9210-206
Level 7 Post Graduate Diploma in Engineering
Structural design

GUa d`Y˙DUdYf

.

You should have the following for this examination	**A reference booklet is attached**
• one answer book	
• non-programmable calculator	
• pen, pencil, drawing instruments	

General instructions
- The maximum marks for each section within a question is shown.
- Use large, clearly labelled diagrams or sketches wherever these will help your answers.
- This examination is of **three** hours duration and is structured in **three** parts (A, B and C) giving a total of **seven (07)** questions. Candidates must answer **four (04)** questions in total by selecting at least **one** question from each section. Each question carries 25 marks.
- Candidates may use their own unmarked copies of 'BSI-PP7312- Extracts from British Standards for Students of Structural Design.
- All diagrams and four tables of data are attached.

Section A – Structural Steelwork design to BS 5950

1   A 406 x 178 x 74 UB section in S355 steel is simply supported and spans 8 m. It is
     required to carry an un-factored uniformly distributed dead load of 20 kN/m inclusive
     of self weight over the entire span with un-factored live loads of 100 kN each acting at
     a distance of 2m from each support as shown in Figure Q1.
     a)   Determine the maximum bending moment on the steel beam due to factored
           loading at the ultimate limit state.   (5 marks)
     b)   Determine the maximum shear force on the steel beam due to factored loading at
           the ultimate limit state.   (5 marks)
     c)   Determine the shear capacity of this UB section.   (3 marks)
     d)   Check whether the beam is subjected to a high shear or low shear.   (3 marks)
     e)   Determine the moment capacity of this UB section assuming that the section can
           be classified as a plastic (Class 1) section.   (5 marks)
     f)   If this beam is laterally restrained only at the supports and the points of load
           application, is the beam section adequate to safely withstand the maximum
           bending moment?   (2 marks)
     g)   The maximum deflection of the beam due to the un-factored live loads is 24 mm.
           Show whether the beam is suitable to carry a brittle finish?   (2 marks)
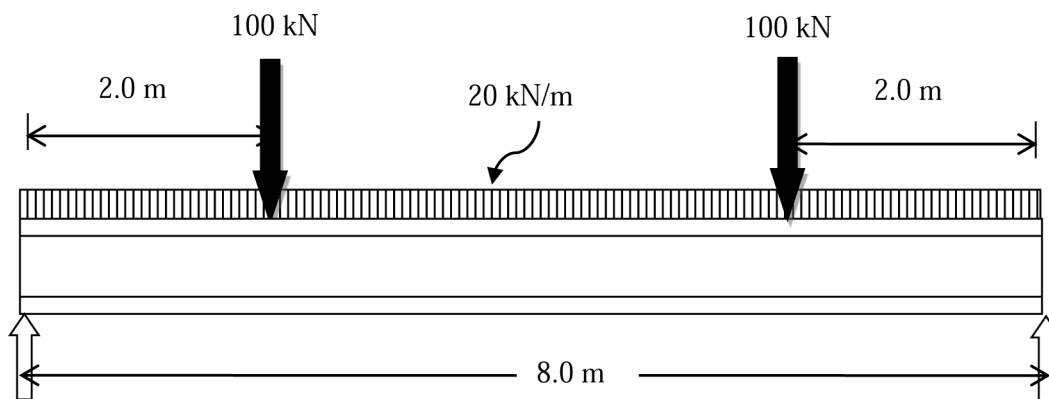
     Table A1 may be used with this question.

Figure Q1

2 An internal column in a braced steel building is subjected to the un-factored axial loads given in Table 2.

Magnitude of axial load (kN)	Type of load	Compression or Tension
500	Dead	Compression
400	Imposed	Compression
100	Wind	Compression
100	Wind	Tension

Table 2 – Loading on the column

It is suggested that a 203 x 203 x 52 UC section of S275 steel be used for this column. The column is held in position about both axes at both top and bottom and partially restrained in direction about the y-y axis at both the top and bottom. The axes are shown in Figure Q2. The overall height of the column between end restraints is 6.0 m.

a) Determine the design load in compression considering all the possible load combinations. (6 marks)

b) Check whether this UC section is required to support a tensile force. (2 marks)

c) Check whether this UC section will buckle locally? (3 marks)

d) Determine the effective height of the column about axis x-x and y-y. (4 marks)

e) Determine the axial capacity of this UC section in compression. (8 marks)

f) Show whether this UC section can safely carry the design axial compression load. (2 marks)
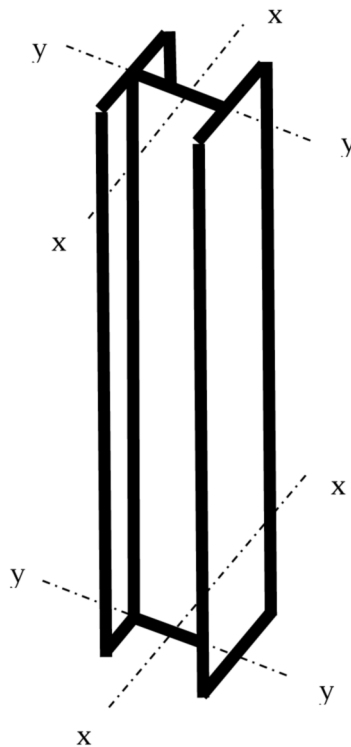
Table A2 may be used with this question.

