

**Company**

Address  
City, State  
Phone

JOB TITLE Example 3.5 - 160' Building on Escarpmer

JOB NO. \_\_\_\_\_ SHEET NO. \_\_\_\_\_  
CALCULATED BY \_\_\_\_\_ DATE \_\_\_\_\_  
CHECKED BY \_\_\_\_\_ DATE \_\_\_\_\_

**STRUCTURAL CALCULATIONS**

FOR

**Example 3.5 - 160' Building on Escarpment**

Guide to Wind Load Procedures ASCE 7-22

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**Code Search****Code:** ASCE 7 - 22**Occupancy:**

Occupancy Group = B Business

**Risk Category & Importance Factors:**

Risk Category =	II
Wind Factor =	1.00
Snow Factor	1.00
Seismic Importance factor =	1.00

**Type of Construction:**

Fire Rating:	
Roof =	0.0 hr
Floor =	0.0 hr

**Building Geometry:**

Roof angle ( $\theta$ )	0.00 / 12	0.0 deg
Building length	200.0 ft	
Least width	100.0 ft	
Mean Roof Ht (h)	157.0 ft	
Parapet ht above grd	160.0 ft	
Minimum parapet ht	3.0 ft	
hb for Elevated bldg	0.0 ft	

**Live Loads:**

**Roof** 0 to 200 sf: 20 psf  
 200 to 600 sf: 24 - 0.02Area, but not less than 12 psf  
 over 600 sf: 12 psf

Roofs used for roof gardens 100 psf

**Floor:**

Typical Floor	50 psf
Partitions	15 psf
Corridors above first floor	80 psf
Lobbies & first floor corridors	100 psf
Stairs and exit ways	100 psf

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**Wind Loads :**

ASCE 7- 22

Ultimate Wind Speed 140 mph  
Nominal Wind Speed 108.4 mph  
Risk Category II  
Exposure Category B  
Enclosure Classif. Enclosed Building  
Internal pressure +/-0.18  
Bldg Directionality (Kd) 0.85  
Kh MWFRS<=60 1.072  
Kh all other 1.072  
Type of roof Monoslope

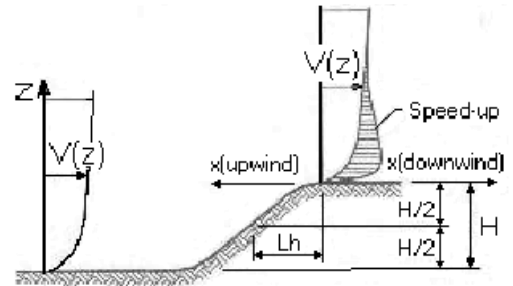
Topographic Factor (Kzt)

Topography 2D Escarpment  
Hill Height (H) 80.0 ft  
Half Hill Length (Lh) 100.0 ft  
Actual H/Lh = 0.80  
Use H/Lh = 0.50  
Modified Lh = 160.0 ft  
From top of crest: x = 50.0 ft  
Bldg up/down wind? downwind

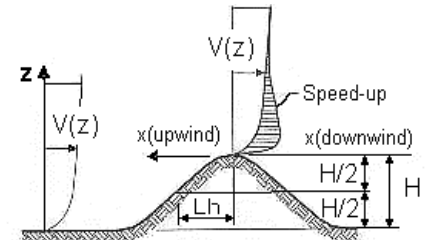
H/Lh= 0.50 K<sub>1</sub> = 0.375  
x/Lh = 0.31 K<sub>2</sub> = 0.922  
z/Lh = 0.98 K<sub>3</sub> = 0.086

At Mean Roof Ht:

$K_{zt} = (1+K_1K_2K_3)^2 = 1.06$



**ESCARPMENT**



**2D RIDGE or 3D AXISYMMETRICAL HILL**

**Gust Effect Factor**

h = 157.0 ft  
B = 100.0 ft  
/z (0.6h) = 94.2 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).  
If building h/B>4 then may be flexible and should be investigated.  
h/B = 1.57

**G = 0.83** Using rigid structure formula

**Rigid Structure**

$\bar{e} = 0.33$   
 $l = 320$  ft  
 $Z_{min} = 30$  ft  
c = 0.30  
 $g_Q, g_v = 3.4$   
 $L_z = 453.9$  ft  
Q = 0.83  
 $I_z = 0.25$   
G = **0.83**

