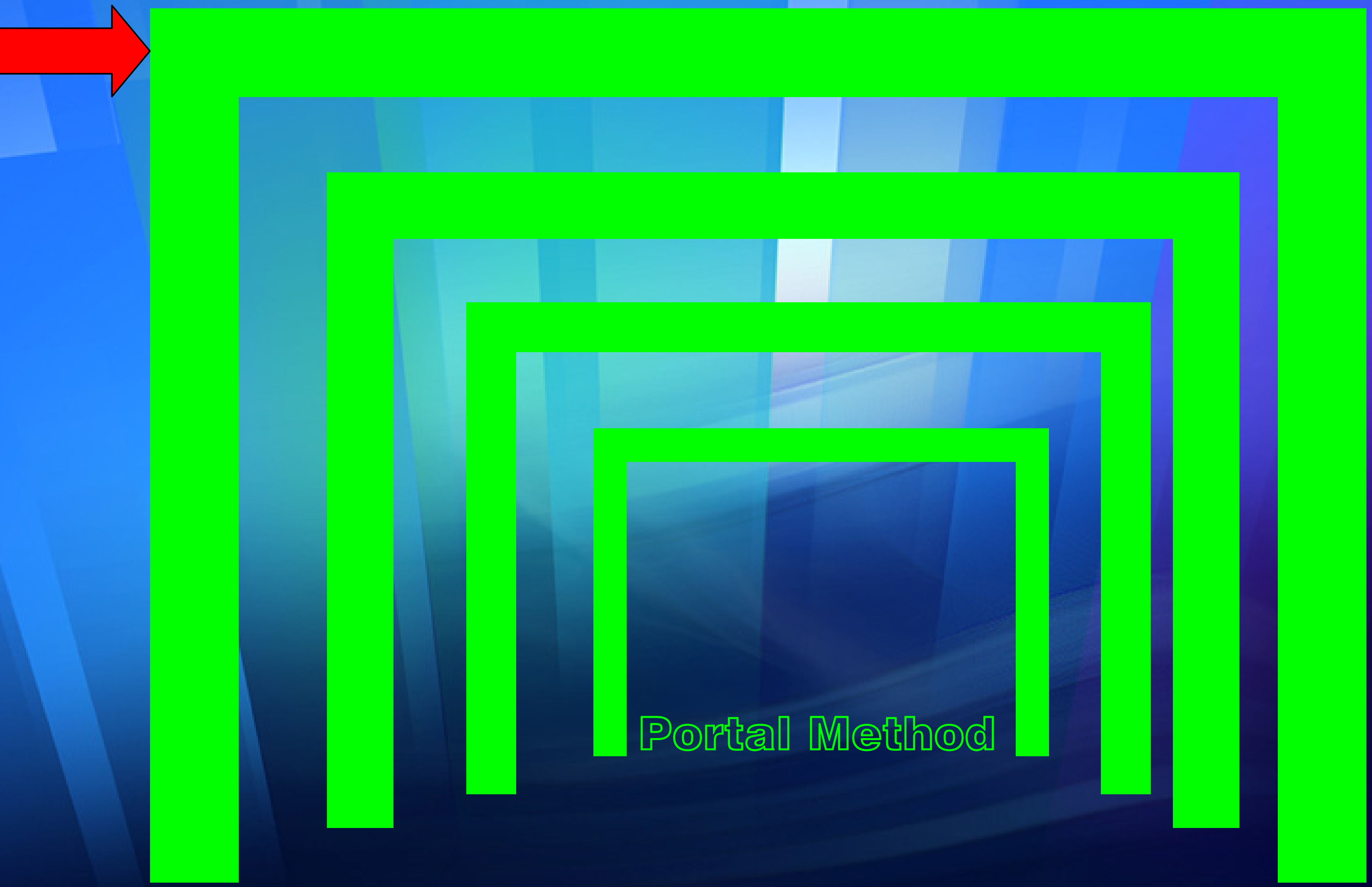
