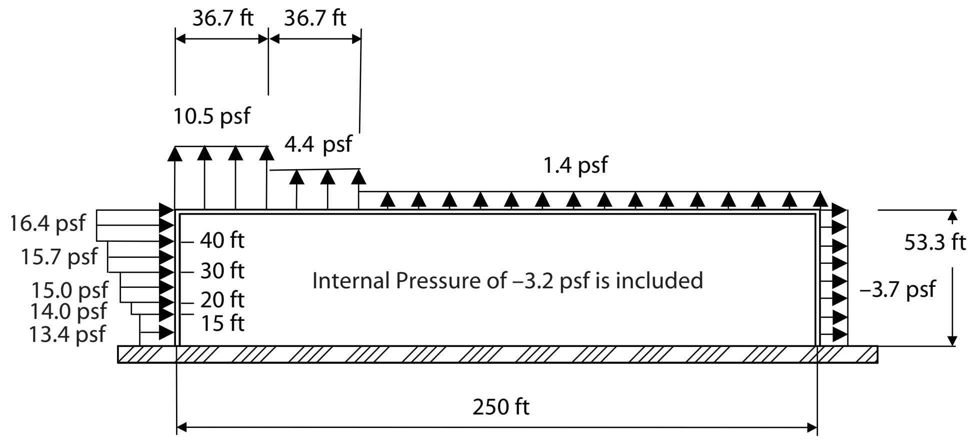

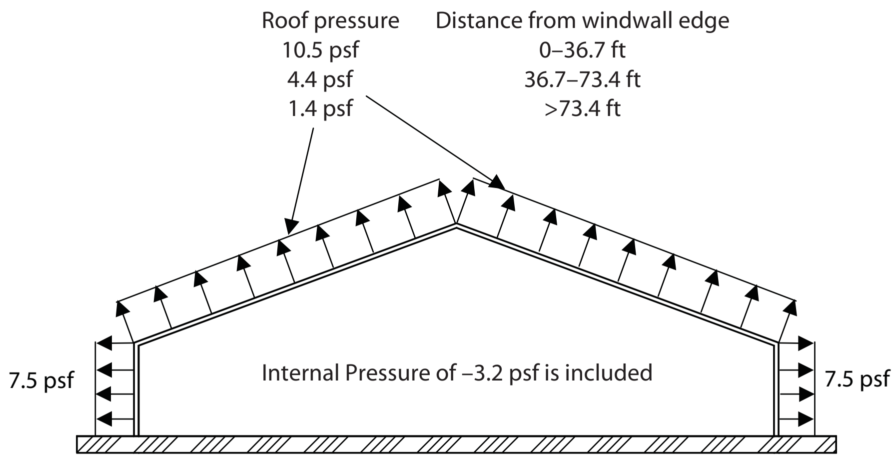

Figure 3-17 Net Design Wind Pressures for MWFRS when Wind is Parallel to Ridge with Negative Internal Pressure

Table 3-24 Net Controlling Wall Component Pressures (psf)

	Controlling design pressures (psf)			
	Zone 4		*Zone 5*	
C&C	*Positive*	*Negative*	*Positive*	*Negative*
Girt	17.1	–18.9	17.1	–20.0
Panel	20.7	–22.5	20.7	–27.4
Fastener	21.2	–23.0	21.2	–28.4
$A \leq 10$ ft^2	21.2	–23.0	21.2	–28.4
$A \geq 500$ ft^2	15.8	–17.6	15.8	–17.6

For maximum negative pressure:

$$p = 18.0[(-0.87) - (\pm 0.18)]$$

$$p = -18.9 \text{ psf with positive internal pressure (controls)}$$

$$p = -12.4 \text{ psf with negative internal pressure}$$

For maximum positive pressure:

$$p = 18.0[(0.77) - (\pm 0.18)]$$

$$p = 10.6 \text{ psf with positive internal pressure}$$

$$p = 17.1 \text{ psf with negative internal pressure (controls)}$$

Roof C&C Pressures

Effective wind areas of roof C&C (Table 3-25):

