

# higher education & training

---

Department:  
Higher Education and Training  
REPUBLIC OF SOUTH AFRICA

T90(E)(N21)T  
**NOVEMBER EXAMINATION**  
**NATIONAL CERTIFICATE**  
**BUILDING AND STRUCTURAL CONSTRUCTION N5**

(8060015)

**21 November 2014 (Y-Paper)**  
**13:00–17:00**

This question paper consists of 6 pages, 1 formula sheet and shape code.

**DEPARTMENT OF HIGHER EDUCATION AND TRAINING**  
**REPUBLIC OF SOUTH AFRICA**  
NATIONAL CERTIFICATE  
BUILDING AND STRUCTURAL CONSTRUCTION N5  
TIME: 4 HOURS  
MARKS: 100

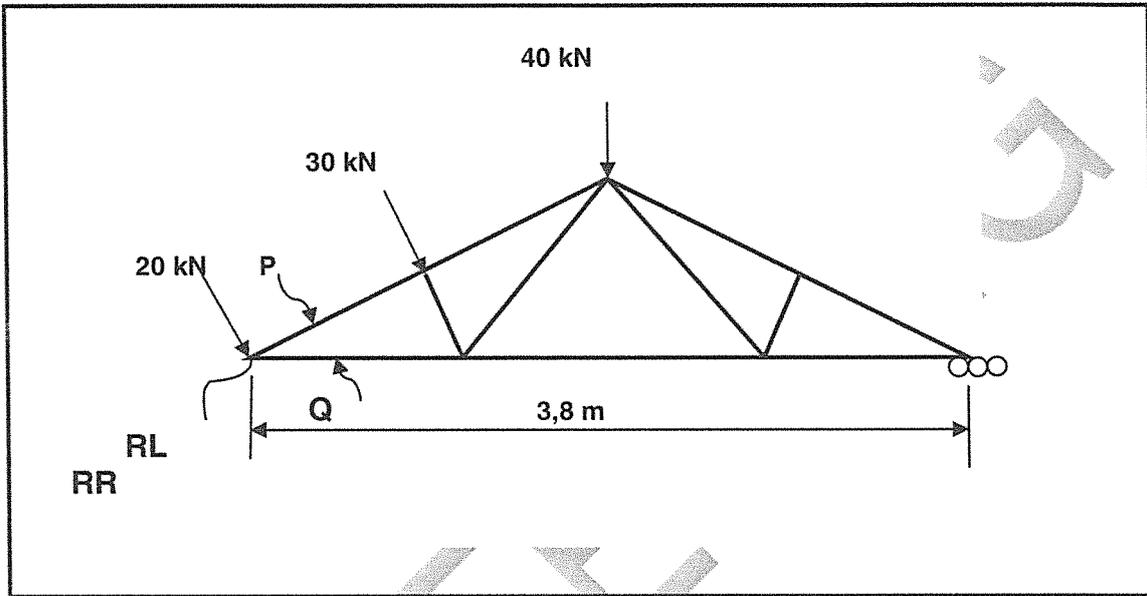
---

**INSTRUCTIONS AND INFORMATION**

1. Answer ALL the questions.
  2. Read ALL the questions carefully.
  3. Number the answers according to the numbering system used in this question paper.
  4. Drawings must be done according to the latest building regulations.
  5. Drawings must be fully dimensioned, labelled and steel coded.
  6. Calculations must be rounded off to THREE decimal places.
  7. Labelling must be done horizontally and in printing.
  8. Use both sides of the drawing paper if needed.
  9. Write neatly and legibly.
-

**QUESTION 1: FRAME STRUCTURE**

FIGURE 1 below shows a loaded roof truss, with three forces and a pitch of  $30^\circ$  at both sides. The roof truss is supported on a hinge at RL and by means of rollers at RR. (The 20 kN, and 30 kN forces are perpendicular to the rafter beam.)

