Approximate Analysis

For performing quicker analysis of indeterminate structure, additional approximations (assumptions) are necessary. Methods of analysis involving such approximations are known as approximate method of analysis.

Exact Analysis

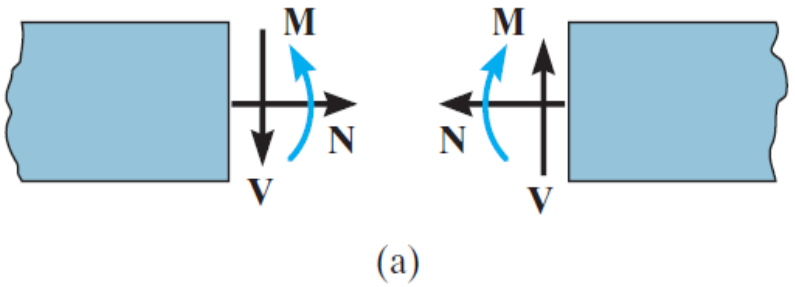
Analysis using the usual assumptions that underline structural theory are called exact

Purposes of Approximate Analysis

- Accurate analysis is time consuming
- Preliminary design and analysis.
- Checking result obtained from computer software
- To enable calculation by hand by reducing the degree of indeterminacy

Structural Analysis & Design I

On the *left-hand face of the cut member the* normal force **N acts to the right, the internal shear force V acts** downward, and the moment **M acts counterclockwise.**



(a)



(b)

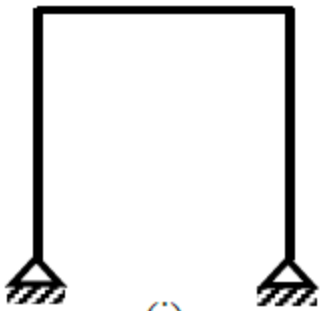


(c)

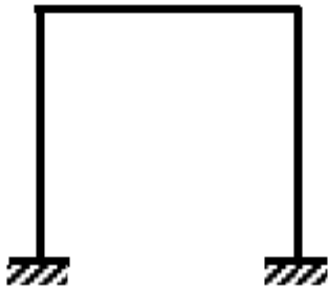


(d)

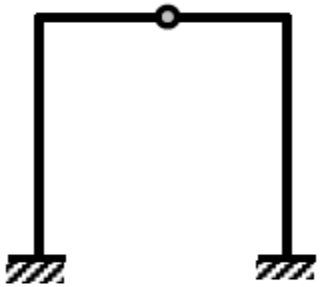
Structural Analysis & Design I



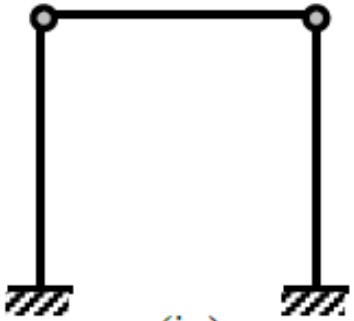
(i)



(ii)



(iii)



(iv)

D of I = (3m + r) – (3J +c)

D of i of portal frames shown in (i), (ii), (iii) and (iv) are 1, 3, 2 and 1

Approximate Analysis Method

- Portal method
- Cantilever method
- Braced trusses
- Vertical load

Structural Analysis & Design I

Portal Frame

Portal frames, used in several Civil Engineering structures like buildings, factories, bridges have the primary purpose of transferring horizontal loads applied at their tops to their foundations. Structural requirements usually necessitate the use of statically indeterminate layout for portal frames, and approximate solutions are often used in their analyses.

Assumptions

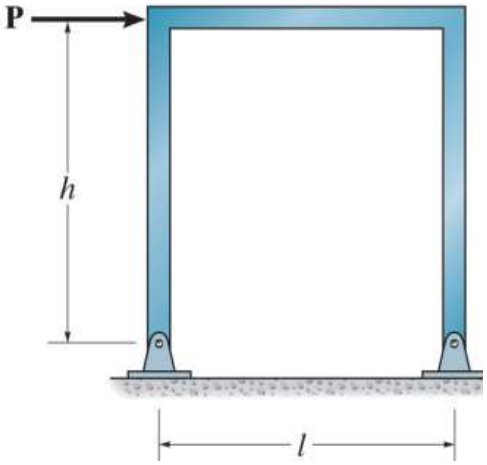
The assumptions used in the approximate analysis of portal frames can be extended for the lateral load analysis of multi-storied structures. The *Portal Method thus formulated is based on three assumptions :*

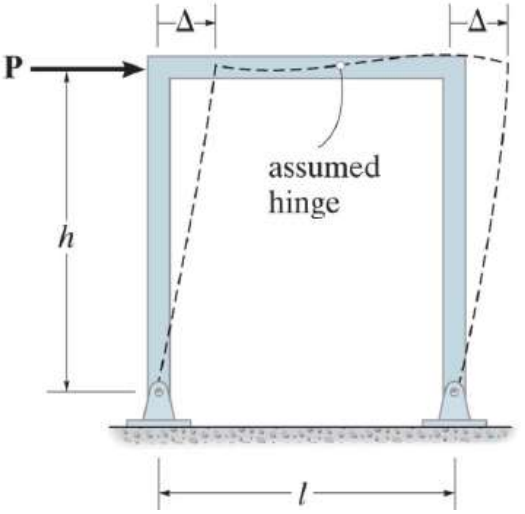
1. The shear force in an interior column is twice the shear force in an exterior column.
2. There is a point of inflection at the center of each column.
3. There is a point of inflection at the center of each beam.

Structural Analysis & Design I

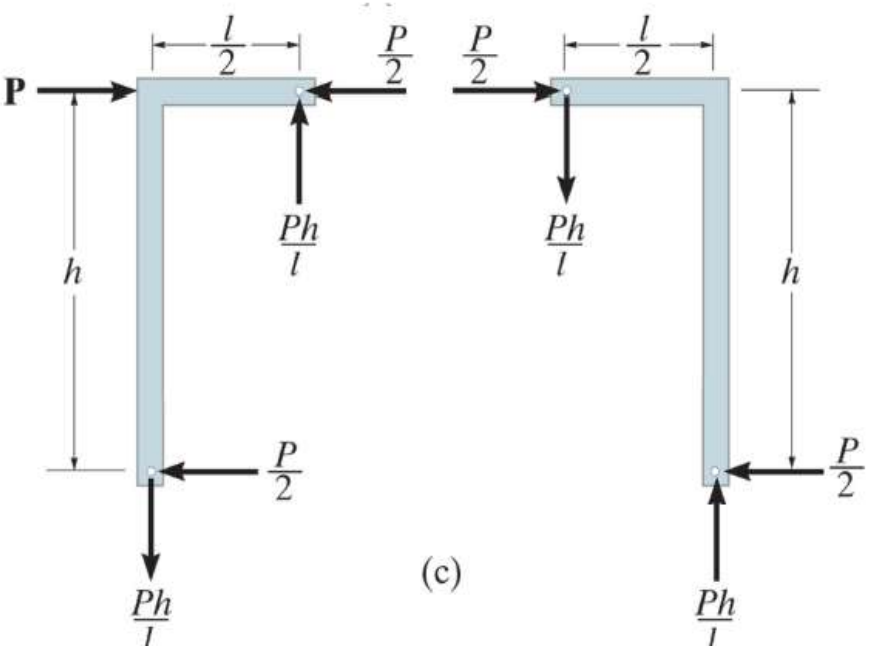
Portal Frames and Trusses

Case 1: Pin supported

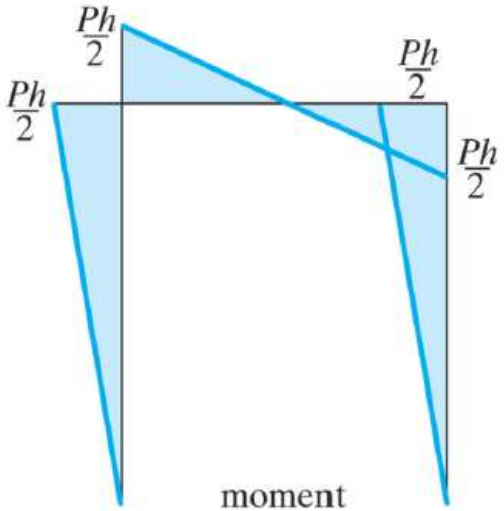




(b)



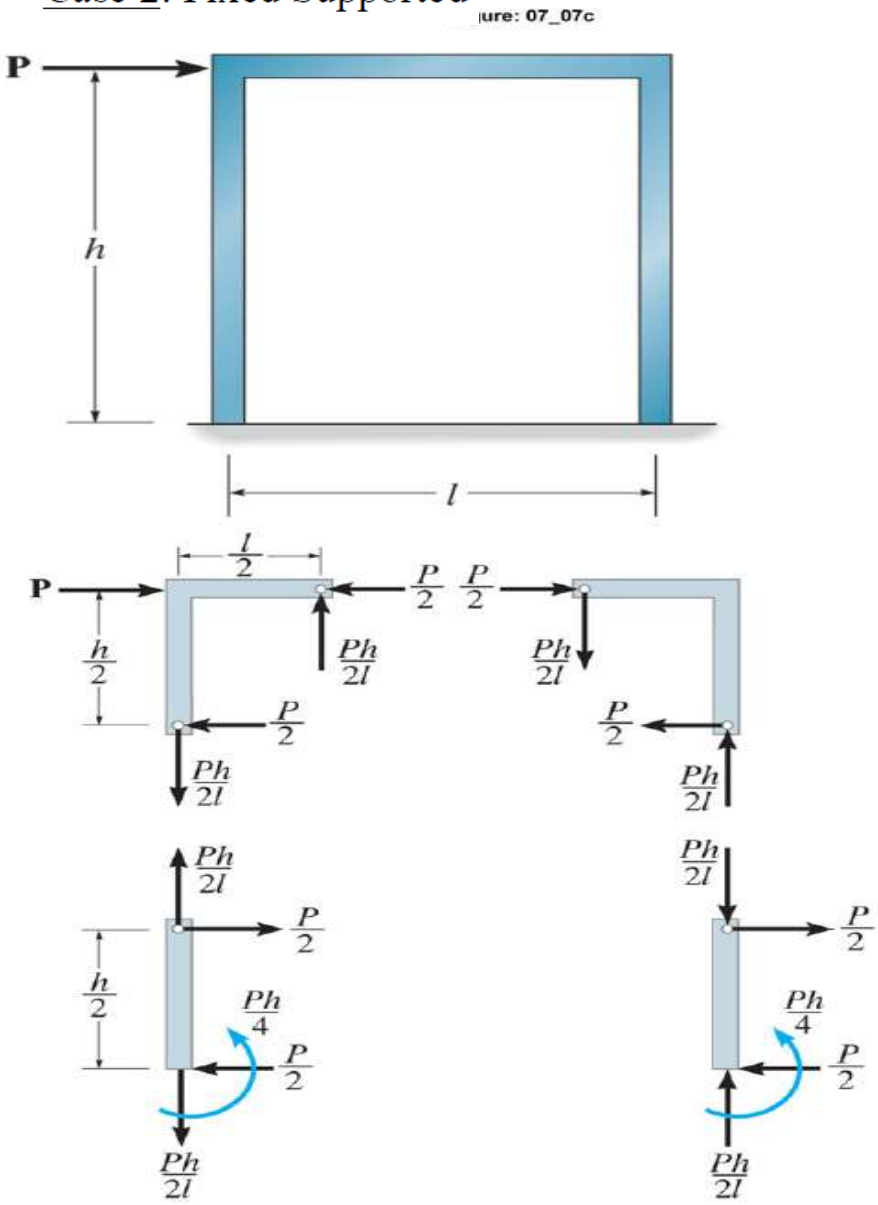
(c)



moment diagram

Structural Analysis & Design I

Case 2: Fixed Supported



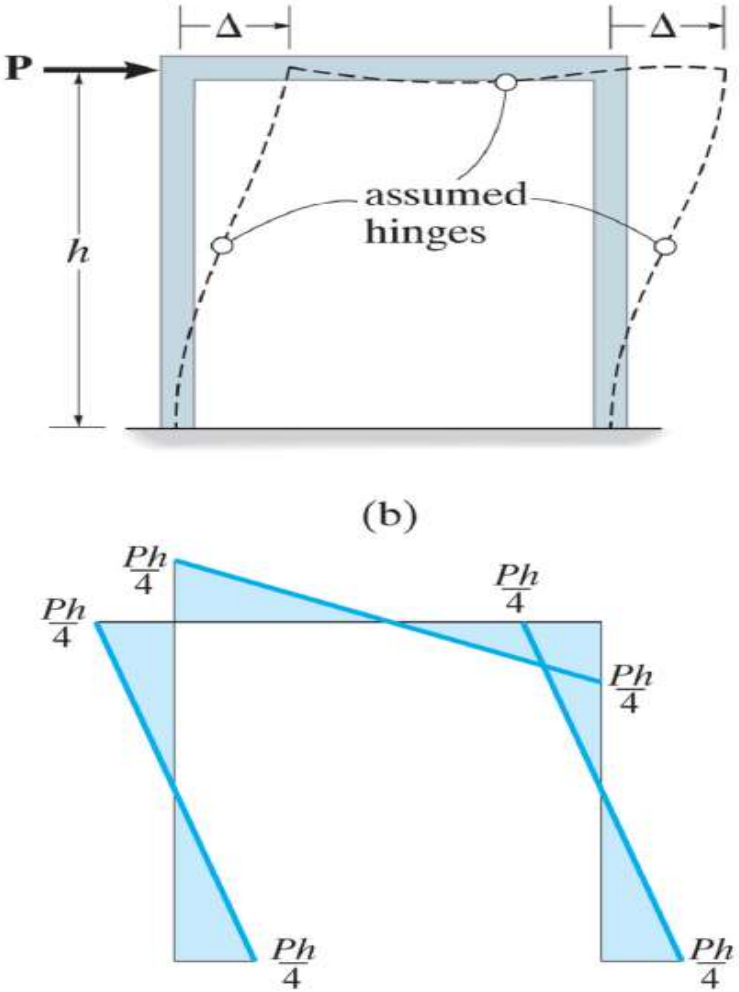
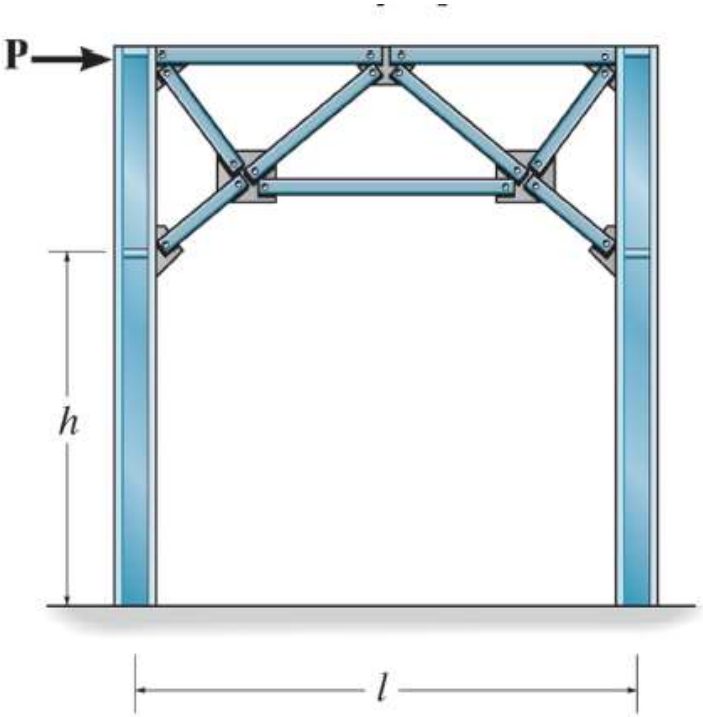


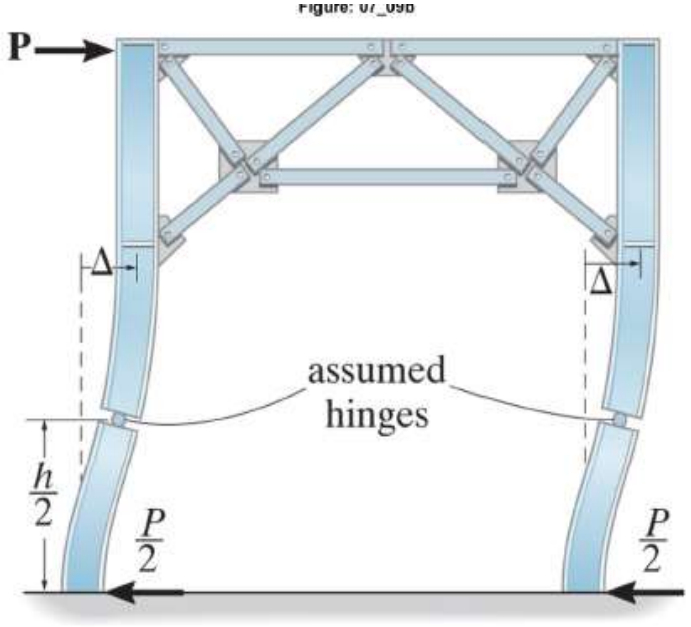
Figure: 07_08d

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Structural Analysis & Design I

