WIND DESIGN MADE SIMPLE
ICC TRI-CHAPTER UNIFORM CODE
COMMITTEE

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WIND DESIGN MADE SIMPLE
ICC TRI-CHAPTER CODE COMMITTEE

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  www.gostructural.com
  &
  The SEI Institute of ASCE
  http://content.seinstitute.org/
Overview of the current Wind design provisions
1605.3.2 ASD Load Combinations
Alternate Basic (UBC 94)

\[
D + L + (L_r \text{ or } S \text{ or } R) \quad \text{(Formula 16-16)}
\]

\[
D + L + (\omega W) \quad \text{(Formula 16-17)}
\]

\[
D + L + \omega W + S/2 \quad \text{(Formula 16-18)}
\]

\[
D + L + S + \omega W/2 \quad \text{(Formula 16-19)}
\]

\[
D + L + S + E/1.4 \quad \text{(Formula 16-20)}
\]

\[
0.9D + E/1.4 \quad \text{(Formula 16-21)}
\]

Where wind loads are calculated in accordance with ASCE 7, the coefficient \(\omega\) in the above formulas shall be taken as 1.3. For other wind loads \(\omega\) shall be taken as 1.0.
ASD Load Combinations Alternate Basic – Allowable Stress Increase

• When using these alternate basic load combinations that include wind or seismic loads, allowable stresses are permitted to be increased or load combinations reduced, where permitted by the material section of this code or referenced standard.

• For load combinations that include the counteracting effects of dead and wind loads, only two-thirds of the minimum dead load likely to be in place during a design wind event shall be used.
WIND-RESISTANT DESIGN
Wind Flow Around Building
External Pressure due to Wind

ROOF SLOPE = 15 DEG

\[
\begin{align*}
\text{HEIGHT} & = \frac{1}{2} \\
\text{DEPTH} & = 2 \\
\text{LENGTH} & = 2 
\end{align*}
\]
Fastest-mile Wind

*Instantaneous velocity of wind at a point as a function of time:*
Variation of Wind Velocity with Height for a Steady Wind
Velocity Pressure-ASCE 6.5.10

- ASCE 7 adds two more factors:
  - Topographic Factor - $K_{zt}$
    - Hills and Escarpments
    - Complex Equations
  - Directionality Factor - $K_d$
    - 0.85 for all building structures
Gust

- Rapid fluctuation of wind
- Ordinary structures are sensitive to peak gusts of about 1 second duration.
- Use of fastest-mile wind in design inadequate
  
  Gust speed, $V_g = G_v V$

- Pressure generated by gust, $p_g = G_p p$
  
  $p \propto V^2 \therefore G_p = G_v^2$

- Flexible structures more sensitive to gust.
Basic Wind Equation – 6.5.12.2

• For buildings with External and Internal Pressure:

\[ q_i = \text{Velocity pressure calculated for internal pressure.} \]
Wind-resistant Design

- *Wind Pressures on a Building*
1609.1 General Requirements

• Requires all parts of all buildings and structures be designed for wind.
• Base method is ASCE 7-05.
• Permits the use of other alternatives subject to some limitations for low rise buildings.
1609.1 General Requirements

- **Allows SSTD 10-99**
  - SBCCI - Standard for Hurricane Resistant Residential Construction.

- **Allows WFCM**
  - AF&PA - Wood Frame Construction Manual for One and Two Family Dwellings.

- **Restricts use of SSTD 10 & WFCM to Exposure B & C in areas without topographic effects**
General Requirements

- *Minimum Wind Load of 10 psf for MWFRS and C&C (ASCE 6.1.4)*
- *Must meet seismic detailing even if wind loads are greater*
1609.2 & 6.2 Definitions

• Important items:
  – Simple Diaphragm Building
    A building in which both windward and leeward wind loads are transmitted through floor and roof diaphragms to the same vertical MWFRS (e.g., no structural separations)
Figure 1609 & 6-1 Basic Wind Speeds

• Based on 3 Second Gust Measurement.
• Conversion Table 1609.3.1 for 3 Second Gust to Fastest Mile wind speed.
1609.4 & 6.5.6 Exposure Categories

• *Exposure A*
  - No longer used in ASCE 7

• *Exposure B:*
  – Use as the default.

• *Exposure C:*
  – Includes shorelines of hurricane prone regions (no longer Exposure D).

