[C022/SQP054]

Higher Civil Engineering

Time: 3 hours

NATIONAL QUALIFICATIONS

Specimen Question Paper

100 marks are allocated to this paper.

Answer **all** questions in Section A (40 marks).

Answer **three** questions is Section B (20 marks each).

Worksheets are provided for questions 8 and 11.
Hand these in with your answer book.

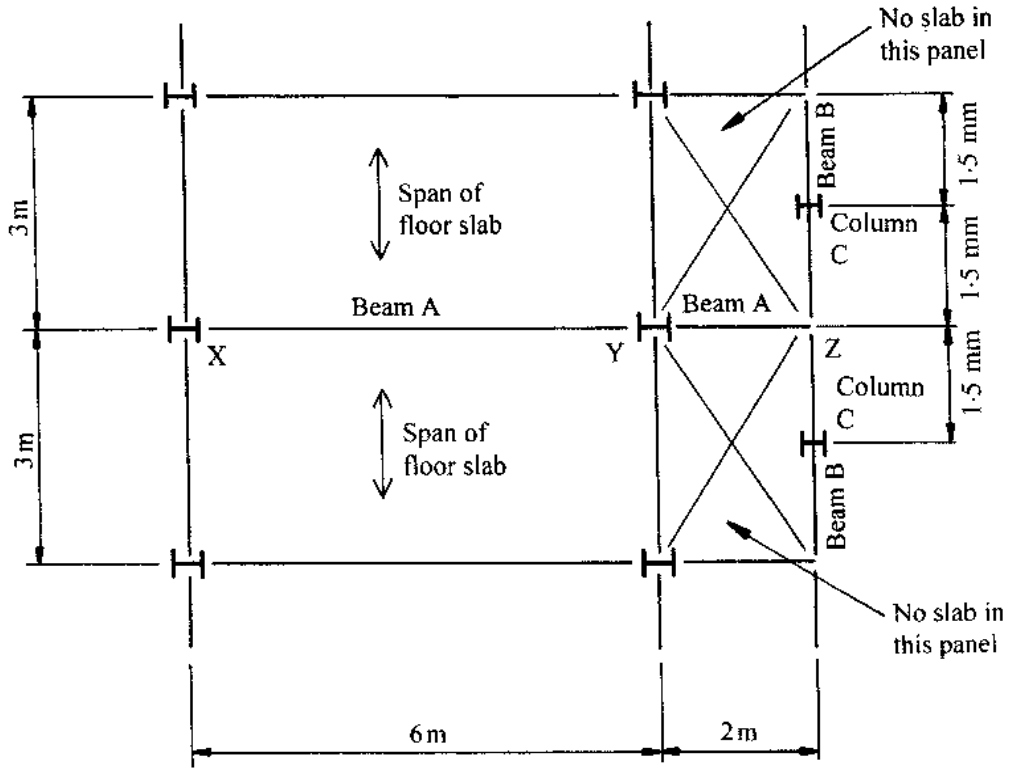
SCOTTISH QUALIFICATIONS

SECTION A

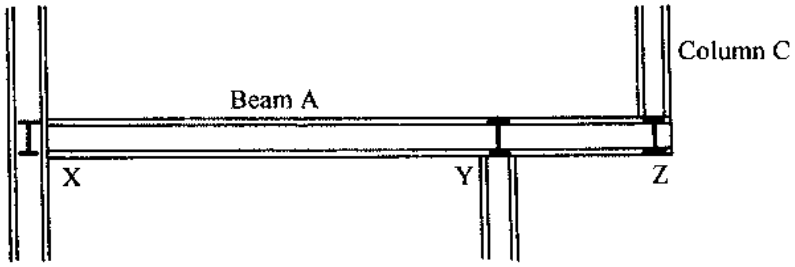
Attempt all the questions in this section (total 40 marks) *Marks*

1. Briefly describe **one** civil engineering computing package with which you are familiar and state **two** advantages of using the package as an alternative to completing a manual solution to a problem. **(3)**

2. (*a*) From the structural layout and design data shown in Figure Q2(*a*), evaluate the loading on beam A. **4**



PLAN



SECTION

DESIGN DATA:
Dead load of floor slab + finishes = 3·5 kN/m^2
Imposed load on floor slab = 5·0 kN/m^2
Self weight of beams A and B = 1·0 kN/m run
Loads on beam B from columns C = 50 kN from each column

Figure Q2(*a*)
Structural Floor Layout

2. (continued)

(*b*) For the loaded beam shown in Figure Q2(*b*), determine the magnitude of each of the support reactions. **6**

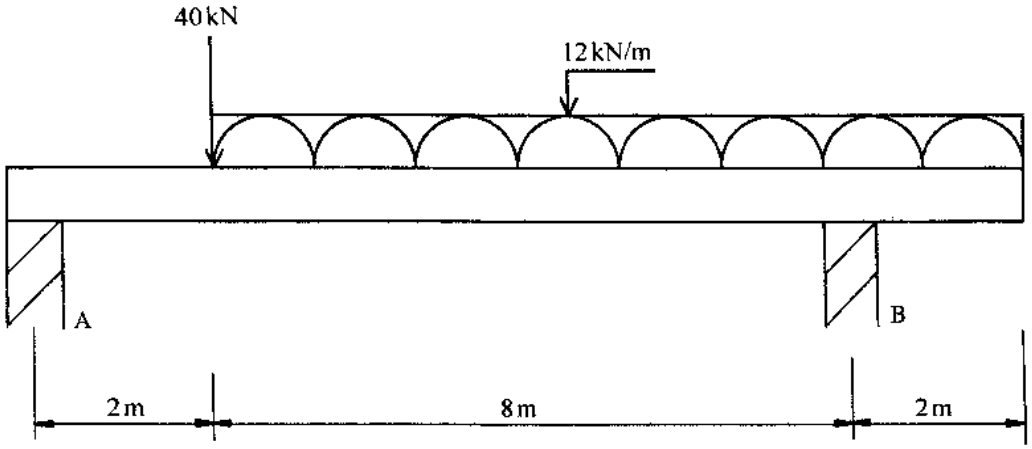


Figure Q2(*b*)
Elevation of loaded beam **(10)**

3. A 500 mm deep by 300 mm wide reinforced concrete beam is to be constructed with four 20 mm bars in the bottom face, two 16 mm bars in the top face and 8 mm links at 200 mm centres. Describe, with the aid of a sketch, all the information required to accurately position, fix and maintain cover to the reinforcement.

