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STRUCTURAL CALCULATIONS

FOR

Chapter 5 examples
20' eave height using MWFRS all heights procedure
20' eave height using MWFRS <60' procedure

Guide to Wind Load Provisions of ASCE 7-10

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Code Search

Code: ASCE 7 - 10

Occupancy:

Occupancy Group =   B   Business

Risk Category & Importance Factors:

Risk Category =   II

Wind factor =   1.00
Snow factor =   1.00
Seismic factor =   1.00

Type of Construction:

Fire Rating:

Roof =   0.0 hr
Floor =   0.0 hr

Building Geometry:

Roof angle   (θ)   4.00 / 12   18.4 deg
Building length (L)   250.0 ft
Least width   (B)   200.0 ft
Mean Roof Ht (h)   36.7 ft
Parapet ht above grd   0.0 ft
Minimum parapet ht   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

Floor:

Typical Floor	50 psf
Partitions	15 psf
Lobbies & first floor corridors	100 psf

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Wind Loads :   ASCE 7- 10

Ultimate Wind Speed	115 mph
Nominal Wind Speed	89.1 mph
Risk Category	II
Exposure Category	C
Enclosure Classif.	Enclosed Building
Internal pressure	+/-0.18
Directionality (Kd)	0.85
Kh case 1	1.025
Kh case 2	1.025
Type of roof	Gable

Topographic Factor   (Kzt)

Topography			Flat
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_1 =	0.000
x/Lh = 0.31	K_2 =	0.792
z/Lh = 0.23	K_3 =	1.000

At Mean Roof Ht:

$$Kzt = (1+K_1 K_2 K_3)^2 = \quad 1.00$$
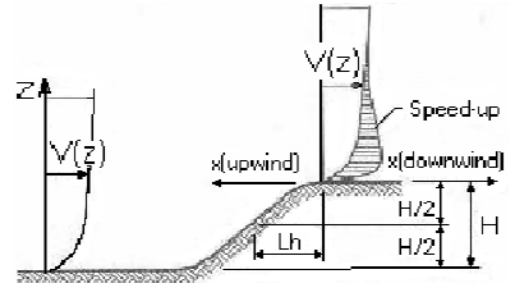
ESCARPMENT
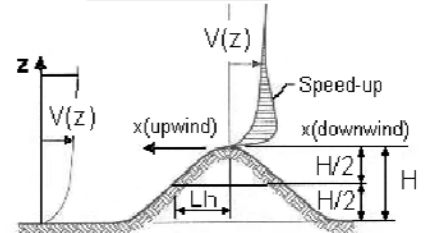
2D RIDGE or 3D AXISYMMETRICAL HILL

Gust Effect Factor

h =	36.7 ft
B =	200.0 ft
/z (0.6h) =	22.0 ft

Flexible structure if natural frequency < 1 Hz (T > 1 second).
However, if building h/B < 4 then probably rigid structure (rule of thumb).
h/B = 0.18   Rigid structure

G =   **0.85**   Using rigid structure default

Rigid Structure		**Flexible or Dynamically Sensitive Structure**					
ē =	0.20	Natural Frequency (η_1) =	0.0 Hz				
ℓ =	500 ft	Damping ratio (β) =	0				
z_{min} =	15 ft	/b =	0.65				
c =	0.20	/α =	0.15				
g_Q, g_v =	3.4	Vz =	103.0				
L_z =	461.1 ft	N_1 =	0.00				
Q =	0.84	R_n =	0.000				
I_z =	0.21	R_h =	28.282	η =	0.000	h =	36.7 ft
G =	0.84	R_B =	28.282	η =	0.000		
		R_L =	28.282	η =	0.000		
		g_R =	0.000				
		R =	0.000				
		G =	0.000				

Enclosure Classification

Test for Enclosed Building: A building that does not qualify as open or partially enclosed.

