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 7-16

Code Search

Code: ASCE 7 - 16

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
Corridors above first floor	80 psf
Balconies (1.5 times live load)	75 psf

Company
Address
City, State
Phone

JOB TITLE Chapter 5 Examples

JOB NO. SHEET NO.
CALCULATED BY DATE
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Wind Loads : ASCE 7- 16

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

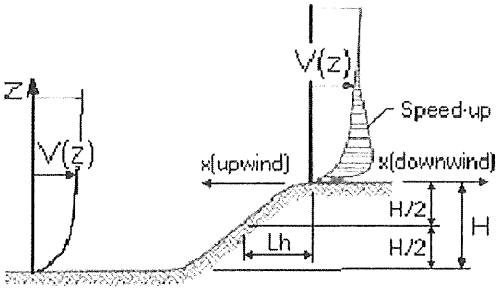
Topographic Factor (Kzt)

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:

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



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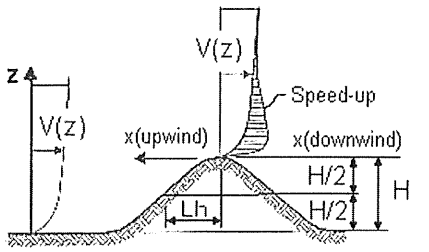


2D RIDGE or 3D AXISYMMETRICAL HILL

Gust Effect Factor

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

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

h/B = 0.18 Rigid structure (low rise bldg)

G = 0.85 Using rigid structure default

Rigid Structure

$\bar{e}$ =	0.20
ℓ =	500 ft
z_{min} =	15 ft
c =	0.20
g_Q, g_v =	3.4
L_z =	461.1 ft
Q =	0.84
I_z =	0.21
G =	0.84

Flexible or Dynamically Sensitive Structure

34 ıcy (η_1) =	0.0 Hz				
Damping ratio (β) =	0				
/b =	0.65				
/α =	0.15				
Vz =	103.0				
N_1 =	0.00				
R_n =	0.000				
R_h =	28.282	η =	0.000	h =	36.7 ft
R_B =	28.282	η =	0.000		
R_L =	28.282	η =	0.000		
g_R =	0.000				
R =	0.000				
Gf =	0.000				

Company
Address
City, State
Phone

JOB TITLE Chapter 5 Examples

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

Enclosure Classification

Test for Enclosed Building: Ao < 0.01Ag or 4 sf, whichever is smaller

Test for Open Building: All walls are at least 80% open.
Ao ≥ 0.8Ag

Test for Partially Enclosed Building: Predominately open on one side only

	Input			Test	
Ao	500.0	sf	Ao ≥ 1.1Aoi	NO	
Ag	600.0	sf	Ao > 4' or 0.01Ag	YES	
Aoi	1000.0	sf	Aoi / Agi ≤ 0.20	YES	Building is NOT
Agi	10000.0	sf			Partially Enclosed

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.

Test for Partially Open Building: A building that does not qualify as open, enclosed or partially enclosed.
(This type building will have same wind pressures as an enclosed building.

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

Ground Elevation Factor (Ke)

Grd level above sea level = 0.0 ft
Constant = 0.00256 Adj Constant = 0.00256
Ke = 1.0000

Company
Address
City, State
Phone

JOB TITLE Chapter 5 Examples

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

Wind Loads - MWFRS all h (Except for Open Buildings)

Kh (case 2) =	1.02	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	qi = qh	
Roof tributary area - (h/2)*L:	4588 sf	B =	200.0 ft		
(h/2)*B:	3670 sf				

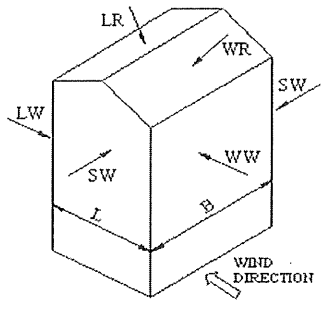
Ultimate Wind Surface Pressures (psf)

