Snow Provisions in *ASCE 7-05*

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What's New in *ASCE 7*?

Recently, changes have been made to the snow load provisions of *ASCE 7 Minimum Design Loads for Buildings and Other Structures.* This paper will address updated provisions of *ASCE 7-05* and, to a lesser extent, *ASCE 7-02*. This is not an exhaustive discussion of changes, instead, focus will be on provisions that have the most impact on low-rise wood frame structures. Two specific changes are discussed in detail: there are sliding snow loads, and provisions for calculating unbalanced snow loads on gable roofs - particularly simplified provisions for residential roof rafter systems.

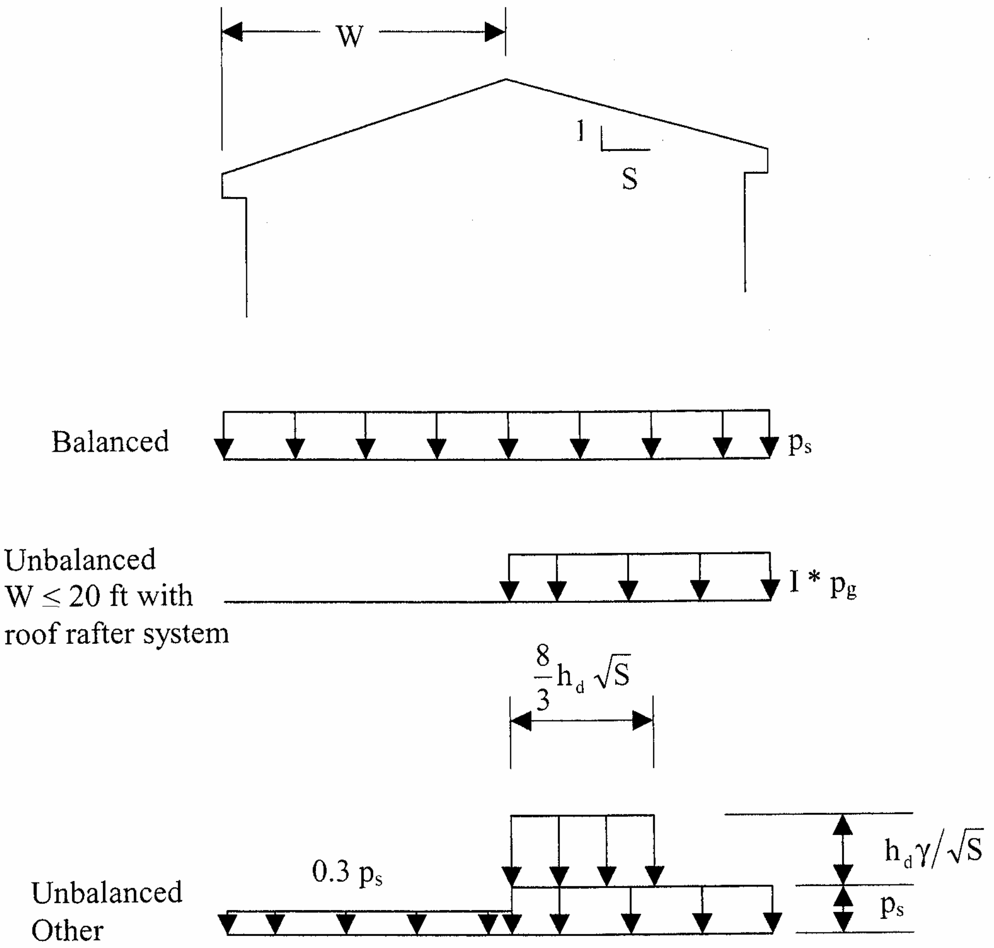
The rain-on-snow surcharge has also changed. In prior versions of the ASCE standard, a 5 psf surcharge was required for low sloped roofs (slope < ½ on 12) in low ground snow load areas (p_g < 20 psf). In *ASCE 7-05*, only roofs that are both low sloped and wide (roof slope < W/50, where W is the eave to ridge distance) potentially require the 5 psf surcharge. Since wood structures typically have roof slopes greater than W/50 (roof slope greater than 1 on 12 for W= 238 ft.), the rain-on-snow surcharge will not be discussed further herein.

