Functional Review Guidance
Roofs and Covers (Code 367)

Background: Both the National and Wisconsin NRCS versions of "Roofs and Covers" (Code 367) require roofs, covers and associated support systems be designed to resist all applicable loads including wind, snow, and seismic loads in accordance the current version of *ASCE 7 "Minimum Design Loads and Associated Criteria for Buildings and Other Structures"*. The most current version is ASCE 7-22 (published in 2022). In the last 12 years, there has been 3 versions of ASCE 7 (2010, 2016, and 2022).

ASCE 7-16 major updates:

- Updated study of wind data from over 1,000 weather recording stations across the U.S. for non-hurricane areas of the country.
- Wind events in the study were separated between thunderstorm and non-thunderstorm events.
- Wind speeds decreased across the country except along the hurricane coastline from Texas to North Carolina.

ASCE 7-22 major updates:

- For the first time, there is a chapter dedicated to tornado loads and effects, including new tornado wind speed maps. Applies to Risk Category III or IV structures (most agricultural structures are Risk Category I or II).
- Ground snow load data to reflect more recent snow load data and reliability-targeted values.

Purpose: The purpose of the guidance covered in this paper is to assist the agency reviewer in determining if the design professional's stamped submittal is functionally complete or incomplete. The guidance contained in this paper is not enough information to perform a complete roof design. It is responsibility of the consulting design professional of record to complete the design in accordance with the appropriate standards and building codes. The guidance in this paper focuses on wind, snow, and seismic loadings as defined in ASCE 7-22.

Functional Review:
Common errors and/or omissions encountered when reviewing roof plans include the following:

1. Incorrect version of ASCE-7 was used.
2. No construction inspection plan.
3. No operation and maintenance plan.
4. No design documentation or documentation only for the trusses (need everything listed in Job sheet 367).
5. Resting posts on NRCS standard walls. If the posts are directly attached to the walls, the designer must provide the necessary calculations showing that the wall and footing is adequate for both the additional vertical and horizontal loadings. Also, the connection of the post to the wall must be shown to be adequate to resist the wind, snow, and seismic loadings.
6. Missing other items listed on Job Sheet 367

The best way to avoid these deficiencies is to go over Job Sheet 367 with the designer prior to them submitting the package for review. It would be ideal if the designer knew what NRCS was asking for in their submittal, prior to the designer providing a quote for engineering services to the landowner and/or general contractor.

ASCE Online Hazards Tool: When performing a functional review, the reviewer should first check the loadings to see they correspond with the ASCE 7 standard. Most of the engineering staff does not have access to ASCE 7. Below is a link to the ASCE Online Hazards Tool. The user inputs the address for the project site or selects the option to "find on map". The user also chooses the version of the ASCE 7 standard to use:

https://asce7hazardtool.online/

- Wind Speed *(V)*: The wind speed maps were updated in ASCE 7-16 and are slightly less than previous versions of ASCE 7. In ASCE 7-16, the basic wind speeds range from approximately 98 mph to 101 mph in Wisconsin and are essentially the same for Risk Category I structures in ASCE 7-22. The lesser wind speeds do not necessarily result in lower design wind pressures.
- Ground Snow Load *(p_g)*: varies across the state for all versions of the ASCE standard referenced in this paper. The ASCE 7-22 version has an updated ground snow load map which can vary significantly from the older versions of ASCE 7.
- Seismic Loads: Wisconsin is generally in Seismic Design Category "A" for Risk Category I and II structures, depending on the soils at the site and the physical location of the structure. Parts of southern Wisconsin can be in the Seismic Design Category "B" (depending on soils and physical location of the structure).

The reviewer should look at the Risk Category, Snow Exposure Factor, Snow Load Importance Factor, Thermal Factor, and Enclosure Classification. All of these are explained in further detail below. It is seldom required to delve deeply into the calculations the designer provides, unless the posts supporting the roof are supported by a concrete wall (then a cursory review of the wall calculations will be required to observe the wall was designed for the added vertical and horizontal loading from wind, snow, and seismic events).

Risk Category. Most roof structures NRCS will deal with are Risk Category I which represent a low risk to human life in the event of failure. The designer is free to design to a higher risk category if they deem appropriate. See Table 1.5-1 below for a summary of the various Risk Categories.

