UNIVERSITY OF RUHUNA

Faculty of Engineering

Semester 5 Examination in Engineering: October 2019

Module Number: CE5251 **Module Name: Design of Timber and Masonry Structures**

[Three Hours]

[Answer **all questions**]

Notes: (1) Codes of Practice BS EN 1995-1-1: 2004+A1:2008 and BS EN 1996-1-1: 2005 are provided separately, (2) Appendix A to this examination paper includes characteristic strengths and other material properties that may be used for the designs.

Q1. Figure Q1.1 shows details of the proposed splice connection of the bottom chord of a timber roof truss. Roof truss is made of D35 strength class timber of cross-sectional dimensions 44 mm x 100 mm. A central slot of 12 mm thickness is made in the timber. A 11 mm thick steel gusset plate is inserted into the slot. Two 16 mm diameter bolts are used at either side of the connection. The bottom chord is subjected to a tensile force of 14 kN due to permanent loads and 7 kN due to short-term loads. You may assume the service class 3 exposure conditions.

(a) Check the adequacy of the timber member in resisting the designed tensile stresses under both the permanent and short-term conditions. Your answer should include all references to the Code of Practice provided.

[8.0 Marks]

(b) Provide ONE recommendation as to how the proposed design can be changed to serve the purpose. Your recommendation should be supported by calculations.

[4.0 Marks]

(c) Durability needs to be ensured in construction of all structural components.

i. Describe the reasons for adverse impacts to the durability of timber structures.

[2.0 Marks]

ii. List TWO methods that can be used to increase the durability of timber structures.

[1.0 Marks]

Q2. Figure Q2.1 shows a cross-section of a suspended timber flooring system proposed for a domestic dwelling unit. Floor deck comprised of tongue and groove boarding of 22 mm thick with a self-weight of 0.1 kN/m^2. Plasterboard ceiling attached to the floor joists has a self-weight of 0.2 kN/m^2. Floor span is 3.20 m. Medium-term imposed load of 1.5 kN/m^2 is expected. You may assume Service Class 2 exposure conditions for the design.

Preliminary calculations have shown that timber joists spaced at 500 mm centre to centre distance apart are adequate to support the floor system.

(a) If joists in timber class D30 with 50 mm breadth is preferred for the above floor system, determine the required size of the joists to meet the minimum requirement in bending. Commercially available solid timber sizes include, 50 x 97, 50 x 122, 50 x 147, 50 x 170, 50 x 195, and 50 x 220 (All dimensions are in millimeters).
For simplicity, you may assume the self-weight of the joists as 0.1 kN/m^2.

[8.0 Marks]

(b) Check the adequacy of the above section in deflection. Instantaneous deflection (δ) at the center of a uniformly loaded beam can be calculated using the following equation with usual notations.

$$\delta = \frac{5}{384} \times \frac{wL^4}{EI}$$

Factors for the Quasi-permanent value of variable actions (ψ_2) can be taken as 0.3 for dwellings.

[7.0 Marks]

(c) If the joists are to be notched (right angled notch at the same side) at bearing equal to half the depth of the joist, determine whether the joists are safe in shear.

[5.0 Marks]

Q3. Cavity wall AB of length 6m supports the RC slab as shown in Figure Q3.1. The inner leaf is built using solid concrete blocks of size 440 mm x 100 mm x 215 mm, faced with plaster, and the outer leaf using standard format clay bricks. The self-weight of the blocks and plaster can be taken as 2.2 kN/m^2. The reinforced concrete roof slab is subjected to a Dead load of 5.1 kN/m^2 and Imposed load of 1.5 kN/m^2. You may assume Class 1 execution control, and Category II manufacturing control of concrete blocks.

(a) State clearly the assumptions you make in designing the cavity wall.

[2.0 Marks]

(b) Calculate the ultimate design load in kN/m

[3.0 Marks]

(c) Calculate the slenderness ratio (SR) of the wall. You may assume that E values of the both leaves are approximately same.

[3.0 Marks]

(d) Determine the Capacity Reduction Factor and the characteristic compressive strength of masonry (f_k). You may assume that for masonry the modulus of elasticity, E = 1000 f_k.

[8.0 Marks]

(e) Provide clearly the specifications for the above cavity wall. You may assume that the Conditioning Factor =1.0, and Shape Factor = 1.38.

