Civinnovate

Discover, Learn, and Innovate in Civil Engineering

https://civinnovate.com/civil-engineering-notes/

Components of bridge - Superstructure
- Bearing
- Sub-structure
- Appartences & site related structures

Bearing is used in bridges not in building because of large span to resist temp' stress, shrinkage & creep.

stopper → sub-structure का part
→ function is during EQ to prevent the disjoining to superstructure with bearing

Note:- if span of bridge < 7-8 m no use of bearing

⇒ more temp', shrinkage & creep effect in bridge than in Building

joint free structure provide more riding quality → so use of framed structure - no bearing is used.

composite bridge → steel beam & RCC slab
→ pre cast beam & cast in situ slab

⇒ Bridge સર્વોત્તમ રહેશે when torsional stiffness is high i.e. load is distributed in more area.

T-Beam bridge → upto 25 m span

Box girder is torsonally more strong than T Beam

In perrineal bridge where diversion is not possible during construction, box bridge can be constructed easily and used in short span

Steel bridge expensive than RCC & prestress

truss bridge can cover upto 300 m span

Codes

IRC 5 general
" 6 → loading standard
" 21 → RCC bridge design based on working stress method
" 22 → composite bridge design
" 24 → limit state based design code
" 78 → Sub-structural part " ~~deside~~ code
" 83 → part I, part II, part III bearing design
" 112 → RCC bridge based on limit state design

DOR webside → code, information related to bridge
Yellow book → download

General design requirements of Bridge (See IRC 5)
OR
Studies to be carried out for the acquisition of basic design data

① Traffic study
② Hydrological study
Linear waterway → width of river for natural passage of water in river.
River training work decides according to flood type

③ Geological & geotechnical study
Bridge is not made in geological fault line.

④ Topographic study
catchment area decides the distance u/s & d/s of the bridge axis & area for bridge survey.

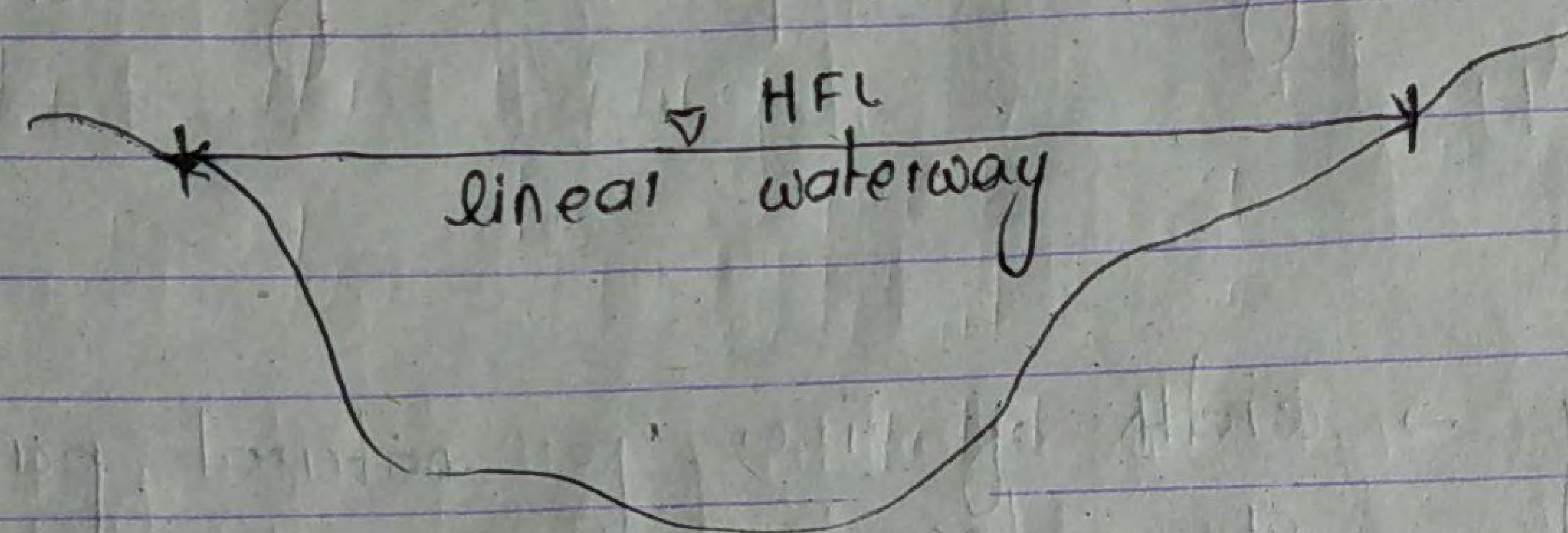
Hydrological Data

⇝ statistical method for finding discharge is the best method for finding the actual discharge of river.
⇝ कमतीमा 50 yrs को data collection needed for statistical method

⇝ In Nepal, Emperical method is used

1 m of RCC bridge → 8-9 lakh
" " " steel " → 10-12 lakh

2. Linear waterway



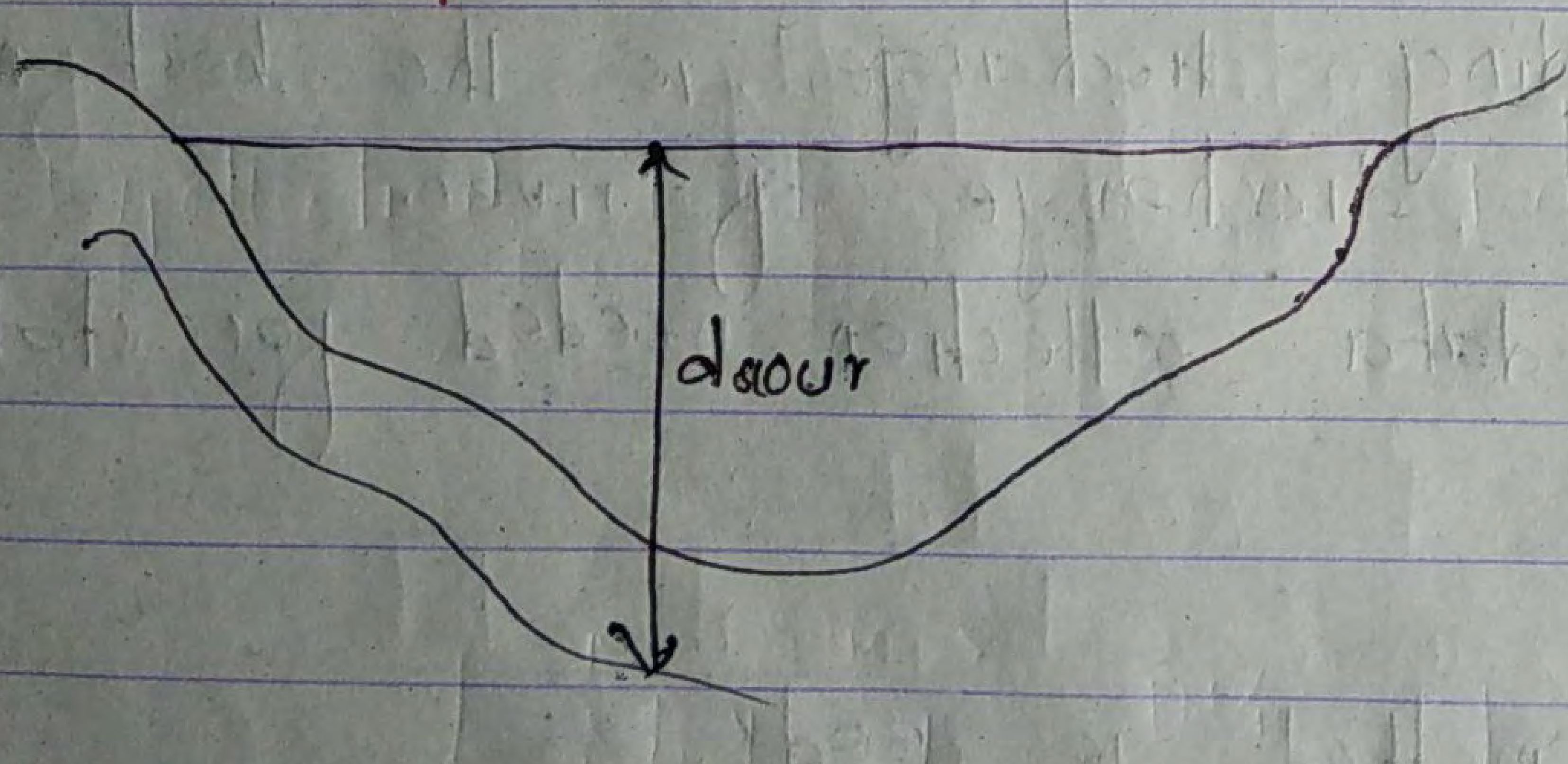
⇒ HFL pass हुने river ले कति width cover गर्छ that is linear waterway.

$w = C\sqrt{Q}$

{ C = 4.8 for perrenial river
{ C = according to designer's judgment for non perrenial

In case of both bank & bed non erodable we can easily determine linear waterway from HFL mark but if any one is erodable further study required.

3. Scour depth



⇒ Here bend भनेको bending of river.

⇒ alluvial bed i.e. terai region of Nepal

D_b = discharge / linear waterway

dsm used in terai i.e. alluvial soil

Safety kerb → where pedestrian traffic is not expected to move
foothpath → where pedestrian traffic is expected then we provide.

carriage way → where vehicles move

Height of railing → min^m 1 m according NBS → Nepal Bridge Standard
vertical clearance = 4.75 m in NBS

Bridge loading → Refer IRC 6-2010 → IRC 6-2014 Revised
→ (amendments download)

Live load → pedestrian load
→ vehicular load → Normal load
→ Abnormal load
↓
Represents millitary & industrial load

Normal load → class A load
class B load
} hypothetical load that represents worst combination of normal real loads

Abnormal load → class AA load → used in specified locations
→ Dolidar को under मा हुने काम
→ class 70R load
→ अरु condition मा 70R
→ DOR को under मा हुने काममा use गर्ने

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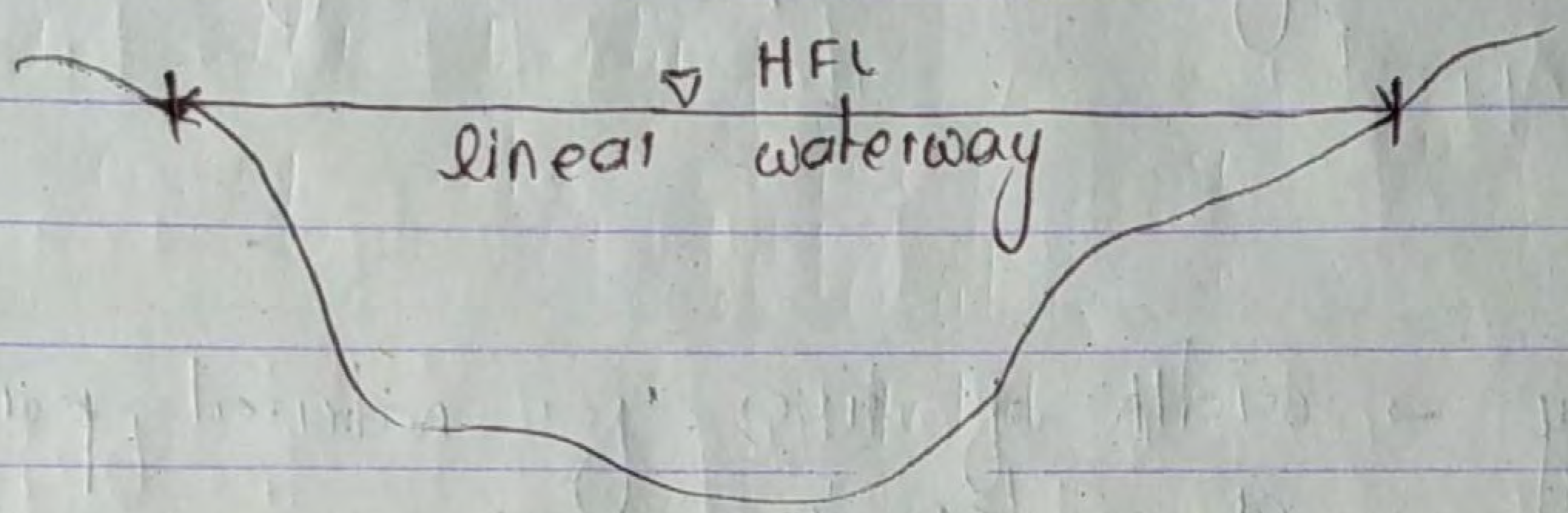

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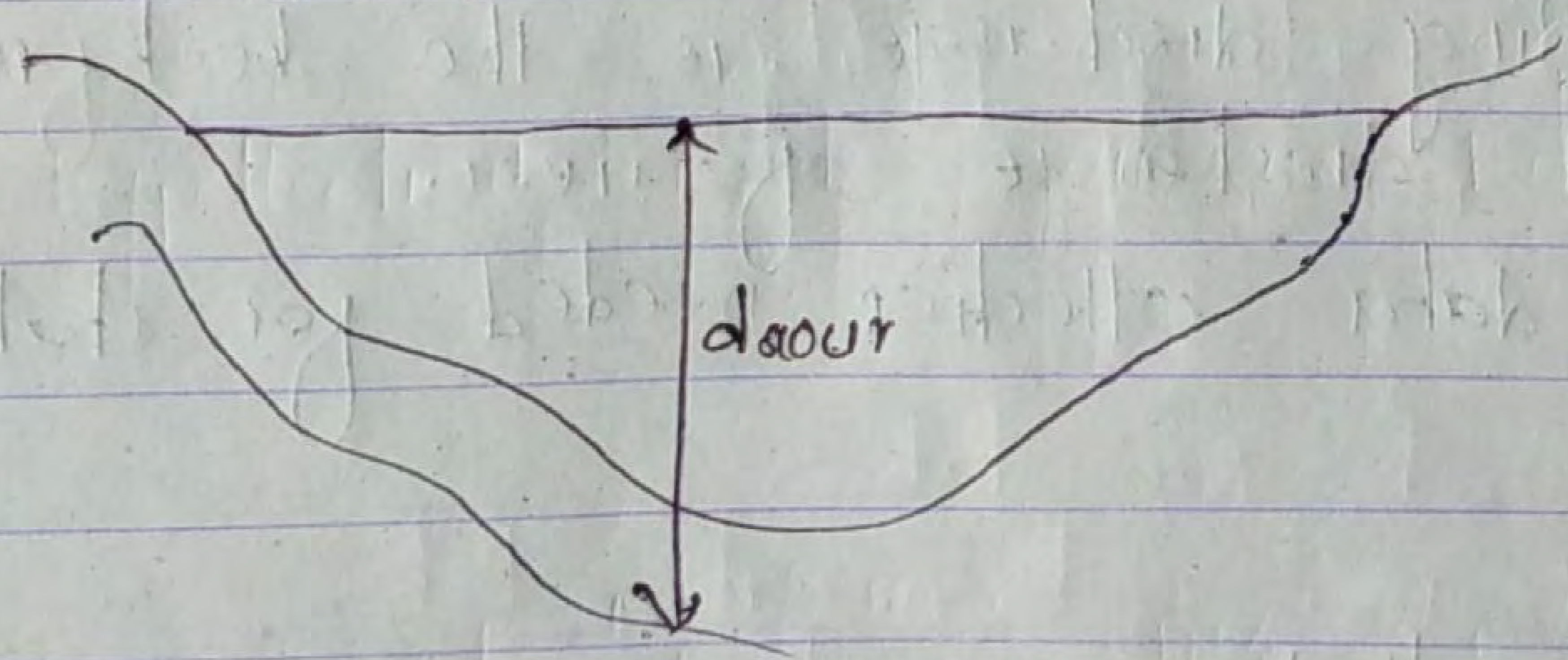

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Class AA load → wheeled load → pneumatic wheel भएको
↘ Tracked load → chain " भएको

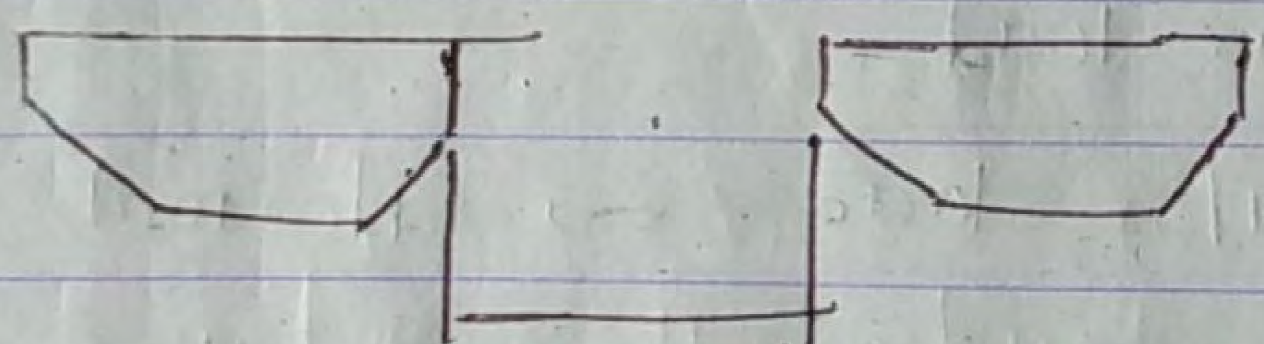
class A/B loading

no. of axles → truck 4
2x trailor 2
total 8

load in B = 60 % of load in A

class 70R loading

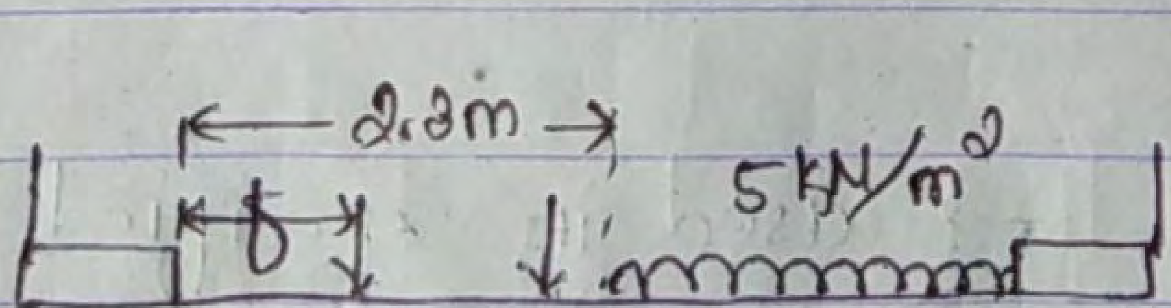
Tracked ⇒

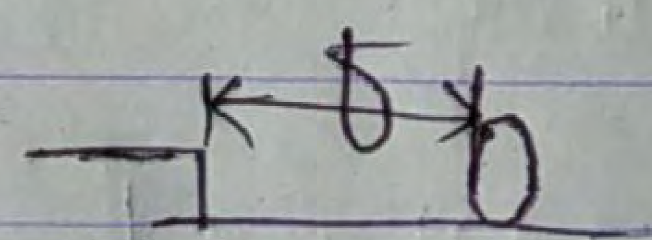


30m in IRC 6 2010
90 m in IRC 6 2014 → so use this

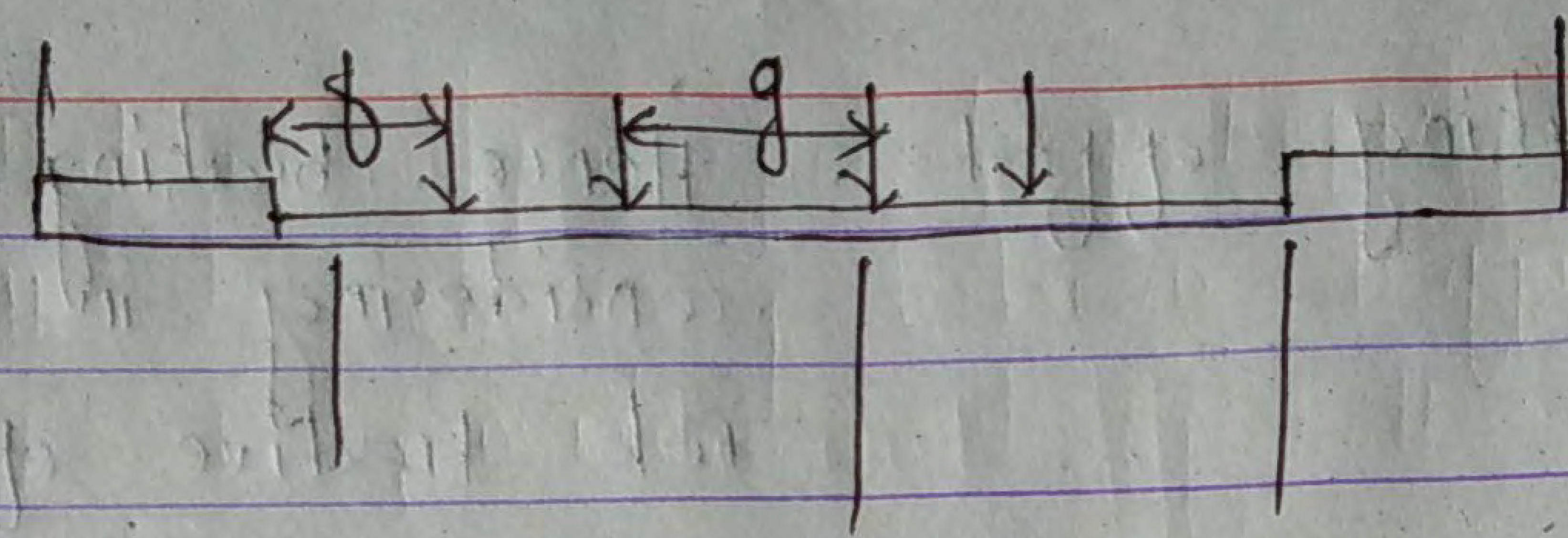
class AA

hypothetical loads - all are taken in only one direction





for single lane



for double lane

Impact load

Impact load = static value of live load × Impact factor
↓
from IRC 6

⇒ Impact depends on :-

span of bridge → impact more in small span

material of bridge → concrete मा impact more than in steel bridge

wheel type → pneumatic tyre impact more than in chain wheel

Impact factor fraction = 0.2

Impact factor = 1.2 (20% increase गर्ने)

Note:- Superstructure को analysis मा always take impact load

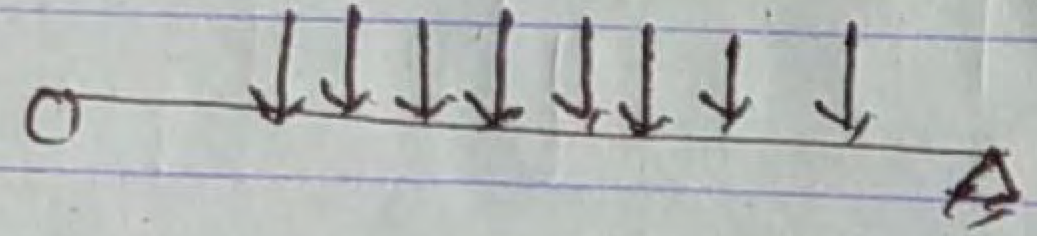
longitudinal axis → parallel to the dirn of vehicular flow

longitudinal force → acting along longitudinal axis

Longitudinal forces

Tractive effort < braking effort. Hence, braking effort is considering in design but not tractive effort

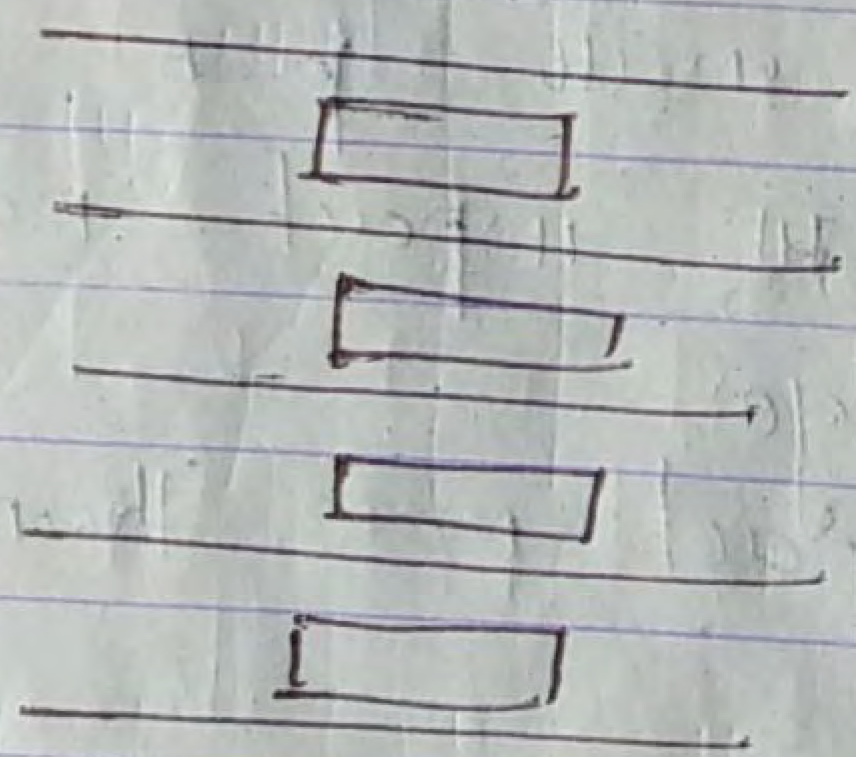
554×0.2 = braking load



$554 \times 0.2 + 27 \times 2 \times 0.1$ = braking load

($27 \times 2 \times 0.1$ → for succeeding vehicle)

4 lane road



plan view

$\Rightarrow 554 \times 2 \times 0.2 + 554 \times 2 \times 0.05$

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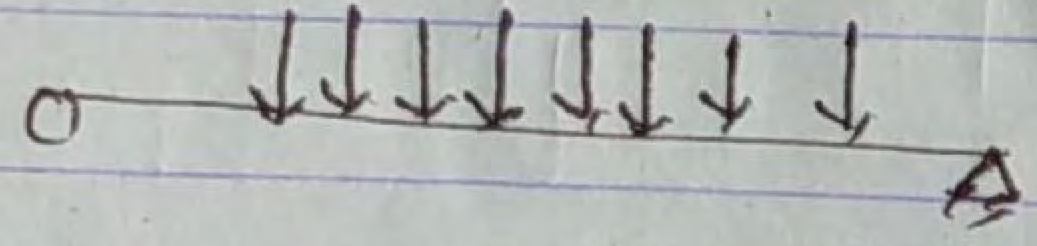

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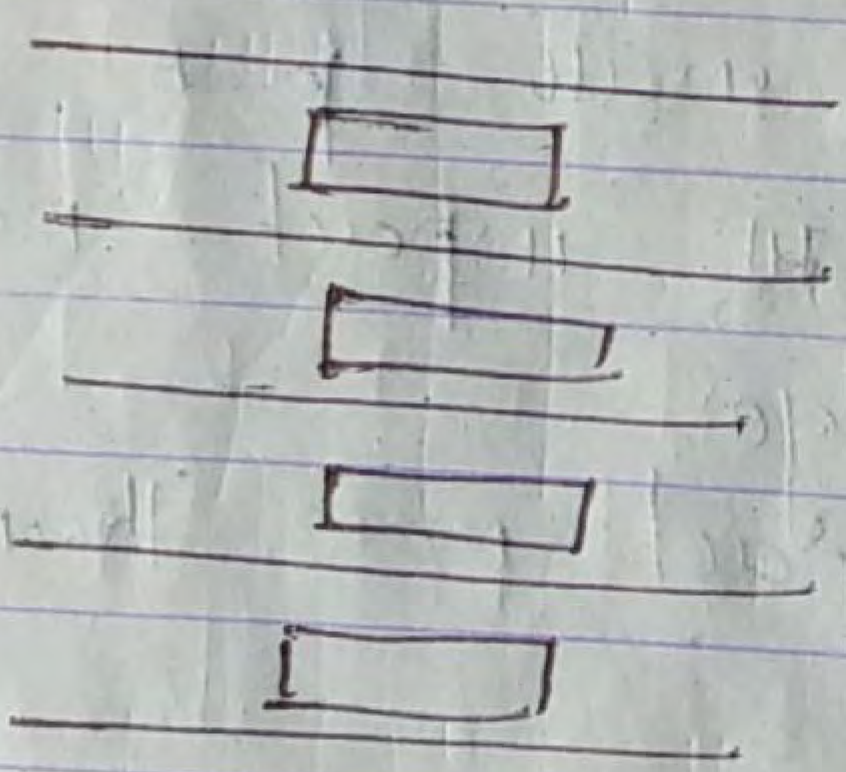


plan view

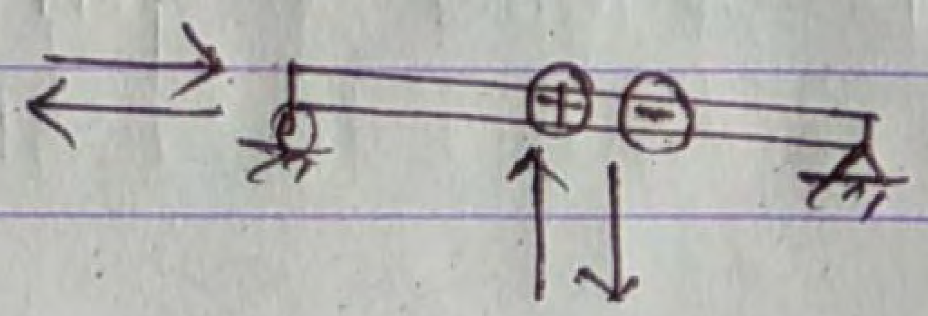
⇒ $554 \times 2 \times 0.2 + 554 \times 2 \times 0.05$

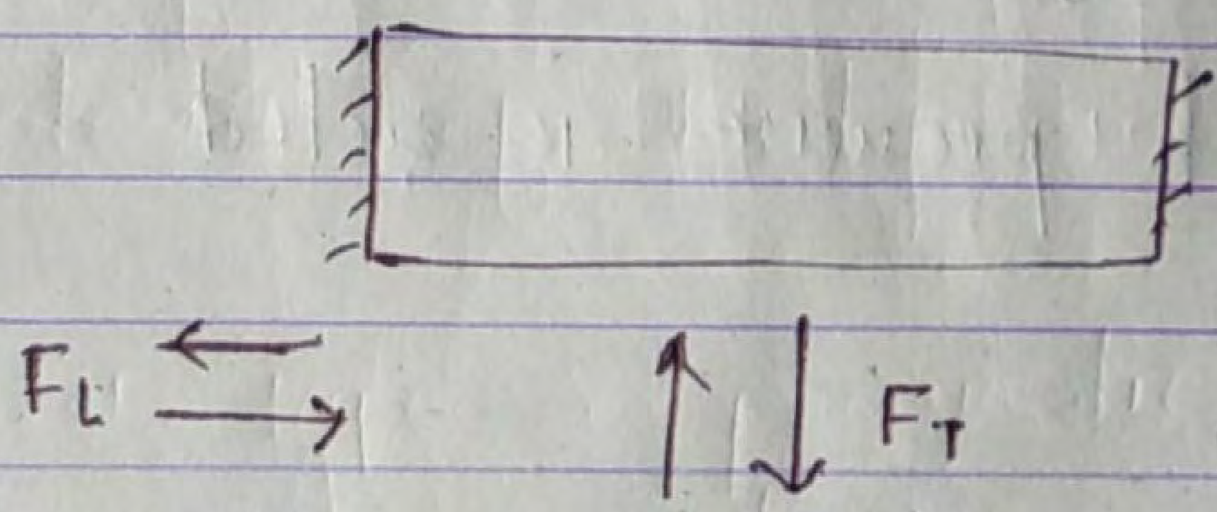
$\sigma = E e$

$\frac{F}{A} = E \frac{\Delta}{L}$

$F = ??$

Wind load





$F_T = P_z A G C_D$

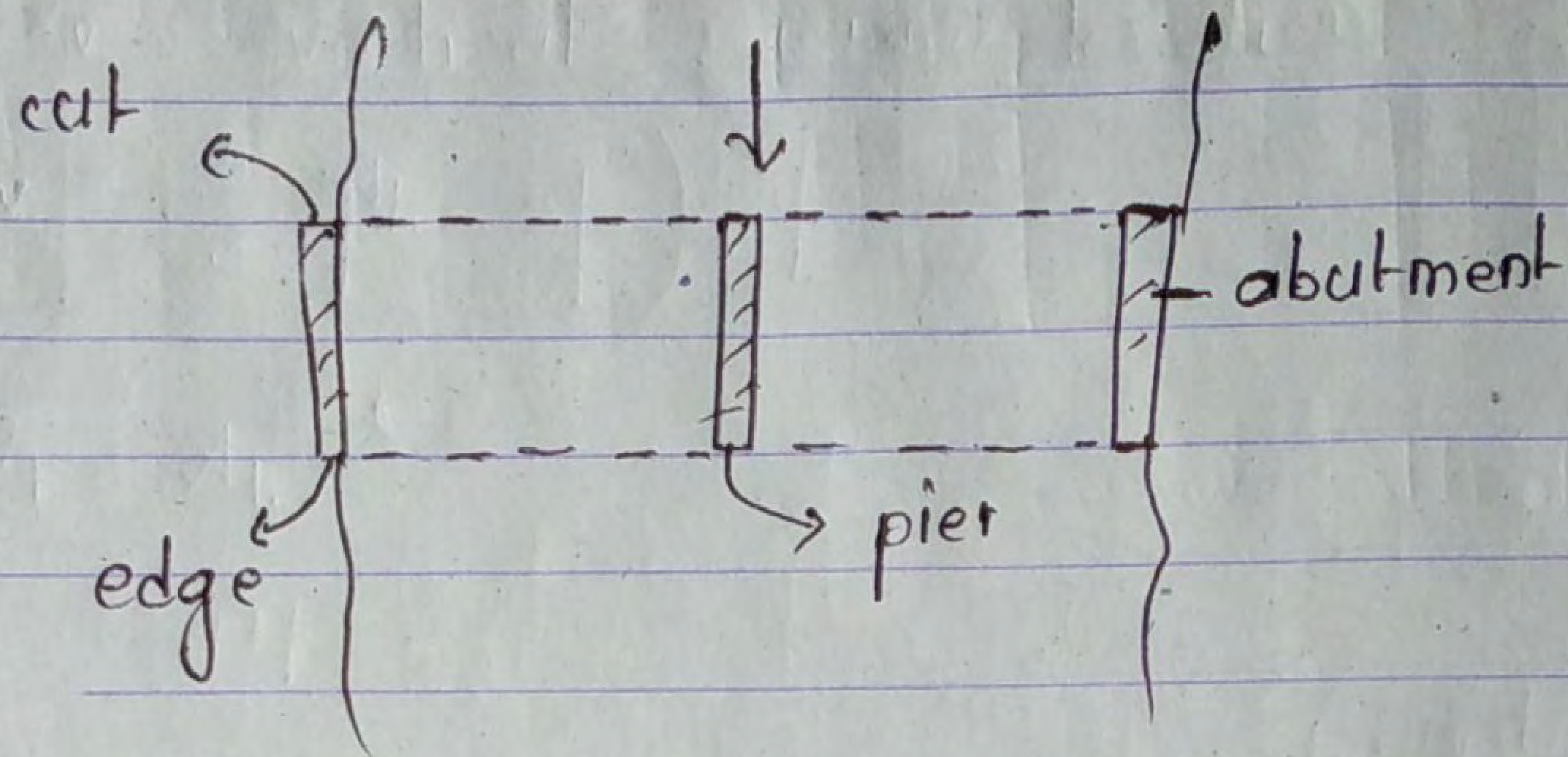
$P_d A$

where $P_d = P_z G C_D$

$V_b = 33$ m/s (basic wind speed)

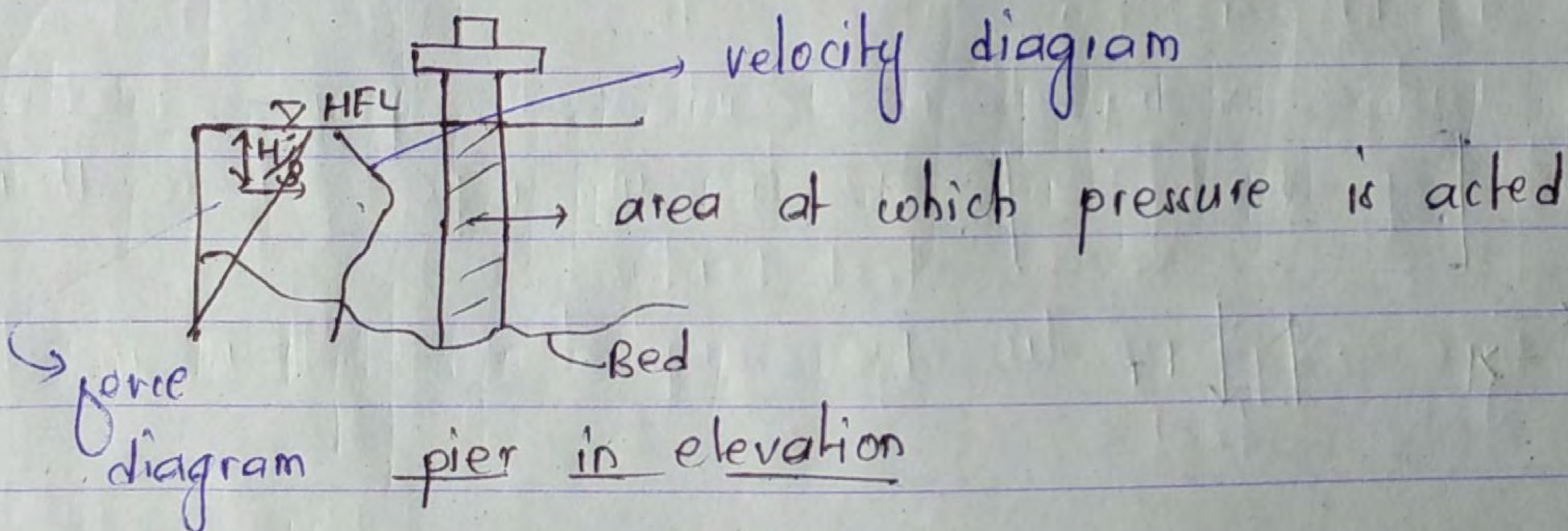
$P_z = ?$ always mean

Horizontal forces due to water current

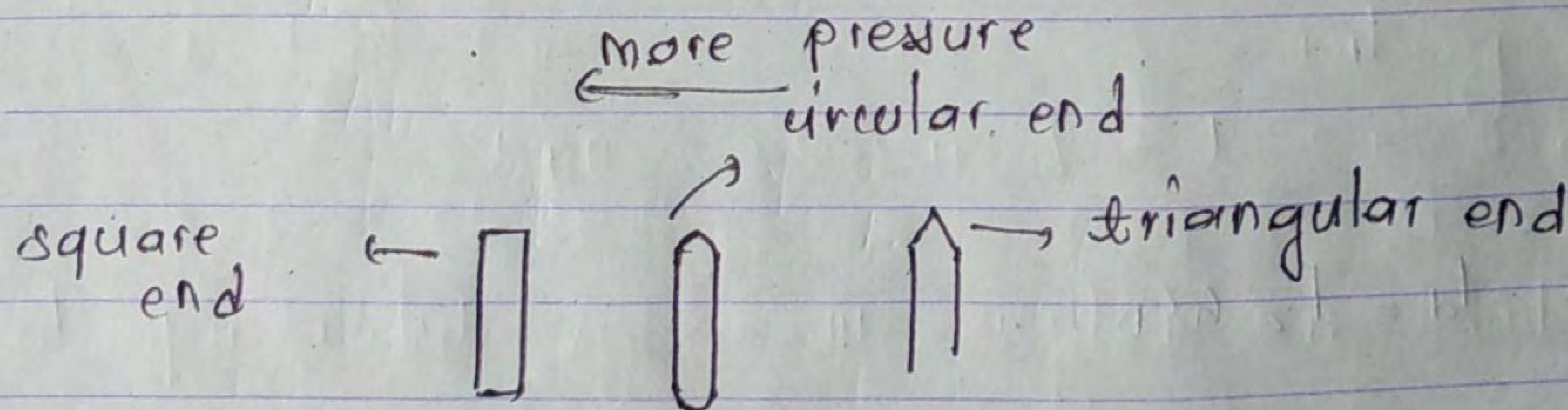


$$F = P \times A$$

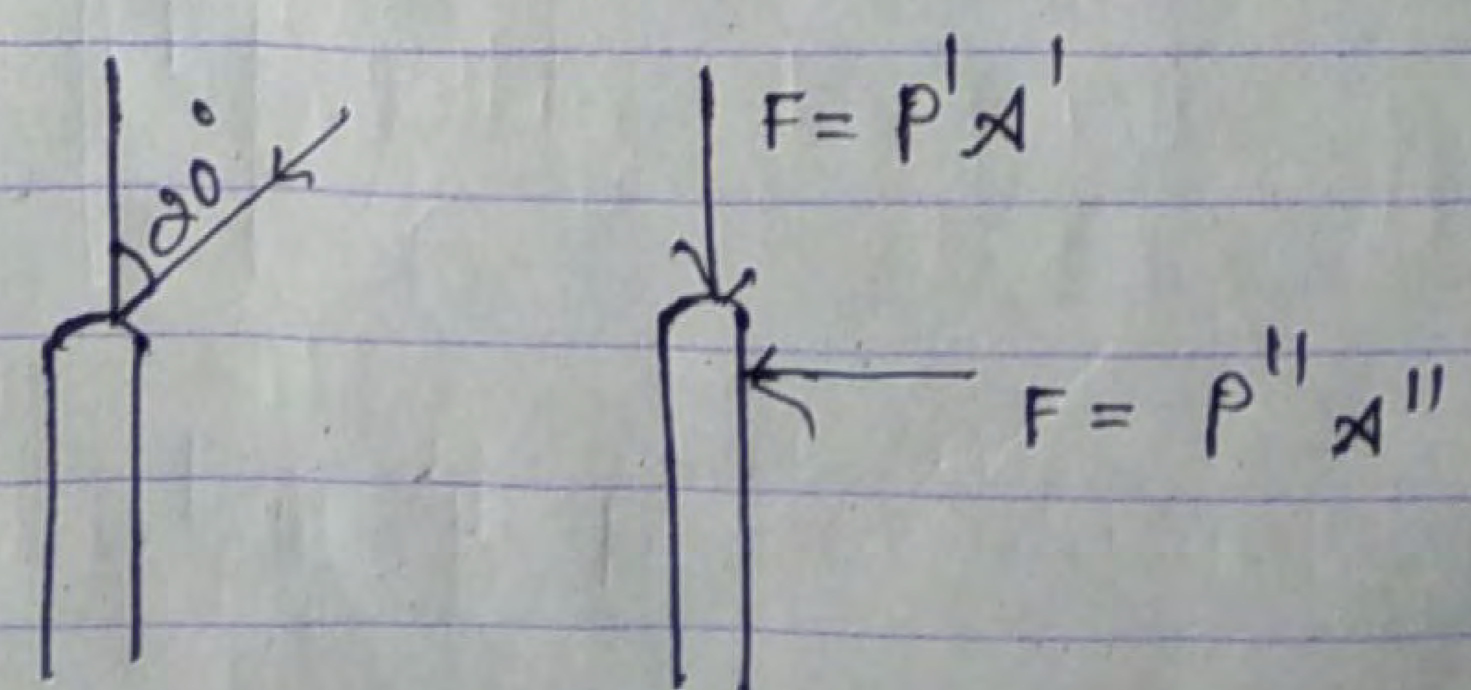
$$P = Kv^2$$



pier in elevation

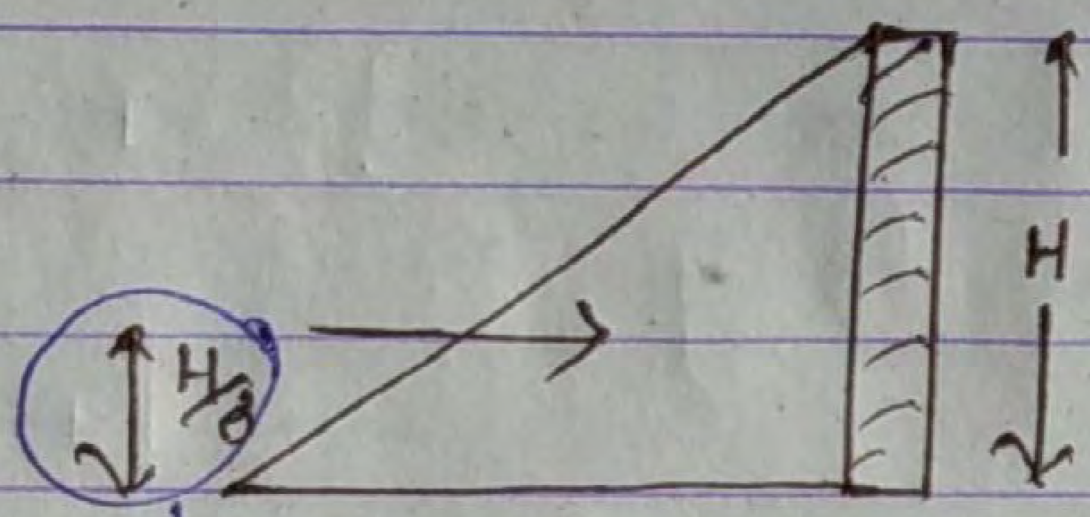


cut jack



Force exerted by earth pressure

passive earth pressure is not significant than active e.p.



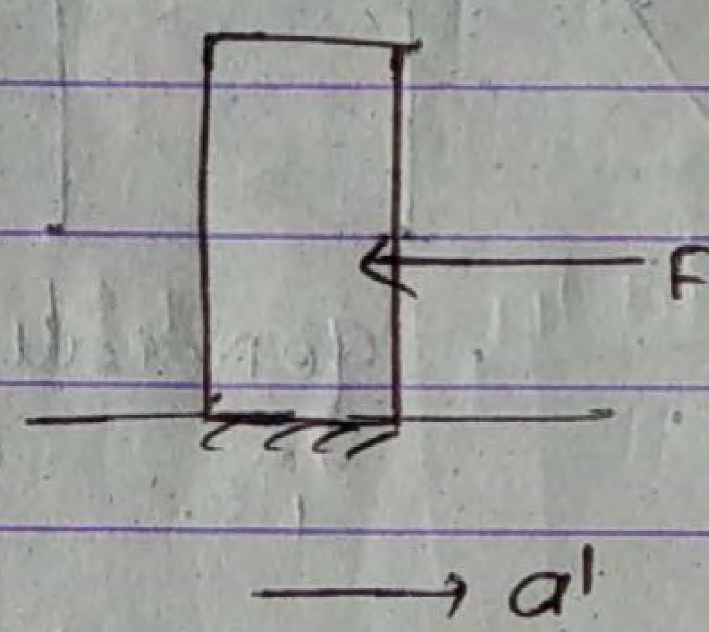
→ normally but in bridge 0.42H (IRC 6)

Seismic force (elastic seismic acceleration method, follow गर्ने generally)

$F = ma'$

$= A_h w$ → seismic wt.

↳ seismic acceleration coef.



for building

$$A_h = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}$$

Z = zonal factor = 0.36 for Nepal in 5th zone

→ This is acceleration according to the past experience

I = importance factor

R = response reduction factor

↳ ductility दर्शाउँछ → in steel allow to yield

$\frac{S_a}{g}$ = spectrual acceleration coef.

→ This is local factor

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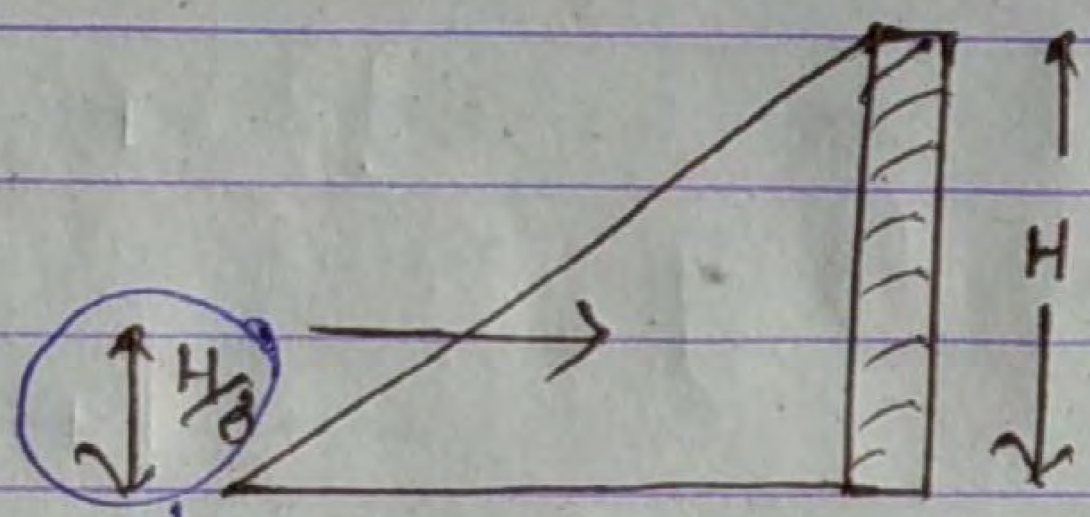

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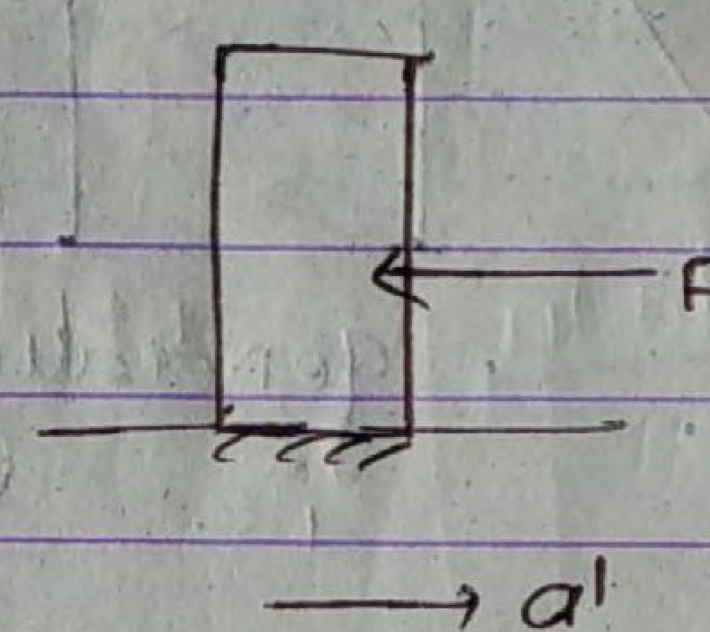

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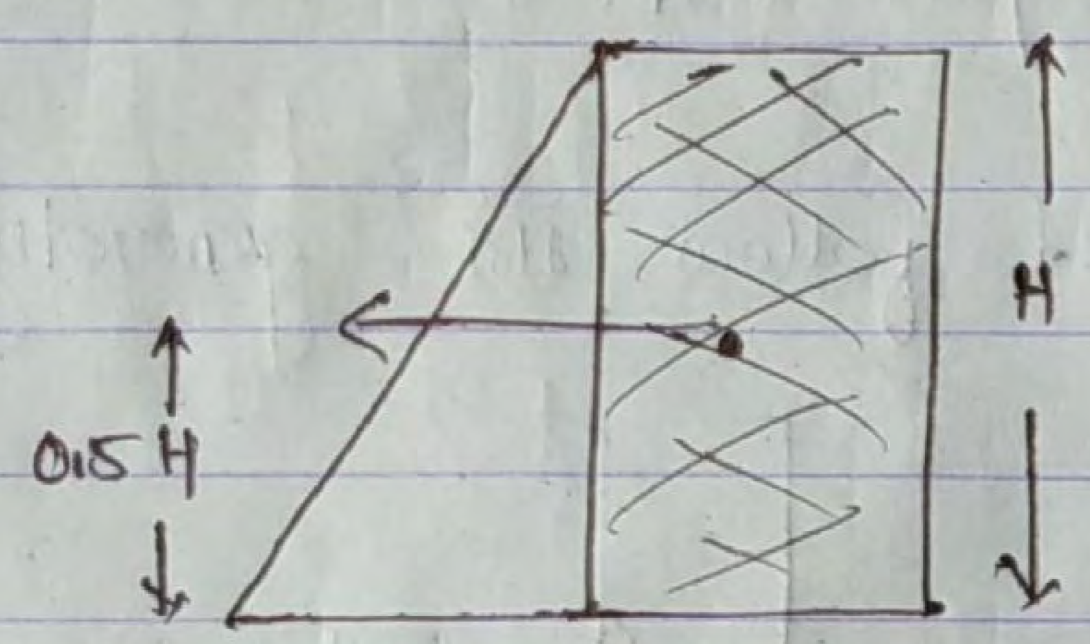
Force Exerted by Dynamic Earth pressure

α_v = vertical seismic acceleration coefficient

$$\alpha_v = \frac{2}{3} A_h$$

$$\alpha_h = A_h$$



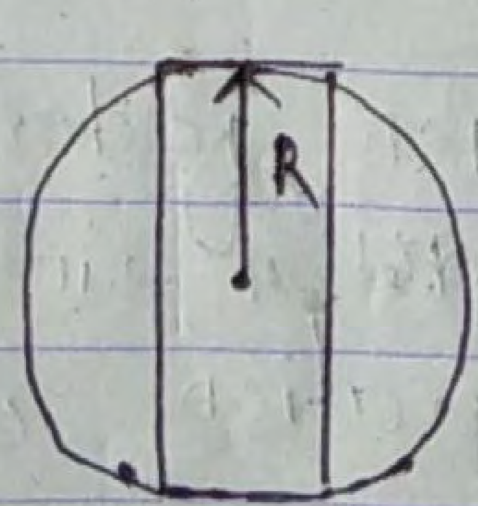
generally seismic load applied at cg of mass i.e. 0.5 H but in bridge take 0.6H

Force due to hydrodynamic pressure

$$F = (C\,\alpha_h)\,W$$

→ A_h

$$\alpha_h = \frac{Z}{2} \times \frac{I}{R} \times \frac{S_a}{g}$$



plan of pier

Note:-
erection load → take only in case of precast

Load combination

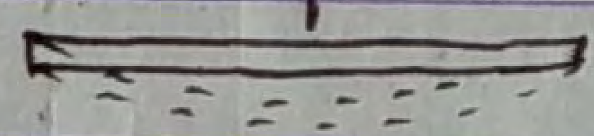
2nd combination = 1st combination + shrinkage, creep, temp' effect
3rd " = 2nd " + wind load

In working stress method, partial FOS is not considered in load for risk factor instead there is another factor in table in IRC 6

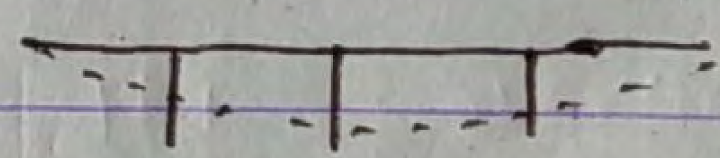
Bridge Responses – (only for superstructure)

Imp. 1. longitudinal BM
Imp. 2. " SF
Imp. 3. transverse BM
4. " SF
5. " TM
6. longitudinal TM

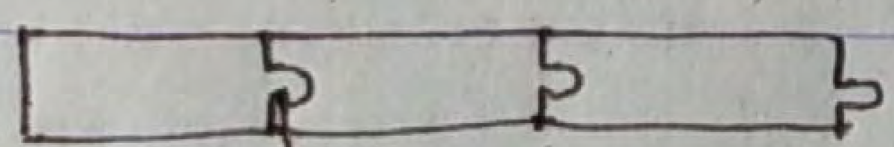
→ longitudinal vertical plane मा bend हुन्छ



→ transverse vertical plane मा bend हुन्छ



transverse shear



pre-cast construction मा मात्र हुन्छ
transverse dirn मा load distribute हुदा shear key मा आउने load is called transverse shear

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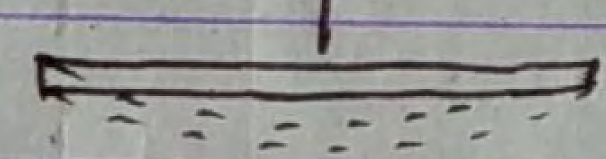
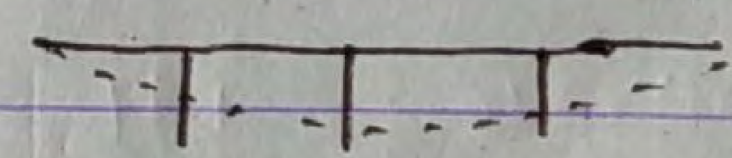
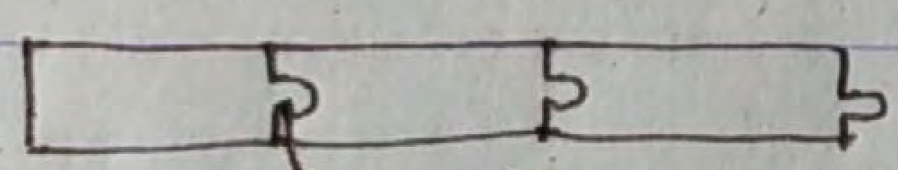