Figure Q2

Section B – Structural Masonry Design to BS 5628 and Structural Timber Design to BS 5268

3   A timber walkway is to be constructed to temporarily link two existing buildings. It is proposed to use 25 mm thick timber floor boards that are 300 mm wide and 900 mm long. The floor boards will be supported on timber trusses that are spaced at 900 mm intervals. The loading on the timber floorboards inclusive of dead and live loads is 2.0 kN/m^2.

The diagonal web members of a timber truss, each consist of two identical timber members connected on either side of a steel plate that is placed between the top and bottom chord members (see Figure Q3). Each of the timber web members is 22 mm thick and 50 mm wide. They are connected at either end with a single 16 mm bolt to a steel gusset plate of 6 mm thickness attached to the chord member. The distance between the bolts is 762 mm in the compression member.

Outdoor conditions should be assumed in the checking of the timber structural elements.

Timber material properties:
Grade stresses:

Bending parallel to the grain	= 7.5 N/mm^2
Tensile parallel to the grain	= 4.5 N/mm^2
Compression parallel to the grain	= 7.9 N/mm^2
Mean modulus of elasticity	= 10,800 N/mm^2
Minimum modulus of elasticity	= 7,200 N/mm^2

a)   Determine the maximum bending stress in the timber floor boards.   (3 marks)

b)   Does the maximum bending stress in the timber floor board exceed the permissible bending stress under medium term conditions?   (5 marks)

c)   Does the deflection of the timber floorboard exceed the maximum permitted value of 3 mm?   (4 marks)

d)   Determine the maximum tensile force that can be safely carried by the diagonal web member under medium term conditions.   (5 marks)

e)   Determine the maximum compressive force that can be safely carried by the diagonal web member under medium term conditions.   (8 marks)
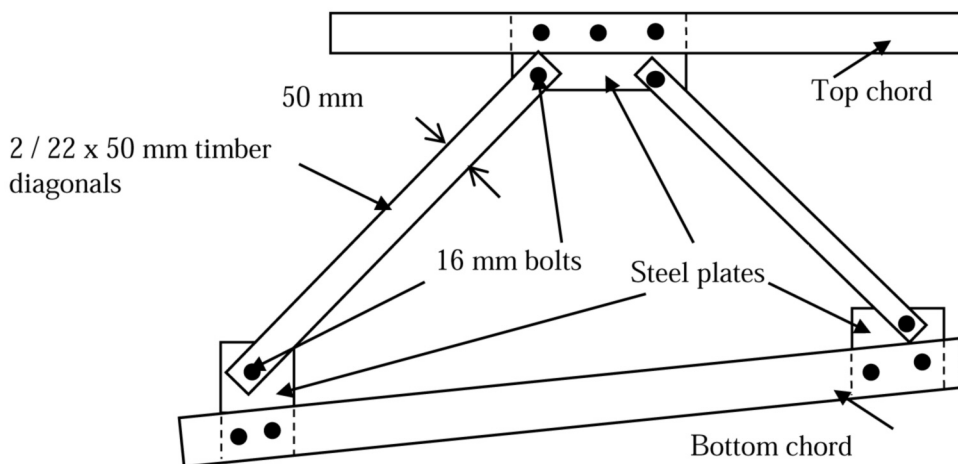

Figure Q3

4   Figure Q4 shows the elevation from ground floor to first floor of a 200 mm thick solid masonry wall of 4.0 m clear height in a multi storeyed building. The first floor slab spans on the wall from both sides. The slab spans 5.0 m. The characteristic dead load on the first floor slab is 3.6 kN/m^2 and the characteristic imposed load on the first floor slab is 2.5 kN/m^2. The wall also carries a design load of 75 kN/m from the upper floors. The density of the wall material is 22 kN/m^3.

