

2009 IBC ALTERNATE WIND DESIGN APPROACH

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OUTLINE

- Design Methods based on ASCE 7-05
- Development of Alternate Wind Design Approach
 - Design Equation
 - Derivation of C_{net} coefficients
 - Main Wind Force Resisting System
 - Components and Cladding
- Special Inspection Requirements
- Design Examples

Alternate Design Provisions

- Design Provisions are meant to
 - Satisfies ASCE 7 Method 2
 - Time saving - avoid interpretation of monographs
 - Simplification - combining K_d , G , C_p and GC_{pi} terms into a single parameter, C_{net}
 - Symbols and Notations in ASCE 7 plus specific ones defined in IBC 1609.6.2

Alternate Design Provisions - limitations

Ref. 2009 IBC 1609.6.1

- Aspect ratios
 - Height to width ratio ≤ 4
 - Height ≤ 75 feet, *OR*
 - Fundamental frequency ≥ 1 Hertz
- Flexibility
 - Building not sensitive to dynamic effects
- Site condition
 - No channeling effects
 - No buffeting in wake of upward obstruction

Alternate Design Provisions - limitations

- Building basic requirement
 - Simple diaphragm – transmits wind loads to MWFRS
- Building or structure OTHER THAN
 - Open building
 - Multi-span Gable Roof
 - Stepped Roof
 - Domed Roof
 - Roof slope $> 45^\circ$
 - Free standing walls and solid signs (ASCE 7 Fig. 6-20)

Main-Wind-Force-Resisting System (MWFRS)

- Determination of K_z & K_{zt} : [Ref. 2009 IBC Sec. 1609.6.4.2]
 - K_z - Velocity exposure coefficient, and
 - K_{zt} - Topography Factor
 - For Windward side of structure :
 - K_z and K_{zt} shall be based on height z
 - For Leeward and side walls :
 - K_z and K_{zt} - based on mean roof height h
 - For windward and leeward roofs :
 - K_z and K_{zt} - based on mean roof height h

Main-Wind-Force-Resisting System (MWFRS)

Ref. 2009 IBC Sec. 1609.6.4.3 and 1609.6.4.4

- Determination of Net Wind Pressure
 - Determine pressure coefficient, C_{net} for walls and roofs from Table 1609.6.2(2)
 - Where more than one value for C_{net} given in table, use the more severe wind load condition for design
- Application of Wind Pressure
 - Apply wind pressure simultaneously on, and in a direction normal to, all building envelope and roof surfaces, but **no less than 10 lb/sq. ft. on projected surface**
- Investigate Torsional Effect - Ref. IBC Sec. 1609.6.4.1

Derivation of Design Equations

- C_{net} values

Based on ASCE 7

$$q_z = 0.00256 K_z K_{zt} K_d V^2 I \quad \text{Eq. (6-15)}$$

$$p = q G C_p - q_i (G C_{pi}) \quad \text{Eq. (6-17)}$$

Combining above equations, rearranging terms and substituting $q_s = 0.00256 V^2$:

$$\begin{aligned} p &= [0.00256 V^2 K_h K_d G C_p \\ &\quad - 0.00256 V^2 K_z K_d (G C_{pi})] [I K_{zt}] \\ &= q_s K_d [K_h G C_p - K_z (G C_{pi})] [I K_{zt}] \quad \text{Eq. (A-1)} \end{aligned}$$

Derivation of Design Equations

- For Leeward Wall and Roof Elements

$$K_h = K_z$$

- For Windward Roof Elements

$$K_h \approx K_z$$

Re-writing Eq. (A1)

$$p = q_s K_z [K_d (GC_p - (GC_{pi}))] [IK_{zt}] \quad \text{Eq. (A-2)}$$

Substitute into Eq. (A-2)

$$C_{net} = K_d (GC_p - (GC_{pi})) \quad \text{Eq. (A-3)}$$

Design wind pressure:

$$p = q_s K_z C_{net} [IK_{zt}] \quad \text{Eq. (A-4)}$$

IBC 2009 Eq. (16-34)

Wind Stagnation Pressure

Reference IBC 2009 Table 1609.6.2 (1)

Table 1609.6.2(1)

Wind Stagnation Pressure (q_s) at Standard Height of 33 Feet ^{a, b, c}

BASIC WIND SPEED, V (mph) ^b	85	90	100	105	110	120	125	130
PRESSURE, q_s (psf) ^c	18.5	20.7	25.6	28.2	31.0	56.9	40.0	43.3

- a. For Wind Speeds not shown, use $q_s = 0.00256 V^2$
- b. Multiply by 1.61 to convert to km/h
- c. Multiply by 0.048 to convert to kN/m²

$$q_s = 0.00256V^2$$

Derivation of Design Equations

- Gust Effect Factor, G

Reference ASCE 7 Sec. 6.5.8.1

$$G = 0.85 \quad \text{for rigid structures}$$

- used in development of T-1609.6.2(2)

– ASCE 7 Eq. (6-4) will give values slightly lower than 0.85

Example:

	Height, h	Width, B	Gust factor, G
Bldg 1	50 ft.	200 ft.	0.85
Bldg 2	50 ft.	500 ft.	0.81

Derivation of Design Equations

- Directional factor, K_d
Reference ASCE 7 Table 6-4

For Buildings

$$K_d = 0.85$$

Other structures affected by shape $K_d \geq 0.85$

- $C_{net} = K_d (GC_p - (GC_{pi}))$ Eq. (A-3)

Re-write equation (A-3) for C_{net}

Substituting K_d and G

$$C_{net} = 0.85 (0.85C_p - (GC_{pi})) \quad \text{Eq. (A-5)}$$

Eq. (A-5) is used to develop C_{net} in Table 1609.6.2(2)

Derivation of Design Equations

Determination of Velocity Pressure Coef., K_z

ASCE Table 6-3

Height above ground level, z		Exposure			
		B	B	C	D
ft	m	Case 1	Case 2	Cases 1 & 2	
0 - 15	0 - 4.6	0.70	0.57	0.85	1.03
20	6.1	0.70	0.62	0.90	1.08
25	7.6	0.70	0.66	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

$$K_z = 2.01(z/z_g)^{2/\alpha}$$

for $15 \leq z \leq z_g$

Where

$\alpha = 7.0$, $z_g = 1200$ for Exp. B
 $\alpha = 9.5$, $z_g = 900$ for Exp. C
 $\alpha = 11.5$, $z_g = 700$ for Exp. D

Note:

Case 1: MWFRS low rise & CC of all heights

Case 2: All MWFRS other than low-rise buildings

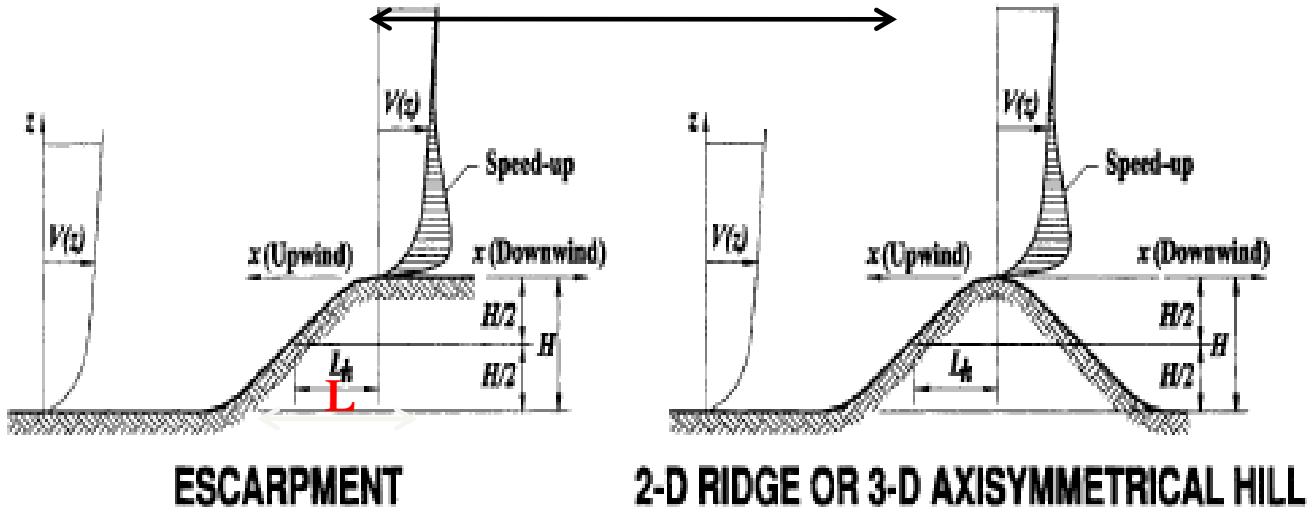


Derivation of Design Equations

- Determination of Topography Factor, K_{zt} refer to ASCE 7 Sec. 6.5.7 and coefficients in Fig. 6 - 4
- Site not impacted by hills, ridges and escarpment listed under 6.5.7.1 – $K_{zt} = 1.0$

Topographic Factor, K_{zt} – Method 2
Figure 6-4

Greater of 1.5 L or 6H



Helpful Guideline:
(Ref 2009 IRC)

Ave slope Top half	Wind speed
Flat	85 mph
0.10 to 0.15	100 mph
0.175 to 0.23	110 mph
≥ 0.25	120 mph

ASCE 7 Fig. 6-4

Derivation of C_{net} Coefficient

- Internal pressure coefficient, GC_{pi}
 - Enclosed buildings $GC_{pi} = +0.18$ or $- 0.18$
 - Partially Enclosed $GC_{pi} = +0.55$ or $- 0.55$

Exposure Classification	GC_{pi}
Open Buildings	0.00
Partially Enclosed Buildings	+0.55 - 0.55
Enclosed Buildings	+0.18 - 0.18

ASCE 7 Fig. 6-5

Derivation of C_{net} Coefficient (MWFRS)

– Windward Wall external pressure coefficient

$$C_p = + 0.8 \quad \text{for all } L/B$$

– Leeward Wall external pressure coefficient

$$C_p = - 0.5 \quad \text{for } L/B \leq 1$$

ASCE 7 Fig. 6-6

Main Wind Force Resisting System		All Height	
Enclosed, Partially Enclosed Buildings		Walls & Roofs	
External Wind Pressure Coefficient, C_p			
Surface	L/B	C_p	Use With
Windward Wall	All Values	+ 0.8	q_z
	Leeward Wall	- 0.5	
Leeward Wall	0 - 1	- 0.5	q_h
	2	- 0.3	
	≥ 4	- 0.2	
Side Wall	All Values	- 0.7	q_h

Derivation of C_{net} Coefficient (MWFRS)

$$C_{net} = 0.85 (0.85C_p - (GC_{pi})) \quad \text{Eq. (A-5)}$$

- For positive internal pressure in **enclosed** building

- Windward wall

$$C_{net} = 0.85(0.85 \times 0.80 - 0.18) = 0.43$$

- Leeward wall

$$C_{net} = 0.85(0.85 \times (-0.50) - 0.18) = -0.51$$

- For negative internal pressure in **enclosed** building

- Windward wall

$$C_{net} = 0.85(0.85 \times 0.80 - (-0.18)) = 0.73$$

- Leeward wall

$$C_{net} = 0.85(0.85 \times (-0.50) - (-0.18)) = -0.21$$

- Σ Windward and Leeward wall pressure coefficients
 $= 0.43 - (-0.51) = 0.94$

Net Pressure Coefficient – Wall

Reference IBC 2009 Table 1609.6.2 (2) (MWFRS)

Structure or Part thereof	DESCRIPTION	C_{net} FACTOR			
		Enclosed		Part. Enclosed	
1. MWFRS	WALLS:	+ ve	- ve	+ ve	- ve
		Int. Pressure		Int. Pressure	
	Windward Wall	0.43	0.73	0.11	1.05
	Leeward Wall	-0.51	-0.21	-0.83	0.11
	Side Wall	-0.66	-0.35	-0.97	-0.04
Parapet Wall	Windward	1.28		1.28	
	Leeward	- 0.85		- 0.85	

Derivation of C_{net} Coefficient (MWFRS)

- Windward Roof external pressure coefficient normal to ridge for roof slope $\leq 2:12$ or 10°
 $C_p = -1.3, -0.18$ for $h/L \leq 0.5$
- Leeward Wall external pressure coefficient
 $C_p = -0.7$ for $h/L \geq 1$

ASCE 7 Fig. 6-6

Roof Pressure Coefficients, C_p , for use with q_h

Wind Direction	h/L	Windward Angle, Θ°				Leeward Θ°		
		10	15	20	30	10	15	≥ 20
Normal to ridge for $\Theta \geq 10^\circ$	≤ 0.25	-0.7, -0.18	-0.5, 0.0	-0.3, 0.2	-0.2, 0.3	-0.3	-0.5	-0.6
	0.50	-0.9, -0.18	-0.7, -0.18	-0.4, 0.0	-0.2, 0.2	-0.5	-0.5	-0.6
	≥ 1.0	-1.3, -0.18	-1.0, -0.18	-0.7, -0.18	-0.3, 0.2	-0.7	-0.6	-0.6
Normal to ridge for $\Theta < 10^\circ$ & Parallel to ridge for all Θ	≤ 0.5	Horiz. Dist. from Windward edge			C_p	Note: reduction for increase area not taken		
		0 to h/2 and h/2 to h			-0.9, -0.18			
	h to 2h			-0.5, -0.18				
	≥ 1.0	0 to h/2			-1.3, -0.18			
$> h/2$			-0.7, -0.18					

Derivation of C_{net} Coefficient (MWFRS)

$$C_{net} = 0.85 (0.85C_p - (GC_{pi})) \quad \text{Eq. (A-7)}$$

- For +ve or -ve internal pressure in enclosed building

– Leeward roof normal to ridge for slope $\leq 2:12$ or 10°

$$C_{net} = 0.85(0.85 \times (-0.70) - 0.18) = -0.66 \quad \text{OR}$$

$$C_{net} = 0.85(0.85 \times (-0.70) + 0.18) = -0.35$$

– Windward roof normal to ridge for slope $\leq 2:12$ or 10°

$$C_{net} = 0.85(0.85 \times (-1.30) - 0.18) = -1.09 \quad \text{OR}$$

$$C_{net} = 0.85(0.85 \times (-1.30) + 0.18) = -0.79$$

$$C_{net} = 0.85(0.85 \times (-0.18) - 0.18) = -0.28 \quad \text{OR}$$

$$C_{net} = 0.85(0.85 \times (-0.18) + 0.18) = +0.02$$

– For Parallel to ridge – same as for normal to ridge w/o slope

Net Pressure Coefficient – Roof (MWFRS)