Case 4: Portal Trusses

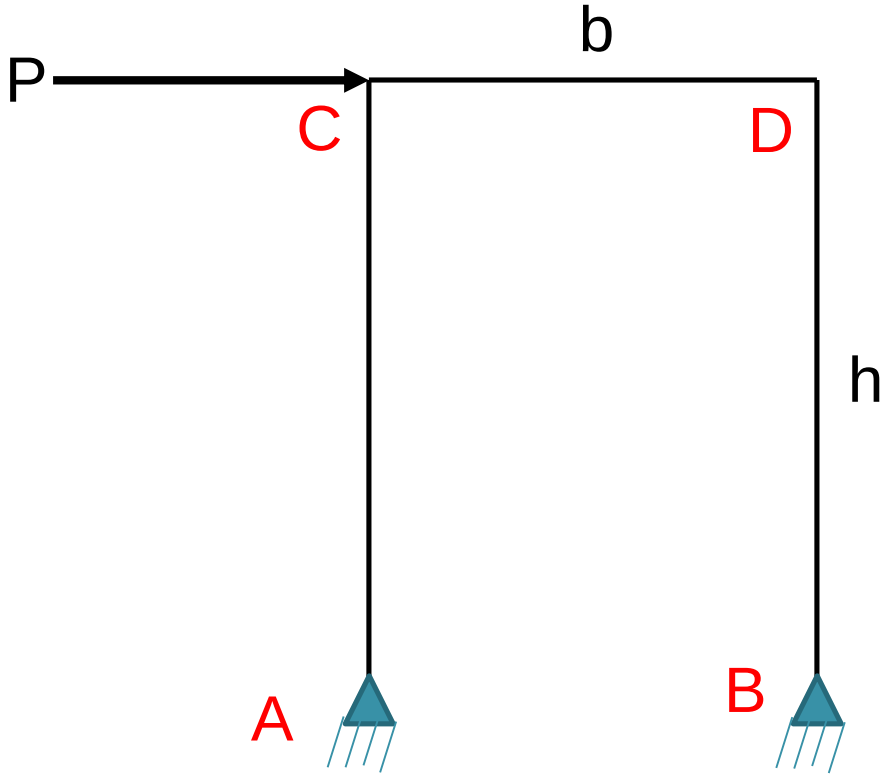




Structural Analysis & Design I

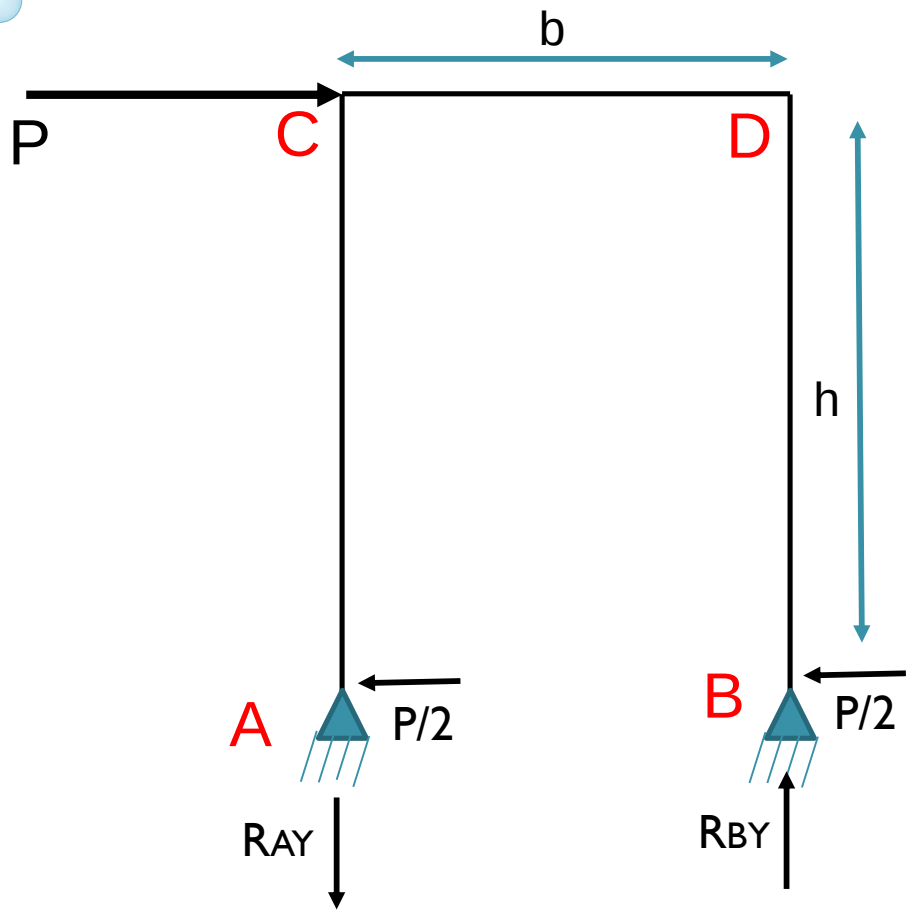
Find the following :

a) AFD
b) SFD
c) BMD
d) Deflected shape



Structural Analysis & Design I

Portal frames



DOI = (3m+r)-(3j+c)

=(3x3+4)-(3x4+0)

= 13 -12 = 1°

+ $M_B = -R_{AY} \times b + P \times h = 0$

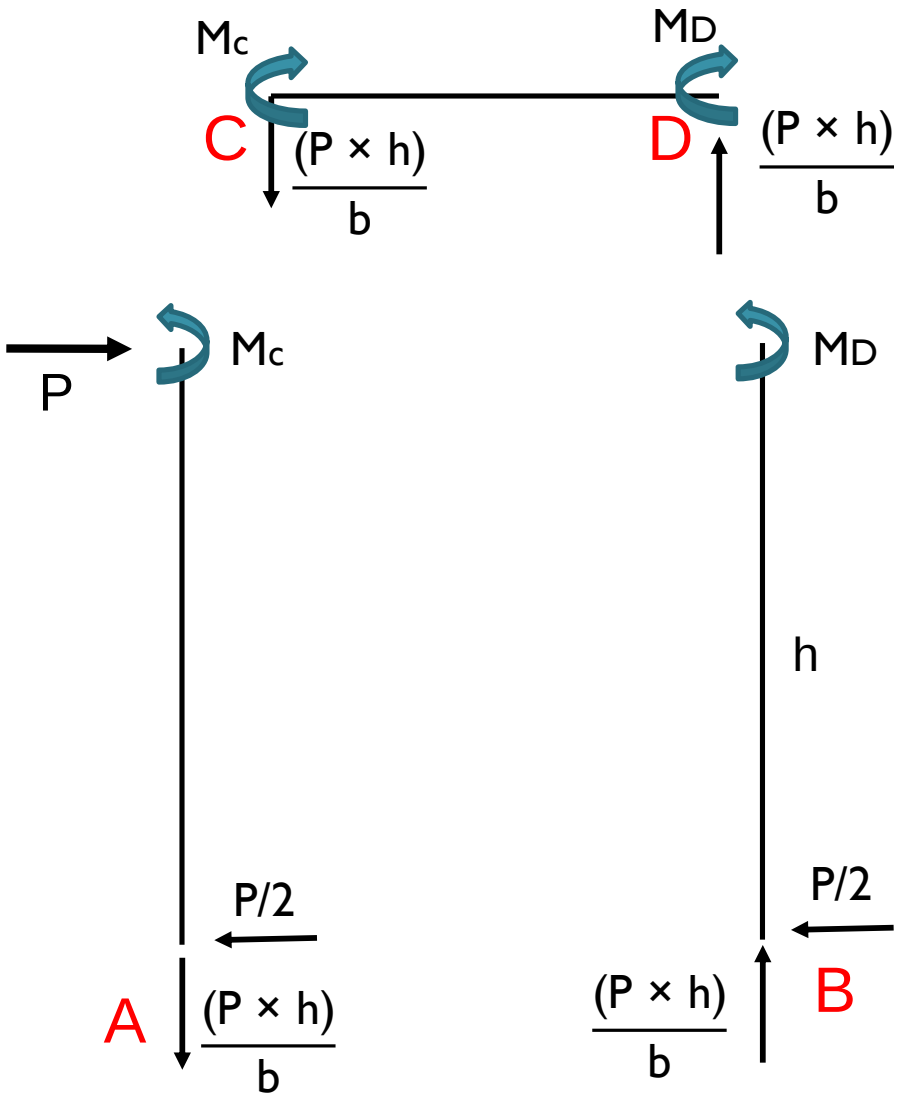
$$R_{AY} = \frac{(P \times h)}{b}$$

Similarly,

$$R_{BY} = \frac{(P \times h)}{b}$$

M_c

Structural Analysis & Design I



$+\circlearrowleft \sum M_c = 0$

$\Rightarrow M_c - P/2 \times h = 0$

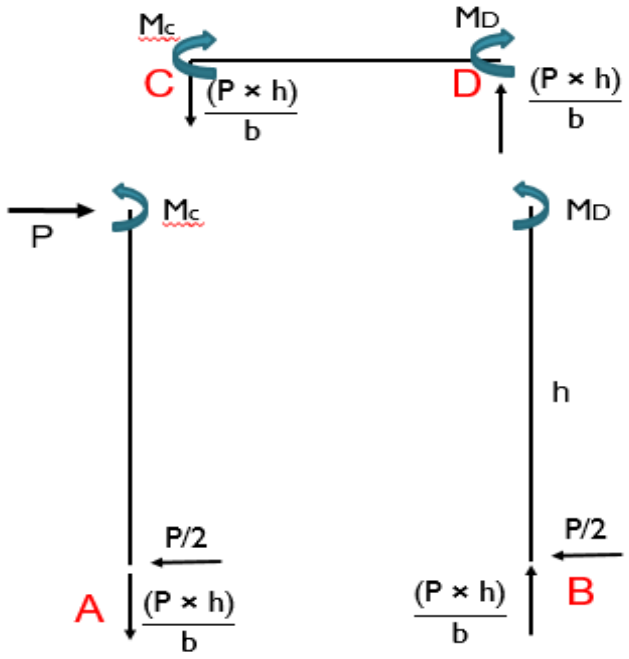
$\Rightarrow M_c = \frac{(P \times h)}{2}$

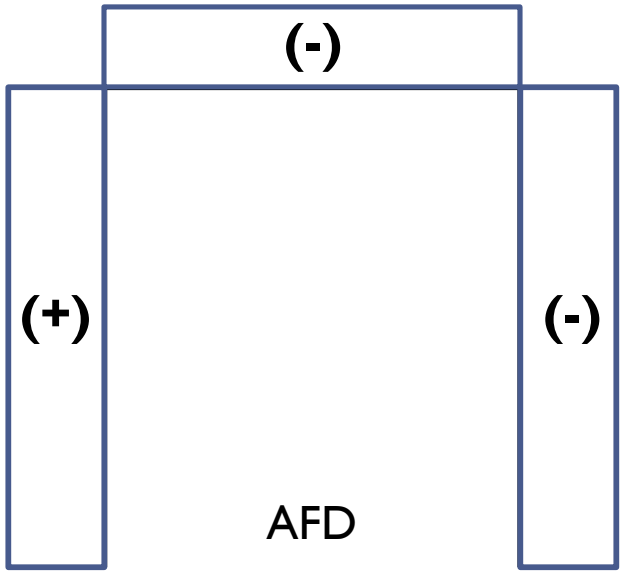
$+\circlearrowleft \sum M_D = 0$

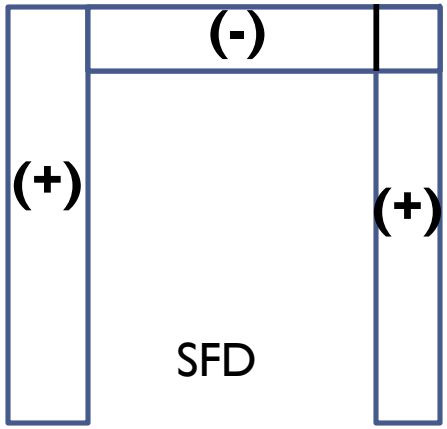
$\Rightarrow M_D - P/2 \times h = 0$

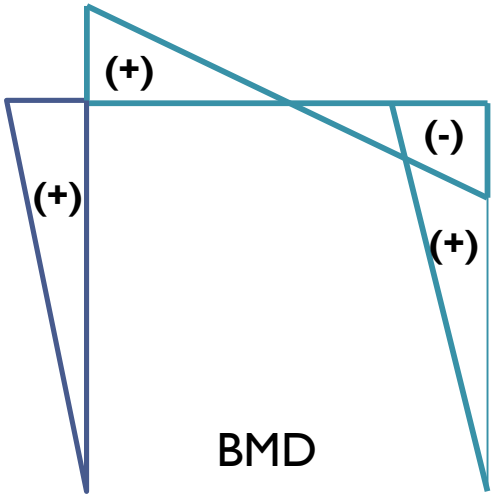
$\Rightarrow M_D = \frac{(P \times h)}{2}$

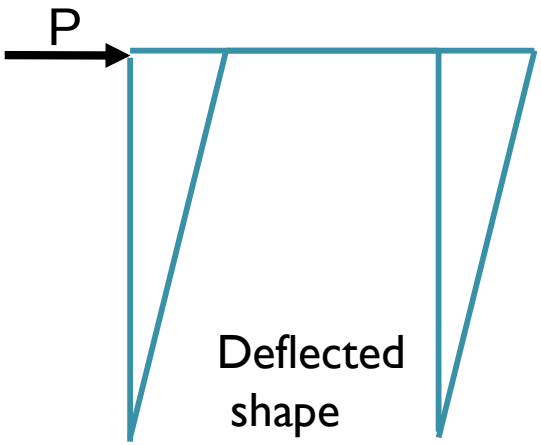
Structural Analysis & Design I







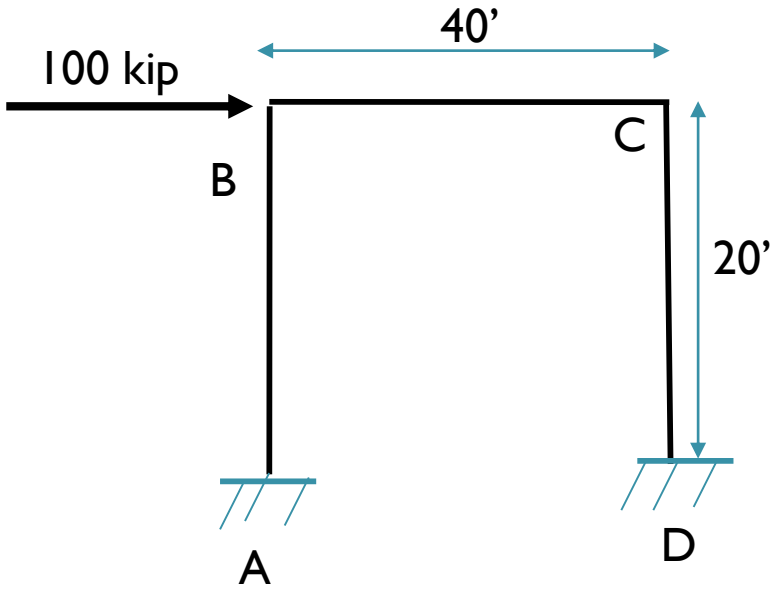




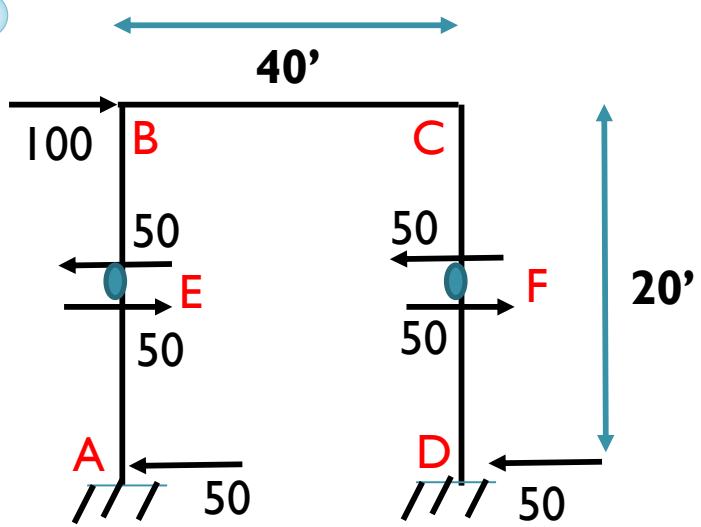
Structural Analysis & Design I

Find the following :

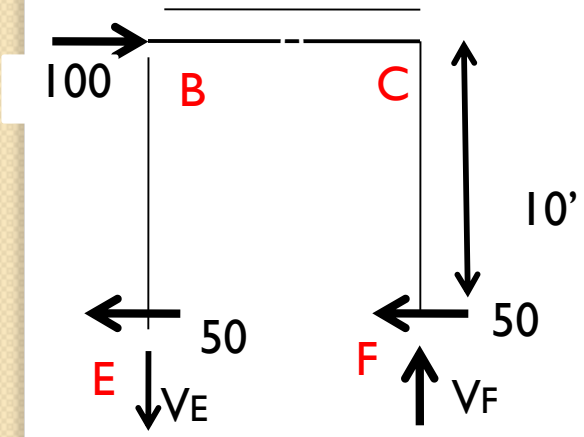
a) AFD
b) SFD
c) BMD
d) Deflected shape



Solution : Assumption 2



Column SF



DI = (3×3+6)-(3×4+0) = 3°

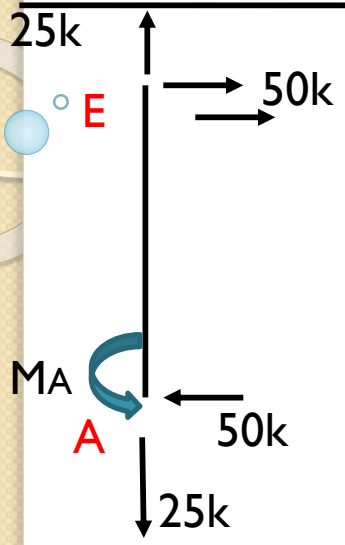
+ ∑ME =100 × 10 –VF × 40 = 0

VF= 25 kips

Similarly ,

VE = -25 kips

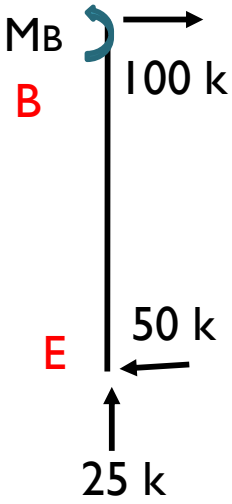
Structural Analysis & Design I



$+\circlearrowright \sum M_A = 0$

$\Rightarrow 50\times10 - M_A = 0$

$\Rightarrow M_A = 500$ k'