Imp. 2. " SF
Imp. 3. transverse BM → transverse vertical plane मा bend हुन्छ



4. " SF
5. " TM
6. longitudinal TM

transverse shear



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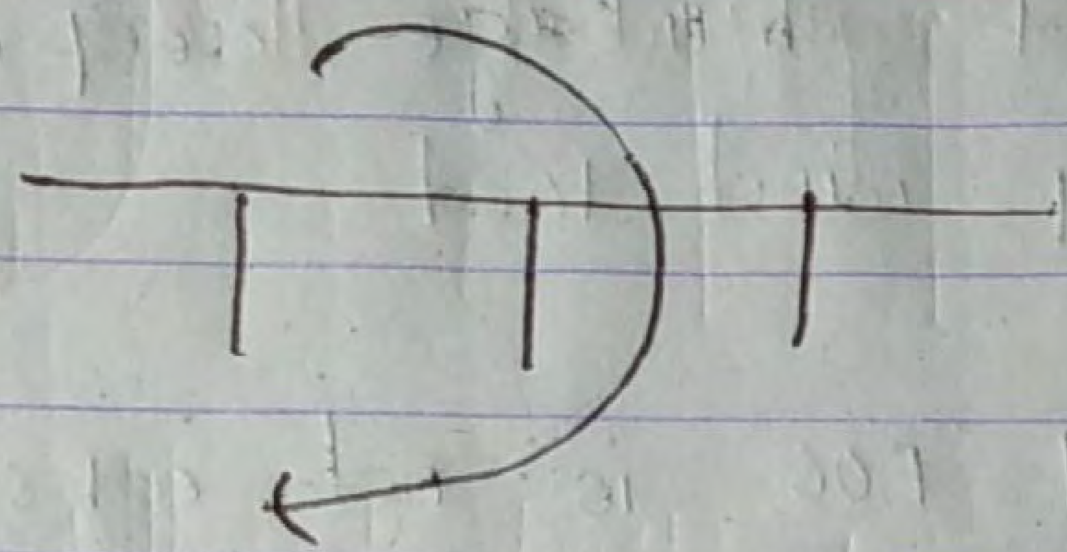
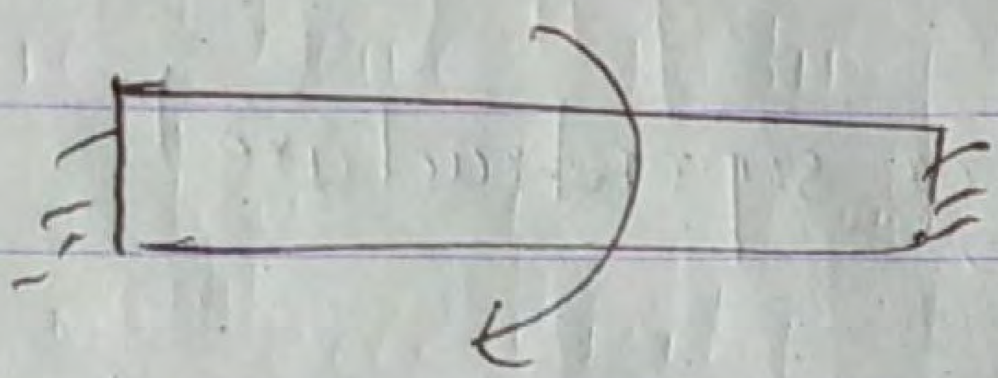


transverse vertical plane

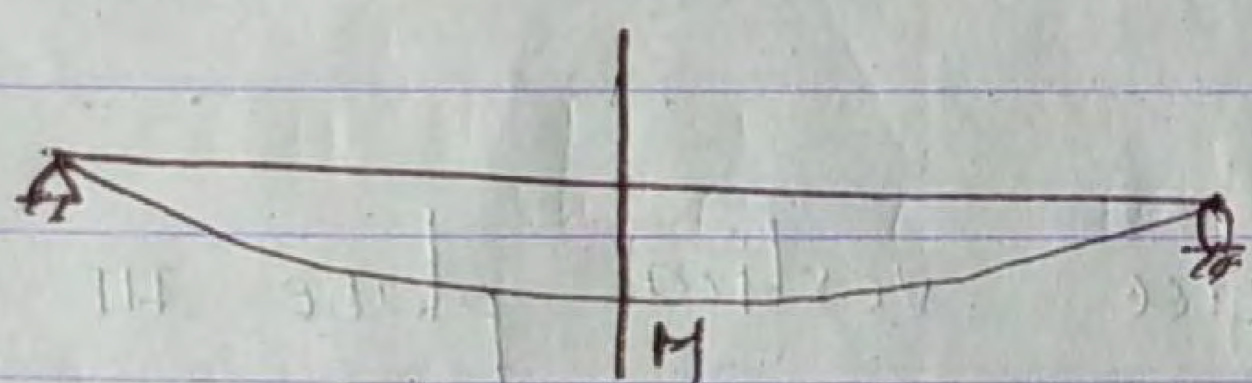
long. TM

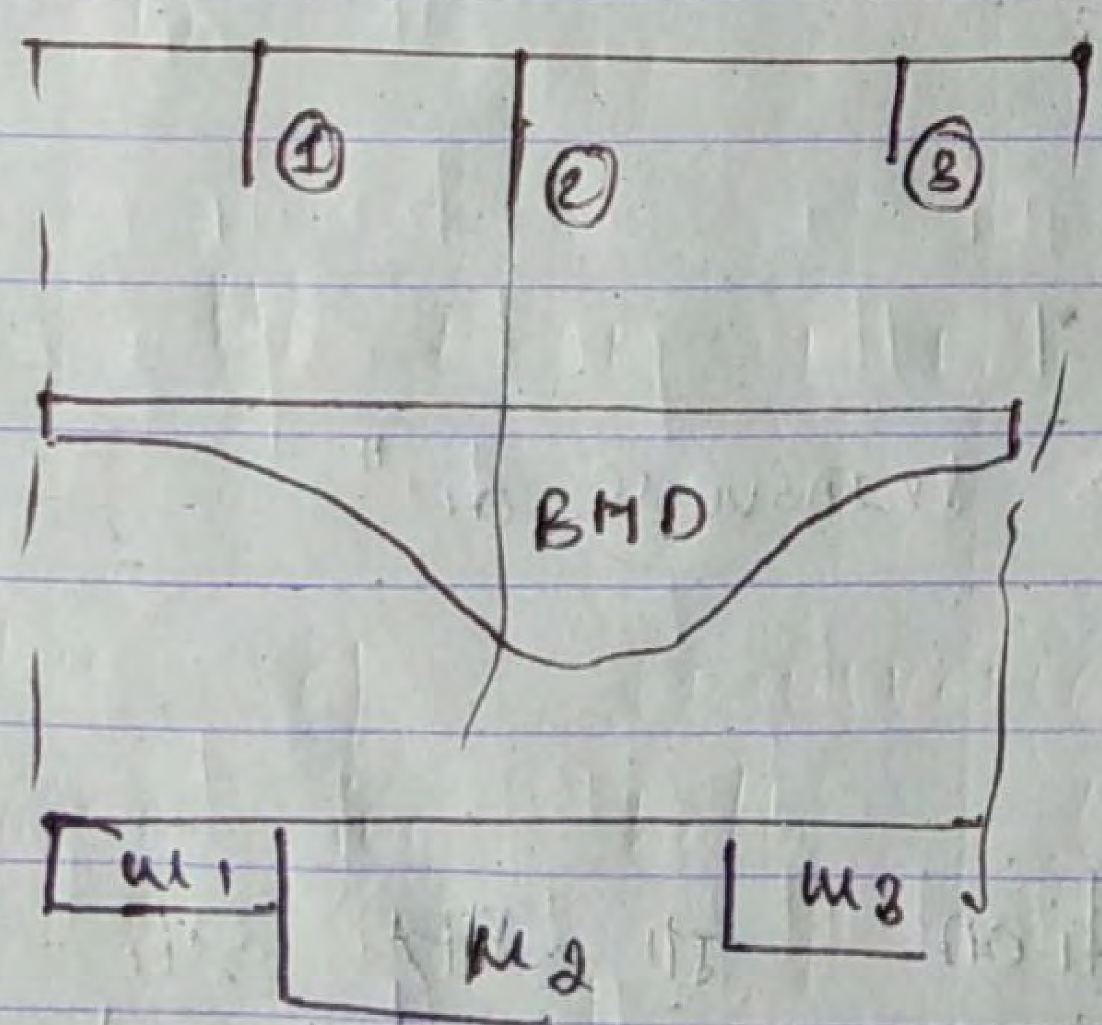


plan

longitudinal horizontal plane

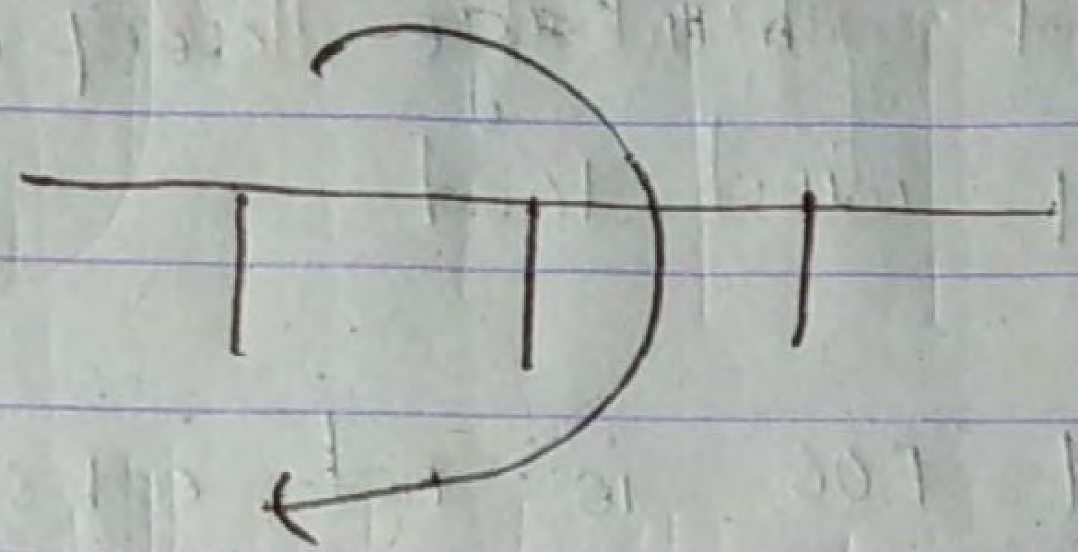
longitudinal BM





$M = m_1 + m_2 + m_3$

fig:- Distribution pattern of longitudinal BM in transverse dir^n transverse TM



transverse vertical plane

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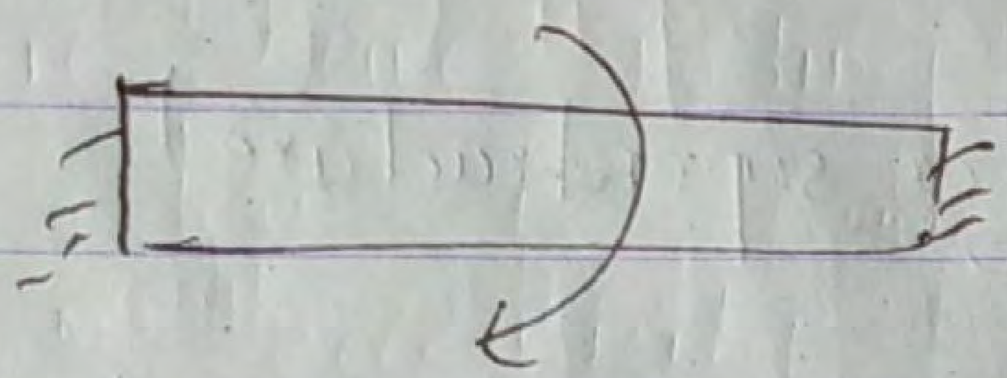
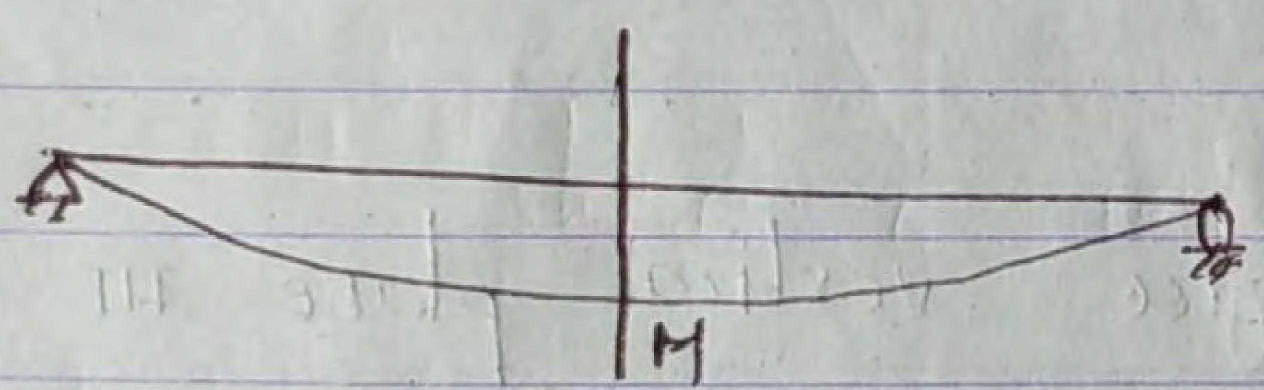


plan

longitudinal horizontal plane

longitudinal BM



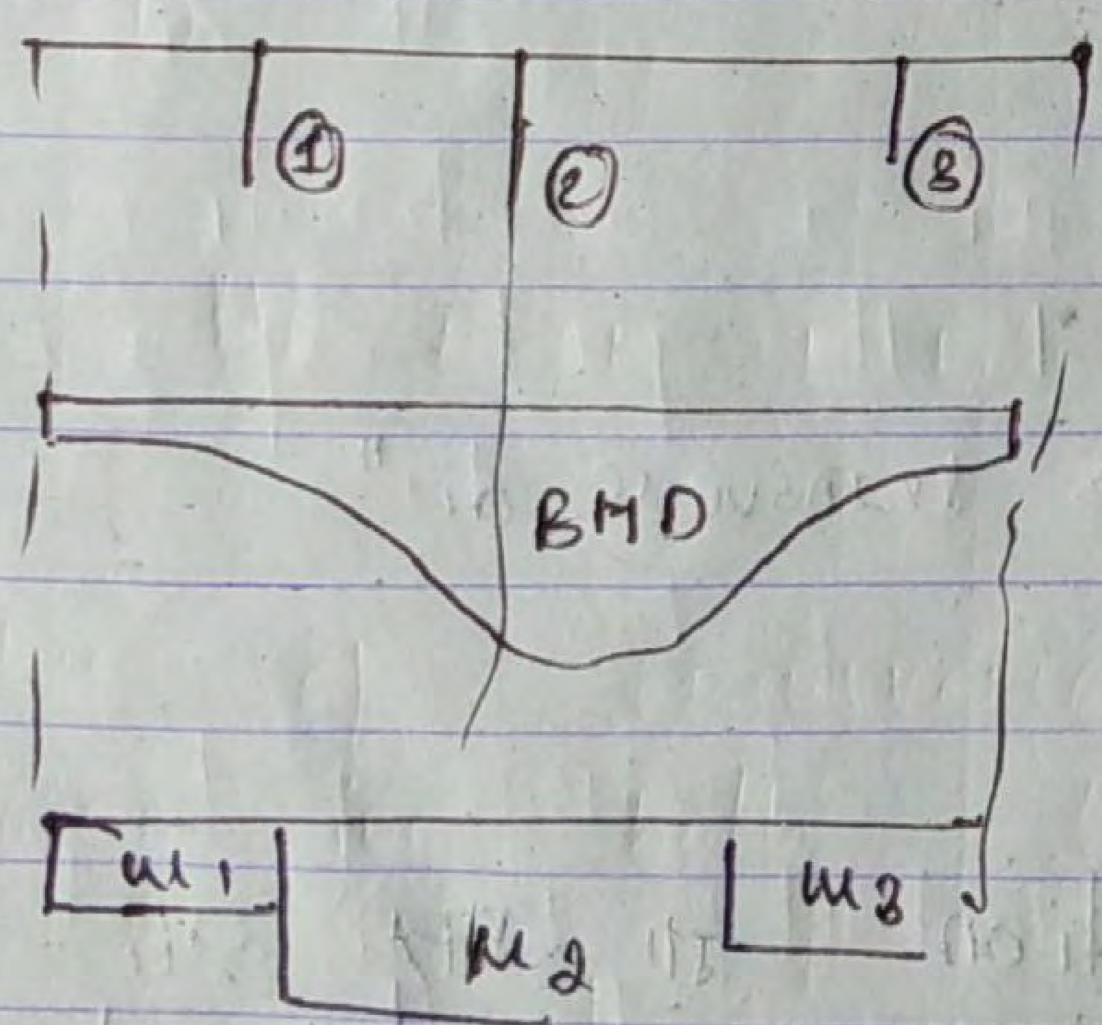


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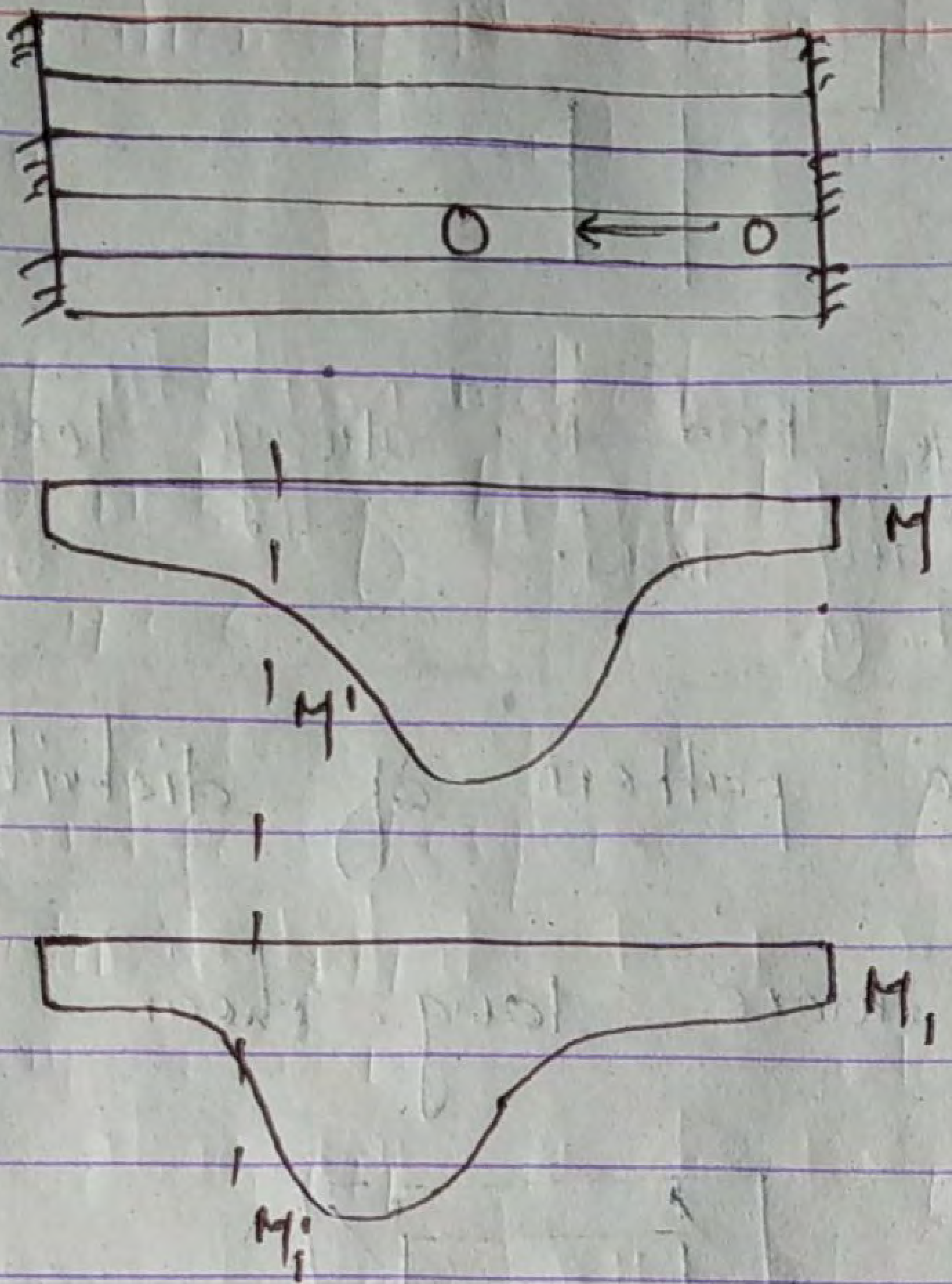
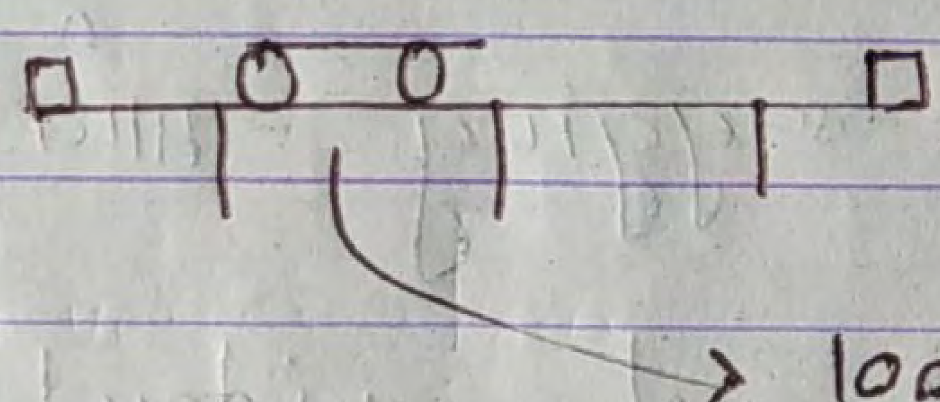
fig:- Distribution pattern of longitudinal BM in transverse dirn



pattern same follow गर्छ i.e.

$$\frac{M'}{M} = \frac{M_1'}{M_1}$$

for same line parallel to the longitudinal axis i.e. pattern of distribution of BM is same for same line of application of load along the longitudinal dirn.



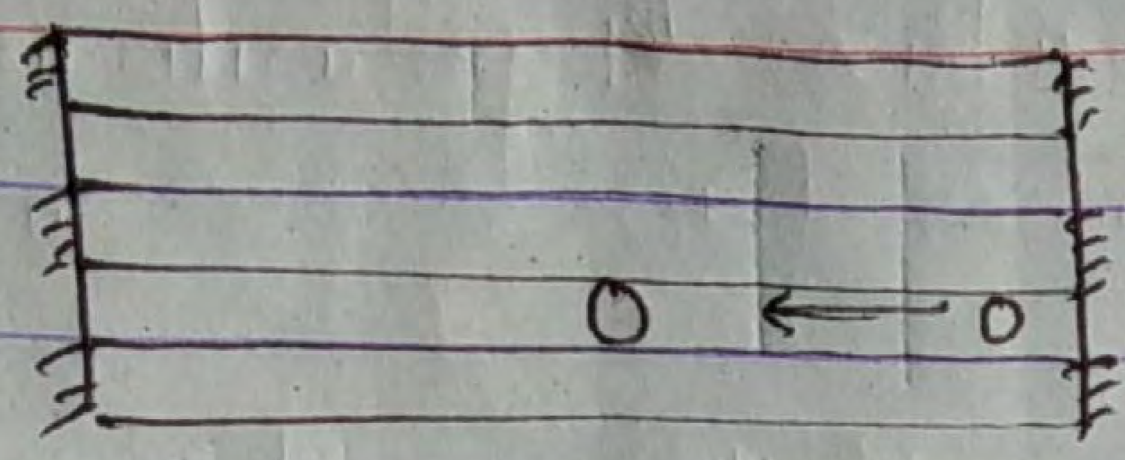
→ load को intensity maxm जब हुन्छ तब load is most eccentric from c.h.

⇒ where e is more the value of longitudinal BM is also more.

⇒ center मा हुन्दा र एजमा हुन्दा 25 % बढी हुन्छ

$b_{ef} = \frac{l_0}{6} + b_w + 6D_f$ ⇒ for building where governing force is UDL

$b_{ef} = \frac{b_0}{5} + b_w$ ⇒ for bridge where governing force is point load or patch load.



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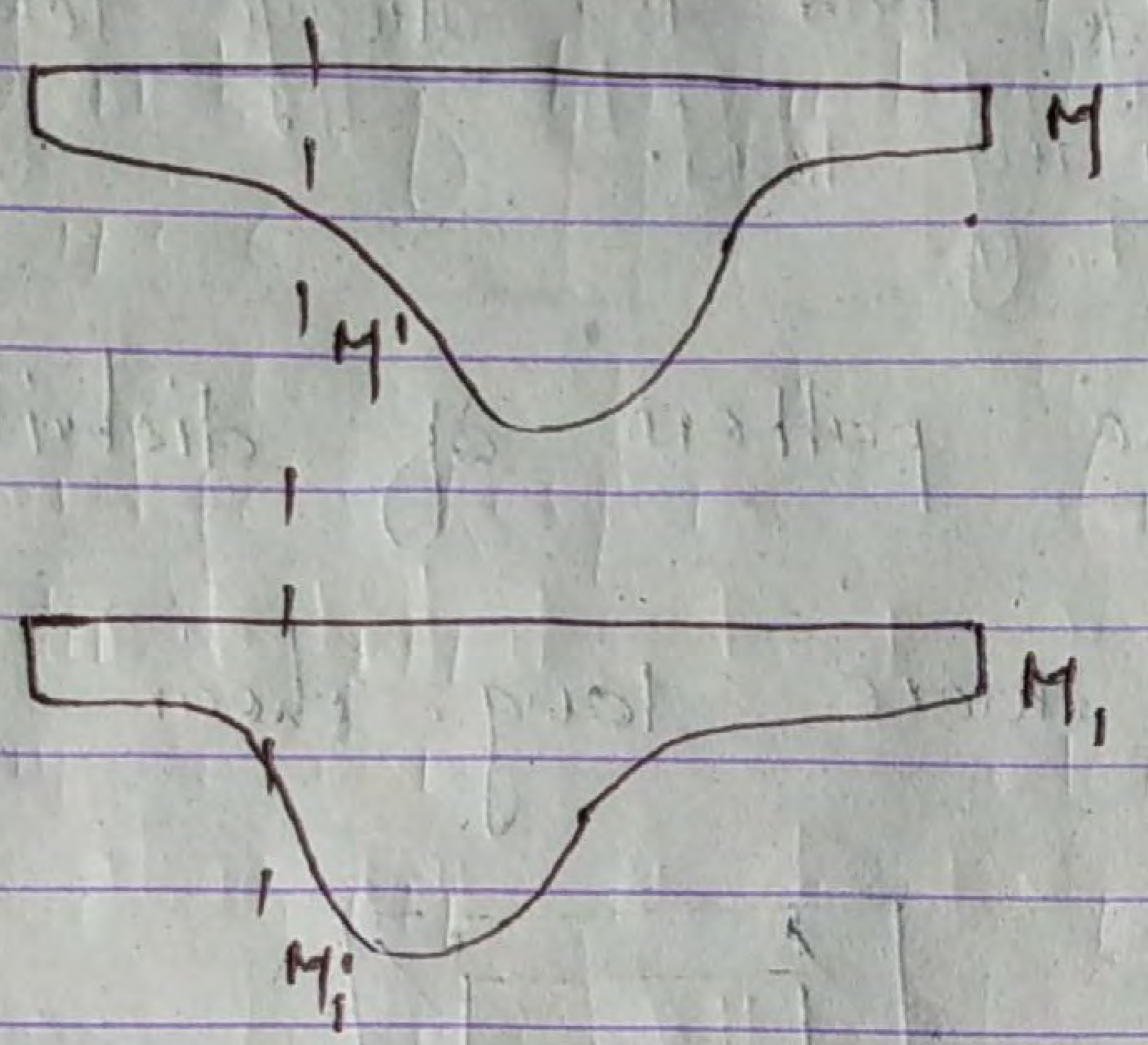

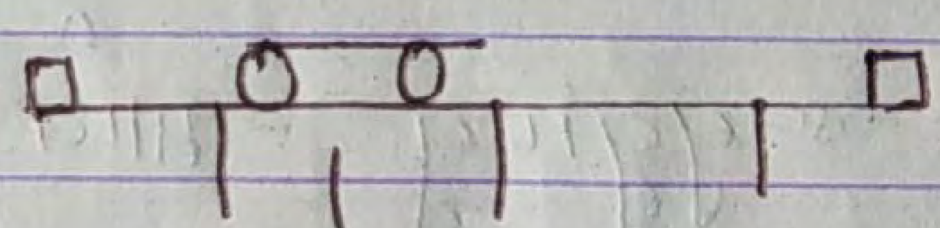

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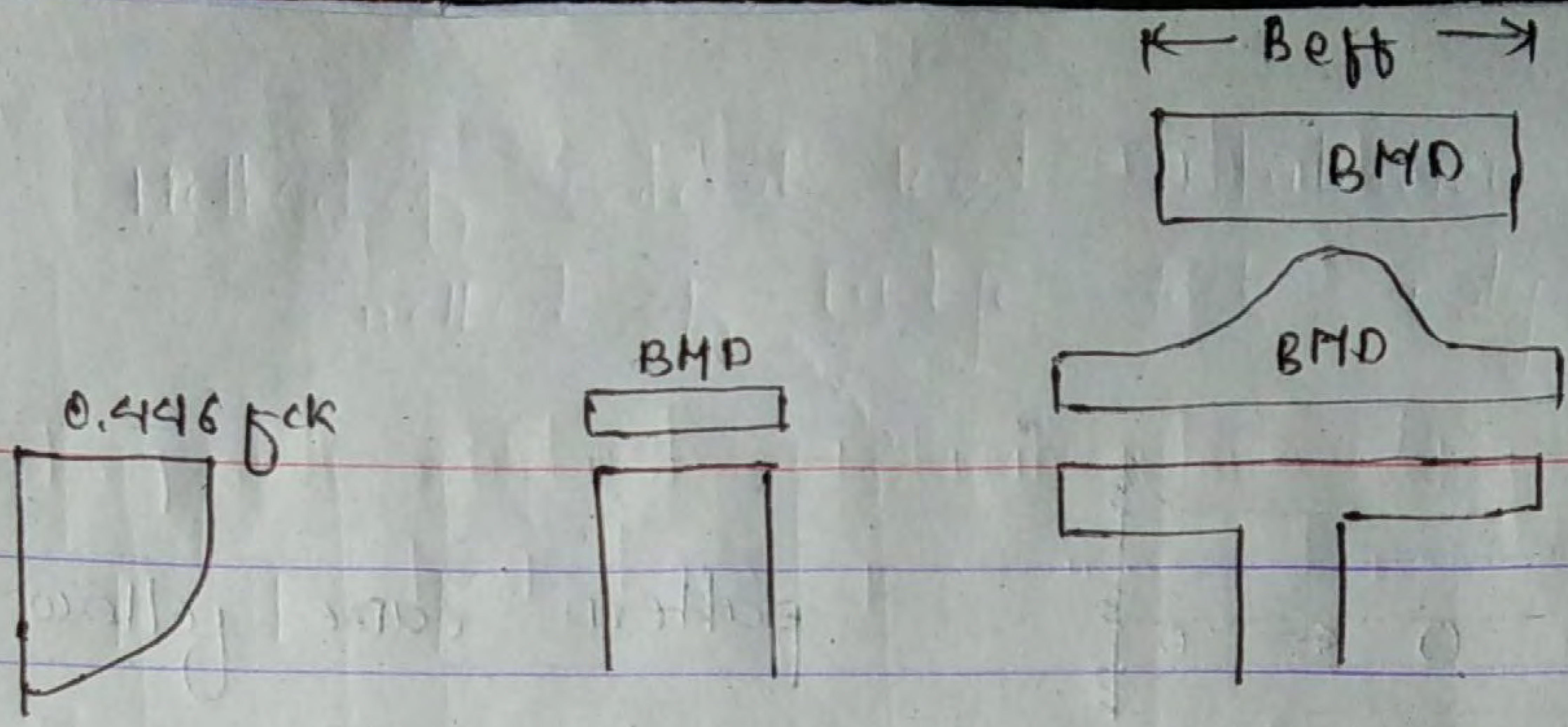
$b_{ef} = \frac{l_0}{6} + b_w + 6D_f$ ⇒ for building where governing force is UDL

$b_{ef} = \frac{b_0}{5} + b_w$ ⇒ for bridge where governing force is point load or patch load.



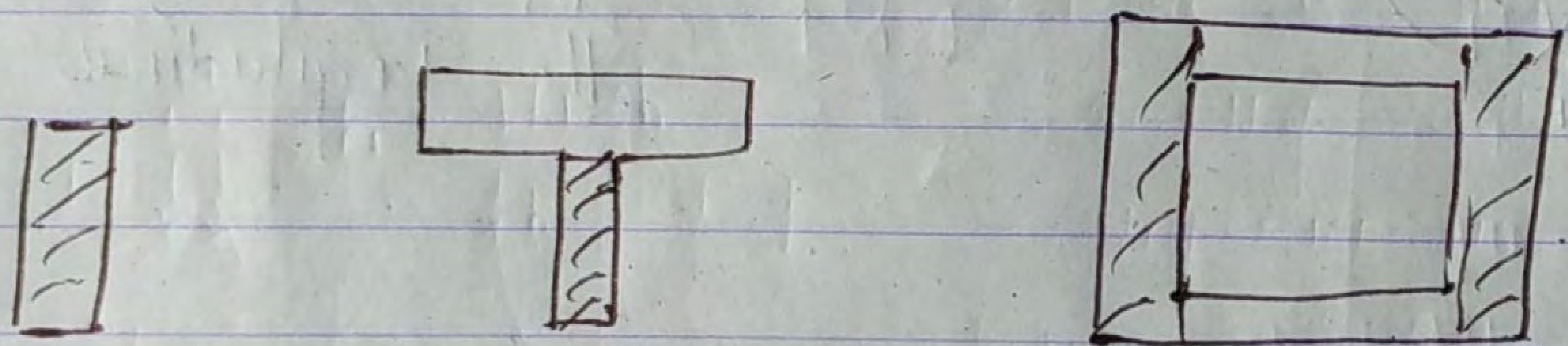
effective width of beam for bridge load is always lesser than effective width of beam for ordinary load.

Longitudinal shear

⇒ for one line loading, the pattern of distribution of long. shear is same.

→ max^m eccentricity gives more long. shear

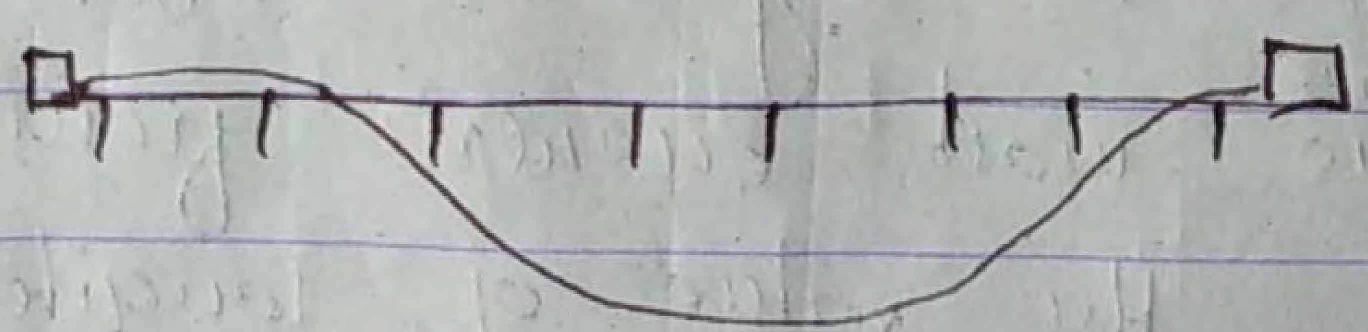
→



shear is resisted by web only.

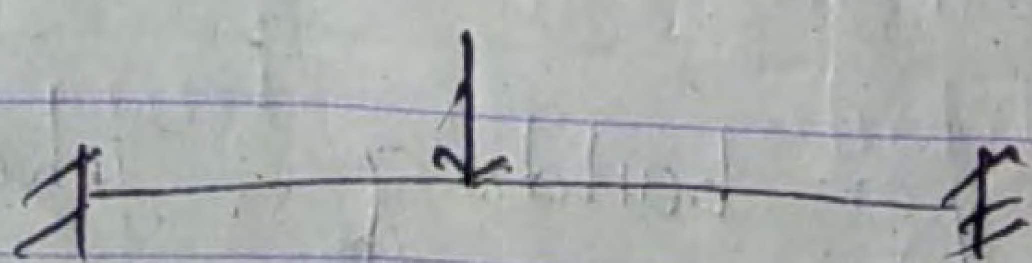
Tranverse BM

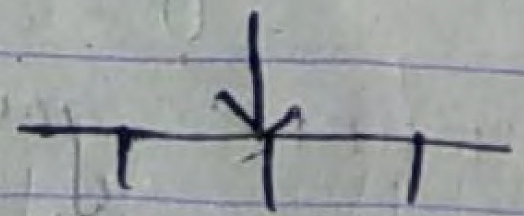
→ nature of BM is alway +ve i.e. sagging - ऊपर comp ression.



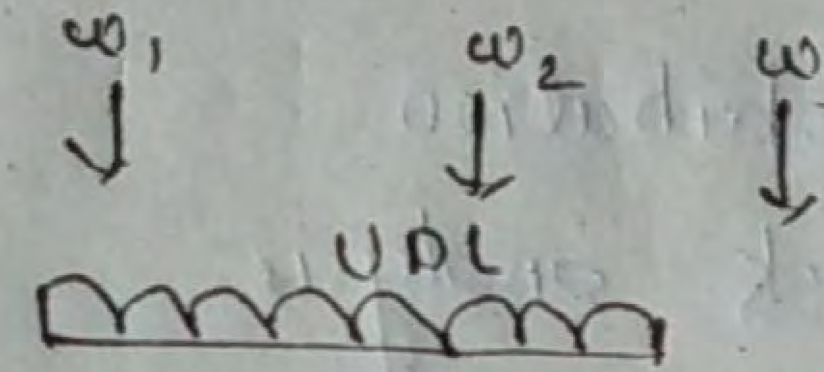
✗ not considered in desig

→ the value of transverse BM is max^m where load at center in both transverse & longitudinal dir^n i.e. CG of load at CG of deck

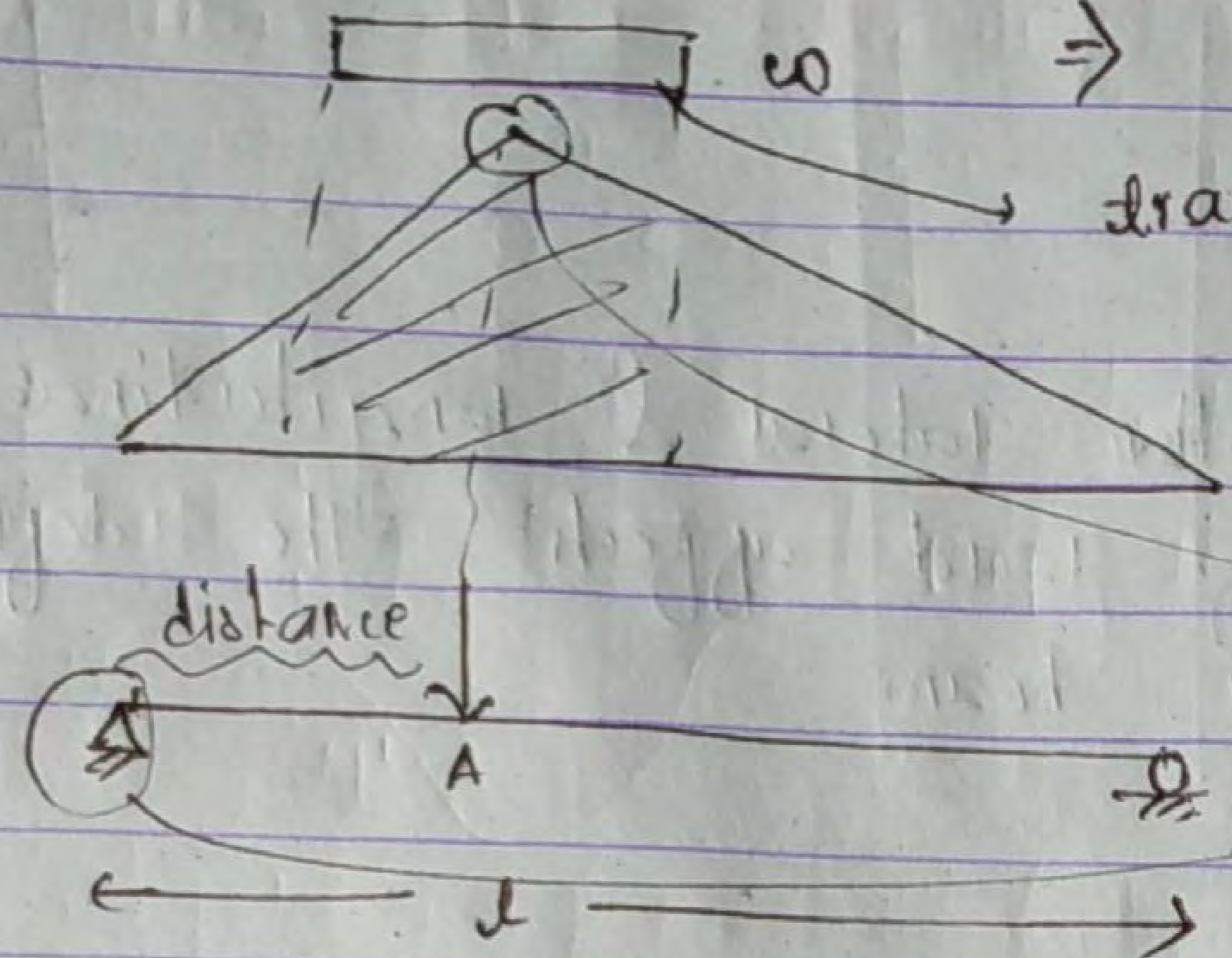




⇒



point load ⇒ $M = \Sigma Wy$ ⇒ max



⇒ $M = w * x$ = max

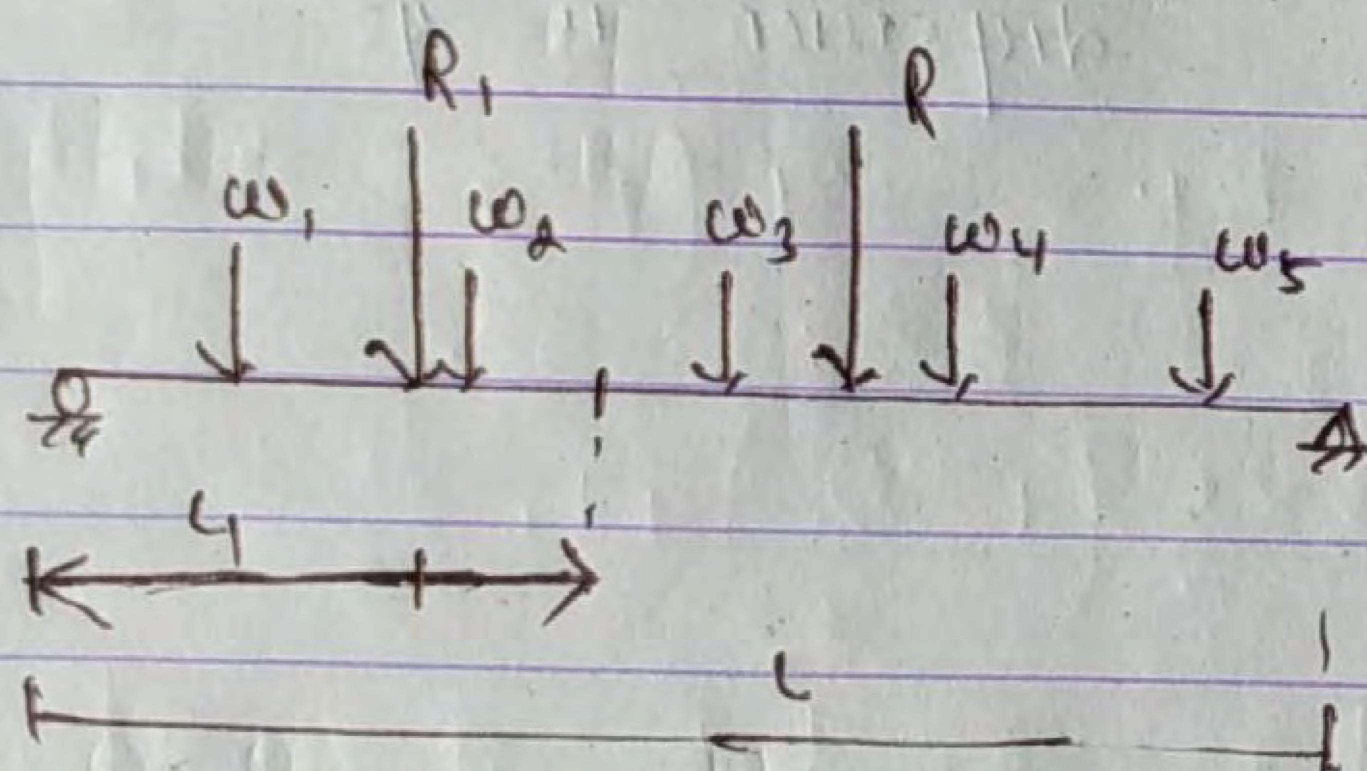
→ track load

ILD at A

→ ordinate = Reaction / distance

fig: ILD method

⇒

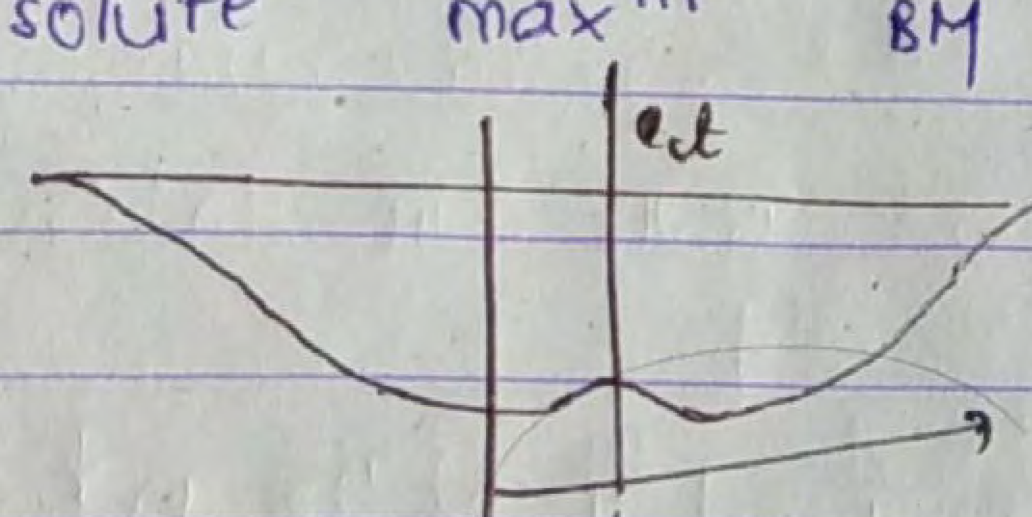


⇒ l_1 length का reaction R_1

L " " " R

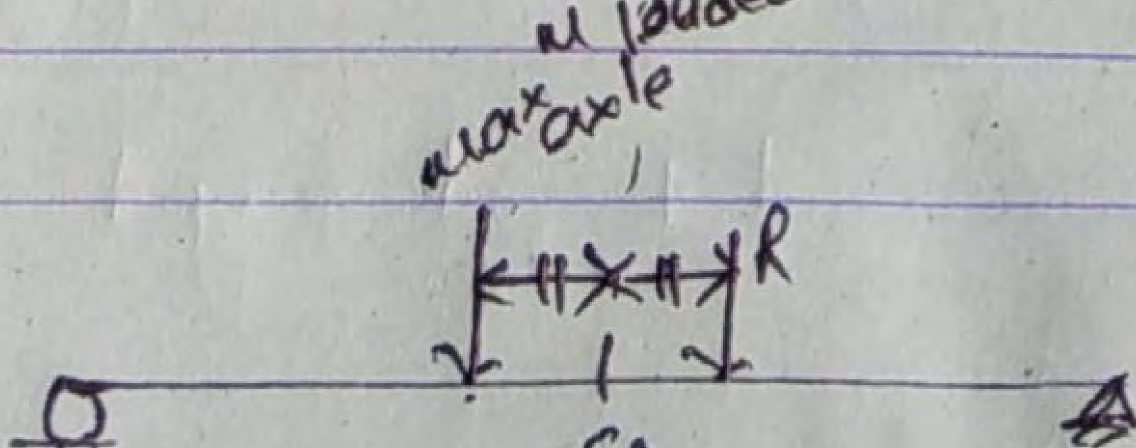
when $\frac{R_1}{l_1} = \frac{R}{L}$ then BM is max^m at that section

⇒ ~~Ast~~ Absolute max^m BM



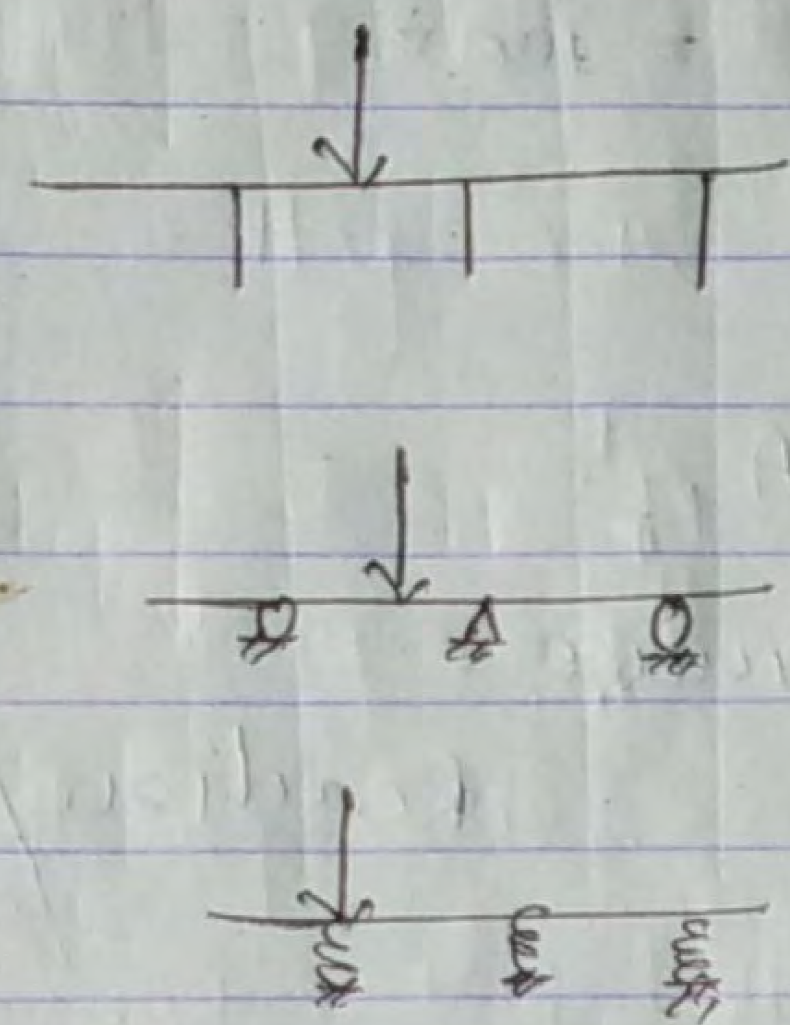
absolute max^m BM

In case of moving load, absolute max BM is near mid, not exactly at mid.



