Proper Snow Loads for Post Frame Buildings

Date: February 27, 2020

Time: 10:20-11:20am

Room Location: 308-310

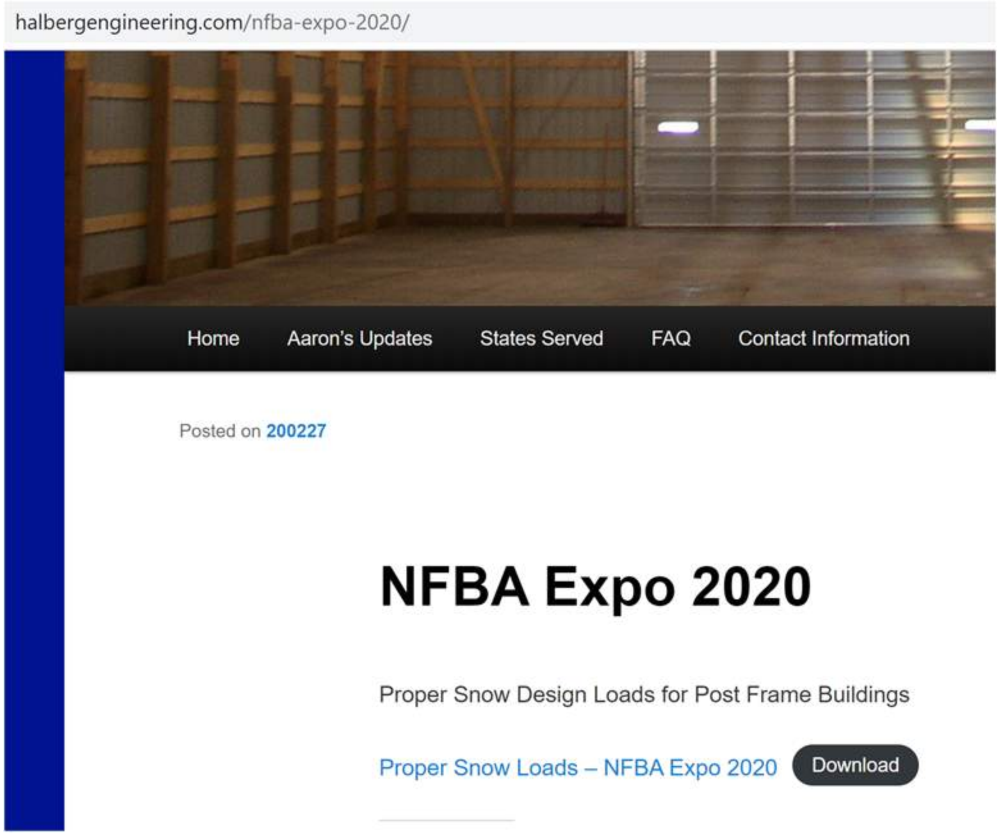
Speaker's Name: Aaron Halberg, P.E.

Aaron (presenter) on Feb 22 2020: After skiing 30 miles out of a 31 mile (50k) race, the excitement of surviving and then seeing friends and family creates an extreme "natural high". The leg cramps and fatigue melt away… the adversity is forgotten, and the emotions of survival dominate. Could this be similar to the psychological response after experiencing extreme weather events?

Today’s Main Ideas…

- Future weather patterns may be a flip of the coin but will seriously test your buildings decade after decade…
- “Trust me, it’s snow problem…” (Have we been here before?)
- Last winters snow “issues”: How does the industry respond?
- The STANDARD we use to predict “weather” forces: **ASCE 7 Minimum Design Loads for Buildings and Other Structures**
- Part 1 of Step 1 – Find your Ground Snow Load
- Some considerations turning Ground Snow into Roof Load

A draft of this presentation is available on my website, under Aaron's Updates: www.halbergengineering.com/nfba-expo-2020



HAVE WE BEEN HERE BEFORE?

At NFBA Expo 2011, Tim Royer, P.E. of Timber Tech Engineering presented on "Snow Loading Patterns Observed During the 2009/2010 Winter"

From Tim's investigation of snow load failures of large Hog Barns in Iowa (designed by others), revealed problems such as:

- Lack of bracing on compression web members (applied to tension members)
- Buildings under-designed for actual snow loads experienced
- Potential Decay in some members
- Inadequate truss bearing area
- Structural issues due to corrosion and premature steel failure, especially truss plates in the area of Manure Pit exhaust

At NFBA Expo 2014, Ryan Michalek, PE of Nationwide Agribusiness Insurance presented on “Avoiding Common Building Failures in Post Frame buildings”
He said “Nationwide's database of actual losses is a treasure trove of empirical data”

Top Causes of Post Frame Building Losses per Nationwide:

- Improper Bracing of Trusses - Lack of lateral braces to locations that require lateral restraints
- Improper Purlin to Truss connections - Smooth nails or lack of clips from purlins to trusses
- Failure to account for Unbalanced or Drifting Snow, which affects truss members differently than balanced snow.

Presentation
10yrs ago Midwest Plan Service 2009

Topic
Developing a Livestock Housing Handbook
"Utilizing the International Building Code 2006 for Agricultural Buildings"

By
Dwaine Bundy, Ph.D., P.E.
Consulting Engineer in Agricultural Engineering
and
Professor Emeritus, Iowa State University

2015 Indian Grass Ct
Ames, Iowa 50014

Tel: 515-292-8025
Cel: 515-291-1608
E-mail: dsbundy@iastate.edu

10 yrs ago Building codes for Agriculture

I was asked by a company to determine which of a list of 26 states in the Southeastern and Midwest are required to build agricultural buildings by a State Building Code.

Only 4 states of the 26 required production agricultural buildings to be built by a building code.

How do you define an agricultural building?

Several states require buildings to built to NEC Code.

10 yrs ago

Type of Building Failures from Snow

- Snow load exceeded design snow load.
- Improper roof system design
    - Under sized design of trusses
    - Inadequate truss bracing
    - Poor construction

10 yrs ago

170 ft wide building with Monoslope with Piggy back trusses (2009 failure)


10 yrs ago
Roof Failure from Wind

10 yrs ago

10 yrs ago

10 yrs ago

Withdraw values are effected by nail diameters and the specific gravity of wood

for 16d common nail (length = 3.5”; dia = 0.162”

Species of wood	Specific Gravity	Withdraw value* (lbs/inch)
Southern Pine	0.55	50
Douglas fir-larch	0.50	40
Spruce Pine-Fir	0.42	26

* For withdraw from wind multiply by 1.6.

10 yrs ago

Construction Concerns

techniques

Pneumatic nailers (are normally coated) --

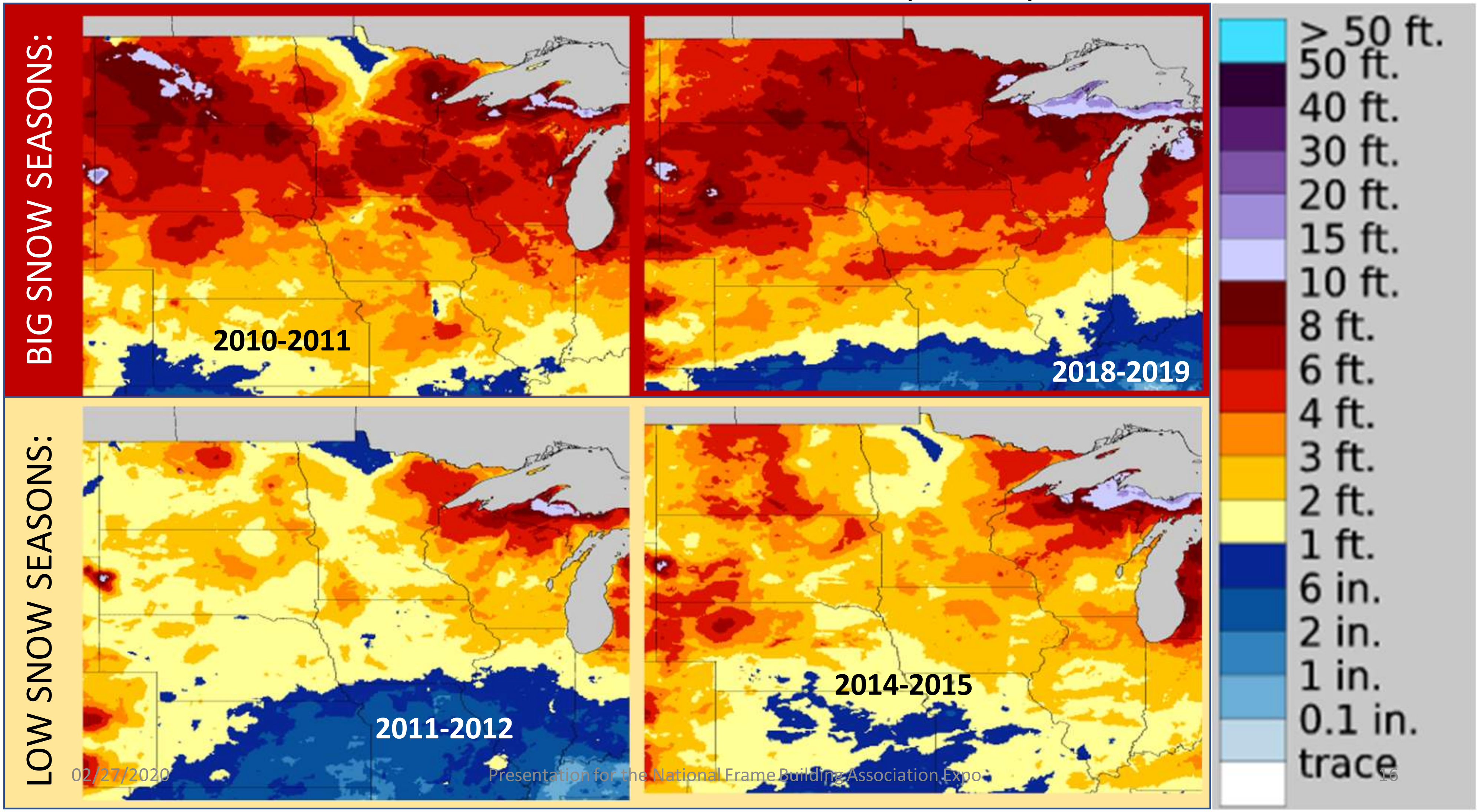
Nail specifications:

Length	Diameter
2 3/8”	0.120”
3”	0.120”
3 ¼”	0.131”
3 ½”	0.131” *

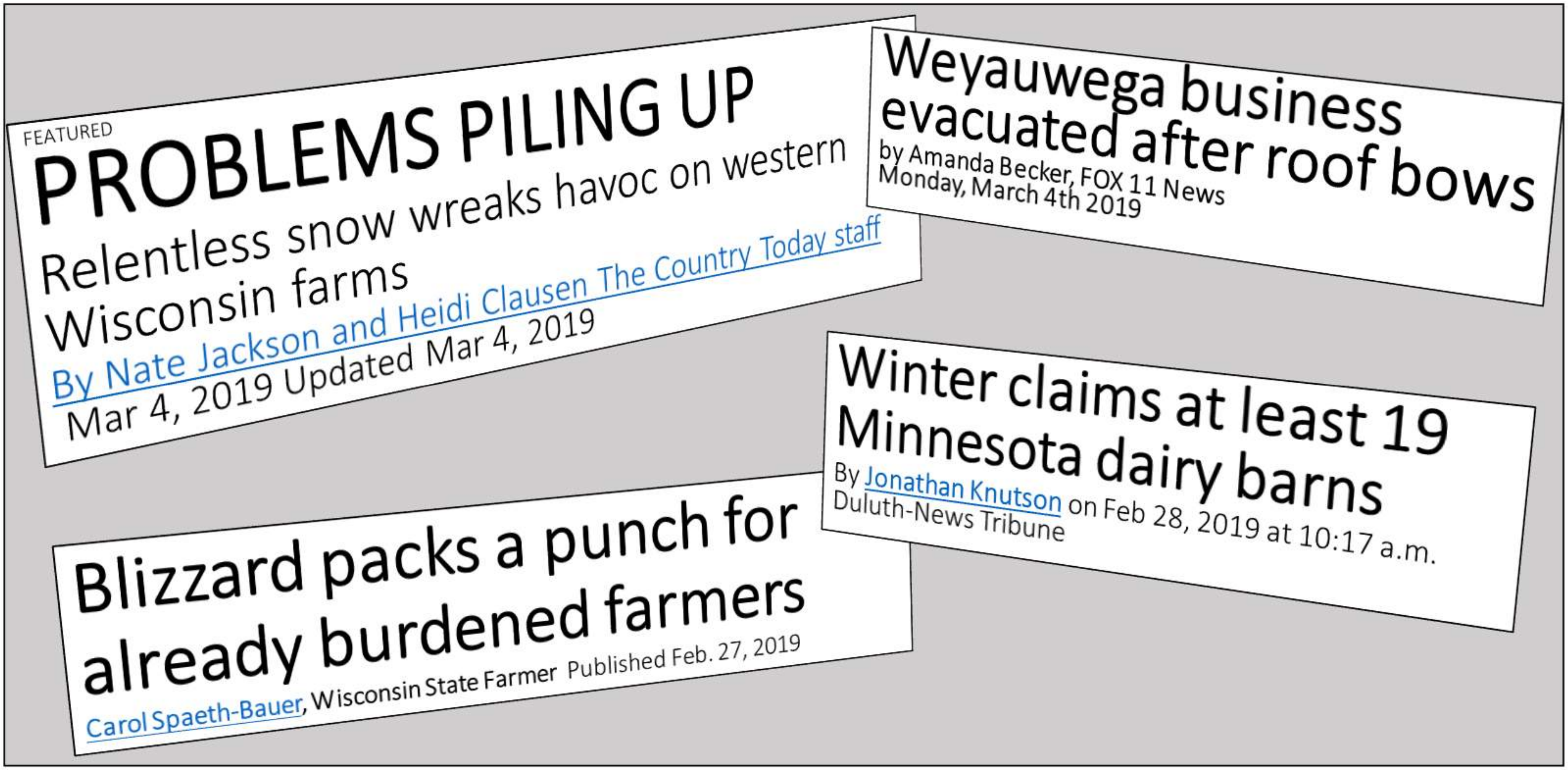
* Note: 16 d common nail is 3 ½” long by 0.162” diameter.

Note: The withdraw value of a 16d common nail is approximately 20 percent greater than for a pneumatic nail. Both are 3.5 inch in length.