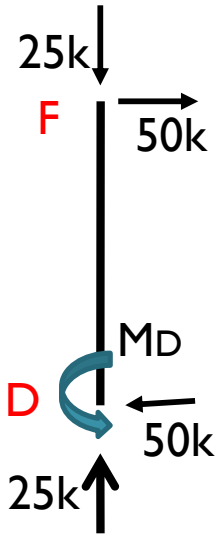


$\sum M_B = 0$

$\Rightarrow 50\times10 - M_B = 0$

$\Rightarrow M_B = 500$ k'

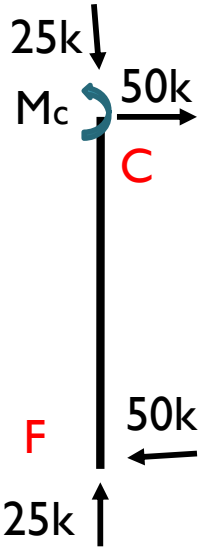
Column BM Determination



$+\circlearrowright \sum M_D = 0$

$\Rightarrow 50\times10 - M_D = 0$

$\Rightarrow M_D = 500$ k'



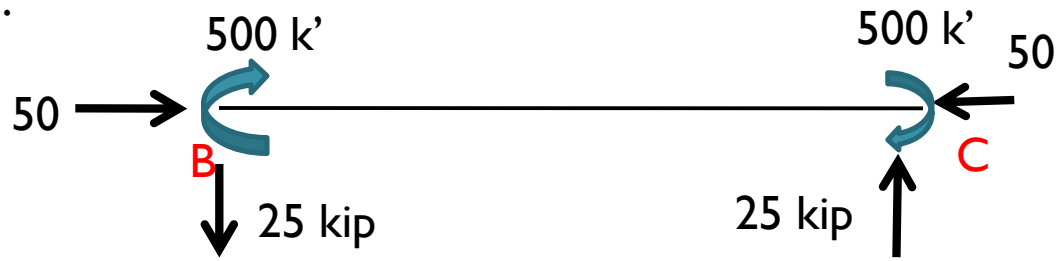
$\sum M_C = 0$

$\Rightarrow 50\times10 - M_C = 0$

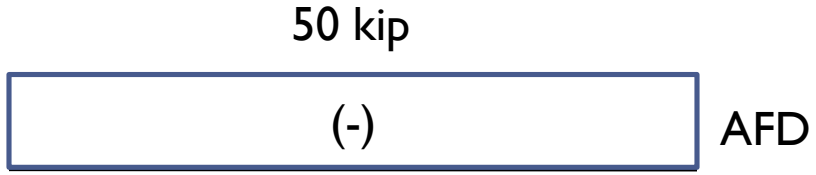
$\Rightarrow M_C = 500$ k'

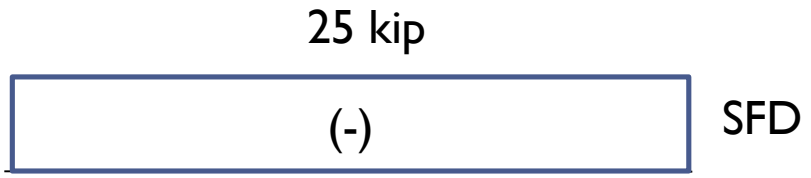
Structural Analysis & Design I

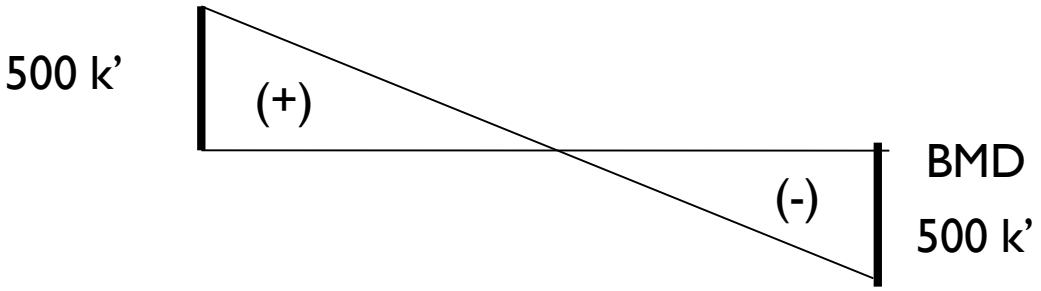
Member BC :



Beam

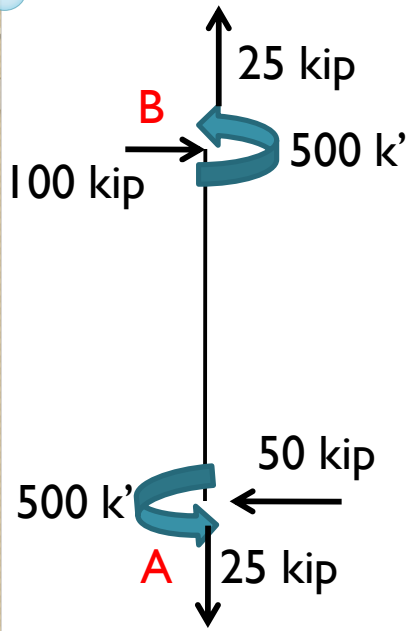




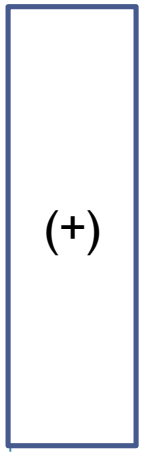


Structural Analysis & Design I

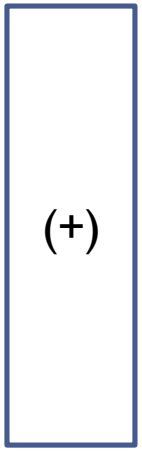
Member AB :



