STRUCTURAL CALCULATIONS

FOR

Example 6 - Wind
Example 11 - Seismic

2000 IBC Handbook - Structural Provisions

Code Search

Code: International Building Code 2000

Occupancy:

Occupancy Group = B Business

Occupancy Category & Importance Factors:

Occupancy Category =	I
Wind factor =	1.00
Snow factor =	1.00
Seismic factor =	1.00

Type of Construction:

Fire Rating:

Roof =	1.0 hr
Floor =	2.0 hr

Building Geometry:

Roof angle (θ)	0.00 / 12	0.0 deg
Building length (L)	130.0 ft	
Least width (B)	130.0 ft	
Mean Roof Ht (h)	255.0 ft	
Parapet ht above grd	258.0 ft	
Minimum parapet ht	3.0 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
Lobbies & first floor corridors	100 psf
Corridors above first floor	80 psf
Mechanical	100 psf
Stairs & Exitways	100 psf
Balcony / Deck	50 psf
Partitions	20 psf

Company
Address
City, State
Phone
other

JOB TITLE Example 6 - Wind

JOB NO. **SHEET NO.**
CALCULATED BY **DATE**
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Wind Loads :

Importance Factor	1.00
Basic Wind speed	85 mph
Directionality (Kd)	0.85
Exposure Category	B
Enclosure Classif.	Partially Enclosed
Internal pressure	+/-0.55
Kh case 1	1.291
Kh case 2	1.291
Type of roof	Monoslope

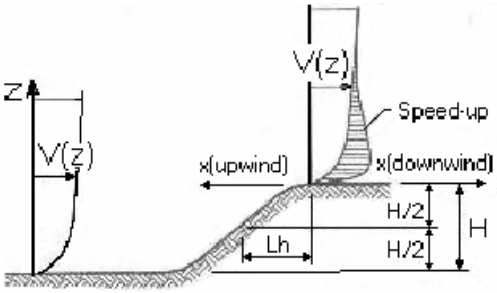
Topographic Factor (Kzt)

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

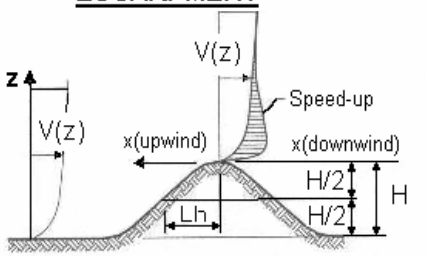
H/Lh= 0.50	K_1 =	0.000
x/Lh = 0.31	K_2 =	0.792
z/Lh = 1.59	K_3 =	1.000

At Mean Roof Ht:

$Kzt = (1+K_1K_2K_3)^2$ = 1.00



ESCARPMENT



2D RIDGE or 3D AXISYMMETRICAL HILL

Gust Effect Factor

h = 255.0 ft
B = 130.0 ft
/z (0.6h) = 153.0 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 = 1.96 Therefore, probably rigid structure

G = 0.88 Using flexible structure formula

Rigid Structure

/ε =	0.33
l =	320 ft
z_{min} =	30 ft
c =	0.30
g_Q, g_v =	3.4
L_z =	533.6 ft
Q =	0.81
I_z =	0.23
G =	0.83

Flexible or Dynamically Sensitive Structure

Natural Frequency (n_1) =	0.5 Hz			
Damping ratio (β) =	0.01			
/b =	0.45			
/α =	0.25			
Vz =	82.3			
N_1 =	3.24			
R_n =	0.067			
R_h =	0.131	η =	7.125	h = 255.0 ft
R_B =	0.237	η =	3.632	
R_L =	0.079	η =	12.160	
g_R =	4.021			
R =	0.342			
G =	0.876			

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other

JOB TITLE Example 6 - Wind

JOB NO. **SHEET NO.**
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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.
$Ao \geq 0.8Ag$

Test for Partially Enclosed Building:

	Input		Test	
Ao	0.0 sf	Ao ≥ 1.1Aoi	YES	
Ag	0.0 sf	Ao > 4' / 0.01Ag	NO	
Aoi	0.0 sf	Aoi / Agi ≤ 0.20	NO	Building is NOT Partially Enclosed.
Agi	0.0 sf			