Table 1.5-1. Risk Category of Buildings and Other Structures for Flood, Wind, Tornado, 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 not included in Risk Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure	
Buildings and other structures not included in Risk Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing toxic or explosive substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released*	
Buildings and other structures designated as Essential Facilities	IV
Buildings and other structures, the failure of which could pose a substantial hazard to the community	
Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing sufficient quantities of highly toxic substances where the quantity of the material exceeds a threshold quantity established by the Authority Having Jurisdiction and is sufficient to pose a threat to the public if released*	
Buildings and other structures required to maintain the functionality of other Risk Category IV structures	

*Buildings and other structures containing toxic, highly toxic, or explosive substances shall be eligible for classification to a lower risk category if it can be demonstrated to the satisfaction of the Authority Having Jurisdiction by a hazard assessment as described in Section 1.5.3 that a release of the substances is commensurate with the risk associated with that risk category.

SNOW LOADS

Ground snow load (p_g): The ground snow load is used to compute the roof snow load, usually the roof snow load will be less. ASCE 7 ground snow load varies throughout the state. It can differ from the WI state building code ground snow load. The ground snow loads in ASCE 7-22 are different than previous versions of ASCE 7.

Ground snow load for Risk Category I from ASCE 7-22 (use ASCE Online Hazards Tool for your precise location)

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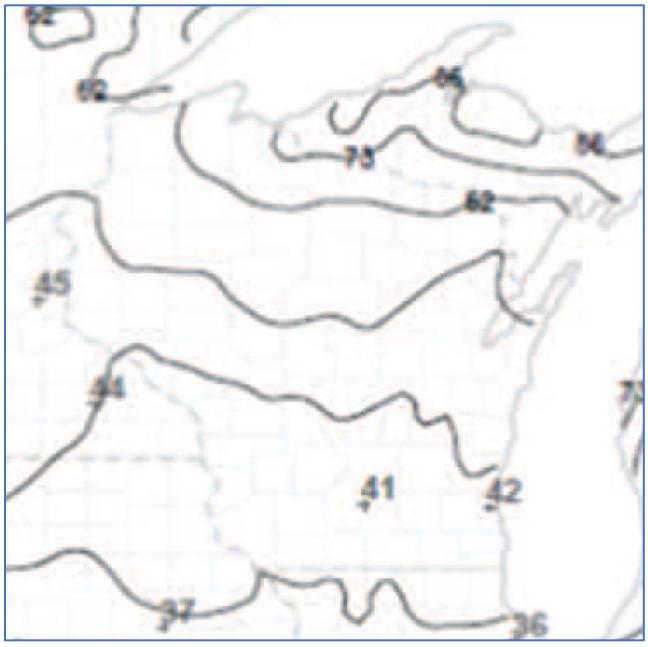
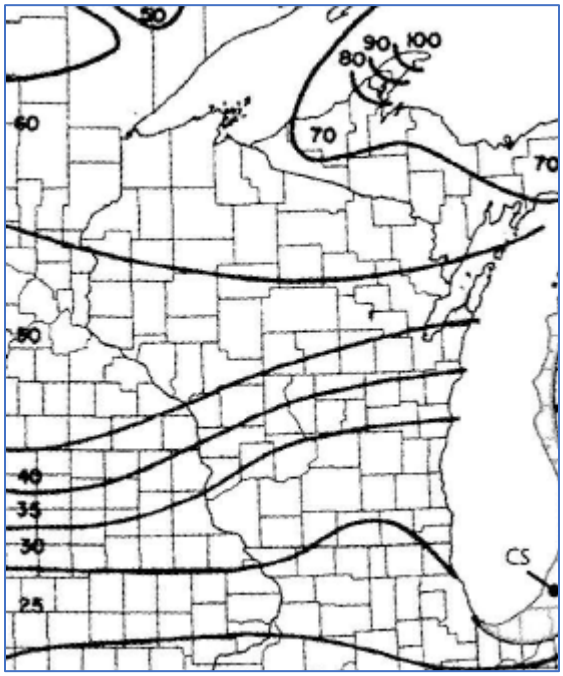


For informational purposes, below is a figure showing the ground snow loads for previous versions of ASCE 7 for Risk Category I structures.