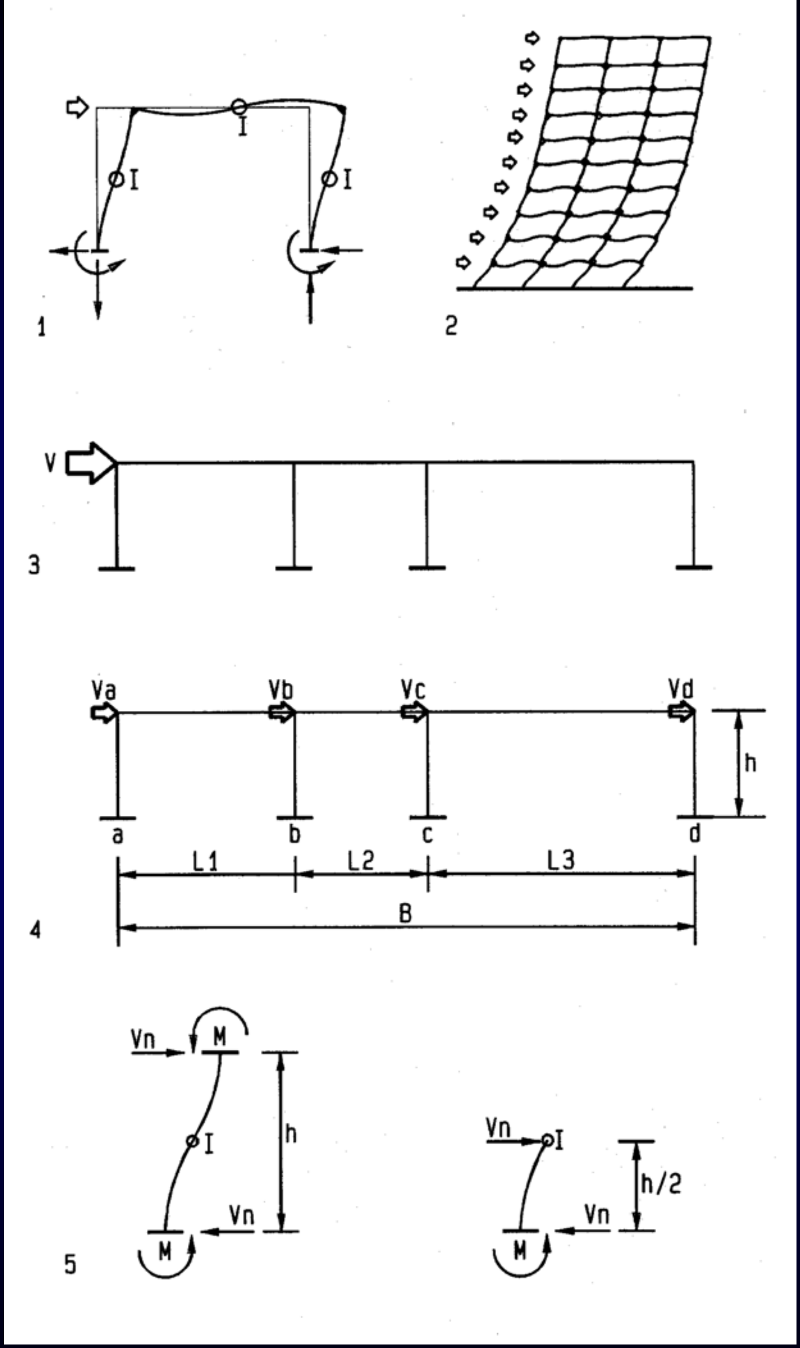