Conditions to qualify as Partially Enclosed Building. Must satisfy all of the following:
Ao >= 1.1Aoi
Ao > smaller of 4' or 0.01 Ag
Aoi / Agi <= 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 :

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

Company
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City, State
Phone
other

JOB TITLE Example 6 - Wind

JOB NO. _____ **SHEET NO.** _____
CALCULATED BY _____ **DATE** _____
CHECKED BY _____ **DATE** _____

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

Kh (case 2) =	1.29	h =	255.0 ft	GCpi =	+/-0.55
Base pressure (q_h) =	**20.3 psf**	ridge ht =	255.0 ft	G =	0.88
Roof Angle =	0.0 deg	L =	130.0 ft	z for qi :	255.0 ft use 90.00
Roof tributary area - (h/2)*L:	16575 sf	B =	130.0 ft	qi =	15.1 psf for positive internal pressures
(h/2)*B:	16575 sf				

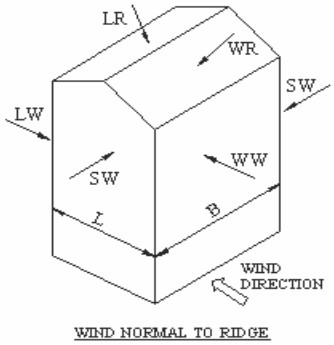
Surface Pressures (psf) / Surface	Wind Normal to Ridge (psf) B/L = 1.00 Cp	q_hGC_p	h/L = 1.96 w/+q_iGC_{pi}	w/-q_hGC_{pi}	Wind Parallel to Ridge (psf) L/B = 1.00 Dist.*	Cp	h/L = 1.96 q_hGC_p	w/ +q_iGC_{pi}	w/ -q_hGC_{pi}
Windward Wall (WW)	0.80	14.2	see table below			0.80	14.2	see table below	
Leeward Wall (LW)	-0.50	-8.9	-17.2	2.3		-0.50	-8.9	-17.2	2.3
Side Wall (SW)	-0.70	-12.5	-20.7	-1.3		-0.70	-12.5	-20.7	-1.3
Leeward Roof (LR)		**				Included in windward roof			
Windward Roof: 0 to h/2*	-1.04	-18.5	-26.8	-7.3	0 to h/2*	-1.04	-18.5	-26.8	-7.3
> h/2*	-0.70	-12.5	-20.7	-1.3	> h/2*	-0.70	-12.5	-20.7	-1.3

**Roof angle < 10 degrees. Therefore, leeward roof is included in windward roof pressure zones.

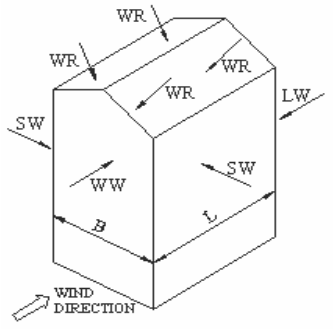
*Horizontal distance from windward edge

Windward Wall Pressures at "z" (psf)

	z	Kz	Kzt	Windward Wall q_zGC_p	w/+q_iGC_{pi}	w/-q_hGC_{pi}	Combined WW + LW Normal to Ridge	Parallel to Ridge
	0 to 15'	0.57	1.00	6.3 psf	-2.0 psf	17.5 psf	15.2 psf	15.2 psf
	20.0 ft	0.62	1.00	6.9	-1.4	18.0	15.8	15.8
	25.0 ft	0.67	1.00	7.3	-1.0	18.5	16.2	16.2
	30.0 ft	0.70	1.00	7.7	-0.6	18.9	16.6	16.6
	40.0 ft	0.76	1.00	8.4	0.1	19.5	17.3	17.3
	50.0 ft	0.81	1.00	8.9	0.6	20.1	17.8	17.8
	60.0 ft	0.85	1.00	9.4	1.1	20.6	18.3	18.3
	70.0 ft	0.89	1.00	9.8	1.5	21.0	18.7	18.7
	80.0 ft	0.93	1.00	10.2	1.9	21.4	19.1	19.1
	90.0 ft	0.96	1.00	10.6	2.3	21.7	19.5	19.5
	100.0 ft	0.99	1.00	10.9	2.6	22.1	19.8	19.8
	120.0 ft	1.04	1.00	11.5	3.2	22.6	20.4	20.4
	140.0 ft	1.09	1.00	12.0	3.7	23.2	20.9	20.9
	160.0 ft	1.13	1.00	12.5	4.2	23.6	21.4	21.4
	180.0 ft	1.17	1.00	12.9	4.6	24.0	21.8	21.8
	200.0 ft	1.20	1.00	13.3	5.0	24.4	22.2	22.2
	250.0 ft	1.28	1.00	14.2	5.9	25.3	23.0	23.0
h=	255.0 ft	1.29	1.00	14.2	5.9	25.4	23.1	23.1



