CALCULATION OF WIND LOADS ON STRUCTURES ACCORDING TO ASCE 7– 2005

Wind Load Calculation Procedures

The design wind loads for buildings and other structures shall be determined according to
one of the following procedures:
(1) Method 1 – Simplified procedure for low-rise simple diaphragm buildings
(2) Method 2 – Analytical procedure for regular shaped building and structures
(3) Method 3 – Wind tunnel procedure for geometrically complex buildings and structures.

Method 2 – Analytical Procedure

Wind loads for buildings and structures that do not satisfy the conditions for using the simplified procedure can be calculated using the analytical procedure provided that they are not geometrically complex structures.

The steps of analytical procedure, described in ASCE 7 Section 6.5.3 only, are as follows:
1. Determine the *basic wind speed*, *V*, and *wind directionality factor*, K_d in accordance with ASCE 7 Section 6.5.4.

Table (6.4): Wind Directionality Factor K_d

Structure Type	Directionality Factor K_d*
Buildings	
Main Wind Force Resisting System	0.85
Components and Cladding	0.85
Arched Roofs	0.85
Chimneys, Tanks, and Similar Structures	
Square	0.90
Hexagonal	0.95
Round	0.95
Solid Signs	0.85
Open Signs and Lattice Framework	0.85
Trussed Towers	
Triangular, square, rectangular	0.85
All other cross sections	0.95

2. Determine the *importance factor*, *I*, in accordance with ASCE Section 6.5.5.

TABLE 1-1 OCCUPANCY CATEGORY OF BUILDINGS AND OTHER STRUCTURES FOR FLOOD, WIND, SNOW, EARTHQUAKE, AND ICE LOADS

Nature of Occupancy	Occupancy Category
Buildings and other structures that represent a low hazard to human life in the event of failure, including, but not limited to: • Agricultural facilities • Certain temporary facilities • Minor storage facilities	I
All buildings and other structures except those listed in Occupancy Categories I, III, and IV	II
Buildings and other structures that represent a substantial hazard to human life in the event of failure, including, but not limited to: • Buildings and other structures where more than 300 people congregate in one area • Buildings and other structures with daycare facilities with a capacity greater than 150 • Buildings and other structures with elementary school or secondary school facilities with a capacity greater than 250 • Buildings and other structures with a capacity greater than 500 for colleges or adult education facilities • Health care facilities with a capacity of 50 or more resident patients, but not having surgery or emergency treatment facilities • Jails and detention facilities Buildings and other structures, not included in Occupancy Category IV, with potential to cause a substantial economic impact and/or mass disruption of day-to-day civilian life in the event of failure, including, but not limited to: • Power generating stations[a] • Water treatment facilities • Sewage treatment facilities • Telecommunication centers Buildings and other structures not included in Occupancy Category IV (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, hazardous waste, or explosives) containing sufficient quantities of toxic or explosive substances to be dangerous to the public if released. Buildings and other structures containing toxic or explosive substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the toxic or explosive substances does not pose a threat to the public.	III
Buildings and other structures designated as essential facilities, including, but not limited to: • Hospitals and other health care facilities having surgery or emergency treatment facilities • Fire, rescue, ambulance, and police stations and emergency vehicle garages • Designated earthquake, hurricane, or other emergency shelters • Designated emergency preparedness, communication, and operation centers and other facilities required for emergency response • Power generating stations and other public utility facilities required in an emergency • Ancillary structures (including, but not limited to, communication towers, fuel storage tanks, cooling towers, electrical substation structures, fire water storage tanks or other structures housing or supporting water, or other fire-suppression material or equipment) required for operation of Occupancy Category IV structures during an emergency • Aviation control towers, air traffic control centers, and emergency aircraft hangars • Water storage facilities and pump structures required to maintain water pressure for fire suppression • Buildings and other structures having critical national defense functions Buildings and other structures (including, but not limited to, facilities that manufacture, process, handle, store, use, or dispose of such substances as hazardous fuels, hazardous chemicals, or hazardous waste) containing highly toxic substances where the quantity of the material exceeds a threshold quantity established by the authority having jurisdiction. Buildings and other structures containing highly toxic substances shall be eligible for classification as Occupancy Category II structures if it can be demonstrated to the satisfaction of the authority having jurisdiction by a hazard assessment as described in Section 1.5.2 that a release of the highly toxic substances does not pose a threat to the public. This reduced classification shall not be permitted if the buildings or other structures also function as essential facilities.	IV

Table (6-1): Wind Importance Factors

Category	Non-Hurricane Prone Regions and Hurricane Prone Regions with V = 85-100 mph and Alaska	Hurricane Prone Regions with V > 100 mph
I	0.87	0.77
II	1.00	1.00
III	1.15	1.15
IV	1.15	1.15

3. Determine the *exposure category or exposure categories* and *velocity pressure exposure coefficient,* K_z or K_h, as applicable, for each wind direction according to ASCE 7 Section 6.5.6.

