



# UNIVERSITY OF RUHUNA

## Faculty of Engineering

End-Semester 5 Examination in Engineering: August 2015

**Module Number:** CE5251

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

[Three Hours]

Answer all questions

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Code of Practice BS 5268 Part 2: 2002 and BS 5628 Part 1: 2005 are provided

- Q1. a) List three factors affecting the strength properties of timber? Briefly discuss the effect of each factor on the strength of timber material. [3 Marks]
- b) Timber is an anisotropic material. Explain what is meant by anisotropic material and how it affects the design of timber elements. [2 Marks]
- c) The column shown in Figure Q1 has a cross-section  $100 \text{ mm} \times 200 \text{ mm}$ , is of strength class C24 to BS 5268-2, and functions under wet exposure condition. It supports a characteristic permanent axial load of 10 kN and a characteristic variable medium-term axial load of 17.5 kN. The loading is applied 25 mm eccentric from the  $y$ - $y$  axis and 10 mm from the  $z$ - $z$  axis as shown in the Figure Q1(a) and the permanent action includes an allowance to cover for the effect of the self-weight of the column. The column is 3.75 m high and at each end is effectively held in position but not in direction about the  $z$ - $z$  and about the  $y$ - $y$  axes.
- i) Determine the critical slenderness ratio. Check whether the critical slenderness ratio satisfies the BS 5268 limits. [3 Marks]
- ii) Check the adequacy of the column. [7 Marks]
- Q2. a) Discuss three different structural forms of timber pitch roof trusses. [3 Marks]
- b) A tension chord of  $38 \text{ mm} \times 69 \text{ mm}$  in a truss is spliced by two cover plates ( $29 \text{ mm} \times 69 \text{ mm}$ ) as shown in Figure 2(a) is subjected to a tensile force due to a medium term load of 2.3 kN. The joint comprises of 3.4 mm diameter of round wire and 65 mm long nails acting in single shear in C14 timber. Assuming the connection is subjected to service class 2 conditions.
- i) Determine how many nails are required to receive the adequate capacity of the joint. [2 Marks]

ii) Estimate the length of the cover plate.

[3 Marks]

iii) If 1.5 mm thick steel plate (pre-drilled) is used as cover plates, how many nails would be appropriate for the joint.

[3 Marks]

c) The Figure 2(b) shows a web member connection details of a lattice beam. Timber strength class is C24 and functions under service class 2. The bolt is M12, 4.6 grade bolt. Assuming medium term loading for the beam determine the permissible load for the bolt.

[4 Marks]

Q3. Figures Q3 (a), (b), (c), (d) and (e) show the details of a two storey house designed by an architect. It consists of a corrugated asbestos sheeted roof with timber roof truss, reinforced upper floor structure, load bearing masonry wall elements. All the upper floor slabs are either two-way spanning slabs or one-way spanning cantilevers. The design of roof structure, slab, column and beam was completed and balance work, which consists of design of masonry wall, is assigned to you.

a) Consider wall AA, BB at ground level and wall CC at first floor, identify the walls that should be designed for critically loaded under,

- Direct compression
- Flexural bending parallel to bed joints
- Flexural bending perpendicular to bed joints
- In-plane shear

Briefly discuss of your selection with reasons.

[6 Marks]

b) i) Explain, with examples, what is the effect of lateral supports on the slenderness ratio of the wall.

[2 Marks]

ii) Calculate the effective height ( $h_e$ ), effective thickness ( $t_e$ ) and slenderness ratio of the wall AA.

