Cantilever Method

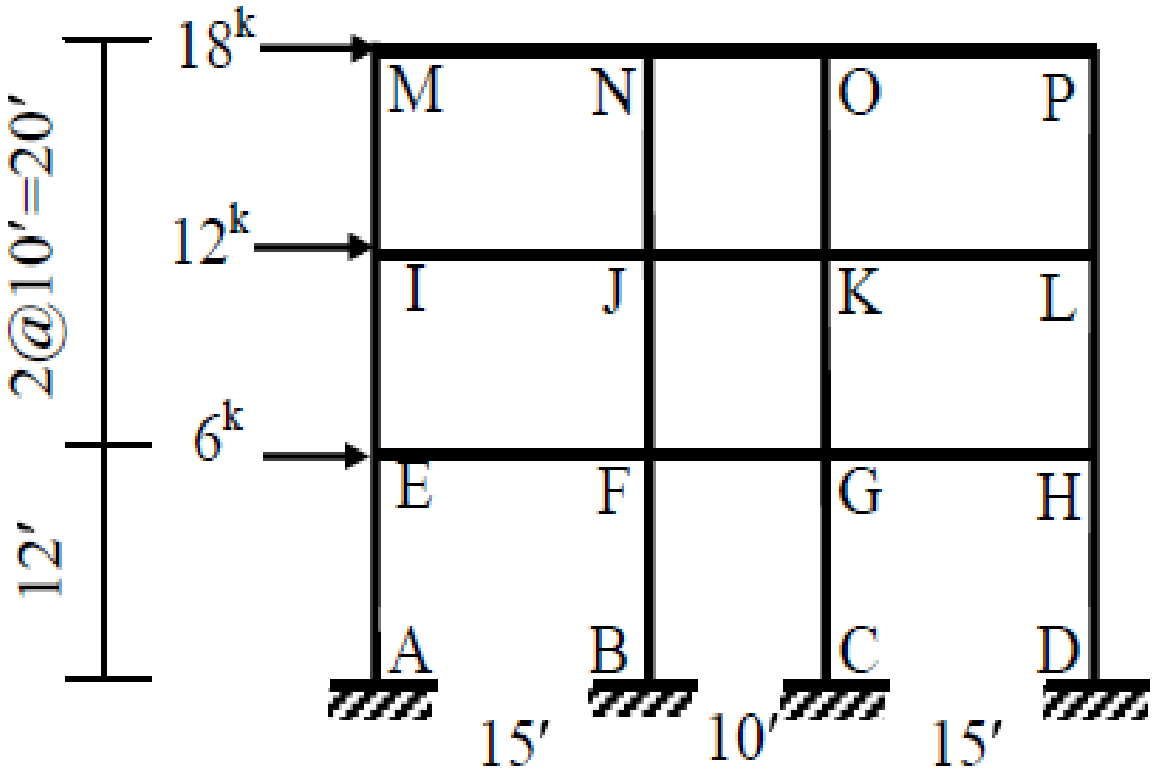
The results using the Portal Method are reasonable in most cases, the method suffers due to the **lack of consideration** given to the variation of **structural response** due to the difference between sectional properties of various members. The Cantilever Method attempts to rectify this limitation by considering the **cross-sectional areas of columns** in distributing the axial forces in various columns of a story.

Assumptions

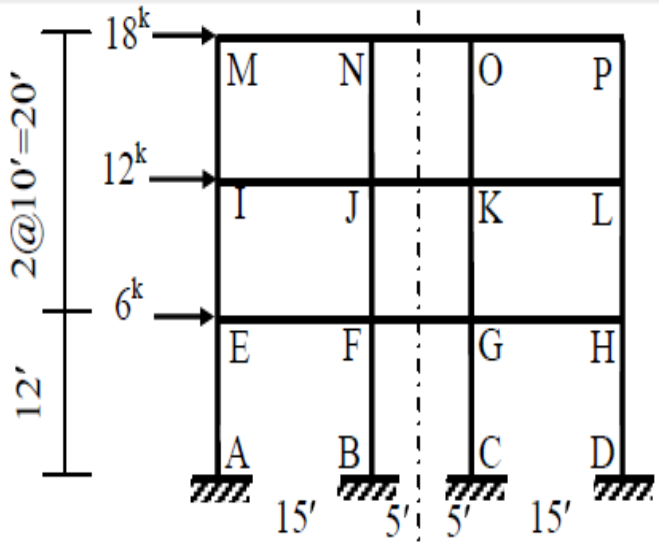
1. The axial force in each column of a storey is proportional to its horizontal distance from the centroidal axis of all the columns of the storey.
2. There is a point of inflection at the center of each column.
3. There is a point of inflection at the center of each beam.

Structural Analysis & Design I

Use the Cantilever Method to draw the axial force, shear force and bending moment diagrams of the three -storied frame structure loaded as shown below



Structural Analysis & Design I



Sol :

$X = (1x0+1x15+1X25+1x40)/(1+1+1+1)$

$= 80/4 = 20$

Axial force= Moment at each bar x distance up CG/(Sum of square distance from CG)

The dotted line is the column centerline (at all floors)

∴ Column axial forces are at the ratio of 20: 5: −5: −20.

∴ Axial force in (P) columns IM, JN, KO, LP are

$[18 \times 5 \times 20/\{20^2 + 5^2 + (-5)^2 + (-20)^2\} =] 2.12^k$, $[18 \times 5 \times 5/(20^2 + 5^2 + (-5)^2 + (-20)^2\} =] 0.53^k$, -0.53^k, -2.12^k respectively.

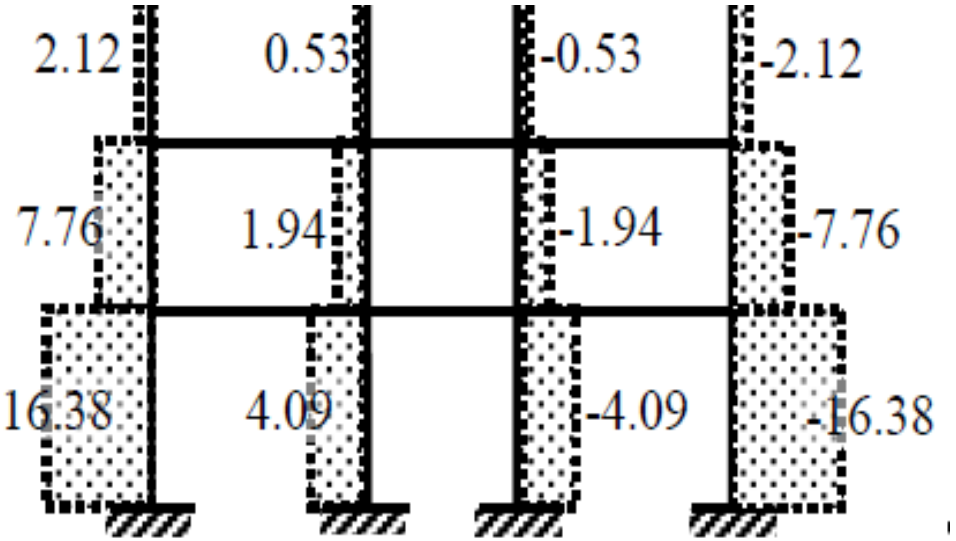
Similarly, $P_{EI} = 330\times20/(850) = 7.76^k$, $P_{FJ} = 1.94^k$, $P_{GK} = -1.94^k$, $P_{HL} = -7.76^k$; and

$P_{AE} = 696\times20/(850) = 16.38^k$, $P_{BF} = 4.09^k$, $P_{CG} = -4.09^k$, $P_{DH} = -16.38^k$

∴ Axial force in (P) columns IM, JN, KO, LP are $[18 \times 5 \times 20/\{20^2 + 5^2 + (-5)^2 + (-20)^2\} =]\ 2.12^k$, $[18 \times 5 \times 5/(20^2 + 5^2 + (-5)^2 + (-20)^2\} =]\ 0.53^k, -0.53^k, -2.12^k$ respectively.

Similarly, $P_{EI} = 330 \times 20/(850) = 7.76^k$, $P_{FJ} = 1.94^k$, $P_{GK} = -1.94^k$, $P_{HL} = -7.76^k$; and

$P_{AE} = 696 \times 20/(850) = 16.38^k$, $P_{BF} = 4.09^k$, $P_{CG} = -4.09^k$, $P_{DH} = 16.38^k$