Test for Open Building: All walls are at least 80% open.
$$A_o \geq 0.8 A_g$$

Test for Partially Enclosed Building:

	Input			Test	
Ao	0.0	sf	$A_o \geq 1.1 A_{oi}$	YES	
Ag	0.0	sf	$A_o > 4'$ or $0.01 A_g$	NO	
Aoi	0.0	sf	$A_{oi} / A_{gi} \leq 0.20$	NO	Building is NOT
Agi	0.0	sf			Partially Enclosed

Conditions to qualify as Partially Enclosed Building. Must satisfy all of the following:
   $A_o \geq 1.1 A_{oi}$
   $A_o >$ smaller of 4' or 0.01 Ag
   $A_{oi} / A_{gi} \leq 0.20$
Where:
Ao = the total area of openings in a wall that receives positive external pressure.
Ag = the gross area of that wall in which Ao is identified.
Aoi = the sum of the areas of openings in the building envelope (walls and roof) not including Ao.
Agi = the sum of the gross surface areas of the building envelope (walls and roof) not including Ag.

Reduction Factor for large volume partially enclosed buildings (Ri) :

If the partially enclosed building contains a single room that is unpartitioned , the internal
pressure coefficient may be multiplied by the reduction factor Ri.

Total area of all wall & roof openings (Aog):	0	sf
Unpartitioned internal volume (Vi) :	0	cf
Ri =	1.00	

Altitude adjustment to constant 0.00256 (caution - see code) :

Altitude =	0	feet	Average Air Density =	0.0765 lbm/ft^3
Constant =	0.00256			

Wind Loads - MWFRS all h (Enclosed/partially enclosed only)

K_h (case 2) =	1.025	h =	36.7 ft	GCpi =	+/-0.18
Base pressure (q_h) =	**29.5 psf**	ridge ht =	53.4 ft	G =	0.85
Roof Angle (θ) =	18.4 deg	L =	250.0 ft	$q_i = q_h$	
Roof tributary area - (h/2)*L:	4588 sf	B =	200.0 ft		
(h/2)*B:	3670 sf				

Ultimate Wind Surface Pressures (psf)

	Wind Normal to Ridge				Wind Parallel to Ridge				
	B/L = 0.80		h/L = 0.18			L/B = 1.25		h/L = 0.15	
Surface	Cp	q_hGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Dist.*	Cp	q_hGC_p	w/ +q_iGC_{pi}	w/ -q_hGC_{pi}
Windward Wall (WW)	0.80	20.1	see table below			0.80	20.1	see table below	
Leeward Wall (LW)	-0.50	-12.5	-17.8	-7.2		-0.45	-11.3	-16.6	-6.0
Side Wall (SW)	-0.70	-17.5	-22.9	-12.2		-0.70	-17.5	-22.9	-12.2
Leeward Roof (LR)	-0.57	-14.3	-19.6	-8.9		Included in windward roof			
Windward Roof neg press.	-0.36	-9.1	-14.4	-3.8	0 to h/2*	-0.90	-22.6	-27.9	-17.3
Windward Roof pos press.	0.14	3.4	-1.9	8.8	h/2 to h*	-0.90	-22.6	-27.9	-17.3
					h to 2h*	-0.50	-12.5	-17.8	-7.2
					> 2h*	-0.30	-7.5	-12.8	-2.2

*Horizontal distance from windward edge

Windward Wall Pressures at "z" (psf)

			Windward Wall			Combined WW + LW	
						Normal	Parallel
z	Kz	Kzt	q_zGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	to Ridge	to Ridge
0 to 15'	0.85	1.00	16.6	11.3	21.9	29.1	27.9
20.0 ft	0.90	1.00	17.6	12.3	23.0	30.2	28.9
25.0 ft	0.95	1.00	18.5	13.2	23.8	31.0	29.8
30.0 ft	0.98	1.00	19.2	13.9	24.5	31.8	30.5
h= 36.7 ft	1.02	1.00	20.1	14.7	25.4	32.6	31.3
ridge = 53.4 ft	1.11	1.00	21.7	16.4	27.0	34.2	33.0

WIND NORMAL TO RIDGE

WIND PARALLEL TO RIDGE

TYPICAL WIND LOADING

NOTE:
See figure in ASCE7 for the application of full and partial loading
of the above wind pressures. There are 4 different loading cases.