(6)

4. Various site personnel are employed by civil engineering contractors. Draw an *organisation tree* illustrating a typical contractor's site personnel structure.

(6)

5. (*a*) State **three** properties which must be considered in the selection of an aggregate for use in the production of concrete for a reinforced concrete structure. **3**

(*b*) Two convenient sources of aggregate for concrete production are being considered. One is a river gravel, while the other is a quarried granite.

(i) State the main difference which would be noticed in the particle shape of the two aggregates and indicate the reason for this. **2**

(ii) Compare the two aggregates of part (i) for use in each of the following situations:

surface layers requiring good wearing resistance;
foundations subject to sulphate attack;
critical elements requiring good fire resistance. **3**

(8)

Marks

6. (*a*) Define the term *workability* in relation to a concrete mix. **2**

(*b*) Compare the degree of workability required for the two following site operations:

(i) concrete which is to be pumped from the mixing plant to the point of use in heavily reinforced concrete beams;

(ii) concrete which is to be delivered by truck for use in a road slab. **5**

(7)

SECTION B

Attempt any THREE questions in this Section (Total 60 marks) *Marks*

7. (*a*) Brick walls are to be used between the columns of a structure which will be exposed to strong prevailing winds, associated wind-borne rain and sleet, plus seasonal frosts.

Briefly describe **two** of the main properties which should be considered in choosing a suitable type of brick for the walls. **2**

(*b*) Briefly explain how the appearance of brickwork can deteriorate if affected by the action of chemical salts below ground and suggest how such a problem might be minimised. **4**

(*c*) The specification for the concrete required for a mass concrete base indicates that a C25 concrete is called for.

Explain what is meant by the designation C25 and how the concrete produced is shown to have complied with the specification. **3**

(*d*) Figure Q7(*d*) shows a 400 mm square reinforced concrete column which is supported on a square mass concrete base. The column carries an axial load of 200 kN and the base is to be supported by a dense gravel of safe bearing capacity 250 kN/m^2.

Determine a suitable plan area and a suitable thickness for the base. **6**

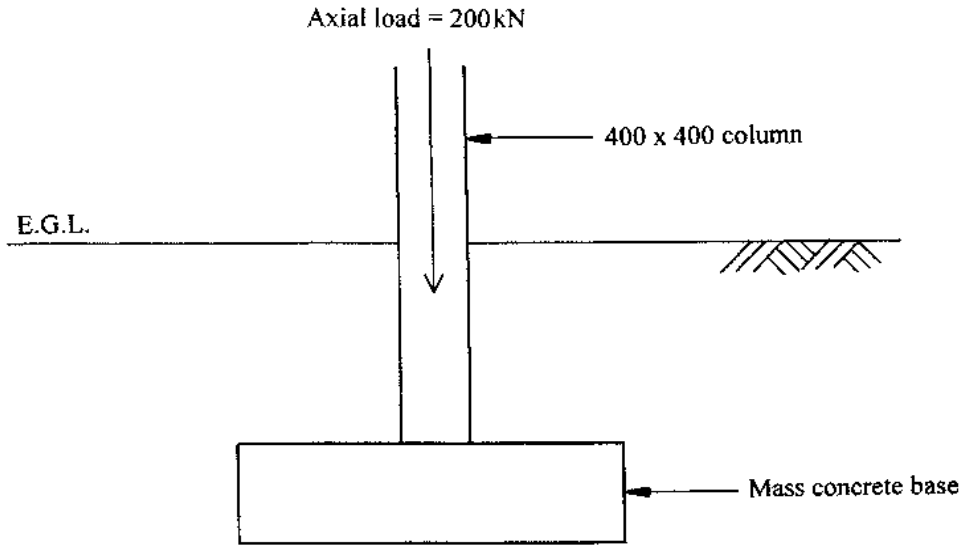


Figure Q7(*d*)
Elevation of base and column

(*e*) After the initial design of the base considered in (*d*), and prior to construction, it is found that the groundwater level is only 0·5 m below the underside of the base. Explain the implication of the position of the water table on the design of the base and how the original solution would be modified. **5**

(20)

Marks

8. The network diagram shown on **Worksheet Q8** relates to a small civil engineering project.

(*a*) Using the **Worksheet Q8**, determine the duration of the project. **6**

(*b*) Explain the meaning of the term *critical path* and identify the critical path for the project. **4**

(*c*) Determine the total float for each of the non-critical activities. **5**

(*d*) After 28 days of the contract, it was found that activity F was likely to over-run its estimated duration of 12 days. The contract is of the cost reimbursement type, based on a target price and duration.

Outline the implications to the contractor of a five day over-run in activity F. **5**

(20)

9. (*a*) Sketch steel beam to steel column connections which may be considered as:

(i) simply supported;

(ii) fixed. **6**

(*b*) A beam of the cross-section shown in Figure Q9(*b*)(i) is to be simply supported over an effective span of 7·6 m.

(i) Determine the second moment of area of the section. **4**

(ii) Given that the bending stress in the beam material is not to exceed 265 N/mm^2, determine the maximum value of the uniformly distributed load which the beam may carry, inclusive of its self-weight. **5**

(iii) At a later stage in the design process, it is found that headroom restrictions limit the depth of the beam which can be used to 250 mm.

