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Problem 3.4 Solution

2003 IBC requirements

Given: The plan and section of the building in Fig. 3.B. The basic wind speed is 100 mph, and exposure B applies. The building is enclosed and has a standard occupancy classification. Roof dead load $D = 15$ psf on a horizontal plane. Wind forces to the primary LFRS are to be in accordance with IBC Sec. 1609.6.

Per IBC equation 16-34, $p_s = \lambda I_w p_{s30}$

From IBC Table 1604.5, $I_w = 1.0$ for standard occupancy structures.

Mean roof height = $8 \text{ ft} + 5 \text{ ft}/2 = 10.5 \text{ ft}$

From IBC Table 1609.6.2.1(4), for mean roof height less than 15 ft and Exposure B, $\lambda = 1.0$.

$p_s = \lambda I_w p_{s30} = 1.0(1.0)p_{s30} = p_{s30}$

Roof slope = 5 feet in 14 ft $\theta = \tan^{-1} 5/14 = 20$ degrees

From Table 1606.6.2.1(1), for a basic wind speed of 100 mph and a roof slope of 20 degrees:

Zone	Design Wind Pressure (psf) = $p_{s30} = p_e$
A	22.0
B	-5.8
C	14.6
D	-3.2
E	-19.1
F	-13.3
G	-13.3
H	-10.1
E _{OH}	-26.7
G _{OH}	-20.9

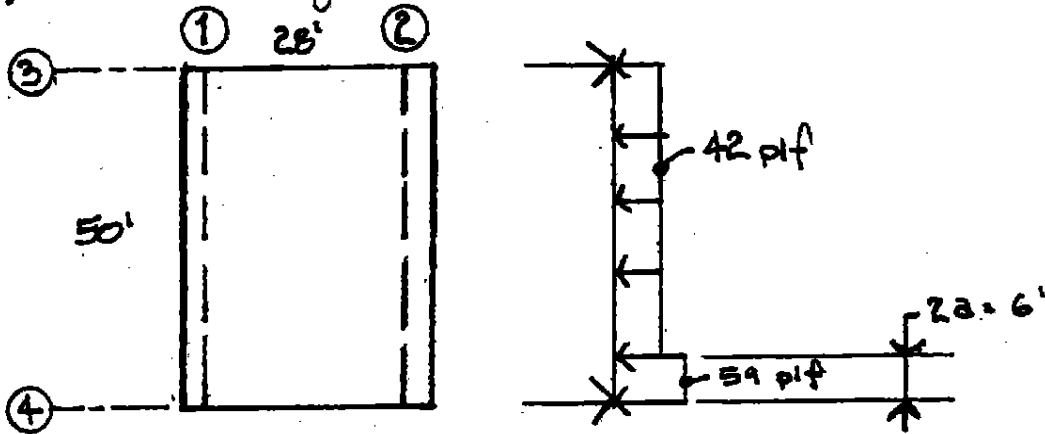
"a" Dimension

$a =$ lesser of: $0.1 \times \text{least plan dimension} = 0.1 (28 \text{ ft}) = 2.8 \text{ ft}$
 $0.4 \times \text{mean roof height} = 0.4 (10.5) = 4.2 \text{ ft}$
 but not less than 3 ft and $0.04 (28 \text{ ft}) = 1.1 \text{ ft}$.
 Minimum $a = 3 \text{ ft}$ controls. $2a = 6 \text{ ft}$

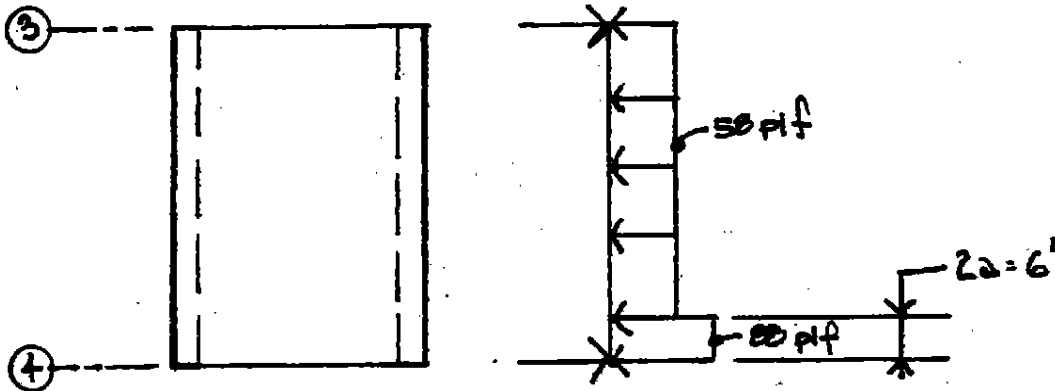
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Wind loading diagrams: plan-