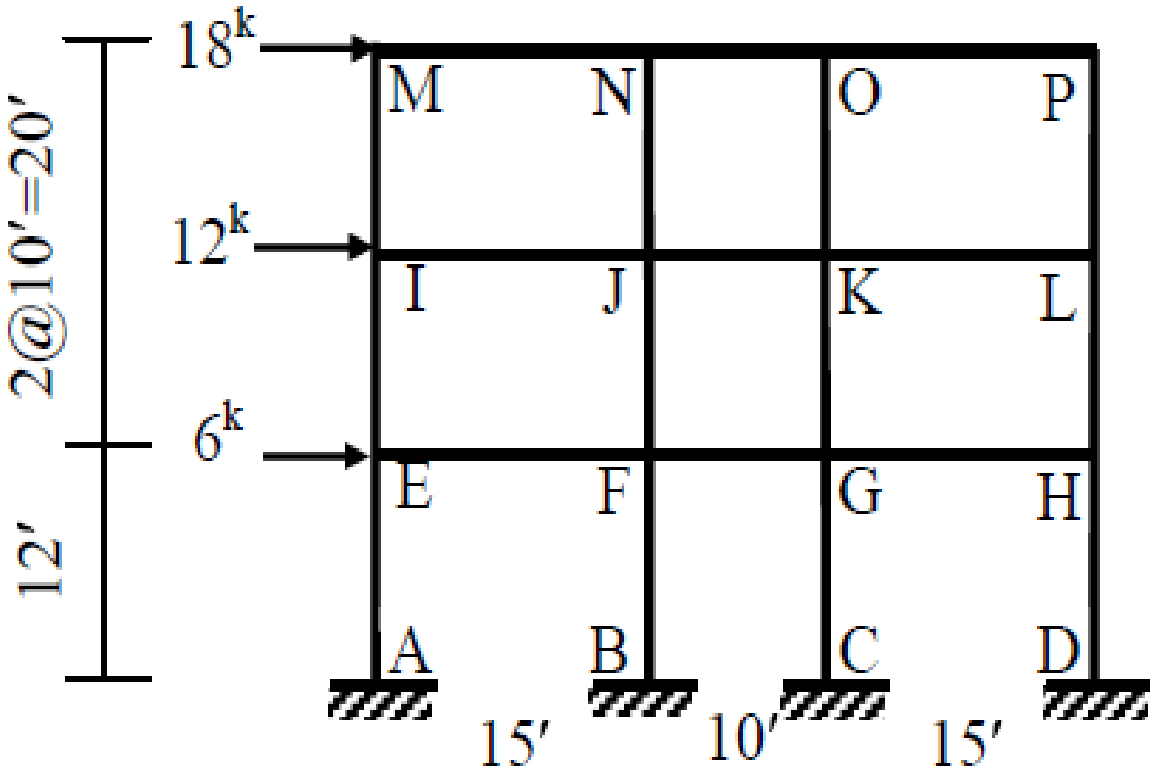


Column AFD (k)

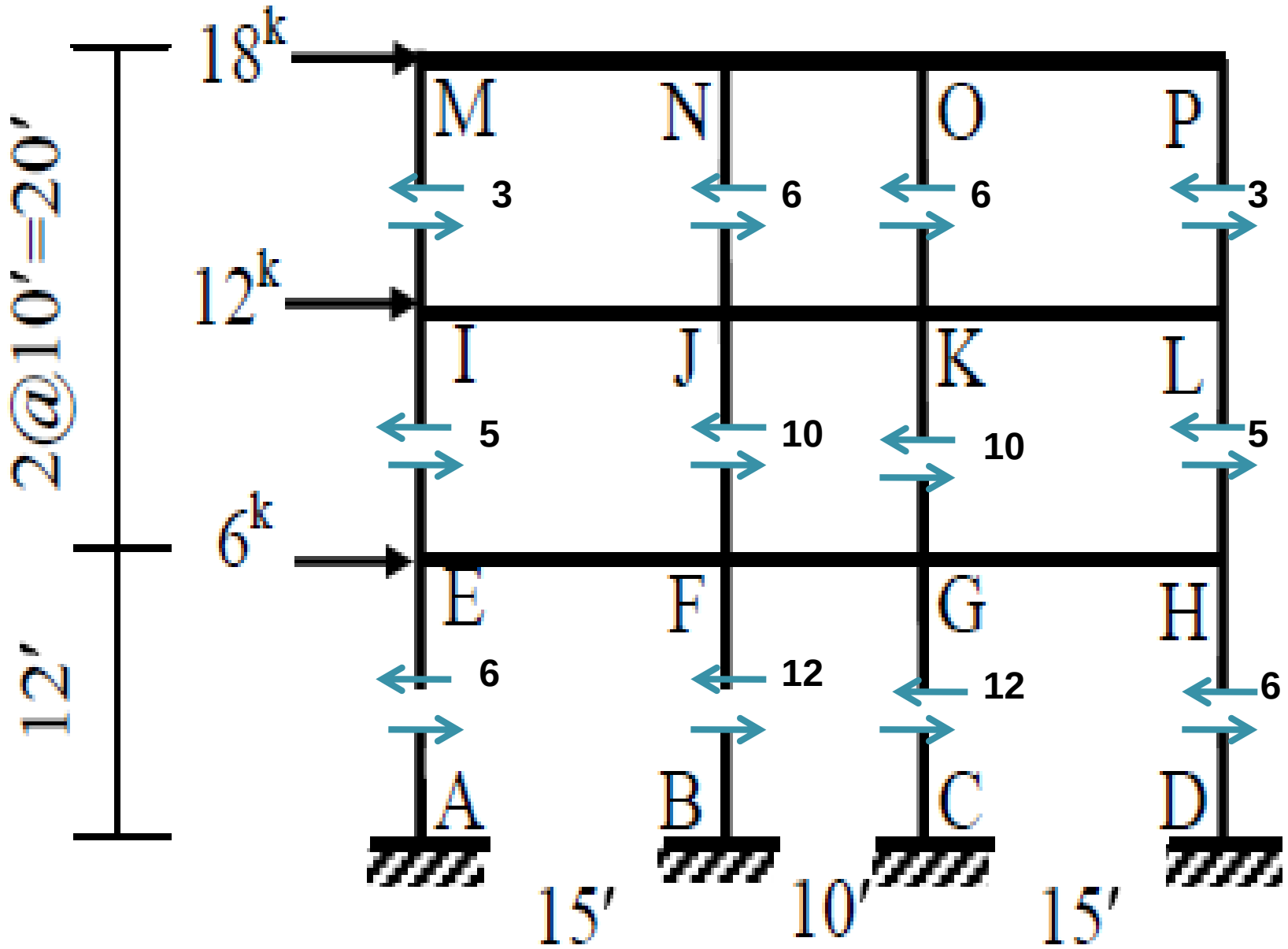
Structural Analysis & Design I

Structural Analysis & Design I

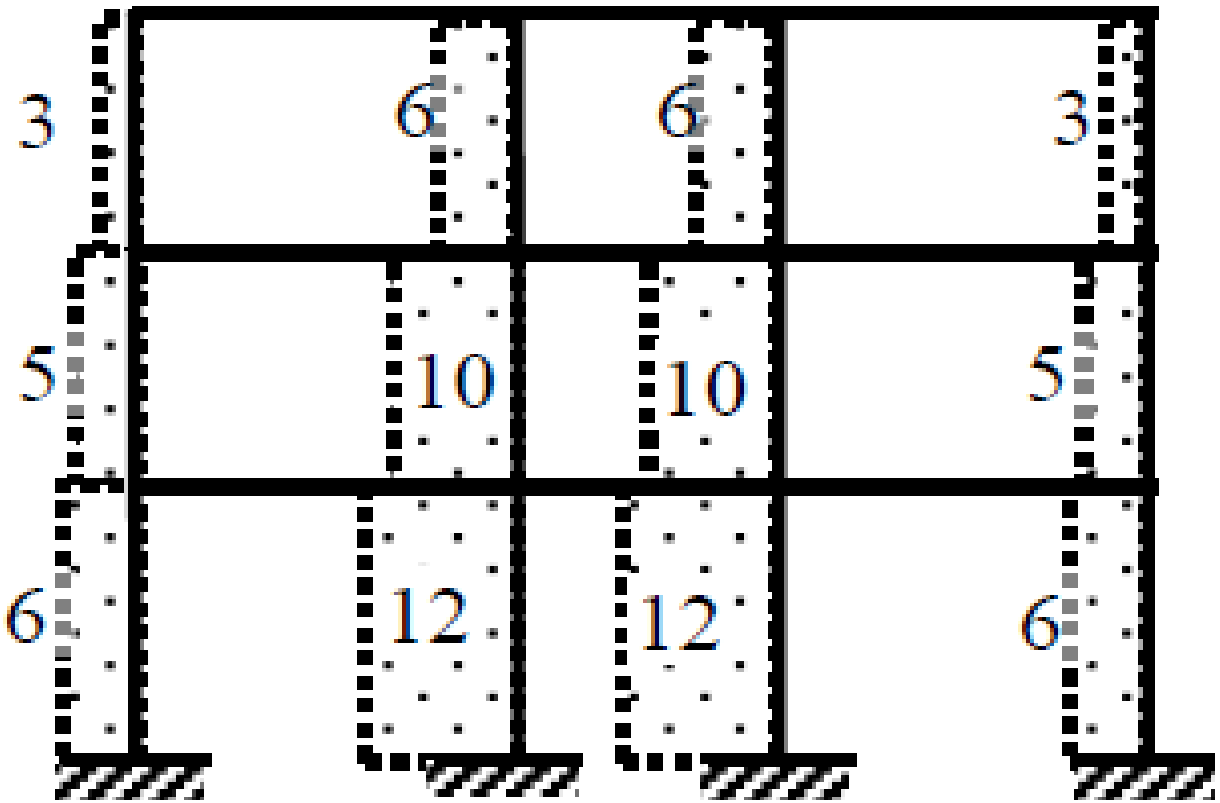
Use the Cantilever Method to draw the axial force, shear force and bending moment diagrams of the three -storied frame structure loaded as shown below



Structural Analysis & Design I



Structural Analysis & Design I



Column SFD (k)

