31·8·2015

CE-311

Rouf Sir

Syllabus—

1. Stability
2. Determinacy of structures
3. Analysis of statically determinate trusses
4. " " " arches
5. influence lines
6. moving loads on beams, frames and trusses
7. analysis of suspension bridge
8. Wind load
9. Earthquake loads
10. Approximate analysis of statically indeterminate structures : braced trusses, portal Method, cantilever method and vertical load analysis of multi-storied building frames.
11. Deflection of beams, trusses and frames by virtual work method.

Books :

1) Structural analysis

— by Norris + Willbur + Utku

2) Structural analysis

— By shedd + Vawter

Stability —

A structure is —

1) Statically unstable

if total eq^n > total unknown

2) Geometrically unstable —

if general arrangement of reactions or members are not properly made.

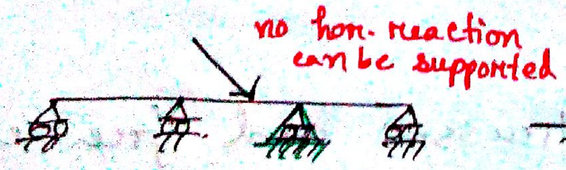


fig-1 (Geo. unstable)

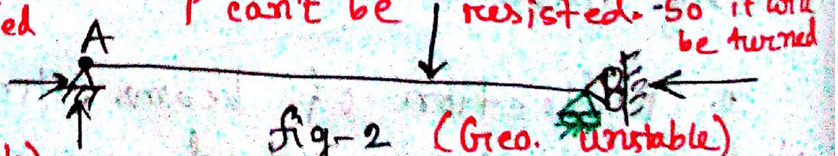


fig-2 (Geo. unstable)

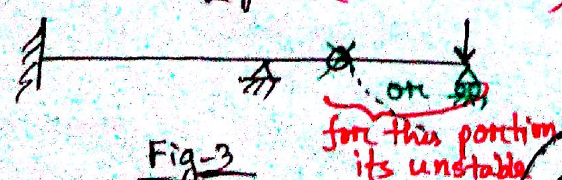


Fig-3

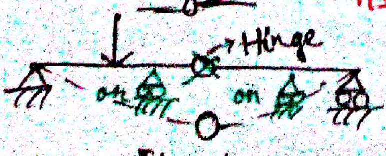


Fig-4

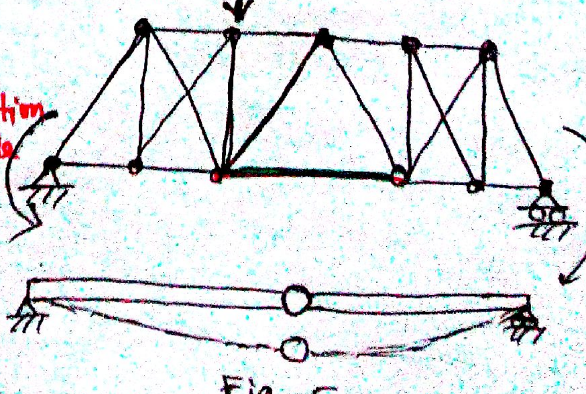
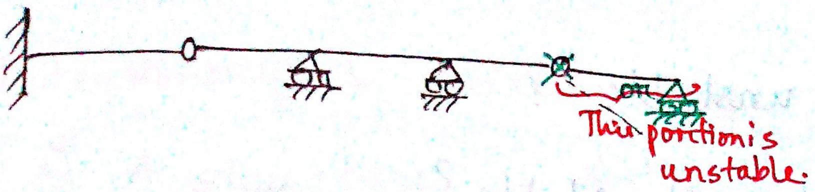
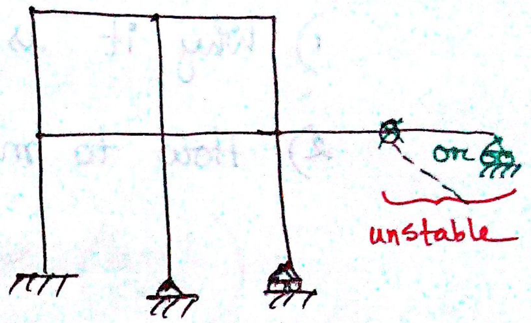
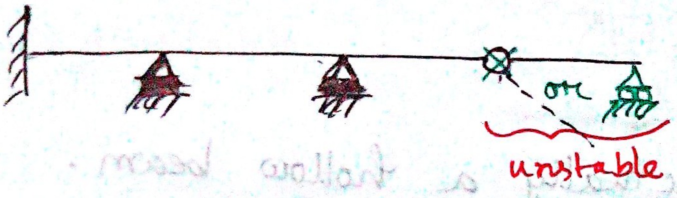


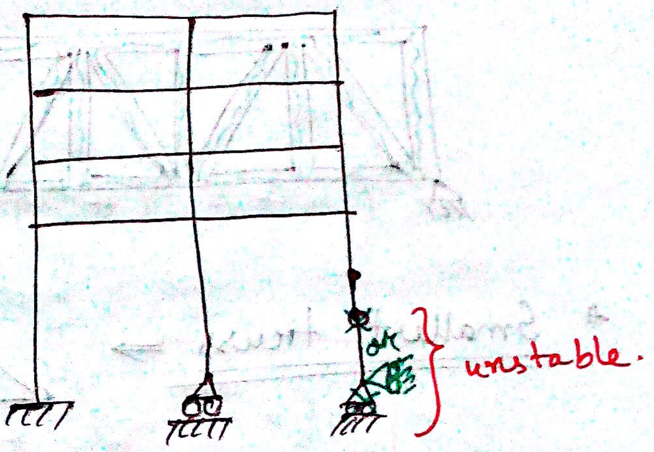
Fig-5







○ ⇒ Hinge support
but দরজার কবজার মত-
আটকাতে পারবে but force
resist করতে পারবে না।
So এর পরের portion -এটার
respect -এ ঘুরে যাবে।



All the above structures are geometrically unstable.

* <u>In fig-1</u>

statically stable → cz eq^n < unknowns

but geometrically unstable → cz no such support

⊛ যেকোন ছোট portion-ও unstable হলেই total টা
unstable হবে!

↓

Unstable can't be analysed.

↓

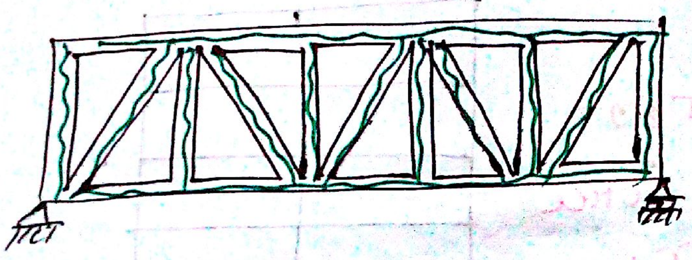
So we must make it stable.

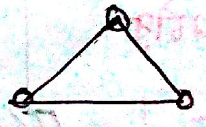
(*) So first is identify —

1) Why it is unstable ?

2) How to make it stable ?

Truss ⇒ this is actually a hollow beam.



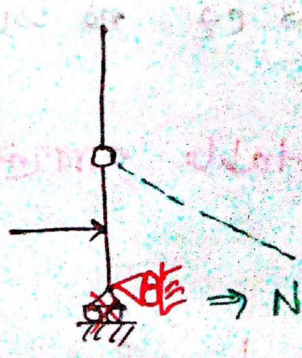
Smallest truss ⇒ 

$$\boxed{b = 2j - 3}$$

⇓

minimum no. of bars required for a truss.

How to understand stable/unstable —



i.e. hori-load can not resist

⇒ Now the load can be resisted.

Structural Stability.

*** Determinacy & Indeterminacy —**

a) A structure is statically :

i. Unstable if (total unkown forces) < (Total Eqⁿs)

ii. Stable and determinate if (") = (")

iii. Stable and indeterminate if (") > (")

AND $\boxed{D^\circ \text{ of Indeterminancy} = (\text{"}) - (\text{"})}$

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Determinancy and Indeterminancy (Contd.) ⇒

b) Total Unknown Forces = Member forces + R's

$= \underset{\hookrightarrow (AF)}{\underline{1}}\, b + r$ for a (2D) truss

$= \underset{\hookrightarrow (AF, SF, BM)}{\underline{3}}\, m + r$ for a (2D) frame

$= r$ for a beam/col.

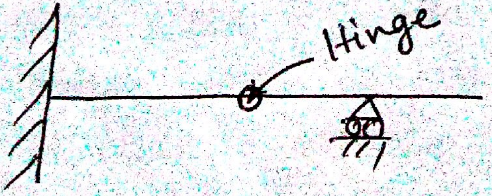
c) Total Eqⁿs = Equillibrium Eqⁿs for joints + Eqⁿs of conditions

$= \underset{}{\overset{(\Sigma F_x, \Sigma F_y)}{2}}\, j + 0$ ⇒ beez truss-এ special condition হয় না কারণ প্রত্যেক joint-এ hinge. for a (2D) truss

$= \overset{\Sigma F_x, \Sigma F_y, \Sigma M}{3}\, j + c$ for a (2D) frame

$= 3 + c$ for a beam/col.

- b = No. of bars ; r = No. of reactions
  m = no. of members ; c = No. of conditions (e.g. Hinges)
  j = no. of joints



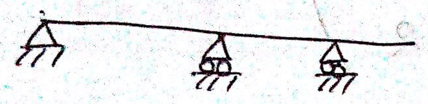
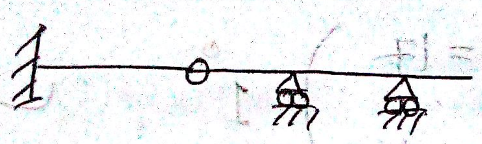
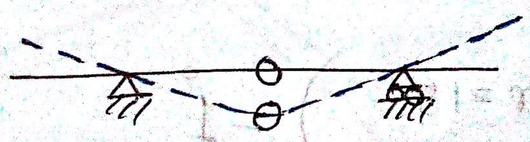
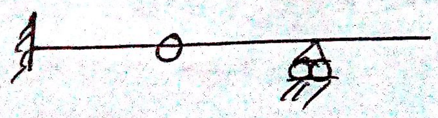
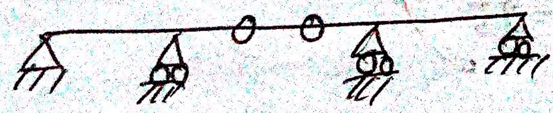
$Eq^n = 3 + c$; Here, c = Condition $\Rightarrow \Sigma M_{Hinge} = 0$

$= 3 + 1$

$= 4$

Problems :-

Beams –

Geo. Stability		No. of R's	Indeterminacy	Statically Stability ?
✓		$r=4$	$4-3=1^\circ$	✓
✓		$r=5$	$5-(3+1)=1^\circ$	✓
✗		$r=3$	$3-(3+1)=\underline{-1}^\circ$	✗
✓		$r=4$	$4-(3+1)=0^\circ$	✓
✓		$r=5$	$5-(3+2)=0^\circ$	✓

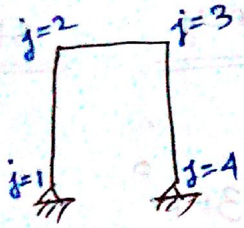
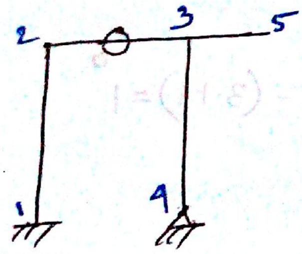
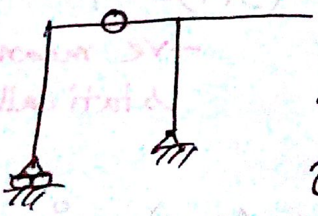
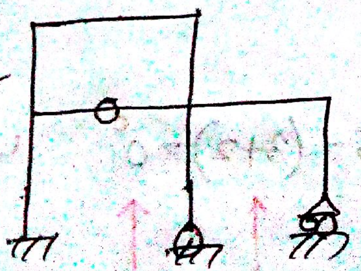
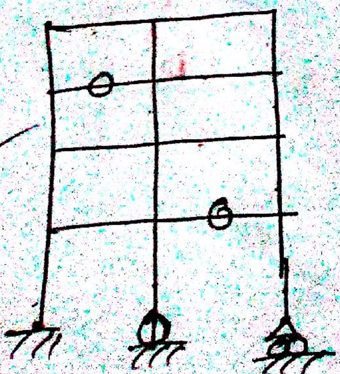
–ve means this is statically unstable.

Unknown

$Eq^n s$
$(3+c)$

D°

Plane (2D) Frames:

Geo. Stability	Frame	Values	Equations	Indeterminancy	Stat. Stability
✓		$m=3$, $r=4$, $j=4$, $c=0$	Total unk. $= 3m + r = 13$; Total eq^{n}s. $3j + c = 12$	1°	✓
✓		$m=4$, $j=5$, $r=5$, $c=1$	$3m + r = 17$; $3j + c = 16$	1°	✓
✗		$m=4$, $r=3$, $j=5$, $c=1$	$3m + r = 15$; $3j + c = 16$	-1°	✗
✓		$m=8$, $r=6$, $j=8$, $c=1$	$3m + r = 30$; $3j + c = 25$	5°	✓
✓		$m=20$, $r=6$, $j=15$, $c=2$	$3m + r = 66$; $3j + c = 47$	19°	✓

* free end is a joint

* Statically unstable হলে Geometrically stable হতে পারে (nominally)

Truss —

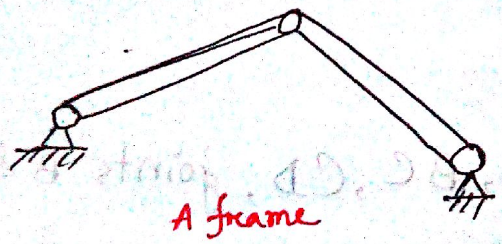
Special symbol of supports

Fig 4.2 (NORRIS)

Fig 4.3 (NORRIS)

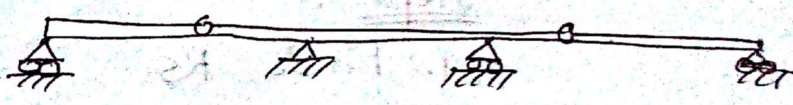
Fig 4.10 (NORRIS) ⇒ All stable.

(i) top Leftmost



A frame

(ii) top rightmost

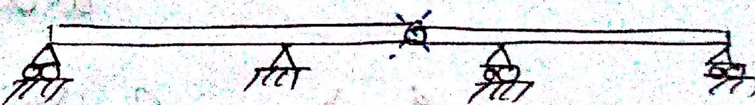


* যদি ফাঁকার খানে একটা member add করা হয় then

b=17

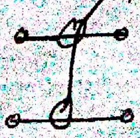
∴ +1° Indet.

(iii)



এখানে hinge কোনটা দিলে আলাদাভাবে stable. So total টা stable.

→ Link ⇒ vertically connection.



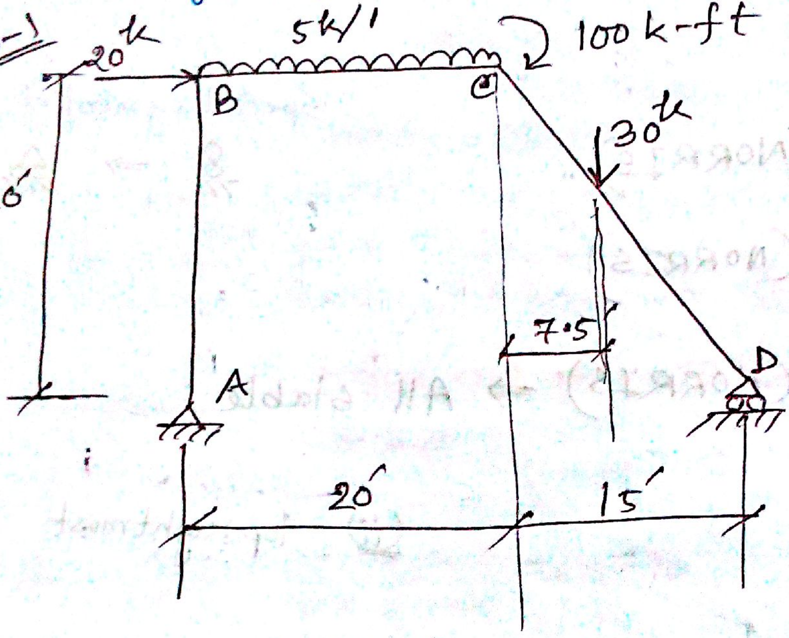
→ Horizontally connection থাকলে Tie.

CT-syllabus

Shedd Vawter (P-46) ⇒ Reactions

Analysis of frame —

Preb-1



Steps :

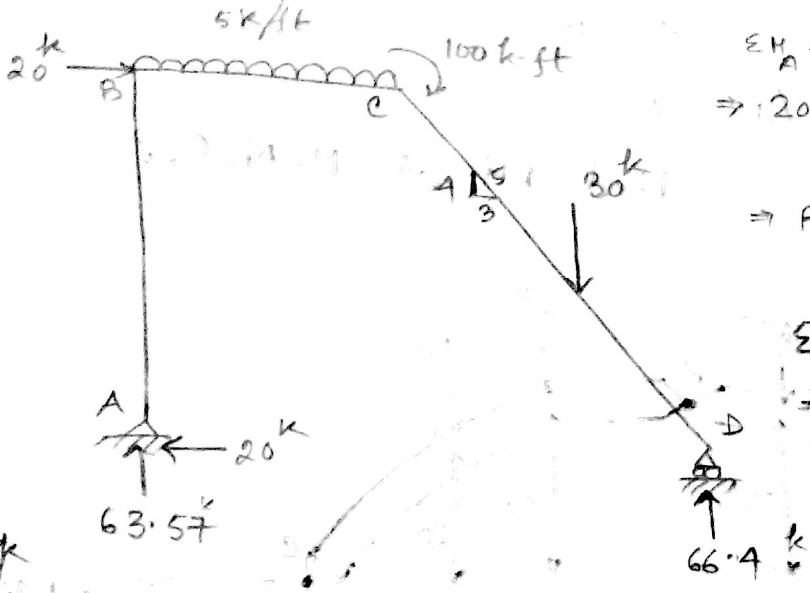
1. Find R's.

2. Draw free body of AB, BC, CD, joints B & C

3. Draw SF, BM and AF diagrams of AB, BC and CD.

4. Draw Combined SF, AF & BM diagrams.

H.W



$\Sigma M_A = 0$ ↻+ve

$\Rightarrow 20\times 20 + 100\times 10 + 30\times 27.5 + 100 - R_D \times 35 = 0$

$\Rightarrow R_D = 66.4^k (\uparrow)$

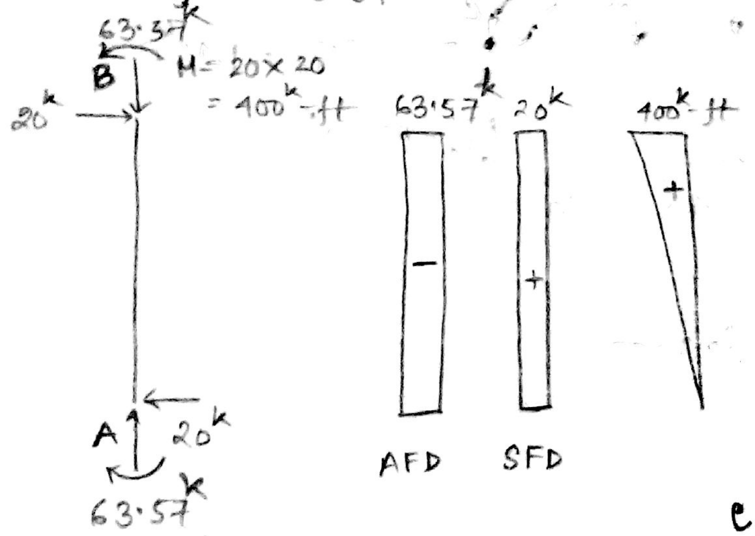
$\Sigma F_y = 0 \uparrow$

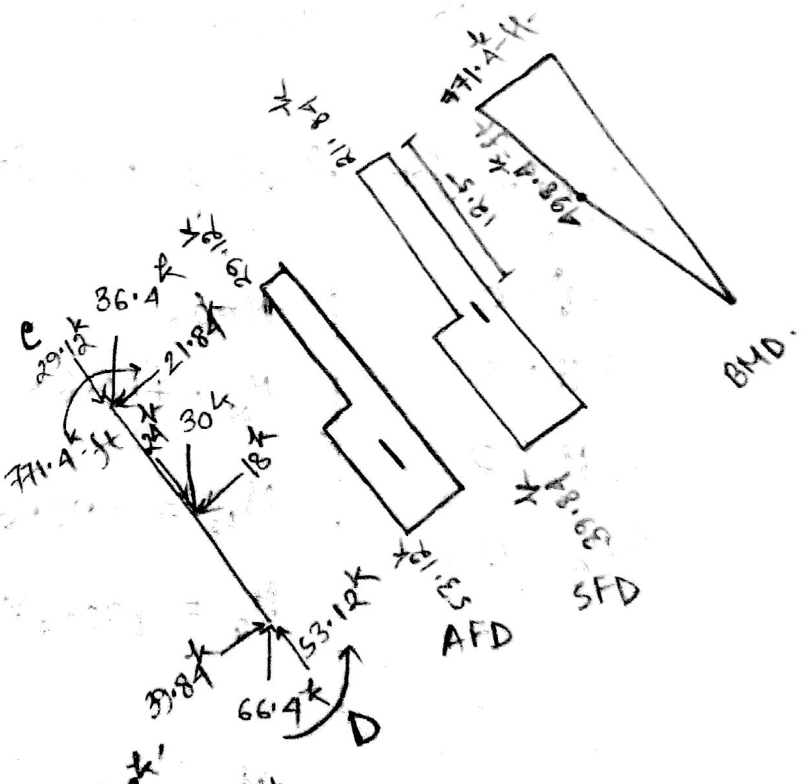
$\Rightarrow R_{Ay} + 66.4 - 100 - 30 = 0$

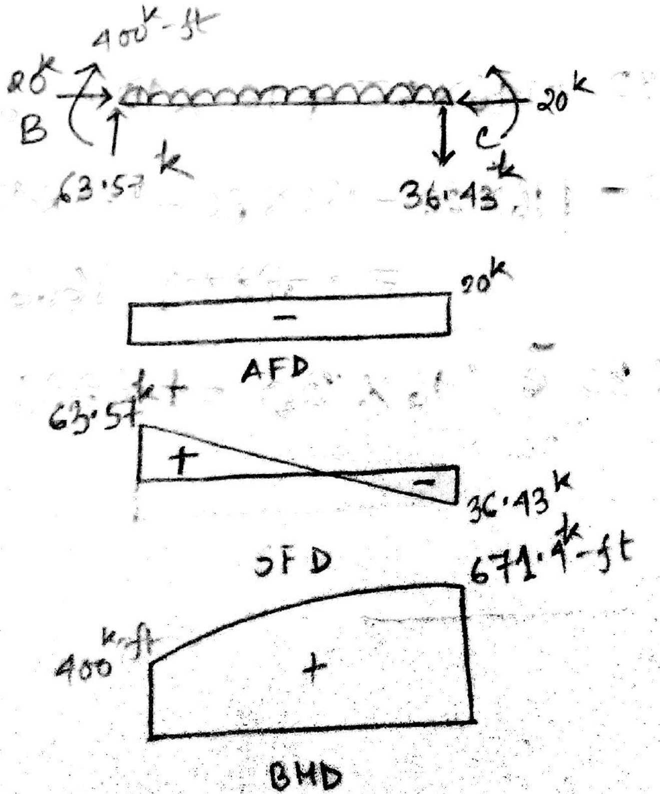
$\Rightarrow R_{Ay} = 63.57^k (\uparrow)$

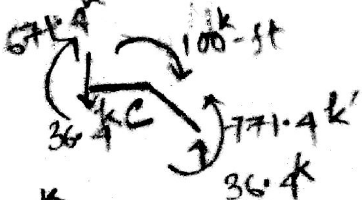
$\Sigma F_x = 0$

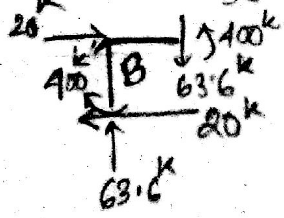
$\Rightarrow -R_{Ax} + 20 = 0 \rightarrow R_{Ax} = 20^k$



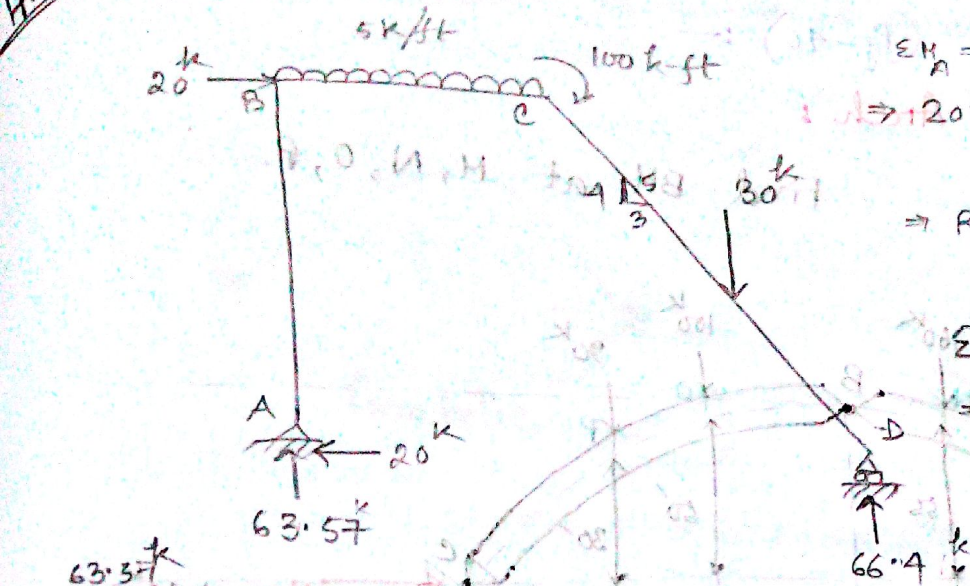








H.W



$\Sigma M_A = 0$ D+ve

$\Rightarrow 20 \times 20 + 160 \times 10 + 30 \times 27.5 + 100 - R_D \times 35 = 0$