[4.0 Marks]

(f) Alternatively, a single-leaf brick wall stiffened by piers as given in Figure Q3.2 has been proposed instead of the cavity wall AB. Discuss the effect of this new proposal to the above design. Show brief calculations if necessary.

[5.0 Marks]

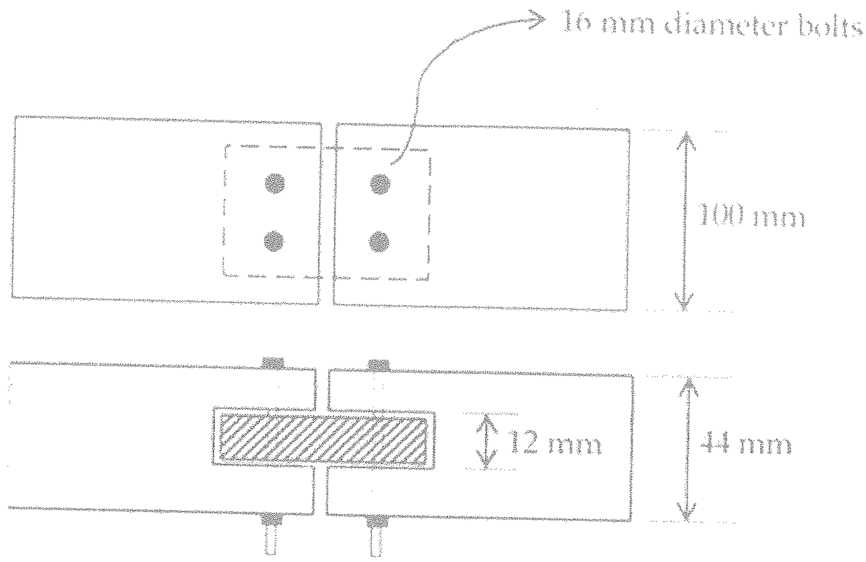


Figure Q1.1: Elevation and Plan view of the splice connection

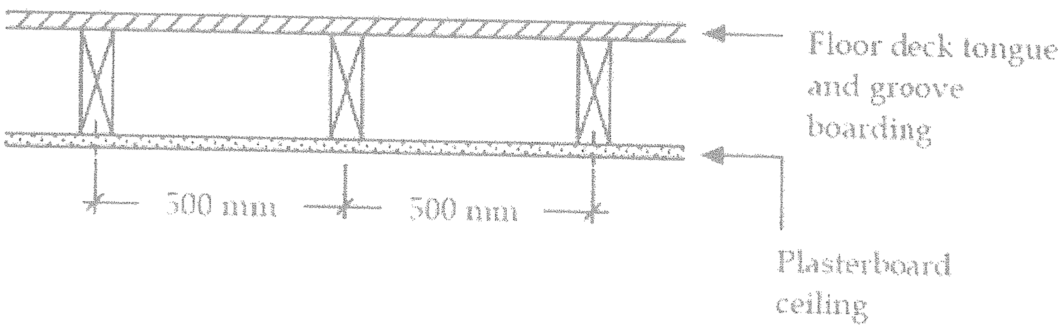


Figure Q2.1: Cross-section of the flooring system

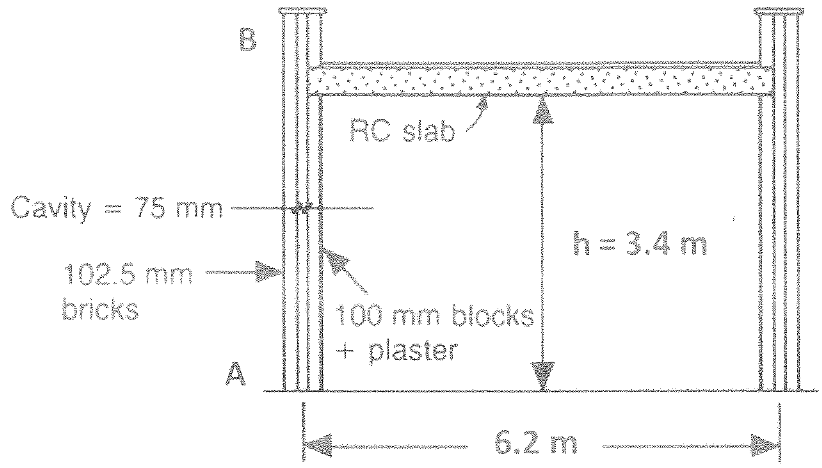
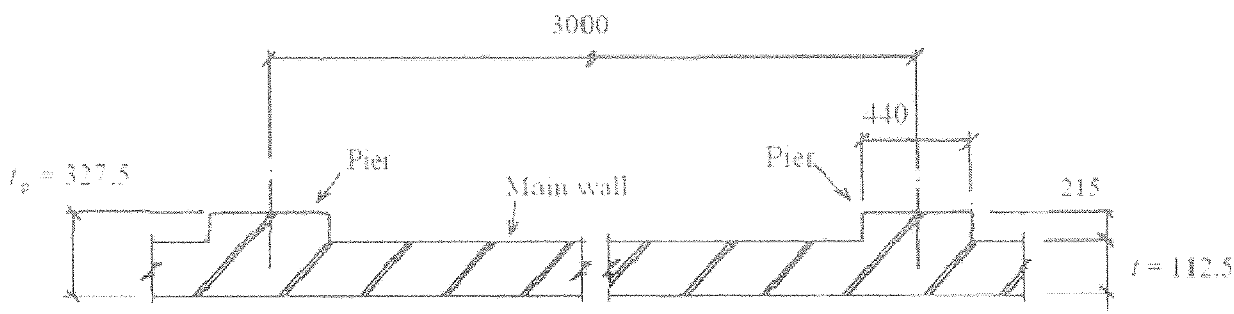


Figure Q3.1: Cross-section of cavity wall AB and the RC slab



(All dimensions are in 'mm')

Figure Q3.2: Cross-section of the proposed single-leaf brick wall stiffened by piers

APPENDIX A

Table A.1: Characteristic Values for Hardwood Timber (Extracted from EN 338:2009)

Wood Class	Strength Properties (in N/mm²)						Stiffness properties (in kN/mm²)				Density (in kg/m³)	
	Bending	Tension Parallel	Tension Perpendicular	Compression Parallel	Compression Perpendicular	Shear	Mean modulus of elasticity parallel	5% modulus of elasticity parallel	Mean modulus of elasticity perpendicular	Mean shear modulus	Density (kg/m3)	Density (kg/m3)
	$f_{m,k}$	$f_{t,0,k}$	$f_{t,90,k}$	$f_{c,0,k}$	$f_{c,90,k}$	$f_{v,k}$	$E_{0,mean}$	$E_{0,05}$	$E_{90,mean}$	G_{mean}	ρ_k	ρ_{mean}