Structural Analysis & Design I

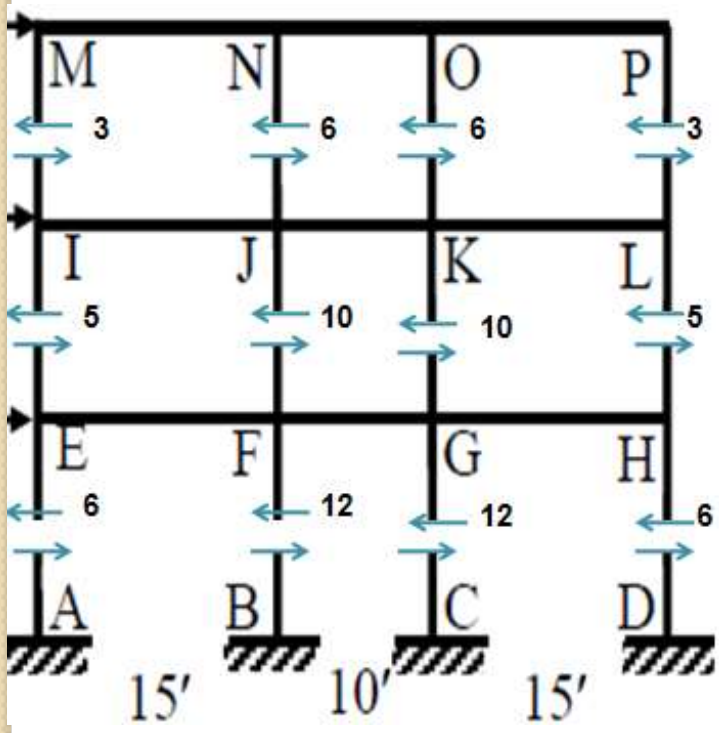
Bending moments are

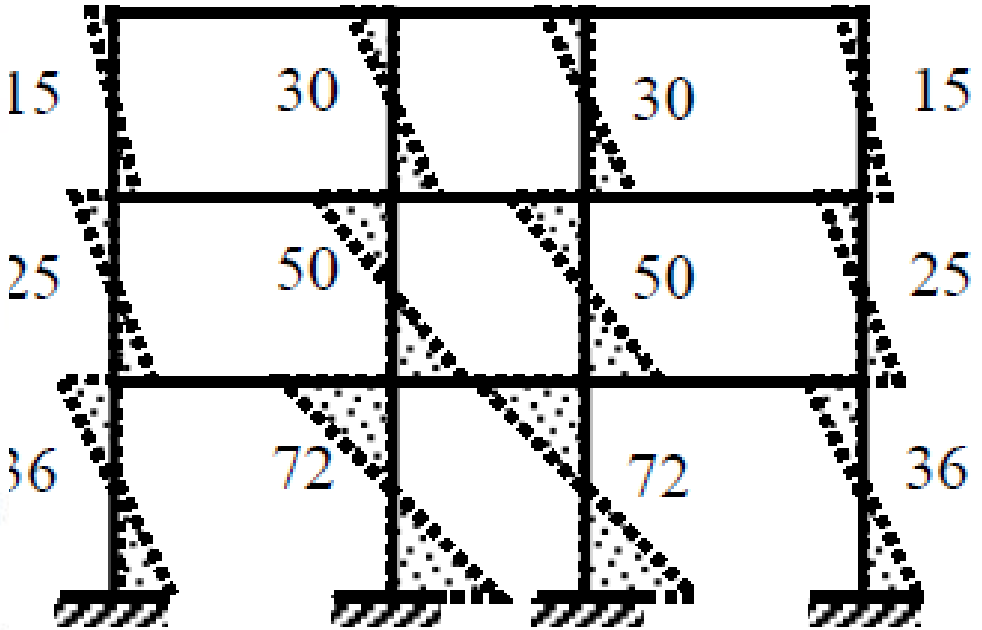
$M_{IM} = 3\times10/2 = 15^{k'}$, $M_{JN} = 30^{k'}$, $M_{KO} = 30^{k'}$, $M_{LP} = 15^{k'}$

$M_{EI} = 5\times10/2 = 25^{k'}$, $M_{FJ} = 50^{k'}$, $M_{GK} = 50^{k'}$, $M_{HL} = 25^{k'}$

$M_{AE} = 6\times10/2 = 30^{k'}$, $M_{FJ} = 60^{k'}$, $M_{GK} = 60^{k'}$, $M_{HL} = 30^{k'}$

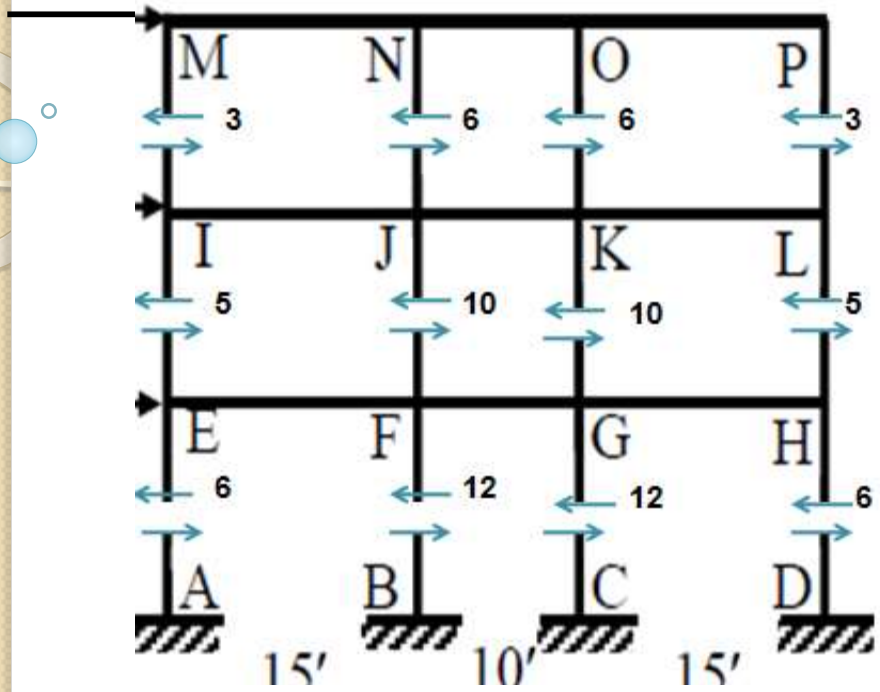
AE=6x12/2=36k'
BF=12x12/2=72k'
CG=12x12/2=72k'
DH=6x12/2=36k'

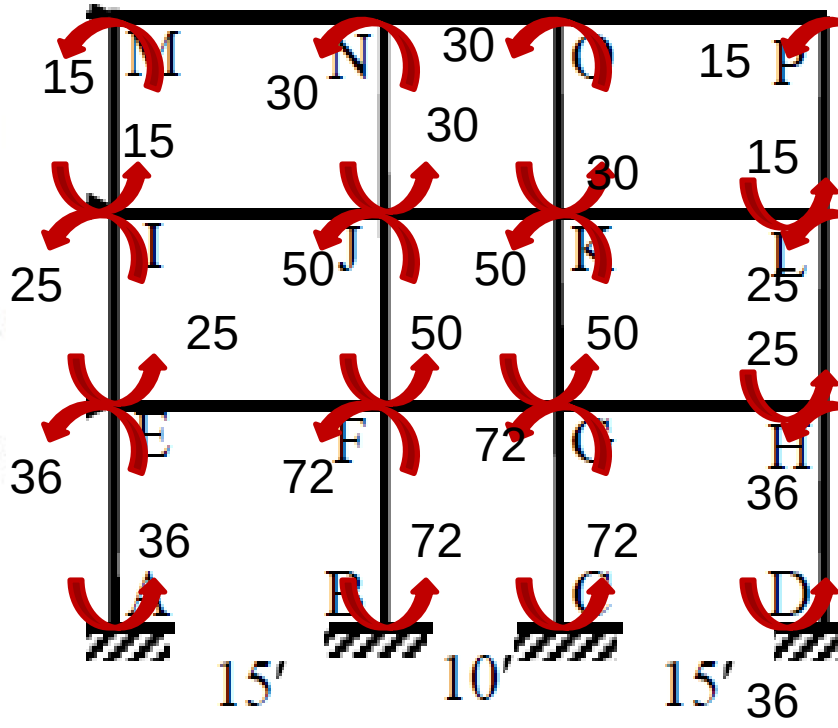


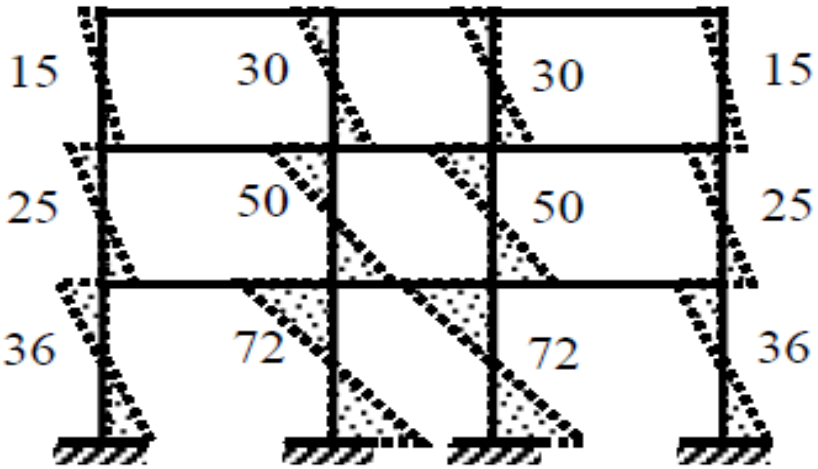


Column BMD (k-ft)

