



VYSOKÉ UČENÍ TECHNICKÉ V BRNĚ

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FAKULTA STAVEBNÍ

FACULTY OF CIVIL ENGINEERING

ÚSTAV BETONOVÝCH A ZDĚNÝCH KONSTRUKCÍ

INSTITUTE OF CONCRETE AND MASONRY STRUCTURES

VYBRANÉ KONSTRUKCE ČOV

SELECTED CONSTRUCTIONS WTP

P4. STATICKÝ VÝPOČET

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SEZNAM PŘÍLOH:

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2. STATICKÝ VÝPOČET 2. ČÁST

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Pomocná mapa statického výpočtu

Počítané hodnoty jsou odlišeny čísly v indexu, každý znak, ikdyž je ve statickém výpočtu počítán vícekrát, má vždy přiřazené jiné číslo, aby mohlo v Blockpadu fungovat vzorcování a tracking hodnot. Tato vytvořená mapa slouží jako kontrola a podklad k orientaci v počítaných hodnotách.

Hodnota u posuzované části výpočtu značí použitý poslední index (číslo) pro danou část. V závorce je uvedeno z jakých číselných indexů z předchozích výpočtů se vycházelo.

STROPNÍ DESKA

- MSÚ
- směr x dolní

1
- směr y dolní

2
- směr x horní

3
- směr y horní

4
- MSP
- směr x

1

(1,3)
- směr y

2

(2,4)

STĚNY

Vnější nádrže
0-1m

- MSÚ
- směr y svislá

5
- interakční diagram

1
- směr x vodorovná

6
- interakční diagram

2
- SMYK
- směr y svislá

1

(5)
- KOTVENÍ
- směr y svislá

1

(5)
- směr x vodorovná

2

(6)
- MSP
- směr x vodorovná

3

(6)
- směr y svislá

4

(5)

1-5.625m

- MSÚ
- směr y svislá

7
- interakční diagram

3
- směr x vodorovná

8
- interakční diagram

4
- SMYK
- směr y svislá

2

(7)
- KOTVENÍ
- směr y svislá

3

(7)
- směr x vodorovná

4

(8)
- MSP
- směr x vodorovná

5

(8)
- směr y svislá

6

(7)

ZÁKLADOVÁ DESKA

- MSÚ
- směr y

13
- interakční diagram

9
- směr x

14
- interakční diagram

10
- SMYK
- směr y

5

(13)
- směr x

6

(14)
- KOTVENÍ
- směr y

9

(13)
- směr x

10

(14)
- MSP
- směr x

11

(14)
- směr y

12

(13)

STĚNY

Vnitřní stěna mezi nádržemi

- MSÚ
- směr y svislá

9
- interakční diagram

5
- směr x vodorovná

10
- interakční diagram

6
- SMYK
- směr y svislá

3

(9)
- KOTVENÍ
- směr y svislá

5

(9)
- směr x vodorovná

6

(10)
- MSP
- směr x vodorovná

7

(10)
- směr y svislá

8

(9)
- posouzení šířky trhlín

1

(9,5,8)

STĚNY

Stěny technické místnosti

- MSÚ
- směr y svislá

11
- interakční diagram

7
- směr x vodorovná

12
- interakční diagram

8
- SMYK
- směr y svislá

4

(11)
- KOTVENÍ
- směr y svislá

7

(11)
- směr x vodorovná

8

(12)
- MSP
- směr x vodorovná

9

(12)
- směr y svislá

10

(11)

Materiálové charakteristiky

Beton C30/37

Charakteristická válcová pevnost v tlaku betonu:

$$f_{ck} = 30 \text{ MPa}$$

Součinitel spolehlivosti betonu:

$$\gamma_c = 1.5$$

Návrhová pevnost betonu v tlaku:

$$f_{cd} = \frac{f_{ck}}{\gamma_c} = 20 \text{ MPa}$$

Střední hodnota pevnosti betonu v tahu:

$$f_{ctm} = 2.9 \text{ MPa}$$

5% kvantil pevnosti betonu v tahu:

$$f_{ctk,0,05} = 2.0 \text{ MPa}$$

Modul pružnosti betonu:

$$E_{cm} = 33 \text{ GPa}$$

Mezní přetvoření betonu:

$$\epsilon_{cu3} = 3.5 \cdot 10^{-3} = 0.0035$$

Součinitel definující účinnou výšku tlačené oblasti:

$$\lambda = 0.8$$

Ocel B500B

Charakteristická mez kluzu ocele:

$$f_{yk} = 500 \text{ MPa}$$

Součinitel spolehlivosti ocele:

$$\gamma_s = 1.15$$

Návrhová mez kluzu ocele:

$$f_{yd} = \frac{f_{yk}}{\gamma_s} = 434.78 \text{ MPa}$$

Modul pružnosti ocele:

$$E_s = 200 \text{ GPa}$$

Přetvoření ocele:

$$\epsilon_{yd} = \frac{f_{yd}}{E_s} = 0.0021739$$

Specifikace betonu podle ČSN P 73 2404: NEBO EN 206

C 30/37 XC4 XD2 XF4 XA3 CI 0,4 $D_{max} = 22 \text{ mm}$

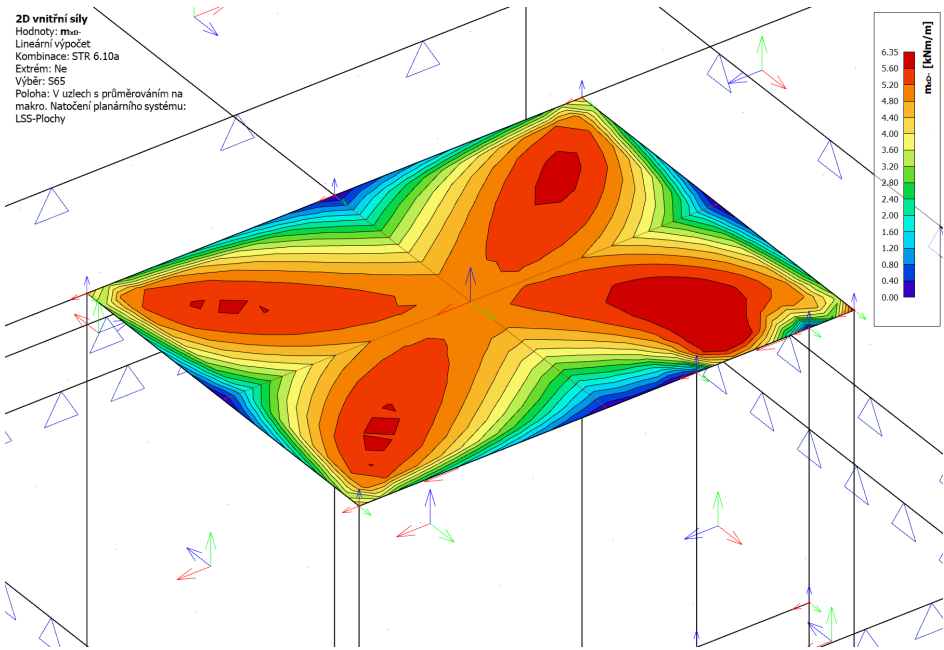
Návrhová životnost 50 let

1. Stropní deska

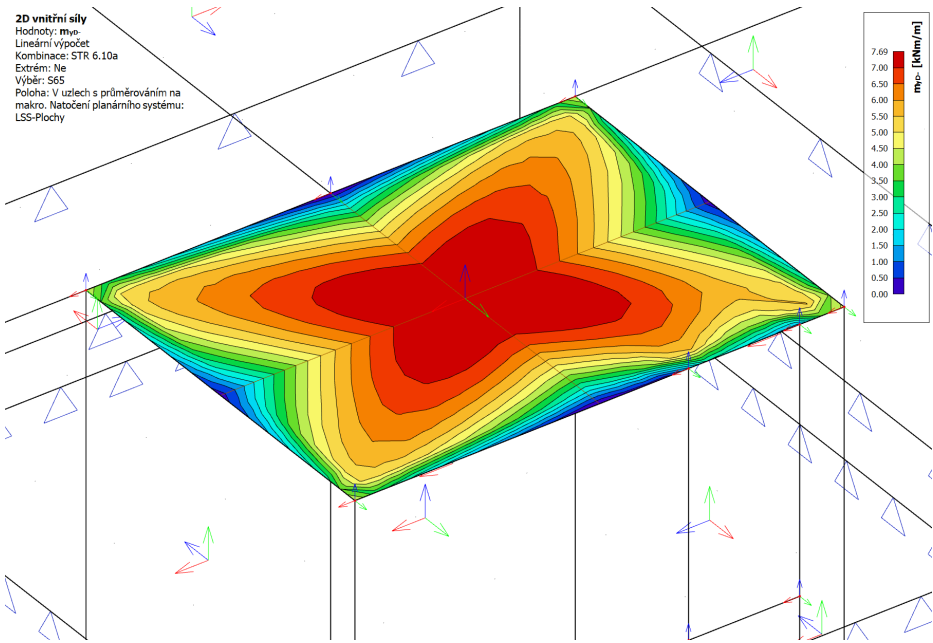
1.1. Posouzení na MSÚ

kombinace K1

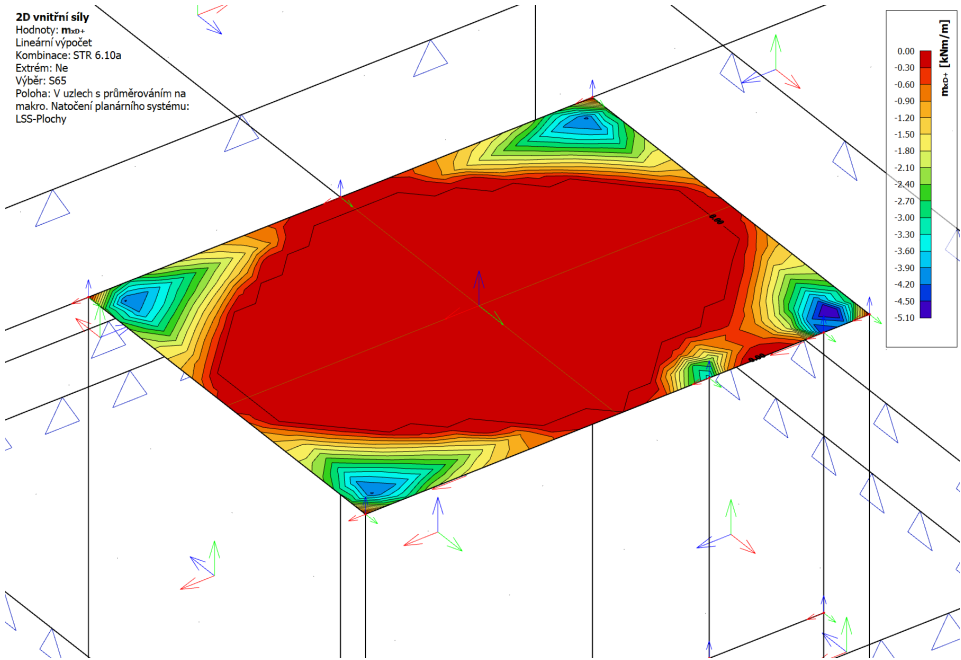
MxD-



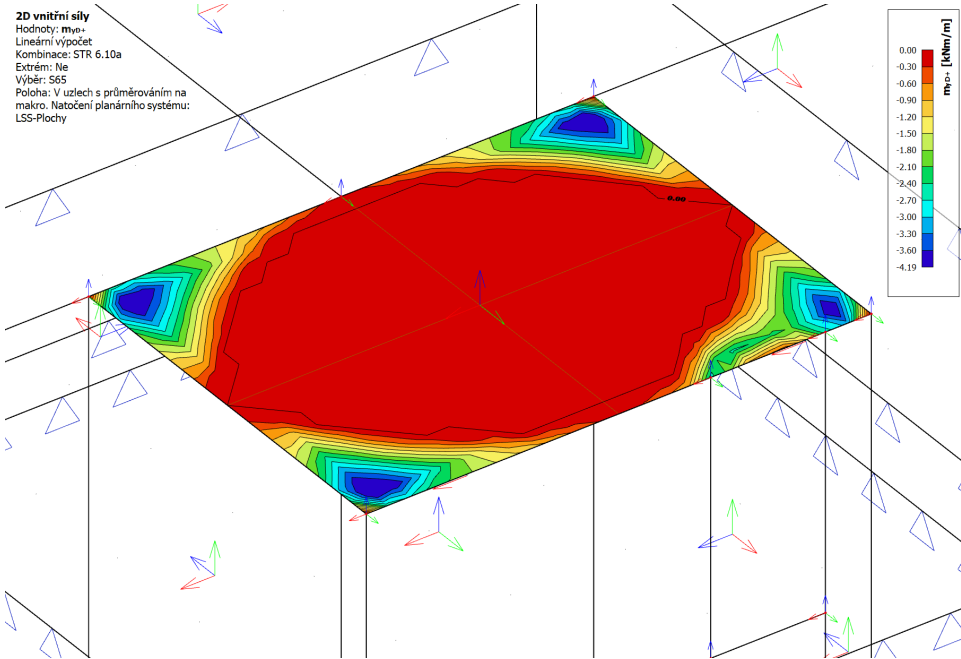
MyD-



MxD+



MyD+



krytí nosné výztuže u všech konstrukcí

$$c_{\min,b,1} = 12 \text{ mm}$$

$$c_{\min,dur,1} = 40 \text{ mm}$$

$$\Delta c_{dev,1} = 10 \text{ mm}$$

$$\Delta c_{dur,\gamma,1} = 0 \text{ mm}$$

$$\Delta c_{dur,st,1} = 0 \text{ mm}$$

$$\Delta c_{dur,add,1} = 0 \text{ mm}$$

$$c_{\min,1} = \text{Max}(c_{\min,b,1}, c_{\min,dur,1} + \Delta c_{dur,\gamma,1} - \Delta c_{dur,st,1} - \Delta c_{dur,add,1}, 10 \text{ mm}) = 40 \text{ mm}$$

$$c_{\text{nom},1} = c_{\min,1} + \Delta c_{dev,1} = 40 \text{ mm} + 10 \text{ mm} = 50 \text{ mm}$$

1.1.1. Dolní výztuž stropní desky

1.1.1.1. směr x (mxd-)

geometrie

$$h_1 = 200 \text{ mm}$$

$$d_{1,1} = c_{\text{nom},1} + 0.5 * \varnothing_{x,\text{dolní,strop}} + \varnothing_{y,\text{dolní,strop},1} = 50 \text{ mm} + 0.5 * 8 \text{ mm} + 8 \text{ mm} = 62 \text{ mm}$$

Odhad průměru výztuže: $\varnothing_{x,\text{dolní,strop}} = 8 \text{ mm}$

$$d_1 = h_1 - d_{1,1} = 200 \text{ mm} - 62 \text{ mm} = 138 \text{ mm}$$

$$b_1 = 1 \text{ m}$$

návrh výztuže

-posuzovaný ohybový moment

$$M_{Ed1} = 6.35 \text{ kN} \cdot \text{m}$$

-nutná plocha výztuže

$$A_{s,req,1} = b_1 * d_1 * \left(\frac{f_{cd}}{f_{yd}} \right) * \left(1 - \sqrt{1 - \frac{2 * M_{Ed1}}{b_1 * d_1^2 * f_{cd}}} \right)$$

$$= 1 \text{ m} * 138 \text{ mm} * \left(\frac{20 \text{ MPa}}{434.78 \text{ MPa}} \right) * \left(1 - \sqrt{1 - \frac{2 * 6.35 \text{ kN} \cdot \text{m}}{1 \text{ m} * (138 \text{ mm})^2 * 20 \text{ MPa}}} \right) = 0.000107 \text{ m}^2$$

-návrh výztuže

$$\varnothing_{x,\text{dolní,strop},1} = \varnothing_{x,\text{dolní,strop}} = 8 \text{ mm} \quad s_1 = 200 \text{ mm}$$

$$A_{s,1} = \left(\frac{\left(\frac{\pi * \varnothing_{x,\text{dolní,strop},1}^2}{4} \right) * b_1}{s_1} \right) = \left(\frac{\left(\frac{3.142 * (8 \text{ mm})^2}{4} \right) * 1 \text{ m}}{200 \text{ mm}} \right) = 0.000251 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,1} = 0.26 * \left(\frac{f_{ctm}}{f_{yk}} \right) * b_1 * d_1 = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 138 \text{ mm} = 0.000208 \text{ m}^2$$

$$A_{s,2,min,1} = 0.0013 * b_1 * d_1 = 0.0013 * 1 \text{ m} * 138 \text{ mm} = 0.000179 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,1} > \text{Max}(A_{s,1,min,1}, A_{s,2,min,1}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 > \text{Max}(0.000208 \text{ m}^2, 0.000179 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,max1} = 0.04 * h_1 * b_1 = 0.04 * 200 \text{ mm} * 1 \text{ m} = 0.008 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,1} < A_{s,max1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 < 0.008 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,1} = 3 * h_1 = 3 * 200 \text{ mm} = 600 \text{ mm}$$

$$s_{2,max,1} = 400 \text{ mm}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_1 < \text{Max}(s_{1,max,1}, s_{2,max,1}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} < \text{Max}(600 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

$$s_{min,1} = \text{Max}(1.2 * \varnothing_{x,dolní,strop,1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 8 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_1 > s_{min,1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

posouzení

-výška tlačené části:

$$x_1 = \frac{A_{s,1} * f_{yd}}{\lambda * b_1 * f_{cd}} = \frac{0.000251 \text{ m}^2 * 434.78 \text{ MPa}}{0.8 * 1 \text{ m} * 20 \text{ MPa}} = 0.00683 \text{ m}$$

$$x_{lim,1} = \frac{\varepsilon_{cu3} * d_1}{\varepsilon_{cu3} + \varepsilon_{yd}} = \frac{0.0035 * 138 \text{ mm}}{0.0035 + 0.0021739} = 0.0851 \text{ m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } x_1 < x_{lim,1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00683 \text{ m} < 0.0851 \text{ m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

-rameno vnitřních sil:

$$z_{c,1} = d_1 - \frac{\lambda * x_1}{2} = 138 \text{ mm} - \frac{0.8 * 0.00683 \text{ m}}{2} = 0.135 \text{ m}$$

-moment na mezi únosnosti:

$$M_{Rd1} = A_{s,1} * f_{yd} * z_{c,1} = 0.000251 \text{ m}^2 * 434.78 \text{ MPa} * 0.135 \text{ m} = 14.781 \text{ kN} * \text{m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } M_{Rd1} > M_{Ed1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 14.781 \text{ kN} * \text{m} > 6.35 \text{ kN} * \text{m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

1.1.1.2. směr y (myd-)

geometrie

$$h_2 = 200 \text{ mm}$$

$$d_{1,2} = c_{nom,1} + 0.5 * \varnothing_{y,dolní,strop} = 50 \text{ mm} + 0.5 * 8 \text{ mm} = 54 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{y,dolní,strop} = 8 \text{ mm}$$

$$d_2 = h_2 - d_{1,2} = 200 \text{ mm} - 54 \text{ mm} = 146 \text{ mm}$$

$$b_2 = 1 \text{ m}$$

návrh výztuže

-posuzovaný ohybový moment

$$M_{Ed2} = 7.69 \text{ kN} * \text{m}$$

-nutná plocha výztuže

$$\begin{aligned} A_{s,req,2} &= b_2 * d_2 * \left(\frac{f_{cd}}{f_{yd}} \right) * \left(1 - \sqrt{1 - \frac{2 * M_{Ed2}}{b_2 * d_2^2 * f_{cd}}} \right) \\ &= 1 \text{ m} * 146 \text{ mm} * \left(\frac{20 \text{ MPa}}{434.78 \text{ MPa}} \right) * \left(1 - \sqrt{1 - \frac{2 * 7.69 \text{ kN} * \text{m}}{1 \text{ m} * (146 \text{ mm})^2 * 20 \text{ MPa}}} \right) = 0.000122 \text{ m}^2 \end{aligned}$$

-návrh výztuže

$$\varnothing_{y,dolní,strop,1} = \varnothing_{y,dolní,strop} = 8 \text{ mm}$$

$$s_2 = 200 \text{ mm}$$

$$A_{s,2} = \left(\frac{\left(\frac{\pi * \varnothing_{y,dolní,strop,1}^2}{4} \right) * b_2}{s_2} \right) = \left(\frac{\left(\frac{3.142 * (8 \text{ mm})^2}{4} \right) * 1 \text{ m}}{200 \text{ mm}} \right) = 0.000251 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,2} = 0.26 * \left(\frac{f_{ctm}}{f_{yk}} \right) * b_2 * d_2 = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 146 \text{ mm} = 0.000220 \text{ m}^2$$

$$A_{s,2,min,2} = 0.0013 * b_2 * d_2 = 0.0013 * 1 \text{ m} * 146 \text{ mm} = 0.000190 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,2} > \text{Max}(A_{s,1,min,2}, A_{s,2,min,2}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 > \text{Max}(0.000220 \text{ m}^2, 0.000190 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,max2} = 0.04 * h_2 * b_2 = 0.04 * 200 \text{ mm} * 1 \text{ m} = 0.008 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,2} < A_{s,max2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 < 0.008 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,2} = 3 * h_2 = 600 \text{ mm}$$

$$s_{2,max,2} = 400 \text{ mm}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_2 < \text{Max}(s_{1,max,2}, s_{2,max,2}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} < \text{Max}(600 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

$$s_{min,2} = \text{Max}(1.2 * \varnothing_{y,dolní,strop,1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 8 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_2 > s_{min,2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

posouzení

-výška tlačené části:

$$x_2 = \frac{A_{s,2} * f_{yd}}{\lambda * b_2 * f_{cd}} = \frac{0.000251 \text{ m}^2 * 434.78 \text{ MPa}}{0.8 * 1 \text{ m} * 20 \text{ MPa}} = 0.00683 \text{ m}$$

$$x_{lim,2} = \frac{\varepsilon_{cu3} * d_2}{\varepsilon_{cu3} + \varepsilon_{yd}} = \frac{0.0035 * 146 \text{ mm}}{0.0035 + 0.0021739} = 0.0901 \text{ m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } x_2 < x_{lim,2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00683 \text{ m} < 0.0901 \text{ m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

-rameno vnitřních sil:

$$z_{c,2} = d_2 - \frac{\lambda * x_2}{2} = 146 \text{ mm} - \frac{0.8 * 0.00683 \text{ m}}{2} = 0.143 \text{ m}$$

-moment na mezi únosnosti:

$$M_{Rd2} = A_{s,2} * f_{yd} * z_{c,2} = 0.000251 \text{ m}^2 * 434.78 \text{ MPa} * 0.143 \text{ m} = 15.655 \text{ kN} * \text{m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } M_{Ed2} < M_{Rd2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 7.69 \text{ kN} * \text{m} < 15.655 \text{ kN} * \text{m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

1.1.2. Horní výztuž stropní desky

1.1.2.1. směr x

(mxd+)

geometrie

$$h_3 = 200 \text{ mm}$$

$$d_{1,3} = c_{nom,1} + 0.5 * \varnothing_{x,horní,strop} + \varnothing_{y,horní,strop,1} = 50 \text{ mm} + 0.5 * 8 \text{ mm} + 8 \text{ mm} = 62 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{x,horní,strop} = 8 \text{ mm}$$

$$d_3 = h_3 - d_{1,3} = 200 \text{ mm} - 62 \text{ mm} = 138 \text{ mm}$$

$$b_3 = 1 \text{ m}$$

návrh výztuže

-posuzovaný ohybový moment

$$M_{Ed3} = 5.10 \text{ kN} * \text{m}$$

-nutná plocha výztuže

$$A_{s,req,3} = b_3 * d_3 * \left(\frac{f_{cd}}{f_{yd}} \right) * \left(1 - \sqrt{1 - \frac{2 * M_{Ed3}}{b_3 * d_3^2 * f_{cd}}} \right)$$

$$= 1 \text{ m} * 138 \text{ mm} * \left(\frac{20 \text{ MPa}}{434.78 \text{ MPa}} \right) * \left(1 - \sqrt{1 - \frac{2 * 5.10 \text{ kN} * \text{m}}{1 \text{ m} * (138 \text{ mm})^2 * 20 \text{ MPa}}} \right) = 0.0000856 \text{ m}^2$$

-návrh výztuže

$$\varnothing_{x,horní,strop,1} = \varnothing_{x,horní,strop} = 8 \text{ mm}$$

$$s_3 = 200 \text{ mm}$$

$$A_{s,3} = \left(\frac{\left(\frac{\pi * \varnothing_{x,horní,strop,1}^2}{4} \right) * b_3}{s_3} \right) = \left(\frac{\left(\frac{3.142 * (8 \text{ mm})^2}{4} \right) * 1 \text{ m}}{200 \text{ mm}} \right) = 0.000251 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,3} = 0.26 * \left(\frac{f_{ctm}}{f_{yk}} \right) * b_3 * d_3 = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 138 \text{ mm} = 0.000208 \text{ m}^2$$

$$A_{s,2,min,3} = 0.0013 * b_3 * d_3 = 0.0013 * 1 \text{ m} * 138 \text{ mm} = 0.000179 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,3} > \text{Max}(A_{s,1,min,3}, A_{s,2,min,3}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 > \text{Max}(0.000208 \text{ m}^2, 0.000179 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,max3} = 0.04 * h_3 * b_3 = 0.04 * 200 \text{ mm} * 1 \text{ m} = 0.008 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,3} < A_{s,max3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 < 0.008 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,3} = 3 * h_3 = 600 \text{ mm}$$

$$s_{2,max,3} = 400 \text{ mm}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_3 < \text{Max}(s_{1,max,3}, s_{2,max,3}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} < \text{Max}(600 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

$$s_{min,3} = \text{Max}(1.2 * \varnothing_{x,horní,strop,1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 8 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_3 > s_{min,3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

posouzení

-výška tlačené části:

$$x_3 = \frac{A_{s,3} * f_{yd}}{\lambda * b_3 * f_{cd}} = \frac{0.000251 \text{ m}^2 * 434.78 \text{ MPa}}{0.8 * 1 \text{ m} * 20 \text{ MPa}} = 0.00683 \text{ m}$$

$$x_{lim,3} = \frac{\varepsilon_{cu3} * d_3}{\varepsilon_{cu3} + \varepsilon_{yd}} = \frac{0.0035 * 138 \text{ mm}}{0.0035 + 0.0021739} = 0.0851 \text{ m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } x_3 < x_{\text{lim},3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00683 \text{ m} < 0.0851 \text{ m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

-rameno vnitřních sil:

$$z_{c,3} = d_3 - \frac{\lambda * x_3}{2} = 138 \text{ mm} - \frac{0.8 * 0.00683 \text{ m}}{2} = 0.135 \text{ m}$$

-moment na mezi únosnosti:

$$M_{\text{Rd}3} = A_{s,3} * f_{yd} * z_{c,3} = 0.000251 \text{ m}^2 * 434.78 \text{ MPa} * 0.135 \text{ m} = 14.781 \text{ kN} * \text{m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } M_{\text{Rd}3} > M_{\text{Ed}3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 14.781 \text{ kN} * \text{m} > 5.10 \text{ kN} * \text{m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

1.1.2.2. směr y

(myd+)

geometrie

$$h_4 = 200 \text{ mm}$$

$$d_{1,4} = c_{\text{nom},1} + 0.5 * \varnothing_{y,\text{horní,strop}} = 50 \text{ mm} + 0.5 * 8 \text{ mm} = 54 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{y,\text{horní,strop}} = 8 \text{ mm}$$

$$d_4 = h_4 - d_{1,4} = 200 \text{ mm} - 54 \text{ mm} = 146 \text{ mm}$$

$$b_4 = 1 \text{ m}$$

návrh výztuže

-posuzovaný ohybový moment

$$M_{\text{Ed}4} = 4.19 \text{ kN} * \text{m}$$

-nutná plocha výztuže

$$A_{s,\text{req},4} = b_4 * d_4 * \left(\frac{f_{cd}}{f_{yd}} \right) * \left(1 - \sqrt{1 - \frac{2 * M_{\text{Ed}4}}{b_4 * d_4^2 * f_{cd}}} \right)$$

$$= 1 \text{ m} * 146 \text{ mm} * \left(\frac{20 \text{ MPa}}{434.78 \text{ MPa}} \right) * \left(1 - \sqrt{1 - \frac{2 * 4.19 \text{ kN} * \text{m}}{1 \text{ m} * (146 \text{ mm})^2 * 20 \text{ MPa}}} \right) = 0.0000663 \text{ m}^2$$

-návrh výztuže

$$\varnothing_{y,\text{horní,strop},1} = \varnothing_{y,\text{horní,strop}} = 8 \text{ mm}$$

$$s_4 = 200 \text{ mm}$$

$$A_{s,4} = \left(\frac{\left(\frac{\pi * \varnothing_{y,\text{horní,strop},1}^2}{4} \right) * b_4}{s_4} \right) = \left(\frac{\left(\frac{3.142 * (8 \text{ mm})^2}{4} \right) * 1 \text{ m}}{200 \text{ mm}} \right) = 0.000251 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,4} = 0.26 * \left(\frac{f_{ctm}}{f_{yk}} \right) * b_4 * d_4 = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 146 \text{ mm} = 0.000220 \text{ m}^2$$

$$A_{s,2,min,4} = 0.0013 * b_4 * d_4 = 0.0013 * 1 \text{ m} * 146 \text{ mm} = 0.000190 \text{ m}^2$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } A_{s,4} > \text{Max}(A_{s,1,min,4}, A_{s,2,min,4}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 > \text{Max}(0.000220 \text{ m}^2, 0.000190 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

-maximální plocha vyztužení

$$A_{s,max4} = 0.04 * h_4 * b_4 = 0.04 * 200 \text{ mm} * 1 \text{ m} = 0.008 \text{ m}^2$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } A_{s,4} < A_{s,max4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 0.000251 \text{ m}^2 < 0.008 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,4} = 3 * h_4 = 3 * 200 \text{ mm} = 600 \text{ mm}$$

$$s_{2,max,4} = 400 \text{ mm}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } s_4 < \text{Max}(s_{1,max,4}, s_{2,max,4}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} < \text{Max}(600 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

$$s_{min,4} = \text{Max}(1.2 * \varnothing_{x,horní,strop,1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 8 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm})$$

$$= 21 \text{ mm}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } s_4 > s_{min,4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

posouzení

-výška tlačené části:

$$x_4 = \frac{A_{s,4} * f_{yd}}{\lambda * b_4 * f_{cd}} = \frac{0.000251 \text{ m}^2 * 434.78 \text{ MPa}}{0.8 * 1 \text{ m} * 20 \text{ MPa}} = 0.00683 \text{ m}$$

$$x_{lim,4} = \frac{\varepsilon_{cu3} * d_4}{\varepsilon_{cu3} + \varepsilon_{yd}} = \frac{0.0035 * 146 \text{ mm}}{0.0035 + 0.0021739} = 0.0901 \text{ m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } x_4 < x_{lim,4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00683 \text{ m} < 0.0901 \text{ m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

-rameno vnitřních sil:

$$z_{c,4} = d_4 - \frac{\lambda * x_4}{2} = 146 \text{ mm} - \frac{0.8 * 0.00683 \text{ m}}{2} = 0.143 \text{ m}$$

-moment na mezi únosnosti:

$$M_{Rd4} = A_{s,4} * f_{yd} * z_{c,4} = 0.000251 \text{ m}^2 * 434.78 \text{ MPa} * 0.143 \text{ m} = 15.655 \text{ kN} * \text{m}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } M_{Ed4} < M_{Rd4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 4.19 \text{ kN} * \text{m} < 15.655 \text{ kN} * \text{m} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

1.1.3. přivýztužení

- u otvoru není vzhledem k velkému poměru potřebné/navržené výztuži a malému momentu potřeba posuzovat

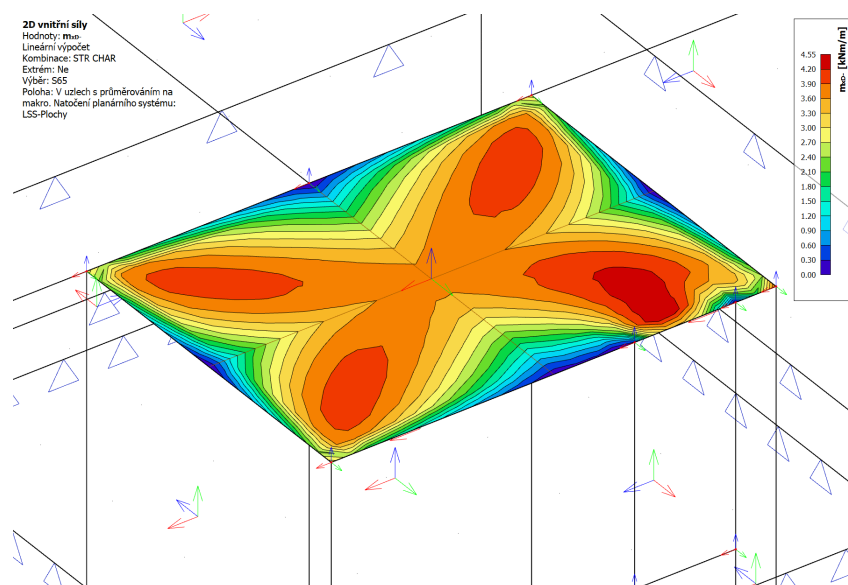
1.2. Posouzení na MSP

1.2.1. směr x

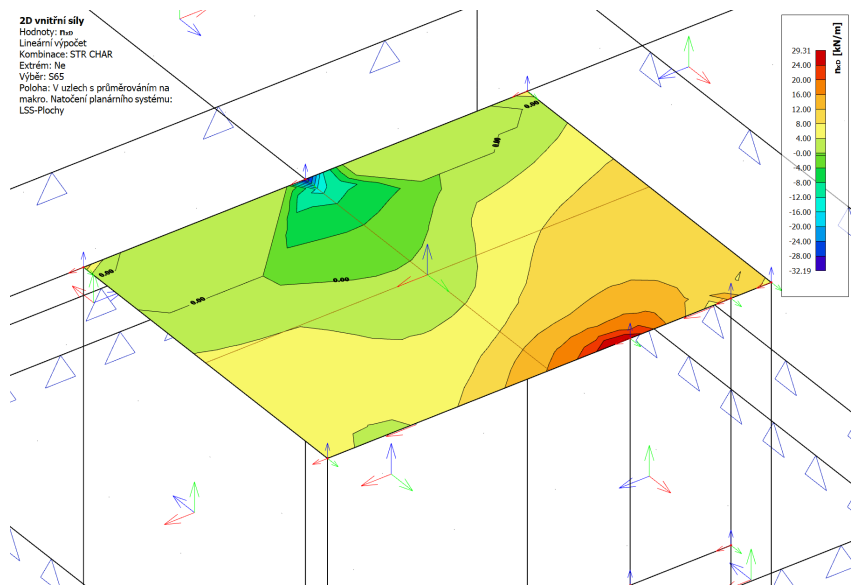
Kombinace K1

Charakteristická

Mxd-

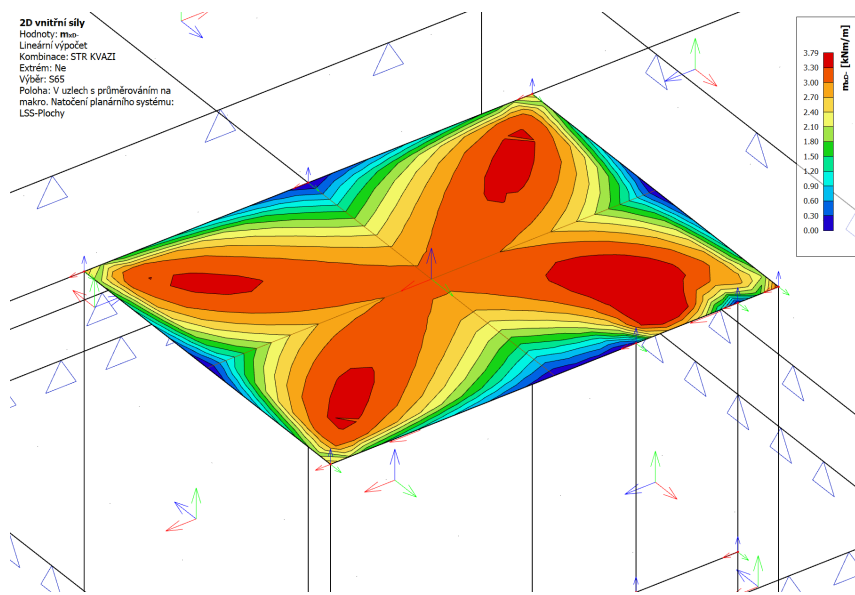


NxD



Kvazistálá

Mxd-



(Table 14)

Kombinace	Mx	Nx
Charakteristická	4.55	32.19
Kvazistálá	3.79	
Charakteristická	4.55 kN*m	32.19 kN
Kvazistálá	3.79 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,1} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,1} = b_1 * h_1 = 1 \text{ m} * 200 \text{ mm} = 0.2 \text{ m}^2$$

$$A_{S,S,1} = A_{s,1} = 0.000251 \text{ m}^2$$

$$A_{i,1} = A_{C,C,1} + A_{S,S,1} * \alpha_{e,1} = 0.2 \text{ m}^2 + 0.000251 \text{ m}^2 * 6.061 = 0.202 \text{ m}^2$$

$$a_{c,c,1} = \frac{h_1}{2} = \frac{200 \text{ mm}}{2} = 0.1 \text{ m}$$

$$a_{gi,1} = \frac{A_{C,C,1} * a_{c,c,1} + \alpha_{e,1} * (A_{S,S,1} * d_1)}{A_{i,1}} = \frac{0.2 \text{ m}^2 * 0.1 \text{ m} + 6.061 * (0.000251 \text{ m}^2 * 138 \text{ mm})}{0.202 \text{ m}^2}$$

$$= 0.100 \text{ m}$$

$$I_{c,c,1} = \left(\frac{1}{12} \right) * b_1 * h_1^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (200 \text{ mm})^3 = 0.000667 \text{ m}^4$$

$$I_{i,1} = I_{c,c,1} + A_{C,C,1} * (a_{gi,1} - a_{c,c,1})^2 + \alpha_{e,1} * (A_{S,S,1} * (d_1 - a_{gi,1})^2)$$

$$= 0.000667 \text{ m}^4 + 0.2 \text{ m}^2 * (0.100 \text{ m} - 0.1 \text{ m})^2 + 6.061 * (0.000251 \text{ m}^2 * (138 \text{ mm} - 0.100 \text{ m})^2)$$

$$= 0.000669 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,1} = \left| \left(\left(\frac{\text{Table14.C4}}{A_{i,1}} \right) - \left(\frac{\text{Table14.B4} * a_{gi,1}}{I_{i,1}} \right) \right) \right| = \left| \left(\left(\frac{32.19 \text{ kN}}{0.202 \text{ m}^2} \right) - \left(\frac{4.55 \text{ kN} * \text{m} * 0.100 \text{ m}}{0.000669 \text{ m}^4} \right) \right) \right|$$

$$= 522.493 \text{ kPa}$$

$$f_{ct,eff,1,1} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} & \text{if } \sigma_{C,C,1,1} < f_{ct,eff,1,1} \\ \text{"NEVYHOVUJE TRHLINY NEVZNIKNOU"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} & \text{if } 522.493 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY NEVZNIKNOU"} & \text{otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

$$\sigma_{C,C,2,1} = \left| \left(\left(\frac{\text{Table14.C4}}{A_{i,1}} \right) + \left(\frac{\text{Table14.B4} * (h_1 - a_{gi,1})}{I_{i,1}} \right) \right) \right| = 838.052 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,2,1} < f_{ct,eff,1,1}$
 "NEVYHOVUJE TRHLINY NEVZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $838.052 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY NEVZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

Napětí ve výztuži

$$e_{kd,1} = \frac{\text{Table14.B4}}{\text{Table14.C4}} = 0.141 \text{ m}$$

$$e_1 = e_{kd,1} + a_{c,c,1} = 0.241 \text{ m}$$

$$\begin{aligned}
 \sigma_{S,S,1,1} &= \left(\frac{\text{Table14.C4}}{A_{i,1}} \right) * \left(1 + \left(\frac{A_{i,1} * (a_{gi,1} - e_1) * (a_{gi,1} - d_1)}{I_{i,1}} \right) \right) * \alpha_{e,1} \\
 &= \left(\frac{32.19 \text{ kN}}{0.202 \text{ m}^2} \right) * \left(1 + \left(\frac{0.202 \text{ m}^2 * (0.100 \text{ m} - 0.241 \text{ m}) * (0.100 \text{ m} - 138 \text{ mm})}{0.000669 \text{ m}^4} \right) \right) * 6.061 = 2519.769 \text{ kPa}
 \end{aligned}$$

"VYHOVUJE" if $\sigma_{S,S,1,1} < 0.8 * f_{yk}$ = "VYHOVUJE" if $2519.769 \text{ kPa} < 0.8 * 500 \text{ MPa}$
 "NEVYHOVUJE" otherwise = "NEVYHOVUJE" otherwise
 = VYHOVUJE

$$\begin{aligned}
 \sigma_{S,S,2,1} &= \left(\frac{\text{Table14.C4}}{A_{i,1}} \right) * \left(1 + \left(\frac{A_{i,1} * (a_{gi,1} - e_1) * (a_{gi,1} - d_1)}{I_{i,1}} \right) \right) * \alpha_{e,1} \\
 &= \left(\frac{32.19 \text{ kN}}{0.202 \text{ m}^2} \right) * \left(1 + \left(\frac{0.202 \text{ m}^2 * (0.100 \text{ m} - 0.241 \text{ m}) * (0.100 \text{ m} - 138 \text{ mm})}{0.000669 \text{ m}^4} \right) \right) * 6.061 = 2519.769 \text{ kPa}
 \end{aligned}$$

