TORNADO LOADS – IMPACTS FROM ASCE 7-22

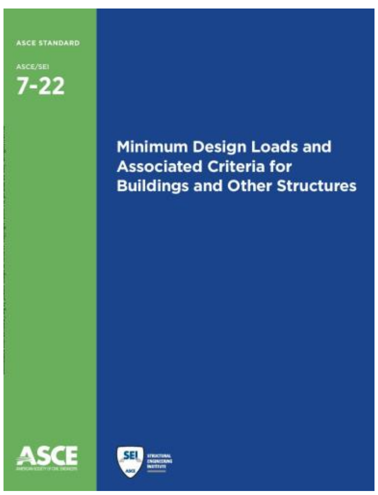
June 2024

OVERVIEW OF THE NEW TORNADO LOAD PROVISIONS IN ASCE 7-22

8TH EDITION (2023) FLORIDA BUILDING CODE, BUILDING

New Tornado Load Requirements in ASCE 7-22

The 8th Edition (2023) Florida Building Code, Building (FBCB) has been updated to reference ASCE 7-22 *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*. One of the key changes in ASCE 7-22 is the addition of new Chapter 32 which specifies tornado loads for buildings and structures. Topics addressed in this fact sheet are as follows:



- Introduction to tornado design.
- Tornado speed (V_T) maps.
- Exceptions to tornado design.
- Impact protection required for tornado design.
- Design parameters.
- Determining when tornado loads control.
- Example calculations.

Introduction to Tornado Design – Chapter 32 in ASCE 7-22

The new tornado load design requirements in ASCE 7-22 apply only to Risk Category III and IV buildings.

> Risk Category III – buildings and structures that represent a substantial hazard to human life in the event of failure.
>
> Risk Category IV – buildings and structures designated as essential facilities.

See Table 1604.5 in the 8th Edition (2023) Florida Building Code, Building for specific buildings and structures included in these Risk Categories.

Two new sections have been added to the 8th Edition (2023) FBCB addressing tornado design:

Non-HVHZ

1609.5 Tornado loads. The design and construction of Risk Category III and IV buildings and other structures shall be in accordance with Chapter 32 of ASCE 7, except as modified by this code.

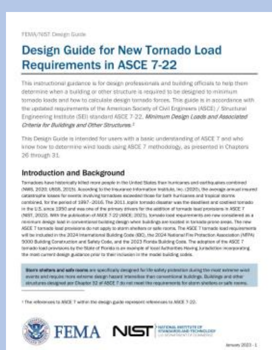
HVHZ

1620.7 Tornado Loads. The design and construction of Risk Category III and IV buildings and other structures shall be in accordance with Chapter 32 of ASCE 7.

FEMA/NIST

Design Guide for New Tornado Load Requirements in ASCE 7-22

For additional information for determining when a building or other structure is required to be design to minimum tornado loads and how to calculate design tornado loads, a free to the public design guide published by FEMA and NIST is available. The FEMA/NIST *Design Guide for New Tornado Load Requirements in ASCE 7-22* provides instructional guidance for design professionals and building officials on the new tornado load requirements in ASCE 7-22. This design guide can be downloaded at https://www.fema.gov/node/design-guide-new-tornado-load-requirements-asce-7-22.



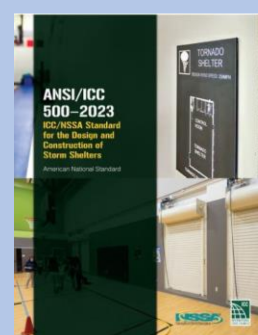
Buildings and structures required to comply with Chapter 32 of ASCE 7-22 are required to be designed and constructed to resist the greater of the tornado loads in Chapter 32 or the wind loads determined in accordance with Chapters 26 through 31 of ASCE 7-22. For brevity in this fact sheet, wind loads determined in accordance with Chapters 26 through 31 of ASCE 7-22 will be referred to as "normal wind loads". For risk category III and IV buildings in the northern part of the state, tornado loads may govern the design of some parts of the building while normal wind loads govern for most of the building components and structural systems. For example, on some buildings where the tornado loads apply, the roof MWFRS may have to be designed for tornado loads and the wall MWFRS designed for normal wind loads.

Tornado Speeds

The tornado loads in Chapter 32 of ASCE 7-22 are based on tornado speeds (V_T) with a return period of 1700 years for Risk Category III and 3000 years for Risk Category IV. These return periods are the same as return periods for the V_{ult} wind speeds in Chapter 16 of the FBCB. Using these return periods, tornado speeds correspond to EF0 to EF2 tornado intensity which are by far the most common tornadoes. While buildings and structures designed in accordance with Chapter 32 of ASCE 7-22 address loads from common weak tornadoes, they do not come close to meeting the more stringent life safety targets adopted for storm shelters. For life safety protection, an ICC 500 consistent storm shelter would need to be provided.

Storm Shelters

To qualify as a storm a shelter a building or structure must be designed and constructed in accordance with ICC 500 *Standard for the Design and Construction of Storm Shelters*.



Chapter 32 in ASCE 7-22 contains 8 tornado speed maps for Risk Category III buildings and 8 tornado speed maps for Risk Category IV buildings. Tornado speeds range in Florida from approximately 50 mph to 108 mph for Risk Category III buildings and approximately 51 mph to 122 mph for Risk Category IV buildings. While the tornado speeds are generally much lower than the V_{ult} design wind speeds, other factors may result in the tornado loads controlling over normal wind loads in some situations. Site-specific tornado speeds, V_T can also be obtained from the ASCE 7 Hazard Tool.