Ground snow load from ASCE 7-16 and ASCE 7-10 (use ASCE Online Hazards Tool for the precise location of the structure)



Flat roof snow load (p_f): Most modern barn roof slopes are 15° or less (approximately a 3.2:12 pitch) and qualify as flat roofs when calculating the snow loading.

$$p_f = 0.7\, C_e\, C_t\, I_s\, p_g \quad \text{(ASCE 7-16)}$$

$$p_f = 0.7\, C_e\, C_t\, p_g \quad \text{(ASCE 7-22)}$$

the factors in this equation are discussed below.

1. Exposure factor (C_e): This affects the computation of the roof snow load and is based on the ground Surface Roughness Category along with the Exposure of Roof. Exposure Categories can be B, C or D. The Exposure of Roof is affected by immediate obstructions to wind.

Table 7.3-1. Exposure Factor, C_e.

Surface Roughness Category	Exposure of Roof[a]		
	Fully Exposed[b]	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
Above the tree line in windswept mountainous areas	0.7	0.8	N/A
In Alaska, in areas where trees do not exist within a 2 mi (3 km) radius of the site	0.7	0.8	N/A

The terrain category and roof exposure condition chosen shall be representative of the anticipated conditions during the life of the structure. An exposure factor shall be determined for each roof of a structure.

[a] Partially Exposed: All roofs not Fully Exposed or Sheltered. Fully Exposed: Roofs exposed on all sides with no shelter[b] afforded by terrain, higher structures, or trees. Roofs that contain several large pieces of mechanical equipment, parapets that extend above the height of the balanced snow load (h_b), or other obstructions are not in this category. Sheltered: Roofs located tight in among conifers that qualify as obstructions.

[b] Obstructions within a distance of $10h_o$ provide "shelter," where h_o is the height of the obstruction above the roof level. If the only obstructions are a few deciduous trees that are leafless in winter, the "fully exposed" category shall be used. Note that these are heights above the roof. Heights used to establish the Exposure Category in Section 26.7 are heights above the ground.

The Surface Roughness Categories are defined below, and the Exposure Categories are defined in the footnotes to Table 7.3-1:

Surface Roughness B. Urban and suburban areas, wooded areas, or other terrain with numerous, closely spaced obstructions that have the size of single-family dwellings or larger.

Surface Roughness C. Open terrain with scattered obstructions that have heights generally less than 30 ft (9.1 m). This category includes flat, open country and grasslands.

Surface Roughness D. Flat, unobstructed areas and water surfaces. This category includes smooth mud flats, salt flats, and unbroken ice.

2. Thermal factor (C_t): This factor accounts for thermal effects from the building affecting snow accumulation on the roof during the anticipated winter conditions. It is used in the computation of roof snow loads. A typical scenario would assume C_t = 1.2 representing "Unheated and open-air structures". The Thermal Factors are from Tables 7.3-2 and 7.3-3.

Table 7.3-2. Thermal Factor, C_t.

Thermal condition[a]	C_t
All structures except as indicated as follows	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.

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

		P_g (psf [kPa])						
R_{roof} (h·ft²·°F/Btu [m²·K/W])	U_{roof} (Btu/h·ft²·°F [W/m²·K])	≤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.

3. Snow importance factor (I_s): The snow importance factor is related to the Risk Category and is used in in the computation of roof snow loads in ASCE 7-10 and ASCE 7-16, but not in ASCE 7-22, since the 2022 version has a different snow load map for each Risk Category. Table 1.5-2 below is from ASCE 7-16.

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: The component importance factor, I_p, applicable to earthquake loads, is not included in this table because it depends on the importance of the individual component rather than that of the building as a whole, or its occupancy. Refer to Section 13.1.3.

~~4.~~ Sloped roof snow load (p_s):

$p_s = C_s\, p_f$

where;

C_s = 1.0 for unheated structures with a roof slope of 15° or less where the roof's surface is slippery and unobstructed and sufficient space is available below the eaves to accept all sliding snow.

C_s < 1.0 for same conditions as above, but steeper roofs (obtain C_s from ASCE 7-16 and ASCE 7-22 Figure 7.4-1c). A smaller value of C_s for steeper roofs reduces the snow load because more snow slides off.