Purlin:

larger of

$$A = 25(5) = 125 \text{ ft}^2$$

or

$$A = 25(25/3) = 208 \text{ ft}^2 \text{(controls)}$$

Panel:

larger of

$$A = 5(2) = 10 \text{ ft}^2 \text{(controls)}$$

or

$$A = 5(5/3) = 8.3 \text{ ft}^2$$

Fastener:

$$A = 5(1) = 5 \text{ ft}^2$$

Typical calculations of design pressures for purlin in Zone 1 are as follows and roof C&C pressures are summarized in Table 3-26:

For maximum negative pressure:

$$p = 18.0[(-0.8) - (\pm 0.18)]$$

$$p = -17.6 \text{ psf with positive internal pressure (controls)}$$

$$p = -11.2 \text{ psf with negative internal pressure}$$

Table 3-25 Roof Coefficients (GC_p) in Figure 6-11C; $7° < \theta \leq 27°$

		External (GC_p)			
Component	*A (ft^2)*	*Zones 1, 2, and 3*	*Zone 1*	*Zone 2*	*Zone 3*
Purlin	208	0.3	–0.8	–1.2	–2.0
Panel	10	0.5	–0.9	–1.7	–2.6
Fastener	5	0.5	–0.9	–1.7	–2.6
Other*	≤10	0.5	–0.9	–1.7	–2.6
Other*	≥100	0.3	–0.8	–1.2	–2.0

*Other C&C can be skylight, etc.

Table 3-26 Net Controlling Roof Component Pressures (psf)

	Controlling design pressures (psf)			
	Positive	*Negative*		
Component	*Zones 1, 2, and 3*	*Zone 1*	*Zone 2*	*Zone 3*
Purlin	10.0*	–17.6	–24.8	–39.2
Panel	12.2	–19.4	–33.8	–50.0
Fastener	12.2	–19.4	–33.8	–50.0
$A \leq 10$ ft^2	12.2	–19.4	–33.8	–50.0
$A \geq 500$ ft^2	10.0*	–17.6	–24.8	–39.2

*Minimum net pressure controls (Section 6.1.4.2 of the Standard).

For maximum positive pressure:

$p = 18.0[(0.3) - (\pm 0.18)]$

$p = 2.1$ psf with positive internal pressure

$p = 8.6$ psf with negative internal pressure

$p = 10$ psf minimum net pressure (controls)
(Section 6.1.4.2 of the Standard)

Special case of girt that transverses Zones 4 and 5:

Width of Zone 5:

smaller of

$a = 0.1(200) = 20$ ft

or

$a = 0.4(36.7) = 14.7$ ft (controls)

but not less than

$0.04(200) = 8$ ft

or 3 ft

Weighted average design pressure:

$$P = \frac{14.7(-20.0) + 10.3(-18.9)}{25} = -19.6 \text{ psf}$$

This procedure of using a weighted average may be used for other components and cladding.

Special Case of Strut Purlin (interior)

Strut purlins in the end bay experience combined uplift pressure as a roof component (C&C) and axial load as part of the MWFRS

Component Pressure

End bay purlin located in Zones 1 and 2

Width of Zone 2, $a = 14.7$ ft

Weighted average design pressure:

$$= \frac{14.7(-24.8) + 10.3(-17.6)}{25} = -21.9 \text{ psf}$$

(Purlin in Zones 2 and 3 will have higher pressure)

