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Test I – September 2016

Sub:	Design of Steel Structures						Code:	10CV72
Date:	06/08/ 16	Duration:	90 mins	Max Marks:	50	Sem: VII	Branch:	CV

Note: **Use of IS 800:2007 and steel table is permitted. Sketch figures wherever necessary**
Assume any missing data suitably.

Answer any TWO FULL questions from part A and ONE question from part B:

PART A

Q1) a) What are the advantages and disadvantage of steel structures. Explain different types steel products.**(10m)**
b) With the help of neat sketches, explain the mode of failure of Bolted Joint. **(10m)**

Q2) a) Explain different types of steel sections based on the process of manufacturing. What are finished and Unfinished Bolts. **(10m)**
b) What are the failure criteria for structural steel, With sketches explain different types of bolted arrangement. **(10m)**

Q3) Two ISF section 200mm X 10mm each and 1.5m long are to be jointed to make a member length of 3.0m. Design a butt joint with the bolts arranged in the diamond pattern. The flat are supposed to carry a service load 300KN. Steel is of grade Fe410. 20mm diameter bolts of grade 4.6 are used to make the connections. Also, determine the net tensile strength of the main plate and cover plate. **(20m)**

PART B

Q4) Calculate the strength of joint of a 20mm diameter bolt of grade 4.6. The thickness of the main plate is 12mm. The joint is Butt connection with cover plate thickness 8mm. **(10m)**

Q5) Explain the Limit state method of design for steel structures. How do you calculate the bolt value using IS 800:2007. **(10m)**

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$A_n = (\quad\quad)$

Net strength of plate per pitch length.

$= 0.9 \times \frac{f_u}{\gamma_{m1}} \times (p - d_h) t$

Eq. 32 $T_{nd} = 0.9 \frac{f_u}{\gamma_{m1}} A_n$ $= 0.9 \times \frac{410}{1.25} (100 - 22) \times 10 \times 10^{-3}$

$= \underline{230.25 \text{ kN}}$.

Hence, the strength of the joint per pitch length

$= \underline{90.52 \text{ kN}}$.

Strength of solid plate per pitch length,

$= 0.9 \times \frac{410}{1.25} \times 100 \times 10 \times 10^{-3} = \underline{295.2 \text{ kN}}$

Efficiency of the joint,

$= \frac{90.52}{295.2} \times 100 = \underline{30.66\%}$.

(3). Two ISF section 200mm × 10mm each and 1.5m long are to be jointed to make a member length of 3.0m. Design a butt joint with the bolts arranged in the diamond pattern. The ~~pla~~ flates are supposed to carry a factored tensile force of 450kN. Steel is of grade Fe410. 20mm diameter bolts of grade 4.6 are used to make the connections. Also, determine the net tensile strength of the main plate and cover plate.

Soln

For Fe410 grade of steel. $f_u = 410\ MPa$

For Bolts of grade 4.6 $f_{ub} = 400\ MPa$

For 20mm diameter bolts, $A_{nb} = 245\ mm^2$

d_h and $d_o = 22\ mm$.

γ_{mb} = Partial safety factor for material of bolt = 1.2

γ_{m1} = Partial safety factor for resistance governed by ultimate stress = 1.25

Let us, provide a double-cover butt joint.

Strength of the bolt in double shear,

$$V_{sb} = 2 \times A_{nb} \frac{f_{ub}}{\sqrt{3}\,\gamma_{mb}} = 2 \times 245 \times \frac{400}{\sqrt{3} \times 1.25} \times 10^{-3} = 90.52\ kN$$

Strength of the bolt in bearing,

$$V_{pb} = 2.5\, k_b\, d\, t\, \frac{f_u}{\gamma_{mb}}$$

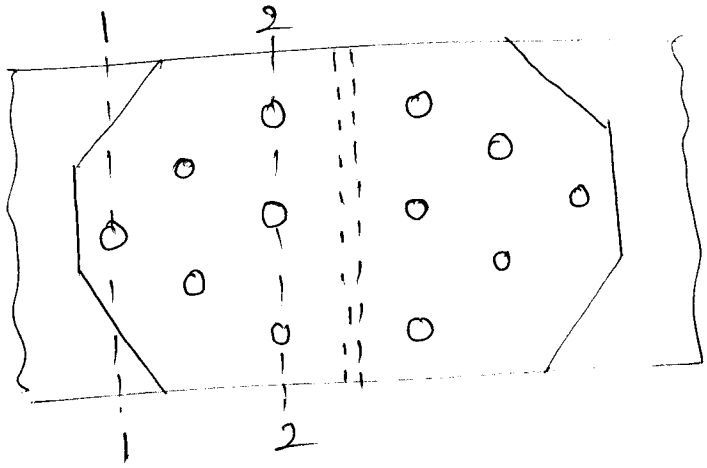
Here, k_b is least of $\frac{e}{3d_o} = \frac{33}{3 \times 22} = 0.5$,