a)   Determine the design vertical load in kN/m at the ultimate limit state at the ground level that is applied on the wall.   (7 marks)

b)   Show whether the design vertical load can be safely applied on this wall, if it is proposed to use masonry units of compressive strength of 5.0 N/mm^2 and mortar designation type (iii). You may assume normal conditions of quality control for both manufacture of the brick units and the construction of the wall.   (11 marks)

c)   Briefly explain whether by improving the standard of quality control, the design vertical load can be safely withstood by this wall while still using bricks of the same characteristic compressive strength. Show also whether greater quality control should be exercised only during manufacture of the bricks or only during construction of the wall unit.   (7 marks)
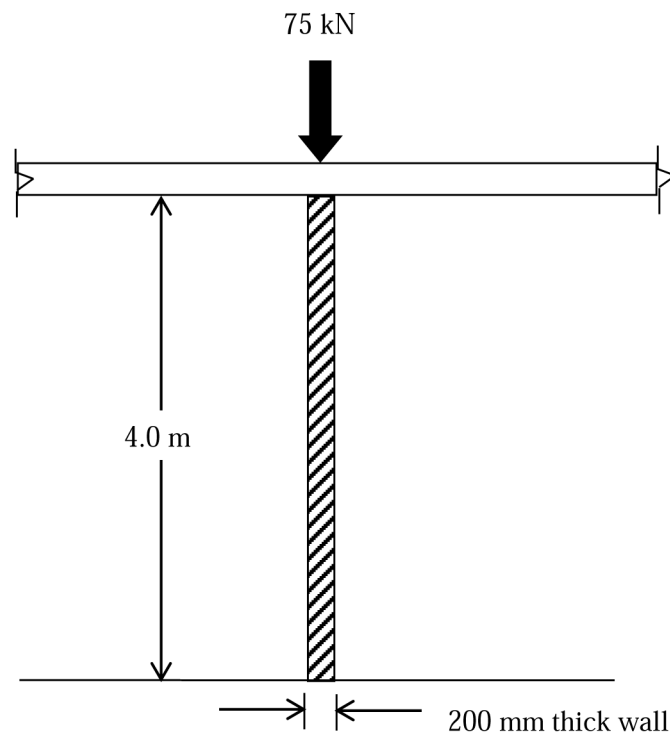

Figure Q4

Section C – Structural Concrete Design to BS 8110

Materials

Concrete compressive strength   = 30 N/ mm^2
Reinforcement characteristic strength   = 460 N/mm^2
Unit weight of concrete   = 24 kN/m^3

Tables A3 and A4 may be used with these questions.

5   Figure Q5a shows a reinforced concrete beam ABC of overall depth 350 mm and width 300 mm that is required to span 6.0 m between supports A and B with an overhang portion BC of 2.0 m length.
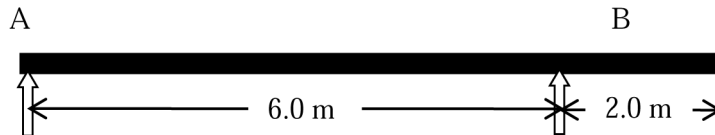

Figure Q5a

It supports a design load of 30 kN/m at the ultimate limit state. Figures Q5b and Q5c show the steel reinforcement arrangement for the beam. You may assume a cover of 30 mm to the links.

a)   Determine the maximum design support moment in the beam.   (2 marks)
b)   Determine the maximum design span moment in the beam.   (6 marks)
c)   Check whether the steel reinforcement provided as shown in Figure Q5c is sufficient to withstand the maximum design support moment assuming that compression steel is not required.   (7 marks)
d)   Check whether compression steel is required to withstand the design span moment.   (4 marks)
e)   Determine a suitable spacing for 10 mm high yield steel shear links to safely withstand the maximum shear force that occurs in the beam. Assume a value of design concrete shear stress of 0.59 N/mm^2.   (6 marks)
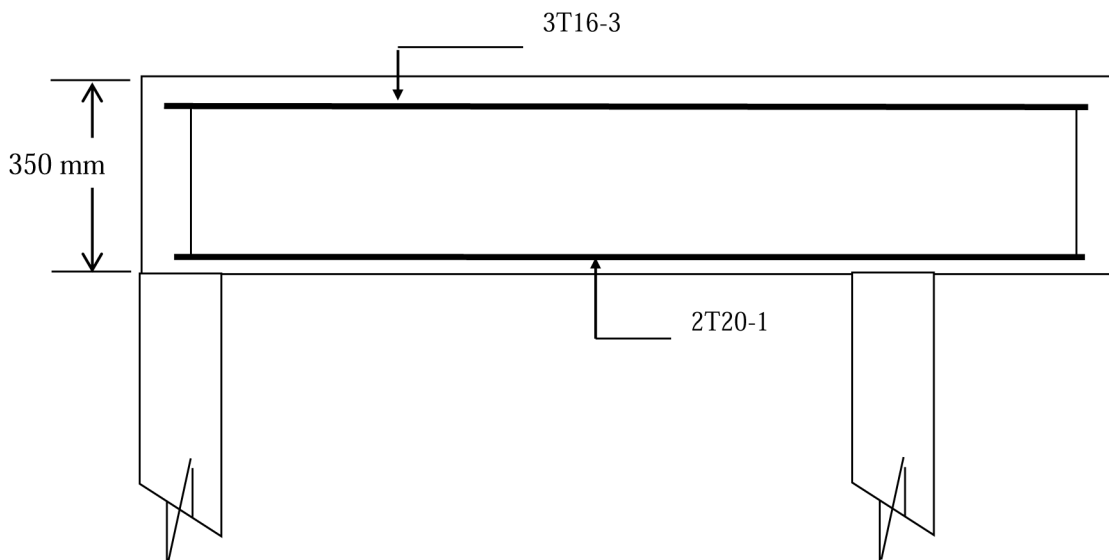

