ASCE 7 Wind Design: 7-16 Changes and 7-22 Preview

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ASCE Wind Loads

ASCE 7-16
- Wind Maps
- Roof Pressure Coefficients
- Elevation Factor
- Canopies
- Solar PV
- Irregular Buildings
- Rooftop Equipment h>60’
- Screenwalls

ASCE 7-22
- NCSEA Wind Engineering Committee
- Updates
- Tornadoes
- Performance-Based Design

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ASCE 7-16

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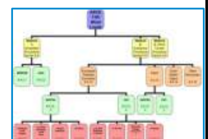
ASCE Wind Loads



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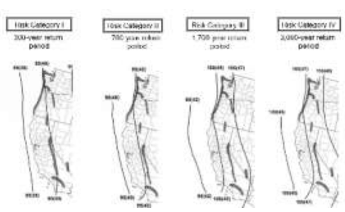
Wind Maps

1. Separate return period maps for Risk Category III and IV structures
2. New conterminous US maps, incorporating
   - Completely new analysis of non-hurricane winds
   - Revised hurricane modeling affecting northeast
   - Revised/Corrected Special Wind Regions
3. Revised Alaska maps
4. New maps for Hawaii, incorporating topographic effects
5. Web-based tools for wind speed determination



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Wind Maps

Reliability analysis conducted to estimate return periods needed to achieve target reliability indexes.

(Analysis conducted by Dr. Terri McAllister, ASCE 7 Load Combinations Subcommittee)

Risk Category	Target Beta (Ch. 1)	ASCE 7-10 Map MRI (years)	ASCE 7-16 Map MRI (years)
I	2.50	300	300
II	3.00	700	700
III	3.25	1,700	1,700
IV	3.50	1,700	3,000

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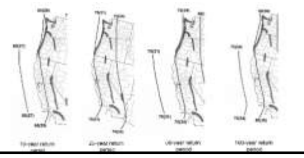
Wind Maps

- Incorporated analysis of additional wind climate data for non-hurricane winds
  - More stations and more years of data
  - Account for terrain exposure at anemometer locations
- Revised inland winds developed using threshold exceedance approach (Pintar and Simiu, 2014)
- Updated hurricane model for northeast coast
- Replaced all 7 existing maps
  - Standard (300, 700, 1700-yr) and Commentary (10, 25, 50, 100-yr)
- Added a new 3,000-year map for RC IV structures



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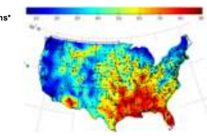
Wind Maps

- Improved Data Analysis: Accounting for Storm Type
  - Non-hurricane winds are broken down into thunderstorm and non-thunderstorm for analysis, then recombined as statistically independent
  - Separate distributions for different storm types (Lombardo et al., 2009)
  - Similar to how hurricane and non-hurricane winds are treated separately in the previous ASCE 7 map analyses

% of Annual Maximum Wind Speeds from Thunderstorms*

Extreme wind climate dominated by different storm types in different parts of the country



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Wind Maps

- 50 Year MRI Non-hurricane Smoothed Wind Speeds

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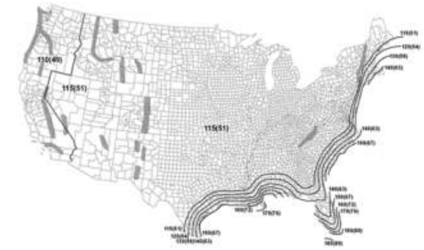
Wind Maps

- 700 Year (Risk Cat II) Map in ASCE 7-10



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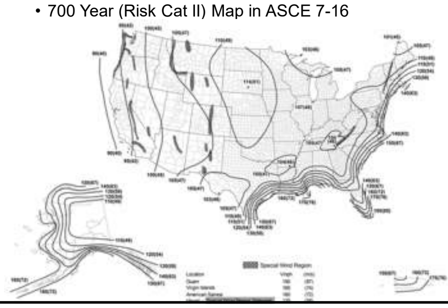
- 700 Year (Risk Cat II) Map in ASCE 7-16



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Wind Maps

- ASCE 7-10 Risk Category III and IV Map

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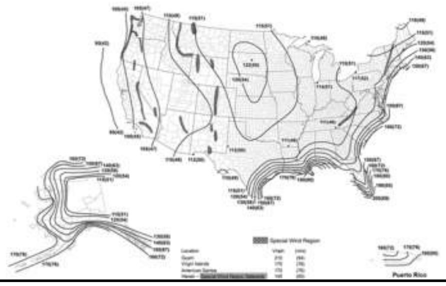
Wind Maps