Assuming that a hollow rectangular section with flange and web thicknesses of 20 mm, as shown in Figure Q9(*b*)(iii), is to be used and that the beam material now has a maximum permissible bending stress of 345 N/mm^2, determine a suitable breadth (B) for the new beam. **5**

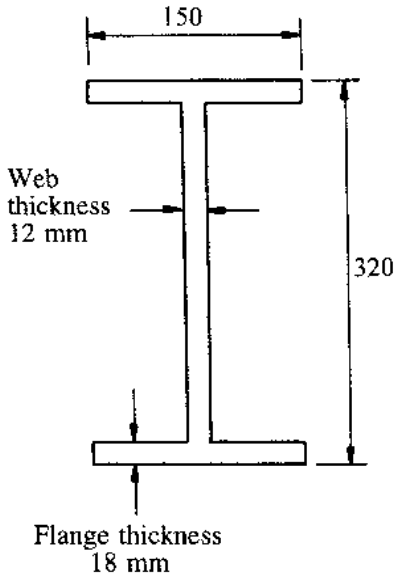


Figure Q9(*b*)(i)
Cross-section of beam

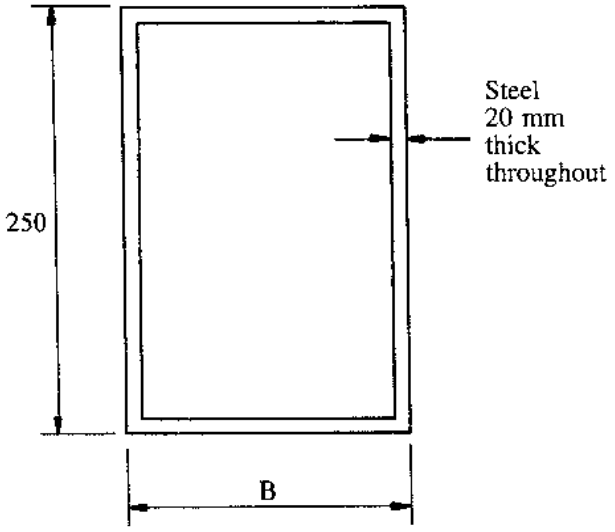


Figure Q9(*b*)(iii)
Cross-section of beam

(20)

Marks

10. (*a*) (i) Explain how the quantities, for inclusion against bill items, are arrived at when preparing a Bill of Quantities. **2**

(ii) State **three** of the main advantages which may be claimed for a contract based upon a Bill of Quantities. **3**

(*b*) Figure Q10 shows the elevation of and loading diagram for a beam.

(i) State **two** possible sources of the concentrated loads on the beam. **3**

(ii) The loading diagram relates to a steel beam having a moment capacity of 132 kNm. Construct the bending moment diagram for the beam and check its suitability in bending. **7**

(iii) Calculate the increased value of the concentrated load at the end of the cantilever which would make the **resulting** span and support moments equal in magnitude. **5**

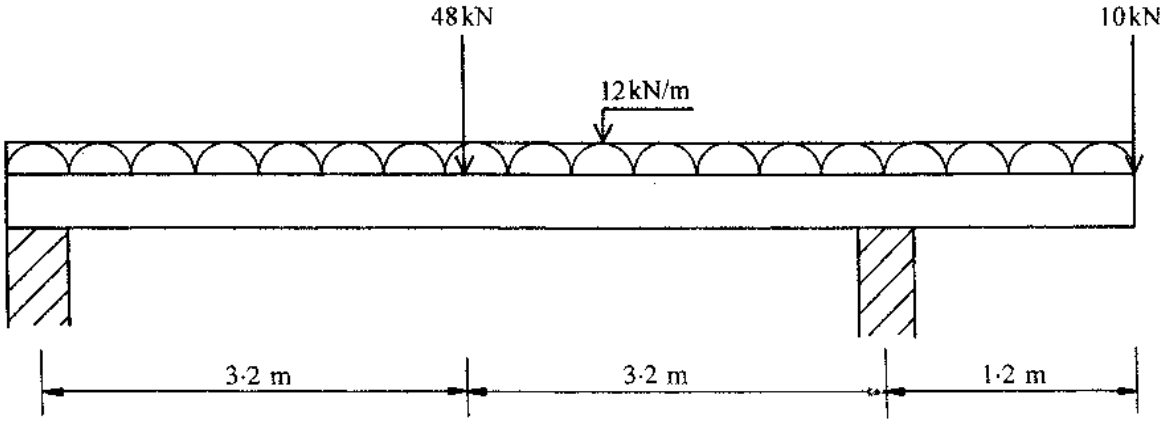


Figure Q10
Elevation of loaded beam **(20)**

Marks

1. (*a*) The results of liquid limit and plastic limit tests on a cohesive soil are shown in Tables 11(*a*)(i) and 11(*a*)(ii).

Determine, using **Worksheet Q11**, the plasticity index of the soil and state its Casagrande classification. **12**

Percentage moisture content	*Penetration* (mm)
34·8	15·1
46·9	17·6
78·0	21·6
86·1	22·9

Table 11(*a*)(i)
Liquid Limit Data

Mass of container (g)	*Mass of container plus wet soil* (g)	*Mass of container plus oven dry soil* (g)
37·13	49·16	47·66
38·83	49·52	48·22

Table 11(*a*)(ii)
Plastic Limit Data

(*b*) State the main difference between a *face shovel excavator* and a *dragline excavator*. For **each** machine, indicate **one** situation where it would normally be used. **3**

(*c*) A strip footing is to be constructed at the bottom of a 2·5 m deep trench. The trench is to be excavated through 2 m of firm clay which lies over a deep layer of dense gravel. The trench is to be 6 m long, the formation width 2·5 m and the water table is found to be at a depth of 2 m.

Describe a suitable method of excavation and groundwater control for the trench and the sequence of operations and safety measures required. **5**

(20)

[END OF QUESTION PAPER]

FOR OFFICIAL USE

Centre No.	Subject No.	Level	Paper No.	Group No.	Marker's No.

Total

[C022/SQP54]

Higher
Civil Engineering
Specimen Question Paper
Worksheets for Questions 8 and 11

NATIONAL QUALIFICATIONS

Fill in these boxes and read what is printed below.

