ASCE/SEI 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures

JANUARY 21, 2026

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- 32 Years with Nucor:
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  - Vulcraft-Verco Group
- ASCE 7 Snow & Rain Load Subcommittee
- Past Chair, MBMA Technical Committee



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Webinar Description

ASCE/SEI 7 Minimum Design Loads and Associated Criteria for Buildings and Other Structures is a nationally adopted loading standard for the analysis and design of buildings and other structures. The 2022 edition of this consensus standard has been adopted into the 2024 International Building Code. This presentation is intended to provide a brief overview of the significant changes to the snow loads in the 2025 CBC.

This session will highlight the adoption of reliability-targeted ground snow loads (GSLs), including the methodology for developing four new maps for Risk Category I, II, III, and IV. The new ground snow loads replace the 50-year uniform hazard design snow loads that have been adopted by the Codes for decades. This session will also include details on the new winter wind parameter, revisions to the design drift loads, and more. Additional information regarding the new digital platform and webtool available from ASCE will also be presented. This tool was developed to support the full version of ASCE 7-22, easily accessible and free for all users.

Learning Objectives

- Understand the significant updates to the snow provisions in ASCE 7-22, including how the new ground snow maps were developed.
- Understand the ASCE 7-22 provisions adopted by the 2024 IBC
- Learn how to use the new digital platform and webtool available from ASCE
- Identify and apply new provisions for thermal factors, snow drift heights, and windward drift widths in accordance with ASCE 7-22.
- Explain the revised rain load calculation methodology in Chapter 8, including the inclusion of ponding head and updated guidance for drainage systems.
- How to specify snow loads for joist and joist girders.

Revisions to Snow Loading in Chapter 7

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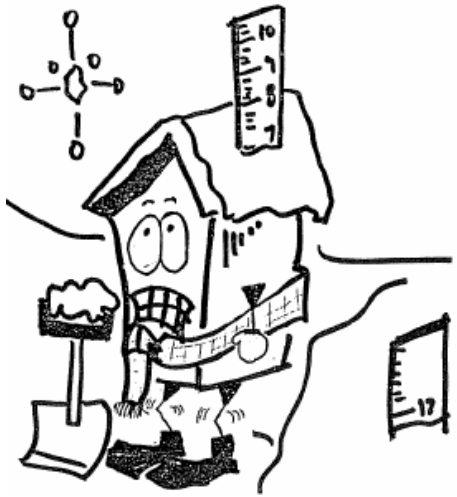
Outline

New Ground Snow Load Values

- Why was this needed?
- Why reliability-targeted loads?
- Impacts of new values
- Reliability-targeted GSL impacts on ASCE 7



Additional Revisions to Chapter 7

- Thermal factor changes
- Snow drift heights
- Windward snow drift widths

Why New Ground Snow Loads?

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- Basis data collected in 1980's
- Limited number of locations
- Uniform risk assumption (50-yr MRI)
- Significant undefined regions
- Not trusted by many

Why? Aging/Limited Technology

Why? Aging Data, Case Study Areas

C7.2 GROUND SNOW LOADS, p_g

The mapped snow load provisions in Fig. 7.2-1 were developed from an extreme-value statistical analysis of weather records of snow on the ground (Ellingwood and Redfield 1983). The map was produced by the Corps of Engineers, Cold Regions Research and Engineering Laboratory (CRREL).The lognormal distribution was selected to estimate ground snow loads, which have a 2% annual probability of being exceeded (50-yr mean recurrence interval).

Maximum measured ground snow loads and ground snow loads with a 2% annual probability of being exceeded are presented in Table C7.2-1 for National Weather Service (NWS) "first-order" stations at which ground snow loads have been measured for at least 11 years during the period 1952–1992.

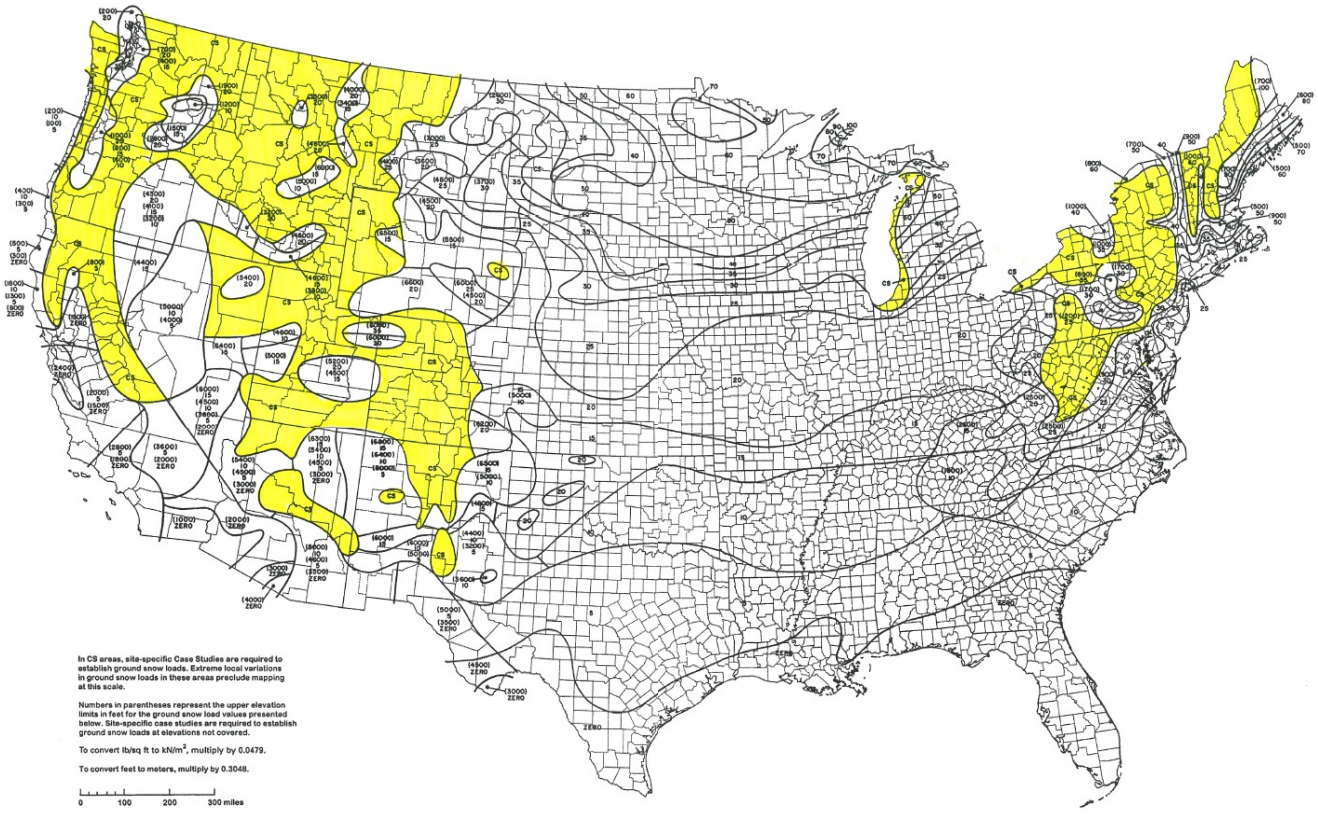
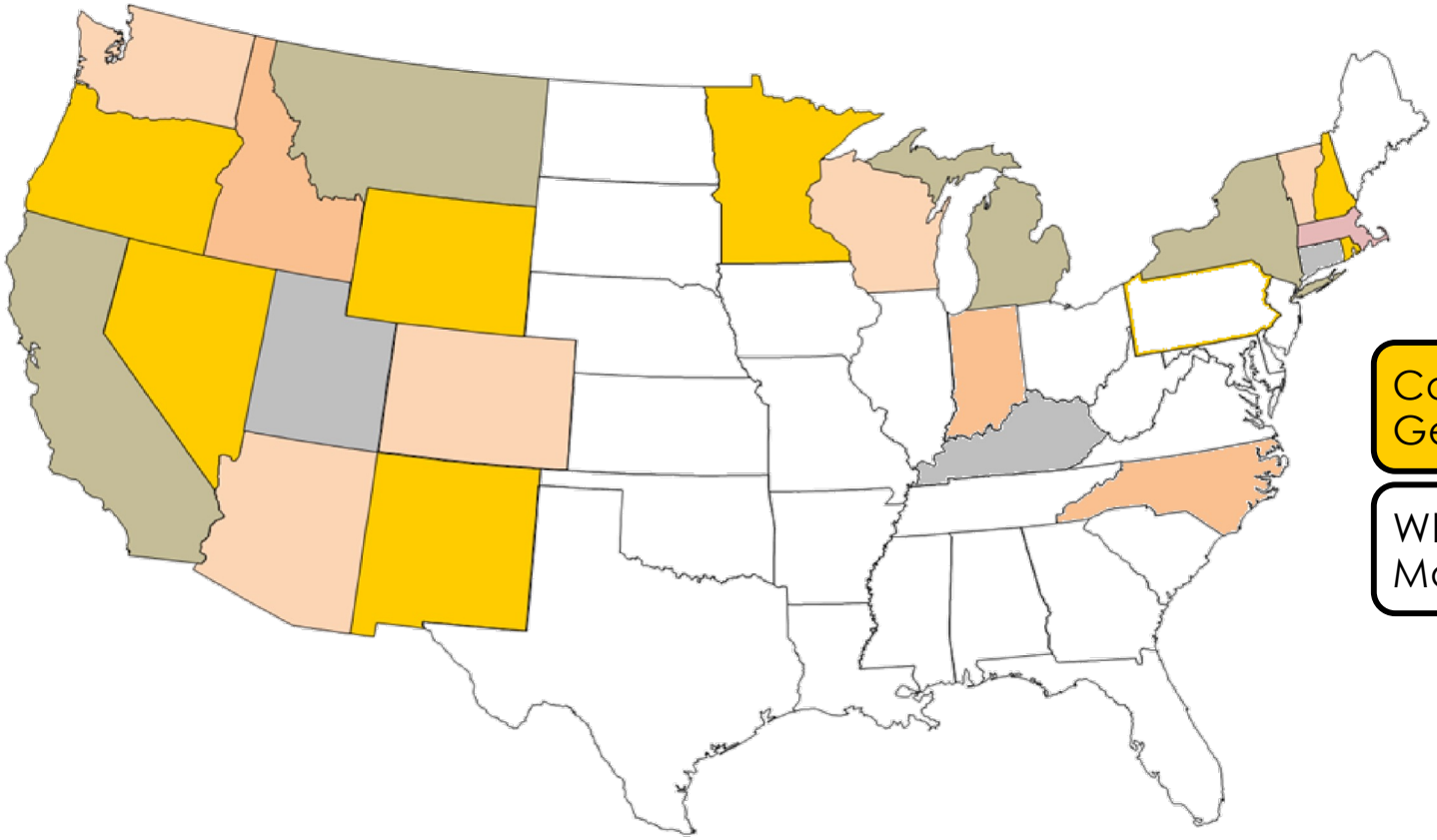


FIGURE 7-1 Ground Snow Loads, P_g, for the United States (Lb/Ft²).

Why? Situation in US prior to 2022…



Colored Regions – Locally-Generated/Specified GSL Info

White Regions – ASCE 7-Maintained GSL Info

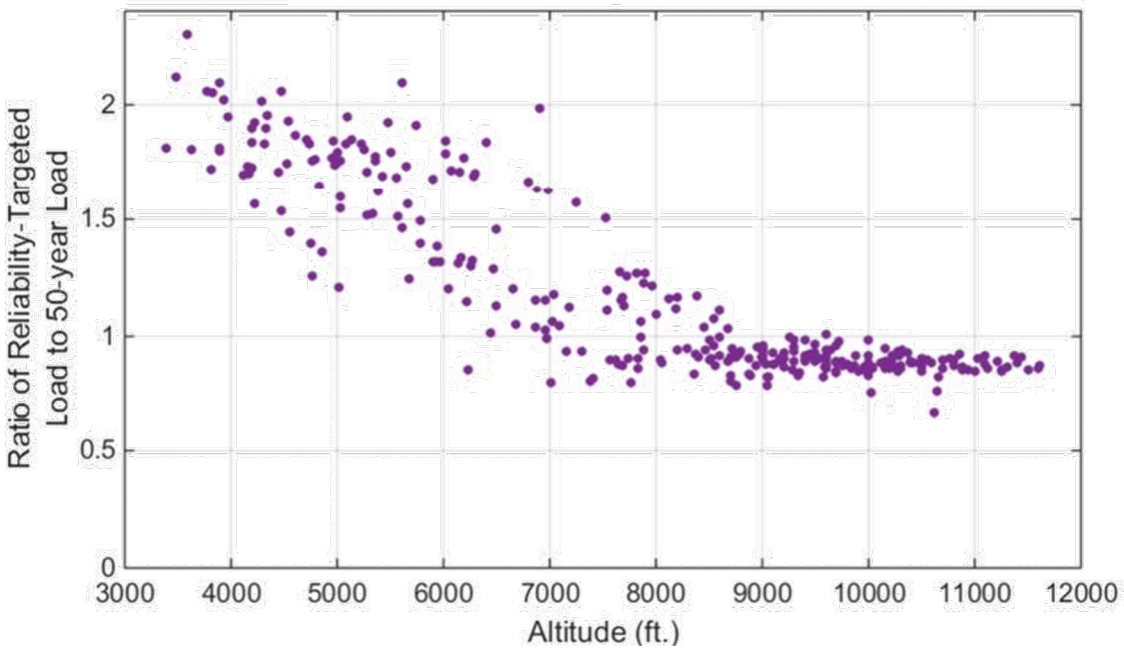
Colorado Case Study (SEAC, 2016)

Uniform Hazard

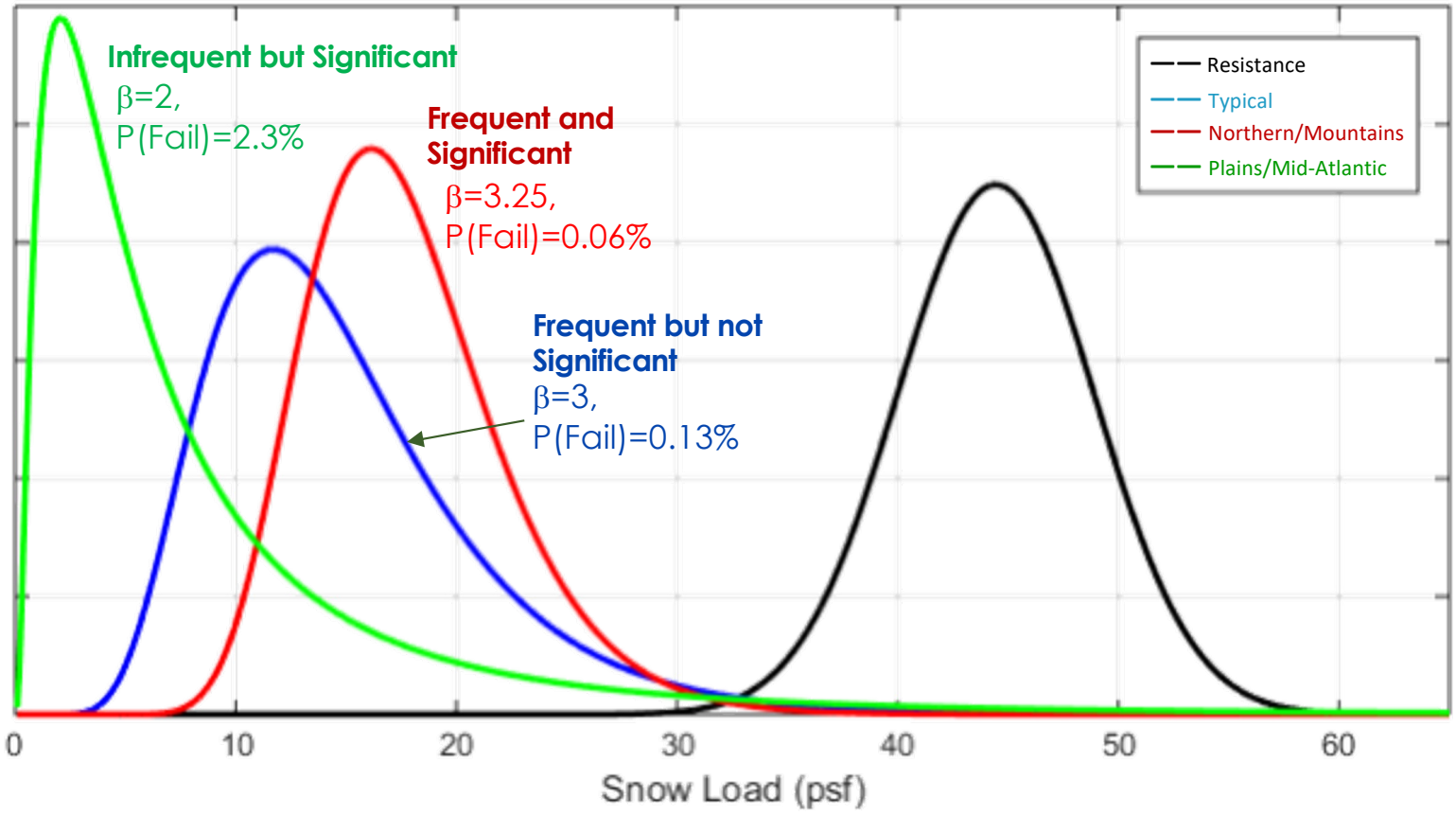
- 50-year snow load for design, corresponds to 2% annual probability of load occurring
- Produces varying probabilities of failure, from β=2 (2.3% in 50 years) to β=3.25 (0.06% in 50 years)

Uniform Risk

- Annual probability of design load occurring varies
- Satisfies industry standard for all load and structure types to balance economy and safety corresponding to probability of failure for β=3 (0.13% in 50 years)



Why? Reliability-Targeted Loads



ASCE 7 – Target Reliability Goals

Table 1.3-1. Target Reliability (Annual Probability of Failure, P_F) and Associated Reliability Indices (β) for Load Conditions That Do Not Include Earthquake, Tsunami, or Extraordinary Events.

	Risk Category			
Basis	**I**	**II**	**III**	**IV**
Failure that is not sudden and does not lead to widespread progression of damage	$P_F = 1.25 \times 10^{-4}$ per year $\beta = 2.5$	$P_F = 3.0 \times 10^{-5}$ per year $\beta = 3.0$	$P_F = 1.25 \times 10^{-5}$ per year $\beta = 3.25$	$P_F = 5.0 \times 10^{-6}$ per year $\beta = 3.5$
Failure that is either sudden or leads to widespread progression of damage	$P_F = 3.0 \times 10^{-5}$ per year $\beta = 3.0$	$P_F = 5.0 \times 10^{-6}$ per year $\beta = 3.5$	$P_F = 2.0 \times 10^{-6}$ per year $\beta = 3.75$	$P_F = 7.0 \times 10^{-7}$ per year $\beta = 4.0$
Failure that is sudden and results in widespread progression of damage	$P_F = 5.0 \times 10^{-6}$ per year $\beta = 3.5$	$P_F = 7.0 \times 10^{-7}$ per year $\beta = 4.0$	$P_F = 2.5 \times 10^{-7}$ per year $\beta = 4.25$	$P_F = 1.0 \times 10^{-7}$ per year $\beta = 4.5$

Notes:

[1]The target reliability indexes are provided for a 50-year reference period, and the probabilities of failure have been annualized. The equations presented in Section 2.3.6 are based on reliability indexes for 50 years, because the load combination requirements in Section 2.3.2 are based on the maximum loads for the 50-year reference period.

