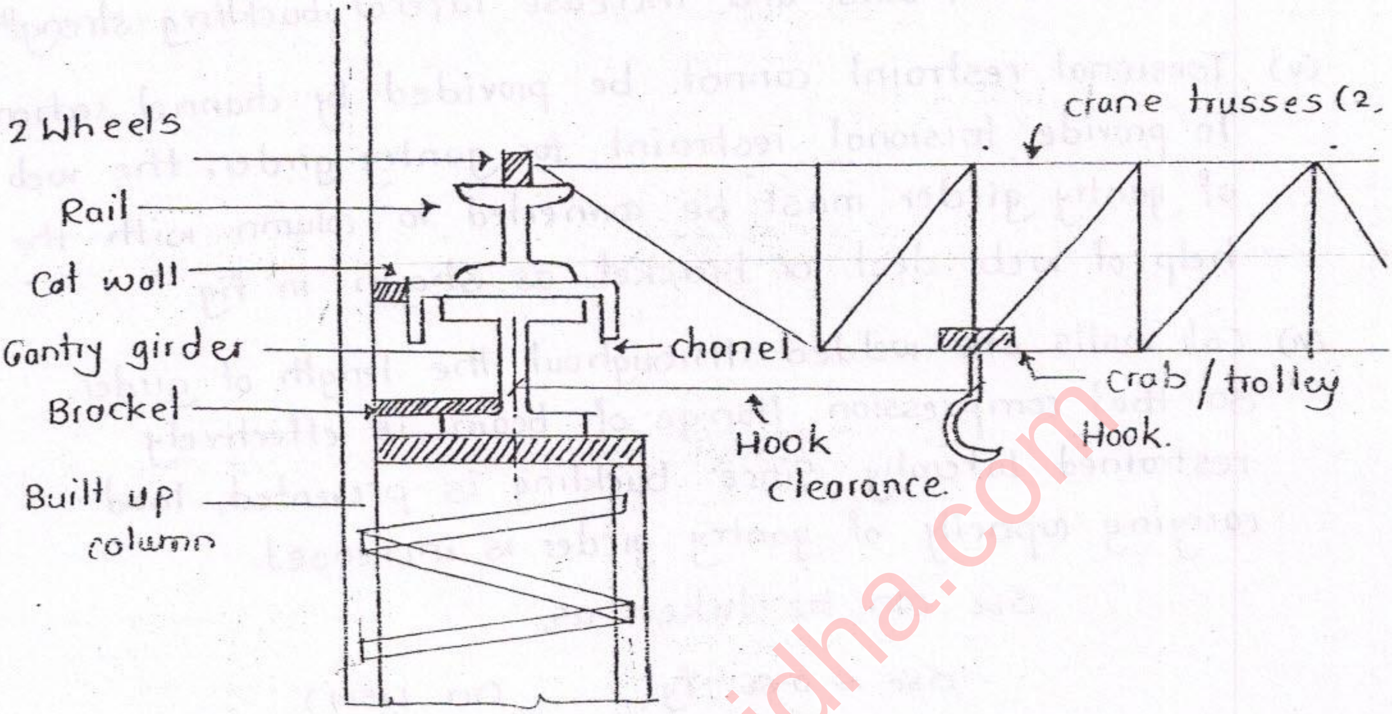
Design of gantry girder
(beam supporting crane loads)



(i) Gantry girders are subjected to gravity loads (i.e. D.L + L.L. + wt. of crane truss + wt. of trolley etc.), laterals loads and longitudinal loads.

(These three loads are mutually perpendicular to each other)

(ii) Lateral loads are due to moving and stopping of crab and longitudinal loads are due to movement of the truss on rail.

(iii) Impact:

The dynamic action of a moving load is called as impact. Since truss and trolley move on gantry girder, impact loads are developed on the beam. To get the effect of impact load, loads are multiplied with impact factor. (Impact factor converts dynamic load into an equivalent static load)

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(iv) Channel section is provided to increase the lateral stability of the gantry girder when subjected to lateral loads. The function of this top channel is to increase M.I. about Y-axis and increase lateral buckling strength.