• *Exposure D:*
  – Now applies only to inland waterways, Great Lakes, Coastal California, Oregon, Washington, Alaska.
Enclosure Classifications (6.2)

For the purpose of determining internal pressure coefficients, all buildings shall be classified as enclosed, partially enclosed, or open as defined in 6.2
Enclosure Classifications (6.2)

- **BUILDING, OPEN**: A building having each wall at least 80 percent open. This condition is expressed for each wall by the equation $A_o \geq 0.8A_g$ where
  - $A_o =$ total area of openings in a wall that receives positive external pressure, in ft$^2$
  - $A_g =$ the gross area of that wall in which $A_o$ is identified, in ft$^2$
BUILDING, PARTIALLY ENCLOSED

BUILDING, PARTIALLY ENCLOSED: A building that complies with both of the following conditions:

1. The total area of openings in a wall that receives positive external pressure exceeds the sum of the areas of openings in the balance of the building envelope (walls and roof) by more than 10 percent.

2. The total area of openings in a wall that receives positive external pressure exceeds 4 ft² (0.37 m²) or 1 percent of the area of that wall, whichever is smaller, and the percentage of openings in the balance of the building envelope does not exceed 20 percent.

These conditions are expressed by the following equations:

1. \[ A_o > 1.10 A_{oi} \]
2. \[ A_o > 4 \text{ sq ft (0.37 m²)} \text{ or } >0.01 A_g, \text{ whichever is smaller, and } A_{oi}/A_{gi} \leq 0.20 \]

where

\( A_o, A_g \) are as defined for Open Building

\( A_{oi} \) = the sum of the areas of openings in the building envelope (walls and roof) not including \( A_o \), in ft² (m²)

\( A_{gi} \) = the sum of the gross surface areas of the building envelope (walls and roof) not including \( A_g \), in ft² (m²)
1609.5 Roof Systems

- *All Roof Decks must be designed for wind loads*
- *All Roof Coverings must be designed for wind loads*
  - Except:
    - Wind loads on Rigid Tiles have special loading provisions in 1609.5.3.
ASCE 7-05
6.4 - 6.6 Design Procedures

• Choice of 3 Design Procedures
  – 6.4 - Method 1 - Simplified Procedure
  – 6.5 - Method 2 - Analytical Procedure
  – 6.6 - Method 3 - Wind Tunnel Procedure
Simplified Provisions for Low-Rise Buildings 6.4

• ASCE 7-05 Method 1 provisions
• Allows buildings up to 60 ft
• Applies loads like SBC Simplified Method: on projected areas
• Restricted to simple diaphragm buildings
ASCE
6.4– Simplified Wind Load Method

• **Conditions**
  1. The building is a simple diaphragm building as defined in Section 6.2.
  2. The building is a low-rise building as defined in Section 6.2.
  3. The building is enclosed as defined in Section 6.2 and conforms to the wind-borne debris provisions of Section 6.5.9.3.
  4. The building is a regular-shaped building or structure as defined in Section 6.2.
  5. The building is not classified as a flexible building as defined in Section 6.2.
  6. The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; and does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
  7. The building has an approximately symmetrical cross-section in each direction with either a flat roof or a gable or hip roof with $\theta \leq 45^\circ$.
  8. The building is exempted from torsional load cases as indicated in Note 5 of Fig. 6-10, or the torsional load cases defined in Note 5 do not control the design of any of the MWFRSs of the building.
Simplified Provisions

• **MWFRS (6.4.2.1)**
  Simplified design wind pressures for the MWFRS represent the net pressures (sum of internal and external) to be applied to the horizontal and vertical projections of building surfaces as shown in Figure 6-2. For the horizontal pressures (Zones A, B, C, D), $p_s$ is the combination of the windward and leeward pressures.
Simplified Provisions

\[ p_s = \lambda K_{zt} I p_{s30} \]  \hspace{1cm} (6-1)

- \( \lambda \) = adjustment factor for building height and exposure
- from Fig. 6-2
- \( K_{zt} \) = topographic factor as defined in Section 6.5.7 evaluated at mean roof height, \( h \)
- \( I \) = importance factor as defined in Section 6.2
- \( p_{s30} \) = simplified design wind pressure for Exposure B, at \( h = 30 \) ft, and for \( I = 1.0 \), from Fig. 6-2
IBC Provisions
Figure 6-2 MWFRS
Analytical Procedures – ASCE 7-05

• **Method 2 – Analytical Procedure of Sect. 6.5**

  This method is applicable to all buildings that satisfy the two conditions in Sect. 6.5.1

  1. The building is regular in shape as defined in ASCE 7-05 Section 6.2

  2. The building does not have response characteristics making it subject to across wind loading, vortex shedding, instability due to galloping or flutter; or does not have a site location for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration
6.5 Analytical Procedure

