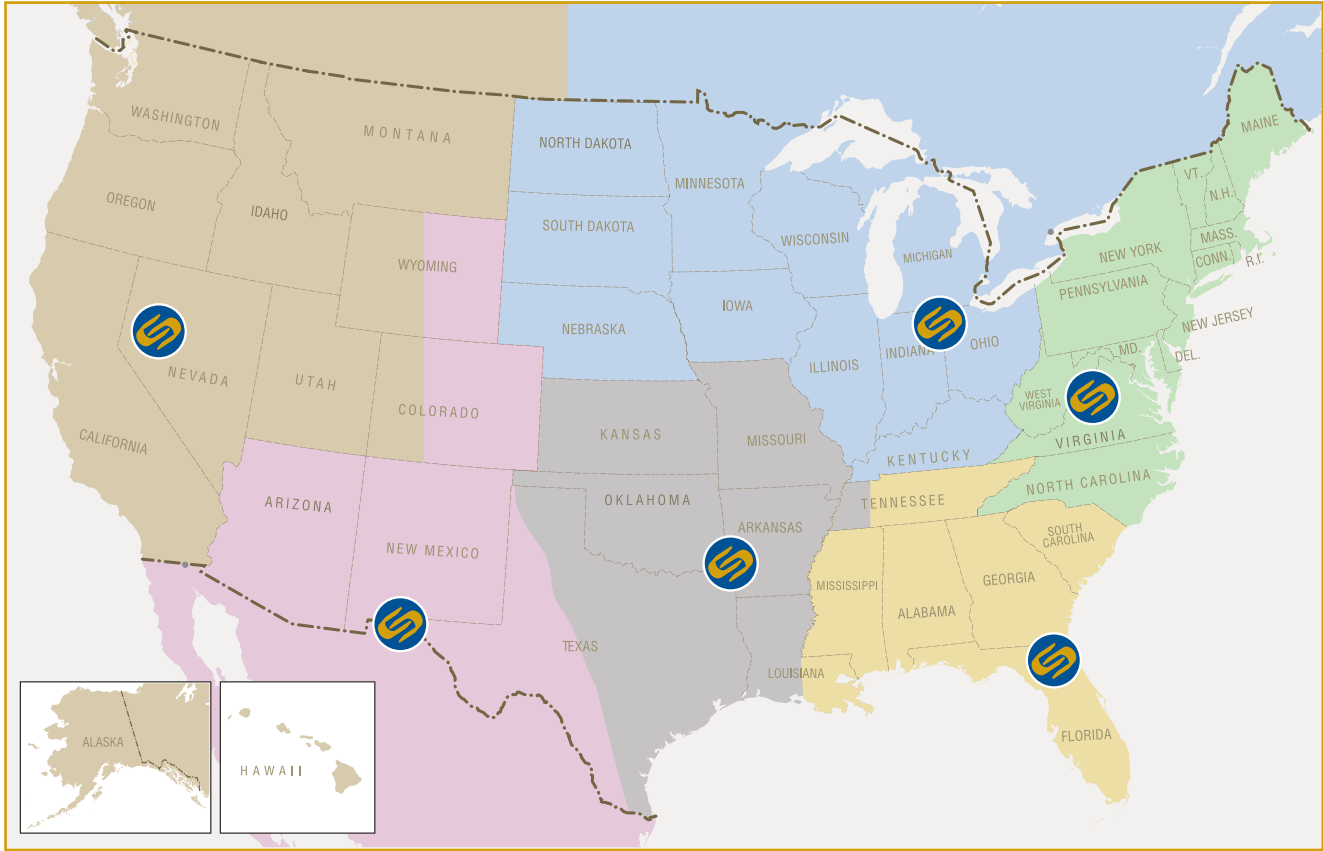
New Millennium is a Steel Joist Institute (SJI) member company, fully certified to manufacture K, LH and DLH-Series Steel Joists, and Joist Girders. New Millennium is also a Steel Deck Institute (SDI) member company, fully certified to manufacture roof deck, form deck, and composite floor deck.

- New Millennium products meet FM, UL and ULC requirements.
- Welders are certified in accordance with AWS D1.1 and D1.3.
- The Indiana and Nevada facilities meet CSA Standard W47.1 in Division 2 for open web joists.
- 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 Miami-Dade County, Florida Building Code, Article IV, Chapter 8.
- The Arkansas and Florida facilities are certified in accordance with the Houston, Texas Building Code, Section 1704.2.2.
- The Nevada and Mexico facilities are certified in accordance with the requirements of Clark County, LA City, IAS (pending).



Nationwide Support

New Millennium is your nationwide resource for design, manufacturing, and delivery of structural steel joists, and steel roof and floor decking.



