higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

BUILDING AND STRUCTURAL CONSTRUCTION N6

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This marking guideline consists of 10 pages.

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QUESTION 1

All references taken from SANS 10100-1 (2000)

Fcu = 25 MPa Table 2 (4.1.5.1)
Fy = 250 MPa Table 3 (4.1.5.2)
Width = 1,45 metres
Density of reinforced concrete = 2 400 kg/m³

1.1 The length of the slope

$\text{Length of slope} = \sqrt{2\,420^2 + 1\,760^2}$ ✓

$\text{Length of slope} = 2\,992{,}32 \text{ mm}$ ✓

Calculations of load

Waist:

$W = \text{Vol x density x g.a. x } 10^{-3}$

$W = 2{,}992 \text{ x } 1{,}45 \text{ x } 0{,}125 \text{ x } 2\,400 \text{ kg/m}^3 \text{ x } 9{,}81 \text{ x } 10^{-3}$ ✓

$W = 12{,}77 \text{ kN}$ ✓

Treads or steps:

$W = \text{Vol x density x g.a x } 9{,}81 \text{ x } 10^{-3}$

$W = ½\text{bh x width x density x g.a x } 9{,}81 \text{ x } 10^{-3}$

$W = ½ \text{ x } 1{,}76 \text{ x } 0{,}220 \text{ x } 1{,}45 \text{ x } 2\,400 \text{ kg/m}^3 \text{ x } 9{,}81 \text{ x } 10^{-3}$ ✓

$W = 6{,}609 \text{ kN}$ ✓

Total design dead load.

$1{,}2 \text{ Gn } (12{,}77 \text{ kN} + 6{,}609 \text{ kN}) = 23{,}255 \text{ kN}$ ✓ (Cl 4.2.2.1)

Design imposed load.

$1{,}6 \text{ Qn } (2{,}5 \text{ kN/m}^2 \text{ x } 1{,}45 \text{ m x } 2{,}420 \text{ m}) = 14{,}036 \text{ kN}$ ✓ (Cl 4.2.2.1) (8)

1.2 Maximum bending moment

$\text{BM}_{max} = \frac{WL}{10} + \frac{WL}{10}$

$\text{BM}_{max} = \frac{23{,}255\ x\ 2{,}420}{10} + \frac{14{,}036\ x\ 2{,}420}{10}$ ✓✓

$\text{BM}_{max} = 5{,}63 + 3{,}4$

$\text{BM}_{max} = 9{,}02 \text{ kNm}$ ✓ (3)

1.3 Value for 'K' (CL 4.3.3.4.1)

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

$K = \frac{9{,}02\ x\ 10^6}{25\ x\ 1\ 450\ x\ 100^2}$ ✓

Let eff depth
(d) = 125 – 25
Cover = 100 mm

$K = 0{,}025 < K^1 = 0{,}156$✓

Only tension reinforcement will be required.✓

Distance of lever arm (Z) (CL 4.3.3.4.1)

$Z = d\left\{0{,}5 + \sqrt{0{,}25 - \frac{K}{0{,}9}}\right\} \leq 0{,}95\text{d}$

$Z = 100\left\{0{,}5 + \sqrt{0{,}25 - \frac{0{,}025}{0{,}9}}\right\} \leq 0{,}95 \text{ x } 100$✓

$Z = 100(0{,}971) \leq 0{,}95 \text{ x } 100$

$Z = 97{,}1 \text{ mm} > 95 \text{ mm}$✓

Use $Z = 95$ mm (least)✓ (6)

1.4 Tension reinforcement (CL 4.3.3.4.1)

$As = \frac{BM}{0{,}87\ fy\ z}$

$As = \frac{9{,}02\ x\ 10^6}{0{,}87x\ 250\ x\ 95}$ ✓

$As = 436{,}54 \text{ mm}^2$✓

Use R10 bars @ 175 c/c $(As = 449 \text{ mm}^2)$✓ (3)

1.5 Secondary reinforcement

$\frac{100\ AS}{AC} = 0{,}24$ ✓ Table 23 (CL 4.11.4.3)

$As = \frac{0{,}24\ x\ AC}{100}$

$As = \frac{0{,}24\ x\ 1\ 450\ x\ 125}{100}$ ✓

$As = 435 \text{ mm}^2$

Use R10 bars @ 175 c/c $(As = 449 \text{ mm}^2)$✓ (3)

[23]

QUESTION 2

2.1 $L_{effective} = 5{,}75 \text{ mm x } 0{,}7$ SABS 0162-1984 (Table 19)

$= 4\,025 \text{ mm}$✓

The cross-sectional area of the steel section

$\text{Area} = 2(375 \text{ x } 16) + (12 \text{ x } 450)$✓

$\text{Area} = 12\,000 + 5\,400$

$\text{Cross-sectional area} = 17\,400 \text{ mm}^2$✓ (3)