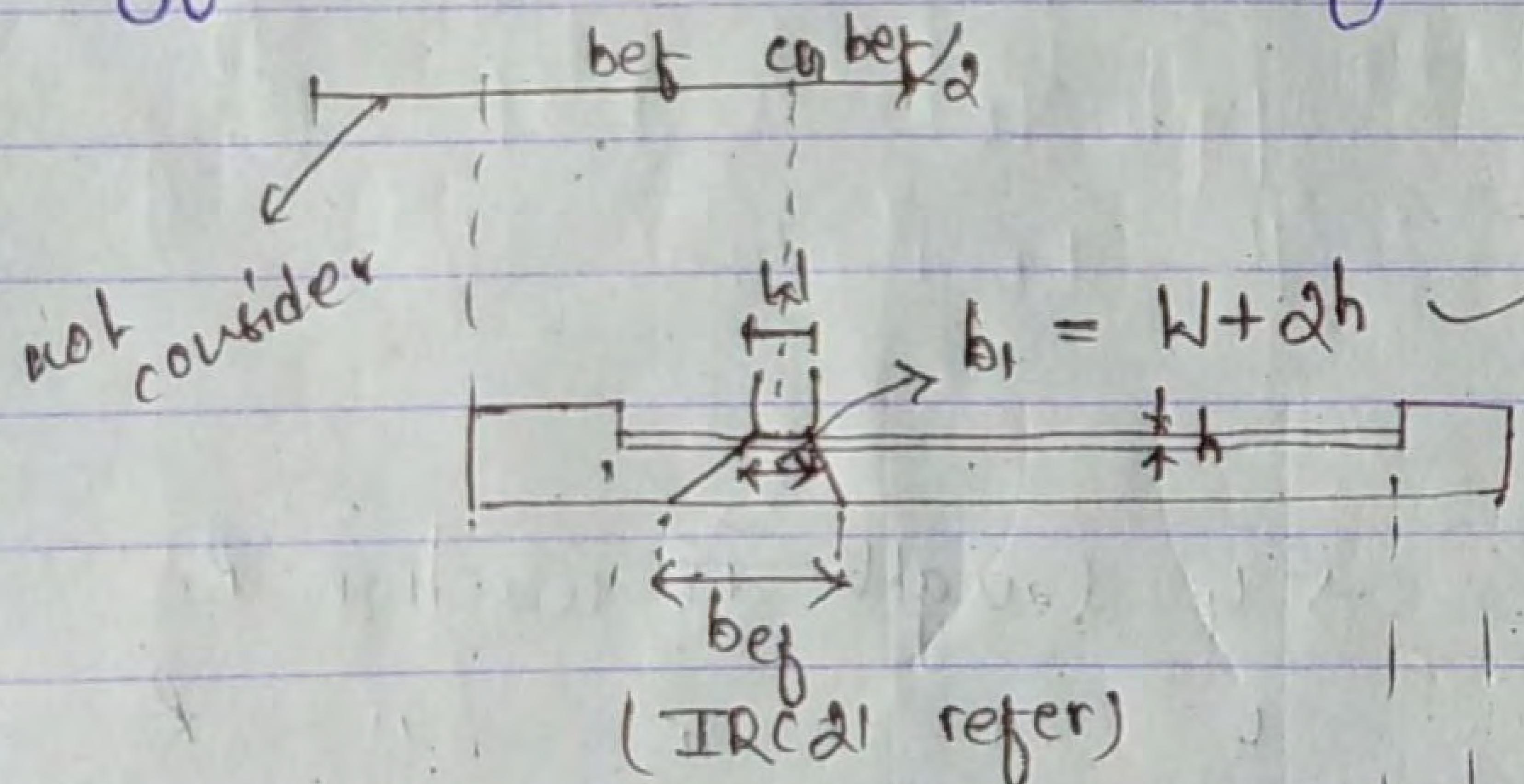
⇒ then max^m loaded axle को ~~नीचे~~ absolute max^m BM होगा

Method of lateral load distribution
method of bridge deck analysis



Both lateral & longitudinal position of load affects the deflection of T beam

Effective width method of lateral load distribution



load is immediate disperse in wearing coat & angle of dispersion is 45°

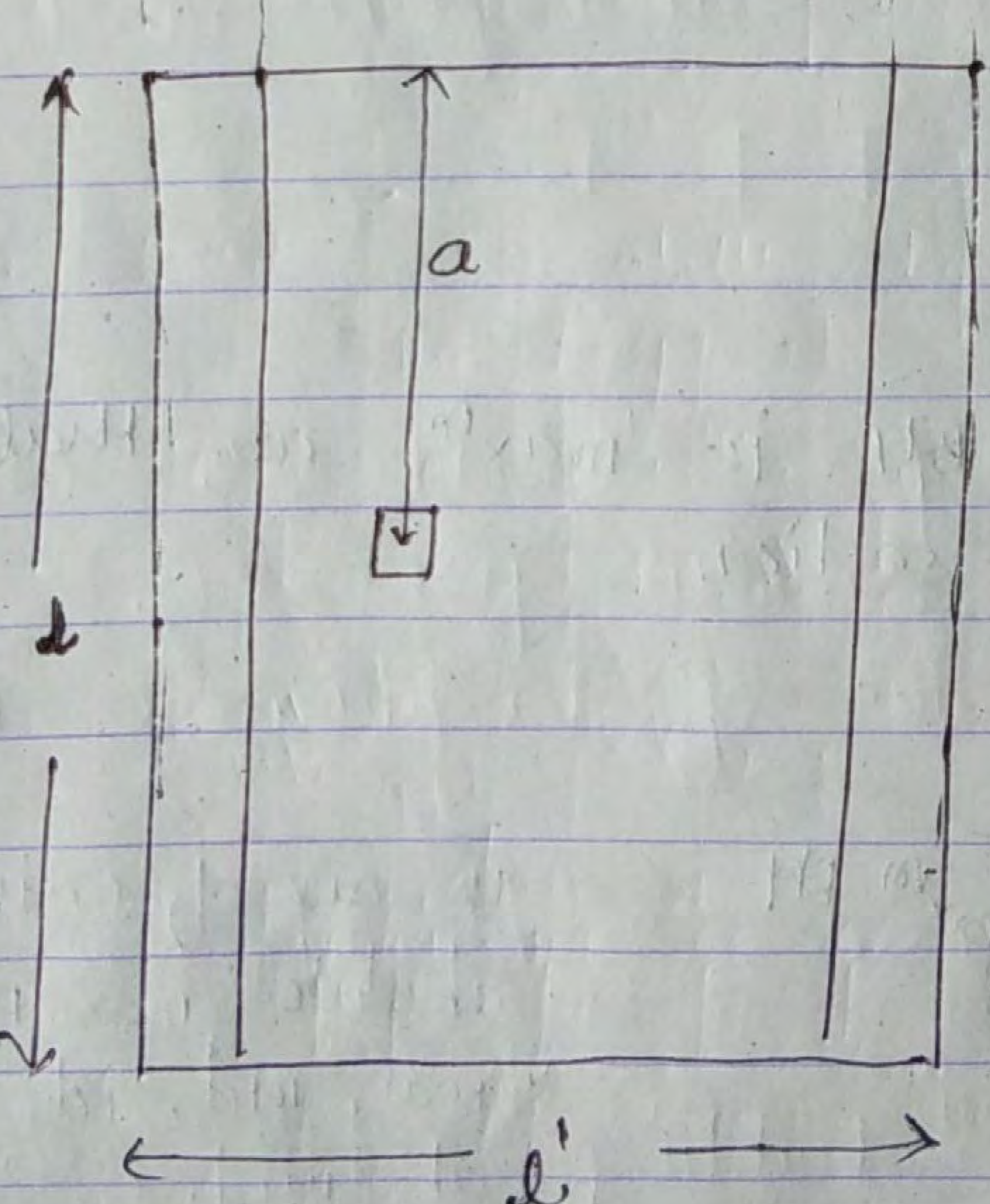
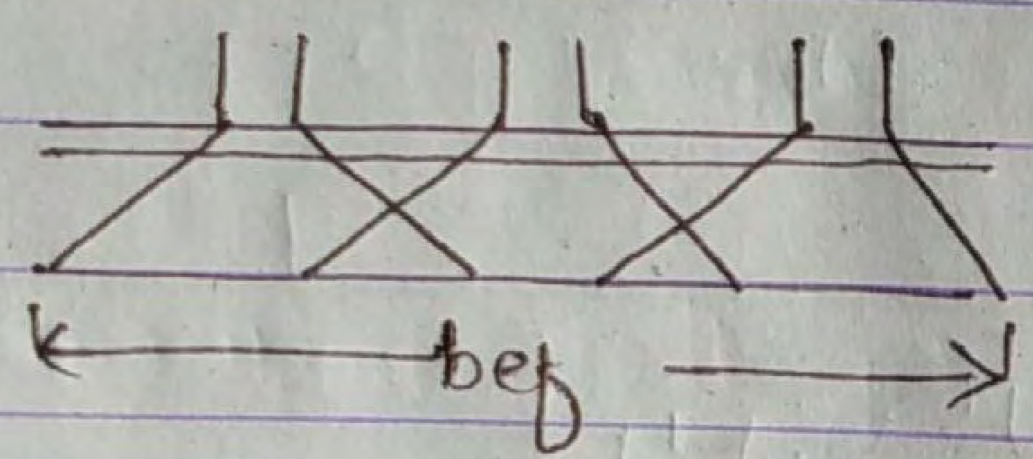


fig: Simply supported case

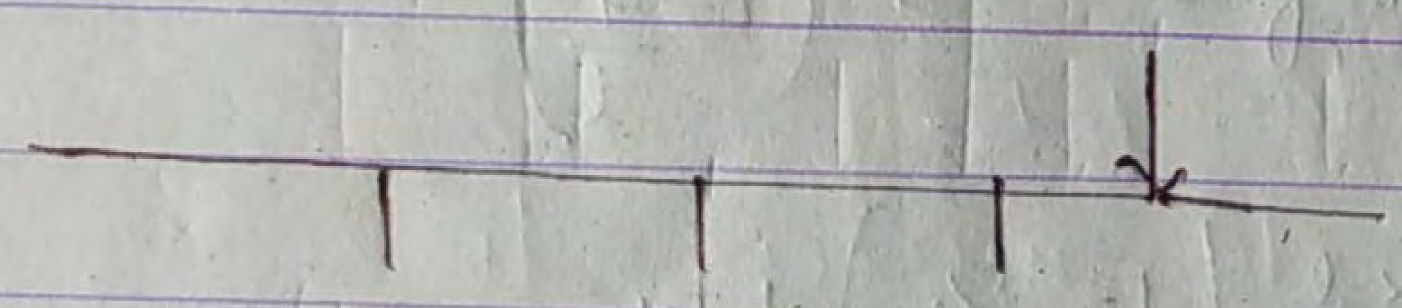
$$b_{ef} = \alpha a(1 - a/l) + b_1$$

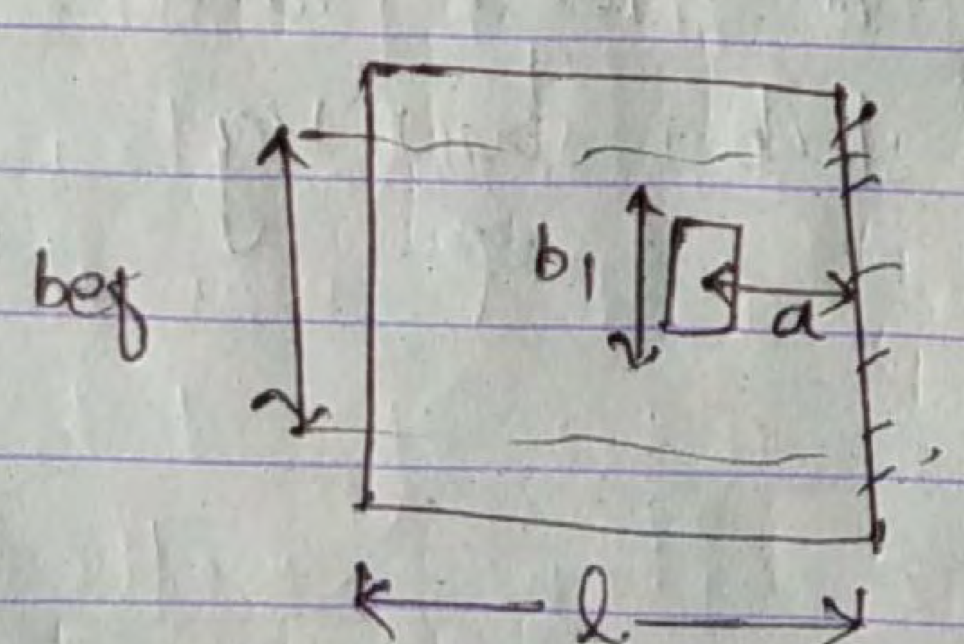
b_1 = immediate dispersion of load

⇒ for overlapping



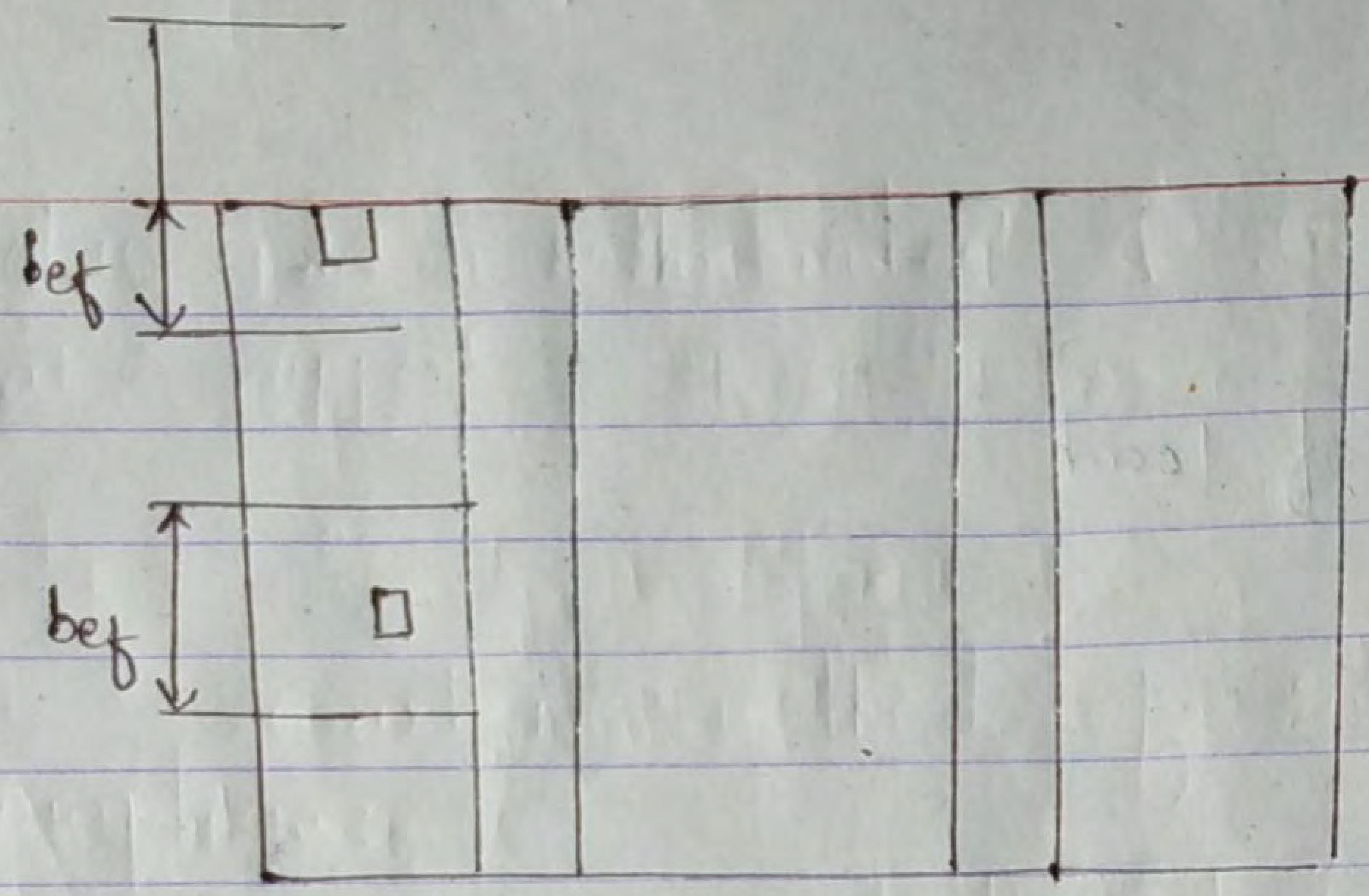
⇒ for cantilever slab



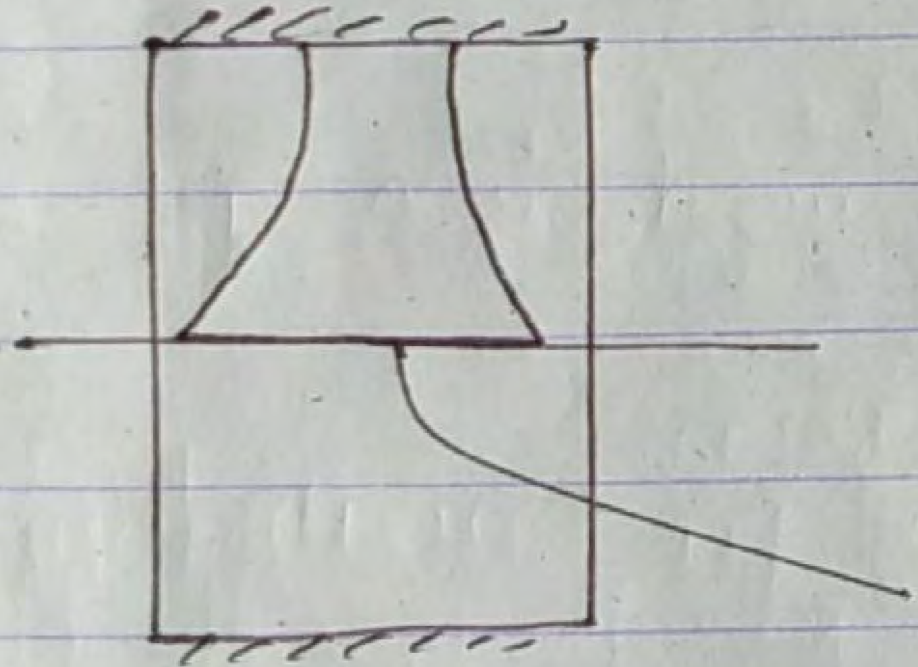


⇒ for cantilever portion load is shared along transverse dirn

$$b_{ef} \le \frac{l}{3}$$



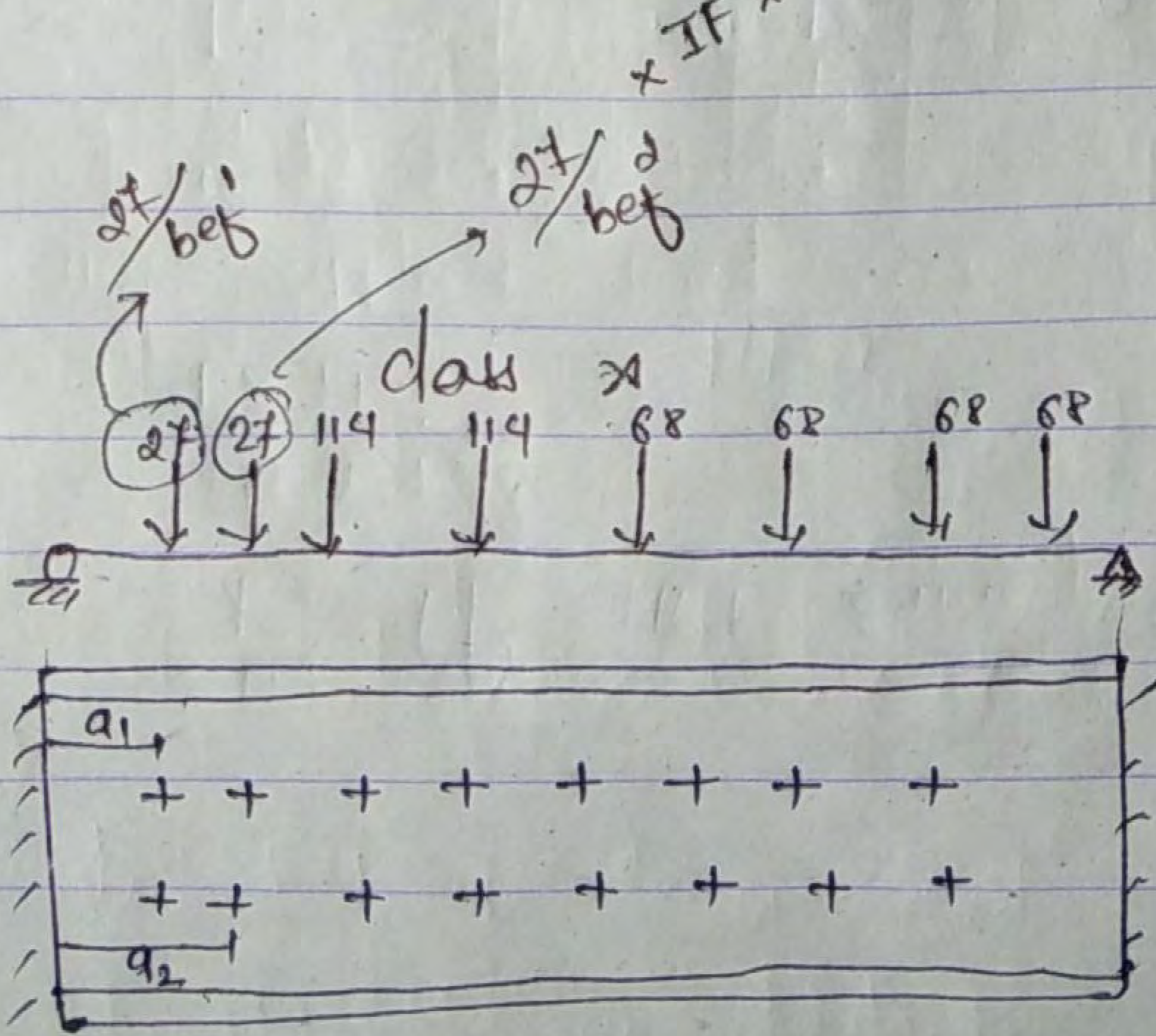
plan



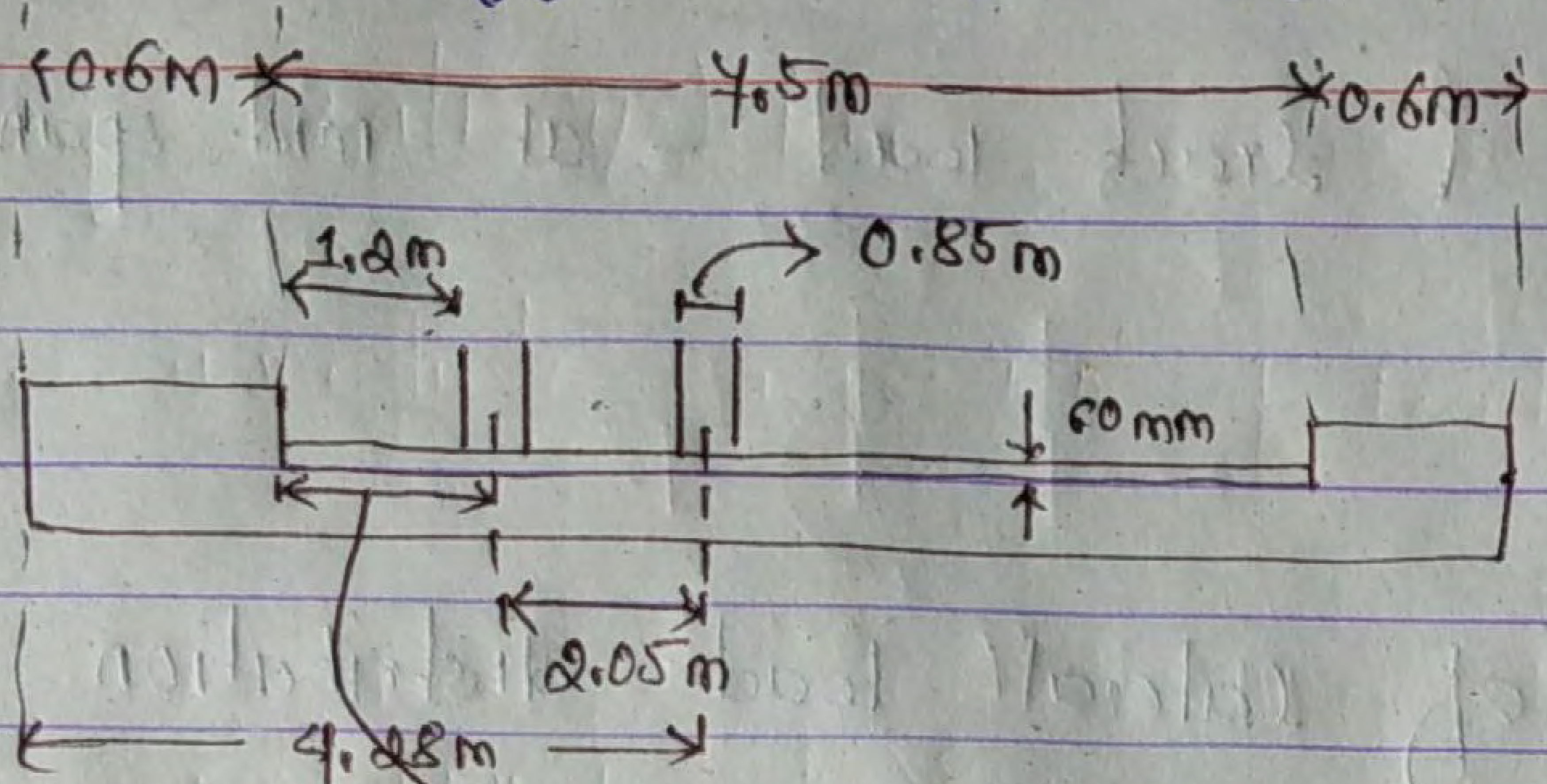
$$b_{ef} = \alpha a \left(1 - \frac{a}{l}\right) + b_1$$

$$\alpha \times \frac{l}{2}\left(1 - \frac{l/2}{l}\right) + b_1$$

full bend કુલ ઠાકેમાં વધુ strip of slab તે load લેશે but at the support the portion of slab sharing the load is min^m.



example on effective width method



$1.2 + \frac{0.85}{2} = 1.625$ m

$b_{ef} = \alpha a \left(1 - \frac{a}{l}\right) + b_1$

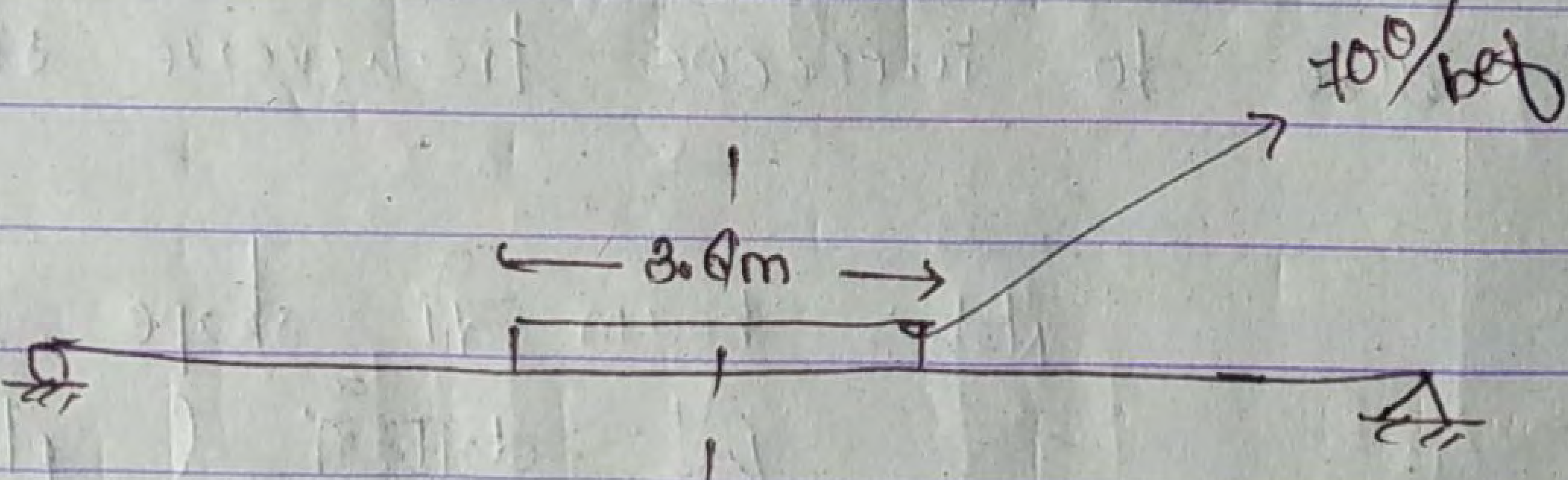
$\alpha = \frac{7.5 + 2 \times 0.6}{8} = 1.1 \Rightarrow \alpha = 2.6$

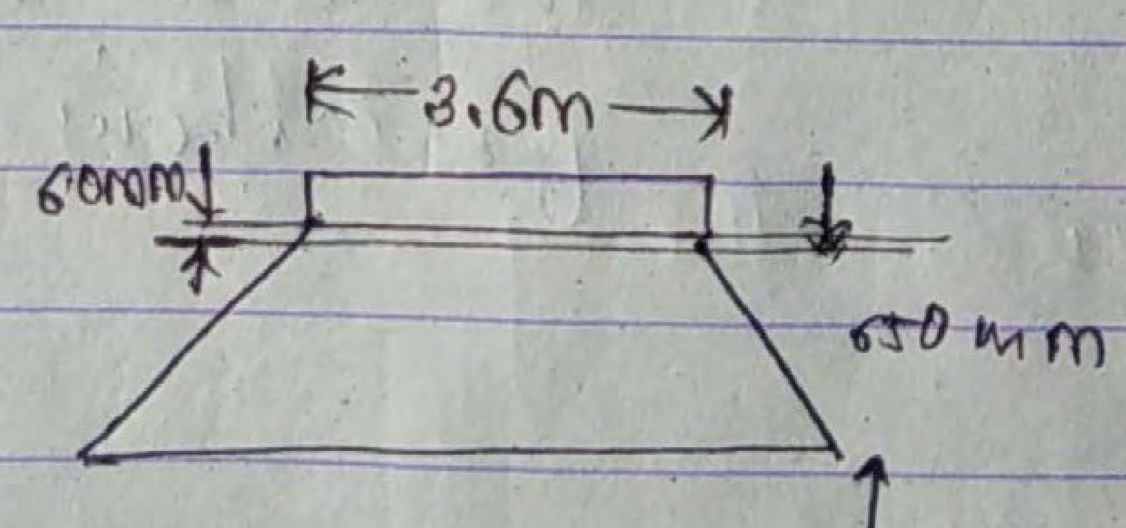
$a = 4m$

$b_1 = 0.85 + 2 \times 0.06 = 0.97$ m

$b_{ef} = 6.17$ m

OR $\frac{700}{b_{ef}[3.6 + 2(h+D)]} \times IF \times 1/f$





$3.6 + 2(h+D)$

H.W

class AA both wheel & track load - at mid span & at support

courbon's method of lateral load distribution

Assumptions:-

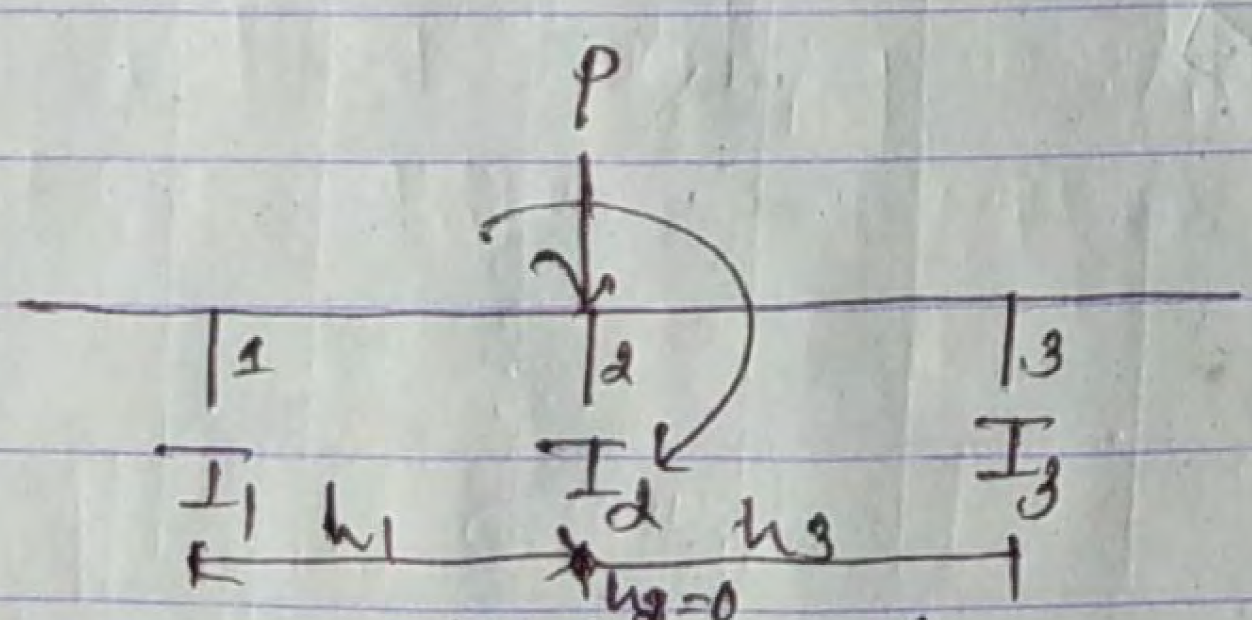
1. If the load is applied centrally, then in that x section at any point the deflection is same.

2. If the moment is applied at center, then linear rotation takes places.

main function of cross beam → increase stiffness in transverse direction.

0.75D in einitation is also to increase transverse stiffness

Note:- beam की shape, size एक जैसे बनाऊंगे & placing the load & moment at the center of deck for courbon's method



for centrally applied load

$$R_1 = \frac{P \times I_1}{I_1 + I_2 + I_3}$$

$$= \frac{P}{n} \quad \text{(if MOI same)}$$

for centrally applied moment

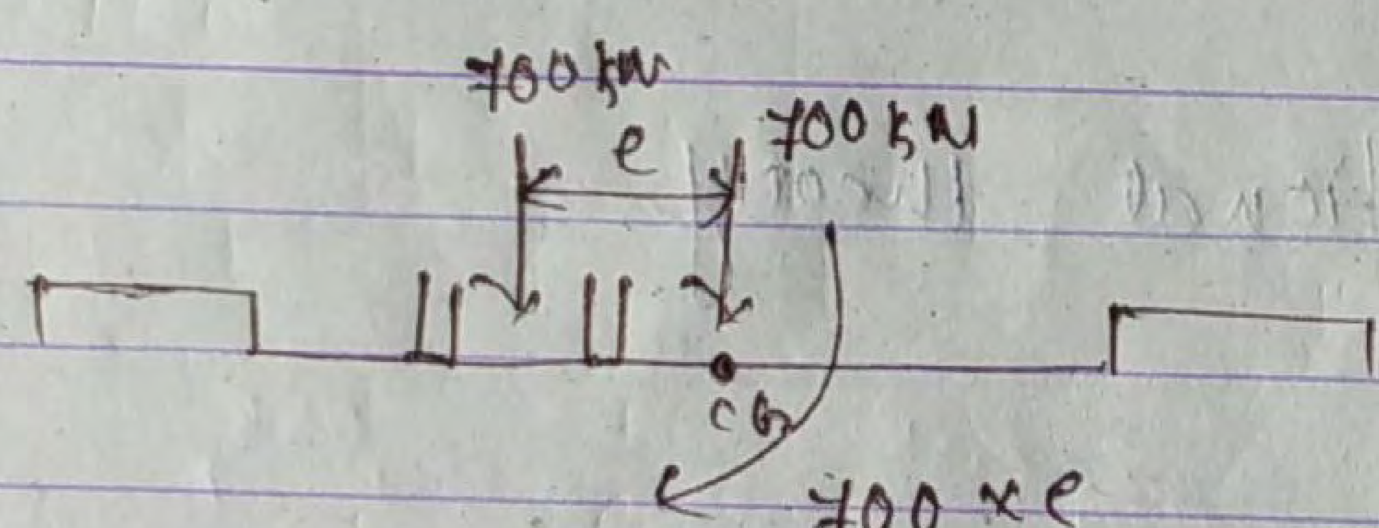
h = distance from c.g of load to girder

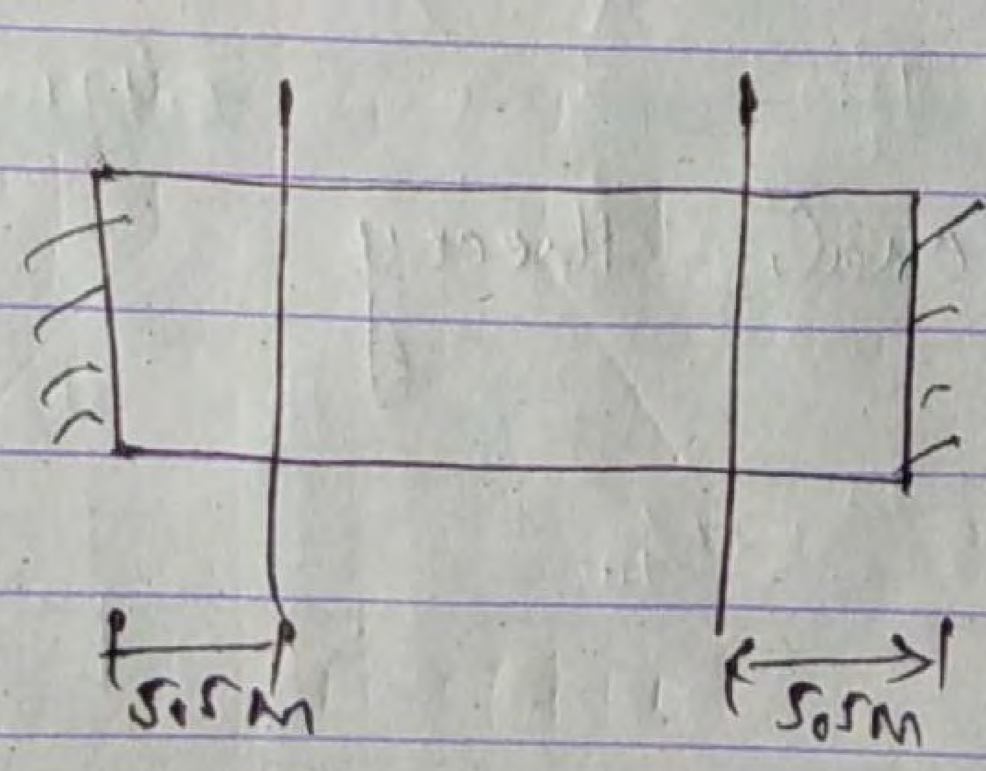
$$R_1 = \frac{M \times I_1 h_1}{\Sigma I h^2}$$

$$= \frac{M h_1}{\Sigma h^2} \quad \text{when MOI same}$$

In real practise beam का shape size same i.e. I same only reinforcement different.

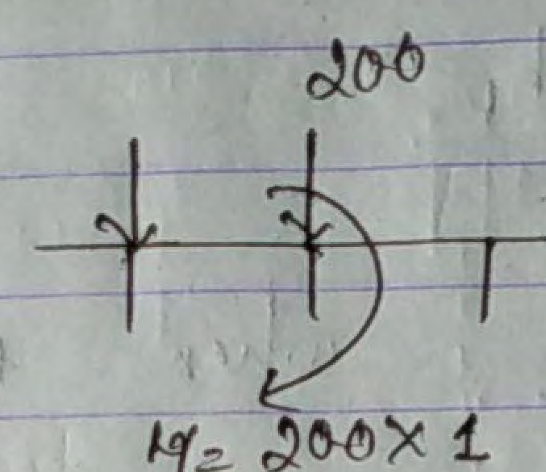
In real practise load & moment is not at center so we calculate the equivalent loading.





⇒ In this case not we courbon's method because deflection low i.e. the support behaves as rigid.

$$R_n = \frac{P I_n}{\Sigma I} + \frac{M I_n h_n}{\Sigma I h^2}$$



$$R_1 = \frac{200}{3} + \frac{200 \times 1}{h_1^2 + h_2^2 + h_3^2}$$

where $h_1 = 1$

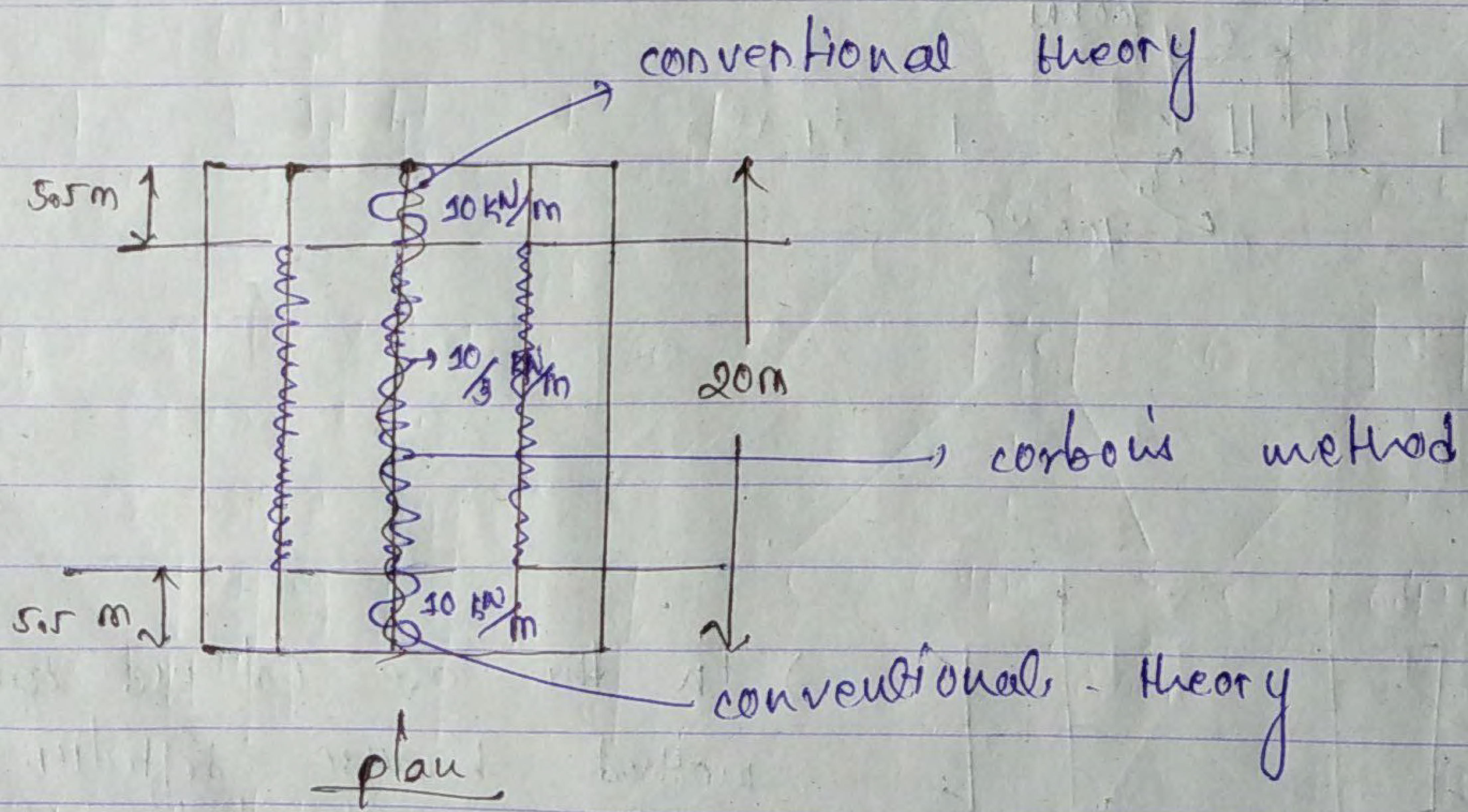
$h_2 = 0$

$h_3 = 1$

$$R_2 = \frac{200}{3} + 0$$

$$R_3 = \frac{200}{3} - \frac{200 \times 1}{h_1^2 + h_2^2 + h_3^2}$$

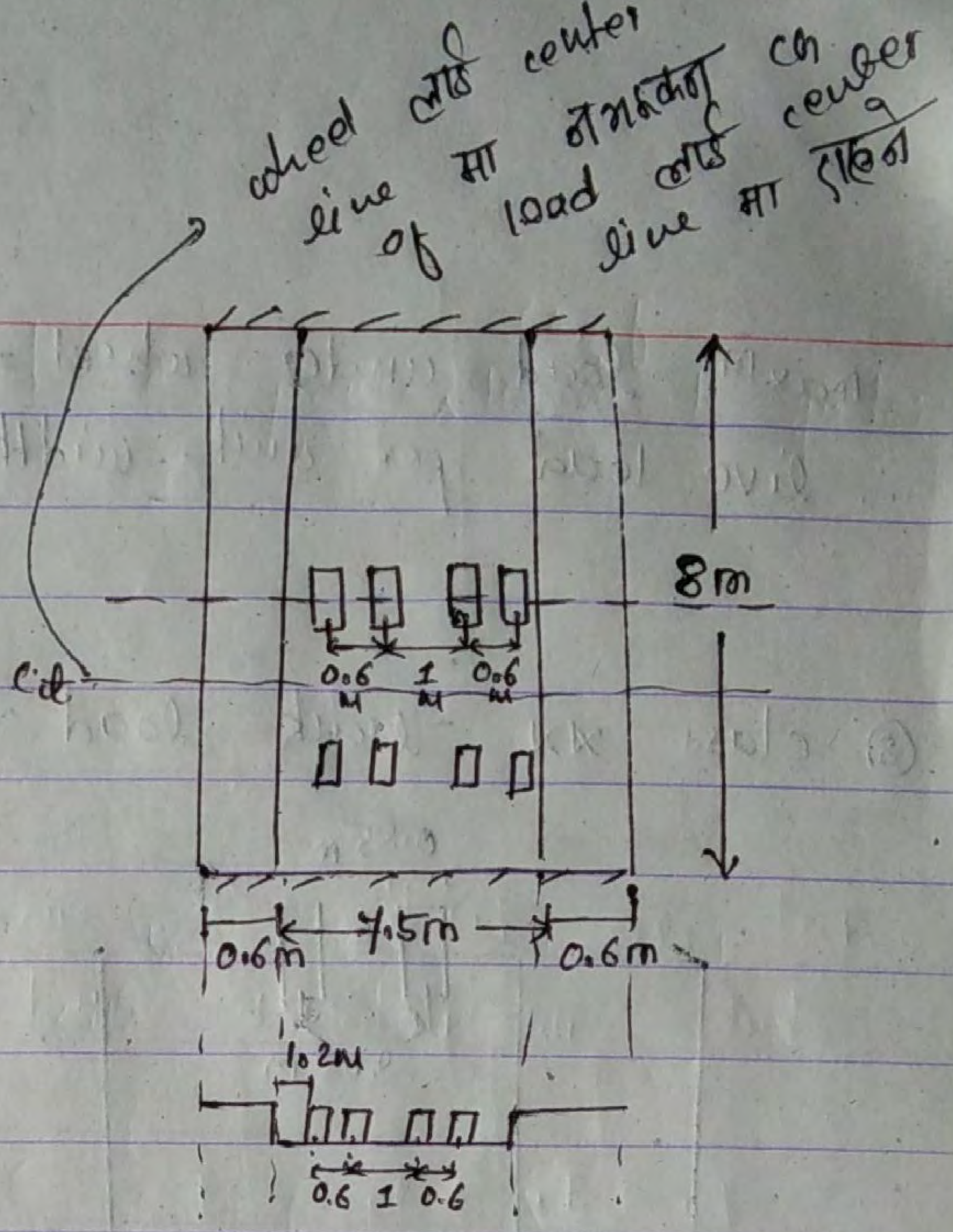
if तत माथे- दूंगे compression or tension नथो गने +ve



plan

H.W in effective width method

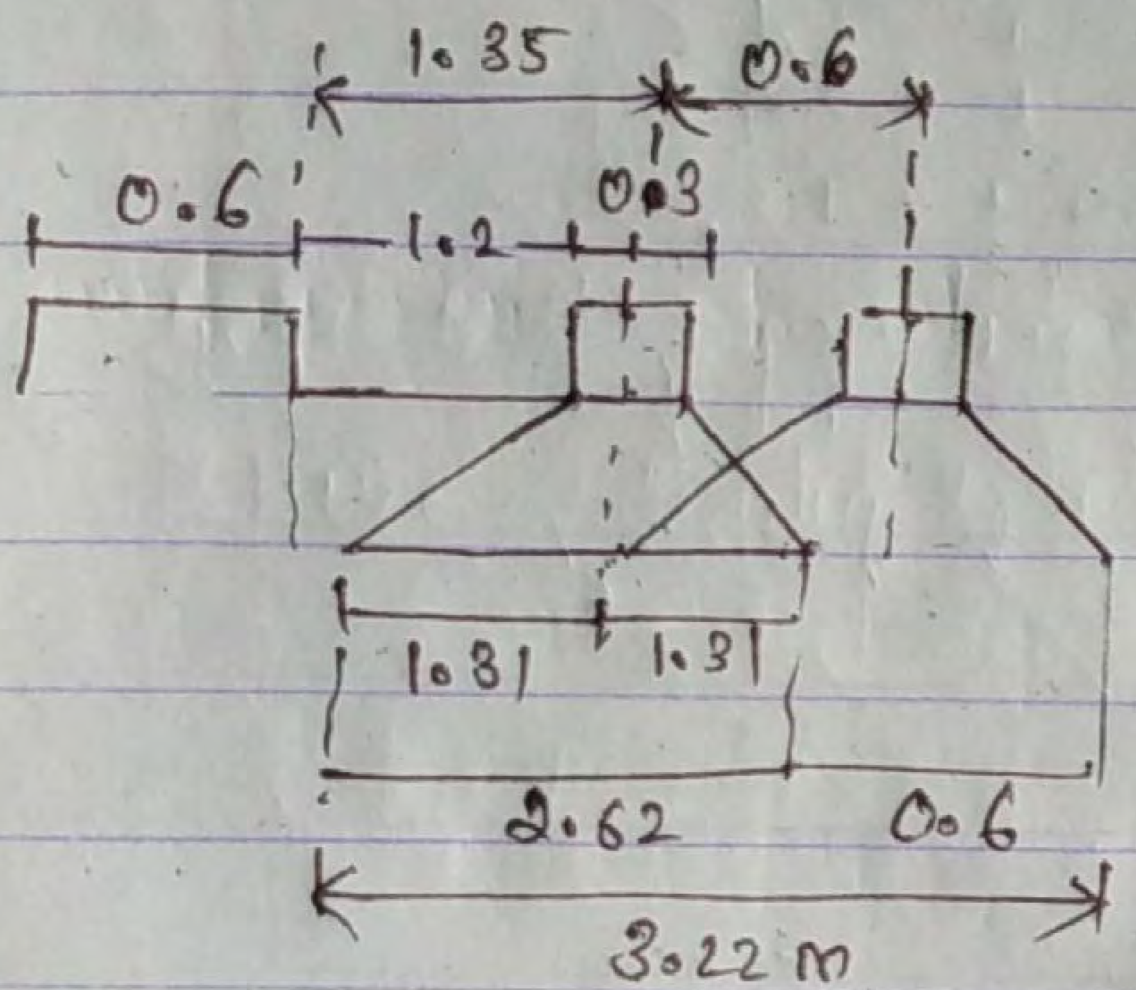
① class A-A wheel load at ~~support~~ center

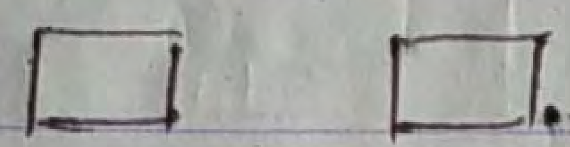


$b_{ef} = \alpha a \left(1 - \frac{a}{l}\right) + b_1$

$= 1.1 \times 4 \left(1 - \frac{4}{8}\right) + 0.3 + 2 \times 0.06$ (2.6)

$= 2.62$ m





overlapping case

Hence,

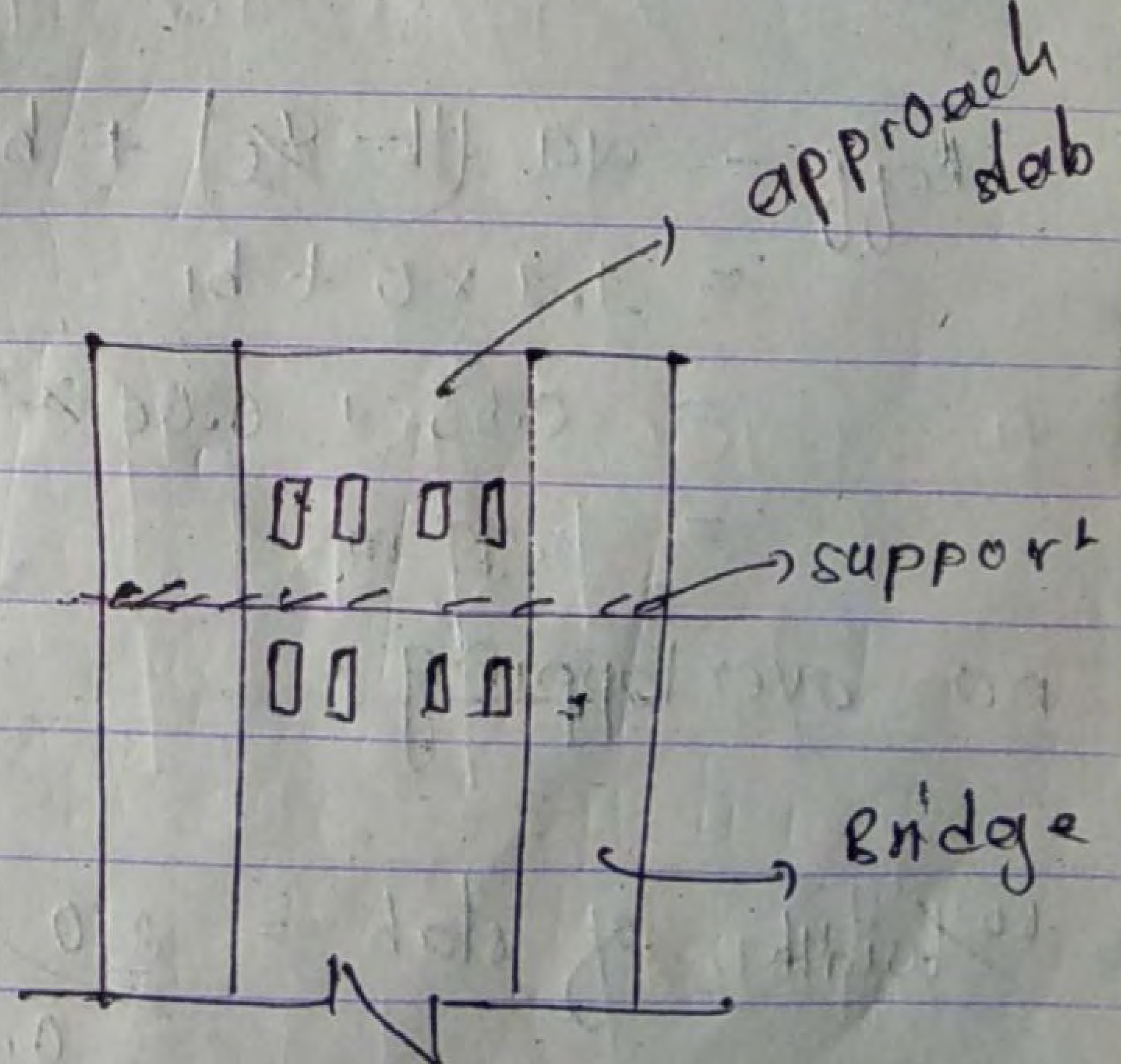
$b_{ef}^{modified} = 1.31 + 0.6 + 1 + 0.6 + 1.31$

$= 4.82$ m

LL per unit width of slab = 400 (200) / 4.82 kN/m

= 82.99 kN/m

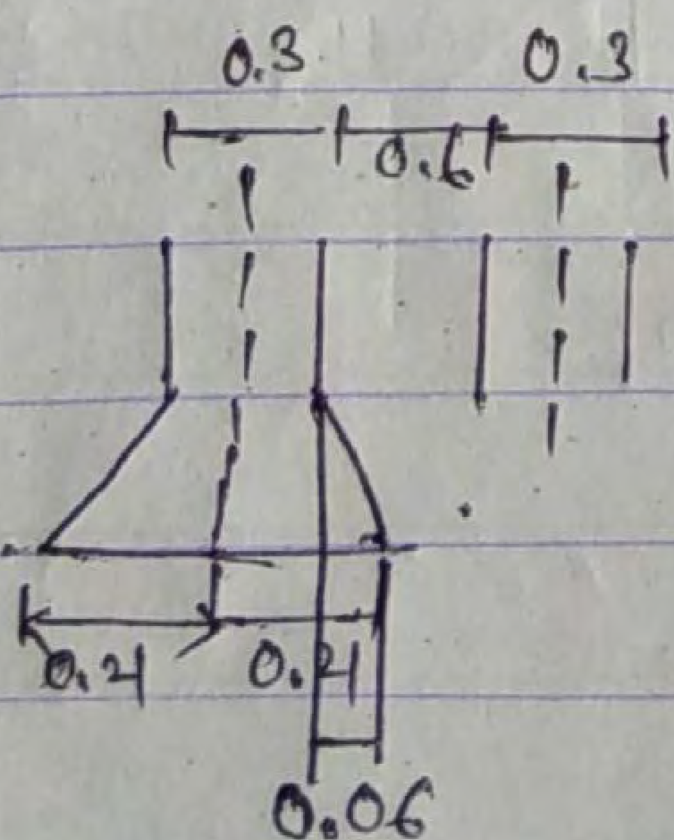
② class A-A wheel load at support



$b_{ef} = b_1$

$= 0.3 + 2 \times 0.06$

$= 0.42$ m

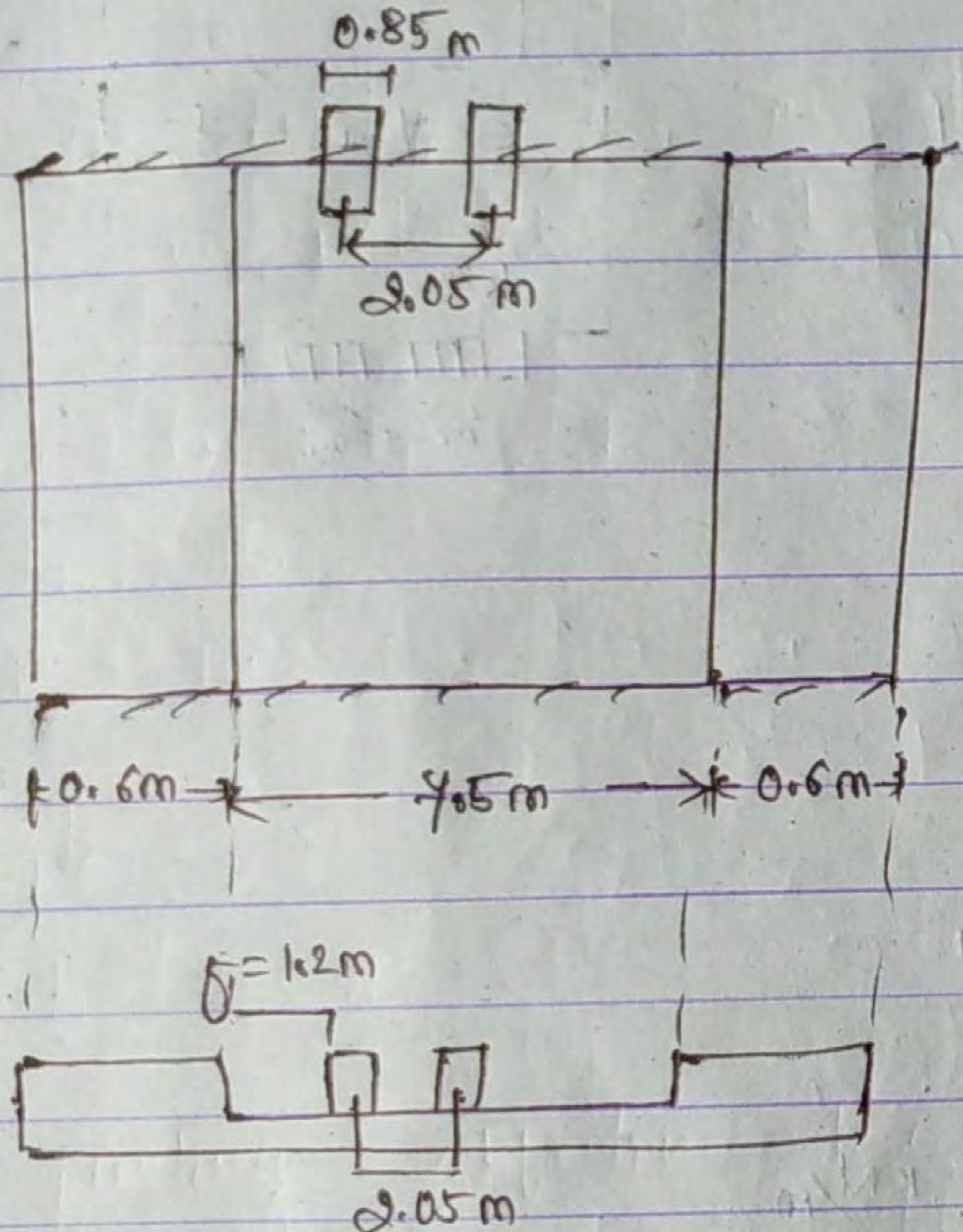


no-overlapping

max^m load under wheel = 62.5 kN

$\therefore$ live load per unit width of slab $= \frac{62.5 \times 2}{0.42} = 297.62$ kN/m

