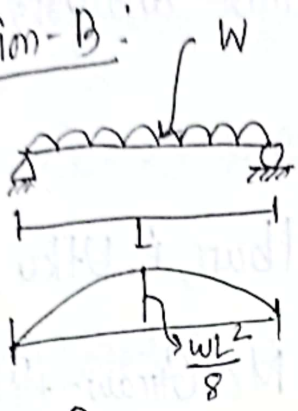
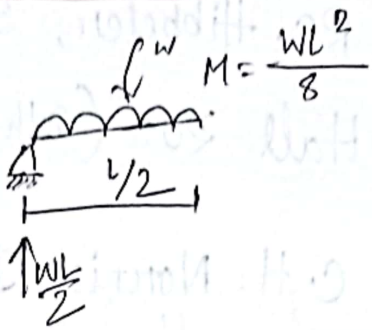
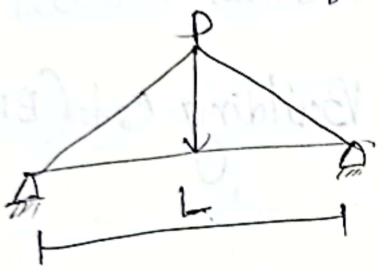
[1] Lecture-01: কোনো Theory আলোচনা 23.01.24

Section-B:







- Determinate structure → মাধ্যমে $\Sigma fv, \Sigma fh, \Sigma M$ সমাধান করে বের করা যায়।

Deflection → $\Delta = \frac{5WL^4}{384EI}$

Syllabus:

1. ~~Wind~~ and earthquake loads, approximate analysis of statically indeterminate structures; braced trusses, portal method, cantilever method and vertical load analysis of multi-storied building frame
2. Deflection of beams, trusses and frames by energy method (strain energy, principle of virtual work)

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Reference books :

1. RC. Hibbeler, "Structural analysis", Prentice Hall 2011 (8th Ed)

2. C. H. Norris, J. B. Wilbur, i.. Utku, "Elementary structural analysis", Mc. Graw-Hill, 1991

3. Bangladesh National Building Code (BNBC 1993/2020)

4. Aslam Kassimali, "structural analysis" 4th

5. T. C. Shedd and J. Vawter, "Theory of simple structures", 2nd Ed.

Lecture Schedule :

1. Eq and wind load (cl1 – cl6) Ref BNBC 2020 – Assign. and test-1

2. Approximate analysis of statically indeterminate structures (cl 7 to cl 15) – Assign and test-2

3. Deflection of beams, trusses and frames

by energy method (Cl 16 to Cl 26)

- Assignment.

4. Review (Cl 27 to Cl 28)

Analysis: Detail examination of the elements/data.

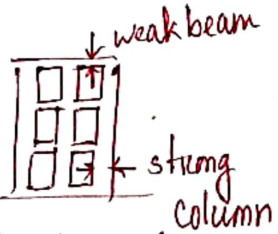
Design: It is the creation of a plan or convertion for the construction of an object.

Loads:

- DL (Structural element, Partion wall, FF)
  Dead load (floor, slab → যেগুলো move করা যায় না)
- LL (BNBC 2020, Ch-2)
  Live load (move করা যায় → chair, table এর load)
- Lateral loads
  - EQ load (BNBC 2020, Ch-2)
  - Wind load (BNBC 2020, Ch-2)

Earthquake:

- Design philosophy

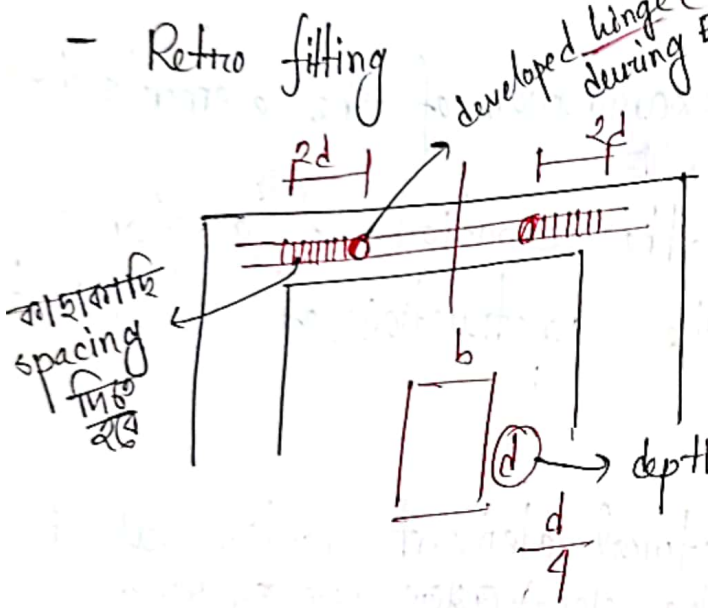


  - Strong columns week beam
- EQ philosophy
  - EQ proof buildings
  - EQ resistance.

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Part 6 → chap 1 → photocopy
" → chap 2

- Catastrophic failure.
  is very dangerous
- Column এবং beam এর joint -এ stress বেশি হয়। তাই joint strong হতে হবে।
- Retro filling (এখনো কিন্তু পড়ে যাবেনা)



2d পর্যন্ত $\frac{d}{4}$ L এর rod দিতে হবে যাতে EQ হলে energy absorb করে building.

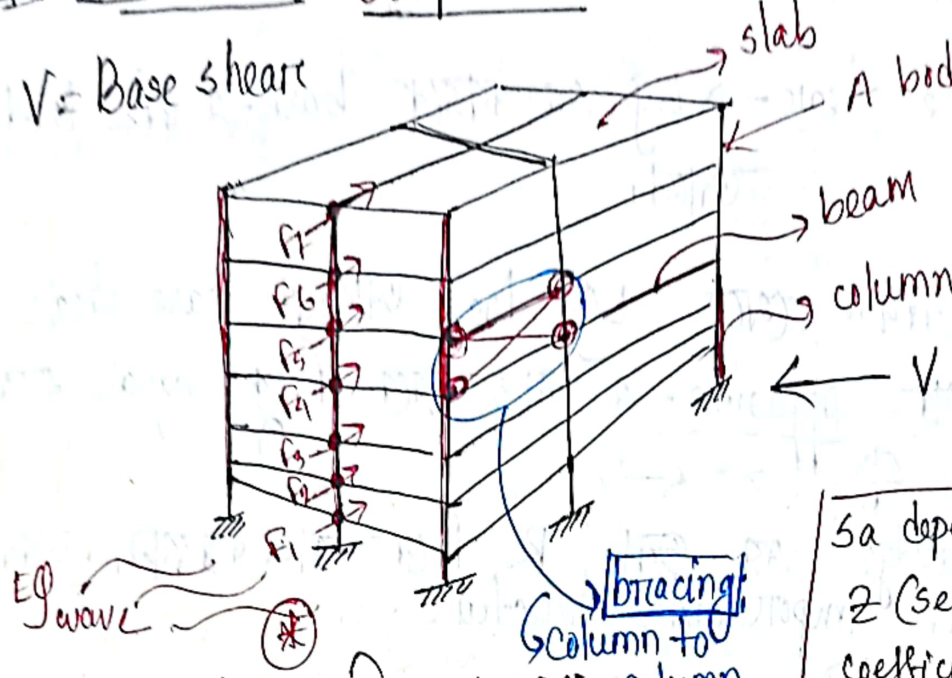
Seismic Design method :

- ~~E~~Equivalent static force method

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[1] Lecture-02: V.V.Imp Chapter-2 30.04.24

V = Base shear



Sa depends on Z (seismic zone coefficient)

- Dead load CG দিয়ে কাজ করে।

- moment-resisting frame → beam column দিয়ে তৈরি।

- column এবং beam এর joint-এ EQ force কাজ করে।

Chapter-2 (Part-6), para-2.5:

Earthquake loads:

Base shear, $V = S_a \times W$ → total seismic weight of building

S_a = Spectral acceleration $= \frac{2}{3} \times \frac{ZI}{R} C_s$ → Z: seismic zone coefficient; R: Response reduction factor for structural systems

C_s = normalized acceleration response spectrum

T = Time period $= C_t (h_n)^m$ → for structure

T → fundamental time period (এটা দুর্যোগের সময়ান্ত করতে যে time লাগে)

C_t → numerical coefficient

h_n → height of the structure. Base-to-top / Basement-to-top.

- live load material density এর উপর নির্ভরশীল।
- Base shear → EQ এর কারণে base-এ যে load আসে।
- মাটিক থেকে EQ load আসবে base shear আসবে কিন্তু equal হবে opposite-এ



- Bridge এর জন্য R দিয়ে ভাগ করা যাবে না। কারণ এটা important structure.

$$S_a = \frac{2}{3} \times \frac{ZI}{R} C_s$$

S_a depends on seismic zone coefficient

material কিছু load absorb করে তাই R দিয়ে ভাগ করে ২/৩ দিয়ে গুণ করে কমানো হয়।

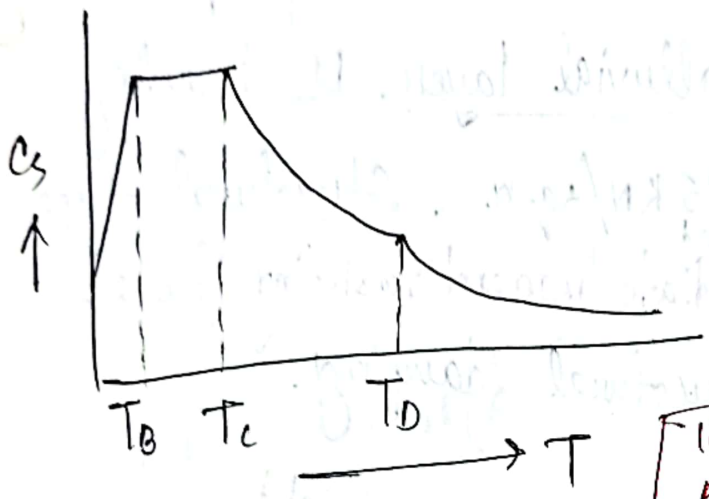
- structure এর detailing-এ পার্থক্য আছে তা বোঝা যায় seismic design category দ্বারা।
- from site class we will get → S, T_B, T_C

T_D → Time period of soil.

- Time period of soil ≠ time period of structure
  - equal হলে collaspe করবে।
- Site class depends on soil type.
- Detailing → কোথায় joint দিবো, কতগুলো rod, কতদূর

- C_s will depend on T, T_B, T_c, T_D

(*) What is acceleration response spectrum?



অনেক গুলো EQ এর time Vs acceleration data নিয়ে combined করে সে data থাকে সেটাই response spectrum

10% damping এর জন্য $\varepsilon = 10$
5% " " $\varepsilon = 5$

$\eta = \sqrt{10/(5+\varepsilon)} \geq 0.55$ as percentage.

ε → structural damping এ কোনো কিছু না বলা থাকলে damping 5%

$$f_x = V \times \frac{W_x h_x^k}{\sum_{i=1}^{n} W_i h_i^k}$$

W_x → weight of the structure
h_x → height of floor from base

η এর value always 0.5 এর বেশি হবে

$K = 1$ for $T \leq 0.5$

$= 2$ " $T \geq 2.5s$

= linear interpolation for T between 1 and 2

- Base shear → total design lateral force or shear due to EQ at the base of a structure.

20 marks

Problem: Calculate the distribution of EQ force on the 20 storied office building shown in figure. Location-Dhaka. A soil profile consisting of a surface alluvial layer. DL including partition = 13.25 KN/sq-m (Dead load). Structural type IMRF. Intermediate moment resisting frame. Consider 5% structural damping.

R=8



floor height

20 @ 3m = 60m → building height

floor number



Soln: Given data,

$h_n = 60\ m$

Building type = II

Table 1.2.1 $\therefore I = 1.0$

Location Dhaka

$Z = 0.2$

Site class = SE
↳ Table-2.5.1
S = 1.4

Table-2.5.9 $T_B = 0.15$
$T_C = 0.5$
$T_D = 2.0$

(*) live load ৫০% ধরলে dead load ১০০% ধরতে হবে।

$T = C_t (h_n)^m$; C_t → Table-2.5.8 = 0.0466, m = 0.9

$T = 0.0466 (60)^{0.9}$

$= 1.86$

$\eta = \sqrt{10/(5+5)}$; $\varepsilon = 5$

$= 1$

$\therefore C_s = 2.5 \eta \left(\frac{T_c}{T}\right)$ for $T_c \leq T \leq T_D$

$= 2.5 \times 1.4 \times 1 \left(\frac{0.5}{1.86}\right)$

$= 0.942$ (no unit)

(*) If value of R is not given bring from table (table-2.5.7)

$\therefore S_a = \frac{2}{3} \times \frac{ZI}{R} C_s$

$= \frac{2}{3} \times \frac{0.2 \times 1}{8} \times 0.942$

$= 0.0157$

$\therefore W = \underbrace{24 \times 24}_{\text{Length width}} \times \underbrace{13.25}_{\text{per-square-A force}} \times \underbrace{20}_{\text{floor number}}$

$= 15640$ KN / 152640 KN

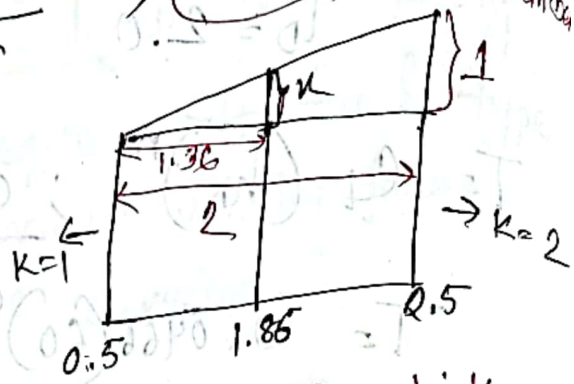
$\therefore V = S_a \times W = 0.0157 \times 15640$

$= 2052\ KN$

$$f_x = V \times \frac{W_x h_x^K}{\sum_{i=1}^{n} W_i h_i^K}$$

; n = 20 → floor number

table থেকে value নিয়ে বসাতে হবে।
উপরের floor-এ load দিলে হবে। → its a check



$\frac{1}{x} = \frac{1.36}{2}$

$\therefore x = 0.68$

$\therefore K = 0.68 + 1 = 1.68$

W_x → per floor W

$W_x = 24 \times 24 \times 13.25$ (height × width × per square - A load)

$= 7632$

f_x এর formula দিয়ে each floor এর value বের করতে হবে

bottom থেকে প্রতি floor এর height

Floor	h_x	W	h^K	$W \times h^K$	Base shear (V_x)
20	60				
19	57				
18	54				
17	51				
16	48				
15	45				
14	42				
13	39				
12					
11					
10					
9					
8					
7					
6					

যদি live load দেয়া থাকলে তবে

$W = DL + LL \rightarrow 3\,kN/m^2$ — LL এর 25% নিতে হবে

$= DL + 24 \times 24 \times 3 \times 20 \times 0.25$

[20/25 marks]

Assignment-1:

20 storied (each floor 25m × 25m) RC office building at Dhaka/Chittgong/Sylhet/Barishal. (Reinforced concrete IMRF)

Soil condition soft to medium stiff clay (SC). (ques-A site class)

Dead load including partition wall / floor = 12 কেজি/বর্গ মি

kn/m² add 25% of live load (LL) of building where LL = 4KN/m², (BNBC, 2020), Damping 5% and R = 8

→ 25×25×4×20×0.25

Date submission: Before next class

CT-syllabus → EQ load and wind load

যদি DL, LL দুটোই দেয়া থাকলে,

$W = DL + LL \times 25\%$

Table:

(1) 1.2.1 → Page (5) [Ch-1] Building-type → Occupancy Category

(2) 2.5.5 → page (85) [Ch-2] Occupancy category → Importance factor (I)

(3) 2.5.3 → page (81) location → zone (Z)

(4) 2.5.1 → page (79) Soil profile → Soil class, site class

(5) 2.5.4 → page (83) Site class → S, T_B, T_C, T_D

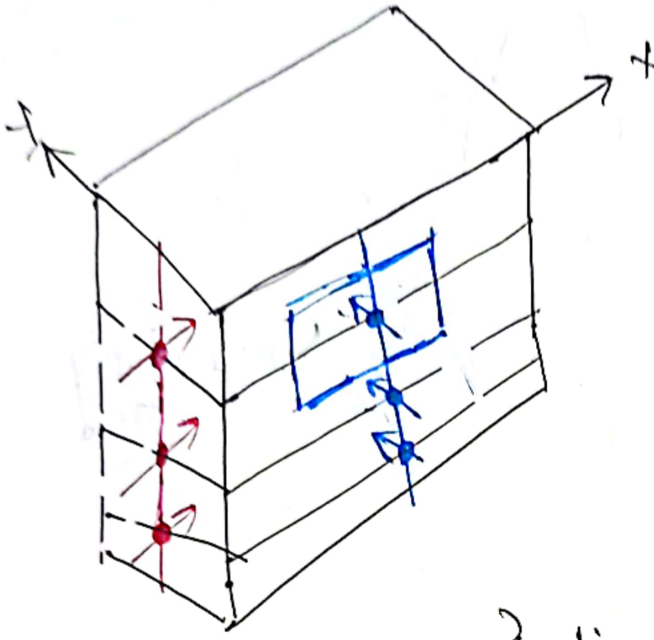
(6) 2.5.8 → page (93) Structure type → C_t, m

(7) 2.5.7 → page (90) Structure type → R

07.05.24

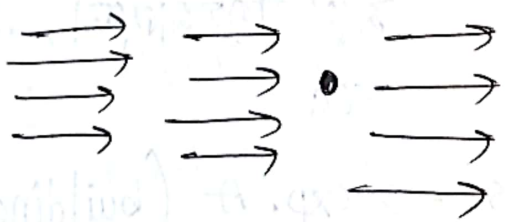
Lecture-03:

Wind load : (Ch-2, para-2.4)



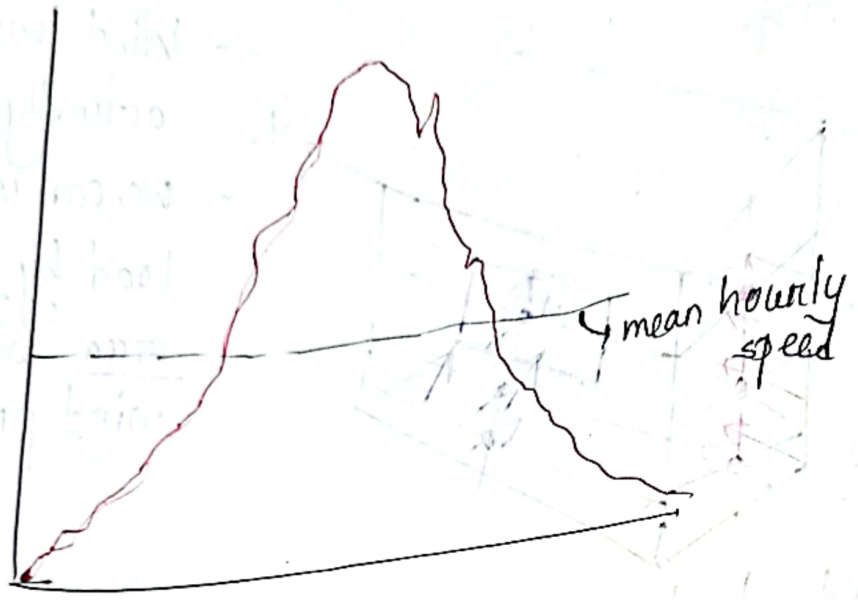
- Wind load actually pressure
- we can make it load by multiplying area with the wind pressure.

- Wind load x, y দুটো direction-এই বের করতে হবে।
- load বের করতে হয় প্রত্যেক node-এ (beam-column joint)
- pressure নির্ভর করে wind এর velocity এর উপর।
- যেকোনো point এর উপর pressure, $q = \frac{1}{2}\rho V^2$



- Wind pressure is directly proportional to V^2.