[2 Marks]

c) It is now necessary to design the wall AA at ground floor for vertical loads. Standard bricks of compressive strength 20.0 N/mm<sup>2</sup>, mortar designation (ii), maximum water absorption 10%, and nominal brick size (with 10mm mortar joint) 210mm×105mm×60mm high, are to be used. The category of manufacturing control is to be category II and that for construction is special. Some of the characteristic load acting on wall AA was computed to be as follows:

- Characteristic vertical load on wall AA due to the upper floor, wall above wall AA = 80 kN/m
- Characteristic vertical load on wall AA due to the dead load of upper floor concrete slab = 40 kN/m
- Characteristic vertical load on wall AA due to the imposed load of upper floor slab = 20 kN/m

- i) Determine the design vertical load on wall **AA**. [1 Mark]
- ii) Check for wall **AA** for
- Slenderness assuming the wall **AA** is fixed at ground level.
  - Failure due to direct compression.
- [8 Marks]
- d) If the wall A-A is subject to a lateral characteristic wind load of 2.0 kN/m<sup>2</sup>, determine,
- i) Orthogonal ratio ( $\mu$ ) [2 Marks]
- ii) Design moment of resistance parallels to bed joint and perpendicular to the bed joint. [2 Marks]
- iii) Design applied moment parallel to bed joint and perpendicular to the bed joint. [2 Marks]
- iv) Safety factor for failure due to flexural bending. [1 Mark]
- e) If similar dead load and live load acting on wall **BB** as wall **AA**,
- i) Check for wall **BB** for
- Slenderness assuming the wall **BB** is fixed at ground level.
  - Failure due to direct compression.
- [3 Marks]
- ii) If wall **BB** was not safe for direct compression, then discuss about possible alternation. [1 Mark]