Surface Roughness B: Urban and suburban areas, wooded areas, or other terrain with numerous closely spaced obstructions having the size of single-family dwellings or larger.
Surface Roughness C: Open terrain with scattered obstructions having heights generally less than 30 ft (9.1 m). This category includes flat open country, grasslands, and all water surfaces in hurricane prone regions.
Surface Roughness D: Flat, unobstructed areas and water surfaces outside hurricane prone regions. This category includes smooth mud flats, salt flats, and unbroken ice.

Table (6-3): Velocity pressure exposure coefficients, K_h and K_z

Height above ground level, z		Exposure (Note 1)			
		B		C	D
ft	(m)	Case 1	Case 2	Cases 1 & 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	0.70	0.98	1.16
40	(12.2)	0.76	0.76	1.04	1.22
50	(15.2)	0.81	0.81	1.09	1.27
60	(18)	0.85	0.85	1.13	1.31
70	(21.3)	0.89	0.89	1.17	1.34
80	(24.4)	0.93	0.93	1.21	1.38
90	(27.4)	0.96	0.96	1.24	1.40
100	(30.5)	0.99	0.99	1.26	1.43
120	(36.6)	1.04	1.04	1.31	1.48
140	(42.7)	1.09	1.09	1.36	1.52
160	(48.8)	1.13	1.13	1.39	1.55
180	(54.9)	1.17	1.17	1.43	1.58
200	(61.0)	1.20	1.20	1.46	1.61
250	(76.2)	1.28	1.28	1.53	1.68
300	(91.4)	1.35	1.35	1.59	1.73
350	(106.7)	1.41	1.41	1.64	1.78
400	(121.9)	1.47	1.47	1.69	1.82
450	(137.2)	1.52	1.52	1.73	1.86
500	(152.4)	1.56	1.56	1.77	1.89

4. Determine the *topographic factor*, K_{zt}, if applicable, according to ASCE 7 Section 6.5.7.
If site conditions and locations of structures do not meet all the conditions specified in Section 6.5.7.1 then K_{zt} = 1.0 (level ground).
5. Determine the *gust effect factor G* , in accordance with ASCE 7 Section 6.5.8. For rigid structures as defined in Section 6.2, the gust-effect factor shall be taken as 0.85 or calculated by a formula.

6. Determine the *external pressure coefficients*, C_p, in accordance with ASCE 7 Section 6.5.11.2 or 6.5.11.3.

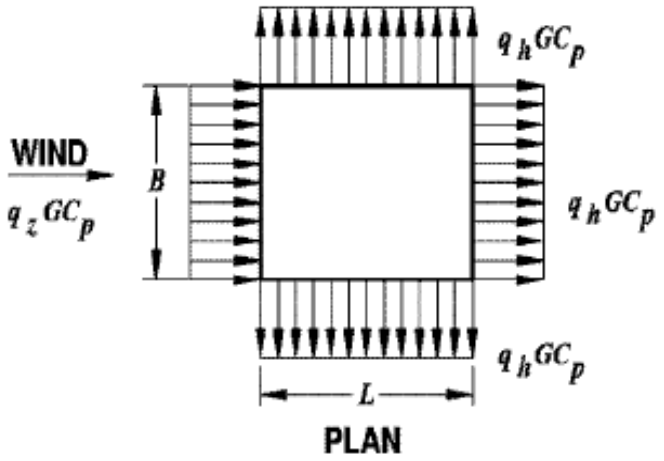


Table (6-6): Wall pressure coefficients, C_p

Wall Pressure Coefficients, C_p			
Surface	**L/B**	**C_p**	**Use With**
Windward Wall	All values	0.8	q_z
Leeward Wall	0-1	-0.5	q_h
	2	-0.3	
	≥4	-0.2	
Side Wall	All values	-0.7	q_h