Surface	Wind Normal to Ridge B/L = 0.80 Cp	q_hGC_p	h/L = 0.18 w/+q_iGC_{pi}	w/-q_hGC_{pi}	Wind Parallel to Ridge L/B = 1.25 Dist.*	Cp	q_hGC_p	h/L = 0.15 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			
Neg Windward Roof pressure	-0.36	-9.1	-14.4	-3.8	0 to h/2*	-0.90	-22.6	-27.9	-17.3
Pos/min Windward Roof 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
					Min press.	-0.18	-4.5	-9.8	0.8

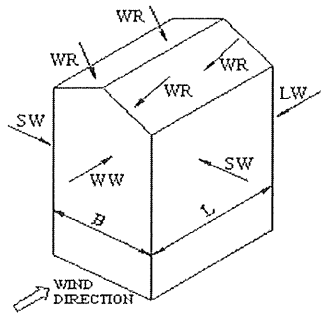
*Horizontal distance from windward edge

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'	0.85	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

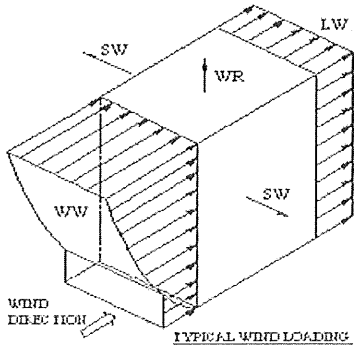
NOTE:
See figure in ASCE7 for the application of full and partial loading of the above wind pressures. There are 4 different loading cases.

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)



TYPICAL WIND LOADING

Company
Address
City, State
Phone

JOB TITLE Chapter 5 Examples

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

Wind Loads - MWFRS h≤60' (Low-rise Buildings) except for open buildings

Kz = Kh (case 1) = 1.02
Base pressure (qh) = **29.5 psf**
GCpi = +/-0.18

Edge Strip (a) = 14.7 ft
End Zone (2a) = 29.4 ft
Zone 2 length = 91.8 ft

Wind Pressure Coefficients

	CASE A				CASE B		
		θ = 18.4 deg					
Surface	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)

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)
Leeward parapet = 0.0 psf (GCpn = -1.0)

Windward roof overhangs = 20.6 psf (upward) add to windward roof pressure

Horizontal MWFRS Simple Diaphragm Pressures (psf)

Transverse direction (normal to L)

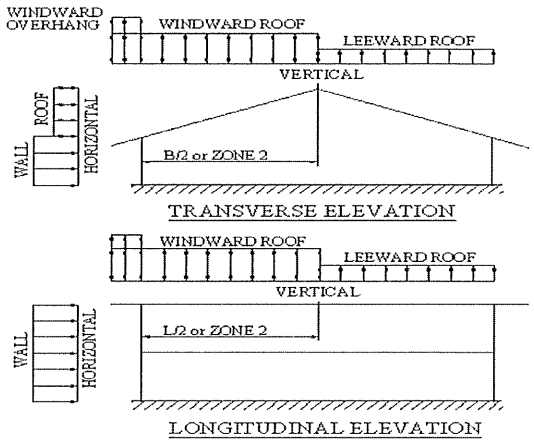
Interior Zone: Wall 27.5 psf
Roof -6.5 psf **
End Zone: Wall 41.2 psf
Roof -11.7 psf **

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.



