ELIZADE UNIVERSITY, ILARA-MOKIN

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING

FIRST SEMESTER 2019/2020 EXAMINATION

CVE 407: DESIGN OF STRUCTURES II

Instructions: A. This question paper consists of six (6) pages

B. Answer **Question 1** plus any other **2 Questions. Answer 3 Questions in all.**

C. Write your **name** and **matric number** clearly on your answer sheets

Time Allowed: $2^1/_2$ Hrs **2 units**

Question 1 - (50 marks)

a) A 406 x 140 x 46 Universal beam (UB) of grade S355 is to carry a uniformly distributed load of 75kN/m design load. The load includes the self-weight of the beam and the load is applied to the top flange of the beam. The top flange is fully restrained against lateral torsional buckling by casting of the slab alongside with the top flange. The span of the beam is 6m and it is simply supported. Check the suitability of the section in carrying the specified load. **(20 marks)**

b) In question 1a above, assuming the load is applied to the top flange without any lateral restrain throughout the entire span of the beam and the compression flange is laterally restrained at the two supports against rotation on plan. Assume the initial bending strength (P_b) to be 60N/mm² and the beam depth (D) be 600mm. Select a suitable UB section using the following questions as guide.

i. Calculate the reactions at the two supports **(3 marks)**

ii. Draw the shear force and bending moment diagrams **(6 marks)**

iii. Determine the design shear and moment **(3 marks)**

iv. Select a suitable UB section in grade S355 steel and write out the properties **(6 marks)**

v. Classify the section and check its suitability in term of moment capacity and buckling resistant moment **(12 marks)**

Question 2 - (25 marks)

a) Explain the principles of (i) Working stress method of design (ii) Ultimate load design and (iii) Limit state design. **(9 marks)**

b) Explain how limit state design differs from working stress method of design. **(3 marks)**

c) Explain how limit state design differs from ultimate load design. **(3 marks)**

d) Both flanges of a Universal Column Section have 24 mm diameter holes arranged as shown in **Figure Q2**. If the gross area of the section is $262\ X\ 10^2\ mm^2$ and the flange thickness is $31.4\ mm$.

i. Determine the net area An of the member which is effective in tension. **(6 marks)**

ii. Determine also the tension capacity of this tension member if the design strength is $P_y = 440N/mm^2$ **(4 marks)**

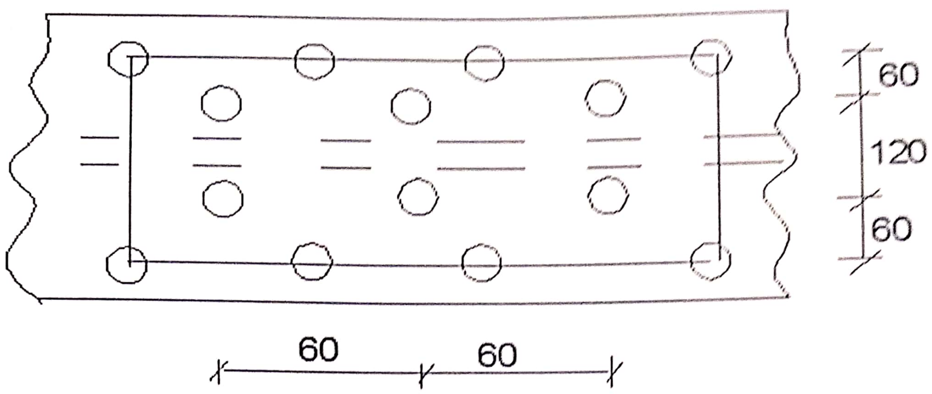


Figure Q2- Flange of a Universal Column Section

Question 3 - (25 marks)

a) A 305 x 305 x 137 UC in grade S355 steel is 7.0m long and is fixed at its ends in both planes. It has a positional restraint at its mid-height that prevents lateral moment parallel to the flanges while at the other axis there is also another positional restraint at 2m to the top of the column. Determine its compression resistance. **(15 marks)**

b) Explain the following terms:

i) Partial safety factor for loads **(2 marks)**
ii) Partial safety factor for material **(2 marks)**
iii) Clearly state the difference between factor of safety and partial safety factor **(3 marks)**
iv) between characteristic loads and design loads. **(3 marks)**