$\Rightarrow R_D = 66.4^k (\uparrow)$

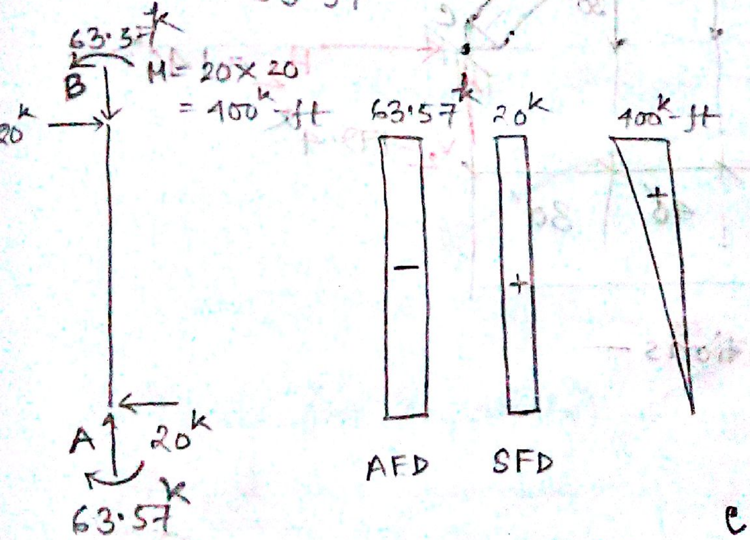
$\Sigma F_y = 0 \uparrow$

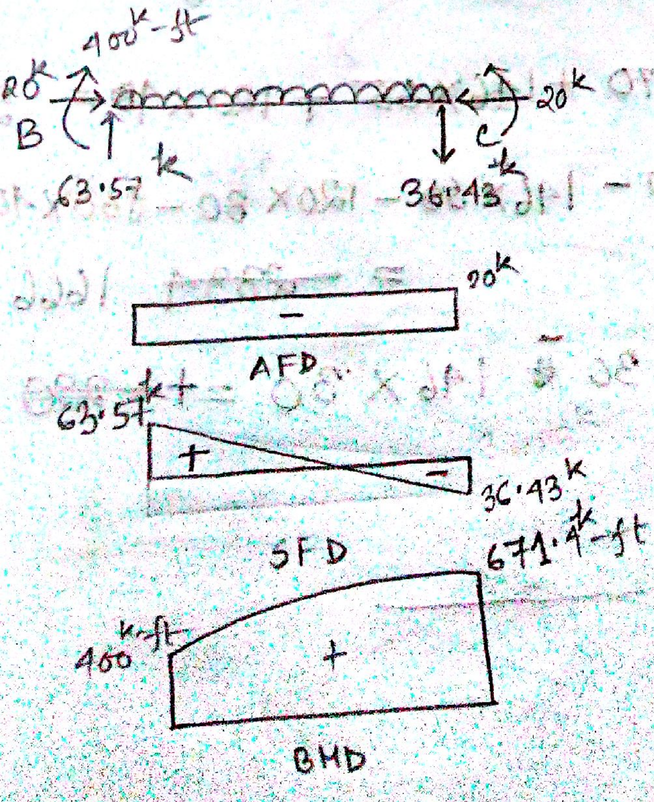
$\Rightarrow R_{Ay} + 66.4 - 100 - 30 = 0$

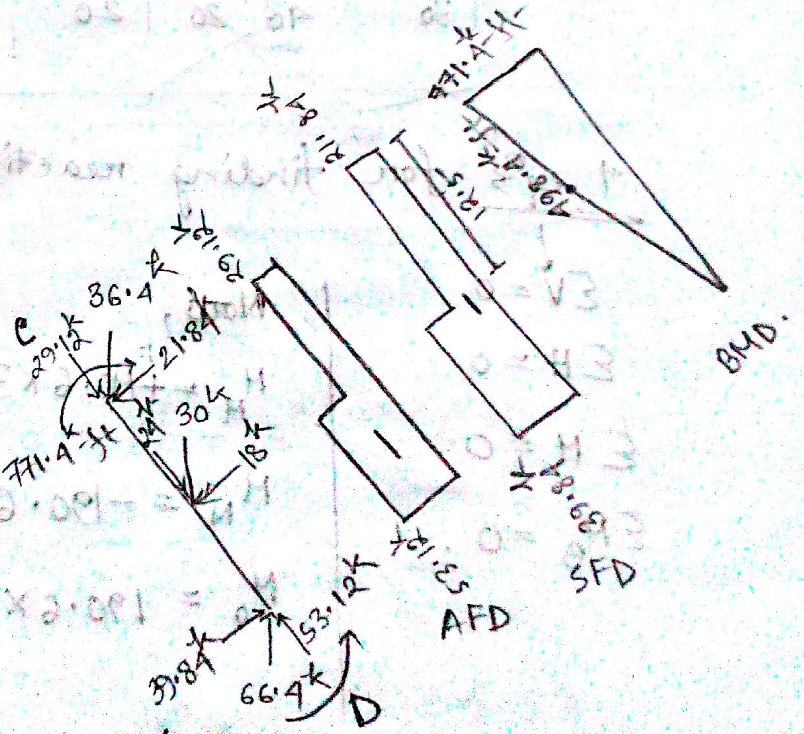
$\Rightarrow R_{Ay} = 63.57^k (\uparrow)$

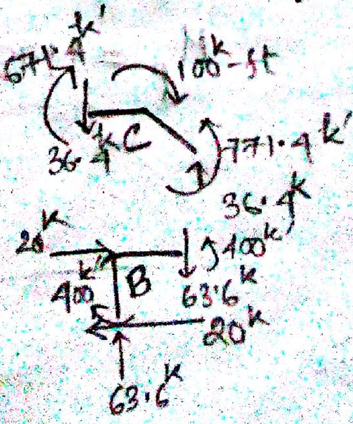
$\Sigma F_x = 0$

$\Rightarrow -R_{Ax} + 20 = 0 \rightarrow R_{Ax} = 20^k$









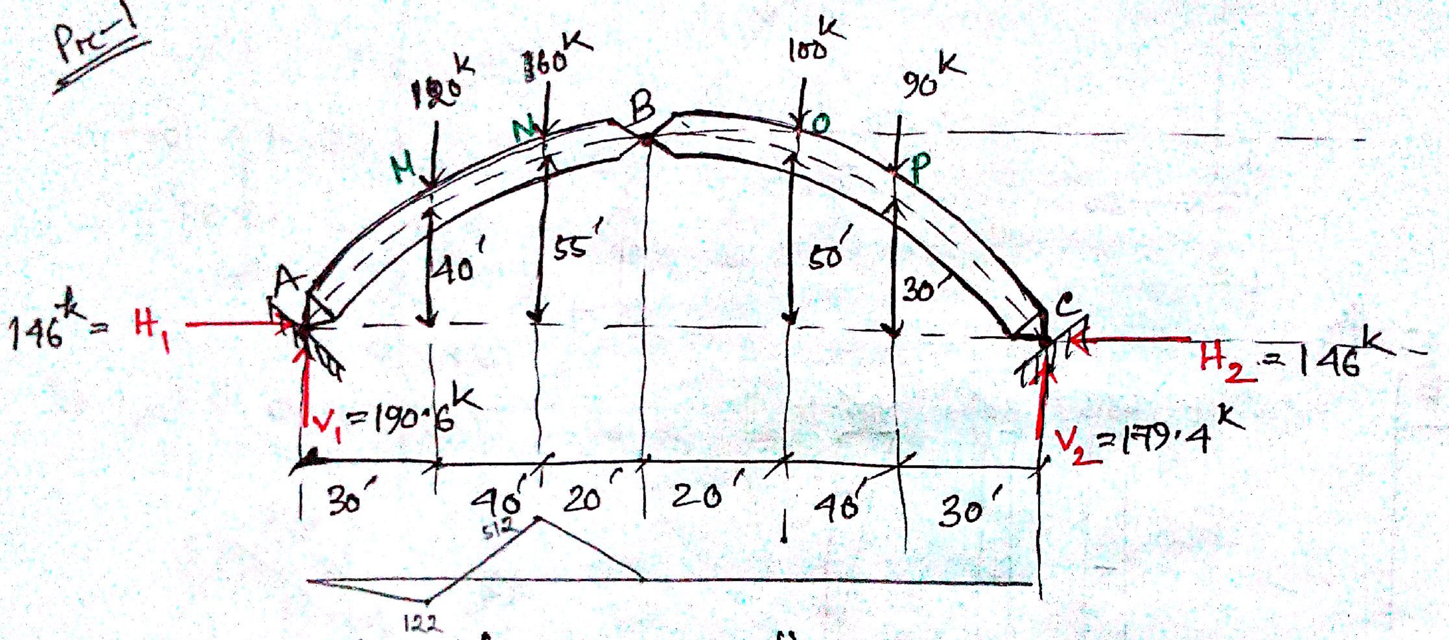
7.9.2015

Shedd Vawter (Pg-46) :–

- Analysis of Arch :

Find BM at M, N, O, P.

Pr-1



4 eqⁿs for finding reactions –

$\Sigma V = 0$

$\Sigma H = 0$

$\Sigma M = 0$

$\Sigma M_B = 0$.

Now,

$M_M = +190.6\times30 - 146\times40 = -122$

$M_N = -190.6\times70 + 146\times55 + 120\times40 = 512$

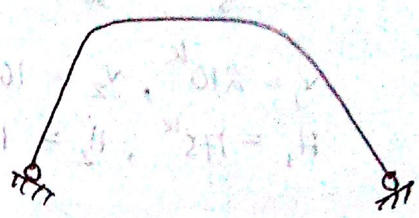
$M_O = 190.6\times110 - 146\times50 - 120\times80 - 160\times40$

$= \cancel{-2334}\ 1666$

$M_P = +179.4\times30 - 146\times30 = +\cancel{990}\ 100$

• Types of arches — (on the shape of axis)

Parabolic



Elliptical

Circular

• Types (on supports)

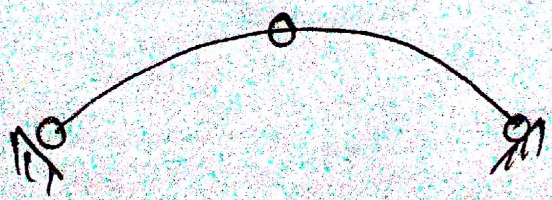
Fixed

$D^{\circ} = 3^{\circ}$ (6-3)

2-Hinge

$D^{\circ} = 1^{\circ}$ (4-3)

3-Hinge



$D^{\circ} = 0^{\circ}$ (3-3)

Shedd Vawter — Pg-47. Q. Find the BM at the loads

Pr-2

P: 120 ↓, Q: 60 ↓, R: 100 ↓, S: 90 ↓

35', 50', 55', 50'

$V_1 = 210^k$, $V_2 = 160^k$

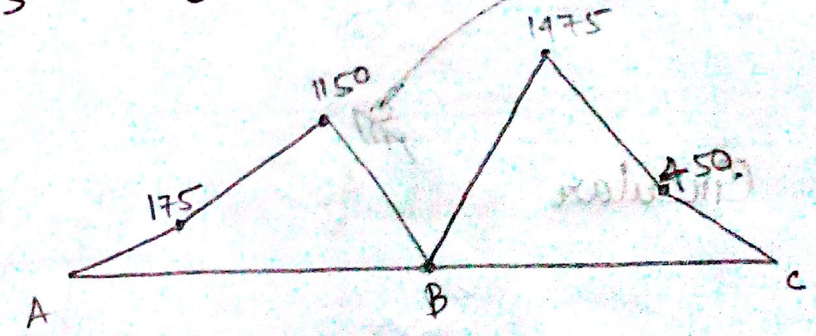
$H_1 = 175^k$, $H_2 = 175^k$

$M_P = 210 \times 30 - 175 \times 35 = +175$

$M_Q = 210 \times 70 - 175 \times 50 - 120 \times 40 = +1150$

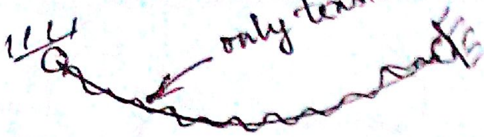
$M_R = 210 \times 110 - 175 \times 55 - 120 \times 80 - 60 \times 40 = +1475$

$M_S = -160 \times 30 + 175 \times 30 = 450$



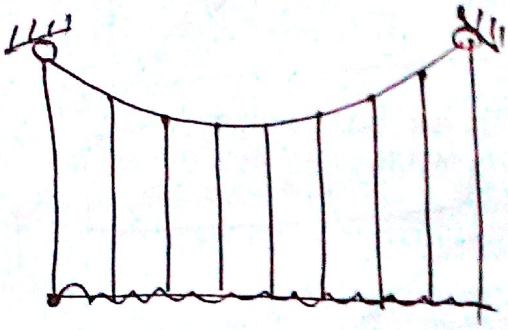
BMD

Cable



Cable shape ⇒ Catenary

Fig-1

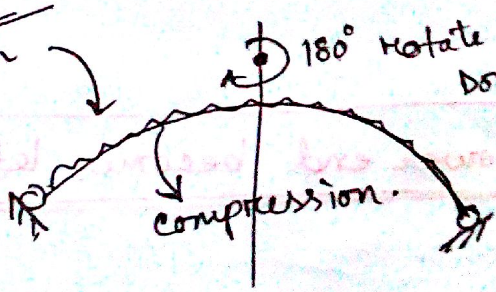


Cable shape ⇒ Parabola.

Fig-2

Fig-(1) & (2) are diff. becz in (2) udl is on horizo

Cable = কে উল্টালে
Arch

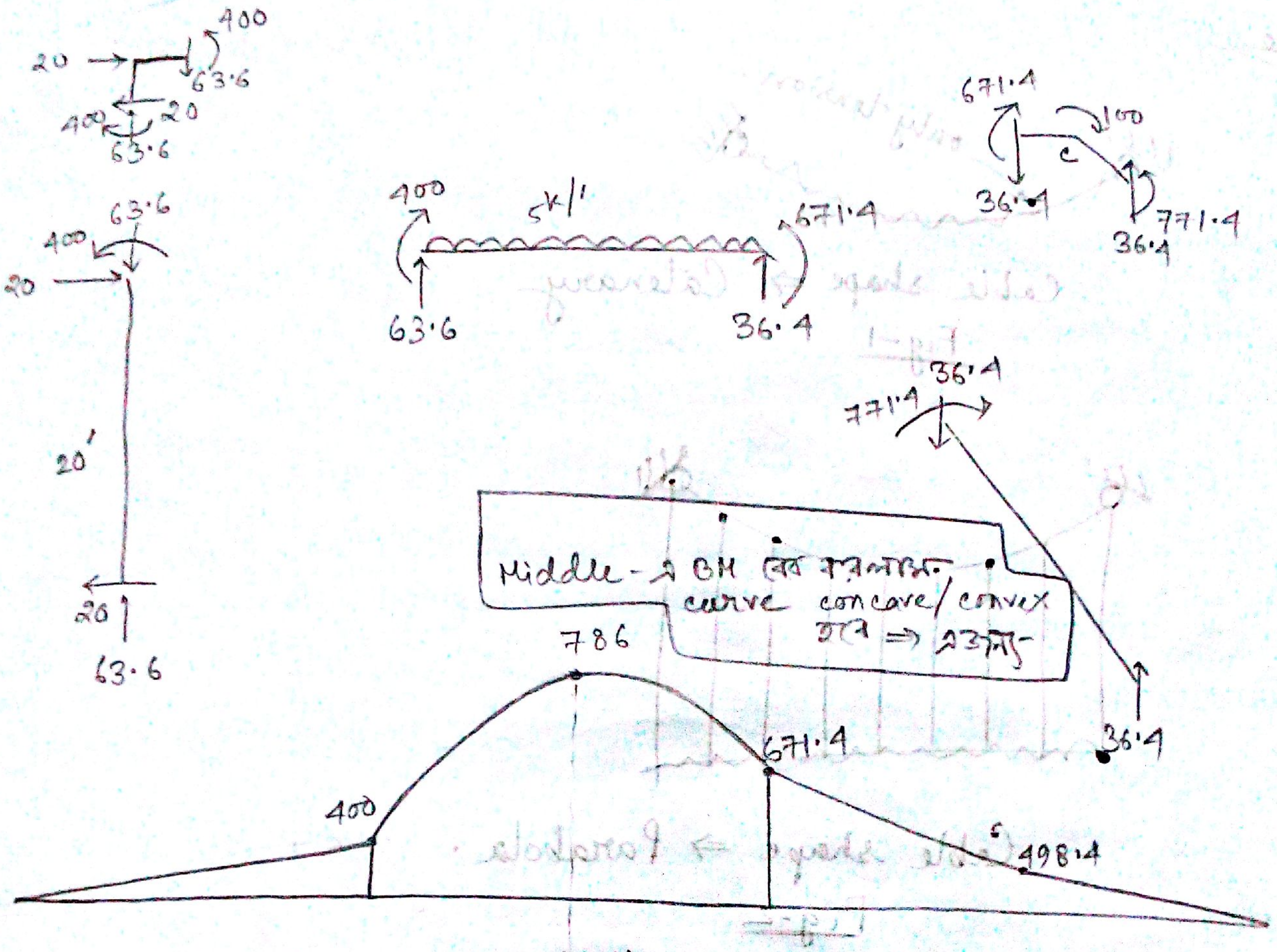


Dome.

(*) Arch/Dome বেশি durable cz here no steel.
⇓
But in RCC. steel will corrode after long time.

Scanned by CamScanner

In all parts $\Sigma F_x, \Sigma F_y, \Sigma M = 0$ must satisfy.



k-ft

(BMD)

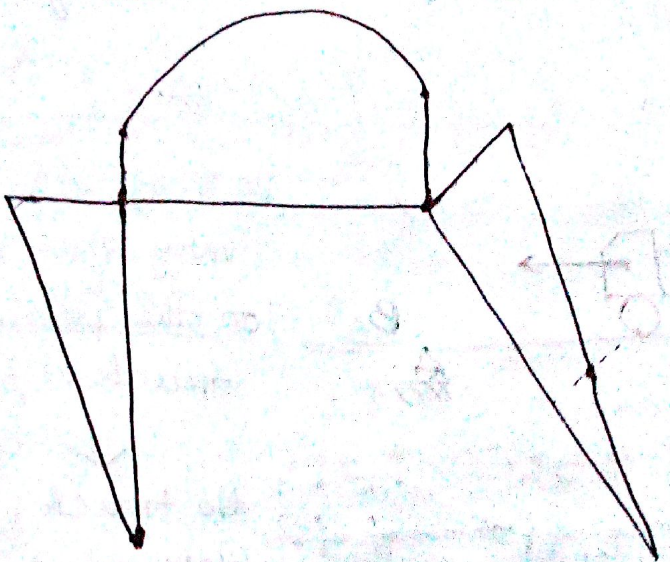
⊛ Column-কে ঘুরিয়ে beam করব। Lower end becomes left end.

BM (sign convention)

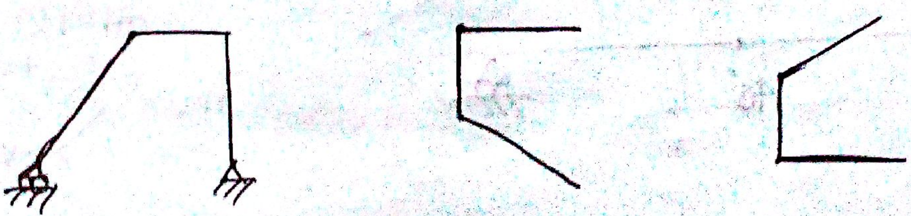
v.v.imp $\boxed{\text{BM due to upward load is +ve}}$ ⇒ (in Beam)

9.9.15

Combined BHD

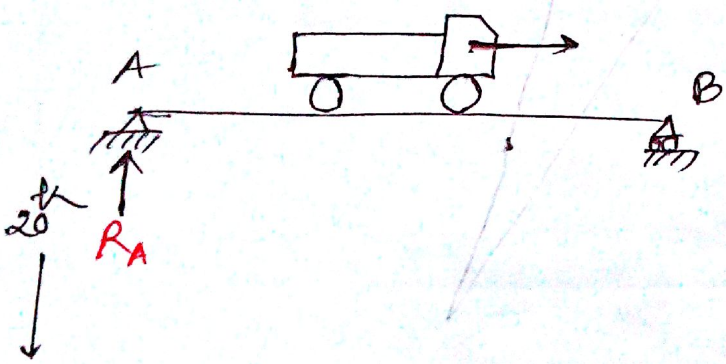


Problems



(Shedd Vawter) ⇒ Pg (100)

Influence Lines : (for internal forces under moving loads)



এখানে R_A-এর value vary করবে depending on the position of the truck.

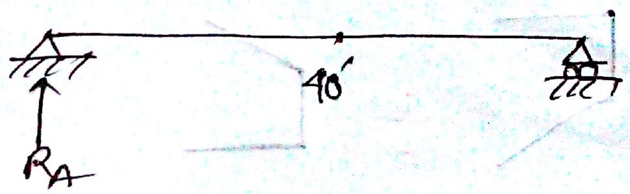
⇓

No truck, $R_A = 0$

closest to A, $R_A = max^m$.

⇓

So design-এর জন্য max^m & min^m লাগবে।



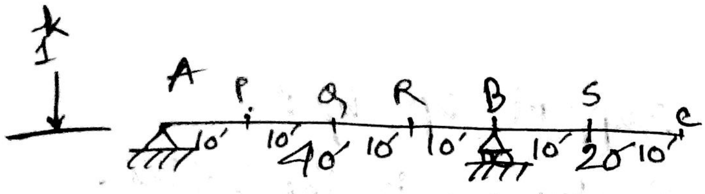
max^m → +ve (upward), −ve (downward)

$\boxed{\text{IL is drawn for a \underline{unit} load (1 lb / 1k / 1 kg)}}$

- for variation of loads, IF is drawn.
- **Our Aim** ⇒ how to draw Influence Lines and how to work with IL.

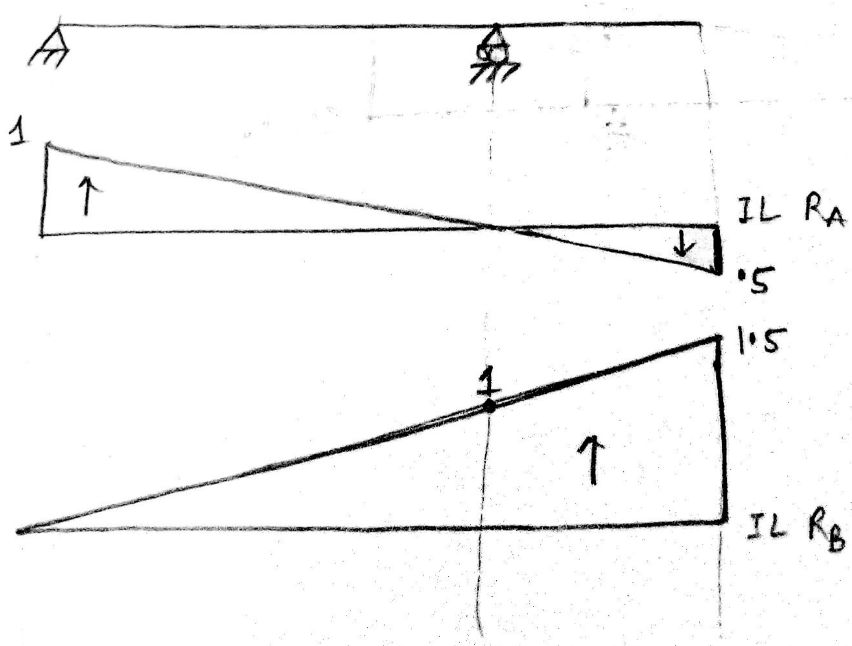
I. Line (This is crude method)

unit (k/k or #/# or kg/kg)



Draw I-Line for R_A & R_B.

1^k load at	R_A	R_B
A	1 ↑	0
P	·75 ↑	·25 ↑
Q	·5 ↑	·5 ↑
R	·25 ↑	·75 ↑
B	0	1 ↑
S	·25 ↓	1·25 ↑
C	·5 ↓	1·5 ↑



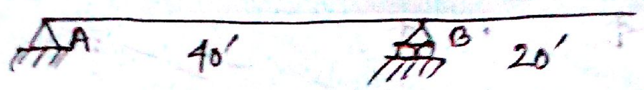
Influence line for beams— (to draw)

1) Reactions —

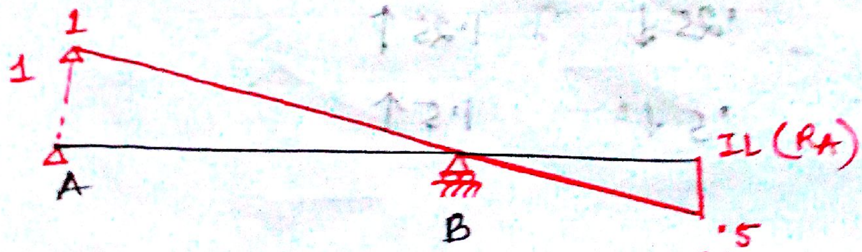
i. Push the support up by 1.

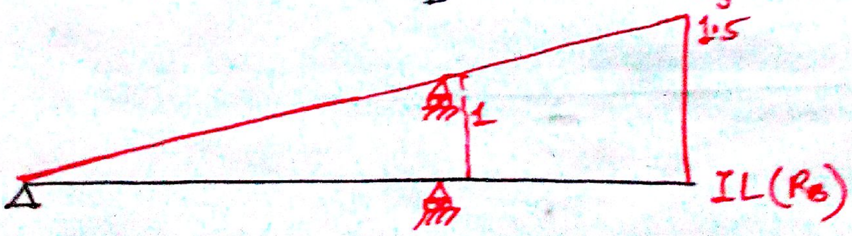
ii. Draw the δ-shape— is the I-Line.

Beam-I



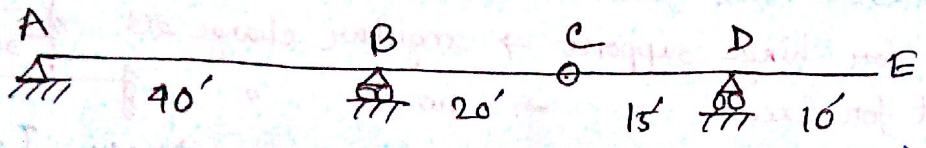
for drawing R_A, we will push A support.





Beam-2

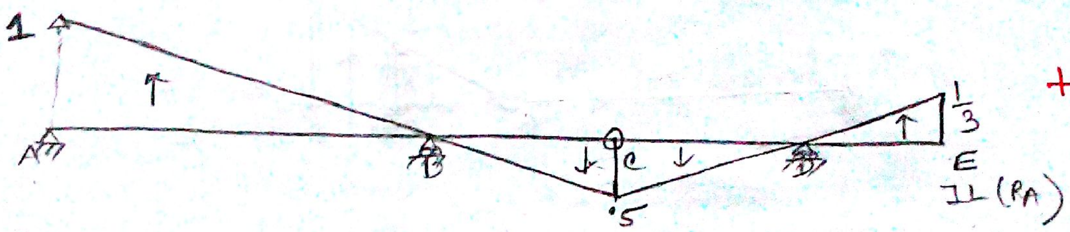
Here 4 reactions, but for IL, load is only one i.e. (1^k)
(normally this unit load is vertical. But sometimes it can be hor. or inclined)

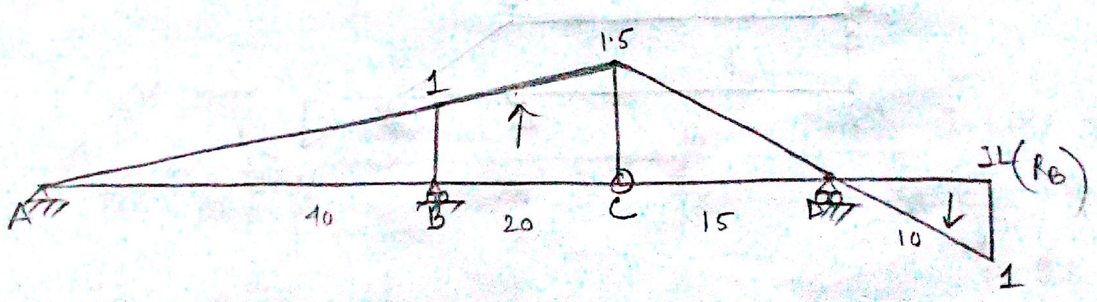


original beam-এ যেগুলো straight Line সেগুলোতে IL হবে।
⇓
for this beam two straight lines.
⇓
two sides of the hinges.