- 1,700 Year (Risk Cat III) Map in ASCE 7-16



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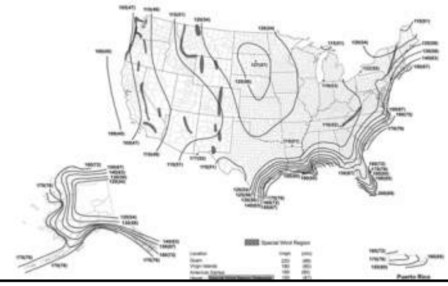
Wind Maps

- 3,000 Year (Risk Cat IV) Map in ASCE 7-16



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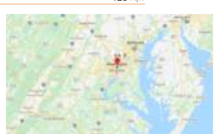
Wind Maps

ASCE 7-10	Select a dataset to view contours.
MRI 10-Year	76 mph
MRI 25-Year	84 mph
MRI 50-Year	90 mph
MRI 100-Year	96 mph
Risk Category I	105 mph
Risk Category II	115 mph
Risk Category III-IV	120 mph



ASCE 7-16	Select a dataset to view contours.
MRI 10-Year	76 mph
MRI 25-Year	81 mph
MRI 50-Year	87 mph
MRI 100-Year	94 mph
Risk Category I	103 mph
Risk Category II	111 mph
Risk Category III	119 mph
Risk Category IV	124 mph

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Wind Maps

- Net Effects of Map Changes
  - Hurricane Prone Regions
    - Wind speeds decrease along northeast coast
    - No changes to hurricane contours from the Carolinas to Texas
      - Except interior (landward) contours where transitioning to non-tropical storms controlling
    - No changes to Puerto Rico and island territories
  - Locations not Controlled by Hurricanes
    - Maps now better reflect regional variation in extreme wind climate
    - Wind speeds in Great Plains states nearly unchanged
    - Wind speeds decrease for the rest of the country, significantly so on the west coast

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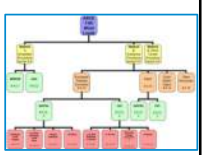

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Roof Pressure Coefficients

- Background
  - The low-rise C&C provisions in ASCE 7-10 are largely based on ground-breaking wind tunnel studies conducted at University of Western Ontario in the late 1970s
  - Since then, there has been a significant increase in knowledge of the aerodynamics of low-rise buildings, and validation of wind tunnel studies using full-scale field experiments.
  - Higher turbulence levels were required to have wind tunnel studies match full-scale data. The early studies lead to pressure coefficients which were too low in magnitude when compared to full-scale.
  - The Texas Tech University field studies changed our understanding, indicating higher levels of turbulence.

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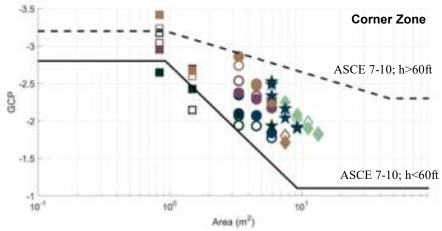
Roof Pressure Coefficients

- Evaluation of ASCE 7-10, roof C&C



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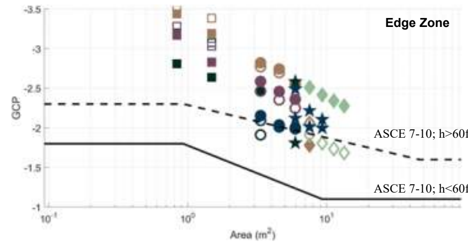
Roof Pressure Coefficients

- Evaluation of ASCE 7-10, roof C&C



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Roof Pressure Coefficients

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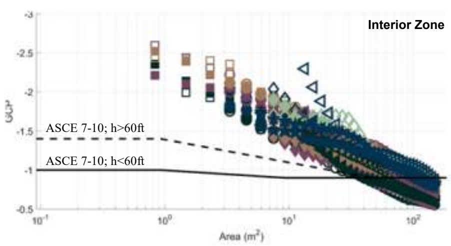

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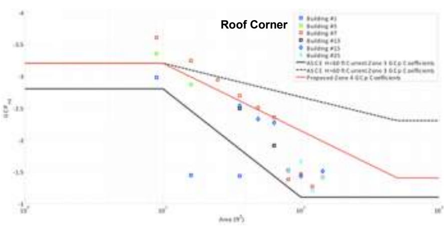
Roof Pressure Coefficients

