| | |
|---|---|
| **Project:** | Amsterdam industrial |
| **Project number:** | 20231090 |
| **Author:** | Dave the Engineer |

## Table of contents



# 1 Project data

| | |
|---|---|
| Project title | Amsterdam industrial |
| Author | Dave the Engineer |
| Date of creation | 04.01.2023 |
| Version | 23.0.0.3259 |

National code

| | |
|---|---|
| National code | EN 1992-1-1:2014-12 |
| Design working life | 50 years |

# 2 Brief summary of results of sectional checks

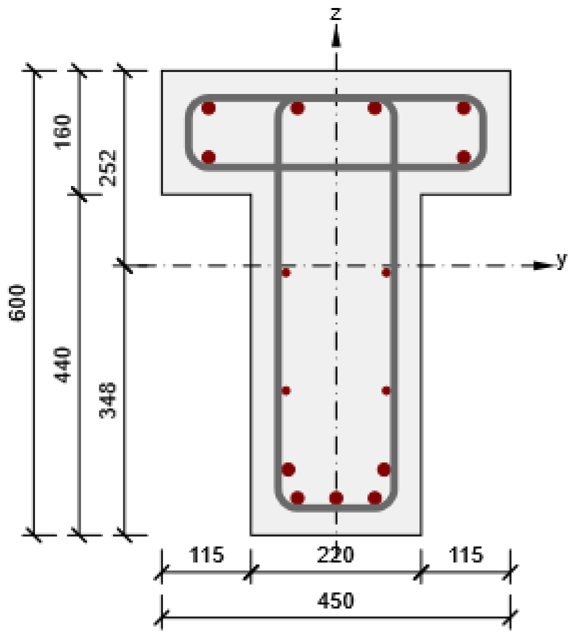
| Section name | Design member | Reinforced cross-section | Value [%] | Result status |
|---|---|---|---|---|
| S 1 | M 1 (Beam) | R 1 | 93,4 | ✓ |

# 3 Sectional checks

## 3.1 Section S 1

### 3.1.1 Critical extreme S 1 - E 1

| | |
|---|---|
| Design member | M 1 |
| Reinforced cross-section | R 1 |




Concrete: C30/37
Age: 28,0 d
Reinforcement: (B 500B)
4ø16 (804mm²), z = 204 mm
2ø16 (402mm²), z = 140 mm
2ø10 (157mm²), z = -9 mm
2ø10 (157mm²), z = -161 mm
2ø16 (402mm²), z = -263 mm
3ø16 (603mm²), z = -300 mm
Stirrups:
ø10 - 350 mm
ø10 - 350 mm
Cover:
Other edges: 30 mm
Lower edge: 30 mm
Upper edge: 30 mm

### 3.1.1.1 Load effects - internal forces

| Load type | Combination type | N [kN] | $V_y$ [kN] | $V_z$ [kN] | T [kNm] | $M_y$ [kNm] | $M_z$ [kNm] |
|---|---|---|---|---|---|---|---|
| Total | Fundamental ULS | 0,0 | 0,0 | 50,0 | 10,0 | 145,0 | 20,0 |
| Total | Characteristic | 0,0 | 0,0 | 0,0 | 0,0 | 120,0 | 0,0 |
| Total | Quasi-permanent | 0,0 | 0,0 | 0,0 | 0,0 | 100,0 | 0,0 |

### 3.1.1.2 Overall

| Governing type of check | $N_{Ed}$ [kN] | $M_{Ed,y}$ [kNm] | $M_{Ed,z}$ [kNm] | $V_{Ed}$ [kN] | $T_{Ed}$ [kNm] | Value [%] | Check |
|---|---|---|---|---|---|---|---|
| Interaction | 0,0 | 145,0 | 20,0 | 50,0 | 10,0 | 93,4 | OK |
| **Type of check** | **$N_{Ed}$ [kN]** | **$M_{Ed,y}$ [kNm]** | **$M_{Ed,z}$ [kNm]** | **$V_{Ed}$ [kN]** | **$T_{Ed}$ [kNm]** | **Value [%]** | **Check** |
| Capacity N-M-M | 0,0 | 145,0 | 20,0 | | | 53,3 | OK |
| Shear | 0,0 | | | 50,0 | 10,0 | 24,3 | OK |
| Torsion | | | | | 10,0 | 32,2 | OK |
| Interaction | 0,0 | 145,0 | 20,0 | 50,0 | 10,0 | 93,4 | OK |
| Stress Limitation | 0,0 | 120,0 | 0,0 | | | 58,7 | OK |
| Crack Width | 0,0 | 100,0 | 0,0 | | | 56,3 | OK |

**Limit value of the exploitation of the cross-section: 100,0 %**

**Nonconformity**

| | Nonconformities |
|---|---|
| ⚠ | Shear is resisted by concrete, shear reinforcement is required according to detailing provisions, see 6.2.2 |
| ⚠ | Check of interaction of shear and torsion acc. to 6.3.2 (5) is not satisfactory, therefore it was necessary to check ultimate capacity at interaction of all components of internal forces |
| ⚠ | Upper or lower design value of internal forces of one of SLS combinations caused to happen concrete stress higher than concrete tensile strength (section is cracked). Based on code and calculation settings it is assumed that the concrete resists no tension in SLS checks for all combinations of current extreme. The assumptions for SLS checks in other extremes of current section are not influenced. |

⚠ The action of concrete in tension is excluded because the cracks appear, see clause 7.1 (2)

### 3.1.1.3 Capacity N-M-M

**Results presented for combination : Fundamental ULS**

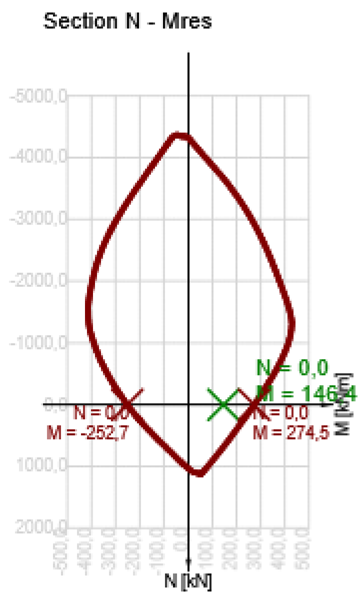
| $N_{Ed}$ [kN] | $M_{Ed,y}$ [kNm] | $M_{Ed,z}$ [kNm] | Type | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|
| 0,0 | 145,0 | 20,0 | Nu-Mu-Mu | 53,3 | 100,0 | OK |

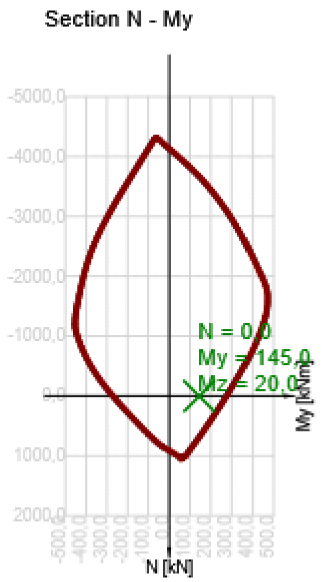
**Design resistance of css subjected to bending and axial force**

| Type | $F_{Ed}$ | $F_{Rd1}$ | $F_{Rd2}$ |
|---|---|---|---|
| N [kN] | 0,0 | 0,0 | 0,0 |
| $M_y$ [kNm] | 145,0 | 271,9 | -250,4 |
| $M_z$ [kNm] | 20,0 | 37,5 | -34,5 |

