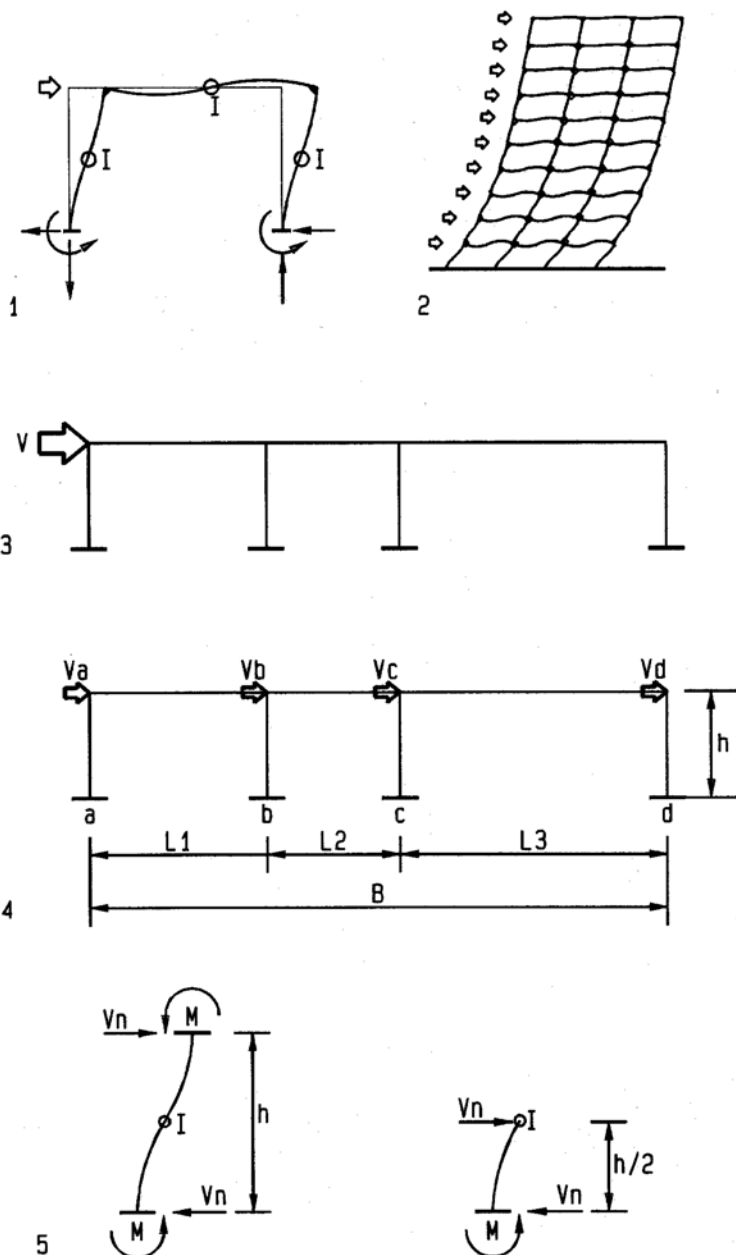


Portal Method

Portal Method

The Portal Method for approximate analysis of moment frames is based on the following assumptions:

- Lateral forces resisted by frame action
- Inflection points at mid-height of columns
- Inflection points at mid-span of beams
- Column shear is based on tributary area
- Overturn is resisted by exterior columns only