Reference IBC 2009 Table 1609.6.2 (2)

Structure or Part thereof	DESCRIPTION	C_{net} FACTOR			
		Enclosed		Partially Encl.	
1. MWFRS	ROOFS:	+ ve	- ve	+ ve	- ve
		Int. Pressure		Int. Pressure	
Wind \perp to Ridge					
Leeward or Flat Roof		-0.66	-0.35	-0.97	-0.04
Windward Roof Slope					
Slope < 2:12 (10°)	Condition 1	-1.09	-0.79	-1.41	-0.47
	Condition 2	-0.28	0.02	-0.60	0.34
Slope = 4:12 (18°)	Condition 1	-0.73	-0.42	-1.04	-0.11
	Condition 2	-0.58	0.25	-0.37	0.57
Slope 12:12 (45°)		0.14	0.44	-0.18	0.76
Wind \parallel Ridge and Flat Roof		-1.09	-0.79	-1.41	-0.49



Derivation of C_{net} Coefficient (C & C)

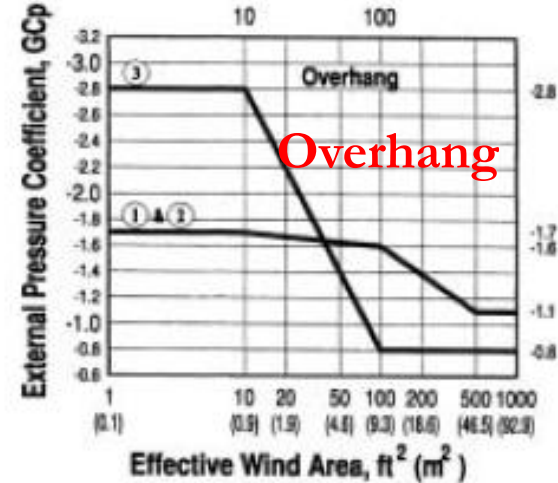
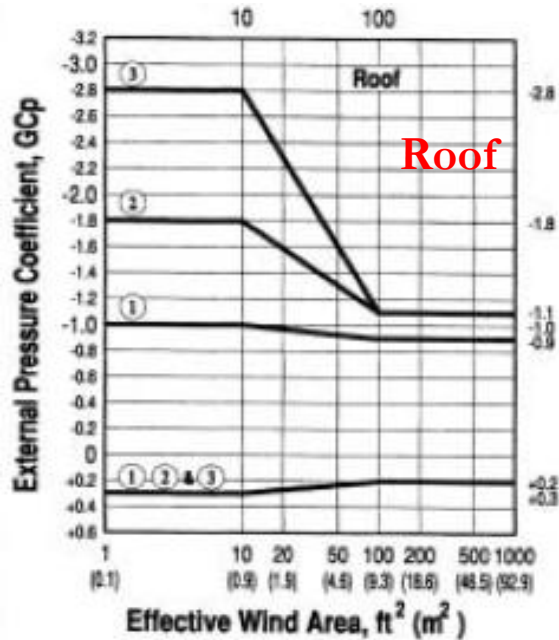
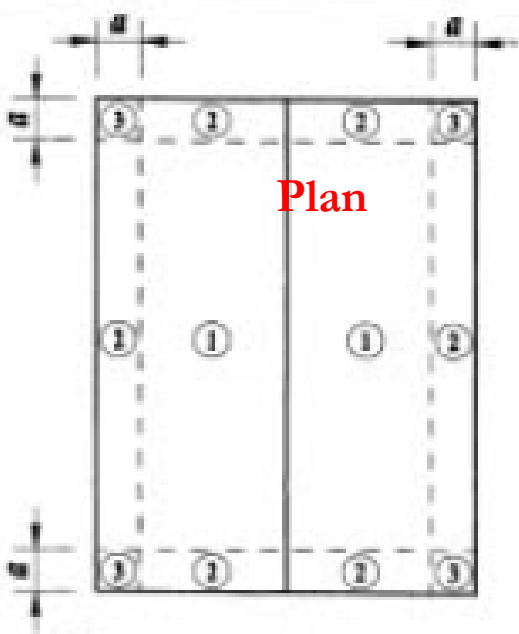
- For components and Cladding – apply internal pressure (positive or negative) that result in the largest total pressure on element
- ASCE 7 Figures 6-11A through 6-11D, 6-14A, 6-14B, 6-17 give zones of discontinuity and external pressure coefficient, GC_p
- $p = q_h[(GC_p) - (GC_{pi})]$ for $h \leq 60$ ft.
 $p = q(GC_p) - q_i(GC_{pi})$ for $h > 60$ ft.
- $C_{net} = K_d(GC_p - (GC_{pi}))$ Eq. (A-3)
- $C_{net} = 0.85[(GC_p) - (GC_{pi})]$ Eq. (A-5)
- Minimum design pressure = 10 psf

Components and Cladding – Roof (C & C)

Reference ASCE 7 Fig.6-11B

$h \leq 60$ feet

Slope $\leq 5/8:12$ or 7°



ROOF

OVERHANG

Zone	1	2	3	1	2, 3	1, 2, 3	1,2	1,2	3	3
A, s.f.	10	10	10	100	100	10	10	100	10	100
GC _p	-1.0	-1.8	-2.8	-0.9	-1.1	+0.3	-1.7	-0.8	-2.8	-1.1
C _{net}	-1.00	-1.68	-2.53	-0.92	-1.09	+0.41	-1.45	-0.68	-2.38	-0.95

