Let it snow! Let it snow! Let it snow?!?

Post-frame building owners should be able to enjoy long, peaceful, winter naps for years to come if their buildings are properly engineered, constructed, and maintained.

By Aaron J. Halberg, P.E.

Over the past decade, snow has contributed to the collapse of many buildings throughout rural areas, especially where large buildings are exempt from building codes and inspections. Most recently, in February and March of 2019, many buildings collapsed throughout Minnesota, Iowa, and Wisconsin after receiving relatively high seasonal snowfall amounts (see Fig. 1).

![Seasonal Snowfall totals in the Midwest from 2013-14 and 2018-19 winter seasons, each of these winters resulted in numerous collapses. (Graphic Source: nohrsc.noaa.gov)](image)

Some think of this as nature’s way of “spring-cleaning”, removing old and weak buildings from our communities, but I have witnessed new buildings collapse, as well as the old (see Fig. 2).

![This new freestall barn experienced a partial collapse in February 2014 in Northern Wisconsin before the first dairy cow had even moved in. The design for this “Pole Barn” was not engineered.](image)
Many of the larger buildings constructed for farms or storage are post-frame buildings because they are structurally efficient, environmentally friendly (low embodied energy) and affordable. As a result, when collapses occur in these areas, they are likely to include a large number of post-frame buildings. Although it varies by state, rural and agricultural buildings are often exempt from building codes and inspections in many states, regardless of building size (see Figure 3).

Figure 3 - These pictures show typical farm operations found throughout the Midwestern US, with a dairy barn from the early 20th century (top) compared to an early 21st century dairy operation (bottom). Except for the electrical systems, the larger buildings are often exempt from structural building codes and inspections.

For buildings with no building code requirement, a builder and owner can agree to whatever building design specifications they want, meaning it would be legal to construct a building that has been engineered to support loads lower than the minimums prescribed in the ASCE 7 standard (see Figures 4 and 5). The more common option is that they build a non-engineered post-frame building; that is, they construct a post-frame building without having a comprehensive structural analysis performed, and without such an analysis, no technical basis exists for the size and grade of framing members, nor for how they are connected. In such a situation, the building design capacity is essentially unknown. It’s an uneducated guess, or the flip of a coin, whether wind or snow will cause a collapse. When designed improperly or not designed at all, any material efficiency gains associated with the post-frame building system are nullified because of the increased probability of structural failure.
Figure 4 - ASCE 7: the preeminent Minimum Design Load standard for buildings in the United States. (-16 indicates this is the 2016 edition of the standard)

UPDATE: Buffalo Co. farm ruled total loss after fire that cause $10M in damages

Figure 5 – A post-frame hog barn collapsed in Wisconsin after a March 2019 snow event which then caught on fire from an electrical source. The building was engineered for a 30psf Roof Snow load, less than the ASCE 7 standard for the building’s location.
Any such under-designed or non-engineered post-frame structure has no merit to be compared to a properly designed and constructed post-frame building, which utilizes the technical advances made over the past 30 years through efforts and initiatives supported by the National Frame Building Association (NFBA) and summarized in the Post-Frame Building Design Manual.

To assess the situation after many collapses occurred in the winter of 2018-19, about 30 professionals joined the Engineering Committee of the Wisconsin Frame Builders Association (WFBA) in April 2019 for a meeting. The goal was to seek consensus on actions that could and should be taken on behalf of the industry and future post-frame building owners.

After a spirited day-long discussion, three main ideas and objectives seemed agreeable to this group:

1. Conduct a survey of farm building collapses over the past decade to establish the magnitude and nature of the problem, explore trends in the age and type of structures affected, and measure financial impact to farmers and insurers.
2. Promote the use of ASCE 7 (see Fig. 4) as the document for establishing minimum design loads (snow, wind, seismic, etc.) for all structures.
3. Educate building owners, builders, insurers, and lenders about their responsibilities and options for quality decision making on new building projects, so they will end up with a reliable post-frame building instead of an under-designed look-alike.

These three initiatives are underway, with a survey and follow up interviews ongoing, conducted by University of Wisconsin outreach specialists. Also, this article and live presentations I have made since April 2019 have focused on promoting ASCE 7 as the minimum design load standard for all buildings and educating building owners on the importance of getting a fully engineered post-frame building. The NFBA Technical and Research committee will continue to focus on education materials to promote these ideas.

Even a properly engineered post-frame building could experience damage or collapse due to an extreme snow event, wind storm or tornado, but it is my opinion that many of the buildings which collapsed in recent snow and wind storm events will be found (through the survey) to have been under-designed or non-engineered post-frame look-alikes.

Some of the key decisions an owner should make for a reliable post-frame building include:

- Have the building designed by a Professional Engineer familiar with post-frame construction;
- Select design loads for snow, wind, and other applicable loads which meet or exceed ASCE 7 minimums;
- Receive a set of certified (stamped) set of construction plans for the building design before construction begins. A stamped truss design does not mean the building itself is engineered! Building design documents are not only useful during construction, but also for inspection of the finished project by insurance, lenders, and others; also useful for future reference when changes, repairs, or improvements are considered;
- Work with a competent builder, identified by a commitment to keep up with the latest advances, such as the NFBA’s Accredited Builder program; and
- Perform the recommended preventative maintenance and routine inspections to ensure that the building design integrity is maintained throughout the building’s useful life.

