

28.3 WIND LOADS: MAIN WIND FORCE RESISTING SYSTEM

28.3.1 Design Wind Pressure for Low-Rise Buildings Design wind pressures for the MWFRS of low-rise buildings shall be determined by the following equation:

$$p = q_h K_d [(GC_{pf}) - (GC_{pi})] (\text{lb/ft}^2) \quad (28.3-1)$$

$$p = q_h K_d [(GC_{pf}) - (GC_{pi})] (\text{N/m}^2) \quad (28.3-1.SI)$$

where

q_h = Velocity pressure evaluated at mean roof height h , as defined in Section 26.3;

K_d = Wind directionality factor, see Section 26.6;

(GC_{pf}) = External pressure coefficient from Section 28.3.2; and

(GC_{pi}) = Internal pressure coefficient from Table 26.13-1.

28.3.1.1 External Pressure Coefficients, (GC_{pf}) The combined gust-effect factor and external pressure coefficients used in this chapter, (GC_{pf}) , are not permitted to be separated.

28.3.2 Load Cases Buildings shall be evaluated using each of the basic load cases and the torsional load cases acting independently in accordance with this section.

EXCEPTION: Design for the torsional cases is not required for

1. One-story buildings with h less than or equal to 30 ft (9.1 m),
2. One-story and two-story light-frame buildings, or
3. One-story and two-story buildings with flexible diaphragms.

28.3.2.1 Basic Load Cases The external pressure coefficient, (GC_{pf}) , for basic load cases shall be determined in accordance with Figure 28.3-1. The building shall be evaluated with each corner taken as the windward corner, with loading patterns applied as shown, and with all zones being loaded simultaneously. Each corner shall be evaluated separately for the two load cases. In each load case, Zones 2E and 3E shall be located along the roof edge perpendicular to the ridge that is nearest the corner being evaluated. Combinations of external and internal pressures (see Table 26.13-1) shall be evaluated as required to obtain the most severe loadings.

For flat roofs, the roof angle, θ , shall be taken as 0, with the Zone 2/3 and Zone 2E/3E boundary located at the mid-width of the building.

The roof pressure coefficient, (GC_{pf}) , when negative in Zones 2 and 2E, shall be applied in Zone 2/2E for a distance from the edge of roof equal to 0.5 times the horizontal dimension of the building parallel to the direction of the MWFRS being designed or 2.5 times the eave height at the windward wall, whichever is less; the remainder of Zone 2/2E extending to the ridge line shall use the pressure coefficient (GC_{pf}) for Zone 3/3E.

28.3.2.2 Torsional Load Cases The external pressure coefficient, (GC_{pf}) , for torsional load cases shall be determined in accordance with Figure 28.3-2. For Zones 1 to 6 and 1E to 6E, Load Case 3 shall use Load Case 1 pressure coefficients from Figure 28.3-1, and Load Case 4 shall use Load Case 2 pressure coefficients from Figure 28.3-1. For zones designated with a "T" (1T to 6T), the pressure coefficients from Figure 28.3-2 shall be used.

The building shall be evaluated with each corner taken as the windward corner with loading patterns applied as shown and with all zones being loaded simultaneously. Each corner shall be evaluated separately for the two load cases. In each load case, Zones 2E and 3E shall be located along the roof edge perpendicular to the ridge that is nearest the corner being

evaluated. Combinations of external and internal pressures (see Table 26.13-1) shall be evaluated as required to obtain the most severe loadings.

For flat roofs, the roof angle, θ , shall be taken as 0. For Zone 2/3 and Zone 2E/3E boundary at the mid-width of the building. The roof pressure coefficient, (GC_{pf}) , when negative in Zones 2 and 2E, shall be applied in Zone 2/2E for a distance from the edge of roof equal to 0.5 times the horizontal dimension of the building parallel to the direction of the MWFRS being designed or 2.5 times the eave height at the windward wall, whichever is less; the remainder of Zone 2/2E extending to the ridge line shall use the pressure coefficient, (GC_{pf}) for Zone 3/3E.