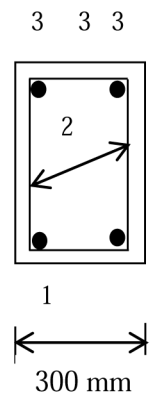**Figure Q5b**   **Figure Q5c**

6   A reinforced concrete staircase 1000 mm wide of the type shown in Figure Q6 spans horizontally and is set into two pockets in the two supporting beams. The effective span is 3.0 m and the floor to floor height is 1.5 m. Each step has a tread of 260 mm and a riser of 150 mm. The waist of the staircase is 140 mm. The live loading on the stairs may be assumed as 2.50 kN/m^2. The cover to all steel may be assumed as 30 mm.
   a)   Determine the factored loading on the staircase.   (6 marks)
   b)   Determine the spacing of T10 bars required to resist the maximum bending moment assuming a simply supported span.   (10 marks)
   c)   Determine the spacing for transverse distribution steel of T10 bars.   (4 marks)
   d)   Check for deflection based on the allowable span/depth ratio assuming an appropriate value for the modification factor for tension reinforcement.   (5 marks)
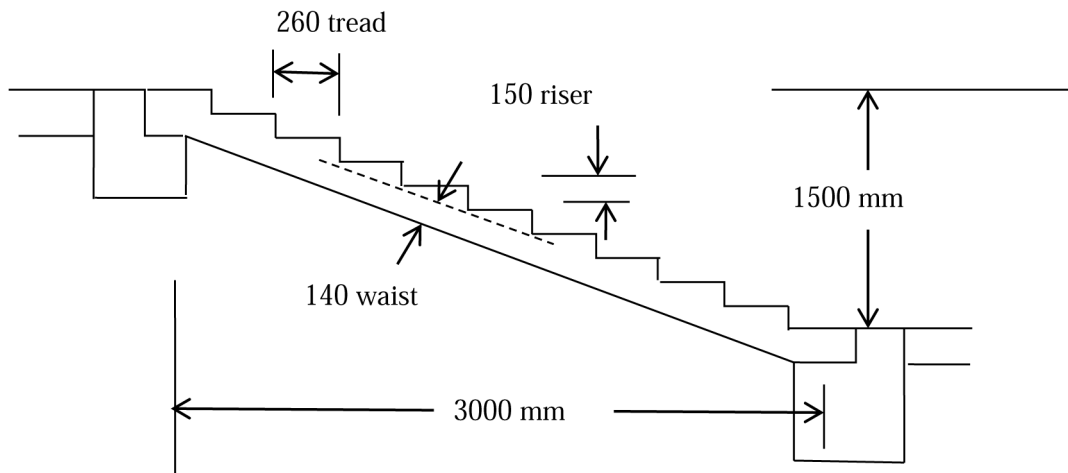

Figure Q6

7   A short braced square reinforced concrete column is required to resist an unfactored dead load of 400 kN inclusive of the column selfweight and an unfactored live load of 300 kN at the top level of its square pad foundation. The pad foundation is of 2.0 m x 2.0 m plan dimensions and 400 mm thick. Cover to the bottom steel in the foundation may be assumed as 50 mm.
   a)   Determine whether 4 Nos of T20 bars are sufficient to withstand the design axial compressive load in the column at the ultimate limit state.   (5 marks)
   b)   Check that the pressure beneath the foundation is within the safe bearing pressure of 200 kN/m^2.   (4 marks)
   c)   Determine the spacing of T20 bars to resist the bending moment in the base.   (8 marks)
   d)   Determine the shear stress in the base at a line across the base of 1.0 × the tensile steel effective depth from the column face.   (4 marks)
   e)   Determine the punching shear stress in the base at a perimeter of 1.5 x the tensile steel effective depth from the column face.   (4 marks)