UNIVERSITY OF RUHUNA

Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2018

Module Number: CE5201 Module Name: Design of Steel Structures

[Three Hours]

[Answer **all questions**, each question carries 12 marks]

British Standards BS 5950 Part I (2000) and BS 6399 Part 2 (1997) are provided.

Q1. Plan view and elevation view of a steel portal frame building are shown in Fig. Q1 (a) and Fig. Q1(b), respectively. The building is planned to constructed in the hill country. STAR Design Company (SDC), a reputed steel design and fabrication company has been awarded the tender for the design and construction of the above building. Consider you are at the SDC undergoing your industrial training during the design stage of this building and the Project Manager (PM) requests from you to conduct the preliminary structural analysis and design for this building. You are advised to initiate the analysis with the calculation of wind load assuming the basic wind speed 35 m/s, site altitude 100 m from the mean sea level (MSL), and the basic wind speed modification factors (i.e. seasonal, directional, and probability) to be 1.0. The building site is in the country with closest upwind distance to sea more than 100 km, and the site topography is insignificant.

a) For the given condition, calculate the dynamic wind pressure on the building.

[4.0 Marks]

b) For the cross-wind case, calculate the external wind load (kN/m) on the columns for an internal portal frame.

[4.0 Marks]

c) For the cross-wind case, calculate the external wind load (kN/m) on the rafter of 2nd portal frame from one end of the building. In the calculation, assume that the building is located in an isolated place.

[4.0 Marks]

Q2. An idealized roof bracing system for a half of the end bay in one side of the proposed building in Question 1 is shown in Fig. Q2. During the long wind condition, the pressure build up on the end wall is transferred to the roof bracing system as nodal loads (see Fig. Q2).

a) Assuming that all joints in Fig. Q2 as pin ends, show that the member AE in the bracing system is subjected to **compression** force of magnitude 43 kN. Check the adequacy of hot-finished rectangular hollow section of size 120x80x5 RHS (Grade S275) for the member AE.

[8.0 Marks]

b) (a) Showing that the member AF in the bracing system is subjected to **tension** force of magnitude 35 kN, check the adequacy of the same section used for the member AE in Fig. Q2. Assume end connection details for member AF as shown in Fig. Q2(b).

[4.0 Marks]

Q3. A timber floor of an office building is supported on steel beam girders consisting of primary and secondary beams as shown in Fig. Q3. The timber floor is supported on secondary beams and the secondary beams are supported on the primary beams. The primary beams are connected to the columns using flexible joints at both ends. The bottom flanges of the secondary beams are connected to the top flanges of the primary beams restraining the lateral movements of primary beams. Unfactored dead and imposed loads transferred to the primary beams are as follows.

Dead loads

Uniformly Distributed Load (self-weight)	w_g = 1.6 kN/m
Concentrated load at B	W_{d1} = 50 kN
Concentrated load at C	W_{d2} = 25 kN

Imposed loads

Concentrated load at B	W_{i1} = 60 kN
Concentrated load at C	W_{i2} = 30 kN

a) Plot the bending moment and shear force diagram for the primary beam and hence find the design bending moment and design shear force to check the capacities of flexural, shear, and web bearing.

[2.0 Marks]

b) Check the adequacy of 533x210x101 UB section (Grade S275) for primary beam with respect to the following design criteria.

(i) Cross section classification

[1.0 Marks]

(ii) Shear and shear buckling resistance

[2.0 Marks]

(iii) Moment resistance

[1.0 Marks]

(iv) Web bearing and web buckling resistance at the support. Take the stiff bearing length b_1=100 mm and end distance b_e=0.

[2.0 Marks]

c) Using the bending moment diagram plotted in Part (a) and the geometrical configurations provided in Fig. Q3, check the adequacy of 533x210x101 UB section for segment BC against the lateral torsional buckling. Consider normal loading condition.

[4.0 Marks]

Q4. A warehouse building consists of a portal truss frames spaced at equal intervals. A typical portal truss frame comprises of two columns and a roof truss is shown in Fig. Q4(a). The roof truss is rested on cap-plates attached to the column tops. Fig. Q4(b) shows an idealized column in the portal truss frame showing the applied compression force due to the roof truss and the bending moment diagrams about major and minor axes. Assess the suitability of 254x254x73 UC (Grade S275) section under the following steps involved in the design of column subjected to axial compression and bi-axial bending.

a) Classify the above cross section for combined bending and axial compression forces indicated in Fig. Q4(b).

[2.0 Marks]

b) In terms of cross sectional capacity, verify the adequacy of the proposed column size

[4.0 Marks]

b) Verify the adequacy of the proposed column size for in-plane and out-of-plane buckling using simplified method. Assume that the columns are pinned to the ground at base and fixed to the roof truss at column top.

