1

2

Agenda

ASCE 7

(American Society of Civil Engineers)

- Background
  - ASCE 7 and why it is important for roof wind design
  - ASCE 7 and the IBC
- Building Characteristics
  - Location and Use
  - Physical Parameters
- Changes from ASCE 7-10, ASCE 7-16 & ASCE 7-22

3

Why is ASCE 7 important?

- **The building code (IBC)** requires roof assemblies resist the uplift pressures calculated by the **ASCE 7**
- Independent testing of the assembly **(ANSI/FM 4474)** is used to certify compliance with the **IBC**
- **Rating** achieved by assembly must be **greater than or equal** to the ASCE 7 results.

4

Background

ASCE 7
(American Society of Civil Engineers)

Provides method to calculate building pressure loads (lbs./sqft.) due to:

- Soil
- Hydrostatic Pressure
- Floods
- Snow
- Rain
- Earthquake
- Wind
- Etc.

5

Standard

ASCE 7
(American Society of Civil Engineers)

- 1988 was first edition of the ASCE 7
- Updated – 1993, 1995, 1997, 2002, 2005, 2010, 2016 & 2022

- Latest publication is 1,046-pages
- Roof Systems uplift, approximate 100-pages, explains methods on how to calculated wind loads (lbs./sqft.)

6

Adoption by State

International Code Council (February 2024)

FBC / IBC edition	ASCE 7 edition	States
FBC 2024	2022	FL*
2018 & 2021	2016	AL, AK, AR, CA, CT, FL, GA, HI, ID, LA, MD, MN, MS, MT, NE, NH, NJ, NY, ND, OH, OK, OR, PA, RI, SC, SD, UT, VA, WA, WV, & WY **Total 31 States**
2012 & 2015	2010	IN, IA, KY, ME, MA, MI, NM, NC, TN, TX, VT, & WI **Total 12 States & DC****
2006 & 2009	2005	0
Adopted by Local Governments	??	AZ, CO, DE, IL, KS, MO, & NV **Total 7 States**

*Florida 8th Edition = IBC 2021

**District of Columbia

7

Factors to Determine Uplift

ASCE 7

- **Building location**
  - Wind
  - Terrain
- **Building use**
  - Risk Category
- **Building physical parameters**
  - Height
  - Openings

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Building Location

Terrain & Wind

Terrain

- Exposure
  - "B" = urban/suburban
  - "C" = open terrain
  - "D" = close to a large body of water
- Hills & Escarpments

Wind

- ASCE 7 Basic Wind Maps (Ultimate Winds or Vult)

9

Risk Categories (Building Use)

Risk Categories Ultimate Wind Speed Maps

Risk Category I	Risk Category II	Risk Category III	Risk Category IV
Unoccupied (Barns, Storage Shelters, Gatehouses, etc.)	Not I, III, or IV (Police / Fire Stations, Hospitals, etc.)	High Occupancy (Schools, Health-Care Facilities, etc.)	Eccentrical (Police / Fire Stations, Hospitals, etc.)

For complete definition of each Risk Category, refer to ASCE 7 Table 1.5-1

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Building Physical Parameters
Characteristics

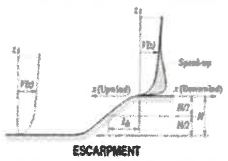
Roof Area
- Height & Slope
- Parapets Heights

Building Structure
- On a hill or precipices
- Building Openings
  - Open, Partially Open, Partially Enclosed, Enclosed
- Building Overhangs

11

Building Location
Hills and Escarpments

Special calculations are required for hills and escarpments:



ESCARPMENT

Note: No calculations available for intensified winds at the end of valleys. Local authorities would need to help.

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Building Physical Parameters
Openings

Consider closely, truck dock doors, breakable windows, or other openings on a single wall with a combined total greater than 4-sq.ft.

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Building Physical Parameters
Openings

Open Building: A building have each wall at least 80% open.