Tornado speeds differ significantly from the V_{ult} design wind speeds. While they are location-specific, they are also based on the "effective plan area" of the building or structure. The effective plan area is the area of the smallest convex polygon enclosing the plan of the building. For essential facilities, the effective plan area also includes detached buildings and structures that maintain the functionality of the essential facility within the polygon.

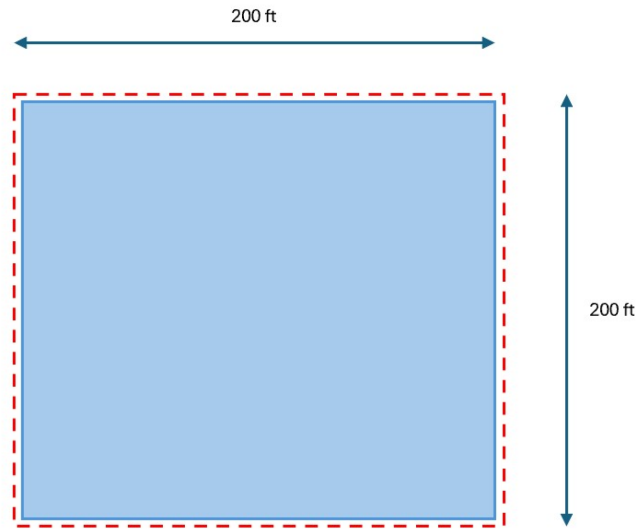
By using the smallest convex polygon enclosing the plan, two buildings may have different floor areas but similar or the same effective plan area. In the example below, Building A and Building B have different net floor areas, but for tornado design have the same effective plan area.

Tornado speed maps are provided in Chapter 32 of ASCE 7-22 for effective plan areas of 1 ft^2, 2,000 ft^2, 10,000 ft^2, 40,000 ft^2, 100,000 ft^2, 250,000 ft^2, 1,000,000 ft^2, and 4,000,000 ft^2. Linear interpolation for effective plan areas between those provide is permitted using the logarithm of the effective plan area.

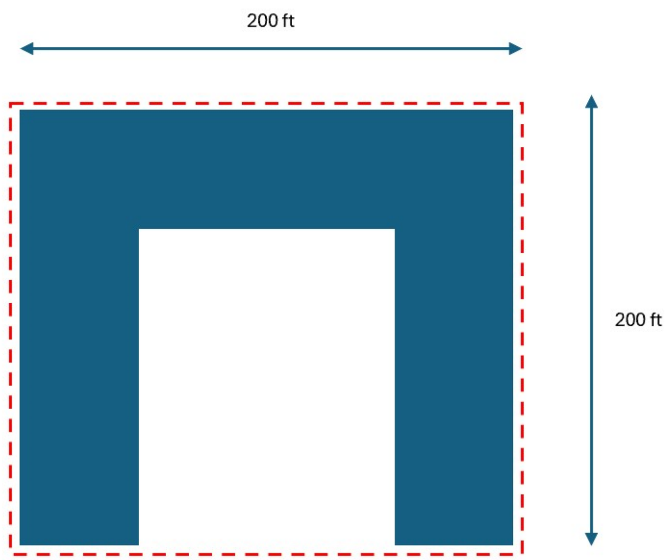
Because tornado impact areas are much smaller than those of hurricanes and other large footprint storms, the probability of a tornado striking some portion of a large or spread-out facility increases as the facility becomes larger. It is somewhat like the increased probability of hitting anywhere on a dart board versus just hitting the bullseye.

Tornado Design Not Required

Design for tornado loads is not required for all Risk Category III and IV buildings and structures. Consideration of tornado loads is not required for buildings and structures located outside of the tornado-prone region (Figure 32.1-1 in ASCE 7-22). Unfortunately, the entire State of Florida is located within the tornado-prone region. However, ASCE 7-22 does provide some additional guidance concerning when tornado design is not required.



Building A
Effective Plan Area = 200 ft x 200 ft = 40,000 ft²



Building B
Effective Plan Area = 200 ft x 200 ft = 40,000 ft²

For example, building and structures that have tornado speeds, $V_T < 60$ mph are not required to be designed for tornado loads. Based on this trigger, Risk Category III buildings in Florida with an effective plan area of 100,000 square feet and less are not required to be designed for tornado loads. For Risk Category IV buildings, design for tornado loads is not required unless the effective plan area is nearly 10,000 square feet.

Design for tornado loads is also not required where the tornado speed, $V_T \geq 60$ mph but less than the following thresholds. Buildings and structures are not required to be designed for tornado loads when the tornado design wind speed is below the indicated percentage of the normal design wind speed for the indicated normal wind design exposure.

Exposure B: $V_T < 0.5V_{ULT}$
Exposure C: $V_T < 0.6V_{ULT}$
Exposure D: $V_T < 0.67V_{ULT}$

These requirements provide approximate triggers on the tornado speed below which the tornado loads will not control any part of the design of the building.

The figures on the following page provide a graphical representation of where design for tornado loads is required for Risk Category III buildings and structures with an effective plan area of 250,000 ft^2. The first figure is for buildings located within Exposure Category B. For Risk Category III buildings located in gray shaded areas, design for tornado loads is not required based on the tornado speed and ultimate design wind speed triggers. In the yellow and orange shaded areas, design for tornado loads is required. It's important to note that even in areas where design for tornado loads is required, the tornado loads may only control over normal wind loads for certain components or elements; but are still required to be checked.