Company
Address
City, State
Phone

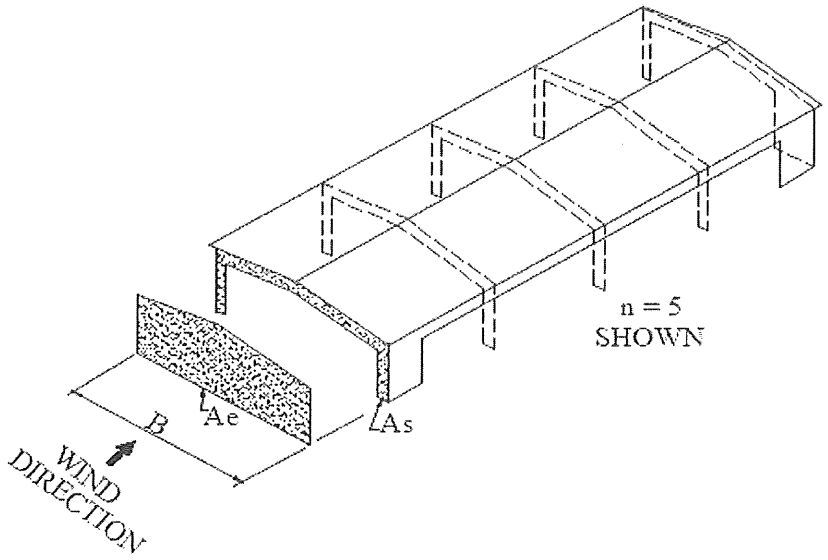
JOB TITLE Chapter 5 Examples

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

Wind Loads - h≤60' Longitudinal Direction MWFRS On Open or Partially Enclosed Buildings with Transverse Frames and Pitched Roofs

ASCE 7-16 procedure

Base pressure (qh) = **29.5 psf**
GCpi = +/-0.18 Enclosed bldg, procdure doesn't apply
Roof Angle (θ) = 18.4 deg



B=	200.0 ft
# of frames (n) =	5
Solid are of end wall including fascia (As) =	1,500.0 sf
Roof ridge height =	53.4 ft
Roof eave height =	20.0 ft
Total end wall area if soild (Ae) =	7,340.0 sf

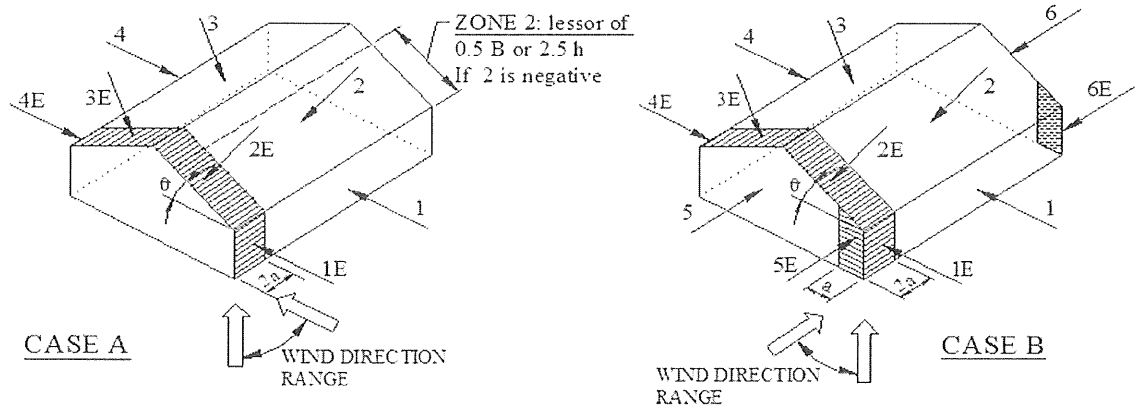
Longidinal Directional Force (F) = pAe

$p = qh\,[(GCpf)_{windward} - (GCpf)_{leeward}]\,K_B\,K_S$

Solidarity ratio (Φ) =	0.204
n =	5
KB =	-0.2
KS =	0.818
Zones 5 & 6 area =	6,924 sf
5E & 6E area =	416 sf
(GCpf) windward - (GCpf) leeward] =	0.710
p =	-3.4 psf