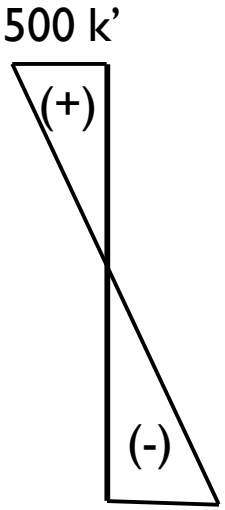
Column



AFD

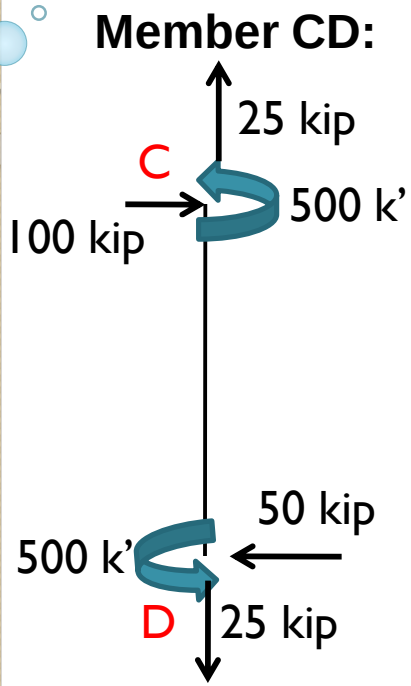


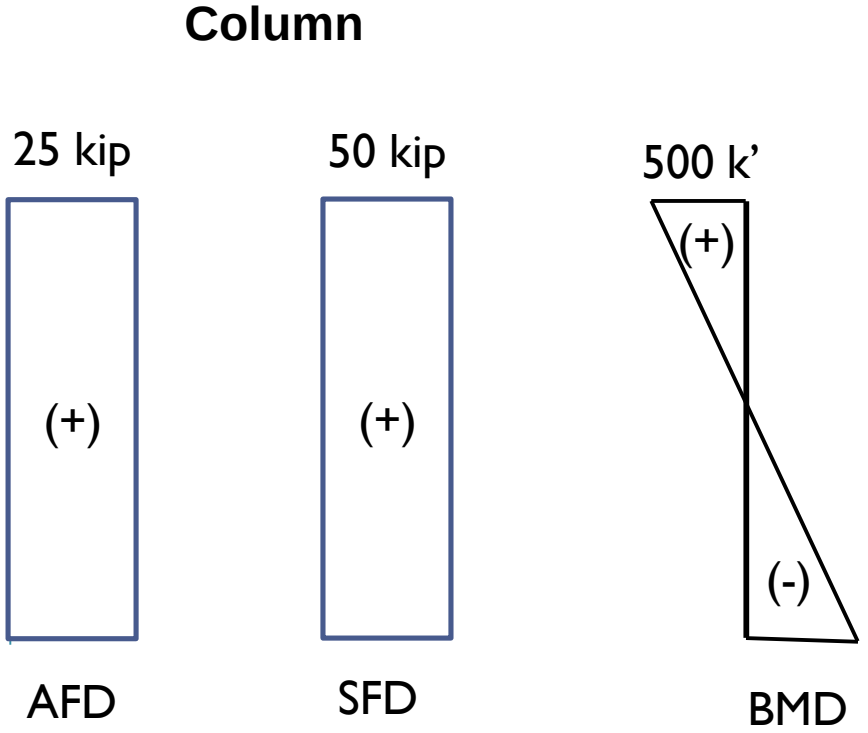
SFD



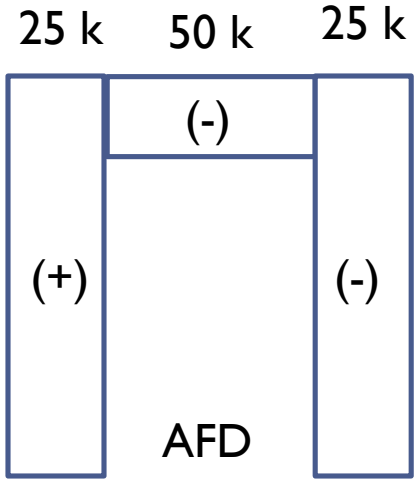
BMD

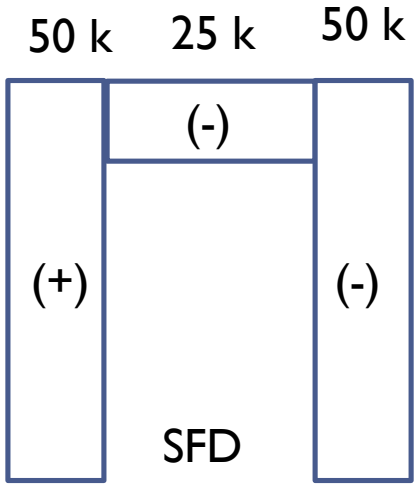
Structural Analysis & Design I

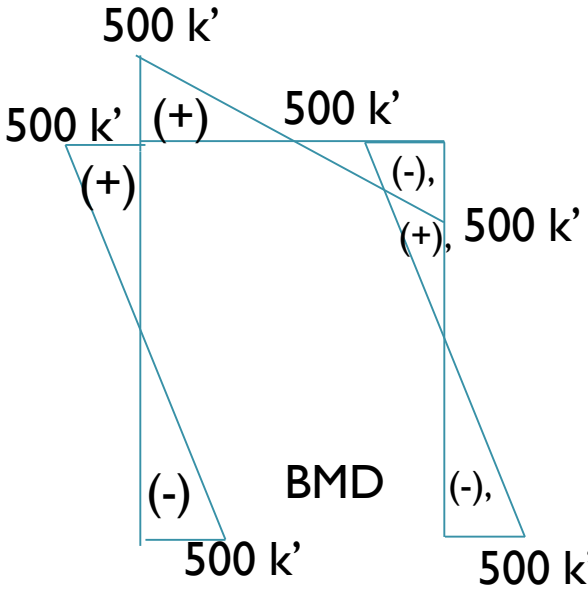


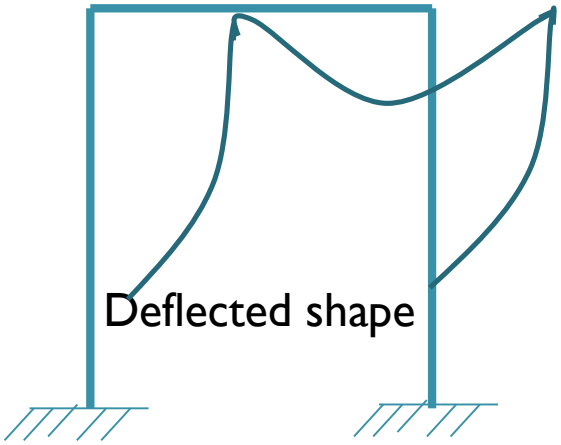


Structural Analysis & Design I





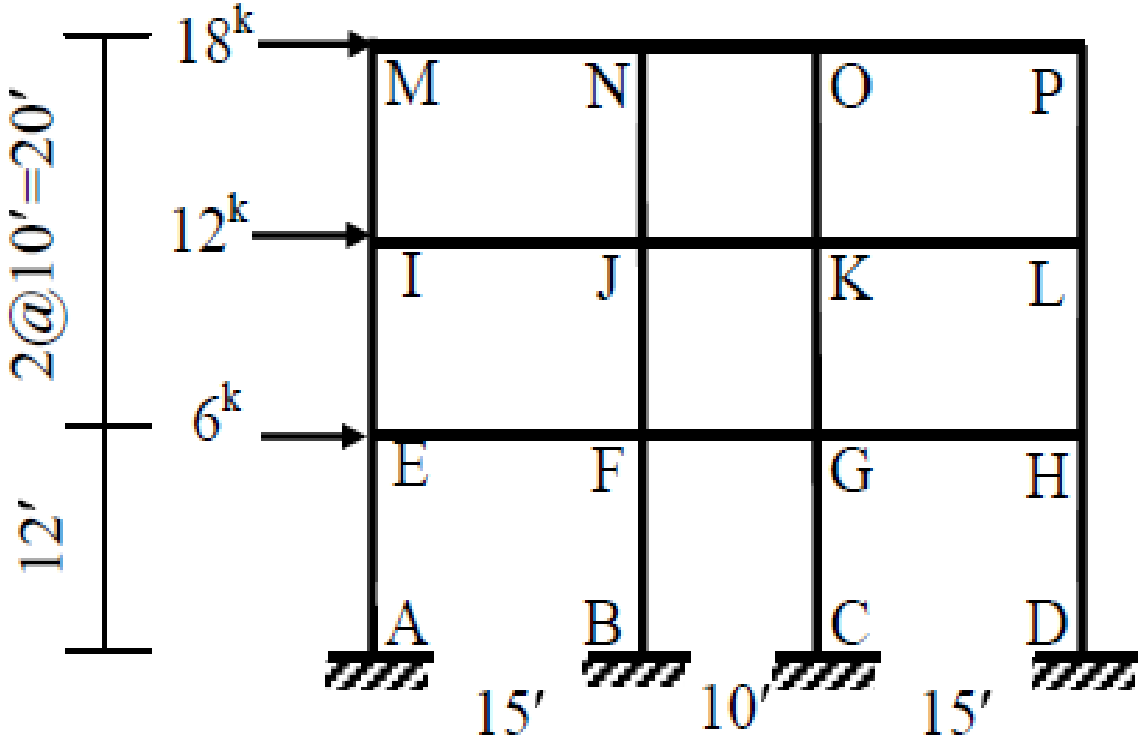




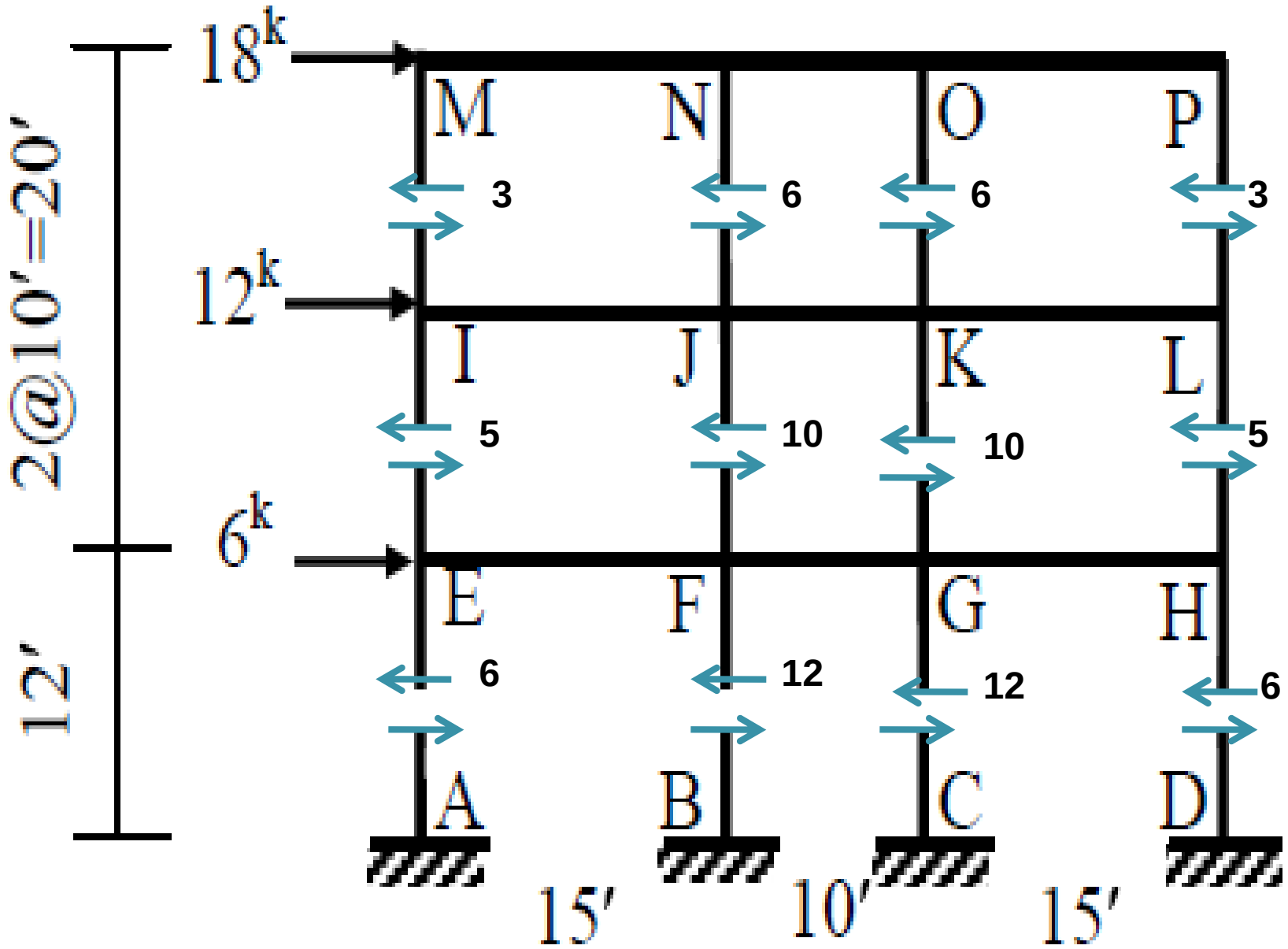
Structural Analysis & Design I

Example

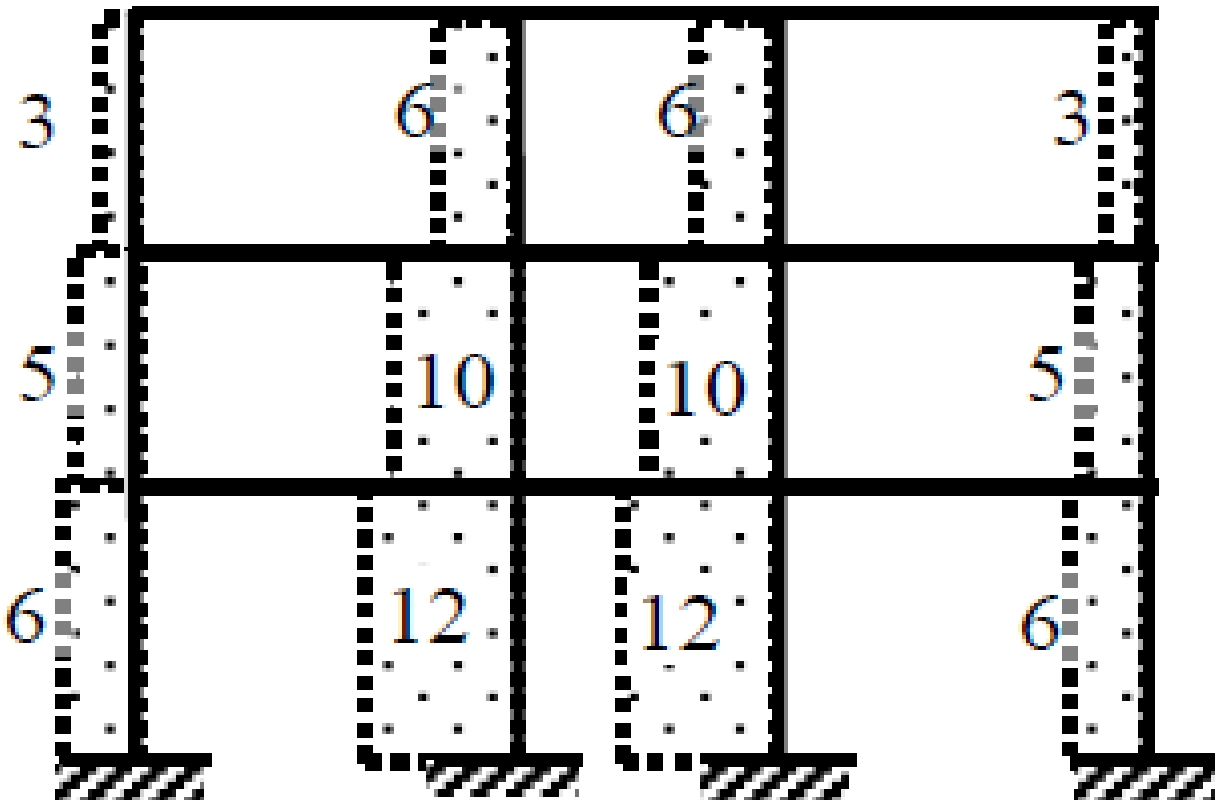
Use the Portal Method to draw the axial force, shear force and bending moment diagrams of the three-storied frame structure loaded as shown below.



Structural Analysis & Design I



Structural Analysis & Design I



Column SFD (k)

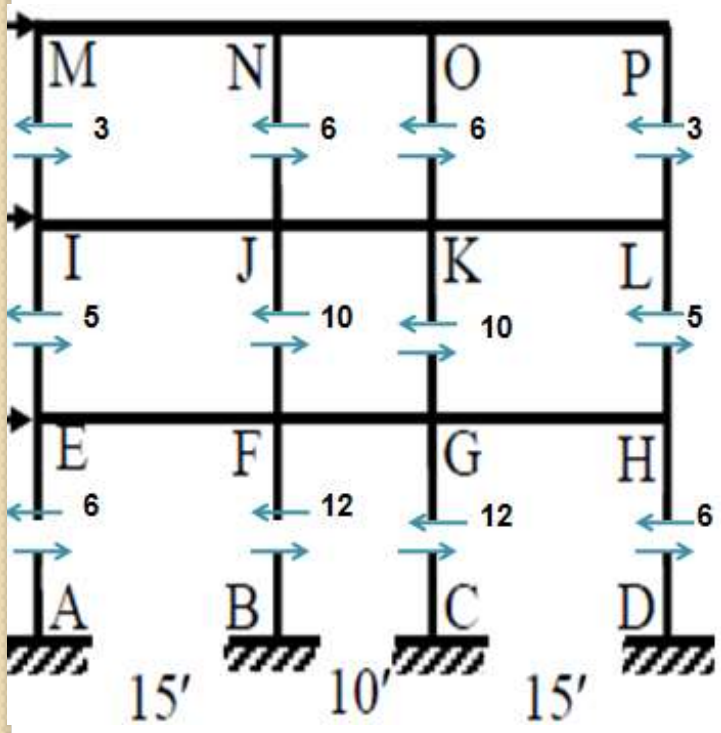
Structural Analysis & Design I

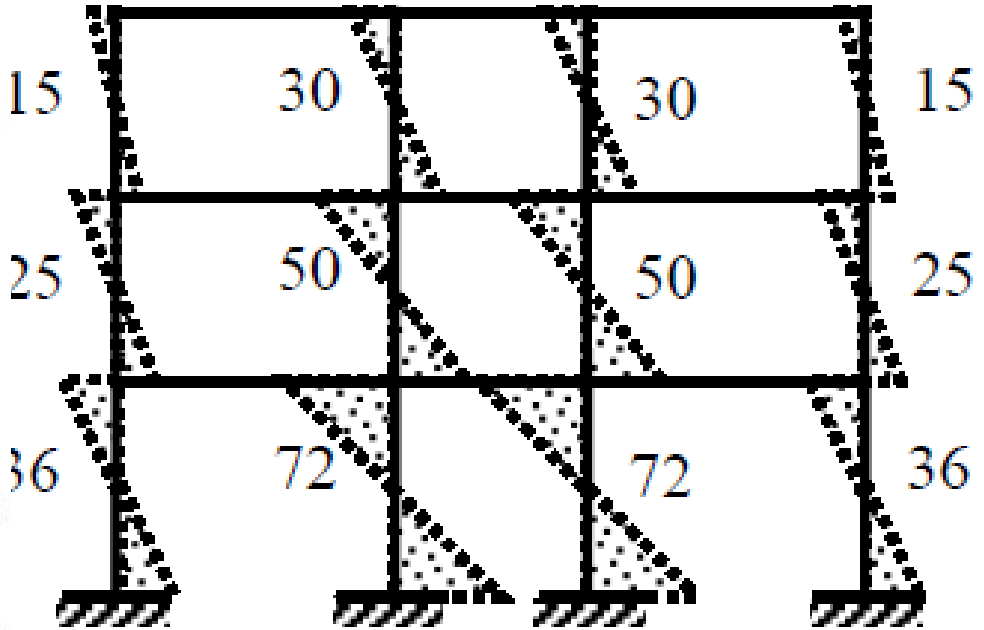
Bending moments are

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

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

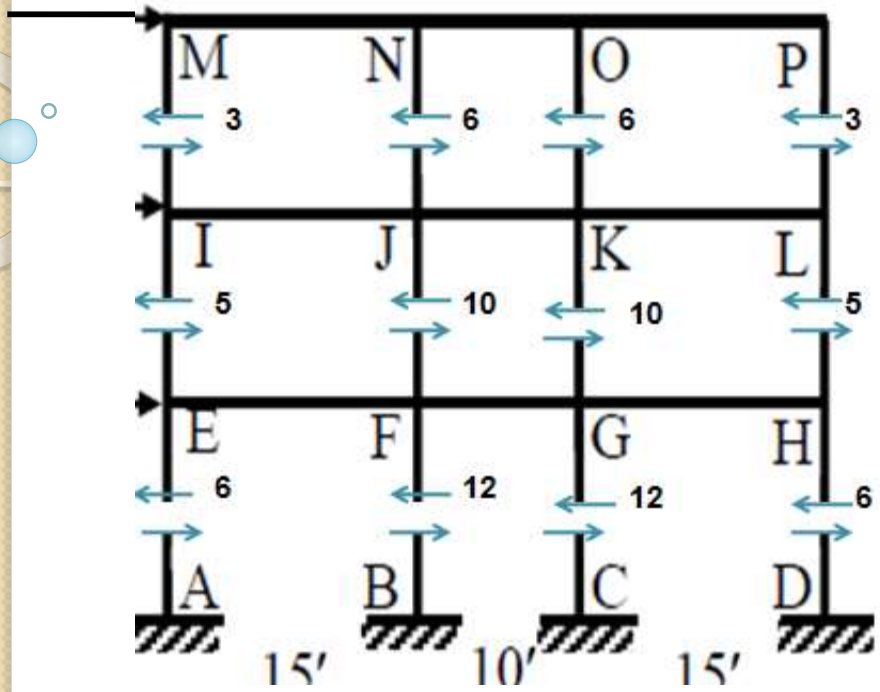
AE=6x12/2=36k'
BF=12x12/2=72k'
CG=12x12/2=72k'
DH=6x12/2=36k'

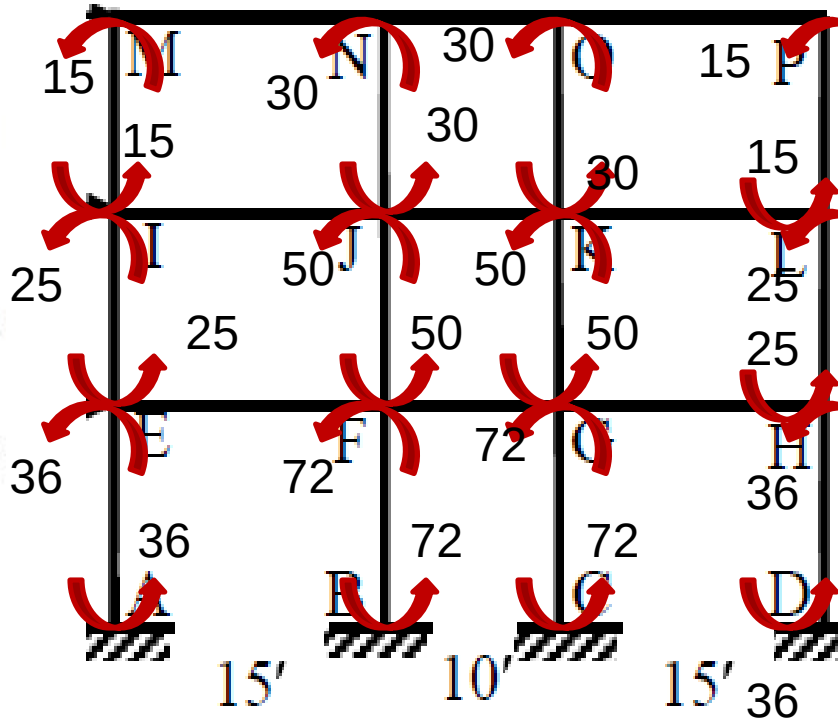


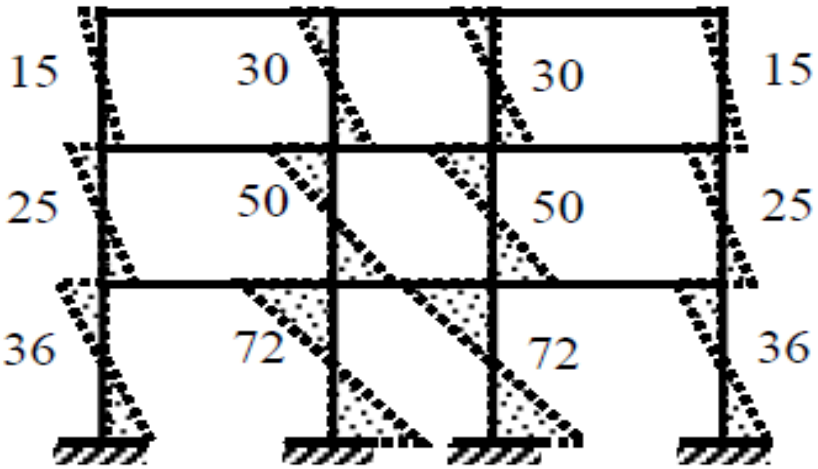


Column BMD (k-ft)

Structural Analysis & Design I

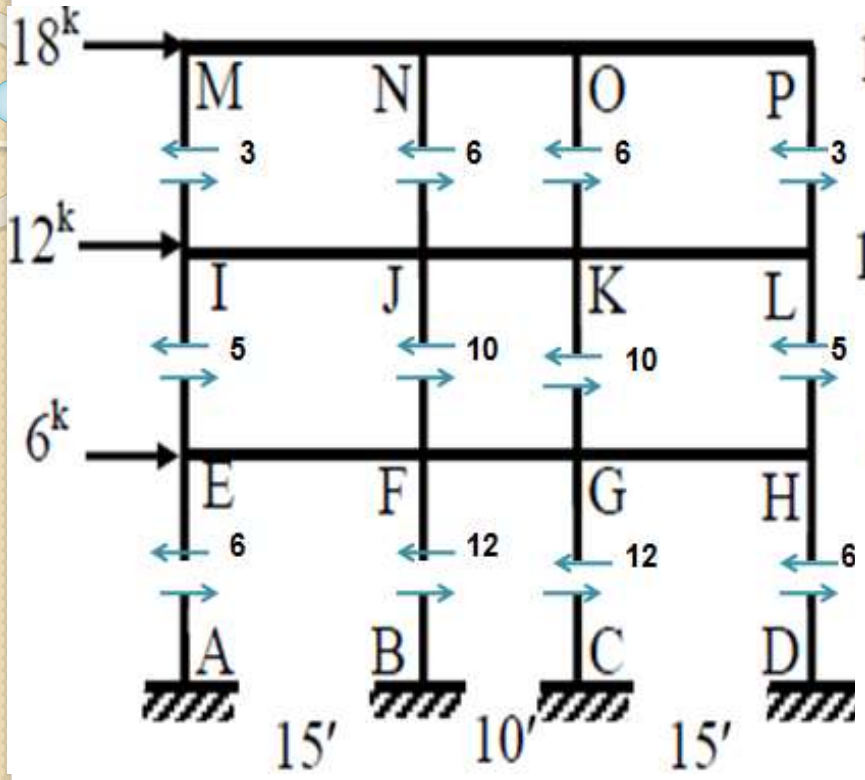


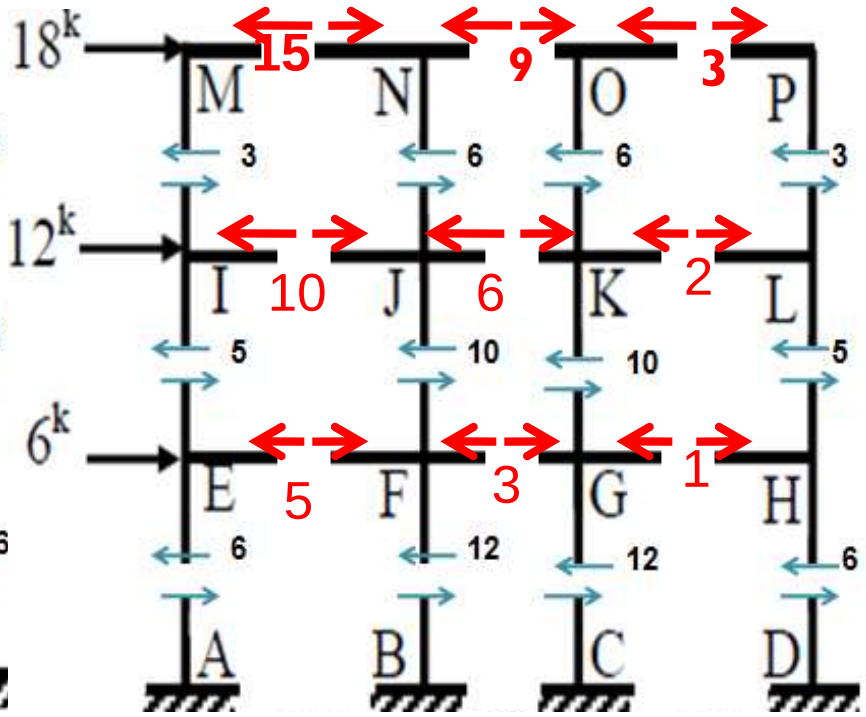


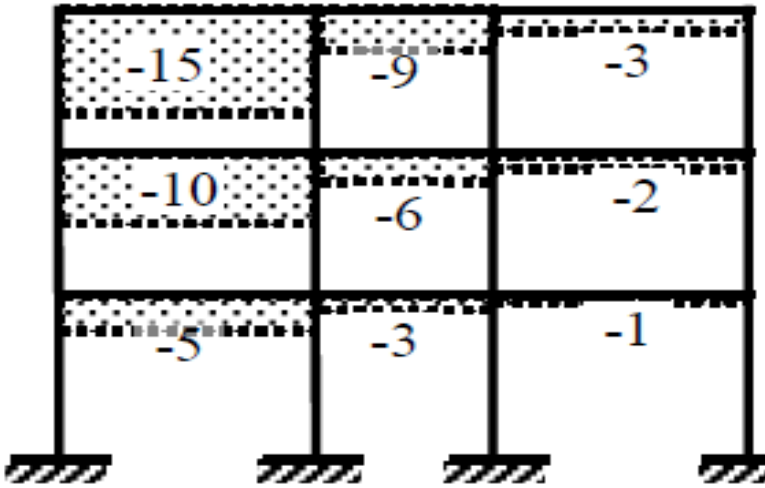


Column BMD (k-ft)