Parapet

z	Kz	Kzt	qp (psf)
0.0 ft	0.85	1.00	0.0

Windward parapet:	0.0 psf	(GCpn = +1.5)
Leeward parapet:	0.0 psf	(GCpn = -1.0)

Windward roof overhangs (add to windward roof pressure) :   20.1 psf (upward)

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## Wind Loads - MWFRS h≤60' (Low-rise Buildings) Enclosed/partially enclosed only

Kz = Kh (case 1) =   1.02   Edge Strip   (a) =   14.7 ft
Base pressure (qh) =   **29.5 psf**   End Zone   (2a) =   29.4 ft
GCpi =   +/-0.18   Zone 2 length   =   91.8 ft

Wind Pressure Coefficients

Surface	CASE A				CASE B		
		θ = 18.4 deg					
	GCpf	w/-GCpi	w/+GCpi		GCpf	w/-GCpi	w/+GCpi
1	0.52	0.70	0.34		-0.45	-0.27	-0.63
2	-0.69	-0.51	-0.87		-0.69	-0.51	-0.87
3	-0.47	-0.29	-0.65		-0.37	-0.19	-0.55
4	-0.42	-0.24	-0.60		-0.45	-0.27	-0.63
5					0.40	0.58	0.22
6					-0.29	-0.11	-0.47
1E	0.78	0.96	0.60		-0.48	-0.30	-0.66
2E	-1.07	-0.89	-1.25		-1.07	-0.89	-1.25
3E	-0.67	-0.49	-0.85		-0.53	-0.35	-0.71
4E	-0.62	-0.44	-0.80		-0.48	-0.30	-0.66
5E					0.61	0.79	0.43
6E					-0.43	-0.25	-0.61

Ultimate Wind Surface Pressures (psf)

Surface							
1		20.5	9.9			-8.0	-18.6
2		-15.0	-25.7			-15.0	-25.7
3		-8.5	-19.1			-5.6	-16.2
4		-6.9	-17.6			-8.0	-18.6
5						17.1	6.5
6						-3.2	-13.9
1E		28.3	17.7			-8.8	-19.5
2E		-26.2	-36.9			-26.2	-36.9
3E		-14.5	-25.2			-10.3	-20.9
4E		-12.9	-23.5			-8.8	-19.5
5E						23.3	12.7
6E						-7.4	-18.0

Parapet

Windward parapet =   0.0 psf   (GCpn = +1.5)   Windward roof
Leeward parapet =   0.0 psf   (GCpn = -1.0)   overhangs =   20.6 psf (upward) add to
                                                                       windward roof pressure

Horizontal MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)
Interior Zone: Wall   27.5 psf
                Roof   -6.5 psf **
End Zone: Wall   41.2 psf
                Roof   -11.7 psf **

Longitudinal direction (parallel to L)
Interior Zone: Wall   20.3 psf
End Zone: Wall   30.7 psf

** NOTE: Total horiz force shall not be less than that determined
by neglecting roof forces (except for MWFRS moment frames).