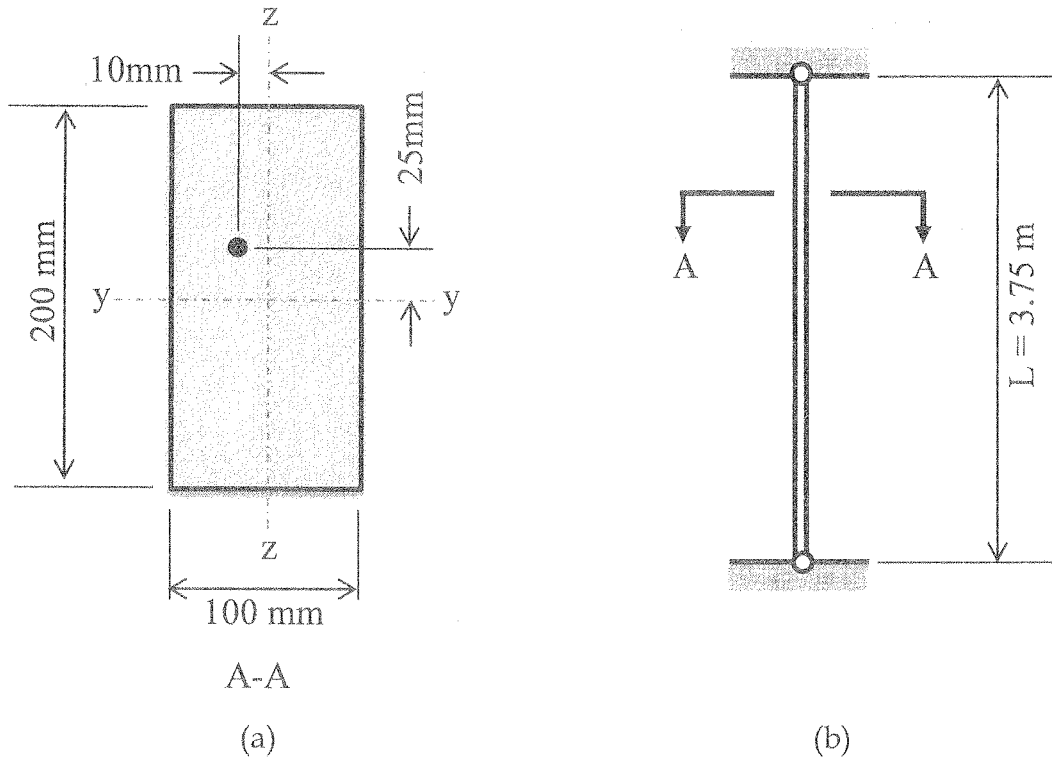


Figure Q1

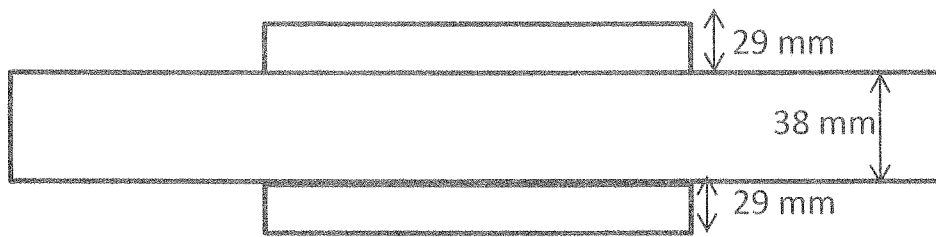


Figure Q2(a)

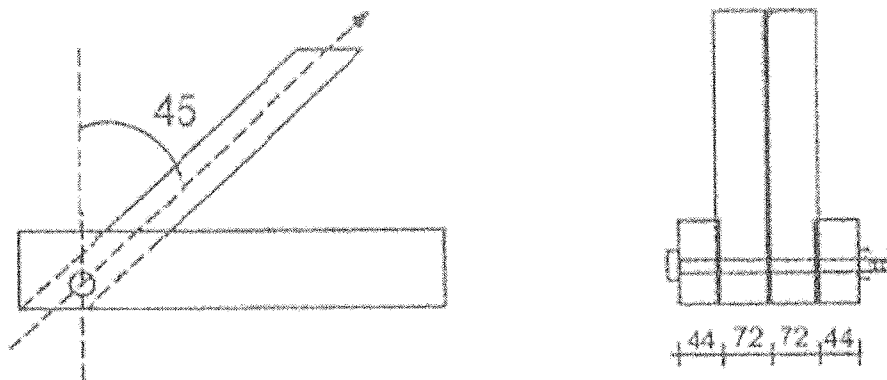


Figure Q2(b)