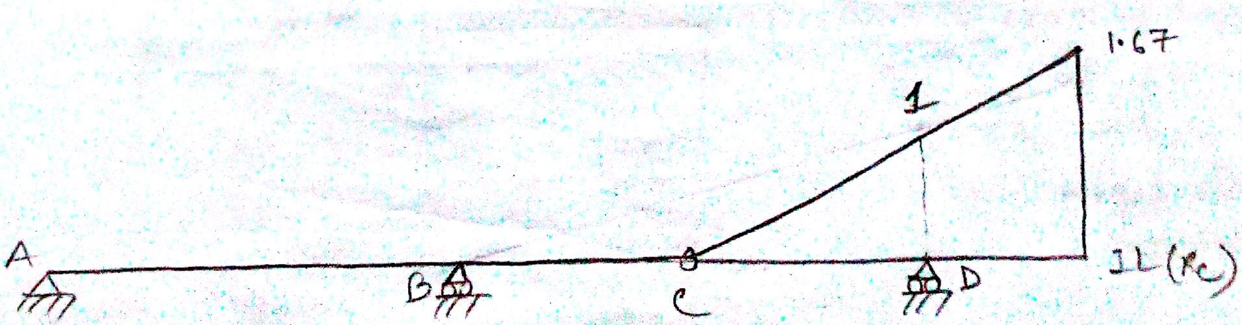
But for only ver. load no R_{Ax}.

So the reactions are R_A, R_B, R_D





IL(RB)



Chp-4 (from book for practice)

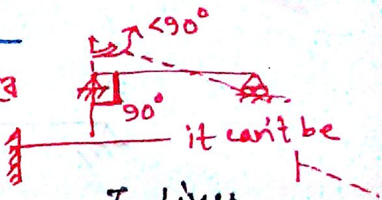
Influence Line for reactions in Beams –

Beam-3

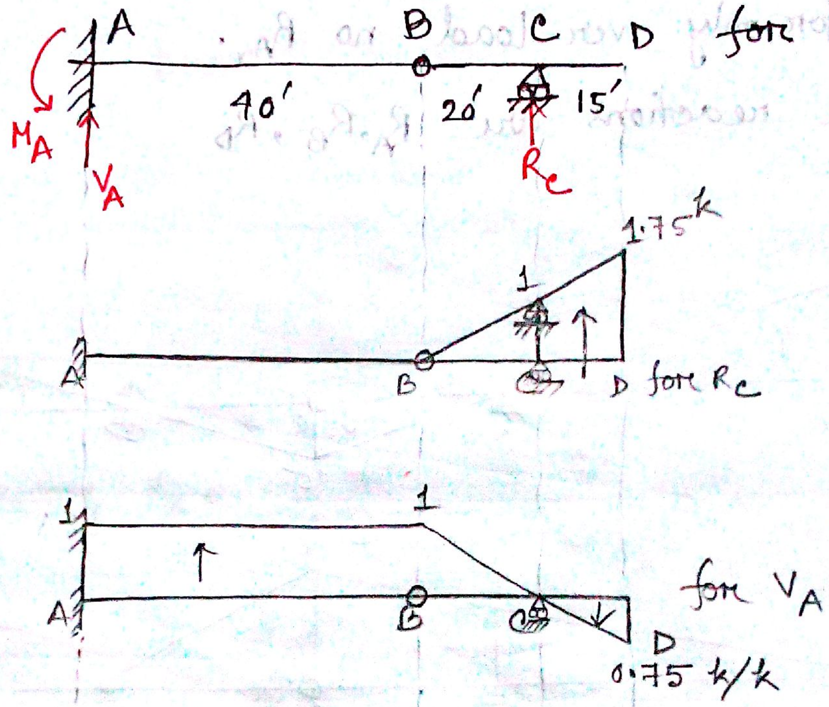
for hinge support ⇒ angular change হবে

but for fixed " ⇒ no " "

i.e. 90° & 90° should be maintained.



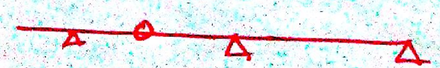
Draw I. Lines for V_A, R_C, (M_A later)



Days,

- Alltime first – এ stable part draw করতে হবে।

e.g.  এইক্ষ left side stable so এটা first draw

but for  " right " " so right আগে draw

I.Lines for shear force in beams –

Steps —

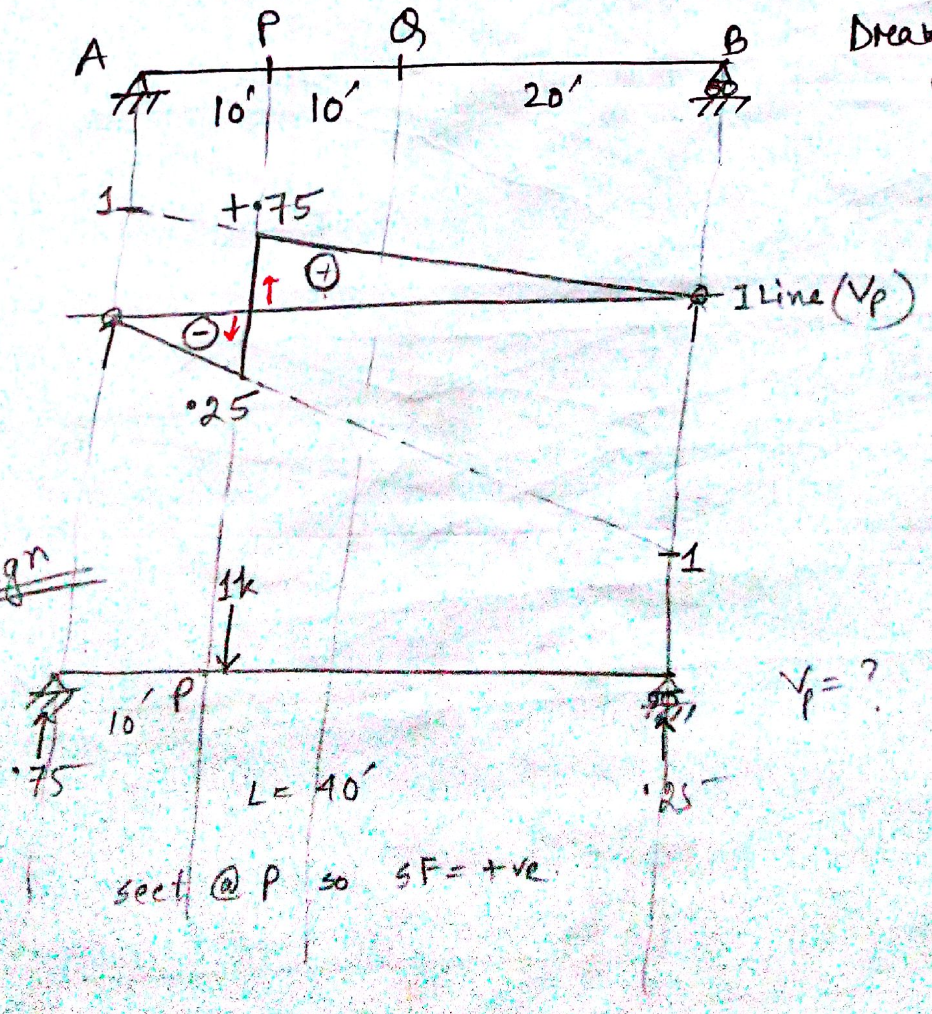
1) Cut at the section X

2) Push the left part ~~up~~ down and right part ~~down~~ up. (by two sides of x)

3) Draw δ-shape → is the I.Line

4) Put the ordinates and sign.

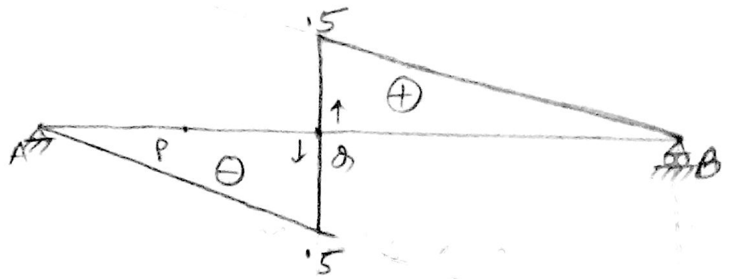
Beam-1



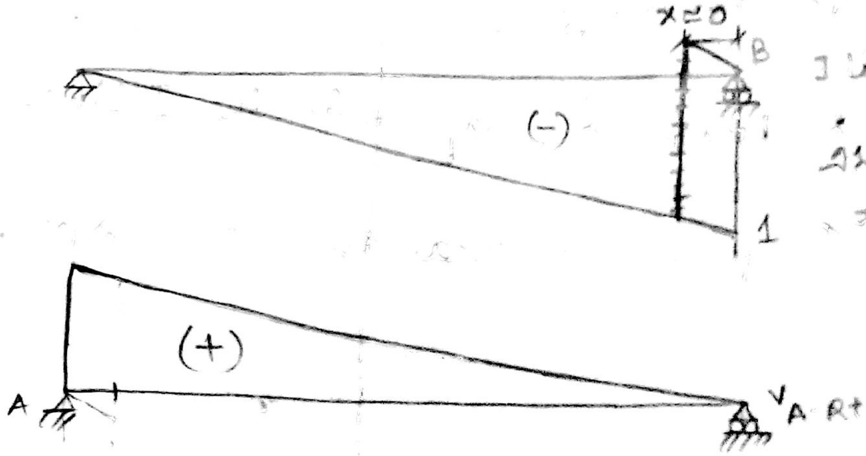
Draw I.Line for V_{A-Rt}, V_P, V_Q & V_{B-Rt}.

⇓

exactly support-এ SF হয় না। So either left/right draw করতে হবে।



I Line (VQ)



I line Ve-lf

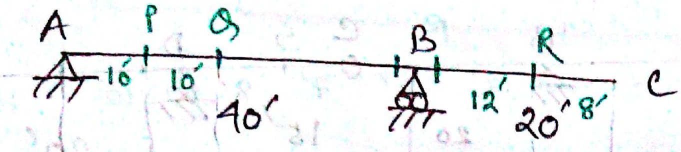
এখানে বোঝার সুবিধার জন্য x একটু দূরে কাটলাম but it tends to 0

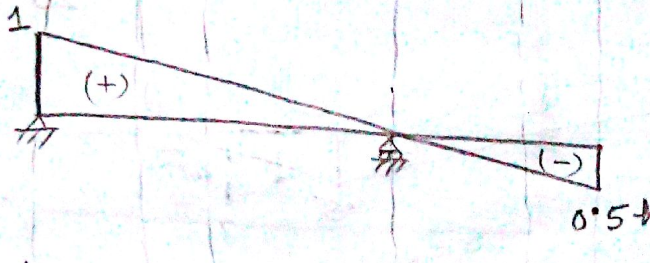
⇓

So only নিচের line টা থাকবে

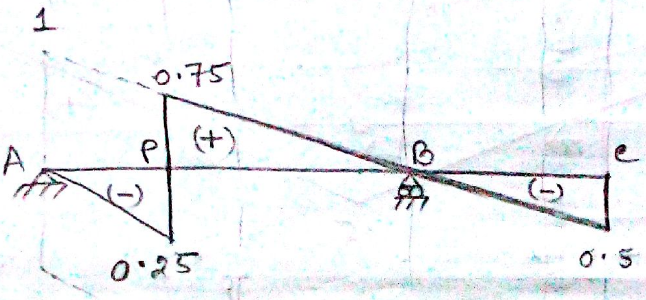
Beam-2

Draw I. Line for V_{A-Rt}, V_P, V_Q, V_{B-Lt}, V_{B-Rt}, V_R.

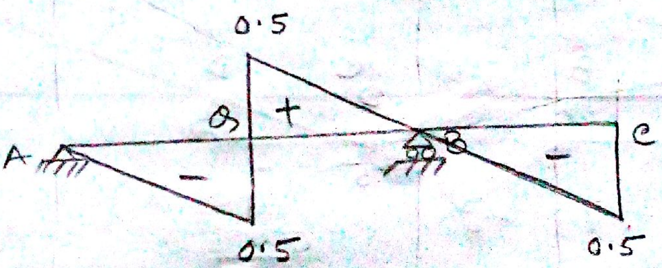




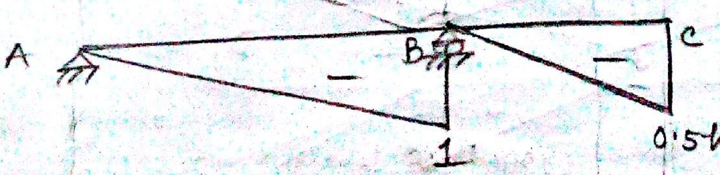
I. Line for V_{ARt}



I line for V_P



I line for V_Q.



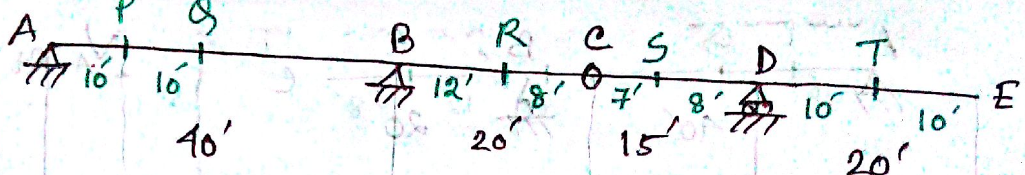
I. Line for V_{B-Lt}

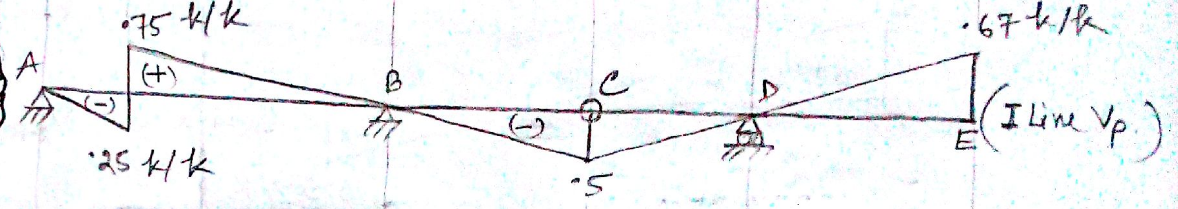
I line for V_{B-Rt}

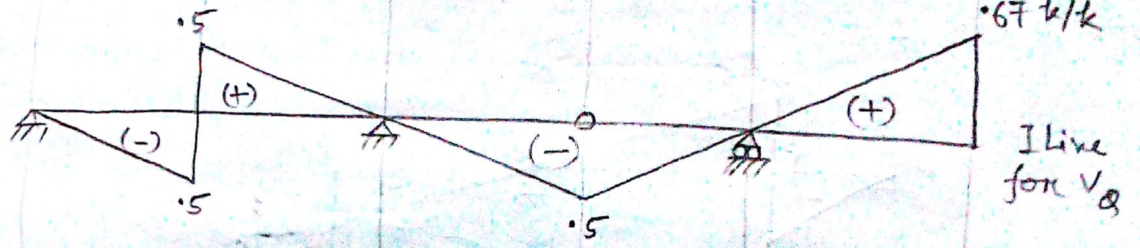
I line for V_R

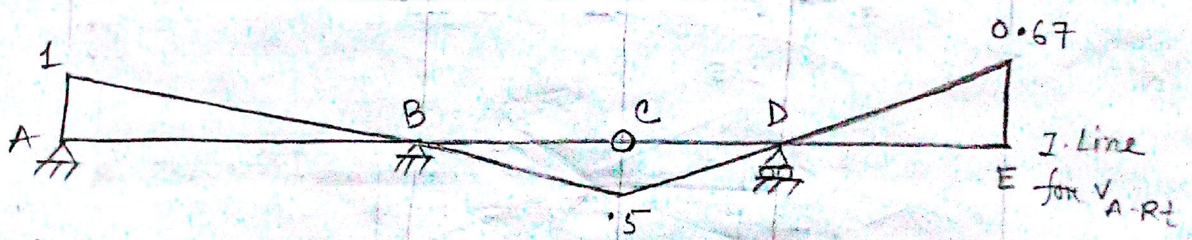
Beam-3

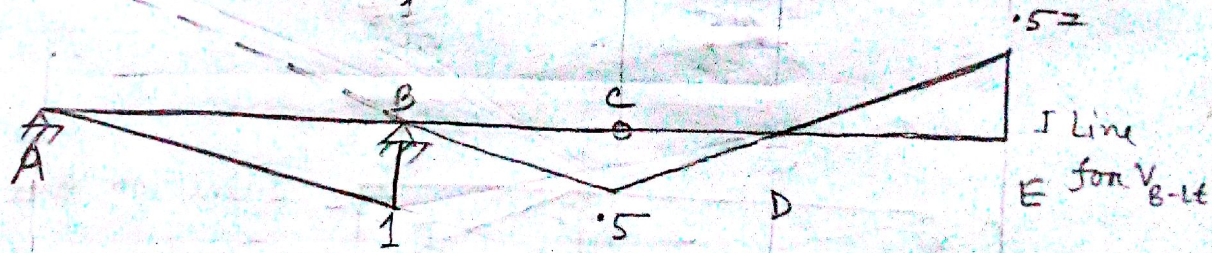
$V_{A-Rt}, V_P, V_Q,$
$V_{B-Lt}, V_{B-Rt},$
$V_R, V_S, V_{D-Lt}, V_{D-Rt}$
V_T





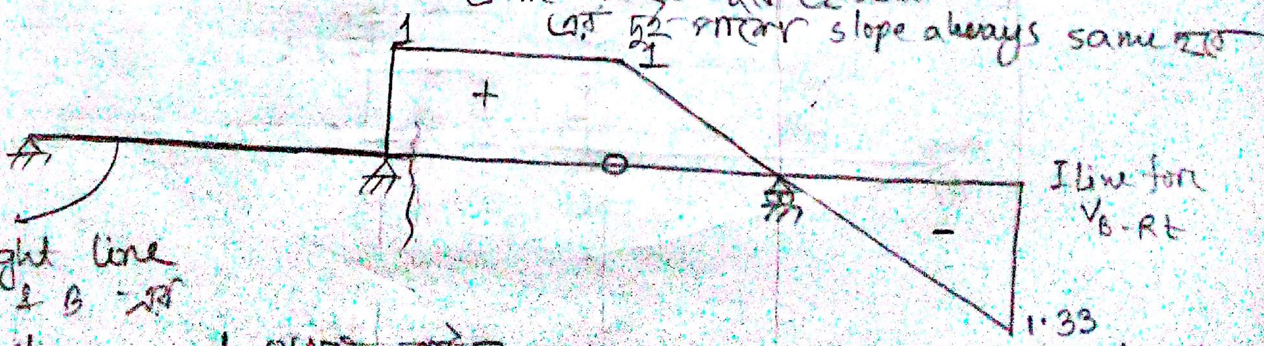






এখানে actually Dotted Line এর portion হব

এখানে st line হবে cz sect^n এর দুই পাশের slope always same হবে



straight line cz A & B এর support change হয় নাই. and যেখানে কাটা হয়েছে EF of left & Right diff is 1.

$$EF - (F_{Right} + F_{left})_{sect^n} = 1.$$

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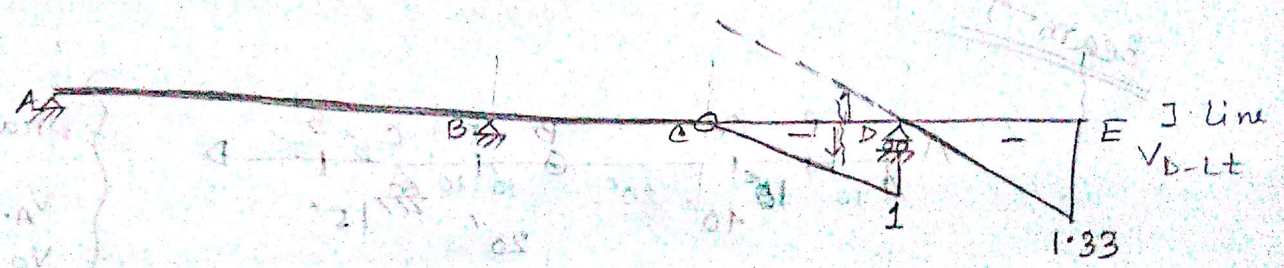
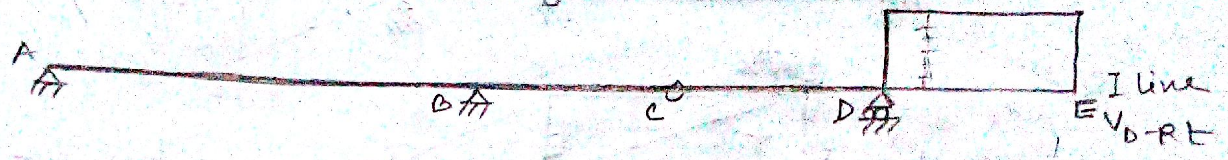
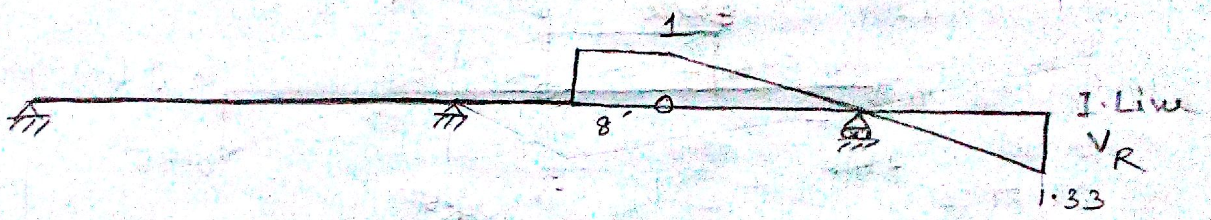
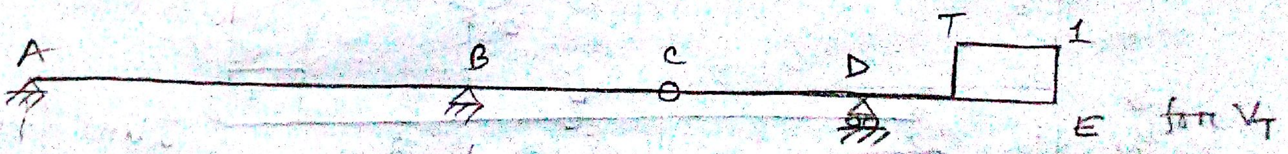
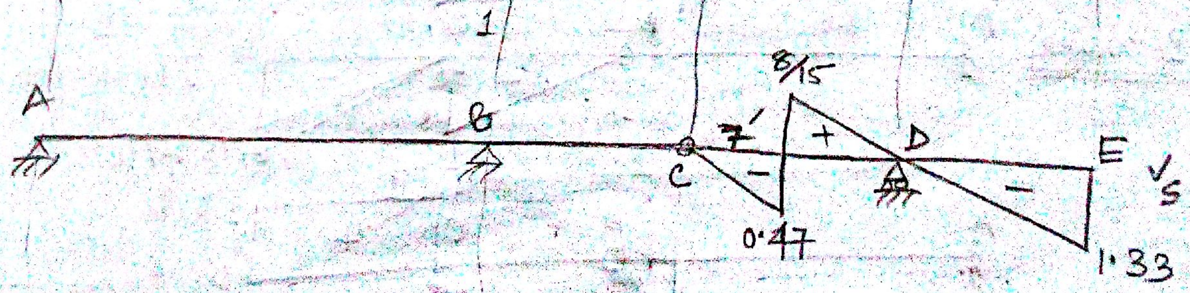

A
B
C
D
E
I line
V_{D-Lt}
1
1·33


A
B
C
D
E
I line
V_{D-Rt}

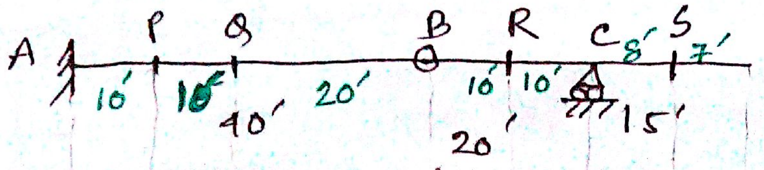

1
8
I. Line
V_R
1·33


A
B
C
D
T
1
E
for V_T

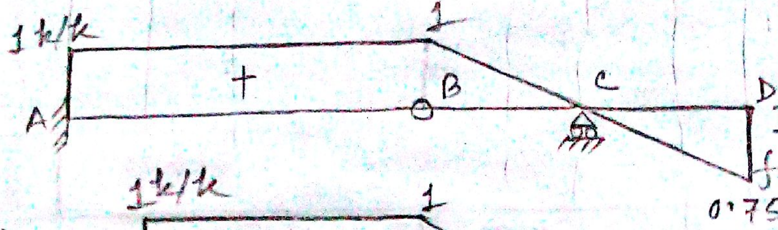

1
A
B
C
8/15
7
+
D
E
V_S
0·47
1·33

(fixed support থাকলে beam-এর right portion টা Totally 1 unit উপরে উঠে যাবে।)

Beam-1



Draw I lines for V_{A-Rt}, V_P, V_Q, V_R, V_S, V_{B-Lt}, V_{B-Rt}, V_{C-Rt}



I line for V_{A-Rt}

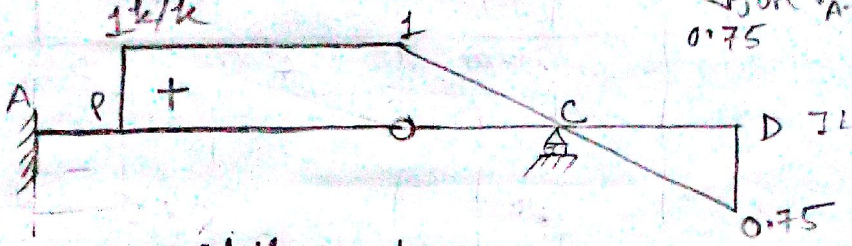
deflected shape but এখানে curve হবে না only strt. line হবে।

