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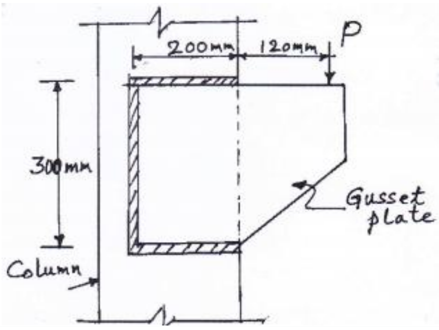
Internal Assessment Test 2 – Nov. 2017

Sub:	DESIGN OF STEEL STRUCTURES					Sub Code:	10CV72	Branch:	CIVIL
Date:	07/ 11 / 2017	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VII (A & B)		OBE

<u>Attempt any FOUR question.</u>

		MARKS	CO	RBT
1	For the welded bracket shown in figure below, determine the greatest safe load that can be applied at a distance of 120mm from flanges of column. The size of weld is 6mm. Assume shop weld.	[$12\frac{1}{2}$]	CIV702.1	L1



		MARKS	CO	RBT
2	Design the member consists of a single angle to carry a tensile force of 200kN. The length of tension member is 3.5m and subjected to reversal stresses due to wind forces. If the yield strength and the ultimate strength of the steel used are 250MPa and 410MPa and using 18mm bolts.	[$12\frac{1}{2}$]	CIV702.2	L1
3	A single unequal angle 100 X 75 X6 mm is connected to a 8mm thick gusset plate at the ends by 4mm welds as shown in figure Fig Q3. Determine the design tensile strength of the angle if the gusset is connected to the 100mm leg. The yield strength and ultimate strength of the steel used are 250MPa and 400MPa.	[$12\frac{1}{2}$]	CIV702.2	L1
4	Calculate the compressive resistance of a compound column consisting of ISHB 300 with one cover plate of 350 x 20 mm on each flange and having a length of 5m as shown in figure Fig Q4. Assume that the bottom of the column is fixed and top is rotation fixed, translation free and fy = 250 MPa.	[$12\frac{1}{2}$]	CIV702.3	L3

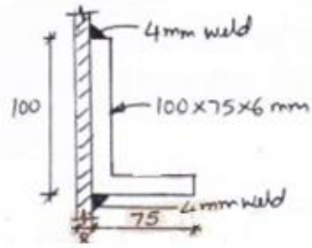


Fig Q3

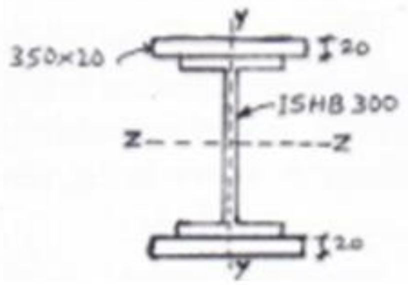


Fig Q4

		MARKS	CO	RBT
5	Design a built up column consisting of two channel section placed back to back carrying an axial factored load of 1400kN. Effective length of column is 5m. Also design single lacing system.	[$12\frac{1}{2}$]	CIV702.3	L3