(3) class AA track load at support

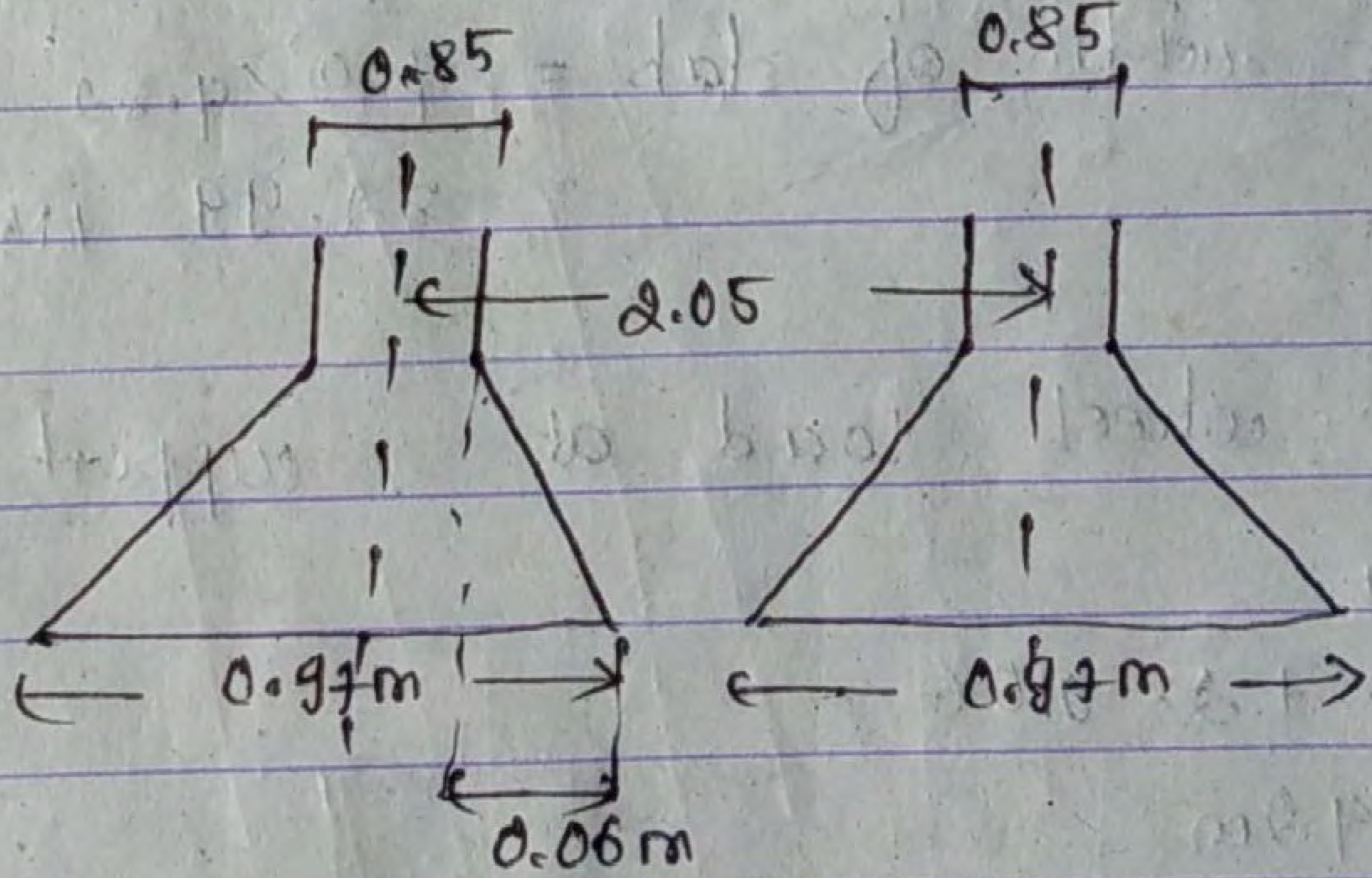


$b_{eff} = \alpha a \left(1 - \frac{a}{l}\right) + b_1$

$= 1.1 \times 0 + b_1$

$= 0.85 + 0.06 \times 2$

$= 0.97$ m



no overlapping

LL/width of slab $= \frac{350}{0.97} = 360.825$ kN/m

Simplified method of lateral load distribution

Hendry - Jaeger Method of lateral load distribution
→ Semi - continum plate theory

Application - relatively wide bridge मा use गर्ने

semi - continum plate → cross girder लाई slab मा convert गर
so that there is only slab & longitudinal girder

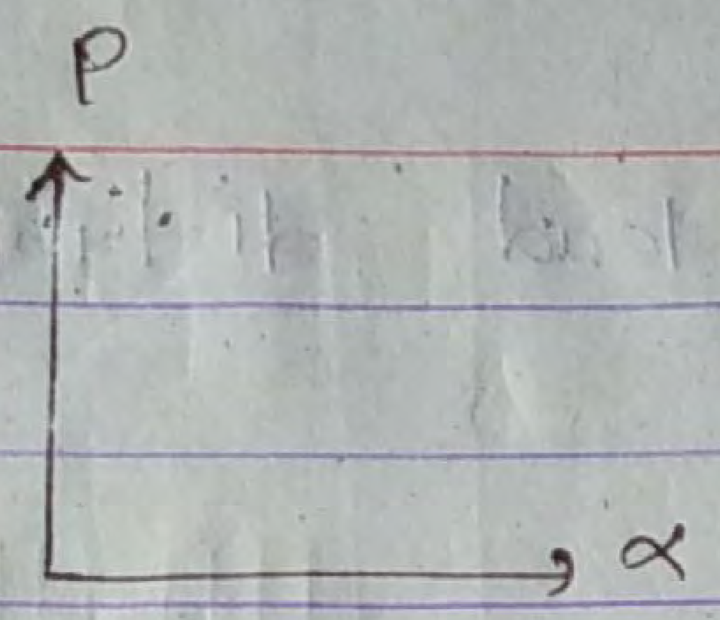
for this load girder माथि हुँने पर्छ

P_{11} → unit load girder 1 मा हुँदा girder 1 को reaction
P_{12} → " " " " " " " 2 " "

α = flexural characterising parameter
β = torsional " "

I_T = MOI of slab & cross beam
I = MOI of main girder
GJ = torsional rigidity
C = torsional stiffness
J = torsional MOI

graph for β = 0 → torsionally very weak
& β = ∞ → torsionally very strong



$\beta = 0$
$\beta = \infty$

But our bridge is in between so have to do interpolation
but interpolation not linear

$P_{11} + P_{12} + P_{13} = 1$

$P_{12} = P_{21}$

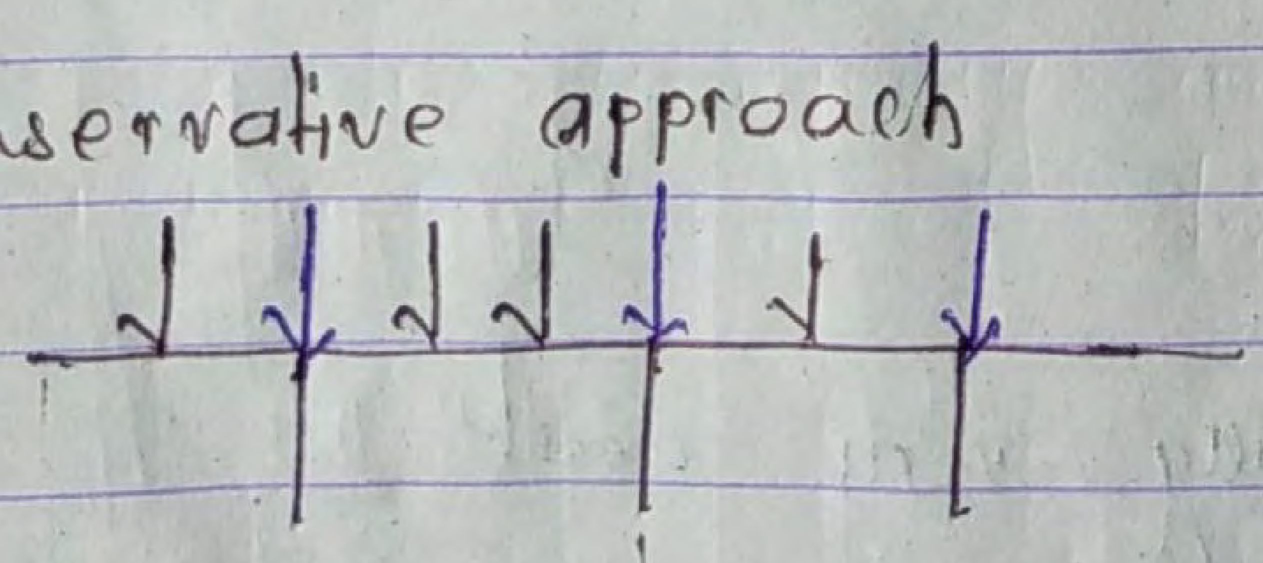
$P_{13} = P_{31}$ . . . .

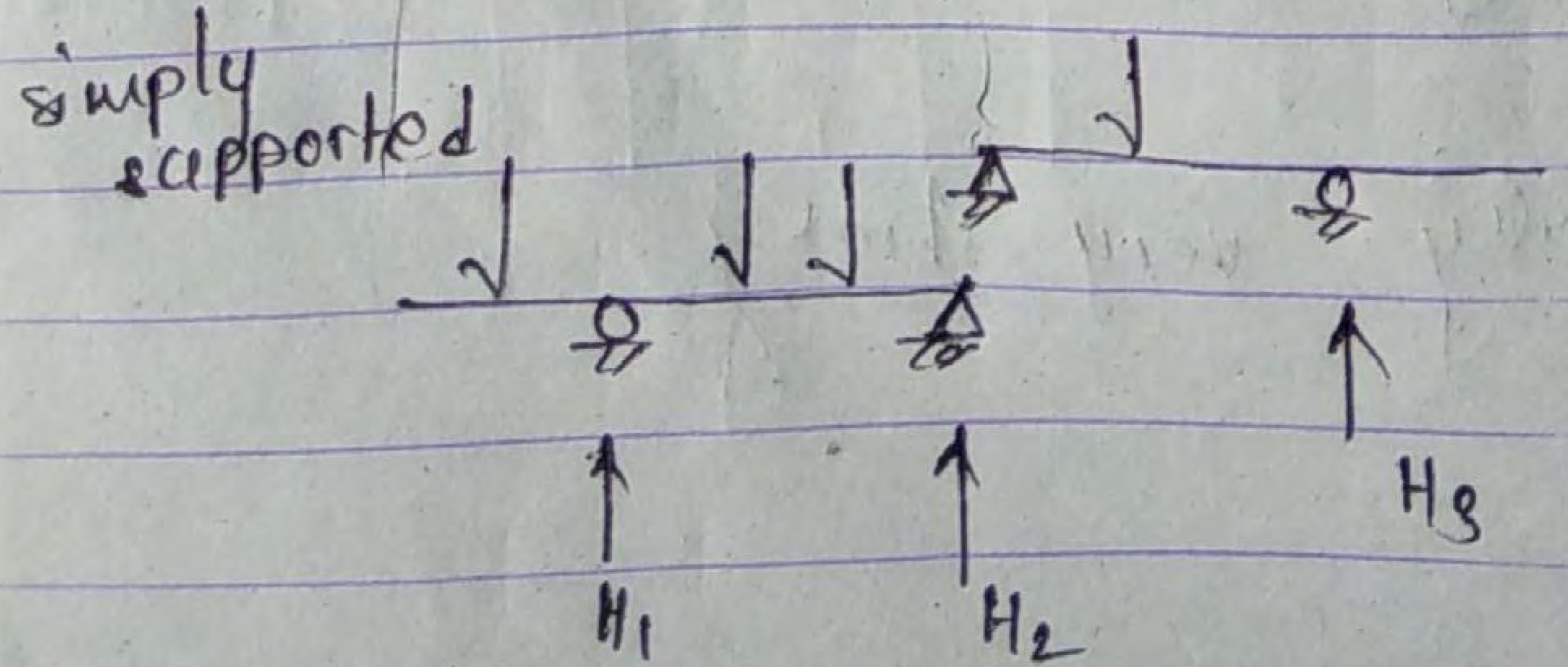
Example

2 no. of class A

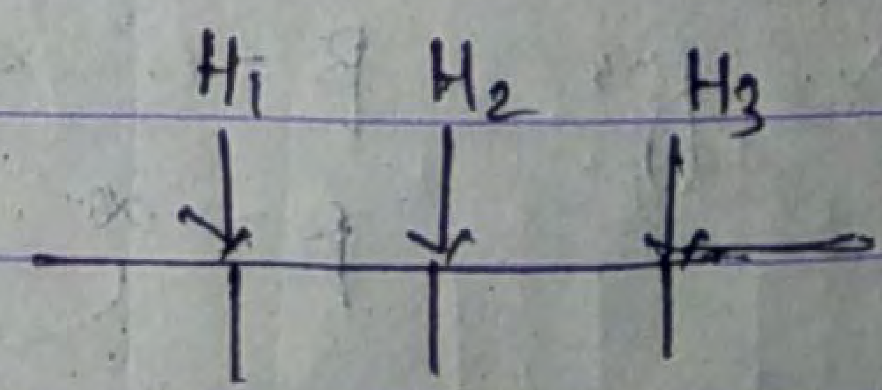
for finding effective load
- conservative approach
- Modern "

① conservative approach

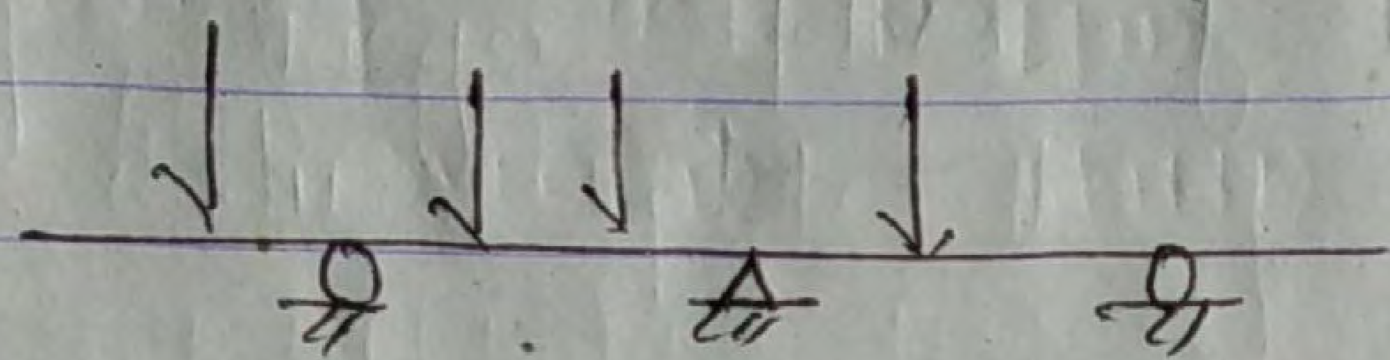




⇒



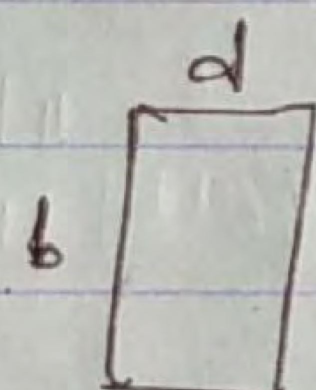
② Modern approach



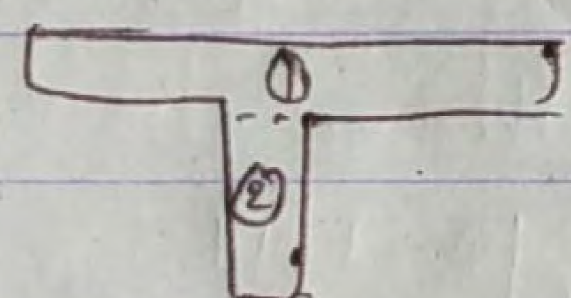
continuous support

$J \Rightarrow$

$\frac{\pi d^4}{64}$ for circle i.e. exact



$\Rightarrow J = \alpha b d^3$ strength of material $\Rightarrow$ seint. venans equ^n



$J = J_1 + J_2$

$\beta = \infty$ ⌉ β for 5 or greater हुदैं जाने हुन्छ so take $\beta = \infty$

Distribution coefficient method

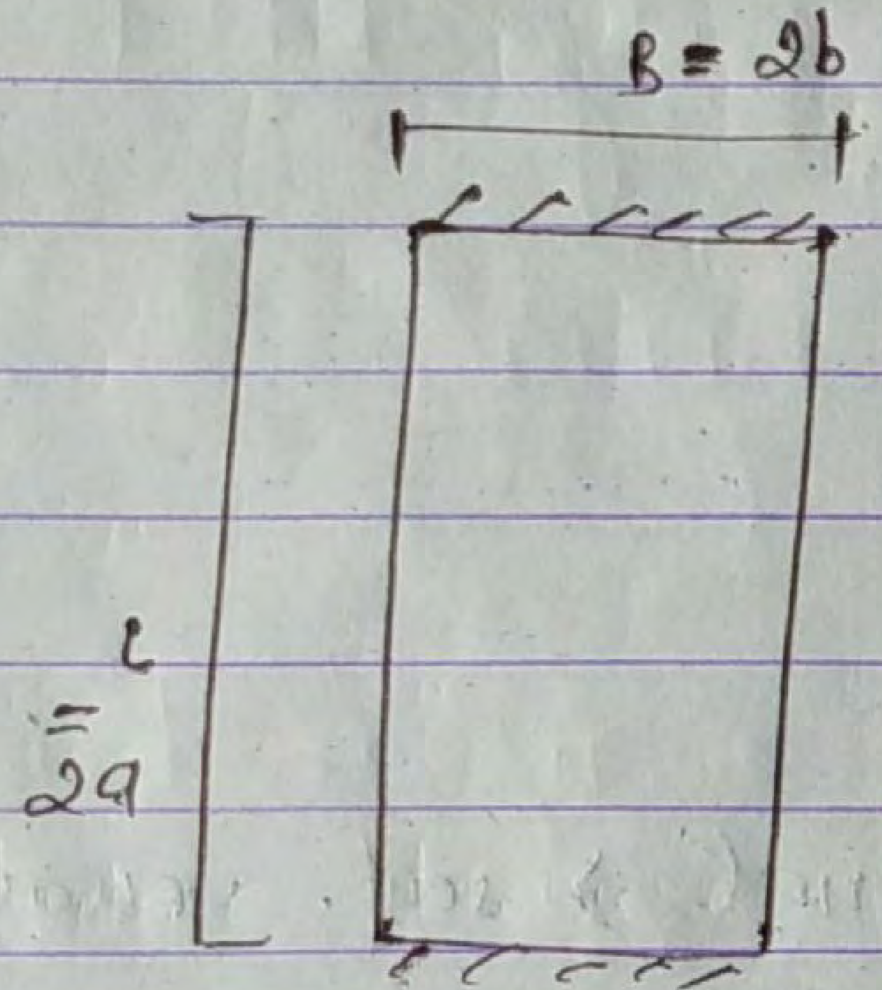
→ this is most accurate but time taking method among simplified method of bridge deck analysis

| concrete bridge by Raina way • see in library |

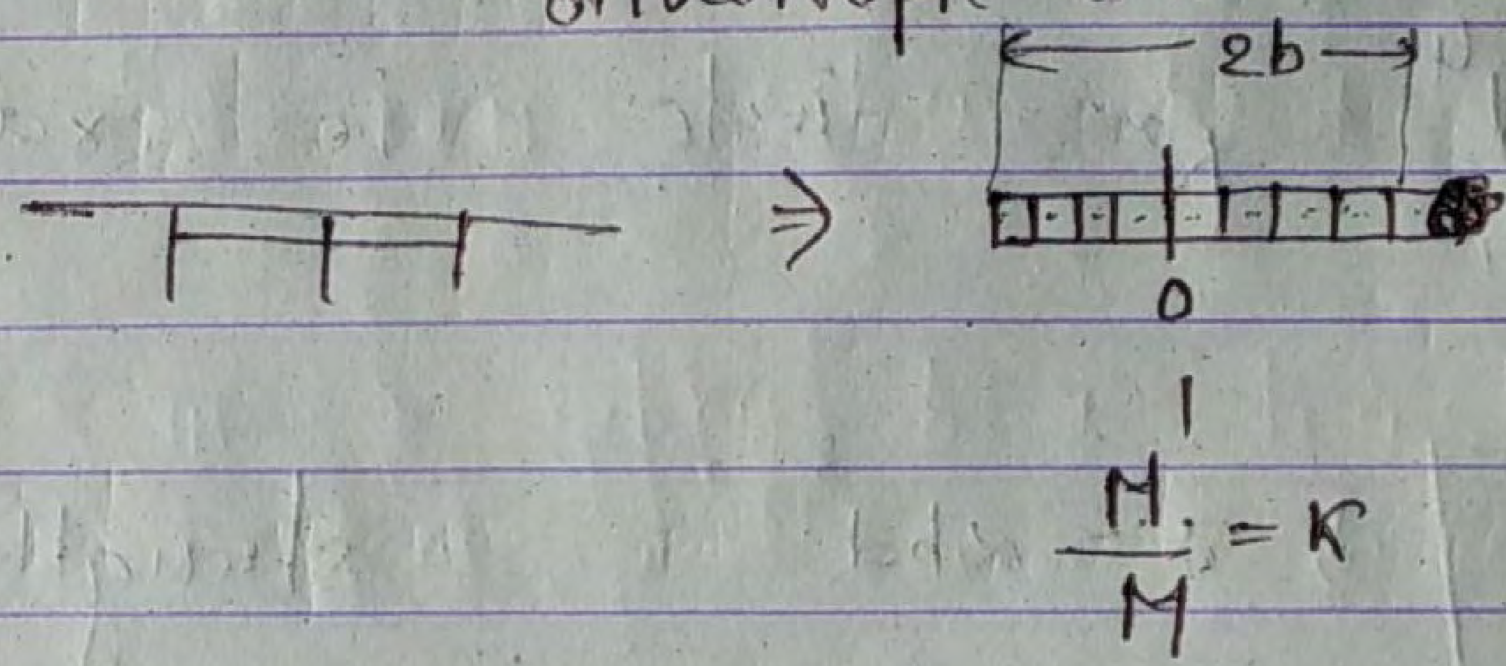
$j_0 = j_T / p$ ⇒ correction

G → shear modulus

E = elastic "



orthotropic conversion

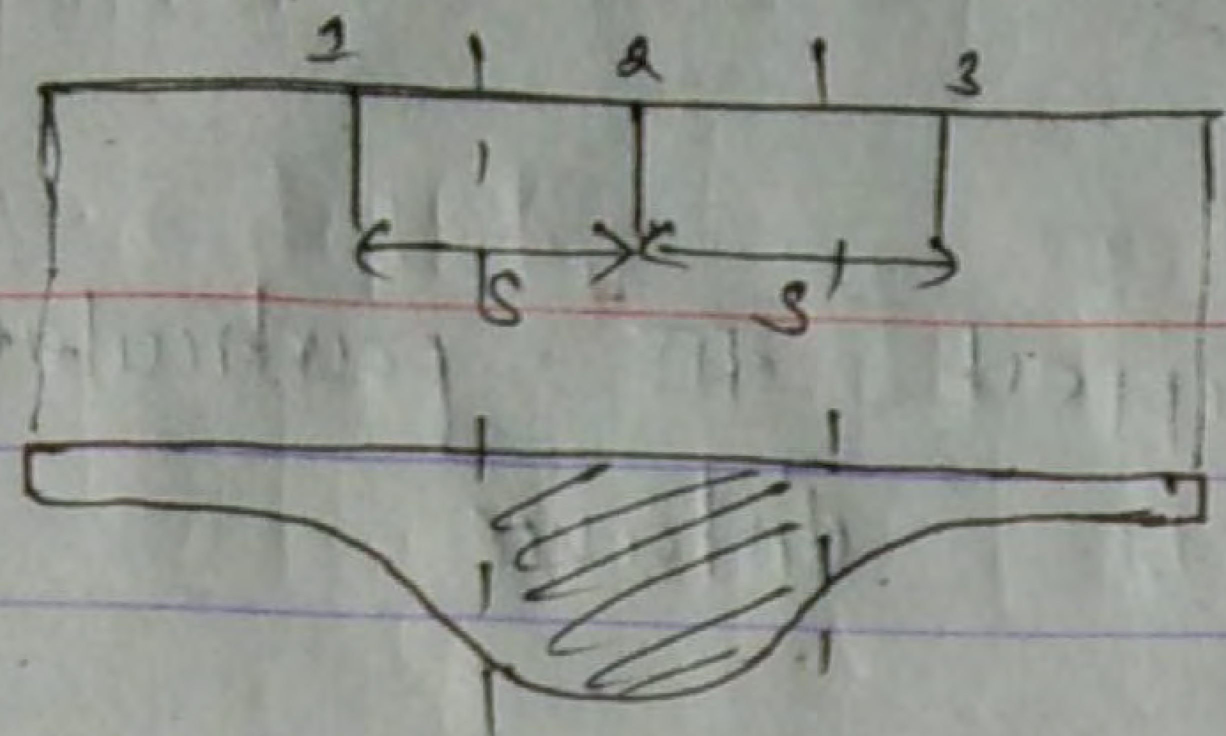


isotropic → all dir^n का same

orthotropic → 1^r dir^n का different

$\alpha = 0$ ⇒ torsionally weak

$\alpha = 1$ ⇒ " strong



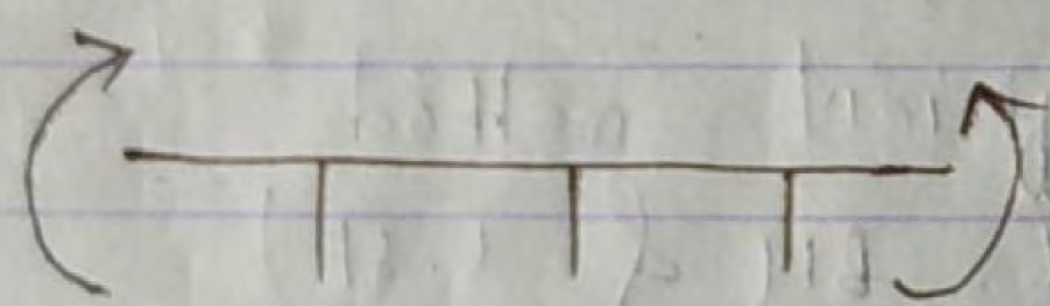
M' = intensity of BM
M = average BM

$M_2 = M' \times S$

$= K \times M \times S \qquad \because \frac{M'}{M} = K$

Note:- cross section को BM always same only share of total BM to girder is different.

Transverse BM by Distribution coff. method



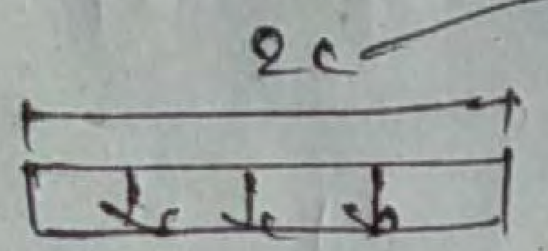
⇒ transverse BM that bends the slab in transverse dir^n acc. to which we design cross beam

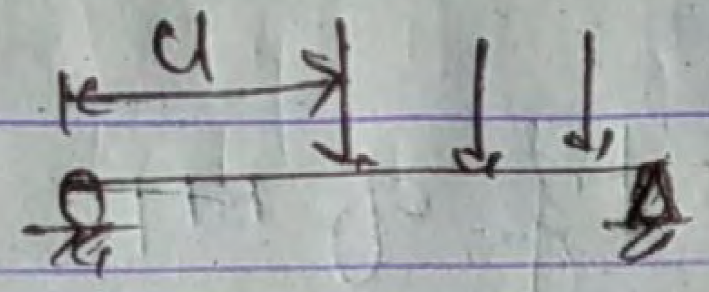
⇒ for transverse BM we can use conventional method

M_y ⇒ transverse dir^n. का unit length का आउने BM

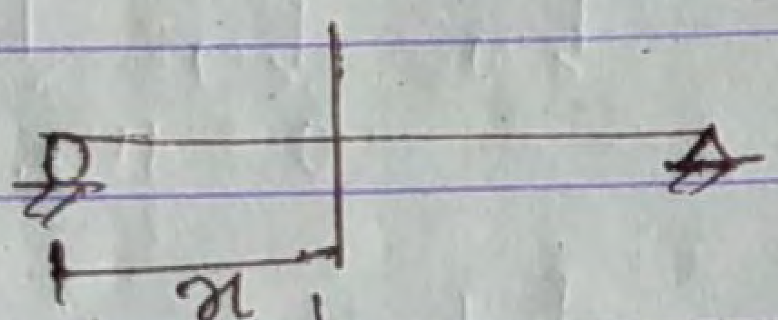
⇒ In this formula just take 3 terms & others neglect

Here, $a = l/2$





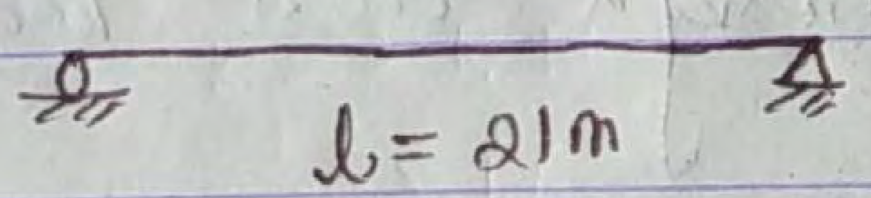
left support बाट particular wheel सम्मको distance

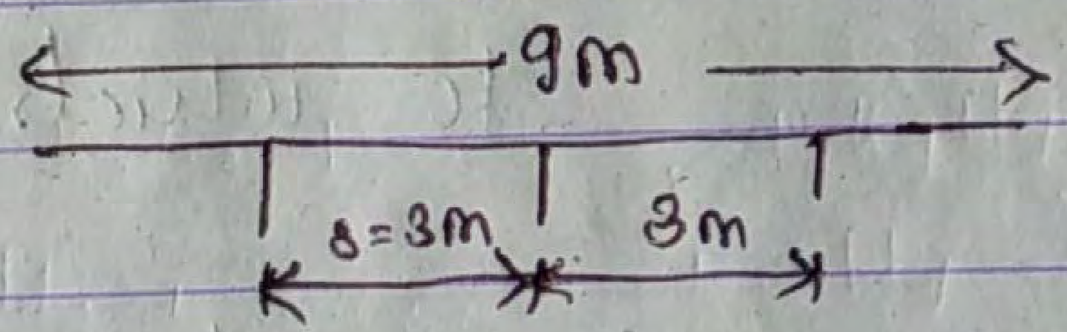


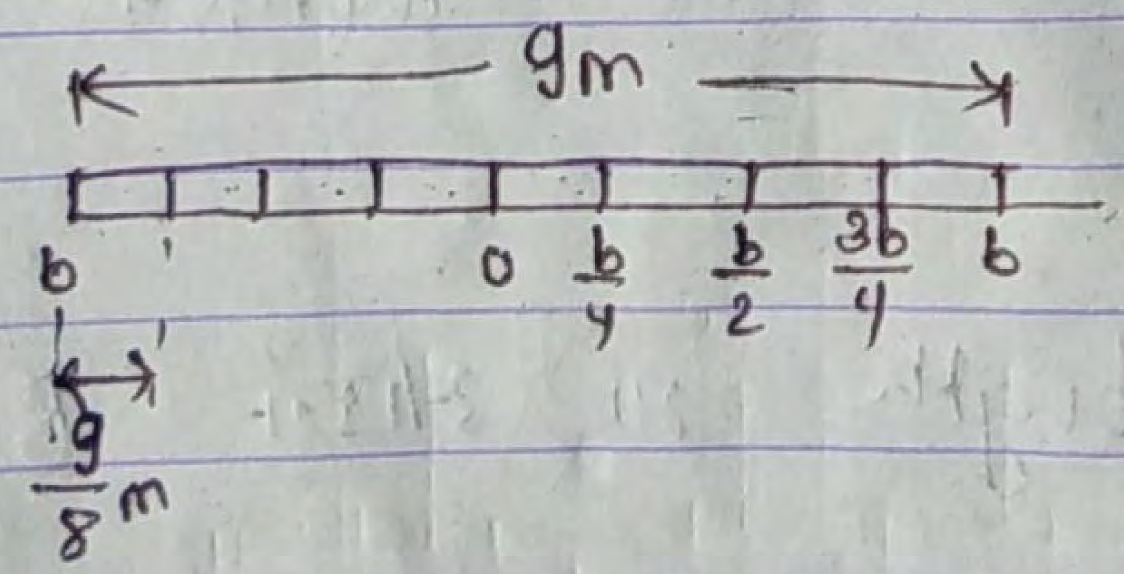
transverse BM पत्ता section मा निकाल्नुपर्ने हो त्यो section सम्मको distance from left support

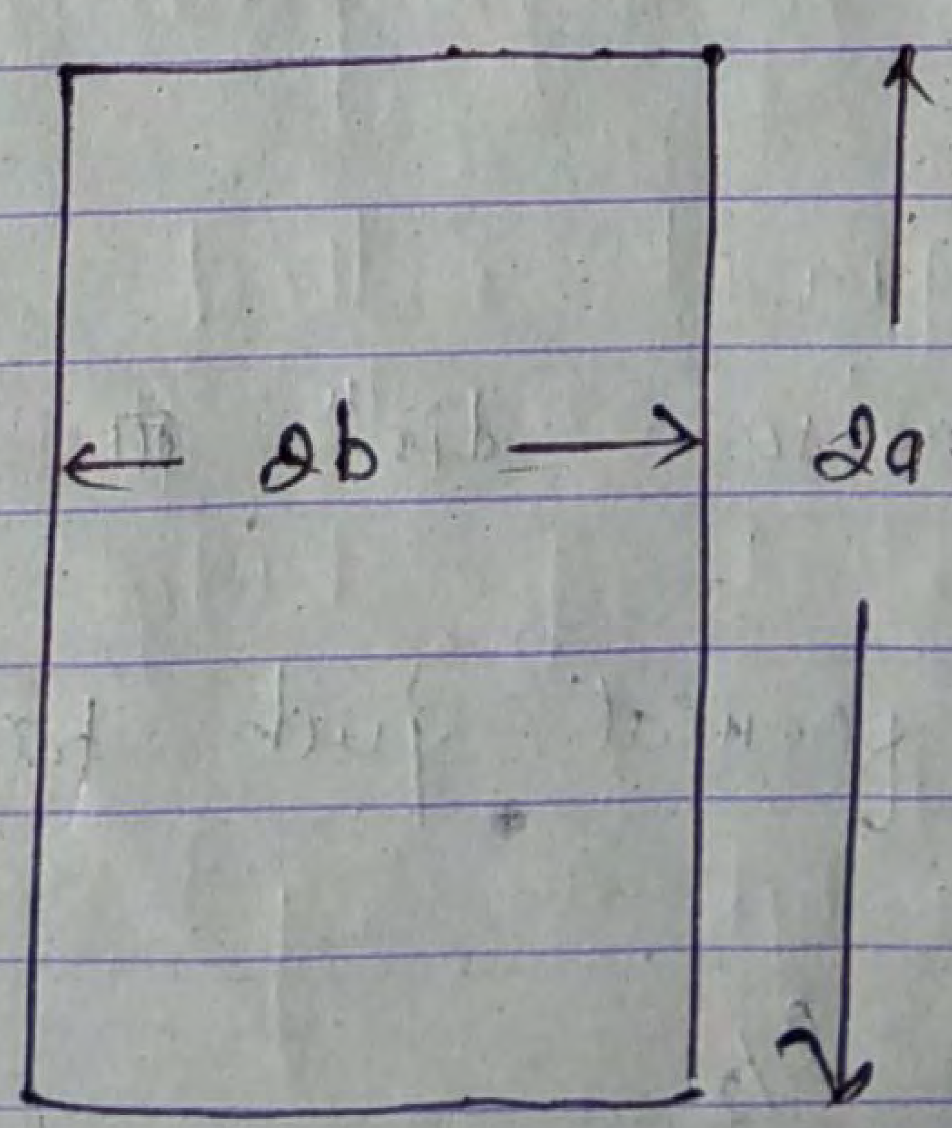
absolute transver BM → mid span को mid section

Example on distribution coefficient method
(Related to longitudinal BM & L.SF)









orthotropic plate → 2 तरह direction मा properties फरक हुन्छ

$i_0 = \frac{J}{s}$ torsional MOI per unit length
s = spacing of main beam

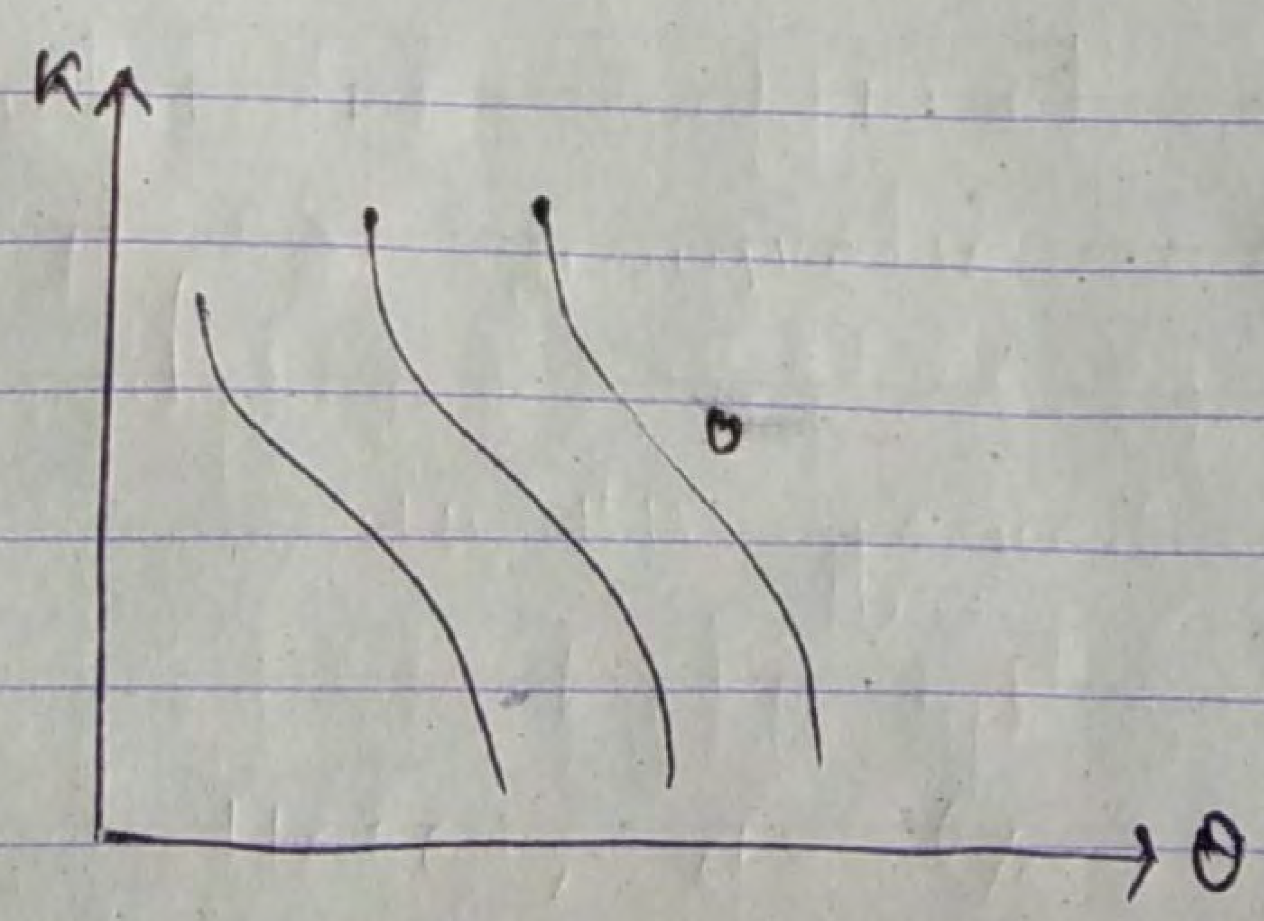
$j_0 = \frac{J_T}{p}$ → torsional MOI of cross beam
p → spacing of " " "

$i = \frac{I}{s}$ → MOI of main beam.

$j = \frac{I_T}{p}$ → MOI of cross beam
G = modulus of rigidity

→ when no. of cross beam increases – rigidy increases – so α & θ को value near to 1 हुन्छ
→ inverse is near to 0 हुन्छ

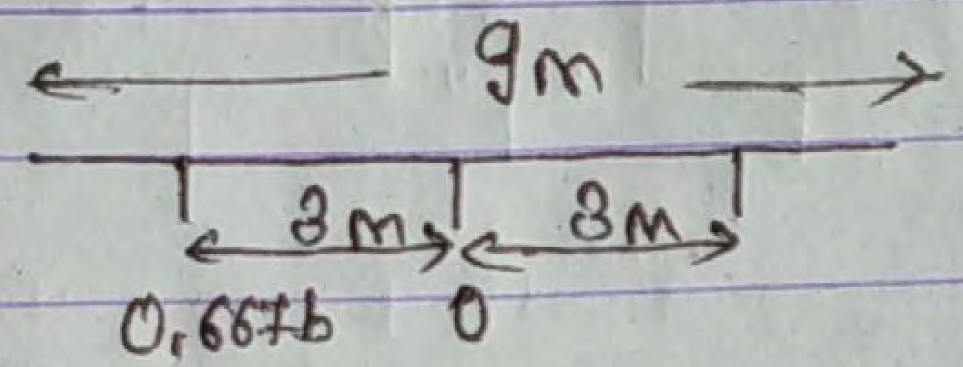
graph for α = 0
α = 1



α = 0
α = 1

for interpolation (non-linear interpolation for distribution coef. k)

$$K_\alpha = K_0 + (K_1 - K_0)\sqrt{\alpha}$$



for 0 reference station i.e. girder ①

K_1 K_2 K_3 K_4 K_5 K_6 K_7 K_8 K_9

$= 0.89$

for girder ②

K_{10} K_{11} .. .. K_{18}

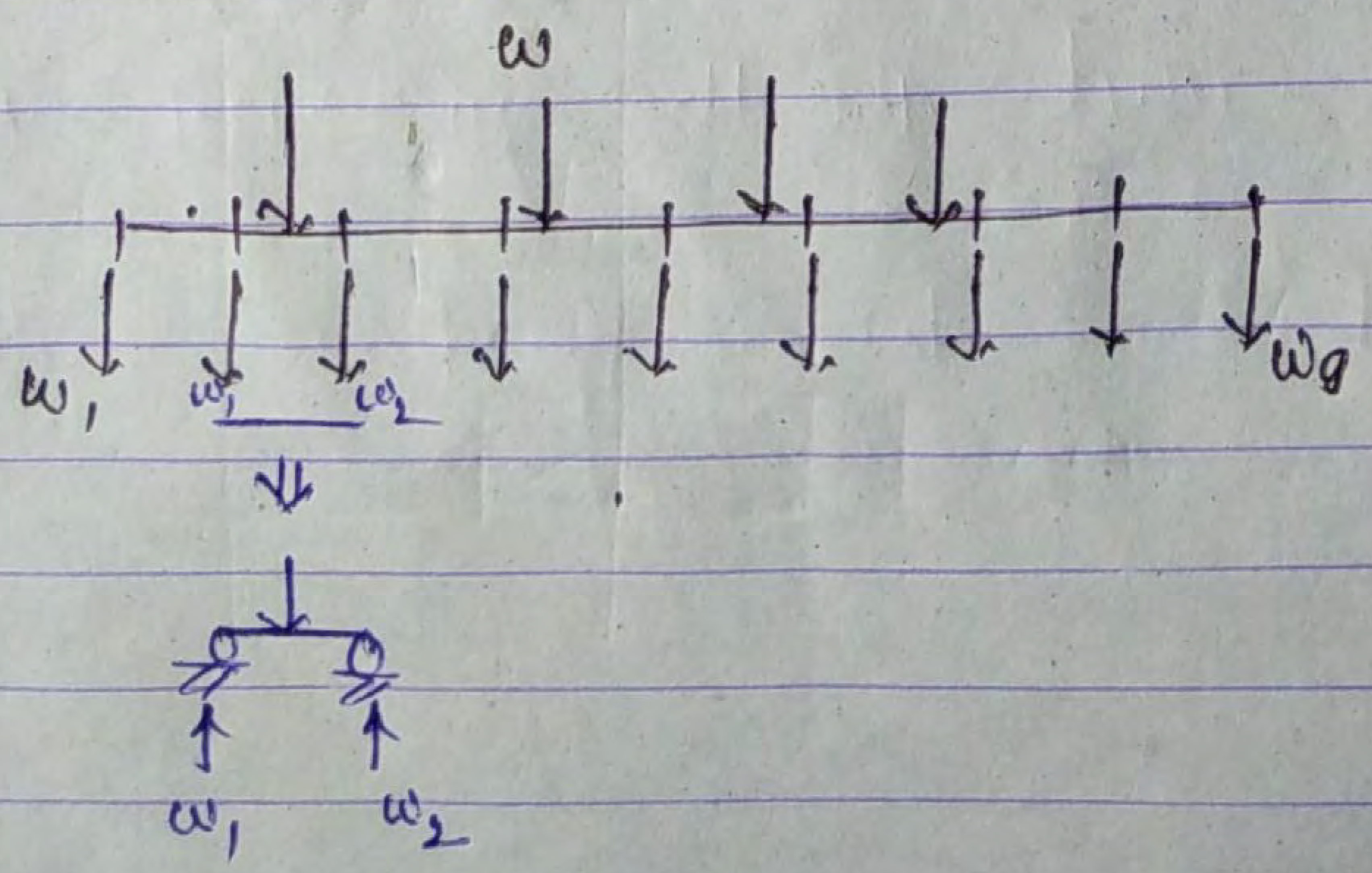
girder ③

K_{19} K_{20} .. .. K_{27}

for girder ①

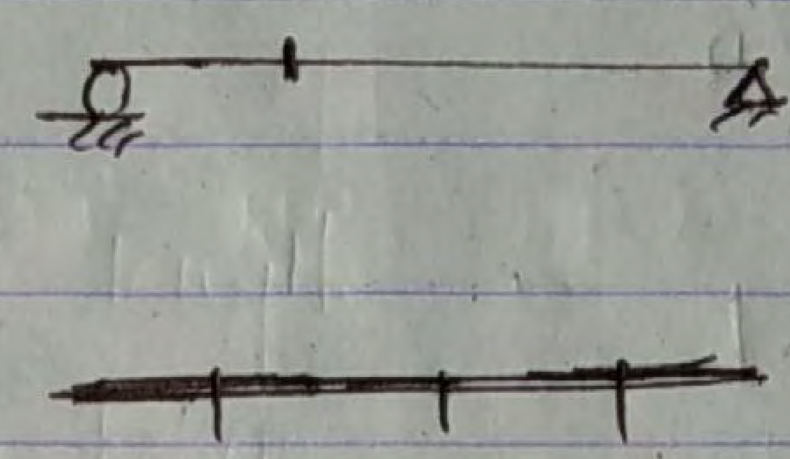
$$K = \frac{\Sigma K W}{\Sigma W} = \frac{K_1 W_1 + K_2 W_2 + \ldots + K_9 W_9}{W_1 + W_2 + \ldots + W_9}$$

where w_1, w_2 ... different station मा आउने load



$M = 1.1 \, K' \, M_{av}$ → fourier series use करतो where K' is only for addressing 1st term so इसे 10% increase करते

$V = 1.1 \, K' \, V_{av}$ ⇒



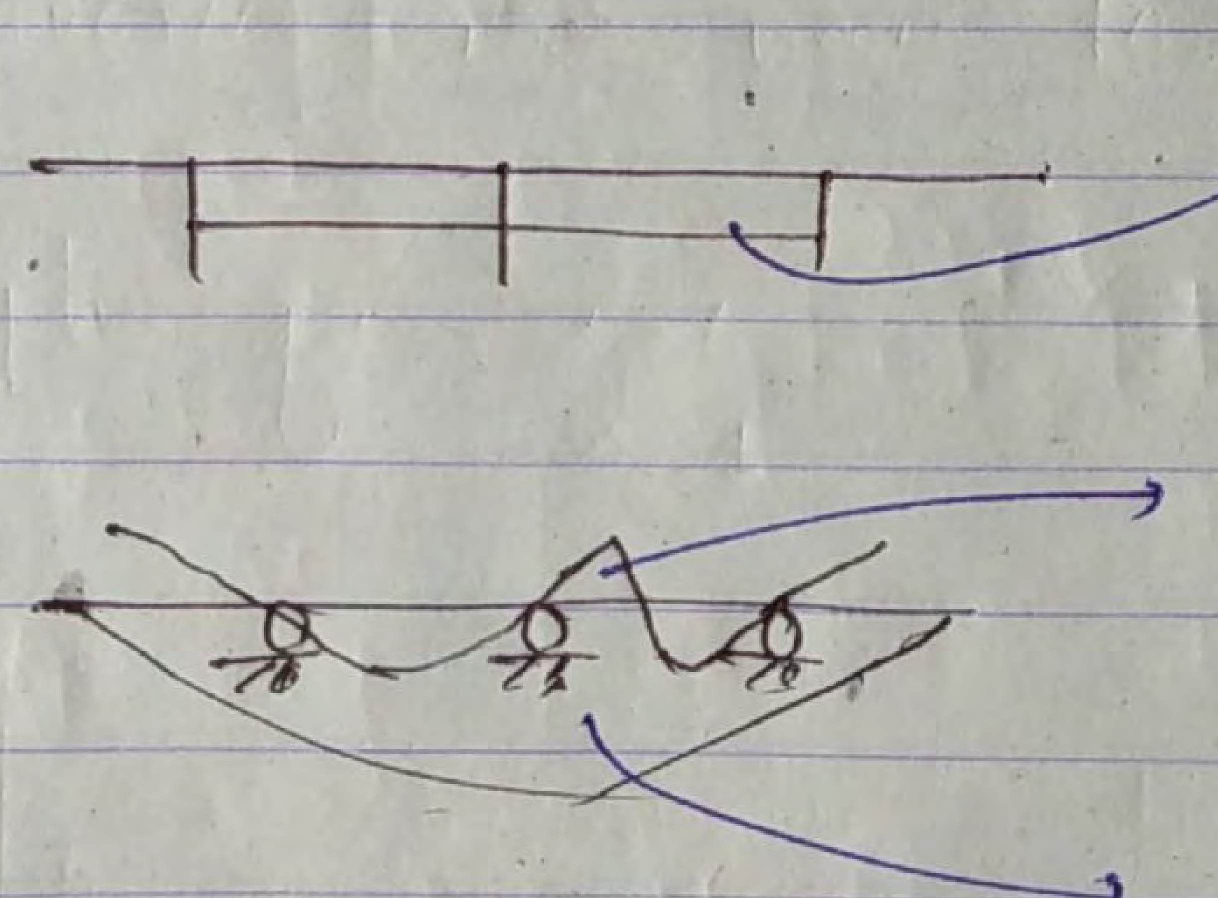
$M = M_1 + M_2 + M_3$

$M_{av} = \frac{M}{n}$

<u>H.W.</u>

same example do for class AA both track & wheel load.

example on transverse BM by distribution coef method
→ modern method



→ actual मा only sagging i.e. +ve BM

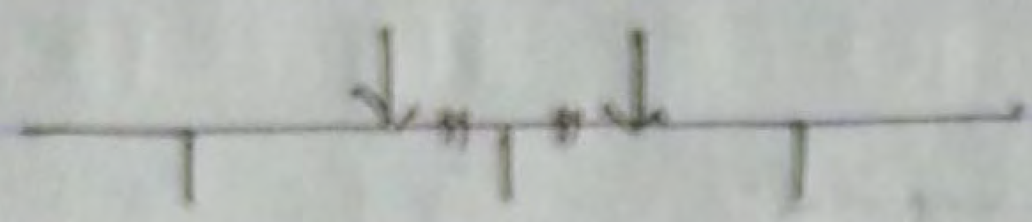
→ conventional method BM

→ modern BM ⇒ this is used in this e.g.

longitudinal BM & longit. SF ⇒ courbons
transverse " ⇒ conventional method

θ & α same as अगाडिको eq:-

Another option



But calculation easier in slide & final result मा केही फरक पर्दैन.

$n = a \Rightarrow$ mid span

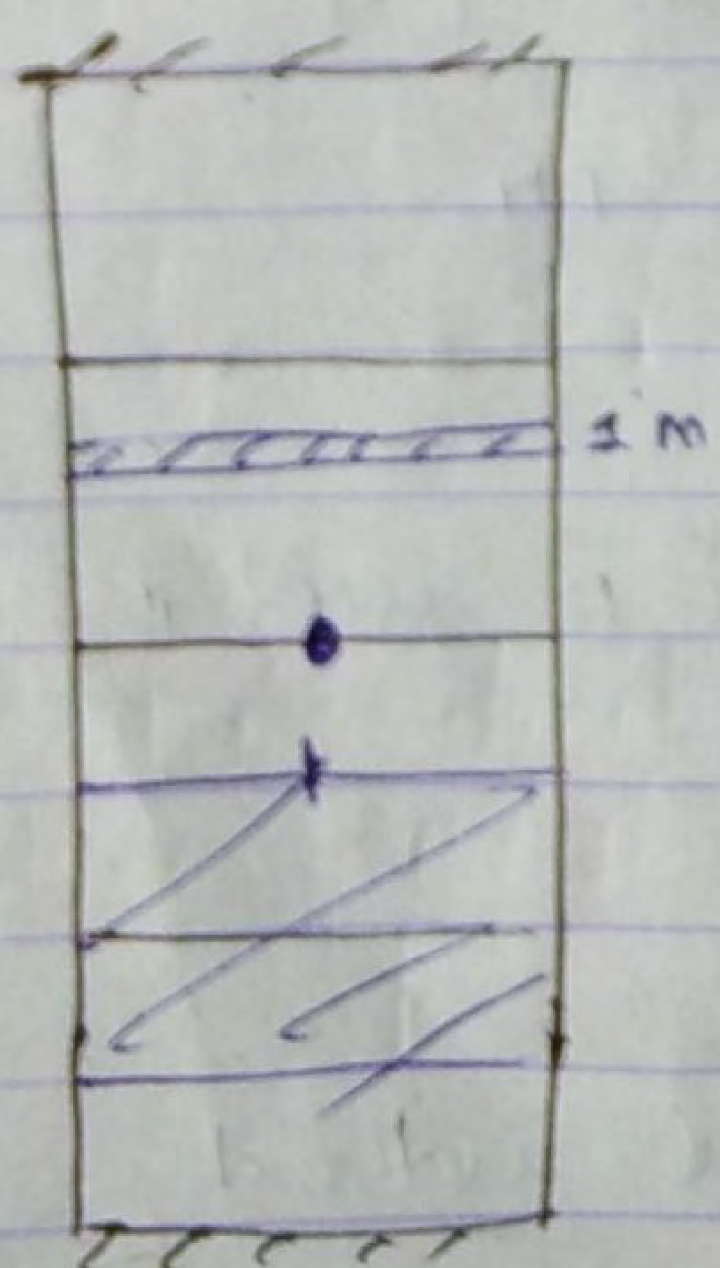
p = intensity of track = load/length of track

graph for $\alpha = 0$ & $\alpha = 1$

μ_1 for θ

$\mu_3 \Rightarrow 3\theta$

$\mu_5 \Rightarrow 5\theta$



Slab bridge

If the depth of void is less than 60% of total depth of ~~salb~~ slab then the design is similar to slab bridge

2-2.5 % ⇒ normally bridge मा यात्रे rauber provide गर्नें

for slab bridge < 6-7 m span instead of bearing tar paper is used.

crash barrier → railing should be designed as crash barrier

Design steps of RCC solid slab bridge

depth of slab is found by ⇒

⇒ span effective depth ratio

slab design → singly reinforced under reinforced section

TBM per unit width per running meter ⇒ !?