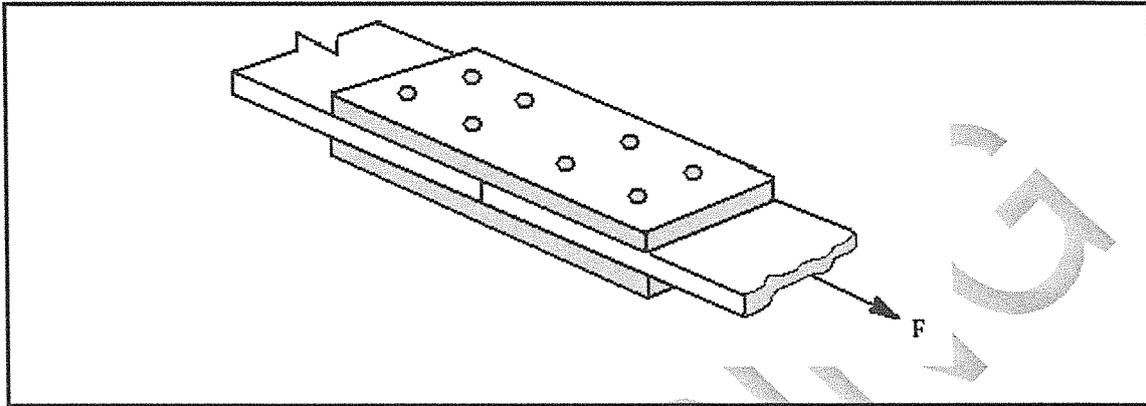
**FIGURE 1**

- 1.1 Calculate the magnitude and directions, at the reactions, to keep the roof in balance, of the roof truss as shown. (12)
- 1.2 Determine the size of the forces in the members marked 'P' and 'Q' and distinguish between *tension* and *compression* forces in the members. (5)

[17]

**QUESTION 2: BOLT CONNECTION**

FIGURE 2 shows a bolt connection with M10, grade 4,6 bolts between two tie-bars.

**FIGURE 2**

Calculate the:

- |     |  |     |
|-----|--|-----|
| 2.1 | Resistance of the bolts to shearing                | (4) |
| 2.2 | Resistance of the bolts to crushing                | (4) |
| 2.3 | Resistance of the tie to tearing                   | (4) |
| 2.4 | Maximum force this connection can withstand safely | (1) |

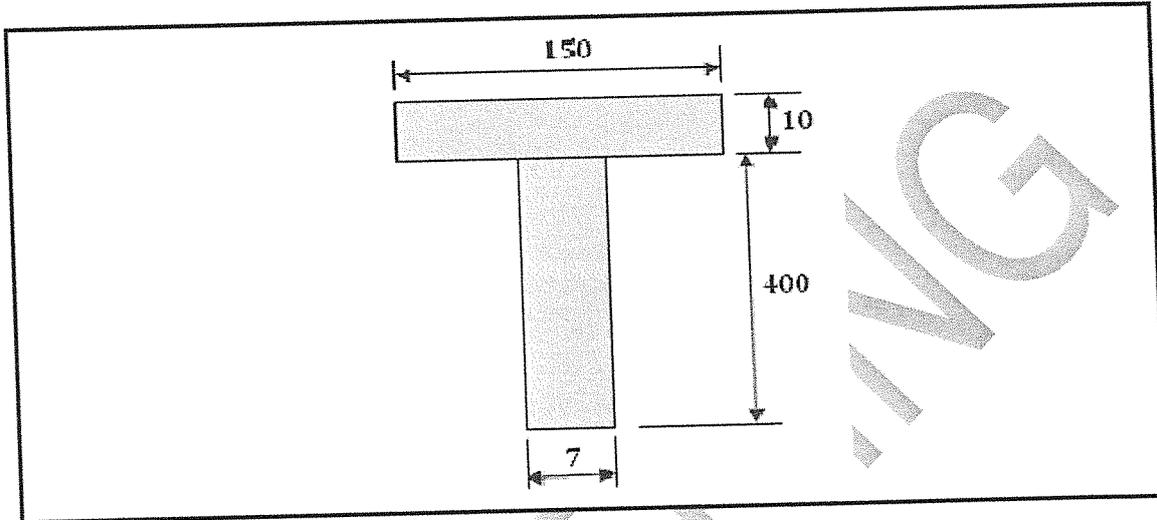
Use the following specification:

Bolts	- M12 (12 mm)
Tie bars	- 60 x 8 mm
Connector plates	- 60 x 6 mm
Holes in the tie bars	- 14 mm
Maximum shear stress of bolt	- 100 MPa
Maximum tensile stress of tie	- 155 MPa
Maximum crushing stress between bolt and tie-bar	- 240 MPa

[13]

**QUESTION 3: CENTROIDS**

FIGURE 3 below shows a cross section through a build-up steel section welded together as one. The dimensions are given in mm.