Unbalanced Snow Loads on Gable Roof

Over the past decade or so, there have been more changes to the unbalanced load provisions than any other snow load in the ASCE standard. The unbalanced load for a gable roof has been prescribed to be a uniform load from ridge to eave, or a load which increases from ridge to eave. The magnitude of the load has been prescribed, at various times, to be a function of the ground snow load or the roof aspect ratio.

The difficulty in establishing an appropriate unbalanced load was due, in part, to the fact that it is actually a drift load. That is, the windward side of the gable serves as the snow source area for the drift which accumulates downwind of the ridge on the leeward side. The top surface of the actual drift is nominally flat and, except for very narrow, low sloped roofs in particularly windy locations, the drift does not extend all the way to the eave. The unbalanced gable roof load in *ASCE 7-05* is intended to mimic the expected triangular drift surcharge near the ridge. Based on water flume studies, the size or cross-sectional area of the gable roof drift is taken as that for a roof step drift with the same upwind fetch. The horizontal extent of the gable roof drift is related to the size of the drift (size of the windward snow source area) and the space available for drift formation as quantified by the roof slope. In an attempt to make the provisions user friendly, the triangular surcharge is replaced with an equivalent rectangular surcharge. The centroids of the triangle and rectangle match. The intensity of the uniform rectangular surcharge equals the average of that for the triangular surcharge.

As in the past, gable roof drift loads are not required for very steep roofs (slopes of 70° or more), where not even the balanced load is expected to stick. At the other extreme, gable roof drifts are not required for near flat roofs where there is no area of areodynamic shade at which the drift can form. Specifically, gable roof drifts are not required when the roof slope is less than the larger of 2.38° (1/2 on 12) and 70/W + 0.5 (see Figure 1).



Note: Unbalanced loads need not be considered for $\theta > 70°$ or for $\theta <$ larger of 2.38° and $70/W + 0.5$.

Figure 1. **Balanced and unbalanced snow loads for hip and gable roofs per ASCE 7-05 (reprinted with permission of ASCE).**

Simpler provisions have been incorporated in *ASCE 7-05* for residential roof rafter systems with $W \leq 20$ ft. Residential roof rafter systems are those with simply supported prismatic joists spanning from eave to ridge, supported by either a ridge board or a ridge beam. For such systems the prescribed unbalanced condition is a uniform snow load on the leeward side equal to the importance factor, I, times the ground snow load, p_g. Since rafters in such systems are typically selected from span tables, the prescribed unbalanced loading was established to correspond to a uniform load from eave to ridge. The intensity of the load is such that the peak moment and shear for the prescribed uniform load are larger than the corresponding values for the expected triangular load. Since the locations of the maximum shear and moment are different, the so-called residential roof rafter system must utilize prismatic joists so that the specific location of the actual maximums is of no consequence.

By their nature, roof trusses are not prismatic in this sense – their bending moment and shear force capacity vary along the span, although their components may well be prismatic. As such, roof trusses are not eligible for the uniform Ip_g load from eave to ridge.

Example Problem 1

Determine the governing balanced and unbalanced load for a cold, ventilated, symmetric, asphalt shingled, gable roof with W = 30 ft; slope of 7 on 12; exposure factor, $C_e = 1.0$; $I = 1.0$; and $p_g = 30$ psf.

Balanced Snow Load

For a cold, ventilated roof structure, the thermal factor, $C_t = 1.1$ and slope factor, $C_s = 1.0$ for non-slippery surfaces with slopes up to 7 on 12 slope. Hence, the sloped roof load:

$p_s = 0.7\, C_e\, C_t\, C_s\, I\, p_g = 0.7(1.0)(1.1)(1.0)(30) = 23.1$ psf.

Since $p_g > 20$, the 5 psf rain-on-snow surcharge does not apply.

The larger of 2.38° (1/2 on 12) and 70/W + 0.5 (70/30 + 0.5 = 2.83°) is 2.83°. Since the roof slope of 30.2° (7 on 12) is greater than 2.83°, unbalanced snow loads must be considered (see Figure 1), and as a result, minimum roof loading need not be considered. Therefore, the roof snow load of 23.1 psf is the governing uniform or balanced load.