Let’s remember that snow falls varies GREATLY from year to year…



At last year's Expo in Louisville (March 7th, 2019), I presented this slide:



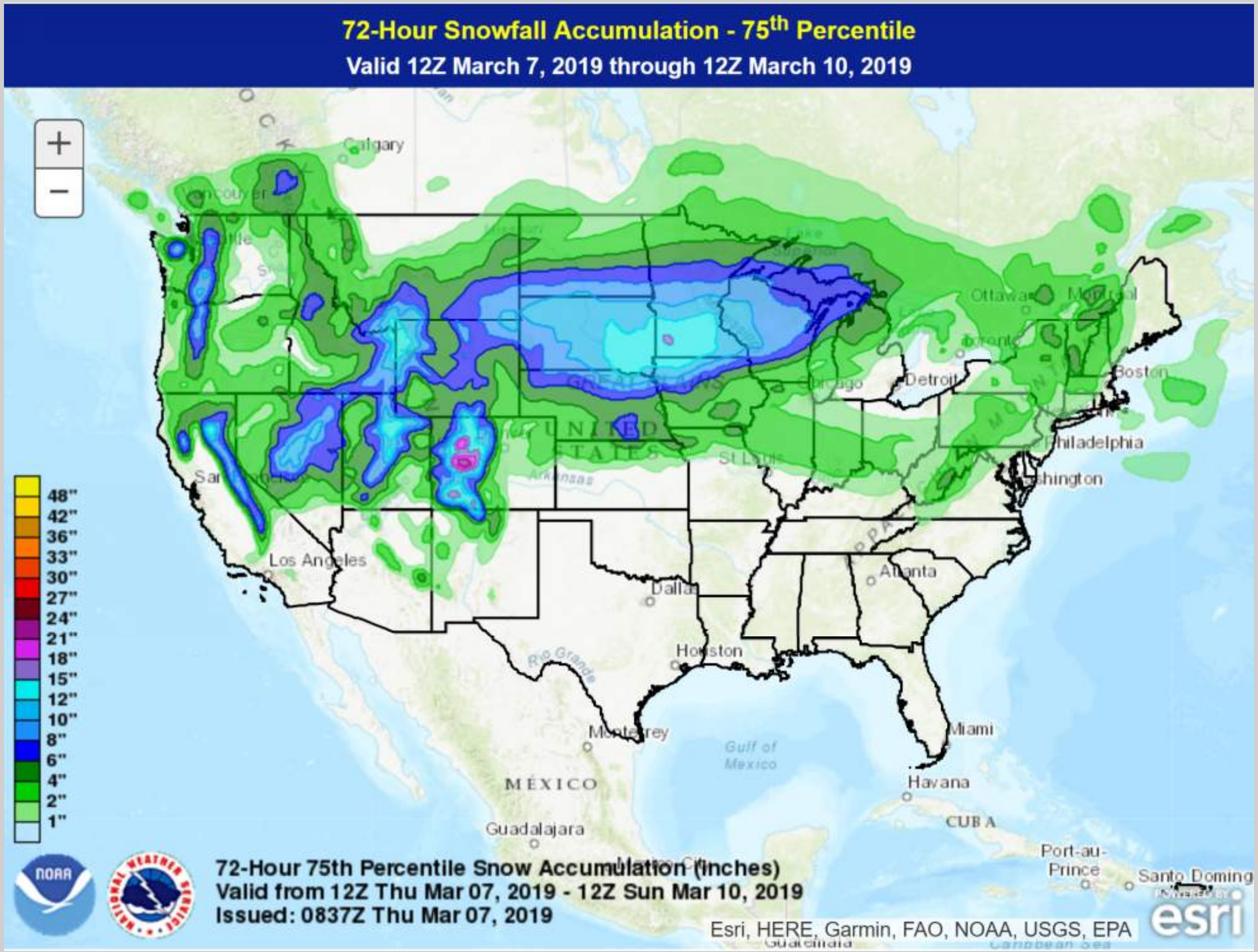
FEATURED
PROBLEMS PILING UP
Relentless snow wreaks havoc on western Wisconsin farms
By Nate Jackson and Heidi Clausen The Country Today staff
Mar 4, 2019 Updated Mar 4, 2019

Weyauwega business evacuated after roof bows
by Amanda Becker, FOX 11 News
Monday, March 4th 2019

Winter claims at least 19 Minnesota dairy barns
By Jonathan Knutson on Feb 28, 2019 at 10:17 a.m.
Duluth-News Tribune

Blizzard packs a punch for already burdened farmers
Carol Spaeth-Bauer, Wisconsin State Farmer Published Feb. 27, 2019

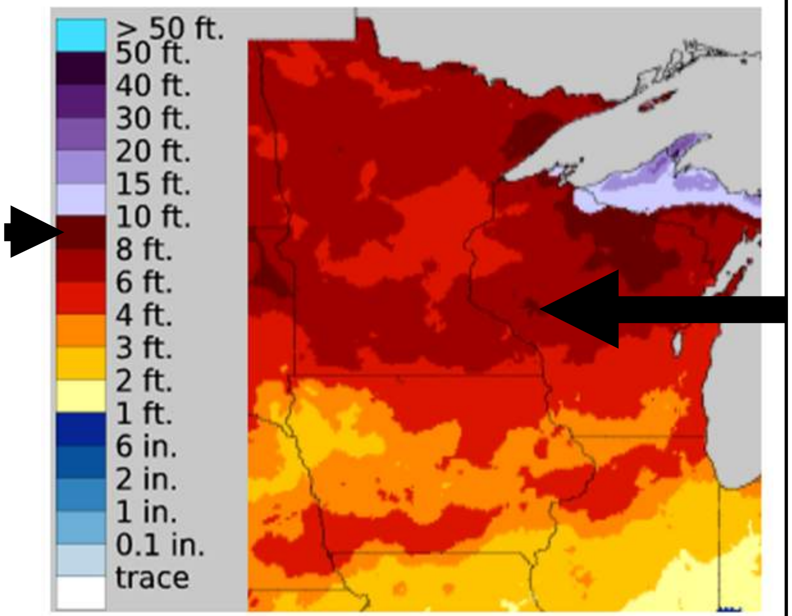
And also this slide:



"What, me worry?"

Snow Forecast through the next 3 days predicts significant snow for parts of the Midwest with quite a bit of snow already.

Building collapses occurred, including this collapse, then fire (Mar. 13, 2019)



Seasonal Snowfall in region: 8-10 ft

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

"The Buffalo County Sheriff's Department says the cause is believed to be electrical after part of the roof collapsed either the night before or early that morning. Authorities say all of the roughly 4,000 hogs in the barn were lost. The investigation is complete, and the barn is regarded as a total loss." Source: WEAU TV-13 News - Eau Claire, Wisconsin

This building WAS engineered, but to what level?

DESIGN LOADS

CODE BODY:	IBC 2015	
GROUND SNOW LOAD:	50 PSF	
RISK CATEGORY:	I	This implies "unoccupied" or "low risk to human life"
C_t:	1.1	This thermal factor is for heated building, maybe OK?
C_e:	1.0	This is an exposure factor, OK
I_s:	0.8	This factor is 0.8 for Risk Cat. I, 1.0 for Risk Cat. II
C_s:	0.94	This reduction is for the Slippery Roof assumption.
ROOF LIVE LOAD:	30 PSF (REQUESTED)	Requested by the Buyer? ... remember "Buyer Beware"?
ROOF DEAD LOAD:	5 PSF	
CEILING LIVE LOAD:	0 PSF	
CEILING DEAD LOAD:	7 PSF	
V_{ult}:	105 MPH	
V_{asd}:	82 MPH	
EXPOSURE:	C	
k_h:	0.85	

Using my 0.77 x PG simplification for heated, occupied (Risk Cat. II) buildings, this would be 38.5 psf. For an Unoccupied building (Risk Cat. I, little concern for loss of life), it could be as low as 30.8 psf. This building was designed for less than that.

Also, no indication of Unbalanced Snow Load consideration was made. This happened to be a large building with interior supports. Unbalanced snow should definitely be considered in the design of such a building.

In a headline driven world, our worries about snow simply “melted”. This is Davenport, Iowa in April 2019

Photo by Andy Abeyta, from www.qctimes.com
© 2019 Quad-City Times

While the flood waters were still working down to the Gulf:

Over 30 people, many were professional engineers, joined the WFBA in April 2020 for an engineering committee to decide what could and should be done to reduce collapses, if anything:

1. Consensus existed to recommend ASCE 7 as the minimum design load standard to be used for All Code Exempt Buildings
2. Generate hard data with a building collapse survey and analyze to support or refute assumptions about collapse problem
3. Educate the farm industry with options for the owner to consider in order to avoid future collapses.

- Trusses usually only engineered component in collapsed Ag Buildings (assumption the entire building was engineered)

Since there is a widely granted exemption from the building code in most states for farming buildings, we operate in an environment governed by the concept of

CAVEAT EMPTOR

“Buyer Beware”

Under this system, the Buyer (not the seller) bears the responsibility for determining adequacy of the product for the intended use. Is this working out OK?

“Dairy barns” have changed a bit since the 1950’s. New barns are often “Post Frame” buildings

Snow Loads for Ag and Other Buildings

1965-1983 ASAE (Ag Engineers) Committee S288 published various snow load documents

1972 ANSI A58.1 introduced: "Minimum Design Loads for Buildings and Other Structures"

1985 New ASAE EP288 standard: Agricultural Building Snow and Wind Loads

1988 ANSI A58.1 updated and becomes ASCE 7-88, updated in '93, '95, '98, 2002, '05, '10, '16, and '22 (underway)

2003 ASAE EP288 withdrawn as a standard by ASAE: "This Engineering Practice has become out-of-date and has been superseded by **ASCE 7**"

Snow Loads for ALL Buildings

ASAE was the American Society of Agricultural Engineers (now ASABE, adding "Biological")

ASCE is the American Society of Civil Engineers

Because ASCE 7 is adopted and used in all commercial buildings, there may be the perception that when Ag Buildings are exempt from the building code, they also should not (or need not) meet the ASCE 7 standard. But the C in ASCE stands for CIVIL, not COMMERCIAL…

It may be better to speak of Minimum Design Loads and Associated Criteria for Buildings and Other Structures.

Is ASCE 7 right for "Ag" buildings?

Use or Occupancy of Buildings and Structures	**Risk Category**	**Snow Load Multiplier (I_S)**
Buildings and other structures that represent a low risk to human life in the event of failure	I	0.80
All buildings and other structures except those listed in Risk Categories I, III, and IV *(I consider this "Normal" or "Default")*	II	1.00
Buildings and other structures, the failure of which could pose a substantial risk to human life. *(more descriptions listed)*	III	1.10
Buildings and other structures designated as essential facilities. *(more descriptions and considerations listed in ASCE 7)*	IV	1.20

If you have a farm building with workers inside on a regular basis, what Risk Category should be used?

ASCE STANDARD

ASCE/SEI

7-16

Minimum Design Loads and Associated Criteria for Buildings and Other Structures

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

SEI
ASCE
STRUCTURAL ENGINEERING INSTITUTE

Minimum Design Loads and
Associated Criteria for
Buildings and Other Structures

ASCE/SEI

7-16

ASCE STANDARD NUMBER 7
Compare to ASCE 32 which is for Frost Protected Shallow Foundations

16 is the Edition / Version: This is the 2016 Edition

ASCE
AMERICAN SOCIETY OF CIVIL ENGINEERS

SEI ASCE
STRUCTURAL ENGINEERING INSTITUTE

ASCE/SEI 7-22	2022
ASCE/SEI 7-16	2016
ASCE/SEI 7-10	2010
ASCE/SEI 7-05	2005
SEI/ASCE 7-02	2002
ASCE 7-98	1998
ANSI/ASCE 7-95	1995
ANSI/ASCE 7-93	1993
ANSI/ASCE 7-88	1988

ASCE 7-22	2022
ASCE 7-16	2016
ASCE 7-10	2010
ASCE 7-05	2005
ASCE 7-02	2002
ASCE 7-98	1998
ASCE 7-95	1995
ASCE 7-93	1993
ASCE 7-88	1988

Uh-oh! Y2K88!

What will they call ASCE 7 in 2088?

Graphical interpretation of Risk Category from the Post Frame Building Design Manual:

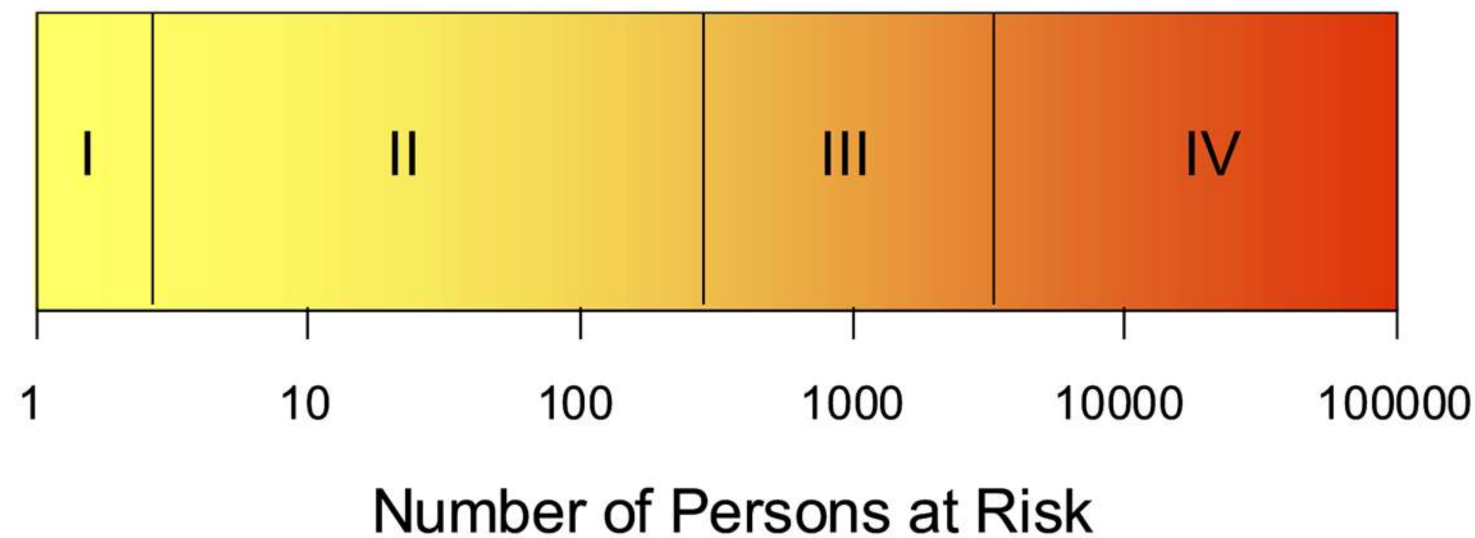


Figure 3-1. ASCE/SEI 7 Risk Category as a function of the number of lives placed at risk by a failure.