**Nonconformity**

| |
|---|
| No nonconformities |




## Explanation

| Symbol | Explanation |
|---|---|
| $N_{Ed}$ | Design value of the applied axial force caused by permanent and variable external load, and by secondary effects of prestressing |
| $M_{Ed,y}$ | Design value of the applied bending moment around y axis caused by permanent and variable external load, and by secondary effects of prestressing |
| $M_{Ed,z}$ | Design value of the applied bending moment around z axis caused by permanent and variable external load, and by secondary effects of prestressing |
| Type | Nu-Mu-Mu: Cross-sectional resistance is determined assuming proportional change of all components of acting internal forces (the eccentricity of normal force remains constant) until interaction surface is reached. The change of acting internal forces can be interpreted as the movement along the line connecting the origin of coordinate system (0,0,0) and the point of acting internal forces (NEd, MEdy, MEdz). Two points of intersection of the connecting line and interaction surface, which can be found, |

| | |
|---|---|
| | represent two sets of forces of resistance. Three resistance forces are determined in each point of intersection by the program: normal force capacity NRd, and capacities in flexure MRdy and MRdz |
| Value | Utilization of the cross-section or its component (e.g. reinforcement bar) related to the limit value |
| Limit | Limit value of the exploitation of the cross-section |
| Check | Result of the check |
| $F_{Ed}$ | The applied design force caused by external load (without effects of prestressing) |
| $F_{Rd1}$ | First set of forces of resistance resulting from first point of intersection reached at interaction surface |
| $F_{Rd2}$ | Second set of forces of resistance resulting from second point of intersection reached at interaction surface |

### 3.1.1.4 Shear

**Results presented for combination : Fundamental ULS**

| $V_{Ed}$ [kN] | $N_{Ed}$ [kN] | $V_{Rd}$ [kN] | Check zone | Clause | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|
| 50,0 | 0,0 | 206,1 | without reduction | 6.2.3(3) | 24,3 | 100,0 | OK |

**Design and resistance shear forces**

| $V_{Ed}$ [kN] | $V_{Rd,c}$ [kN] | $V_{Rd,max}$ [kN] | $V_{Rd,r}$ [kN] | $V_{Rd,s}$ [kN] | $V_{Rd}$ [kN] |
|---|---|---|---|---|---|
| 50,0 | 75,4 | 418,1 | 593,5 | 206,1 | 206,1 |

**Input values and intermediate results of shear design**

| $n_c$ | $a_{sw}$ [mm²/m] | $A_{sl}$ [mm²] | $b_w$ [mm] | d [mm] | z [mm] | θ [°] | α [°] | $\sigma^*_{cp}$ [MPa] | $\alpha_{cw}$ [-] |
|---|---|---|---|---|---|---|---|---|---|
| 2 | 449 | 1521 | 220 | 511 | 459 | 21,8 | 90,0 | 0,0 | 1,00 |

| $C_{Rd,c}$ [-] | k [-] | $k_1$ [-] | $\rho_l$ [-] | $\sigma_{cp}$ [MPa] | $\sigma_{wd}$ [MPa] | $v_{min}$ [MPa] | v [-] | $v_1$ [-] |
|---|---|---|---|---|---|---|---|---|
| 0,12 | 1,63 | 0,15 | 0,01 | 0,0 | 231,4 | 0,4 | 0,53 | 0,60 |

**Nonconformity**

| | Nonconformities |
|---|---|
| ⚠ | Shear is resisted by concrete, shear reinforcement is required according to detailing provisions, see 6.2.2 |

## Explanation

| Symbol | Explanation |
|---|---|
| $V_{Ed}$ | Design value of the applied shear force (with effect of prestressing) |
| $N_{Ed}$ | Design value of the applied axial force (with effect of prestressing) |
| $V_{Rd}$ | Final value of the design shear resistance |
| Check zone | Type of zone in which check is performed |
| Clause | The number of clause (type of method) used for shear check |
| Value | Utilization of the cross-section or its component (e.g. reinforcement bar) related to the limit value |
| Limit | Limit value of the exploitation of the cross-section |
| Check | Result of the check |
| $V_{Rd,c}$ | The design shear resistance of the member without shear reinforcement |
| $V_{Rd,max}$ | The design value of the maximum shear force which can be sustained by the member, limited by crushing of the compression struts |
| $V_{Rd,r}$ | Limit value of design shear force considered without reduction by Beta factor acc. (6.2.2(6)) |
| $V_{Rd,s}$ | Design value of the shear force which can be sustained by the yielding of shear reinforcement |
| $n_c$ | Number of branches of shear reinforcement |

| | |
|---|---|
| $a_{sw}$ | The cross-sectional area of the shear reinforcement per unit length |
| $A_{sl}$ | The area of the tensile longitudinal reinforcement |
| $b_w$ | The width of the cross-section in the centroid of css |
| d | Effective depth of the cross-section |
| z | The inner lever arm |
| θ | The angle between the concrete compression strut and the beam axis perpendicular to the shear force |
| α | The angle between shear reinforcement and the beam axis perpendicular to the shear force |
| $\sigma^*_{cp}$ | The mean compressive stress (measured positive) in the concrete due to the design axial force taking account of the reinforcement. σcp* serves for determining αcw (see. EN 1992-1-1, chap. 6.2.3 (3)) |
| $\alpha_{cw}$ | Coefficient taking account of the state of the stress in the compression chord |
| $C_{Rd,c}$ | Coefficient for calculation the design shear resistance of the member without shear reinforcement |
| k | Coefficient for calculation the design shear resistance of the member without shear reinforcement |
| $k_1$ | Coefficient for calculation the design shear resistance of the member without shear reinforcement |
| $\rho_l$ | Reinforcement ratio of the tensile longitudinal reinforcement |
| $\sigma_{cp}$ | The mean compressive stress (measured positive) in the concrete cross-section due to the design axial force. σcp is limited to value 0,2·fcd (EN 1992-1-1 chap. 6.2.2 (1)) |
| $\sigma_{wd}$ | Design stress of the shear reinforcement, see note 2 of clause 6.2.3 (3) |
| $v_{min}$ | Coefficient for calculation the design shear resistance of the member without shear reinforcement |
| v | Concrete strength reduction factor for the calculation of shear resistance |
| $v_1$ | Concrete strength reduction factor for the calculation of shear resistance |

### 3.1.1.5 Torsion

**Results presented for combination : Fundamental ULS**

| $T_{Ed}$ [kNm] | $T_{Rd}$ [kNm] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|
| 10,0 | 31,0 | 32,2 | 100,0 | OK |

**Design and resistance torsional moments**

| $T_{Ed}$ [kNm] | $T_{Rd,c}$ [kNm] | $T_{Rd,max}$ [kNm] | $T_{Rd,s}$ [kNm] | $T_{Rd,sl}$ [kNm] | $T_{Rd}$ [kNm] |
|---|---|---|---|---|---|
| 10,0 | 16,1 | 43,5 | 32,3 | 31,0 | 31,0 |

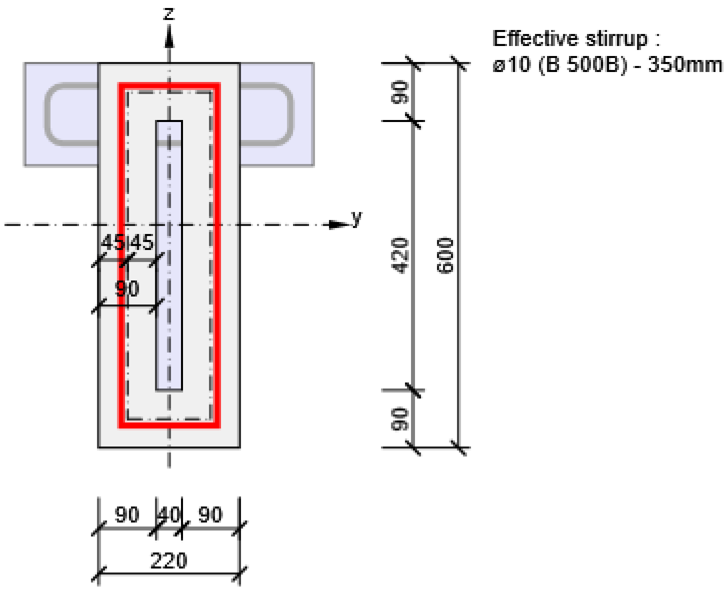
**Input values and intermediate results of torsion design**

| $A_k$ [mm$^2$] | $u_k$ [mm] | $t_{eff}$ [mm] | $a_{sw}$ [mm$^2$/m] | $A_{sl}$ [mm$^2$] | $A_{sp}$ [mm$^2$] | θ [°] |
|---|---|---|---|---|---|---|
| 66300 | 1280 | 90 | 224 | 1722 | 0 | 21,8 |

