ASCE 7-22 Snow Load Updates

SEAAK Lunch Meeting

January 19th, 2022

Sterling Strait, SE

Summary

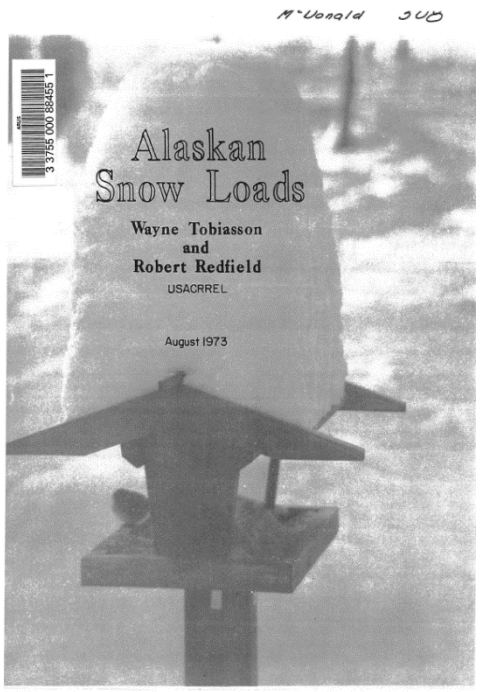
- Updated Snow Loads for Alaska Locations
- Ground Snow Loads now ‘Reliability Targeted’
- Thermal Factor Revised
- Snow Drift Calculation now Location-Dependent

Why do Codes Change?

- Bad Things Happen
- Additional Data Available
- Changing Technology
- Research and Development
- Lower Reliance on Hand Calc Methods
- Design by Committee – Politics, Personalities, and Pedantics

Alaska Snow Loads

- Current Code (ASCE 7-16)
  - 33 Alaska Locations
  - Based on 1973 Paper *Alaskan Snow Loads* (Tobiasson & Redfield)
- Inadequate Coverage
- Inaccurate Loads in Some Locations
  - Several AHJs amended local snow loads



Alaska Snow Loads

- UAA Research Project
  - Collect Snow Load Climate Data
    - 451 Weather Stations
  - Completed Probability Analysis of Data
  - Selected 50 yr MRI for each site
- UAA Research Published 2018

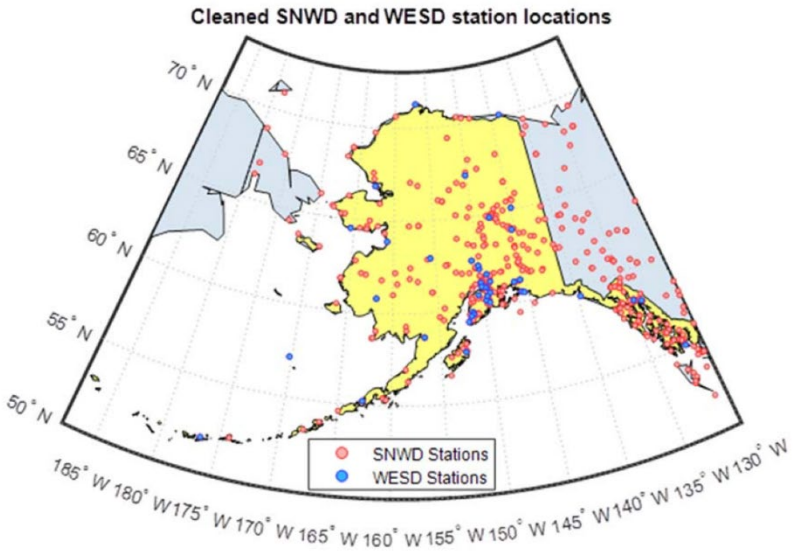
UAA College of Engineering
University of Alaska Anchorage

Snow Cover in Alaska:
Comprehensive Review

Final Report

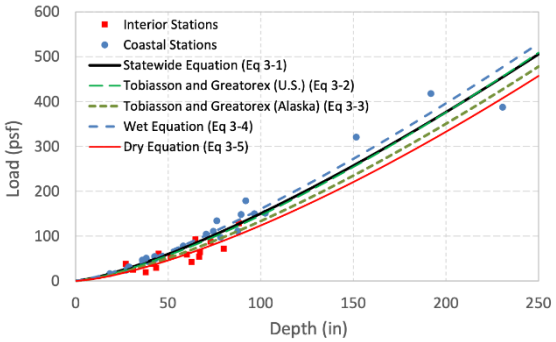
Prepared by:

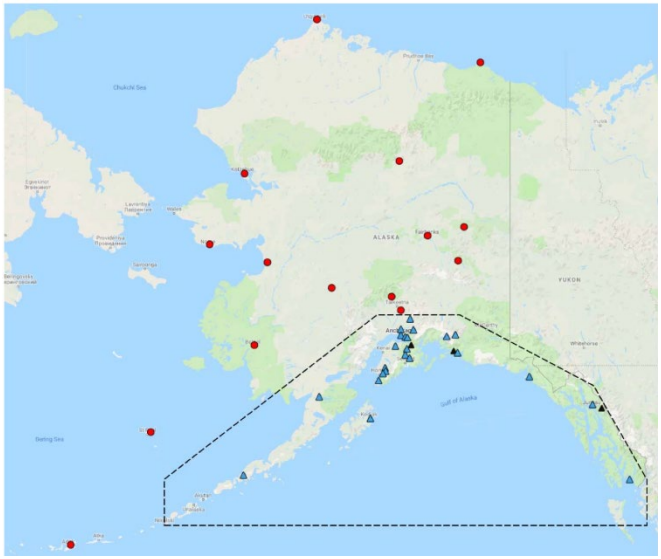
Principal Investigator: Gennady Gienko
Co-investigator: Rob Lang
Co-investigator: Scott Hamel
Research Assistant: Kurt Meehleis
Research Assistant: Tommy Folan