Question 4 - (25 marks)

a) Every piece of strength-graded timber should be marked clearly and indelibly with the some information,

i. Write out these information with examples. **(3 marks)**
ii. Sketch a typical grading mark/stamp **(2 marks)**

b) One the main types of defects in timber is the defect that is due to natural forces, list and briefly discuss all the various category of defects in timber that can be caused by natural forces. **(5 marks)**

c) The timber structurally arranged as shown in Figures Q4a and b consists of suspended timber floor system (tongue and groove floor boards) being supported by the timber joists in which the joists at 700 mm centres are simply supported by timber beams on load-bearing concrete walls.. Using the design data shown below and Appendix A;

i. Determine a suitable section size for the tongue and groove floor boards with respect to bending and deflection **(12 marks)**
ii. Determine also the uniformly distributed load coming on each joist including its self weight. **(3 marks)**

Design data:

Centre of timber joists	700 mm
Distance between the centre-lines of the timber column(i.e the beam span)	5.0 m
Span of the joist	4.0m
Strength class of timber for joists and tongue and groove boarding and beams	C24

Imposed loading (long-term)	3.0 kN/m^2
Exposure condition Service	Class 1
Initial assumption of the floor boarding thickness	21mm

assume that wane is permitted;

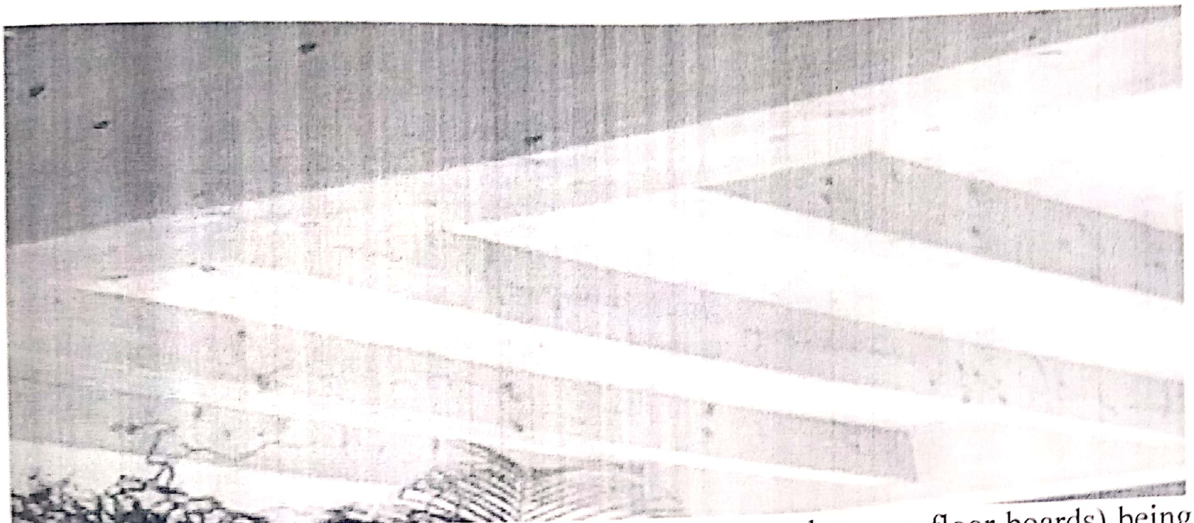


Figure Q4a: Suspended timber floor system (tongue and groove floor boards) being supported by the timber joists @ 700mm