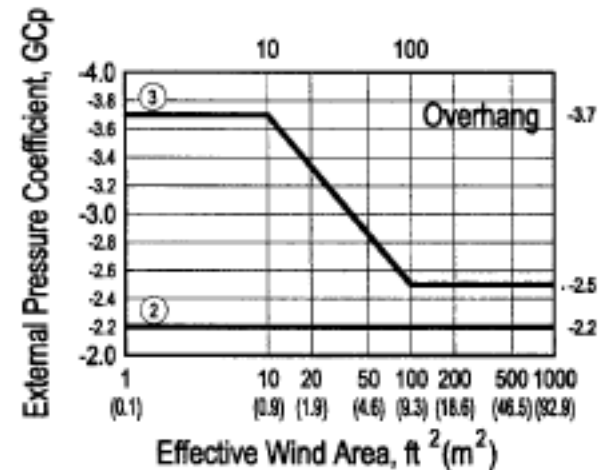
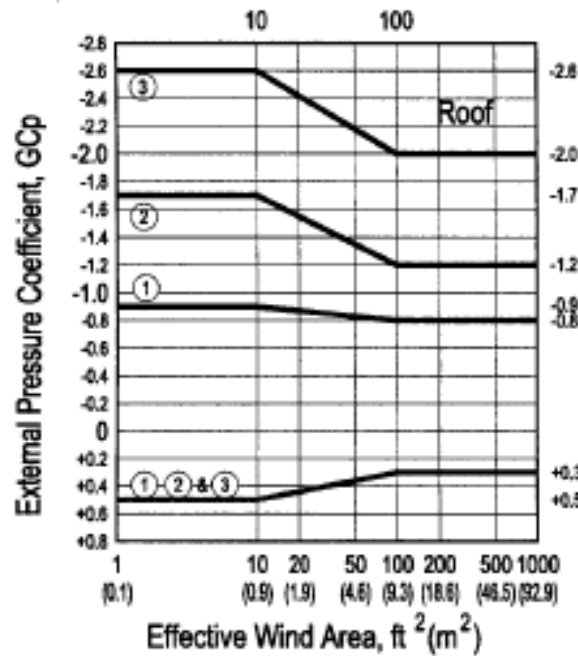
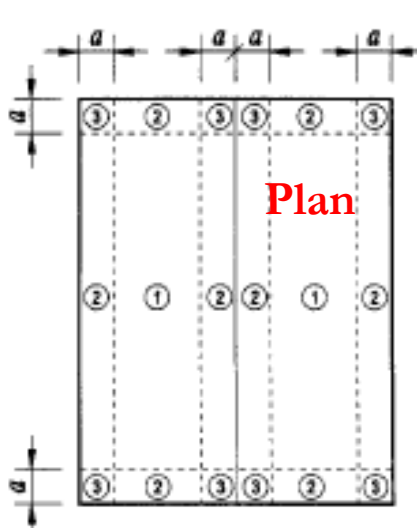
Note: $GC_{pi} = 0$ at overhang

$$C_{net} = 0.85 (GC_p - (GC_{pi})) \quad \text{Eq. (A-5)}$$

Components and Cladding – Roof (C & C)

Reference ASCE 7 Fig.6-11C $h \leq 60$ feet

Slope $\leq 6:12$ or 27°



For hip roof see
Fig. 6-11C

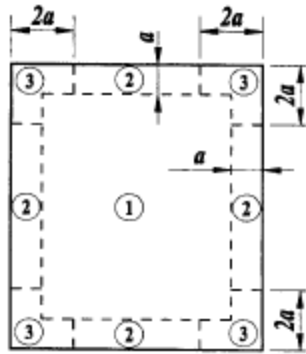
	ROOF						OVERHANG			
Zone	1	2	3	1	2	3	1, 2, 3	1, 2	3	3
$A, \text{ s.f.}$	10	10	10	100	100	10	100	≤ 100	10	100
GC_p	-0.9	-1.7	-2.8	-0.8	-1.2	-2.0	+0.5	-2.2	-3.7	-2.5
C_{net}	-0.92	-1.60	-2.53	-0.83	-1.17	-1.85	+0.58	-1.87	-3.15	-2.13

$$C_{net} = 0.85 (GC_p - (GC_{pi})) \quad \text{Eq. (A-5)}$$

Components and Cladding – Roof (c & c)

Reference ASCE 7 Fig.6-17

$h \geq 60$ feet



ROOF PLAN

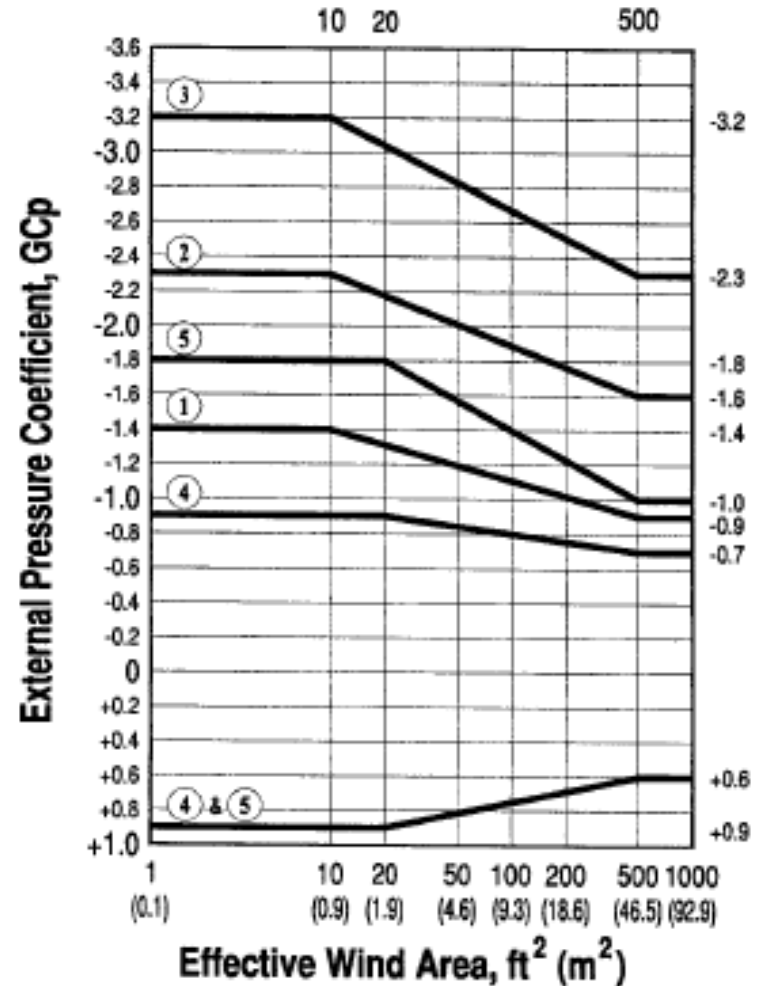
a: 10% of least horiz. dimension
 or 0.4 h
 $\geq 4\%$ of least horiz. Dimension, or
 ≥ 3 feet

ROOF

Zone	1	2	3	1	2	3
A, s.f.	10	10	10	500	500	500
GC _p	-1.4	-2.3	-3.2	-1.0	-1.6	-2.3
C _{net}	-1.34	-2.11	-2.87	-1.00	-1.51	-2.11

No + ve pressure

$$C_{net} = 0.85 (GC_p - (GC_{pi})) \quad \text{Eq. (A-5)}$$



Net Pressure Coefficient – Roof (C & C)

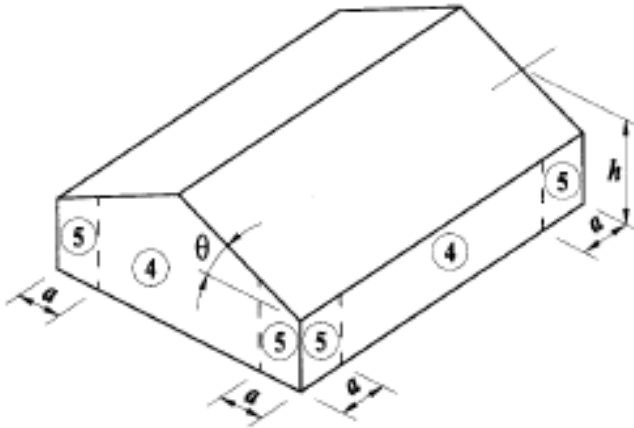
Reference IBC 2009 Table 1609.6.2 (2)