- BNBC wind কে define করছে three second gust হিসেবে।



Surface roughness and terrain exposure:

- exposure A → অব building, জনবসতি (ঘন)
- " B → open field, গাছপালা, কয়েকটা building
- " C → coastal area, 10m এলাকার মধ্যে কিছু থাকবেনা, very close to sea

Mirpur DOHS → exp. A (building height অব অসমান প্রায়)

Cox's bazar near sea → exp. C

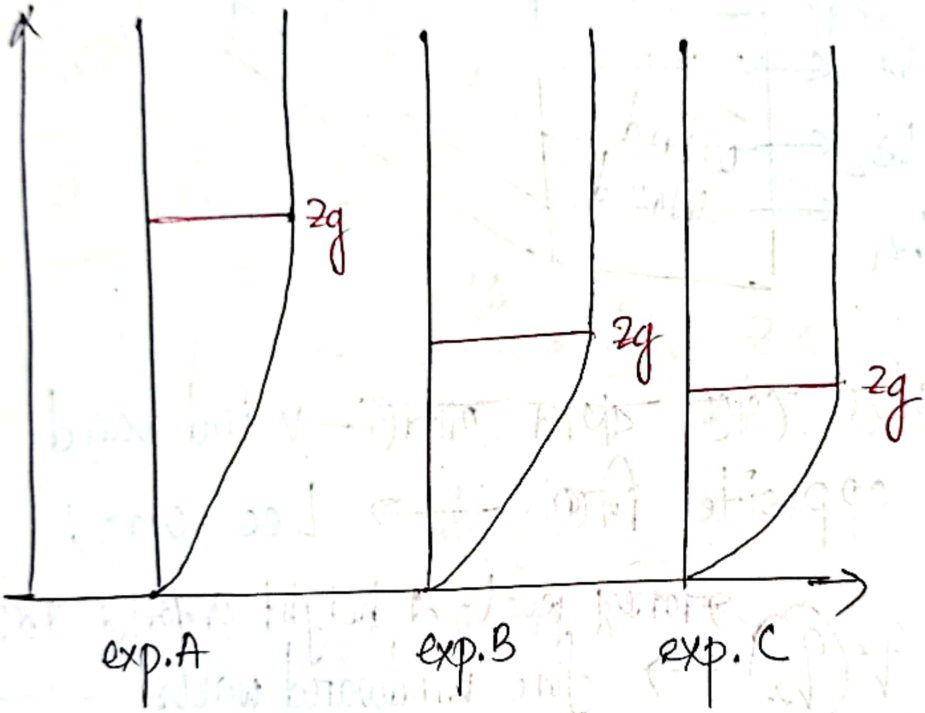
" " Baitmiz bazar → exp A

- ছোট ছোট building এর জন্য হবে বড় building জন্যে তা exp. B.

Wind speed variation with height :

$$V_z = V_g \left(\frac{z}{z_g}\right)^{\alpha} \leq V_g$$

↳ যেই height এর variation আছে।



Method-1 ; 60' height এর জন্য

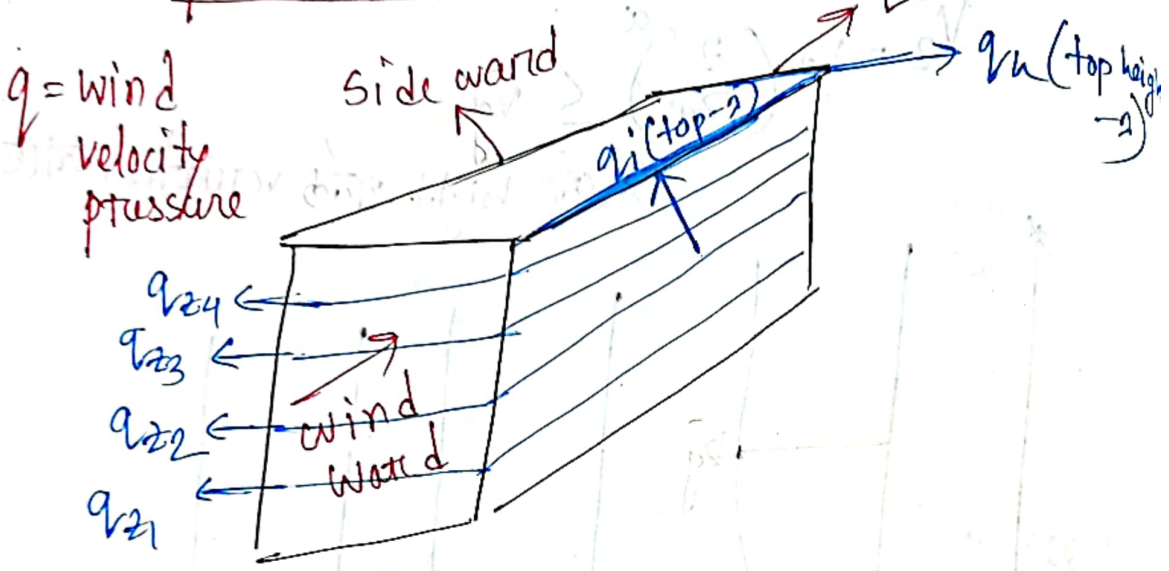
2 : যেকোনো height (বড় দালান)

3 : Wind Tunnel

Method 2: Analytical process

Design wind pressure, p

$$\therefore \boxed{p = q G_i C_p - q_i (G_i C_{pi})}$$



- যেদিক থেকে বাতাস আসবে – wind ward
  opposite দিকে ⟶ Lee ward

$q = (q_z)$ → ভিন্ন ভিন্ন level - z height অনুযায়ী নিবে।
→ for windward walls

$q = (q_h)$ ⟶ for leeward walls
→ topmost height - z

$q_i = (q_h)$ ⟶ internal side wall এর জন্য
→ topmost height - z

G_i = gust effect factor (2.4.8)

C_p = external pressure coefficient (6.2.6/6.2.8)

C_{pi} = Internal " "

quer-2 থাকবে

$$q_z = 0.000613 K_z K_{zt} K_d V^2 I \ , \ KN/m^2$$

V in m/s

K_{zt} → plane surface এর জন্য value 1

K_z → Velocity pressure coefficient

(I) $K_z = 2.01 \left(\frac{z}{z_g}\right)^{2/\alpha}$ → for height $4.57m \leq z \leq z_g$

(II) $K_z = 2.01 \left(4.57/z_g\right)^{2/\alpha}$ → for $z < 4.57m$

1st floor এর জন্য formula (II)

2nd floor থেকে উপরে " (I)

Table 6.2.10 → α, z_g

→ page 67, table - 2.4.3

- Importance factor, I → table 2.4.2

- K_{zt} → topographic factor

$$K_{zt} = (1 + K_1 K_2 K_3)^2$$

→ for plane surface, $K_{zt} = 1$ (for our purpose)

- Directionality factor → K_d

most of the case, $K_d = 0.85$

- pressure coefficient → C_p

↳ ① $0 \leq \frac{L}{B} \leq 1$ → $C_p = 0.8$ (Wind)

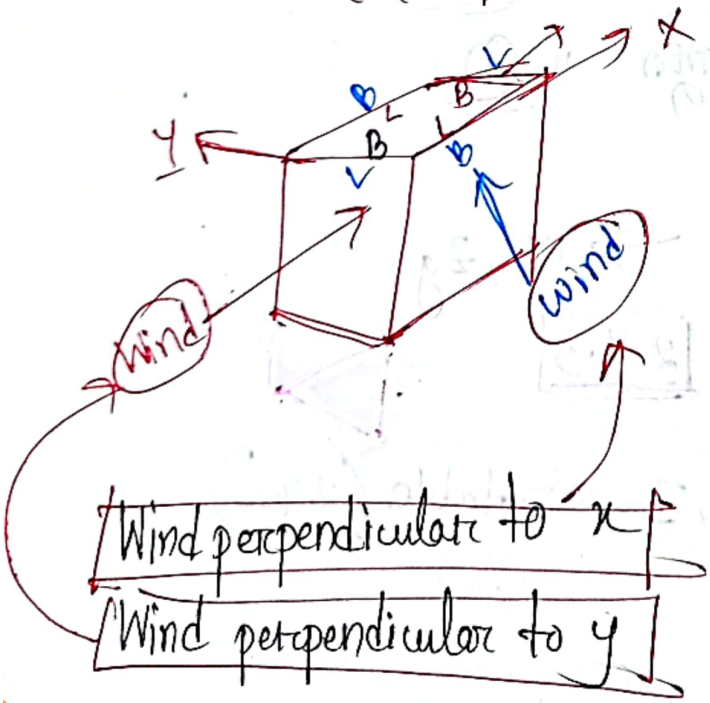
$C_p = -0.5$ (lee)

$C_p = -0.7$ (Side

Sidewall

B

সেদিক থেকে বাতাস আসবে



Wind perpendicular to x

Wind perpendicular to y

- Gust factor → G_f

Time period > 1 → flexible structure

n ≤ 1 → rigid structure (10 storey)

$T = C_t (h_n)^m$; $f = \frac{1}{T}$

$G_f = 0.85$ (period (T) less than 1)

↳ Simple method

for $T > 1$,

$$G_f = 0.925 \left(\frac{1 + 1.7 I_z}{} \right)$$

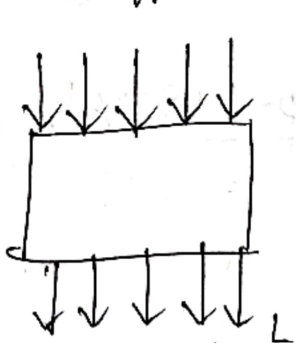
Method-2 : Wind load cases: (দুটি আছে, সেগুলো দুটিই use করলেই হবে)

Case-1 :



X direction

দুটো দিকের (W+L) সোজা করবে



Y direction

GC_{pi} → internal pressure coefficient এর term (figure = 2.4.5)

for open building = 0
খোলা বাড়ি যেখানে বেড় হয়েছে

partially enclosed = ± 0.55
কিছু building-এ void আছে

enclosed building = ± 0.18

2 Marks → formula মুখস্থ করতে হবে না, দেয়া থাকবে.

Problem: Calculate the design load of the following building. Rectangular $(72 \times 48)_{y \times x}$ m. Hospital building (6 storey). Storey height = 3m. City Dhaka, Exposure = A. Calculate as per BNBC - 2020. IMRF

⇒ Step-1 : find Value of

Solution: We know,

$$q_z = 0.000613 \times K_z K_d K_{zt} V^2 I$$

$$p = q_s G C_p - q_i (G C_{pi})$$

Given Data,

Storey = 6

building height = 6@3 = 18 m

Size = 72 x 48 m

Type = Hospital

Occupancy catagory = IV (Hospital) (Table-1.2.1)

Importance factor, I = 1.15 (Table-2.4.2)

Location = Dhaka

Exposure = A

$K_{zt} = 1$

$K_d = 0.85$ (table-2.4.5)

Basic wind speed, V = 65.7 m/s (Table-2.4.1)

For 1st floor:

$$K_z = 2.01 \times (4.57/365.76)^{2/7} = 0.57$$

$$q_z = 0.000613 \times K_z \times K_d \times K_{zt} \times V^2 \times I$$

for 2nd floor:

$K_z =$

$q_z =$

Time period, $T = C_t (h_n)^m$; $C_t = 0.0466$, $m = 0.9$

$= 0.0466 \times (16)^{0.9} = 0.628\ s$

frequency $= \frac{1}{T} = 1.59\ Hz$

As frequency > 1, The structure is rigid

$\therefore G = 0.85$

for C_p (external pressure coefficient),

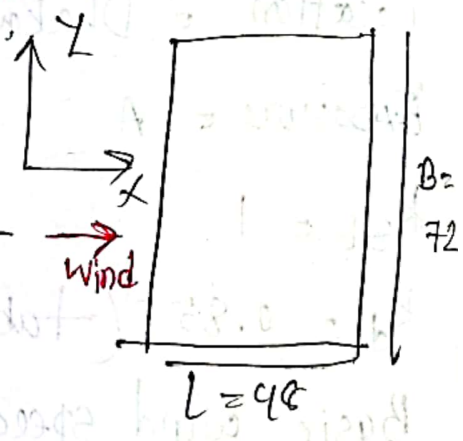
for wind at x-direction, parallel to x

$\frac{L}{B} = \frac{98}{72} = 0.667$

Windward wall, $C_p = 0.8$

Lee " " , $C_p = -0.5$

Side " , $C_p = -0.7$



(±) 0.18 → সবসময় (-) দিয়ে নিলে সাধারণ বেশি design load পাওয়া যায়।

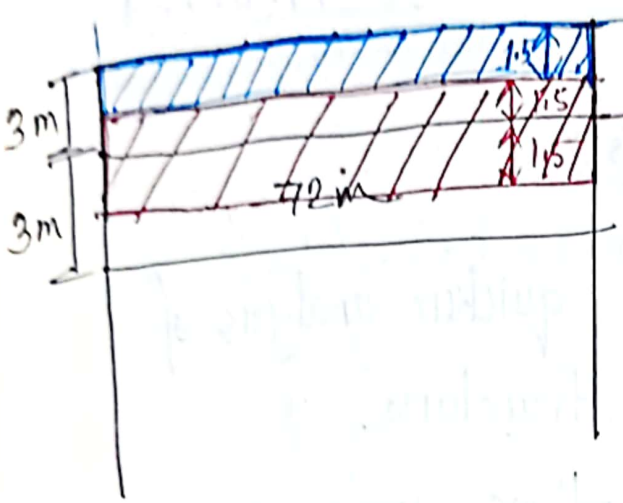
$$P = q G C_p - q_i (G C_{pi})$$

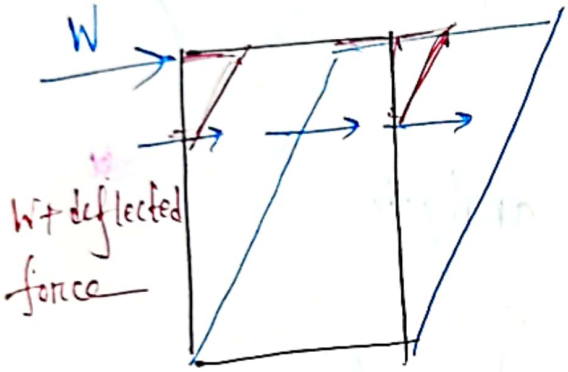
						External pressure					Internal pressure	
Location	Floor	Height above ground (m)	α (Table 6.4.3)	z_g (m)	K_z	q_z (KPa)	G_f	C_p	$q_z \times G_f \times C_p$ (KPa)	$q_i = q_h$	$G_f C_{pi}$ (+) (−) from code formula	$q_i \times G_f C_{pi}$ (KPa)
Windward wall	F1	3	7	365.76	0.574698		0.85	0.8		2.23		
	F2	6	7	365.76	0.621131		0.85					
	F3	9	7	365.76	0.697421		0.85					
	F4	12	7	365.76	0.757167							
	F5	15	7	365.76								
	F6	18	7	365.76								
Leeward Wall						$q_h = q_z$		−0.5				
Side wall								−0.7				

(28)

Case-1

Floor	Height above ground (m)	B (m)	Tributery height (m)	Area	Windward wall: External design wind pressure (KPa) p এর formula নিচে দেয়া আছে	Windward wall: Design wind force P_{Hx} (KN) (A)	Lee ward wall: External Design Wind pressure (KPa)	Lee ward wall: Design Wind force, P_{Lx} (KN) (B)	Total design wind force (A)+(B) সাইজ করার সময় এটা positive sign হবে।





সোজা কথায় main force পাওয়া যাবে।

Force diagram আঁকতে হবে

Assignment-2: Submit before next class.

Calculate the design load of the following building (IMRF). Rectangular (80x50)m. Hospital building (10 storied). Storey height = 3m. City Dhaka/ Chittagong / Sylhet, Exposure = B. Calculate as per BNBC-2020.

Method-2: Analytical procedure.

+ previous problem এর Y-direction এ assignment করতে হবে।

14.05.24

Lecture - 04 :

Approximate analysis:

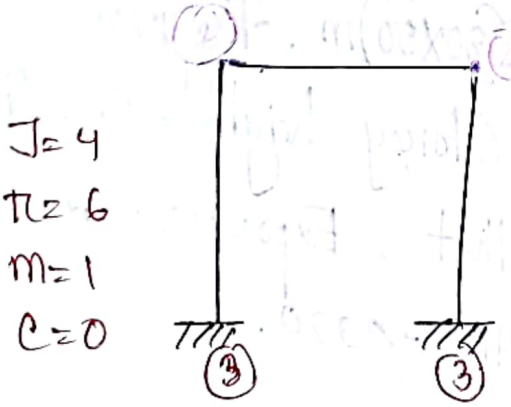
- for performing quicker analysis of indeterminant structure.
- additional assumptions are necessary

Exact analysis :

- requires usual analysis

Purpose of approximate analysis :

- for Preliminary design



$r = 6$

$n = 1 \quad \therefore 3n = 3$

$\because r > 3n$

$\therefore DOI = r - 3n$

$= 6 - 3 = 3$

$DOF = (3m + r) - (3j + c)$

reaction

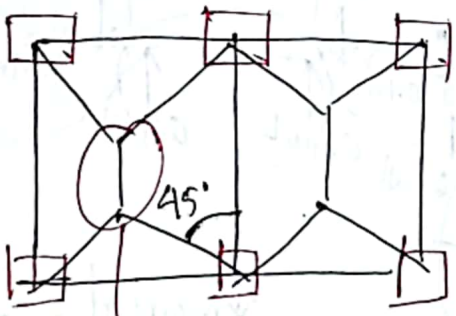
member

joint

hinge (0)

Structural analysis :

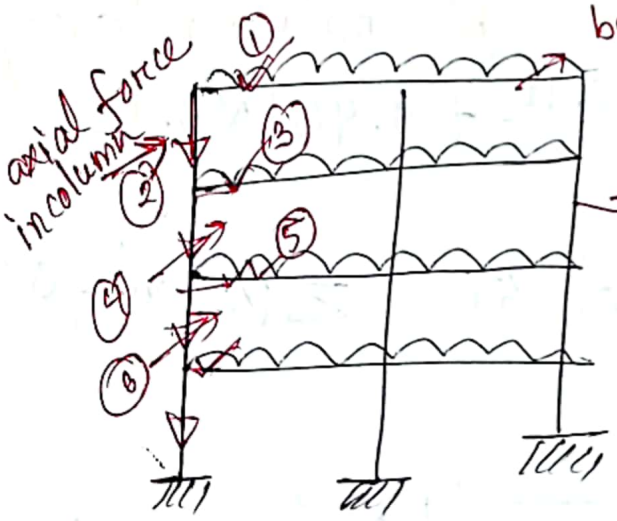
Slab
(DL+LL+FF+Pwall) → Floor finish
↓
beam
↓
Column



room square হলে মিলেমাবে
না হলে মিলবেনা

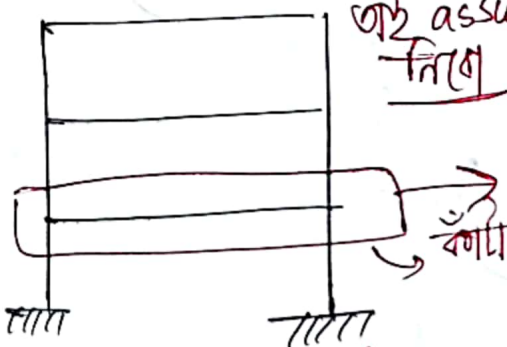
Vertical load analysis :