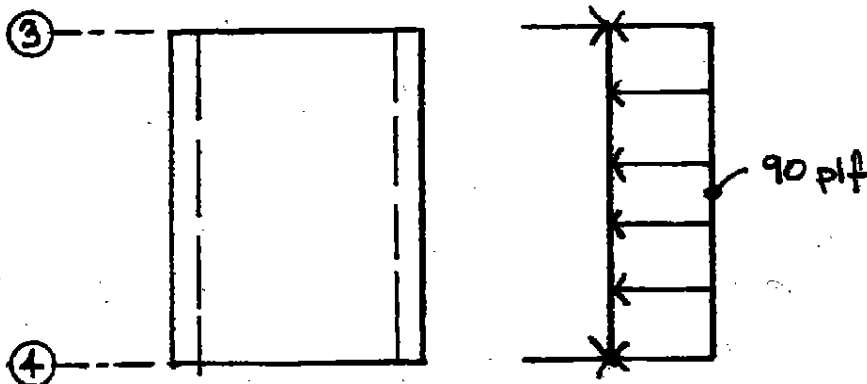
i) Basic Design Loads



ii) Figure 1609.6.2.1 Footnote 7



iii) Sec 1609.12 Minimum Loads



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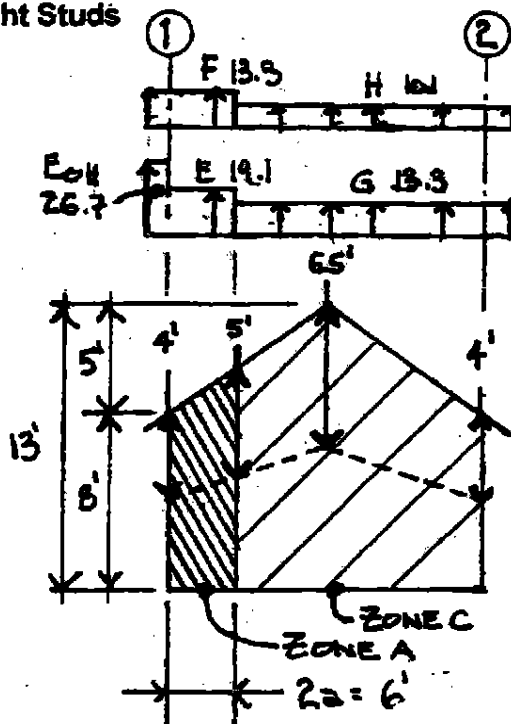
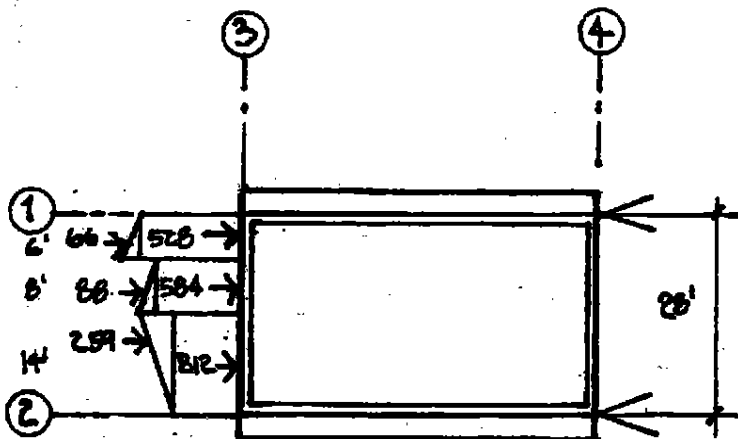
b. The wind force distributed on the roof diaphragm in the longitudinal direction. Draw the loading diagram.

The load to the diaphragm can vary depending on the approach taken to framing the gable end wall and the location of the ceiling (cathedral or sloped versus flat at roughly eave height). Two common conditions are illustrated in this solution, however others may exist. The second solution generally leads to a conservative design of the diaphragm and shear walls.

Wind zones and unit loads from transverse direction are applicable.

Approach I: Cathedral Ceiling with Full Height Studs

- A Zone unit loads 22 psf x 4 ft = 88 plf
- 22 psf x 5 ft = 110 plf
- C Zone unit loads 14.6 psf x 5 ft = 73 plf
- 14.6 psf x 6.5 ft = 95 plf
- 14.6 psf x 4 ft = 58 plf