Unbalanced Snow Load

From *ASCE 7-05* Figure 7-9, the roof step drift height, h_d, for W = 30 ft and $p_g = 30$ psf is $h_d = 1.86$ ft. For a 7 on 12 slope, the roof run for a rise of one, S = 12/7; while from *ASCE 7-05* Equation 7-3, the unit weight of snow is:

$\gamma = 0.13(30) + 14 = 17.9$ pcf.

The intensity of the rectangular surcharge is:

$h_d\, \gamma / (S)^{1/2} = 1.86(17.9)/(12/7)^{1/2} = 25.4$ psf

While the horizontal extent is:

$8h_d\, (S)^{1/2} / 3 = (8/3)(1.86)(12/7)^{1/2} = 6.5$ ft

The windward side load is:

$0.3\, p_s = 0.3(23.1) = 6.9$ psf

The balanced and unbalanced load cases from Example Problem 1 are shown in Figure 2. Table 1 shows balanced and unbalanced snow loads (in pounds per linear foot) on exterior load bearing walls for symmetric gable roofs with various spans (eave to eave distances). The table lists unbalanced loads from both the 1998 and 2005 versions of *ASCE 7*. The darkened value is the controlling load condition in *ASCE 7-05* for each ground snow load and roof span. Note that unbalanced snow is the controlling bearing wall load for short spans (W≤20), while the balanced snow controls for longer spans (W>20).

The comparison with *ASCE 7-98* provisions shows that the current unbalanced snow load is significantly less than in *ASCE 7-98*. For smaller spans the current unbalanced load is 87% of the *ASCE 7-98* value. For larger spans, the current values are 66% of the *ASCE 7-98* values. This highlights the significant changes in the gable roof drift load provisions over the past decade or so.

Table 1 Comparison of Balanced and Unbalanced Snow Loads on Single Story Exterior Loadbearing Walls Using ASCE 7-05 vs. ASCE 7-98[a]

	Ground Snow Load (psf)											
	30				50				70			
	Balanced	Unbalanced			Balanced	Unbalanced			Balanced	Unbalanced		
		ASCE 7-98[b]	ASCE 7-05	7-05 / 7-98		ASCE 7-98[b]	ASCE 7-05	7-05 / 7-98		ASCE 7-98[b]	ASCE 7-05	7-05 / 7-98
Roof Span (ft)	Unit Load on Exterior Loadbearing Wall/Header/Girder (plf)											
12	185	231	**200**	0.87	308	385	**333**	0.87	431	539	**467**	0.87
24	323	384	**333**	0.87	539	640	**554**	0.87	755	896	**776**	0.87
36	462	539	**467**	0.87	770	898	**778**	0.87	1078	1258	**1089**	0.87
48	**601**	875	578	0.66	**1001**	1458	966	0.66	**1401**	2041	1360	0.66
60	**739**	1072	710	0.66	**1232**	1786	1183	0.66	**1725**	2501	1663	0.66

a. Assumes 2 foot overhangs, no dead load, roof slope of 7 on 12, $C_e = 1.0$, $C_t = 1.1$, $C_s = 1.0$, $I = 1.0$.

b. The gable roof drift parameter, beta, used for W>20 is conservatively assumed to be unity for this example.