Structure or Part thereof	DESCRIPTION		C_{net} FACTOR	
3. C & C in areas of discontinuities – Roofs and Overhangs	Roof Elements & Slopes		Enclosed	Partially Encl.
	Gable or Hipped Config. at Ridges, Eaves and Rakes (Zone 2)			
	Flat < Slope < 6:12 (27°) – See ASCE 7 Fig. 6-11C Zone 2			
	Positive	≤ 10 SF	0.58	0.89
		≥ 100 SF	0.41	0.72
	Negative	≤ 10 SF	- 1.68	- 2.00
		≥ 100 SF	- 1.17	- 1.49
	Overhang for Flat < Slope < 6:12 (27°)			
	Negative	≤ 10 SF	- 1.87	
		≥ 100 SF	- 1.87	
Monosloped Config. at Ridges, Eaves, and Rakes (Zone 2)				
Negative	≤ 10 SF	- 1.51	-1.83	
	≥ 100 SF	- 1.43	- 1.74	

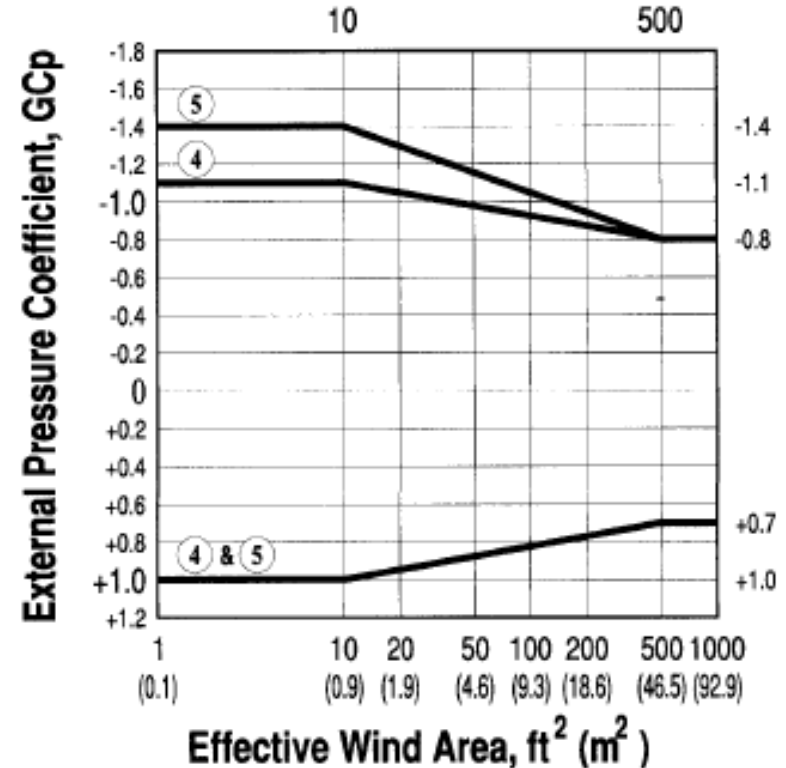
Components and Cladding – Wall (c & c)

Reference ASCE 7 Fig.6-11A

$h \leq 60$ feet



- a: 10% of least horizontal dimension
- or 0.4 h
- $\geq 4\%$ of least horizontal Dimension
- ≥ 3 feet



WALL

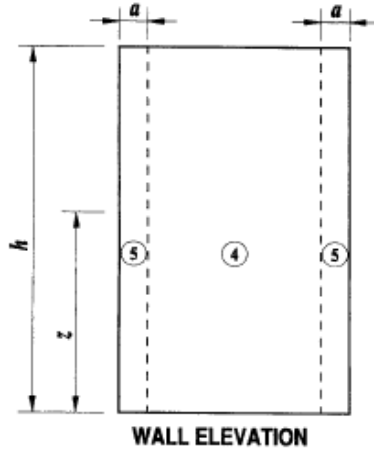
Zone	4	5	4, 5	4	5	4, 5
$A, \text{ s.f.}$	20	20	20	500	500	500
GC_p	-0.9	-1.8	+0.9	-0.7	-1.0	+0.6
C_{net}	-0.92	-1.68	+0.92	+0.75	-1.0	+0.66

$$C_{net} = 0.85 (GC_p - (GC_{pi})) \quad \text{Eq. (A-5)}$$

Components and Cladding – Wall (c & c)

Reference ASCE 7 Fig.6-17

$h \geq 60$ feet

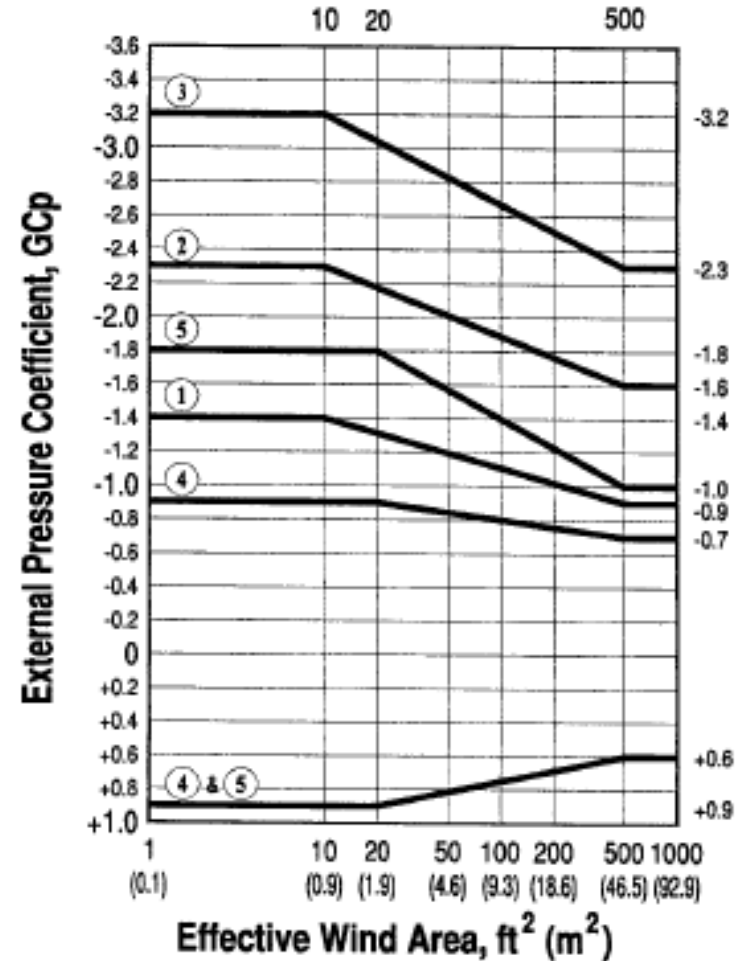


a : 10% of least horiz. dimension
 or $0.4 h$
 $\geq 4\%$ of least horiz. Dimension, or
 ≥ 3 feet

