

**ВХОДНИ ДАННИ / ADDITIONAL INFORMATION****Нормативни натоварвания от вятър/Wind load**

Съгласно наредба №3 за основни положения за проектиране на конструкции на строежите и за въздействията върху тях от 2004г, раздел VI, чл. 94

Acc. to Regulation No3 for Basic conditions for building constructions design and interferences, published 2004, section VI, article. 94

Нормативното натоварване от вятър при скорост на вятъра:

Wind load corresponding to wind velocity:

$$v := 35 \cdot \frac{\text{m}}{\text{s}}$$

$$W_m := \frac{v^2}{1600} \cdot \frac{1000 \cdot \text{kg}}{\text{m}^3} \quad W_m = 0.77 \cdot \frac{\text{kN}}{\text{m}^2}$$

**Определяне на сеизмичната сила / Earthquake load**

Съгласно "Наредба №РД-02-20-2 за проектиране на сгради и съоръжения в земетръсни райони" от 2012

Acc.to "Regulation №РД-02-20-2 for building design in seismic areas", published 2012

изчислителната сеизмична сила е/ the calculated earthquake load is:  $E_{ik} = C \cdot R \cdot K_C \cdot \beta_i \cdot \eta_{ik} \cdot Q_k = a_h \cdot Q_k = a_v \cdot Q_k$ ,

където/ where:

$C := 1.5$  коефициент на значимост на сградите и съоръженията за електро и термични централи от общонационално значение с мощност над 100MW;  
coefficient for building and equipment priority of electrical and thermal power plants, rated over 100MW

$R := 0.33$  коефициент на реагиране на конструкцията;

$K_C := 0.27$  сеизмичен коефициент/ seismic coefficient

$\beta_i := 2.5$  динамичен коефициент за трета група почви;

$\eta_{ik} := 1$  коефициент за разпределение на изчислителното сеизмично натоварване;

$$a_h := C \cdot R \cdot K_C \cdot \beta_i \cdot \eta_{ik}$$

$$a_v := a_h$$

$$a_h = 0.33$$

$$a_v = 0.33$$

Модул на еластичност на профилна стомана ВСт3/ / Elastic modulus steel ВСт3

$$E_{St3} := 210000 \cdot \text{MPa}$$

Модул на еластичност на бетон клас В20/ Elastic modulus concrete class В20

$$E_b := 27500 \cdot \text{MPa}$$

Модул на еластичност на стомана А III/ Elastic modulus steel AIII

$$E_s := 200000 \cdot \text{MPa}$$

**КОЕФИЦИЕНТИ ЗА НАТОВАРВАНЕ/ PARTIAL SAFETY FACTORS**

$\gamma_M := 1.10$  коефициент за натоварване за стомана/  
partial safety factor for steel

$\gamma_C := 1.20$  коефициент за натоварване за бетон/  
partial safety factor for concrete

**Максимални напрежения/ Maximum stresses:**

**S235 JRG2 ( DIN 18800):**

**C380/230 (ВСт3сп5) (БДС2592-71)**

$$f_{Y24} := 240 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$f_{Sta24} := \frac{f_{Y24}}{\gamma_M}$$

$$f_{Sta24} = 218.18 \cdot \frac{\text{N}}{\text{mm}^{2.00}}$$

**S355 JRG3 ( DIN 18800):**

**C500/360 (10Г2СФ) (БДС4880-74)**

$$f_{Y36} := 360 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$f_{Sta36} := \frac{f_{Y36}}{\gamma_M}$$

$$f_{Sta36} = 327.27 \cdot \frac{\text{N}}{\text{mm}^{2.00}}$$

**Максимални напрежения на смачкване/ Maximum stresses:**

**S235JRG2:**

M12

$$e_{12} := 25 \text{ mm}$$

$$d_{12} := 14 \text{ mm}$$

$$f_{ba2412} := \frac{f_{Y24}}{\gamma_M} \left( 1.1 \frac{e_{12}}{d_{12}} - 0.3 \right)$$

$$f_{ba2412} = 363.12 \cdot \frac{\text{N}}{\text{mm}^2}$$

**( DIN 18800):**

**C380/230**

**(ВСт3сп5)**

**(БДС2592-71)**

M16

$$e_{16} := 35 \text{ mm}$$

$$d_{16} := 18 \text{ mm}$$

$$f_{ba2416} := \frac{f_{Y24}}{\gamma_M} \left( 1.1 \frac{e_{16}}{d_{16}} - 0.3 \right)$$

$$f_{ba2416} = 401.21 \cdot \frac{\text{N}}{\text{mm}^{2.00}}$$

|                               |                         |                         |                                                                                         |                                                        |
|-------------------------------|-------------------------|-------------------------|-----------------------------------------------------------------------------------------|--------------------------------------------------------|
| M20                           | $e_{20} := 40\text{mm}$ | $d_{20} := 22\text{mm}$ | $f_{ba2420} := \frac{f_{Y24}}{\gamma M} \left( 1.1 \frac{e_{20}}{d_{20}} - 0.3 \right)$ | $f_{ba2420} = 370.91 \cdot \frac{N}{\text{mm}^{2.00}}$ |
| M24                           | $e_{24} := 50\text{mm}$ | $d_{24} := 27\text{mm}$ | $f_{ba2424} := \frac{f_{Y24}}{\gamma M} \left( 1.1 \frac{e_{24}}{d_{24}} - 0.3 \right)$ | $f_{ba2424} = 378.99 \cdot \frac{N}{\text{mm}^{2.00}}$ |
| <b>S355 JRG3 (DIN 18800):</b> | M12                     |                         | $f_{ba3612} := \frac{f_{Y36}}{\gamma M} \left( 1.1 \frac{e_{12}}{d_{12}} - 0.3 \right)$ | $f_{ba3612} = 544.68 \cdot \frac{N}{\text{mm}^{2.00}}$ |
| <b>C500/360 (10Г2СФ)</b>      | M16                     |                         | $f_{ba3616} := \frac{f_{Y36}}{\gamma M} \left( 1.1 \frac{e_{16}}{d_{16}} - 0.3 \right)$ | $f_{ba3616} = 601.82 \cdot \frac{N}{\text{mm}^{2.00}}$ |
| <b>(БДС4880-74)</b>           | M20                     |                         | $f_{ba3620} := \frac{f_{Y36}}{\gamma M} \left( 1.1 \frac{e_{20}}{d_{20}} - 0.3 \right)$ | $f_{ba3620} = 556.36 \cdot \frac{N}{\text{mm}^{2.00}}$ |
|                               | M24                     |                         | $f_{ba3624} := \frac{f_{Y36}}{\gamma M} \left( 1.1 \frac{e_{24}}{d_{24}} - 0.3 \right)$ | $f_{ba3624} = 568.48 \cdot \frac{N}{\text{mm}^{2.00}}$ |

**За HV гайки 10.9 с 0.5 Fv начално усилие/ For HV-screws 10.9 with 0.5 Fv initial stressing:**

|                                        |     |                                                                                              |                                                        |
|----------------------------------------|-----|----------------------------------------------------------------------------------------------|--------------------------------------------------------|
| <b>S235JRG2:( DIN 18800):</b>          | M12 | $f_{ba24Fv} := 1.35 \frac{f_{Y24}}{\gamma M} \left( 1.1 \frac{e_{12}}{d_{12}} - 0.3 \right)$ | $f_{ba24Fv} = 490.21 \cdot \frac{N}{\text{mm}^{2.00}}$ |
| <b>C380/230 (ВСтЗсп5) (БДС2592-71)</b> |     |                                                                                              |                                                        |
| <b>S355 JRG3 (DIN 18800):</b>          | M12 | $f_{ba36Fv} := 1.35 \frac{f_{Y36}}{\gamma M} \left( 1.1 \frac{e_{12}}{d_{12}} - 0.3 \right)$ | $f_{ba36Fv} = 735.31 \cdot \frac{N}{\text{mm}^{2.00}}$ |
| <b>C500/360 (10Г2СФ) (БДС4880-74)</b>  |     |                                                                                              |                                                        |

**Максимално усилие на срязване/ Maximum shearing stress:**максимална якост на скъсване/  
tensile breaking stress: $f_K$ 

|                          |                                           |                                                                |                                                       |
|--------------------------|-------------------------------------------|----------------------------------------------------------------|-------------------------------------------------------|
| $\alpha_{a4.6} := 0.60$  | $f_{K4.6} := 400 \frac{N}{\text{mm}^2}$   | $f_{a4.6} := \frac{f_{K4.6} \cdot \alpha_{a4.6}}{\gamma M}$    | $f_{a4.6} = 218.18 \cdot \frac{N}{\text{mm}^{2.00}}$  |
| $\alpha_{a5.6} := 0.60$  | $f_{K5.6} := 500 \frac{N}{\text{mm}^2}$   | $f_{a5.6} := \frac{f_{K5.6} \cdot \alpha_{a5.6}}{\gamma M}$    | $f_{a5.6} = 272.73 \cdot \frac{N}{\text{mm}^{2.00}}$  |
| $\alpha_{a8.8} := 0.60$  | $f_{K8.8} := 800 \frac{N}{\text{mm}^2}$   | $f_{a8.8} := \frac{f_{K8.8} \cdot \alpha_{a8.8}}{\gamma M}$    | $f_{a8.8} = 436.36 \cdot \frac{N}{\text{mm}^{2.00}}$  |
| $\alpha_{a10.9} := 0.55$ | $f_{K10.9} := 1000 \frac{N}{\text{mm}^2}$ | $f_{a10.9} := \frac{f_{K10.9} \cdot \alpha_{a10.9}}{\gamma M}$ | $f_{a10.9} = 500.00 \cdot \frac{N}{\text{mm}^{2.00}}$ |

**Максимални усилия на опън/ Maximum tensile stress:**

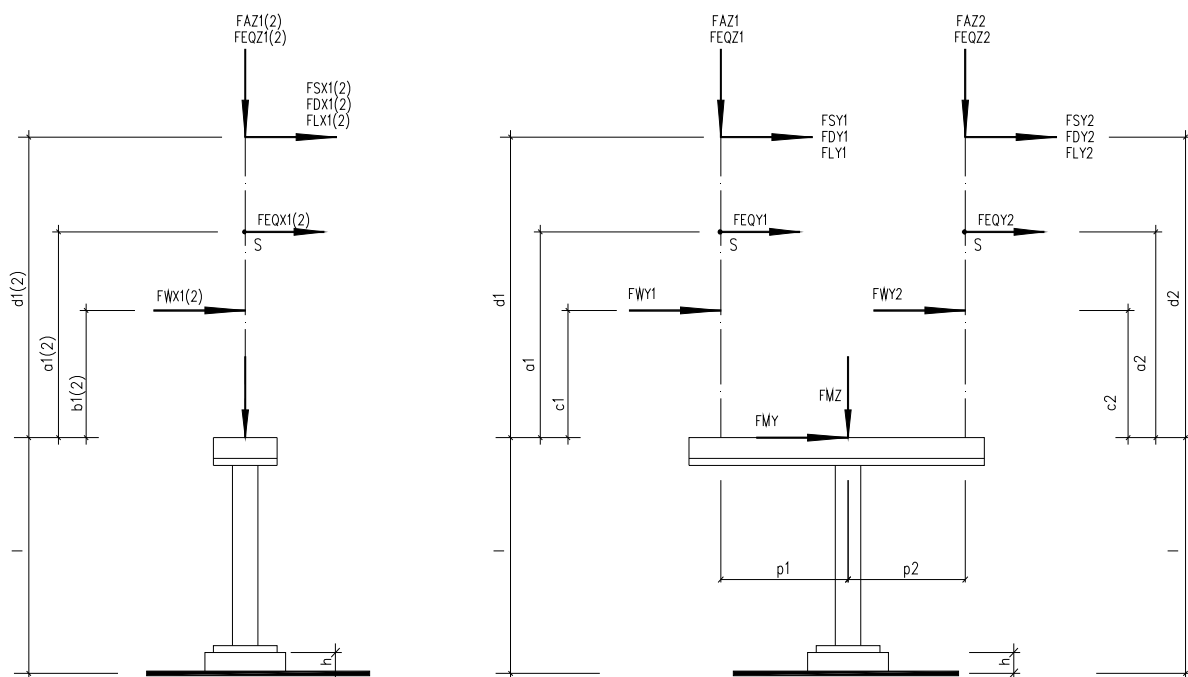
|                                          |                                                |                                                        |
|------------------------------------------|------------------------------------------------|--------------------------------------------------------|
| $f_{Y4.6} := 240 \frac{N}{\text{mm}^2}$  | $f_{ta4.6} := 0.9 \frac{f_{Y4.6}}{\gamma M}$   | $f_{ta4.6} = 196.36 \cdot \frac{N}{\text{mm}^{2.00}}$  |
| $f_{Y5.6} := 300 \frac{N}{\text{mm}^2}$  | $f_{ta5.6} := 0.9 \frac{f_{Y5.6}}{\gamma M}$   | $f_{ta5.6} = 245.45 \cdot \frac{N}{\text{mm}^{2.00}}$  |
| $f_{Y8.8} := 640 \frac{N}{\text{mm}^2}$  | $f_{ta8.8} := 0.9 \frac{f_{Y8.8}}{\gamma M}$   | $f_{ta8.8} = 523.64 \cdot \frac{N}{\text{mm}^{2.00}}$  |
| $f_{Y10.9} := 900 \frac{N}{\text{mm}^2}$ | $f_{ta10.9} := 0.9 \frac{f_{Y10.9}}{\gamma M}$ | $f_{ta10.9} = 736.36 \cdot \frac{N}{\text{mm}^{2.00}}$ |

**ОПРЕДЕЛЯНЕ НА УСИЛИЯТА НА ГОРЕН РЪБ ФУНДАМЕНТ.**

СХЕМА НА НАТОВАРВАНИЯТА

**CACULATION OF UPPER EDGE FOUNDATION STRESS .**

LOAD DIAGRAM

**Дименсии / Dimensions**

$$\begin{aligned}
 l &:= 2250\text{mm} & h &:= 150\text{mm} & a_1 &:= 1200\text{mm} & b_1 &:= 1200\text{mm} & a_2 &:= 1125\text{mm} & b_2 &:= 1125\text{mm} & p_1 &:= 900\text{mm} \\
 n &:= l - h & n &= 2100.00\text{mm} & c_1 &:= 1200\text{mm} & d_1 &:= 2395\text{mm} & c_2 &:= 1125\text{mm} & d_2 &:= 2250\text{mm} & p_2 &:= 900\text{mm}
 \end{aligned}$$

диаметър на съоръжението/ equipment diameter:

$$d_{k1} := 500\text{mm} \quad d_{k2} := 550\text{mm}$$

**Товари от съоръжението/ Equipment loads:****ОСНОВНИ/ NORMAL:**Собствено тегло на съоръжението/  
Dead load of equipment:

$$F_{AZ1n} := 4.0\text{kN} \quad F_{AZ1c} := 1.2F_{AZ1n} \quad F_{AZ1c} = 4.80\text{kN}$$

$$F_{AZ2n} := 3.45\text{kN} \quad F_{AZ2c} := 1.2F_{AZ2n} \quad F_{AZ2c} = 4.14\text{kN}$$

Вятър върху съоръжение/ Windload on equipment:

 $k_z$  -коэффициент за отчитане на вятъра по височина/  
windload height coefficientпо табл.9 на Наредба 3/  
acc.to Regulation No3,tab.9

$$k_z := 0.75 \quad \gamma_{fw} := 1.4$$

по схема 12а табл.8.2 на Наредба 3  
acc.to diagram 12a,tab.8.2 of  
Regulation No3

$$R_{e1} := 0.88 \cdot d_{k1} \cdot \sqrt{W_m \cdot k_z \cdot \gamma_{fw}} \cdot 10^5 \quad R_{e1} = 1.25 \times 10^6 \frac{\text{m}^{0.50} \cdot \text{kg}^{0.50}}{\text{s}}$$

по схема 13 (т 1) табл.8.2 на Наредба 3 за/  
acc.to Regulation No3,tab.8.2

$$\lambda_e := \frac{d_1}{d_{k1}} \quad \lambda_e = 4.79$$

$$k := 0.60$$

 $\Delta := 0.001$  - за стоманени конструкции/  
for steel constructions:

$$\frac{\Delta}{d_{k1}} = 2.00 \times 10^{-3} \frac{1}{\text{m}}$$

 $c_w$  - аеродинамичен коефициент/  
streamline coefficient

$$c_{\chi 001} := 0.95 \quad \text{по схема 14 табл.8.2 на Наредба 3/} \\ \text{acc.to Regulation} \\ \text{No3,diaqram14,tab.8.2}$$

$$c_{w1} := k \cdot c_{\chi 001} \quad c_{w1} = 0.57$$

нормативна стойност на статичната компонента на натоварване от вятър/  
static winload:

$$W_{n1} := W_m \cdot k_z \cdot c_{w1} \quad W_{n1} = 0.33 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$F_{WX1n} := d_{k1} \cdot W_{n1} \cdot 2b_1 \quad F_{WX1n} = 0.39 \cdot \text{kN} \quad F_{WX1c} := F_{WX1n} \cdot \gamma_{fw} \quad F_{WX1c} = 0.55 \cdot \text{kN}$$

$$F_{WY1n} := d_{k1} \cdot W_{n1} \cdot 2c_1 \quad F_{WY1n} = 0.39 \cdot \text{kN} \quad F_{WY1c} := F_{WY1n} \cdot \gamma_{fw} \quad F_{WY1c} = 0.55 \cdot \text{kN}$$

по схема 12а табл.8.2 на Наредба 3  
acc.to diagram 12a, tab.8.2 of  
Regulation No3

$$R_{e2} := 0.88 \cdot d_{k2} \cdot \sqrt{W_m \cdot k_z \cdot \gamma_{fw}} \cdot 10^5 \quad R_{e2} = 1.37 \times 10^6 \frac{\text{m}^{0.50} \cdot \text{kg}^{0.50}}{\text{s}}$$

по схема 13 (т 1) табл.8.2 на Наредба 3 за/  
acc.to Regulation No3, tab.8.2

$$\lambda_{e2} := \frac{d_2}{d_{k2}} \quad \lambda_{e2} = 4.09$$

$$k_2 := 0.60$$

$$\Delta := 0.001 \quad \text{- за стоманени конструкции/} \\ \text{for steel constructions:}$$

$$\frac{\Delta}{d_{k2}} = 1.82 \times 10^{-3} \frac{1}{\text{m}}$$

$c_w$  - аеродинамичен коефициент/  
streamline coefficient

$c_{\chi_{002}} := 0.97$  по схема 14 табл.8.2 на Наредба 3/  
acc.to Regulation  
No3, diagram 14, tab.8.2

$$c_{w2} := k \cdot c_{\chi_{002}} \quad c_{w2} = 0.58$$

нормативна стойност на статичната компонента на натоварване от вятър/  
static winload:

$$W_{n2} := W_m \cdot k_z \cdot c_{w2} \quad W_{n2} = 0.33 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$F_{WX2n} := d_{k1} \cdot W_{n2} \cdot 2b_1 \quad F_{WX2n} = 0.40 \cdot \text{kN} \quad F_{WX2c} := F_{WX2n} \cdot \gamma_{fw} \quad F_{WX2c} = 0.56 \cdot \text{kN}$$

$$F_{WY2n} := d_{k1} \cdot W_{n2} \cdot 2c_1 \quad F_{WY2n} = 0.40 \cdot \text{kN} \quad F_{WY2c} := F_{WY2n} \cdot \gamma_{fw} \quad F_{WY2c} = 0.56 \cdot \text{kN}$$

Опъвателна сила на проводник:  
Static conductor tension

$$F_{SX1n} := 0.00 \cdot \text{kN} \quad F_{SX1c} := 1.3 F_{SX1n} \quad F_{SX1c} = 0.00 \cdot \text{kN}$$

$$F_{SY1n} := 0.15 \cdot \text{kN} \quad F_{SY1c} := 1.3 F_{SY1n} \quad F_{SY1c} = 0.20 \cdot \text{kN}$$

$$F_{SX2n} := 0.00 \cdot \text{kN} \quad F_{SX2c} := 1.3 F_{SX2n} \quad F_{SX2c} = 0.00 \cdot \text{kN}$$

$$F_{SY2n} := 0.150 \cdot \text{kN} \quad F_{SY2c} := 1.3 F_{SY2n} \quad F_{SY2c} = 0.20 \cdot \text{kN}$$

Вятър върху проводник/  
Windload on conductor:

$$F_{LX1n} := 0.10 \cdot \text{kN} \quad F_{LX1c} := \gamma_{fw} F_{LX1n} \quad F_{LX1c} = 0.14 \cdot \text{kN}$$

$$F_{LY1n} := 0.00 \cdot \text{kN} \quad F_{LY1c} := \gamma_{fw} F_{LY1n} \quad F_{LY1c} = 0.00 \cdot \text{kN}$$

$$F_{LX2n} := 0.10 \cdot \text{kN} \quad F_{LX2c} := \gamma_{fw} F_{LX2n} \quad F_{LX2c} = 0.14 \cdot \text{kN}$$

$$F_{LY2n} := 0.00 \cdot \text{kN} \quad F_{LY2c} := \gamma_{fw} F_{LY2n} \quad F_{LY2c} = 0.00 \cdot \text{kN}$$