- Coefficients for ASCE 7-16



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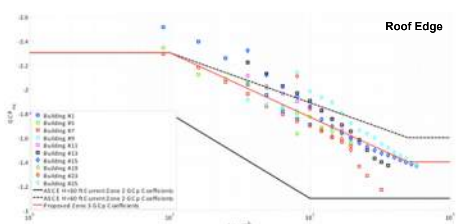
Roof Pressure Coefficients

- Coefficients for ASCE 7-16



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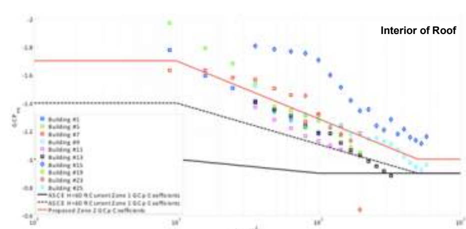
Roof Pressure Coefficients

- Coefficients for ASCE 7-16



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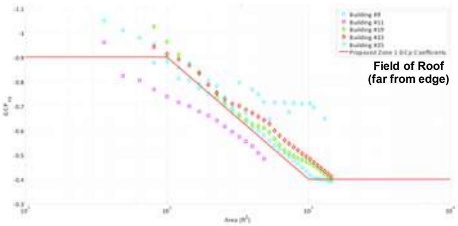
Roof Pressure Coefficients

- Coefficients for ASCE 7-16



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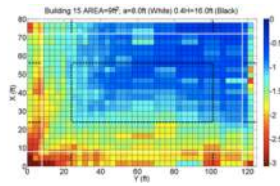
Roof Pressure Coefficients

- Evaluation of ASCE 7-10, roof C&C
  - Enveloped *GCp* values for tributary areas of 9 ft²
  - Building plan dimensions of **80 ft x 125 ft** in open-country terrain
  - The white lines corresponds to the current ASCE 7 definitions for the roof zones

BUILDING HEIGHT = 40 FT



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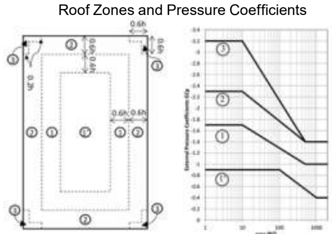
Roof Pressure Coefficients

- Zoning for ASCE 7-16

Roof Zones and Pressure Coefficients



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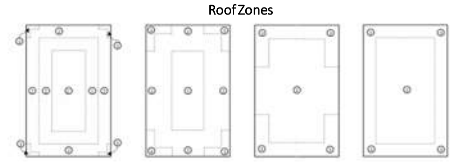
Roof Pressure Coefficients

- Zoning for ASCE 7-16

Roof Zones



Roof zones for buildings with (left) *L/h* > 2.4, (left-center) 1.2 < *L/h* < 2.4, (right-center) *L/h* < 1.2 and *W/h* > 1.2, and (right) *L/H* < 1.2 and *W/h* < 1.2

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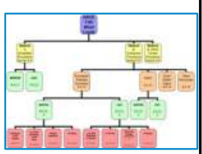

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Elevation Factor

- In Commentary for previous editions.

Table 26.9-1 Ground Elevation Factor, K_e

Ground Elevation above Sea Level		Ground Elevation Factor
ft	m	K_e
<0	<0	See note 2
0	0	1.00
1,000	305	0.96
2,000	610	0.93
3,000	914	0.90
4,000	1,219	0.86
5,000	1,524	0.83
6,000	1,829	0.80
>6,000	>1,829	See note 2

$$q_z = 0.00256 K_z K_{zt} K_d K_e V^2 \ (\text{lb/ft}^2);\ V \text{ in mi/h} \qquad (26.10\text{-}1)$$

- Anaheim Hills is approximately at elevation 410'→ K_e = 0.98
- Denver, CO is approximately at elevation 5,280' → K_e = 0.82
- K_e permitted to always be taken as 1.0

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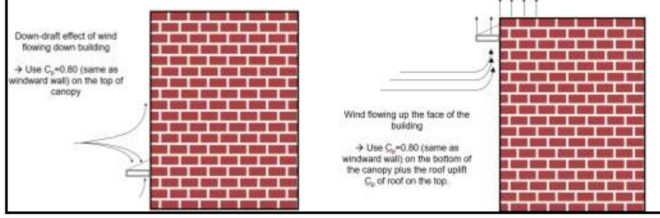
Canopies