28.3.3 Total Horizontal Load The total horizontal load shall not be less than that determined by neglecting the wind pressure on the roof.

EXCEPTION: This provision does not apply to buildings using moment frames for the MWFRS.

28.3.4 Parapets The design wind pressure for the parapets on MWFRS of low-rise buildings with flat roofs shall be determined by the following equation:

$$p_p = q_p K_d (GC_{pn}) (\text{lb/ft}^2)$$

$$p_p = q_p K_d (GC_{pn}) (\text{N/m}^2)$$

where

p_p = Combined net pressure on the parapet calculated as a combination of the net pressures from the windward and leeward back parapet surfaces; plus (and minus) the net pressure acting toward (and away from) the windward (exterior) side of the parapet;

q_p = Velocity pressure evaluated at the top of the parapet;

K_d = Wind directionality factor, see Section 26.6;

(GC_{pn}) = Combined net pressure coefficient: +1.5 for windward parapet, -1.0 for leeward parapet.

28.3.5 Roof Overhangs The positive external pressure on the bottom surface of windward roof overhangs shall be determined using $GC_p = 0.7$ in combination with the top surface pressure determined using Figure 28.3-1.

28.3.6 Minimum Design Wind Loads The wind load used in the design of the MWFRS for an enclosed building shall not be less than 16 lb/ft² multiplied by the wall area of the building, and 8 lb/ft² multiplied by the roof area of the building projected on a vertical plane normal to the assumed wind direction.

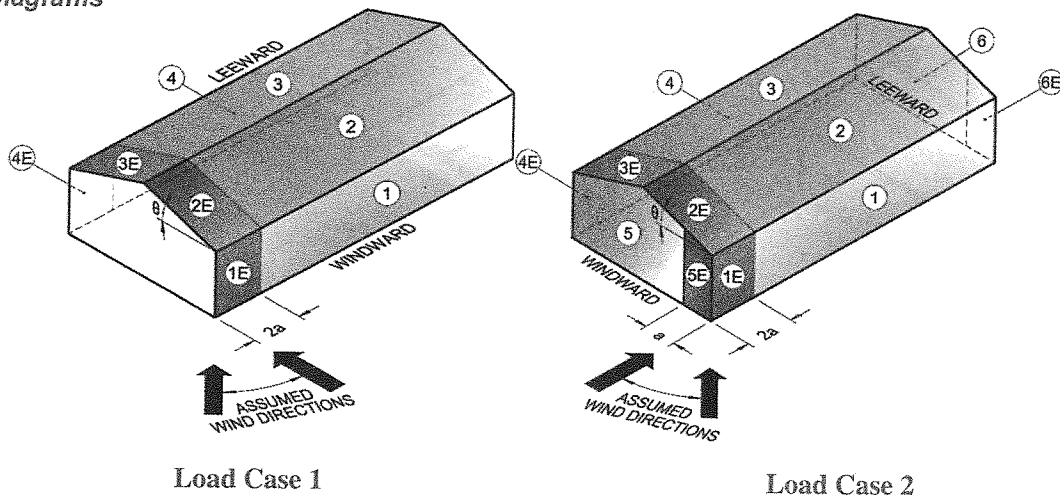
28.3.7 Horizontal Wind Loads on Open Enclosed Buildings with Transverse Frames A horizontal pressure in the longitudinal direction (parallel to the ridge) that acts in combination with the wind load calculated in Section 27.4.3 for an open or partially enclosed building with transverse frames and a pitched roof (degrees) shall be determined by the following equation:

$$p = q_h K_d [(GC_{pf})_{\text{windward}} - (GC_{pf})_{\text{leeward}}] K_B$$

where

q_h = Velocity pressure evaluated at mean roof height using the exposure as defined in Section 26.3.

**Basic Load Cases
Diagrams**



Notation

a = 10% of least horizontal dimension or $0.4 h$, whichever is smaller, but not less than either 4% of least horizontal dimension or 3 ft (0.9 m).