Alaska Snow Loads

- SEAAK Snow Load Committee
  - Selected 50 communities for new table
  - Reviewed snow loads for each location
- Published whitepaper 2020
- Proposal to ASCE Snow Loads Committee
  - Accepted with minimal comments





ALASKA SNOW LOADS FOR THE 2022 UPDATE OF ASCE 7

by

Structural Engineers Association of Alaska
Snow Loads Committee
December 2019

Primary Authors
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Snow Loads Committee
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Sterling Strait, PE, SE, Alyeska Pipeline

Alaska Snow Loads

Table 7.2-1 Ground Snow Loads, p_g, for Alaskan Locations[1,2,4]		
City/Town	Ground Snow Load (lb/ft^2)	Elevation (ft)
Adak	25	100
Anchorage/Eagle River[3]	50	500
Arctic Village	30	2,100
Bethel	40	100
Bettles	80	700
Cantwell	85	2,100
Cold Bay	35	100
Cordova	100	100
Deadhorse	25	100
Delta Junction	40	400
Dillingham	110	100
Emmonak	100	100
Fairbanks	60	1200
Fort Yukon	50	400
Galena	60	200
Girdwood	140	200
Glennallen	45	1,400
Haines	185	100
Holy Cross	120	100
Homer[3]	45	500
Iliamna	80	200
Juneau	70	100
Kaktovik	45	100
Kenai/Soldotna	65	200
Ketchikan	30	100
Kobuk	90	200
Kodiak	40	100
Kotzebue	60	100
McGrath	65	400
Nenana	75	400
Nikiski	80	200
Nome	70	100
Palmer/Wasilla	50	500
Petersburg	90	100
Point Hope	45	100
Saint Lawrence Island	95	100
Saint Paul Island	40	100
Seward	60	100
Sitka	50	100
Talkeetna	120	400
Tok	35	1,700
Umiat	30	300
Unalakleet	35	100
Unalaska	75	100
Utqiaġvik (Barrow)	25	100
Valdez	160	100
Wainwright	25	100
Whittier	270	100
Willow	80	300
Yakutat	140	100

- New Values for ASCE 7-22
- 50 Locations
  - Population Centers
  - Geographically Distributed
- Data on Additional Sites Available
  - www.seaak.net

Alaska Snow Loads

- Anchorage and Homer
  - Geographically Large with Significant Elevation Change
  - Greater Snow at Higher Elevations

The ground snow load shall be increased by 7.0 psf for every 100 ft above the cited elevation.

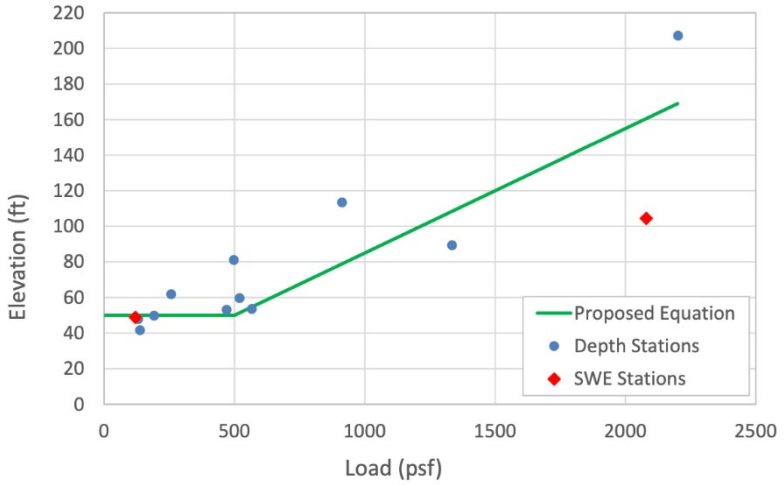


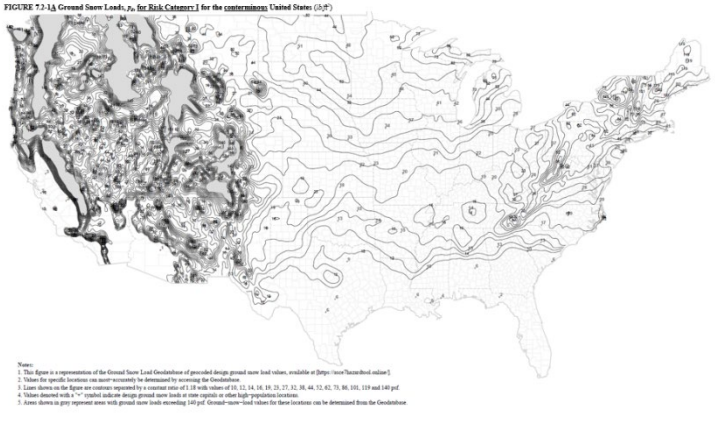
Figure 4.1: Load vs Elevation for Anchorage, AK. Proposed equation is 50psf + 7psf per 100 feet of elevation above 500 feet.