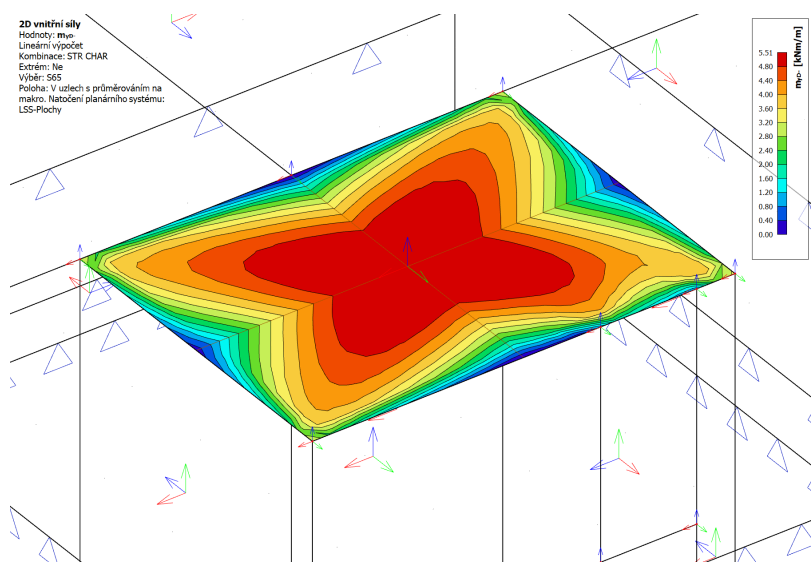
"VYHOVUJE" if $\sigma_{S,S,2,1} < 0.8 * f_{yk}$ = "VYHOVUJE" if $2519.769 \text{ kPa} < 0.8 * 500 \text{ MPa}$
 "NEVYHOVUJE" otherwise = "NEVYHOVUJE" otherwise
 = VYHOVUJE

1.2.2. směr y

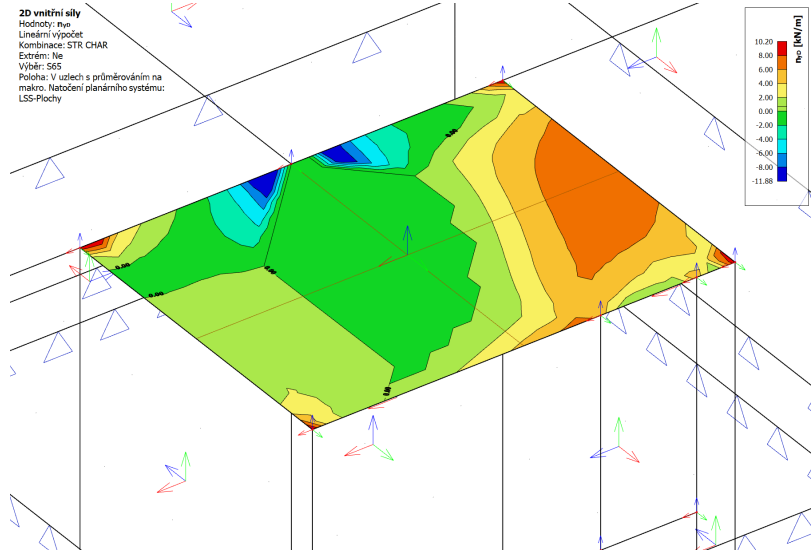
Kombinace K1

Charakteristická

Myd-

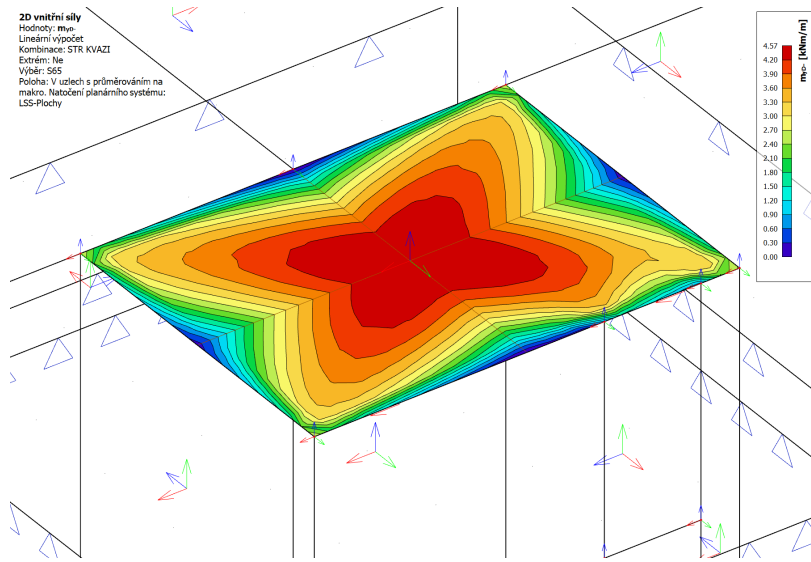


NyD



Kvazistálá

Myd-



(Table 13)

Kombinace	MyD	NyD
Charakteristická	5.51	-11.88
Kvazistálá	4.57	
Charakteristická	5.51 kN*m	11.88 kN
Kvazistálá	4.57 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,2} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,2} = b_2 * h_2 = 1 \text{ m} * 200 \text{ mm} = 0.2 \text{ m}^2$$

$$A_{S,S,2} = A_{s,2} = 0.000251 \text{ m}^2$$

$$A_{i,2} = A_{C,C,2} + A_{S,S,2} * \alpha_{e,2} = 0.2 \text{ m}^2 + 0.000251 \text{ m}^2 * 6.061 = 0.202 \text{ m}^2$$

$$a_{c,c,2} = \frac{h_2}{2} = \frac{200 \text{ mm}}{2} = 0.1 \text{ m}$$

$$a_{gi,2} = \frac{A_{C,C,2} * a_{c,c,2} + \alpha_{e,2} * (A_{S,S,2} * d_1)}{A_{i,2}} = \frac{0.2 \text{ m}^2 * 0.1 \text{ m} + 6.061 * (0.000251 \text{ m}^2 * 138 \text{ mm})}{0.202 \text{ m}^2}$$

$$= 0.100 \text{ m}$$

$$I_{c,c,2} = \left(\frac{1}{12} \right) * b_2 * h_2^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (200 \text{ mm})^3 = 0.000667 \text{ m}^4$$

$$I_{i,2} = I_{c,c,2} + A_{C,C,2} * (a_{gi,2} - a_{c,c,2})^2 + \alpha_{e,2} * (A_{S,S,2} * (d_2 - a_{gi,2})^2)$$

$$= 0.000667 \text{ m}^4 + 0.2 \text{ m}^2 * (0.100 \text{ m} - 0.1 \text{ m})^2 + 6.061 * (0.000251 \text{ m}^2 * (146 \text{ mm} - 0.100 \text{ m})^2)$$

$$= 0.000670 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,2} = \left| \left(\left(\frac{\text{Table13.C4}}{A_{i,2}} \right) - \left(\frac{\text{Table13.B4} * a_{gi,2}}{I_{i,2}} \right) \right) \right| = \left| \left(\left(\frac{11.88 \text{ kN}}{0.202 \text{ m}^2} \right) - \left(\frac{5.51 \text{ kN} * \text{m} * 0.100 \text{ m}}{0.000670 \text{ m}^4} \right) \right) \right|$$

$$= 765.964 \text{ kPa}$$

$$f_{ct,eff,1,2} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,1,2} < f_{ct,eff,1,2}$
 "NEVYHOVUJE TRHLINY NEVZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $765.964 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY NEVZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

$$\sigma_{C,C,2,2} = \left| \left(\left(\frac{\text{Table13.C4}}{A_{i,2}} \right) + \left(\frac{\text{Table13.B4} * (h_2 - a_{gi,2})}{I_{i,2}} \right) \right) \right| = 879.141 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} & \text{if } \sigma_{C,C,2,2} < f_{ct,eff,1,2} \\ \text{"NEVYHOVUJE TRHLINY NEVZNIKNOU"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} & \text{if } 879.141 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY NEVZNIKNOU"} & \text{otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

Napětí ve výztuži

$$e_{kd,2} = \frac{\text{Table13.B4}}{\text{Table13.C4}} = 0.464 \text{ m}$$

$$e_2 = e_{kd,1} + a_{c,c,2} = 0.241 \text{ m}$$

$$\begin{aligned} \sigma_{S,S,1,2} &= \left(\frac{\text{Table13.C4}}{A_{i,2}} \right) * \left(1 + \left(\frac{A_{i,2} * (a_{gi,2} - e_2) * (a_{gi,2} - d_2)}{I_{i,2}} \right) \right) * \alpha_{e,2} \\ &= \left(\frac{11.88 \text{ kN}}{0.202 \text{ m}^2} \right) * \left(1 + \left(\frac{0.202 \text{ m}^2 * (0.100 \text{ m} - 0.241 \text{ m}) * (0.100 \text{ m} - 146 \text{ mm})}{0.000670 \text{ m}^4} \right) \right) * 6.061 = 1050.368 \text{ kPa} \end{aligned}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,1,2} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 1050.368 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \text{VYHOVUJE} \end{aligned}$$

$$\begin{aligned} \sigma_{S,S,2,2} &= \left(\frac{\text{Table13.C4}}{A_{i,2}} \right) * \left(1 + \left(\frac{A_{i,2} * (a_{gi,2} - e_2) * (a_{gi,2} - d_2)}{I_{i,2}} \right) \right) * \alpha_{e,2} \\ &= \left(\frac{11.88 \text{ kN}}{0.202 \text{ m}^2} \right) * \left(1 + \left(\frac{0.202 \text{ m}^2 * (0.100 \text{ m} - 0.241 \text{ m}) * (0.100 \text{ m} - 146 \text{ mm})}{0.000670 \text{ m}^4} \right) \right) * 6.061 = 1050.368 \text{ kPa} \end{aligned}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,2} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 1050.368 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \text{VYHOVUJE} \end{aligned}$$

2. Stěny

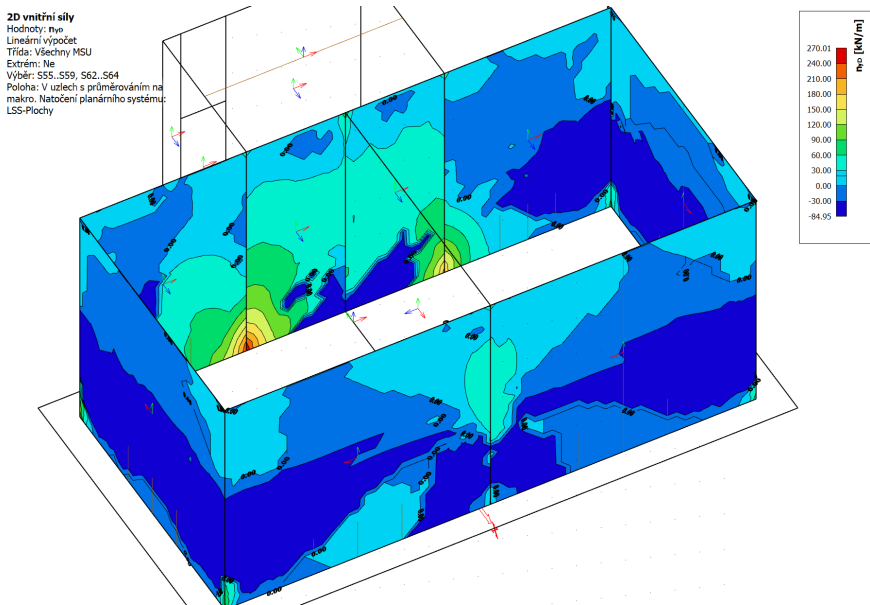
2.1. Vnější nádrže

Pozn. Zkusím porovnat možnost různého vyztužení v dolní a horní části stěny, jestli se neukáže, že se vyplatí stěnu vyztužovat jinak v obou částech, další posudky stěn už budou na celou výšku.

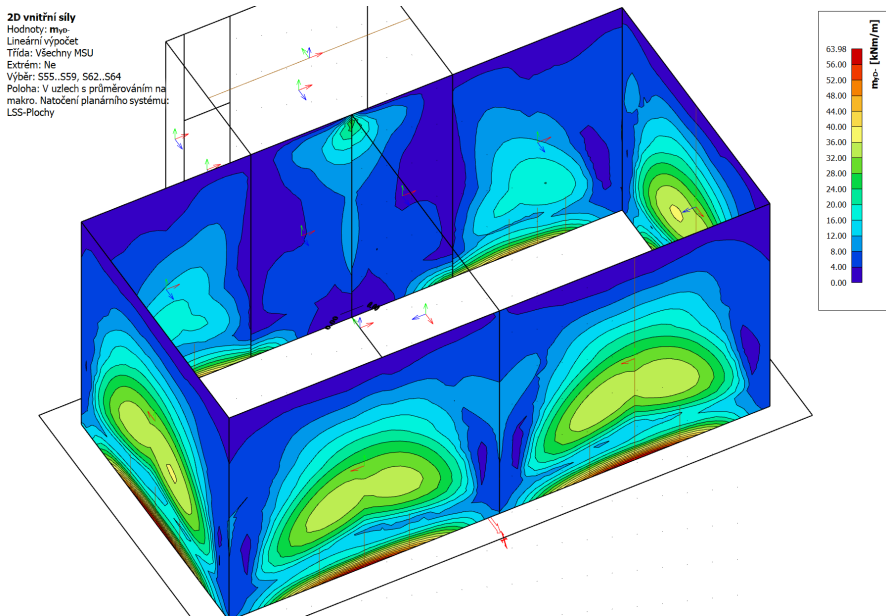
Vykresleny okraje, pouze orientačně, hodnoty do tabulky byly brány z programu Scia a rovnou vypisovány (bylo by jich moc, okraje vykresleny pro kontrolu toho, že jsem se vlezl do uvedených nejhorších hodnot).

Okraje (Třídy) MSÚ

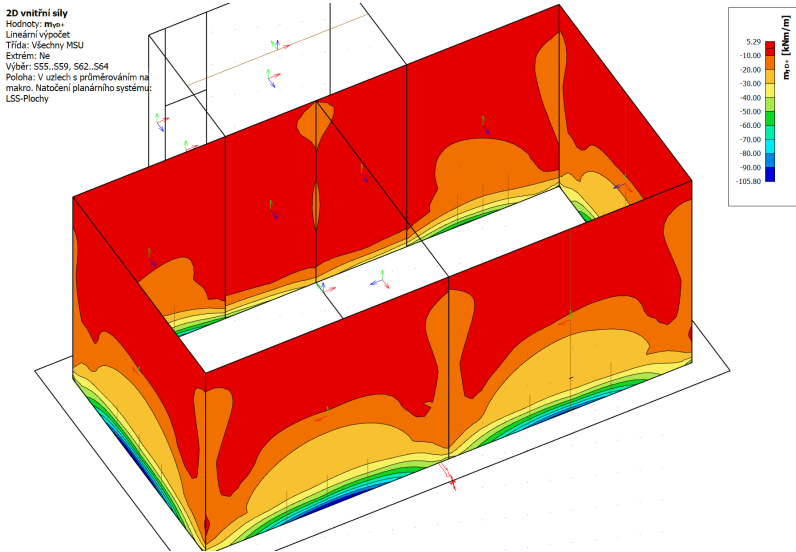
NyD



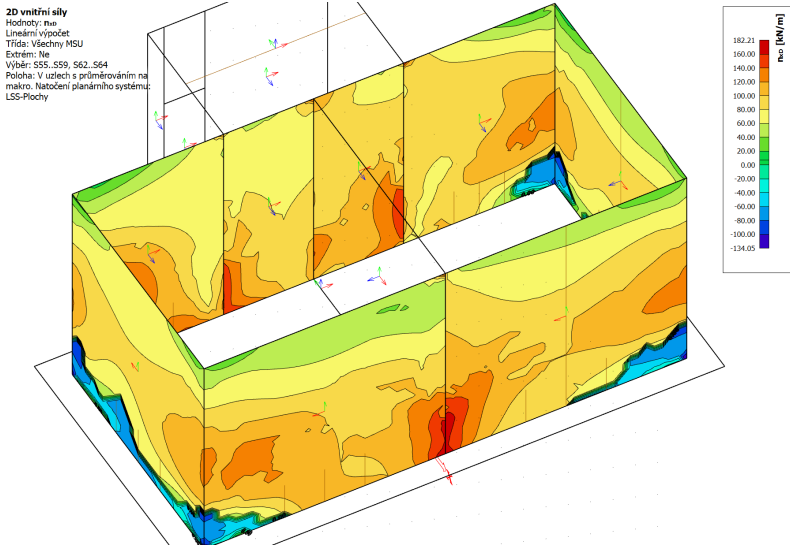
MyD-



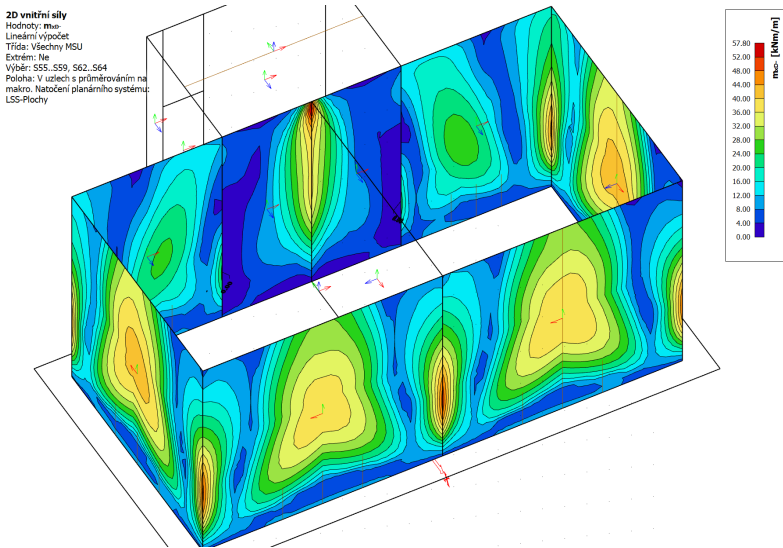
MyD+



NxD

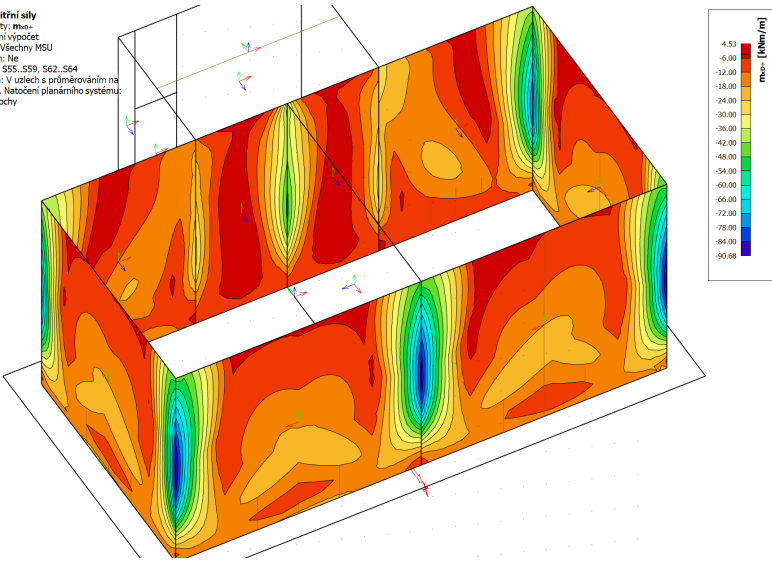


MxD-



Mxd+

2D vnitřní síly
Hodnoty: mN/m
Lineární výpočet
Třída: Všechny MSÚ
Extrém: Ne
Výběr: 555, 559, 562, 564
Položka: V úsečích s průměrováním na makro. Nabízení planárního systému: LSS-Plochy



2.1.1. Výška 0,0-1,0 m

2.1.1.1. Posouzení na MSÚ

Hodnoty z jednotlivých kombinací
(Table 15)

Kombinace	NyD	MyD-	MyD+	NxD	MxD-	MxD+
K2	72.28	42.23	-21.6	75.88	35.09	-16
K3	203.02	17.02	-89.34	163.27	22.91	-33.31
K4	228.97	18.4	-92.59	147.62	19.3	-34.29

2.1.1.1.1. Směr y svislá výztuž

geometrie (pro oba povrchy stejné krytí)

$h_5 = 400 \text{ mm}$

$d_{1,5} = c_{nom,1} + 0.5 * \varnothing_{y,0,1,steny} = 50 \text{ mm} + 0.5 * 12 \text{ mm} = 56 \text{ mm}$

Odhad průměru výztuže:

$\varnothing_{y,0,1,steny} = 12 \text{ mm}$

$d_5 = h_5 - d_{1,5} = 400 \text{ mm} - 56 \text{ mm} = 344 \text{ mm}$

$b_5 = 1 \text{ m}$

návrh výztuže

$\varnothing_{y,0,1,steny1} = \varnothing_{y,0,1,steny} = 12 \text{ mm}$ $s_5 = 150 \text{ mm}$

$$A_{s,5} = \left(\frac{\left(\frac{\pi * \varnothing_{y,0,1,steny1}^2}{4} \right) * b_5}{s_5} \right) = \left(\frac{\left(\frac{3.142 * (12 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.000754 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,5} = 0.26 * \left(\frac{f_{ctm}}{f_{yk}} \right) * b_5 * d_5 = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 344 \text{ mm} = 0.000519 \text{ m}^2$$

$$A_{s,2,min,5} = 0.0013 * b_5 * d_5 = 0.000447 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,5} > \text{Max}(A_{s,1,min,5}, A_{s,2,min,5}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 > \text{Max}(0.000519 \text{ m}^2, 0.000447 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,max5} = 0.04 * h_5 * b_5 = 0.016 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,5} < A_{s,max5} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,5} = 3 * h_5 = 1200 \text{ mm}$$

$$s_{2,max,5} = 400 \text{ mm}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_5 < \text{Max}(s_{1,max,5}, s_{2,max,5}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

$$s_{min,5} = \text{Max}(1.2 * \varnothing_{y,0,1,steny1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 12 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_5 > s_{min,5} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,1} = \text{Max}\left(\frac{h_5}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{400 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,1} = \left(\frac{h_5}{2}\right) - d_{1,5} = \left(\frac{400 \text{ mm}}{2}\right) - 56 \text{ mm} = 0.144 \text{ m}$$

$$\sigma_{s,0,1} = \varepsilon_{cu3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$N_{Rd,0,1} = - \left(b_5 * h_5 * f_{cd} + A_{s,5} * \sigma_{s,0,1} * 2 \right) \\ = - \left(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 700 \text{ MPa} * 2 \right) = -9055.575 \text{ kN}$$

$$M_{Rd,0,1,1} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,1} = d_5 = 0.344 \text{ m}$$

$$\varepsilon_{s,1,1} = \varepsilon_{cu3} * \left(\frac{x_{1,1} - d_{1,5}}{x_{1,1}} \right) = 0.0035 * \left(\frac{0.344 \text{ m} - 56 \text{ mm}}{0.344 \text{ m}} \right) = 0.00293$$

$$\varepsilon_{s,1,1} < \varepsilon_{yd} = 0.00293 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,1} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,1,1} = - \left(b_5 * \lambda * x_{1,1} * f_{cd} + A_{s,5} * \sigma_{s,1,1} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.344 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) = -5831.818 \text{ kN}$$

$$M_{Rd,1,1} = b_5 * \lambda * x_{1,1} * f_{cd} * \left(\frac{h_5 - \lambda * x_{1,1}}{2} \right) + A_{s,5} * \sigma_{s,1,1} * z_{1,1} \\ = 1 \text{ m} * 0.8 * 0.344 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.344 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} \\ = 390.655 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,1} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_5 = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 344 \text{ mm} = 0.212 \text{ m}$$

$$\varepsilon_{s,2,1,1} = \varepsilon_{cu3} * \left(\frac{x_{2,1} - d_{1,5}}{x_{2,1}} \right) = 0.0035 * \left(\frac{0.212 \text{ m} - 56 \text{ mm}}{0.212 \text{ m}} \right) = 0.00258$$

$$\varepsilon_{s,2,1,1} < \varepsilon_{yd} = 0.00258 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,1} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,1} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,1} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,2,1} = - \left(b_5 * \lambda * x_{2,1} * f_{cd} + A_{s,5} * \sigma_{s,2,1,1} - A_{s,5} * \sigma_{s,2,2,1} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.212 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} - 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) \\ = -3395.188 \text{ kN}$$

$$M_{Rd,2,1} = b_5 * \lambda * x_{2,1} * f_{cd} * \left(\frac{h_5 - \lambda * x_{2,1}}{2} \right) + A_{s,5} * \sigma_{s,2,1,1} * z_{1,1} + A_{s,5} * \sigma_{s,2,2,1} * z_{1,1} \\ = 1 \text{ m} * 0.8 * 0.212 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.212 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} \\ = 485.267 \text{ kN} * \text{m}$$

BOD 3 prostý ohyb

$$N_{Rd,3,1} = 0 \text{ kN}$$

$$x_{3,1} = \frac{A_{s,5} \cdot f_{yd} + A_{s,5} \cdot f_{yd}}{b_5 \cdot \lambda \cdot f_{cd}} = \frac{0.000754 \text{ m}^2 \cdot 434.78 \text{ MPa} + 0.000754 \text{ m}^2 \cdot 434.78 \text{ MPa}}{1 \text{ m} \cdot 0.8 \cdot 20 \text{ MPa}} = 0.0410 \text{ m}$$

$$\epsilon_{s,3,1,1} = \epsilon_{cu3} \cdot \left(\frac{d_{1,5} - x_{3,1}}{x_{3,1}} \right) = 0.0035 \cdot \left(\frac{56 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.00128$$

$$\epsilon_{s,3,1,1} < \epsilon_{yd} = 0.00128 < 0.0021739 = \text{True} \quad \sigma_{s,3,1,1} = \epsilon_{s,3,1,1} \cdot E_s = 0.00128 \cdot 200 \text{ GPa} = 0.257 \text{ GPa}$$

$$\epsilon_{s,3,2,1} = \epsilon_{cu3} \cdot \left(\frac{d_5 - x_{3,1}}{x_{3,1}} \right) = 0.0035 \cdot \left(\frac{344 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.0259$$

$$\epsilon_{s,3,2,1} < \epsilon_{yd} = 0.0259 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,1} = f_{yd} = 434.783 \text{ MPa}$$

$$M_{Rd,3,1} = b_5 \cdot \lambda \cdot x_{3,1} \cdot f_{cd} \cdot \left(\frac{h_5 - \lambda \cdot x_{3,1}}{2} \right) + A_{s,5} \cdot \sigma_{s,3,1,1} \cdot z_{1,1} + A_{s,5} \cdot \sigma_{s,3,2,1} \cdot z_{1,1}$$

$$= 1 \text{ m} \cdot 0.8 \cdot 0.0410 \text{ m} \cdot 20 \text{ MPa} \cdot \left(\frac{400 \text{ mm} - 0.8 \cdot 0.0410 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 \cdot 0.257 \text{ GPa} \cdot 0.144 \text{ m} + 0.000754 \text{ m}^2 \cdot 434.783 \text{ MPa} \cdot 0.144 \text{ m}$$

$$= 195.450 \text{ kN} \cdot \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,1} = d_{1,5} = 0.056 \text{ m}$$

$$\epsilon_{s,4,1,1} = \epsilon_{cu3} \cdot \left(\frac{d_5 - x_{4,1}}{x_{4,1}} \right) = 0.0035 \cdot \left(\frac{344 \text{ mm} - 0.056 \text{ m}}{0.056 \text{ m}} \right) = 0.018$$

$$\epsilon_{s,4,1,1} < \epsilon_{yd} = 0.018 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,1} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,1} = A_{s,5} \cdot \sigma_{s,4,1,1} = 0.000754 \text{ m}^2 \cdot 434.783 \text{ MPa} = 327.818 \text{ kN}$$

$$M_{Rd,4,1} = A_{s,5} \cdot \sigma_{s,4,1,1} \cdot z_{1,1} = 0.000754 \text{ m}^2 \cdot 434.783 \text{ MPa} \cdot 0.144 \text{ m} = 47.206 \text{ kN} \cdot \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,1} = A_{s,5} \cdot f_{yd} + A_{s,5} \cdot f_{yd} = 0.000754 \text{ m}^2 \cdot 434.78 \text{ MPa} + 0.000754 \text{ m}^2 \cdot 434.78 \text{ MPa} = 655.637 \text{ kN}$$

$$M_{Rd,5,1} = 0 \text{ kN} \cdot \text{m}$$

Body	N_Rd	M_Rd
0	-9055.6 kN	0 kN*m
1	-5831.8 kN	391 kN*m
2	-3395.2 kN	485 kN*m
3	0 kN	195 kN*m
4	327.818 kN	47.2 kN*m

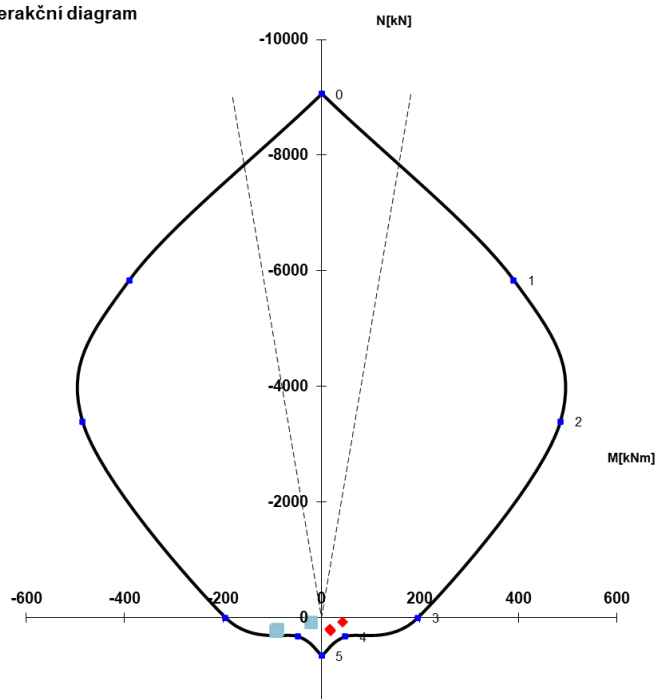
5 655.637 kN 0 kN*m

Kombinace	NyD	MyD-	MyD+
K2	72.28	42.23	-21.6
K3	203.02	17.02	-89.34
K4	228.97	18.4	-92.59

(Table 2)

DIAGRAM

Interakční diagram



2.1.1.2. Směr x vodorovná výztuž geometrie (pro oba povrchy stejné krytí)

$$h_6 = 400 \text{ mm}$$

$$d_{1,6} = c_{\text{nom},1} + 0.5 * \varnothing_{x,0,1,\text{stény}} + \varnothing_{y,0,1,\text{stény}} = 50 \text{ mm} + 0.5 * 10 \text{ mm} + 12 \text{ mm} = 67 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{x,0,1,\text{stény}} = 10 \text{ mm}$$

$$d_6 = h_6 - d_{1,6} = 400 \text{ mm} - 67 \text{ mm} = 333 \text{ mm}$$

$$b_6 = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{x,0,1,\text{stény}1} = \varnothing_{x,0,1,\text{stény}} = 10 \text{ mm} \quad s_6 = 150 \text{ mm}$$

$$A_{s,6} = \left(\frac{\left(\frac{\pi * \varnothing_{x,0,1,\text{stény}1}^2}{4} \right) * b_6}{s_6} \right) = \left(\frac{\left(\frac{3.142 * (10 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.000524 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,6} = 0.26 * \left(\frac{f_{ctm}}{f_{yk}} \right) * b_6 * d_6 = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 333 \text{ mm} = 0.000502 \text{ m}^2$$

$$A_{s,2,min,6} = 0.0013 * b_6 * d_6 = 0.000433 \text{ m}^2$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } A_{s,6} > \text{Max}(A_{s,1,min,6}, A_{s,2,min,6}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } 0.000524 \text{ m}^2 > \text{Max}(0.000502 \text{ m}^2, 0.000433 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

-maximální plocha vyztužení

$$A_{s,max6} = 0.04 * h_6 * b_6 = 0.016 \text{ m}^2$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } A_{s,6} < A_{s,max6} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 0.000524 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,6} = 3 * h_6 = 1200 \text{ mm}$$

$$s_{2,max,6} = 400 \text{ mm}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } s_6 < \text{Max}(s_{1,max,6}, s_{2,max,6}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

$$s_{min,6} = \text{Max}(1.2 * \varnothing_{x,0,1,steny1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 10 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm})$$

$$= 21 \text{ mm}$$

$$\text{value4} = \begin{cases} \text{"VYHOVUJE"} & \text{if } s_6 > s_{min,6} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,2} = \text{Max}\left(\frac{h_6}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{400 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,2} = \left(\frac{h_6}{2} \right) - d_{1,6} = \left(\frac{400 \text{ mm}}{2} \right) - 67 \text{ mm} = 0.133 \text{ m}$$

$$\sigma_{s,0,2} = \varepsilon_{cu3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$N_{Rd,0,2} = - \left(b_6 * h_6 * f_{cd} + A_{s,6} * \sigma_{s,0,2} * 2 \right) \\ = - \left(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000524 \text{ m}^2 * 700 \text{ MPa} * 2 \right) = -8733.038 \text{ kN}$$

$$M_{Rd,0,1,2} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,2} = d_6 = 0.333 \text{ m}$$

$$\varepsilon_{s,1,2} = \varepsilon_{cu3} * \left(\frac{x_{1,2} - d_{1,6}}{x_{1,2}} \right) = 0.0035 * \left(\frac{0.333 \text{ m} - 67 \text{ mm}}{0.333 \text{ m}} \right) = 0.00280$$

$$\varepsilon_{s,1,2} < \varepsilon_{yd} = 0.00280 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,2} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$N_{Rd,1,2} = - \left(b_6 * \lambda * x_{1,2} * f_{cd} + A_{s,6} * \sigma_{s,1,2} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.333 \text{ m} * 20 \text{ MPa} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} \right) = -5555.652 \text{ kN}$$

$$M_{Rd,1,2} = b_6 * \lambda * x_{1,2} * f_{cd} * \left(\frac{h_6 - \lambda * x_{1,2}}{2} \right) + A_{s,6} * \sigma_{s,1,2} * z_{1,2} \\ = 1 \text{ m} * 0.8 * 0.333 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.333 \text{ m}}{2} \right) + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.133 \text{ m} \\ = 386.188 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,2} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_6 = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 333 \text{ mm} = 0.205 \text{ m}$$

$$\varepsilon_{s,2,1,2} = \varepsilon_{cu3} * \left(\frac{x_{2,2} - d_{1,6}}{x_{2,2}} \right) = 0.0035 * \left(\frac{0.205 \text{ m} - 67 \text{ mm}}{0.205 \text{ m}} \right) = 0.00236$$

$$\varepsilon_{s,2,1,2} < \varepsilon_{yd} = 0.00236 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,2} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,2} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,2} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,2,2} = - \left(b_6 * \lambda * x_{2,2} * f_{cd} + A_{s,6} * \sigma_{s,2,1,2} - A_{s,6} * \sigma_{s,2,2,2} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.205 \text{ m} * 20 \text{ MPa} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} - 0.000524 \text{ m}^2 * 434.783 \text{ MPa} \right) \\ = -3286.621 \text{ kN}$$

$$M_{Rd,2,2} = b_6 * \lambda * x_{2,2} * f_{cd} * \left(\frac{h_6 - \lambda * x_{2,2}}{2} \right) + A_{s,6} * \sigma_{s,2,1,2} * z_{1,2} + A_{s,6} * \sigma_{s,2,2,2} * z_{1,2} \\ = 1 \text{ m} * 0.8 * 0.205 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.205 \text{ m}}{2} \right) + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.133 \text{ m} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.133 \text{ m} \\ = 447.833 \text{ kN} * \text{m}$$

BOD 3 prostý ohyb

$$N_{Rd,3,2} = 0 \text{ kN}$$

$$x_{3,2} = \frac{A_{s,6} * f_{yd} + A_{s,6} * f_{yd}}{b_6 * \lambda * f_{cd}} = \frac{0.000524 \text{ m}^2 * 434.78 \text{ MPa} + 0.000524 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} = 0.0285 \text{ m}$$

$$\varepsilon_{s,3,1,2} = \varepsilon_{cu3} * \left(\frac{d_{1,6} - x_{3,2}}{x_{3,2}} \right) = 0.0035 * \left(\frac{67 \text{ mm} - 0.0285 \text{ m}}{0.0285 \text{ m}} \right) = 0.00474$$

$$\varepsilon_{s,3,1,2} < \varepsilon_{yd} = 0.00474 < 0.0021739 = \text{False}$$

$$\sigma_{s,3,1,2} = \varepsilon_{s,3,1,2} * E_s = 0.00474 * 200 \text{ GPa} = 0.948 \text{ GPa}$$

$$\varepsilon_{s,3,2,2} = \varepsilon_{cu3} * \left(\frac{d_6 - x_{3,2}}{x_{3,2}} \right) = 0.0035 * \left(\frac{333 \text{ mm} - 0.0285 \text{ m}}{0.0285 \text{ m}} \right) = 0.0375$$

$$\varepsilon_{s,3,2,2} < \varepsilon_{yd} = 0.0375 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,2} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$M_{Rd,3,2} = b_6 * \lambda * x_{3,2} * f_{cd} * \left(\frac{h_6 - \lambda * x_{3,2}}{2} \right) + A_{s,6} * \sigma_{s,3,1,2} * z_{1,2} + A_{s,6} * \sigma_{s,3,2,2} * z_{1,2}$$

$$= 1 \text{ m} * 0.8 * 0.0285 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.0285 \text{ m}}{2} \right) + 0.000524 \text{ m}^2 * 0.948 \text{ GPa} * 0.133 \text{ m} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.133 \text{ m}$$

$$= 182.182 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,2} = d_{1,6} = 67 \text{ mm} = 0.067 \text{ m}$$

$$\varepsilon_{s,4,1,2} = \varepsilon_{cu3} * \left(\frac{d_6 - x_{4,2}}{x_{4,2}} \right) = 0.0035 * \left(\frac{333 \text{ mm} - 0.067 \text{ m}}{0.067 \text{ m}} \right) = 0.0139$$

$$\varepsilon_{s,4,1,2} < \varepsilon_{yd} = 0.0139 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,2} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,2} = A_{s,6} * \sigma_{s,4,1,2} = 0.000524 \text{ m}^2 * 434.783 \text{ MPa} = 227.652 \text{ kN}$$

$$M_{Rd,4,2} = A_{s,6} * \sigma_{s,4,1,2} * z_{1,2} = 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.133 \text{ m} = 30.278 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,2} = A_{s,6} * f_{yd} + A_{s,6} * f_{yd} = 0.000524 \text{ m}^2 * 434.78 \text{ MPa} + 0.000524 \text{ m}^2 * 434.78 \text{ MPa}$$

$$= 455.303 \text{ kN}$$

$$M_{Rd,5,2} = 0 \text{ kN} * \text{m}$$

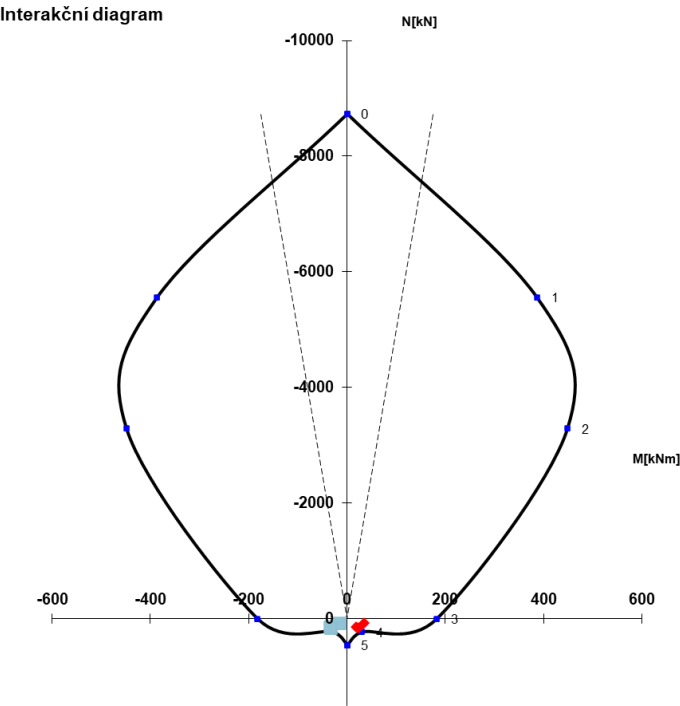
Body	N_Rd	M_Rd
0	-8733.0 kN	0 kN*m
1	-5555.7 kN	386 kN*m

2	-3286.6 kN	448 kN*m
3	0 kN	182 kN*m
4	227.652 kN	30.3 kN*m
5	455.303 kN	0 kN*m

Kombinace	NxD	MxD-	MxD+
K2	75.88	35.09	-16
K3	163.27	22.91	-33.31
K4	147.62	19.3	-34.29

(Table 4)

DIAGRAM



2.1.1.2. Posouzení na smyk

2.1.1.2.1. Směr y svislá výztuž

(Table 9)

