

**MARKING GUIDELINE**

**NATIONAL CERTIFICATE**

# STRENGTH OF MATERIALS AND STRUCTURES N6

## 12 August 2021

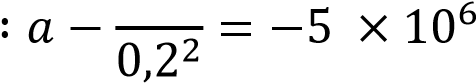
**This marking guideline consists of 10 pages.**

Copyright reserved Please turn over

### QUESTION 1

1.1 at 200 mm ∶ 𝑎𝑎 + 0𝑏𝑏2 = 25 × 106 … … … . (1) 

,2

𝑏𝑏 (2)  at 200 mm… …

1. + (2) ∶ 2𝑎𝑎 = 20 × 106

𝑎𝑎 = 10 × 106 

𝑏𝑏 = 600 × 103 

𝑏𝑏

at 300 mm ∶ 𝜎𝜎𝑅𝑅 = 𝑎𝑎 + 0,32

600 × 103

= 10 × 106 + 0,32

𝜎𝜎𝑅𝑅 = 16,667 MPa  (5)

* 1. 𝑏𝑏

𝑎𝑎t 300 mm ∶ 𝜎𝜎𝐻𝐻 = 𝑎𝑎 − 0,32

600 × 103

= 10 × 106 − 0,32

𝜎𝜎𝐻𝐻 = 3,333 MPa  (compressive)  (2)

* 1. 𝑏𝑏

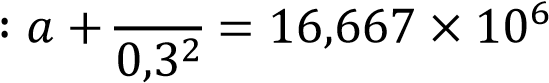
𝜎𝜎𝐻𝐻 = 0 where: 𝑎𝑎 −𝐷𝐷𝑥𝑥2 = 0

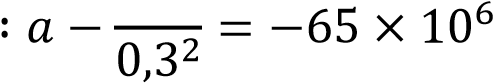
6 − 600𝐷𝐷×𝑥𝑥2103 = 0

10 × 10

𝐷𝐷𝑥𝑥 = 244,949 mm  (1)

1.4 𝑏𝑏

at 300 mm  … … … . (1) 

𝑏𝑏 at 300 mm  … … … … … (2) 

(1) + (2) ∶ 2𝑎𝑎 = −48,333 × 106

𝑎𝑎 = −24,167 × 106 

𝑏𝑏 = 3,675 × 106 

𝑏𝑏

at 𝐷𝐷 ∶ 𝑎𝑎 + 𝐷𝐷2 = 0

3,675 × 106

−24,167 × 106 + 𝐷𝐷2 = 0

𝐷𝐷 = 389,9 mm  (5)

**[13]**

### QUESTION 2

2.1 𝐹𝐹𝑇𝑇𝐵𝐵 6000

𝑦𝑦𝐵𝐵 = = = 150 m 

𝑤𝑤 40

𝑦𝑦𝐴𝐴 = 𝑦𝑦𝐵𝐵 − ℎ = 150 − 6 = 144 m 

𝐹𝐹𝑇𝑇𝐴𝐴 = 𝑤𝑤𝑦𝑦𝐴𝐴 = 40 × 144 = 5 760 N  (3)

2.2 𝑦𝑦0 = 𝑦𝑦𝐴𝐴 − 𝑑𝑑 = 144 − 4 = 140 m 

ℓ𝐴𝐴 = 𝑦𝑦𝐴𝐴2 − 𝑦𝑦02 = 1442 − 1402 = 33,705 m 

ℓ𝐵𝐵 = 𝑦𝑦𝐵𝐵2 − 𝑦𝑦02 = 1502 − 1402 = 53,852 m 

ℓ𝑇𝑇 = ℓ𝐴𝐴 + ℓ𝐵𝐵 = 87,556 m  (4)