**Flexible or Dynamically Sensitive Structure**

Natural Frequency ( $\eta_1$ ) = 0.7 Hz  
Damping ratio ( $\beta$ ) = 0.01  
 $/b = 0.470$   
 $/\alpha = 0.222$   
 $V_z = 121.8$   
 $N_1 = 2.61$   
 $R_n = 0.076$   
 $R_h = 0.212$   $\eta = 4.149$   $h = 157.0$  ft  
 $R_B = 0.307$   $\eta = 2.643$   
 $R_L = 0.055$   $\eta = 17.695$   
 $g_R = 4.104$   
R = 0.525  
Gf = 0.951





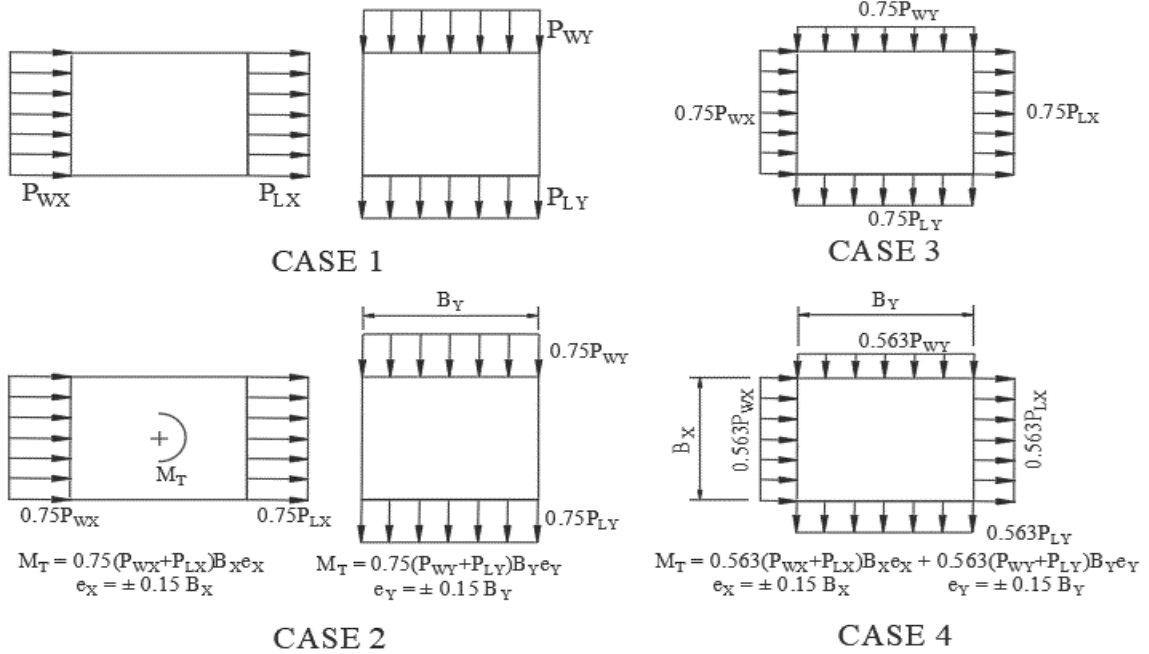
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NOTE: ASCE 7 requires the application of full and partial loading of the wind pressures per the 4 cases below.



**Wind Forces at Floors**

Total Floors above grade = 11  
 T/Fdn (dist below grade) = 2.0 ft

Building dimension (parallel with ridge) = 200.0 ft  
 Building dimension (normal to ridge) = 100.0 ft  
 L is the building dimension parallel to the wind direction