Kombinace	VyD	NyD	VyD
K2	118.9 kN	72.28 kN	118.9
K3	140.32 kN	203.02 kN	140.32
K4	150.66 kN	228.97 kN	150.66

$$C_{Rd,c,1} = \frac{0.18}{\gamma_c} = 0.12$$

$$d_{5,1} = \frac{d_5}{1 \text{ mm}} = 344$$

$$K_1 = 1 + \sqrt{\left(\frac{200}{d_{5,1}}\right)} = 1 + \sqrt{\left(\frac{200}{344}\right)} = 1.762$$

$$\zeta_{sl,1} = \frac{A_{s,5}}{b_5 * d_5} = \frac{0.000754 \text{ m}^2}{1 \text{ m} * 344 \text{ mm}} = 0.00219$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \zeta_{sl,1} < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00219 < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

$$f_{ck,1} = 30$$

$$v_{min,1} = 0.035 * K_1^{\left(\frac{2}{3}\right)} * f_{ck,1}^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.035 * 1.762^{\left(\frac{2}{3}\right)} * 30^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.280 \text{ MPa}$$

$$V_{Rd,cn,1} = \left(C_{Rd,c,1} * K_1 * \left(100 * \zeta_{sl,1} * f_{ck,1} \right)^{\left(\frac{1}{3}\right)} \right) * b_5 * d_5 * 1 \text{ MPa}$$

$$= \left(0.12 * 1.762 * \left(100 * 0.00219 * 30 \right)^{\left(\frac{1}{3}\right)} \right) * 1 \text{ m} * 344 \text{ mm} * 1 \text{ MPa} = 136.304 \text{ kN}$$

$$V_{min,1} = v_{min,1} * b_5 * d_5 = 0.280 \text{ MPa} * 1 \text{ m} * 344 \text{ mm} = 96.221 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,cn,1} \geq V_{min,1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 136.304 \text{ kN} \geq 96.221 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Vliv normálové síly

K2

$$\sigma_{cp,1,1} = \frac{\text{Table9.C2}}{b_5 * d_5} = \frac{72.28 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 210.116 \text{ kPa } k_{1,1} = 0.15$$

$$V_{Rd,c,1,1} = V_{Rd,cn,1} + k_{1,1} * \sigma_{cp,1,1} * b_5 * d_5 = 136.304 \text{ kN} + 0.15 * 210.116 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 147.146 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,1,1} > \text{Table9.B2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 147.146 \text{ kN} > 118.9 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

K3

$$\sigma_{cp,2,1} = \frac{\text{Table9.C3}}{b_5 * d_5} = \frac{203.02 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 590.174 \text{ kPa } k_{2,1} = 0.15$$

$$V_{Rd,c,2,1} = V_{Rd,cn,1} + k_{2,1} * \sigma_{cp,2,1} * b_5 * d_5 = 136.304 \text{ kN} + 0.15 * 590.174 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 166.757 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,2,1} > \text{Table9.B3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 166.757 \text{ kN} > 140.32 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

K4

$$\sigma_{cp,3,1} = \frac{\text{Table9.C4}}{b_5 * d_5} = \frac{228.97 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 665.610 \text{ kPa} \quad k_{3,1} = 0.15$$

$$V_{Rd,c,3,1} = V_{Rd,cn,1} + k_{3,1} * \sigma_{cp,3,1} * b_5 * d_5 = 136.304 \text{ kN} + 0.15 * 665.610 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 170.649 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,3,1} > \text{Table9.B4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 170.649 \text{ kN} > 150.66 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

NENÍ POTŘEBA SMYKOVÁ VÝZTUŽ

2.1.1.3. Kotevní a stykovací délky

2.1.1.3.1. Směr y svislá výztuž

Kotvení

$$\eta_{1,1} = 0.7$$

$$\eta_{2,1} = 1.0 \quad \alpha_{ct,1} = 1.0$$

$$f_{ctd,1} = \alpha_{ct,1} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1.0 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,1} = 2.25 * \eta_{1,1} * \eta_{2,1} * f_{ctd,1} = 2.25 * 0.7 * 1.0 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,1} = \left(\frac{\varnothing_{y,0,1,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,1}} \right) = \left(\frac{12 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 621.118 \text{ mm}$$

$$L_{bdrqd,1} = \text{RoundUp}(l_{bdrqd,1}) = \text{RoundUp}(621.118 \text{ mm}) = 622 \text{ mm}$$

Stykování

$$\alpha_{1,1} = 1.0 \quad \alpha_{2,1} = 1 \quad \alpha_{3,1} = 1 \quad \alpha_{5,1} = 1 \quad \alpha_{6,1} = 1.5$$

$$l_{0,1} = \alpha_{1,1} * \alpha_{2,1} * \alpha_{3,1} * \alpha_{5,1} * \alpha_{6,1} * L_{bdrqd,1} = 1.0 * 1 * 1 * 1 * 1.5 * 622 \text{ mm} = 933 \text{ mm}$$

$$L_{0,1} = \text{RoundUp}(l_{0,1}) = 933 \text{ mm} \dots \text{návrhová délka přesahu}$$

$$l_{0,min,1} = \text{Max}(0.6 * \alpha_{6,1} * L_{bdrqd,1}, 15 * \varnothing_{y,0,1,steny}, 200 \text{ mm})$$

$$= \text{Max}(0.6 * 1.5 * 622 \text{ mm}, 15 * 12 \text{ mm}, 200 \text{ mm}) = 559.8 \text{ mm} \dots \text{minimální délka přesahu}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,1} > l_{0,\min,1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 933 \text{ mm} > 559.8 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

2.1.1.3.2. Směr x vodorovná výztuž

Kotvení

$$\eta_{1,2} = 0.7$$

$$\eta_{2,2} = 1 \quad \alpha_{ct,2} = 1$$

$$f_{ctd,2} = \alpha_{ct,2} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,2} = 2.25 * \eta_{1,2} * \eta_{2,2} * f_{ctd,2} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,2} = \left(\frac{\varnothing_{x,0,1,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,2}} \right) = \left(\frac{10 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 517.598 \text{ mm}$$

$$L_{bdrqd,2} = \text{RoundUp}(l_{bdrqd,2}) = 518 \text{ mm}$$

Stykování

$$\alpha_{1,2} = 1 \quad \alpha_{2,2} = 1 \quad \alpha_{3,2} = 1 \quad \alpha_{5,2} = 1 \quad \alpha_{6,2} = 1.5$$

$$l_{0,2} = \alpha_{1,2} * \alpha_{2,2} * \alpha_{3,2} * \alpha_{5,2} * \alpha_{6,2} * L_{bdrqd,2} = 1 * 1 * 1 * 1 * 1.5 * 518 \text{ mm} = 777 \text{ mm}$$

$$L_{0,2} = \text{RoundUp}(l_{0,2}) = \text{RoundUp}(777 \text{ mm}) = 777 \text{ mm}$$

$$l_{0,\min,2} = \text{Max}(0.3 * \alpha_{6,2} * L_{bdrqd,2}, 15 * \varnothing_{y,0,1,steny1}, 200 \text{ mm})$$

$$= \text{Max}(0.3 * 1.5 * 518 \text{ mm}, 15 * 12 \text{ mm}, 200 \text{ mm}) = 233.1 \text{ mm}$$

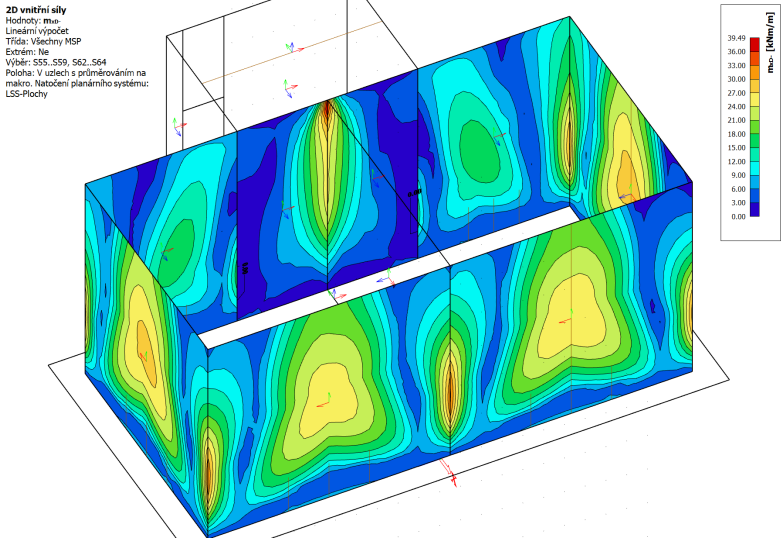
$$\text{value1} = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,2} > l_{0,\min,2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 777 \text{ mm} > 233.1 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

2.1.1.4. Posouzení na MSP

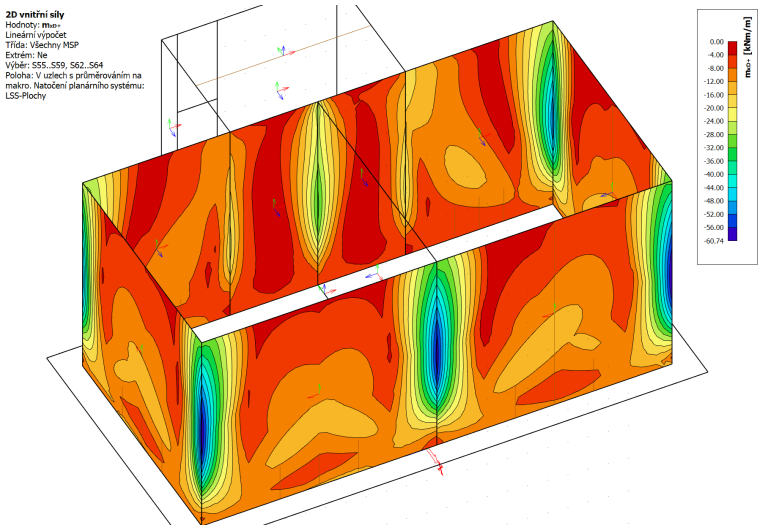
Okraje (Třídy) MSP

Všechny MSP

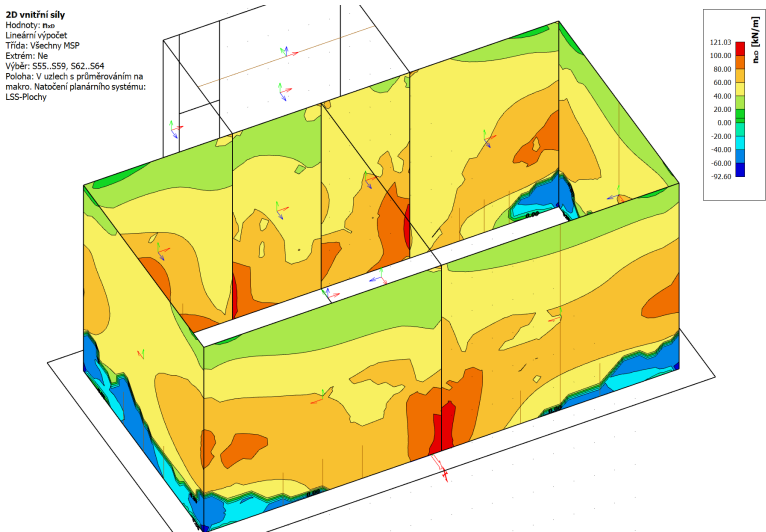
MxD-



MxD+

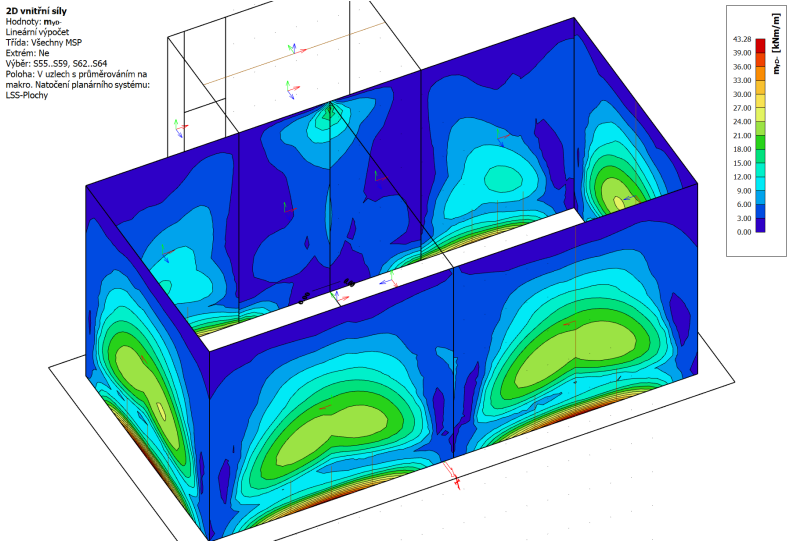


NxD

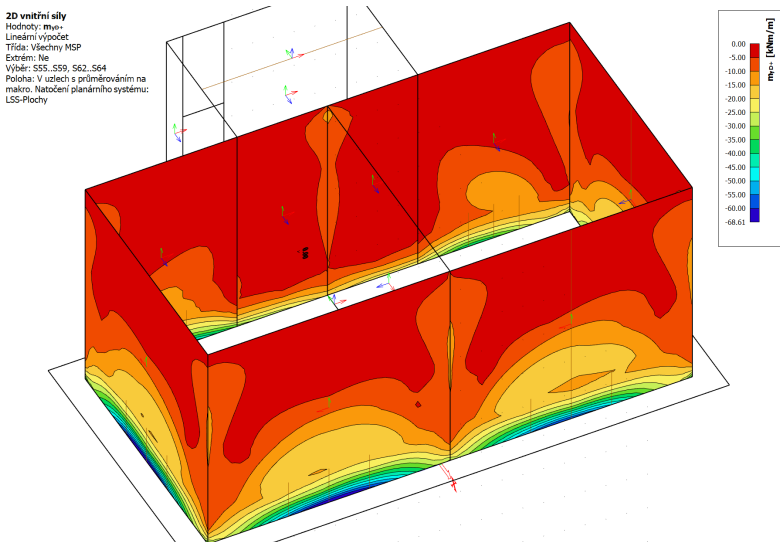


Všechny MSP

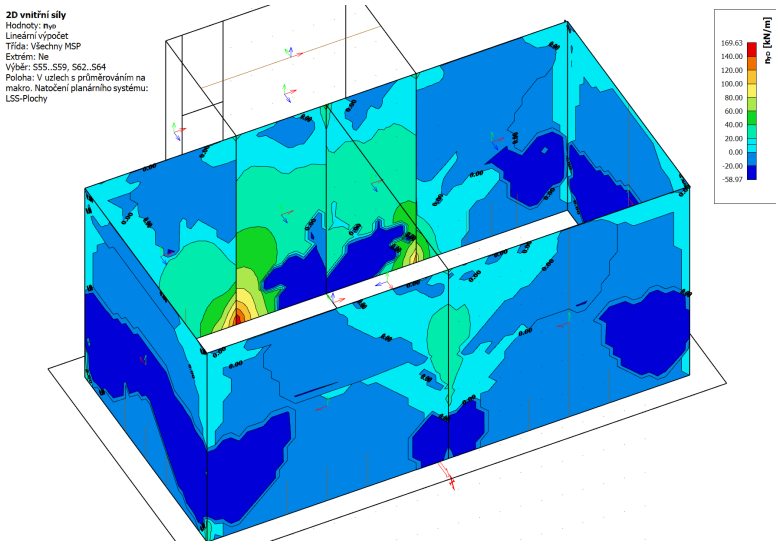
MyD-



MyD+



NyD



(Uvedeno v absolutních hodnotách)

(Table 5)

Kombinace	MxD- Char	MxD+ Char	NxD Char	MxD- Kvazi	MxD+ Kvazi	MyD- Char	MyD+ Char	NyD Char	MyD- Kvazi	MyD+ Kvazi
K2	25.54	11.75	134.05	26.87	11.68	31.29	15.89	57.85	31.34	15.96
K3	16.97	29.54	120.91	13.95	24.03	12.61	66.17	105.5	10.68	52.17
K4	13.39	25.41	109.46	10.94	19.63	13.65	68.58	89.59	8.79	53.69

2.1.1.4.1. směr x

(Table 16)

Kombinace	MxD	Nx
Charakteristická	29.54 kN*m	134.05 kN
Kvazistálá	26.87 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,3} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,3} = b_6 * h_6 = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,3} = A_{s,6} = 0.000524 \text{ m}^2$$

$$A_{i,3} = A_{C,C,3} + A_{S,S,3} * \alpha_{e,3} = 0.4 \text{ m}^2 + 0.000524 \text{ m}^2 * 6.061 = 0.403 \text{ m}^2$$

$$a_{c,c,3} = \frac{h_6}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,3} = \frac{A_{C,C,3} * a_{c,c,3} + \alpha_{e,3} * (A_{S,S,3} * d_6)}{A_{i,3}} = \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000524 \text{ m}^2 * 333 \text{ mm})}{0.403 \text{ m}^2}$$

$$= 0.201 \text{ m}$$

$$I_{c,c,3} = \left(\frac{1}{12} \right) * b_6 * h_6^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,3} = I_{c,c,3} + A_{C,C,3} * (a_{gi,3} - a_{c,c,3})^2 + \alpha_{e,3} * \left(A_{S,S,3} * (d_6 - a_{gi,3})^2 \right)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.201 \text{ m} - 0.2 \text{ m})^2 + 6.061 * \left(0.000524 \text{ m}^2 * (333 \text{ mm} - 0.201 \text{ m})^2 \right)$$

$$= 0.00539 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,3} = \left| \left(\left(\frac{\text{Table16.C2}}{A_{i,3}} \right) - \left(\frac{\text{Table16.B2} * a_{gi,3}}{I_{i,3}} \right) \right) \right| = \left| \left(\left(\frac{134.05 \text{ kN}}{0.403 \text{ m}^2} \right) - \left(\frac{29.54 \text{ kN} * \text{m} * 0.201 \text{ m}}{0.00539 \text{ m}^4} \right) \right) \right|$$

$$= 769.553 \text{ kPa}$$

$$f_{ct,eff,1,3} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,1,3} < f_{ct,eff,1,3}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $769.553 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

$$\sigma_{C,C,2,3} = \left| \left(\left(\frac{\text{Table16.C2}}{A_{i,3}} \right) + \left(\frac{\text{Table16.B2} * (h_6 - a_{gi,3})}{I_{i,3}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{134.05 \text{ kN}}{0.403 \text{ m}^2} \right) + \left(\frac{29.54 \text{ kN} * \text{m} * (400 \text{ mm} - 0.201 \text{ m})}{0.00539 \text{ m}^4} \right) \right) \right| = 1423.051 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,2,3} < f_{ct,eff,1,3}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $1423.051 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

Napětí ve výztuži

$$e_{kd,3} = \frac{\text{Table16.B2}}{\text{Table16.C2}} = \frac{29.54 \text{ kN} * \text{m}}{134.05 \text{ kN}} = 0.220 \text{ m}$$

$$e_3 = e_{kd,3} + a_{c,c,3} = 0.220 \text{ m} + 0.2 \text{ m} = 0.420 \text{ m}$$

$$\sigma_{S,S,1,3} = \left(\frac{\text{Table16.C2}}{A_{i,3}} \right) * \left(1 + \left(\frac{A_{i,3} * (a_{gi,3} - e_3) * (a_{gi,3} - d_6)}{I_{i,3}} \right) \right) * \alpha_{e,3}$$

$$= \left(\frac{134.05 \text{ kN}}{0.403 \text{ m}^2} \right) * \left(1 + \left(\frac{0.403 \text{ m}^2 * (0.201 \text{ m} - 0.420 \text{ m}) * (0.201 \text{ m} - 333 \text{ mm})}{0.00539 \text{ m}^4} \right) \right) * 6.061 = 6377.904 \text{ kPa}$$

"VYHOVUJE" if $\sigma_{S,S,1,3} < 0.8 * f_{yk}$ = "VYHOVUJE" if $6377.904 \text{ kPa} < 0.8 * 500 \text{ MPa}$
 "NEVYHOVUJE" otherwise = "NEVYHOVUJE" otherwise
 = VYHOVUJE

$$\sigma_{S,S,2,3} = \left(\frac{\text{Table16.C2}}{A_{i,3}} \right) * \left(1 + \left(\frac{A_{i,3} * (a_{gi,3} - e_3) * (a_{gi,3} - d_6)}{I_{i,3}} \right) \right) * \alpha_{e,3}$$

$$= \left(\frac{134.05 \text{ kN}}{0.403 \text{ m}^2} \right) * \left(1 + \left(\frac{0.403 \text{ m}^2 * (0.201 \text{ m} - 0.420 \text{ m}) * (0.201 \text{ m} - 333 \text{ mm})}{0.00539 \text{ m}^4} \right) \right) * 6.061 = 6377.904 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,3} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 6377.904 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

2.1.1.4.2. směr y

(Table 17)

Kombinace	MyD	Ny
Charakteristická	68.58 kN*m	105.5 kN
Kvazistálá	53.69 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,4} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,4} = b_5 * h_5 = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,4} = A_{s,5} = 0.000754 \text{ m}^2$$

$$A_{i,4} = A_{C,C,4} + A_{S,S,4} * \alpha_{e,4} = 0.4 \text{ m}^2 + 0.000754 \text{ m}^2 * 6.061 = 0.405 \text{ m}^2$$

$$a_{c,c,4} = \frac{h_5}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,4} = \frac{A_{C,C,4} * a_{c,c,4} + \alpha_{e,4} * (A_{S,S,4} * d_5)}{A_{i,4}} = \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000754 \text{ m}^2 * 344 \text{ mm})}{0.405 \text{ m}^2}$$

= 0.202 m

$$I_{c,c,4} = \left(\frac{1}{12} \right) * b_5 * h_5^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,4} = I_{c,c,4} + A_{C,C,4} * (a_{gi,4} - a_{c,c,4})^2 + \alpha_{e,4} * \left(A_{S,S,4} * (d_5 - a_{gi,4})^2 \right)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.202 \text{ m} - 0.2 \text{ m})^2 + 6.061 * \left(0.000754 \text{ m}^2 * (344 \text{ mm} - 0.202 \text{ m})^2 \right)$$

$$= 0.00543 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,4} = \left| \left(\left(\frac{\text{Table17.C2}}{A_{i,4}} \right) - \left(\frac{\text{Table17.B2} * a_{gi,4}}{I_{i,4}} \right) \right) \right| = \left| \left(\left(\frac{105.5 \text{ kN}}{0.405 \text{ m}^2} \right) - \left(\frac{68.58 \text{ kN} * \text{m} * 0.202 \text{ m}}{0.00543 \text{ m}^4} \right) \right) \right|$$

$$= 2287.137 \text{ kPa}$$

$$f_{ct,eff,1,4} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,1,4} < f_{ct,eff,1,4} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 2287.137 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

$$\sigma_{C,C,2,4} = \left| \left(\left(\frac{\text{Table17.C2}}{A_{i,4}} \right) + \left(\frac{\text{Table17.B2} * (h_5 - a_{gi,4})}{I_{i,4}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{105.5 \text{ kN}}{0.405 \text{ m}^2} \right) + \left(\frac{68.58 \text{ kN} * \text{m} * (400 \text{ mm} - 0.202 \text{ m})}{0.00543 \text{ m}^4} \right) \right) \right| = 2767.572 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,2,4} < f_{ct,eff,1,4} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 2767.572 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

Napětí ve výztuži

$$e_{kd,4} = \frac{\text{Table17.B2}}{\text{Table17.C2}} = \frac{68.58 \text{ kN} * \text{m}}{105.5 \text{ kN}} = 0.650 \text{ m}$$

$$e_4 = e_{kd,4} + a_{c,c,4} = 0.650 \text{ m} + 0.2 \text{ m} = 0.850 \text{ m}$$

$$\sigma_{S,S,1,4} = \left(\frac{\text{Table17.C2}}{A_{i,4}} \right) * \left(1 + \left(\frac{A_{i,4} * (a_{gi,4} - e_4) * (a_{gi,4} - d_5)}{I_{i,4}} \right) \right) * \alpha_{e,4}$$

$$= \left(\frac{105.5 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.850 \text{ m}) * (0.202 \text{ m} - 344 \text{ mm})}{0.00543 \text{ m}^4} \right) \right) * 6.061$$

$$= 12457.039 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,1,4} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 12457.039 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

$$\sigma_{S,S,2,4} = \left(\frac{\text{Table17.C2}}{A_{i,4}} \right) * \left(1 + \left(\frac{A_{i,4} * (a_{gi,4} - e_4) * (a_{gi,4} - d_5)}{I_{i,4}} \right) \right) * \alpha_{e,4}$$

$$= \left(\frac{105.5 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.850 \text{ m}) * (0.202 \text{ m} - 344 \text{ mm})}{0.00543 \text{ m}^4} \right) \right) * 6.061$$

= 12457.039 kPa

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,4} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 12457.039 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

2.1.2. Výška 1,0-5,625 m

2.1.2.1. Posouzení na MSÚ

Hodnoty z jednotlivých kombinací

(Table 18)

Kombinace	NyD	MyD-	MyD+	NxD	MxD-	MxD+
K2	-60.24	7.68	-24.17	-78.14	44.32	-17.26
K3	59.35	30.23	14.07	158.62	34.68	-79.99
K4	63.14	29.33	13.78	131.26	33.92	-75.2

2.1.2.1.1. Směr y svislá výztuž

geometrie (pro oba povrchy stejné krytí)

$$h_7 = 400 \text{ mm}$$

$$d_{1,7} = c_{\text{nom},1} + 0.5 * \varnothing_{y,1,5,\text{steny}} = 50 \text{ mm} + 0.5 * 10 \text{ mm} = 55 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{y,1,5,\text{steny}} = 10 \text{ mm}$$

$$d_7 = h_7 - d_{1,7} = 400 \text{ mm} - 55 \text{ mm} = 345 \text{ mm}$$

$$b_7 = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{y,1,5,\text{steny}1} = \varnothing_{y,1,5,\text{steny}} = 10 \text{ mm}$$

$$s_7 = 150 \text{ mm}$$

$$A_{s,7} = \left(\frac{\left(\frac{\pi \cdot \varnothing_{y,1,5,steny1}^2}{4} \right) \cdot b_7}{s_7} \right) = \left(\frac{\left(\frac{3.142 \cdot (10 \text{ mm})^2}{4} \right) \cdot 1 \text{ m}}{150 \text{ mm}} \right) = 0.000524 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,7} = 0.26 \cdot \left(\frac{f_{ctm}}{f_{yk}} \right) \cdot b_7 \cdot d_7 = 0.26 \cdot \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) \cdot 1 \text{ m} \cdot 345 \text{ mm} = 0.000520 \text{ m}^2$$

$$A_{s,2,min,7} = 0.0013 \cdot b_7 \cdot d_7 = 0.000448 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,7} > \text{Max}(A_{s,1,min,7}, A_{s,2,min,7}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000524 \text{ m}^2 > \text{Max}(0.000520 \text{ m}^2, 0.000448 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,max7} = 0.04 \cdot h_7 \cdot b_7 = 0.016 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,7} < A_{s,max7} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000524 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,7} = 3 \cdot h_7 = 1200 \text{ mm}$$

$$s_{2,max,7} = 400 \text{ mm}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_7 < \text{Max}(s_{1,max,7}, s_{2,max,7}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

$$s_{min,7} = \text{Max}(1.2 \cdot \varnothing_{y,1,5,steny1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 \cdot 10 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_7 > s_{min,7} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,3} = \text{Max} \left(\frac{h_7}{30}, 20 \text{ mm} \right) = \text{Max} \left(\frac{400 \text{ mm}}{30}, 20 \text{ mm} \right) = 0.02 \text{ m}$$

$$z_{1,3} = \left(\frac{h_7}{2} \right) - d_{1,7} = \left(\frac{400 \text{ mm}}{2} \right) - 55 \text{ mm} = 0.145 \text{ m}$$

$$\sigma_{s,0,3} = \varepsilon_{cu3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$N_{Rd,0,3} = - \left(b_7 * h_7 * f_{cd} + A_{s,7} * \sigma_{s,0,3} * 2 \right) \\ = - \left(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000524 \text{ m}^2 * 700 \text{ MPa} * 2 \right) = -8733.038 \text{ kN}$$

$$M_{Rd,0,1,3} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,3} = d_7 = 0.345 \text{ m}$$

$$\varepsilon_{s,1,3} = \varepsilon_{cu3} * \left(\frac{x_{1,3} - d_{1,7}}{x_{1,3}} \right) = 0.0035 * \left(\frac{0.345 \text{ m} - 55 \text{ mm}}{0.345 \text{ m}} \right) = 0.00294$$

$$\varepsilon_{s,1,3} < \varepsilon_{yd} = 0.00294 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,3} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,1,3} = - \left(b_7 * \lambda * x_{1,3} * f_{cd} + A_{s,7} * \sigma_{s,1,3} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.345 \text{ m} * 20 \text{ MPa} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} \right) = -5747.652 \text{ kN}$$

$$M_{Rd,1,3} = b_7 * \lambda * x_{1,3} * f_{cd} * \left(\frac{h_7 - \lambda * x_{1,3}}{2} \right) + A_{s,7} * \sigma_{s,1,3} * z_{1,3} \\ = 1 \text{ m} * 0.8 * 0.345 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.345 \text{ m}}{2} \right) + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.145 \text{ m} \\ = 375.249 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,3} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_7 = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 345 \text{ mm} = 0.213 \text{ m}$$

$$\varepsilon_{s,2,1,3} = \varepsilon_{cu3} * \left(\frac{x_{2,3} - d_{1,7}}{x_{2,3}} \right) = 0.0035 * \left(\frac{0.213 \text{ m} - 55 \text{ mm}}{0.213 \text{ m}} \right) = 0.00260$$

$$\varepsilon_{s,2,1,3} < \varepsilon_{yd} = 0.00260 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,3} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,3} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,3} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,2,3} = - \left(b_7 * \lambda * x_{2,3} * f_{cd} + A_{s,7} * \sigma_{s,2,1,3} - A_{s,7} * \sigma_{s,2,2,3} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.213 \text{ m} * 20 \text{ MPa} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} - 0.000524 \text{ m}^2 * 434.783 \text{ MPa} \right)$$

$$= -3405.057 \text{ kN}$$

$$M_{Rd,2,3} = b_7 * \lambda * x_{2,3} * f_{cd} * \left(\frac{h_7 - \lambda * x_{2,3}}{2} \right) + A_{s,7} * \sigma_{s,2,1,3} * z_{1,3} + A_{s,7} * \sigma_{s,2,2,3} * z_{1,3}$$

$$= 1 \text{ m} * 0.8 * 0.213 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.213 \text{ m}}{2} \right) + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.145 \text{ m} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.145 \text{ m}$$

$$= 457.170 \text{ kN} * \text{m}$$

BOD 3 prostý ohyb

$$N_{Rd,3,3} = 0 \text{ kN}$$

$$x_{3,3} = \frac{A_{s,7} * f_{yd} + A_{s,7} * f_{yd}}{b_7 * \lambda * f_{cd}} = \frac{0.000524 \text{ m}^2 * 434.78 \text{ MPa} + 0.000524 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} = 0.0285 \text{ m}$$

$$\epsilon_{s,3,1,3} = \epsilon_{cu3} * \left(\frac{d_{1,7} - x_{3,3}}{x_{3,3}} \right) = 0.0035 * \left(\frac{55 \text{ mm} - 0.0285 \text{ m}}{0.0285 \text{ m}} \right) = 0.00326$$

$$\epsilon_{s,3,1,3} < \epsilon_{yd} = 0.00326 < 0.0021739 = \text{False} \quad \sigma_{s,3,1,3} = \epsilon_{s,3,1,3} * E_s = 0.00326 * 200 \text{ GPa}$$

$$= 0.653 \text{ GPa}$$

$$\epsilon_{s,3,2,3} = \epsilon_{cu3} * \left(\frac{d_7 - x_{3,3}}{x_{3,3}} \right) = 0.0035 * \left(\frac{345 \text{ mm} - 0.0285 \text{ m}}{0.0285 \text{ m}} \right) = 0.0389$$

$$\epsilon_{s,3,2,3} < \epsilon_{yd} = 0.0389 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,3} = f_{yd} = 434.783 \text{ MPa}$$

$$M_{Rd,3,3} = b_7 * \lambda * x_{3,3} * f_{cd} * \left(\frac{h_7 - \lambda * x_{3,3}}{2} \right) + A_{s,7} * \sigma_{s,3,1,3} * z_{1,3} + A_{s,7} * \sigma_{s,3,2,3} * z_{1,3}$$

$$= 1 \text{ m} * 0.8 * 0.0285 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.0285 \text{ m}}{2} \right) + 0.000524 \text{ m}^2 * 0.653 \text{ GPa} * 0.145 \text{ m} + 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.145 \text{ m}$$

$$= 168.460 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,3} = d_{1,7} = 0.055 \text{ m}$$

$$\epsilon_{s,4,1,3} = \epsilon_{cu3} * \left(\frac{d_7 - x_{4,3}}{x_{4,3}} \right) = 0.0035 * \left(\frac{345 \text{ mm} - 0.055 \text{ m}}{0.055 \text{ m}} \right) = 0.0185$$

$$\epsilon_{s,4,1,3} < \epsilon_{yd} = 0.0185 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,3} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,3} = A_{s,7} * \sigma_{s,4,1,3} = 0.000524 \text{ m}^2 * 434.783 \text{ MPa} = 227.652 \text{ kN}$$

$$M_{Rd,4,3} = A_{s,7} * \sigma_{s,4,1,3} * z_{1,3} = 0.000524 \text{ m}^2 * 434.783 \text{ MPa} * 0.145 \text{ m} = 33.009 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,3} = A_{s,7} * f_{yd} + A_{s,7} * f_{yd} = 0.000524 \text{ m}^2 * 434.78 \text{ MPa} + 0.000524 \text{ m}^2 * 434.78 \text{ MPa}$$

$$= 455.303 \text{ kN}$$

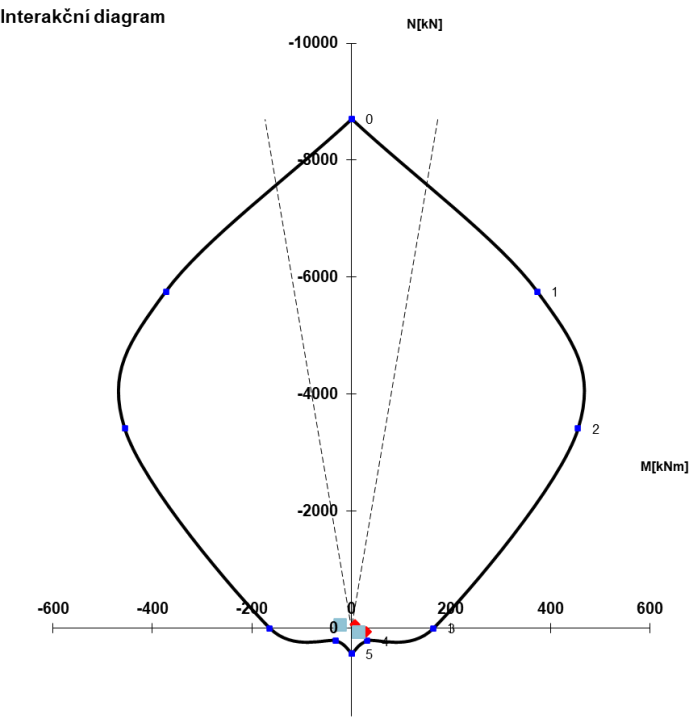
$$M_{Rd,5,3} = 0 \text{ kN} * \text{m}$$

Body	N_Rd	M_Rd
0	-8733.0 kN	0 kN*m
1	-5747.7 kN	375 kN*m
2	-3405.1 kN	457 kN*m
3	0 kN	168 kN*m
4	227.652 kN	33.0 kN*m
5	455.303 kN	0 kN*m

Kombinace	NyD	MyD-	MyD+
K2	-60.24	7.68	-24.17
K3	59.35	30.23	14.07
K4	63.14	29.33	13.78

(Table 7)

DIAGRAM



2.1.2.1.2. Směr x vodorovná výztuž geometrie (pro oba povrchy stejné krytí)

$$h_g = 400 \text{ mm}$$

$$d_{1,8} = c_{nom,1} + 0.5 \cdot \varnothing_{x,1,5,steny} + \varnothing_{y,1,5,steny} = 50 \text{ mm} + 0.5 \cdot 12 \text{ mm} + 10 \text{ mm} = 66 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{x,1,5,steny} = 12 \text{ mm}$$

$$d_8 = h_8 - d_{1,8} = 400 \text{ mm} - 66 \text{ mm} = 334 \text{ mm}$$

$$b_8 = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{x,1,5,steny1} = \varnothing_{x,1,5,steny} = 12 \text{ mm} \quad s_8 = 150 \text{ mm}$$

$$A_{s,8} = \left(\frac{\left(\frac{\pi \cdot \varnothing_{x,1,5,steny1}^2}{4} \right) \cdot b_8}{s_8} \right) = \left(\frac{\left(\frac{3.142 \cdot (12 \text{ mm})^2}{4} \right) \cdot 1 \text{ m}}{150 \text{ mm}} \right) = 0.000754 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,min,8} = 0.26 \cdot \left(\frac{f_{ctm}}{f_{yk}} \right) \cdot b_8 \cdot d_8 = 0.26 \cdot \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) \cdot 1 \text{ m} \cdot 334 \text{ mm} = 0.000504 \text{ m}^2$$

$$A_{s,2,min,8} = 0.0013 \cdot b_8 \cdot d_8 = 0.000434 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,8} > \text{Max}(A_{s,1,min,8}, A_{s,2,min,8}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 > \text{Max}(0.000504 \text{ m}^2, 0.000434 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,max8} = 0.04 \cdot h_8 \cdot b_8 = 0.016 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,8} < A_{s,max8} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,8} = 3 \cdot h_8 = 1200 \text{ mm}$$

$$s_{2,max,8} = 400 \text{ mm}$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_8 < \text{Max}(s_{1,max,8}, s_{2,max,8}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

$$\begin{aligned} s_{min,8} &= \text{Max}(1.2 \cdot \varnothing_{x,1,5,steny1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 \cdot 12 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) \\ &= 21 \text{ mm} \end{aligned}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_8 > s_{\min,8} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,4} = \text{Max} \left(\frac{h_8}{30}, 20 \text{ mm} \right) = \text{Max} \left(\frac{400 \text{ mm}}{30}, 20 \text{ mm} \right) = 0.02 \text{ m}$$

$$z_{1,4} = \left(\frac{h_8}{2} \right) - d_{1,8} = \left(\frac{400 \text{ mm}}{2} \right) - 66 \text{ mm} = 0.134 \text{ m}$$

$$\sigma_{s,0,4} = \varepsilon_{cu3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$N_{Rd,0,4} = - \left(b_8 * h_8 * f_{cd} + A_{s,8} * \sigma_{s,0,4} * 2 \right) \\ = - \left(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 700 \text{ MPa} * 2 \right) = -9055.575 \text{ kN}$$

$$M_{Rd,0,1,4} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,4} = d_8 = 0.334 \text{ m}$$

$$\varepsilon_{s,1,4} = \varepsilon_{cu3} * \left(\frac{x_{1,4} - d_{1,8}}{x_{1,4}} \right) = 0.0035 * \left(\frac{0.334 \text{ m} - 66 \text{ mm}}{0.334 \text{ m}} \right) = 0.00281$$

$$\varepsilon_{s,1,4} < \varepsilon_{yd} = 0.00281 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,4} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$N_{Rd,1,4} = - \left(b_8 * \lambda * x_{1,4} * f_{cd} + A_{s,8} * \sigma_{s,1,4} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.334 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) = -5671.818 \text{ kN}$$

$$M_{Rd,1,4} = b_8 * \lambda * x_{1,4} * f_{cd} * \left(\frac{h_8 - \lambda * x_{1,4}}{2} \right) + A_{s,8} * \sigma_{s,1,4} * z_{1,4} \\ = 1 \text{ m} * 0.8 * 0.334 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.334 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.134 \text{ m} \\ = 398.769 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,4} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_8 = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 334 \text{ mm} = 0.206 \text{ m}$$

$$\varepsilon_{s,2,1,4} = \varepsilon_{cu3} * \left(\frac{x_{2,4} - d_{1,8}}{x_{2,4}} \right) = 0.0035 * \left(\frac{0.206 \text{ m} - 66 \text{ mm}}{0.206 \text{ m}} \right) = 0.00238$$

$$\varepsilon_{s,2,1,4} < \varepsilon_{yd} = 0.00238 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,4} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,4} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,4} = f_{yd} = 434.783 \text{ MPa}$$

$$\begin{aligned} N_{Rd,2,4} &= -(b_8 * \lambda * x_{2,4} * f_{cd} + A_{s,8} * \sigma_{s,2,1,4} - A_{s,8} * \sigma_{s,2,2,4}) \\ &= -(1 \text{ m} * 0.8 * 0.206 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} - 0.000754 \text{ m}^2 * 434.783 \text{ MPa}) \\ &= -3296.490 \text{ kN} \end{aligned}$$

$$\begin{aligned} M_{Rd,2,4} &= b_8 * \lambda * x_{2,4} * f_{cd} * \left(\frac{h_8 - \lambda * x_{2,4}}{2} \right) + A_{s,8} * \sigma_{s,2,1,4} * z_{1,4} + A_{s,8} * \sigma_{s,2,2,4} * z_{1,4} \\ &= 1 \text{ m} * 0.8 * 0.206 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.206 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.134 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.134 \text{ m} \\ &= 475.482 \text{ kN} * \text{m} \end{aligned}$$