(v) Torsional restraint cannot be provided by channel section. To provide torsional restraint for gantry girder, the web of gantry girder must be connected to column with the help of web cleat or bracket as shown in fig.

(vi) Cat walls are welded throughout the length of girder. So that compression flange of beam is effectively restrained laterally. Since buckling is prevented, load carrying capacity of gantry girder is increased.

σ_{bc} can be taken as,

$$\sigma_{bc} = 0.66\ f_y \quad \text{(in WSM)}$$

$$= \frac{f_y}{1.1} \quad \text{(in LSM)}$$

(vii) Since crane movement and crab movement are not permitted simultaneously, it is assumed that lateral loads and longitudinal load will not act simultaneously on the beam.

(viii) Since vertical and horizontal loads are applied, simultaneously, allowable stresses in gantry girders are increased by 10 %.

(ix) Additional loads due to impact :

(a) For manually operated cranes, 10 % of static wheel load is taken as impact load.

(b) For electrically operated cranes, 25 % of static wheel load is taken as impact load.

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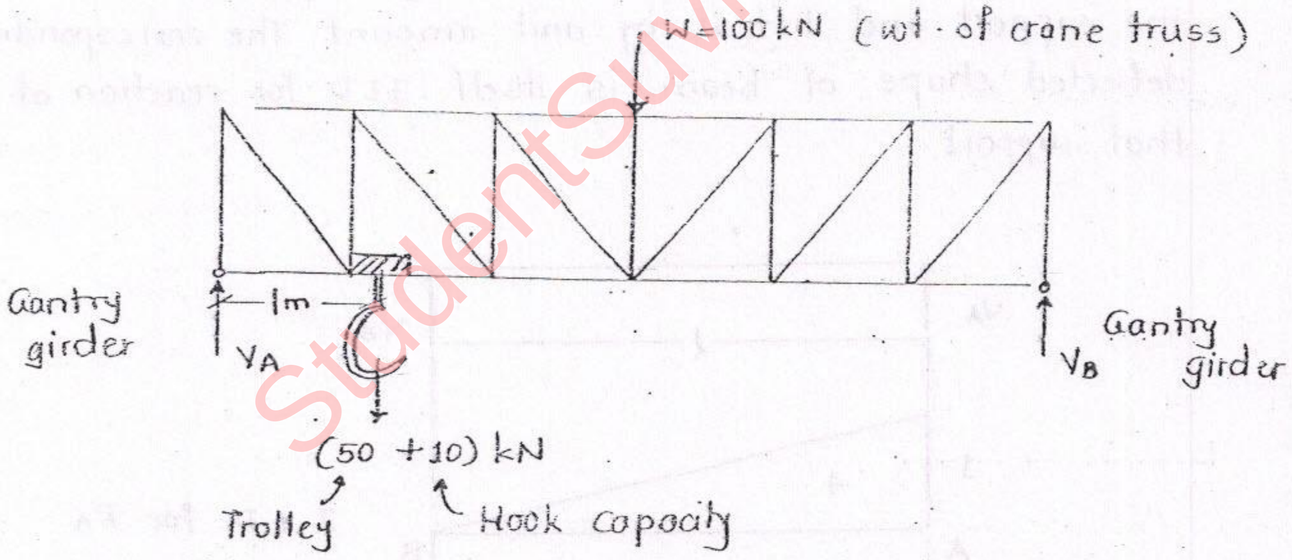
Note:

For manually operated cranes, where cranes move slowly, effect of impact is less. So only 10% of static load is taken as impact load.

(x) Maximum static wheel load is the maximum reaction exerted by the bebeels on rail when the crab is nearer to girder. This maximum static wheel loads is shared by two wheels on gantry girders equally.