[6.0 Marks]

Q5. Fig. Q5 shows a beam-column flexible connection made by using fin-plates. Two fin-plates of size 230x110x10 mm (Grade S275) have been welded to the column flange using 8 mm fillet weld. The fin-plates are then connected to the beam web using 3 M20 Grade 8.8 bolts. The connection requires to transfer 300 kN reaction force from the beam to the column through bolt and weld connection.

a) Check the adequacy of bolt connection between the beam web and the fin-plates in terms of shear capacity of bolts, and bearing capacity of bolts and connected parts. Take tensile stress area of M20 bolt as 245 mm^2. Web thickness (t) of the 406x178x85 UB section is 10.9 mm

[4.0 Marks]

b) Check whether the given distances for end, edge and spacing satisfy the minimum and maximum requirement of the bolt group.

[2.0 Marks]

c) Assess the adequacy of 8 mm fillet weld to resist the applied reaction force.

[6.0 Marks]

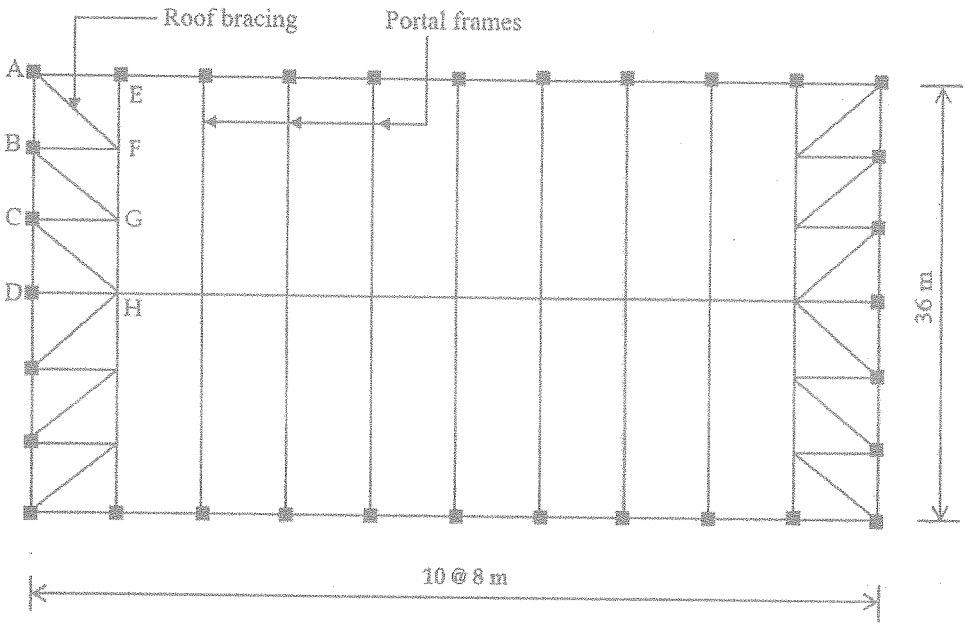

Fig. Q1(a)

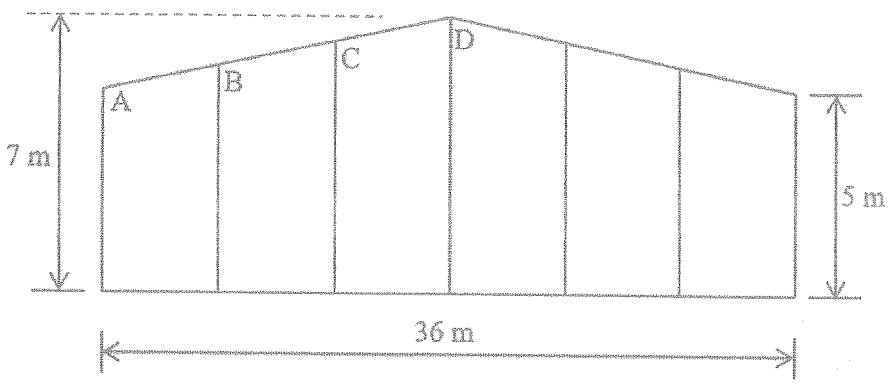

Fig. Q1(b)