- **Design Procedure (6.5.3):**
  1. Wind Speed \( V \) (Figure 6-1 map)
  2. Wind Directionality Factor \( K_d \) (6.5.4.4, Table 6-4)
  3. Importance Factor \( I \) (6.5.5, Table 6-1 & Table 1-1)
  4. For each wind direction:
     - Exposure Category (6.5.6)
     - Velocity Pressure Exposure Coefficient \( K_z, K_h \) (6.5.6, Table 6-3)
  5. Topographic Factor, \( K_{zt} \) (6.5.7, Figure 6-4)
ASCE 7-05
6.5 Analytical Procedure

• *Design Procedure* (6.5.3):

  6. Gust Effect Factor $G$ or $G_f$ (6.5.8)
  7. Enclosure Classification (6.5.9)
  8. Internal Pressure Coefficient $GC_{pi}$ (6.5.11.1, Figure 6-5)
  9. External Pressure Coefficients $C_p$, $GC_{pf}$ (6.5.11.2) or force coefficients $C_f$ (6.5.11.3)
  10. Velocity Pressure $q_z$, $q_h$ (6.5.10)

$$q_z = 0.00256 \ k_z \ k_{zt} \ k_d \ V^2 \ l$$  
   Eq. 6-15
6.5 Analytical Procedure

• *Design Procedure* (6.5.3)

11. Design wind load \( p \) (6.5.12) or \( F \) (6.5.13)

**MWFRS:**

Rigid Buildings of All heights:

\[
p = q GC_p - q_i(GC_{pi}) \quad \text{Eq. 6-17}
\]

Low rise: \( p = q_h [(GC_{pf}) - (GC_{pi})] \quad \text{Eq. 6-18}

ASCE 7-05
6.5 Analytical Procedure

• Design Pressure – Components & Cladding (6.5.12.4):
  – Low rise and buildings with $h \leq 60$ ft
    \[ p = q_h[(GC_p) - (GC_{pi})] \quad \text{Eq. 6-22} \]
  – Buildings with $h > 60$ ft
    \[ p = q(GC_p) - q_i(GC_{pi}) \quad \text{Eq. 6-23} \]
We need a simpler method
WIND DESIGN MADE SIMPLE
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TUCC ALTERNATE WIND DESIGN
PROVISIONS
Alternate 1:

- Allows relatively small and uncomplicated projects such as residential buildings, store fronts, etc. to use the **MAXIMUM** wind load values indicated in the following table:
## Simple Projects (SFD, Store Front, etc.)

### Wind Pressure – psf

<table>
<thead>
<tr>
<th>Roof Slope</th>
<th>0 to 12</th>
<th>2 to 12</th>
<th>3 to 12</th>
<th>4 to 12</th>
<th>5 to 12</th>
<th>6 to 12</th>
<th>8 to 12</th>
<th>12 to 12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roof Height</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abs Max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Exposure B**


20 - feet  | 15.40   | 15.08  | 15.08  | 15.08  | 15.40  | 15.08  | 15.08  | 15.08  |

25 - feet  | 15.42   | 15.42  | 15.42  | 15.42  | 15.42  | 15.42  | 15.42  | 15.42  |

30 - feet  | 15.73   | 15.73  | 15.73  | 15.73  | 15.73  | 15.73  | 15.73  | 15.73  |


Simple Projects (SFD, Store Front, etc.)

Wind Pressure – psf

<table>
<thead>
<tr>
<th>Roof Slope</th>
<th>0 to 12</th>
<th>2 to 12</th>
<th>3 to 12</th>
<th>4 to 12</th>
<th>5 to 12</th>
<th>6 to 12</th>
<th>8 to 12</th>
<th>12 to 12</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Abs Max</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exposure C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20 - feet</td>
<td>21.21</td>
<td>21.21</td>
<td>17.72</td>
<td>15.08</td>
<td>15.40</td>
<td>15.08</td>
<td>15.08</td>
<td>15.08</td>
</tr>
<tr>
<td>35 - feet</td>
<td>22.33</td>
<td>22.16</td>
<td>22.16</td>
<td>22.33</td>
<td>22.16</td>
<td>22.16</td>
<td>22.16</td>
<td>22.16</td>
</tr>
<tr>
<td>40 - feet</td>
<td>22.95</td>
<td>22.40</td>
<td>22.40</td>
<td>22.95</td>
<td>22.47</td>
<td>22.40</td>
<td>22.40</td>
<td>22.40</td>
</tr>
</tbody>
</table>
**Alternate 1**

**Table Assumptions:**

- **Building Size** = 50-feet x 100-feet
- **Building Shape** = Gable end roof with regular shape
- **Basic Wind Speed (3Sec. Gust)** = 85 mph.
- **Topography factor Kzt** = 1.26
- **Directionality factor Kd** = 0.85
- **Gust Effect factor G** = 0.85
Alternate 2:

- Allows the use of 2009 IBC’s new section 1609.6 in lieu of ASCE Method 2 for buildings up to 75 ft in height.
- The new section 1609.6 is the result of two proposals that were submitted to the ICC Structural Review Committee. The proposal by the National Council of Structural Engineers Associations (NCSEA) won the final approval with some modification.
Quote From The Structural Engineer magazine:
“The original motivation for these proposal was to provide a simplified way to obtain the wind forces on a structure to engineers who design for areas of the country where wind forces do not govern the design of structures other than, perhaps, low-rise, light-framed buildings.