Level	Elevation Above Grade (ft)	Height of Centroid to Fdn (ft)	Wind Normal to Ridge						Wind Parallel to Ridge			
			L	B	Area (sf)	Applied Force (k)	Story Shear (k)	Overturning Moment (k)	Area	Applied Force (k)	Story Shear (k)	Overturning Moment (k)
Equip, etc	158.00	160.00	wind on equip, screenwalls, etc =						0			
Parapet	160.00	160.50	100.0	200.0	600.0	72.9			300.0	36.4		
T/Ridge	157.00	159.00	100.0	200.0	0.0	0.0			0.0	0.0		
Roof	157.00	159.00	100.0	200.0	1,400.0	73.8	148.7	111.3	700.0	31.3	67.7	54.6 Roof
11	143.00	145.00	100.0	200.0	2,800.0	146.8	295.5	2,192.9	1,400.0	62.1	129.8	1,002.3 11
10	129.00	131.00	100.0	200.0	2,800.0	146.1	441.6	6,329.9	1,400.0	61.7	191.5	2,819.2 10
9	115.00	117.00	100.0	200.0	2,800.0	145.5	587.0	12,511.8	1,400.0	61.4	252.9	5,500.3 9
8	101.00	103.00	100.0	200.0	2,800.0	145.0	732.0	20,730.1	1,400.0	61.2	314.1	9,041.2 8
7	87.00	89.00	100.0	200.0	2,800.0	144.6	876.6	30,978.0	1,400.0	61.0	375.1	13,438.6 7
6	73.00	75.00	100.0	200.0	2,800.0	144.3	1,020.9	43,250.6	1,400.0	60.9	436.0	18,690.0 6
5	59.00	61.00	100.0	200.0	2,800.0	144.0	1,165.0	57,543.9	1,400.0	60.7	496.6	24,793.3 5
4	45.00	47.00	100.0	200.0	2,800.0	143.3	1,308.2	73,853.2	1,400.0	60.3	557.0	31,746.4 4
3	31.00	33.00	100.0	200.0	2,800.0	141.4	1,449.6	92,168.5	1,400.0	59.4	616.3	39,544.0 3
2	17.00	19.00	100.0	200.0	3,100.0	151.2	1,600.8	112,462.8	1,550.0	63.1	679.4	48,172.8 2
1	0.00	2.00	100.0	200.0	1,700.0	84.5	1,685.3	139,676.9	850.0	35.4	714.8	59,723.3 1
GRD		2.00						139,676.9				59,723.3 GRD
FDN		0.00						143,047.6				61,153.0 FDN



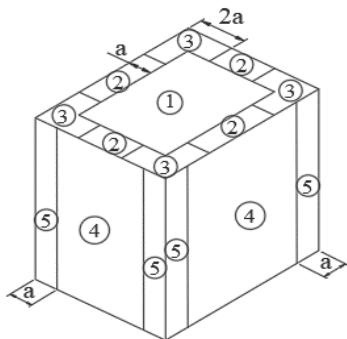
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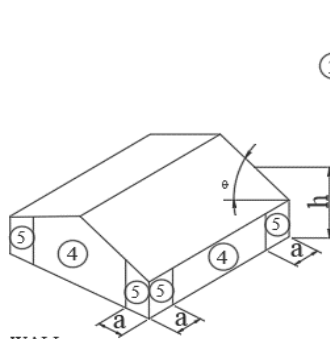
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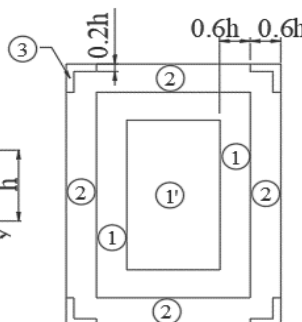
**Location of C&C Wind Pressure Zones - ASCE 7-22**



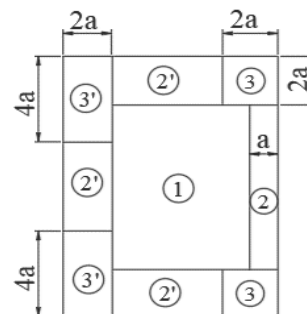
Roofs w/  $\theta \leq 10^\circ$   
and all walls  
 $h > 60'$



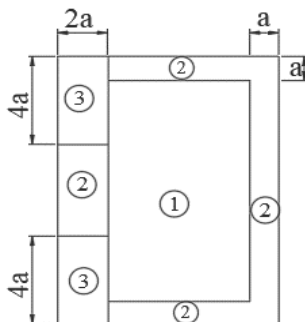
**WALLS**  
Walls  $h \leq 60'$   
& alt design  $h < 90'$



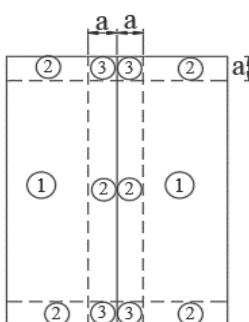
Multispan Gable & Sawtooth  $\leq 10^\circ$   
& Gable  $\theta \leq 7$  degrees &  
Monoslope  $\leq 3$  degrees  
 $h \leq 60'$  & alt design  $h < 90'$



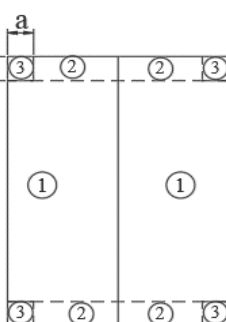
Monoslope roofs  
 $3^\circ < \theta \leq 10^\circ$   
 $h \leq 60'$  & alt design  $h < 90'$