beam এর Moment, shear বের করব

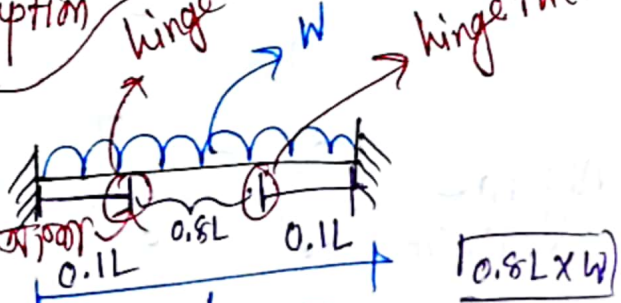


Column এর Moment, shear, axial বের করব

indeterminant structure so solve করবনা
এর assumption নিতে

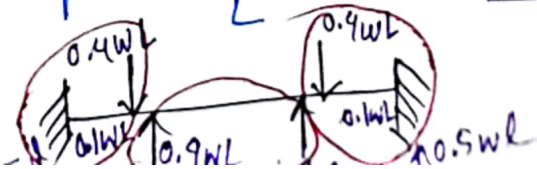


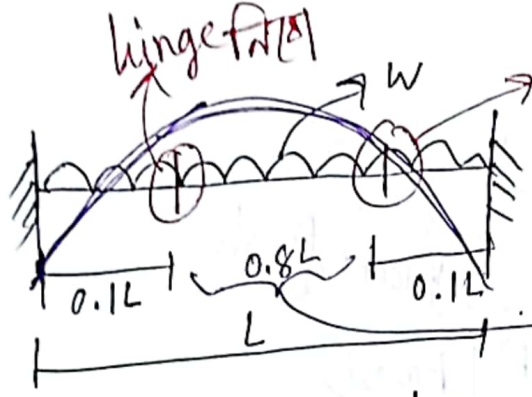
কোনা অংকা



0.8L × W

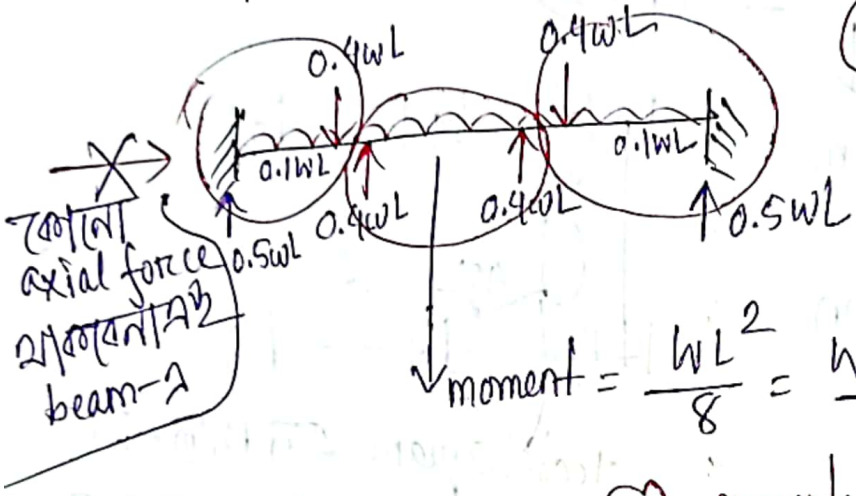
এই beam-1 এর axial





(i) Both side থেকে 0.1L দূরে Hinge নিবে

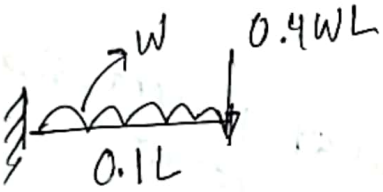
(ii) No force. (axial) in beam



কোনো axial force এখানে এসে beam-এ

$$\text{moment} = \frac{WL^2}{8} = \frac{W \times (0.8L)^2}{8}$$

(iii) moment distribution



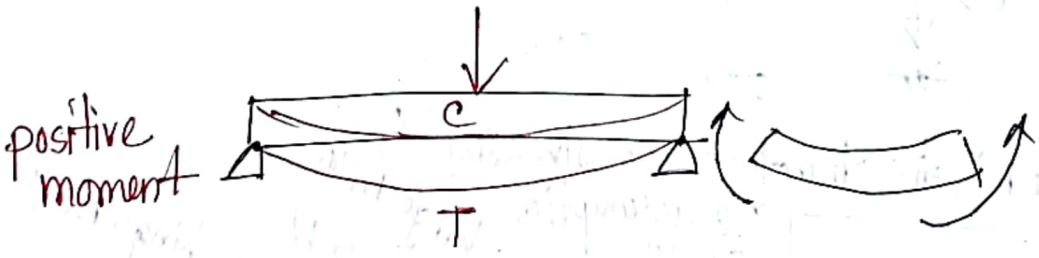
হবে, $M = \frac{EI}{I}$

I = moment of inertia

E = modulus of elasticity

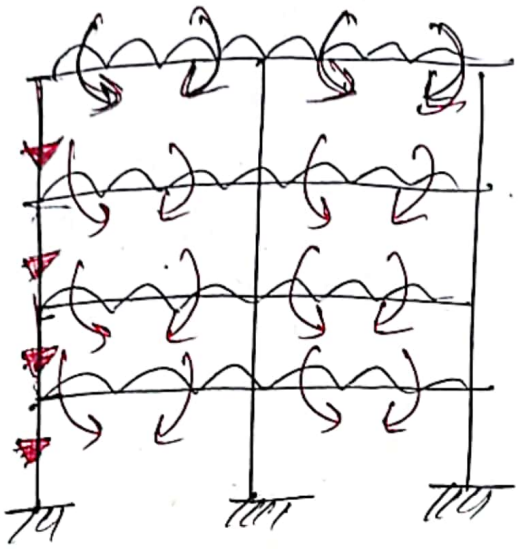
$$\text{Moment} = 0.1L \times W \times \frac{0.1L}{2} + 0.4WL \times 0.1L$$

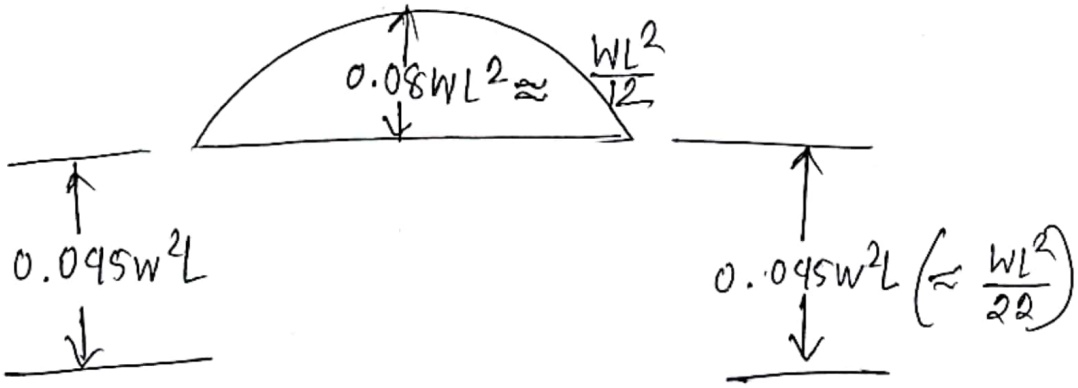
- সকলো বলৰ joint ত $\Sigma \text{Moment} = 0$ হব।





- support - a negative moment
- middle - a positie m





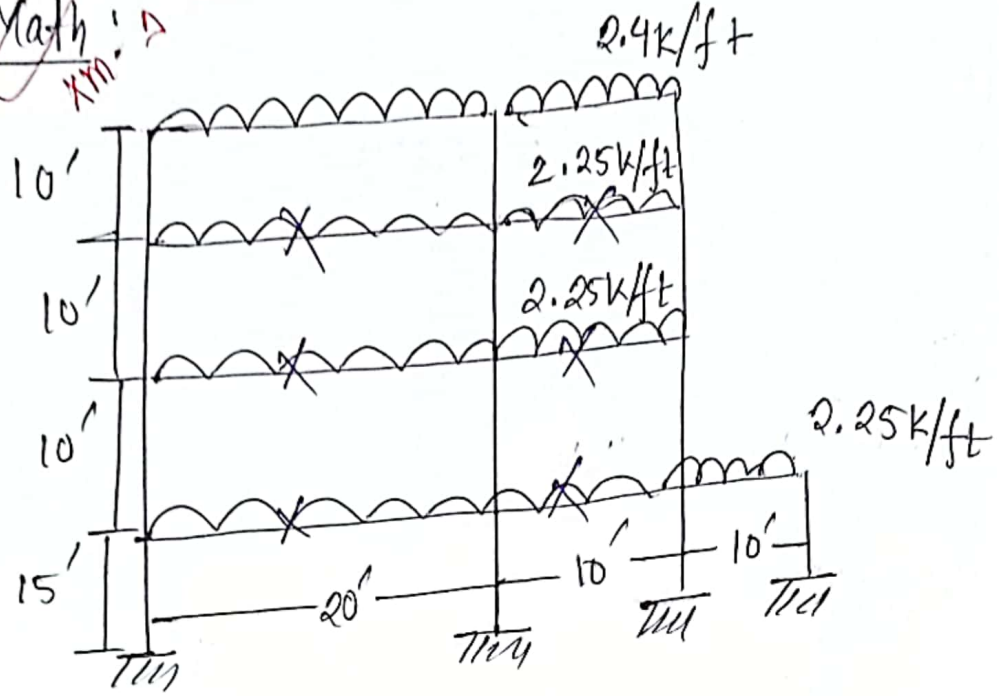
Bending moment dia

$$M_{max(+)} = \frac{Wx(0.8L)^2}{8} = 0.08\,WL^2$$

$$M_{max(-)} = 0.4WL \times 0.1L + 0.1WL \times 0.1\frac{L}{2}$$

$$= 0.045\,WL^2$$

X → same



Problem: approximate analysis of Building frames under vertical load.

Floor slab (6") Roof (7.2")

FF = 15psf

LC = 30psf

frame spacing = 15'

LL, floor 60 psf

Roof 40 psf

1. BM → Beam
   ↓ → Column
   max (+) moment
   max (−) "
2. Girder shear
3. Axial force of column
   → exterior
   → interior
4. Column moment

find the following:

(a) Max positive girder moment (M_{max+})

(b) " negative " " (M_{max-})

(c) Girder shear (V)

(d) Exterior column compression

(e) Interior " "

(f) Column moment

Solution: BM in Beams:

20' span

Positive moment (+ve) = $0.08 WL^2 = 0.08 \times 2.4 \times 20^2$

different load
W different

= 76.8 on (roof) W = 2.4

= 72 on (floor) W = 2.25

Negative moment (−ve) = $0.045 WL^2 = 0.045 \times 2.4 \times 20^2$

= 43.2 on (roof)

= 40.5 on (floor)

10' span

Positive moment (+v) = $0.08 WL^2 = 0.08 \times 2.4 \times 10^2$

= 19.2 on (roof)

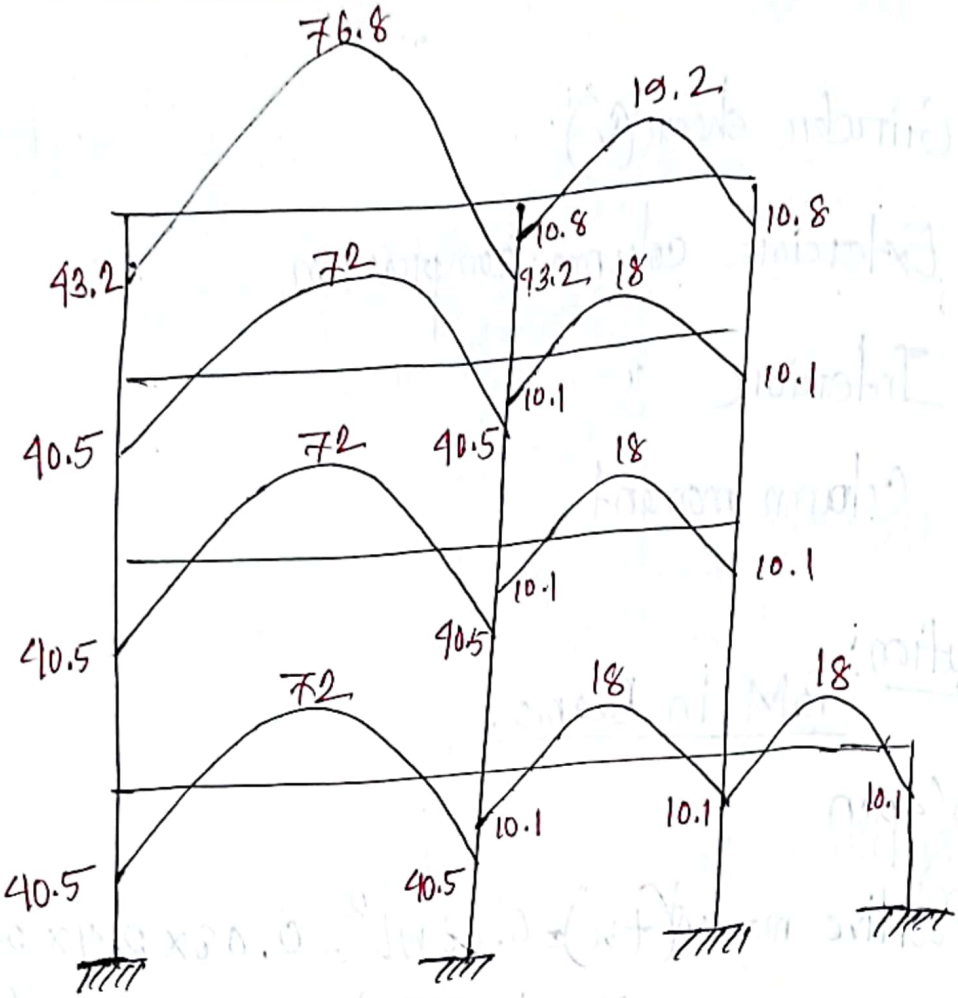
= 18 on (floor)

Negative moment (−ve) = $0.045 WL^2 = 0.045 \times 2.4 \times 10^2$

= 10.8 on (roof)

= 10.1 on (floor)

CamScanner

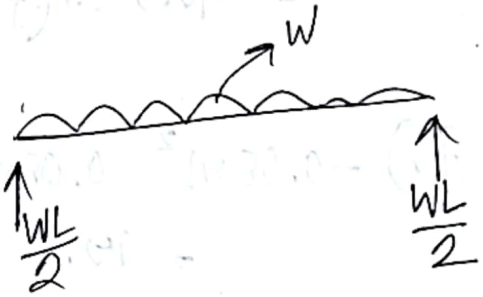


Beam BMD
যদি আঁকতে হবে, calc না দেখালে শুধু ছবি আঁকলেও হবে।

Lecture-05;

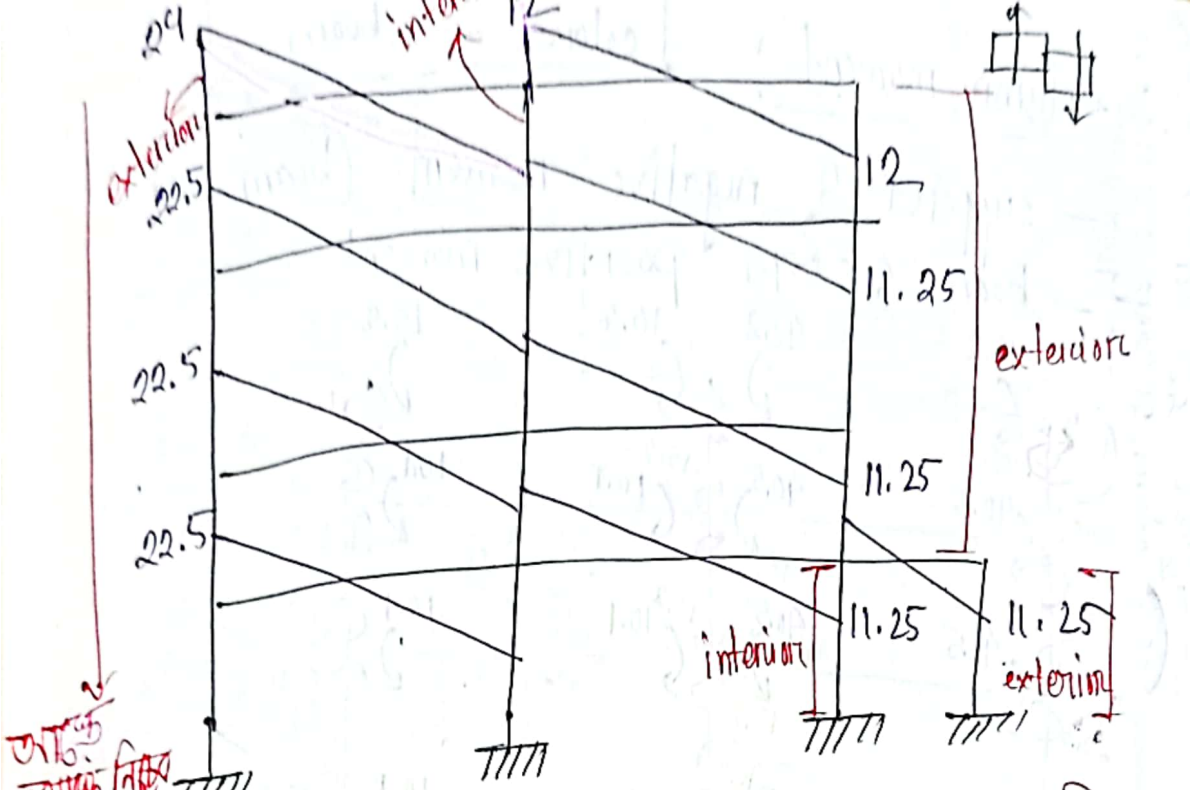
21.05.24

Shear force in beam;



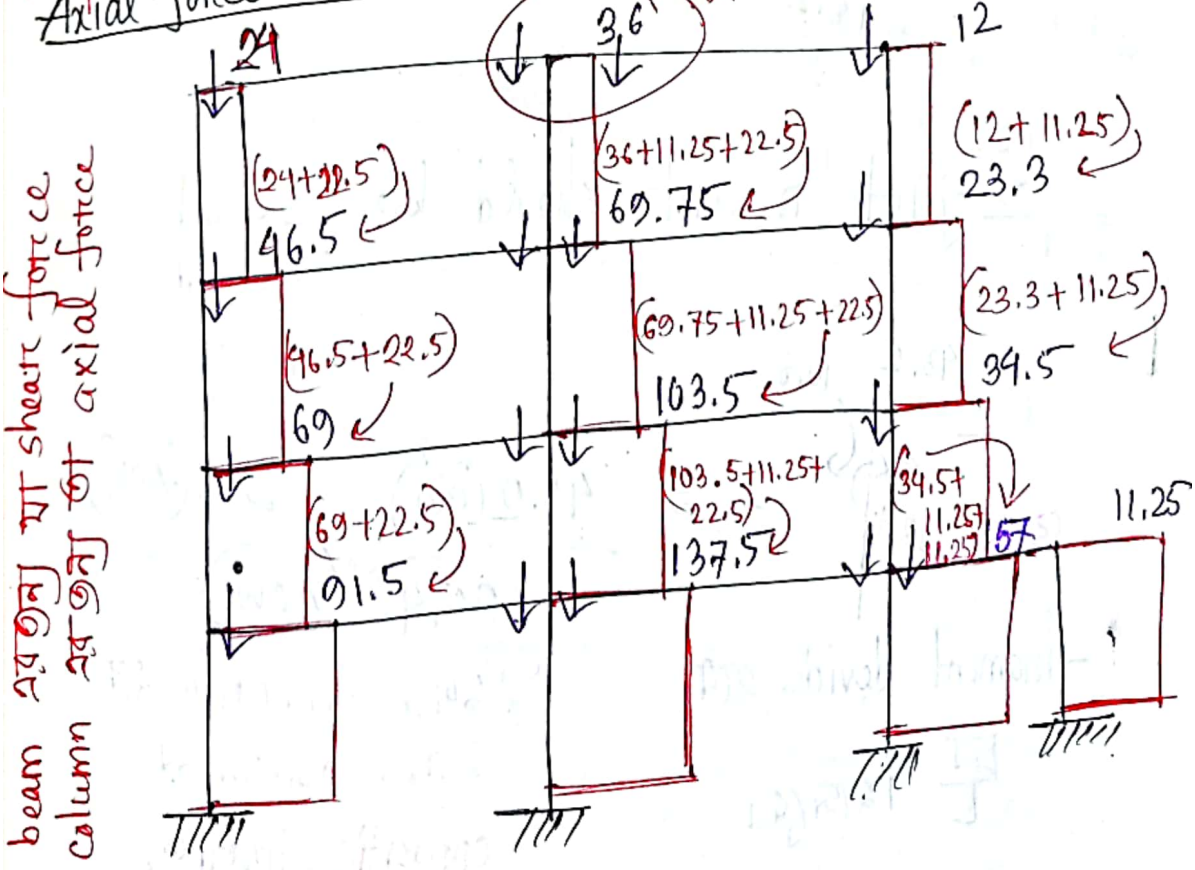
$W = 2.2$

$\frac{WL}{2} = \frac{2.2 \times 20^{10}}{2} = 22$ (for roof - 20' span)



Beam SFD

Axial force in column:



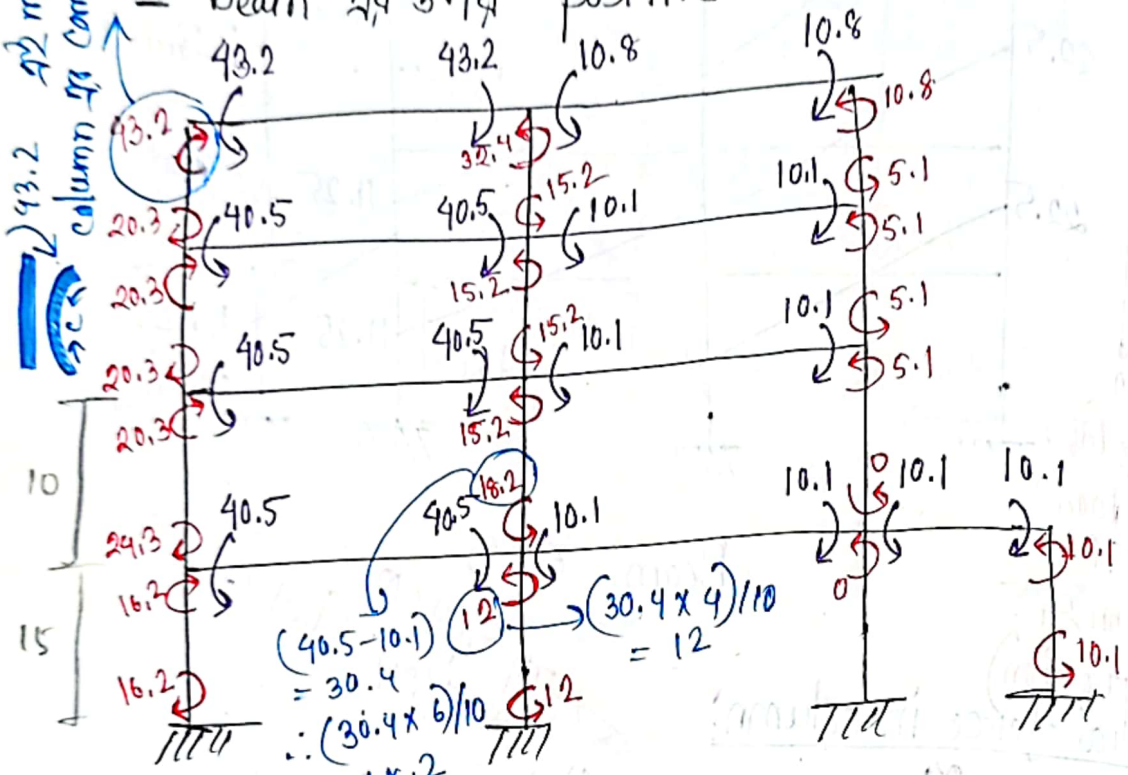
beam এর জন্য যা shear force
column এর জন্য তা axial force

of Column

colu• → column
colo• → beam

Column moment :

- support এ negative moment (beam এর)
- beam এর উপর postive moment

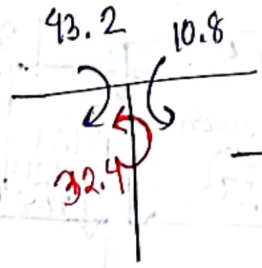


$\frac{40.5}{25} = 1.62$

$1.62 \times 15 = 24.3$ (10 ফুট)

$1.62 \times 10 = 16.2$ (15 ফুট)

= Σ joint moment should be zero



→ 43.2 (CW) − 10.8 (ACW)

= 32.4 (ACW)

- moment devide হবে $\frac{EI}{L}$ দিয়ে।

যার direction হবে baro moment এর opposite direction

28.05.24

Lecture-06:

Calculation:

$M = \frac{EI}{L} = \frac{1}{10}$ → সমান ভাগ 1 ধরলে

(*) মাঝ column এর center-এ moment zero.

and, $\frac{EI}{L} = \frac{1}{15}$

Now, $\left(\frac{EI}{L}\right)' = \frac{1}{10} + \frac{1}{15} = \frac{1}{6}$

Now, $\left(\frac{EI}{L}\right) / \left(\frac{EI}{L}\right)' = \left(\frac{1}{10} \div \frac{1}{6}\right) = \frac{6M}{10}$

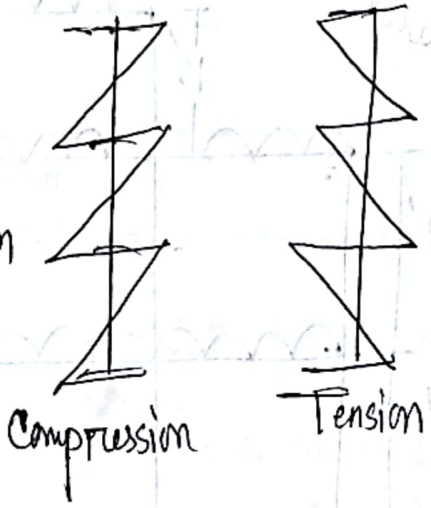
$\left(\frac{EI}{L}\right) / \left(\frac{EI}{L}\right)' = \left(\frac{1}{15} \div \frac{1}{6}\right) = \frac{4M}{10}$

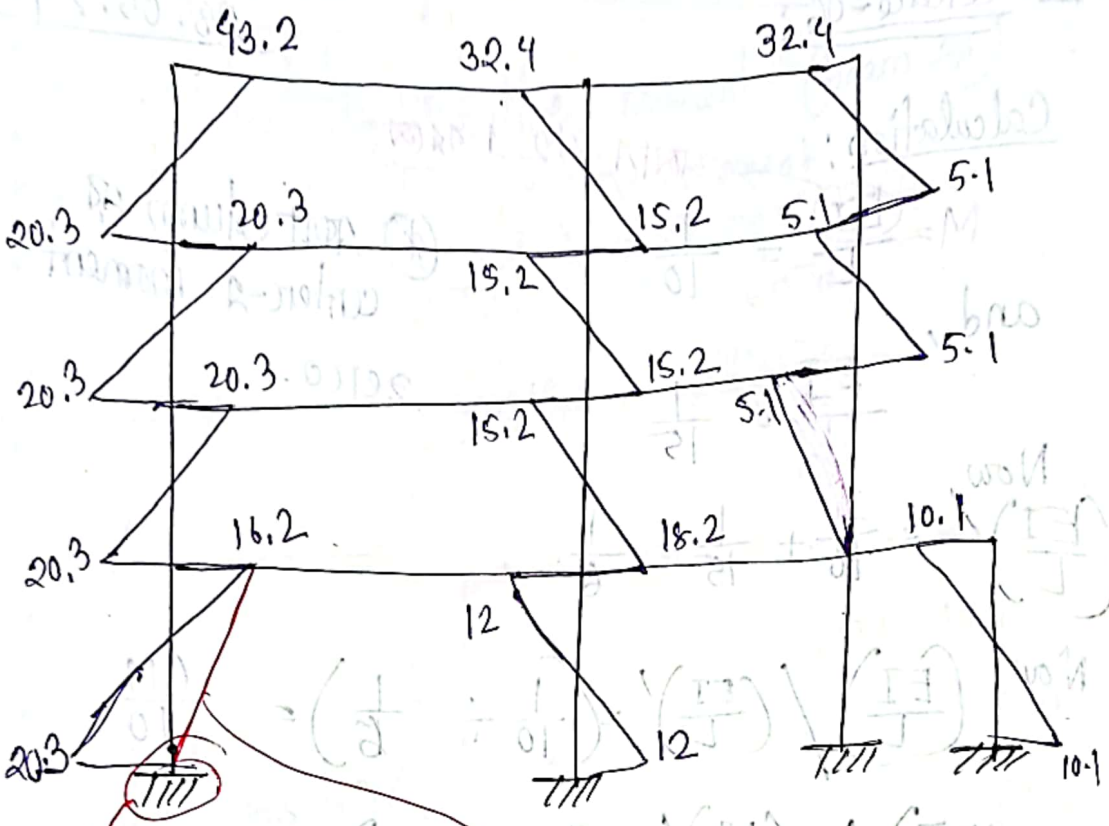
$\Rightarrow (40.5 \times 6)/10 = 24.3$

$\Rightarrow (40.5 \times 4)/10 = 16.2$

- Column এর bending moment diagram compression phase-এ আঁকব।

(*) যদি tension phase-এ আঁকতে বলে, তাহলে compression phase এর উল্টা আঁকবে।



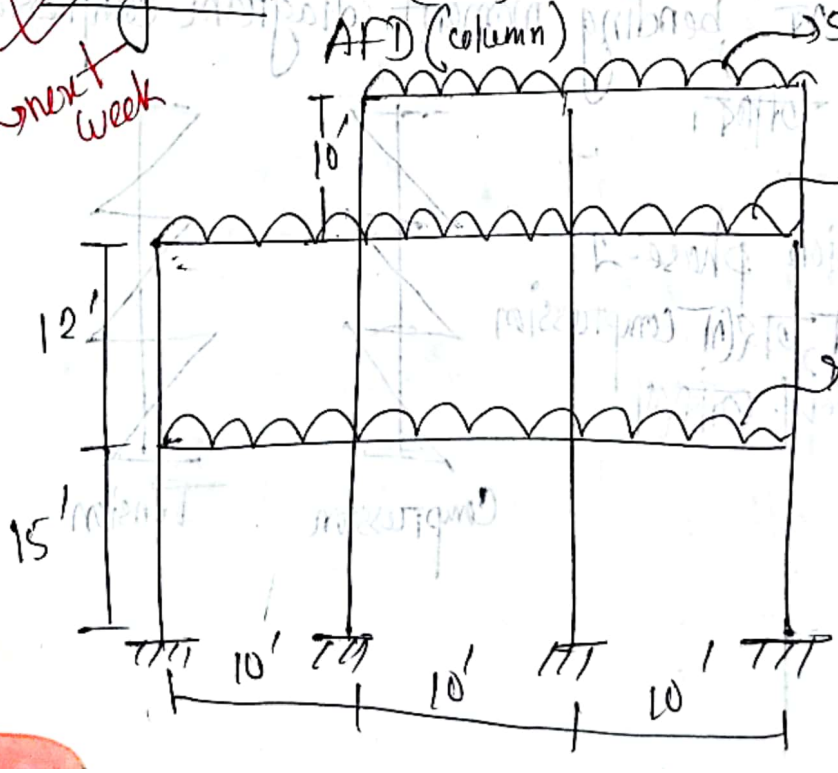


এখানে hinge হল
কোনো moment থাকবেনা।
moment dia এরকমহবে

Column BMD

~~Assignment~~: Max (+/−) moment, BMD (beam, column), AFD (column)

next week



Portal frame :→ approximate solution for indeterminate structural analyses.

- used in structures like building, factories, bridges, have the purpose of transferring horizontal loads applied at their tops to their foundations.

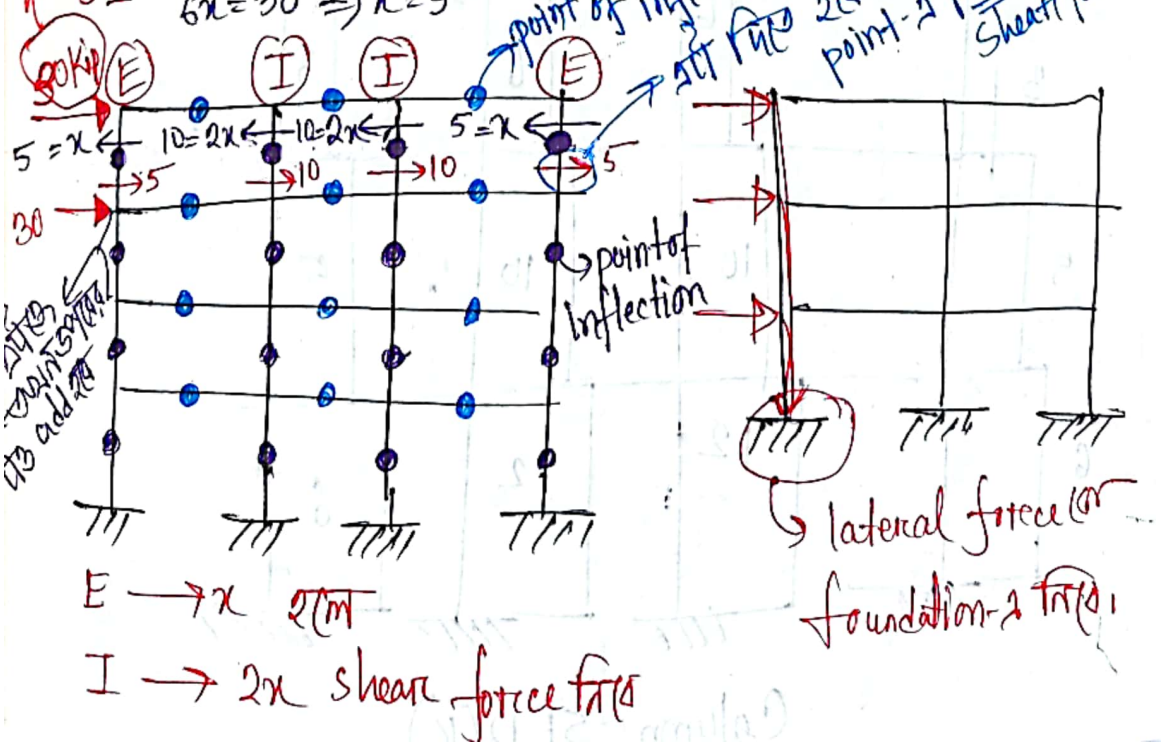
Lateral force

Assumption:

1. The shear force in an interior (I) column is twice the shear force in an exterior (E) 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.

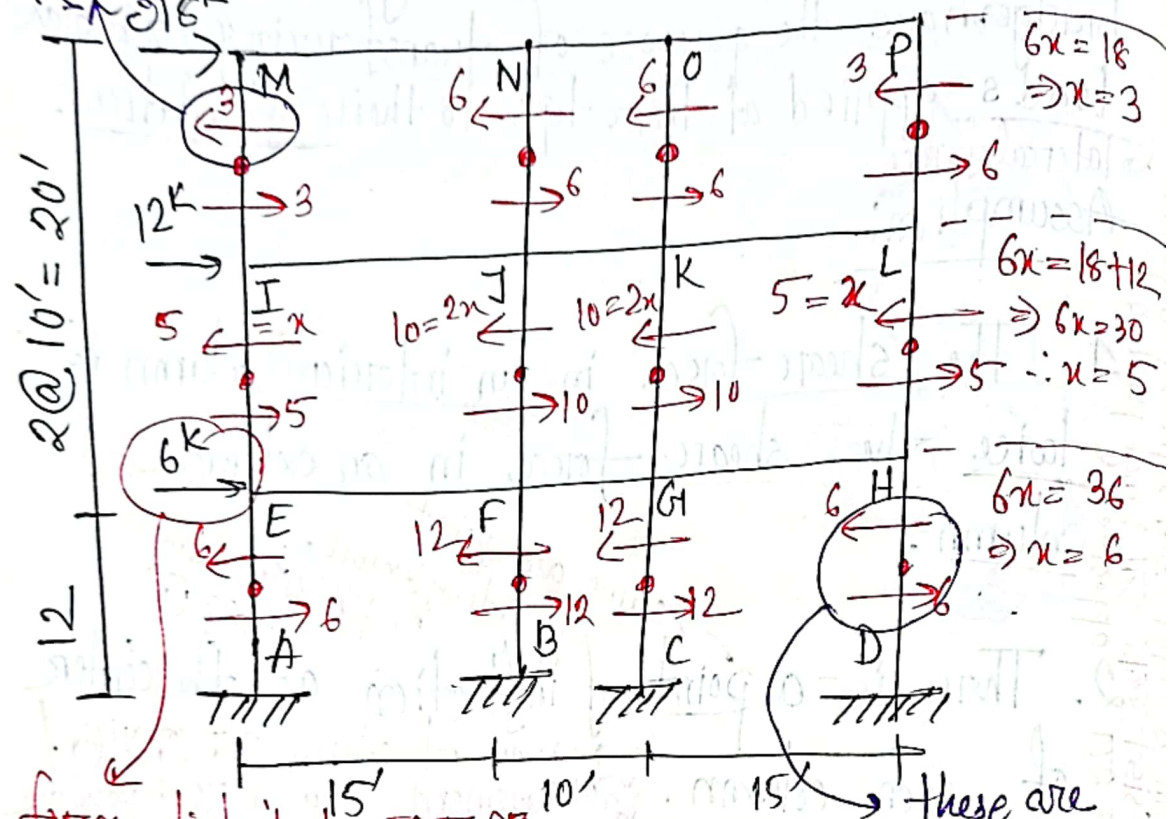


portal analysis এর ক্ষেত্রে আমরা কাজ করেছি যে কোন load দেয়া থাকলে সেটাকে আমরা axial load এ convert করে নিতাম।

Example: Draw AFD, SFD, BMD of 3-storied frame structure

c+b c+b c+b

c → column
b → beam



force distribute করার পর

2 lateral force গুলো আর নিবেন।



Column SFD (K)

Bending moments are (force) (distance)

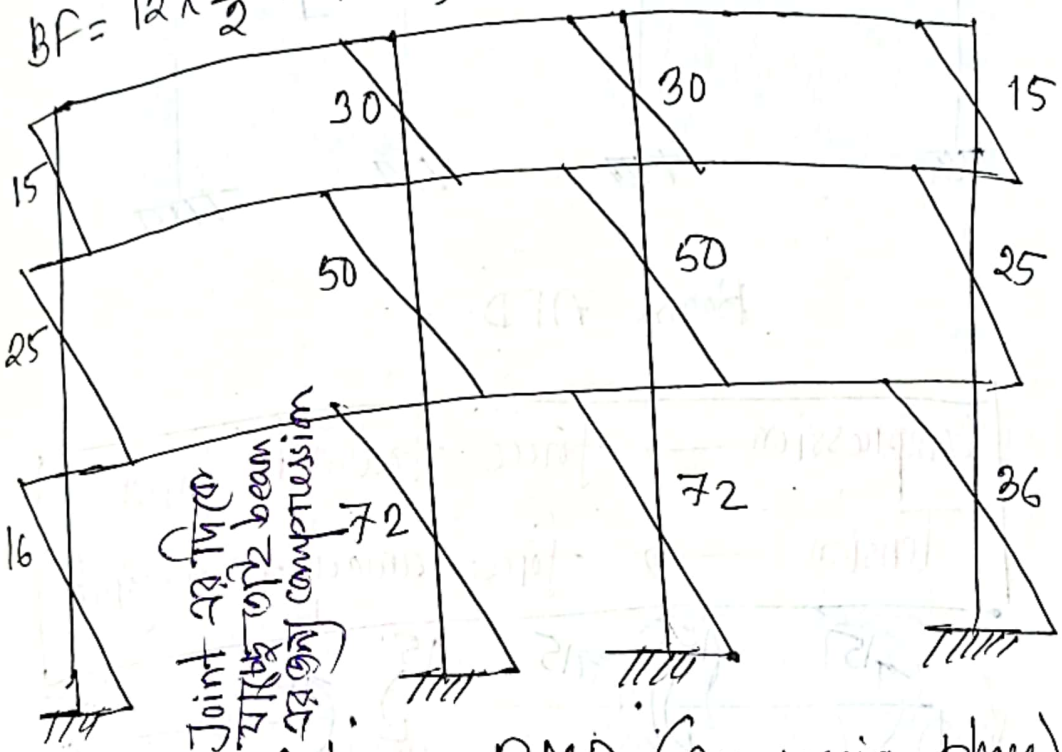
$M_{IM} = 3 \times \frac{10}{2} = 15^k$, $M_{JN} = 30^k$, $M_{KO} = 30^k$,