BOD 3 prostý ohyb

$$N_{Rd,3,4} = 0 \text{ kN}$$

$$x_{3,4} = \frac{A_{s,8} * f_{yd} + A_{s,8} * f_{yd}}{b_8 * \lambda * f_{cd}} = \frac{0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} = 0.0410 \text{ m}$$

$$\varepsilon_{s,3,1,4} = \varepsilon_{cu3} * \left(\frac{d_{1,8} - x_{3,4}}{x_{3,4}} \right) = 0.0035 * \left(\frac{66 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.00214$$

$$\varepsilon_{s,3,1,4} < \varepsilon_{yd} = 0.00214 < 0.0021739 = \text{True}$$

$$\sigma_{s,3,1,4} = \varepsilon_{s,3,1,4} * E_s = 0.00214 * 200 \text{ GPa} = 0.427 \text{ GPa}$$

$$\varepsilon_{s,3,2,4} = \varepsilon_{cu3} * \left(\frac{d_{8} - x_{3,4}}{x_{3,4}} \right) = 0.0035 * \left(\frac{334 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.0250$$

$$\varepsilon_{s,3,2,4} < \varepsilon_{yd} = 0.0250 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,4} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$\begin{aligned} M_{Rd,3,4} &= b_8 * \lambda * x_{3,4} * f_{cd} * \left(\frac{h_8 - \lambda * x_{3,4}}{2} \right) + A_{s,8} * \sigma_{s,3,1,4} * z_{1,4} + A_{s,8} * \sigma_{s,3,2,4} * z_{1,4} \\ &= 1 \text{ m} * 0.8 * 0.0410 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.0410 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 0.427 \text{ GPa} * 0.134 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.134 \text{ m} \\ &= 207.496 \text{ kN} * \text{m} \end{aligned}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,4} = d_{1,8} = 66 \text{ mm} = 0.066 \text{ m}$$

$$\varepsilon_{s,4,1,4} = \varepsilon_{cu3} * \left(\frac{d_{8} - x_{4,4}}{x_{4,4}} \right) = 0.0035 * \left(\frac{334 \text{ mm} - 0.066 \text{ m}}{0.066 \text{ m}} \right) = 0.0142$$

$$\varepsilon_{s,4,1,4} < \varepsilon_{yd} = 0.0142 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,4} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,4} = A_{s,8} * \sigma_{s,4,1,4} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} = 327.818 \text{ kN}$$

$$M_{Rd,4,4} = A_{s,8} * \sigma_{s,4,1,4} * z_{1,4} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.134 \text{ m} = 43.928 \text{ kN} * \text{m}$$

2.1.2.2. Posouzení na smyk

2.1.2.2.1. Směr y svislá výztuž

(Table 11)

Kombinace	VyD	NyD	VyD
K2	19.94 kN	60.24 kN	19.94
K3	57.69 kN	59.35 kN	57.69
K4	62.44 kN	63.14 kN	62.44

$$C_{Rd,c,2} = \frac{0.18}{\gamma_c} = 0.12 \quad d_{5,2} = \frac{d_7}{1 \text{ mm}} = 345$$

$$K_2 = 1 + \sqrt{\left(\frac{200}{d_{5,2}}\right)} = 1 + \sqrt{\left(\frac{200}{345}\right)} = 1.761$$

$$\zeta_{sl,2} = \frac{A_{s,7}}{b_7 * d_7} = \frac{0.000524 \text{ m}^2}{1 \text{ m} * 345 \text{ mm}} = 0.00152$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \zeta_{sl,2} < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00152 < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

$$f_{ck,2} = 30$$

$$v_{min,2} = 0.035 * K_2 \left(\frac{2}{3}\right) * f_{ck,2} \left(\frac{1}{2}\right) * 1 \text{ MPa} = 0.035 * 1.761 \left(\frac{2}{3}\right) * 30 \left(\frac{1}{2}\right) * 1 \text{ MPa} = 0.280 \text{ MPa}$$

$$V_{Rd,cn,2} = \left[C_{Rd,c,2} * K_2 * \left(100 * \zeta_{sl,2} * f_{ck,2} \right)^{\left(\frac{1}{3}\right)} \right] * b_7 * d_7 * 1 \text{ MPa}$$

$$= \left[0.12 * 1.761 * \left(100 * 0.00152 * 30 \right)^{\left(\frac{1}{3}\right)} \right] * 1 \text{ m} * 345 \text{ mm} * 1 \text{ MPa} = 120.862 \text{ kN}$$

$$V_{min,2} = v_{min,2} * b_7 * d_7 = 0.280 \text{ MPa} * 1 \text{ m} * 345 \text{ mm} = 96.461 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,cn,2} \geq V_{min,2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 120.862 \text{ kN} \geq 96.461 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Vliv normálové síly

K2

$$\sigma_{cp,1,2} = \frac{\text{Table11.C2}}{b_7 * d_7} = \frac{60.24 \text{ kN}}{1 \text{ m} * 345 \text{ mm}} = 174.609 \text{ kPa} \quad k_{1,3} = 0.15$$

$$V_{Rd,c,1,2} = V_{Rd,cn,2} + k_{1,3} * \sigma_{cp,1,2} * b_7 * d_7 = 120.862 \text{ kN} + 0.15 * 174.609 \text{ kPa} * 1 \text{ m} * 345 \text{ mm}$$

$$= 129.898 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,1,2} > \text{Table11.B2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 129.898 \text{ kN} > 19.94 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

$$= \text{VYHOVUJE}$$

K3

$$\sigma_{cp,2,2} = \frac{\text{Table11.C3}}{b_7 * d_7} = \frac{59.35 \text{ kN}}{1 \text{ m} * 345 \text{ mm}} = 172.029 \text{ kPa} \quad k_{2,3} = 0.15$$

$$V_{Rd,c,2,2} = V_{Rd,cn,2} + k_{2,3} * \sigma_{cp,2,2} * b_7 * d_7 = 120.862 \text{ kN} + 0.15 * 172.029 \text{ kPa} * 1 \text{ m} * 345 \text{ mm}$$

$$= 129.764 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,2,2} > \text{Table11.B3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 129.764 \text{ kN} > 57.69 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

$$= \text{VYHOVUJE}$$

K4

$$\sigma_{cp,3,2} = \frac{\text{Table11.C4}}{b_7 * d_7} = \frac{63.14 \text{ kN}}{1 \text{ m} * 345 \text{ mm}} = 183.014 \text{ kPa} \quad k_{3,3} = 0.15$$

$$V_{Rd,c,3,2} = V_{Rd,cn,2} + k_{3,3} * \sigma_{cp,3,2} * b_7 * d_7 = 120.862 \text{ kN} + 0.15 * 183.014 \text{ kPa} * 1 \text{ m} * 345 \text{ mm}$$

$$= 130.333 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,3,2} > \text{Table11.B4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 130.333 \text{ kN} > 62.44 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

$$= \text{VYHOVUJE}$$

NENÍ POTŘEBA SMYKOVÁ VÝZTUŽ

2.1.2.3. Kotevní a stykovací délky

2.1.2.3.1. Směr y svislá výztuž

Kotvení

$$\eta_{1,3} = 0.7$$

$$\eta_{2,3} = 1 \quad \alpha_{ct,3} = 1$$

$$f_{ctd,3} = \alpha_{ct,3} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,3} = 2.25 * \eta_{1,3} * \eta_{2,3} * f_{ctd,3} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,3} = \left(\frac{\varnothing_{y,1,5,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,3}} \right) = \left(\frac{10 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 517.598 \text{ mm}$$

$$L_{bdrqd,3} = \text{RoundUp}(l_{bdrqd,3}) = \text{RoundUp}(517.598 \text{ mm}) = 518 \text{ mm}$$

Stykování

$$\alpha_{1,3} = 1 \quad \alpha_{2,3} = 1 \quad \alpha_{3,3} = 1 \quad \alpha_{5,3} = 1 \quad \alpha_{6,3} = 1.5$$

$$l_{0,3} = \alpha_{1,3} * \alpha_{2,3} * \alpha_{3,3} * \alpha_{5,3} * \alpha_{6,3} * L_{bdrqd,3} = 1 * 1 * 1 * 1 * 1.5 * 518 \text{ mm} = 777 \text{ mm}$$

$$L_{0,3} = \text{RoundUp}(l_{0,3}) = 777 \text{ mm}$$

$$l_{0,min,3} = \text{Max}(0.6 * \alpha_{6,3} * L_{bdrqd,3}, 15 * \varnothing_{y,1,5,steny1}, 200 \text{ mm})$$

$$= \text{Max}(0.6 * 1.5 * 518 \text{ mm}, 15 * 10 \text{ mm}, 200 \text{ mm}) = 466.2 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,3} > l_{0,min,3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 777 \text{ mm} > 466.2 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

2.1.2.3.2. Směr x vodorovná výztuž

Kotvení

$$\eta_{1,4} = 0.7$$

$$\eta_{2,4} = 1 \quad \alpha_{ct,4} = 1$$

$$f_{ctd,4} = \alpha_{ct,4} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,4} = 2.25 * \eta_{1,4} * \eta_{2,4} * f_{ctd,4} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,4} = \left(\frac{\varnothing_{x,1,5,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,4}} \right) = \left(\frac{12 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 621.118 \text{ mm}$$

$$L_{bdrqd,4} = \text{RoundUp}(l_{bdrqd,4}) = 622 \text{ mm}$$

Stykování

$$\alpha_{1,4} = 1 \quad \alpha_{2,4} = 1 \quad \alpha_{3,4} = 1 \quad \alpha_{5,4} = 1 \quad \alpha_{6,4} = 1.5$$

$$l_{0,4} = \alpha_{1,4} * \alpha_{2,4} * \alpha_{3,4} * \alpha_{5,4} * \alpha_{6,4} * L_{bdrqd,4} = 1 * 1 * 1 * 1 * 1.5 * 622 \text{ mm} = 933 \text{ mm}$$

$$L_{0,4} = \text{RoundUp}(l_{0,4}) = \text{RoundUp}(933 \text{ mm}) = 933 \text{ mm}$$

$$l_{0,min,4} = \text{Max}(0.3 * \alpha_{6,4} * L_{bdrqd,4}, 15 * \varnothing_{y,1,5,steny1}, 200 \text{ mm})$$

$$= \text{Max}(0.3 * 1.5 * 622 \text{ mm}, 15 * 10 \text{ mm}, 200 \text{ mm}) = 279.9 \text{ mm}$$

$$\text{value2} = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,4} > l_{0,min,4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 933 \text{ mm} > 279.9 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

2.1.2.4. Posouzení na MSP

Okraje (Třídy) MSP viz. 0-1m

(Uvedeno v absolutních hodnotách)

(Table 12)

Kombinace	MxD- Char	MxD+ Char	NxD Char	MxD- Kvazi	MxD+ Kvazi	MyD- Char	MyD+ Char	NyD Char	MyD- Kvazi	MyD+ Kvazi
K2	32.83	13.25	57.43	32.85	13.38	17	18.37	54.48	16.92	18.38
K3	28.06	59.26	117.49	22.78	48	23.94	8.73	54.59	18.15	7.83
K4	26.54	55.71	97.32	21.45	45.03	22.75	10.21	58.52	17.58	8.29

2.1.2.4.1. směr x

(Table 19)

Kombinace	MxD	Nx
Charakteristická	59.26 kN*m	117.49 kN
Kvazistálá	48 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,5} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,5} = b_8 * h_8 = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,5} = A_{s,8} = 0.000754 \text{ m}^2$$

$$A_{i,5} = A_{C,C,5} + A_{S,S,5} * \alpha_{e,5} = 0.4 \text{ m}^2 + 0.000754 \text{ m}^2 * 6.061 = 0.405 \text{ m}^2$$

$$a_{c,c,5} = \frac{h_8}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,5} = \frac{A_{C,C,5} * a_{c,c,5} + \alpha_{e,5} * (A_{S,S,5} * d_8)}{A_{i,5}} = \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000754 \text{ m}^2 * 334 \text{ mm})}{0.405 \text{ m}^2}$$

$$= 0.202 \text{ m}$$

$$I_{c,c,5} = \left(\frac{1}{12} \right) * b_8 * h_8^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,5} = I_{c,c,5} + A_{C,C,5} * (a_{gi,5} - a_{c,c,5})^2 + \alpha_{e,5} * \left(A_{S,S,5} * (d_8 - a_{gi,5})^2 \right)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.202 \text{ m} - 0.2 \text{ m})^2 + 6.061 * \left(0.000754 \text{ m}^2 * (334 \text{ mm} - 0.202 \text{ m})^2 \right)$$

$$= 0.00541 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,5} = \left| \left(\left(\frac{\text{Table19.C2}}{A_{i,5}} \right) - \left(\frac{\text{Table19.B2} * a_{gi,5}}{I_{i,5}} \right) \right) \right| = \left| \left(\left(\frac{117.49 \text{ kN}}{0.405 \text{ m}^2} \right) - \left(\frac{59.26 \text{ kN} * \text{m} * 0.202 \text{ m}}{0.00541 \text{ m}^4} \right) \right) \right|$$

$$= 1915.112 \text{ kPa}$$

$$f_{ct,eff,1,5} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,1,5} < f_{ct,eff,1,5}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $1915.112 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

$$\sigma_{C,C,2,5} = \left| \left(\left(\frac{\text{Table19.C2}}{A_{i,5}} \right) + \left(\frac{\text{Table19.B2} * (h_8 - a_{gi,5})}{I_{i,5}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{117.49 \text{ kN}}{0.405 \text{ m}^2} \right) + \left(\frac{59.26 \text{ kN} * \text{m} * (400 \text{ mm} - 0.202 \text{ m})}{0.00541 \text{ m}^4} \right) \right) \right| = 2462.796 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,2,5} < f_{ct,eff,1,5}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $2462.796 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

Napětí ve výztuži

$$e_{kd,5} = \frac{\text{Table19.B2}}{\text{Table19.C2}} = 0.504 \text{ m}$$

$$e_5 = e_{kd,5} + a_{c,c,5} = 0.704 \text{ m}$$

$$\sigma_{S,S,1,5} = \left(\frac{\text{Table19.C2}}{A_{i,5}} \right) * \left(1 + \left(\frac{A_{i,5} * (a_{gi,5} - e_5) * (a_{gi,5} - d_8)}{I_{i,5}} \right) \right) * \alpha_{e,5}$$

$$= \left(\frac{117.49 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.704 \text{ m}) * (0.202 \text{ m} - 334 \text{ mm})}{0.00541 \text{ m}^4} \right) \right) * 6.061$$

$$= 10521.759 \text{ kPa}$$

"VYHOVUJE" if $\sigma_{S,S,1,5} < 0.8 * f_{yk}$ = "VYHOVUJE" if $10521.759 \text{ kPa} < 0.8 * 500 \text{ MPa}$
 "NEVYHOVUJE" otherwise = "NEVYHOVUJE" otherwise
 = VYHOVUJE

$$\sigma_{S,S,2,5} = \left(\frac{\text{Table 19.C2}}{A_{i,5}} \right) * \left(1 + \left(\frac{A_{i,5} * (a_{gi,5} - e_5) * (a_{gi,5} - d_8)}{I_{i,5}} \right) \right) * \alpha_{e,5}$$

$$= \left(\frac{117.49 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.704 \text{ m}) * (0.202 \text{ m} - 334 \text{ mm})}{0.00541 \text{ m}^4} \right) \right) * 6.061$$

$$= 10521.759 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,5} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 10521.759 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

2.1.2.4.2. směr y

(Table 20)

Kombinace	MyD	Ny
Charakteristická	23.94 kN*m	58.52 kN
Kvazistálá	18.38 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,6} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,6} = b_7 * h_7 = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,6} = A_{s,7} = 0.000524 \text{ m}^2$$

$$A_{i,6} = A_{C,C,6} + A_{S,S,6} * \alpha_{e,6} = 0.4 \text{ m}^2 + 0.000524 \text{ m}^2 * 6.061 = 0.403 \text{ m}^2$$

$$a_{c,c,6} = \frac{h_7}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,6} = \frac{A_{C,C,6} * a_{c,c,6} + \alpha_{e,6} * (A_{S,S,6} * d_7)}{A_{i,6}} = \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000524 \text{ m}^2 * 345 \text{ mm})}{0.403 \text{ m}^2}$$

$$= 0.201 \text{ m}$$

$$I_{c,c,6} = \left(\frac{1}{12} \right) * b_7 * h_7^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,6} = I_{c,c,6} + A_{C,C,6} * (a_{gi,6} - a_{c,c,6})^2 + \alpha_{e,6} * \left(A_{S,S,6} * (d_7 - a_{gi,6})^2 \right)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.201 \text{ m} - 0.2 \text{ m})^2 + 6.061 * \left(0.000524 \text{ m}^2 * (345 \text{ mm} - 0.201 \text{ m})^2 \right)$$

$$= 0.00540 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,6} = \left| \left(\left(\frac{\text{Table20.C2}}{A_{i,6}} \right) - \left(\frac{\text{Table20.B2} * a_{gi,6}}{I_{i,6}} \right) \right) \right| = \left| \left(\left(\frac{58.52 \text{ kN}}{0.403 \text{ m}^2} \right) - \left(\frac{23.94 \text{ kN} * \text{m} * 0.201 \text{ m}}{0.00540 \text{ m}^4} \right) \right) \right|$$

$$= 746.656 \text{ kPa}$$

$$f_{ct,eff,1,6} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,1,6} < f_{ct,eff,1,6}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $746.656 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

$$\sigma_{C,C,2,6} = \left| \left(\left(\frac{\text{Table20.C2}}{A_{i,6}} \right) + \left(\frac{\text{Table20.B2} * (h_7 - a_{gi,6})}{I_{i,6}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{58.52 \text{ kN}}{0.403 \text{ m}^2} \right) + \left(\frac{23.94 \text{ kN} * \text{m} * (400 \text{ mm} - 0.201 \text{ m})}{0.00540 \text{ m}^4} \right) \right) \right| = 1026.833 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,2,6} < f_{ct,eff,1,6}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $1026.833 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

Napětí ve výztuži

$$e_{kd,6} = \frac{\text{Table20.B2}}{\text{Table20.C2}} = 0.409 \text{ m}$$

$$e_6 = e_{kd,6} + a_{c,c,6} = 0.609 \text{ m}$$

$$\sigma_{S,S,1,6} = \left(\frac{\text{Table20.C2}}{A_{i,6}} \right) * \left(1 + \left(\frac{A_{i,6} * (a_{gi,6} - e_6) * (a_{gi,6} - d_7)}{I_{i,6}} \right) \right) * \alpha_{e,6}$$

$$= \left(\frac{58.52 \text{ kN}}{0.403 \text{ m}^2} \right) * \left(1 + \left(\frac{0.403 \text{ m}^2 * (0.201 \text{ m} - 0.609 \text{ m}) * (0.201 \text{ m} - 345 \text{ mm})}{0.00540 \text{ m}^4} \right) \right) * 6.061 = 4734.537 \text{ kPa}$$

"VYHOVUJE" if $\sigma_{S,S,1,6} < 0.8 * f_{yk}$ = "VYHOVUJE" if $4734.537 \text{ kPa} < 0.8 * 500 \text{ MPa}$
 "NEVYHOVUJE" otherwise = "NEVYHOVUJE" otherwise
 = VYHOVUJE

$$\sigma_{S,S,2,6} = \left(\frac{\text{Table20.C2}}{A_{i,6}} \right) * \left(1 + \left(\frac{A_{i,6} * (a_{gi,6} - e_6) * (a_{gi,6} - d_7)}{I_{i,6}} \right) \right) * \alpha_{e,6}$$

$$= \left(\frac{58.52 \text{ kN}}{0.403 \text{ m}^2} \right) * \left(1 + \left(\frac{0.403 \text{ m}^2 * (0.201 \text{ m} - 0.609 \text{ m}) * (0.201 \text{ m} - 345 \text{ mm})}{0.00540 \text{ m}^4} \right) \right) * 6.061 = 4734.537 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,6} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 4734.537 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

2.1.3. Závěr

Výztuž na obvodových stěnách nádrže by mohla být rozdělena na 2 části: od 0-1m a 1-5,625m. S těmito návrhy:

$$\emptyset_{y,0,1,steny1} = 12 \text{ mm } s_5 = 150 \text{ mm}$$

$$\emptyset_{x,0,1,steny1} = 10 \text{ mm } s_6 = 150 \text{ mm}$$

$$\emptyset_{y,1,5,steny1} = 10 \text{ mm } s_7 = 150 \text{ mm}$$

$$\emptyset_{x,1,5,steny1} = 12 \text{ mm } s_8 = 150 \text{ mm}$$

Vzhledem ke složitosti vyztužování takového objektu bude na stěnu navržena nejhorší posuzovaná výztuž a to:

$$\emptyset_{y,0,1,steny1} = 12 \text{ mm } s_5 = 150 \text{ mm}$$

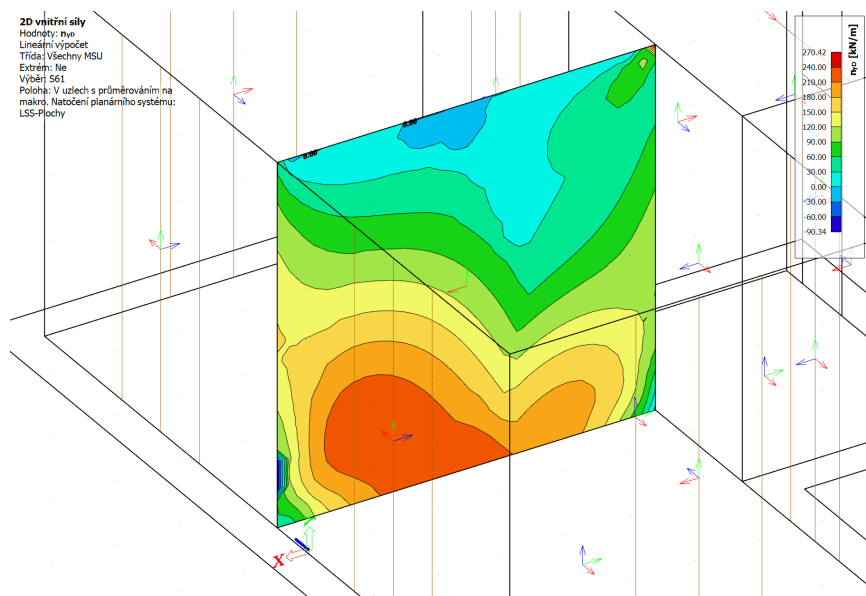
V dalších částech objektu budu výztuž dimenzovat na celou posuzovanou konstrukci viz. pokračování

2.2. Vnitřní stěna mezi nádržemi

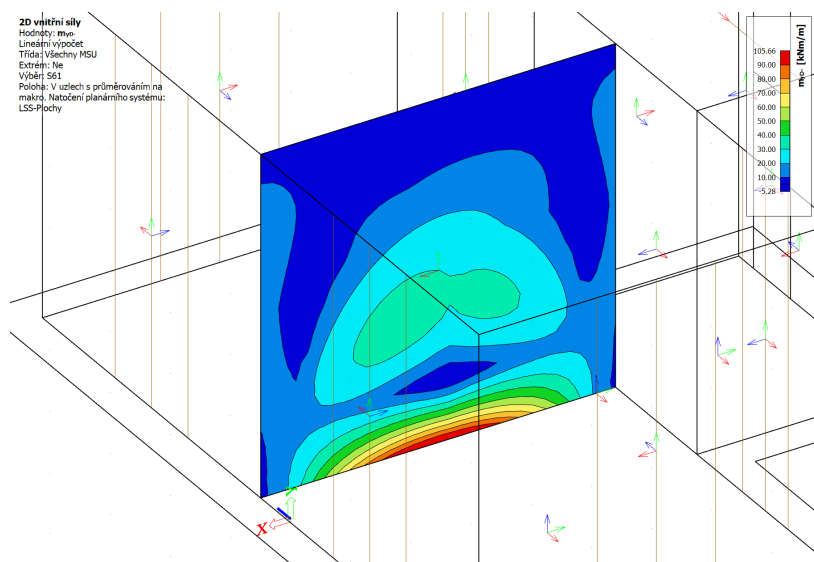
2.2.1. Posouzení na MSÚ

Okraje (Třídy) MSÚ

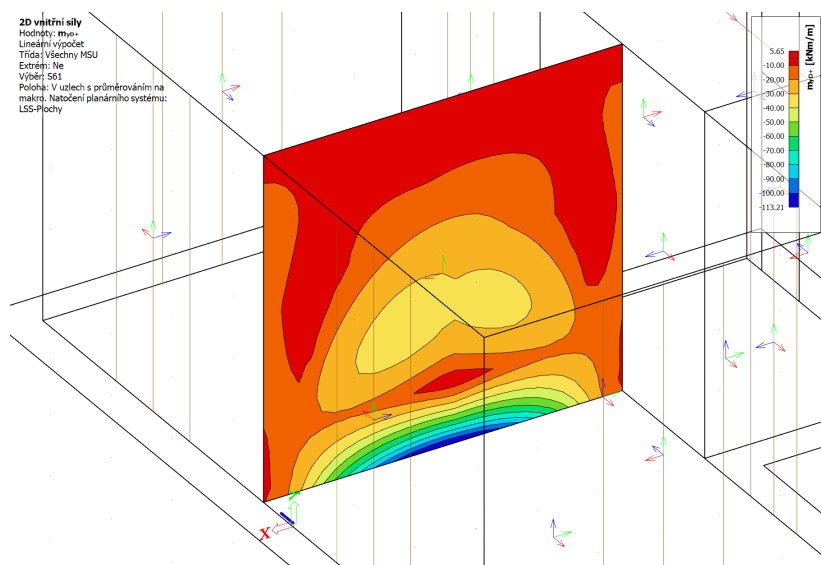
NyD



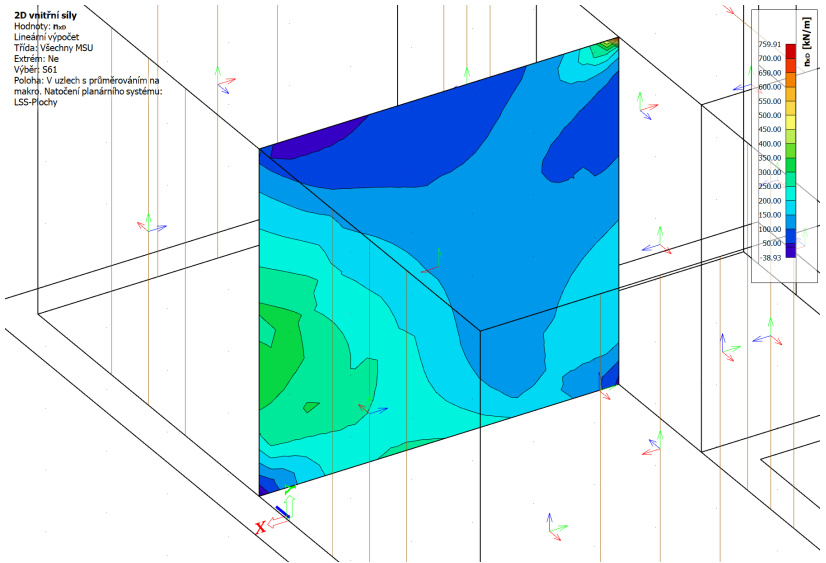
MyD-



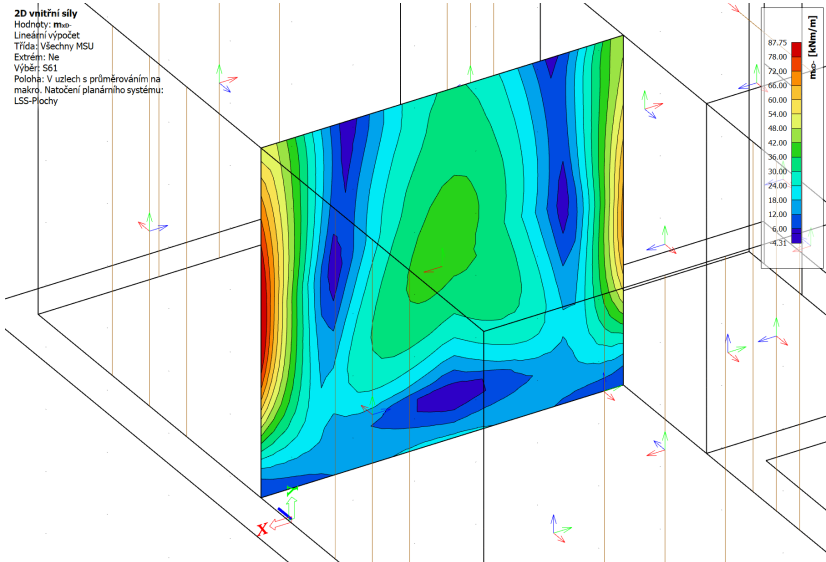
MyD+



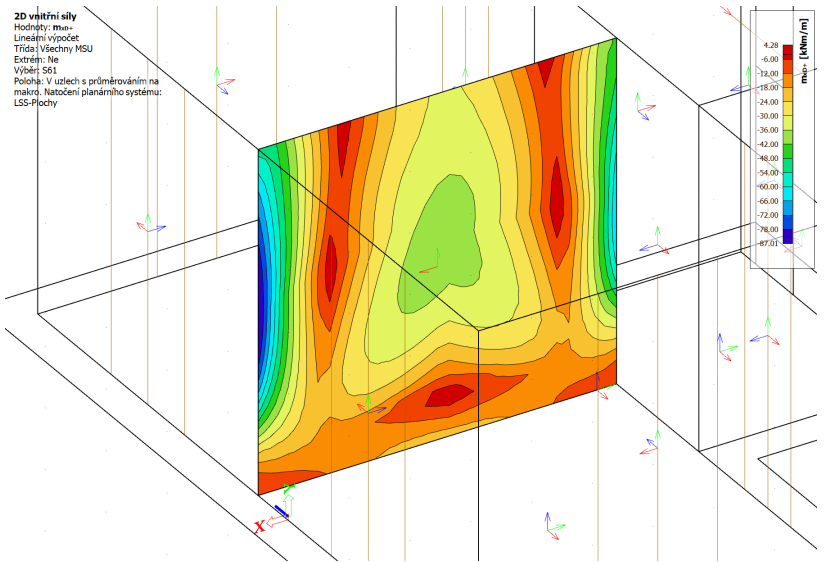
NxD



MxD-



MxD+



Hodnoty z jednotlivých kombinací

(Table 21)

Kombinace	NyD	MyD-	MyD+	NxD	MxD-	MxD+
K2	-150.86	0.95	-1.03	102.87	5.2	-5.59
K3	187.5	0.9	-6.89	331	3.36	-2.31
K4	86.44	30.67	-101.93	183.54	34.68	-78.42

2.2.1.1. Směr y svislá výztuž

geometrie (pro oba povrchy stejné krytí)

$$h_g = 400 \text{ mm}$$

$$d_{1,9} = c_{\text{nom},1} + 0.5 * \varnothing_{y,\text{rozd},\text{steny}} = 50 \text{ mm} + 0.5 * 12 \text{ mm} = 56 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{y,\text{rozd},\text{steny}} = 12 \text{ mm}$$

$$d_g = h_g - d_{1,9} = 400 \text{ mm} - 56 \text{ mm} = 344 \text{ mm}$$

$$b_g = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{y,\text{rozd},\text{steny}1} = \varnothing_{y,\text{rozd},\text{steny}} = 12 \text{ mm}$$

$$s_g = 150 \text{ mm}$$

$$A_{s,9} = \left(\frac{\left(\frac{\pi * \varnothing_{y,\text{rozd},\text{steny}1}^2}{4} \right) * b_g}{s_g} \right) = \left(\frac{\left(\frac{3.142 * (12 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.000754 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,\text{min},9} = 0.26 * \left(\frac{f_{\text{ctm}}}{f_{y,k}} \right) * b_g * d_g = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 344 \text{ mm} = 0.000519 \text{ m}^2$$

$$A_{s,2,\text{min},9} = 0.0013 * b_g * d_g = 0.000447 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,9} > \text{Max}(A_{s,1,\text{min},9}, A_{s,2,\text{min},9}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 > \text{Max}(0.000519 \text{ m}^2, 0.000447 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,\text{max}9} = 0.04 * h_g * b_g = 0.016 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,9} < A_{s,\text{max}9} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,9} = 3 * h_9 = 1200 \text{ mm}$$

$$s_{2,max,9} = 400 \text{ mm}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } s_9 < \text{Max}(s_{1,max,9}, s_{2,max,9}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

$$s_{min,9} = \text{Max}(1.2 * \varnothing_{y,rozd,steny1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 12 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$= \begin{cases} \text{"VYHOVUJE"} & \text{if } s_9 > s_{min,9} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,5} = \text{Max}\left(\frac{h_9}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{400 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,5} = \left(\frac{h_9}{2}\right) - d_{1,9} = \left(\frac{400 \text{ mm}}{2}\right) - 56 \text{ mm} = 0.144 \text{ m}$$

$$\sigma_{s,0,5} = \varepsilon_{cu3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$N_{Rd,0,5} = -(b_9 * h_9 * f_{cd} + A_{s,9} * \sigma_{s,0,5} * 2) = -(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 700 \text{ MPa} * 2) = -9055.575 \text{ kN}$$

$$M_{Rd,0,1,5} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,5} = d_9 = 0.344 \text{ m}$$

$$\varepsilon_{s,1,5} = \varepsilon_{cu3} * \left(\frac{x_{1,5} - d_{1,9}}{x_{1,5}}\right) = 0.0035 * \left(\frac{0.344 \text{ m} - 56 \text{ mm}}{0.344 \text{ m}}\right) = 0.00293$$

$$\varepsilon_{s,1,5} < \varepsilon_{yd} = 0.00293 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,5} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,1,5} = -(b_9 * \lambda * x_{1,5} * f_{cd} + A_{s,9} * \sigma_{s,1,5}) = -(1 \text{ m} * 0.8 * 0.344 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa}) = -5831.818 \text{ kN}$$

$$M_{Rd,1,5} = b_9 * \lambda * x_{1,5} * f_{cd} * \left(\frac{h_9 - \lambda * x_{1,5}}{2}\right) + A_{s,9} * \sigma_{s,1,5} * z_{1,5}$$

$$= 1 \text{ m} * 0.8 * 0.344 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.344 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m}$$

$$= 390.655 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,5} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_9 = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 344 \text{ mm} = 0.212 \text{ m}$$

$$\varepsilon_{s,2,1,5} = \varepsilon_{cu3} * \left(\frac{x_{2,5} - d_{1,9}}{x_{2,5}} \right) = 0.0035 * \left(\frac{0.212 \text{ m} - 56 \text{ mm}}{0.212 \text{ m}} \right) = 0.00258$$

$$\varepsilon_{s,2,1,5} < \varepsilon_{yd} = 0.00258 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,5} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,5} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,5} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,2,5} = - \left(b_9 * \lambda * x_{2,5} * f_{cd} + A_{s,9} * \sigma_{s,2,1,5} - A_{s,9} * \sigma_{s,2,2,5} \right)$$

$$= - \left(1 \text{ m} * 0.8 * 0.212 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} - 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right)$$

$$= -3395.188 \text{ kN}$$

$$M_{Rd,2,5} = b_9 * \lambda * x_{2,5} * f_{cd} * \left(\frac{h_9 - \lambda * x_{2,5}}{2} \right) + A_{s,9} * \sigma_{s,2,1,5} * z_{1,5} + A_{s,9} * \sigma_{s,2,2,5} * z_{1,5}$$

$$= 1 \text{ m} * 0.8 * 0.212 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.212 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m}$$

$$= 485.267 \text{ kN} * \text{m}$$

BOD 3 prostý ohyb

$$N_{Rd,3,5} = 0 \text{ kN}$$

$$x_{3,5} = \frac{A_{s,9} * f_{yd} + A_{s,9} * f_{yd}}{b_9 * \lambda * f_{cd}} = \frac{0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} = 0.0410 \text{ m}$$

$$\varepsilon_{s,3,1,5} = \varepsilon_{cu3} * \left(\frac{d_{1,9} - x_{3,5}}{x_{3,5}} \right) = 0.0035 * \left(\frac{56 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.00128$$

$$\varepsilon_{s,3,1,5} < \varepsilon_{yd} = 0.00128 < 0.0021739 = \text{True} \quad \sigma_{s,3,1,5} = \varepsilon_{s,3,1,5} * E_s = 0.00128 * 200 \text{ GPa}$$

$$= 0.257 \text{ GPa}$$

$$\varepsilon_{s,3,2,5} = \varepsilon_{cu3} * \left(\frac{d_9 - x_{3,5}}{x_{3,5}} \right) = 0.0035 * \left(\frac{344 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.0259$$

$$\varepsilon_{s,3,2,5} < \varepsilon_{yd} = 0.0259 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,5} = f_{yd} = 434.783 \text{ MPa}$$

$$M_{Rd,3,5} = b_9 * \lambda * x_{3,5} * f_{cd} * \left(\frac{h_9 - \lambda * x_{3,5}}{2} \right) + A_{s,9} * \sigma_{s,3,1,5} * z_{1,5} + A_{s,9} * \sigma_{s,3,2,5} * z_{1,5}$$

$$= 1 \text{ m} * 0.8 * 0.0410 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.0410 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 0.257 \text{ GPa} * 0.144 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m}$$

$$= 195.450 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,5} = d_{1,9} = 0.056 \text{ m}$$

$$\epsilon_{s,4,1,5} = \epsilon_{cu3} * \left(\frac{d_9 - x_{4,5}}{x_{4,5}} \right) = 0.0035 * \left(\frac{344 \text{ mm} - 0.056 \text{ m}}{0.056 \text{ m}} \right) = 0.018$$

$$\epsilon_{s,4,1,5} < \epsilon_{yd} = 0.018 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,5} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,5} = A_{s,9} * \sigma_{s,4,1,5} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} = 327.818 \text{ kN}$$

$$M_{Rd,4,5} = A_{s,9} * \sigma_{s,4,1,5} * z_{1,5} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} = 47.206 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,5} = A_{s,9} * f_{yd} + A_{s,9} * f_{yd} = 0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa} = 655.637 \text{ kN}$$

$$M_{Rd,5,5} = 0 \text{ kN} * \text{m}$$

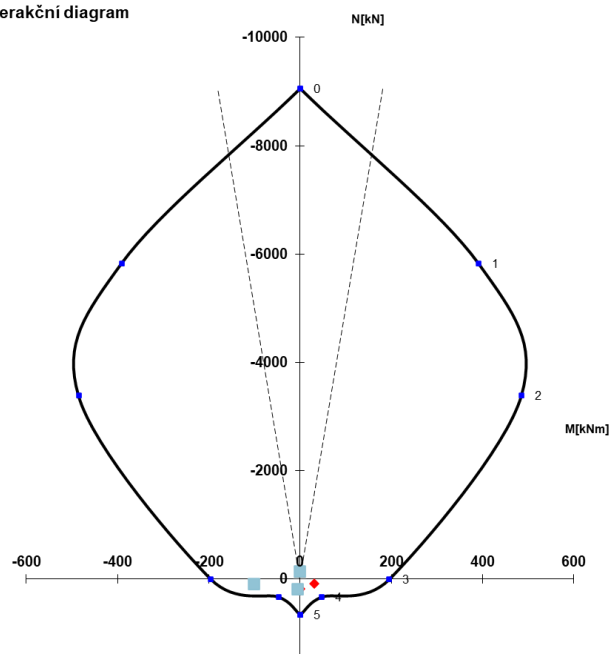
Body	N_Rd	M_Rd
0	-9055.6 kN	0 kN*m
1	-5831.8 kN	391 kN*m
2	-3395.2 kN	485 kN*m
3	0 kN	195 kN*m
4	327.818 kN	47.2 kN*m
5	655.637 kN	0 kN*m

Kombinace	NyD	MyD-	MyD+
K2	-150.86	0.95	-1.03
K3	187.5	0.9	-6.89
K4	86.44	30.67	-101.93

(Table 23)

