1.10.15

Tuesday

Lec-1

Prof. Abdur Rouf

Must be familiar with

1) Supports + Reactions
2) Shear force - Diagram (Sign Convention)
3) B. M.D (Sign Conv)
4) Axial force Dia
5) Free body

Books

1. Structural Analysis
- Norris, willbur, Utku

2. Structural Analysis
- Shedd, Vawter

Syllabus:

① Stability ② determinacy of structures (statically determinate) ③ Trusses ④ Arches ⑤ Influence line ⑥ Moving loads on beams, frames & trusses ⑦ Analysis of suspension Bridge ⑧ wind and ⑨ earthquake loads, (10) approx analysis of statically undeterminate structure, braced trusses, portal method, cantilever method & V.Load analysis of multi storey building frames; (11) deflection of beams trusses frames by virtual work method

* There is another force except the upper three
It is torsional force, it is also called twisting moment. It is a rotational force.

Stability

A structure is :

1) Statically Unstable

if total eqn > Total unknowns

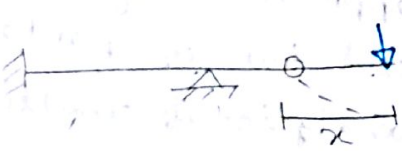
for plain structure 3 eqn

2) Geometrically Unstable :

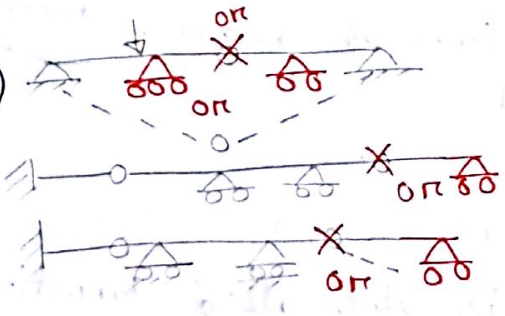
if general arrangement of reactions and/or members are not properly made

1)

2)



3)



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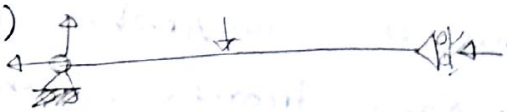
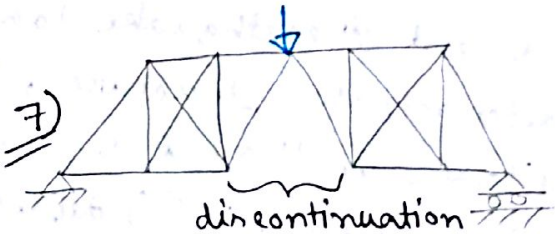


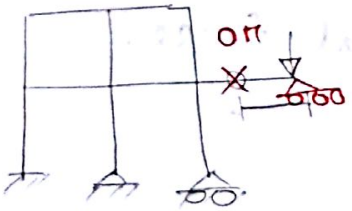
7)



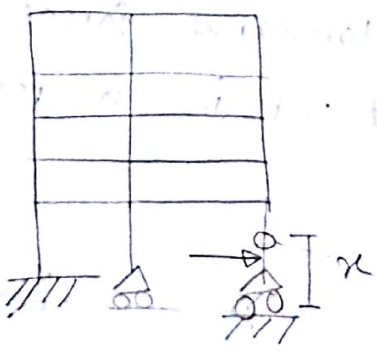
discontinuation

So একটা beam এর with internal hindge

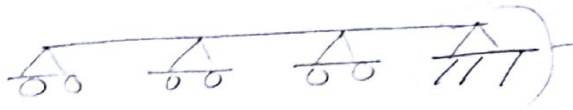
5)



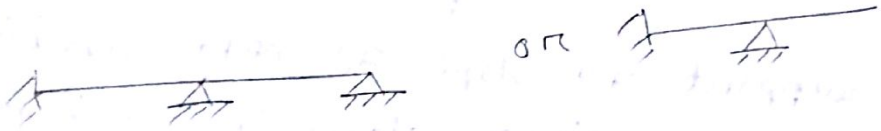
6)



① Statically stable, but it will start running if we apply load cause horizontal reaction resist করতে পারে না, so geometrically unstable.
So provide a hindge. and make geometrically stable.



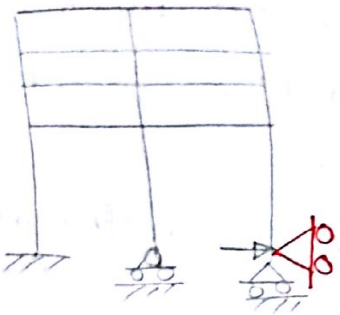
(2) x এর জন্য unstable. Either remove internal hindge or provide hindge

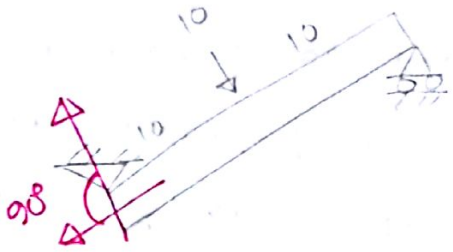


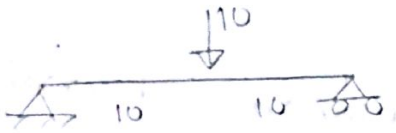
4) Three reactions meet at a point. So rotational moment resist করতে না, so beam starts rotating So all reactions must not meet a point. এটা হলে rotational resistance করতে না.

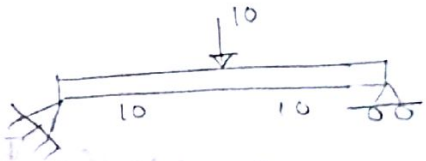
5) For part x the structure is unstable. so either remove hindge or give roller support.

6) unstable for x, cause → force দিলে side এ move করবে. or roller কে change করে hindge or fixed support.





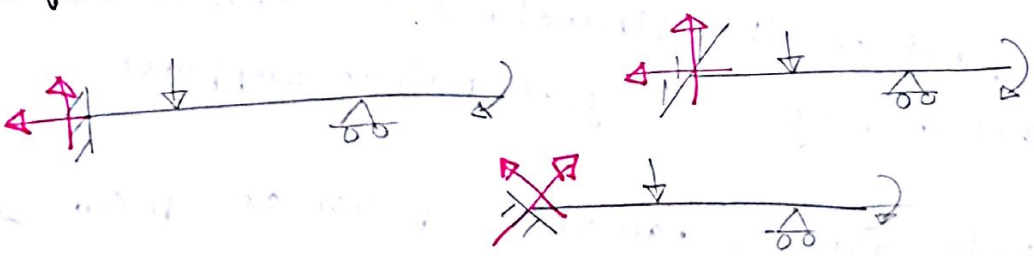




Hindge এ support এর slope এর কোন significance নাই, we draw reactions along two orthogonal surfaces.

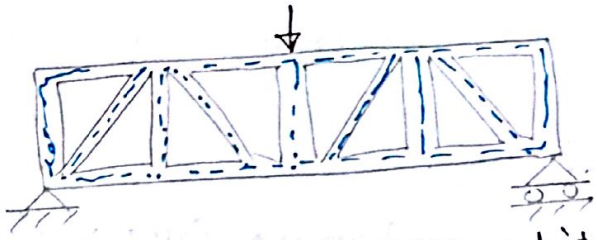
Horizontal / vertical এর cause load mostly horizontal & vertical except fluid pressure.

In roller the reaction will be normal to the surface.



slope এর significance নাই,

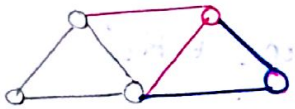
Truss is a Hollow Beam:



Blue lines এলাকার মাঝের white portion তুলে নেয়া, so truss is a hollow Beam. Top compression, bottom tension.

Smallest Truss:

3 members & three joints



এলাকে 2 members & 1 joint add করে truss বাড়াব, Truss must contain of series of triangles. নয়তো triangle এলাকে না হলে unstable.

(7) এ truss continuous না, so it may be considered as a beam with hindge.

12.9.15
Saturday

Lec-2

Structural Stability & Determinancy - Indeterminancy

a) A structure is statically :

i) unstable if T. Number of unknowns forces < Total Eqn

2) Stable & determinate if (") = (")

3) Stable & indeterminate if " > "

And degree of Indet = (") − (")

(b) Total Unk. Forces = Member force + Rs'

(सदस्य number A.F. = (1)b+r for a (2D) Truss
सदस्य Force)

Beam सदस्य 3 (A.F, SF.D, BM) = (3)m + r for a (2D) frame, there can be twisting force too.
force

= r for a beam/col

(c) Total eqns = Eq^ns eq^n for joints + Eqns of conditions

ΣFx, ΣFy = (2)j + 0 for a 2D truss (cause all the joints are hinge, so no int. or external hinge)

" , " , ΣM = (3)j + c for a 2D frame

= 3+c for a beam/col

↓
from hinges

b = Number of bars

m = Number of members

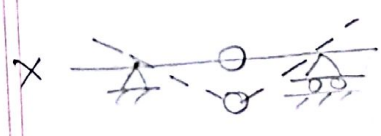
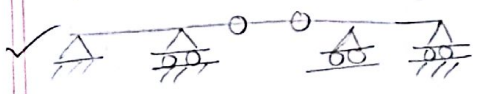
J = No of joints

r = No. of reactions

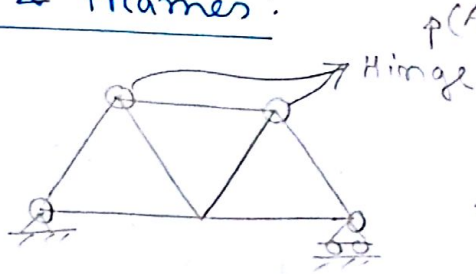
c = No. of conditions (e.g. hinges)

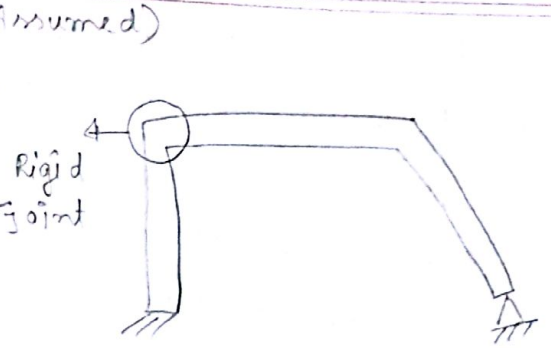
Beams

Geometrical stability:

	No of R's	Indet	Stat Sablk ?
	$r = 4$	$4 - 3 = 1^\circ$	✓
	$r = 5$	$5 - (3+1) = 1^\circ$ ↳ from internal hindge	✓
	$r = 3$	$3 - (+3+1) = -1^\circ$	✗
	$r = 4$	$4 - (3+1) = 0^\circ$	✓
	$r = 5$ unknowns	$5 - (3+2) = 0^\circ$	✓

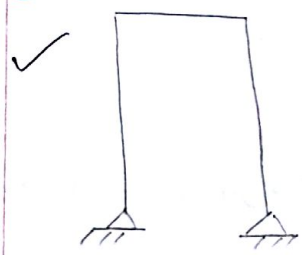
Trusses & Frames:





Plane (2D) Frames:

Geo. stable



$m = 3$, $b = 4$

$j = 4$

$c = 0$

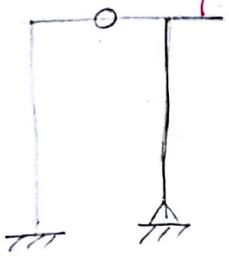
Total unkn $= 3m + r = 13$

T.E $= 3j + c = 12$

Deg of fr. $= 1^\circ$

Statically Stable ✓

free end is also a joint



$m = 4$

$r = 5$

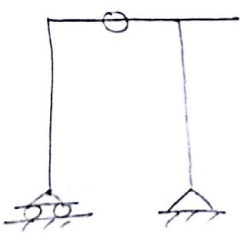
$j = 5$

$c = 1$

$3m + r = 17$

$3j + c = 16$

1° ✓



$m = 4$

$r = 3$

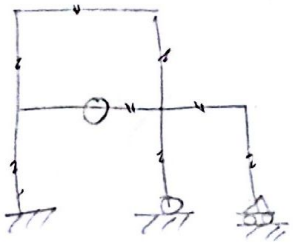
$j = 5$

$c = 1$

$3m + r = 15$

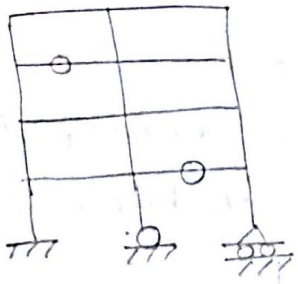
$3j + c = 16$

-1° ✗



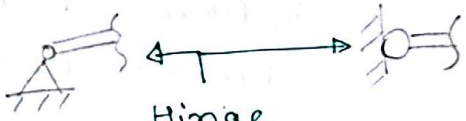
$m = 8$
$r = 6$
$j = 8$
$c = 1$

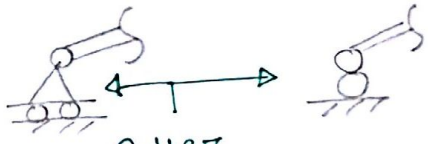
$3m + r = 30$
$3j + c = 25$
$\Big) 5°$



$m = 20$
$r = 6$
$j = 15$
$c = 2$

$3m + r = 66$
$3j + c = 47$
$\Big) 19°$





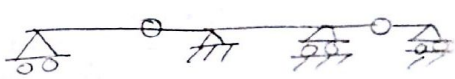
Truss: Fig 4·8 / Norris

All are unstable structure geometrically.

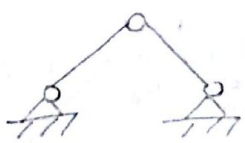
Fig 4·9 / Norris:

Fig 4·2 / Norris, Fig 4·3, 4·10 → All stable

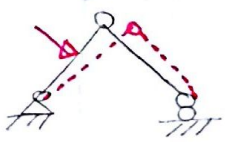
4·10 (b) → 3টা অপ্রয়োজনীয় truss connected



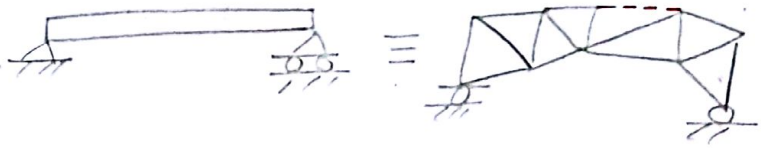
4·10 (a) →



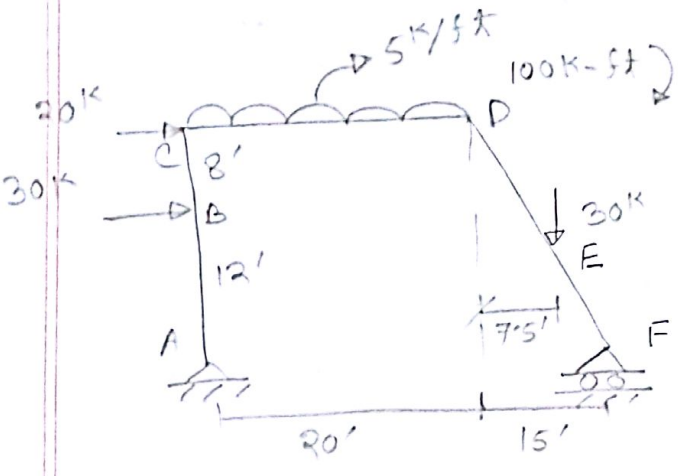
unstable if



यदि blank space में member नहीं then इसको truss & इसको beam.



Annalysis of FRAME :



1. Find R's
2. Draw freebody of ABC, CD, DEF & joints C & D
3. Draw SF, AF, BM Dig for ABC, CD, DEF
4. Draw combined SF, AF, BM Diagrams

$R_{Ax} + 30 + 20 = 0$

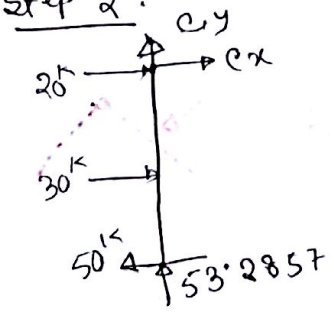
$R_{Ax} = 50 (\leftarrow)$

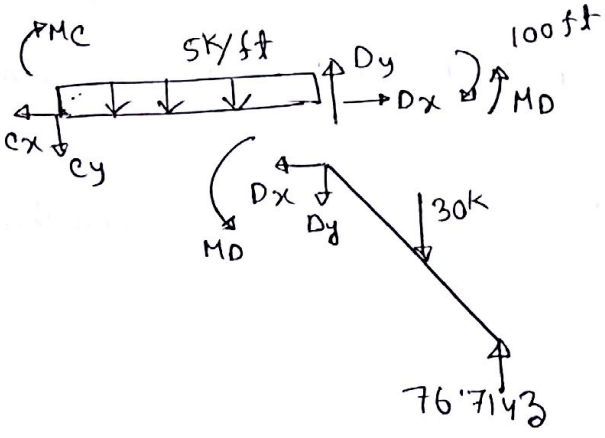
$R_{AY} + R_{EY} = 130$

$-R_{FY} \times 35 + 30 \times 12 + 20 \times 20 + 100 \times 10 + 100 + 30 \times 27.5 = 0$

$R_{FY} = 76.7143 \uparrow$ $\quad R_{AY} = 53.2857 (\uparrow)$

Step 2':





$C_y + 53.2857 = 0$

$C_y = -53.2857 (\downarrow)$

$C_x + 20 + 30 - 50 = 0$

$C_x = 0 \quad M_c = 760$

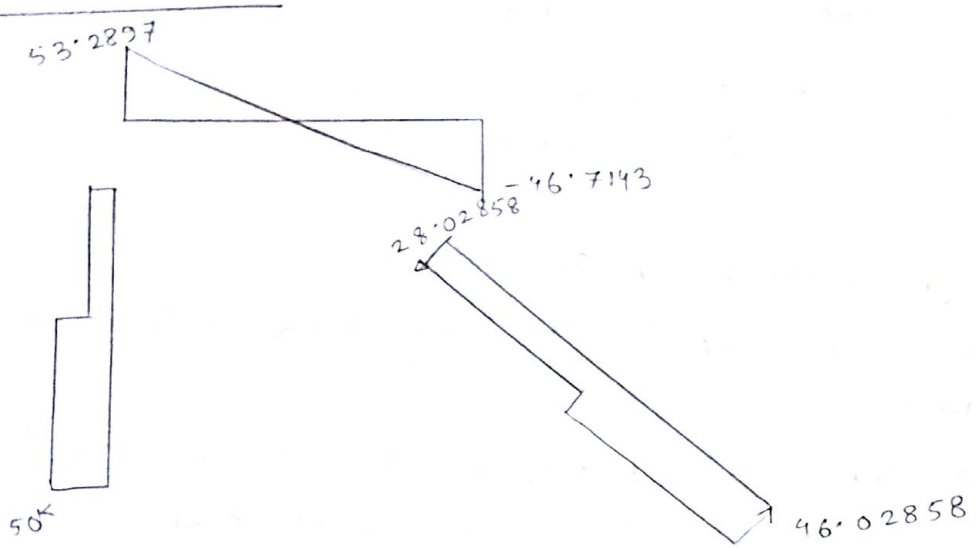
$D_x = 0$

$760 + 100 \times 10 - D_y \times 20 + 100 - M_D = 0$

$\Rightarrow C_y + D_y = 100$

$\therefore D_y = 46.7143 \uparrow$ $\quad M_D = 925.714 (\circlearrowleft)$

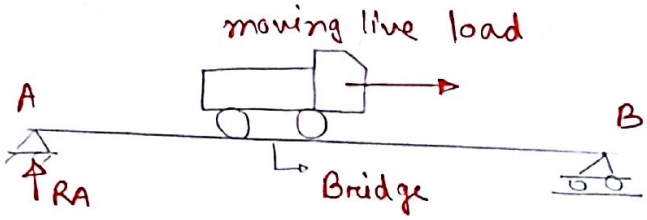
Shear force Dia



(#) Shear & Vortex এর exercise এর ans দেয়া math practice 15.9.15 Tuesday

Lec - 3

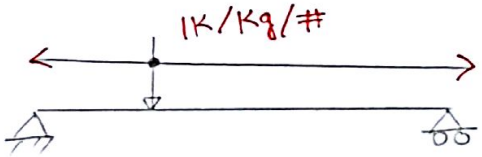
Influence lines



RA vary করবে, truck না থাকলে 0
A তে থাকলে max
B ,, ,, min

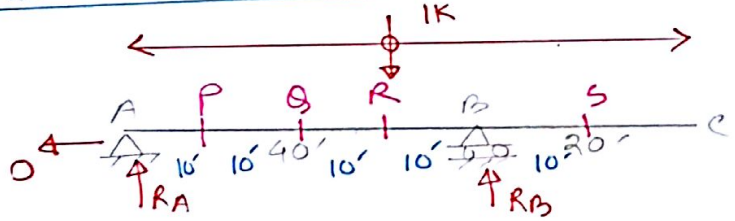
For design অবশ্যই max^m নিতে হবে.
Max^m internal force for moving load এর জন্য influence line নিতে হবে.

(*) Influence lines are always drawn for unit load (1kg/1lb/1kip) usually working vertically downward. কারণ load vertically move করতে পারে, then horizontally হবে.



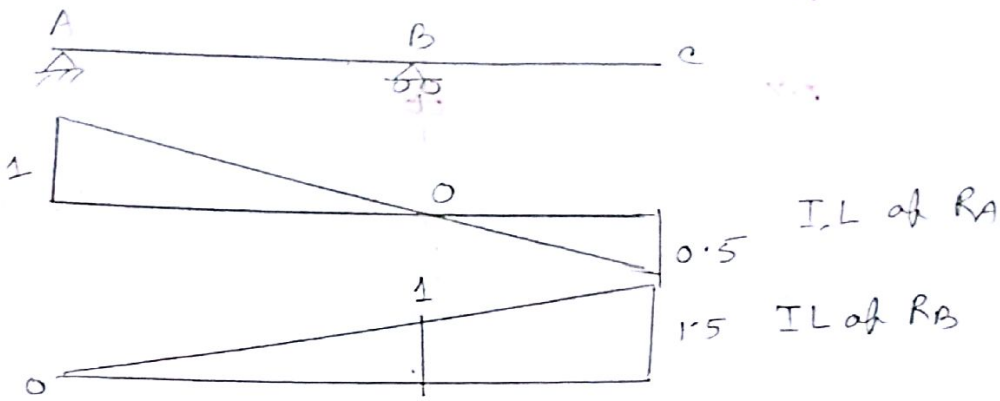
Influence line for reactions in Beams:

Beam



Diff points এ unit load বসিয়ে reaction এর plotting these করলে influence lines পাব

unit load at	R_A	R_B
A	1↑	0
P	0.75↑	0.25↑
Q	0.5↑	0.5↑
R	0.25↑	0.75↑
S	0.25↑	1.25↑
B	0	1↑
C	0.5↓	1.5↑



Influence line is a curve that shows variation of a function under moving load.

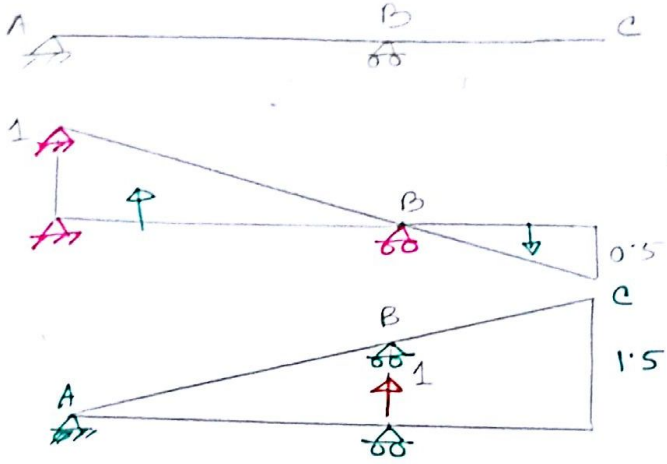
Drawing of I. line for R's in Beams:

Steps: 1. Push the support up by 1

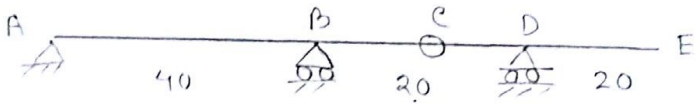
2. Draw the S-shape ⟶ in the I. line

3. Complete the ordinates & direction (sign)

Beam 1

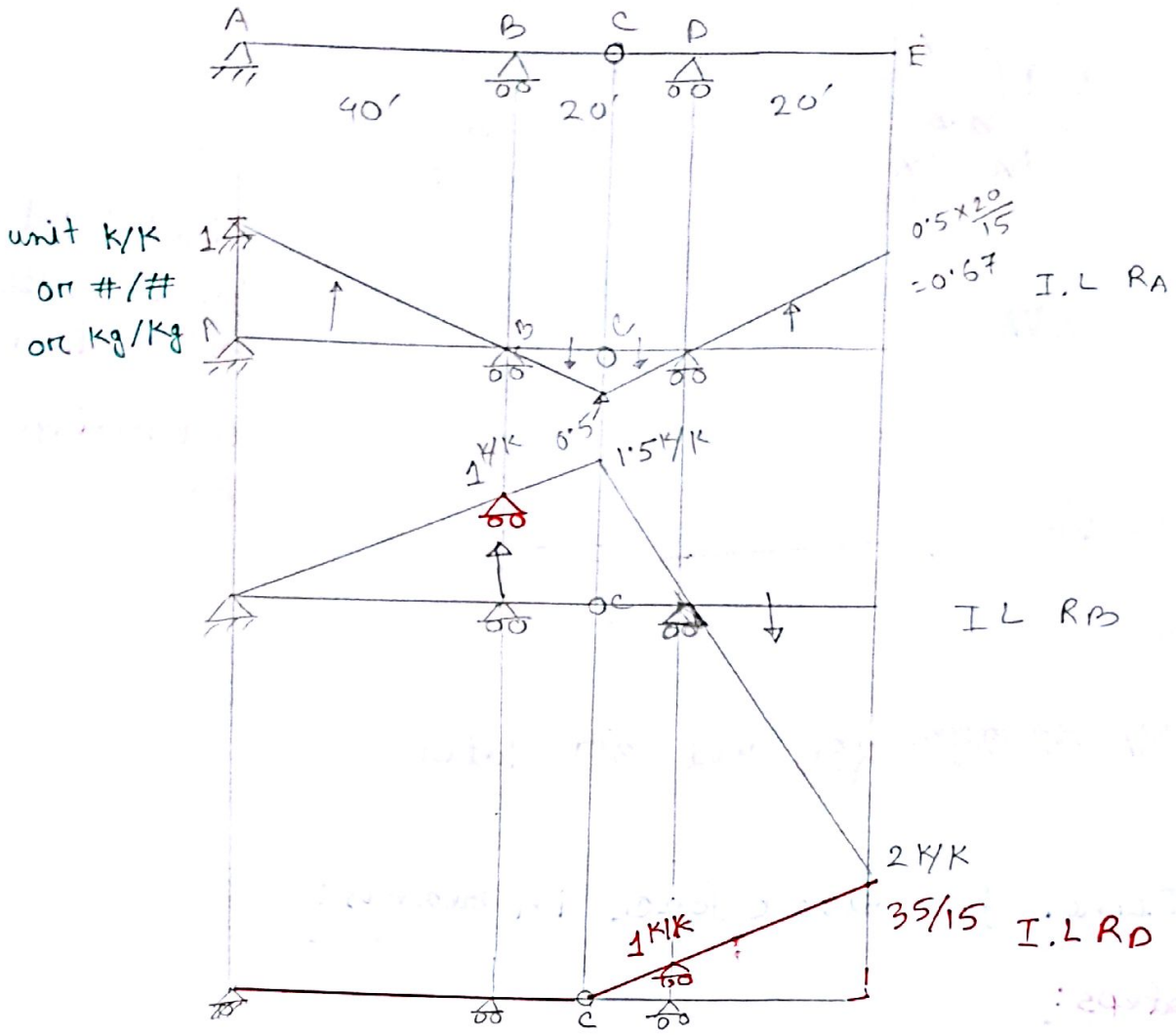


Beam 2:

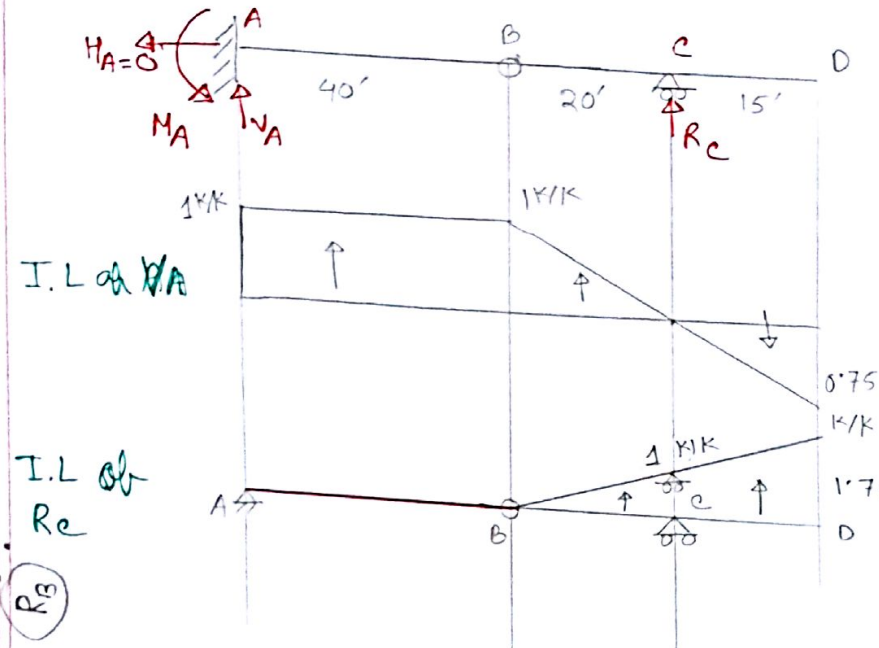


C hinge কোথে দিলে CE পড়ে যাবে cause ABC হল self stable section. So always ABC এরে draw করতে হবে।

এখানে hinge আছে, so 2টা st. lines. So IL ও হবে combination of 2 st. lines.


A
B
C
D
E
40'
20'
20'
unit K/K
or #/#
or Kg/Kg
1
0.5 × 20/15
= 0.67
I.L RA
1 K/K
0.5
1.5 K/K
I L RB
2 K/K
35/15
I.L RD
1 K/K
C

Beam 3



Here AB is self stable. So Draw this 1st.

Fixed joint এ joint ⊥ Beam. 90° relation main tained. But in hinge এমন না,

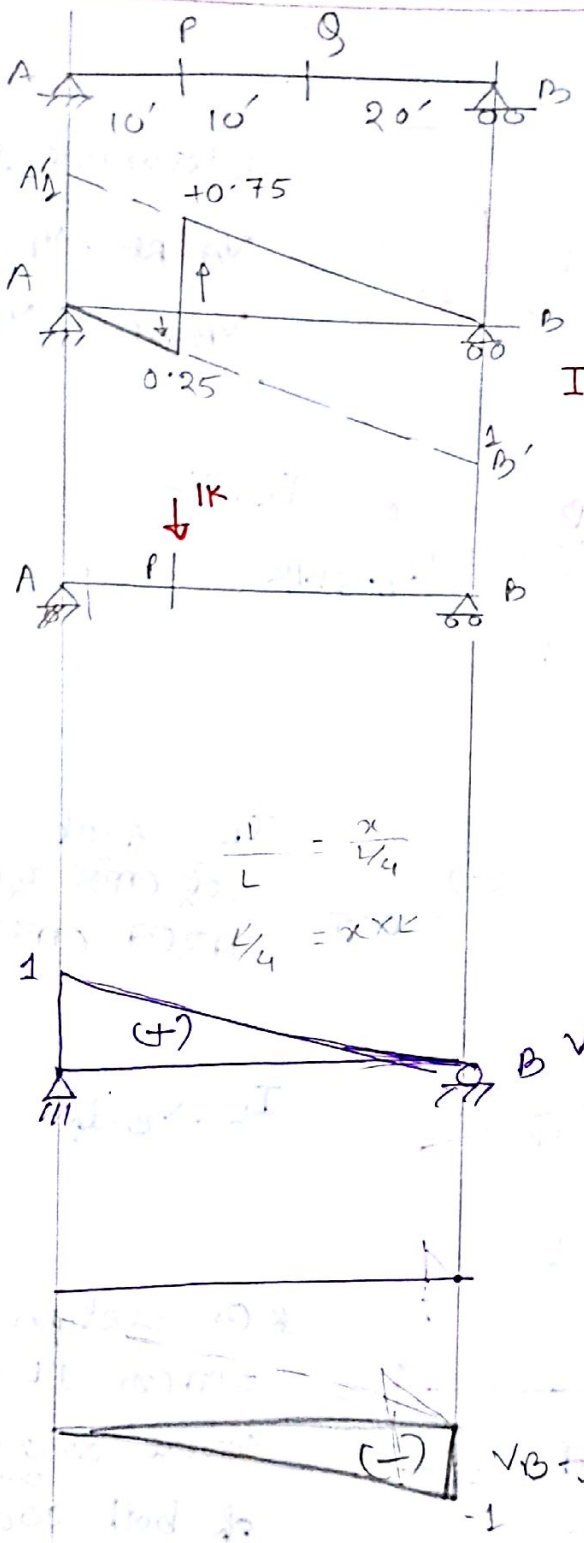
R_B

MA এ শূন্য হবে, But কেন later.

I. Liner for Shear force in Beams:

Steps:

1. Cut at the section X
2. Push the left part down and right part UP
3. Draw the S-shape - is the I.L
4. Put the ordinate & sign



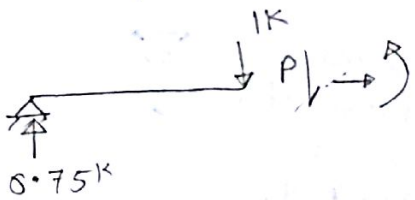
I.L of V_P

Shear force on exact support এর বের can't calculate. তাই A, B কে left right বলা।

I.L of $V_{A\,rt}$, $V_{B\text{-}lt}$, V_P, V_Q

Slope of AB' & A'B always 0 to 1

যে ordinate বের করতে চাই তার বের 1K load বসাব but actually 0.25 slightly on left and 0.75 " to right of P.