The code requires the MWFRS be designed for a min ultimate
force of 16 psf multiplied by the wall area plus an 8 psf force
applied to the vertical projection of the roof.
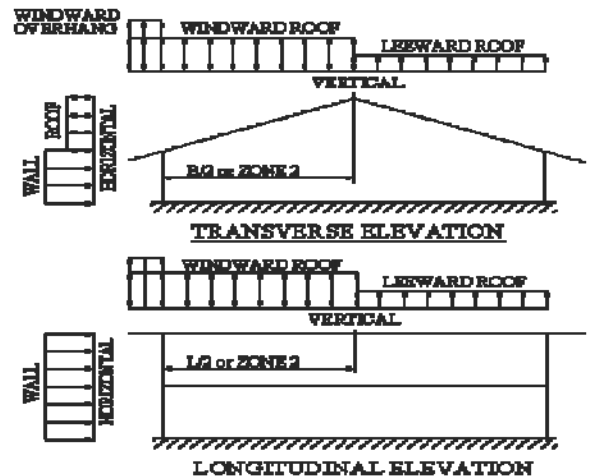
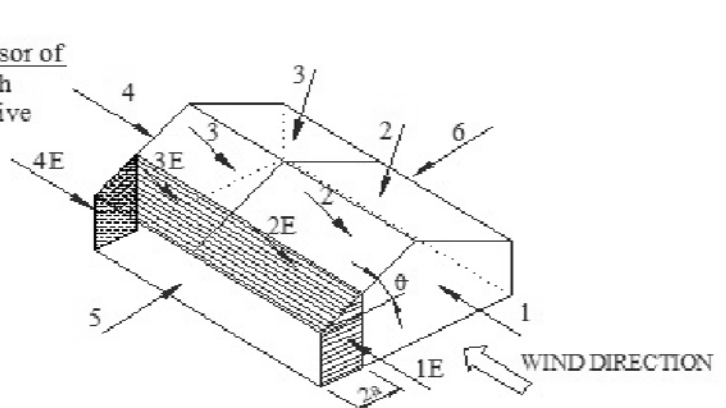# Location of MWFRS Wind Pressure Zones

CASE A

CASE B
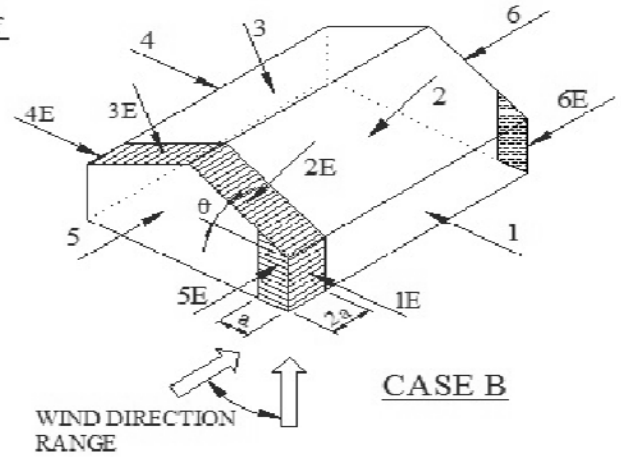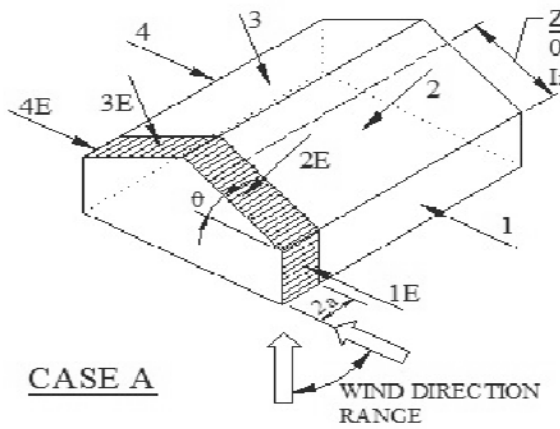
NOTE: Torsional loads are 25% of zones 1 - 6. See code for loading diagram.

ASCE 7 -99 and ASCE 7-10 (& later)
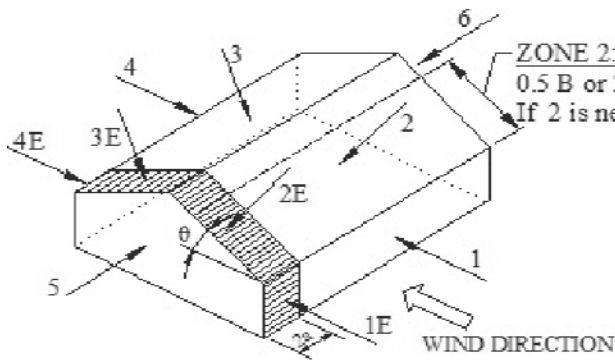
Transverse Direction

Longitudinal Direction

NOTE: Torsional loads are 25% of zones 1 - 4. See code for loading diagram.

