Exemplar examination paper

The following is an example of a final examination paper.

Candidates are always reminded to carefully read the instructions before answering the questions

Duration: 4 hours **Mark allocation: 100 marks**

Instructions and information:

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system laid out in the question paper.
4. Drawings must be done in accordance with the latest Code of Practice for Building Drawing.
5. Drawings must be fully labelled and dimensioned.
6. All labelling must be neatly printed horizontally.
7. Calculations must be written neatly and orderly and to the nearest three decimal places.
8. Use both sides of the drawing paper.
9. Write neatly and legibly.

Formula sheet

Any other applicable formula is also accepted.

$\Sigma CWM = \Sigma ACWM$	$VC = F \times \sin\theta$
$\Sigma\uparrow F = \Sigma\uparrow F$	$D = \frac{\text{Mass}}{\text{Volume}}$
Moment = Force × distance	W = mass × ga
BM = Reaction moment – Load moment	$\text{Stress} = \frac{\textit{Load}}{\textit{Area}}$
$\frac{m}{I} = \frac{f}{y}$	$Z = \frac{m}{f}$
$Z = \frac{I}{y}$	$X = \frac{\Sigma Ax}{\Sigma A}$
$I_{xx} = \frac{bd^3}{12}$	$I_{yy} = \frac{db^3}{12}$
$I_{xx} = \frac{bd^3}{36}$	$I_{xx} = \frac{\pi D^4}{64}$
$I_{xx} = \frac{bd^3}{12} + al^2$	$I_{xx} = \frac{BD^3}{12} - \frac{bd^3}{12}$
$F_s = A_s \times f_s \times n$	
$F_t = A_t \times f_t \times n$	
$F_c = A_c \times f_c \times n$	
$A_s = \frac{d^2}{4}$ $A_s = \frac{\pi(\varnothing - 0{,}9382\,p)^2}{4}$	
$A_t = [(B \times T) - n\,(d \times t)]$	
$A_c = (d \times t) \times n$	

QUESTION 1

1.1 Draw large neat drawings to show the following typical types of concrete structures:

1.1.1 The front of a cantilever foundation. Include all the labels. (3)

1.1.2 Retaining wall. Show the position of the tension reinforcement as well as where the tension and compression occurs. (3)

1.2 Draw TWO neat top-view drawings of a slab to show the difference between:

1.2.1 One-way spanning. (2)

1.2.3 Two-way spanning. (2)

The direction(s) of the span must be clearly indicated. **[10]**

QUESTION 2

2.1 Draw the top view of a woodblock floor laid in a herringbone pattern. The drawing must be drawn within a 375 mm × 750 mm rectangle. (2)

2.2 Draw an isometric view of a concrete floor laid with brick tiles. Use the half-bond pattern. Use a sand- and cement-based adhesive.

Size: FIVE bricks wide and FOUR bricks long.
Do not use half bricks.
Concrete floor: 365 mm wide × 1 000 mm long × 75 mm thick.
Brick tiles: 215 × 65 × 22 mm with spaces of 10 mm.
Cement screed: 25 mm (5)

[7]

QUESTION 3

A first-floor structure consists of a reinforced concrete slab supported on L-beams and T-beams.

Use a scale of 1:10 and draw a longitudinal section through the L-beam and slab. A reinforced concrete staircase ends at the top of the L-beam.

Use and include the following details and label the drawing correctly:

L-beam: 500 × 330 mm that includes the thickness of the slab.
Reinforcement:
4Y20 tension reinforcement.
3Y16 compression reinforcing.
R10 binders at 200 mm c/c.

Concrete slab: 150 mm thick included in the L-beam.
Reinforcement:
Y12 main reinforcement at 200 c/c with alternate bars bent up. Y10 secondary reinforcement at 250 mm c/c.

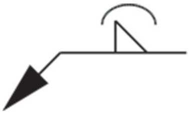
Staircase: THREE steps down from the top of the edge beam.
Treads 225 mm.
Rise 175 mm.
Waist 125 mm thick.
Reinforcement:
Y12 main reinforcement at 200 c/c.
Y10 secondary reinforcement at 200 mm c/c.

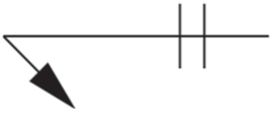
Floor and staircase: 300 × 300 mm cement tiles laid with a cement mortar mix.

Finishing:
The completed drawing must include all the labels and dimensions. **[20]**

QUESTION 4

The figures below show THREE types of welding symbols. Name and explain the symbols.