WIND NORMAL TO RIDGE



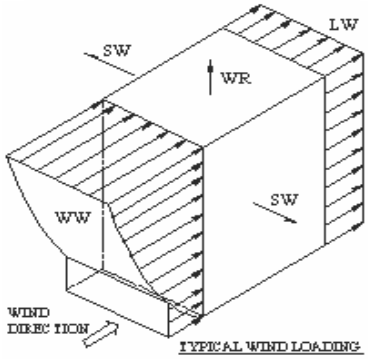
WIND PARALLEL TO RIDGE

NOTE:
See figure 6-9 of 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)
258.0 ft	1.30	1.00	20.4

Windward parapet: 30.6 psf (GCpn = +1.5)
Leeward parapet: -20.4 psf (GCpn = -1.0)



TYPICAL WIND LOADING

Company
Address
City, State
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other

JOB TITLE Example 6 - Wind

JOB NO. _____ **SHEET NO.** _____
CALCULATED BY _____ **DATE** _____
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Wind Loads - Components & Cladding : h > 60'

Kh (case 1) =	1.29	h =	255.0 ft
Base pressure (qh) =	**20.3 psf**	a =	13.0 ft
Minimum parapet ht =	3.0 ft	GCpi =	+/-0.55
Roof Angle =	0.0 deg	qi =	15.1 psf for positive internal pressures

Roof

	GCp			Surface Pressure (psf)			**User input**	
Area	10 sf	100 sf	500 sf	10 sf	100 sf	500 sf	75 sf	250 sf
Negative Zone 1	-1.40	-1.11	-0.90	-36.7 psf	-30.7 psf	-26.6 psf	-31.5 psf	-28.4 psf
Negative Zone 2	-2.30	-1.89	-1.60	-55.0 psf	-46.6 psf	-40.8 psf	-47.7 psf	-43.3 psf
Negative Zone 3	-2.30	-1.89	-1.60	-55.0 psf	-46.6 psf	-40.8 psf	-47.7 psf	-43.3 psf
Positive Zones 1-3	-	-	-	10.0 psf	10.0 psf	10.0 psf	10.0 psf	10.0 psf

Negative zone 3 = zone 2, since parapet >= 3ft.

Parapet

qp = 20.4 psf

CASE A = pressure towards building
CASE B = pressure away from building

	Surface Pressure (psf)			**User input**
Solid Parapet Pressure	10 sf	100 sf	500 sf	40 sf
CASE A : Interior zone:	65.2 psf	53.7 psf	44.8 psf	58.8 psf
Corner zone:	65.2 psf	53.7 psf	44.8 psf	58.8 psf
CASE B : Interior zone:	-36.7 psf	-31.6 psf	-26.5 psf	-34.5 psf
Corner zone:	-55.0 psf	-43.8 psf	-32.6 psf	-50.2 psf

Walls

	GCp			Surface Pressure at "h"			**User input**	
Area	20 sf	100 sf	500 sf	20 sf	100 sf	500 sf	50 sf	200 sf
Negative Zone 4	-0.90	-0.80	-0.70	-26.6 psf	-24.5 psf	-22.5 psf	-25.4 psf	-23.7 psf
Negative Zone 5	-1.80	-1.40	-1.00	-44.8 psf	-36.7 psf	-28.6 psf	-40.2 psf	-33.2 psf
Positive Zone 4 & 5	0.90	0.75	0.60	29.4 psf	26.4 psf	23.3 psf	27.7 psf	25.1 psf

NOTE: Negative zones 4 & 5 pressures apply to all heights. Positive pressures vary with height, see below.