WALL

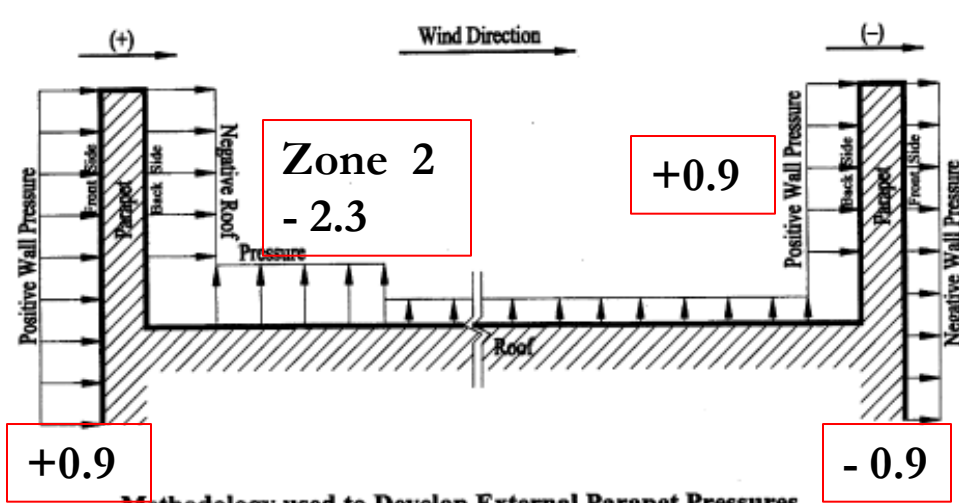
Zone	4	5	4	5	4, 5	4, 5
A , s.f.	20	20	500	500	20	500
GC_p	-0.9	-1.8	-0.7	-1.0	+0.9	+0.6
C_{net}	-0.92	-1.68	-0.75	-1.00	+0.92	+0.66

$$C_{net} = 0.85 (GC_p - (GC_{pi})) \quad \text{Eq. (A-5)}$$

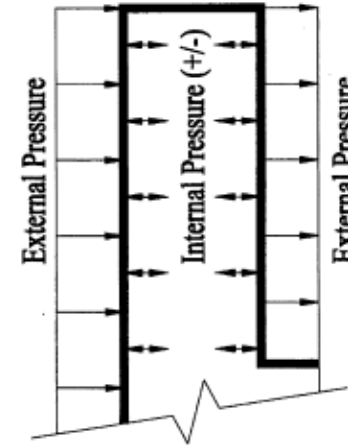


Derivation of C_{net} Coef. – Parapet (C & C)

Parapet (C & C) - Reference ASCE 7 Eq. (6-24), Fig. 6-17



Methodology used to Develop External Parapet Pressures
(Main Wind Force Resisting Systems and Components and Cladding)



External and Internal Parapet Pressures
(Components and Cladding Only)

For zone 4,

Case A $C_{net} = 0.85 [(+0.9 - (-2.3)) + 0.18] = +2.87$

Case B $C_{net} = 0.85 [(-0.9 - (+0.9)) - 0.18] = -1.68$

For zone 5

Case A $C_{net} = 0.85 [(0.9 - (-3.2)) + 0.18] = +3.64$

Case B $C_{net} = 0.85 [(-1.8 - (+0.9)) - 0.18] = -2.45$

Net Pressure Coefficient – Wall (C & C)

Reference IBC 2009 Table 1609.6.2 (2)

Structure or Part thereof	DESCRIPTION		C_{net} FACTOR	
			Enclosed	Partially Encl.
4. C & C in areas of discontinuities – Walls & Parapets	Wall Elem. $h \leq 60$ ft (Zone 4)			
	Positive	≤ 10 SF	1.00	1.32
		≥ 500 SF	0.75	1.06
	Negative	≤ 10 SF	- 1.09	- 1.40
		≥ 500 SF	- 0.83	- 1.15
	Wall Elem. $H > 60$ ft (Zone 4) – ASCE 7 Fig. 6-17 Zone 4			
	Positive	≤ 20 SF	0.92	1.23
		≥ 500 SF	0.66	0.98
Negative	≤ 20 SF	- 0.92	-1.23	
	≥ 500 SF	- 0.75	- 1.06	
Parapet Walls				
Positive		2.87	3.19	
Negative		-1.68	-2.00	

Inspection Requirement

Reference: IBC 1706

- Special inspection for wind requirement;
 - Exp. Category B when $V_{3\text{sec}} \geq 120$ mph
 - Exp. Category C or D when $V_{3\text{sec}} \geq 110$ mph
- Structural Wood
 - Shear panels, diaphragms when nail spcg $< 4''$ o.c. – nailing, bolting, hold-downs of MWFRS
- Steel light-framed
 - Gypsum board or fiberboard
 - Wood structural panel or steel sheets shear panel or diaphragms
- Roof cladding and wall cladding

SUMMARY

- Alternate Wind Design Approach satisfies ASCE 7 Method 2
- Some limitation on aspect ratio, flexibility, and site condition
- Consider torsion if not trivial
- Methodology applies to non-flexible building; simple diaphragms; flat, gable or hipped roofs
- Simplification - combining K_d , G , C_p and GC_{pi} terms into a single parameter
- Derivation of design equation and C_{net} have been presented

Example No. 56B

Problem Description and Data

Given:

- A three story office building as shown in Figure A1
- Structure is not susceptible to dynamic effects, and is considered to be enclosed
- Lateral force resisting system: special steel moment frame at three transverse grids and brace frames at longitudinal grids (1 & 3)
- Gable roof with a pitch of 4 ft. in 30 ft. ($\approx 8^\circ$)

Criteria:

- Basic wind speed $V = 85$ mph
- Wind Exposure Category B
- $K_d = 0.85$, $K_{zt} = 1.0$ and $I_w = 1.0$

Determine: Based on 2009 IBC Alternate wind design approach

- Calculate base shear for wind and story forces along N-S direction at frame line A
- Determine Component Cladding Pressure for exterior wall elements at 2nd story mullion @ 5 ft. o. c.

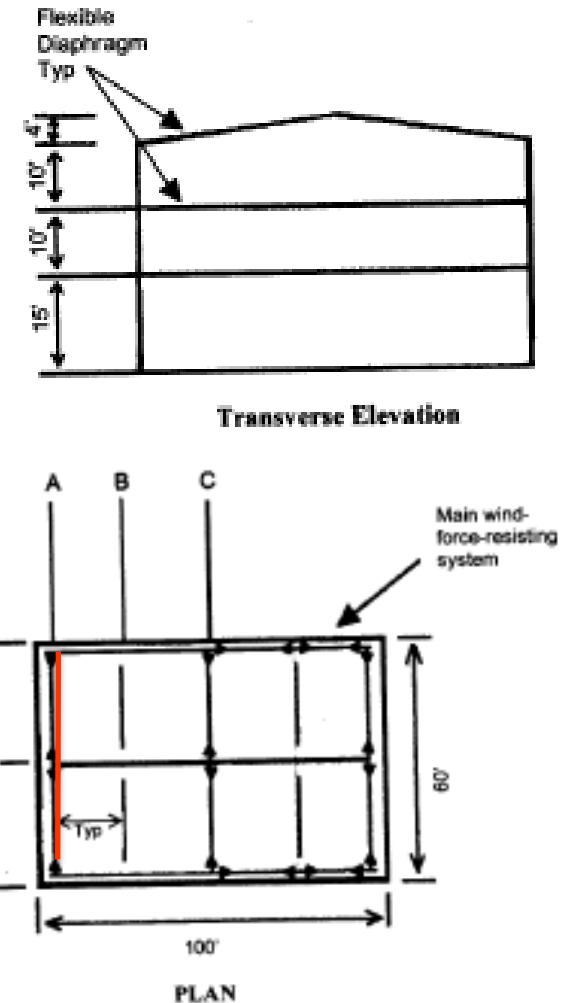


Fig. A-1 Typical Floor Plan and Elevation

Example No. 56B

Based on Alternate Design Procedure (IBC 2009)

Mean Roof Height $h = 15 + 2 \times 10 + 4/2 = 37$ ft.