1.

(2)

2.

(2)

3.

(2)
[6]

QUESTION 5

An H-section parallel flange column is supported by means of a 25-mm thick base plate. TWO 12-mm thick flange plates are welded to both sides of the column flanges.

A main beam is welded to the flange of the column and a secondary beam is welded to the web of the column. Both the beams are supported by 100 × 100 × 10 mm seating cleats.

The distance between the top of the base plate and the top of both beams is 1 200 mm. The column flange must be on the left-hand side of the drawing.

Base plate:	600 × 600 × 25 mm
Bolt holes:	Φ22 mm for M20 bolts
Flange plates:	600 × 600 × 12 mm
H-section column:	254 × 254 × 84,7 kg/m
I-section parallel flange Main beam:	305 × 165 × 40,5 kg/m
I-section parallel flange Secondary beam:	203 × 133 × 25,3 kg/m
Seating cleats:	100 × 100 × 10 mm

Use a scale of 1:5 and draw an isometric view of the column and beam connection. The completed drawing must include all the labels and welding symbols. **[25]**

QUESTION 6

Figure 1 shows a loaded simply supported steel beam supporting THREE point loads and a 15 kNm uniformly distributed load.

Calculate the following:

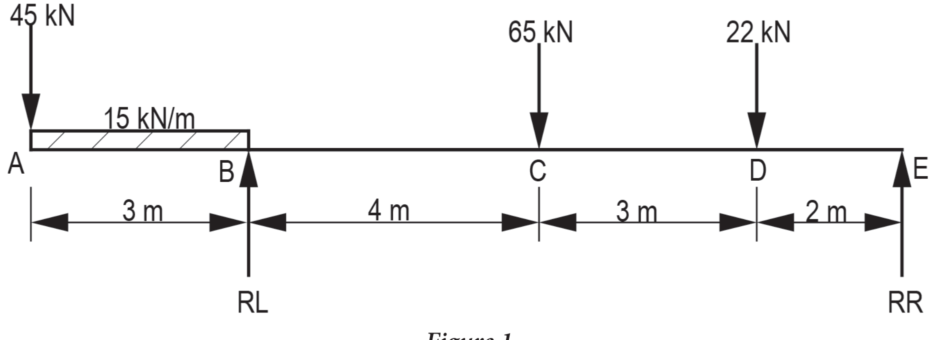


Figure 1

6.1 Calculate the reaction at RL and RR. (4)

6.2 Calculate and draw the shear force diagram. Insert all the values in the diagram. (5)

6.3 Calculate and draw the bending moment diagram. Insert the value of the bending moment maximum in the diagram. (4)

6.4 Calculate the maximum section modulus for the loaded beam. (2)

6.5 From the tables, select a suitable I-section parallel flange for the loaded beam. (1)

6.6 Calculate the maximum shear stress for the given beam. (2)

Use the following scales:
Load diagram: 140 mm = 11 m
Shear force: 2 mm = 1 kN; Bending moment: 3 mm = 1 kN.m

[18]

QUESTION 7

Figure 2 shows a front view of an ornamental stand. All dimensions are given in mm.
Calculate:

7.1 The position of the neutral axes (NA) from AB (4)

7.2 The moment of inertia of the profile about the neutral axis N-A (7)

7.3 The profile modules (z) about the neutral axis N-A (2)

7.4 Select a suitable I-section parallel flange steel beam to replace the given section. (1)

[14]

