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Solution of Internal Assessment Test 3 – July 2022

Sub:	Design of steel structures					Sub Code:	18CV61	Branch:	Civil
Date:	9/07/2022	Duration:	90 min's	Max Marks:	50	Sem / Sec:	6		OBE

Answer ALL Questions
Note: Use of IS 800:2007 is permitted and assume missing data.

		MARKS	CO	RBT
1	*Design an unequal single angle section act as tie member of length 1.56m in a roof truss, if it is to carry an **axial load of 60Kn**, when subjected to possible **reversal stress** into compression resulting from the action of wind or earthquake.*	[25]	CO4	L4

Solution:

Missing things from previous questions: Size of the section, no and dia of bolt,

Bolted connection:

axial load= 60Kn — 1

T_{dg} =Factored load =1.5*60=90Kn — 1

$T_{dg} = f_y \times A_g / \lambda_{m0}$ — 1

$A_g = T_{dg} * \lambda_{m0} / f_y = 90*1000*1.1/250 = 396mm^2 = 3.96cm^2$ — 1

Try ISA 65*45*5 a=5.26=526mm²

$r_{min} = 0.96cm = 9.6mm$ — 2

Check for slenderness ratio: P-20 table 3 of IS 800:2007

$¥ = \frac{L_{eff}}{r_{min}} = \frac{1560}{9.6} =$ *162.5 less than 180 hence good to proceed*

1. **Design Yielding Strength T_{dg}- (6.2)**

$T_{dg} = f_y \times A_g / \lambda_{m0}$ (λ_{m0} = 1.10 from table 5) — 3

= 250×526/1.1*1000= 119.5 Kn is greater than 90Kn hence safe

Connection details:

Assume 16mm dia bolt

- Strength shear (*assume **shank** interfere the shear plane of bolts*)

$V_{dsb} = \frac{f_{ub}}{\sqrt{3}}(n_n A_{nb} + n_s A_{sb}) / \gamma_{mb}$ — 2

$= \frac{400}{\sqrt{3}}(0 + 1 * (pi * 16 * 16/4) / 1.25 =$ 37.14Kn

- Bolts in Bearing

$V_{nsb} = (2.5 K_b\, d\, t\, f_u) / \gamma_{mb}$ — 4

K_b *is least of the following* $e/3d_o$, $p/3d_o - 0.25$, f_{ub}/f_u , 1

Assuming p=2.5*d=50mm and e=1.7*do= 40mm

40/ 3*18= 0.74

50/3*18-0.25= 0.68

400/410= 0.98

1

V_{nsb} = (2.5*0.68*16*5*400)/1.25*1000= 43.52Kn

No. of bolts = load /bolt value = 90/37.14= 2.42= 3No's

2. **Design Rupture Strength of Net Area T_{dn}- (6.3.3)** *since it is an* ***angle (since it is affected by shear lag)*** 3

T_{dn} = $0.9 \times A_{nc} \times f_u / \gamma_{m1} + \beta \times A_{go} \times f_y / \gamma_{m0}$ (γ_{m1} = 1.25)

A_{nc} = *Net c/s area of the* ***connected*** *leg* = ((60-5/2-18) *5) =222.5mm^2

A_{go} = *Gross c/s area of the* ***unconnected*** *leg*= (45-5/2) *5= 212.5mm^2

β= 1.4-0.076$\left(\frac{W}{t}\right)\left(\frac{f_y}{f_u}\right)\left(\frac{b_s}{L_c}\right) \leq \left(\frac{f_u}{f_y}\right)\left(\frac{\gamma m0}{\gamma m1}\right)$ ≥0.7 ………. Pg. 33

β= 1.4-0.076$\left(\frac{45}{5}\right)\left(\frac{250}{410}\right)\left(\frac{75}{150}\right) \leq \left(\frac{410}{250}\right)\left(\frac{1.1}{1.25}\right)$ ≥0.7

=1.19 ≤1.44≥0.7

$b_s = w + w_1 - t$ = 45+35-5= 75mm

L_c= 3*50= 150mm

T_{dn} = 0.9 ×222.5 × 410 / 1.25 +1.19×212×250 / 1.1=123.08Kn

3. **Design Block Shear Strength T_{db} (6.4.1)**

T_{db1} =$[A_{vg} \times (f_y/\sqrt{3}) / \gamma_{m0} + 0.9 \times A_{tn} \times f_u / \gamma_{m1}]$................................pg 33, 6.4.1 5