The second figure provides a similar representation but for Exposure Category C. For this condition, tornado design is not required for nearly the entire state. While tornado loads do not change for different wind exposures, normal wind loads do increase significantly from Exposure B to Exposure C which is the reason tornado loads apply to a much smaller portion of the state for buildings designed for normal winds in Exposure Category C compared to Exposure Category B.

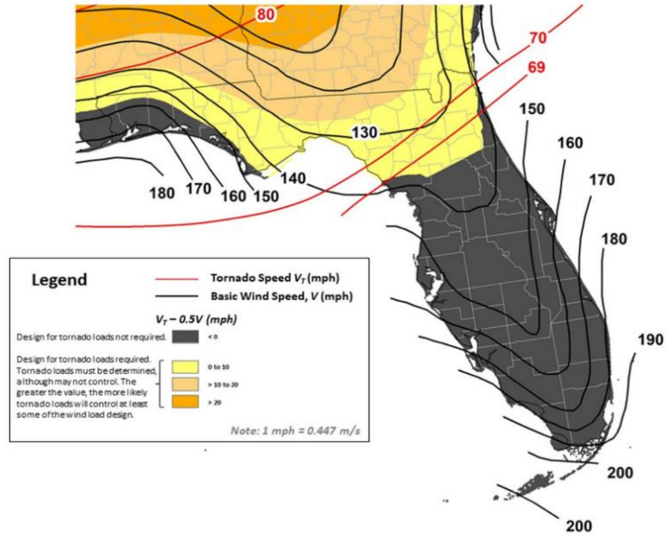
Impact Protection for Tornado Design

Impact protection for glazed openings is optional for Risk Category III buildings and structures and required for Risk Category IV buildings and structures including ancillary buildings and structures required to maintain functionality. While impact protection of glazed openings is not required for Risk Category III buildings and structures, the lack of impact protection will typically result in an enclosure classification of partially enclosed which will necessitate the use of higher negative internal pressure coefficients (See section on Tornado Design Parameters).

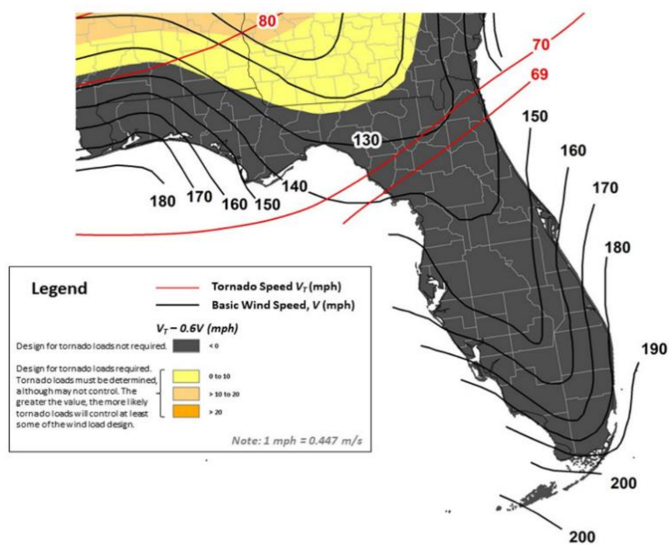
Required impact protection for Risk Category IV buildings and structures is not completely clear in ASCE 7-22 for all circumstances where tornado design is required. Clearly if tornado design is not required ($V_T <$ 60 mph; $V_T < 0.5V_{ULT}$ for Exposure B; ; $V_T < 0.6V_{ULT}$ for Exposure C; or ; $V_T < 0.67V_{ULT}$ for Exposure D) impact protection for Risk Category IV buildings and structures is not required unless it is located in a Wind-borne Debris Region. However, if tornado design is required but does not control over normal wind design for any element, it is not clear in ASCE 7-22 if impact protection for Risk Category IV buildings is still required. One practical interpretation would be that if tornado loads on a Risk Category IV building or structure, calculated assuming a partially enclosed classification, do not control over normal wind loads then, impact protection would not be required. However, design professionals should contact the applicable local jurisdiction regarding this interpretation.

Impact protection for tornado design is permitted to be impact-protective systems (shutters) or impact-resistant glazing. If impact-protective systems are selected, they are required to be permanently mounted. If they are operable, they can only used in buildings that are staffed 24 hours per day and must be deployable from inside the building within 5 minutes.

Testing requirements for tornado impact protection are generally consistent with what is required for hurricanes with a few differences. Impact protective systems and impact-resistant glazing are required to be tested in accordance with ASTM E1886 and ASTM E1996 using missile level D or E (large missile). While normal wind design would permit the use of products tested to missile level A (small missile) for glazed openings located more than 30 feet above grade, tornado design requires products to be tested using the large missile for all heights. Impact protection for tornadoes is required to comply with the Enhanced Protection requirements specified in Table 3 of ASTM E1996 using the tornado speed, V_T, in place of the V_{ULT} wind speed for the determination of the wind zone. Based on the Risk Category III and Risk Category IV tornado speeds in Florida, this effectively requires impact products to be tested using Missile Level D.