~~ASCE 7 -02 and ASCE 7-05~~

Ultimate Wind Pressures

Wind Loads - Components & Cladding : h <= 60'

Kh (case 1) =	1.02	h =	36.7 ft
Base pressure (qh) =	**29.5 psf**	a =	14.7 ft
Minimum parapet ht =	0.0 ft	GCpi =	+/-0.18
Roof Angle (θ) =	18.4 deg		
Type of roof =	Gable		

Roof

Area	GCp +/- GCpi			Surface Pressure (psf)			User input	
	10 sf	50 sf	100 sf	10 sf	50 sf	100 sf	208 sf	500 sf
Negative Zone 1	-1.08	-1.01	-0.98	-31.9	-29.8	-28.9	-28.0	-28.9
Negative Zone 2	-1.88	-1.53	-1.38	-55.4	-45.1	-40.7	-40.7	-40.7
Negative Zone 3	-2.78	-2.36	-2.18	-82.0	-69.6	-64.3	-64.3	-64.3
Positive All Zones	0.68	0.54	0.48	20.1	16.0	16.0	16.0	16.0
Overhang Zone 2	-2.20	-2.20	-2.20	-64.9	-64.9	-64.9	-64.9	-64.9
Overhang Zone 3	-3.70	-2.86	-2.50	-109.1	-84.4	-73.7	-73.7	-73.7

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0

Overhang soffit pressure equals adjacent wall pressure reduced by internal pressure of 5.3 psf

Parapet

qp =   0.0 psf

CASE A = pressure towards building (pos)
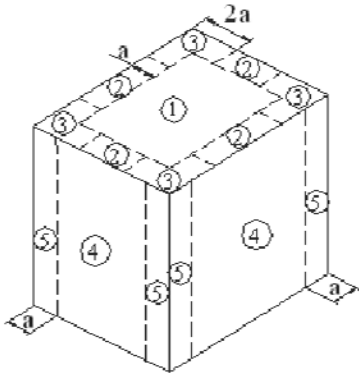CASE B = pressure away from bldg (neg)

Solid Parapet Pressure	Surface Pressure (psf)			User input
	10 sf	100 sf	500 sf	40 sf
CASE A : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0
CASE B : Interior zone:	0.0	0.0	0.0	0.0
Corner zone:	0.0	0.0	0.0	0.0

Walls

Area	GCp +/- GCpi			Surface Pressure (psf)			User input	
	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	15 sf	208 sf
Negative Zone 4	-1.28	-1.10	-0.98	-37.8	-32.5	-28.9	-36.9	-30.9
Negative Zone 5	-1.58	-1.23	-0.98	-46.6	-36.2	-28.9	-44.8	-32.9
Positive Zone 4 & 5	1.18	1.00	0.88	34.8	29.6	26.0	33.9	27.9