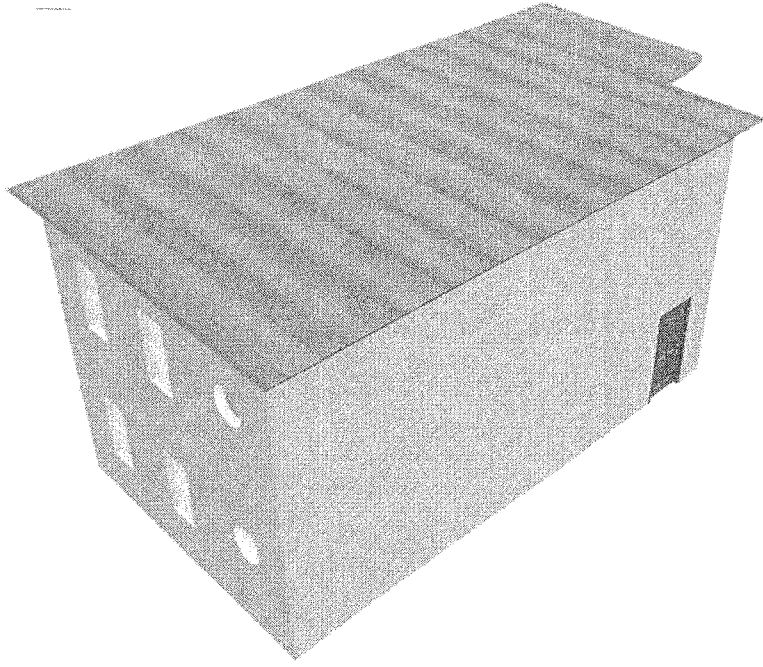


Figure Q3(a): House isometric view with roof

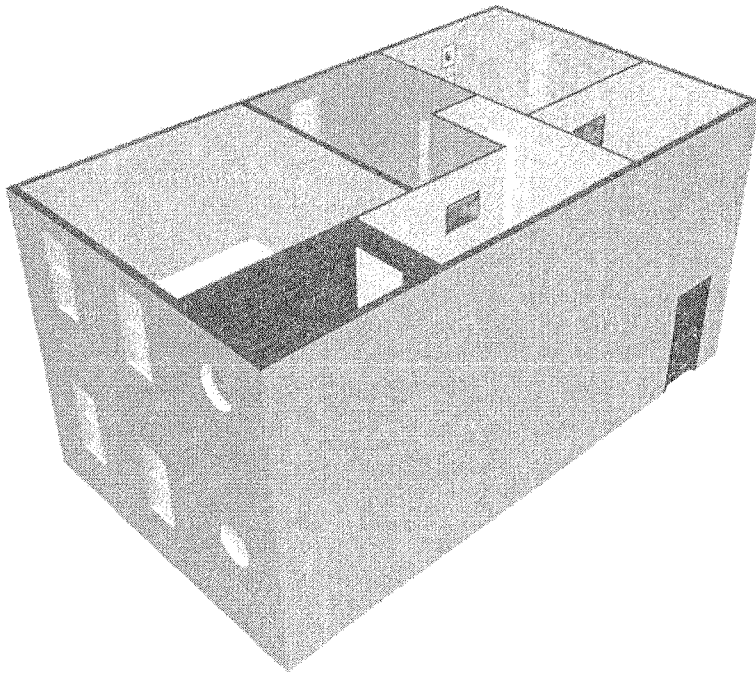