ASCE 7-22 V_T and V_{ULT}
Risk Category III
Effective Plan Area = 250,000 ft^2
Exposure B
Source: National Institute of Standards and Technology



ASCE 7-22 V_T and V_{ULT}
Risk Category III
Effective Plan Area = 250,000 ft^2
Exposure C
Source: National Institute of Standards and Technology

Tornado Design Parameters

The determination of tornado loads on buildings and structures is similar to the methods used for normal wind loads with modifications. For the MWFRS, the tornado design equations and procedures correspond to the Directional Procedure of Chapter 27 of ASCE 7-22. The Envelope Procedure, as specified in Chapter 28 of ASCE 7-22, is not permitted to be used for tornado MWFRS design. For components and cladding, the tornado design equations and procedures correspond to the methods specified in Chapter 30 of ASCE 7-22.

The various factors used to determine tornado loads are similar to normal wind loads but with many of the factors adjusted to account for tornadoes.

Tornado Directionality Factor, K_{dT} – the tornado directionality factor varies depending on the element being designed. For the MWFRS, K_{dT} = 0.8. For components and cladding K_{dT} ranges from 1.0 to 0.75.

Tornado Velocity Pressure Exposure Coefficient, K_{zTor} – the tornado velocity pressure exposure coefficient is 1.0 for mean roof heights up to 200 feet. It decreases slightly for mean roof heights that exceed 200 ft.

Tornado Internal Pressure Coefficient, GC_{piT} – Tornado internal pressure coefficients are the same for normal loads except the positive internal pressure coefficient for enclosed buildings is +0.55.

Tornado Pressure Coefficient Adjustment Factor for Vertical Winds, K_{vT} – A new coefficient to account for updrafts that occur in tornadoes. Its value ranges from 1.0 to 1.2 and is essentially a multiplier on the external pressure coefficient.

Impacts on MWFRS and C&C for Buildings Required to be Designed for Tornado Loads

It is important to point out that for most of the State of Florida design for tornado loads will not be required. This is due to the high V_{ULT} wind speeds in Florida relative to the tornado speeds, V_T. The region most likely to require consideration of tornado loads in the design of the building is around the Big Bend area. The V_{ULT} wind speeds are the lowest in this region and depending on factors such as the effective plan area of the building, design for tornado loads may be required.

However, even for buildings that are required to be designed for tornadoes, the tornado loads will not control all aspects of the design of the building for wind. Due to changes in the design wind load parameters for tornado loads, some elements may be controlled by tornado loads and others will not.

Generally, if tornado loads are going to control over normal wind design loads, they tend to show up first in MWFRS or C&C loads with the smallest negative external pressure coefficients. This is easily attributed to the increase in the positive internal pressure from +0.18 to +0.55. Other important changes that increase tornado loads are the specification of K_d = 1.0 for essential facilities and the application of K_{vT} values that are greater than 1.0. Furthermore, if a risk category III building does not have impact resistant or protected windows or doors it has to be designed for tornado loads as a partially enclosed building. The increase in negative internal pressure coefficient to -0.55 from the value of -0.18 used for an enclosed building can result in net positive tornado design pressures exceeding the normal positive design pressures.

Finally, design for tornado winds uses a single definition of K_{zTor} regardless of the terrain exposure classification used in normal design. The value of K_{zTor} is set to 1.0 up to a height of 200-feet. This exceeds the normal wind design value of K_z for terrain exposure B up to about 120-feet and for terrain exposure C up to about 30-feet. The result is that low buildings with a large footprint located on a site that would be considered terrain exposure B are ones that are most likely to have tornado design loads exceed the normal wind design loads.

The increases in design loads, that arise from addressing tornado effects in the design, generally lead to consideration of different loads and load combinations for certain portions of the building. However, designers are reporting that other load effects and typical conservatism in the member/component selection process result in little net impact on the overall design and cost of the building.

The MWFRS and C&C elements that will be among the first to be controlled by tornado loads include the following:

- MWFRS roof uplift where the external pressure coefficients are lower (e.g. >2h from the windward edge).
- Positive pressure situations for Risk Category III buildings where opening protection is not provided.

Determining When Tornado Loads Control

Most of the existing guidance for incorporating tornado design simply directs the engineer to calculate a new set of loads using the tornado design provisions of Chapter 32 and compare the results with normal wind design loads. However, as noted above, the instances where specific tornado loads exceed normal wind design loads may be limited to a few load effects. It is possible to identify which loads may be impacted by tornado design requirements by determining the ratio of tornado wind speeds to normal design wind speeds that produce the same design loads and comparing the ratio obtained to the ratio of V_T to V_{ULT} for the size of the facility and normal terrain exposure at the site.

As an example, consider the ASCE 7-22 MWFRS normal wind design pressure equation [ASCE 7-22 Eq. 27.3-1]

$$p = 0.00256 K_h K_{zt} K_e V_{ult}^2 \left(K_d G C_p - K_d\left(G C_{pi}\right)\right)$$

and the ASCE 7-22 MWFRS tornado wind design pressure equation [ASCE 7-22 Eq. 32.15-1]

$$p_T = 0.00256 K_{hTor} K_e V_T^2 \left(K_{dT} K_{vT} G_T C_p - \left(G C_{piT}\right)\right)$$

Setting p = p_T, it is possible to solve for the ratio of V_T/V_{ULT} where the tornado loads are equal to the normal design wind loads for a particular MWFRS loading.