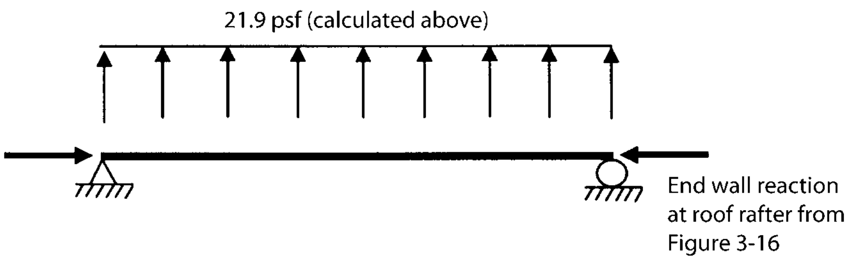

Figure 3-18A Combined Uplift and Axial Design Loads on Interior Strut Purlin

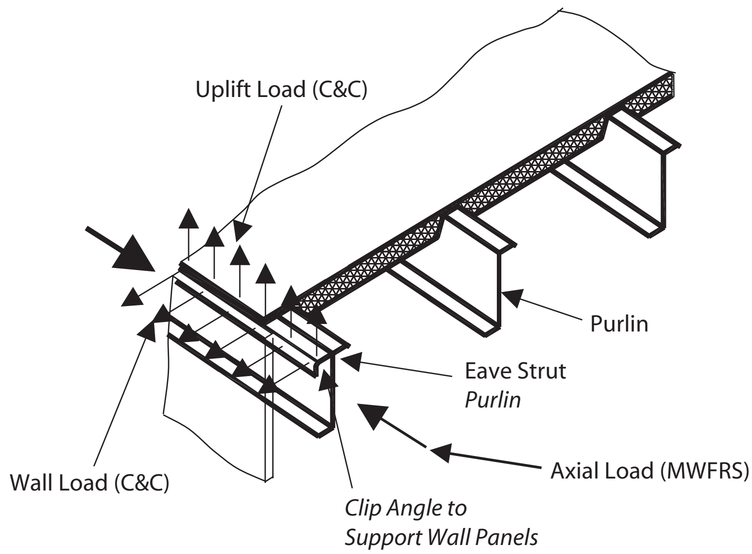

Figure 3-18B Eave Strut Purlin Supports Roof and Wall Panels

MWFRS Load

Figure 3-16 shows design pressure on end wall with wind parallel to ridge with positive internal pressure (consistent with high uplift on the purlin). Assuming that the end wall is supported at the bottom and at the roof line, the effective axial load on an end bay purlin can be determined.

Combined Design Loads on Interior Strut Purlin

Figure 3-18A shows combined design load on interior strut purlin. Note that many metal building manufacturers support the top of the wall panels with the eave strut purlin (see Figure 3-18B). For this case, the eave purlin also serves as a girt, and the negative wall pressures of Zones 5 and 4 would occur for the same wind direction as the maximum negative uplift pressures on the purlin (refer to Zones 3 and 2). Thus, in this instance, the correct load combination would involve biaxial bending loads based on C&C pressures combined with the MWFRS axial load.

3.7 Example 7 Building of Ex. 6 Using Low-Rise Building Provisions

This example illustrates the use of the low-rise building provisions to determine design pressures for the MWFRS. For this purpose, the building used has the same dimensions as the building in Ex. 6 (Section 3.6 of this guide). The design pressures on C&C will be the same as Ex. 6. The building is shown in Figure 3-13. The building data are as follows:

Location:	Memphis, Tennessee
Terrain:	Flat farmland
Dimensions:	200 ft × 250 ft in plan Eave height of 20 ft Roof slope 4:12 (18.4°)
Framing:	Rigid frame spans the 200-ft direction Rigid frame bay spacing is 25 ft Lateral bracing in the 250-ft direction is provided by a "wind truss" spanning the 200 ft to side walls and cable/rod bracing in the planes of the walls Openings uniformly distributed

Low-Rise Building

Section 6.2 of the Standard specifies two requirements for a building to qualify as a low-rise building: (1) mean roof height has to be less than or equal to 60 ft, and (2) mean roof height does not exceed least horizontal dimension. A building with these dimensions qualifies as a low-rise building and the alternate provisions of Section 6.5.12.2.2 may be used.

Exposure, Building Classification, and Basic Wind Speed

Same as Ex. 6:

Exposure C

Category II

Enclosed building (openings uniformly distributed)

$V = 90$ mph

Velocity Pressure

The low-rise building provisions for MWFRS in the Standard use the velocity pressure at mean roof height, h, for calculation of all external and internal pressures, including the windward wall. All pressures for a given zone are assumed to be uniformly distributed with respect to height above ground.