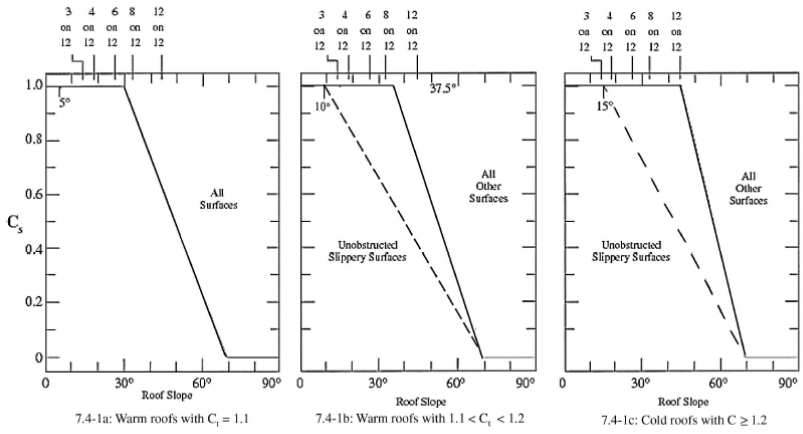


Figure 7.4-1. Graphs for determining slope factor, C_s.
Note: See Tables 7.3-2 and 7.3-3 for C_t definitions.

WIND LOADS

Basic wind speed (V): This equates to a 3 second gust 33 ft. above the ground in Exposure C Category. The wind speed varies across the state and is basically the same for both ASCE 7-16 and ASCE 7-22 for Risk Category I buildings. The wind loads are generally determined using one of the 2 following procedures:

1. Directional Procedure for building of all heights as specified in Chapter 27.
2. Envelope Procedure for low-rise buildings (enclosed or partially enclosed building with a mean roof height of 60 feet or less and the mean roof height does not exceed the least horizontal dimension) as specified in Chapter 28.

The wind pressure procedure described below is from Chapter 28 of ASCE 7-22. (Envelope Procedure).

Table 28.2-1. Steps to Determine Wind Loads on MWFRS Low-Rise Buildings.

Step 1: Determine risk category of building; see Table 1.5-1.
Step 2: Determine the basic wind speed, V, for applicable risk category; see Figure 26.5-1.
Step 3: Determine wind load parameters:

- Wind directionality factor, K_d; see Section 26.6 and Table 26.6-1.
- Exposure Category (B, C, or D); see Section 26.7.
- Topographic factor, K_{zt}; see Section 26.8 and Figure 26.8-1.
- Ground elevation factor, K_e; see Section 26.9 and Table 26.9-1.
- Enclosure classification; see Section 26.12.
- Internal pressure coefficient, (GC_{pi}); see Section 26.13 and Table 26.13-1.

Step 4: Determine velocity pressure exposure coefficient, K_z or K_h; see Table 26.10-1.
Step 5: Determine velocity pressure, q_z or q_h, from Equation (26.10-1).
Step 6: Determine external pressure coefficient, (GC_{pf}), for each load case using Section 28.3.2 for flat and gable roofs.

User Note: See Commentary Figure C28.3-2 for guidance on hip roofs.

Step 7: Calculate wind pressure, p, from Equation (28.3-1).

1. **Enclosure classification**. This is an important factor in computing wind loads on a building based on the percentage of open areas and its effects on internal pressures. A building can be considered one of 3 classifications:

   a. **Enclosed**: A building is considered "Enclosed" if the area of openings for each wall is the smaller of 4 ft^2 or 1% of the area of that wall.

   b. **Partially Enclosed**: A building is considered "Partially Enclosed" if it meets both of the following conditions:

      1) The total area of openings in one wall exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10% and

      2) The total area of openings in a wall that receives positive external pressure exceeds 4 ft^2 or 1% of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20%

   c. **Open**: A building is considered "Open" has each wall at least 80% open.

2. **Velocity pressure (q_z or q_h)**: The calculation of the velocity pressure is slightly different for ASCE 7-10 and ASCE 7-22.

   q_z = velocity pressure evaluated at height, z

   q_h = q_z calculated at mean roof height, h

   $q_z = 0.00256\ K_z\ K_{zt}\ K_d\ K_e\ V^2$ ASCE 7-10

   $q_z = 0.00256\ K_z\ K_{zt}\ K_e\ V^2$ ASCE 7-22 (K_d comes into play later when determining the design pressure, p)

   (the above equations are in psf where V is in mph) → the factors in these equations are discussed below, other than V (basic wind speed).

   a. **Velocity pressure exposure coefficient** (K_z): A function dependent both on height above ground level and Exposure Category B, C, or D and is determined from Table 26.10-1 in both ASCE 7-16 and ASCE 7-22.