⇓

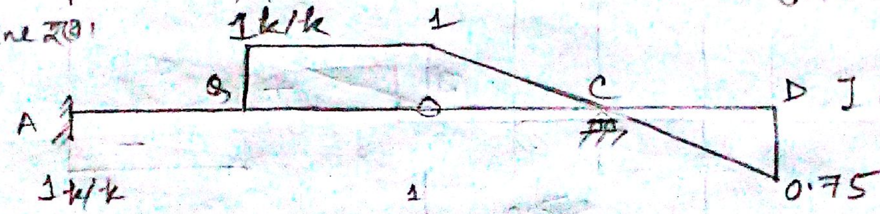
This line may be AB but এটা হবে না cz fixed support নড়ে বাঁকাতে পারবে না।

⇓

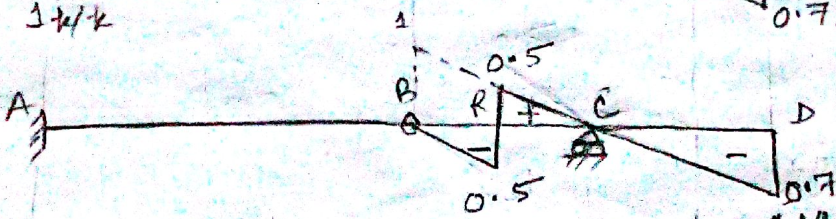
So the only line will be <u>Zeroline</u>



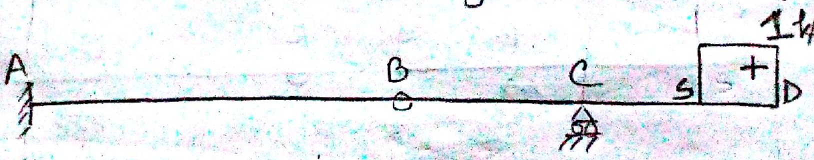
I Line for V_P



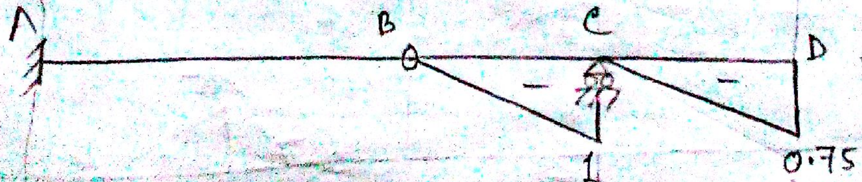
I line for V_Q



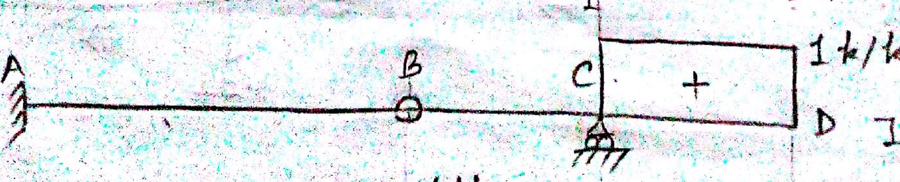
I line for V_R



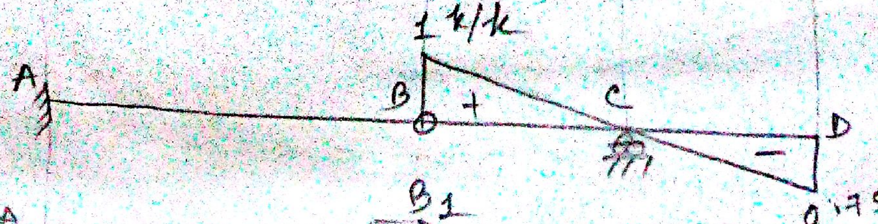
I line for V_S



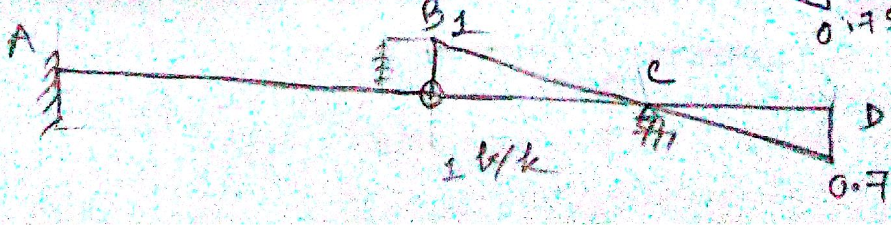
I line for V_{C-Lt}



I Line for V_{C-Rt}



I Line for V_{B-Rt}



I Line for V_{B-Lt}.

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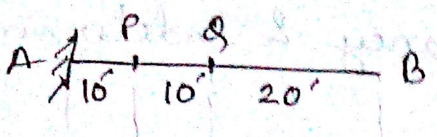
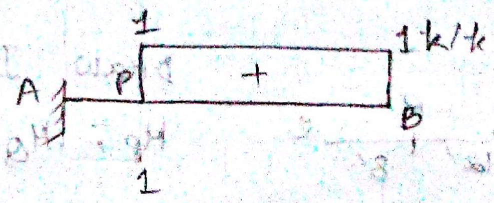
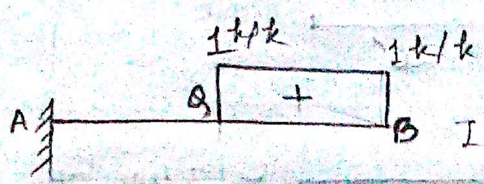
Beam-5



I Line for $V_{A\text{-}Rt}$



I Line for V_P



I Line for V_Q

* To draw I Line for shear force boundary conditions —

1. Slope same হবে section-এর দুই side-এ
2. দুই side-এ $\boxed{\text{sum} = 1}$ হবে

05.10.15

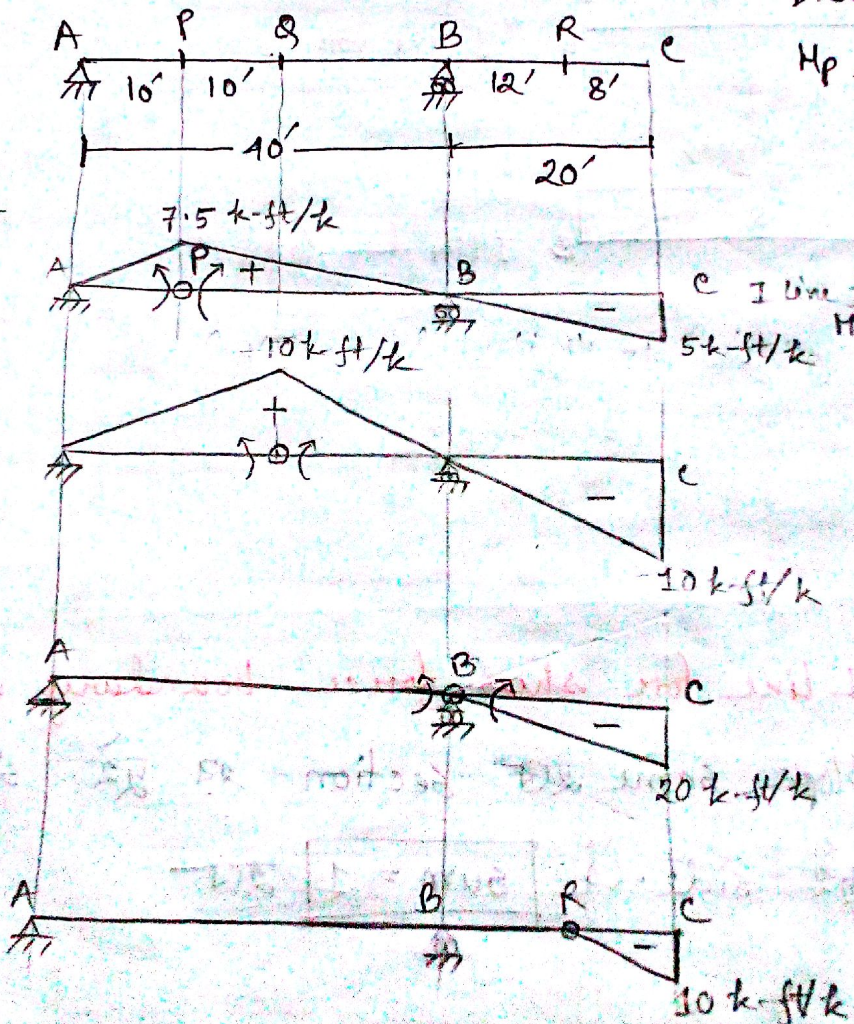
Class Test → Determinancy & Indeterminancy, Stability
Wednesday

* I Lines for Bending Moments in Beams :-

Beam-2

[I line for BM এরকম যে point এ I line দরকার ওখানে HINGE [o] বসাবে।]

Draw I lines for M_P, M_Q, M_B, M_R.



* In original beam
⇓
1 straight line
⇓
but hinge বসালে 2 parts. So I line হবে 2 lines.

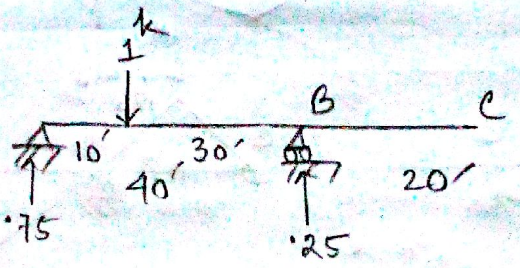
S shape actual
⇓
but no curve line

<u>Steps</u> — I line for BM at X →

1. Put a hinge at X
2. Apply B. Moments ↻ ↺
3. Draw δ-shape
4. Find the ordinates

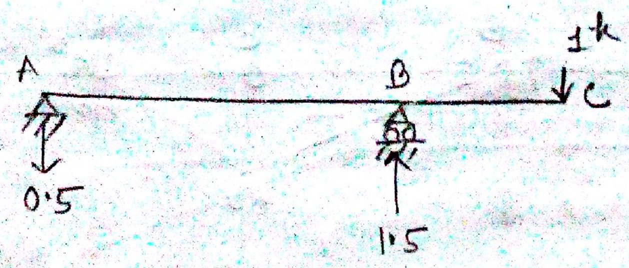
- Calculation of ordinates at P for M_P —

Place unit load at P and calculate M_P.



$M_P = \underline{\underline{7.5\,k'}}$

for M_Q & M_B



$M_Q = -10$

$M_B = -20$

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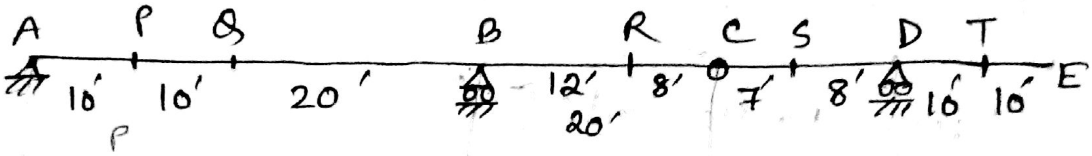
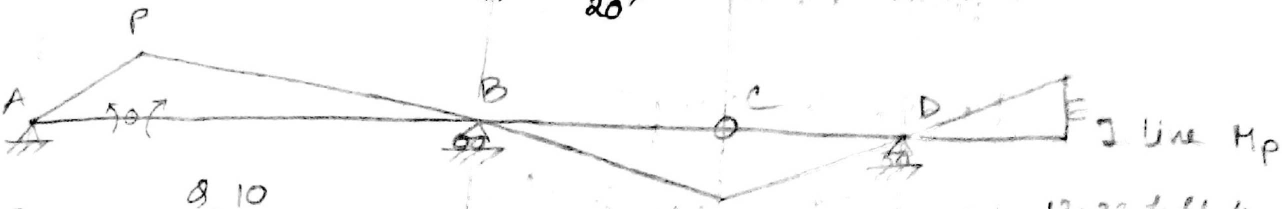
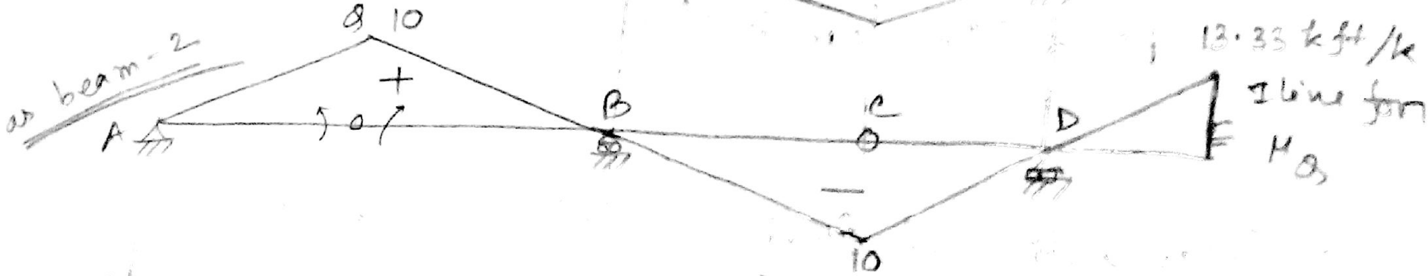
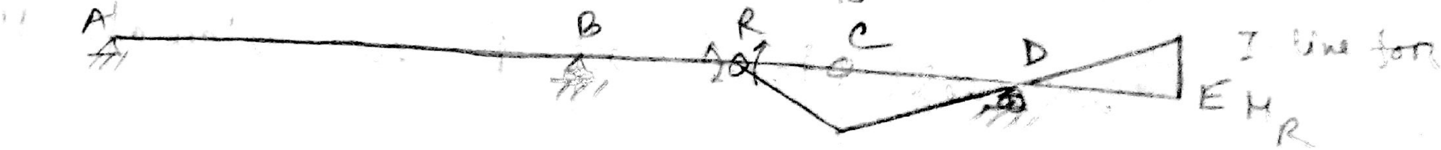
7.10.15

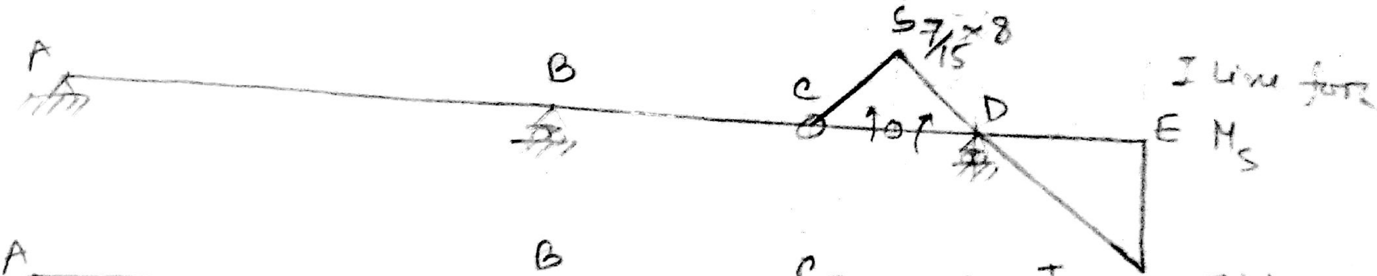
Beam-3 Draw I lines for BM at $M_P, M_Q, M_R, M_S, M_T, M_B, M_D$,

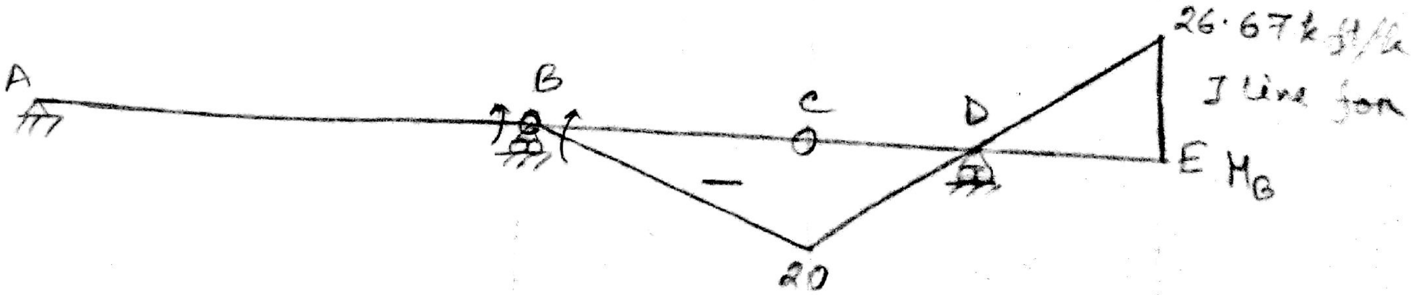


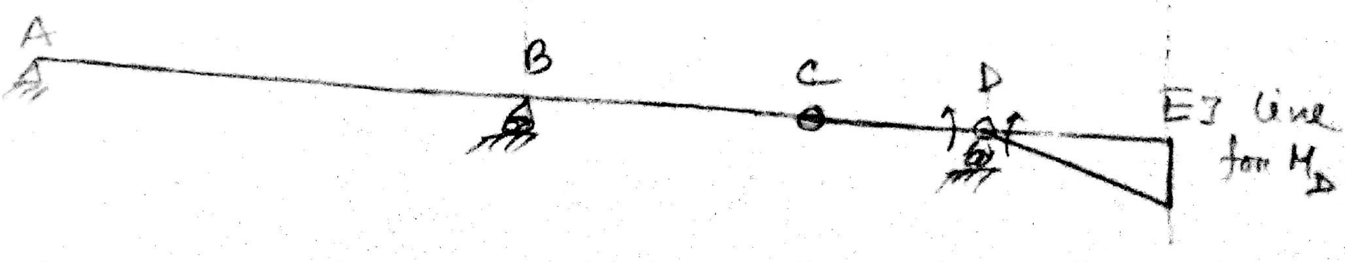






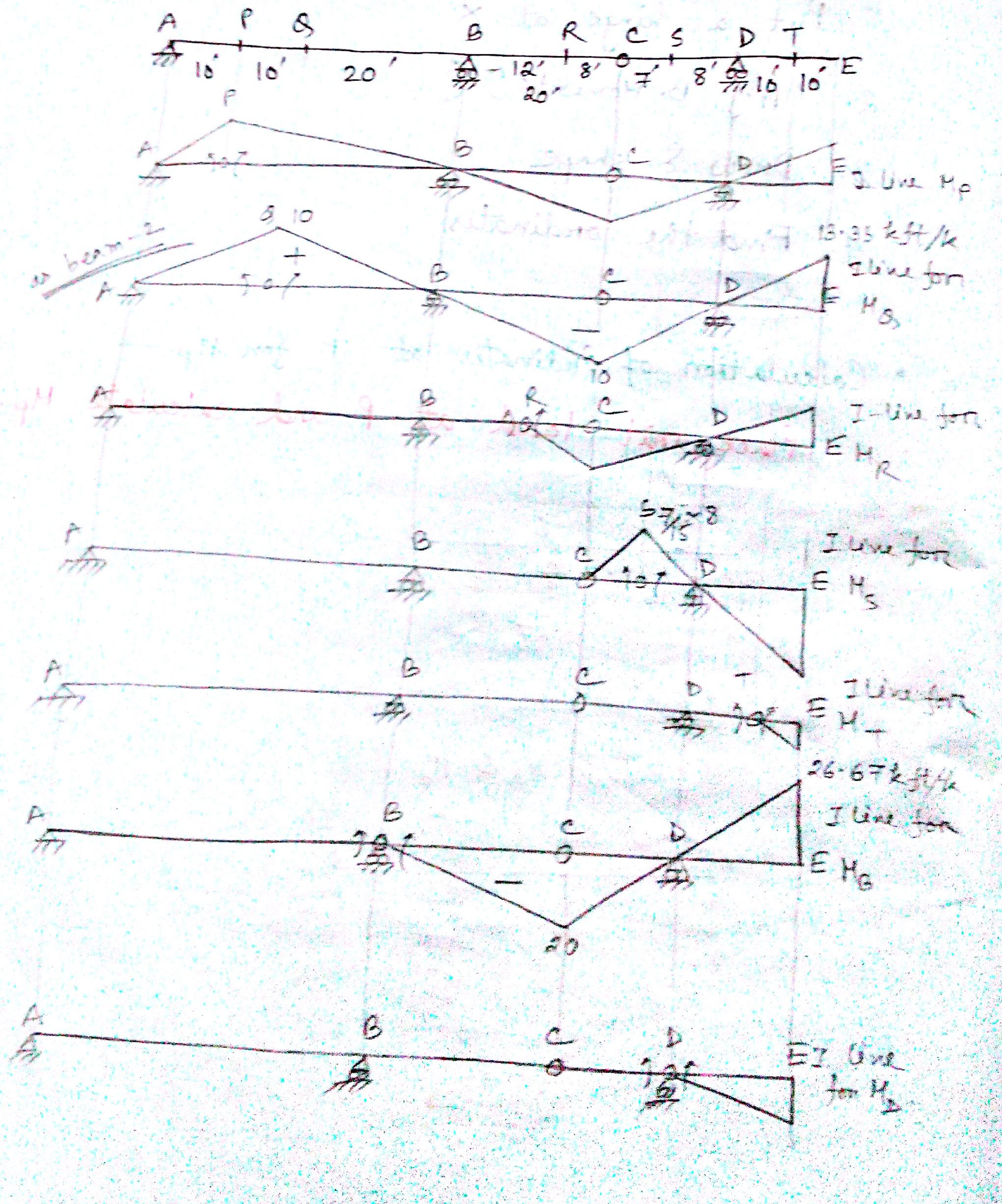


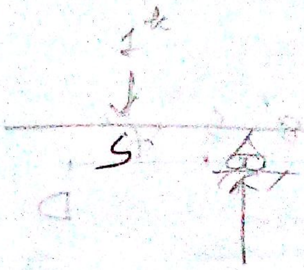




7.10.15

Beam-3 Draw I lines for BM at $M_P, M_Q, M_R, M_S, M_T, M_B, M_D$.

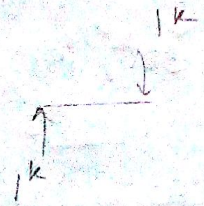




$$1 \times 7 - R \times 15 = 0$$

$$\Rightarrow R = \frac{7}{15}$$

$$\therefore M = \frac{7}{15} \times 8.$$



12.10.15

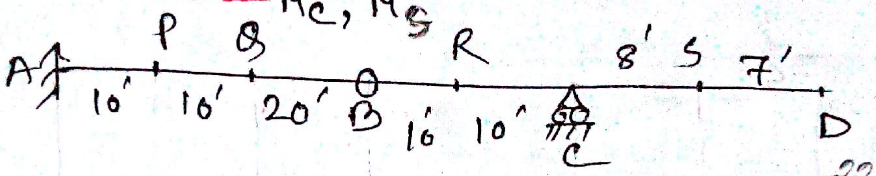
Beam-A

Draw I-line for

Gr I M_A - M_P, M_Q

Gr II M_R

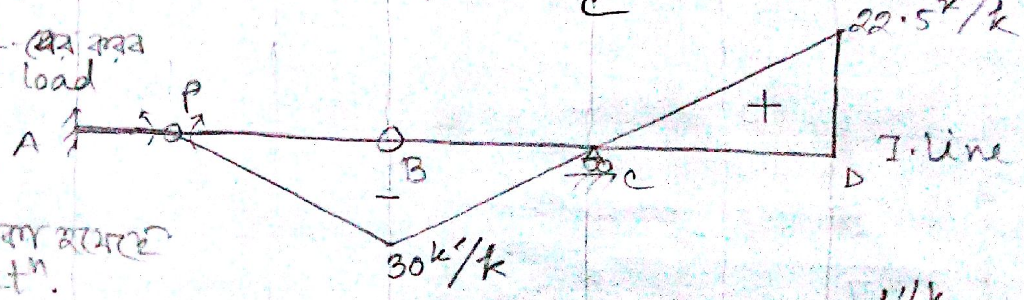
Gr III M_C, M_S



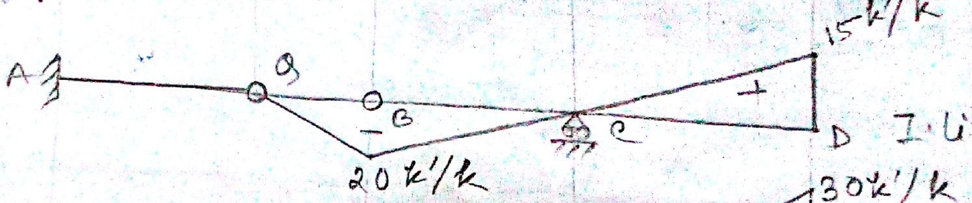
এ ordinate এর জন্য সেখানে unit load দিব।

⇓

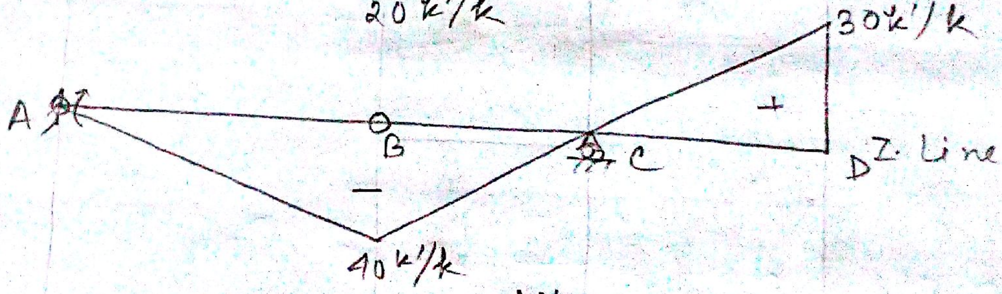
যেটির I-line আঁকা হচ্ছে সেখানে sect^n.



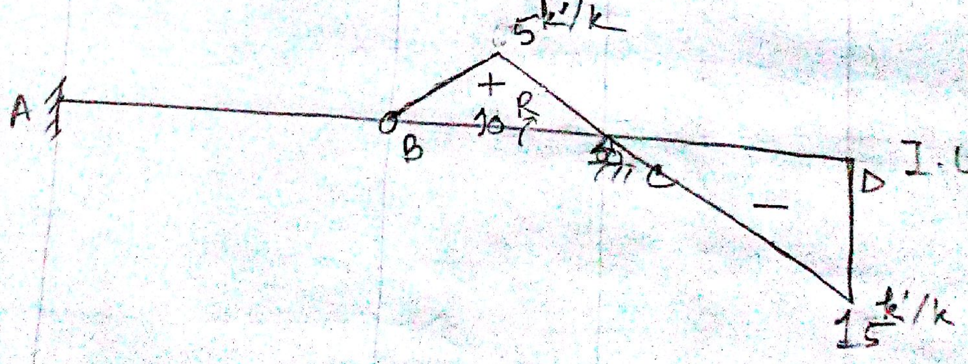
I. Line for M_P.