$\sum F_y = 0 \Rightarrow 0.75 - 1 + -y = 0$

$\Rightarrow y = -0.25^K$

$\frac{1}{40} = \frac{x}{30}$

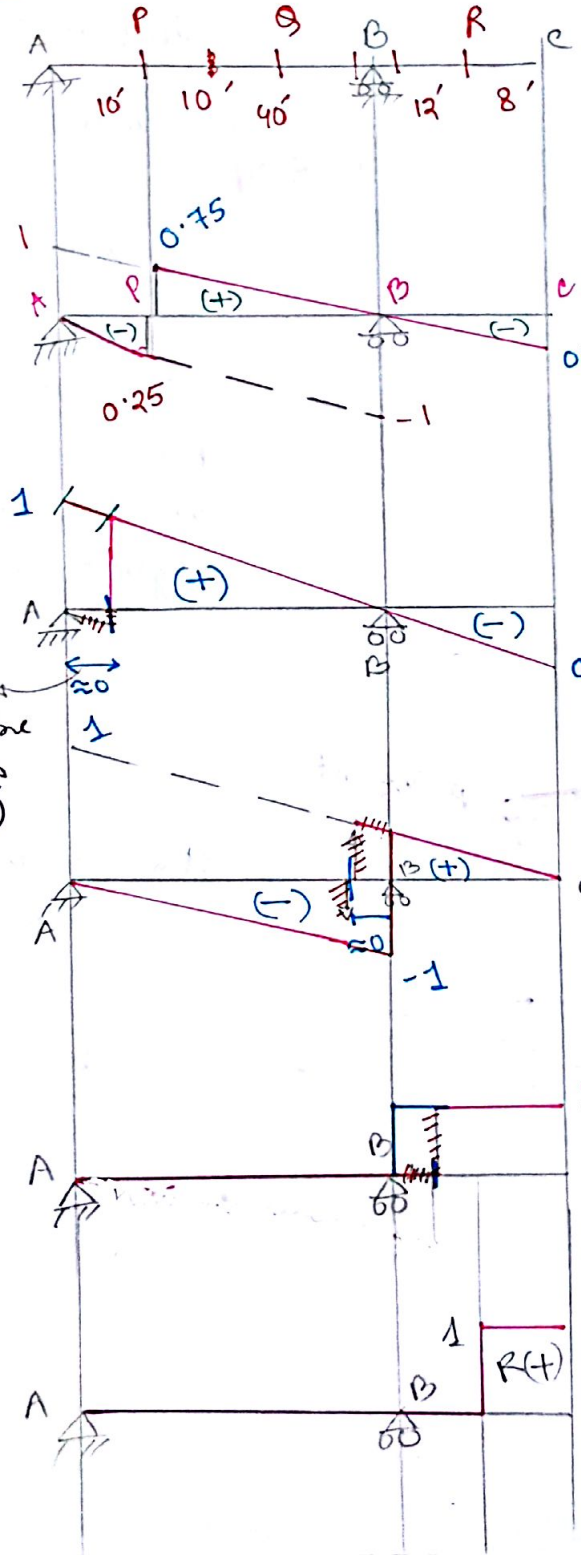
$1 \times 10 = R_B$

$R_B = 0.25$

3.10.15
Saturday

Lec - 4

Beam 2:



Determine I.L for

V_{A-Rt}, V_P, V_Q, V_{B-lft}

V_{B-Rt}, V_R

$I_L \cdot V_P$

$I_L - V_{A-rt}$

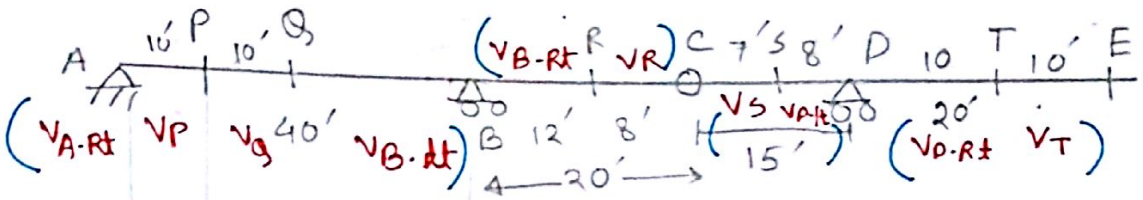
একটু বেশি দূরে কাটবে, নাহলে বোঝা যায় না

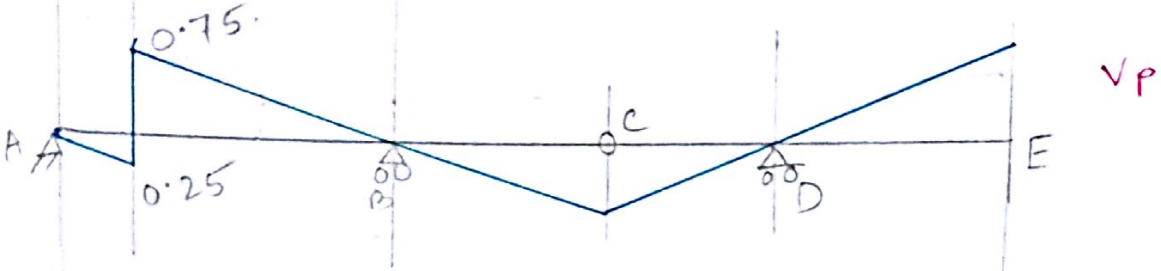
এই distance 0 হওয়ায় নিচের line হবে না, তাই উপরে adjusted (red)

$I_L \cdot V_{B-lft}$

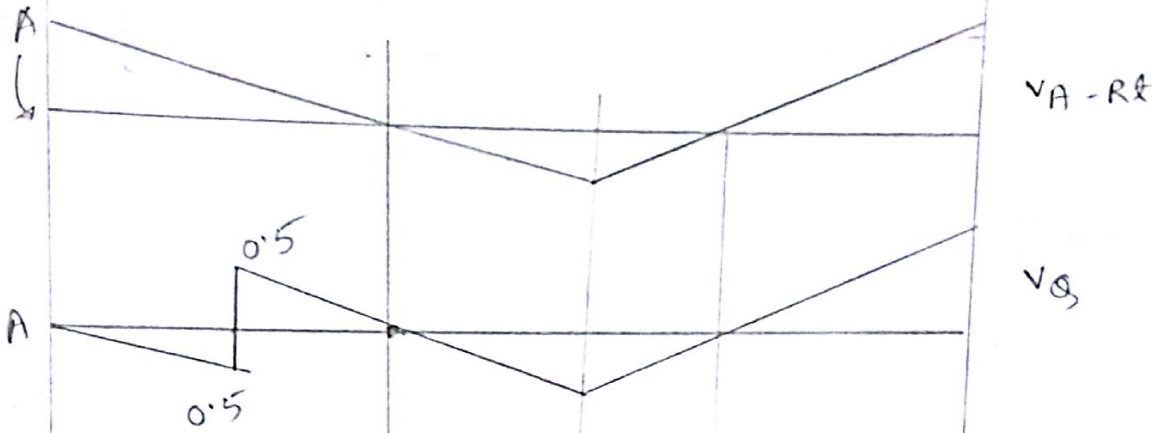
* যে section এ কাটব, সেখানে IL এর slope same and sum of both coordinates value = 1.

eam 3:



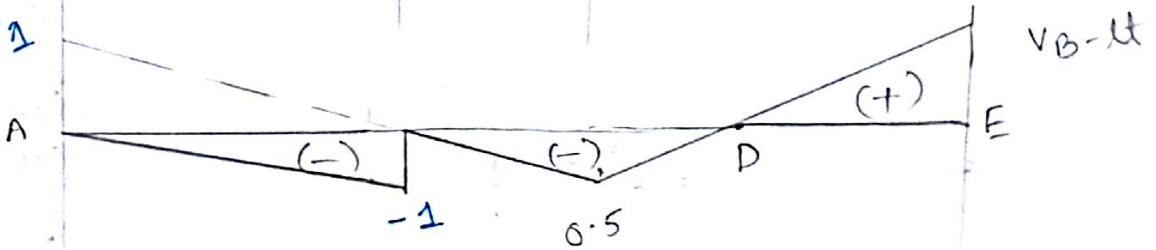


VP



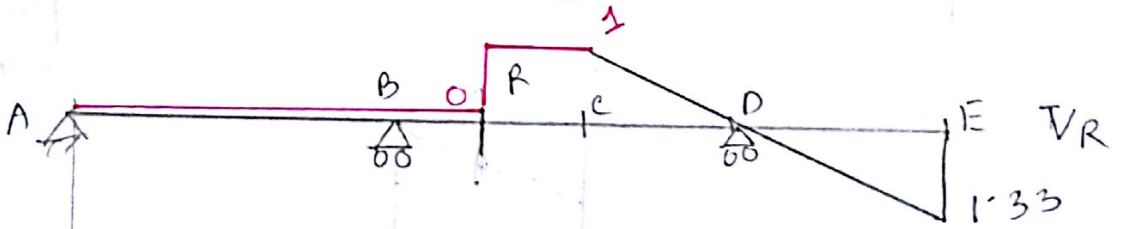
VA-Rt

VQ

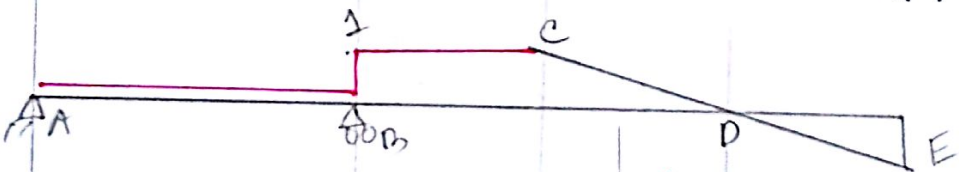


VB-Lt

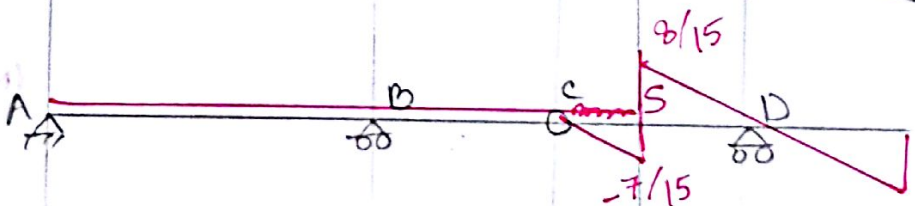
??



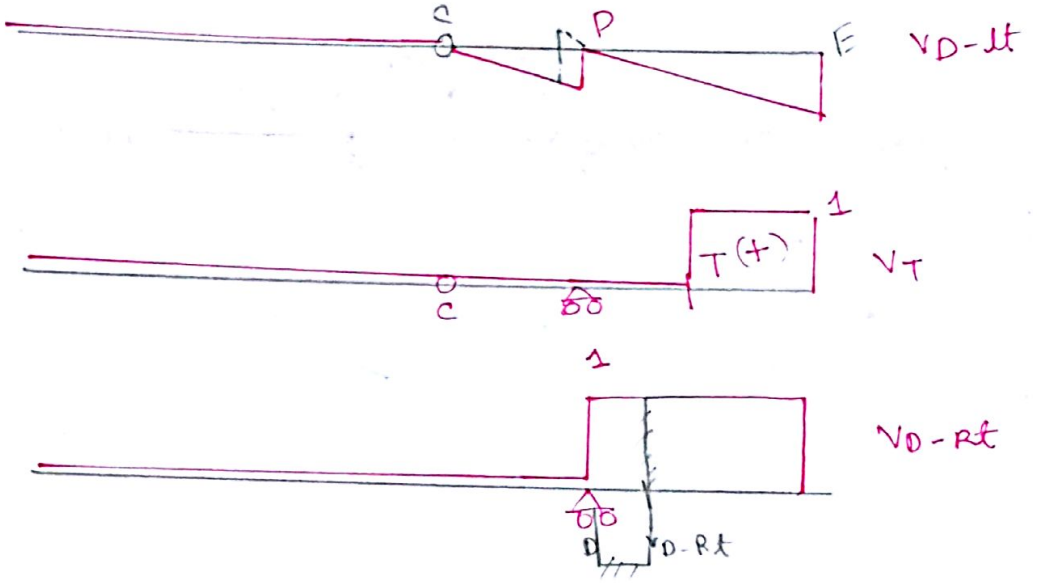
VR



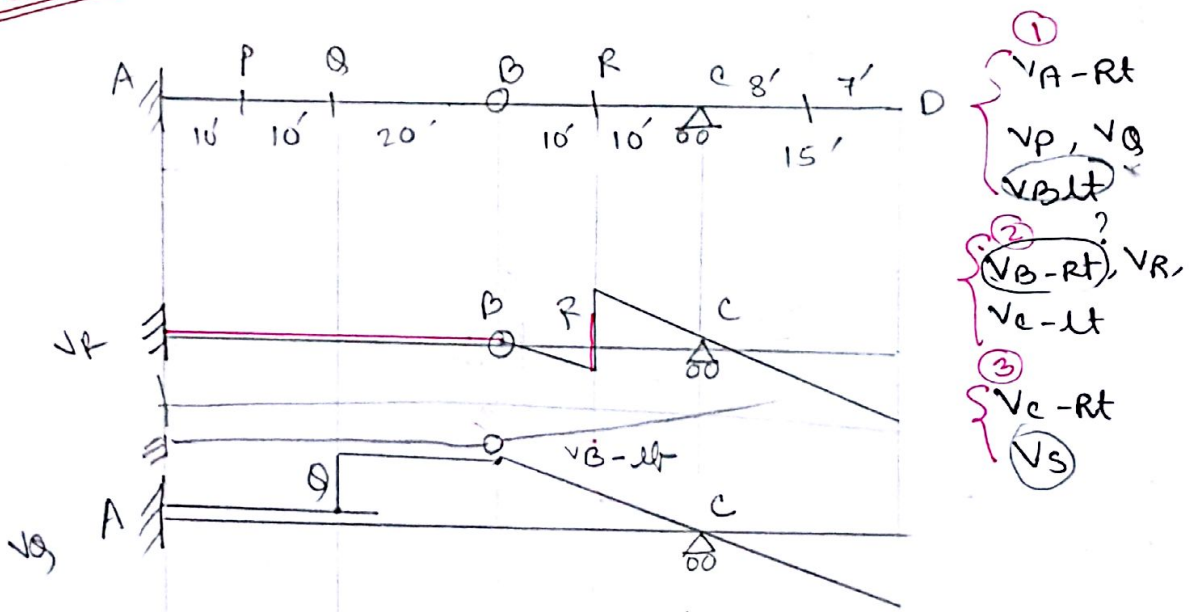
VB-Rt



Vs



Beam 4:

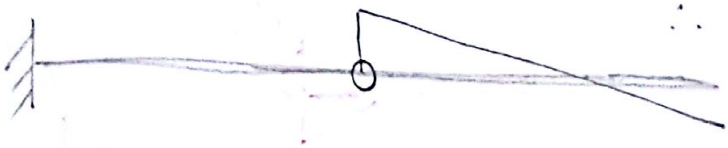


For reaction of Rc

$\Sigma M_B = 0$

$1 \times 10 = R_c \times 20$

$\therefore R_c = 0.5$ *



(Next Pg)

6.10.15
Tuesday

Lec - 5

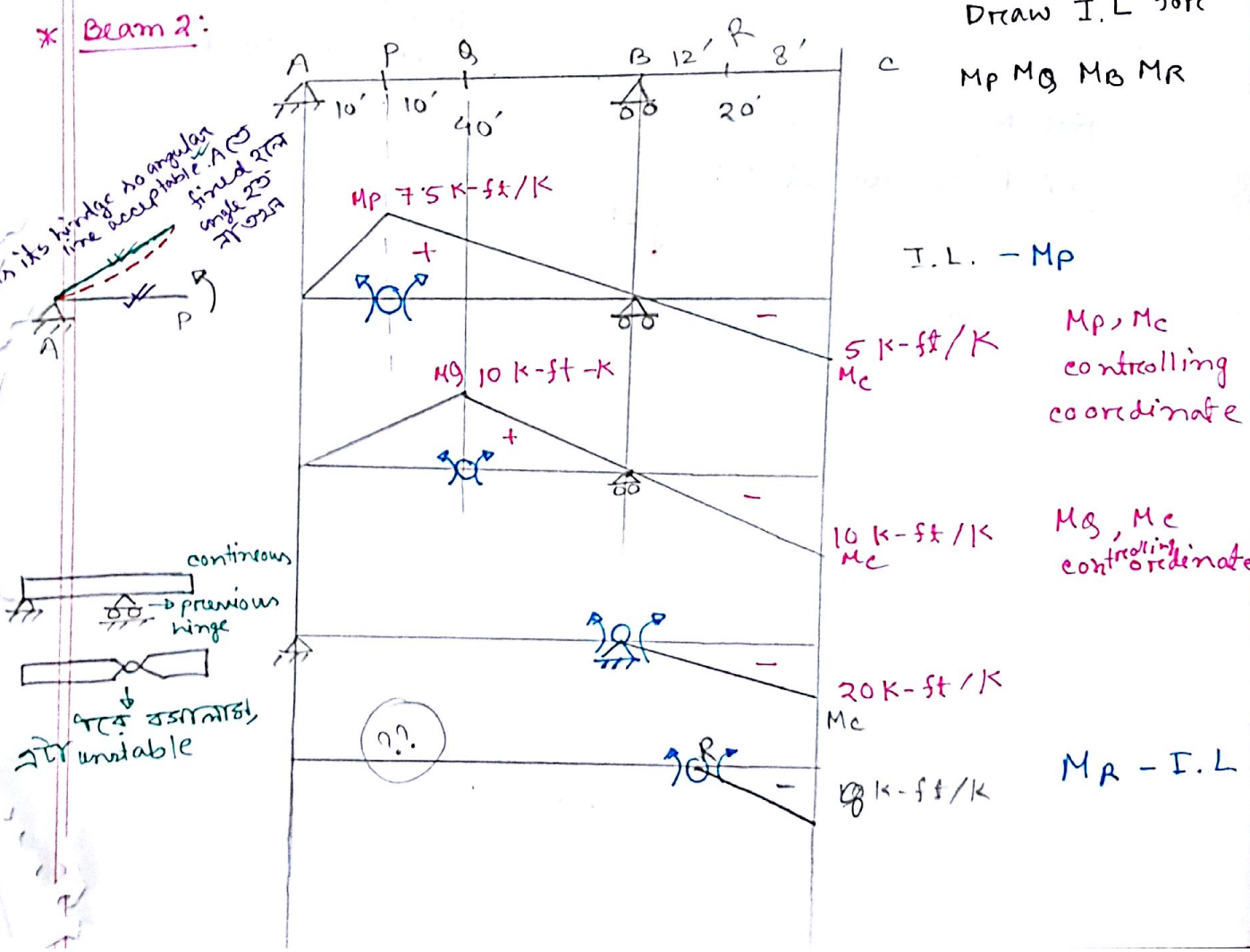
I.L for bending B. moment in Beam:

* **Steps (for I line Mx)** : সবসময় ordinate বের করতে হলে calculation লাগবে

1) Put a hindge at X
2) apply B. Moments (↺) or (↻) around the hindge
3) Draw a δ shape
4) Find the ordinates

* **Beam 2:**

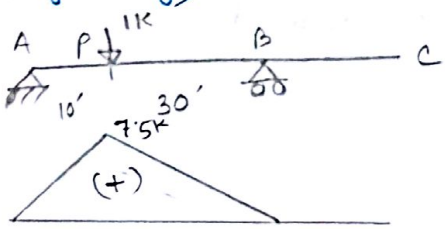
Draw I.L for
Mp MQ MB MR



For M_P:

Find ord at P:

Put ↓1K load at P in the original Beam and Find M_P. (Hinge বসালে unstable হয়, but it's not calculated cause হবে imaginary)



Reactions ~~the~~ moment at section P.

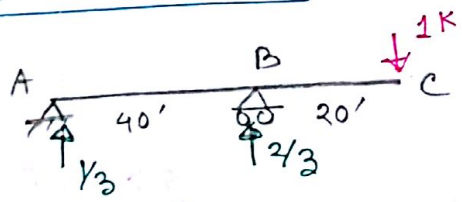
① বসাতে section at P

② then ঐ portion এর reaction

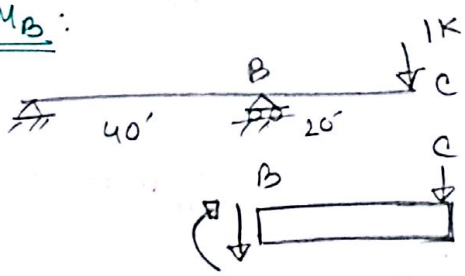
③ Moment of P

For M_B:

Find co-ord at C:



For M_B:

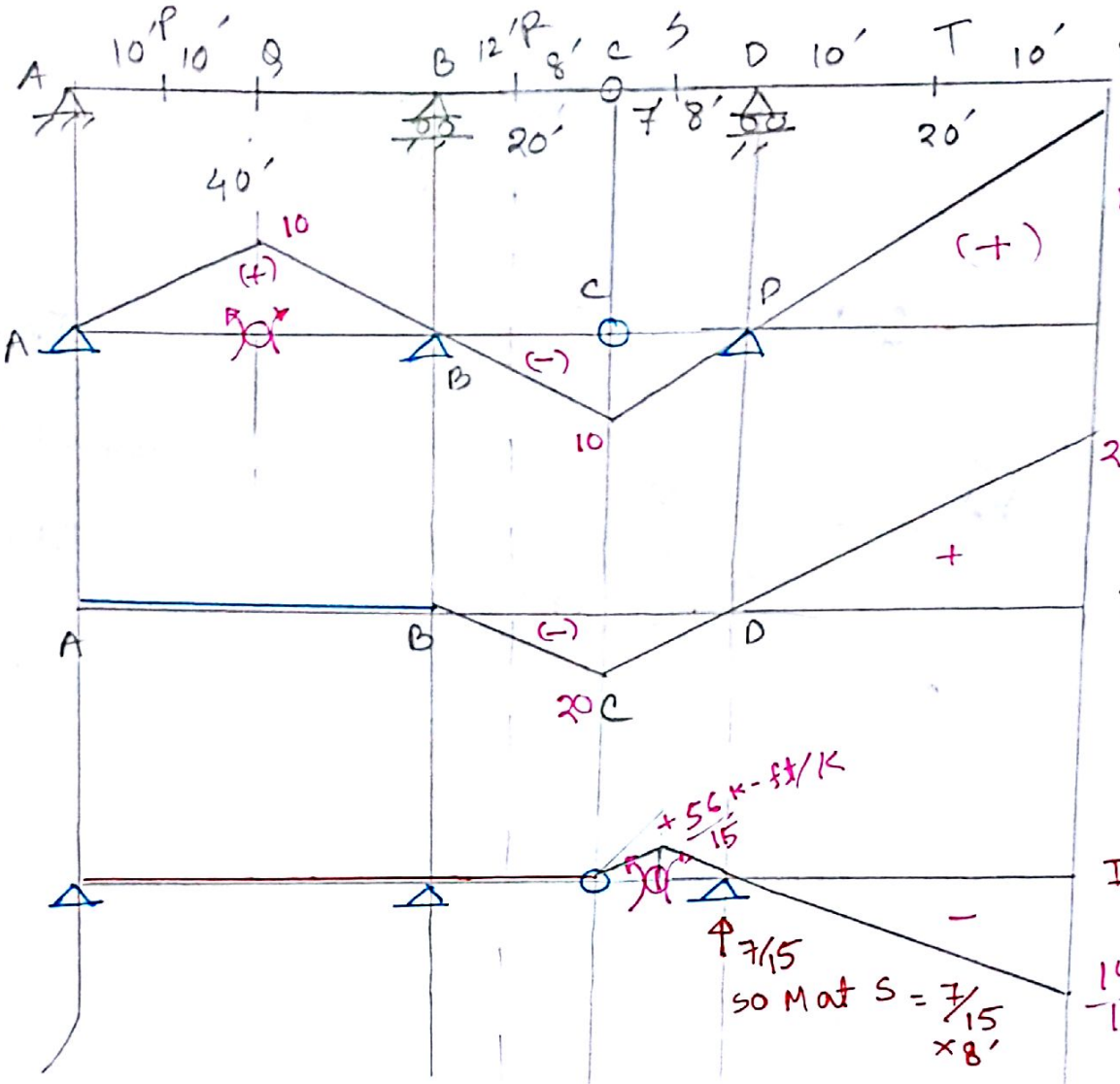


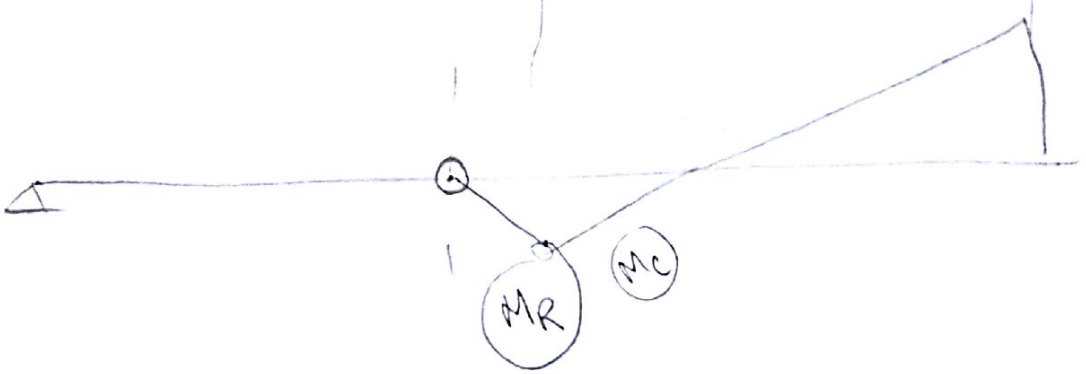
$M_B + 1 \times 20 = 0$

$\therefore M_B = -20$ k-ft

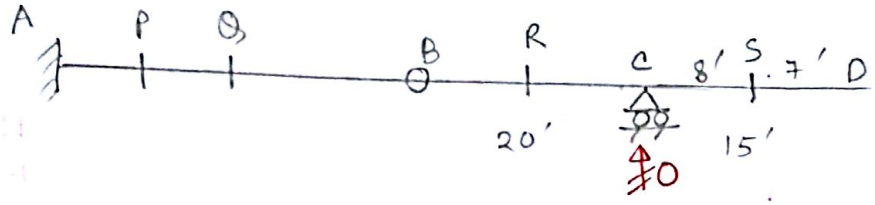
Beam 3:

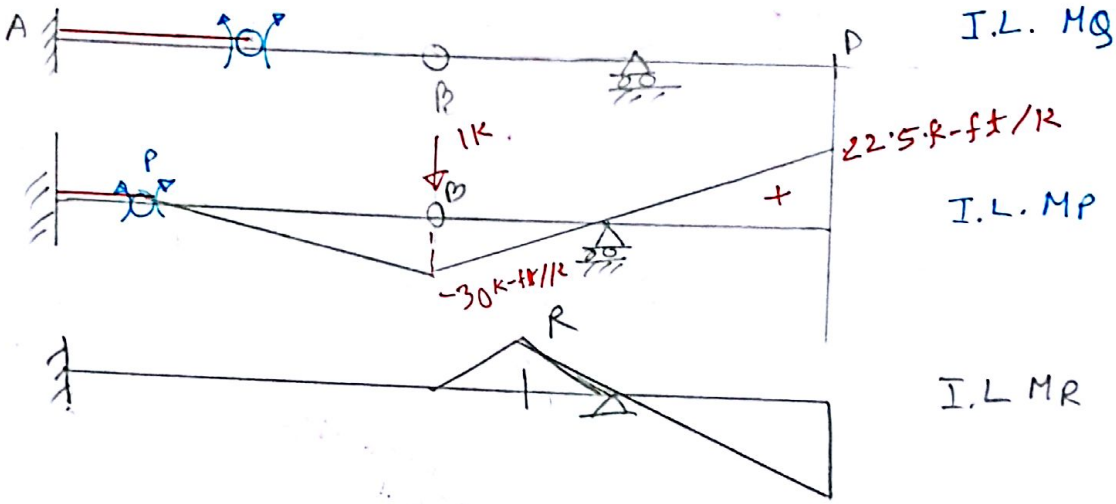
Draw M_P, M_Q, M_B, M_R, M_S, M_D, M_T





Beam 4:





I.L. MQ

I.L. MP

I.L MR

10.10.15
Saturday

Lec-6

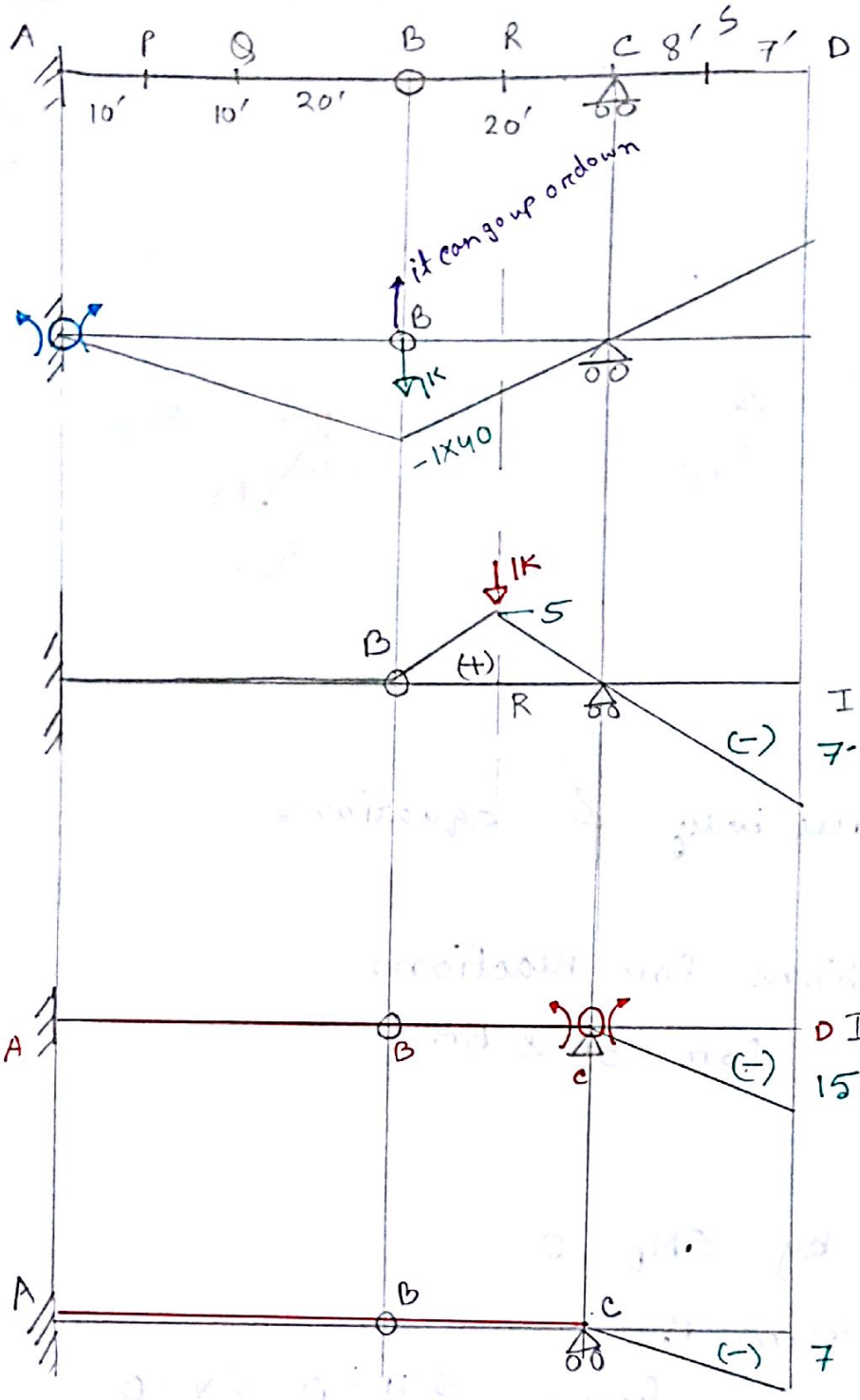
Beam 4:

Draw I.L

M_A, M_P, M_Q

M_R

M_C M_S



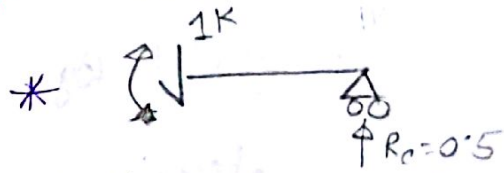
I.L M_A

putting 1K at B find M_A (taking the ~~right~~ left side)

$R_C = 0$ and from right portion

IL – M_R

putting 1K at R, find M_R.



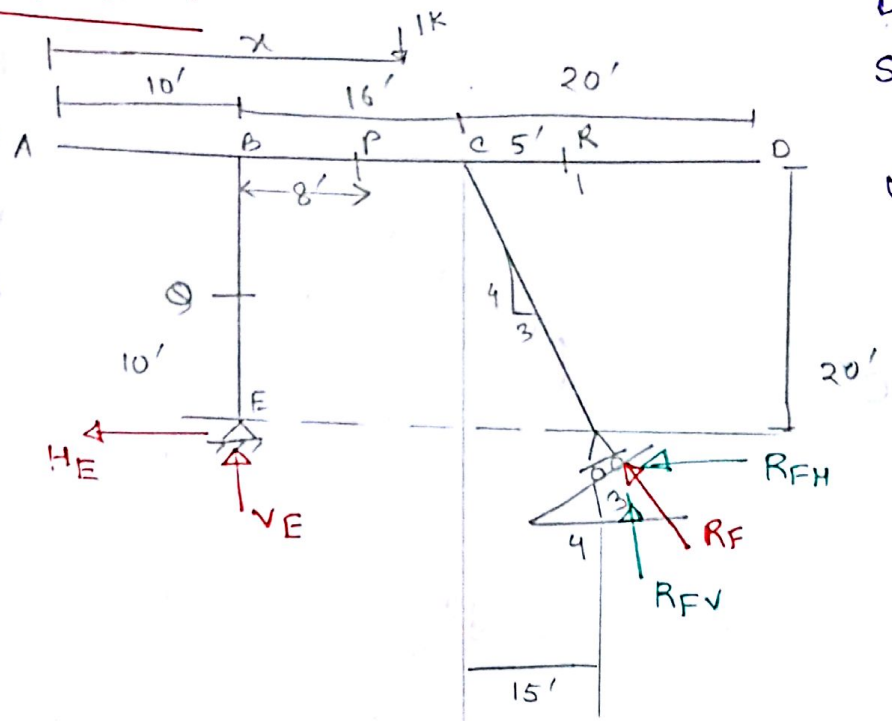
$\therefore M_R = R_C \times 10 = 5$

D I.L M_C

IL – M_S

I.L of frames:

Draw IL, SF & BM at P, Q, R
Unit load moves A to D



Soln: By free body & equations

Steps:

1) Find Equations for Reactions
2) Find " for SF & BM

Reactions:

1) Find R_{FV} by $\Sigma M_E = 0$
2) Then R_{FH} from R_{FV}
3) Find V_E & H_E from $\Sigma H = 0$ $\Sigma V = 0$
   ⇓
   or from $\Sigma M_F = 0$

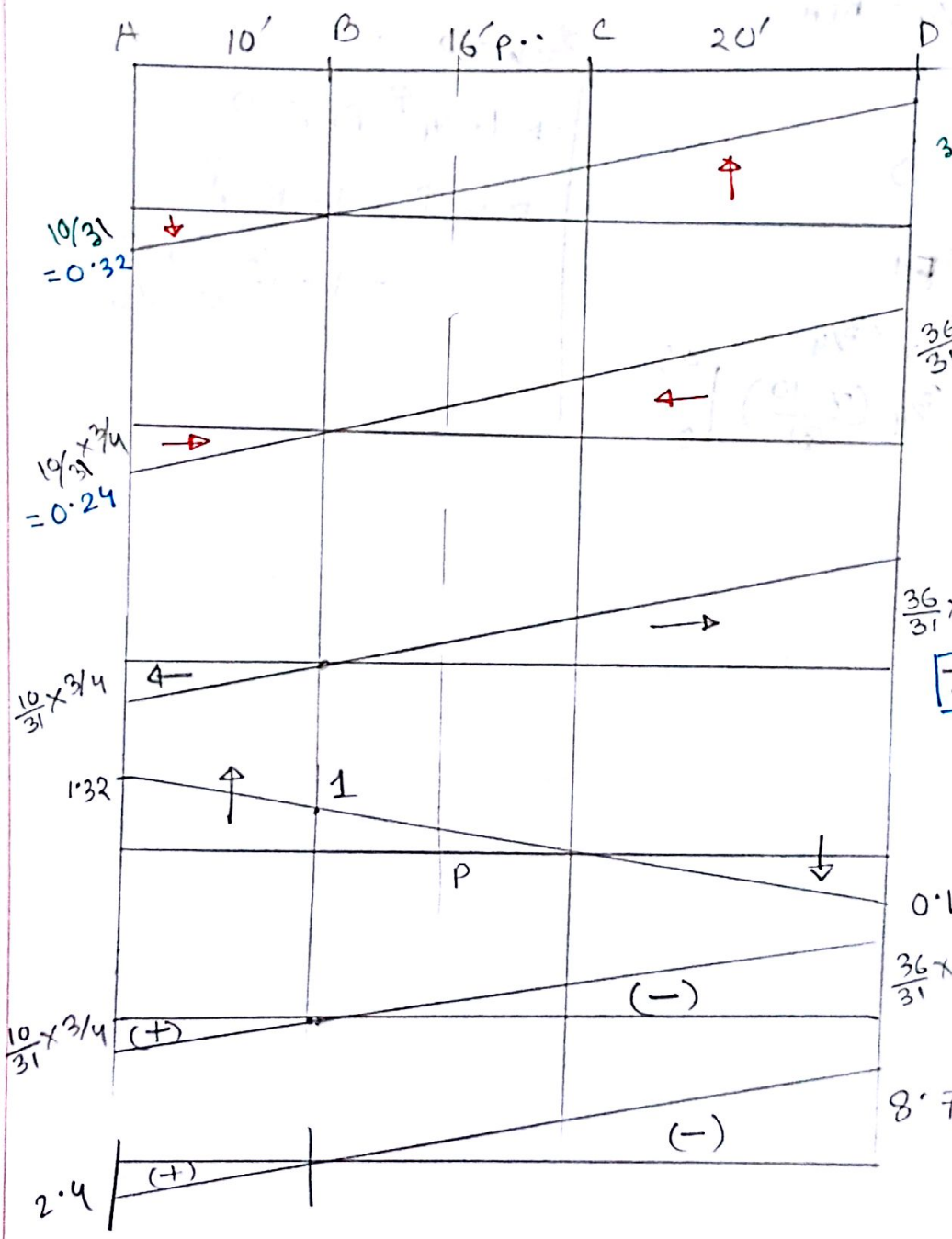
R_{FV} : $\Sigma M_E = 0$

$$\Rightarrow 1 \times (x-10) - R_{FV} \times 31 = 0$$

$$\Rightarrow R_{FV} = \frac{x-10}{31} \quad \begin{cases} x = 46 \text{ at D} \\ x = 0 \text{ at A} \end{cases}$$

$$= \ominus 10/31 \text{ at A and } \oplus \frac{36}{31} \text{ at D}$$

$$R_{FH} = R_{FV} \times \frac{3}{4}$$



36/31

I L – R_{FV}

$\frac{36}{31} \times 3/4$ (2 digit after decimal enough)

I. L – R_{HF}

(R_{VH} ↑ ⇒ R_{FH} ←
R_{VH} ↓ ⇒ R_{FH} →)

$\frac{36}{31} \times 3/4$

I.L – R_{HE}

* decimal ⇒ fraction, not fraction

IL for V_E

0.16

$\frac{36}{31} \times 0.75$ I.L for V_G

8.7 IL for M_G

$\Sigma V = 0$ at A

$\Rightarrow V_E + \left(-\frac{10}{31}\right) - 1 = 0$

$\therefore V_E = \frac{41}{31}\uparrow$

$\Sigma V = 0$ at D

$\Rightarrow V_E + \frac{36}{31} - 1 = 0$

$\therefore V_E = -5/31$

$\Sigma F_H = 0 \Rightarrow H_E = \frac{10}{31} \times 3/4$ at A (←)

at D $\Rightarrow H_E = -\frac{36}{31} \times 3/4$

$\therefore H_E = \rightarrow$

If $R_{FV}\uparrow * 3/4 = R_{FH}\leftarrow$

$\Sigma F_H = 0$

$\Rightarrow H_E\leftarrow + R_{FH}\leftarrow = 0$

$\therefore H_E\leftarrow = -R_{FH}\leftarrow$

$= \ominus R_{FV} \times 3/4$

$= -3/4 \left(\frac{x-10}{31}\right)\Big|_0^{46}$

$*\Sigma V = 0$

$\Rightarrow 1 - V_E\uparrow - R_{FV}\uparrow = 0$

$\Rightarrow V_E\uparrow = 1 - R_{FV}\uparrow$

$= 1 - \left(\frac{x-10}{31}\right)_0^{46}$

13.10.15
Tuesday

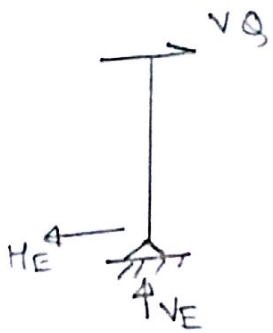
Lecture - 07

continued from last lecture:

$$R_{FV} = \frac{(x-10)}{31} \Bigg|_{x=0 \text{ at } A}^{x=46 \text{ at } D}$$

IL for SF & BM:

SF at Q: Take section at Q and take the lower portion



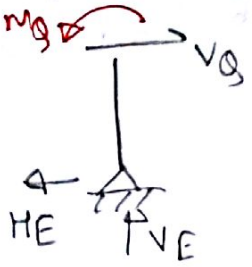
$V_Q = \overleftarrow{H_E}$

*positive (-ve) এর theory এর জন্য column কে ঘুরায় beam. এভাবে ধরার যেন lower part left হয়.