2.3 𝐹𝐹𝑣𝑣𝑣𝑣 = 𝑤𝑤ℓ𝐴𝐴 = 40 × 33,705 = 1 348,184 N 

𝐹𝐹𝑣𝑣𝑣𝑣 = 𝐹𝐹𝑇𝑇𝐴𝐴 cos 𝛼𝛼 = 5 760 × cos 30 = 4988,306 N 

𝐹𝐹𝑣𝑣𝑣𝑣 = 𝐹𝐹𝑣𝑣𝑣𝑣 + 𝐹𝐹𝑣𝑣𝑣𝑣 = 6336,49 N  (3)

2.4 𝐹𝐹𝐻𝐻𝑣𝑣 = 𝑤𝑤𝑦𝑦0 = 40 × 140 = 5 600 N = 𝐹𝐹𝐻𝐻𝑣𝑣 

𝐹𝐹𝐻𝐻𝑣𝑣 5 600

𝐹𝐹𝑇𝑇𝑣𝑣 = = = 11 200 N  (2)

sin 𝜃𝜃 sin 30

**[12]**

### QUESTION 3

#### 3.1 𝑤𝑤ℓ14 𝑤𝑤ℓ13 × ℓ2

∆1= +

#### 8𝐸𝐸𝐸𝐸 6𝐸𝐸𝐸𝐸

10 × 103 × 2,54 10 × 103 × 2,53 × 1,5

= 8 × 200 × 109 × 𝐸𝐸 + 6 × 200 × 109 × 𝐸𝐸 

439,453 × 10−9

∆1= 

#### 𝐸𝐸

𝐹𝐹𝐿𝐿3 20 × 103 × 43 2,133 × 10−6

∆2= 3𝐸𝐸𝐸𝐸 = 3 × 200 × 109 × 𝐸𝐸 = 𝐸𝐸 

#### ∆𝑇𝑇= ∆1 + ∆2

439,453 × 10−9 2,133 × 10−6

11 × 10−3 = + 

𝐸𝐸 𝐸𝐸

𝐸𝐸 = 233,89 × 10−6 𝑚𝑚4 

𝜋𝜋(𝐷𝐷4 − 𝑑𝑑4)

#### 𝐸𝐸 =

64

−6 = 𝜋𝜋((2𝑑𝑑)4 − 𝑑𝑑4) 

233,89 × 10

64

𝑑𝑑 = 133,502 mm 

𝐷𝐷 = 267,004 mm 

(8)

3.2 For 𝐸𝐸 = 233,89 × 10−6 m4 select 305 × 305 × 118 kg/m   (1)

3.3 𝑤𝑤ℓ2

#### 𝑀𝑀 = 𝐹𝐹𝐿𝐿 +

2

3 × 4 + 10 × 103 × 2,52 

= 20 × 10

2 M = 111,25 kNm 

𝑀𝑀 111,25 × 103

𝜎𝜎 = 𝑍𝑍 = 1755 × 10−6 = 63,39 MPa 

(3)

**[12]**

### QUESTION 4

4.1 𝜋𝜋(𝐷𝐷2 − 𝑑𝑑2) 𝜋𝜋(32 − 2,52)

𝐴𝐴 = = = 2,16 m2 

1. 4

𝑊𝑊 = 𝜌𝜌𝜌𝜌𝐴𝐴ℎ = 2 500 × 9,81 × 2,16 × 15 = 794,553 kN 

𝑊𝑊 794,553 × 103

𝜎𝜎𝐷𝐷 = = = 367,875 kPa (compressive) 

𝐴𝐴 2,16

(3)

4.2 𝜋𝜋(𝐷𝐷4 − 𝑑𝑑4) 𝜋𝜋(34 − 2,54)

𝐸𝐸 = = = 2,059 m4 

64 64

𝑀𝑀 = 𝐹𝐹 × 𝑒𝑒 = 60 × 103 × 7,5 = 450 kNm 

𝑀𝑀𝑀𝑀 450 × 103 × 1,5

𝜎𝜎𝑏𝑏 = = = 327,892 kPa 

𝐸𝐸 2,059

(3)

4.3 𝜎𝜎𝑚𝑚𝑣𝑣𝑥𝑥 = 𝜎𝜎𝑑𝑑 + 𝜎𝜎𝑏𝑏 = 695,767 kPa  (compressive) 

