DRCS IAT-3

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1CR17CV032

Gantry girder

Given - centre to centre dist b/w ganthy rails = 22 m

centre to centre dist b/w ~~col~~ columns - 7.4 m

crane capacity 220 kN

self wt of the crane girder excluding trolley 200kN at centre

self wt of the crab or trolley, electric motor, hook etc. 60kN

approximate minimum approach of the crane hook to the ganthy girder 1.2 m

wheel base 3.4 m

self wt of rail section 300N/m

Diameter of crane wheel 150 mm

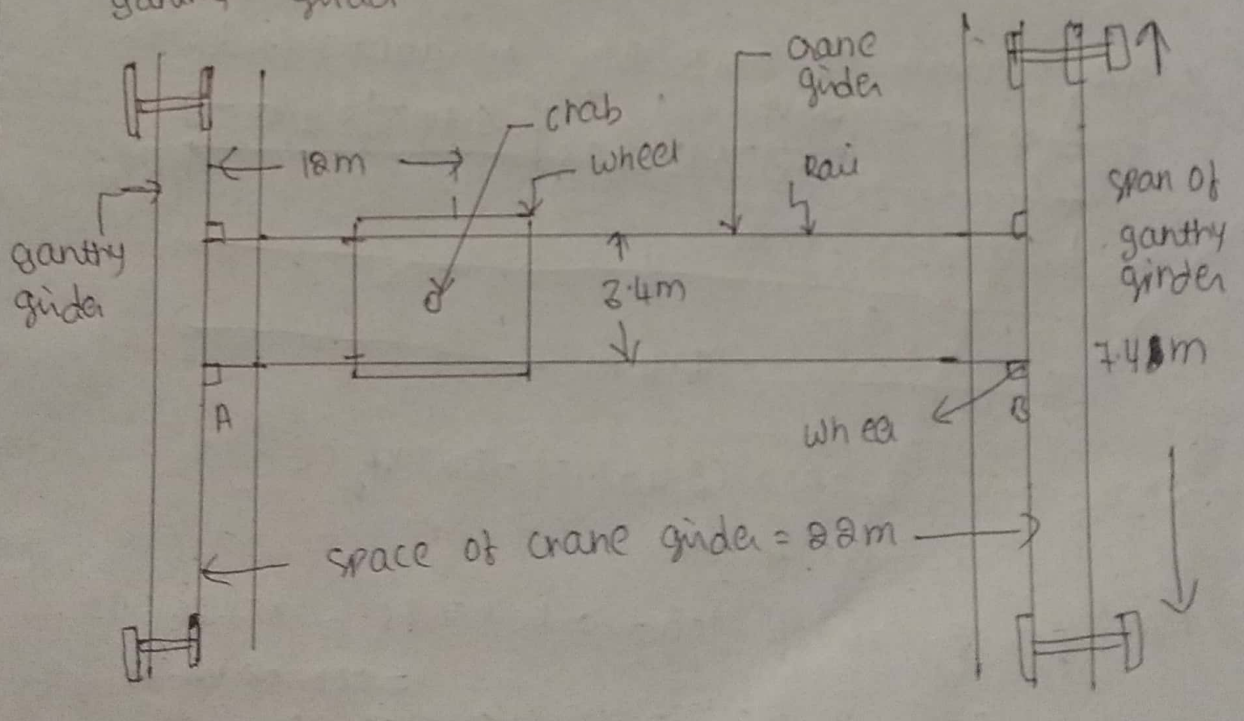
Height of rail 105 mm

steel is of grade Fe 410.