Mean roof height $h = 36.7$ ft

The velocity pressures are computed using:

$$q_h = 0.00256 K_h K_{zt} K_d V^2 I \text{ (psf)} \qquad \text{(Eq. 6-15)}$$

where

q_h = Velocity pressure at mean roof height, h
K_h = 1.02 for Exposure C (see Table 6-3 of the Standard)
K_{zt} = 1.0 topographic factor (see Section 6.5.7.1)
K_d = 0.85 (see Table 6-4)

V = 90 mph basic wind speed (see Figure 6-1)
I = 1.0 for Category II (50-yr mean return interval)

Therefore:

$$q_h = 0.00256(1.02)(1.0)(0.85)(90)^2(1.0) = 18.0 \text{ psf}$$

Design Pressures for the MWFRS

The equation for the determination of design wind pressures for MWFRS for low-rise buildings is given by Eq. 6-18 in Section 6.5.12.2.2 of the Standard:

$$p = q_h[(GC_{pf}) - (GC_{pi})] \quad \text{(Eq. 6-18)}$$

where

q_h = The velocity pressure at mean roof height associated with Exposure C
(GC_{pf}) = The external pressure coefficients from Figure 6-10 of the Standard
(GC_{pi}) = The internal pressure coefficients from Figure 6-5 of the Standard

The building must be designed for all wind directions using the eight loading patterns shown in Figure 6-10 of the Standard. For each of these patterns, both positive and negative internal pressures must be considered, resulting in a total of 16 separate loading conditions. However, if the building is symmetrical, the number of separate loading conditions will be reduced to eight (two directions of MWFRS being designed for normal load and torsional load cases—a total of four load cases, one windward corner, and two internal pressures). The load patterns are applied to each building corner in turn as the reference corner.

External Pressure Coefficients (GC_{pf})

The roof and wall coefficients are functions of the roof slope, θ (see Tables 3-27 and 3-28).

Width of end zone surface:
smaller of
$2a = 2(0.1)(200) = 40$ ft
or
$2(0.4)(36.7) = 29.4$ ft (controls)
but not less than
$2(0.04)(200) = 16$ ft
or $2(3) = 6$ ft

Internal Pressure Coefficients (GC_{pi})

Openings are assumed to be evenly distributed in the walls, and since Memphis, Tennessee, is not located in a hurricane-prone region, the building qualifies as an enclosed building (see Section 6.2 of the Standard). The internal pressure coefficients are given from Figure 6-5 as $(GC_{pi}) = \pm 0.18$.

Design Wind Pressures (psf)

Design wind pressures in the transverse and longitudinal directions are shown in Tables 3-29 and 3-30.

Table 3-27 Transverse Direction (θ = 18.4°)

	Building surface									
GC_{pf}*	*1*	*2*	*3*	*4*	*5*	*6*	*1E*	*2E*	*3E*	*4E*
	0.52	–0.69	–0.47	–0.42	–0.45	–0.45	0.78	–1.07	–0.67	–0.62

*By linear interpolation.

Table 3-28 Longitudinal Direction (θ = 0°)

	Building surface									
GC_{pf}	*1*	*2*	*3*	*4*	*5*	*6*	*1E*	*2E*	*3E*	*4E*
	0.40	–0.69	–0.37	–0.29	–0.45	–0.45	0.61	–1.07	–0.53	–0.43

Table 3-29 Design Wind Pressures, Transverse Direction

		Design pressure (psf)	
Building surface	(GC_{pf})	$(+GC_{pi})$	$(-GC_{pi})$
1	0.52	6.1	12.6
2	–0.69	–15.6	–9.2
3	–0.47	–11.7	–5.2
4	–0.42	–10.8	–4.3
5	–0.45	–11.3	–4.9
6	–0.45	–11.3	–4.9
1E	–0.78	10.8	17.3
2E	–1.07	–22.5	–16.0
3E	–0.67	–15.3	–8.8
4E	–0.62	–14.4	–7.9