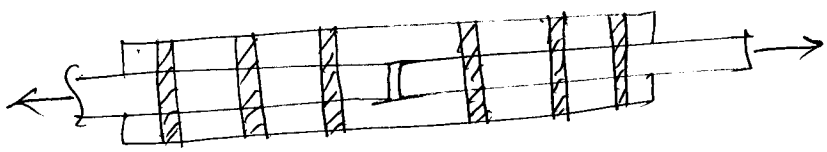
$\frac{p}{3d_o} - 0.25 = \frac{50}{3 \times 22} - 0.25 = 0.5$, $\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975$

or 1.0,

Hence, $k_b = 0.50$.

end distance, e has been assumed to be for rolled edge. ~~from~~ ~~to~~ Also, Minimum pitch = 2.5×20 = 50mm has been assumed.





Strength of bolt in bearing,

$$V_{Pb} = 2.5 \times 0.5 \times 20 \times 10 \times \frac{400}{1.25} \times 10^{-3} = 80\,kN.$$

Hence, strength of the bolt = 80.0 kN.

Number of bolts required to make the joint.

$$= \frac{450 \times 10^{3}}{80} = 5.62 \simeq 6.$$

Arrange the bolt in the diamond pattern as shown figure. Thickness of the cover plate $\geq \frac{5}{8} t$.

$$t_{cp} = \frac{5}{8} \times 10 = 6.2 \simeq 8\,mm.$$

provide 8mm thick cover plate to make a double cover butt joint.

The Tensile strength of the main plate will be critical at section 1–1.

$$T_{dn} = 0.9 \frac{f_u}{\gamma_{m1}} (b - n d_h)\, t = 0.9 \times \frac{410}{1.25} (200 - 1 \times 22) \times 10 \times 10^{-3}$$

$$= 525.45\,kN.$$

The tensile strength of the cover plate will by critical at section 2-2.

$$T_{nd2} = 0.9 \frac{f_u}{\gamma_{m1}} (b - n d_h) t = 0.9 \times \frac{410}{1.25} (200 - 3 \times 22) \times 16$$

$$= \underline{632.90 \text{ kN}}$$

(4) Two framing angles ISA 150mm × 150mm × 10mm are used to make beam to column connection. One Angle is placed on either side of the web of the beam as shown in figure. Three bolt of 16mm diameter and of 4.6 grade are used to connect the angle legs to the beam web. Determine the reaction that can be transferred through the joint. Given,

Column section ISHB 300 @ 618.3 N/m, $t_f = 10.6$ mm

Beam section ISMB 300 @ 514.04 N/m, $t_w = 8.1$ mm

Soln

For Fe410 grade of steel; $f_u = 410 \text{ MPa}$.

For Bolts of grade 4.6, $f_{ub} = 400 \text{ MPa}$.

For 16mm ϕ bolt; $A_{nb} = 157 \text{ mm}^2$.

d_h and $d_o = 18$ mm.

γ_{mb} = Partial safety factor for material of bolt = 1.25.

γ_{m1} = Partial safety factor for resistance governed by ultimate stress = 1.25

The bolts for making framed connection of angle legs with web of the beam will be in double shear and bearing

$$V_{sb} = 2 A_{nb} \frac{f_{ub}}{\sqrt{3}\gamma_{mb}} = 2 \times 157 \times \frac{400}{\sqrt{3} \times 1.25} \times 10^{-3} = \underline{58\ kN}$$

Strength of bolt in bearing,

$$V_{pb} = 2.5\, k_b\, d\, t\, \frac{f_u}{\gamma_{mb}} \quad (f_u \text{ will be least of } f_u \text{ \& } f_{ub})$$

Let end distance $e = 40\ mm$ & pitch $= 65$ $(> 2.5 \times 20)$

k_b is least of

$$\frac{e}{3d_o} = \frac{40}{3 \times 18} = 0.7 \qquad \frac{p}{3d_o} - 0.25 = \frac{65}{3 \times 18} - 0.25 = 0.73$$

$$\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975, \quad 1.0$$

Strength of bolt in bearing on web of

$$V_{pb} = 2.5 \times 0.7 \times 16 \times 8.1 \times \frac{400}{1.25} = \underline{76.72\ kN}$$

Hence, the strength of one bolt, $= \underline{58.0\ kN}$

Since three bolts have been provid, maximum end reaction that can be transferred $= 3 \times 58 = \underline{174.0\ kN}$