EXCEPTION: For buildings with $\theta = 0$ to 7° and a least horizontal dimension greater than 300 ft (90 m), dimension a shall be limited to a maximum of $0.8 h$.

h = Mean roof height, ft (m), except that eave height shall be used for $\theta \leq 10^\circ$.

θ = Angle of plane of roof from horizontal, in degrees.

Load Case 1

Roof Angle θ (degrees)	Building Surface							
	1	2	3	4	1E	2E	3E	4E
0-5	0.40	-0.69	-0.37	-0.29	0.61	-1.07	-0.53	-0.43
20	0.53	-0.69	-0.48	-0.43	0.80	-1.07	-0.69	-0.64
30-45	0.56	0.21	-0.43	-0.37	0.69	0.27	-0.53	-0.48
90	0.56	0.56	-0.37	-0.37	0.69	0.69	-0.48	-0.48

Load Case 2

Roof Angle θ (degrees)	Building Surface											
	1	2	3	4	5	6	1E	2E	3E	4E	5E	6E
0-90	-0.45	-0.69	-0.37	-0.45	0.40	-0.29	-0.48	-1.07	-0.53	-0.48	0.61	-0.43

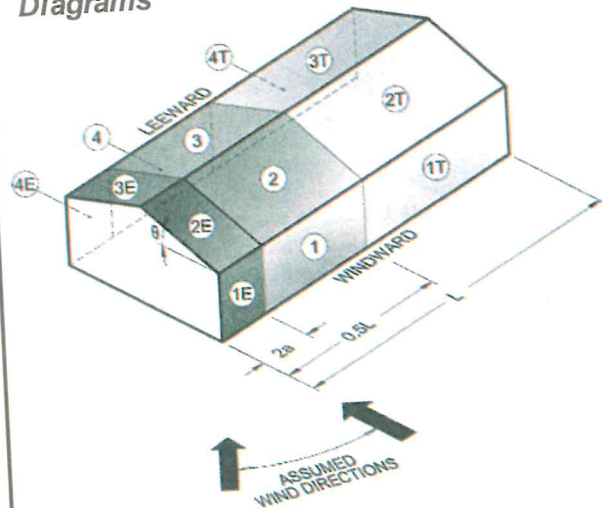
Notes

1. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
2. For values of θ other than those shown, linear interpolation is permitted.

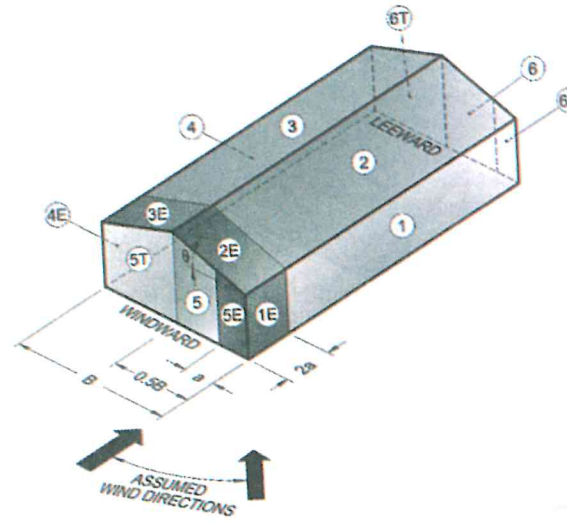
Figure 28.3-1. Basic load cases for main wind force resisting system [$h \leq 60$ ft ($h \leq 18.3$ m)]: external pressure coefficients, (GC_{pf}), for enclosed, partially enclosed, and partially open buildings—low-rise walls and roofs.

Torsional Load Cases

Diagrams



Load Case 3



Load Case 4

Notation

$a = 10\%$ of least horizontal dimension or $0.4 h$, whichever is smaller, but not less than either 4% of least horizontal dimension or 3ft (0.9 m).

EXCEPTION: For buildings with $\theta = 0$ to 7° and a least horizontal dimension greater than 300 ft (90 m), dimension a shall be limited to a maximum of $0.8 h$.