Structural Analysis & Design I

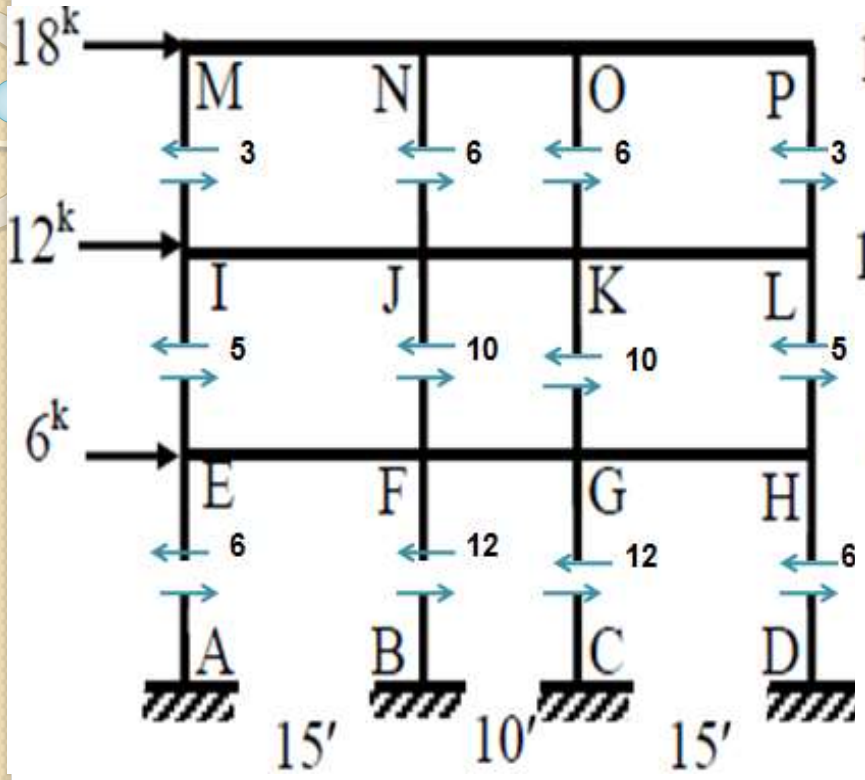


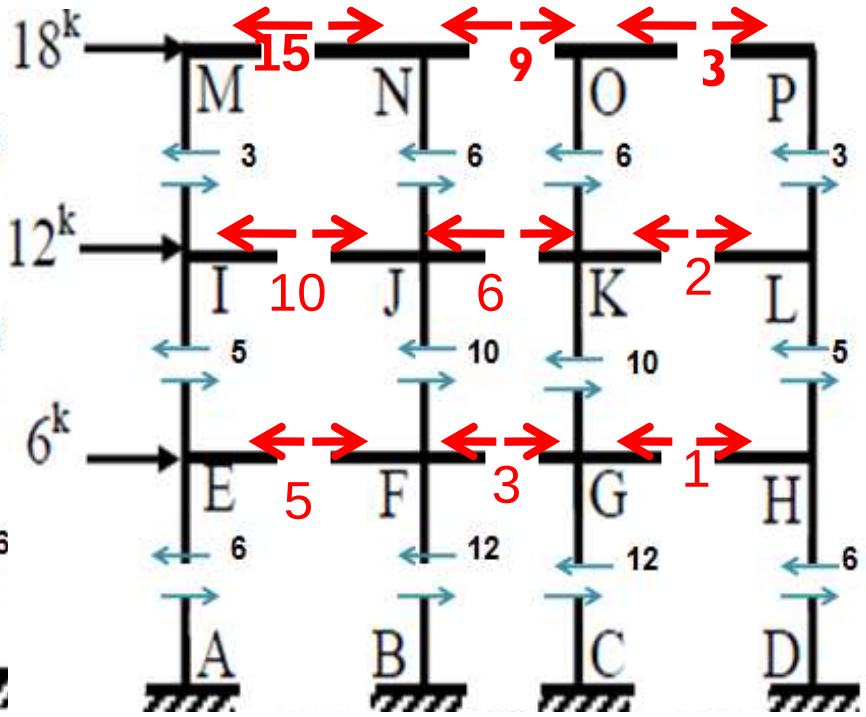


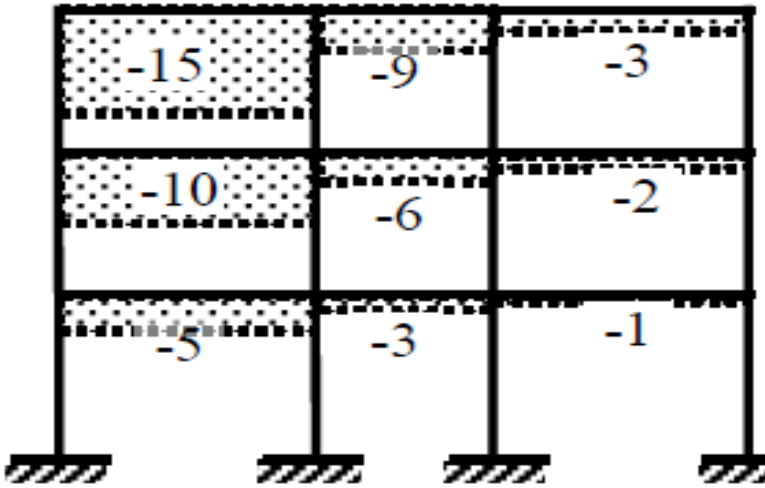


Column BMD (k-ft)