Design example of design of RC slab bridge

not less than 50 mm of asphalt concrete for wearing coat
→ most suitable for Nepal

city को नजिक 2 lane अरु 1 lane for bridges of dolidar

$\frac{\text{span}}{d} = 12 \text{ to } 15$

carriageway for 2 lane road = 7.5 m for bridge inside city
= 7 m " " outside "

footpath for city area ≮ 1 m
" " village area = take minm i.e. 0.6 m

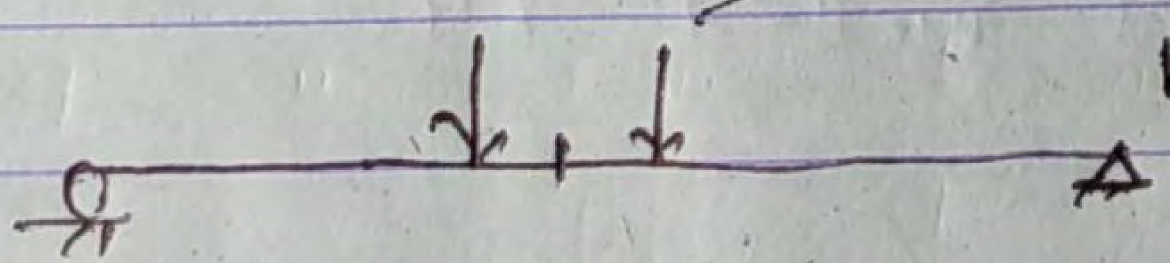
Drainage spout को interval 3- 4.5 or 5 m incase of Nepal

सानो bridge मा maxm load लाई बिच राख्ने for longitudinal positioning

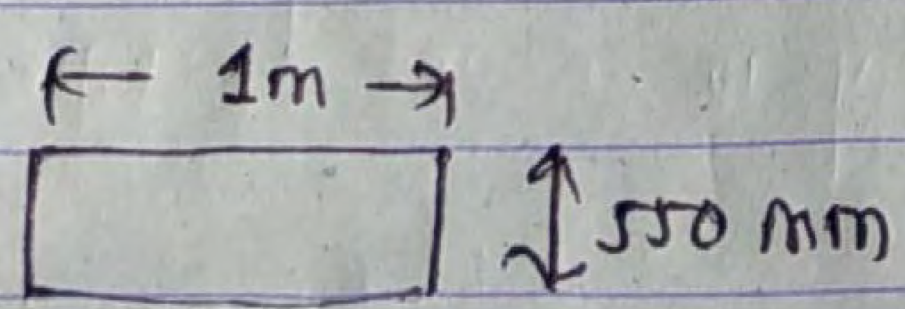
2×114

$\frac{9\times57 \text{ kN}}{\text{wodi}} \times IF \times FOS$

bef



Rectangular section

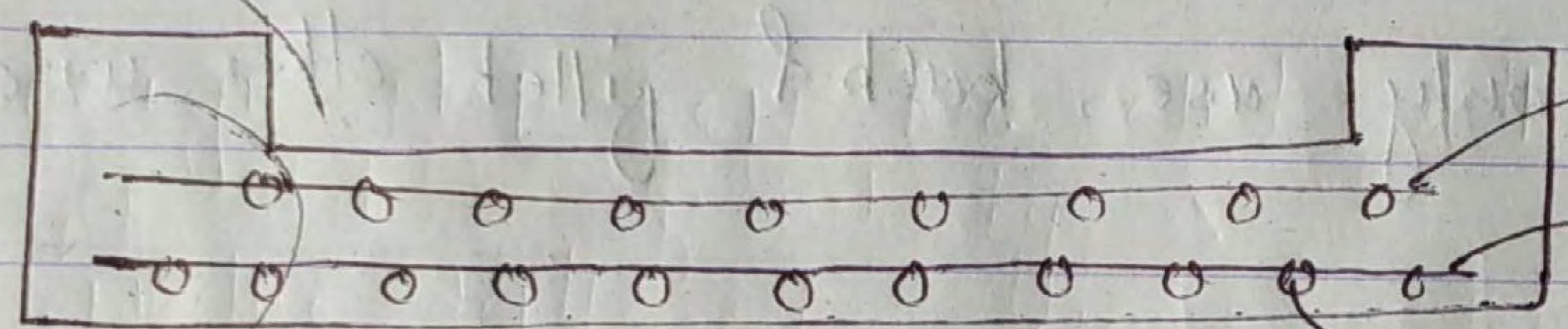


$d \geq d_{bal}$ → singly reinforced

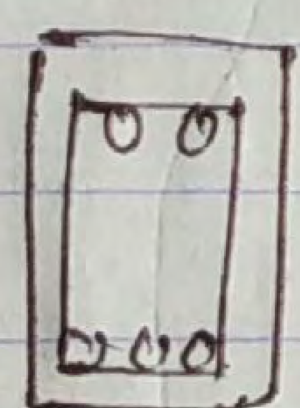
slab मा thickness relatively सानो हुन्छ so singly reinforced use गरिन्छ

IRC 21 & IRC 112 → for detailing of reinforcement
↓ working stress ↓ limit stress

longitudinal BM लाई design गरेर bar हालेसकेपछि मुनि हाल्ने
त्यसमाथि transverse BM लाई provide गरेको bar हाल्ने



slab with free edge
" " stiffened "



अगाडि calculate गरेको b_{eff} is for slab with free edge

यसमा more portion of slab in transverse dir^n ले load share गर्छ।

Bar bending schedule बनाउने

class A load → for permanent bridges
class B " → " temporary "

class AA load → for specified locations
class 70R load → other than specified locations

Design of T Beam bridge

जति माथि rod सरक्यो त्यति lever arm घट्छ so moment resisting capacity of beam decreases.

If span ≥ 15 m then only use bulb & fillet otherwise rectangular section.

slab → cantilever slab
→ restrained slab (slab pannel को corners are prevented from lift up) → एउटा rigid connection दिएर राख्नो अर्को torsion reinforcement दिएर रोक्ने from lift up

one edge supported slab
2 " " " → slab bridge
4 " " "

In case of T beam bridge support is flexible but in building support is rigid (fixed)

Piegaud's Method

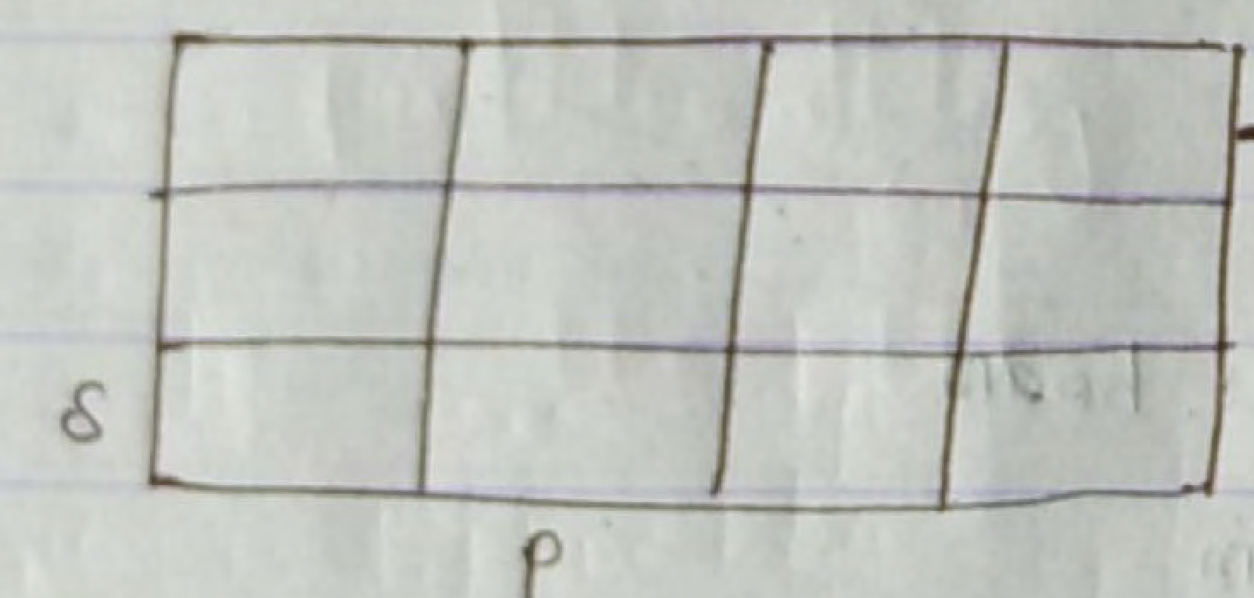
In practice main beam को thickness start with 300 mm & for x beam start with 250 mm.

$B = 500 - 600$ mm in general

In practice fillet 1:1 को ratio मा राख्ने → for smooth transfer of force
1:2 ↳ to resist shear

$S = 2\text{-}3$ m in general

In general, no. of x beam = 5 or more

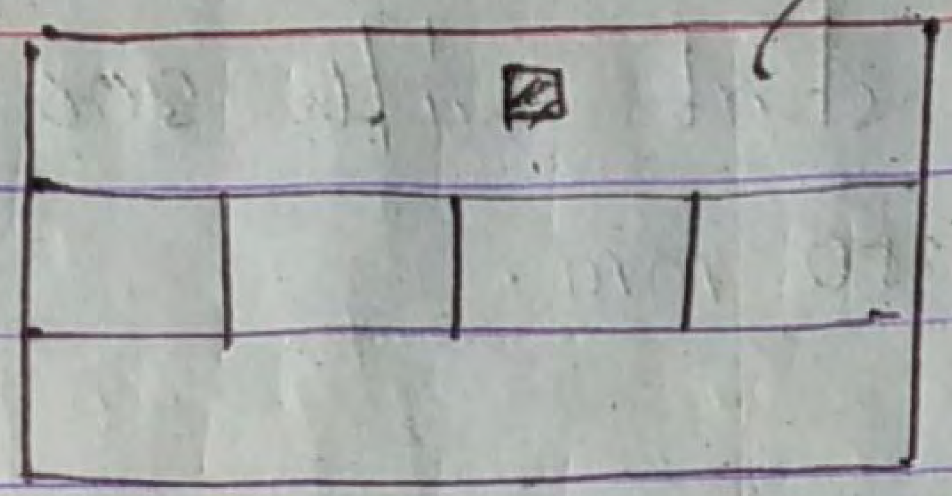


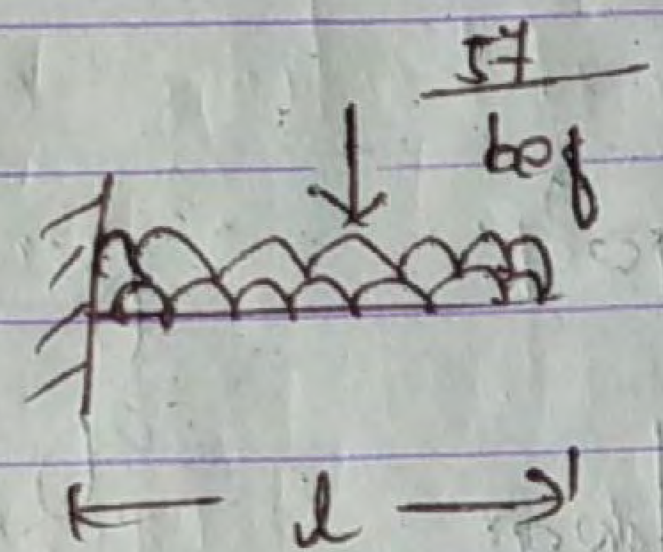
→ x beam at line of bearing

$\frac{P}{S} \le 2 \Rightarrow$ for two way slab लागि (two way bend हुन्छ)

cantilever slab

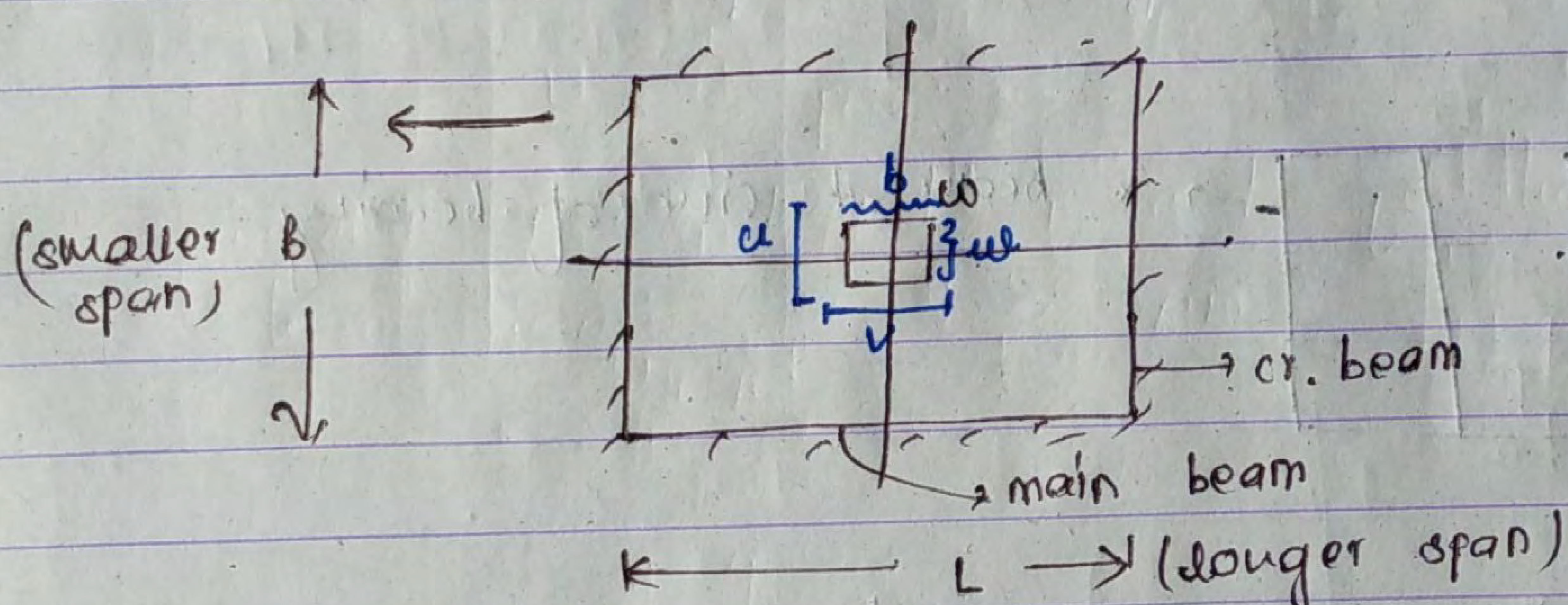
aesthetically not pleasant

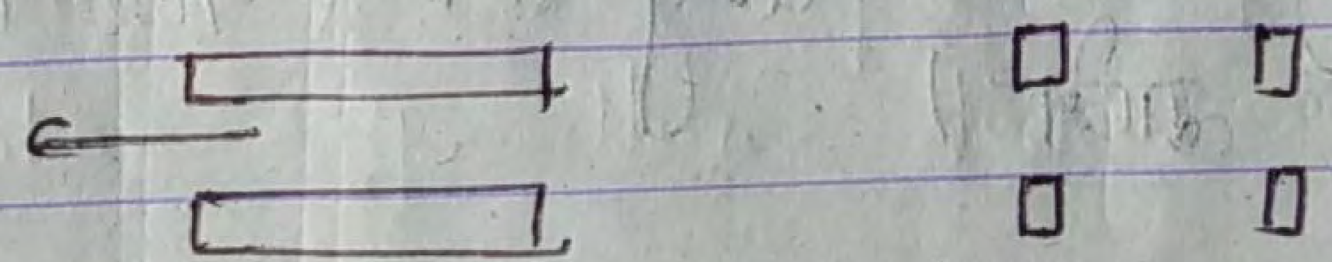




Restrained slab

Pigeaud's Method





$M_1 = (m_1 + \mu m_2)\, w \times 0.8$ → shorter dir^n को mid पर आइडल BM

$M_2 = (m_2 + \mu m_1)\, w \times 0.8$ → longer " " " " " "

μ → poisions ratio

m_1 & m_2 ⇒ BM coefficient

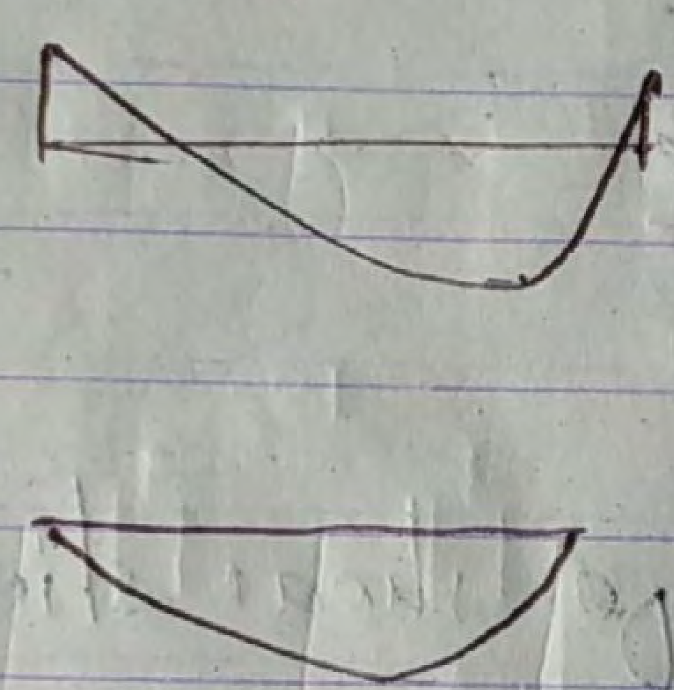
$\mu = 0.15$

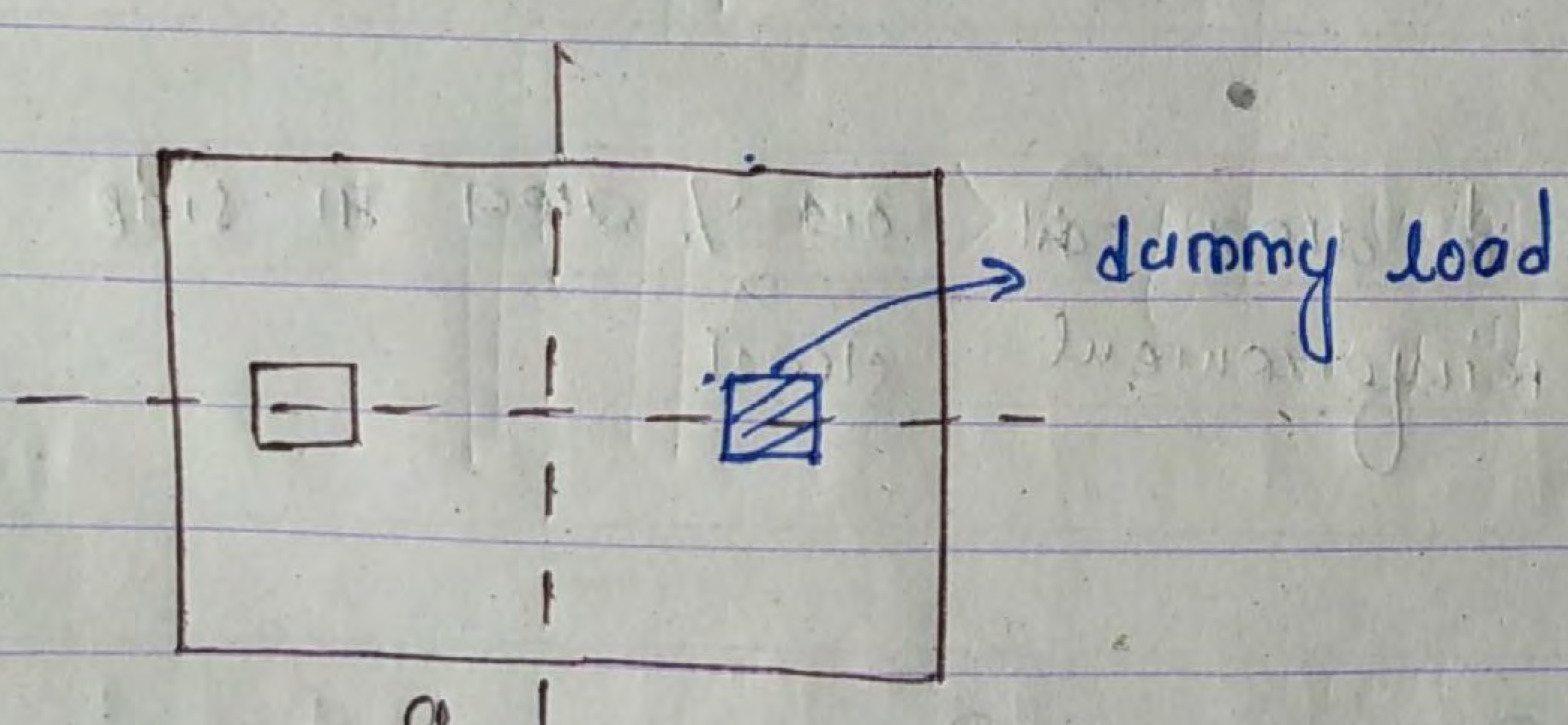
$u = w + 2h$ } Immediate dispersion
$v = b + 2h$

$m_1, m_2 = f\left(\frac{u}{B}, \frac{v}{L}, \frac{B}{L}\right) \Rightarrow$ for LL

$m_1, m_2 = f\left(\frac{B}{L}, \frac{L}{B}\right) \Rightarrow$ for DL

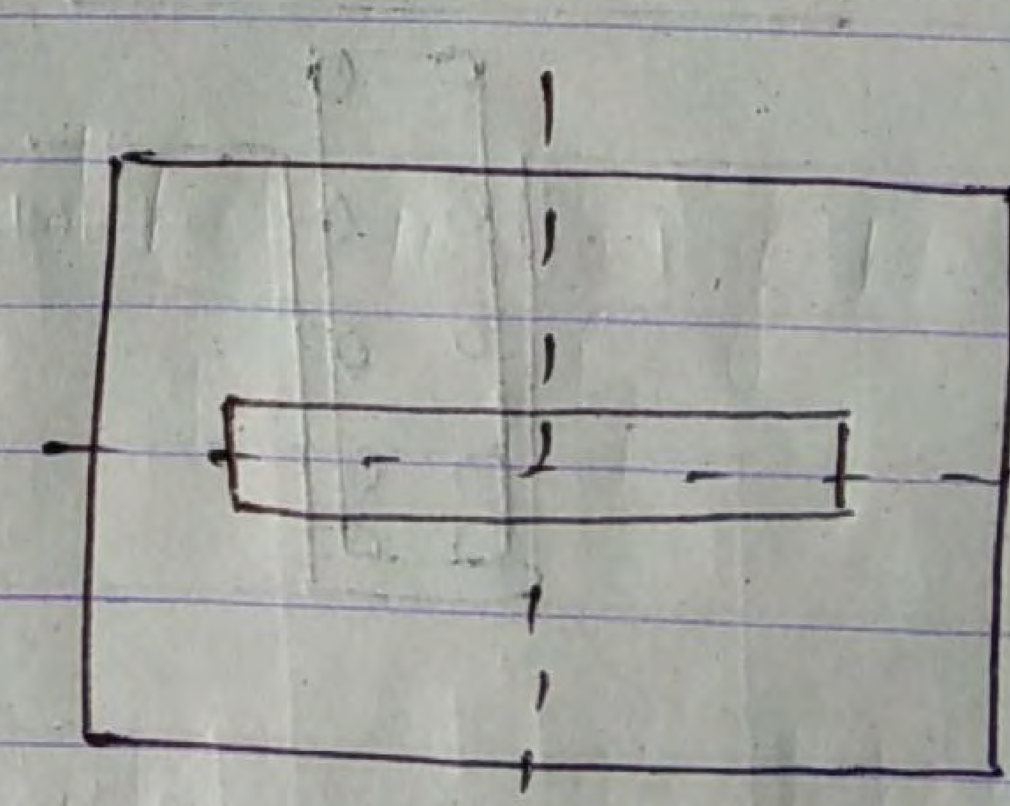
0.8 for rigidly connected restrained edge



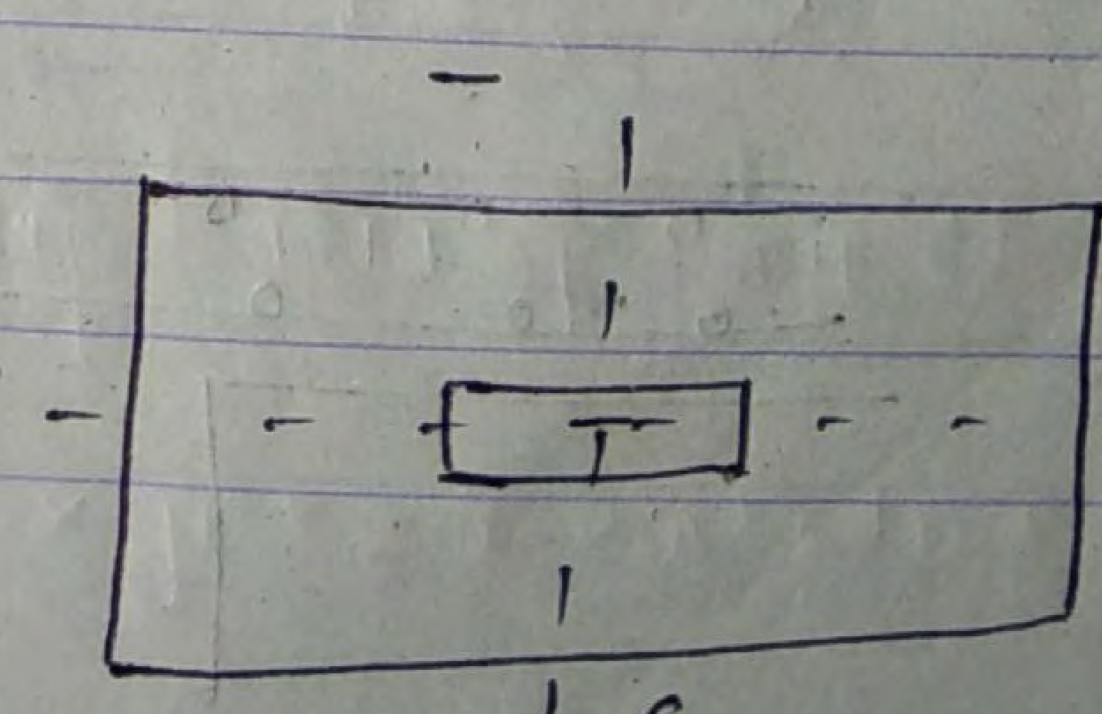


a

=

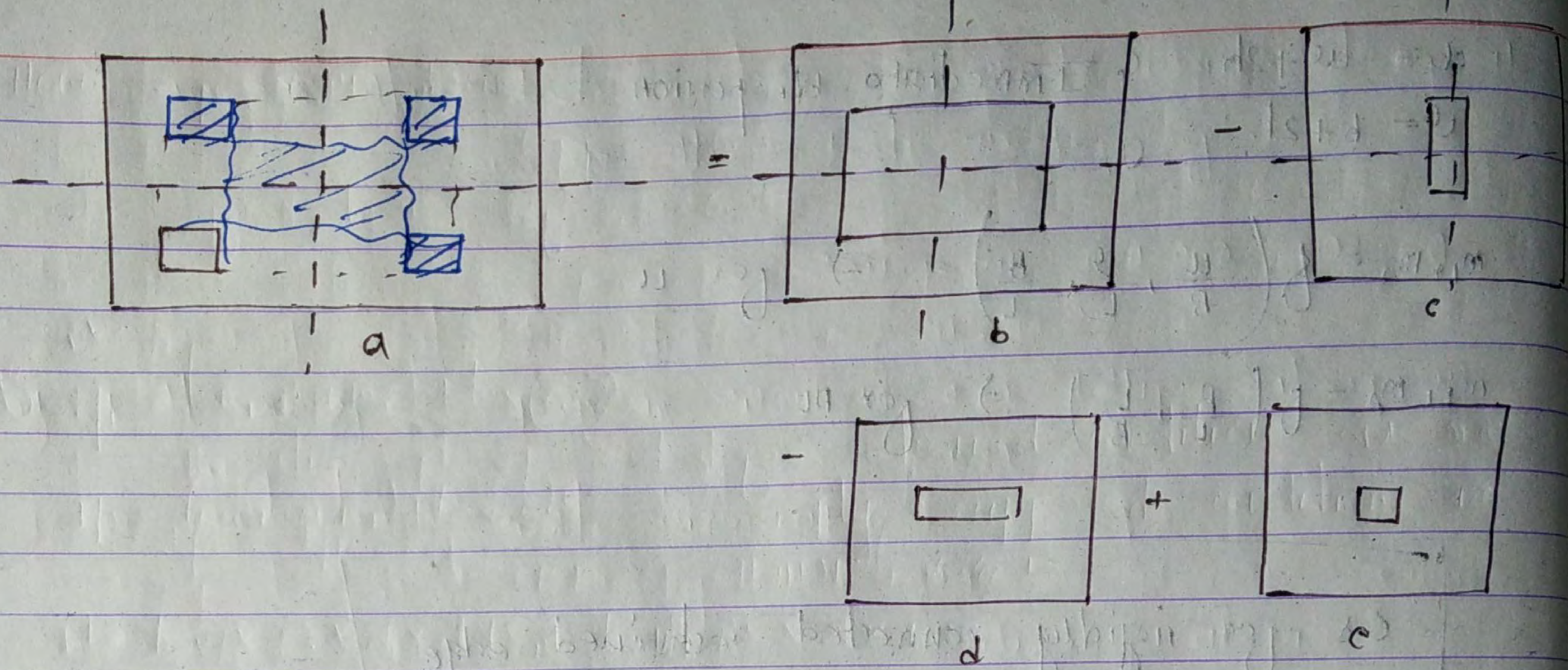


b



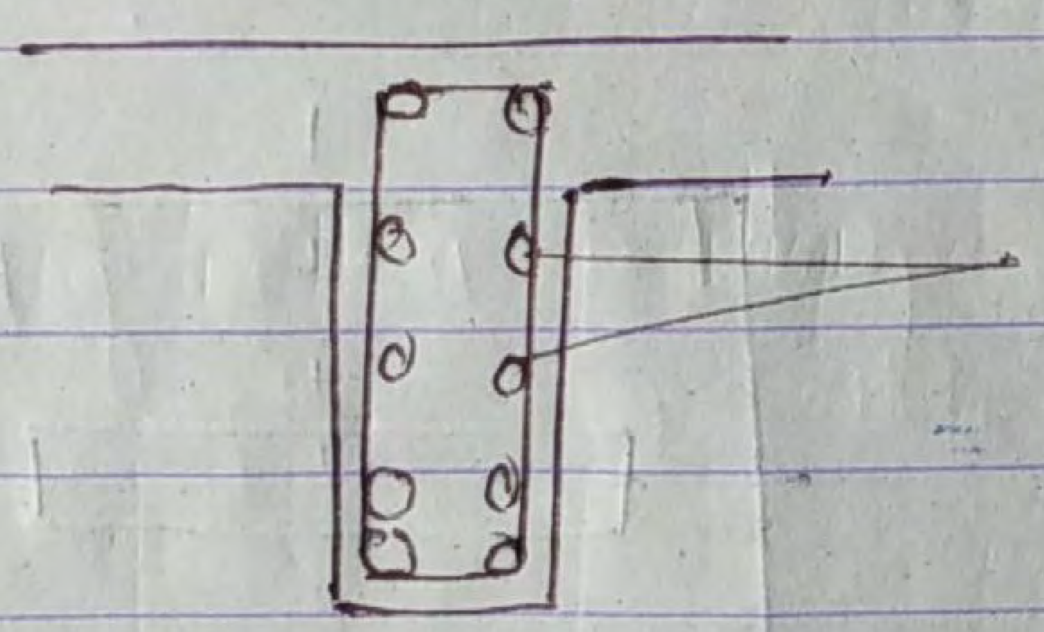
c

$M = \frac{M_a}{2} = \frac{M_b - M_c}{2}$ ⇐



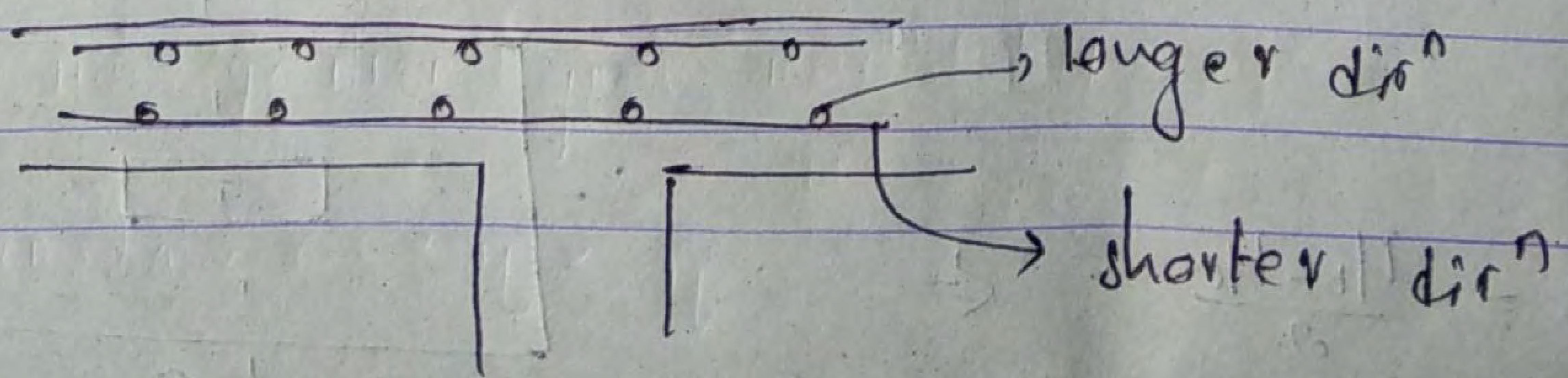
$$M = \frac{M_a}{4} = \frac{M_b - M_c - M_d + M_e}{4}$$

generally 4 or 3 legged is used for shear stirrups.
shear stirrups का $\phi \geq 8$ mm



web area को 0.1 % area का side reinforcement डालते

सबसे अन्दर तक shorter dir^n के bar डालते

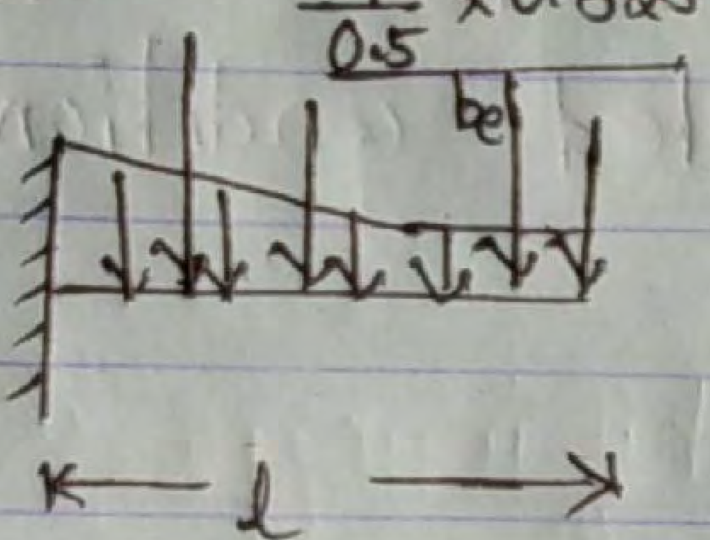


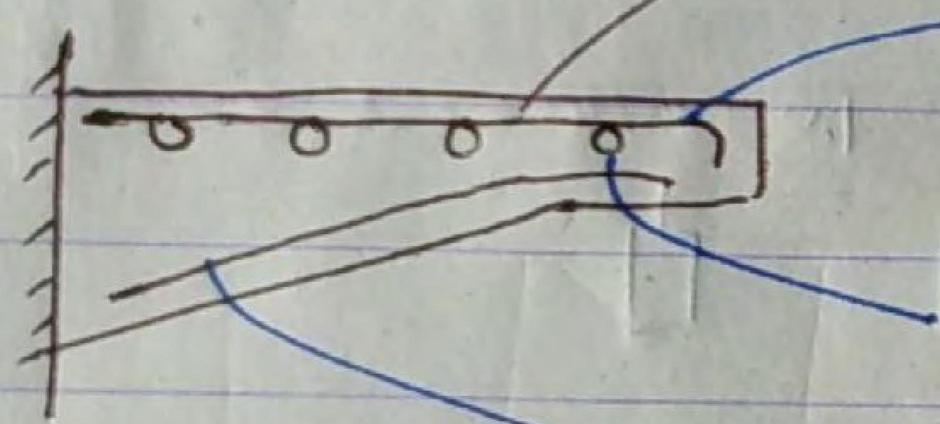
In general, bridge मा doubly reinforced हुँदैन because d provided is always greater than d balanced

Example :-

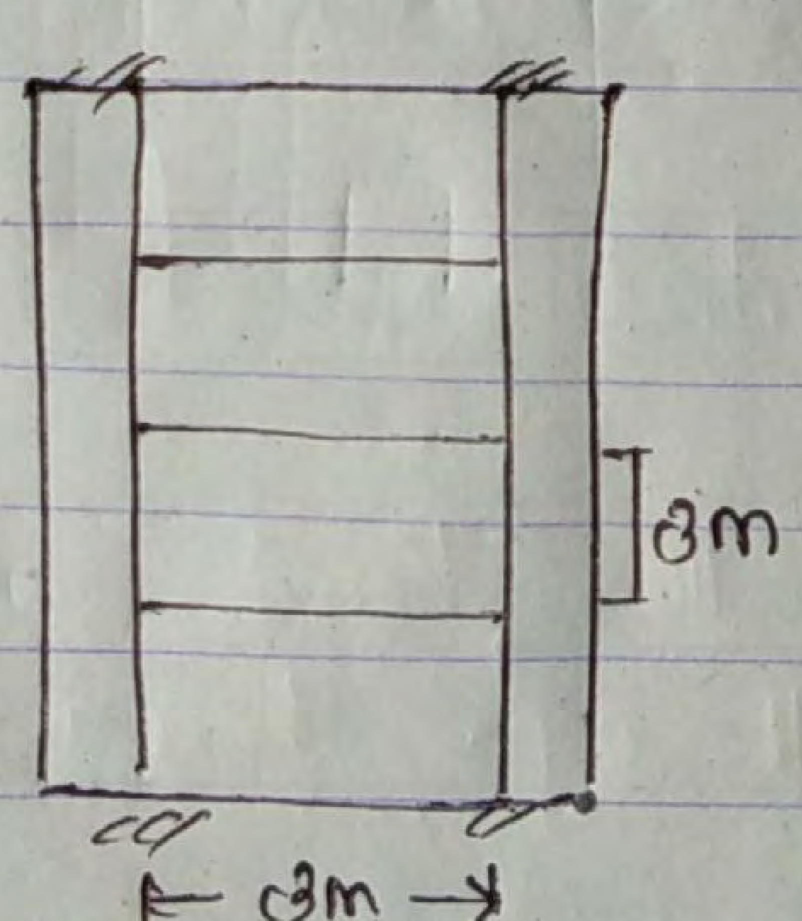
Analysis of cantilever slab

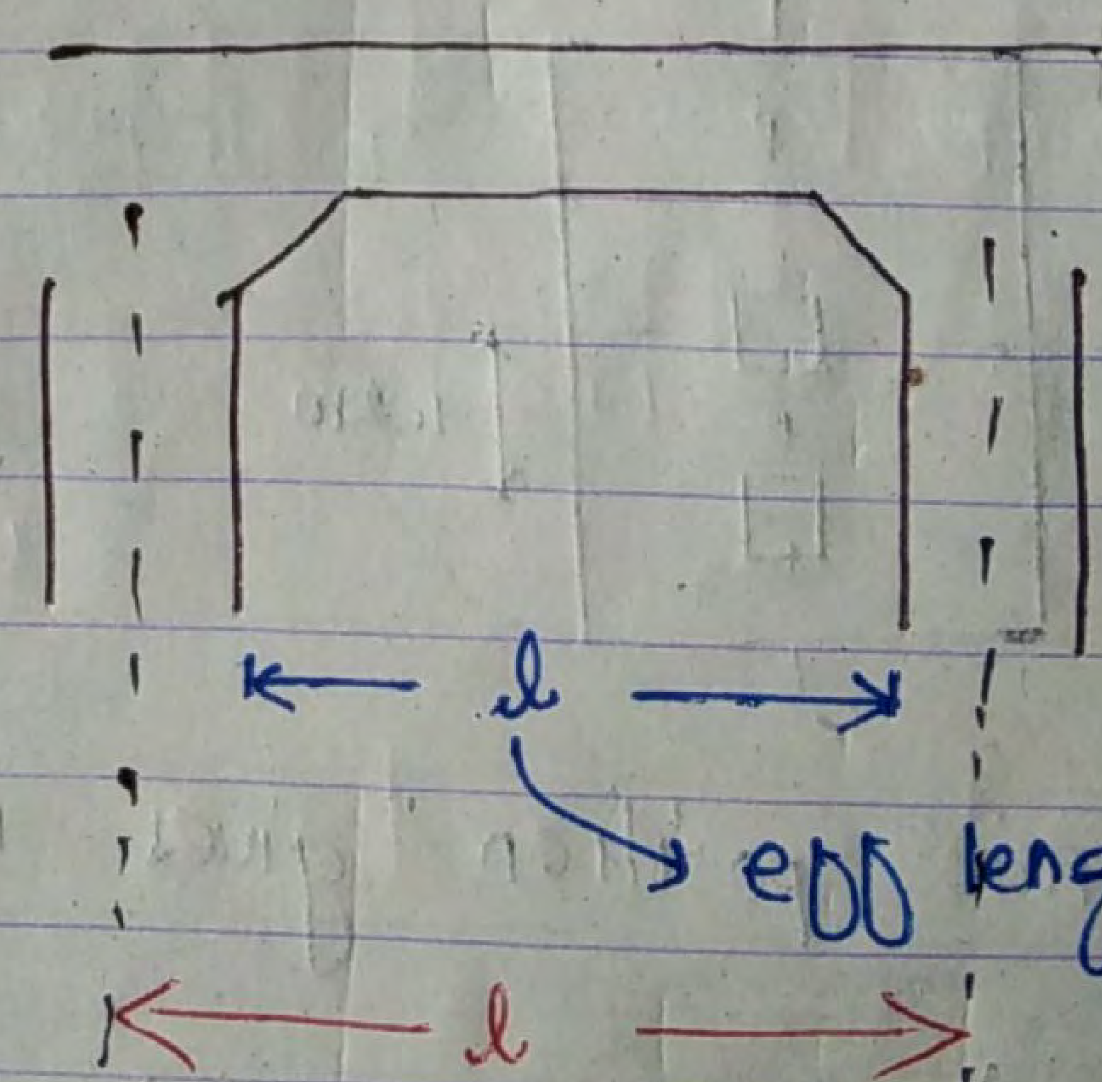
$\frac{57}{0.5} \times 0.325 \times I_f \times r_f^{LL}$





Analysis of restrained slab





If there is fillet stiffness is more – so can resist transitional & rotational forces & moment – so face वाट नै leff लिने

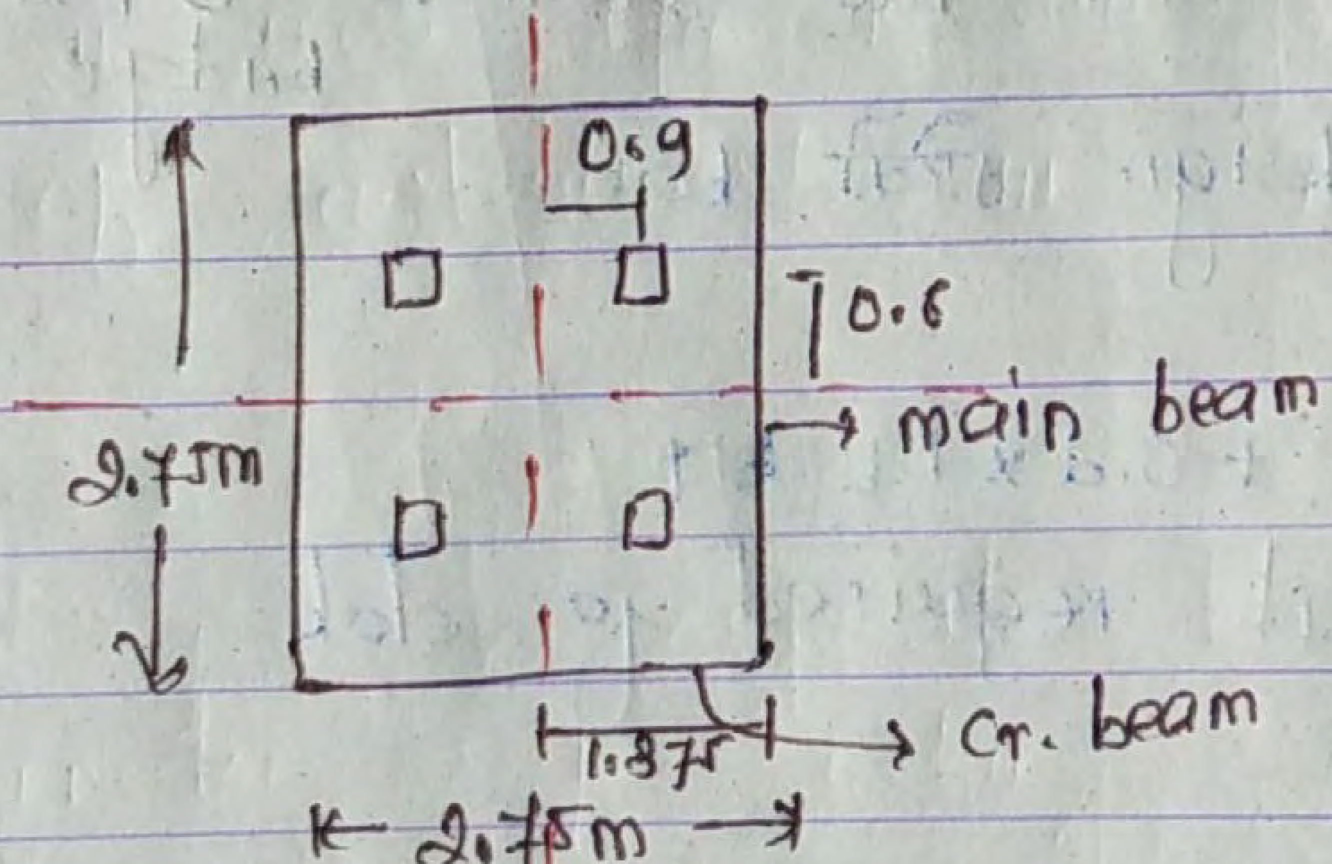
Hence, for main beam
$$l_{eff} = 3 - 0.3$$
for x beam $l_{ef} = 3 - 0.25$

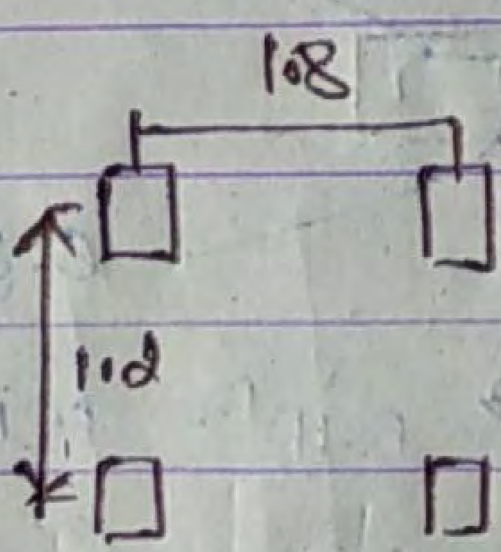
for DL
$$M_1 = (m_1 + \mu m_2) W \times 0.8$$
$$M_2 = (m_2 + \mu m_1) W \times 0.8$$

for restrained condition बाट भने simply supported condition को लागि हुन्छ।

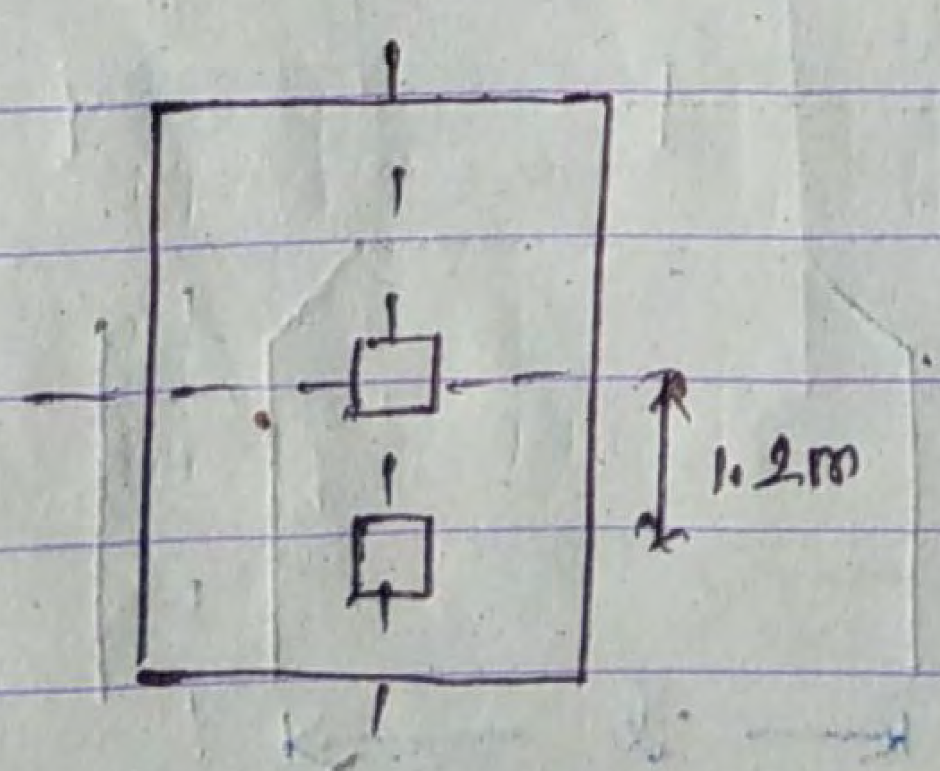
$$W = h_{av} \times 22 \times \alpha \times 1.75 + h_{slab} \times 25 \times \alpha \times 1.35$$

for LL





Another position



This position gives max^m BM

$$M_1 = (m_1 + \mu m_2) \omega \times 0.8 \times I_f \times \gamma_f$$

यदि slab is on beam → i.e. interior pannel i.e. all edge continuous

$$m_1, m_2 = f\left(\frac{u}{B}, \frac{v}{L}, \frac{B}{L}\right)$$

$u = 0.5 + 2h_{wc}$

$v = 0.25 + 2h_{wc}$ ll

for shear
for modern approach → wheel should be arranged in such a way that dispersion is away from the support because support मा shear enhancement हुन्छ ।

But conservative approach मा support मा नै wheel राख्ने

shear को case मा fixed support होस्, या simply supported होस्. reaction is same.

Design of Main girder

Note:
beam column मा बसेको हुन्छ so beam को bar always column को bar को भित्र राख्नै for reinforcement detailing

length को आधारमा thickness averaging गर्ने

Imp:
$b_{ef} = 6D_f + b_w + \frac{l_0}{6}$ for building

$b_{ef} = \frac{l_0}{5} + b_w$ & back for bridge

→ In the similar manner cr. beam main beam माथि बसेको हुन्छ so cr. beam को bar main beam को bar को भित्र राख्ने तर actually in field मा यसो गर्न गाह्रो भएको हुनाले practise मा बाहिर राख्ने

Theoritical point of curtailment मा bar लाई काटिदै पनि नकाइने which should be done at practical point of curtailment because at theoritical point of curtailment, actual moment (i.e. theoritical moment) in that section is equal to the MOR of the section but the theoritical moment in that section is always varying, may not be exact at the same section.

for theoritical pt. of curtailment

$M_u = M_R$ ⟶ MOR of the section

↓ actual moment in section

but in real M_u is always varying in section so practical pt. of curtailment मा $M_u < M_R$

Composite bridge

Stud connector → for making connection of steel beam & concrete slab rigid

for 25-45 m span composite bridge is economical

shear connector → main function longitudinal shear लाई रोक्ने

Rigid shear connector → connector आफैं bend हुदैन & load transmit through bearing

flexible shear connector → connector bend हुन्छ - bending through load transfer

Repeated load के case मा rigid shear connect है उसमें काम नहीं so use flexible one

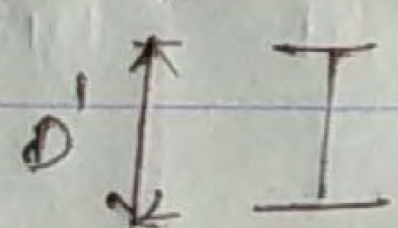
laterally unrestrained beam

Note:-

cross beam design यहाँ steel beam जैसे design होंगे not composite beam because span is less & load also less

spacing of main girder depends on thickness of slab

→ If spacing of main beam increases, thickness of slab also increases & vice versa.



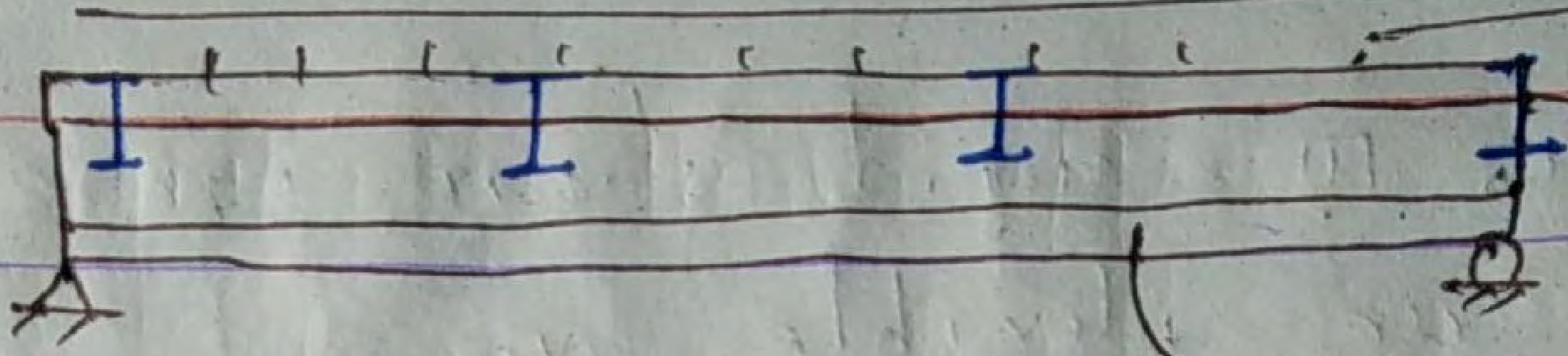
$$D' \simeq 5.3\sqrt{\frac{M}{\sigma_{bt}}}$$

σ_{bt} → permissible bending stress in tension

$= 0.6 f_y$

IRC 24 2010 → limit state

grade A, B, C → degree of weldability   IS 800



① Design in bending

$M_u \le M_d$

↳ limit

$\sigma_{bt}^{cal} \le \sigma_{bt}$

$\sigma_{bc}^{cal} \le \sigma_{bc}$ } working

$\sigma_b = \frac{M}{Z} \le \sigma_{bt} = 0.66 f_y$

$\sigma_{bc} = 0.66 f_y$

② Design in shear

check for shear

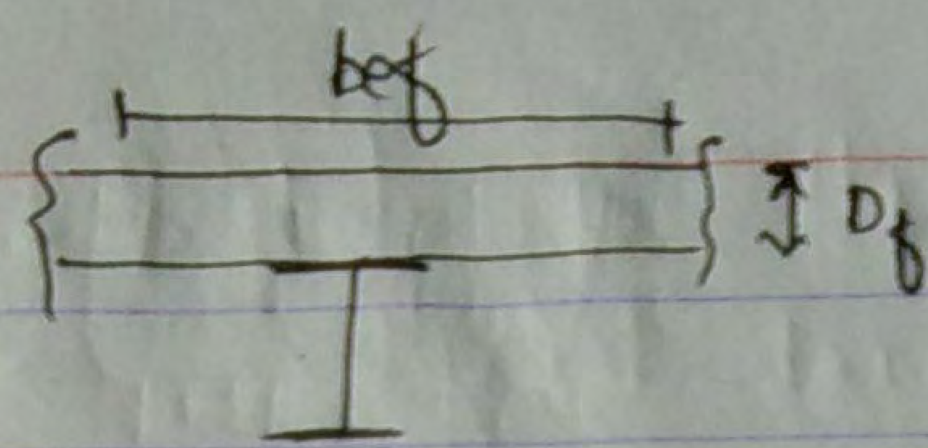
$V_u \le V_d$ or $\tau_v \le \tau_{va}$

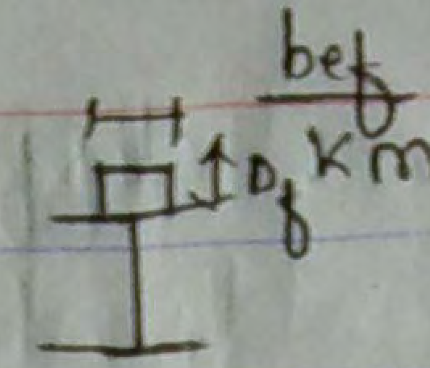
$\simeq 0.4 f_y$

③ check for deflection

④ check for lateral stability

Design of stiffners





where $m = \frac{E_s}{E_c}$

DL + SIDL
→ super imposed DL
जसले creep effect दिन्छ
थप्नमा k = 2

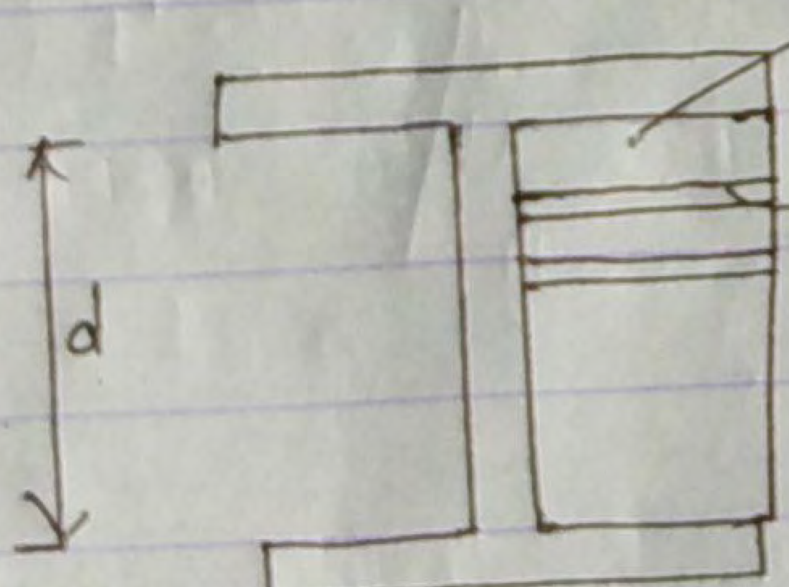
तर अर्को

DL + SIDL + LL
where k = 1

single rolled &
Built up
plate girder }.