MANUFACTURING LOCATIONS:

Indiana Facility	Florida Facility	Virginia Facility	Arkansas Facility	Nevada Facility	Mexico Facility
6115 County Road 42 Butler, IN 46721 Phone: (260) 868-6000 Fax: (260) 868-6001	1992 NW Bascom Norris Drive Lake City, FL 32055 Phone: (386) 466-1300 Fax: (386) 466-1301	100 Diuguids Lane Post Office Box 3400 Salem, VA 24153 Phone: (540) 389-0211 Fax: (540) 389-0378	3565 Highway 32 North Hope, AR 71801 Phone: (870) 722-4100 Fax: (870) 722-4245	8200 Woolery Way Fallon, NV 89406 Phone: (775) 867-2130 Fax: (775) 867-2169	Carr. Panamericana 9920 Col. Puente Alto C.P. 32695 Cuidad Juarez Chihuahua Mexico Phone: (915) 298-5050 Fax: (915) 298-4040

To quickly identify the sales representative that services your area, log on to www.newmill.com/contactus.html



Industry-leading 3D BIM design • State-of-the-art manufacturing • Nationwide delivery and support • Steel joists and metal decking

Product Flexibility

Assure the winning success of your project, with our full range of structural steel roofing and flooring systems development.

For faster and easier specification, start with our convenient web-based or mobile app design tools. See page 6 of this catalog or visit www.newmill.com/digital-tools



STANDARD STEEL JOISTS

Joist products include K, LH and DLH Series joists and joist girders, and CJ Series joists (Composite Joist). Joists can be furnished as a single-piece up to 15 feet deep and up to 125 feet long, depending on location and shipping restrictions. All are produced in accordance with the specifications of the Steel Joist Institute.



FLEX-JOIST™ TENSION-CONTROLLED STEEL JOIST DESIGN

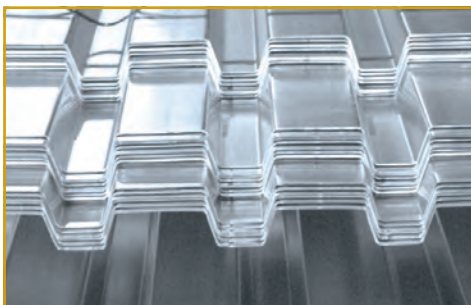
Flex-Joist™ tension controlled steel joist design results in a joist that characteristically displays both higher strength levels and large inelastic deformations prior to collapse. The result is a roof or floor framing system with improved strength, an improved reliability index, and improved sensory alert to overload prior to collapse.

Flex-Joist™ tension-controlled steel joist design is ideally suited to electronic monitoring of deflection and/or strain for early warning of high loads, if desired. This can allow time for building evacuation, load removal, and/or shoring to prevent collapse. Although electronic monitoring is not provided by NMBS, we can help coordinate requirements with your electronic monitoring supplier.



SPECIAL PROFILE STEEL JOISTS

Unique roofline designs are now practical and economical using special profile steel joists, due to our development of engineering specifications enabling over 40,000 special profile steel joist design possibilities. We manufacture a complete range of special profile steel joist products, including bowstring, arched, scissor, double-pitched, and single-pitched steel joists.



METAL DECKING

Roof and floor metal deck options include B deck, N deck, form deck and composite deck. Engineered to the application, our decking systems are certified to address performance requirements related to such factors as wind uplift, fire resistance and noise reduction.



Elevate the long-term success of your business with our proactive approach to your project needs.



ARCHITECTURAL SOLUTIONS

Bring us in early on the project to help achieve your architectural vision, while holding the line on structural execution and related project costs. We can show you new design solutions made possible by our leading development of over 40,000 new engineering specifications in the discipline of special profile steel joist design.

ENGINEERED COST REDUCTIONS

We remove a chain reaction of project costs, starting with reduced steel tonnage and ending with lower on-site labor costs for handling, lifting and erection. Our approach to cost-accountable engineering can shorten project timelines and prevent delayed occupancy or lost retail revenues.

BIM DESIGN COLLABORATION

We participate in BIM based projects using our new Dynamic Joist® digital design component. The component is available as a free, downloadable add-on for Tekla Structures. New Millennium supports the Industry Foundation Classes (IFC) standard for data transport and the sharing of our component across various BIM platforms.

DYNAMIC MANUFACTURING & DELIVERY

Our dynamic manufacturing can adjust to any project timeline or changing erection site needs, including staged and just-in-time deliveries. Just tell us what you need and when you need it.

Digital Specification Tools

Discover the easiest way to specify special profile steel joists: www.newmill.com/digital-tools

- **Easier and faster specification**
- **Helpful cost-saving guidelines and options**
- **Mobile app for on-the-go convenience**
- **Complete range of digital design tools:**
 - Standard steel joists and steel Joist Girders
 - Special profile steel joists
 - Steel roof and floor decking



3D BIM-BASED DESIGN

Our Dynamic Joist® component is the leading choice for BIM-based steel joist 3D design.

New Millennium pioneered IPD (integrated project delivery) with steel joists by making BIM-based process management a reality. Since early 2010, Dynamic Joist® has enhanced design collaboration in real-world projects throughout North America.