Structural Analysis & Design I

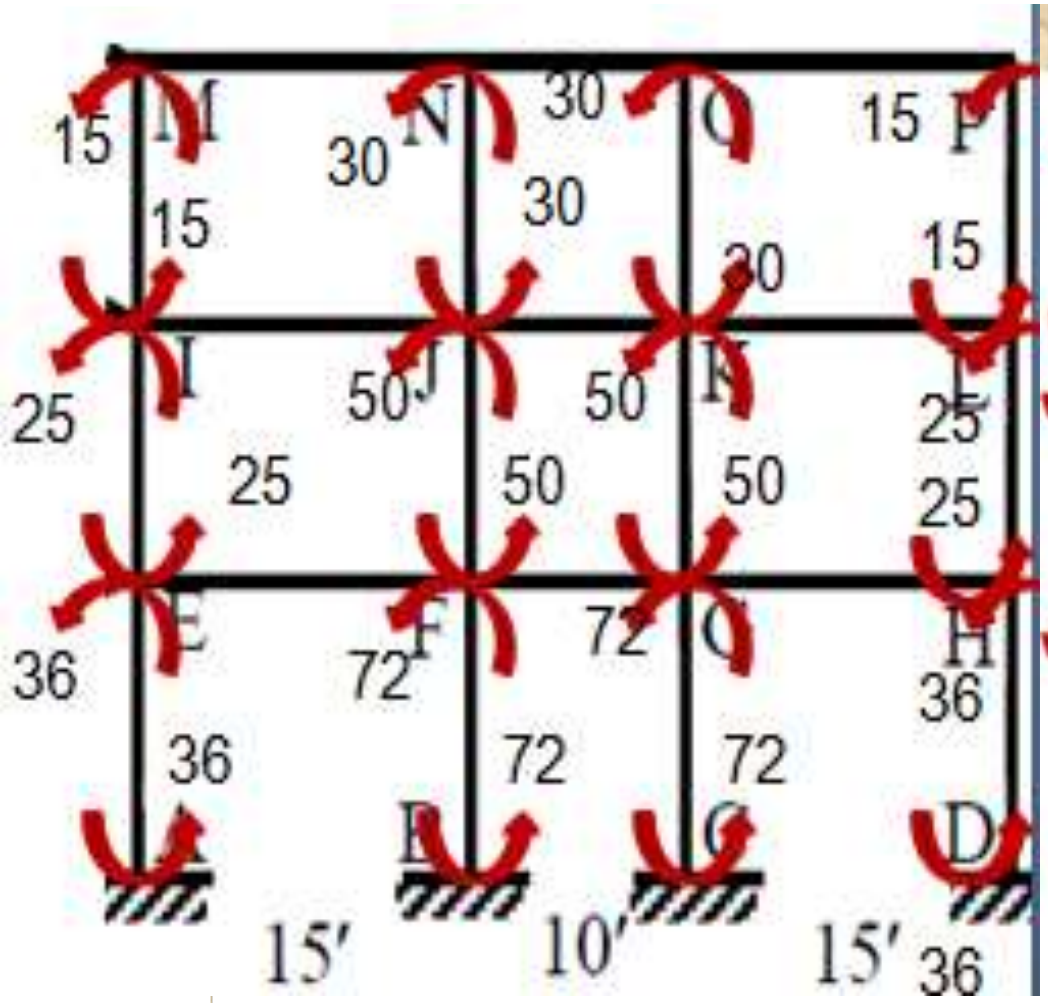




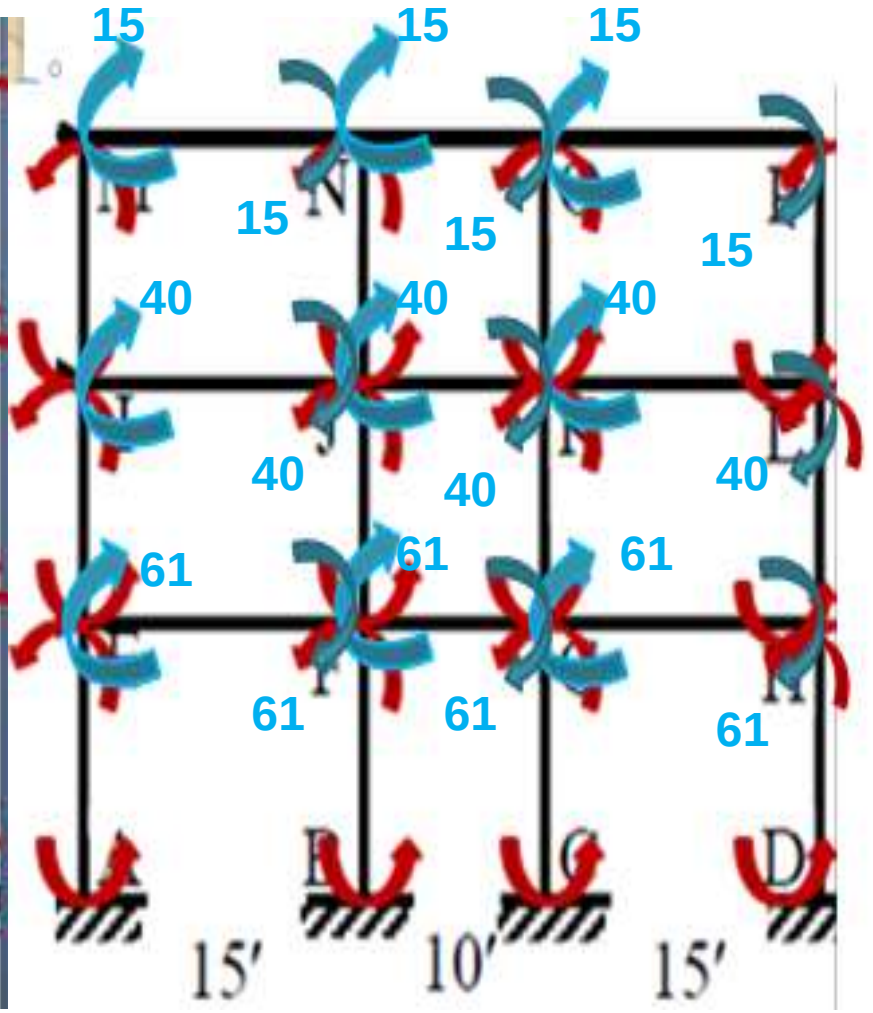


AFD Beam

Structural Analysis & Design I



Column BM

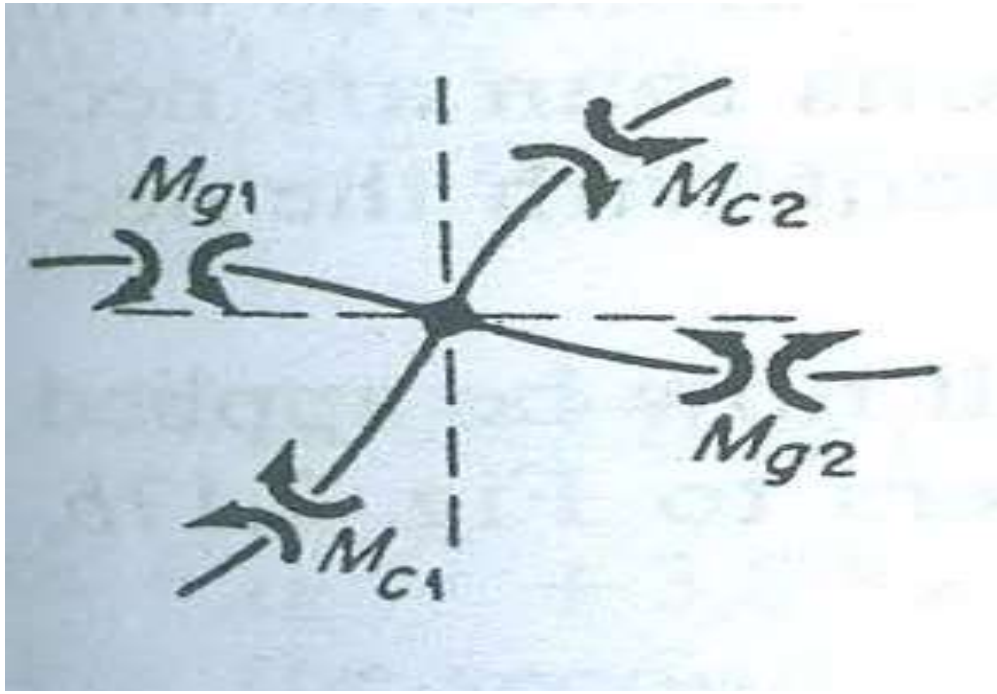


Girder BM

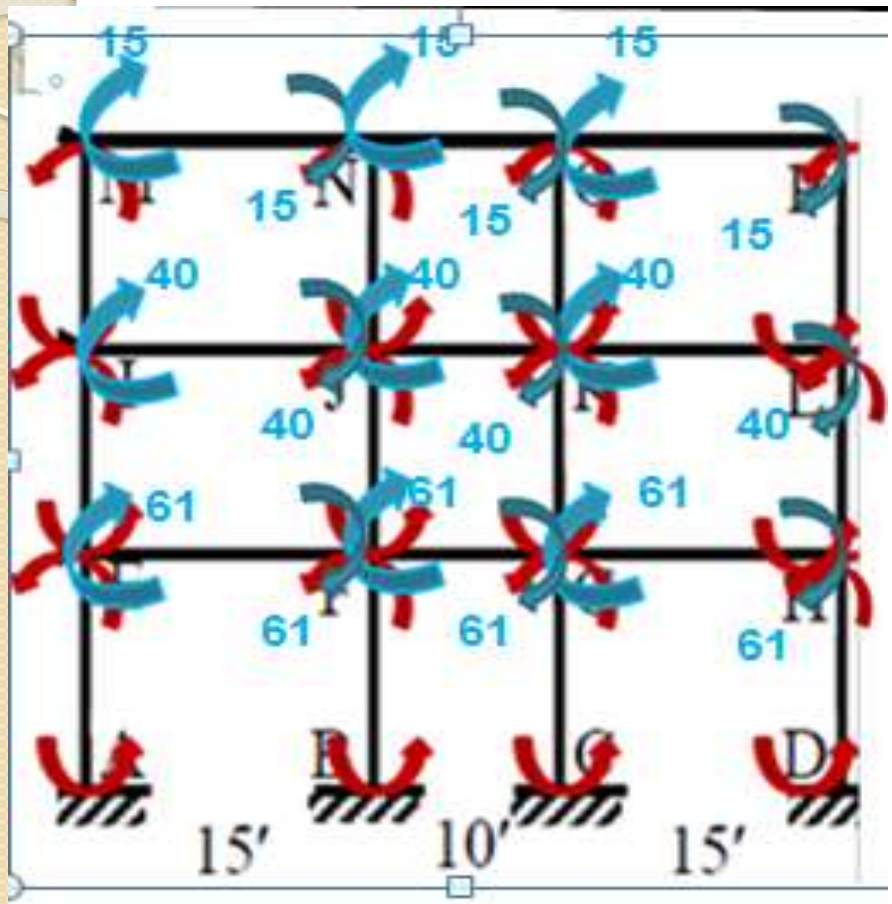
Structural Analysis & Design I

- Girder moment opposite in sense to column moments.
- Start at an exterior end of a girder and work along its length

