higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

BUILDING AND STRUCTURAL CONSTRUCTION N6

27 JULY 2018

This marking guideline consists of 11 pages.

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INSTRUCTIONS AND INFORMATION

1. This marking guideline conforms to:

   - SANS 10100 (2000) Part 1 Design (The structural use of concrete)
   - SABS 0162-1984 (The structural use of steel)
   - Alternate correct answers must be considered.
   - The marker must check the candidate's method of obtaining the answer.
   - Subtract 1 mark per answer if references and clauses are not stated.

2. Use your own discretion.

QUESTION 1

1.1 1.1.1 Curing of concrete is defined as providing adequate moisture, temperature and time to allow the concrete to achieve the desired properties for its intended use.

1.1.2 Bulking of sand is the ability of sand to expand when it is wet.

(2 × 2) (4)

1.2 Nonferrous metals do not contain iron content. It is therefore resistant to rust and corrosion. Nonferrous metals are also nonmagnetic. (2)

1.3
- Aluminium
- Copper
- Lead
- Zinc

(Any 2 × 1) (2)

1.4
- Iron ore
- Coal
- Limestone
- Recycled steel

(Any 2 × 1) (2)

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QUESTION 2

All references are taken from SANS 10100-1 (2000).

Fcu = 25 MPa — Table 2
Fy = 450 MPa — (4.1.5.1)
Span = 8 m — Table 3
Density of reinforced concrete = 2 425 kg/m^3 — (4.1.5.2)
Cl 4.3.1.2

2.1 Effective depth = span/16
Eff d = 8 000/16 — Table 10
Eff d = 500 mm✓ — (4.3.6.2.1) (1)

2.2 Assume Y25 main steel and Y10 binders.

Assume cover of 25 mm.

Overall depth = 500 + $\frac{25}{2}$ + 10 + 25✓

Overall depth = 547,5 mm

Use overall depth = 550 mm✓

Design dead load = Volume × density × 9,81 × 10^{-3} × 1,2 Gn

DDL = 0,55 × 0,33 × 1 × 2 425 kg/m³ × 9,81 × 10^{-3} × 1,2 Gn✓ — Cl 4.2.2.1

Design dead load = 5,18 kN/m✓

Design imposed load = 36 kN/m × 1,6 Qn✓

Design imposed load = 57,6 kN/m✓

Cl 4.2.2.1

Total design load = 5,18 + 57,6 = 62,78 kN/m✓ (7)

2.3 $BM_{max} = \frac{WL^2}{8}$

$BM_{max} = \frac{62{,}78 \times 8{,}0^2}{8}$✓

$BM_{max} = 502{,}25\ \text{kN/m}$✓

$k = \frac{BM}{fcu\ b\ d^2}$

Cl 4.3.3.4.1

$k = \frac{502{,}25 \times 10^6}{25 \times 330 \times 500^2}$ ✓✓

$k = 0{,}244 > K^1 = 0{,}156$

Tension and compression reinforcement required.✓ (5)

2.4 $Z = d\left\{0{,}5 + \sqrt{0{,}25 - \frac{k^1}{0{,}9}}\right\}$ Cl 4.3.3.4.1

$Z = 500\left\{0{,}5 + \sqrt{0{,}25 - \frac{0{,}156}{0{,}9}}\right\}$✓

$Z = 500\{0{,}777\}$

$Z = 388{,}50\ \text{mm}$✓ (2)

2.5 A's = $\frac{(k - k^1)\ Fcu\ bd^2}{Fyc\ (d - d^1)}$ (Use d^1 = 50 mm) Cl 4.3.3.4.1

Where: Fyc = $\frac{Fy}{1{,}15 + \frac{Fy}{2\,000}}$✓

Fyc = $\frac{450}{1{,}15 + \frac{450}{2\,000}}$

Fyc = $327\ \text{MPa}$✓ FIGURE 2
ɣm = 1,15
Cl 3.3.3.2

A's = $\frac{(0{,}244 - 0{,}156)\ 25 \times 330 \times 500^2}{327\ (500 - 50)}$✓

A's = $1\,233{,}44\ \text{mm}^2$✓

Use 4Y20 (As = 1 257 mm²)

