DESIGN OF STEEL STRUCTURES
(CIVL 3201)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

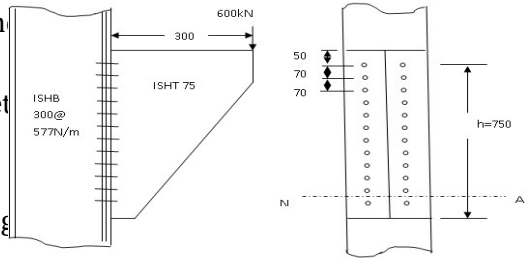
N.B.: STUDENTS ARE ALLOWED TO USE RELEVANT CODES SUPPLIED

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) High strength bolts are design
(a) friction (b) tension

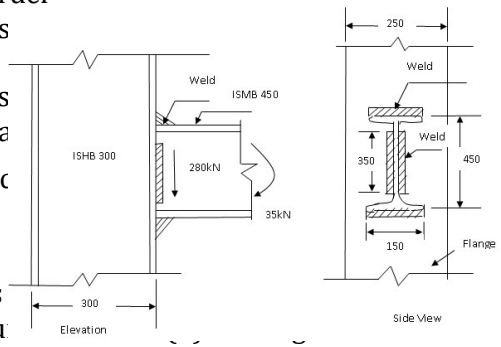
(ii) The effective width of the fillet
(a) total length-2x throat size
(c) 0.7x weld size



(iii) Angle of inclination of lacing preferably in between
(a) 10^0 to 30^0 (b) 30^0 to 40^0 (c) 40^0 to 70^0 (d) 90^0.

(iv) The design compressive stress of an axially loaded compression member in IS:800-2007 is given by
(a) Rankine's formula (b) Secant formula
(c) Merchant-Rankine's formula (d) Perry Robert son formula.

(v) Stiffeners are used in a plate girder
(a) to reduce the compressive s
(b) to reduce the shear stress
(c) to reduce the bearing stress
(d) to avoid buckling of web pla



(vi) In rolled steel beams, shear forc
(a) web only
(c) web and flanges together

(vii) Web crippling generally occurs
(a) bending moment is maximu
(c) concentrated load acts (d) deflection is maximum.

(viii) As per IS: 800 – 2007, the partial factor of safety for material resistance governed by yielding (γ_{m0}) is
(a) 1.20 (b) 1.10 (c) 1.30 (d) 1.40.

(ix) The ratio of plastic section modulus to elastic section modulus
(a) is equal to 1 (b) is always less than 1
(c) is always greater than 1 (d) can be less than 1.

(x) What horizontal traction force acts along the rails of a gantry girder due to applying brakes of the crane girder?
(a) 20 percent of all static wheel loads
(b) 15 percent of all static wheel loads
(c) 10 percent of all static wheel loads
(d) 5 percent of all static wheel loads.

Group – B

2. Design a suitable bolted bracket connection of a ISHT-75 section attached to the flange of a ISHB 300 at 577 N/m to carry a vertical factored load of 600 kN at an eccentricity of 300 mm shown in fig.1. For ISHB 300 (t_f) and (t_w) are 10.6 mm and 7.6 mm and for ISHT 75 (t_f) and (t_w) are 9.0 mm and 8.4 mm respectively. Use M24 bolts of grade 4.6.

Fig.1

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3. (a) The tie member of a truss is made of ISA 75 × 75 × 6 mm and is subjected to a factored load of 100 kN. Design a welded joint if thickness of the gusset plate is 8 mm.

(b) Determine the size of weld for a connection as shown in fig.2. Assume site welding, the joint is subjected to a factored shear force of 280 kN and factored bending moment of 35 kNm. Flange thickness for ISHB 300 (t_f) =10.6 mm and for ISMB 450 (t_f) = 17.4 mm and (t_w) = 9.4 mm.

Fig.2

4 + 8 = 12

Group – C

4. Design a suitable angle section to carry a factored tensile force of 210 kN assuming a single row of M20 bolts. The yield strength and ultimate strength of the material is 250 Mpa and 410 Mpa respectively. The length of the member is 3 m. Select an angle 65 × 65 × 8 with Ag = 976 mm^2, r_{xx} = 20.2 mm and r_{yy} = 12.5 mm.

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5. (a) Determine the design axial load on column section ISMB450 @ 710.3 N/m, height of column is 4 m and it is pin-ended. Assume that f_y = 250 N/mm^2, f_u = 410 N/mm^2, E = 2 × 10^5 N/mm^2. Properties of the section: A_n = 9227 mm^2, depth of section h = 450 mm, width of flange b_f = 150 mm, thickness of flange t_f = 17.4 mm, thickness of web t_w = 9.4, radius of gyration r_{zz} = 181.5 mm, r_{yy} = 30.10 mm.