Mc1+Mc2=Mg1+Mg2

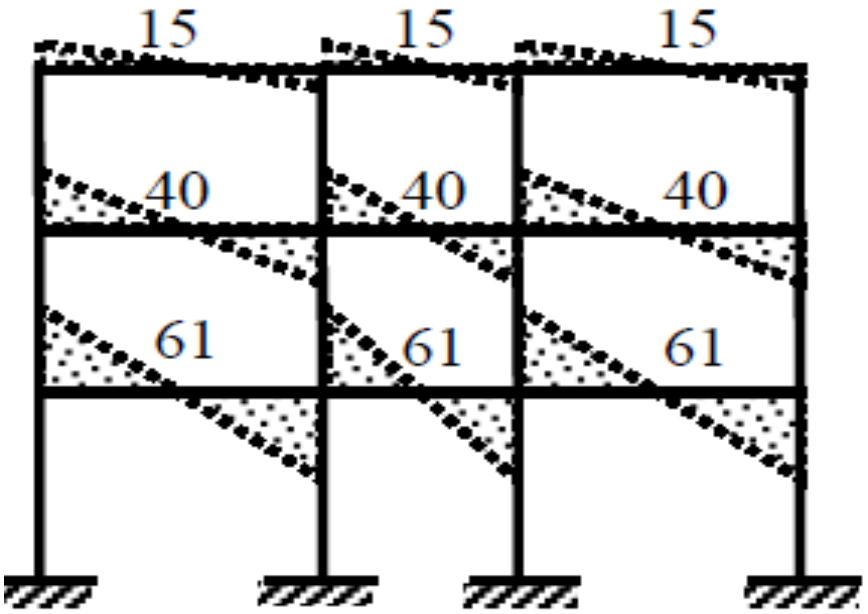


Structural Analysis & Design I



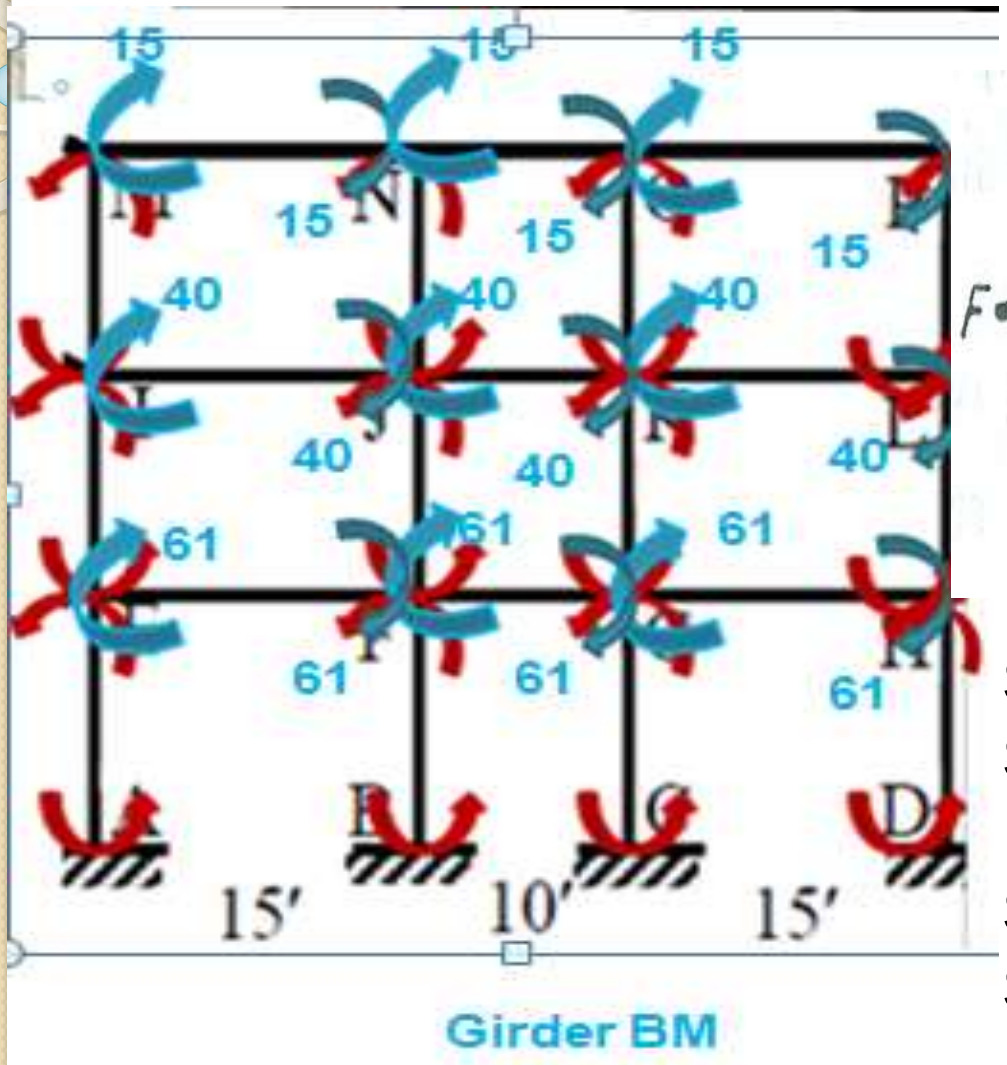
Girder BM

- Girder moment opposite in sense to column moments.
- Start at an exterior end of a girder and work along its length

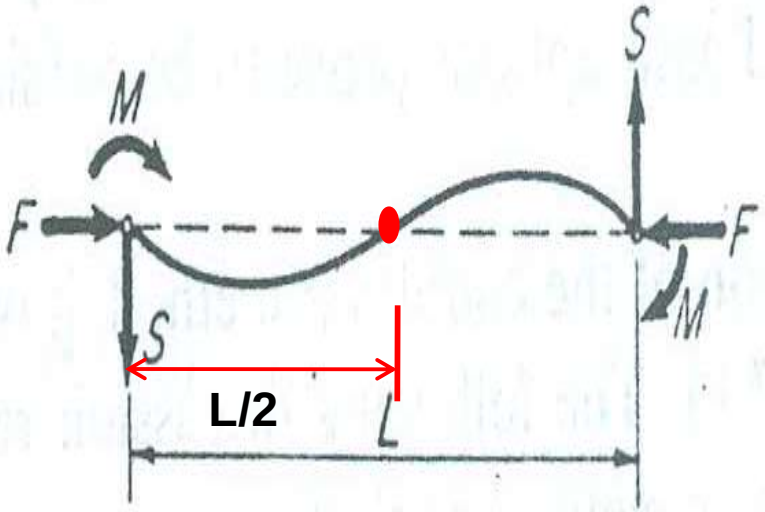


Beam BMD (k-ft)

Structural Analysis & Design I



Girder BM



S X L/S - M=0

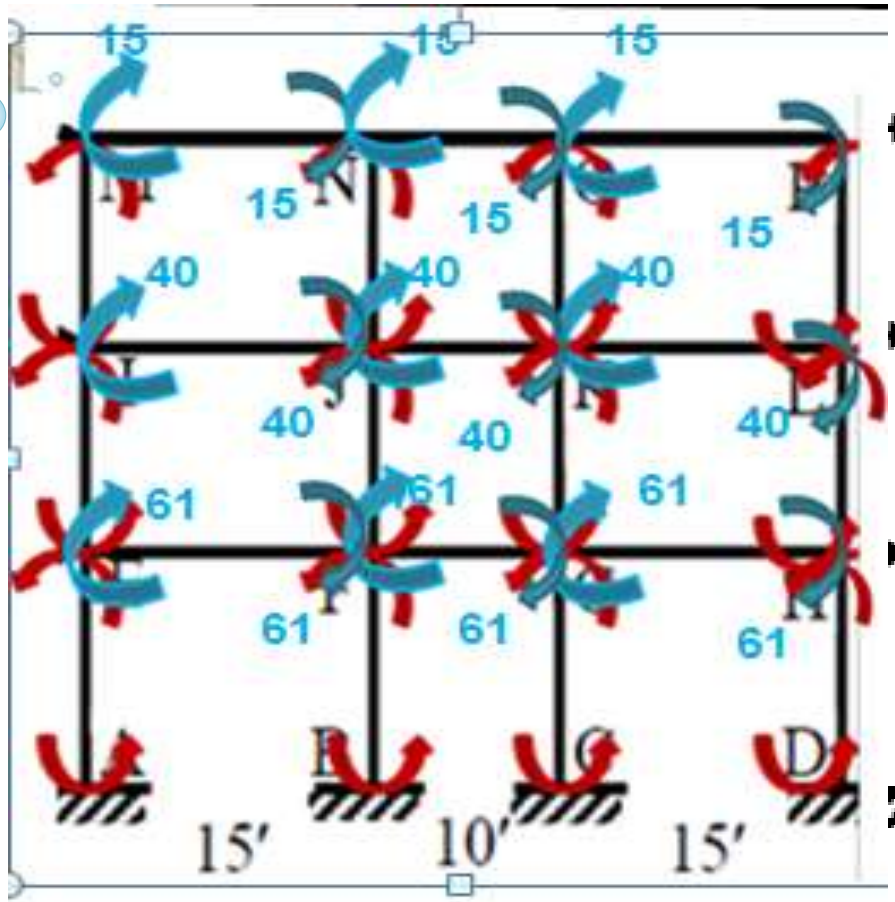
S = 2M/L

= 2x15/15 = 2 kip (MN)

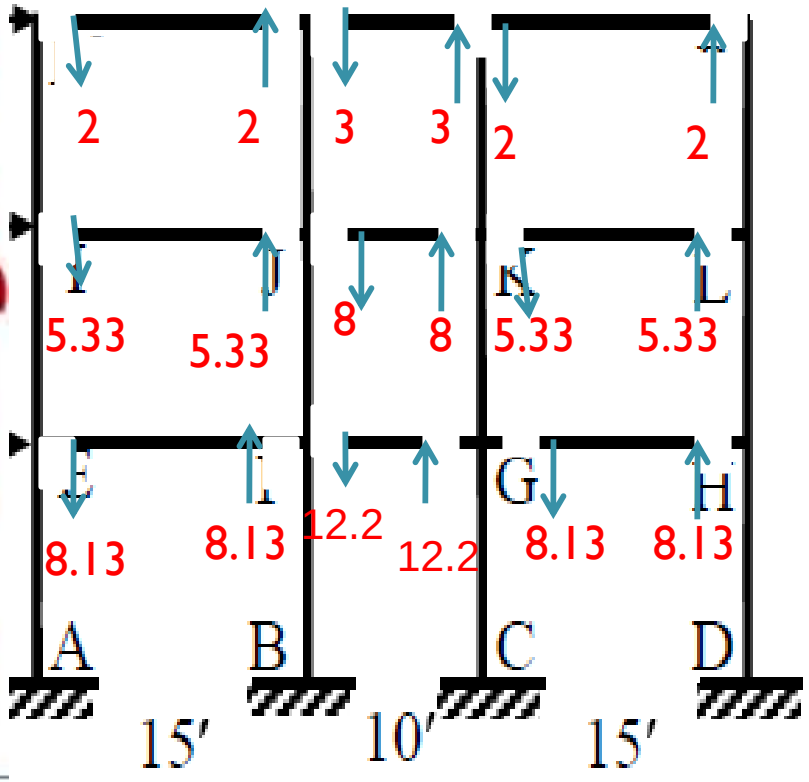
S = 2x15/10 = 3 kip (NO)

S = 2 kip (OP)

