



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

BUILDING AND STRUCTURAL CONSTRUCTION N6

13 November 2020

This marking guideline consists of 11 pages.

Note to markers

- This marking guideline conforms to:
 - SANS 10 100 (2000) Part 1 Design (The structural use of concrete).
 - SANS 0162 (1984) (The structural use of steel).
- Alternative answers must be considered.
- The marker must check the candidate's method of obtaining the answer.
- Subtract 1 (one) mark per answer where references and causes are not stated.
- Use own discretion.

QUESTION 1*Given information:*610 x 305 x 149 kg/m I-parallel flange:

$$I_{xx} = 1\,247 \times 10^{-6} \text{ m}^4$$

$$\text{Area} = 19,03 \times 10^{-3} \text{ m}^2$$

$$\frac{H}{2} = \frac{609,6}{2} = 304,8 \text{ mm}$$

Calculate max point load at P1.1 Calculate bending moment maximum (bending stress = 172 MPa)

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

$$BM_{max} = \frac{1247 \times 10^{-6} \times 172}{304,8} \checkmark \checkmark$$

$$BM_{max} = 703,69 \text{ kNm} \checkmark$$

(3)

Self-weight of the beam

$$\text{Weight of beam: } 149 \text{ kg/m} \times 9,81 \times 10^{-3} = 1,462 \text{ kN/m} \checkmark$$

(1)

Take moments about RL to find 'P'

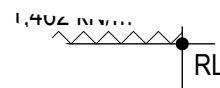
$$BM = (P \times 3,5) + (1,462 \times 3,5 \times 1,75) \checkmark$$

$$703,69 = 3,5 P \times 8,95$$

$$P = \frac{703,69 - 8,95}{3,5} \checkmark$$

$$P = 198,5 \text{ kN} \checkmark$$

(3)

1.2 **Determine the reactions**

(4)

Take moments about RL

$$RR \times 5,2 + (198,5 \times 3,5) + (1,462 \times 3,5 \times 1,75)$$

$$= (1,462 \times 5,2 \times 2,6) \checkmark$$

$$RR = \frac{19,77 - 694,75 - 8,95}{5,2} \left(\frac{-683,93}{5,2} \right)$$

$$RR = -131,53 \text{ kN} \checkmark \text{ (negative)}$$

Take moments about RR

$$RL \times 5,2 = (198,5 \times 8,7) + (1,462 \times 8,7 \times 4,34) \checkmark$$

$$RL = \frac{1726,95 + 55,2}{5,2} \left(\frac{1782,15}{5,2} \right)$$

RL = 342,72 kN ✓ (positive)

1.3 **Determine number of M20 bolts**

Maximum tensile strength = 145 MPa (Table 21 SABS 0162-1984)

Maximum tensile force = 342,72 kN

A_{eff} of M20 bolt = 245 mm²

Force of 1 bolt = tensile stress x A_{eff}

$$= 145 \text{ MPa} \times 245 \text{ mm}^2 \checkmark$$

Force of 1 bolt = 35,53 kN ✓

Number of bolts required = $\frac{\text{Tensile force}}{\text{Force of one bolt}} \checkmark$

$$= \frac{342,72 \text{ kN}}{35,53 \text{ kN}} \checkmark$$

Number of bolts required = 9,6 bolts (Say 10 bolts) ✓ (not realistic)

(5)
[16]

QUESTION 2

Calculate the direct shear on each bolt.

Force direct = Force / No of bolts

$$F_{\text{direct}} = 32 \text{ kN} / 2 = 16 \text{ kN} \checkmark$$

(1)

Calculate the distance from the centroid to the furthest bolt.

$$r = 235 / 2 = 117,5 \text{ mm} \checkmark$$

(1)

The direct load on the bolts due to the imposed load

$$\Sigma cwm = \Sigma acwm$$

$$(32 \times 375) = (F_T \times 117,5 \times 2) \checkmark \checkmark$$

$$F_T = \frac{32 \times 375}{117,5 \times 2}$$

$$F_T = 51,06 \text{ kN} \checkmark$$

(3)

The resultant load on each bolt

$$F_R = 16 + 51,06 = 67,06 \text{ kN} \checkmark \checkmark$$

(2)

