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.

Group – A
(Multiple Choice Type Questions)

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

(i) Which of the followings are the Yield and Ultimate stresses of a bolt of Grade 5.6?
(a) 180 MPa and 330 MPa (b) 300 MPa and 500 MPa
(c) 240 MPa and 400 MPa (d) 400 MPa and 520 MPa.

(ii) 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.

(iii) What is the value of the imperfection factor (α) for buckling class 'c'?
(a) 0.21 (b) 0.49 (c) 0.34 (d) 0.76

(iv) What is the nominal bearing strength of bolt on any plate?
(a) $2.5k_b dtf_u/\gamma_{m0}$ (b) $2.5k_b dtf_u$
(c) $2.5k_b dtf_y/\gamma_{m0}$ (d) $2.5k_b dtf_u/\gamma_{mb}$.

(v) What is the buckling class of built – up members?
(a) a (b) b (c) c (d) d.

(vi) What is the effective length of a column of length 'L' and fixed at one end and propped at the other end?
(a) 2L (b) 0.8L (c) 0.65L (d) 0.7L.

(vii) What is the maximum effective slenderness ratio for a member carrying compressive loads resulting from dead loads and imposed loads?
(a) 250 (b) 180 (c) 300 (d) 400.

(viii) The partial safety factor for the material of bolts is
(a) 1·0 (b) 1·10 (c) 1·15 (d) 1·25.

(ix) The slenderness ratio of lacing bar shall not exceed
(a) 135 (b) 145 (c) 155 (d) 165.

(x) The design bending strength of a laterally unsupported beam is given by
(a) $\beta_b Z_p f_y / \gamma_{m0}$ (b) $\beta_b Z_p f_{bd} / \gamma_{m0}$
(c) $\beta_b Z_p f_{bd} / \gamma_{m0}$ (d) $Z_p f_{bd} / \gamma_{m0}$.

Group- B

2. Design a connection to joint two plates of 250 × 12 mm of grade Fe 410 to mobilize full plate tensile strength using shop fillet welds, if: (i) a lap joint is used (ii) a doubly cover butt joint is used. [(CO1)(Create/HOCQ)] **12**

3. A bracket plate bolted to a vertical column is loaded as shown in Fig.1. If M 20 bolts of grade 4.6 are used, evaluate the maximum value of factored load P which can be carried safely. For ISHB 300 flange thickness (t_f) = 10.6 mm and (t_w) = 9.4 mm.

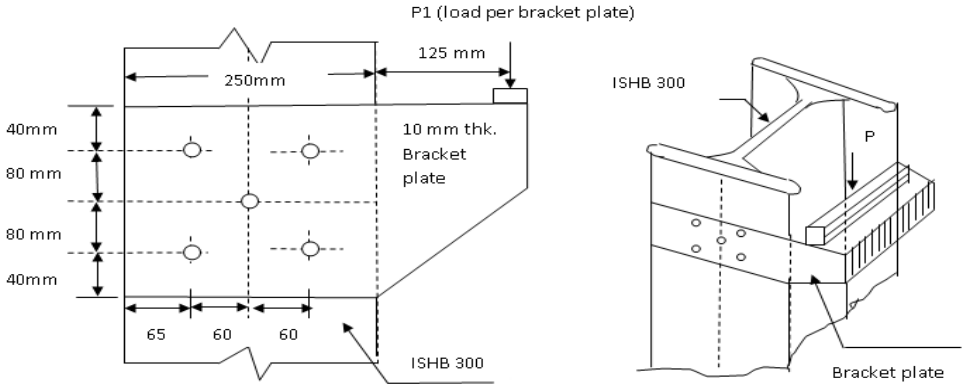

Fig. 1

[(CO1)(Evaluate/HOCQ)] **12**

Group - C

4. (a) Evaluate the tensile strength of an ISA 200 × 200 × 12 considering, "Gross Section Yielding", "Net Section Rupture" and "Block Shear Failure" for the arrangement of bolts shown in the Fig. 2. Consider f_y = 250 N/mm², f_u = 410 N/mm². Gross area of the angle is 46.61 cm². Assume thickness of gusset plate as 12 mm.

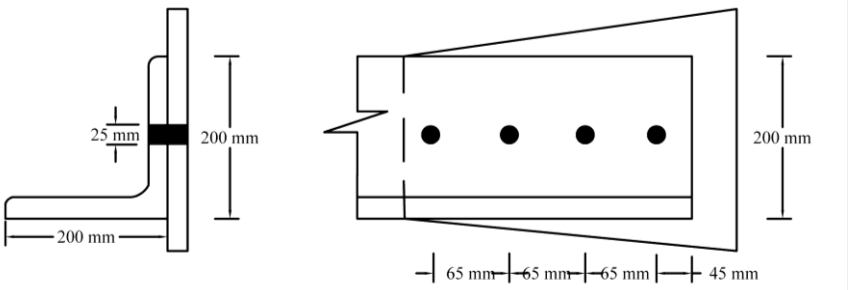

Fig. 2

[(CO1,CO2)(Evaluate/HOCQ)]