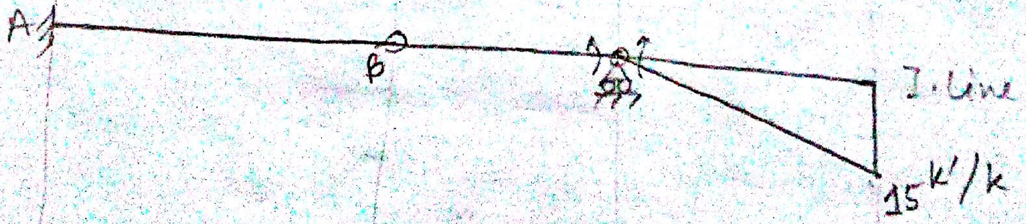
I. Line for M_Q



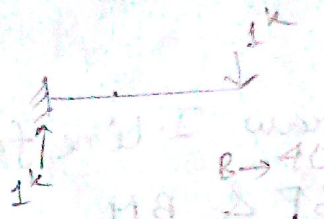
I. Line for M_A



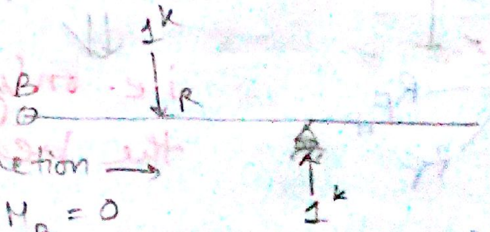
I. Line for M_R



I. Line for M_C



P = $40^k - 10^k$



for reaction →

$\Sigma M_B = 0$

$1 \times 10 - R \times 20 = 0$

→ $R = 0.5$

$\Sigma M_B = 1 \times 35 - R \times 20 = 0$

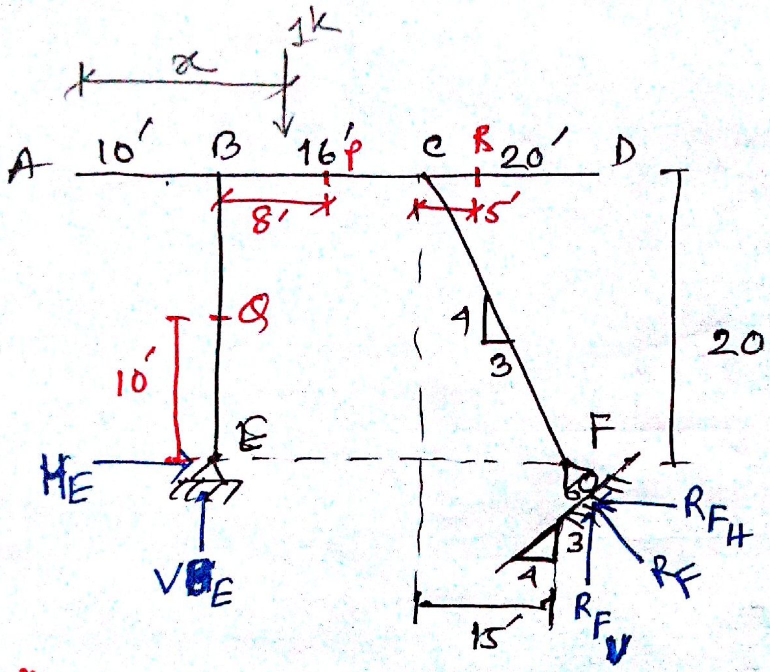
I·line for frames —

Draw I·line for SF & BM at P, Q, R.

(Unit load moves A to D)

⇓

i.e. only on the beam



Sol^n (By free body & eq^n)

Steps

1. Find eq^{n}s for R's — & Draw I·line for R's.
2. Find eq^{n}s for required functions. (i.e. SF & BM)

* For eq^n ⇒ assume unit load is somewhere at a distance x.

$$\Sigma M_E = 0 \circlearrowright + \Rightarrow 1\times(x-10) - R_{F_V}\times 31 = 0$$ ⇒ eq^n → direc^n ধরতে হবে

$$\Rightarrow R_{F_V}\uparrow = \frac{x-10}{31}$$

$x = 46$ at D.

$x = 0$ at A

$\Rightarrow \dfrac{R_{F_V}}{R_{F_H}} = \dfrac{4}{3}$

$\therefore \overleftarrow{R_{F_H}} = \dfrac{\overset{\uparrow}{R_{F_V}}}{4} \times 3$

$\Rightarrow \overleftarrow{R_{F_H}} = \left.\dfrac{x-10}{31} \times 0{\cdot}75\right)_{x=0}^{46}$

By $\Sigma F_x = 0 \longrightarrow$.

$\overleftarrow{H_E} = -\overleftarrow{R_{F_H}}$

$\Rightarrow \overleftarrow{H_E} = - \left.\dfrac{x-10}{31} \times {\cdot}75\right)_{x=0}^{46}$

$\Sigma F_y = 0 \uparrow$

$\Rightarrow \overset{\uparrow}{V_E} = 1 - \overset{\uparrow}{R_{F_V}}$

$\Rightarrow \overset{\uparrow}{V_E} = 1 - \left.\dfrac{x-10}{31}\right)_{x=0}^{46}$

Then Draw the I-Line for AD $\Rightarrow$ (x- এর value বসালে ordinate পাবো)

14.10.15

Eq^{n}s of reactions

$R_{F_V}^{\uparrow} = \left.\dfrac{x-10}{31}\right|_{x=0}^{46}$; $R_{F_H}^{\leftarrow} = 0.75 \left.\dfrac{x-10}{31}\right|_{x=0}^{46}$

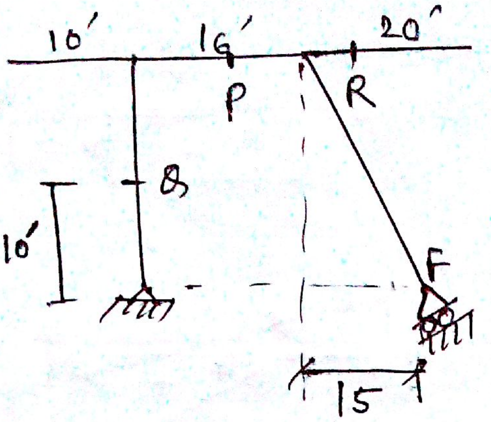
$H_E^{\leftarrow} = -0.75 \left.\dfrac{x-10}{31}\right|_{x=0}^{46}$; $V_E^{\uparrow} = 1 - \left.\dfrac{x-10}{31}\right|_{x=0}^{46}$

I line for $R_{F_V}^{\uparrow}$

I. Line for $R_{F_H}^{\leftarrow}$

I. line for H_E

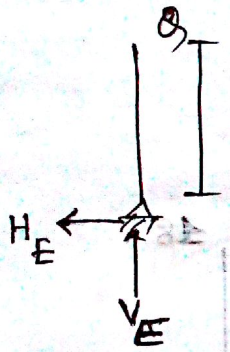
I. line for V_E



I. Line for shear force & BM at Q ⇒

1. First section at Q —

(unit load-এর path বাঁকে পড়ে না so একটাই eq^n হবে)



$$\therefore \overset{+}{V_Q} = \overset{\leftarrow}{H_E} = -0.75 \, \frac{x-10}{31} \Bigg|_{x=0}^{46}$$

$$\& \quad \overset{+}{M_Q} = \overset{\leftarrow}{H_E} \times 10 = -10 \times 0.75 \, \frac{x-10}{31} \Bigg|_{x=0}^{46}$$

I' Line for SF, BM at R ⇒

- unit load-এর path বাঁক আছে। So, দুই ভাগে ভাগ হবে ⇒

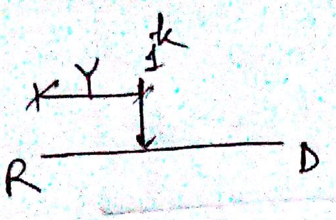
1. Unit load A-R → Consider Rt part $\overline{R \quad D}$

$\therefore V_R = 0, \; H_R = 0.$

2. " " R-D.

⇓

Consider also Rt part cz only 1 unit load is there.



$\therefore V_R^{+} = 1$

$M_R^{-} = 1 \cdot Y \Big|_{Y=0}^{15}$

I. Line for SF, BM at P ⇒

1. Unit load A−P (Consider Rt part)

2. Unit load P−D (Consider left part)

$$V_P^{-} = R_{FV}^{\uparrow} = \frac{x-10}{31}\Big|_{x=0}^{18}$$

$$M_P = 23 R_{FV}^{\uparrow} - R_{FH}^{\leftarrow} \times 20$$

$$= \left(23\,\frac{x-10}{31} - 20 \times 0.75\,\frac{x-10}{31}\right)\Big|_{x=0}^{18}$$

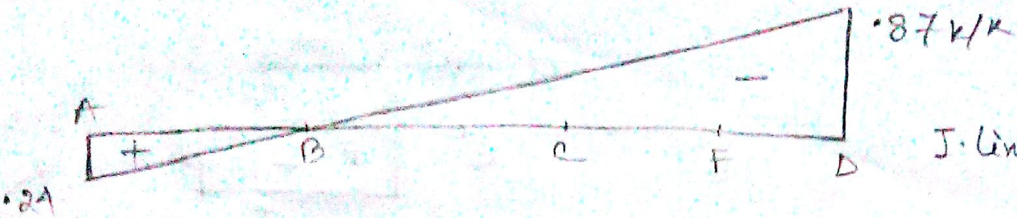
$$= 8\,\frac{x-10}{31}\Big|_{x=0}^{18}$$

2. Unit load P−D :

$$V_P^{+} = V_E^{\uparrow} = 1 - \frac{x-10}{31}\Big|_{x=0}^{28}$$

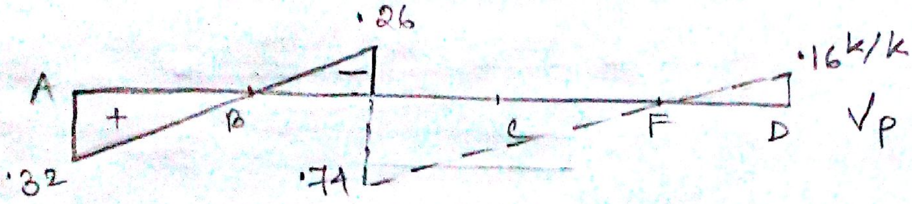
$$M_P = 8 V_E^{\uparrow} - 20 H_E^{\leftarrow} = 8\left(1 - \frac{x-10}{31}\right) - 20(-0.75)\,\frac{x-10}{31}\Big|_{x=0}^{28}$$

$$\therefore M_P = 8 + 7\,\frac{x-10}{31}\Big|_{x=0}^{28}$$

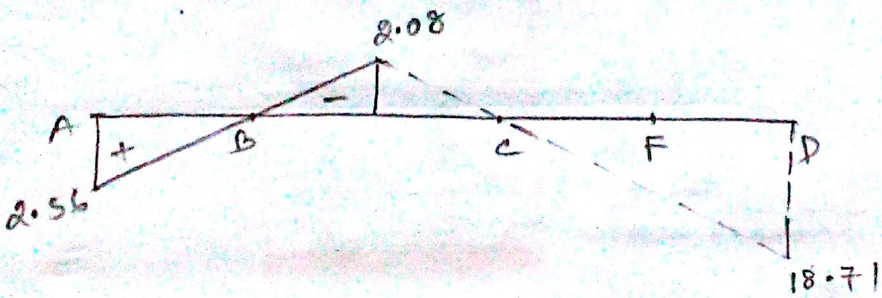


J. Line for V_B.

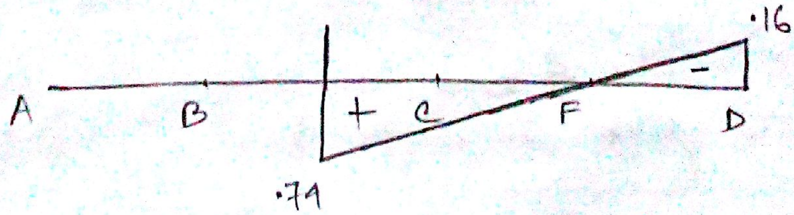
J.L – M_a.



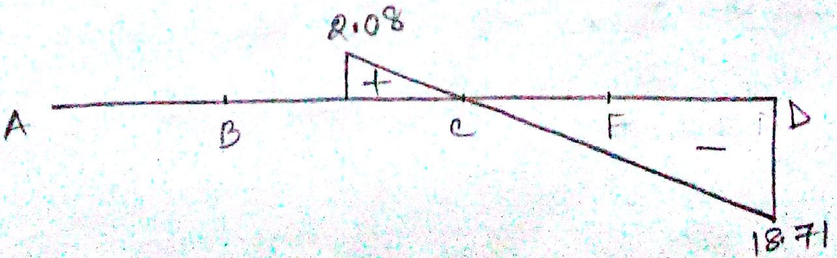
V_p (part)



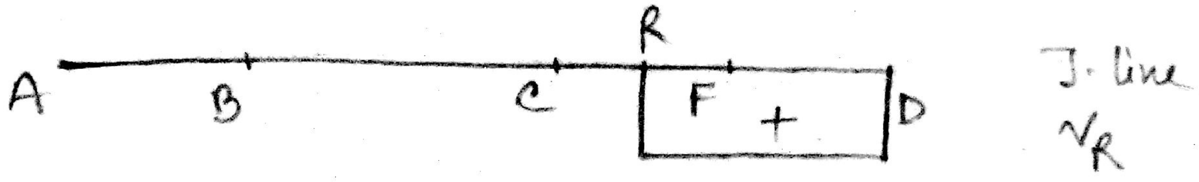
I Line
M_p (Part)

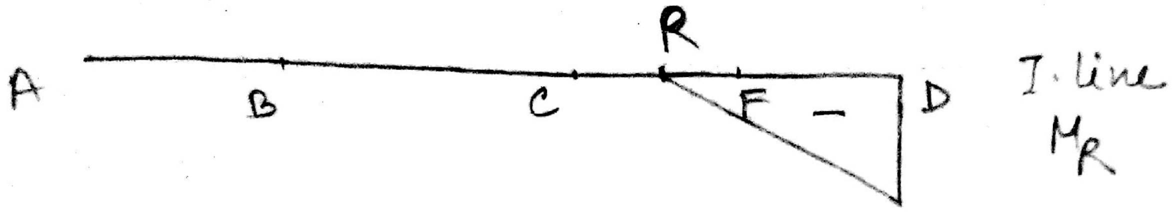


I Line
V_p (Part)



J. Line
M_p (Part)


R
A
B
C
F
+
D
I. line
V_R


R
A
B
C
F
−
D
I. line
M_R

19·10·15

I·line for

Girder with floor beams

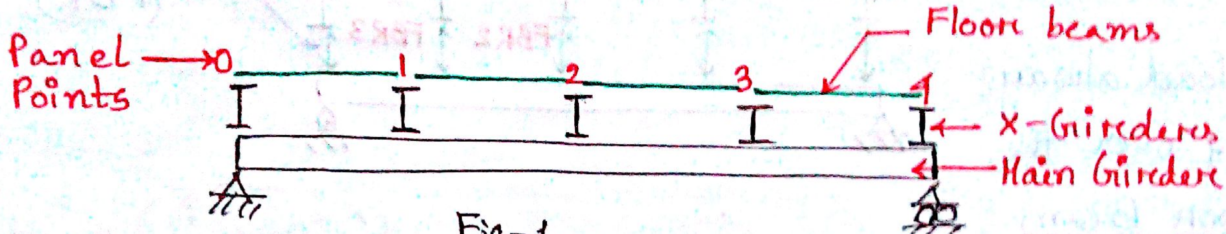
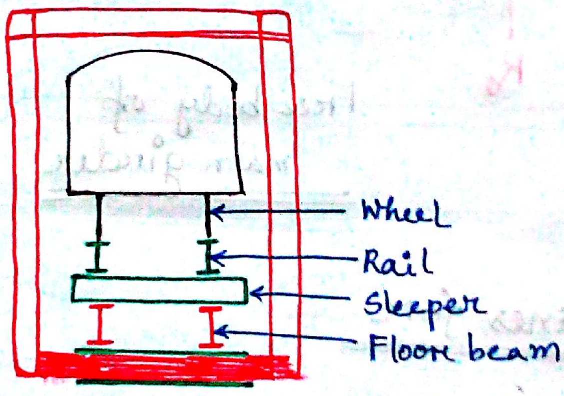


Fig-1

Norris

1·6·4 Bracing Systems.



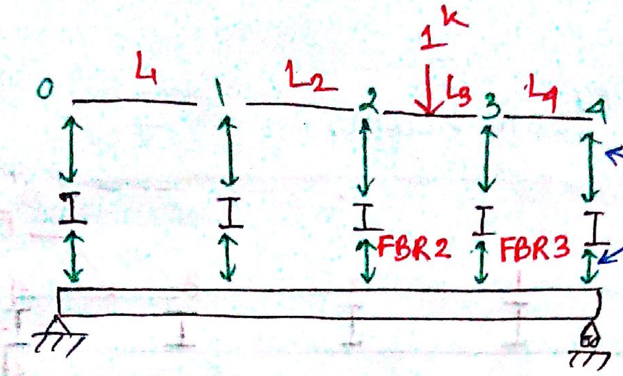
Cross section

* truss only joint -এ force দিয়ে থাকে যে member-এর middle -এ load পড়লে bending হবে।

⇓

To avoid this we need floor system. to take the load only to the joints of the bottom chord

Free body of fig-1

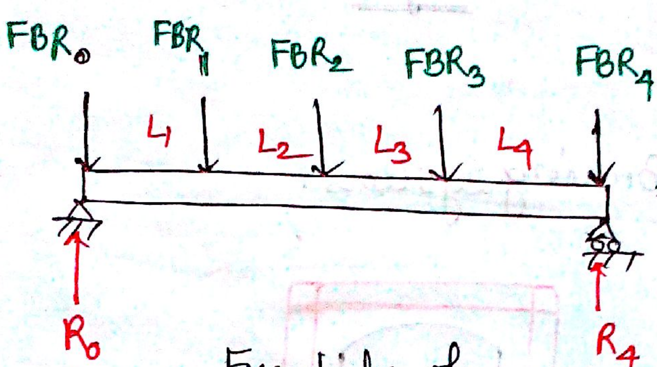


Floor beam reactions (FBR)

Unit load alwayz moving over the floor Beam

⇓

It will never directly come to the girder/ main girder.



Free body of main girder

⇒ 0 & 1 Panel Points এর মাঝে কোন load কখনও আসবে না

⇓

So SF এই দুই point এর মধ্যে always constant

- Draw I-lines for

1. FBR's
2. R_0 & R_4

} as for R's in beams.

3. SF within Panel Points $\left(V_{0-1}, V_{1-2}, V_{2-3}, V_{3-4}\right)$
4. BM at PP's $\left(M_1, M_2, M_3\right)$ → BM always change হয় between two successive Panel points.

→ from freebody:

M_0 & M_4 ⇒ Iline is zero line cz at 0 & 4, $M = 0$.

SF eq^n's : $V_{0-1}^{+} = R_0^{\uparrow} - FBR_0^{\downarrow}$

$V_{1-2}^{+} = R_0^{\uparrow} - FBR_0^{\downarrow} - FBR_1^{\downarrow}$ ⇒ sect^n কাটব bet^n ① & ②

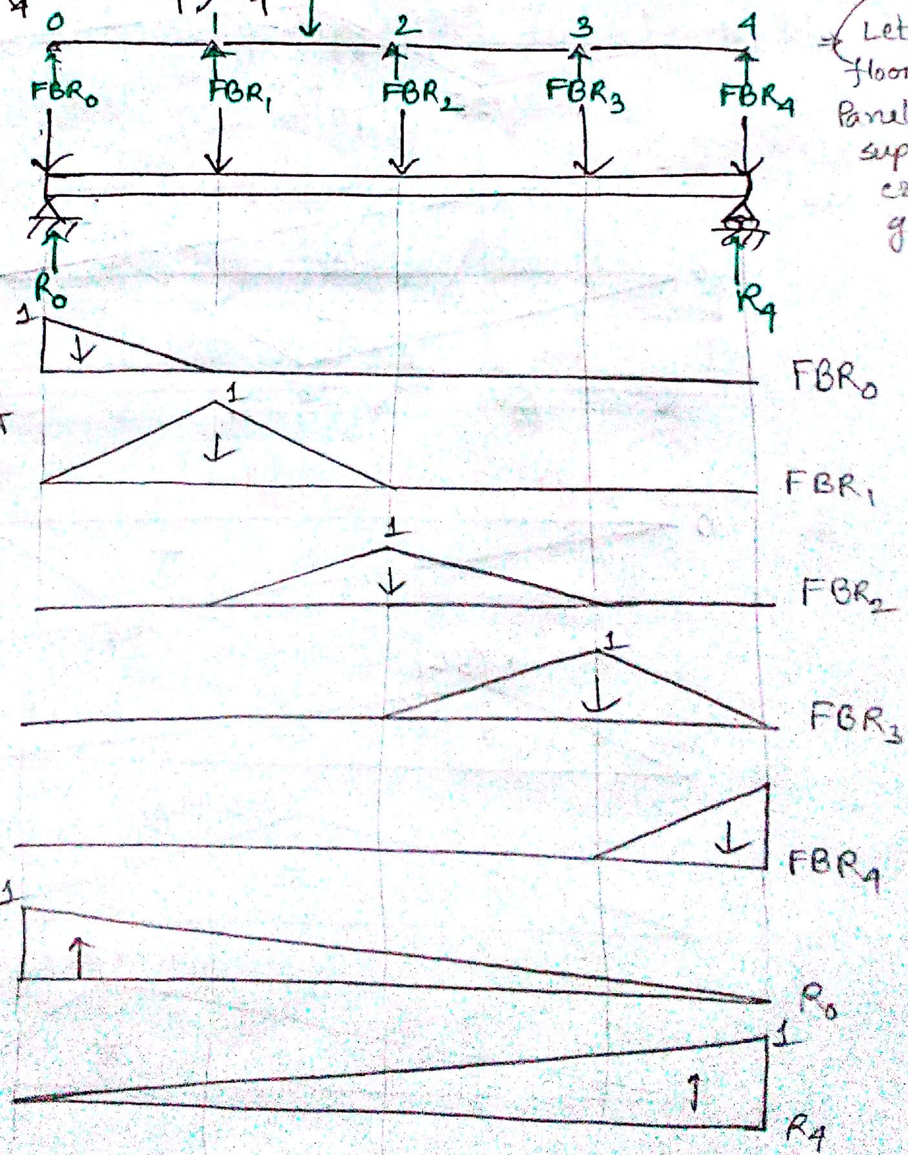
$V_{3-4}^{-} = R_4^{\uparrow} - FBR_4^{\downarrow}$ → sect^n কাটলে bet^n ③ & ④

BM eq^n's :

$M_1^{+} = (R_0^{\uparrow} - FBR_0^{\downarrow}) L_1$

$M_2^{+} = (R_0^{\uparrow} - FBR_0^{\downarrow})(L_1 + L_2) - FBR_1^{\downarrow} (L_2)$

$M_3^{+} = (R_4^{\uparrow} - FBR_4^{\downarrow}) L_4$ 1^k



⇒ (Let's assume floor beam এর Panel point-এ support আছে ie cross girder আছে)

direct^n floor beam চিন্তা করলে (↑) হবে but main girder চিন্তা করলে (↓) হবে

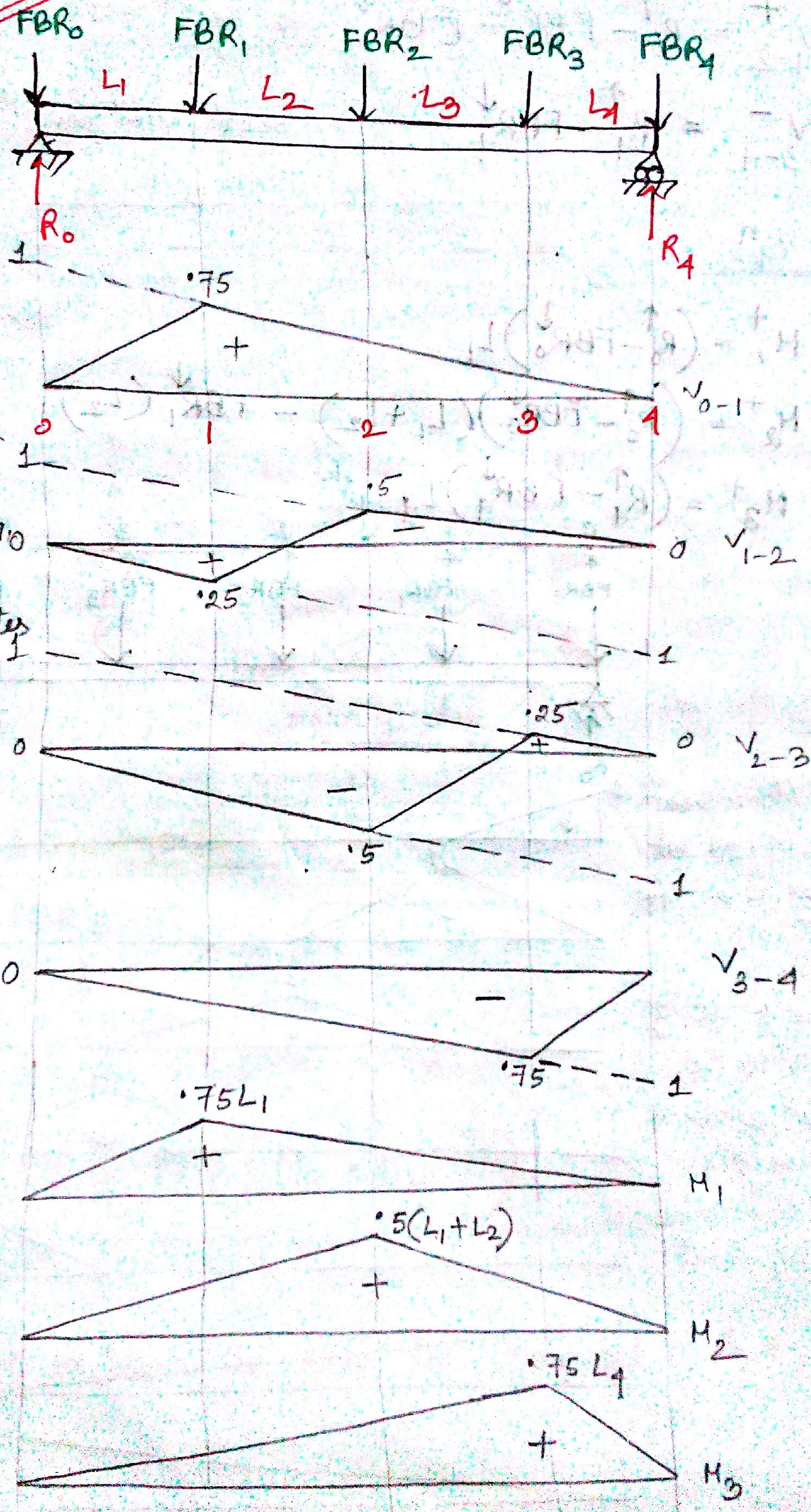
⇓

mainly main girder-ই আমাদের লাগবে so, আমরা main girder এর direct^n use করব।

Scanned by CamScanner

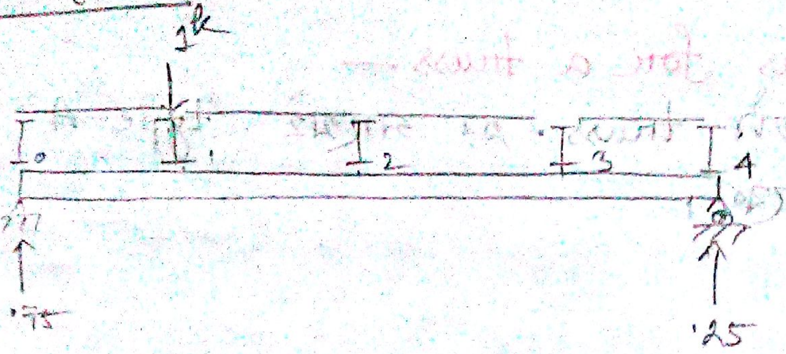
02.11.15

মুখস্থ রাখতে হবে Pattern



(*) first parallel line দুটি টানব।
Then ঐ দুই point এ SF যোগ করে ঐ point দুটি add করব।
⇓
Then find ordinates by similar Δs.