Full name of centre

Town

First name and initials

Surname

Date of birth
Day Month Year

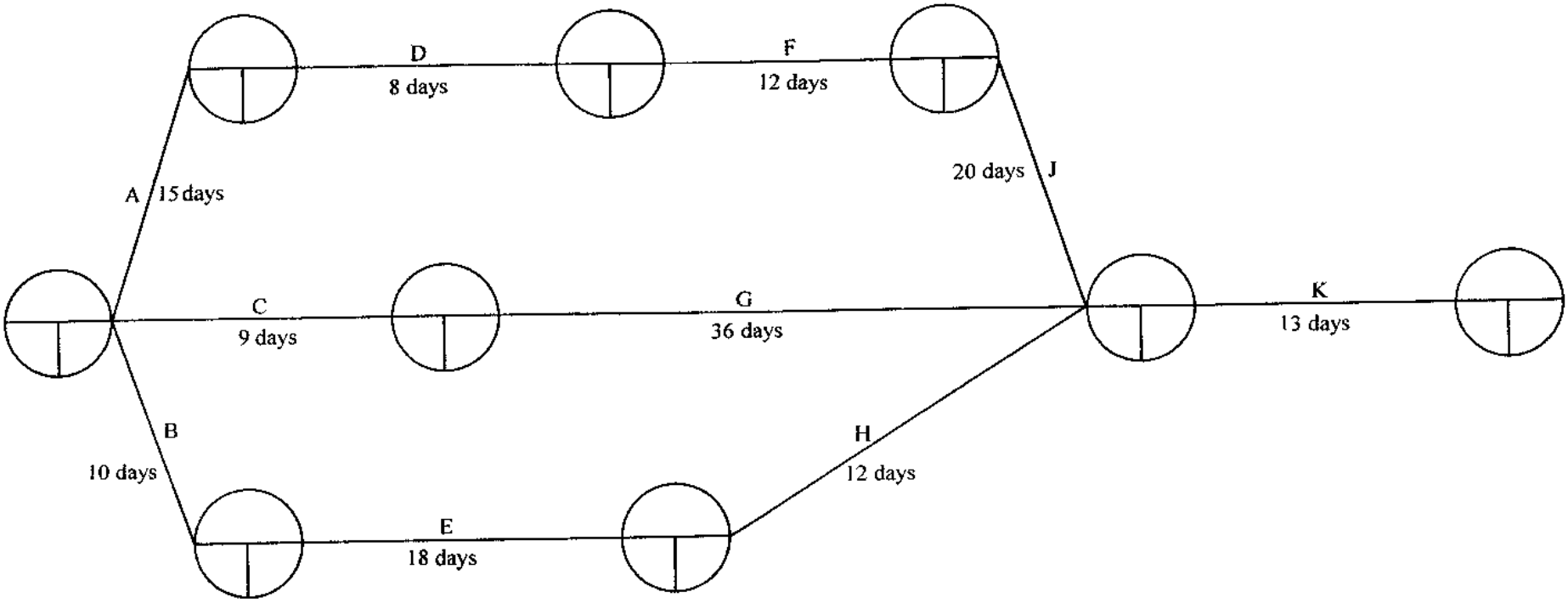
Candidate number

Number of seat

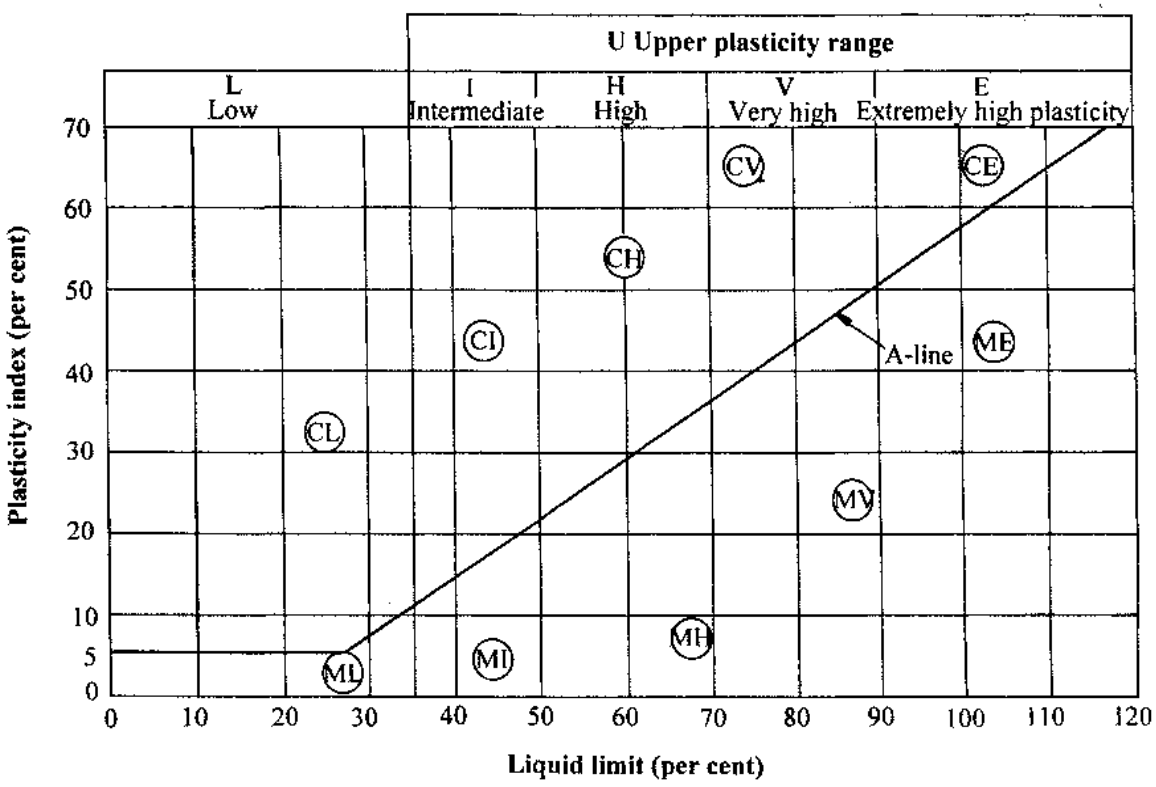
To be inserted inside the front cover of the candidate's answer book and returned with it ONLY by candidates who attempt Question 8 and/or Question 11.

