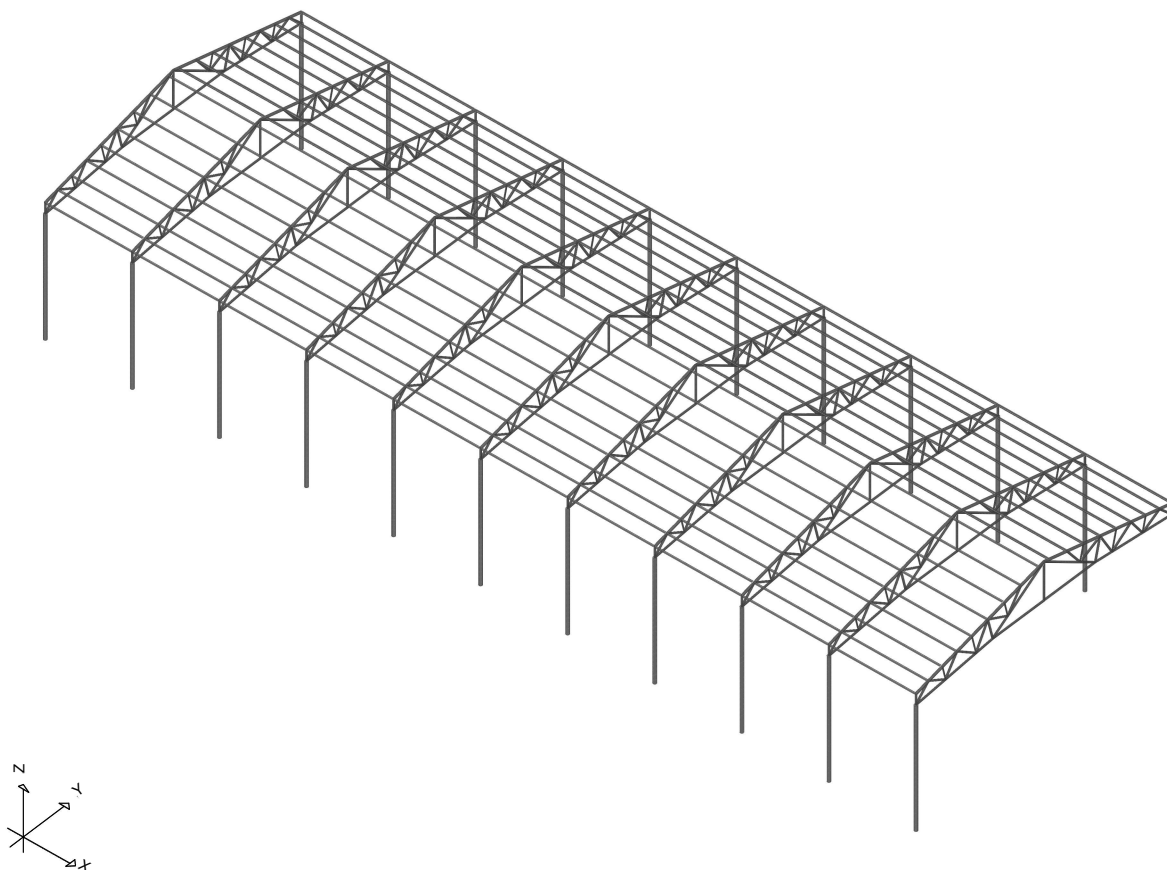


# Statická analýza

## SO-02 Skladová hala

Posúdenie možnosti osadenia FVE na strechu ocelejovej haly

Vypracoval: Ing. Tomáš Keresztesi



## Input data - Structure

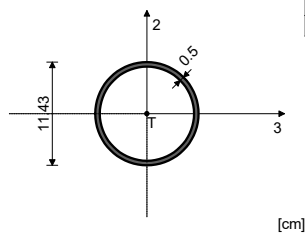
### Table of materials

| No | Material name | E[kN/m <sup>2</sup> ] | $\mu$ | $\gamma$ [kN/m <sup>3</sup> ] | $\alpha$ [1/C] | Em[kN/m <sup>2</sup> ] | $\mu$ m |
|----|---------------|-----------------------|-------|-------------------------------|----------------|------------------------|---------|
| 1  | Stahl         | 2.100e+8              | 0.30  | 78.50                         | 1.000e-5       | 2.100e+8               | 0.30    |

### Beam sets

Set: 1 Section: D= 114.3x5, Approx. eccentricity, PV - HP

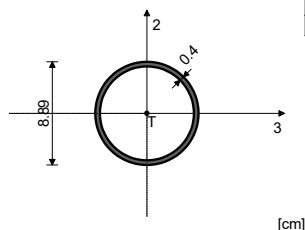
| Mat.      | A1       | A2       | A3       | I1       | I2       | I3       |
|-----------|----------|----------|----------|----------|----------|----------|
| 1 - Stahl | 1.717e-3 | 8.580e-4 | 8.580e-4 | 5.136e-6 | 2.569e-6 | 2.569e-6 |



[cm]

Set: 2 Section: D= 88.9x4, Approx. eccentricity, PV - HP

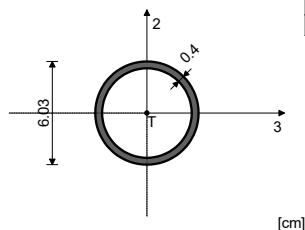
| Mat.      | A1       | A2       | A3       | I1       | I2       | I3       |
|-----------|----------|----------|----------|----------|----------|----------|
| 1 - Stahl | 1.067e-3 | 5.332e-4 | 5.332e-4 | 1.926e-6 | 9.634e-7 | 9.634e-7 |



[cm]

Set: 3 Section: D= 60.3x4, Approx. eccentricity, PV - D

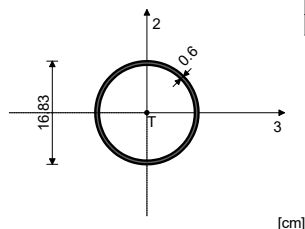
| Mat.      | A1       | A2       | A3       | I1       | I2       | I3       |
|-----------|----------|----------|----------|----------|----------|----------|
| 1 - Stahl | 7.070e-4 | 3.536e-4 | 3.536e-4 | 5.632e-7 | 2.817e-7 | 2.817e-7 |



[cm]

Set: 4 Section: D= 168.3x6, Approx. eccentricity, Stlp

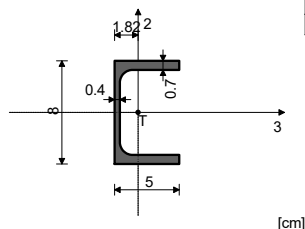
| Mat.      | A1       | A2       | A3       | I1       | I2       | I3       |
|-----------|----------|----------|----------|----------|----------|----------|
| 1 - Stahl | 3.059e-3 | 1.529e-3 | 1.529e-3 | 2.016e-5 | 1.009e-5 | 1.009e-5 |



[cm]