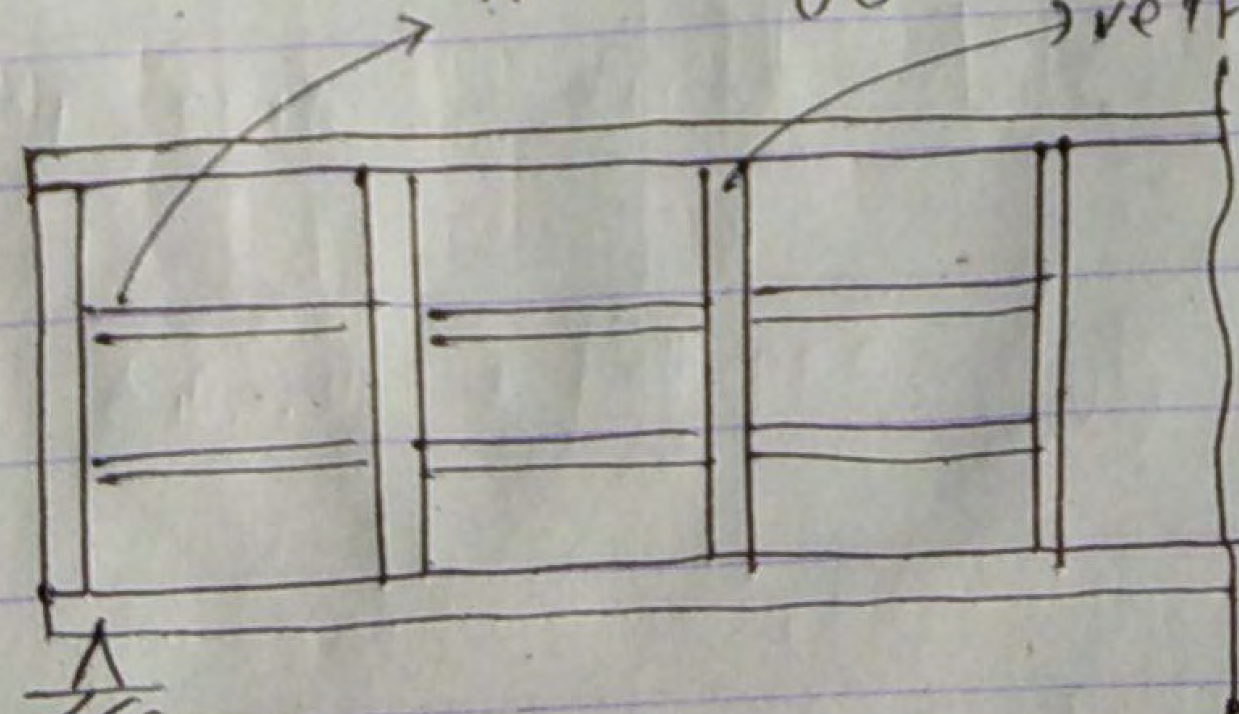
vertical stiffner → to prevent vertical plane मा हुने buckling

Horizontal stiffner → to prevent horizontal plane मा हुने buckling



Buckling depends on slenderness ratio i.e. $\frac{d}{t_w}$

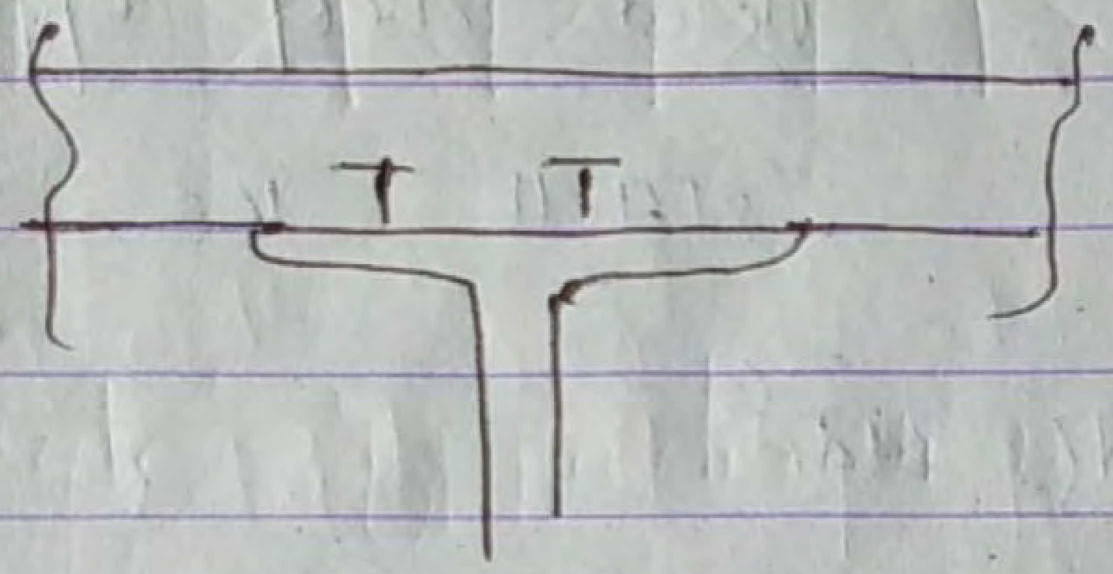
Hor. stiffner
vert. stiffner



यदि 400 भन्दा बढी भयो भने tw increase

for designing vertical stiffner

$I_{prov} \leq I_{req}$.



$$\tau = \frac{VS}{Ib}$$

$$V_L = \tau \times (b \times 1) = \frac{VS}{I}$$

(b×1) → one meter length म shear force taken by shear connector

$$n = \frac{V_L}{\Sigma Q}$$

$$\text{spacing} = \frac{1}{n} = \frac{\Sigma Q}{V_L}$$

Truss Bridge

Hindge connected truss → only axial force
rigidly " " → axial force & BM

welded connected → rigidly connected
bolted connection → Hindge connection

→ यो थोरै use हुन्छ in bridge because fatigue मा चाँडै fail हुन्छ

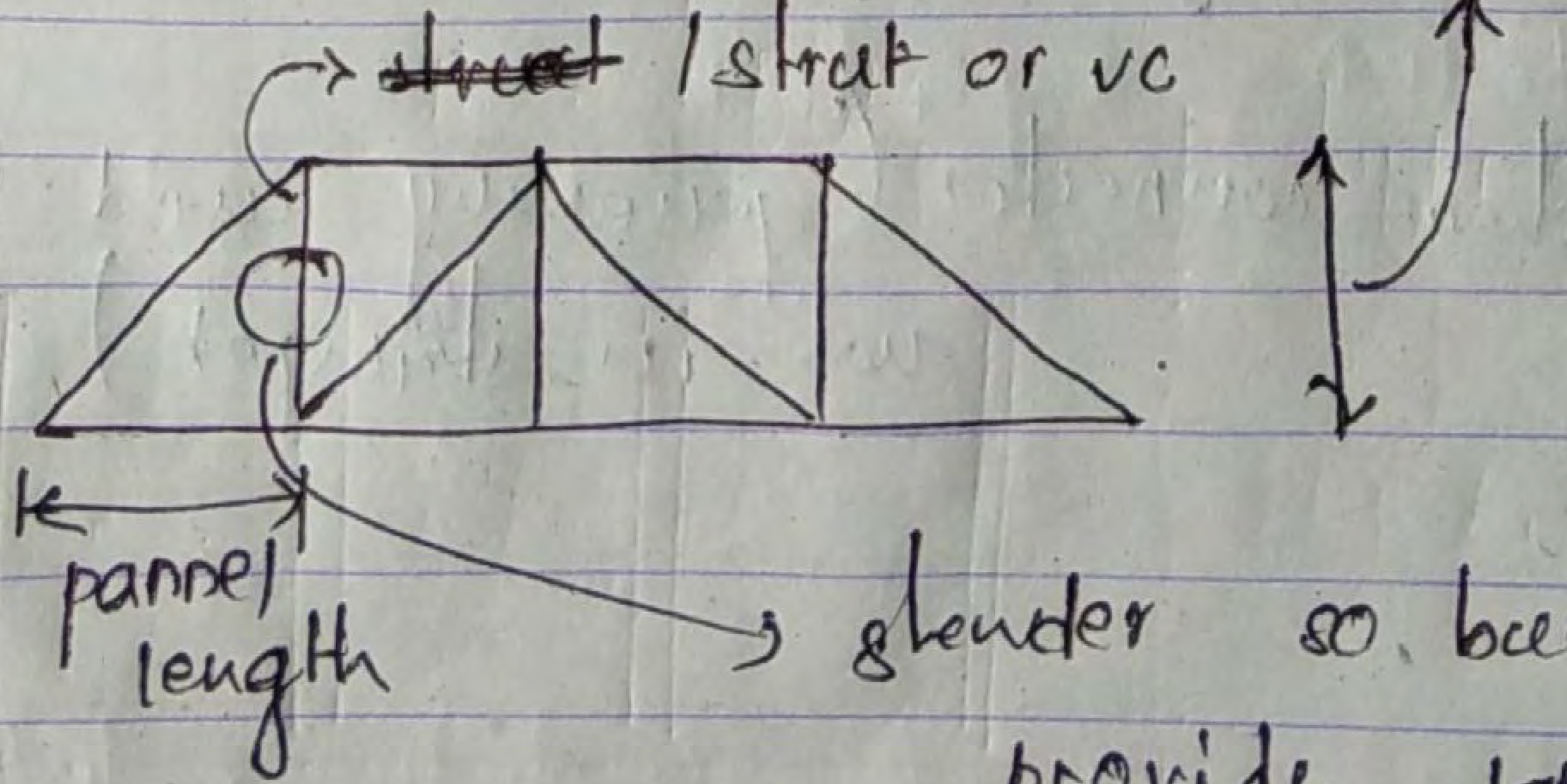
composite bridge is economic than truss bridge
for span < 50 m ⇒ truss bridge is not economic

truss bridge मा सबै load joint मा आउँछ।
Mostly built up section use गर्ने

लामो span bridge मा top bracing plan use गर्दैन त साधैं always use

stability provide
lateral load resist गर्छ } function of bracing

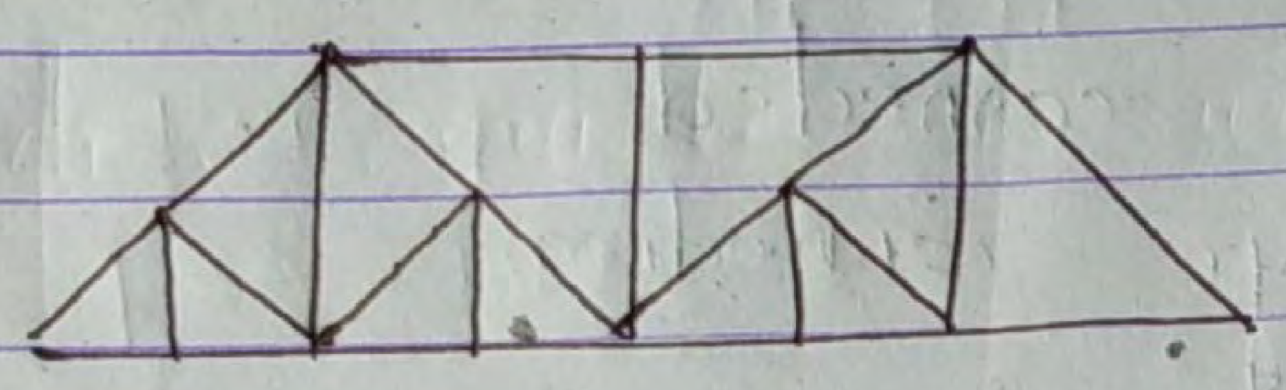
truss को span increase गर्यो भने depth बढाउने



→ slender so buckle हुन्छ so we have to provide lateral support for which we use K type

https://civinnovate.com/civil-engineering-notes/

when pannel length increase depth of slab & beam (→ stringer) increases — so we divide pannel length



α = angle of inclination ઘટશે ગને pannel length increase

→ stringer which is always rolled section

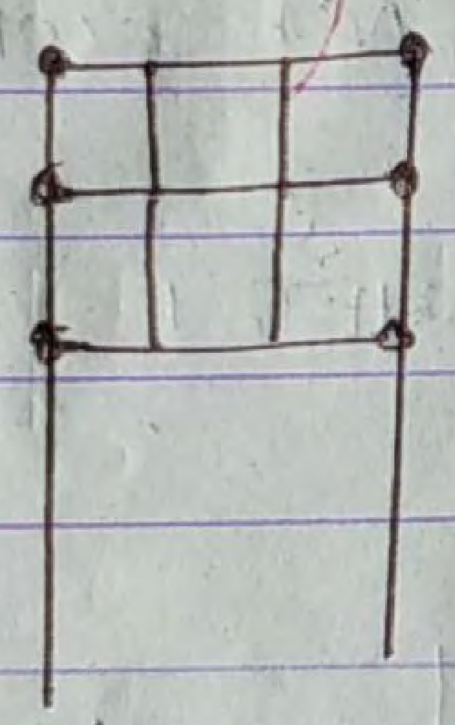
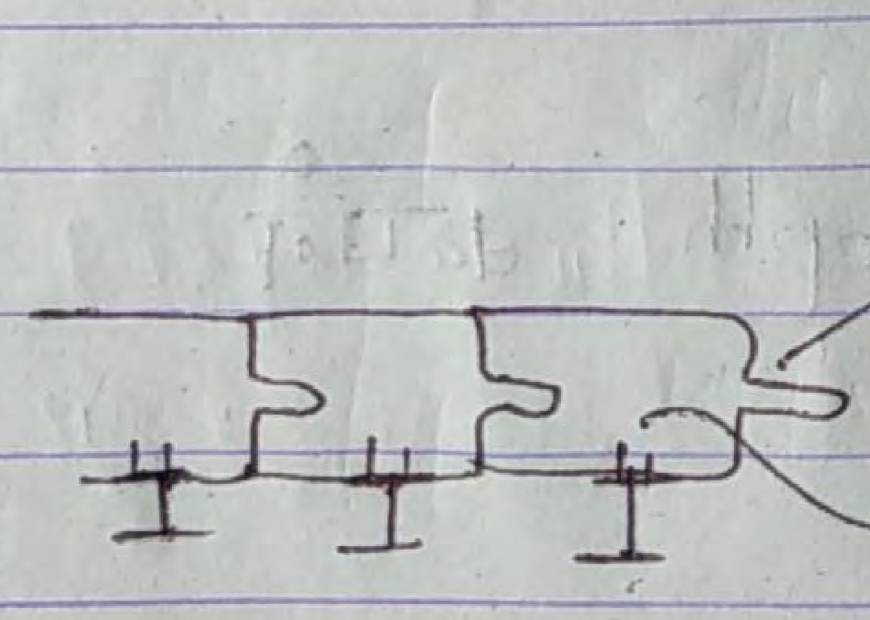


fig: plan

distribution of force

slab → stringer → cross beam → panal point so થતો truss મા always only axial force

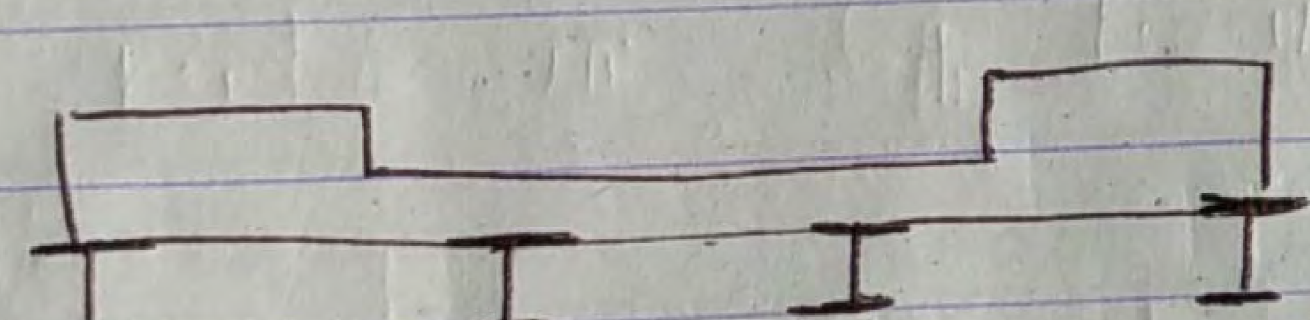


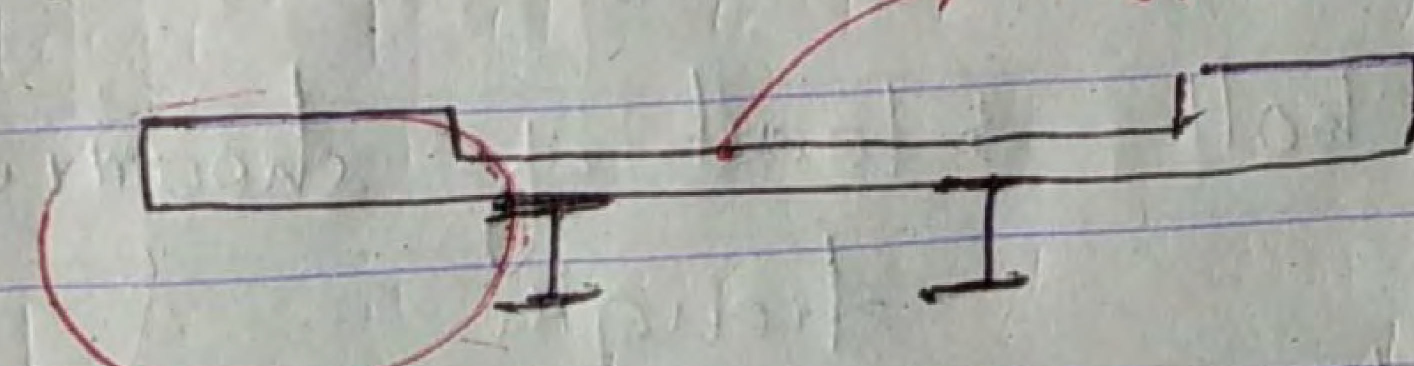
A – bolted
B – welded } grade

Regular bolt □
heavy bolt ⬡ } depends on tensile force used for tightening

M12 ⇒ 12 nominal diameter of shank

High strength friction bolt is generally used एवं machine जैसे दोलन संरचना – friction का काम नहीं i.e. cyclic load का loose होना

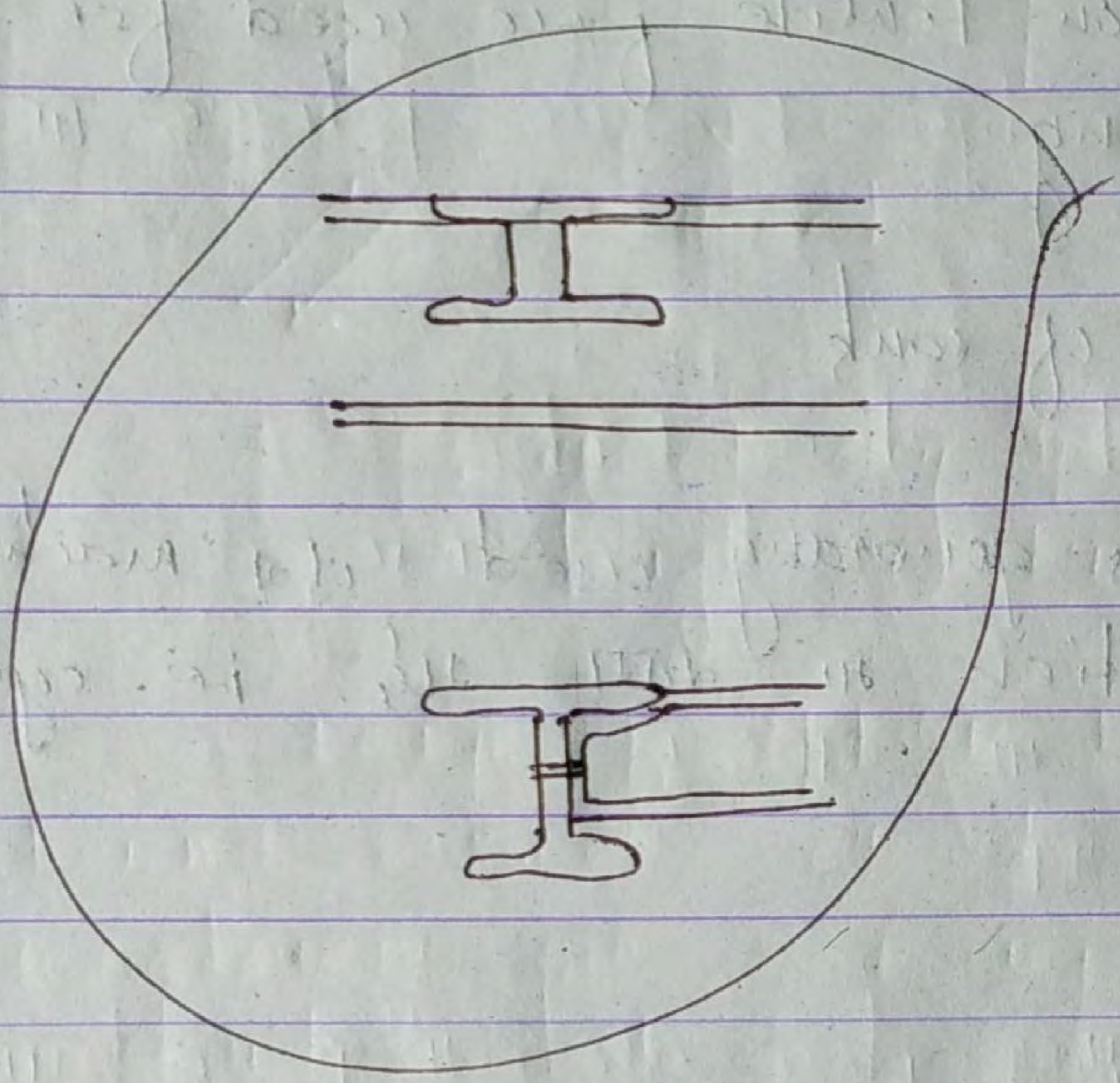




simple beam
Build up
plate girder } type of steel beam

depth of cr. beam depends on the lane of bridge - if lane increases depth increases.

Rolled section avaliabe in market in only upto 1 m depth



no. of bolt = $\frac{\text{Design load}}{\text{Design strength of a bolt}}$

Design strength of a bolt:
- for ordinary bolt → least of shearing & bearing strength
- for high tension → friction

Design action ≤ Design strength

$\sigma_T \le \sigma_{at} = 0.6 f_y \Rightarrow \sigma_T = \frac{T}{A_{net}}$

$T \le T_d$

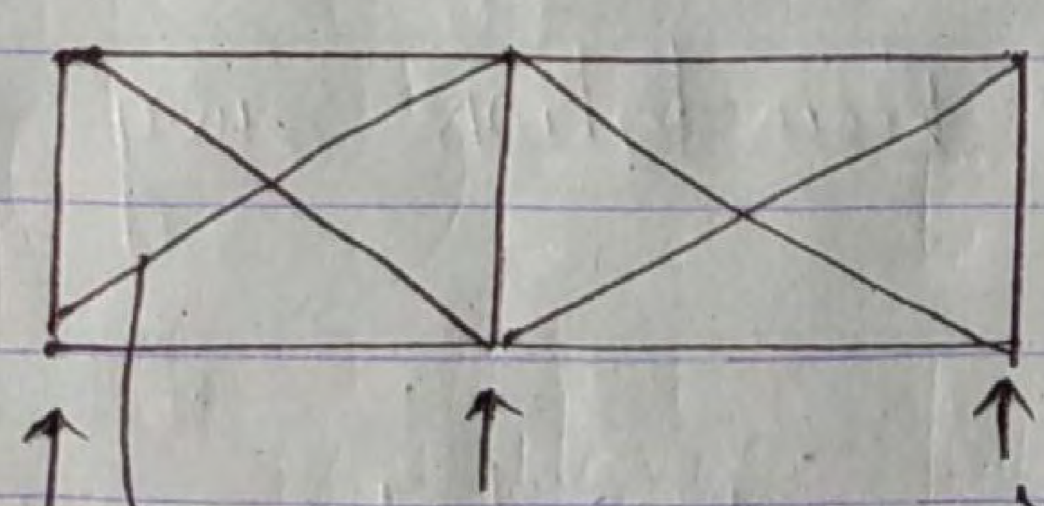
$C \le C_d$

$\sigma_c \le \sigma_{ac} \Rightarrow \sigma_{ac} \le 0.6 f_y$

$\chi \times \frac{f_y}{\gamma_{m0}}$

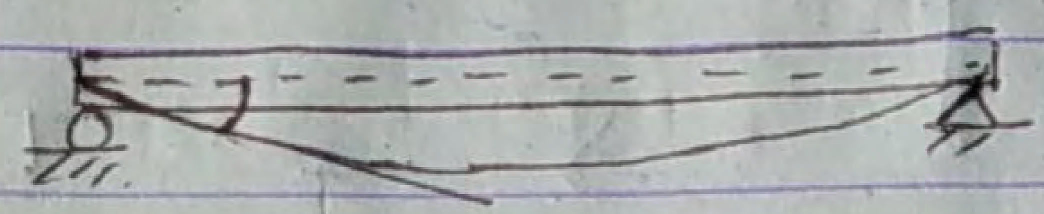
χ → stress reduction factor

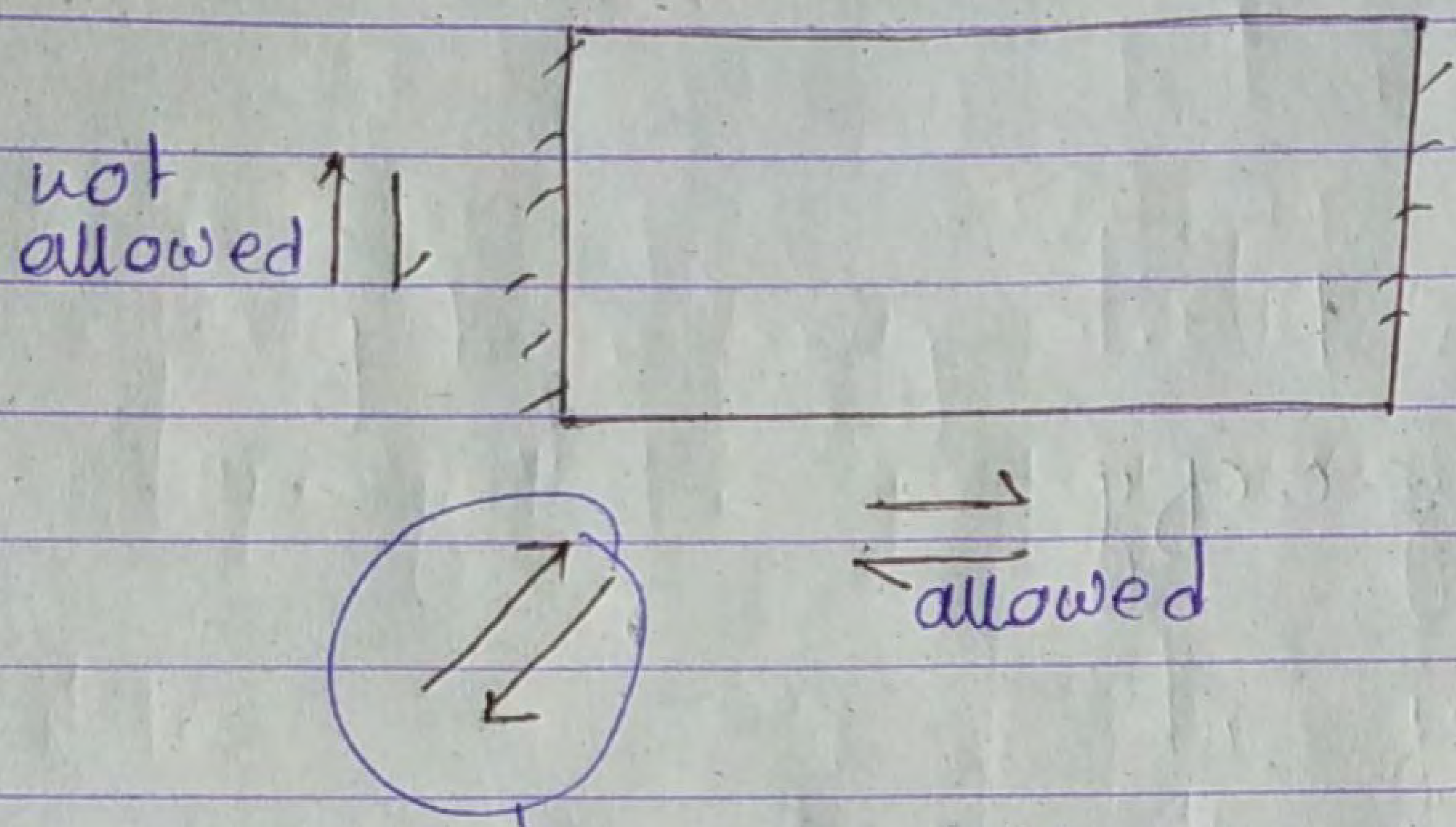
Bracing member is always designed as tension member



→ एउटा compression हुन्छ र अर्को tension & vice versa - पुन compression हुँदा त्यो buckle हुन्छ weak हुन्छ so load लिँदैन that's why सबै load tension हुने member ले लिन्छ i.e. why always designed as tension member

Bridge Bearing





allowed only on skew/ curvilinear bridge not in straight bridge

Rotational movement allowed only in longitudinal dir^n not in transverse dir^n

fixed bearing → hinge support
free " → roller "

Roller bearing → allow rotation & translation only in longitudinal dir^n

Rocker bearing → allow rotation of longitudinal dir^n
linear

point → allow rotation in all dir^n

linear Rocker → allow rotation only in longitudinal dir^n

knuckle bearing
- cylindrical → allow rotation in long. dir^n
- spherical → allow rotation in all dir^n
- pin → " " " longi. dir^n

sliding plate bearing → allow translation only in long. dir^n
→ teflon coated
→ rotation allow only in small amount

elastomeric bearing → hardness 25-30
→ life 25 yrs.
→ used upto span of 45 m (pad)

slab मा seismic load consider गर्दैन because it is considered as stiff (rigid diaphragm effect) so that it does not buckle due to seismic load.
यदि buckle हुन्छ भने seismic load consider गर्ने

seismic action हुँदा 20% LL present in bridge
T. यसको 20% नै brake लाइन } code

In some cases in slab bridge elastomeric bearing without steel plates/laminar is used but in all other cases laminar is used.

IRC 87 I → metalic bearing } pad bearing
" " II → elastomeric "
" " III → pot bearing

Hmin → only or vertical

Shape factor is performance factor & stability factor.

Note:-
compressive force है यानी shear strain develop होगा

Design of Metallic Bearing

cast iron } Bearing
stainless steel

roller cum rocker → roller की साथ rocker
→ यदि rotational movement provided by roller is not sufficient, then we use

IRC 83 I (metalic bearing)

Design example of Roller cum Rocker bearing

$\sigma_{ac} \le 0.6 f_y$

$\sigma_{at} = 0.6 f_y$

$\sigma_{bc} \le 0.66 f_y$

$\sigma_{bt} = 0.66 f_y$

$\tau_{va} \le 0.4 f_y$

$\sigma_{pa} = 0.75 f_y$

Find the size of top & bottom bearing

→ Bearing stress

$\sigma_p \le \sigma_{pa}$

$\frac{V}{x} = 0.75 f_y$

$x = ??$

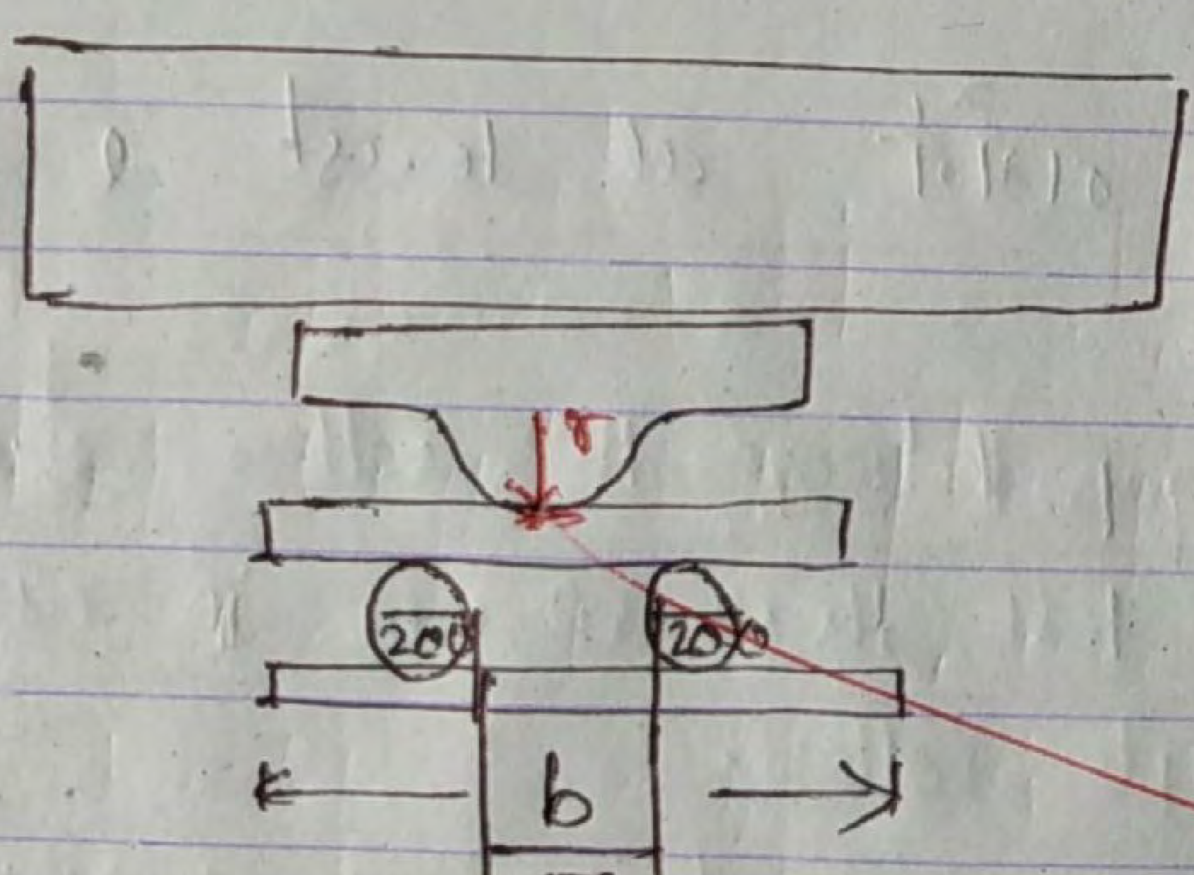


fig: section

→ length of bearing is normally greater than width of the beam

यसको contact width मानेको radius को half लिने

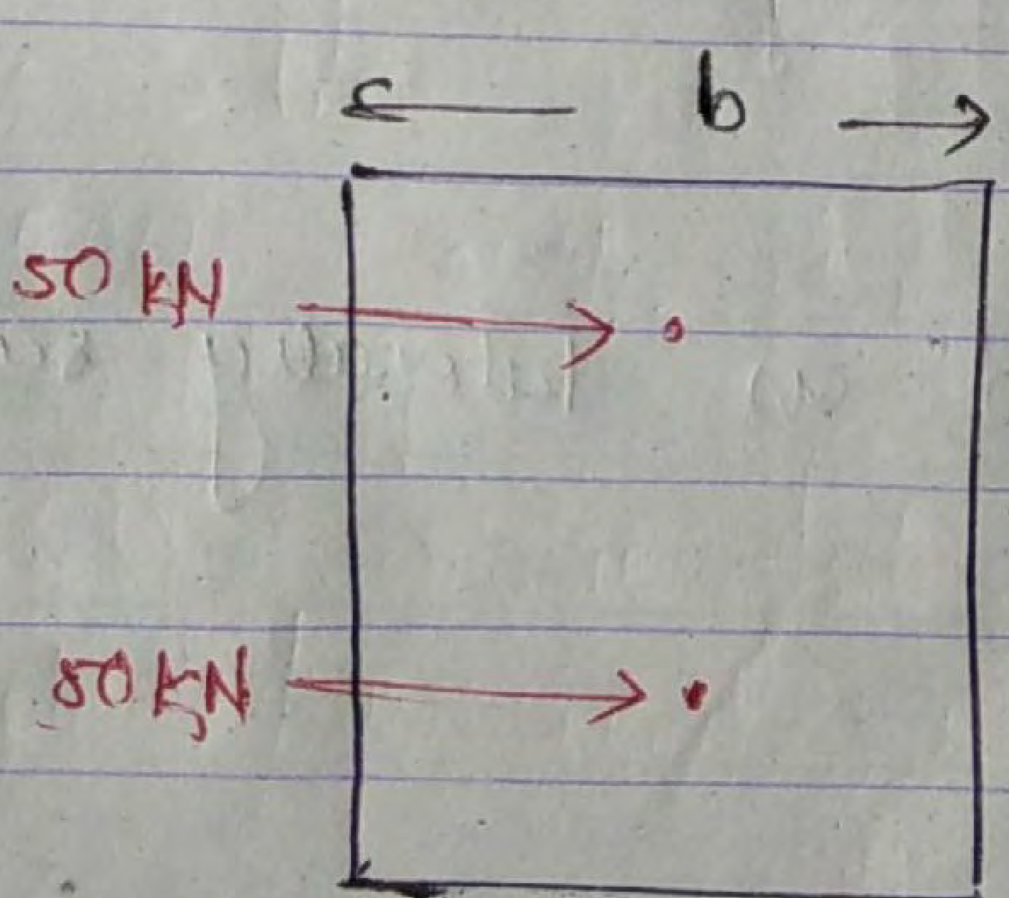
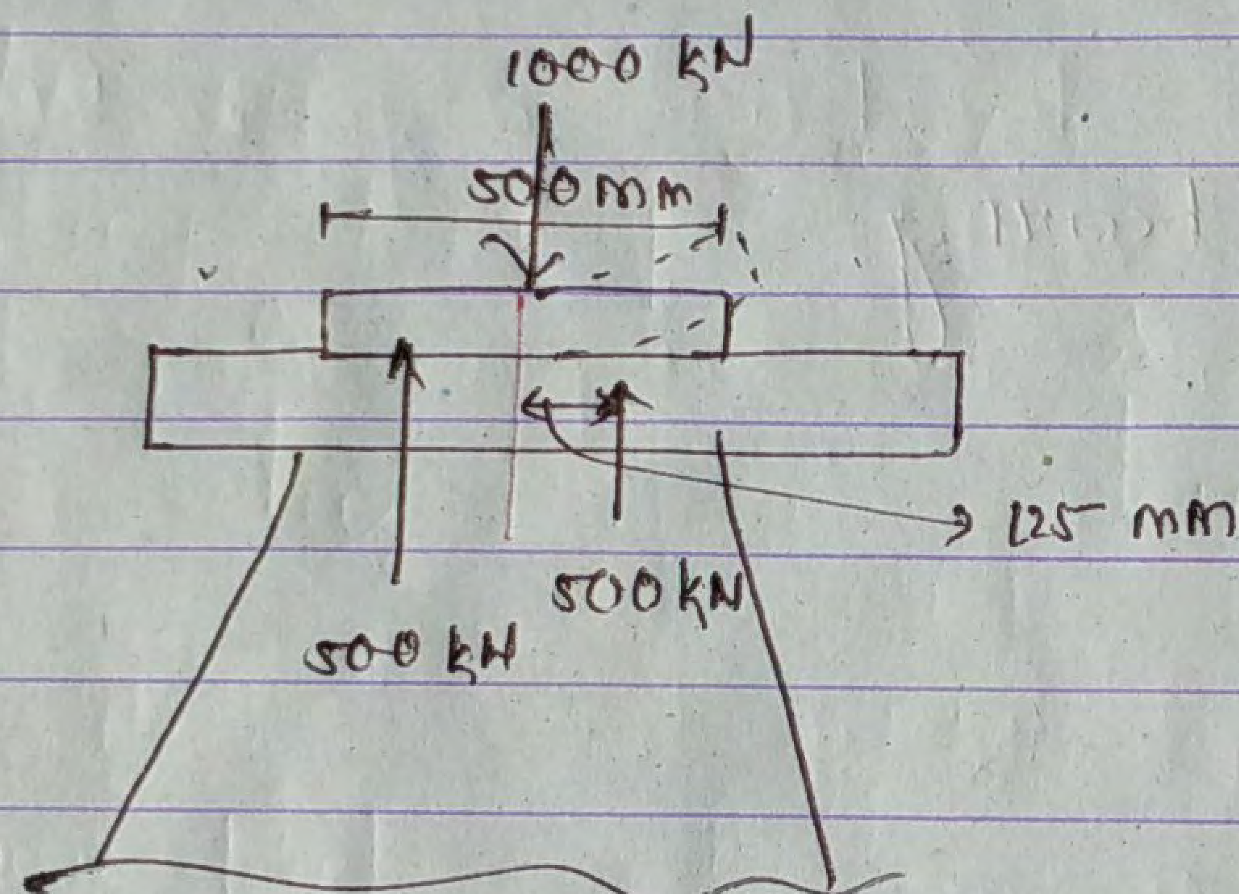


fig: plan

$\tau_v = \frac{50}{\pi r^2} \le \tau_{va} = 0.4 f_y = 100$ MPa

$\therefore r = \ldots$



$\sigma_b \le \sigma_{bt} = 0.66 f_y$

$\Rightarrow t = ?$

$\sigma_b = \frac{M}{Z}$

$Z = \frac{bt^2}{6}$

$M = 125 \times 500 \times 10^3$ Nmm

normally एउटा मात्र roller use नगर्ने at least 2 roller

$s = 100 + c + 100$ ($c \rightarrow 100$)

$= 300$

The gap between the rollers shall not be less than 50 mm in case of multiple rollers.

laterally supported }
" un " } → steel beam design गर्दा को case

Here, in bearing plate is designed as laterally supported ca for lug

$$\frac{V}{L \times t} \le \tau_{vg}$$

$\Rightarrow t = \ldots$

Design of elastomeric bearing

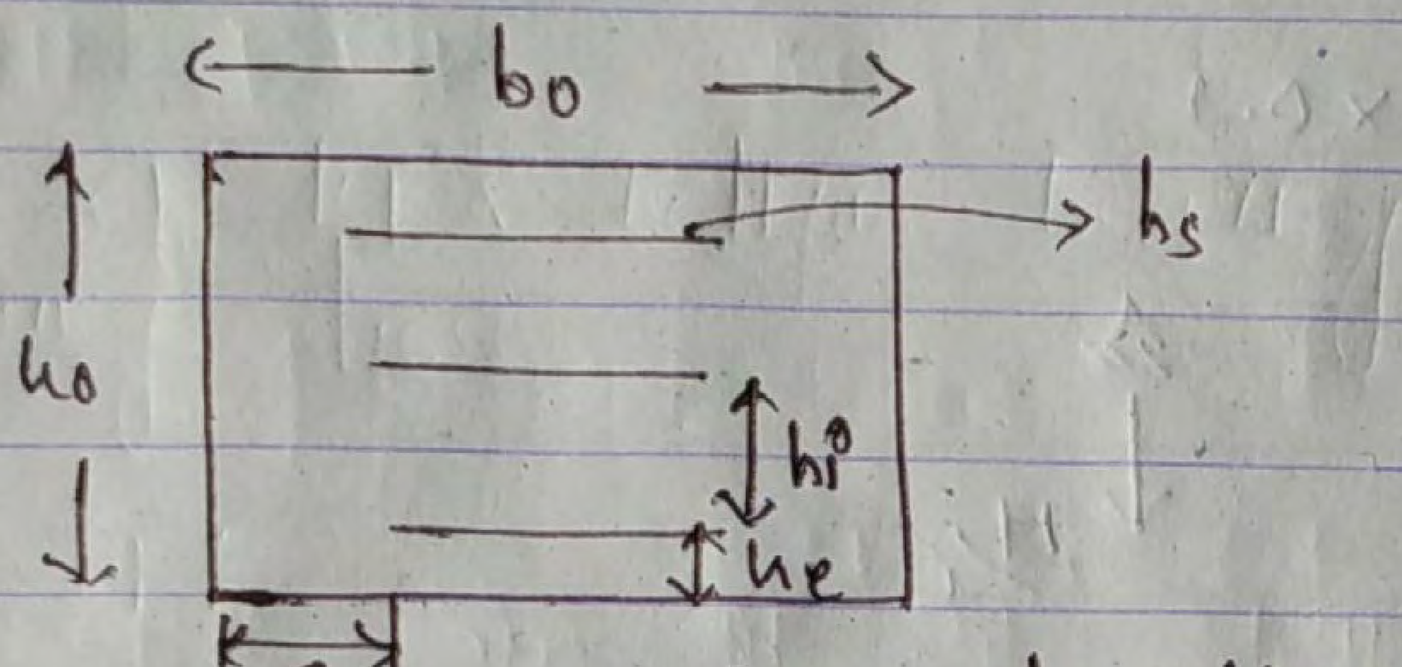


fig: Elevation

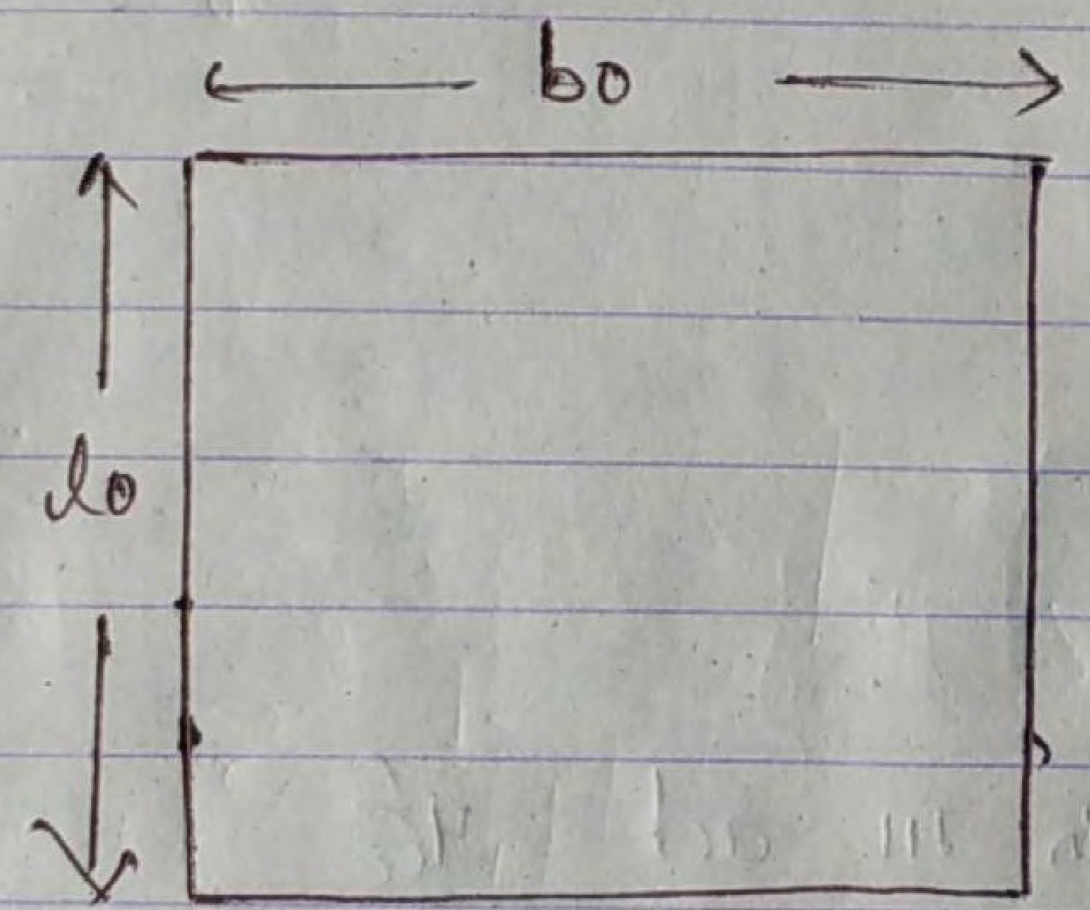


fig: plan

$\sigma = E\epsilon$ (σ → stress, ε → strain, E → Modulus of elasticity)

$\tau = G\phi$ → in case of shear

N_{max} → dead load + variable load

N_{min} → only dead load

probability of risk is always greater in DL+LL combination

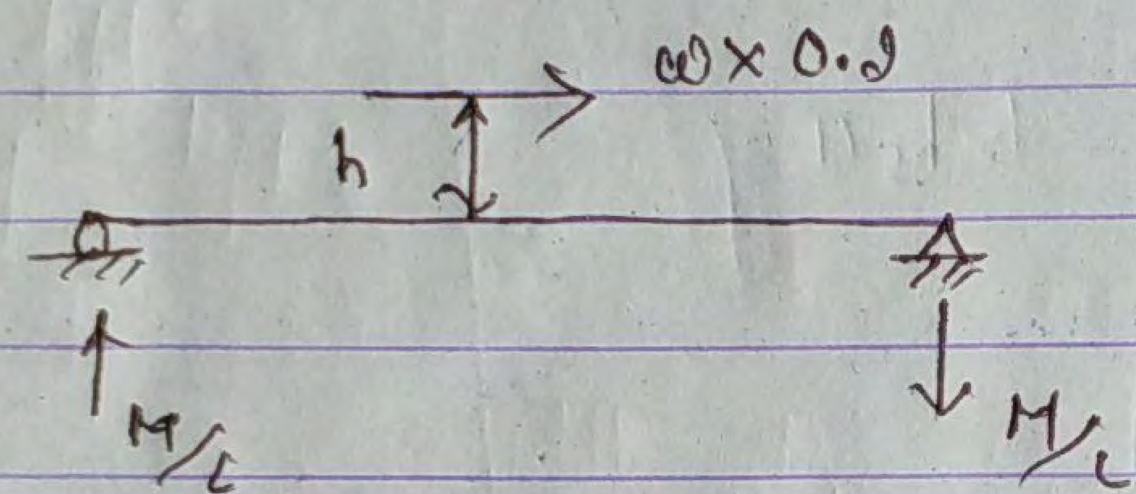
so यसमा design गर्दा अरु combination मा check गर्ने

Why minimum v. load N_{min} is required?

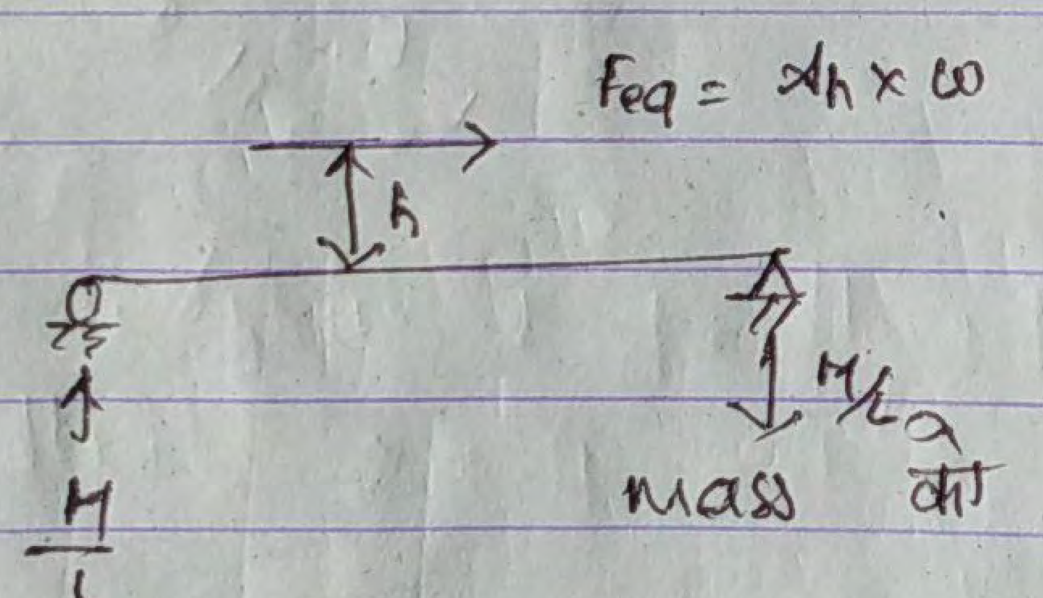
(1) when vertical load increases frictional resistance also increases.