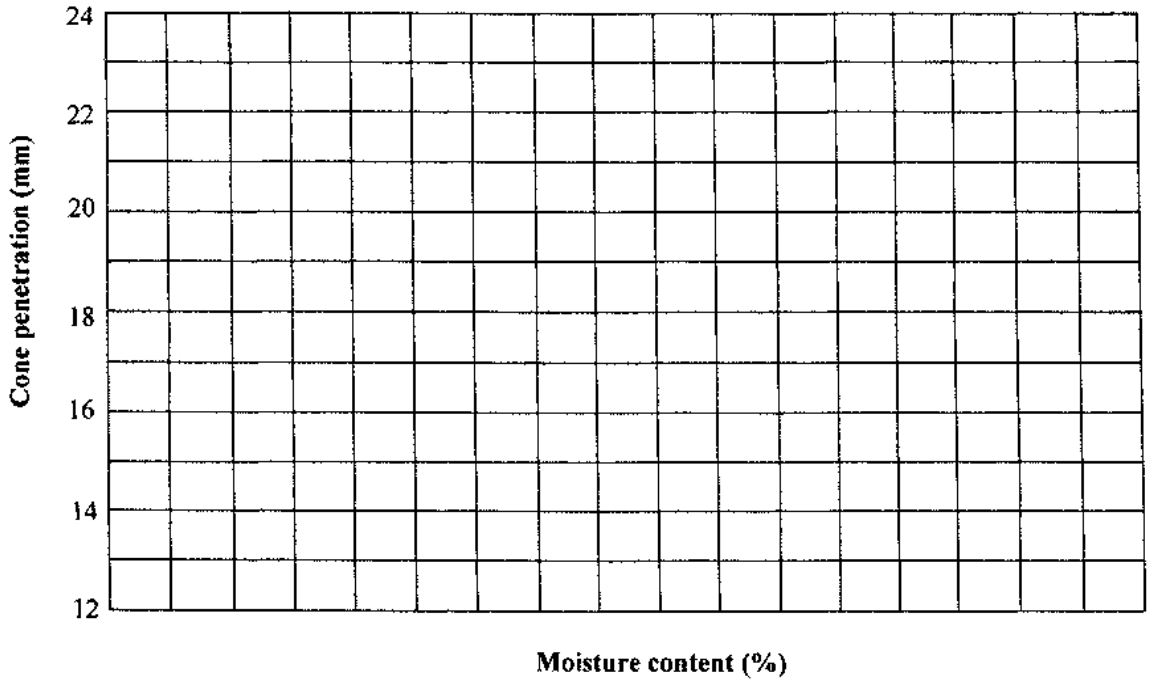
SCOTTISH QUALIFICATIONS

WORKSHEET Q8



WORKSHEET Q11



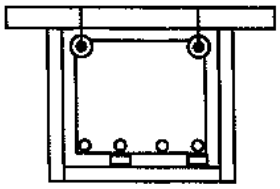
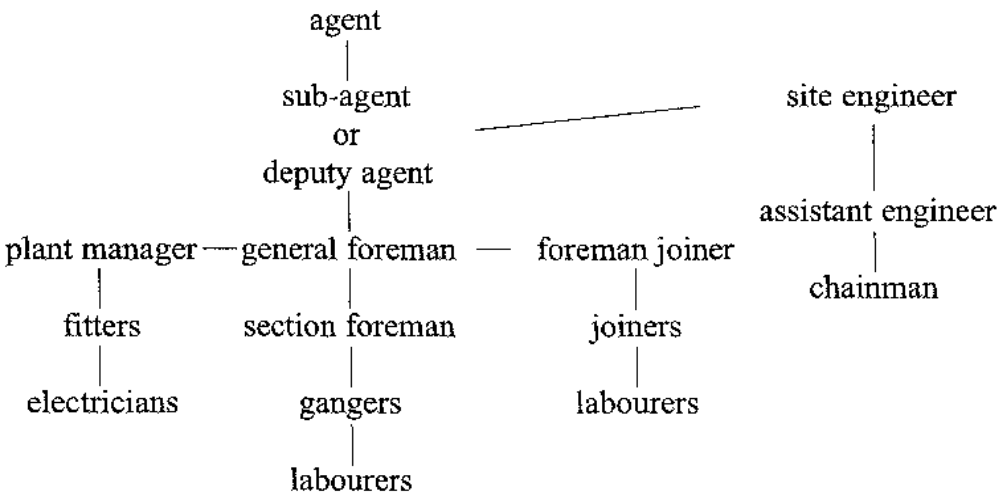


Higher
Civil Engineering
Solutions

NATIONAL
QUALIFICATIONS

SCOTTISH
QUALIFICATIONS

HIGHER CIVIL ENGINEERING
SOLUTIONS
SECTION A

Q	Solution	Marks
1	Either give title of program or indicate its coverage. General Advantages: variables can be changed and results compared easily. arithmetical errors eliminated. solution much quicker. More specific advantages of a particular program would be accepted.	3
2	a. Beam A - part XY - Load / m run = 3 x 1(5 + 3·5) + 1 = 26·5 kN/m part YZ - Load / m run = 1 kN/m Concentrated load at free end of cantilever = 50/2 + 50/2 + 3 x 1 = 53kN b. Moments about A = $40 \times 2 + 12 \times 10 \times 5 = RB \times 10$ Thus RB = 68 kN & RA = $40 + 12 \times 10 - 68 = 92$ kN	4 6
3	Concrete cover to top, bottom and sides of beam will be indicated on detail drawings. Bottom cover to main reinforcement may be maintained by either plastic spacers or by concrete blocks tied to reinforcement by wire. Top cover may be maintained by supporting the top reinforcement from timber battens resting upon side formwork. Side cover may be maintained by concrete spacers between side formwork and longitudinal bars or vertical shear links. Sketch 	6
4	 *or equivalent 'tree'*	6