(*) এখানে $H_E \uparrow$, so left side goes up so shear force (+ve)

$\therefore V_Q \overset{(+)}{=} \overleftarrow{H_E}$

Moment at Q:



$M_Q \overset{(+)}{=} \overleftarrow{H_E} \times 10$

[Bending moment due to upward force is positive)

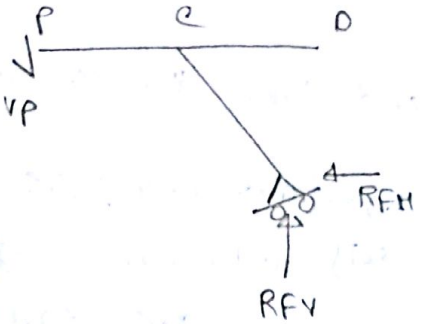
As $H_E \uparrow$ so M_Q (+ve)

IL for SF & BM at P:

[এখানে problem unit load moving so take 2 portions]

Unit load A to P

V_P =



(*) Right up এ গেছে, so left down so shear force (-ve)

$\therefore V_P^{(-)} = R_{FV}\uparrow$

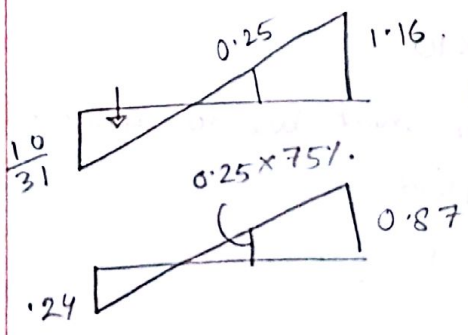
$M_P = (+)R_{FV}\uparrow \times (15+8) \; (-)R_{FH}^{(4-)} \times 20$

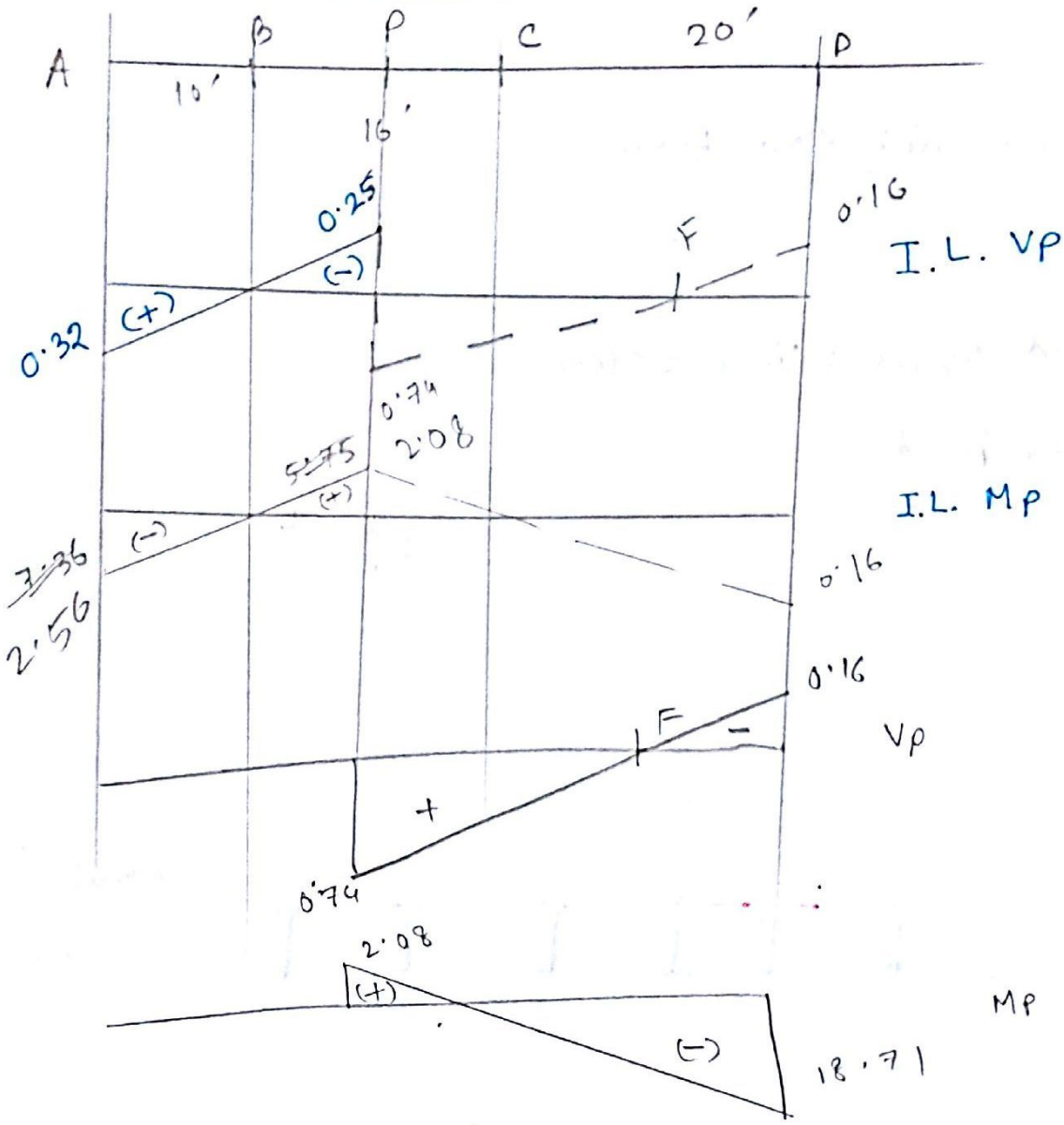
as $R_{FV}\uparrow$

$\Rightarrow M_P = (+)23\left(\frac{x-10}{31}\right)\Big|_{x=0}^{x=46}$

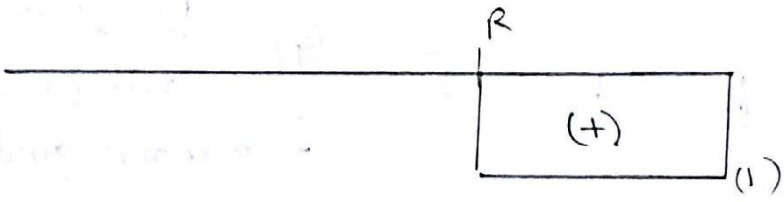
$(-)20 \times 0.75\left(\frac{x-10}{31}\right)\Big|_{10}^{46}$

$= (+)8\left(\frac{x-10}{31}\right)_0^{46}$





combine the two parts for Vp & Mp



VR from 11, 12

MR from 11, 12

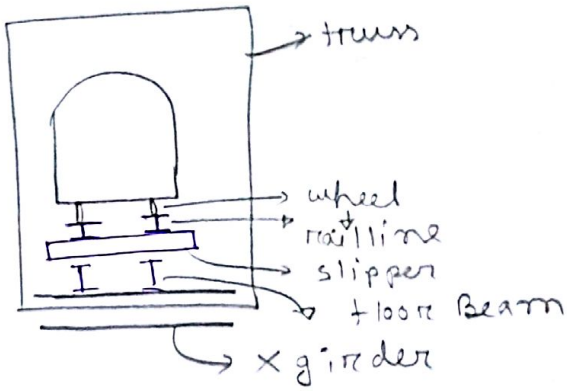
31.10.15

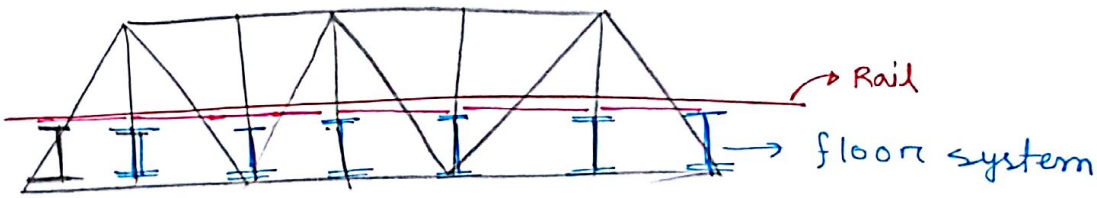
Saturday

Lec-8

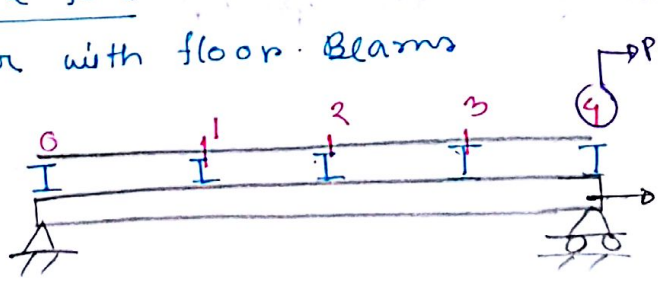
Truss with floor Beam:

Load wheel → line বরাবর transfered.





I Line for Girder with floor Beams



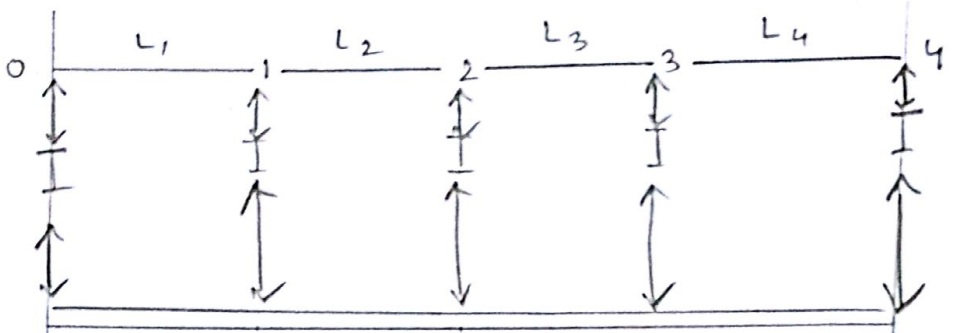
1 & 2 এর মাঝে load বরাবর না, joint এ ,, এর 2টা

panel points ছাড়া অন্য point এ load পড়বে না।

7.11.15
Saturday

Lec - 39

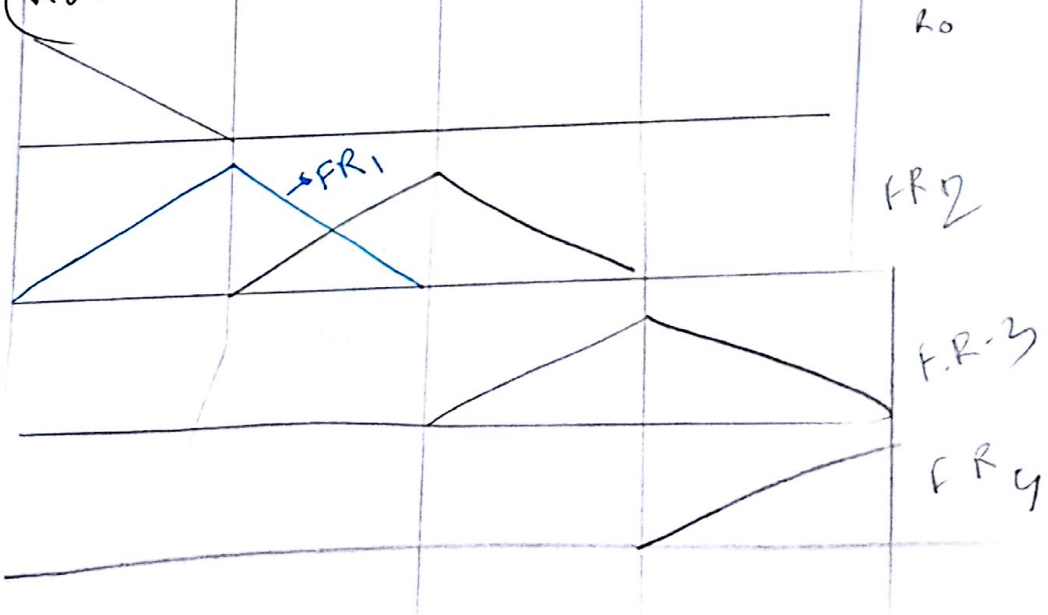
Freelbody:



Draw. I. Lines:

1. FBR's
2. R_0 & R_4
3. SF
4. BM at PP's

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



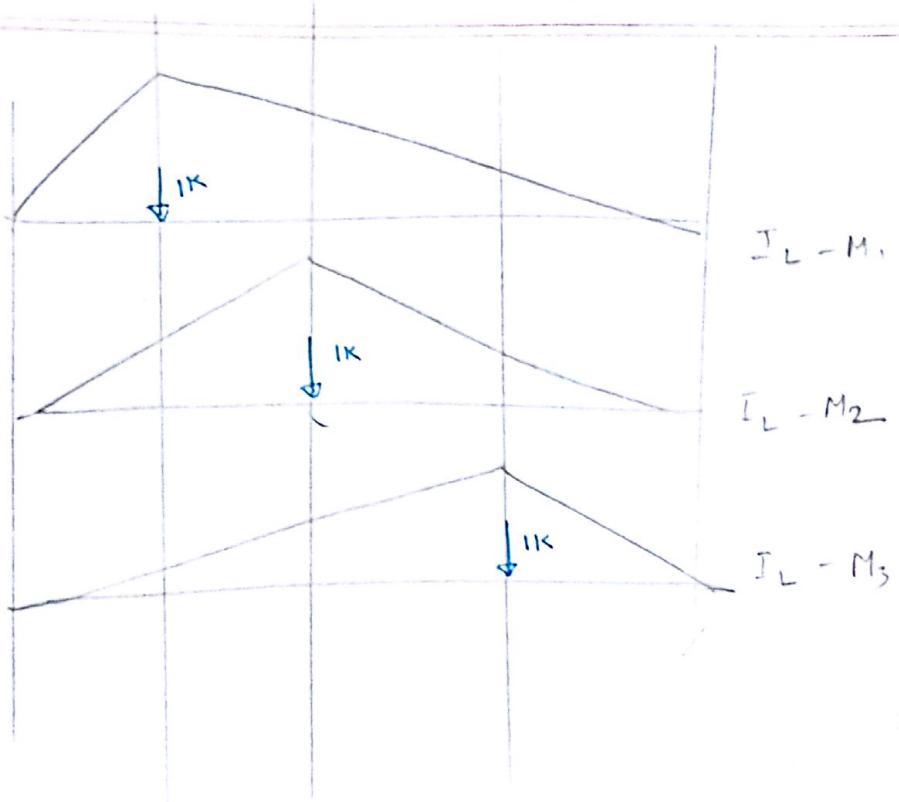


Fig 145/ P-264 /Shedd & Vawter

IL for truss members:

A Bridge Truss is fitted with a floor systems either at the Bottom chord level (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 Line load.

Force in a member of Truss is calculated either by freebody of a joint, or freebody of a part of truss after taking a section. (i.e. joint or section method as usual) while the truss is acted upon by only the Floor Beam Reactions.

STEPS:

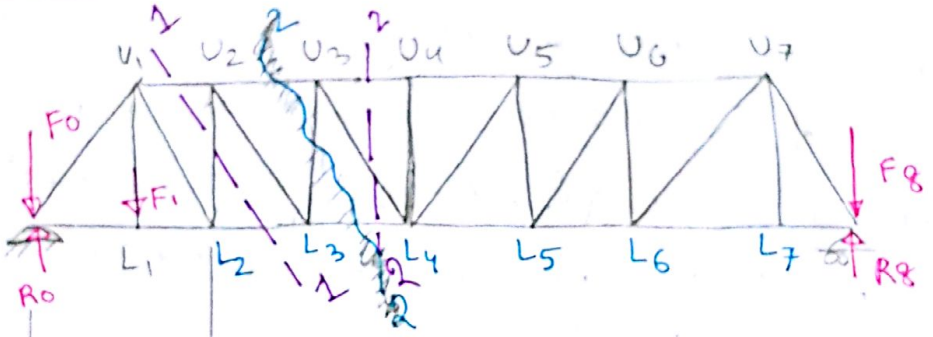
Find the shape of I.L applying truss Analysis by joint / section method.

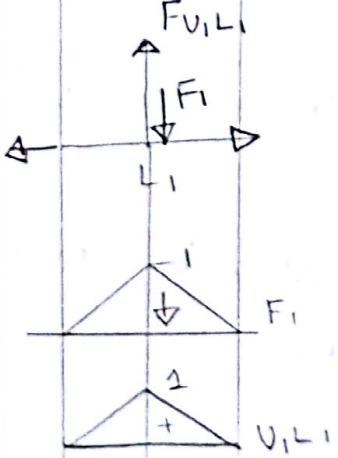
Then find the controlling ordinates by truss analysis for specific position of unit load.

1. Top Chord (TC) members
2. Bottom " "
3. Vertical Web " "
4. Inclined " " "

3. V. web members:

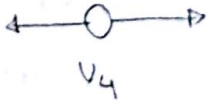
U_1L_1 : at L_1, $\Sigma V = 0$





$\Sigma V = 0 \quad FU_1L_1 \overset{(+)}{=} F_1 \downarrow$

Similarly : $U_7L_7 \overset{(+)}{=} F_7 \downarrow$ (joint L_7)

$U_4L_4 =$  0

U_2L_2 : Inclined Sec : Through L_2-L_3

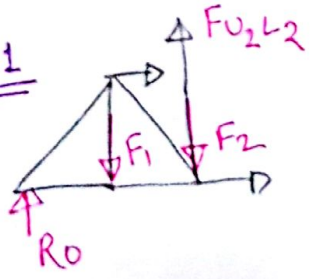
consider left part

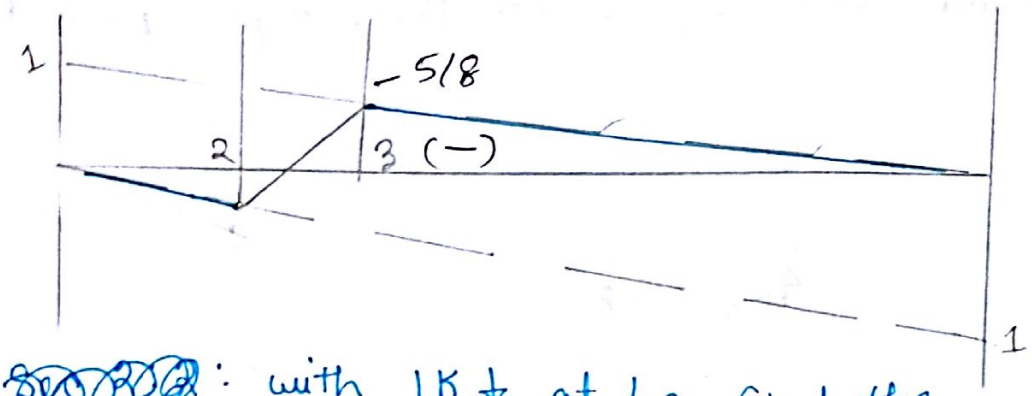
$\Sigma V = 0 = R_0 - F_0 - F_1 - F_2 + FU_2L_2$

$FU_2L_2 = -(R_0 - F_0 - F_1 - F_2)$

$= -V_{2-3}$

1-1





$V_2 - 3$

To find ordinates L_3 ⊙ unit load

: with 1K ↓ at L_3 find the reaction $R_0 = 5/8$

$V_3 L_3 = V_{3-4}$

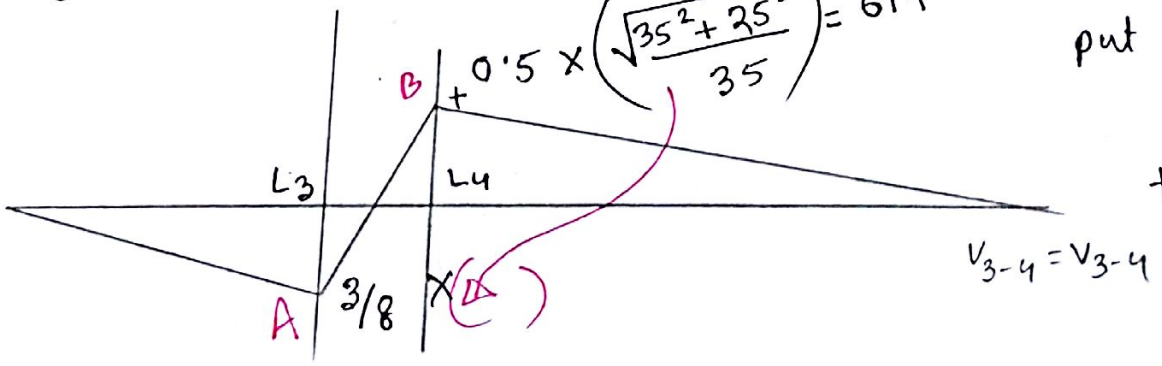
$V_5 L_5 =$

Inclined Web Members:

V_3L_4: verticle section Through 3-4 & (2-2)

$\leq V = 0$

$\therefore V_3L_4$ = would be like $V_3 - 4$



put unit load at L_4 then $R_0 = 0.5$

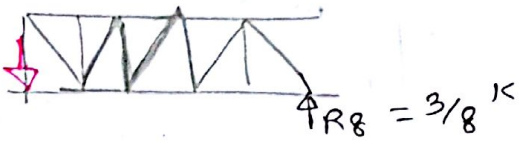
sec 2-2 ⊙ $\leq v_0 = 0$

$\Rightarrow 0.5 - Fv_3L_4 = 0$ $\quad \therefore Fv_3L_4 = 0.5$

this is verticle,

so inclined ⊙ $0.5 \times \frac{\sqrt{35^2+25^2}}{35}$

(A) এর co-ord থেকে L_3 এ 1K then right part নিব,



U_1L_0 = V_{0-1}

U_1L_2 = V_{1-2}

U_2L_3 =

U_3L_4 =

U_5L_4 = v. section paring through L_4L_5

V_{4-5}

11 from iqbal

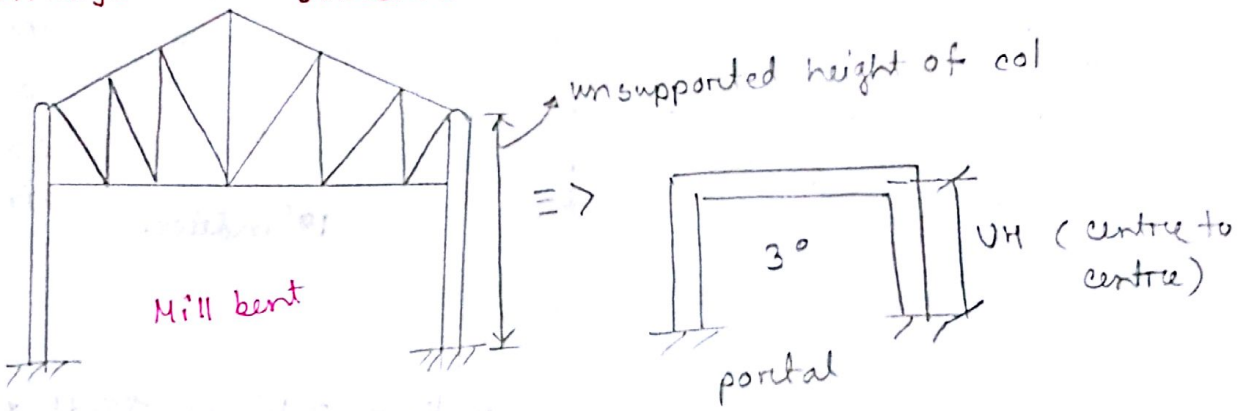
17.11.15
Tuesday

(*) Norris & Wiber & Vorter both ಪುಸ್ತಕ
↓
chapter 6-7

Lec-12

Approx Analysis of Indeterminate Structure:

1) Portals, Bridge" & Mill bents



Assumptions:

A) There is a hindge at the middle of **un supported** **height** of each col → 2 eqn

B) Total lateral load is equally devided among two cols → 1 eqn
↓
At the level of hinges

---

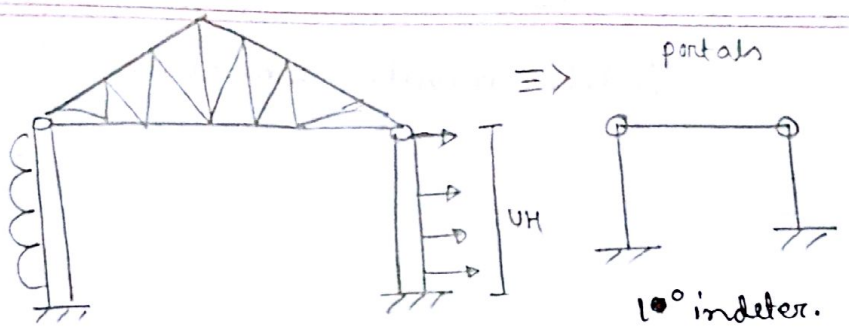
for 1° Indel — use B
2° — use A
3° — use A+B

Condition:

1. Portals, Mill Bents must be symmetric
for unsymmetric structures - have to use accurate methods.

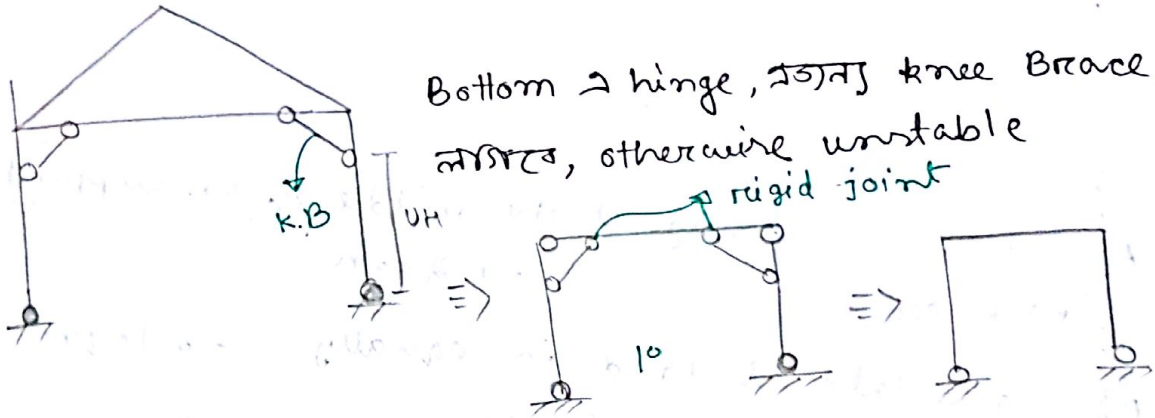
(*) Support ಅ hinge ಆಗಿದ್ದರೆ point of contraflexure ಆ point ಅ
" ಅ fixed " " " " at mid point of UH.

A)



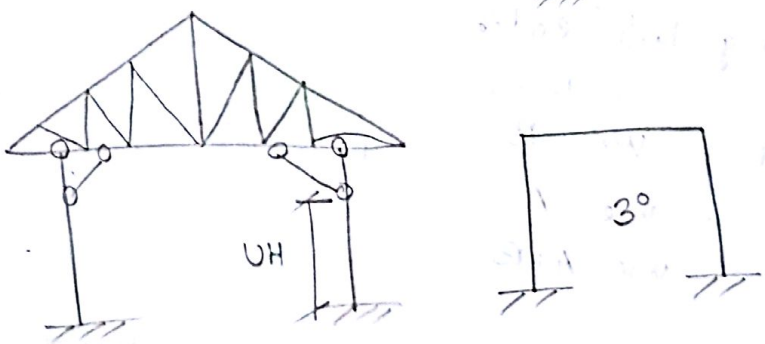
2 columns & Truss considered as beam. connected by hinge

B)

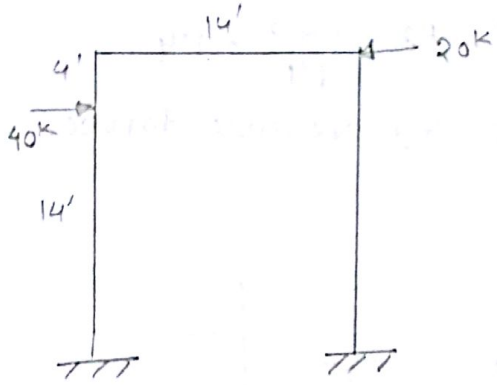


Bottom ⇒ hinge, knee Brace, otherwise unstable

C)



Analysis Portal Frames:

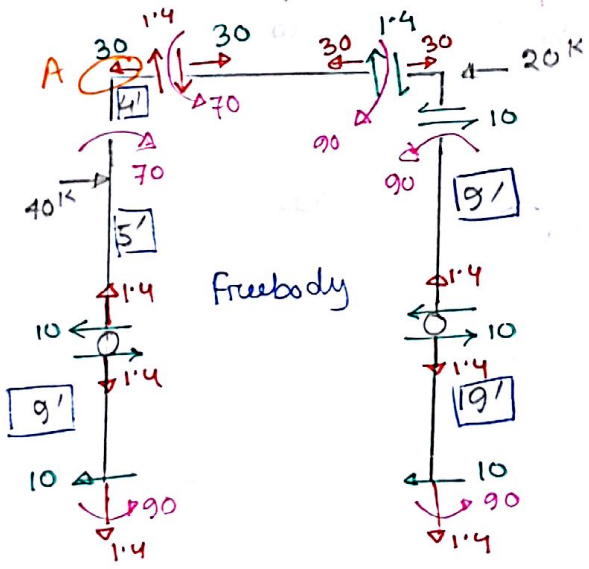


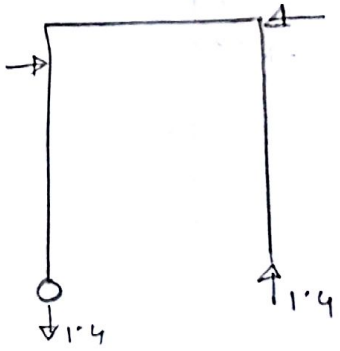
3° Indet

needs assumptions 1+2
= 3 eqns

Steps:

1) Find Indet
2) Apply Assump & Find some forces
3) Apply freebody
4) Draw SF, BM, AF Digms





1st → assume 9' (mid height)

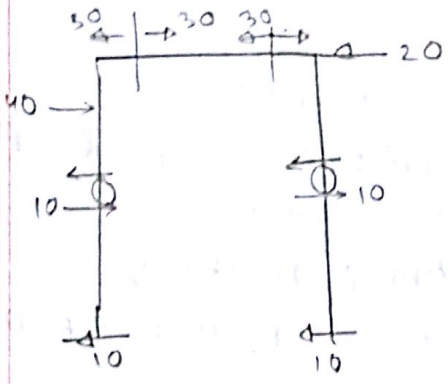
Lat force = 40 - 20 = 20 → (This will be equally devided in two colums

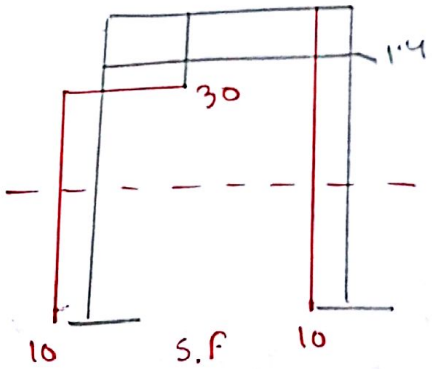
A joint can be exhibitted caused কোন force নাই.
na

Hinge এ lateral force বের বাম্বার পর ΣM করলে axial force পাব. (considering upper part)

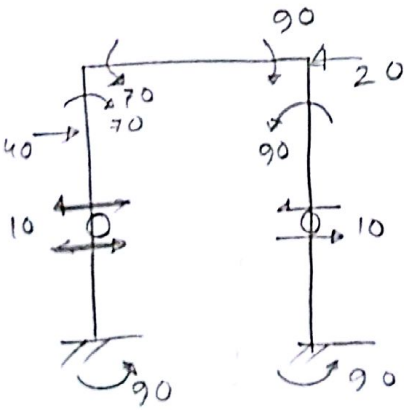
$40 \times 5 - 20 \times 9 = A.F \times 14 \quad \therefore AF = +\frac{20}{14} = 1.4$

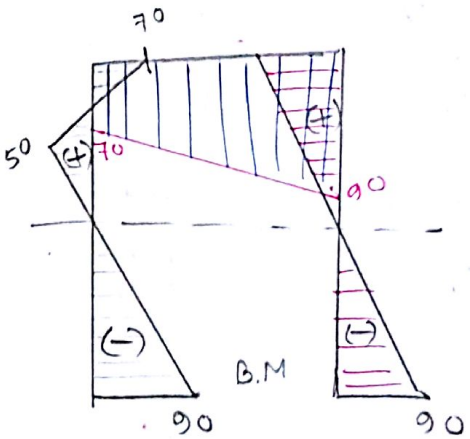
Then ΣV থেকে other hinge এর verticle force.



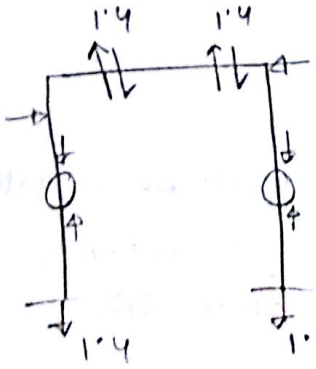


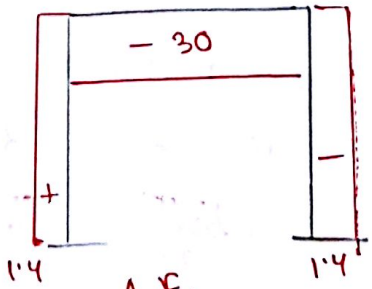
S.F





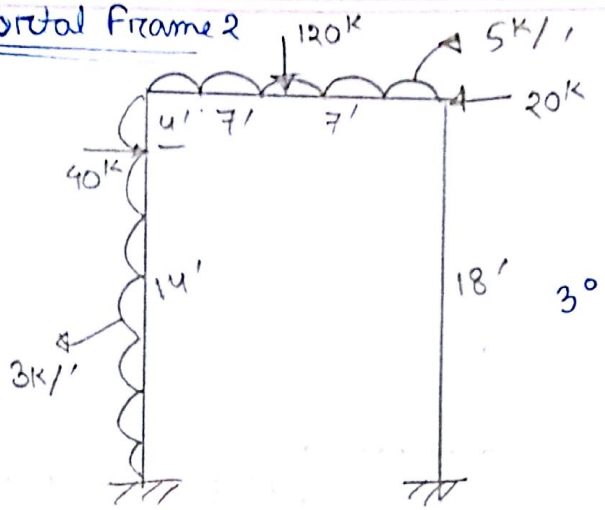
B.M





A.F.