The following table provides velocity ratio (V_T/V_{ULT}) results as a function of mean roof height for roof uplift loads on a low-slope roof or for winds parallel to the ridge on a roof with any slope. These results are for a building that would be in Exposure Category B for normal wind design. Note that as the roof height increases, K_z, or Kh in this case, for the normal design increases while K_{hTor} remains 1.0. The result is an increase in the tornado wind speed is needed to create the same uplift loads on the roof.

If a large square footprint (300-ft by 300-ft) Risk Category III or IV building with a mean roof height of 50-ft is being designed, then h/L is 0.167 and the values of V_T/V_{ULT} highlighted in yellow would apply to wind loads on various parts of the roof depending on the distance from the roof edge. Now, if the ratio of V_T/V_{ULT} for the site based on the ASCE wind hazard tool was say 0.614 or lower, none of the tornado design roof uplift loads for this case would exceed the normal design wind loads. However, if the ratio of V_T/V_{ULT} at the site were 0.70, then the design uplift loads more than h distance (50-ft) from the roof edge would need to be increased to account for tornado design loads. The amount of increase in loads can also be determined from the ratio information. For the area of the roof between 50-ft and 100-ft from the edge, the ratio of the Site V_T/V_{ULT} (0.70) to equal load V_T/V_{ULT} from the Table (0.663) would be 0.70/0.663 = 1.056. Since pressures depend on velocity squared, the 1.056 is squared to get 1.115. The tornado design roof uplift loads would be 11.5% higher than the normal design uplift loads for this portion of the roof. For areas greater than 2h (100-ft) from the roof edge, the tornado design wind loads would be increased by $(0.70/0.614)^2 = 1.30$, or 30 percent.

MWFRS Low-Slope (θ ≤ 7 Deg.) and Wind Parallel to Ridge - Uplift Loads					
	Wind Exposure B				
	Velocity Ratio V_T/V_{ULT} for Equivalent loads				
	MWFRS Roof Uplift			MWFRS Roof Uplift	
	h/L < 0.5			h/L > 1.0	
Mean Roof Height Feet	0 to h	h to 2h	> 2h	0 to h/2	> h/2
0-15	0.613	0.565	0.523	0.641	0.593
20	0.637	0.587	0.543	0.666	0.616
25	0.657	0.604	0.560	0.686	0.635
30	0.673	0.619	0.574	0.703	0.650
40	0.699	0.644	0.596	0.731	0.676
50	0.720	0.663	0.614	0.753	0.696
60	0.738	0.679	0.629	0.771	0.713
70	0.753	0.693	0.642	0.787	0.728
80	0.767	0.706	0.654	0.801	0.741
90	0.779	0.717	0.664	0.814	0.753
100	0.790	0.727	0.674	0.826	0.764
120	0.809	0.745	0.690	0.846	0.782
140	0.826	0.761	0.704	0.864	0.799
160	0.841	0.774	0.717	0.879	0.813
180	0.854	0.786	0.728	0.893	0.826
200	0.866	0.798	0.739	0.906	0.837
250	0.903	0.828	0.766	0.945	0.871
300	0.935	0.856	0.789	0.981	0.902

Once the tables have been setup for a particular normal design terrain exposure category, the velocity ratios for other normal design terrain exposures just depend on the square root of the ratio between the K_z values for the different terrains [e.g. square root of (K_z Exposure C divided by K_z Exposure B) for a given height]. The following table provides the adjustment factors for velocity ratios listed in the Table above when the normal building design exposure for the site is C or D.

Adjustments to V_T/V_{ULT} Ratios for Exposure C and D Based Designs

Height Above Grade Feet	Ratio Adj. Exposure C	Ratio Adj. Exposure D
0-15	1.219	1.344
20	1.208	1.326
25	1.200	1.313
30	1.193	1.302
40	1.182	1.284
50	1.174	1.271
60	1.167	1.260
70	1.162	1.251
80	1.157	1.244
90	1.152	1.237
100	1.149	1.231
120	1.142	1.221
140	1.137	1.212
160	1.132	1.204
180	1.128	1.198
200	1.124	1.192
250	1.116	1.180
300	1.110	1.170

Note that the velocity ratios where tornado loads equal normal design loads increase substantially when the normal building design is for terrain Exposure C or Exposure D versus those determined for Exposure B.

Tornado Loads Example Calculations

On the following pages, two examples comparing wind pressures from normal wind loads and tornado loads are provided for a building with an effective plan area, A_e, of approximately 250,000 square feet. The first example assumes the building is used as a school which would be classified as Risk Category III. The second example assumes the same building is used as a hospital which would be classified as Risk Category IV. The other details are as follows:

Location: Tallahassee, Florida

Building Use: High School = Risk Category III

Number of stories: 2

Roof: Gable roof with 6:12 pitch

Mean roof height: 50 ft

Exposure Category: B

Glazed openings protected from impact

Conditions where tornado loads are higher than normal wind loads are highlighted in the red cells.