**Nonconformity**

| |
|---|
| No nonconformities |

Equivalent thin-walled section for torsion check




## Explanation

| Symbol | Explanation |
|---|---|
| $T_{Ed}$ | Design value of the applied torsional moment (with effect of prestressing) |
| $T_{Rd}$ | Governing design torsional resistance moment |
| Value | Utilization of the cross-section or its component (e.g. reinforcement bar) related to the limit value |
| Limit | Limit value of the exploitation of the cross-section |
| Check | Result of the check |
| $T_{Rd,c}$ | The design torsional cracking moment |
| $T_{Rd,max}$ | The design torsional resistance moment |
| $T_{Rd,s}$ | The design value of the torsional moment, which can be sustained by the yielding of torsion reinforcement |
| $T_{Rd,sl}$ | The design value of the torsional moment, which can be sustained by the yielding of longitudal reinforcement |
| $A_k$ | The area enclosed by the centre-lines of the connecting walls, including inner hollow areas |
| $u_k$ | The perimeter of the area Ak |
| $t_{eff}$ | The effective wall thickness |
| $a_{sw}$ | Cross-sectional area of the shear reinforcement per unit length used for torsion check |
| $A_{sl}$ | Area of longitudinal reinforcement inside of the stirrup, which is effective for torsion resistance |
| $A_{sp}$ | Area of prestressing reinforcement inside of the stirrup, which is effective for torsion resistance |
| θ | The angle between the concrete compression strut and the beam axis perpendicular to the shear force |

## 3.1.1.6 Interaction

**Results presented for combination : Fundamental ULS**

| $N_{Ed}$ [kN] | $M_{Edy}$ [kNm] | $M_{Edz}$ [kNm] | $V_{Ed}$ [kN] | $T_{Ed}$ [kNm] | Value V+T [%] | Value V+T+M [%] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|---|---|
| 0,0 | 145,0 | 20,0 | 50,0 | 10,0 | 53,2 | 93,4 | 93,4 | 100,0 | OK |

**Interaction check of shear and torsion (concrete)**

| $V_{Rd,c}$ [kN] | $T_{Rd,c}$ [kNm] | $V_{Rd,max}$ [kN] | $T_{Rd,max}$ [kNm] | Eq. 6.31 [%] | Eq. 6.29 [%] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|---|
| 75,4 | 16,1 | 418,1 | 43,5 | 128,3 | 35,0 | 35,0 | 100,0 | OK |

**Interaction check of shear and torsion (longitudinal reinforcement)**

| $A_{sl}$ [mm$^2$] | $F_{sl}$ [kN] | $F_{sl,lim}$ [kN] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|
| 2526 | 366,4 | 1176,9 | 31,1 | 100,0 | OK |

**Interaction check of shear and torsion (shear reinforcement)**

| $a_{sw}$ [mm$^2$/m] | $F_{sw}$ [kN] | $F_{sw,lim}$ [kN] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|
| 224 | 51,9 | 97,6 | 53,2 | 100,0 | OK |

**Interaction check of shear, torsion, bending and normal force**

| $F_b$ [kN] | $\Delta F_{td,s}$ [kN] | $\Delta F_{td,t}$ [kN] | $\Delta\varepsilon_s$ [1e-4] | $\Delta\varepsilon_t$ [1e-4] | Extreme in bar | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|---|
| 260,9 | 125,0 | 241,3 | 2,5 | 8,7 | 5 | 93,4 | 100,0 | OK |

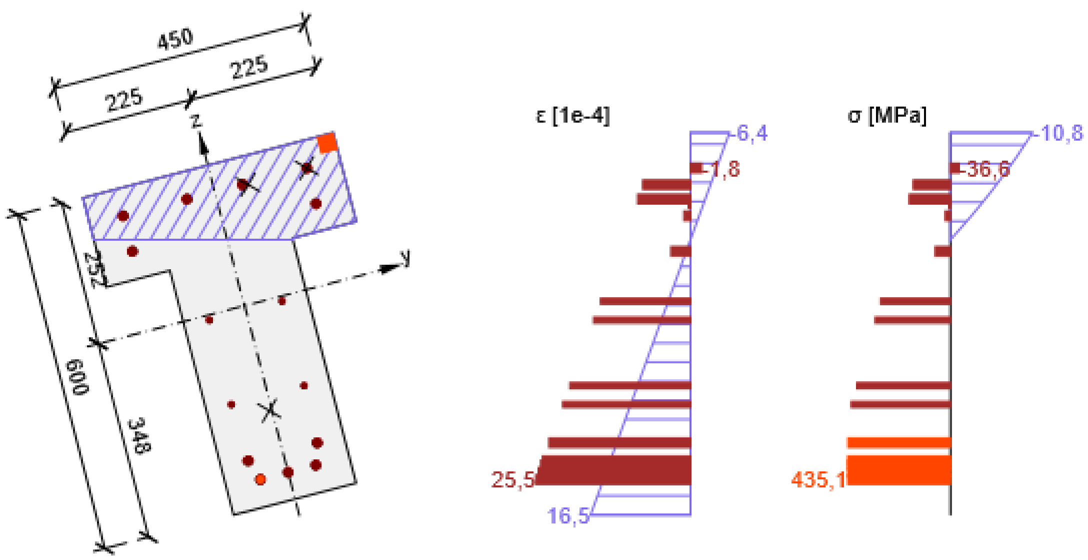
**Detailed check of reinforcement**

| Bar | $y_i$ [mm] | $z_i$ [mm] | $\Delta\varepsilon_{st}$ [1e-4] | $\varepsilon$ [1e-4] | $\varepsilon_{lim}$ [1e-4] | $\Delta\sigma_{st}$ [MPa] | $\sigma$ [MPa] | $\sigma_{lim}$ [MPa] | Value [%] | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| 5 | -50 | -300 | 11,1 | 25,5 | 450,0 | 147,6 | 435,1 | 465,9 | 93,4 | OK |

**Nonconformity**

| | Nonconformities |
|---|---|
| ⚠ | Check of interaction of shear and torsion acc. to 6.3.2 (5) is not satisfactory, therefore it was necessary to check ultimate capacity at interaction of all components of internal forces |

Stress and strain distributions in the cross-section




## Explanation

| Symbol | Explanation |
|---|---|
| $N_{Ed}$ | Design value of the applied axial force (with effect of prestressing) |
| $M_{Edy}$ | Design value of the applied bending moment around y axis (with effect of prestressing) |

| | |
|---|---|
| $M_{Edz}$ | Design value of the applied bending moment around z axis (with effect of prestressing) |
| $V_{Ed}$ | Design value of the applied shear force (with effect of prestressing) |
| $T_{Ed}$ | Design value of the applied torsional moment (with effect of prestressing) |
| Value V+T | Utilization of the cross-section (for interaction of shear and torsion) related to the limit value |
| Value V+T+M | Utilization of the cross-section (for interaction of shear, torsion and bending) related to the limit value |
| Value | Utilization of the cross-section or its component (e.g. reinforcement bar) related to the limit value |
| Limit | Limit value of the exploitation of the cross-section |
| Check | Result of the check |
| $V_{Rd,c}$ | The design shear resistance of the member without shear reinforcement |
| $T_{Rd,c}$ | The design torsional cracking moment |
| $V_{Rd,max}$ | The design value of the maximum shear force which can be sustained by the member, limited by crushing of the compression struts |
| $T_{Rd,max}$ | The design torsional resistance moment |
| Eq. 6.31 | The value of the exploitation of the cross-section according to equation (6.31) EN 1992-1-1 |
| Eq. 6.29 | The value of the exploitation of the cross-section according to equation (6.29) EN 1992-1-1 |
| $A_{sl}$ | Cross-sectional area of longitudinal reinforcement used for shear and/or torsion check. In case of torsion, it is area of reinforcement inside of the stirrup, which is effective for torsion resistance |
| $F_{sl}$ | Tensile force due to shear and torsion in longitudinal reinforcement inside of the stirrup, which is effective for torsion resistance |
| $F_{sl,lim}$ | Limit value of tensile force in longitudinal reinforcement inside of the stirrup, which is effective for torsion resistance (Fsl,lim=Asl*fyd) |
| $a_{sw}$ | The cross-sectional area (per unit length) of the most utilized stirrup leg due to shear and torsion |
| $F_{sw}$ | Tensile force (per unit length) in the most utilized stirrup leg due to shear and torsion. |
| $F_{sw,lim}$ | Load bearing resistance (per unit length) of the most utilized stirrup length due to shear and torsion (usually Fsw,lim=asw*fywd) |
| $F_b$ | Resultant force in longitudinal reinforcement due to bending and normal force |
| $\Delta F_{td,s}$ | Additional tensile force in longitudinal reinforcement due to shear calculated as VEd * cotθ |
| $\Delta F_{td,t}$ | Additional tensile force in longitudinal reinforcement due to torsion |
| $\Delta \varepsilon_s$ | Additional tensile strain in the bar/tendon due to shear |
| $\Delta \varepsilon_t$ | Additional tensile strain in the bar/tendon due to torsion |
| Extreme in bar | Number of the non-prestressed bar with the extreme value of the check |
| Bar | Number of reinforcement bar with the extreme value of the check |
| $y_i$ | y-coordinate of the css component (fibre/bar/tendon...) related to the centroid of css |
| $z_i$ | z-coordinate of the css component (fibre/bar/tendon...) related to the centroid of css |
| $\Delta \varepsilon_{st}$ | Additional tensile strain in the bar/tendon due to shear and torsion |
| $\varepsilon$ | Strain in the bar/tendon due to shear, torsion and bending |
| $\varepsilon_{lim}$ | Limit value of strain in the bar/tendon |
| $\Delta \sigma_{st}$ | Additional tensile stress in the bar/tendon due to shear and torsion |
| $\sigma$ | Stress in the bar/tendon due to shear, torsion and bending |
| $\sigma_{lim}$ | Limit value of the stress in the bar/tendon |