Set: 5 Section: UPE 80, Approx. eccentricity

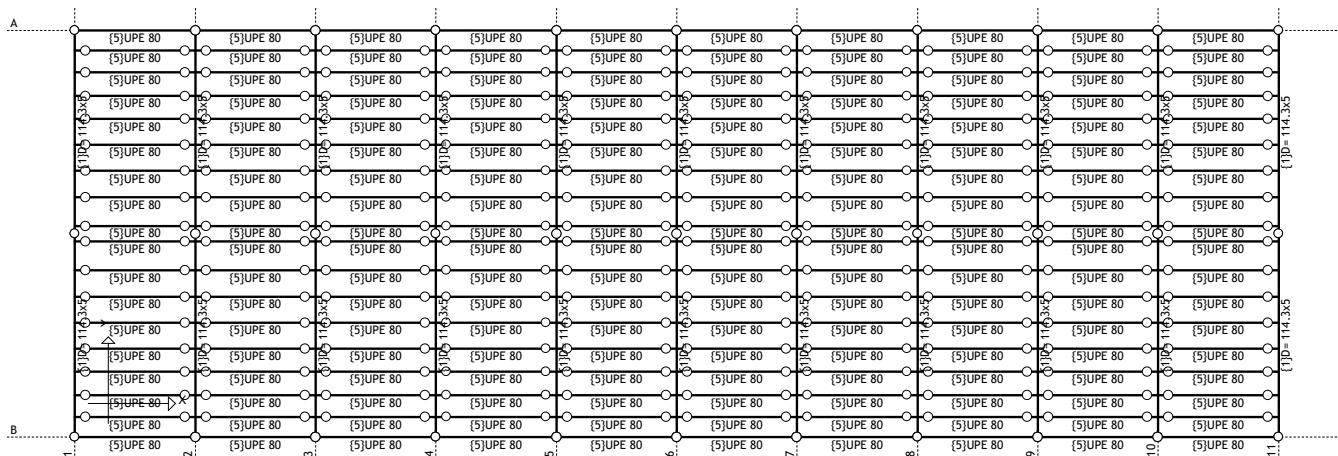
| Mat.      | A1       | A2       | A3       | I1       | I2       | I3       |
|-----------|----------|----------|----------|----------|----------|----------|
| 1 - Stahl | 1.007e-3 | 3.200e-4 | 7.000e-4 | 1.271e-8 | 2.539e-7 | 1.072e-6 |



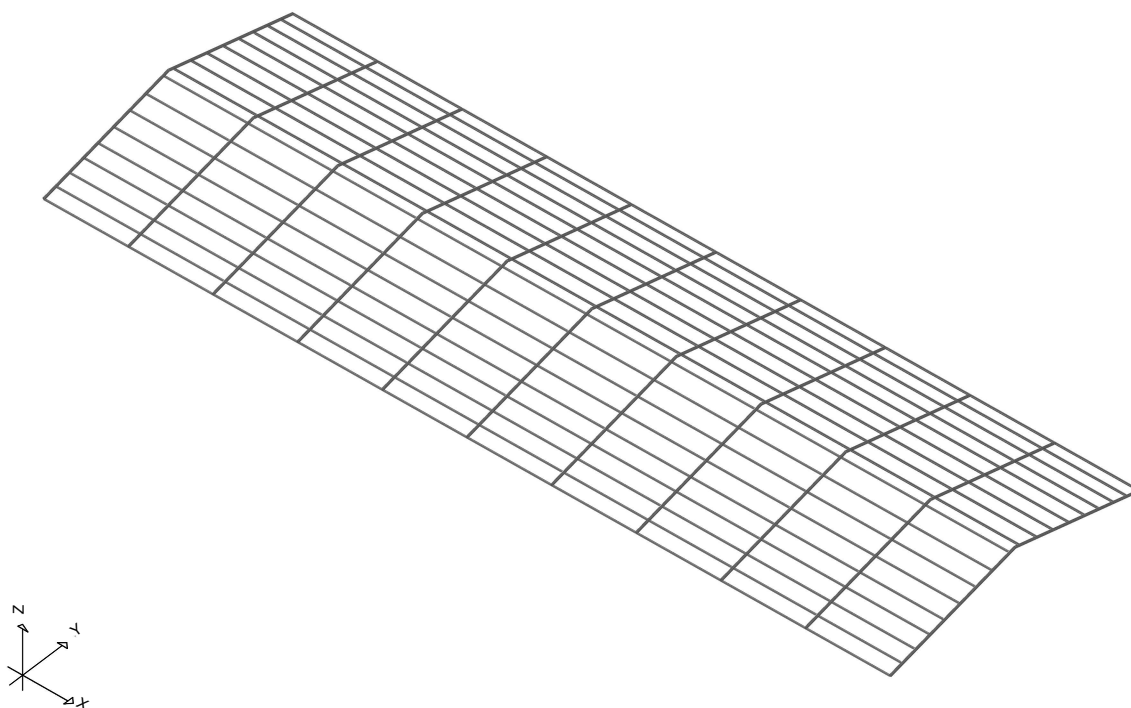
[cm]

### Point support sets

| Set | K,R1      | K,R2      | K,R3      | K,M1      | K,M2      | K,M3 |
|-----|-----------|-----------|-----------|-----------|-----------|------|
| 2   | 1.000e+10 | 1.000e+10 | 1.000e+10 | 1.000e+10 | 1.000e+10 |      |

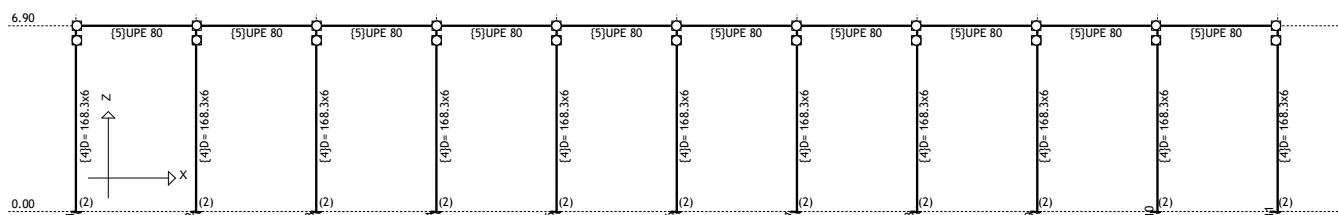
**Input data - Structure**

View: Strecha - Group: Hala SO.02

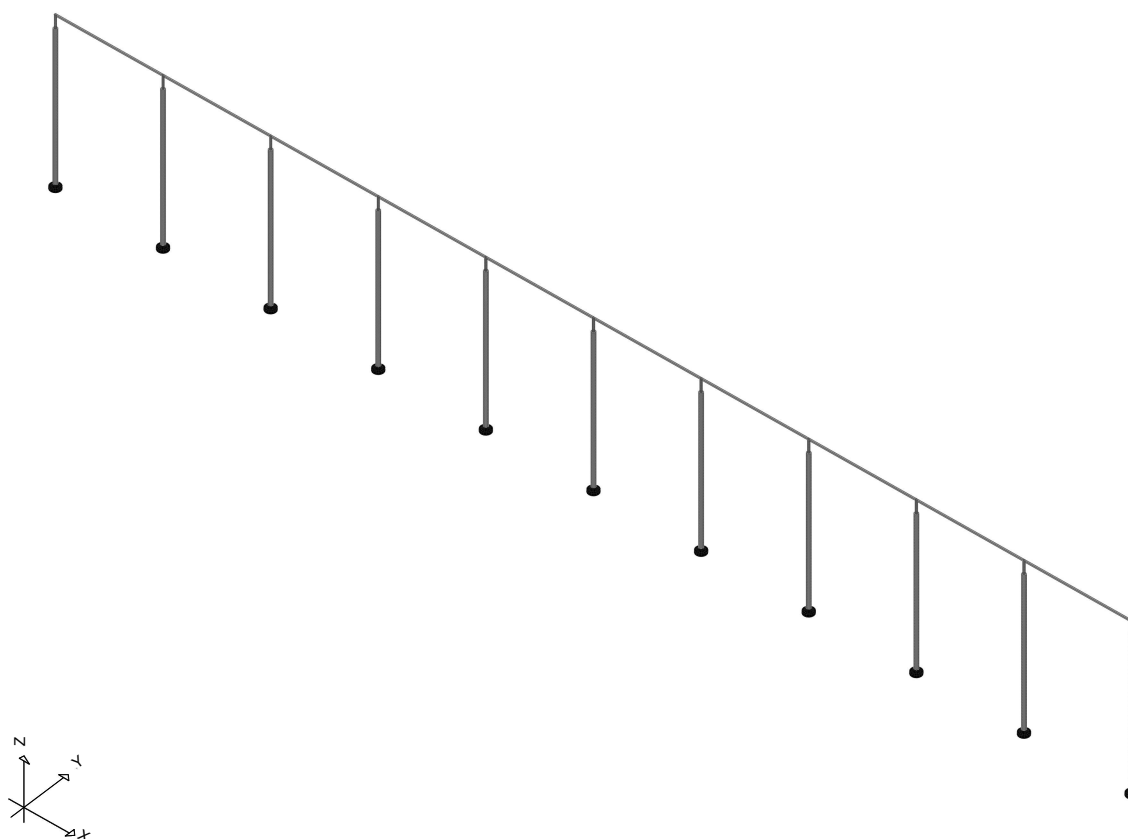


View: Strecha (Group: Hala SO.02)