Typically these structures would be located in areas where earthquake design controls. However, since we started our efforts, we have heard from engineers across the country that are eager to see simplification incorporated into the building code process.”
2009 IBC ALTERNATE WIND DESIGN PROVISIONS
2009 IBC ALTERNATE ALL HEIGHTS DESIGN PROVISIONS

• 1609.6.1 Scope. As an alternate to ASCE 7 Section 6.5, the following provisions are permitted to be used to determine the wind effects on regularly shaped buildings, or other structures which meet all of the following conditions:
  • 1. The building or other structure is less than 75 feet in height, with a height to least width ratio of 4 or less.
  • 2. The building or other structure is not sensitive to dynamic effects.
  • 3. The building or other structure is not located on a site for which channeling effects or buffeting in the wake of upwind obstructions warrant special consideration.
2009 IBC ALTERNATE ALL HEIGHTS
DESIGN PROVISIONS

• \( P_{\text{net}} = q_s K_z C_{\text{net}} I K_{zt} \)  \hspace{1cm} \text{(Equation 16-36)}

Where:

\( C_{\text{net}} = \text{Net pressure coefficient based on} \)

\( Kd \ [(G) \ (Cp) – (GCpi)], \text{ per Table 1609.6.2(2)} \)

\( q_s = \text{Wind velocity pressure in lb/ft2 (N/m2),} \)

\( \text{Per Table 1609.6.2(1)} \)
2009 IBC ALTERNATE ALL HEIGHTS DESIGN PROVISIONS

**TABLE 1609.6.2(1)**

<table>
<thead>
<tr>
<th>BASIC WIND SPEED, V (mph)</th>
<th>85</th>
<th>90</th>
<th>100</th>
<th>105</th>
<th>110</th>
<th>120</th>
<th>125</th>
<th>130</th>
<th>140</th>
<th>150</th>
<th>160</th>
<th>170</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESSURE, q, (psf)</td>
<td>18.5</td>
<td>20.7</td>
<td>25.6</td>
<td>28.2</td>
<td>31.0</td>
<td>36.9</td>
<td>40.0</td>
<td>43.3</td>
<td>50.2</td>
<td>57.6</td>
<td>65.5</td>
<td>74.0</td>
</tr>
</tbody>
</table>
## 2009 IBC ALTERNATE ALL HEIGHTS DESIGN PROVISIONS

### Table 1609.6.2(2)

**Net Pressure Coefficients, \( C_{\text{ref}} \)**

<table>
<thead>
<tr>
<th>Structure or Part Thereof</th>
<th>Description</th>
<th>( C_{\text{w}} ) Factor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Walls:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Windward wall</td>
<td>Enclosed</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>Partially Enclosed</td>
<td>0.11</td>
</tr>
<tr>
<td>Leeward wall</td>
<td></td>
<td>-0.51</td>
</tr>
<tr>
<td>Side wall</td>
<td></td>
<td>-0.66</td>
</tr>
<tr>
<td></td>
<td>Partially Enclosed</td>
<td>-0.97</td>
</tr>
<tr>
<td>Parapet wall</td>
<td>Windward</td>
<td>1.28</td>
</tr>
<tr>
<td></td>
<td>Leeward</td>
<td>-0.85</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.85</td>
</tr>
<tr>
<td><strong>Roofs:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wind perpendicular to ridge</td>
<td>Enclosed</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Partially Enclosed</td>
<td></td>
</tr>
<tr>
<td>Leeward roof or flat roof</td>
<td></td>
<td>-0.66</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.97</td>
</tr>
<tr>
<td>Windward roof slopes:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slope &lt; 2:12 (10°)</td>
<td>Case 1</td>
<td>-1.09</td>
</tr>
<tr>
<td></td>
<td>Case 2</td>
<td>-1.41</td>
</tr>
<tr>
<td>Slope = 4:12 (18°)</td>
<td>Case 1</td>
<td>-0.37</td>
</tr>
<tr>
<td></td>
<td>Case 2</td>
<td>-0.73</td>
</tr>
<tr>
<td>Slope = 5:12 (23°)</td>
<td>Case 1</td>
<td>-0.58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>-0.90</td>
</tr>
</tbody>
</table>
2009 IBC ALTERNATE ALL HEIGHTS DESIGN PROVISIONS