Монтажен товар/ Errection load:

$$F_{MXn} := 1.00 \cdot \text{kN} \quad F_{MXc} := 1.3 F_{MXn} \quad F_{MXc} = 1.30 \cdot \text{kN}$$

$$F_{MYn} := 1.00 \cdot \text{kN} \quad F_{MYc} := 1.3 F_{MYn} \quad F_{MYc} = 1.30 \cdot \text{kN}$$

$$F_{MZn} := 1.00 \cdot \text{kN} \quad F_{MZc} := 1.3 F_{MZn} \quad F_{MZc} = 1.30 \cdot \text{kN}$$

## ОСОБЕНИ/EXCEPTIONAL

Късо съединение/ Short-circuit forces:  $F_{DX1n} := 1.20 \cdot \text{kN}$   $F_{DX2n} := 1.20 \cdot \text{kN}$   $F_{DY1n} := 0.00 \cdot \text{kN}$   $F_{DY2n} := 0.00 \cdot \text{kN}$

Сили от превключване/  
Switching forces:

$$F_{CX1n} := 0.00 \cdot \text{kN} \quad F_{CY1n} := 0.00 \cdot \text{kN} \quad F_{CZmax1n} := 0.00 \cdot \text{kN} \quad F_{CZmax2n} := 0.00 \cdot \text{kN}$$

$$F_{CX2n} := 0.00 \cdot \text{kN} \quad F_{CY2n} := 0.00 \cdot \text{kN} \quad F_{CZmin1n} := 0.00 \cdot \text{kN} \quad F_{CZmin2n} := 0.00 \cdot \text{kN}$$

Сеизмични сили/  
Earthquake load:

$$F_{EQX1n} := a_h \cdot F_{AZ1n} \quad F_{EQX1n} = 1.34 \cdot \text{kN}$$

$$F_{EQY1n} := a_h \cdot F_{AZ1n} \quad F_{EQY1n} = 1.34 \cdot \text{kN}$$

$$F_{EQZ1n} := a_v \cdot F_{AZ1n} \quad F_{EQZ1n} = 1.34 \cdot \text{kN}$$

$$F_{EQX2n} := a_h \cdot F_{AZ2n} \quad F_{EQX2n} = 1.15 \cdot \text{kN}$$

$$F_{EQY2n} := a_h \cdot F_{AZ2n} \quad F_{EQY2n} = 1.15 \cdot \text{kN}$$

$$F_{EQZ2n} := a_v \cdot F_{AZ2n} \quad F_{EQZ2n} = 1.15 \cdot \text{kN}$$

**Опорна конструкция/ Supporting structures****Колона/ Column**

Собствено тепло/Dead load:

$$q_{UCzn} := 1.1 \cdot \frac{\text{kN}}{\text{m}} \quad F_{UCzn} := q_{UCzn} \cdot n \quad F_{UCzn} = 2.31 \cdot \text{kN}$$

$$q_{UCzc} := 1.1 q_{UCzn} \quad F_{UCzc} := q_{UCzc} \cdot n \quad F_{UCzc} = 2.54 \cdot \text{kN}$$

Вятър върху опорна конструкция:

$$b_{cx} := 300 \cdot \text{mm} \quad b_{cy} := 220 \cdot \text{mm}$$

$$q_{Cwx} := b_{cx} \cdot 1.4 \cdot W_m \quad q_{Cwx} = 0.32 \cdot \frac{\text{kN}}{\text{m}} \quad q_{Cwy} := b_{cy} \cdot 1.4 \cdot W_m \quad q_{Cwy} = 0.24 \cdot \frac{\text{kN}}{\text{m}}$$

$$F_{UCWxn} := q_{Cwx} \cdot n \quad F_{UCWxn} = 0.68 \cdot \text{kN} \quad F_{UCWxc} := 1.4 \cdot F_{UCWxn} \quad F_{UCWxc} = 0.95 \cdot \text{kN}$$

$$F_{UCWyn} := q_{Cwy} \cdot n \quad F_{UCWyn} = 0.50 \cdot \text{kN} \quad F_{UCWyc} := 1.4 \cdot F_{UCWyn} \quad F_{UCWyc} = 0.69 \cdot \text{kN}$$

Сеизмични сили/  
Earthquake load:

$$F_{UCEQxn} := a_h \cdot F_{UCzn} \quad F_{UCEQxn} = 0.77 \cdot \text{kN}$$

$$F_{UCEQyn} := a_h \cdot F_{UCzn} \quad F_{UCEQyn} = 0.77 \cdot \text{kN}$$

$$F_{UCEQzn} := a_v \cdot F_{UCzn} \quad F_{UCEQzn} = 0.77 \cdot \text{kN}$$

**Греда/ Beam**

Собствено тепло/Dead load:

$$q_{UGz} := 1.3 \cdot \frac{\text{kN}}{\text{m}} \quad F_{UGzn} := q_{UGz} \cdot 2P_1 \quad F_{UGzn} = 2.34 \cdot \text{kN} \quad F_{UGzc} := 1.1 F_{UGzn} \quad F_{UGzc} = 2.57 \cdot \text{kN}$$

Вятър върху опорна конструкция/Windload on support structure:

$$b_g := 100 \cdot \text{mm}$$

$$q_{gwx} := b_g \cdot 1.4 \cdot W_m \quad q_{gwx} = 0.11 \cdot \frac{\text{kN}}{\text{m}} \quad q_{gwy} := b_g \cdot 1.4 \cdot W_m \quad q_{gwy} = 0.11 \cdot \frac{\text{kN}}{\text{m}}$$

$$F_{UGWxn} := 0 \quad F_{UGWxn} = 0.00 \cdot \text{kN} \quad F_{UGWxc} := 1.4 \cdot F_{UGWxn} \quad F_{UGWxc} = 0.00 \cdot \text{kN}$$

$$F_{UGWyn} := q_{gwy} \cdot 2P_1 \quad F_{UGWyn} = 0.19 \cdot \text{kN} \quad F_{UGWyc} := 1.4 \cdot F_{UGWyn} \quad F_{UGWyc} = 0.27 \cdot \text{kN}$$

Сеизмични сили/  
Earthquake load:

$$F_{UGEQxn} := a_h \cdot F_{UGzn} \quad F_{UGEQxn} = 0.78 \cdot \text{kN}$$

$$F_{UGEQyn} := a_h \cdot F_{UGzn} \quad F_{UGEQyn} = 0.78 \cdot \text{kN}$$

$$F_{UGEQzn} := a_v \cdot F_{UGzn} \quad F_{UGEQzn} = 0.78 \cdot \text{kN}$$

## **ОПРЕДЕЛЯНЕ НА УСИЛИЯТА НА ГОРЕН РЪБ ФУНДАМЕНТ ЗА ЕДНА СТОЙКА. CALCULATION OF THE STRESS ON THE UPPER EDGE FOUNDATION.**

**A: Собствено тепло / Dead load:**

нормативни натоварвания/normative loads

$$F_{ZmaxAn} := F_{AZ1n} + F_{AZ2n} + F_{UCzn} + F_{UGzn} \quad F_{ZmaxAn} = 12.10 \cdot \text{kN}$$

$$F_{ZminAn} := F_{AZ1n} + F_{AZ2n} + F_{UCzn} + F_{UGzn} \quad F_{ZminAn} = 12.10 \cdot \text{kN}$$

$$M_{XAn} := F_{AZ1n} \cdot P_1 - F_{AZ2n} \cdot P_2 \quad M_{XAn} = 0.50 \cdot \text{kN} \cdot \text{m}$$

$$F_{XAn} := 0.00 \cdot \text{kN} \quad M_{YAn} := 0.00 \cdot \text{kN} \quad F_{YAn} := 0.00 \cdot \text{kN}$$

изчислителни натоварвания/calculating loads

$$F_{ZmaxAc} := F_{AZ1c} + F_{AZ2c} + F_{UCzc} + F_{UGzc} \quad F_{ZmaxAc} = 14.05 \cdot \text{kN}$$

$$F_{ZminAc} := F_{AZ1c} + F_{AZ2c} + F_{UCzc} + F_{UGzc} \quad F_{ZminAc} = 14.05 \cdot \text{kN}$$

$$M_{XAc} := F_{AZ1c} \cdot P_1 - F_{AZ2c} \cdot P_2 \quad M_{XAc} = 0.59 \cdot \text{kN} \cdot \text{m}$$

$$F_{XAc} := 0.00 \cdot \text{kN} \quad M_{YAc} := 0.00 \cdot \text{kN} \quad F_{YAc} := 0.00 \cdot \text{kN}$$

**C.1: Вятър по ос X / Windload direction X**

нормативни натоварвания/normative loads

$$F_{ZmaxC1n} := 0.00 \cdot \text{kN}$$

$$F_{ZminC1n} := 0.00 \cdot \text{kN}$$

$$F_{XC1n} := F_{WX1n} + F_{WX2n} + F_{LX1n} + F_{LX2n} + F_{UCWXn} + F_{UGWXn}$$

$$M_{YC1n} := F_{WX1n}(n + b_1) + F_{WX2n}(n + b_2) + F_{LX1n}(n + d_1) + F_{LX2n}(n + d_2) + F_{UCWXn} \cdot \frac{n}{2} + F_{UGWXn} \cdot n$$

$$F_{YC1n} := 0.00 \cdot \text{kN}$$

$$M_{XC1n} := 0.00 \cdot \text{kN} \cdot \text{m}$$

изчислителни натоварвания/calculating loads

$$F_{ZmaxC1c} := 0.00 \cdot \text{kN}$$

$$F_{ZminC1c} := 0.00 \cdot \text{kN}$$

$$F_{XC1c} := F_{WX1c} + F_{WX2c} + F_{LX1c} + F_{LX2c} + F_{UCWXc} + F_{UGWXc}$$

$$M_{YC1c} := F_{WX1c}(n + b_1) + F_{WX2c}(n + b_2) + F_{LX1c}(n + d_1) + F_{LX2c}(n + d_2) + F_{UCWXc} \cdot \frac{n}{2} + F_{UGWXc} \cdot n$$

$$F_{YC1c} := 0.00 \cdot \text{kN}$$

$$M_{XC1c} := 0.00 \cdot \text{kN} \cdot \text{m}$$

**C.2: Вятър по ос Y / Windload on direction Y**

нормативни натоварвания/normative loads

$$F_{ZmaxC2n} := 0.00 \cdot \text{kN}$$

$$F_{ZminC2n} := 0.00 \cdot \text{kN}$$

$$F_{XC2n} := 0.00 \cdot \text{kN}$$

$$M_{YC2n} := 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YC2n} := F_{WY1n} + F_{WY2n} + F_{LY1n} + F_{LY2n} + F_{UCWYn} + F_{UGWYn}$$

$$M_{XC2n} := F_{WY1n}(n + b_1) + F_{WY2n}(n + b_2) + F_{LY1n}(n + d_1) + F_{LY2n}(n + d_2) + F_{UCWYn} \cdot \frac{n}{2} + F_{UGWYn} \cdot n$$

изчислителни натоварвания/calculating loads

$$F_{ZmaxC2c} := 0.00 \cdot \text{kN}$$

$$F_{ZminC2c} := 0.00 \cdot \text{kN}$$

$$F_{XC2c} := 0.00 \cdot \text{kN}$$

$$M_{YC2c} := 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YC2c} := F_{WY1c} + F_{WY2c} + F_{LY1c} + F_{LY2c} + F_{UCWYc} + F_{UGWYc}$$

$$M_{XC2c} := F_{WY1c}(n + b_1) + F_{WY2c}(n + b_2) + F_{LY1c}(n + d_1) + F_{LY2c}(n + d_2) + F_{UCWYc} \cdot \frac{n}{2} + F_{UGWYc} \cdot n$$

**D: Опъвателна сила от проводник / Static conductor tension**

нормативни натоварвания/normative loads

$$F_{ZmaxDn} := \frac{F_{SY1n} \cdot d_1 - F_{SY2n} \cdot d_2}{p_1 + p_2}$$

$$F_{ZmaxDn} = 0.01 \cdot \text{kN}$$

$$F_{ZminDn} := -F_{ZmaxDn}$$

$$F_{ZminDn} = -0.01 \cdot \text{kN}$$

$$F_{XDn} := F_{SX1n} + F_{SX2n}$$

$$F_{XDn} = 0.00 \cdot \text{kN}$$

$$M_{YDn} := F_{SX1n} \cdot (n + d_1) + F_{SX2n} \cdot (n + d_2)$$

$$M_{YDn} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YDn} := F_{SY1n}$$

$$F_{YDn} = 0.15 \cdot \text{kN}$$

$$M_{XDn} := F_{SY1n} \cdot (n + d_1)$$

$$M_{XDn} = 0.67 \cdot \text{kN} \cdot \text{m}$$

изчислителни натоварвания/calculating loads

$$F_{ZmaxDc} := \frac{F_{SY1c} \cdot d_1 - F_{SY2c} \cdot d_2}{p_1 + p_2}$$

$$F_{ZmaxDc} = 0.02 \cdot \text{kN}$$

$$F_{ZminDc} := -F_{ZmaxDc}$$

$$F_{ZminDc} = -0.02 \cdot \text{kN}$$

$$F_{XDc} := F_{SX1c} + F_{SX2c}$$

$$F_{XDc} = 0.00 \cdot \text{kN}$$

$$M_{YDc} := F_{SX1c} \cdot (n + d_1) + F_{SX2c} \cdot (n + d_2)$$

$$M_{YDc} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YDc} := F_{SY1c}$$

$$F_{YDc} = 0.20 \cdot \text{kN}$$

$$M_{XDc} := F_{SY1c} \cdot (n + d_1)$$

$$M_{XDc} = 0.88 \cdot \text{kN} \cdot \text{m}$$

**E: Късо съединение / Short-circuit forces**

нормативни натоварвания/normative loads

$$F_{ZmaxEn} := 0$$

$$F_{ZmaxEn} = 0.00 \cdot \text{kN}$$

$$F_{ZminEn} := -F_{ZmaxEn}$$

$$F_{ZminEn} = 0.00 \cdot \text{kN}$$

$$F_{XEn} := F_{DX1n} + F_{DX2n}$$

$$F_{XEn} = 2.40 \cdot \text{kN}$$

$$M_{YEn} := F_{DX1n} \cdot (n + d_1) + F_{DX2n} \cdot (n + d_2)$$

$$M_{YEn} = 10.61 \cdot \text{kN} \cdot \text{m}$$

$$F_{YEn} := F_{DY1n}$$

$$F_{YEn} = 0.00 \cdot \text{kN}$$

$$M_{XEn} := F_{DY1n} \cdot (n + d_1)$$

$$M_{XEn} = 0.00 \cdot \text{kN} \cdot \text{m}$$

**H: Монтажен товар / Erection load**

нормативни натоварвания/normative loads

$$F_{ZmaxHn} := F_{MZn}$$

$$F_{ZmaxHn} = 1.00 \cdot \text{kN}$$

$$F_{ZminHn} := 0.00 \cdot \text{kN}$$

$$F_{ZminHn} = 0.00 \cdot \text{kN}$$

$$F_{XHn} := F_{MXn}$$

$$F_{XHn} = 1.00 \cdot \text{kN}$$

$$M_{YHn} := F_{MXn} \cdot n$$

$$M_{YHn} = 2.10 \cdot \text{kN} \cdot \text{m}$$

$$F_{YHn} := F_{MYn}$$

$$F_{YHn} = 1.00 \cdot \text{kN}$$

$$M_{XHn} := F_{MYn} \cdot n$$

$$M_{XHn} = 2.10 \cdot \text{kN} \cdot \text{m}$$

изчислителни натоварвания/calculating loads

$$F_{ZmaxHc} := F_{MZc}$$

$$F_{ZmaxHc} = 1.30 \cdot \text{kN}$$

$$F_{ZminHc} := 0.00 \cdot \text{kN}$$

$$F_{ZminHc} = 0.00 \cdot \text{kN}$$

$$F_{XHc} := F_{MXc}$$

$$F_{XHc} = 1.30 \cdot \text{kN}$$

$$M_{YHc} := F_{MXc} \cdot n$$

$$F_{YHc} := F_{MYc}$$

$$M_{XHc} := F_{MYc} \cdot n$$

$$M_{YHc} = 2.73 \cdot \text{kN} \cdot \text{m}$$

$$F_{YHc} = 1.30 \cdot \text{kN}$$

$$M_{XHc} = 2.73 \cdot \text{kN} \cdot \text{m}$$

### **F: Превключвателни сили / Switching forces**

нормативни натоварвания/normative loads

$$F_{ZmaxFn} := 0 \cdot \text{kN}$$

$$F_{ZminFn} := 0 \cdot \text{kN}$$

$$F_{XF_n} := 0 \cdot \text{kN}$$

$$M_{YFn} := 0 \cdot \text{kN} \cdot \text{m}$$

$$F_{YFn} := 0 \cdot \text{kN}$$

$$M_{XF_n} := 0 \cdot \text{kN} \cdot \text{m}$$

$$F_{ZmaxFn} = 0.00 \cdot \text{kN}$$

$$F_{ZminFn} = 0.00 \cdot \text{kN}$$

$$F_{XF_n} = 0.00 \cdot \text{kN}$$

$$M_{YFn} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YFn} = 0.00 \cdot \text{kN}$$

$$M_{XF_n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

### **G1: Земетресение по ос X / Earthquake load direction X**

нормативни натоварвания/normative loads

$$F_{ZmaxG1n} := 0.00 \text{ kN}$$

$$F_{ZminG1n} := 0.00 \text{ kN}$$

$$F_{XG1n} := F_{EQX1n} + F_{EQX2n} + F_{UCEQXn} + F_{UGEQXn}$$

$$M_{YG1n} := F_{EQX1n} \cdot (n + a_1) + F_{EQX2n} \cdot (n + a_2) + F_{UCEQXn} \cdot \frac{n}{2} + F_{UGEQXn} \cdot n$$

$$F_{YG1n} := 0.00 \cdot \text{kN}$$

$$M_{XG1n} := 0.00$$

$$F_{ZmaxG1n} = 0.00 \cdot \text{kN}$$

$$F_{ZminG1n} = 0.00 \cdot \text{kN}$$

$$F_{XG1n} = 4.04 \cdot \text{kN}$$

$$M_{YG1n} = 10.58 \cdot \text{kN} \cdot \text{m}$$

$$F_{YG1n} = 0.00 \cdot \text{kN}$$

$$M_{XG1n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

### **G2: Земетресение по ос Y / Earthquake load direction Y**

нормативни натоварвания/normative loads

$$F_{ZmaxG2n} := 0.00 \cdot \text{kN}$$

$$F_{ZminG2n} := 0.00 \cdot \text{kN}$$

$$F_{XG2n} := 0.00 \cdot \text{kN}$$

$$M_{YG2n} := 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YG2n} := F_{EQY1n} + F_{EQY2n} + F_{UCEQYn} + F_{UGEQYn}$$

$$M_{XG2n} := F_{EQY1n} \cdot (n + a_1) + F_{EQY2n} \cdot (n + a_2) + F_{UCEQYn} \cdot \frac{n}{2} + F_{UGEQYn} \cdot n$$

$$F_{ZmaxG2n} = 0.00 \cdot \text{kN}$$

$$F_{ZminG2n} = 0.00 \cdot \text{kN}$$

$$F_{XG2n} = 0.00 \cdot \text{kN}$$

$$M_{YG2n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YG2n} = 4.04 \cdot \text{kN}$$

$$M_{XG2n} = 10.58 \cdot \text{kN} \cdot \text{m}$$

### **G3: Земетресение по ос Z / Earthquake load direction Z**

нормативни натоварвания/normative loads

$$F_{ZmaxG3n} := F_{EQZ1n} + F_{EQZ2n} + F_{UCEQZn} + F_{UGEQZn}$$

$$F_{ZminG3n} := -F_{ZmaxG3n}$$

$$F_{XG3n} := 0.00 \cdot \text{kN}$$

$$M_{YG3n} := 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YG3n} := 0.00 \cdot \text{kN}$$

$$M_{XG3n} := F_{EQZ1n} \cdot p_1 - F_{EQZ2n} \cdot p_2$$

$$F_{ZmaxG3n} = 4.04 \cdot \text{kN}$$

$$F_{ZminG3n} = -4.04 \cdot \text{kN}$$

$$F_{XG3n} = 0.00 \cdot \text{kN}$$

$$M_{YG3n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{YG3n} = 0.00 \cdot \text{kN}$$

$$M_{XG3n} = 0.17 \cdot \text{kN} \cdot \text{m}$$



## Комбинации от натоварванията/ Foundation loadcases ОСНОВНИ КОМБИНАЦИИ/ NORMAL LOADCASES

### Комбинация 1: Собствено тегло (A)/ Loadcase 1: Dead load (A)

нормативни натоварвания/normative loads

$$F_{Zmax1n} := F_{ZmaxAn}$$

$$F_{Zmax1n} = 12.10 \cdot \text{kN}$$

$$F_{Zmin1n} := F_{ZminAn}$$

$$F_{Zmin1n} = 12.10 \cdot \text{kN}$$

$$F_{X1n} := F_{XAn}$$

$$F_{X1n} = 0.00 \cdot \text{kN}$$

$$M_{Y1n} := M_{YAn}$$

$$M_{Y1n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y1n} := F_{YAn}$$

$$F_{Y1n} = 0.00 \cdot \text{kN}$$

$$M_{X1n} := M_{XAn}$$

$$M_{X1n} = 0.50 \cdot \text{kN} \cdot \text{m}$$

изчислителни натоварвания/calculating loads

$$F_{Zmax1c} := F_{ZmaxAc}$$

$$F_{Zmax1c} = 14.05 \cdot \text{kN}$$

$$F_{Zmin1c} := F_{ZminAc}$$

$$F_{Zmin1c} = 14.05 \cdot \text{kN}$$

$$F_{X1c} := F_{XAc}$$

$$F_{X1c} = 0.00 \cdot \text{kN}$$

$$M_{Y1c} := M_{YAc}$$

$$M_{Y1c} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y1c} := F_{YAc}$$

$$F_{Y1c} = 0.00 \cdot \text{kN}$$

$$M_{X1c} := M_{XAc}$$

$$M_{X1c} = 0.59 \cdot \text{kN} \cdot \text{m}$$

### Комбинация 2: СТ(А)+Опъвателна сила от проводник(Д)+Монтажен товар(Н) Loadcase СТ(А)+ Static conductor tension (D)+ Erection load (H)