$M_{EI} = 5 \times \frac{10}{2} = 25^k$, $M_{LP} = 15^k$, $M_{FJ} = 50^k$,

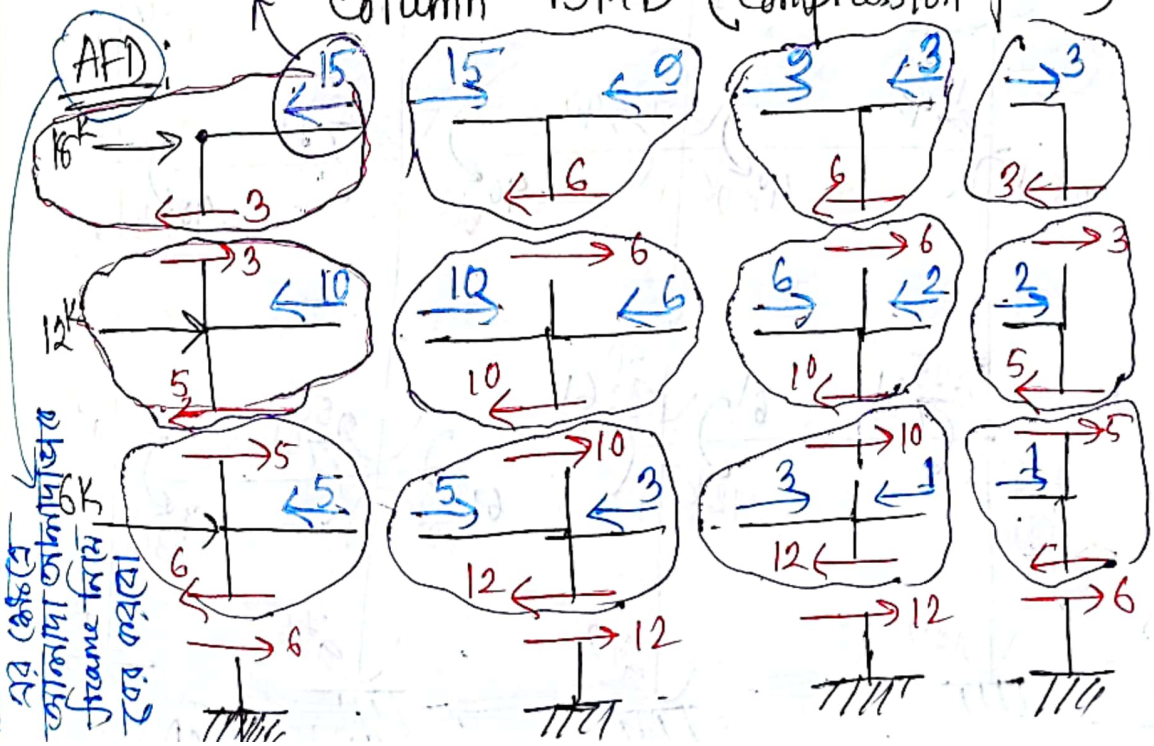
$M_{GK} = 50$, $M_{HL} = 25$

$AE = 6 \times \frac{12}{2} = 36^k$; $CG = 12 \times \frac{12}{2} = 72^k$

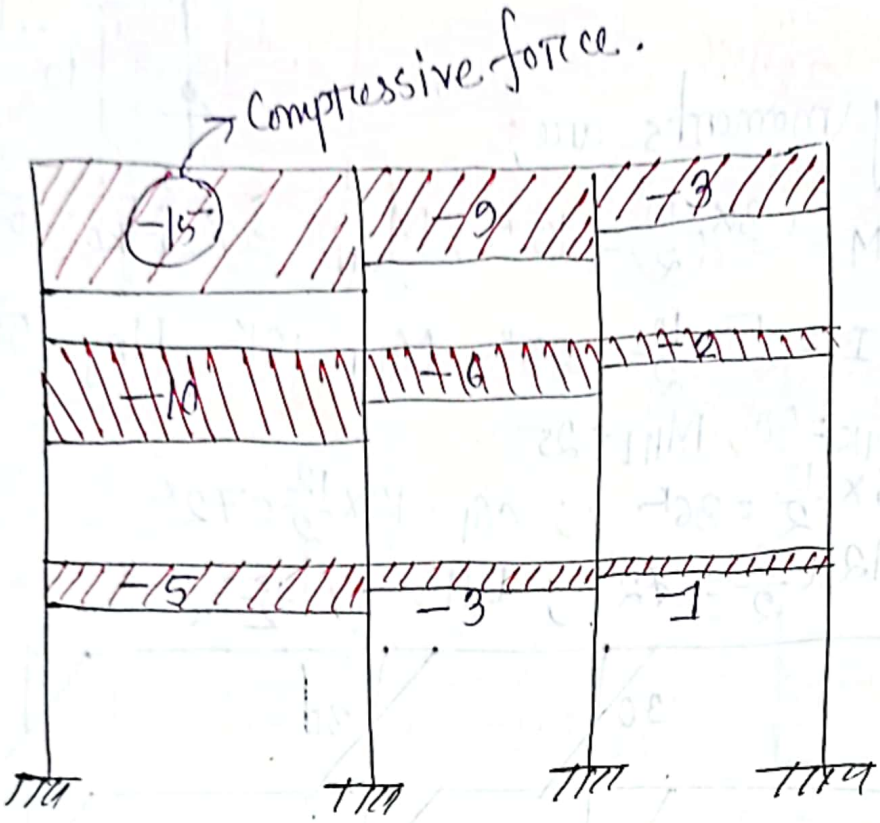
$BF = 12 \times \frac{12}{2} = 72^k$; $DH = 6 \times \frac{12}{2} = 36^k$



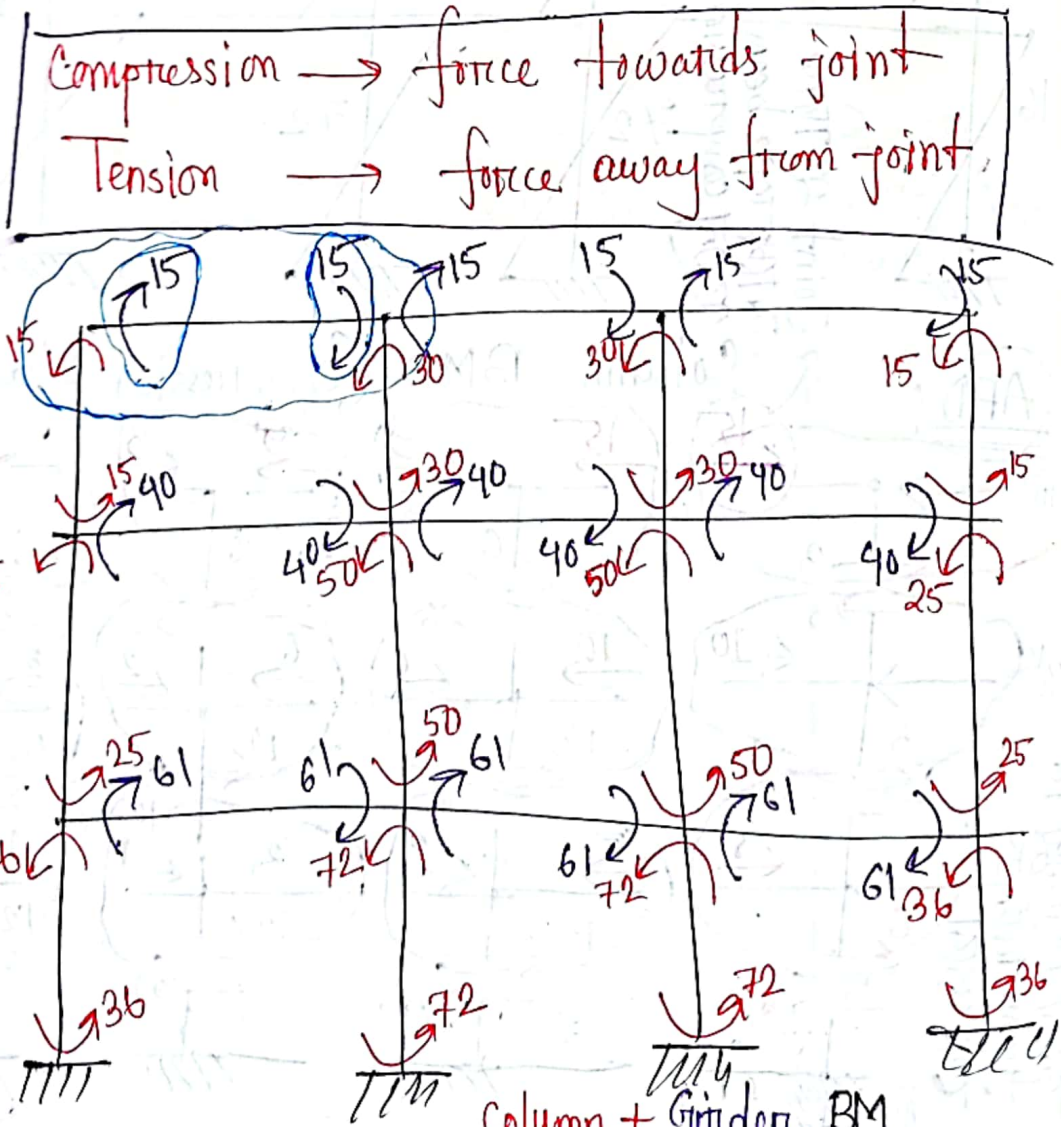
Column BMD (Compression phase)



এর ক্ষেত্রে কলামের অক্ষীয় চাপের frame-নিয়ে দেখা যাবে।

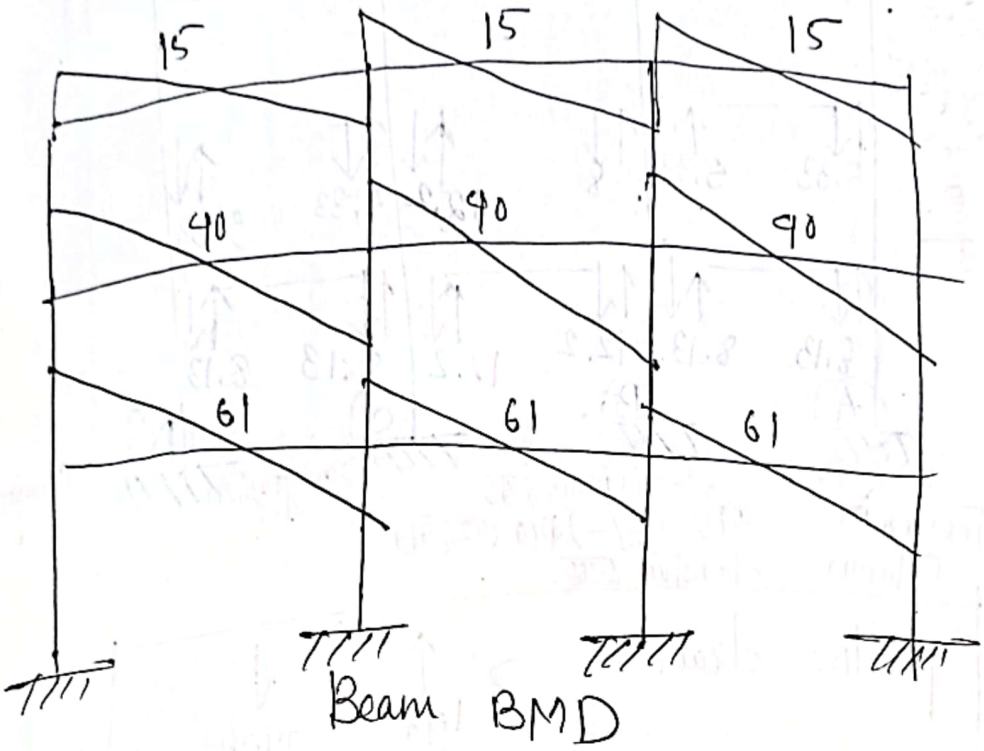


Beam AFD



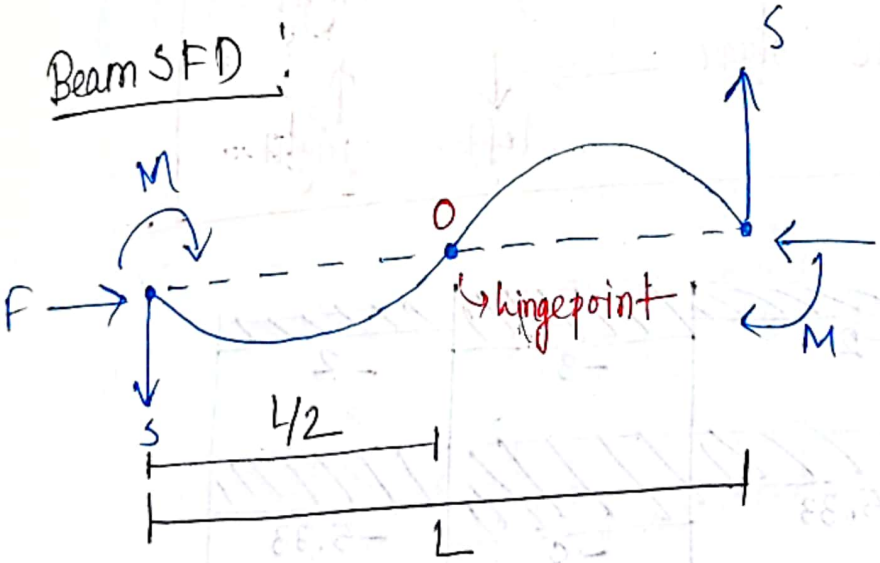
Column + Girder BM

- portal analysis এ column এর distance বের হওয়ার জন্য moment distribute... হবে না।



Beam BMD

Beam SFD :



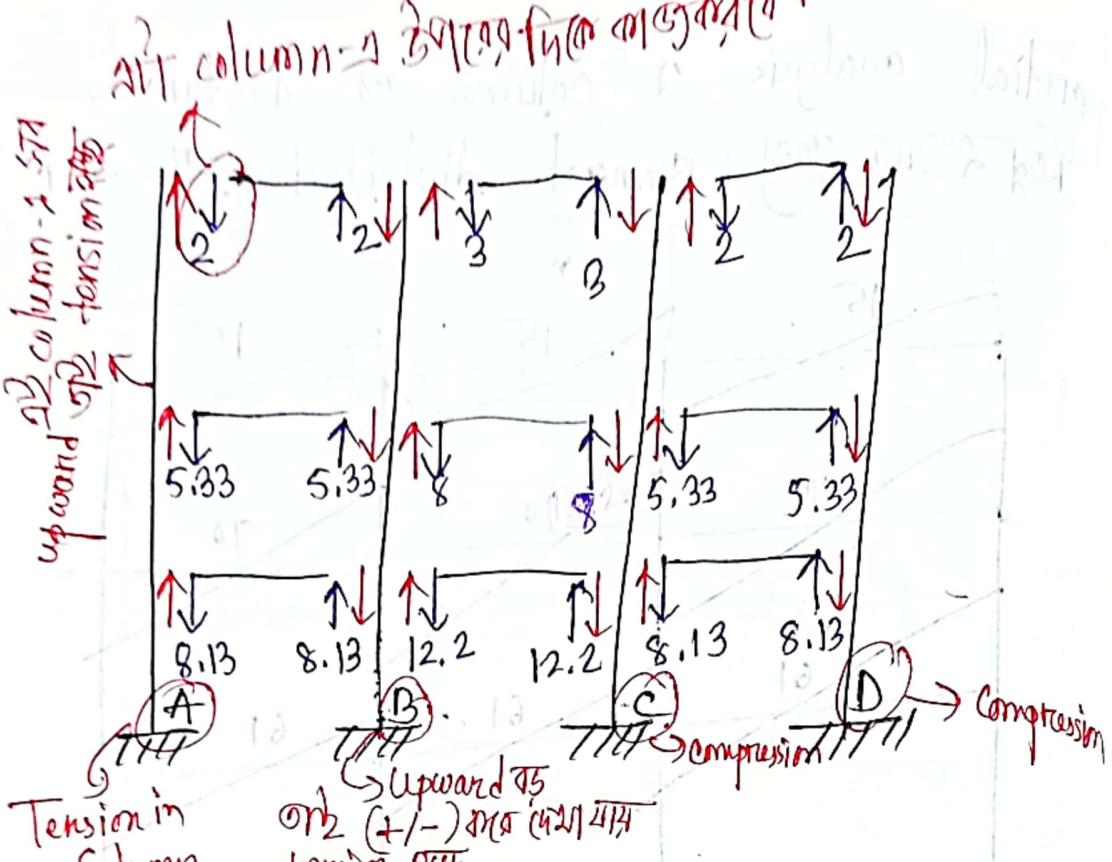
$\curvearrowleft \Sigma M_o = 0$

$\Rightarrow S \times \frac{L}{2} - M = 0$

$S = \frac{2M}{L} = \frac{2 \times 15}{15} = 2 \text{ kip (MN)}$

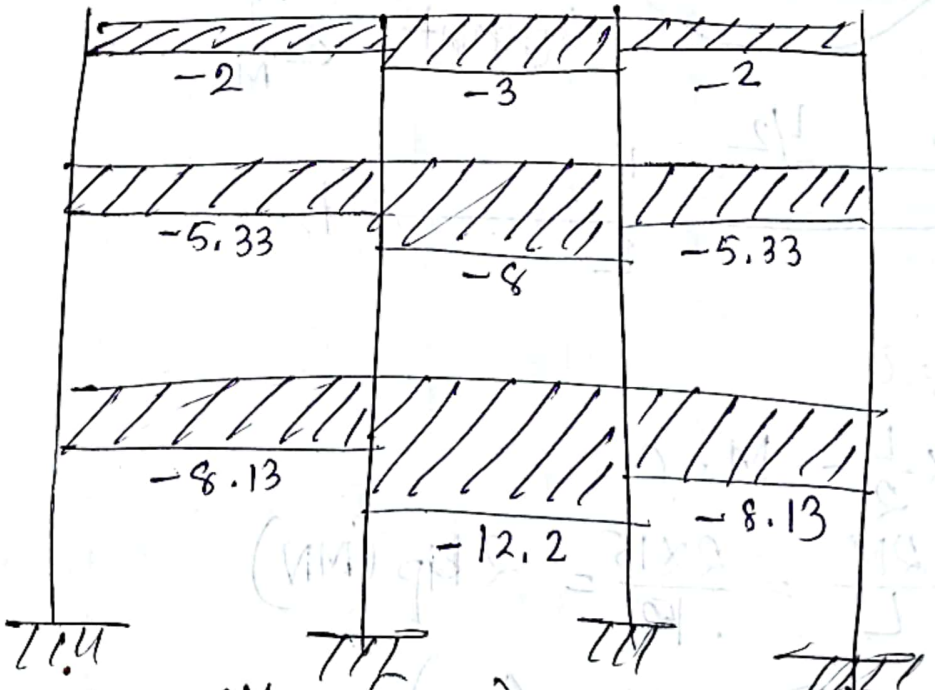
$S = \frac{2 \times 15}{10} = 3 \text{ kip (NO)}$

