19402

**21718**

**3 Hours / 100 Marks** Seat No. | | | | | | | | |

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***Instructions :*** (1) All Questions are *compulsory.*

(2) Answer each next main Question on a new page.

(3) Illustrate your answers with neat sketches wherever necessary.

(4) Figures to the right indicate full marks.

(5) Assume suitable data, if necessary.

(6) Use of Non-programmable Electronic Pocket Calculator is permissible.

(7) Mobile Phone, Pager and any other Electronic Communication devices are not permissible in Examination Hall.

(8) Use of IS:800 – 2007 is permitted.

**Marks**

**1. Attempt any FIVE of the following :** **$5 \times 4 = 20$**

(a) Draw neat sketch of unequal angle section and channel section with their geometric properties.

(b) State the various loads considered in design of steel structure. State two IS codes used in design of steel structure.

(c) Define effective length of weld. State how to calculate length of weld required.

(d) Define pitch of rivets and state minimum and maximum pitch values as per IS code.

(e) List types of failures in tension members and describe any one of them.

(f) When lacing is provided for column ? Give the function of lacing.

(g) Differentiate between slab base and gusseted base.

**2. Attempt any TWO :** **$2 \times 8 = 16$**

(a) A single rivetted lap joint is to be provided for connecting 12 mm thick plate using 20 mm diameter rivets. Calculate the minimum pitch of the rivets for maximum strength of joints. The allowable stress in shearing, bearing and tearing are 100 MPa, 300 MPa and 150 MPa respectively. Also calculate efficiency of joint.

(b) Design a lap joint between the plates of sizes $100 \times 16$ mm thick and $100 \times 10$ mm so as to transmit a factored load of 110 kN using single row of 16 mm dia. power driven rivets. For PDR $\lambda_{vf} = 100$ MPa, $\lambda_{pf} = 300$ MPa.

(c) A single rivetted single cover butt joint is used to connect two plates of 12 mm thick. Calculate the strength and efficiency of joint if PDS rivets at 75 mm pitch are used. $\lambda_{pf} = 300$ MPa and $\lambda_{vf} = 100$ MPa.

**3. Attempt any TWO of the following : $2 \times 8 = 16$**

(a) A diagonal member of the truss is an ISA 65 × 65 × 6 mm, welded in field to a gusset plate 8 mm thick, the grade of steel used for angle is Fe 410. Design the joint to the full strength of angle.

(i) If field weld is provided along the length of the member.

(ii) If field weld is provided along all sides of angle.

Area of angle = 744 $mm^2$ and distance of CG from its head 18.1 mm.

(b) A tie member 75 mm × 8 mm has to transmit an axial load of 90 kN. Design the fillet weld and calculate the necessary overlap. Consider the weld on all four sides.

(c) (i) Find the length of 8 mm thick fillet weld to connect tie 100 mm × 12 mm to 16 mm thick gusset plate. Consider full strength of plate.

(ii) A single angle 150 × 90 × 10 mm is used as a tension member. Connected to 12 mm thick gusset plate at ends with 5 of 18 mm dia. rivets. Rivets are pitched at 50 mm. Find the net area of longer leg connected to gusset plate.

**4. Attempt any TWO of the following : 2 × 8 = 16**

(a) Design a tie member using suitable equal angle section to carry a tensile factored load of 210 kN. The connection are with 20 mm dia. rivets and 12 mm thick gusset plate. Design strength of 20 mm dia. rivets = 45.3 kN. $f_y$ = 250 MPa, $f_u$ = 410 MPa, α = 0.8 sections available.

| **ISA (mm)** | **Area ($mm^2$)** |
|---|---|
| 90 × 90 × 8 | 1137 |
| 100 × 75 × 6 | 1014.0 |
| 125 × 75 × 6 | 1166 |

(b) An unequal angle 1.5 m long of a truss is connected to the gusset plate. It carries ultimate tension of 230 kN. Design the section using 4 mm weld. Assume $f_y$ = 250 MPa and $f_y$ = 410 MPa. (Use properties of ISA given above)

(c) A tension member consists of 2 ISA 90 × 90 × 8 mm connected back to back with 10 mm thick gusset plate by 20 mm diameter bolts. Tacking bolts are provided. Calculate design tension load if angles are on both sides of gusset plate.

Consider $A_{nb}$ = 245 $mm^2$, $A_g$ of single ISA 90 × 90 × 8 = 1379 $mm^2$.

**5. Attempt any TWO :** **$2 \times 8 = 16$**

(a) A Strut 2.4 m long of a roof truss consists of a single angle 90 × 90 × 6 mm. Calculate load carrying capacity if it is connected to 8 mm thick gusset plate by welding. Assume properties of ISA 90 × 90 × 6 mm, $f_y = 250$ N/mm$^2$, Area = 1047 mm$^2$.

$C_{xx} = C_{yy} = 24.2$ mm, $r_{xx} = r_{yy} = 27.2$ mm, $r_w = 17.5$ mm

| KL/r | 80 | 90 | 100 | 110 | 120 | 130 |
|---|---|---|---|---|---|---|
| $f_{cd}$ (N/mm$^2$) | 136 | 121 | 107 | 94.6 | 83.7 | 74.4 |

(b) Design a double angle discontinuous strut to carry a factored load of 140 kN. The length of strut is 4.0 m between intersections. The two angles are placed back to back (with long legs connected) and are tack bolted. Use steel grade of Fe 410.

(i) Angles are placed on opposite sides of 12 mm gusset plate.