for calculating M_1:

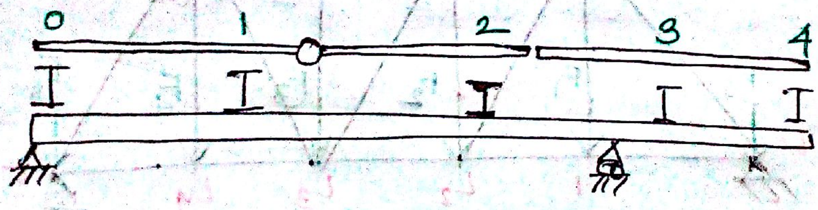


$\therefore M_1 = .75 L_1^{+}$

- Types of girder with floor beams —

  A. With simply supported floor beams

  B. With non-simply supported floor beams.
  (from Norris ⇒ দেখতে হবে)



By free-body & Eq^ns —

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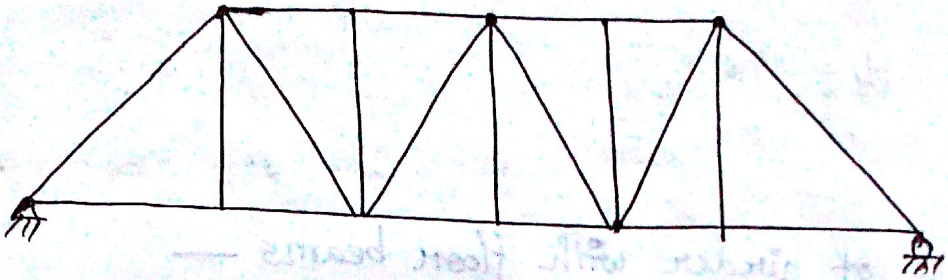
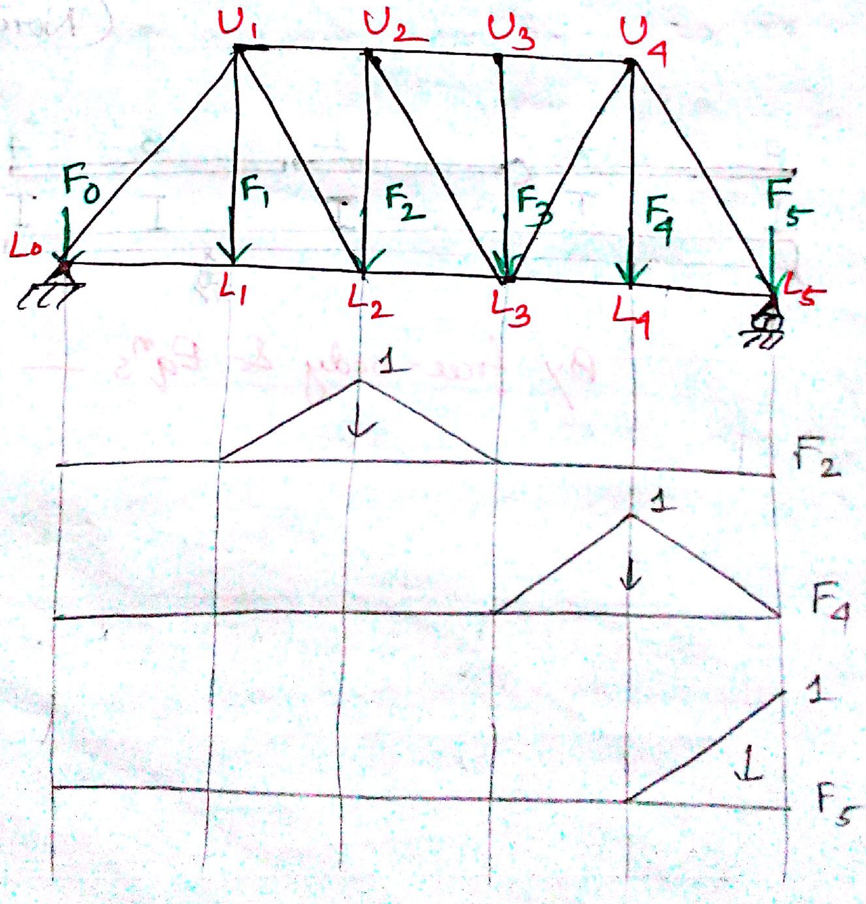
I·Lines for a truss —

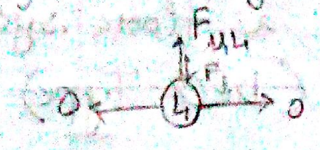
(*) প্রতিটি truss - এর সাথেই type-A floor beams থাকে।





Find the I-line for U_1L_1

* for finding U_1L_1 force, L_1 joint analysis



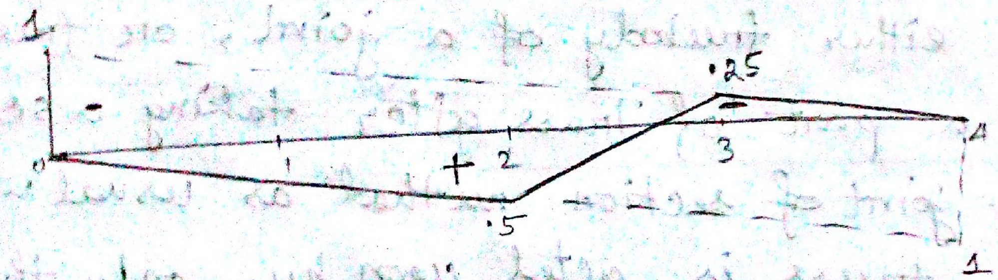
$\Sigma V = 0$

$\Rightarrow F_{U_1L_1}^{(T)} = F_1 \downarrow$

We know IL for F_1. So from this we can get $F_{U_1L_1}$

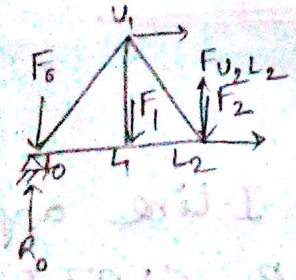
I Line for $F_{U_1L_1}$

Find the I Line for $F_{U_2L_2}$



I-Line for $F_{U_2L_2}$

for L_2U_2



$\Sigma V = 0 \Rightarrow F_{U_2L_2} + R_0 - F_0 - F_1 - F_2$

$\Rightarrow F_{U_2L_2} = F_0 + F_1 + F_2 - R_0$ —— (2)

This eq^n (2) is similar to V_{2-3}

So the ILine will be equal to V_{2-3}

04.11.15

- Influence lines for truss members —

— A bridge is fitted with a floor systems either at the bottom chord level ~~(Deck Type)~~ (Through type or at the Top chord level (Deck Type).

— Hence a Truss is acted upon by floor beam reactions resulting from the unit load / Moving Live load.

— Force in a member of Truss is calculated by either freebody of a joint, or free body of a part of Truss after taking a section (i.e. joint of section method as usual wheile the truss is acted upon by only the

FLOOR BEAM REACTIONS

- STepts —

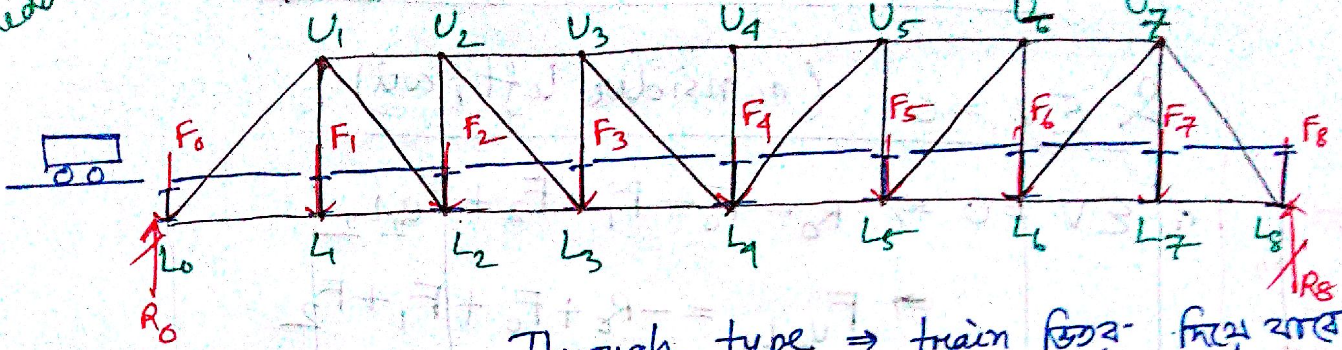
1. Find the shape of I.Line applying TRUSS ANALYSIS BY JOINT OR SECTION METHOD.

2. Then find the controlling ordinates by truss analysis for specific position of UNIT LOAD.

fig-1.5
Pg-264
Shedd Vawter

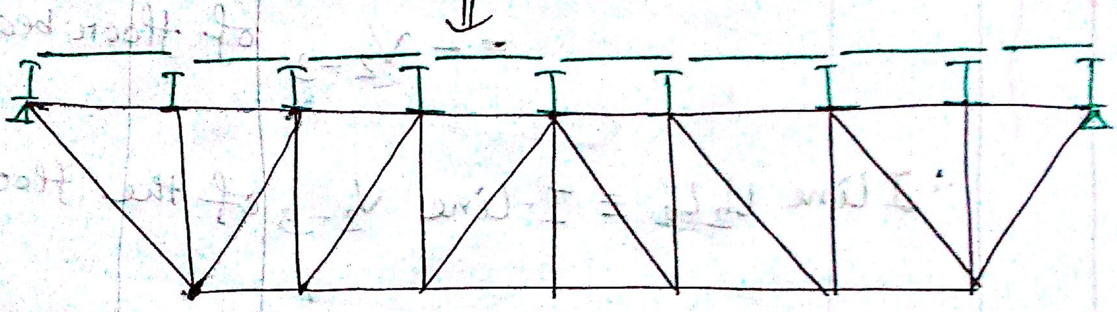
Truss - 1 ⇒ Paralled Chord Truss

8' @ 25' = 200'



Through type ⇒ train ভিতর দিয়ে যাবে

Deck " ⇒ " truss এর উপর " "

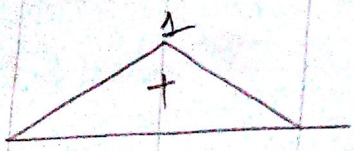


Iline for U_1L_1 ⇒ Jt L_1 & $\Sigma V = 0$.

$$\therefore F_{U_1L_1}^{\oplus} = F_1 \downarrow$$

Similarly, U_7L_7 & U_4L_4

$$U_7L_7^{\oplus} = F_7 \downarrow, \quad U_4L_4 = 0$$



$U_2L_2 \rightarrow$ Inclined section through L_2-L_3

& $\Sigma V = 0$ (consider left part)

eqⁿ না নিলেও চলবে direct $F_{U_2L_2} = V_{2-3}$

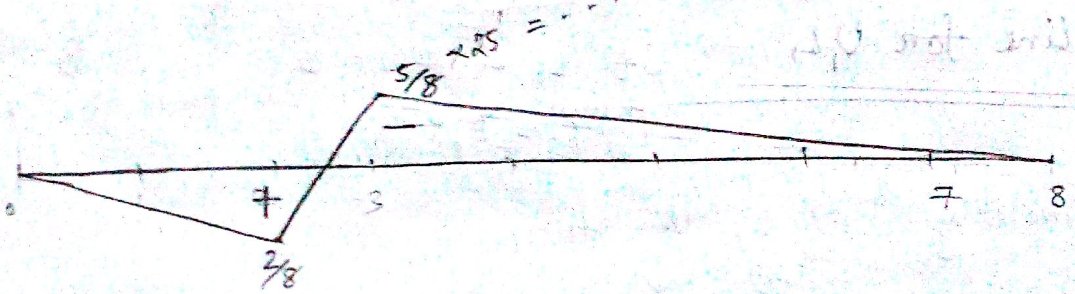
$\therefore \Sigma V = 0 \Rightarrow R_0 - F_0 - F_1 - F_2 + F_{U_2L_2}$

$\Rightarrow F_{U_2L_2} = -R_0 + F_0 + F_1 + F_2$

$= -(R_0 - F_0 - F_1 - F_2)$

$= -V_{2-3}$ of floor beam system

$\therefore$ I line $U_2L_2 \equiv$ I-line V_{2-3} of the floor system



Load ③ এ থাকলে

$5/8 \Rightarrow$ এর right side 5 টা part আছে
& left " 3 টা "

$\Sigma V = 0 \Rightarrow$ React$^n \uparrow$ so force of U_2L_2 is $\downarrow$ i.e. comp

$\uparrow = 5/8^k$ & in the member this is compression — so $\underline{-ve}$

$\therefore$ $\underline{-ve}$

Iline for $U_3 - U_4 \Rightarrow$ Ver Sect^n Truss $L_3 - L_4$

& $\Sigma M_{L_4} = 0$.

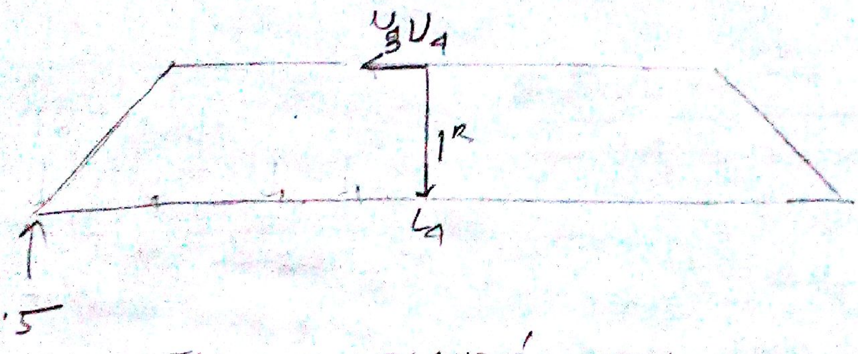
$\Sigma M_{L_4} = 0 =$ ______________

= — — —

$\therefore U_3U_4 \equiv M_{L_4}$.

for ordinate ⇒

unit load at L_4 & taking left —



$$\Sigma M_{at\,4} = {\cdot}5 \times 4 \times 25' - U_3U_4 \times 35$$

$$\Rightarrow M_{U_3U_4} = \frac{{\cdot}5 \times 4 \times 25}{35}$$

Similarly Top Chord Members

এই point-এ moment নিলে bar force বের হবে	$U_1U_2 = M_2$
যেটার M dia হবে এবং হবে	$U_2U_3 = M_3$
	$U_3U_4 = M_4$
	$U_4U_5 = M_4$
	$U_5U_6 = M_5$
	$U_6U_7 = M_6$

BC Members

$L_0L_1 = M_1$

$L_1L_2 = M_1$

$L_2L_3 = M_2$

$L_3L_4 = M_3$

$L_4L_5 = M_4$

$L_5L_6 = M_5$

$L_6L_7 = M_6$

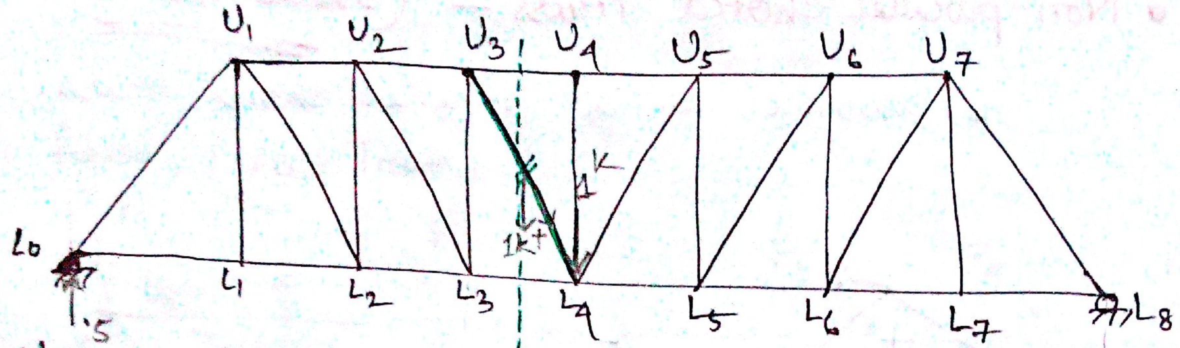
$L_7L_8 = M_7$

Inclined member $\Rightarrow (U_3L_4)$ Vertical sect^n through L_3-L_4 & $\Sigma V=0$

$\therefore U_3L_4 = V_{3-4}$

$\boxed{\text{ordinate} \Rightarrow \text{next class}}$

8.11.15



for $U_3L_4 \Rightarrow$

$\therefore F_{U_4L_4} = .5 \times \frac{\sqrt{35^2+25^2}}{35} = .614$

for ordinate put unit load U_3L_4 at pt 4

Similarly,

$U_1L_0 \equiv V_{0-1}$

$U_1L_2 \equiv V_{1-2}$

$U_2L_3 \equiv V_{2-3}$

$U_3L_4 \equiv V_{3-4}$

U_5L_4

U_6L_5

U_7L_7

U_7L_8.

Ordinate for T.C. Members

for $U_3U_4 \Rightarrow$ Ver. sect^n through L_3L_4 & Left part & $\Sigma M_{L_4} = 0$.

$\therefore U_3U_4 \equiv M_4$

- point 4 – @ unit load.

$\therefore \Sigma M_{L_4} = 0 \Rightarrow .5 \times 100 + F_{U_3U_4} \times 35$

$\Rightarrow F^{\ominus}_{U_3U_4} = 1.428$

Ordinate for B.C. Members

for $L_3L_4 \Rightarrow$ sect^n (vert.) & ΣM_{U_3}

$\therefore L_3L_4 \equiv M_3$

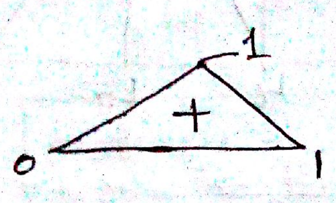
- point 3 @ unit load –

& $\Sigma M_{U_3} = 0 \Rightarrow \frac{5}{8} \times 75 = F_{L_2L_3} \times 35$

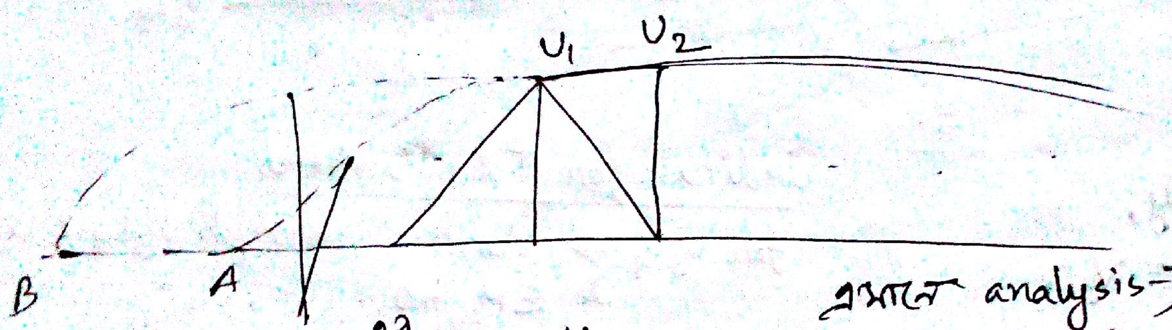
$\Rightarrow F^{\ominus}_{L_2L_3} = 1.339$

• Non-parallel chord Truss — (Shedd Vawter)

assume as a parallel chord truss.



$F_{U_1L_1} \equiv F_1$



U_2U_3 & U_1U_2-এর projected Length

(A = U_1U_2-এর project করলে A তে meet করবে and এখানেEM নিলে force বের হবে)

Similarly B = for U_2U_3

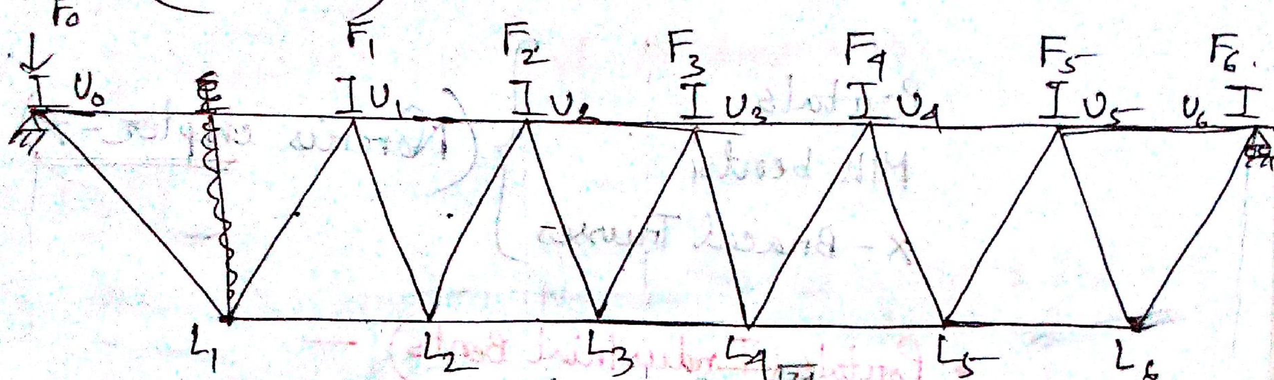
এখানে analysis-এ Top chord-এর ver. & hor member থাকবে & so analysis করা tough

So projection is used.

- Truss without verticals —

Fig. 151 (shedd Vawter)

1st figure, (Deck Truss)



L_3L_4

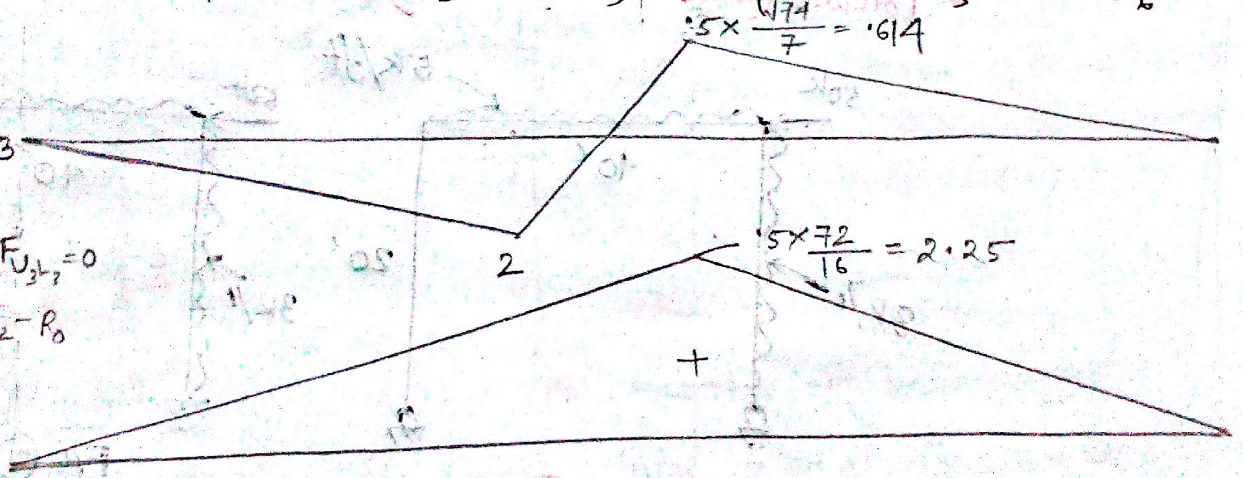
U_3L_3

$\Sigma V = 0$

$\Rightarrow R_0 - F_0 - F_1 - F_2 + F_{U_3L_3} = 0$

$\Rightarrow F_{U_3L_3} = F_0 + F_1 + F_2 - R_0$

$= 1/2 - 3$



(*) for U_1U_2 and U_2U_3 ⇒ ΣM_{L_2} but L_2 হলো U_1U_2 - এর মাঝে not ver.
So actually M_{L_2} এর জন্য IL হওয়ার কথা but
L_2 is not a panel point with girder.

(So একটার peak এর মান দিয়ে এ point টা add করতে হবে।)
⇓
Ordinate same way এ বের করব।

(*) class test ⇒ I Lines for beams

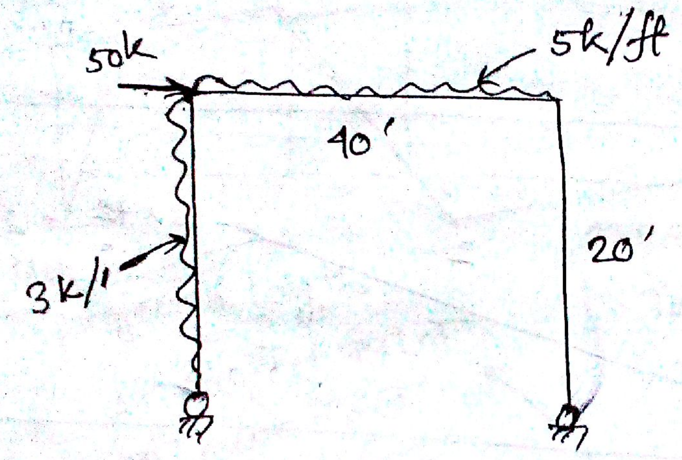
(23.11.2015)

11.11.15

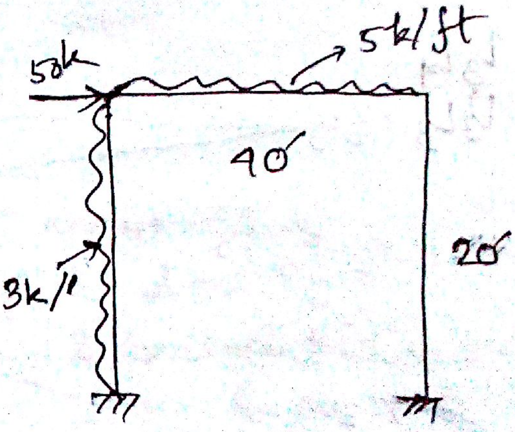
Approximate ANalysis of Indeterminate Structures

Portals
Mill bents
X - Braced Trusses
(Norris chapter-7)

• Portals (Industrial Bents) —



FR ①



FR ②

D° Ind $= 1^\circ$ $\qquad$ D° Ind $= 3^\circ$

* Assumptions of identifying extra eq^{n}s for Portals :

1. There is a hinge at the mid-height of each column.

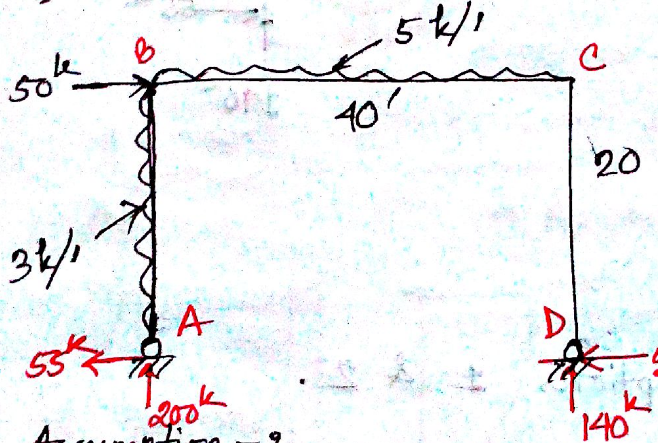
2. Total lateral force at the level of hinges are equally divided among two columns.