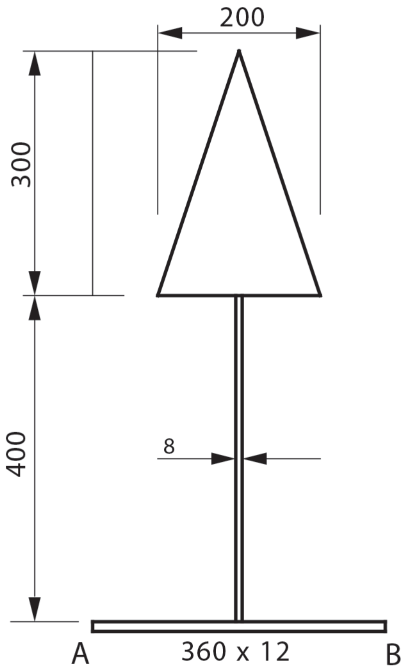


Figure 2

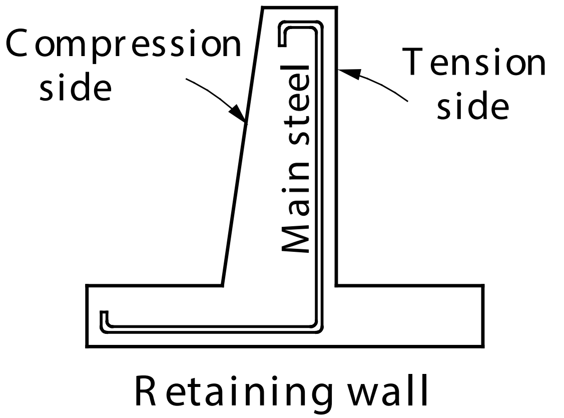
Total: 100 marks

Exemplar examination memorandum

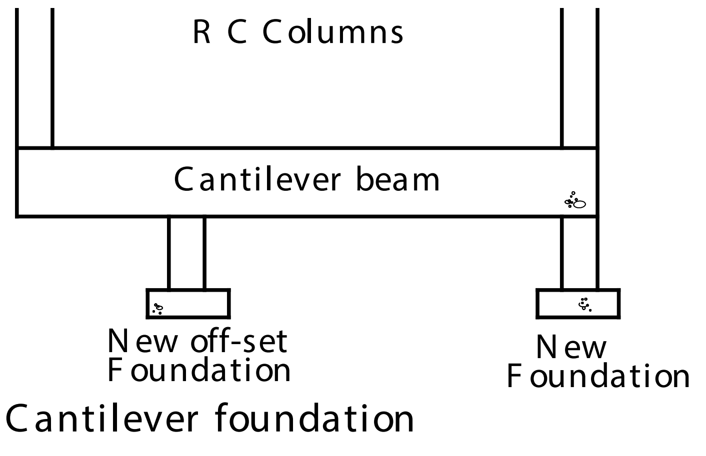
The following is an example of the marking guidelines for a final examination paper.

QUESTION 1

1.1 1.1.1



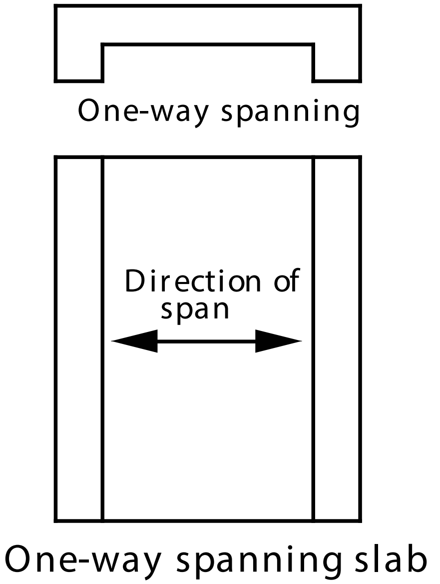
1.1.2



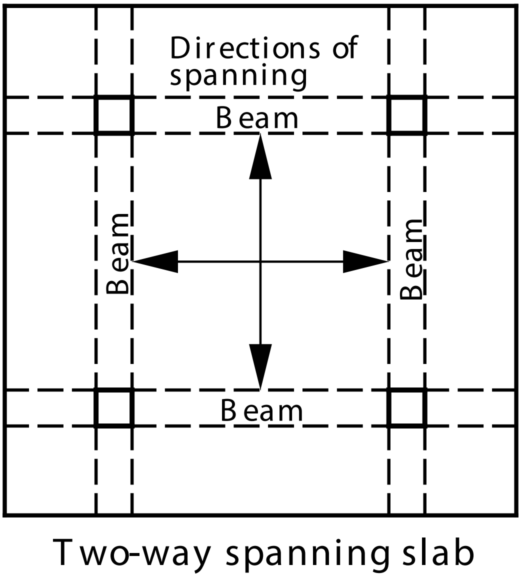
Question 1.1.1	
Drawing corr	1
Main steel	1
Labels	1
Total	3

Question 1.1.2	
Drawing corr	1
Fndn off-set	1
Labels	1
Total	3

1.2.1



1.2.2

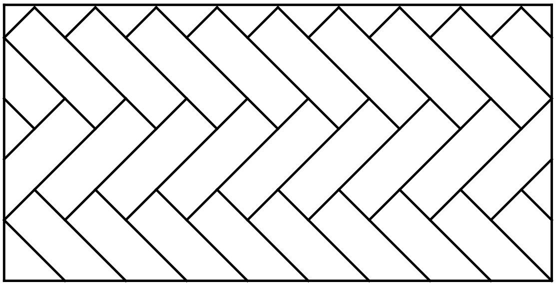


(4)