Overview of ASCE 7-22 Method

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- Therese McAllister, PhD (NIST)
- Jeannette Torrents (JVA Engineers)

ASCE Staff
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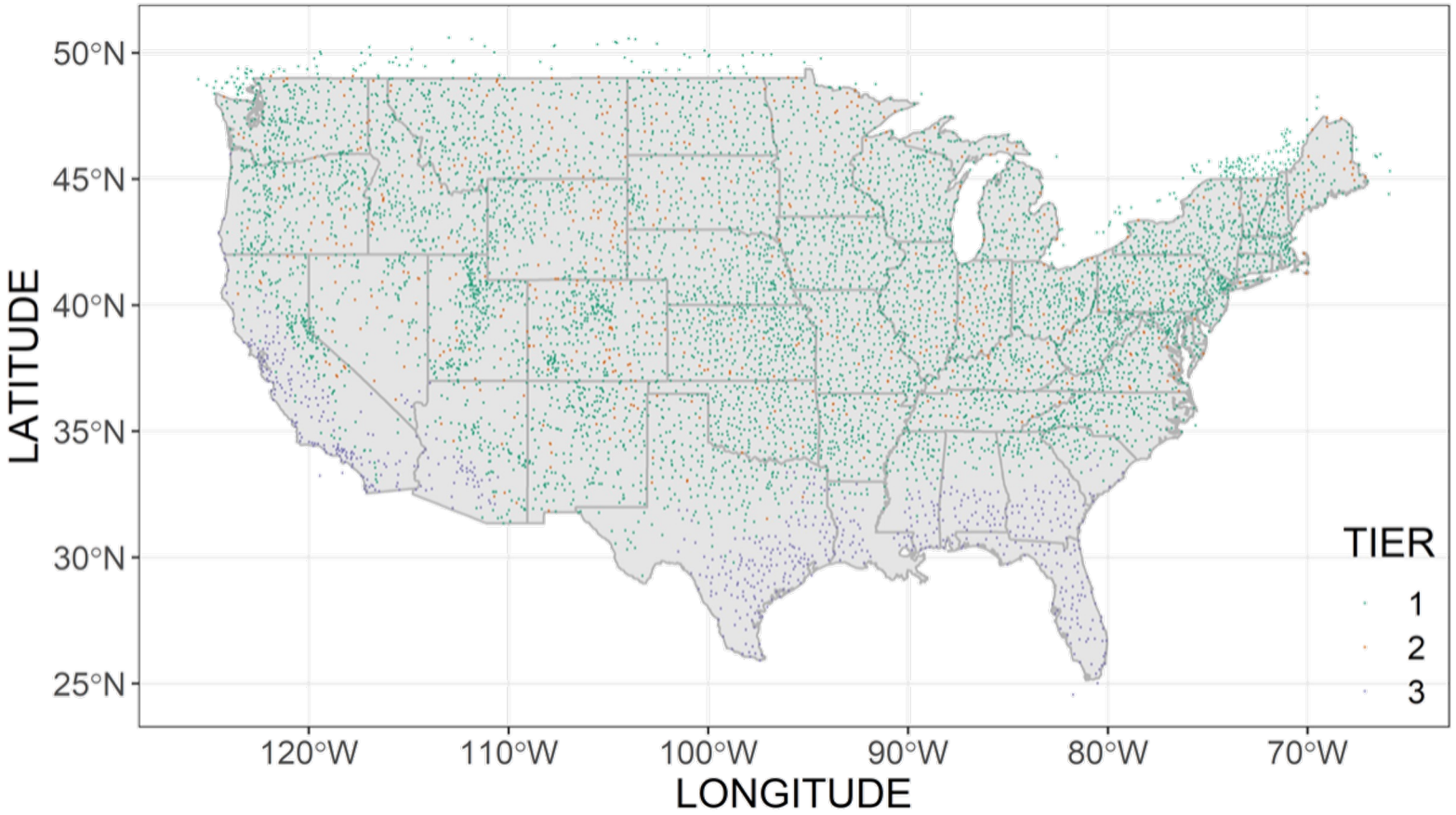
- Laura Champion

Modern Snowfall Data

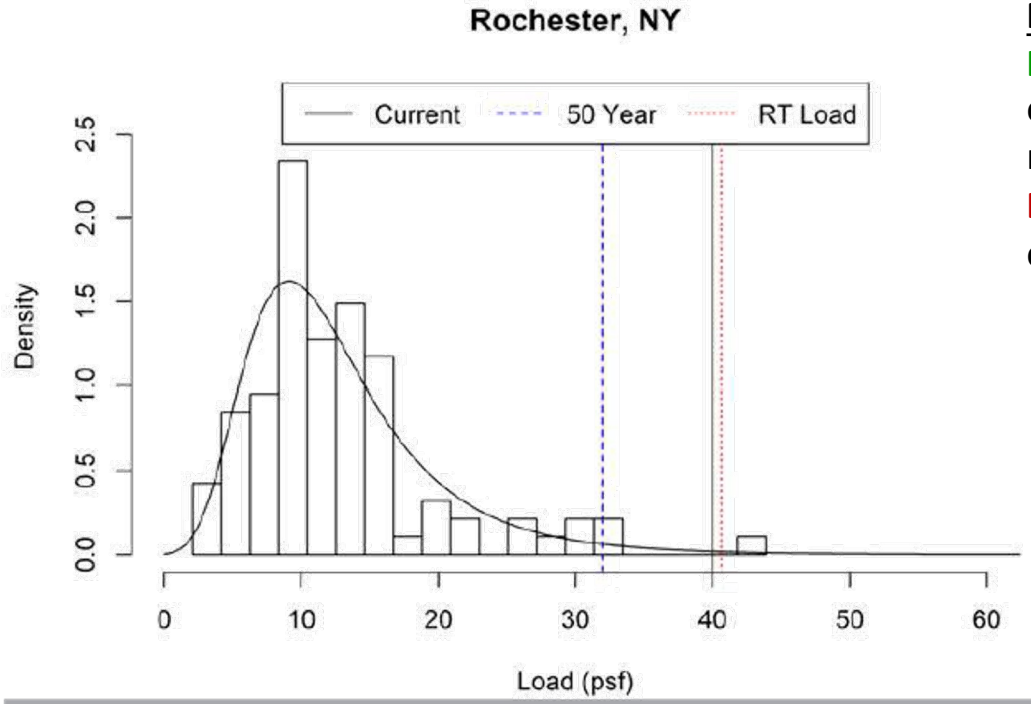
Global Historical Climatological Network Database



500,000+ GSL_{max} Values @ 12,000 Stations

Scrutinized, both electronically and manually

Distribution Fitting



Current = ASCE 7-16 load
50 Year = 50-Year load from ASCE 7-22 analysis
RT Load = Reliability-targeted Load ÷ 1.6

ProbStat 101

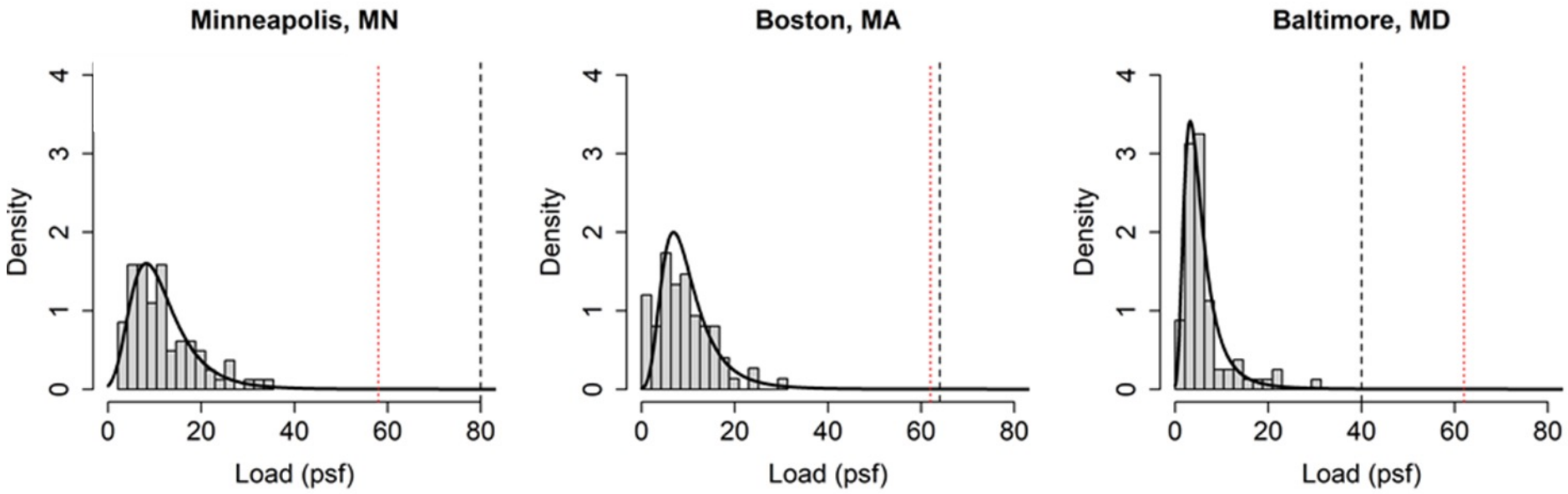
Histogram: Measures # of observations within a given range

Density: Relative frequency of occurrence

A “Tail” of Three Cities

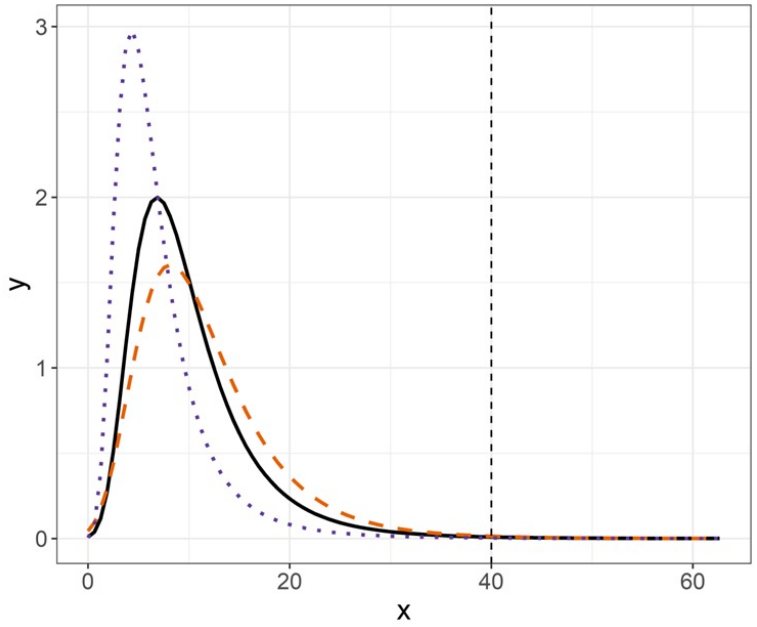
Different “typical” snow behavior
Similar “extreme” snow loads

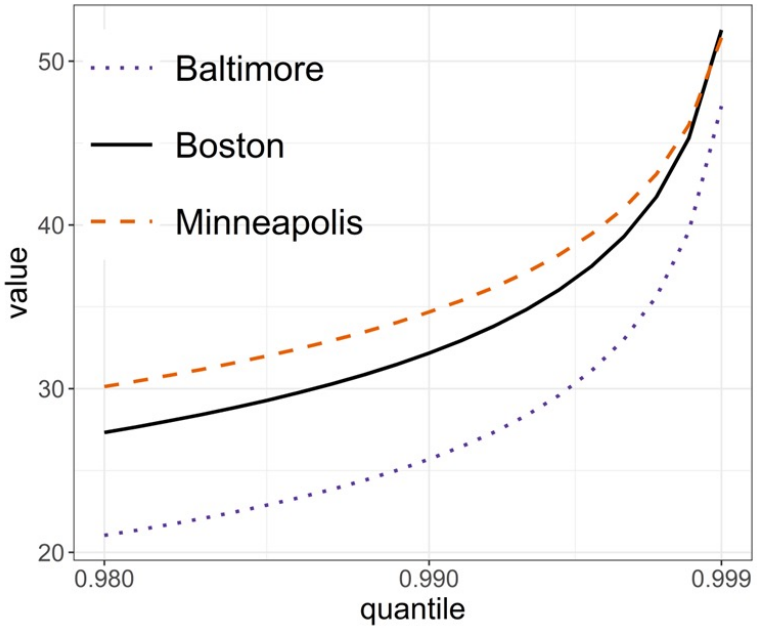
City	Winter Precipitation, Dec – Feb (Inches of H_2O)	Coldest Month Temperature (°F)
Baltimore	9.6	33.9
Boston	10.9	28.4
Minneapolis	2.9	15.9



A “Tail” of Three Cities

Different “typical” snow behavior
Similar “extreme” snow loads

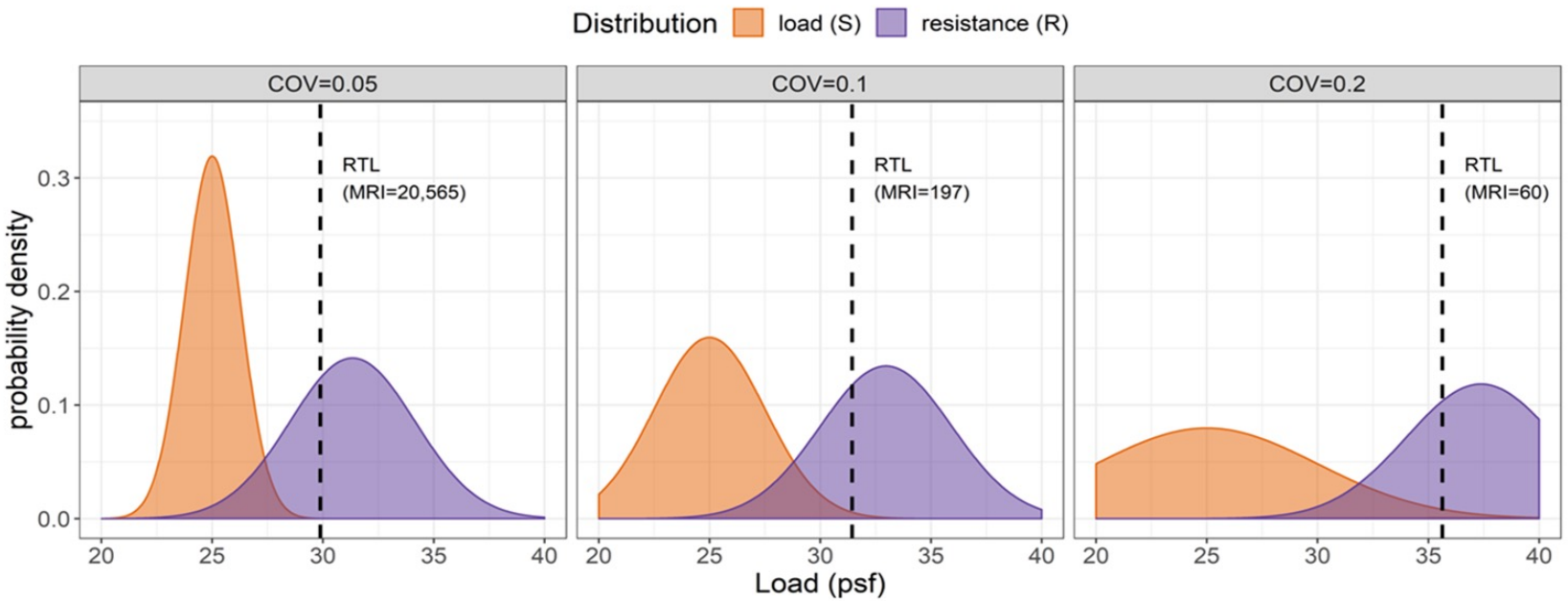




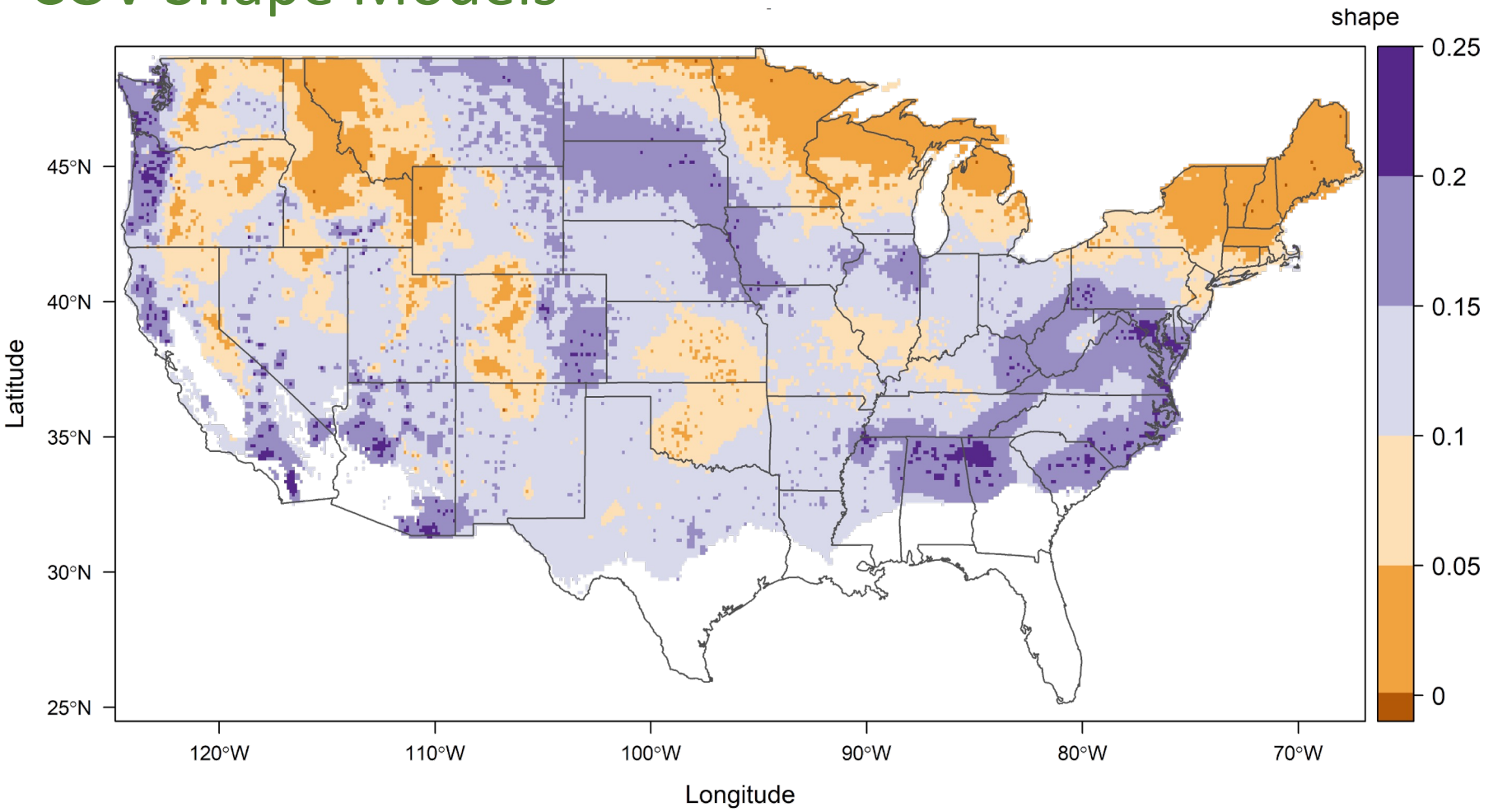
Targeting Reliability

Reliability-targeted loads seek to estimate the probability that:

$$Random\ Resistance\ -(Random\ Roof\ Load) < 0$$

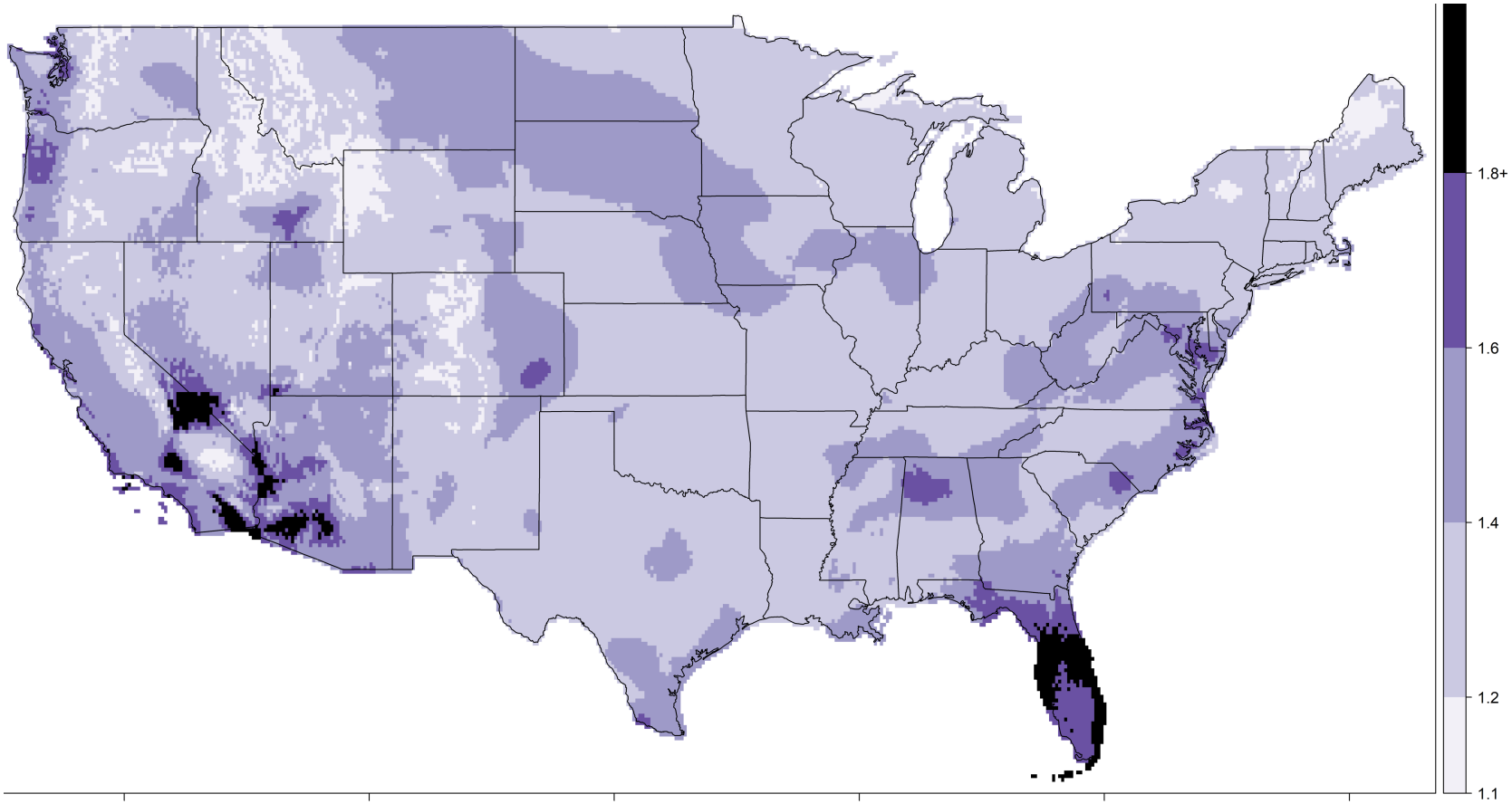


COV Shape Models



Effects of Reliability-Targeted Loads

- Why four GSL maps, one per Risk Category? See RT_IV / RT_II below…



EPA Eco-Regions

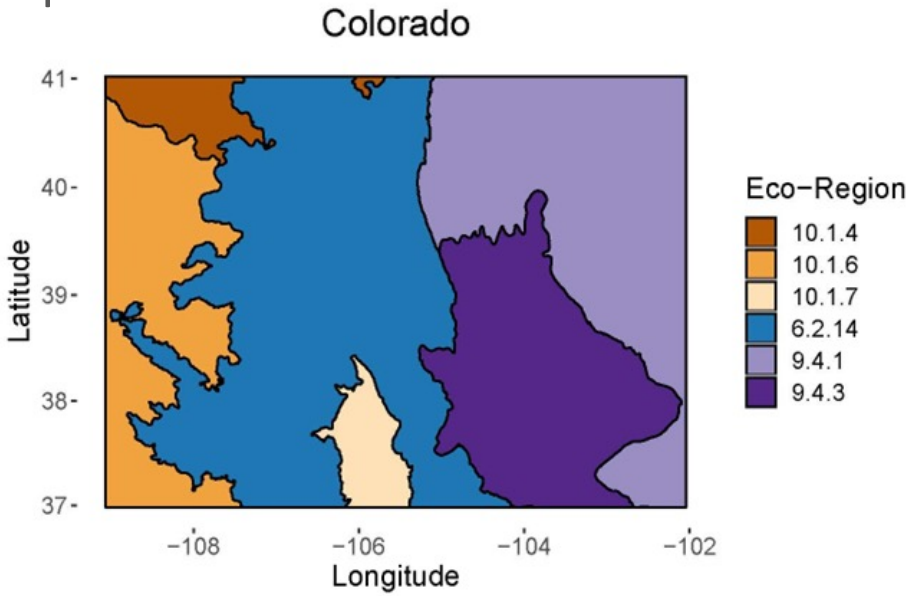


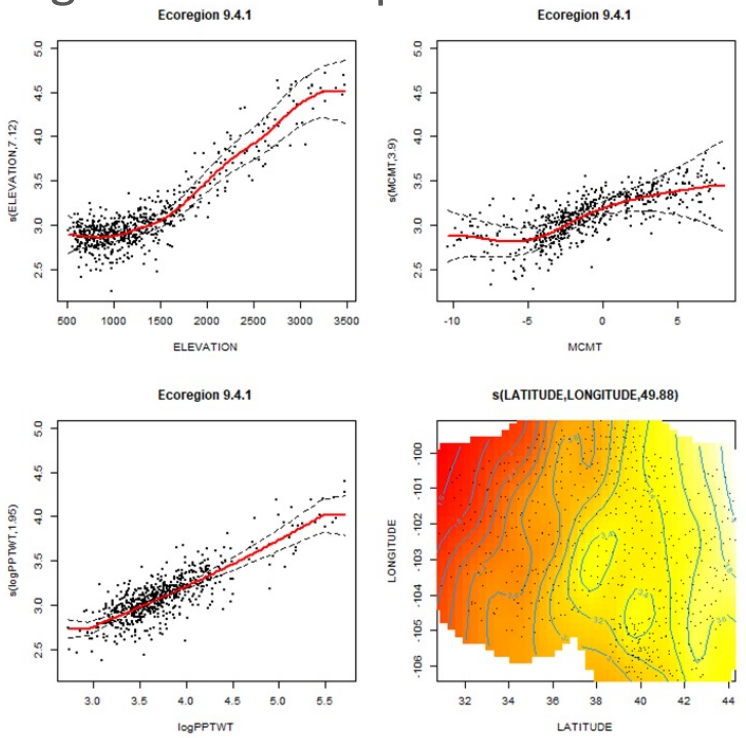
Image taken from https://www.epa.gov/eco-research/ecoregions-north-america

- Eco-regions are regions where geology, landforms, climate, and hydrology are similar
- Fit models by eco-region instead of by state

Mapping Reliability-Targeted Loads

Generalized Additive Models (GAMS) with splines on the sphere flexibly model snow loads across regions using elevation and average winter temperature as input.





The R software package “remap” smooths predictions between regions.

Q1 - Audience Poll

What is the primary purpose of reliability-targeted ground snow loads in ASCE 7-22?

A. Simplify calculations
B. Reduce construction cost
C. Achieve uniform failure probability
D. Match historical snowfall records

GSL Changes in ASCE 7-22

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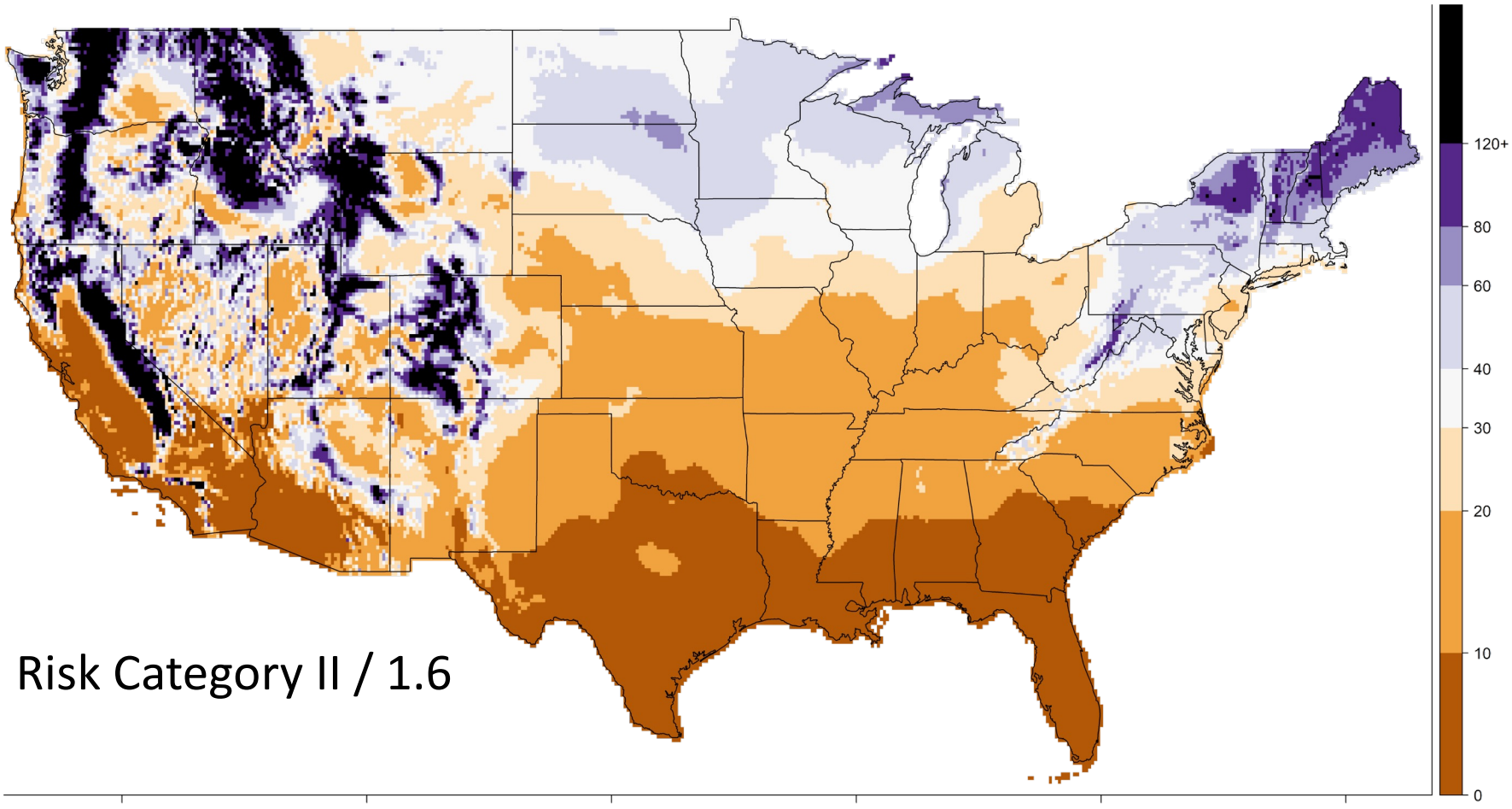
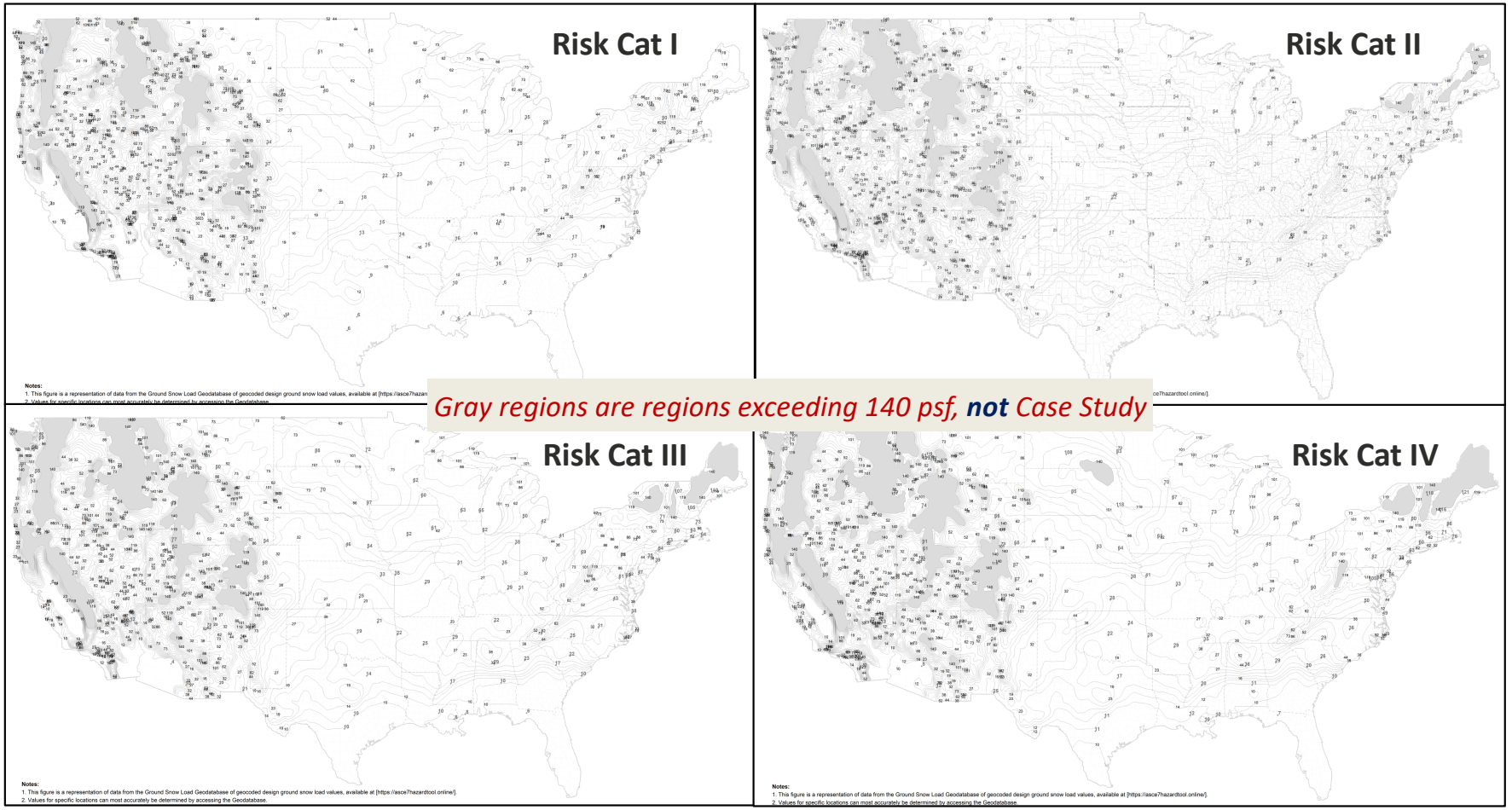
ASCE 7-22 Ground Snow Loads