Wall surface pressure at 'z'				Positive zone 4 & 5 (psf)			**User input**	
z	Kz	Kzt	qz (psf)	20	100	500	50 sf	200 sf
0 to 15'	0.70	1.00	11.0	21.1	19.4	17.8	20.1	18.7
20.0 ft	0.70	1.00	11.0	21.1	19.4	17.8	20.1	18.7
25.0 ft	0.70	1.00	11.0	21.1	19.4	17.8	20.1	18.7
30.0 ft	0.70	1.00	11.0	21.1	19.4	17.8	20.1	18.7
40.0 ft	0.76	1.00	12.0	21.9	20.1	18.3	20.9	19.4
50.0 ft	0.81	1.00	12.7	22.6	20.7	18.8	21.5	19.9
60.0 ft	0.85	1.00	13.4	23.2	21.2	19.2	22.1	20.4
70.0 ft	0.89	1.00	14.0	23.8	21.7	19.6	22.6	20.8
80.0 ft	0.93	1.00	14.6	24.3	22.1	19.9	23.0	21.2
90.0 ft	0.96	1.00	15.1	24.7	22.5	20.2	23.4	21.5
100.0 ft	0.99	1.00	15.5	25.1	22.8	20.5	23.8	21.8
120.0 ft	1.04	1.00	16.4	25.9	23.4	21.0	24.5	22.4
140.0 ft	1.09	1.00	17.1	26.6	24.0	21.4	25.1	22.9
160.0 ft	1.13	1.00	17.8	27.2	24.5	21.8	25.6	23.3
180.0 ft	1.17	1.00	18.4	27.7	24.9	22.2	26.1	23.8
200.0 ft	1.20	1.00	18.9	28.2	25.4	22.5	26.6	24.1
250.0 ft	1.28	1.00	20.2	29.3	26.3	23.3	27.6	25.0
h = 255.0 ft	1.29	1.00	20.3	29.4	26.4	23.3	27.7	25.1

Company
Address
City, State
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other

JOB TITLE Example 6 - Wind

JOB NO. _____ **SHEET NO.** _____
CALCULATED BY _____ **DATE** _____
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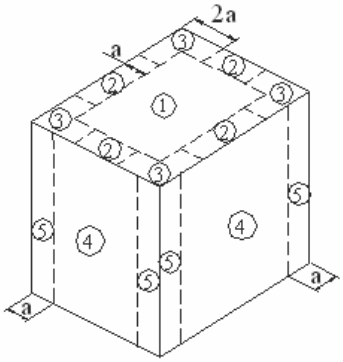
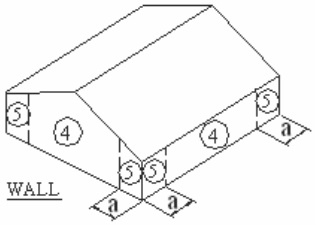
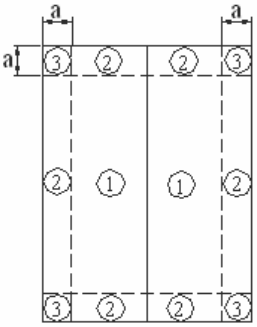
Location of Wind Pressure Zones



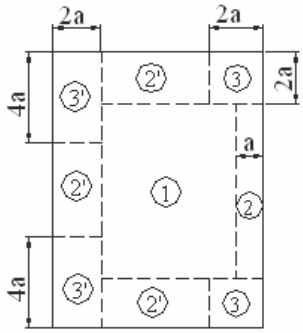
Roofs w/ $\theta \leq 10°$
and all walls
h > 60'



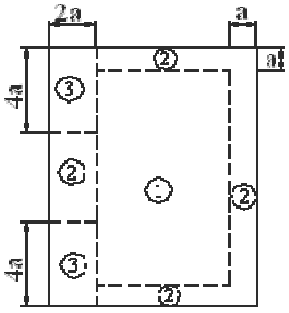
Walls h ≤ 60'
& alt design h<90'