Wall Pressure Coefficients, C_p			
Surface	L/B	C_p	Use With
Windward Wall	All values	0.8	q_z
Leeward Wall	0-1	-0.5	q_h
	2	-0.3	
	≥4	-0.2	
Side Wall	All values	-0.7	q_h



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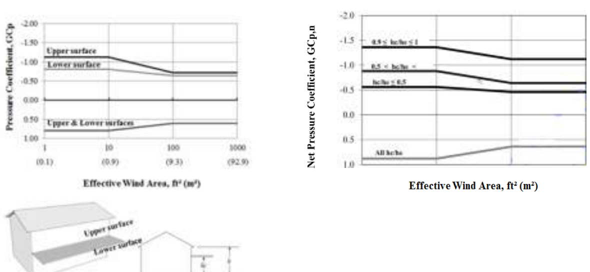
Canopies



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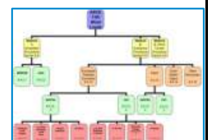

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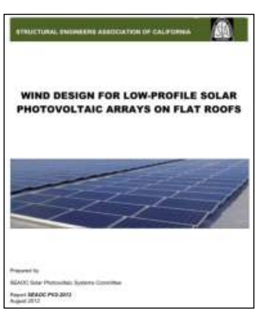
Solar PV



ASCE 7-16

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Solar PV

- The SEAOC PV committee was formed in September 2011.
- Goal: To address the lack of requirements in the code for PV systems.

2012:
- PV1-2012: Seismic Design
- PV2-2012: Wind Design → ASCE 7-16 incorporates and adopts PV2-2012

2016:
- PV2-2016: Supersedes PV2-2012
- References ASCE 7-16
- Knowledge from research since 2012
- Updated terminology, effective wind area determination, wind tunnel requirements
- In some cases, "recommended additional requirements" where the ASCE 7-16 requirements may not be adequate.

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Solar PV

Guide DOES Cover:
- Arrays with tilted panels on flat or low-slope roof buildings (Section 4)
- Parallel-to-roof (flush-mounted) arrays on sloped roofs (Section 5)
- Ground-mounted solar arrays (Section 8)

Guide DOES NOT Cover:
- Roof-mounted systems with tilted panels that are not low-profile
- Arrays on other roof shapes (e.g. hip, gable, saw-tooth, etc.)

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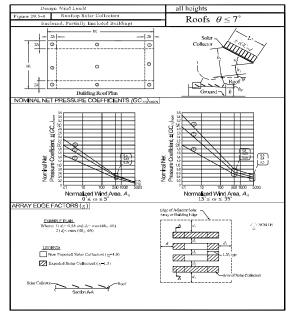
Solar PV



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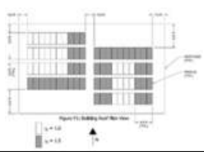
Solar PV

SEAOC PV2-2016 Examples

Steps:
- Roof wind zones
- Normalized wind area (A_n)
- Nominal net pressure coefficient ($(GC_{rn})_{nom}$)
- Parapet factor (γ_p)
- Chord factor (γ_c)
- Edge factor (γ_E)
- Effective wind area (A) and design wind pressure (p)
- Design of an unattached (ballast-only) array to resist uplift
- Design of an unattached (ballast-only) array to resist sliding
- Parallel-to-roof (flush-mounted) modules



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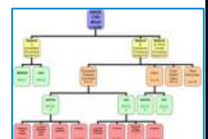

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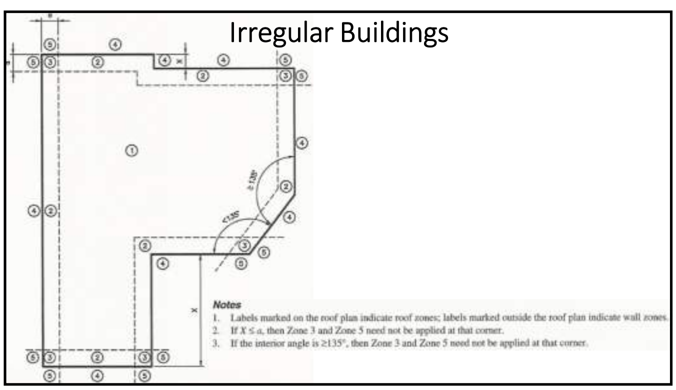
Irregular Buildings



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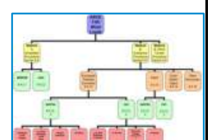

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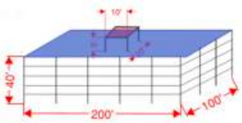
Rooftop Equipment H>60'



$$F_h = q_h(GC_r)A_f \quad 1.0 \le (GC_r) \le 1.9$$
$$F_v = q_h(GC_r)A_r \quad 1.0 \le (GC_r) \le 1.5$$

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Rooftop Screenwalls

Poll: What wind pressure do you use to design a rooftop screenwall?

a) Rooftop Structures and Equipment?