DIAGRAM

Interakční diagram



2.2.1.2. Směr x vodorovná výztuž geometrie (pro oba povrchy stejné krytí)

$$h_{10} = 400 \text{ mm}$$

$$d_{1,10} = c_{\text{nom},1} + 0.5 * \varnothing_{x,\text{rozd},\text{steny}} + \varnothing_{y,\text{rozd},\text{steny}} = 50 \text{ mm} + 0.5 * 12 \text{ mm} + 12 \text{ mm} = 68 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{x,\text{rozd},\text{steny}} = 12 \text{ mm}$$

$$d_{10} = h_{10} - d_{1,10} = 400 \text{ mm} - 68 \text{ mm} = 332 \text{ mm}$$

$$b_{10} = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{x,\text{rozd},\text{steny}1} = \varnothing_{x,\text{rozd},\text{steny}} = 12 \text{ mm}$$

$$s_{10} = 150 \text{ mm}$$

$$A_{s,10} = \left(\frac{\left(\frac{\pi * \varnothing_{x,\text{rozd},\text{steny}1}^2}{4} \right) * b_{10}}{s_{10}} \right) = \left(\frac{\left(\frac{3.142 * (12 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.000754 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,\text{min},10} = 0.26 * \left(\frac{f_{\text{ctm}}}{f_{y\text{k}}} \right) * b_{10} * d_{10} = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 332 \text{ mm} = 0.000501 \text{ m}^2$$

$$A_{s,2,\text{min},10} = 0.0013 * b_{10} * d_{10} = 0.000432 \text{ m}^2$$

$$\begin{aligned}
 & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,10} > \text{Max}(A_{s,1,\text{min},10}, A_{s,2,\text{min},10}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\
 = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 > \text{Max}(0.000501 \text{ m}^2, 0.000432 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}
 \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,\text{max}10} = 0.04 * h_{10} * b_{10} = 0.016 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,10} < A_{s,\text{max}10} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,\text{max},10} = 3 * h_{10} = 1200 \text{ mm}$$

$$s_{2,\text{max},10} = 400 \text{ mm}$$

$$\begin{aligned}
 & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_{10} < \text{Max}(s_{1,\text{max},10}, s_{2,\text{max},10}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\
 = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}
 \end{aligned}$$

$$\begin{aligned}
 s_{\text{min},10} &= \text{Max}(1.2 * \varnothing_{x,\text{rozd},\text{steny}1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) \\
 &= \text{Max}(1.2 * 12 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}
 \end{aligned}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_4 > s_{\text{min},10} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,6} = \text{Max}\left(\frac{h_{10}}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{400 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,6} = \left(\frac{h_{10}}{2}\right) - d_{1,10} = \left(\frac{400 \text{ mm}}{2}\right) - 68 \text{ mm} = 0.132 \text{ m}$$

$$\sigma_{s,0,6} = \varepsilon_{\text{cu}3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$\begin{aligned}
 N_{\text{Rd},0,6} &= -(b_{10} * h_{10} * f_{cd} + A_{s,10} * \sigma_{s,0,6} * 2) \\
 &= -(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 700 \text{ MPa} * 2) = -9055.575 \text{ kN}
 \end{aligned}$$

$$M_{\text{Rd},0,1,6} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,6} = d_{10} = 0.332 \text{ m}$$

$$\varepsilon_{s,1,6} = \varepsilon_{cu3} * \left(\frac{x_{1,6} - d_{1,10}}{x_{1,6}} \right) = 0.0035 * \left(\frac{0.332 \text{ m} - 68 \text{ mm}}{0.332 \text{ m}} \right) = 0.00278$$

$$\varepsilon_{s,1,6} < \varepsilon_{yd} = 0.00278 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,6} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$N_{Rd,1,6} = - \left(b_{10} * \lambda * x_{1,6} * f_{cd} + A_{s,10} * \sigma_{s,1,6} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.332 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) = -5639.818 \text{ kN}$$

$$M_{Rd,1,6} = b_{10} * \lambda * x_{1,6} * f_{cd} * \left(\frac{h_{10} - \lambda * x_{1,6}}{2} \right) + A_{s,10} * \sigma_{s,1,6} * z_{1,6} \\ = 1 \text{ m} * 0.8 * 0.332 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.332 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} \\ = 400.238 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,6} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_{10} = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 332 \text{ mm} = 0.205 \text{ m}$$

$$\varepsilon_{s,2,1,6} = \varepsilon_{cu3} * \left(\frac{x_{2,6} - d_{1,10}}{x_{2,6}} \right) = 0.0035 * \left(\frac{0.205 \text{ m} - 68 \text{ mm}}{0.205 \text{ m}} \right) = 0.00234$$

$$\varepsilon_{s,2,1,6} < \varepsilon_{yd} = 0.00234 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,6} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,6} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,6} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,2,6} = - \left(b_{10} * \lambda * x_{2,6} * f_{cd} + A_{s,10} * \sigma_{s,2,1,6} - A_{s,10} * \sigma_{s,2,2,6} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.205 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} - 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) \\ = -3276.751 \text{ kN}$$

$$M_{Rd,2,6} = b_{10} * \lambda * x_{2,6} * f_{cd} * \left(\frac{h_{10} - \lambda * x_{2,6}}{2} \right) + A_{s,10} * \sigma_{s,2,1,6} * z_{1,6} + A_{s,10} * \sigma_{s,2,2,6} * z_{1,6} \\ = 1 \text{ m} * 0.8 * 0.205 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.205 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} \\ = 473.467 \text{ kN} * \text{m}$$

BOD 3 prostý ohyb

$$N_{Rd,3,6} = 0 \text{ kN}$$

$$x_{3,6} = \frac{A_{s,10} * f_{yd} + A_{s,10} * f_{yd}}{b_{10} * \lambda * f_{cd}} = \frac{0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} \\ = 0.0410 \text{ m}$$

$$\varepsilon_{s,3,1,6} = \varepsilon_{cu3} * \left(\frac{d_{1,10} - x_{3,6}}{x_{3,6}} \right) = 0.0035 * \left(\frac{68 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.00231$$

$$\varepsilon_{s,3,1,6} < \varepsilon_{yd} = 0.00231 < 0.0021739 = \text{False}$$

$$\sigma_{s,3,1,6} = \varepsilon_{s,3,1,6} * E_s = 0.00231 * 200 \text{ GPa} = 0.462 \text{ GPa}$$

$$\varepsilon_{s,3,2,6} = \varepsilon_{cu3} * \left(\frac{d_{10} - x_{3,6}}{x_{3,6}} \right) = 0.0035 * \left(\frac{332 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.0249$$

$$\varepsilon_{s,3,2,6} < \varepsilon_{yd} = 0.0249 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,6} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$M_{Rd,3,6} = b_{10} * \lambda * x_{3,6} * f_{cd} * \left(\frac{h_{10} - \lambda * x_{3,6}}{2} \right) + A_{s,10} * \sigma_{s,3,1,6} * z_{1,6} + A_{s,10} * \sigma_{s,3,2,6} * z_{1,6}$$

$$= 1 \text{ m} * 0.8 * 0.0410 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.0410 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 0.462 \text{ GPa} * 0.132 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m}$$

$$= 209.596 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,6} = d_{1,10} = 68 \text{ mm} = 0.068 \text{ m}$$

$$\varepsilon_{s,4,1,6} = \varepsilon_{cu3} * \left(\frac{d_{10} - x_{4,6}}{x_{4,6}} \right) = 0.0035 * \left(\frac{332 \text{ mm} - 0.068 \text{ m}}{0.068 \text{ m}} \right) = 0.0136$$

$$\varepsilon_{s,4,1,6} < \varepsilon_{yd} = 0.0136 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,6} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,6} = A_{s,10} * \sigma_{s,4,1,6} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} = 327.818 \text{ kN}$$

$$M_{Rd,4,6} = A_{s,10} * \sigma_{s,4,1,6} * z_{1,6} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} = 43.272 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,6} = A_{s,10} * f_{yd} + A_{s,10} * f_{yd} = 0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}$$

$$= 655.637 \text{ kN}$$

$$M_{Rd,5,6} = 0 \text{ kN} * \text{m}$$

Body	N_Rd	M_Rd
0	-9055.6 kN	0 kN*m
1	-5639.8 kN	400 kN*m
2	-3276.8 kN	473 kN*m
3	0 kN	210 kN*m
4	327.818 kN	43.3 kN*m
5	655.637 kN	0 kN*m

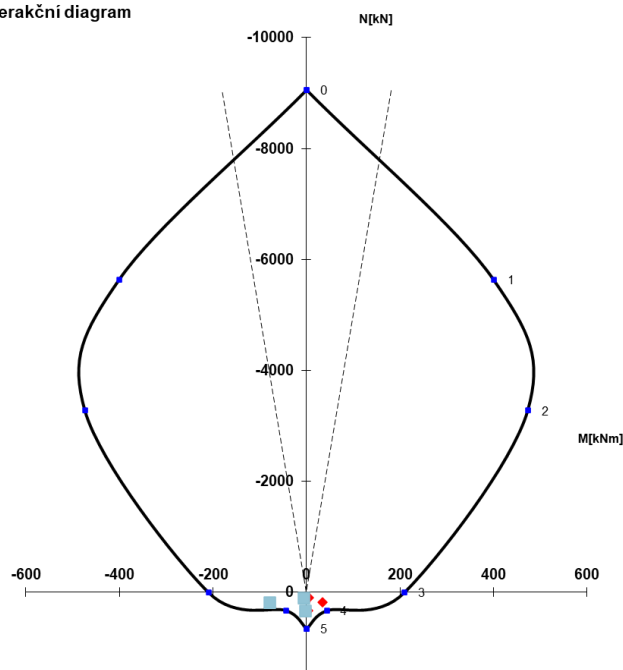
Kombinace	NxD	MxD-	MxD+
K2	102.87	5.2	-5.59
K3	331	3.36	-2.31

K4	183.54	34.68	-78.42
----	--------	-------	--------

(Table 25)

DIAGRAM

Interakční diagram



2.2.2. Posouzení na smyk

2.2.2.1. Směr y svislá výztuž

(Table 26)

Kombinace	VyD	NyD	VyD
K2	4.81 kN	150.86 kN	4.81
K3	6.47 kN	187.5 kN	6.47
K4	148.17 kN	86.44 kN	148.17

$$C_{Rd,c,3} = \frac{0.18}{\gamma_c} = 0.12 \quad d_{5,3} = \frac{d_9}{1 \text{ mm}} = 344$$

$$K_3 = 1 + \sqrt{\left(\frac{200}{d_{5.3}}\right)} = 1 + \sqrt{\left(\frac{200}{344}\right)} = 1.762$$

$$\zeta_{sl,3} = \frac{A_{s,9}}{b_g * d_g} = \frac{0.000754 \text{ m}^2}{1 \text{ m} * 344 \text{ mm}} = 0.00219$$

$$\begin{cases} \text{"VYHOVUJE"} & \text{if } \zeta_{sl,3} < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 0.00219 < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

$$f_{ck,3} = 30$$

$$v_{min,3} = 0.035 * K_3^{\left(\frac{2}{3}\right)} * f_{ck,3}^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.035 * 1.762^{\left(\frac{2}{3}\right)} * 30^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.280 \text{ MPa}$$

$$V_{Rd,cn,3} = \left[C_{Rd,c,3} * K_3 * \left(100 * \zeta_{sl,3} * f_{ck,3} \right)^{\left(\frac{1}{3}\right)} * b_9 * d_9 * 1 \text{ MPa} \right]$$

$$= \left[0.12 * 1.762 * \left(100 * 0.00219 * 30 \right)^{\left(\frac{1}{3}\right)} * 1 \text{ m} * 344 \text{ mm} * 1 \text{ MPa} \right] = 136.304 \text{ kN}$$

$$V_{min,3} = v_{min,3} * b_9 * d_9 = 0.280 \text{ MPa} * 1 \text{ m} * 344 \text{ mm} = 96.221 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,cn,3} \geq V_{min,3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 136.304 \text{ kN} \geq 96.221 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Vliv normálové síly

K2

$$\sigma_{cp,1,3} = \frac{\text{Table26.C2}}{b_9 * d_9} = \frac{150.86 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 438.547 \text{ kPa} \quad k_{1,2} = 0.15$$

$$V_{Rd,c,1,3} = V_{Rd,cn,3} + k_{1,2} * \sigma_{cp,1,3} * b_9 * d_9 = 136.304 \text{ kN} + 0.15 * 438.547 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 158.933 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,1,3} > \text{Table26.B2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 158.933 \text{ kN} > 4.81 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

K3

$$\sigma_{cp,2,3} = \frac{\text{Table26.C3}}{b_9 * d_9} = \frac{187.5 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 545.058 \text{ kPa} \quad k_{2,2} = 0.15$$

$$V_{Rd,c,2,3} = V_{Rd,cn,3} + k_{2,2} * \sigma_{cp,2,3} * b_9 * d_9 = 136.304 \text{ kN} + 0.15 * 545.058 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 164.429 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,2,3} > \text{Table26.B3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 164.429 \text{ kN} > 6.47 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

K4

$$\sigma_{cp,3,3} = \frac{\text{Table26.C4}}{b_9 * d_9} = \frac{86.44 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 251.279 \text{ kPa} \quad k_{3,2} = 0.15$$

$$V_{Rd,c,3,3} = V_{Rd,cn,3} + k_{3,2} * \sigma_{cp,3,3} * b_9 * d_9 = 136.304 \text{ kN} + 0.15 * 251.279 \text{ kPa} * 1 \text{ m} * 344 \text{ mm}$$

$$= 149.270 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,3,3} > \text{Table26.B4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 149.270 \text{ kN} > 148.17 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

NENÍ POTŘEBA NAVRHNOUT SMYKOVOU VÝZTUŽ

2.2.3. Kotevní a stykové délky

2.2.3.1. Směr y svislá výztuž

Kotvení

$$\eta_{1,5} = 0.7$$

$$\eta_{2,5} = 1 \quad \alpha_{ct,5} = 1$$

$$f_{ctd,5} = \alpha_{ct,5} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,5} = 2.25 * \eta_{1,5} * \eta_{2,5} * f_{ctd,5} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,5} = \left(\frac{\emptyset_{y,rozd,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,5}} \right) = \left(\frac{12 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 621.118 \text{ mm}$$

$$L_{bdrqd,5} = \text{RoundUp}(l_{bdrqd,5}) = \text{RoundUp}(621.118 \text{ mm}) = 622 \text{ mm}$$

Stykování

$$\alpha_{1,5} = 1 \quad \alpha_{2,5} = 1 \quad \alpha_{3,5} = 1 \quad \alpha_{5,5} = 1 \quad \alpha_{6,5} = 1.5$$

$$l_{0,5} = \alpha_{1,5} * \alpha_{2,5} * \alpha_{3,5} * \alpha_{5,5} * \alpha_{6,5} * L_{bdrqd,5} = 1 * 1 * 1 * 1 * 1.5 * 622 \text{ mm} = 933 \text{ mm}$$

$$L_{0,5} = \text{RoundUp}(l_{0,5}) = 933 \text{ mm}$$

$$l_{0,min,5} = \text{Max}(0.6 * \alpha_{6,5} * L_{bdrqd,5}, 15 * \emptyset_{y,rozd,steny}, 200 \text{ mm})$$

$$= \text{Max}(0.6 * 1.5 * 622 \text{ mm}, 15 * 12 \text{ mm}, 200 \text{ mm}) = 559.8 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,5} > l_{0,min,5} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 933 \text{ mm} > 559.8 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

2.2.3.2. Směr x vodorovná výztuž

Kotvení

$$\eta_{1,6} = 0.7$$

$$\eta_{2,6} = 1 \quad \alpha_{ct,6} = 1$$

$$f_{ctd,6} = \alpha_{ct,6} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,6} = 2.25 * \eta_{1,6} * \eta_{2,6} * f_{ctd,6} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,6} = \left(\frac{\varnothing_{x,rozd,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,6}} \right) = \left(\frac{12 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 621.118 \text{ mm}$$

$$L_{bdrqd,6} = \text{RoundUp}(l_{bdrqd,6}) = 622 \text{ mm}$$

Stykování

$$\alpha_{1,6} = 1 \quad \alpha_{2,6} = 1 \quad \alpha_{3,6} = 1 \quad \alpha_{5,6} = 1 \quad \alpha_{6,6} = 1.5$$

$$l_{0,6} = \alpha_{1,6} * \alpha_{2,6} * \alpha_{3,6} * \alpha_{5,6} * \alpha_{6,6} * L_{bdrqd,6} = 1 * 1 * 1 * 1 * 1.5 * 622 \text{ mm} = 933 \text{ mm}$$

$$L_{0,6} = \text{RoundUp}(l_{0,6}) = \text{RoundUp}(933 \text{ mm}) = 933 \text{ mm}$$

$$l_{0,min,6} = \text{Max}(0.3 * \alpha_{6,6} * L_{bdrqd,6}, 15 * \varnothing_{y,rozd,steny1}, 200 \text{ mm})$$

$$= \text{Max}(0.3 * 1.5 * 622 \text{ mm}, 15 * 12 \text{ mm}, 200 \text{ mm}) = 279.9 \text{ mm}$$

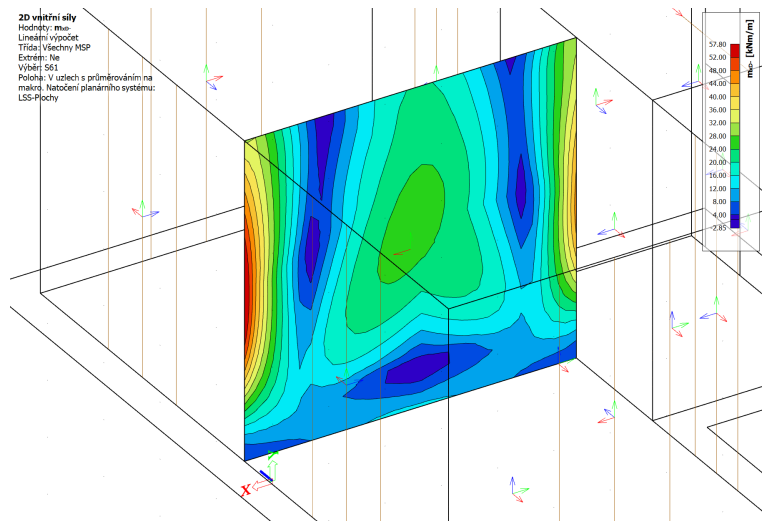
$$\text{value3} = \begin{cases} \text{"VYHOVUJE"} & \text{if } L_{0,6} > l_{0,min,6} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 933 \text{ mm} > 279.9 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

2.2.4. Posouzení na MSP

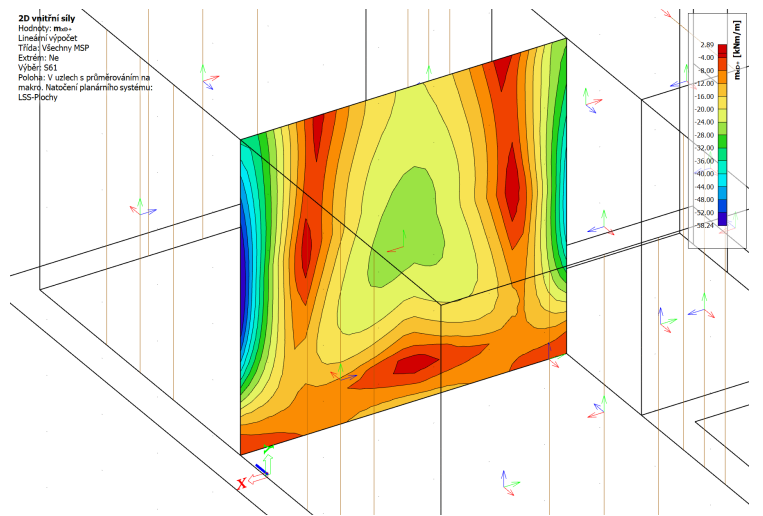
Okraje (Třídy) MSP

Všechny MSP

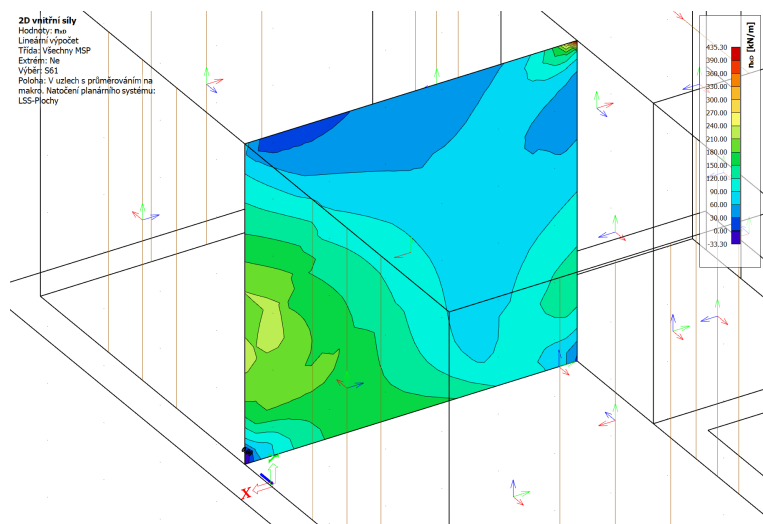
MxD-



MxD+

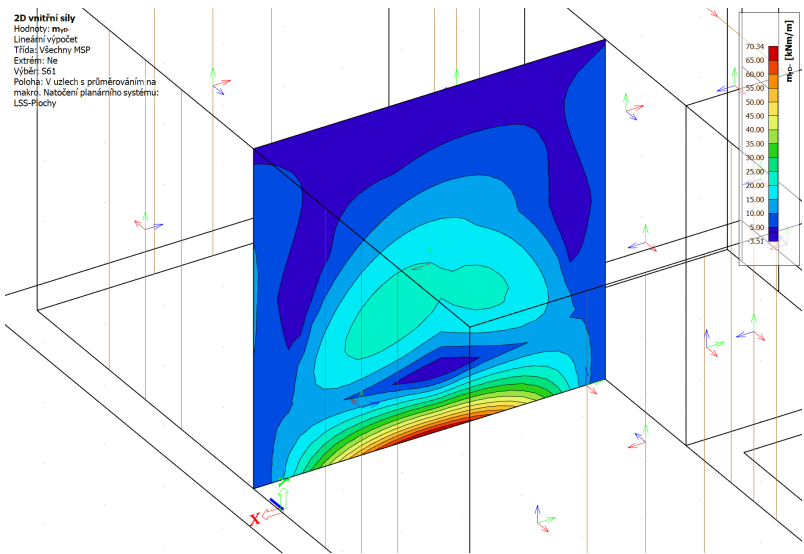


NxD

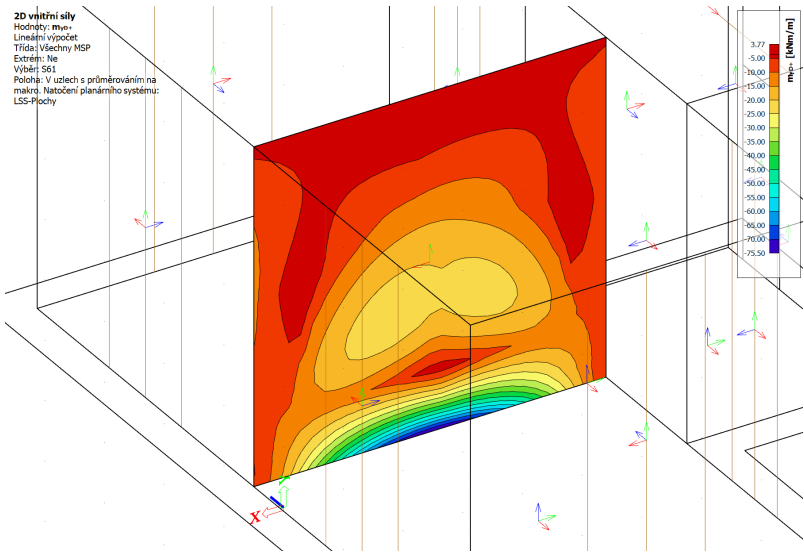


Všechny MSP

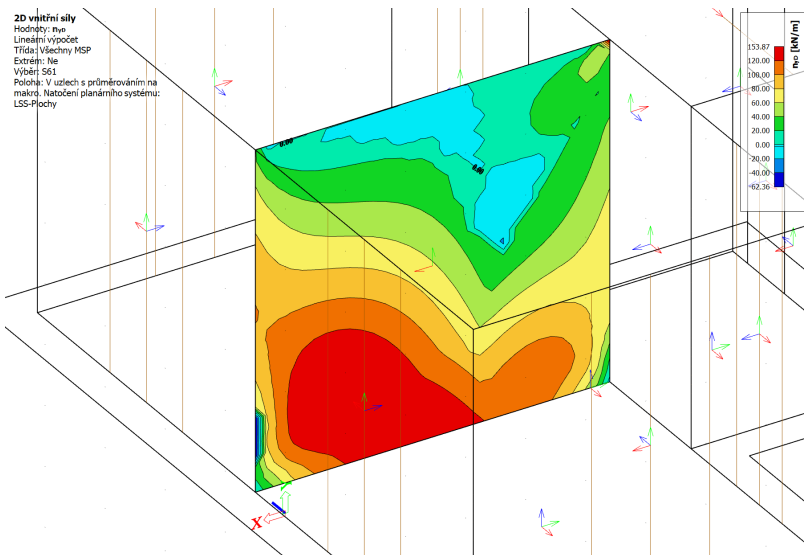
MyD-



MyD+



NyD



(Uvedeno v absolutních hodnotách)

(Table 27)

Kombinace	MxD- Char	MxD+ Char	NxD Char	MxD- Kvazi	MxD+ Kvazi	MyD- Char	MyD+ Char	NyD Char	MyD- Kvazi	MyD+ Kvazi
K2	3.88	4.16	76.16	3.99	4.28	0.71	0.77	111.83	0.73	0.79
K3	2.49	1.71	245.15	2.01	2.1	0.66	5.11	138.81	0.53	4.18
K4	25.69	58.1	135.92	20.66	46.98	22.72	75.5	63.98	18.29	60.46

2.2.4.1. směr x

(Table 28)

Kombinace	MxD	Nx
Charakteristická	58.1 kN*m	245.15 kN
Kvazistálá	46.98 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,7} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,7} = b_{10} * h_{10} = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,7} = A_{S,10} = 0.000754 \text{ m}^2$$

$$A_{i,7} = A_{C,C,7} + A_{S,S,7} * \alpha_{e,7} = 0.4 \text{ m}^2 + 0.000754 \text{ m}^2 * 6.061 = 0.405 \text{ m}^2$$

$$a_{c,c,7} = \frac{h_{10}}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,7} = \frac{A_{C,C,7} * a_{c,c,7} + \alpha_{e,7} * (A_{S,S,7} * d_{10})}{A_{i,7}} = \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000754 \text{ m}^2 * 332 \text{ mm})}{0.405 \text{ m}^2}$$

$$= 0.201 \text{ m}$$

$$I_{c,c,7} = \left(\frac{1}{12} \right) * b_{10} * h_{10}^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,7} = I_{c,c,7} + A_{C,C,7} * (a_{gi,7} - a_{c,c,7})^2 + \alpha_{e,7} * \left(A_{S,S,7} * (d_{10} - a_{gi,7})^2 \right)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.201 \text{ m} - 0.2 \text{ m})^2 + 6.061 * \left(0.000754 \text{ m}^2 * (332 \text{ mm} - 0.201 \text{ m})^2 \right)$$

$$= 0.00541 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,7} = \left| \left(\left(\frac{\text{Table28.C2}}{A_{i,7}} \right) - \left(\frac{\text{Table28.B2} * a_{gi,7}}{I_{i,7}} \right) \right) \right| = \left| \left(\left(\frac{245.15 \text{ kN}}{0.405 \text{ m}^2} \right) - \left(\frac{58.1 \text{ kN} * \text{m} * 0.201 \text{ m}}{0.00541 \text{ m}^4} \right) \right) \right|$$

$$= 1557.112 \text{ kPa}$$

$$f_{ct,eff,1,7} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,1,7} < f_{ct,eff,1,7} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 1557.112 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

$$\begin{aligned} \sigma_{C,C,2,7} &= \left| \left(\left(\frac{\text{Table28.C2}}{A_{i,7}} \right) + \left(\frac{\text{Table28.B2} * (h_{10} - a_{gi,7})}{l_{i,7}} \right) \right) \right| \\ &= \left| \left(\left(\frac{245.15 \text{ kN}}{0.405 \text{ m}^2} \right) + \left(\frac{58.1 \text{ kN} * \text{m} * (400 \text{ mm} - 0.201 \text{ m})}{0.00541 \text{ m}^4} \right) \right) \right| = 2737.006 \text{ kPa} \end{aligned}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,2,7} < f_{ct,eff,1,7} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 2737.006 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

Napětí ve výztuži

$$e_{kd,7} = \frac{\text{Table28.B2}}{\text{Table28.C2}} = \frac{58.1 \text{ kN} * \text{m}}{245.15 \text{ kN}} = 0.237 \text{ m}$$

$$e_7 = e_{kd,7} + a_{c,c,7} = 0.237 \text{ m} + 0.2 \text{ m} = 0.437 \text{ m}$$

$$\begin{aligned} \sigma_{S,S,1,7} &= \left(\frac{\text{Table28.C2}}{A_{i,7}} \right) * \left(1 + \left(\frac{A_{i,7} * (a_{gi,7} - e_7) * (a_{gi,7} - d_{10})}{l_{i,7}} \right) \right) * \alpha_{e,7} \\ &= \left(\frac{245.15 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.201 \text{ m} - 0.437 \text{ m}) * (0.201 \text{ m} - 332 \text{ mm})}{0.00541 \text{ m}^4} \right) \right) * 6.061 \\ &= 12110.255 \text{ kPa} \end{aligned}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE"} \text{ if } \sigma_{S,S,1,7} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} \text{ otherwise} \end{array} \right. = \left| \begin{array}{l} \text{"VYHOVUJE"} \text{ if } 12110.255 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE} \end{aligned}$$

$$\sigma_{S,S,2,7} = \left(\frac{\text{Table28.C2}}{A_{i,7}} \right) * \left(1 + \left(\frac{A_{i,7} * (a_{gi,7} - e_7) * (a_{gi,7} - d_{10})}{l_{i,7}} \right) \right) * \alpha_{e,7}$$

$$= \left(\frac{245.15 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.201 \text{ m} - 0.437 \text{ m}) * (0.201 \text{ m} - 332 \text{ mm})}{0.00541 \text{ m}^4} \right) \right) * 6.061$$

$$= 12110.255 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,7} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 12110.255 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

$$= \text{VYHOVUJE}$$

2.2.4.2. směr y

(Table 29)

Kombinace	MyD	Ny
Charakteristická	75.5 kN*m	138.81 kN
Kvazistálá	60.46 kN*m	

omezení napětí v betonu a ve výztuži

$$\alpha_{e,8} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,8} = b_g * h_g = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,8} = A_{s,9} = 0.000754 \text{ m}^2$$

$$A_{i,8} = A_{C,C,8} + A_{S,S,8} * \alpha_{e,8} = 0.4 \text{ m}^2 + 0.000754 \text{ m}^2 * 6.061 = 0.405 \text{ m}^2$$

$$a_{c,c,8} = \frac{h_g}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,8} = \frac{A_{C,C,8} * a_{c,c,8} + \alpha_{e,8} * (A_{S,S,8} * d_g)}{A_{i,8}} = \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000754 \text{ m}^2 * 344 \text{ mm})}{0.405 \text{ m}^2}$$

= 0.202 m ... výška tlačené části betonu

$$I_{c,c,8} = \left(\frac{1}{12} \right) * b_g * h_g^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,8} = I_{c,c,8} + A_{C,C,8} * (a_{gi,8} - a_{c,c,8})^2 + \alpha_{e,8} * \left(A_{S,S,8} * (d_g - a_{gi,8})^2 \right)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.202 \text{ m} - 0.2 \text{ m})^2 + 6.061 * \left(0.000754 \text{ m}^2 * (344 \text{ mm} - 0.202 \text{ m})^2 \right)$$

$$= 0.00543 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,8} = \left| \left(\left(\frac{\text{Table29.C2}}{A_{i,8}} \right) - \left(\frac{\text{Table29.B2} * a_{gi,8}}{I_{i,8}} \right) \right) \right| = \left| \left(\left(\frac{138.81 \text{ kN}}{0.405 \text{ m}^2} \right) - \left(\frac{75.5 \text{ kN} * \text{m} * 0.202 \text{ m}}{0.00543 \text{ m}^4} \right) \right) \right|$$

$$= 2461.897 \text{ kPa}$$

$$f_{ct,eff,1,8} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,1,8} < f_{ct,eff,1,8} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 2461.897 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

$$\sigma_{C,C,2,8} = \left| \left(\left(\frac{\text{Table29.C2}}{A_{i,8}} \right) + \left(\frac{\text{Table29.B2} * (h_g - a_{gi,8})}{I_{i,8}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{138.81 \text{ kN}}{0.405 \text{ m}^2} \right) + \left(\frac{75.5 \text{ kN} * \text{m} * (400 \text{ mm} - 0.202 \text{ m})}{0.00543 \text{ m}^4} \right) \right) \right| = 3102.853 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,2,8} < f_{ct,eff,1,8} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 3102.853 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{NEVYHOVUJE TRHLINY VZNIKNOU} \end{aligned}$$

Napětí ve výztuži

$$e_{kd,8} = \frac{\text{Table29.B2}}{\text{Table29.C2}} = \frac{75.5 \text{ kN} * \text{m}}{138.81 \text{ kN}} = 0.544 \text{ m}$$

$$e_8 = e_{kd,8} + a_{c,c,8} = 0.544 \text{ m} + 0.2 \text{ m} = 0.744 \text{ m}$$

$$\sigma_{S,S,1,8} = \left(\frac{\text{Table29.C2}}{A_{i,8}} \right) * \left(1 + \left(\frac{A_{i,8} * (a_{gi,8} - e_8) * (a_{gi,8} - d_g)}{I_{i,8}} \right) \right) * \alpha_{e,8}$$

$$= \left(\frac{138.81 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.744 \text{ m}) * (0.202 \text{ m} - 344 \text{ mm})}{0.00543 \text{ m}^4} \right) \right) * 6.061$$

$$= 14047.668 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE"} \text{ if } \sigma_{S,S,1,8} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} \text{ otherwise} \end{array} \right. = \left| \begin{array}{l} \text{"VYHOVUJE"} \text{ if } 14047.668 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE} \end{aligned}$$

$$\begin{aligned}\sigma_{S,S,2,8} &= \left(\frac{\text{Table29.C2}}{A_{i,8}} \right) * \left(1 + \left(\frac{A_{i,8} * (a_{gi,8} - e_8) * (a_{gi,8} - d_9)}{I_{i,8}} \right) \right) * \alpha_{e,8} \\ &= \left(\frac{138.81 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.744 \text{ m}) * (0.202 \text{ m} - 344 \text{ mm})}{0.00543 \text{ m}^4} \right) \right) * 6.061 \\ &= 14047.668 \text{ kPa} \\ \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,8} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| &= \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 14047.668 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| \\ &= \text{VYHOVUJE}\end{aligned}$$

posouzení šířky trhlin

$$\begin{aligned}h_{c,eff,1} &= \text{Min} \left(2.5 * (h_9 - d_9), \frac{h_9 - x_{3,5}}{3}, \frac{h_9}{2} \right) \\ &= \text{Min} \left(2.5 * (400 \text{ mm} - 344 \text{ mm}), \frac{400 \text{ mm} - 0.0410 \text{ m}}{3}, \frac{400 \text{ mm}}{2} \right) = 0.120 \text{ m}\end{aligned}$$

$$A_{c,eff,1} = b_9 * h_{c,eff,1} = 1 \text{ m} * 0.120 \text{ m} = 0.120 \text{ m}^2$$

$$A_{p,1} = 0 \text{ m}^2$$

$$\xi_1 = 0$$

$$\rho_{p,eff,1} = \frac{A_{S,S,8} + \xi_1^2 * A_{p,1}}{A_{c,eff,1}} = \frac{0.000754 \text{ m}^2 + 0^2 * 0 \text{ m}^2}{0.120 \text{ m}^2} = 0.00630$$

$$f_{ct,eff,2,1} = 0.5 * f_{ctm} = 0.5 * 2.9 \text{ MPa} = 1450 \text{ kPa}$$

$$k_{t,1} = 0.6 \dots \text{dlouhodobé zatížení}$$

$$a_{s,1} = \frac{h_9}{2} - d_{1,9} = \frac{400 \text{ mm}}{2} - 56 \text{ mm} = 0.144 \text{ m}$$

$$\begin{aligned}\epsilon_{\text{rozdíl,smcm},1} &= \frac{\left(\sigma_{S,S,1,8} - k_{t,1} * \left(\frac{f_{ct,eff,2,1}}{\rho_{p,eff,1}} \right) * (1 + \alpha_{e,8} * \rho_{p,eff,1}) \right)}{E_s} \\ &= \frac{\left(14047.668 \text{ kPa} - 0.6 * \left(\frac{1450 \text{ kPa}}{0.00630} \right) * (1 + 6.061 * 0.00630) \right)}{200 \text{ GPa}} = -0.000647\end{aligned}$$

$$\text{value13} = \begin{cases} \varepsilon_{\text{rozdl,smcm,1}} & \text{if } \varepsilon_{\text{rozdl,smcm,1}} \geq 0.6 * \left(\frac{\sigma_{S,S,1,8}}{E_s} \right) \\ 0.6 * \left(\frac{\sigma_{S,S,1,8}}{E_s} \right) & \text{otherwise} \end{cases}$$

$$= \begin{cases} \varepsilon_{\text{rozdl,smcm,1}} & \text{if } -0.000647 \geq 0.6 * \left(\frac{14047.668 \text{ kPa}}{200 \text{ GPa}} \right) \\ 0.6 * \left(\frac{14047.668 \text{ kPa}}{200 \text{ GPa}} \right) & \text{otherwise} \end{cases} = 0.0000421$$

$$k_{11} = 0.8$$

$$k_{21} = 0.5$$

$$k_{31} = 3.4$$

$$k_{41} = 0.425$$

$$s_{r,\max,1} = k_{31} * c_{\text{nom},1} + k_{11} * k_{21} * k_{41} * \left(\frac{\varnothing_{y,\text{rozdl,steny1}}}{\rho_{p,\text{eff},1}} \right)$$

$$= 3.4 * 50 \text{ mm} + 0.8 * 0.5 * 0.425 * \left(\frac{12 \text{ mm}}{0.00630} \right) = 0.494 \text{ m}$$

$$w_{k,1} = s_{r,\max,1} * \text{value13} = 0.494 \text{ m} * 0.0000421 = 0.0208 \text{ mm}$$

$h_0 = 5.4 \text{ m}$...výška hladiny vody

$$h_{9,1} = h_9 = 0.4 \text{ m}$$

$$\frac{h_0}{h_{9,1}} = \frac{5.4 \text{ m}}{0.4 \text{ m}} = 13.5$$

interpolace mezi hodnotami

$$\text{pro } \frac{h_0}{h_{9,1}} \leq 5 \dots w_{k,\max,1} = 0.2 \text{ mm}$$

$$\text{pro } \frac{h_0}{h_{9,1}} \geq 35 \dots w_{k,\max,1} = 0.05 \text{ mm}$$

$$w_{k,\max,1} = 0.1575 \text{ mm}$$

$$\begin{cases} \text{"VYHOVUJE"} & \text{if } w_{k,\max,1} > w_{k,1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 0.1575 \text{ mm} > 0.0208 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \text{VYHOVUJE}$$

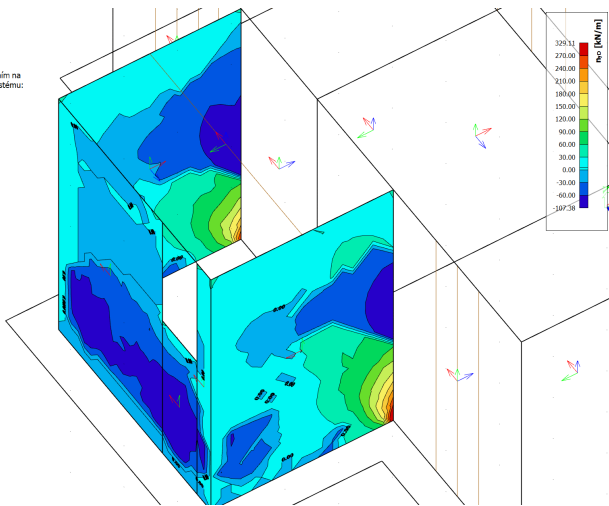
2.3. Stěna technické místnosti

2.3.1. Posouzení na MSÚ

Okraje (Třídy) MSÚ

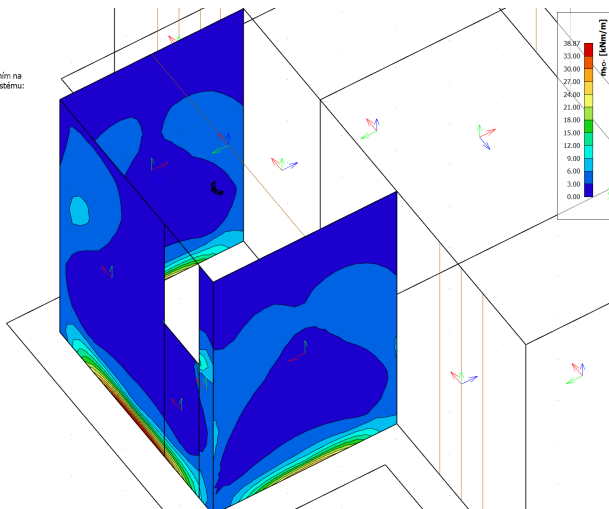
NyD

2D vnitřní síly
Hodnoty: $m \cdot m$
Lineární výpočet
Třída: Všechny MSÚ
Extrém: Ne
Výběr: S51, S54, S60
Položka: V úzlech s průměrováním na
makro. Nátěžní planárního systému:
LSS-Plochy



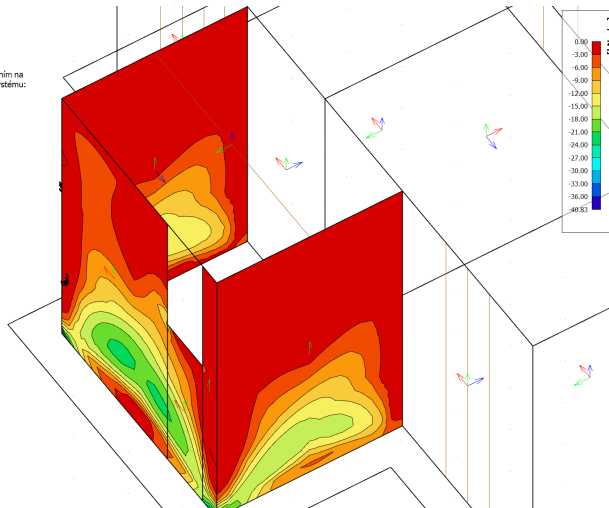
MyD-

2D vnitřní síly
Hodnoty: $m \cdot m$
Lineární výpočet
Třída: Všechny MSÚ
Extrém: Ne
Výběr: S51, S54, S60
Položka: V úzlech s průměrováním na
makro. Nátěžní planárního systému:
LSS-Plochy