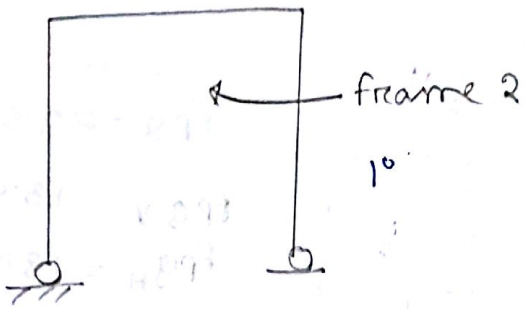
Portal Frame 2



use assumption A+B

Portal 3:

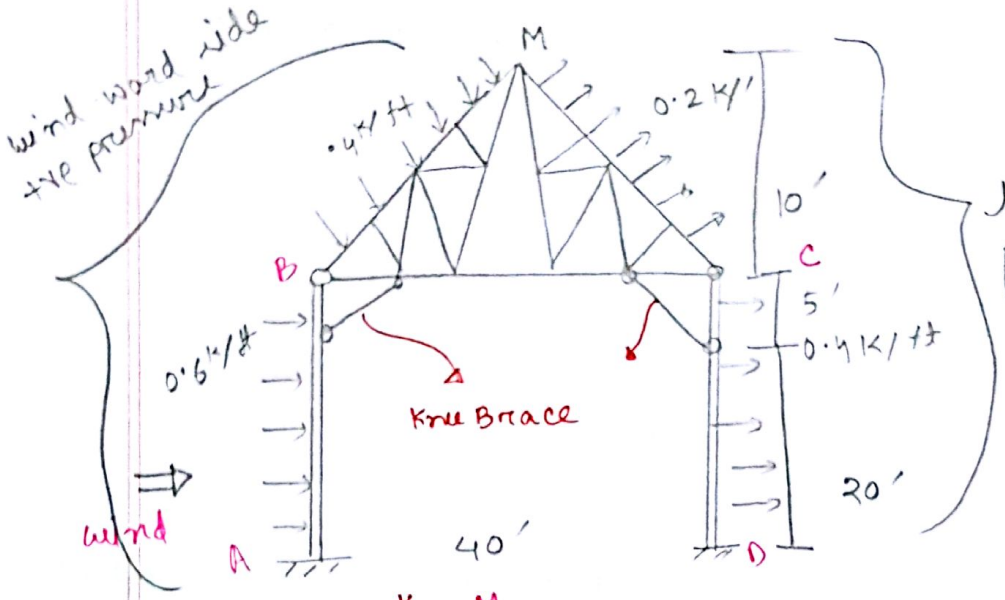
(Portal 2 with hinge support)

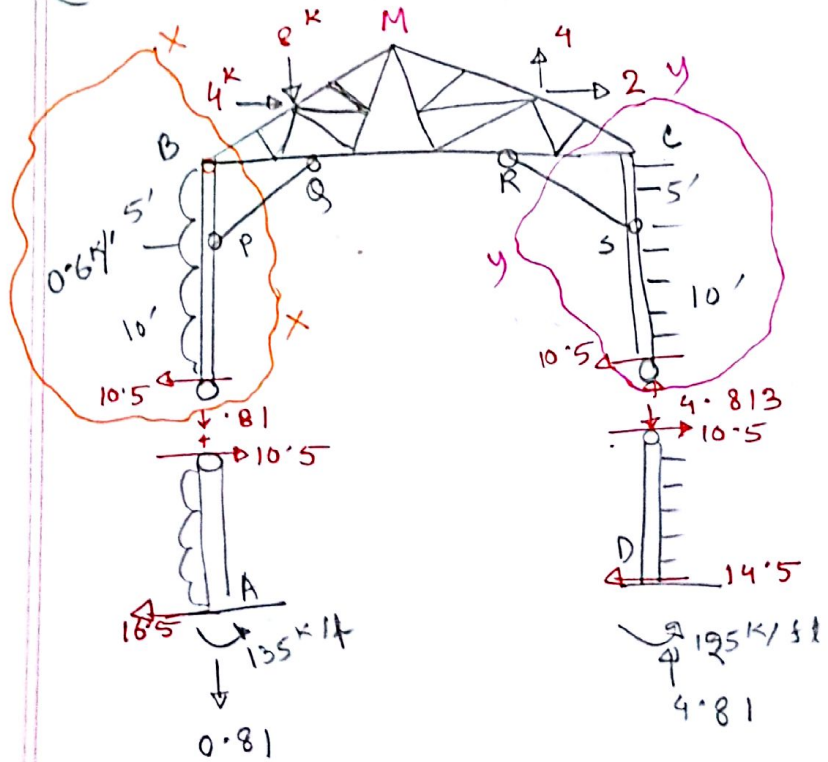


use assumption B

21.11.15
Saturday

Lec-13





(sec X-X and ΣM_B)

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

$F_{PQ_V} = 13.5$

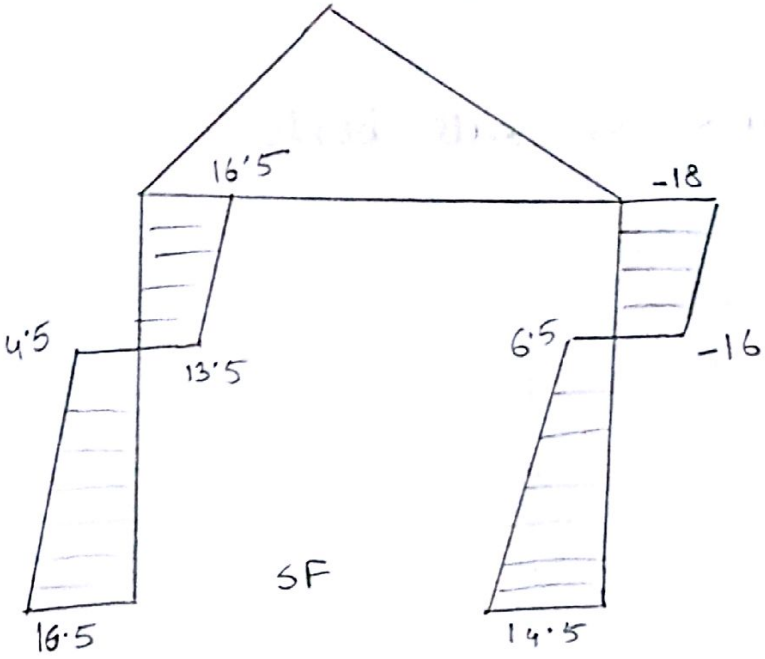
$F_{PQ_H} = 18^K$

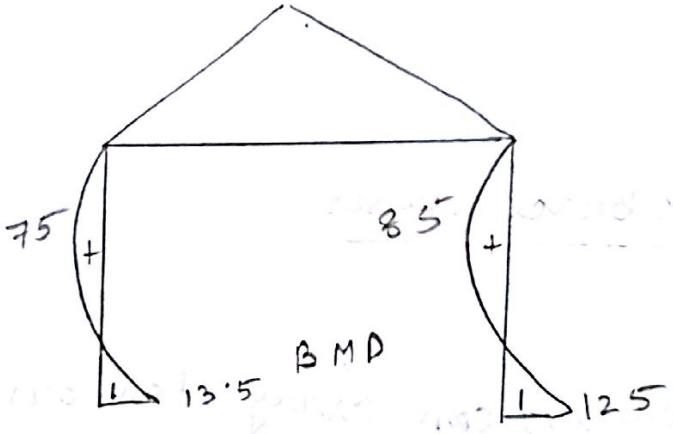
$F_{RS} = 28.13^K$ $\Sigma M_C = 0$ (sec-Y-Y)

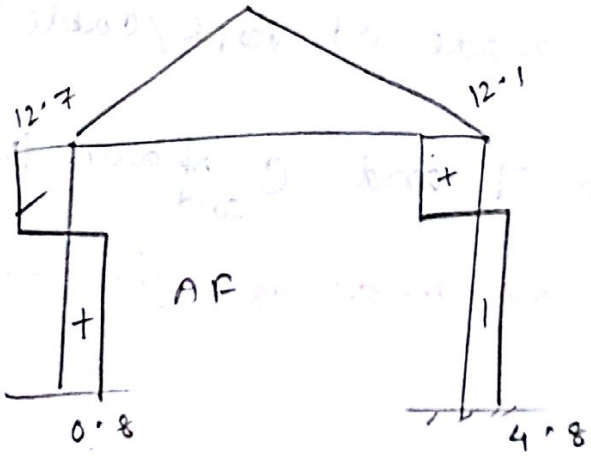
$\Rightarrow$ " $H = 22.5$

$\Rightarrow$ " $V = 16.88$

$\Rightarrow$ Draw SF, BM, AF for cols
Find forces in knee Braces
" " in Truss member
} 8

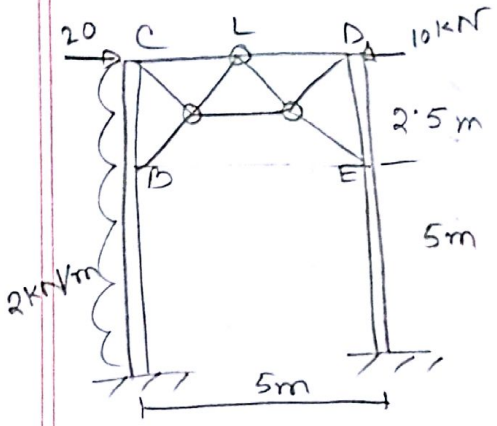

16·5
-18
4·5
13·5
6·5
-16
SF
16·5
14·5


75
+
8 5
+
BMD
1
13·5
1
125


12·7
12·1
+
+
AF
1
0·8
4·8

Bridge Portal:

Almost same as mill bents.



X Brace Trusses

Assumption:

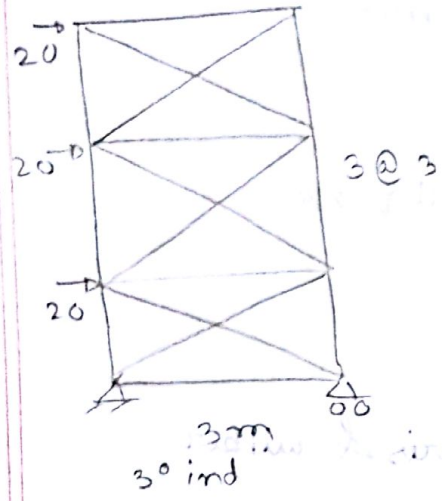
1) Diagonals (Bracings) can carry tension only (i.e. Diagonals are made of rope/cable)

2) OR can carry both T and C and shares the panel shear equally (Diagonals are made of rigid members)

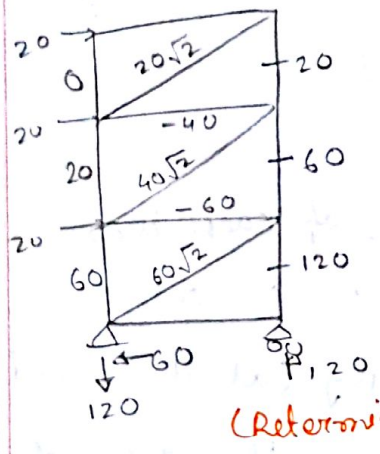
24.11.15
Tuesday

Lec - 14

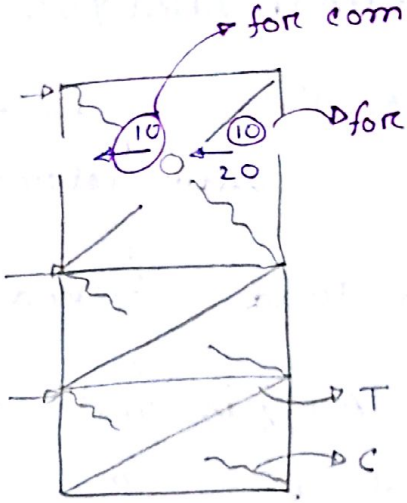
X - Braced Truss:



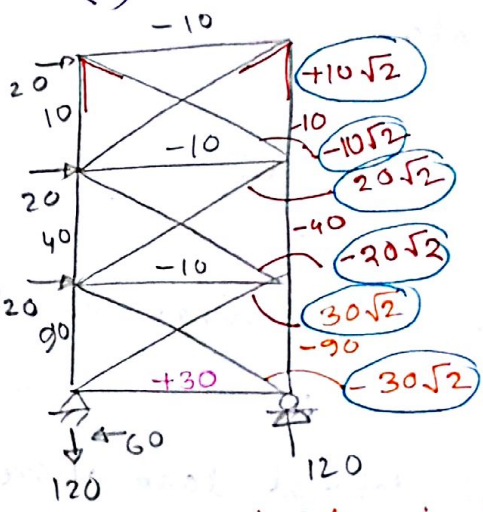
(a) Tension only



(Determinate)



(b) Tension & compression



(indeterminate)

28.11.15
Saturday

Lec - 15

APPROXIMATE ANALYSIS OF Multistoried Building Frames Under lateral loads

Lateral load — i) wind ii) Earthquake

Approx Analysis methods

1) Portal "
2) Cantilever " ⇒ norris & wilber
3) Factor

⇒ Portal Method:

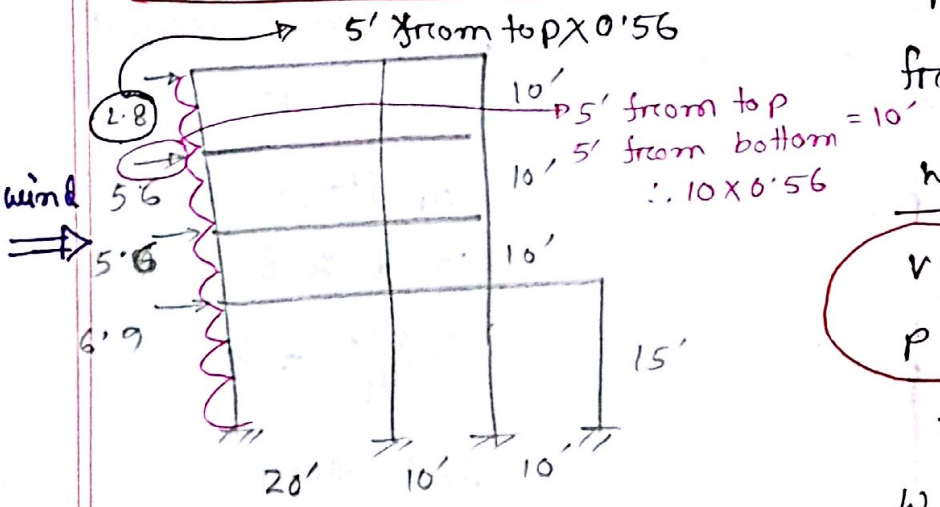
Assumptions:

1) There is a hinge at the centre of each beam
2) " " " " " " " " col^n
3) Total lateral load above any story (at the level of hinge) shall be devided among the cols of that story so that an internal col takes twice the shear force taken by an external col.

Analysis: To be done by freebody

Prob 1 **Portal Method:**

Approx analysis of building frames . . .



frame spacing @ 15' c/c

Wind load

Formula

$V = 120$ mph

$p = 0.00256\ V^2$ (in psf)

$= 37$ psf

$w = 0.37 \times 15 = 0.56$ K/ft of height

Analysis steps and order:

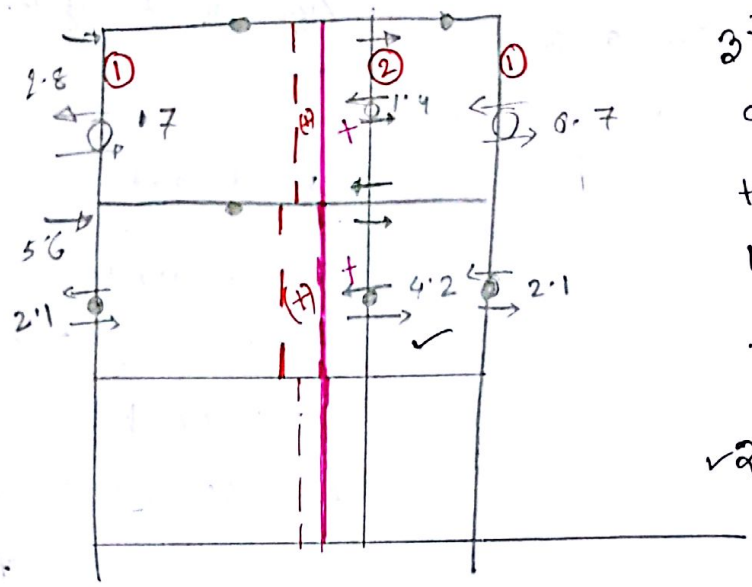
Calculation of

1) col SF → by Assumption
2) Beam AF
3) col BM
4) Beam BM
5) Beam SF
6) col AF

} By Freebody (top to bottom)

6.9 consists 5' from top and 7.5' from bottom

$= 0.56 \times (7.5 + 5)$



3য় colm, আরেকটার double নিব,

top floor এ Lateral load 2·8

$\therefore \frac{2·8}{4} = 0·7$

✓2nd floor

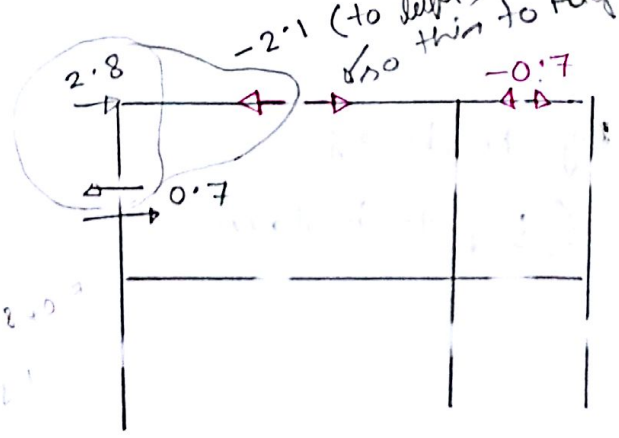
$2·8 + 5·6 = 8·4$

$\Rightarrow \frac{8·4}{4} =$

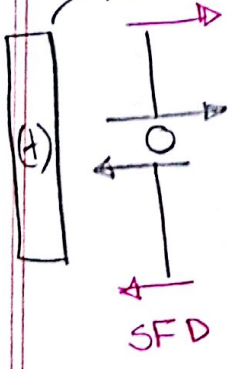
Beam A.F:

(- কারণ compression, towards the section

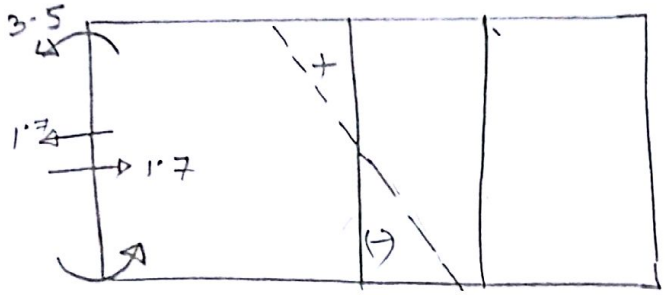
$-2·8 + 0·7 = -2·1$

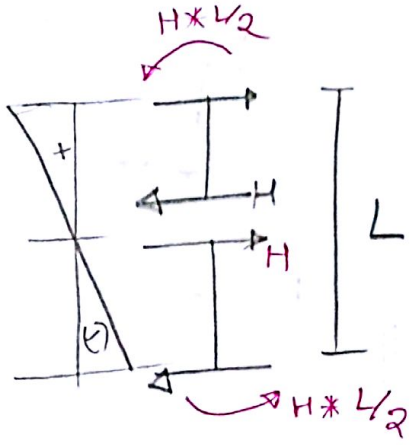


(+) কারণ clock wise shear



Comm Bending M:

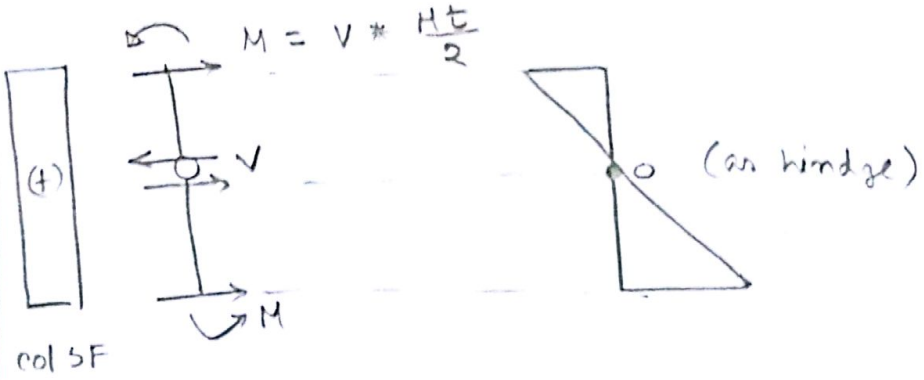




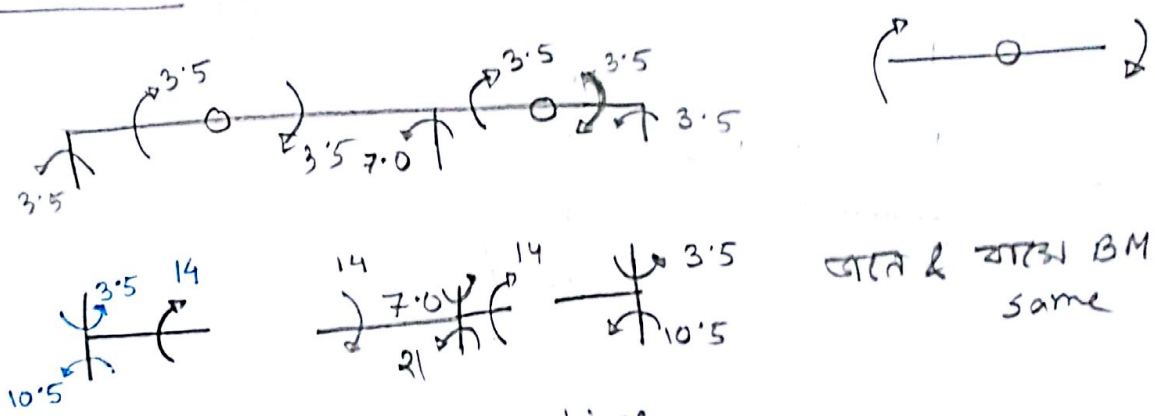
B.M.D

1.12.15
Tuesday

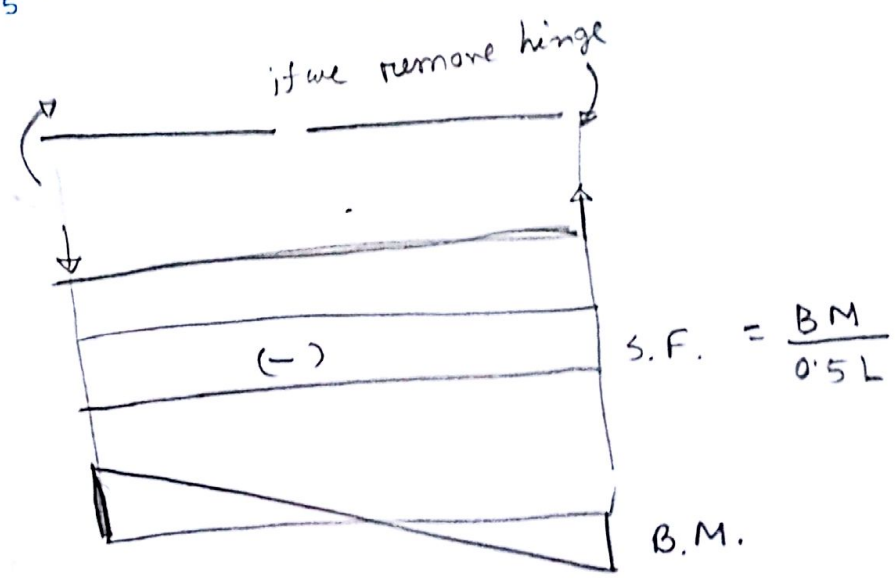
lec - 16



Beam B.M: By free body of joints ($\Sigma M = 0$)



বামে & ডানে BM same

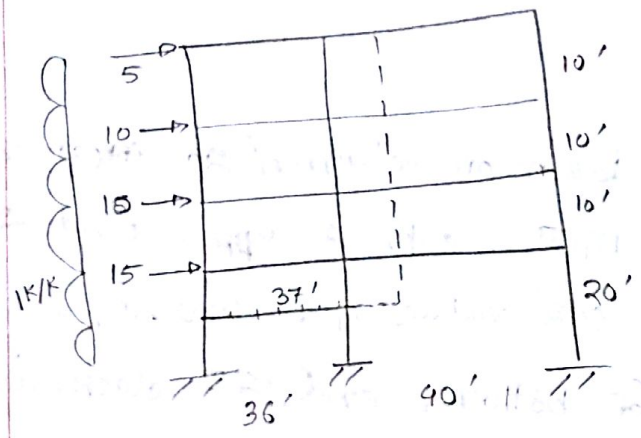


6. col AF ≠ By free body:

Beam ⇒ S.F ভাবতে A.F for column ভাবা যাবে,

Building Frames under Lateral load:

⊛ Cantilever Method: (Imp)



Wind pressure = 40 psf

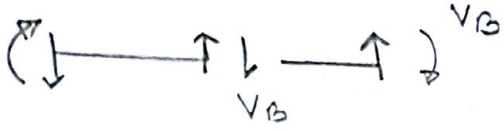
Annalysis top to bottom

$f = \frac{My}{I}$ $\quad c.g = \bar{X} = \frac{4A(36) + 2A(76)}{8A} = 37'$ from left

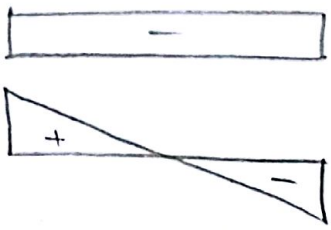
05.12.15
Saturday

Lec - 17

Beam Free body :



$B.M = V_B * L/2$
(at both ends)



portal & cantilever → beam or column এর মধ্যে no force. So moment একই দিকে, colm এ upper end এ যে value lower end এও সেই value of moment. & clockwise এক end এ হলে bottom end এও clockwise.

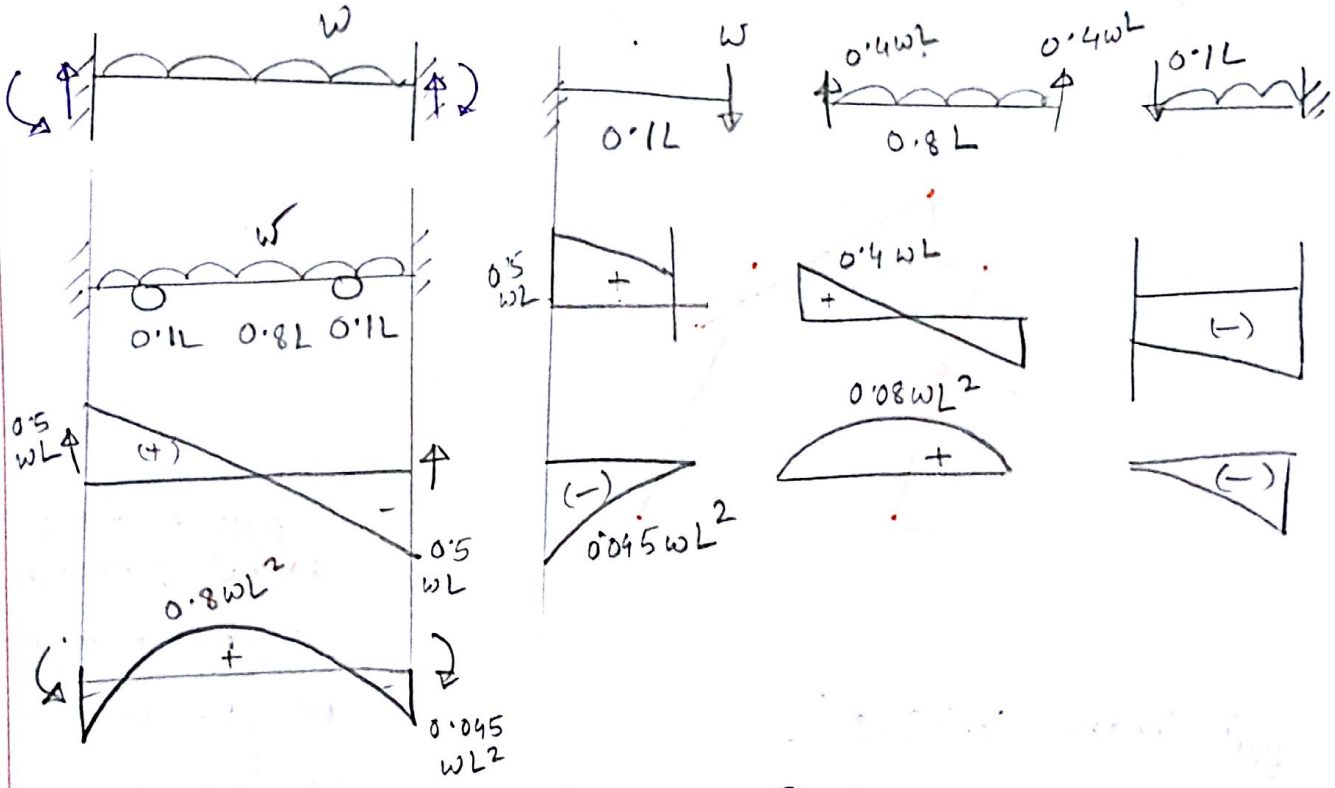
Beam এ axial force not that imp, shear & B.M imp.
Colmn " shear " " " " , axial & B.M. " .

Approx annalysis of Building frames under V. Load

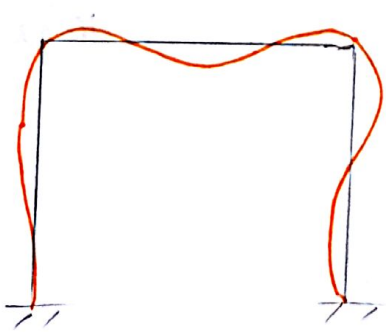
Assumptions:

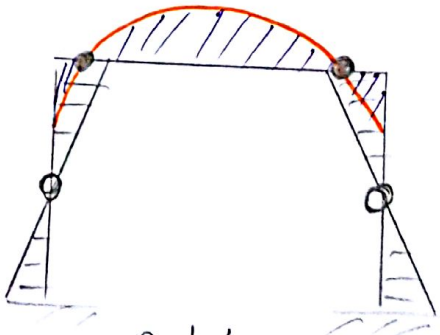
1) A hinge at L/10 from left end of beam
2) " " " " " right " " "
3. Axial force in beam negligible

4) The unbalanced BM at a joint shall be distributed among col^n at the joint as per their ~~differences~~ stiffnesses ($= \frac{EI}{L}$)

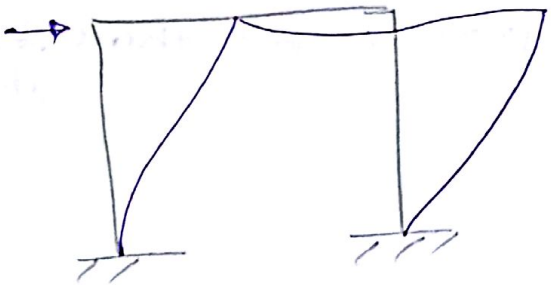


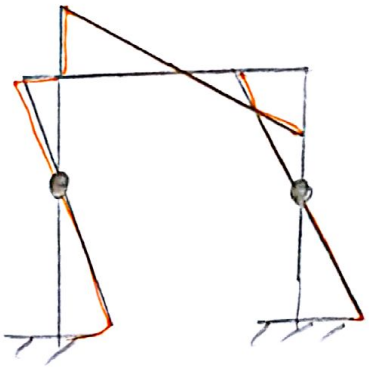
* Hinge ⇒ BM = 0, axial force & shear. → neglected





portal under vert. load

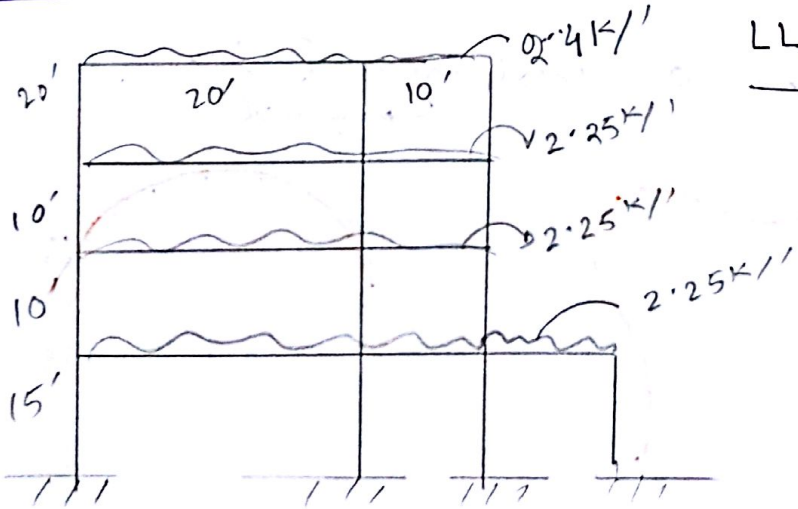




BNBC অনুযায়ী actual load find out

	Roof	Floor	R	F
DL	1·8	1·35	120	90
LL	0·6	0·90	40	60
	K-ft		psf	

Prob Under V. Load :



DD + LL on frame
(space @ 15' C/C)

Load in psf X 15 (convert to kip) = kip/ft এ পাব।
spacing

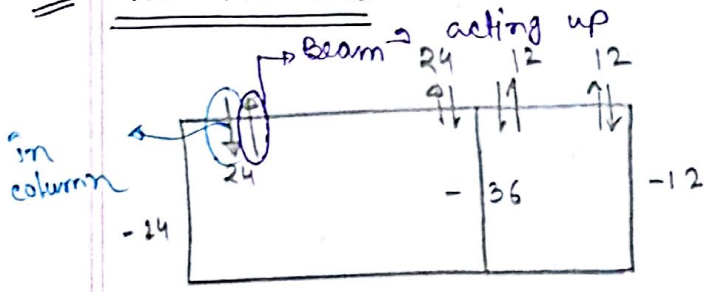
Analysis order:

1. Beam SF
2. Beam BM
3. Col BM
4. Col AF
5. Col SF
6. Beam AF → not needed

8.12.15
Tuesday

Lec - 18

2. AF in Cols:



For any colmn find AF in columns by taking sum of S.F of above beams

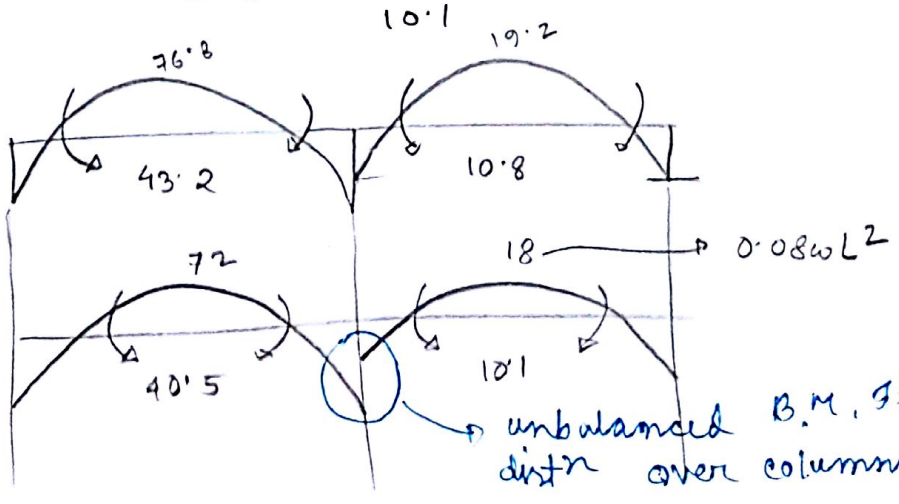
3. B.M in Beams:

20' span +ve BM = 0.08 wL^2 ⇒ 76.8 (roof)
⇒ 72 (floor)

-ve BM = 0.045 wL^2 ⇒ 43.2 on roof
⇒ 40.5 on floor

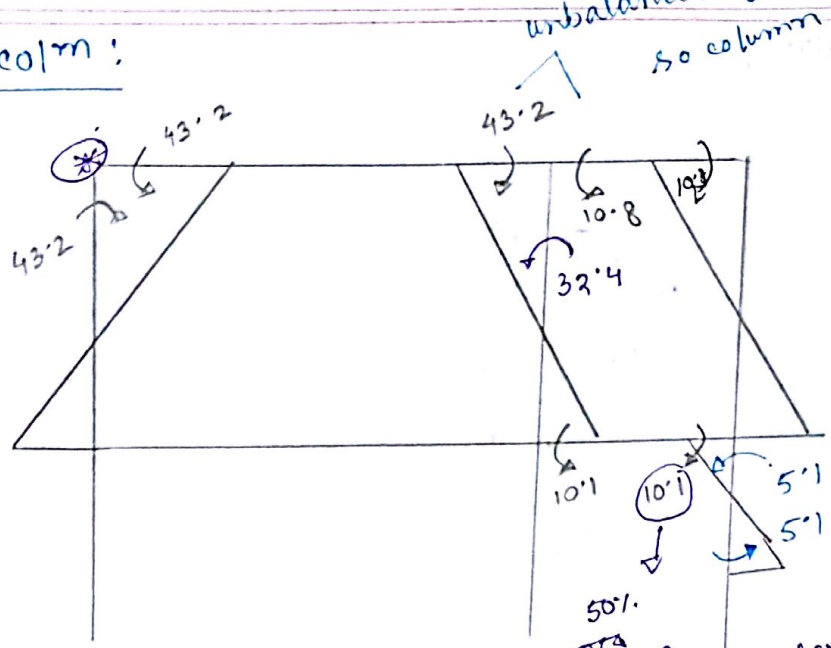
10' span = +ve BM = 19.2
18

-ve BM = 10.8
10.1



unbalanced B.M. It will be distr over columns as per stiffness

4. BM of colm :

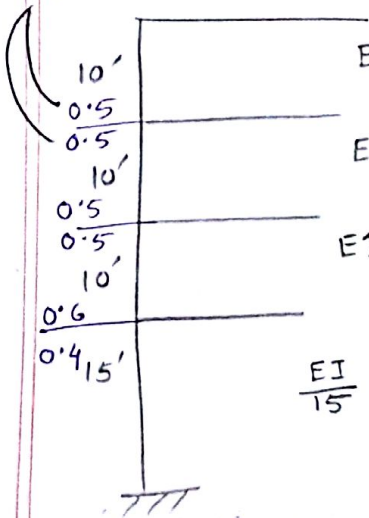


level & joint by joint হবে।

Top level left joint *

50% বাকি দুপাশে & নিচের colm এ divide হবে

as both 3, no 50% বাকি



EI/10 = stiffness, $\frac{EI}{L}$

EI/10 I may vary

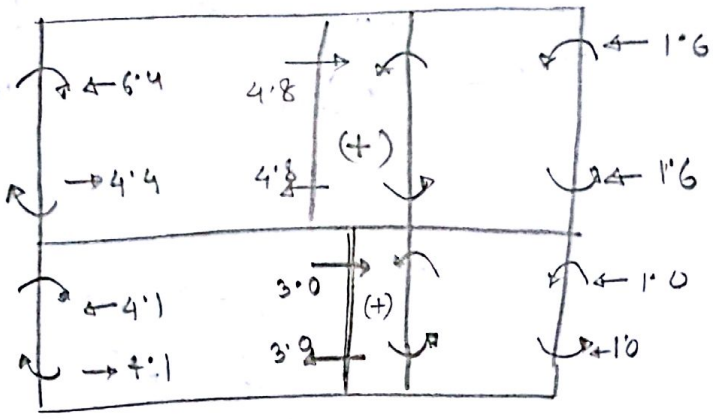
EI/10

$\frac{EI}{15}$

	Relative value	To eliminate decimal
	1·5	1·5×2 = 3
	1·5	,,
	1·5	,,
(1)	ধরলাম	1×2 = 2

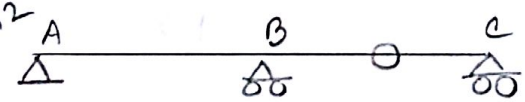
support এ distn undefined. এজন্য ground floor এর colm এ যখনই B.M নিচের colm এত তাই, তখনি সবে hinge.

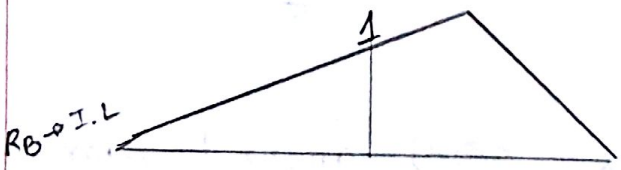
5. SF in Colm :



Moving Loads :

Beam 2

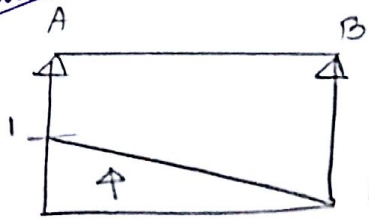




Find max^m R_B for moving load

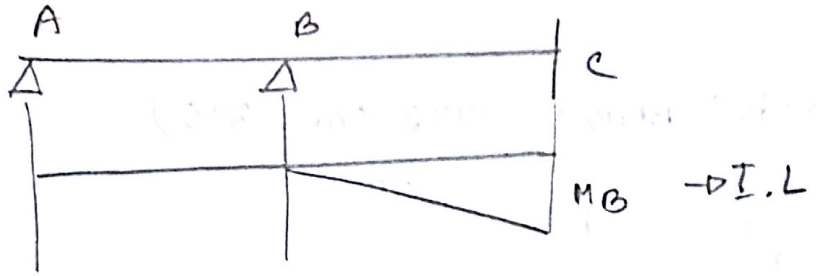
$$\frac{WL}{a} \geq \frac{W}{L} = \text{check}$$

Beam 1



Q. Find Max^m R_A for

check for ΔR



Find max^m MB for moving loads. ⊘25T

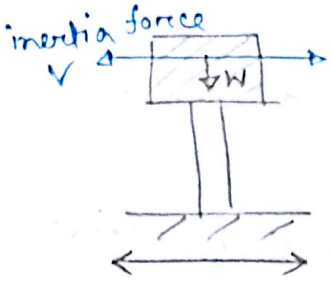
check for ΔR.