* Steps of Analysis —

1. Make necessary assumption(s)
2. Find forces from freebody
3. DRAW SF, BM and AF diagrams.

FRAME ①

1. Make assumption No-2 ⇒ (Ct এখানে 1° Ind., so only 1 eqⁿ is needed. But Ass. ① যদি নেই তাহলে ২ টা eqⁿ চলে আসে। So assumption ② নিব।)



⇓ Now this can be analyzed.

Assumption - 2

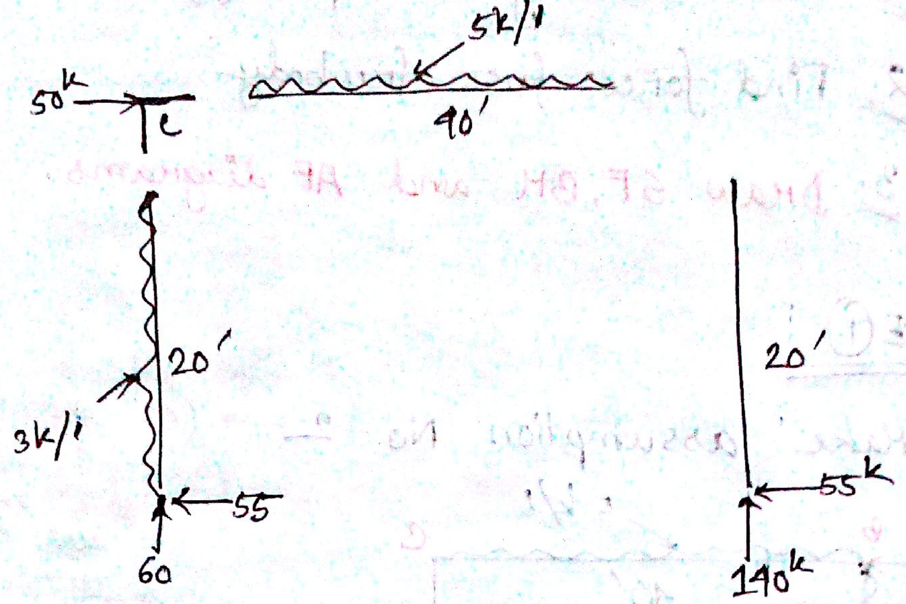
At the level of hinges, total lateral forces = 50 + 60 = 110^k

It will be equally distributed to the hinges in the opposite direction.

$\Sigma M_A = 0 \Rightarrow 50 \times 20 + 60 \times 10 + 200 \times 20 = R_D \times 40$

$\Rightarrow R_D = 140 (\uparrow)$

Now free-body –



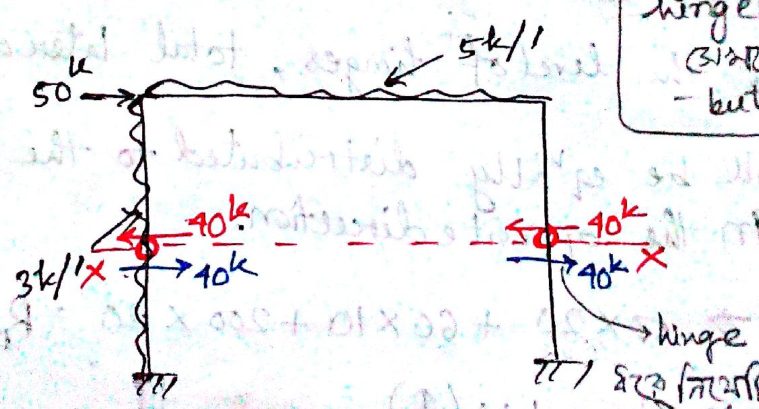
FRAME ②

1. Make assumptions 1 & 2.

আগেরবারের দুই support hinge ছিল। তখন তাদের equally distributed হয়েছে।

⇓

But এখানে hinge is inserted so এই level এ lateral load divide হবে।

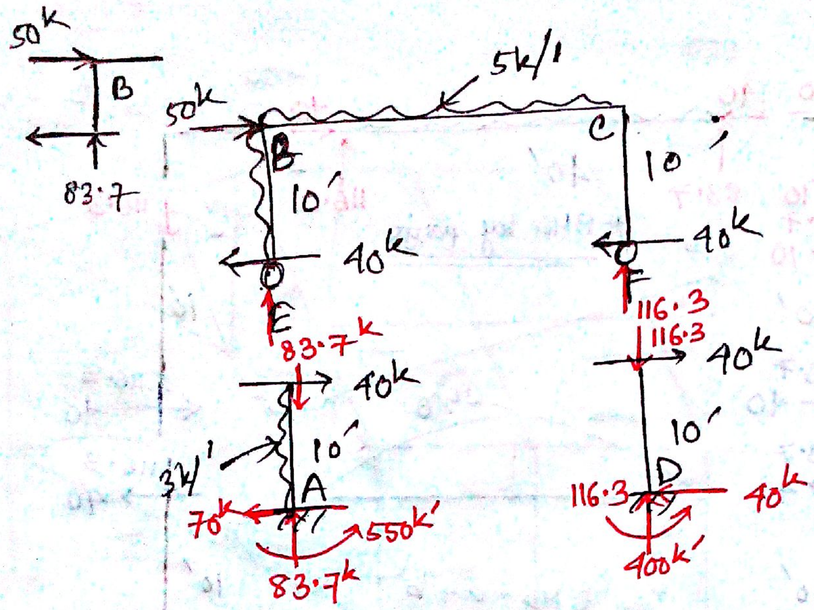


ইকে নিয়েছি তাই কাজটা করবার জন্য এটা দেখো

total lateral load at XX ⇒

$50 + 3 \times 10 = 80^k$

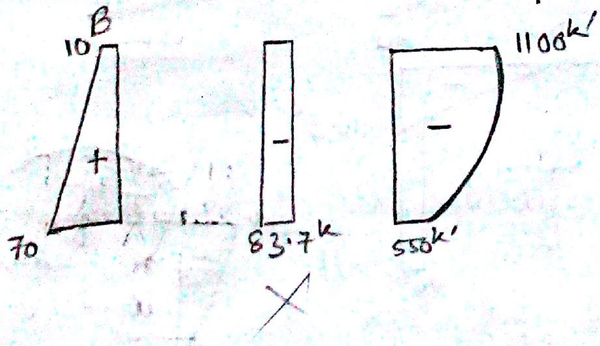
Free body



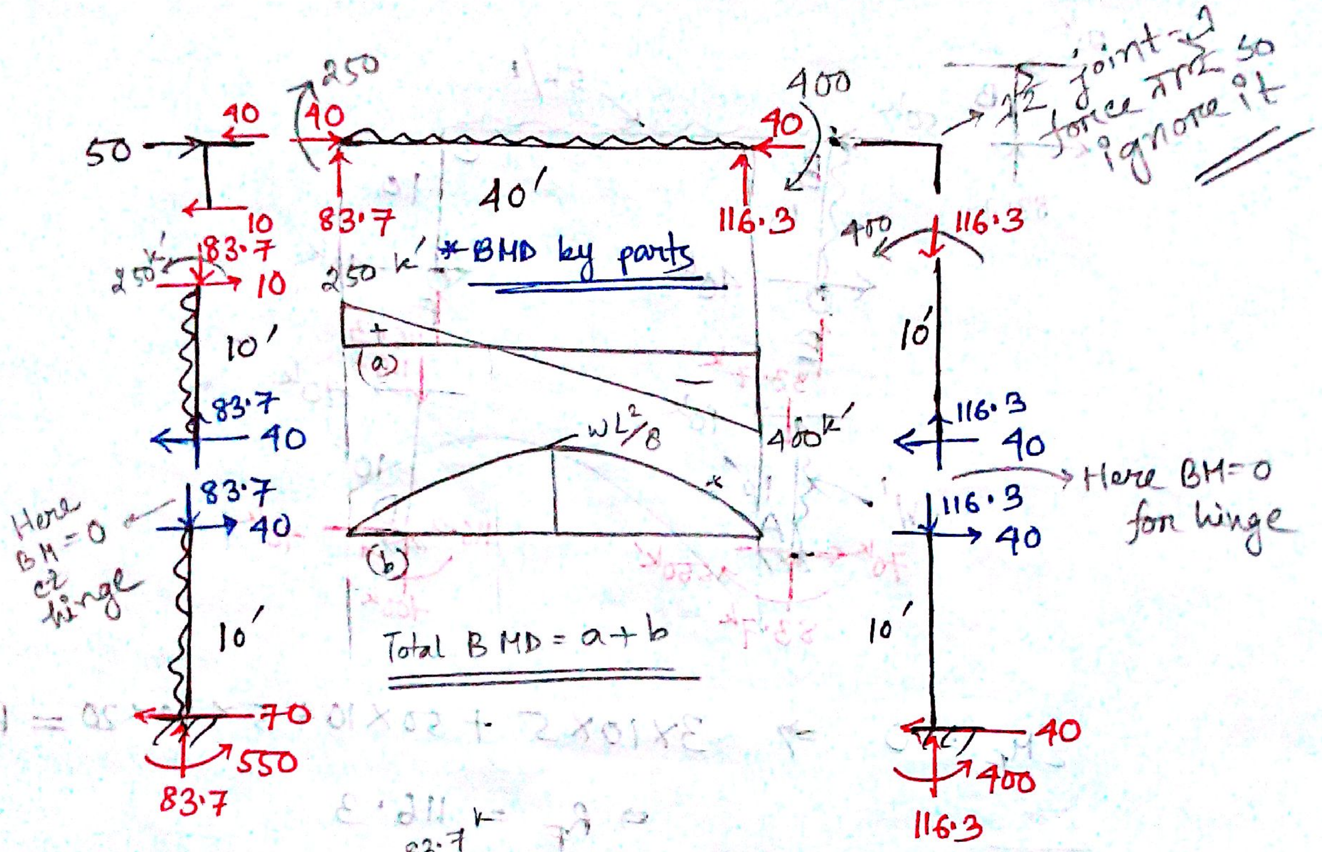
$$\Sigma M_E = 0 \Rightarrow 3\times10\times5 + 50\times10 + 5\times40\times20 = R_F \times 40$$

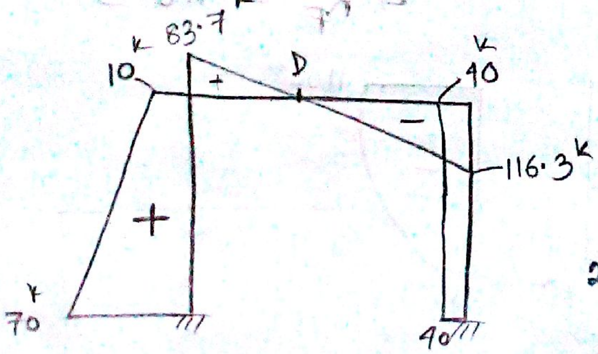
$$\Rightarrow R_F = 116.3$$

AE

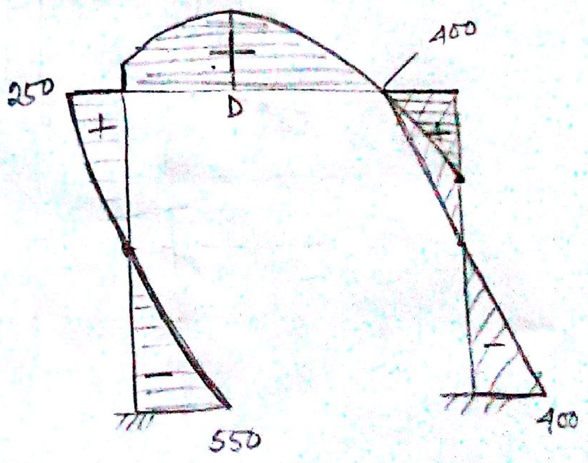


P.T.O


250
400
50
40
40
40
10
83·7
116·3
40'
joint এ force নাই so ignore it
250 k'
* BMD by parts
(a)
400 k'
$wL^2/8$
(b)
Total BMD = a + b
10'
Here BM = 0 at hinge
Here BM = 0 for hinge
70
550
400


83·7 k
10 k
40 k
D
116·3 k
70 k
40
+
−

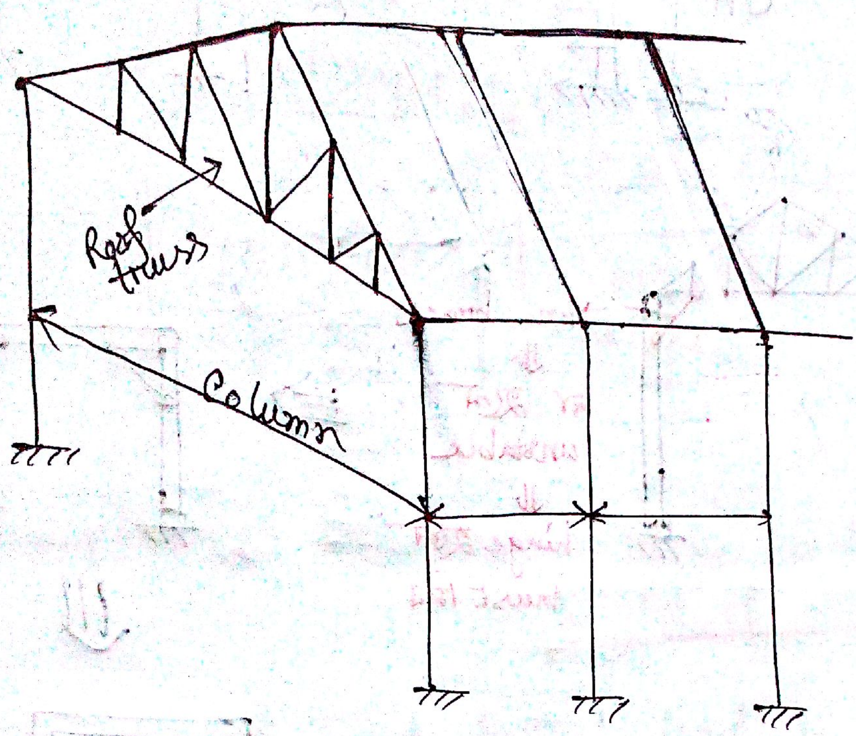
SFD


250
400
D
550
400
+
−

BMD

16·11·15

- **Mill Bents —**



* Mill bent is always a truss or steel frame.

⇓

cz RCC হলে beam depth অনেক বেশি হবে। cz mill-এ column দেওয়া interrupting cz mill-এ অনেক long space লাগে without interruption

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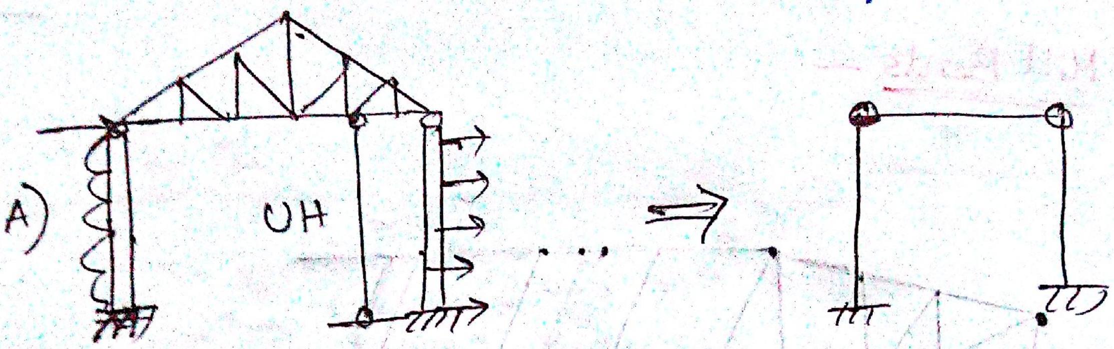
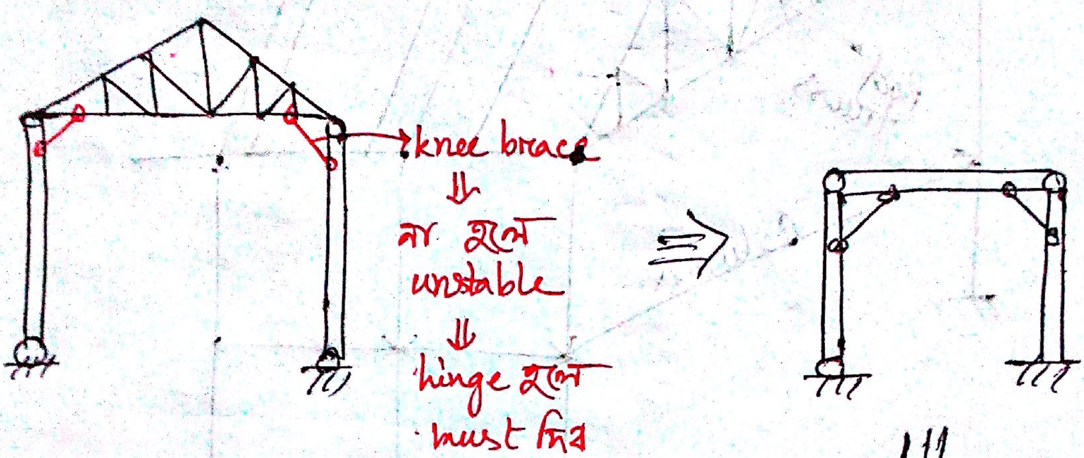
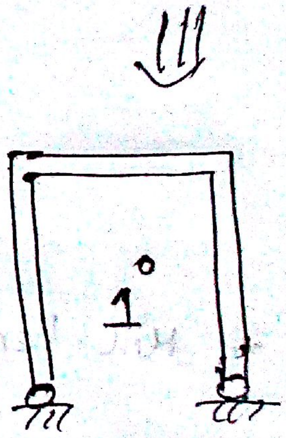
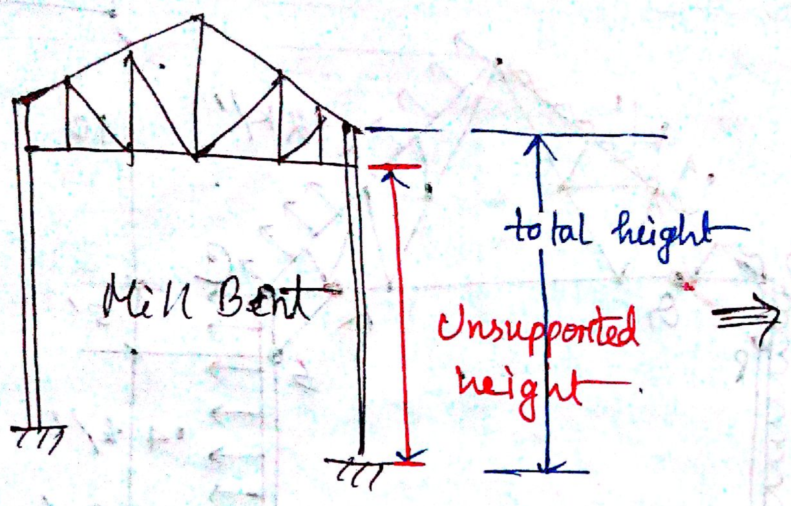
Mill bents | Equivalent Portals.

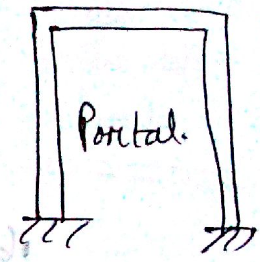






• Unsupported Height of each column –





Assumption (1) ⇒ Hinge will be in the middle of unsupported height of column.

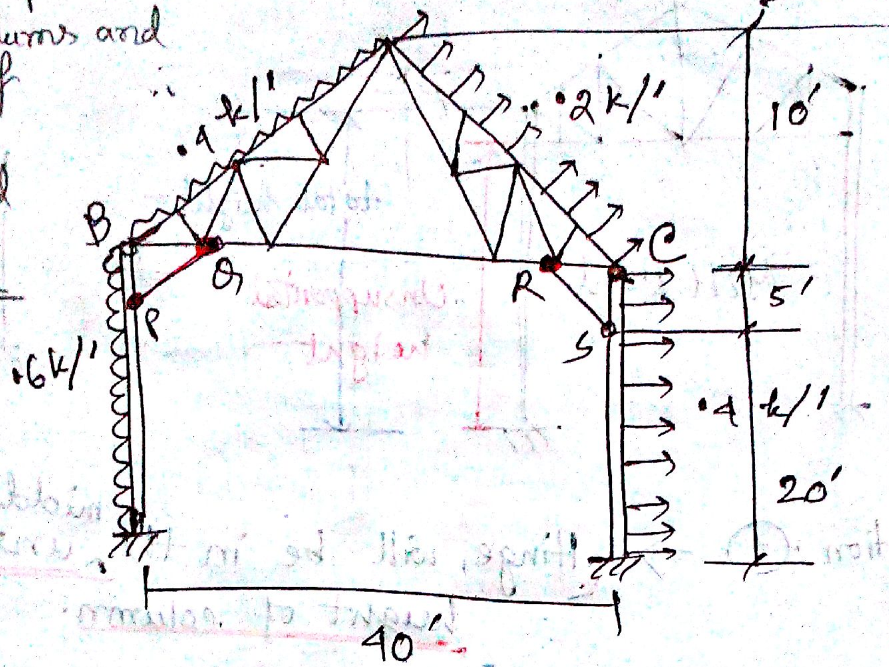
(2) Total lateral load is equally divided among two columns ⇒ 1 eqn. at the level of hinges.

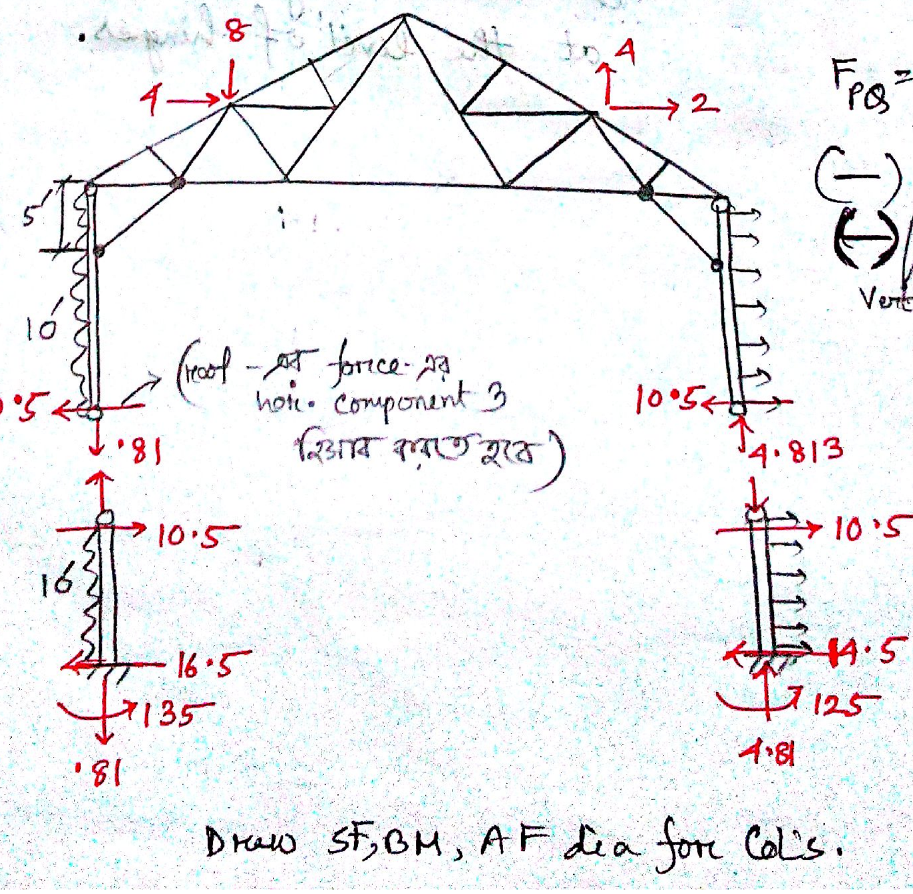
• Mill Bent #2

Draw SF, BM for col^{n}s & bar force in

KNEE BRACES

downward & upward UDL in columns and roof
⇓
for wind load





c.t unsupported col^n height = 20'

∴ hinge is at 10'

(roof - এর force-এর hori. component ও হিসাব করতে হবে)

$F_{PQ} = 22.5^k (T)$

$(\rightarrow) V = 13.5^k$

$(\leftarrow) H = 18^k$

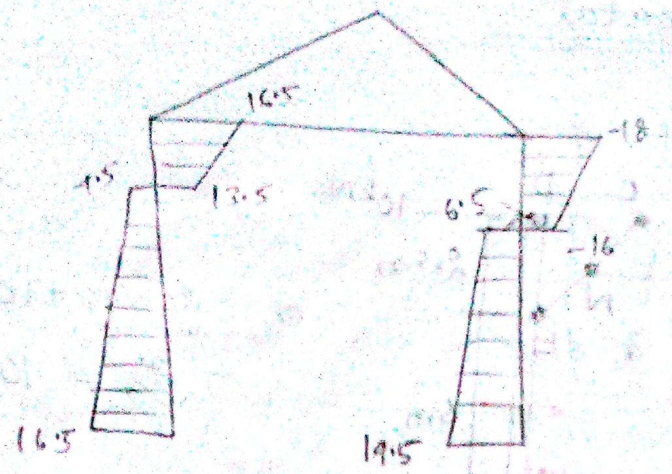
Vert & Hor. comp of F_{PQ}

$F_{RS} = 28.13^k$

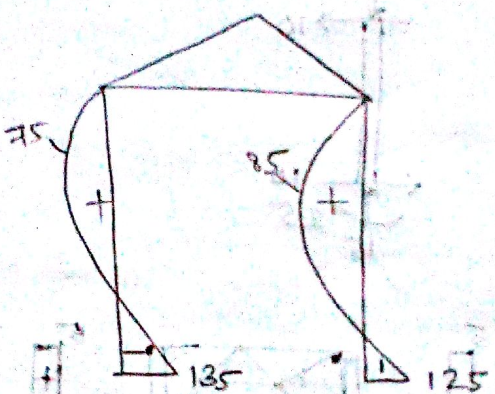
$(\ ) H = 22.5$

$(\ ) V = 16.88$

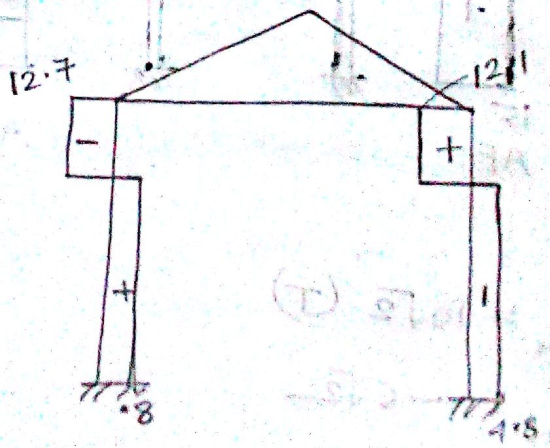
Draw SF, BM, AF dia for Col's.