Available as a FREE download on our website. Get yours today!

WEB-BASED AND MOBILE SPECIFICATION TOOLS

Whether you're in the office or out in the field, New Millennium has you covered. Introducing the industry's first complete set of digital specification tools. To further simplify and accelerate the steel package design process, New Millennium has packed the power of our specification catalogs into advanced web and mobile applications.

Built upon our expertise in steel joist and metal deck engineering, and backed by our database of load and weight tables, this toolset will prove to be your handy go-to resource. You will find everything you need... from standard steel joists and girders, to our industry-leading special profile steel joist designs, to a wide range of roof, form, and composite floor decking.

Our commitment to building a better steel experience is focused on you. Log on to our website and start using these tools today.



LEED (Leadership in Energy & Environmental Design)

New Millennium is a member of the US Green Building Council, the governing body of LEED, the most widely recognized and used green building program around the globe.

New Millennium monitors changes in the LEED rating system as well as other environmental rating systems and can provide documentation on recycled content and regional material information depending on project location.

Current New Millennium LEED information can be found under the DOWNLOADS tab on our website at www.newmill.com.



Scan the QR-code at the right for a quick link to our detailed LEED information page, including downloadable PDFs regarding our current recycled content.



LEED® Green Building Rating System™

The LEED Green Building Rating System™ is a voluntary, consensus-based standard to support and certify successful green building design, construction and operations. LEED certification is available for all building types including new construction and major renovation, schools, healthcare, retail, homes, neighborhoods, core and shell, commercial interiors and even existing buildings.

What's driving green building? The growth of green building is being expedited by three factors:

- Unprecedented level of government initiatives
- Heightened demand for green construction
- Improvements in sustainable materials

Why build green? Green buildings consume less energy and fewer resources. In comparison to the average commercial building, green buildings:

- Consume 26% less energy
- Have 13% lower maintenance costs
- Have 27% higher occupant satisfaction
- Produce 33% less greenhouse gas emissions

Source: GSA Public Buildings Service (2008). Assessing Green Building Performance: A Post Occupancy Evaluation of 12 GSA Building.

The LEED certification system is organized into five environmental categories: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR) and Indoor Environmental Quality (IEQ). An additional category, Innovation in Design (ID), addresses sustainable building expertise as well as design measures not covered under the five environmental categories. The number of points the project earns determines the level of LEED Certification the project receives.

NEW MILLENNIUM RECYCLED CONTENT

New Millennium steel joists and metal decking products are fabricated from steel manufactured at mini-mills using scrap steel. Therefore, our product can be used towards points under the Materials and Resources Credit 4 which covers Recycled Content.

Under MR Credit 4 you can obtain up to 2 points towards LEED certification if you use materials with recycled content such that the postconsumer recycled content plus 1/2 of the preconsumer content constitutes at least 10% (1 point) or 20% (2 points), based on cost, of the total value of the materials in the project.



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.

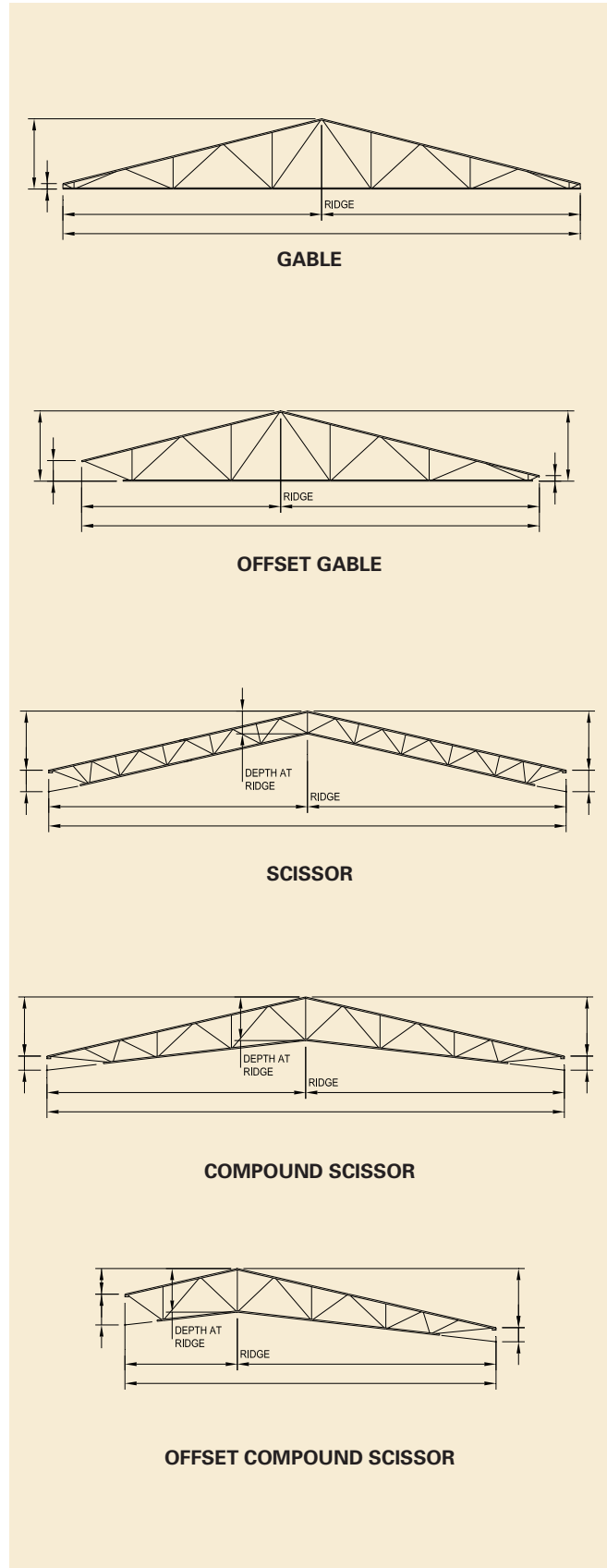
Experienced NMBS design personnel equipped with sophisticated design software are on staff to help with the design of SP-Series joists or joist girders. In a matter of minutes, NMBS can design a SP-Series joist and e-mail a STAAD or AutoCAD file at no charge. This preliminary design can give you the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