нормативни натоварвания/normative loads

$$F_{Zmax2n} := F_{ZmaxAn} + F_{ZmaxDn} + F_{ZmaxHn}$$

$$F_{Zmax2n} = 13.11 \cdot \text{kN}$$

$$F_{Zmin2n} := F_{ZminAn} + F_{ZminDn} + F_{ZminHn}$$

$$F_{Zmin2n} = 12.09 \cdot \text{kN}$$

$$F_{X2n} := F_{XAn} + F_{XDn} + F_{XHn}$$

$$F_{X2n} = 1.00 \cdot \text{kN}$$

$$M_{Y2n} := M_{YAn} + M_{YDn} + M_{YHn}$$

$$M_{Y2n} = 2.10 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y2n} := F_{YAn} + F_{YDn} + F_{YHn}$$

$$F_{Y2n} = 1.15 \cdot \text{kN}$$

$$M_{X2n} := M_{XAn} + M_{XDn} + M_{XHn}$$

$$M_{X2n} = 3.27 \cdot \text{kN} \cdot \text{m}$$

изчислителни натоварвания/calculating loads

$$F_{Zmax2c} := F_{ZmaxAc} + F_{ZmaxDc} + F_{ZmaxHc}$$

$$F_{Zmax2c} = 15.37 \cdot \text{kN}$$

$$F_{Zmin2c} := F_{ZminAc} + F_{ZminDc} + F_{ZminHc}$$

$$F_{Zmin2c} = 14.04 \cdot \text{kN}$$

$$F_{X2c} := F_{XAc} + F_{XDc} + F_{XHc}$$

$$F_{X2c} = 1.30 \cdot \text{kN}$$

$$M_{Y2c} := M_{YAc} + M_{YDc} + M_{YHc}$$

$$M_{Y2c} = 2.73 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y2c} := F_{YAc} + F_{YDc} + F_{YHc}$$

$$F_{Y2c} = 1.50 \cdot \text{kN}$$

$$M_{X2c} := M_{XAc} + M_{XDc} + M_{XHc}$$

$$M_{X2c} = 4.20 \cdot \text{kN} \cdot \text{m}$$

### Комбинация 3: СТ(А)+Вятър по ос Х(С1)+Опъвателна сила от проводник(Д) Loadcase 3: СТ(А)+Wind direction X(C1)+Static conductor tension (D)

нормативни натоварвания/normative loads

$$F_{Zmax3n} := F_{ZmaxAn} + 0.9F_{ZmaxC1n} + 0.95F_{ZmaxDn}$$

$$F_{Zmax3n} = 12.11 \cdot \text{kN}$$

$$F_{Zmin3n} := F_{ZminAn} + 0.9F_{ZminC1n} + 0.95F_{ZminDn}$$

$$F_{Zmin3n} = 12.09 \cdot \text{kN}$$

$$F_{X3n} := F_{XAn} + 0.9F_{XC1n} + 0.95F_{XDn}$$

$$F_{X3n} = 1.50 \cdot \text{kN}$$

$$M_{Y3n} := M_{YAn} + 0.9M_{YC1n} + 0.95M_{YDn}$$

$$M_{Y3n} = 3.76 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y3n} := F_{YAn} + 0.9F_{YC1n} + 0.95F_{YDn}$$

$$F_{Y3n} = 0.14 \cdot \text{kN}$$

$$M_{X3n} := M_{XAn} + 0.9M_{XC1n} + 0.95M_{XDn}$$

$$M_{X3n} = 1.14 \cdot \text{kN} \cdot \text{m}$$

изчислителни натоварвания/calculating loads

$$F_{Zmax3c} := F_{ZmaxAc} + 0.9F_{ZmaxC1c} + 0.95F_{ZmaxDc}$$

$$F_{Zmax3c} = 14.07 \cdot \text{kN}$$

$$F_{Zmin3c} := F_{ZminAc} + 0.9F_{ZminC1c} + 0.95F_{ZminDc}$$

$$F_{Zmin3c} = 14.04 \cdot \text{kN}$$

$$F_{X3c} := F_{XAc} + 0.9F_{XC1c} + 0.95F_{XDc}$$

$$F_{X3c} = 2.10 \cdot \text{kN}$$

$$M_{Y3c} := M_{YAc} + 0.9M_{YC1c} + 0.95M_{YDc}$$

$$M_{Y3c} = 5.27 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y3c} := F_{YAc} + 0.9F_{YC1c} + 0.95F_{YDc}$$

$$F_{Y3c} = 0.19 \cdot \text{kN}$$

$$M_{X3c} := M_{XAc} + 0.9M_{XC1c} + 0.95M_{XDc}$$

$$M_{X3c} = 1.43 \cdot \text{kN} \cdot \text{m}$$

#### **Комбинация 4: СТ(А)+Вятър по ос Y(C2)+Опъвателна сила от проводник(D)**

##### **Loadcase 4: СТ(А)+Wind direction Y(C2)+Static conductor tension (D)**

нормативни натоварвания/normative loads

$$F_{Zmax4n} := F_{ZmaxAn} + 0.9F_{ZmaxC2n} + 0.95F_{ZmaxDn}$$

$$F_{Zmax4n} = 12.11 \cdot \text{kN}$$

$$F_{Zmin4n} := F_{ZminAn} + 0.9F_{ZminC2n} + 0.95F_{ZminDn}$$

$$F_{Zmin4n} = 12.09 \cdot \text{kN}$$

$$F_{X4n} := F_{XAn} + 0.9F_{XC2n} + 0.95F_{XDn}$$

$$F_{X4n} = 0.00 \cdot \text{kN}$$

$$M_{Y4n} := M_{YAn} + 0.9M_{YC2n} + 0.95M_{YDn}$$

$$M_{Y4n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y4n} := F_{YAn} + 0.9F_{YC2n} + 0.95F_{YDn}$$

$$F_{Y4n} = 1.48 \cdot \text{kN}$$

$$M_{X4n} := M_{XAn} + 0.9M_{XC2n} + 0.95M_{XDn}$$

$$M_{X4n} = 4.30 \cdot \text{kN} \cdot \text{m}$$

изчислителни натоварвания/calculating loads

$$F_{Zmax4c} := F_{ZmaxAc} + 0.9F_{ZmaxC2c} + 0.95F_{ZmaxDc}$$

$$F_{Zmax4c} = 14.07 \cdot \text{kN}$$

$$F_{Zmin4c} := F_{ZminAc} + 0.9F_{ZminC2c} + 0.95F_{ZminDc}$$

$$F_{Zmin4c} = 14.04 \cdot \text{kN}$$

$$F_{X4c} := F_{XAc} + 0.9F_{XC2c} + 0.95F_{XDc}$$

$$F_{X4c} = 0.00 \cdot \text{kN}$$

$$M_{Y4c} := M_{YAc} + 0.9M_{YC2c} + 0.95M_{YDc}$$

$$M_{Y4c} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y4c} := F_{YAc} + 0.9F_{YC2c} + 0.95F_{YDc}$$

$$F_{Y4c} = 2.05 \cdot \text{kN}$$

$$M_{X4c} := M_{XAc} + 0.9M_{XC2c} + 0.95M_{XDc}$$

$$M_{X4c} = 5.86 \cdot \text{kN} \cdot \text{m}$$

#### **ОСОБЕНИ КОМБИНАЦИИ/ EXCEPTIONAL LOADCASES**

от нормативни натоварвания / from normative loads

##### **Комбинация 5: СТ(А)+Късо съединение(E)/ Loadcase 5: СТ(А)+Short circuit forces**

$$F_{Zmax5n} := F_{ZmaxAn} + F_{ZmaxEn}$$

$$F_{Zmax5n} = 12.10 \cdot \text{kN}$$

$$F_{Zmin5n} := F_{ZminAn} + F_{ZminEn}$$

$$F_{Zmin5n} = 12.10 \cdot \text{kN}$$

$$F_{X5n} := F_{XAn} + F_{XEn}$$

$$F_{X5n} = 2.40 \cdot \text{kN}$$

$$M_{Y5n} := M_{YAn} + M_{YEn}$$

$$M_{Y5n} = 10.61 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y5n} := F_{YAn} + F_{YEn}$$

$$F_{Y5n} = 0.00 \cdot \text{kN}$$

$$M_{X5n} := M_{XAn} + M_{XEn}$$

$$M_{X5n} = 0.50 \cdot \text{kN} \cdot \text{m}$$

##### **Комбинация 6: СТ(А)+Опъвателна сила от проводник(D)+Превключване(F)**

##### **Loadcase 6: СТ(А)+Static conductor tension(D)+Switching (F)**

$$F_{Zmax6n} := F_{ZmaxAn} + 0.95F_{ZmaxDn} + F_{ZmaxFn}$$

$$F_{Zmax6n} = 12.11 \cdot \text{kN}$$

$$F_{Zmin6n} := F_{ZminAn} + 0.95F_{ZminDn} + F_{ZminFn}$$

$$F_{Zmin6n} = 12.09 \cdot \text{kN}$$

$$F_{X6n} := F_{XAn} + 0.95F_{XDn} + F_{XF_n}$$

$$F_{X6n} = 0.00 \cdot \text{kN}$$

$$M_{Y6n} := M_{YAn} + 0.95M_{YDn} + M_{YF_n}$$

$$M_{Y6n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y6n} := F_{YAn} + 0.95F_{YDn} + F_{YF_n}$$

$$F_{Y6n} = 0.14 \cdot \text{kN}$$

$$M_{X6n} := M_{XAn} + 0.95M_{XDn} + M_{XF_n}$$

$$M_{X6n} = 1.14 \cdot \text{kN} \cdot \text{m}$$

**Комбинация 7: СТ(А)+Опъвателна сила от проводник(D)+Сеизмични сили по X(G.1)+/-Z(G.3)**  
**Loadcase 7: CT(A)+Static conductor tension(D)+Earthquake load direction X(G.1)+/-Z(G.3)**

$$F_{Zmax7n} := F_{ZmaxAn} + 0.95F_{ZmaxDn} + F_{ZmaxG1n} + F_{ZmaxG3n}$$

$$F_{Zmax7n} = 16.15 \cdot \text{kN}$$

$$F_{Zmin7n} := F_{ZminAn} + 0.95F_{ZminDn} + F_{ZminG1n} + F_{ZminG3n}$$

$$F_{Zmin7n} = 8.05 \cdot \text{kN}$$

$$F_{X7n} := F_{XAn} + 0.95F_{XDn} + F_{XG1n} + F_{XG3n}$$

$$F_{X7n} = 4.04 \cdot \text{kN}$$

$$M_{Y7n} := M_{YAn} + 0.95M_{YDn} + M_{YG1n} + M_{YG3n}$$

$$M_{Y7n} = 10.58 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y7n} := F_{YAn} + 0.95F_{YDn} + F_{YG1n} + F_{YG3n}$$

$$F_{Y7n} = 0.14 \cdot \text{kN}$$

$$M_{X7n} := M_{XAn} + 0.95M_{XDn} + M_{XG1n} + M_{XG3n}$$

$$M_{X7n} = 1.30 \cdot \text{kN} \cdot \text{m}$$

**Комбинация 8: СТ(1)+Опъвателна сила от проводник(D)+Сеизмични сили по Y(G.2)+/-Z(G.3)**  
**Loadcase 8: CT(1)+Static conductor tension(D)+Earthquake load direction Y(G.2)+/-Z(G.3)**

$$F_{Zmax8n} := F_{ZmaxAn} + 0.95F_{ZmaxDn} + F_{ZmaxG2n} + F_{ZmaxG3n}$$

$$F_{Zmax8n} = 16.15 \cdot \text{kN}$$

$$F_{Zmin8n} := F_{ZminAn} + 0.95F_{ZminDn} + F_{ZminG2n} + F_{ZminG3n}$$

$$F_{Zmin8n} = 8.05 \cdot \text{kN}$$

$$F_{X8n} := F_{XAn} + 0.95F_{XDn} + F_{XG2n} + F_{XG3n}$$

$$F_{X8n} = 0.00 \cdot \text{kN}$$

$$M_{Y8n} := M_{YAn} + 0.95M_{YDn} + M_{YG2n} + M_{YG3n}$$

$$M_{Y8n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y8n} := F_{YAn} + 0.95F_{YDn} + F_{YG2n} + F_{YG3n}$$

$$F_{Y8n} = 4.19 \cdot \text{kN}$$

$$M_{X8n} := M_{XAn} + 0.95M_{XDn} + M_{XG2n} + M_{XG3n}$$

$$M_{X8n} = 11.88 \cdot \text{kN} \cdot \text{m}$$

**Комбинация 9.1: СТ(А)+Вятър по ос X(C.1)+Късо съединение (E)**  
**Loadcase 9.1: CT(A)+Windload direction X(C.1)+Short-circuit forces (E)**

$$F_{Zmax91n} := F_{ZmaxAn} + 0.8F_{ZmaxC1n} + F_{ZmaxEn}$$

$$F_{Zmax91n} = 12.10 \cdot \text{kN}$$

$$F_{Zmin91n} := F_{ZminAn} + 0.8F_{ZminC1n} + F_{ZminEn}$$

$$F_{Zmin91n} = 12.10 \cdot \text{kN}$$

$$F_{X91n} := F_{XAn} + 0.8F_{XC1n} + F_{XEn}$$

$$F_{X91n} = 3.74 \cdot \text{kN}$$

$$M_{Y91n} := M_{YAn} + 0.8M_{YC1n} + M_{YEn}$$

$$M_{Y91n} = 13.96 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y91n} := F_{YAn} + 0.8F_{YC1n} + F_{YEn}$$

$$F_{Y91n} = 0.00 \cdot \text{kN}$$

$$M_{X91n} := M_{XAn} + 0.8M_{XC1n} + M_{XEn}$$

$$M_{X91n} = 0.50 \cdot \text{kN} \cdot \text{m}$$

**Комбинация 9.2: СТ(А)+Вятър по ос Y(C.2)+Късо съединение (E)**  
**Loadcase 9.2: CT(A)+Wind load direction Y(C.2)+Short-circuit forces (E)**

$$F_{Zmax92n} := F_{ZmaxAn} + 0.8F_{ZmaxC2n} + F_{ZmaxEn}$$

$$F_{Zmax92n} = 12.10 \cdot \text{kN}$$

$$F_{Zmin92n} := F_{ZminAn} + 0.8F_{ZminC2n} + F_{ZminEn}$$

$$F_{Zmin92n} = 12.10 \cdot \text{kN}$$

$$F_{X92n} := F_{XAn} + 0.8F_{XC2n} + F_{XEn}$$

$$F_{X92n} = 2.40 \cdot \text{kN}$$

$$M_{Y92n} := M_{YAn} + 0.8M_{YC2n} + M_{YEn}$$

$$M_{Y92n} = 10.61 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y92n} := F_{YAn} + 0.8F_{YC2n} + F_{YEn}$$

$$F_{Y92n} = 1.19 \cdot \text{kN}$$

$$M_{X92n} := M_{XAn} + 0.8M_{XC2n} + M_{XEn}$$

$$M_{X92n} = 3.31 \cdot \text{kN} \cdot \text{m}$$

**Комбинация 10.1: СТ(А)+Сеизмични сили по оси X(G.1)+/-Z(G.3)****Loadcase 10.1: CT(A)+Earthquake load direction X(G.1)+/-Z(G.3)**

$$F_{Zmax101n} := F_{ZmaxAn} + F_{ZmaxG1n} + F_{ZmaxG3n}$$

$$F_{Zmin101n} := F_{ZminAn} + F_{ZminG1n} + F_{ZminG3n}$$

$$F_{X101n} := F_{XAn} + F_{XG1n} + F_{XG3n}$$

$$M_{Y101n} := M_{YAn} + M_{YG1n} + M_{YG3n}$$

$$F_{Y101n} := F_{YAn} + F_{YG1n} + F_{YG3n}$$

$$M_{X101n} := M_{XAn} + M_{XG1n} + M_{XG3n}$$

$$F_{Zmax101n} = 16.14 \cdot \text{kN}$$

$$F_{Zmin101n} = 8.06 \cdot \text{kN}$$

$$F_{X101n} = 4.04 \cdot \text{kN}$$

$$M_{Y101n} = 10.58 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y101n} = 0.00 \cdot \text{kN}$$

$$M_{X101n} = 0.66 \cdot \text{kN} \cdot \text{m}$$

**Комбинация 10.2: СТ(А)+Сеизмични сили по ос Y(G.2)+/-Z(G.3)****Loadcase 10.2: CT(A)+Earthquake load direction Y(G.2)+/-Z(G.3)**

$$F_{Zmax102n} := F_{ZmaxAn} + F_{ZmaxG2n} + F_{ZmaxG3n}$$

$$F_{Zmin102n} := F_{ZminAn} + F_{ZminG2n} + F_{ZminG3n}$$

$$F_{X102n} := F_{XAn} + F_{XG2n} + F_{XG3n}$$

$$M_{Y102n} := M_{YAn} + M_{YG2n} + M_{YG3n}$$

$$F_{Y102n} := F_{YAn} + F_{YG2n} + F_{YG3n}$$

$$M_{X102n} := M_{XAn} + M_{XG2n} + M_{XG3n}$$

$$F_{Zmax102n} = 16.14 \cdot \text{kN}$$

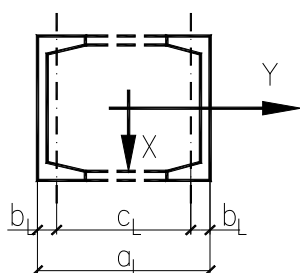
$$F_{Zmin102n} = 8.06 \cdot \text{kN}$$

$$F_{X102n} = 0.00 \cdot \text{kN}$$

$$M_{Y102n} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$F_{Y102n} = 4.04 \cdot \text{kN}$$

$$M_{X102n} = 11.24 \cdot \text{kN} \cdot \text{m}$$

**Оразмеряване на стойката/Dimensioning of the stand**избран профил/ chosen **UPN 140 S235**

$$a_L := 300\text{mm} \quad b_L := 17.5\text{mm} \quad l_1 := 800\text{mm}$$

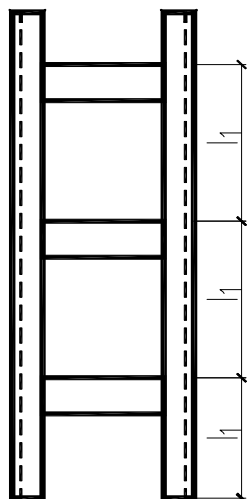
$$c_L := a_L - 2 \cdot b_L \quad c_L = 265.00 \cdot \text{mm} \quad b_U := 140\text{mm}$$