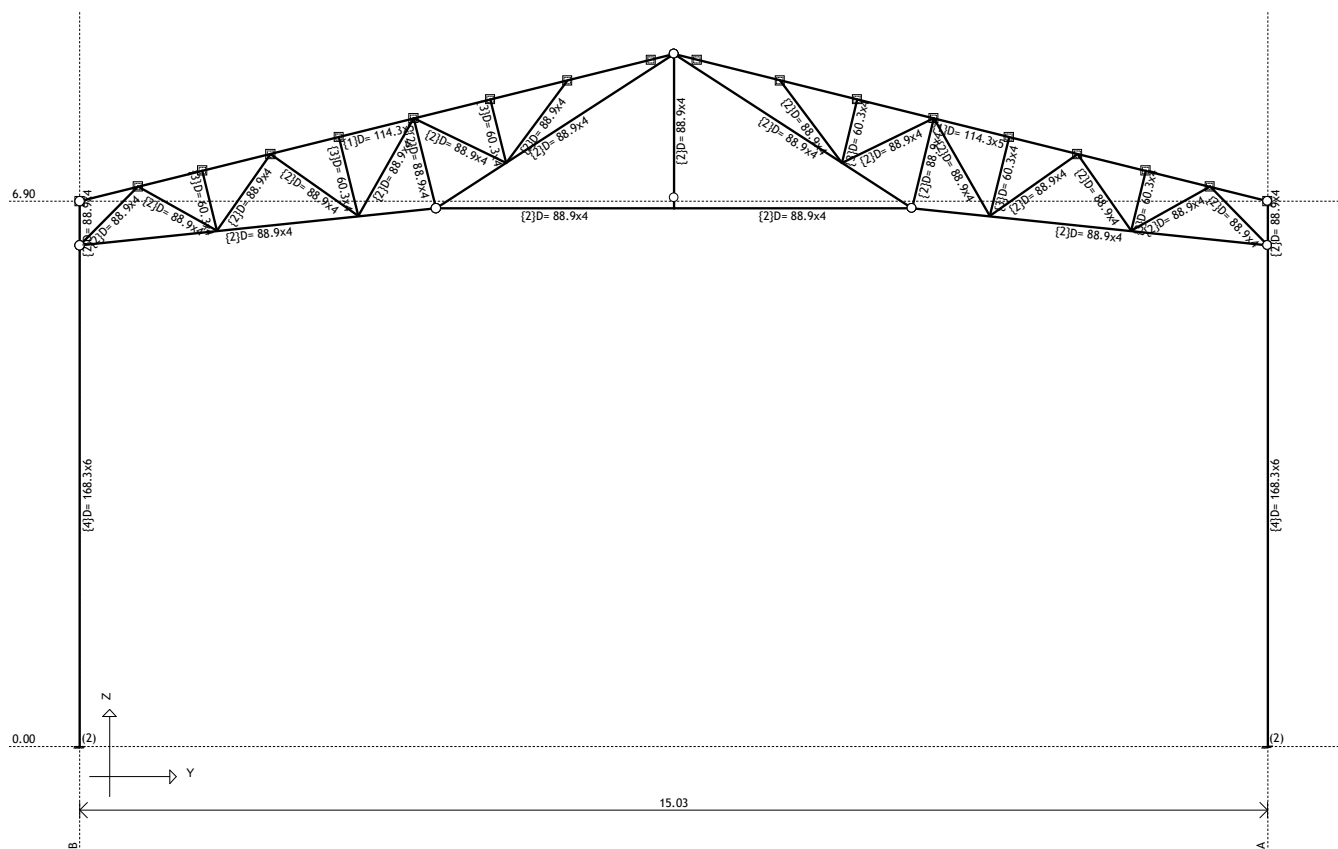
## Input data - Structure



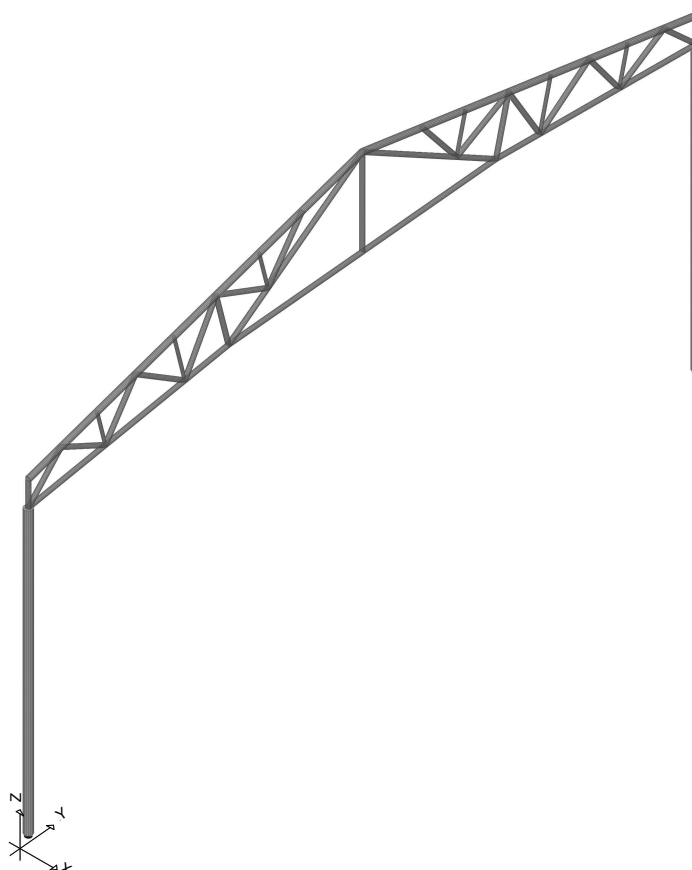
Frame: H 1 - Group: Hala SO.02



Frame: H 1 (Group: Hala SO.02)

**Input data - Structure**

Frame: V 3 - Group: Hala SO.02

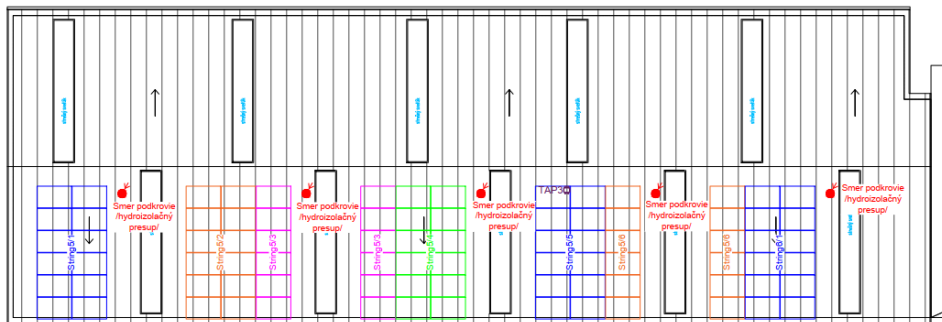


Frame: V 3 (Group: Hala SO.02)