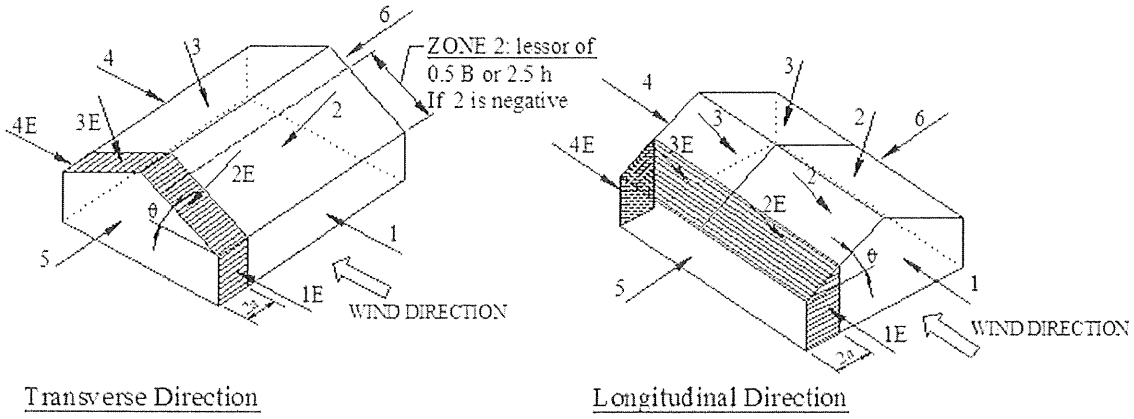
Total force to be resisted by MWFRS (F) = **-25.1 kips** applied at the centroid of the end wall area Ae

Note: The longidudinal force acts in combination with roof loads calculated elsewhere for an open or partially enclosed building.



NOTE: Torsional loads are 25% of zones 1 - 6. See code for loading diagram.
Exception: One story buildings h<30' and 1 to 2 storybuildings framed with light-frame construction or with flexible diaphragms need not be designed for the torsional load case.

ASCE 7-98 & ASCE 7-10 (& later) - MWFRS wind pressure zones



NOTE: Torsional loads are 25% of zones 1 - 4. See code for loading diagram.
Exception: One story buildings h<30' and 1 to 2 storybuildings framed with light-frame construction or with flexible diaphragms need not be designed for the torsional load case.

ASCE 7-02 and ASCE 7-05 - MWFRS wind pressure zones

Company
Address
City, State
Phone

JOB TITLE Chapter 5 Examples

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

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	qi = qh =	29.5 psf
Type of roof =	Gable		

Roof

	Surface Pressure (psf)								User input	
Area	2 sf	10 sf	20 sf	50 sf	75 sf	100 sf	200 sf	250 sf	5 sf	208 sf
Negative Zone 1 & 2e	-64.3	-64.3	-64.3	-39.1	-28.0	-20.1	-20.1	-20.1	-64.3	-20.1
Negative Zone 2n, 2r &3e	-93.8	-93.8	-81.1	-64.3	-56.9	-51.6	-38.9	-34.8	-93.8	-38.2
Negative Zone 3r	-111.5	-111.5	-95.5	-74.4	-65.0	-58.4	-58.4	-58.4	-111.5	-58.4
Positive All Zones	26	21.1	19	16.2	16.0	16.0	16.0	16.0	23.2	16.0
Overhang Zone 1 & 2e	-73.7	-73.7	-73.7	-56.9	-49.5	-44.2	-44.2	-44.2	-73.7	-44.2
Overhang Zone 2n & 2r	-103.2	-103.2	-93.7	-81.1	-75.5	-71.6	-62.1	-59.0	-103.2	-61.5
Overhang Zone 3e	-120.9	-120.9	-104.4	-82.6	-72.9	-66.1	-49.6	-44.2	-120.9	-48.6
Overhang Zone 3r	-138.6	-138.6	-117.3	-89.1	-76.7	-67.8	-67.8	-67.8	-138.6	-67.8