D18	18	11	0.6	18	7.5	3.4	9.5	8	0.63	0.59	475	570
D24	24	14	0.6	21	7.8	4	10	8.5	0.67	0.62	485	580
D30	30	18	0.6	23	8	4	11	9.2	0.73	0.69	530	640
D35	35	21	0.6	25	8.1	4	12	10.1	0.8	0.75	540	650
D40	40	24	0.6	26	8.3	4	13	10.9	0.86	0.81	550	660
D50	50	30	0.6	29	9.3	4	14	11.8	0.93	0.88	620	750
D60	60	36	0.6	32	10.5	4.5	17	14.3	1.13	1.06	700	840
D70	70	42	0.6	34	13.5	5	20	16.8	1.33	1.25	900	1080

Table A.2: The partial factor for materials (γ_M)

	Class of execution control	
	1	*2*
When in a state of direct or flexural compression		
Unreinforced masonry made with:		
units of category I	2.3	2.7
units of category II	2.6	3.0
When in a state of flexural tension		
units of category I and II	2.3	2.7

Table A.3: Types of Mortar

Compressive strength class	*Prescribed mortars (proportion of materials by volume)*				*Mortar designation*
	Cement-lime-sand with or without air entrainment	*Cement-sand with or without air entrainment*	*Masonry cement[1]-sand*	*Masonry cement[2]-sand*	
M12	1:0 to 1/4:3	–	–	–	(i)
M6	1:½:4 to 4½	1:3 to 4	1:2½ to 3½	1:3	(ii)
M4	1:1:5 to 6	1:5 to 6	1:4 to 5	1:3½ to 4	(iii)
M2	1:2:8 to 9	1:7 to 8	1:5½ to 6½	1:4½	(iv)

Notes:
[1]Masonry cement with organic filler other than lime
[2]Masonry cement with lime