1 Single moment frame (portal)

2 Multistory moment frame

3 Moment frame subject to total shear V

4 Column shear is proportional to tributary area:

$$V_a = (V/B) L_1/2$$

$$V_b = (V/B) (L_1+L_2)/2$$

$$V_c = (V/B) (L_2+L_3)/2$$

$$V_d = (V/B) L_3/2$$

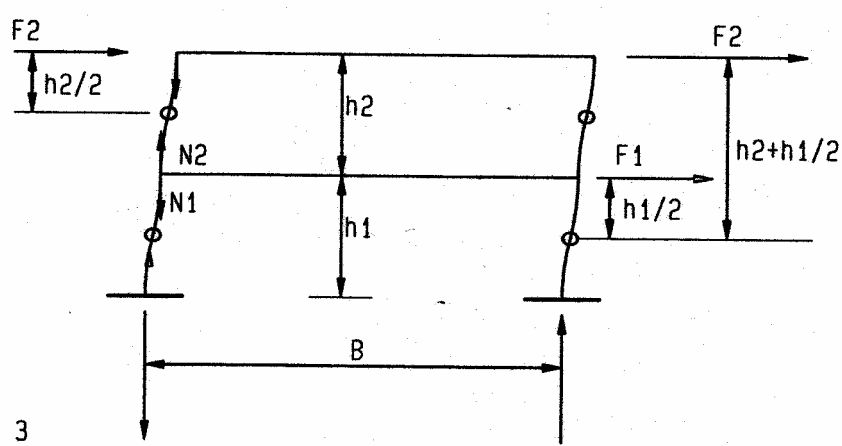
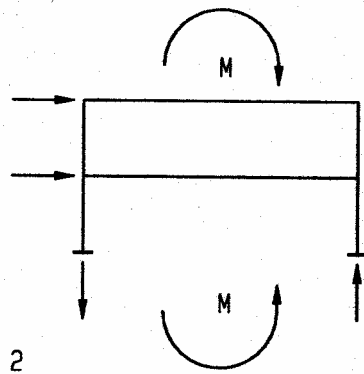
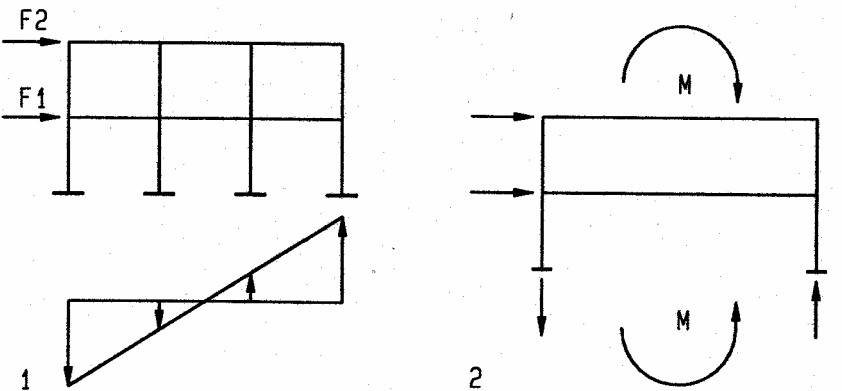
5 Column moment = shear \times height to inflection point

$$M_a = V_a h/2$$

$$M_b = V_b h/2$$

$$M_c = V_c h/2$$

$$M_d = V_d h/2$$



Column axial force N:

Overturn moment generates column axial force

- 1 Exterior columns resist most overturn
- 2 Portal method assumes exterior columns resist all overturn

Column axial force = overturn / building width
 $N = M / B$

- 3 Overturn moments per level are the sum of forces above the level times lever arm of each force to inflection point at respective level:

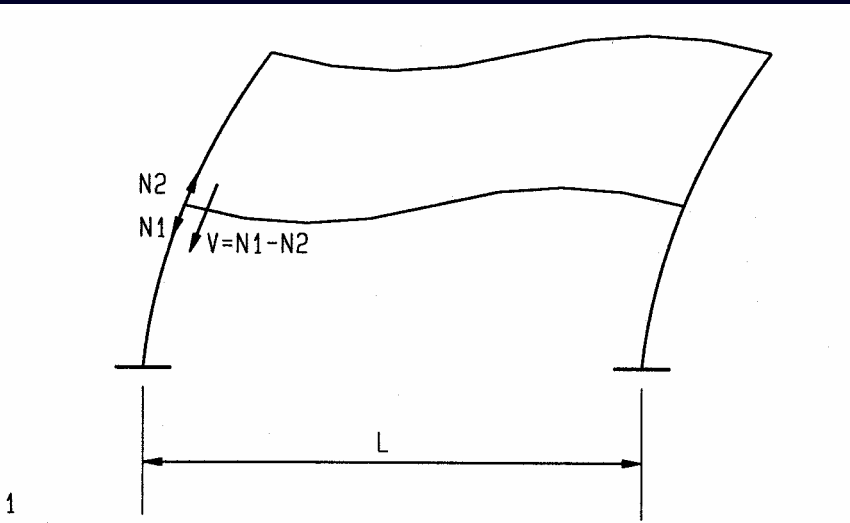
$$M_2 = F_2 h_2/2 \quad (\text{level 2})$$

$$M_1 = F_2 (h_2+h_1/2) + F_1 h_1/2 \quad (\text{level 1})$$

Column axial force per level:

$$N_2 = M_2 / B \quad (\text{level 2})$$

$$N_1 = M_1 / B \quad (\text{level 1})$$



1

- 1 Beam shear at any level is column axial force below beam minus column axial force above beam

Level 1 beam shear:

$$V = N1 - N2$$

Roof beam:

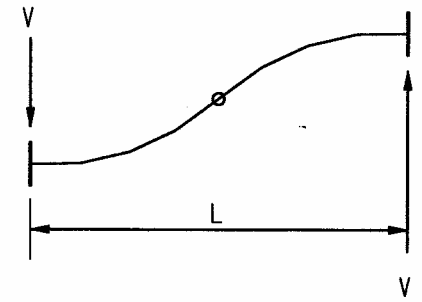
$$V = N2 - 0 = N2$$

- 2 Beam bending moment is beam shear times distance to beam inflection point

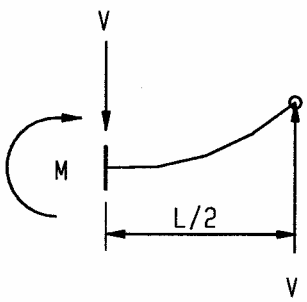
- 3 The beam inflection point is assumed at mid-span. Hence beam bending is:

$$M = V L/2$$

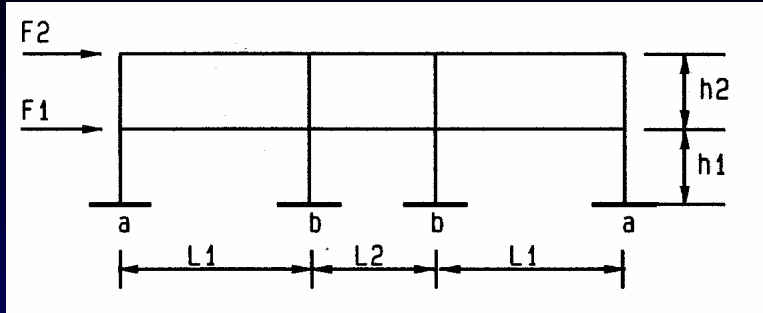
Beam axial force is negligible and assumed 0



2



3



Analyze 1st floor columns and beams

Column shear and bending

Base shear

$$V = F1 + F2 = 8 + 12$$

$$V = 20 \text{ k}$$

Column shear

$$V_a = (L1/2) (V/B) = 15' \times 20/80$$

$$V_a = 3.75 \text{ k}$$

$$V_b = (L1 + L2)/2 (V/B)$$

$$V_b = 25' \times 20/80$$

$$V_b = 6.25 \text{ k}$$

Column bending

$$M_a = V_a h/2 = 3.75 \times 14/2$$

$$M_a = 26 \text{ k'}$$

$$M_b = V_b h/2 = 6.25 \times 14/2$$

$$M_b = 44 \text{ k'}$$

Example: two-story building

Assume:

$$L1 = 30'$$

$$L2 = 20'$$

$$B = 30 + 20 + 30$$

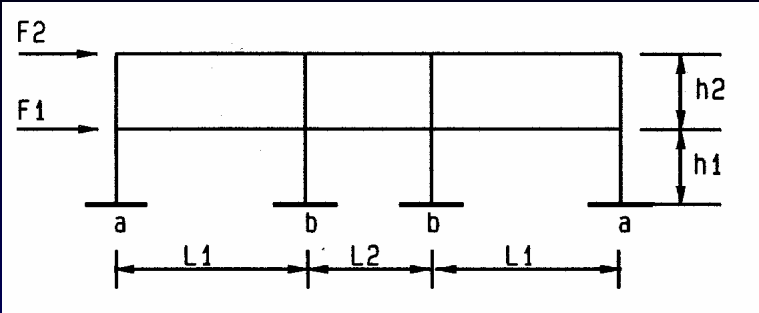
$$B = 80'$$

$$h = h1 = h2$$

$$h = 14'$$

$$F1 = 8 \text{ k}$$

$$F2 = 12 \text{ k}$$



Example: two-story building

Assume:

$$L1 = 30'$$

$$L2 = 20'$$

$$B = 30+20+30$$

$$B = 80'$$

$$h = h1 = h2$$

$$h = 14'$$

$$F1 = 8k$$

$$F2 = 12k$$

Beam shear and bending

Overturn moments

$$M1 = F2 (h2+h1/2)+F1 h/2$$

$$M1 = 12 (14+7)+8 \times 7$$

$$M1 = 308 \text{ k'}$$

$$M2 = F2 h/2 = 12 \times 14/2$$

$$M2 = 84 \text{ k'}$$

Column axial load 1st floor

$$N1 = M1/B = 308/80$$

$$N1 = 3.9 \text{ k}$$

Column axial load 2nd floor

$$N2 = M2/B = 84/80$$

$$N2 = 1.1 \text{ k}$$

Beam shear

$$V1 = N1 - N2 = 3.9 - 1.1$$

$$V1 = 2.8 \text{ k}$$

Beam bending

$$M1 = V1 L1/2 = 2.8 \times 30/2$$

$$M1 = 42 \text{ k'}$$

$$M2 = V1 L2/2 = 2.8 \times 20/2$$

$$M2 = 28 \text{ k'}$$