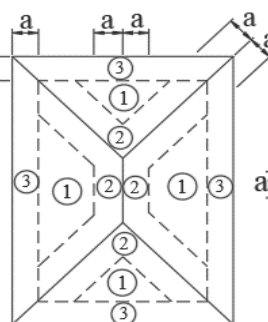
Monoslope roofs  
 $10^\circ < \theta \leq 30^\circ$   
 $h \leq 60'$  & alt design  $h < 90'$



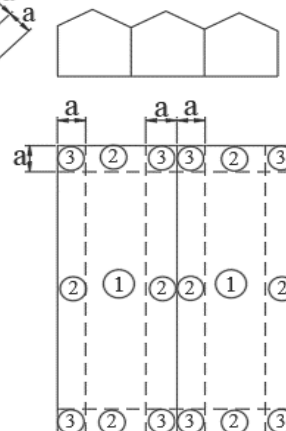
Gable  $7^\circ < \theta \leq 27^\circ$



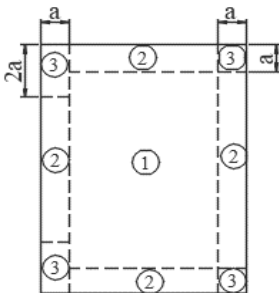
Gable  $27^\circ < \theta \leq 45^\circ$



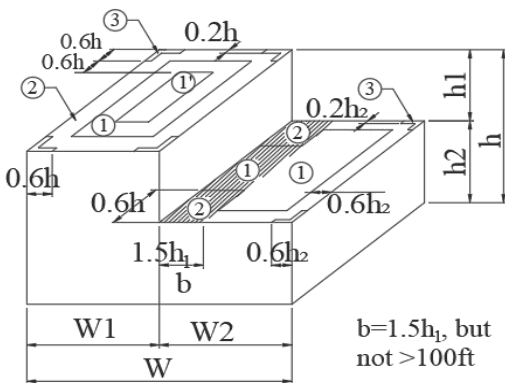
Hip  $7^\circ < \theta \leq 45^\circ$



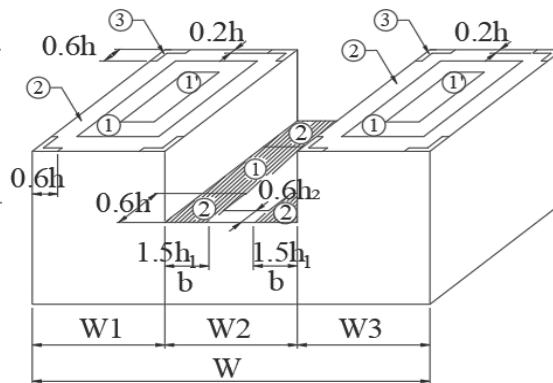
Multispan gable  $10^\circ < \theta \leq 45^\circ$   
 $h \leq 60'$  & alt design  $h < 90'$



Sawtooth  $10^\circ < \theta \leq 45^\circ$   
 $h \leq 60'$  & alt design  $h < 90'$



Stepped roofs  $\theta \leq 3^\circ$   
 $h \leq 60'$  & alt design  $h < 90'$



Note: The hatched area indicates where roof positive pressures are equal to the adjacent wall positive pressure.



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**Roof Design Loads**

Items	Description	Multiple	psf (max)	psf (min)
Roofing	3 ply felt & gravel		5.5	5.0
Decking	Metal Roof deck, 1.5, 22 ga.		1.7	1.2
Framing	Steel roof joists & girders		3.0	2.0
Insulation	Rigid insulation, per 1"	x 2.0	3.0	1.4
Ceiling	Suspended acoustical tile		1.8	1.0
Sprinklers	Sprinklers		2.0	0.0
Mech & Elec	Mech. & Elec.		2.0	0.0
			0.0	0.0
Actual Dead Load			<input type="radio"/> 19.0	<input type="radio"/> 10.6
Use this DL instead			<input checked="" type="radio"/> 20.0	<input checked="" type="radio"/> 9.0
Live Load			20.0	0.0
Snow Load			12.1	0.0
Ultimate Wind (zone 2 - 100 sf)			16.0	-100.2
<b>ASD Loading</b>				
D + Lr			40.0	-
D + 0.75(0.6W + Lr)			42.2	-
0.6*D + 0.6*W			-	-54.7
<b>LRFD Loading</b>				
1.2D + 1.6 Lr + 0.5W			64.0	-
1.2D + 1.0W + 0.5Lr			50.0	-
0.9D + 1.0W			-	-92.1