Q. A crane with two wheels per side has a capacity of 50 kN. Weight of crane is 100 kN. weight of trolley is 10 kN and span of crane is 12 m. The max. static wheel load with hook clearance of 1 m from beam is.



$\Sigma M_B = 0$ $\quad$ $+V_A \times 12 - (50+10)11 - 100 \times 6 = 0$

+ve -ve $\quad$ $V_A = 105$ kN

This max. static reaction is shared by 2 wheels at A

Static load on each wheel $= \frac{105}{2}$

$= 52.5$ kN

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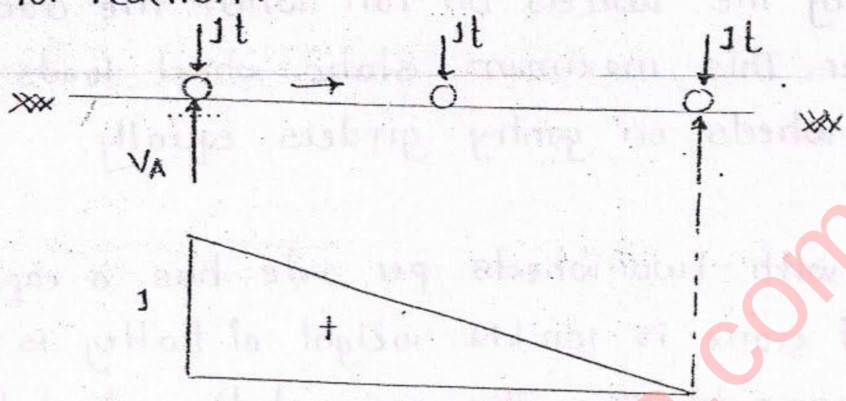
Influence line diagram (I.L.D.)

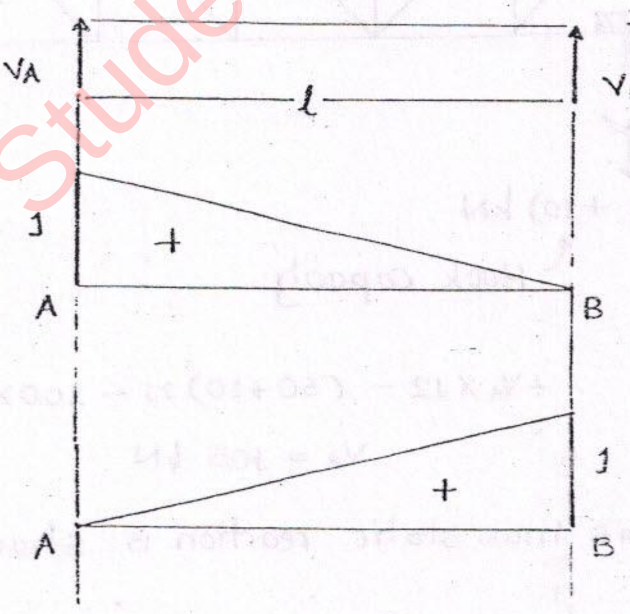
(i) It is the graphical representation of variation of the reaction, shear force, bending moment etc. as unit load moves from one end to the other end of a structure.

(ii) ILD for reaction :



I.L.D. for V_A

To draw I.L.D. for reaction at any support, remove the support and lift it by unit amount. The corresponding deflected shape of beam is itself ILD for reaction at that support.