$\frac{100\ As}{Ac}$ = $\frac{100 \times 1\,257}{550 \times 330}$

= 1,06✓ Table 23
Cl 4.11.4

0,69 > 0,24

The reinforcement is sufficient. (5)

2.6 As = $\frac{k^1\ Fcu\ b\ d^2}{0{,}87 \times fy \times z}$ + $\frac{A's\ Fyc}{0{,}87 \times fy}$ Cl 4.3.3.4.2

As = $\frac{0{,}156 \times 25 \times 330 \times 500^2}{0{,}87 \times 450 \times 388{,}5}$ + $\frac{1\,257 \times 327}{0{,}87 \times 450}$✓✓

As = $2\,115{,}42 + 1\,049{,}91$

As = $3\,165{,}33\ \text{mm}^2$✓

Use 4y32 (As = 3 217 mm²)✓ (4)

2.7 $\frac{100\ As}{Ac}$ = $\frac{100 \times 3\,217}{550 \times 330}$

= 1,77✓ Table 23
Cl 4.11.4

1,77 > 0,45

The reinforcement is sufficient.

4% of AC

= 4% × 550 × 330 (cl 4.11.5.1)

= 5 940 mm²✓

(3 217 + 1 257) < 7 260

The reinforcement is sufficient. (2)

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QUESTION 3

3.1 3.1.1 Take moments about RL:

(RR × 9) = (48 × 6,75) + (55 × 4,5) + (28 × 2,25)✓

RR9 = 324 + 247,5 + 63

RR = 634,5/9

RR = 70,5 kN✓

Take moments about RR:

(RL × 9) = (28 × 6,75) + (55 × 4,5) + (48 × 2,25)✓

RL 9 = 189 + 247,5 + 108

RL = 544,5/9

RL = 60,5 kN✓ (4)

3.1.2 **ΣVC = 0**

ABSin30º = 60,5 kN✓

AB = 60,5/Sin 30º

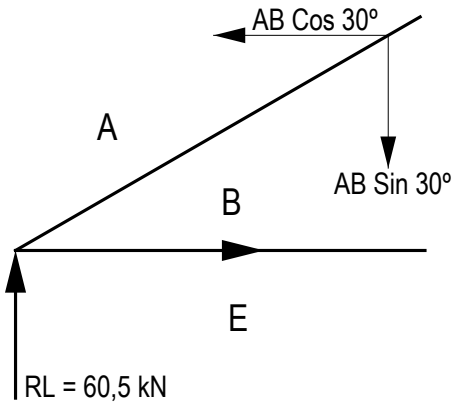
AB = 121 kN (strut)✓✓

ΣHC = 0

BE = ACos30º✓

BE = 121 × Cos 30º

BE = 104,79 kN (tie)✓✓



ΣVC = 0

121Sin30º + BDSin30º = 28 + CDSin30º✓

60,5 + 0,5BD = 28 + 0,5CD

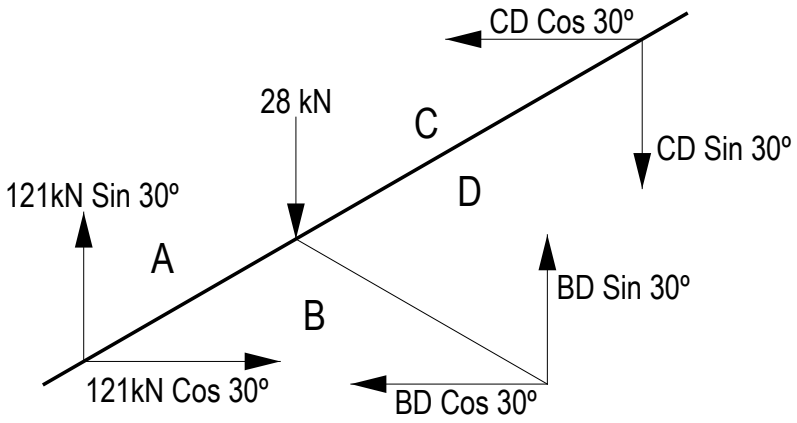
60,5 + 0,5BD – 28 = 0,5CD✓

32,5 + 0,5BD = 0,5CD

CD = $\frac{32,5+0,5BD}{0,5}$

CD = 65 + BD ……(1)✓ (9)