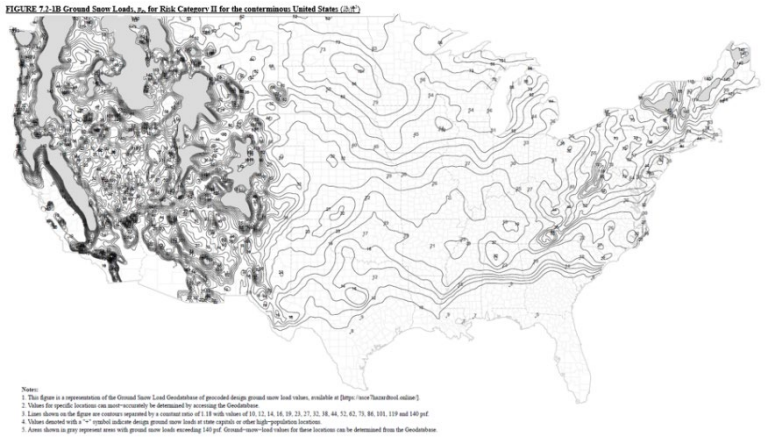
- Anchorage Bowl = 50 psf
- Glen Alps = 155 psf

  (El = 2,200 ft)

Reliability Targeted Loads

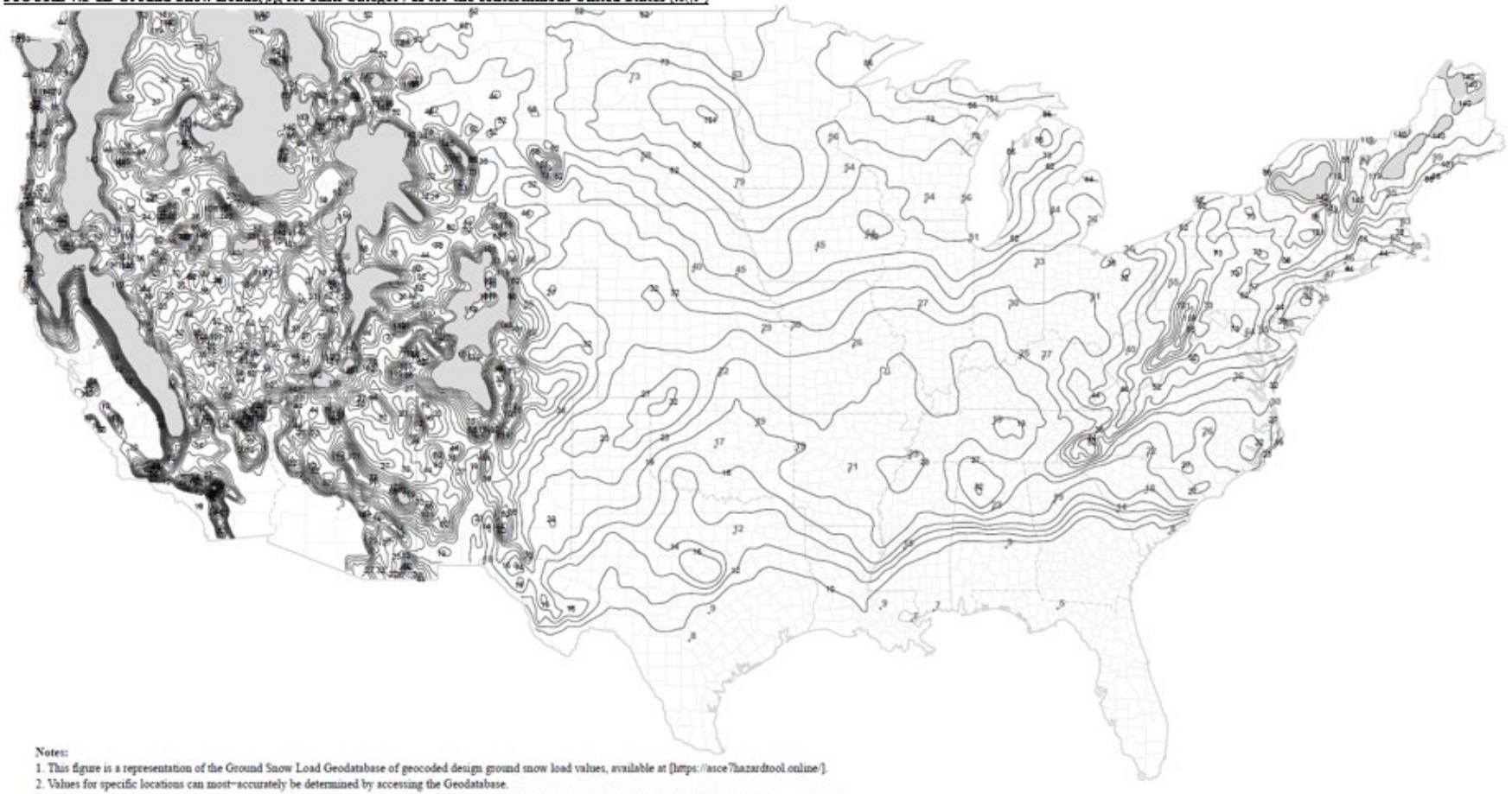
- New Ground Snow Load Map Created for L48
  - Similar Issues to AK
  - 9 State-Specific Tables in ASCE 7-16
- Data Analysis Project for L48 States
  - 7,964 Snow Measurement Stations
  - Utilized Machine Learning to Determine Depth-Weight Ratio
- Converted to Reliability-Targeted Loads
  - Individual Maps in Code for each Risk Cat
  - Similar to Wind Load Transition in ASCE 7-10





Reliability Targeted Loads

FIGURE 7.2-1B Ground Snow Loads, p_g, for Risk Category II for the conterminous United States (lb/ft²)



Notes:
1. This figure is a representation of 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 high-population locations.
5. Areas shown in gray represent areas with ground snow loads exceeding 140 psf. Ground-snow-load values for these locations can be determined from the Geodatabase.