Overhang pressures in the table above assume an internal pressure coefficient (Gcpi) of 0.0
Overhang soffit pressure equals adj wall pressure (which includes internal pressure of 5.3 psf)

Parapet

qp = 0.0 psf

	Surface Pressure (psf)						User input
Solid Parapet Pressure	10 sf	20 sf	50 sf	100 sf	250 sf	500 sf	50 sf
CASE A: Zone 2e :	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zone 2n, 2r & 3e :	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Zone 3r :	0.0	0.0	0.0	0.0	0.0	0.0	0.0
CASE B : Interior zone :	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Corner zone :	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Walls

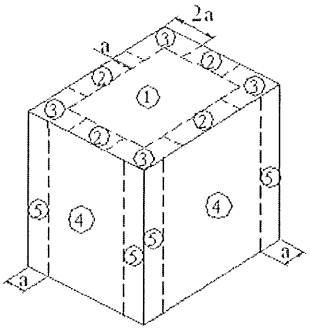
	GCp +/- GCpi				Surface Pressure at h				User input	
Area	10 sf	100 sf	200 sf	500 sf	10 sf	100 sf	200 sf	500 sf	15 sf	208 sf
Negative Zone 4	-1.28	-1.10	-1.05	-0.98	-37.8	-32.5	-31.0	-28.9	-36.8	-30.9
Negative Zone 5	-1.58	-1.23	-1.12	-0.98	-46.6	-36.2	-33.0	-28.9	-44.8	-32.9
Positive Zone 4 & 5	1.18	1.00	0.95	0.88	34.8	29.6	28.0	26.0	33.9	27.9

Company
Address
City, State
Phone

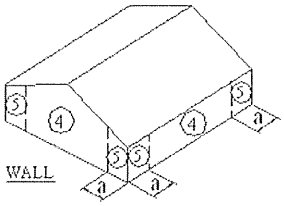
JOB TITLE Chapter 5 Examples

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

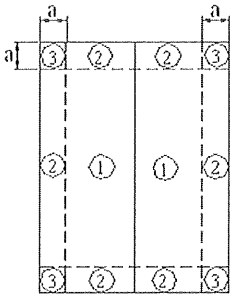
Location of C&C Wind Pressure Zones - ASCE 7-10 & earlier



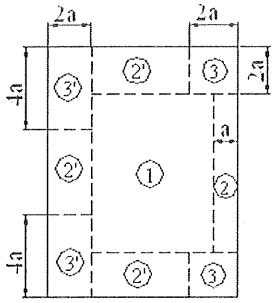
Roofs w/ θ ≤ 10°
and all walls
h > 60'



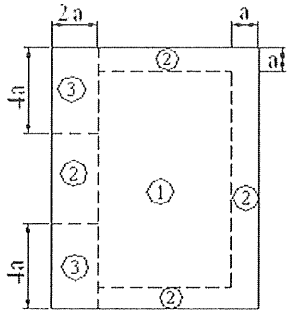
Walls h ≤ 60'
& alt design h<90'



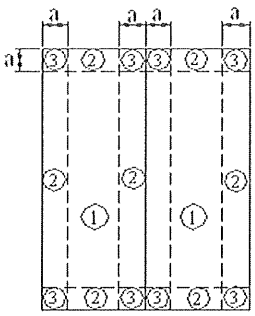
Gable, Sawtooth and
Multispan Gable θ ≤ 7 degrees &
Monoslope ≤ 3 degrees
h ≤ 60' & alt design h<90'



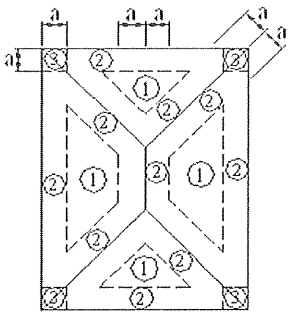
Monoslope roofs
3° < θ ≤ 10°
h ≤ 60' & alt design h<90'