Structural Analysis & Design I



Girder BM



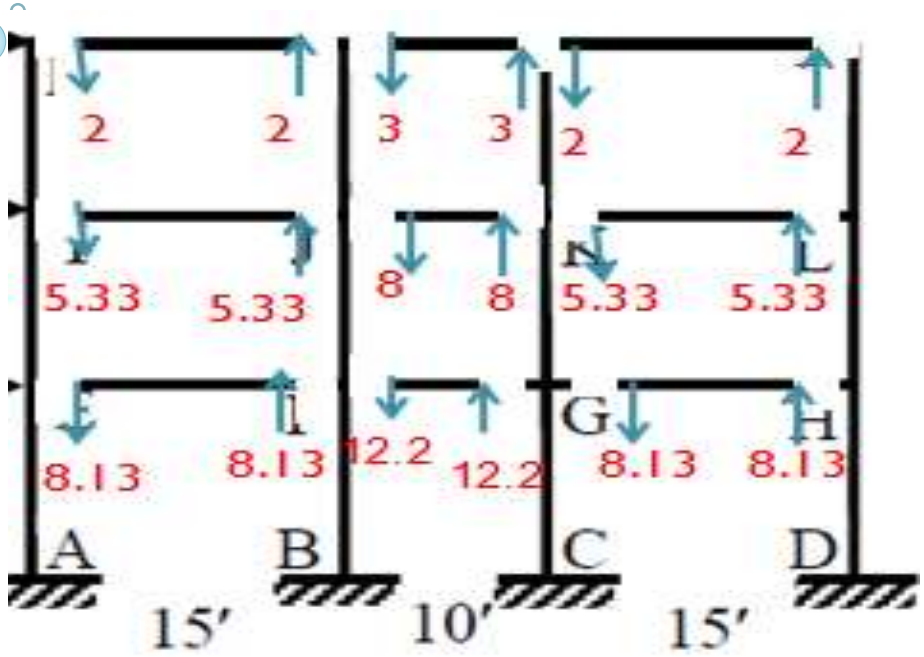
SF in Girder

S = 2M/L = 2x40/15 = 5.33 kip

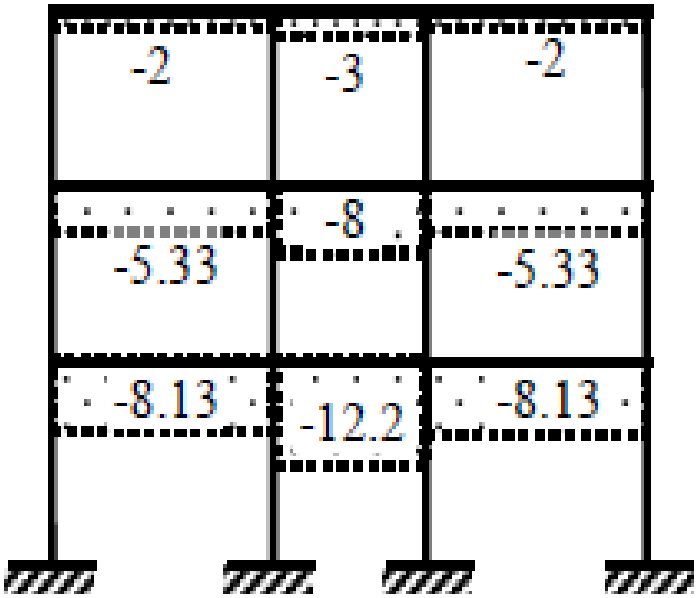
S = 2x40/10 = 8 kip

S = 25.33 kip

Structural Analysis & Design I

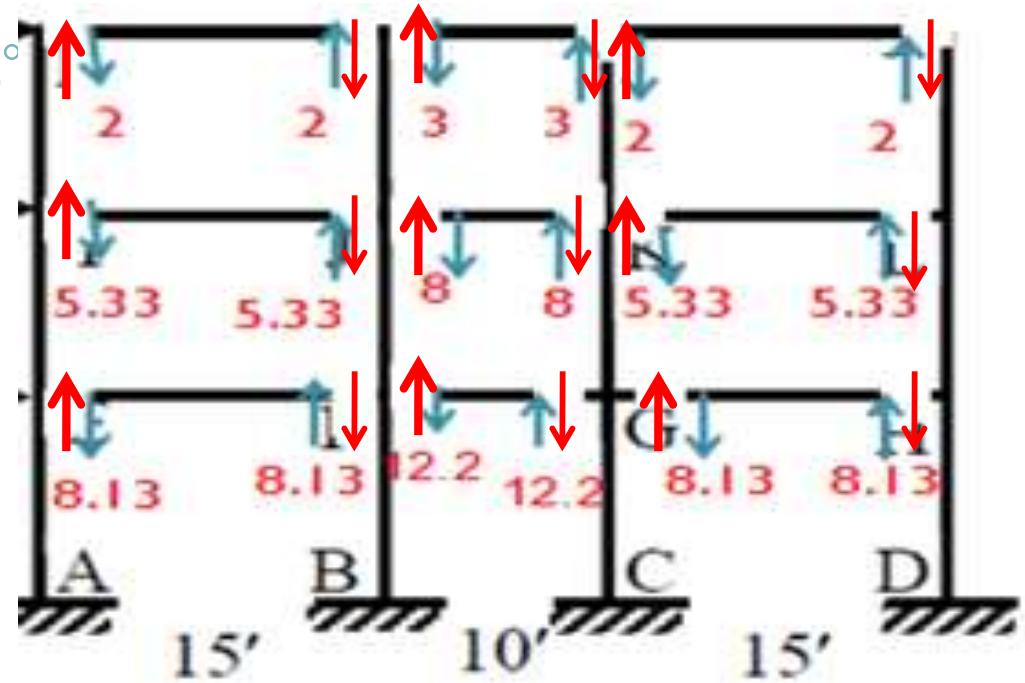


SF in Girder

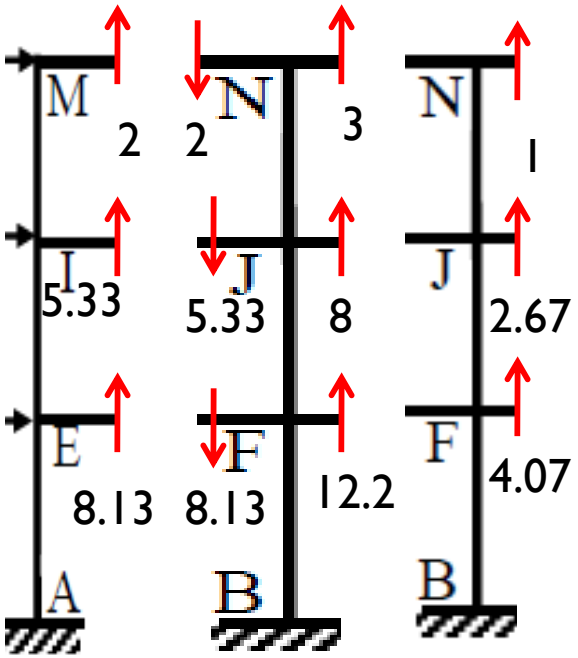


Girder SFD

Structural Analysis & Design I



SF in Girder



Column AF

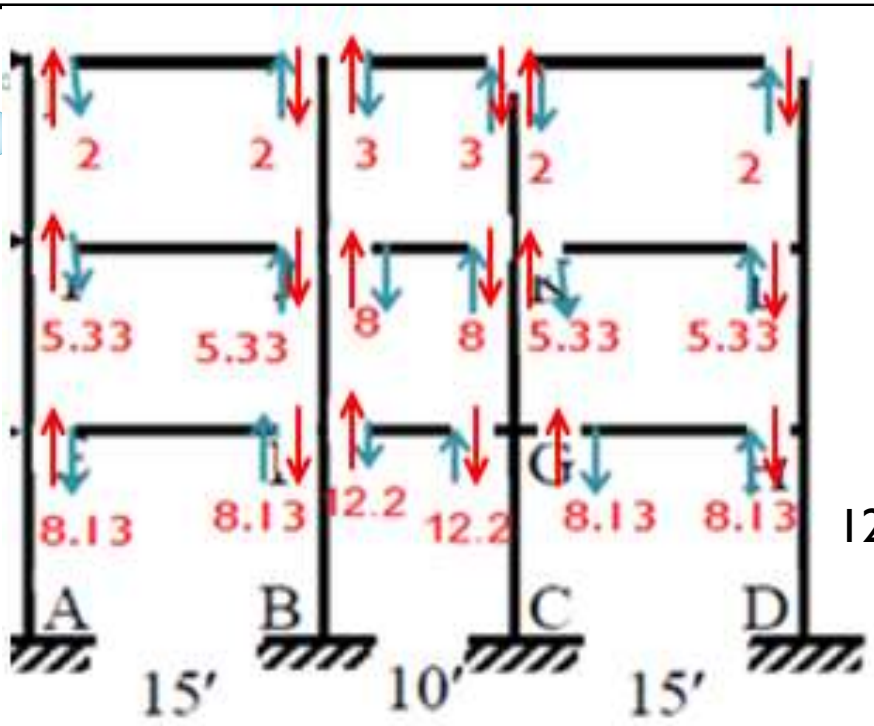
Tension

N = 3-1