GEOMETRY

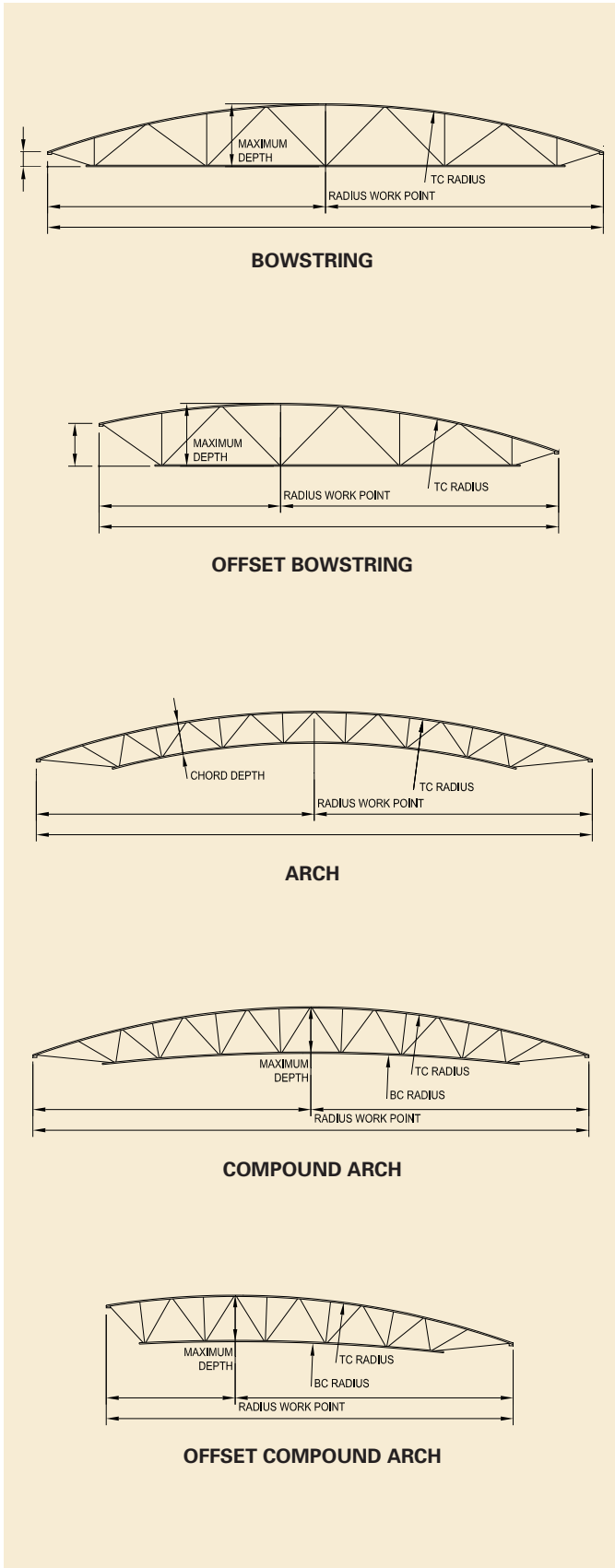
The dimensions shown on the SP-Series profile diagrams to the right and in the following page should be clearly shown and noted in the construction documents. Web layouts in SP-Series joists vary greatly depending on geometry and loading. Special web layouts may be specified on the contract documents 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.



Special Profile Steel Joists, SP-Series



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 17 through 23 for further explanation. There are also several abbreviated examples on pages 100 through 103.