За съставеното сечение/for this section:

$$W_x := 14700 \cdot \text{mm}^3 \quad A_U := 2040 \cdot \text{mm}^2$$

$$W_y := 86400 \cdot \text{mm}^3$$

$$f_{Sta24} = 218.18 \cdot \frac{\text{N}}{\text{mm}^2}$$

**Комбинация 2 / Loadcase 2:**

$$S_{maxc2} := \frac{M_{X2c}}{c_L} + \frac{F_{Zmax2c}}{2}$$

$$S_{maxc2} = 23.54 \cdot \text{kN}$$

$$Q_{UY2} := F_{Y2c}$$

$$Q_{UY2} = 1.50 \cdot \text{kN}$$

$$M_{UX2} := \frac{Q_{UY2} \cdot l_1}{2 \cdot 2}$$

$$M_{UX2} = 0.30 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL2} := \frac{M_{Y2c}}{2 \cdot W_y} + \frac{M_{UX2}}{W_x} + \frac{S_{maxc2}}{A_U}$$

$$f_{cL2} = 47.68 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL2}}{f_{Sta24}} = 0.22 \quad \blacksquare < 1$$

**Комбинация 3 / Loadcase 3:**

$$S_{maxc3} := \frac{M_{X3c}}{c_L} + \frac{F_{Zmax3c}}{2}$$

$$S_{maxc3} = 12.42 \cdot \text{kN}$$

$$Q_{UY3} := F_{Y3c}$$

$$Q_{UY3} = 0.19 \cdot \text{kN}$$

$$M_{UX3} := \frac{Q_{UY3} \cdot l_1}{2 \cdot 2}$$

$$M_{UX3} = 0.04 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL3} := \frac{M_{Y3c}}{2 \cdot W_y} + \frac{M_{UX3}}{W_x} + \frac{S_{maxc3}}{A_U}$$

$$f_{cL3} = 39.11 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL3}}{f_{Sta24}} = 0.18 \quad \blacksquare < 1$$

**Комбинация 4 / Loadcase 4:**

$$S_{maxc4} := \frac{M_{X4c}}{c_L} + \frac{F_{Zmax4c}}{2}$$

$$S_{maxc4} = 29.13 \cdot \text{kN}$$

$$Q_{UY4} := F_{Y4c}$$

$$Q_{UY4} = 2.05 \cdot \text{kN}$$

$$M_{UX4} := \frac{Q_{UY4} \cdot l_1}{2 \cdot 2}$$

$$M_{UX4} = 0.41 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL4} := \frac{M_{Y4c}}{2 \cdot W_y} + \frac{M_{UX4}}{W_x} + \frac{S_{maxc4}}{A_U}$$

$$f_{cL4} = 42.20 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL4}}{f_{Sta24}} = 0.19 \quad \blacksquare < 1$$

**Комбинация 5 / Loadcase 5:**

$$S_{maxc5} := \frac{M_{X5n}}{c_L} + \frac{F_{Zmax5n}}{2}$$

$$S_{maxc5} = 7.92 \cdot \text{kN}$$

$$Q_{UY5} := F_{Y5n}$$

$$Q_{UY5} = 0.00 \cdot \text{kN}$$

$$M_{UX5} := \frac{Q_{UY5} \cdot l_1}{2 \cdot 2}$$

$$M_{UX5} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL5} := \frac{M_{Y5n}}{2 \cdot W_y} + \frac{M_{UX5}}{W_x} + \frac{S_{maxc5}}{A_U}$$

$$f_{cL5} = 65.30 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL5}}{f_{Sta24}} = 0.30 \quad \blacksquare < 1$$

**Комбинация 6 / Loadcase 6:**

$$S_{maxc6} := \frac{M_{X6n}}{c_L} + \frac{F_{Zmax6n}}{2}$$

$$S_{maxc6} = 10.34 \cdot \text{kN}$$

$$Q_{UY6} := F_{Y6n}$$

$$Q_{UY6} = 0.14 \cdot \text{kN}$$

$$M_{UX6} := \frac{Q_{UY6} \cdot l_1}{2 \cdot 2}$$

$$M_{UX6} = 0.03 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL6} := \frac{M_{Y6n}}{2 \cdot W_y} + \frac{M_{UX6}}{W_x} + \frac{S_{maxc6}}{A_U}$$

$$f_{cL6} = 7.01 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL6}}{f_{Sta24}} = 0.03 \quad \blacksquare < 1$$

**Комбинация 7 / Loadcase 7:**

$$S_{maxc7} := \frac{M_{X7n}}{c_L} + \frac{F_{Zmax7n}}{2}$$

$$S_{maxc7} = 12.99 \cdot \text{kN}$$

$$Q_{UY7} := F_{Y7n}$$

$$Q_{UY7} = 0.14 \cdot \text{kN}$$

$$M_{UX7} := \frac{Q_{UY7} \cdot l_1}{2 \cdot 2}$$

$$M_{UX7} = 0.03 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL7} := \frac{M_{Y7n}}{2 \cdot W_y} + \frac{M_{UX7}}{W_x} + \frac{S_{maxc7}}{A_U}$$

$$f_{cL7} = 69.53 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL7}}{f_{Sta24}} = 0.32 \quad \blacksquare < 1$$

**Комбинация 8 / Loadcase 8:**

$$S_{maxc8} := \frac{M_{X8n}}{c_L} + \frac{F_{Zmax8n}}{2}$$

$$S_{maxc8} = 52.91 \cdot \text{kN}$$

$$Q_{UY8} := F_{Y8n}$$

$$Q_{UY8} = 4.19 \cdot \text{kN}$$

$$M_{UX8} := \frac{Q_{UY8} \cdot l_1}{2 \cdot 2}$$

$$M_{UX8} = 0.84 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL8} := \frac{M_{Y8n}}{2 \cdot W_y} + \frac{M_{UX8}}{W_x} + \frac{S_{maxc8}}{A_U}$$

$$f_{cL8} = 82.88 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL8}}{f_{Sta24}} = 0.38 \quad \blacksquare < 1$$

**Комбинация 9.1 / Loadcase 9.1:**

$$S_{maxc91} := \frac{M_{X91n}}{c_L} + \frac{F_{Zmax91n}}{2}$$

$$S_{maxc91} = 7.92 \cdot \text{kN}$$

$$Q_{UY91} := F_{Y91n}$$

$$Q_{UY91} = 0.00 \cdot \text{kN}$$

$$M_{UX91} := \frac{Q_{UY91} \cdot l_1}{2 \cdot 2}$$

$$M_{UX91} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL91} := \frac{M_{Y91n}}{2 \cdot W_y} + \frac{M_{UX91}}{W_x} + \frac{S_{maxc91}}{A_U}$$

$$f_{cL91} = 84.67 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL91}}{f_{Sta24}} = 0.39 \quad \blacksquare < 1$$

**Комбинация 9.2 / Loadcase 9.2:**

$$S_{maxc92} := \frac{M_{X92n}}{c_L} + \frac{F_{Zmax92n}}{2}$$

$$S_{maxc92} = 18.53 \cdot \text{kN}$$

$$Q_{UY92} := F_{Y92n}$$

$$Q_{UY92} = 1.19 \cdot \text{kN}$$

$$M_{UX92} := \frac{Q_{UY92} \cdot l_1}{2 \cdot 2}$$

$$M_{UX92} = 0.24 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL92} := \frac{M_{Y92n}}{2 \cdot W_y} + \frac{M_{UX92}}{W_x} + \frac{S_{maxc92}}{A_U}$$

$$f_{cL92} = 86.64 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL92}}{f_{Sta24}} = 0.40 \quad \blacksquare < 1$$

**Комбинация 10.1 / Loadcase 10.1:**

$$S_{maxc101} := \frac{M_{X101n}}{c_L} + \frac{F_{Zmax101n}}{2}$$

$$S_{maxc101} = 10.56 \cdot \text{kN}$$

$$Q_{UY101} := F_{Y101n}$$

$$Q_{UY101} = 0.00 \cdot \text{kN}$$

$$M_{UX101} := \frac{Q_{UY101} \cdot l_1}{2 \cdot 2}$$

$$M_{UX101} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL101} := \frac{M_{Y101n}}{2 \cdot W_y} + \frac{M_{UX101}}{W_x} + \frac{S_{maxc101}}{A_U}$$

$$f_{cL101} = 66.41 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL101}}{f_{Sta24}} = 0.30 \quad \blacksquare < 1$$

**Комбинация 10.2 / Loadcase 10.2:**

$$S_{maxc102} := \frac{M_{X102n}}{c_L} + \frac{F_{Zmax102n}}{2}$$

$$S_{maxc102} = 50.49 \cdot \text{kN}$$

$$Q_{UY102} := F_{Y102n}$$

$$Q_{UY102} = 4.04 \cdot \text{kN}$$

$$M_{UX102} := \frac{Q_{UY102} \cdot l_1}{2 \cdot 2}$$

$$M_{UX102} = 0.81 \cdot \text{kN} \cdot \text{m}$$

$$f_{cL102} := \frac{M_{Y102n}}{2 \cdot W_y} + \frac{M_{UX102}}{W_x} + \frac{S_{maxc102}}{A_U}$$

$$f_{cL102} = 79.76 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{cL102}}{f_{Sta24}} = 0.37 \quad \blacksquare < 1$$

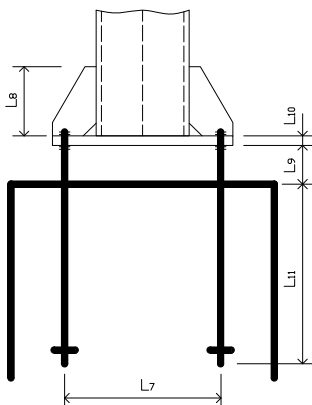
**Заклучение:** Всички напрежения са по-малки от  $\sigma_{max} = 218.18 \text{ MPa}$

**Conclusion:** All stresses are lower than  $\sigma_{max} = 218.18 \text{ MPa}$

**Свързващи планки / Fixing plates** **FL.140/8 S235**

$$l_2 := 140 \cdot \text{mm} \quad M_{\max fl} := 2 \cdot M_{UX102} \quad M_{\max fl} = 1.62 \cdot \text{kN} \cdot \text{m}$$

$$t_2 := 8 \text{ mm} \quad Q_{fl} := 2 \cdot \frac{M_{\max fl}}{c_L} \quad Q_{fl} = 12.21 \cdot \text{kN} \quad f_{fl} := \frac{M_{\max fl} \cdot 6}{t_2 \cdot l_2^2} \quad f_{fl} = 61.88 \cdot \frac{\text{N}}{\text{mm}^2} \quad \frac{f_{fl}}{f_{Sta24}} = 0.28 \quad \blacksquare < 1$$



нормална сила/  
normal force:

срязваща сила/  
shearing force:

огъващ момент/  
bending moment:

напрежение на натиск/  
compression stress:

избрани: **Анкерни болтове M24 S355**

chosen: **Anchorbolts M24 S355**

$$l_7 := 400 \text{ mm} \quad l_8 := 250 \text{ mm} \quad l_9 := 100.00 \text{ mm} \quad l_{10} := 20 \text{ mm}$$

$$l_{11min} := 600 \text{ mm} \quad A_{b24} := 353 \text{ mm}^2 \quad W_{b24} := 935.46 \text{ mm}^3$$

$$f_{ta5.6} = 245.45 \cdot \frac{\text{N}}{\text{mm}^{2.00}}$$

**Комбинация 2/ Loadcase 2:**

$$N_{\max 2} := \frac{M_{X2c}}{2 \cdot l_7} + \frac{M_{Y2c}}{2l_7} + \frac{F_{Z\max 2c}}{2 \cdot 2}$$

$$N_{\max 2} = 12.51 \cdot \text{kN}$$

$$Q_{\max 2} := \sqrt{\left(\frac{F_{X2c}}{4}\right)^2 + \left(\frac{F_{Y2c}}{4}\right)^2}$$

$$Q_{\max 2} = 0.50 \cdot \text{kN}$$

$$M_{\max 2} := Q_{\max 2} \cdot l_9 \cdot 0.5$$

$$M_{\max 2} = 0.02 \cdot \text{kN} \cdot \text{m}$$

$$f_{cb2} := \frac{N_{\max 2}}{A_{b24}} + \frac{M_{\max 2}}{W_{b24}} \quad f_{cb2} = 61.90 \cdot \text{MPa}$$

$$\frac{f_{cb2}}{f_{ta5.6}} = 0.25 \quad \blacksquare < 1$$

**Комбинация 3/ Loadcase 3:**

$$N_{\max 3} := \frac{M_{X3c}}{2l_7} + \frac{M_{Y3c}}{2 \cdot l_7} + \frac{F_{Z\max 3c}}{2 \cdot 2}$$

$$N_{\max 3} = 11.89 \cdot \text{kN}$$

$$Q_{\max 3} := \sqrt{\left(\frac{F_{X3c}}{4}\right)^2 + \left(\frac{F_{Y3c}}{4}\right)^2}$$

$$Q_{\max 3} = 0.53 \cdot \text{kN}$$

$$M_{\max 3} := Q_{\max 3} \cdot l_9 \cdot 0.5$$

$$M_{\max 3} = 0.03 \cdot \text{kN} \cdot \text{m}$$

$$f_{cb3} := \frac{N_{\max 3}}{A_{b24}} + \frac{M_{\max 3}}{W_{b24}} \quad f_{cb3} = 61.89 \cdot \text{MPa}$$

$$\frac{f_{cb3}}{f_{ta5.6}} = 0.25 \quad \blacksquare < 1$$

**Комбинация 4/ Loadcase 4:**

$$N_{\max 4} := \frac{M_{X4c}}{2l_7} + \frac{M_{Y4c}}{2 \cdot l_7} + \frac{F_{Z\max 4c}}{2 \cdot 2}$$

$$N_{\max 4} = 10.84 \cdot \text{kN}$$

$$Q_{\max 4} := \sqrt{\left(\frac{F_{X4c}}{4}\right)^2 + \left(\frac{F_{Y4c}}{4}\right)^2}$$

$$Q_{\max 4} = 0.51 \cdot \text{kN}$$

$$M_{\max 4} := Q_{\max 4} \cdot l_9 \cdot 0.5$$

$$M_{\max 4} = 0.03 \cdot \text{kN} \cdot \text{m}$$

$$f_{cb4} := \frac{N_{\max 4}}{A_{b24}} + \frac{M_{\max 4}}{W_{b24}} \quad f_{cb4} = 58.12 \cdot \text{MPa}$$

$$\frac{f_{cb4}}{f_{ta5.6}} = 0.24 \quad \blacksquare < 1$$

нормална сила/  
normal force:

срязваща сила/  
shearing force:

огъващ момент/  
bending moment:

напрежение на натиск/  
compression stress:

**Комбинация 5/ Loadcase 5:****нормална сила/  
normal force:**

$$N_{\max 5} := \frac{M_{X5n}}{2l_7} + \frac{M_{Y5n}}{2 \cdot l_7} + \frac{F_{Z\max 5n}}{2 \cdot 2}$$

$$N_{\max 5} = 16.91 \cdot \text{kN}$$

**срязваща сила/  
shearing force:**

$$Q_{\max 5} := \sqrt{\left(\frac{F_{X5n}}{4}\right)^2 + \left(\frac{F_{Y5n}}{4}\right)^2}$$

$$Q_{\max 5} = 0.60 \cdot \text{kN}$$

**огъващ момент/  
bending moment:**

$$M_{\max 5} := Q_{\max 5} \cdot l_g \cdot 0.5$$

$$M_{\max 5} = 0.03 \cdot \text{kN} \cdot \text{m}$$

**напрежение на натиск/  
compression stress:**

$$f_{cb5} := \frac{N_{\max 5}}{A_{b24}} + \frac{M_{\max 5}}{W_{b24}} \quad f_{cb5} = 79.98 \cdot \text{MPa}$$

$$\frac{f_{cb5}}{f_{ta5.6}} = 0.33 \quad \blacksquare < 1$$

**Комбинация 6/ Loadcase 6:****нормална сила/  
normal force:**

$$N_{\max 6} := \frac{M_{X6n}}{2l_7} + \frac{M_{Y6n}}{2 \cdot l_7} + \frac{F_{Z\max 6n}}{2 \cdot 2}$$

$$N_{\max 6} = 4.45 \cdot \text{kN}$$

**срязваща сила/  
shearing force:**

$$Q_{\max 6} := \sqrt{\left(\frac{F_{X6n}}{4}\right)^2 + \left(\frac{F_{Y6n}}{4}\right)^2}$$

$$Q_{\max 6} = 0.04 \cdot \text{kN}$$

**огъващ момент/  
bending moment:**

$$M_{\max 6} := Q_{\max 6} \cdot l_g \cdot 0.5$$

$$M_{\max 6} = 0.03 \cdot \text{kN} \cdot \text{m}$$

**напрежение на натиск/  
compression stress:**

$$f_{cb6} := \frac{N_{\max 6}}{A_{b24}} + \frac{M_{\max 6}}{W_{b24}} \quad f_{cb6} = 44.67 \cdot \text{MPa}$$

$$\frac{f_{cb6}}{f_{ta5.6}} = 0.18 \quad \blacksquare < 1$$

**Комбинация 7/ Loadcase 7:****нормална сила/  
normal force:**

$$N_{\max 7} := \frac{M_{X7n}}{2l_7} + \frac{M_{Y7n}}{2 \cdot l_7} + \frac{F_{Z\max 7n}}{2 \cdot 2}$$

$$N_{\max 7} = 18.89 \cdot \text{kN}$$

**срязваща сила/  
shearing force:**

$$Q_{\max 7} := \sqrt{\left(\frac{F_{X7n}}{4}\right)^2 + \left(\frac{F_{Y7n}}{4}\right)^2}$$

$$Q_{\max 7} = 1.01 \cdot \text{kN}$$

**огъващ момент/  
bending moment:**

$$M_{\max 7} := Q_{\max 7} \cdot l_g \cdot 0.5$$

$$M_{\max 7} = 0.05 \cdot \text{kN} \cdot \text{m}$$

**напрежение на натиск/  
compression stress:**

$$f_{cb7} := \frac{N_{\max 7}}{A_{b24}} + \frac{M_{\max 7}}{W_{b24}} \quad f_{cb7} = 107.57 \cdot \text{MPa}$$

$$\frac{f_{cb7}}{f_{ta5.6}} = 0.44 \quad \blacksquare < 1$$

**Комбинация 8/ Loadcase 8:****нормална сила/  
normal force:**

$$N_{\max 8} := \frac{M_{X8n}}{2l_7} + \frac{M_{Y8n}}{2 \cdot l_7} + \frac{F_{Z\max 8n}}{2 \cdot 2}$$

$$N_{\max 8} = 18.89 \cdot \text{kN}$$

**срязваща сила/  
shearing force:**

$$Q_{\max 8} := \sqrt{\left(\frac{F_{X8n}}{4}\right)^2 + \left(\frac{F_{Y8n}}{4}\right)^2}$$

$$Q_{\max 8} = 1.05 \cdot \text{kN}$$

**огъващ момент/  
bending moment:**

$$M_{\max 8} := Q_{\max 8} \cdot l_g \cdot 0.5$$

$$M_{\max 8} = 0.05 \cdot \text{kN} \cdot \text{m}$$

**напрежение на натиск/  
compression stress:**

$$f_{cb8} := \frac{N_{\max 8}}{A_{b24}} + \frac{M_{\max 8}}{W_{b24}} \quad f_{cb8} = 109.44 \cdot \text{MPa}$$

$$\frac{f_{cb8}}{f_{ta5.6}} = 0.45 \quad \blacksquare < 1$$

**Комбинация 9.1/ Loadcase 9.1:****нормална сила/  
normal force:**

$$N_{\max 91} := \frac{M_{X91n}}{2l_7} + \frac{M_{Y91n}}{2 \cdot l_7} + \frac{F_{Z\max 91n}}{2 \cdot 2}$$

$$N_{\max 91} = 21.09 \cdot \text{kN}$$



срязваща сила/  
shearing force:огъващ момент/  
bending moment:напрежение на натиск/  
compression stress:

$$Q_{\max 91} := \sqrt{\left(\frac{F_{X91n}}{4}\right)^2 + \left(\frac{F_{Y91n}}{4}\right)^2}$$

$$M_{\max 91} := Q_{\max 91} \cdot l_g \cdot 0.5$$

$$f_{cb91} := \frac{N_{\max 91}}{A_{b24}} + \frac{M_{\max 91}}{W_{b24}} \quad f_{cb91} = 109.67 \cdot \text{MPa}$$

$$Q_{\max 91} = 0.93 \cdot \text{kN}$$

$$M_{\max 91} = 0.05 \cdot \text{kN} \cdot \text{m}$$

$$\frac{f_{cb91}}{f_{ta5.6}} = 0.45 \quad \blacksquare < 1$$

**Комбинация 9.2/ Loadcase 9.2:**нормална сила/  
normal force:срязваща сила/  
shearing force:огъващ момент/  
bending moment:напрежение на натиск/  
compression stress:

$$N_{\max 92} := \frac{M_{X92n}}{2l_7} + \frac{M_{Y92n}}{2 \cdot l_7} + \frac{F_{Z\max 92n}}{2 \cdot 2}$$

$$Q_{\max 92} := \sqrt{\left(\frac{F_{X92n}}{4}\right)^2 + \left(\frac{F_{Y92n}}{4}\right)^2}$$