Structural Analysis & Design I





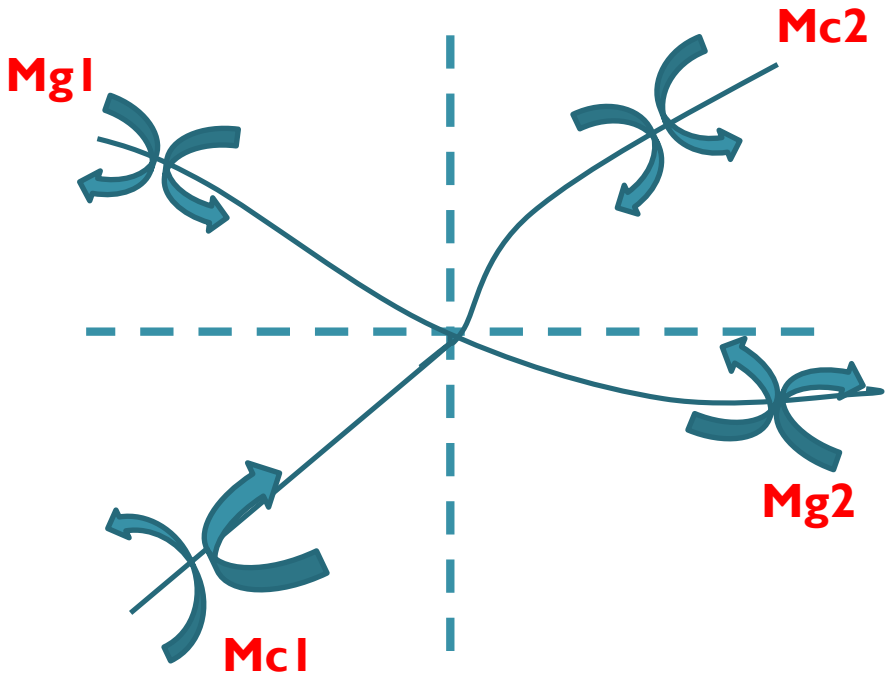


AFD Beam

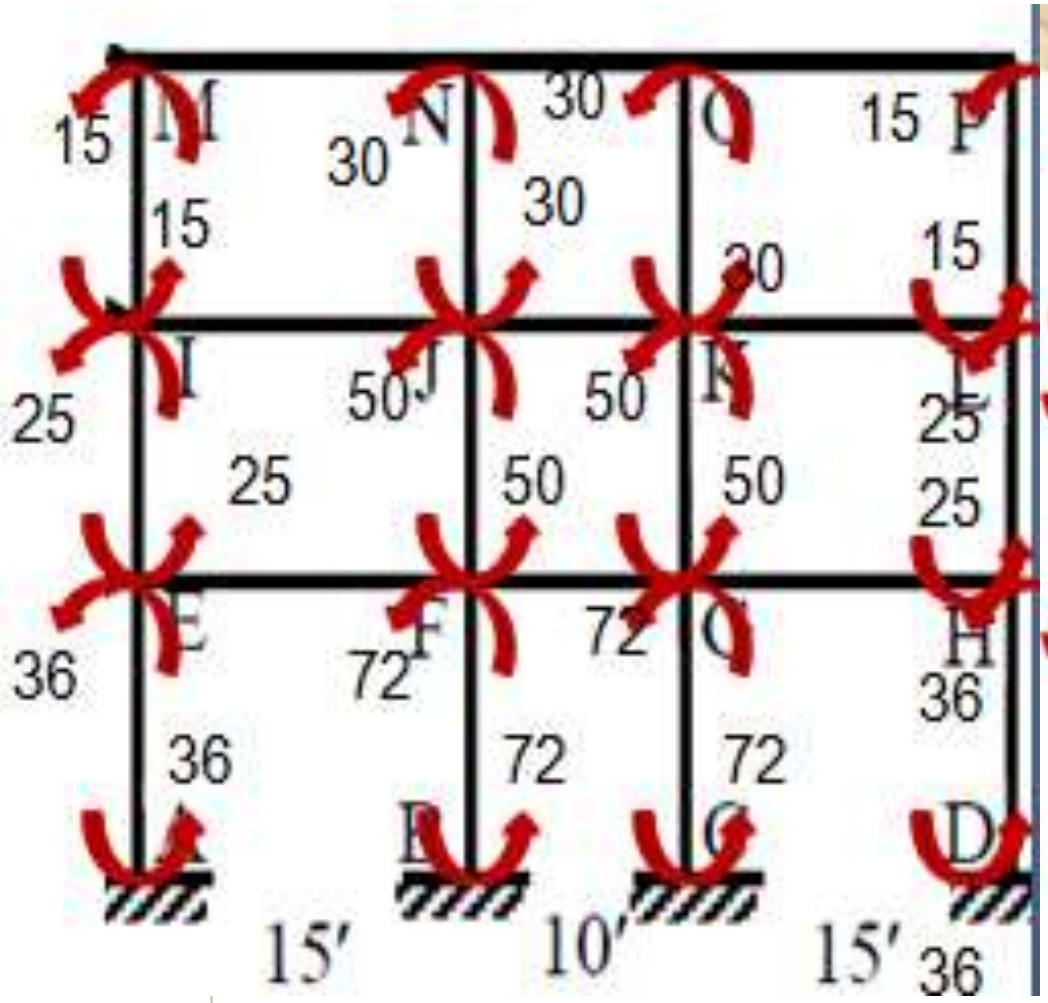
Structural Analysis & Design I

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

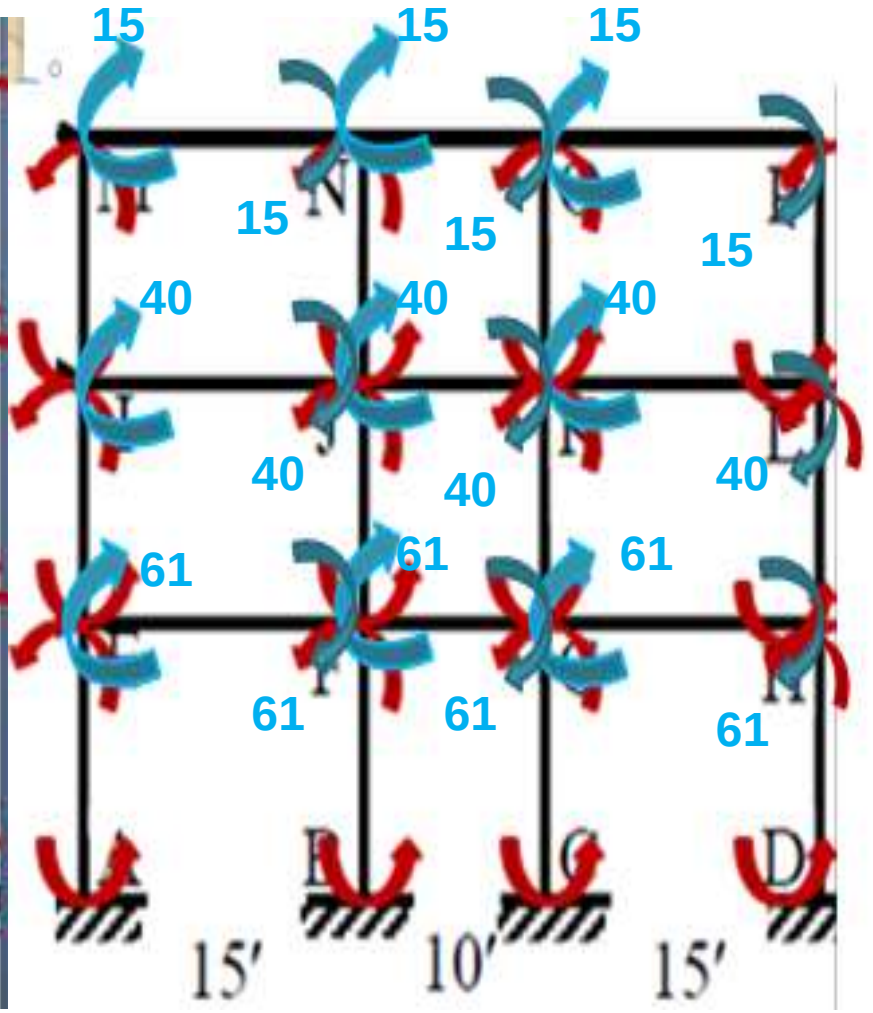
Mc1+Mc2=Mg1+Mg2



Structural Analysis & Design I

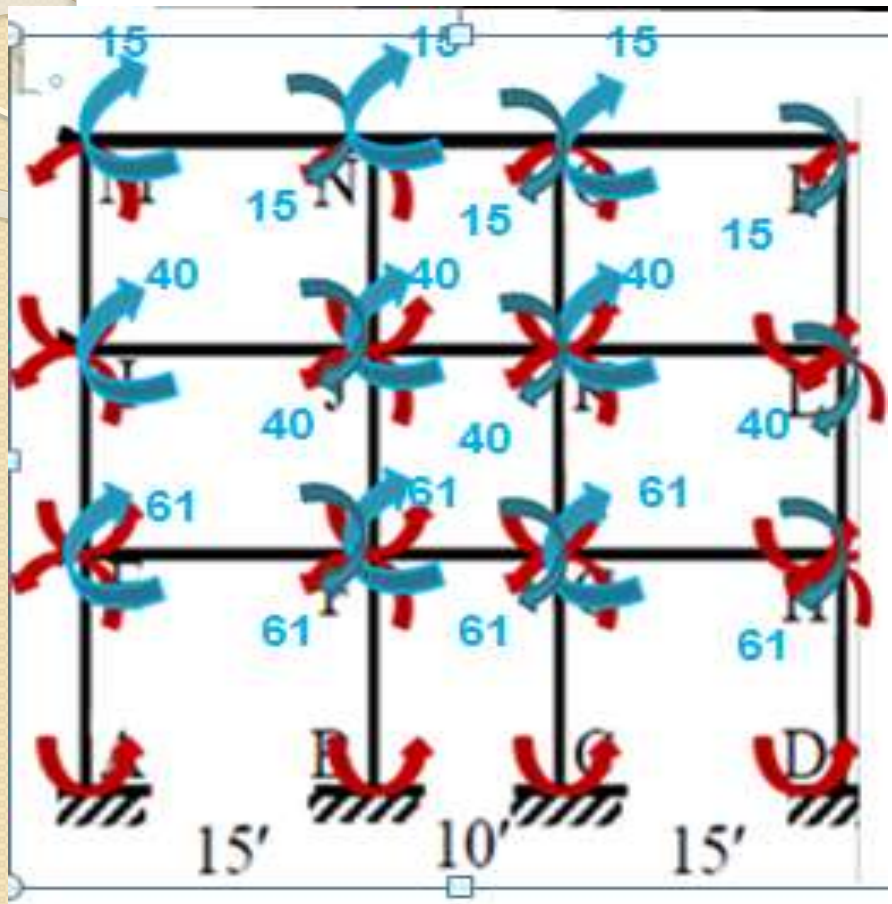


Column BM



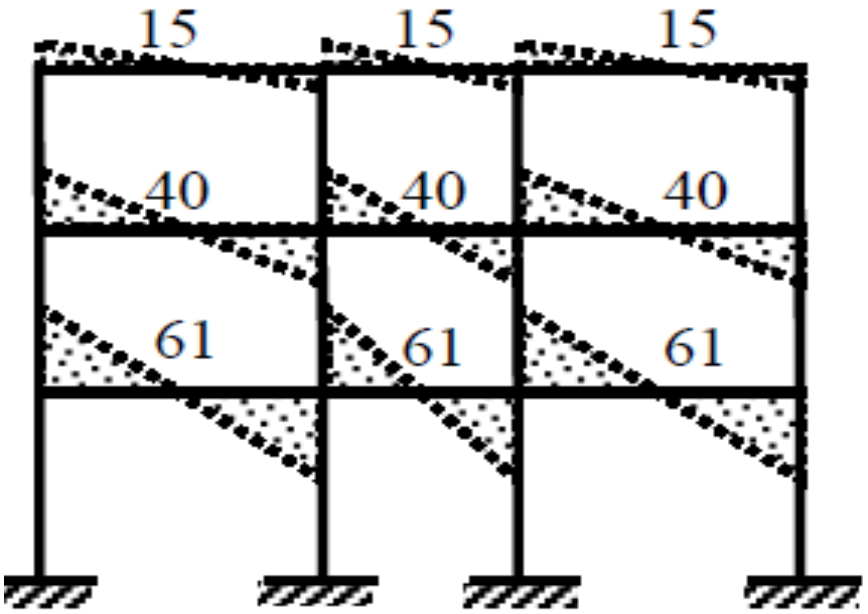
Girder BM

Structural Analysis & Design I



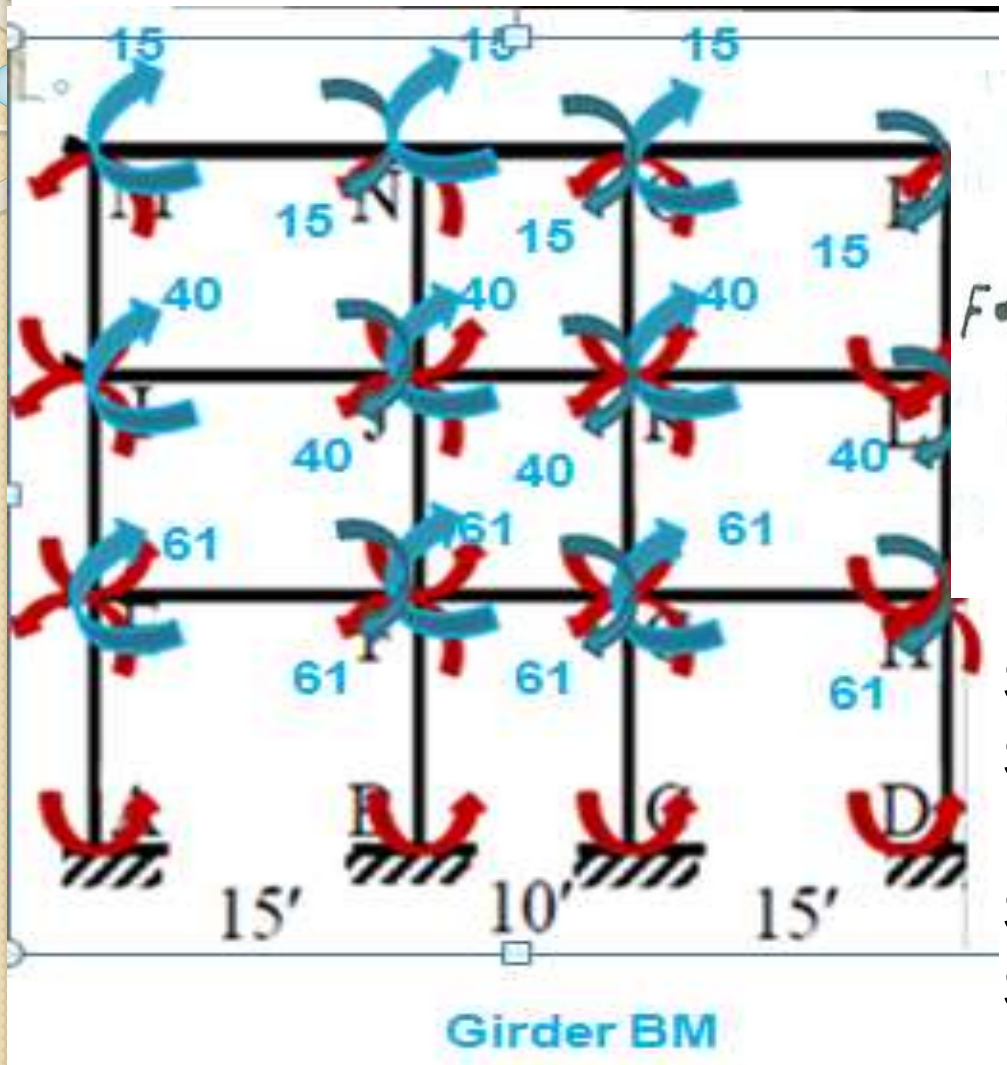
Girder BM

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

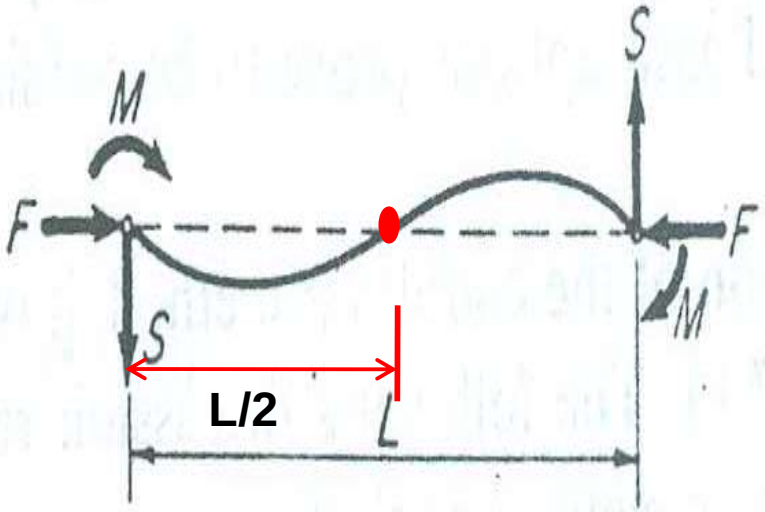


Beam BMD (k-ft)