      1) Exposure Class B: applies to buildings with a mean roof height of 30 ft or less and is in an urban, suburban, or wooded area with numerous closely spaced obstructions → K_z = 0.70

      2) Exposure Class C: applies to all cases where B or D do not apply. → K_z = 0.85 from 0 to 15 ft height up to 0.98 at 30 ft height.

      3) Exposure Class D: applies to buildings in flat, unobstructed areas and water surfaces (included smooth mud flats, salt flats, and unbroken ice) → K_z = 1.03 from 0 to 15 ft height up to 1.16 at 30 ft height.

   b. **Topographic factor** (K_{zt}): This factor accounts for the wind speed-up effect caused by a nearby a hill, ridge, or escarpment. This factor is generally equal to 1.0 for relatively flat ground. Figure 26.8-1 of ASCE 7-16 and ASCE 7-22 provides the necessary information for determining K_{zt} for structures on or near a hill, ridge, or escarpment.

   c. **Ground elevation factor** (K_e): This factor is obtained from Table 26.9-1 of ASCE 7-16 and ASCE 7-22 and ranges from 1.00 for buildings at sea level, 0.93 for buildings 2,000 feet above sea level, and 0.8 for buildings 6,000 feet above sea level.

   d. **Wind Directionality factor** (K_d): This factor is obtained from Table 26.6-1 of ASCE 7-16 and ASCE 7-22 and is 0.85 for typical buildings.

3. **Design pressure for determination of wind loads for buildings, psf** (p): The equations for ASCE 7-16 and ASCE 7-22 are slightly different for the design pressure (p):

   $p = q_h\ (GC_{pf} - GC_{pi})$ *(psf)* ASCE 7-16

   $p = q_h K_d\ (GC_{pf} - GC_{pi})$ *(psf)* ASCE 7-22

a. **External pressure coefficient** (GC_{pf}): This is obtained from Figure 28.3-1 (a copy is included on the next page) of both ASCE 7-10 and ASCE 7-16 and is a function of roof pitch, wind direction, and location on building. For a roof pitch of 20deg (2.7:12 pitch), GC_{pf} ranges from +0.8 to -1.07 at different points on the structure. The plus and minus signs signify pressures acting toward and away from the surfaces, respectively.

b. **Internal pressure coefficient** (GC_{pi}): The internal pressure coefficient is obtained from Table 26.13-1 of ASCE 7-16 and ASCE 7-22 and is a function of enclosure classification. The plus and minus signs signify pressures acting toward and away from the surfaces, respectively.

Table 26.13-1. Main Wind Force Resisting System and Components and Cladding (All Heights): Internal Pressure Coefficient, (GC_{pi}), for Enclosed, Partially Enclosed, Partially Open, and Open Buildings (Walls and Roof).

Enclosure Classification	Criteria for Enclosure Classification	Internal Pressure	Internal Pressure Coefficient (GC_{pi})
Enclosed buildings	A_o is less than the smaller of $0.01A_g$ or 4 ft^2 (0.37 m^2), and $A_{oi}/A_{gi} \le 0.2$	Moderate	+0.18 −0.18
Partially enclosed buildings	$A_o > 1.1A_{oi}$, and $A_o >$ the lesser of $0.01A_g$ or 4 ft^2 (0.37 m^2), and $A_{oi}/A_{gi} \le 0.2$	High	+0.55 −0.55
Partially open buildings	A building that does not comply with Enclosed, Partially Enclosed, or Open classifications	Moderate	+0.18 −0.18
Open buildings	Each wall is at least 80% open	Negligible	0.00

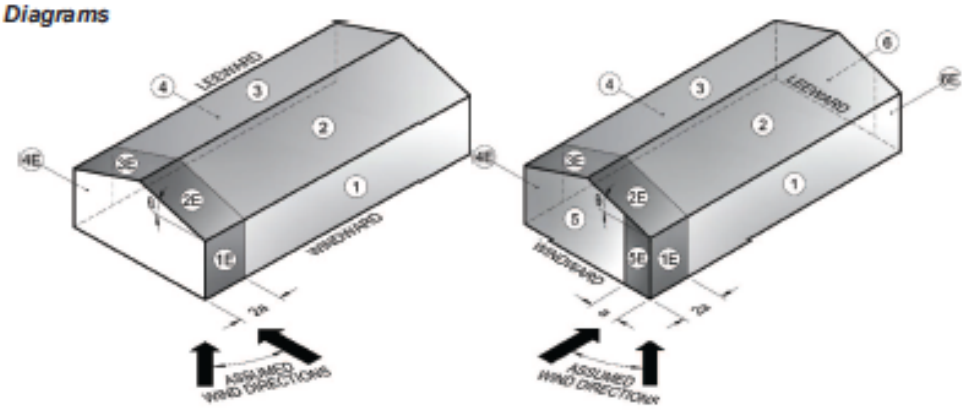
Notes:
1. Plus and minus signs signify pressures acting toward and away from the internal surfaces, respectively.
2. Values of (GC_{pi}) shall be used with q_z or q_h as specified.
3. Two cases shall be considered to determine the critical load requirements for the appropriate condition:
   (a) A positive value of (GC_{pi}) applied to all internal surfaces, or
   (b) A negative value of (GC_{pi}) applied to all internal surfaces.