Table 3-30 Design Wind Pressures, Longitudinal Direction

		Design pressure (psf)	
Building surface	(GC_{pf})	$(+GC_{pi})$	$(-GC_{pi})$
1	0.40	4.0	10.5
2	–0.69	–15.6	–9.2
3	–0.37	–9.9	–3.4
4	–0.29	–8.5	–2.0
5	–0.45	–11.3	–4.9
6	–0.45	–11.3	–4.9
1E	0.61	7.7	14.2
2E	–1.07	–22.5	–16.0
3E	–0.53	–12.8	–6.3
4E	–0.43	–11.0	–4.5

Calculation for Surface 1:

$$p = 18.0\ [0.52 - (\pm 0.18)] = +6.1 \text{ or } +12.6$$

Application of Pressures on Building Surfaces 2 and 3

Note 8 of Figure 6-10 of the Standard states that when the roof pressure coefficient, GC_{pf}, is negative in Zone 2, it shall be applied in Zone 2 for a distance from the edge of the roof equal to 0.5 times the horizontal dimension of the building measured parallel to the direction of the MWFRS being designed or 2.5h, whichever is less. The remainder of Zone 2 that extends to the ridge line shall use the pressure coefficient GC_{pf} for Zone 3. Thus, the distance from the edge of the roof is the smaller of:

0.5(200) = 100 ft for transverse direction
0.5(250) = 125 ft for longitudinal direction

or

(2.5)(36.7) = 92 ft for both directions (controls)

Therefore, Zone 3 applies over a distance of 105 – 92 = 13 ft in what is normally considered to be Zone 2 (adjacent to ridge line) for transverse direction and 125 – 92 = 33 ft for longitudinal direction.

Loading Cases

Because the building is symmetrical, the four loading cases provide all the required combinations provided the design is accomplished by applying loads for each of the four corners. The load combinations illustrated in Figures 3-19 through 3-22 are to be used to design the rigid frames, the "wind truss" spanning across the building in the 200-ft direction, and the rod/cable bracing in the planes of the walls (see Figure 3-13) (Section 3.6 of this guide).

Torsional Load Cases

Since the mean roof height, h = 36.7 ft, is greater than 30 ft and if the roof diaphragm is assumed to be rigid, torsional load cases need to be considered (see exception in Note 5 in Figure 6-10 of the Standard if building is designed with flexible diaphragm). Pressures in "T" zones are 25% of the

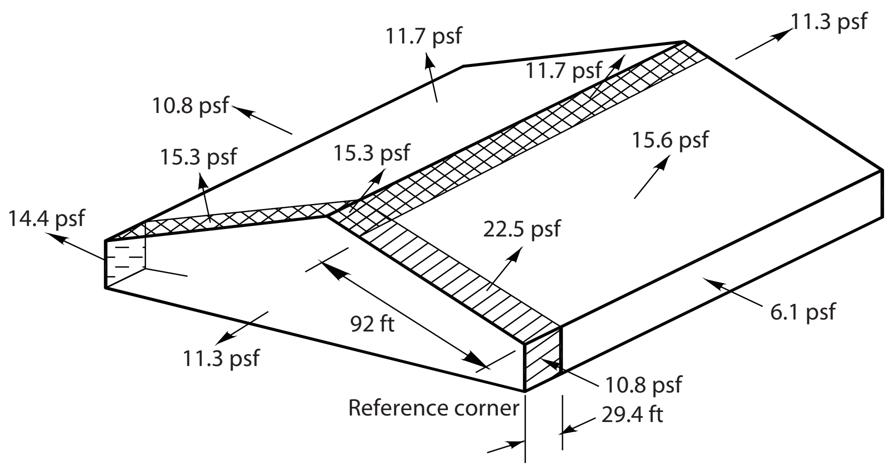

Figure 3-19 Design Pressures for Transverse Direction with Positive Internal Pressure