2.2 The second moment of area about the x-x axis

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

$I_{xx} = 2\left(\frac{375\,x\,16^3}{12} + 375 \text{ x } 16 \text{ x } 233^2\right) + \left(\frac{12\,x\,450^3}{12}\right)$ ✓✓

$I_{xx} = 2(128\,000 \text{ mm}^4 + 325\,734\,000 \text{ mm}^4) + 91\,125\,000 \text{ mm}^4$

$I_{xx} = 651\,724\,000 \text{ mm}^4 + 91\,125\,000 \text{ mm}^4$

$I_{xx} = 742\,849\,000 \text{ mm}^4$ ✓ (3)

2.3 The second moment of area about the y-y axis

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

$I_{yy} = 2\left(\frac{16\,x\,375^3}{12}\right) + \left(\frac{450\,x\,12^3}{12}\right)$ ✓✓

$I_{yy} = 140\,625\,000 \text{ mm}^4 + 64\,800 \text{ mm}^4$

$I_{yy} = 140\,689\,800 \text{ mm}^4$ ✓ (3)

2.4 The minimum second moment of area

Least second moment of area = $I_{yy} = 140\,689\,800 \text{ mm}^4$✓ (1)

2.5 The minimum radius of gyration

Least second moment of area (I) = $I_{yy} = 121\,396\,248 \text{ mm}^4$

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

$r_{min} = \sqrt{\frac{140\,689\,800 \text{ mm4}}{17\,400\ mm^2}}$✓

$r_{min} = 89{,}9 \text{ mm}$ (Use 90 mm)✓

The slenderness ratio

$L/r = \frac{4\,025}{90} = 44{,}72$ ✓

From Table 17 (SABS 0162-1984)

$44{,}72 = 136{,}28$ MPa ✓ (4)

2.6 The maximum axial load

Load = Stress x area

Load = 136,28 N/mm² x 17 400 mm²

Load = 2 371,27 kN ✓ (1)

[15]

QUESTION 3

All references taken from SANS 10100-1 (2000)

Fcu = 25 MPa	Table 2 (4.1.5.1)
Fy = 250 MPa	Table 3 (4.1.5.2)
Span = 7,0 metres	CL 4.3.1.2

The effective width of the beam

Use the lesser of the two: (Cl 4.3.1.5)

1. Web width $+ \frac{lz}{10}$

   $= 0,300 + \frac{7}{10}$ ✓

   L-beam width = 1 metre wide (1 000 mm) ✓

   OR

2. Actual width (Not given)

Loading of the beam

Design dead load = 5,5 kN/m² x 1 x 1,2 Gn (Cl 4.2.2.1)

= 6,6 kN/m ✓

Design imposed load = 2,75 kN/m² x 1,6 Qn = 4,4 kN/m ✓ (Cl 4.2.2.1)

Bending moment maximum

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

$BM_{max} = \frac{6{,}6\,x\,7^2}{8} + \frac{4{,}4\,x\,7^2}{8}$ ✓

BM max = 40,43 + 26,95

BM max = 67,38 kNm✓

Distance of lever arm (Z)

$Z = d\left\{0{,}5 + \sqrt{0{,}25 - \frac{K}{0{,}9}}\right\}$ (CL 4.3.3.4)

$Z = 460\left\{0{,}5 + \sqrt{0{,}25 - \frac{0{,}156}{0{,}9}}\right\}$ ✓

$Z = 460\ (0{,}777)$

$Z = 357{,}42\ \text{mm}$ ✓

Tension reinforcement

NA is within the flange, therefore; (CL 4.3.3.4.1)

$As = \frac{BM}{0{,}87\ fy\ z}$

$As = \frac{67{,}38\ x\ 10^6}{0{,}87x\ 250\ x\ 357{,}42}$ ✓

$As = 866{,}75\ \text{mm}^2$ ✓

Use 2Y25 bars $(As = 982\ \text{mm}^2)$ ✓

[11]

QUESTION 4

All references taken from SANS 10100-1 (2000)

4.1 Fcu = 30 MPa Table 2 (4.1.5.1)
Fy = 450 MPa Table 3 (4.1.5.2)

4.1.1 The nett area of the concrete

$\text{Nett area of the steel} = 6(\frac{\pi d^2}{4}) + (\frac{\pi d^2}{4})$ ✓

$= 6(\frac{\pi 25^2}{4}) + (\frac{\pi 75^2}{4})$ ✓

$= 2\,945{,}24 + 4\,417{,}86$

$\text{Nett area of the steel} = 7\,363{,}11\ \text{mm}^2$ `✓

$\text{Nett area of concrete} = (650 \text{ x } 330) - 7\,363{,}11\ \text{mm}^2$
$= 207\,136{,}89\ \text{mm}^2$✓ (4)