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Basic Information to Determine Uplift
Check List

- Applicable Code and Standard
- Building Location for:
  - Ultimate wind speed
  - Topography
  - Surrounding Terrain
  - Wind Direction
- Building Use
- Building Physical Parameters
  - Height
  - Openings

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Velocity Pressure Formula

ASCE 7-10: $q_z = 0.00256 \times K_z \times K_{zt} \times K_d \times V^2 \times 0.6$

ASCE 7-16: $q_z = 0.00256 \times K_z \times K_{zt} \times K_e \times K_d \times V^2 \times 0.6$

ASCE 7-22: $q_z = 0.00256 \times K_z \times K_{zt} \times K_e \times K_d \times V^2 \times 0.6$

- q_z = velocity pressure
- 0.00256 = numerical coefficient (air density)
- K_z = exposure coefficient evaluated at height
- K_{zt} = topographic factor
- K_d = wind directionality factor
- V = basic ultimate wind speed
- 0.6 = allowable stress factor
- K_e = Elevation Factor

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Design Pressure Calculations
(Zonal Pressure Calculation)

$P = q_z [(GC_p) - (GC_{pi})]$

- P = Design Pressure for each roof Zone
- GCp = external pressure coefficient & gust-effect factor
- GCpi = internal pressure coefficient & gust-effect factor

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ASCE 7-2010, 7-2016, & 7-2022

Minimum Design Loads and Associated Criteria for Buildings and Other Structures

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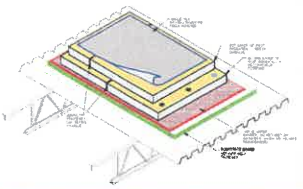
ASCE 7-10, 7-16, & 7-22
Cladding and Components

Both standard refer to roofing systems and materials as cladding. Roofing assemblies are not structural members.



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ASCE 7 Similarities
Chapters

ASCE-7 edition	2010	2016	2022
Chapter(s)	Chapters 26-31	Chapters 26-31	Chapters 26-32
General Requirements	X	X	X
MWFRS* (Directional Procedure)	X	X	X
MWFRS* (Envelope Procedure)	X	X	X
Appurtenances and Other Structures (Directional Procedure)	X	X	X
Components and Cladding	X	X	X
Wind Tunnel Procedure	X	X	X
Tornado			X

*MWFRS: Main Wind Force Resistance System

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ASCE 7
Chapter 26 – General Requirements

ASCE-7 edition	2010	2016	2022
Scope	X	X	X
Definitions	X	X	X
Ultimate Wind Speed Maps	X	X	X
Wind Directionality Factor	X	X	X
Exposure	X	X	X
Gust Factor	X	X	X
Topographic Factor	X	X	X
Elevation Above Sea Level Factor		X	X

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ASCE 7

Chapter 30 – Components & Cladding

ASCE-7 edition	2010	2016	2022
Analytical Method (h <= 60-ft)	X	X	X
Simplified Method (h<= 60-ft)	X	X	Removed
Analytical Method (h> 60-ft)	X	X	X
Simplified Method (h <= 160-ft)	X	X	Removed
Internal Pressure Coefficient (GCpi)	X	X	X
External Pressure Coefficient (GCp)	X	X	X

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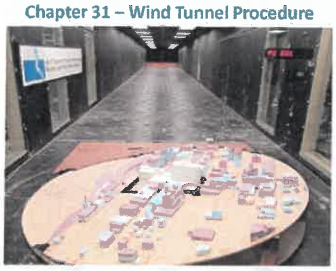
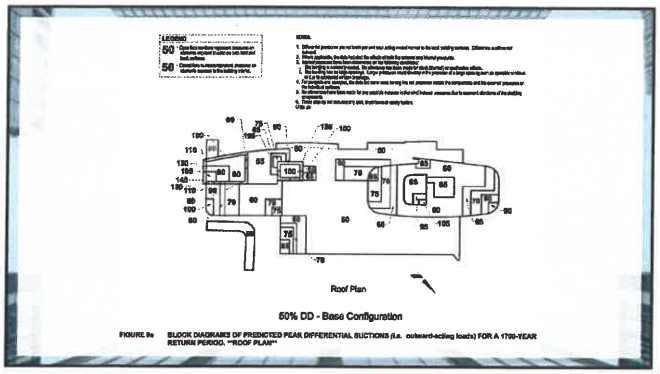
ASCE 7

Chapter 31 – Wind Tunnel Procedure



23

24



25

ASCE 7-2016

Minimum Design Loads and Associated Criteria for Buildings and Other Structures

26

ASCE 7-16

Adjusted from ASCE 7-10

- Adjusted the Calculations
- Reduced Exposure "B" Kz factor for bldg. heights < 30-ft
- New Wind Speed Maps (4 sets)
- New Roof Area Zones (60-ft or less in height)
- Higher GCp for 60-ft or less height

Incorporate in IBC 2018 & 2021

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ASCE 7-16
Modified Uplift Equation