   (b) Design a gusseted base for a column ISHB350 @710 N/m with two plates 450 mm × 20 mm carrying a factored load of 2500 kN. The column is to be supported on concrete pedestal with M20 grade concrete. Properties of ISHB 350 @ 710 N/m A = 92.21 cm^2, h = 350 mm, b_f = 250 mm, t_f = 11.6 mm, t_w = 10.1 mm, Assuming ISA 150 × 150 × 15 as shoe angle and 16 mm gusset plate.

4 + 8 = 12

Group – D

6. Check the safety of an ISMB 350 @ 52.4 kg/m laterally unrestrained beam subjected to factored bending moment 100 kN-m and factored shear force 100 kN. The length of the simply supported beam is 2.0 m. Check for deflection also. Consider f_y = 250 N/mm^2, f_u = 410 N/mm^2. The properties of ISMB 350 @ 52.4 kg/m are given as follows: sectional area (A) of I – section = 66.71 cm^2, I_{xx} = 13630.3 cm^4, I_{yy} = 537.7 cm^4, width of flange (b_f) = 140 mm, thickness of flange (t_f) = 14.2 mm, thickness of web (t_w) = 8.1 mm, radii of Gyration (r_z) = 14.32 cm, (r_y) = 2.84 cm, Section Modulus (Z_{ez}) = 779.0 cm^3, Plastic modulus (Z_{pz}) = 889.57 cm^3.

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7. Determine the moment and shear capacities of a plate girder having 450 mm × 30 mm flange plate at top, 1200 mm × 15 mm web plate and 450 mm × 30 mm flange plate at the bottom. Consider f_y = 250 N/mm^2, f_u = 410 N/mm^2 and Simple Post Critical method. Calculate local capacity or bearing capacity of web also.

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Group – E

8. A welded gantry girder, without lateral restraint along its span, to be used in an industrial building carrying an overhead travelling crane is fabricated using ISMB 500 @86.9 kg/m with a channel ISMC 250@30.4 kg/m at the top. Centre-to-centre distance between columns (i.e. span of gantry girder) = 7 m. Calculate the moment capacity and buckling resistance of the gantry girder. Consider f_y = 250 N/mm^2, f_u = 410 N/mm2, E = 2 × 10^5 N/mm^2.

   The properties of ISMB 500 @ 31.2 kg/m are given as follows:
   Sectional area (a) = 110.74 cm^2, Depth of section (h) = 500 mm, Width of flange (b) = 180 mm, Thickness of flange (t_f) = 17.2 mm, Thickness of web (t_w) = 10.2 mm, Radii of Gyration (r_z) = 20.21 cm, (r_y) = 3.52 cm, Moment of inertia (I_{zz}) = 45218.3 cm^4, Moment of inertia (I_{yy}) = 1369.8 cm^4.

   The properties of ISMC 250 @ 30.4 kg/m are given as follows:
   Sectional area (a) = 38.67 cm^2, Depth of section (h) = 250 mm, Width of flange (b) = 80 mm, Thickness of flange (t_f) = 14.1 mm, Thickness of web (t_w) = 7.1 mm, Radii of Gyration (r_z) = 9.94 cm, (r_y) = 2.38 cm, Moment of inertia (I_{zz}) = 3816.8 cm^4, Moment of inertia (I_{yy}) = 219.1cm^4.

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9. A gantry column, 11 m long, is fixed at base and hinged at top. The length of the crane leg is 9 m and that for roof leg is 2 m. The axial compression on roof leg is 55 kN and that on crane leg is 950 kN. The crane leg has ISMB 500 @ 86.9 kg/m with 600 mm spacing between the columns. The roof leg uses ISMB225 @ 31.2 kg/m. Check the safety of the gantry column for axial compression only. Consider f_y = 250 N/mm^2, f_u = 410 N/mm^2, E = 2 × 10^5 N/mm^2.

   The properties of ISMB 500 @ 31.2 kg/m are given as follows:
   Sectional area (a) = 110.74 cm^2, Depth of section (h) = 500 mm, Width of flange (b) = 180 mm, Thickness of flange (t_f) = 17.2 mm, Thickness of web (t_w) = 10.2 mm, Radii of Gyration (r_z) = 20.21 cm, (r_y) = 3.52 cm, Moment of inertia (I_{zz}) = 45218.3 cm^4, Moment of inertia (I_{yy}) = 1369.8 cm^4.

   The properties of ISMB225 @ 31.2 kg/m are given as follows:
   Sectional area (a) = 39.72 cm^2, Depth of section (h) = 225 mm, Width of flange (b) =110 mm, Thickness of flange (t_f) = 11.8 mm, Thickness of web (t_w) = 6.5 mm, Radii of Gyration (r_z) = 9.31 cm, (r_y) = 2.34 cm, Section Modulus (Z_{ez}) = 305.9 cm^3, Plastic modulus (Z_{pz}) = 348.27 cm^3.

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