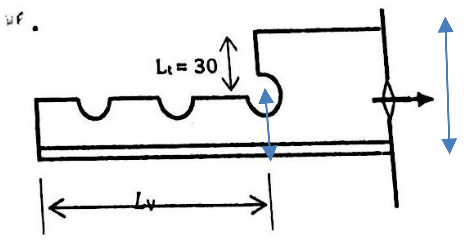
=700 × (250/√3) / 1.1 + 0.9 ×105 ×410/ 1.25

= 122.85Kn

T_{db2} = $[0.9\times A_{vn}\times (f_u/\sqrt{3}) / \gamma_{m1} + A_{tg} \times f_y / \gamma_{m0}]$................................pg 33, 6.4.1

=0.9× 475× (410/√3) / 1.25 +150 × 250/ 1.1

=115.05 Kn



A_{vg}= L_v*t=140*5=700 mm^2

A_{tn}= (L_t-nd_o)*t=(30-0.5*18)5=105mm^2

A_{vn}= (L_v-nd_o)*t=(140-2.5*18)*5=475 mm^2

A_{tg}= L_t*t =30*5= 150mm^2

DESIGN STRENGTH= least of T_{dg}, T_{dn}, T_{db1}, and T_{db2}

*Therefore, Design strength of the angle is 115.05Kn is greater than 90Kn hence safe to proceed with ISA 65*45*5 as tie member* 2

2	*Design a built-up member to carry an factored load of 1400Kn and effective length in both planes is 6.5m. the column is restrained in position but not in direction at both ends. Provide double lacing system with bolted connections. Assume steel of grade Fe 410 and bolts of grade 4.6. design the column with two channels placed toe-to-toe.*	[25]	CO3	L4

Solution:

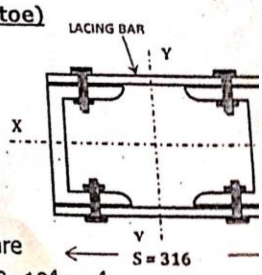
Design of compression member (Channels toe to toe)

Factored Load= 1400 KN

Assuming permissible stress $= 0.6\, f_y = 0.6 \times 250 = 150\ N/mm^2$

Area of 2 channels $= \dfrac{Load}{\sigma_{ac}} = \dfrac{1400\times10^3}{150}$

$= 9333.33\ mm^2 = 93.33\ cm^2$



Try 2 – ISMC 350 @ 42.1 kg /m. Properties of each channels are

$a = 53.66\ cm^2 = 5366\ mm^2$ $\quad I_{yy} = 430.6\ cm^4 = 430\times10^4\ mm^4$,

$I_{zz} = 10008\ cm^4 = 10008\times10^4\ mm^4$, $\quad C_{yy} = 2.44\ cm = 24.4\ mm$

5

Spacing (S): Equate $I_{ZZ} = I_{YY}$ of builtup sections

$2\times I_{zz} = 2\times I_{yy}$

$2\times I_{zz} = 2\times\left[I_{yy} + A\times\left(\frac{S}{2} - C_{yy}\right)^2\right]$

$2\times10008\times10^4 = 2\times\left[430\times10^4 + 5366\times\left(\frac{S}{2} - 24.4\right)^2\right]$

$S = 316mm$

P-48, Cl: 7.6.1.5

Slenderness ratio of builtup section $(\lambda) = 1.05\times\dfrac{KL}{r}$

Effective length (Table11, Cl: 7.2.2, P - 45)

End condition : Effectively held in postion at both ends,
but not restained against rotation. (Both ends Hinged)

$KL = L = 6.5\ m = 6500\ mm$

$r = \sqrt{\dfrac{I}{A}} = \sqrt{\dfrac{2\times10008\times10^4}{2\times5366}} = 136.57$

44, Table 10, Buckling curve class about any axis 'c'.
P-42, Table 9(c) for f_y = 250 N/mm².

5

Compressive stress about ZZ- axis, ($f_{cd\text{-}zz}$)

$\lambda_{zz} = 1.05\times\dfrac{6500}{136.57} = 50$

Compressive stress f_{cd} = 183 N/mm².

Load carrying capacity $= f_{cd}\times Area = \dfrac{183\times2\times5366}{1000}$

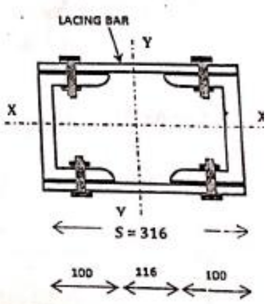
$= 1964\ KN > 1400\ KN$

Safe

Provide 2 - ISMC 350

Design Of Lacing: (Double lacing system)

Check for local buckling of column section (P -50, cl 7.6.5)



$\dfrac{a_1}{r_1} \not> 50$ or 0.7λ of builtup section, whichever is less.