Extreme weather will provide the ultimate test for a building’s reliability and reveal which buildings are properly engineered post-frame buildings and which are “look-alikes”. It would be immoral to represent a new building as a properly and fully engineered post-frame building if that is not true. I strongly encourage building owners and builders to have clear and honest conversations about engineering, design loads, and expected service life before the building purchase agreement is signed.

**ASCE 7 and Snow Loads**

While ASCE 7 is the preeminent design load standard for buildings and other structures within the United States, it is a relatively technical standard and not easily understood by those unfamiliar with its engineering terminology. Any
document containing considerable technical terminology or jargon tends to be misunderstood by the unversed, yet because of continual updates to ASCE-7, many building design professionals also have difficulty maintaining a working understanding of the standard.

Rather than getting too deep into the full snow load provisions of ASCE 7 (and risk losing your attention), I would like to focus on just two variables which should be understood by every building owner and builder for each project: Building Risk Category and, to a lesser extent, Ground Snow Load.

In ASCE 7, the Sloped Roof Snow Load (also known as Balanced Snow Load) is based on the Ground Snow Load for the building location (units: [lbs. per square foot]) multiplied by several factors, including an Importance Factor, \( I_s \) (no units) which is based upon the Building Risk Category, or just Risk Category. Before a building analysis is performed, the building owner, the builder, and the professional engineer/designer need to discuss and agree upon the Risk Category for the project. Because Risk Category establishes safety factors, its selection impacts design load levels, and hence overall building cost.

Note: Determining proper snow and other loads is NOT the responsibility of the truss supplier or truss designer, even if they are very experienced and have a good feel for typical design load levels. Truss suppliers and designers are also not responsible for setting the Building Risk Category, even though they have software available to them that allows them to quickly select a value from a drop-down menu during truss design and associated price estimating. Instead, the Building Designer is specifically responsible for determining the magnitude, direction and nature of all design loads to be applied in the design of the trusses for the project. (Source: TPI 1 2014 – Section 2.3.2.4)

There are four Risk Categories in ASCE 7 and they are identified by roman numerals I, II, III, and IV. The higher the numeral, the higher the safety factor associated with the design of the structure. This can be seen in Table 1 which contains excerpts from ASCE 7-10 Tables 1.5-1 and 1.5-2. The “normal” Risk Category or default scenario is Risk Category II. This Risk Category is associated with an Importance Factor (multiplier) for snow load of 1. The Snow Importance Factor for the other Building Risk Categories shows how the Sloped Roof Snow is affected: from a 20% reduction in design snow load for Risk Category I, \( I_s = 0.80 \), all the way up to a 20% increase in design snow load for Risk Category IV, \( I_s = 1.20 \).

Table 1. Snow Load Importance Factors*

<table>
<thead>
<tr>
<th>Use or Occupancy of Buildings and Structures</th>
<th>Building Risk Category</th>
<th>Snow Importance Factor (( I_s ))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buildings and other structures that represent a low risk to human life in the event of failure</td>
<td>I</td>
<td>0.80</td>
</tr>
<tr>
<td>All buildings and other structures except those listed in Risk Categories I, III, and IV (“Normal”)</td>
<td>II</td>
<td>1.00</td>
</tr>
<tr>
<td>Buildings and other structures, the failure of which could pose a substantial risk to human life</td>
<td>III</td>
<td>1.10</td>
</tr>
<tr>
<td>Buildings and other structures designated as essential facilities</td>
<td>IV</td>
<td>1.20</td>
</tr>
</tbody>
</table>

* From ASCE 7-10 Tables 1.5-1 and 1.5-2.
I propose that the following simplified descriptions for ASCE 7-10 Risk Categories be considered for general use and discussions:

- Risk Category I: **Temporary**
- Risk Category II: **Standard**
- Risk Category III: **Better**
- Risk Category IV: **Best**

Although these single word descriptors don’t transmit the technical information contained in Table 1, I feel their use would improve comprehension of Risk Category levels to those unfamiliar with the technical jargon of ASCE 7. I would even suggest builders and building stakeholders consider something like the “Informed Consent” form shown in Figure 6 as a way to clearly communicate the Risk Category desired for a project. The consistent use of such a form would allow sales representatives for competent builders to demonstrate their understanding of the design process to potential building owners and impress upon them that they alone can and should dictate the level of risk they are willing to assume, which translates into the structural performance level they can expect out of their fully engineered building.

| Building Risk Category - Owner to identify desired Risk Category for use in Structural Design |
|-----------------------------------|-------------|-----------------------------------|---------------------------------|
| Risk Category | Design Level | Owner's Initials by chosen Risk Category | Adjustment to "Standard" Snow Load |
| I               | Temporary    |                                     | 0.80 (20% Decrease)             |
| II              | Standard     |                                     | 1.00 (Standard)                 |
| III             | Better       |                                     | 1.10 (10% Increase)             |
| IV              | Best         |                                     | 1.20 (20% Increase)             |

Building Project Name: ____________________________________________________________

As the building owner, I understand that the Risk Category for this building will affect the building design loads for this building, including wind and snow and I want the Risk Category as selected above to be used to determine the minimum design loads for this building.