### 3.1.1.7 Stress limitation

**Stress limitation - short-term effect**

| Type of check | Component type | Index | $\sigma$ [MPa] | $\sigma_{lim}$ [MPa] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|
| 7.2(3)-Quasi | Concrete fibre | 1 | -7,6 | -13,5 | 56,5 | 100,0 | OK |

**Stress limitation - long-term effect**

| Type of check | Component type | Index | $\sigma$ [MPa] | $\sigma_{lim}$ [MPa] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|
| 7.2(5)-Char | Reinforcement bar | 5 | 234,8 | 400,0 | 58,7 | 100,0 | OK |

### Detailed check of concrete - short-term effect

| Type of check | Fibre | $y_i$ [mm] | $z_i$ [mm] | N [kN] | $M_y$ [kNm] | $M_z$ [kNm] | σ [MPa] | $σ_{lim}$ [MPa] | Value [%] | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.2(2)-Char | 1 | -225 | 252 | 0,0 | 120,0 | 0,0 | -9,2 | -18,0 | 50,9 | OK |
| 7.2(3)-Quasi | 1 | -225 | 252 | 0,0 | 100,0 | 0,0 | -7,6 | -13,5 | 56,5 | OK |

### Detailed check of reinforcement - short-term effect

| Type of check | Bar | $y_i$ [mm] | $z_i$ [mm] | N [kN] | $M_y$ [kNm] | $M_z$ [kNm] | σ [MPa] | $σ_{lim}$ [MPa] | Value [%] | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.2(5)-Char | 9 | 50 | -300 | 0,0 | 120,0 | 0,0 | 222,9 | 400,0 | 55,7 | OK |

### Detailed check of concrete - long-term effect

| Type of check | Fibre | $y_i$ [mm] | $z_i$ [mm] | N [kN] | $M_y$ [kNm] | $M_z$ [kNm] | σ [MPa] | $σ_{lim}$ [MPa] | Value [%] | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.2(2)-Char | 1 | -225 | 252 | 0,0 | 120,0 | 0,0 | -5,3 | -18,0 | 29,4 | OK |
| 7.2(3)-Quasi | 1 | -225 | 252 | 0,0 | 100,0 | 0,0 | -4,4 | -13,5 | 32,6 | OK |

### Detailed check of reinforcement - long-term effect

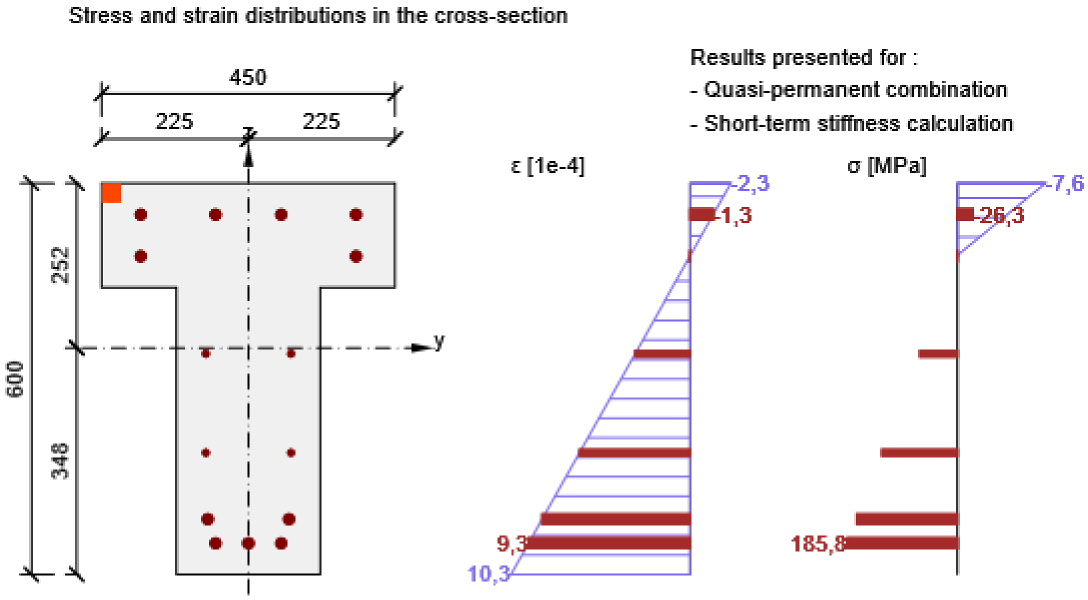
| Type of check | Bar | $y_i$ [mm] | $z_i$ [mm] | N [kN] | $M_y$ [kNm] | $M_z$ [kNm] | σ [MPa] | $σ_{lim}$ [MPa] | Value [%] | Check |
|---|---|---|---|---|---|---|---|---|---|---|
| 7.2(5)-Char | 5 | -50 | -300 | 0,0 | 120,0 | 0,0 | 234,8 | 400,0 | 58,7 | OK |

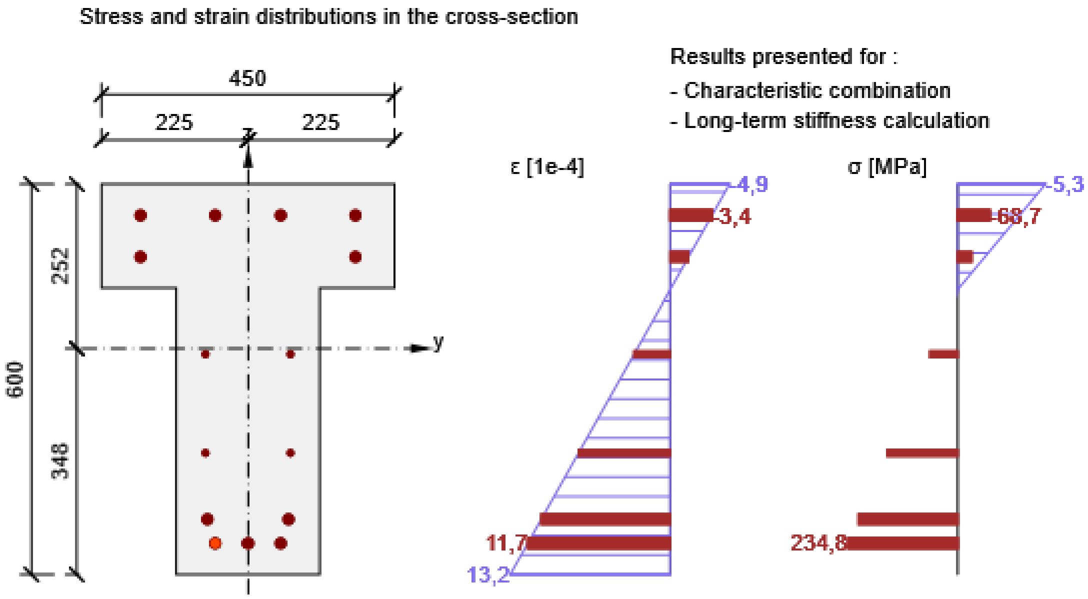
### Creep coefficient

| Way of assessment | $h_0$ [mm] | $A_c$ [mm$^2$] | u [mm] | t [d] | $t_0$ [d] | $t_s$ [d] | RH [%] | Use $γ_{lt}$ | $φ(t,t_0)$ [-] |
|---|---|---|---|---|---|---|---|---|---|
| Automatic | 161 | 168800 | 2100 | 18250,0 | 28,0 | 7,0 | 65,0 | No | 2,03 |