$$M_{\max 92} := Q_{\max 92} \cdot l_g \cdot 0.5$$

$$f_{cb92} := \frac{N_{\max 92}}{A_{b24}} + \frac{M_{\max 92}}{W_{b24}} \quad f_{cb92} = 93.63 \cdot \text{MPa}$$

$$N_{\max 92} = 20.43 \cdot \text{kN}$$

$$Q_{\max 92} = 0.67 \cdot \text{kN}$$

$$M_{\max 92} = 0.03 \cdot \text{kN} \cdot \text{m}$$

$$\frac{f_{cb92}}{f_{ta5.6}} = 0.38 \quad \blacksquare < 1$$

**Комбинация 10.1/ Loadcase 10.1:**нормална сила/  
normal force:срязваща сила/  
shearing force:огъващ момент/  
bending moment:напрежение на натиск/  
compression stress:

$$N_{\max 101} := \frac{M_{X101n}}{2l_7} + \frac{M_{Y101n}}{2 \cdot l_7} + \frac{F_{Z\max 101n}}{2 \cdot 2}$$

$$Q_{\max 101} := \sqrt{\left(\frac{F_{X101n}}{4}\right)^2 + \left(\frac{F_{Y101n}}{4}\right)^2}$$

$$M_{\max 101} := Q_{\max 101} \cdot l_g \cdot 0.5$$

$$f_{cb101} := \frac{N_{\max 101}}{A_{b24}} + \frac{M_{\max 101}}{W_{b24}} \quad f_{cb101} = 105.26 \cdot \text{MPa}$$

$$N_{\max 101} = 18.09 \cdot \text{kN}$$

$$Q_{\max 101} = 1.01 \cdot \text{kN}$$

$$M_{\max 101} = 0.05 \cdot \text{kN} \cdot \text{m}$$

$$\frac{f_{cb101}}{f_{ta5.6}} = 0.43 \quad \blacksquare < 1$$

**Комбинация 10.2/ Loadcase 10.2:**нормална сила/  
normal force:срязваща сила/  
shearing force:огъващ момент/  
bending moment:напрежение на натиск/  
compression stress:

$$N_{\max 102} := \frac{M_{X102n}}{2l_7} + \frac{M_{Y102n}}{2 \cdot l_7} + \frac{F_{Z\max 102n}}{2 \cdot 2}$$

$$Q_{\max 102} := \sqrt{\left(\frac{F_{X102n}}{4}\right)^2 + \left(\frac{F_{Y102n}}{4}\right)^2}$$

$$M_{\max 102} := Q_{\max 102} \cdot l_g \cdot 0.5$$

$$f_{cb102} := \frac{N_{\max 102}}{A_{b24}} + \frac{M_{\max 102}}{W_{b24}} \quad f_{cb102} = 105.26 \cdot \text{MPa}$$

$$N_{\max 102} = 18.09 \cdot \text{kN}$$

$$Q_{\max 102} = 1.01 \cdot \text{kN}$$

$$M_{\max 102} = 0.05 \cdot \text{kN} \cdot \text{m}$$

$$\frac{f_{cb102}}{f_{ta5.6}} = 0.43 \quad \blacksquare < 1$$

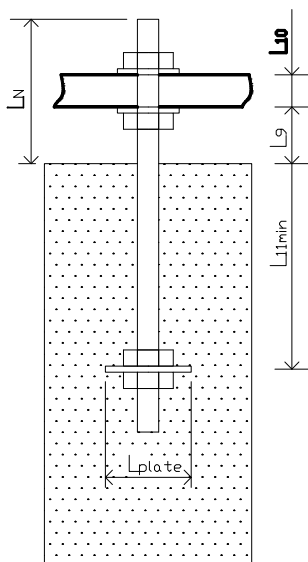
**Анкерни планки/ Anchor plates****pl. 10/100x100**

напрежение на натиск/ срязваща сила бетон **B20**  
compression stress/ shearing stress concrete **B20**

$$f_{\text{conpa}} := 12.3 \cdot \frac{N}{\text{mm}^2}$$

$$f_{\text{consa}} := 1.80 \cdot \frac{N}{\text{mm}^2}$$

$$l_{11\text{min}} = 0.60 \text{ m} \quad l_{\text{plate}} := 100.00 \text{ mm}$$

**Комбинация 2/ Loadcase 2:**

$$f_{\text{comp2}} := \frac{N_{\text{max2}}}{l_{\text{plate}}^2 - A_{b24}} \quad f_{\text{comp2}} = 1.30 \cdot \text{MPa}$$

$$\frac{f_{\text{comp2}}}{f_{\text{conpa}}} = 0.11 \quad \blacksquare < 1$$

$$f_{\text{cons2}} := \frac{N_{\text{max2}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons2}} = 0.05 \cdot \text{MPa}$$

$$\frac{f_{\text{cons2}}}{f_{\text{consa}}} = 0.03 \quad \blacksquare < 1$$

**Комбинация 3/ Loadcase 3:**

$$f_{\text{comp3}} := \frac{N_{\text{max3}}}{l_{\text{plate}}^2 - A_{b24}} \quad f_{\text{comp3}} = 1.23 \cdot \text{MPa}$$

$$\frac{f_{\text{comp3}}}{f_{\text{conpa}}} = 0.10 \quad \blacksquare < 1$$

$$f_{\text{cons3}} := \frac{N_{\text{max3}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons3}} = 0.05 \cdot \text{MPa}$$

$$\frac{f_{\text{cons3}}}{f_{\text{consa}}} = 0.03 \quad \blacksquare < 1$$

**Комбинация 4/ Loadcase 4:**

$$f_{\text{comp4}} := \frac{N_{\text{max4}}}{l_{\text{plate}}^2 - A_{b24}} \quad f_{\text{comp4}} = 1.12 \cdot \text{MPa}$$

$$\frac{f_{\text{comp4}}}{f_{\text{conpa}}} = 0.09 \quad \blacksquare < 1$$

$$f_{\text{cons4}} := \frac{N_{\text{max4}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons4}} = 0.05 \cdot \text{MPa}$$

$$\frac{f_{\text{cons4}}}{f_{\text{consa}}} = 0.03 \quad \blacksquare < 1$$

**Комбинация 5/ Loadcase 5:**

$$f_{\text{comp5}} := \frac{N_{\text{max5}}}{l_{\text{plate}}^2 - A_{b24}} \quad f_{\text{comp5}} = 1.75 \cdot \text{MPa}$$

$$\frac{f_{\text{comp5}}}{f_{\text{conpa}}} = 0.14 \quad \blacksquare < 1$$

$$f_{\text{cons5}} := \frac{N_{\text{max5}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons5}} = 0.07 \cdot \text{MPa}$$

$$\frac{f_{\text{cons5}}}{f_{\text{consa}}} = 0.04 \quad \blacksquare < 1$$

**Комбинация 7/ Loadcase 7:**

$$f_{\text{comp7}} := \frac{N_{\text{max7}}}{l_{\text{plate}}^2 - A_{b24}} \quad f_{\text{comp7}} = 1.96 \cdot \text{MPa}$$

$$\frac{f_{\text{comp7}}}{f_{\text{conpa}}} = 0.16 \quad \blacksquare < 1$$

$$f_{\text{cons7}} := \frac{N_{\text{max7}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons7}} = 0.08 \cdot \text{MPa}$$

$$\frac{f_{\text{cons7}}}{f_{\text{consa}}} = 0.04 \quad \blacksquare < 1$$

**Комбинация 8/ Loadcase 8:**

$$f_{\text{comp8}} := \frac{N_{\text{max8}}}{l_{\text{plate}}^2 - A_{b24}} \quad f_{\text{comp8}} = 1.96 \cdot \text{MPa}$$

$$\frac{f_{\text{comp8}}}{f_{\text{conpa}}} = 0.16 \quad \blacksquare < 1$$

$$f_{\text{cons8}} := \frac{N_{\text{max8}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons8}} = 0.08 \cdot \text{MPa}$$

$$\frac{f_{\text{cons8}}}{f_{\text{consa}}} = 0.04 \quad \blacksquare < 1$$

**Комбинация 9.1/ Loadcase 9.1:**

$$f_{\text{comp91}} := \frac{N_{\text{max91}}}{l_{\text{plate}}^2 - A_{\text{b24}}} \quad f_{\text{comp91}} = 2.19 \cdot \text{MPa}$$

$$\frac{f_{\text{comp91}}}{f_{\text{compa}}} = 0.18 \quad \blacksquare < 1$$

$$f_{\text{cons91}} := \frac{N_{\text{max91}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons91}} = 0.09 \cdot \text{MPa}$$

$$\frac{f_{\text{cons91}}}{f_{\text{consa}}} = 0.05 \quad \blacksquare < 1$$

**Комбинация 9.2/ Loadcase 9.2:**

$$f_{\text{comp92}} := \frac{N_{\text{max92}}}{l_{\text{plate}}^2 - A_{\text{b24}}} \quad f_{\text{comp92}} = 2.12 \cdot \text{MPa}$$

$$\frac{f_{\text{comp92}}}{f_{\text{compa}}} = 0.17 \quad \blacksquare < 1$$

$$f_{\text{cons92}} := \frac{N_{\text{max92}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons92}} = 0.09 \cdot \text{MPa}$$

$$\frac{f_{\text{cons92}}}{f_{\text{consa}}} = 0.05 \quad \blacksquare < 1$$

**Комбинация 10.1/ Loadcase 10.1:**

$$f_{\text{comp101}} := \frac{N_{\text{max101}}}{l_{\text{plate}}^2 - A_{\text{b24}}} \quad f_{\text{comp101}} = 1.87 \cdot \text{MPa}$$

$$\frac{f_{\text{comp101}}}{f_{\text{compa}}} = 0.15 \quad \blacksquare < 1$$

$$f_{\text{cons101}} := \frac{N_{\text{max101}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons101}} = 0.08 \cdot \text{MPa}$$

$$\frac{f_{\text{cons101}}}{f_{\text{consa}}} = 0.04 \quad \blacksquare < 1$$

**Комбинация 10.2/ Loadcase 10.2:**

$$f_{\text{comp102}} := \frac{N_{\text{max102}}}{l_{\text{plate}}^2 - A_{\text{b24}}} \quad f_{\text{comp102}} = 1.87 \cdot \text{MPa}$$

$$\frac{f_{\text{comp102}}}{f_{\text{compa}}} = 0.15 \quad \blacksquare < 1$$

$$f_{\text{cons102}} := \frac{N_{\text{max102}}}{4 \cdot l_{\text{plate}} \cdot l_{11\text{min}}} \quad f_{\text{cons102}} = 0.08 \cdot \text{MPa}$$

$$\frac{f_{\text{cons102}}}{f_{\text{consa}}} = 0.04 \quad \blacksquare < 1$$

**Планки/ Plates      pl. 8/200x120      S235**

$$b_U = 140.00 \cdot \text{mm} \quad l_8 = 250.00 \cdot \text{mm} \quad t_r := 8 \cdot \text{mm} \quad l_{\text{supportingY}} := (l_7 - b_U) \cdot 0.5 \quad l_{\text{supportingY}} = 130.00 \cdot \text{mm} \quad l_{\text{bolt}} := 20 \cdot \text{mm}$$

$$W_r := \frac{l_8^2 \cdot t_r}{6} \quad W_r = 8.33 \times 10^4 \cdot \text{mm}^3$$

**Комбинация 2/ Loadcase 2:**

$$f_{\text{tr2}} := \frac{N_{\text{max2}} \cdot l_{\text{supportingY}}}{W_r} \quad f_{\text{tr2}} = 19.51 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{\text{tr2}}}{f_{\text{Sta24}}} = 0.09 \quad \blacksquare < 1$$

**Комбинация 3/ Loadcase 3:**

$$f_{\text{tr3}} := \frac{N_{\text{max3}} \cdot l_{\text{supportingY}}}{W_r} \quad f_{\text{tr3}} = 18.55 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{\text{tr3}}}{f_{\text{Sta24}}} = 0.09 \quad \blacksquare < 1$$

**Комбинация 4/ Loadcase 4:**

$$f_{\text{tr4}} := \frac{N_{\text{max4}} \cdot l_{\text{supportingY}}}{W_r} \quad f_{\text{tr4}} = 16.90 \cdot \frac{\text{N}}{\text{mm}^2}$$

$$\frac{f_{\text{tr4}}}{f_{\text{Sta24}}} = 0.08 \quad \blacksquare < 1$$

**Комбинация 5/ Loadcase 5:**

$$f_{tr5} := \frac{N_{max5} \cdot l_{supportingY}}{W_r} \quad f_{tr5} = 26.38 \cdot \frac{N}{mm^2} \quad \frac{f_{tr5}}{f_{Sta24}} = 0.12 \quad \blacksquare < 1$$

**Комбинация 6/ Loadcase 6:**

$$f_{tr6} := \frac{N_{max6} \cdot l_{supportingY}}{W_r} \quad f_{tr6} = 6.94 \cdot \frac{N}{mm^2} \quad \frac{f_{tr6}}{f_{Sta24}} = 0.03 \quad \blacksquare < 1$$

**Комбинация 7/ Loadcase 7:**

$$f_{tr7} := \frac{N_{max7} \cdot l_{supportingY}}{W_r} \quad f_{tr7} = 29.47 \cdot \frac{N}{mm^2} \quad \frac{f_{tr7}}{f_{Sta24}} = 0.14 \quad \blacksquare < 1$$

**Комбинация 8/ Loadcase 8:**

$$f_{tr8} := \frac{N_{max8} \cdot l_{supportingY}}{W_r} \quad f_{tr8} = 29.47 \cdot \frac{N}{mm^2} \quad \frac{f_{tr8}}{f_{Sta24}} = 0.14 \quad \blacksquare < 1$$

**Комбинация 9.1/ Loadcase 9.1:**

$$f_{tr91} := \frac{N_{max91} \cdot l_{supportingY}}{W_r} \quad f_{tr91} = 32.91 \cdot \frac{N}{mm^2} \quad \frac{f_{tr91}}{f_{Sta24}} = 0.15 \quad \blacksquare < 1$$

**Комбинация 9.2/ Loadcase 9.2:**

$$f_{tr92} := \frac{N_{max92} \cdot l_{supportingY}}{W_r} \quad f_{tr92} = 31.86 \cdot \frac{N}{mm^2} \quad \frac{f_{tr92}}{f_{Sta24}} = 0.15 \quad \blacksquare < 1$$

**Комбинация 10.1/ Loadcase 10.1:**

$$f_{tr101} := \frac{N_{max101} \cdot l_{supportingY}}{W_r} \quad f_{tr101} = 28.22 \cdot \frac{N}{mm^2} \quad \frac{f_{tr101}}{f_{Sta24}} = 0.13 \quad \blacksquare < 1$$

**Комбинация 10.2/ Loadcase 10.2:**

$$f_{tr102} := \frac{N_{max102} \cdot l_{supportingY}}{W_r} \quad f_{tr102} = 28.22 \cdot \frac{N}{mm^2} \quad \frac{f_{tr102}}{f_{Sta24}} = 0.13 \quad \blacksquare < 1$$

**Опорна планка/ Supporting plate****pl. 20/520x520 S335**

$$l_{10} = 20.00 \cdot mm$$

$$l_{suppY} := (l_7 - a_L) \cdot 0.5 + 20 \cdot mm \quad l_{suppY} = 70.00 \cdot mm \quad l_{bolt} = 20.00 \cdot mm$$

$$W_{pl} := \frac{l_{10}^2}{6} (2 \cdot l_{suppY} + l_{bolt}) \quad W_{pl} = 1.07 \times 10^4 \cdot mm^3$$

**Комбинация 2/ Loadcase 2:**

$$f_{tGp2} := \frac{N_{max2} \cdot l_{suppY}}{W_{pl}} \quad f_{tGp2} = 82.07 \cdot \frac{N}{mm^2} \quad \frac{f_{tGp2}}{f_{Sta36}} = 0.25 \quad \blacksquare < 1$$

**Комбинация 3/ Loadcase 3:**

$$f_{tGp3} := \frac{N_{max3} \cdot l_{suppY}}{W_{pl}} \quad f_{tGp3} = 78.02 \cdot \frac{N}{mm^2} \quad \frac{f_{tGp3}}{f_{Sta36}} = 0.24 \quad \blacksquare < 1$$

**Комбинация 4/ Loadcase 4:**

$$f_{tGp4} := \frac{N_{\max 4} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp4} = 71.11 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp4}}{f_{\text{Sta36}}} = 0.22 \quad \blacksquare < 1$$

**Комбинация 5/ Loadcase 5:**

$$f_{tGp5} := \frac{N_{\max 5} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp5} = 110.98 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp5}}{f_{\text{Sta36}}} = 0.34 \quad \blacksquare < 1$$

**Комбинация 6/ Loadcase 6:**

$$f_{tGp6} := \frac{N_{\max 6} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp6} = 29.19 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp6}}{f_{\text{Sta36}}} = 0.09 \quad \blacksquare < 1$$

**Комбинация 7/ Loadcase 7:**

$$f_{tGp7} := \frac{N_{\max 7} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp7} = 123.97 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp7}}{f_{\text{Sta36}}} = 0.38 \quad \blacksquare < 1$$

**Комбинация 8/ Loadcase 8:**

$$f_{tGp8} := \frac{N_{\max 8} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp8} = 123.97 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp8}}{f_{\text{Sta36}}} = 0.38 \quad \blacksquare < 1$$

**Комбинация 9.1/ Loadcase 9.1:**

$$f_{tGp91} := \frac{N_{\max 91} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp91} = 138.43 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp91}}{f_{\text{Sta36}}} = 0.42 \quad \blacksquare < 1$$

**Комбинация 9.2/ Loadcase 9.2:**

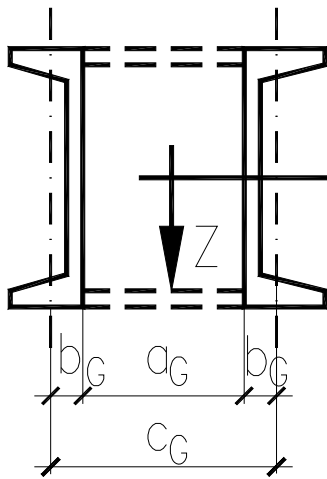
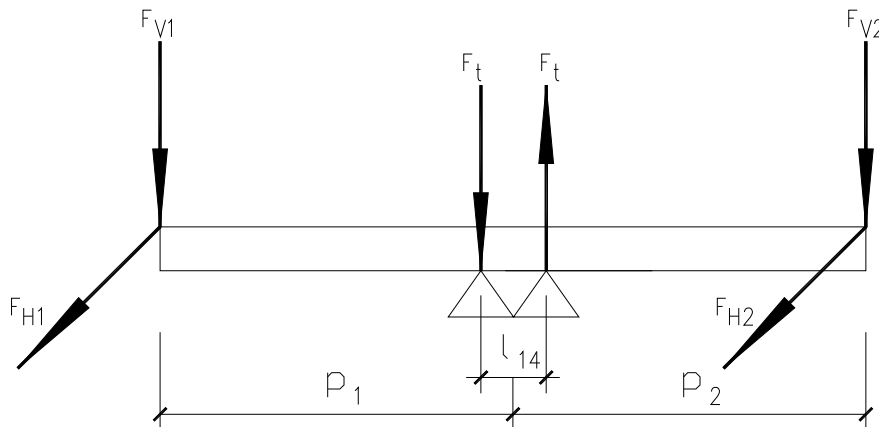
$$f_{tGp92} := \frac{N_{\max 92} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp92} = 134.04 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp92}}{f_{\text{Sta36}}} = 0.41 \quad \blacksquare < 1$$

**Комбинация 10.1/ Loadcase 10.1:**

$$f_{tGp101} := \frac{N_{\max 101} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp101} = 118.69 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp101}}{f_{\text{Sta36}}} = 0.36 \quad \blacksquare < 1$$

**Комбинация 10.2/ Loadcase 10.2:**

$$f_{tGp102} := \frac{N_{\max 102} \cdot l_{\text{suppY}}}{W_{pl}} \quad f_{tGp102} = 118.69 \cdot \frac{N}{\text{mm}^2} \quad \frac{f_{tGp102}}{f_{\text{Sta36}}} = 0.36 \quad \blacksquare < 1$$