Dim. Normal to wind direction $B = 100$ ft.

Dim. Parallel to wind direction $L = 60$ ft.

- Aspect ratios
 - Height to width ratio $= 37/60 = 0.6 < 4$
 - Height < 75 feet
 - Fundamental frequency $f > 1$ Hz
- Flexibility
 - Building not sensitive to dynamic effects
- Topography factor $K_{zt} = 1.0$ (Given)

Example No. 56B

Reference [T1609.6.2(1), T1609.6.2(2)] For V= 85 mph $q_s = 18.5$ psf

Walls: $C_{net} = 0.43$ Windward and -0.51 Leeward

Roofs: $C_{net} = -0.28$ Windward and -0.66 Leeward

Floor	Ht.	Ht. Trib.	Width Trib.	Area Trib.	K_z	Windward				Leeward				Total
						$K_z q_s$	C_{net}	P_{net}	F_x	$K_z q_s$	C_{net}	P_{net}	F_x	
	Ft.	Ft.	Ft.	Ft ²		psf		psf	kip	psf		psf	kip	kip
R	37	4.0	100	400	0.74	13.7	-0.28	-3.8	-1.5	13.7	-0.66	-9.0	-3.6	2.1
Rf	35	5.0	100	500	0.73	13.5	0.43	5.8	2.9	13.5	-0.51	-6.9	-3.5	6.4
3	25	10.0	100	1000	0.70	13.0	0.43	5.6	5.6	13.5	-0.51	-6.9	-6.9	12.5
2	15	12.5	100	1250	0.70	13.0	0.43	5.6	7.0	13.5	-0.51	-6.9	-8.6	15.6
1							$\Sigma =$		14.0				-22.6	36.6

Consider flexible diaphragm and 25% tributary to frame lines,

Force to Frame A : Roof level $(2.1+6.4) \times 25\% = 2.1$ k
 3rd Level $12.5 \times 25\% = 3.1$ k
 2nd Level $15.6 \times 25\% = 3.9$ k

Example No. 56B

- Components and Cladding

- Determine width ‘a’ of effective end zone

$$a = 60.0 \times 10\% = 6.0 \text{ feet SAY } 6'0'' \text{ ends}$$

OR $a = 37.0 \times 40\% = 14.8 \text{ feet} > 60.0 \times 4\% > 3.0 \text{ feet}$

$$q_h = 18.5 \times 0.74 = 13.7 \text{ psf}$$

		Zone	a	q_h	A	C_{net}	P_{net}	A	C_{net}	P_{net}
			ft	psf	sf		psf	sf		psf
Wall	Field	4		13.7	10	-1.09	-14.9	500	-0.83	-11.4
Wall	Edge	5	6.0	13.7	10	-1.34	-18.4	500	-0.83	-11.4
Wall	ALL	4, 5	6.0	13.7	10	1.00	+13.7	500	0.75	+10.3

At 2nd story south elevation, mullions are 5 ft. o.c. away from end

Limiting width $1/3 \times \text{height} = (10-1)/3 = 3.0 \text{ ft.}$ for eff. pressure

Effective wind $A = 3.0 \times 9 = 27 \text{ ft}^2$; Trib. $A = 5 \times 9 = 45 \text{ ft}^2$

Design force: $13.7[1.09-(1.09-0.83)(\log 27 - \log 10)/(\log 500 - \log 10)] \times 5$
 $= 14.1 \times 5 = 70 \text{ lb/ft}$ (75 lb/ft using linear interpretation)

Example No. 57B

Problem Description and Data

Given:

- A nine story office building as shown in Figure A1
- Fundamental period = 0.9 seconds
- Structure is not susceptible to dynamic effects, and is considered to be enclosed
- Lateral force resisting system: special steel moment frame at building perimeter
- Parapet is 3'-0" high all around perimeter of bldg

Criteria:

- Basic wind speed $V = 85$ mph
- Wind Exposure Category B
- $K_d = 0.85$, $K_{zt} = 1.0$ and $I_w = 1.0$

Determine: Based on 2009 IBC Alternate wind design approach

- Calculate base shear for wind along N-S direction
- Determine Component Cladding Pressure for exterior wall elements

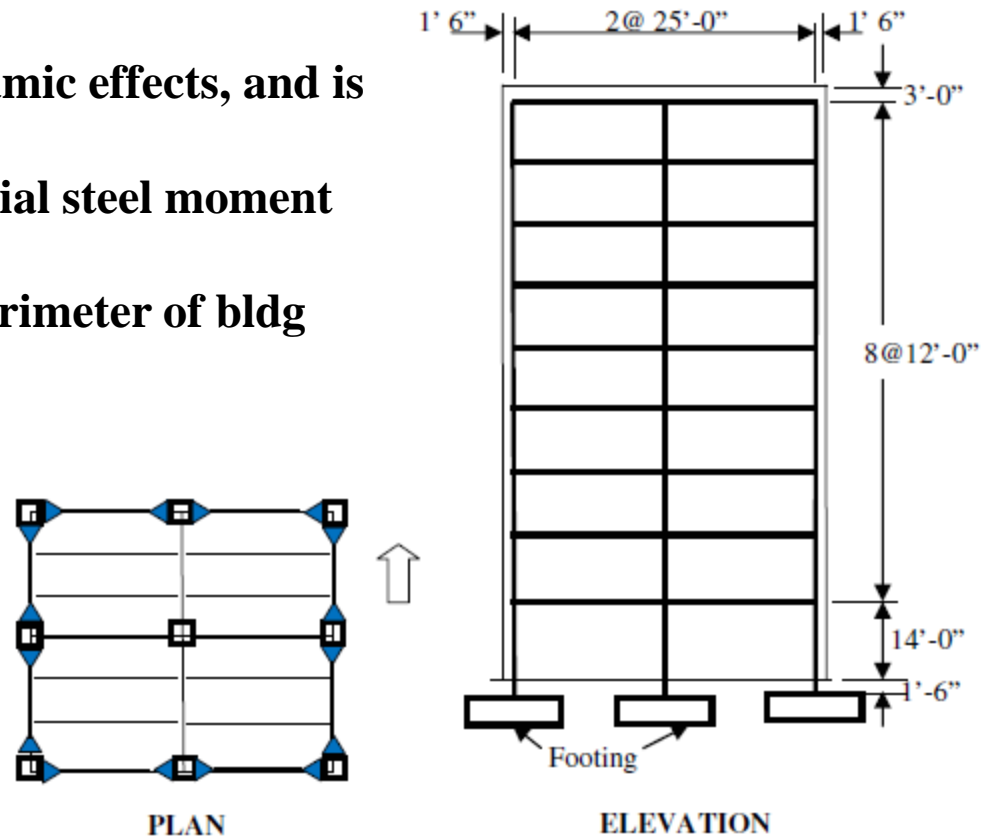


Fig. A-1 Typical Floor Plan and Elevation

Example No. 57B

Based on Alternate Design Procedure (IBC 2009)

Mean Roof Height $h = 14 + 8 \times 12 = 108$ ft.

