# Changes in Snow Load Calculations in ASCE 7-02

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Prior to the release of the 2000 edition of the International Building Code (IBC), the only person who could correctly tell you what "ASCE" stood for was a member of ASCE itself - the pocket-protector wearing, calculator-toting engineer. With the release of the IBC, most people now know that ASCE is an acronym for the American Society of Civil Engineers, an organization that, just as its name implies, is comprised mainly of Civil Engineers. One of the many functions of ASCE is the publishing of a standard titled, "*ASCE 7 - Minimum Design Loads for Buildings and Other Structures*." But before we discuss the purpose of ASCE's *Minimum Design Loads* standard and the changes found in the 2002 edition of the ASCE standard, let's discuss how ASCE's load standard comes into play in the design of metal plate connected wood trusses and light-gage steel trusses.

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## Protecting the Public's Health

With few exceptions, all structures are required to be designed in accordance with the governing building code determined by the geographical location of the structure. The purpose of having a published building code is to provide regulatory requirements that can be adopted to protect the public's health. Currently, the push is on to implement the IBC, and the companion IRC (International Residential Code) for one- and two-family dwellings, as the sole nationwide model building codes. So far, over 80% of the states have made the switch to the International Codes.

The IBC and IRC cover everything from fire protection systems to building accessibility and building exits; from the application of design loads to the design of structures using concrete, steel, and wood. The inclusion of all information pertinent to the topics covered by the IBC and IRC would result in a series of manuals on par with the Encyclopedia Britannica. The use of referenced standards such as TPI 1-2002, for the design of metal plate connected wood trusses, and ASCE 7-02 for the determination of all applicable design loads, allows the code administrators to minimize the size of the published codes. The use of referenced standards within the building code also allows the code administrators to take advantage of outside technical experts who have compiled the latest and most up-to-date information on the specific topics addressed by the code.

When a standard is referenced in a code such as the IBC or IRC, that standard becomes an extension of the code. Once a building code is adopted by a state or other jurisdiction, all referenced standards within that code become a part of the code and are therefore legally enforceable, as is the main building code. The 2003 editions of the IBC state that for a given structure, the design snow loads and the design wind loads shall be determined in accordance with the appropriate sections of ASCE 7-02.

ASCE 7-02, like its predecessors 7-98, 7-95, 7-93, and so on, is a standard that provides the minimum load requirements for the design of buildings and other structures that are subject to building code requirements. The loads specified in ASCE 7-02 have been derived from research and service performance of buildings and other structures. The snow load section of ASCE 7-02 lists over fifty referenced research papers that were used in the compilation of the snow load calculations found in ASCE 7-02.

## ASCE 7-02 Impact on Snow Loads

So how will the implementation of the 2003 editions of IBC and IRC, having ASCE 7-02 as the referenced load determination standard, affect the snow loads that are applied to metal plate connected wood trusses and light-gage steel trusses? As states began adopting IBC 2000 and the code-referenced ASCE 7-98, the impact of the unbalanced snow load provisions in 7-98 created quite a stir. Several states amended the IBC/IRC to eliminate the requirement for unbalanced snow loads if minimum, state-specified, balanced design snow loads were used in the design of the structure. What can we expect to find in ASCE 7-02?

The basic ground snow map found in ASCE 7-02 was generated from data collected by the National Weather Service. The ground snow loads shown on the map are based on a 2% annual probability that the indicated snow loads will be exceeded. This type of map is also referred to as a 50-year recurrence interval map, which means that the indicated ground snow loads are not expected to be exceeded more than once every fifty years. The ground snow map contained in ASCE 7-02 is an updated version of the map used in 7-93 and is the same map that was used in 7-95 and 7-98.

### Amended State Snow Maps

Even though the ground snow loads have not changed between ASCE 7-98 and 7-02, this does not prevent a state from amending IBC and IRC with their own state snow map. Several states, Michigan and New York to name two, have amended the IBC and IRC with their own state ground snow map even though the snow maps in 7-98 and 7-02 did not change. It is advisable for every Building Designer to verify the state-required ground snow loads for a certain location to ensure that the various structural components of the building are designed in accordance with local requirements.

Along with the same ground snow map in ASCE 7-02 that was used in 7-98, the ground-to-roof adjustment factors are unchanged from 7-98. The various adjustment factors that take into consideration building usage (importance factor), building location (exposure factor), and building heating conditions (thermal factor) have remained the same as they were in 7-98. Unless a state amends or implements its own state ground snow map when adopting the 2003 editions of IBC and IRC, the calculated balanced snow load using ASCE 7-02 for a particular location will be the same as the calculated balanced snow load using ASCE 7-98 for that same location.