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Ultimate Wind Pressures

Location of C&C Wind Pressure Zones

Roofs w/ θ ≤ 10°
and all walls
h > 60'
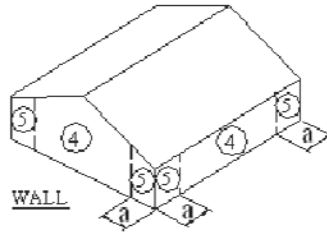
Walls h ≤ 60'
& alt design h<90'
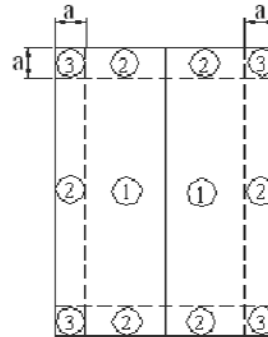
Gable, Sawtooth and
Multispan Gable θ ≤ 7 degrees &
Monoslope ≤ 3 degrees
h ≤ 60' & alt design h<90'
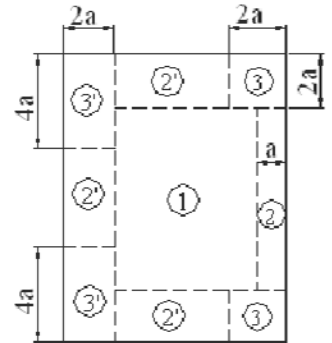
Monoslope roofs
3° < θ ≤ 10°
h ≤ 60' & alt design h<90'
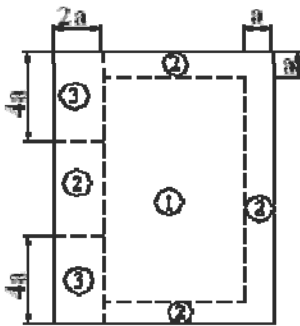
Monoslope roofs
10° < θ ≤ 30°
h ≤ 60' & alt design h<90'
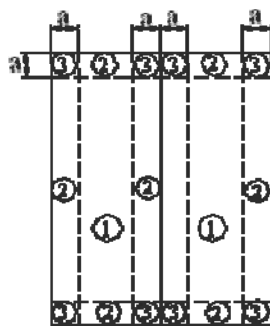
Multispan Gable &
Gable 7° < θ ≤ 45°

Hip 7° < θ ≤ 27°
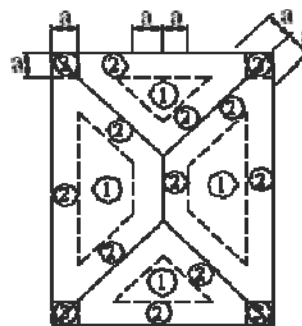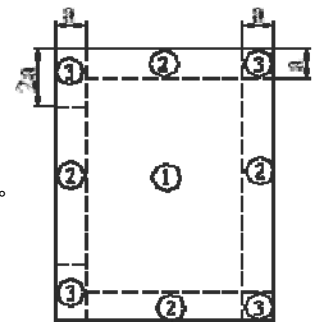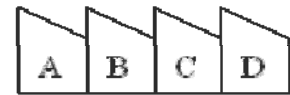
Sawtooth 10° < θ ≤ 45°
h ≤ 60' & alt design h<90'
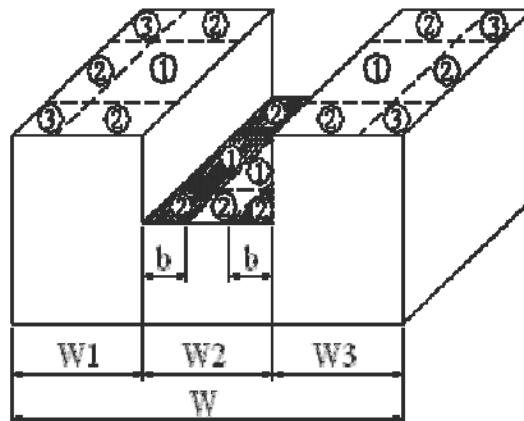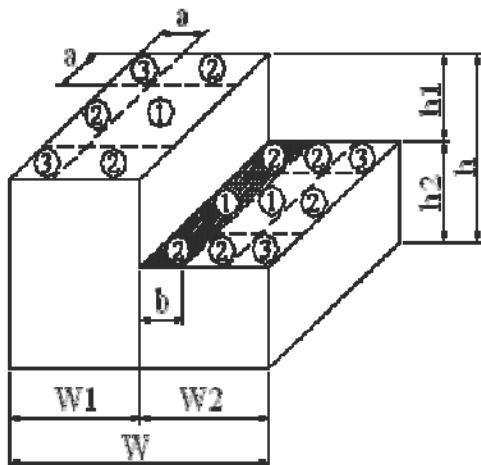
Stepped roofs θ ≤ 3°
h ≤ 60' & alt design h<90'