Table 1.5-1 Risk Category of Buildings and Other Structures for Flood, Wind, Snow, Earthquake, and Ice Loads

Use or Occupancy of Buildings and Structures	Risk Category
Buildings and other structures that represent low risk to human life in the event of failure	I
All buildings and other structures except those listed in Risk Categories I, III, and IV	II
Buildings and other structures, the failure of which could pose a substantial risk to human life	III
Buildings and other structures designated as essential facilities	IV

Table 1.5-2 Importance Factors by Risk Category of Buildings and Other Structures for Snow, Ice, and Earthquake Loads

Risk Category from Table 1.5-1	Snow Importance Factor, I_s	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w *	Seismic Importance Factor, I_e
I	0.80	0.80	1.00	1.00
II	1.00	1.00	1.00	1.00
III	1.10	1.15	1.00	1.25
IV	1.20	1.25	1.00	1.50

*Note that Risk Category does affect wind loads as Design Wind Speeds are now selected by Risk Category, starting with the ASCE 7-10 edition.

So, with Buyer Beware, what do you do?

My Suggestion (Aaron Halberg) to Building Owners:

"If the loss of your building (and contents) would be merely inconvenient, but you are well insured and not worried about loss of life, property, business income after a collapse, use ASCE 7 Risk Category I Loads (or higher).

If you or any stakeholder IS concerned about loss of life, property, business income or the stress of a building collapse, use ASCE 7 Risk Category II Loads (or higher).

Informed Consent of Owner at Outset?

Building Risk Classification - Selection of the Risk Category for use in Structural Design

Risk Category	Design Level	Initial by Selected 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)**

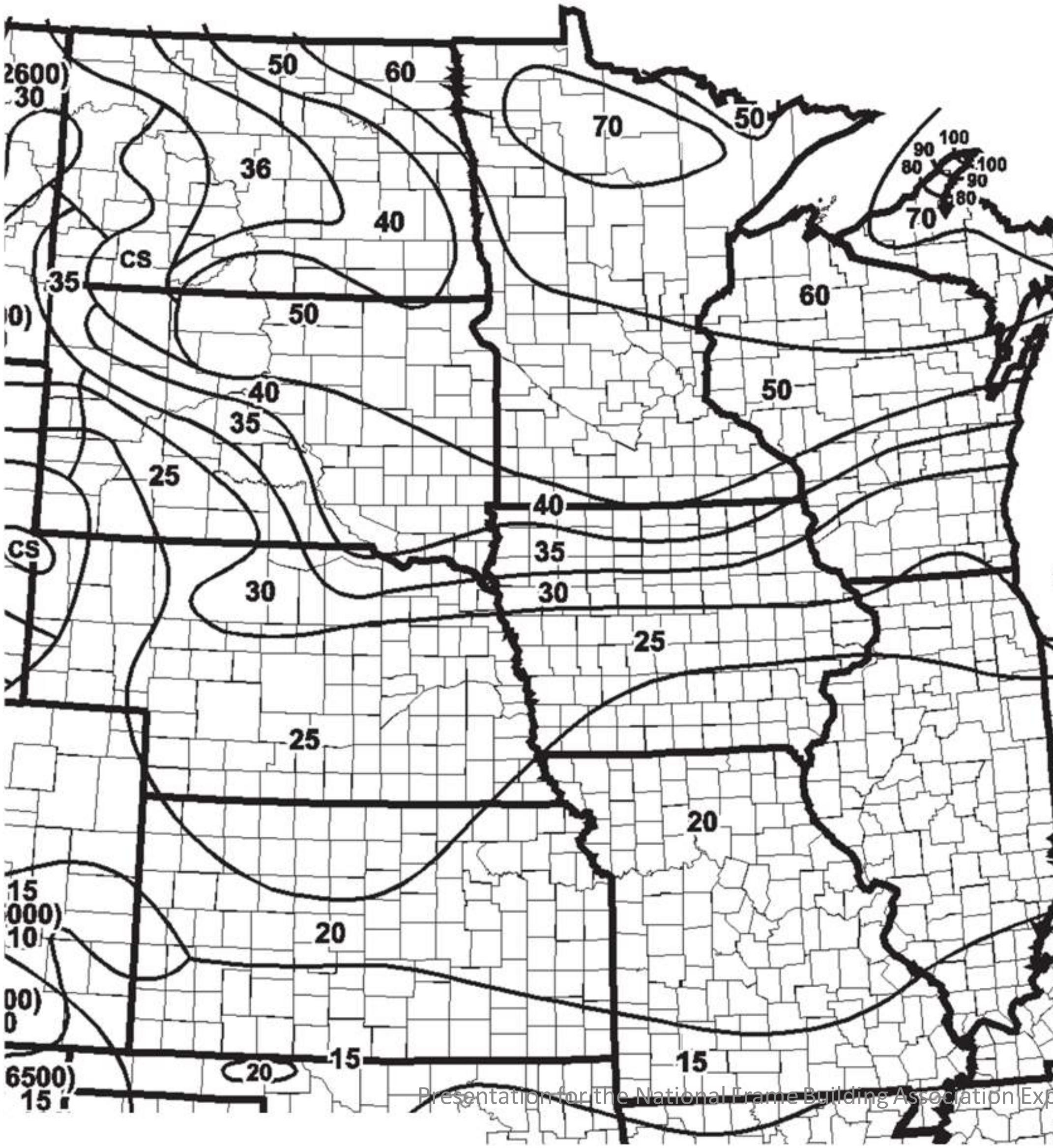
Name of Building Project: ____

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 select the Risk Category initialed above be used for this building project.

____

Building owner's signature Date

2002: ASCE 7-02
Ground Snow Load Map
[psf]



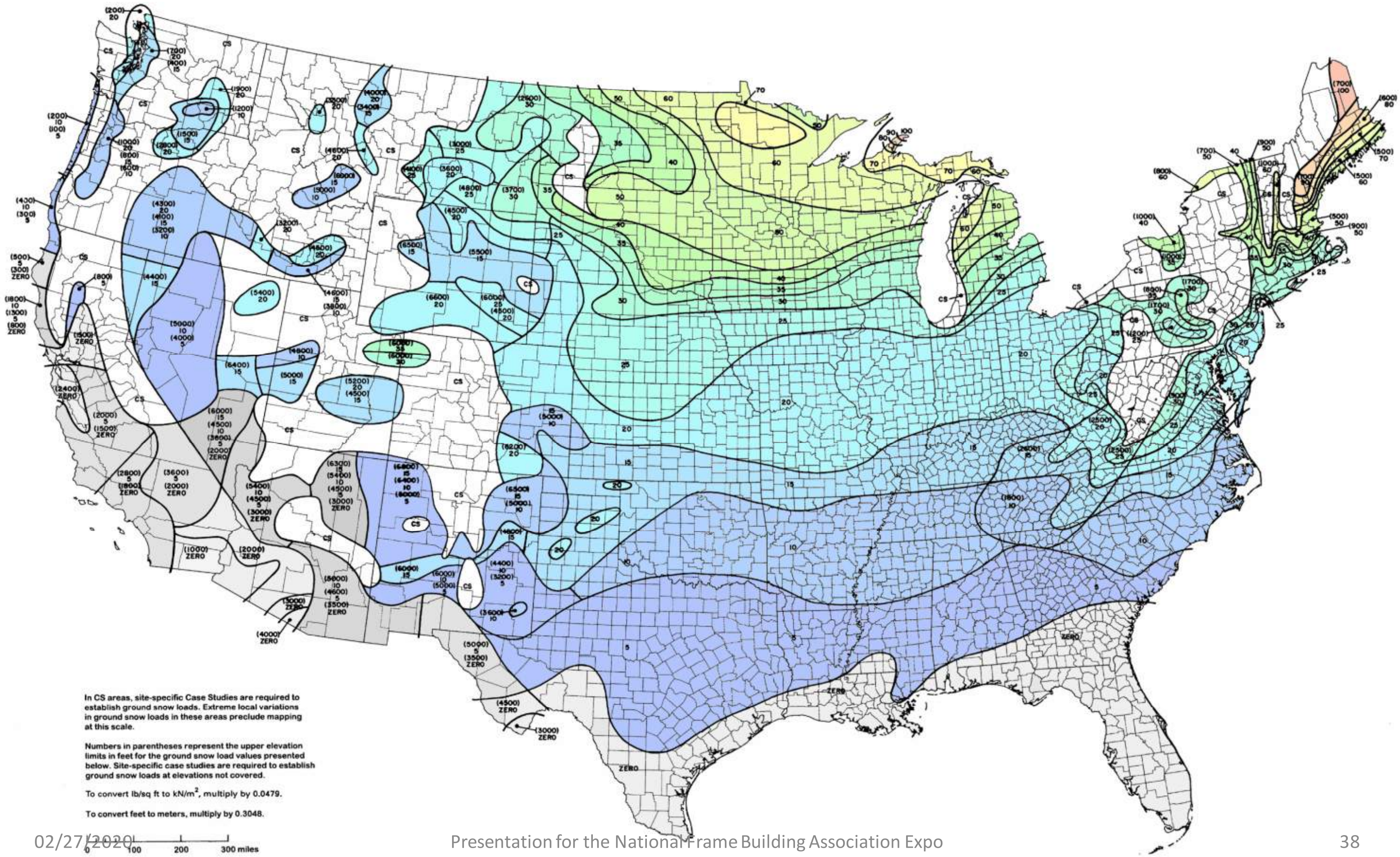
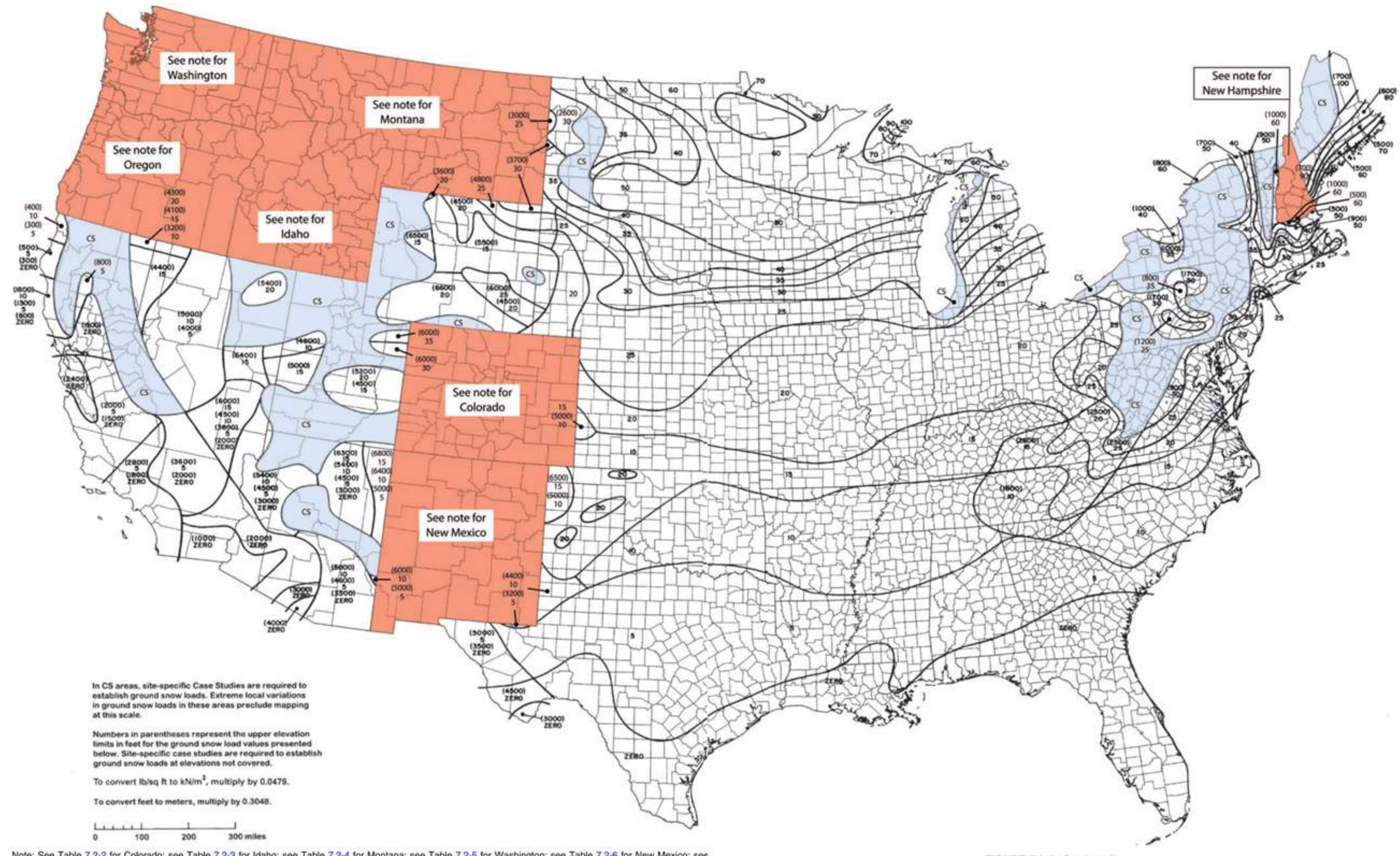


FIGURE 7-1 Ground Snow Loads, P_g, for the United States (Lb/Ft^2).



Note: See Table 7.2-2 for Colorado; see Table 7.2-3 for Idaho; see Table 7.2-4 for Montana; see Table 7.2-5 for Washington; see Table 7.2-6 for New Mexico; see Table 7.2-7 for Oregon; see Table 7.2-8 for New Hampshire.