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

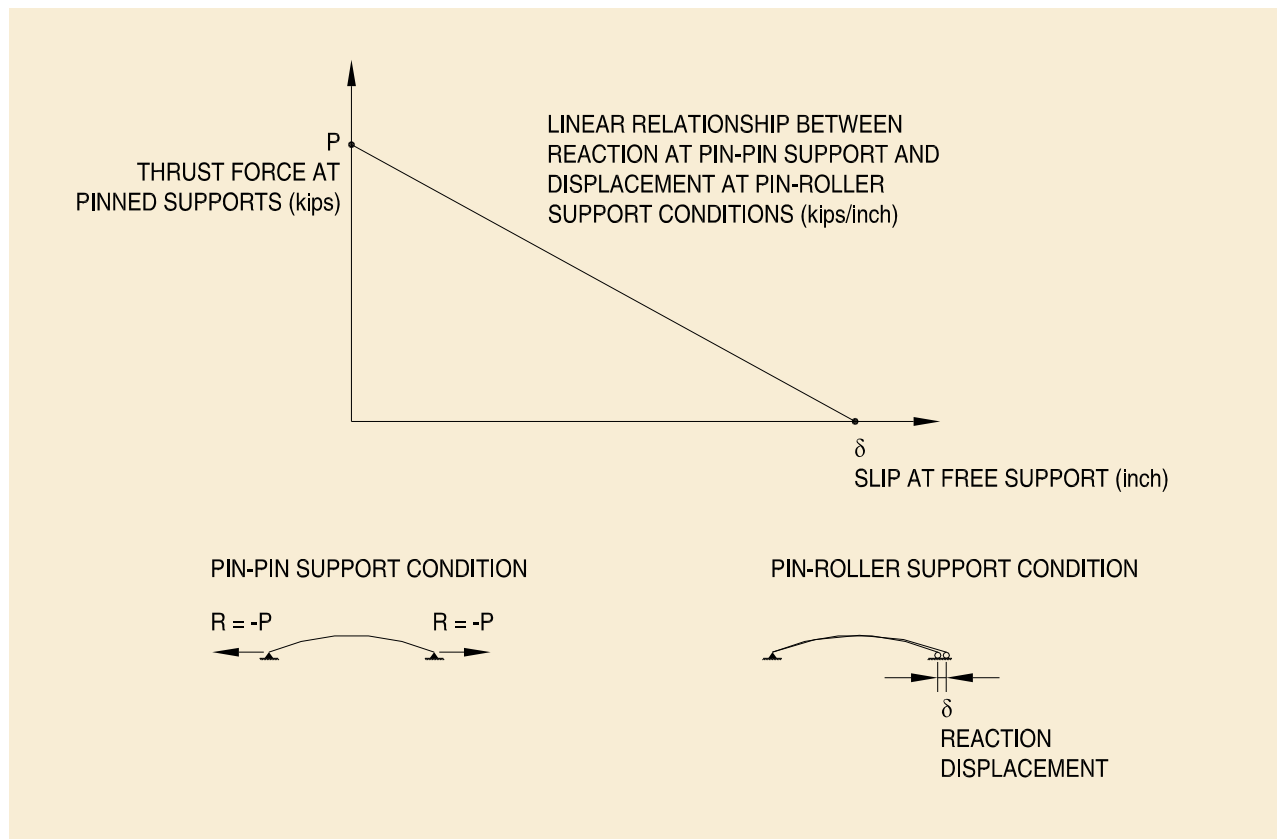
HORIZONTAL REACTIONS

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

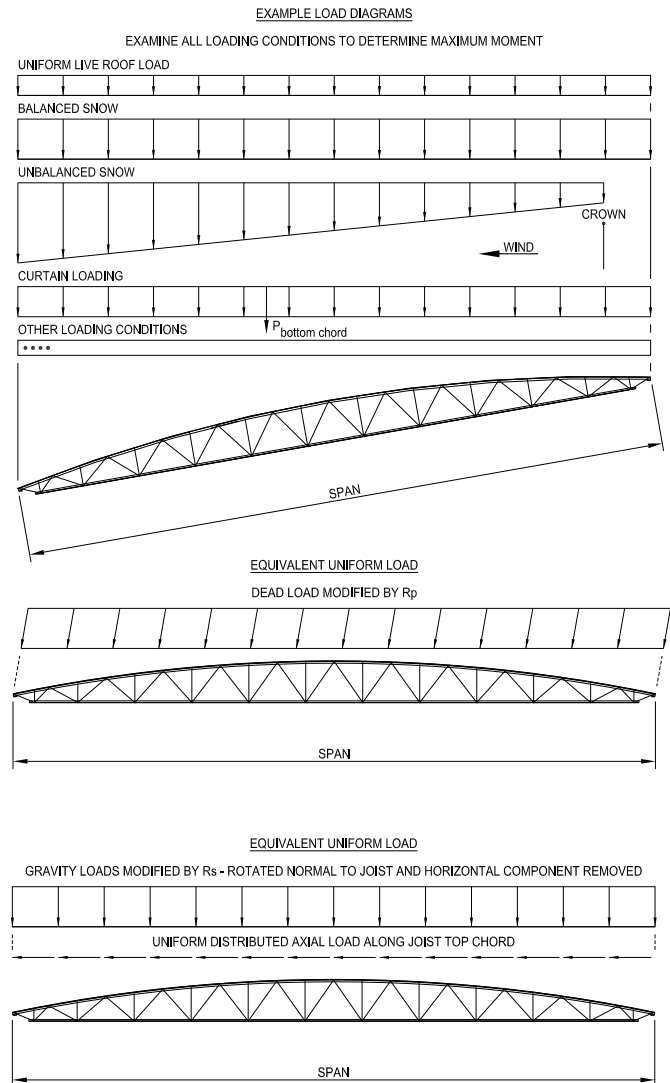
The SP-Series Weight Tables were generated using a uniform distributed load on a horizontal span. Therefore, the uniform loads specified in the SP-Series joist designations should be calculated as distributed normal to the span. Loads in design development are generally defined as horizontal or vertical. 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 95. 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 17 through 23.