ASCE 7-10

$qz = 0.00256 \times Kz \times Kzt \times Kd \times V2$

ASCE 7-16

$qz = 0.00256 \times Kz \times Kzt \times Ke \times Kd \times V2$

Ke = Ground Elevation Factor

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ASCE 7-16

Table 26.9-1 Ground Elevation Factor, K_e

Ground Elevation above Sea Level ft	K_e
<0	See note 2
0	1.00
1,000	0.96
2,000	0.93
3,000	0.90
4,000	0.86
5,000	0.83
6,000	0.80
>6,000	See note 2

Note:
1. The conservative approximation Ke = 1.00 is permitted in all cases
2. The factor Ke shall be determined using interpolation or from another formula

Can reduce uplift from 4% to 20% depending on elevation above sea level

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ASCE 7-16
Modified Kz Factor for less than 30-ft high

Table 26.10-1 Velocity Pressure Exposure Coefficients, K_h and K_z

Exposure B	C	D
0.57 (0.70)[a]	0.85	1.03
0.62 (0.70)[a]	0.90	1.08
0.66 (0.70)[a]	0.94	1.12
0.70	0.98	1.16

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ASCE 7-10 & 7-16 Wind Maps

Risk Category Based

ASCE 7-10

Based on Risk Category (use of bldg.) return period:

- Risk Cat I: (US = 105-mph)
- Risk C… …nph)
- R…

3,000-year *MRI means
1/3000 chance in one year of wind of this wind speed may happen.
(0.00033)

ASCE…

Based…

- …
- Ris… …<)
- Risk Cat II… …00-mph <)
- Risk Cat IV: 3,000-year MRI (US = 105-mph <)

*Mean Recurrence Interval

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ASCE 7-10 & 7-16 Wind Maps

3-Sec Peak Gust Wind

ASCE 7-2010
Risk Category III/IV

ASCE 7-2016
Risk Category IV

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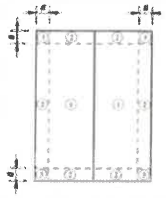
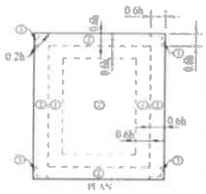
ASCE 7-10 & 7-16

Roof Zone Layout (60-ft or less)



- a = 0.4 x height or 0.1 x width, whichever is less, but not less than 0.04 x width or 3-ft.



- Zone 1' = "One Prime"
- 0.6 x height for all areas, except corner which is 0.2 x height

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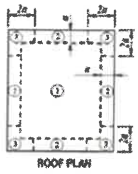
ASCE 7-10, 7-16, & 7-22
Roof Zone Layout (greater than 60-ft)



a = 0.1 x width, but not less than or 3-ft.

34

ASCE 7-16 & 7-22
GCp = external pressure coefficient

Design Pressure Calculations

- P (pressure) = q_z [$(GC_p) - (GC_{pi})$]
- GC_p = external pressure coefficient & gust-effect factor
- GC_{pi} = internal pressure coefficient & gust-effect factor

GCp is determined based on roof zones:

Roof Zones for Bldgs. 60 or less	ASCE 7-10 GCp Coefficient
Zone 1	1
Zone 2	1.8
Zone 3	2.8

Roof Zones for Bldgs. 60 or less	ASCE 7-16 & 7-22 GCp Coefficient
Zone 1'	0.9
Zone 1	1.7
Zone 2	2.3
Zone 3	3.2

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ASCE 7-16 & 7-22
GCpi = internal pressure coefficient

Opening Types	Amount of Openings	GCpi Coefficient
Enclosed	Less than 10%	.18
Partially Enclosed	10% to 20%	.55
Partially Open	Does not comply with the others	.18
Open	80%	0

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ASCE 7 Calculations
Wind Loads on the Roof

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Examples
Determine the forces exposed to a roof using ASCE 7-16 Calculations

Chapter 30 Components and Cladding Examples

- **Part 1 – Analytical method for h ≤ 60 ft**
- Part 2 – Simplified method for h ≤ 60 ft
- **Part 3 – Analytical method for h > 60 ft**
- Part 4 – Simplified method for h ≤ 160 ft

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Building Configuration

Location: Concord, NC
Building Elevation: 597-ft
Exposure Category: "C" Flat open terrain
Building Height: 40-ft
Parapet Height: 18-inches
Roof Width: 200-ft
Roof Length: 400-ft
Enclosure Type: Enclosed
Occupancy: Risk Category IV