FIGURE 7.2-1 Ground Snow Loads, p_g, for the United States (lb/ft^2)

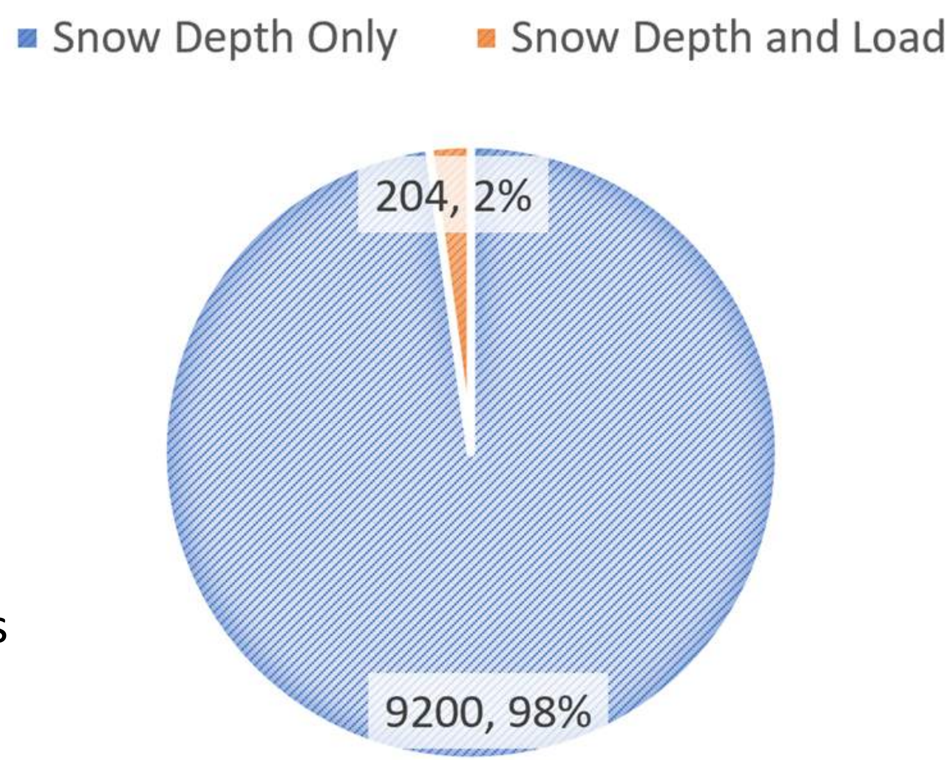
FIGURE 7.2-1 *(Continued)*

ASCE 7 Ground Snow Loads

Who weighed all the snow to make the map?

- Data used from over 9,400 National Weather Service stations
- 9,200 stations recorded ground snow depth.
- 204 "1st Class" stations recorded ground snow depth **AND** load
- By dividing the measured load [lbs/ft^2] by the measured depth [ft], snow density was determined.
- By using regression fit of the densities, the remaining depth data for the 9,200 stations was converted to loads.

Source: "Snow Engineering: Recent Advances: Proceedings of the third international conference, Sendai, Japan, 26-31 May 1996" page 6.



How dense is snow? It depends… anyone who has shoveled after TWO or more snow storms already knows!

Typical densities of snow and ice [1]	kg/m^3 [1]	lb/ft^3 [2]	Specific Gravity [2]	Load at 2ft Deep [2]
New snow (immediately after falling in calm)	50 - 70	3 - 4.5	5% - 7%	9 psf
Damp new snow	100 - 200	6 - 12.5	10% - 20%	25 psf
Settled snow	200 - 300	12.5 - 18.5	20% - 30%	37 psf
Wind packed snow	350 - 400	22 - 25	35% - 40%	50 psf
Very wet snow	700 - 800	43.5 - 50	70% - 80%	100 psf
Glacier ice	830 - 917	52 - 57	83% - 91%	114 psf
Water	1,000	62.4	100%	124.8 psf

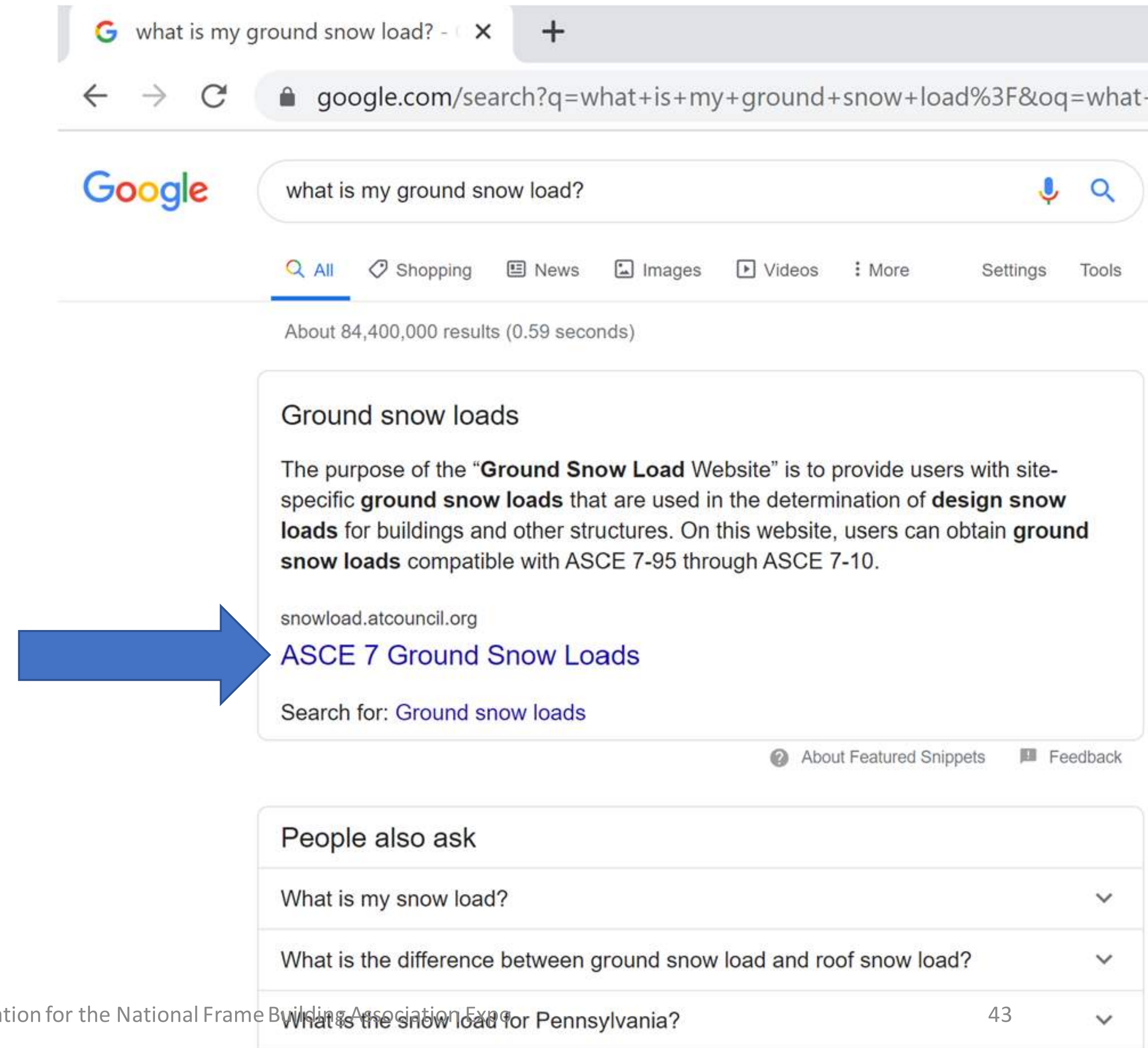
Source[1]: Paterson, W.S.B. 1994. *The Physics of Glaciers.*

Conversions[2] by Aaron Halberg, Halberg Engineering

How do you find the ASCE 7 Ground Snow Load for a building site?

1. Use the Ground Snow Load Map. ASCE 7 map has State and County lines.
2. Use a web tool, such as hazards.atcouncil.org
3. When required or when ASCE 7 doesn't have adequate or accurate information, rely on local or state resources to guide you. This is common in lake-effect snow and mountainous regions

How do you find the ASCE 7 Ground Snow Load for a building site?



hazards.atcouncil.org

Lots of fine print here, read it!

ATC Hazards by Location

hazards.atcouncil.org

Overview

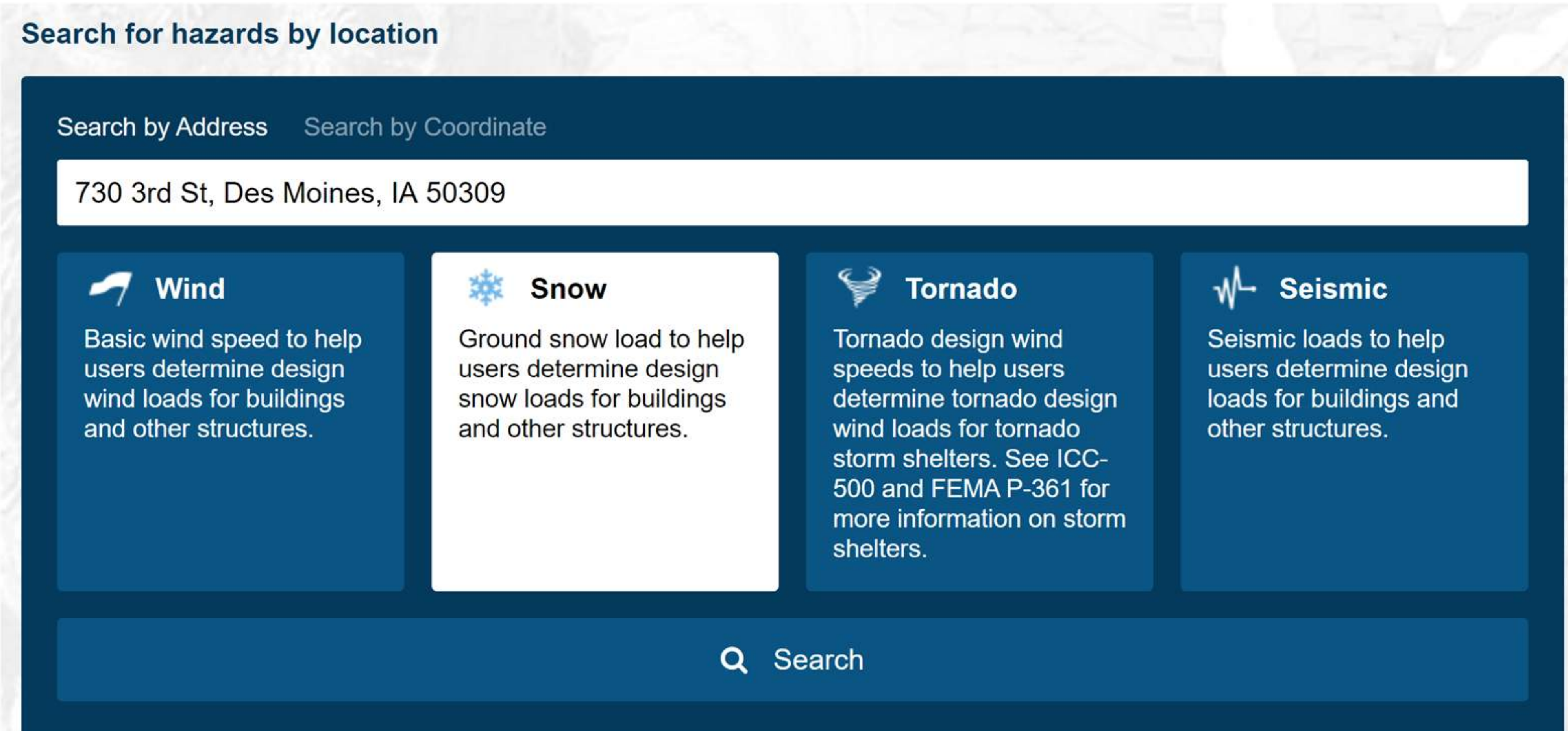
The purpose of this website is to provide users with site-specific hazard information that can be used to determine design loads for buildings and other structures. It is assumed that the users of this site have competency to understand how to calculate and apply the information provided here to determine design loads to structural models of buildings or other structures.

This website only returns values provided by the indicated reference documents. The results DO NOT reflect any state or local amendments to the values or any delineation lines made during the building code adoption process. Users should confirm any output obtained from this tool with the local Authority Having Jurisdiction before proceeding with design.

Values are site-specific for the location entered and may be dependent upon the elevation of the site, depending on the hazard of interest. Users are cautioned to provide the most accurate location for the building or structure site by specifying either the known street address, city and state or the latitude and longitude to at least five (5) decimal places. If only the name of the city/state or zipcode is provided, the website will return data for the centroid of the city or zipcode and thus could either over- or underestimate the values that should be used for the site of interest. An underestimation could result in a design that does not meet the requirements for minimum design loads for the building or structure under consideration.

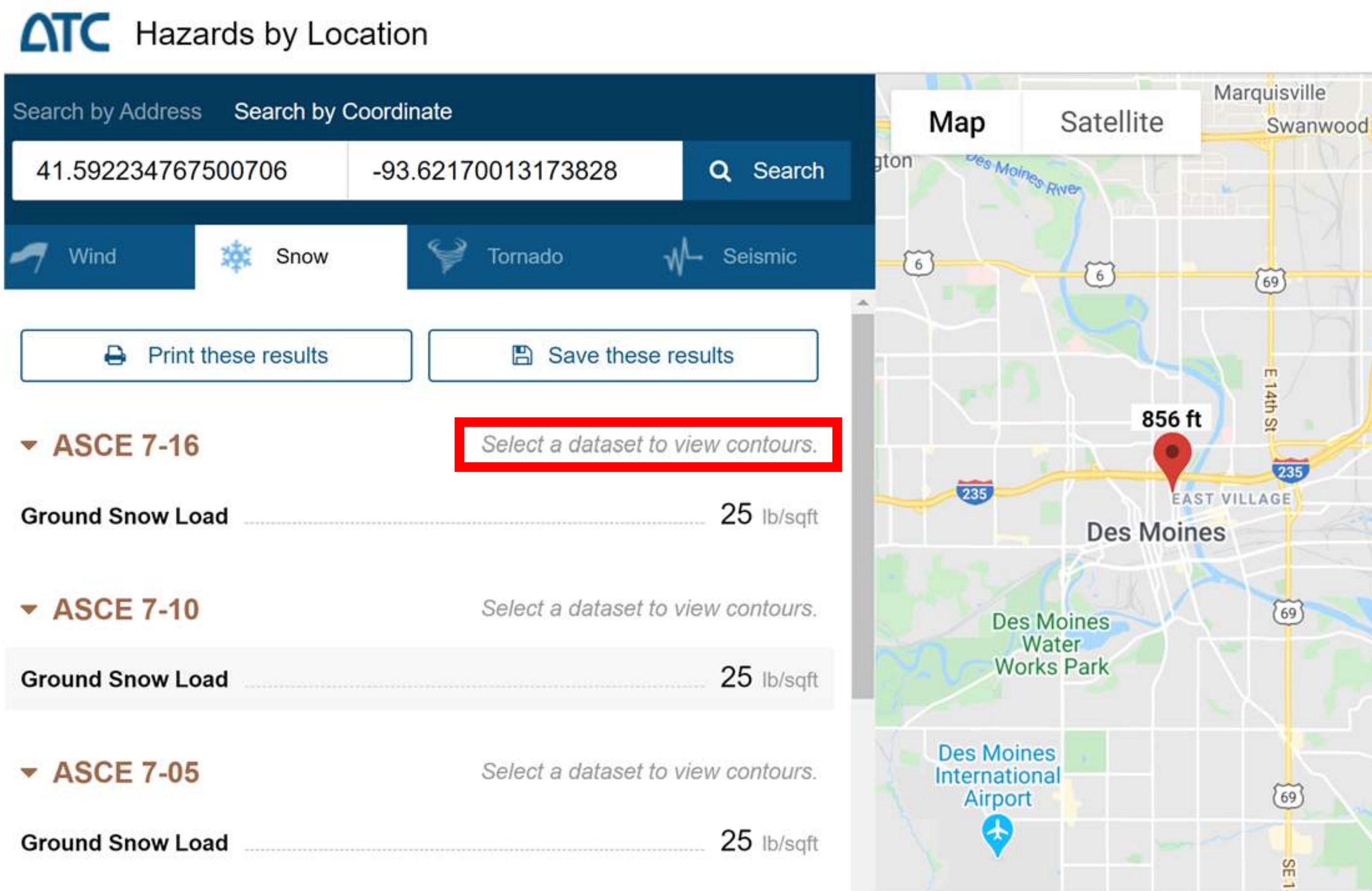
hazards.atcouncil.org

I did a search for the Iowa Events Center address:



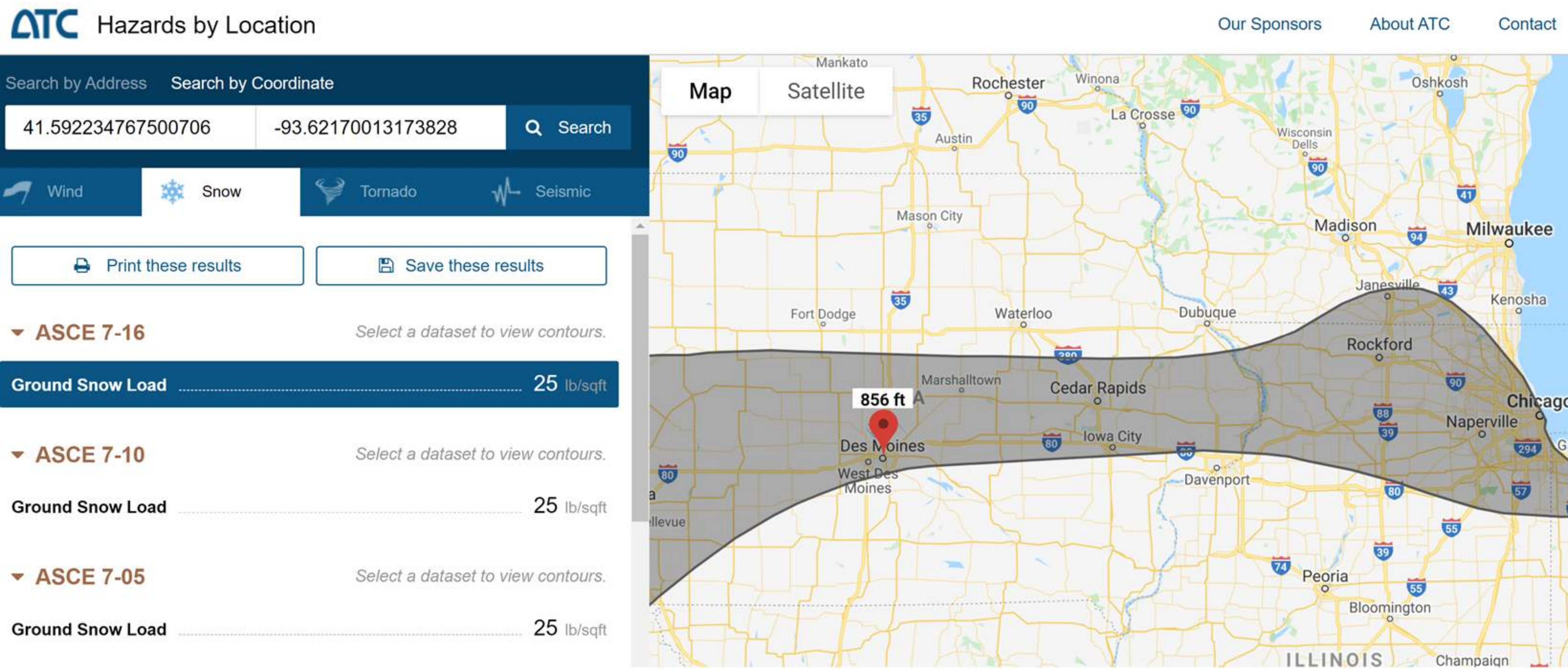
hazards.atcouncil.org

The Iowa Events Center Snow Load information:



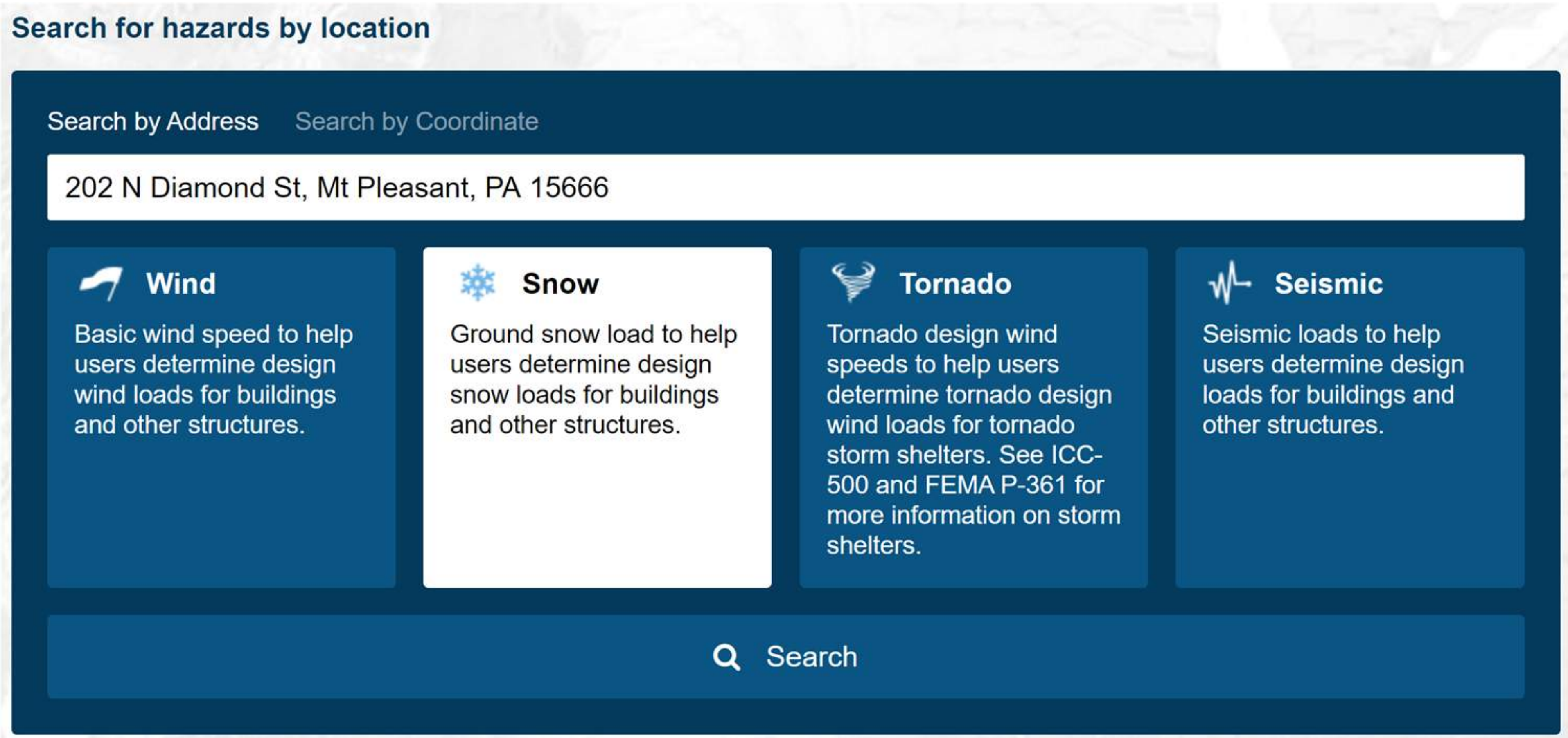
hazards.atcouncil.org

The Iowa Events Center Snow Load information:



hazards.atcouncil.org

I did a search for the snow loads at Leo’s Pub & Grille in Pennsylvania



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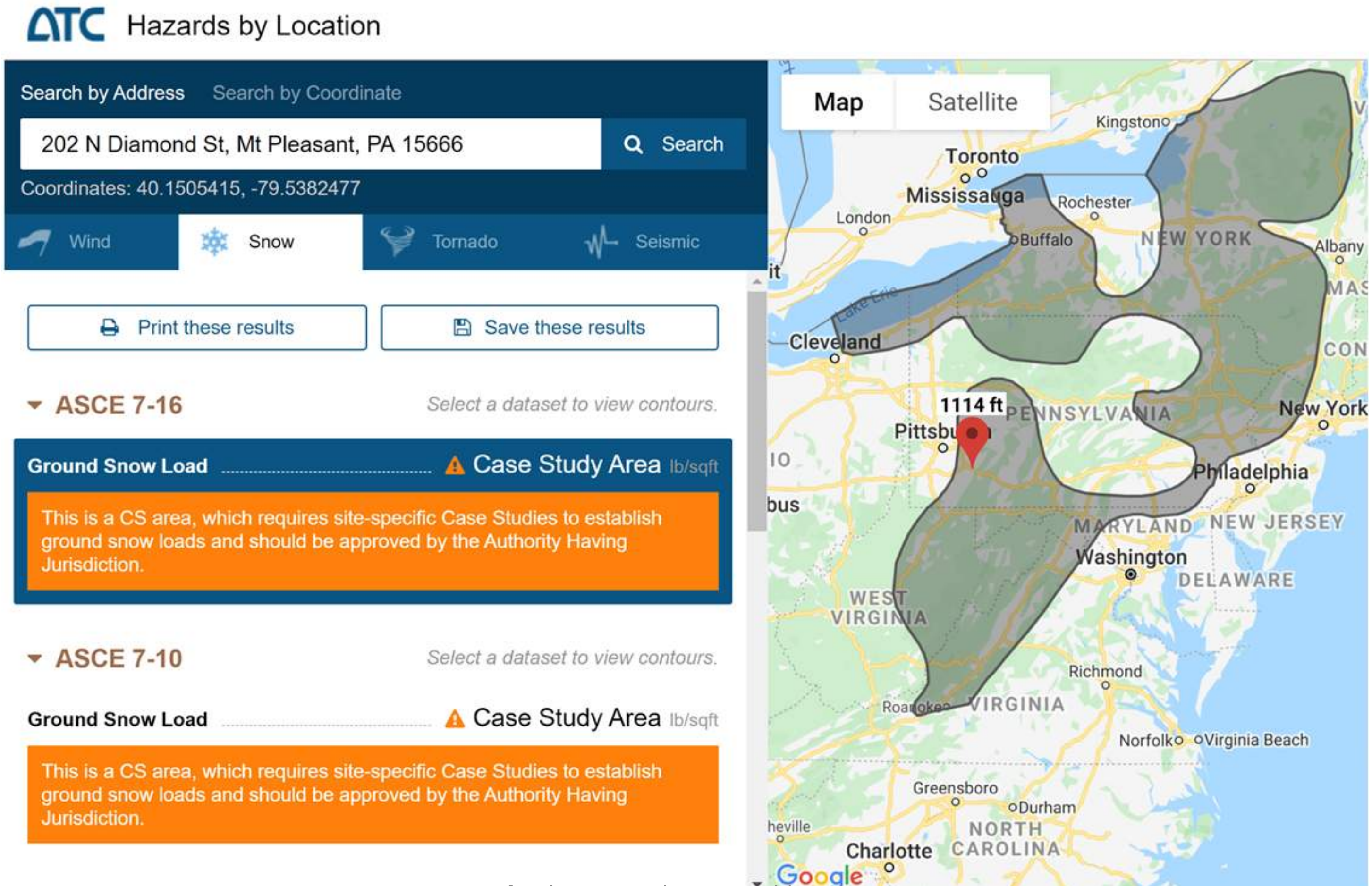
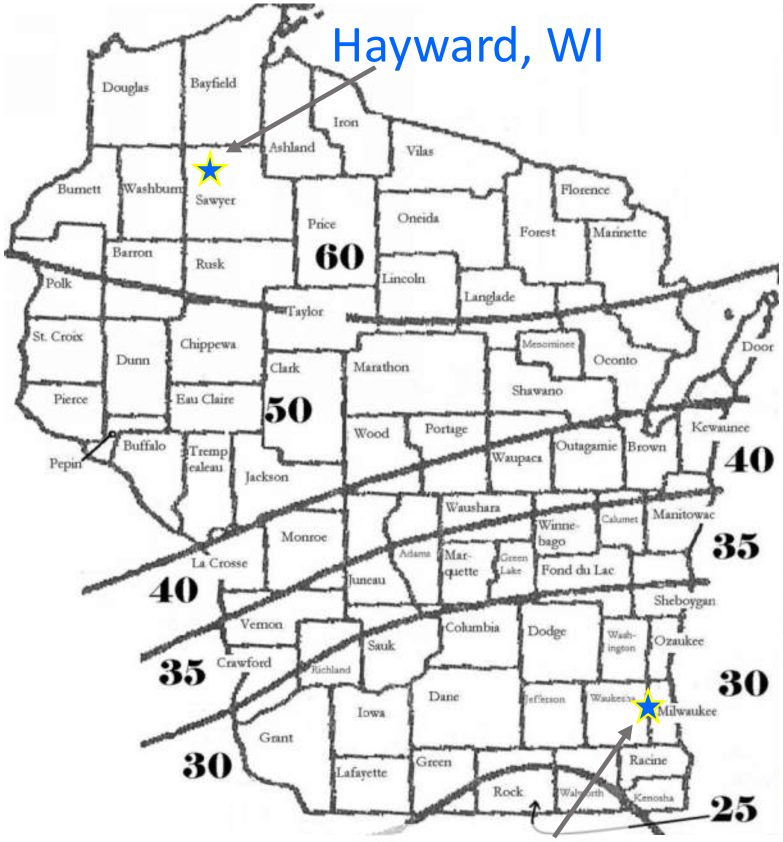