**Оразмеряване на гредата / Dimensioning of the beam**избран профил/ chosen **2UPN 180 S235**

$$a_G := 140\text{mm} \quad b_G := 17.5\text{mm} \quad l_{14} := 230\text{mm}$$

$$c_G := a_G + 2 \cdot b_G \quad c_G = 175.00\text{mm} \quad h_{U2} := 140\text{mm}$$

$$W_{UV} := 14.7\text{cm}^3 \quad W_{UH} := 86.4\text{cm}^3$$

$$f_{\text{Sta24}} = 218.18 \cdot \frac{\text{N}}{\text{mm}^2}$$

**Комбинация 3/ Loadcase 3:**

$$F_{1H3} := \frac{F_{WX1c} + F_{LX1c} + F_{SX1c}}{2}$$

$$F_{1H3} = 0.34 \cdot \text{kN}$$

$$F_{2H3} := \frac{F_{WX2c} + F_{LX2c} + F_{SX2c}}{2}$$

$$F_{2H3} = 0.35 \cdot \text{kN}$$

$$F_{1V3} := \frac{F_{AZ1c}}{2}$$

$$F_{1V3} = 2.40 \cdot \text{kN}$$

$$F_{2V3} := \frac{F_{AZ2c}}{2}$$

$$F_{2V3} = 2.07 \cdot \text{kN}$$

$$M_{1V3} := F_{1V3} \cdot p_1 + F_{SY1c} \cdot \frac{d_1}{2}$$

$$M_{1V3} = 2.39 \cdot \text{kN} \cdot \text{m}$$

$$M_{2V3} := F_{2V3} \cdot p_2 + F_{SY2c} \cdot \frac{d_2}{2}$$

$$M_{2V3} = 2.08 \cdot \text{kN} \cdot \text{m}$$

$$M_{1H3} := F_{1H3} \cdot p_1 + q_{\text{gwx}} \cdot 0.5 \cdot p_1^2$$

$$M_{1H3} = 0.35 \cdot \text{kN} \cdot \text{m}$$

$$M_{2H3} := F_{2H3} \cdot p_2 + q_{\text{gwx}} \cdot 0.5 \cdot p_2^2$$

$$M_{2H3} = 0.36 \cdot \text{kN} \cdot \text{m}$$

$$M_{1T3} := 0$$

$$M_{1T3} = 0.00 \cdot \text{kN}$$

$$M_{2T3} := 0$$

$$M_{2T3} = 0.00 \cdot \text{kN}$$

$$f_{1G3} := \frac{M_{1H3}}{W_{UV}} + \frac{M_{1V3}}{W_{UH}}$$

$$f_{1G3} = 5.18 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{1G3}}{f_{\text{Sta24}}} = 0.24 \quad \blacksquare < 1$$

$$f_{2G3} := \frac{M_{2H3}}{W_{UV}} + \frac{M_{2V3}}{W_{UH}}$$

$$f_{2G3} = 4.85 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{2G3}}{f_{\text{Sta24}}} = 0.22 \quad \blacksquare < 1$$

$$F_{\text{tmax3}} := \frac{M_{1V3}}{l_{14}} + \frac{M_{1T3}}{l_{14}}$$

$$F_{\text{tmax3}} = 10.41 \cdot \text{kN}$$

**Комбинация 4/ Loadcase 4:**

$$\begin{aligned}
 F_{1H4} &:= \frac{F_{SX1c}}{2} & F_{1H4} &= 0.00 \cdot \text{kN} & F_{2H4} &:= \frac{F_{SX2c}}{2} & F_{2H4} &= 0.00 \cdot \text{kN} \\
 F_{1V4} &:= \frac{F_{AZ1c}}{2} + F_{SX1c} \cdot \frac{d_1}{c_G} & F_{1V4} &= 2.40 \cdot \text{kN} & F_{2V4} &:= \frac{F_{AZ2c}}{2} + F_{SX2c} \cdot \frac{d_2}{c_G} & F_{2V4} &= 2.07 \cdot \text{kN} \\
 M_{1V4} &:= F_{1V4} \cdot p_1 + F_{WY1c} \cdot \frac{c_1}{2} + (F_{SY1c} + F_{LY1c}) \cdot \frac{d_1}{2} & M_{2V4} &:= F_{2V4} \cdot p_2 + F_{WY2c} \cdot \frac{c_2}{2} + (F_{SY2c} + F_{LY2c}) \cdot \frac{d_2}{2} \\
 M_{1V4} &= 2.72 \cdot \text{kN} \cdot \text{m} & M_{2V4} &= 2.40 \cdot \text{kN} \cdot \text{m} \\
 M_{1H4} &:= F_{1H4} \cdot p_1 & M_{1H4} &= 0.00 \cdot \text{kN} \cdot \text{m} & M_{2H4} &:= F_{2H4} \cdot p_2 & M_{2H4} &= 0.32 \cdot \text{kN} \cdot \text{m} \\
 M_{1T4} &:= 0 & M_{1T4} &= 0.00 \cdot \text{kN} & M_{2T4} &:= 0 & M_{2T4} &= 0.00 \cdot \text{kN} \\
 f_{1G4} &:= \frac{M_{1H4}}{W_{UV}} + \frac{M_{1V4}}{W_{UH}} & f_{1G4} &= 3.15 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{1G4}}{f_{Sta24}} &= 0.14 & & < 1 \\
 f_{2G4} &:= \frac{M_{2H4}}{W_{UV}} + \frac{M_{2V4}}{W_{UH}} & f_{2G4} &= 4.92 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{2G4}}{f_{Sta24}} &= 0.23 & & < 1 \\
 F_{tmax4} &:= \frac{M_{1V4}}{l_{14}} + \frac{M_{1T4}}{l_{14}} & F_{tmax4} &= 11.84 \cdot \text{kN}
 \end{aligned}$$

**Комбинация 5/ Loadcase 5:**

$$\begin{aligned}
 F_{1H5} &:= 0 & F_{1H5} &= 0.00 \cdot \text{kN} & F_{2H5} &:= 0 & F_{2H5} &= 0.00 \cdot \text{kN} \\
 F_{1V5} &:= \frac{F_{AZ1n}}{2} & F_{1V5} &= 2.00 \cdot \text{kN} & F_{2V5} &:= \frac{F_{AZ2n}}{2} & F_{2V5} &= 1.73 \cdot \text{kN} \\
 M_{1V5} &:= F_{1V5} \cdot p_1 & M_{1V5} &= 1.80 \cdot \text{kN} \cdot \text{m} & M_{2V5} &:= F_{2V5} \cdot p_2 & M_{2V5} &= 1.55 \cdot \text{kN} \cdot \text{m} \\
 M_{1H5} &:= F_{1H5} \cdot p_1 + q_{gwx} \cdot 0.5 \cdot p_1^2 & M_{1H5} &= 0.04 \cdot \text{kN} \cdot \text{m} & M_{2H5} &:= F_{2H5} \cdot p_2 + q_{gwx} \cdot 0.5 \cdot p_2^2 & M_{2H5} &= 0.04 \cdot \text{kN} \cdot \text{m} \\
 M_{1T5} &:= 0 & M_{1T5} &= 0.00 \cdot \text{kN} & M_{2T5} &:= 0 & M_{2T5} &= 0.00 \cdot \text{kN} \\
 f_{1G5} &:= \frac{M_{1H5}}{W_{UV}} + \frac{M_{1V5}}{W_{UH}} & f_{1G5} &= 2.38 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{1G5}}{f_{Sta24}} &= 0.11 & & < 1 \\
 f_{2G5} &:= \frac{M_{2H5}}{W_{UV}} + \frac{M_{2V5}}{W_{UH}} & f_{2G5} &= 2.09 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{2G5}}{f_{Sta24}} &= 0.10 & & < 1 \\
 F_{tmax5} &:= \frac{M_{1V5}}{l_{14}} + \frac{M_{1T5}}{l_{14}} & F_{tmax5} &= 7.83 \cdot \text{kN}
 \end{aligned}$$

**Комбинация 7/ Loadcase 7:**

$$\begin{aligned}
 F_{1H7} &:= \frac{F_{EQX1n} + F_{SX1n}}{2} & F_{1H7} &= 0.67 \cdot \text{kN} & F_{2H7} &:= \frac{F_{EQX2n} + F_{SX2n}}{2} & F_{2H7} &= 0.58 \cdot \text{kN} \\
 F_{1V7} &:= \frac{F_{AZ1n} + F_{EQZ1n}}{2} & F_{1V7} &= 2.67 \cdot \text{kN} & F_{2V7} &:= \frac{F_{AZ2n} + F_{EQZ2n}}{2} & F_{2V7} &= 2.30 \cdot \text{kN} \\
 M_{1V7} &:= F_{1V7} \cdot p_1 + F_{SY1n} \cdot \frac{d_1}{2} & M_{1V7} &= 2.58 \cdot \text{kN} \cdot \text{m} & M_{2V7} &:= F_{2V7} \cdot p_2 + F_{SY2n} \cdot \frac{d_2}{2} & M_{2V7} &= 2.24 \cdot \text{kN} \cdot \text{m} \\
 M_{1H7} &:= F_{1H7} \cdot p_1 & M_{1H7} &= 0.60 \cdot \text{kN} \cdot \text{m} & M_{2H7} &:= F_{2H7} \cdot p_2 & M_{2H7} &= 0.52 \cdot \text{kN} \cdot \text{m}
 \end{aligned}$$

$$M_{1T7} := 0$$

$$M_{1T7} = 0.00 \cdot \text{kN}$$

$$M_{2T7} := 0$$

$$M_{2T7} = 0.00 \cdot \text{kN}$$

$$f_{1G7} := \frac{M_{1H7}}{W_{UV}} + \frac{M_{1V7}}{W_{UH}}$$

$$f_{1G7} = 7.08 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{1G7}}{f_{\text{Sta24}}} = 0.32 \quad \blacksquare < 1$$

$$f_{2G7} := \frac{M_{2H7}}{W_{UV}} + \frac{M_{2V7}}{W_{UH}}$$

$$f_{2G7} = 6.12 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{2G7}}{f_{\text{Sta24}}} = 0.28 \quad \blacksquare < 1$$

$$F_{\text{tmax7}} := \frac{M_{1V7}}{l_{14}} + \frac{M_{1T7}}{l_{14}}$$

$$F_{\text{tmax7}} = 11.22 \cdot \text{kN}$$

### Комбинация 8/ Loadcase 8:

$$F_{1H8} := \frac{F_{\text{SX1n}}}{2}$$

$$F_{1H8} = 0.00 \cdot \text{kN}$$

$$F_{2H8} := \frac{F_{\text{SX2n}}}{2}$$

$$F_{2H8} = 0.00 \cdot \text{kN}$$

$$F_{1V8} := \frac{F_{\text{AZ1n}} + F_{\text{EQZ1n}}}{2}$$

$$F_{1V8} = 2.67 \cdot \text{kN}$$

$$F_{2V8} := \frac{F_{\text{AZ2n}} + F_{\text{EQZ2n}}}{2}$$

$$F_{2V8} = 2.30 \cdot \text{kN}$$

$$M_{1V8} := F_{1V8} \cdot p_1 + F_{\text{EQY1n}} \cdot \frac{a_1}{2} + F_{\text{SY1n}} \cdot \frac{d_1}{2}$$

$$M_{2V8} := F_{2V8} \cdot p_2 + F_{\text{EQY2n}} \cdot \frac{a_2}{2} + F_{\text{SY2n}} \cdot \frac{d_2}{2}$$

$$M_{1V8} = 3.38 \cdot \text{kN} \cdot \text{m}$$

$$M_{2V8} = 2.89 \cdot \text{kN} \cdot \text{m}$$

$$M_{1H8} := F_{1H8} \cdot p_1$$

$$M_{1H8} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$M_{2H8} := F_{2H8} \cdot p_2$$

$$M_{2H8} = 0.00 \cdot \text{kN} \cdot \text{m}$$

$$M_{1T8} := 0$$

$$M_{1T8} = 0.00 \cdot \text{kN}$$

$$M_{2T8} := 0$$

$$M_{2T8} = 0.00 \cdot \text{kN}$$

$$f_{1G8} := \frac{M_{1H8}}{W_{UV}} + \frac{M_{1V8}}{W_{UH}}$$

$$f_{1G8} = 3.92 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{1G8}}{f_{\text{Sta24}}} = 0.18 \quad \blacksquare < 1$$

$$f_{2G8} := \frac{M_{2H8}}{W_{UV}} + \frac{M_{2V8}}{W_{UH}}$$

$$f_{2G8} = 3.34 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{2G8}}{f_{\text{Sta24}}} = 0.15 \quad \blacksquare < 1$$

$$F_{\text{tmax8}} := \frac{M_{1V8}}{l_{14}} + \frac{M_{1T8}}{l_{14}}$$

$$F_{\text{tmax8}} = 14.71 \cdot \text{kN}$$

### Комбинация 9.1/ Loadcase 9.1:

$$F_{1H91} := \frac{F_{\text{WX1n}} + F_{\text{LX1n}}}{2}$$

$$F_{1H91} = 0.25 \cdot \text{kN}$$

$$F_{2H91} := \frac{F_{\text{WX2n}} + F_{\text{LX2n}}}{2}$$

$$F_{2H91} = 0.25 \cdot \text{kN}$$

$$F_{1V91} := \frac{F_{\text{AZ1n}}}{2}$$

$$F_{1V91} = 2.00 \cdot \text{kN}$$

$$F_{2V91} := \frac{F_{\text{AZ2n}}}{2}$$

$$F_{2V91} = 1.73 \cdot \text{kN}$$

$$M_{1V91} := F_{1V91} \cdot p_1$$

$$M_{1V91} = 1.80 \cdot \text{kN} \cdot \text{m}$$

$$M_{2V91} := F_{2V91} \cdot p_2$$

$$M_{2V91} = 1.55 \cdot \text{kN} \cdot \text{m}$$

$$M_{1H91} := F_{1H91} \cdot p_1 + q_{\text{gwx}} \cdot 0.5 \cdot p_1^2$$

$$M_{1H91} = 0.27 \cdot \text{kN} \cdot \text{m}$$

$$M_{2H91} := F_{2H91} \cdot p_2 + q_{\text{gwx}} \cdot 0.5 \cdot p_2^2$$

$$M_{2H91} = 0.27 \cdot \text{kN} \cdot \text{m}$$

$$M_{1T91} := 0$$

$$M_{1T91} = 0.00 \cdot \text{kN}$$

$$M_{2T91} := 0$$

$$M_{2T91} = 0.00 \cdot \text{kN}$$

$$f_{1G91} := \frac{M_{1H91}}{W_{UV}} + \frac{M_{1V91}}{W_{UH}}$$

$$f_{1G91} = 3.89 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{1G91}}{f_{\text{Sta24}}} = 0.18 \quad \blacksquare < 1$$

$$f_{2G91} := \frac{M_{2H91}}{W_{UV}} + \frac{M_{2V91}}{W_{UH}}$$

$$f_{2G91} = 3.63 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2}$$

$$\frac{f_{2G91}}{f_{\text{Sta24}}} = 0.17 \quad \blacksquare < 1$$

$$F_{\text{tmax91}} := \frac{M_{1V91}}{l_{14}} + \frac{M_{1T91}}{l_{14}}$$

$$F_{\text{tmax91}} = 7.83 \cdot \text{kN}$$



**Комбинация 9.2/ Loadcase 9.2:**

$$\begin{aligned}
 F_{1H92} &:= 0 & F_{1H92} &= 0.00 \cdot \text{kN} & F_{2H92} &:= 0 & F_{2H92} &= 0.00 \cdot \text{kN} \\
 F_{1V92} &:= \frac{F_{AZ1n}}{2} & F_{1V92} &= 2.00 \cdot \text{kN} & F_{2V92} &:= \frac{F_{AZ2n}}{2} & F_{2V92} &= 1.73 \cdot \text{kN} \\
 M_{1V92} &:= F_{1V92} \cdot p_1 + F_{WY1n} \cdot \frac{c_1}{2} + F_{LY1n} \cdot \frac{d_1}{2} & M_{2V92} &:= F_{2V92} \cdot p_2 + F_{WY2n} \cdot \frac{c_2}{2} + F_{LY2n} \cdot \frac{d_2}{2} \\
 & & M_{1V92} &= 2.04 \cdot \text{kN} \cdot \text{m} & & & M_{2V92} &= 1.78 \cdot \text{kN} \cdot \text{m} \\
 M_{1H92} &:= F_{1H92} \cdot p_1 & M_{1H92} &= 0.00 \cdot \text{kN} \cdot \text{m} & M_{2H92} &:= F_{2H92} \cdot p_2 & M_{2H92} &= 0.00 \cdot \text{kN} \cdot \text{m} \\
 M_{1T92} &:= 0 & M_{1T92} &= 0.00 \cdot \text{kN} & M_{2T92} &:= 0 & M_{2T92} &= 0.00 \cdot \text{kN} \\
 f_{1G92} &:= \frac{M_{1H92}}{W_{UV}} + \frac{M_{1V92}}{W_{UH}} & f_{1G92} &= 2.36 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{1G92}}{f_{Sta24}} &= 0.11 & & \blacksquare < 1 \\
 f_{2G92} &:= \frac{M_{2H92}}{W_{UV}} + \frac{M_{2V92}}{W_{UH}} & f_{2G92} &= 2.06 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{2G92}}{f_{Sta24}} &= 0.09 & & \blacksquare < 1 \\
 F_{tmax92} &:= \frac{M_{1V92}}{l_{14}} + \frac{M_{1T92}}{l_{14}} & F_{tmax92} &= 8.85 \cdot \text{kN} & & & & 
 \end{aligned}$$

**Комбинация 10.1/ Loadcase 10.1:**

$$\begin{aligned}
 F_{1H101} &:= \frac{F_{EQX1n}}{2} & F_{1H101} &= 0.67 \cdot \text{kN} & F_{2H101} &:= \frac{F_{EQX2n}}{2} & F_{2H101} &= 0.58 \cdot \text{kN} \\
 F_{1V101} &:= \frac{F_{AZ1n} + F_{EQZ1n}}{2} & F_{1V101} &= 2.67 \cdot \text{kN} & F_{2V101} &:= \frac{F_{AZ2n} + F_{EQZ2n}}{2} & F_{2V101} &= 2.30 \cdot \text{kN} \\
 M_{1V101} &:= F_{1V101} \cdot p_1 & M_{1V101} &= 2.40 \cdot \text{kN} \cdot \text{m} & M_{2V101} &:= F_{2V101} \cdot p_2 & M_{2V101} &= 2.07 \cdot \text{kN} \cdot \text{m} \\
 M_{1H101} &:= F_{1H101} \cdot p_1 & M_{1H101} &= 0.60 \cdot \text{kN} \cdot \text{m} & M_{2H101} &:= F_{2H101} \cdot p_2 & M_{2H101} &= 0.52 \cdot \text{kN} \cdot \text{m} \\
 M_{1T101} &:= 0 & M_{1T101} &= 0.00 \cdot \text{kN} & M_{2T101} &:= 0 & M_{2T101} &= 0.00 \cdot \text{kN} \\
 f_{1G101} &:= \frac{M_{1H101}}{W_{UV}} + \frac{M_{1V101}}{W_{UH}} & f_{1G101} &= 6.87 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{1G101}}{f_{Sta24}} &= 0.31 & & \blacksquare < 1 \\
 f_{2G101} &:= \frac{M_{2H101}}{W_{UV}} + \frac{M_{2V101}}{W_{UH}} & f_{2G101} &= 5.93 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{2G101}}{f_{Sta24}} &= 0.27 & & \blacksquare < 1 \\
 F_{tmax101} &:= \frac{M_{1V101}}{l_{14}} + \frac{M_{1T101}}{l_{14}} & F_{tmax101} &= 10.44 \cdot \text{kN} & & & & 
 \end{aligned}$$

**Комбинация 10.2/ Loadcase 10.2:**

$$\begin{aligned}
 F_{1H102} &:= 0 & F_{1H102} &= 0.00 \cdot \text{kN} & F_{2H102} &:= 0 & F_{2H102} &= 0.00 \cdot \text{kN} \\
 F_{1V102} &:= \frac{F_{AZ1n} + F_{EQZ1n}}{2} & F_{1V102} &= 2.67 \cdot \text{kN} & F_{2V102} &:= \frac{F_{AZ2n} + F_{EQZ2n}}{2} & F_{2V102} &= 2.30 \cdot \text{kN} \\
 M_{1V102} &:= F_{1V102} \cdot p_1 + F_{EQY1n} \cdot \frac{a_1}{2} & M_{2V102} &:= F_{2V102} \cdot p_2 + F_{EQY2n} \cdot \frac{a_2}{2} \\
 & & M_{1V102} &= 3.20 \cdot \text{kN} \cdot \text{m} & & & M_{2V102} &= 2.72 \cdot \text{kN} \cdot \text{m} \\
 M_{1H102} &:= F_{1H102} \cdot p_1 & M_{1H102} &= 0.00 \cdot \text{kN} \cdot \text{m} & M_{2H102} &:= F_{2H102} \cdot p_2 & M_{2H102} &= 0.00 \cdot \text{kN} \cdot \text{m}
 \end{aligned}$$