Dim. Normal to wind direction $B = 53$ ft.

Dim. Parallel to wind direction $L = 53$ ft.

- Aspect ratios
 - Height to width ratio $= 108/53 = 2.0 < 4$
 - Height > 75 feet, *BUT*
 - Fundamental frequency $f = 1/0.9 = 1.1 > 1$ Hz
- Wind stagnation pressure $q_s = 18.5$ psf [T-1609.6.2(1)]
- Flexibility - Building not sensitive to dynamic effects
- Importance factor $I_w = 1.0$ (given)
- Exposure Category B (given)

Example No. 57B

- Main wind force resisting system (MWFRS)
 - Building is enclosed $V = 85$ mph $q_s = 18.5$ psf
 - Velocity exposure coefficient K_z - see ASCE 7 T 6-3)
 - Topography factor $K_{zt} = 1.0$ (given)
 - Determine net pressure coefficient, C_{net} [T1609.6.2(2)]
 - +ve int. pressure
 - ve int. pressure
 - Windward wall $C_{net} = 0.43$ $C_{net} = 0.73$
 - Leeward wall $C_{net} = -0.51$ $C_{net} = -0.21$
 - Side wall $C_{net} = -0.35$ $C_{net} = -0.66$
 - Parapet wall
 - Windward $C_{net} = 1.28$
 - Leeward $C_{net} = -0.85$

Example No. 57B

$C_{net} = 0.43$ Windward and -0.51 Leeward [T1609.6.2(2)]

Floor	Ht. Ft.	Ht. Trib. Ft.	Width Trib. Ft.	Area Trib. Ft ²	K_z	Windward				Leeward				Total kip
						K_{zq_s} psf	C_{net}	P_{net} psf	F_x kip	K_{zq_s} psf	C_{net}	P_{net} psf	F_x kip	
Pp	113	3	53.0	159	1.02	18.9	1.28	24.1	3.8	18.9	-0.85	-16.1	-2.6	6.4
Rf	110	6	53.0	318	1.02	18.8	0.43	8.1	2.6	18.8	-0.51	-9.6	-3.0	5.6
9	98	12	53.0	636	0.98	18.2	0.43	7.8	5.0	18.8	-0.51	-9.6	-6.1	11.1
8	86	12	53.0	636	0.95	17.5	0.43	7.5	4.8	18.8	-0.51	-9.6	-6.1	10.9
7	74	12	53.0	636	0.91	16.8	0.43	7.2	4.6	18.8	-0.51	-9.6	-6.1	10.7
6	62	12	53.0	636	0.86	15.9	0.43	6.9	4.4	18.8	-0.51	-9.6	-6.1	10.5
5	50	12	53.0	636	0.81	15.0	0.43	6.4	4.1	18.8	-0.51	-9.6	-6.1	10.2
4	38	12	53.0	636	0.75	13.9	0.43	6.0	3.8	18.8	-0.51	-9.6	-6.1	9.9
3	26	12	53.0	636	0.67	12.4	0.43	5.3	3.4	18.8	-0.51	-9.6	-6.1	9.5
2	14	13	53.0	689	0.56	10.4	0.43	4.5	3.1	18.8	-0.51	-9.6	-6.6	9.7
1							$\Sigma =$		39.6				-54.9	94.5

Example No. 57B

- Components and Cladding

- Determine width ‘a’ of effective end zone

$$a = 53.0 \times 10\% = 5.3 \text{ feet SAY } 5'6''$$

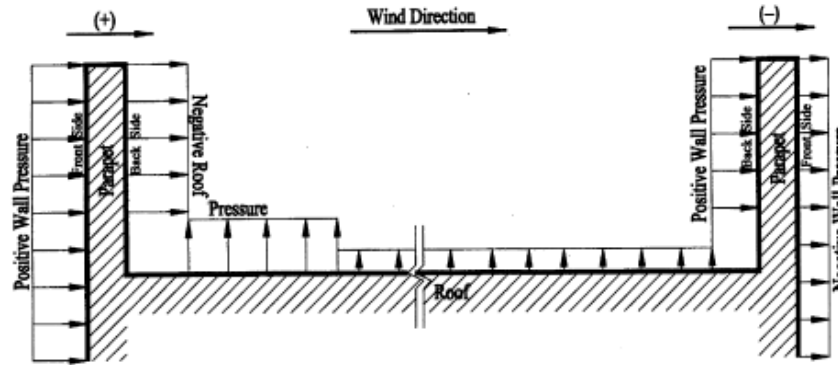
OR $a = 108.0 \times 40\% = 43.2 \text{ feet} > 53.0 \times 4\% > 3.0 \text{ feet}$

$$q_h = 18.5 \times 1.02 = 18.8 \text{ psf}$$

		Zone	a	2a	q_h	A	C_{net}	P_{net}	A	C_{net}	P_{net}
			ft	ft	psf	sf		psf	sf		psf
Roof	Field	1			18.8	10	- 1.34	- 25.2	500	- 0.92	- 17.2
Roof	Edge	2	6.0	12.0	18.8	10	- 2.11	- 39.6	500	- 1.51	- 28.4
Roof	Corner	3	6.0	12.0	18.8	10	- 2.87	- 54.0	500	- 2.11	- 39.6
Wall	Field	4	--	--	18.8	20	- 0.92	- 17.2	500	- 0.75	- 14.0
Wall	Edge	5	6.0	12.0	18.8	20	- 1.68	- 31.6	500	- 1.00	- 18.8
Wall	ALL	4, 5	6.0	12.0	18.8	20	+ 0.92	+17.2	500	+ 0.66	+12.5

Example No. 57B

Parapet (C & C) - Reference ASCE 7 Eq. (6-24), Fig. 6-17



Methodology used to Develop External Parapet Pressures
(Main Wind Force Resisting Systems and Components and Cladding)

For zone 4,

Case A $C_{net} = +2.87$ $p_{net} = 18.8 \times 2.87 = 54.0$ psf

Case B $C_{net} = -1.68$ $p_{net} = 18.8 \times (-1.68) = -31.6$ psf

For zone 5

Case A $C_{net} = +3.64$ $p_{net} = 18.8 \times 3.64 = 68.4$ psf

Case B $C_{net} = -2.45$ $p_{net} = 18.8 \times (-2.45) = -46.0$ psf