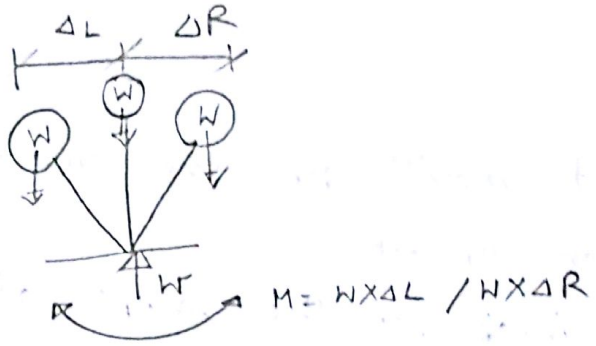
For check see the shapes of IL & then decide.

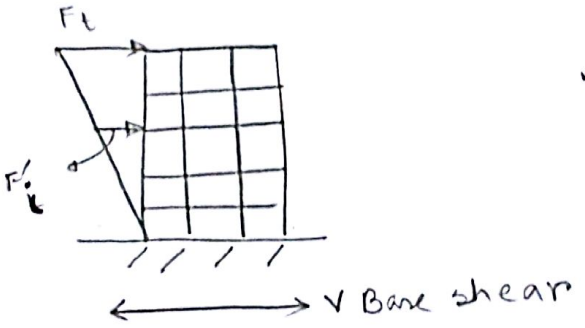
12.12.15
Saturday

Lec - 19

Earthquake Loads: BNBC - 1993 (Art 2.5)







$$V = F_t + \sum_{i=1}^{N} F_i \quad (N = \text{No. of storey})$$

Lec - 20

15.12.15
Tuesday

Summary:

2.4.4:
1. Urban industrial
2. Open terrain
3. Flat & sparsely terrain

2.4.5: Basic wind speed
Fig 6.2.1

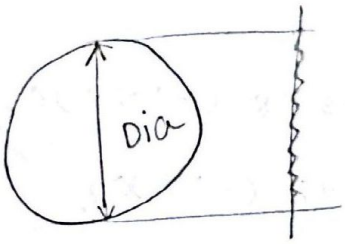
2.4.6. Sustained wind pressure:

$$q_z = C_c C_1 C_2 V_b^2$$

2.4.6.3: $P_z = G_q C_p q_z$ ---

2.4.6.4 Design wind load

(see somewhere Lecture)



q_z =

C_c = I hate everything

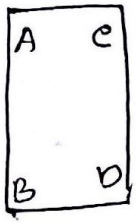
C_z =

P_z = shit, I hate, everyone hates

wind ward side $C_{pe} = +0.8$

lee side $C_{pe} = -0.57$

side walls $C_{pe} = -0.7$



B = 66m

L/B = 0.5

L/B = 0.76

$V_b = 210 \text{ km/h}$

Exp A

$q_z = C_e C_I C_z V_b^2 = 47.2 \times 10^{-6} \times 1.0 \times C_z (210)^2$

$p_z = G_{G_1} C_p q_z = C_G C_p \; 2.082 \; C_z$

$C_{G_1} = C_{\pi h}$

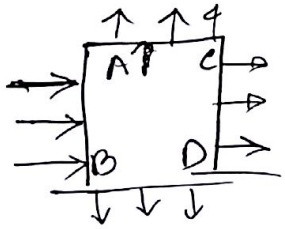
$C_p = C_{pe}$

$= 2.082 (1.238) \; C_p C_z$

$= 2.578 (.8) C_z \quad = 2.578 (-.57) C_z$ windward side wall

leeward $= 2.578 (-.7 \times z)$

Method 1 :



$F_1 = \Sigma p A_z$

Method 1 :

	wind(W)	lee
0-45	-.76	
6	-.86	
9	-1.17	
15	1.59	
18	1.99	
21	2.20	
24		

1.10.15

Tuesday

Lec-1

Prof. Abdur Rouf

Must be familiar with

Supports + Reactions

Shear force - Diagram (Sign Convention)

B. M.D (Sign Conv)

Axial force Dia

Free body

Books

1. Structural Annalysis
- Norris, willbur, Utku

2. Structural Analysis
- Shedd, Vawter

Syllabus:

① Stability ② determinacy of structures (statically determinate) ③ Trusses ④ Arches ⑤ Influence line ⑥ Moving loads on beams, frames & trusses ⑦ Annalysis of suspension Bridge ⑧ wind and ⑨ earthquake loads, (10) approx analysis of statically undeterminate structure, braced trusses, portal method, cantilever method & V.Load analysis of multi story building frames; (11) deflection of beams trusses frames by virtual work method

There is another force except the upper three
It is torsional force, it is also called twisting moment. It is a rotational force.

Stability

A structure is :

1) Statically Unstable

if total eqn > Total unknowns

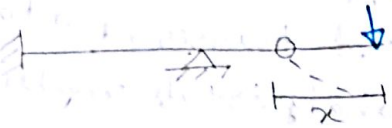
for plain structure 3 eqn

2) Geometrically Unstable :

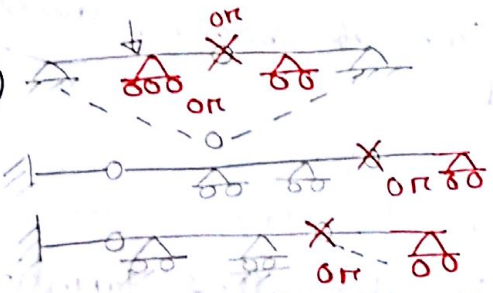
if general arrangement of reactions and/or members are not properly made

1)

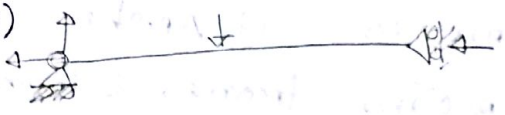
2)



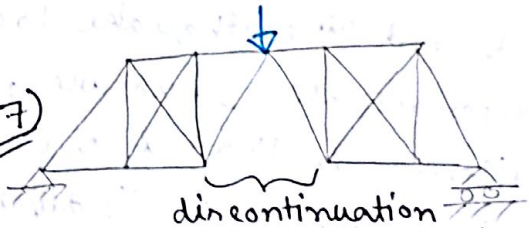
3)



4)



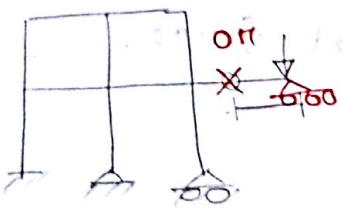
7)



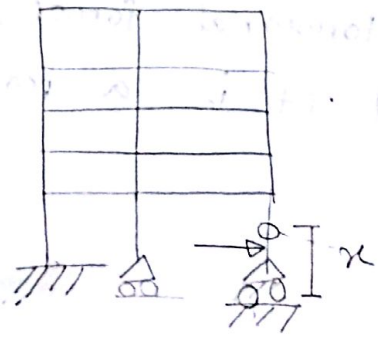
discontinuation

So सहज beam बन with internal hinge

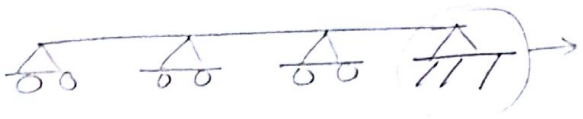
5)



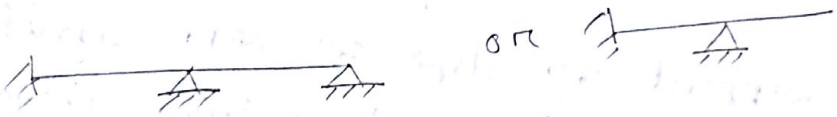
6)



① Statically stable, but it will start running if we apply load cause horizontal reaction resist করতে পারে না, so geometrically unstable.
So provide a hindge and make geometrically stable.



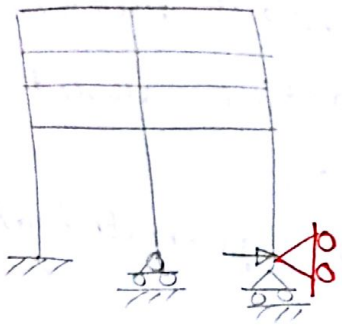
(2) x এর জন্য unstable. Either remove internal hindge or provide hindge

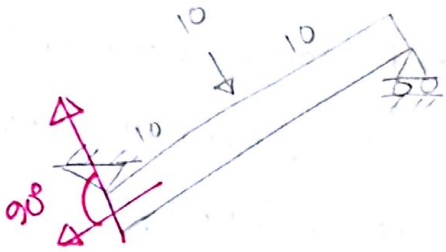


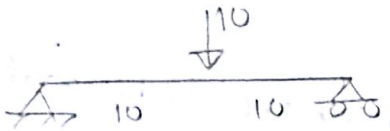
4) Three reactions meet at a point. So rotational moment resist করতে না, so beam starts rotating So all reactions must not meet a point. এটার rotational resistance থাকতে না,

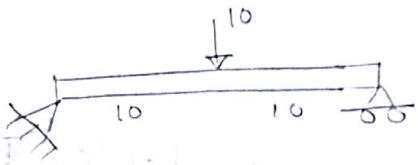
5) For part x the structure is unstable. so either remove hindge or give roller support.

6) unstable for x, cause → force নিচে side এ move করবে. or roller কে change করে hindge or fixed support.





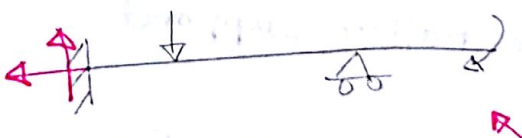


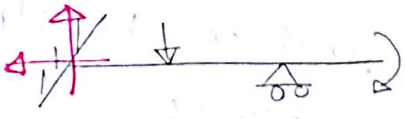


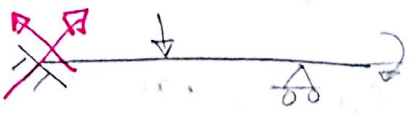
Hindge এ support এর slope এর কোন significance নাই, we draw reactions along two orthogonal surfaces.

Horizontal / vertical এর cause load mostly horizontal & vertical except fluid pressure.

In roller the reaction will be normal to the surface.

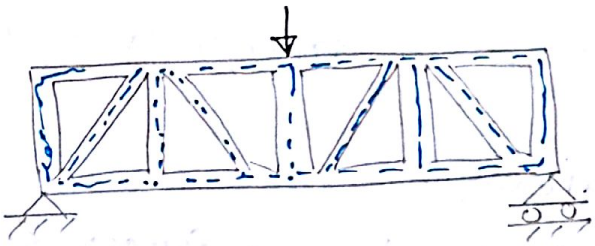






slope এর significance নাই,

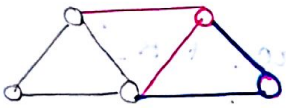
Truss is a Hollow Beam:



Blue lines এবারে মাঝের white portion তুলে নেয়ব, so truss is a hollow Beam. Top compression, bottom tension.

Smallest Truss:

3 members & three joints



এভাবে 2 members & 1 joint add করে truss বাড়াব, Truss must contain of series of triangles. যেহেতু triangle এভাবে না হলে unstable. (7) এ truss continuous না, so it may be considered as a beam with hindge.

12.9.15
Saturday

Lec - 2

Structural Stability & Determinancy - Indeterminancy

a) A structure is statically:

i) unstable if T. Number of unknowns forces < Total Eqn

2) Stable & determinate if (") = (")

3) Stable & indeterminate if " > "

And degree of Indet = (") − (")

(b) Total Unk. Forces = Member force + Rs'

(सदस्य member बल Force) A.F. = (1)b + r for a (2D) Truss

Beam सदस्य में (A.F, SF.D, BM) force = (3)m + r for a (2D) frame, there can be twisting force too.

= r for a beam/col

(c) Total eqns = Eq^ns eq^n for joints + Eqns of conditions

ΣF_x, ΣF_y = (2)j + 0 for a 2D truss (cause all the joints are hinge, so no int. or external hinge)

" , " , ΣM = (3)j + c for a 2D frame

= 3 + c for a beam/col

↓ from hinges

b = Number of bars

m = Number of members

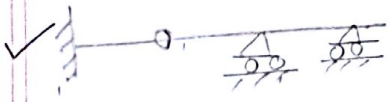
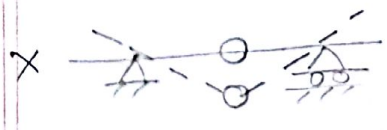
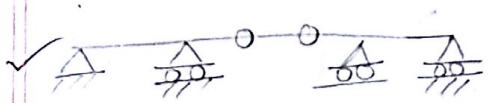
J = No of joints

r = No. of reactions

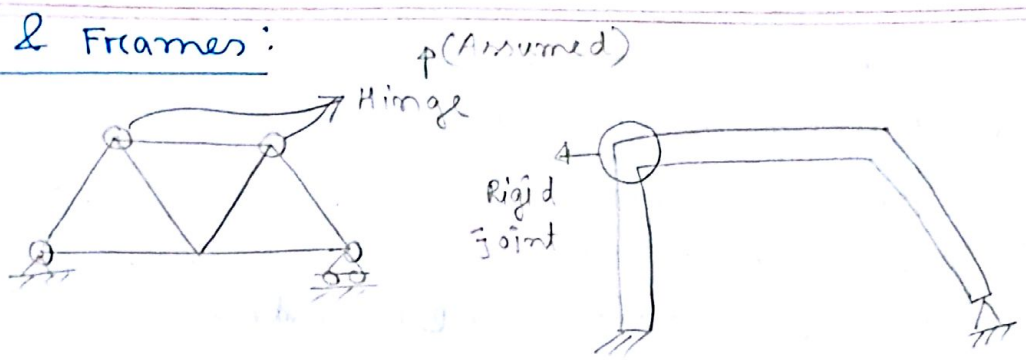
c = No. of conditions (e.g. hinges)

Beams

Geometrical stability:

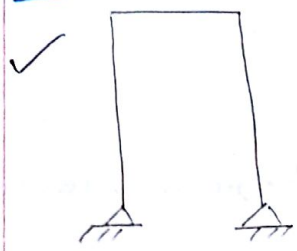
	No of R's	Indet	Stat Sabl?
	r = 4	$4-3=1^{\circ}$	✓
	r = 5	$5-(3+1)=1^{\circ}$ ↳ from internal hindge	✓
	r = 3	$3-(+3+1)=-1^{\circ}$	✗
	r = 4	$4-(3+1)=0^{\circ}$	✓
	r = 5 ✓ unknowns	$5-(3+2)=0^{\circ}$	✓

Truss & Frames:



Plane (2D) Frames:

Geo. stable



$m = 3$, $r = 4$, $j = 4$, $c = 0$

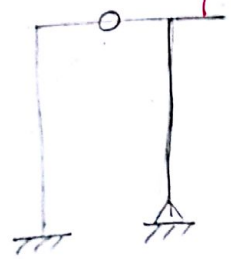
Total unkn $= 3m + r = 13$

T.E $= 3j + c = 12$

Deg of gt. $= 1^\circ$

Statically Stable ✓

free end is also a joint

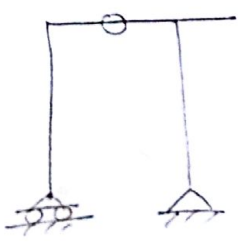


$m = 4$, $r = 5$, $j = 5$, $c = 1$

$3m + r = 17$

$3j + c = 16$

1° ✓

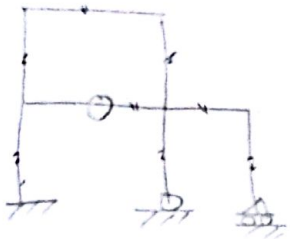


$m = 4$, $r = 3$, $j = 5$, $c = 1$

$3m + r = 15$

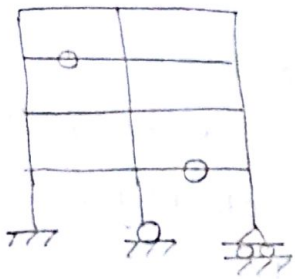
$3j + c = 16$

-1° ✗



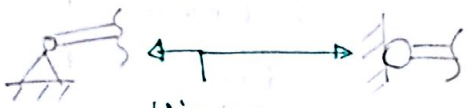
$m = 8$
$r = 6$
$j = 8$
$c = 1$

$3m + r = 30$
$3j + c = 25$
) 5°



$m = 20$
$r = 6$
$j = 15$
$c = 2$

$3m + r = 66$
$3j + c = 47$
) 19°



Truss: Fig 4·8 / Norris

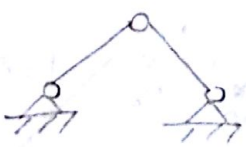
All are unstable structure ~~ata~~ geometrically.

Fig 4·9 / Norris:

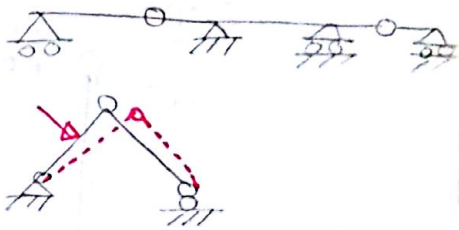
Fig 4·2 / Norris, Fig 4·3, 4·10 (এখানে truss এ triangle নাই → All stable তাও stable)

4·10 (b) → ৩টা আলাদা truss connected

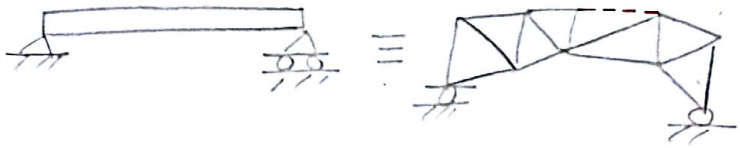
4·10 (a) →



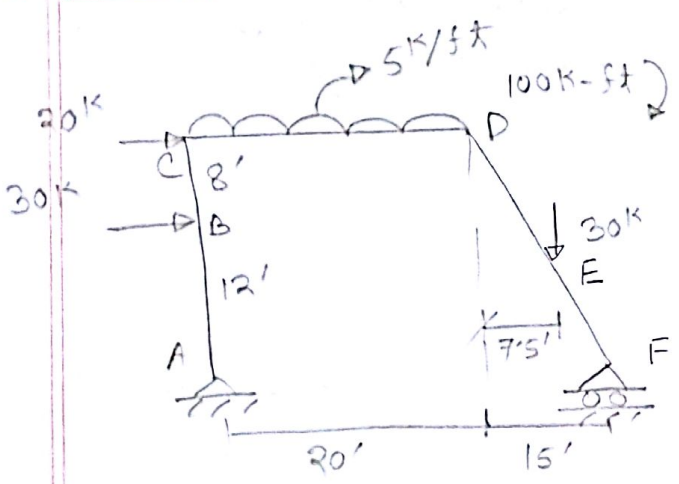
unstable if



यदि blank space ए member छोड़े then इसको truss & इसको beam.



Annalysis of FRAME :



1. Find R's
2. Draw freebody of ABC, CD, DEF & joints C & D
3. Draw SF, AF, BM Dig for ABC, CD, DEF
4. Draw combined SF, AF, BM Diagrams

$R_{Ax} + 30 + 20 = 0$

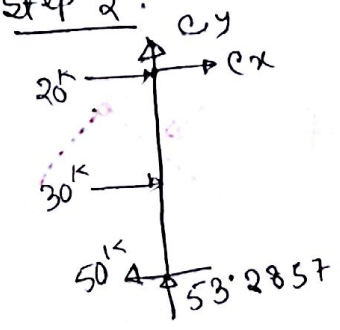
$R_{Ax} = 50 \ (\leftarrow)$

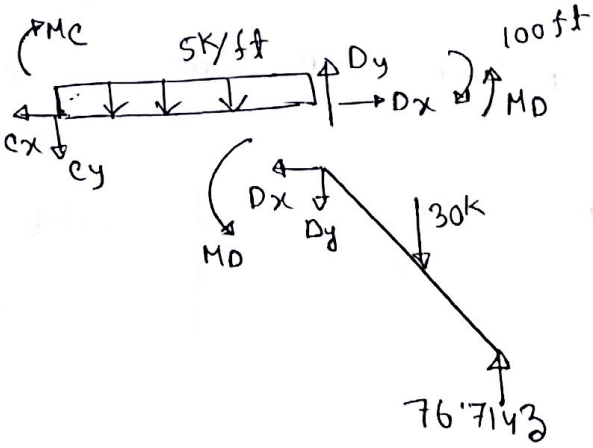
$R_{AY} + R_{EY} = 130$

$-R_{FY} \times 35 + 30 \times 12 + 20 \times 20 + 100 \times 10 + 100 + 30 \times 27.5 = 0$

$R_{FY} = 76.7143 \uparrow$ $\quad R_{AY} = 53.2857 (\uparrow)$

Step 2:





$C_y + 53.2857 = 0$

$C_y = -53.2857 (\downarrow)$

$C_x + 20 + 30 - 50 = 0$

$C_x = 0 \quad M_C = 760$

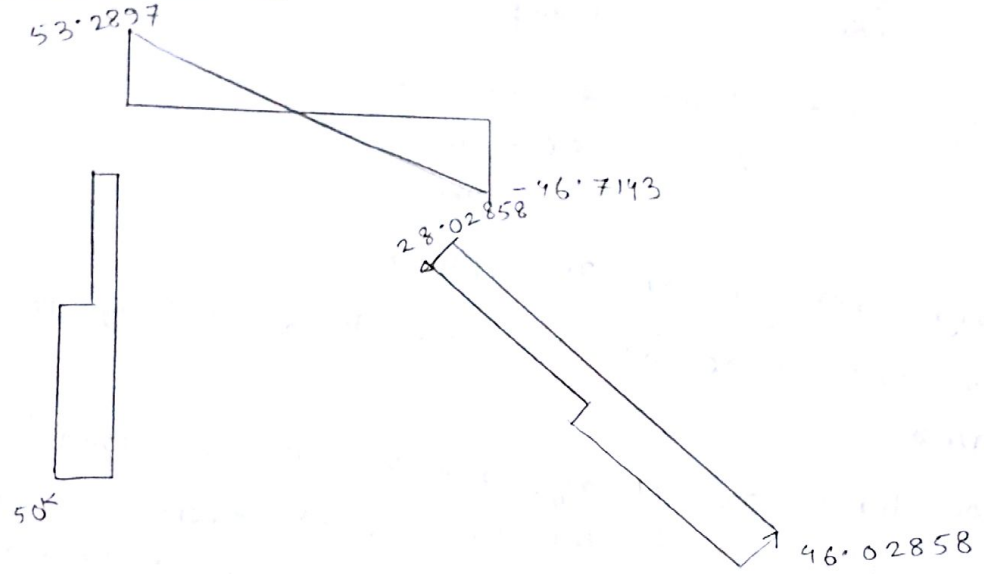
$D_x = 0$

$760 + 100 \times 10 - D_y \times 20 + 100 - M_D = 0$

$\Rightarrow C_y + D_y = 100$

$\therefore D_y = 46.7143 \uparrow \qquad M_D = 925.714 (\circlearrowleft)$

Shear force Dia

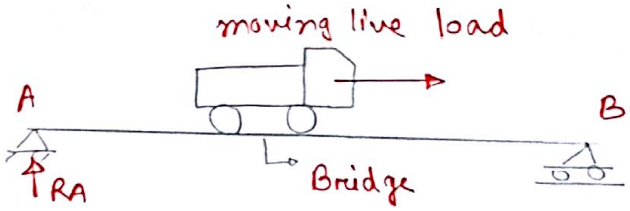


(*) Shear & Vorter এর exercise এর ans দেয়া math practice

15.9.15
Tuesday

Lec - 3

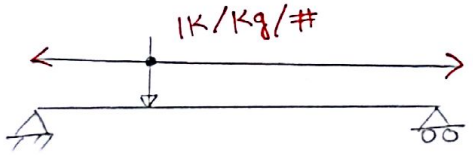
Influence lines



RA vary করবে, truck না থাকলে 0
A তে থাকলে max
B ,, ,, min

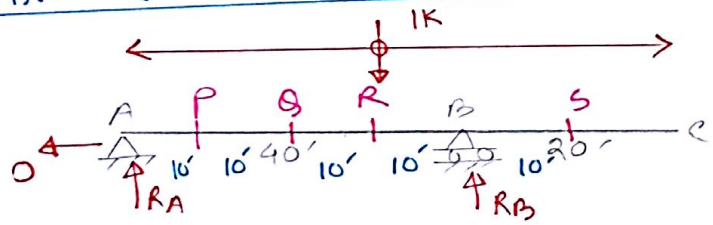
For design অর্থাৎ max^m নাগবে.
Max^m internal force for moving load এর জন্য influence line লাগবে.

(*) Influence lines are always drawn for unit load (1kg/1lb/1kip) usually working vertically downward. অর্থাৎ load vertically 3 move করতে পারে, then horizontally হবে.



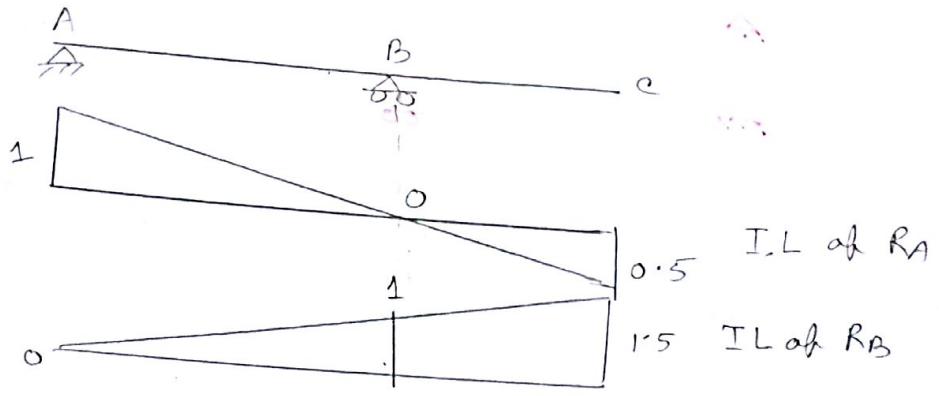
Influence line for reactions in Beams:

Beam:



Diff points এ unit load বসায়ে reaction বের plotting these করলে influence lines পাব

unit load at	R_A	R_B
A	1↑	0
P	0.75↑	0.25↑
Q	0.5↑	0.5↑
R	0.25↑	0.75↑
S	0.25↑↓	1.25↑
B	0	1↑
C	0.5↓	1.5↑



Influence line is a curve that shows variation of a function under moving load.

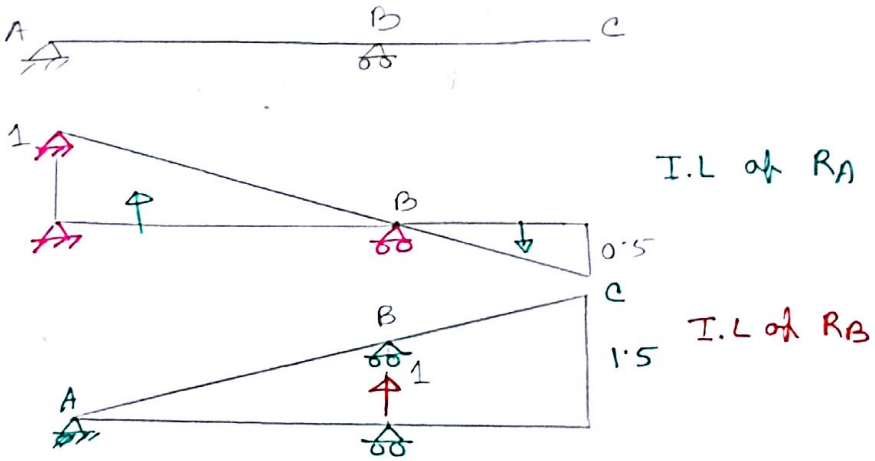
Drawing of I. line for R's in Beams:

Steps: 1. Push the support up by 1

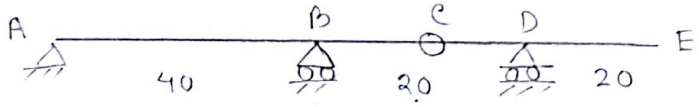
2. Draw the S-shape → is the I. line

3. complete the ordinates & direction (sign)

Beam 1

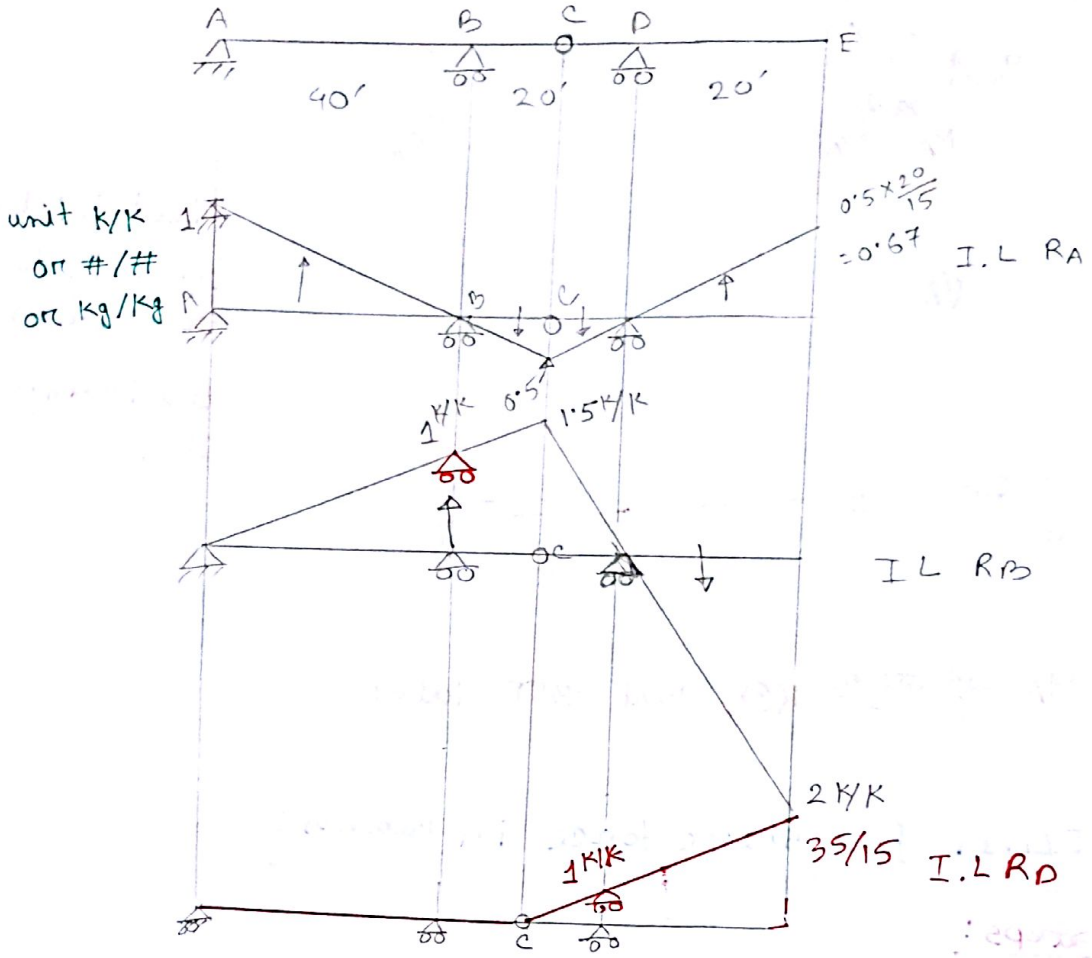


Beam 2:

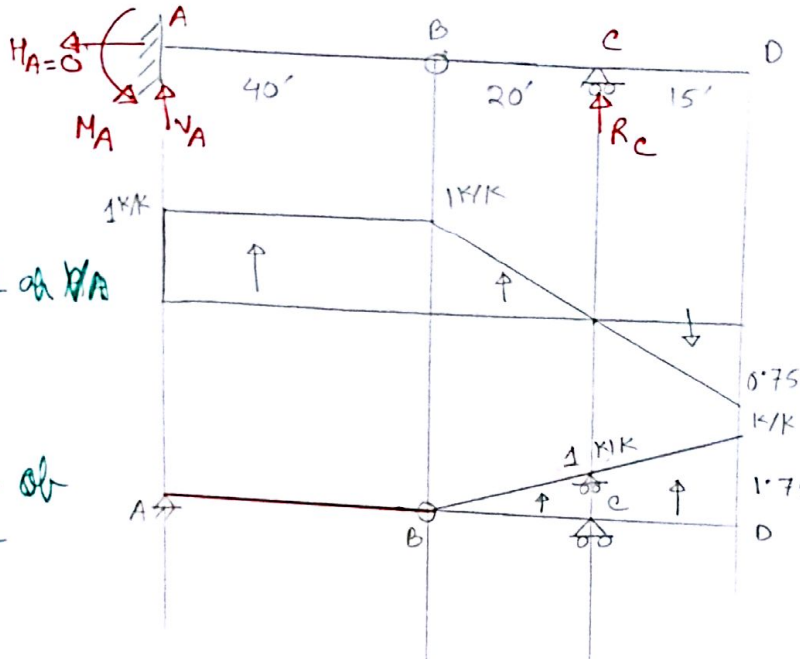


C hinge কোথে দিলে CE পড়ে যাবে cause ABC হল self stable section. So always ABC ধরে draw করতে হবে।

মাঝে hinge থাকে, so 2টা st. lines. So IL ও হবে combination of 2 st. lines.


A
B
C
D
E
40'
20'
20'
unit K/K
or #/#
or Kg/Kg
1
A
B
C
0.5 × 20/15
= 0.67
I.L RA
1 K/K
0.5
1.5 K/K
I L RB
2 K/K
35/15
I.L RD
1 K/K
C

Beam 3



Here AB is self stable. So Draw this 1st.

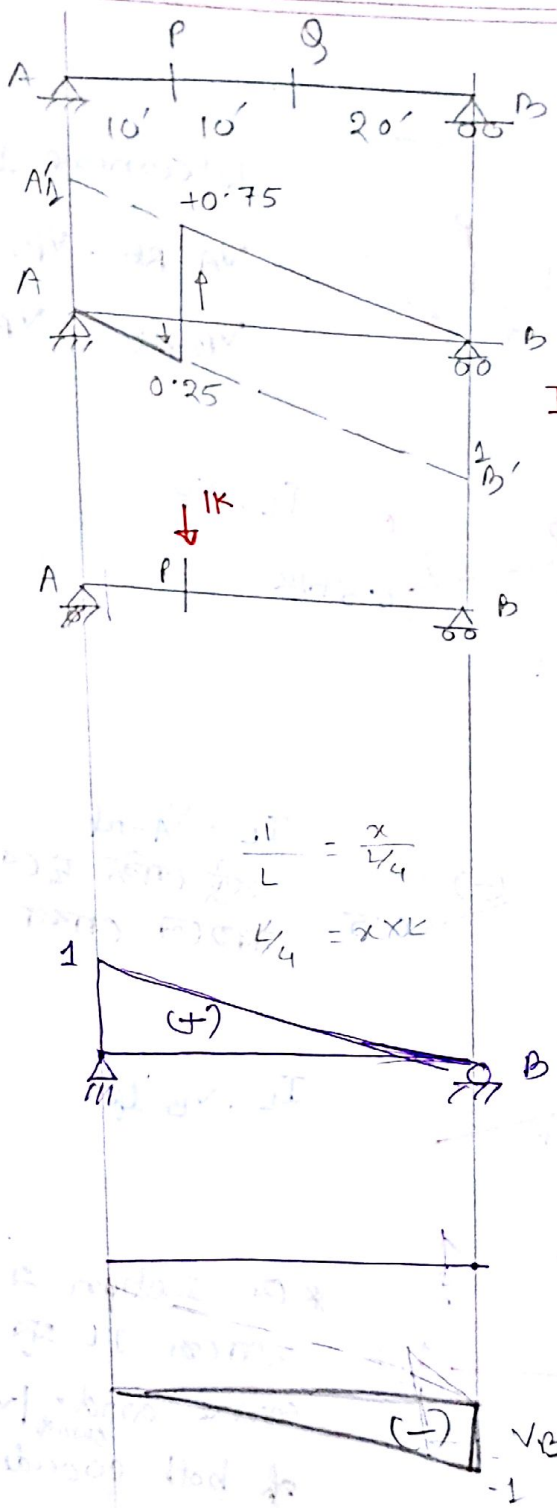
Fixed joint এ joint ⊥ Beam. 90° relation maintained. But in hinge এমন না,

M_A এর মানও হবে, But ওটা later.

I.Liner for Shear force in Beams:

Steps:

1. Cut at the section X
2. Push the left part down and right part up
3. Draw the S-shape - is the I.L
4. Put the ordinate & sign

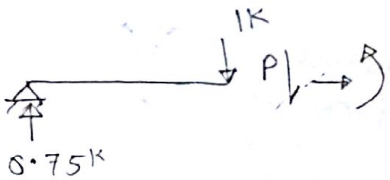


Shear force on exact support এর বেলা can't calculate. তাই A, B কে left right বলা,

I.L of $V_{A\,rt}$, $V_{B\text{-}lft}$, V_P, V_Q

Slope of AB' & A'B always 0 to 1

যে ordinate বের করতে চাই তার বেলা 1K load বসাব But actually 0·25 slightly on left and 0·75 " to right of P.