Question 1.2.1 & 1.2.2	
Beams layout corr	2
Spanning directions	2
Total 2 × 2 = 4	4

QUESTION 2

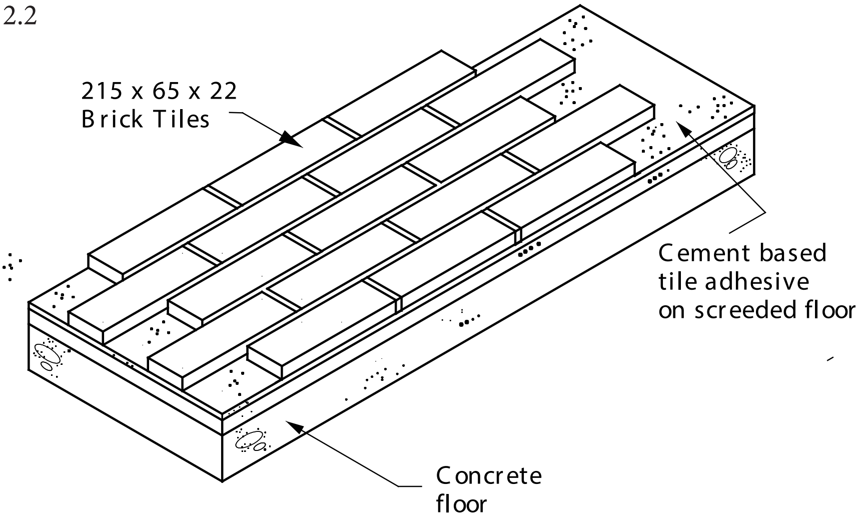
2.1

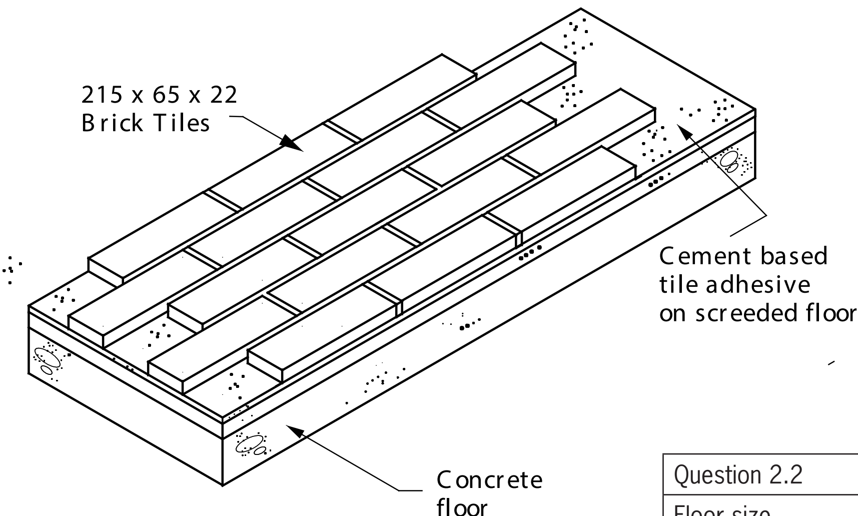


Woodblock Herringbone pattern floor

Question 2.1	
Size corr	1
Pattern corr	1
Total	2

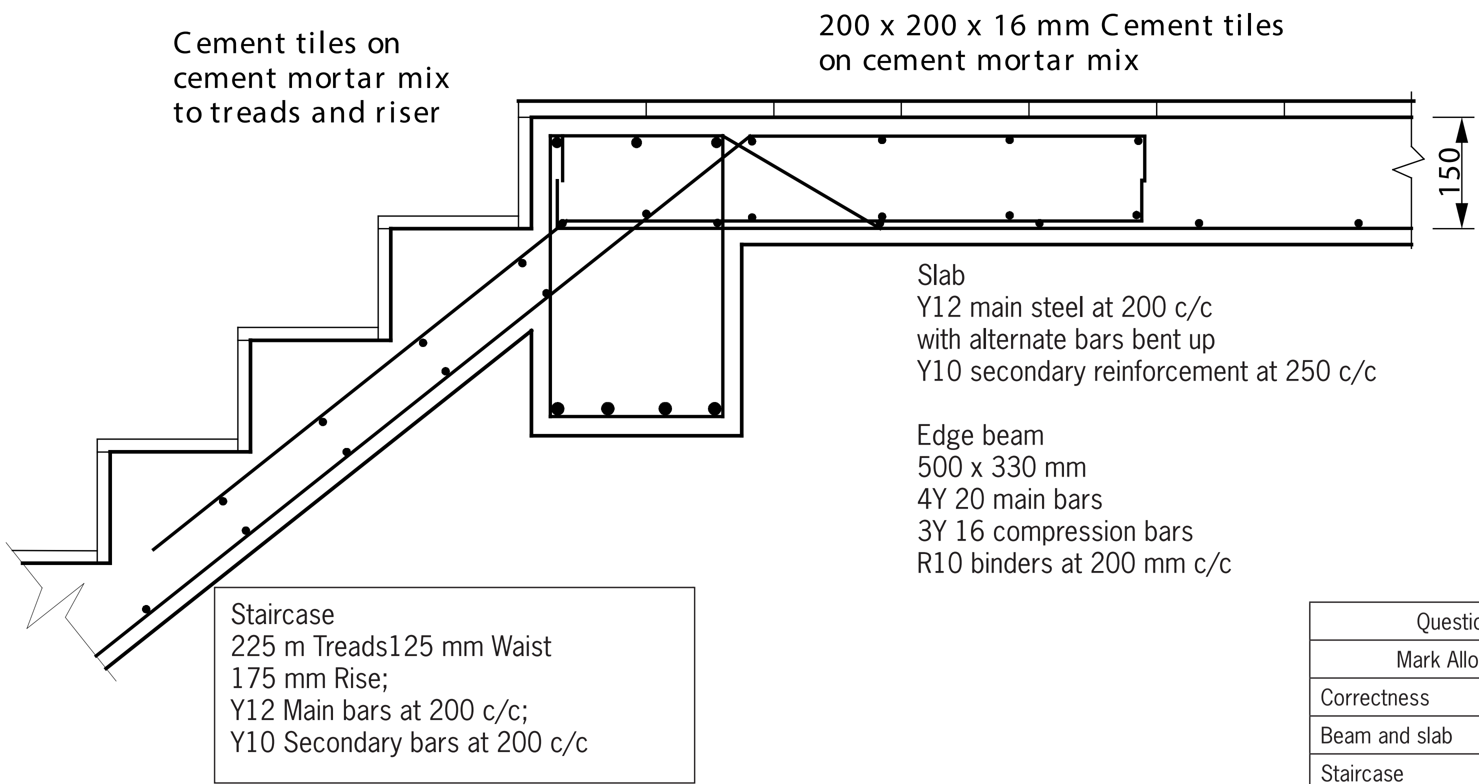
2.2





Question 2.2	
Floor size	1
No. of Bricks corr	2
Accuracy	1
Labels	1
Total	5

QUESTION 3



Question 3		
Mark Allocation		
Correctness	14	
Beam and slab	2	
Staircase	2	
Beam reinforcement	3	
Slab reinforcement	2	
Stair reinforcement	3	
Floor covering	2	
Accuracy		3
Labels & Dims		3
Total	20	