Reliability Targeted Loads

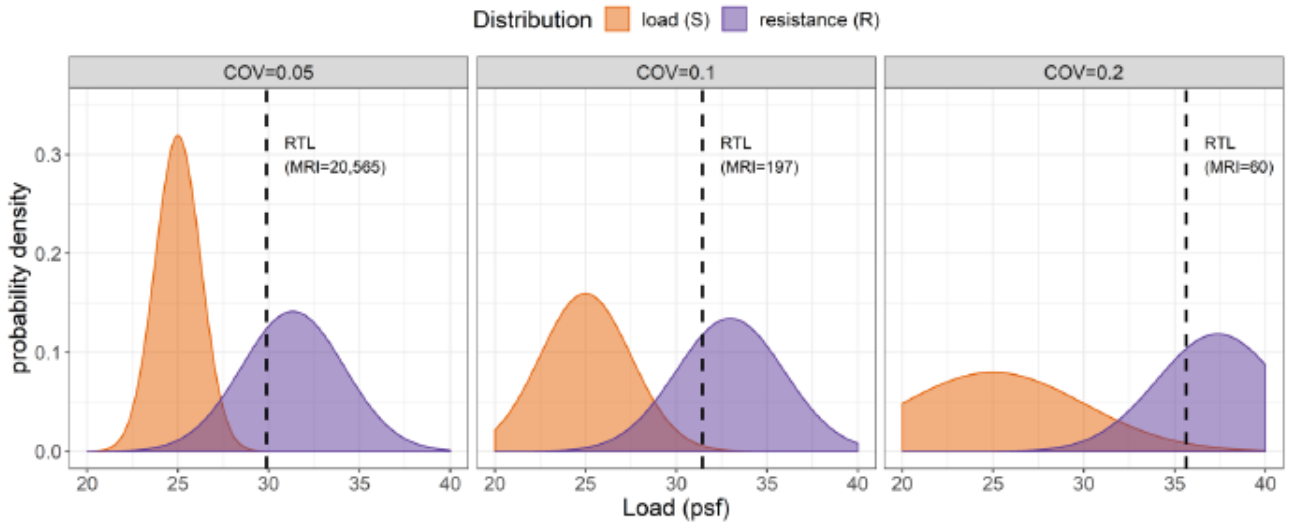
- ASCE 7-22 Ground Snow Loads are now 'Reliability Targeted'
  - Ultimate Level Loads
- Aligned with Requirements of ASCE 7 Chapter 1
  - Risk Cat II = Annual Probability of Failure of 3 x 10^{-5} (30,000 yr intvl)
- Load Combinations Revised
  - 1.0 Factor for LRFD
  - 0.7 Factor for ASD

Table 1.3-1 Target Reliability (Annual Probability of Failure, P_F) and Associated Reliability Indices (β)[1] for Load Conditions That Do Not Include Earthquake, Tsunami, or Extraordinary Events[2]

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

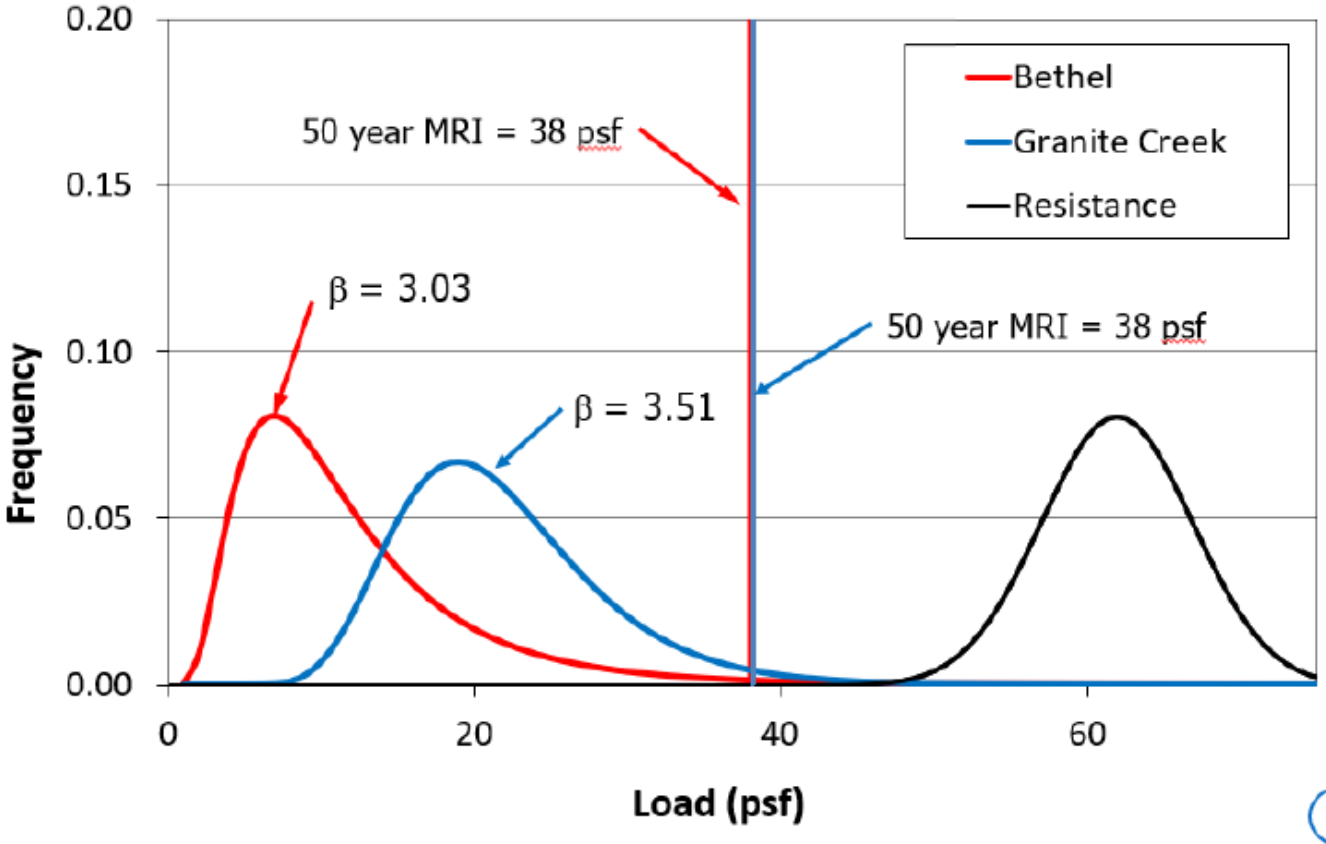
Reliability Targeted Loads

- Takes into Accounts for Multiple Uncertainties
  - Load (snow)
  - Resistance (materials)
- Greater Uncertainty = Higher Design Load
  - Locations with Rare, Significant Storms will have Higher Loads
  - Locations with Regular, Predictable Snow will have Lower Loads



Reliability Targeted Loads

Why This Change (Alaska)?