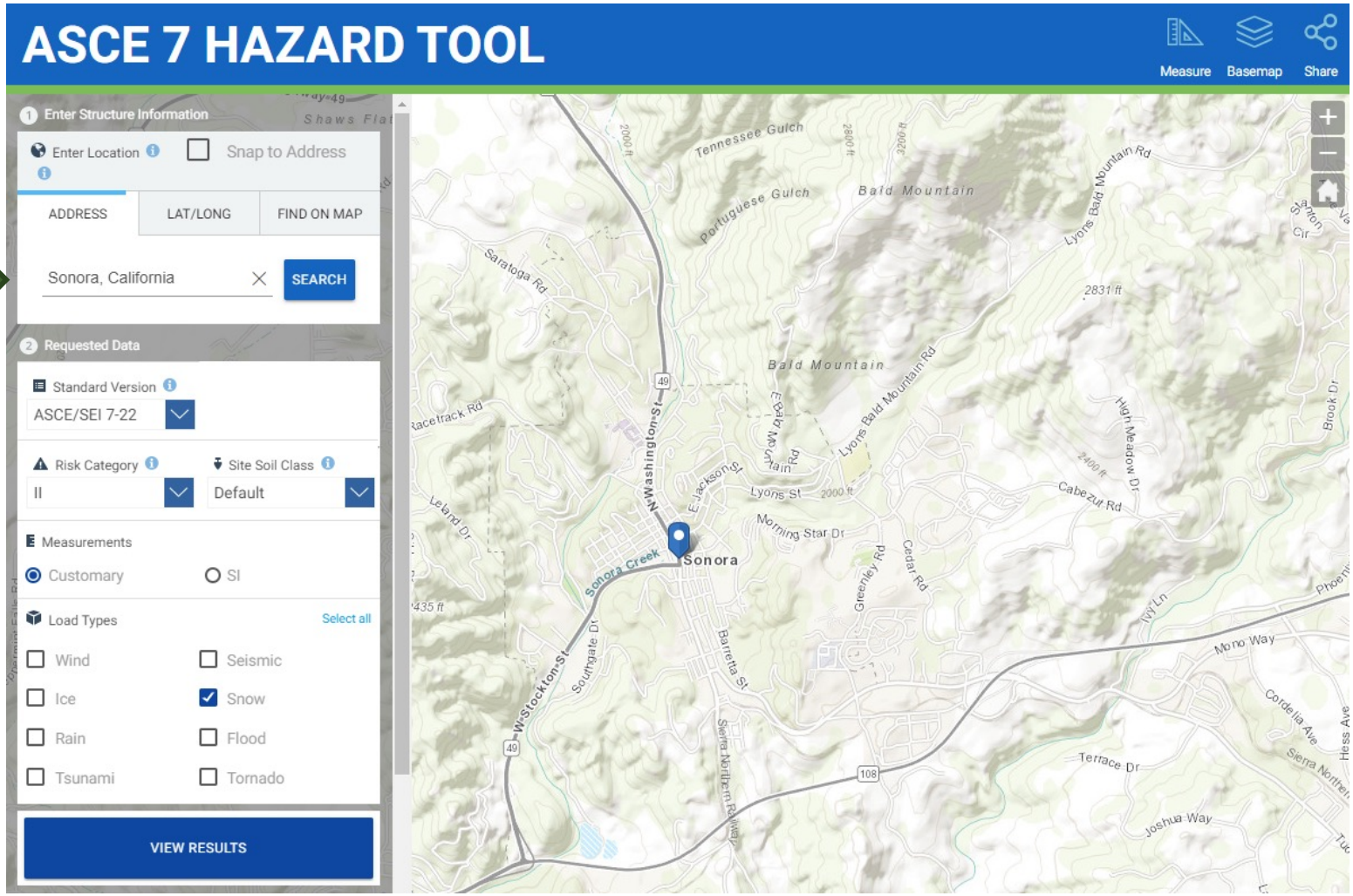


Risk Category II / 1.6

Four GSL Maps – Each Risk Category



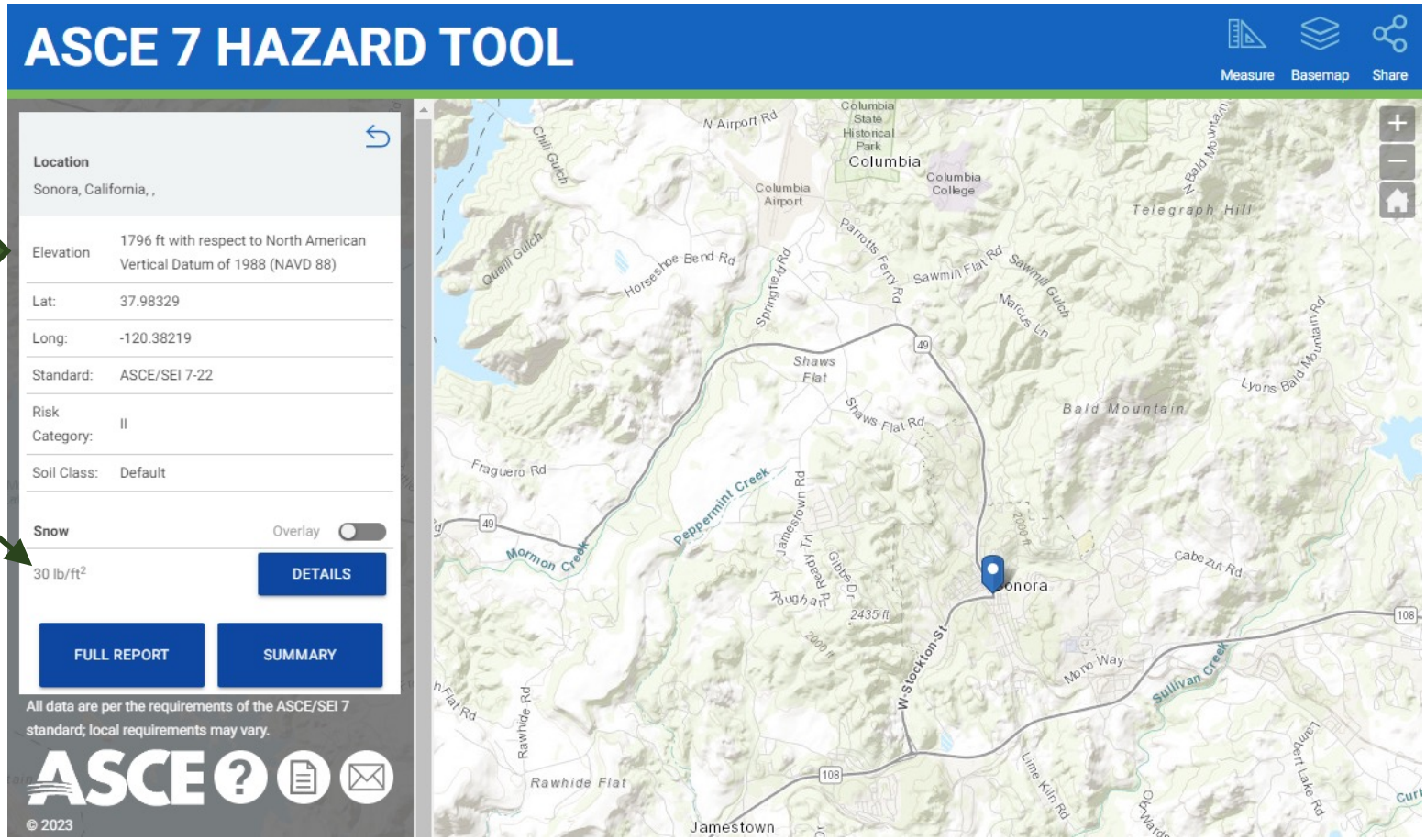
Inputs



https://asce7hazardtool.online/

Outputs

Snow Results Here



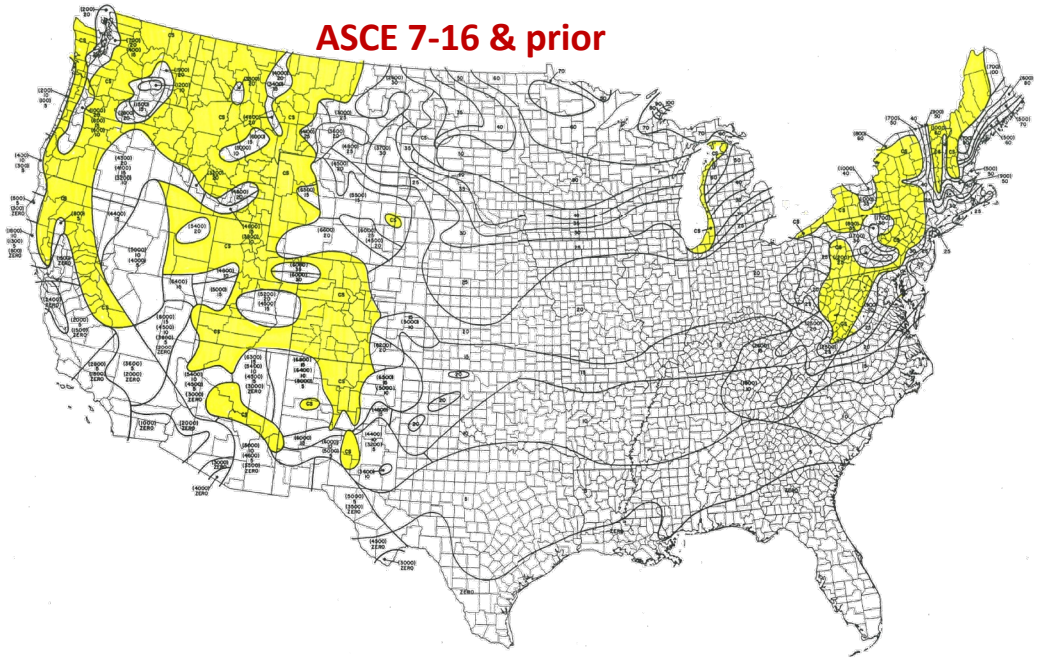
https://asce7hazardtool.online/

Revised Case Study Regions

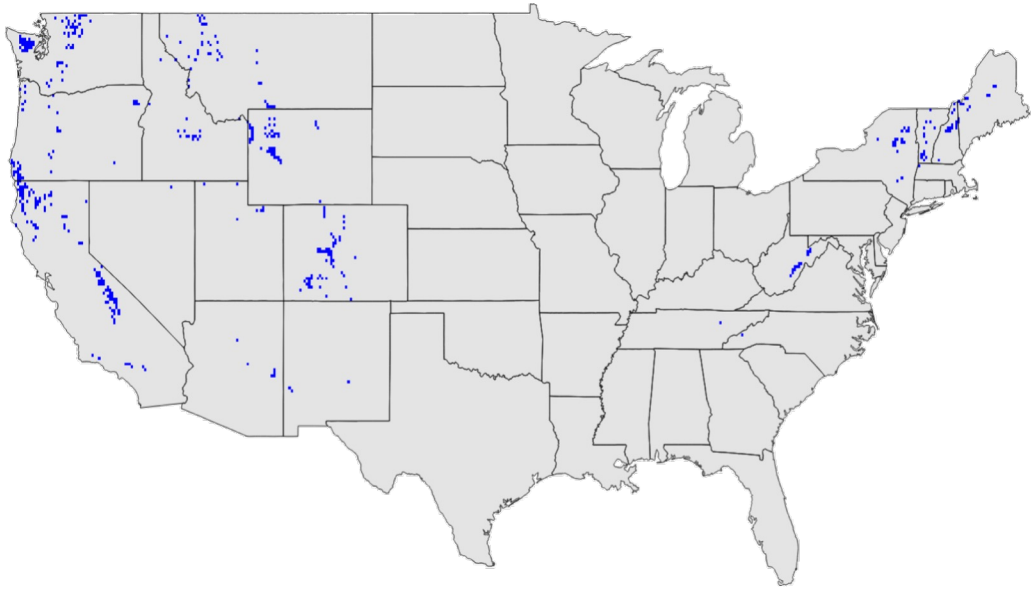
New CS Definition: Locations where elevation or temperature conditions exceed the bounds observed in the dataset

ASCE 7-22 CS regions reduced by 91% from ASCE 7-16

ASCE 7-16 & prior



ASCE 7-22



What About Baltimore?

- Site Selected: Baltimore, MD
  - One of the highest-impact locations on new GSL maps.
  - GSL (RT-II) = 60 psf
  - GSL (7-16, 50-yr MRI) = 25 psf
    (*FYI: City of Baltimore requires Roof SL = 30 psf*)
  - After proper application of Load Factors (1.0 vs. 1.6), Roof Total Load increases by 15%
- Two Metal Buildings – configured to be highly affected by this change:

MB Structure	MB Weight Impact	MB Cost Impact	Total Cost Impact
70'w x 125'l x 15'h 2:12	+6.5%	+4.5%	+0.8%
200'w x 550'l x 18'h 3:12	+8.7%	+6.4%	+0.9%

Across the US of A…

					1.2D+1.6S	1.2D+1.0S		
City	State	2016	2022	GSL '22/'16	TL-2016	TL-2022		RATIO '22/'16
Aberdeen	SD	50	59	18%	544	426		0.78
Akron	OH	20	20	--	275	208		0.76
Albany	NY	40	41	3%	454	326		0.72
Allentown	PA	25	29	16%	320	258		0.81
Alpena	MI	50	40	(20%)	544	320		0.59
Atlantic City	NJ	20	24	20%	275	230		0.84
Baltimore	MD	25	38	52%	320	309		0.97
Beckley	WV	20	36	80%	275	298		1.08
Billings	MT	29	27	(7%)	356	247		0.69
Bismarck	ND	35	45	29%	410	348		0.85
Boise	ID	15	19	27%	230	202		0.88
Boston	MA	40	39	(3%)	454	314		0.69
Bridgeport	CT	30	26	(13%)	365	242		0.66
Burlington	VT	40	52	30%	454	387		0.85
Caribou	ME	100	87	(13%)	992	583		0.59
Casper	WY	15	27	80%	230	247		1.07

Total Load Map

Q2 - Audience Poll

Why were multiple ground snow load maps introduced in ASCE 7-22?

A. Different roof slopes
B. Different Risk Categories
C. Different exposure categories
D. Different building materials

Effects of Reliability-Targeted GSLs

ASCE 7-22 Updates

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Effects of Reliability-Targeted GSL Values

When to Consider Snow	Load Combinations	Importance Factor
Winter Wind Parameter	Thermal Factor	Drifts on Lower Roofs

Effects: When to Consider Snow

7.2 GROUND SNOW LOADS, p_g

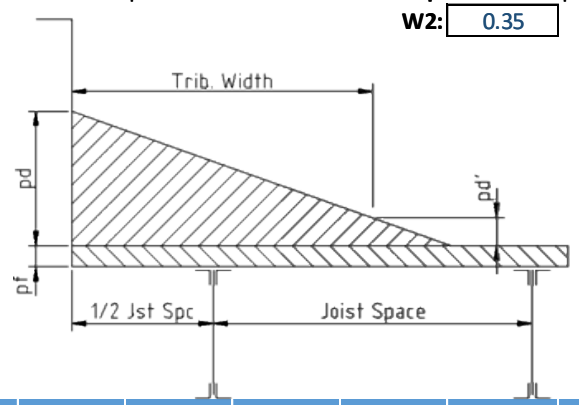
EXCEPTION: The snow load provisions of this chapter need not be considered for roofs or roof members with no potential for drift accumulation or unbalanced snow loading where the ground snow load, p_g, is less than the factored roof live load used in design. For all other roofs or roof members, the snow load provisions in this chapter do not need to be considered in either of the following situations:

- The ground snow load, p_g, is less than or equal to 10 lb/ft^2 (0.48 kN/m^2) and the length of the roof upwind from any potential drifting location, l_u, is less than or equal to 100 ft (30.48 m).
- The ground snow load, p_g, is less than or equal to 5 lb/ft^2 (0.24 kN/m^2) and the length of the roof upwind from any potential drifting location, l_u, is less than or equal to 300 ft (91.44 m).

Effects: When to Consider Snow

Snow Drift vs. Roof Live TOTAL LOAD Comparison Tool

D:	10	psf	**pg:**	9	psf
Lr:	20	psf	**Ct:**	1.2	
Joist Span:	50	ft	**Cs:**	1	
Joist W_trib:	8	ft	**Ce:**	1	
Joist Trib Area:	400	ft²	**pf:**	9	
Adj RLL:	16	psf	**γ:**	15.67	pcf
			W2:	0.35	



lu (ft)	hd (ft)	pd (psf)	wd (ft)	hd' (ft)	pd' (psf)	S_dr (plf)	TL_Snow (plf)	TL_Live (psf)	
101.46	1.79	27.18	7.17	0.00	0.00	108.7	276.7	276.7	✓
25	1.10	16.65	4.39	0.00	0.00	66.6	234.6	276.7	✓
50	1.40	21.22	5.60	0.00	0.00	84.9	252.9	276.7	✓
100	1.78	27.05	7.13	0.00	0.00	108.2	276.2	276.7	✓
200	2.27	34.47	9.09	0.27	4.13	154.4	322.4	276.7	✗
350	2.76	41.93	11.06	0.76	11.59	214.1	382.1	276.7	✗
500	3.13	47.51	12.53	1.13	17.17	258.7	426.7	276.7	✗
750	3.61	54.75	14.44	1.61	24.41	316.6	484.6	276.7	✗
1000	3.99	60.55	15.97	1.99	30.21	363.0	531.0	276.7	✗

Comparing Load Combinations - ASD

2021 ASD Load Combinations

D	D + L_r	D + S	D + 0.6W_d	D + 0.75L_r + 0.45W_d	D + 0.75S + 0.45W_d	0.6D + 0.6W_u

2024 ASD Load Combinations

D	D + L_r	D + 0.7S	D + 0.6W_d	D + 0.75L_r + 0.45W_d	D + 0.53S + 0.45W_d	0.6D + 0.6W_u

Comparing Load Combinations - LRFD

2021 LRFD Load Combinations

1.4D	1.2D + 1.6L_r	1.2D + 1.6S	1.2D + W_d	1.2D + 1.6L_r + 0.5W_d	1.2D + 1.6S + 0.5W_d	1.2D + 0.5L_r + W_d	1.2D + 0.5S + W_d

2024 LRFD Load Combinations

1.4D	1.2D + 1.6L_r	1.2D + S	1.2D + W_d	1.2D + 1.6L_r + 0.5W_d	1.2D + S + 0.5W_d	1.2D + 0.5L_r + W_d	1.2D + 0.3S + W_d

Effects: No Snow Importance Factor, I_S

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

Effects: Adjust Provisions That Included I_S

- Section 7.3
  - Removed I_s from p_f/p_s & p_m equations.

$$p_f = 0.7C_eC_t\cancel{I_s}p_g \quad (7.3\text{-}1)$$

- p_m now references Risk Category
  - If $p_g \leq p_{m,max}$, from Table 7.3-4: $p_m = p_g$
  - If $p_g > p_{m,max}$, from Table 7.3-4: $p_m = p_{m,max}$

Table 7.3-4 – Minimum Snow Loads for Low-Slope Roofs

Risk Category	$p_{m,max}$
I	24 lb/ft^2 (1.15 kN/m^2)
II	30 lb/ft^2 (1.44 kN/m^2)
III	33 lb/ft^2 (1.58 kN/m^2)
IV	36 lb/ft^2 (1.73 kN/m^2)

Effects: Seismic Provision Changes

- Effective Seismic Weight, W
  - Where the flat roof snow load, pf > 45 ~~30~~ psf, add 15 ~~20~~% thereof to W

12.7 MODELING CRITERIA

12.7.2 Effective Seismic Weight The effective seismic weight, W, of a structure shall include the dead load above the base and other loads above the base as follows:

4. Where the flat roof snow load, P_f, exceeds 45 lb/ft^2 (2.16 kN/m^2), 15% of the uniform design snow load, regardless of actual roof slope.

- Load Combinations
  - Section 2.3.6: (6) 1.2D + E_v + E_h + L + ~~0.2~~ 0.15S (LRFD)
  - Section 2.4.5: (9) 1.0D + 0.525E_v + 0.525E_h + 0.75L + ~~0.7~~ 0.1S (ASD)

Effects: Serviceability (Appx Comm CC)

APPENDIX CC
SERVICEABILITY CONSIDERATIONS

ASCE 7-16

For serviceability limit states involving visually objectionable deformations, reparable cracking or other damage to interior finishes, and other short-term effects, the suggested load combinations are

$$D + L \qquad \text{(CC.2-1a)}$$

$$D + 0.5S \qquad \text{(CC.2-1b)}$$

ASCE 7-22

For serviceability limit states involving visually objectionable deformations, reparable cracking or other damage to interior finishes, and other short-term effects, the suggested load combinations are

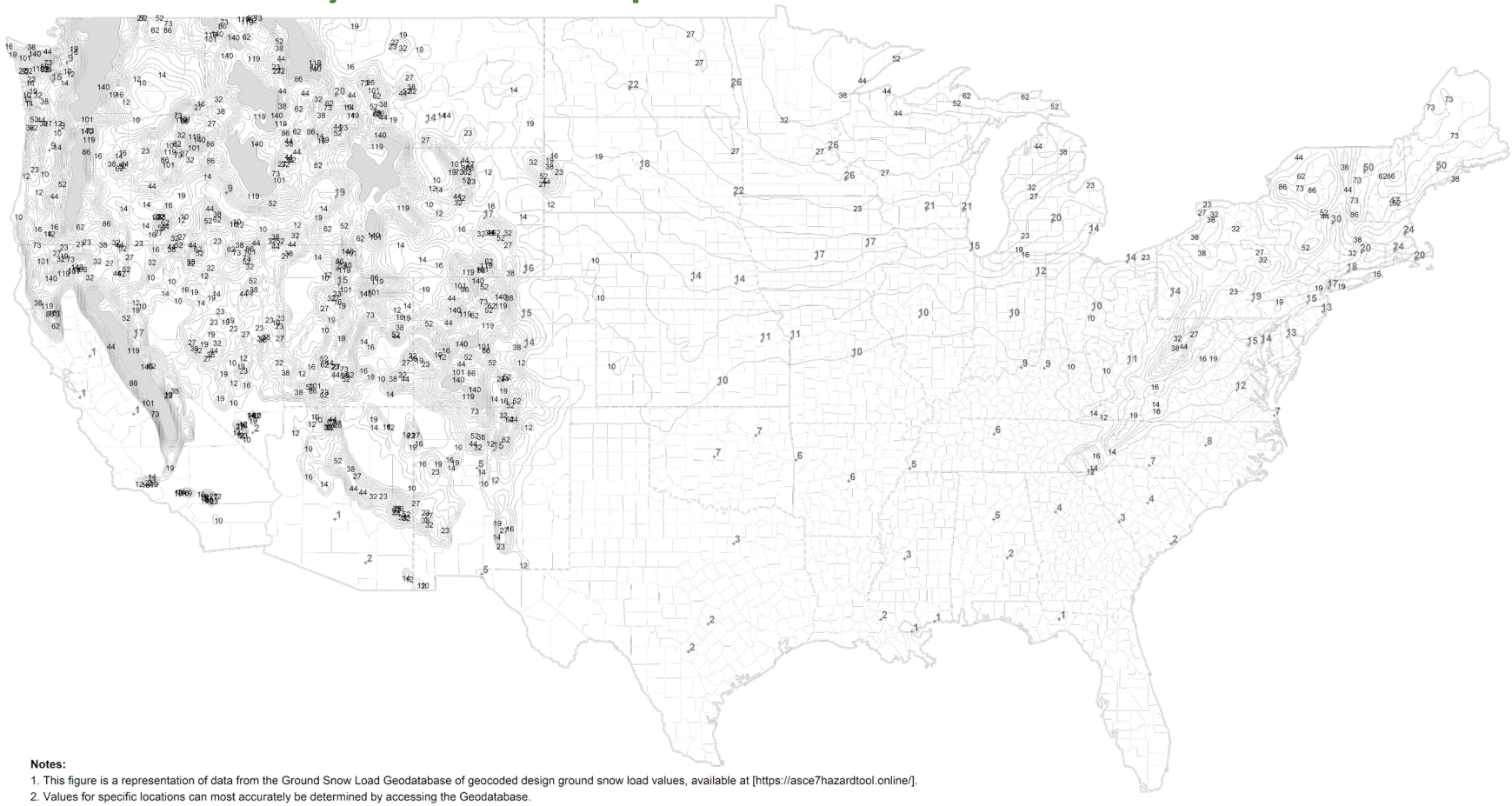
$$D + L \qquad \text{(CC.2-1a)}$$

$$D + S_{ser} \qquad \text{(CC.2-1b)}$$

where

D = Dead load;
L = Live load; and
S_{ser} = Design roof snow load determined using the provisions in Chapter 7 with p_g = 20-year MRI ground snow load from Figure CC.2-1. These 20-year MRI ground snow loads are available in the ASCE Design Ground Snow Load Geodatabase (https://asce7hazardtool.online/).