• In the meantime the State of California issued January 1, 2009 amendments to the CBC Volume II incorporating these provisions. However, the amendments only apply to certain occupancies:

1609.6 [BSC, OSHPD 2, HCD 1 & HCD 2] Alternate all-heights method. The alternate wind design provisions in this section are simplifications of the ASCE 7 Method 2-Analytical Procedure.
2009 IBC ALTERNATE ALL HEIGHTS DESIGN PROVISIONS

• And, the amendments are not technically effective until August 1, 2009.

8. (BSCP 01/08, HCD 02/07, OSHPD 02/07, OSHPD 03/07, SFM 01/07, DSA/AC 01/07, DSA/AC EF 01/08) Amended California Building Code Vol. 1 & 2, California Chapter 1, Chapters 2, 3, 4, 5, 6, 7, 7A, 8, 9, 10, 11A, 11B, 11C, 12, 16, 16A, 17, 19A, 21A, 23, 27, 30, 31A, 34, 35, and Appendix Ch. 1, filed with the Secretary of State on September 12, 2008 and effective August 1, 2009. Errata changes to Index for CBC, California Chapter 1, Chapters 3, 4, 7, 9, 10, 16A, 17, 31A, and 34.
Mechanisms for allowing these alternatives

1. Adopt a local ordinance (complicated & time consuming)
2. Allow by requiring the submittal of an Application for Alternate Materials And Methods of Construction (quick and streamlined)
Example 1 for Alternate 2
1. Given:
   - A seven story office building as shown in Figure 1
   - Fundamental Period = 1.0 seconds perpendicular to the long side.
   - Structure is not susceptible to dynamic effects, and is considered to be enclosed.
   - Steel Braced Frames for resisting lateral forces of equal rigidity on all four sides.
   - Parapet is 3’ – 0” high all around exterior of building.

2. Criteria:
   - Basic wind speed 85 mph
   - Wind Exposure Category B
   - $K_v = 0.85$, $K_r = 1.0$, and $I = 1.0$
Example 1 for Alternate 2

1. The general equation is: \( p = q_s \cdot K_c \cdot C_{net}[I,K_{res}] \)

2. The basic wind speed, \( V \), has been given in the problem statement: \( V = 85 \text{ mph} \). Using Simplified Procedure Table 1609.6.2.1(2), we determine that \( q_s = 18.5 \text{ psf} \).

3. The Importance factor, \( I \), in ASCE 7 Tables 1-1 and 6-1, is equal to 1.0, as is the topographic factor, \( K_{ct} \), and the Enclosure classification is “Enclosed”.

4. Determine the relevant \( C_{net} \) values from proposed IBC Table 1609.6.3.1(2) under the enclosed building column. Note that these net coefficients are modified for internal pressures.
   - Windward Walls: \( C_{net} = 0.43 \)
   - Leeward Walls: \( C_{net} = -0.53 \)
   - Parapet Walls: \( C_{net} = +1.28 \text{ on the windward side and -0.85 on the leeward side of the building.} \)

5. Design wind load, \( p_n \), shall be determined in accordance with proposed IBC Section 1609.6.4
Example 1 for Alternate 2

6. The exposure category and velocity pressure exposure coefficient, $K_c$ for Exposure B is using the “Framing” portion of the Exposure B values below 30 feet (Case 2) in ASCE 7 Table 6-3. The Mean Roof Height, $h$, is given as 83 ft. Therefore determine $K_c$ by interpolation or calculation for the following values of ‘$z$’ measured at the top of the story for convenience of calculation. Then multiplying $K_c$ times $q_v$, the velocity pressure, yields the $C_{net}$ values for positive pressures:

<table>
<thead>
<tr>
<th>Level</th>
<th>$K_c$</th>
<th>$q_v$</th>
<th>$C_{net}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$z = 14.0'$ (1st Story)</td>
<td>0.57</td>
<td>18.5</td>
<td>10.5 x 0.43 = 4.5 psf</td>
</tr>
<tr>
<td>$z = 25.5'$ (2nd Story)</td>
<td>0.68</td>
<td>18.5</td>
<td>12.4 x 0.43 = 5.3 psf</td>
</tr>
<tr>
<td>$z = 37.0'$ (3rd Story)</td>
<td>0.74</td>
<td>18.5</td>
<td>13.9 x 0.43 = 6.0 psf</td>
</tr>
<tr>
<td>$z = 48.5'$ (4th Story)</td>
<td>0.80</td>
<td>18.5</td>
<td>14.8 x 0.43 = 6.4 psf</td>
</tr>
<tr>
<td>$z = 60.0'$ (5th Story)</td>
<td>0.85</td>
<td>18.5</td>
<td>15.7 x 0.43 = 6.8 psf</td>
</tr>
<tr>
<td>$z = 71.5'$ (6th Story)</td>
<td>0.90</td>
<td>18.5</td>
<td>16.7 x 0.43 = 7.2 psf</td>
</tr>
<tr>
<td>$z = 83.0'$ (7th Story)</td>
<td>0.94</td>
<td>18.5</td>
<td>17.4 x 0.43 = 7.5 psf</td>
</tr>
<tr>
<td>$z = 86.0'$ (Parapet)</td>
<td>0.95</td>
<td>18.5</td>
<td>17.6 x 1.28 = 22.5 psf</td>
</tr>
</tbody>
</table>

For negative, leeward pressures, $-\rho$, they are all the same up to the mean roof height, at $z = 83'$ for which the pressure is 17.4 psf x 0.53 = -9.2 psf and at the top of the parapet, the pressure is 17.6 x 0.85 = -15.0 psf.
### Example 1 for Alternate 2

F2.2.1  *Horizontal Wind Forces in North/South Direction*

<table>
<thead>
<tr>
<th>Wall</th>
<th>Story</th>
<th>Height</th>
<th>$p_{w} \text{ (psf)}$</th>
<th>B (ft)</th>
<th>h (ft)</th>
<th>$V_{s} \text{ (lbs)}$</th>
<th>$Z_{a} \text{ (ft)}$</th>
<th>Moment (ft-lbs)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>0.0 to 14.0</td>
<td>4.5</td>
<td>123</td>
<td>553</td>
<td>14.0</td>
<td>7,749</td>
<td>52,243</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>14.0 to 25.5</td>
<td>5.3</td>
<td>123</td>
<td>652</td>
<td>11.5</td>
<td>7,477</td>
<td>148,438</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>25.5 to 37.0</td>
<td>6.0</td>
<td>123</td>
<td>738</td>
<td>11.5</td>
<td>8,487</td>
<td>265,460</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>37.0 to 48.5</td>
<td>6.4</td>
<td>123</td>
<td>787</td>
<td>11.5</td>
<td>9,053</td>
<td>387,190</td>
</tr>
<tr>
<td>Windward</td>
<td>5</td>
<td>48.5 to 60.0</td>
<td>6.8</td>
<td>123</td>
<td>836</td>
<td>11.5</td>
<td>9,619</td>
<td>522,290</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>60.0 to 71.5</td>
<td>7.5</td>
<td>123</td>
<td>922</td>
<td>11.5</td>
<td>10,609</td>
<td>698,056</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>71.5 to 83.0</td>
<td>7.6</td>
<td>123</td>
<td>935</td>
<td>11.5</td>
<td>10,750</td>
<td>830,990</td>
</tr>
<tr>
<td></td>
<td>parapet</td>
<td>83.0 to 86.0</td>
<td>22.5</td>
<td>123</td>
<td>2,768</td>
<td>3.0</td>
<td>8,302</td>
<td>701,561</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>Subtotal</strong></td>
<td><strong>3,606,278</strong></td>
</tr>
</tbody>
</table>

|       | 1     | 0.0 to 14.0 | -9.2*              | 123   | 1,132 | 14.0           | 15,842         | 110,897        |
|       | 2     | 14.0 to 25.5 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 257,756        |
|       | 3     | 25.5 to 37.0 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 407,463        |
|       | 4     | 37.0 to 48.5 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 557,170        |
| Leeward | 5    | 48.5 to 60.0 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 706,877        |
|       | 6     | 60.0 to 71.5 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 856,584        |
|       | 7     | 71.5 to 83.0 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 1,006,291      |
|       | parapet | 83.0 to 86.0 | -15.0*             | 123   | 1,845 | 3.0            | 5,535          | 467,708        |
|       |       |          |                   |       |       |                |                |                |
|       |       |          |                   |       |       |                | **Subtotal**   | **9,485**       |

* Note: negative leeward pressures are outward and additive. **Totals =**

|       | 1    | 0.0 to 14.0 | -9.2*              | 123   | 1,132 | 14.0           | 15,842         | 110,897        |
|       | 2    | 14.0 to 25.5 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 257,756        |
|       | 3    | 25.5 to 37.0 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 407,463        |
|       | 4    | 37.0 to 48.5 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 557,170        |
|       | 5    | 48.5 to 60.0 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 706,877        |
|       | 6    | 60.0 to 71.5 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 856,584        |
|       | 7    | 71.5 to 83.0 | -9.2*              | 123   | 1,132 | 11.5           | 13,018         | 1,006,291      |
|       | 8    | 83.0 to 86.0 | -15.0*             | 123   | 1,845 | 3.0            | 5,535          | 467,708        |
|       |       |          |                   |       |       |                |                |                |