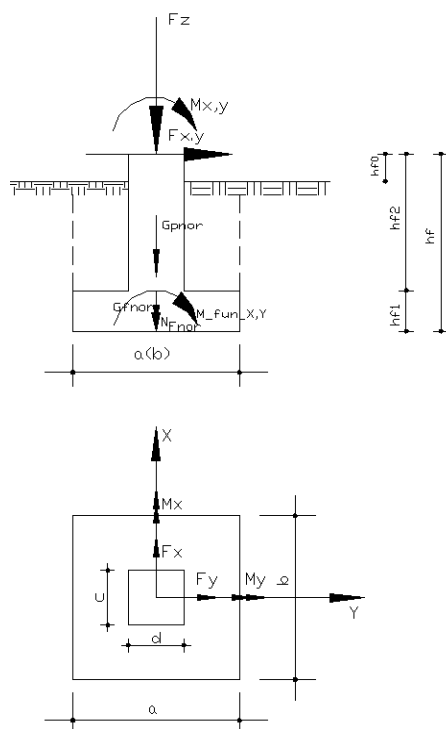
$$\begin{aligned}
 M_{1T102} &:= 0 & M_{1T102} &= 0.00 \cdot \text{kN} & M_{2T102} &:= 0 & M_{2T102} &= 0.00 \cdot \text{kN} \\
 f_{1G102} &:= \frac{M_{1H102}}{W_{UV}} + \frac{M_{1V102}}{W_{UH}} & f_{1G102} &= 3.71 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{1G102}}{f_{\text{Sta24}}} &= 0.17 & & < 1 \\
 f_{2G102} &:= \frac{M_{2H102}}{W_{UV}} + \frac{M_{2V102}}{W_{UH}} & f_{2G102} &= 3.15 \times 10^4 \cdot \frac{\text{kN}}{\text{m}^2} & \frac{f_{2G102}}{f_{\text{Sta24}}} &= 0.14 & & < 1 \\
 F_{\text{tmax102}} &:= \frac{M_{1V102}}{l_{14}} + \frac{M_{1T102}}{l_{14}} & F_{\text{tmax102}} &= 13.93 \cdot \text{kN}
 \end{aligned}$$

избрани: **Болтове за връзка греда-колона 6 M16 5.6 S355**chosen: **Bolts for fixing beam on column 6 M16 5.6 S355**

$$A_{16} := 157 \cdot \text{mm}^2$$

$$\begin{aligned}
 f_{tS3} &:= \frac{F_{\text{tmax3}}}{2A_{16}} & f_{tS3} &= 33.14 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS3}}{f_{a5.6}} &= 0.12 & & < 1 \\
 f_{tS4} &:= \frac{F_{\text{tmax4}}}{2A_{16}} & f_{tS4} &= 37.71 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS4}}{f_{a5.6}} &= 0.14 & & < 1 \\
 f_{tS5} &:= \frac{F_{\text{tmax5}}}{2A_{16}} & f_{tS5} &= 24.92 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS5}}{f_{a5.6}} &= 0.09 & & < 1 \\
 f_{tS7} &:= \frac{F_{\text{tmax7}}}{2A_{16}} & f_{tS7} &= 35.74 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS7}}{f_{a5.6}} &= 0.13 & & < 1 \\
 f_{tS8} &:= \frac{F_{\text{tmax8}}}{2A_{16}} & f_{tS8} &= 46.84 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS8}}{f_{a5.6}} &= 0.17 & & < 1 \\
 f_{tS91} &:= \frac{F_{\text{tmax91}}}{2A_{16}} & f_{tS91} &= 24.92 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS91}}{f_{a5.6}} &= 0.09 & & < 1 \\
 f_{tS92} &:= \frac{F_{\text{tmax92}}}{2A_{16}} & f_{tS92} &= 28.19 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS92}}{f_{a5.6}} &= 0.10 & & < 1 \\
 f_{tS101} &:= \frac{F_{\text{tmax101}}}{2A_{16}} & f_{tS101} &= 33.25 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS101}}{f_{a5.6}} &= 0.12 & & < 1 \\
 f_{tS102} &:= \frac{F_{\text{tmax102}}}{2A_{16}} & f_{tS102} &= 44.36 \cdot \frac{\text{N}}{\text{mm}^2} & \frac{f_{tS102}}{f_{a5.6}} &= 0.16 & & < 1
 \end{aligned}$$

ПРОВЕРКА НА ЗЕМНАТА ОСНОВА ПОД ФУНДАМЕНТ  
CALCULATION OF SOIL BASE UNDER FOUNDATION



Входни данни за усилията на горен ръб фундамент, съгласно Табл. 2

Input data for the stress on upper edge foundation, acc.to Table 2

$$\begin{aligned}
 F_{X\_1.5} &:= \begin{pmatrix} F_{X1n} \\ F_{X2n} \\ F_{X3n} \\ F_{X4n} \end{pmatrix} & F_{Y\_1.5} &:= \begin{pmatrix} F_{Y1n} \\ F_{Y2n} \\ F_{Y3n} \\ F_{Y4n} \end{pmatrix} & F_{Zmax\_1.5} &:= \begin{pmatrix} F_{Zmax1n} \\ F_{Zmax2n} \\ F_{Zmax3n} \\ F_{Zmax4n} \end{pmatrix} & F_{Zmin\_1.5} &:= \begin{pmatrix} F_{Zmin1n} \\ F_{Zmin2n} \\ F_{Zmin3n} \\ F_{Zmin4n} \end{pmatrix} \\
 F_{X\_1.2} &:= \begin{pmatrix} F_{X5n} \\ F_{X6n} \\ F_{X7n} \\ F_{X8n} \\ F_{X91n} \\ F_{X92n} \\ F_{X101n} \\ F_{X102n} \end{pmatrix} & F_{Y\_1.2} &:= \begin{pmatrix} F_{Y5n} \\ F_{Y6n} \\ F_{Y7n} \\ F_{Y8n} \\ F_{Y91n} \\ F_{Y92n} \\ F_{Y101n} \\ F_{Y102n} \end{pmatrix} & F_{Zmax\_1.2} &:= \begin{pmatrix} F_{Zmax5n} \\ F_{Zmax6n} \\ F_{Zmax7n} \\ F_{Zmax8n} \\ F_{Zmax91n} \\ F_{Zmax92n} \\ F_{Zmax101n} \\ F_{Zmax102n} \end{pmatrix} & F_{Zmin\_1.2} &:= \begin{pmatrix} F_{Zmin5n} \\ F_{Zmin6n} \\ F_{Zmin7n} \\ F_{Zmin8n} \\ F_{Zmin91n} \\ F_{Zmin92n} \\ F_{Zmin101n} \\ F_{Zmin102n} \end{pmatrix} \\
 M_{X\_1.5} &:= \begin{pmatrix} M_{X1n} \\ M_{X2n} \\ M_{X3n} \\ M_{X4n} \end{pmatrix} & M_{Y\_1.5} &:= \begin{pmatrix} M_{Y1n} \\ M_{Y2n} \\ M_{Y3n} \\ M_{Y4n} \end{pmatrix}
 \end{aligned}$$

$$M_{X\_1.2} := \begin{pmatrix} M_{X5n} \\ M_{X6n} \\ M_{X7n} \\ M_{X8n} \\ M_{X91n} \\ M_{X92n} \\ M_{X101n} \\ M_{X102n} \end{pmatrix} \quad M_{Y\_1.2} := \begin{pmatrix} M_{Y5n} \\ M_{Y6n} \\ M_{Y7n} \\ M_{Y8n} \\ M_{Y91n} \\ M_{Y92n} \\ M_{Y101n} \\ M_{Y102n} \end{pmatrix}$$

**Размери на фундамента. Foundation dimensions.**

|                          |                                                                                 |
|--------------------------|---------------------------------------------------------------------------------|
| $b := 1.40\text{m}$      | Ширина на основата на фундамента / Foundation width                             |
| $a := 1.40\text{m}$      | Дължина на основата на фундамента / Foundation length                           |
| $d := 0.70\text{m}$      | Ширина на подколонника / Foundation width over the base                         |
| $c := 0.70\text{m}$      | Дължина на подколонника / Foundation length over the base                       |
| $h_{f0} := 0.15\text{m}$ | Височина на подколонника над засипката / Foundation height above the embankment |
| $h_{f1} := 0.35\text{m}$ | Височина на стъпката / Foundation base height                                   |
| $h_{f2} := 1.20\text{m}$ | Височина на подколонника / Height of the foundation over the base               |
| $h_f := h_{f1} + h_{f2}$ | $h_f = 1.55\text{m}$ Височина на фундамента / Foundation height                 |

**Определяне на вертикалната сила на долен ръб фундамент.** $N_{F\_nor}$ **Vertical stress on lower edge foundation**

|                                                                              |                                                                          |                                    |
|------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------------------------------|
| $\gamma := 24 \cdot \frac{\text{kN}}{\text{m}^3}$                            | Обемно тегло на бетона. Concrete unit weight.                            |                                    |
| $\gamma_z := 16.5 \cdot \frac{\text{kN}}{\text{m}^3}$                        | Обемно тегло на засипка/ Converse embankment unit weight                 |                                    |
| $G_1 := a \cdot b \cdot h_{f1} \cdot \gamma$                                 | Тегло на фундаментната плоча/<br>Foundation base weight                  | $G_1 = 16.46 \cdot \text{kN}$      |
| $G_2 := c \cdot d \cdot h_{f2} \cdot \gamma$                                 | Тегло на подколонникът/<br>Foundation weight over the base               | $G_2 = 14.11 \cdot \text{kN}$      |
| $G_{fnor} := G_1 + G_2$                                                      | Собствено тегло на фундамента/<br>Foundation dead weight                 | $G_{fnor} = 30.58 \cdot \text{kN}$ |
| $G_{pnor} := (a \cdot b - c \cdot d) \cdot (h_{f2} - h_{f0}) \cdot \gamma_z$ | Теглото на почвената засипка върху фундамента/<br>Soil embankment weight | $G_{pnor} = 25.47 \cdot \text{kN}$ |

$$N_{F\_nor\_max\_1.5} := F_{Zmax\_1.5} + G_{fnor} + G_{pnor} \quad N_{F\_nor\_max\_1.2} := F_{Zmax\_1.2} + G_{fnor} + G_{pnor}$$

$$N_{F\_nor\_min\_1.5} := F_{Zmin\_1.5} + G_{fnor} + G_{pnor} \quad N_{F\_nor\_min\_1.2} := F_{Zmin\_1.2} + G_{fnor} + G_{pnor}$$

$$N_{F\_nor\_max\_1.5} = \begin{pmatrix} 68.144 \\ 69.156 \\ 68.155 \\ 68.155 \end{pmatrix} \cdot \text{kN}$$

$$N_{F\_nor\_min\_1.5} = \begin{pmatrix} 68.144 \\ 68.132 \\ 68.132 \\ 68.132 \end{pmatrix} \cdot \text{kN}$$

$$N_{F\_nor\_max\_1.2} = \begin{pmatrix} 68.144 \\ 68.155 \\ 72.198 \\ 72.198 \\ 68.144 \\ 68.144 \\ 72.187 \\ 72.187 \end{pmatrix} \cdot \text{kN} \quad N_{F\_nor\_min\_1.2} = \begin{pmatrix} 68.144 \\ 68.132 \\ 64.089 \\ 64.089 \\ 68.144 \\ 68.144 \\ 64.101 \\ 64.101 \end{pmatrix} \cdot \text{kN}$$

**Определяне на запъващите моменти в основната плоскост на фундамента.  $M_{fun}$**

**Restraining moments on the foundation base.  $M_{fun}$**

Запъващ момент спрямо ос x в основната плоскост на фундамента./ Restraining moment direction X

$$M_{fun\_X\_1.5} := M_{X\_1.5} + F_{Y\_1.5} \cdot h_f \quad M_{fun\_X\_1.2} := M_{X\_1.2} + F_{Y\_1.2} \cdot h_f$$

Запъващ момент спрямо ос y в основната плоскост на фундамента./ Restraining moment direction Y

$$M_{fun\_Y\_1.5} := M_{Y\_1.5} + F_{X\_1.5} \cdot h_f \quad M_{fun\_Y\_1.2} := M_{Y\_1.2} + F_{X\_1.2} \cdot h_f$$

$$M_{fun\_X\_1.5} = \begin{pmatrix} 0.495 \\ 5.052 \\ 1.356 \\ 6.587 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{fun\_Y\_1.5} = \begin{pmatrix} 0 \\ 3.65 \\ 6.093 \\ 0 \end{pmatrix} \cdot \text{kN} \cdot \text{m}$$

$$M_{fun\_X\_1.2} = \begin{pmatrix} 0.495 \\ 1.356 \\ 1.522 \\ 18.369 \\ 0.495 \\ 5.144 \\ 0.66 \\ 17.507 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{fun\_Y\_1.2} = \begin{pmatrix} 14.334 \\ 0 \\ 16.847 \\ 0 \\ 19.75 \\ 14.334 \\ 16.847 \\ 0 \end{pmatrix} \cdot \text{kN} \cdot \text{m}$$

**Определяне на напрежението на почвата под ъглите на фундамента/ soil stress under foundation corners.  $\sigma_{1\_4}$**

$F_{fund} := a \cdot b$  Основна площ на фундамента. Basic area of the Foundation.

$$F_{fund} = 1.96 \text{ m}^{2.00}$$

$W_x := \frac{a^2 \cdot b}{6}$   $W_x$  и  $W_y$  са съпротивителните моменти на основната плоскост на фундамента

$$W_x = 0.46 \cdot \text{m}^{3.00}$$

$W_y := \frac{a \cdot b^2}{6}$   $W_x$  and  $W_y$  are the resistance moments of the Foundation bed.

$$W_y = 0.46 \cdot \text{m}^{3.00}$$

$$\begin{aligned} \sigma_{1\_max\_1.5} &:= \frac{N_{F\_nor\_max\_1.5}}{F_{fund}} - \frac{M_{fun\_X\_1.5}}{W_x} - \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{1\_max\_1.2} &:= \frac{N_{F\_nor\_max\_1.2}}{F_{fund}} - \frac{M_{fun\_X\_1.2}}{W_x} - \frac{M_{fun\_Y\_1.2}}{W_y} \\ \sigma_{1\_min\_1.5} &:= \frac{N_{F\_nor\_min\_1.5}}{F_{fund}} - \frac{M_{fun\_X\_1.5}}{W_x} - \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{1\_min\_1.2} &:= \frac{N_{F\_nor\_min\_1.2}}{F_{fund}} - \frac{M_{fun\_X\_1.2}}{W_x} - \frac{M_{fun\_Y\_1.2}}{W_y} \\ \sigma_{2\_max\_1.5} &:= \frac{N_{F\_nor\_max\_1.5}}{F_{fund}} - \frac{M_{fun\_X\_1.5}}{W_x} + \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{2\_max\_1.2} &:= \frac{N_{F\_nor\_max\_1.2}}{F_{fund}} - \frac{M_{fun\_X\_1.2}}{W_x} + \frac{M_{fun\_Y\_1.2}}{W_y} \\ \sigma_{2\_min\_1.5} &:= \frac{N_{F\_nor\_min\_1.5}}{F_{fund}} - \frac{M_{fun\_X\_1.5}}{W_x} + \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{2\_min\_1.2} &:= \frac{N_{F\_nor\_min\_1.2}}{F_{fund}} - \frac{M_{fun\_X\_1.2}}{W_x} + \frac{M_{fun\_Y\_1.2}}{W_y} \end{aligned}$$

$$\begin{aligned}\sigma_{3\_max\_1.5} &:= \frac{N_{F\_nor\_max\_1.5}}{F_{fund}} + \frac{M_{fun\_X\_1.5}}{W_x} + \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{3\_max\_1.2} &:= \frac{N_{F\_nor\_max\_1.2}}{F_{fund}} + \frac{M_{fun\_X\_1.2}}{W_x} + \frac{M_{fun\_Y\_1.2}}{W_y} \\ \sigma_{3\_min\_1.5} &:= \frac{N_{F\_nor\_min\_1.5}}{F_{fund}} + \frac{M_{fun\_X\_1.5}}{W_x} + \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{3\_min\_1.2} &:= \frac{N_{F\_nor\_min\_1.2}}{F_{fund}} + \frac{M_{fun\_X\_1.2}}{W_x} + \frac{M_{fun\_Y\_1.2}}{W_y} \\ \sigma_{4\_max\_1.5} &:= \frac{N_{F\_nor\_max\_1.5}}{F_{fund}} + \frac{M_{fun\_X\_1.5}}{W_x} - \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{4\_max\_1.2} &:= \frac{N_{F\_nor\_max\_1.2}}{F_{fund}} + \frac{M_{fun\_X\_1.2}}{W_x} - \frac{M_{fun\_Y\_1.2}}{W_y} \\ \sigma_{4\_min\_1.5} &:= \frac{N_{F\_nor\_min\_1.5}}{F_{fund}} + \frac{M_{fun\_X\_1.5}}{W_x} - \frac{M_{fun\_Y\_1.5}}{W_y} & \sigma_{4\_min\_1.2} &:= \frac{N_{F\_nor\_min\_1.2}}{F_{fund}} + \frac{M_{fun\_X\_1.2}}{W_x} - \frac{M_{fun\_Y\_1.2}}{W_y}\end{aligned}$$

$$\begin{aligned}\sigma_{1\_max\_1.5} &= \begin{pmatrix} 33.685 \\ 16.256 \\ 18.484 \\ 20.37 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{2\_max\_1.5} &= \begin{pmatrix} 33.685 \\ 32.219 \\ 45.13 \\ 20.37 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{3\_max\_1.5} &= \begin{pmatrix} 35.85 \\ 54.311 \\ 51.062 \\ 49.176 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{4\_max\_1.5} &= \begin{pmatrix} 35.85 \\ 38.349 \\ 24.416 \\ 49.176 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} \\ \sigma_{1\_max\_1.2} &= \begin{pmatrix} 2.342 \\ 31.807 \\ -3.329 \\ -3.329 \\ -9.5 \\ -7.824 \\ -1.451 \\ -1.451 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{2\_max\_1.2} &= \begin{pmatrix} 65.027 \\ 31.807 \\ 70.345 \\ -3.329 \\ 76.87 \\ 54.861 \\ 72.223 \\ -1.451 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{3\_max\_1.2} &= \begin{pmatrix} 67.192 \\ 37.739 \\ 77 \\ 77 \\ 79.035 \\ 77.358 \\ 75.111 \\ 75.111 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{4\_max\_1.2} &= \begin{pmatrix} 4.507 \\ 37.739 \\ 3.326 \\ 77 \\ -7.336 \\ 14.673 \\ 1.437 \\ 75.111 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} \\ \sigma_{1\_min\_1.5} &= \begin{pmatrix} 33.685 \\ 15.734 \\ 18.472 \\ 20.359 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{2\_min\_1.5} &= \begin{pmatrix} 33.685 \\ 31.696 \\ 45.118 \\ 20.359 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{3\_min\_1.5} &= \begin{pmatrix} 35.85 \\ 53.788 \\ 51.05 \\ 49.164 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{4\_min\_1.5} &= \begin{pmatrix} 35.85 \\ 37.826 \\ 24.404 \\ 49.164 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} \\ \sigma_{1\_min\_1.2} &= \begin{pmatrix} 2.342 \\ 31.795 \\ -7.466 \\ -7.466 \\ -9.5 \\ -7.824 \\ -5.577 \\ -5.577 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{2\_min\_1.2} &= \begin{pmatrix} 65.027 \\ 31.795 \\ 66.208 \\ -7.466 \\ 76.87 \\ 54.861 \\ 68.098 \\ -5.577 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{3\_min\_1.2} &= \begin{pmatrix} 67.192 \\ 37.727 \\ 72.863 \\ 72.863 \\ 79.035 \\ 77.358 \\ 70.986 \\ 70.986 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2} & \sigma_{4\_min\_1.2} &= \begin{pmatrix} 4.507 \\ 37.727 \\ -0.811 \\ 72.863 \\ -7.336 \\ 14.673 \\ -2.689 \\ 70.986 \end{pmatrix} \cdot \frac{\text{kN}}{\text{m}^2}\end{aligned}$$

**Заклучение:** Удовлетворени са условията на чл. 57(4) от Наредба №1 за проектиране на плоско фундиране..  
Ъгловите и ръбовите напрежения не надвишават 150 kN/m<sup>2</sup>.

**Conclusion:** The requirements of article 57(4) of Regulation No1 are fulfilled.  
The stress on the edges and corners are below the limit of 150 kN/m<sup>2</sup>.