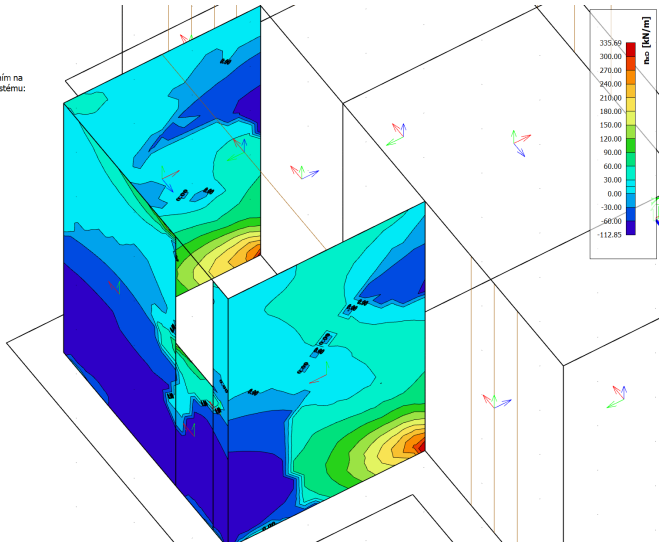
MyD+

2D vnitřní síly
Hodnoty: $m \cdot m$
Lineární výpočet
Třída: Všechny MSÚ
Extrém: Ne
Výběr: S51, S54, S60
Položka: V úzlech s průměrováním na
makro. Nátěžní planárního systému:
LSS-Plochy



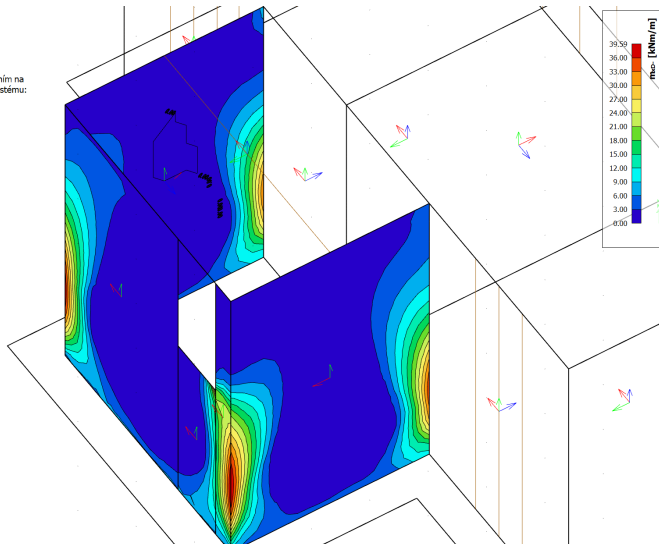
NxD

2D vnitřní síly
Hodnoty: m_{xe}
Lineární výpočet
Třída: Všechny MSU
Extrém: Ne
Výběr: S51, S54, S60
Poloha: V uzlech s průměrováním na makro. Natočení planárního systému: LSS-Plochy



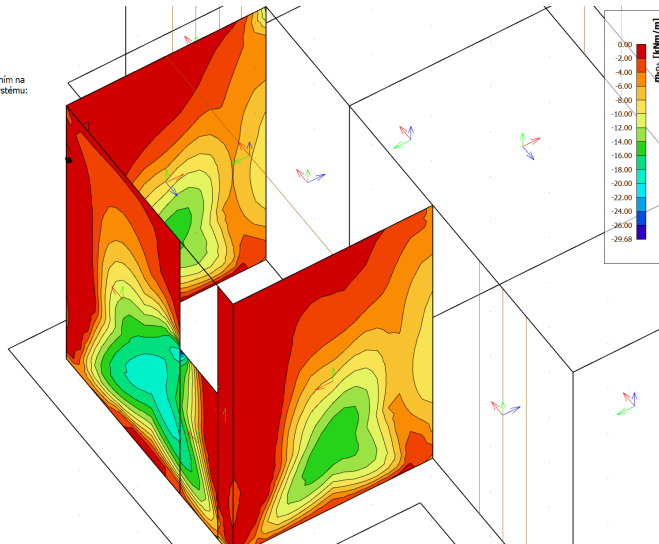
MxD-

2D vnitřní síly
Hodnoty: m_{xe}
Lineární výpočet
Třída: Všechny MSU
Extrém: Ne
Výběr: S51, S54, S60
Poloha: V uzlech s průměrováním na makro. Natočení planárního systému: LSS-Plochy



MxD+

2D vnitřní síly
Hodnoty: m_{xe}
Lineární výpočet
Třída: Všechny MSU
Extrém: Ne
Výběr: S51, S54, S60
Poloha: V uzlech s průměrováním na makro. Natočení planárního systému: LSS-Plochy



Hodnoty z jednotlivých kombinací
(Table 30)

Kombinace	NyD	MyD-	MyD+	NxD	MxD-	MxD+
K2	-74.68	26.98	-22.74	127.26	34.01	-26.74
K3	179.71	2.43	-38.67	137.65	6.04	-8.4
K4	199.07	1.96	-37.16	143.26	5.92	-10.24

2.3.1.1. Směr y svislá výztuž

geometrie (pro oba povrchy stejné krytí)

$$h_{11} = 400 \text{ mm}$$

$$d_{1,11} = c_{\text{nom},1} + 0.5 * \varnothing_{y,\text{TM},\text{steny}} = 50 \text{ mm} + 0.5 * 12 \text{ mm} = 56 \text{ mm}$$

$$\text{Odhad průměru výztuže:} \quad \varnothing_{y,\text{TM},\text{steny}} = 12 \text{ mm}$$

$$d_{11} = h_{11} - d_{1,11} = 400 \text{ mm} - 56 \text{ mm} = 344 \text{ mm}$$

$$b_{11} = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{y,\text{TM},\text{steny}1} = \varnothing_{y,\text{TM},\text{steny}} = 12 \text{ mm} \quad s_{11} = 150 \text{ mm}$$

$$A_{s,11} = \left(\frac{\left(\frac{\pi * \varnothing_{y,\text{TM},\text{steny}1}^2}{4} \right) * b_{11}}{s_{11}} \right) = \left(\frac{\left(\frac{3.142 * (12 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.000754 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,\text{min},11} = 0.26 * \left(\frac{f_{\text{ctm}}}{f_{y\text{k}}} \right) * b_{11} * d_{11} = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 344 \text{ mm} = 0.000519 \text{ m}^2$$

$$A_{s,2,\text{min},11} = 0.0013 * b_{11} * d_{11} = 0.000447 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,11} > \text{Max}(A_{s,1,\text{min},11}, A_{s,2,\text{min},11}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 > \text{Max}(0.000519 \text{ m}^2, 0.000447 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,\text{max}11} = 0.04 * h_{11} * b_{11} = 0.016 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,11} < A_{s,max11} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,11} = 3 * h_{11} = 1200 \text{ mm}$$

$$s_{2,max,11} = 400 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_{11} < \text{Max}(s_{1,max,11}, s_{2,max,11}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

$$s_{min,11} = \text{Max}(1.2 * \varnothing_{y,TM,steny1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 12 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_{11} > s_{min,11} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,7} = \text{Max}\left(\frac{h_{11}}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{400 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,7} = \left(\frac{h_{11}}{2}\right) - d_{1,11} = \left(\frac{400 \text{ mm}}{2}\right) - 56 \text{ mm} = 0.144 \text{ m}$$

$$\sigma_{s,0,7} = \varepsilon_{cu3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$N_{Rd,0,7} = -(b_{11} * h_{11} * f_{cd} + A_{s,11} * \sigma_{s,0,7} * 2) = -(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 700 \text{ MPa} * 2) = -9055.575 \text{ kN}$$

$$M_{Rd,0,1,7} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,7} = d_{11} = 0.344 \text{ m}$$

$$\varepsilon_{s,1,7} = \varepsilon_{cu3} * \left(\frac{x_{1,7} - d_{1,11}}{x_{1,7}}\right) = 0.0035 * \left(\frac{0.344 \text{ m} - 56 \text{ mm}}{0.344 \text{ m}}\right) = 0.00293$$

$$\varepsilon_{s,1,7} < \varepsilon_{yd} = 0.00293 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,7} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,1,7} = -(b_{11} * \lambda * x_{1,7} * f_{cd} + A_{s,11} * \sigma_{s,1,7}) = -(1 \text{ m} * 0.8 * 0.344 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa}) = -5831.818 \text{ kN}$$

$$\begin{aligned}
 M_{Rd,1,7} &= b_{11} * \lambda * x_{1,7} * f_{cd} * \left(\frac{h_{11} - \lambda * x_{1,7}}{2} \right) + A_{s,11} * \sigma_{s,1,7} * z_{1,7} \\
 &= 1 \text{ m} * 0.8 * 0.344 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.344 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} \\
 &= 390.655 \text{ kN} * \text{m}
 \end{aligned}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,7} = \left(\frac{\epsilon_{cu3}}{\epsilon_{cu3} + \epsilon_{yd}} \right) * d_{11} = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 344 \text{ mm} = 0.212 \text{ m}$$

$$\epsilon_{s,2,1,7} = \epsilon_{cu3} * \left(\frac{x_{2,7} - d_{1,11}}{x_{2,7}} \right) = 0.0035 * \left(\frac{0.212 \text{ m} - 56 \text{ mm}}{0.212 \text{ m}} \right) = 0.00258$$

$$\epsilon_{s,2,1,7} < \epsilon_{yd} = 0.00258 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,7} = f_{yd} = 434.783 \text{ MPa}$$

$$\epsilon_{s,2,2,7} = \epsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,7} = f_{yd} = 434.783 \text{ MPa}$$

$$\begin{aligned}
 N_{Rd,2,7} &= - \left(b_{11} * \lambda * x_{2,7} * f_{cd} + A_{s,11} * \sigma_{s,2,1,7} - A_{s,11} * \sigma_{s,2,2,7} \right) \\
 &= - \left(1 \text{ m} * 0.8 * 0.212 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} - 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) \\
 &= -3395.188 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 M_{Rd,2,7} &= b_{11} * \lambda * x_{2,7} * f_{cd} * \left(\frac{h_{11} - \lambda * x_{2,7}}{2} \right) + A_{s,11} * \sigma_{s,2,1,7} * z_{1,7} + A_{s,11} * \sigma_{s,2,2,7} * z_{1,7} \\
 &= 1 \text{ m} * 0.8 * 0.212 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.212 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} \\
 &= 485.267 \text{ kN} * \text{m}
 \end{aligned}$$

BOD 3 prostý ohyb

$$N_{Rd,3,7} = 0 \text{ kN}$$

$$x_{3,7} = \frac{A_{s,11} * f_{yd} + A_{s,11} * f_{yd}}{b_{11} * \lambda * f_{cd}} = \frac{0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} = 0.0410 \text{ m}$$

$$\epsilon_{s,3,1,7} = \epsilon_{cu3} * \left(\frac{d_{1,11} - x_{3,7}}{x_{3,7}} \right) = 0.0035 * \left(\frac{56 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.00128$$

$$\epsilon_{s,3,1,7} < \epsilon_{yd} = 0.00128 < 0.0021739 = \text{True} \quad \sigma_{s,3,1,7} = \epsilon_{s,3,1,7} * E_s = 0.00128 * 200 \text{ GPa} = 0.257 \text{ GPa}$$

$$\epsilon_{s,3,2,7} = \epsilon_{cu3} * \left(\frac{d_{11} - x_{3,7}}{x_{3,7}} \right) = 0.0035 * \left(\frac{344 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.0259$$

$$\epsilon_{s,3,2,7} < \epsilon_{yd} = 0.0259 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,7} = f_{yd} = 434.783 \text{ MPa}$$

$$M_{Rd,3,7} = b_{11} * \lambda * x_{3,7} * f_{cd} * \left(\frac{h_{11} - \lambda * x_{3,7}}{2} \right) + A_{s,11} * \sigma_{s,3,1,7} * z_{1,7} + A_{s,11} * \sigma_{s,3,2,7} * z_{1,7}$$

$$= 1 \text{ m} * 0.8 * 0.0410 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.0410 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 0.257 \text{ GPa} * 0.144 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m}$$

$$= 195.450 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,7} = d_{1,11} = 0.056 \text{ m}$$

$$\varepsilon_{s,4,1,7} = \varepsilon_{cu3} * \left(\frac{d_{11} - x_{4,7}}{x_{4,7}} \right) = 0.0035 * \left(\frac{344 \text{ mm} - 0.056 \text{ m}}{0.056 \text{ m}} \right) = 0.018$$

$$\varepsilon_{s,4,1,7} < \varepsilon_{yd} = 0.018 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,7} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,7} = A_{s,11} * \sigma_{s,4,1,7} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} = 327.818 \text{ kN}$$

$$M_{Rd,4,7} = A_{s,11} * \sigma_{s,4,1,7} * z_{1,7} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.144 \text{ m} = 47.206 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,7} = A_{s,11} * f_{yd} + A_{s,11} * f_{yd} = 0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}$$

$$= 655.637 \text{ kN}$$

$$M_{Rd,5,7} = 0 \text{ kN} * \text{m}$$

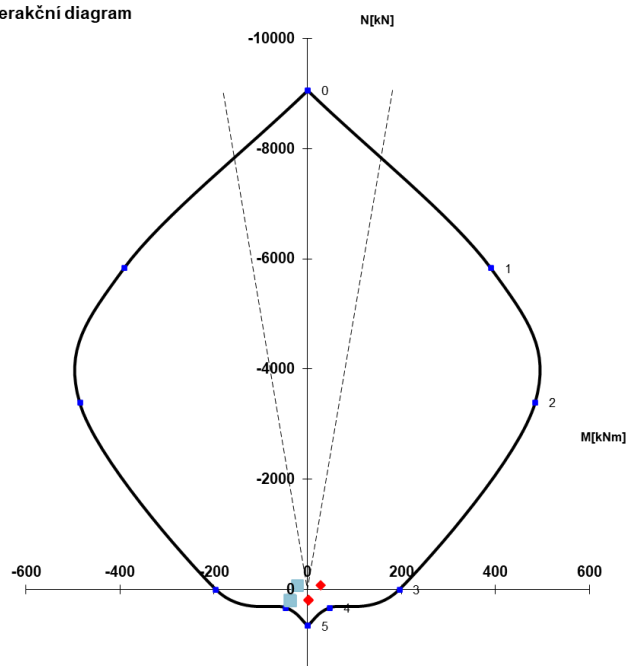
Body	N_Rd	M_Rd
0	-9055.6 kN	0 kN*m
1	-5831.8 kN	391 kN*m
2	-3395.2 kN	485 kN*m
3	0 kN	195 kN*m
4	327.818 kN	47.2 kN*m
5	655.637 kN	0 kN*m

Kombinace	NyD	MyD-	MyD+
K2	-74.68	26.98	-22.74
K3	179.71	2.43	-38.67
K4	199.07	1.96	-37.16

(Table 32)

DIAGRAM

Interakční diagram



2.3.1.2. Směr x vodorovná výztuž geometrie (pro oba povrchy stejné krytí)

$$h_{12} = 400 \text{ mm}$$

$$d_{1,12} = c_{\text{nom},1} + 0.5 * \varnothing_{x,\text{TM},\text{steny}} + \varnothing_{y,\text{TM},\text{steny}} = 50 \text{ mm} + 0.5 * 12 \text{ mm} + 12 \text{ mm} = 68 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{x,\text{TM},\text{steny}} = 12 \text{ mm}$$

$$d_{12} = h_{12} - d_{1,12} = 400 \text{ mm} - 68 \text{ mm} = 332 \text{ mm}$$

$$b_{12} = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{x,\text{TM},\text{steny}1} = \varnothing_{x,\text{TM},\text{steny}} = 12 \text{ mm}$$

$$s_{12} = 150 \text{ mm}$$

$$A_{s,12} = \left(\frac{\left(\frac{\pi * \varnothing_{x,\text{TM},\text{steny}1}^2}{4} \right) * b_{12}}{s_{12}} \right) = \left(\frac{\left(\frac{3.142 * (12 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.000754 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,\text{min},12} = 0.26 * \left(\frac{f_{\text{ctm}}}{f_{y\text{k}}} \right) * b_{12} * d_{12} = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 332 \text{ mm} = 0.000501 \text{ m}^2$$

$$A_{s,2,\text{min},12} = 0.0013 * b_{12} * d_{12} = 0.000432 \text{ m}^2$$

$$\begin{aligned}
 & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,12} > \text{Max}(A_{s,1,\text{min},12}, A_{s,2,\text{min},12}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\
 = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 > \text{Max}(0.000501 \text{ m}^2, 0.000432 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}
 \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,\text{max}12} = 0.04 * h_{12} * b_{12} = 0.016 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,12} < A_{s,\text{max}12} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.000754 \text{ m}^2 < 0.016 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,\text{max},12} = 3 * h_{12} = 1200 \text{ mm}$$

$$s_{2,\text{max},12} = 400 \text{ mm}$$

$$\begin{aligned}
 & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_{12} < \text{Max}(s_{1,\text{max},12}, s_{2,\text{max},12}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\
 = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1200 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}
 \end{aligned}$$

$$s_{\text{min},12} = \text{Max}(1.2 * \varnothing_{x,\text{TM},\text{steny}1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 12 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_4 > s_{\text{min},12} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,8} = \text{Max}\left(\frac{h_{12}}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{400 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,8} = \left(\frac{h_{12}}{2}\right) - d_{1,12} = \left(\frac{400 \text{ mm}}{2}\right) - 68 \text{ mm} = 0.132 \text{ m}$$

$$\sigma_{s,0,8} = \varepsilon_{\text{cu}3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$\begin{aligned}
 N_{\text{Rd},0,8} &= -(b_{12} * h_{12} * f_{\text{cd}} + A_{s,12} * \sigma_{s,0,8} * 2) \\
 &= -(1 \text{ m} * 400 \text{ mm} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 700 \text{ MPa} * 2) = -9055.575 \text{ kN}
 \end{aligned}$$

$$M_{\text{Rd},0,1,8} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,8} = d_{12} = 0.332 \text{ m}$$

$$\varepsilon_{s,1,8} = \varepsilon_{cu3} * \left(\frac{x_{1,8} - d_{1,12}}{x_{1,8}} \right) = 0.0035 * \left(\frac{0.332 \text{ m} - 68 \text{ mm}}{0.332 \text{ m}} \right) = 0.00278$$

$$\varepsilon_{s,1,8} < \varepsilon_{yd} = 0.00278 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,8} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$N_{Rd,1,8} = - \left(b_{12} * \lambda * x_{1,8} * f_{cd} + A_{s,12} * \sigma_{s,1,8} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.332 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) = -5639.818 \text{ kN}$$

$$M_{Rd,1,8} = b_{12} * \lambda * x_{1,8} * f_{cd} * \left(\frac{h_{12} - \lambda * x_{1,8}}{2} \right) + A_{s,12} * \sigma_{s,1,8} * z_{1,8} \\ = 1 \text{ m} * 0.8 * 0.332 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.332 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} \\ = 400.238 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,8} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_{12} = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 332 \text{ mm} = 0.205 \text{ m}$$

$$\varepsilon_{s,2,1,8} = \varepsilon_{cu3} * \left(\frac{x_{2,8} - d_{1,12}}{x_{2,8}} \right) = 0.0035 * \left(\frac{0.205 \text{ m} - 68 \text{ mm}}{0.205 \text{ m}} \right) = 0.00234$$

$$\varepsilon_{s,2,1,8} < \varepsilon_{yd} = 0.00234 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,8} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,8} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,8} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,2,8} = - \left(b_{12} * \lambda * x_{2,8} * f_{cd} + A_{s,12} * \sigma_{s,2,1,8} - A_{s,12} * \sigma_{s,2,2,8} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.205 \text{ m} * 20 \text{ MPa} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} - 0.000754 \text{ m}^2 * 434.783 \text{ MPa} \right) \\ = -3276.751 \text{ kN}$$

$$M_{Rd,2,8} = b_{12} * \lambda * x_{2,8} * f_{cd} * \left(\frac{h_{12} - \lambda * x_{2,8}}{2} \right) + A_{s,12} * \sigma_{s,2,1,8} * z_{1,8} + A_{s,12} * \sigma_{s,2,2,8} * z_{1,8} \\ = 1 \text{ m} * 0.8 * 0.205 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.205 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} \\ = 473.467 \text{ kN} * \text{m}$$

BOD 3 prostý ohyb

$$N_{Rd,3,8} = 0 \text{ kN}$$

$$x_{3,8} = \frac{A_{s,12} * f_{yd} + A_{s,12} * f_{yd}}{b_{12} * \lambda * f_{cd}} = \frac{0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} \\ = 0.0410 \text{ m}$$

$$\varepsilon_{s,3,1,8} = \varepsilon_{cu3} * \left(\frac{d_{1,12} - x_{3,8}}{x_{3,8}} \right) = 0.0035 * \left(\frac{68 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.00231$$

$$\varepsilon_{s,3,1,8} < \varepsilon_{yd} = 0.00231 < 0.0021739 = \text{False}$$

$$\sigma_{s,3,1,8} = \varepsilon_{s,3,1,8} * E_s = 0.00231 * 200 \text{ GPa} = 0.462 \text{ GPa}$$

$$\varepsilon_{s,3,2,8} = \varepsilon_{cu3} * \left(\frac{d_{12} - x_{3,8}}{x_{3,8}} \right) = 0.0035 * \left(\frac{332 \text{ mm} - 0.0410 \text{ m}}{0.0410 \text{ m}} \right) = 0.0249$$

$$\varepsilon_{s,3,2,8} < \varepsilon_{yd} = 0.0249 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,8} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$M_{Rd,3,8} = b_{12} * \lambda * x_{3,8} * f_{cd} * \left(\frac{h_{12} - \lambda * x_{3,8}}{2} \right) + A_{s,12} * \sigma_{s,3,1,8} * z_{1,8} + A_{s,12} * \sigma_{s,3,2,8} * z_{1,8}$$

$$= 1 \text{ m} * 0.8 * 0.0410 \text{ m} * 20 \text{ MPa} * \left(\frac{400 \text{ mm} - 0.8 * 0.0410 \text{ m}}{2} \right) + 0.000754 \text{ m}^2 * 0.462 \text{ GPa} * 0.132 \text{ m} + 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m}$$

$$= 209.596 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,8} = d_{1,12} = 68 \text{ mm} = 0.068 \text{ m}$$

$$\varepsilon_{s,4,1,8} = \varepsilon_{cu3} * \left(\frac{d_{12} - x_{4,8}}{x_{4,8}} \right) = 0.0035 * \left(\frac{332 \text{ mm} - 0.068 \text{ m}}{0.068 \text{ m}} \right) = 0.0136$$

$$\varepsilon_{s,4,1,8} < \varepsilon_{yd} = 0.0136 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,8} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,8} = A_{s,12} * \sigma_{s,4,1,8} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} = 327.818 \text{ kN}$$

$$M_{Rd,4,8} = A_{s,12} * \sigma_{s,4,1,8} * z_{1,8} = 0.000754 \text{ m}^2 * 434.783 \text{ MPa} * 0.132 \text{ m} = 43.272 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,8} = A_{s,12} * f_{yd} + A_{s,12} * f_{yd} = 0.000754 \text{ m}^2 * 434.78 \text{ MPa} + 0.000754 \text{ m}^2 * 434.78 \text{ MPa}$$

$$= 655.637 \text{ kN}$$

$$M_{Rd,5,8} = 0 \text{ kN} * \text{m}$$

Body	N_Rd	M_Rd	
0	-9055.6 kN	0 kN*m	
1	-5639.8 kN	400 kN*m	
2	-3276.8 kN	473 kN*m	
3	0 kN	210 kN*m	
4	327.818 kN	43.3 kN*m	
5	655.637 kN	0 kN*m	
Kombinace	NxD	MxD-	MxD+
K2	127.26	34.01	-26.74

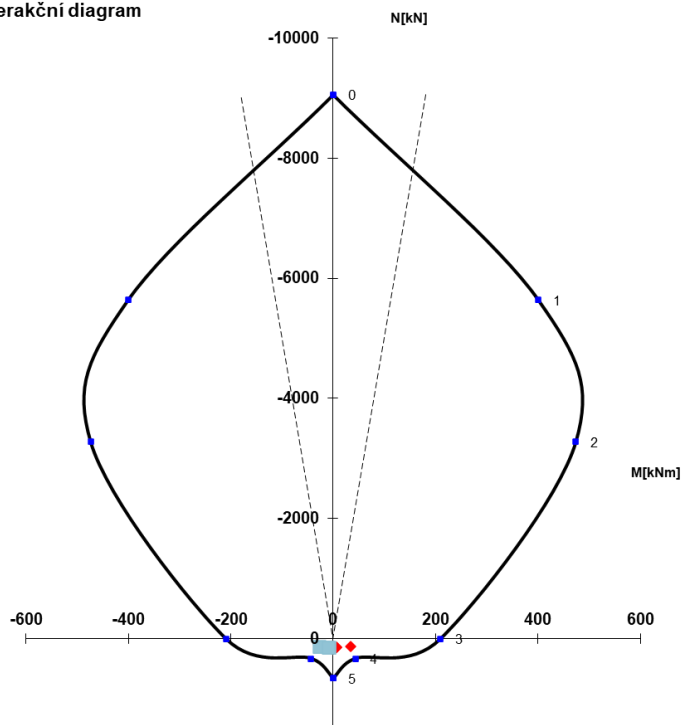
K3 137.65 6.04 -8.4

K4 143.26 5.92 -10.24

(Table 34)

DIAGRAM

Interakční diagram



2.3.2. Posouzení na smyk

2.3.2.1. Směr y svislá výztuž

(Table 35)

Kombinace	VyD	NyD	Vyd
K2	91.97 kN	74.68 kN	91.97
K3	63.61 kN	179.71 kN	63.61
K4	60.49 kN	199.07 kN	60.49

$$C_{Rd,c,4} = \frac{0.18}{\gamma_c} = 0.12 \quad d_{5,4} = \frac{d_{11}}{1 \text{ mm}} = 344$$

$$K_4 = 1 + \sqrt{\left(\frac{200}{d_{5,4}}\right)} = 1 + \sqrt{\left(\frac{200}{344}\right)} = 1.762$$

$$\zeta_{sl,4} = \frac{A_{s,11}}{b_{11} * d_{11}} = \frac{0.000754 \text{ m}^2}{1 \text{ m} * 344 \text{ mm}} = 0.00219$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \zeta_{sl,4} < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00219 < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

$$f_{ck,4} = 30$$

$$v_{min,4} = 0.035 * K_4^{\left(\frac{2}{3}\right)} * f_{ck,4}^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.035 * 1.762^{\left(\frac{2}{3}\right)} * 30^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.280 \text{ MPa}$$

$$V_{Rd,cn,4} = \left(C_{Rd,c,4} * K_4 * \left(100 * \zeta_{sl,4} * f_{ck,4} \right)^{\left(\frac{1}{3}\right)} \right) * b_{11} * d_{11} * 1 \text{ MPa}$$

$$= \left(0.12 * 1.762 * \left(100 * 0.00219 * 30 \right)^{\left(\frac{1}{3}\right)} \right) * 1 \text{ m} * 344 \text{ mm} * 1 \text{ MPa} = 136.304 \text{ kN}$$

$$V_{min,4} = v_{min,4} * b_{11} * d_{11} = 0.280 \text{ MPa} * 1 \text{ m} * 344 \text{ mm} = 96.221 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,cn,4} \geq V_{min,4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 136.304 \text{ kN} \geq 96.221 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Vliv normálové síly

K2

$$\sigma_{cp,1,4} = \frac{\text{Table35.C2}}{b_{11} * d_{11}} = \frac{74.68 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 217.093 \text{ kPa} \quad k_{1,4} = 0.15$$

$$V_{Rd,c,1,4} = V_{Rd,cn,4} + k_{1,4} * \sigma_{cp,1,4} * b_{11} * d_{11} = 136.304 \text{ kN} + 0.15 * 217.093 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 147.506 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,1,4} > \text{Table35.B2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 147.506 \text{ kN} > 91.97 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

K3

$$\sigma_{cp,2,4} = \frac{\text{Table35.C3}}{b_{11} * d_{11}} = \frac{179.71 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 522.413 \text{ kPa} \quad k_{2,4} = 0.15$$

$$V_{Rd,c,2,4} = V_{Rd,cn,4} + k_{2,4} * \sigma_{cp,2,4} * b_{11} * d_{11} = 136.304 \text{ kN} + 0.15 * 522.413 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 163.260 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,2,4} > \text{Table35.B3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 163.260 \text{ kN} > 63.61 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

K4

$$\sigma_{cp,3,4} = \frac{\text{Table35.C4}}{b_{11} * d_{11}} = \frac{199.07 \text{ kN}}{1 \text{ m} * 344 \text{ mm}} = 578.692 \text{ kPa} \quad k_{3,4} = 0.15$$

$$V_{Rd,c,3,4} = V_{Rd,cn,4} + k_{3,4} * \sigma_{cp,3,4} * b_{11} * d_{11} = 136.304 \text{ kN} + 0.15 * 578.692 \text{ kPa} * 1 \text{ m} * 344 \text{ mm} = 166.164 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,3,4} > \text{Table35.B4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 166.164 \text{ kN} > 60.49 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

NENÍ POTŘEBA SMYKOVÁ VÝZTUŽ

2.3.3. Kotevní a stykovací délky

2.3.3.1. Směr y svislá výztuž

Kotvení

$$\eta_{1,7} = 0.7$$

$$\eta_{2,7} = 1 \quad \alpha_{ct,7} = 1$$

$$f_{ctd,7} = \alpha_{ct,7} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,7} = 2.25 * \eta_{1,7} * \eta_{2,7} * f_{ctd,7} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,7} = \left(\frac{\varnothing_{y,TM,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,7}} \right) = \left(\frac{12 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 621.118 \text{ mm}$$

$$L_{bdrqd,7} = \text{RoundUp}(l_{bdrqd,7}) = \text{RoundUp}(621.118 \text{ mm}) = 622 \text{ mm}$$

Stykování

$$\alpha_{1,7} = 1 \quad \alpha_{2,7} = 1 \quad \alpha_{3,7} = 1 \quad \alpha_{5,7} = 1 \quad \alpha_{6,7} = 1.5$$

$$l_{0,7} = \alpha_{1,7} * \alpha_{2,7} * \alpha_{3,7} * \alpha_{5,7} * \alpha_{6,7} * L_{bdrqd,7} = 1 * 1 * 1 * 1 * 1.5 * 622 \text{ mm} = 933 \text{ mm}$$

$$L_{0,7} = \text{RoundUp}(l_{0,7}) = 933 \text{ mm}$$

$$l_{0,min,7} = \text{Max}(0.6 * \alpha_{6,7} * L_{bdrqd,7}, 15 * \varnothing_{y,TM,steny}, 200 \text{ mm})$$

$$= \text{Max}(0.6 * 1.5 * 622 \text{ mm}, 15 * 12 \text{ mm}, 200 \text{ mm}) = 559.8 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,7} > l_{0,\min,7} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 933 \text{ mm} > 559.8 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

2.3.3.2. Směr x vodorovná výztuž

Kotvení

$$\eta_{1,8} = 0.7$$

$$\eta_{2,8} = 1 \quad \alpha_{ct,8} = 1$$

$$f_{ctd,8} = \alpha_{ct,8} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,8} = 2.25 * \eta_{1,8} * \eta_{2,8} * f_{ctd,8} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,8} = \left(\frac{\varnothing_{x,TM,steny1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,8}} \right) = \left(\frac{12 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 621.118 \text{ mm}$$

$$L_{bdrqd,8} = \text{RoundUp}(l_{bdrqd,8}) = 622 \text{ mm}$$

Stykování

$$\alpha_{1,8} = 1 \quad \alpha_{2,8} = 1 \quad \alpha_{3,8} = 1 \quad \alpha_{5,8} = 1 \quad \alpha_{6,8} = 1.5$$

$$l_{0,8} = \alpha_{1,8} * \alpha_{2,8} * \alpha_{3,8} * \alpha_{5,8} * \alpha_{6,8} * L_{bdrqd,8} = 1 * 1 * 1 * 1 * 1.5 * 622 \text{ mm} = 933 \text{ mm}$$

$$L_{0,8} = \text{RoundUp}(l_{0,8}) = \text{RoundUp}(933 \text{ mm}) = 933 \text{ mm}$$

$$l_{0,\min,8} = \text{Max}(0.3 * \alpha_{6,8} * L_{bdrqd,8}, 15 * \varnothing_{y,TM,steny1}, 200 \text{ mm})$$

$$= \text{Max}(0.3 * 1.5 * 622 \text{ mm}, 15 * 12 \text{ mm}, 200 \text{ mm}) = 279.9 \text{ mm}$$

$$\text{value5} = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,8} > l_{0,\min,8} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 933 \text{ mm} > 279.9 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

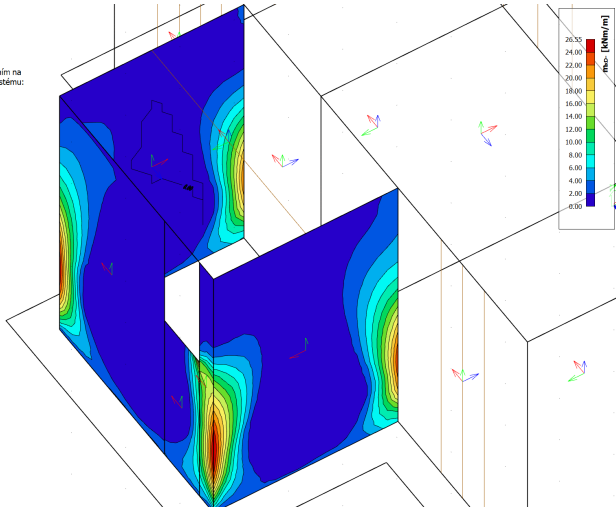
2.3.4. Posouzení na MSP

Okraje (Třídy) MSP

Všechny MSP

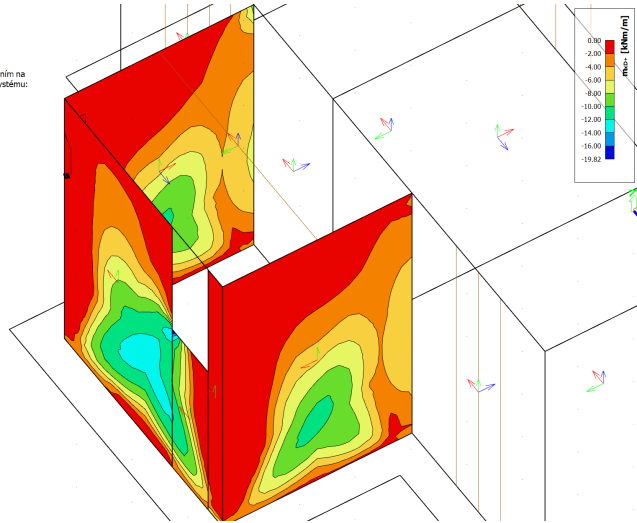
MxD-

2D vnitřní síly
Hodnoty: m-x
Lineární výpočet
Třída: Všechny MSP
Extrém: Ne
Výběr: S51, S54, S60
Položka: V úzlech s průměrováním na
makro. Nátvoření planárního systému:
LSS-Plochy



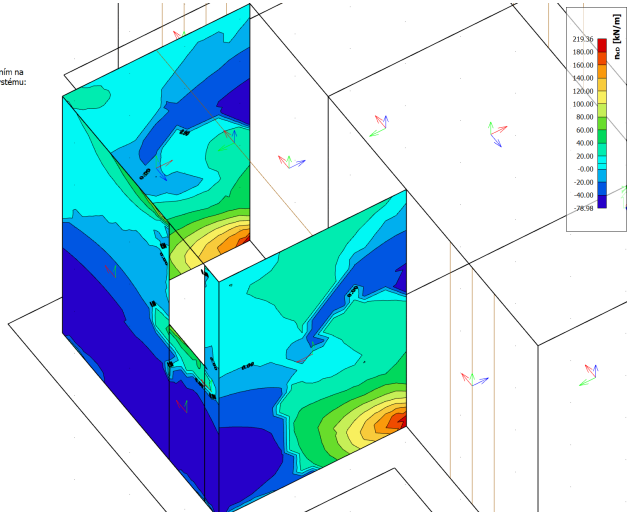
MxD+

2D vnitřní síly
Hodnoty: m-x
Lineární výpočet
Třída: Všechny MSP
Extrém: Ne
Výběr: S51, S54, S60
Položka: V úzlech s průměrováním na
makro. Nátvoření planárního systému:
LSS-Plochy



NxD

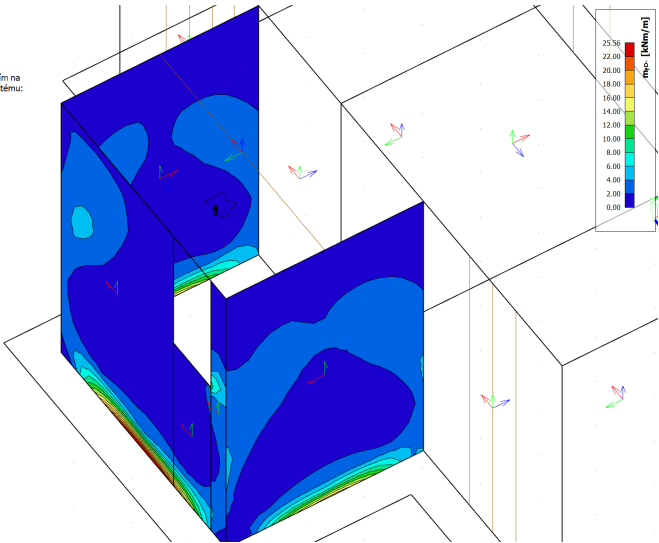
2D vnitřní síly
Hodnoty: m-x
Lineární výpočet
Třída: Všechny MSP
Extrém: Ne
Výběr: S51, S54, S60
Položka: V úzlech s průměrováním na
makro. Nátvoření planárního systému:
LSS-Plochy



Všechny MSP

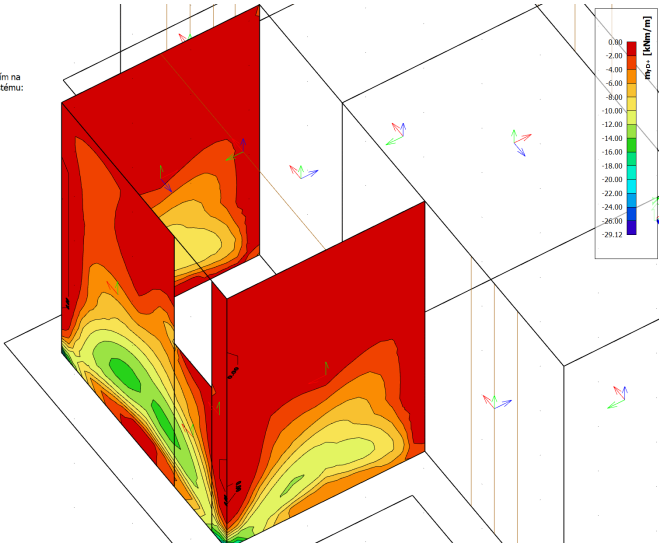
MyD-

2D vnitřní síly
Hodnoty: mve
Lineární výpočet
Třída: Všechny MSP
Extrém: Ne
Výběr: S51, S54, S60
Položka: V uzlech s průměrováním na makro. Natožení planárního systému:
LSS-Plochy



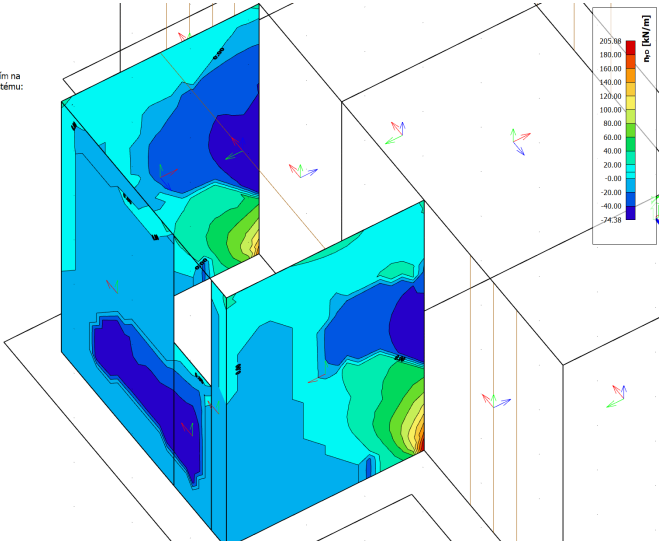
MyD+

2D vnitřní síly
Hodnoty: mve+
Lineární výpočet
Třída: Všechny MSP
Extrém: Ne
Výběr: S51, S54, S60
Položka: V uzlech s průměrováním na makro. Natožení planárního systému:
LSS-Plochy



NyD

2D vnitřní síly
Hodnoty: mve
Lineární výpočet
Třída: Všechny MSP
Extrém: Ne
Výběr: S51, S54, S60
Položka: V uzlech s průměrováním na makro. Natožení planárního systému:
LSS-Plochy



(Vypsáno ze SCII a uvedeno v absolutních hodnotách)

(Table 36)