**Subtotal =**

$$V_{\text{front wall}} = \text{Sum (Vs)} = 171,531 \text{ lbs}$$

$$\text{Sum of Moment} = 7,976,974 \text{ lb-ft}$$
Example 2 for Alternate 2
**Given**
- The 2 story house configuration shown below
- The roof is sloped at a 4:12 pitch
- The house is located adjacent to open fields near Boise, Idaho
- The house is wood framed with plywood sheathing on walls, roof and floor.
- Wind loading in North-South direction

**Determine**
- Wall B maximum shear and uplift forces based on the following provisions:
  1. ASCE 7-05 Wind Analytical Procedure Method 2
  2. Proposed Alternate Wind Procedures (see attached)
ASCE 7-05 Method 2 Analytical Procedures

1. Basic Wind Speed and Wind Directionality Factor
   \( V = 90 \text{ mph (Figure 6-1, Boise Idaho)} \)
   \( K_d = 0.85 \) (Table 6-4, MWFRS)

2. Importance Factor
   \( I = 1.0 \) (Occupancy Category II)

3. Exposure Category and Velocity Pressure Exposure Coefficient
   Exposure Category = C (Site adjacent to open fields)
   Building qualifies as Low Rise Building
   \( h = (18.0' + 3.33'/2) = 19.67' < 60' \)
   \( h = 19.67' < 20' \)
   \( K_h = 0.90 \) (Table 6-3)

4. Topographic Factor
   \( K_T = 1.0 \) (Assumed since near open fields)

5. Gust Effect Factor
   \( G = 0.85 \) (rigid structure based on 2 story building height)

6. Enclosure Classification
   Enclosed Building (Section 6.5.9)
7. Internal Pressure Coefficient
   \( GC_{pd} = \pm 0.18 \) (Figure 6-5, Enclosed Building)

8. External Pressure Coefficient (Figure 6-10)
   Roof Angle \( \theta = 18^\circ \sim 20^\circ \)
   \( GC_{pf.1} = 0.53 \quad GC_{pf.1E} = 0.80 \)
   \( GC_{pf.2} = -0.69 \quad GC_{pf.2E} = -1.07 \)
   \( GC_{pf.3} = -0.48 \quad GC_{pf.3E} = -0.69 \)
   \( GC_{pf.4} = -0.43 \quad GC_{pf.4E} = -0.64 \)

9. Velocity Pressure
   \( q_v = 0.00256 K_s K_m K_d V^2 I \)
   \( = 0.00256 \times 0.90 \times 1.0 \times 0.85 \times 90^2 \times 1.0 = 15.86 \text{ psf} \)

10. Design Wind Load
    \( p = q_v [(GC_{pf}) - (GC_{pd})] \quad \text{Eq. (6-18)} \)
    \( p_1 = 15.86 \text{ psf} \quad [0.53)-(0.18)] = 5.55 \text{ psf} \)
    \( p_2 = 15.86 \text{ psf} \quad [-0.69)-(0.18)] = -13.80 \text{ psf} \)
    \( p_3 = 15.86 \text{ psf} \quad [-0.48)-(0.18)] = -10.47 \text{ psf} \)
    \( p_4 = 15.86 \text{ psf} \quad [-0.43)-(0.18)] = -9.67 \text{ psf} \)
    \( p_{1E} = 15.86 \text{ psf} \quad [0.80)-(0.18)] = 9.83 \text{ psf} \)
    \( p_{2E} = 15.86 \text{ psf} \quad [-1.07)-(0.18)] = -19.83 \text{ psf} \)
    \( p_{3E} = 15.86 \text{ psf} \quad [-0.69)-(0.18)] = -13.80 \text{ psf} \)
\[ p_{Bw} = 15.86 \text{ psf} \cdot [(0.64) \cdot (0.18)] = -13.01 \text{ psf} \]

11. Wall Forces

Determine width of pressure coefficient zone (a) per Figure 6-10:

- \( a = 0.10 \times 20' = 2' \)
- \( a = 0.4 \times 19.67' = 7.87' \)
- \( a = 0.4 \times 20' = 0.8' \)
- \( a = 3' \) (Governs)
- \( 2a = 2 \times 3' = 6' \)

I need not consider torsional load cases since building is 2 stories with flexible diaphragms per Note #5 of Figure 6-10.