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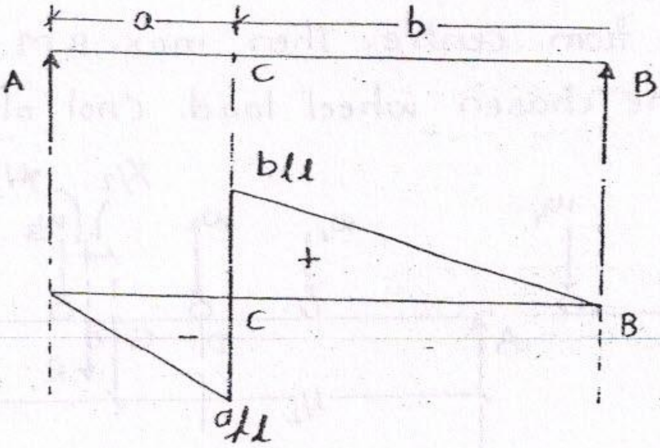
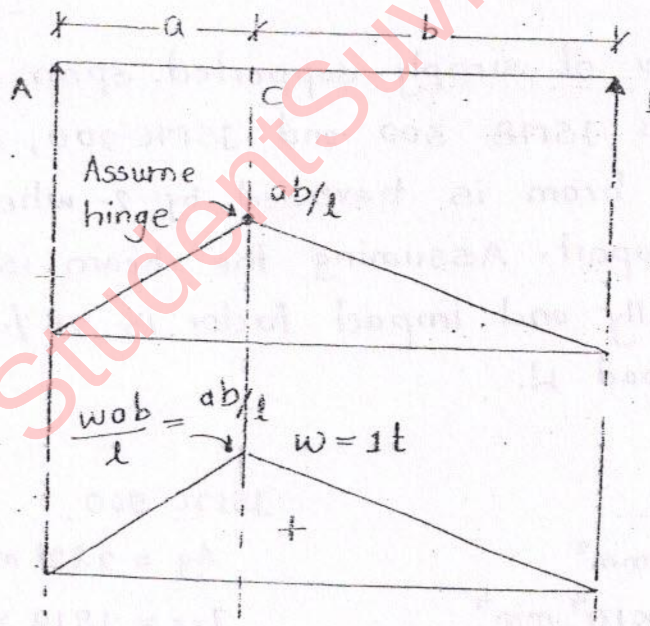
(iii) ILD for S.F. at any section.



I.L.D. for S.F. at C

To draw ILD for S.F. at C, tear the beam at C & lift it as shown in fig. Corresponding deflected shape of beam itself is ILD for S.F. at C.

(iv) ILD for B.M. at any section :



I.L.D. for BM @ C.

B.M.D. for w = 1 t

To draw ILD for BM at any section 'C', assume an imaginary hinge at C and lift it by an amount of (ab/l). Corresponding deflected shape of beam is itself a ILD for B.M at C'

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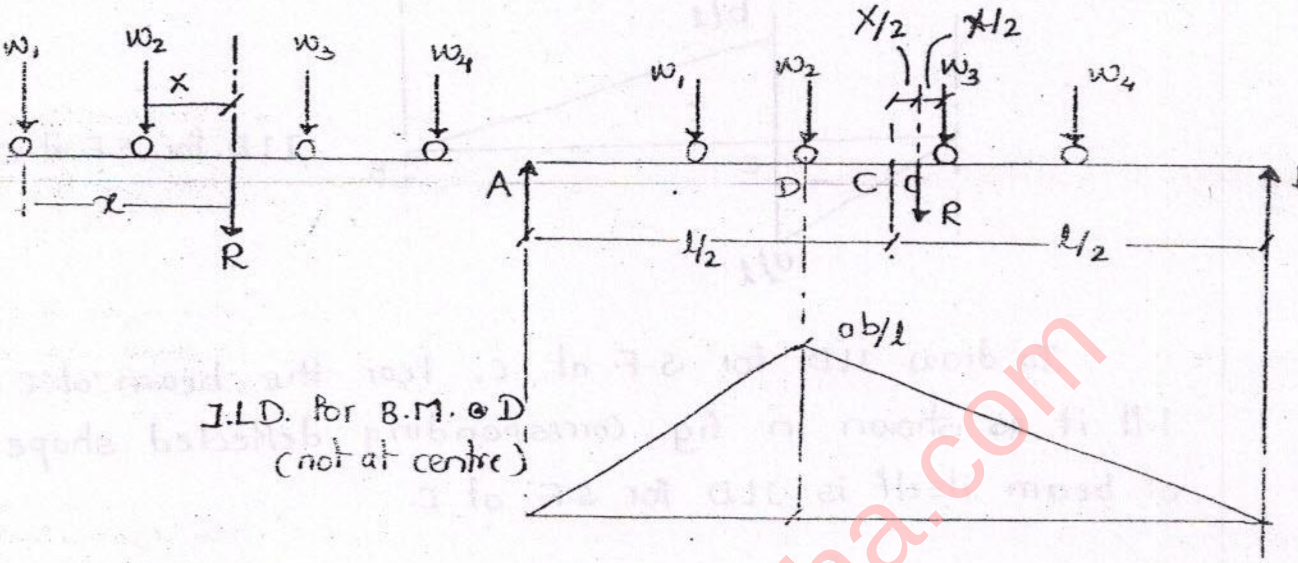
(v) To get maximum B.M. under a chosen wheel load keep the load and resultant of all loads at equal distance from centre. Then max. B.M. will occur under the chosen wheel load. (not at centre)