Serviceability Snow Map



Notes:

1. This figure is a representation of data from the Ground Snow Load Geodatabase of geocoded design ground snow load values, available at [https://asce7hazardtool.online/].
2. Values for specific locations can most accurately be determined by accessing the Geodatabase.
3. Lines shown on the figure are contours separated by a constant ratio of 1.18 with values of 10, 12, 14, 16, 19, 23, 27, 32, 38, 44, 52, 62, 73, 86, 101, 119 and 140 psf.
4. Values denoted with a "+" symbol indicate design ground snow loads at state capitals or other cities with large populations.
5. Areas shown in gray represent areas with ground snow loads exceeding 140 psf. Ground snow load values for these locations must be determined from the Geodatabase.

Q3 - Audience Poll

ASCE 7-22 serviceability snow loads are based on the design snow loads.

A. True

B. False

Example

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Example – Reno, Nevada

Joist Spacing = 8.0’

Uniform Loads (in psf) for RENO, NV						
	D	L_r	S	W_d	W_u	S_{ser}
2021	15	20	30*	15	30	15.0
2024	15	20	44	15	30	13.6

** IBC 2021 (ASCE 7-16) lists this location as ‘Case Study Required’. Washoe County Design Requirements define this location (Reno Center @ Elev. 4500’) as GSL = 30 psf.*

Example – Reno, Nevada, cont.

2021 ASD Load Combinations

	D	D + L_r	D + S	D + 0.6W_d	D + 0.75L_r + 0.45W_d	D + 0.75S + 0.45W_d	0.6D + 0.6W_u
D	1	1	1	1	1	1	0.6
Lr	0	1	0	0	0.75	0	0
S	0	0	1	0	0	0.75	0
Wd	0	0	0	0.6	0.45	0.45	0
Wu	0	0	0	0	0	0	0.6
Total	120	216	288	192	246	300	-72

2024 ASD Load Combinations

	D	D + L_r	D + 0.7S	D + 0.6W_d	D + 0.75L_r + 0.45W_d	D + 0.53S + 0.45W_d	0.6D + 0.6W_u
D	1	1	1	1	1	1	0.6
Lr	0	1	0	0	0.75	0	0
S	0	0	0.7	0	0	0.53	0
Wd	0	0	0	0.6	0.45	0.45	0
Wu	0	0	0	0	0	0	0.6
Total	120	216	292	192	246	305	-72

Example – Reno, Nevada

2021 LRFD Load Combinations

	1.4D	1.2D + 1.6L_r	1.2D + 1.6S	1.2D + W_d	1.2D + 1.6L_r + 0.5W_d	1.2D + 1.6S + 0.5W_d	1.2D + 0.5L_r + W_d	1.2D + 0.5S + W_d
D	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lr	0	1.6	0	0	1.6	0	0.5	0
S	0	0	1.6	0	0	1.6	0	0.5
Wd	0	0	0	1	0.5	0.5	1	1
Wu	0	0	0	0	0	0	0	0
Total	168	298	413	264	358	473	312	348

2024 LRFD Load Combinations

	1.4D	1.2D + 1.6L_r	1.2D + S	1.2D + W_d	1.2D + 1.6L_r + 0.5Wd	1.2D + S + 0.5W_d	1.2D + 0.5L_r + W_d	1.2D + 0.3S + W_d
D	1.4	1.2	1.2	1.2	1.2	1.2	1.2	1.2
Lr	0	1.6	0	0	1.6	0	0.5	0
S	0	0	1.0	0	0	1.0	0	0.3
Wd	0	0	0	1	0.5	0.5	1	1
Wu	0	0	0	0	0	0	0	0
Total	168	298	390	264	358	450	312	338

How to Specify Joists for Snow Loads

Option 1: Select…

- Standard joist designation, i.e. 24K7
- The specifier is responsible for finding the controlling loads and serviceability limits.
- The specifier picks a joist from the SJI table.
- The joist manufacturer does NOT run a load combination analysis.

Option 2: Designate…

- Joist using a load per foot designation, i.e. 24K300/250 (Total/Serviceability Load) -or-
- Joist with additional loads to the uniform loads, i.e. 24K300/250SP.
- The specifier is responsible for finding the controlling loads and serviceability limits.
- Additional loads to the uniform loads need to be clearly noted.
- The joist manufacturer does NOT run a load combination analysis.

How to Specify Joists for Snow Loads

Option 3: Select…

- KCS designation for a constant moment and shear envelope from the SJI load table, i.e. 24KCS4
- The specifier is responsible for determining the controlling loads and serviceability limits and selecting the appropriate joist from the SJI load table.
- The joist manufacturer does NOT run a load combination analysis.

Option 4: Specify…

- SPECIAL joist designation, i.e. 24KSP
  - for complex loading or
  - when there are multiple potential controlling load combinations using a loading table and load diagrams
- The joist manufacturer does run a load combination analysis.

Joist Specification (Canadian Engineers)

DATA (AS PER O.B.C.)

LOCATION	GUELPH, ONTARIO
FLOOR DL	N/A
ROOF DL	1.5kPa
SNOW LOAD	1.9 kPa
WIND LOAD	$q_{1/50}$=0.36 kPa
NET FACTORED WIND UPLIFT FORCE	0.5 kPa

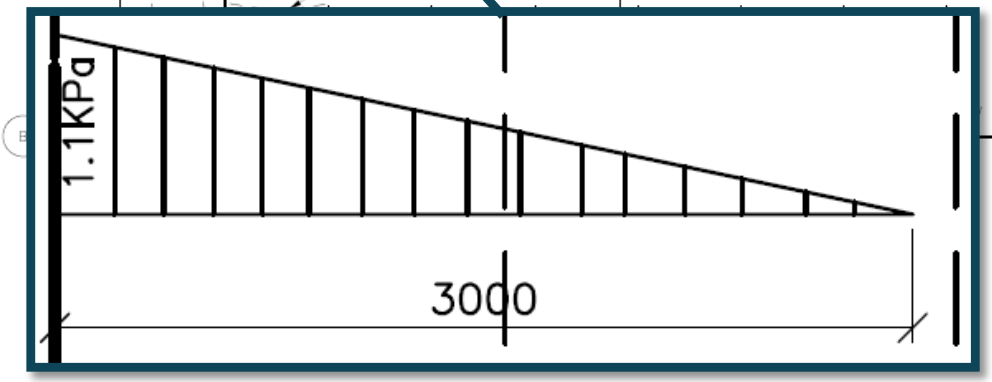
GENERAL NOTES:

DESIGN LOADS (SEE O.B.C. 2012)

a) ROOF LOADS:
LL = 1.92 kPa
DL = 1.0kPa
LL DOES NOT INCLUDE SNOW ACCUMULATION. REFER TO PLAN. DL INCLUDES ROOFING, MECHANICAL, ELECTRICAL, STEEL BEAMS & METAL DECK.

b) WIND LOAD:
$q_{1/50}$ = 0.36 kPa
(MULTIPLIED BY APPROPRIATE EXPOSURE, GUST AND PRESSURE COEFFICIENTS ACCORDING TO N.B.C. COMMENTARY).

c) SEISMIC LOAD:
Sa (0.2) = 0.170
Sa (0.1) = 0.100
Sa (0.5) = 0.059
Sa (2.0) = 0.019
SOIL CLASS TYPE "D" AS PER GEOTECHNICAL REPORT.



OWSJ 700mm DEEP MAX. SPACING	600mm MAX.
W/ BNT .76X38 STEEL DECK	

How to Specify Joists for Snow Loads

Moving Forward:

Joists with snow loads specified will –only– be designed with ASCE 7-22 load combinations.

If a load-per-foot designation is specified (e.g., '30K400/150'), the second load value, (i.e., '150' in this example), will be assumed to be used only for verifying serviceability requirements, notably vertical deflection against the specified limits.

Q4 - Audience Poll

In ASCE 7-22 LRFD, what is the load factor applied to the snow load case, S?

A. 1.6

B. 1.4

C. 1.0

D. 0.7

Other Ch 7 Changes:

- Modernized Thermal Factor (C_t)

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Modernized Thermal Factor, C_t

ASCE 7-16

Table 7.3-2 Thermal Factor, Ct

Thermal Condition[a]	*Ct*
All structures except as indicated below	1
Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (R-value) between the ventilated space and the heated space exceeds 25 °F×h×ft²/Btu (4.4 K×m²/W)	1.1
Unheated and open air structures	1.2
Freezer building	1.3
Continuously heated greenhouses[b] with a roof having a thermal resistance (R-value) less than 2.0°F × h × ft²/Btu (0.4 K × m²/W)	0.85

[a]These conditions shall be representative of the anticipated conditions during winters for the life of the structure.

[b]Greenhouses with a constantly maintained interior temperature of 50°F (10°C) or more at any point 3 ft (0.9 m) above the floor level during winters and having either a maintenance attendant on duty at all times or a temperature alarm system to provide warning in the event of a heating failure.

ASCE 7-22

Table 7.3-2. Thermal Factor, Ct .

Thermal condition[a]	C_t
All structures except as indicated as follows See Table 7.3-3	See Table 7.3-3
Unheated structures, open-air structures, structures kept just above freezing [40 to 50 °F (4 to 10 °C)], and other structures with cold, ventilated roofs meeting the minimum requirements of the applicable energy code	1.2
Freezer building	1.3
Continuously heated greenhouses[b] with a roof having a thermal resistance (R-value) less than 2.0 h·ft²·°F/Btu (0.4 m²·K/W) or a thermal transmittance (U-factor) greater than 0.5 Btu/h·ft²·°F (2.5 W/m²·K)	0.85

[a] These conditions shall be representative of the anticipated conditions during winters for the life of the structure.

[b] Greenhouses with a constantly maintained interior temperature of 50°F (10°C) or more, at any point 3 ft (0.9 m) above the floor level during winters and having either a maintenance attendant on duty at all times or a temperature alarm system to provide warning in the event of a heating failure.

Why? Vented vs. Unvented

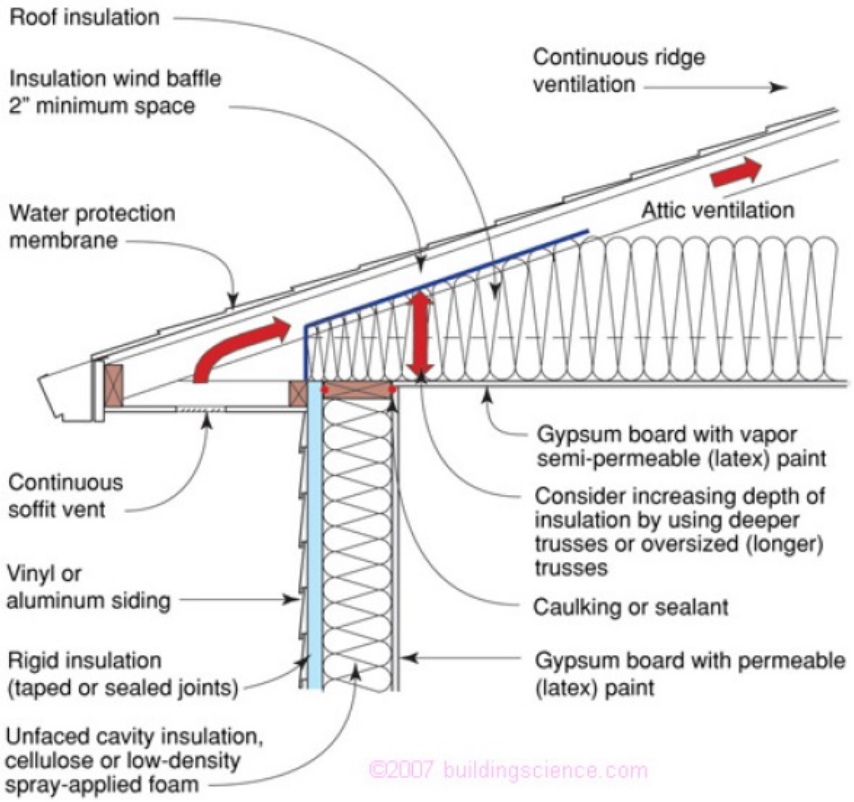


Figure 3: Vented Roof Assembly

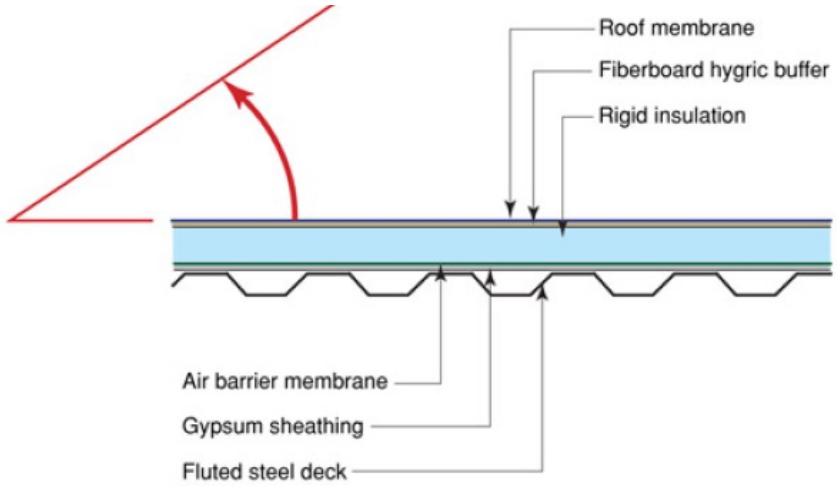
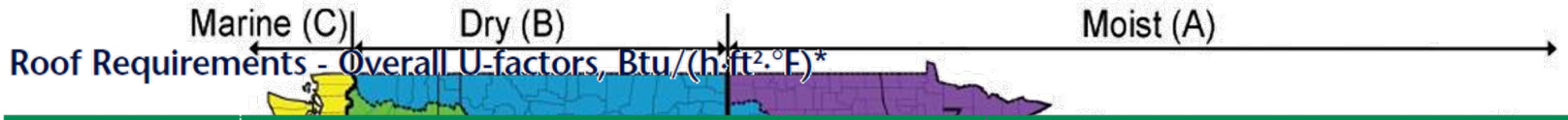


Figure 8: Typical Commercial Compact Unvented Roof Assembly

Why? Effects of Modern Energy Codes



Roof Requirements - Overall U-factors, Btu/(h·ft²·°F)*

Climate Zone	Conditioned Space		Semiheated Space	
	Assembly Max. U-factor	Insulation Min. R-Value	Assembly Max. U-factor	Insulation Min. R-Value
0	0.041	R-10 + R-19 FC	0.115	R-10
1	0.041	R-10 + R-19 FC	0.115	R-10
2	0.041	R-10 + R-19 FC	0.096	R-16
3	0.041	R-10 + R-19 FC	0.096	R-16
4	0.037	R-19 + R-11 LS or R-25 + R-8 LS	0.082	R-19
5	0.037	R-19 + R-11 LS or R-25 + R-8 LS	0.082	R-19
6	0.031	R-25 + R-11 LS	0.060	R-19 + R-19
7	0.029	R-30 + R-11 LS	0.037	R-19 + R-11 LS or R-25 + R-8 LS
8	0.026	R-25 + R-11 + R-11 LS	0.037	R-19 + R-11 LS or R-25 + R-8 LS

FC = Full Cavity
LS = Liner System

Thermal Factor, C_t – Unvented, Heated

Table 7.3-3. Thermal Factor, C_t, for Heated Structures with Unventilated Roofs.[a]

R_{roof} (h·ft²·°F/Btu [m²·K/W])	U_{roof} (Btu/h·ft²·°F [W/m²·K])	P_g (psf [kPa]) ≤10 [0.48]	20 [0.96]	30 [1.44]	40 [1.92]	50 [2.40]	60 [2.88]	≥70 [3.36]
≤20 [3.52]	≥0.050 [0.284]	1.20	1.11	1.05	1.01	1.00	1.00	1.00
30 [5.28]	0.033 [0.189]	1.20	1.17	1.14	1.13	1.12	1.11	1.10
40 [7.04]	0.025 [0.142]	1.20	1.19	1.17	1.16	1.16	1.15	1.15
50 [8.80][b]	0.020 [0.114][b]	1.20	1.20	1.19	1.19	1.19	1.18	1.18

[a] For values of P_g and R_{roof} that fall between those shown in the table, linear interpolation may be used to determine the value of C_t.
[b] For values of R_{roof} > 50 h·ft²·°F/Btu (8.80 m²·K/W) or U_{roof} < 0.020 Btu/h·ft²·°F (0.114 W/m²·K), C_t should be taken as equal to 1.2.