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Analytical Method for $h \leq 60$ ft

ASCE 7-16 Calculation for Wind Loads on a Roof

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ATC Hazards by Location

Search Information

Address:	Concord, NC, USA
Coordinates:	35.4087917, -80.579511
Elevation:	704 ft
Timestamp:	2024-10-10T13:26:30.165Z
Hazard Type:	Wind

ASCE 7-16		ASCE 7-10		ASCE 7-05	
MRI 10-Year	73 mph	MRI 10-Year	70 mph	ASCE 7-05 Wind Speed	90 mph
MRI 25-Year	81 mph	MRI 25-Year	84 mph		
MRI 50-Year	88 mph	MRI 50-Year	90 mph		
MRI 100-Year	93 mph	MRI 100-Year	96 mph		
Risk Category I	103 mph	Risk Category I	105 mph		
Risk Category II	111 mph	Risk Category II	115 mph		
Risk Category III	119 mph	Risk Category III-IV	120 mph		
Risk Category IV	124 mph				

http://hazards.atcouncil.org

Except for Oregon

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ASCE 7-16

$$qz = 0.00256 \times Kz \times Kzt \times Ke \times Kd \times V^2$$

- 0.00256 = numerical coefficient to be used except where sufficient climatic data are available
- Kz = velocity pressure exposure coefficient evaluated at height z = h
- Kzt = Topographic factor
- Ke = Elevation above sea level
- Kd = wind directionality factor
- V^2 = basic ultimate wind speed base on Risk Category

$$P \text{ (pressure)} = q_z [(GC_p) - (GC_{pi})]$$

- GC_p = external pressure coefficient & gust-effect factor
- GC_{pi} = internal pressure coefficient & gust-effect factor

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Kz
(TABLE 26.10-1)

Table 26.10-1 Velocity Pressure Exposure Coefficients, K_h and K_z

Height above Ground Level, z		Exposure		
ft	m	B	C	D
0-15	0-4.6	0.57 (0.70)[a]	0.85	1.03
20	6.1	0.62 (0.70)[a]	0.90	1.08
25	7.6	0.66 (0.70)[a]	0.94	1.12
30	9.1	0.70	0.98	1.16
40	12.2	0.76	1.04	1.22
50	15.2	0.81	1.09	1.27
60	18.0	0.85	1.13	1.31

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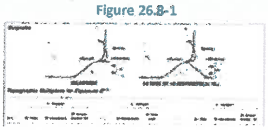
Kzt
Topographical Factor
Figure 26.8-1



$Kzt = (1+K_1K_2K_3)^2$

- K1 = Factor to account for shape of topographic feature and maximum speed-up effect.
- K2 = Factor to account for reduction in speed-up with distance upwind or downwind of crest.
- K3 = Factor to account for reduction in speed-up with height above local terrain.

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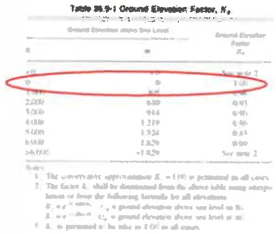
Ke
Elevation Factor

Table 26.9-1 Ground Elevation Factor, K_e



45

Kd

Wind Directionality

Table 26.6-1

Table 26.6-1 Wind Directionality Factor, K_d

Structure Type	Directionality Factor K_d
Buildings	
[illegible] and Cladding	0.85
Arched Roofs	0.85
Circular Domes	1.0
Chimneys, Tanks, and Similar Structures	
Square	0.90
Hexagonal	0.95
Octagonal	1.0
Round	1.0
Solid Freestanding Walls, Roof Top Equipment, and Solid Freestanding and Attached Signs	0.85
Open Signs and Single-Plane Open Frames	0.85
Trussed Towers	
Triangular, square, or rectangular	0.85
All other cross sections	0.95

Directionality factor K_d = 0.85 shall be permitted for round or octagonal structures with [illegible] structural systems.

