Technical Q & A

Unbalanced Snow Loads

Depending on the approach taken, determining snow loads can range from a simple to a more complicated calculation.

at a glance

- ❑ A new provision was introduced to the wood truss section (i.e., R810.2) of the 2006 edition of the IRC that permits the use of roof snow load computed using $0.7p_g$.
- ❑ Engineered design, through ASCE 7, is required in instances where the limitations on which the IRC is based are exceeded.
- ❑ ASCE 7 snow load design provisions require the evaluation of other conditions that may produce load surcharges in addition to the balanced uniform loads of p_f or p_s.

by Jim Vogt, P.E. & Richard Zimmermann

Metal plate connected wood trusses are used in the roofs of the majority of one- and two-family dwellings constructed in the U.S. today. The gravity load design for many of these roofs is controlled by snow loads. The 2000 and 2003 editions of the International Residential Code (IRC®) permit these roofs to be designed using either ground snow load or the provisions in ASCE 7. In addition, the 2006 edition of the IRC also permits roof trusses to be designed using a roof snow load of $0.7p_g$, as long as the stated applicability limits are met. Using the ground snow load is the simplest approach, but often yields more conservative results. The provisions of ASCE 7 provide more accurate loads, but can also be very complicated and require an in-depth knowledge of the building and site conditions.

Question

Do unbalanced snow loads need to be considered on pitched roof trusses designed in accordance with the IRC?

Answer

The consideration of unbalanced snow due to drifting across roof breaks (i.e., gable or hips) is not explicitly required by the IRC. Section R301.6 indicates that roofs must be designed to support the greater of roof live load or snow load,

> **R301.6 Roof load.** The roof shall be designed for the live load indicated in Table R301.6 <u>or the snow load indicated in Table R301.2(1), whichever is greater</u>.*

where the snow load provided in Table R301.2(1) is the Ground Snow Load.

Section R301.2.3 refers to Chapters 5, 6 and 8 for specific information pertaining to snow loads supported by members in floors (Chapter 5), walls (Chapter 6), and roofs (Chapter 8),

> **R301.2.3 Snow loads.** Wood framed construction, cold-formed steel framed construction and masonry and concrete construction in regions with ground snow loads 70 pounds per square foot (3.35 kPa) or less, shall be in accordance with Chapters 5, 6 and 8. Buildings in regions with ground snow loads greater than 70 pounds per square foot (3.35 kPa) shall be designed in accordance with accepted engineering practice.

Span tables provided in Chapters 5, 6 and 8 for wood structural framing members such as cantilevered floor joists supporting roof loads, girders and headers in exterior walls, wall studs and rafters are based on ground snow loads.

Ground snow load (p_g) varies by region and is typically specified by each jurisdiction that adopts and enforces the code. P_g is a base value that does not include any of the ground-to-roof adjustments that often result in a reduction in load. Using p_g as the roof design snow load for one- and two-family dwellings is considered a fairly simple, yet conservative approach. Unbalanced snow loading is not typically considered if p_g is used as the roof design snow load.

A new provision was introduced to the wood truss section (i.e., R810.2) of the 2006 edition of the IRC that permits the use of roof snow load computed using $0.7p_g$.

*Underline added for emphasis.

•••• Key Definition ••••

Building Designer: The Owner of the Building or the person that contracts with the Owner for the design of the Framing Structural System and/or who is responsible for the preparation of the Construction Documents. When mandated by the Legal Requirements, the Building Designer shall be a Registered Design Professional.

> **R802.10.2.1 Applicability limits.** <u>The provisions of this section shall control the design of truss roof framing when snow controls</u> for buildings not greater than 60 feet (18 288 mm) in length perpendicular to the joist, rafter or truss span, not greater than 36 feet (10 973 mm) in width parallel to the joist span or truss, not greater than two stories in height with each story not greater than 10 feet (3048 mm) high, and roof slopes not smaller than 3:12 (25-percent slope) or greater than 12:12 (100-percent slope). Truss roof framing constructed in accordance with the provisions of this section shall be limited to sites subjected to a maximum design wind speed of 110 miles per hour (49 m/s), Exposure A, B or C, and a maximum ground snow load of 70 psf (3352 Pa). <u>Roof snow load is to be computed as: 0.7 p_g</u>.*

Section R802.10.2.1 provides the specific limitations for which this provision applies, including building size, building height, roof pitch, wind speed, exposure category and ground snow load and is similar to the applicability limits established for cold-formed steel.

Section R301.1.3 of the IRC also permits the building, structure and parts thereof to be designed using accepted engineering practice in accordance with the International Building Code (IBC®). Engineered design is required in instances where the limitations on which the IRC is based are exceeded.

The design snow loads in the IBC are determined using the provisions of the SEI/ASCE 7, *Minimum Design Loads for Buildings and Other Structures.* ASCE 7 is developed and maintained by the American Society of Civil Engineers.

Using the provisions of ASCE 7, p_g is modified by applying factors to account for the importance of the building, I, the exposure condition of the roof, C_e, and the thermal characteristics of the building, C_t, to obtain the flat roof snow load, p_f:

$$p_f = 0.7(C_e)(C_t)(I)p_g$$

The sloped roof snow load, p_s, is obtained by multiplying the p_f by the roof slope factor C_s. The value of C_s is dependent on the magnitude of the roof slope, the thermal characteristics of the building and slipperiness of the roof surface. For many residential roof applications, C_s = 1.0. The values of the various factors used to derive p_f and p_s are site and building specific and are best determined by the Building Designer for the project. In the absence of a Building Designer, the contractor and/or building official may also be able to provide the correct information.