Other Ch 7 Changes:

- New Drift Height (h_d)

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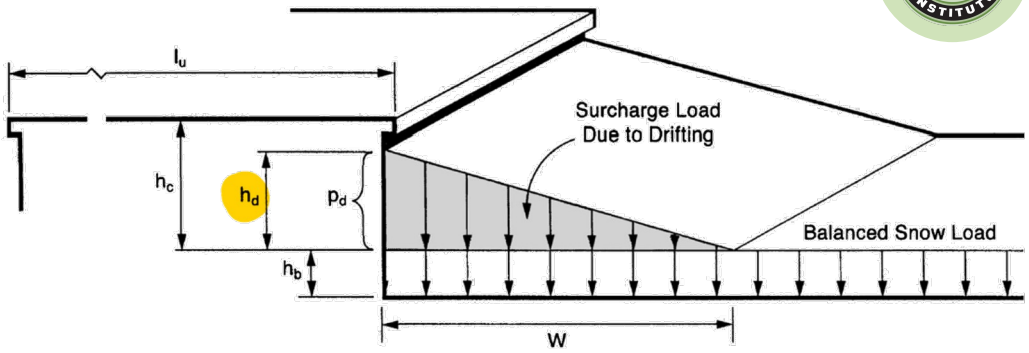
New Drift Provisions



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$$h_d = \left[\left(0.43\sqrt[3]{l_u}\sqrt[4]{p_g + 10}\right) - 1.5\right]\sqrt{I_S}$$

ASCE 7-22

$$h_d = 1.5\sqrt{\frac{p_g^{0.74} l_u^{0.7} W_2^{1.7}}{\gamma}}$$

W_2 = Winter Windiness Factor

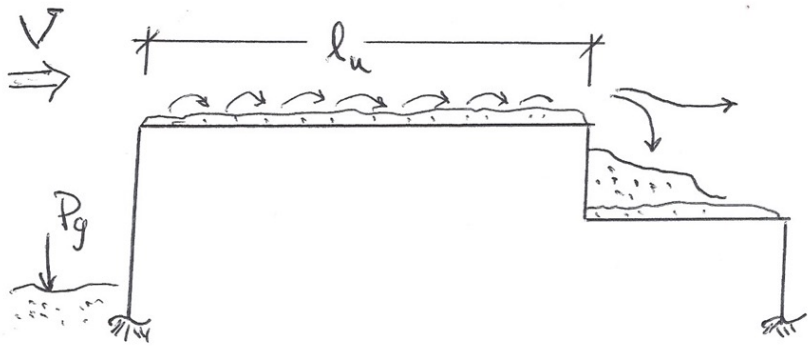
Winter Wind Parameter: Drift Simulation

Physics Based Simulation

- Transport Rate (lbs/hr per foot width)

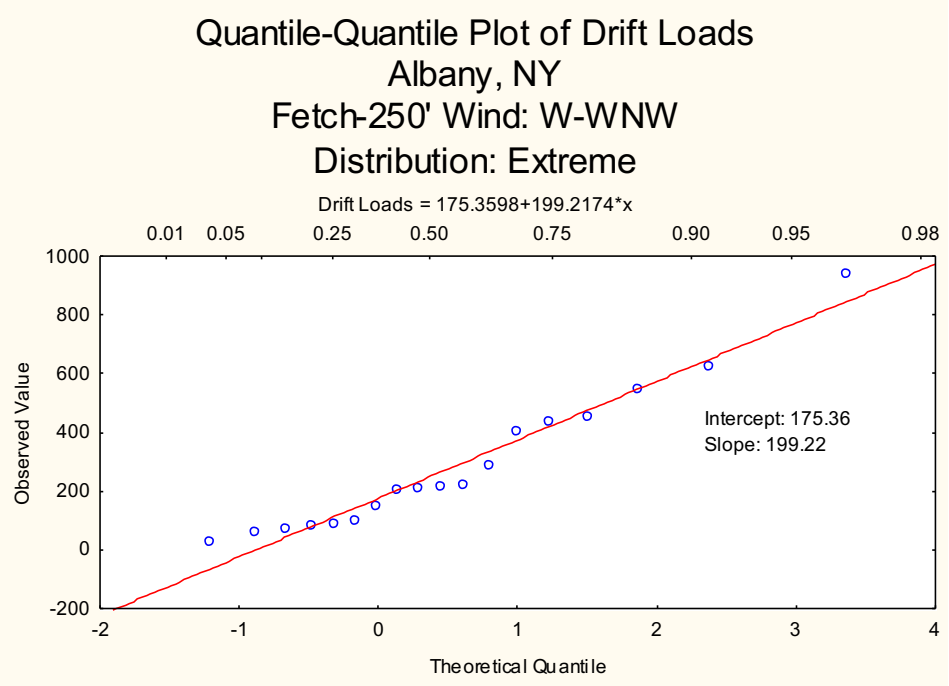
- $T_r(V)=.00048V^{3.8}$ (Unlimited l_u)
  - 492-984 ft. for fully developed transport

- $T_r(V)=.00048V^{3.8} *(L/750)^{0.5}$
  - Trapping efficiency: how much snow in drift
  - 50% assumed based on water flume testing



Winter Wind Parameter: Drift Simulation

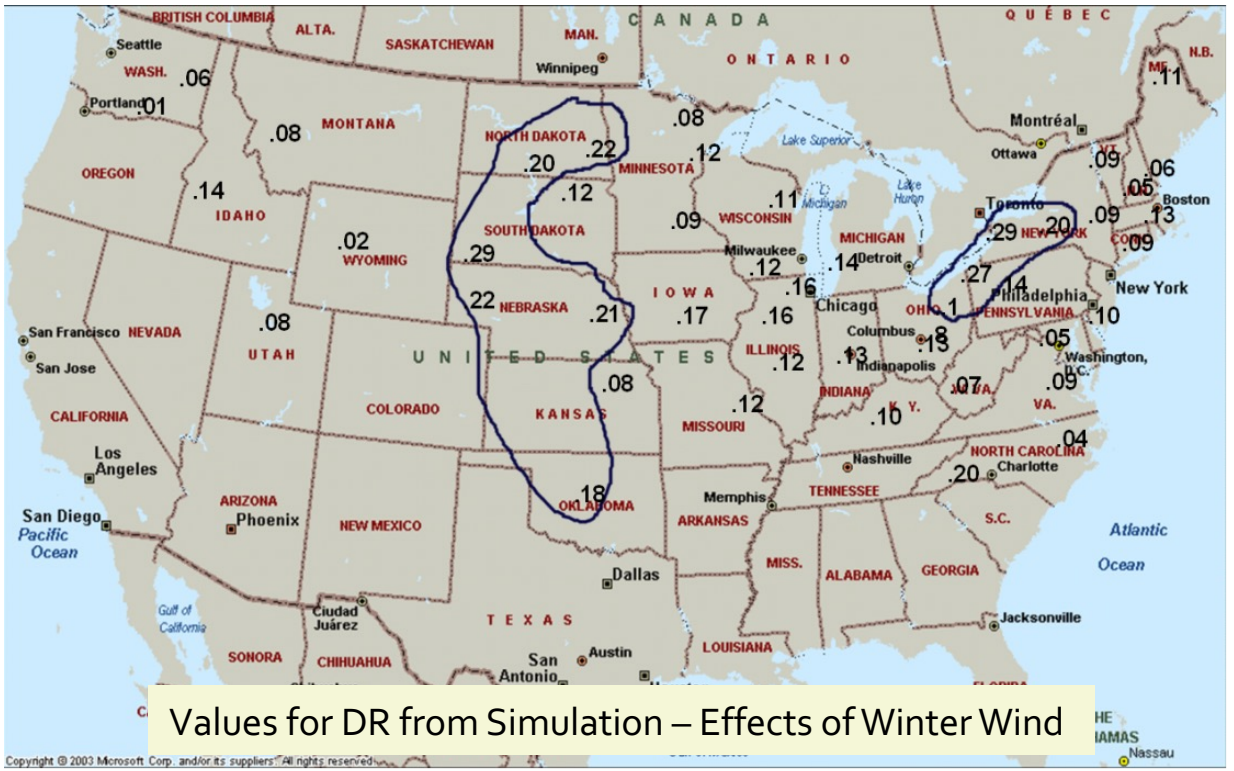
- Initial Study
  - 46 locations/stations ×
  - 19 annual max drift loads ×
  - 8 wind directions ×
  - 10 fetch distances =
  - 70,000 50-yr-MRI drift loads
- Drifts were normalized into a…
  - Drift Ratio (DR)
  - DR = drift/source
  - DR = $(0.5 \times h_d \times w \times y) / (I_u \times p_g)$



Winter Wind Parameter: Drift Simulation

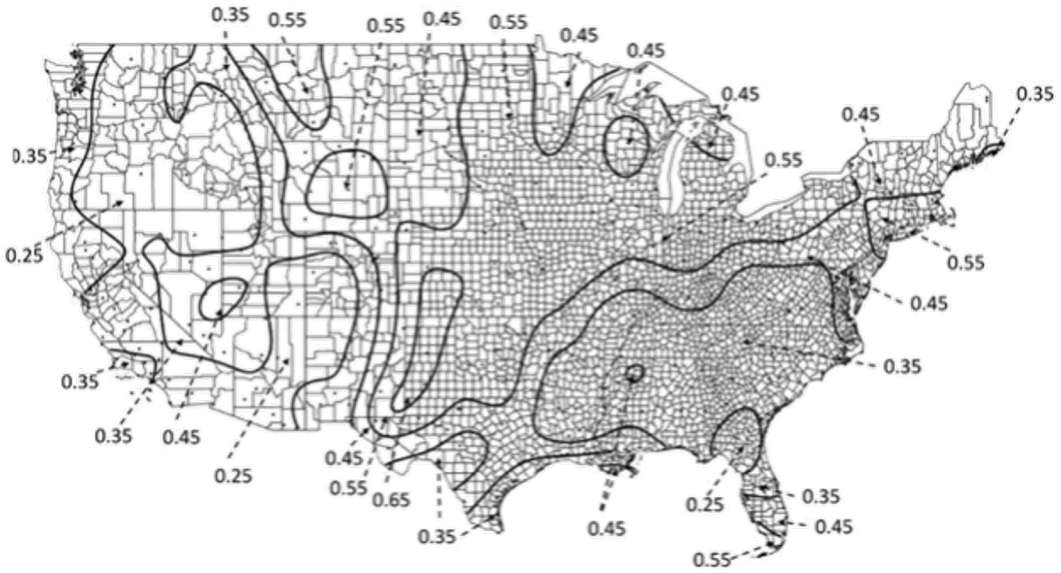
For l_u = 250 ft.

DR for…	ASCE 7-16	Simulation
Buffalo	0.13	0.29
Yakima	0.14	0.01
Boston	0.13	0.13

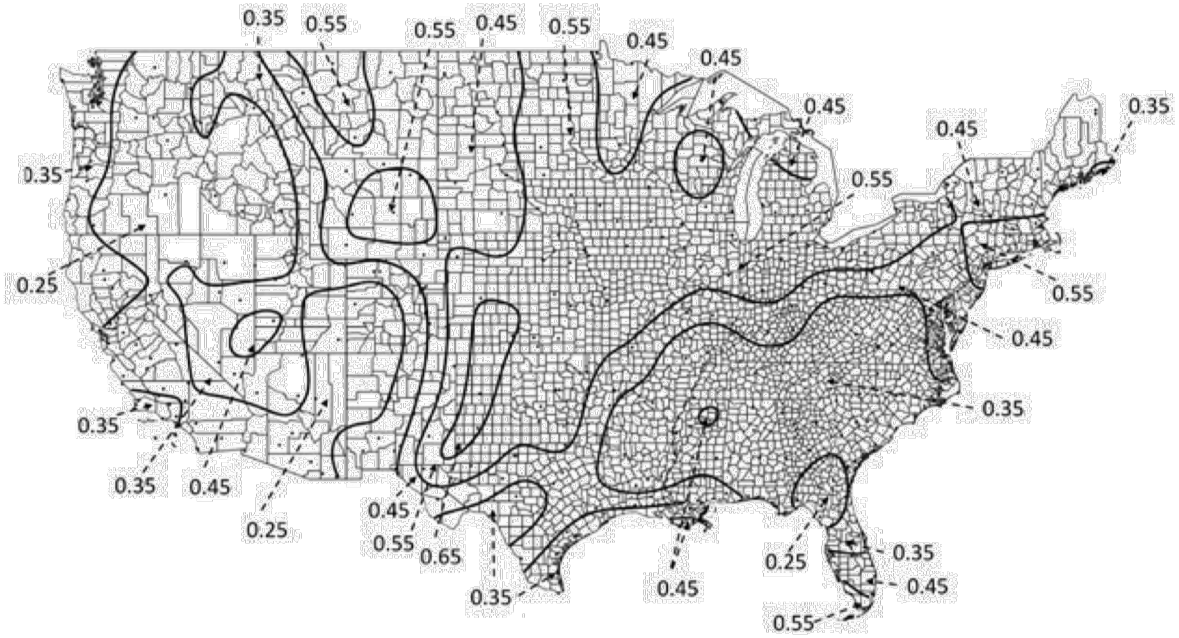


Winter Wind Parameter: Mapping of W_2

- Original 46 stations used in the were not enough to map W_2
- NOAA's Integrated Surface Global History (ISH) database:
  - Wind speed data from 272 stations
  - Each with at least 30 years of records
  - Data value used: 2-minute average wind speed each hour
  - Data cleaned for outliers, nonsensical
- Result: ASCE 7-22 Figure 7.6-1



Effects of W_2 on Drift Magnitude



- Low Winter Windiness:
  - W_2=0.25 → Average decrease of 40%
- Moderate Winter Windiness
  - W_2=0.45 → Average decrease of 10%
- High Winter Windiness
  - W_2=0.65 → Average increase of 25%

Other Ch 7 Changes:

- The Length of Windward Drifts

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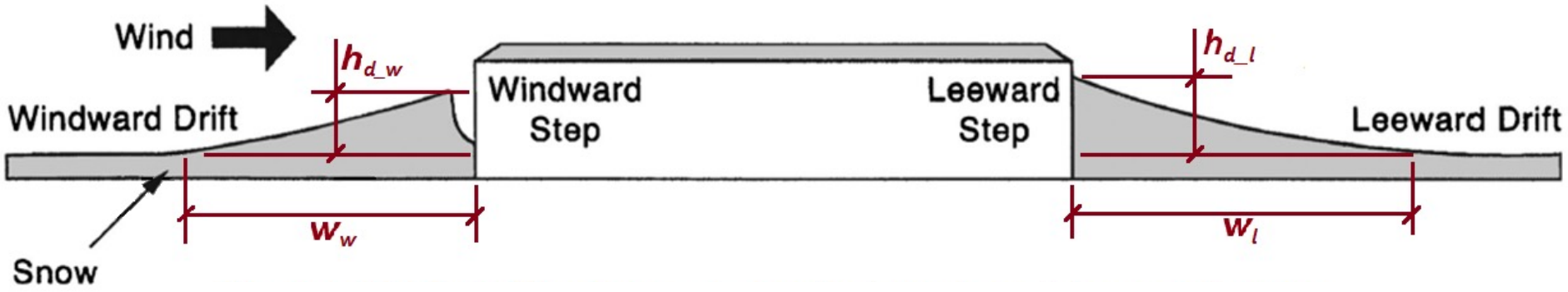
Drifts on Lower Roofs (Aerodynamic Shade)

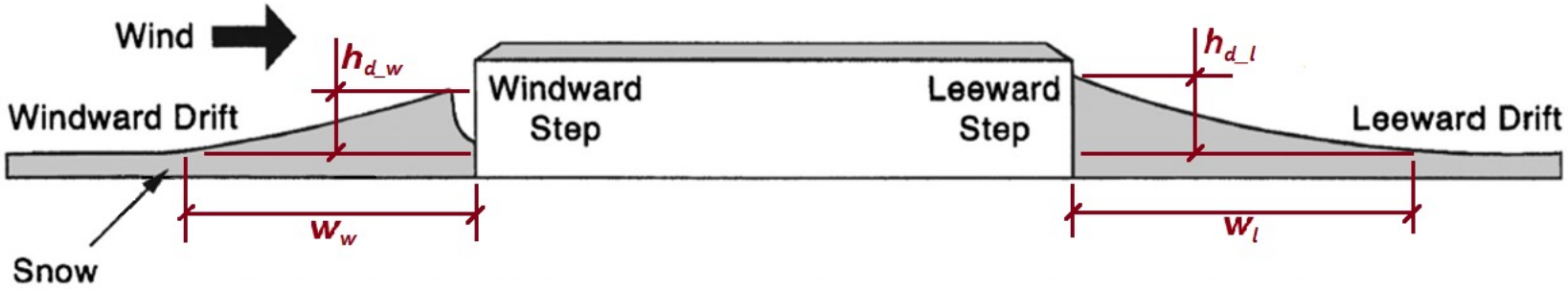
- Two types of drifts:



Drifts on Lower Roofs (Aerodynamic Shade)

$$h_{d_w} = 0.75(h_{d_l}) = 0.75\left[1.5\sqrt{\frac{p_g^{0.74} l_u^{0.7} W_2^{1.7}}{\gamma}}\right]$$

Drifts on Lower Roofs



ASCE 7-16

$$w_w = w_l = 4[max(h_{d_w}, h_{d_l})]$$

Only drift heights need to be compared to determine controlling drift.

ASCE 7-22

$$w_w = 8h_{d_w} \mid w_l = 4h_{d_l}$$

Total drift mass must be compared to determine controlling drift.

Summary

New ASCE 7-22 GSLs

- First significant update since 1995
- Reliability-targeted values

Drift Load Changes

- Regional variability of winter wind included in drift height
- Wind trapping efficiency included in windward drift

Thermal Factor Changes

- Consideration of vented vs. unvented
- Consideration of variability in roof assembly thermal conductivity

Revisions to Rain Loads in Chapter 8

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Chapter 8 – Rain Loads

- Modified Design Rain Load
- Updated Guidance for Bays with Low Slope
- Added Guidance for Determining Ponding Head
- Added Guidance for Drainage to Existing Roofs

CHAPTER 8
RAIN LOADS

8.1 DEFINITIONS AND SYMBOLS

8.1.1 Definitions

BAY: A portion of the roof bounded by adjacent column lines or structural walls.

CONTROLLED FLOW ROOF DRAIN: A roof drain designed to intentionally regulate the rate of drainage.

PONDING: The accumulation of water caused by the deflection of the roof structure, resulting in added load.

PONDING INSTABILITY: Member instability caused by progressive deflection because of ponding on roofs.

PRIMARY DRAINAGE SYSTEM: Roof drainage system through which water is normally conveyed off the roof.

SECONDARY DRAINAGE SYSTEM FOR STRUCTURAL LOADING (SDSL): Roof drainage system through which water is drained from the roof when the drainage systems listed in Section 8.2 (a) through (d) are blocked or not working.

SECONDARY MEMBER: For the purposes of Section 8.3, structural members not having direct attachment to the columns.

8.1.2 Symbols

d_h = Hydraulic head equal to the depth of water on the undeflected roof above the inlet of the secondary drainage system for structural loading (SDSL) required to achieve the design flow, in. (mm)

d_s = Static head equal to the depth of water on the undeflected roof up to the inlet of the secondary drainage system for structural loading (SDSL), in. (mm)

d_p = Ponding head equal to the depth of water due to deflections of the roof subjected to unfactored rain load and unfactored dead load in. (mm)

L_s = Span of secondary members, in. (mm)

S = Spacing of secondary members, in. (mm)

R = Rain load, lb/ft^2 (kN/m^2)

8.2 DESIGN RAIN LOADS

Each portion of a roof shall be designed to sustain the load of all rainwater that will accumulate on it, assuming all drainage systems that meet any of the following criteria are blocked:

(a) The primary drainage system,
(b) Secondary drainage systems with an inlet that is vertically separated from the inlet to the primary drainage system by less than 2 in. (51 mm),
(c) Secondary drainage systems that share drain lines with the primary drainage system, or
(d) Secondary drainage systems with controlled flow roof drains.