29.5.1 ROOFTOP STRUCTURES AND EQUIPMENT FOR BUILDINGS WITH $h \le 60$ ft (18.3 m)

The lateral force F_h on rooftop structures and equipment located on buildings with a mean roof height $h \le 60$ ft (18.3 m) shall be determined from Eq. 29.5-2.

$$F_h = q_h(GC_r)A_f \text{ (lb) (N)} \quad (29.5\text{-}2)$$

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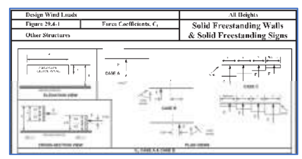
Rooftop Screenwalls

Poll: What wind pressure do you use to design a rooftop screenwall?

a) Rooftop Structures and Equipment?

b) Solid Freestanding Sign (with adjustment)?



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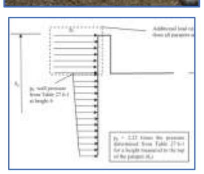
Rooftop Screenwalls

Poll: What wind pressure do you use to design a rooftop screenwall?

a) Rooftop Structures and Equipment?

b) Solid Freestanding Sign (with adjustment)?

c) Parapet Pressures?



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Rooftop Screenwalls

ASCE 7-16: New Commentary

C29.4.1: Mechanical equipment screens commonly are used to conceal plumbing, electrical, or mechanical equipment from view… and located away from the edge of the building roof such that they are not considered parapets… Though the use of equipment screens is prevalent, little research is available to provide guidance for determining wind loads on screen walls and equipment behind screens. Accordingly, rooftop screens, equipment behind screens, and their supports and attachments to buildings should be designed for the full wind load determined in accordance with Section 29.4.1.

Where substantiating data have been obtained using the Wind Tunnel Procedure (Chapter 31), design professionals may consider wind load reductions in the design of rooftop screens and equipment. For example, studies by Zuo et al. (2011)and Erwin et al. (2011) suggest that wind loads on some types of screen materials and equipment behind screens may be overestimated by the equations defined in Section 29.4.

29.4.1 Rooftop Structures and Equipment for Buildings. The lateral force, F_h, and vertical force, F_v, for rooftop structures and equipment, except as otherwise specified for roof-mounted solar panels (Sections 29.4.3 and 29.4.4) and structures identified in Section 29.4, shall be determined as specified following.

The resultant lateral force, F_h, shall be determined from Eq. (29.4-2) and applied at a height above the roof surface equal to or greater than the centroid of the projected area, A_f.

$$F_h = q_h(GC_r)A_f \text{ (lb)} \quad (29.4\text{-}2)$$

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ASCE 7-16 Wind Load Impacts

Effects vary across the US based on new roof pressure coefficients, new design wind speeds, new elevation factor.

Review (4) locations across the US and compare to ASCE 7-10

1. Miami, FL
2. Nashville, TN
3. Casper, WY
4. San Francisco, CA

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ASCE 7-16 Wind Load Impacts

1. Miami, FL
   1. Basic Wind Speed = 171 mph
   2. Exposure D
   3. Elevation = 3'

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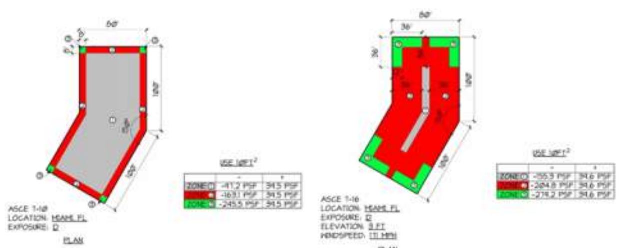
ASCE 7-16 Wind Load Impacts

1. Miami, FL



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ASCE 7-16 Wind Load Impacts

2. Nashville, TN
   - Basic Wind Speed = 105 mph
   - Exposure B
   - Elevation = 500'

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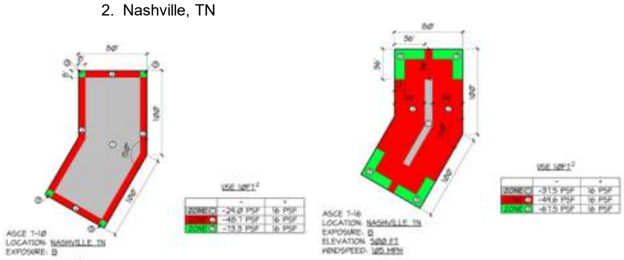
ASCE 7-16 Wind Load Impacts