### Nonconformity

| | Nonconformities |
|---|---|
| ⚠ | Upper or lower design value of internal forces of one of SLS combinations caused to happen concrete stress higher than concrete tensile strength (section is cracked). Based on code and calculation settings it is assumed that the concrete resists no tension in SLS checks for all combinations of current extreme. The assumptions for SLS checks in other extremes of current section are not influenced. |
| ⚠ | The action of concrete in tension is excluded because the cracks appear, see clause 7.1 (2) |




## Explanation

| Symbol | Explanation |
|---|---|
| Type of check | The number of clause and the type of SLS combination used for the calculation of stress limitation |
| Component type | Specification of type of css component (concrete fibre/bar/tendon) with extreme value of the check |
| Index | Number of concrete fibre, reinforcement bar or tendon with the extreme value of the check |
| σ | Stress in css component (fibre/bar/tendon...) calculated for appropriate SLS combination |
| $\sigma_{lim}$ | Limit value of the stress in css component (fibre/bar/tendon...) calculated for appropriate SLS combination |
| Value | Utilization of the cross-section or its component (e.g. reinforcement bar) related to the limit value |
| Limit | Limit value of the exploitation of the cross-section |
| Check | Result of the check |
| Fibre | Number of concrete fibre with the extreme value of the check |

| | |
|---|---|
| $y_i$ | y-coordinate of the css component (fibre/bar/tendon...) related to the centroid of css |
| $z_i$ | z-coordinate of the css component (fibre/bar/tendon...) related to the centroid of css |
| N | Normal force for appropriate SLS combination |
| $M_y$ | Bending moment around y axis for appropriate SLS combination |
| $M_z$ | Bending moment around z axis for appropriate SLS combination |
| Bar | Number of reinforcement bar with the extreme value of the check |
| $h_0$ | The notional size = 2Ac /u, where Ac is the concrete cross-sectional area and u is the perimeter of that part which is exposed to drying |
| $A_c$ | The cross-sectional area of the concrete |
| u | The perimeter of that part which is exposed to drying |
| t | The age of concrete at the moment considered |
| $t_0$ | The age of concrete at loading |
| $t_s$ | The age of the concrete at the beginning of drying shrinkage (or swelling). Normally this is at the end of curing |
| RH | is the factor to account for relative humidity |
| Use $\gamma_{lt}$ | Use long-term delayed strain estimation factor acc. to Annex B, clause B.105 (103) |
| $\varphi(t,t_0)$ | Calculated value of creep coefficient |

### 3.1.1.8 Crack width

**Crack width - short-term effect**

| Combination | N [kN] | $M_y$ [kNm] | $M_z$ [kNm] | $w_k$ [mm] | $w_{lim}$ [mm] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|---|
| Quasi | 0,0 | 100,0 | 0,0 | 0,133 | 0,300 | 44,2 | 100,0 | OK |

**Crack width - long-term effect**

| Combination | N [kN] | $M_y$ [kNm] | $M_z$ [kNm] | $w_k$ [mm] | $w_{lim}$ [mm] | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|---|
| Quasi | 0,0 | 100,0 | 0,0 | 0,169 | 0,300 | 56,3 | 100,0 | OK |

**Intermediate results and coefficients for crack width calculation - short-term effect**

| x [mm] | $h_{c,eff}$ [mm] | d [mm] | $A_{c,eff}$ [mm$^2$] | $A_{s,eff}$ [mm$^2$] | $A_{p,eff}$ [mm$^2$] | $\rho_{p,eff}$ [-] |
|---|---|---|---|---|---|---|
| 110 | 155 | 538 | 34117 | 1005 | 0 | 0,03 |

| $k_t$ [-] | $\varepsilon_{sm}-\varepsilon_{cm}$ [1e-4] | $k_1$ [-] | $k_2$ [-] | $k_3$ [-] | $k_4$ [-] |
|---|---|---|---|---|---|
| 0,60 | 5,8 | 0,80 | 0,50 | 3,40 | 0,43 |

| c [mm] | $\varepsilon_1$ [1e-4] | $\varepsilon_2$ [1e-4] | $s_{r,max}$ [mm] | Φ [mm] | $\sigma_s$ [MPa] |
|---|---|---|---|---|---|
| 40 | 10,3 | -2,3 | 228 | 16 | 185,8 |

**Intermediate results and coefficients for crack width calculation - long-term effect**

| x [mm] | $h_{c,eff}$ [mm] | d [mm] | $A_{c,eff}$ [mm$^2$] | $A_{s,eff}$ [mm$^2$] | $A_{p,eff}$ [mm$^2$] | $\rho_{p,eff}$ [-] |
|---|---|---|---|---|---|---|
| 162 | 146 | 538 | 32114 | 1005 | 0 | 0,03 |

| $k_t$ [-] | $\varepsilon_{sm}-\varepsilon_{cm}$ [1e-4] | $k_1$ [-] | $k_2$ [-] | $k_3$ [-] | $k_4$ [-] |
|---|---|---|---|---|---|
| 0,40 | 7,6 | 0,80 | 0,50 | 3,40 | 0,43 |

| c [mm] | $\varepsilon_1$ [1e-4] | $\varepsilon_2$ [1e-4] | $s_{r,max}$ [mm] | Φ [mm] | $\sigma_s$ [MPa] |
|---|---|---|---|---|---|
| 40 | 11,0 | -4,1 | 223 | 16 | 195,7 |

Project: Amsterdam industrial
Project number: 20231090
Author: Dave the Engineer

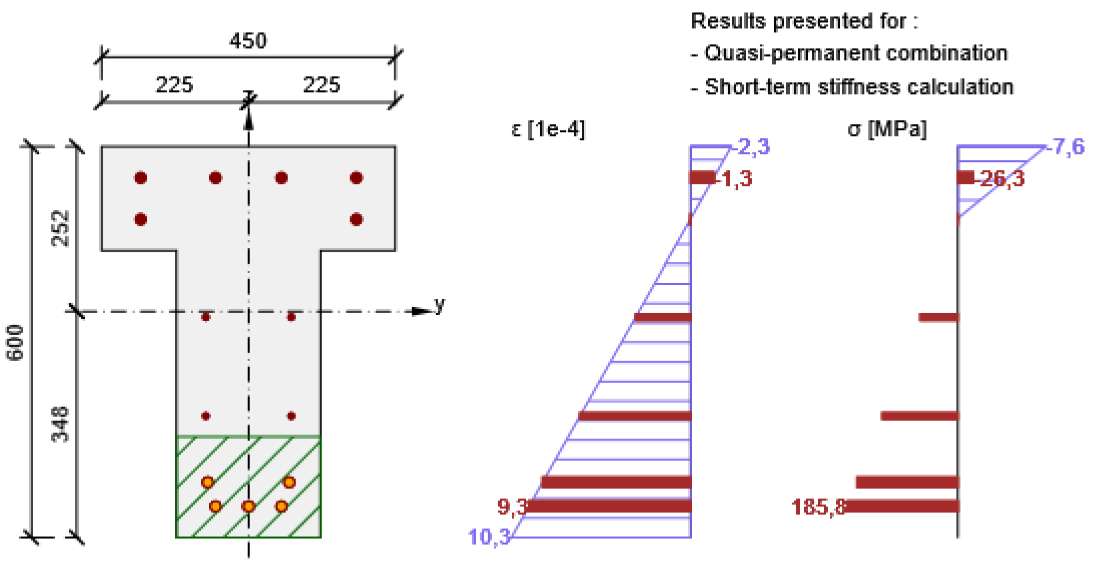
**Creep coefficient**

| Way of assessment | $h_0$ [mm] | $A_c$ [mm$^2$] | u [mm] | t [d] | $t_0$ [d] | $t_s$ [d] | RH [%] | Use $\gamma_{lt}$ | $\varphi(t,t_0)$ [-] |
|---|---|---|---|---|---|---|---|---|---|
| Automatic | 161 | 168800 | 2100 | 18250,0 | 28,0 | 7,0 | 65,0 | No | 2,03 |