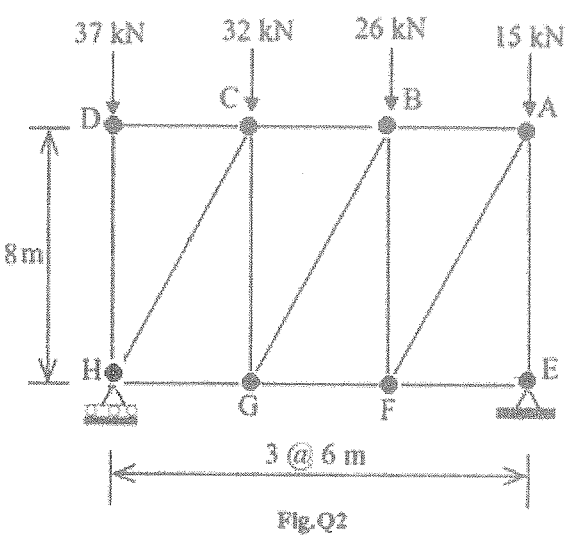

Fig. Q2

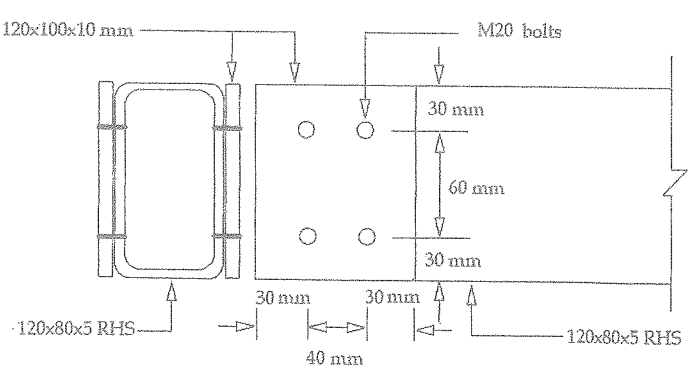

Fig Q2(b)

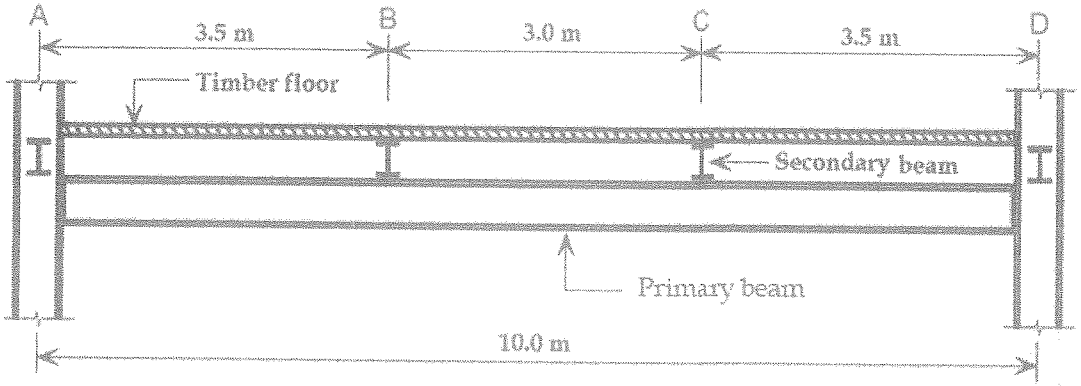

Fig. Q3

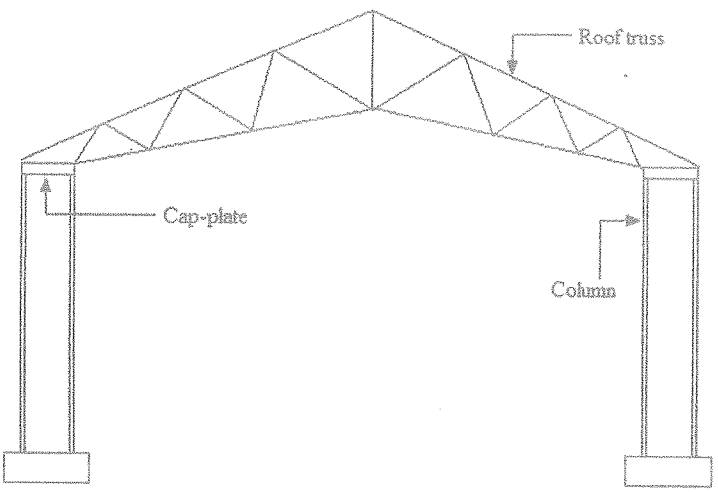

Fig. Q4(a)

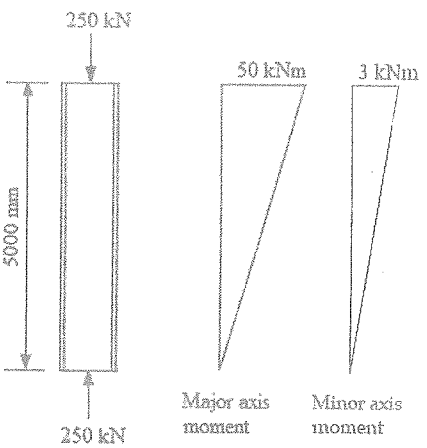

Fig. Q4(b)