**Проверка за преобръщане на фундамента/ Foundation overturn check**

Приемаме коефициент на сигурност 1,5 за основно съчетание и 1,2 за особено съчетание на натоварването съгласно чл. 75 от Наредба №1 за проектиране на плоско фундиране.

$$k_{1.2} := 1.2 \quad \text{Safety coefficient for exceptional loadcases} \quad k_{1.5} := 1.5 \quad \text{Safety coefficient for normal loadcases}$$

$$M_{\text{zad\_X\_max\_1.5}} := N_{\text{F\_nor\_max\_1.5}} \cdot \frac{a}{2} \quad M_{\text{zad\_X\_max\_1.2}} := N_{\text{F\_nor\_max\_1.2}} \cdot \frac{a}{2}$$

Задържащ момент спрямо ос X в основната плоскост/ Restraining moment direction X

$$M_{\text{zad\_X\_min\_1.5}} := N_{\text{F\_nor\_min\_1.5}} \cdot \frac{a}{2} \quad M_{\text{zad\_X\_min\_1.2}} := N_{\text{F\_nor\_min\_1.2}} \cdot \frac{a}{2}$$

Задържащ момент спрямо ос Y в основната плоскост/ Restraining moment direction Y

$$M_{\text{zad\_Y\_max\_1.5}} := N_{\text{F\_nor\_max\_1.5}} \cdot \frac{b}{2} \quad M_{\text{zad\_Y\_max\_1.2}} := N_{\text{F\_nor\_max\_1.2}} \cdot \frac{b}{2}$$

$$M_{\text{zad\_Y\_min\_1.5}} := N_{\text{F\_nor\_min\_1.5}} \cdot \frac{b}{2} \quad M_{\text{zad\_Y\_min\_1.2}} := N_{\text{F\_nor\_min\_1.2}} \cdot \frac{b}{2}$$

Проверка за преобръщане по ос X.

$$M_{\text{check\_X\_1.5}} := M_{\text{fun\_X\_1.5}} \cdot k_{1.5} \quad M_{\text{check\_X\_1.2}} := M_{\text{fun\_X\_1.2}} \cdot k_{1.2}$$

Проверка за преобръщане по ос Y.

$$M_{\text{check\_Y\_1.5}} := M_{\text{fun\_Y\_1.5}} \cdot k_{1.5} \quad M_{\text{check\_Y\_1.2}} := M_{\text{fun\_Y\_1.2}} \cdot k_{1.2}$$

**Условие за устойчивост на фундамента срещу преобръщане./ Conditions against overturn**

$$\frac{M_{\text{zad\_X\_max\_1.5}}}{M_{\text{fun\_X\_1.5}}} \geq k_{1.5} \quad \frac{M_{\text{zad\_X\_min\_1.5}}}{M_{\text{fun\_X\_1.5}}} \geq k_{1.5} \quad \frac{M_{\text{zad\_Y\_max\_1.5}}}{M_{\text{fun\_Y\_1.5}}} \geq k_{1.5} \quad \frac{M_{\text{zad\_Y\_min\_1.5}}}{M_{\text{fun\_Y\_1.5}}} \geq k_{1.5}$$

$$\frac{M_{\text{zad\_X\_max\_1.2}}}{M_{\text{fun\_X\_1.2}}} \geq k_{1.2} \quad \frac{M_{\text{zad\_X\_min\_1.2}}}{M_{\text{fun\_X\_1.2}}} \geq k_{1.2} \quad \frac{M_{\text{zad\_Y\_max\_1.2}}}{M_{\text{fun\_Y\_1.2}}} \geq k_{1.2} \quad \frac{M_{\text{zad\_Y\_min\_1.2}}}{M_{\text{fun\_Y\_1.2}}} \geq k_{1.2}$$

$$M_{\text{check\_X\_1.5}} = \begin{pmatrix} 0.743 \\ 7.578 \\ 2.035 \\ 9.88 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_X\_max\_1.5}} = \begin{pmatrix} 47.701 \\ 48.409 \\ 47.709 \\ 47.709 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_X\_min\_1.5}} = \begin{pmatrix} 47.701 \\ 47.692 \\ 47.693 \\ 47.693 \end{pmatrix} \cdot \text{kN} \cdot \text{m}$$

$$M_{\text{check\_X\_1.2}} = \begin{pmatrix} 0.594 \\ 1.628 \\ 1.826 \\ 22.042 \\ 0.594 \\ 6.173 \\ 0.792 \\ 21.009 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_X\_max\_1.2}} = \begin{pmatrix} 47.701 \\ 47.709 \\ 50.539 \\ 50.539 \\ 47.701 \\ 47.701 \\ 50.531 \\ 50.531 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_X\_min\_1.2}} = \begin{pmatrix} 47.701 \\ 47.693 \\ 44.863 \\ 44.863 \\ 47.701 \\ 47.701 \\ 44.871 \\ 44.871 \end{pmatrix} \cdot \text{kN} \cdot \text{m}$$

$$M_{\text{check\_Y\_1.5}} = \begin{pmatrix} 0 \\ 5.475 \\ 9.14 \\ 0 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_Y\_max\_1.5}} = \begin{pmatrix} 47.701 \\ 48.409 \\ 47.709 \\ 47.709 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_Y\_min\_1.5}} = \begin{pmatrix} 47.701 \\ 47.692 \\ 47.693 \\ 47.693 \end{pmatrix} \cdot \text{kN} \cdot \text{m}$$

$$M_{\text{check\_Y\_1.2}} = \begin{pmatrix} 17.201 \\ 0 \\ 20.216 \\ 0 \\ 23.7 \\ 17.201 \\ 20.216 \\ 0 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_Y\_max\_1.2}} = \begin{pmatrix} 47.701 \\ 47.709 \\ 50.539 \\ 50.539 \\ 47.701 \\ 47.701 \\ 50.531 \\ 50.531 \end{pmatrix} \cdot \text{kN} \cdot \text{m} \quad M_{\text{zad\_Y\_min\_1.2}} = \begin{pmatrix} 47.701 \\ 47.693 \\ 44.863 \\ 44.863 \\ 47.701 \\ 47.701 \\ 44.871 \\ 44.871 \end{pmatrix} \cdot \text{kN} \cdot \text{m}$$

$j := 0..3$   
 $j1 := 0..7$

$$k_{X\_max\_1.5(j)} := \begin{cases} y \leftarrow M_{\text{fun\_X\_1.5}_j} \\ z \leftarrow \frac{M_{\text{zad\_X\_max\_1.5}_j}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{X\_min\_1.5(j)} := \begin{cases} y \leftarrow M_{\text{fun\_X\_1.5}_j} \\ z \leftarrow \frac{M_{\text{zad\_X\_min\_1.5}_j}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{X\_max\_1.2(j1)} := \begin{cases} y \leftarrow M_{\text{fun\_X\_1.2}_{j1}} \\ z \leftarrow \frac{M_{\text{zad\_X\_max\_1.2}_{j1}}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{Y\_max\_1.2(j1)} := \begin{cases} y \leftarrow M_{\text{fun\_Y\_1.2}_{j1}} \\ z \leftarrow \frac{M_{\text{zad\_Y\_max\_1.2}_{j1}}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{Y\_max\_1.5(j)} := \begin{cases} y \leftarrow M_{\text{fun\_Y\_1.5}_j} \\ z \leftarrow \frac{M_{\text{zad\_Y\_max\_1.5}_j}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{Y\_min\_1.5(j)} := \begin{cases} y \leftarrow M_{\text{fun\_Y\_1.5}_j} \\ z \leftarrow \frac{M_{\text{zad\_Y\_min\_1.5}_j}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{X\_min\_1.2(j)} := \begin{cases} y \leftarrow M_{\text{fun\_X\_1.2}_j} \\ z \leftarrow \frac{M_{\text{zad\_X\_min\_1.2}_j}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{Y\_min\_1.2(j)} := \begin{cases} y \leftarrow M_{\text{fun\_Y\_1.2}_j} \\ z \leftarrow \frac{M_{\text{zad\_Y\_min\_1.2}_j}}{y} & \text{if } y \neq 0 \\ z \leftarrow \infty & \text{otherwise} \end{cases}$$

$$k_{X\_max\_1.5(j)} =$$

|        |
|--------|
| 96.365 |
| 9.583  |
| 35.173 |
| 7.243  |

$$k_{X\_min\_1.5(j)} =$$

|        |
|--------|
| 96.365 |
| 9.441  |
| 35.161 |
| 7.241  |

$$k_{Y\_max\_1.5(j)} =$$

|                     |
|---------------------|
| 1·10 <sup>307</sup> |
| 13.263              |
| 7.83                |
| 1·10 <sup>307</sup> |

$$k_{Y\_min\_1.5(j)} =$$

|                     |
|---------------------|
| 1·10 <sup>307</sup> |
| 13.066              |
| 7.827               |
| 1·10 <sup>307</sup> |



|                         |                         |                         |                         |
|-------------------------|-------------------------|-------------------------|-------------------------|
| $k_{X\_max\_1.2(j1)} =$ | $k_{X\_min\_1.2(j1)} =$ | $k_{Y\_max\_1.2(j1)} =$ | $k_{Y\_min\_1.2(j1)} =$ |
| 96.365                  | 96.365                  | 3.328                   | 3.328                   |
| 35.173                  | 35.161                  | $1 \cdot 10^{307}$      | $1 \cdot 10^{307}$      |
| 33.21                   | 29.48                   | 3                       | 2.663                   |
| 2.751                   | 2.442                   | $1 \cdot 10^{307}$      | $1 \cdot 10^{307}$      |
| 96.365                  | 96.365                  | 2.415                   | 2.415                   |
| 9.273                   | 9.273                   | 3.328                   | 3.328                   |
| 76.516                  | 67.945                  | 2.999                   | 2.663                   |
| 2.886                   | 2.563                   | $1 \cdot 10^{307}$      | $1 \cdot 10^{307}$      |

**Заклучение:** Минималният коефициент на преобръщане при основни комбинации е по-голям от 1.5.  
Минималният коефициент на преобръщане при особени комбинации е по-голям 1.2.  
Следователно фундамента е устойчив в експлоатационно отношение.

**Conclusion:** The min. overturn coefficient of normal loadcases is bigger than 1.5.  
The min. overturn coefficient of exceptional loadcases is bigger than 1.2.  
Hence the foundation is stable.

**Изчисляване на земната основа по I-во гранично състояние - по носеща способност.**  
**Calculation of the soil base acc.to the 1st limit condition - carrying ability**

$$k_s := 1.2$$

$$e_{a\_1.5} := \frac{k_s \cdot M_{fun\_X\_1.5}}{k_s \cdot \max(N_{F\_nor\_max\_1.5})}$$

$$e_{b\_1.5} := \frac{k_s \cdot M_{fun\_Y\_1.5}}{k_s \cdot \max(N_{F\_nor\_max\_1.5})}$$

$$e_{a\_1.2} := \frac{k_s \cdot M_{fun\_X\_1.2}}{k_s \cdot \max(N_{F\_nor\_max\_1.2})}$$

$$e_{b\_1.2} := \frac{k_s \cdot M_{fun\_Y\_1.2}}{k_s \cdot \max(N_{F\_nor\_max\_1.2})}$$

$$e_{a\_1.5} = \begin{pmatrix} 7.158 \times 10^{-3} \\ 0.073 \\ 0.02 \\ 0.095 \end{pmatrix} m \quad e_{b\_1.5} = \begin{pmatrix} 0 \\ 0.053 \\ 0.088 \\ 0 \end{pmatrix} m$$

$$\max(e_{a\_1.2}) \leq \frac{a}{3} \quad \max(e_{b\_1.2}) \leq \frac{b}{3}$$

$$e_{a\_1.2} = \begin{pmatrix} 6.856 \times 10^{-3} \\ 0.019 \\ 0.021 \\ 0.254 \\ 6.856 \times 10^{-3} \\ 0.071 \\ 9.147 \times 10^{-3} \\ 0.242 \end{pmatrix} m \quad e_{b\_1.2} = \begin{pmatrix} 0.199 \\ 0 \\ 0.233 \\ 0 \\ 0.274 \\ 0.199 \\ 0.233 \\ 0 \end{pmatrix} m$$

$$\max(e_{a\_1.2}) = 0.25 m \quad \frac{a}{3} = 0.47 m$$

$$\max(e_{b\_1.2}) = 0.27 m \quad \frac{b}{3} = 0.47 m$$

**ОПРЕДЕЛЯНЕ НА АРМИРОВКАТА НА ФУНДАМЕНТА  
СЪГЛАСНО НОРМИ ЗА ПРОЕКТИРАНЕ НА БЕТОННИ И СТОМАНОБЕТОННИ КОНСТРУКЦИИ-1995г.  
НЕЦЕНТРИЧНО НАТИСНАТИ КОЛОНИ С ПРАВОЪГЪЛНО СЕЧЕНИЕ И СИМЕТРИЧНА АРИМРОВКА ЗА  
ПОДКОЛОННИКА.**

**FOUNDATION REINFORCEMENT**

$$N_f := \max(F_{Z_{\max\_1.2}}) + G_2 \quad N_f = 30.27 \cdot \text{kN}$$

$$\gamma_{b2} := 1.0$$

$$b_c := c$$

$$\xi_R := 0.537$$

$$h_0 := c - 5 \cdot \text{cm}$$

$$R_b := 17.00 \cdot \text{MPa}$$

за бетон клас B20. / concrete class B20

$$R_{bt} := 1.2 \cdot \text{MPa}$$

за бетон клас B20. / concrete class B20

$$x_1 := \frac{N_f}{\gamma_{b2} \cdot R_b \cdot b_c}$$

$$x_1 = 0.25 \cdot \text{cm}$$

$$x_R := \xi_R \cdot h_0$$

$$x_R = 34.90 \cdot \text{cm}$$

$$\omega := 0.5 \cdot (1 + \xi_R)$$

$$\omega = 0.77$$

$$R_{sc} := 375 \cdot \text{MPa}$$

$$M_I := \max(M_{X\_1.2}) + \max(F_{Y\_1.2}) \cdot h_{f2}$$

$$e_0 := \frac{M_I}{N_f}$$

$$e_0 = 55.85 \cdot \text{cm}$$

$$l_0 := 2 \cdot h_{f2}$$

$$e_a := \text{if} \left( \frac{c}{30} \geq \frac{l_0}{600}, \frac{c}{30}, \frac{l_0}{600} \right)$$

$$e_a = 2.33 \cdot \text{cm}$$

$$A_{s\_p\_min} := 0.05\% \cdot c \cdot d$$

$$A_{s\_min} := A_{s\_p\_min}$$

$$A_{s\_p\_min} = 2.45 \cdot \text{cm}^{2.00}$$

$$J_s := A_{s\_min} \cdot \left( \frac{c}{2} - 5 \cdot \text{cm} \right)^2 + A_{s\_p\_min} \cdot \left( \frac{c}{2} - 5 \cdot \text{cm} \right)^2$$

$$J_s = 4410.00 \cdot \text{cm}^{4.00}$$

$$\alpha := \frac{E_s}{E_b}$$

$$\alpha = 7.27$$

За бетон клас B20 и стомана A III/  
concrete class B20 an steel A III

$$\delta_e := \frac{e_0}{c}$$

$$\delta_e = 0.80$$

$$M_{11} := M_{X\_1.5_1} + F_{Y\_1.5_1} \cdot h_{f2}$$

$$\text{за/ for } \frac{a}{b} = 1.00$$

избираме/  
chosen

$$\beta := 0.70$$

коэффициент за изчисляване на слягането в зависимост от  
формата на фундамента. По Табл. 4.1 от НППФ-1996г. /  
subsiding coefficient acc. to Table 4.1. НППФ-1996

$$\varphi_1 := 1 + \beta \cdot \frac{M_{11}}{M_I}$$

$$J_i := \frac{c \cdot d^3}{12}$$

$$N_{cr} := \frac{6.4 \cdot E_b}{l_0^2} \cdot \left[ \frac{J_i}{\varphi_1} \left( \frac{0.11}{0.1 + \delta_e} \right) + \alpha \cdot J_s \right]$$

$$N_{cr} = 72608.46 \cdot \text{kN}$$

$$\eta := \frac{1}{1 - \frac{N_f}{N_{cr}}}$$

$$\eta = 1.00$$

$$e_n := e_0 + e_a$$

$$e_{\max} := e_n \cdot \eta + \frac{c}{2} + 5 \cdot \text{cm}$$

$$e_{\max} = 0.98 \text{ m}$$

$$A_s := \frac{N_f \cdot e_{\max} - \gamma_{b2} \cdot R_b \cdot x_1 \cdot b_c \cdot (h_0 - 0.5 \cdot x_1)}{R_{sc} \cdot (h_0 - 5 \cdot \text{cm})}$$

$$A_{s1} := \frac{N_f \cdot e_{\max} - \gamma_{b2} \cdot R_b \cdot b_c \cdot h_0^2 \cdot \omega \cdot (1 - 0.5 \cdot \omega)}{R_{sc} \cdot (h_0 - 5 \cdot \text{cm})}$$

$$x_1 = 0.25 \cdot \text{cm}$$

$$x_R = 34.90 \cdot \text{cm}$$

$$\text{Reinforcement} := \text{if}(x_1 \leq x_R, A_s, A_{s1})$$

Опънна (натискова) армировка на подколонника -  
Stretching (stress) reinforcement

$$\text{Reinforcement} = 0.45 \cdot \text{cm}^{2.00}$$

### ОПРЕДЕЛЯНЕ НА НОСЕЩАТА АРМИРОВКА НА СРЯЗВАНЕ - СТРЕМЕНА ЗА ПОДКОЛОННИКА. CALCULATION OF THE CARRYING REINFORCEMENT OF THE FOUNDATION TOP

$$Q := \text{if}(\max(F_{X\_1.2}) > \max(F_{Y\_1.2}), \max(F_{X\_1.2}), \max(F_{Y\_1.2}))$$

$$Q = 4.19 \cdot \text{kN}$$

1. Проверка за достатъчност на сечението  $Q \leq Q_{b1}$   
1. Checking the reinf. section

$$Q_{b1} := 0.3 \cdot R_b \cdot d \cdot h_0$$

$$Q_{b1} = 2.32 \times 10^3 \cdot \text{kN}$$

2. Проверка за способността на сечението само да понесе Q/ Q restrain check

$$Q \leq Q_{b2}$$

$$Q_{b2} := 0.6 \cdot R_{bt} \cdot d \cdot h_0$$

$$Q_{b2} = 327.60 \cdot \text{kN}$$

**Заклучение:** Сечението е в състояние само да понесе срязването. Армировката е конструктивна - стремена  $\phi 8$  през 20 см.

**Conclusion:** The requirements are fulfilled. The reinforcement is constructive  $\phi 8$  through 20cm

### ПРОВЕРКА НА ПРОДЪНВАНЕ/ COLLAPSE CHECK

$$\alpha_m := 1.2 \quad \text{за обикновен бетон клас B20/ concrete class B20}$$

$$u_m := 2 \cdot c + 2 \cdot d + 4 \cdot h_{f1}$$

$$N_{f\_chk} := \alpha_m \cdot R_{bt} \cdot u_m \cdot h_0$$

$$N_f = 30.27 \cdot \text{kN}$$

$$N_{f\_chk} = 3931.20 \cdot \text{kN}$$

### ОПРЕДЕЛЯНЕ НА НОСЕЩА АРМИРОВКА ЗА ФУНДАМЕНТНАТА ПЛОЧА/ FOUNDATION REINFORCEMENT

1. Горна армировка/ Upper reinforcement

$$q := (h_{f2} - h_{f0}) \gamma_z$$

$$q = 17.32 \cdot \text{kN} \cdot \text{m}^{-2.00}$$

$$l_k := \frac{a - c}{2}$$

$$l_k = 0.35 \text{ m}$$

$$M_{ku} := \frac{q \cdot l_k^2 \cdot 1 \cdot \text{m}}{2}$$

$$M_{ku} = 1.06 \cdot \text{kN} \cdot \text{m}$$

$$\alpha_u := \frac{M_{ku}}{R_b \cdot 100 \cdot \text{cm} \cdot (h_{f1} - 5 \cdot \text{cm})^2}$$

$$\alpha_u = 0.00069$$

$$\eta_{ku} := 0.995$$

$$A_{su} := \frac{M_{ku}}{R_{sc} \cdot \eta_{ku} \cdot (h_{f1} - 5 \cdot \text{cm})}$$

$$A_{su} = 0.09 \cdot \text{cm}^{2.00}$$

за 1 линеен метър/ per linear meter

## 2. Долна армировка/ Lower reinforcement

$$\sigma_{\max} := \max\left(\max(\sigma_{1_{\max\_1.2}), \max(\sigma_{2_{\max\_1.2}), \max(\sigma_{3_{\max\_1.2}), \max(\sigma_{4_{\max\_1.2})}\right)$$

$$\sigma_{\max} = 79.03 \cdot \frac{\text{kN}}{\text{m}^{2.00}}$$

$$M_{kb} := \frac{\sigma_{\max} \cdot l_k^2 \cdot 1 \cdot \text{m}}{2}$$

$$M_{kb} = 4.84 \cdot \text{kN} \cdot \text{m}$$

$$\alpha_b := \frac{M_{kb}}{R_b \cdot 100 \cdot \text{cm} \cdot (h_{f1} - 5 \cdot \text{cm})^2}$$

$$\alpha_b = 0.003$$

$$\eta_{kb} := 0.9925$$

$$A_{sb} := \frac{M_{kb}}{R_{sc} \cdot \eta_{kb} \cdot (h_{f1} - 5 \cdot \text{cm})}$$

$$A_{sb} = 0.43 \cdot \text{cm}^{2.00}$$

за 1 линеен метър/ per linear meter