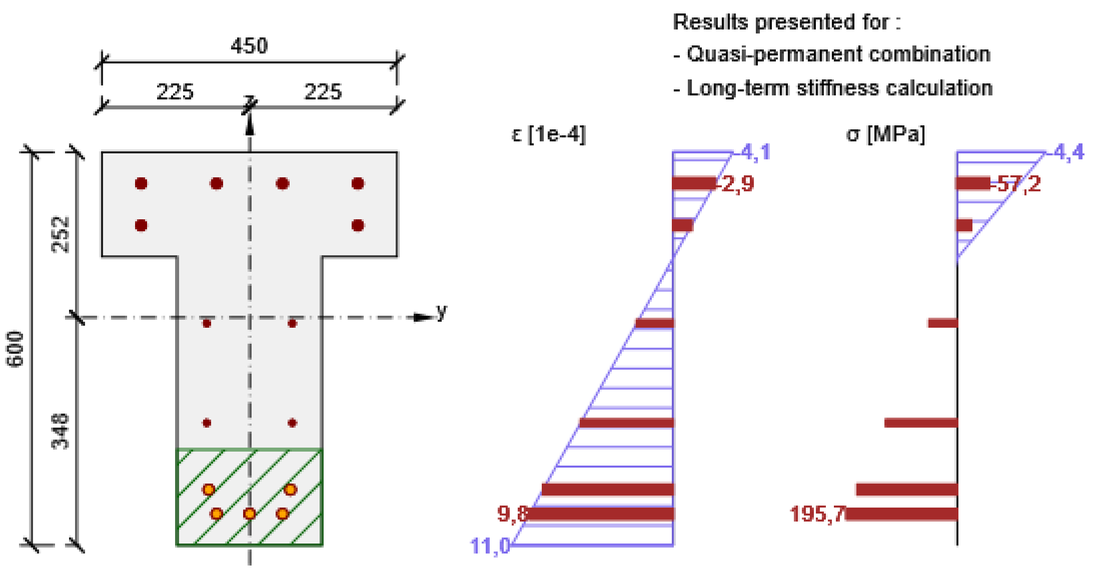
**Nonconformity**

| | Nonconformities |
|---|---|
| ⚠ | Upper or lower design value of internal forces of one of SLS combinations caused to happen concrete stress higher than concrete tensile strength (section is cracked). Based on code and calculation settings it is assumed that the concrete resists no tension in SLS checks for all combinations of current extreme. The assumptions for SLS checks in other extremes of current section are not influenced. |

Stress and strain distributions in the cross-section




Stress and strain distributions in the cross-section



## Explanation

| Symbol | Explanation |
|---|---|
| Combination | Combination used for calculation including rsup or rinf coefficient acc. to 5.10.9 |
| N | Normal force for quasi-permanent combination |
| $M_y$ | Bending moment around y axis for quasi-permanent combination |
| $M_z$ | Bending moment around z axis for quasi-permanent combination |
| $w_k$ | The crack width calculated according to 7.3.4 |
| $w_{lim}$ | Limit value of crack width according to table 7.1N |
| Value | Utilization of the cross-section or its component (e.g. reinforcement bar) related to the limit value |
| Limit | Limit value of the exploitation of the cross-section |
| Check | Result of the check |
| x | Depth of compression zone (position of neutral axis) |
| $h_{c,eff}$ | Depth of effective tension area of the concrete surrounding the reinforcement or prestressing tendons (7.3.2 (3)) |
| d | Effective depth of the cross-section |
| $A_{c,eff}$ | Effective area of the concrete in tension surrounding the reinforcement or prestressing tendons |
| $A_{s,eff}$ | Effective area of reinforcing steel within effective area of the concrete |
| $A_{p,eff}$ | Effective area of prestressing steel within effective area of the concrete |
| $\rho_{p,eff}$ | Ratio of the effective area of prestressing and reinforcing steel and effective area of the concrete in tension |
| $k_t$ | Factor dependent on the duration of the load (7.3.4 (2)) |
| $k_1$ | Coefficient which takes account of the bond properties of the bonded reinforcement (7.3.4 (3)) |
| $k_2$ | Coefficient which takes account of the distribution of strain |
| c | Thickness of concrete cover of main longitudinal reinforcement |
| $\varepsilon_1$ | Greater tensile strain at the boundaries of the section considered, assessed on the basis of a cracked section |
| $\varepsilon_2$ | Lesser tensile strain at the boundaries of the section considered, assessed on the basis of a cracked section |
| $s_{r,max}$ | Maximum final crack spacing |
| Φ | Diameter of bar or equivalent diameter of bar for more diameters of bars within effective tension area of the concrete |
| $\sigma_s$ | Maximum stress in the tension reinforcement assuming a cracked section |
| $h_0$ | The notional size = 2Ac /u, where Ac is the concrete cross-sectional area and u is the perimeter of that part which is exposed to drying |
| $A_c$ | The cross-sectional area of the concrete |
| u | The perimeter of that part which is exposed to drying |
| t | The age of concrete at the moment considered |
| $t_0$ | The age of concrete at loading |
| $t_s$ | The age of the concrete at the beginning of drying shrinkage (or swelling). Normally this is at the end of curing |
| RH | is the factor to account for relative humidity |
| Use $\gamma_{lt}$ | Use long-term delayed strain estimation factor acc. to Annex B, clause B.105 (103) |
| $\varphi(t,t_0)$ | Calculated value of creep coefficient |

## 3.1.1.9 Detailing rules

**Results presented for combination : Fundamental ULS**

| $N_{Ed}$ [kN] | $M_{Ed,y}$ [kNm] | $M_{Ed,z}$ [kNm] | $Ratio_{long}$ [%] | $Ratio_{shear}$ [%] | Governing [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|
| 0,0 | 145,0 | 20,0 | 91,7 | 100,0 | 100,0 | 100,0 | OK |

**Check of detailing provisions of longitudinal reinforcement**

| Type | $Value_{calc}$ | $Value_{lim}$ | Ratio [%] | Check |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Minimal reinf. ratio for longitudinal reinforcement (9.2.1.1 (1)) [%] | 1,01 | 0,15 | 15,0 | OK |
| Maximal reinf. ratio for longitudinal reinforcement (9.2.1.1(3)) [%] | 1,50 | 4,00 | 37,4 | OK |
| Minimal clear distance of longitudinal reinforcement (8.2 (2)) [mm] | 23 | 21 | 91,7 | OK |
| Maximal axial distance of longitudinal reinforcement (9.2.3 (4)) [mm] | 214 | 350 | 61,0 | OK |

**Check detailing provisions of shear reinforcement**

| Type | $Value_{calc}$ | $Value_{lim}$ | Ratio [%] | Check |
|---|---|---|---|---|
| Minimal reinf. ratio for shear reinforcement (9.2.2 (5)) [%] | 0,20 | 0,09 | 43,0 | OK |
| Maximal distance of stirrups (9.2.2 (6)) [mm] | 350 | 383 | 91,3 | OK |
| Maximal transversal distance of branches of stirrups (9.2.2 (8)) [mm] | 150 | 383 | 39,1 | OK |
| Minimum mandrel diameter of stirrup (8.3 (2)) [-] | 4,00 | 4,00 | 100,0 | OK |

**Input values and intermediate results for detailing**

| $b_w$ [mm] | d [mm] | $A_c$ [mm$^2$] | $b_t$ * d [mm$^2$] | $f_{yk}$ [MPa] | $f_{yd}$ [MPa] | $f_{ck}$ [MPa] | $f_{ctm}$ [MPa] | $f_{cd}$ [MPa] |
|---|---|---|---|---|---|---|---|---|
| 220 | 511 | 168800 | 151116 | 500,0 | 434,8 | 30,0 | 2,9 | 20,0 |

