

Frost Depth Study TAG

Meeting Notes

Date: Wednesday, August 4, 2021

Meeting Location: WebEx Event

Call to order:

Dan Kelsey called the meeting to order at 9:06 AM

Attendance:

TAG Members present: Dan Kelsey (DLI), Greg Metz (DLI), Ezra Ballinger, (Braun Intertec), Mark Hallan (Widseth), Mitch Okeson (Alternate -Sandman Structural Engineers), Don Dabbert (Dabbert Custom Homes), Kurt Welker (Welker Custom Homes), and Jack Nyberg (City of Moorhead)

TAG Members absent: Kurt Sandman (Sandman Structural Engineers)

Guests attending: Amanda Spuckler (DLI), Chad Payment (DLI), Rich Lockrem (DLI), Jeff Lebowski (DLI), Brittany Wysokinski (DLI), Steve Shold (DLI), Elizabeth Tomlinson, Kevin Toskey, Clayton Talbot, Kevin Goodno, Lisa Bode, Peter Glessing, Mustafa Igdelioglu, Craig Oswell, Cullen Sheehan, Scott Thompson, Roger Axel, Mark Romano, Nick Erickson, Steve Schmidt, and Jim Newham

1. Call to order

- WebEx instructions/procedures

2. Reviewed Minnesota Statutes, Chapter 13, Data Practices Act and Chapter 13D, Open Meeting Law

3. Reviewed the scope of the Frost Depth TAG. The TAG is to evaluate the current minimum allowable footing depth due to freezing contained in the State of Minnesota Building Code for Clay county. The TAG shall evaluate at minimum:

- Whether the current required minimum depth below grade of five feet is necessary to protect foundations and supporting structures from the damaging effects of freezing soil located both beneath and adjacent to foundations;
- Whether a lesser frost depth requirement would reduce the structural integrity or otherwise negatively affect the foundation or supporting structure and if not, what lesser depth could be recommended;

- Whether a lesser frost depth requirement could extend beyond Clay county and if so to what extent; and
- Whether the minimum required frost depth requirement for residential housing should or can be regulated differently from other building types.

4. Reviewed [map with current requirements for frost depth in Minnesota](#).

5. Reviewed [NOAA Manual NOS NGS 1 Geodetic Bench Marks](#) that includes a frost depth map.

6. Reviewed [MNDOT Data: Otter Tail County Frozen Soil Profile](#). MNDOT data is for an open roadway and shows that frost will penetrate when no heat is present.

7. Reviewed [BSI-045: Double Rubble Toil and Trouble](#) which provides background about how temperature moves through soil.

8. Reviewed [ASCE 32 air freezing index map overlay on Minnesota county map](#), [DNR Frost Depth in Minnesota for January 2017](#), and [DNR Frost Depth in Minnesota for Winter 2018](#).

- Discussed ASCE 32 shallow frost protection requirements as an alternative method to prescriptive requirements.
- Discussed if current insulation requirements provide sufficient protection from the effects of frost as well as insulation required by ASCE 32 for frost protection.
- Reviewed DNR frost depth data for Moorhead and compared the data to Minnesota State Building Code frost depth requirements.
- Data for the ASCE 32 map is from the National Climate Data Center data set for the air freezing index for the United States from 1951 to 1980 based upon statistical probability with a mean reoccurrence interval.

9. Reviewed [ASHRAE 90.1-2019 Climate Zone Map for Minnesota](#).

- ASHRAE 90.1-2019 shows the climate zones shifting northward.
- The data used to develop ASHRAE 90.1-2019 climate zones is based on thirty years of historical data and is not based on extreme events.
 - The data does not have the depth of the air freezing index.
- ASHRAE 90.1-2019 climate zones are used for determining building envelope criteria.

10. Reviewed [Calculation of an Air-Freezing Index for the 1981-2010 Climate Normals Period in the Coterminous United States](#)

- Compares air-freezing index to frost depth but it is theoretical and the method works best for mid-latitude regions that do not experience prolonged winters.

11. Reviewed [Jay Crandall's email](#) and [code change proposal](#) to revise design frost depth for an updated edition of ASCE 32.