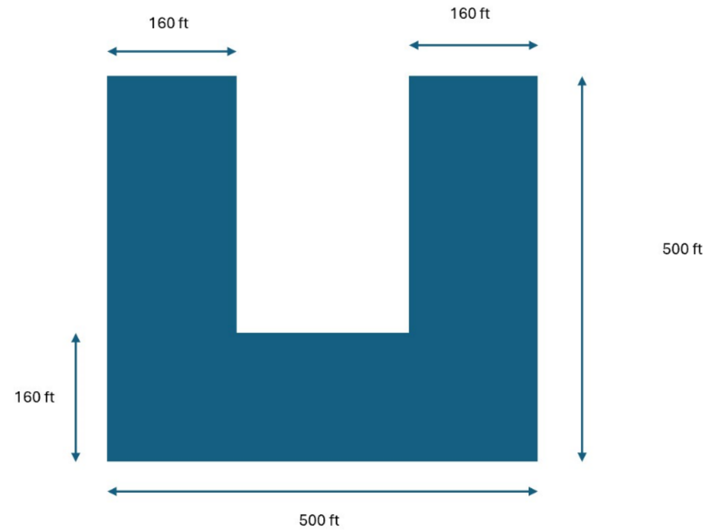
In Example 1, normal wind loads control the design of the building over tornado loads for all conditions except roof uplift for normal to the ridge. However, the loads for roof uplift normal to the ridge are essentially the same (-9.6 psf for normal wind loads and -9.8 psf for tornado loads).

In Example 2, where the same building in Example 1 is now used as a hospital, tornado loads govern over more conditions. Again, however, the increase in loads for tornado design is very small.

Example 1

Building Parameters

Location: Tallahassee, Florida
Building Use: High School = Risk Category III
Number of stories: 2
Roof: Gable roof with 6:12 pitch
Mean roof height: 50 ft
Exposure Category: B
Glazed openings protected from impact



Effective Plan Area, A_e: 500 ft x 500 ft = 250,000 ft^2

ASCE Hazard Tool:

V_{ULT} = 126 mph

V_T = 74 mph

Normal Wind Loads			Tornado Loads		
V_{ULT}	126		V_T	74	
K_{z15}	0.57		K_{zTOR}	1.0	
K_{z30}	0.7				
K_h	0.79				
K_e	1.0		K_e	1.0	
K_{zt}	1.0		K_{zt}	N/A	
$q = 0.00256K_zK_{zt}K_eV^2$			$q_T = 0.00256K_{zTOR}K_eV_T^2$		
	q_{15} = 23.2 psf			q_{hT} = 14 psf	
	q_{30} = 28.5 psf				
	q_h = 32.1 psf				
K_d	0.85		K_{dT} (MWFRS)	0.8	
			K_{dT} (C&C)	0.75	
G	0.85		G_T	0.85	
			K_{vT} (MWFRS)	1.1	
			K_{vT} (C&C)	1.2 Zone 1	
			K_{vT} (C&C)	1.2 Zone 2	
			K_{vT} (C&C)	1.3 Zone 3	
GC_{pi}	+0.18, -0.18		GC_{piT}	+0.55, -0.18	
MWFRS					
$p = qK_dGC_p - qK_d(GC_{pi})$			$p_T = q_{hT}G_TK_{dT}K_{vT}C_p - q_{hT}GC_{piT}$		
Windward wall	C_p = +0.8	p_{15} = 18.3 psf	Windward wall	C_p = +0.8	p_T = 10.2 psf
		p_{30} = 21.4 psf			
		p_h = 23.5 psf			
Leeward wall	C_p = -0.5	p_h = -16.5 psf	Leeward wall	C_p = -0.5	p_T = -12.5 psf
Side wall	C_p = -0.7	p_h = -21.2 psf	Side wall	C_p = -0.7	p_T = -14.4 psf

Roof, normal to ridge (windward)	C_p = -0.2	p_h = -9.6 psf	Roof, normal to ridge (windward)	C_p = -0.2	p_T = -9.8 psf
	C_p = 0.3	p_h = 11.9 psf		C_p = 0.3	p_T = 5.7 psf
Roof, normal to ridge (leeward)	C_p = -0.6	p_h = -18.8 psf	Roof, normal to ridge (leeward)	C_p = -0.6	p_h = -14.0 psf
Roof, parallel to ridge	C_p = -0.9 (0 to h)	p_h = -25.8 psf	Roof, parallel to ridge	C_p = -0.9 (0 to h)	p_T = -17.1 psf
	C_p = -0.5 (h to 2h)	p_h = -16.5 psf		C_p = -0.5 (h to 2h)	p_T = -13.0 psf
Components and Cladding					
$p = q_h K_d[(GC_p) - (GC_{pi})]$			$p_T = q_{hT}[K_{dT} K_{vT}(GC_{piT}) - (GC_{piT})]$		
Walls, 10 ft^2, Zone 5	GC_p = -1.4	p = -43.1 psf	Walls, 10 ft^2, Zone 5	GC_p = -1.4	p_T = -22.4 psf
	GC_p = 1.0	p = 32.2 psf		GC_p = 1.0	p_T = 13.0 psf
Walls, 10 ft^2, Zone 4	GC_p = -1.1	p = -34.9 psf	Walls, 10 ft^2, Zone 4	GC_p = -1.1	p_T = -19.3 psf
	GC_p = 1.0	p = 32.2 psf		GC_p = 1.0	p_T = 13.0 psf
Walls, 100 ft^2, Zone 5	GC_p = -1.1	p = -34.9 psf	Walls, 100 ft^2, Zone 5	GC_p = -1.1	p_T = -19.3 psf
	GC_p = 0.8	p = 26.7 psf		GC_p = 0.8	p_T = 10.9 psf
Walls, 100 ft^2, Zone 4	GC_p = -0.9	p = -29.5 psf	Walls, 100 ft^2, Zone 4	GC_p = -0.9	p_T = -17.2 psf
	GC_p = 0.8	p = 26.7 psf		GC_p = 0.8	p_T = -10.9 psf
Walls, 500 ft^2, Zone 5 and 4	GC_p = -0.8	p = -26.7 psf	Walls, 500 ft^2, Zone 5 and 4	GC_p = -0.8	p_T = -16.1 psf
	GC_p = 0.7	p = 24.0 psf		GC_p = 0.7	p_T = 19.9 psf
Roof, 10 ft^2, Zone 3	GC_p = -3.0	p = -86.8 psf	Roof, 10 ft^2, Zone 3	GC_p = -3.0	p_T = -48.7 psf
	GC_p = 0.6	p = 21.3 psf		GC_p = 0.6	p_T = 8.8 psf
Roof, 200 ft^2, Zone 3	GC_p = -1.4	p = -43.1 psf	Roof, 200 ft^2, Zone 3	GC_p = -1.4	p_T = -26.8 psf
	GC_p = 0.3	p = 13.1 psf		GC_p = 0.3	p_T = 5.7 psf
Roof, 10 ft^2, Zone 2	GC_p = -2.5	p = -73.1 psf	Roof, 10 ft^2, Zone 2	GC_p = -2.5	p_T = -39.3 psf
	GC_p = 0.6	p = 21.3 psf		GC_p = 0.6	p_T = 8.8 psf
Roof, 200 ft^2, Zone 2	GC_p = -1.2	p = -37.7 psf	Roof, 200 ft^2, Zone 2	GC_p = -1.2	p_T = -22.9 psf
	GC_p = 0.3	p = 13.1 psf		GC_p = 0.3	p_T = 5.7 psf
Roof, 10 ft^2, Zone 1	GC_p = -1.5	p = -45.8 psf	Roof, 10 ft^2, Zone 1	GC_p = -1.5	p_T = -26.6 psf
	GC_p = 0.6	p = 21.3 psf		GC_p = 0.6	p_T = 8.8 psf
Roof, 200 ft^2, Zone 1	GC_p = -0.8	p = -26.7 psf	Roof, 200 ft^2, Zone 1	GC_p = -0.8	p_T = -17.8 psf
	GC_p = 0.3	p = 13.1 psf		GC_p = 0.3	p_T = 5.7 psf