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Credit: Dr. Scott Hamel UAA

Reliability Targeted Loads

Table 7.2-1 Snow Load Design Criteria for Alaskan Locations

City/Town	Elevation (ft)	Ground Snow Load, p_s[1,2,4] (lb/ft²)				Winter Wind Parameter, W_2
		Risk Category				
		I	II	III	IV	
Adak	100	32	40	46	50	0.7
Anchorage/Eagle River[3]	500	64	80	92	100	0.2
Arctic Village	2,100	38	48	55	60	0.2
Bethel	100	51	64	74	80	0.7
Bettles	700	102	128	147	160	0.2
Cantwell	2,100	109	136	156	170	0.3
Cold Bay	100	45	56	64	70	0.8
Cordova	100	128	160	184	200	0.3
Deadhorse	100	32	40	46	50	0.6
Delta Junction	400	51	64	74	80	0.5
Dillingham	100	141	176	202	220	0.5
Emmonak	100	128	160	184	200	0.7
Fairbanks	1200	77	96	110	120	0.1
Fort Yukon	400	64	80	92	100	0.2
Galena	200	77	96	110	120	0.3
Girdwood	200	179	224	258	280	0.2
Glennallen	1,400	58	72	83	90	0.2
Haines	100	237	296	340	370	0.7
Holy Cross	100	154	192	221	240	0.2
Homer[3]	500	58	72	83	90	0.5
Iliamna	200	102	128	147	160	0.5
Juneau	100	90	112	129	140	0.5
Kaktovik	100	58	72	83	90	0.6
Kenai/Soldotna	200	83	104	120	130	0.4
Ketchikan	100	38	48	55	60	0.5
Kobuk	200	115	144	166	180	0.6
Kodiak	100	45	56	64	70	0.6
Kotzebue	100	77	96	110	120	0.6
McGrath	400	83	104	120	130	0.2
Nenana	400	96	120	138	150	0.2
Nikiski	200	102	128	147	160	0.4
Nome	100	90	112	129	140	0.6
Palmer/Wasilla	500	64	80	92	100	0.2
Petersburg	100	122	152	175	190	0.2
Point Hope	100	58	72	83	90	0.6
Saint Lawrence Island	100	122	152	175	190	0.8
Saint Paul Island	100	51	64	74	80	0.9
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Tok	1,700	45	56	64	70	0.2
Umiat	300	38	48	55	60	0.2
Unalakleet	100	45	56	64	70	0.7
Unalaska	100	96	120	138	150	0.6
Utqiaġvik (Barrow)	100	32	40	46	50	0.6
Valdez	100	205	256	294	320	0.3
Wainwright	100	32	40	46	50	0.6
Whittier	100	346	432	497	540	0.3
Willow	300	102	128	147	160	0.2
Yakutat	100	179	224	258	280	0.3

- New Table 7.2-1 in ASCE 7-22
  - Values for each Risk Category
- 50 Locations
  - Population Centers
  - Geographically Distributed
- Additional Info Available
  - www.seaak.net

Thermal Factor (c_t)

- Accounts for Building Heat
- Last Revised in 1995
  - Used R-25 as typical roof insulation
  - Low by modern standards
- Better Insulation = More Roof Snow

<u>2022 Updates:</u>

- Increased Factor for Cold Roof
- New Table for Hot Roof
  - Accounts for Insulation from Snow

Thermal Factor (c_t)

Table 7.3-2 Thermal Factor, C_t

Thermal Condition[a]	C_t
All structures except as indicated below	~~1.0~~ *See Table 7.3-3*
Unheated, open-air structures, structures kept just above freezing, and others with cold, ventilated roofs meeting the minimum requirements of the appropriate energy conservation code	~~1.1~~ 1.2
Freezer building	1.3
Continuously heated greenhouses[b] with a roof having a thermal resistance (R-value) less than 2.0 ft²·°F·h /BTU (0.4 m²·K /W) or a thermal transmittance (U-factor) greater than 0.5 BTU/ft²·°F·h (2.5 W/ m²·K)	0.85

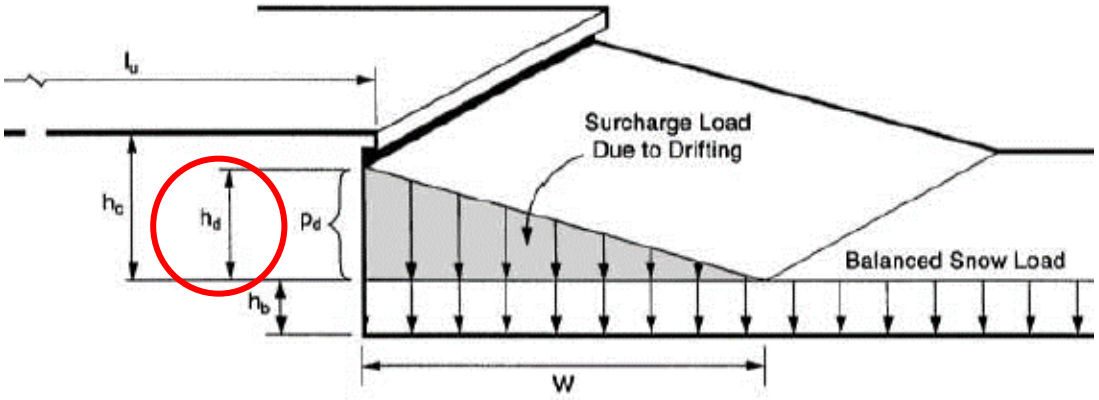
[a]These conditions shall be representative of the anticipated conditions during winters for the life of the structure.
[b]Greenhouses with a constantly maintained interior temperature of 50°F (10°C) or more at any point 3 ft (0.9 m) above the floor level during winters and having either a maintenance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