Structural Analysis & Design I



Girder BM



S X L/S - M=0

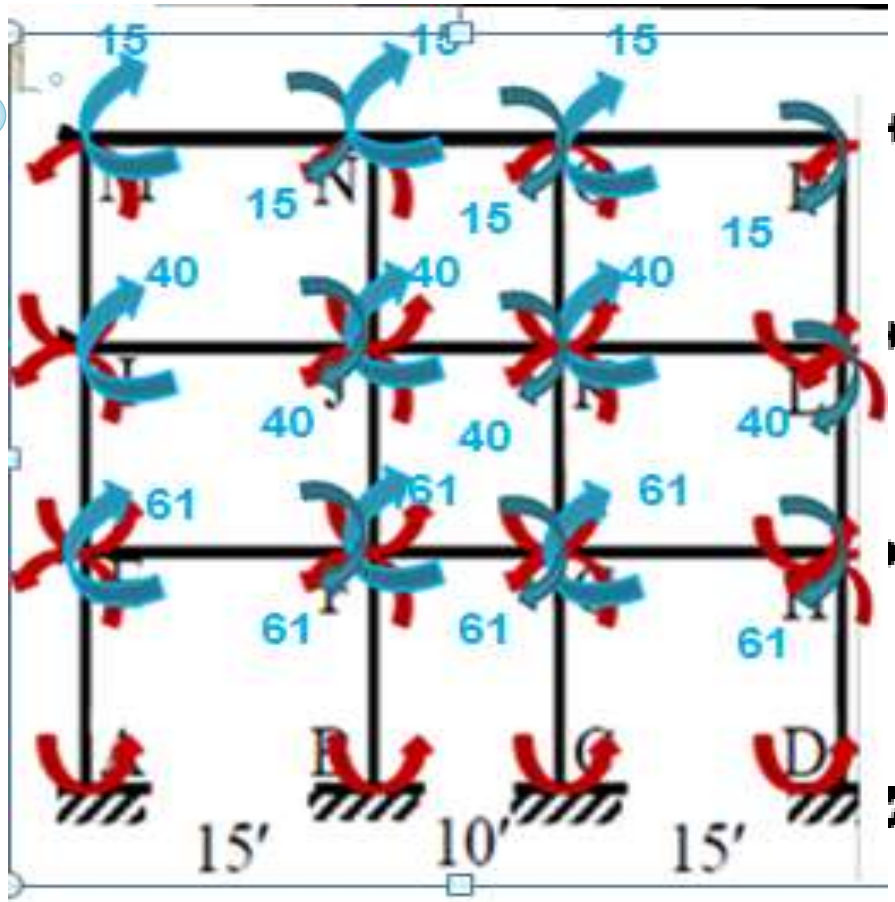
S = 2M/L

= 2x15/15 = 2 kip (MN)

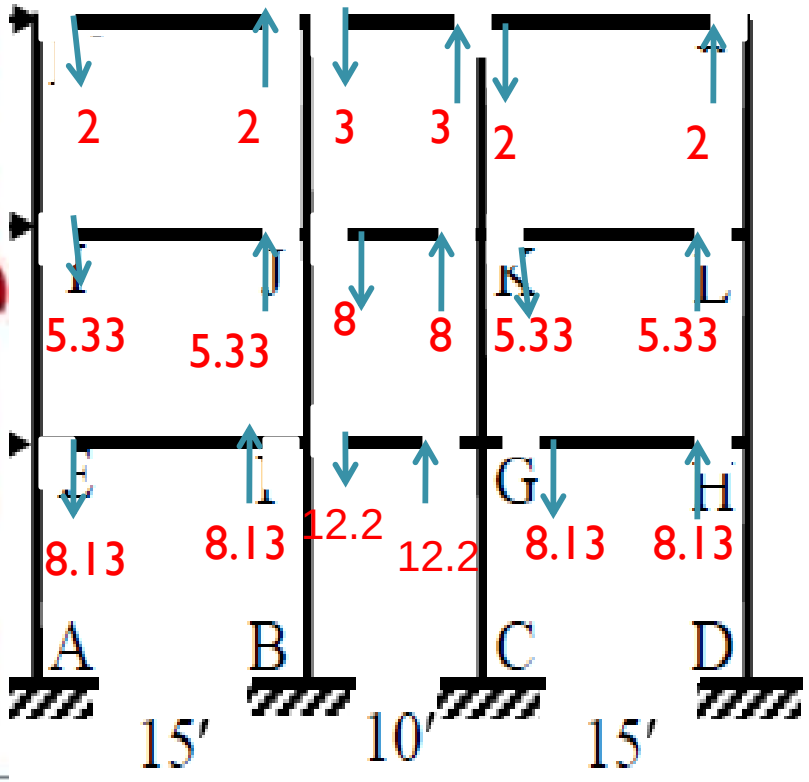
S = 2x15/10 = 3 kip (NO)

S = 2 kip (OP)