**FIGURE 3**

Calculate:

- 3.1 The distance of the neutral axis from bottom (4)
  - 3.2 The moment of inertia of the profile about the neutral axis (5)
  - 3.3 The profile modulus (z) about the neutral axis (4)
  - 3.4 Select from the structural steel tables a I-profile parallel flange to replace this build-up beam. (2)
- [15]

**QUESTION 4**

- 4.1 The maximum bending moment and the shear force of a loaded simply supported beam is 140,2 KN.m and 145,5 KN respectively.

Select from the steel tables, a suitable I-section with tapered flanges if the following maximum values may not be exceeded:

Bending stress = 165 MPa  
Shear stress = 100 MPa (9)

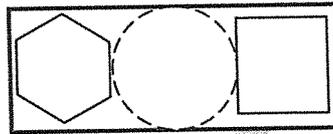
- 4.2 Write down the steps, and the reasons, that need to be followed in the calculation of beam design. (11)
- [20]

**QUESTION 5**

A concrete pile with a diameter of 800 mm, supports a pile cap of 2 092 mm x 800 mm x 0,5 m deep, which supports two concrete columns. The one is a hexagon column with 400 mm sides and the other is a square column with 600 mm sides. The side of the square column starts and is in line with the right edges of the pile cap. The centre point of the pile is 1 m from the right edge of the pile cap and on the centre line. The hexagon column starts, with one flat side, at the left edge of the pile cap, which must be constructed on the remaining space of the pile cap.

Draw to scale 1 : 10, only a top view of the columns, pile cap and pile, with the following steel reinforcement and constructional details. Drawing must be fully labelled.

Hint is provided, but accuracy is very important.



Use the following steel reinforcement specifications:

- 5.1 8Y20 main steel reinforcement with 10 mm helical binders at 200 mm c/c in the concrete pile
- 5.2 In the hexagon column use 6Y16 main reinforcement, and 8 mm helical binders at 150 mm c/c
- 5.3 In the square columns use 8Y20 main steel reinforcement with 8 mm binders at 350 mm c/c

[20]

**QUESTION 6**

Draw a vertical longitudinal section through a wooden staircase to scale 1 : 10 and show the following specifications:

- |   |   |                   |
|---|---|-------------------|
| A | Anchor block:   | 152 x 38 mm       |
| B | Rough carriage:                                       | 114 x 76 mm       |
| C | Rough bracket:  | 114 x 25 mm       |
| D | Tread:  | 310 x 30 mm thick |
| E | Going:  | 280 mm            |
| F | Rise:   | 180 x 22 mm       |
| G | Wedge and corner fillet to support the housing joints |                   |

[15]

**TOTAL: 100**

## FORMULA SHEET

Any applicable formula may also be used.