$h =$ Mean roof height, in feet (meters), except that eave height shall be used for $\theta \leq 10^\circ$.

$\theta =$ Angle of plane of roof from horizontal, in degrees.

Load Case 3

Roof Angle θ (degrees)	Building Surface			
	1T	2T	3T	4T
0–5	0.10	-0.17	-0.09	-0.07
20	0.13	-0.17	-0.12	-0.11
30–45	0.14	0.05	-0.11	-0.09
90	0.14	0.14	-0.09	-0.09

Load Case 4

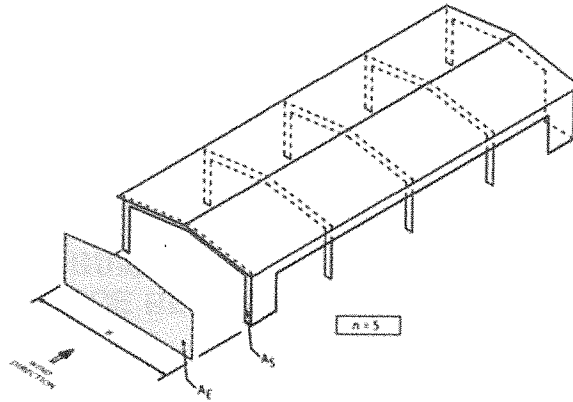
Roof Angle θ (degrees)	Building Surface	
	5T	6T
0–90	0.10	-0.07

Notes

1. Plus and minus signs signify pressures acting toward and away from the surfaces, respectively.
2. For values of θ other than those shown, linear interpolation is permitted.

Figure 28.3-2. Torsional load cases for main wind force resisting system [$h \leq 60\text{ ft}$ ($h \leq 18.3\text{ m}$)]: external coefficients, ($G_{C_{pf}}$), for enclosed, partially enclosed, and partially open buildings—low-rise walls and

Diagram



Notation

- B = Width of the building perpendicular to the ridge, ft (m)
- A_S = Effective solid area of the end wall (i.e., the projected area of any portion of the end wall that would be exposed to the wind)
- A_E = Total end wall area for an equivalent enclosed building
- n = Number of frames, but shall not be taken as less than 3, even for 2-frame building.

Figure 28.3-3. Horizontal wind loads on open or partially enclosed buildings with transverse frames and pitched roofs: definitions of geometric terminology.

- K_d = Wind directionality factor, see Section 26.6;
- (GC_{pf}) = External pressure coefficient given in Figure 28.3-1 for Load Case 2, where building surfaces 5 and 5E shall be used to compute the average windward end wall pressure and building surfaces 6 and 6E shall be used to compute the average leeward end wall pressure;
- K_B = Frame width factor = $1.8 - 0.01B$, $B < 100$ ft ($B < 30.5$ m), or 0.8, $B \geq 100$ ft ($B \geq 30.5$ m);
- K_S = Shielding factor = $0.60 + 0.073(n - 3) + (1.25 \phi^{1.8})$;
- ϕ = Solidity ratio = A_S/A_E ;
- B = Width of the building perpendicular to the ridge, ft (m);
- n = Number of frames, but shall not be taken as less than 3, even for small 2-frame building;
- A_S = Effective solid area of the end wall, that is, the projected area of any portion of the end wall that would be exposed to the wind (Figure 28.3-3); and
- A_E = Total end wall area for an equivalent enclosed building (Figure 28.3-3).

The total longitudinal force F to be resisted by the MWFRS shall be determined by Equation (28.3-4):

$$F = pA_E \quad (28.3-4)$$

Equation (28.3-3) is applicable to buildings with open end walls and with end walls fully or partially enclosed with cladding. For all cases, A_E shall be the area that is equivalent to the end wall fully enclosed. The longitudinal force, F , given by Equation (28.3-4) represents the total force for which the MWFRS longitudinal bracing shall be designed. The distribution to each sidewall shall be based on the force F applied at the centroid of the end wall area A_E .