SFD



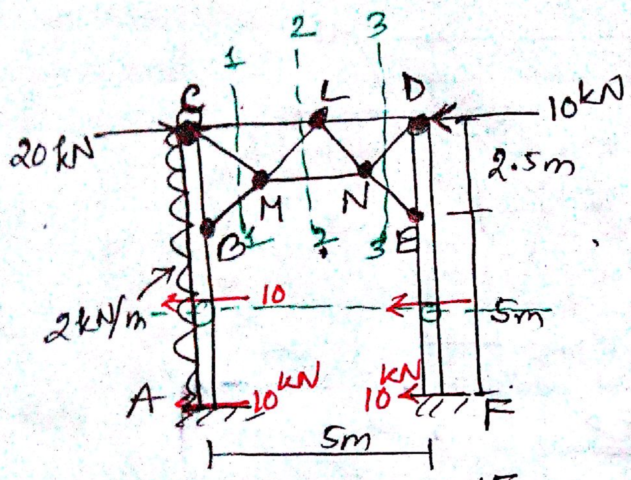
BMD



AFD

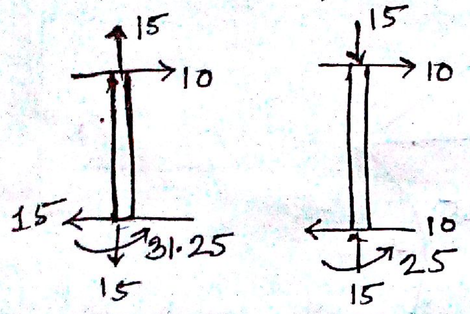
18.11.15

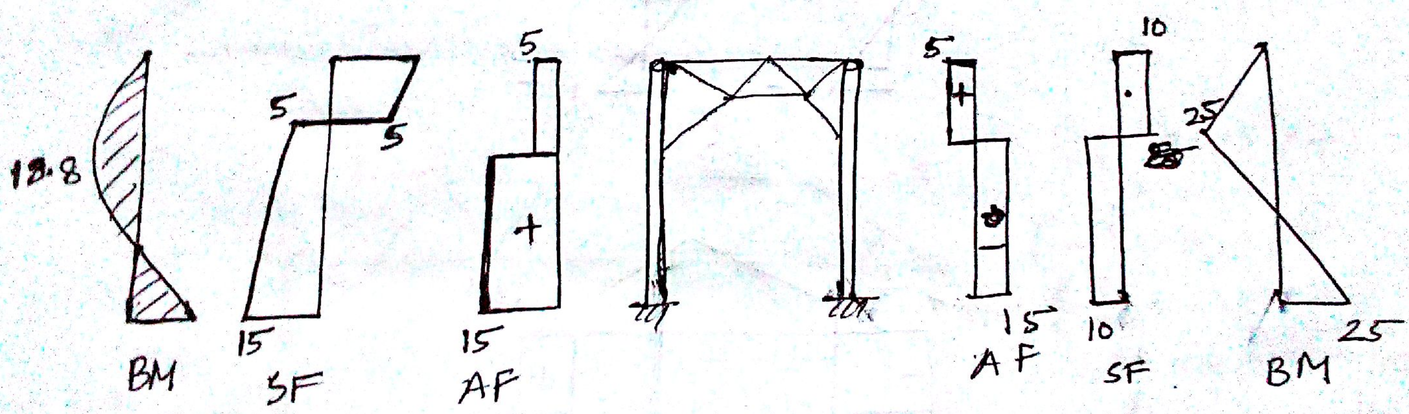
Bridge Portal



$\Rightarrow 20 - 10 + 10$

$= 20/2 = 10$





Sec 1-1

$\Sigma M_c = 0 \rightarrow F_{BM} = 10\sqrt{2}$ (T)

$\Sigma V = 0 \rightarrow F_{CM} = -5\sqrt{2}$

$\Sigma H = 0 \rightarrow F_{CL} = -25$

Sec 2-2

$\Sigma M_L = 0$, $F_{MN} = -10$

Sec 3-3

$\Sigma M_N = 0 \Rightarrow F_{LD} = 5 \, (+)$

$\Sigma M_D = 0 \Rightarrow F_{NE} = 20\sqrt{2}$

$\Sigma V = 0 \rightarrow F_{ND} = -5\sqrt{2}$

JTM

$\Sigma H = 0 \Rightarrow F_{ML} = +15\sqrt{2}$

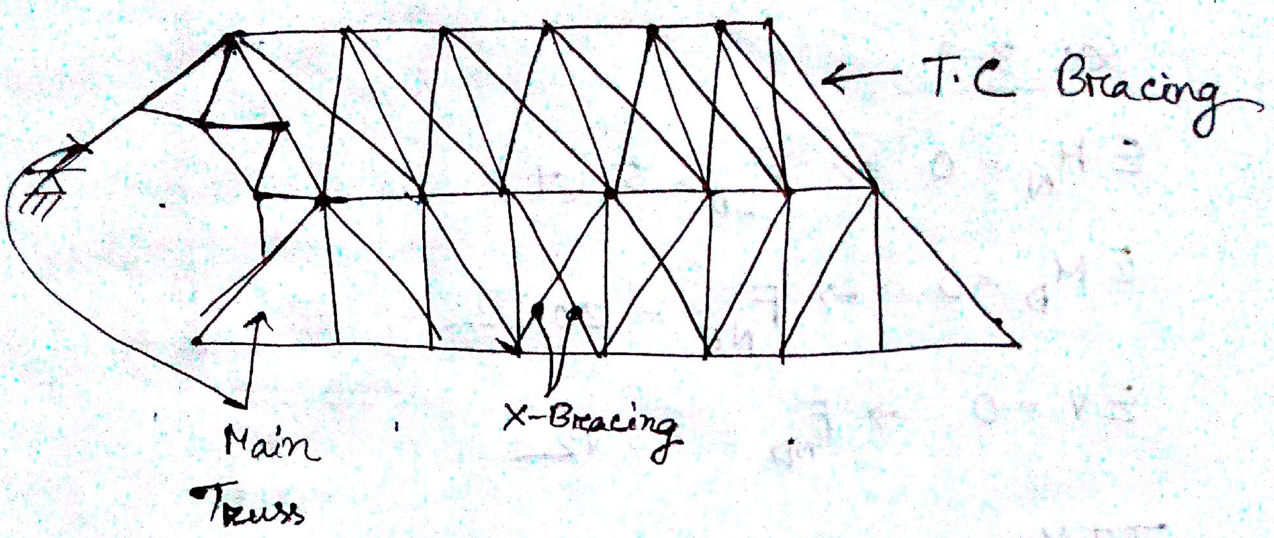
JTL

$\Sigma V = 0 \rightarrow F_{LN} = -15\sqrt{2}$

$\Sigma H = 0 \Rightarrow F_{LD} = +5$

$\boxed{\text{BAR FORCES}}$

Approx. Analysis of X-braced Structures



Assumptions

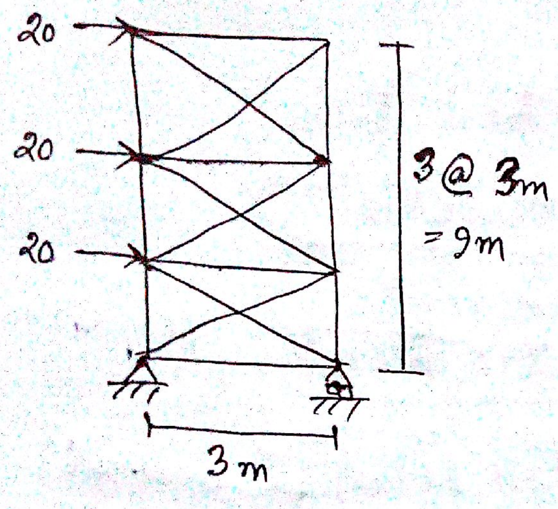
1) Diagonals (Bracings) can carry tension only (i.e. diagonals are made of rope)

or

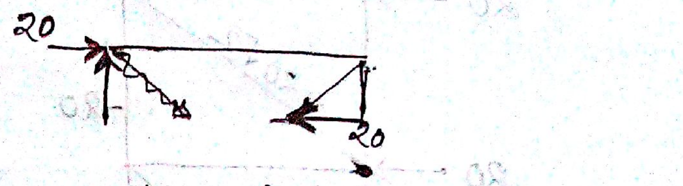
i) Diagonals can carry both the tension and compression and shares the panel shear equally.
(i.e. Diagonals are made of rigid members)

$\boxed{\text{Indet.} = 1^\circ \text{ for each additional X-bracing}}$

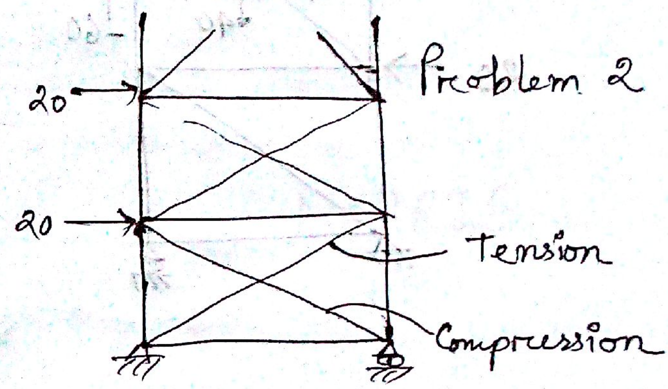
(A) Tension Only



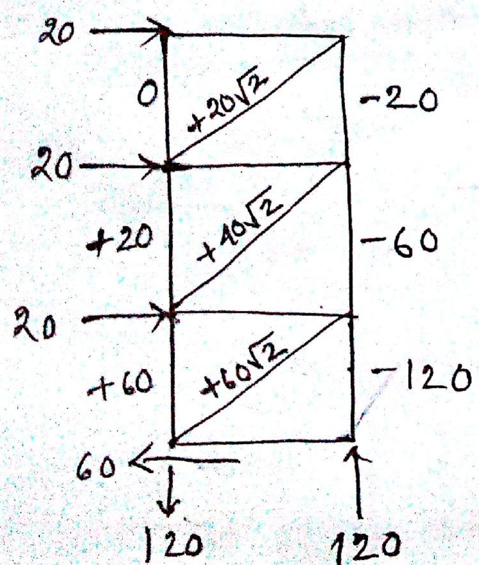
Problem = (3° Indet.)



Horizontal Component = 10

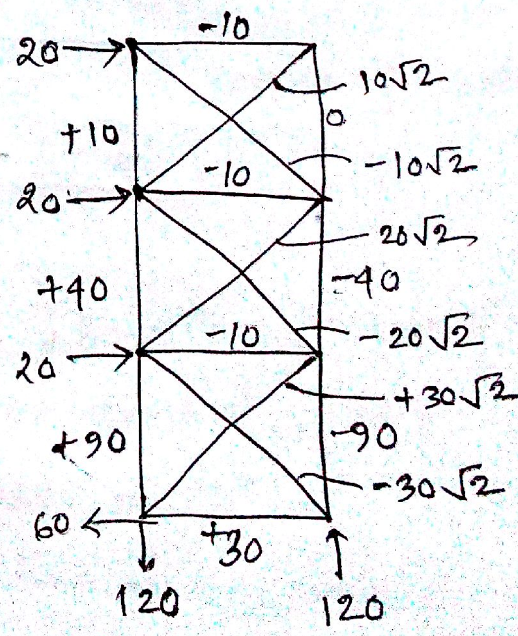


(a) Tension only



(Determinate)

(b) Can carry Tension & Comp.



(Indet.)

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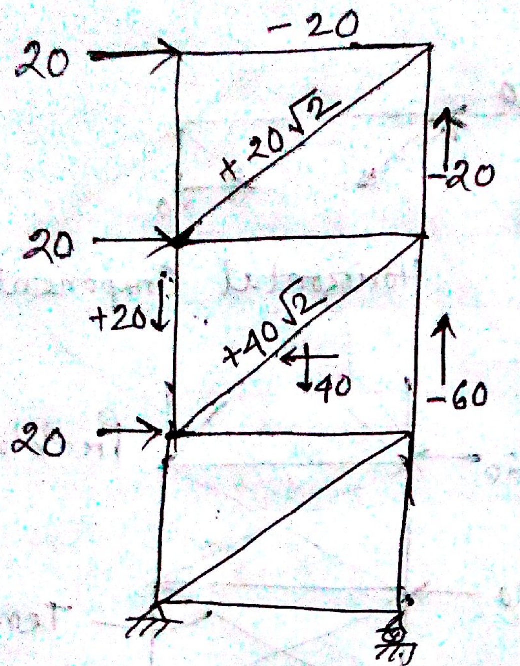
- How to solve trusses easily?



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Multistoried Building Frames under Lateral loads

Lateral loads:

1) Wind load
2) Earthquake load

Approximate analysis Method

1) Portal Method
2) Cantilever Method
3) Factor Method

⇒ NORRIS

Portal Method

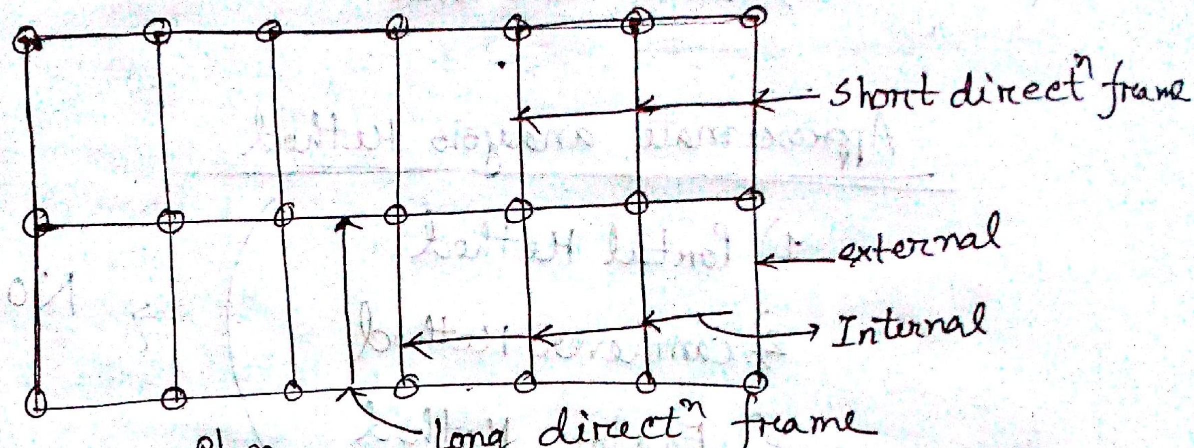
Assumptions

1) There is a hinge at the center of each beam
2) " " " " " " " " " column.
3) Total lateral load above any storey (at the level of hinges) shall be divided among the columns of that storey so that an internal column takes twice the shear force taken by an external column.

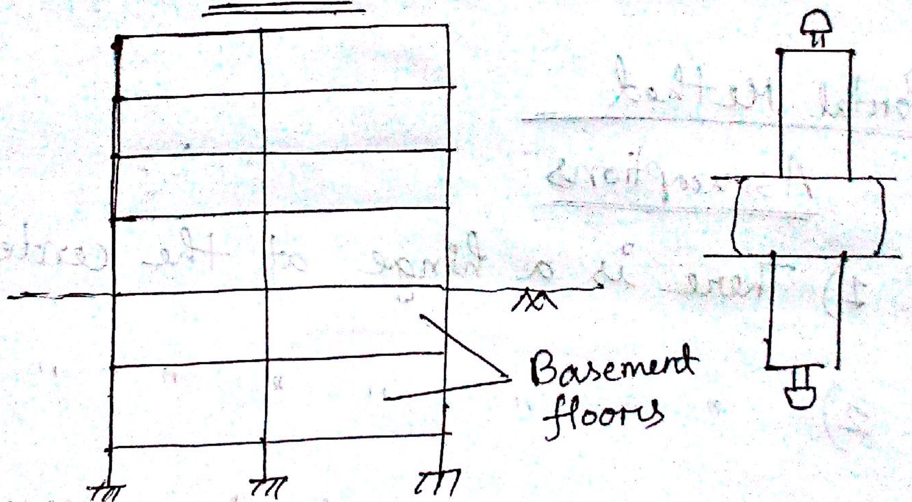
Analysis

To be done by Freebody.

Building Frame



Plan

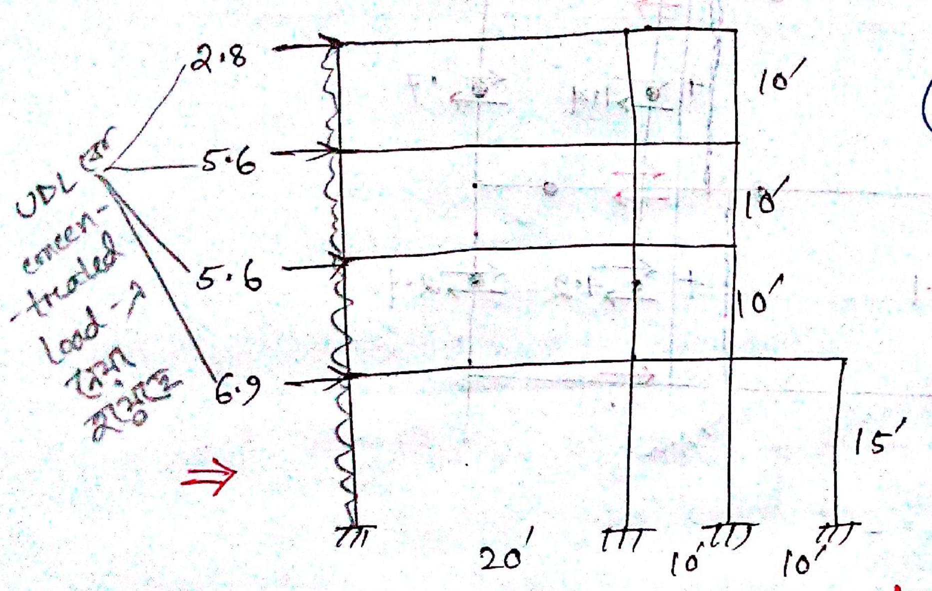


Problem-1

PORTAL METHOD

30.11.15

Approximate analysis of building frames under Lateral loads (Portal Method)



Frame spacing @ 15' c/c

Problem

Wind load

$V = 120$ mph

$P = 0.00256\, V^2$ — in psf

$= 37$ psf

↳ This is the crude formula for wind load calculation.

$W = 0.37 \times 15$

$= .56$ k/ft of Height

frame এর উপর UDL

- Analysis steps and order:

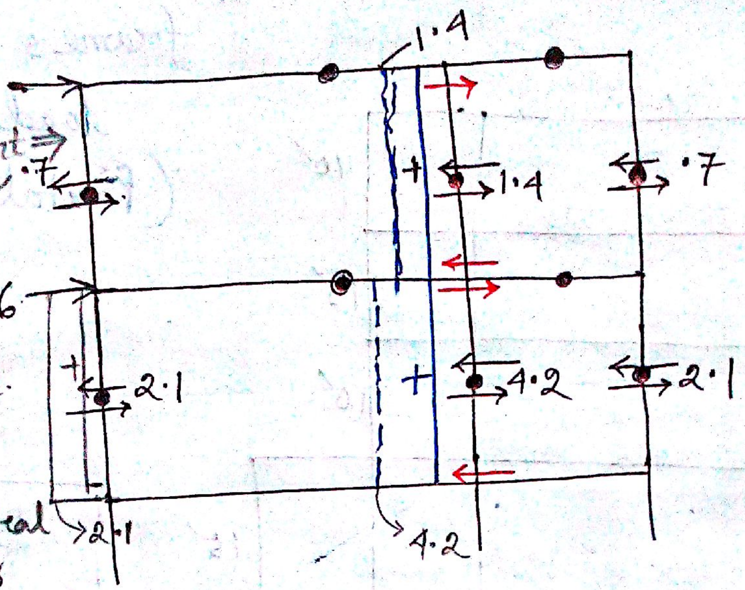
  Calculation of =

  1) Col. SF → By assumptions
  2) Beam AF
  3) Col. BM
  4) Beam BM
  5) Beam SF
  6) Col. AF

  (2)–(6): by Freebody (Top to Bottom)

  এই order এ করতে হবে

- **Col SF — By Assumption**



- for the upper part ⇒ Internal col. will take twice of the load of external col.

⇓

Here total lateral load = 2.8

External = 2 & Internal = 1

⇓

1+1 = 2 & 1×2 = 2

$\frac{2.8}{4} = 0.7$ ⇒ This will taken by external cols & $\frac{2.8}{2} = 1.4$

This is taken by internal cols.

- for 2nd upperpart → Total load = 2.8 + 5.6 = 8.4

∴ External = $\frac{8.4}{4} = 2.1$ & Internal = $\frac{8.4}{2} = 4.2$

- for the lowest part ⇒ 4 cols, 2 ex. & 2 int.

∴ (total load)/6 ⇒

- **Beam AF (by freebody) —**

এখানে Wind load left -এ থাকে। যদি right -এ থাকে then ওর direction উল্টো হবে
⇑
This depends on wind load direct^n
⇑

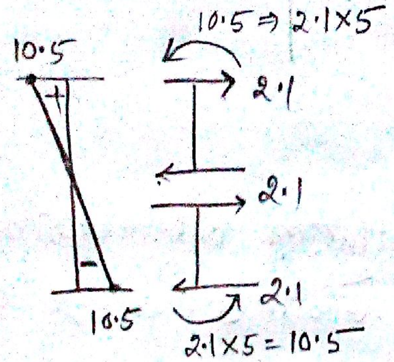
for col & beam → 2 sides' moment will always be in the same direct^n (clock & anticlock wise)

v.v. Imp

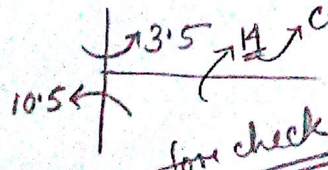
⇑

* for both col & beam only joint -এ load & থাকে Hinge
⇓
So middle -এ 0 & upper & lower coordinate equal of the BMD

- **Col. BM —**

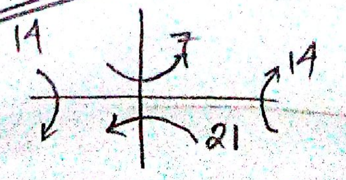


- **Beam BM — (by freebody of joints)**



উপরের col.এ 3.5↺ & নিচের col.এ 10.5↺ ⇒ So দুটো add $(3.5+10.5)↺ = 14↺$

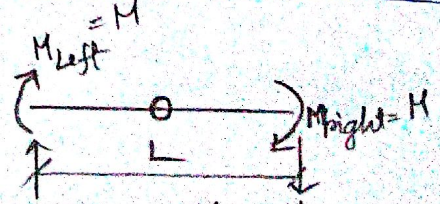
for check



$14+14=28$ & in col. $7+21=28$
⇓
So BMs were right

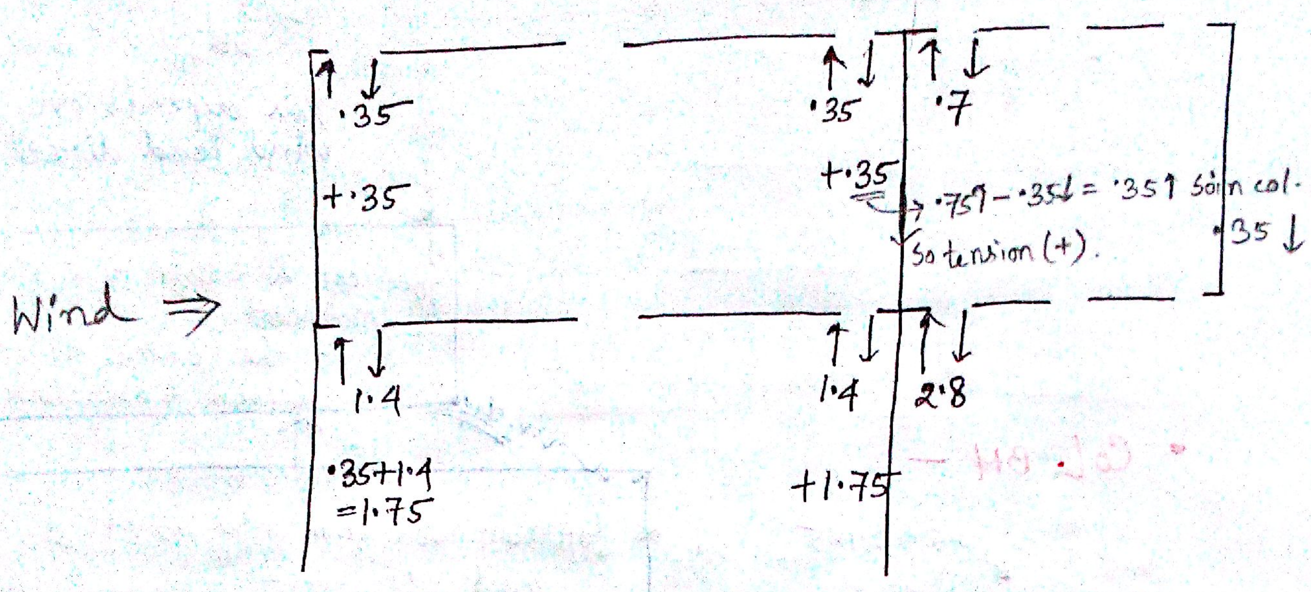
- **Beam SF —**

For any beam



$\therefore SF = \dfrac{M}{.5L} / \dfrac{M}{L/2}$

- Col AF — (By Freebody)



Pattern Imp.

Wind যেদিক থেকে আসবে ⇒ সেদিকের col. tension & উল্টাদিকের col. এ compression

⇓

and যত building - এর নিচের দিকে যাবে তত AF বাড়তে থাকবে।

CANTILEVER METHOD

- Assumptions —

1. There is a hinge at center of each beam.
2. " " " " " " " " col.
3. Axial stress in a col. of a storey is $\propto$ to Hor. distance of that col. from c.g. of cols of the storey.

i.e. Ax. stress $\propto Y$

$\Rightarrow$ " $= KY$

$\therefore$ Ax. Stress $= \frac{MY}{I}$

as Bending stress in col.