## Input data - Load

### Stále zaťaženia podľa STN EN 1991-1

- Vlastná tiaž nosnej konštrukcie je spočítaná výpočtovým programom
- Stále zaťaženie pôsobiace na konštrukciu tvorí tiaž sendvičových panelov (strešných a stenových), ktorá bola uvažovaná ako hodnota 0,14 kN/m<sup>2</sup>
- Novou zložkou stáleho zaťaženia je tiaž fotovoltických panelov: prírastok 0,20 kN/m<sup>2</sup>

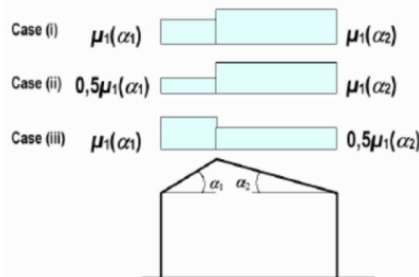


Obr.: Schéma rozmiestnenia panelov na streche objektu (podľa projektu FBB Electric)

### Zaťaženie sedlovej strechy snehom - podľa STN EN 1991-1-3

#### Vstupné údaje:

Sklon strechy: 10 ° (α 1) 10 ° (α 2)  
 Expozícia: normálna (Ce)  
 Snehová oblasť: 1  
 Nadmorská výška miesta stavby: 125 m.n.m (A)



#### Výpočet:

Charakteristické zaťaženie snehom  $s$  pôsobiace na strechu:

$$s_{sk} := \mu_1 \cdot C_e \cdot C_t \cdot s_k$$

$\mu$  - tvarový súčiniteľ zaťaženia snehom (STN EN 1991-1-3)

$$\mu_1 \alpha_1 = 0.80 \quad \mu_1 \alpha_2 = 0.80$$

$C_e$  - súčiniteľ podmienok expozície (STN EN 1991-1-3)

$$C_e = 1.00$$

$C_t$  - teplotný súčiniteľ (STN EN 1991-1-3)

$$C_t = 1.00$$

$s_k$  - charakteristická hodnota zaťaženia snehom na povrchu zeme (kN/m<sup>2</sup>) (STN EN 1991-1-3)

$$a = 0.454$$

$$A = 125$$

$$b = 970$$

$$s_k := a + \frac{A}{b}$$

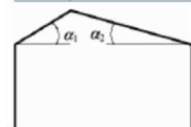
$$s_k = 0.58 \quad \text{kN/m}^2$$

Charakteristické zaťaženie snehom  $s$  pôsobiace na strechu:  $s_{sk} := \mu_1 \cdot C_e \cdot C_t \cdot s_k$

$$s_{I\mu_1\alpha_1} := \mu_{1\alpha_1} \cdot C_e \cdot C_t \cdot s_k \quad 0.466 \quad \text{kN/m}^2 \quad s_{I\mu_1\alpha_2} := \mu_{1\alpha_2} \cdot C_e \cdot C_t \cdot s_k \quad 0.466 \quad \text{kN/m}^2$$

$$s_{II\mu_1\alpha_1} := 0.5\mu_{1\alpha_1} \cdot C_e \cdot C_t \cdot s_k \quad 0.233 \quad \text{kN/m}^2 \quad s_{II\mu_1\alpha_2} := \mu_{1\alpha_2} \cdot C_e \cdot C_t \cdot s_k \quad 0.233 \quad \text{kN/m}^2$$

$$s_{III\mu_1\alpha_1} := \mu_{1\alpha_1} \cdot C_e \cdot C_t \cdot s_k \quad 0.466 \quad \text{kN/m}^2 \quad s_{III\mu_1\alpha_2} := 0.5\mu_{1\alpha_2} \cdot C_e \cdot C_t \cdot s_k \quad 0.233 \quad \text{kN/m}^2$$



**Input data - Load****Governing load - EC2 (EN 1992-1-1:2004)**

LFK für Gebäude

**Load Case**

I vl. + st. (g) - <Permanent>(long-term)  
II sn. - <Snow - <= 1000 m>(short-term)  
III w.y - <Wind>(short-term)

09. [PT] 1.35×I  
10. [PT] I+II+0.60×III  
11. [PT] I+0.50×II+III  
12. [PT] I+III  
13. [PT] I+II  
14. [PT] I+0.20×III  
15. [PT] I+0.20×II  
16. [PT] I

**Partial factors for materials**[PT] Persistent and Transient:  $\gamma_C = 1.50$ ,  $\gamma_S = 1.15$ [SE] Seismic combinations:  $\gamma_C = 1.50$ ,  $\gamma_S = 1.15$ [AC] Accidental:  $\gamma_C = 1.20$ ,  $\gamma_S = 1.00$ **Combinations for fissure and deflection calculation**

(characteristic combinations - long-term)

1. I  
2. I  
3. I  
4. I  
5. I

**User-defined load combinations**

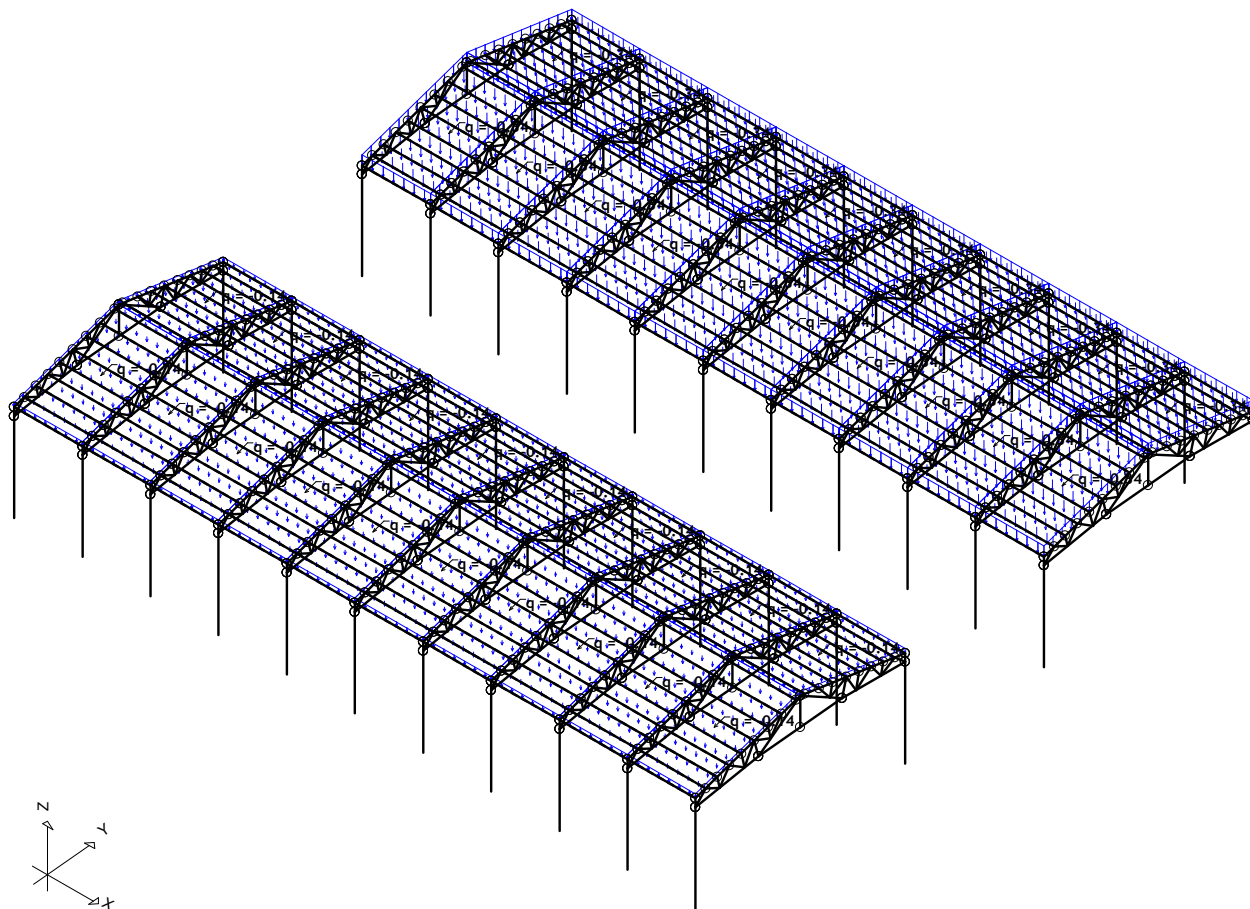
01. [PT] 1.35×I+1.50×II+0.90×III  
02. [PT] 1.35×I+0.75×II+1.50×III  
03. [PT] I+1.50×II+0.90×III  
04. [PT] I+0.75×II+1.50×III  
05. [PT] 1.35×I+1.50×III  
06. [PT] 1.35×I+1.50×II  
07. [PT] I+1.50×III  
08. [PT] I+1.50×II