To get max B.M. under w_2 load.

Q. A Gantry girder of simply supported span of 6m is composed of an ISMB 300 and ISMC 200, welded at top flange. The beam is traversed by 2-wheel loads of W, spaced 3m apart. Assuming the beam is fully restrained laterally and impact factor is 25%. Find the safe value of load W.

10 Marks

Given:

ISMB 300

$A_g = 5626\ mm^2$

$I_{xx} = 8604 \times 10^4\ mm^4$

$I_{yy} = 454 \times 10^4\ mm^4$

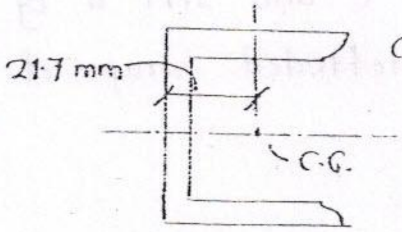
ISMC 200

$A_g = 2821\ mm^2$

$I_{xx} = 1819 \times 10^4\ mm^4$

$I_{yy} = 140 \times 10^4\ mm^4$

$t_w = 6.1\ mm$



C.G. of channel from web = 21.7 mm

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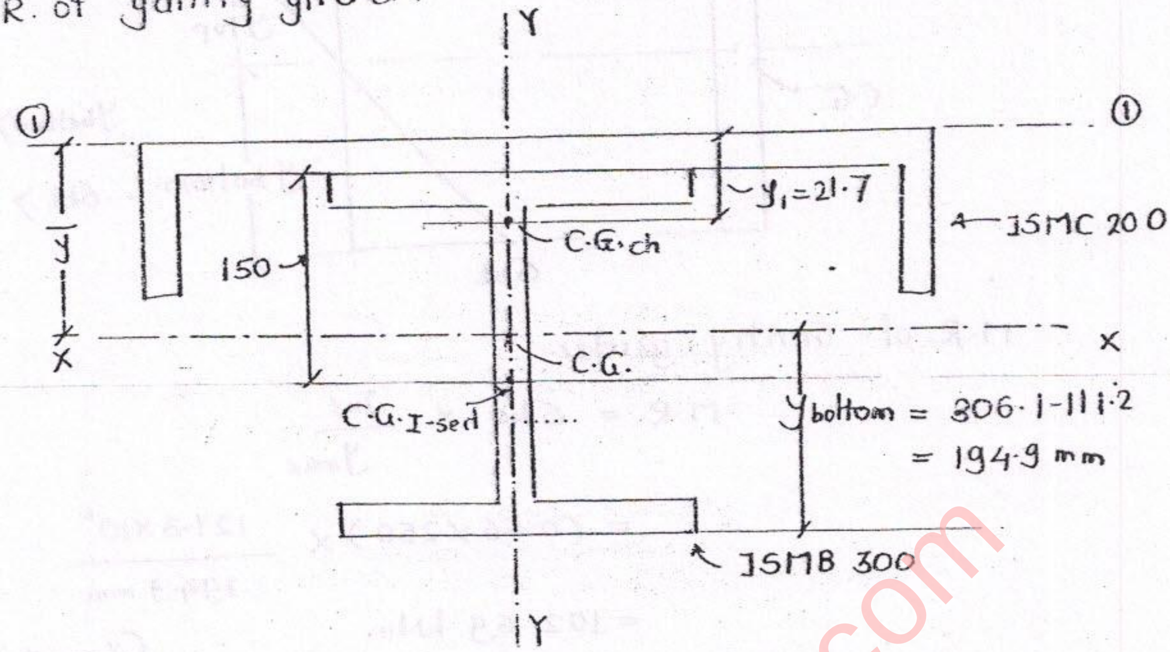
Analysis :