Portal Method



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

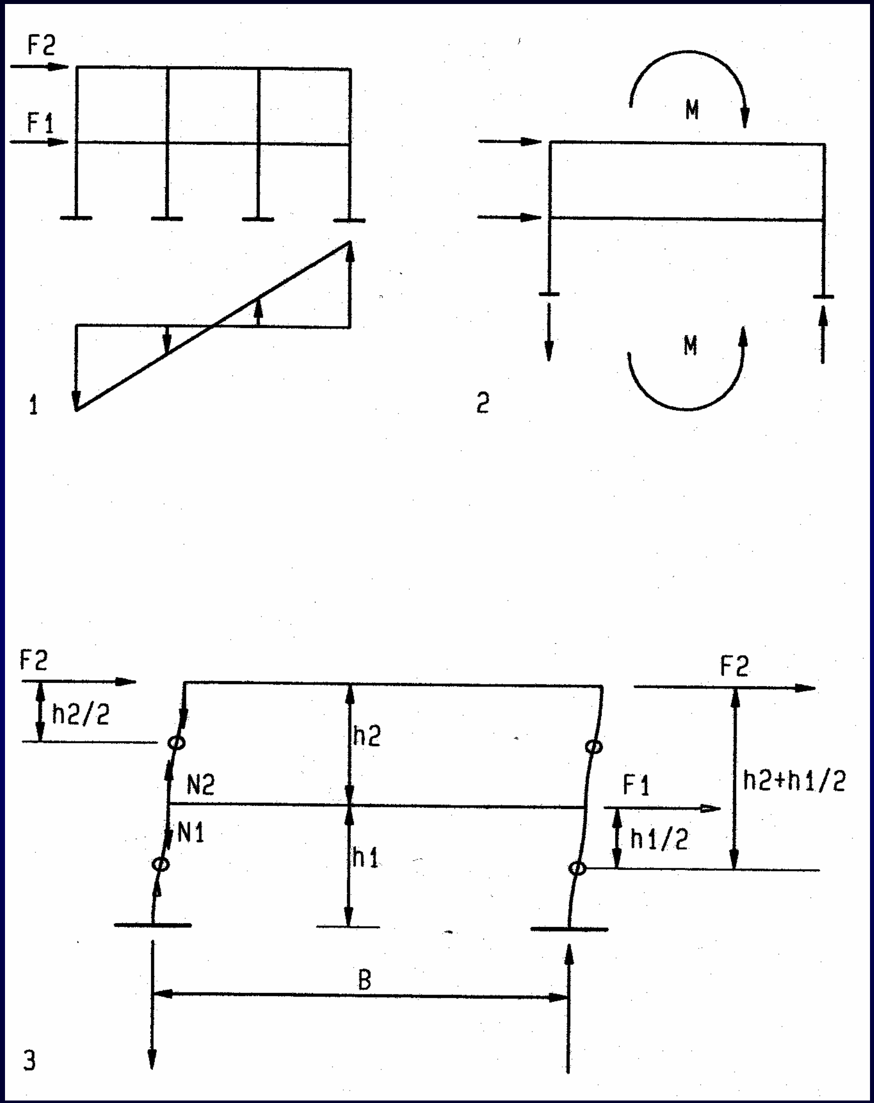
1 Single moment frame (portal)
2 Multistory moment frame

3 Moment frame subject to total shear V
4 Column shear is proportional to tributary area:

Va = (V/B) L1/2
Vb = (V/B) (L1+L2)/2
Vc = (V/B) (L2+L3)/2
Vd = (V/B) L3/2

5 Column moment = shear x height to inflection point

Ma = Va h/2
Mb = Vb h/2
Mc = Vc h/2
Md = Vd 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:

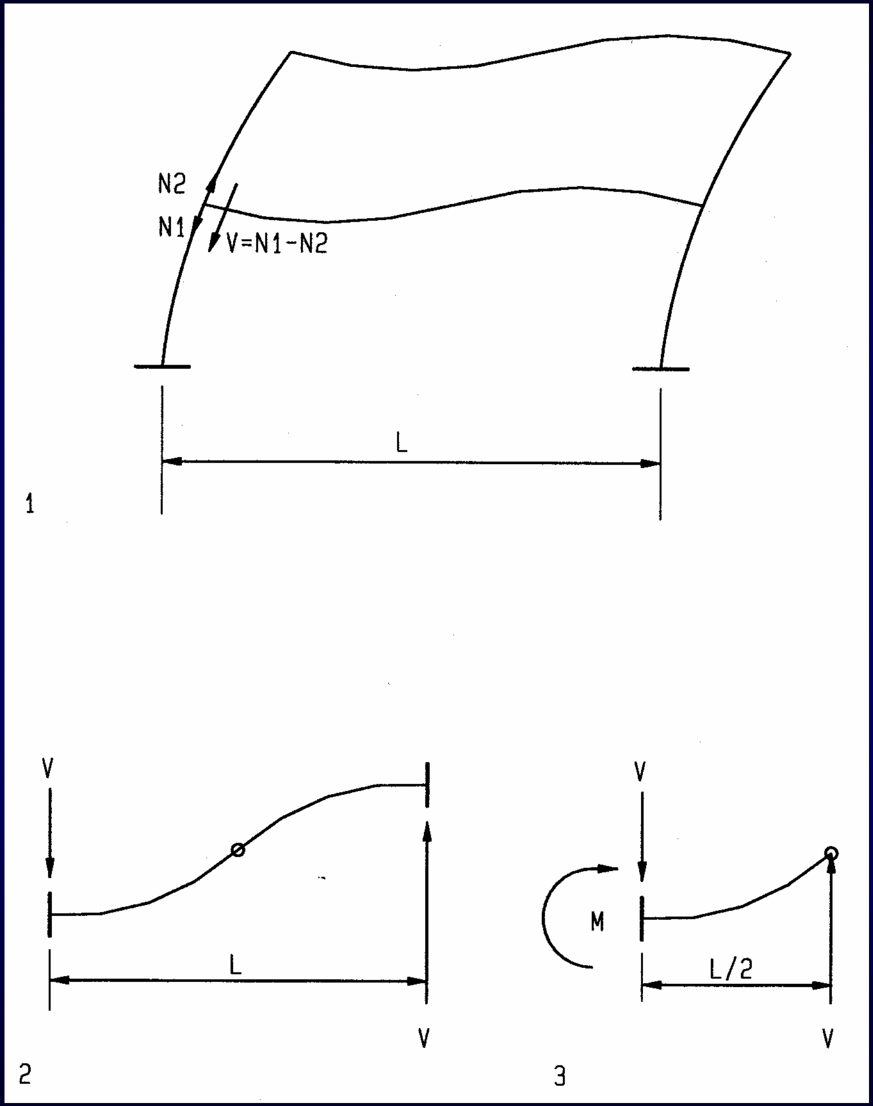
M2 = F2 h2/2 (level 2)