3.2



ΣHC = 0

121Cos30º = CDCos30º + BDCos30º✓

104,79 = 0,866 CD + 0,866 BD

104,79 = 0,866 (65 + BD) + 0,866 BD

104,54 = 56,29 + 0,866 BD + 0,866 BD

BD = $\frac{164,54-56,29}{1,732}$

BD = 62,5 kN (strut)✓✓

Therefore CD = 65 + BD

CD = 65 + 62,5 = 127,50 kN (strut)✓✓ (5)

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QUESTION 4

4.1 All references are taken from SANS 10100-2000.

Calculate the diameter of the column:
N = 1 850 kN and ASc = 0,4% AC

Table 23
(4.11.4.2.2)
Cl 4.7.4.3

N = 0,4 fcu Ac + 0,67 fy Asc
But: Asc not to exceed 0,4% Asc = 0,004 Ac

Therefore: N = 0,4 fcu Ac + 0,67 fy (0,004 Ac)✓

N = AC (0,4 fcu + 0,0026 fy)✓

$$Ac = \frac{N}{0{,}4\ fcu + 0{,}0026\ fy}\checkmark$$

$$Ac = \frac{1\,850 \times 10^3}{(0{,}4 \times 30) + (0{,}0026 \times 250)}$$

$$Ac = \frac{1\,850 \times 10^3}{(12) + (0{,}65)}\checkmark$$

$$Ac = 146\,245{,}06\ \text{mm}^2\checkmark$$

Therefore, area of column:

$$Ac = \frac{\pi d^2}{4}$$

Then:
$$d = \sqrt{\frac{146\,246{,}06 \times 4}{\pi}}\checkmark$$

Diameter of column = 431,50 mm
Use column diameter of 435 mm✓ (7)

4.2 Number and diameter of bars

Asc = 0,4% Ac✓ (Table 23)

$$Asc = \frac{0{,}4}{100} \times \frac{\pi d^2}{4}$$

$$Asc = \frac{0{,}4}{100} \times \frac{\pi \times 435^2}{4}\checkmark$$

$$Asc = 594{,}5\ \text{mm}^2$$

Use 6R12 (As = 679 mm²)✓
OR Use 8R12 (As = 905 mm²)

NOTE: (4.11.4.2.2)
Min bar diameter = 12 mm with a min of 6 bars (round column) (3)

4.3 The diameter and pitch of the helical binder:

Binders: ¼ of the smallest main bar Cl 4.11.4.5.1
¼ × 12 = 3 mm (not available)✓
Use: min R6 or R8 helical binder✓
(Note: R6 not available)

Pitch of the helical binder: 12 × diameter of smallest main bar
12 × 12 = 144 mm✓

Use pitch of 150 mm✓

Summary of round column:

RC column Ø 435 mm with 6R12 (8R12) main bars evenly spaced and R8 helical binder at 150 mm pitch✓ (5)
[15]

QUESTION 5

5.1 The effective height of the column:

Effective height (l) = 0,7L✓ (SABS 0162-1984 Table 19)

Where: $L_{effective}$ = 0,7 × 5,60 m
= 3,92 m (3 920 mm)✓ (2)

5.2 The cross-sectional area of the steel section:

Area = 2(250 × 18) + (16 × 300)✓

Area = 9 000 + 4 800

Cross-sectional area = 13 800 mm²✓ (2)

5.3 The second moment of area about the x-x axis:

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

$$I_{xx} = 2\left(\frac{250 \times 18^3}{12} + 250 \times 18 \times 159^2\right) + \left(\frac{16 \times 300^3}{12}\right)✓✓$$

$$I_{xx} = 2(121\,500\ mm^4 + 113\,764\,500\ mm^4 + 36\,000\,000\ mm^4)$$

$$I_{xx} = 227\,772\,000\ mm^4 + 36\,000\,000\ mm^4$$

$$I_{xx} = 263\,772\,000\ mm^4✓$$ (3)