2. Nashville, TN



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ASCE 7-16 Wind Load Impacts

3. Casper, WY
   - Basic Wind Speed = 108 mph
   - Exposure B
   - Elevation = 5,150'

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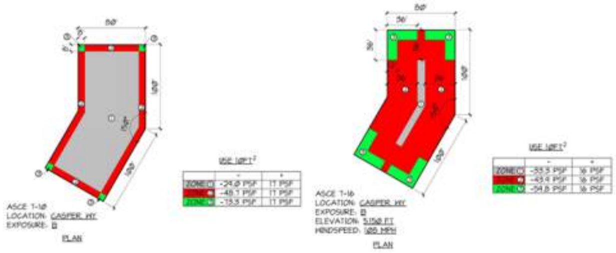
ASCE 7-16 Wind Load Impacts

3. Casper, WY



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ASCE 7-16 Wind Load Impacts

4. San Francisco, CA
   - Basic Wind Speed = 92 mph
   - Exposure B
   - Elevation = 34'

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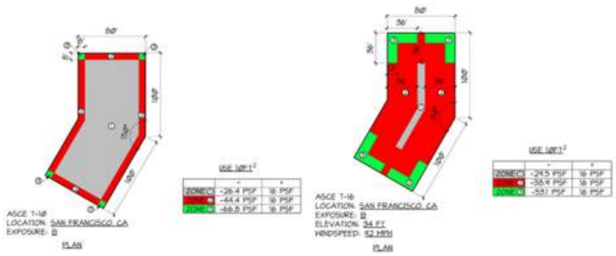
ASCE 7-16 Wind Load Impacts

4. San Francisco, CA



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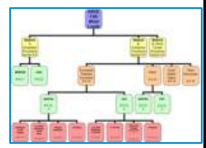
ASCE Wind Loads



ASCE 7-16
- Wind Maps
- Roof Pressure Coefficients
- Elevation Factor
- Canopies
- Solar PV
- Irregular Buildings
- Rooftop Equipment h>60'
- Screenwalls

ASCE 7-22
- NCSEA Wind Engineering Committee
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- Tornadoes
- Performance-Based Design

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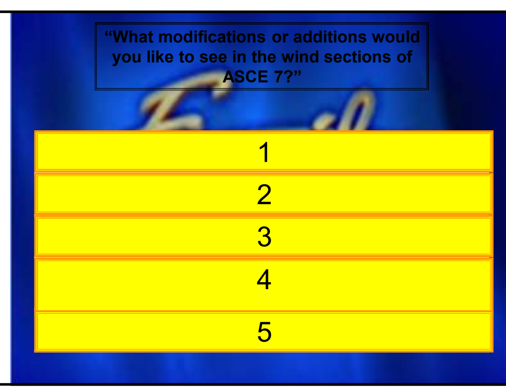
NCSEA Wind Engineering Committee:

2011: NCSEA Code Survey

- 9,500 engineers
- 10% response rate

59



60

NCSEA Recommendations to ASCE 7:

1. Reduce Number of Methods to one (1) Computational Method and one (1) Tabular Method.

2. Consolidate Wind Provision from ASCE 7 and IBC into ASCE 7 and simplify the provisions.

3. Provide criteria for commonly encountered conditions (Canopies, Tall Parapets, Mechanical Screens, PV Panels).

4. Provide design procedures for RTUs on buildings > 60'.

5. Simplify free-standing wall provisions.

6. Provide guidance for irregular building configurations.

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NCSEA Recommendations to ASCE 7:

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2017: NCSEA Code Survey

- 10,000 engineers
- > 10% response rate

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NCSEA Wind Survey

"What is the primary method you use for determining wind loads on structures?"

ANSWER CHOICES
Chapter 27, Part 1: Directional Procedure, Buildings of All Heights
Chapter 27, Part 2: Directional Procedure, Simple Diaphragm Buildings h<160 ft
Chapter 28, Part 1: Envelope Procedure, Low-Rise Buildings
Chapter 28, Part 2: Envelope Procedure, Low-Rise Simple Diaphragm Buildings
Chapter 31: Wind Tunnel Procedure
TOTAL

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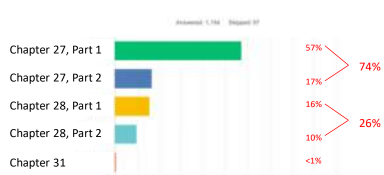
NCSEA Wind Survey

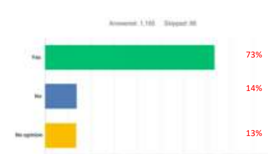
"What is the primary method you use for determining wind loads on structures?"