$\Sigma F_y = 0 \Rightarrow 0.75 - 1 + y = 0$

$\Rightarrow y = -0.25^K$

$\frac{1}{40} = \frac{x}{30}$

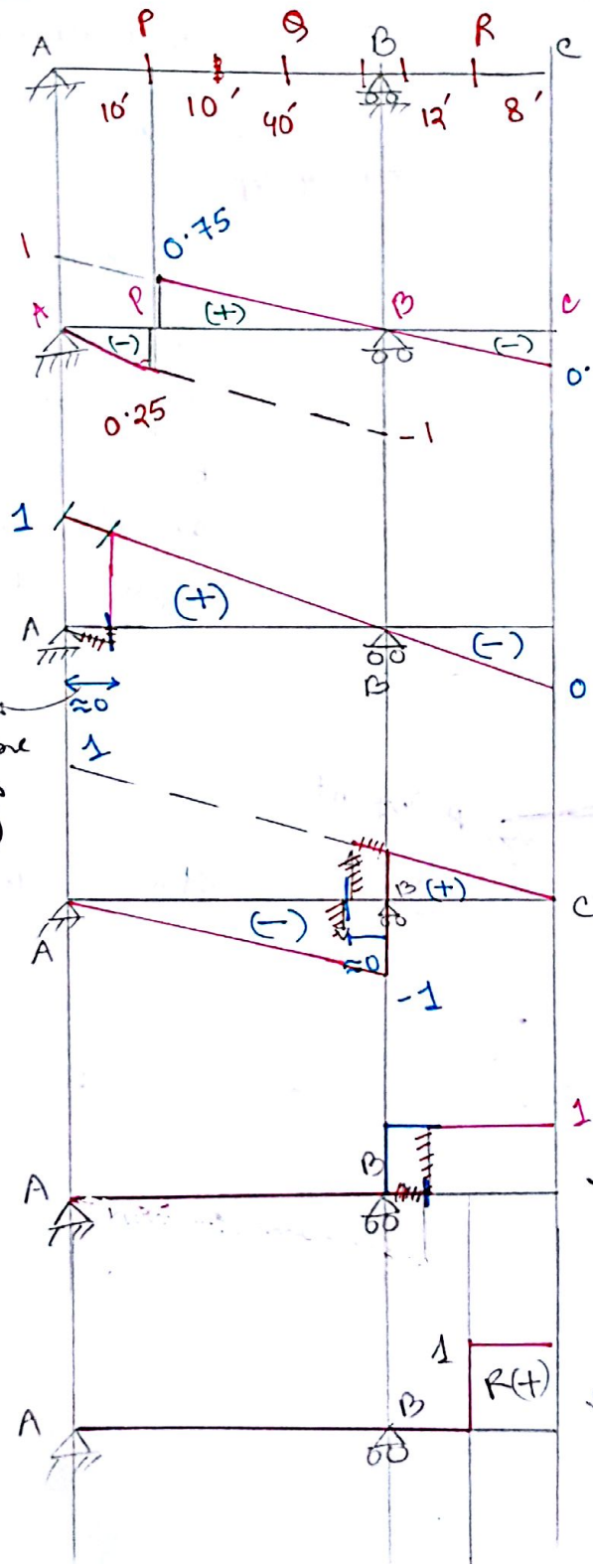
$\frac{1 \times 10}{40} = x_B$

$= 0.25$

3.10.15
Saturday

Lec - 4

Beam 2:



Determine I.L for

$V_{A\text{-}Rt}$, V_P, V_Q, $V_{B\text{-}lf}$

$V_{B\text{-}Rt}$, V_R

$I_L \cdot V_P$

$I_L - V_{A\text{-}Rt}$

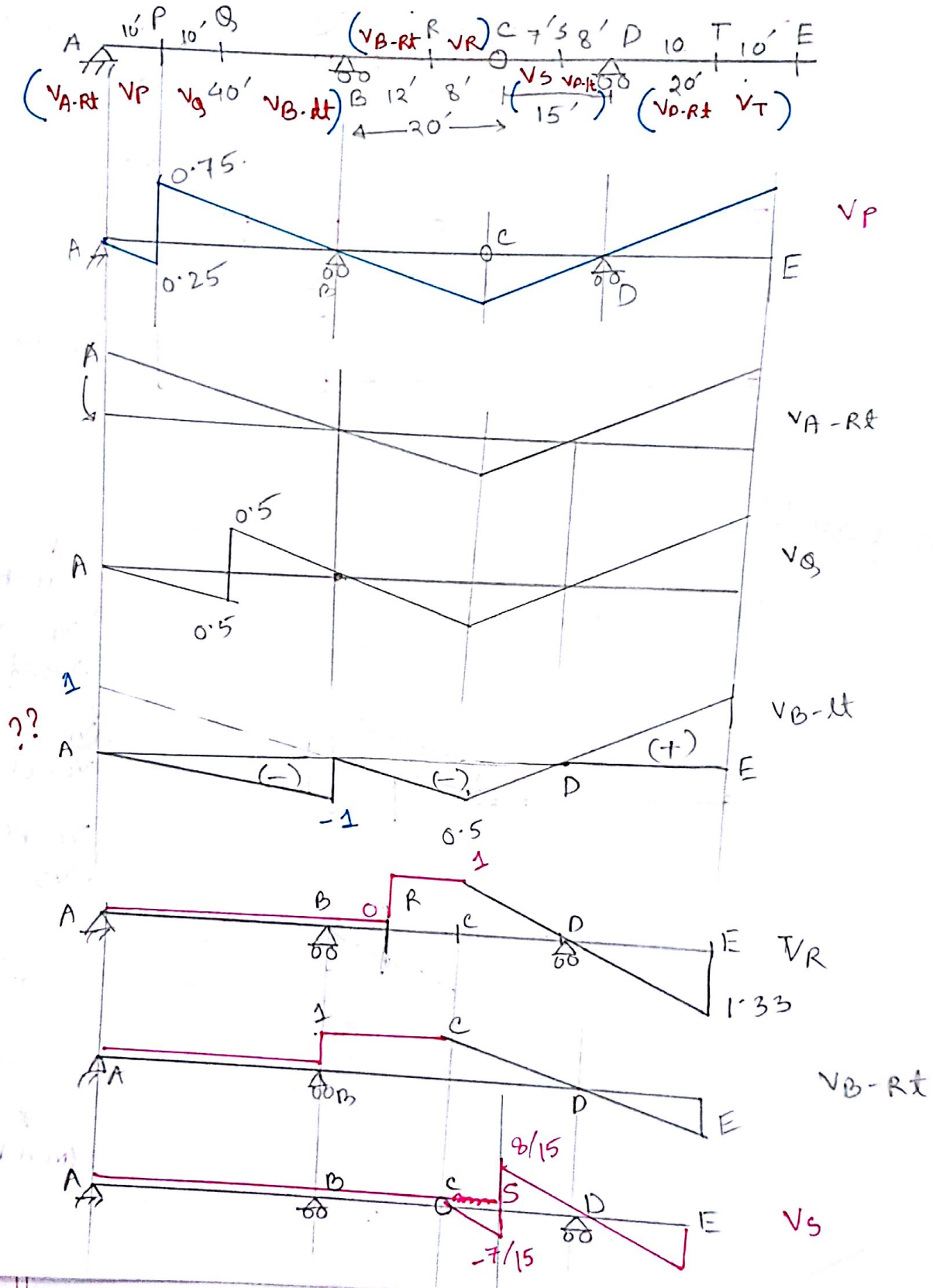
একটু বেশি দূরে কাটব, নাহলে বোঝা যায় না

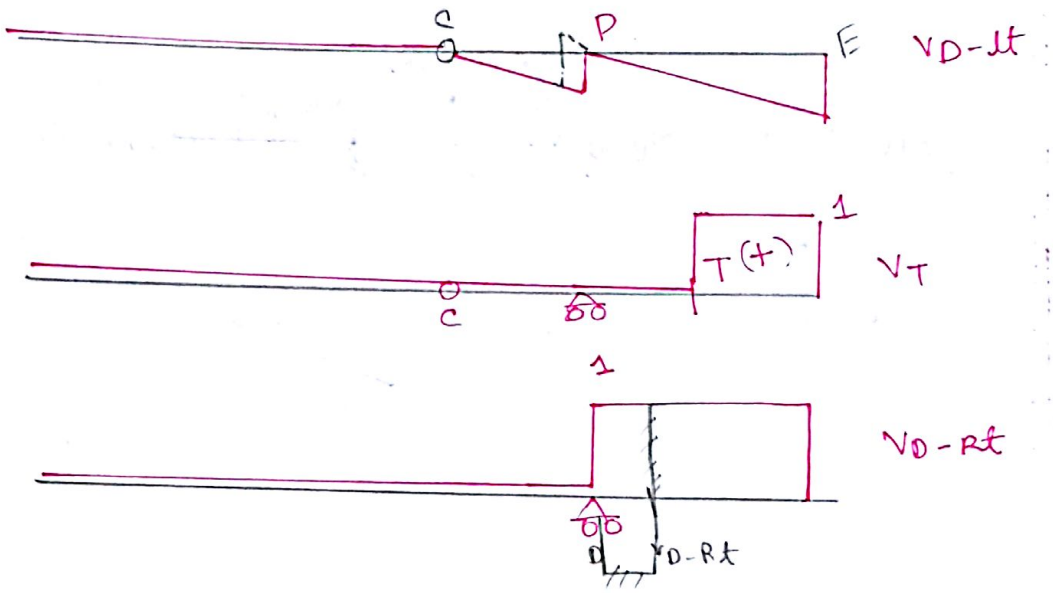
এই distance 0 হওয়ায় নিচের line হবে না, sb উপরে adjusted (red)

$I_L \cdot V_{B\text{-}lf}$

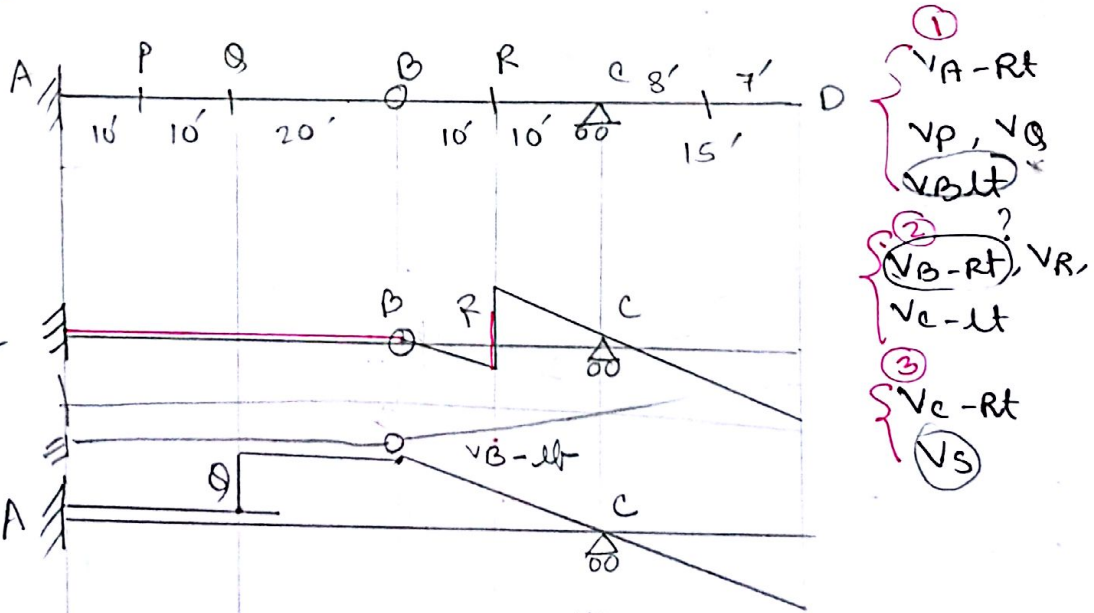
* যে section এ কাটব, সেখানে IL এর slope same and sum of value of both coordinates = 1.

Beam 3:

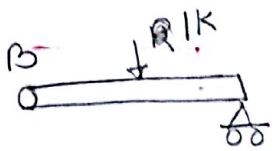

A 10' P 10' Q (VB-Rt R VR) C 7'5 8' D 10 T 10' E
(VA-Rt VP VQ 40' VB-Lt) B 12' 8' (VS VR-Lt 15') 20' (VD-Rt VT)
20'
0.75
0.25
VP
A
B
C
D
E
VA-Rt
0.5
0.5
VQ
1
??
(−)
(−)
(+)
-1
0.5
VB-Lt
1
1.33
VR
1
8/15
-7/15
VS
VB-Rt



Beam 4:



For reaction of RC



$\Sigma M_B = 0$

$1 \times 10 = R_C \times 20$

$\therefore R_C = 0.5$ ✱

(Next Pg)

6.10.15
Tuesday

Lec - 5

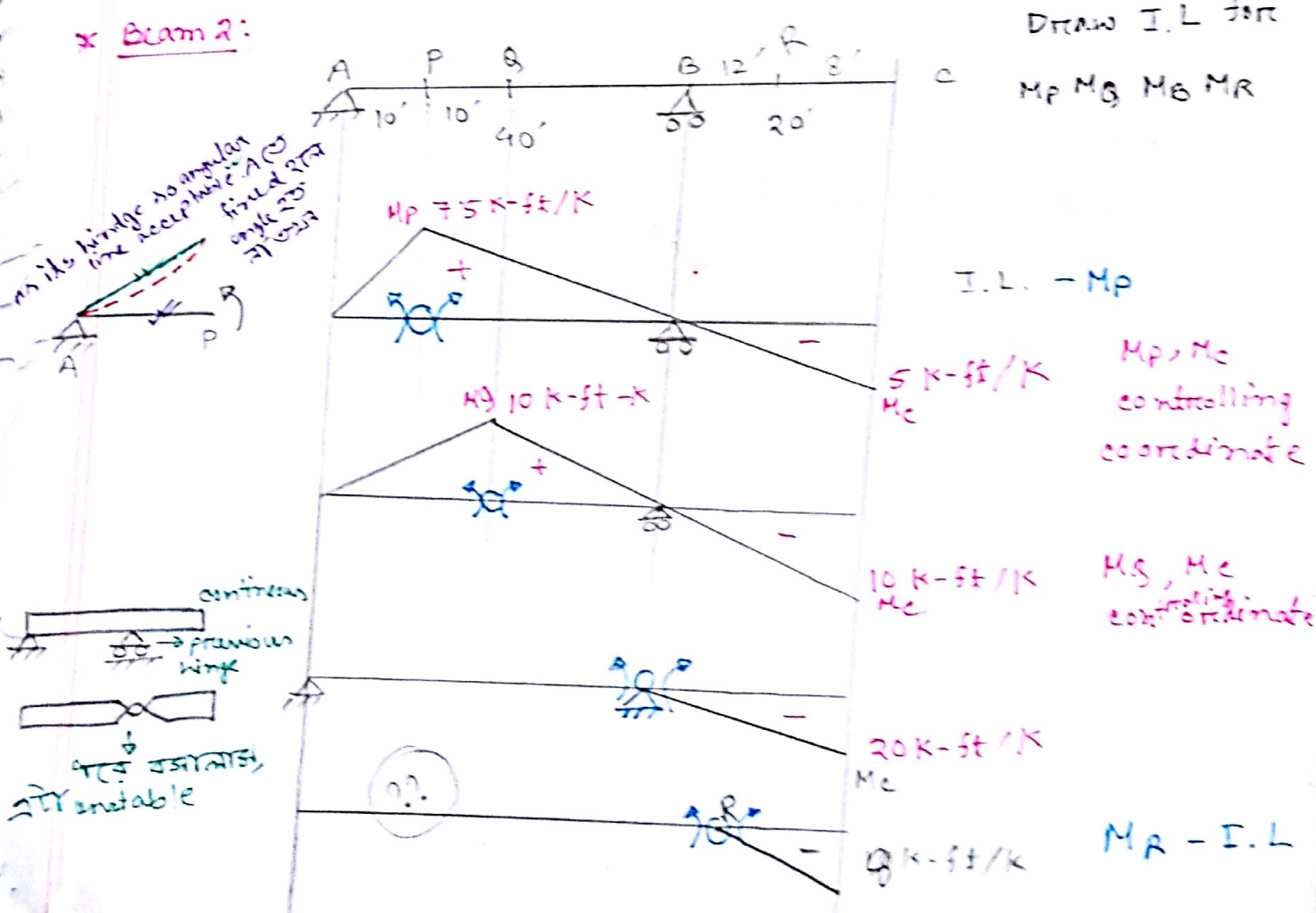
I.L for bending B. moment in Beams:

* **Steps (for I line M_x):** একটা ordinate এর মান বের করার calculation করার

1) Put a hinge at x
2) apply B. Moments (↺ o ↻) around the hinge
3) Draw a δ shape
4) Find the ordinates

* **Beam 2:**

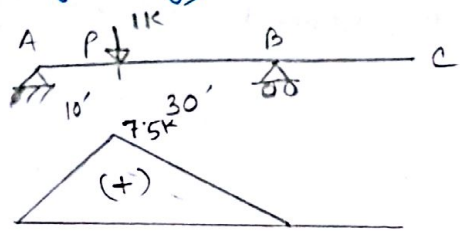
Draw I.L for M_P M_Q M_B M_R



For M_P:

Find ord at P:

Put ↓1K load at P in the original Beam and Find M_P. (Hinge বসালে unstable হয়, but it's not calculated cause এটা imaginary)



Reactions then moment at section P.

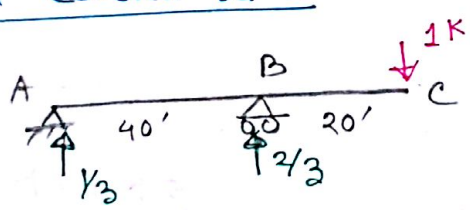
① বসাতে section at P

② then ঐ portion এর reaction

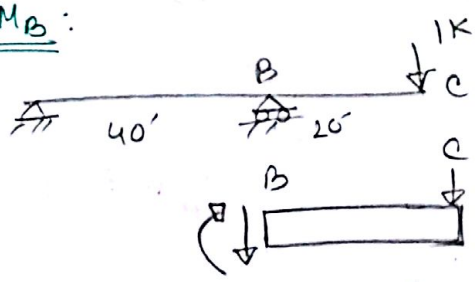
③ Moment of P

For M_B:

Find co-ord at C:



For M_B:

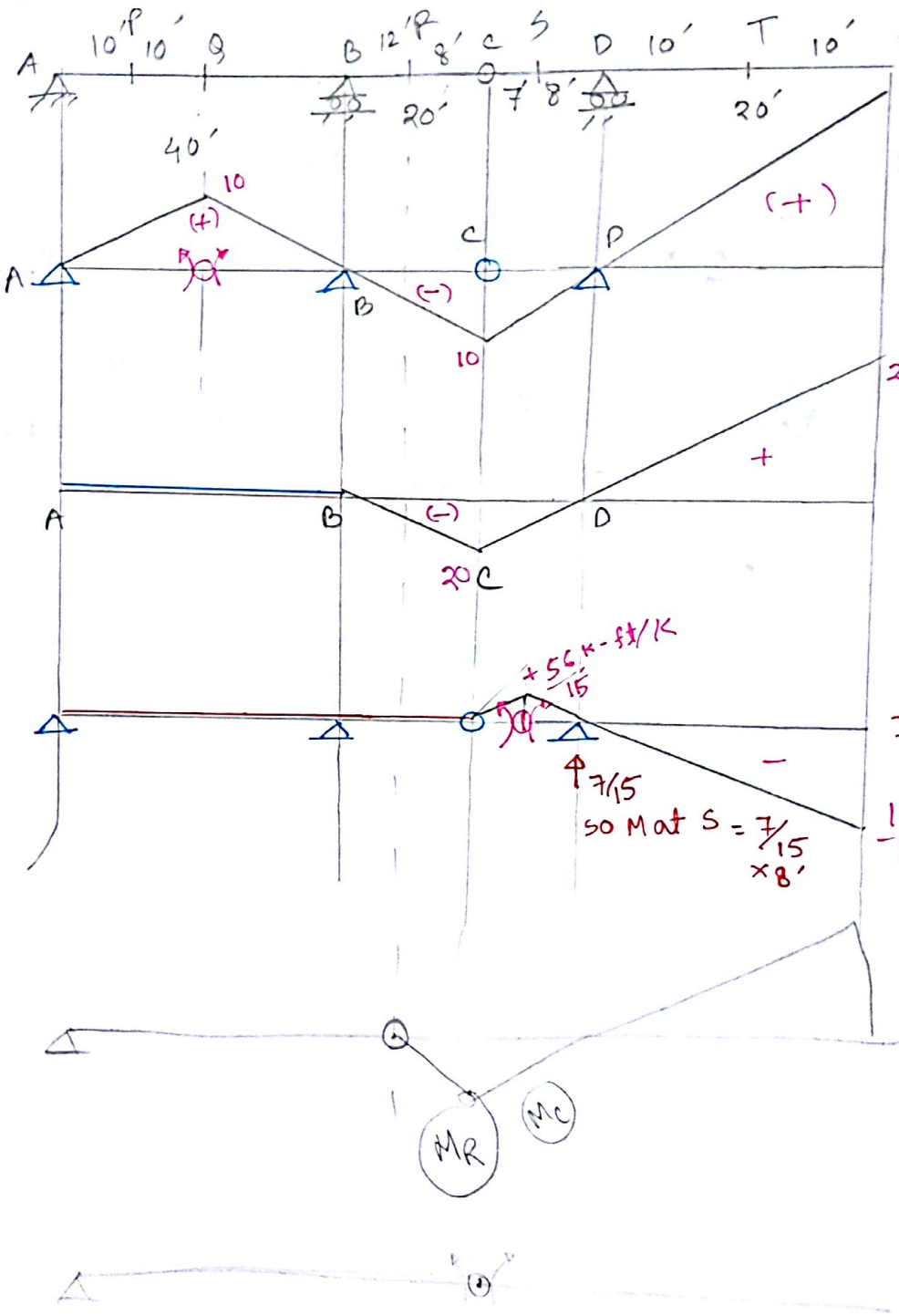


$M_B + 1 \times 20 = 0$

$\therefore M_B = -20$ k-ft

Beam 3:

Draw M_P, M_Q, M_B, M_R, M_S, M_D, M_T



13.33 K-ft/K

I.L. - M_Q

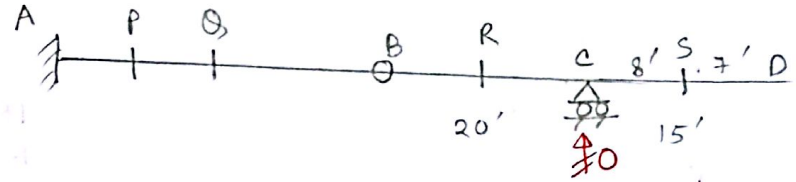
25.67 K-ft/K

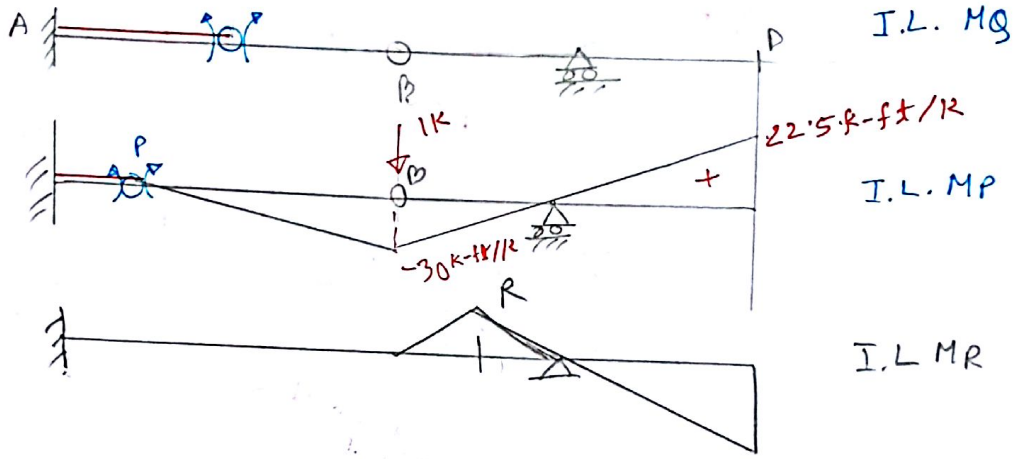
I.L. - M_B

I.L. - M_S

$\frac{140}{15}$ K-ft/K

Beam 4:





10.10.15
Saturday

Lec-6

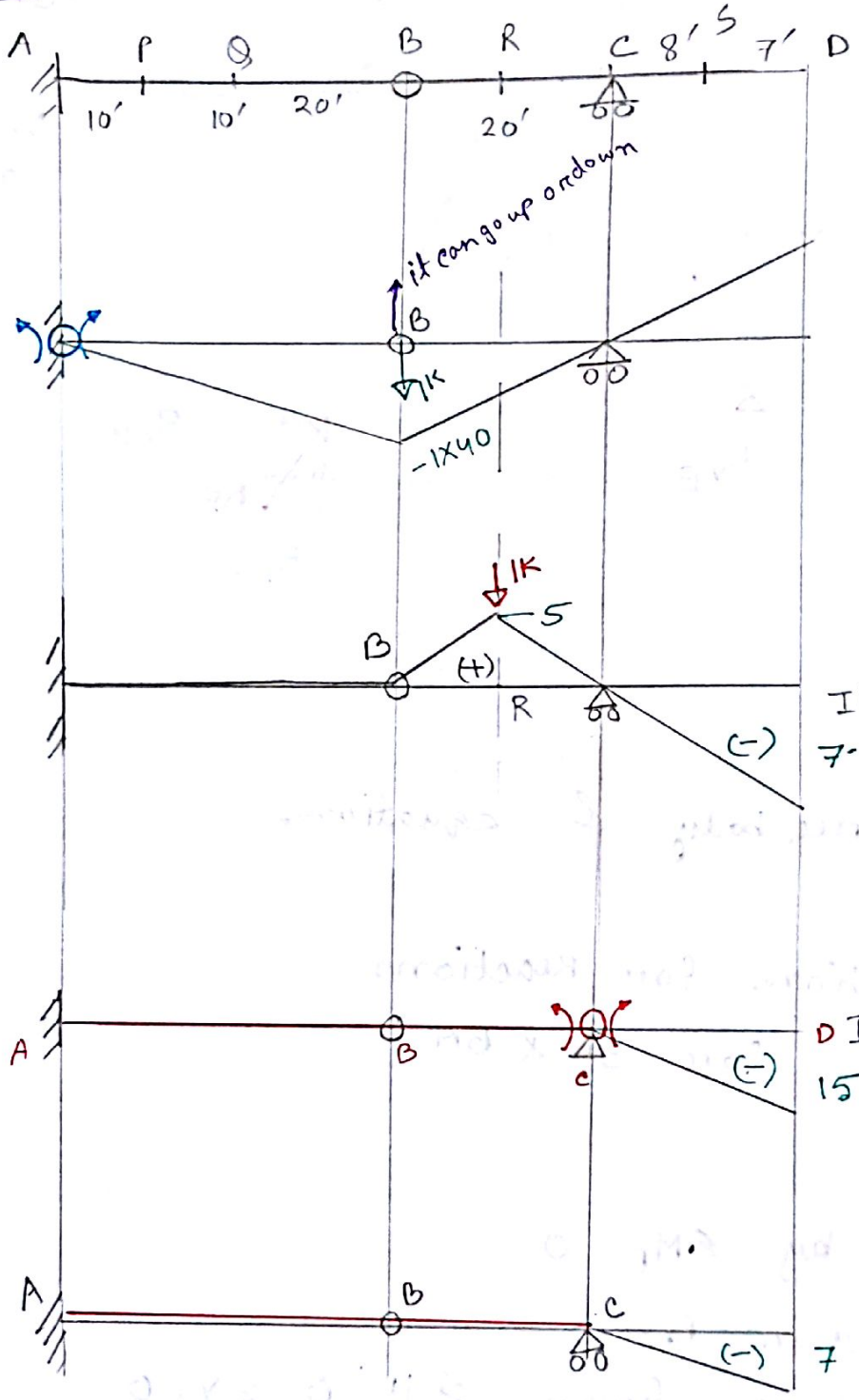
Beam 4:

Draw I.L

M_A, M_P, M_Q

M_R

M_C M_S

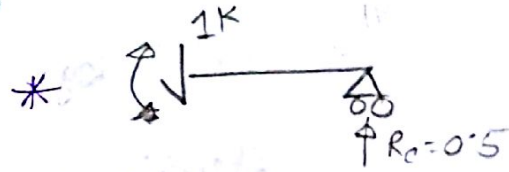


I.L M_A

putting 1K at B find M_A (taking the ~~right~~ left side)

$R_C = 0$ ~~and~~ from right portion

IL – M_R putting 1K at R, find M_R.



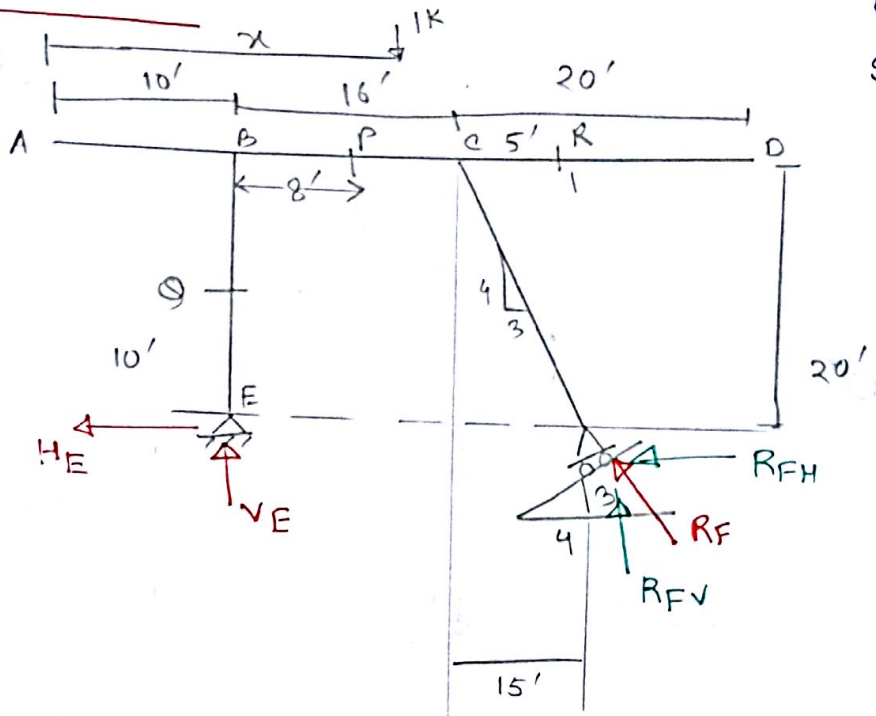
$\therefore M_R = R_C \times 10 = 5$

D I.L M_C

IL – M_S

I.L of frames:

Draw I.L, SF & BM at P, Q, R Unit load moves A to D



Soln: By free body & equations

Steps:

1) Find Equations for Reactions
2) Find " for SF & BM

Reactions:

1) Find R_{FV} by $\Sigma M_E = 0$
2) Then R_{FH} from R_{FV}
3) Find V_E & H_E from $\Sigma H = 0$ $\Sigma V = 0$

⇓

or from $\Sigma M_F = 0$

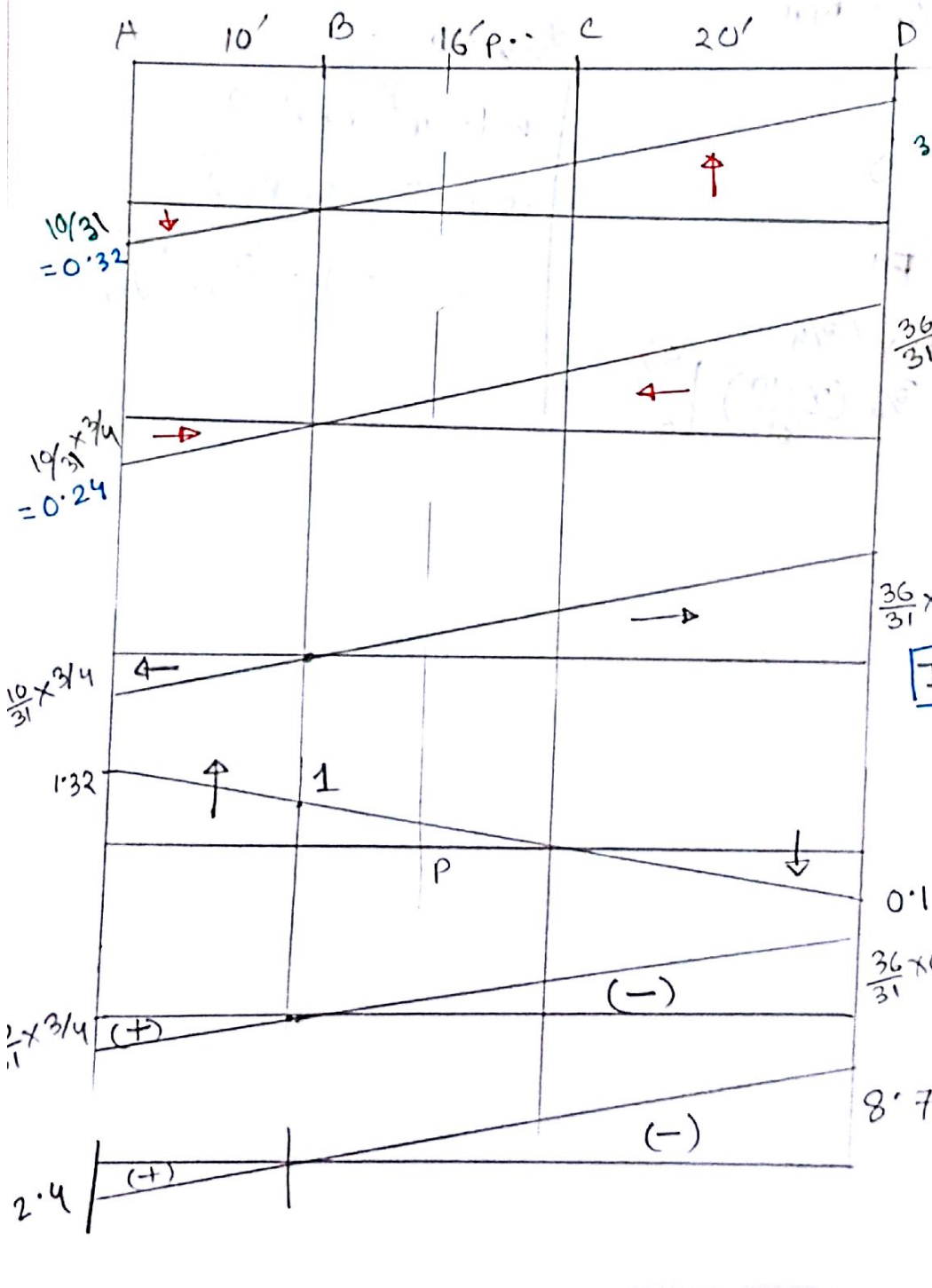
R_{FV} : $\Sigma M_E = 0$

$\Rightarrow 1 \times (x-10) - R_{FV} \times 31 = 0$

$\Rightarrow R_{FV} = \frac{x-10}{31}$ | $x = 46$ at D, $x = 0$ at A

$= \ominus 10/31$ at A and $\oplus \frac{36}{31}$ at D

$R_{FH} = R_{FV} \times \frac{3}{4}$



$36/31$

I L – R_{FV}

$\frac{36}{31} \times 3/4$ (2 digit after decimal enough)

I. L – R_{HF}

(R_{VH} ↑ ⇒ R_{FH} ←

R_{VH} ↓ " R_{FH} →)

$\frac{36}{31} \times 3/4$

I.L – R_{HE}

IL for V_E

0·16

$\frac{36}{31} \times 0.75$ I.L for V_G

8·7 IL for M_G

* decimal I লিখবে, not fraction

$\leq V = 0$ at A

$\Rightarrow V_E + \left(-\frac{10}{31}\right) - 1 = 0$

$\therefore V_E = \frac{41}{31} \uparrow$

$\leq V = 0$ at D

$\Rightarrow V_E + \frac{36}{31} - 1 = 0$

$\therefore V_E = -5/31$

$\leq F_H = 0 \Rightarrow H_E = \frac{10}{31} \times 3/4$ at A (+)

at D $\Rightarrow H_E = -\frac{36}{31} \times 3/4$

$\therefore H_E = -$

If $R_{FV} \uparrow * 3/4 = R_{FH} \leftarrow$

$\leq F_H = 0$

$\Rightarrow H_E \leftarrow + R_{FH} \leftarrow = 0$

$\therefore H_E \leftarrow = - R_{FH} \leftarrow$

$= \ominus R_{FV} \times 3/4$

$= -3/4 \left(\frac{x-10}{31}\right) \Big|_0^{46}$

$\leq V = 0$

$\Rightarrow 1 - V_E \uparrow - R_{FV} \uparrow = 0$

$\Rightarrow V_E \uparrow = 1 - R_{FV} \uparrow$

$= 1 - \left(\frac{x-10}{31}\right)_0^{46}$

13.10.15
Tuesday

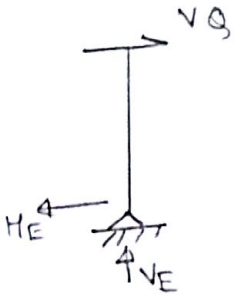
Lecture - 07

continued from last lecture:

$$R_{FV} = \frac{(x-10)}{31} \Big|_{x=0 \text{ at } A}^{x=46 \text{ at } D}$$

IL for SF & BM:

SF at Q: Take section at Q and take the lower portion



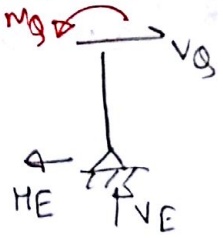
$V_Q = \overleftarrow{H_E}$

* positive (-ve) এর theory এর জন্য column কে ঘুরায় beam. এভাবে যাবার যেন lower part left হয়.