(i) M.R. of gantry girder :



$$M.R. = \sigma_c \cdot Z = 0.66 f_y \cdot Z \quad \text{(in WSM)}$$

$$= \sigma_{bc} \cdot Z_p = \left(\frac{f_y}{1.1}\right) \cdot Z_p \quad \text{(in LSM)}$$

Using WSM :

ⓐ C.G. of c/s from ① - ①

$$\bar{y} = \frac{a_1 y_1 + a_2 y_2}{(a_1 + a_2)}$$

$$\therefore \quad = \frac{\overset{\text{channel}}{(2821 \times 21.7)} + \overset{\text{beam}}{5626 \times (150 + 6.1)}}{(2821 + 5626)}$$

$$\bar{y} = 111.2 \text{ mm} \quad \text{from ① - ①}$$

ⓑ I_{xx} of gantry girder :

$$I_{xx} = [\underset{I_{kok_o}}{\overset{I_{YY} \text{ for } \sqsubset}{140 \times 10^4}} + \underset{A}{2821} \times \underset{h^2}{(111.2 - 21.7)^2}] + $$

(for channel)

$$[8604 \times 10^4 + 5626 \times (156.1 - 111.2)^2]$$

(for beam)

$$I_{xx} = 121.3 \times 10^6 \text{ mm}^4$$

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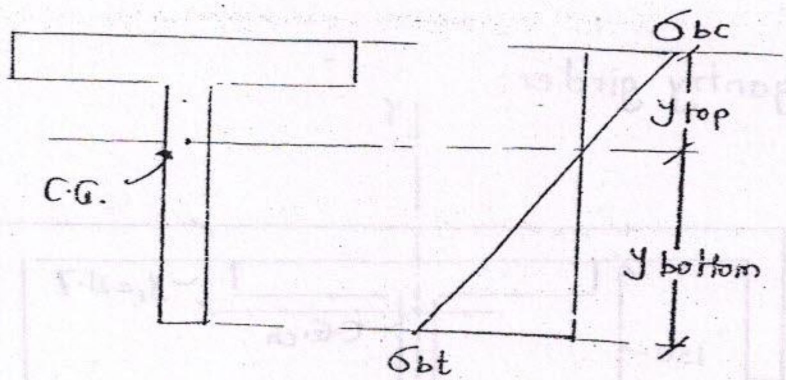


$y_{bottom} > y_{top}$ $\therefore \sigma_{bt} > \sigma_{bc}$

M.R. of Gantry girder

$$M.R. = \sigma_{bc} \times \frac{I_{xx}}{y_{max}}$$

$$= (0.66 \times 250) \times \frac{121.3 \times 10^6}{194.9 \text{ mm}}$$

$$= 102.69 \text{ kNm}$$

$(y_{max} = y_{bottom})$

$\therefore$ Moment carrying capacity of beam c/s = 102.69 kNm.