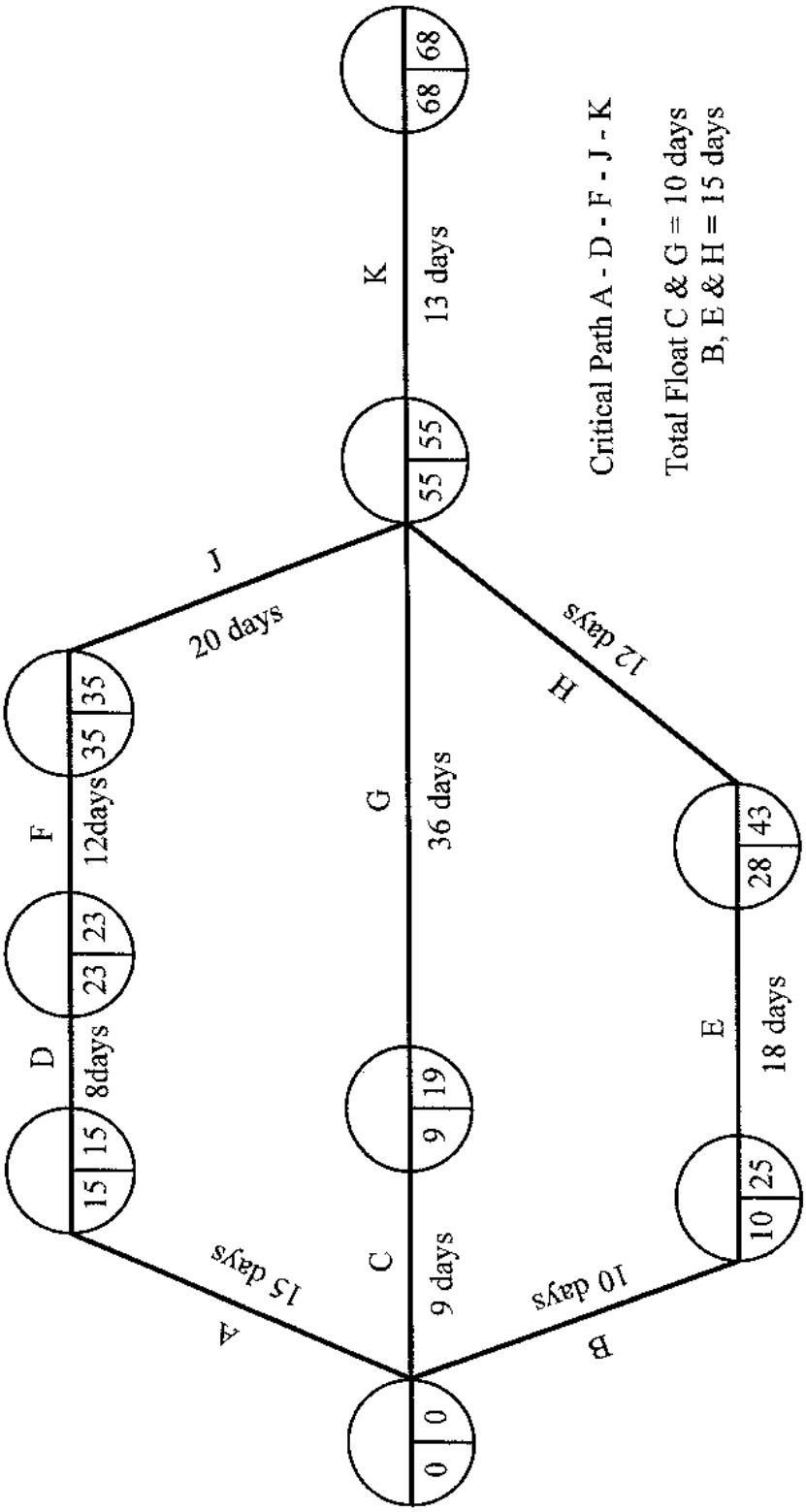
Q	Solution	Marks
5	a. Aggregate properties: particle shape and grading, surface moisture content, porosity (absorption), density and hardness, cleanliness. any three from above list	3
	b. (i) River gravel will be well rounded due to movement by water while the quarried granite will be more angular due to extraction process.	2
	(ii) Rounded gravel aggregate is not generally suitable for surfaces subject to abrasion such as roads. Rounded gravel aggregate generally has a high resistance to sulphates eg in foundation construction. Rounded gravel aggregate tends to split under intense heat, particularly if there is a high proportion of flint in the aggregate.	3
6	a. Workability is that property of the concrete mix which enables it to be placed and compacted in the forms and around reinforcement, and depends, largely, on its consistence.	2
	b. (i) Such concrete should have a higher degree of workability which will cause the concrete to flow from the pump to the point of placing, into the formwork and around the reinforcement.	
	(ii) Such concrete should have a lower degree of workability since heavier external compaction equipment will be used.	5
	Total	40

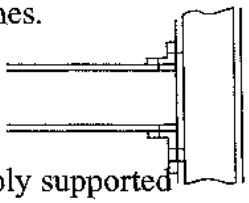
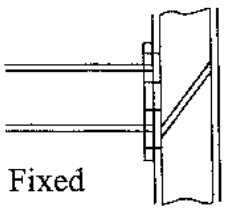
SECTION B

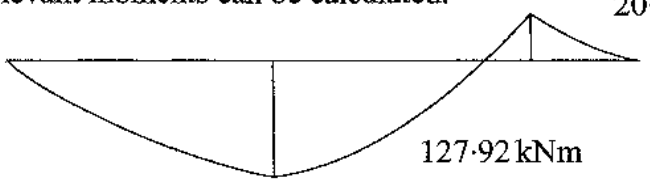
Q	Solution	Marks
7	a. The main properties to be considered in making a choice are: The less porous the brick, the less susceptible to frost. Clay bricks with a high lime content are less likely to be susceptible to moisture expansion. Underfired bricks are more susceptible to frost damage. (any 2 of these) b. Chemical action below ground can cause efflorescence on surface of brickwork. If certain salts crystallise, then the brickwork surface can flake. Cement based mortars are susceptible to sulphate attack and can deteriorate. Use specially selected bricks whose surface can resist attack and use a sulphate resistant cement in the mortar. c. A C25 concrete is one with a 28 day strength of 25 N/mm^2. To prove that such a concrete is being produced and used, cubes are made during construction, cured and independently tested, all to British Standard specifications. These cubes must reach the required strength. d. Plan area of base required = 200 / 250 = 0·8 m^2 = 900 mm × 900 mm. Base thickness not less than overhang of base beyond column face i.e. not less than (900 – 400) / 2 = 250 mm. e. Since the soil beneath the base will be affected by the base loading to a depth 1·5 to 2 times the base width, the presence of groundwater level will affect the bearing capacity used. Its value will be approximately 50% of the initial value thus being reduced to 125 kN/m^2. Plan area = 1·6 m^2 = 1·3 × 1·3 m, and thickness = (1300 – 400)/2 = 450 mm.	2 4 3 6 5
	Total	20