* এখানে $H_E \uparrow$, so left side goes up so shear force (+ve)

$\therefore V_Q \overset{(+)}{=} \overleftarrow{H_E}$

Moment at Q:



$M_Q \overset{(+)}{=} \overleftarrow{H_E} \times 10$

[Bending moment due to upward force is positive)

As $H_E \uparrow$ so M_Q (+ve)

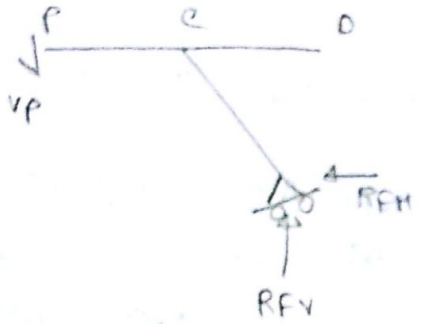
IL for SF & BM at P:

[This problem unit load moving so take 2 portions]

Unit load A to P

Unit load P to D

V_P =



(*) Right up ↑ so left down ↓ so shear force (-ve)

$\therefore V_P^{(-)} = R_{FV}\uparrow$

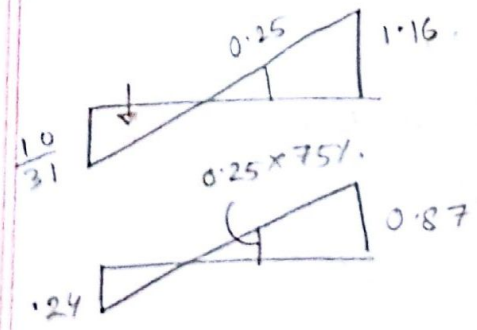
$M_P = (+)R_{FV}\uparrow \times (15+8) \; (-)R_{FH}^{(4-)} \times 20$

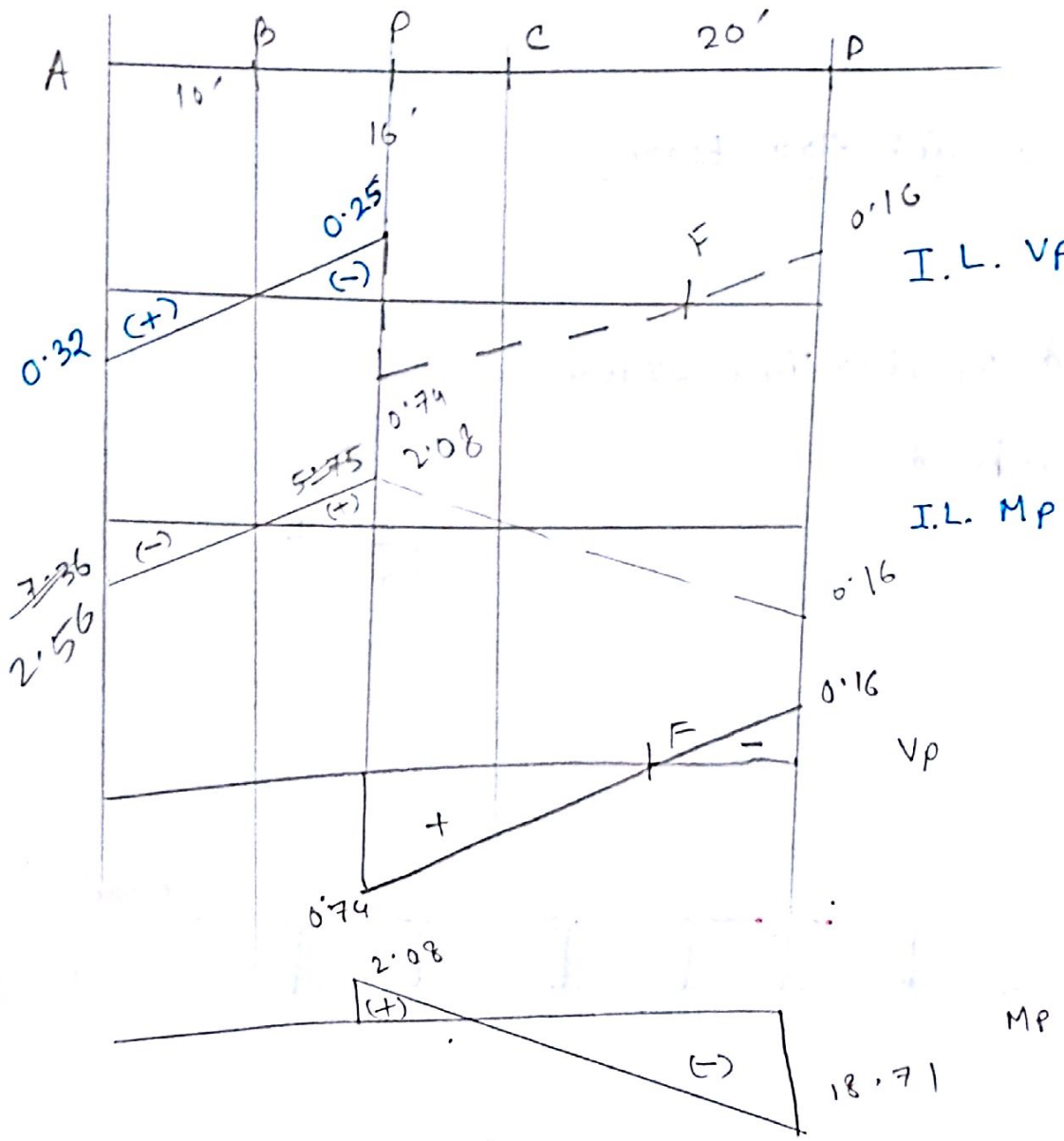
as $R_{FV}\uparrow$

$\Rightarrow M_P = (+)23\left(\frac{x-10}{31}\right)\Big|_{x=0}^{x=46}$

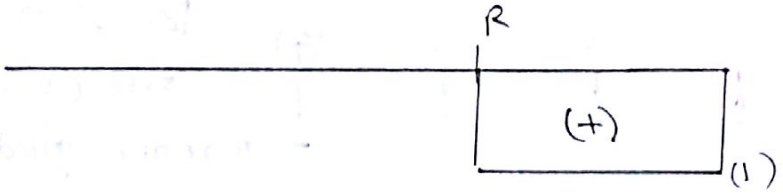
$(-)20 \times 0.75\left(\frac{x-10}{31}\right)\Big|_{10}^{46}$

$= (+)8\left(\frac{x-10}{31}\right)_0^{46}$

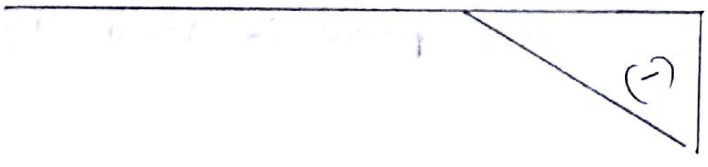




combine the two parts for Vp & Mp



VR from 11, 12



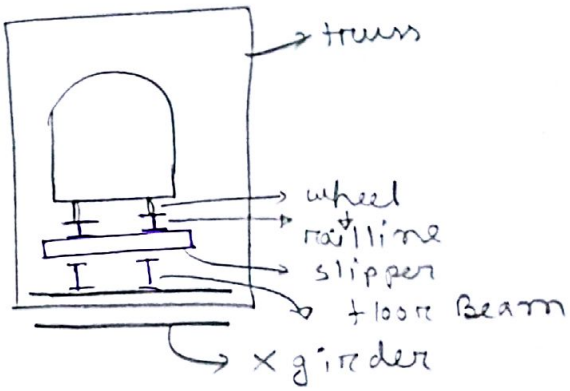
MR from 11, 12

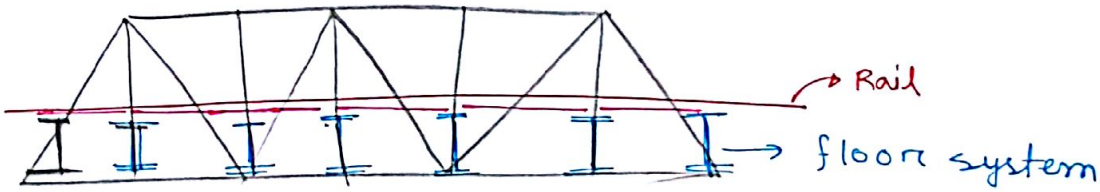
31.10.15
Saturday

Lec-8

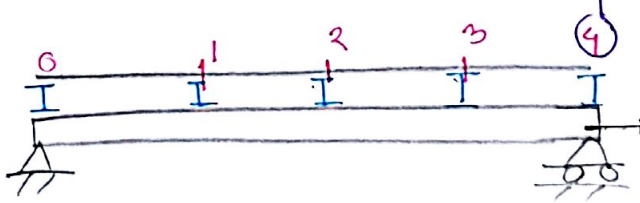
Truss with floor Beam:

Load wheel → line বরাবর transfered.





I Line for Girder with floor Beams



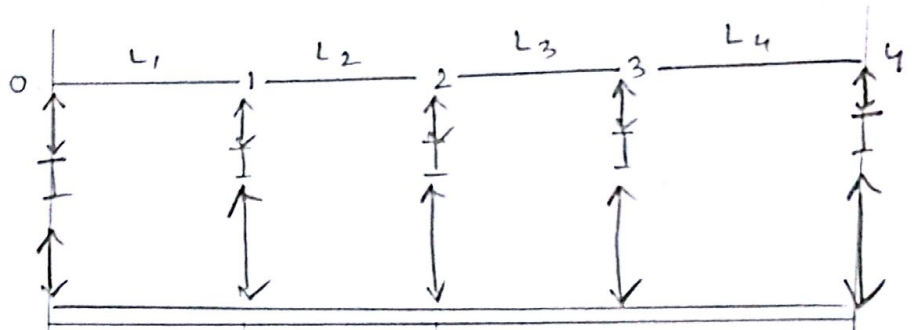
যে 2 টা জায়গায় load বরাবর না, joint এ, main girder, so SF, BM এর হবে

panel points ছাড়া অন্য point এ load পড়বে না।

7.11.15
Saturday

Lec - 09

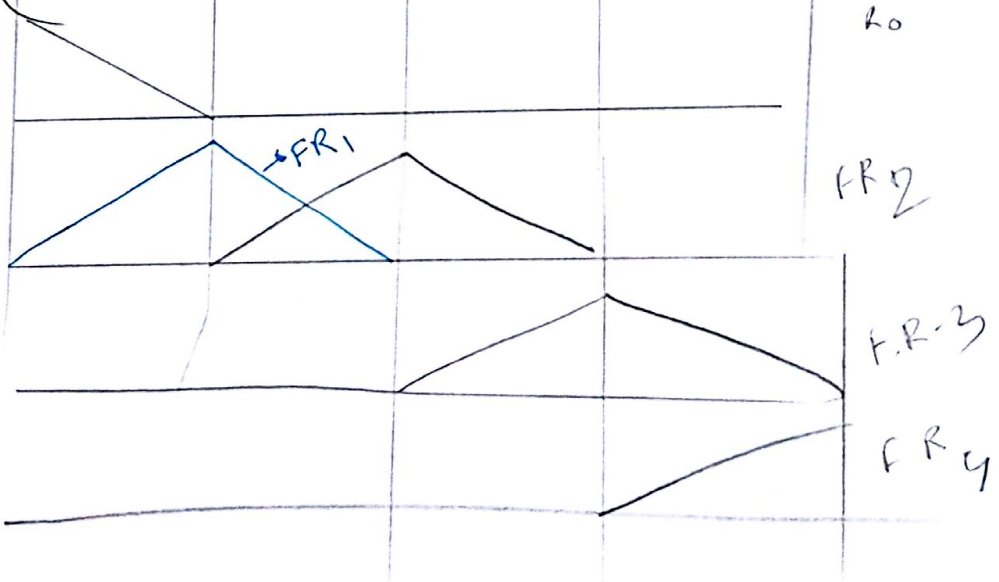
Freebody:



Draw. I. Lines:

1. FBR's
2. R_0 & R_4
3. SF
4. BM at PP's

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



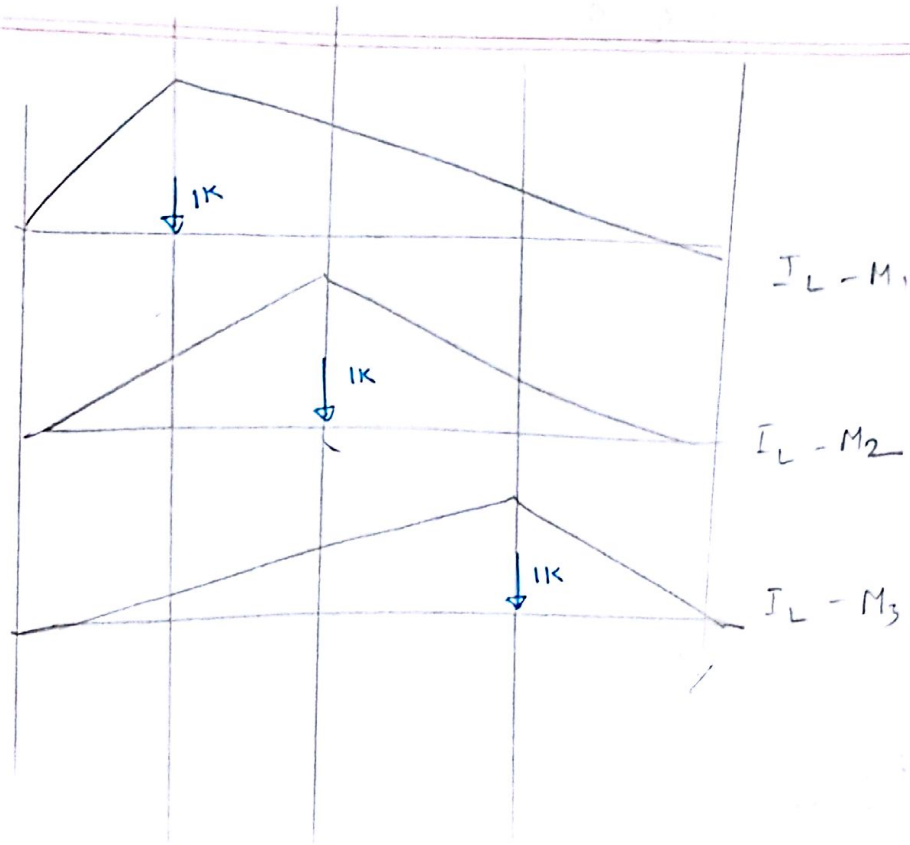


Fig 145/ P-264 /shedd & vaulter

10.11.15
Tuesday

Lec -10

IL for truss members:

- A Bridge Truss is fitted with a floor systems either at the Bottom chord level (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 Line load.

- Force in a member of Truss is calculated either by freebody of a joint, or freebody of a part of truss after taking a section. (i.e. joint or section method as usual) while the truss is acted upon by only the Floor Beam Reactions.

STEPS:

*) Find the shape of IL applying truss Analysis by joint / section method.

*) Then find the controlling ordinates by truss analysis for specific position of unit load.

1. Top Chord (TC) members

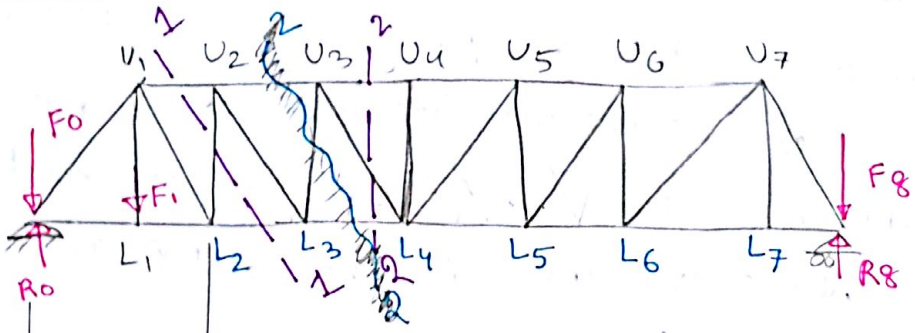
2. Bottom " "

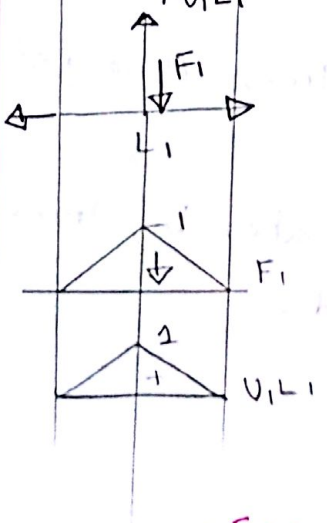
3. Verticle Web " "

4. Inclined " " "

3. V. web members:

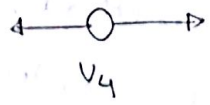
V_1L_1 : at L_1, $\Sigma V = 0$





$\Sigma V = 0 \quad FV_1L_1 \overset{(+)}{=} F_1 \downarrow$

Similarly : $V_7L_7 \overset{(+)}{=} F_7 \downarrow$ (joint L_7)

$V_4L_4 =$  0

V_2L_2 : Inclined Sec : Through L_2-L_3

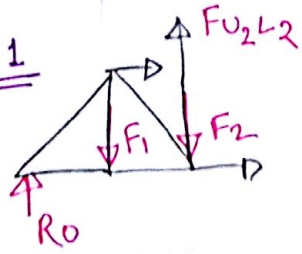
consider left part

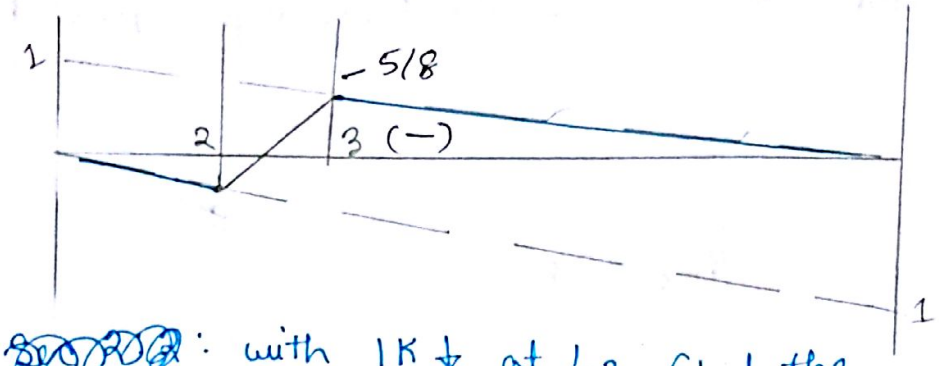
$\Sigma V = 0 = R_0 - F_0 - F_1 - F_2 + FV_2L_2$

$FV_2L_2 = -(R_0 - F_0 - F_1 - F_2)$

$= -V_{2-3}$

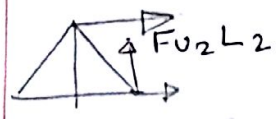
1-1





$V_2 - 3$

To find ordinates L_3 ⊙ unit load : with 1K ↓ at L_3 find the reaction $R_0 = 5/8$



$V_3 L_3 = V_{3-4}$

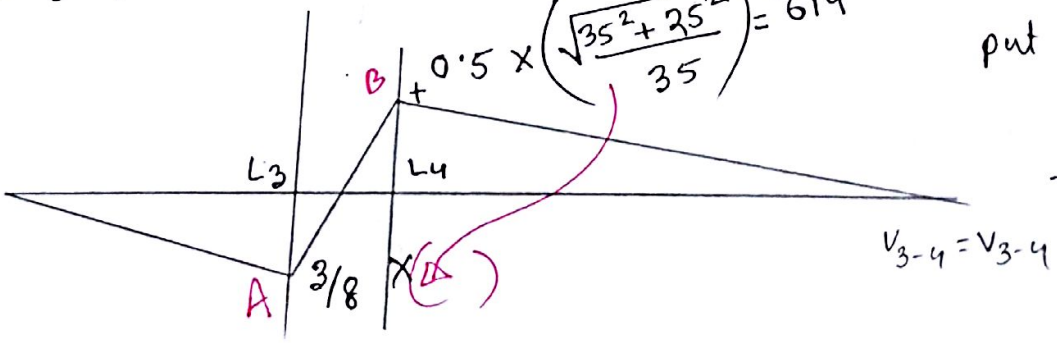
$V_5 L_5 =$

Inclined Web Members:

V_3L_4: verticle section Through 3-4 & (2-2)

$\leq V = 0$

$\therefore V_3L_4$ = would be like $V_3 - 4$



put unit load at L_4 then $R_0 = 0.5$

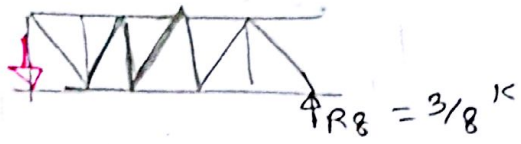
sec 2-2 ⊙ $\leq V_0 = 0$

$\Rightarrow 0.5 - Fv_3L_4 = 0$ $\quad \therefore Fv_3L_4 = 0.5$

this is verticle,

so inclined ⊙ $0.5 \times \frac{\sqrt{35^2+25^2}}{35}$

(A) এর co-ord থেকে L_3 এ 1K then right pard নিব,



U_1L_0 = V_{0-1}

U_1L_2 = V_{1-2}

U_2L_3 =

U_3L_4 =

U_5L_4 = v. section paring throgh L_4L_5

V_{4-5}

11 from irfan

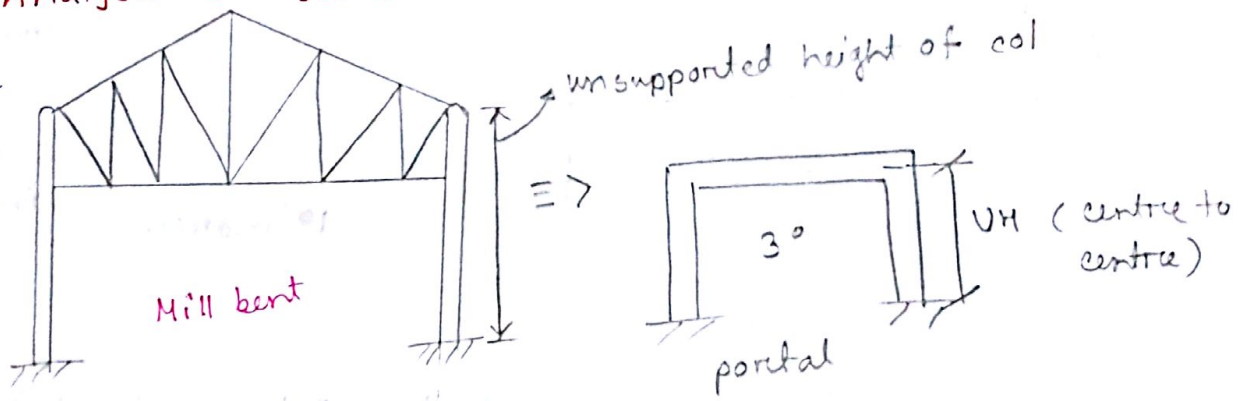
17.11.15
Tuesday

(*) Norris & Wiber & Vorter both (ಕನ್ನಡ)
↓
chapter 6-7

Lec-12

Approx Analysis of Indeterminate Structure:

1) Portals, Bridge " & Mill bents



Assumptions:

A) There is a hindge at the middle of **unsupported** **height** of each col → 2 eqn

B) Total lateral load is equally devided among two cols → 1 eqn
↓ At the level of hinges

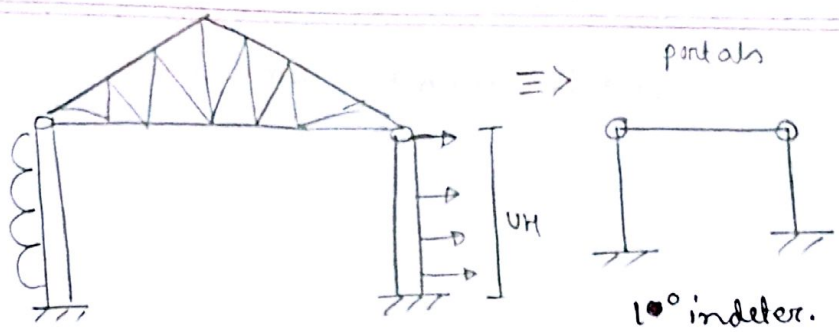
for 1° Indel — use B
2° — use A
3° — use A+B

Condition:

1. Portals, Mill Bents must be symmetric
for unsymmetric structures - have to use accurate methods.

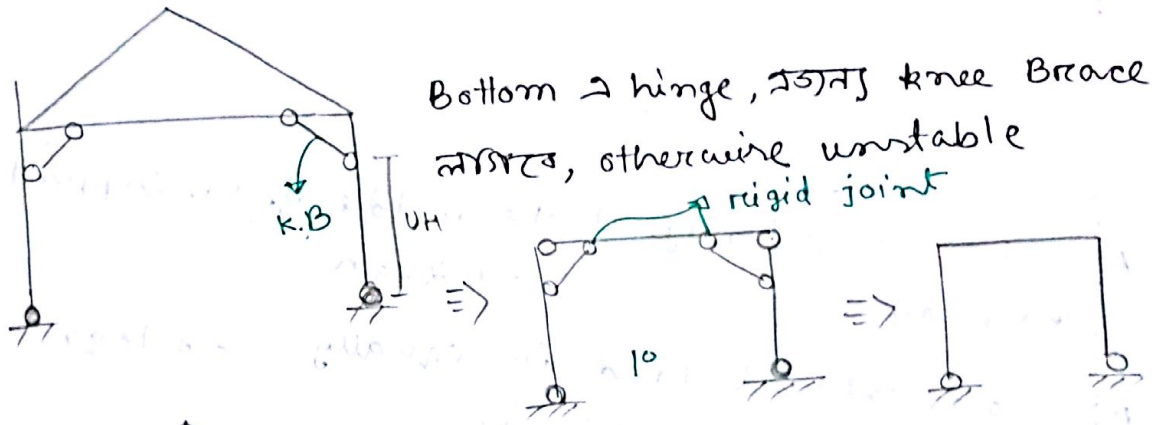
(*) Support ಎ hinge ಆದರೆ point of contraflexure ಆ point ಎ
" ಎ fixed " " " at mid point of UH.

A)



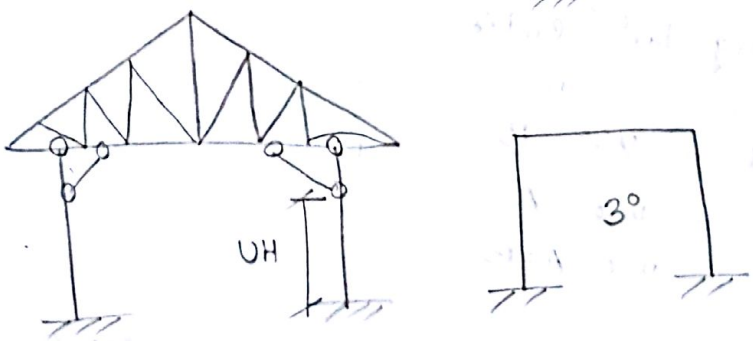
2 columns & Truss considered as beam. connected by hinge

B)

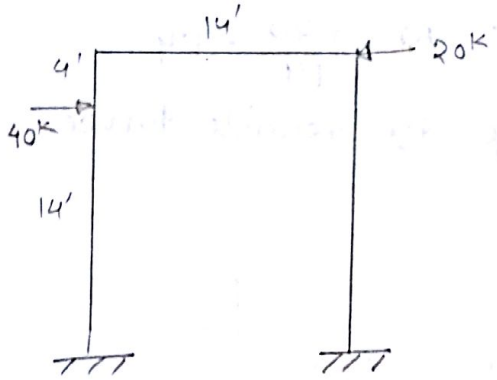


Bottom → hinge, ~~knee~~ knee Brace ~~नहीं~~, otherwise unstable

C)



Analysis Portal Frames:

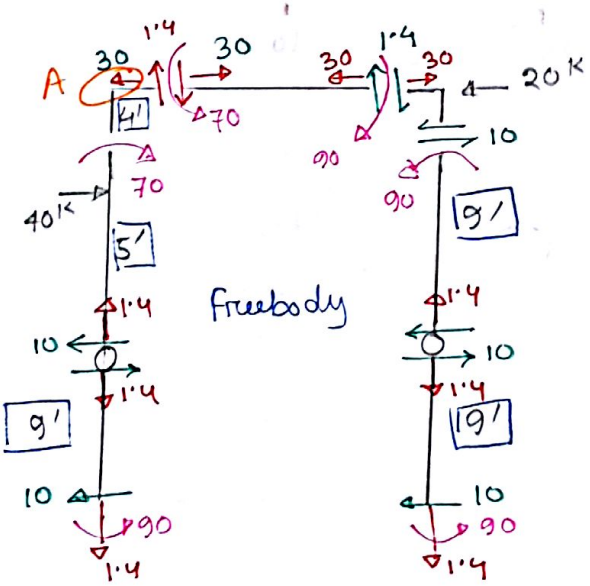


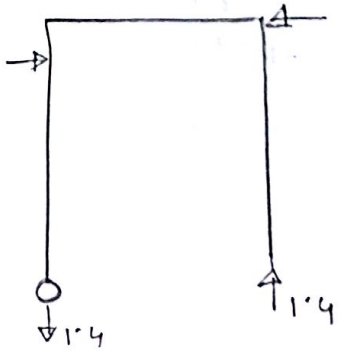
3° Indet

needs assumptions 1+2
= 3 eqns

Steps:

1) Find Indet
2) Apply Assump & find some forces
3) Apply freebody
4) Draw SF, BM, AF Digms





1st ⇒ assume 9' (mid height)

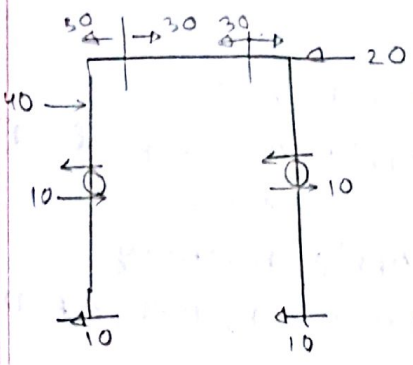
Lat force = 40 - 20 = 20 → (This will be equally devided in two colums

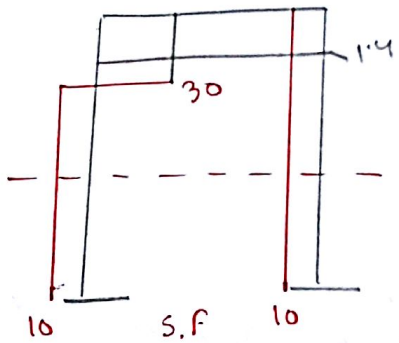
A joint can be ~~exhibitted~~ na caused কোন force নাই.

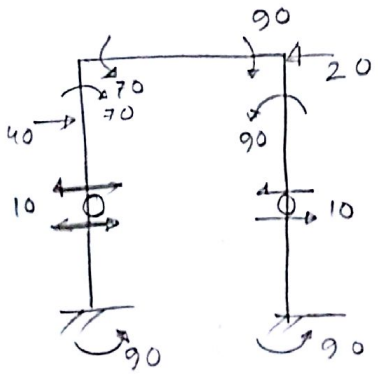
Hinge এ lateral force বের বাম্যর পর ΣM করলে axial force পাব, (considering upper part)

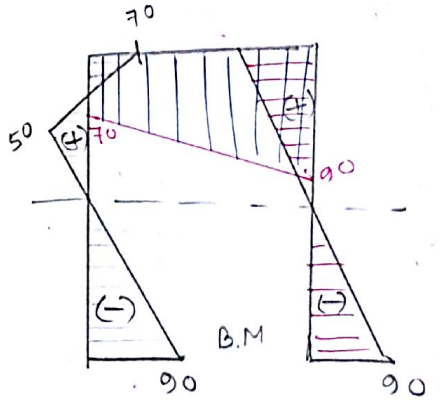
$40 \times 5 - 20 \times 9 = A_y \times 14 \quad \therefore A_y = +\frac{20}{14} = 1.4$

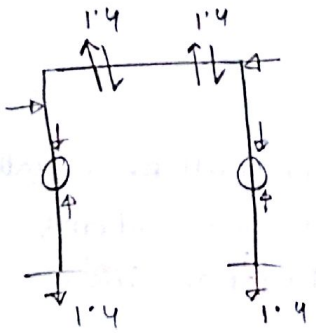
Then ΣV থেকে other hinge এর verticle force.

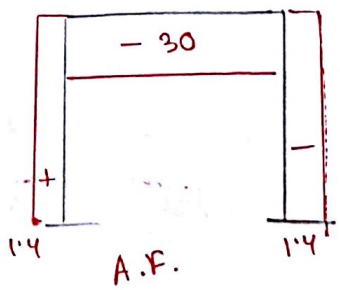




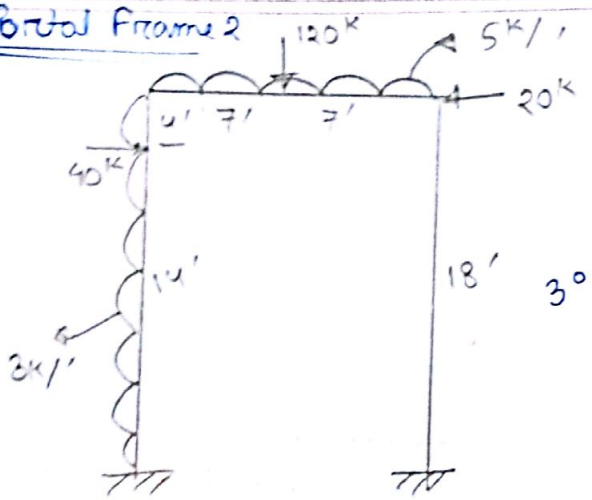








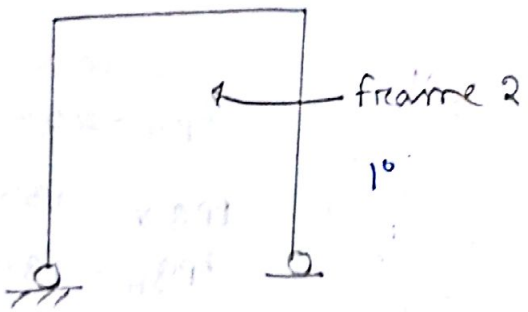
Portal Frame 2



use assumption A+B

Portal 3:

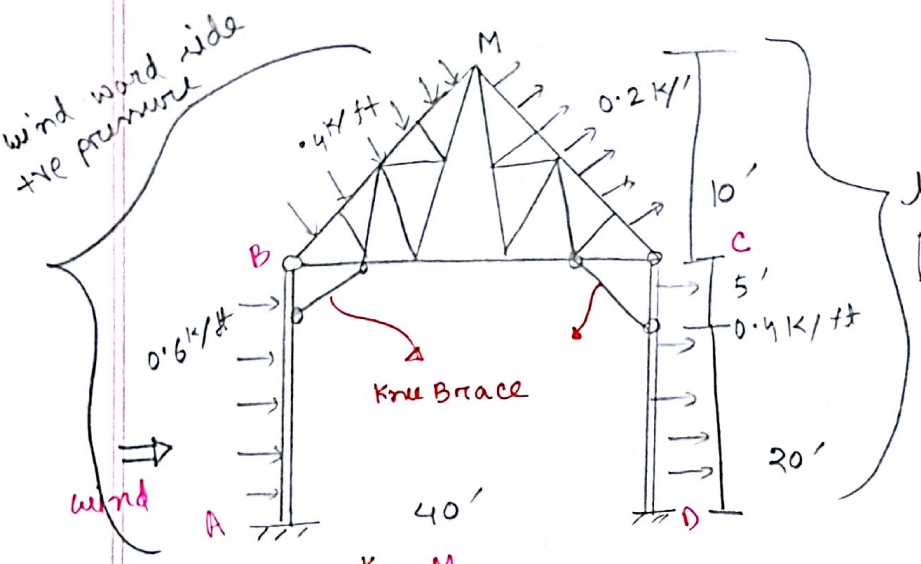
(Portal 2 with hinge support)

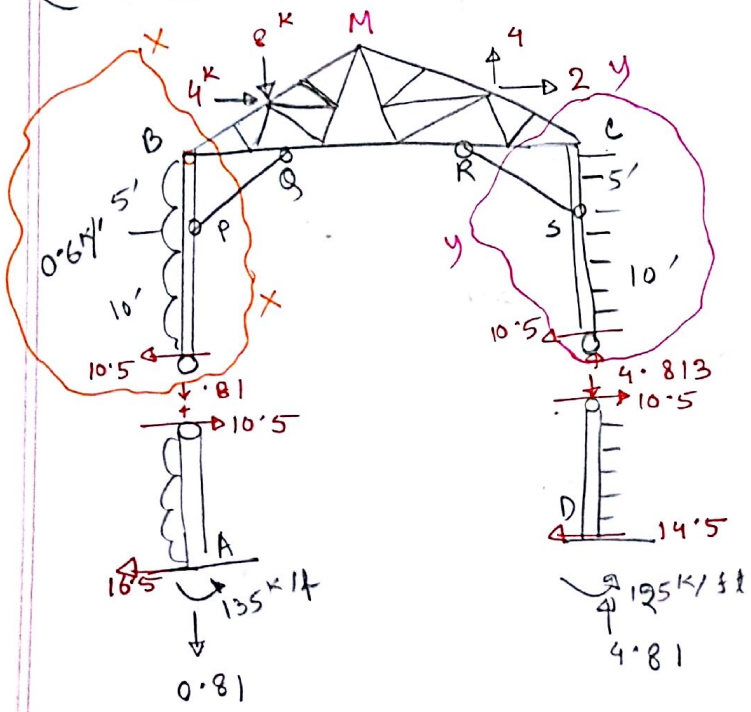


use assumption B

21.11.15
Saturday

Lec-13





(sec X-X and ΣM_B)

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

$F_{PQ_V} = 13.5$

$F_{PQ_H} = 18^K$

$F_{RS} = 28.13^K$ $\Sigma M_C = 0$ (sec-Y-Y)

$\Rightarrow$ H = 22.5

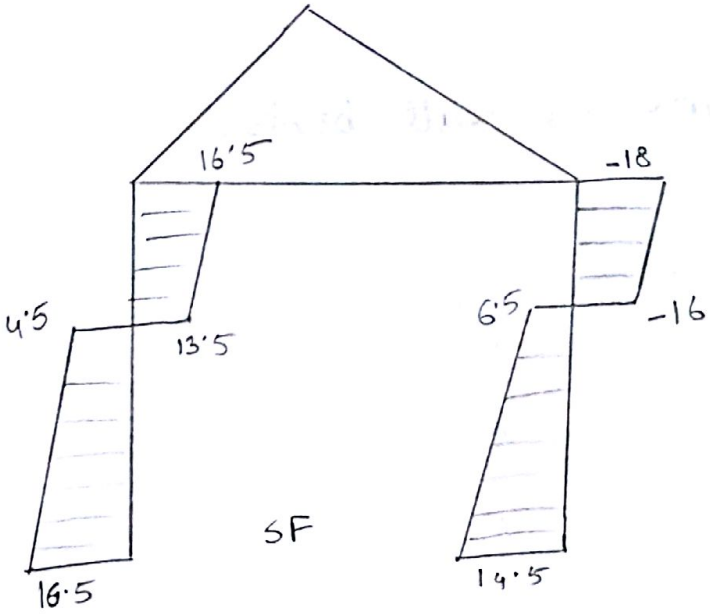
$\Rightarrow$ V = 16.88

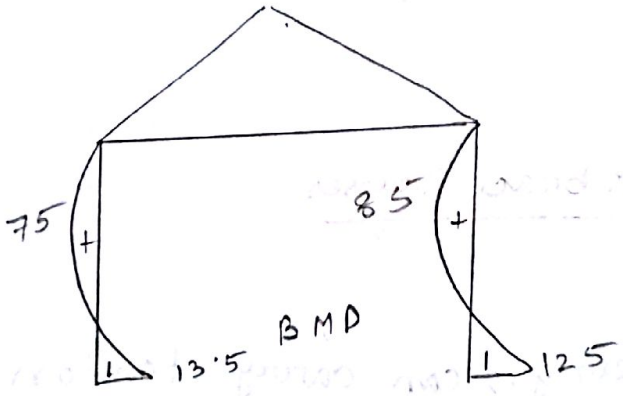
$\Rightarrow$ Draw SF, BM, AF for cols

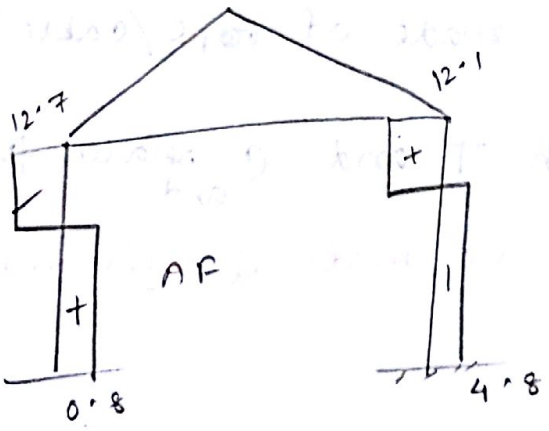
Find forces in knee Braces

" " in Truss member

} 9

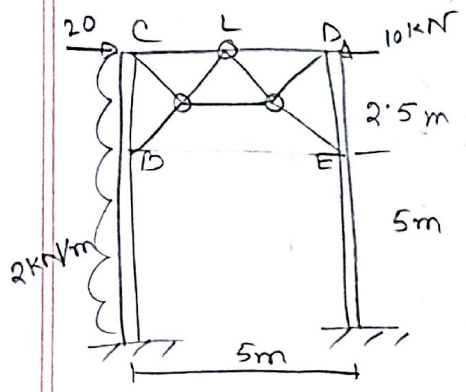

16·5
-18
4·5
13·5
6·5
-16
SF
16·5
14·5


75
+
85
+
BMD
13·5
125


12·7
12·1
+
+
AF
0·8
4·8

Bridge Portal:

Almost same as mill bents.