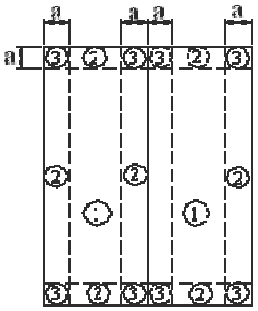
Gable, Sawtooth and
Multispan Gable $\theta \leq 10$ degrees &
Monoslope ≤ 3 degrees
h ≤ 60' & alt design h<90'



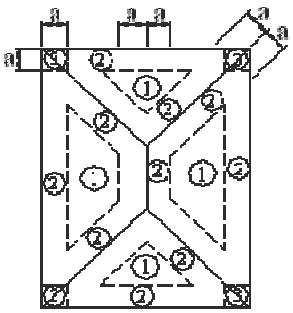
Monoslope roofs
$3° < \theta \leq 10°$
h ≤ 60' & alt design h<90'



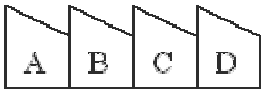
Monoslope roofs
$10° < \theta \leq 30°$
h ≤ 60' & alt design h<90'

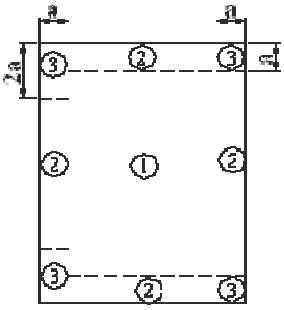


Multispan Gable &
Gable $7° < \theta \leq 45°$

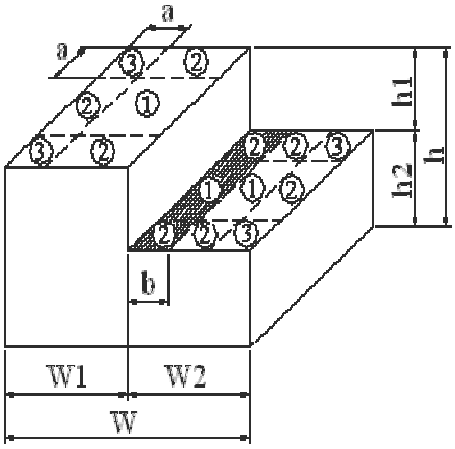


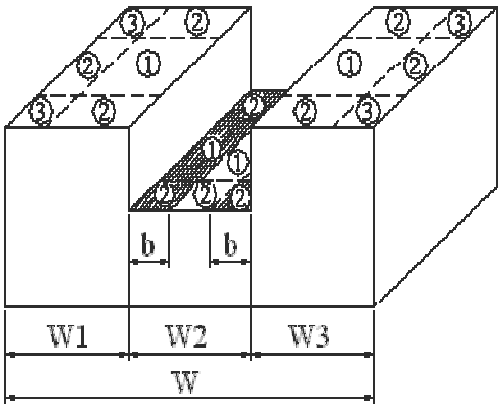
Hip $10° < \theta \leq 30°$





Sawtooth $10° < \theta \leq 45°$
h ≤ 60' & alt design h<90'





Stepped roofs $\theta \leq 3°$
h ≤ 60' & alt design h<90'

Company
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Phone
other

JOB TITLE Example 6 - Wind

JOB NO. _____ SHEET NO. _____
CALCULATED BY _____ DATE _____
CHECKED BY _____ DATE _____

Seismic Loads:

Seismic Use Group : I
Importance Factor (I) : 1.00

Site Class : D

Ss (0.2 sec) = 150.00 %g
S1 (1.0 sec) = 60.00 %g

Fa =	1.000		Sms =	1.500	S_{DS} =	1.000	Design Category =	D
Fv =	1.500		Sm1 =	0.900	S_{D1} =	0.600	Design Category =	D

Seismic Design Category = **D**

Number of Stories: 20

Structure Type: Not applicable

Plan Structural Irregularities: No plan Irregularity

Vertical Structural Irregularities: No vertical Irregularity

Flexible Diaphragms: No

Building System: **Dual Systems with special Moment Frames**

Seismic resisting system: **Special reinforced concrete shear walls**

System Building Height Limit: **Height not limited**

Actual Building Height (hn) = 255.0 ft

See Code section 1617.6.4 for exceptions and other system limitations

DESIGN COEFFICIENTS AND FACTORS

Response Modification Factor (R) = 8
System Over-Strength Factor (Ωo) = 2.5
Deflection Amplification Factor (Cd) = 6.5
S_{DS} = 1.000
S_{D1} = 0.600