Note: The pressures are assumed to be uniformly distributed over each of the surfaces shown

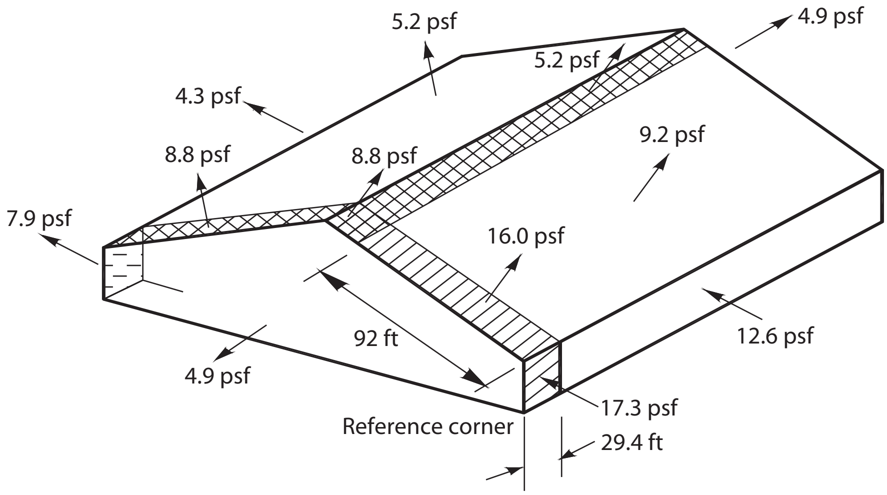

Figure 3-20 Design Pressures for Transverse Direction with Negative Internal Pressure

Note: The pressures are assumed to be uniformly distributed over each of the surfaces shown

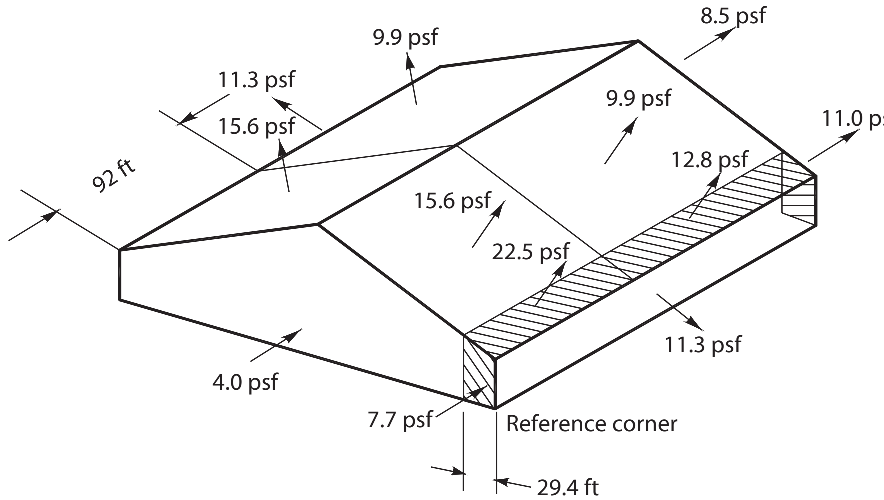

Figure 3-21 Design Pressures for Longitudinal Direction with Positive Internal Pressure

Note: The pressures are assumed to be uniformly distributed over each of the surfaces shown