$S = 2 \text{ kip (OP)}$



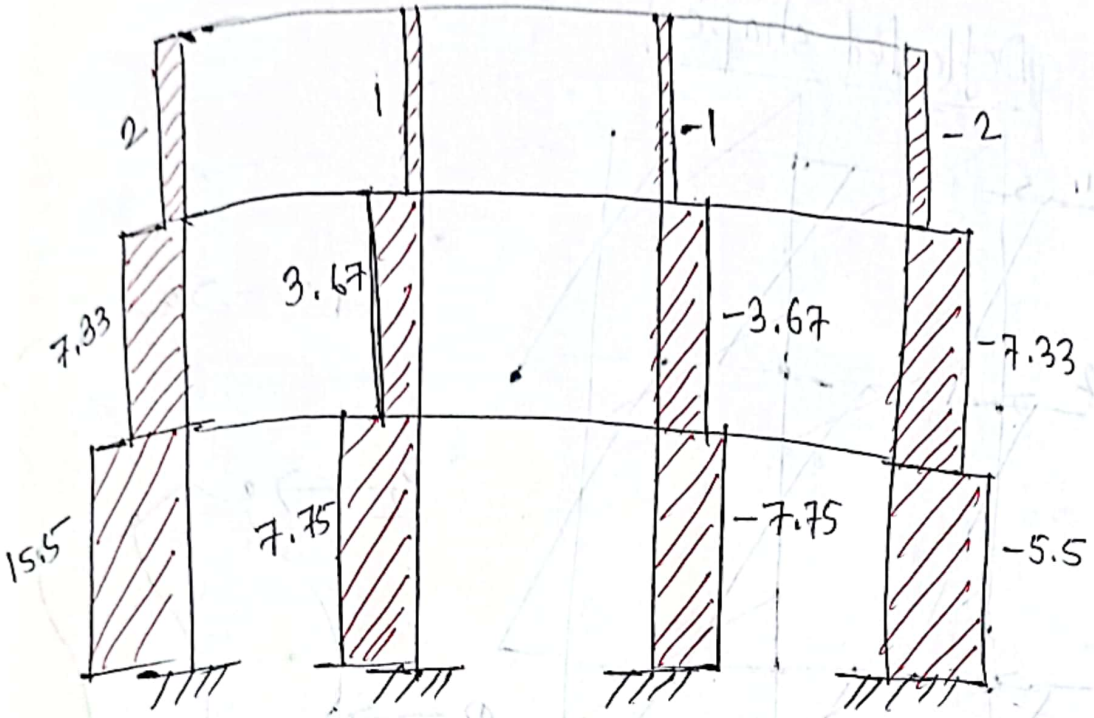
positive shear → ↑ left ↓ right

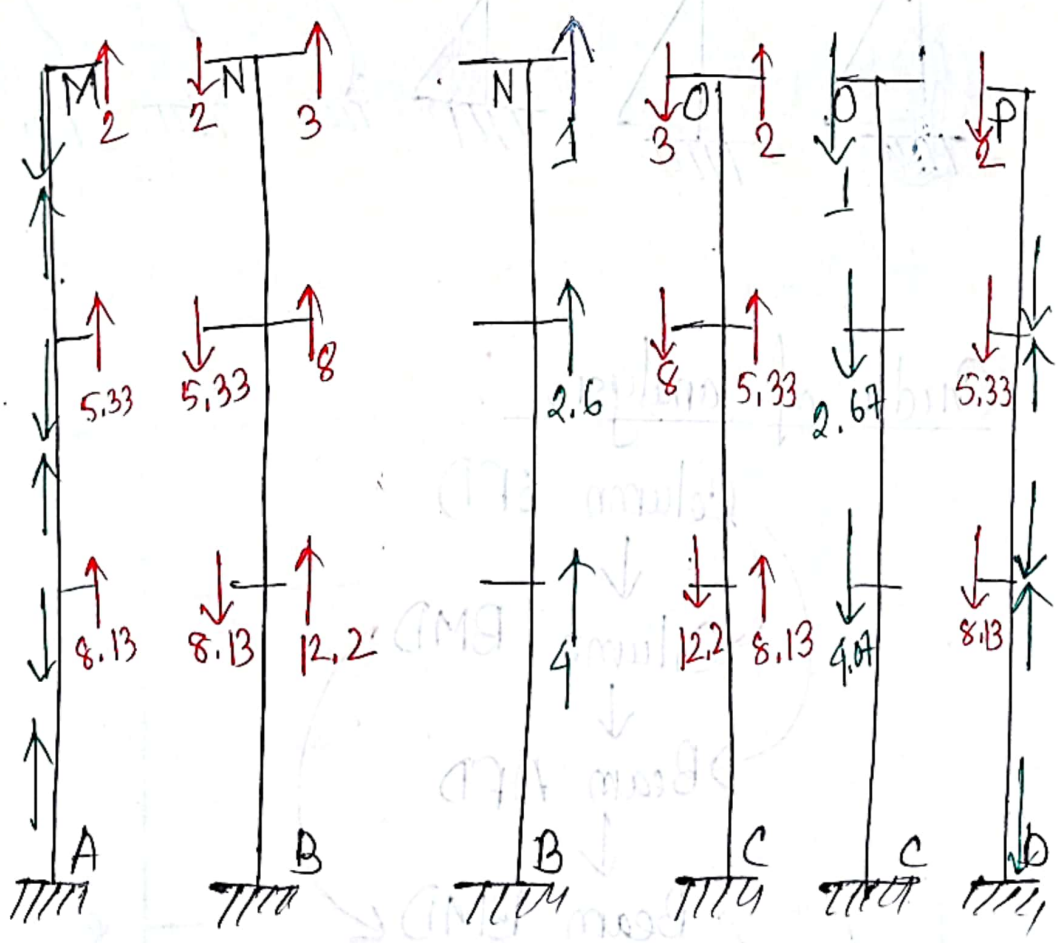
negative shear → ↓ left ↑ right



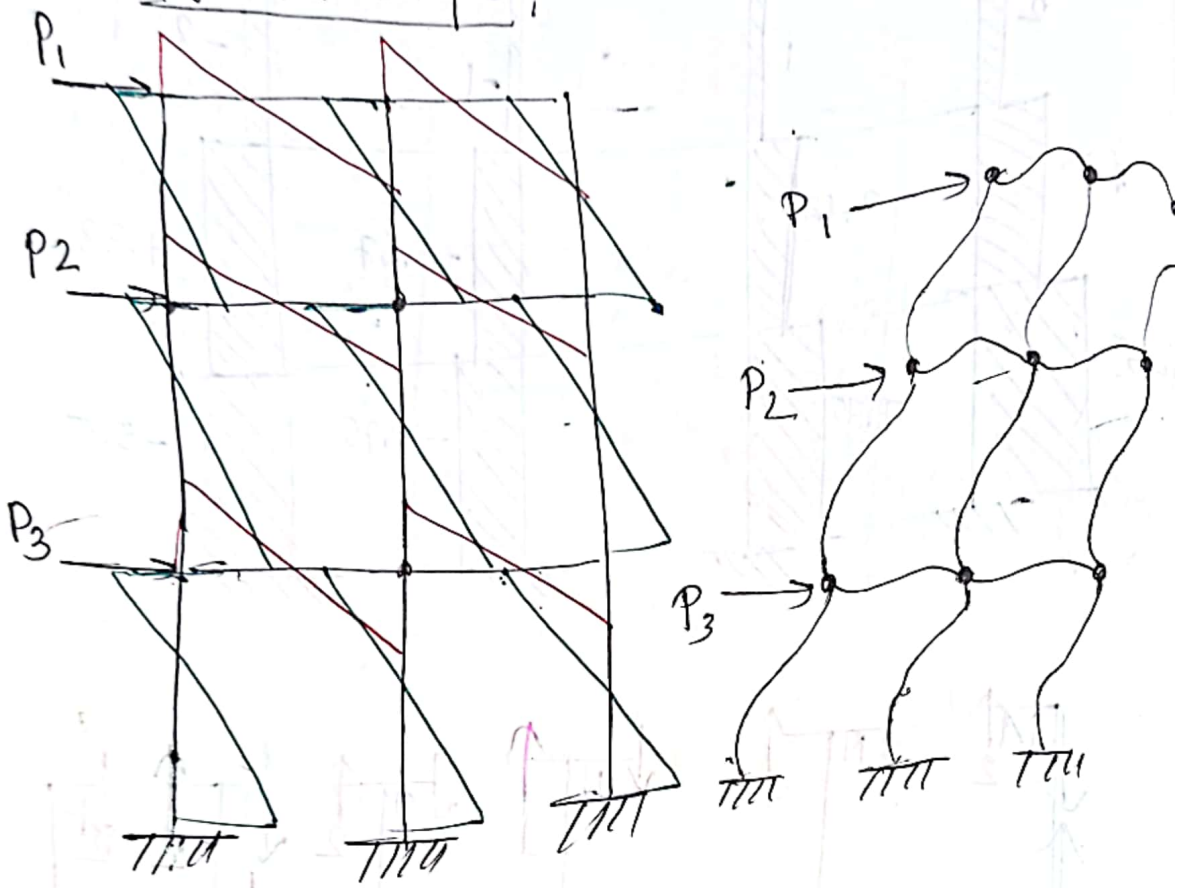
$S = \frac{2M}{L} = (2\times40)/15 = 5.33$ kip

$S = (2\times40)/10 = 8$ kip ; $S = 8.13$ kip


2
1
-1
-2
7.33
3.67
-3.67
-7.33
15.5
7.75
-7.75
-5.5


M
N
N
O
O
P
2
2
3
3
2
1
2
5.33
5.33
8
2.6
8
5.33
2.67
5.33
8.13
8.13
12.2
4
12.2
8.13
4.07
8.13
A
B
B
C
C
D

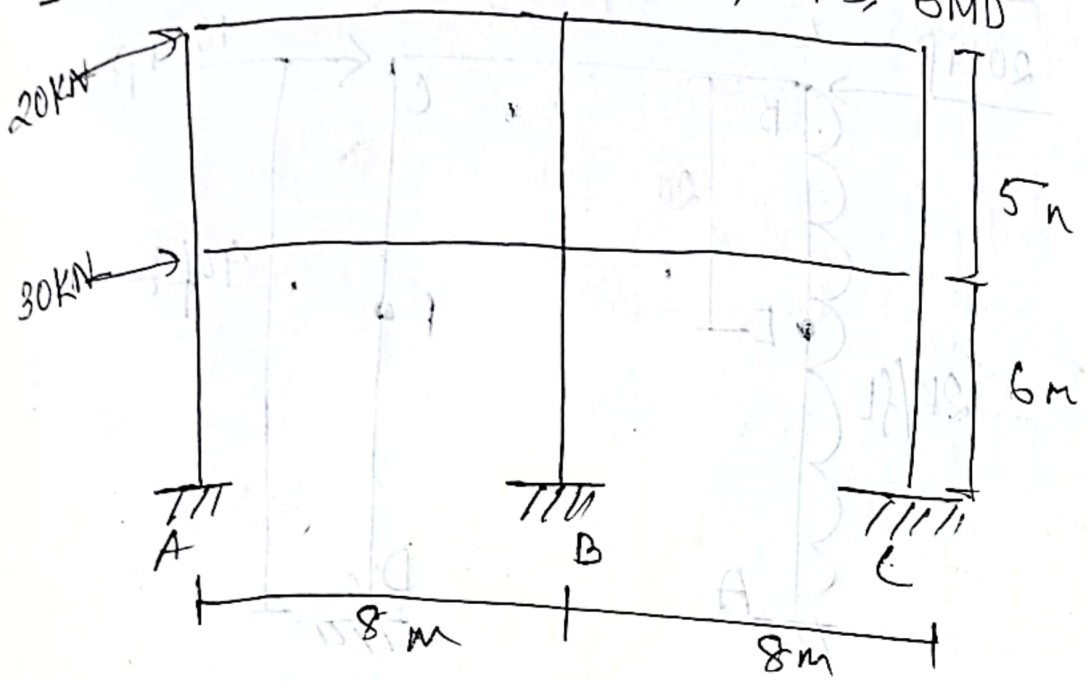
Deflected shape :



Order of analysis :

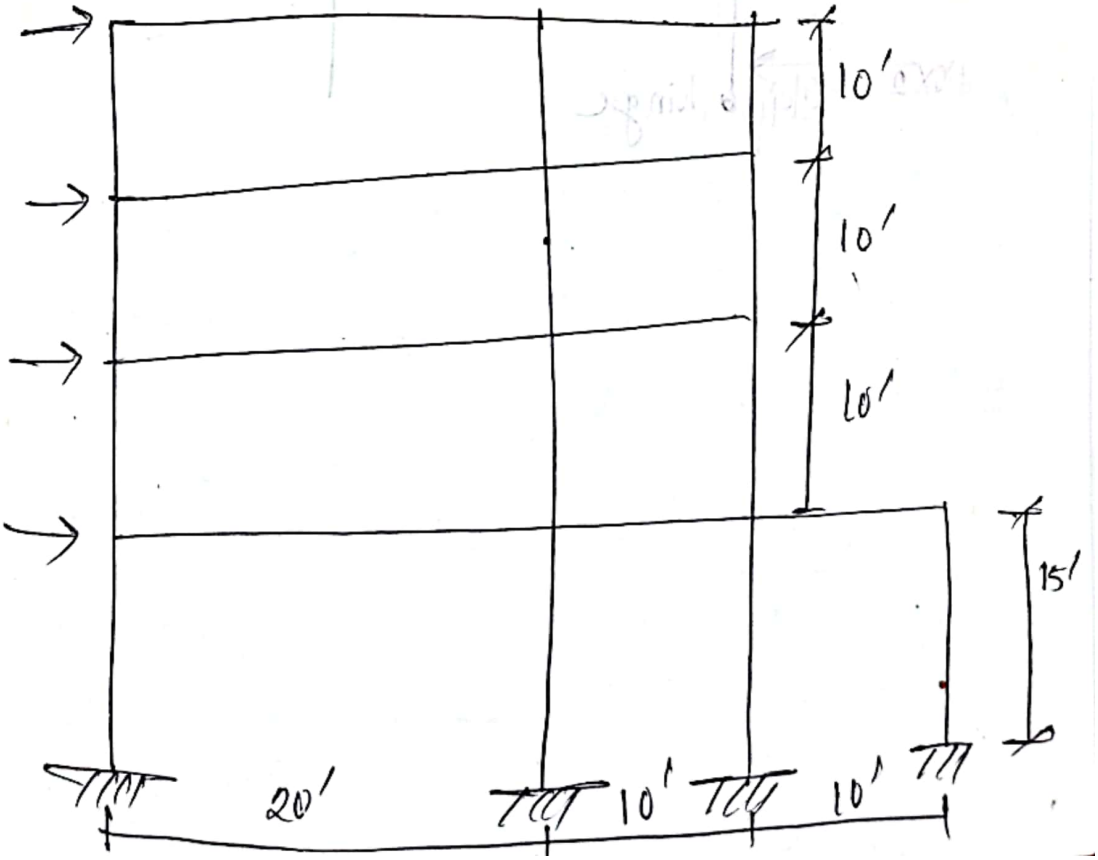
Column SFD
↓
Column BMD
↓
Beam AFD
↓
Beam BMD
↓
Beam SFD
↓
Column AFD

Assignment: (Portal-1) Column SFD, BMD
Beam AFD, SFD, BMD

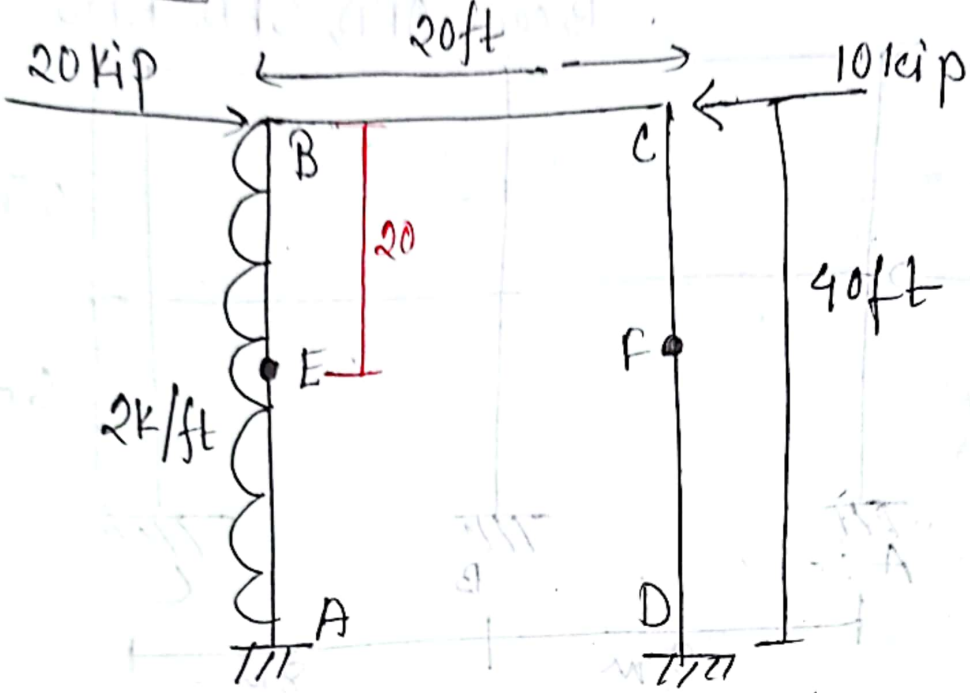


(Portal-2) → Example, section (7.10) Norris and Wilbur

(Portal-3) Column → AFD, SFD, BMD
+ Beam →

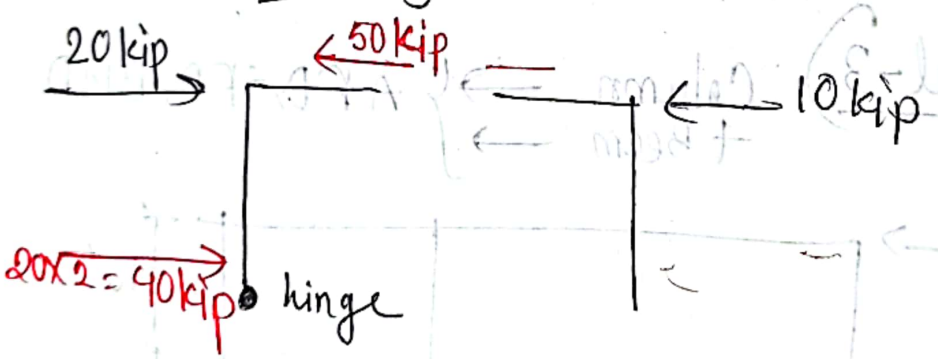


Problem:

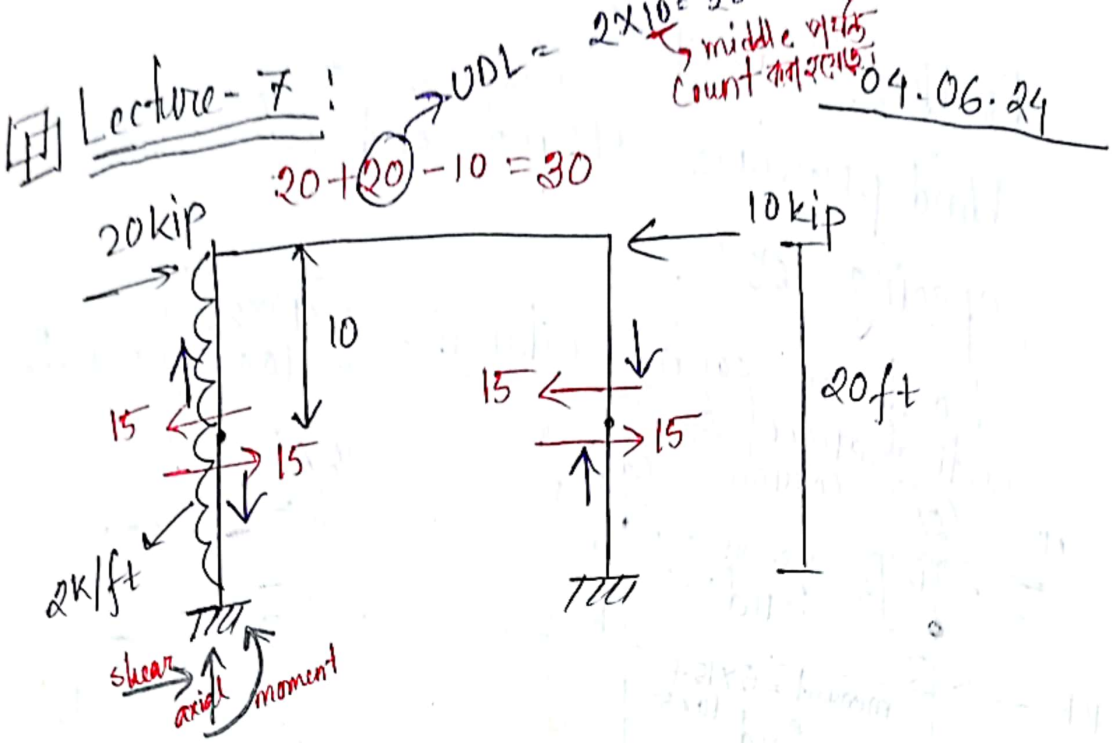


Soln: $DI = (3\times3+6) - (3\times4+0)$

$= 3$



Lecture - 7 : 04.06.24



Cantilever method :→ portal ~~এর~~ better

- lack of consideration in portal method.
- considering cross-sectional areas of columns in distributing axial force.