Table 7.3-3 Thermal Factor, C_t, for Heated Structures with Unventilated Roofs

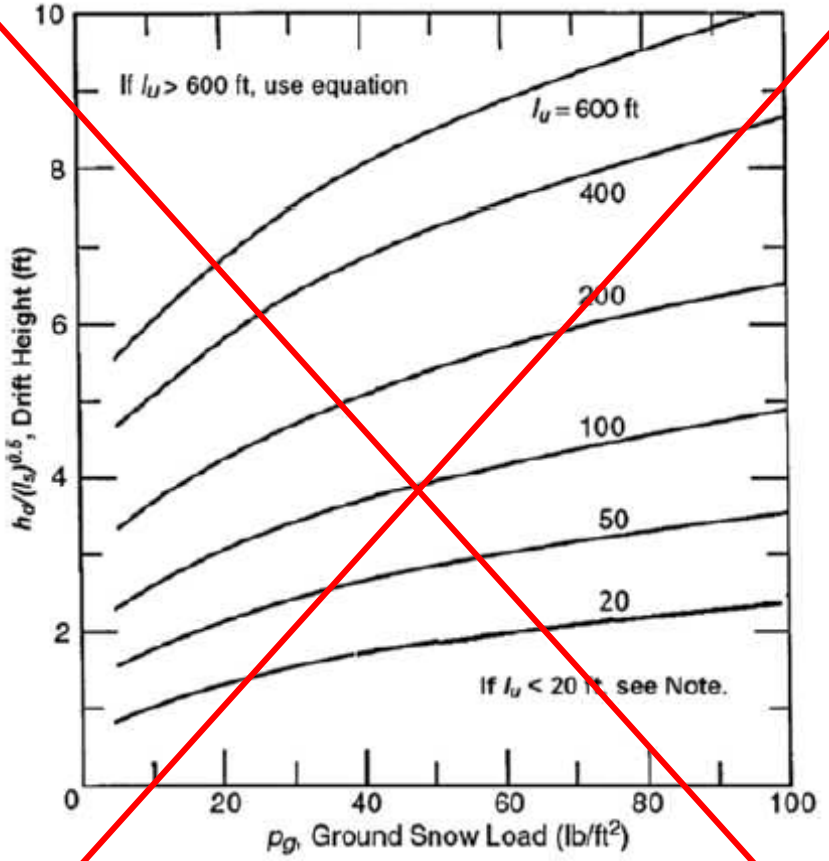
		P_g (psf)						
R_{roof} (ft²·°F·h /BTU)	U_{roof} (BTU/ft²·°F·h)	10	20	30	40	50	60	≥70
20	0.050	1.20	1.11	1.05	1.01	1.00	1.00	1.00
30	0.033	1.20	1.17	1.14	1.13	1.12	1.11	1.10
40	0.025	1.20	1.19	1.17	1.16	1.16	1.15	1.15
50	0.020	1.20	1.20	1.19	1.19	1.19	1.18	1.18

Snow Drifting

- Snow Drift Formation tied to Winter Windiness
  - W2 = Winter Wind = % time wind speed > 10 mph in winter (Oct – Apr)
  - Obtained from Map or Table in ASCE 7
- Drift Height (h_d)Formula Updated to be Location Specific



Snow Drifting



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

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$$h_d = 1.5\sqrt{\frac{P_g^{.74} l_u^{.70} W_2^{1.7}}{\gamma}}$$