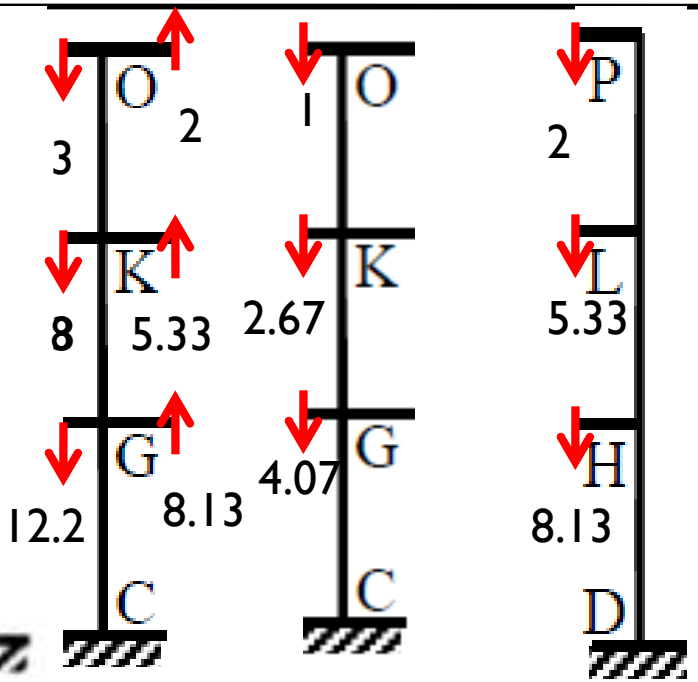
J = 8-5.33= 2.67

F = 12.2-8.13= 4.07

Structural Analysis & Design I

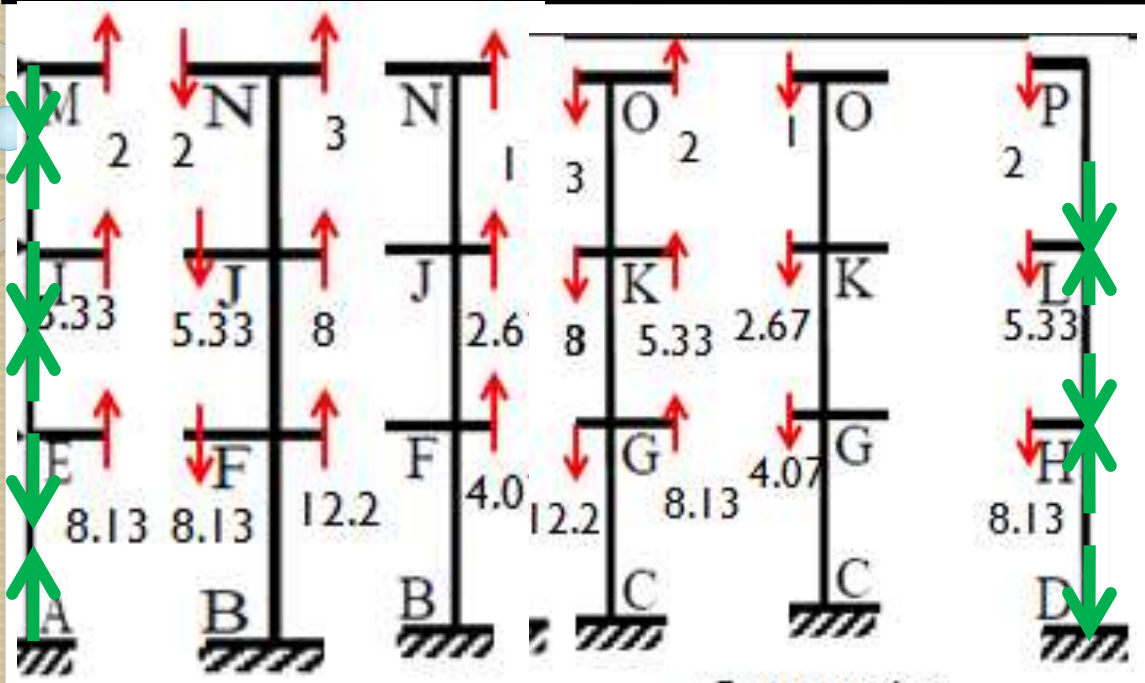


SF in Girder

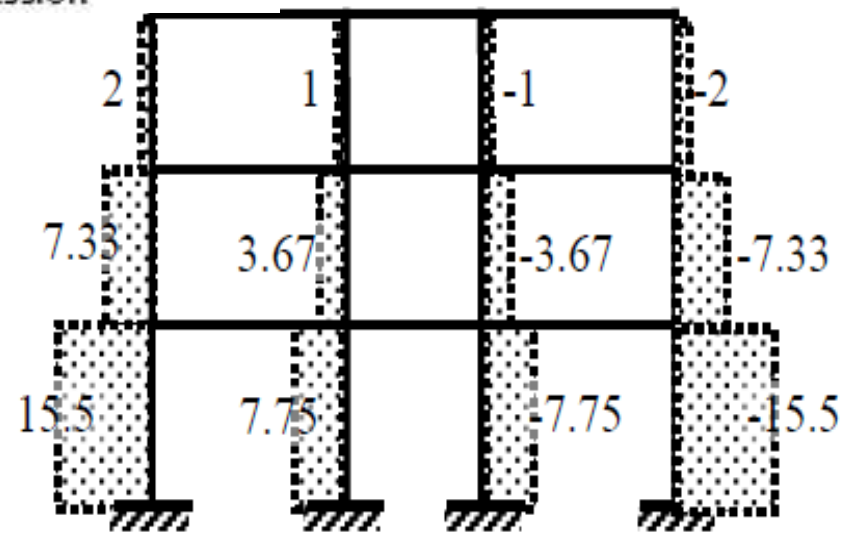


Compression

Structural Analysis & Design I

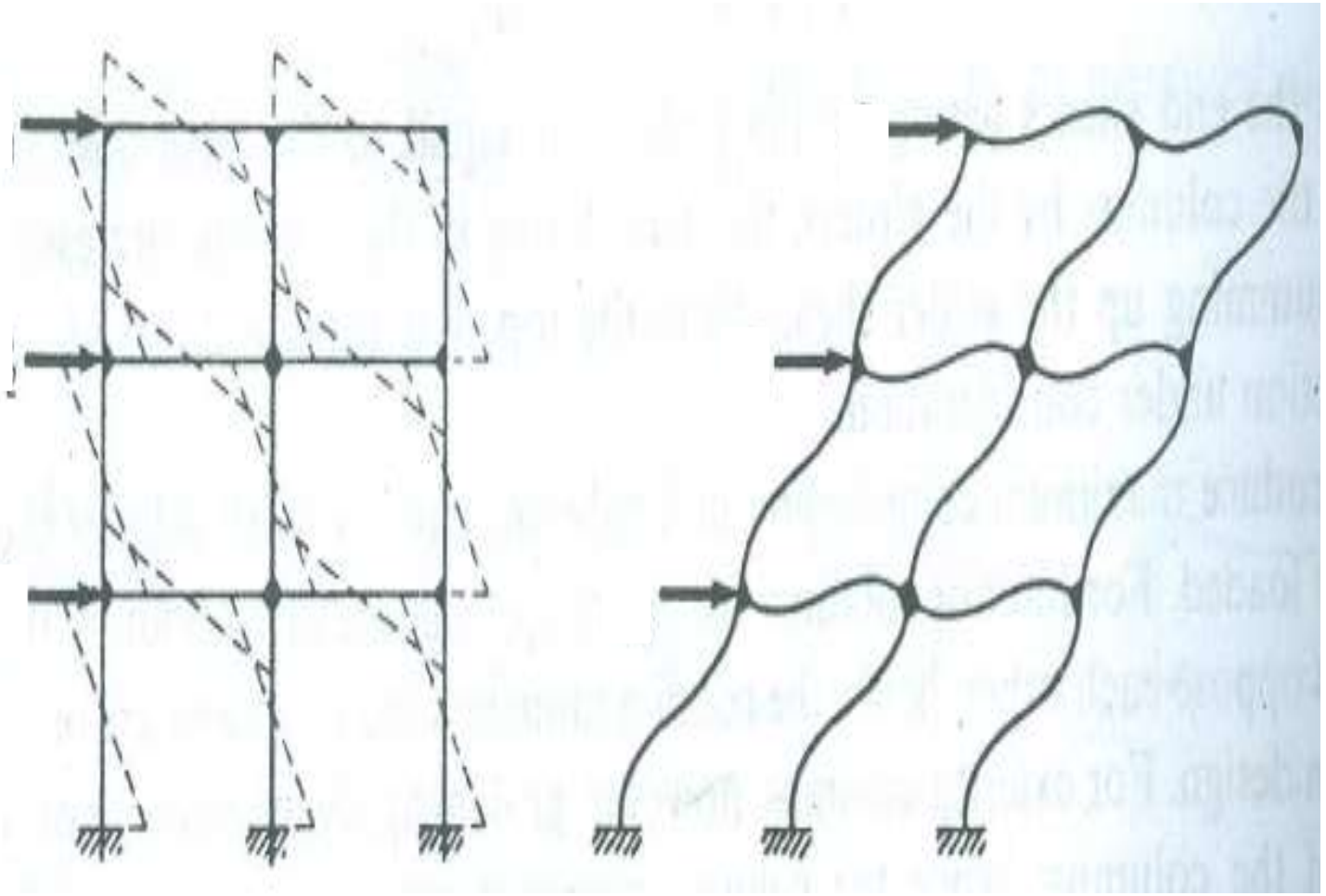


Compression



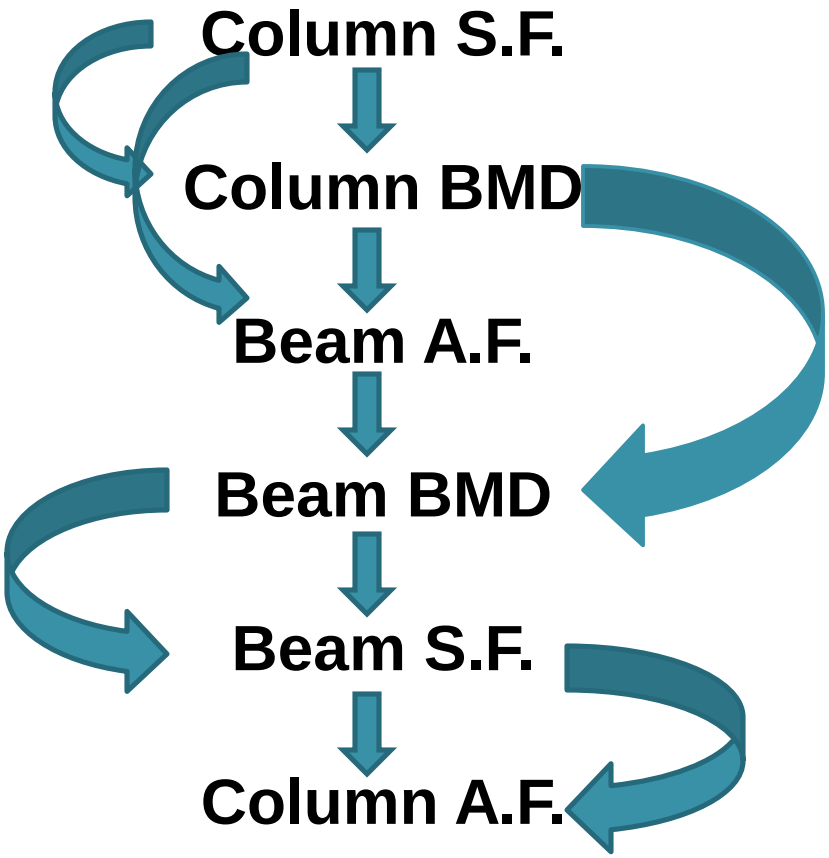
Column A.F.

Deflected Shape



Structural Analysis & Design I

Order of analysis



Structural Analysis & Design I

- **Assignment**