Σ Horizontal Forces = 2337 lb

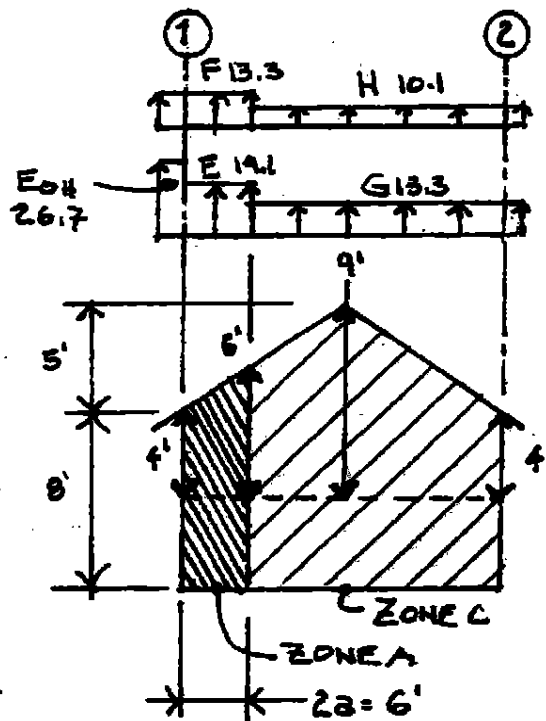
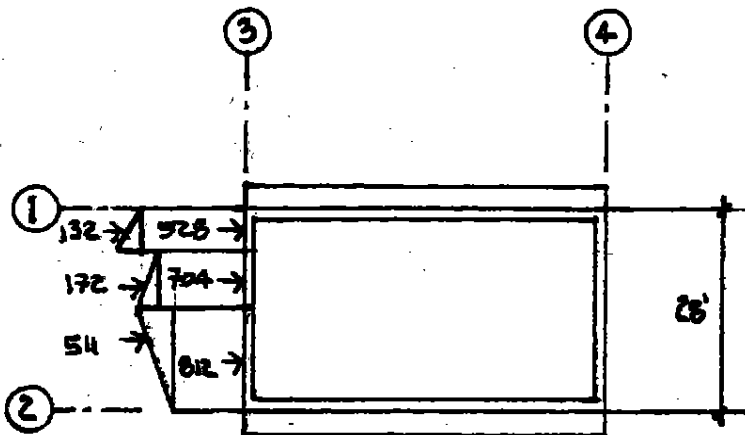
REACTION @ ① = $528 \left(\frac{25}{28} \right) = 471$ lb
 $66 \left(\frac{24}{28} \right) = 57$
 $584 \left(\frac{18}{28} \right) = 375$
 $88 \left(\frac{16.7}{28} \right) = 52$
 $812 \left(\frac{7}{28} \right) = 203$
 $259 \left(\frac{9.3}{28} \right) = 86$
 $\Sigma 1224$ lb

REACTION @ ②
 = 2337 - 1224
 = 1093 lb

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Approach II: Level Ceiling Braced to the Roof with 8 Ft Studs

A Zone unit loads 22 psf x 4 ft = 88 plf
 22 psf x 6 ft = 132 plf
 C Zone unit loads 14.6 psf x 6 ft = 88 plf
 14.6 psf x 9 ft = 131 plf
 14.6 psf x 4 ft = 58 plf



Σ HORIZONTAL FORCES = 2859 lb

REACTION @ ①

528	($\frac{25}{20}$)	=	471
132	($\frac{24}{25}$)	=	113
704	($\frac{12}{20}$)	=	483
172	($\frac{16.7}{25}$)	=	103
812	($\frac{7}{20}$)	=	203
511	($\frac{9.3}{20}$)	=	170
Σ			1513 lb

REACTION @ ②

= 2859 - 1513

= 1346 lb

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c. The total diaphragm shear and the unit diaphragm shear at Line 1.

Maximum shear $V = R = 1224$ lb Approach 1, 1513 lb Approach 2

Unit shear $v = V/b$

b = diaphragm depth in direction of load

Using 28 ft depth $v = 1224$ lb / 50 ft = 25 plf ASD Approach 1

$v = 1513$ lb / 50 ft = 30 plf ASD Approach 2

(Either answer is acceptable)

d. The total diaphragm shear and the unit diaphragm shear at Line 4.

Maximum shear $V = R = 2250$ lb

Unit shear $v = V/b$

b = diaphragm depth in direction of load

Note that the diaphragm depth is generally taken as the dimension between Lines 1 and 2. In special cases, detailing might be provided to make the entire roof dimension, including the overhangs, the effective depth. See Chapter 9 for further discussion.

Using 28 ft depth $v = 2250$ lb / 28 ft = 80 plf ASD

Using 32 ft depth $v = 2250$ lb / 32 ft = 70 plf ASD

(Either answer is acceptable)

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Note On Roof Uplift Forces:

For wind loads to the main wind-force-resisting system, IBC Figure 1609.6.2.1 (ASCE 7 Figure 6.20) provides a diagram of forces for a building without an overhang. Interpretation of the requirements is required for application of uplift forces to a building with an overhang. The following suggested application comes from several of the experts involved in developing the ASCE 7 wind provisions. At time of writing several guide and commentary documents are going to be available in the near future through SEAW, ATC and ASCE/SEI. Users of this text are encouraged to go to these resources for further explanation.

Transverse Loading