c. **Wind Directionality factor** (K_d): This factor is obtained from Table 26.6-1 of ASCE 7-16 and ASCE 7-22 and is 0.85 for typical buildings.

Figure below from ASCE 7-22 (GC_{pf} values are the same for ASCE 7-16)

Basic Load Cases

Diagrams



Load Case 1 **Load Case 2**

Notation

a = 10% of least horizontal dimension or 0.4 h, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).
EXCEPTION: For buildings with $\theta = 0$ to 7° and a least horizontal dimension greater than 300 ft (90 m), dimension a shall be limited to a maximum of 0.8 h.

h = Mean roof height, ft (m), except that eave height shall be used for $\theta \leq 10°$.

θ = Angle of plane of roof from horizontal, in degrees.

Load Case 1

Roof Angle θ (degrees)	Building Surface 1	2	3	4	1E	2E	3E	4E
0–5	0.40	–0.69	–0.37	–0.29	0.61	–1.07	–0.53	–0.43
20	0.53	–0.69	–0.48	–0.43	0.80	–1.07	–0.69	–0.64
30–45	0.56	0.21	–0.43	–0.37	0.69	0.27	–0.53	–0.48
90	0.56	0.56	–0.37	–0.37	0.69	0.69	–0.48	–0.48

Load Case 2

Roof Angle θ (degrees)	Building Surface 1	2	3	4	5	6	1E	2E	3E	4E	5E	6E
0–90	–0.45	–0.69	–0.37	–0.45	0.40	–0.29	–0.48	–1.07	–0.53	–0.48	0.61	–0.43

Notes

1. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
2. For values of θ other than those shown, linear interpolation is permitted.

Figure 28.3-1. Basic load cases for main wind force resisting system [$h \leq 60$ ft ($h \leq 18.3$ m)]: external pressure coefficients, (GC_{pf}), for enclosed, partially enclosed, and partially open buildings—low-rise walls and roofs.

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SEISMIC LOADS

Risk Category: In general, roofs for agricultural facilities should be designed for Risk Category I structures. If the operation includes regular access by personnel, then Risk Catgory II could be considered. See Table 1.5-1 (page 3 of this guidance document) for determination of Risk Category.

Earthquake Importance Factor, I_e: See Table 1.5-2 (page 6 of this guidance document). The table is self-explanatory. As noted, both Risk Category I and II are assigned an importance factor of 1.0 for seismic loads.

Site Classification is based on the foundation soils at the structure location. Table 20.2-1 summarizes the various site classification categories. Unless otherwise determined by a site investigation, Site Classification D should be used.

Table 20.2-1. Site Classification.

Site Class	$\bar{v}_s$ Calculated Using Measured or Estimated Shear Wave Velocity Profile (ft/s)
A. Hard rock	>5,000
B. Medium hard rock	>3,000 to 5,000
BC. Soft rock	>2,100 to 3,000
C. Very dense sand or hard clay	>1,450 to 2,100
CD. Dense sand or very stiff clay	>1,000 to 1,450
D. Medium dense sand or stiff clay	>700 to 1,000
DE. Loose sand or medium stiff clay	>500 to 700
E. Very loose sand or soft clay	≥500
F. Soils requiring site response analysis in accordance with Section 21.1	See Section 20.2.1

Note: For SI: 1 ft = 0.3048 m; 1 ft/s = 0.3048 m/s.