Calculate the size of the bolts. (Shear stress = 175 Mpa)

$$F_R = \text{Shear stress} \times \text{Area of bolt}$$

<u>Calculate bending moment maximum</u> $BM_{\max} = \frac{WL^2}{8}$ $BM_{\max} = \frac{28,62 \times 4,75^2}{8} \checkmark$ $BM_{\max} = 80,72 \text{ kNm} \checkmark$		(2)
<u>Calculate value for 'K'</u> $K = \frac{BM}{f_{cu} b d^2}$ $K = \frac{80,72 \times 10^6}{25 \times 1000 \times 296,88^2} \checkmark \checkmark$ $K = 0,037 < K^1 = 0,156$ Only tension reinforcement required. $\checkmark$		(3)
<u>Calculate distance of lever arm (Z)</u> $Z = d \left\{ 0,5 + \sqrt{0,25 - \frac{k}{0,9}} \right\} \leq 0,95d$ $Z = 296,88 \left\{ 0,5 + \sqrt{0,25 - \frac{0,037}{0,9}} \right\} \leq 0,95d \checkmark$ $Z = 296,88 [0,96] \leq 0,95 \times 296,88$ $Z = 285 \text{ mm} \checkmark > 282,04 \text{ mm}$ Use Z = 282,04 mm (Least Z) $\checkmark$	(cl 4.3.3.4.1)	(3)
<u>Calculate tension reinforcement</u> $A_s = \frac{M}{0,87 \times f_y \times z}$ $A_s = \frac{80,72 \times 10^6}{0,87 \times 450 \times 282,04} \checkmark$ $A_s = 731,04 \text{ mm}^2 \checkmark$ Use R12 at 150 centres ($A_s = 754 \text{ mm}^2$) $\checkmark$	(cl 4.3.3.4.1)	(3)
<u>Check for minimum main reinforcement</u> $\frac{100 A_s}{A_c} = \frac{100 \times 754}{1000 \times 330} \checkmark$ $= 0,22$ $0,24 > 0,22 \checkmark$ The reinforcement is sufficient	Table 23 (cl 4.11.4)	(2)

<u>Determine secondary reinforcement</u> $\frac{100 A_s}{A_c} = 0,24$ $A_s = \frac{0,24 \times 1000 \times 330}{100} \checkmark$ $A_s = 792 \text{ mm}^2$ Use R12 at 125 centres ($A_s = 905 \text{ mm}^2$) $\checkmark$	Cl 4.11.4.3.1 & Table 23
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(2)

[22]

QUESTION 4

All references taken from SANS 10100-1 (2000)

$F_{cu} = 25 \text{ MPa}$ $F_y = 450 \text{ Mpa}$ Load = 250 kN	Table 2 (4.1.5.1) Table 3 (4.1.5.2)
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Calculate the longitudinal compression reinforcement

$$N = 0,4 f_{cu} A_c + 0,67 f_y A_{sc} \quad (\text{Clause 4.7.4.3})$$

$$250 \times 10^3 = (0,4 \times 25 \times 350 \times 350) + (0,67 \times 450 \times A_{sc}) \checkmark \checkmark$$

$$250 \times 10^3 = 1225\,000 + (301,5 A_{sc})$$

$$A_{sc} = \frac{250 \times 10^3 - 1\,225\,000}{301,5} \checkmark$$

$$A_{sc} = -3\,234,83 \text{ kN} \checkmark \text{ (minus)}$$

No compression reinforcement required. $\checkmark$

Use minimum reinforcement (table 23)

(5)

Calculate the minimum required reinforcement

Minimum area of main steel: 0,4% AC

(Table 23)

$$0,4\% \times 350 \times 350 \checkmark$$

Minimum area = 490 mm² $\checkmark$

Use 4Y16 main bars. (804 mm²) $\checkmark$

(3)

Diameter and spacing of the binders

Binders: ¼ of the smallest main bar

(Clause 4.11.4.5.1)

$$\frac{1}{4} \times 16 = 4 \text{ mm (not available)} \checkmark$$

Use: min R8 binders.