4.1.2 The axial load

$N = 0{,}4\ fcu\ Ac + 0{,}67\ fy\ Asc$ (Clause 4.7.4.3)

$N = (0{,}4 \times 30 \times 207\,136{,}89) + (0{,}67 \times 450 \times 2\,945{,}24)$✓✓

$N = 2\,485\,642{,}68 + 887\,989{,}86$✓

$N = 1\,597{,}65$ kN✓ (4)

4.1.3 Diameter and spacing of binders

Binders: ¼ of the smallest compression bar (Clause 4.11.4.5.1)

¼ x 25 = 6,25 mm (not available)✓

Use minimum of R8 binders.

Spacing of binders

12 x diameter of smallest compression bar

12 x 25 = 300 mm ✓

Use spacing of 300 mm. (2)

4.2 Area of pad foundation

$\text{Area} = \frac{\Sigma\ of\ Downward\ loads}{Upward\ soil\ pressure}$

$\text{Area} = \frac{1\,597{,}65\ kN + 750\ kN + 95\ kN}{210\ kN/m^2}$ ✓

Area = 11, 632 m^2✓

Size of foundation = $\sqrt{11,632\ m^2}$

3,41 m x 3,41 m✓

Use base size of 3,5 m x 3,5 m.✓ (4)

[14]

QUESTION 5

GIVEN:

<u>203 × 203 × 53,5 kg/m H-section:</u>

$I_{xx} = 49{,}78 \times 10^{-6}\ m^4$

$Area = 6{,}821 \times 10^{-3}\ m^2$

$\frac{H}{2} = \frac{203{,}9}{2} = 101{,}95\ mm$

<u>Plate: 180 mm × 150 mm × 4 mm HRS</u>

$I_{xx} = \left(\frac{BD^3}{12}\right) - \left(\frac{bd^3}{12}\right)$

$I_{xx} = \left(\frac{0{,}18\ x\ 0{,}15^3}{12}\right)\ minus\ \left(\frac{0{,}172\ x\ 0{,}142^3}{12}\right)$

$I_{xx} = 50{,}625 - 41{,}04 = 9{,}585 \times 10^{-6}\ m^4$ ✓

$Area = (0{,}18 \times 0{,}15) - (0{,}172 \times 0{,}142)$

$Area = 2{,}576 \times 10^{-3}\ m^2$ ✓

$Total\ area = 6{,}821 \times 10^{-3}\ m^2 + 2{,}576 \times 10^{-3}\ m^2$

$Total\ Area = 9{,}397 \times 10^{-3}\ m^2$ ✓

<u>Neutral axis using area moments from bottom</u>

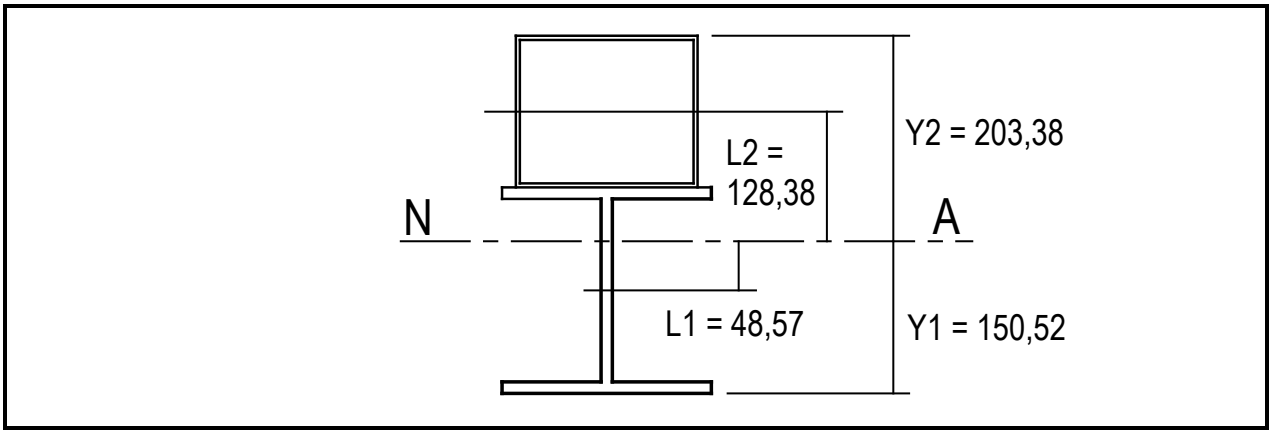
$9{,}397 \times 10^{-3}\ m^2 \times Y1 = (6{,}821 \times 10^{-3}\ m^2 \times 0{,}102) + (2{,}576 \times 10^{-3}\ m^2 \times 0{,}279)$