Kombinace	MxD- Char	MxD+ Char	NxD Char	MxD- Kvazi	MxD+ Kvazi	MyD- Char	MyD+ Char	NyD Char	MyD- Kvazi	MyD+ Kvazi
K2	25.19	19.81	61.1	25.2	19.81	19.99	16.89	55.52	20	17.14
K3	4.48	6.24	177.45	4.13	5.97	1.79	28.69	169.62	1.4	26.91
K4	4.39	7.61	175.44	4.06	7.1	1.44	27.57	181.85	1.34	26.01

2.3.4.1. směr x

(Table 37)

Kombinace	MxD	Nx
Charakteristická	25.19 kN*m	177.45 kN
Kvazistálá	25.2 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,9} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,9} = b_{12} * h_{12} = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,9} = A_{S,12} = 0.000754 \text{ m}^2$$

$$A_{i,9} = A_{C,C,9} + A_{S,S,9} * \alpha_{e,9} = 0.4 \text{ m}^2 + 0.000754 \text{ m}^2 * 6.061 = 0.405 \text{ m}^2$$

$$a_{c,c,9} = \frac{h_{12}}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,9} = \frac{A_{C,C,9} * a_{c,c,9} + \alpha_{e,9} * (A_{S,S,9} * d_{12})}{A_{i,9}} = \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000754 \text{ m}^2 * 332 \text{ mm})}{0.405 \text{ m}^2}$$

$$= 0.201 \text{ m}$$

$$I_{c,c,9} = \left(\frac{1}{12} \right) * b_{12} * h_{12}^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,9} = I_{c,c,9} + A_{C,C,9} * (a_{gi,9} - a_{c,c,9})^2 + \alpha_{e,9} * (A_{S,S,9} * (d_{12} - a_{gi,9})^2)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.201 \text{ m} - 0.2 \text{ m})^2 + 6.061 * (0.000754 \text{ m}^2 * (332 \text{ mm} - 0.201 \text{ m})^2)$$

$$= 0.00541 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,9} = \left| \left(\left(\frac{\text{Table37.C2}}{A_{i,9}} \right) - \left(\frac{\text{Table37.B2} * a_{gi,9}}{I_{i,9}} \right) \right) \right| = \left| \left(\left(\frac{177.45 \text{ kN}}{0.405 \text{ m}^2} \right) - \left(\frac{25.19 \text{ kN} * \text{m} * 0.201 \text{ m}}{0.00541 \text{ m}^4} \right) \right) \right|$$

$$= 499.210 \text{ kPa}$$

$$f_{ct,eff,1,9} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,1,9} < f_{ct,eff,1,9} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 499.210 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

$$\begin{aligned} \sigma_{C,C,2,9} &= \left| \left(\left(\frac{\text{Table37.C2}}{A_{i,9}} \right) + \left(\frac{\text{Table37.B2} * (h_{12} - a_{gi,9})}{I_{i,9}} \right) \right) \right| \\ &= \left| \left(\left(\frac{177.45 \text{ kN}}{0.405 \text{ m}^2} \right) + \left(\frac{25.19 \text{ kN} * \text{m} * (400 \text{ mm} - 0.201 \text{ m})}{0.00541 \text{ m}^4} \right) \right) \right| = 1362.560 \text{ kPa} \end{aligned}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,2,9} < f_{ct,eff,1,9} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 1362.560 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

Napětí ve výztuži

$$e_{kd,9} = \frac{\text{Table37.B2}}{\text{Table37.C2}} = \frac{25.19 \text{ kN} * \text{m}}{177.45 \text{ kN}} = 0.142 \text{ m}$$

$$e_9 = e_{kd,9} + a_{c,c,9} = 0.142 \text{ m} + 0.2 \text{ m} = 0.342 \text{ m}$$

$$\begin{aligned} \sigma_{S,S,1,9} &= \left(\frac{\text{Table37.C2}}{A_{i,9}} \right) * \left(1 + \left(\frac{A_{i,9} * (a_{gi,9} - e_9) * (a_{gi,9} - d_{12})}{I_{i,9}} \right) \right) * \alpha_{e,9} \\ &= \left(\frac{177.45 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.201 \text{ m} - 0.342 \text{ m}) * (0.201 \text{ m} - 332 \text{ mm})}{0.00541 \text{ m}^4} \right) \right) * 6.061 = 6301.085 \text{ kPa} \end{aligned}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE"} \text{ if } \sigma_{S,S,1,9} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} \text{ otherwise} \end{array} \right| = \left| \begin{array}{l} \text{"VYHOVUJE"} \text{ if } 6301.085 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} \text{ otherwise} \end{array} \right| \\ & = \text{VYHOVUJE} \end{aligned}$$

$$\sigma_{S,S,2,9} = \left(\frac{\text{Table37.C2}}{A_{i,9}} \right) * \left(1 + \left(\frac{A_{i,9} * (a_{gi,9} - e_9) * (a_{gi,9} - d_{12})}{I_{i,9}} \right) \right) * \alpha_{e,9}$$

$$= \left(\frac{177.45 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.201 \text{ m} - 0.342 \text{ m}) * (0.201 \text{ m} - 332 \text{ mm})}{0.00541 \text{ m}^4} \right) \right) * 6.061 = 6301.085 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,9} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 6301.085 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

2.3.4.2. směr y

(Table 38)

Kombinace	MyD	Ny
Charakteristická	28.69 kN*m	181.85 kN
Kvazistálá	26.91 kN*m	

o mezení napětí v betonu a ve výztuži

$$\alpha_{e,10} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,10} = b_{11} * h_{11} = 1 \text{ m} * 400 \text{ mm} = 0.4 \text{ m}^2$$

$$A_{S,S,10} = A_{s,11} = 0.000754 \text{ m}^2$$

$$A_{i,10} = A_{C,C,10} + A_{S,S,10} * \alpha_{e,10} = 0.4 \text{ m}^2 + 0.000754 \text{ m}^2 * 6.061 = 0.405 \text{ m}^2$$

$$a_{c,c,10} = \frac{h_{11}}{2} = \frac{400 \text{ mm}}{2} = 0.2 \text{ m}$$

$$a_{gi,10} = \frac{A_{C,C,10} * a_{c,c,10} + \alpha_{e,10} * (A_{S,S,10} * d_{11})}{A_{i,10}}$$

$$= \frac{0.4 \text{ m}^2 * 0.2 \text{ m} + 6.061 * (0.000754 \text{ m}^2 * 344 \text{ mm})}{0.405 \text{ m}^2} = 0.202 \text{ m}$$

$$I_{c,c,10} = \left(\frac{1}{12} \right) * b_{11} * h_{11}^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (400 \text{ mm})^3 = 0.00533 \text{ m}^4$$

$$I_{i,10} = I_{c,c,10} + A_{C,C,10} * (a_{gi,10} - a_{c,c,10})^2 + \alpha_{e,10} * \left(A_{S,S,10} * (d_{11} - a_{gi,10})^2 \right)$$

$$= 0.00533 \text{ m}^4 + 0.4 \text{ m}^2 * (0.202 \text{ m} - 0.2 \text{ m})^2 + 6.061 * \left(0.000754 \text{ m}^2 * (344 \text{ mm} - 0.202 \text{ m})^2 \right)$$

$$= 0.00543 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,10} = \left| \left(\left(\frac{\text{Table38.C2}}{A_{i,10}} \right) - \left(\frac{\text{Table38.B2} * a_{gi,10}}{l_{i,10}} \right) \right) \right| = \left| \left(\left(\frac{181.85 \text{ kN}}{0.405 \text{ m}^2} \right) - \left(\frac{28.69 \text{ kN} * \text{m} * 0.202 \text{ m}}{0.00543 \text{ m}^4} \right) \right) \right|$$

$$= 616.411 \text{ kPa}$$

$$f_{ct,eff,1,10} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,1,10} < f_{ct,eff,1,10}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $616.411 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

$$\sigma_{C,C,2,10} = \left| \left(\left(\frac{\text{Table38.C2}}{A_{i,10}} \right) + \left(\frac{\text{Table38.B2} * (h_{11} - a_{gi,10})}{l_{i,10}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{181.85 \text{ kN}}{0.405 \text{ m}^2} \right) + \left(\frac{28.69 \text{ kN} * \text{m} * (400 \text{ mm} - 0.202 \text{ m})}{0.00543 \text{ m}^4} \right) \right) \right| = 1498.194 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,2,10} < f_{ct,eff,1,10}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $1498.194 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

Napětí ve výztuži

$$e_{kd,10} = \frac{\text{Table38.B2}}{\text{Table38.C2}} = \frac{28.69 \text{ kN} * \text{m}}{181.85 \text{ kN}} = 0.158 \text{ m}$$

$$e_{10} = e_{kd,10} + a_{c,c,10} = 0.158 \text{ m} + 0.2 \text{ m} = 0.358 \text{ m}$$

$$\sigma_{S,S,1,10} = \left(\frac{\text{Table38.C2}}{A_{i,10}} \right) * \left(1 + \left(\frac{A_{i,10} * (a_{gi,10} - e_{10}) * (a_{gi,10} - d_{11})}{l_{i,10}} \right) \right) * \alpha_{e,10}$$

$$= \left(\frac{181.85 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.358 \text{ m}) * (0.202 \text{ m} - 344 \text{ mm})}{0.00543 \text{ m}^4} \right) \right) * 6.061 = 7238.728 \text{ kPa}$$

"VYHOVUJE" if $\sigma_{S,S,1,10} < 0.8 * f_{yk}$ = "VYHOVUJE" if $7238.728 \text{ kPa} < 0.8 * 500 \text{ MPa}$
 "NEVYHOVUJE" otherwise = "NEVYHOVUJE" otherwise
 = VYHOVUJE

$$\sigma_{S,S,2,10} = \left(\frac{\text{Table38.C2}}{A_{i,10}} \right) * \left(1 + \left(\frac{A_{i,10} * (a_{gi,10} - e_{10}) * (a_{gi,10} - d_{11})}{I_{i,10}} \right) \right) * \alpha_{e,10}$$

$$= \left(\frac{181.85 \text{ kN}}{0.405 \text{ m}^2} \right) * \left(1 + \left(\frac{0.405 \text{ m}^2 * (0.202 \text{ m} - 0.358 \text{ m}) * (0.202 \text{ m} - 344 \text{ mm})}{0.00543 \text{ m}^4} \right) \right) * 6.061 = 7238.728 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,10} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 7238.728 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

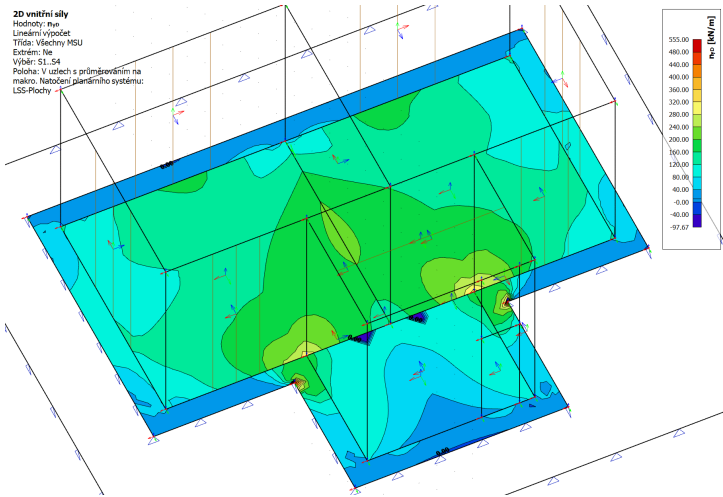
= VYHOVUJE

3. Základová deska

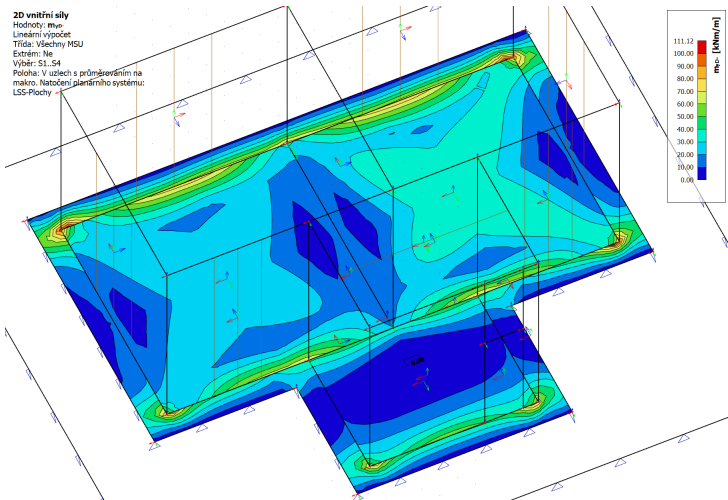
3.1. Posouzení na MSÚ

Okraje (Třídy) MSÚ

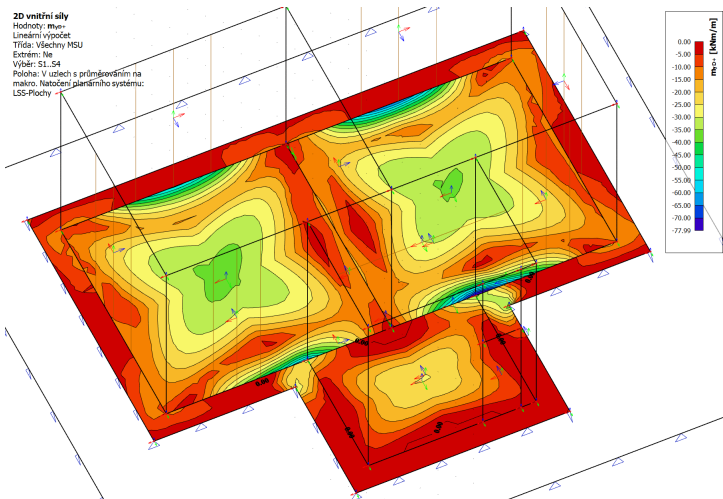
NyD



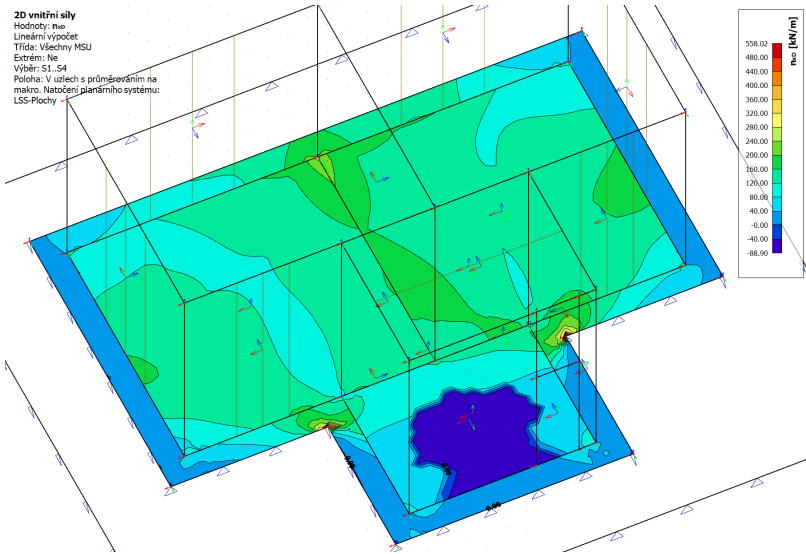
MyD-



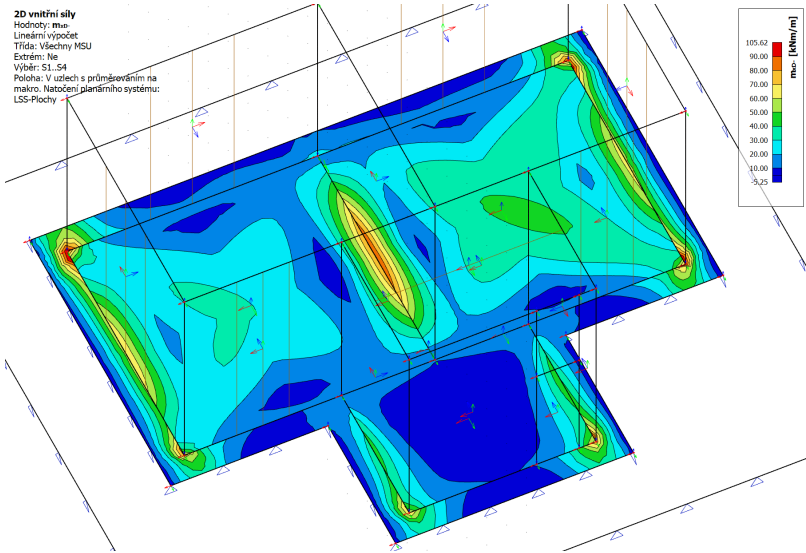
MyD+



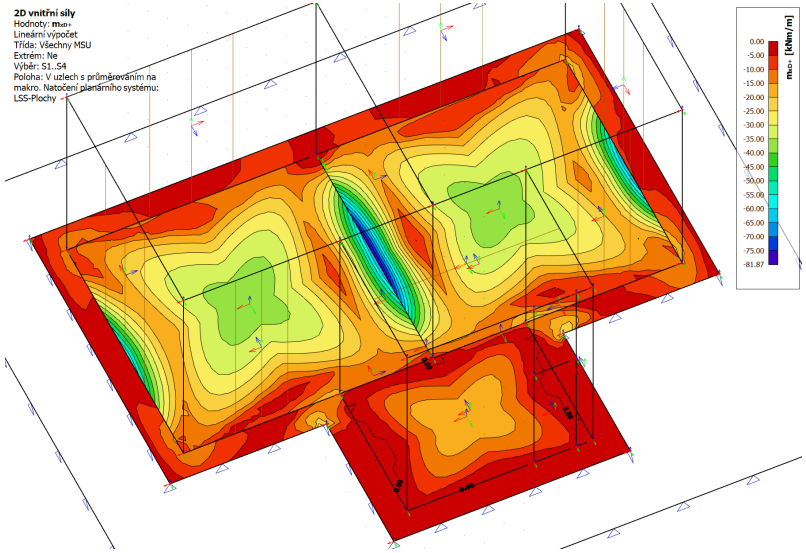
NxD



MxD-



MxD+



Hodnoty z jednotlivých kombinací
(Table 39)

Kombinace	NyD	MyD-	MyD+	NxD	MxD-	MxD+
K2	-61.54	42.35	-20.65	-66.35	44.82	-20.65
K3	241.64	98.74	-39.74	228.12	99.04	-39.74
K4	221.53	103.81	-55.32	237.36	92.1	-55.32

3.1.1. Směr y

geometrie (pro oba povrchy stejné krytí)

$$h_{13} = 450 \text{ mm}$$

$$d_{1,13} = c_{\text{nom},1} + 0.5 * \varnothing_{y,ZD} = 50 \text{ mm} + 0.5 * 14 \text{ mm} = 57 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{y,ZD} = 14 \text{ mm}$$

$$d_{13} = h_{13} - d_{1,13} = 450 \text{ mm} - 57 \text{ mm} = 393 \text{ mm}$$

$$b_{13} = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{y,ZD1} = \varnothing_{y,ZD} = 14 \text{ mm}$$

$$s_{13} = 150 \text{ mm}$$

$$A_{s,13} = \left(\frac{\left(\frac{\pi * \varnothing_{y,ZD1}^2}{4} \right) * b_{13}}{s_{13}} \right) = \left(\frac{\left(\frac{3.142 * (14 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.00103 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,\text{min},13} = 0.26 * \left(\frac{f_{\text{ctm}}}{f_{\text{yk}}} \right) * b_{13} * d_{13} = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 393 \text{ mm} = 0.000593 \text{ m}^2$$

$$A_{s,2,\text{min},13} = 0.0013 * b_{13} * d_{13} = 0.000511 \text{ m}^2$$

$$\begin{aligned} & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,13} > \text{Max}(A_{s,1,\text{min},13}, A_{s,2,\text{min},13}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\ & = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00103 \text{ m}^2 > \text{Max}(0.000593 \text{ m}^2, 0.000511 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE} \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,\text{max}13} = 0.04 * h_{13} * b_{13} = 0.018 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,13} < A_{s,max13} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00103 \text{ m}^2 < 0.018 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,max,13} = 3 * h_{13} = 1350 \text{ mm}$$

$$s_{2,max,13} = 400 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_{13} < \text{Max}(s_{1,max,13}, s_{2,max,13}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1350 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

$$s_{min,13} = \text{Max}(1.2 * \varnothing_{y,ZD1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 14 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = 21 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_{13} > s_{min,13} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,9} = \text{Max}\left(\frac{h_{13}}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{450 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,9} = \left(\frac{h_{13}}{2}\right) - d_{1,13} = \left(\frac{450 \text{ mm}}{2}\right) - 57 \text{ mm} = 0.168 \text{ m}$$

$$\sigma_{s,0,9} = \varepsilon_{cu3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$N_{Rd,0,9} = -\left(b_{13} * h_{13} * f_{cd} + A_{s,13} * \sigma_{s,0,9} * 2\right) = -\left(1 \text{ m} * 450 \text{ mm} * 20 \text{ MPa} + 0.00103 \text{ m}^2 * 700 \text{ MPa} * 2\right) = -10436.755 \text{ kN}$$

$$M_{Rd,0,1,9} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,9} = d_{13} = 0.393 \text{ m}$$

$$\varepsilon_{s,1,9} = \varepsilon_{cu3} * \left(\frac{x_{1,9} - d_{1,13}}{x_{1,9}}\right) = 0.0035 * \left(\frac{0.393 \text{ m} - 57 \text{ mm}}{0.393 \text{ m}}\right) = 0.00299$$

$$\varepsilon_{s,1,9} < \varepsilon_{yd} = 0.00299 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,9} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,1,9} = -\left(b_{13} * \lambda * x_{1,9} * f_{cd} + A_{s,13} * \sigma_{s,1,9}\right) = -\left(1 \text{ m} * 0.8 * 0.393 \text{ m} * 20 \text{ MPa} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa}\right) = -6734.197 \text{ kN}$$

$$\begin{aligned}
 M_{Rd,1,9} &= b_{13} * \lambda * x_{1,9} * f_{cd} * \left(\frac{h_{13} - \lambda * x_{1,9}}{2} \right) + A_{s,13} * \sigma_{s,1,9} * z_{1,9} \\
 &= 1 \text{ m} * 0.8 * 0.393 \text{ m} * 20 \text{ MPa} * \left(\frac{450 \text{ mm} - 0.8 * 0.393 \text{ m}}{2} \right) + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.168 \text{ m} \\
 &= 501.288 \text{ kN} * \text{m}
 \end{aligned}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,9} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_{13} = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 393 \text{ mm} = 0.242 \text{ m}$$

$$\varepsilon_{s,2,1,9} = \varepsilon_{cu3} * \left(\frac{x_{2,9} - d_{1,13}}{x_{2,9}} \right) = 0.0035 * \left(\frac{0.242 \text{ m} - 57 \text{ mm}}{0.242 \text{ m}} \right) = 0.00268$$

$$\varepsilon_{s,2,1,9} < \varepsilon_{yd} = 0.00268 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,9} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,9} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,9} = f_{yd} = 434.783 \text{ MPa}$$

$$\begin{aligned}
 N_{Rd,2,9} &= - \left(b_{13} * \lambda * x_{2,9} * f_{cd} + A_{s,13} * \sigma_{s,2,1,9} - A_{s,13} * \sigma_{s,2,2,9} \right) \\
 &= - \left(1 \text{ m} * 0.8 * 0.242 \text{ m} * 20 \text{ MPa} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} - 0.00103 \text{ m}^2 * 434.783 \text{ MPa} \right) \\
 &= -3878.805 \text{ kN}
 \end{aligned}$$

$$\begin{aligned}
 M_{Rd,2,9} &= b_{13} * \lambda * x_{2,9} * f_{cd} * \left(\frac{h_{13} - \lambda * x_{2,9}}{2} \right) + A_{s,13} * \sigma_{s,2,1,9} * z_{1,9} + A_{s,13} * \sigma_{s,2,2,9} * z_{1,9} \\
 &= 1 \text{ m} * 0.8 * 0.242 \text{ m} * 20 \text{ MPa} * \left(\frac{450 \text{ mm} - 0.8 * 0.242 \text{ m}}{2} \right) + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.168 \text{ m} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.168 \text{ m} \\
 &= 646.525 \text{ kN} * \text{m}
 \end{aligned}$$

BOD 3 prostý ohyb

$$N_{Rd,3,9} = 0 \text{ kN}$$

$$x_{3,9} = \frac{A_{s,13} * f_{yd} + A_{s,13} * f_{yd}}{b_{13} * \lambda * f_{cd}} = \frac{0.00103 \text{ m}^2 * 434.78 \text{ MPa} + 0.00103 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} = 0.0558 \text{ m}$$

$$\varepsilon_{s,3,1,9} = \varepsilon_{cu3} * \left(\frac{d_{1,13} - x_{3,9}}{x_{3,9}} \right) = 0.0035 * \left(\frac{57 \text{ mm} - 0.0558 \text{ m}}{0.0558 \text{ m}} \right) = 0.0000769$$

$$\begin{aligned}
 \varepsilon_{s,3,1,9} < \varepsilon_{yd} &= 0.0000769 < 0.0021739 = \text{True} \quad \sigma_{s,3,1,9} = \varepsilon_{s,3,1,9} * E_s \\
 &= 0.0000769 * 200 \text{ GPa} = 0.0154 \text{ GPa}
 \end{aligned}$$

$$\varepsilon_{s,3,2,9} = \varepsilon_{cu3} * \left(\frac{d_{13} - x_{3,9}}{x_{3,9}} \right) = 0.0035 * \left(\frac{393 \text{ mm} - 0.0558 \text{ m}}{0.0558 \text{ m}} \right) = 0.0212$$

$$\varepsilon_{s,3,2,9} < \varepsilon_{yd} = 0.0212 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,9} = f_{yd} = 434.783 \text{ MPa}$$

$$M_{Rd,3,9} = b_{13} * \lambda * x_{3,9} * f_{cd} * \left(\frac{h_{13} - \lambda * x_{3,9}}{2} \right) + A_{s,13} * \sigma_{s,3,1,9} * z_{1,9} + A_{s,13} * \sigma_{s,3,2,9} * z_{1,9}$$

$$= 1 \text{ m} * 0.8 * 0.0558 \text{ m} * 20 \text{ MPa} * \left(\frac{450 \text{ mm} - 0.8 * 0.0558 \text{ m}}{2} \right) + 0.00103 \text{ m}^2 * 0.0154 \text{ GPa} * 0.168 \text{ m} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.168 \text{ m}$$

$$= 258.492 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,9} = d_{1,13} = 0.057 \text{ m}$$

$$\epsilon_{s,4,1,9} = \epsilon_{cu3} * \left(\frac{d_{13} - x_{4,9}}{x_{4,9}} \right) = 0.0035 * \left(\frac{393 \text{ mm} - 0.057 \text{ m}}{0.057 \text{ m}} \right) = 0.0206$$

$$\epsilon_{s,4,1,9} < \epsilon_{yd} = 0.0206 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,9} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,9} = A_{s,13} * \sigma_{s,4,1,9} = 0.00103 \text{ m}^2 * 434.783 \text{ MPa} = 446.197 \text{ kN}$$

$$M_{Rd,4,9} = A_{s,13} * \sigma_{s,4,1,9} * z_{1,9} = 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.168 \text{ m} = 74.961 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,9} = A_{s,13} * f_{yd} + A_{s,13} * f_{yd} = 0.00103 \text{ m}^2 * 434.78 \text{ MPa} + 0.00103 \text{ m}^2 * 434.78 \text{ MPa}$$

$$= 892.394 \text{ kN}$$

$$M_{Rd,5,9} = 0 \text{ kN} * \text{m}$$

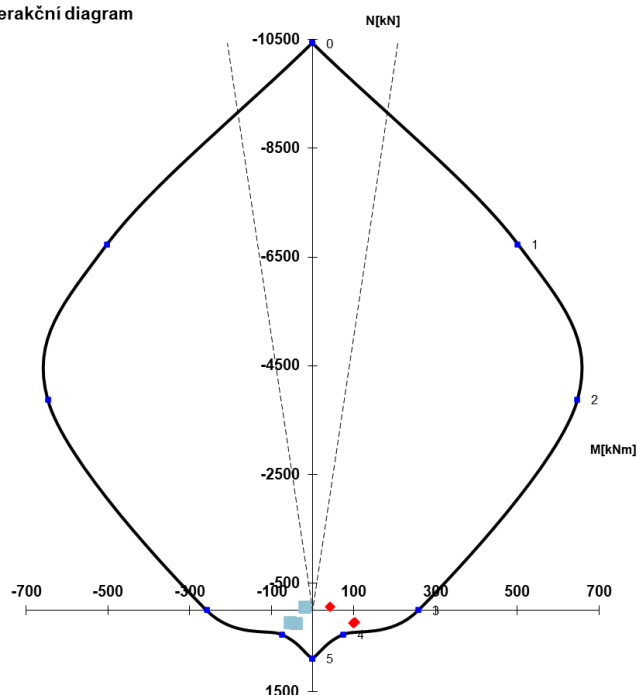
Body	N_Rd	M_Rd
0	-10437 kN	0 kN*m
1	-6734.2 kN	501 kN*m
2	-3878.8 kN	647 kN*m
3	0 kN	258 kN*m
4	446.197 kN	75.0 kN*m
5	892.394 kN	0 kN*m

Kombinace	NyD	MyD-	MyD+
K2	-61.54	42.35	-20.65
K3	241.64	98.74	-39.74
K4	221.53	103.81	-55.32

(Table 41)

DIAGRAM

Interakční diagram



3.1.2. Směr x

geometrie (pro oba povrchy stejné krytí)

$$h_{14} = 450 \text{ mm}$$

$$d_{1,14} = c_{\text{nom},1} + 0.5 * \varnothing_{x,ZD} + \varnothing_{y,ZD} = 50 \text{ mm} + 0.5 * 14 \text{ mm} + 14 \text{ mm} = 71 \text{ mm}$$

Odhad průměru výztuže:

$$\varnothing_{x,ZD} = 14 \text{ mm}$$

$$d_{14} = h_{14} - d_{1,14} = 450 \text{ mm} - 71 \text{ mm} = 379 \text{ mm}$$

$$b_{14} = 1 \text{ m}$$

návrh výztuže

$$\varnothing_{x,ZD1} = \varnothing_{x,ZD} = 14 \text{ mm}$$

$$s_{14} = 150 \text{ mm}$$

$$A_{s,14} = \left(\frac{\left(\frac{\pi * \varnothing_{x,ZD1}^2}{4} \right) * b_{14}}{s_{14}} \right) = \left(\frac{\left(\frac{3.142 * (14 \text{ mm})^2}{4} \right) * 1 \text{ m}}{150 \text{ mm}} \right) = 0.00103 \text{ m}^2$$

kontrola vyztužení

-minimální plocha vyztužení

$$A_{s,1,\text{min},14} = 0.26 * \left(\frac{f_{\text{ctm}}}{f_{yk}} \right) * b_{14} * d_{14} = 0.26 * \left(\frac{2.9 \text{ MPa}}{500 \text{ MPa}} \right) * 1 \text{ m} * 379 \text{ mm} = 0.000572 \text{ m}^2$$

$$A_{s,2,\text{min},14} = 0.0013 * b_{14} * d_{14} = 0.000493 \text{ m}^2$$

$$\begin{aligned}
 & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,14} > \text{Max}(A_{s,1,\text{min},14}, A_{s,2,\text{min},14}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\
 = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00103 \text{ m}^2 > \text{Max}(0.000572 \text{ m}^2, 0.000493 \text{ m}^2) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}
 \end{aligned}$$

-maximální plocha vyztužení

$$A_{s,\text{max}14} = 0.04 * h_{14} * b_{14} = 0.018 \text{ m}^2$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } A_{s,14} < A_{s,\text{max}14} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00103 \text{ m}^2 < 0.018 \text{ m}^2 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

kontrola vzdálenosti výztuže

$$s_{1,\text{max},14} = 3 * h_{14} = 1350 \text{ mm}$$

$$s_{2,\text{max},14} = 400 \text{ mm}$$

$$\begin{aligned}
 & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_{14} < \text{Max}(s_{1,\text{max},14}, s_{2,\text{max},14}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. \\
 = & \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ mm} < \text{Max}(1350 \text{ mm}, 400 \text{ mm}) \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}
 \end{aligned}$$

$$\begin{aligned}
 s_{\text{min},14} &= \text{Max}(1.2 * \varnothing_{x,\text{ZD}1}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) = \text{Max}(1.2 * 14 \text{ mm}, 16 \text{ mm} + 5 \text{ mm}, 20 \text{ mm}) \\
 &= 21 \text{ mm}
 \end{aligned}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } s_4 > s_{\text{min},14} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 200 \text{ mm} > 21 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right. = \text{VYHOVUJE}$$

Interakční diagram

BOD 0 dostředný tlak

$$e_{0,10} = \text{Max}\left(\frac{h_{14}}{30}, 20 \text{ mm}\right) = \text{Max}\left(\frac{450 \text{ mm}}{30}, 20 \text{ mm}\right) = 0.02 \text{ m}$$

$$z_{1,10} = \left(\frac{h_{14}}{2}\right) - d_{1,14} = \left(\frac{450 \text{ mm}}{2}\right) - 71 \text{ mm} = 0.154 \text{ m}$$

$$\sigma_{s,0,10} = \varepsilon_{\text{cu}3} * E_s = 0.0035 * 200 \text{ GPa} = 700 \text{ MPa}$$

$$\begin{aligned}
 N_{\text{Rd},0,10} &= -\left(b_{14} * h_{14} * f_{\text{cd}} + A_{s,14} * \sigma_{s,0,10} * 2\right) \\
 &= -\left(1 \text{ m} * 450 \text{ mm} * 20 \text{ MPa} + 0.00103 \text{ m}^2 * 700 \text{ MPa} * 2\right) = -10436.755 \text{ kN}
 \end{aligned}$$

$$M_{\text{Rd},0,1,10} = 0 \text{ kN} * \text{m}$$

BOD 1 nulové přetvoření "tažené" výztuže

$$x_{1,10} = d_{14} = 0.379 \text{ m}$$

$$\varepsilon_{s,1,10} = \varepsilon_{cu3} * \left(\frac{x_{1,10} - d_{1,14}}{x_{1,10}} \right) = 0.0035 * \left(\frac{0.379 \text{ m} - 71 \text{ mm}}{0.379 \text{ m}} \right) = 0.00284$$

$$\varepsilon_{s,1,10} < \varepsilon_{yd} = 0.00284 < 0.0021739 = \text{False}$$

$$\sigma_{s,1,10} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$N_{Rd,1,10} = - \left(b_{14} * \lambda * x_{1,10} * f_{cd} + A_{s,14} * \sigma_{s,1,10} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.379 \text{ m} * 20 \text{ MPa} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} \right) = -6510.197 \text{ kN}$$

$$M_{Rd,1,10} = b_{14} * \lambda * x_{1,10} * f_{cd} * \left(\frac{h_{14} - \lambda * x_{1,10}}{2} \right) + A_{s,14} * \sigma_{s,1,10} * z_{1,10} \\ = 1 \text{ m} * 0.8 * 0.379 \text{ m} * 20 \text{ MPa} * \left(\frac{450 \text{ mm} - 0.8 * 0.379 \text{ m}}{2} \right) + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.154 \text{ m} \\ = 513.812 \text{ kN} * \text{m}$$

BOD 2 napětí v tažené výztuži na mezi kluzu

$$x_{2,10} = \left(\frac{\varepsilon_{cu3}}{\varepsilon_{cu3} + \varepsilon_{yd}} \right) * d_{14} = \left(\frac{0.0035}{0.0035 + 0.0021739} \right) * 379 \text{ mm} = 0.234 \text{ m}$$

$$\varepsilon_{s,2,1,10} = \varepsilon_{cu3} * \left(\frac{x_{2,10} - d_{1,14}}{x_{2,10}} \right) = 0.0035 * \left(\frac{0.234 \text{ m} - 71 \text{ mm}}{0.234 \text{ m}} \right) = 0.00244$$

$$\varepsilon_{s,2,1,10} < \varepsilon_{yd} = 0.00244 < 0.0021739 = \text{False} \quad \sigma_{s,2,1,10} = f_{yd} = 434.783 \text{ MPa}$$

$$\varepsilon_{s,2,2,10} = \varepsilon_{yd} = 0.00217 \quad \sigma_{s,2,2,10} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,2,10} = - \left(b_{14} * \lambda * x_{2,10} * f_{cd} + A_{s,14} * \sigma_{s,2,1,10} - A_{s,14} * \sigma_{s,2,2,10} \right) \\ = - \left(1 \text{ m} * 0.8 * 0.234 \text{ m} * 20 \text{ MPa} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} - 0.00103 \text{ m}^2 * 434.783 \text{ MPa} \right) \\ = -3740.628 \text{ kN}$$

$$M_{Rd,2,10} = b_{14} * \lambda * x_{2,10} * f_{cd} * \left(\frac{h_{14} - \lambda * x_{2,10}}{2} \right) + A_{s,14} * \sigma_{s,2,1,10} * z_{1,10} + A_{s,14} * \sigma_{s,2,2,10} * z_{1,10} \\ = 1 \text{ m} * 0.8 * 0.234 \text{ m} * 20 \text{ MPa} * \left(\frac{450 \text{ mm} - 0.8 * 0.234 \text{ m}}{2} \right) + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.154 \text{ m} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.154 \text{ m} \\ = 629.263 \text{ kN} * \text{m}$$

BOD 3 prostý ohyb

$$N_{Rd,3,10} = 0 \text{ kN}$$

$$x_{3,10} = \frac{A_{s,14} * f_{yd} + A_{s,14} * f_{yd}}{b_{14} * \lambda * f_{cd}} = \frac{0.00103 \text{ m}^2 * 434.78 \text{ MPa} + 0.00103 \text{ m}^2 * 434.78 \text{ MPa}}{1 \text{ m} * 0.8 * 20 \text{ MPa}} \\ = 0.0558 \text{ m}$$

$$\varepsilon_{s,3,1,10} = \varepsilon_{cu3} * \left(\frac{d_{1,14} - x_{3,10}}{x_{3,10}} \right) = 0.0035 * \left(\frac{71 \text{ mm} - 0.0558 \text{ m}}{0.0558 \text{ m}} \right) = 0.000955$$

$$\varepsilon_{s,3,1,10} < \varepsilon_{yd} = 0.000955 < 0.0021739 = \text{True}$$

$$\sigma_{s,3,1,10} = \varepsilon_{s,3,1,10} * E_s = 0.000955 * 200 \text{ GPa} = 0.191 \text{ GPa}$$

$$\varepsilon_{s,3,2,10} = \varepsilon_{cu3} * \left(\frac{d_{14} - x_{3,10}}{x_{3,10}} \right) = 0.0035 * \left(\frac{379 \text{ mm} - 0.0558 \text{ m}}{0.0558 \text{ m}} \right) = 0.0203$$

$$\varepsilon_{s,3,2,10} < \varepsilon_{yd} = 0.0203 < 0.0021739 = \text{False} \quad \sigma_{s,3,2,10} = f_{yd} = 434.78 \text{ MPa} = 434.783 \text{ MPa}$$

$$M_{Rd,3,10} = b_{14} * \lambda * x_{3,10} * f_{cd} * \left(\frac{h_{14} - \lambda * x_{3,10}}{2} \right) + A_{s,14} * \sigma_{s,3,1,10} * z_{1,10} + A_{s,14} * \sigma_{s,3,2,10} * z_{1,10}$$

$$= 1 \text{ m} * 0.8 * 0.0558 \text{ m} * 20 \text{ MPa} * \left(\frac{450 \text{ mm} - 0.8 * 0.0558 \text{ m}}{2} \right) + 0.00103 \text{ m}^2 * 0.191 \text{ GPa} * 0.154 \text{ m} + 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.154 \text{ m}$$

$$= 279.794 \text{ kN} * \text{m}$$

BOD 4 nulové přetvoření "tlačené" výztuže

$$x_{4,10} = d_{1,14} = 71 \text{ mm} = 0.071 \text{ m}$$

$$\varepsilon_{s,4,1,10} = \varepsilon_{cu3} * \left(\frac{d_{14} - x_{4,10}}{x_{4,10}} \right) = 0.0035 * \left(\frac{379 \text{ mm} - 0.071 \text{ m}}{0.071 \text{ m}} \right) = 0.0152$$

$$\varepsilon_{s,4,1,10} < \varepsilon_{yd} = 0.0152 < 0.0021739 = \text{False} \quad \sigma_{s,4,1,10} = f_{yd} = 434.783 \text{ MPa}$$

$$N_{Rd,4,10} = A_{s,14} * \sigma_{s,4,1,10} = 0.00103 \text{ m}^2 * 434.783 \text{ MPa} = 446.197 \text{ kN}$$

$$M_{Rd,4,10} = A_{s,14} * \sigma_{s,4,1,10} * z_{1,10} = 0.00103 \text{ m}^2 * 434.783 \text{ MPa} * 0.154 \text{ m} = 68.714 \text{ kN} * \text{m}$$

BOD 5 dostředný tlak

$$N_{Rd,5,10} = A_{s,14} * f_{yd} + A_{s,14} * f_{yd} = 0.00103 \text{ m}^2 * 434.78 \text{ MPa} + 0.00103 \text{ m}^2 * 434.78 \text{ MPa}$$

$$= 892.394 \text{ kN}$$

$$M_{Rd,5,10} = 0 \text{ kN} * \text{m}$$

Body	N_Rd	M_Rd	
0	-10437 kN	0 kN*m	
1	-6510.2 kN	514 kN*m	
2	-3740.6 kN	629 kN*m	
3	0 kN	280 kN*m	
4	446.197 kN	68.7 kN*m	
5	892.394 kN	0 kN*m	
Kombinace	NxD	MxD-	MxD+
K2	-66.35	44.82	-20.65