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Velocity Pressure Calculation

$qz = 0.00256 \times Kz \times Kzt \times Ke \times Kd \times V^2$

Variable	Building	ASCE 7-16
Kz	Height & Terrain	1.04
Kzt	Topographic	1
Kd	Wind Directionality	0.85
Ke	Elevation above Sea Level	1
V	Risk Cat Maps	124-mph
q_z	**Results**	**34.8-lbs/sqft**

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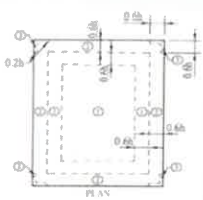
Wind Load

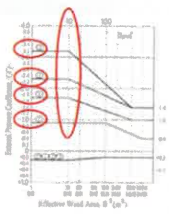
Calculating Uplift Pressure

$P = qz \{ GCp - Gcpi \}$

- Gcp = External Pressure Coefficient (Table 30.3-2A)



- 0.6 x height for all areas, except corner which is 0.2 x height



ASCE 7-16

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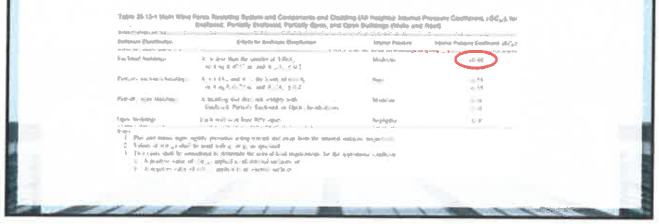
Wind Load

Calculating Uplift Pressure

$P = qz \{ GCp - GCpi \}$

- GCpi = Internal Pressure Coefficient (Table 26.13-1)



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Calculating Uplift Pressure

$P = qz \{ GCp - GCpi \}$

Roof Area	qz	GCp	GCpi	Ult. Strength Result in Lbs/Sqft
Zone 1'	34.8	-0.9	0.18	-37.6
Zone 1	34.8	-1.7	0.18	-65.4
Zone 2	34.8	-2.3	0.18	-86.3
Zone 3	34.8	-3.0	0.18	-117.6

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ASCE Ultimate Wind Maps

ASCE 7-10 & ASCE 7-16

ASCE 7-05 results where Allowable Stress Design, while 7-10, 7-16, & 7-22 results are Ultimate Strength

Allowable Stress Design (Vasd)

Are nominal loads for cladding so as not to exceed the structure. Roofing assemblies are defined as cladding.

Ultimate Strength (Vult)

Are the strength loads necessary for structural members

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ASCE Ultimate Wind Maps

Allowable vs. Ultimate

ASCE 7-10 & 7-16 Results are Ultimate Strength Pressures (Ult.)

But...

Cladding uses **Allowable Stress Design Pressures (ASD)**, how is this determined?

ASD = ASCE 7-16 Ult. results x 0.6

Or

Convert wind speed back to Allowable for Calculations

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International Building Code:

Editions 2012, 2015, 2018, 2021 & 2024

1609.3.1 Wind speed conversion. When required, the ultimate design wind speeds of Figures 1609A, 1609B and 1609C shall be converted to nominal design wind speeds, V_{asd}, using Table 1609.3.1 or Equation 16-33.

$V_{asd} = V_{ult}\sqrt{0.6}$ = Vult x 0.775 (Equation 16-33)

TABLE 1609.3.1
WIND SPEED CONVERSIONS[a, b, c]

V_{ult}	100	110	120	130	140	150	160	170	180	190	200
V_{asd}	78	85	93	101	108	116	124	132	139	147	155

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Design Pressure

Roof Area	ASCE 7-16 Results in lbs/sqft.
Zone 1'	-37.6 x 0.6= **-22.5**
Zone 1	-65.4 x 0.6 = **-39.3**
Zone 2	-86.3 x 0.6 = **-51.8**
Zone 3	-117.6 x 0.6 = **-70.6**

Ultimate or strength-based wind speeds are used in the wind speed maps. Apply 0.6 factor for allowable stress design

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Building Configuration

Location: St. Petersburg, FL
Building Elevation: 597-ft
Exposure Category: "D" within 1 mile of the ocean
Building Height: 100-ft
Parapet Height: 24-inches
Roof Width: 200-ft
Roof Length: 400-ft
Enclosure Type: Enclosed
Occupancy: Risk Category IV

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Analytical Method for h > 60 ft