Figure Q3(b): House isometric view without roof

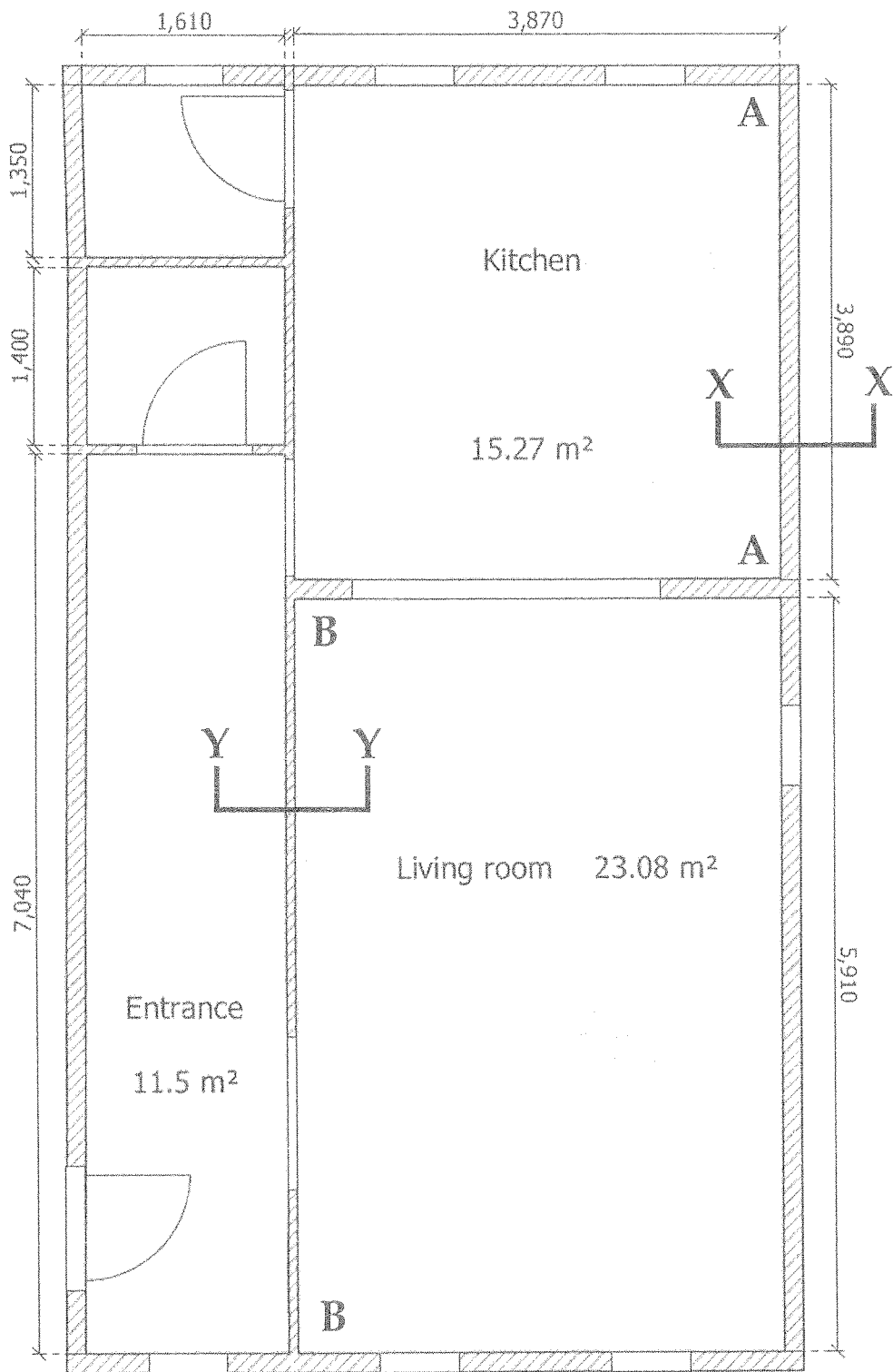


Figure Q3(c): Ground Floor (All dimensions are in 'mm')