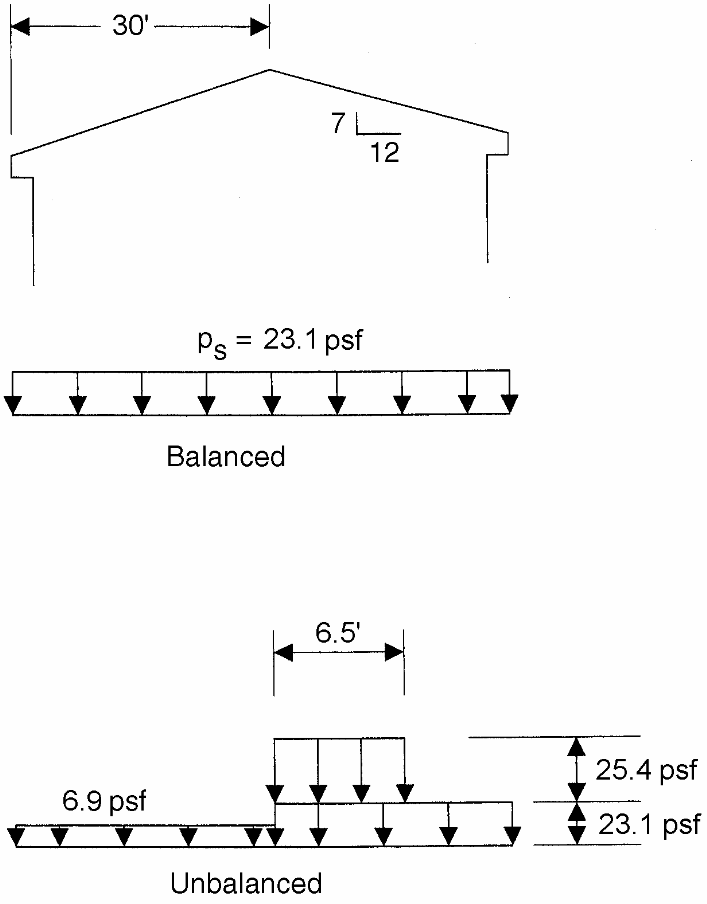


Figure 2 Balanced and unbalanced load cases for ASCE 7-05 from Example Problem 1.

Sliding Snow Load

In earlier versions of the *ASCE 7* load standard, for example in *ASCE 7-98*, the sliding snow load was taken to be all of the sloped roof snow load on the upper roof. A strict interpretation of this provision would require a sliding load check for upper level roofs of any slope. In addition, the older provisions resulted in a smaller sliding load from a steeply sloped upper roof, and a larger sliding load from a mildly sloped upper roof, which is counterintuitive. Finally, the provision was a bit vague in relation to the spatial extent of the sliding load surcharge atop the lower "receiving" roof. In the new approach, which first appeared in *ASCE 7-02*, the sliding load is 40% of the flat roof snow load, p_f, over the horizontal distance from the ridge to the eave of the upper roof, or $0.4\ p_f\ W$. The sliding snow is to be uniformly distributed over 15 ft from the upper roof eave. This load is superimposed on the lower roof balanced snow load, p_s. This provision applies to upper roofs with slippery surfaces and slopes > ¼ in 12 and to non-slippery roof surfaces with slopes > 2 in 12. Although the thermal characteristics of the upper roof (heated, unheated, south facing, etc.) likely influence the potential for sliding, these parameters are not currently considered.

Example Problem 2

Determine the sliding load for the unheated garage (thermal factor, $C_t = 1.2$) attached to a cold roof residence ($C_t = 1.1$) with a roof slope of 4 on 12 as shown in Figure 3. Exposure factor, $C_e = 1.0$ for both, Importance factor, $I = 1.0$ (residence) and $I = 0.8$ (garage), and ground snow load, $p_g = 30$ psf.

Calculate Sliding Snow Load

The residence roof slope is large enough (4 on 12) that sliding loads apply. Surcharge is based on the residence flat roof load:

$$p_f = 0.7\, C_e\, C_t\, I\, p_g$$
$$= 0.7(1.0)(1.1)(1.0)(30) = 23.1 \text{ psf}$$

The balanced load on the garage ($C_s = 1.0$ for the flat roof garage):

$$p_s = 0.7\, C_e\, C_t\, C_s\, I\, p_g$$
$$= 0.7(1.0)(1.2)(1.0)(0.8)(30) = 20.2 \text{ psf}$$

The sliding surcharge is:

$$S = 0.4\, p_f\, W = 0.4(23.1\text{psf})(18\text{ft}) = 166.3 \text{ plf}$$

Distributing over a 15 ft width:

$$166 \text{ plf} / 15 \text{ ft} = 11.1 \text{ psf}$$

The resulting additional load due to sliding snow is shown in Figure 4. Note that sliding snow from the upper level roof would overshoot the edge of a narrow lower level roof. In the example, the horizontal extent of the garage (12 feet) is 80% of the prescribed 15 foot width of the sliding load. Hence, the garage receives 80% of the total sliding load (11.1 psf x 12 feet = 133 plf = 0.80 x 166 plf).