Assumption:

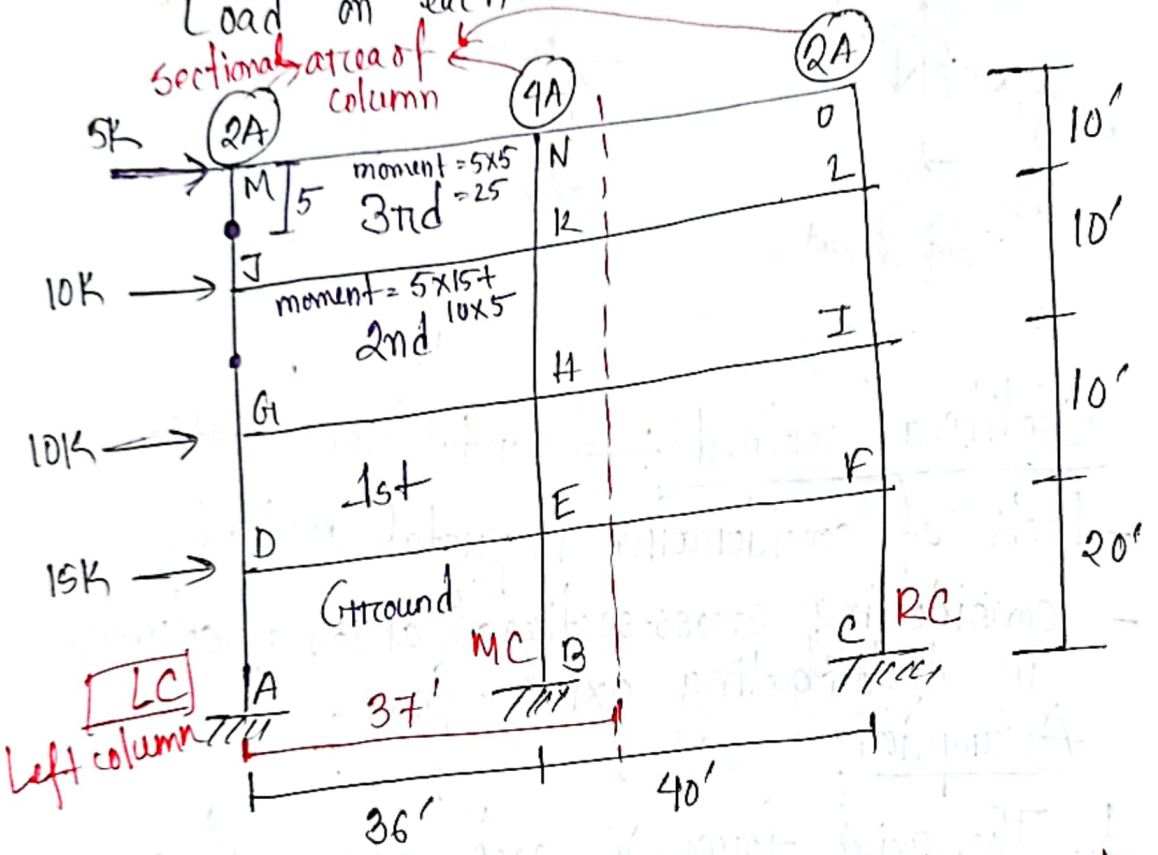
1. The axial force in each column of a storey is proportional to its horizontal distance from the C.G of all the columns of the storey. and size of the column
2. There is a point of inflection at the center of each column.
3. There is a point of inflection at the center of each beam.

CamScanner

Problem: D of I

Wind pressure 40 psf and c/c column spacing 25'.

Load on each column = $\left(\frac{40 \times 25}{1000}\right)$ = 1 k/ft



Beam → AFD, BMD, SFD → Draw using Cantilever method

Column → AFD, BMD, SFD

Solution: CG বের করে axial force different হবে তাই CG বের করতে হবে।

Determine the distance of CG:

$$\bar{x} = \frac{a_1 x_1 + \dots + a_n x_n}{a_1 + \dots + a_n}$$

x → horizontal distance from starting

$$\bar{x} = \frac{(2A \times 0 + 4A \times 36 + 2A \times 76)}{(2A + 4A + 2A)}$$

$$= 37'$$

- column এর নিচের দিকে জোর হয় উপরের দিকে টান হয়। তাই আলাদা area (একটা column এর) দিলে ২বার CG বের করতে হবে।

- CG দ্বারা বের করা যায় কোন column-এ tension না compression হচ্ছে তা।

- এখানে যেহেতু CG এর বাম দিক থেকে load আসছে তাই বাম দিকে tension ডানে Compression.

- stress, $\sigma \propto$ d (distance) → এটা দ্বারা বুঝানো হচ্ছে stress এর সাথে distance related.

$\sigma \propto y$

$\Rightarrow \sigma = Ky \quad ; K = \frac{My}{I}$

$\Rightarrow \boxed{\sigma = \frac{M(c)}{I}}$ → CG থেকে point এর distance

- CG থেকে distance যত বেশি stress তত বেশি

$I = \Sigma Ad^2$

$= 2 \times A \times (37)^2 + 4A \times (37 - 36)^2 + 2A \times (37 - 7)^2$

$= 5784A$

force in terms of moment

stress → Left column = $\frac{M \times 37 \times RA}{5789A}$ → area আসছে কলামের stress এর আগে area দুইবার কেটে force পাবো

$= 0.012M\,(LC)$

$MC = \frac{M \times (37-36) \times 4A}{I}$

$= 0.000692M\,(MC)$

$RC = \frac{M \times (37-76) \times 2A}{I}$

$= -0.0135M\,(RC)$ → মানে compression হচ্ছে

LC = 0.012M
MC = 0.000692M
RC = −0.0135M

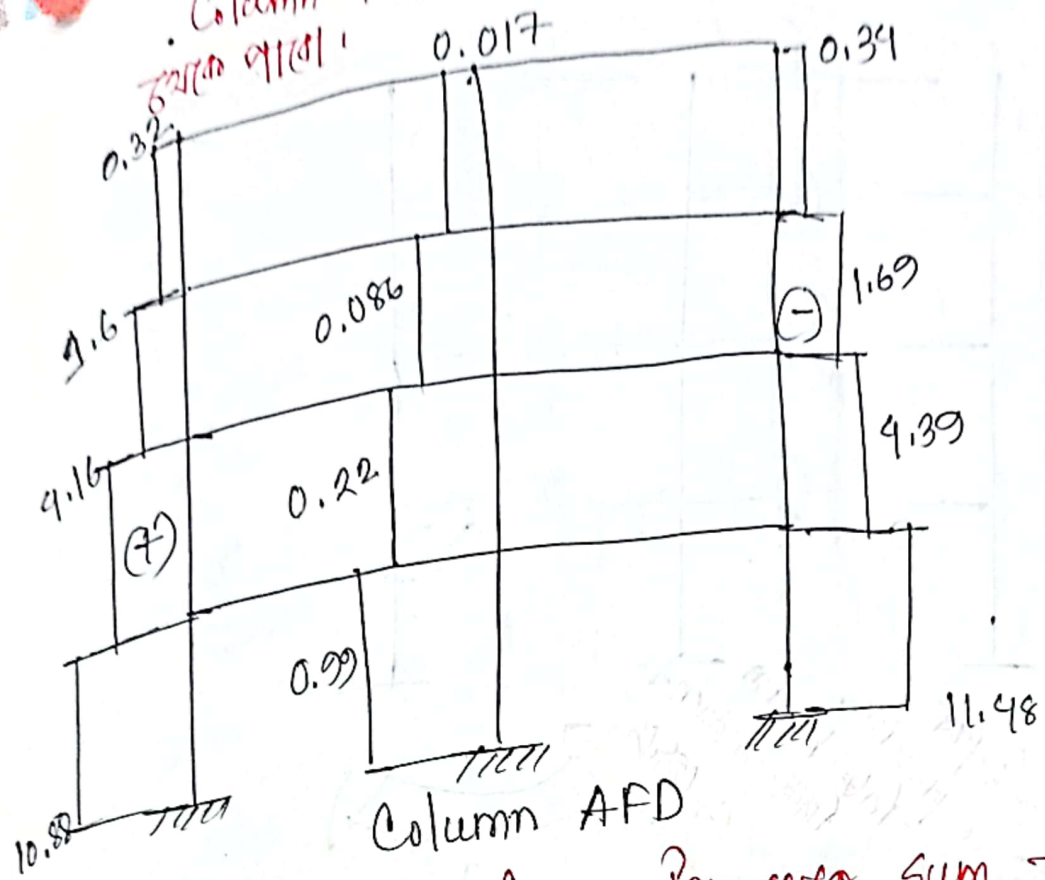
force এর বেস বরাবর হচ্ছে

Floor	Moment (K-ft)	Column AF (Kip)		
		LC	MC	RC
3rd	5×5 = 25	0.32	0.017	−0.34
2nd	5×15+10×5 = 125	1.6	0.086	−1.69
1st	5×25+10×15 +10×5 = 325	4.16	0.22	−4.39
GF	5×40+10×30+ 10×20+15×10 = 850	10.88	0.59	−11.48



CamScanner

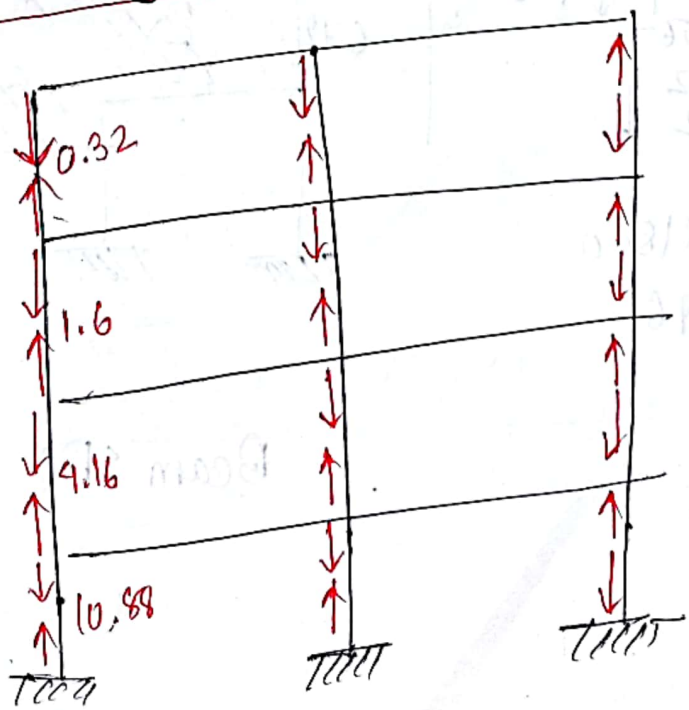
· Column এর axial force বের করা।

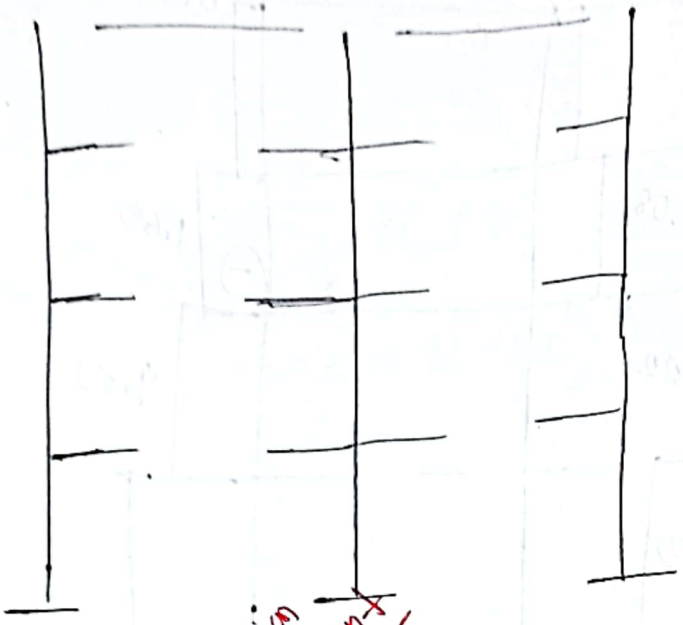


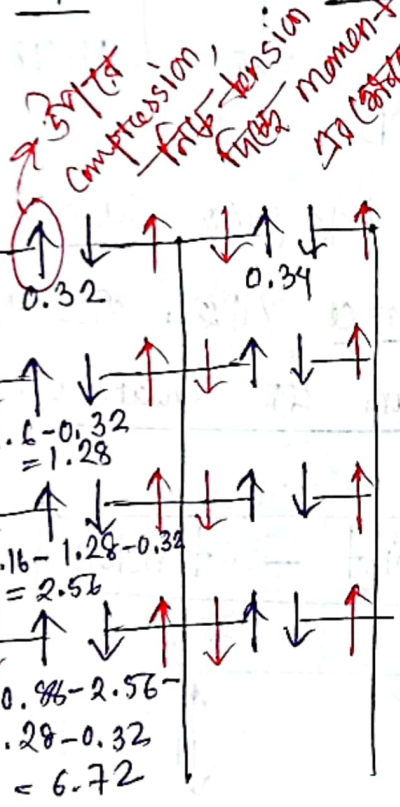
Column AFD

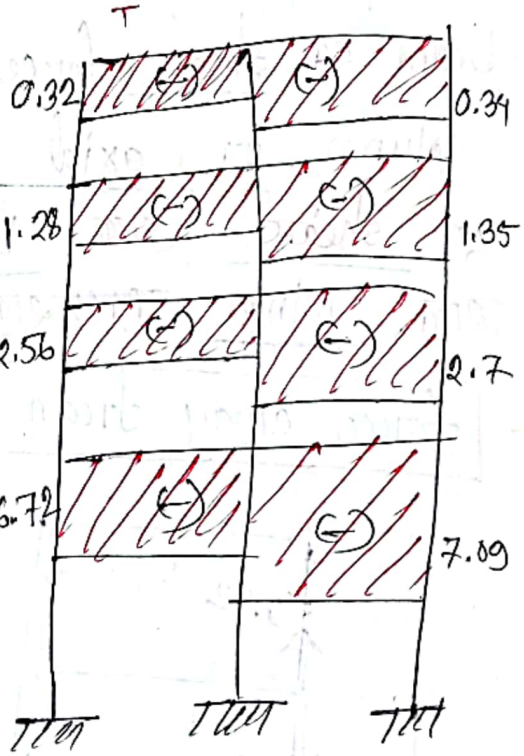
- beam এর shear force উপর থেকে sum করে column এর axial force পাই। তাই column এর axial থেকে beam এর shear বের করতে হলে minus করতে হবে।