$$BM = \frac{wl}{4}$$

$$BM = \frac{wl^2}{8}$$

$$n = 5d$$

$$n = 5.5d$$

$$h = 9d$$

$$h = 11d$$

$$F = f.a$$

$$F = fs \frac{\pi.D^2 n}{4}$$

$$F = ft (W - n.d)$$

$$F = f_c D.t.n$$

$$F = \frac{\pi.(\phi - 0,9382\rho)^2 n}{4}$$

$$I = \left[ \frac{BD^3}{12} \right] + [2.area.y^2]$$

$$\frac{M_r}{I} = \frac{f}{y} = \frac{E}{R}$$

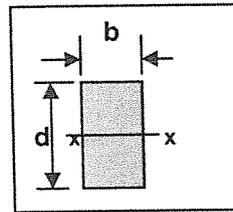
$$M = fZ$$

$$Z = \frac{I_{NA}}{y}$$

$$M = f \frac{I}{y}$$

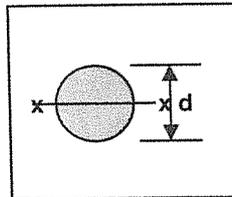
$$M = \frac{fbd^2}{6}$$

$\pi .$



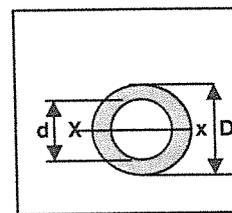
$$I_{xx} = \frac{bd^3}{12}$$

$$Z_{xx} = \frac{bd^2}{6}$$



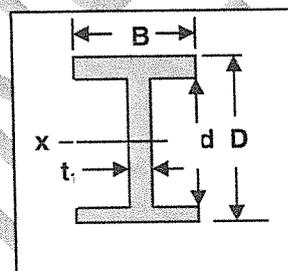
$$I_{xx} = \frac{1}{4} \pi r^4$$

$$Z_{xx} = \frac{\pi.d^3}{32}$$

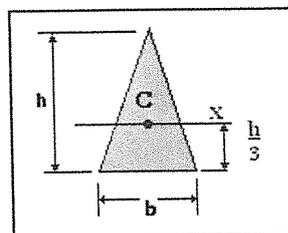


$$I_{xx} = \frac{\pi}{64} (D^4 - d^4)$$

$$Z_{xx} = \frac{\pi (D^4 - d^4)}{64 \cdot \frac{D}{2}}$$

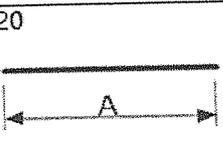
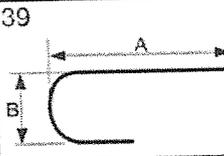
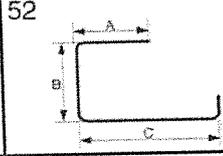
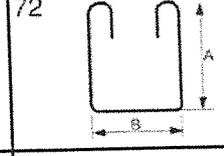
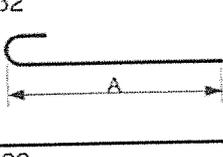
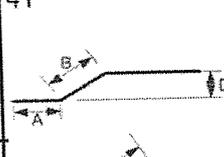
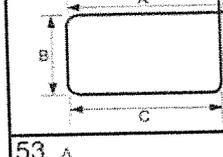
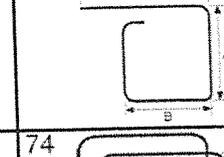
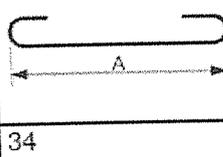
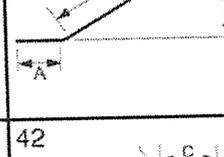
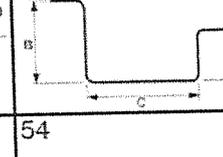
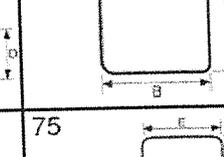
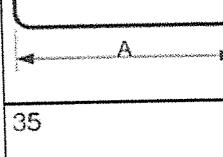
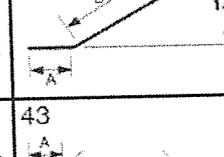
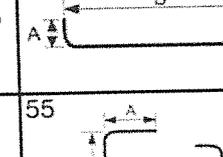
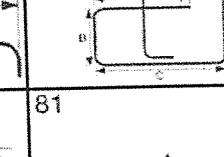
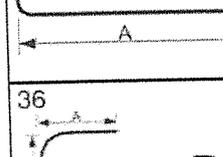
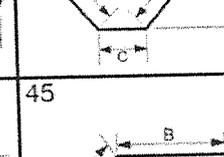
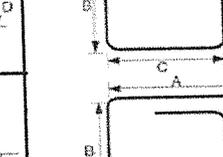
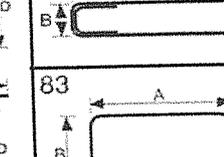
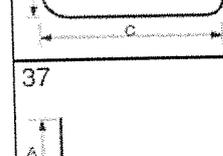
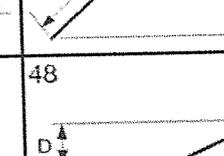
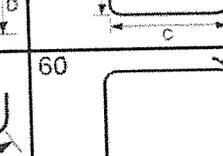
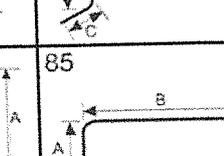
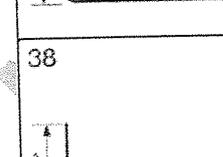
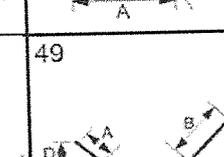
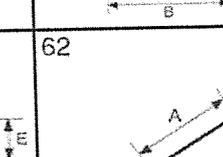
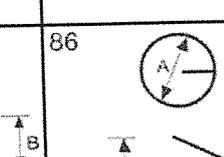
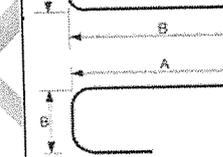
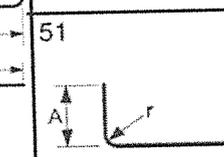