<table>
<thead>
<tr>
<th>Owner's Signature</th>
<th>Date</th>
</tr>
</thead>
</table>

Figure 6 – A proposed Informed Consent form that could be used for each project to help the Building Owner and Builder or Sales Representative have a good discussion about the design levels and reliability of the building up front.

I think this simple step could have a very positive step in “leveling the playing field” for builders bidding on the same projects. When adopted and widely used, the consent form would essentially require all those bidding on a particular project to provide a building designed to approximately the same load levels. This in turn, better ensures that building owners are comparing apples to apples when analyzing bids.
When presented the “Informed Consent” form, owners may balk at having to select a Risk Category and will try to get someone else to make the decision. But I strongly recommend owners make this very important decision themselves. Where uncertainty in selection exists, I would advise them to consider their choice of Risk Category in this way:

If your building will be unoccupied by humans during any likely collapse scenario and the loss of your building and its contents would be a mere inconvenience to you (you are not worried about the loss of life, property, and/or business income after a collapse), you could use ASCE 7 Risk Category I.

If it is quite likely your building could be occupied by humans during a potential collapse scenario, and/or if you are concerned about loss of animal life, property, business income or the stress of a building collapse, use ASCE 7 Risk Category II (which is standard) or even higher: III would be considered “Better”, IV would be considered “Best”.

As always, when considering technical design compliance, a professional engineer on the design team should be able to advise on ASCE 7 compliance options and the impact they may have on the project.

The Ground Snow Load assigned to each building site location can be found by using: maps in the ASCE 7 standard, local government snow load provisions (where they exist), or an online design tool such as the one provided at http://hazards.atcouncil.org (see Fig. 7). However it is determined, the prescribed Ground Snow Load should be treated as a minimum and hence with some skepticism, especially when a builder, an owner, or a designer has knowledge about individual snow fall events that have produced ground snow loads in the area that measurably exceed the minimum prescribed value. It is for this very reason (i.e., personal experiences and observations) that I use minimum snow loads within certain areas of Wisconsin that exceed those required by ASCE 7.

Figure 7 – ASCE 7 loads for Snow, Wind and Seismic events can be found for most U.S. locations using hazards.atcouncil.org, as shown for the recent location of the NFBA Expo site.
In July of 2002, the State of Wisconsin adopted the International Building Code (IBC) as its commercial building code. From 1914 through 2002, Wisconsin wrote and maintained its own commercial building code. The IBC relies on ASCE 7 for structural load calculations, so the adoption of the IBC in 2002 was a significant change in minimum snow load levels. The minimum loads increased in northern parts of the state, but in southern parts of the state, the changes reduced minimum loads by more than 35%. Actual snow falls in these areas since 2002 have demonstrated that the Wisconsin building code (i.e., pre-IBC) minimum snow loads were more appropriate for safe design.

Since the switch to the IBC and ASCE 7 in 2002, I have wondered how ASCE 7 snow load provisions are adjusted over time for locations where original ground snow loads were inadequate, and/or where recent shifts in weather patterns significantly affect local snow events. When I reached out to the ASCE 7 Snow Load sub-committee, I was told that there are efforts underway to evaluate weather data on an ongoing basis and to use these evaluations to modify future versions of the ASCE 7 standard where needed. The next edition of the standard is ASCE 7-22, but I don’t yet know if this edition will include any major changes to snow load provisions.

When it comes to performance levels for structural design and reliability, it is important to realize that building codes establish MINIMUM values, not the high-level “gold standard” values that you would associate with quality construction. In many respects, minimum building code values represent the biggest trade-off that the government is willing to allow between keeping building costs down and risking the lives of its citizens. Does that sound like a ringing endorsement? It’s not.

It seems that some people think that a “code compliant” design load or building design is a lofty standard, such that once that level is reached, anyone would be foolish for designing better than that. But think about another type of legal limit, the speed limit. When the speed limit is 60 mph, how fast do you typically drive? I’m guessing at least 63 or 64 mph, and many of our fellow citizens are comfortable driving at least 10mph over the limit.

We treat our maximum speed limit like the minimum speed, but we treat our minimum design loads as maximums to be considered. Isn’t that crazy? I know the incentive is to go faster on the highway and to build cheaper buildings, but at what ultimate cost? More than 35,000 people die in vehicle crashes in our country each year, so maybe we should treat our vehicles and the energy associated with high speeds more respectfully. Although we haven’t been experiencing statistically significant danger to human life from building collapses, I wonder if the construction industry is designing and building for the appropriate levels of snow, wind, and seismic events that will be experienced during the next 50 years.

Time will tell.