ASCE 7-16 Calculation for
Design Pressures on a Roof

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ASCE 7-16

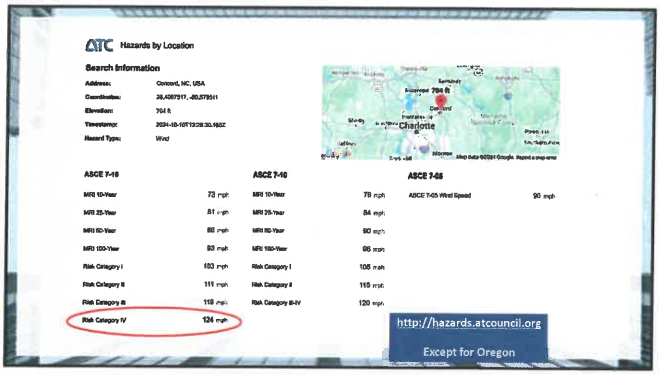
$$qz = 0.00256 \times Kz \times Kzt \times Ke \times Kd \times V^2$$

- 0.00256 = numerical coefficient to be used except where sufficient climatic data are available
- Kz = velocity pressure exposure coefficient evaluated at height z = h
- Kzt = Topographic factor
- Ke = Elevation above sea level
- Kd = wind directionality factor
- V^2 = basic ultimate wind speed base on Risk Category

$$P \text{ (pressure)} = q_z [(GC_p) - (GC_{pi})]$$

- GC_p = external pressure coefficient & gust-effect factor
- GC_{pi} = internal pressure coefficient & gust-effect factor

57


ATC Hazards by Location
Search Information
Address:
Coordinates:
Elevation:
Timestamp:
Hazard Type:
Wind
ASCE 7-16
MRI 10-Year 73 mph
MRI 25-Year 81 mph
MRI 50-Year 88 mph
MRI 100-Year 93 mph
Risk Category I 103 mph
Risk Category II 111 mph
Risk Category III 118 mph
Risk Category IV 124 mph
ASCE 7-10
MRI 10-Year 78 mph
MRI 25-Year 84 mph
MRI 50-Year 90 mph
MRI 100-Year 96 mph
Risk Category I 105 mph
Risk Category II 113 mph
Risk Category III-IV 120 mph
ASCE 7-05
ASCE 7-05 Wind Speed 90 mph
Charlotte
http://hazards.atcouncil.org
Except for Oregon

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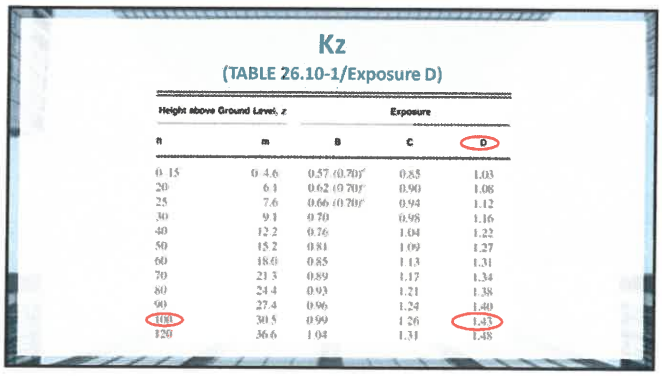
Kz
(TABLE 26.10-1/Exposure D)
Height above Ground Level, z
Exposure
ft
m
B
C
D
0-15 0-4.6 0.57 (0.70)* 0.85 1.03
20 6.1 0.62 (0.70)* 0.90 1.08
25 7.6 0.66 (0.70)* 0.94 1.12
30 9.1 0.70 0.98 1.16
40 12.2 0.76 1.04 1.22
50 15.2 0.81 1.09 1.27
60 18.0 0.85 1.13 1.31
70 21.3 0.89 1.17 1.34
80 24.4 0.93 1.21 1.38
90 27.4 0.96 1.24 1.40
100 30.5 0.99 1.26 1.43
120 36.6 1.04 1.31 1.48

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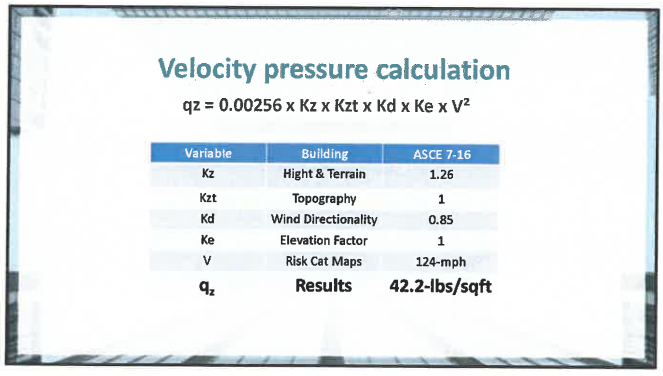
Velocity pressure calculation
qz = 0.00256 x Kz x Kzt x Kd x Ke x V²
Variable | Building | ASCE 7-16
Kz | Hight & Terrain | 1.26
Kzt | Topography | 1
Kd | Wind Directionality | 0.85
Ke | Elevation Factor | 1
V | Risk Cat Maps | 124-mph
qz | Results | 42.2-lbs/sqft