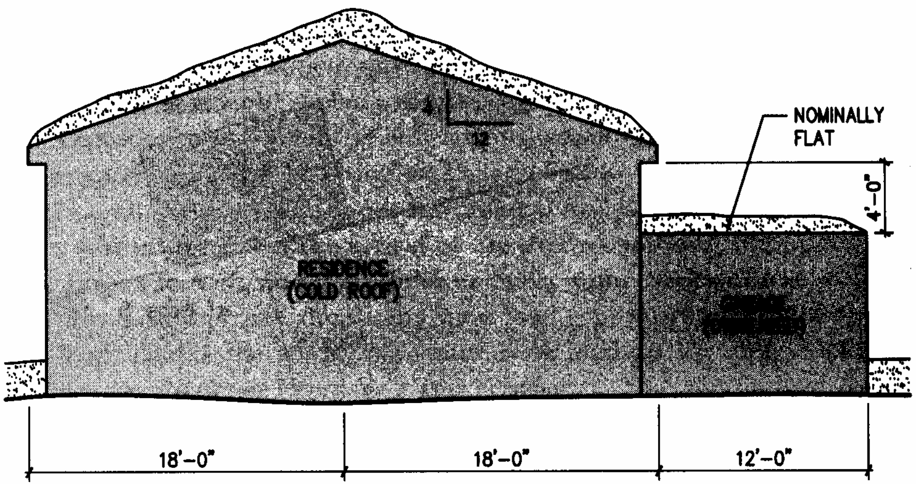


Figure 3. Example problem for determining sliding snow load.

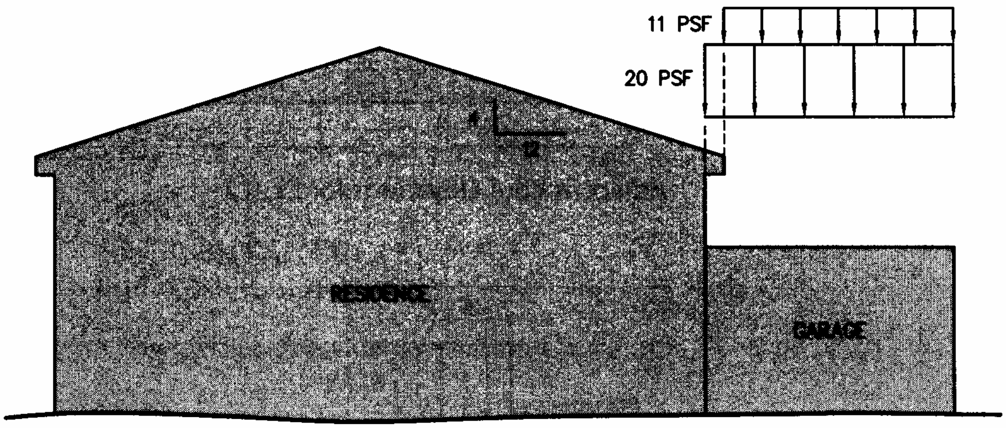


Figure 4. Resulting additional load due to sliding snow.

Summary

This article describes recent changes to snow load provisions of *ASCE 7* which impact low-rise wood framed construction. Specifically, changes to the sliding snow load and gable roof unbalanced snow load criteria are discussed and the new provisions are illustrated with examples. Of particular interest to low-rise wood framed construction are simplified unbalanced load provisions for residential roof rafter systems with ridge to eave spans of 20 ft or less, and simply supported prismatic joists with either a ridge board or a supporting ridge beam.

A more complete description of the *ASCE 7-05* snow load provision; with additional examples for wood framed, as well as other types of construction, will soon be available in *Snow Loads: Guide to the Snow Load Provisions of ASCE 7-05,* published by ASCE Press.

Appendix: Calculations Supporting Values for Table 1 of *Snow Provisions in ASCE 7-05*

This example assumes 2 ft overhangs (OH), no dead load, and a roof slope of 7 on 12.