Next Meeting:

Date: September 1, 2021

Time: 9:00 AM

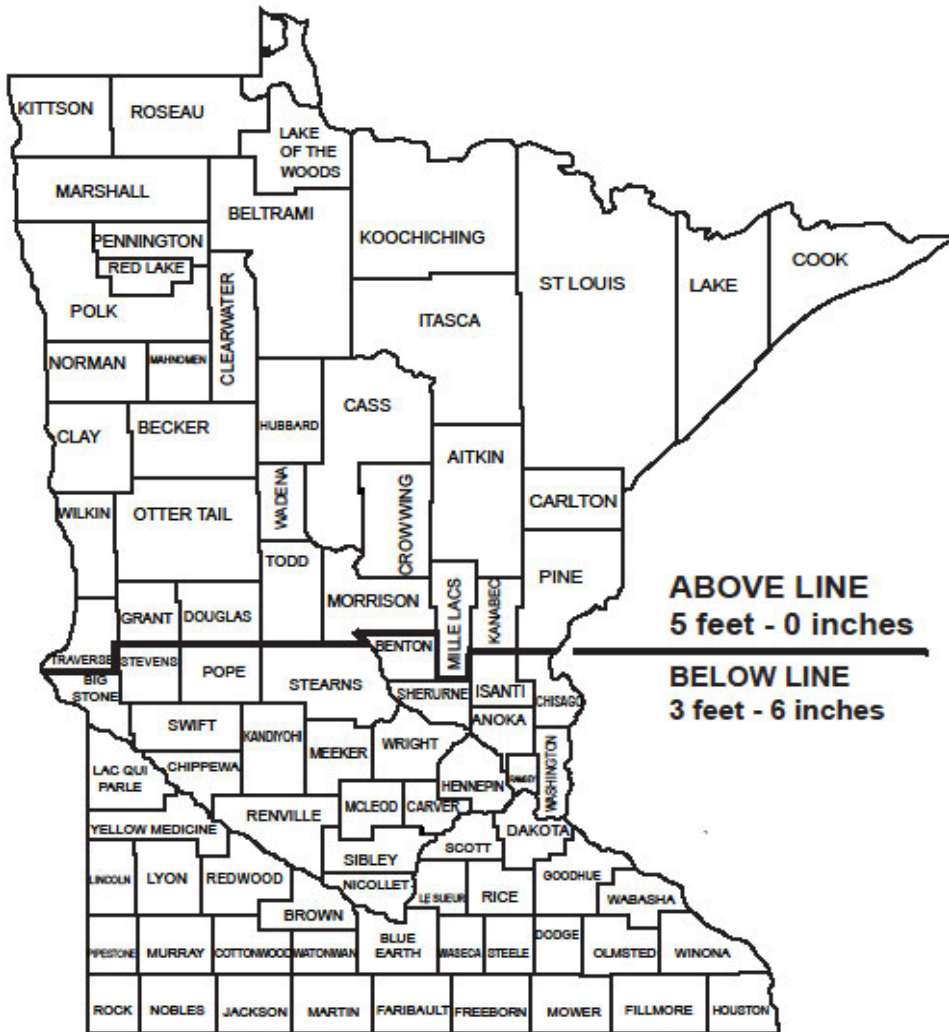
Location: WebEx Event

Meeting Adjourned: 11:00 AM

Prepared by: Dan Kelsey

FROST DEPTH

MSBC RULES 1303.1600



ASCE 32 Air Freezing Index Map Overlay on Minnesota County Map



Jay Crandell's Email

From: Jay Crandell [REDACTED]
Sent: Monday, August 02, 2021 5:31 PM
To: Kelsey, Daniel (DLI)
Subject: RE: Frost protection for structures in Minnesota
Attachments: Frost Depth Proposal for ASCE 32 (2017).docx

Daniel,

Good to hear from you. There has been no change in the ASCE 32-2001 standard provisions for FPSF as you are aware. As far as climate, it has warmed based on latest climate analysis for energy codes (shifting the climate zones slightly northward). So, this would suggest that the existing AFI map (and MAT maps) for FPSF design have become conservative since they are based on older climate data. There has been some new analysis for those maps in the literature, but it has not been adopted or proposed for ASCE 32 (and the study also included somewhat conservative frost-depth calculations, but to my knowledge did not correlate it to actual frost-depth data as I discuss below).