Mapped Spectral Response Acceleration:

Short Period: S_{MS}	Figure 22-1	Pages 232-233 of ASCE 7-22
Long Period: S_{M1}	Figure 22-2	Pages 234-235 of ASCE 7-22

For all areas of Wisconsin, values for S_{MS} are less than *0.15g*. For all areas of Wisconsin, values for S_{M1} are less than *0.14g*. For a statewide design, use of this maximum value would be considered acceptable. Use of lesser values at a specific location corresponding with Figures 22-1 and 22-2 is also acceptable.

In ASCE 7-16 and earlier versions, the mapped spectral accelerations, S_s and S_1, were then multiplied by a short-period site coefficient, F_v, and, a long-period site coefficient, F_a, respectively. These multipliers are included in the mapped values presented in Figures 22-1 and 22-2, in ASCE 7-22. It is important that a designer familiar with using ASCE 7-16 does not erroneously multiply the mapped values from ASCE 7-22 by the site coefficients from ASCE 7-16.

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Design Spectral Response Acceleration:

Short Period: S_{DS}	Equation 11.4-1	Page 107 of ASCE 7-22
Long Period: S_{D1}	Equation 11.4-2	Page 107 of ASCE 7-22

The design spectral response acceleration is calculated as 2/3 of the mapped spectral response acceleration

$$S_{DS} = \frac{2}{3} S_{MS} \qquad (11.4\text{-}1)$$

$$S_{D1} = \frac{2}{3} S_{M1} \qquad (11.4\text{-}2)$$

Seismic Design Category:

Short Period:	Table 11.6-1	Page 108 of ASCE 7-22
Long Period:	Table 11.6-2	Page 108 of ASCE 7-22

As the short period Design Spectral Response Acceleration will almost always control the development of a seismic lateral force to be used in the design of agricultural waste storage facility roof structures, these structures will almost always fall under a Seismic Design Category "A" classification.

Table 11.6-1. Seismic Design Category Based on Short-Period Response Acceleration Parameter.

	Risk Category	
Value of S_{DS}	I or II or III	IV
$S_{DS} < 0.167$	A	A
$0.167 \le S_{DS} < 0.33$	B	C
$0.33 \le S_{DS} < 0.50$	C	D
$0.50 \le S_{DS}$	D	D

Table 11.6-2. Seismic Design Category Based on 1 s Period Response Acceleration Parameter.

	Risk Category	
Value of S_{D1}	I or II or III	IV
$S_{D1} < 0.067$	A	A
$0.067 \le S_{D1} < 0.133$	B	C
$0.133 \le S_{D1} < 0.20$	C	D
$0.20 \le S_{D1}$.	D	

Response Modifcation Factor, *R*:

Table 12.2-1	Page 112-114 of ASCE 7-22
Table 12.14-1	Page 140-141 of ASCE 7-22
Table 15.4-2	Page 170-171 of ASCE 7-22

In general, the design of buildings to be constructed with knee or cross-bracing, and, built using commercially available dimension lumber using bolts, screws, or nails as connectors, should use a Response Modification Factor value of 1.0. Wood construction bracing generally functions in both compression and tension, and a tension failure would be considered a non-ductile failure mode. Accordingly, with little or no available ductility, the

Seismic Response Coefficient (see below) should not be reduced by using a larger value for the response modification factor.
In Section G, subsection 6 of Table 12.2-1, a response modification factor of 1.5 is noted for Timber Framed structures. No further definition of a "timber frame" is provided in ASCE 7. Many post-frame (i.e. "pole barn") building designers use a response modification factor of 1.5 for braced wood construction, citing this section of Table 12.2-1.

Seismic Response Coefficient, C_s : For post-frame roof structures, Method 2 will almost always control the selection of the seismic response coefficient.

Section 12.8.1.1, Method 2 Page 124 of ASCE 7-22

Equation 12.8-3 Page 124 of ASCE 7-22

$$C_s = \frac{S_{DS}}{\left(\frac{R}{I_e}\right)} \qquad (12.8\text{-}3)$$

Seismic Base Shear, V : Section 12.8.1 Page 124 of ASCE 7-22

$V = C_s W$ Equation 12.8-1 Page 124 of ASCE 7-22

Seismic base shear is expressed as a percentage of the weight, or mass, of the roof structure. It is applied to a post-frame building, or roof structure, as a load. Values calculated using ASCE 7-22 are for strength, or capacity, design, and utilize a load factor of 1.0. When used for allowable stress design, a load factor of 0.7 should be applied.