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-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:

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

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, $R_s = 1$.

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

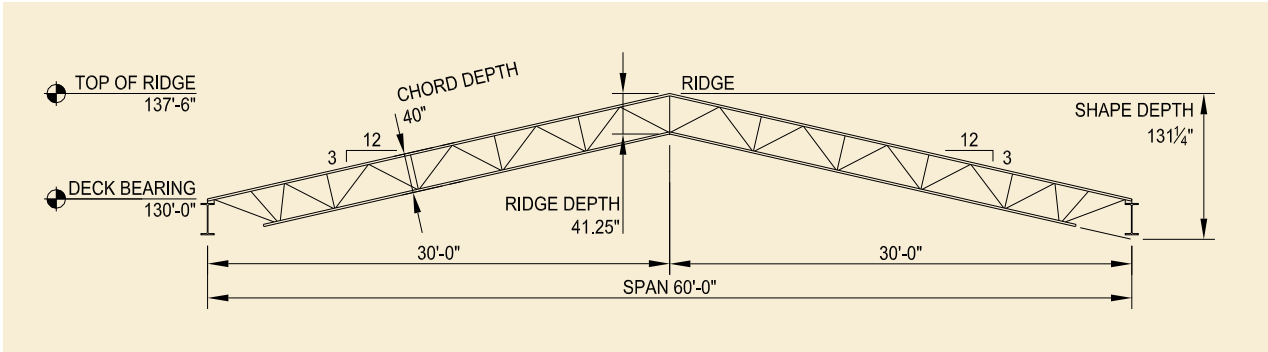
Rise = Difference in elevation between the top of the joist chord at each bearing location

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. Joist Span = 60'-0" (center to center of steel supports)
 Load Combinations: ASD Joist Spacing = 9'-0"
 Building Class: II Roof Pitch = 3:12
 Importance Factor: I = 1.0 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 C_t I p_g = 24.5 psf
 Sloped Roof Snow: p_s = C_sp_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.



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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.

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

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

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

Windward side:

$$\text{Uniform Snow Load} = 0.3 * p_s = 7.35 \text{ psf}$$

Leeward side:

$$\text{Uniform Snow Load full width leeward} = p_s = 24.5 \text{ psf}$$

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

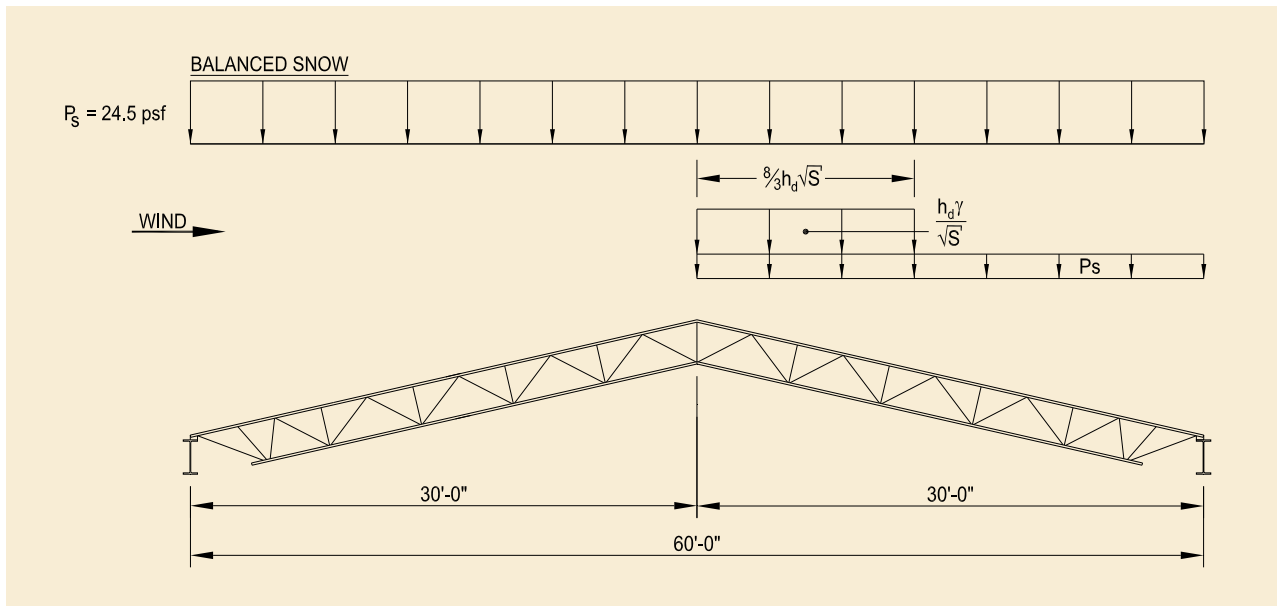
$$\text{Where } h_d = 0.43 \times \sqrt[3]{l_u} \times \sqrt[4]{(p_g + 10)} - 1.5 = 1.96$$