7. Determine the *velocity pressure*, q_z or q_h, as applicable, in accordance with ASCE 7 Section 6.5.10. The velocity pressure, q_z evaluated at height *z* is calculated by the following equation:

$$q_z = 0.0047\, K_z\, K_{zt}\, K_d\, V^2\, I \quad (kg/cm^2\,;V \text{ in } km/hr)$$

8. Determine the *design wind load, F*, as applicable, in accordance with ASCE 7 Section 6.5.12 and 6.5.13.

The *design wind load, F*, on open buildings and other structures is determined by the following formula:

$$F = q_z \, G \, C_p \, A_f$$

where

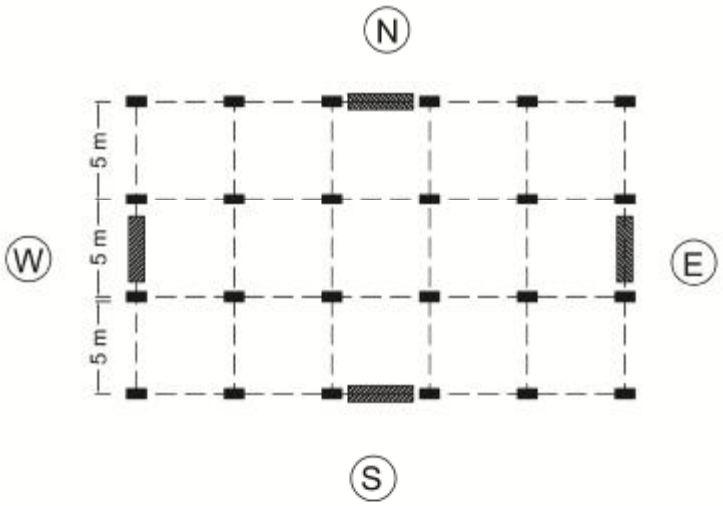
q_z = Velocity pressure evaluated at height z of the centroid of area A_f

A_f = Projected area normal to the wind (m^2)

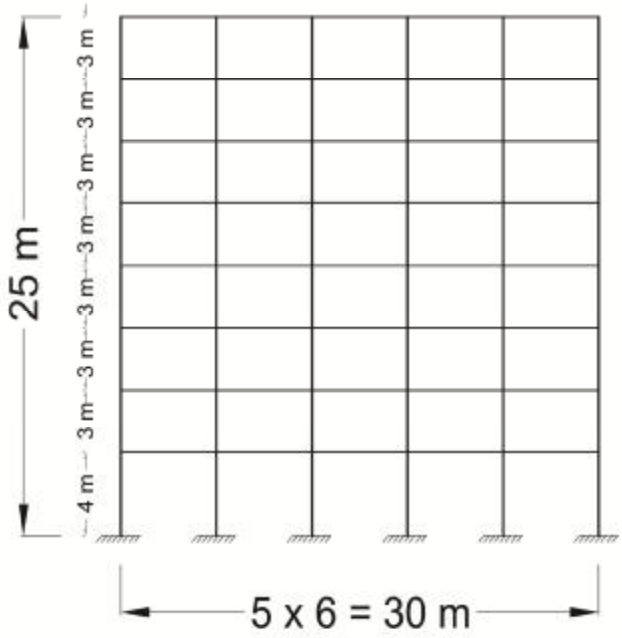
Example (8):

It is required to calculate the lateral wind loads acting on the 8-story building considering the wind is acting first in the North-South direction, and second in the East-West direction. The building which is used as a headquarter for police operation is 30 m x 15 m in plan as shown in the figure, and located right on the Gaza Beach.

Note: Use a basic wind speed of 100 Km/hr and ASCE 7-05 Procedure.



Plan

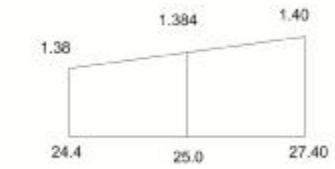


Elevation

Wind Acting in North-South Direction:

The building is categorized as exposure D

$K_z = 1.384$ (Interpolating values given in Table 6.3, for exposure D)



$I = 1.15$, police operations

$K_{zt} = 1.0$ (Topographic factor leveled ground)