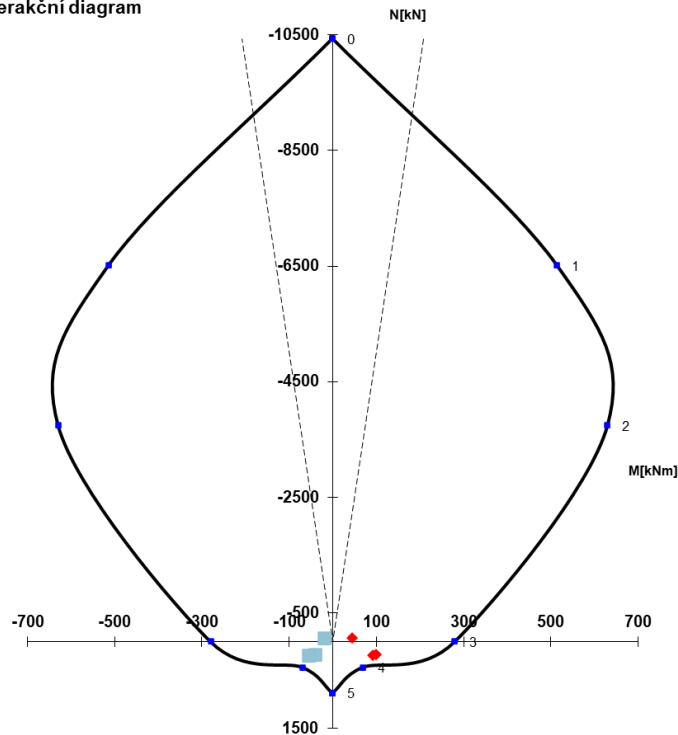
K3 228.12 99.04 -39.74

K4 237.36 92.1 -55.32

(Table 43)

DIAGRAM

Interakční diagram



3.2. Posouzení na smyk

3.2.1. Směr y

(Table 44)

Kombinace	VyD	NyD	VyD
K2	81.59 kN	61.54 kN	81.59
K3	123.26 kN	241.64 kN	123.26
K4	129.22 kN	221.53 kN	129.22

$$C_{Rd,c,5} = \frac{0.18}{\gamma_c} = 0.12 \quad d_{5,5} = \frac{d_{13}}{1 \text{ mm}} = 393$$

$$K_5 = 1 + \sqrt{\left(\frac{200}{d_{5,5}}\right)} = 1 + \sqrt{\left(\frac{200}{393}\right)} = 1.713$$

$$\zeta_{sl,5} = \frac{A_{s,13}}{b_{13} * d_{13}} = \frac{0.00103 \text{ m}^2}{1 \text{ m} * 393 \text{ mm}} = 0.00261$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \zeta_{sl,5} < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00261 < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

$$f_{ck,5} = 30$$

$$v_{min,5} = 0.035 * K_5 \left(\frac{2}{3}\right) * f_{ck,5} \left(\frac{1}{2}\right) * 1 \text{ MPa} = 0.035 * 1.713 \left(\frac{2}{3}\right) * 30 \left(\frac{1}{2}\right) * 1 \text{ MPa} = 0.274 \text{ MPa}$$

$$V_{Rd,cn,5} = \left(C_{Rd,c,5} * K_5 * \left(100 * \zeta_{sl,5} * f_{ck,5} \right)^{\left(\frac{1}{3}\right)} \right) * b_{13} * d_{13} * 1 \text{ MPa}$$

$$= \left(0.12 * 1.713 * \left(100 * 0.00261 * 30 \right)^{\left(\frac{1}{3}\right)} \right) * 1 \text{ m} * 393 \text{ mm} * 1 \text{ MPa} = 160.480 \text{ kN}$$

$$V_{min,5} = v_{min,5} * b_{13} * d_{13} = 0.274 \text{ MPa} * 1 \text{ m} * 393 \text{ mm} = 107.876 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,cn,5} \geq V_{min,5} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 160.480 \text{ kN} \geq 107.876 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

Vliv normálové síly

K2

$$\sigma_{cp,1,5} = \frac{\text{Table44.C2}}{b_{13} * d_{13}} = \frac{61.54 \text{ kN}}{1 \text{ m} * 393 \text{ mm}} = 156.590 \text{ kPa} \quad k_{1,5} = 0.15$$

$$V_{Rd,c,1,5} = V_{Rd,cn,5} + k_{1,5} * \sigma_{cp,1,5} * b_{13} * d_{13} = 160.480 \text{ kN} + 0.15 * 156.590 \text{ kPa} * 1 \text{ m} * 393 \text{ mm} = 169.711 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,1,5} > \text{Table44.B2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 169.711 \text{ kN} > 81.59 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

K3

$$\sigma_{cp,2,5} = \frac{\text{Table44.C3}}{b_{13} * d_{13}} = \frac{241.64 \text{ kN}}{1 \text{ m} * 393 \text{ mm}} = 614.860 \text{ kPa} \quad k_{2,5} = 0.15$$

$$V_{Rd,c,2,5} = V_{Rd,cn,5} + k_{2,5} * \sigma_{cp,2,5} * b_{13} * d_{13} = 160.480 \text{ kN} + 0.15 * 614.860 \text{ kPa} * 1 \text{ m} * 393 \text{ mm} = 196.726 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,2,5} > \text{Table44.B3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 196.726 \text{ kN} > 123.26 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

K4

$$\sigma_{cp,3,5} = \frac{\text{Table44.C4}}{b_{13} * d_{13}} = \frac{221.53 \text{ kN}}{1 \text{ m} * 393 \text{ mm}} = 563.690 \text{ kPa} \quad k_{3,5} = 0.15$$

$$V_{Rd,c,3,5} = V_{Rd,cn,5} + k_{3,5} * \sigma_{cp,3,5} * b_{13} * d_{13} = 160.480 \text{ kN} + 0.15 * 563.690 \text{ kPa} * 1 \text{ m} * 393 \text{ mm} = 193.710 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,3,5} > \text{Table44.B4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 193.710 \text{ kN} > 129.22 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

NENÍ POTŘEBA SMYKOVÁ VÝZTUŽ

3.2.2. Směr x

(Table 48)

Kombinace	VxD	NxD	VxD
K2	65.11 kN	61.54 kN	65.11
K3	115.47 kN	241.64 kN	115.47
K4	123.43 kN	221.53 kN	123.43

$$C_{Rd,c,6} = \frac{0.18}{\gamma_c} = 0.12 \quad d_{5,6} = \frac{d_{14}}{1 \text{ mm}} = 379$$

$$K_6 = 1 + \sqrt{\left(\frac{200}{d_{5,6}}\right)} = 1 + \sqrt{\left(\frac{200}{379}\right)} = 1.726$$

$$\zeta_{sl,6} = \frac{A_{s,14}}{b_{14} * d_{14}} = \frac{0.00103 \text{ m}^2}{1 \text{ m} * 379 \text{ mm}} = 0.00271$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \zeta_{sl,6} < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 0.00271 < 0.02 \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

$$f_{ck,6} = 30$$

$$v_{min,6} = 0.035 * K_6^{\left(\frac{2}{3}\right)} * f_{ck,6}^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.035 * 1.726^{\left(\frac{2}{3}\right)} * 30^{\left(\frac{1}{2}\right)} * 1 \text{ MPa} = 0.276 \text{ MPa}$$

$$V_{Rd,cn,6} = \left(C_{Rd,c,6} * K_6 * \left(100 * \zeta_{sl,6} * f_{ck,6} \right)^{\left(\frac{1}{3}\right)} \right) * b_{14} * d_{14} * 1 \text{ MPa}$$

$$= \left(0.12 * 1.726 * \left(100 * 0.00271 * 30 \right)^{\left(\frac{1}{3}\right)} \right) * 1 \text{ m} * 379 \text{ mm} * 1 \text{ MPa} = 157.839 \text{ kN}$$

$$V_{\min,6} = v_{\min,6} * b_{14} * d_{14} = 0.276 \text{ MPa} * 1 \text{ m} * 379 \text{ mm} = 104.561 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,cn,6} \geq V_{\min,6} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 157.839 \text{ kN} \geq 104.561 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

Vliv normálové síly

K2

$$\sigma_{cp,1,6} = \frac{\text{Table48.C2}}{b_{14} * d_{14}} = \frac{61.54 \text{ kN}}{1 \text{ m} * 379 \text{ mm}} = 162.375 \text{ kPa} \quad k_{1,6} = 0.15$$

$$V_{Rd,c,1,6} = V_{Rd,cn,6} + k_{1,6} * \sigma_{cp,1,6} * b_{14} * d_{14} = 157.839 \text{ kN} + 0.15 * 162.375 \text{ kPa} * 1 \text{ m} * 379 \text{ mm} = 167.070 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,1,6} > \text{Table48.B2} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 167.070 \text{ kN} > 65.11 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

K3

$$\sigma_{cp,2,6} = \frac{\text{Table48.C3}}{b_{14} * d_{14}} = \frac{241.64 \text{ kN}}{1 \text{ m} * 379 \text{ mm}} = 637.573 \text{ kPa} \quad k_{2,6} = 0.15$$

$$V_{Rd,c,2,6} = V_{Rd,cn,6} + k_{2,6} * \sigma_{cp,2,6} * b_{14} * d_{14} = 157.839 \text{ kN} + 0.15 * 637.573 \text{ kPa} * 1 \text{ m} * 379 \text{ mm} = 194.085 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,2,6} > \text{Table48.B3} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 194.085 \text{ kN} > 115.47 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

K4

$$\sigma_{cp,3,6} = \frac{\text{Table48.C4}}{b_{14} * d_{14}} = \frac{221.53 \text{ kN}}{1 \text{ m} * 379 \text{ mm}} = 584.512 \text{ kPa} \quad k_{3,6} = 0.15$$

$$V_{Rd,c,3,6} = V_{Rd,cn,6} + k_{3,6} * \sigma_{cp,3,6} * b_{14} * d_{14} = 157.839 \text{ kN} + 0.15 * 584.512 \text{ kPa} * 1 \text{ m} * 379 \text{ mm} = 191.069 \text{ kN}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } V_{Rd,c,3,6} > \text{Table48.B4} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 191.069 \text{ kN} > 123.43 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

NENÍ POTŘEBA SMYKOVÁ VÝZTUŽ

3.3. Kotevní a stykovací délky

3.3.1. Směr y

Kotvení

$$\eta_{1,9} = 0.7$$

$$\eta_{2,9} = 1 \quad \alpha_{ct,9} = 1$$

$$f_{ctd,9} = \alpha_{ct,9} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,9} = 2.25 * \eta_{1,9} * \eta_{2,9} * f_{ctd,9} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,9} = \left(\frac{\varnothing_{y,ZD1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,9}} \right) = \left(\frac{14 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 724.638 \text{ mm}$$

$$L_{bdrqd,9} = \text{RoundUp}(l_{bdrqd,9}) = \text{RoundUp}(724.638 \text{ mm}) = 725 \text{ mm}$$

Stykování

$$\alpha_{1,9} = 1 \quad \alpha_{2,9} = 1 \quad \alpha_{3,9} = 1 \quad \alpha_{5,9} = 1 \quad \alpha_{6,9} = 1.5$$

$$l_{0,9} = \alpha_{1,9} * \alpha_{2,9} * \alpha_{3,9} * \alpha_{5,9} * \alpha_{6,9} * L_{bdrqd,9} = 1 * 1 * 1 * 1 * 1.5 * 725 \text{ mm} = 1087.5 \text{ mm}$$

$$L_{0,9} = \text{RoundUp}(l_{0,9}) = 1088 \text{ mm}$$

$$l_{0,min,9} = \text{Max}(0.6 * \alpha_{6,9} * L_{bdrqd,9}, 15 * \varnothing_{y,ZD}, 200 \text{ mm})$$

$$= \text{Max}(0.6 * 1.5 * 725 \text{ mm}, 15 * 14 \text{ mm}, 200 \text{ mm}) = 652.5 \text{ mm}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } L_{0,9} > l_{0,min,9} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 1088 \text{ mm} > 652.5 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

3.3.2. Směr x

Kotvení

$$\eta_{1,10} = 0.7$$

$$\eta_{2,10} = 1 \quad \alpha_{ct,10} = 1$$

$$f_{ctd,10} = \alpha_{ct,10} * \left(\frac{f_{ctk,0,05}}{\gamma_c} \right) = 1 * \left(\frac{2.0 \text{ MPa}}{1.5} \right) = 1.333 \text{ MPa}$$

$$f_{bd,10} = 2.25 * \eta_{1,10} * \eta_{2,10} * f_{ctd,10} = 2.25 * 0.7 * 1 * 1.333 \text{ MPa} = 2.1 \text{ MPa}$$

$$l_{bdrqd,10} = \left(\frac{\varnothing_{x,ZD1}}{4} \right) * \left(\frac{f_{yd}}{f_{bd,10}} \right) = \left(\frac{14 \text{ mm}}{4} \right) * \left(\frac{434.78 \text{ MPa}}{2.1 \text{ MPa}} \right) = 724.638 \text{ mm}$$

$$L_{bdrqd,10} = \text{RoundUp}(l_{bdrqd,10}) = 725 \text{ mm}$$

Stykování

$$\alpha_{1,10} = 1 \quad \alpha_{2,10} = 1 \quad \alpha_{3,10} = 1 \quad \alpha_{5,10} = 1 \quad \alpha_{6,10} = 1.5$$

$$l_{0,10} = \alpha_{1,10} * \alpha_{2,10} * \alpha_{3,10} * \alpha_{5,10} * \alpha_{6,10} * L_{bdrqd,10} = 1 * 1 * 1 * 1 * 1.5 * 725 \text{ mm} = 1087.5 \text{ mm}$$

$$L_{0,10} = \text{RoundUp}(l_{0,10}) = \text{RoundUp}(1087.5 \text{ mm}) = 1088 \text{ mm}$$

$$l_{0,min,10} = \text{Max}(0.3 * \alpha_{6,10} * L_{bdrqd,10}, 15 * \varnothing_{y,ZD1}, 200 \text{ mm})$$

$$= \text{Max}(0.3 * 1.5 * 725 \text{ mm}, 15 * 14 \text{ mm}, 200 \text{ mm}) = 326.25 \text{ mm}$$

$$\text{value6} = \begin{cases} \text{"VYHOVUJE"} & \text{if } L_{0,10} > l_{0,min,10} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases} = \begin{cases} \text{"VYHOVUJE"} & \text{if } 1088 \text{ mm} > 326.25 \text{ mm} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{cases}$$

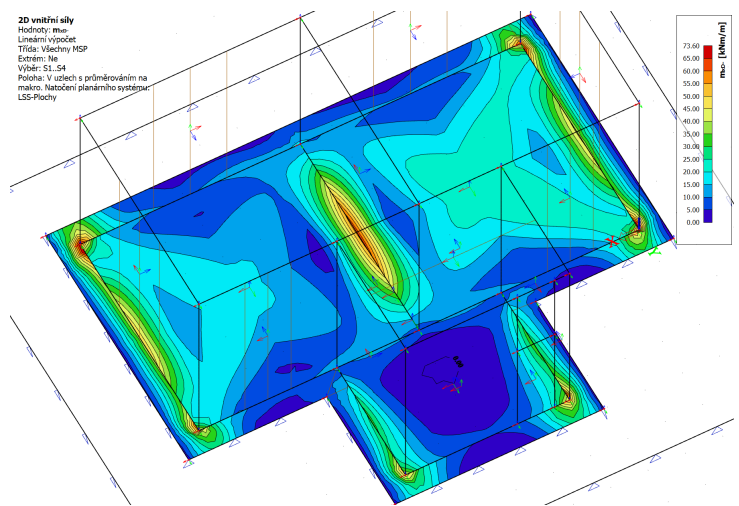
$$= \text{VYHOVUJE}$$

3.4. Posouzení na MSP

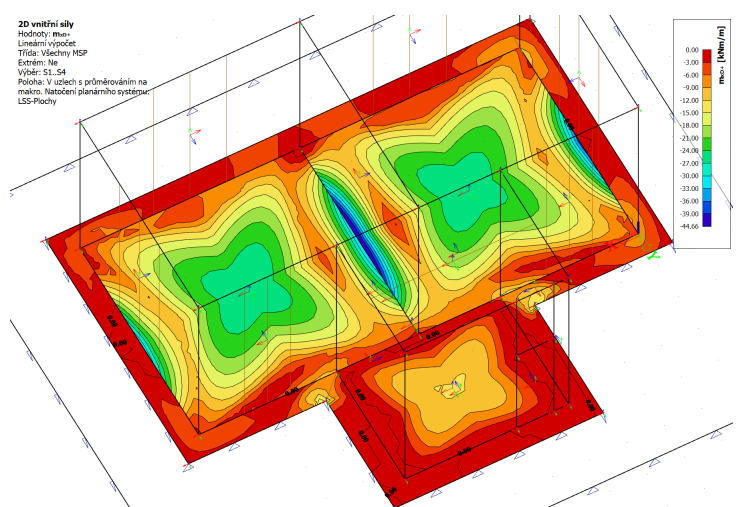
Okraje (Třídy) MSP

Všechny MSP

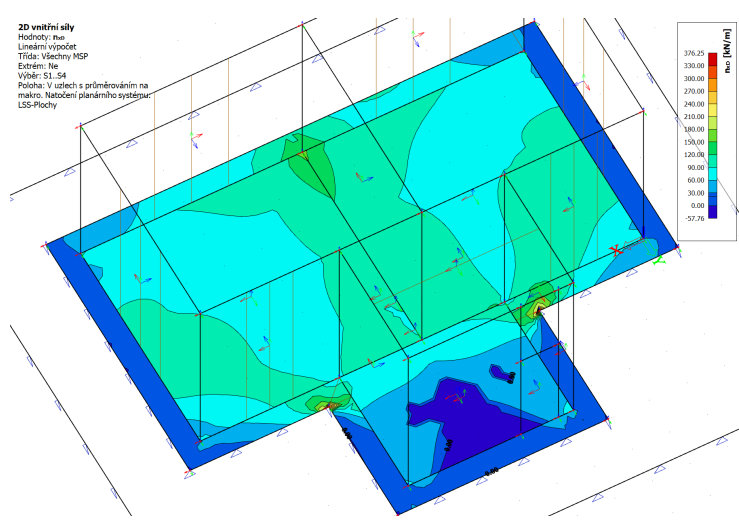
MxD-



MxD+

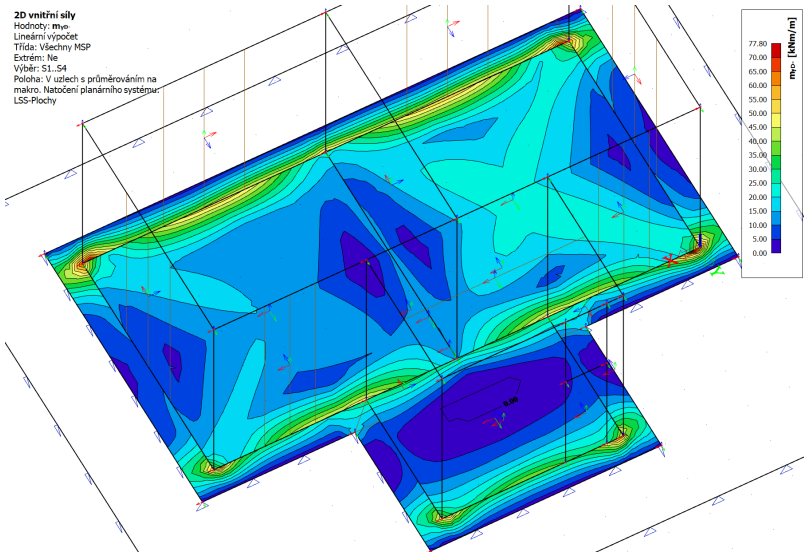


NxD

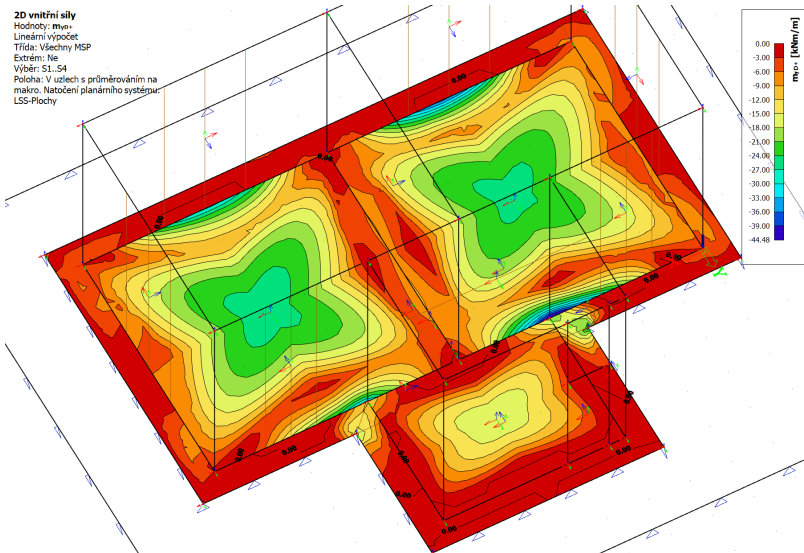


Všechny MSP

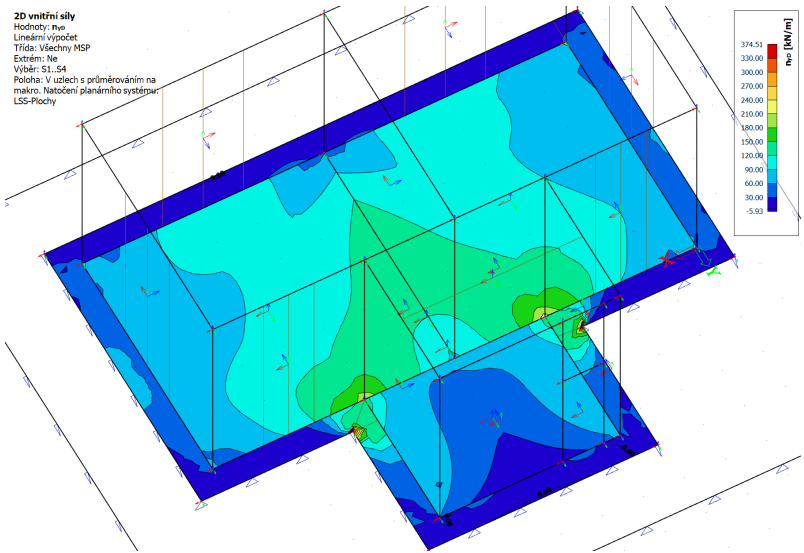
MyD-



MyD+



NyD



(Vypsáno ze SCII a uvedeno v absolutních hodnotách)

(Table 45)

Kombinace	MxD- Char	MxD+ Char	NxD Char	MxD- Kvazi	MxD+ Kvazi	MyD- Char	MyD+ Char	NyD Char	MyD- Kvazi	MyD+ Kvazi
K2	44.55	14.66	60.37	43.31	11.5	43.68	15.08	54.87	42.68	11.86
K3	73.35	36.98	169.22	64.87	25.43	73.13	29.42	179.14	64.46	18.98
K4	68.28	37.32	175.95	61.01	25.97	76.97	40.95	164.1	69.15	28.17

3.4.1. směr x

(Table 46)

Kombinace	MxD	Nx
Charakteristická	73.35 kN*m	175.95 kN
Kvazistálá	64.87 kN*m	

Omezení napětí v betonu a ve výztuži

$$\alpha_{e,11} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,11} = b_{14} * h_{14} = 1 \text{ m} * 450 \text{ mm} = 0.45 \text{ m}^2$$

$$A_{S,S,11} = A_{s,14} = 0.00103 \text{ m}^2$$

$$A_{i,11} = A_{C,C,11} + A_{S,S,11} * \alpha_{e,11} = 0.45 \text{ m}^2 + 0.00103 \text{ m}^2 * 6.061 = 0.456 \text{ m}^2$$

$$a_{c,c,11} = \frac{h_{14}}{2} = \frac{450 \text{ mm}}{2} = 0.225 \text{ m}$$

$$a_{gi,11} = \frac{A_{C,C,11} * a_{c,c,11} + \alpha_{e,11} * (A_{S,S,11} * d_{14})}{A_{i,11}}$$

$$= \frac{0.45 \text{ m}^2 * 0.225 \text{ m} + 6.061 * (0.00103 \text{ m}^2 * 379 \text{ mm})}{0.456 \text{ m}^2} = 0.227 \text{ m}$$

$$I_{c,c,11} = \left(\frac{1}{12} \right) * b_{14} * h_{14}^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (450 \text{ mm})^3 = 0.00759 \text{ m}^4$$

$$I_{i,11} = I_{c,c,11} + A_{C,C,11} * (a_{gi,11} - a_{c,c,11})^2 + \alpha_{e,11} * \left(A_{S,S,11} * (d_{14} - a_{gi,11})^2 \right)$$

$$= 0.00759 \text{ m}^4 + 0.45 \text{ m}^2 * (0.227 \text{ m} - 0.225 \text{ m})^2 + 6.061 * \left(0.00103 \text{ m}^2 * (379 \text{ mm} - 0.227 \text{ m})^2 \right)$$

$$= 0.00774 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,11} = \left| \left(\left(\frac{\text{Table46.C2}}{A_{i,11}} \right) - \left(\frac{\text{Table46.B2} * a_{gi,11}}{I_{i,11}} \right) \right) \right| = \left| \left(\left(\frac{175.95 \text{ kN}}{0.456 \text{ m}^2} \right) - \left(\frac{73.35 \text{ kN} * \text{m} * 0.227 \text{ m}}{0.00774 \text{ m}^4} \right) \right) \right|$$

$$= 1766.704 \text{ kPa}$$

$$f_{ct,eff,1,11} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,1,11} < f_{ct,eff,1,11}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $1766.704 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

$$\sigma_{C,C,2,11} = \left| \left(\left(\frac{\text{Table46.C2}}{A_{i,11}} \right) + \left(\frac{\text{Table46.B2} * (h_{14} - a_{gi,11})}{I_{i,11}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{175.95 \text{ kN}}{0.456 \text{ m}^2} \right) + \left(\frac{73.35 \text{ kN} * \text{m} * (450 \text{ mm} - 0.227 \text{ m})}{0.00774 \text{ m}^4} \right) \right) \right| = 2498.246 \text{ kPa}$$

"VYHOVUJE TRHLINY NEVZNIKNOU" if $\sigma_{C,C,2,11} < f_{ct,eff,1,11}$
 "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = "VYHOVUJE TRHLINY NEVZNIKNOU" if $2498.246 \text{ kPa} < 2900 \text{ kPa}$
 = "NEVYHOVUJE TRHLINY VZNIKNOU" otherwise
 = VYHOVUJE TRHLINY NEVZNIKNOU

Napětí ve výztuži

$$e_{kd,11} = \frac{\text{Table46.B2}}{\text{Table46.C2}} = \frac{73.35 \text{ kN} * \text{m}}{175.95 \text{ kN}} = 0.417 \text{ m}$$

$$e_{11} = e_{kd,11} + a_{c,c,11} = 0.417 \text{ m} + 0.225 \text{ m} = 0.642 \text{ m}$$

$$\sigma_{S,S,1,11} = \left(\frac{\text{Table46.C2}}{A_{i,11}} \right) * \left(1 + \left(\frac{A_{i,11} * (a_{gi,11} - e_{11}) * (a_{gi,11} - d_{14})}{I_{i,11}} \right) \right) * \alpha_{e,11}$$

$$= \left(\frac{175.95 \text{ kN}}{0.456 \text{ m}^2} \right) * \left(1 + \left(\frac{0.456 \text{ m}^2 * (0.227 \text{ m} - 0.642 \text{ m}) * (0.227 \text{ m} - 379 \text{ mm})}{0.00774 \text{ m}^4} \right) \right) * 6.061$$

$$= 11018.675 \text{ kPa}$$

"VYHOVUJE" if $\sigma_{S,S,1,11} < 0.8 * f_{yk}$ = "VYHOVUJE" if $11018.675 \text{ kPa} < 0.8 * 500 \text{ MPa}$
 "NEVYHOVUJE" otherwise = "NEVYHOVUJE" otherwise
 = VYHOVUJE

$$\begin{aligned}\sigma_{S,S,2,11} &= \left(\frac{\text{Table46.C2}}{A_{i,11}} \right) * \left(1 + \left(\frac{A_{i,11} * (a_{gi,11} - e_{11}) * (a_{gi,11} - d_{14})}{I_{i,11}} \right) \right) * \alpha_{e,11} \\ &= \left(\frac{175.95 \text{ kN}}{0.456 \text{ m}^2} \right) * \left(1 + \left(\frac{0.456 \text{ m}^2 * (0.227 \text{ m} - 0.642 \text{ m}) * (0.227 \text{ m} - 379 \text{ mm})}{0.00774 \text{ m}^4} \right) \right) * 6.061 \\ &= 11018.675 \text{ kPa}\end{aligned}$$

$$\begin{aligned}& \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,11} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 11018.675 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| \\ &= \text{VYHOVUJE}\end{aligned}$$

3.4.2. směr y

(Table 47)

Kombinace	MyD	Ny
Charakteristická	76.97 kN*m	179.14 kN
Kvazistálá	69.15 kN*m	

omezení napětí v betonu a ve výztuži

$$\alpha_{e,12} = \frac{E_s}{E_{cm}} = \frac{200 \text{ GPa}}{33 \text{ GPa}} = 6.061$$

$$A_{C,C,12} = b_{13} * h_{13} = 1 \text{ m} * 450 \text{ mm} = 0.45 \text{ m}^2$$

$$A_{S,S,12} = A_{s,13} = 0.00103 \text{ m}^2$$

$$A_{i,12} = A_{C,C,12} + A_{S,S,12} * \alpha_{e,12} = 0.45 \text{ m}^2 + 0.00103 \text{ m}^2 * 6.061 = 0.456 \text{ m}^2$$

$$a_{c,c,12} = \frac{h_{13}}{2} = \frac{450 \text{ mm}}{2} = 0.225 \text{ m}$$

$$\begin{aligned}a_{gi,12} &= \frac{A_{C,C,12} * a_{c,c,12} + \alpha_{e,12} * (A_{S,S,12} * d_{13})}{A_{i,12}} \\ &= \frac{0.45 \text{ m}^2 * 0.225 \text{ m} + 6.061 * (0.00103 \text{ m}^2 * 393 \text{ mm})}{0.456 \text{ m}^2} = 0.227 \text{ m}\end{aligned}$$

$$I_{c,c,12} = \left(\frac{1}{12} \right) * b_{13} * h_{13}^3 = \left(\frac{1}{12} \right) * 1 \text{ m} * (450 \text{ mm})^3 = 0.00759 \text{ m}^4$$

$$I_{i,12} = I_{c,c,12} + A_{C,C,12} * (a_{gi,12} - a_{c,c,12})^2 + \alpha_{e,12} * \left(A_{S,S,12} * (d_{13} - a_{gi,12})^2 \right)$$

$$= 0.00759 \text{ m}^4 + 0.45 \text{ m}^2 * (0.227 \text{ m} - 0.225 \text{ m})^2 + 6.061 * \left(0.00103 \text{ m}^2 * (393 \text{ mm} - 0.227 \text{ m})^2 \right)$$

$$= 0.00777 \text{ m}^4$$

Napětí v betonu

$$\sigma_{C,C,1,12} = \left| \left(\left(\frac{\text{Table47.C2}}{A_{i,12}} \right) - \left(\frac{\text{Table47.B2} * a_{gi,12}}{I_{i,12}} \right) \right) \right| = \left| \left(\left(\frac{179.14 \text{ kN}}{0.456 \text{ m}^2} \right) - \left(\frac{76.97 \text{ kN} * \text{m} * 0.227 \text{ m}}{0.00777 \text{ m}^4} \right) \right) \right|$$

$$= 1859.786 \text{ kPa}$$

$$f_{ct,eff,1,12} = f_{ctm} = 2.9 \text{ MPa} = 2900 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,1,12} < f_{ct,eff,1,12} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 1859.786 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

$$\sigma_{C,C,2,12} = \left| \left(\left(\frac{\text{Table47.C2}}{A_{i,12}} \right) + \left(\frac{\text{Table47.B2} * (h_{13} - a_{gi,12})}{I_{i,12}} \right) \right) \right|$$

$$= \left| \left(\left(\frac{179.14 \text{ kN}}{0.456 \text{ m}^2} \right) + \left(\frac{76.97 \text{ kN} * \text{m} * (450 \text{ mm} - 0.227 \text{ m})}{0.00777 \text{ m}^4} \right) \right) \right| = 2599.714 \text{ kPa}$$

$$\begin{aligned} & \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } \sigma_{C,C,2,12} < f_{ct,eff,1,12} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \left| \begin{array}{l} \text{"VYHOVUJE TRHLINY NEVZNIKNOU"} \text{ if } 2599.714 \text{ kPa} < 2900 \text{ kPa} \\ \text{"NEVYHOVUJE TRHLINY VZNIKNOU"} \text{ otherwise} \end{array} \right. \\ & = \text{VYHOVUJE TRHLINY NEVZNIKNOU} \end{aligned}$$

Napětí ve výztuži

$$e_{kd,12} = \frac{\text{Table47.B2}}{\text{Table47.C2}} = \frac{76.97 \text{ kN} * \text{m}}{179.14 \text{ kN}} = 0.430 \text{ m}$$

$$e_{12} = e_{kd,12} + a_{c,c,12} = 0.430 \text{ m} + 0.225 \text{ m} = 0.655 \text{ m}$$

$$\sigma_{S,S,1,12} = \left(\frac{\text{Table47.C2}}{A_{i,12}} \right) * \left(1 + \left(\frac{A_{i,12} * (a_{gi,12} - e_{12}) * (a_{gi,12} - d_{13})}{I_{i,12}} \right) \right) * \alpha_{e,12}$$

$$= \left(\frac{179.14 \text{ kN}}{0.456 \text{ m}^2} \right) * \left(1 + \left(\frac{0.456 \text{ m}^2 * (0.227 \text{ m} - 0.655 \text{ m}) * (0.227 \text{ m} - 393 \text{ mm})}{0.00777 \text{ m}^4} \right) \right) * 6.061$$

$$= 12279.335 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,1,12} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 12279.335 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

$$\sigma_{S,S,2,12} = \left(\frac{\text{Table47.C2}}{A_{i,12}} \right) * \left(1 + \left(\frac{A_{i,12} * (a_{gi,12} - e_{12}) * (a_{gi,12} - d_{13})}{I_{i,12}} \right) \right) * \alpha_{e,12}$$

$$= \left(\frac{179.14 \text{ kN}}{0.456 \text{ m}^2} \right) * \left(1 + \left(\frac{0.456 \text{ m}^2 * (0.227 \text{ m} - 0.655 \text{ m}) * (0.227 \text{ m} - 393 \text{ mm})}{0.00777 \text{ m}^4} \right) \right) * 6.061$$

= 12279.335 kPa

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } \sigma_{S,S,2,12} < 0.8 * f_{yk} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 12279.335 \text{ kPa} < 0.8 * 500 \text{ MPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right|$$

= VYHOVUJE

4. Posudek na vyplavání

$$\gamma_{zb} = 25 \frac{\text{kN}}{\text{m}^3}$$

$$\gamma_w = 10 \frac{\text{kN}}{\text{m}^3}$$

$$\gamma_{F6} = 21.0 \frac{\text{kN}}{\text{m}^3}$$

$$\gamma_{G,\text{sup}} = 0.9$$

$$\gamma_{G,\text{inf}} = 1.5$$

$$h_{\text{zákl,deska}} = 0.45 \text{ m}$$

$$\begin{aligned} G_{\text{zákl,deska}} &= (13 \text{ m} * 6.7 \text{ m} + 3.8 \text{ m} * 5.6 \text{ m}) * h_{\text{zákl,deska}} * \gamma_{zb} \\ &= (13 \text{ m} * 6.7 \text{ m} + 3.8 \text{ m} * 5.6 \text{ m}) * 0.45 \text{ m} * 25 \frac{\text{kN}}{\text{m}^3} = 1219.275 \text{ kN} \end{aligned}$$

$$h_{\text{stěna}} = 0.4 \text{ m}$$

$$\begin{aligned} G_{\text{stěny}} &= (5.9 \text{ m} * 5.4 \text{ m} * 7 + 3.4 \text{ m} * 5.4 \text{ m} * 2 + 4 \text{ m} * 5.4 \text{ m}) * h_{\text{stěna}} * \gamma_{zb} \\ &= (5.9 \text{ m} * 5.4 \text{ m} * 7 + 3.4 \text{ m} * 5.4 \text{ m} * 2 + 4 \text{ m} * 5.4 \text{ m}) * 0.4 \text{ m} * 25 \frac{\text{kN}}{\text{m}^3} = 2813.4 \text{ kN} \end{aligned}$$

$$h_{\text{strop,deska}} = 0.2 \text{ m}$$

$$G_{\text{strop,deska}} = (3.8 \text{ m} * 4.8 \text{ m}) * h_{\text{strop,deska}} * \gamma_{zb} = (3.8 \text{ m} * 4.8 \text{ m}) * 0.2 \text{ m} * 25 \frac{\text{kN}}{\text{m}^3} = 91.2 \text{ kN}$$

$$b_{\text{násyp10}^\circ} = 0.665 \text{ m}$$

$$h_{\text{vztlak}} = 3.45 \text{ m}$$

$$\begin{aligned} G_{\text{násyp}} &= (13 \text{ m} * 2 + 10.5 \text{ m} * 2) * b_{\text{násyp10}^\circ} * h_{\text{vztlak}} * \gamma_{F6} \\ &= (13 \text{ m} * 2 + 10.5 \text{ m} * 2) * 0.665 \text{ m} * 3.45 \text{ m} * 21.0 \frac{\text{kN}}{\text{m}^3} = 2264.425 \text{ kN} \end{aligned}$$

$$\begin{aligned} G_{\text{celkem}} &= (G_{\text{zákl,deska}} + G_{\text{stěny}} + G_{\text{strop,deska}} + G_{\text{násyp}}) * \gamma_{G,\text{sup}} \\ &= (1219.275 \text{ kN} + 2813.4 \text{ kN} + 91.2 \text{ kN} + 2264.425 \text{ kN}) * 0.9 = 5749.470 \text{ kN} \end{aligned}$$

$$\begin{aligned} Vz &= (12.2 \text{ m} * 6.3 \text{ m} + 3.4 \text{ m} * 4.8 \text{ m}) * h_{\text{vztlak}} * \gamma_w * \gamma_{G,\text{inf}} \\ &= (12.2 \text{ m} * 6.3 \text{ m} + 3.4 \text{ m} * 4.8 \text{ m}) * 3.45 \text{ m} * 10 \frac{\text{kN}}{\text{m}^3} * 1.5 = 4822.065 \text{ kN} \end{aligned}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } G_{\text{celkem}} > Vz \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 5749.470 \text{ kN} > 4822.065 \text{ kN} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

5. Posudek napětí v základové spáře

$$\text{value7} = G_{\text{zákl,deska}} = 1219.275 \text{ kN}$$

$$\text{value8} = G_{\text{stěny}} = 2813.4 \text{ kN}$$

$$\text{value9} = G_{\text{strop,deska}} = 91.2 \text{ kN}$$

$$\text{value10} = G_{\text{násyp}} = 2264.425 \text{ kN}$$

$$h_{\text{stěny}} = 5.4 \text{ m}$$

$$Q_{\text{voda}} = (5.5 \text{ m} * 5.5 \text{ m} * 2) * h_{\text{stěny}} * \gamma_w = (5.5 \text{ m} * 5.5 \text{ m} * 2) * 5.4 \text{ m} * 10 \frac{\text{kN}}{\text{m}^3} = 3267 \text{ kN}$$

$$G_{\text{celkem,k}} = \text{value7} + \text{value8} + \text{value9} + \text{value10} = 1219.275 \text{ kN} + 2813.4 \text{ kN} + 91.2 \text{ kN} + 2264.425 \text{ kN} = 6388.300 \text{ kN}$$

$$Q_{\text{celkem,k}} = Q_{\text{voda}} = 3267 \text{ kN}$$

$$\gamma_{G,1} = 1.35 \quad \gamma_{Q,1} = 1.35$$

$$F_{d,1} = \gamma_{G,1} * G_{\text{celkem,k}} + \gamma_{Q,1} * Q_{\text{celkem,k}} = 1.35 * 6388.300 \text{ kN} + 1.35 * 3267 \text{ kN} = 13034.655 \text{ kN}$$

$$A_{\text{desky,nádrže}} = 13 \text{ m} * 6.7 \text{ m} + 3.8 \text{ m} * 5.6 \text{ m} = 108.38 \text{ m}^2$$

$$\sigma_{Z,1} = \frac{F_{d,1}}{A_{\text{desky,nádrže}}} = \frac{13034.655 \text{ kN}}{108.38 \text{ m}^2} = 120.268 \text{ kPa}$$

$$R_{dt} = 150 \text{ kPa}$$

$$\left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } R_{dt} > \sigma_{Z,1} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \left| \begin{array}{ll} \text{"VYHOVUJE"} & \text{if } 150 \text{ kPa} > 120.268 \text{ kPa} \\ \text{"NEVYHOVUJE"} & \text{otherwise} \end{array} \right| = \text{VYHOVUJE}$$

3D přemístění
Hodnoty: u_x
Lineární výpočet
Kombinace: ZÁK CHAR SEDÁNÍ
Výběr: Vše
Poloha: V uzlech s průměrováním na
makro. Systém: LSS prvků sítě