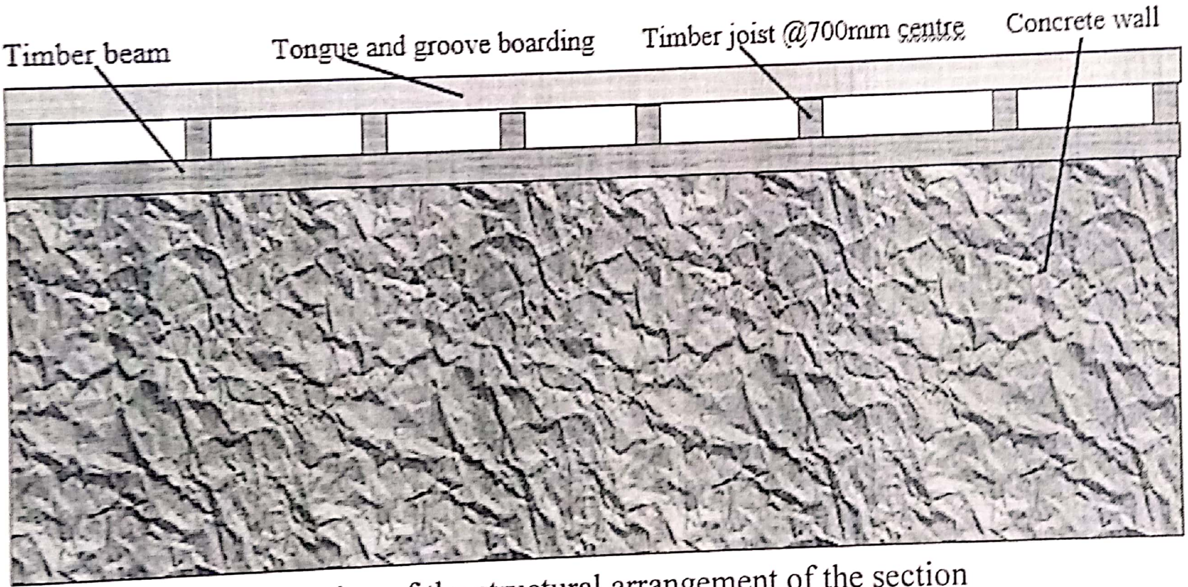
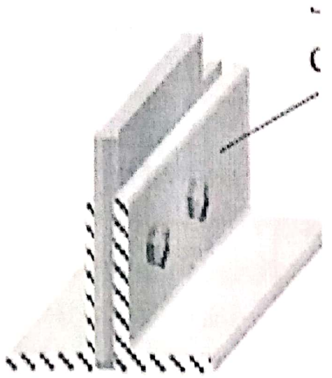


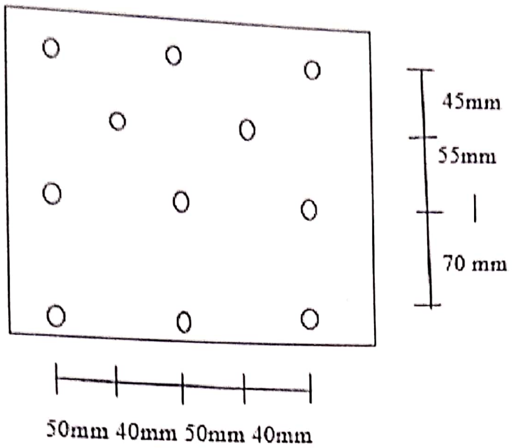
Figure Q4b: Cross section of the structural arrangement of the section

Question 5 - (25 marks)

a) Determine the tension capacity of the angle section and the plate shown in **Figures Q5(a) and (b)**, considering the strength of the sections only (i.e. ignoring block shear and bolt strength). The angle is 2 / 100 × 75 × 10 double angle sections with the long legs connected to each side of a gusset plate by 16 mm diameter bolts or welded. Take the grade of the angle sections to be S275 and that of the plate to be S355. **(15 marks)**

b) If the angle is to be 100 × 75 × 10 single angle section connected to a gusset plate by 16mm diameter bolts or welded and a designed load of 525kN is to come on it; will the single angle section have sufficient capacity for the designed load? Take the grade of the angle sections to be S275. **(10 marks)**