**Roof Live Load Reduction**

Roof angle 0.00 / 12 0.0 deg

0 to 200 sf: 20.0 psf  
 200 to 600 sf:  $24 - 0.02 \text{Area}$ , but not less than 12 psf  
 over 600 sf: 12.0 psf

	300 sf	18.0 psf
	400 sf	16.0 psf
	500 sf	14.0 psf
User Input:	450 sf	15.0 psf

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**Floor Design Loads**

Items	Description	Multiple	psf (max)	psf (min)
Flooring	Carpet & pad		1.0	1.0
Topping	Concrete regular per 1"	x 4.3	53.8	51.6
Decking	Metal Floor deck - 2", 20ga		2.0	1.5
Framing	Steel floor bms/joists & girders		8.0	5.0
Topping	Deflection Concrete	x 0.8	10.0	1.6
Ceiling	Suspended acoustical tile		1.8	1.0
Sprinklers	Sprinklers		2.0	0.0
Mech & Elec	Mech. & Elec.		2.0	0.0
Misc.	Misc.		0.5	0.0
Actual Dead Load			<input type="radio"/> 81.1	<input checked="" type="radio"/> 61.7
Use this DL instead			<input checked="" type="radio"/> 85.0	<input type="radio"/> 65.0
Partitions			15.0	0.0
Live Load			50.0	0.0
Total Live Load			65.0	0.0
Total Load			150.0	61.7

**FLOOR LIVE LOAD REDUCTION (not including partitions)**

NOTE: Not allowed for assembly occupancy or LL>100psf or passenger car garages, except may reduce members supporting 2 or more floors & non-assembly 20%.

$$L = L_o(0.25 + 15/\sqrt{K_{LL}A_T})$$

Unreduced design live load:  $L_o = 50$  psf

**Floor member & 1 floor cols**  $K_{LL} = 2$

Tributary Area  $A_T = 300$  sf

Reduced live load:  $L = 43.1$  psf

**Columns (2 or more floors)**  $K_{LL} = 4$

Tributary Area  $A_T = 500$  sf

Reduced live load:  $L = 29.3$  psf

**IBC alternate procedure**

Smallest of:

$$R = .08\%(SF - 150)$$

$$R = 23.1(1+D/L) = 62.4\%$$

R = 40% beams; 60% columns

$$R = 12.0\%$$

Reduced live load:  $L = 44.0$  psf

$$R = 28.0\%$$

Reduced live load:  $L = 36.0$  psf

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**Wall Design Load #1**

Items	Description	Multiple	psf (max)	psf (min)
Sheathing	7/16" plywood/OSB		1.6	1.4
Sheathing	5/8" gypsum		2.8	2.5
Framing	6" metal studs @16"		2.5	0.9
veneer	4" Clay Brick		40.0	38.0
Wall Covering	1" Wood Paneling	x 0.38	0.9	0.9
Insulation	R-11 Fiberglass insul.		0.4	0.4
Mech & Elec	Mech. & Elec.		1.0	0.0
Misc.	Misc.		0.5	0.0
Actual Dead Load			<input type="radio"/> 49.7	<input type="radio"/> 44.0
Use this DL instead			<input checked="" type="radio"/> 50.0	<input checked="" type="radio"/> 40.0

**Wall Design Load #2**

Items	Description	Multiple	psf (max)	psf (min)
Sheathing	7/16" plywood/OSB		1.6	1.4
Sheathing	5/8" gypsum		2.8	2.5
Framing	CMU wall		47.0	45.0
veneer	7/8" Stucco		10.0	10.0
			0.0	0.0
Insulation	R-11 Fiberglass insul.		0.4	0.4
Mech & Elec	Mech. & Elec.		1.0	0.0
Misc.	Misc.		0.5	0.0
Actual Dead Load			<input type="radio"/> 63.3	<input type="radio"/> 59.3
Use this DL instead			<input checked="" type="radio"/> 65.0	<input checked="" type="radio"/> 55.0

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**CODE SUMMARY****Code:** ASCE 7 - 22**Live Loads:**