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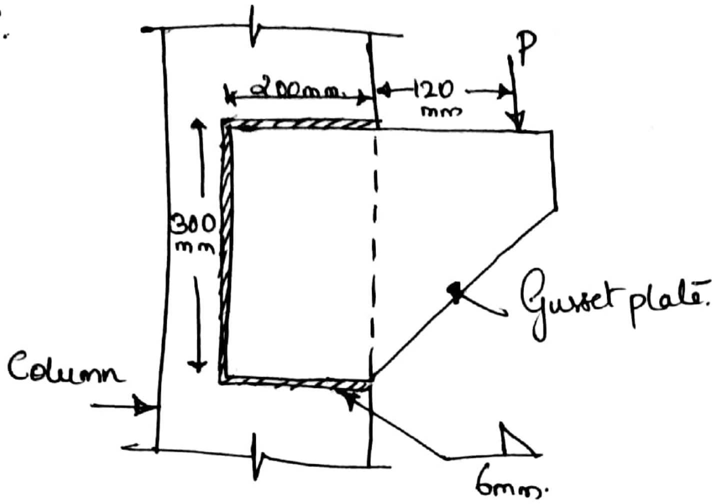
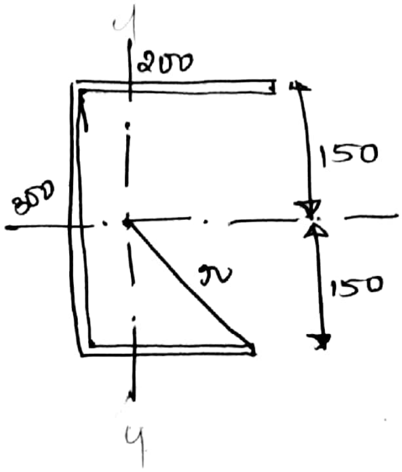
DSS – 10CV72 – IInd IA SOLUTION – NOV2017

Q.1).





Solution

Total length of weld = 2×200 + 300 = 700 mm.

$t = 0.7 \times s = 0.7 \times 6 = 4.2\ mm$

$$\bar{x} = \frac{(2\times200\times t)\times100 + (300\times t)\times0}{(2\times200\times t) + (t\times300)} = 57.143\ mm.$$

Eccentricity $\bar{e} = 120 + 200 - 57.143$

$= 262.86\ mm.$

$\therefore M = P\times\bar{e} = P\times262.86$

$\therefore r = \sqrt{142.86^2 + 150^2} = 207.145\ mm$

$$I_{xx} = 2\left[\frac{200\times t^3}{12} + (200\times t)\times(150^2)\right] + \left[\frac{t\times300^3}{12} + (t\times300\times0)\right] = 11.25\times10^6\ t\ mm^4$$

$$I_{yy} = 2\left[\frac{t\times200^3}{12} + (t\times200)\times42.857^2\right] + \left[\frac{300\times t^3}{12} + (300\times t)\times57.143^2\right]$$

$= 3.048\times10^6\ t\ mm^4$

$I_p = I_x + I_y = (11.25 \times 10^6 + 3.048 \times 10^6)\,t$

$= 14.297 \times 10^6\, t$

$= 14.297 \times 4.2 = \underline{60.05 \times 10^6\ mm^4}$

$f_1 = \dfrac{P}{l \times t} = \dfrac{P}{700 \times 4.2} = 3.4 \times 10^{-4}\, P$

$f_2 = \dfrac{M \cdot r}{I_p} = \dfrac{262.86 P \times 207.145}{\times 10^6} = 9.067 \times 10^{-4} P$

$f_R = \sqrt{f_1^2 + f_2^2 + 2 f_1 f_2 \cos\theta} = \dfrac{f_u}{\sqrt{3}\,\gamma_{mw}}$

$\cos\theta = \dfrac{142.857}{207.145} = 0.69$

$\therefore f_R = \sqrt{(3.4 \times 10^{-4} P)^2 + (9.067 \times 10^{-4} P)^2 + 2 \times 3.4 \times 10^{-4} P \times 9.067 \times 10^{-4} P \times 0.69}$

$\dfrac{410}{\sqrt{3} \times 1.25} = 1.167 \times 10^{-3}\, P$

$\therefore P = 162.19\ kN$

<u>Q.2</u>

Factored load $= 1.5 \times 200 = 300\ kN$.

$T_{dn} = \alpha \cdot A_n \cdot \dfrac{f_u}{\gamma_{m1}}$

$300 \times 10^3 = 0.8 \times A_n \times \dfrac{410}{1.25}$

$\therefore A_n = 1143.3\ mm^2$

Increasing the above value approximately by 30%.

$A_g = 1.3 \times 1143.3 = 1486.3\ mm^2 \approx 14.86\ cm^2$

Try ISA 100×65×10 @ 12.2 kg/m
$a = 15.51 cm^2$

b) Given M18, ~~4.6~~ bolts (assuming 4.6 grade bolts).