Solution :- for fe 410 grade of steel; $f_u = 410$ mpa,

$f_y = f_{yw} = f_{yf} = 250$ mpa

* Design maximum load transferred from crane girder to ganthy girder



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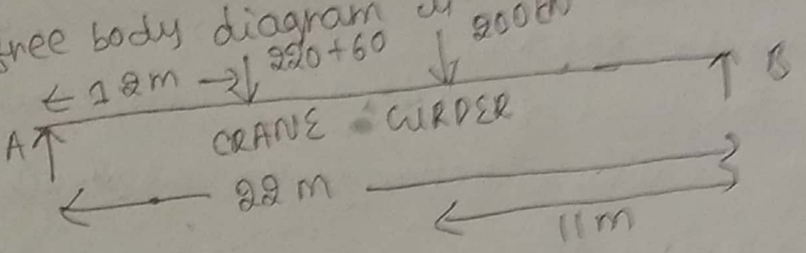
Step 1: Design max load transferred from crane girder to gantry girder

The max reaction / load in crane girder occurs when the crab or trolley along with hook is at its toward left or right of a crane girder with a minimum hook distance of 1.2 m

The free body diagram is



$\Sigma M_B = 0,$

$R_A \times 22 - (220+60) \times 20.8 - 200 \times 11 = 0$

$R_A = 364.73$ kN

Since there are two wheels @ each end of crane bridge
load on wheel by trolley $= \frac{364.73}{2} = 182.36$ kN

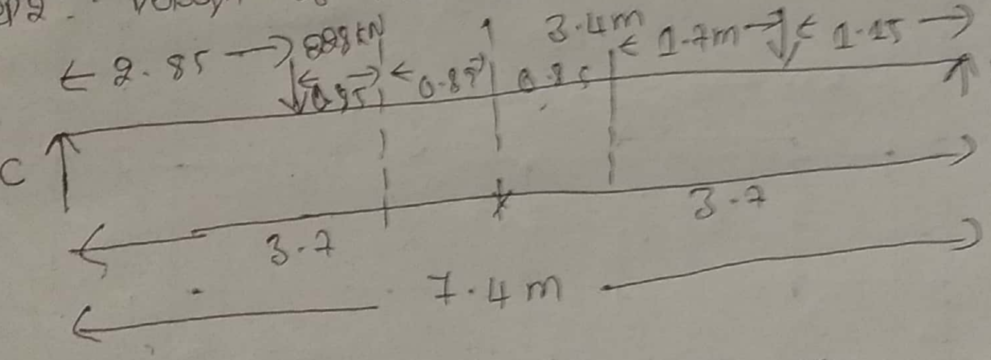
As per IS-875 part 2-1987,

As per IS-875 CL 6.1 Pg 15

For electrically operated crane (EOT) vertical forces transferred to wheels = 25% of the max static load

Load on each wheel $= 1.25 \times 182.36$
$= 227.95$ kN $\simeq 228$ kN

Step 2: Design of max BM on gantry girder



$\Sigma M_D = R_C \times 7.4 - 228 \times (3.4 + 1.15) - 228 \times 1.15 = 0$

$R_C = 175.62$ kN

max BM @ wheel load $= R_C \times 2.85 = 175.62 \times 2.85$
$= 500.52$ kN-m

Factored BM $= 500.52 \times 1.5 = 750.78$ kN-m

Scanned by CamScanner

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Assume self wt of gantry girder as = 1.6 kN/m

Self wt of rail = 0.3 kN/m

total self wt = 1.6 + 0.3 = 1.9 kN/m

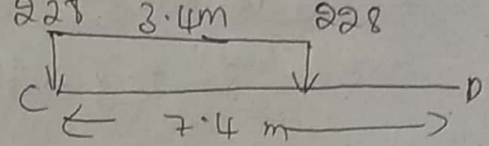
factored self wt = ~~1.6 + 0.3 = 1.9 kN/m~~ 1.5 × 1.9 = 2.85 kN/m

B.M due to self wt = $\frac{wl^2}{8}$ = $\frac{2.85 \times 7.4^2}{8}$ = 19.51 kN-m