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Snow Drifting

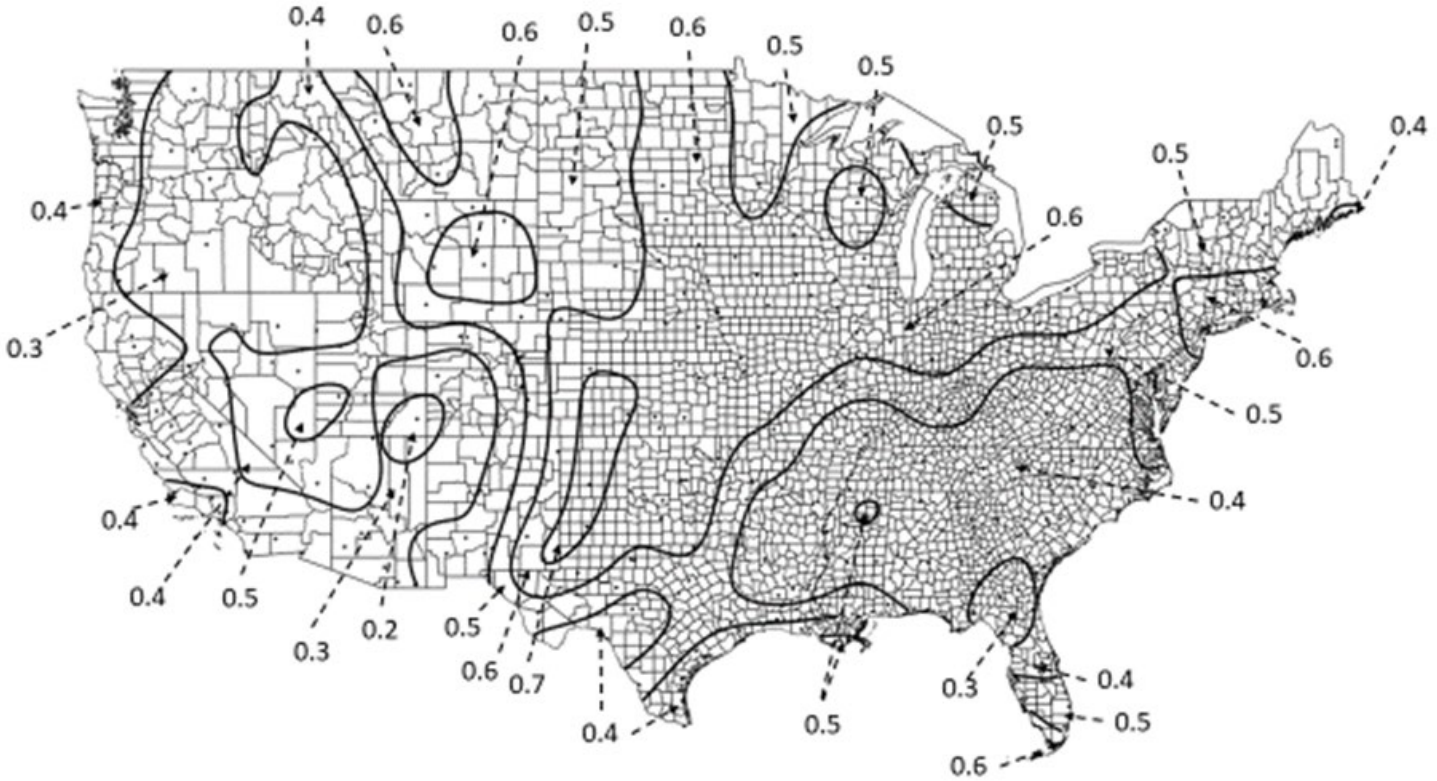
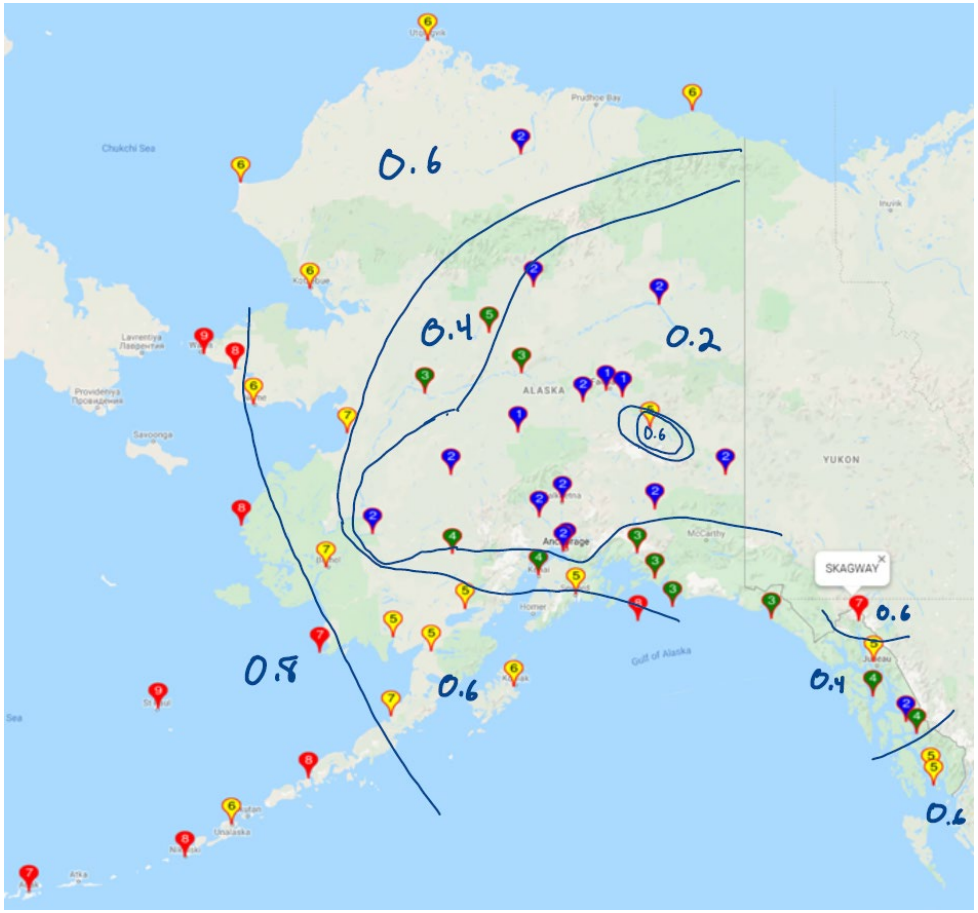