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

$$\text{Rectangular Snow Load surcharge} = 1.96 \times 18.55 / 0.5 = 72.72 \text{ psf}$$

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

$$\text{Width of surcharge from ridge} = (8 / 3) \times 0.5 \times 1.96 = 2.613'$$



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

$$\begin{aligned} V_{ub} &= 12.825 \text{ kips} & W_{eqV-TL} &= 2 \times V_{ub} / L & &= 427 \text{ plf.} \\ M_{ub} &= 181.425 \text{ kip-ft.} & W_{eqM-TL} &= 8 \times M_{ub} / L^2 & &= 403 \text{ plf} \end{aligned}$$

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 $W_{eq} = 453 \text{ plf}$ 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.



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

$$R_s = \frac{\sqrt{Rise^2 + Run^2}}{Run} \quad \text{Rise} = 0 \text{ and Run} = 12 \text{ therefore } R_s = 1.0$$

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'-0 3/4". This gives a ridge depth of 3'-5 1/4" 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 62), 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.

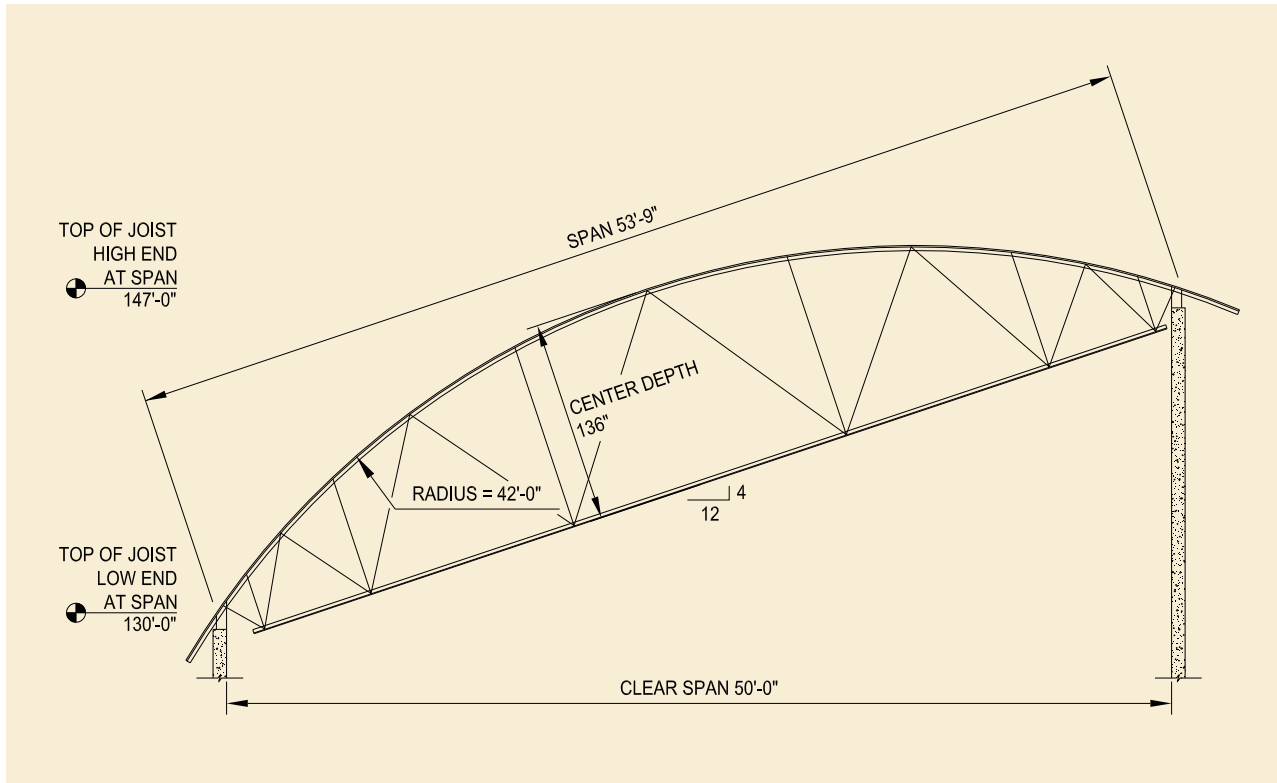
This example investigates only the basic calculation for a snow load example. All loading conditions, combinations, and compliance with local building code requirements should be fully investigated by the specifying professional. Specific loads and load combinations shall be furnished to NMBS by the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



