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) The minimum pitch allowed in the code is
(a) 1.5 × diameter of bolt (b) 3 × diameter of bolt
(c) 2.5 × diameter of bolt (d) 2.7 × diameter of bolt.

(ii) For a single unequal angle tie member, the leg preferred for making connection is the
(a) shorter leg (b) longer leg
(c) any of the two (d) longer if bolted and shorter if welded.

(iii) The effective slenderness ratio of a laced column is
(a) increased by 10% (b) increased by 5%
(c) 0.8 times the actual length of column (d) 0.9 times the actual length of column.

(iv) The effective width of the fillet weld is
(a) total length-2 × throat size (b) total length-2×weld size
(c) 0.7 × weld size (d) total length-√2×weld size.

(v) Angle of inclination of lacing bar with longitudinal axis of column preferably in between
(a) 10^0 to 30^0 (b) 30^0 to 40^0 (c) 40^0 to 70^0 (d) 90^0.

(vi) In rolled steel beams, shear force is mostly resisted by
(a) web only (b) flanges only
(c) web and flanges together (d) upper flange only

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

(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) 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.

(x) 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.

Group – B

2. (a) Design a bolted lap joint between two plates of width 80 mm as shown in the Fig.1 so as to transmit a factored load of 70 kN using M16 bolts of grade 4.6 and grade 410 plates. [(CO1)(Evaluate/HOCQ)]

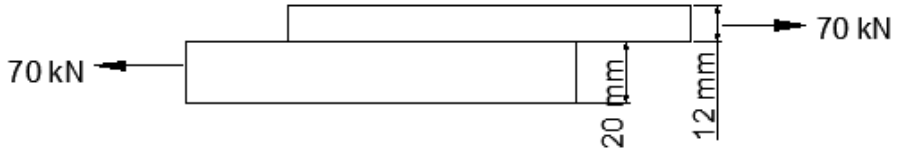

Fig.1

(b) An ISA 110 mm × 110 mm × 10 mm carries a factor tensile force of 150 kN. It is to be jointed with a 10 mm thick gusset plate. Design the joint using HSFG bolt when slip is permitted. Assume steel is of grade Fe 410. [(CO1)(Evaluate/HOCQ)]

6 + 6 = 12

3. Design a bolted bracket connection to transfer an end reaction of 300 kN with an eccentricity of 170 mm due to factored load as shown in the Fig.2. The steel used is of grade Fe 410. Use M20 bolt of 4.6 grade. The thickness of the bracket plate is 10 mm and column section is ISHB 200 @ 37.3 kg/m. (properties of ISHB 200 : a = 47.54 sq.cm, b = 200 mm, t_f = 9 mm, t_w = 6.1 mm, r_{xx} = 8.71 cm, r_{yy} = 4.51 cm, g = 100 mm). [(CO1,CO4)(Evaluate/HOCQ)]

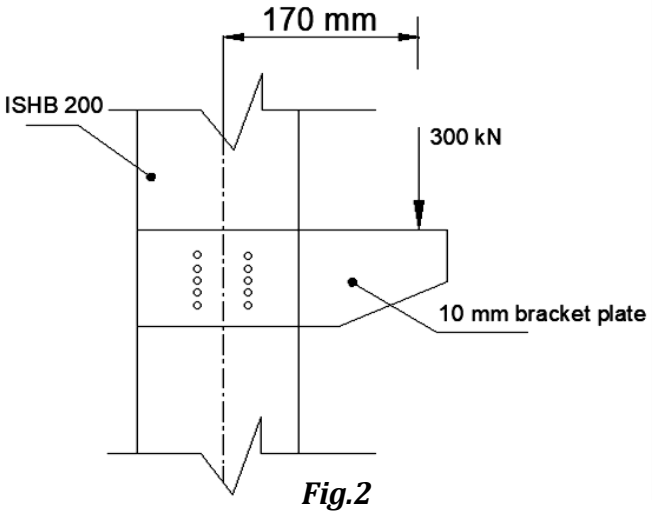

Fig.2

12

Group – C

4. (a) An ISA 75 × 50 × 8 angle of Fe 410 grade steel is connected to a 10 mm thick gusset plate by 4 numbers M18 bolts of grade 4.6. Find the design tensile strength of the angle if the gusset is connected to longer leg. (Properties of ISA 75 × 50 × 8 : a = 9.38 sq.cm, c_{xx} = 2.52 cm, c_{yy} = 1.28 cm, e_{xx} = 4.98 cm, e_{yy} = 3.72 cm, r_{xx} = 2.35 cm, r_{yy} = 1.4 cm). [(CO2)(Evaluate/IOCQ)]