𝜎𝜎𝑚𝑚𝑚𝑚𝑚𝑚 = 𝜎𝜎𝑑𝑑 − 𝜎𝜎𝑏𝑏 = 39,983 kPa  (compressive) 

(4)

4.4 𝜎𝜎𝑑𝑑 × 𝐸𝐸 367,875 × 103 × 2,059

𝑀𝑀0 = 𝑀𝑀 = 450 × 103 = 1,683 m (from the centroid) 

𝑀𝑀 = 1,683 + 1,5 = 3,183 mm (outside the profile) 

OR

𝜎𝜎𝑚𝑚𝑣𝑣𝑥𝑥 𝜎𝜎𝑚𝑚𝑚𝑚𝑚𝑚

=

#### 𝑥𝑥 𝑥𝑥 − 𝐷𝐷

695,767 39,983

= 

#### 𝑥𝑥 𝑥𝑥 − 3

|  |  |  |  |
| --- | --- | --- | --- |
| 𝑥𝑥 = 3,183 mm (outside the profile)  | |  |  |
|  | |  | (2) |
| **QUESTION 5** | |  | **[12]** |
|  |  |
| 5.1 | 𝑊𝑊1 = 𝜌𝜌𝜌𝜌𝐴𝐴ℓ = 2200 × 9,81 × 0,5 × 5 × 𝑏𝑏 × 1 = 53,955𝑏𝑏 kN     𝑊𝑊2 = 𝜌𝜌𝜌𝜌𝐴𝐴ℓ = 2200 × 9,81 × 2 × 5 × 1 = 215,82 kN     𝑉𝑉 = 𝑊𝑊1 + 𝑊𝑊2 = 53,955𝑏𝑏 + 215,82 kN     𝑉𝑉 6𝑉𝑉𝑒𝑒  𝜎𝜎𝑚𝑚𝑣𝑣𝑥𝑥 = + 2 − − − (1)   𝐵𝐵 𝐵𝐵    𝑉𝑉 6𝑉𝑉𝑒𝑒  𝜎𝜎𝑚𝑚𝑚𝑚𝑚𝑚 = − 2 − − − (2)   𝐵𝐵 𝐵𝐵    2𝑉𝑉  (1) + (2): 107,91 + 35,97 =   𝐵𝐵    2(53,955𝑏𝑏 + 215,82)  143,88 =   2 + 𝑏𝑏    143,88 × (2 + 𝑏𝑏) = 2(53,955𝑏𝑏 + 215,82)     𝑏𝑏 = 4 m  and 𝐵𝐵 = 4 + 2 = 6 m  |  |  |
|  |  |  | (10) |

5.2 𝑉𝑉 = 53,955𝑏𝑏 + 215,82 = 53,955 × 4 + 215,82 = 431,64 kN 

𝑉𝑉 431,64

𝜎𝜎𝑑𝑑 = = = 71,94 kPa 

#### 𝐵𝐵 6

𝜎𝜎𝑏𝑏 = 𝜎𝜎𝑚𝑚𝑣𝑣𝑥𝑥 − 𝜎𝜎𝑑𝑑 = 107,91 − 71,94  = 35,97 kPa 

(4)

**[14]**

### QUESTION 6

6.1 𝑊𝑊𝑇𝑇 3 × 106 2 

𝐴𝐴 = 𝑝𝑝 = 187,5 × 103 = 16 m

𝐿𝐿 = 4 m 

(2)

6.2 𝑊𝑊(𝐿𝐿 − ℓ) 2,5 × 106(4 − 0,8)

𝑀𝑀 = = = 1 MNm 

8 8

𝑀𝑀 1 × 106

𝑍𝑍 = 𝜎𝜎 × 𝑛𝑛 = 100 × 106 × 5 = 2 000 × 10−6 m3 

lighest I − beam is 533 × 210 × 92,5 kg/m 

(3)