S.F due to self wt = $\frac{2.85 \times 7.4}{2}$ = $\frac{wl}{2}$ = 10.545 kN

* Design max shear force

the shear due to the wheel load is maximum when one of the wheel is at support



$\Sigma M_D = 0$

$R_C \times 7.4 - 228 \times 7.4 - 228 \times 4 = 0$

$R_C = 351.24$ kN

factored S.F = 351.24 × 1.5 = 526.86 kN

* lateral load & its moment

lateral load is developed due to the application of brake of sudden acceleration of the trolley as per IS 875 (Part-2)

lateral load or horizontal force transverse to the rail 10% of the weight of the crab or trolley & the weight lifted on the crane

lateral force or horizontal force

= $\frac{10}{100}$ × (220 + 60) = 28 kN

lateral load acting on each wheel = $\frac{28}{4}$ = 7 kN

factored lateral load = 7 × 1.5 = 10.5 kN

Bending moment due to lateral load = ?

for 228 kN BM → 750.78

for 10.5 kN → ?

B.M due to lateral load = 34.57 kN-m

nanodeviations!

Total design Bending moment = LL + lateral load + dead load
= 750.48 + 24.57 + 10.51
= 804.96 KN-m

Total design Shear force = 526.86 + 10.5 + 10.545
= 547.905 KN-m

Step 5 Preliminary trial section

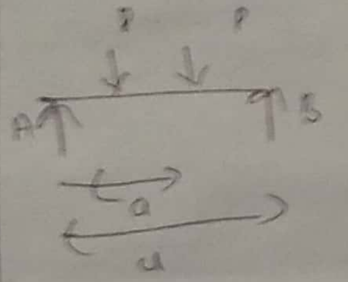
The trial section is selected based on deflection criteria IS 800, page 31 table 6

max deflection, for electrically operated crane

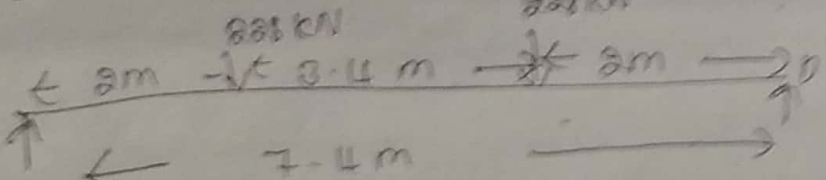
δ_{max} deflection = $\frac{span}{750}$ = $\frac{7400}{750}$ = 9.87 mm

But, max deflection = deflection due to D.L + deflection LL

Let us assume deflection due to DL as 1mm



Δmax (@ centre = $\frac{Pa}{24EI}$ $(3L^2 - 4a^2)$



Taking Δmax = δ live load + δ dead load

$9.87 = 1 + \frac{Pa}{24EI}(3L^2 - 4a^2) = 9.87 = 1 + \frac{888 \times 10^3 \times 2000}{24 \times 2 \times 10^5 I}(3 \times 7400^2 - 4 \times 2000^2)$

We need to calculate moment of inertia I for the section of the section of gantry girder

$I = 1588.12 \times 10^6 \ mm^4$

increase the value of I by 30% = $1.3 \times 1588 \times 10^6$ = 2064.56×10^6 mm

The built up section from page of the steel table & select a built up section

& Table based on Ixx value

Selecting ISMC 400 @ 49.4 kg/m & ISWB 500 @ 95.2 kg/m

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A = 376.15 cm² , r_{yy} = 9.57