(b) Design a base plate for ISMB 300 with a factored axial load 850 kN and moment 95 kN-m. Maximum depth of base plate is restricted to 460 mm. Grade of concrete is 30 MPa.
Dimensions and properties of ISMB 300 : a = 56.26 cm^2, b = 140 mm, t_f = 12.4 mm, t_w = 7.5 mm, $I_{xx} = I_{zz}$ = 5306.6 cm^4, I_{yy} = 453.9 cm^4, $r_{xx} = r_{zz}$ = 12.37 cm, r_{yy} = 2.84 cm. [(CO4)(Create/HOCQ)]

6 + 6 = 12

5. Design a laced column 9 m long to carry a factored load of 1250 kN. The column is fixed at both the ends. Assume that the two channels are kept back-to-back. Select ISMC 350 @ 413 N/m. A = 5366 mm^2, h = 350 mm, b_w = 100 mm, t_f = 13.5 mm, t_w = 8.1 mm, $I_{xx} = I_{zz}$ = 100.88 × 10^6 mm^4, I_{yy} = 4.306 × 10^6 mm^4, $r_{xx} = r_{zz}$ = 136.60 mm, r_{yy} = 28.3, c_{yy} = 24.4 mm, guage distance g = 50 mm, design strength of 16 mm bolt is 57.54 kN.
[(CO4)(Create/HOCQ)]

12

Group - D

6. Examine the safety of an ISMB 200 @ 25.4 kg/m laterally unrestrained subjected to factored bending moment 30kN-m and factored shear force 55 kN. The length of the simply supported beam is 1.6 m. Examine for deflection also. Consider E250 (Fe410 W)A. The properties of ISMB 200 @ 25.4 kg/m are given as follows: Sectional area(a)=32.33cm^2, Depth of section(h) = 200 mm, Width of flange(b) = 100 mm, Thickness of flange(t_f) = 10.8 mm, Thickness of web(t_w) = 5.7 mm, Radii of Gyration(r_z) = 10.8 cm, r_y = 2.15 cm, Section Modulus(Z_{ez}) = 223.5 cm^3, Plastic modulus(Z_{pz}) = 253.86 cm^3 , r_1 = 11 mm. [(CO1, CO2, CO3, CO5)(Analyze/IOCQ)]

12

7. A simply supported plate girder of span 7 m. supports uniformly distributed load of w kN/m over its entire span. The compression flange is restrained throughout. Determine the factored value of 'w' and the shear capacity for the cross section : Flange plate- (200×12) mm. , Web plate - (400×5) mm. Consider fy = 250 N/mm^2, fu = 410 N/mm^2.
[(CO5)(Create/HOCQ)]

12

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 400 @ 61.6 kg/m with a ISMC 200 @ 22.1 kg/m at the top. Centre-to-centre distance between columns (i.e. span of gantry girder) =8 m. Calculate the moment capacity 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 400 @ 61.6 kg/m are given as follows:
Sectional area (a) of I – section = 78.46 cm^2, width of flange (b_f) = 140 mm , thickness of flange (t_f) = 16.0 mm, thickness of web (t_w) = 8.9 mm, I_{xx} = 20458.4 cm^4, I_{yy} = 622.1 cm^4,

Radii of Gyration (r_{xx}) = 16.15 cm, (r_{yy})= 2.82 cm, Section Modulus (Z_{xx}) = 1022.9 cm^3, (Z_{yy}) = 88.9 cm^3.

The properties of ISMC 200 @ 22.1 kg/m are given as follows:

(a) = 33.01 cm^2, (b_f) = 75 mm, (t_f) = 11.4 mm, (t_w) = 6.1 mm, (I_{xx}) = 1819.3 cm^4, (I_{yy}) = 140.4 cm^4, (r_{xx}) = 8.03cm, (r_{yy}) = 2.23 cm, (Z_{xx}) = 181.9 cm^3, (Z_{yy}) = 25.3 cm^3.

[(CO6)(Create/HOCQ)] **12**

9. (a) A gantry girder, without lateral restraint along its span, to be used in an industrial building carrying an overhead travelling crane for the following data.
Centre-to-centre distance between columns (i.e. span of gantry girder) = 7.2 m
Crane capacity = 200 kN
Self-weight of the crane girder excluding trolley = 100 kN
Self-weight of trolley, electrical motor, hook etc. = 40kN
Minimum hook approach = 1.5 m
Distance between wheel centres = 3.5 m
Centre-to-centre distance between gantry rails (i.e., span of the crane) =14 m
Self weight of the rail section = 350 N/m
Yield stress of steel = 250MPa.
Calculate the maximum bending moment and shear force on the girder.

[(CO6)(Create/HOCQ)] **12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	16.67	20.83	62.5

Course Outcome (CO):

After going through this course, the students will be able to:

1. Familiar with the material properties of structural steel, analyse the different bolted and welded connections and design them for concentric and eccentric loads.
2. Design different steel sections subjected to axial compression and tension following Indian codes of practices.
3. Comprehend the differences between laterally supported and unsupported flexure members and design of the flexure members using Indian codes of practice.
4. Analyse and design rolled and built up compression members along with base connection subjected to axial compression, bending and tension.
5. Calculate shear force and bending moment on rolled and built up girders and design it following Indian Standard design guidelines.
6. Identify different components of gantry system, calculate lateral and vertical loads acting on the system and design them.

*LOCQ: Lower Order Cognitive Question; IOCQ: Intermediate Order Cognitive Question; HOCQ: Higher Order Cognitive Question