If you are interested in evaluating footing depths for conventional building foundations, I participated in a study on that matter with NOAA and HUD to improve frost-depth prediction/modeling based on actual weather data (freezing temps and snow cover) as compared to actual frost depth data. Based on that research, I prepared a proposal for the ASCE 32 standard in 2017 (see attached) for conventional footing depths, but its update process has stalled. The attached pending proposal has the background and references for further study as needed. So, this could be starting point for what might work for Minnesota. Also, I've been intrigued by the approach taken in Alaska (I think the Anchorage building code) whereby they distinguish footing frost depths based on a "warm" (e.g., column footing within a basement or perimeter footings for exterior walls) or "cold footing" (e.g., a deck pier). This also makes a lot of sense as these two footing conditions have very different frost depths. But, the attached proposal and the NOAA research proposal do not make this distinction because this distinction is not currently made in the lower 48 states.

I will be unavailable for the remainder of this week, but I hope this helps. I'll respond to e-mail as soon as I'm able if you have any further questions.

Regards,

Jay

Jay H. Crandell, P.E.

ARES Consulting, www.aresconsulting.biz

ABTG, www.appliedbuildingtech.com

301-466-7420

From: Kelsey, Daniel (DLI) [<mailto:dan.kelsey@state.mn.us>]

Sent: Monday, August 2, 2021 3:06 PM

To: Jay Crandell <[REDACTED]>

Subject: Frost protection for structures in Minnesota

Mr. Crandell,

The Minnesota Department of Labor and Industry is in the process of reviewing the minimum footing depth for frost protection requirements in the Minnesota State Building Code, MR 1303.1600. To start with our study is focused on Clay County, and depending on what we learn the group may look the requirements for the whole state.

We read your article "Comparison of Methods Used to Create Estimate of Air-Freezing Index". Do you have any information, or are you aware on any, that would help our technical advisory group reevaluate our minimum footing depth requirements?

It has been quite a while since the ICC Ad Hoc Wall bracing Committee met for the last time. I hope the time has been very good to you and your family.

Thank you

Daniel Kelsey, P.E. (MN, IA, ND, WI)

Administrative Structural Engineer | Construction, Codes & Licensing- Building Plan Review

Minnesota Department of Labor and Industry

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BALLOT PROPOSAL TO REVISE SEI/ASCE 32 STANDARD

Add the following provisions for Design Frost Depth:

3.2 DEFINITIONS

Design Frost Depth: The minimum depth at which the soil temperature remains above freezing, for an extreme winter event, based on analysis, local regulations, or experience.

4.1 GENERAL

In regions of seasonal ground freezing, shallow foundations ~~not extending below the design frost depth~~ shall be protected against frost heave by one or more of the following methods:

1. use of non-frost susceptible layers of undisturbed ground or fill materials (Section 4.2);
2. insulation of foundations to mitigate frost penetration and effects of frost heave (Section 4.3); or
3. approved design and details supported by engineering analysis; or
4. extending the base of the building foundation to or below the design frost depth as prescribed in local regulations, as determined by a site specific analysis or experience, or as determined in accordance with FIGURE A1 and TABLE 4.

TABLE 4. Design Frost Depth¹

<u>100-YEAR AIR-FREEZING INDEX</u> <u>[Figure A1]</u>	<u>DESIGN FROST DEPTH</u> <u>(inches)</u>
<u>≤ 350</u>	<u>12</u>
<u>500</u>	<u>16</u>
<u>1000</u>	<u>24</u>
<u>1500</u>	<u>32</u>
<u>2000</u>	<u>40</u>
<u>2500</u>	<u>45</u>
<u>3000</u>	<u>52</u>
<u>3500</u>	<u>57</u>
<u>4000</u>	<u>62</u>
<u>4250</u>	<u>65</u>

Note: 1. These design frost depths are applicable to building foundations and are not applicable to site or street utilities or other non-building applications.