Balanced Snow Loads

Per Example Problem 1, the sloped roof load, $p_s = 23.1$ psf for $p_g = 30$ psf. Sum moments about the top of the left wall (see Figure 2) for a 12 ft roof span:

$\Sigma M_{left} = 0$

$\Sigma M_{left} = 23.1(\text{Span} + \text{OH})(\text{Span} + \text{OH})/2 – 23.1(\text{OH})(\text{OH}/2) – R_{right}(\text{Span})$
$= 23.1(12 + 2)(12 + 2)/2 – 23.1(2)(2/2) - R_{right}(12)$

$R_{right} = 185$ plf (for a span of 12 ft and $p_g = 30$ psf)

Unbalanced Snow Loads

ASCE 7-05

For $W \leq 20$ ft:

Per Figure 1, sum moments about the top of the left wall assuming $p_g = 30$ psf and a 12 ft roof span:

$\Sigma M_{left} = 0$

$\Sigma M_{left} = 30(\text{Span}/2)(\text{Span}*3/4) + 30(\text{OH})(\text{Span} + \text{OH}/2) – R_{right}(\text{Span}) = 0$

$= 30(12/2)(12*3/4) + 30(2)(12 + 2/2) – R_{right}(12) = 0$

$R_{right} = 200$ plf (for a span of 12 ft and $p_g = 30$ psf)

For $W > 20$ ft:

Per Figure 2, sum moments about the top of the left wall assuming $p_g = 30$ psf and a 60 ft roof span:

$\Sigma M_{left} = 0$

$\Sigma M_{left} = 6.9(\text{Span}/2)(\text{Span}/4) + 25.4(6.5)(\text{Span}/2 + 6.5/2) + 23.1(\text{Span}/2)(\text{Span}*3/4)$
$+ 23.1(\text{OH})(\text{Span} + \text{OH}/2) – 6.9(\text{OH})(\text{OH}/2) – R_{right}(\text{Span}) = 0$

$= 6.9(60/2)(60/4) + 25.4(6.5)(60/2 + 3.25) + 23.1(60/2)(60*3/4) + 23.1(2)(60 + 2/2) – 6.9(2)(2/2) - R_{right}(60) = 0$

$R_{right} = 710$ plf (for a span of 60 ft and $p_g = 30$ psf)

ASCE 7-98

For $W \leq 20$ ft:

Per ASCE 7-98, for $W \leq 20$ the unbalanced snow load is uniformly distributed on one side of the roof and is calculated as $1.5p_s/C_e$ for roof slopes greater than 5°. For $p_g = 30$ psf:

$1.5p_s / C_e = 1.5(23.1)/(1.0) = 34.65$ psf

Similar to earlier calculations for *ASCE 7-05* for $W \leq 20$, sum moments about the top of the left wall assuming a 12 ft roof span:

$\Sigma M_{left} = 0$

$\Sigma M_{left} = 34.65(Span/2)(Span*3/4) + 34.65(OH)(Span + OH/2) – R_{right}(Span) = 0$

$= 34.65(12/2)(12*3/4) + 34.65(2)(12 + 2/2) – R_{right}(12) = 0$

$R_{right} = 231$ plf (for a span of 12 ft and $p_g = 30$ psf)

For $W > 20$ ft:

Per ASCE 7-98, for $W > 20$ ft an additional parameter for determining unbalanced loads is the roof slope. This trigger is calculated as $(275\ \beta\ p_f / \gamma\ W)$, where β is the gable roof drift parameter, which ranges from 0.5 to 1.0 depending on the length to width ratio of the building. A conservative assumption is to assume $\beta = 1.0$, which is done for this analysis.

In Table 1, which is based on a roof slope of 7 on 12 and a maximum ground snow load of $p_g = 70$ psf, the slope always exceeds the trigger. For roof slopes greater than the trigger and spans greater than 20 ft, the windward side snow load is $0.3p_s$ and the leeward side snow load is:

$1.2(1 + (\beta/2)p_s / C_e = 1.2(1 + (1/2))23.1 / (1.0) = 41.6$ psf

Similar to earlier calculations for *ASCE 7-05* for $W > 20$, sum moments about the top of the left wall assuming $p_g = 30$ psf and a 60 ft roof span:

$\Sigma M_{left} = 0$

$$\Sigma M_{left} = 0.3p_s(Span/2)(Span/4) + 41.6(Span/2)(Span*3/4) + 41.6(OH)(Span + OH/2) – 0.3p_s(OH)(OH/2) – R_{right}(Span) = 0$$

$= 6.9(60/2)(60/4) + 41.6(60/2)(60*3/4) + 41.6(2)(60 + 2/2) – 6.9(2)(2/2) - R_{right}(60) = 0$

$R_{right} = 1072$ plf (for a span of 60 ft and $p_g = 30$ psf)