$d = 18mm$, $d_o = 20mm$.
$e = 1.5 d_o = 30mm$.
$p = 2.5d = 45mm$
$f_u = 400 N/mm^2$

Shear capacity of bolt

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

$$= \frac{400}{\sqrt{3}\times 1.25}(1\times 0.78 \times \pi/4 \times 18^2)$$

$$= 36.67 \times 10^3 N = 36.67 kN.$$

Bearing Capacity of bolt (Assuming 10mm thk. gusset plate)

$$V_{dpb} = \frac{1}{\gamma_{mb}}[2.5 k_b d t \cdot f_u]$$

$$k_b = \frac{e}{3d_o} = 0.5$$

$$= \frac{p}{3d_o} - 0.25 = 0.5$$

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

$$= 1$$

$\therefore k_b = 0.5$

$$\therefore V_{dpb} = \frac{1}{1.25}(2.5\times 0.5 \times 18 \times 10 \times 410) = 73.8 kN$$

$\therefore$ Bolt value $= \underline{\underline{36.67 kN}}$.

$\therefore$ No. of bolts $= \frac{300}{36.67} = 8.2 \approx 9$ bolts.

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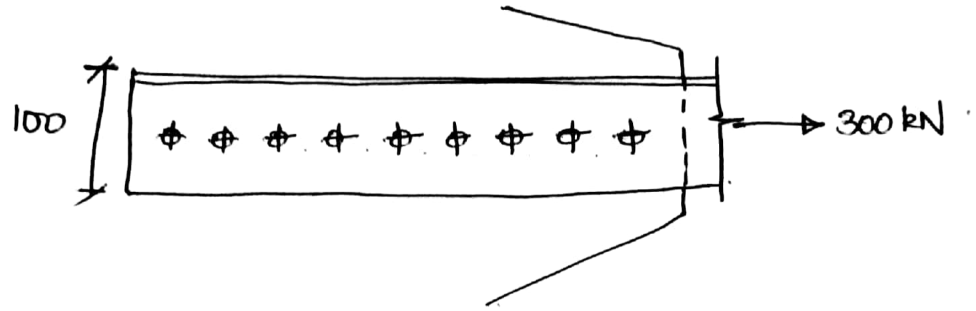


Check for yield strength

$T_{dg} = \frac{A_g f_y}{\gamma_{m0}} = \frac{1551 \times 250}{1.1} = 352.5 \text{ kN} > 300 \text{ kN}$. Hence Safe.

Check for rupture strength

$T_{dn} = \frac{0.9 A_{nc} f_u}{\gamma_{m1}} + \frac{\beta A_{go} f_y}{\gamma_{m0}}$

$\therefore \beta = 1.4 - 0.076 (w/t)(f_y/f_u)(b_s/L_c) \le (f_u \gamma_{m0} / f_y \gamma_{m1})$.
≥ 0.7.

where,
$w = 65\text{mm}$, $t = 10\text{mm}$, $f_y = 250\text{MPa}$, $f_u = 410\text{MPa}$.

$b_s = w + w_1 - t$
$= 65 + 60 - 10 = 115 \text{ mm}$.

$L_c = 8 \times 45 = 360\text{mm}$.

$A_{go} = (B - t/2) \times t = (65 - 10/2) \times 10 = 600\text{mm}^2$

$A_{nc} = (A - d_0 - t/2) \times t = (100 - 20 - 10/2) \times 10 = 750\text{mm}^2$.

$\beta = 1.4 - 0.076 (65/10)\left(\frac{250}{410}\right)\left(\frac{115}{360}\right) = 1.304 \le 1.44$
≥ 0.7

$T_{dn} = \frac{0.9 \times 750 \times 410}{1.25} + \frac{1.304 \times 600 \times 250}{1.1}$

$= 399.22 \text{ kN} > 300 \text{ kN}$ Hence Safe.