Code Reference Section for Detailing : 1910.2.4

ρ = redundancy coefficient

Seismic Load Effect (E) = ρQ_E +/- $0.2S_{DS}$ D = ρ Q_E +/- 0.200D

Q_E = horizontal seismic force

Special Seismic Load Effect (Em) = $\Omega o\, Q_E$ +/- $0.2S_{DS}$ D = 2.5 Q_E +/- 0.200D

D = dead load

PERMITTED ANALYTICAL PROCEDURES

Index Force Analysis (Seismic Category A only) Method Not Permitted

Simplified Analysis Method Not Permitted

Equivalent Lateral-Force Analysis Method Not Permitted

Building period coef. (C_T) = 0.020 Cu = 1.20

Approx fundamental period (Ta) = $C_T h_n^{\,x}$ = 1.276 sec x= 0.75 Tmax = CuTa = 1.531

User calculated fundamental period (T) = 2.94 sec Use T = 1.531

Seismic response coef. (Cs) = SdsI/R = 0.125

need not exceed Cs = Sd1 I /RT = 0.049

but not less than Cs = 0.044SdsI = 0.044

USE Cs = 0.049

Design Base Shear V = Method Not Permitted

Model, Linear & Nonlinear Response Analysis - Permitted (see code for procedure)

ALLOWABLE STORY DRIFT

Structure Type: All other structures

Allowable story drift = 0.020hsx where hsx is the story height below level x

Seismic Loads - cont. :

Seismic Design Category (SDC)= D
I = 1.00
Sds = 1.000

CONNECTIONS

Force to connect smaller portions of structure to remainder of structure

$Fp = 0.133 Sds w_p$ = 0.13 w_p
or $Fp = 0.5 w_p$ = 0.05 w_p Use Fp = 0.13 w_p w_p = weight of smaller portion

Beam, girder or truss connection for resisting horizontal force parallel to member

F_p = no less than 0.05 times dead plus live load vertical reaction

Anchorage of Concrete or Masonry Walls to elements providing lateral support

$Fp = 1.2 IeSds Ww$ = 1.200 w_w
or $Fp = 0.1 w_w$ = 0.10 w_w Use Fp = 1.20 w_w but not less than 200.0 plf = 400SdsIe
Connection force given is for flexible diaphragms (use architectural components for ridgid diaphrams)

MEMBER DESIGN

Bearing Walls and Shear Walls (out of plane force)

$Fp = 0.40 IeSds w_w$ = 0.400 w_w
or $Fp = 0.1 w_w$ = 0.10 w_w Use Fp = 0.40 w_w

Diaphragms

Fp = (Sum Fi / Sum Wi)Wpx + Vpx = (Sum Fi / Sum Wi)Wpx + Vpx
need not exceed 0.3 SdsIeWpx + Vpx = 0.300 Wpx + Vpx
but not less than 0.15 SdsIeWpx + Vpx = 0.150 Wpx + Vpx

ARCHITECTURAL COMPONENTS SEISMIC COEFFICIENTS

Architectural Component : 2. Cantilever Elements (Unbraced or Braced to Structural Frame Below Its Center of Mass)
a. Parapets and cantilever interior nonstructural walls

Importance Factor (Ip) : 1.0

Component Amplification Factor (a_p) = 2.5 h= 255.0 feet
Comp Response Modification Factor (R_p) = 2.5 z= 50.0 feet z/h = 0.20

$Fp = 0.4 a_p SdsIpWp(1+2z/h)/Rp$ = 0.557 Wp
not greater than $Fp = 1.6 SdsIpWp$ = 1.600 Wp
but not less than $Fp = 0.3 SdsIpWp$ = 0.300 Wp use Fp = 0.557 Wp

MECH AND ELEC COMPONENTS SEISMIC COEFFICIENTS

Seismic Design Category D & Ip=1.0, therefore see 2000IBC Section 1621.1.1 for exceptions

Mech or Electrical Component : General Electrical - Distribution systems (bus ducts, conduit, cable tray)
error