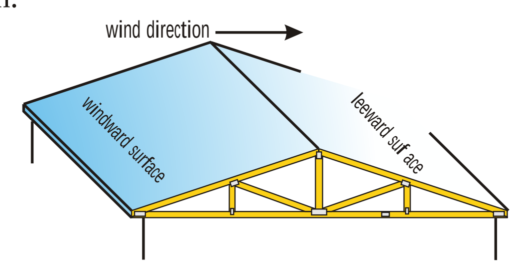
### Good News/Bad News

The unbalanced snow load provision in ASCE 7-02 is a "good news / bad news" situation. The bad news is that, once again, the requirements for unbalanced snow loading have changed. The good news is that the method used to calculate the unbalanced snow loads has been simplified, although the calculated unbalanced loads haven't necessarily decreased from what was specified in ASCE 7-98. But first let's look at unbalanced snow loads in general and how we went from ASCE 7-95 to 7-98 to 7-02.

An unbalanced snow load is just like it sounds – a snow load that is not balanced, or uniform, across a roof surface. This means that on a roof surface, snow accumulates in varying depths depending on the roof profile. There are a few conditions required to create an unbalanced snow load. First, a change in the roof profile, such as a change in slope, is needed to create areas where snow can accumulate in depths greater than or less than the expected balanced snow depths. Next, you need a snow event. And, finally, you need wind. The wind will redistribute the snow across the roof surface depending on the direction of the wind and the roof geometry.

### Windward and Leeward Surfaces

When we talk about unbalanced snow load cases, we tend to use the terms "windward surface" and "leeward surface". The windward surface of a roof is the surface that faces the wind. The leeward surface of a roof does not directly face the wind. The tendency is for wind to clear most, if not all, the snow off the windward surface of the roof and redeposit the snow on the leeward surface of the roof, on top of the snow that had previously fallen on the leeward roof surface. As a result, the windward roof surface ends up with little or no snow while the leeward roof surface ends up with snow depths exceeding the standard balanced snow depth.

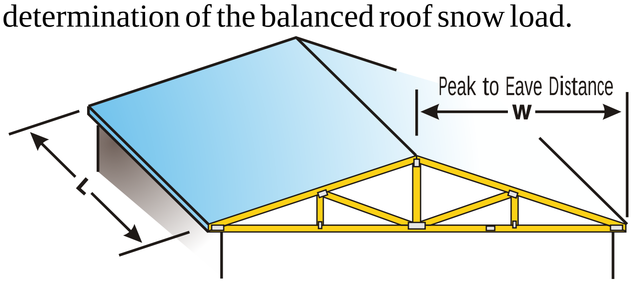



Unbalanced snow loads used to be much simpler to calculate. ASCE 7-93 required the windward roof surface to be designed with no snow, while the leeward roof surface was to be designed for 1.5 times the balanced roof snow. ASCE 7-95 dropped the leeward factor to 1.3 times the balanced roof snow while using zero snow on the windward surface. With the release of ASCE 7-98 and the adoption of IBC 2000, the method of determining unbalanced snow loads was completely revamped.

The specified unbalanced snow load provisions in ASCE 7-98 were based on a "wind from all directions" approach. In prior editions of ASCE, the roof profile was viewed as a simple two-dimensional shape. The unbalanced snow load provisions in 7-98 looked at a building as a three-dimensional object and reasoned that the length of the building was just as critical as the roof span and pitch in calculating the unbalanced snow load. ASCE 7-98 based the unbalanced snow load calculations on an aspect ratio of the building length (L) to the distance from the roof peak to the eave (W). It was believed necessary to consider that for a long, wide building with a low pitched roof, snow could be carried from one end of the building, across the peak, to the opposite end of the building, resulting in substantial snow accumulations on the leeward roof surface.

As was mentioned earlier, while ASCE 7-02 did not necessarily reduce the unbalanced snow loads for all situations, it did simplify the methods used to determine the unbalanced snow loads as well as change the basis for determining these loads. Whereas ASCE 7-98 took into consideration the building geometry for its load calculations, 7-02 bases its load calculations on the ground snow load. ASCE 7-02 also has only two possible load cases for unbalanced snow loads compared to three possible load cases found in 7-98.

The unbalanced snow load calculations in ASCE 7-02 and 7-98 are similar when the peak-to-eave distance (W) is less than or equal to twenty feet. In both editions of ASCE, when W is less than or equal to twenty feet, the windward roof surface is to be designed with no snow and the leeward roof surface is to be designed with 1.5 times the balanced roof snow. When W exceeds twenty feet, the unbalanced snow loading will be based on the ground snow load used in the initial determination of the balanced roof snow load.




For longer roof spans (e.g. - spans exceeding forty feet, assuming a peak-to-eave distance of twenty feet and no overhangs), the windward roof surface is considered of sufficient length that wind will not completely remove all snow from the surface. ASCE 7-02 specifies that the windward roof surface be designed for 0.30 times the balanced snow load when W exceeds twenty feet. The multiplier factor for the balanced snow load on the leeward roof surface will be dependent on the ground snow load.