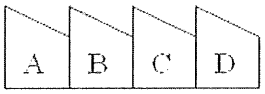
Monoslope roofs
10° < θ ≤ 30°
h ≤ 60' & alt design h<90'

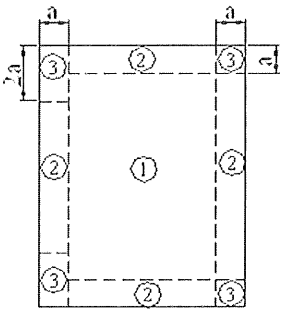


Multispan Gable &
Gable 7° < θ ≤ 45°

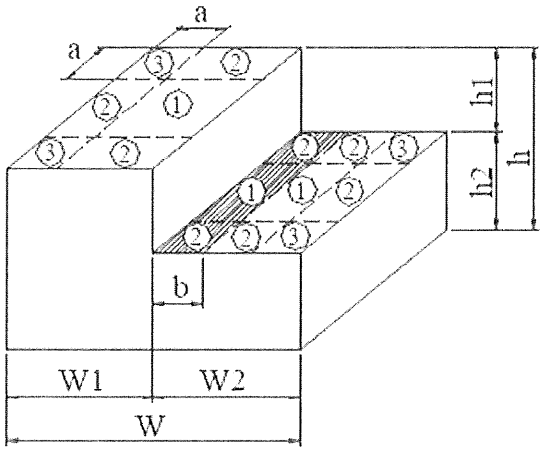


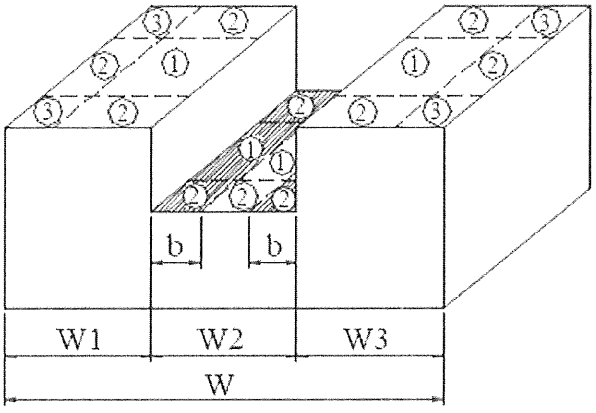
Hip 7° < θ ≤ 27°





Sawtooth 10° < θ ≤ 45°
h ≤ 60' & alt design h<90'





Stepped roofs θ ≤ 3°
h ≤ 60' & alt design h<90'

Company
Address
City, State
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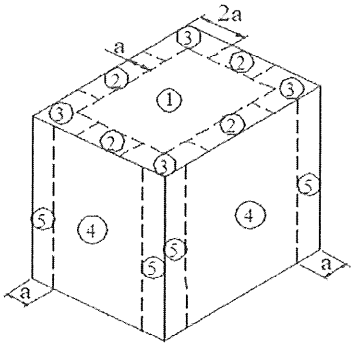
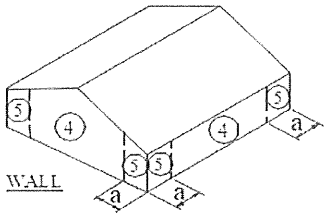
JOB TITLE Chapter 5 Examples

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

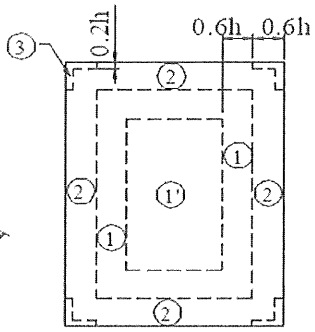
Location of C&C Wind Pressure Zones - ASCE 7-16