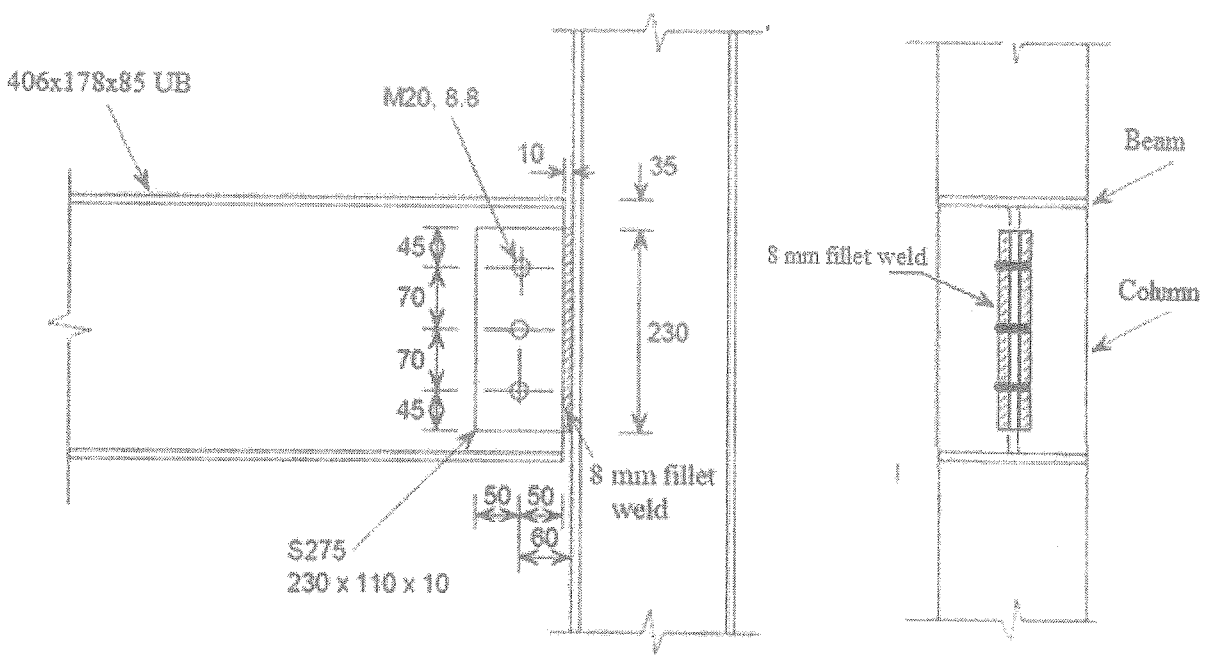

Fig. Q5.

Section Property Table - RHS Sections

Section designation DxBxt	Mass per meter	Area	Ratios for local buckling		Second moment of area		Radius of Gyration		Elastic Modulus		Plastic Modulus		Torsional Constants		Surface area of section	
	M	A	d/t	b/t	Axis xx	Axis yy	Axis xx	Axis yy	Axis xx	Axis yy	Axis xx	Axis yy	J	C	Per meter	Per tonne
	kg/m	cm^2			cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3	cm^4	cm^3	m^2	m^2
120x80x5	14.7	18.7	21	13	365	193	4.42	3.21	60.9	48.2	74.6	56.1	401	77.9	0.387	26.3

Section Property Table - I, H Sections

Designation DxBxM	Mass per m	Depth of Section	Width of Section	Thickness of		Root Radius	Depth between Fillets	Area of Section	Second Moment Area		Radius of Gyration		Section (Elastic) Modulus		Plastic Modulus		Buckling parameter	Torsional Index
				Web	Flange				Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y	Axis x-x	Axis y-y		
	M	D	B	t	T	r	d	A	Ix	Iy	rx	ry	Zx	Zy	Sx	Sy	u	x
	kg/m	mm	mm	mm	mm	mm	mm	cm^2	cm^4	cm^4	cm	cm	cm^3	cm^3	cm^3	cm^3		
533x210x101	101	536.7	210.0	10.8	17.4	12.7	476.5	129	61500	2690	21.9	4.57	2290	256	2610	399	0.874	33.2
254x254x73	73.1	254.1	254.6	8.6	14.2	12.7	200.3	93.1	11400	3910	11.1	6.48	898	307	992	465	0.849	17.3