240mm x 10mm thick plate, S355

22mm diameter bolts

Figure Q5a. The angle section

Figure Q5b- The plate section

Appendix A

Table 8 — Grade stresses and moduli of elasticity for various strength classes: for service classes 1 and 2

Strength class	Bending parallel to grain N/mm²	Tension parallel to grain N/mm²	Compression parallel to grain N/mm²	Compression perpendicular to grain ᵃ N/mm²		Shear parallel to grain N/mm²	Modulus of elasticity		Characteristic density, ρ_k ᵇ kg/m³	Average density, ρ_{mean} ᵇ kg/m³
							Mean N/mm²	Minimum N/mm²		
C14	4.1	2.5	5.2	2.1	1.6	0.60	6 800	4 600	290	350
C16	5.3	3.2	6.8	2.2	1.7	0.67	8 800	5 800	310	370
C18	5.8	3.5	7.1	2.2	1.7	0.67	9 100	6 000	320	380
C22	6.8	4.1	7.5	2.3	1.7	0.71	9 700	6 500	340	410
C24	7.5	4.5	7.9	2.4	1.9	0.71	10 800	7 200	350	420
C27	(A1) 9.5 (A1)	6.0	8.2	2.5	2.0	1.10	(A1) 11 500 (A1)	8 200	370	450
C30	11.0	6.6	8.6	2.7	2.2	1.20	12 300	8 200	380	460
C35	12.0	7.2	8.7	2.9	2.4	1.30	13 400	9 000	400	480
C40	13.0	7.8	8.7	3.0	2.6	1.40	14 500	10 000	420	500
D30	9.0	5.4	8.1	2.8	2.2	1.40	9 500	6 000	530	640
D35	11.0	6.6	8.6	3.4	2.6	1.70	10 000	6 500	560	670
D40	12.5	7.5	12.6	3.9	3.0	2.00	10 800	7 500	590	700
D50	16.0	9.6	15.2	4.5	3.5	2.20	15 000	12 600	650	780
D60	18.0	10.8	18.0	5.2	4.0	2.40	18 500	15 600	700	840
D70	23.0	13.8	23.0	6.0	4.6	2.60	21 000	18 000	900	1 080

NOTE Strength classes C14 to C40 are for softwoods and D30 to D70 are for hardwoods.

ᵃ When the specification specifically prohibits wane at bearing areas, the higher values of compression perpendicular to grain stress may be used, otherwise the lower values apply.

ᵇ The values of characteristic density given above are for use when designing joints. For the calculation of dead load, the average density should be used.

Table 16 — Modification factor, K_2, by which stresses and moduli for service classes 1 and 2 should be multiplied to obtain stresses and moduli applicable to service class 3

Property	Value of K_2
Bending parallel to grain	0.8
Tension parallel to grain	0.8
Compression parallel to grain	0.6
Compression perpendicular to grain	0.6
Shear parallel to grain	0.9
Mean and minimum modulus of elasticity	0.8

2.7 Additional properties

In the absence of specific test data, values which are one-third of those for shear parallel to the grain (see Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14 and Table 15) should be used for tension perpendicular to the grain, torsional shear and rolling shear.

For modulus of elasticity perpendicular to the grain, a value of one-twentieth (i.e. 0.05) of the permissible modulus of elasticity (see Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14 and Table 15) should be used.

For shear modulus, a value of one-sixteenth (i.e. 0.062 5) of the permissible modulus of elasticity (see Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14 and Table 15) should be used.

Where the direction of the load is inclined to the grain at an angle α, the permissible compression stress for the inclined surface should be calculated from the equation:

$$\sigma_{c,adm,\alpha} = \sigma_{c,adm,\parallel} - (\sigma_{c,adm,\parallel} - \sigma_{c,adm,\perp}) \sin \alpha$$

where

$\sigma_{c,adm,\parallel}$ and $\sigma_{c,adm,\perp}$ are the grade compression stresses, parallel and perpendicular to the grain, respectively, modified as appropriate for moisture content and/or duration of loading (see 2.6.2 and 2.8).