Structural Analysis & Design I



Girder BM



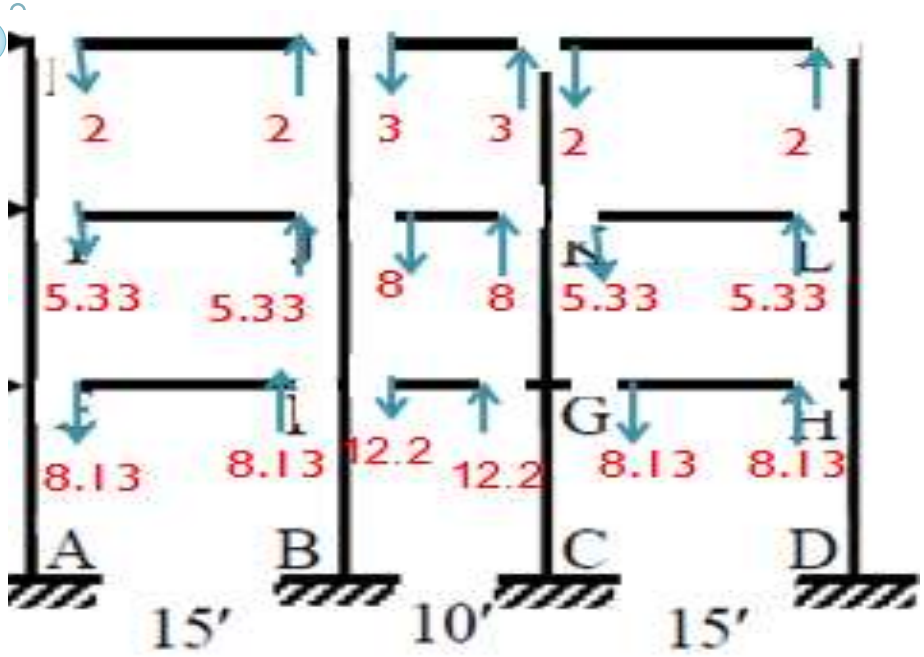
SF in Girder

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

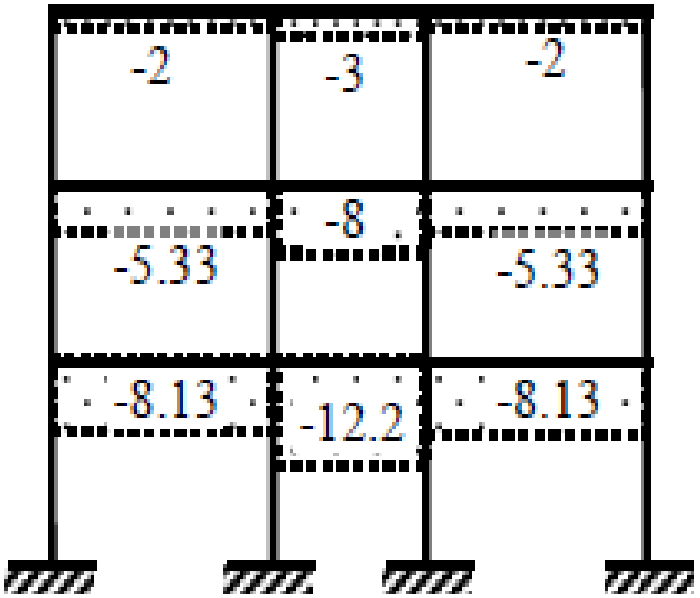
S = 2x40/10 = 8 kip

S = 8.13 kip

Structural Analysis & Design I

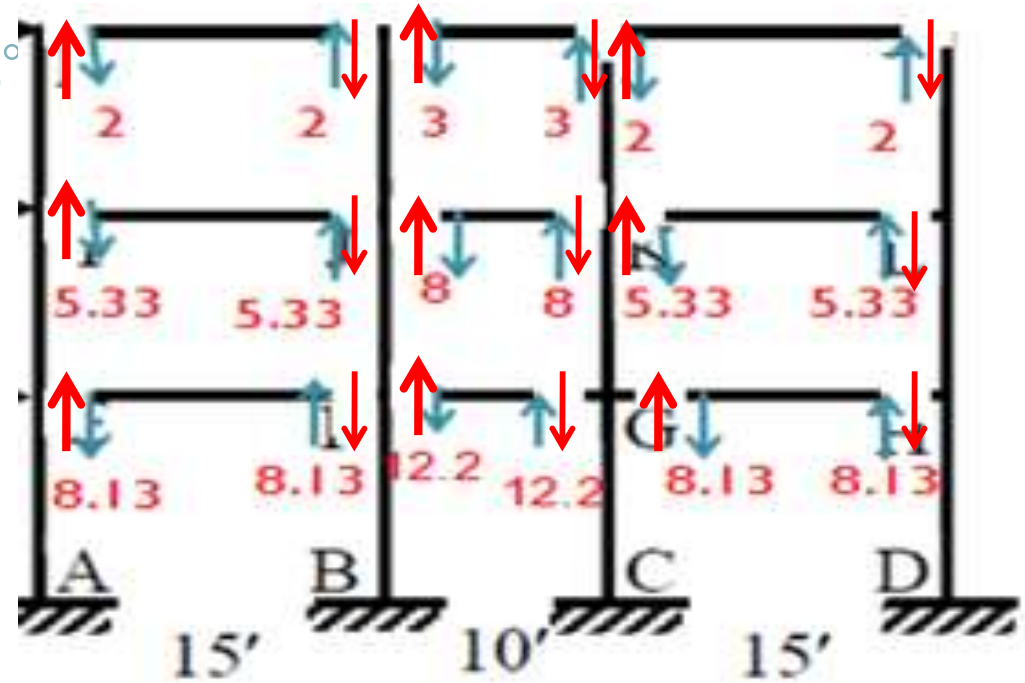


SF in Girder

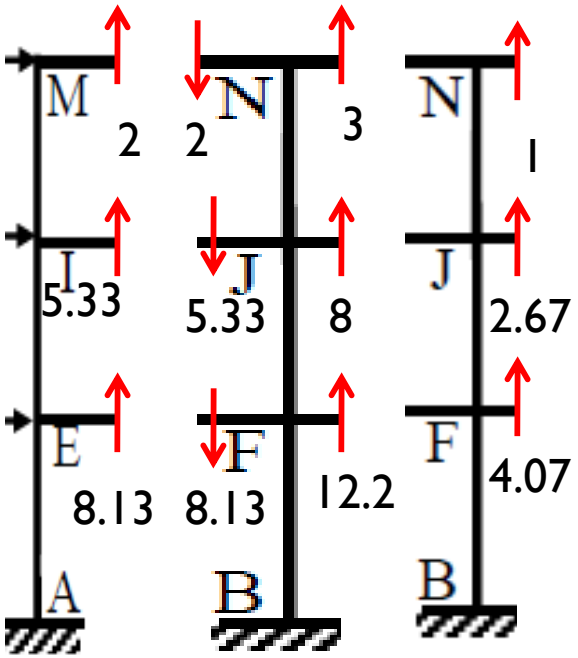


Girder SFD

Structural Analysis & Design I



SF in Girder



Column AF

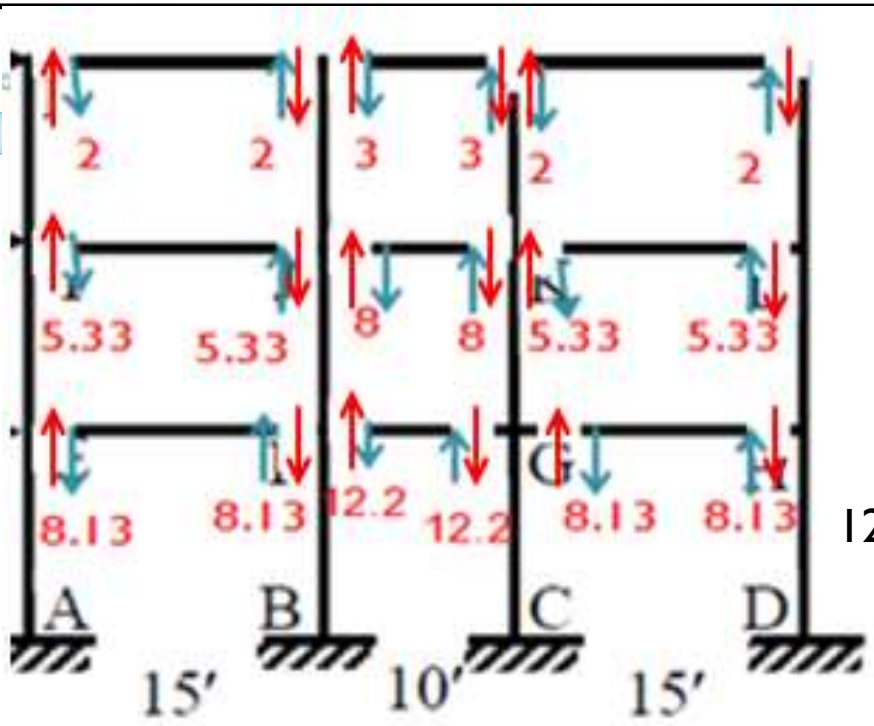
Tension

N = 3-2=1

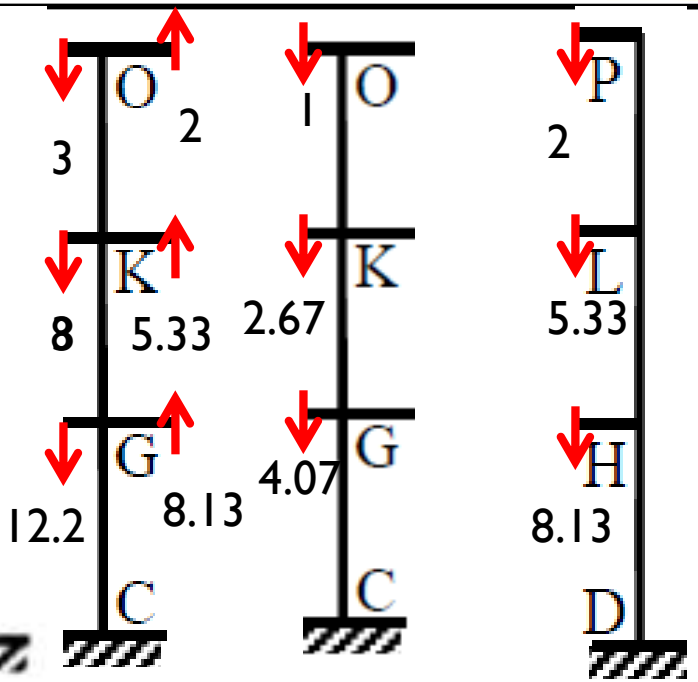
J = 8-5.33= 2.67

F = 12.2-8.13= 4.07

Structural Analysis & Design I

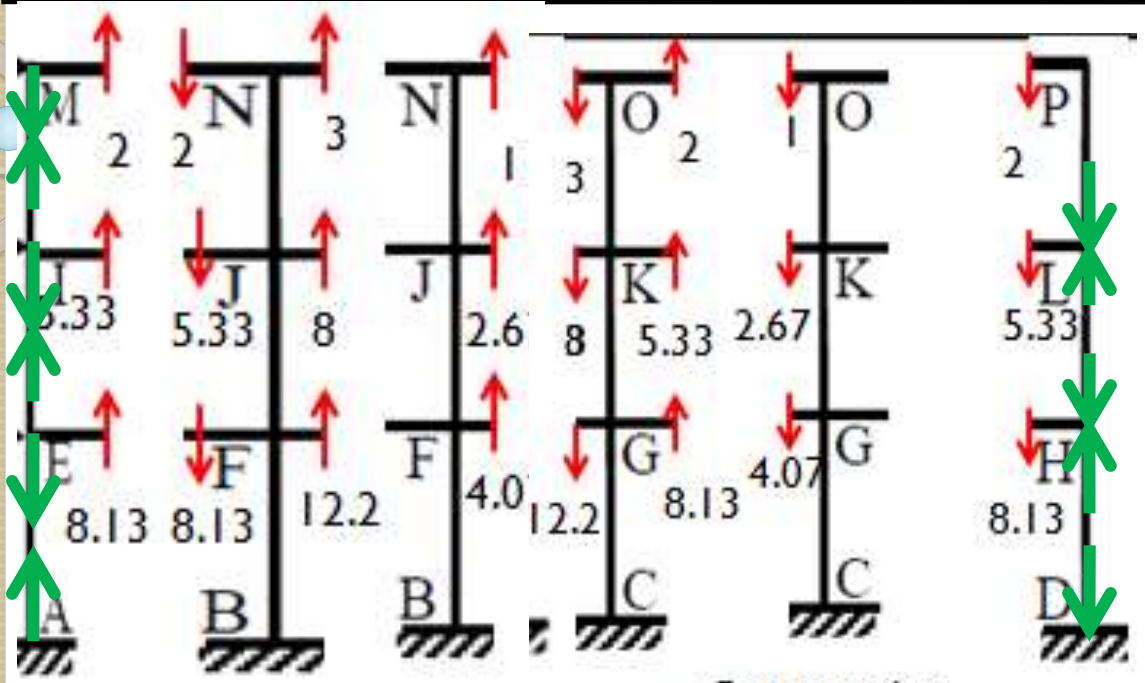


SF in Girder

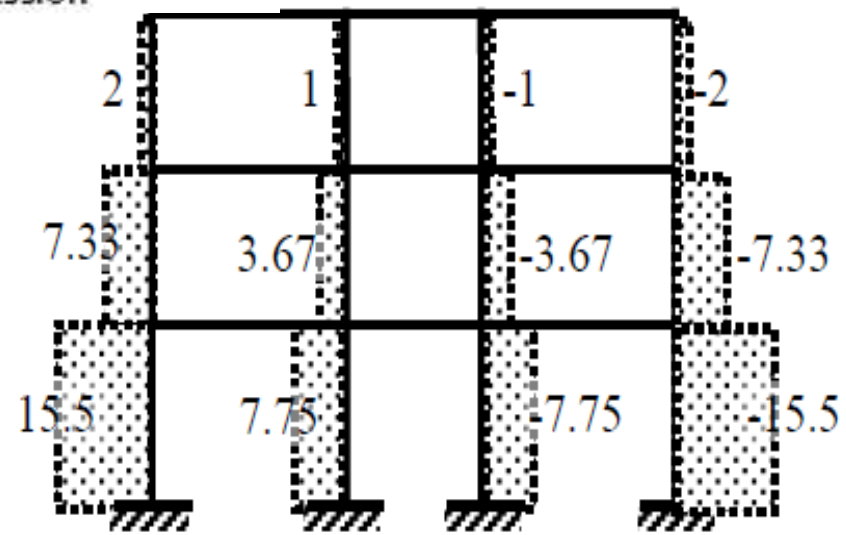


Compression

Structural Analysis & Design I



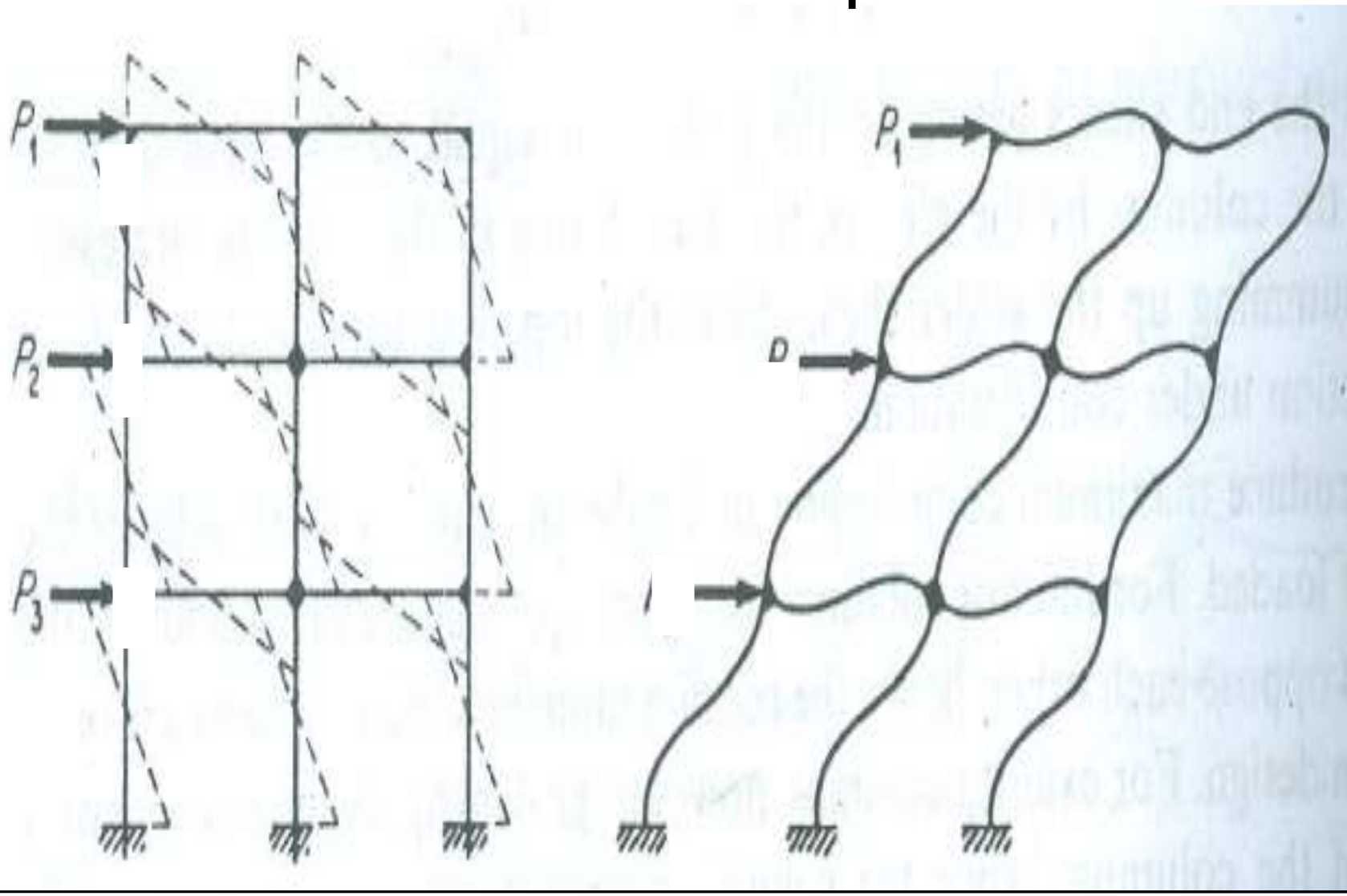
Compression



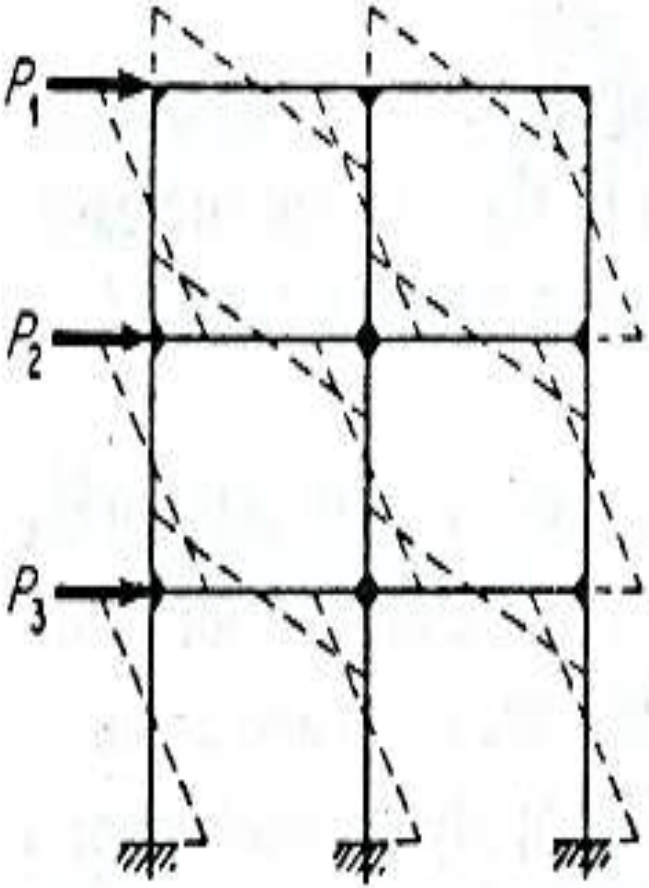
Column A.F.

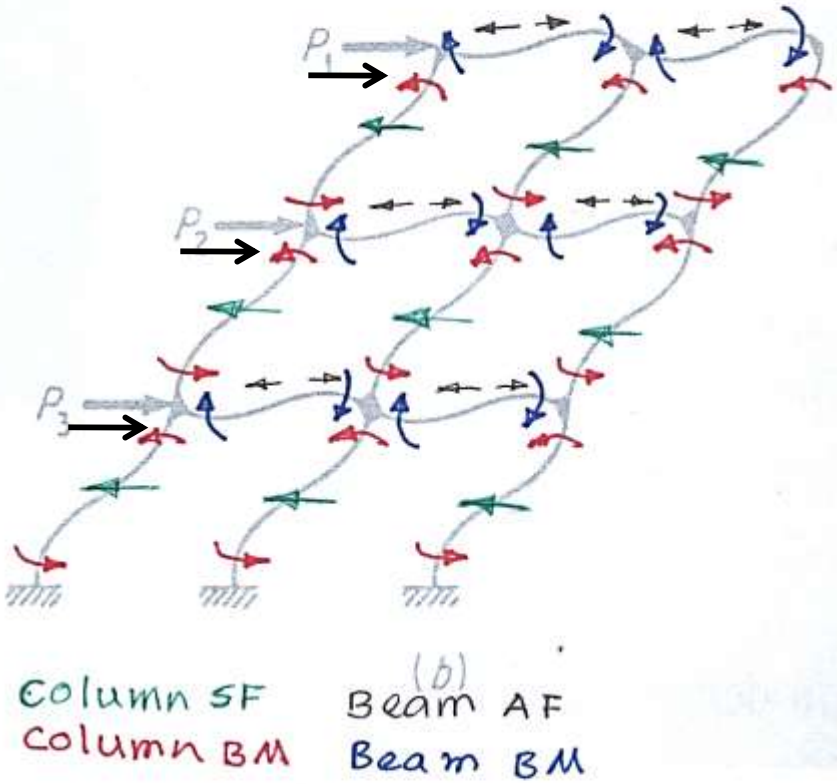
Structural Analysis & Design I

Deflected Shape



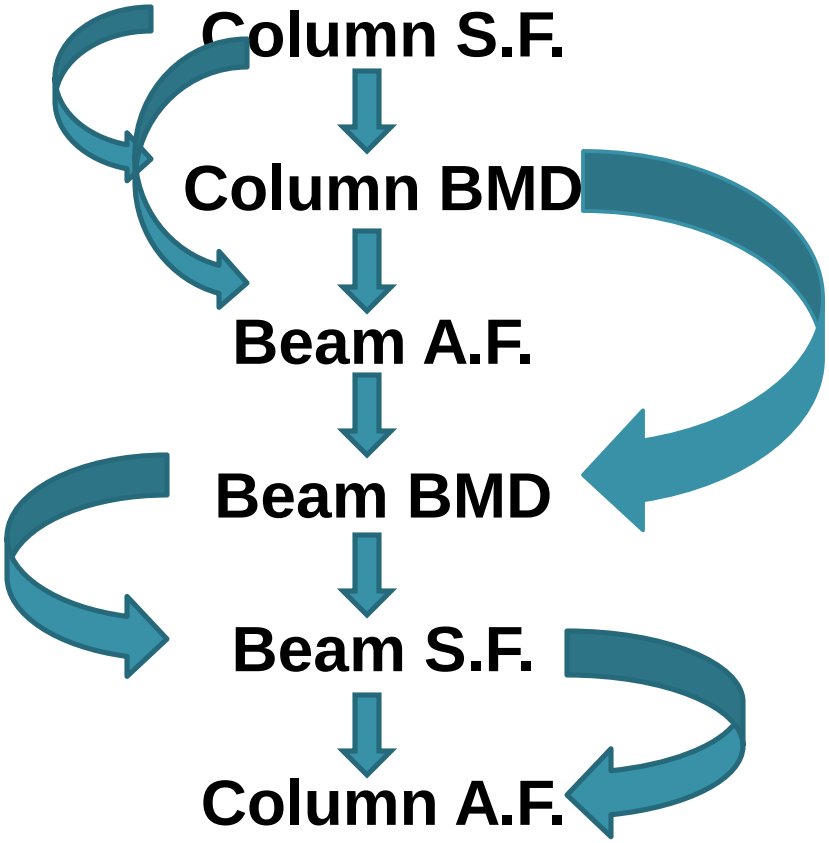
Structural Analysis & Design I





Structural Analysis & Design I

Order of analysis

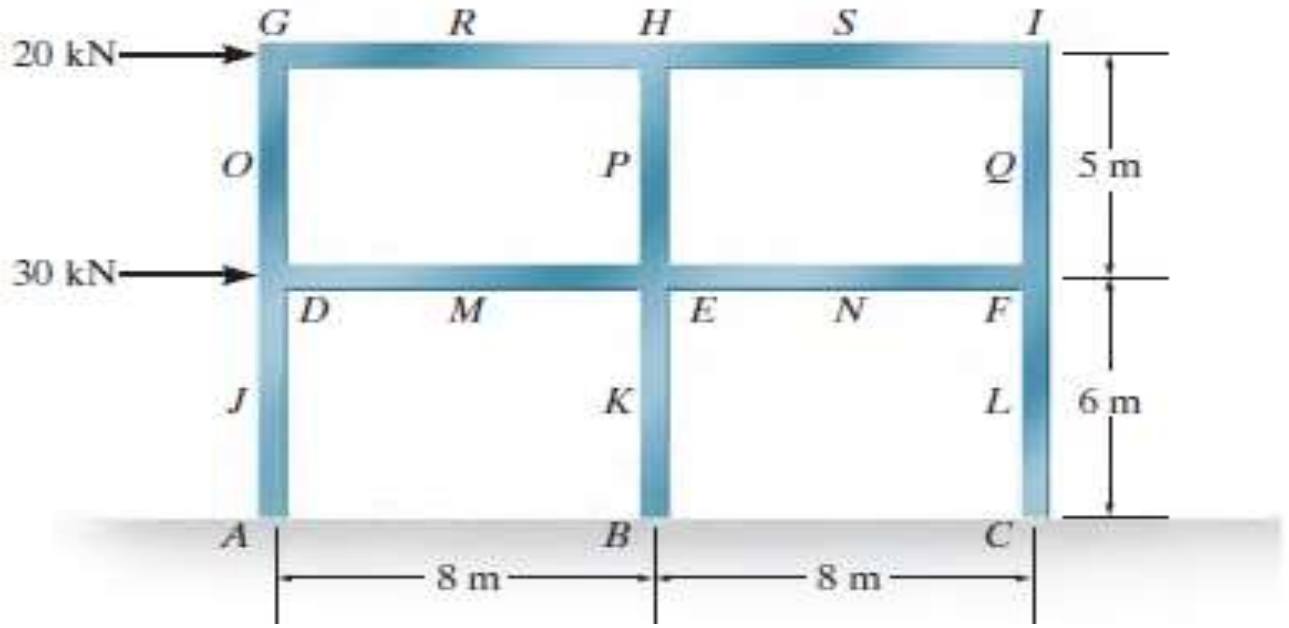


Deflected Shape

Structural Analysis & Design I

Assignment (Portal)-1

Determine (approximately) the reactions at the base of the columns of the frame shown in Fig. . Use the portal method of analysis.



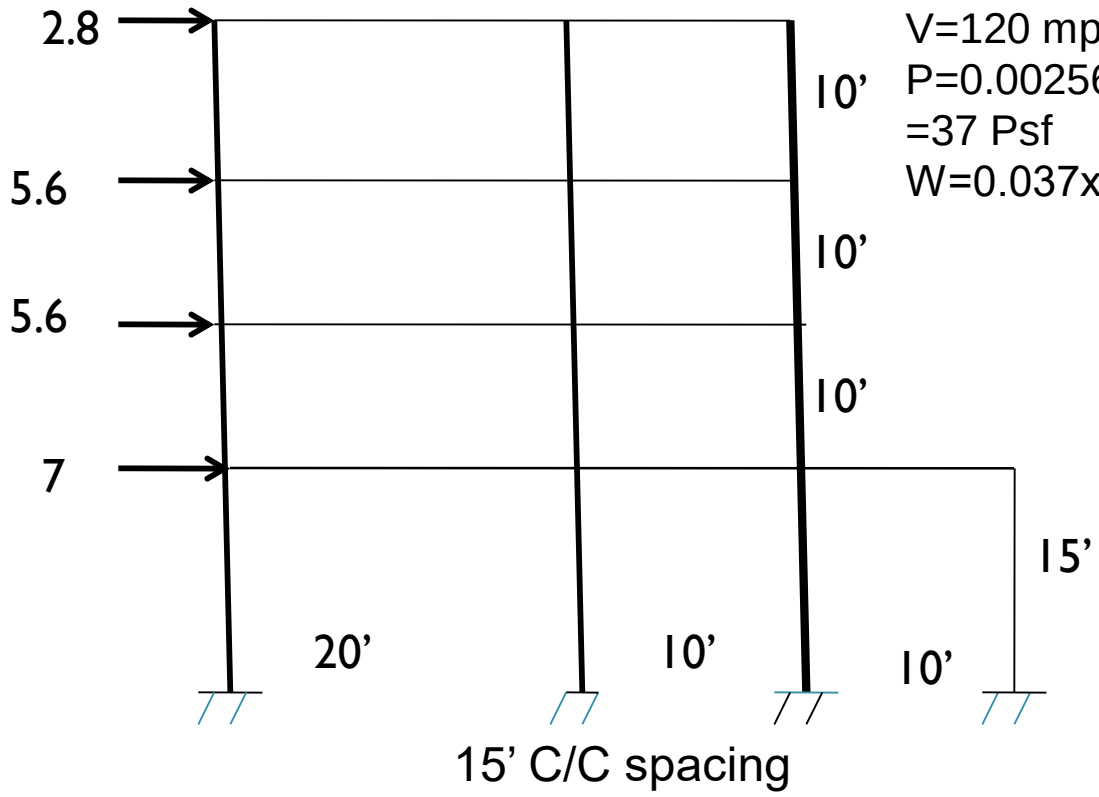
Also, Column SFD, BMD and Beam A.F. , BMD and SFD

Structural Analysis & Design I

Assignment (Portal)-2

Example , Section 7.10 Norris and Wilber

Assignment (Portal)-3



Given, Wind velocity
V=120 mph
P=0.00256V^2 (psf)
=37 Psf
W=0.037x15=0.56k/' of Ht

Find Col S.F, B.M.,A.F.