Roof	0 to 200 sf: 20 psf
	200 to 600 sf: 24 - 0.02Area, but not less than 12 psf
	over 600 sf: 12 psf
Roofs used for roof gardens	100 psf
Typical Floor	50 psf
Partitions	15 psf
Corridors above first floor	80 psf
Lobbies & first floor corridors	100 psf
Stairs and exit ways	100 psf

**Dead Loads:**

Floor	85.0 psf
Roof	20.0 psf

**Roof Snow Loads:**

Design Uniform Roof Snow load	=	12.1 psf
Flat Roof Snow Load	Pf =	4.1 psf
Risk Category	=	II
Balanced Snow Load	Ps =	4.1 psf
Ground Snow Load	Pg =	5.0 psf
Importance Factor	I =	1.00
Snow Exposure Factor	Ce =	0.97
Thermal Factor	Ct =	1.20
Sloped-roof Factor	Cs =	1.00
Drift Surcharge load	Pd =	
Width of Snow Drift	w =	
Winter wind Parameter	W2 =	0.55

**Earthquake Design Data:**

Risk Category	=	II
Importance Factor	I =	1.00
Mapped spectral response accelerat	Ss =	0.60 g
	S1 =	0.10 g
Site Class	=	C
Spectral Response Coef.	Sds =	0.007
	Sd1 =	0.007
Seismic Design Category	=	A
Basic Structural System	=	Structural steel systems not specifically detailed for seismic resistance
Seismic Resisting System	=	Structural steel systems not specifically detailed for seismic resistance
Design Base Shear	V =	0.010W
Seismic Response Coef.	Cs =	0.010
Response Modification Factor	R =	3
Analysis Procedure	=	Equivalent Lateral-Force Analysis

**Rain Design Data:**

Rain intensity	i =	7.23 in/hr
Rain Load	R =	34.8 psf

**Wind Design Data:**

Ultimate Design Wind Speed	140 mph
Nominal Design Wind Speed	108.44 mph
Risk Category	II
Mean Roof Ht (h)	157.0 ft
Exposure Category	B
Enclosure Classif.	Enclosed Building
Internal pressure Coef.	+/-0.18
Directionality (Kd)	0.85

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**Component and Cladding Ultimate Wind Pressures**

Roof Area	Surface Pressure (psf)							
	10 sf	50 sf	100 sf	500 sf				
Negative Zone 1	-76.6	-66.6	-62.3	-52.3				
Negative Zone 2	-120.2	-106.2	-100.2	-86.3				
Negative Zone 3	-120.2	-106.2	-100.2	-86.3				
Positive All Zones	16.0	16.0	16.0	16.0				
Overhang Zone 1	-111.5	-98.7	-92.3	-77.5				
Overhang Zone 2	-155.1	-138.4	-130.3	-111.5				
Overhang Zone 3 @zone 4	-155.1	-138.4	-130.3	-111.5				
Overhang Zone 3 @zone 5	-198.7	-173.7	-159.3	-126.0				

Overhang soffit pressure equals adj wall pressure (which includes internal pressure of 8.7 psf)

Parapet Area	Solid Parapet Pressure (psf)					
	10 sf	20 sf	50 sf	100 sf	200 sf	500 sf
CASE A : Edge zones:	155.4	149.4	137.3	128.1	119.0	106.9
Corner zones:	155.4	149.4	137.3	128.1	119.0	106.9
CASE B : Edge zones:	-87.4	-87.4	-80.5	-75.3	-70.1	-63.2
Corner zones:	-131.2	-131.2	-115.9	-104.4	-92.9	-77.7

Wall Area	Surface Pressure (psf)			
	20 sf	100 sf	200 sf	500 sf
Negative Zone 4	-52.3	-47.5	-45.4	-42.6
Negative Zone 5	-96.0	-76.6	-68.2	-57.2
<u>Positive Zone 4 &amp; 5</u>				
0 to 15'	46.3	40.0	37.4	33.8
20 ft	46.6	40.3	37.6	34.0
25 ft	47.7	41.2	38.4	34.7
30 ft	48.4	41.8	39.0	35.2
40 ft	49.9	43.0	40.1	36.1
50 ft	50.3	43.4	40.4	36.4
60 ft	50.5	43.6	40.6	36.6
70 ft	50.7	43.7	40.7	36.7
80 ft	50.8	43.8	40.8	36.8
90 ft	51.0	43.9	40.9	36.9
100 ft	51.1	44.1	41.0	37.0
120 ft	51.9	44.7	41.6	37.5
140 ft	52.3	45.1	41.9	37.8
h = 157 ft	52.7	45.4	42.2	38.0