**Nonconformity**

| |
|---|
| No nonconformities |

## Explanation

| Symbol | Explanation |
|---|---|
| $N_{Ed}$ | Design value of the applied axial force (with effect of prestressing) |
| $M_{Ed,y}$ | Design value of the applied bending moment around y axis (with effect of prestressing) |
| $M_{Ed,z}$ | Design value of the applied bending moment around z axis (with effect of prestressing) |
| $Ratio_{long}$ | Critical ratio of calculated to limit value, which expresses detailing rules for longitudinal reinforcement |
| $Ratio_{shear}$ | Critical ratio of calculated to limit value, which expresses detailing rules for shear reinforcement |
| Governing | Governing ratio of calculated to limit value, which expresses detailing rules |
| Limit | Limit ratio representing detailing rules |
| Check | Result of the check |
| Type | Type of checked detailing provisions |
| $Value_{calc}$ | Calculated or input quantity, which expresses given detailing rule |
| $Value_{lim}$ | Limit value of the quantity, which expresses given detailing rule |
| Ratio | Ratio of calculated or input quantity, which expresses given detailing rule, to its limit value |

## 3.1.1.10 Response N-M-M

**Results presented for combination : Fundamental ULS**

| $N_{Ed,tot}$ [kN] | $M_{Ed,ytot}$ [kNm] | $M_{Ed,ztot}$ [kNm] | Concrete fibre | Extreme in bar | Value [%] | Limit [%] | Check |
|---|---|---|---|---|---|---|---|
| 0,0 | 145,0 | 20,0 | 8 | 5 | 61,7 | 100,0 | OK |

**Plane of strain**

| x [mm] | d [mm] | z [mm] | $\varepsilon_x$ [1e-4] | $\varphi_z$ [1e-4] | $\varphi_y$ [1e-4] |
|---|---|---|---|---|---|
| 186 | 552 | 460 | 3,9 | -8,7 | -33,4 |

**Forces in components of cross-section**

| Component of css | N [kN] | $M_y$ [kNm] | $M_z$ [kNm] | A [mm$^2$] | $y_i$ [mm] | $z_i$ [mm] |
|---|---|---|---|---|---|---|
| Concrete | -260,9 | 52,6 | 15,3 | 58273 | 59 | 202 |
| Reinforcement in tension | 315,7 | 81,7 | 1,1 | 1521 | -4 | -259 |
| Reinforcement in compression | -54,9 | 10,6 | 3,5 | 1005 | 64 | 194 |
| Total | 0,0 | 145,0 | 20,0 | | | |

**Detailed check of concrete**

| Fibre | $y_i$ [mm] | $z_i$ [mm] | ε [1e-4] | $\varepsilon_{lim}$ [1e-4] | σ [MPa] | $\sigma_{lim}$ [MPa] | Value [%] | Check |
|---|---|---|---|---|---|---|---|---|
| 8 | 225 | 252 | -6,4 | -35,0 | -10,8 | -20,0 | 53,9 | OK |

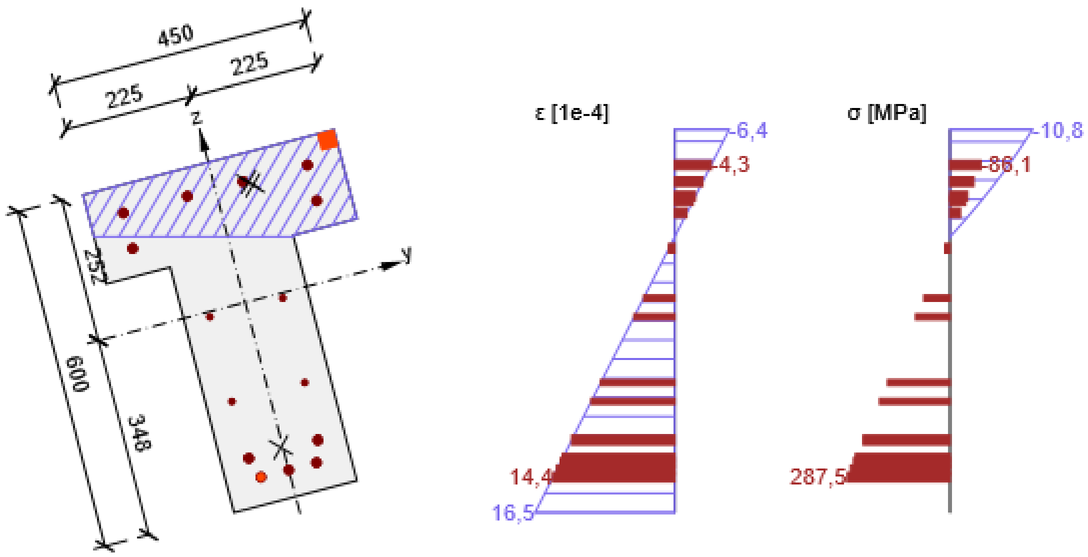
**Detailed check of reinforcement**

| Bar | $y_i$ [mm] | $z_i$ [mm] | ε [1e-4] | $\varepsilon_{lim}$ [1e-4] | σ [MPa] | $\sigma_{lim}$ [MPa] | Value [%] | Check |
|---|---|---|---|---|---|---|---|---|
| 5 | -50 | -300 | 14,4 | 450,0 | 287,5 | 465,9 | 61,7 | OK |

**Nonconformity**

No nonconformities

Stress and strain distributions in the cross-section




## Explanation

| Symbol | Explanation |
|---|---|
| $N_{Ed,tot}$ | Design value of the applied axial force (with effect of prestressing) |
| $M_{Ed,ytot}$ | Design value of the applied bending moment around y axis (with effect of prestressing) |
| $M_{Ed,ztot}$ | Design value of the applied bending moment around z axis (with effect of prestressing) |
| Concrete fibre | Number of the fibre with the extreme value of the check |
| Extreme in bar | Number of the non-prestressed bar with the extreme value of the check |
| Value | Utilization of the cross-section or its component (e.g. reinforcement bar) related to the limit value |
| Limit | Limit value of the exploitation of the cross-section |
| Check | Result of the check |
| x | Depth of compression zone (position of neutral axis) |

| | |
|---|---|
| d | Effective depth of the cross-section |
| z | The inner lever arm |
| $\varepsilon_x$ | Axial strain |
| $\varphi_z$ | Tangent of the angle between 'z' axis and its perpendicular projection into plane of strain (around 'y' axis) |
| $\varphi_y$ | Tangent of the angle between 'y' axis and its perpendicular projection into plane of strain (around 'z' axis) |
| Component of css | Type of component of the css |
| N | The value of normal force resisted by component of the css |
| $M_y$ | The value of bending moment around 'y' axis resisted by component of css |
| $M_z$ | The value of bending moment around 'z' axis resisted by component of css |
| A | Area of css component (fibre/bar/tendon...) |
| $y_i$ | y-coordinate of the css component (fibre/bar/tendon...) related to the centroid of css |
| $z_i$ | z-coordinate of the css component (fibre/bar/tendon...) related to the centroid of css |
| Fibre | Number of concrete fibre with the extreme value of the check |
| $\varepsilon$ | Strain in current css component (fibre/bar/tendon...) calculated for ULS |
| $\varepsilon_{lim}$ | Limit value of strain in css component (fibre/bar/tendon...) |
| $\sigma$ | Stress in css component (fibre/bar/tendon...) calculated for appropriate SLS combination |
| $\sigma_{lim}$ | Limit value of the stress in css component (fibre/bar/tendon...) calculated for appropriate SLS combination |
| Bar | Number of reinforcement bar with the extreme value of the check |