M1 = F2 (h2+h1/2) + F1 h1/2 (level 1)

Column axial force per level:

N2 = M2 / B (level 2)

N1 = M1 / B (level 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

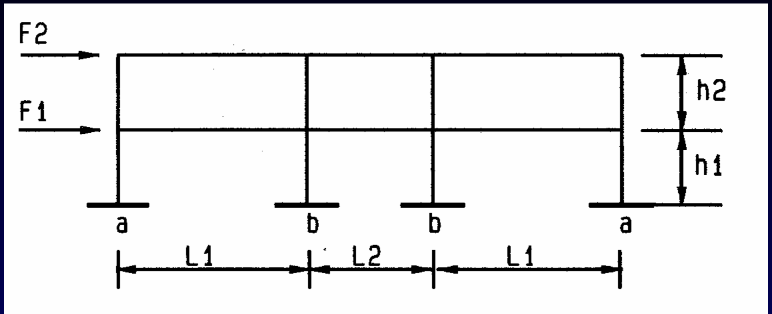
2 Beam bending moment is beam shear times distance to beam inflection point

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



Example: two-story building

Assume:

L1 = 30’

L2 = 20’

B = 30+20+30 B = 80’

h = h1 = h2 h = 14’

F1 = 8 k

F2 = 12 k

Analyze 1st floor columns and beams

Column shear and bending

Base shear

V = F1+F2 = 8+12 V = 20 k

Column shear

Va = (L1/2) (V/B) = 15’x20/80 Va = 3.75 k

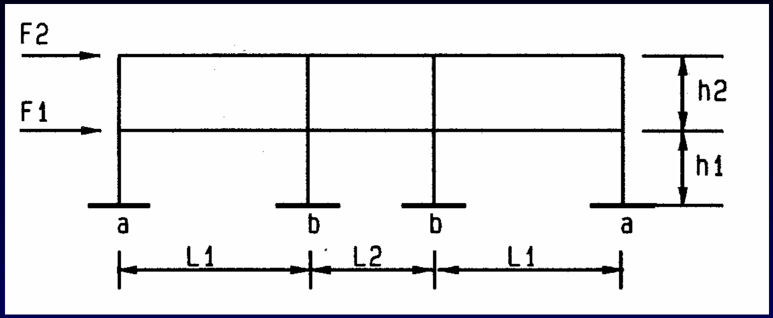
Vb = (L1+L2)/2 (V/B)

Vb = 25’x20/80 Vb = 6.25 k

Column bending

Ma = Va h/2 = 3.75 x 14/2 Ma = 26 k’

Mb = Vb h/2 = 6.25 x 14/2 Mb = 44 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)+8x7 M1 = 308 k’

M2 = F2 h/2 = 12x14/2 M2 = 84 k’