Fig 7.6-1: W2 Map for L48

Note: W2 = 0.4 ≈ Current Formula

Snow Drifting



Rough W2 Map for Alaska

Table 7.2-1 Ground Snow Loads, p_g, for Alaskan Locations

Table 7.2-1 Snow Load Design Criteria for Alaskan Locations

City/Town	Elevation (ft)	Ground Snow Load, p_g[1,2,4] (lb/ft²) Risk Category I	II	III	IV	Winter Wind Parameter, W_2
Adak	100	32	40	46	50	0.7
Anchorage/Eagle River[3]	500	64	80	92	100	0.2
Arctic Village	2,100	38	48	55	60	0.2
Bethel	100	51	64	74	80	0.7
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Cordova	100	128	160	184	200	0.3
Deadhorse	100	32	40	46	50	0.6
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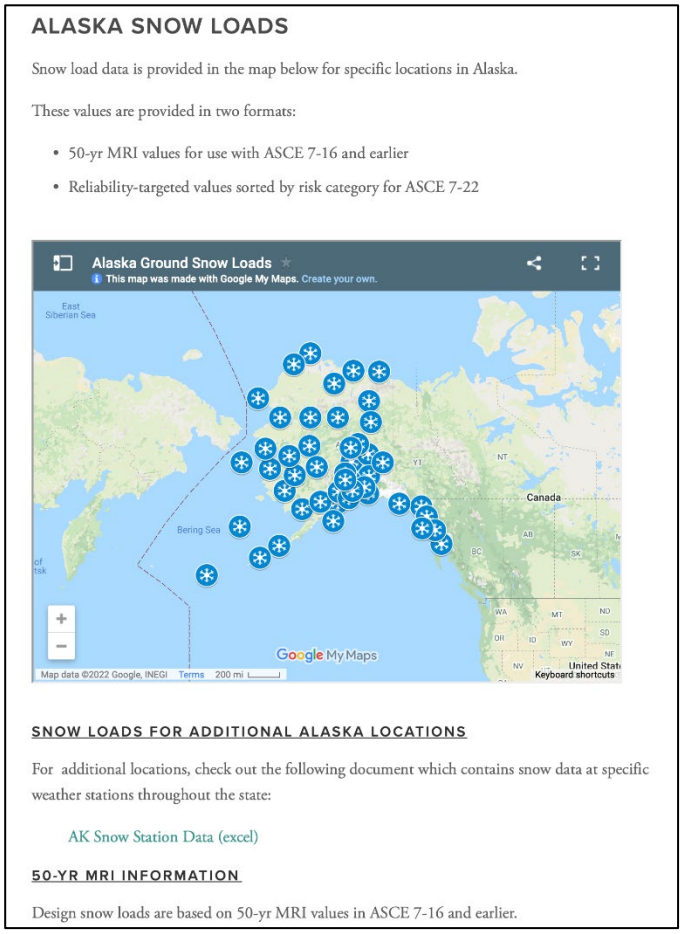
Dillingham	100	141	176	202	220	0.5
Emmonak	100	128	160	184	200	0.7
Fairbanks	1200	77	96	110	120	0.1
Fort Yukon	400	64	80	92	100	0.2
Galena	200	77	96	110	120	0.3

ASCE 7-22 Table 7.2-1

Note: W2 = 0.4 ≈ Current Formula

Additional Resources

- https://seaak.net/alaska-snow-loads
- Mapped Alaska Snow Values
- UAA Research Paper
- Data on 200+ AK Sites
- Excel File with Sortable Data



ALASKA SNOW LOADS

Snow load data is provided in the map below for specific locations in Alaska.

These values are provided in two formats:

- 50-yr MRI values for use with ASCE 7-16 and earlier
- Reliability-targeted values sorted by risk category for ASCE 7-22

SNOW LOADS FOR ADDITIONAL ALASKA LOCATIONS

For additional locations, check out the following document which contains snow data at specific weather stations throughout the state:

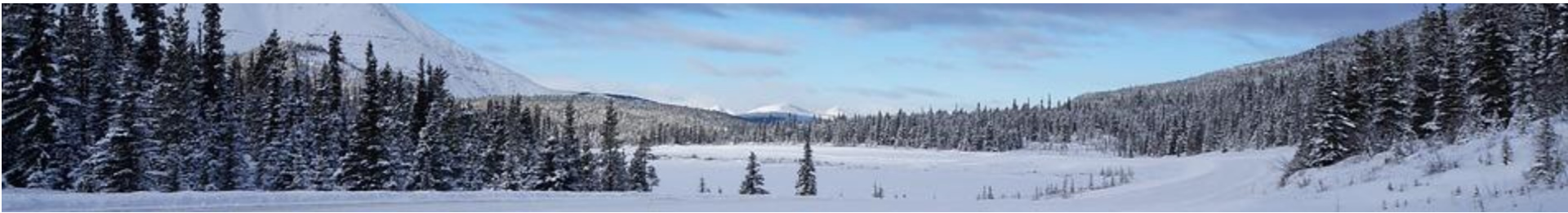
AK Snow Station Data (excel)

50-YR MRI INFORMATION

Design snow loads are based on 50-yr MRI values in ASCE 7-16 and earlier.

References

- Alaska Snow Loads
  - SEAAK Whitepaper: “Alaska Snow Loads for the 2022 Update of ASCE 7” 2020
  - Gienko et. Al, “Snow Cover in Alaska: Comprehensive Review” (2018) UAA Graduate Thesis
- Reliability-Targeted Loads
  - Maguire et. al, "Ground Snow Loads for ASCE 7-22 – What Has Changed and Why?" (2021). *Mathematics and Statistics Faculty Publications.* Paper 277. https://digitalcommons.usu.edu/mathsci_facpub/277
  - SEAAK Whitepaper: “Reliability Targeted Alaska Ground Snow Loads for the 2022 Edition of ASCE 7 Standard”
- Thermal Factor
  - O’Rourke, Michael and Russell, Scott “Snow Thermal Factors for Structural Renovations.” *Structure.* July 2019: 24-26. Print.
- Snow Drifting
  - O’Rourke M, and Cocca J., (2019) “Improved Snow Drift Relations” J. Structural Engineering ASCE. ASCE, ISSN 0733-9445, DOI:10.1061
  - O’Rourke M, Sinh, H., Cocca J., and Williams, T., (2019) “Winter Wind Parameter for Snow Drifts” J. Structural Engineering ASCE



ASCE 7-22 Snow Load Updates

Questions?

Thank You!