(characteristic combinations - short-term)

1. II+0.60×III  
2. 0.50×II+III  
3. III  
4. II  
5. ---

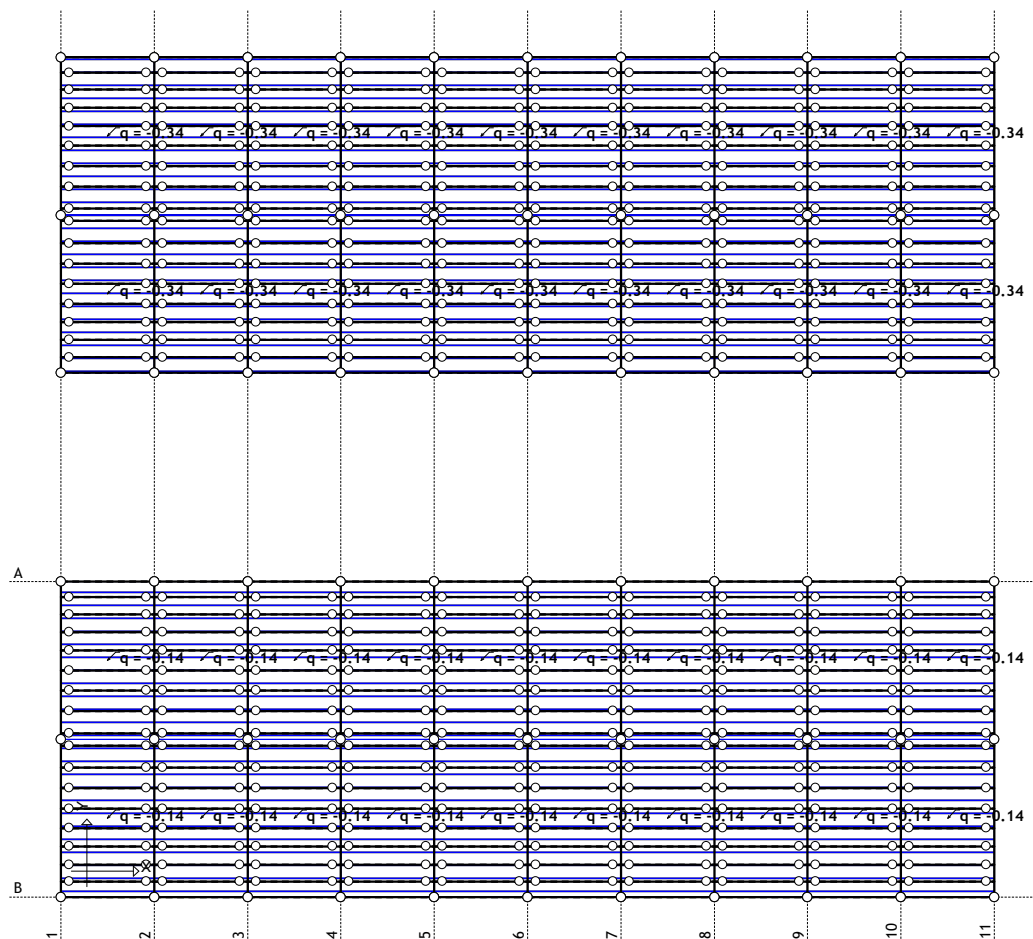
**Input data - Load**

Load 1: vl. + st. (g)



Isometric

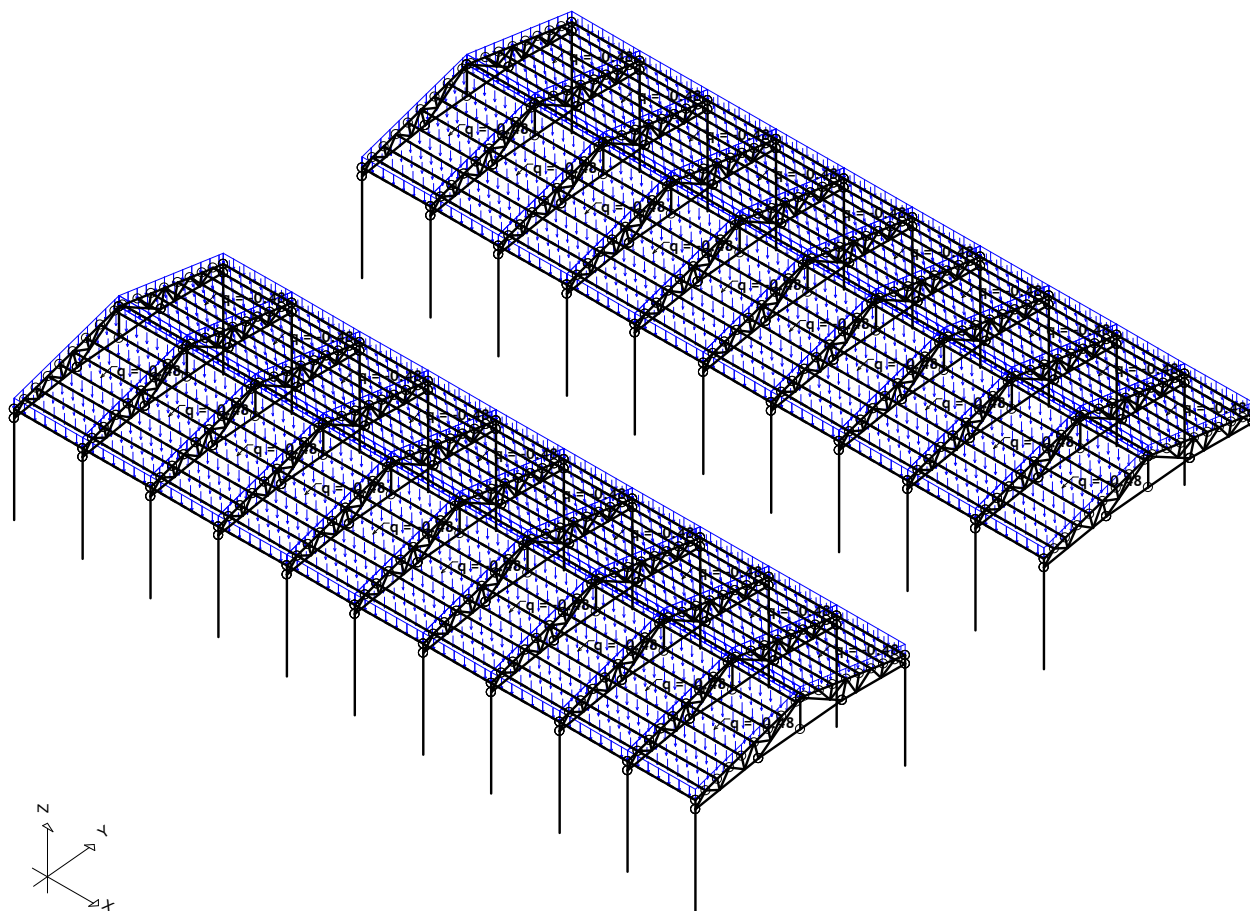
Load 1: vl. + st. (g)