$0{,}696 \times 10^{-3} + 0{,}719 \times 10^{-3}$ ✓✓

$Y_1 = \frac{1{,}414\ x\ 10^{-3}\ m^2}{9{,}397\ x\ 10^{-3}\ m^2}$ ✓

$Y_1 = 0{,}15052\ m$

$Y_1 = 150{,}52\ mm$ ✓✓



<u>Second moment of area</u>

$I_{xx\ tot} = (Ixx\ beam + al^2) + (Ixx\ RHS + al^2)$

$I_{xx\ Beam} = (49{,}78\ x\ 10^{-6} + 6{,}821\ x\ 10^{-3}\ x\ 0{,}04838^2)$

$= (49{,}78\ x\ 10^{-6} + 15{,}97\ x\ 10^{-6}) = \underline{65{,}75 \times 10^{-6}\ m^4}$ ✓✓

$I_{xx\ RHS} = (9{,}585\ x\ 10^{-6} + 2{,}576\ x\ 10^{-3}\ x\ 0{,}12838^2)$

$(9{,}585\ x\ 10^{-6} + 42{,}456\ x\ 10^{-6}) = \underline{52{,}041 \times 10^{-6}\ m^4}$ ✓✓

$I_{xx\ total} = \underline{117{,}791 \times 10^{-6}\ m^4}$ ✓

Bending moment maximum (Bending stress = 148 MPa)

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

$BM_{max} = \frac{117,791\ x\ 10^6\ x\ 148}{150,52}$ ✓✓

$BM_{max} = 115,82$ kNm✓

The UDL Assume self-weight to be 1,25 kN/m

$BM = \frac{W\ l^2}{8} + \frac{W\ l^2}{8}$

$115,82 = \frac{1,25\ x\ 6,5^2}{8} + \frac{W\ x\ 6,5^2}{8}$ ✓

$W = 6,6 + 5,28\ W$ ✓

$W = \frac{115,82 - 6,6}{5,28}$ ✓

$W = 20,69$ kN/m ✓

[20]

QUESTION 6

6.1 The number of bolts for the part marked 'B'

Force = Area eff x stress x number

$N = \frac{Force}{Pv\ x\ Aeff}$

Stress =
Pv = 100 MPa

$Aeff = \frac{\pi(Dia - 0,9382\ P)^2}{4}$

Clause 9.5.1

$Aeff = \frac{\pi(16 - 0,9382\ x\ 2)^2}{4}$ ✓

$Aeff = 156,67$ mm² ✓

$N = \frac{52\ x\ 10^3}{100\ x\ 156,67}$ ✓

N = 3,32 bolts ✓ (Use 4 M16 bolts) ✓

(5)

6.2 Minimum effective length of the weld at 'W'

SABS 0162
P= 130 MPa
(Cl 10.7.1.2)

The throat thickness = Sin 45º x 5 mm ✓

= 3,54 mm ✓

Calculate the effective length:

$F = P\ x\ A_{eff}$

F = P x Throat x L

$L = \frac{F}{P\ x\ Throat}$ ✓

$L = \frac{66\ x\ 10^3}{130\ x\ 3,54}$ ✓

L = 143 ,42 mm✓

(5)

[10]

QUESTION 7

I -Section parallel flange
533 × 210 × 92,5 kg/m:

$I_{xx} = 553,3 \times 10^{-6}\ m^4$

$h/2 = 533,1/2 = 266,5$ mm

Bending stress = 159 MPa

The self-weight of the beam:

$W = 92,5\ kg/m \times 9,81 \times 10^{-3}$

$W = 0,907\ kN/m$ ✓

$BM = \frac{WL}{4} + \frac{Wl^2}{8}$ ✓

$BM = \frac{150\ x\ L}{4} + \frac{0,907\ x\ l^2}{8}$ ✓

$BM = (37,5\ L + 0,113\ l^2)\ kN\ m$

The span of the beam:

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

$\frac{(37,5\ l + 0,113\ l^2)10^6}{533,3\ x\ 10^6} = \frac{159}{266,5}$ ✓

$(9\ 995,63\ l + 30,12\ l^2) = 84\ 794,7$ (Divide by 30,12)✓

$L = l^2 + 331,86\ l - 2\ 815,23$

$Span\ (L) = \frac{-b \pm \sqrt{b^2-4ac}}{2a}$

$Span\ (L) = \frac{-331,86 \pm \sqrt{331,86^2-4\ x\ 1\ x\ 2\ 815,23}}{2\ x\ 1}$ ✓

$Span\ (L) = \frac{-331,86 \pm 348,41}{2}$

$Span(L) = 8,3$ metres ✓

[7]

TOTAL: 100

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