2.8 Duration of loading

The stresses given in Table 8, Table 9, Table 10, Table 11, Table 12, Table 13, Table 14 and Table 15 apply to long-term loading. Table 17 gives the modification factor K_3 by which these should be multiplied for various durations of loading. When a modification factor, K_3, greater than unity is used in accordance with this clause, the design should be checked to ensure that the permissible stresses are not exceeded for any other condition of loading that might be relevant.

NOTE 1 The modification factor K_3 is applicable to all strength properties, but is not applicable to moduli of elasticity or to shear moduli.

NOTE 2 For domestic floors, the concentrated loading condition given in BS 6399-1 (i.e. 1.4 kN) may be superimposed on the dead load and both may be treated as of medium-term duration.

Table 17 — Modification factor, K_3, for duration of loading

Duration of loading	Value of K_3
Long-term (e.g. dead + permanent imposed [a])	1.00
Medium-term (e.g. dead + snow, dead + temporary imposed)	1.25
Short-term (e.g. dead + imposed + wind [b], dead + imposed + snow + wind [b])	1.50
Very short-term (e.g. dead + imposed + wind [c])	1.75

[a] For uniformly distributed imposed floor loads $K_3 = 1.00$ except for type C3 occupancy (see BS 6399-1:1996, Table 1) where for foot traffic on corridors, hallways, landings and stairs, K_3, may be taken as 1.5.

[b] [A1] For wind where the largest diagonal dimension of the loaded area a, as defined in BS 6399-2, exceeds 50 m.

[c] For wind where the largest diagonal dimension of the loaded area a, as defined in BS 6399-2, does not exceed 50 m. [A1]

2.9 Load-sharing systems

In a load-sharing system which consists of four or more members such as rafters, joists, trusses or wall studs, spaced a maximum of 610 mm centre to centre, and which has adequate provision for the lateral distribution of loads by means of purlins, binders, boarding, battens, etc., the following permissible stresses and moduli of elasticity appropriate to the strength class or species and grade should apply.

a) The appropriate grade stresses should be multiplied by the load sharing modification factor, K_8, which has a value of 1.1.

b) The mean modulus of elasticity should be used to calculate deflections and displacements under both dead and imposed load unless the imposed load is for an area intended for mechanical plant and equipment, or for storage, or for floors subject to vibrations, e.g. gymnasia and ballrooms, in which case the minimum modulus of elasticity should be used.

Special provisions for built-up beams, trimmer joists and lintels, and laminated beams, are given in 2.10.10, 2.10.11 and section 3, respectively.

The provisions of this clause do not extend to the calculation of modification factor, K_{12}, (given in Table 22 and Annex B) for load-sharing columns.

2.10.5 Form factor

Grade bending stresses apply to solid timber members of rectangular cross-section. For other shapes of cross-section the grade bending stresses should be multiplied by the modification factor, K_6, where

K_6 = 1.18 for solid circular sections; and

K_6 = 1.41 for solid square sections loaded on a diagonal.

2.10.6 Total depth of beam

A1 The grade bending stresses given in Table 13 apply to solid timber graded in accordance with the North American MSR rules having the particular depth quoted.

The grade bending stresses given in Table 8, Table 9, Table 10, Table 11, Table 12, Table 14 and Table 15 apply to solid timber having a depth, h, of 300 mm. For other depths of beams, the grade bending stresses should be multiplied by the depth modification factor, K_7, where: A1

K_7 = 1.17 for solid timber beams having $h \leqslant 72$ mm;

$K_7 = (300/h)^{0.11}$ for solid and glued laminated beams having $72 \text{ mm} < h \leqslant 300$ mm;

$$K_7 = 0.81 \frac{(h^2 + 92\,300)}{(h^2 + 56\,800)}$$ for solid and glued laminated beams having $h > 300$ mm.