The equation for the leeward roof surface factor, to be multiplied by the balanced snow load, is:

Leeward Snow Multiplier = 1.2 x (1 + ( b/2 ) )

where b = 1.0 when the ground snow ($p_g$) is less than or equal to 20 psf

b = 0.50 when the ground snow is greater than or equal to 40 psf

b = 1.5-(0.025) ($p_g$) when the ground snow is greater than 20 psf but less than 40 psf

The above equation results in the following windward and leeward unbalanced snow loads:

| Peak-to-Eave Distance and Ground Snow Load | Windward Roof Surface | Leeward Roof Surface |
|---|---|---|
| W≤20' | No Snow | 1.5 x Balanced Snow |
| W≥20'<br>Ground Snow ≤ 20 psf | 0.3 x Balanced Snow | 1.8 x Balanced Snow |
| W>20'<br>20 psf<Ground Snow<40 psf | 0.3 x Balanced Snow | 1.8 to 1.5 x Balanced Snow<br>Factor decreases as ground snow increases |
| W>20'<br>Ground Snow≥40 psf | 0.3 x Balanced Snow | 1.5 x Balanced Snow |

As the chart indicates, the factor by which the balanced snow load increases on the leeward roof surface will decrease as the ground snow load increases. The overall unbalanced snow load on the leeward roof surface, however, will still be greater for a 40-psf ground snow load than for a 20-psf ground snow load. The rationale behind the unbalanced snow calculations in ASCE 7-02 is that a lesser depth of base snow of a roof surface will allow more depth for drifted snow to accumulate on top of the base snow.

Let's look at a roof that has a 4' height difference between the peak and the eave, and we will use a snow density of 20 pounds per cubic foot. If we have a 20-psf calculated balanced snow load, the depth of the balanced snow will be one foot. This leaves a vertical distance of three feet between the peak and the balanced snow for drifted snow to accumulate. If the same roof is located in an area where the calculated balanced snow load is 40 psf, the depth of the balanced snow load would be two feet, leaving a vertical distance of two feet for drifted snow to accumulate.

This was only an example, as drifted snow is seldom expected to accumulate to a depth level with the peak elevation, but the concept is that lesser snow depths permit greater drifted snow accumulation in proportion to the balanced snow load. Studies of roof collapses attributed to unbalanced snow loads have shown that almost 90% of the collapses occurred in areas where the ground snow load was 30 psf or less. A roof truss designed for a balanced snow load of 20 psf that is subjected to a snow increase on the leeward roof surface of 1.8 times the balanced snow load will be pushed closer to the ultimate design capacity of the lumber and connector plates than would a roof truss designed for 40 psf of snow, and subjected to an increase of 1.5 times the balanced snow load.

### Sliding Snow Also Modified

The requirements for sliding snow in ASCE 7-02 have also been modified from the requirements specified in ASCE 7-98. Under ASCE 7-98, you were required to consider that all snow on an upper sloped roof would slide down onto a lower roof, using the calculated sloping roof snow value. The calculated balanced roof snow can be adjusted by a slope reduction factor based on the pitch of the roof and the roofing material (e.g. a slippery surface versus a non-slippery surface). The adjustment was allowed on the basis of a reduction in the balanced roof snow resulting from snow slide-off. ASCE 7-98 allowed the use of the slope-reduced snow on an upper roof when calculating sliding onto a lower roof without considering that the amount of snow by which the upper roof balanced snow was reduced would also end up on the lower roof. Only the slope-adjusted snow was to be considered as sliding snow, not the portion of the balanced snow that was removed using the slope reduction factor.

ASCE 7-02 corrected this inaccuracy, along with making a few other changes. Using ASCE 7-02, sliding snow is only to be considered for slippery roofs (e.g. metal, slate, and glass) for roof slopes greater than or equal to 0.25/12. Sliding snow must be considered for non-slippery roofs (e.g. asphalt shingles, wood shingles, and wood shakes) having slopes greater than 2/12. This is a change from ASCE 7-98, which required that sliding snow be considered for all roof slopes.

The amount of snow from an upper roof that is to be considered for sliding onto a lower roof is taken as 0.4 times the flat-roof snow ( $p_f$ ) on the upper roof, multiplied by the horizontal distance from the peak to the eave (W) of the upper roof. By including the length of the sloping upper roof, the magnitude of the sliding snow will vary depending on the area of accumulated snow on the upper, sloping roof. Larger upper roof surfaces will hold a greater amount of snow that can slide onto a lower roof. Therefore it is appropriate to take the length of the upper roof into consideration when calculating the amount of snow that may end up on the lower roof. The resulting calculated unit length (pounds per linear foot) of sliding slow is then divided by and distributed over, a distance of fifteen feet on the lower roof. ■