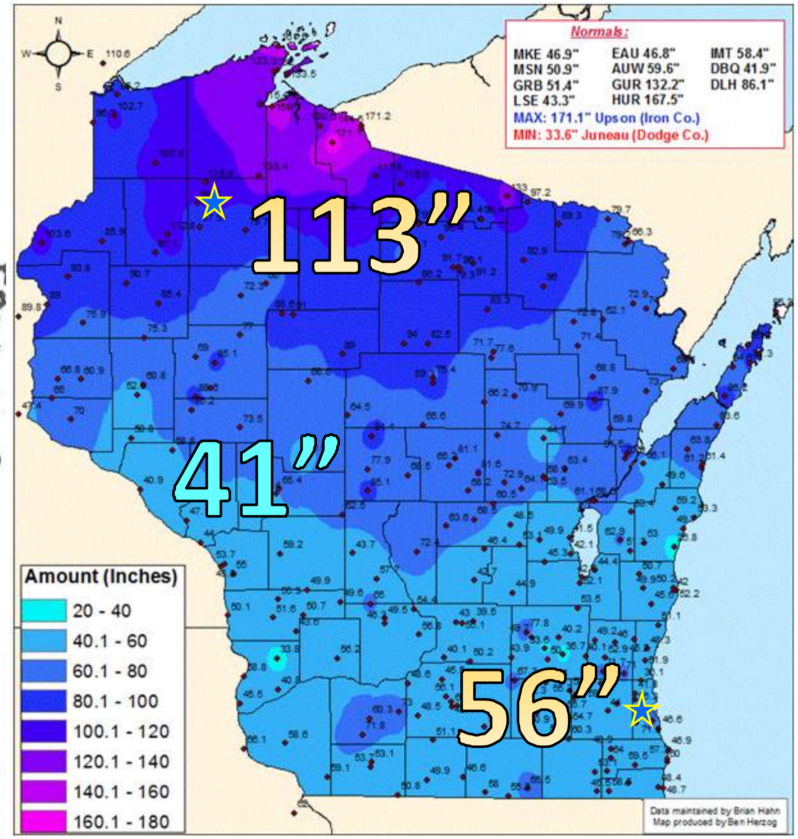
hazards.atcouncil.org

I did a search for the snow loads at Leo’s Pub & Grille in Pennsylvania

This is a CS area, which requires site-specific Case Studies to establish ground snow loads and should be approved by the Authority Having Jurisdiction.

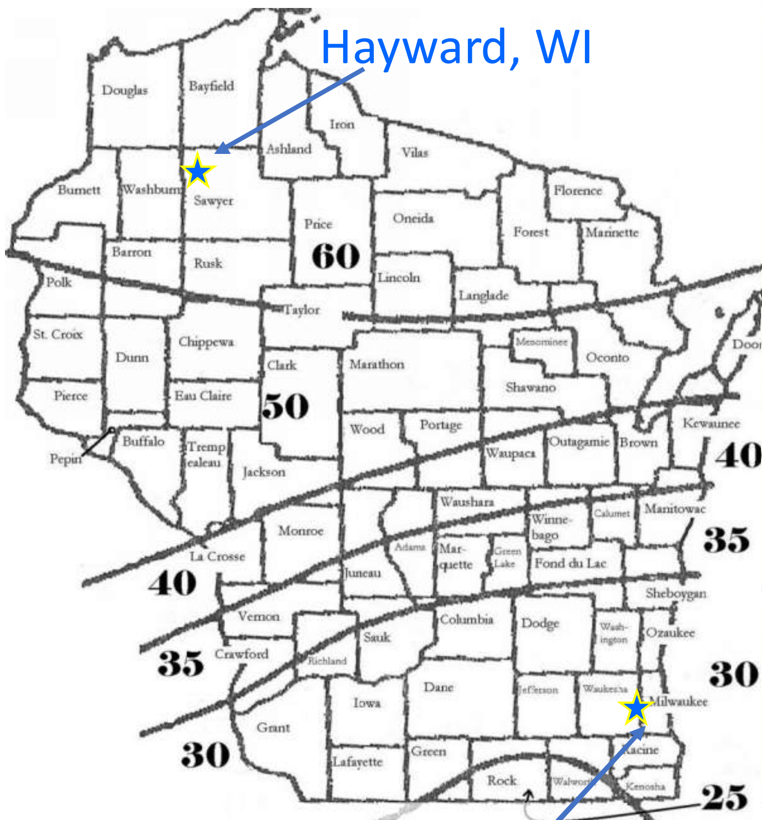
Snow Design Loads (P_G) Season Snow Total: 2013-14



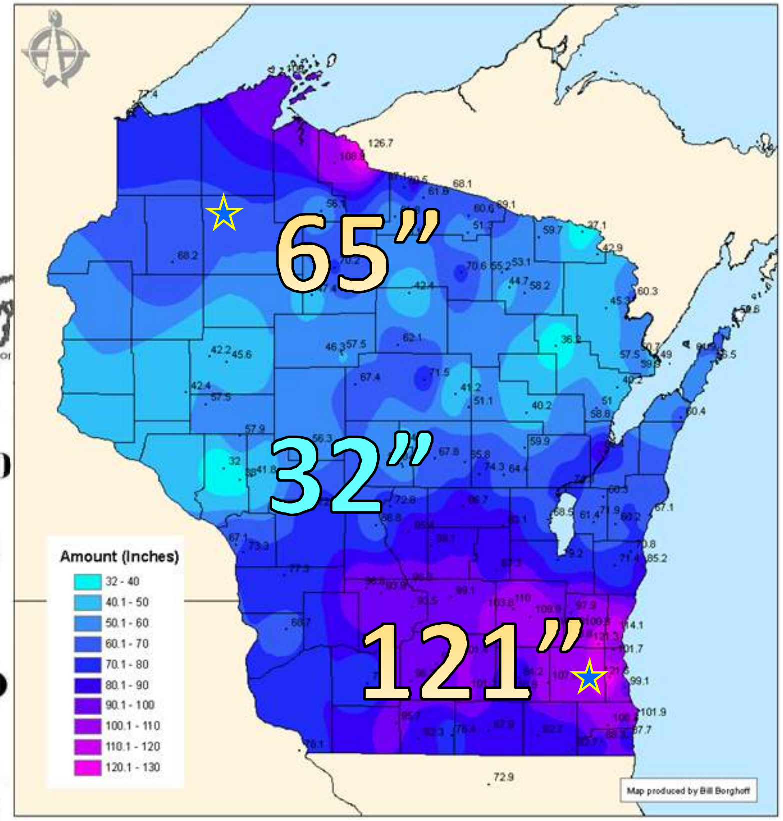


Sometimes snow falls where expected…

Snow Design Loads (P_G)



Season Snow Total: 2007-08

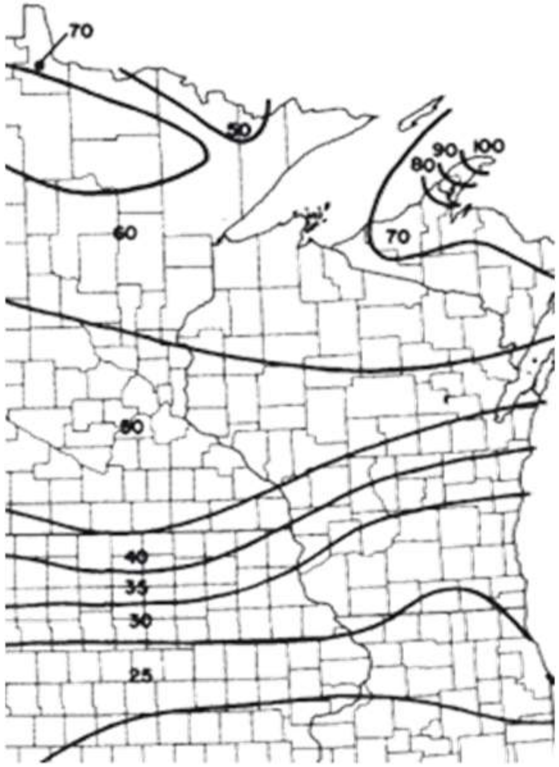


Sometimes it doesn't…

ASCE 7 Snow – By the Book

- Determine the Ground Snow Load (p_g) at the project location by using ASCE 7 map or Site Specific Information
- Modify the Ground Snow Load by factors reflecting variables affecting how much of the load makes up the Balanced Sloped Roof Snow Load (p_s)

$$p_s = 0.7 \cdot C_e \cdot C_t \cdot C_s \cdot I_s \cdot p_g$$



Ground Snow Load is just the STARTING variable:

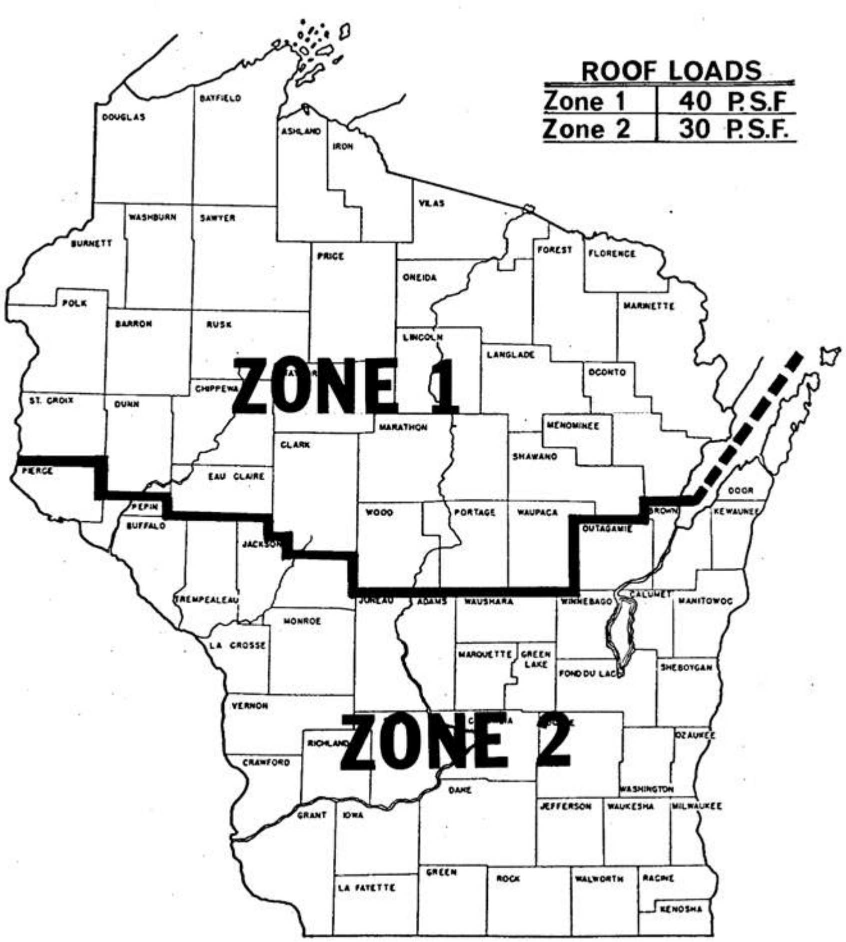
Ground Snow Load [psf]	Ground Snow to Roof Snow Conversion:		Risk Cat. II, I_s = 1.0		Thermal Factor, C_t = 1.1		Exposure Factor, C_e = 1.0		Sloped Roof Factor, C_s = 1.0	Sloped Roof Snow Load, P_s =	Calculated Depth [inches] at nominal density:
60		42.0		42.0		46.2		46.2		**46.2**	25
50		35.0		35.0		38.5		38.5		**38.5**	23
40	x 0.7 =	28.0	x1.0=	28.0	x1.1=	30.8	x1.0=	30.8	x1.0=	**30.8**	19
35		24.5		24.5		27.0		27.0		**27.0**	17
30		21.0		21.0		23.1		23.1		**23.1**	15
25		17.5		17.5		19.3		19.3		**19.3**	13

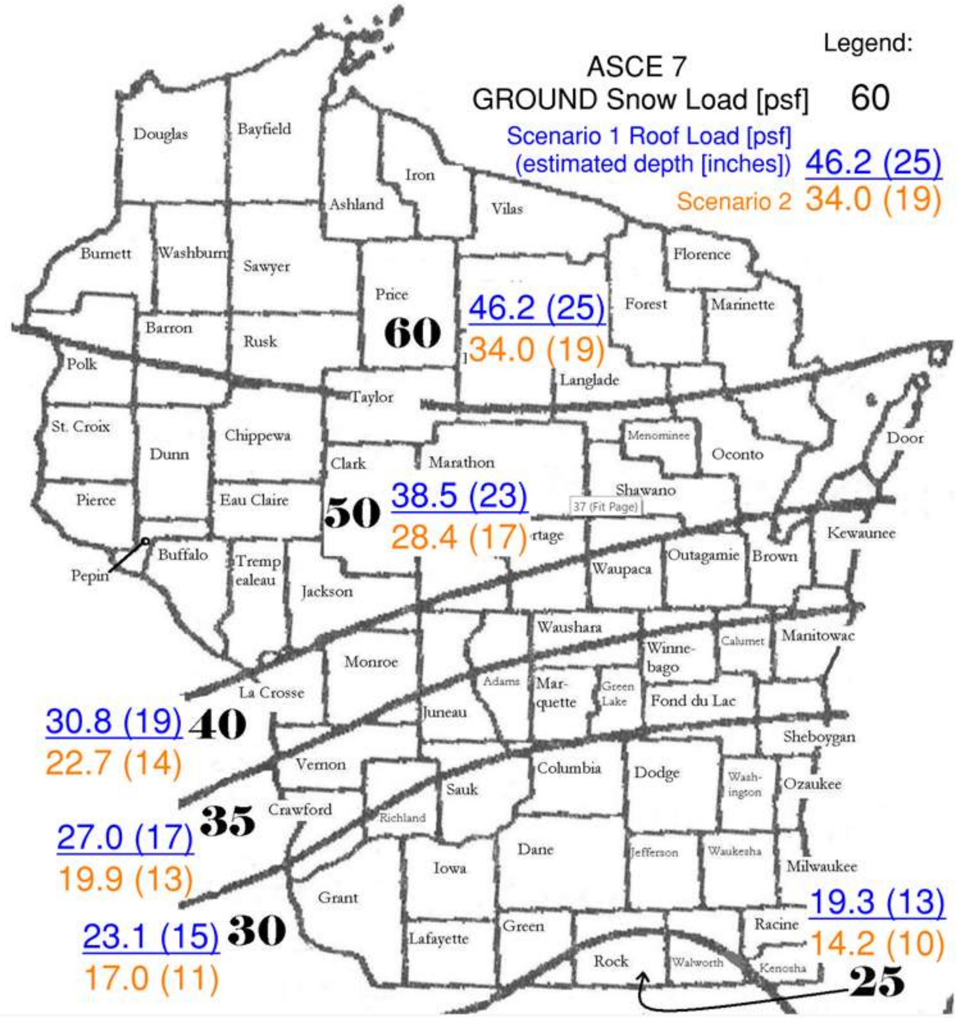
Table 1 - Example Scenario 1 – Roof Snow Loads for occupied, heated building in partially exposed terrain, non-slippery roof.