(2) with horizontal load but no vertical load ## more deformation than with both horizontal & vertical load

Note:- Breaking load always acts in longitudinal dir^n of bridge



for seismic load



mass को CG मा act गर्छ

for load due to creep, shrinkage & temp^r variation

Hooks law

stress ← $\tau \propto \phi$

$$\frac{F}{A} = G\phi \rightarrow \text{strain}$$

$$F = G\phi A$$

$G = 0.8$ to 1.2 MPa acc. to code

we take $n = 1$

$\therefore F = \phi x$ where x = bearing को area

$\phi = 5 \times 10^{-4}$

$\Delta = \alpha \times \Delta t \times L$ ⇒ change in length due to temp' i.e. deformation

Now, strain $e = \frac{\Delta}{L}$

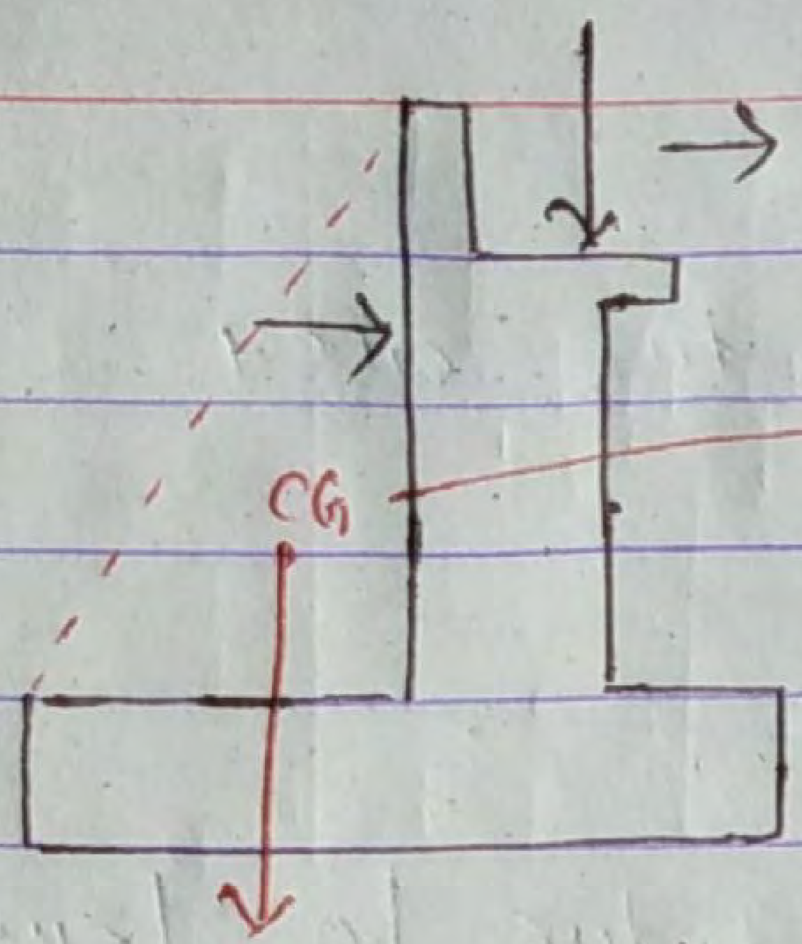
Analysis & design of abutment & pier

Function of abutment
- To transfer load from superstructure to substructure
- To retain earth mass

Function of abutment cap
- To transmit load uniformly from bearing to stem.
- Bearing को area सानो हुन्छ so हुन्छ bearing stress under bearing so bearing को cap use गर्छ with high grade of concrete.

Function of dirt wall
- To retain earth mass
- earth mass बाट आउने dirt लाई रोक्ने
- to support approach slab

steam 6-7 m को लाई RCC
को अलिक wt. बढी लाई prestress } abutment type



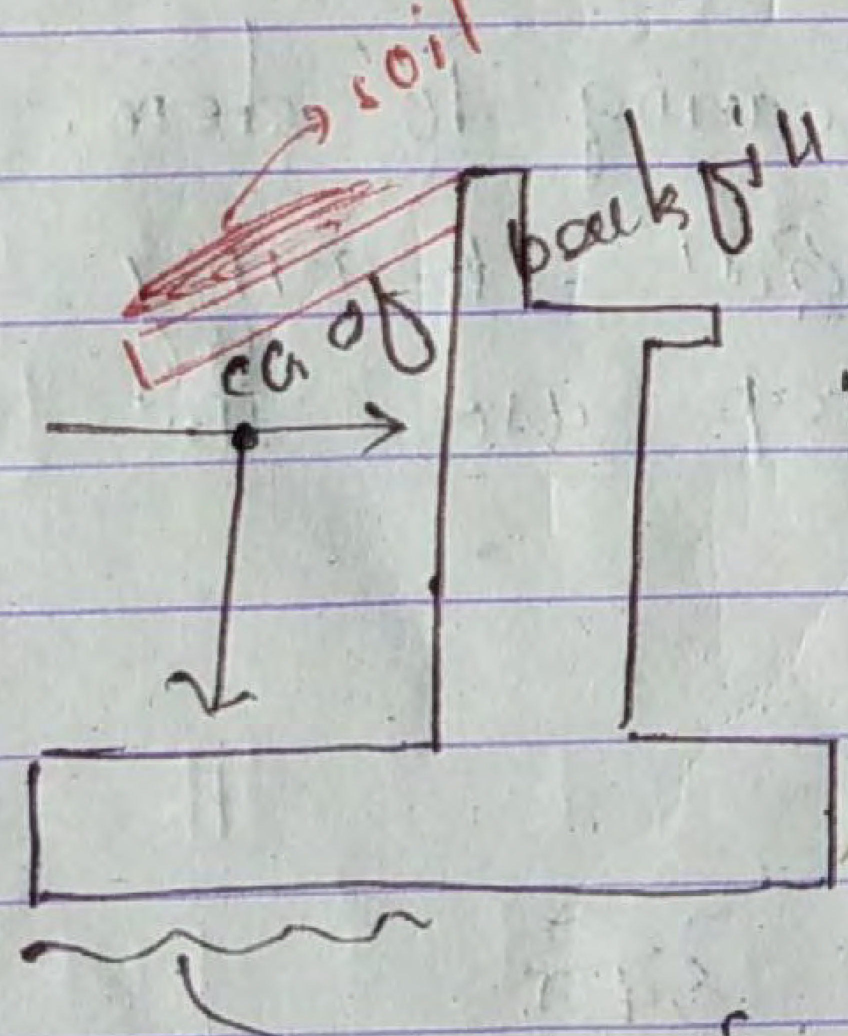
CG backfill लेर हुन्छ so that lever arm increases & restoring moment increases

Types of abutment on the basis of overturning moment लाई कसरी management गर्ने

1. Gravity type
2. Balancing type
3. Buried

→ धेरै U.S मा use गर्ने

Balancing type



→ थप्नलाई लाउने (heel slab लाई लगाउने stem constant)

Buried type

- toe तिर पनि माटोले छुने
- This type is used mostly in road-road intersection but not in road-river intersection

यदि multispan bridge छ भने abutment मा always use free bearing

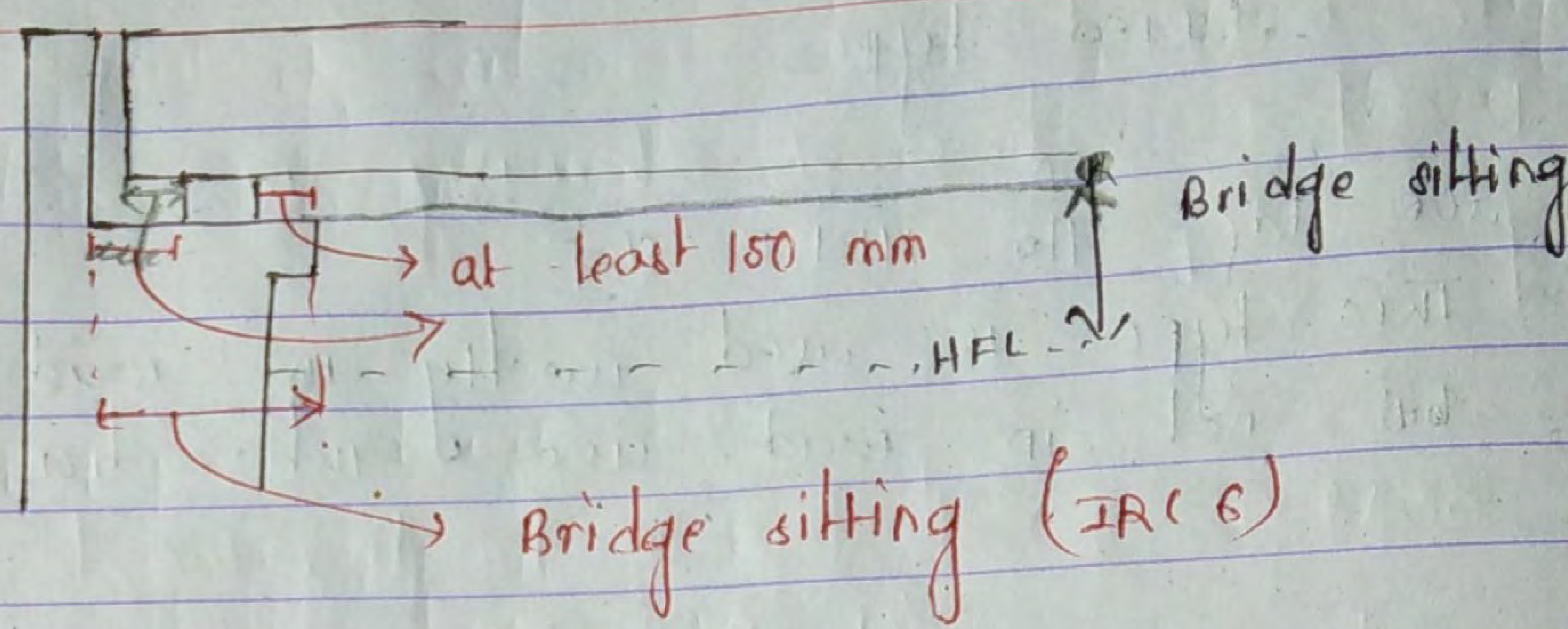
single span – one abutment free one fixed
↓ higher abutment
↳ lower abutment

If the height of abutment lower than 6-7 m, then stone masonary can be used otherwise always use RCC abutment balancing type.

Analysis & design of abutment

Main governing parameter for preliminary design is the height of abutment.

thickness of cap depends on span of bridge & grade of concrete used.



Bridge sitting is always 1 to 1.5 m above HFL

Expansion joint → at least 20 mm clear gap (codal provision)

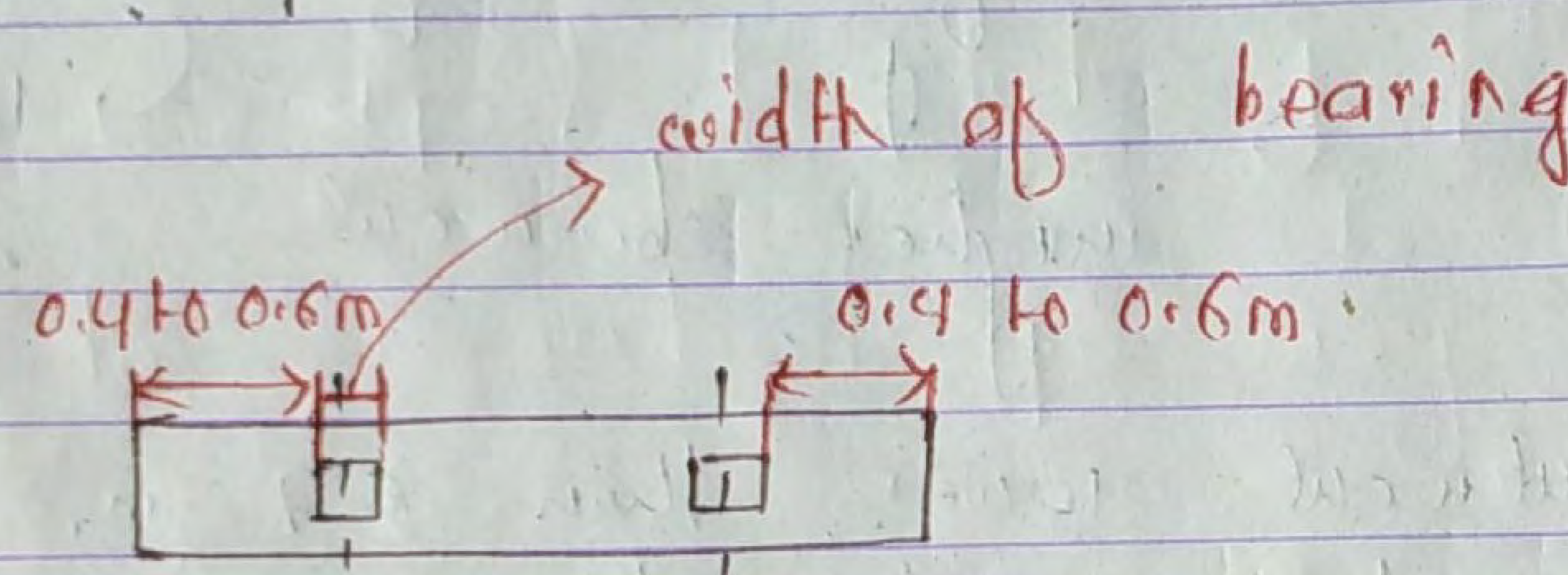
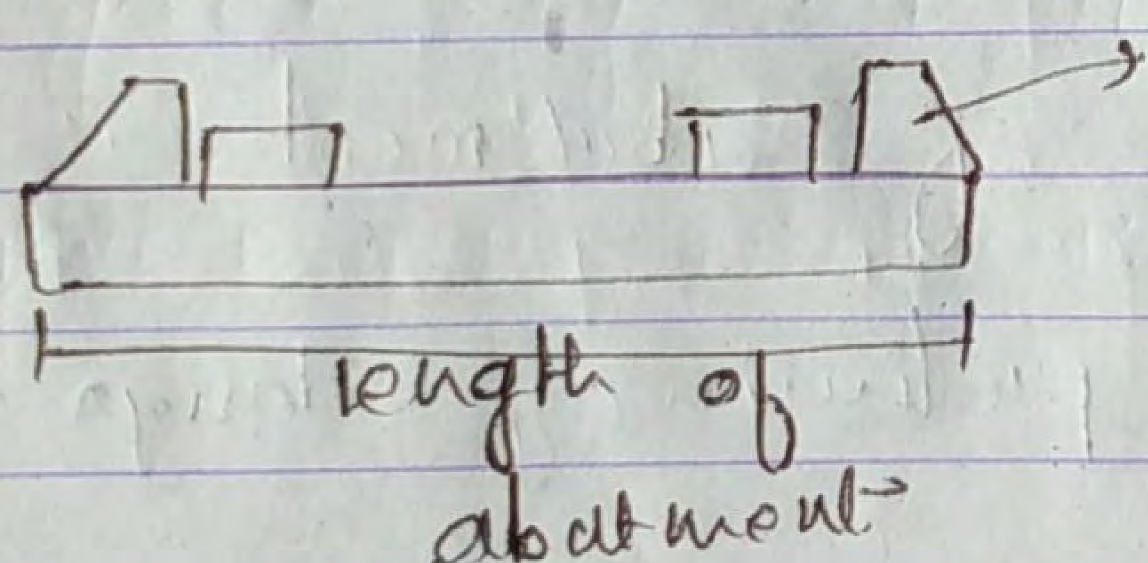


fig: plan



→ stopper whose width = 0.4 to 0.6m

Mass concrete → nominal bar नहीं concrete
bearing का काम नहीं structure का use होता
vol. of concrete is very high so during concreting heat evolution high
so M10 otherwise min^{m} M20.

9 का combination of loads in working ~~state~~, but in limit state 3 का " state

Basic combination → all loads without seismic load ~~&~~ but wind load is included

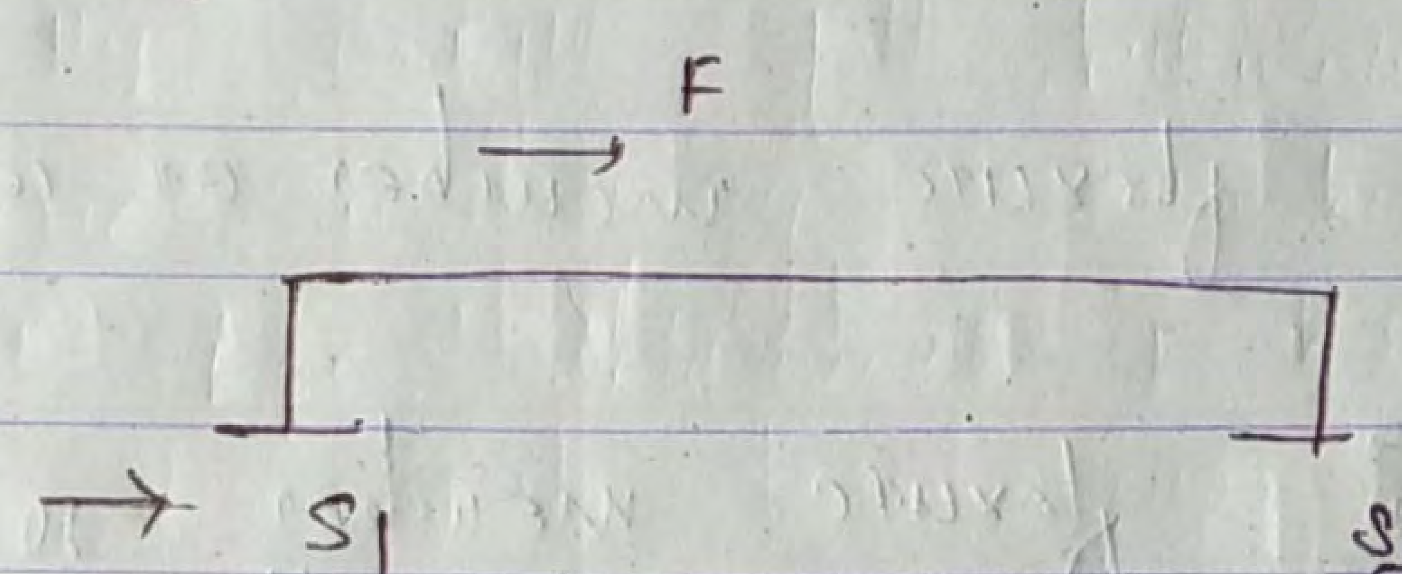
seismic combination → all loads without wind load

Accidental combination → only for bridge with ship navigation.

Imp for viva

partial FOS for foundation, strength, serviceability & no. of combination

For bridge with span < 15 m दुबैमा free bearing we गर्दै



$F_1 = F \times \frac{S_1}{\Sigma S}$

$F_2 = F \times \frac{S_2}{\Sigma S}$

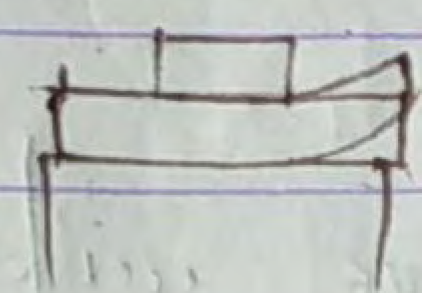
load distribution is always according to the stiffness of the support

stiffness → force per unit deflection

जसको more stiffness उसले more lateral load shear गर्छ

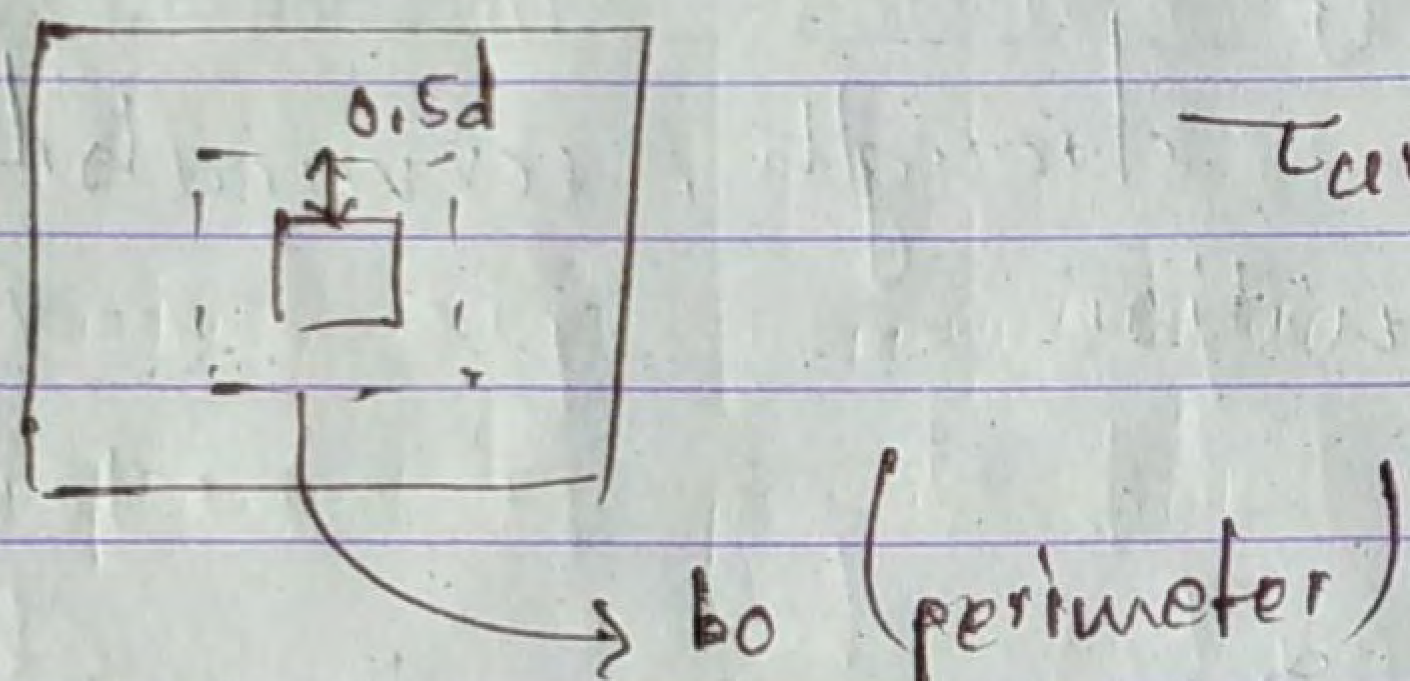
यदि एउटा free एउटा fixed than all is taken by fixed bearing.

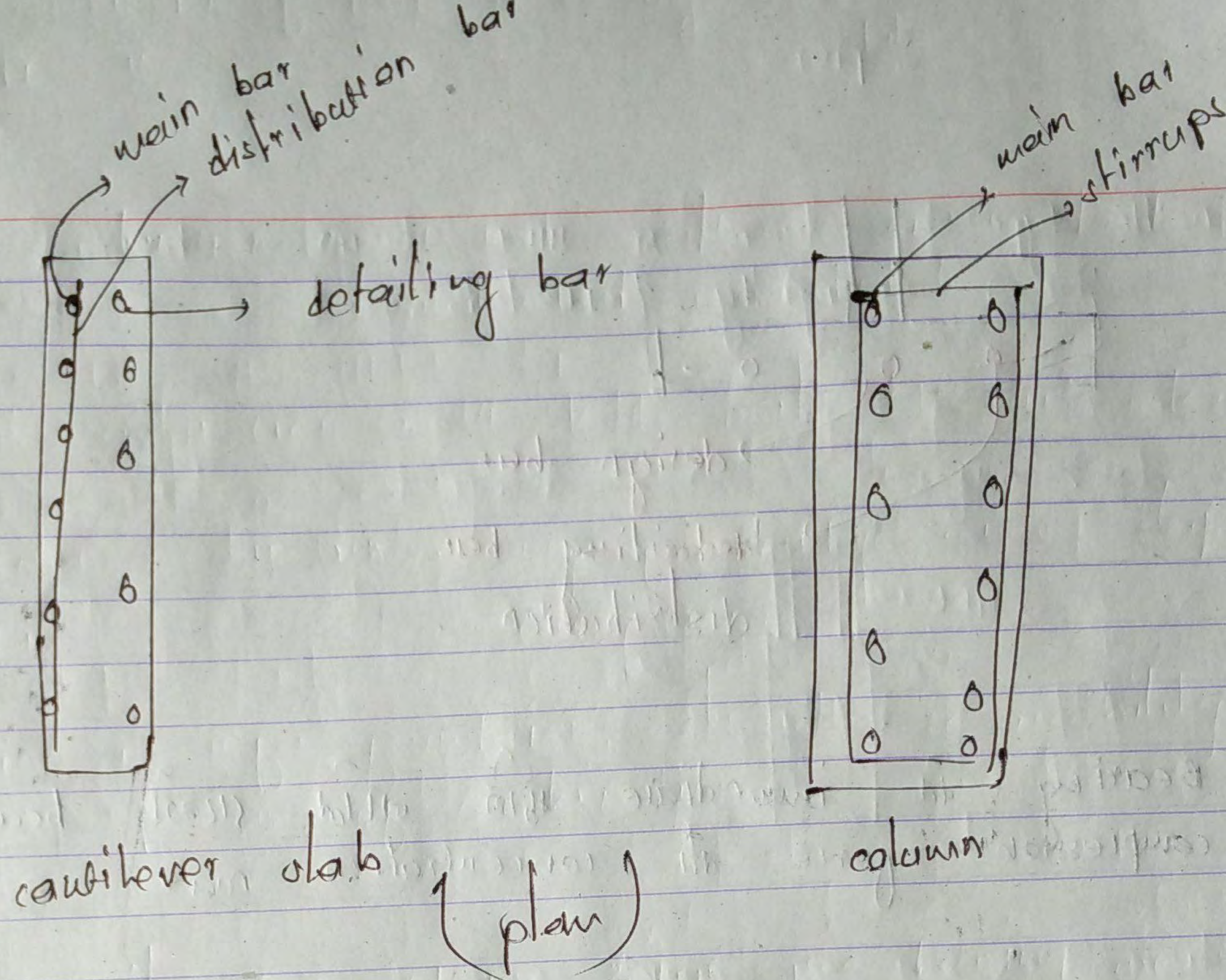
Upward pressure of soil should be positive - If negative no connection between soil & foundation base



$$\tau_{uv} = \frac{V_u}{b_o d}$$

$$\tau_{uv} < \tau_{uc} K_s$$



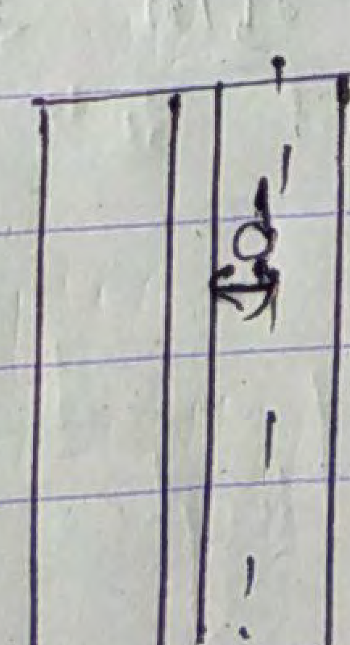


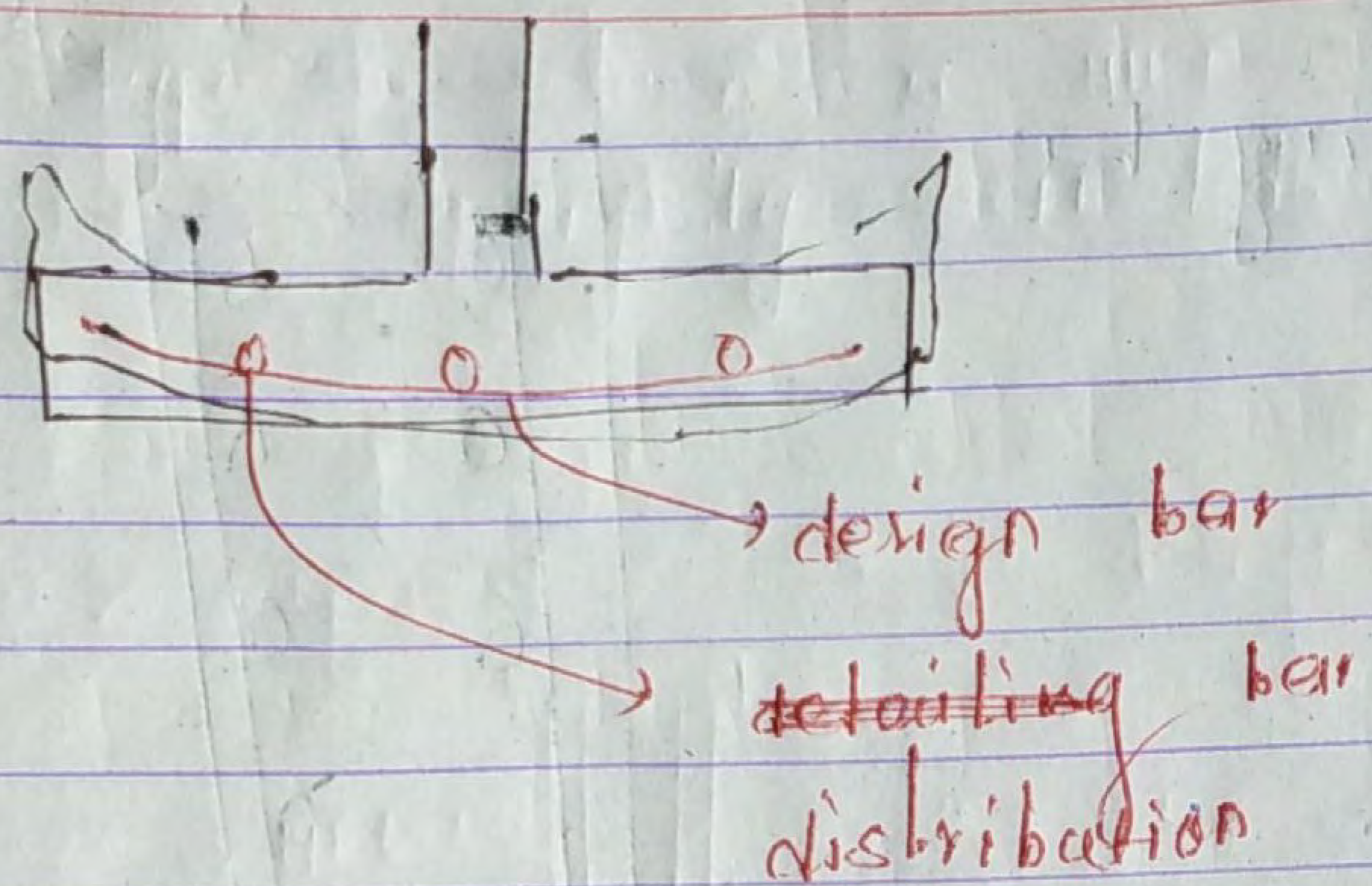
d ≥ d bar
⇒ SRURS

for resisting shear

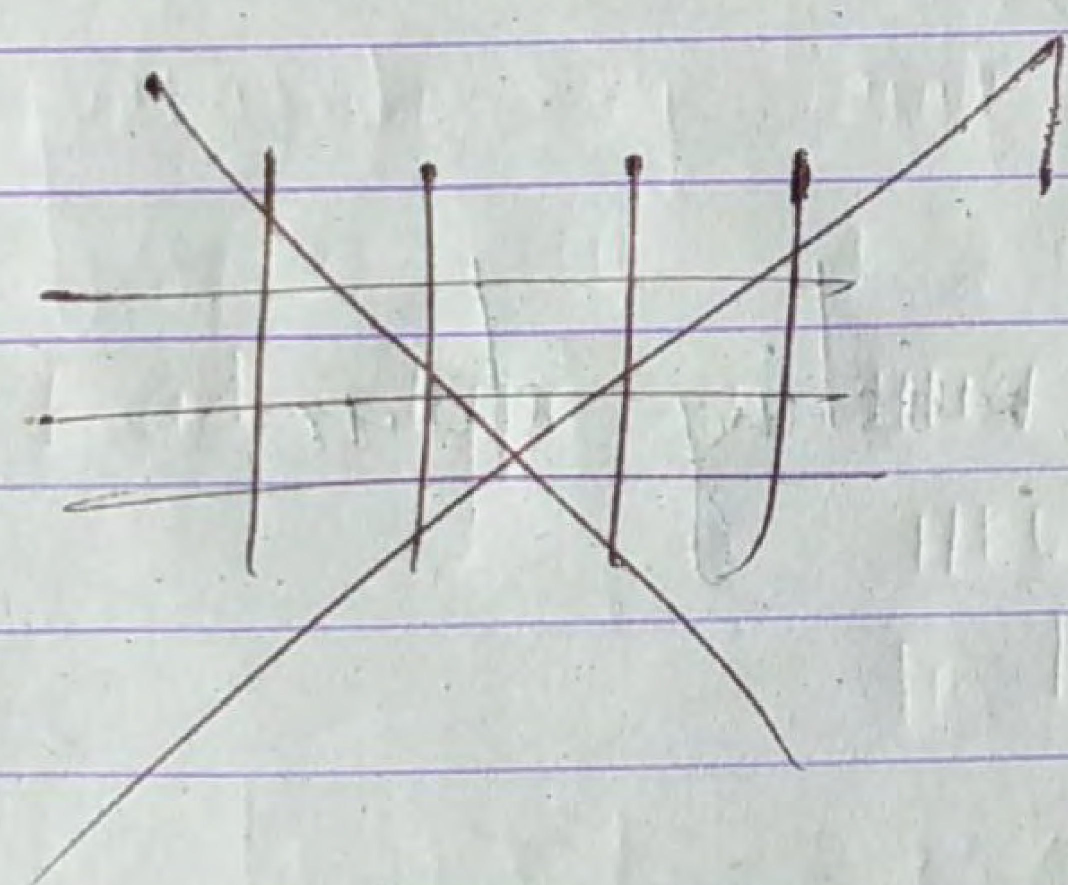
Footing (design as spread footing)

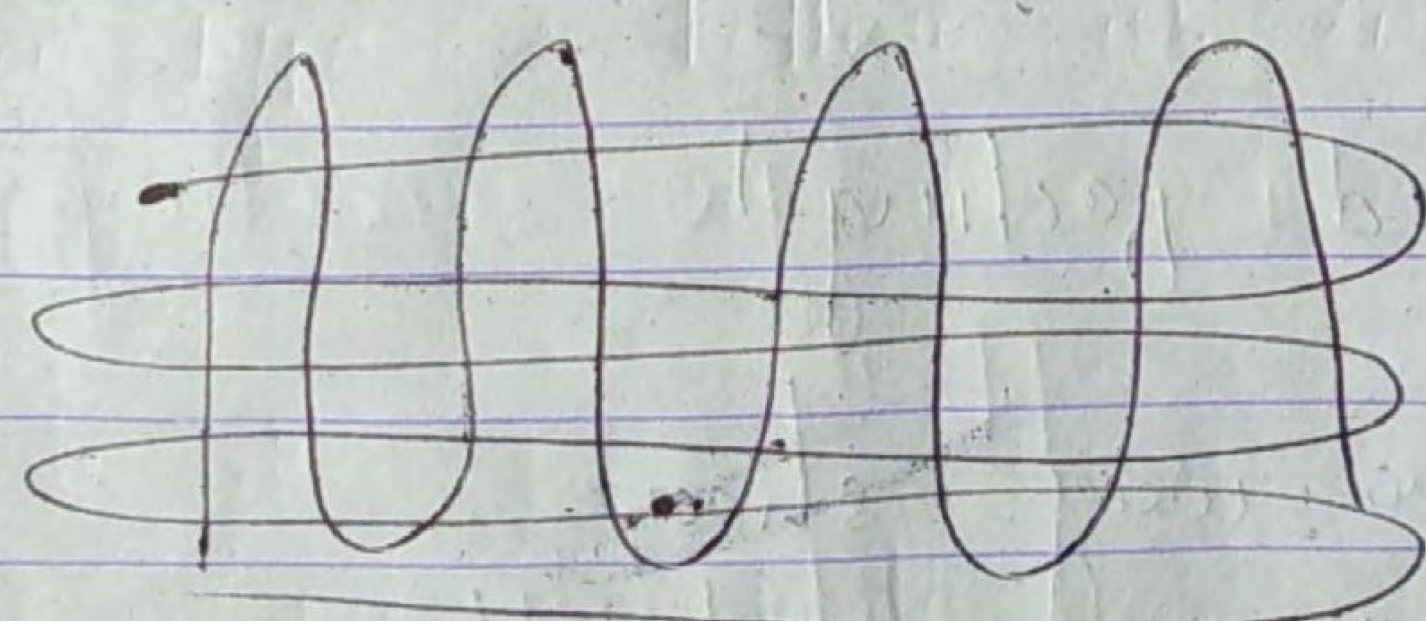
- always consider one way shear
- 2 way shear is always safe because area होते है





Bearing को immediate मुनि जाली राख्ने because compression force को concentration max



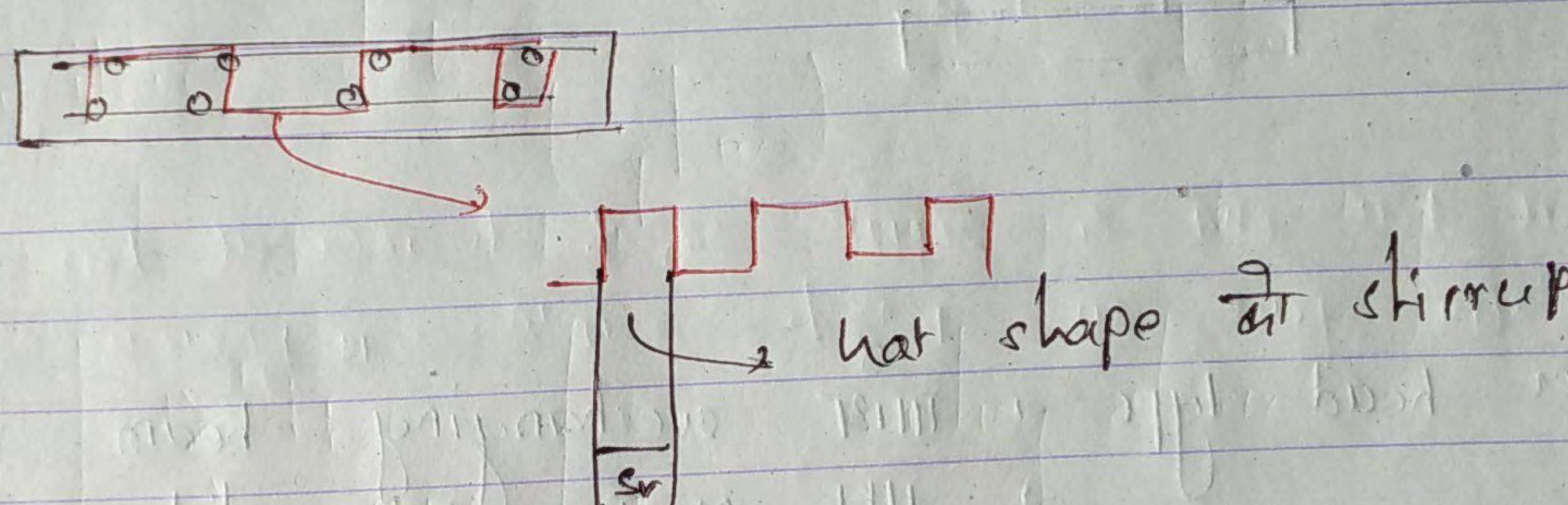


to prevent bursting in tension because cube fails in tension

20 mm मुनि एउटा जाली 100 mm मुनि अर्को जाली

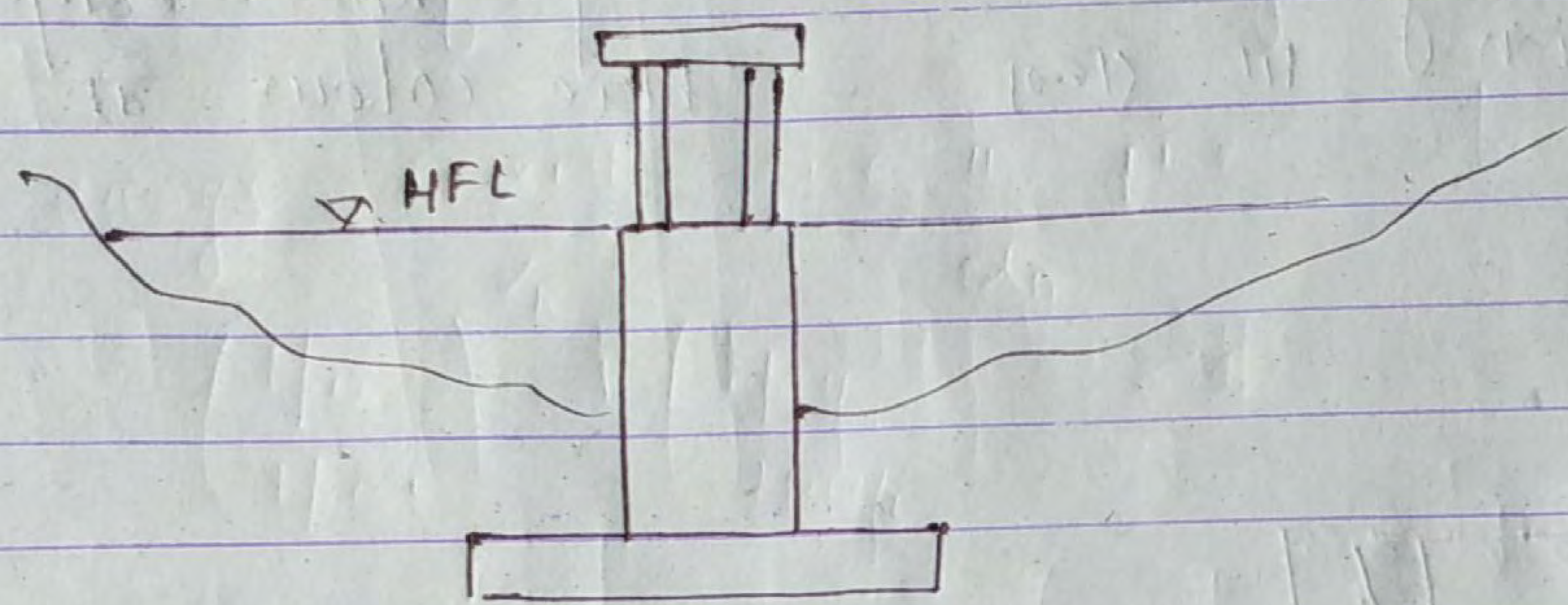
cap मा use हुने reinforcement to prevent bursting action so use acc. to detailing rule → Bending moment आउँदैन.

cross tie → detailing bar → connecting गर्दै design bar कोर्ति position मा राख्न → blue colour को



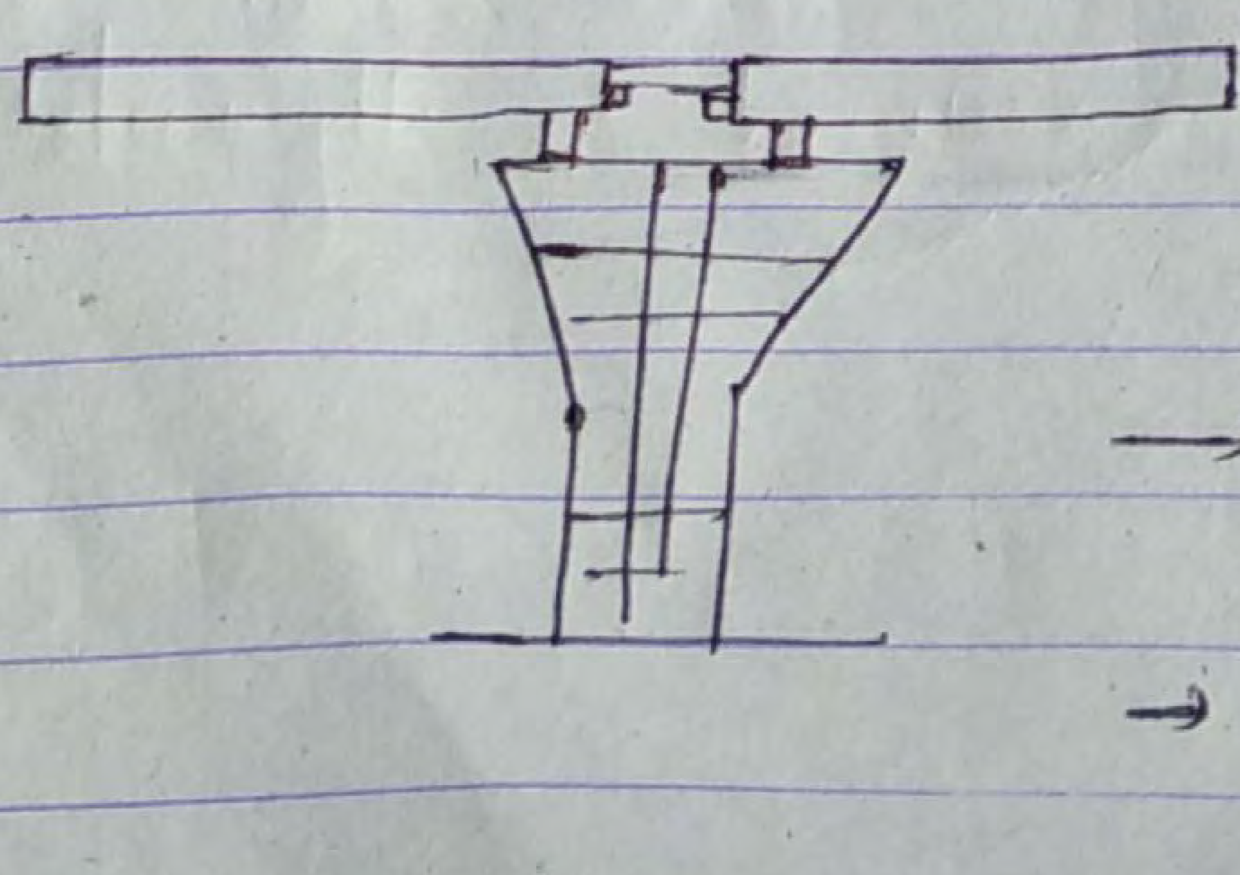
- pier -

Trestle type → column को साथै beam - beam & column are rigidly connected.



Hammer head type → साथै overhanging beam
→ HFL भन्दा तल solid wall as in trestle type

cellular type → hollow wh [illegible]

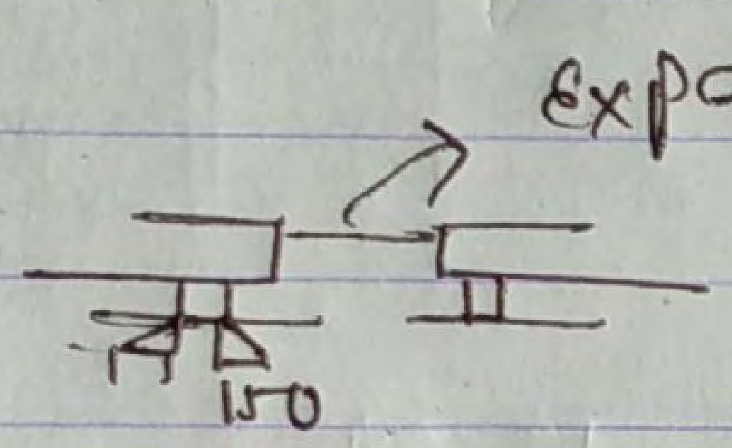


→ longitudinal dir^n of bridge

→ not widely used because width of pier higher so obstruct the flow

→ but यदि span छोटै सानो छैन पर्‍यो भने use गर्नै

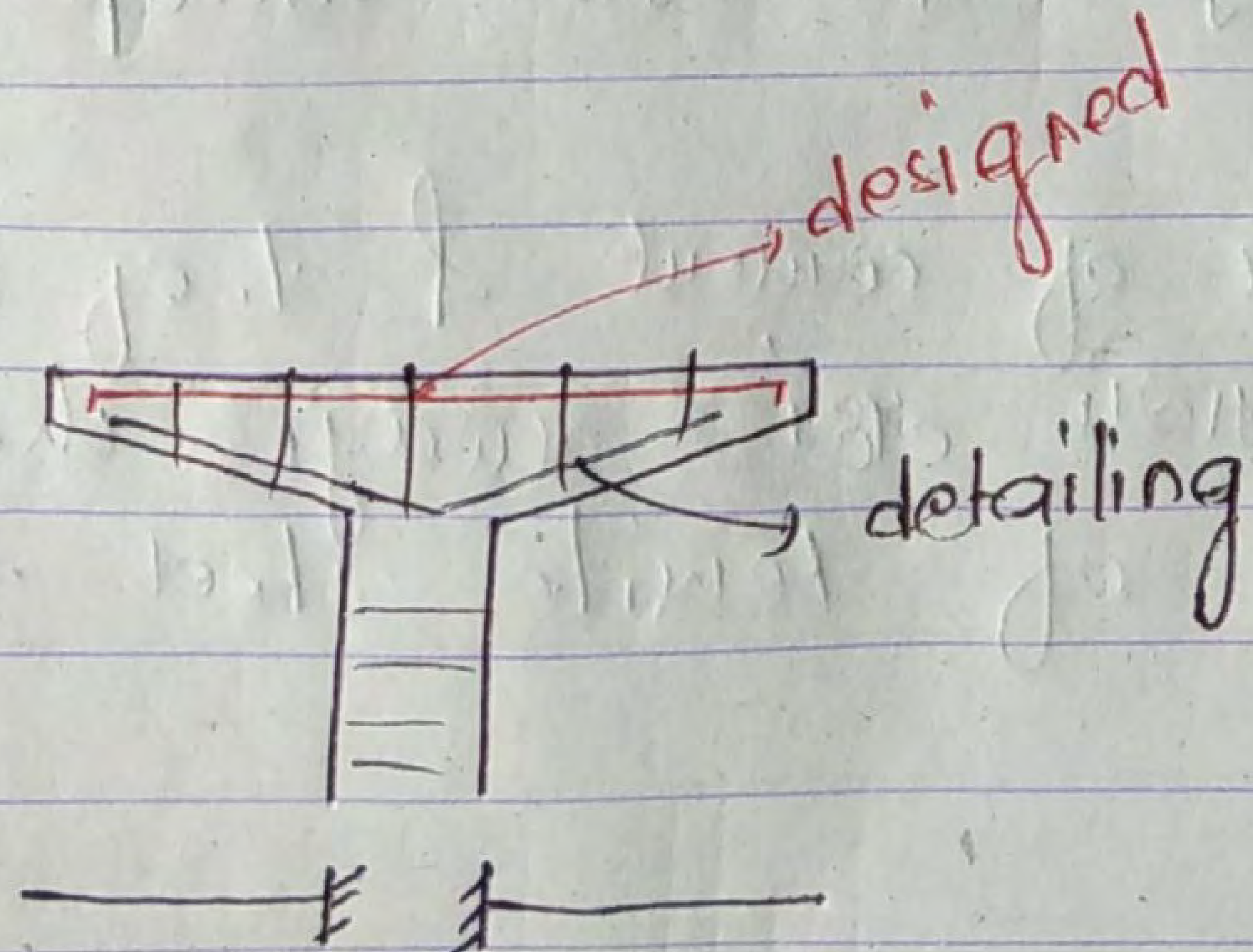
1 to 1.5 m from HFL upto bridge sitting

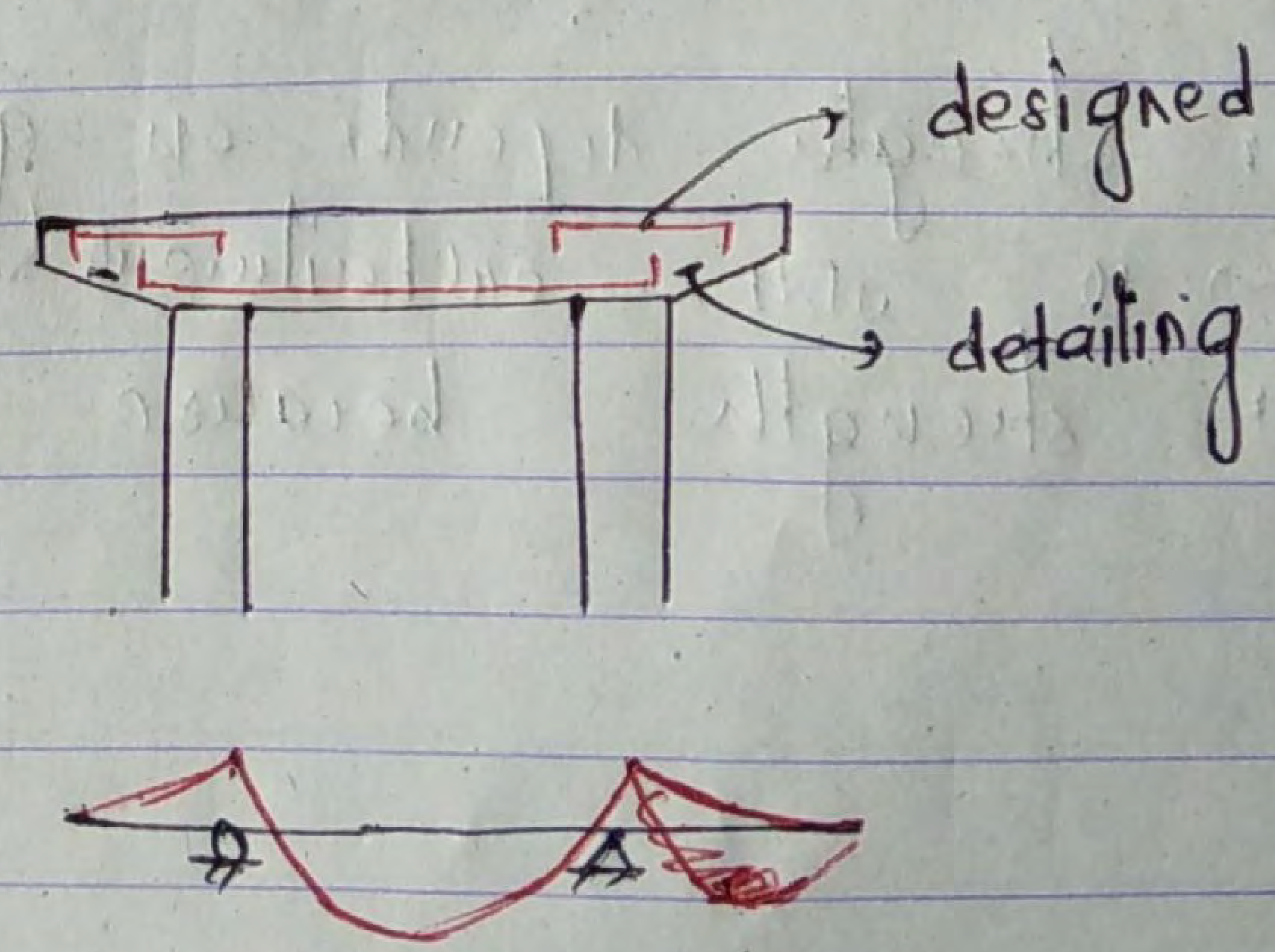


Surcharge & EP ⇒ Abutment
buoyancy & hydrodynamic pressure ⇒ pier

Design of pier cap & Main stem

cap is beam in case of trestle type of pier





In case of abatment

$P_u \leq 0.1 f_{ck} A$ ⇒ so designed as cantilever slab

↳ axial load

In case of pier

$P_u > 0.1 f_{ck} A$ ⇒ so designed as column

always Biaxial case in pier when designed as column

$$\left(\frac{M_{ux}}{M_{ux1}}\right)^{\alpha_n} + \left(\frac{M_{uy}}{M_{uy1}}\right)^{\alpha_n} \leq 1$$

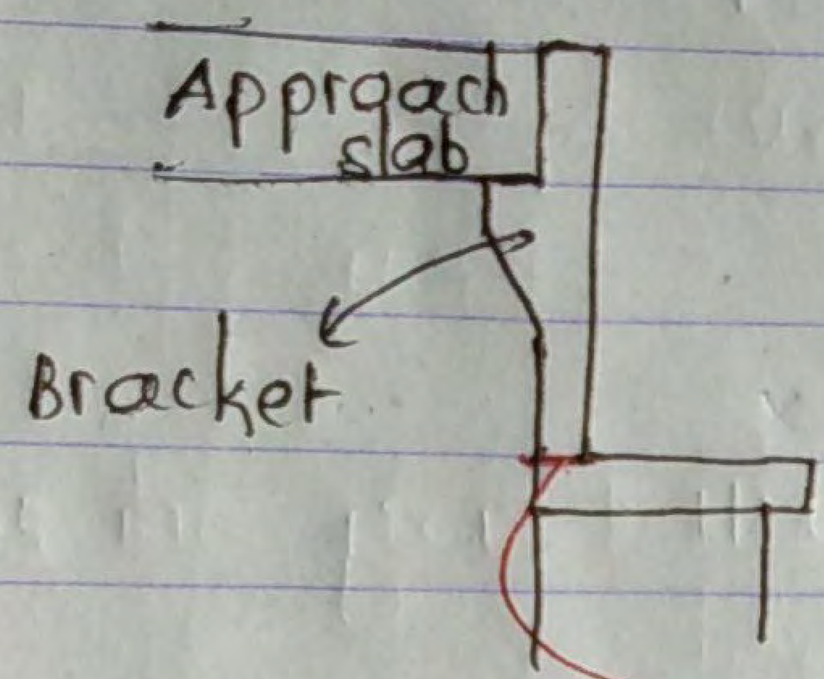
vertical bar नि & उसको 25 % horizontal bar } while design of stirrup acc. to design rule
दुवै पटि face मा 1.2 % min^m reinforcement

→ slab को case मा

column को case मा आफै design गर्ने → shear stirrup

shear strength depends on grade of cement & % of tensile steel → so जता curtailment गर्यौ त्यहाँ always check shear strength because % of tensile steel decrease.