Check for block shear

$$T_{db1} = \left[A_{vg} f_y / (\sqrt{3}\,\gamma_{m0}) + 0.9 A_{tn} f_u / \gamma_{m1}\right]$$

or

$$T_{db2} = \left[\frac{0.9 A_{vn} f_u}{\sqrt{3}\,\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}\right]$$

$A_{vg} = L_v \times t = (390 \times 10) = 3900\ mm^2$

$A_{vn} = [390 - (8.5 \times 20)] \times 10 = 2200\ mm^2$

$A_{tg} = L_t \times t = (40 \times 10) = 400\ mm^2$

$A_{tn} = (40 - 0.5 \times 20) \times 10 = 300\ mm^2$

$$T_{db1} = \left[\frac{3900 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 300 \times 410}{1.25}\right]$$

$= \underline{600.3\ kN}$ $> 300\ kN$

$$T_{db2} = \left[\frac{0.9 \times 2200 \times 410}{\sqrt{3} \times 1.25} + \frac{400 \times 250}{1.1}\right]$$

$= 465.86\ kN > 300\ kN$

Hence safe

Check for reversal of stresses

ISA $100 \times 65 \times 10$ mm

$\therefore r_{xx} = 31.4$ mm

$r_{yy} = 18.1$ mm

$r_{vv} = 33.5$ mm

$r_{uu} = 13.8$ mm.

$\therefore r_{min} = \underline{13.8\ mm}$

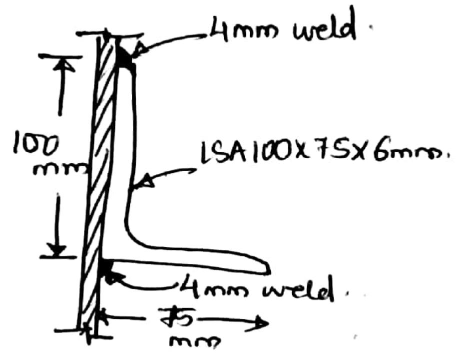
$l_{eff} = 0.85 \times l = 0.85 \times 3500 = 2975 mm.$

∴ Slenderness ratio $= \lambda = \dfrac{l_{eff}}{r_{min}} = \dfrac{2975}{13.8}$

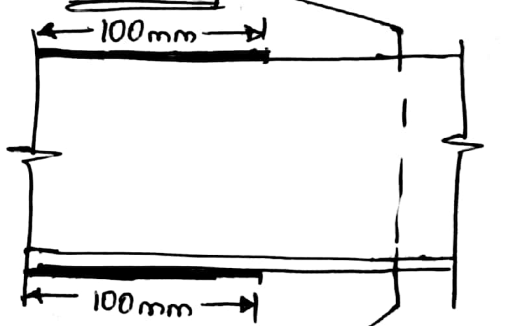
$= 215.57 < 350$ (safe).

Hence adopt ISA 100 65 10mm along with 9 nos of 4.6 grade M18 bolts.

Q.3)



Assuming



i) Design strength due to yielding

$A_g = 10.14 \, cm^2 = 1014 \, mm^2$

$T_{dg} = \dfrac{A_g f_y}{\gamma_{mo}}$

$= \dfrac{1014 \times 250}{1.1} = \underline{230.45 \text{ kN}}$

ii) Design strength due to rupture

$w = 75mm, \quad t = 6mm, \quad b_s = 75mm.$

$L_c = l_1 + l_2 = 100 + 100 = 200mm.$

$A_{go} = (B - t/2) \times t = (75 - 6/2) \times 6 = 432 mm^2$

$A_{nc} = (A - t/2) \times t = (100 - 6/2) \times 6 = 582 mm^2$

$\beta = 1.4 - 0.076 \times \left(\dfrac{75}{6}\right) \times \left(\dfrac{250}{410}\right) \times \left(\dfrac{75}{200}\right)$