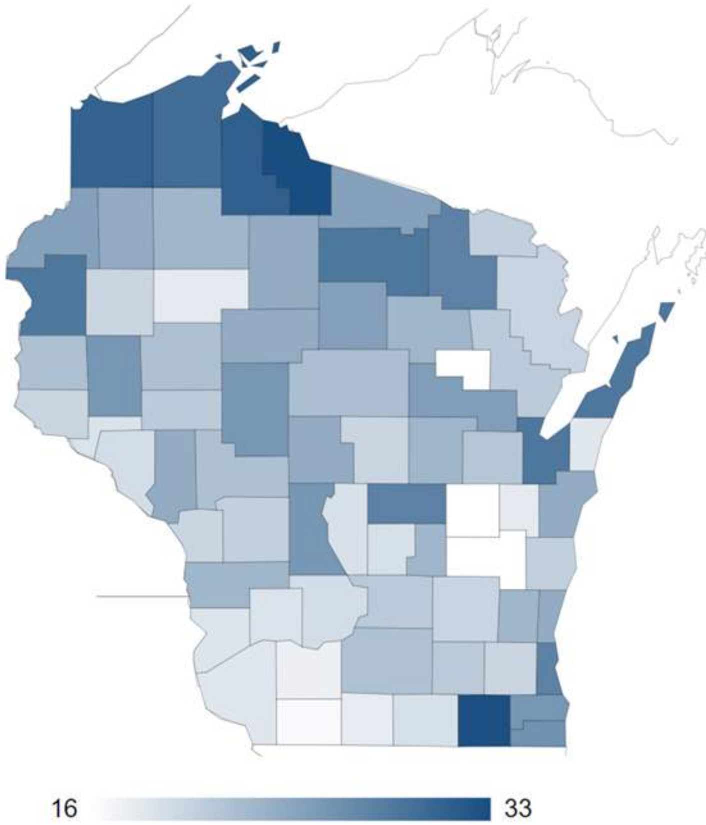
Ground Snow Load [psf]	Ground Snow to Roof Snow Conversion:		Risk Cat. I, I_s = 0.8		Thermal Factor, C_t = 1.2		Exposure Factor, C_e = 0.9		Sloped Roof Factor, C_s = 0.938	Sloped Roof Snow Load, P_s =	Calculated Depth [inches] at nominal density:
60		42.0		33.6		40.3		36.3		**34.0**	19
50		35.0		28.0		33.6		30.2		**28.4**	17
40	x 0.7 =	28.0	x0.8=	22.4	x1.2=	26.9	x0.9=	24.2	x0.938=	**22.7**	14
35		24.5		19.6		23.5		21.2		**19.9**	13
30		21.0		16.8		20.2		18.1		**17.0**	11
25		17.5		14.0		16.8		15.1		**14.2**	10

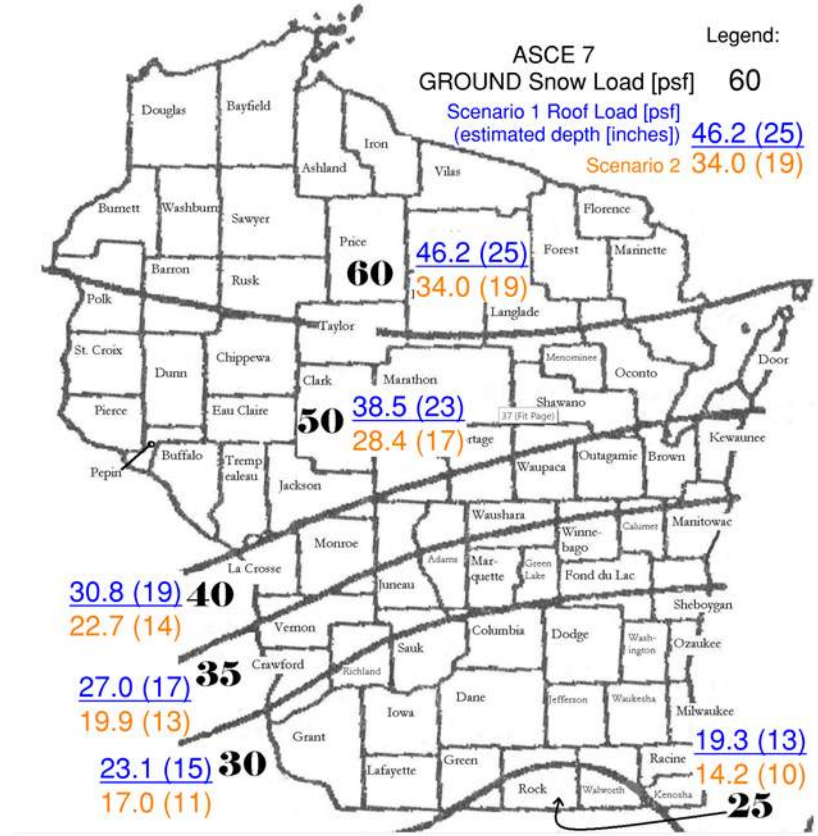
Table 2 - Example Scenario 2 - Calculating Roof Snow Loads for an unoccupied, unheated building in fully exposed terrain, and slippery roof assumption (4:12)

Figure 321.02
ZONE MAP FOR ROOF LOADS



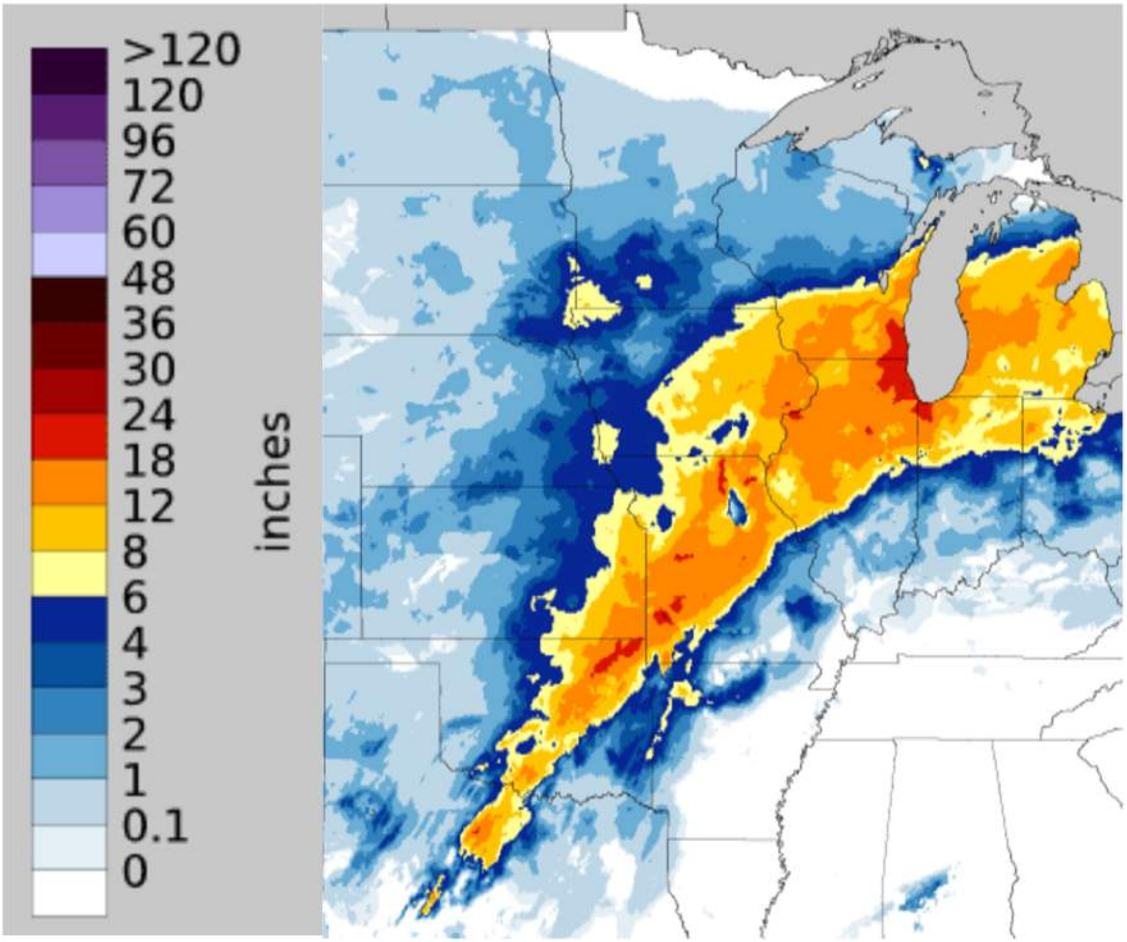


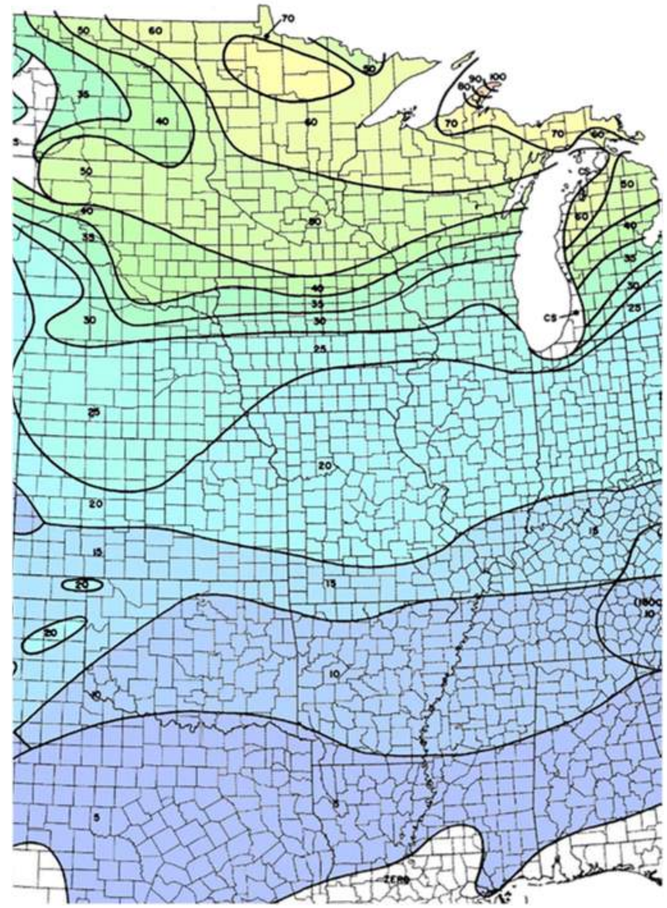




2 day snow fall records [inches] for each Wisconsin county. Walworth, Racine, and Kenosha counties in the extreme southeast of the state received 32.8”, 26.0”, and 26.5” of snow respectively during a snow event ending February 2, 2011. (Source: https://www.ncdc.noaa.gov/snow-and-ice/snowfall-extremes/WI/2)

The 2011 Snow Event that led to heavy snow in SE Wisconsin also brought 2 feet or more in parts of Oklahoma and Missouri where ASCE 7 GROUND SNOW is 10 to 20psf.





ASCE 7 – Simplification?

- Some of the variables could be fixed at a value that might be slightly conservative for some buildings, but covers most building situations
- Variables remaining for each project might be just Risk Factor, Roof Slope, and Roof Width
- Computers allow complex and multiple snow distributions for a given truss design

Simplified ASCE 7 Snow

C_e = Exposure Factor

For open terrain and exposure, a larger percentage of the total snowfall will blow off the roof. Terrain Category C is by FAR the most common terrain encountered for post frame buildings and Sheltered Roof Exposures are fairly uncommon. Simplification of C_e = 1.0 seems reasonable.

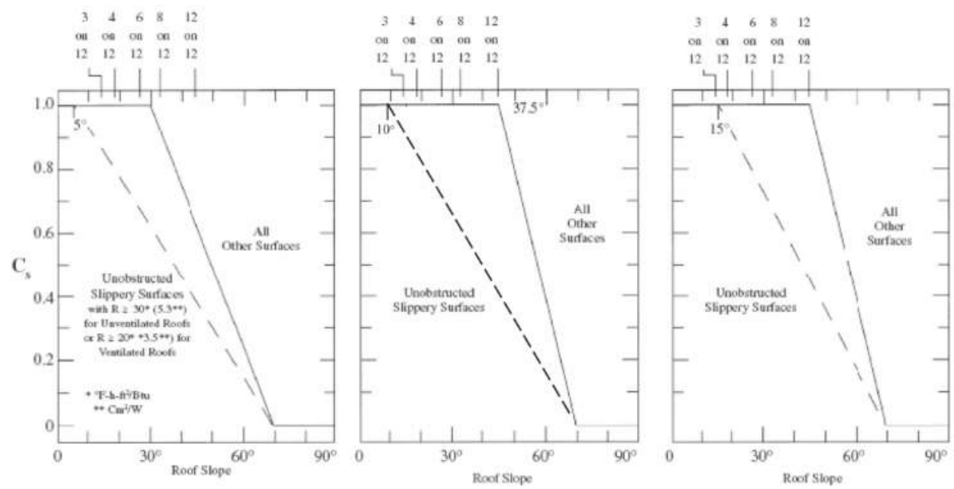
Table 7-2 Exposure Factor, C_e

	Exposure of Roof[a]		
Terrain Category	Fully Exposed	Partially Exposed	Sheltered
B (see Section 26.7)	0.9	1.0	1.2
C (see Section 26.7)	0.9	1.0	1.1
D (see Section 26.7)	0.8	0.9	1.0

Simplified ASCE 7 Snow

C_s = Slide-off Factor – The steeper the roof, the warmer the roof, and the smoother the roofing material, the lower the design snow load will be during a winter as snow has more likelihood of sliding off.

Reasonable to assume no slideoff (safe)



7-2a: Warm roofs with $C_t \le 1.0$ 7-2b: Cold roofs with $C_t = 1.1$ 7-2c: Cold roofs with C = 1.2 or larger

FIGURE 7-2 Graphs for Determining Roof Slope Factor C_s, for Warm and Cold Roofs (See Table 7-3 for C_t Definitions).