(ii) Max. B.M. in gantry girder:

Wheel load = W

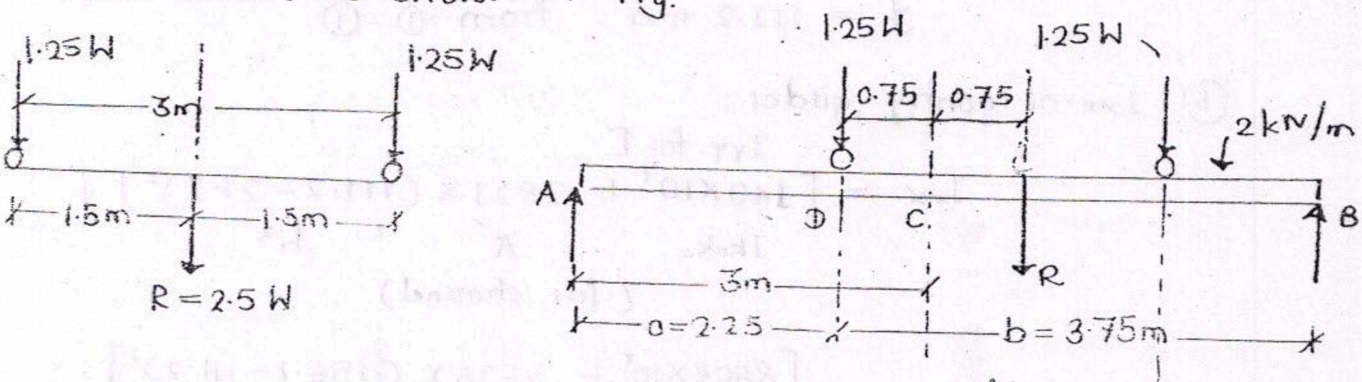
Impact factor = 25 %, Impact load = 0.25 W

Equivalent static wheel load = 1.25 kN.

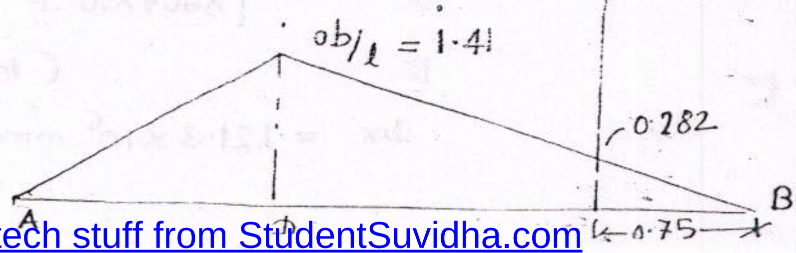
Assume self wt. of gantry girder (Beam + channel)

= 2 kN/m

To get max. B.M. in gantry girder, keep two wheel loads such that the resultant wheel load is at equal distance from centre as shown in fig.



ILD. for B.M. at D



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$$\frac{ab}{l} = \frac{2.25 \times 3.75}{6} = 1.41$$

for $3.75 \longrightarrow 1.41$

for $0.75 \longrightarrow \left(\frac{0.75}{3.75}\right) \times 1.41 = 0.282$

Max. B.M. under wheel load :

$$= (1.25\,W \times 1.41) + (1.25\,W \times 0.282) + 2\left(\frac{1}{2} \times 6 \times 1.4\right)$$

load × ordinat — load × ordinate — Intensity of UDL × Area of ILD

$$= (2.11\,W + 8.46)\ kNm$$

$$\therefore\quad 2.11\,W + 8.46 = 102.65$$

$$W = 44.65\ kN$$

Q. A tension member 0.9 m long has to resist a service dead load of 20 kN and a service live load of 60 kN. Design a rectangular flat bar of standard structural steel of grade Fe 410. Assume that member is connected by one line of 16 mm dia. bolts of grade 4.6. Use Limit state method. Partial safety factor for material ($\gamma_{m_0} = 1.1$ and $\gamma_{m_1} = 1.25$). and partial safety factor for (D.L + L.L) is 1.5.

15 Marks

Factored tensile force $= 1.5\ (D.L. + L.L.)$

$= 1.5\ (20 + 60) = 120\ kN$

For Fe 410 steel, ~~$f_y = 410$ MPa~~ ~~$f_u = 500$ MPa.~~ (increase f_y by 80%.)

