With P reduced to $P/5$, the volume of the frame bars plus the diagonal is:

$$V' = 3\left(\frac{h}{2c}\right)\frac{(P/5)l}{f} + \frac{8}{5}\frac{Pl}{f} = \frac{38}{5}\frac{Pl}{f} = 7.6\frac{Pl}{f}.$$

Thus, the use of a diagonal bar results in a stiffening of the frame by a factor of 5, with a saving of about 75% in the amount of material used.

This result is of wide significance: triangulated frames are always stiffer and lighter than rectangular frames.

7.5 THE APPROXIMATE ANALYSIS OF MULTISTORY FRAMES [8.3]

A. *Vertical Loads.* The *interior* bays of multistory frames may be analyzed for preliminary design by assuming that hinges form in the beams at a distance $0.2l$ from the ends [Fig. 7.5.1(a)]. This assumption implies that the maximum positive and negative moments [Fig. 7.5.1(c)] equal:

$$M_{max} = \frac{w(1-0.4)^2l^2}{8} = 0.045wl^2,$$
$$M_{min} = -w \times 0.3l \times 0.2l - \tfrac{1}{2}w(0.2l)^2 = -0.08wl^2, \qquad (7.5.1)$$

which should be compared with $0.042wl^2$ and $-0.084wl^2$ for a fixed beam. The internal columns may be considered momentless, provided the stress be maintained low, say at 70% to 80% of allowable.

For *exterior* bays the hinge points may be assumed at $0.1l$ from the exterior column and at $0.2l$ from the interior column [Fig. 7.5.1(b)], with moments [Fig. 7.5.1(d)]:

$$M_{max} = \frac{w(0.7l)^2}{8} = 0.061wl^2,$$

$$M_{min,e} = -w \times 0.35l \times 0.1l - \frac{w(0.1l)^2}{2} = -0.040wl^2, \qquad (7.5.2)$$

$$M_{min,i} = -w \times 0.35l \times 0.2l - \frac{w(0.2l)^2}{2} = -0.09wl^2,$$

which should be compared with $0.07wl^2$ and $-0.125wl^2$ for a beam fixed at one end and simply supported at the other.

B. *Horizontal Loads.* Indicating the spacing of the frames in a building by b, the floor height by h, and the wind pressure by p, the wind force per floor on each frame equals:

$$W = pbh, \qquad (7.5.3)$$