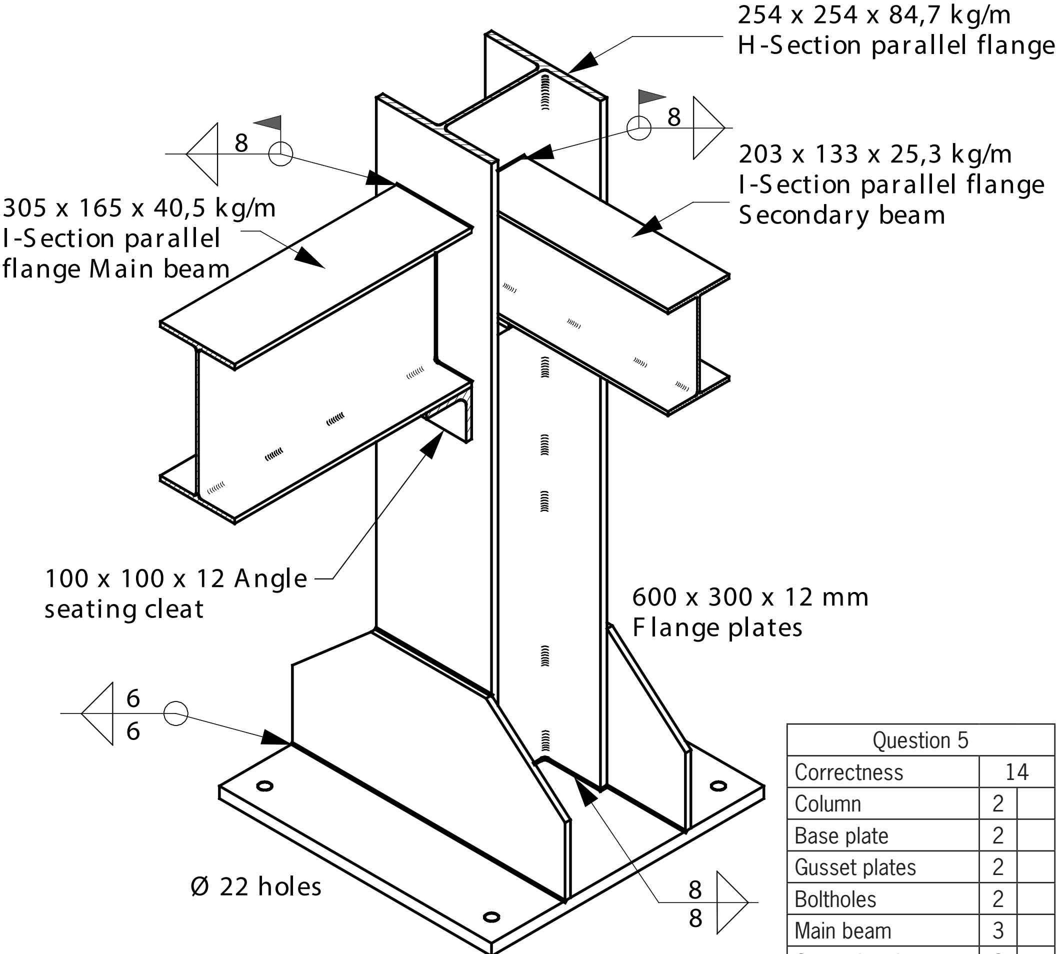
QUESTION 4

The figures below shows THREE types of welding symbols. Name and explain the symbols.

1. Fillet weld. ✓
   On the other side with a convex surface contour. ✓ (2)
2. Square weld. ✓
   Welded on both sides.✓ (2)
3. Plug or slot weld. ✓
   Welded on the other side.✓ (2)

[6]

QUESTION 5



Vertical section through a steel column and steel beams
Scale 1:5

Question 5		
Correctness	14	
Column	2	
Base plate	2	
Gusset plates	2	
Boltholes	2	
Main beam	3	
Secondary beam	3	
Accuracy		3
Weld symbols		3
Hatching lines		1
Labels		3
Total	25	

QUESTION 6

Calculate reactions

6.1 Take moments about RL:

(RR × 9) + (15 × 3 × 1,5) + (45 × 3) = (65 × 4) + (22 × 7) ✓

$RR = \frac{260 + 154 - 67{,}5 - 135}{9}$

RR = 23,5 kN ✓

Take moments about RR:

(RL ×9) = (45 × 12) + (15 × 3 × 10,5) + (65× 5) + (22 × 2) ✓

$RL = \frac{540 + 472{,}5 + 325 + 44}{9}$

RL = 153,5 kN ✓ (4)

Calculate shear force values

6.2

SF A: – 45 kN	– 45 kN
SF B: – 45 – (15 × 3)	**– 90 kN** ✓**(Max)** ✓
SF B: – 45 – (15 × 3) + 153,5	63,5 kN
SF C: 153,5 – 45 – (15 × 3)	63,5 kN
SF C: 153,5 – 45 – (15 × 3) – 65	– 1,5 kN
SF D: 153,5 – 45 – (15 × 3) – 65	– 1,5 kN
SF D: 153,5 – 45 – (15 × 3) – 65 – 22	– 23,5 kN
SF E: 153,5 – 45 – (15 × 3) – 65 – 22	– 23,5 kN

Shear force diagram = 3 marks (3)

Bending moment diagram = 2 marks (2)

Calculate bending moment values

6.3

BM B: – (45 × 3) – (15 × 3 ×1,5) (Max)	– 202,5 kN.m ✓✓
BM C: (153,5 × 4) – (45 × 7) – (15 × 3 × 1,5)	51,5 kN.m ✓
BM D: (23,5 × 2)	47 kN.m ✓