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Roof Design Loads

Items	Description	Multiple	psf (max)	psf (min)
Roofing	Metal, copper, or tin sheets		1.5	1.0
Decking	Metal Roof deck, 1.5, 22 ga.		1.7	1.2
Framing	Steel roof joists & girders		3.0	2.0
Insulation	Fibrous Glass roof board per	x 4.0	4.4	4.4
Ceiling	Suspended acoustical tile		1.8	1.0
Mech & Elec	Mech. & Elec.		2.0	0.0
Misc.	Misc.		0.5	0.0
			0.0	0.0
	Actual Dead Load		○ 14.9	○ 9.6
	Use this DL instead		◉ 20.0	◉ 8.0
	Live Load		20.0	0.0
	Snow Load		0.0	0.0
	Ultimate Wind (zone 2 - 100sf)		16.0	-40.7
ASD Loading		D + Lr	40.0	-
		D + 0.75(0.6*W + Lr)	42.2	-
		0.6*D + 0.6*W	-	-19.6
LRFD Loading		1.2D + 1.6 Lr + 0.5W	64.0	-
		1.2D + 1.0W + 0.5Lr	50.0	-
		0.9D + 1.0W	-	-33.5

Roof Live Load Reduction   Roof angle   4.00 / 12   18.4 deg

0 to 200 sf: 20.0 psf
200 to 600 sf: 24 - 0.02Area, 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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CODE SUMMARY

Code: ASCE 7 - 10

Live Loads:

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

Typical Floor   50 psf
Partitions   15 psf
Lobbies & first floor corridors   100 psf

Dead Loads:

Floor   100.0 psf
Roof   20.0 psf

Wind Design Data:

Ultimate Design Wind Speed   115 mph
Nominal Design Wind Speed   89.08 mph
Risk Category   II
Mean Roof Ht (h)   36.7 ft
Exposure Category   C
Enclosure Classif.   Enclosed Building
Internal pressure Coef   +/-0.18
Directionality (Kd)   0.85

Roof Snow Loads:

Design Uniform Roof Snow load   =   0.0 psf
Flat Roof Snow Load   Pf =   0.0 psf
Balanced Snow Load   Ps =   0.0 psf
Ground Snow Load   Pg =   0.0 psf
Importance Factor   I =   1.00
Snow Exposure Factor   Ce =   1.00
Thermal Factor   Ct =   1.00
Sloped-roof Factor   Cs =   0.79

Earthquake Design Data:

Risk Category   =   II
Importance Factor   I =   1.00
Mapped spectral response acceleration   Ss =   160.00 %g
                               S1 =   52.00 %g
Site Class   =   D
Spectral Response Coef   Sds =   1.067
                               Sd1 =   0.520
Seismic Design Category   =   D
Basic Structural System   = Building Frame Systems
Seismic Resisting System   = Steel ordinary concentrically braced frame
Design Base Shear   V =   0.047W
Seismic Response Coef   Cs =   0.047
Response Modification Factor   R =   3.25
Analysis Procedure   = Equivalent Lateral-Force Analysis

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CODE SUMMARY- continued

Component and cladding ultimate wind pressures

Roof

Area	Surface Pressure (psf)		
	10 sf	50 sf	100 sf
Negative Zone 1	-31.9	-29.8	-28.9
Negative Zone 2	-55.4	-45.1	-40.7
Negative Zone 3	-82.0	-69.6	-64.3
Positive All Zones	20.1	16.0	16.0
Overhang Zone 2	-64.9	-64.9	-64.9
Overhang Zone 3	-109.1	-84.4	-73.7

Overhang soffit pressure equals adjacent wall pressure reduced by internal pressure of 5.3 psf

Parapet

Area	Solid Parapet Pressure (psf)		
	10 sf	100 sf	500 sf
CASE A: Interior zone	0.0	0.0	0.0
Corner zone	0.0	0.0	0.0
CASE B: Interior zone	0.0	0.0	0.0
Corner zone	0.0	0.0	0.0

Wall

Area	Surface Pressure (psf)		
	10 sf	100 sf	500 sf
Negative Zone 4	-37.8	-32.5	-28.9
Negative Zone 5	-46.6	-36.2	-28.9
Positive Zone 4 & 5	34.8	29.6	26.0