$$I_{xx} = \frac{BD^3}{12} - \frac{bd^3}{12}$$

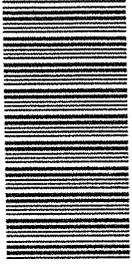


$$x = \frac{bh^3}{36}$$

### SABS 82 SHAPE CODES

20 	39 	52 	72 
32 	41 		73 
33 		54 	74 
34 	43 	55 	81 
35 	45 		83 
36 	48 	62 	85 
37 	49 	65 	86 
38 	51 		

000000000



# higher education & training

Department:  
Higher Education and Training  
**REPUBLIC OF SOUTH AFRICA**

## **MARKING GUIDELINE**

**NATIONAL CERTIFICATE**  
**NOVEMBER EXAMINATION**  
**BUILDING AND STRUCTURAL CONSTRUCTION N5**  
**21 NOVEMBER 2014**

This marking guideline consists of 7 pages.



To find the members P and Q Analytical (work around nodes)

Find member, P

- $P \times \sin 30^\circ = 54,643$
- $P = 109,3 \text{ KN}$  strut  $\checkmark\checkmark$

Find member, Q;

- $Q = 25 + 109,3 \times \cos 30^\circ$
- $Q = 119,6 \text{ KN}$  Tie  $\checkmark\checkmark$

Graphical solution  
Scale 1mm=1KN

(5)  
[17]

**QUESTION 2**

<p><u>2.1</u></p> $f_{\text{shear}} = \frac{\text{force}}{2 \times n \times \pi \times r^2}$ $\text{Load} = f_s \times 2 \times n \times \pi \times r^2 \quad \checkmark$ $= 100 \times 2 \times 4 \times \pi \times 6^2 \quad \checkmark$ $= 90477,868 \text{ N}$ $= 90,478 \text{ KN} \quad \checkmark\checkmark \quad (4)$	<p><u>2.2</u></p> $f_{\text{crushing}} = \frac{\text{force}}{n \times d \times t}$ $\text{load} = f_c \times n \times d \times t \quad \checkmark$ $= 240 \times 4 \times 12 \times 8 \quad \checkmark$ $= 92160 \text{ N}$ $= 92,160 \text{ KN} \quad \checkmark\checkmark \quad (4)$
<p><u>2.3</u></p> $f_{\text{tearing}} = \frac{\text{force}}{(B \times t) - n(d \times t)}$ $\text{load} = f_t \times [(B \times t) - 2(d \times t)] \quad \checkmark$ $= 240 \times [(60 \times 8) - 2(14 \times 8)] \quad \checkmark$ $= 61440 \text{ N}$ $= 61,44 \text{ KN} \quad \checkmark\checkmark \quad (4)$	<p><u>2.4</u></p> <p>Max force this connection can safely withstand, (is the smallest)</p> <p>Thus = 61,44 KN <math>\checkmark</math> (1)</p>

[13]