65

NCSEA Wind Survey

"Are you in favor of reducing the number of methods in ASCE 7 for determining wind loads on structures to (1) computational method and (1) tabular method?"



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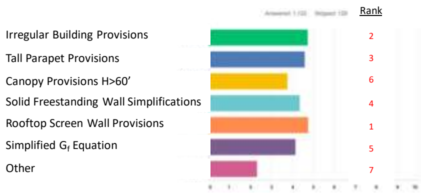
NCSEA Wind Survey

"Please rank in order of importance the following modifications or additions you would like to see in wind design sections of IBC/ASCE 7?"



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NCSEA Wind Survey

1. *SIMPLIFY!* (75 of 130 comments)

1. Eliminate Tabular Procedures (21 of 130 comments)
   - *"I'd prefer just one computational method and NO tabular method."*
   - *"We don't use the tabular method, it's a waste of space in our books…"*
   - *"Don't believe tabular methods should be used. Seen other engineers have not understanding of actual wind flow / dynamics. Simplified tables encourage a lack of understanding by PE's."*
   - *"I go into convulsions every time I use the wind provisions. Too many tables, too many variables, too many distinct methods, too many exceptions, too many footnotes, too many opportunities to make mistakes."*
   - *"Get rid of the "simplified methods". They just bloat the book."*
   - *"Reduce the number of methods."*
   - *"Eliminate all other procedures from MWFRS loads so that the directional method is the only procedure available to users."*

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NCSEA Wind Survey

3. Other Needs:
- Canopies / Open Structures
  - → ASCE 7-16
- Rooftop Equipment / Screens
  - → ASCE 7-16
- Solar Panels
  - → ASCE 7-16
- Direction on what constitutes a corner in an irregularly shaped building.
  - → ASCE 7-16
- Include IBC method in ASCE 7 or remove it entirely.
  - → IBC 2018
- Industrial Structures, Light / Flag Poles
- Design procedures for tornadoes.
- Drift requirements.
- Performance Based Design

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NCSEA Wind Survey

NCSEA Recommendations to ASCE 7-22 Wind Load Committee:

1. Remove the tabular methods (Chapter 27, Part 2 & Chapter 28, Part 2) from the ASCE 7 and move them to the ASCE Wind Design Guide.
2. Remove Chapter 28 Part 1 from the body of the Standard to an Appendix and is referenced from the body of the Standard.
3. Add provisions for common building elements: tall parapets, mechanical screen walls, irregular buildings, open structures, canopies on tall buildings.
4. Simplify the provisions as much as possible!

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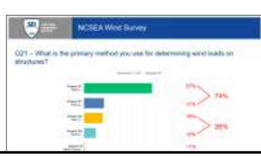
NCSEA Wind Engineering Committee:

ASCE 7-22 Wind Provisions Update



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NCSEA Wind Engineering Committee:

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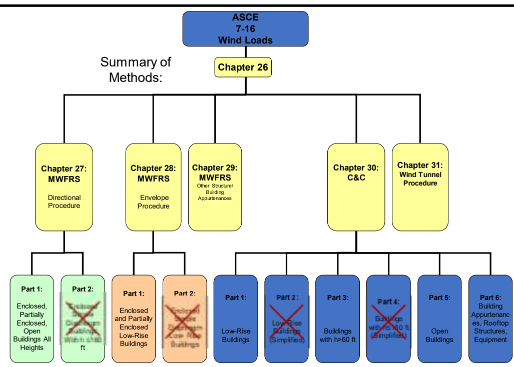

73

NCSEA Wind Engineering Committee:

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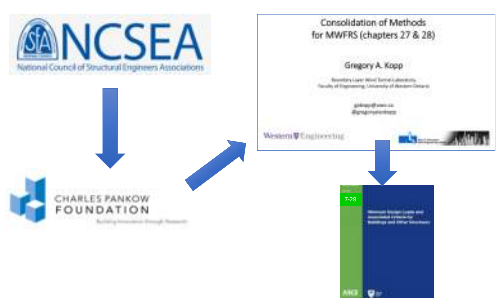
NCSEA Wind Engineering Committee:



75

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ASCE Wind Loads

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ASCE 7-22
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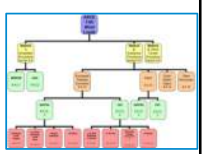

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ASCE 7-22 Updates

Chapter 26:
- Risk Category I – IV map updates
- Hawaii, Puerto Rico, USVI: ASCE Wind Geodatabase
- Long return period maps
- K_d moving from Chapter 26 (out of q_z) to Chapters 27, 28, 29, 30 (into p)

Chapter 26:

$q_z = 0.00256 K_z K_{zt} \not{K_d} K_e V^2 (\text{lb/ft}^2); V \text{ in mi/h}$ (26.10-1)

Chapter 27:

$p = q \underline{K_d} GC_p - q_i \underline{K_d} (GC_{pi})$

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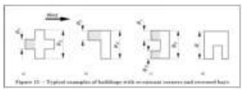
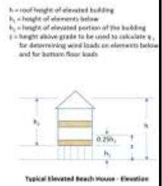
ASCE 7-22 Updates

Chapter 27:
- Elevated buildings
- Commentary for non-rectangular buildings

Chapter 28:
- Commentary for non-rectangular buildings

Chapter 29:
- Rooftop and ground-mounted solar



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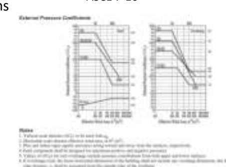
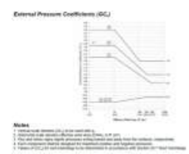
ASCE 7-22 Updates

Chapter 30
- Revisions to GC_p graphs
- Canopies on h>60'

Chapter 31
- ASCE 49: Wind Tunnel Studies for Buildings and Other Structures





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ASCE Wind Loads

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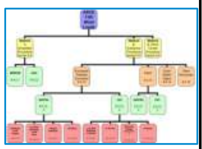

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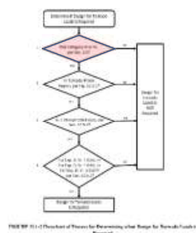
ASCE 7-22 Tornados

Chapter 32: Tornado Loads



Risk Category I and II structures.

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ASCE 7-22 Tornados

Chapter 32 – Tornado Loads

Outside tornado-prone region?

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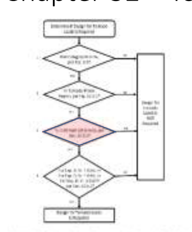
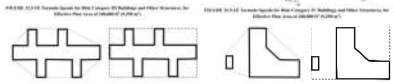
ASCE 7-22 Tornados

Chapter 32 – Tornado Loads



V_T <60 mph (function of location, RC, plan area).



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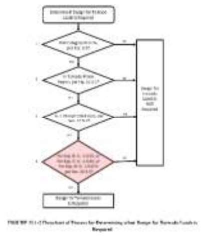
ASCE 7-22 Tornados

Chapter 32 – Tornado Loads



Compare V_T to V.

- Exp. B: $V_T < 0.5V$
- Exp. C: $V_T < 0.6V$
- Exp. D: $V_T < 0.67V$

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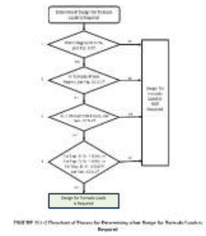
ASCE 7-22 Tornados

Chapter 32 – Tornado Loads



- **Tornado velocity pressure**

$$q_{zT} = 0.00256 K_{zTor} K_e V_T^2 \quad (\text{lb/ft}^2);\ V \text{ in mi/h}$$

$$q_{zT} = 0.613 K_{zTor} K_e V_T^2 \quad (\text{N/m}^2);\ V \text{ in m/s}$$

- **MWFRS loads**

$$p_T = qG_T K_{dT} K_{vT} C_p - q_i(GC_{piT}) \quad (\text{lb/ft}^2)$$

$$p_T = qG_T K_{dT} K_{vT} C_p - q_i(GC_{piT}) \quad (\text{N/m}^2)$$

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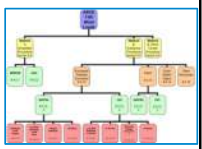

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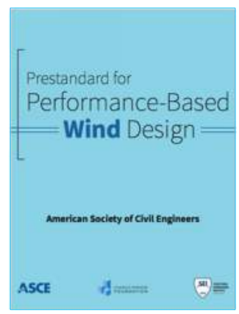
ASCE 7-22 Performance-Based Design



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Questions?

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415-814-0030

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