Q	Solution	Marks
8	a. Total duration = 68 days b. The critical path is that sequence of activities in which a delay in any single activity would lead to an over-run in the project duration. Critical path = A - - - D - - - F - - - J - - - K c. Total float for non critical activities see diagram on page 5 d. As F is part of the critical path, any over-run in this activity will have a knock-on effect on the overall time for the completion of the project, which will now take 73 days. Thus in the form of contract adopted for this project, this will mean the contractor receiving less money than was originally expected, due to the contract taking longer than the target set. The extra time taken for the activity F means that the contractor will be paying out more money on labour costs.	6 2 2 5 5
	Total	20

WORKSHEET Q8 – SOLUTION

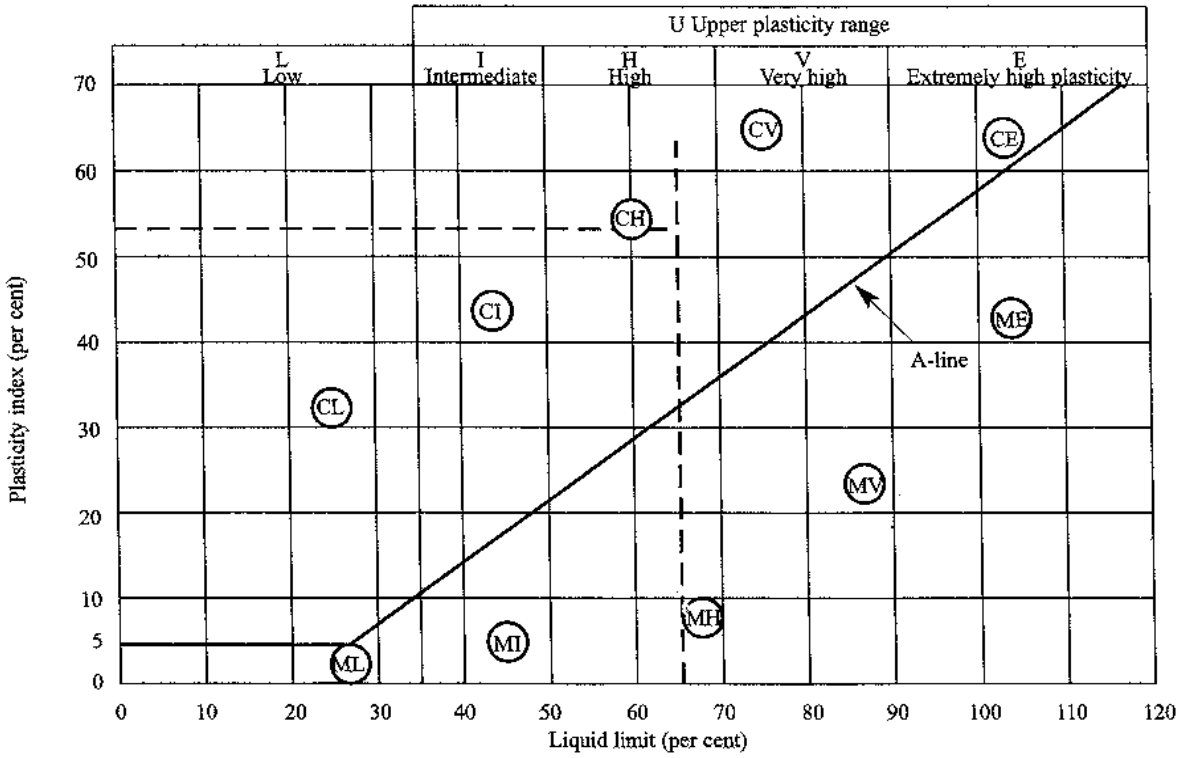


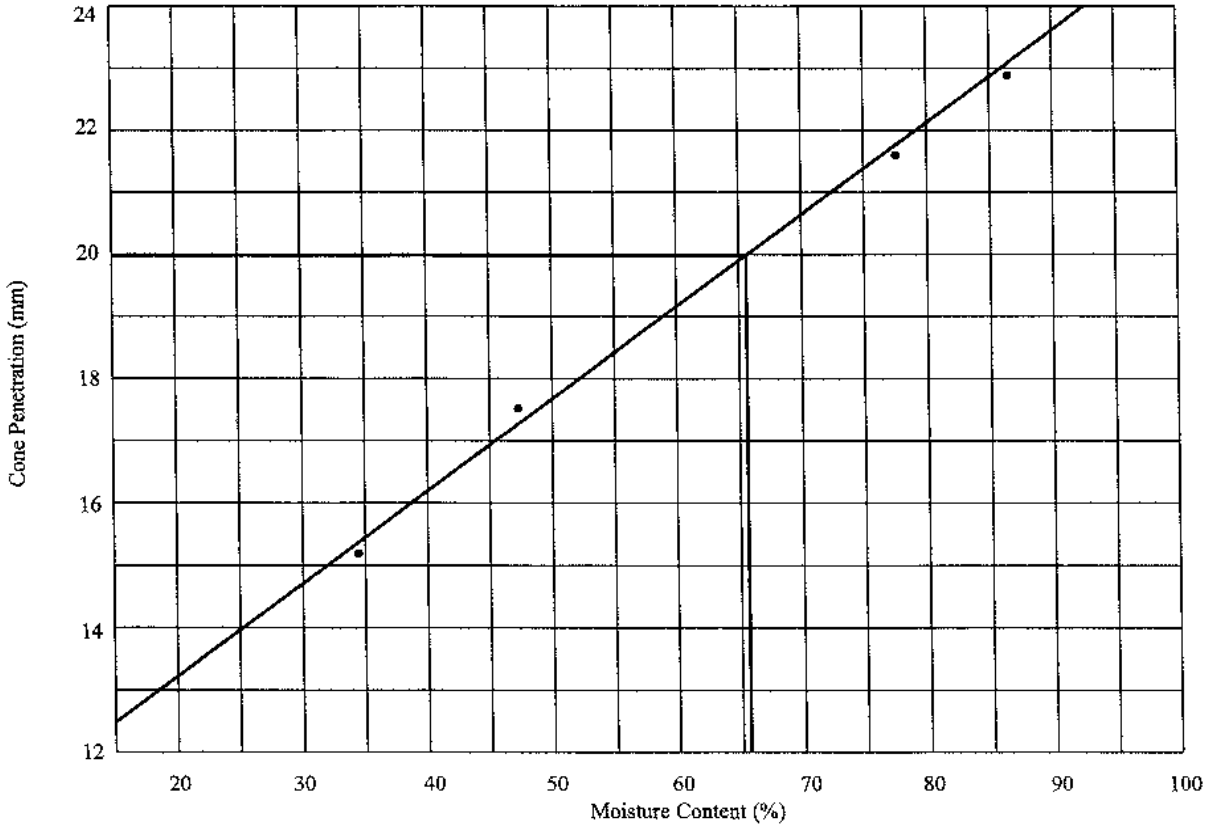
Q	Solution	Marks
9	a. Sketches.  (i) Simply supported  (ii) Fixed	6
	b. (i) $I_{xx} = 2(150 \times 18^3/12 + 150 \times 18 \times 151^2) + 12 \times 284^3/12$ $= 1{\cdot}462 \times 10^8$ mm^4	4
	(ii) $M_{maximum} = 265 \times 1{\cdot}462 \times 10^8 / 160 \times 10^6$ kNm $= 242{\cdot}14$ kNm $= w L^2/8 = w \times 7{\cdot}6 \times 7{\cdot}6/8$ thus $w = 33{\cdot}54$ kN/m	5
	(iii) $M = 242{\cdot}14 \times 10^6 = 345 \times I/125$ thus I required $= 87{\cdot}732 \times 10^6$ mm^4 $I = (B \times 250^3 - (B - 40) \times 210^3)/12$ thus B = 107·2 mm say 108 mm	5
	Total	20

Q	Solution	Marks
10	a. (i) From General Arrangement drawings, the quantity of material or work required for each item is measured.	2
	(ii) Three from: Contractor is generally guaranteed payment for total work done. All tenders are based on exactly the same basis. Client knows the total price for the project at its outset. The rates for any additional work carried out are evident. Or other relevant points.	3
	b. (i) Concentrated loads may be caused by: end reactions from secondary beams, end reaction from a column from above, load from supported plant or equipment. (any 2 from these)	3
	(ii) $RR \times 6{\cdot}4 = 48 \times 3{\cdot}2 + 10 \times 7{\cdot}6 + 12 \times 7{\cdot}6 \times 3{\cdot}8$ RR = 90·025 kN and RL $= 7{\cdot}6 \times 12 + 48 \times 10 - 90{\cdot}025 = 59{\cdot}175$ kN Thus it can be seen that the point of zero shear and hence the point of maximum span moment occurs midway between supports and the value of the relevant moments can be calculated. BMD  20·64 kNm 127·92 kNm	5
	$M_{max} = 127{\cdot}92$ kNm which is less than moment capacity of 132 kNm	2