**QUESTION 3**

	Area	Y-Dist	A x Y	$\frac{bh^3}{12}$	Dist to NA (d)	A x d <sup>2</sup>
1	2800	200	560000	37333333,3	71,511	14318704,74
2	1500	405	607500	12500	133,489	26728969,68
	$\Sigma 4300 \checkmark$		$\Sigma 1167500 \checkmark$	$\Sigma 37345833,33 \checkmark \checkmark$		$\Sigma 41047674,42 \checkmark \checkmark$

(4)

<p>3.1 <math>Y = \frac{\sum A x Y}{\sum A}</math></p> <p><math>Y = \frac{1167500}{4300}</math></p> <p><math>Y = 271,511 \text{ mm} \checkmark \checkmark</math> (4)</p>	<p>3.2;</p> <p><math>I_{xx} = \sum (I_{NA} + Ad^2)</math></p> <p><math>= 37345833,33 + 41047674,42</math></p> <p><math>= 78393507,75 \text{ mm}^4</math></p> <p><math>I_{xx} = 78,394 \times 10^{-6} \text{ mm}^4 \checkmark \checkmark</math> (5)</p>
<p>3.3</p> <p><math>Z = \frac{I_{xx}}{Y}</math></p> <p><math>Z = \frac{78,394 \times 10^{-6} \text{ mm}^4}{271,511 \text{ mm}}</math></p> <p><math>Z = 288730,504 \text{ mm}^3 \checkmark \checkmark</math> (2)</p> <p style="text-align: center;">→</p>	<p>Select a beam I section parallel ?????</p>

[15]

## QUESTION 4

<p><u>To select a beam ?</u></p> <p>1, Calculate the Sectional Modules (Ze)</p> $BM_{\max} = B_{\text{stress}} \times Ze$ $Ze = \frac{BM_{\max}}{B_{\text{stress}}}$ $= \frac{140,2 \times 1000 Nm}{165 \times 10^6 \frac{N}{m^2}} \quad \checkmark$ $= 0,000849697 m^3$ $Ze = 849,697 \times 10^{-6} m^3 \quad \checkmark\checkmark$	<p>2, Select a Beam ( I-section Taper)</p> $= 305 \times 152 \times 86,4 \text{ Kg/m} \quad \checkmark$ <p>Now this selected beam has to be check for safety</p>
<p>3. <u>Check for SHEAR Stress</u></p> $\text{Shear Stress} = \frac{\text{ShearLoad}}{\text{Area}}$ $= \frac{145,5 \times 1000 \cdot N}{305 \cdot x \cdot 10,2 \cdot mm^2} \quad \checkmark$ $= 46,77 \text{ N/mm}^2 \quad \checkmark\checkmark \text{ (MPa)}$	<p>Thus; <math>46,77 &lt; 100 \text{ MPa}</math>, beam is OK <math>\checkmark</math></p>