table 4 PG 4

ISWB 500

A = 121.22 cm²

h = 500 mm

b = 250 mm

t_f = 14.7 mm

t_w = 9.9 mm

r_{xx} = 207.7 mm

r_{yy} = 49.6 mm

PG 5 table 16

ISMC 400

A = 62.93 cm²

h = 400 mm

b = 100 mm

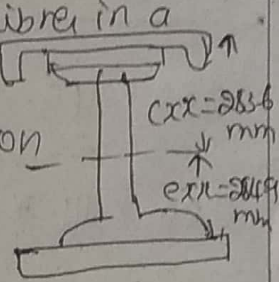
t_f = 15.3 mm

t_w = 8.6 mm

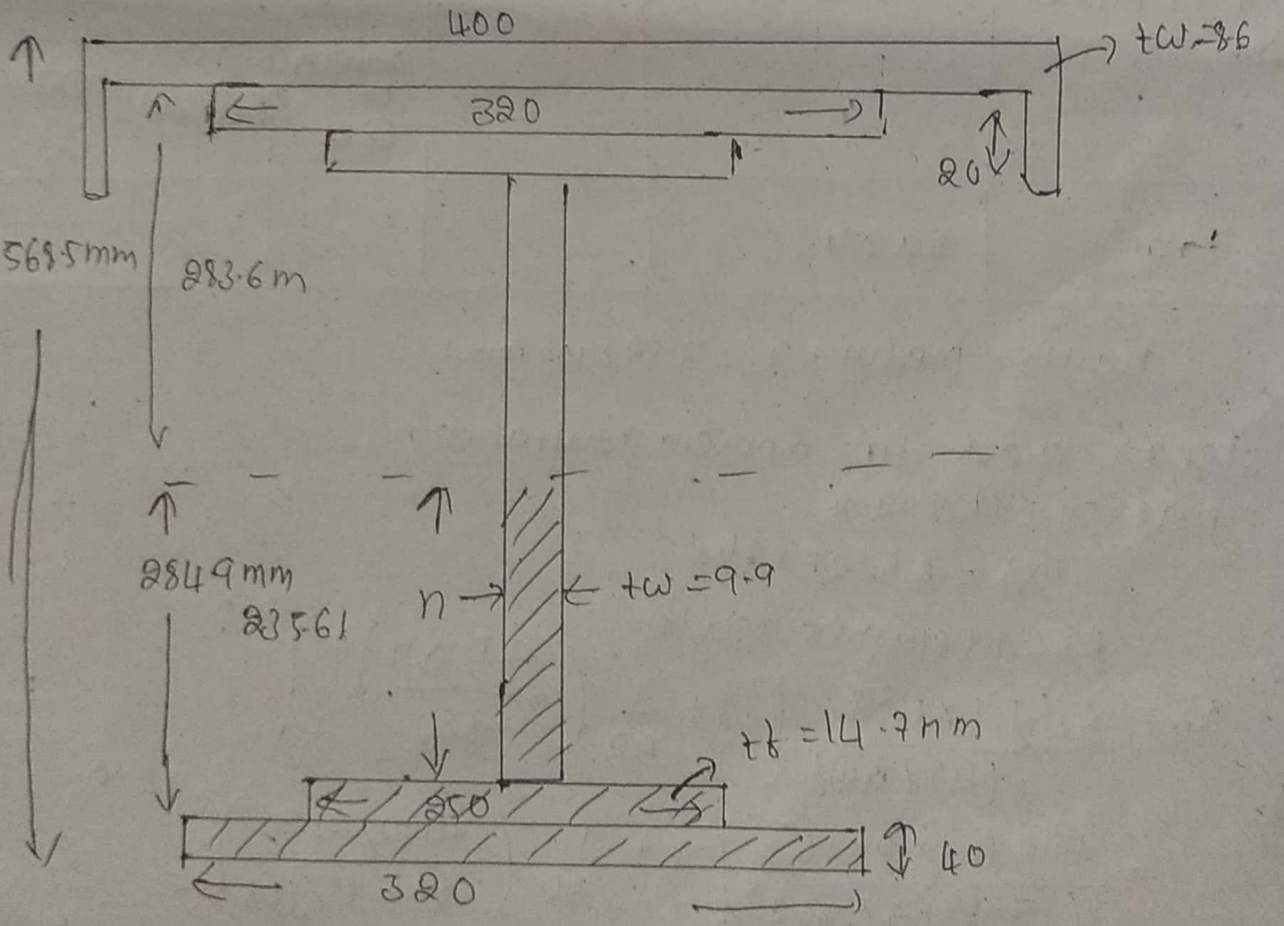
C_{yy} = 24.2 mm

location of Equal area axis

Equal area axis is the location of the axis which resu in equal compressive & tensile forces when all fibres in a section have reached yield stress