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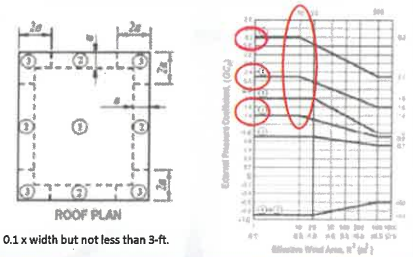
GCp Coefficient
Figure 30.5-1



0.1 x width but not less than 3-ft.

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Gcpi Coefficient
Table 26.13-1

Enclosure Classification	Internal Pressure Coefficient, (GC_{pi})
Enclosed buildings	+0.18 −0.18
Partially enclosed buildings	+0.55 −0.55
Partially open buildings	+0.18 −0.18
Open buildings	0.00

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Calculating Design Pressure

$$P = qz \{ GCp - GCpi \}$$

Roof Area	qz	GCp	GCpi	Result in Lbs/Sqft
Field	42.2	-1.4	0.18	-66.6
Perimeter	42.2	-2.3	0.18	-104.6
Corner	42.2	-3.2	0.18	-142.5

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Design Pressure

Roof Area	ASCE 7-16 Results in Lbs/Sqft
Field	-66.6 x 0.6= -40.0
Perimeter	-104.6 x 0.6 = -62.7
Corner	-142.5 x 0.6 = -85.5

Ultimate or strength-based wind speeds are used in the wind speed maps. Apply 0.6 factor for allowable stress design

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ASCE 7-2022

Minimum Design Loads and Associated Criteria for Buildings and Other Structures

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ASCE 7-22

Adjusted from ASCE 7-16

- **Adjusted** the Calculations (moving wind directionality factor)
- **Removed Simplified Methods** to determine uplift pressures
- **New** Roof Area Zones for Steep Sloped Roofs
- **New Chapter 32 on Tornados Loads**
- **New Calculations** for tornados
- **New Maps** for tornados

Incorporate in IBC 2024

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ASCE 7-22

Velocity Pressure

$q_z = 0.00256 \times K_Z \times K_{Zt} \times K_e \times V^2 \times 0.6$

0.00256 = numerical coefficient to be used except where sufficient climatic data are available
K_Z = velocity pressure exposure coefficient evaluated at height z = h from Table 26.10-1
K_{Zt} = topographic factor as defined in Figure 26.8-1
K_e = ground elevation factor in Table 26.9-1
V^2 = basic wind speed obtained from Fig. 26.5-1A through 26.5-1C.
0.6 = load factor to convert to allowable stress design Section 2.4.1 combination 5a assuming D = 0

Design Pressure (Zonal Pressures)

$P = q_z \times K_d \times [(GC_p) - (GC_{pi})]$

GC_p = external pressure coefficient & gust-effect factor from Figure 30.3-24 (60-ft or less & Slope 7° or less)
GC_{pi} = internal pressure coefficient & gust-effect factor in Table 26.13-1
K_d = wind directionality factor in Table 26.6-1

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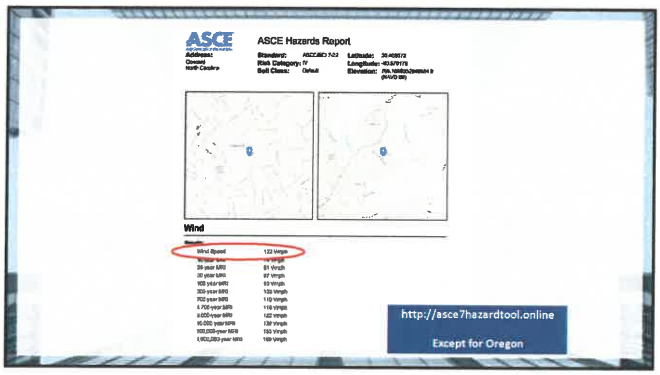

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Vasd Wind Load: ASCE 7-16 vs 7-22