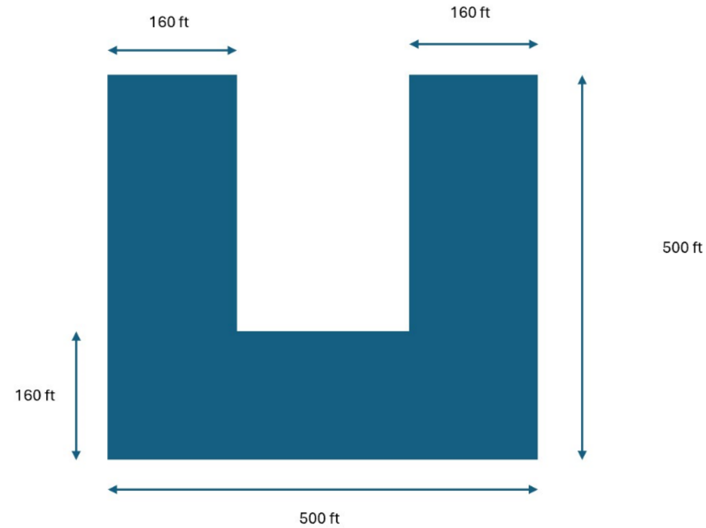
Normal wind loads control

Tornado loads control

Example 2

Building Parameters

Location: Tallahassee, Florida
Building Use: Hospital = Risk Category IV
Number of stories: 2
Roof: Gable roof with 6:12 pitch
Mean roof height: 50 ft
Exposure Category: B
Glazed openings protected from impact



Effective Plan Area, A_e: 500 ft x 500 ft = 250,000 ft^2

ASCE Hazard Tool:

V_{ULT} = 134 mph

V_T = 94 mph

Normal Wind Loads			Tornado Loads		
V_{ULT}	134		V_T	94	
K_{z15}	0.57		K_{zTOR}	1.0	
K_{z30}	0.7				
K_h	0.79				
K_e	1.0		K_e	1.0	
K_{zt}	1.0		K_{zt}	N/A	
$q = 0.00256K_zK_{zt}K_eV^2$			$q_T = 0.00256K_{zTOR}K_eV_T^2$		
	q_{15} = 26.2 psf			q_{hT} = 22.6 psf	
	q_{30} = 32.2 psf				
	q_h = 36.3 psf				
K_d	0.85		K_{dT} (MWFRS)	0.8	
			K_{dT} (C&C)	1.0	
G	0.85		G_T	0.85	
			K_{vT} (MWFRS)	1.1	
			K_{vT} (C&C)	1.2 Zone 1	
			K_{vT} (C&C)	1.2 Zone 2	
			K_{vT} (C&C)	1.3 Zone 3	
GC_{pi}	+0.18, -0.18		GC_{piT}	+0.55, -0.18	
MWFRS					
$p = qK_dGC_p - qK_d(GC_{pi})$			$p_T = q_{hT}G_TK_{dT}K_{vT}C_p - q_{hT}GC_{piT}$		
Windward wall	C_p = +0.8	p_{15} = 20.7 psf	Windward wall	C_p = +0.8	p_T = 16.4 psf
		p_{30} = 24.2 psf			
		p_h = 26.5 psf			
Leeward wall	C_p = -0.5	p_h = -18.7 psf	Leeward wall	C_p = -0.5	p_T = -20.1 psf
Side wall	C_p = -0.7	p_h = -23.9 psf	Side wall	C_p = -0.7	p_T = -23.2 psf