(ii) Angles are placed on same side of 12 mm gusset plate.

| **Section** | **wt/m (kg/m)** | **area mm$^2$** | **$r_{xx} = r_{yy}$** | **$c_{xx}$** |
|---|---|---|---|---|
| 70 × 70 × 6 | 6.33 | 806 | 21.9 | 19.4 |
| 75 × 75 × 6 | 6.80 | 866 | 23.0 | 20.6 |
| 80 × 80 × 6 | 7.29 | 929 | 24.6 | 21.8 |
| 90 × 90 × 6 | 8.22 | 1047 | 27.7 | 24.2 |

Refer Q. 5 (a) for S.R. & $f_{cd}$ values.

(c) A column consists of 2 ISMC – 200 placed back to back at clear spacing of 150 mm. Calculate its design load carrying capacity if its actual length is 5 m with one end fixed and other hinged.

The properties of ISMC – 200 are

Area = 2821 $mm^2$

$I_{xx} = 18.193 \times 10^6$ $mm^4$

$I_{yy} = 1.403 \times 10^6$ $mm^4$

$C_{yy} = 21.7$ mm

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Slenderness ratio | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 |
| $f_{cd}$ (MPa) | 227 | 224 | 211 | 198 | 183 | 168 | 152 | 136 |

**6. Attempt any TWO :** **2 × 8 = 16**

(a) A column ISMB 300 carries an axial load of 1.58 MN. Design a slab bases and concrete pedestal for the column. Take the SBC of soil is 200 kPa and M20 grade of concrete is used for concrete pedestal. For ISMB 300, consider $b_f = 140$ mm and $t_f = 13.1$ mm. Take $f_y = 250$ MPa and $r_{mo} = 1.1$.

(b) (i) Define Gusseted base. Also draw its neat labelled sketch showing all details.

(ii) What is the basic concept to decide the plan area of slab base and concrete block below it ? State the function of cleat angle.

(c) (i) Define radius of gyration and slenderness ratio. Also state maximum values of slenderness ratio for any two conditions of compression members.

(ii) Draw and label any four forms of built up compression members.

## IS : 800-2007 Equations (Formula Sheet)

$$V_{nsb} = \left(\frac{f_u}{\sqrt{3}}\right)(n_n A_{nb} + n_s A_{sb}) \;,\quad V_{dsb} = \frac{V_{nsb}}{\gamma_{mb}} \;,\qquad V_{dpb} = \frac{V_{npb}}{\gamma_{mb}}$$

$$T_{dg} = \frac{A_g f_y}{\gamma_{m0}} \;,\qquad V_{npb} = 2.5 k_b\, d\, t\, f_u$$

$$T_{dn} = \frac{0.9 A_{nc} f_u}{\gamma_{m1}} + \beta \frac{A_{go} f_y}{\gamma_{m0}}$$ where $\beta = 1.4 - 0.076\,(w/t)\,(f_y/f_u)\,(bs/L_c) \quad \le (f_u \gamma_{mo}/f_y \gamma_{m1})$

$\ge 0.7$

$$T_{dn} = \frac{\alpha A_n f_u}{\gamma_{m1}} \;,\quad T_{db1} = \frac{A_{vg} f_y}{\sqrt{3}\gamma_{m0}} + \frac{0.9 A_{tn} f_u}{\gamma_{m1}} \;,\quad T_{db2} = \frac{0.9 A_{vn} f_u}{\sqrt{3}\gamma_{m1}} + \frac{A_{tg} f_y}{\gamma_{m0}}$$

$$P_d = A_e f_{cd} \;,\qquad P_z = 0.6\, V_Z^{\,2} \;,\qquad V_z = V_b\, k_1\, k_2\, k_3$$

$$f_{cd} = \chi \frac{f_y}{\gamma_{m0}} \;,\qquad \chi = \frac{1}{\phi + \sqrt{\phi^2 - \lambda_e^2}}$$ , where $\phi = 0.5[1 + \alpha(\lambda_e - 0.2) + \lambda_e^2]$

$$\lambda_e = \sqrt{k_1 + k_2 \lambda_{vv}^2 + k_3 \lambda_\varphi^2}$$

where $$\lambda_{vv} = \frac{\left(\frac{l}{r_{vv}}\right)}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}}$$ and $$\lambda_\varphi = \frac{(b_1 + b_2)/2t}{\varepsilon\sqrt{\frac{\pi^2 E}{250}}}$$

$$t_s = \sqrt{[2.5 w (a^2 - 0.3 b^2)\gamma_{m0} / f_y]} \;> t_f$$

*Values of $\chi$ and $f_{cd}$ ($N/mm^2$) for different values of $KL/r_{min}$ as per buckling curve 'c'*

| $KL/r_{min}$ | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|
| $\chi$ | 1.000 | 0.987 | 0.930 | 0.870 | 0.807 | 0.740 | 0.670 | 0.600 | 0.533 |
| $f_{cd}$ | 227 | 224 | 211 | 198 | 183 | 168 | 152 | 136 | 121 |

| $KL/r_{min}$ | 100 | 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 |
|---|---|---|---|---|---|---|---|---|---|
| $\chi$ | 0.471 | 0.416 | 0.368 | 0.327 | 0.291 | 0.261 | 0.234 | 0.212 | 0.192 |
| $f_{cd}$ | 107 | 94.6 | 83.7 | 74.3 | 66.2 | 59.2 | 53.3 | 48.1 | 43.6 |