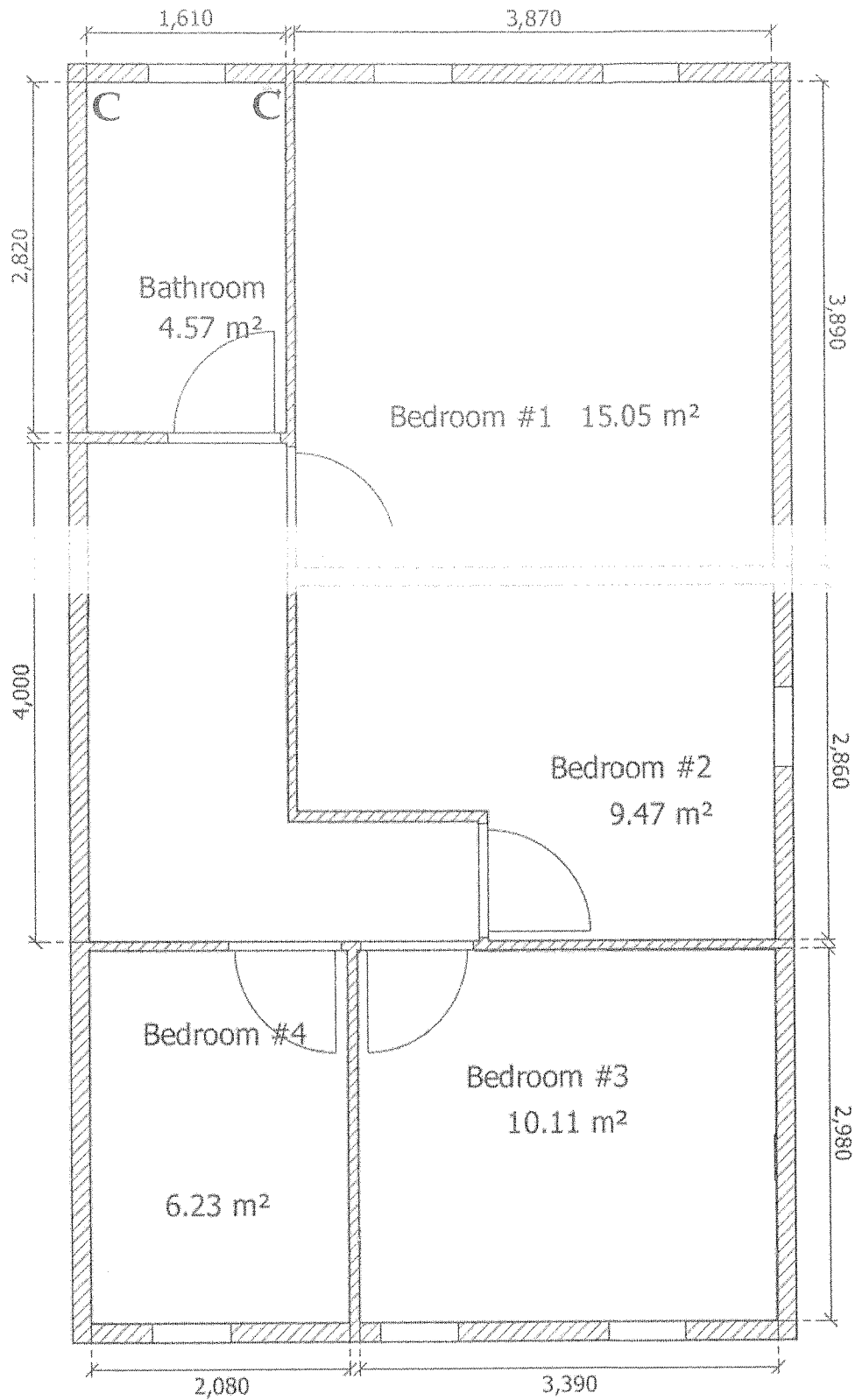
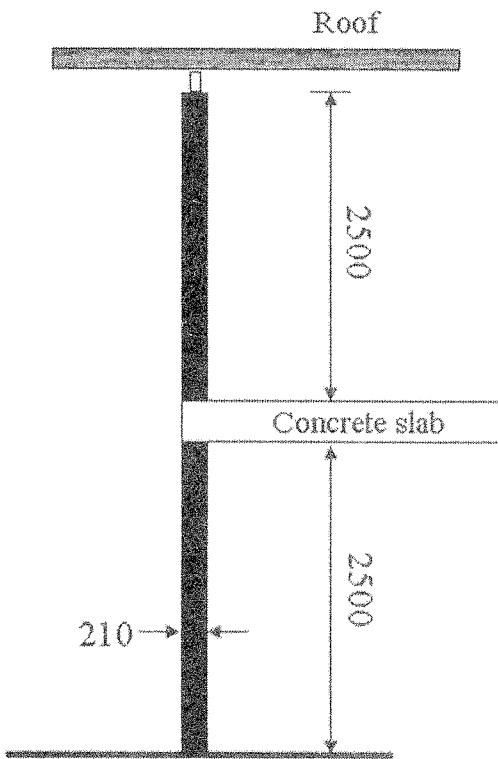
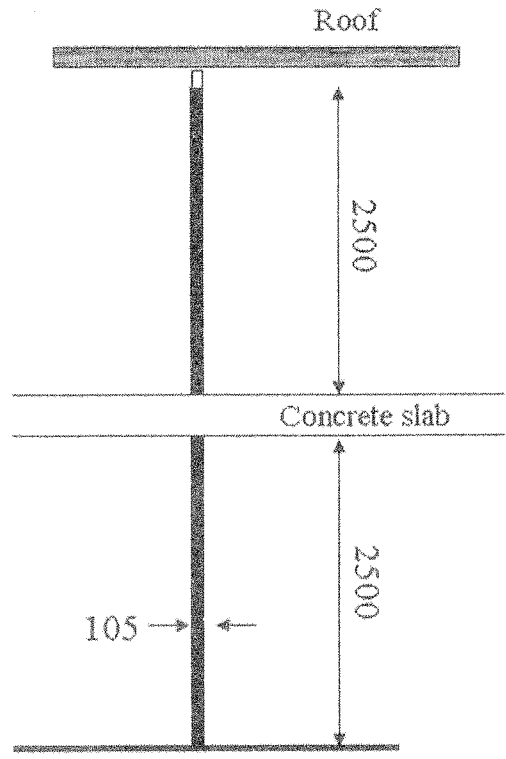


Figure Q3(d): First Floor (All dimensions are in 'mm')



Section X-X



Section Y-Y

Figure Q3(e): Section view (All dimensions are in 'mm')