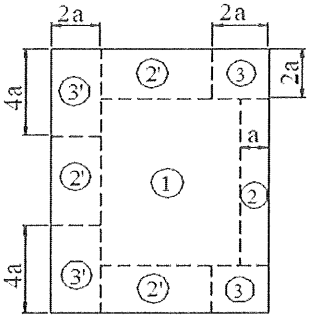
Roofs w/ $\theta \leq 10°$
and all walls
h > 60'



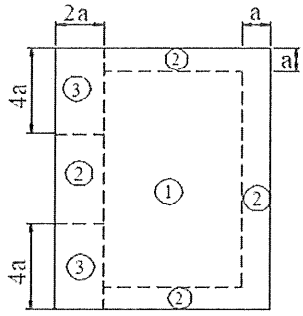
Walls h ≤ 60'
& alt design h<90'



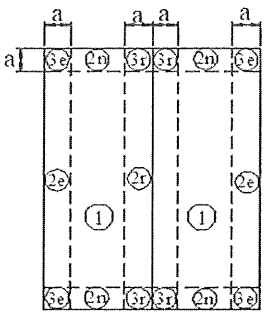
Gable, Sawtooth and
Multispan Gable $\theta \leq 7$ degrees &
Monoslope ≤ 3 degrees
h ≤ 60' & alt design h<90'



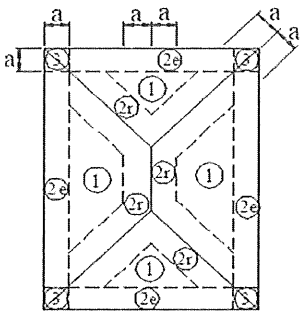
Monoslope roofs
$3° < \theta \leq 10°$
h ≤ 60' & alt design h<90'



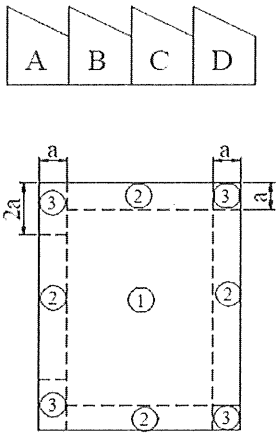
Monoslope roofs
$10° < \theta \leq 30°$
h ≤ 60' & alt design h<90'



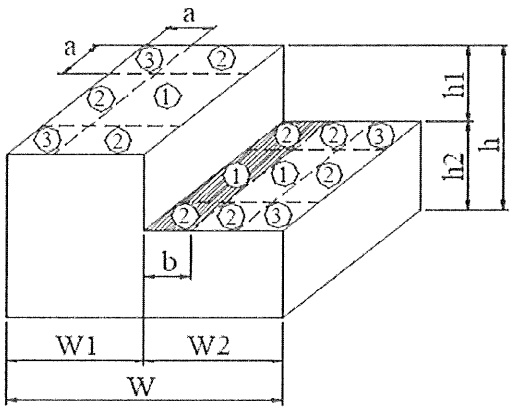
Multispan Gable &
Gable $7° < \theta \leq 45°$

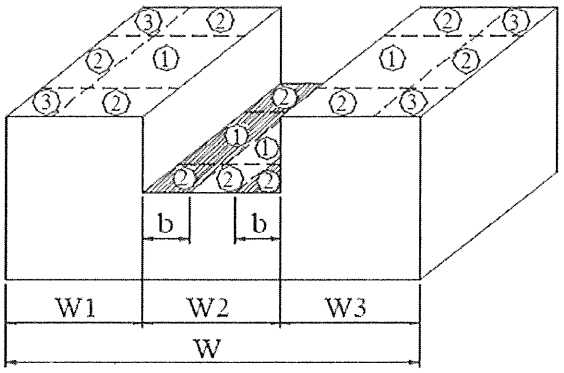


Hip $7° < \theta \leq 27°$



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





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

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JOB TITLE Chapter 5 Examples