To locate Equal area axis (n) area of shaded portion = ½ × total area of section



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To locate equal axis n area of shaded portion
= 1/2 x total area of sec

9.9 x n + 250 x 14.7 + 320 x 40 = 1/2 x (37615)

n = 235.61

* Plastic modulus Zp - it is the sum of areas of compression & tension zones multiplyed by corresponding distance of the centroid of the compressive & tension area from the axis

* calculation of plastic modulus Zp = Σa x y
the distance yi are measured from EAA axis to centroidal axis of the section

shaded area (a)	centroidal distance from EAA y	Za (mm³) ay	unshade area	centroidal dis + y	Za (mm³)
320 x 40	235.61 + 14.7 + 40/2	3459961	23499 x 9.9	23499/2	2733340.48
250 x 14.7	235.61 + 14.7/2	892841.25	250 x 14.7	234.99 + 14.7/2	6347349.75
9.9 x 235.61	235.61/2	274784.76	320 x 20	234.99 + 14.7 + 20/2	1662016
			chareseti for 6293	278272.42	1598882.37
total	Σa x y				

Plastic modulus Zp = 7.52 x 106 mm³

Step 7: check for moment resistance
page 54, cl 8.2.2

$$Md = \beta_b \times Z_p \times f_{bd}$$

$\beta_b = 1$ (plastic section)

$$f_{cr,b} = \frac{1.1 \times \pi^2 E}{(LT/ry)^2}\left[1 + \frac{1}{20}\left(\frac{LT/ry}{h_f/t_f}\right)^2\right]^{0.5}$$

$$= \frac{1.1 \times \pi^2 \times 2 \times 10^5}{(7400/95.7)^2}\left[1 + \frac{1}{20}\left(\frac{7400/95.7}{526.15/33.8}\right)^2\right]^{0.50}$$

$f_{cr,b}$ = 542.75 N/mm²

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find fbd, table 13(a) page 55, IS 800-2007 $f_{cr,b} = 542.75 N/mm^2$

$\lambda_{LT} = \sqrt{\frac{f_y}{f_{cr,b}}} = \sqrt{\frac{250}{542.75}} = 0.68$

from table, 13(a) # 55

$f_{cr,b} = 542.75 N/mm^2$, $\lambda_{LT} = 0.21$, $f_y = 250$

though inter polation

$f_{bd} = 192.49 N/mm^2$

$M_d = 1 \times 7.52 \times 10^6 \times 192.49$

$= 1447.5$ kN-m

$M_d > 904.86$ kN-m

hence it is safe

step 8 :. check for shear resistance

$V_d = \frac{A_v \times f_{yw}}{\sqrt{3}\, \gamma_{m0}} = \frac{h \times t_w \times f_{yw}}{\sqrt{3}\, \gamma_{m0}}$

$= \frac{568.5 \times 9.9 \times 250}{\sqrt{3} \times 1.1}$

$V_d = 738.503$ kN > 547.905 kN it is safe

step 9 :. check for crippling

assume width of bearing plate = 100 mm

use cl 8.7.4 pg 67 IS 800

$F_w = \frac{(b_1 + n_2)\, t_w f_{yw}}{\gamma_{m0}}$

$n_2 = 2.5 \times$ (thickness of bottom plate + thickness of flange)