5.4 Calculate the second moment of area about the y-y axis:

$$Iyy = 2\left(\frac{bd^3}{12}\right) + \left(\frac{bd^3}{12}\right)$$

$$Iyy = 2\left(\frac{18 \times 250^3}{12}\right) + \left(\frac{300 \times 16^3}{12}\right)\checkmark$$

$$Iyy = 46\,875\,000\ \text{mm}^4 + 102\,400\ \text{mm}^4$$

$$Iyy = 46\,977\,400\ \text{mm}^4\checkmark$$ (2)

5.5 The minimum second moment of area:

Least second moment of area = Iyy = 46 977 400 mm^4✓ (1)

5.6 The minimum radius of gyration:

Least second moment of area (I) = I_{yy} = 46 977 400 mm^4

$$r_{min} = \sqrt{\frac{Iyy}{area}}$$

$$r_{min} = \sqrt{\frac{46\,977\,400\ \text{mm}^4}{13\,800\ \text{mm}^2}}\checkmark$$

$$r_{min} = 58{,}35\ \text{mm}\checkmark$$ (2)

5.7 Calculate the slenderness ratio:

$$L/r = \frac{3\,920}{58{,}35} = 67{,}18\checkmark$$

From Table 17 (SABS 0162-1984)

67,18 = 118,82 MPa✓ (2)

5.8 Calculate the maximum load:

Load = Stress × area
Load = 118,82 N/mm^2 × 13 800 mm^2
Load = 1 639,72 kN✓ (1)

NOTE: Allow full marks only where ALL sections were answered. **[15]**

QUESTION 6

Consider the arrangement at beam A.

Given Info:
I-section: 305 × 102 × 28,6 kg/m
Ixx = $54{,}39 \times 10^{-6}$ m^4
Area = $3{,}639 \times 10^{-3}$ m^2
Height (h) = 308,9 mm and h/2 = 154,6 mm (0,1546 m)

Calculate second moment of area:

$Ixx_{total} = 2(Ixx)$
$= 2(54{,}39 \times 10^{-6})$✓
$= 2(54{,}39 \times 10^{-6})$
$Ixx_{total} = 108{,}78 \times 10^{-6}$ m^4✓

Calculate bending moment maximum:

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

$BM_{max} = \frac{108{,}78 \times 10^{6} \times 175}{154{,}6}$✓✓

$BM_{max} = 123{,}134$ kNm✓

Calculate the central point load:

$BM = \frac{W L}{4}$

$123{,}134 = \frac{W \times 5{,}25}{4}$✓

$W = \frac{123{,}134 \times 4}{5{,}25}$

$W = 93{,}82$ kN✓

Consider the arrangement at beam B.

Given: I-section: 305 × 102 × 28,6 kg/m

Ixx = $54{,}39 \times 10^{-6}$ m^4
Area = $3{,}639 \times 10^{-3}$ m^2
Height (h) = 308,9 mm and h/2 = 154,45 mm (0,15445 m)

Calculate second moment of area:

$Ixx_{total} = 2(Ixx + al^2)$

$= 2(54{,}39 \times 10^{-6} + 3{,}639 \times 10^{-3} \times 0{,}15445^2)$✓✓

$= 2(54{,}39 \times 10^{-6} + 86{,}808 \times 10^{-6})$

$Ixx_{total} = 282{,}395 \times 10^{-6}$ m^4 ✓

Calculate bending moment maximum:

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

$BM_{max} = \frac{282{,}395 \times 10^6 \times 175}{308{,}9}$✓

$BM_{max} = 159{,}984\ \text{kN/m}$✓

Calculate the central point load:

$\text{BM} = \frac{W\,L}{4}$

$159{,}984 = \frac{W \times 5{,}25}{4}$✓

$W = \frac{159{,}984 \times 4}{5{,}25}$

$W = 121{,}893\ \text{kN}$✓

The two beams placed on top of each other will carry most of the load.✓ The reason is that the loads are subjected directly through the two webs which increase the Ixx-value which in turn increases the bending moment value.✓ **[16]**

TOTAL: 100

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