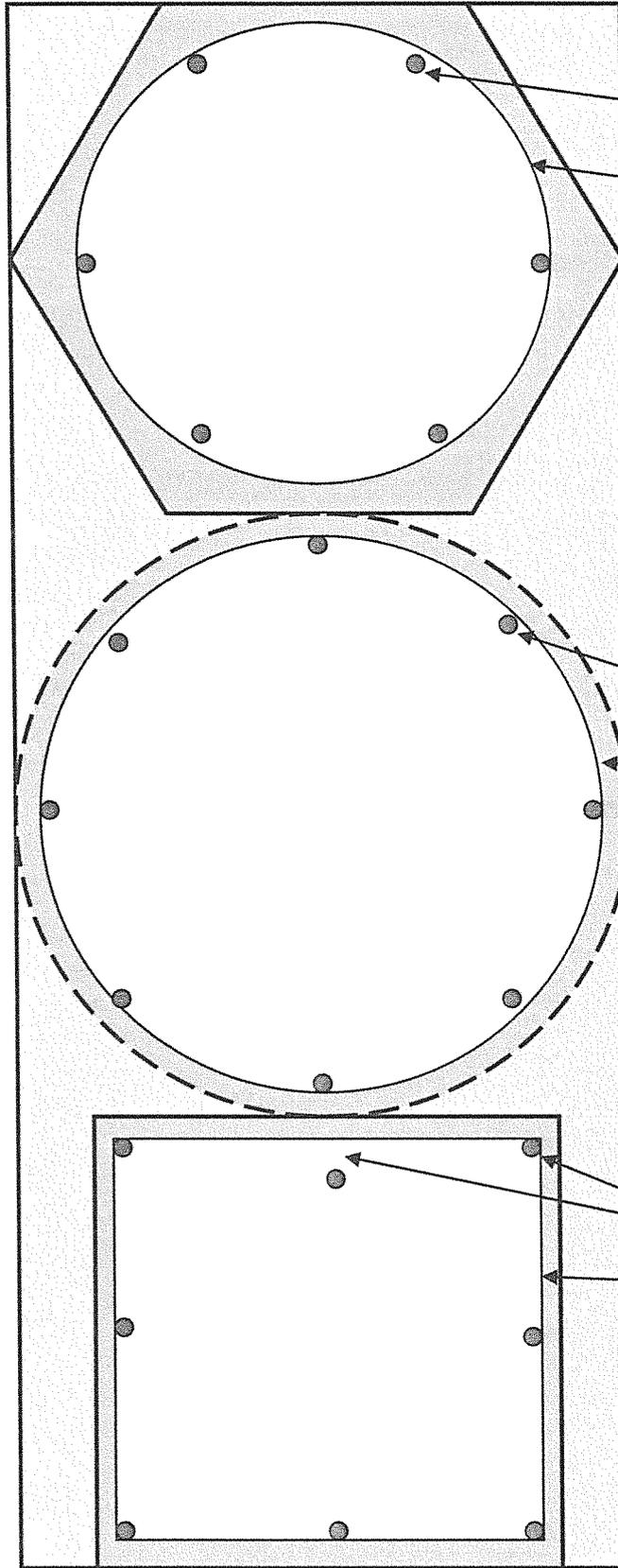
(9)

- 4.2
- 1, Calculating the reactions at the supports,  
A= L and R, this is to determine the load that will be on the columns or supports (2)
  - 2, Calculating the shear forces at different positions,  
A= this is to determine where the maximum shear force will be (2)
  - 3, Calculating the bending moment at different positions,  
A= this is to determine where the maximum bending moment will be. (2)
  - 4, Calculate the Sectional Modules (Ze);  
A= use the formula, "BM<sub>max</sub> = B<sub>stress</sub> x Ze, with this value a beam can be selected to carry the desired loads (2)
  - 5, Select a beam  
A= from the structural steel tables, (1)
  - 6, Check the shear stress;  
A= this is to check the safety of the beam, selected. This must be done because the calculated, Ze, value do not agree the, Ze value of the REAL beam, selected. This must not exceed the shear stress max allowed. (2)

[20]

QUESTION 5

**PILE – PILE CAP AND COLUMNS**



Hexagon Column ✓

6Y16 - Main RS ✓✓

8R-150 - Helical binders ✓✓

Pile ✓

8Y20 - Main RS ✓✓

10R-200 - Helical binders ✓✓

Square Column ✓

8Y20 - Main RS ✓✓

8R-350 - Binders ✓✓

PILE CAP 2092 X 800 ✓✓

Scale 1:10 ✓ Accuracy ✓✓

[20]

QUESTION 6

180 RISE  
STYGER

280 GOING  
AANTREE

310

30

280

180

30 THICK TREAD  
DIK LOOPVLAK

WEDGE  
WIG

CORNER FILLET  
HOEKLYS

114X76 ROUGH CARRIAGE  
RU-TRAPBOOM

114X25 ROUGH BRACKET  
RU-STEUN

152X38 ANCHOR BLOCK  
ANKER BLOK

Section 1

1 1:5

**BUILDING & STRUCTURAL CONSTRUCTION N5**

Memo	
Project number	0001
Date	Issue Date
00003	
Drawn by	PJ Swart
Checked by	JH Hattingh
Scale	1 : 5

2013/10/04 08:55:41 AM

[15]

TOTAL: 100