(b) Determine the design axial load on the column section ISMB 400, given that the height of the column is 3.5 m and it is pin-ended. Also assume f_y = 250 N/mm^2, f_u = 410 N/mm^2, E = 2 × 10^5 N/mm^2. The properties of ISMB 400 is a = 78.46 sq.cm, b =

140 mm, t_f = 16 mm, t_w = 8.9 mm, I_{xx} = 20458.4 cm^4, I_{yy} = 622.1 cm^4, r_{xx} =16.15 cm, r_{yy} = 2.82 cm). [(CO2)(Evaluate/IOCQ)]

6 + 6 = 12

5. (a) Design the lacing member for built up columns 2 nos. ISMC 200 connected back to back subjected to factored axial load of 600 kN. Provide single lacing system with bolted connection. Properties of ISMC 200: a = 28.21 sq.cm, b = 75 mm, t_f = 11.4 mm, t_w = 6.1 mm, c_{yy} = 2.17 cm, I_{xx} = 1819.3 cm^4, I_{yy} = 140.4 cm^4, r_{xx} = 8.03 cm, r_{yy} = 2.23 cm, g = 40 mm. [(CO4)(Evaluate/HOCQ)]

   (b) Design the base plate for an ISHB 200 column to carry a factored load of 450 kN. Assume Fe 410 grade steel and M25 concrete. @ 37.3 kg/m. (properties of ISHB 200: a = 47.54 sq.cm, b = 200 mm, t_f = 9 mm, t_w = 6.1 mm, r_{xx} = 8.71 cm, r_{yy} = 4.51 cm, g = 100 mm). [(CO4)(Evaluate/HOCQ)]

6 + 6 = 12

Group – D

6. Check the adequency of a beam, without lateral restraint along its span is fabricated using ISMB 600 @1202.71 N/m. Effective span 4 m, maximum bending moment 550 kNm and maximum shear force 200 kN. Consider f_y = 250 N/mm^2, f_u = 410 N/mm^2, E = 2 × 10^5 N/mm^2.
   The relevant properties of the section are:
   Depth of section h = 600 mm
   Width of flange b_f = 210 mm
   Thickness of flange t_f = 20.8 mm
   Thickness of web t_w = 12 mm
   Radius as root r = 20 mm
   Depth of web $d = h-2(t_f+r)$ = 600-2 × (20.8+20) = 518.4 mm
   Moment of inertia I_z = 91813×10^4 mm^4, I_y = 2651×10^4 mm^4
   Plastic section modulus Z_{pz} = 3510.63×10^3 mm^3
   Elastic section modulus Z_{ez} = 3060.4×10^3 mm^3 [(CO3,CO5)(Analyze/IOCQ)]

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7. Design a welded plate girder of span 24 m to carry superimposed load of 35 kN/m. Avoid use of bearing and intermediate stiffeners. Consider f_y = 250 N/mm^2, f_u = 410 N/mm^2 and Simple Post Critical method. [(CO3,CO5)(Create/HOCQ)]

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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 @ 30.4kg/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. [(CO6)(Evaluate/HOCQ)] **12**

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 @ 31.2kg/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 @ 31.2kg/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 ISMB 225 @ 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. [(CO6)(Analyze/IOCQ)] **12**

Cognition Level	LOCQ	IOCQ	HOCQ
Percentage distribution	0	37.5	62.5

Course Outcome:

After the completion of the course students will be able to

- CO1 Familiar with the material properties of structural steel, analyse the different bolted and welded connections and design them for concentric and eccentric loads.
- CO2 Design different steel sections subjected to axial compression and tension following Indian codes of practices.
- CO3 Comprehend the differences between laterally supported and unsupported flexure members and design of the flexure members using Indian codes of practice.
- CO4 Analyse and design rolled and built up compression members along with base connection subjected to axial compression, bending and tension.
- CO5 Calculate shear force and bending moment on rolled and built up girders and design it following Indian standard design guidelines.
- CO6 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