# 4 List of design members

## Design member M 1

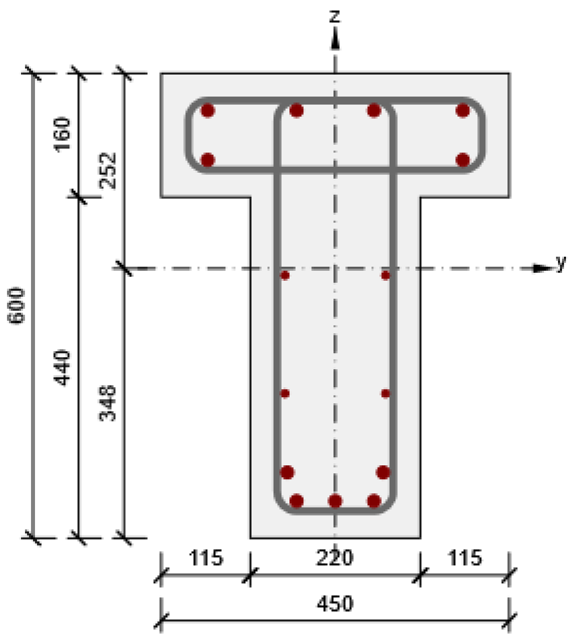
| | |
|---|---|
| Member type | Beam |
| Exposure class | XC3, XD1 |
| Relative humidity | 65,0 % |
| $\Phi_{inf}$ | Calculated |
| Structural member importance | Major |

### Flexural slenderness data

| Clear distance between faces of the supports (5.3.2.2 (1)) m | Width of supporting element (5.3.2.2 (1)) | | Support condition | |
|---|---|---|---|---|
| | Left mm | Right mm | Left | Right |
| 1,00 | 400 | 400 | Non-continuous member | Non-continuous member |

# 5 List of reinforced sections

## Reinforced section R 1




### Cross-section components

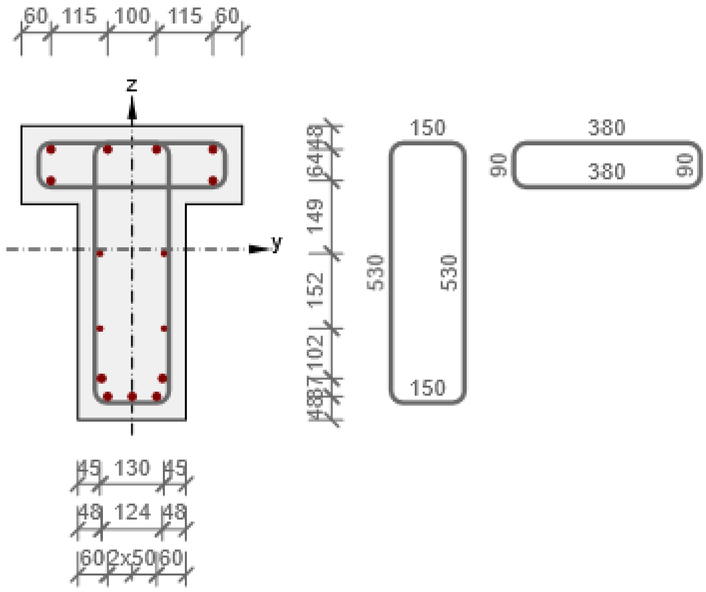
| |
|---|
| T-shaped cross-section (450 / 600 / 220 / 160mm), Material: C30/37 |

### Cross-section characteristics

| A [$mm^2$] | $S_y$ [$mm^3$] | $S_z$ [$mm^3$] | $I_y$ [$mm^4$] | $I_z$ [$mm^4$] | $C_{gy}$ [mm] | $C_{gz}$ [mm] | $i_y$ [mm] | $i_z$ [mm] |
|---|---|---|---|---|---|---|---|---|
| 168800 | 0 | 0 | 5431325624 | 1605426667 | 0 | 0 | 179 | 98 |

### Concrete cover related to cross-section edges

| | |
|---|---|
| 1 | 30 mm |
| 2 | 30 mm |
| 3 | 30 mm |
| 4 | 30 mm |
| 5 | 30 mm |
| 6 | 30 mm |
| 7 | 30 mm |
| 8 | 30 mm |




| Longitudinal reinforcement [kg/m] | Shear reinforcement [kg/m] | Total mass [kg/m] | Reinforcement / m3 concrete [kg/m$^3$] |
|---|---|---|---|
| 20 | 4 | 24 | 141 |

**Longitudinal reinforcement**

| Bar | Ø [mm] | Material | Y [mm] | Z [mm] |
|---|---|---|---|---|
| 1 | 16 | B 500B | 165 | 204 |
| 2 | 16 | B 500B | 50 | 204 |
| 3 | 16 | B 500B | -50 | 204 |
| 4 | 16 | B 500B | -165 | 204 |
| 5 | 16 | B 500B | -50 | -300 |
| 6 | 16 | B 500B | 0 | -300 |
| 9 | 16 | B 500B | 50 | -300 |
| 10 | 16 | B 500B | -62 | -263 |
| 11 | 16 | B 500B | 62 | -263 |
| 7 | 16 | B 500B | -165 | 140 |
| 8 | 16 | B 500B | 165 | 140 |
| 12 | 10 | B 500B | -65 | -9 |
| 13 | 10 | B 500B | -65 | -161 |
| 14 | 10 | B 500B | 65 | -161 |
| 15 | 10 | B 500B | 65 | -9 |

**Stirrups**

| Stirrup | Ø [mm] | Material | Distance [mm] | Closed | Shear check | Torsion check | Diameter of mandrel |
|---|---|---|---|---|---|---|---|
| 1 | 10 | B 500B | 350 | Yes | Yes | Yes | 4,00 |
| 2 | 10 | B 500B | 350 | Yes | Yes | No | 4,00 |

| Stirrup | Vertex | Y [mm] | Z [mm] |
|---|---|---|---|
| 1 | 1 | -75 | 217 |
| 1 | 2 | -75 | -313 |
| 1 | 3 | 75 | -313 |
| 1 | 4 | 75 | 217 |
| 2 | 1 | -190 | 217 |
| 2 | 2 | -190 | 127 |

| | | | |
|---|---|---|---|
| 2 | 3 | 190 | 127 |
| 2 | 4 | 190 | 217 |

# 6 List of used materials

### Concrete

| Name | $f_{ck}$ [MPa] | $f_{cm}$ [MPa] | $f_{ctm}$ [MPa] | $E_{cm}$ [MPa] | v [-] | Unit mass [kg/m$^3$] |
|---|---|---|---|---|---|---|
| C30/37 | 30,0 | 38,0 | 2,9 | 32836,6 | 0,20 | 2500 |
| | $\varepsilon_{c2}$ = 20,0 1e-4,$\varepsilon_{cu2}$ = 35,0 1e-4,$\varepsilon_{c3}$ = 17,5 1e-4,$\varepsilon_{cu3}$ = 35,0 1e-4, Exponent - n: 2,00,Aggregate size = 16 mm,Cement class: R (s = 0,20),Diagram type: Parabolic | | | | | |

## Explanation

| Symbol | Explanation |
|---|---|
| $f_{ck}$ | Characteristic compressive cylinder strength of concrete at 28 days |
| $f_{cm}$ | Mean value of concrete cylinder compressive strength |
| $f_{ctm}$ | Mean value of axial tensile strength of concrete |
| $E_{cm}$ | Secant modulus of elasticity of concrete |
| $\varepsilon_c$ | Compressive strain in the concrete at the peak stress fc |
| $\varepsilon_{cu}$ | Ultimate compressive strain in the concrete |

### Reinforcement Steel

| Name | $f_{yk}$ [MPa] | $f_{tk}$ [MPa] | E [MPa] | v [-] | Unit mass [kg/m$^3$] |
|---|---|---|---|---|---|
| B 500B | 500,0 | 540,0 | 200000,0 | 0,20 | 7850 |
| | $f_{tk}/f_{yk}$ = 1,08,$\varepsilon_{uk}$ = 500,0 1e-4,Type: Bars,Bar surface: Ribbed,Class: B, Fabrication: Hot rolled,Diagram type: Bilinear with an inclined top branch | | | | |

## Explanation

| Symbol | Explanation |
|---|---|
| $f_{yk}$ | Characteristic yield strength of reinforcement |
| $f_{tk}$ | Characteristic tensile strength of reinforcement |
| E | Modulus of elasticity of reinforcement steel |
| $\varepsilon_{uk}$ | Characteristic strain of reinforcement or prestressing steel at maximum load |