(Renumber existing TABLE 4 and subsequent tables accordingly and update text references accordingly)

Add supporting references to COMMENTARY as follows:

C2. REFERENCES

DeGaetano, A.T., D.S. Wilks and M. McKay, Extreme-Value Statistics for Frost Penetration Depths in the Northeastern U.S., *Journal of Geotechnical and Geoenvironmental Engineering*, 123(9), 828-835 (1997).

DeGaetano, A.T., M.D. Cameron and D.S. Wilks, Physical simulation of maximum seasonal soil freezing depths in the United States using routine weather observations, *Journal of Applied Meteorology*, 40, 546-555 (2000).

DeGaetano, A.T. and D.S. Wilks, Extreme-value climatology of maximum soil freezing depths in the United States, *Journal of Cold Regions Engineering*, 16, 51-71(2001).

HUD, *Development of Frost Depth Maps for the United States*, U.S. Department of Housing and Urban Development, Washington, DC (July 2001).

Add supporting text to COMMENTARY before Subsection C4.1.1 (p. 30) in Section C4.1:

An evaluation of probabilistic frost depths by the NOAA/Northeast Regional Climate Center (Cornell University)[DeGaetano, Wilks, and Mckay, 1997; DeGaetano, Cameron, and Wilks, 2000; DeGaetano and Wilks, 2001; HUD, 2001] was used as the basis for TABLE 4 added to the XXXX edition of the standard. Data from that study was compared with and calibrated to locally prescribed design frost depths as shown in FIGURE C4. This risk calibration approach ensured that transitioning to a risk-consistent basis for design frost depths as represented by TABLE 4 remained consistent with successful experience and accepted practice for design frost depths (as represented in local building regulations) in the colder climate conditions

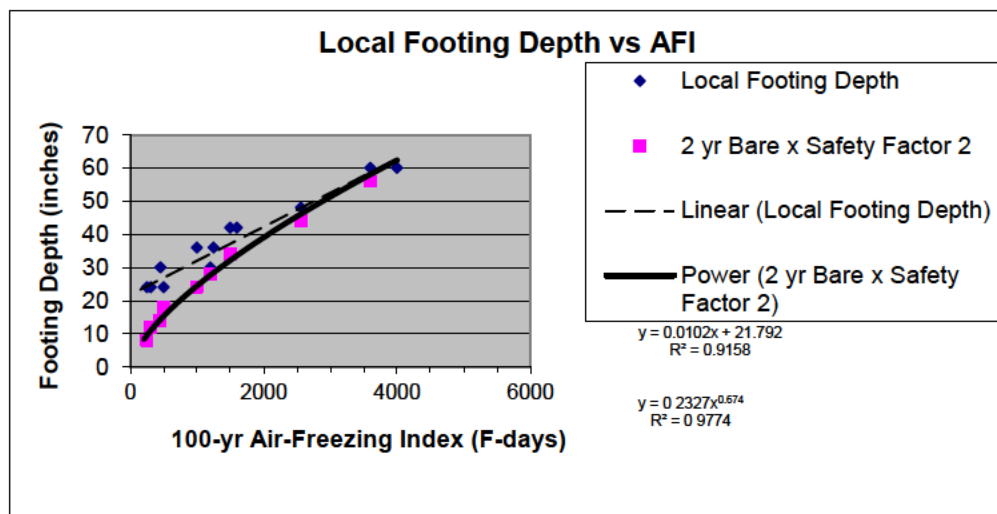


FIGURE C4. DEVELOPMENT OF RECOMMENDED DESIGN FROST DEPTHS

Technical Substantiation: Climate studies, frost-depth data, and risk modeling efforts have improved the understanding of variation in normal and extreme frost depths in the United States. These studies have been conducted by the National Oceanic and Atmospheric Administration and the NOAA Northeast Regional Climate Center at Cornell University (see added References). This revision calibrates results of this newer data to closely match current design frost line depths used in colder U.S. climates, and correlates these depths to Air-Freezing Index in a risk-consistent manner to improve current practice throughout the U.S. Thus, greater consistency in frost protection requirements across various accepted frost-protection methods as addressed in ASCE 32 is achieved by this proposal.