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CALCULATED BY DATE
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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	16.8	0.0
		Ultimate Wind (zone 2 - 100sf)	16.0	-38.9
ASD Loading		D + Lr	40.0	-
		D + 0.75(0.6*W + Lr)	42.2	-
		0.6*D + 0.6*W	-	-18.5
LRFD Loading		1.2D + 1.6 Lr + 0.5W	64.0	-
		1.2D + 1.0W + 0.5Lr	50.0	-
		0.9D + 1.0W	-	-31.7

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

CODE SUMMARY

Code: ASCE 7 - 16

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
Partitions	15 psf
Lobbies & first floor corridors	100 psf
Corridors above first floor	80 psf
Balconies (1.5 times live load)	75 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		=	16.8 psf
Flat Roof Snow Load	Pf	=	16.8 psf
Balanced Snow Load	Ps	=	16.8 psf
Ground Snow Load	Pg	=	20.0 psf
Importance Factor	I	=	1.00
Snow Exposure Factor	Ce	=	1.20
Thermal Factor	Ct	=	1.00
Sloped-roof Factor	Cs	=	1.00
Drift Surcharge load	Pd	=	
Width of Snow Drift	w	=	

Earthquake Design Data:

Risk Category		=	II
Importance Factor	I	=	1.00
Mapped spectral response accelerat	Ss	=	167.00
	S1	=	20.00
Site Class		=	D
Spectral Response Coef.	Sds	=	1.113
	Sd1	=	0.293
Seismic Design Category		=	D
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	=	0.371W
Seismic Response Coef.	Cs	=	0.371
Response Modification Factor	R	=	3
Analysis Procedure		=	Equivalent Lateral-Force Analysis

CODE SUMMARY- continued

Component and cladding ultimate wind pressures

Roof

Area	Surface Pressure (psf) 2 sf	10 sf	20 sf	50 sf	75 sf	100 sf	200 sf	250 sf
Negative Zone 1 & 2e	-64.3	-64.3	-64.3	-39.1	-28.0	-20.1	-20.1	-20.1
Negative Zone 2n, 2r &3e	-93.8	-93.8	-81.1	-64.3	-56.9	-51.6	-38.9	-34.8
Negative Zone 3r	-111.5	-111.5	-95.5	-74.4	-65.0	-58.4	-58.4	-58.4
Positive All Zones	26.0	21.1	19.0	16.2	16.0	16.0	16.0	16.0
Overhang Zone 1 & 2e	-73.7	-73.7	-73.7	-56.9	-49.5	-44.2	-44.2	-44.2
Overhang Zone 2n & 2r	-103.2	-103.2	-93.7	-81.1	-75.5	-71.6	-62.1	-59.0
Overhang Zone 3e	-120.9	-120.9	-104.4	-82.6	-72.9	-66.1	-49.6	-44.2
Overhang Zone 3r	-138.6	-138.6	-117.3	-89.1	-76.7	-67.8	-67.8	-67.8

Overhang soffit pressure equals adj wall pressure (which includes internal pressure of 5.3 psf)

Parapet

	Area	Solid Parapet Pressure (psf) 10 sf	20 sf	50 sf	100 sf	250 sf	500 sf
CASE A:	Zone 2e :	0.0	0.0	0.0	0.0	0.0	0.0
	Zone 2n, 2r & 3e :	0.0	0.0	0.0	0.0	0.0	0.0
	Zone 3r :	0.0	0.0	0.0	0.0	0.0	0.0
CASE B :	Interior zone :	0.0	0.0	0.0	0.0	0.0	0.0
	Corner zone :	0.0	0.0	0.0	0.0	0.0	0.0

Wall

Area	Surface Pressure (psf) 10 sf	100 sf	200 sf	500 sf
Negative Zone 4	-37.8	-32.5	-31.0	-28.9
Negative Zone 5	-46.6	-36.2	-33.0	-28.9
Positive Zone 4 & 5	34.8	29.6	28.0	26.0