Here is a simplified method for reasonably safe Balanced Roof Snow Load:

Ground Snow Load, P_G [psf]
From ASCE 7 map or online resource

x

Ground to Roof adjustment

x

Risk Category Importance - I_S

=

Roof Snow Load, P_S [psf]
Not Less than 20psf RECOMMENDED

Ground to Roof Adjustment Factor (simplified):

If Ground Snow Load is 35psf or higher, use 0.8

If Ground Snow Load is 30psf, use 0.9

If Ground Snow Load is 25psf, use 1.0

If Ground Snow Load is 20psf or less, use 1.1

Risk Category from Table 1.5-1	Snow Importance Factor, I_s
I	0.80
II	1.00
III	1.10
IV	1.20

This is considered the Balanced Roof Snow Load, Sloped Roof Snow Load, or the nominal Top Chord Live Load on a Truss Design

This simplification is NOT the official load standard formulation and is presented here only as a potentially useful reference. Presenter takes NO responsibility for using this approach on any particular building. **THIS ROOF SNOW LOAD DOES NOT ADDRESS SNOW DRIFTS, SLIDING SNOW, OR UNBALANCED SNOW (OVER THE RIDGE DRIFTS). THESE ALSO NEED TO BE ANALYZED!**

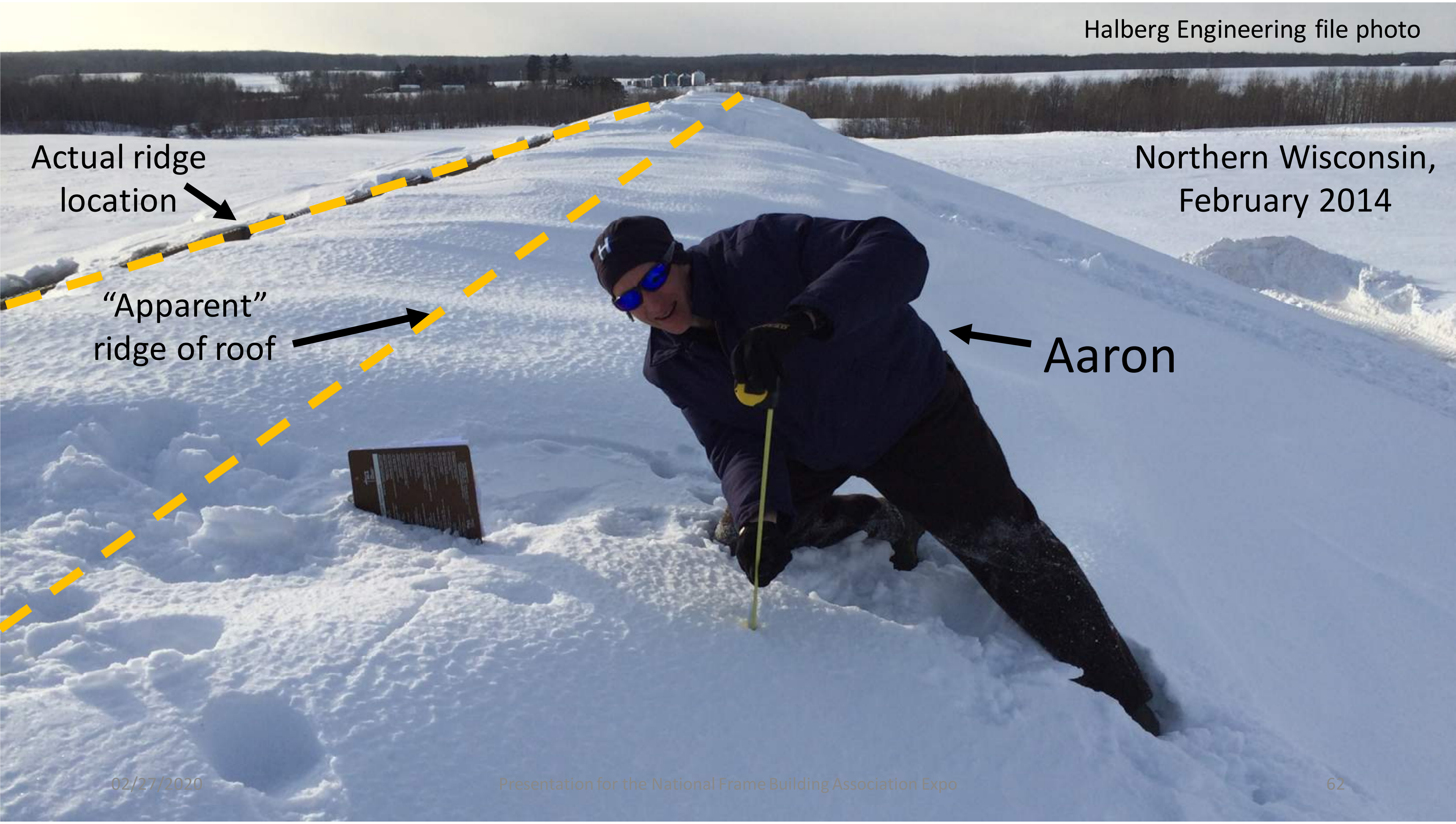
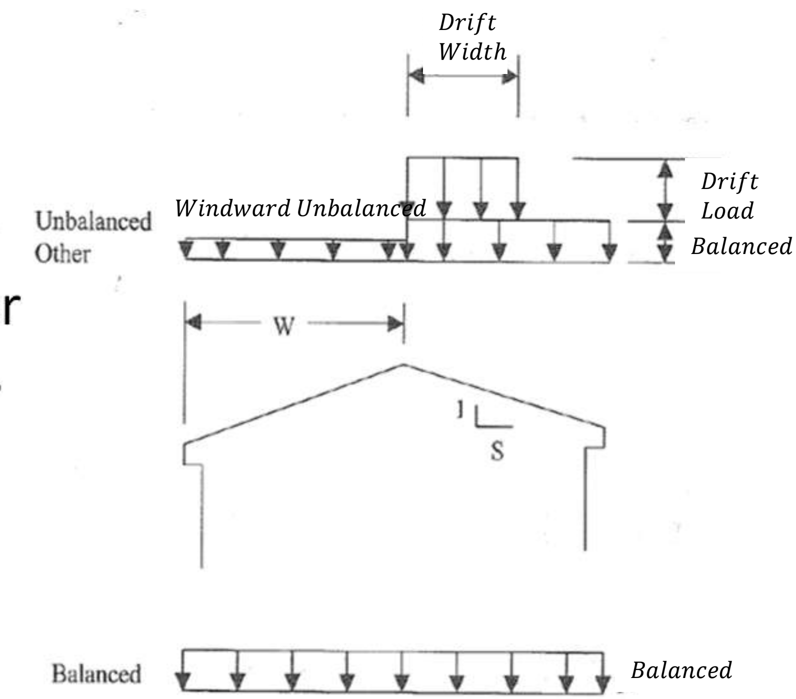

Halberg Engineering file photo
Actual ridge location
"Apparent" ridge of roof
Northern Wisconsin, February 2014
Aaron


Photo by Aaron Halberg, P.E.
Unbalanced Snow on the same building shown from a different angle

ASCE 7 Snow – By the Book

Unbalanced Snow is an additional scenario considered to account for snow blowing and creating a drift at the ridge during or shortly after the snow falls.

Prevailing Wind is NOT considered. Instead, all drift directions are presumed possible and analyzed.



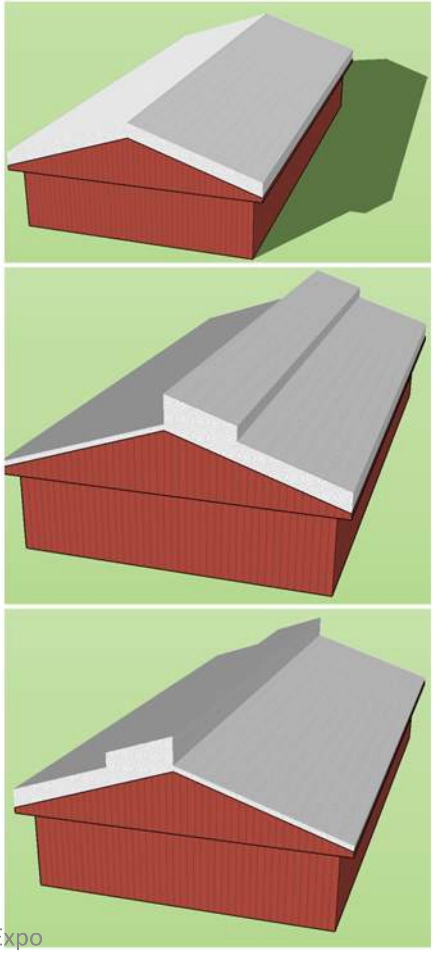
ASCE 7 Snow – By the Book

Challenge:

Complex - Many variables, multiple snow load scenarios, and load patterns that are difficult to describe to someone with words, let alone in a single breath (40, 4, & 5 roof load)

Advantage:

Building Efficiency - The most accurate snow standard based on latest research, allowing designers an approach to minimize failures without over-designing.



ASCE 7 – Unbalanced Snow Loads

Formulas Reduced to a form that depend only on Roof Pitch, Roof Width, and Ground Snow Load

Surcharge: $h_d \gamma / \sqrt{S}$ psf

$S = 12/\text{Pitch}$ (Pitch:12) (e.g. 4:12, 3:12, etc.)

$h_d = 0.43\sqrt[3]{W} \times (P_g+10)^{1/4} - 1.5$

W = ½ Clearspan + Overhang

$\gamma = \text{Min}\left[(0.13 \times P_g + 14), 30\right]$

$$\text{Load} = \frac{\left(0.43 \times \sqrt[3]{W} \times \sqrt[4]{(P_g+10)} - 1.5\right)\left(.13 \times P_g + 14\right)}{\sqrt{(12/\text{Pitch})}}$$

Width: $\frac{8}{3} h_d \sqrt{S}$

$$\frac{8}{3}\left(0.43 \times W^{1/3} \times (P_g+10)^{1/4} - 1.5\right)\sqrt{12/P}$$

- Although somewhat complex, these formulas are easy to put into a spreadsheet for simple output.
- For Price Book considerations, each truss design will have only one roof pitch and roof width, so the only variable for each Truss is the Ground Snow Load
- Risk Factor & Thermal Factor, etc. do not affect Unbalanced Snow Loads

Snow Drifting at Height Changes or Roof Obstructions

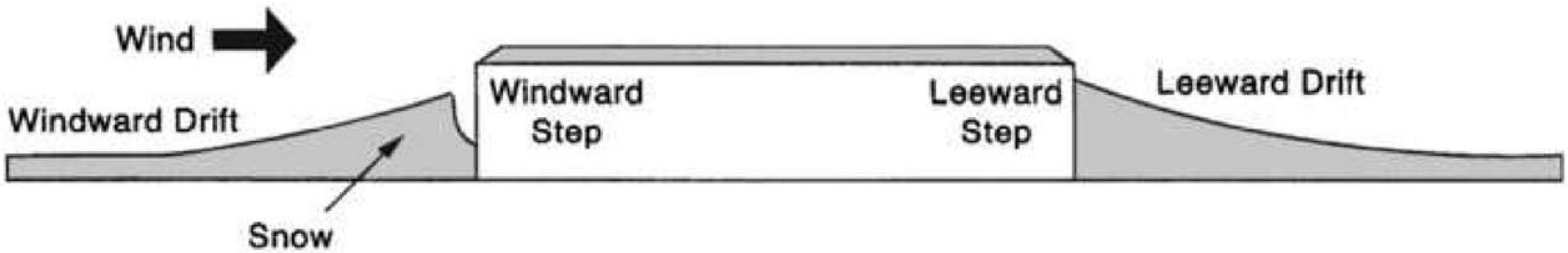


FIGURE 7.7-1 Drifts Formed at Windward and Leeward Steps

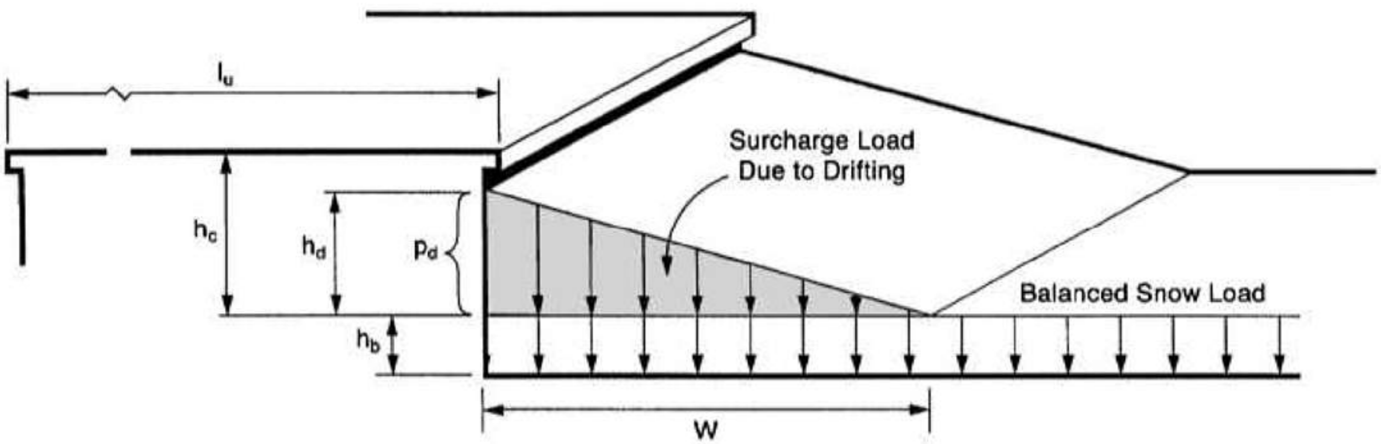


FIGURE 7.7-2 Configuration of Snowdrifts on Lower Roofs

There's even provisions for Ice Dam loads

7.4.5 Ice Dams and Icicles along Eaves. Two types of warm roofs that drain water over their eaves shall be capable of sustaining a uniformly distributed load of $2p_f$ on all overhanging portions: those that are unventilated and have an R-value less than 30 ft^2 hr°F/Btu (5.3°C m^2/W) and those that are ventilated and have an R-value less than 20 ft^2 hr°F/Btu (3.5°C m^2/W). The load on the overhang shall be based upon the flat roof snow load for the heated portion of the roof upslope of the exterior wall. No other loads except dead loads shall be present on the roof when this uniformly distributed load is applied.