X Brace Trusses

Assumption:

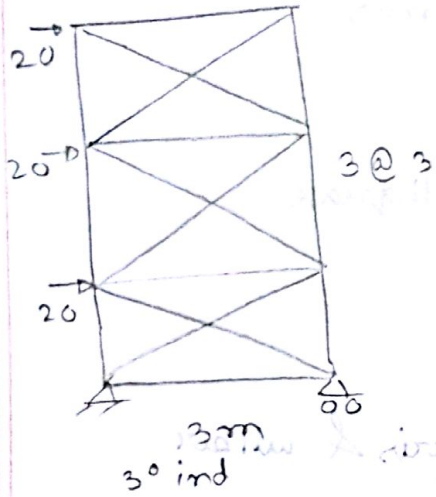
1) Diagonals (Brancings) can carry tension only (i.e. Diagonals are made of rope/cable)

2) OR can carry both T and C and shares the panel shear equally (Diagonals are made of rigid members)

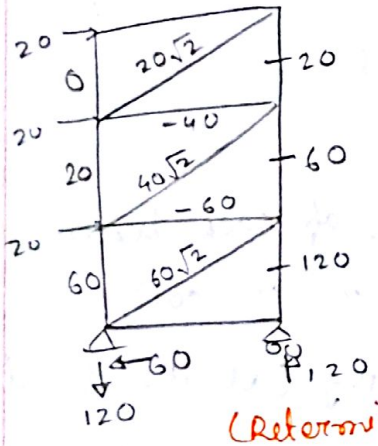
24.11.15
Tuesday

Lec – 14

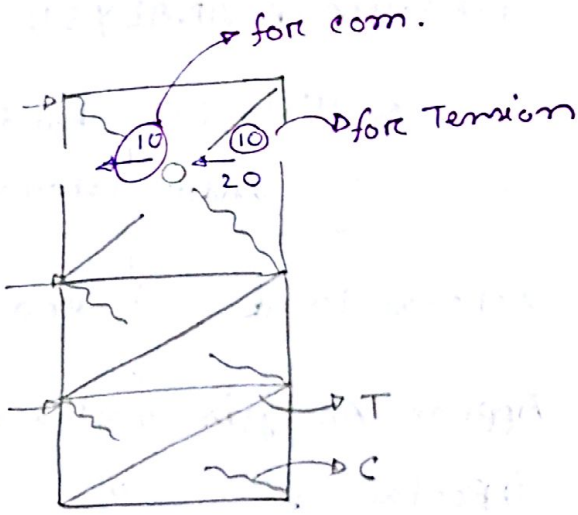
X – Braced Truss:



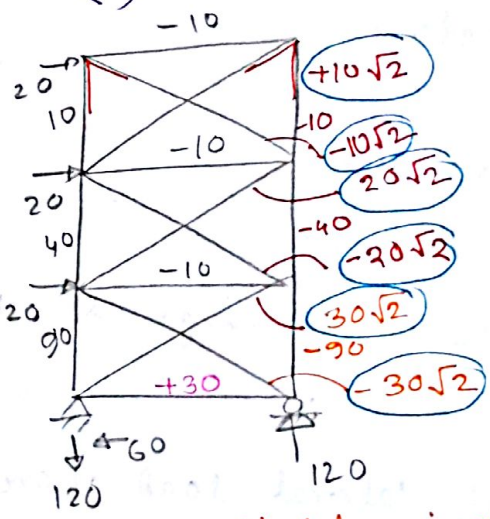
(a) Tension only



(Determinate)



(b) Tension & compression



(indeterminate)

28.11.15
Saturday

Lec - 15

APPROXIMATE ANALYSIS OF
Multistoried Building Frames Under lateral loads

Lateral load — i) wind ii) Earthquake

Approx Analysis methods

1) Portal "
2) Cantilever "
3) Factor

⇒ norris & wilber

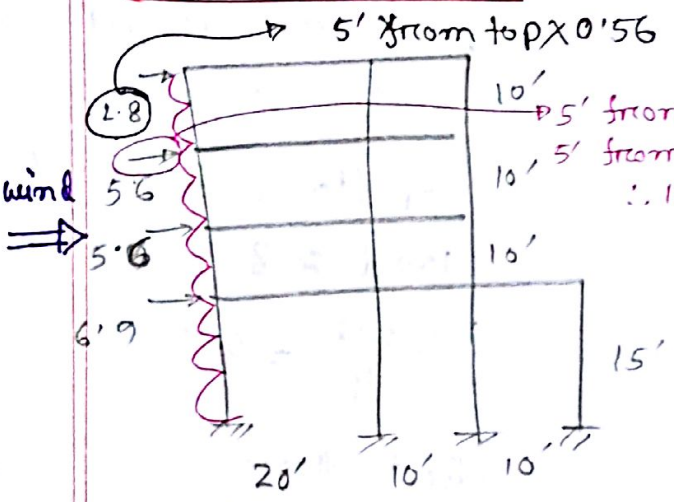
⇒ **Portal Method:**

Assumptions:

1) There is a hinge at the centre of each beam
2) " " " " " " " " col^n
3) Total lateral load above any story (at the level of hinge) shall be devided among the cols of that story so that an internal col takes twice the shear force taken by an external col.

Analysis: To be done by freebody

Prob 1 Portal Method:



frame spacing @15' c/c

Approx analysis of building frames . . .

Wind load

Formula

V = 120 mph

$p = 0.00256\ V^2$ (in psf)

= 37 psf

w = 0.37 × 15 = 0.56 K/ft of height

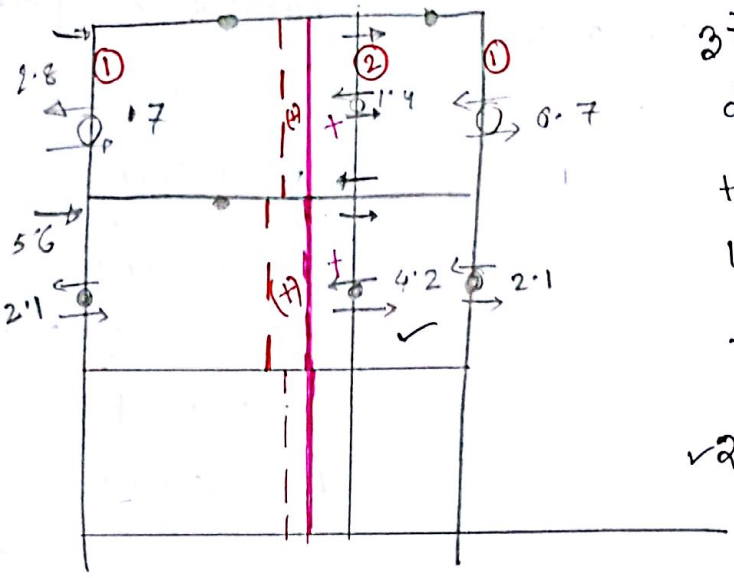
Analysis steps and order:

1) col SF → by Assumption
2) Beam AF
3) col BM
4) Beam BM
5) Beam SF
6) col AF

} By freebody (top to bottom)

6.9 acts 5' from top and 7.5' from bottom

= 0.56 × (7.5 + 5)



3য় colm, আমেরটার double নিব,

top floor এ Lateral load 2·8

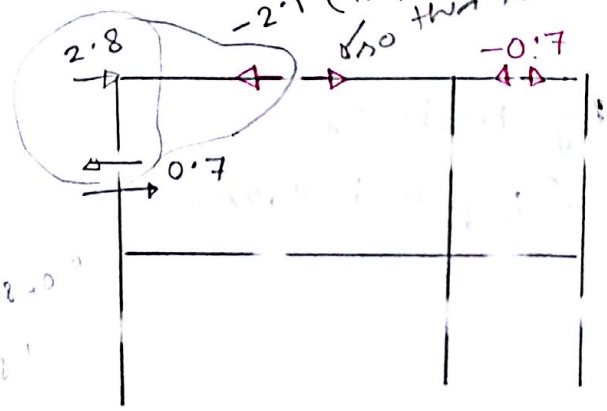
$\therefore \frac{2\cdot8}{4} = 0\cdot7$

✓2nd floor

$2\cdot8 + 5\cdot6 = 8\cdot4$

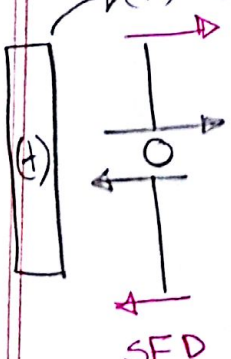
$\Rightarrow \frac{8\cdot4}{4} =$

Beam A.F:

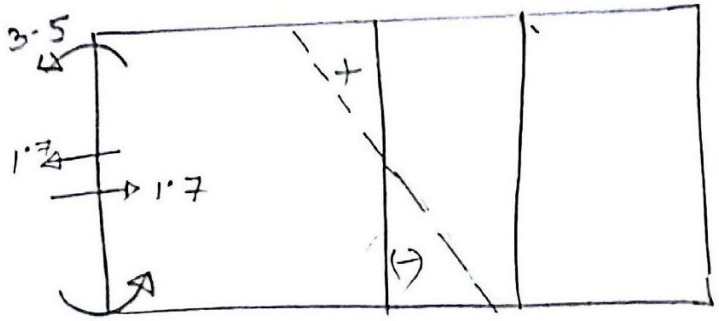


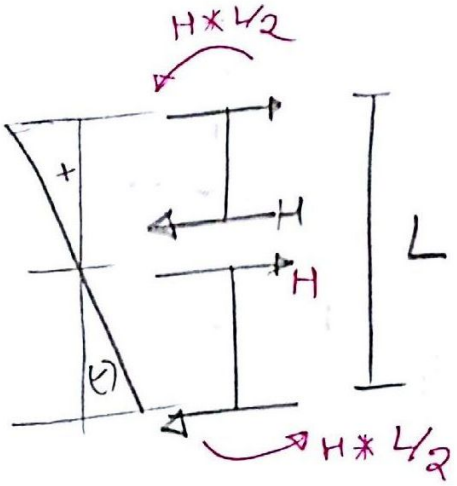
(- cause compression, towards the section

$-2\cdot8 + 0\cdot7 = -2\cdot1$



Colm Bending M:

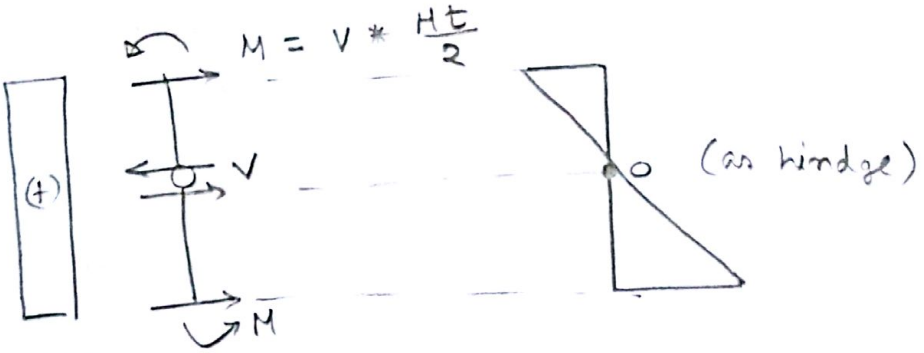




B.M.D

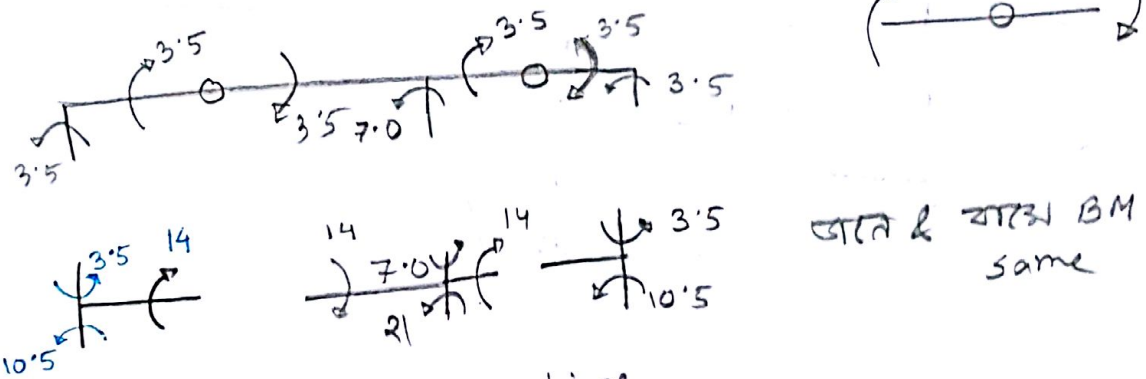
1.12.15
Tuesday

Lec - 16

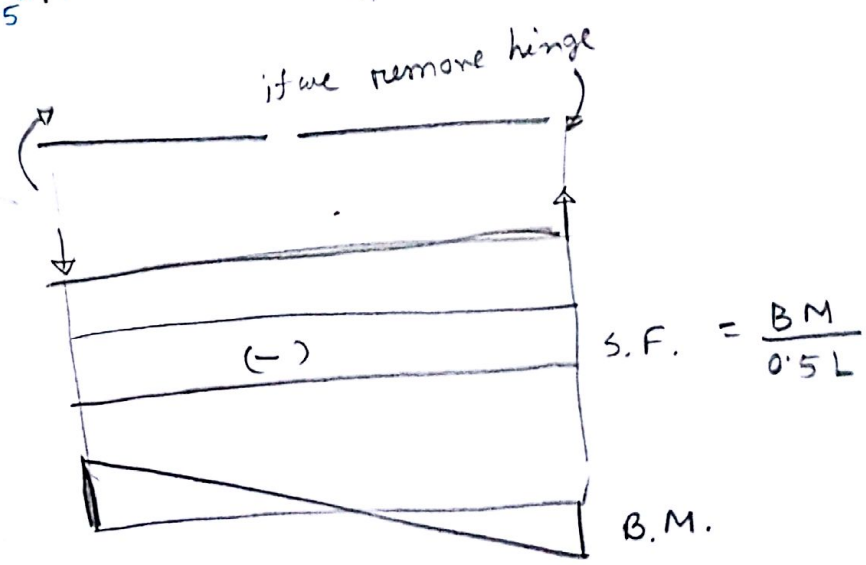


col SF

Beam B.M: By free body of joints ($\Sigma M = 0$)



ডানে & বামে BM same

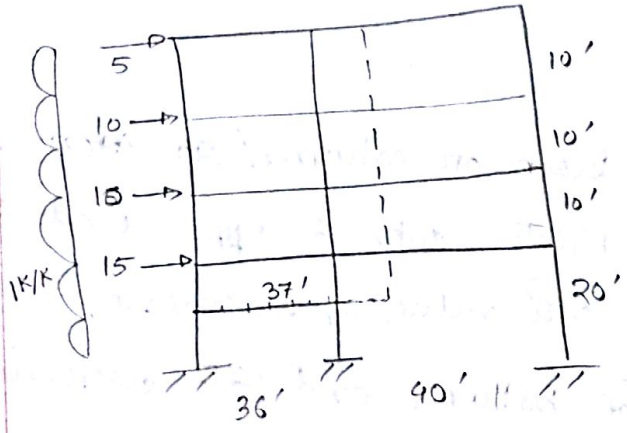


6. col AF এর By free body:

Beam এর S.F ব্যবহার করে A.F for column বের করা যাবে,

Building Frames Under Lateral Load:

⊛ Cantilever Method: (Imp)



Wind pressure = 40 psf

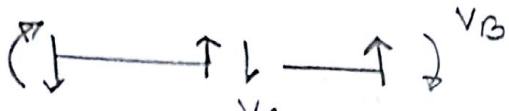
Annalysis top to bottom

$f = \frac{My}{I}$ $\quad c.g = \bar{x} = \frac{4A(36) + 2A(76)}{8A} = 37'$ from left

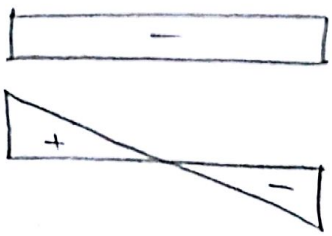
05.12.15
Saturday

Lec - 17

Beam Free body :



B.M = $V_B * L/2$
(at both ends)



portal & cantilever → beam or column এর মাঝে no force. So moment একই দিকে, colm ↑ upper end → যে value lower end এও সেই value of moment. & clockwise যদি end → হলে bottom end এও clockwise.

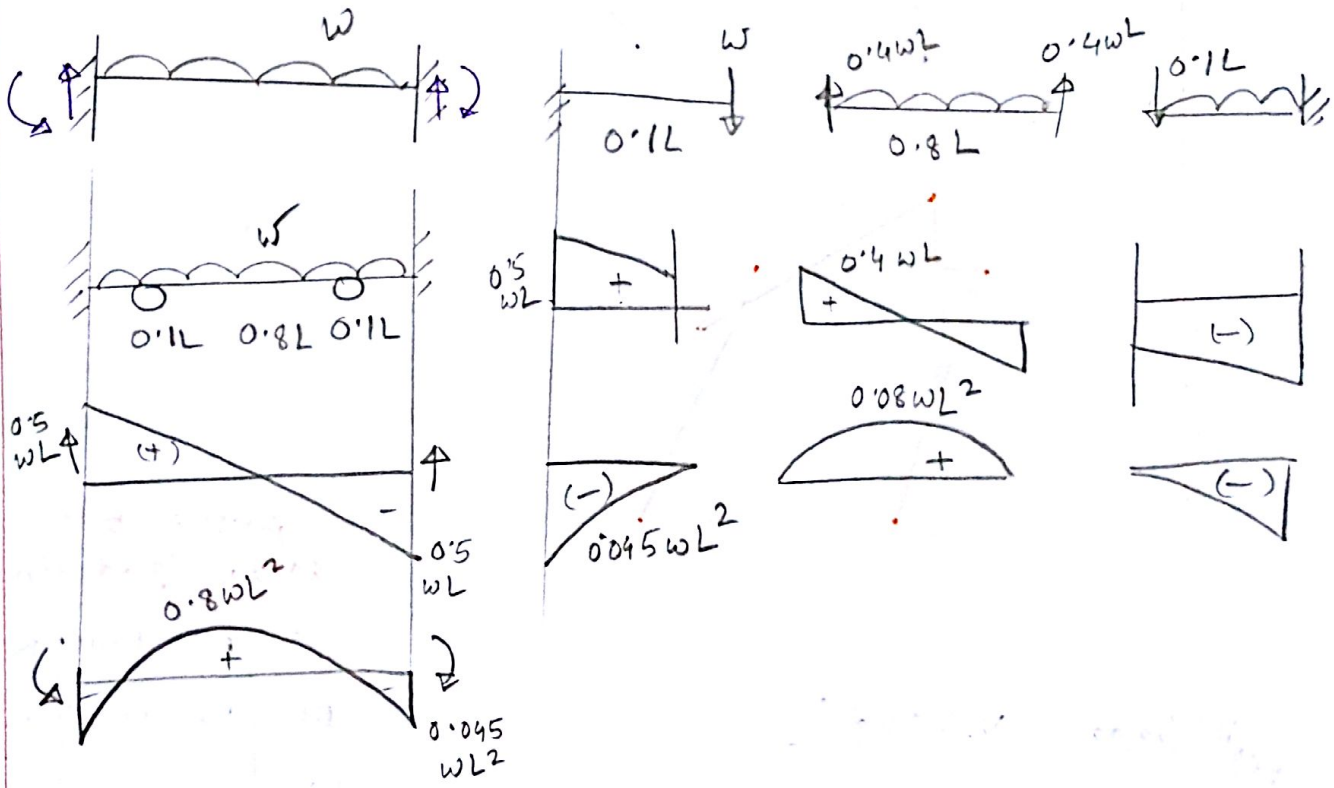
Beam এ axial force not that imp, shear & B.M imp.
Colmn " shear " " " " , axial & B.M. " .

II Approx annalysis of Building frames under V. Load

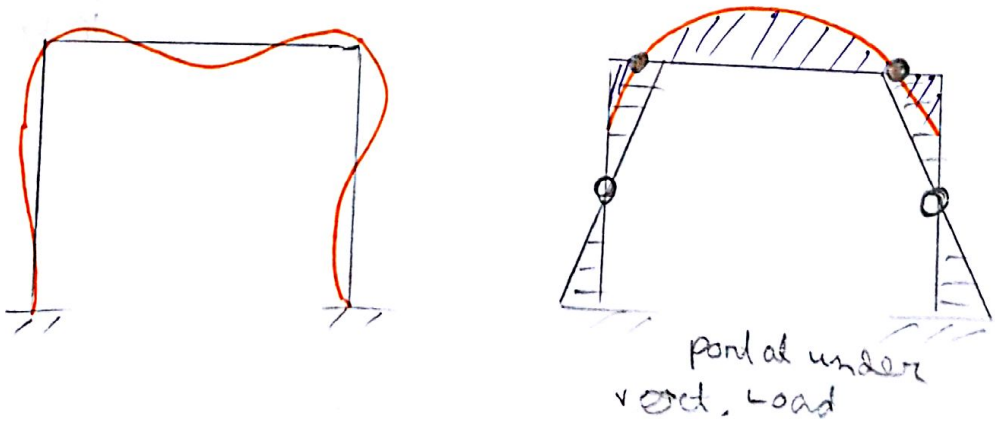
Assumptions:

1) A hinge at L/10 from left end of beam
2) " " " " " right " " "
3. Axial force in beam negligible

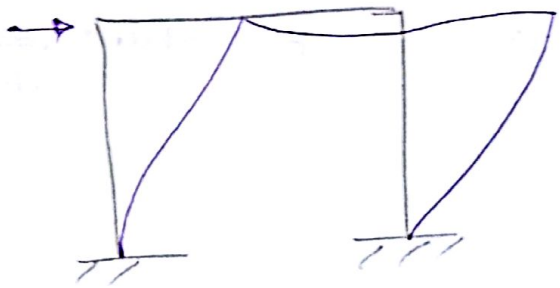
4) The unbalanced BM at a joint shall be distributed among col^n at the joint as per their ~~differences~~ stiffnesses ($= \frac{EI}{L}$)

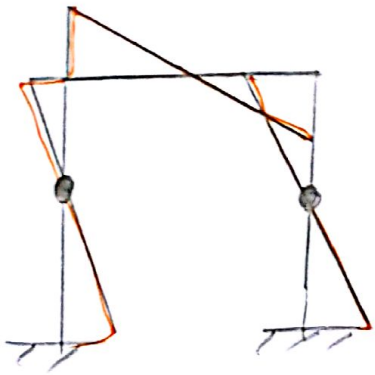


* Hinge ⇒ BM = 0, axial force & shear. ↳ neglected



portal under vert. load

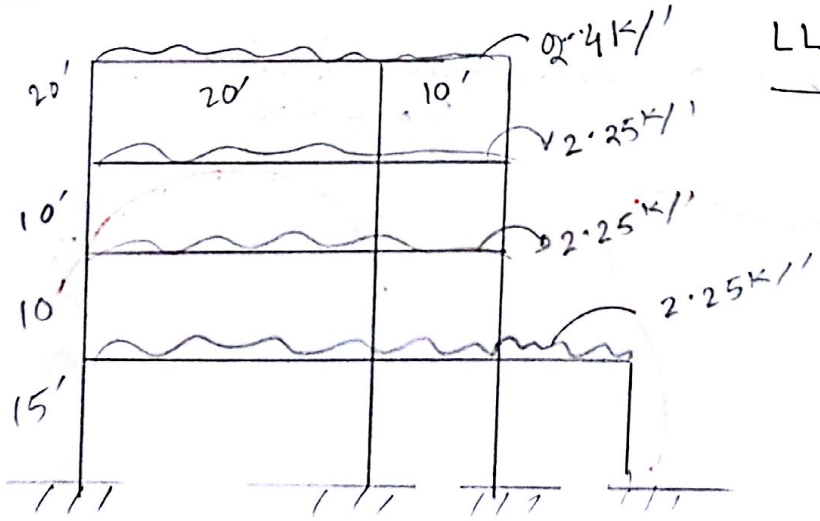




BNBC অনুযায়ী actual load find out

	Roof	Floor	R	F
DL	1·8	1·35	120	90
LL	0·6	0·90	40	60
	K-ft		psf	

Prob Under V. Load :



DD + LL on frame
(space @ 15' c/c)

Load in psf X 15 (convert to kip) = kip/ft এ পাব,
spacing

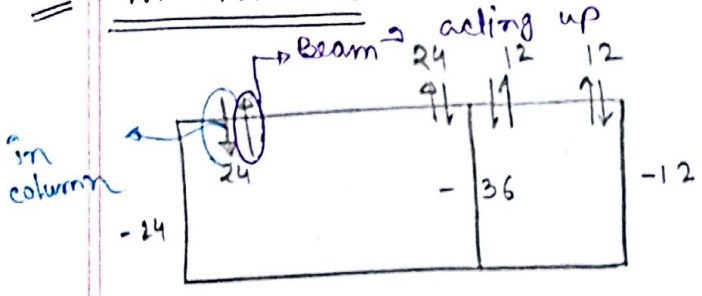
Analysis order:

1. Beam SF
2. Beam BM
3. Col BM
4. Col AF
5. Col SF
6. Beam AF → not needed

8.12.15
Tuesday

Lec - 18

2. AF in Cols:



For any colmn find AF in columns by taking sum of S.F of above beams

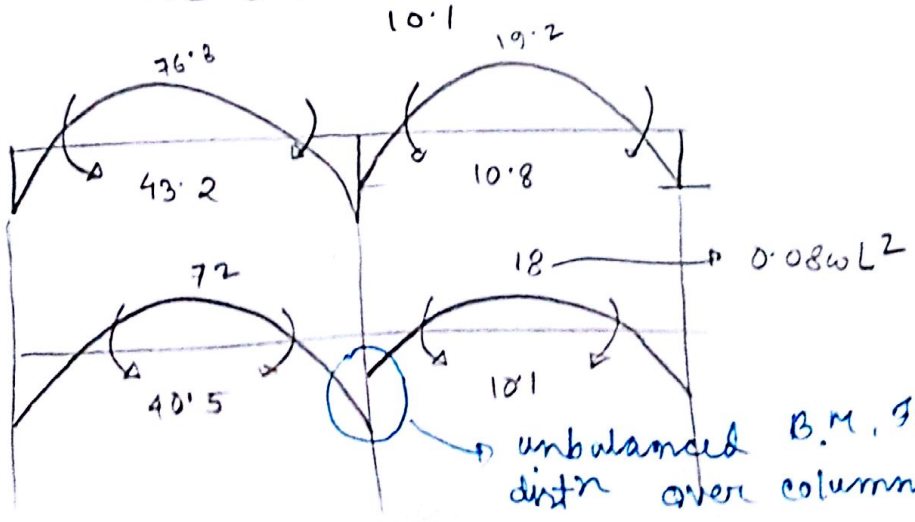
3. B.M in Beams:

20' span +ve BM = $0.08\,wL^2$ ⇒ 76.8 (roof)
⇒ 72 (floor)

-ve BM = $0.045\,wL^2$ ⇒ 43.2 on roof
⇒ 40.5 on floor

10' span = +ve BM = 19.2
18

-ve BM = 10.8
10.1

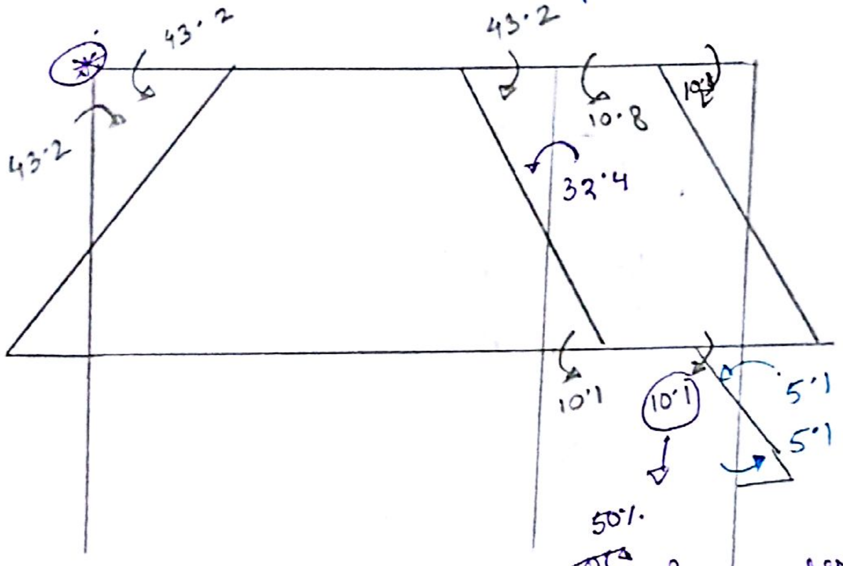


→ unbalanced B.M, It will be distn over columns as per stiffness

4. BM of colm :

unbalanced 32.4 (2)

so column 2

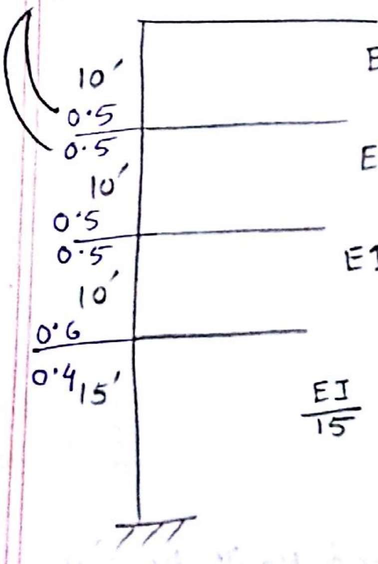


level & joint by joint যেতে হবে।

Top level left joint *

50% বাড়ে & উপরের & নিচের colm এ devide হবে

on both 3, so 50% বাড়ে



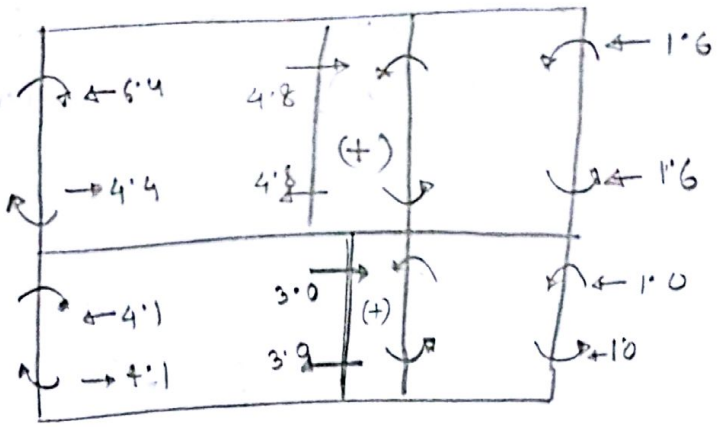
EI/10 = stiffness, $\frac{EI}{L}$

I may vary

Relative value	To eliminate decimal
1.5	1.5×2 = 3
1.5	,,
1.5	,,
(1) → ধরলাম	1×2 = 2

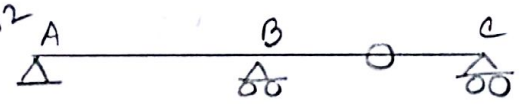
support এ distn undefined. এজন্য ground floor এর colm এ উপরের যে B.M নিচের colm এও তাই, মানে আছে hinge.

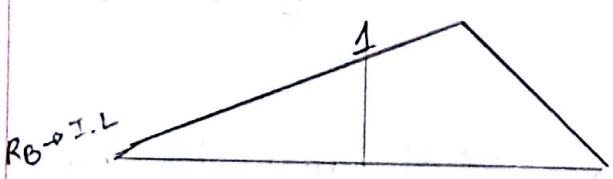
5. SF in Colm :



Moving Loads :

Beam 2

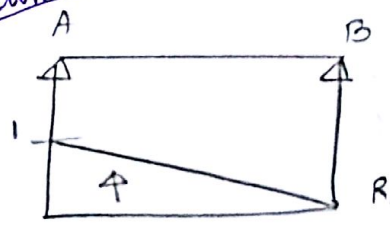




Find max^m R_B for moving load

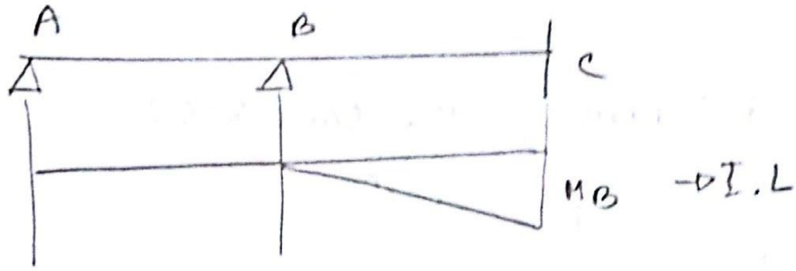
$$\frac{W_L}{a} \geq \frac{W}{L} = \text{check}$$

Beam 1



Q. Find Max^m R_A for

check for ΔR



Find max^m MB for moving loads.

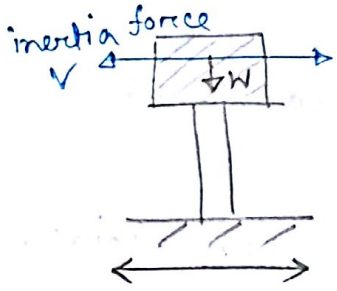
check for ΔR.

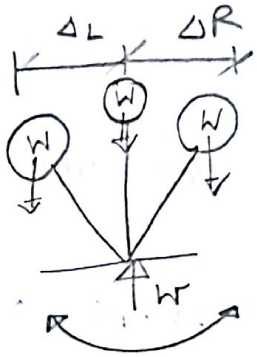
For check see the shapes of IL & then decide.

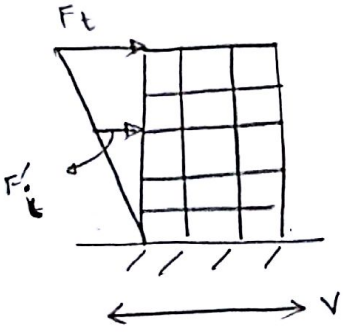
12.12.15
Saturday

Lec-19

Earthquake Loads: BNBC -1993 (Art 2.5)







$$V = F_t + \sum_{i=1}^{N} F_i \quad (N = No.\ of\ storey)$$

Lec-20

15.12.15
Tuesday

Summary:

2.4.4:
1. Urban industrial
2. Open terrain
3. Flat & sparsely in terrain

2.4.5: Basic wind speed
Fig 6.2.1

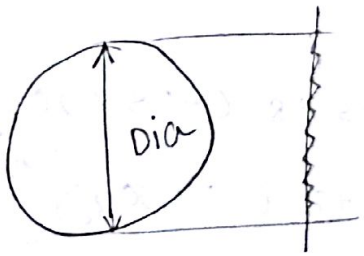
2.4.6. Sustained wind pressure:

$$q_z = C_e C_1 C_2 V_b^2$$

2.4.6.3: $P_z = G_g C_p q_z$ ...

2.4.6.4 Design wind load

(see somewhere Lecture)



q_z =

C_e = I hate everything

C_z =

P_z = सच्ची, I hate, everyone hates

wind ward side $C_{pe} = +0.8$

lee side $C_{pe} = -0.57$

side walls $C_{pe} = -0.7$

B = 66m

L/B = 0.5

L/B = 0.76

$V_b = 210 \text{ kin/h}$

Exp A

$q_z = C_e C_I C_z V_b^2 = 47.2 \times 10^{-6} \times 1.0 \times C_z (210)^2$

$p_z = G_G C_p q_z = C_G C_p \; 2.082 \; C_z$

$C_G = C_{fh}$

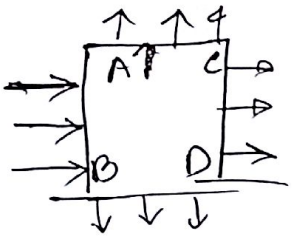
$C_p = C_{pe}$

$= 2.082 \; (1.238) \; C_p C_z$

$= 2.578 (.8) C_z \quad = 2.578 \; (-.57) C_z$ windward side walls

leeward $\quad = 2.578 \; (-.7 \times z)$

Method 1 :



$F_1 = \Sigma p A_z$

Method 1 :

	wind(W)	lee
0-4.5	-.76	
6	-.86	
9	1.17	
15	1.59	
18	1.99	
21	2.20	
24		