$f_u = 410$

For bolt of grade 4.6, $f_u = 400$

(4 means 400) (0.6 means $f_y = 0.6\,f_u$)

$f_y = 60\%$ of $f_u = 0.6 \times 400$

$= 240$ MPa

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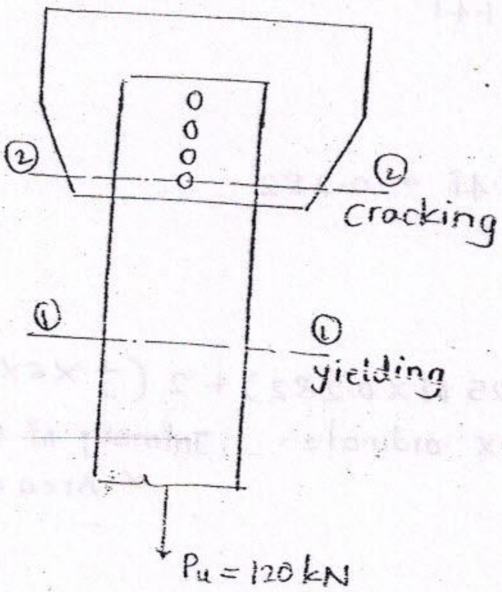


$\phi = 16mm$

$d = 17.5mm$

Tensile strength of plate.

$$P_t = A_g \times \left(\frac{f_y}{1.1}\right) \text{ - yield criteria}$$

$$120 \times 10^3 = A_g \times \left(\frac{410}{1.1}\right)$$

$$(A_g)_{reqd} = 321.95 \ mm^2$$

Tensile strength of plate

$$P_t = A_{net} \times \left(\frac{0.9 f_u}{1.25}\right) \text{.... rupture criteria}$$

$$120 \times 10^3 = \left(A_g - \frac{\pi}{4} \times 17.5^2\right) \times \left(\frac{0.9 \times 500}{1.25}\right).$$

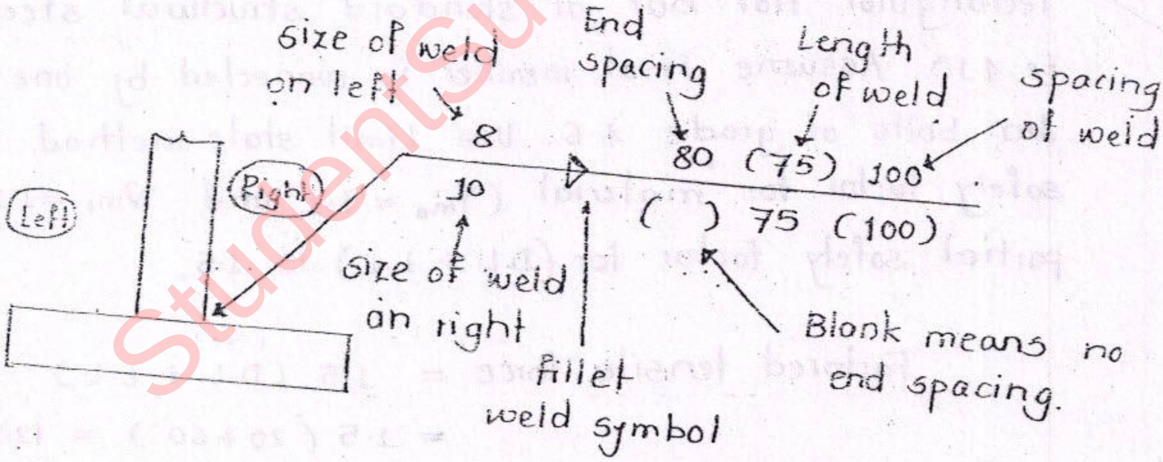
$$(A_g)_{reqd} = 573.86 \ mm^2$$

So provide 60 ISF 10 as tension member

(A_g provided $= 60 \times 10 = 600 \ mm^2$.) Hence safe

Note:

Weld notation:



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