$n_2 = 2.5(40 + 14.7) = 136.75$ mm

$F_w = \frac{(100 + 136.75) \times 9.9 \times 250}{1.1}$

$F_w = 532.69$ kN > 547.905 kN

∴ it is safe

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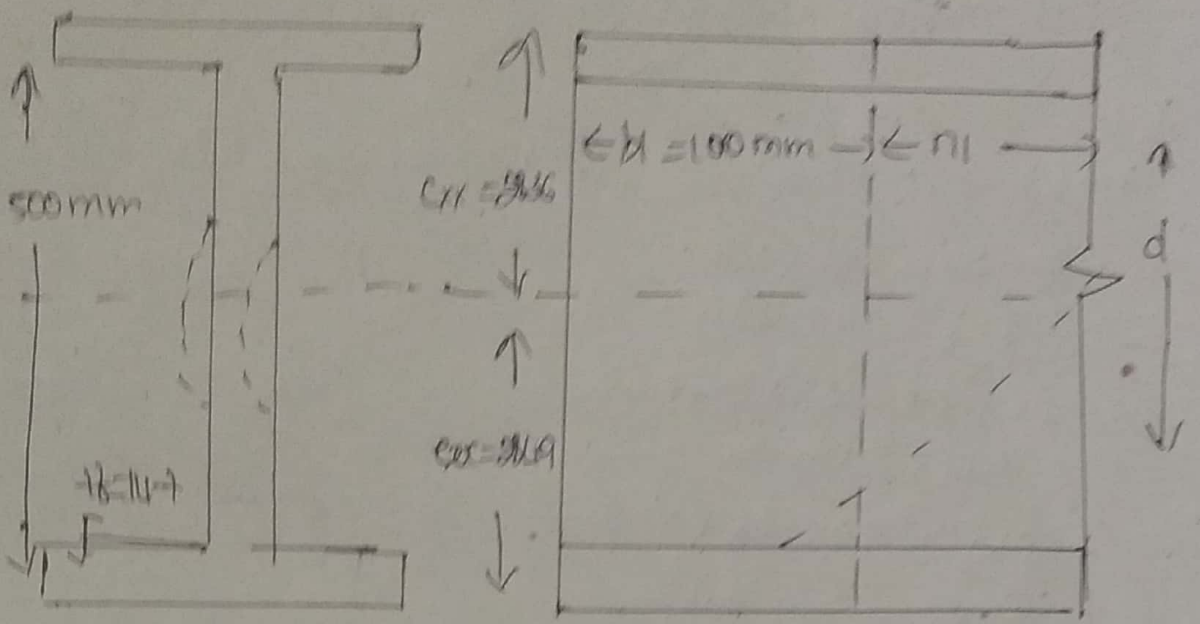
Step 10: Check for buckling of web



$d = 500 - 2 \times 14.7$

$d = 470.6$ mm

Buckling strength of web $= F_{wb} = (b_1 + n_1) t_w f_{cd}$

* Breadth of bearing stiffener, $b_1 = 100$ mm
* Dispersion of 45° line @ the mid depth of section

$n_1 = e_{xx} = 284.9$ mm

Thickness of web, $t_w = 9.9$ mm

To find design comp stress, f_{cd} we need to calculate slenderness ratio, λ

$$\lambda = \frac{l_{eff}}{r_{min}}$$

l_{eff} = eff length of strut $= 0.7 \times d$

$d = 470.6$ mm

$l_{eff} = 0.7 \times 470.6 = 329.42$ mm

$r_{min} = r_{yy} = 95.6$

$$\lambda = \frac{l_{eff}}{r_{min}} = \frac{329.42}{95.6} = 3.44$$

Hence it is built up member it will come under the buckling class 'c' (IS 800 - Page 44, Table 10) use table 9(c)

from table 9(c) fig 42 IS → 800

$\lambda = 2.44$ we get design compress stress

$f_{cd} = 227$ kN m

Hence Buckling strength of web, $f_{wb} = (b_1 + n_1) t_w f_{cd}$

$= (100^7 + 284.9) \times 9.9 \times 227 = 865$ kN > 547.901

connections

using welded connection

force at the junction

$$F = \frac{VAy}{I_Z} = \frac{547.905 \times 10^3 \times (6290) \times (283.6-20) + 320 \times 20 ((286.7 - 56.30)}{230.19 \times 10^6}$$

where Ay is the area of shaded portion multiplying by centroidal distance measured from individual section

$F = 792.39$ kN/m

$$\text{strength of weld} = 2 \times \left(\frac{0.7 \times 5 \times 1 \times 410}{\sqrt{3} \times 1.25} \right) = 792.39$$

$t = 2.99$ mm

Provide 5mm size weld