Fascia load need not be considered separately if fascia areas are included in the A_S calculation.

28.4 CONSENSUS STANDARDS AND OTHER REFERENCED DOCUMENTS

No consensus standards and other documents that shall be considered part of this standard are referenced in this chapter.

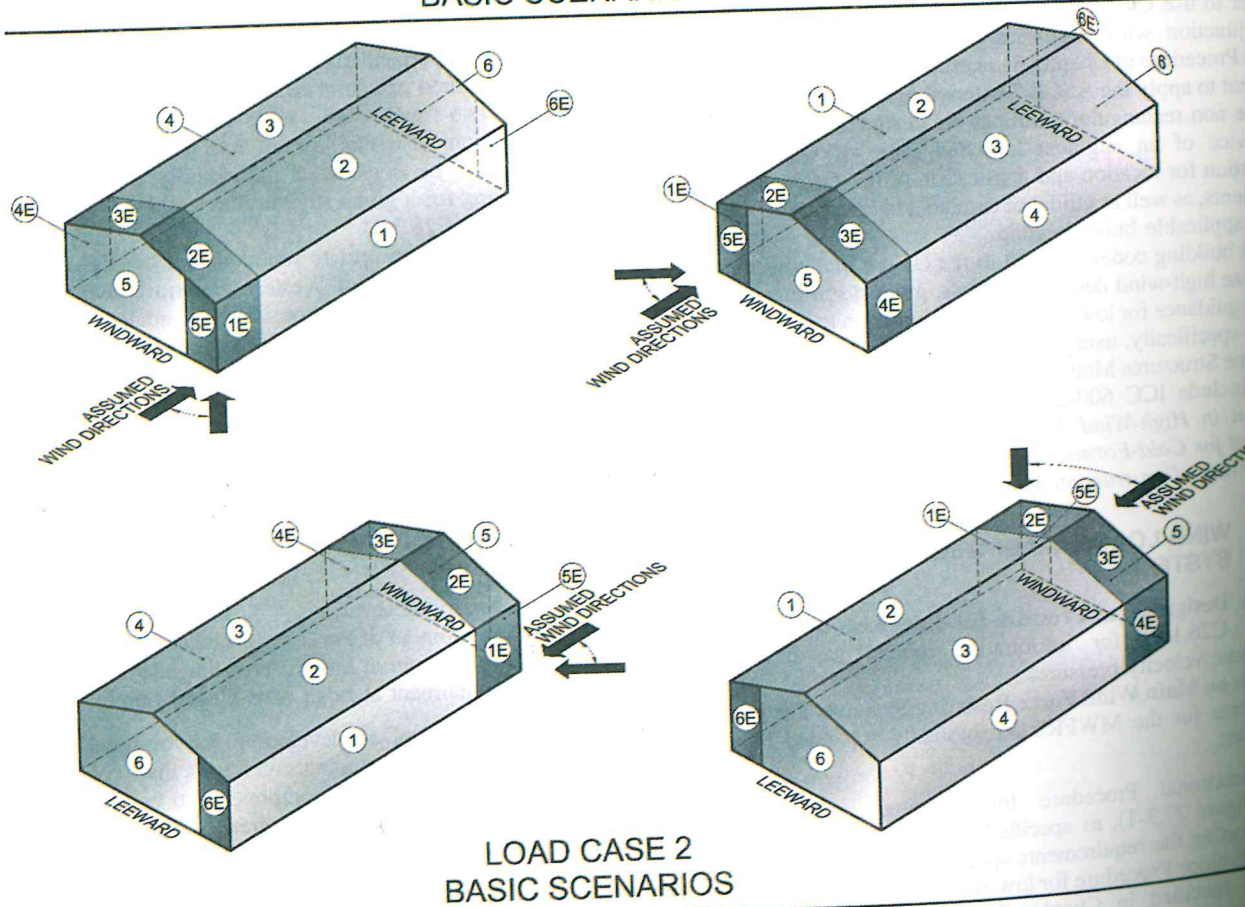
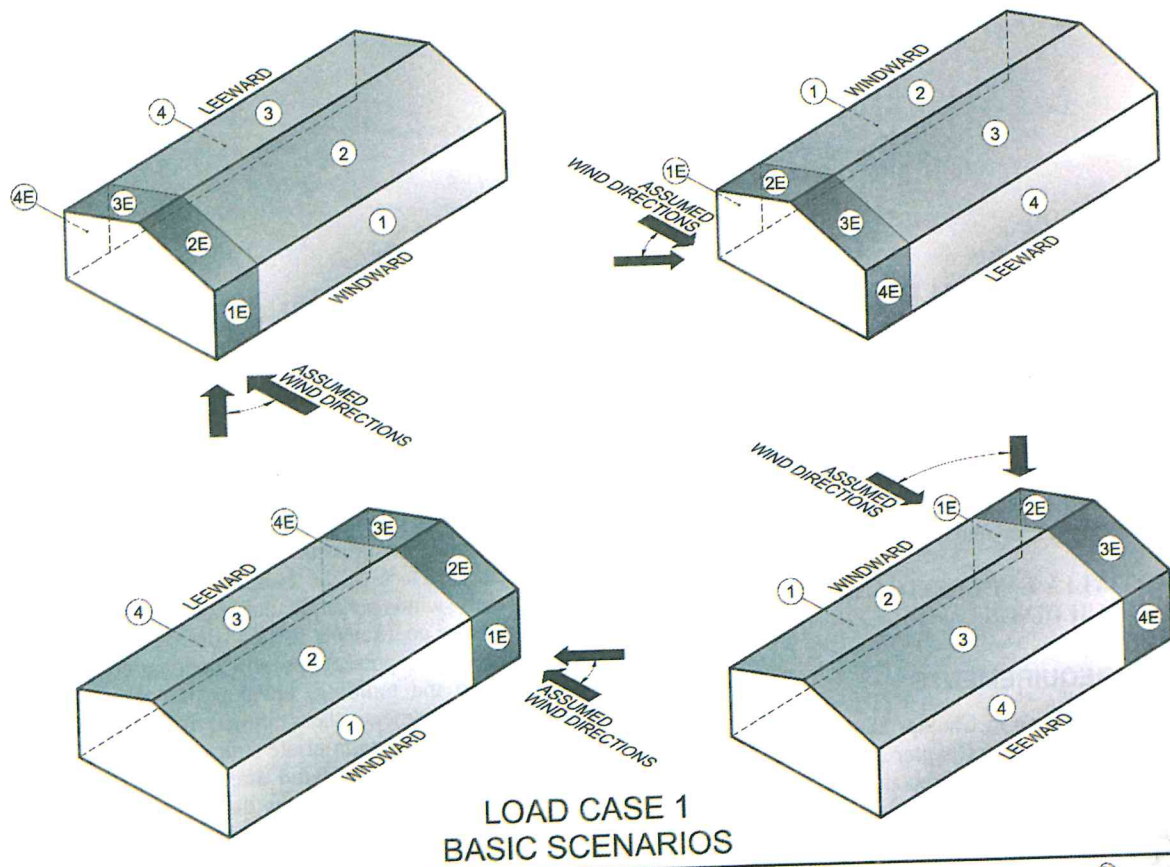