(4)

Calculate the section modulus of the beam

6.4 $Ze = \frac{B\,M\,max}{Stress} = \frac{202{,}5 \times 10^6}{165} = 1\ 227\ 272{,}\ 73\ mm^3$ ✓ (1)

$Ze = 1\ 227{,}\ 27 \times 10^{-6}\ m^3$ ✓ (1)

Select a suitable I-parallel flange beam

6.5 Select: 457 × 191 × 67,1 kg/m ($Ze = 1\ 297 \times 10^{-6}$) ✓ (1)

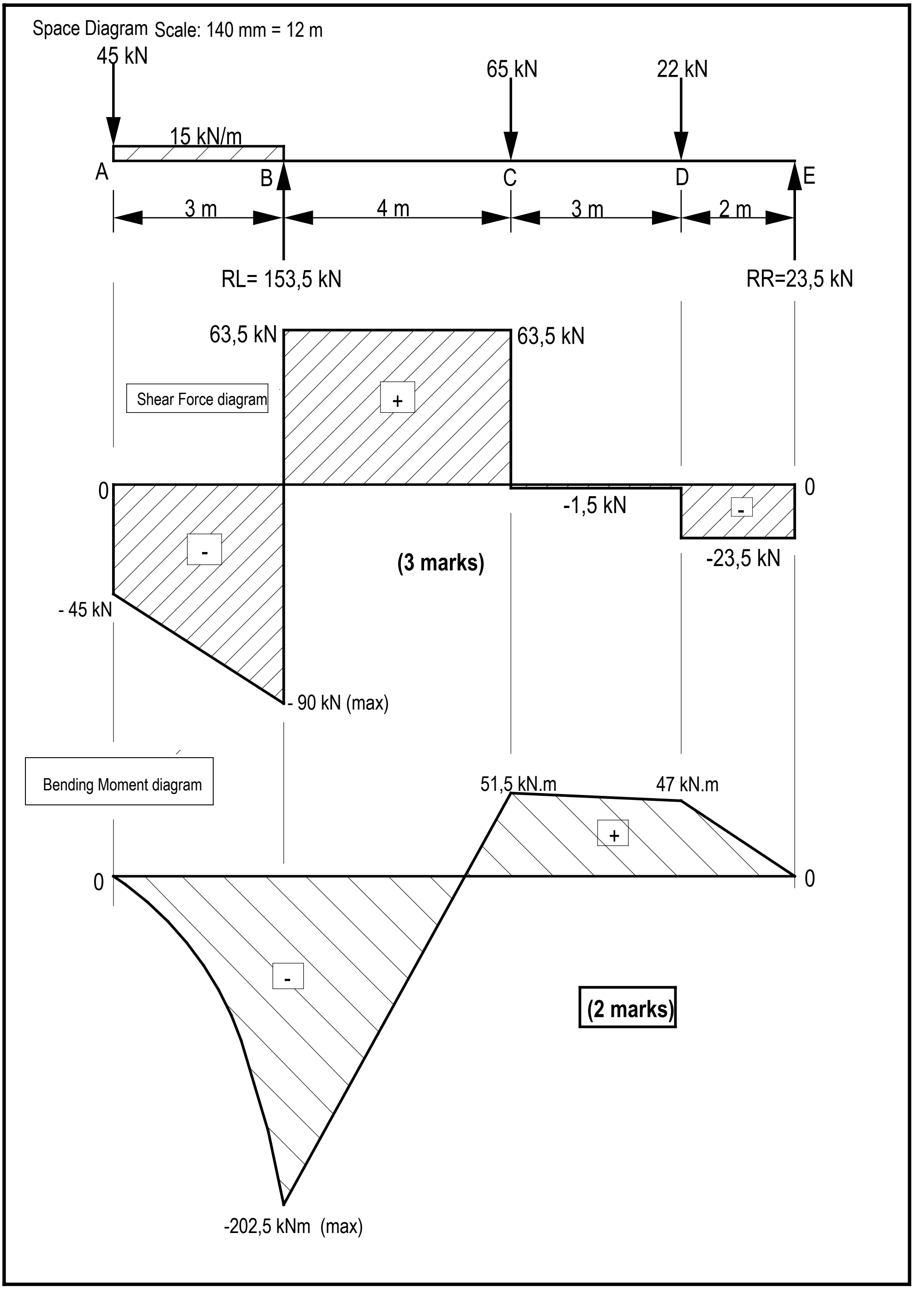
Calculate the maximum shear stress for the given beam