Rain loads shall be based on the summation of the static head, d_s, hydraulic head, d_h, and ponding head, d_p, using Equation (8.2-1). The hydraulic head shall be based on hydraulic test data or hydraulic calculations, assuming a flow rate corresponding to a rainfall intensity equal to or greater than the 15 min duration storm with return period (frequency) given in Table 8.2-1. The ponding head shall be based on structural analysis as the depth of water caused by deflections of the roof subjected to unfactored rain load and unfactored dead load.

$$R = 5.2(d_s + d_h + d_p) \quad (8.2\text{-}1)$$

$$R = 0.0098(d_s + d_h + d_p) \quad (8.2\text{-}1.\text{SI})$$

8.3 BAYS WITH LOW SLOPE

Free-draining bays and internal bays not subjected to accumulated rain load required by Section 8.2 shall have adequate strength and stiffness to preclude progressive deflection (i.e., instability) and resist potential ponding rain loads where either of the following conditions are met:

1. The roof slope is less than 1/4 in. per foot (1.19 degrees), or
2. The bay is adjacent to a free-draining edge with secondary members parallel to the free-draining edge and the roof slope is less than β where $\beta = (L_s/S + \pi)/20$ (in. per foot).

8.4 DRAINAGE TO EXISTING ROOFS

Drainage systems for new construction shall not discharge water onto existing roofs unless the existing roof is evaluated and either is able to support the loads determined using this chapter or is upgraded to support the loads determined using this chapter.

8.5 CONSENSUS STANDARDS AND OTHER REFERENCED DOCUMENTS

No consensus standards and other documents that shall be considered part of this standard are referenced in this chapter.

Table 8.2-1. Design Storm Return Period by Risk Category.

Risk Category	Design Storm Return Period
I and II	100 years
III	200 years
IV	500 years

Summary of Updates

- Modified Design Rain Load Calculation
  - Ponding
  - Return Period based on Risk Category
- Changed Definition
  - Secondary System updated to Secondary Drainage System for Structural Loading (SDSL)
- Updated Guidance for Bays with Low Slope
- Added Guidance for Drainage to Existing Roofs

Design Rain Loads in ASCE 7-22

Rain loads shall be based on the summation of the static head, d_s, hydraulic head, d_h, and **ponding head, d_p,** using Equation (8.2-1).

$$R = 5.2(d_s + d_h + \mathbf{d_p}) \quad (8.2\text{-}1)$$

$$R = 0.0098(d_s + d_h + \mathbf{d_p}) \quad (8.2\text{-}1.SI)$$

Symbols

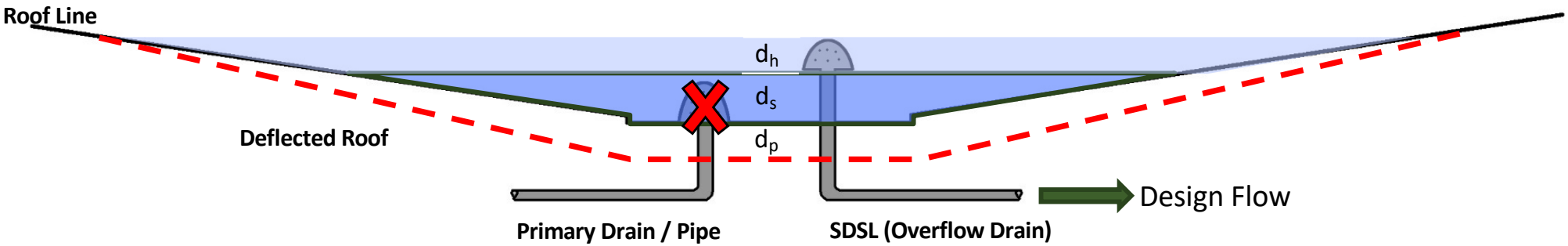
R = Rain load, lb/ft^2 (kN/m^2)

d_s = Static head equal to the depth of water on the undeflected roof up to the inlet of the secondary drainage system for structural loading (SDSL), in. (mm)

d_h = Hydraulic head equal to the depth of water on the undeflected roof above the inlet of the **secondary drainage system for structural loading (SDSL)** required to achieve the design flow, in. (mm)

d_p = Ponding head equal to the depth of water due to deflections of the roof subjected to unfactored rain load and unfactored dead load in. (mm)

Rain Loads – Step by Step



- Static Head (d_s): Difference in elevation between primary and secondary
- Hydraulic Head (d_h): Depth of water required to achieve design flow through the SDSL
- Ponding Head (d_p): Ponding head (dependent on flexibility of structure)

Definition Modification

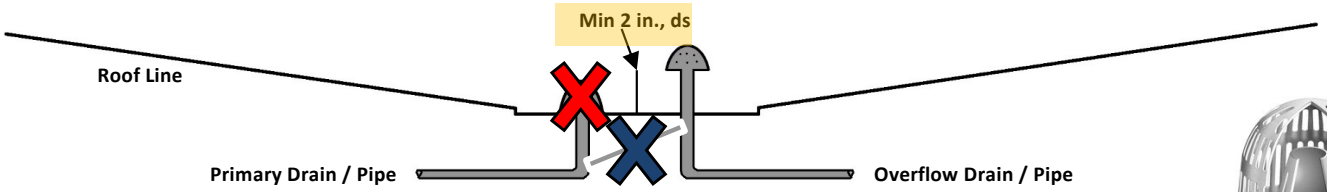
- **SECONDARY DRAINAGE SYSTEM FOR STRUCTURAL LOADING (SDSL)**: Roof drainage system by which water drains off the roof when the drainage systems that are assumed to be blocked (See Section 8.2) are blocked or not working.

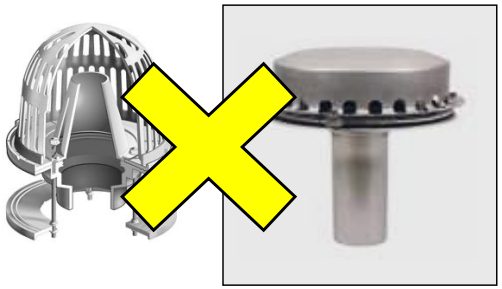
8.2 DESIGN RAIN LOADS

Each portion of a roof shall be designed to sustain the load of all rainwater that will accumulate on it, assuming all drainage systems that meet any of the following criteria are blocked:

(a) The primary drainage system,
(b) Secondary drainage systems with an inlet that is vertically separated from the inlet to the primary drainage system by less than 2 in. (51 mm),
(c) Secondary drainage systems that share drain lines with the primary drainage system, or
(d) Secondary drainage systems with controlled flow roof drains.

Definition Modification





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(c) Secondary drainage systems that share drain lines with the primary drainage system, or

(d) Secondary drainage systems with controlled flow roof drains.

Why a Minimum Elevation Difference?

- Notification – Frequent activation will lessen urgency of alert
- Clogging – Debris can accumulate and clog secondary





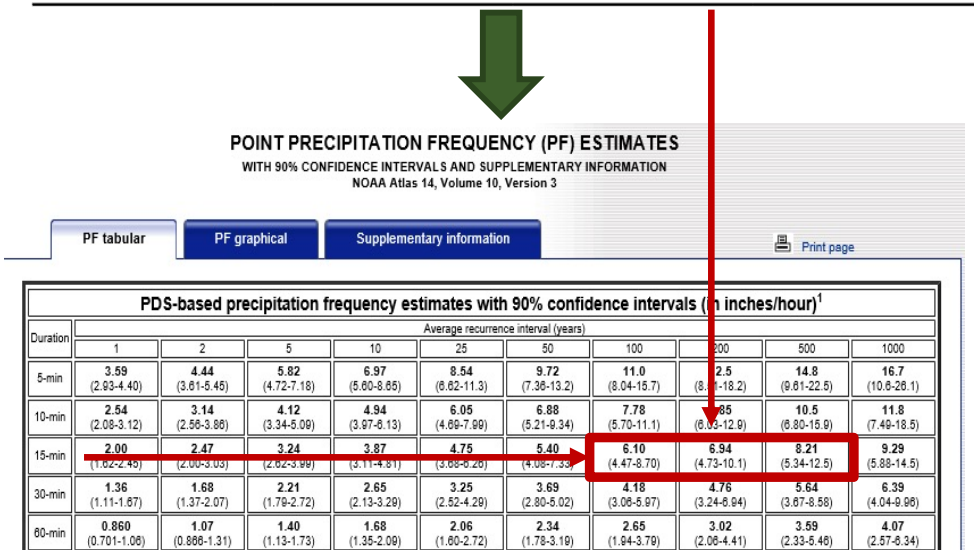


Determine d_h

- Design Flow (Q = C i A)
  - C = 1 for impermeable roof
  - **i = Rainfall intensity (15-Minute Duration)**
    - **Building Risk Category (Chapter 1, Table 1.5-1)**
    - **Return Period**
  - A = Area of Roof

Table 8.2-1. Design Storm Return Period by Risk Category.

Risk Category	Design Storm Return Period
I and II	100 years
III	200 years
IV	500 years



POINT PRECIPITATION FREQUENCY (PF) ESTIMATES

WITH 90% CONFIDENCE INTERVALS AND SUPPLEMENTARY INFORMATION

NOAA Atlas 14, Volume 10, Version 3

PF tabular | PF graphical | Supplementary information | Print page

PDS-based precipitation frequency estimates with 90% confidence intervals (in inches/hour)[1]

Duration	Average recurrence interval (years)									
	1	2	5	10	25	50	100	200	500	1000
5-min	3.59 (2.93-4.40)	4.44 (3.61-5.45)	5.82 (4.72-7.18)	6.97 (5.60-8.65)	8.54 (6.62-11.3)	9.72 (7.36-13.2)	11.0 (8.04-15.7)	12.5 (8.[illegible]-18.2)	14.8 (9.61-22.5)	16.7 (10.6-26.1)
10-min	2.54 (2.08-3.12)	3.14 (2.56-3.86)	4.12 (3.34-5.09)	4.94 (3.97-6.13)	6.05 (4.69-7.99)	6.88 (5.21-9.34)	7.78 (5.70-11.1)	8.85 (6.03-12.9)	10.5 (6.80-15.9)	11.8 (7.49-18.5)
15-min	2.00 (1.62-2.45)	2.47 (2.00-3.03)	3.24 (2.62-3.99)	3.87 (3.11-4.81)	4.75 (3.68-6.26)	5.40 (4.08-7.33)	6.10 (4.47-8.70)	6.94 (4.73-10.1)	8.21 (5.34-12.5)	9.29 (5.88-14.5)
30-min	1.36 (1.11-1.67)	1.68 (1.37-2.07)	2.21 (1.79-2.72)	2.65 (2.13-3.29)	3.25 (2.52-4.29)	3.69 (2.80-5.02)	4.18 (3.06-5.97)	4.76 (3.24-6.94)	5.64 (3.67-8.58)	6.39 (4.04-9.96)
60-min	0.860 (0.701-1.06)	1.07 (0.866-1.31)	1.40 (1.13-1.73)	1.68 (1.35-2.09)	2.06 (1.60-2.72)	2.34 (1.78-3.19)	2.65 (1.94-3.79)	3.02 (2.06-4.41)	3.59 (2.33-5.46)	4.07 (2.57-6.34)

https://hdsc.nws.noaa.gov/hdsc/pfds/

Determine d_h

- Determine SDSL (Scupper, drain, otherwise)
- If Drain use Table C8.2-1
- If Scupper use Table C8.2-3

Table C8.2-3. Flow Rate (Q) in Gallons Per Minute for Scuppers at Various Hydraulic Heads (d_h) in Inches.

	Hydraulic Head, d_h (in.)									
Drainage System	1	2	2.5	3	3.5	4	4.5	5	7	8
6 in. wide channel scupper[a]	18	50	[b]	90	[b]	140	[b]	194	321	393
24 in. wide channel scupper	72	200	[b]	360	[b]	560	[b]	776	1,284	1,572
6 in. wide, 4 in. high, closed scupper[a]	18	50	[b]	90	[b]	140	[b]	177	231	253
24 in. wide, 4-in. high, closed scupper	72	200	[b]	360	[b]	560	[b]	708	924	1,012
6 in. wide, 6 in. high, closed scupper	18	50	[b]	90	[b]	140	[b]	194	303	343
24 in. wide, 6 in. high, closed scupper	72	200	[b]	360	[b]	560	[b]	776	1,212	1,372

[a] Channel scuppers are open-topped (i.e., three-sided). Closed scuppers are four-sided.
[b] Interpolation is appropriate, including between widths of each scupper.
Source: Adapted from FM Global (2016).

Table C8.2-1. Flow Rate (Q) in Gallons per Minute for Secondary (Overflow) Roof Drains at Various Hydraulic Heads (d_h) above the Dam or Standpipe, in Inches.

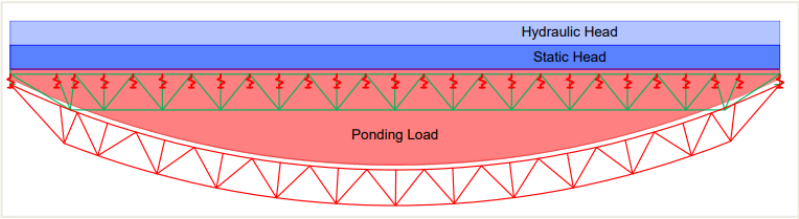
	Hydraulic Head (in.) above Dam or Standpipe						
	Overflow Dam 8 in. Diameter			Overflow Dam 12.75 in. Diameter		Overflow Dam 17 in. Diameter	Overflow Standpipe 6 in. Diameter
	Drain Outlet Size (in.)						
	3	4	6	6	8	10	4
	Drain Bowl Depth (in.)						
Flow Rate (gal./min)	2	2	2	2	3.25	4.25	2
50	0.5	0.5	0.5	0.5	0.5	—	1.0
75	1.0	—	—	—	—	—	—
100	1.5	1.0	1.0	1.0	0.5	1.0	1.5
125	2.0	—	—	—	—	—	—
150	2.0	1.5	1.5	1.0	—	—	2.5
175	3.0	—	—	—	—	—	—
200	—	2.0	2.0	1.5	1.5	1.5	2.5
225	—	—	—	—	—	—	—
250	—	2.5	2.5	1.5	—	—	2.5
300	—	3.0	3.0	2.0	2.0	1.5	3.0
350	—	3.5	3.5	2.5	—	—	3.5
400	—	5.5	3.5	3.0	2.5	2.0	—
450	—	—	4.0	3.0	—	—	—
500	—	—	5.0	3.5	3.0	2.5	—
550	—	—	5.5	4.0	—	—	—
600	—	—	6.0	5.5	3.5	2.5	—
650	—	—	—	—	—	—	—
700	—	—	—	—	3.5	3.0	—
800	—	—	—	—	4.5	3.0	—
900	—	—	—	—	5.0	3.5	—
1,000	—	—	—	—	5.5	3.5	—
1,100	—	—	—	—	—	4.0	—
1,200	—	—	—	—	—	4.5	—

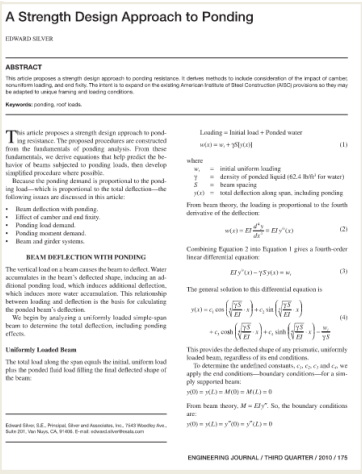
Source: Adapted from FM Global (2016).

Example: Assume Q = 200 gpm
24 in. Wide Scupper: dh = 2.0 in.
6 in. diameter Drain : dh = 2.0 in.

Determine d_p

- Iterative analysis
- Negative springs
- Closed form Solutions (Silver 2010)
- Amplified First-Order Analysis (Denavit 2019)





A Strength Design Approach to Ponding

EDWARD SILVER

ABSTRACT

This article proposes a strength design approach to ponding resistance. It derives methods to include consideration of the impact of camber, nonuniform loading, and end fixity. The intent is to expand on the existing American Institute of Steel Construction (AISC) provisions so they may be adapted to unique framing and loading conditions.

Keywords: ponding, roof loads.

This article proposes a strength design approach to ponding resistance. The proposed procedures are constructed from the fundamentals of ponding analysis. From these fundamentals, we derive equations that help predict the behavior of beams subjected to ponding loads, then develop simplified procedure where possible.

Because the ponding demand is proportional to the ponding load—which is proportional to the total deflection—the following issues are discussed in this article:

- Beam deflection with ponding.
- Effect of camber and end fixity.
- Ponding load demand.
- Ponding moment demand.
- Beam and girder systems.

BEAM DEFLECTION WITH PONDING

The vertical load on a beam causes the beam to deflect. Water accumulates in the beam's deflected shape, inducing an additional ponding load, which induces additional deflection, which induces more water accumulation. This relationship between loading and deflection is the basis for calculating the ponded beam's deflection.

We begin by analyzing a uniformly loaded simple-span beam to determine the total deflection, including ponding effects.

Uniformly Loaded Beam

The total load along the span equals the initial, uniform load plus the ponded fluid load filling the final deflected shape of the beam:

Loading = Initial load + Ponded water

$$w(x) = w_i + \gamma S[y(x)] \quad (1)$$

where

w_i = initial uniform loading
γ = density of ponded liquid (62.4 lb/ft³ for water)
S = beam spacing
$y(x)$ = total deflection along span, including ponding

From beam theory, the loading is proportional to the fourth derivative of the deflection:

$$w(x) = EI\frac{d^4y}{dx^4} = EIy^{iv}(x) \quad (2)$$

Combining Equation 2 into Equation 1 gives a fourth-order linear differential equation:

$$EIy^{iv}(x) - \gamma S y(x) = w_i \quad (3)$$

The general solution to this differential equation is

$$y(x) = c_1\cos\left(\sqrt[4]{\frac{\gamma S}{EI}}x\right) + c_2\sin\left(\sqrt[4]{\frac{\gamma S}{EI}}x\right) + c_3\cosh\left(\sqrt[4]{\frac{\gamma S}{EI}}x\right) + c_4\sinh\left(\sqrt[4]{\frac{\gamma S}{EI}}x\right) - \frac{w_i}{\gamma S} \quad (4)$$

This provides the deflected shape of any prismatic, uniformly loaded beam, regardless of its end conditions.