0.7 times min of λ_{zz} and λ_{yy}

5

Inclination Of Lacing : (P - 50, Cl 7.6.4)

Assuming Inclination Of Lacing = 45° $(40^0 \prec \theta \prec 70^0)$

The gauge distance 'g' for ISMC 350 is 60 mm.

$r_1 = 2.83 cm$

$\therefore$ Horizontal length of lacing b/w bolts $l_h = 316 - 60 - 60 = 196$ mm

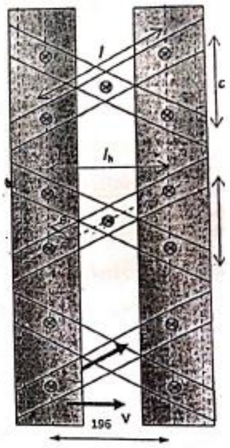
Spacing of lacing is c/c distance of adjacent bolts

$= a_1 = 196$ mm

$$\frac{a_1}{r_1} = \frac{196}{28.3} = 6.93 < 50 \text{ and } < 0.7 \times 50 \Rightarrow 35$$

The local buckling of the column does not occur,

Hence double lacing system can be adopted.



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Dimension of lacing

Width of lacing bar (P- 50, Cl 7.6.2)

Assuming dia of bolt = 16 mm

Width of lacing = 3 x dia of bolt = 3 x 16 = 48 mm Say 50 mm

Thickness of bar (t) (P- 50, Cl 7.6.3)

$t \nless \frac{1}{60}$ of distance of inner bolts

$\sin\theta = \frac{196}{l_{eff}}$

$l_{eff} = \frac{196}{\sin 45} = 277.20 mm$

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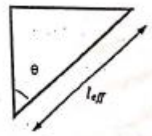


For double lacing system .

$t = \frac{1}{60} \times l_{eff} = \frac{1}{60} \times 277.20 = 4.62$ mm   Say 6 mm

Try a lacing bar of 50 mm width and 6 mm thick

i.e., 50 ISF 6

5

Check for slenderness ratio: (P-50, Cl 7.6.6.3)

$$\lambda = \frac{0.7 \times l_{eff}}{r_{min}} \ngtr 145$$

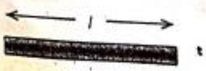
$$\lambda = \frac{0.7 \times l_{eff}}{r_{min}} = \frac{0.7 \times l_{eff} \times \sqrt{12}}{t}$$

$$= \frac{0.7 \times 277.20 \times \sqrt{12}}{6} = 112.03 < 145$$

Safe

$$r_{min} = \sqrt{\frac{I_{xx}}{A}} = \sqrt{\frac{\frac{lt^3}{12}}{lt}}$$

$$r_{min} = \frac{t}{\sqrt{12}}$$



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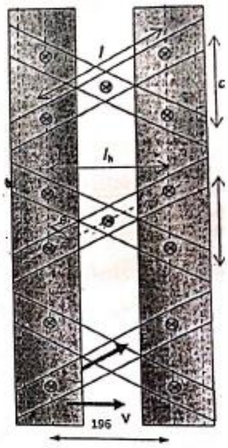

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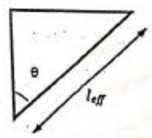

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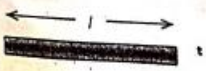

$n_n = 1 \quad n_s = 0 \ , \gamma_{mb} = 1.25$

$$A_{nb} = 0.78 \times \frac{\pi}{4} d^2 = 0.78 \times \frac{\pi}{4} \times 16^2 = 156.83 mm^2$$

$$V_{dsb} = \frac{400}{\sqrt{3}} \times \left(\frac{1 \times 156.83}{1.25 \times 1000}\right) = 28.97KN$$

2) Strength of bolt in Bearing $V_{dpb} = \dfrac{2.5 \times k_b \times d \times t^* \times f_u}{\gamma_{mb}}$

k_b is the least of the following:

1) $\frac{e}{3d_0} = \frac{35}{3 \times 18} = 0.65$ Edge distance e = 1.7 x 18 =30.6 mm say 35 mm

2) $\frac{p}{3d_0} - 0.25 = \frac{50}{3 \times 18} - 0.25 = 0.68$ P = 2.5 x 16 = 40 mm Say 50 mm

3) $\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.98$

4) 1

$k_b = 0.65$

t^* → *Min of 1) Thickness of flange of channel (13.5) and*

2) thickness of lacing bar (6 mm)

$$V_{dpb} = \frac{2.5 \times 0.65 \times 16 \times 6^* \times 400}{1.25 \times 1000} = 49.92KN$$

Bolt value (BV) = 28.97 KN

No of bolts = $\frac{12.37}{28.97} = 0.43$ Say 2 No's (Min) One on each side

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