6.6 Check for shear stress

Shear stress = $\frac{S\,F\,max}{D \times t} = \frac{90 \times 10^3}{453,6 \times 8,5} = 23,34$ MPa ✓

Ze = 23,34 < 100 MPa ✓ (2)

[18]



QUESTION 7

7.1 Calculate areas:

Area 1: $360 \times 12 = 4\,320$

Area 2: $8 \times 400 = 3\,200$

Area 3: $\frac{1}{2} \times 200 \times 300 = 30\,000$

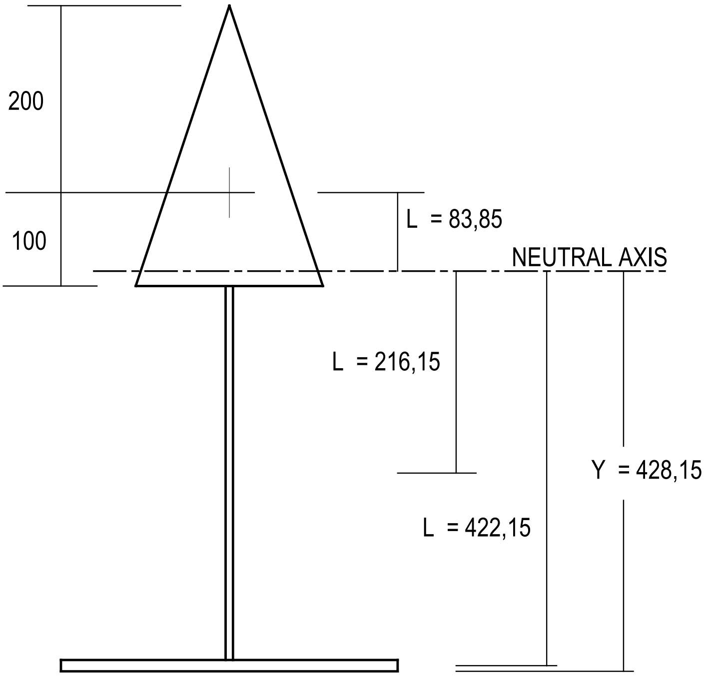
Total area = 37 520 ✓ (1)

7.1 Calculate neutral axis from A-B

$37\,520 \times y_1 = (4\,310 \times 6) + (3\,200 \times 212) + (30\,000 \times 512)$ ✓✓

$$Y_1 = \frac{25\,920 + 678\,400 + 15\,360\,000}{37\,520}$$

$Y_1 = 428{,}15$ mm ✓ (3)



7.2 Calculate second moment of area

$$I_{xx} = \left(\frac{bd^3}{12} + AL^2\right) + \left(\frac{bd^3}{12} + AL^2\right) + \left(\frac{bd^3}{36} + AL^2\right)$$

$$I_{xx} = \left(\frac{360 \times 12^3}{12} + 4\,320 \times 422{,}15^2\right)$$

$51\,840 + 769\,869\,889{,}2 = 769\,921\,729{,}2\ \text{mm}^4$ ✓✓

$$+ \left(\frac{8 \times 400^3}{12} + 3\,200 \times 216{,}15^2\right)$$

$42\,666\,666{,}67 + 149\,506\,632 = 192\,173\,298{,}7\ \text{mm}^4$ ✓✓

$$+ \left(\frac{200 \times 300^3}{36} + 30\,000 \times 83{,}85^2\right)$$

$150\,000\,000 + 210\,924\,675 = 360\,924\,675\ \text{mm}^4$ ✓✓

I_{xx} tot = $1\,323\,019\,702{,}87\ \text{mm}^4$ ✓ (7)

7.3 <u>Calculate the profile modulus (Z)</u>

$Z = \frac{I}{Y}$

$Z = \frac{1323\ 019\ 702{,}87\ mm^4}{428{,}15\ mm}$ ✓

$Z = 309\ 008{,}46\ mm^3$ Therefore $Z = 309{,}008 \times 10^{-6}\ m^3$ ✓ (2)

7.4 <u>Select suitable I-parallel flange beam to replace the given figure</u>

$Ze = 309{,}008 \times 10^{-6}\ m^3$

Use $254 \times 146 \times 31{,}3$ kg/m ($Ze = 352{,}1 \times 10^{-6}\ m^3$ ✓ (1)

[14]

Total : 100 marks