Use tributary area to determine wall forces (slight error using tributary area since wind forces on diaphragm are not uniform). Neglect wind pressure at sloping roof since the net roof horizontal wind pressure reduces the horizontal wind forces on the shear wall.

\[ F_{Br} = [4.5' \times 6' \times (9.83 \text{ psf} + 13.01 \text{ psf})] + \\
[4.5' \times 9' \times (5.55 \text{ psf} + 9.67 \text{ psf})] = 1,232^\text{#} \]

\[ F_{Bl} = [4.5' \times 19.67' \times (5.55 \text{ psf} + 9.67 \text{ psf})] = 1,027^\text{#} \]

\[ F_{Bh} = [4.5' \times 9' \times (5.55 \text{ psf} + 9.67 \text{ psf})] + \\
[4.5' \times 6' \times (9.83 \text{ psf} + 13.01 \text{ psf})] + \\
[4.5' \times 9' \times (5.55 \text{ psf} + 9.67 \text{ psf})] = 2,260^\text{#} \]

\[ V_{max} = 1,232^\text{#} \cdot 1,027^\text{#} \cdot 2,260^\text{#} = 4,519^\text{#} \]

\[ M_{tot} = (1,232^\text{#} \times 18') + (1,027^\text{#} \times 9') + \\
(2,260^\text{#} \times 9') = 51,759^\text{#} \]

\[ T_{max} = C_{max} = \frac{51,759^\text{#}}{9.5'} = 5,448^\text{#} \]
Proposed Alternate Procedure

1. Wind Velocity Pressure
   Basic Wind Speed $V = 90$ mph (Figure 6-1, Boise Idaho)
   $q_s = 20.7$ psf (Table 1609.6.3(1))

2. Velocity Pressure Exposure Coefficient
   Exposure Category = C (Site adjacent to open fields)
   $K_z = 0.90$ (Table 6-3, use $h=20'$ for entire building, conservative)

3. Net Pressure Coefficient (Table 1609.6.3(2))
   $C_{net} = 0.43$ (Windward Wall)
   $C_{net} = -0.53$ (Leeward Wall)
   $C_{net} = -0.73$ (Windward Roof - 4:12 Slope)
   $C_{net} = -0.66$ (Leeward Roof)

4. Importance Factor
   $I = 1.0$ (Occupancy Category II)
5. Topographic Factor
   $K_{at} = 1.0$ (Assumed since near open fields)

6. Design Wind Pressure
   \[ P_{at} = q_{w} K_{d} C_{mf} \times K_{at} \]
   \[ P_{at} = 20.7 \times 0.50 \times C_{mf} \times 1.0 \times 1.0 = 18.63 \text{ psf} \]
   \[ P_{at} = 18.63 \times 0.43 = 8.01 \text{ psf} \text{ (Windward Wall)} \]
   \[ P_{at} = 18.63 \times -0.53 = -9.87 \text{ psf} \text{ (Leeeward Wall)} \]
   \[ P_{at} = 18.63 \times -0.73 = -13.60 \text{ psf} \text{ (Windward Roof)} \]
   \[ P_{at} = 18.63 \times -0.66 = -12.30 \text{ psf} \text{ (Leeeward Roof)} \]

7. Shear Wall Forces
   Assume flexible diaphragm and use tributary area
   \[ F_{bt} = 4.5' \times 15' \times (8.01 \text{ psf} + 9.87 \text{ psf}) = 1,207\#
   \]
   \[ F_{bt} = 4.5' \times 15' \times (8.01 \text{ psf} + 9.87 \text{ psf}) = 1,207\#
   \]
   \[ F_{bt} = 9' \times 15' \times (8.01 \text{ psf} + 9.87 \text{ psf}) = 2,414\#
   \]
   \[ V_{max} = 1,207\# + 1,207\# + 2,414\# = 4,828\#
   \]
   \[ M_{ot} = (1,207\# \times 18') + (1,207\# \times 9') - \]
   \[ (2,414\# \times 9') = 54,315\#
   \]
   \[ T_{max} = C_{max} = 54,315\# / 9.5' = 5,717\#
   \]

**Answer Summary**

<table>
<thead>
<tr>
<th></th>
<th>ASCE 7-05 Analytical Wind Method 2</th>
<th>Proposed Alternate Wind Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wall B - Max Wind Shear Force</td>
<td>4,519#</td>
<td>4,828#</td>
</tr>
<tr>
<td>Wall B - Max Wind Uplift Force</td>
<td>5,448#</td>
<td>5,717#</td>
</tr>
</tbody>
</table>
Thank you for your attention!