6.3 ℓ = 𝑏𝑏 × 𝑛𝑛 + 0,075(𝑛𝑛 − 1) = 0,2093 × 5 + 0,075 × 4 = 1,3465 m 

**T**he given base plate dimension of 1,2 m is not sufficient and must be changed to 1,3465 m 

(2)

6.4 𝑊𝑊(𝐿𝐿 − 𝑙𝑙) 2,5 × 106(4 − 1,3465)

𝑀𝑀 = = = 829,219 kNm 

8 8

𝑀𝑀 829,219 × 103

𝑍𝑍 = 𝜎𝜎 × 𝑛𝑛 = 100 × 106 × 10 = 829,219 × 10−6 m3 

lighest I − beam is 406 × 178 × 53,8 kg/m  (3)

6.5 𝑀𝑀 1 × 106

𝜎𝜎𝑇𝑇 = 𝑍𝑍 × 𝑛𝑛 = 2076 × 10−6 × 5 = 96,339 MPa 

𝑀𝑀 829,219 × 103

𝜎𝜎𝐵𝐵 = 𝑍𝑍 × 𝑛𝑛 = 927,4 × 10−6 × 10 = 89,413 MPa  (2)

**[12]**

### QUESTION 7

#### 7.1 𝜎𝜎𝑠𝑠 𝑚𝑚(𝑑𝑑 − 𝑛𝑛)

=

#### 𝜎𝜎𝑣𝑣 𝑛𝑛

138 15(0,6 − 𝑛𝑛)

= 

#### 6 𝑛𝑛

23𝑛𝑛 = 9 − 15𝑛𝑛 

𝑛𝑛 = 0,237 m  (3)

7.2 𝑛𝑛 0,237

𝑙𝑙𝑣𝑣 = 𝑑𝑑 − = 0,6 − = 0,521 m 

3 3

𝑀𝑀 = 𝜎𝜎𝑠𝑠𝐴𝐴𝑠𝑠𝑙𝑙𝑣𝑣 = 138 × 106 × 2 × 10−3 × 0,521 = 143,811 kNm  (2)

##### 7.3 𝐹𝐹𝐿𝐿 𝑤𝑤𝐿𝐿2

𝑀𝑀 = 4 + 8

60 × 4 𝑤𝑤 × 42

143,811 =  + 

4 8

𝑤𝑤 = 41,905 kN/m  (3)

7.4 𝑀𝑀 = 0,5𝜎𝜎𝑣𝑣𝐴𝐴𝑣𝑣𝑙𝑙𝑣𝑣 143,811 × 103 = 0,5 × 6 × 106 × 𝑏𝑏 × 0,237 × 0,521 

𝑏𝑏 = 0,388 m 

(2)

7.5 2

𝑀𝑀𝑣𝑣 = 0,5𝜎𝜎𝑣𝑣𝐴𝐴𝑣𝑣 𝑛𝑛

3

= 0,5 × 6 × 106 × 0,388 × 0,237 ×  × 0,237 

𝑀𝑀𝑣𝑣 = 43,579 kNm 

(2)

##### 7.6 𝑀𝑀𝑠𝑠 = 𝜎𝜎𝑠𝑠𝐴𝐴𝑠𝑠(𝑑𝑑 − 𝑛𝑛)

= 138 × 106 × 2 × 10−3(0,6 − 0,237) 

𝑀𝑀𝑠𝑠 = 100,232 𝑘𝑘𝑘𝑘𝑚𝑚 

(2)

**[14]**

### QUESTION 8

8.1 O





A BC

B

A



O

C

(4)

STRENGTH OF MATERIALS AND STRUCTURES N6

8.2

1

|  |  |  |
| --- | --- | --- |
| MEMBER | MAGNITUDE | NATURE |
| OA (2-3) | 9 kN  | Strut |
| OB (3-4) | 16,2 kN  | Strut |
| OC (1-4) | 16,2 kN  | Strut |

4

2

,

7

2

,

7



1 4,8  3

4,8 

6

3

1,5 

2

(7)

**[11]**

### TOTAL: 100

Copyright reserved