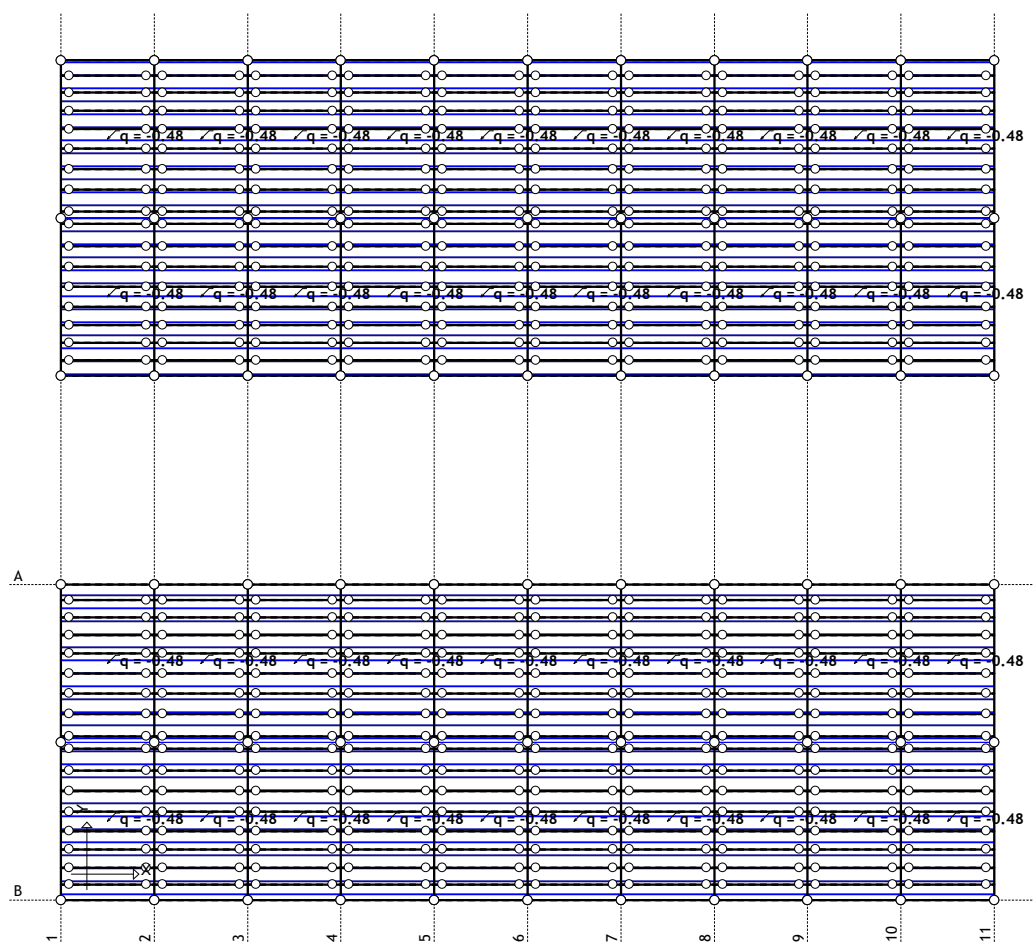
View: Strecha

### Input data - Load

Load 2: sn.



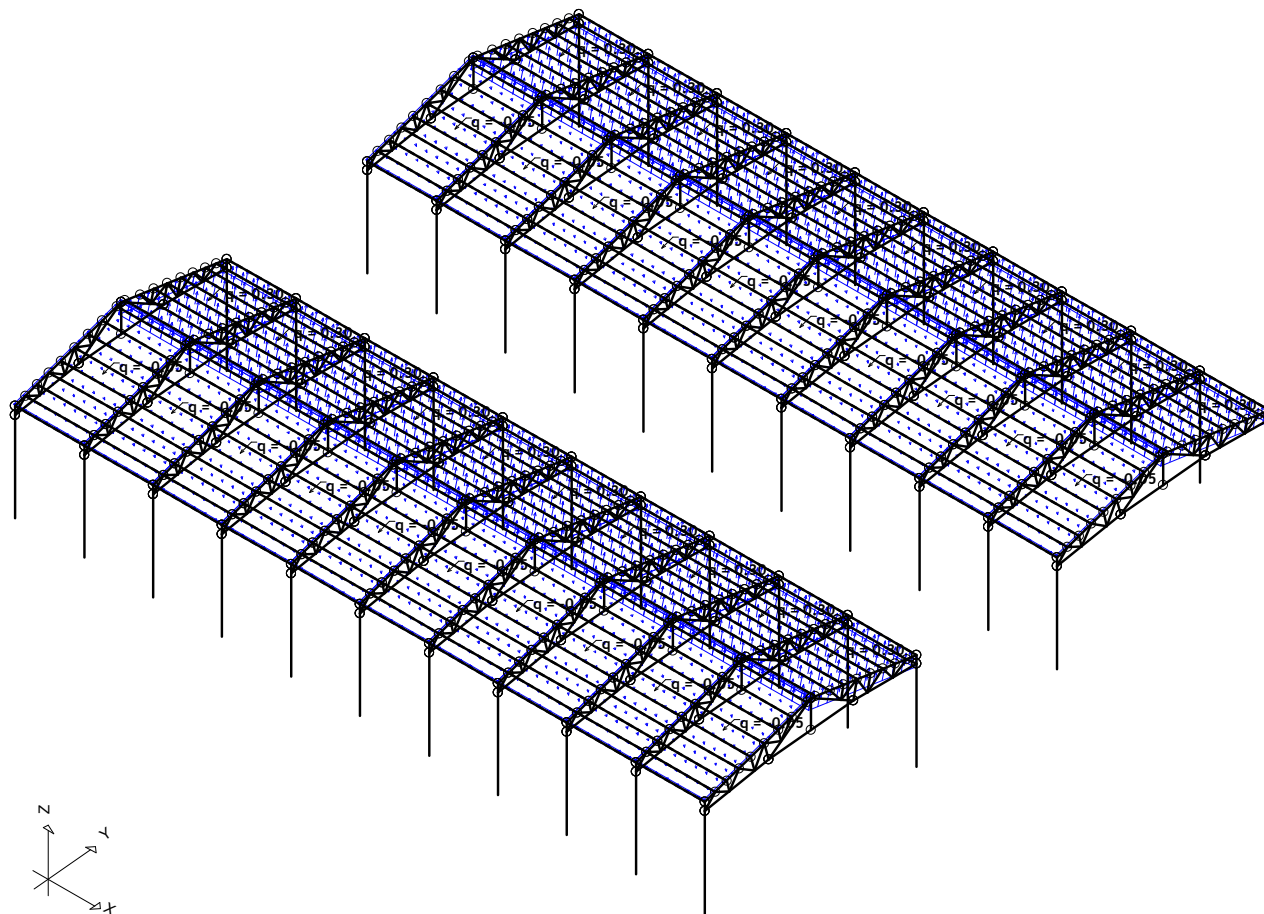
|             |
|-------------|
| Isometric   |
| Load 2: sn. |