Design of RC Abutment with spread footing



→ यो ठाउँमा $\tau_{uv} \le k_s \tau_{uc}$

$\frac{span}{depth} = 7 \Rightarrow$ deflection control criteria in cantilever slab

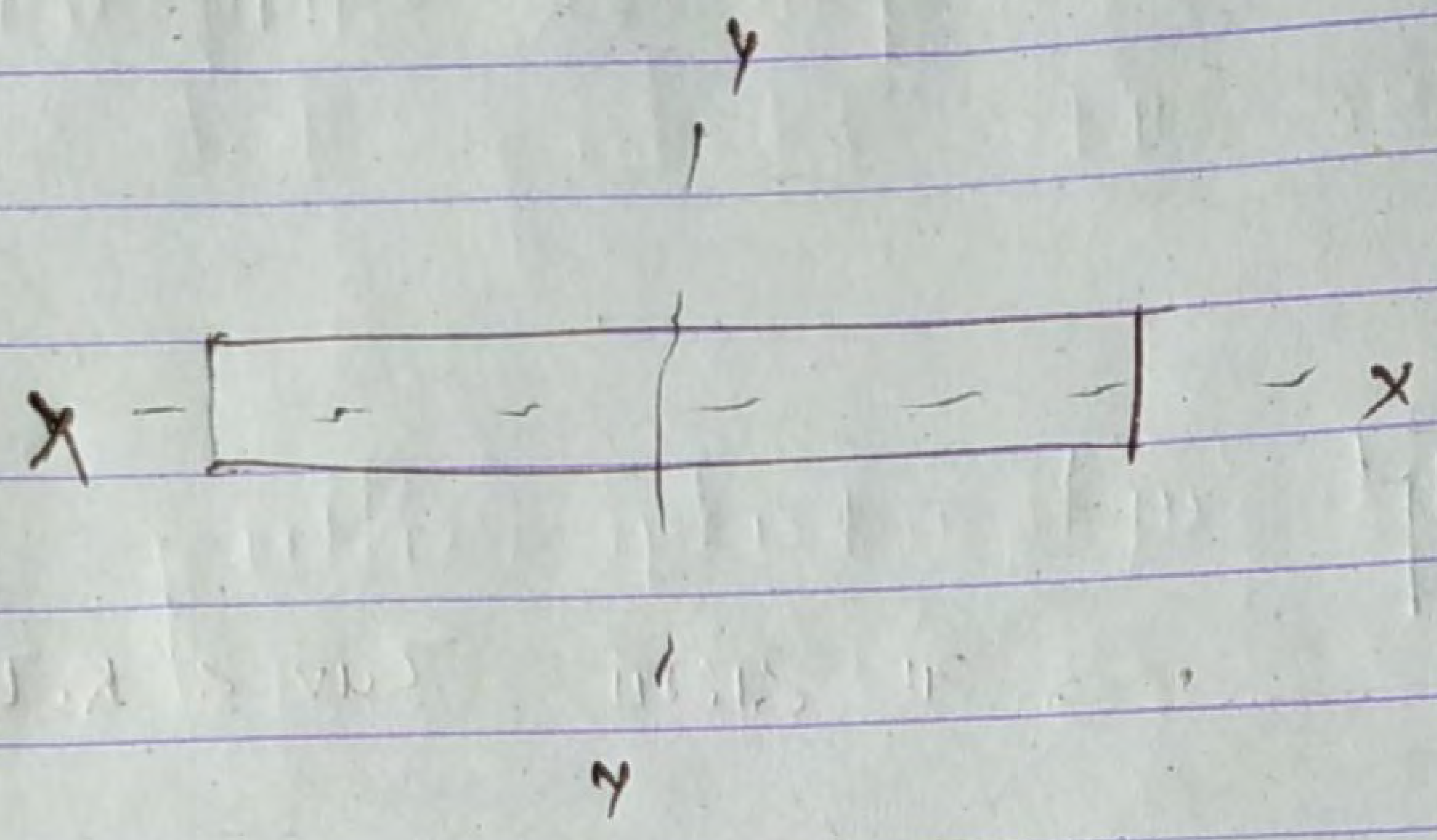
$\frac{span}{depth} = 20 \Rightarrow$ " " " " normal slab

d निकाल्न

normally cap को thickness 300 – 600 mm राख्ने
but min^m is 200 mm

wind load को ~~vertical~~ ~~...~~ combination मा अरु load हुन्छ so यो consider गर्नौं but vertical component consider गर्ने

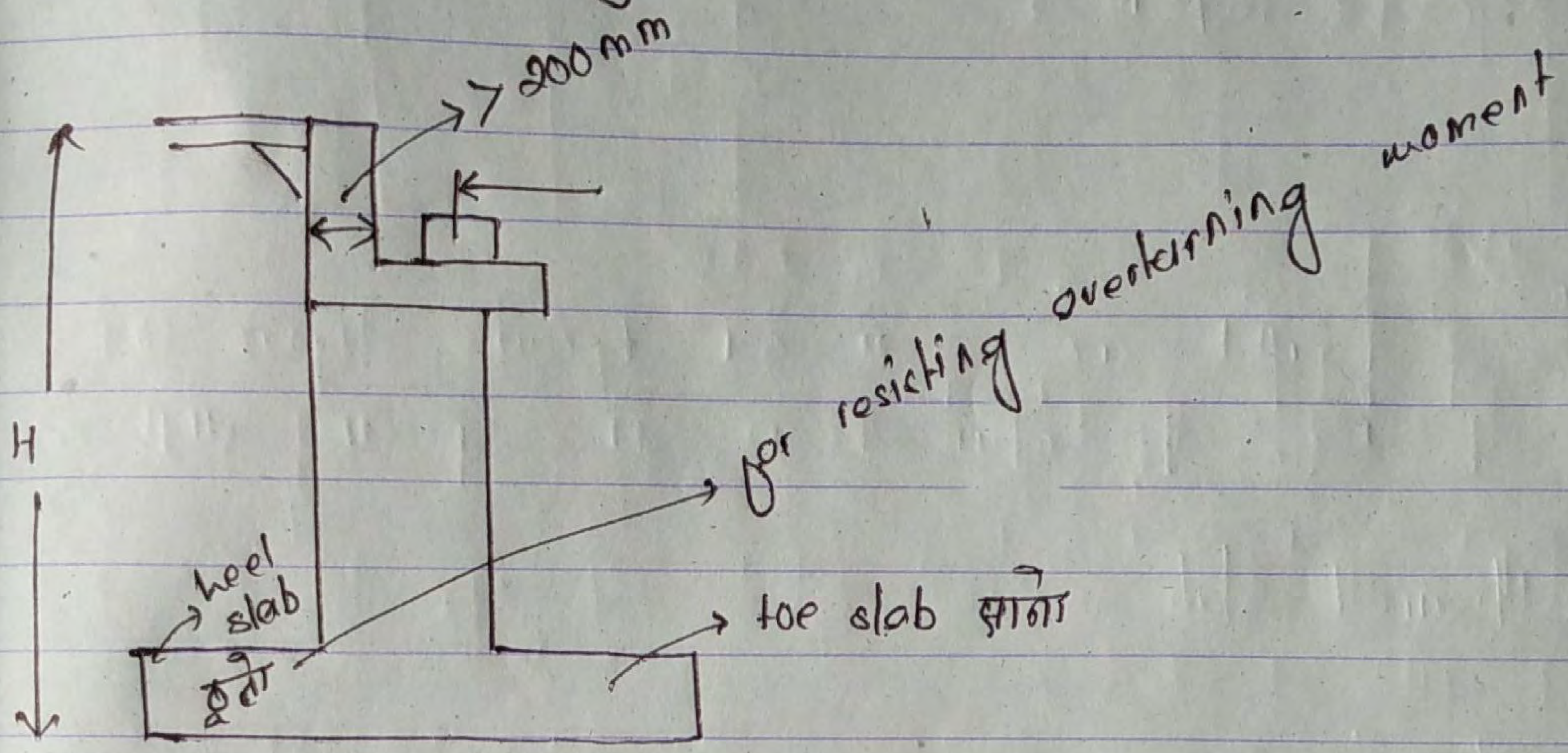
wind load को लागि dry case र wet case consider गर्नुपर्छ



P, Mx, My, Vx, Vy

Abutment design

Types - masonry

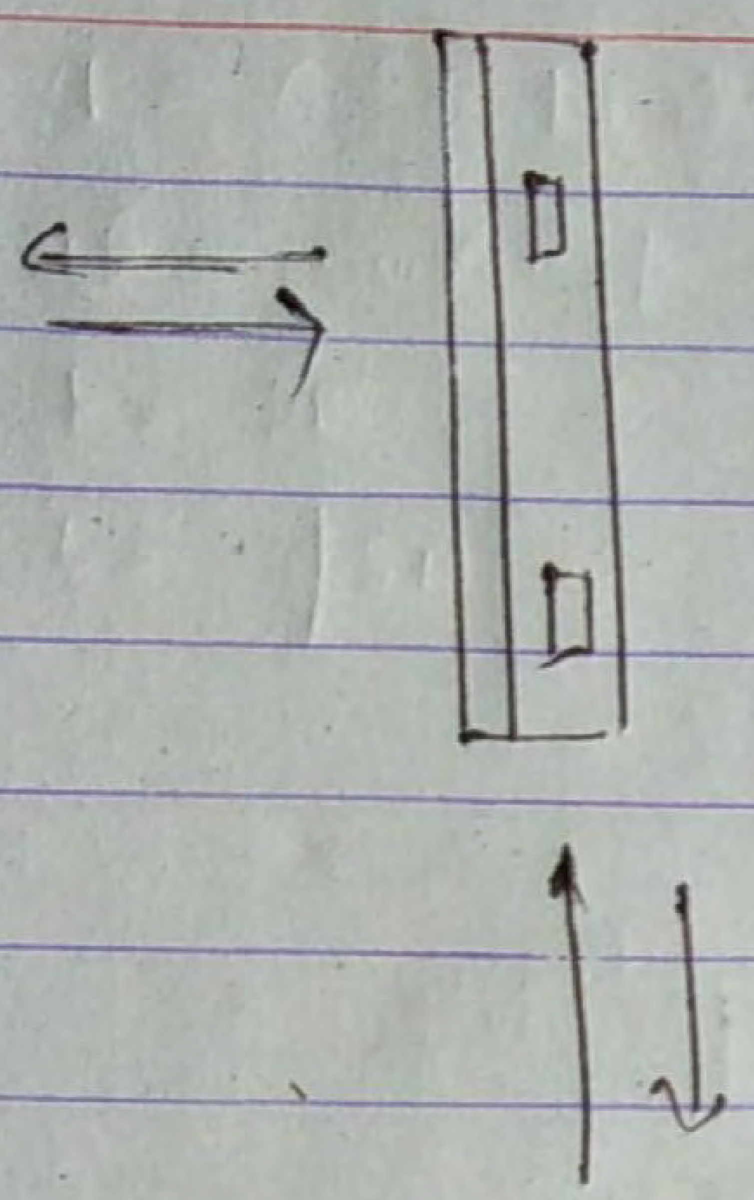


standard penetration test > 30 ⇒ hard soil ⇒ shallow foundation
↳ main above charc range
below charap range → soft soil → so we deep foundation i.e. well foun.

IRC 78
Modified columb's theory → Book of Swami saran
↓
Manonobay Okabey theory

no force due to water current, bayancy, hydrodynamic pressure

combination
basic ✓
accidental × not use for local Road Bridge
seismic ✓



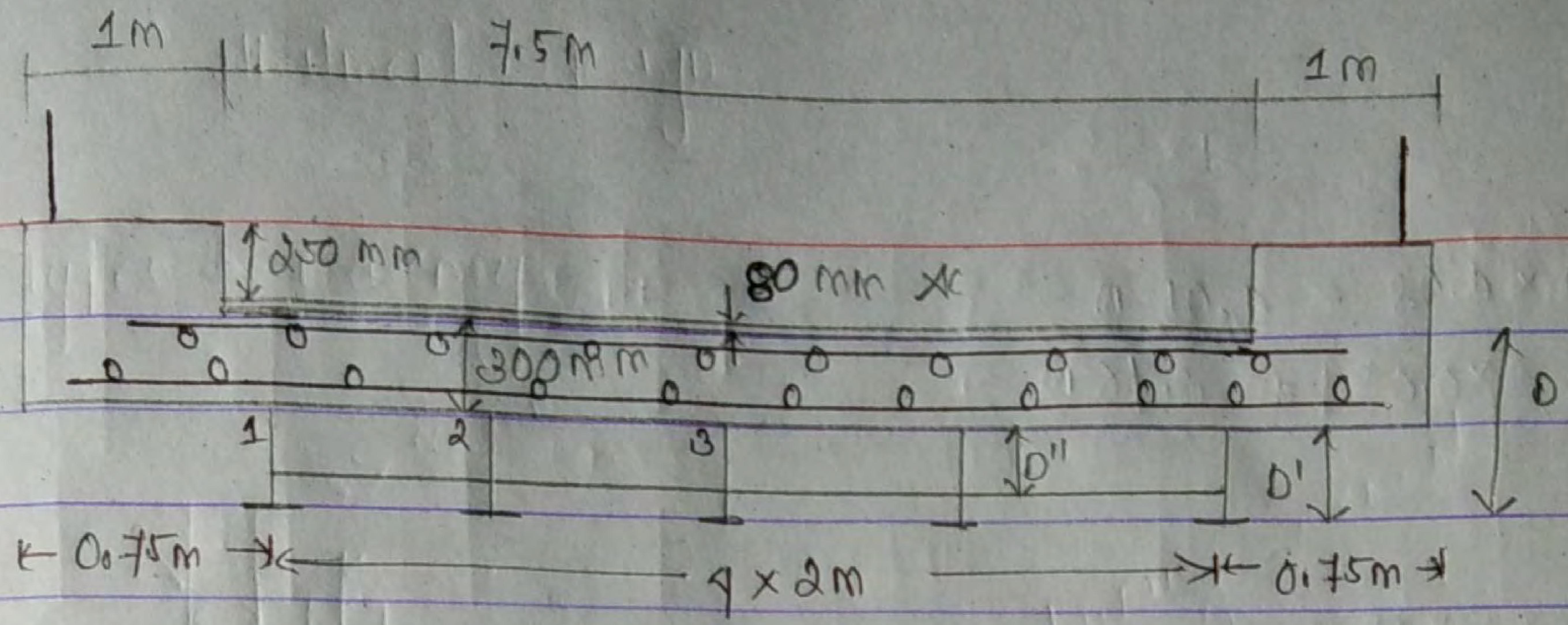
$\frac{M_{Res}}{M_{OT}} \geq 2$

≥ 1.5

Design Example
(On design of composite bridge)

Design a simple composite bridge for the following data.
Span = 18 m
Lane = two
foot path on either side of bridge
live load (class AA tracked)

I. Planning / preliminary Design
Take
M20
Fe 415
E250 C



$D = 1360$ mm

$D' = 1060$ mm

$D'' = 720$ mm

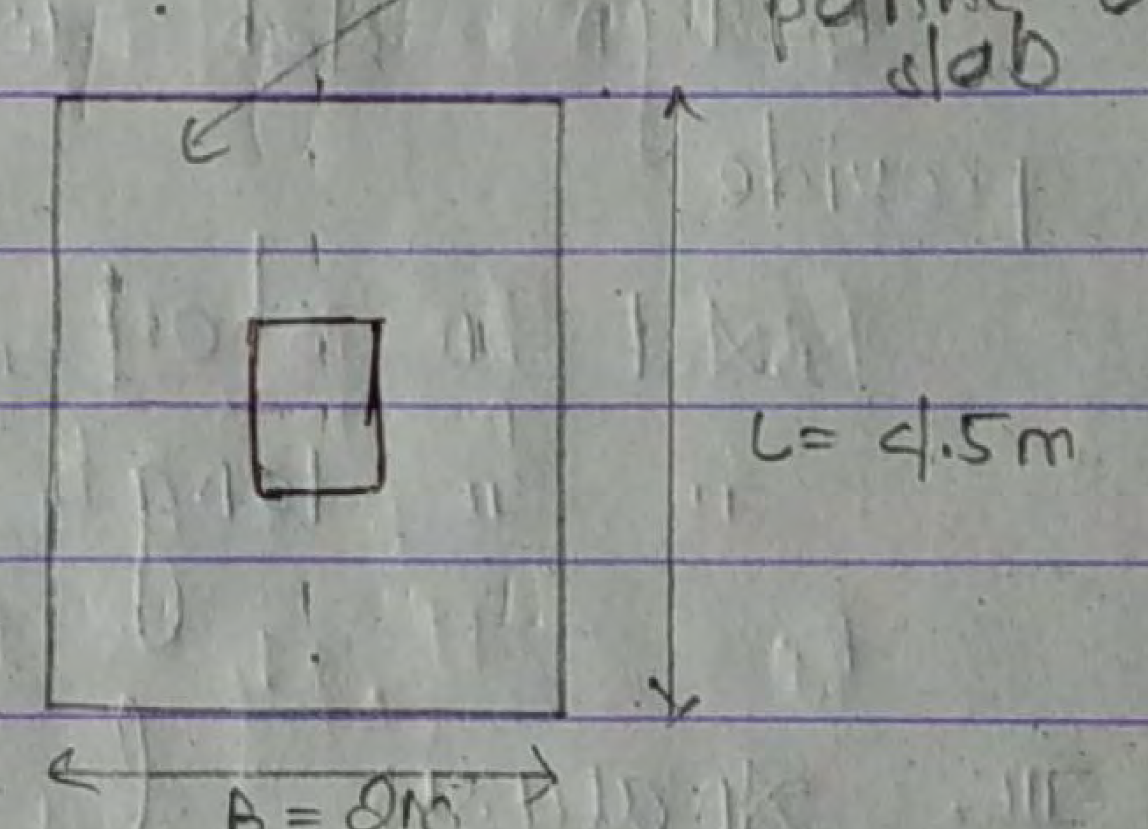
No. of cr. beam = 5

c/c distance between cr. beam = 4.5 m = 18/(5-1)

Note: span / eff. depth = 13 लेखा है i.e. conservative - generally 15 - 20 लिया

II. Analysis & design of slab

(i) Restrained slab



* DL BM

$M_1 = (m_1 + m_2 \mu) W \times 0.8$

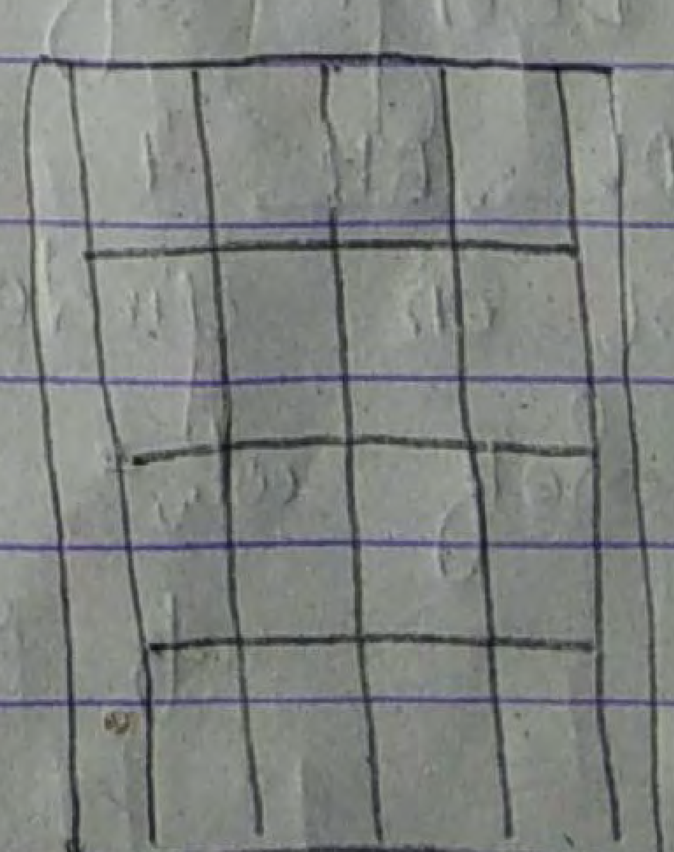
$= 3.15$ kNm

$M_2 = (m_2 + \mu m_1) W \times 0.8$

$= 1.05$ kNm

$W = 2 \times 4.5 \times (0.3 \times 25 + 0.08 \times 22)$

$m_1, m_2 = f\left(\frac{B}{L}, \frac{L}{B}\right)$ Ref P. curve



* $M_1 = (m_1 + \mu m_2) P \times IF \times 0.8 = 31$ kN-m

$M_2 = (m_2 + \mu m_1) P \times IF \times 0.8 = 10.5$ kNm

$P = 3.50$ kN

$\mu = 0.15$

$m_1, m_2 = f\left(\frac{u}{B}, \frac{v}{L}, \frac{B}{L}\right)$ (Ref. P curve)

$u = 0.85 + 2 \times 0.08 = 1.01\ m$

$v = 3.6 + 2 \times 0.08 = 3.76\ m$

$B = 2m$

$L = 4.5m$

Note:-

fillet use કરવો નથી because span નાનો છે & main beam નો spacing નાનો છે

Design of Restrained slab

check

$d \geq d_{bal} = \sqrt{\frac{M}{Qb}} = 149.69\ mm$

$d = 300 - 20 - 12/2 = 274\ mm$

Design slab as SR URS

provide

A_{st} in short dir. 12 mm ϕ @ 140 mm c/c

" " long " 10 mm ϕ @ 150 mm c/c

III. Analysis & design of main beam

Take

propped Method of construction

Design main beam for

(i) DL + SIDL

(ii) DL + SIDL + LL

Design of exterior girder

DL BM + DL SF

DL on girder (a)

Self wt. of slab = $(0.3 \times 25 + 0.08 \times 22) \times 2$

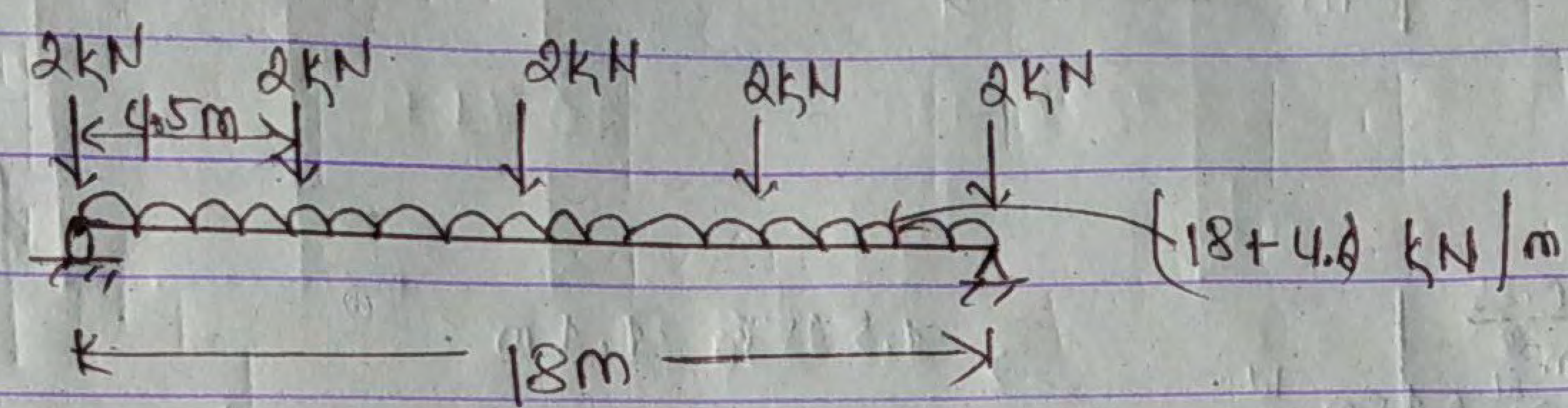
= 18 KN/m

self wt. of main beam = $0.2L + 1$

= 4.6 KN/m

Note :- for main structural member min.^{m} clear cover = 40 mm
& for sub " " " " " = 20 mm

self wt. of cr. beam = 1×2 = 2 kN



support condition
span
loading

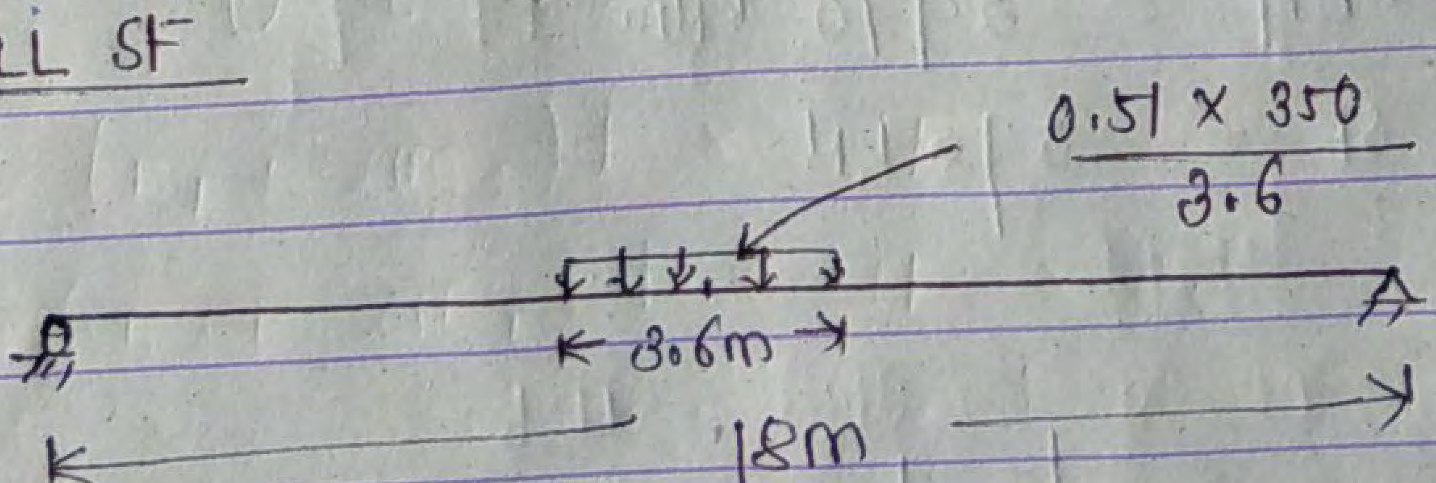
} type of girder के के मा depend गर्छ

cr. beam को case मा 1 kN/m self wt. लिने → for preliminary design

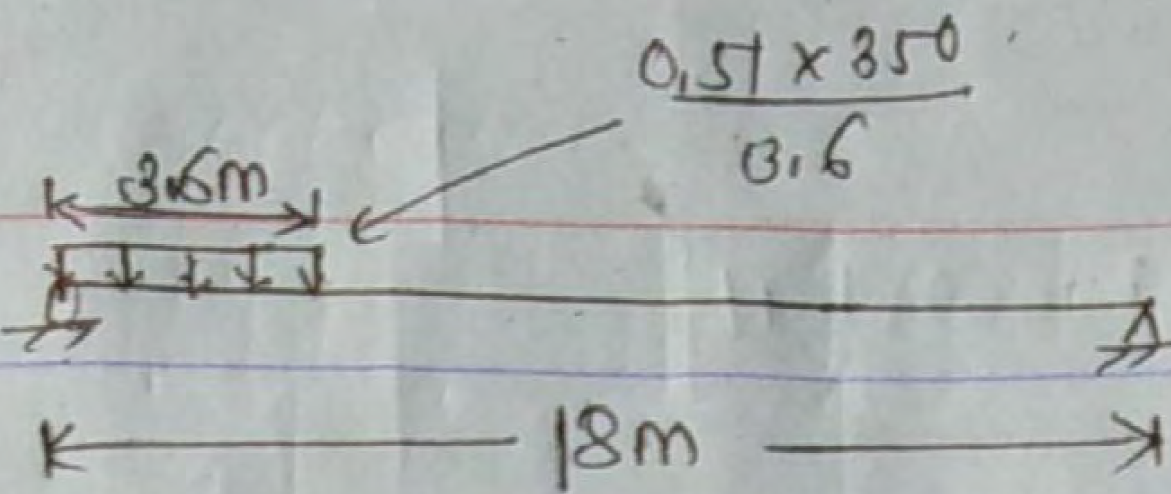
Max^m BM at mid =
Max^m SF at support =

Take M max due to DL = 909 kNm
V max due to DL = 201 kNm

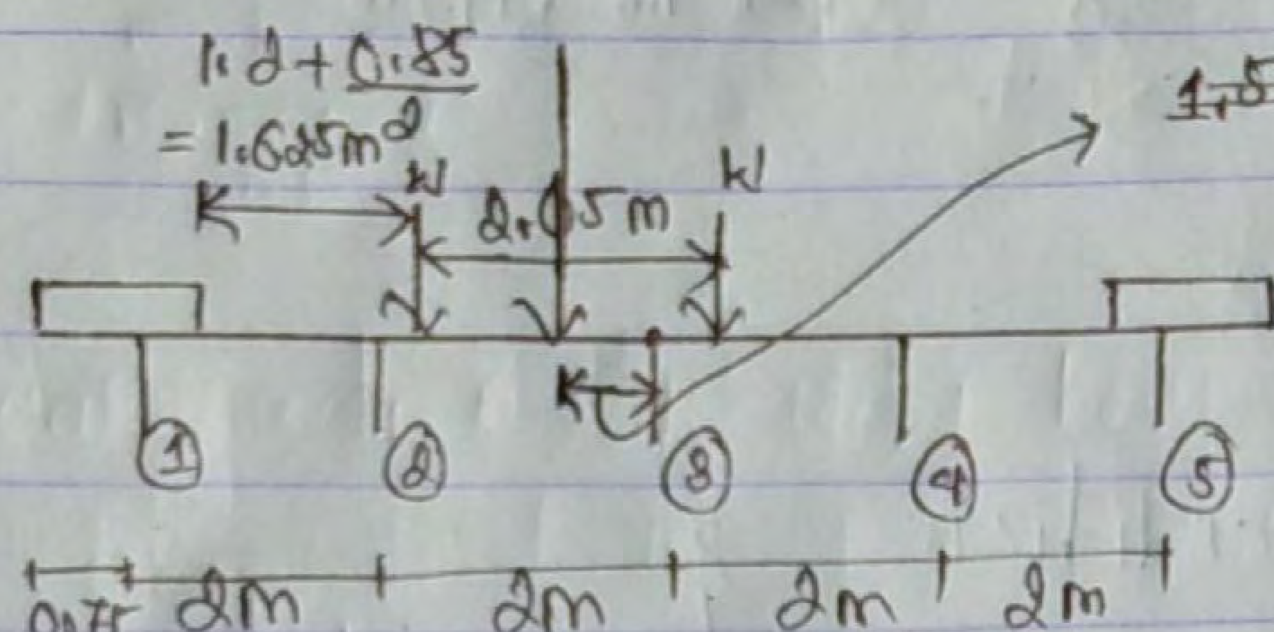
<u>LL BM + LL SF</u>

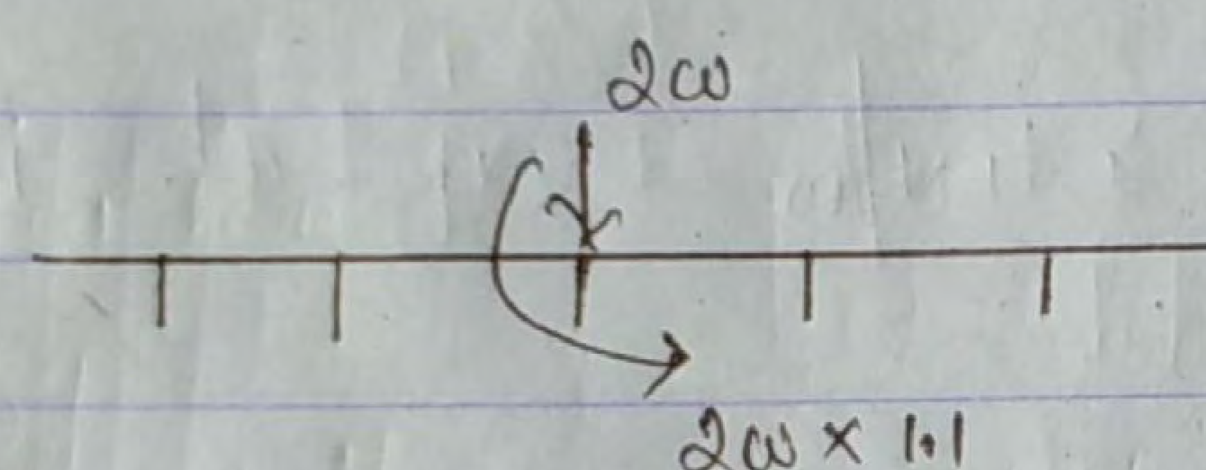


position for max^m BM



position for max^m SF





$$R_n = \frac{P}{n} \pm \frac{M h_i}{\Sigma h_i^2}$$

$$R_2 = \frac{2W}{5} + \frac{2W \times 1.1 \times 2}{4^2 + 2^2 + 0^2 + 2^2 + 4^2}$$

$$= 0.51 \, W$$

Take tot. Design max. BM = 2470 kNm

" " " SF = 548 kN

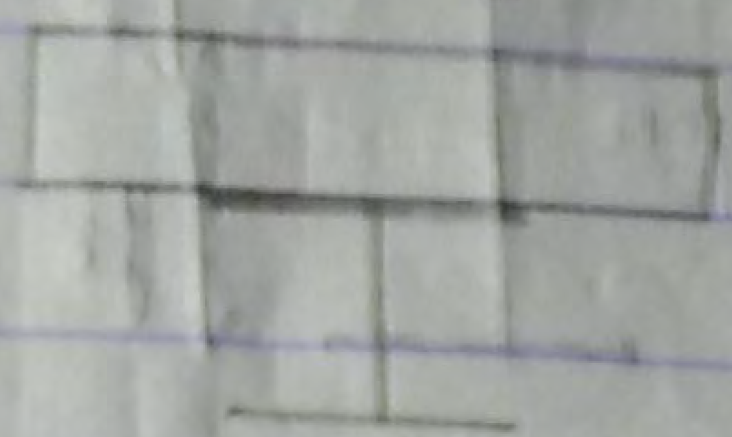
Take propped method of construction

In this method, beam is designed as composite beam for DL + SIDL , DL + SIDL + LL

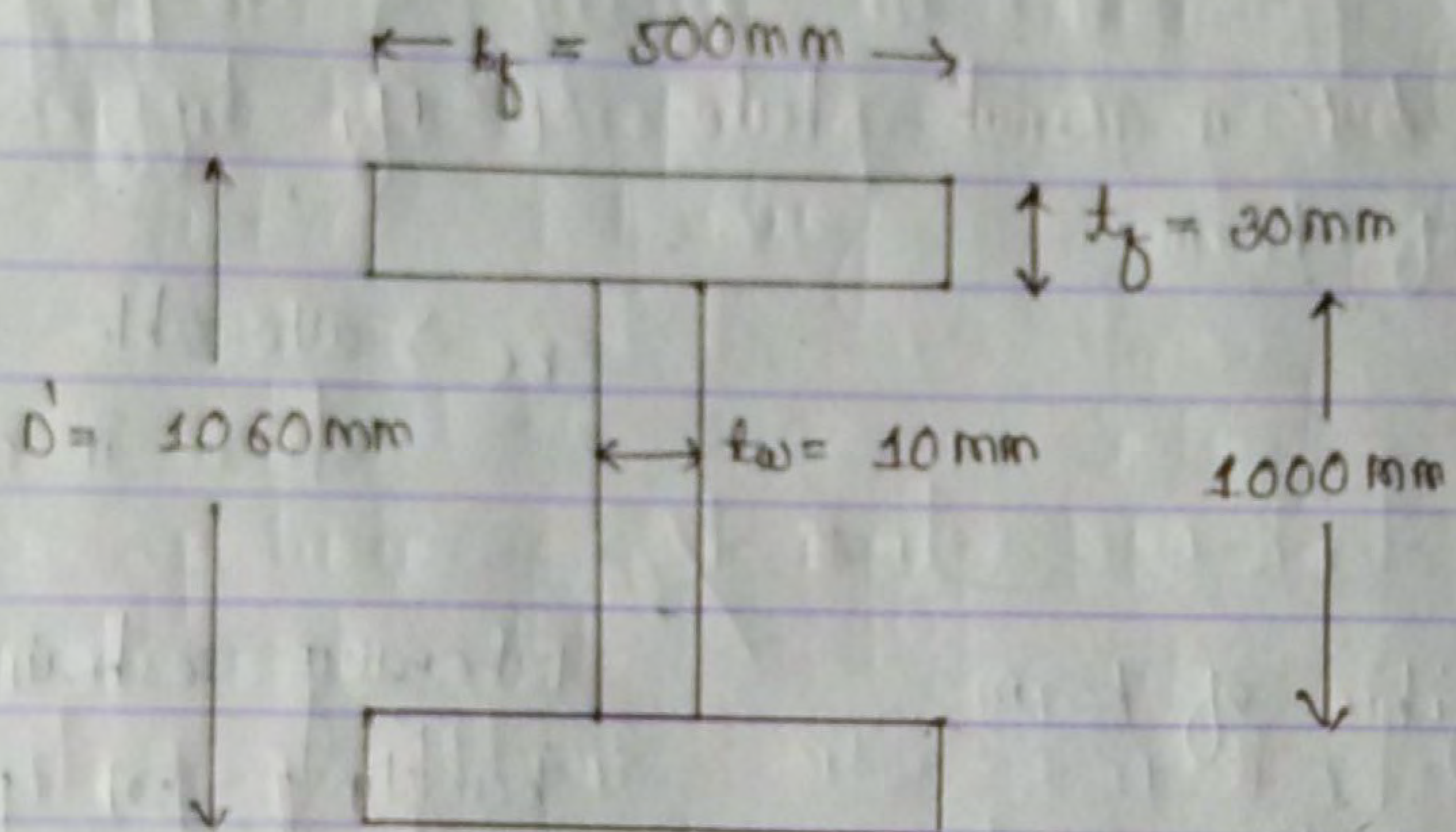
Design for bending

take BM only due to DL + SIDL

- check bending stresses in beam for DL + SIDL



Approximate size of steel beam (plate girder)



$D' = D - 300 = 1060$ mm

$D' = 5\sqrt[3]{\frac{M}{\sigma_{bt}}} = 1272.05$ mm

Adopt D' = 1060 mm

t_w = 10 mm

$b_f = \frac{L}{45}$ to $\frac{L}{40}$

= 500 mm

$A_f = \frac{M}{\sigma_{bt} D} - \frac{A_w}{6}$

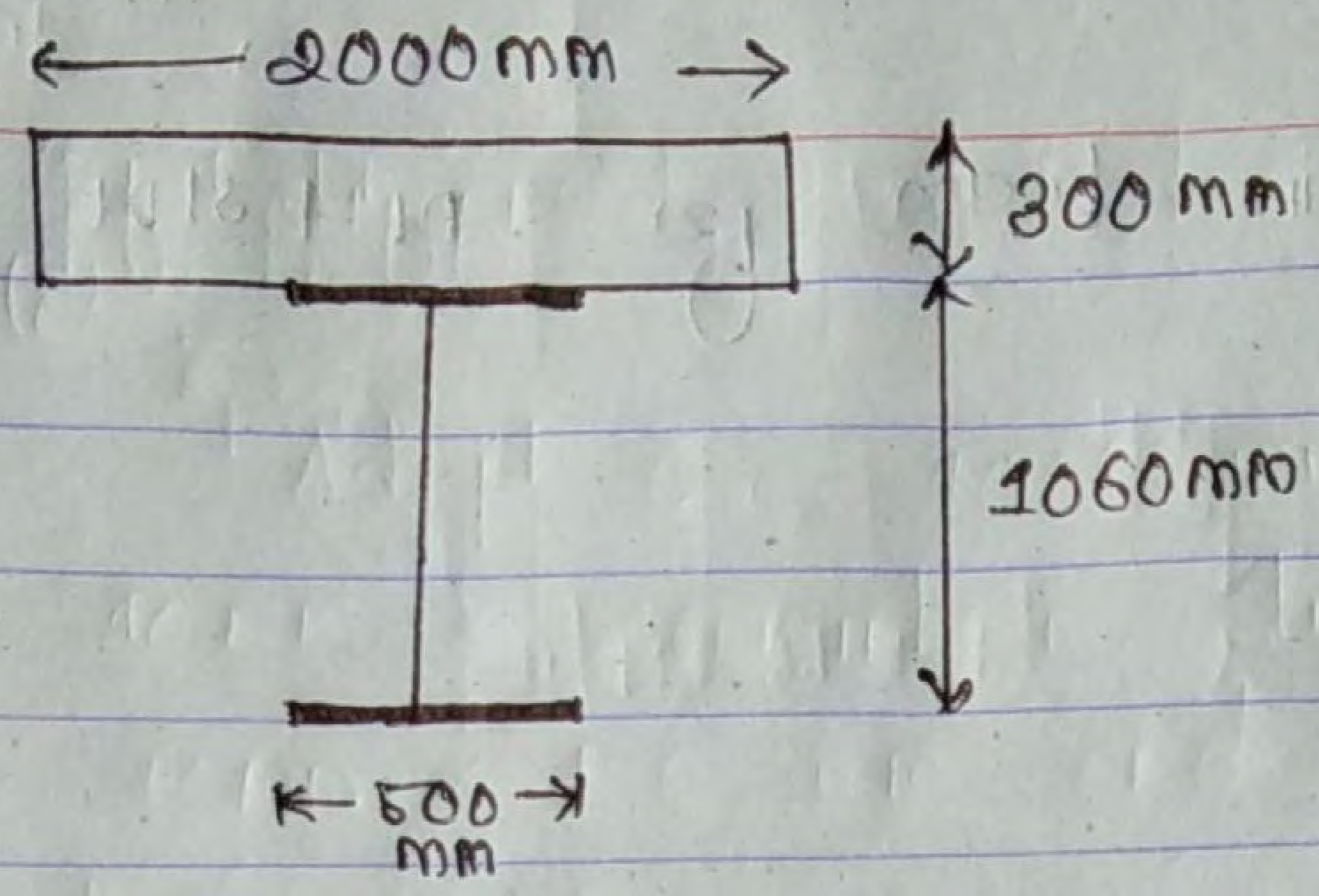
= 18767 mm²

$t_f = \frac{A_f}{b_f}$ = 27.53 mm

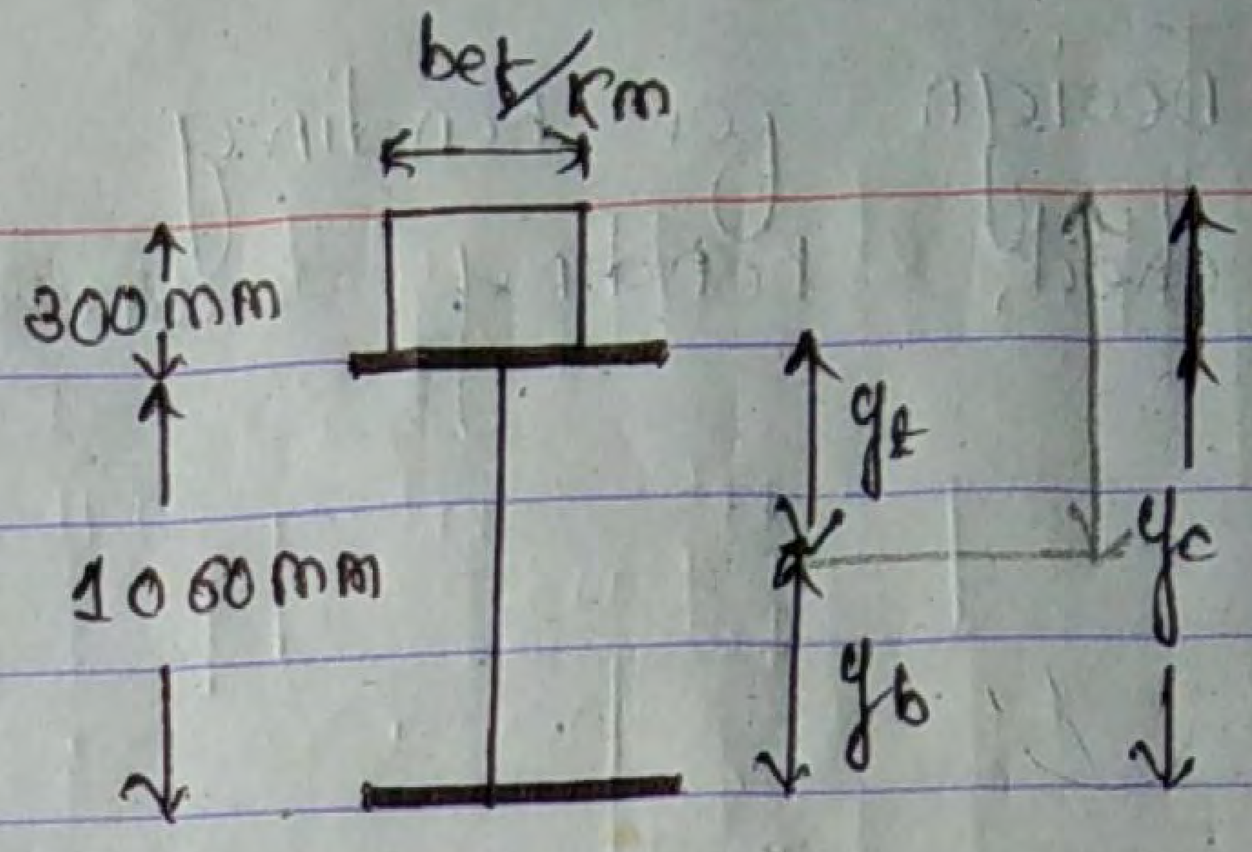
Adopt t_f = 30 mm

σ_{bt} = allowable value of bending stress in tension

$t_w \nless$ 8mm in bridge but 6mm in normal case



Actual section of comp. beam



Eq. st. section

creep factor
K = 2
$m = \frac{E_s}{E_c}$
= 13

→ working state मा but in limit state $M \le M_d$

$\sigma_b \le \sigma_{bc}$ in top fibre of beam

$\sigma_b = \frac{M \times y_t}{I_{eq.\ steel\ beam}}$

σ_{bc} ⇒ allowable bending stress in compression

$\sigma_{bc} = 0.66 f_y$

$\sigma_b \le \sigma_{bt}$ in bottom fibre of beam

laterally restrained - buckling हुन prevent गर्दैको because of slab which is rigidly connected by shear connector

$\sigma_b = \frac{M \times y_b}{I_{eq.\ st.\ beam}}$

$\sigma_{bt} = 0.66 f_y$

equivalent section मा काम गर्दैछौं

$\sigma_b \le m\ \sigma_{cbc}$

$\sigma_b = \frac{M \times y_c}{I_{eq.\ st.\ beam}}$

Note :- creep effect दिने DL is called SIDL

DL + SIDL मा creep effect consider गर्ने

DL + SIDL + LL " " " " नगर्ने

K = 2 in IRC 22

steel मा creep आउँदैन only in concrete मा आउँछ

- check bending stress in

creep factor
K = 2
$m = \frac{E_s}{E_c}$
= 13

ding
pression

d -
event
of slab
dig
shear

Design for shear

$\tau_v \leq \tau_{va}$

$\tau_v = \frac{V_{DL} + SIDL + LL}{D \times t_w}$ → because creep ले depth लाई affect गर्दैन

$\tau_{va} \leq 0.4 f_y$ → for unstiffened beam = 0.4 fy
for stiffened beam < 0.4 fy

unstiffened beam } acc. to lateral support
stiffened beam }
→ plate girder

यदि shear मा safe छैन भने t_w बढाउने - depth normally नचलाउने

Design for lateral stability

$\frac{d}{t_w} = \frac{1000}{10} = 100 > 85$ ⇒ provide vertical stiffener
< 200

Spacing of stiffner (c) = 0.33d to 1.5d

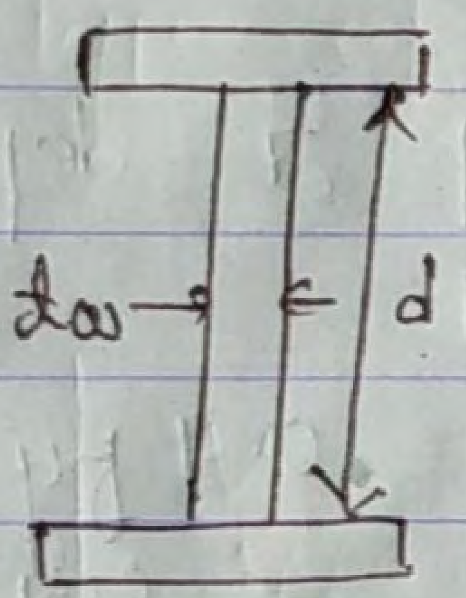
Adopt c = 1000 mm

provide 10 mm × 80mm interm. stiff.

10mm × 180 mm end stiffner

Note

Design for lateral stability मा → simple र built up section मा buckling & creeping हुँदैन तर plate girder मा requirement of stiffner पनि check गर्ने



slenderness ratio = d/t_w

slenderness ratio directly proportional with buckling

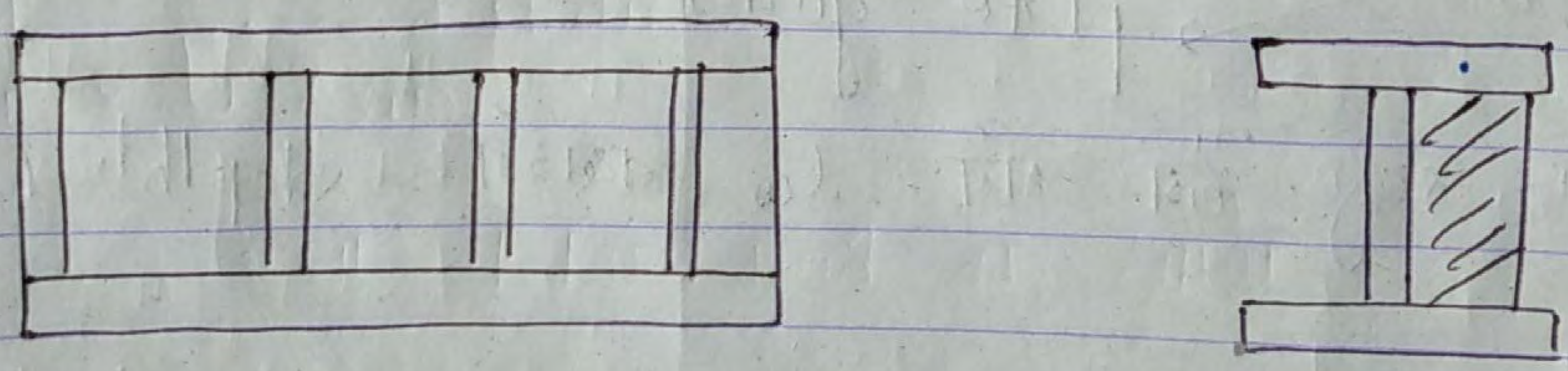
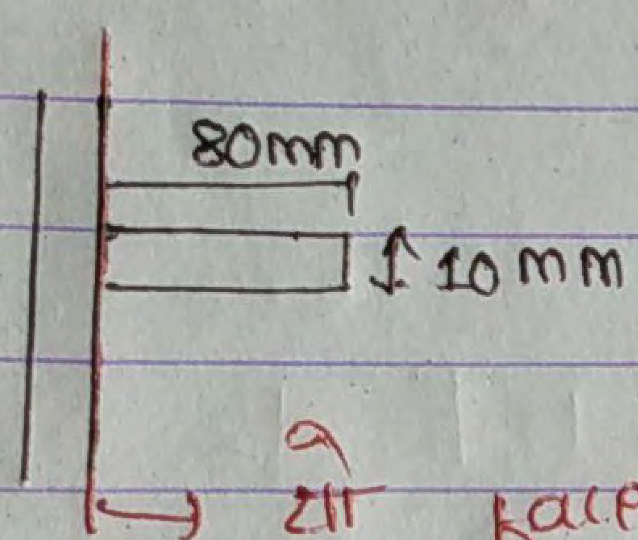


fig:- stiffner

Now, from table c र D use गरेर τ_{va} find out गर

check : $I_{prov.}$ of stiffner $\geq$ $I_{req.}$ of stiffner
↳ code માં છે



↳ ચે face મા MOI નિકાળવે which is $I_{prov.}$

fig. sectional plan of stiffner

યદિ $I_{prov.} >> I_{req.}$ then 80 mm ઘટાડવે

યદિ 245 mm કરતા વધે આવે તો two side મા provide ગણે
mostly used - thickness પણ ઘટાડવ સકિએ।

→ Design of shear connector

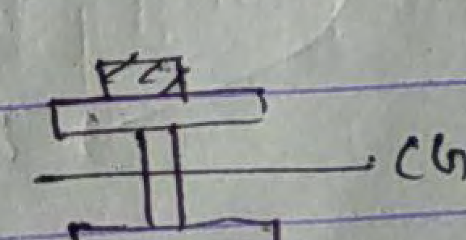
Take, stud for shear connector.

SF per unit length at interface of beam & slab

$= \tau_v \times b \times 1$

$= \frac{VS}{I}$ — S = static moment of area

I eq. st. section for DL + SIDL + LL

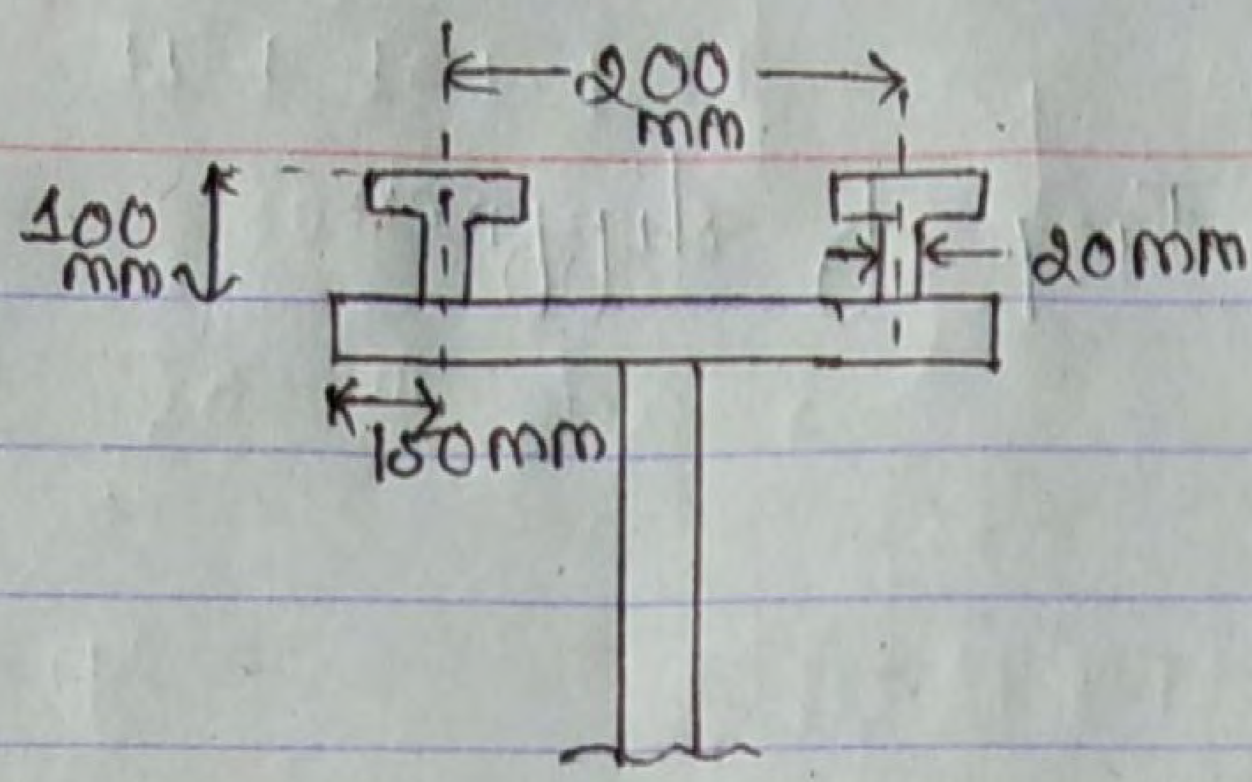


Shear capacity of a stud

$Q = 196\, d^2 \sqrt{f_{ck}}$ (from IRC 22)

$p = \frac{2Q}{V_L}$

d = 20, 22, 24 mm normally use થતા diameter of stud



Ref : Detailing rules of shear connector IRC 22

$P \leq 600$ mm

$\leq 4 \times$ ht. of stud

$\leq 3 \times$ thickness of slab

⇒ Mostly flexible shear connector use गर्छ

⇒ Bolt type of shear connector i.e. stud

$$\frac{V_L}{2Q} = n$$

$$\frac{1}{n} = P$$

consult

⇒ check for deflection

$\Delta max \leq \Delta_{lim}$

→ यो total load को लागि हुन्छ