To determine the undefined constants, c_1, c_2, c_3, and c_4, we apply the end conditions—boundary conditions—for a simply supported beam:

$y(0) = y(L) = M(0) = M(L) = 0$

From beam theory, $M = EIy''$. So, the boundary conditions are:

$y(0) = y(L) = y''(0) = y''(L) = 0$

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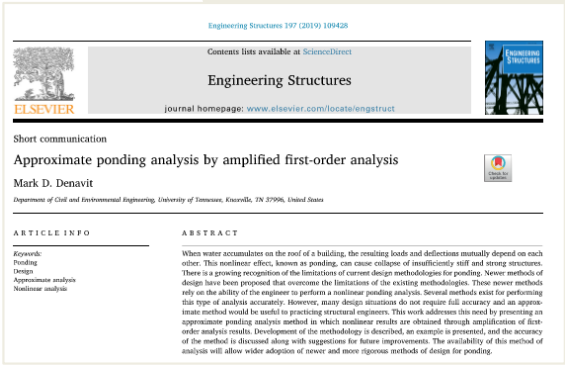

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Short communication

Approximate ponding analysis by amplified first-order analysis

Mark D. Denavit

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ARTICLE INFO

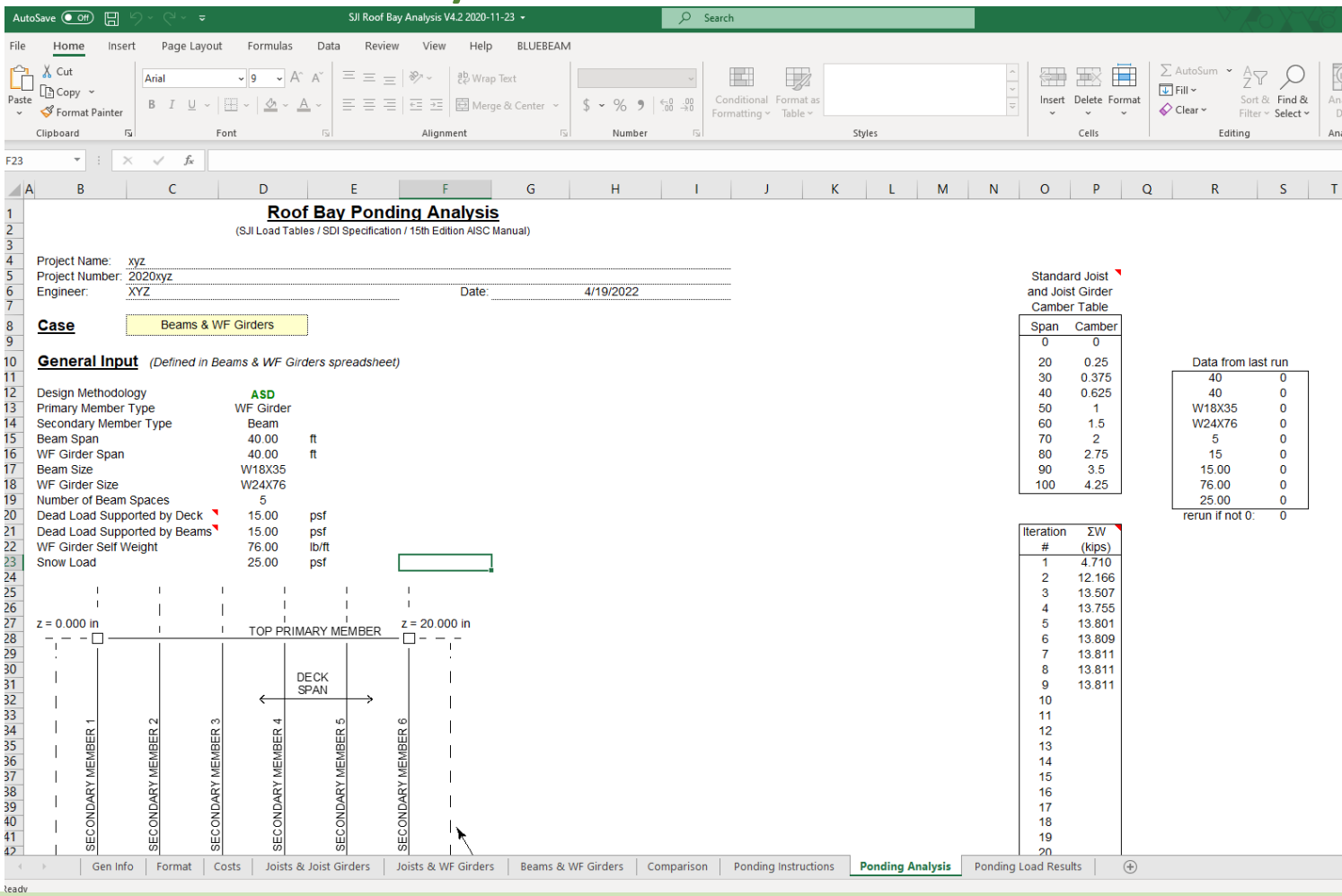
Keywords:
Ponding
Design
Approximate analysis
Nonlinear analysis

ABSTRACT

When water accumulates on the roof of a building, the resulting loads and deflections mutually depend on each other. This nonlinear effect, known as ponding, can cause collapse of insufficiently stiff and strong structures. There is a growing recognition of the limitations of current design methodologies for ponding. Newer methods of design have been proposed that overcome the limitations of the existing methodologies. These newer methods rely on the ability of the engineer to perform a nonlinear ponding analysis. Several methods exist for performing this type of analysis accurately. However, many design situations do not require full accuracy and an approximate method would be useful to practicing structural engineers. This work addresses this need by presenting an approximate ponding analysis method in which nonlinear results are obtained through amplification of first-order analysis results. Development of the methodology is described, an example is presented, and the accuracy of the method is discussed along with suggestions for future improvements. The availability of this method of analysis will allow wider adoption of newer and more rigorous methods of design for ponding.

Determine d_p – Iterative Analysis

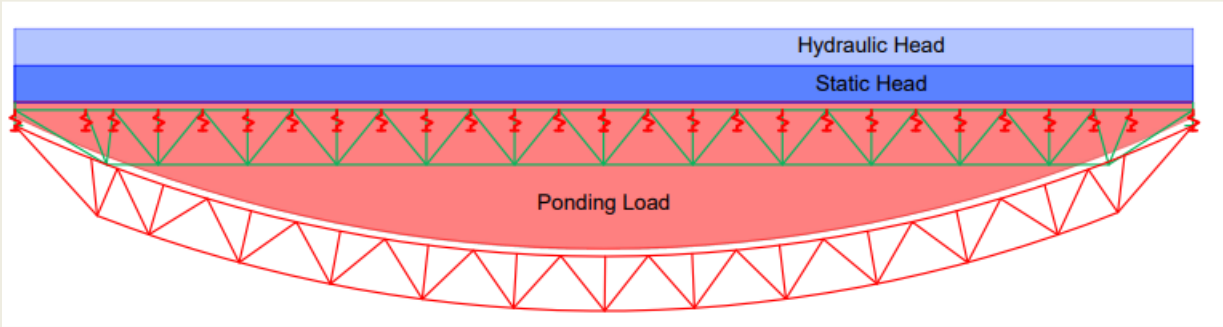
- Iterative analysis
  - SJI Roof Bay Analysis

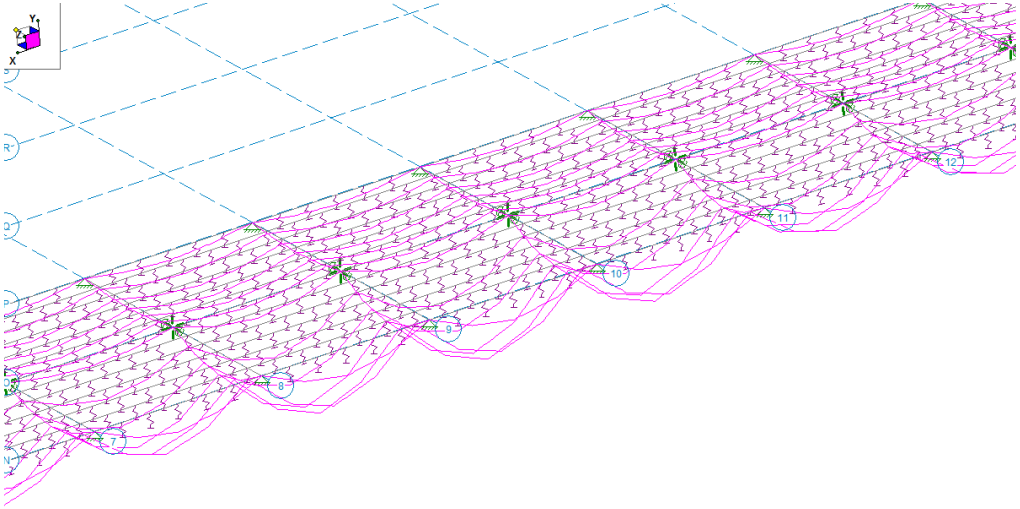


https://steeljoist.org/product/roof-bay-analysis-tool-with-ponding-analysis/

Determine d_p – Negative Springs

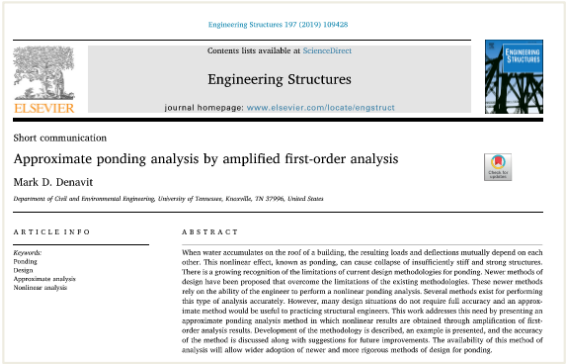
- Negative springs





Determine d_p - Amplified First Order

- Amplified First-Order Analysis (Denavit 2019)
  - Rectangular Framed Bays



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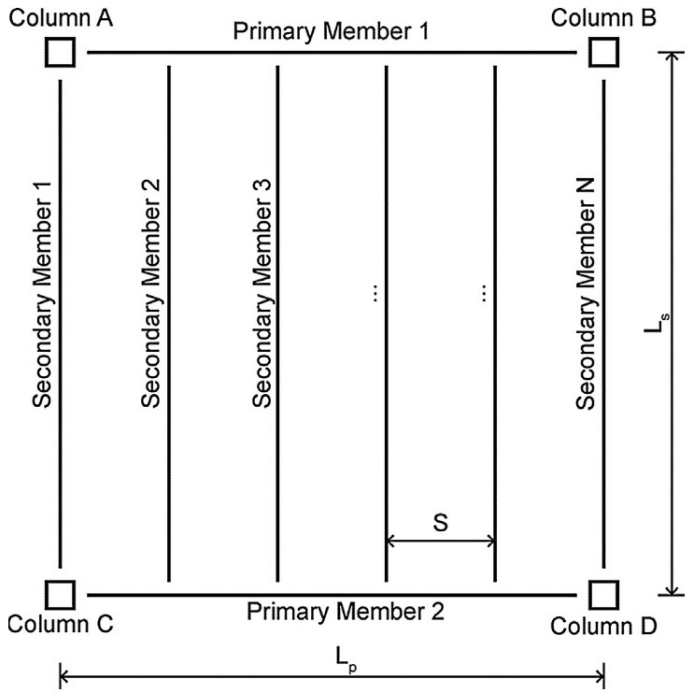
$$B_p = \frac{1}{1 - 1.15C_p - C_s} \qquad \text{(C8.2-4)}$$

$$C_p = \frac{\gamma L_s L_p^4}{\pi^4 E I_p} \qquad \text{(C8.2-5)}$$

$$C_s = \frac{\gamma S L_s^4}{\pi^4 E I_s} \qquad \text{(C8.2-6)}$$

Determine d_p – Amplified First Order Example

- Flat roof
- Dead Load (DL) = 15 psf
- ds + dh = 5 in.
- Primary Member = W24x 76 Girders
  - L_P = 40 ft
  - I_P = 2,100 in^4
- Secondary Member = W18x35
  - L_S = 40 ft
  - S = 8 ft
  - I_S = 510 in^4



Determine d_p – Amplified First Order Example

$$C_p = \frac{\gamma L_s L_p^4}{\pi^4 E I_p}$$

$$= \frac{(62.4\,\frac{\text{lb}}{\text{ft}^3} \times \frac{1\ k}{1{,}000\ \text{lb.}} \times (\frac{1\ \text{ft}}{12\ \text{in.}})^3)(40\ \text{ft} \times \frac{12\ \text{in.}}{1\ \text{ft.}})(40\ \text{ft} \times \frac{12\ \text{in.}}{1\ \text{ft.}})^4}{\pi^4 (29{,}000\ \text{ksi})(2{,}100\ \text{in.}^4)}$$

$$= 0.155$$

$$C_s = \frac{\gamma S L_s^4}{\pi^4 E I_s}$$

$$= \frac{(62.4\,\frac{\text{lb}}{\text{ft}^3} \times \frac{1\ k}{1{,}000\ \text{lb.}} \times (\frac{1\ \text{ft}}{12\ \text{in.}})^3)(8\ \text{ft} \times \frac{12\ \text{in.}}{1\ \text{ft.}})(40\ \text{ft} \times \frac{12\ \text{in.}}{1\ \text{ft.}})^4}{\pi^4 (29{,}000\ \text{ksi})(510\ \text{in.}^4)}$$

$$= 0.128$$

$$B_p = \frac{1}{1 - 1.15C_p - C_s} = \frac{1}{1 - 1.15(0.155) - (0.128)} = 1.44$$

Determine d_p – Amplified First Order Example

- Combined Load (ignoring ponding) = 15 psf + 5.2 psf/in.(5 in.) = 41 psf
- Apply B_p = 1.44 to the Combined Load
- Total Combined (unfactored) = 1.44 x 41 psf = 59 psf
- Therefore, Rain Load (R) = Total Combined – DL = 59 psf – 15 psf = 44 psf

- Does not directly determine d_p

$$(d_s + dh + dp)\ x\ 5.2\frac{psf}{in} = 44\ psf$$

$$d_p = \frac{44\ psf}{5.2\frac{psf}{in}} - (d_s + dh) = 3.5\ in$$

Bays With Low Slope

8.3 BAYS WITH LOW SLOPE

Free-draining bays and internal bays not subjected to accumulated rain load required by Section 8.2 shall have adequate strength and stiffness to preclude progressive deflection (i.e., instability) and resist potential ponding rain loads where either of the following conditions are met:

1. The roof slope is less than 1/4 in. per foot (1.19 degrees), or
2. The bay is adjacent to a free-draining edge with secondary members parallel to the free-draining edge and the roof slope is less than β where $\beta = (L_s/S + \pi)/20$ (in. per foot).

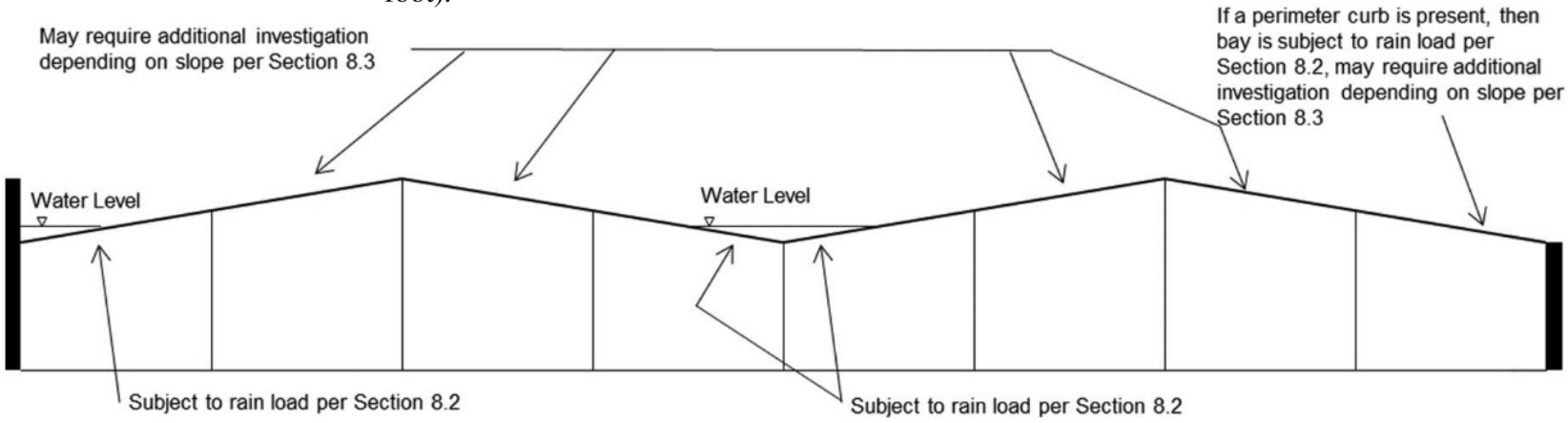


Figure C8.3-1. Identification of bays requiring additional investigation.

Existing Roofs

8.4 DRAINAGE TO EXISTING ROOFS

Drainage systems for new construction shall not discharge water onto existing roofs unless the existing roof is evaluated and either is able to support the loads determined using this chapter or is upgraded to support the loads determined using this chapter.

So, What's New??

- Ponding is now included in the Design Rain Load
- There are different methods to determine d_p
- Return period for design rainfall is dependent on Risk Category
- Structural Engineer required to determine load, assuming hydraulic head is above the SDSL
- Bays with low-slope, even when free draining, may be susceptible to ponding
- Be mindful of new rising walls adjacent to existing roofs

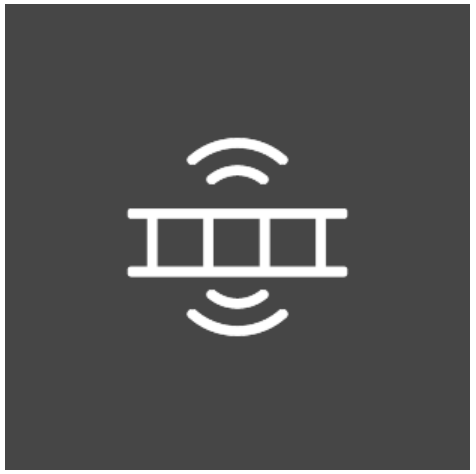
Q5 - Audience Poll

Which component is newly included in the ASCE 7-22 design rain load equation?

A. Hydraulic head
B. Static head
C. Ponding head
D. Roof slope factor

SJI Design Tools

- Free downloads
  - Floor Bay Comparison Tool w/ Vibration
  - Steel Joist Uplift Analysis Tool
  - Joist Girder Analysis Tool
  - Joist and Joist Girder Reinforcement Tool
  - Historical Load Tables
- Floor Vibration Analysis
  - Roof Bay Analysis Tool w/ Ponding Analysis
  - Floor Bay Analysis Tool w/ Vibration Analysis
  - Joist Girder Moment Connection Design Tools
  - Virtual Joists
  - Virtual Joist Girders



SJI Publications

Technical Digests

- #1 Utilizing and Specifying Steel Joists
- #2 Bridging and Bracing of Steel Joists and Joist Girders
- #4 Guidance for Building Design Using Steel Joists
- #5 Vibration of Steel Joist – Concrete Floors
- #6 Design of Steel Joist Roofs to Resist Uplift Loads
- #7 Special Profile Steel Joists and Joist Girders
- #8 Welding of Open Web Steel Joists and Joist Girders
- #9 Handling and Erection of Steel Joists and Joist Girders
- #10 Design of Fire-Resistive Assemblies With Steel Joists
- #11 Design of Lateral Load Resisting Frames Using Steel Joists and Joist Girders
- #12 Evaluation and Modification of Open Web Steel Joists and Joist Girders
- #13 Specification and Design of Composite Steel Joists
- Design Guide 35 Steel-Frames Storm Shelters
- Design Guide 40 Rain Loads and Ponding

Catalogs

- 45th Edition Standard Specifications Load Tables and Weight Tables for Steel Joists and Joist Girders - Free download
- Second Edition CJ-Series Composite Steel Joists – Free download
- 95 Years of Open Web Steel Joist Construction

SJI Webinars

Earn PDHs with the 2026 webinars:

- Our next live webinar is on February 18: Connecting the Load Path: Chords and Collectors in Steel Deck Diaphragms
- Webinars On Demand
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    - Lateral Loads
    - Floor Systems
    - Uplift
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    - CJ-Series Composite Steel Joists
    - Building Retrofit
    - Welding
    - Connections
    - Design Tools
    - Fire
    - Ethics
    - Joists 101

Q&A SESSION



THANK YOU

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