View: Strecha

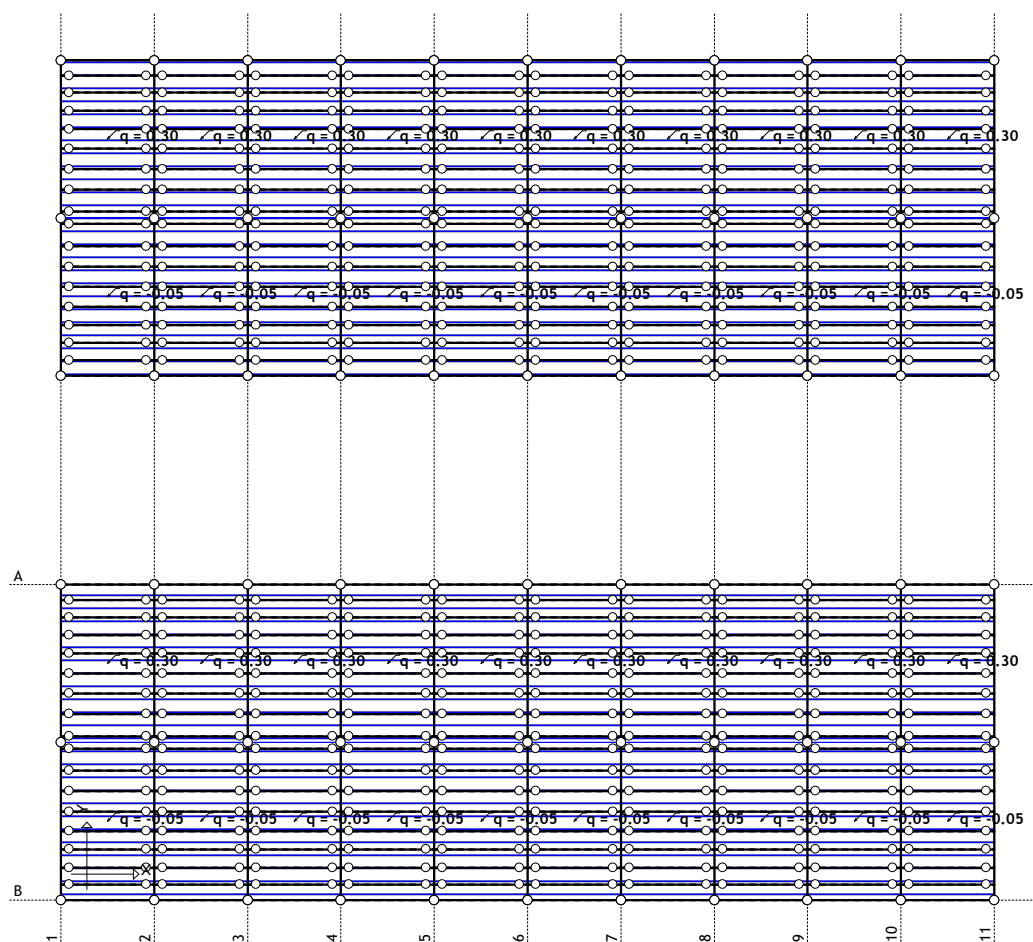
**Input data - Load**

Load 3: w.y



Isometric

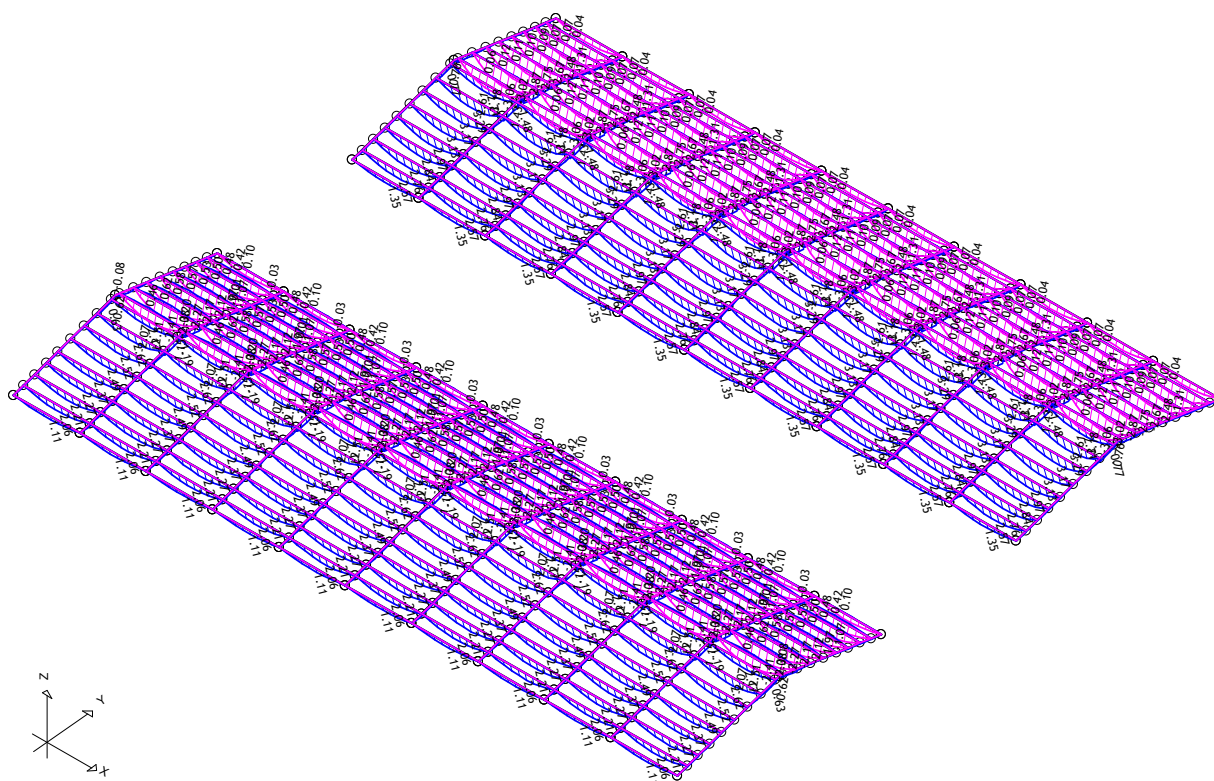
Load 3: w.y



View: Strecha

## Strecha

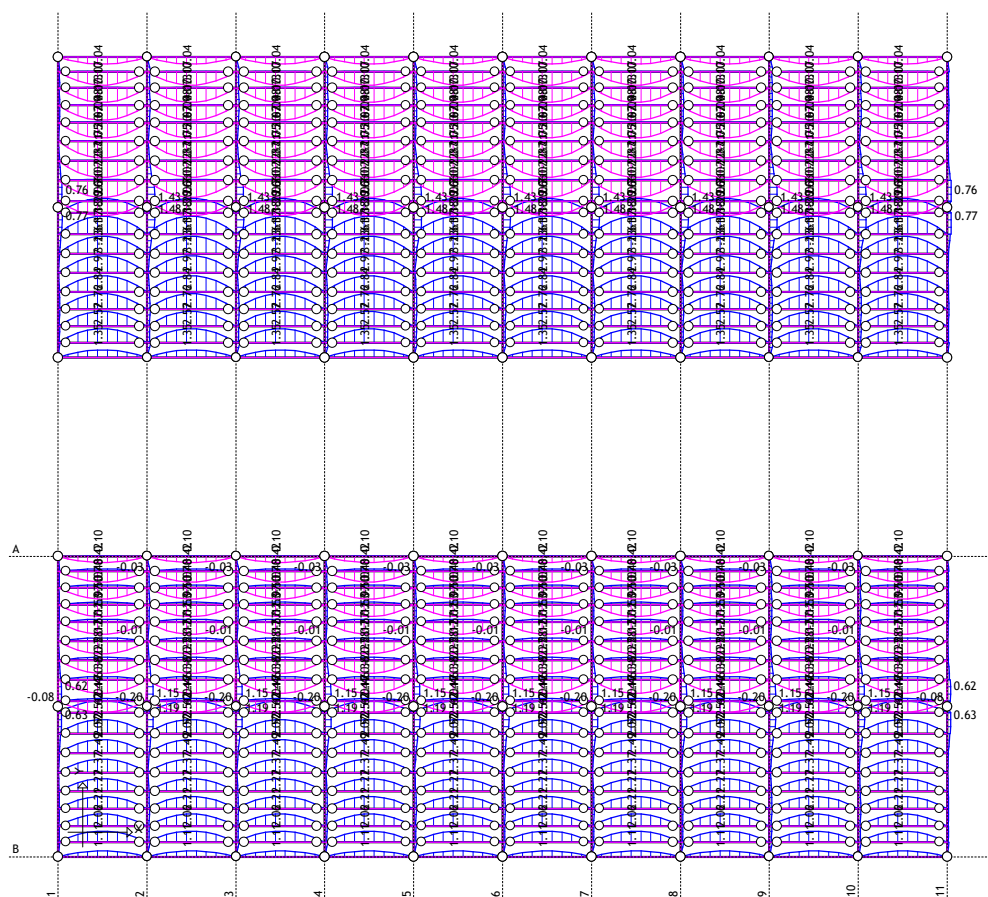
Load 20: [ULS] 4-12



View: Strecha

Beam Results: max M3= 3.29 / min M3= -3.18 kNm

|                     |