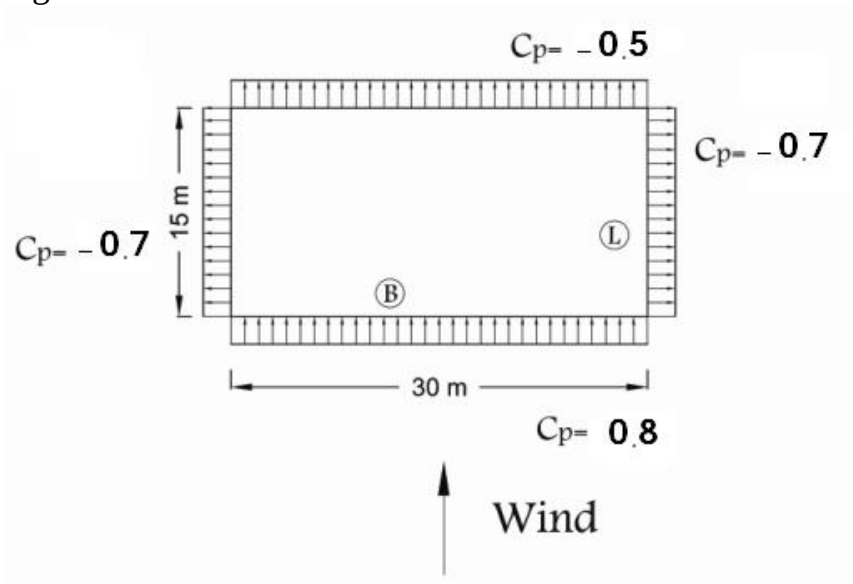
$K_d = 0.85$ (Wind directionality factored evaluated from Table 6.4)

The static wind pressure $q_h = 0.0047\, K_h\, K_{zt}\, K_d\, V^2\, I$

$$= 0.0047\,(1.384)\,(1.0)\,(0.85)(100)^2\,(1.15)$$

$$= 63.58\ Kg/m^2$$

For $L/B = \frac{15}{30} = 0.5$ and using Table (6.6) the external pressure coefficients are shown in the figure.



For the leeward side, $C_p = -0.50$ and the gust factor $G = 0.85$.

Wind pressure (leeward side) = $q_h\, G\, C_p = -\ 63.58(0.85)(0.5) = -27.02\ Kg/m^2$

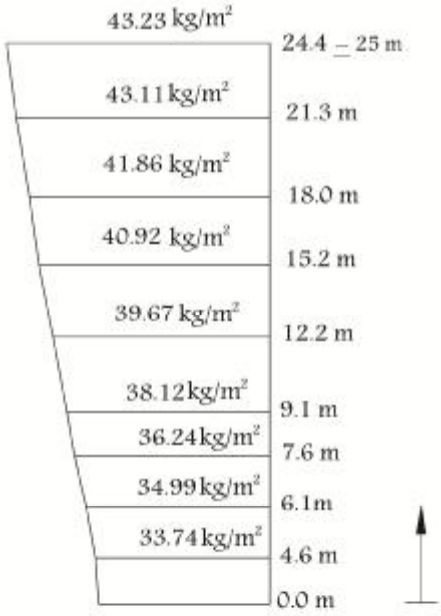
For the sides parallel to the wind direction,

the wind pressure = $q_h G C_p = -\ 63.58(0.85)(0.7) = -37.83\ Kg/m^2$

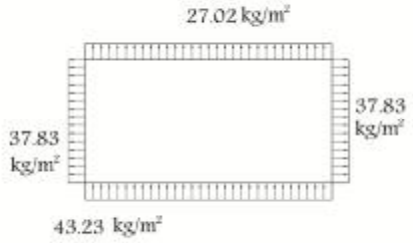
For the windward direction,

$q_z = 0.0047\,(K_z)\,(1.0)\,(0.85)(100)^2\ (1.15) = 45.9425\,K_z\ Kg/m^2$ and

$p = q_z\,G\,C_p = 45.9425\,K_z\,(0.85)(0.8) = 31.2409\,K_z\ Kg/m^2$ (varies with height)



Pressure distribution along the height



Pressure distribution at a height of 25 m

Wind Acting in East-West Direction:

For $L/B = \frac{30}{15} = 2$ and using Table (6.6) the external pressure coefficients are as follows.

Windward, $C_p = 0.8$

Leeward, $C_p = -0.3$

Sides, $C_p = -0.7$

Windward pressure at a height of 25 m, $p = (0.8)(63.58)(0.85) = 43.23\ Kg/m^2$

Leeward pressure at a height of 25 m, $p = (0.3)(63.58)(0.85) = 16.21\ Kg/m^2$

Side pressure at a height of 25 m, $p = (0.7)(63.58)(0.85) = 37.83\ Kg/m^2$