	(iii) Due to an additional load W kN at the end of the cantilever, the additional support moment is 1·2 W kNm and the total support moment becomes 1·2 W + 20 64 kNm. RR due to additional load W can be found as: $RR \times 6{\cdot}4 = W \times 7{\cdot}6$ thus RR = 1·188W kN and RL = –0·188W kN ie additional span moment is $-0{\cdot}188\,W \times 3{\cdot}2 = -0{\cdot}602\,W$ kNm and the total span moment is 127·92 – 0·602W kNm thus for span and support moments to be equal W must = 59·534 kN	5
	Total	20

Q	Solution	Marks
11	a. Liquid Limit Calculation From Worksheet Q11, plotting the given results, gives the Liquid Limit as 66% – equivalent to the moisture content for a penetration of 20 mm.	4
	Plastic Limit Calculation Sample 1: Mass of water = 49·16 – 47·66 = 1·50 g Mass of solids = 47·66 – 37·13 = 10·53 g Moisture content = 1·5 / 10·53 = 0·1424 = 14·24% Sample 2: Mass of water = 49·52 – 48·22 = 1·30 g Mass of solids = 48·22 – 38·83 = 9·39 g Moisture content = 1·3 / 9·39 = 0·1384 = 13·84% Mean value of moisture content = Plastic Limit = 14·04% Plastic Index = 66 – 14 = 52%	5
	From Worksheet Q11, plotting Plasticity Index against Liquid Limit the Casagrande Classification is indicated as CH i.e. inorganic clay of high plasticity.	3
	b. A face shovel is an excavator on which the digging bucket is arranged on the boom so that it digs upwards. It is used, for example, for bulk excavation against a high working face and can directly load to trucks. A dragline is an excavator on which the digging bucket is arranged in the inverted position so that when it is swung out from the excavator, it excavates as it is drawn backwards. it is used, for example, to excavate reasonably loose material, working below track level, such as in clearing out streams and wide ditches.	3
	c. Excavation would be by backacter to within the last 75 mm which could be carried out by hand. During the excavation through the clay, the sides of the foundation strip would be supported by poling boards at approximately 2 m centres with horizontal struts across the excavation at vertical intervals of approximately 1·25 m. The material excavated would be loaded into trucks for removal. When the water bearing gravel is reached, to keep the excavation dry, a sump would be dug in one corner and a pump employed to remove water to ground surface and hence away from excavation. The sides of the excavation through the gravel will require more support than that through the clay. The support can be achieved by driving timber runners into the gravel, the runners being placed through guides which are attached to the upper walings. If the water ingress is thought to be great, then steel sheet piling may be considered as an alternative to the timbering and pumping.	5
		Total 20

WORKSHEET Q11





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