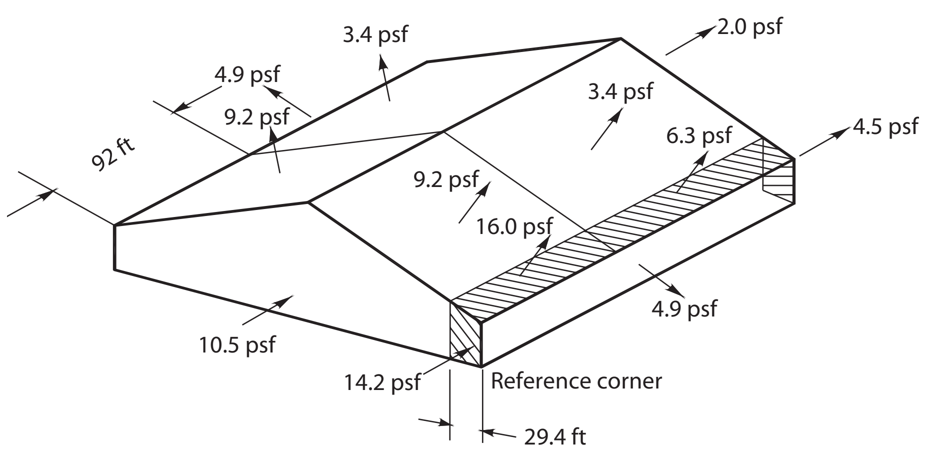

Figure 3-22 Design Pressures for Longitudinal Direction with Negative Internal Pressure

Note: The pressures are assumed to be uniformly distributed over each of the surfaces shown

Table 3-31 Design Wind Pressure for Zone "T," Transverse Direction

Building surface	*Design pressures (psf)* ($+GC_{pi}$)	($-GC_{pi}$)
1T	1.5	3.2
2T	–3.9	–2.3
3T	–2.9	–1.3
4T	–2.7	–1.1

Table 3-32 Design Wind Pressure for Zone "T," Longitudinal Direction

Building surface	*Design pressures (psf)* ($+GC_{pi}$)	($-GC_{pi}$)
1T	1.0	2.6
2T	–3.9	–2.3
3T	–2.5	–0.9
4T	–2.1	–0.5

full design pressures; the "T" zones are shown in Figure 6-10 of the Standard. Other surfaces will have the full design pressures. The "T" zone pressures with positive and negative internal pressures for transverse and longitudinal directions are shown in Tables 3-31 and 3-32, respectively.

Figures 3-19 through 3-26 show design pressure cases for one reference corner; these cases are to be considered for each corner.

Design Wind Pressures for C&C

The design pressures for C&C are the same as shown for Ex. 6 (Section 3.6 of this guide).

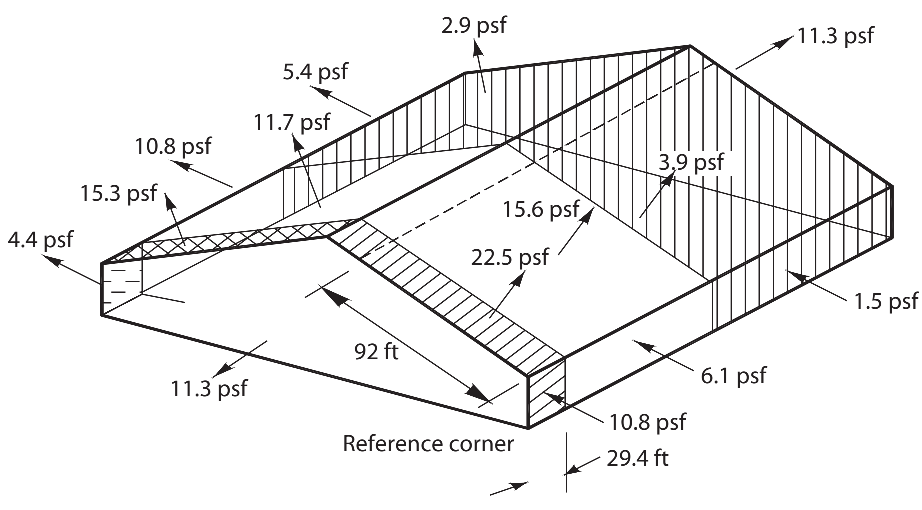

Figure 3-23 Torsional Load Case for Transverse Direction with Positive Internal Pressure

Notes: (1) The pressures are assumed to be uniformly distributed over each of the surfaces shown (2) Roof pressures of 22.5, 15.6, and 3.9 psf apply up to 92 ft; the remaining 13 ft up to the ridge line will have pressure of 15.3, 11.7, and 2.9 psf