Figure C28.3-1. Illustration of load application in Figure 28.3-1.

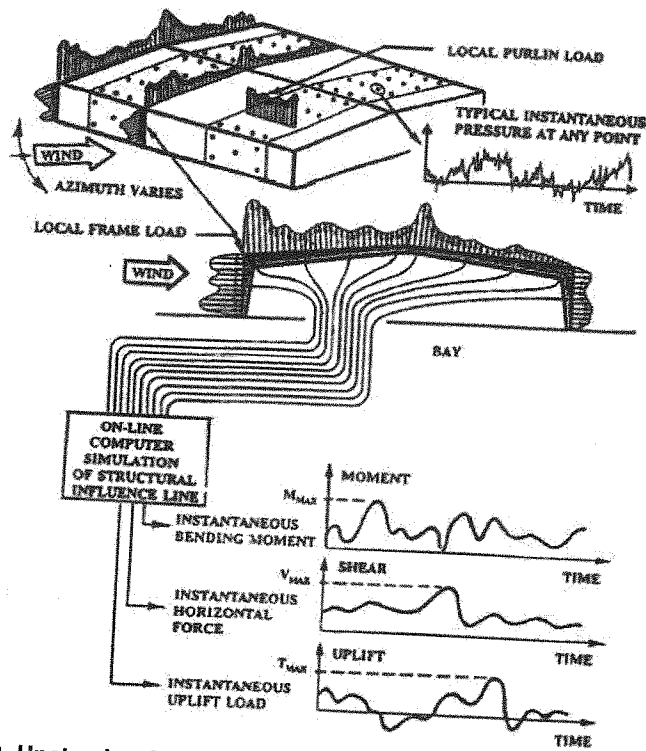
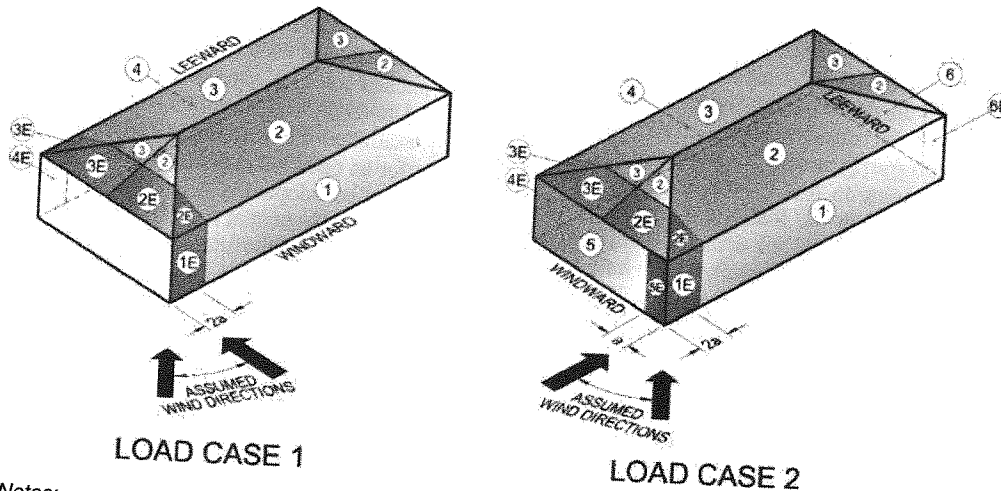


Figure C28.3-2. Unsteady wind loads on low buildings for a given wind direction.



Notes:

1. Adapt the loadings shown in Figure 28.3-1 for hip-roofed buildings as shown. For a given hip roof pitch, use the roof coefficients from the Case 1 table for both Load Case 1 and Load Case 2.
2. The total horizontal shear shall not be less than that determined by neglecting the wind forces on roof surfaces.

Figure C28.3-3. Loads application for hip-roofed low-rise buildings.

...ious loading conditions but that conservatively envelop the maximum induced force components (bending moment, shear, and thrust) to be resisted, independent of wind direction. The original set of coefficients was generated for the framing of conventional pre-engineered buildings, that is, single-story, moment-resisting frames in one of the principal directions and bracing in the other principal direction. The approach was later extended to single-story, moment-resisting frames with interior columns (Kavanagh et al. 1983).

Subsequent wind tunnel studies (Isyumov and Case 1995) have shown that the (GC_{pf}) values of Figure 28.3-1 are also applicable to low-rise buildings with structural systems other than moment-resisting frames. That work examined the instantaneous wind pressures on a low-rise building with a 4:12 pitched gable roof and the resulting wind-induced forces on its MWFRS. Two different MWFRSs were evaluated. One consisted of shear walls and roof trusses at different spacings. The other had moment-resisting frames in one direction, positioned