Concord, NC

40-ft high
Exposure "C"
Enclosed Bldg
Category IV

	ASCE 7-16	ASCE 7-22
Vult Wind Speed	124-mph	122-mph
Zone 1'	23 psf	22 psf
Zone 1	40 psf	38 psf
Zone 2	52 psf	51 psf
Zone 3	71 psf	69 psf

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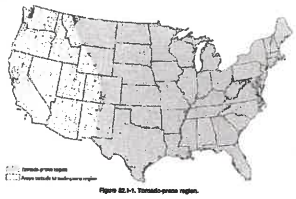
Tornado Loads



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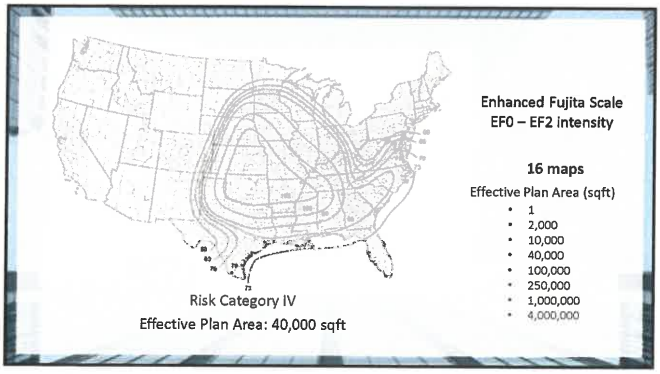

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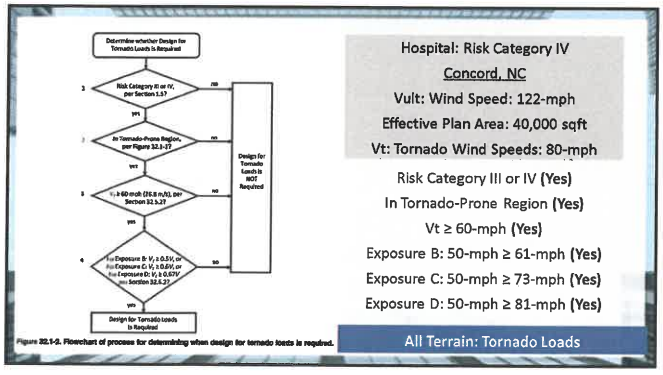

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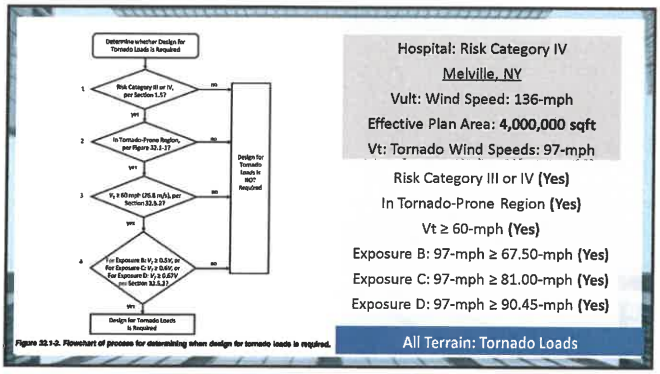

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Results ASCE 7-22 "Wind" vs. "Tornado"

Concord, NC

40-ft high
Exposure "C"
Enclosed Bldg
Category IV
Effective Plan Area: 4,000,000 sqft

	ASCE 7-22	ASCE 7-22 Tornado Loads
	Vult: 122-mph	Vt: 80-mph
Zone 1'	22 psf	16 psf
Zone 1	38 psf	26 psf
Zone 2	51 psf	30 psf
Zone 3	69 psf	39 psf

Results above are all ASD

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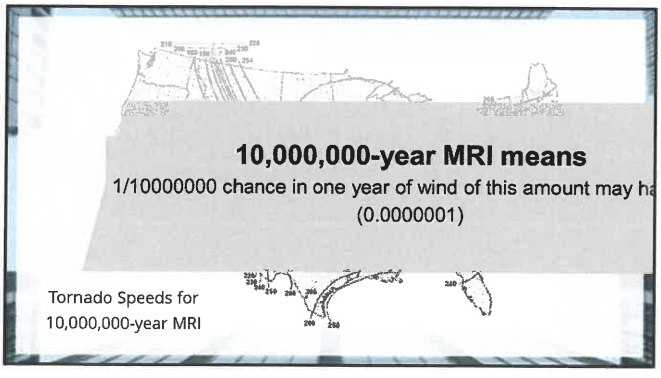

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