Column axial load 1st floor

N1 = M1/B = 308/80 N1 = 3.9 k

Column axial load 2nd floor

N2 = M2/B = 84/80 N2 = 1.1 k

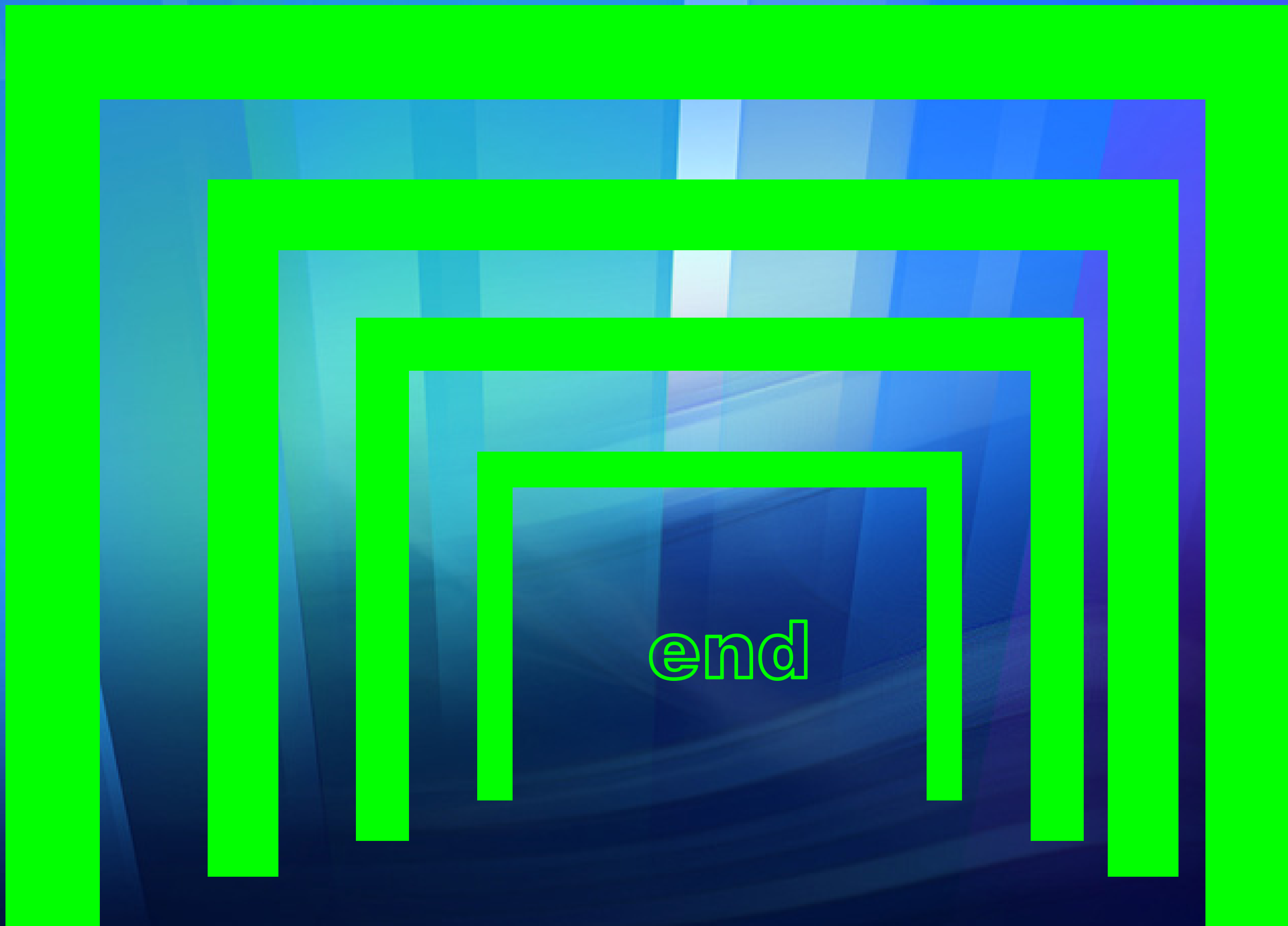
Beam shear

V1 = N1–N2 = 3.9-1.1 V1 = 2.8 k

Beam bending

M1 = V1 L1/2 = 2.8x30/2 M1 = 42 k’

M2 = V1 L2/2 = 2.8x20/2 M2 = 28 k’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