Roof, normal to ridge (windward)	C_p = -0.2	p_h = -10.8 psf	Roof, normal to ridge (windward)	C_p = -0.2	p_T = -15.8 psf
	C_p = 0.3	p_h = 13.4 psf		C_p = 0.3	p_T = 9.1 psf
Roof, normal to ridge (leeward)	C_p = -0.6	p_h = -21.3 psf	Roof, normal to ridge (leeward)	C_p = -0.6	p_T = -22.6 psf
Roof, parallel to ridge	C_p = -0.9 (0 to h)	p_h = -29.2 psf	Roof, parallel to ridge	C_p = -0.9 (0 to h)	p_T = -27.7 psf
	C_p = -0.5 (h to 2h)	p_h = -18.7 psf		C_p = -0.5 (h to 2h)	p_T = -20.9 psf
Components and Cladding					
$p = q_h K_d[(GC_p) - (GC_{pi})]$			$p_T = q_{hT}[K_{dT}K_{vT}(GC_{piT}) - (GC_{piT})]$		
Walls, 10 ft^2, Zone 5	GC_p = -1.4	p = -48.8 psf	Walls, 10 ft^2, Zone 5	GC_p = -1.4	p_T = -44.1 psf
	GC_p = 1.0	p = 36.4 psf		GC_p = 1.0	p_T = 26.7 psf
Walls, 10 ft^2, Zone 4	GC_p = -1.1	p = -39.5 psf	Walls, 10 ft^2, Zone 4	GC_p = -1.1	p_T = -37.3 psf
	GC_p = 1.0	p = 36.4 psf		GC_p = 1.0	p_T = 26.7 psf
Walls, 100 ft^2, Zone 5	GC_p = -1.1	p = -39.5 psf	Walls, 100 ft^2, Zone 5	GC_p = -1.1	p_T = -37.3 psf
	GC_p = 0.8	p = 30.2 psf		GC_p = 0.8	p_T = 22.2 psf
Walls, 100 ft^2, Zone 4	GC_p = -0.9	p = -33.3 psf	Walls, 100 ft^2, Zone 4	GC_p = -0.9	p_T = -32.8 psf
	GC_p = 0.8	p = 30.2 psf		GC_p = 0.8	p_T = 22.2 psf
Walls, 500 ft^2, Zone 5 and 4	GC_p = -0.8	p = -30.2 psf	Walls, 500 ft^2, Zone 5 and 4	GC_p = -0.8	p_T = -30.5 psf
	GC_p = 0.7	p = 27.2 psf		GC_p = 0.7	p_T = 19.9 psf
Roof, 10 ft^2, Zone 3	GC_p = -3.0	p = -98.2 psf	Roof, 10 ft^2, Zone 3	GC_p = -3.0	p_T = -100.7 psf
	GC_p = 0.6	p = 24.1 psf		GC_p = 0.6	p_T = 17.6 psf
Roof, 200 ft^2, Zone 3	GC_p = -1.4	p = -48.8 psf	Roof, 200 ft^2, Zone 3	GC_p = -1.4	p_T = -53.6 psf
	GC_p = 0.3	p = 14.8 psf		GC_p = 0.3	p_T = 10.9 psf
Roof, 10 ft^2, Zone 2	GC_p = -2.5	p = -82.7 psf	Roof, 10 ft^2, Zone 2	GC_p = -2.5	p_T = -80.3 psf
	GC_p = 0.6	p = 24.1 psf		GC_p = 0.6	p_T = 17.6 psf
Roof, 200 ft^2, Zone 2	GC_p = -1.2	p = -42.6 psf	Roof, 200 ft^2, Zone 2	GC_p = -1.2	p_T = -45.0 psf
	GC_p = 0.3	p = 14.8 psf		GC_p = 0.3	p_T = 10.9 psf
Roof, 10 ft^2, Zone 1	GC_p = -1.5	p = -51.9 psf	Roof, 10 ft^2, Zone 1	GC_p = -1.5	p_T = -53.2 psf
	GC_p = 0.6	p = 24.1 psf		GC_p = 0.6	p_T = 17.6 psf
Roof, 200 ft^2, Zone 1	GC_p = -0.8	p = -30.2 psf	Roof, 200 ft^2, Zone 1	GC_p = -0.8	p_T = -34.2 psf
	GC_p = 0.3	p = 14.8 psf		GC_p = 0.3	p_T = 10.9 psf

Normal wind loads control

Tornado loads control

Resources

Florida Building Code, www.floridabuilding.org

International Code Council, www.iccsafe.org

Insurance Institute for Business and Home Safety, www.ibhs.org

American Society of Civil Engineers, www.asce.org

Standard for Design and Construction of Storm Shelters, ANSI/ICC 500-23

Design Guide for New Tornado Load Requirements in ASCE 7-22
https://www.fema.gov/node/design-guide-new-tornado-load-requirements-asce-7-22

Wind Loads: Guide to the Wind Load Provisions of ASCE 7-22
https://sp360.asce.org/personifyebusiness/Merchandise/Product-Details/productId/297599150

Don’t know where to go for an answer to a specific question?

Contact: Florida Building Commission 850-487-1824 www.floridabuilding.org

Contact: Building A Safer Florida, Inc. 850-222-2772 www.buildingasaferflorida.org