- force away from joint → tension





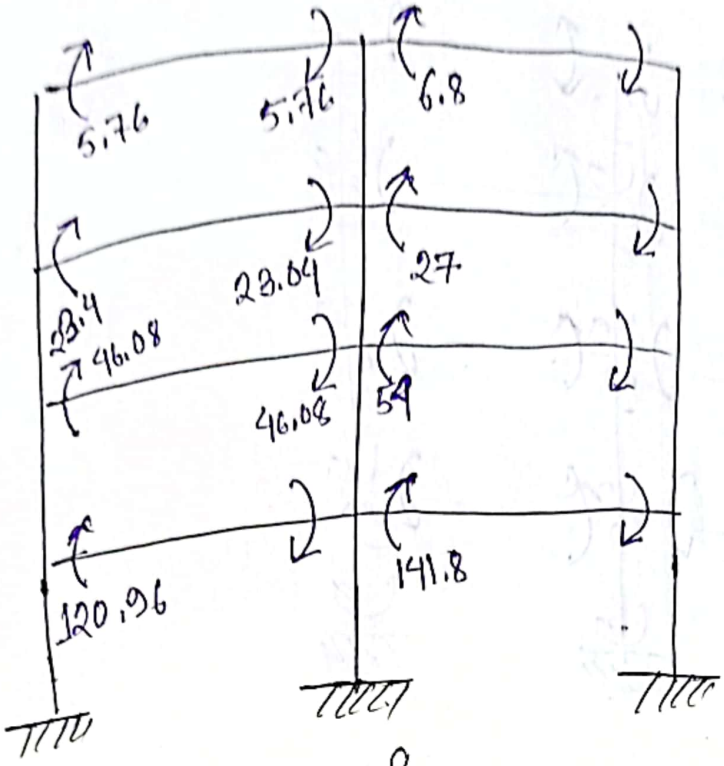


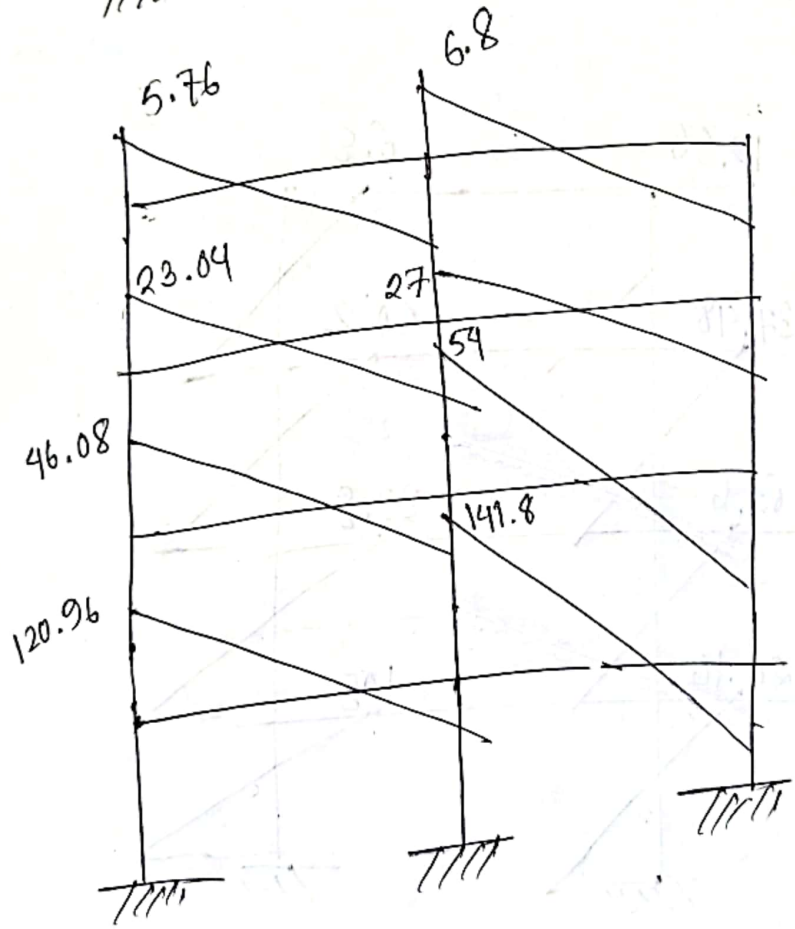


$M_m = 0.32 \times 18 = 0$

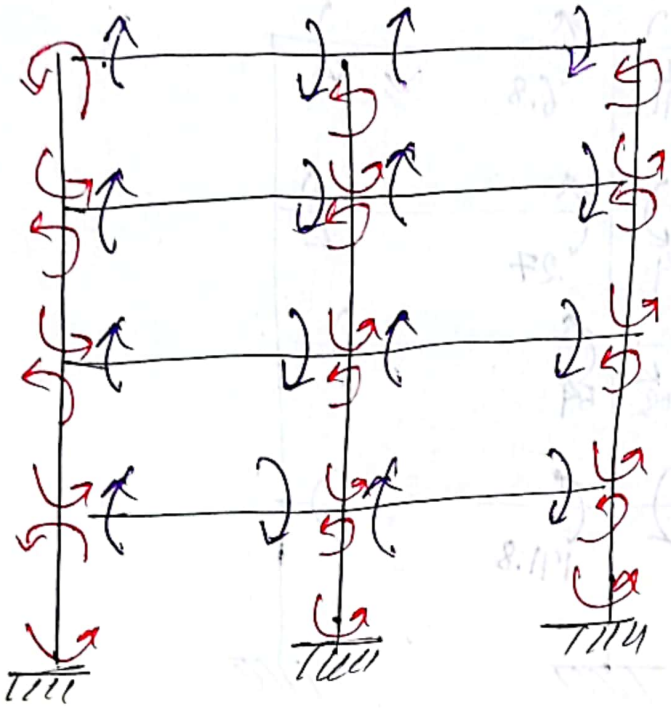
$M_m = 5.76$

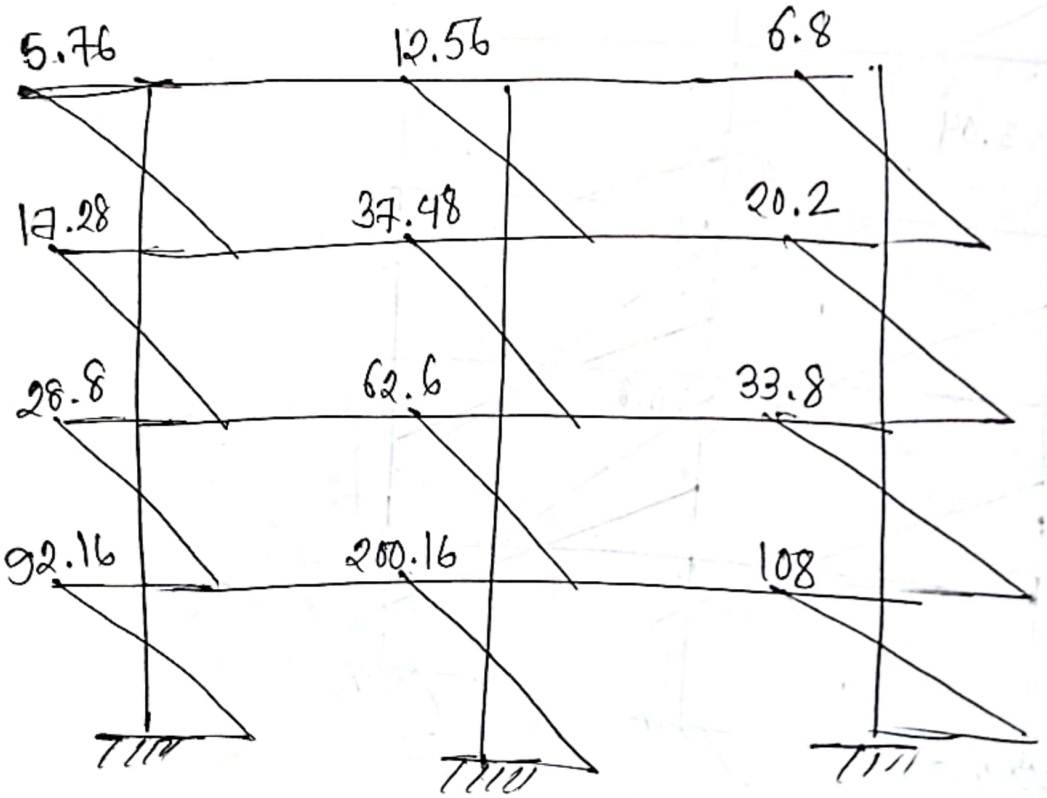
Beam SFD


5.76
5.76
6.8
23.04
27
23.04
46.08
46.08
54
120.96
141.8


5.76
6.8
23.04
27
54
46.08
141.8
120.96

Beam BMD

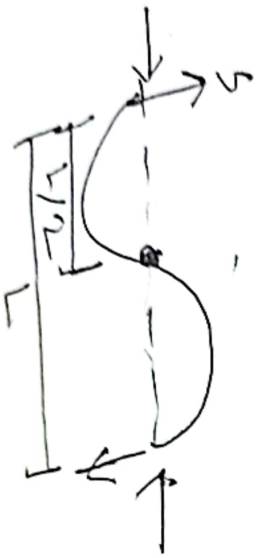




Column BMD

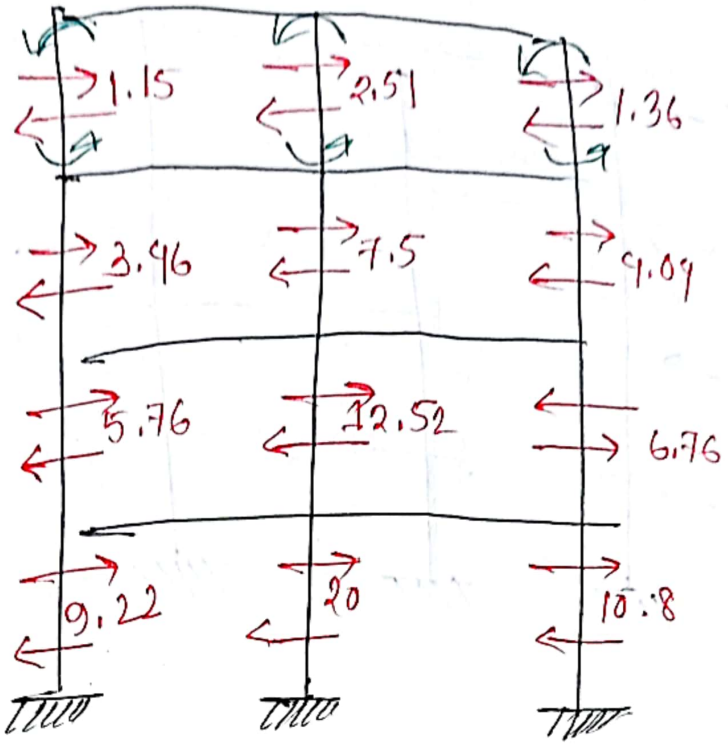
CamScanner

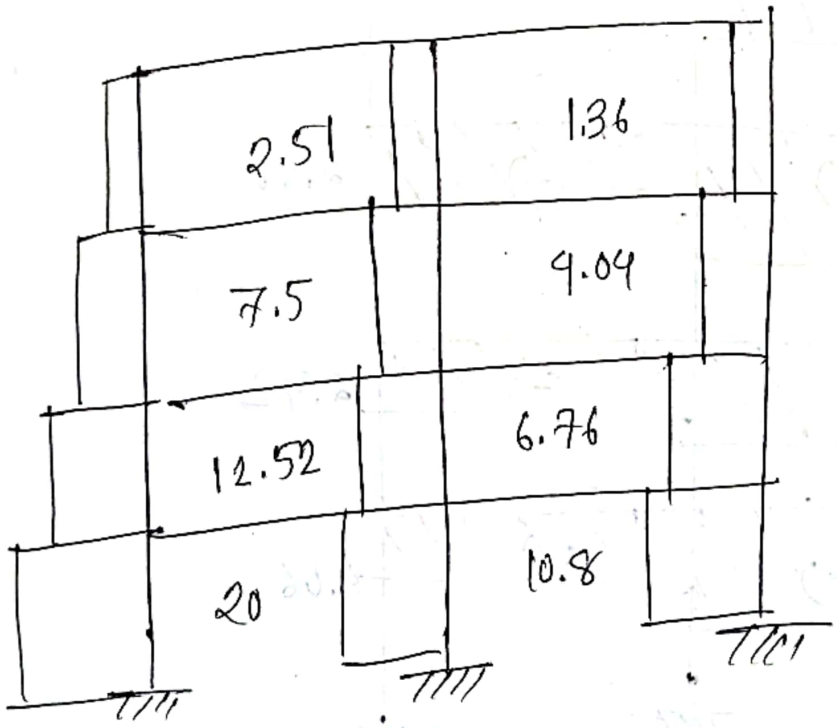
$S = \frac{2M}{L}$



$S \times \frac{L}{2} - M = 0$

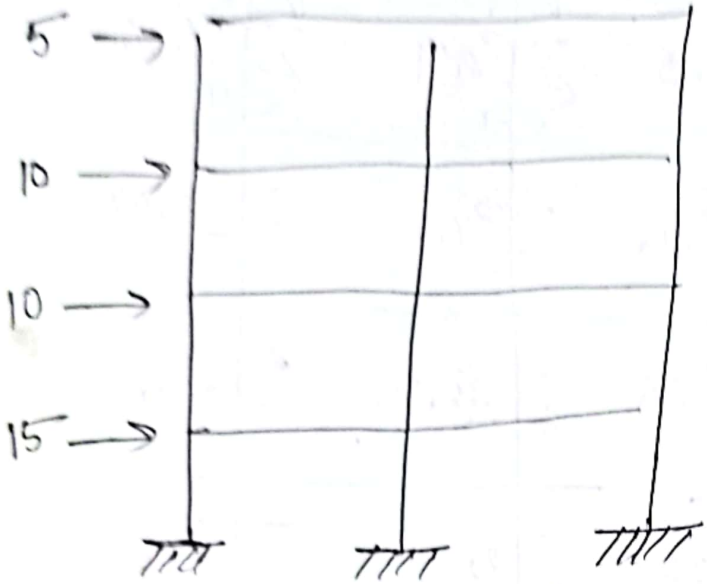
$\Rightarrow S = \frac{2M}{L}$

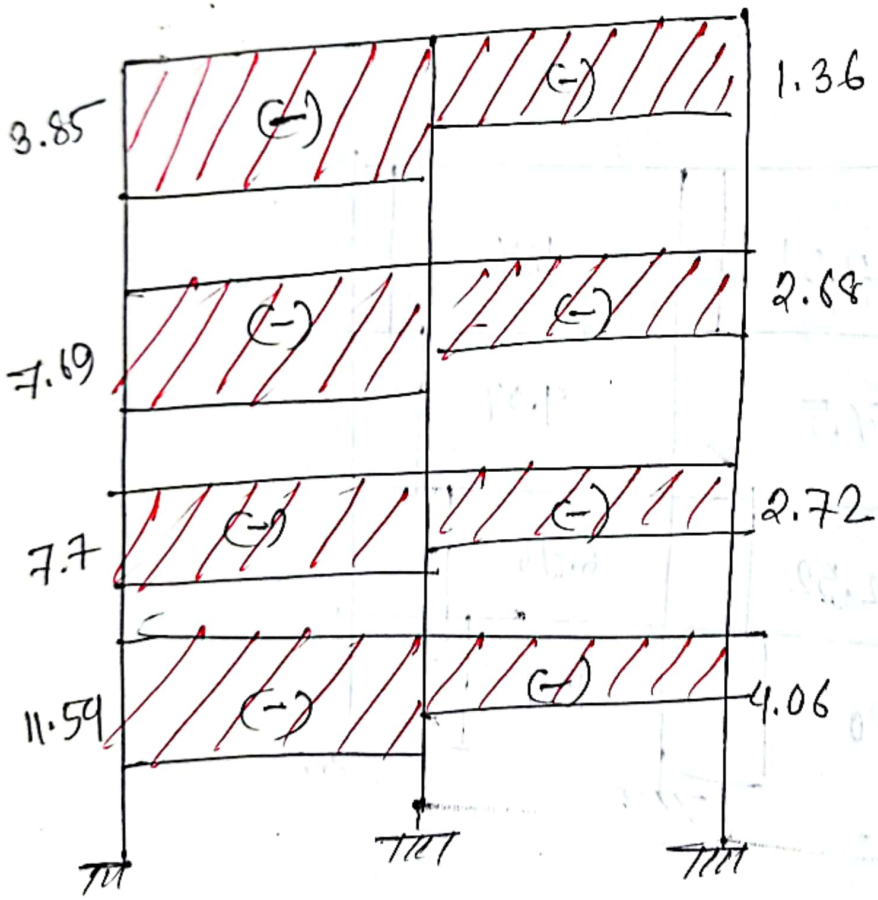




Column SFD

CamScanner





Beam AFD

Order of analysis :

Column AFD (from assumption)

↓

Beam SFD

↓

Beam BMD

↓

Column BMD

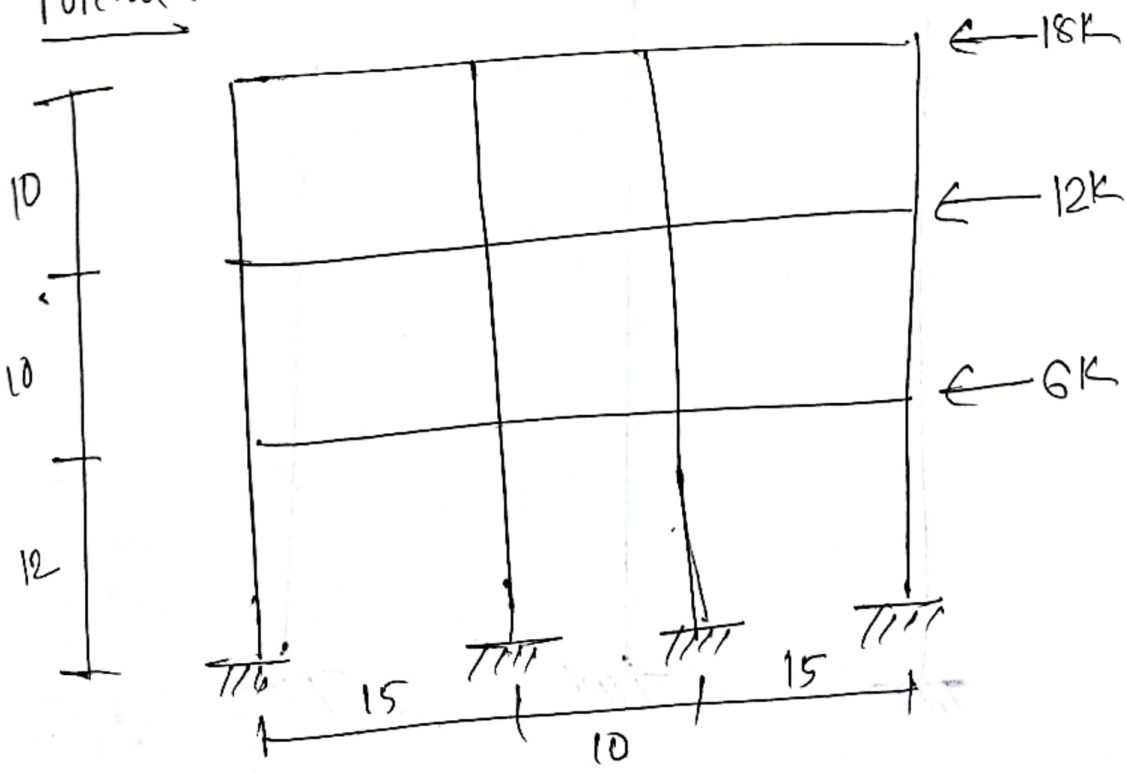
↓

Column SFD

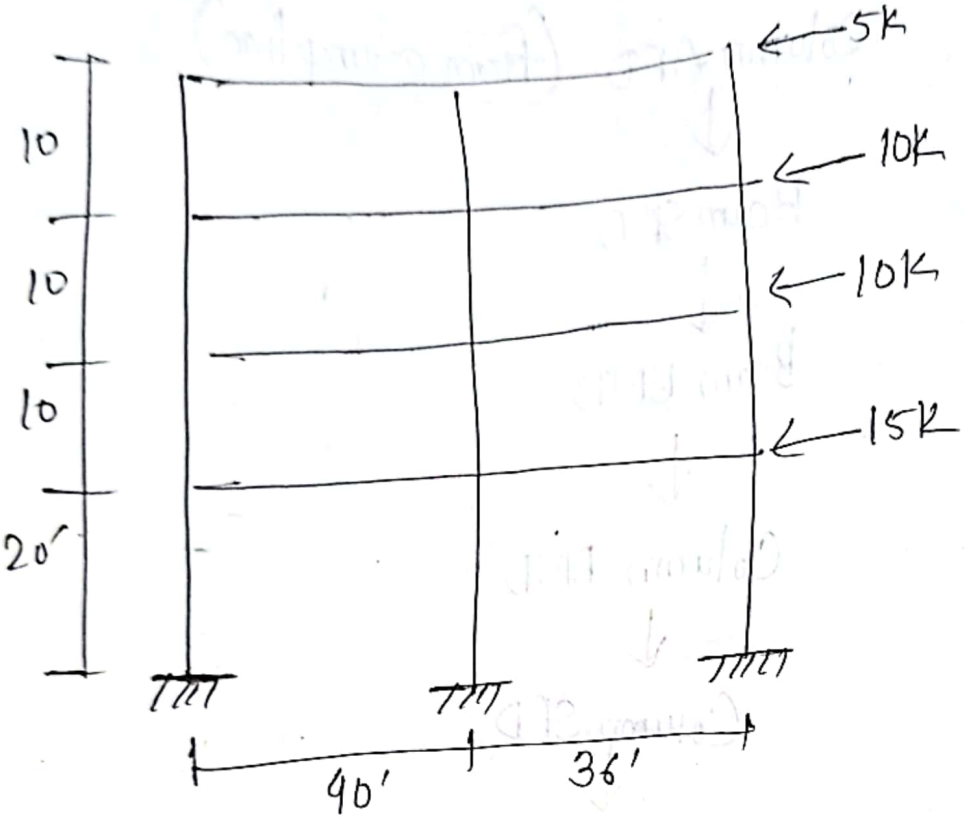
↓

Beam AFD

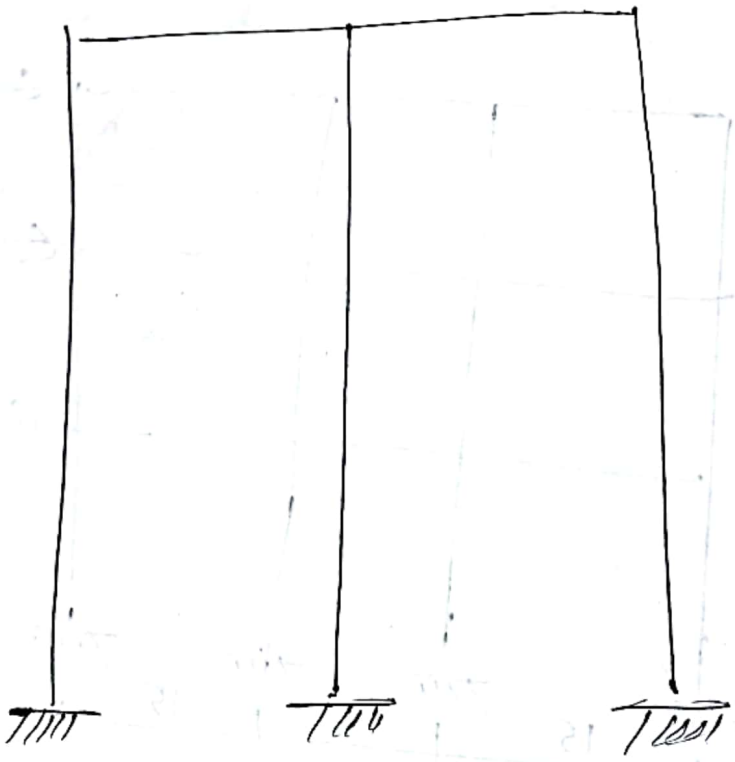
Portal :



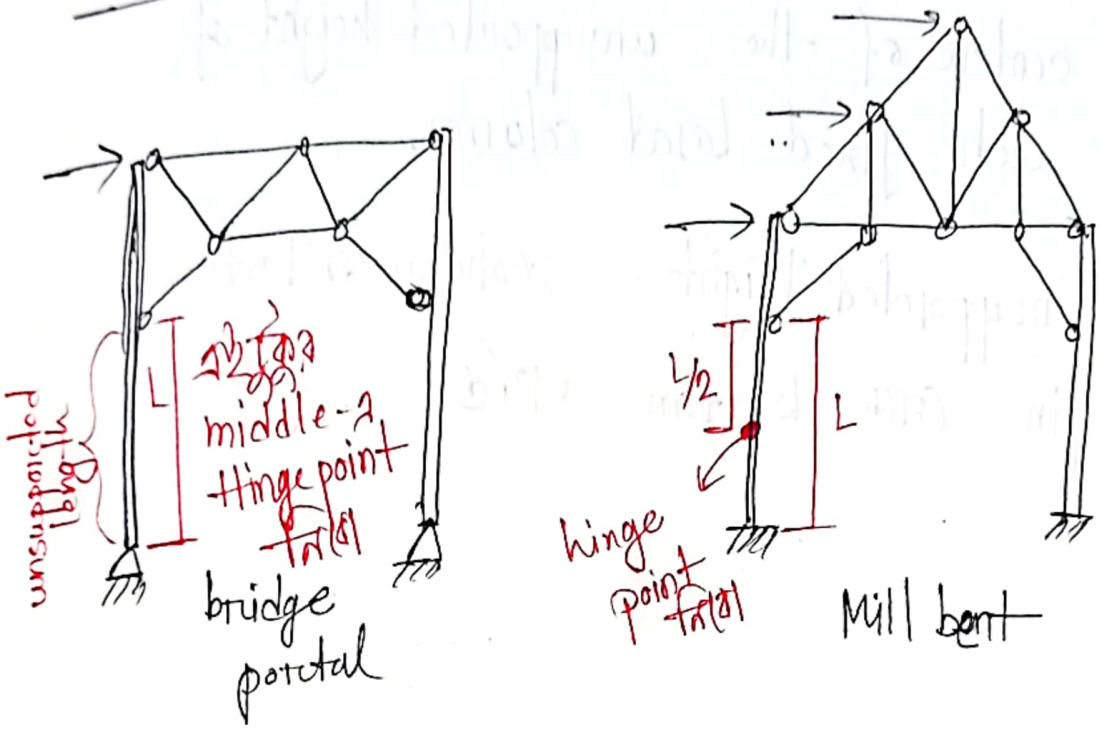
Cantilever :



Assignment :→ 2টি CG বের করতে হবে।



Approximate analysis of Bridge portal and Mill bent:



Bridge portals and Mill bents:

- এই দুটো member moment নেয় তাদেরকে truss দ্বারা যুক্ত করা হয়।
- truss is a single force member either tension or compression.
- Portal-এ যা করেছি mill bent/bridge portal-এও এই করবো যদি statically indeterminant হয়।

1. The horizontal support reactions are equal.

2. There is a point of inflection at the center of the unsupported height of each fixed based column.

— unsupported height → column ನ Last pin ದಿಂದ bottom ವರೆಗೆ