$= 1.183 \leq 1.4432$

≥ 0.7

$T_{dn} = \dfrac{0.9 \times 582 \times 410}{1.25} + \dfrac{1.183 \times 432 \times 250}{1.1} = \underline{287.955 \text{ kN}}$

iii) Design block shear strength

$L_v = 200mm$

$L_t = 100mm$

$A_{vg} = L_v \times t = 200 \times 6 = 1200mm^2 = A_{vn}$

$A_{tg} = A_{tn} = L_t \times t = 100 \times 6 = 600mm^2$

$$T_{db_1} = \left[\frac{A_{vg} f_y}{\sqrt{3}\gamma_{mo}} + \frac{0.9 A_{tn} f_u}{\gamma_{m_1}}\right]$$

$$= \left[\frac{1200 \times 250}{\sqrt{3} \times 1.1} + \frac{0.9 \times 600 \times 410}{1.25}\right]$$

$$= \underline{334.6 kN}$$

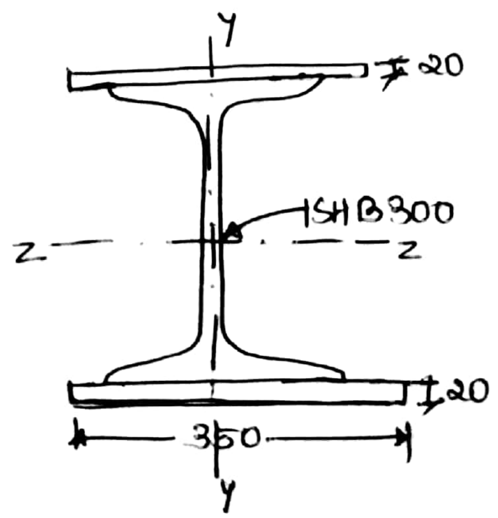
$$T_{db_2} = \left[\left(\frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m_1}}\right) + \left(\frac{A_{tg} f_y}{\gamma_{mo}}\right)\right]$$

$$= \left[\frac{0.9 \times 1200 \times 410}{\sqrt{3} \times 1.25} + \frac{600 \times 250}{1.1}\right]$$

$$= \underline{340.89 kN}$$

Design tensile strength $= \underline{230.45 kN}$

Q.4)



Section properties of ISHB300

$A = 7485mm^2$

$h = 300mm$

$b_f = 250mm$

$t_f = 10.6mm$

$t_w = 7.6mm$

$I_{zz} = 12545.2 \times 10^4 mm^4$

$I_{yy} = 2193.6 \times 10^4 mm^4$

Buckling Classification

For built-up member → buckling class 'c'

$$I_{builtup\,xx} = I_{xx\,ISHB} + 2(I_{xx\,plate})$$

$$= 12545.2 \times 10^4 + 2\left[\frac{350 \times 20^3}{12} + (350 \times 20) \times 160^2\right]$$

$$= 484.32 \times 10^6 \text{ mm}^4$$

$$I_{builtup\,yy} = I_{yy\,ISHB} + 2(I_{yy\,plate})$$

$$= 2193.6 \times 10^4 + 2\left[\frac{20 \times 350^3}{12}\right]$$

$$= 164.85 \times 10^6 \text{ mm}^4$$

$$\therefore I_{min} = 164.85 \times 10^6 \text{ mm}^4$$

$$\therefore r_{min} = \sqrt{\frac{I_{min}}{A_{builtup}}}$$

$$A_{builtup} = A_{ISHB300} + 2A_{plate}$$

$$= 7485 + 2(350 \times 20)$$

$$= 21485 \text{ mm}^2$$

$$\therefore r_{min} = \sqrt{\frac{164.85 \times 10^6}{21485}} = 87.6 \text{ mm}$$

$$\therefore \lambda = \frac{kl}{r_{min}} = \frac{1.2 \times 5000}{87.6} = 68.5$$

Referring table 9(c) for $f_y = 250$.

kl/r	f_{cd}
60	168
68.5	154.4 MPa
70	152

$\therefore$ $P_d = A_e \cdot f_{cd} = 21485 \times 154 \cdot 4$

$= 3317.284 \text{ kN}$