(R6 Discontinued)

Spacing of binders

12 x dia of main bar

(2)

12 x 16 = 192 mm

Use spacing of 175 mm. ✓

[10]

All references taken from SANS 10100-1 (2000)

<u>Determine the maximum moment of resistance in tension</u> Where $A_s = \frac{M}{0,87 f_y z}$ Then: $M = A_s \times 0,87 \times f_y \times Z$ $M = 804 \text{ mm}^2 \times 0,87 \times 250 \text{ N/mm}^2 \times 291,38 \text{ mm} \checkmark$ $M = 50\,96 \text{ kNm} \checkmark$	(Cl 4.3.3.4)
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<u>Determine the Total load</u> Where: Bending moment max = $\frac{WL}{4}$ $50,96 = \frac{W \times 6,35}{4} \checkmark$ $W = 50,96 \times 4 / 6,35$ $W = 32,05 \text{ kN} \checkmark$		(2)
<u>Determine the Dead load</u> Dead load = Vol x density x g a x 10^{-3} ✓ Dead load = $0,425 \times 0,23 \times 1 \times 2\,400 \text{ kg/m}^3 \times 9,81 \times 10^{-3}$ Dead load = 2,301 kN / m ✓		(2)
<u>Determine the max UDL</u> Total load = $1,2(G_n) + 1,6(Q_n)$ ✓ $32,05 \text{ kN} = 1,2(2,301 \text{ kN/m}) + 1,6(Q_n)$ $Q_n = 32,05 \text{ kN} \text{ minus } 2,76 / 1,6 \checkmark$ Max Point Load = 18,31 kN ✓	(CL 4.2.2.1)	(3)

[15]**QUESTION 6**

- 6.1 6.1.1 Ferrous metal
- 6.1.2 Non-ferrous metals
- 6.1.3 Aluminium
- 6.1.4 Iron ore
- 6.1.5 Non-ferrous metals
- (5 × 1) (5)
- 6.2 The importance of the slump test is to determine and maintain the workability of the fresh concrete. (2)
- 6.3 • Soil dug from a garden,
- pit sand,
- wind-blown desert sand,
- beach sand. (Any 2 × 1) (2)

6.4 19 mm. (also accept 13 mm).

(1)
[10]**QUESTION 7**

7.1

I-Taper Flange 178 x 102 x 21,5 kg/m	
<u>Given info:</u>	
Beam A: $I_{yy} = 1,385 \times 10^{-6} \text{ m}^3$	Beam B: $I_{xx} = 15,13 \times 10^{-6} \text{ m}^3$
$\frac{b}{2} = \frac{101,6}{2} = 50,8 \text{ mm}$	$\frac{h}{2} = \frac{177,8}{2} = 88,9 \text{ mm}$

Calculate bending moment maximum

<u>BEAM A:</u>	<u>BEAM B:</u>
$\frac{M}{I} = \frac{F}{Y}$	$\frac{M}{I} = \frac{F}{Y}$
$M = \frac{f \times I}{y}$	$M = \frac{f \times I}{y}$
$M = \frac{163 \times 1,385 \times 10^6}{50,8} \checkmark \checkmark$	$M = \frac{163 \times 15,13 \times 10^6}{88,9}$
$M = 4,444 \text{ kN m} \checkmark$	$\checkmark \checkmark$
	$M = 27,74 \text{ kN m} \checkmark$

Calculate maximum point load

<u>BEAM A:</u>	<u>BEAM B:</u>
$BM = \frac{Wl^2}{8}$	$BM = \frac{Wl^2}{8}$
$4,444 = \frac{W \times 3,5^2}{8} \checkmark$	$27,74 = \frac{W \times 3,5^2}{8} \checkmark$
$W = \frac{4,444 \times 8}{3,25^2}$	$W = \frac{27,74 \times 8}{3,25^2}$
$W = \text{point load} = 2,9 \text{ kN/m}$	$W = \text{point load} = 18,12$
$\checkmark$	$\text{kN/m} \checkmark$

(10)

7.2 The loads are not the same because the second moment of area differs as the beams rotated. This also causes the section modulus to change. (2)

7.3

(2 × 2)

(also consider alternative arrangements) (4)
[16]

TOTAL: 100