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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
 Project Location: Grand Rapids, Mich.
 Load combinations: ASD
 Building Class: II
 Importance Factor I = 1.0

Clear Span = 50'-0"
 Joist Span = 53'-9" on Slope
 Joist Spacing = 6'-0"
 Exposure C

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} .

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

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

The uniform roof Live Load $L_r \times \text{joist spacing} = 20 \text{ psf} \times 6'-0" \text{ c-c} = 120 \text{ plf}$.

The uniform roof Snow Load is $S \times \text{joist spacing} = 24.5 \text{ psf} \times 6'-0" \text{ c-c} = 147 \text{ plf}$.

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

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

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: $D + (L_r \text{ or } S)$.

For the uniform Snow Load case the uniform Total Load, $TL = 278 \text{ plf}$.

$$W_{eqV-TL} = W_{eqM-TL} = 278 \text{ plf}$$

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

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:

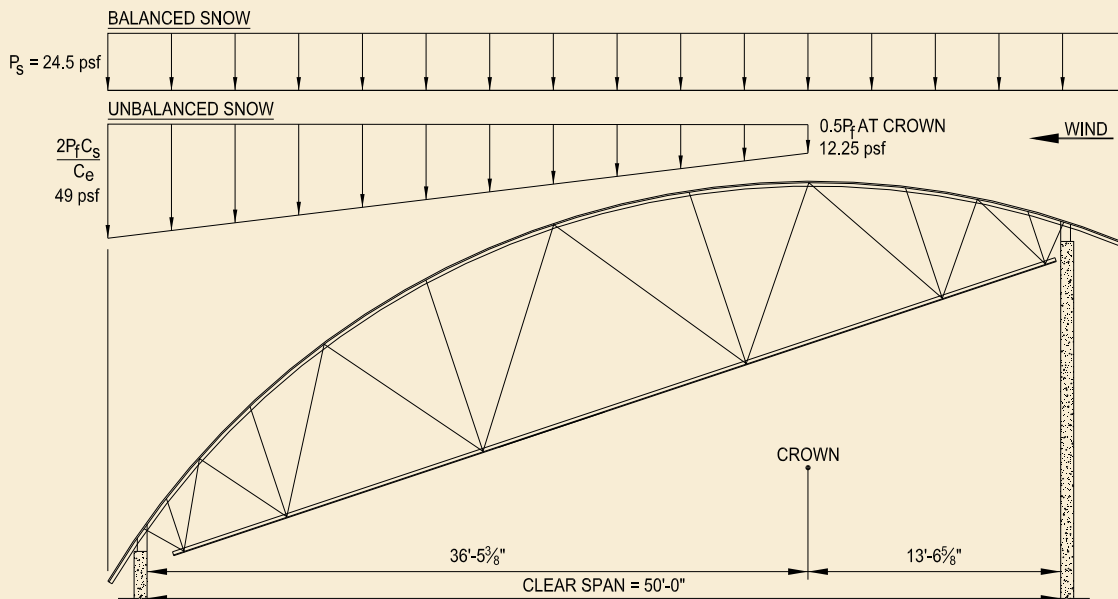
No Snow Load per Figure 7.3 Case 1
With the slope at the eave < 30 degrees

Leeward Side:

Snow Load $S = 2 \times \text{pf} \times C_s / C_e = 49 \text{ psf}$ at the eave
Snow Load $S = S \times \text{Spacing} = 49 \text{ psf} \times 6'-0" = 294 \text{ plf}$

Snow Load $S = 0.5 \times \text{pf} = 12.25 \text{ psf}$ at the crown
Snow Load $S = S \times \text{Spacing} = 12.25 \text{ psf} \times 6'-0" = 74 \text{ plf}$

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

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

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.

$$R_s = \frac{\sqrt{Rise^2 + Run^2}}{Run} \quad \text{Rise} = 4 \text{ and Run} = 12 \text{ therefore } R_s = 1.054$$

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

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

Entering the tables, the uniform Total Load of $W_{eq} = 264 \text{ plf}$ 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



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table only has information for 50 ft (page 45) and 60 ft (page 46) 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:

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

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.