The roof design snow load (i.e., p_f or p_s), obtained using the provisions of ASCE 7 is often substantially less than p_g for most residential roof applications. However, in addition to analyzing the member using a balanced design snow load of p_f or p_s, ASCE 7 requires that other conditions be evaluated, many of which result in a load surcharge to at least a portion of the member.

Unbalanced snow loading is one of the more common conditions that must be evaluated for hip and gable type roofs when using the design snow load provisions of ASCE 7. The unbalanced snow load is intended to account for the drifting caused by wind blowing snow across roof breaks such as ridges. This particular provision has been modified considerably over the past several editions of ASCE 7, and since the

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Edition	Windward	Leeward	Conditions
7-88 & -93	0	$1.5p_s/C_e$	Slope >15 ° or <70°
7-95	0	$1.3p_s/C_e$	Slope >15 ° or <70°
7-98	0	$1.5p_f/C_e$	$W \le 20$ ft & $\theta \le 5°$
	0	$1.5p_s/C_e$	$W \le 20$ ft & $\theta > 5°$
	$0.3p_s$	$1.2(1+\beta/2)\ p_s/C_e$	$W > 20$ ft & $\theta > (275\beta p_f/\gamma W)$
	$0.3p_f$	$1.2p_f/C_e$ sloping to $1.2(1+\beta)\ p_f/C_e \le 1.2(p_f/C_e)+\gamma h_e$	$W > 20$ ft & $\theta \le (275\beta p_f/\gamma W)$
	(β is based on L/W ratio)		
	β =	0.5 — L/W ≤1 0.33+0.167L/W — 1 < L/W ≤4 1.0 — L/W > 4	L = roof parallel to ridge W = horizontal eave to ridge
7-02	0	$1.5p_s/C_e$	W ≤20 ft
	$0.3p_s$	$1.2(1+\beta/2)\ p_s/C_e$	W >20 ft
	(β is based on p_g)		
	β =	1.0 — $p_g \le 20$ lb/ft² $1.5 - 0.025p_g$ — $20 < p_g < 40$ lb/ft² 0.5 — $p_g \ge 40$ lb/ft²	
7-05	0	Ip_g	Roof rafters where W < 20 ft
	$0.3p_s$	p_s uniform + a drift surcharge of $(h_d\gamma/\sqrt{S})$ with an extent of $(\frac{8}{3}h_d\sqrt{S})$	All other roof types

Table 1. Unbalanced Snow Loads for Hip & Gable Roofs

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2000, 2003 and 2006 editions of the IBC each reference a different edition of ASCE 7, it is important that the correct version of ASCE 7 be used.

Table 1 on page 13 provides a summary of the equations used to calculate the unbalanced snow loads for hip and gable type roofs beginning with the 1988 edition of ASCE 7 and culminating with the current 2005 edition. Note that the 2000 IBC references ASCE 7-98, the 2003 IBC references ASCE 7-02, and the 2006 IBC references ASCE 7-05.

Table 2 provides a summary of the maximum design reaction force, maximum design shear and maximum design moment derived for a roof truss spaced at 2' on center, with a 5/12 top chord pitch, a span of 30' and 2' overhangs at each end, using A) p_g for the roof design load; B) p_s for the roof design load; C) the unbalanced snow load based on the ASCE 7-98 and ASCE 7-02 provisions; and D) the unbalanced snow load based on the ASCE 7-05 provisions. Review of this table indicates that, for the parameters chosen, using p_g as the uniform roof snow design load produces the most conservative results. Note also that for this example, p_g was taken as 50 psf and the factors for C_e, C_t, I and C_s were chosen so that $p_s = 0.7p_g$. If we assume that building length, height and site conditions for exposure and wind speed are within the appropriate limits, then the maximum reaction, shear and moment values provided for condition B represent those derived for a truss for which the applicability limits of Section R802.10.2.1 of the 2006 edition of the IRC would apply. A comparison of the reaction, shear and moment values for condition B with those derived for condition D indicate the values are very similar.

As stated above, ASCE 7 snow load design provisions require the evaluation of other conditions that may produce load surcharges in addition to the balanced uniform loads of p_f or p_s. Besides unbalanced loading, other conditions include drifting on lower roofs, drifting at roof projections, sliding snow, rain-on-snow surcharge and ponding instability. While all of these conditions may not apply to each project, the analyses required for those that do can be very complicated and depend on building and site parameters that are best addressed by the Building Designer for the project.

For a more detailed discussion of the ASCE 7 loading provisions, download a copy of The Load Guide at **www.sbcindustry.com/loads.php**. SBC

To pose a question for this column, call the WTCA technical department at 608/274-4849 or email technicalqa@sbcmag.info.

Design Condition	Maximum Design Reaction (lbs)	Maximum Design Shear (lbs)	Maximum Design Moment (lbs-ft)
A. Balanced Design Snow Load = p_g[1]	1,700	1,485	10,802
B. Balanced Design Snow Load = p_s[2]	1,190	1,040	7,561
C. Unbalanced Design Snow Load = 0 psf windward and $1.5p_s/C_e$ leeward (ASCE 7-98 & 7-02)	1,403	1,178	6,352
D. Unbalanced Design Snow Load = $0.3p_s$ windward and p_s + drift surcharge[3] (ASCE 7-05)	1,177	1,027	6,847

Table 2. Maximum Reaction, Shear and Moment Values Using Selected Balanced and Unbalanced Design Snow Load Conditions.

[1]pg = 50 psf; [2]ps = 35 psf = Cspf = Cs0.7(Ce)(Ct)Ipg; where Ce = 1.0, Ct = 1.0, I = 1.0, Cs = 1.0; [3]In calculating the drift surcharge S = 2.4 and hd is calculated using lu = W = 17 ft.

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