Importance Factor (Ip) : 1.0

Component Amplification Factor (a_p) = 1 h= 255.0 feet
Comp Response Modification Factor (R_p) = 3.5 z= 50.0 feet z/h = 0.20

$Fp = 0.4 a_p SdsIpWp(1+2z/h)/Rp$ = 0.159 Wp
not greater than $Fp = 1.6 SdsIpWp$ = 1.600 Wp
but not less than $Fp = 0.3 SdsIpWp$ = 0.300 Wp use Fp = 0.300 Wp

Company
Address
City, State
Phone
other

JOB TITLE Example 6 - Wind

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

www.struware.com

CODE SUMMARY

Code: International Building Code 2000

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

Typical Floor	50 psf
Lobbies & first floor corridors	100 psf
Corridors above first floor	80 psf
Mechanical	100 psf
Stairs & Exitways	100 psf
Balcony / Deck	50 psf
Partitions	20 psf

Dead Loads:

Floor	86.1 psf
Roof	20.0 psf

Wind Design Data:

Basic Wind speed	85 mph
Mean Roof Ht (h)	255.0 ft
Occupancy Category	I
Importance Factor	1.00
Exposure Category	B
Enclosure Classif.	Partially Enclosed
Internal pressure Coef.	+/-0.55
Directionality (Kd)	0.85

Roof Snow Loads:

Design Roof Snow load		=	0.0 psf
Flat Roof Snow Load	Pf	=	33.6 psf
Ground Snow Load	Pg	=	40.0 psf
Rain on Snow Surcharge		=	0.0 psf
Importance Factor	I	=	1.00
Snow Exposure Factor	Ce	=	1.00
Thermal Factor	Ct	=	1.20
Sloped-roof Factor	Cs	=	1.00

Earthquake Design Data:

Seismic Use Group :		=	I
Importance Factor	I	=	1.00
Mapped spectral response	Ss	=	150.00 %g
accelerations	S1	=	60.00 %g
Site Class		=	D
Spectral Response Coef.	Sds	=	1.000
	Sd1	=	0.600
Seismic Design Category		=	D
Basic Structural System		=	Dual Systems with special Moment Frames
Seismic Resisting System		=	Special reinforced concrete shear walls
Design Base Shear	V	=	0.049W
Seismic Response Coef.	Cs	=	0.049
Response Modification Factor	R	=	8
Analysis Procedure		=	Equivalent Lateral-Force Analysis

CODE SUMMARY- continued

Component and cladding wind pressures

Roof	Surface Pressure (psf)		
Area	10 sf	100 sf	500 sf
Negative Zone 1	-36.7	-30.7	-26.6
Negative Zone 2	-55.0	-46.6	-40.8
Negative Zone 3	-55.0	-46.6	-40.8
Positive Zones 1-3	10.0	10.0	10.0

Parapet	Solid Parapet Pressure (psf)		
Area	10 sf	100 sf	500 sf
CASE A: Interior zone	65.2	53.7	44.8
Corner zone	65.2	53.7	44.8
CASE B: Interior zone	-36.7	-31.6	-26.5
Corner zone	-55.0	-43.8	-32.6

Wall	Surface Pressure (psf)		
Area	20 sf	100 sf	500 sf
Negative Zone 4	-26.6	-24.5	-22.5
Negative Zone 5	-44.8	-36.7	-28.6
Positive Zone 4 & 5			
0 to 15'	21.1	19.4	17.8
20 ft	21.1	19.4	17.8
25 ft	21.1	19.4	17.8
30 ft	21.1	19.4	17.8
40 ft	21.9	20.1	18.3
50 ft	22.6	20.7	18.8
60 ft	23.2	21.2	19.2
70 ft	23.8	21.7	19.6
80 ft	24.3	22.1	19.9
90 ft	24.7	22.5	20.2
100 ft	25.1	22.8	20.5
120 ft	25.9	23.4	21.0
140 ft	26.6	24.0	21.4
160 ft	27.2	24.5	21.8
180 ft	27.7	24.9	22.2
200 ft	28.2	25.4	22.5
250 ft	29.3	26.3	23.3
h = 255 ft	29.4	26.4	23.3