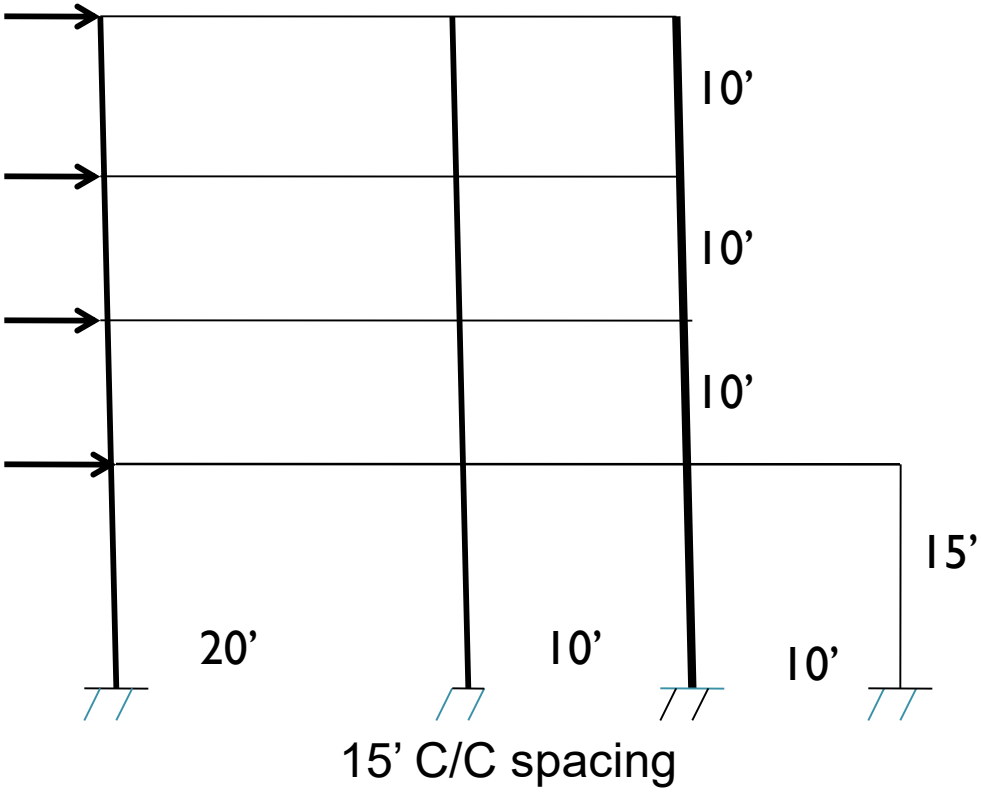
Beam A.F., B.M., A.F.

Structural Analysis & Design I

Assignment (Portal)-2

Example , Section 7.10 Norris and Wilber

Assignment (Portal)-3

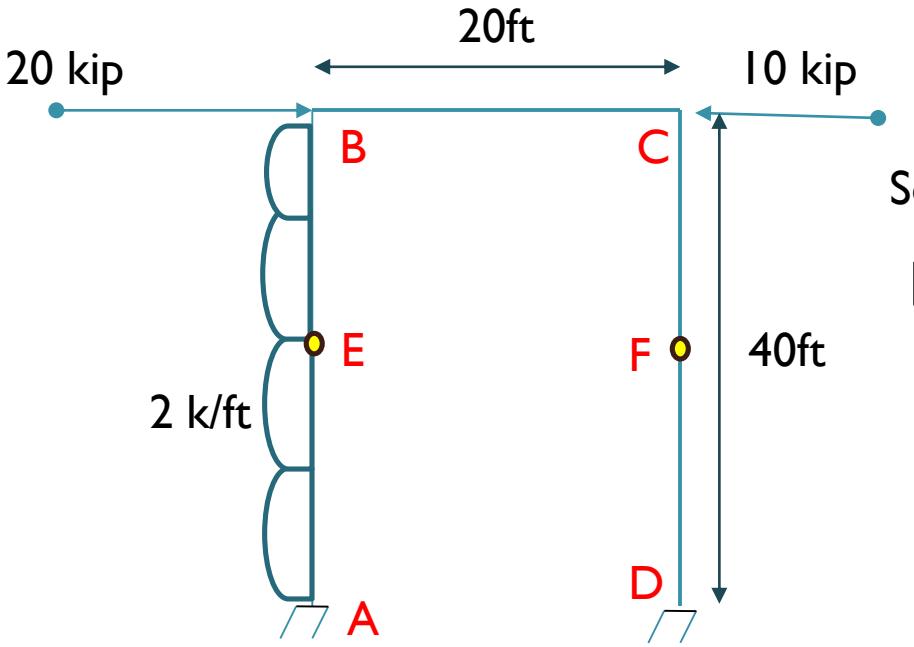


Find Col S.F, B.M.,A.F.

Beam A.F., B.M., A.F.

Structural Analysis & Design I

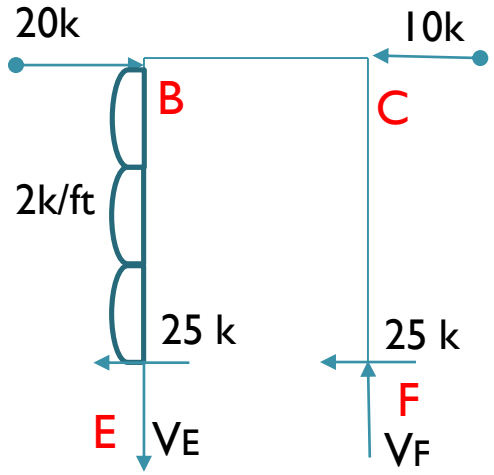
Problem:



Solution:

DI= (3*3+6)-(3*4+0)
=3°

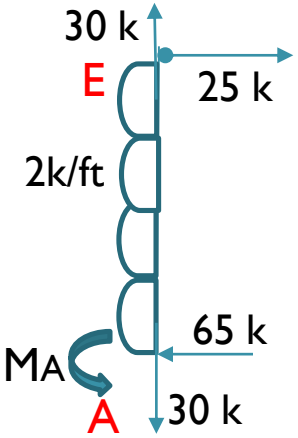
Structural Analysis & Design I



+ $\sum M_E = 20*20+2*20*10-10*20-V_F*20 = 0$

$\Rightarrow V_F = 30$ kip

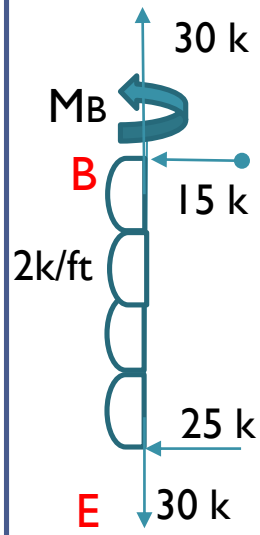
Similarly, $V_E = -30$ kip



+ $\sum M_A = 0$

$\Rightarrow 2*20*10+25*20-M_A = 0$

$\Rightarrow M_A = 900$ kip-ft



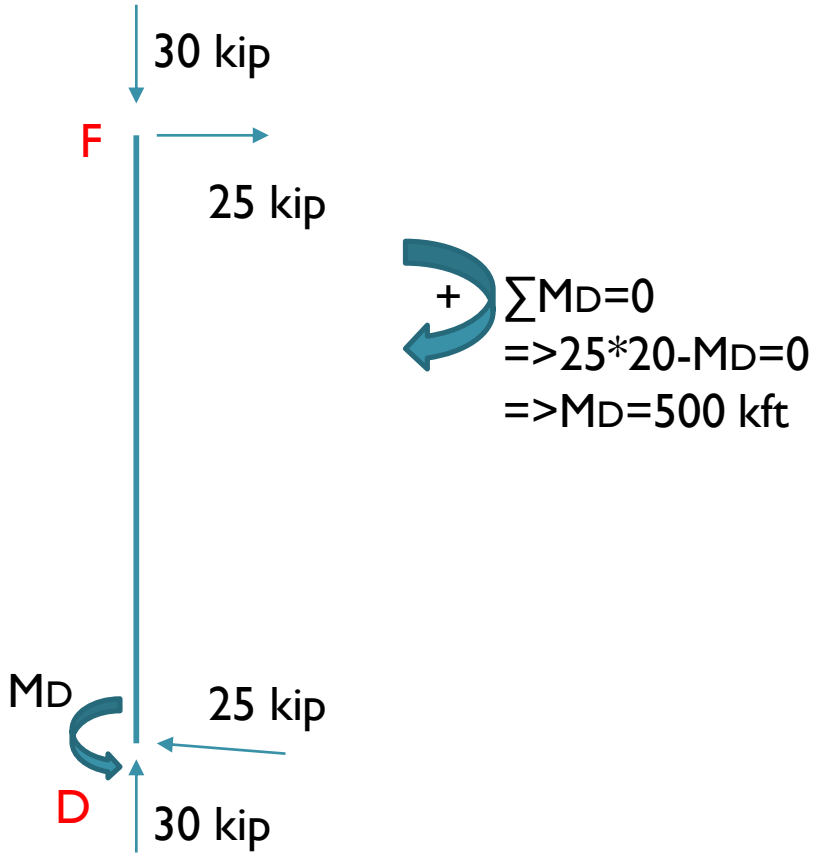
+ $\sum M_B = 0$

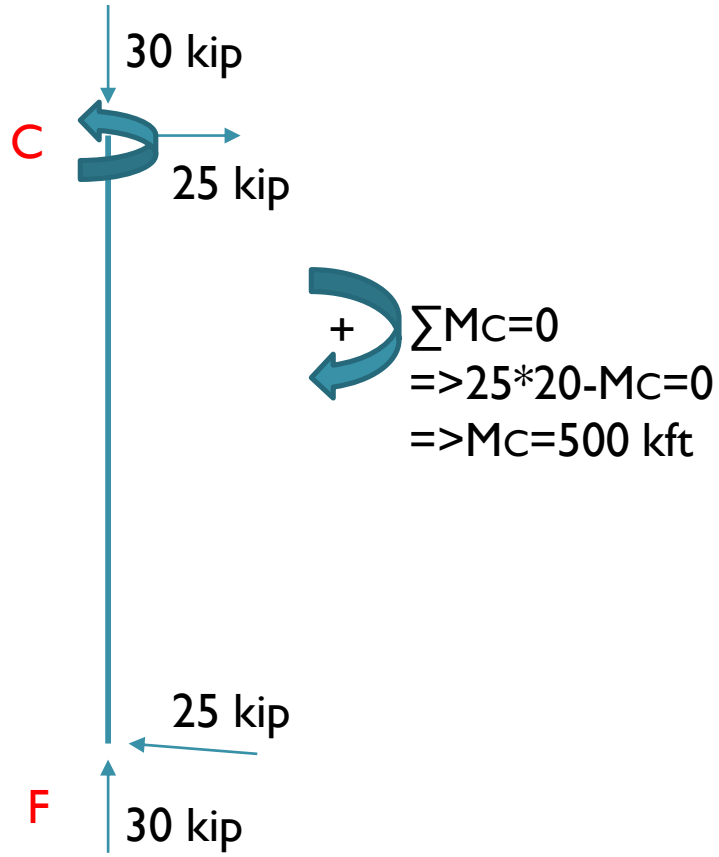
$\Rightarrow 25*20-2*20*10-M_B = 0$

$\Rightarrow M_B = 100$kft

Structural Analysis & Design I

- **Assignment**

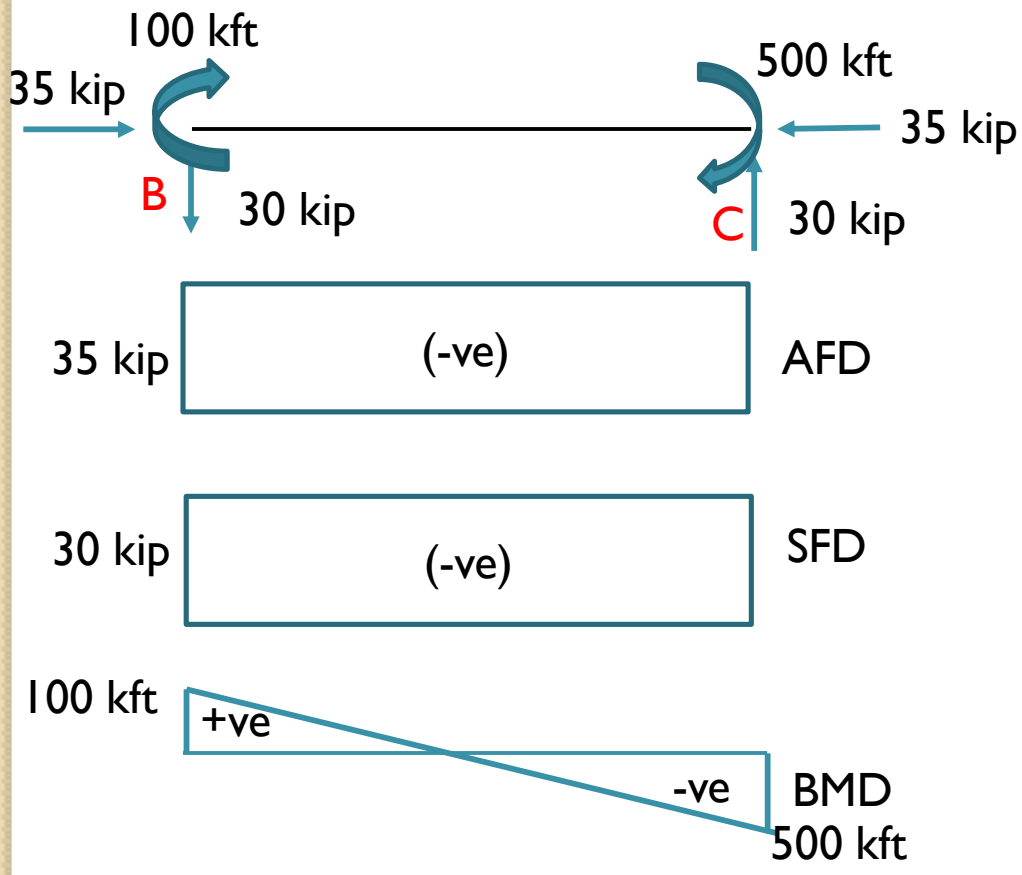




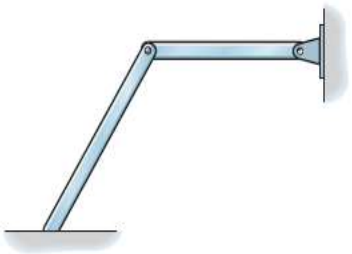
Structural Analysis & Design I

Assignment

Member BC:

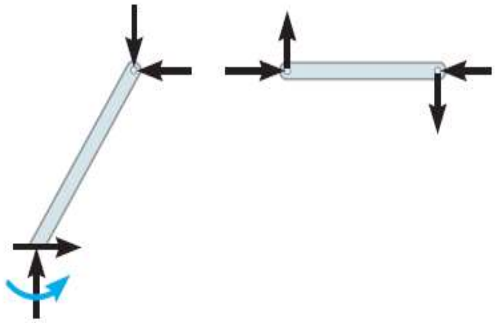


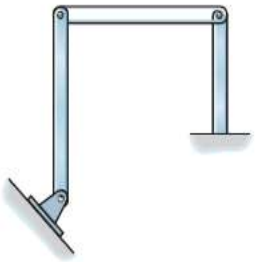
Structural Analysis & Design I



(a)

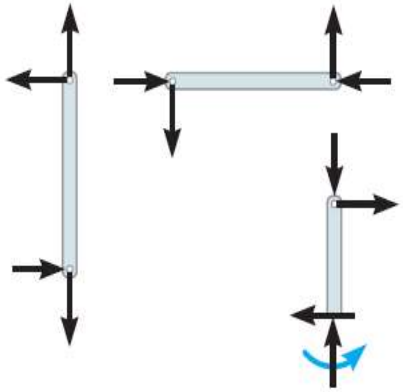
$r = 7, n = 2, 7 > 6$
Statically indeterminate to the first degree *Ans.*

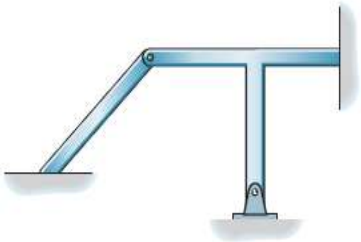




(b)

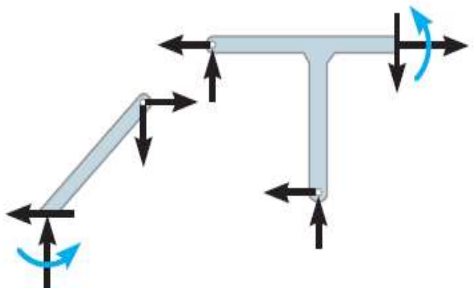
$r = 9, n = 3, 9 = 9,$
Statically determinate *Ans.*



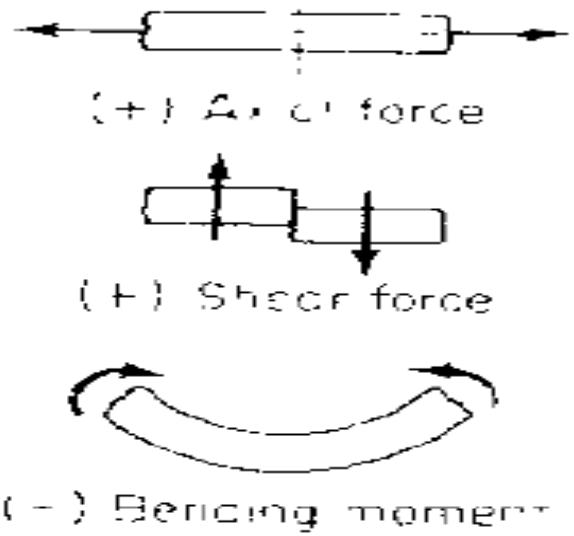


(c)

$r = 10, n = 2, 10 > 6,$
Statically indeterminate to the fourth degree *Ans.*



Structural Analysis & Design I



Structural Analysis & Design I