|---------------------|
| Load 20: [ULS] 4-12 |
|---------------------|

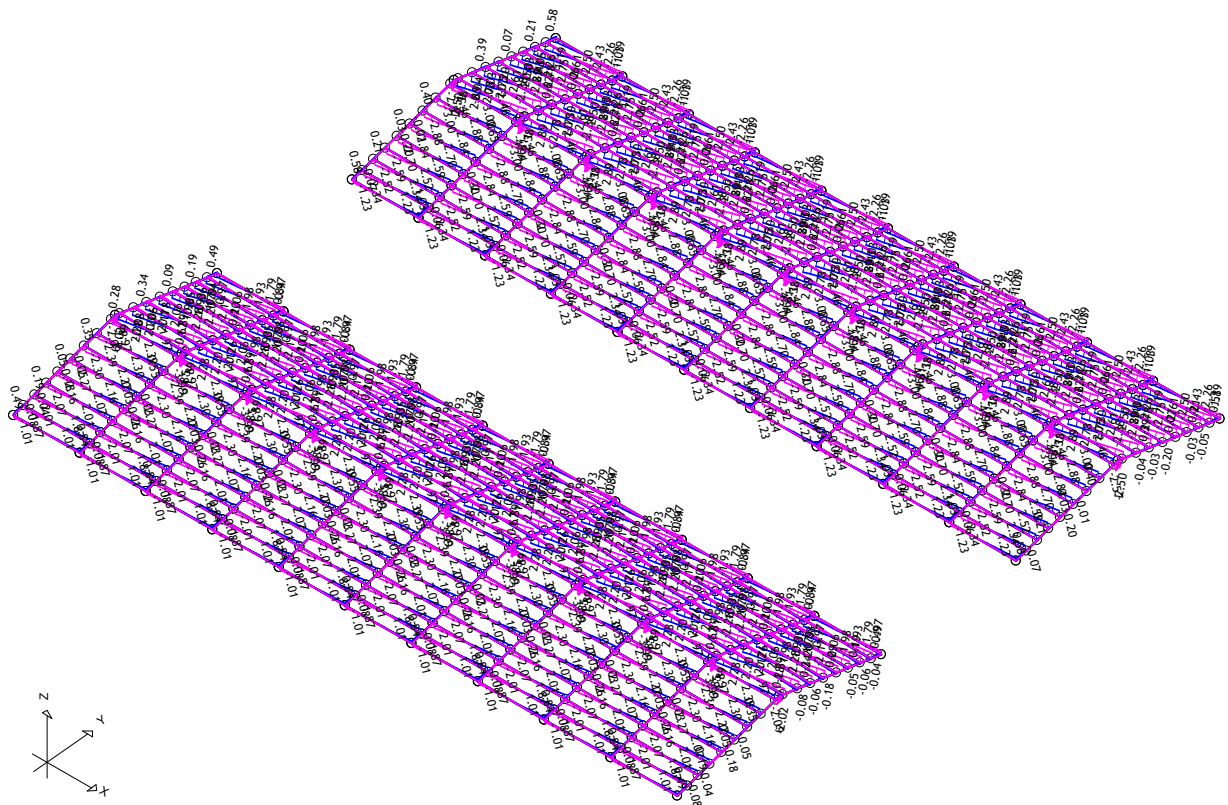


View: Strecha

Beam Results: max M3= 3.29 / min M3= -3.18 kNm

**Strecha**

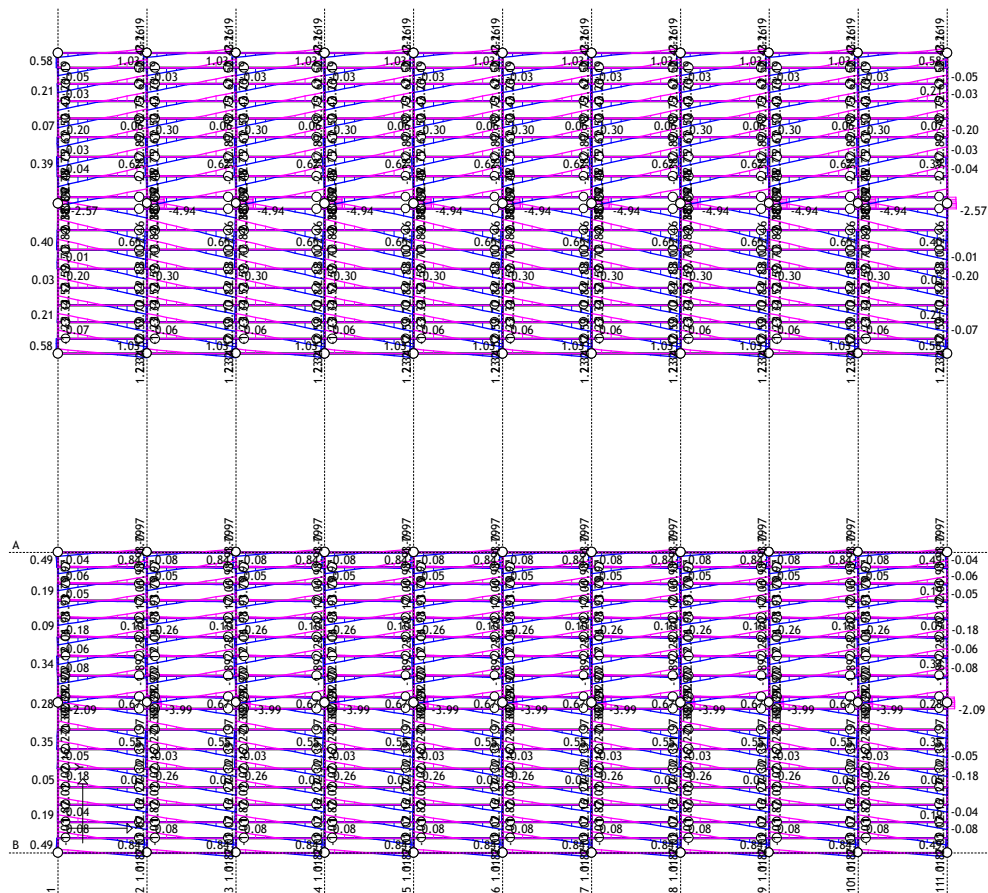
Load 20: [ULS] 4-12



View: Strecha

Beam Results: max V2= 3.00 / min V2= -4.94 kN

Load 20: [ULS] 4-12

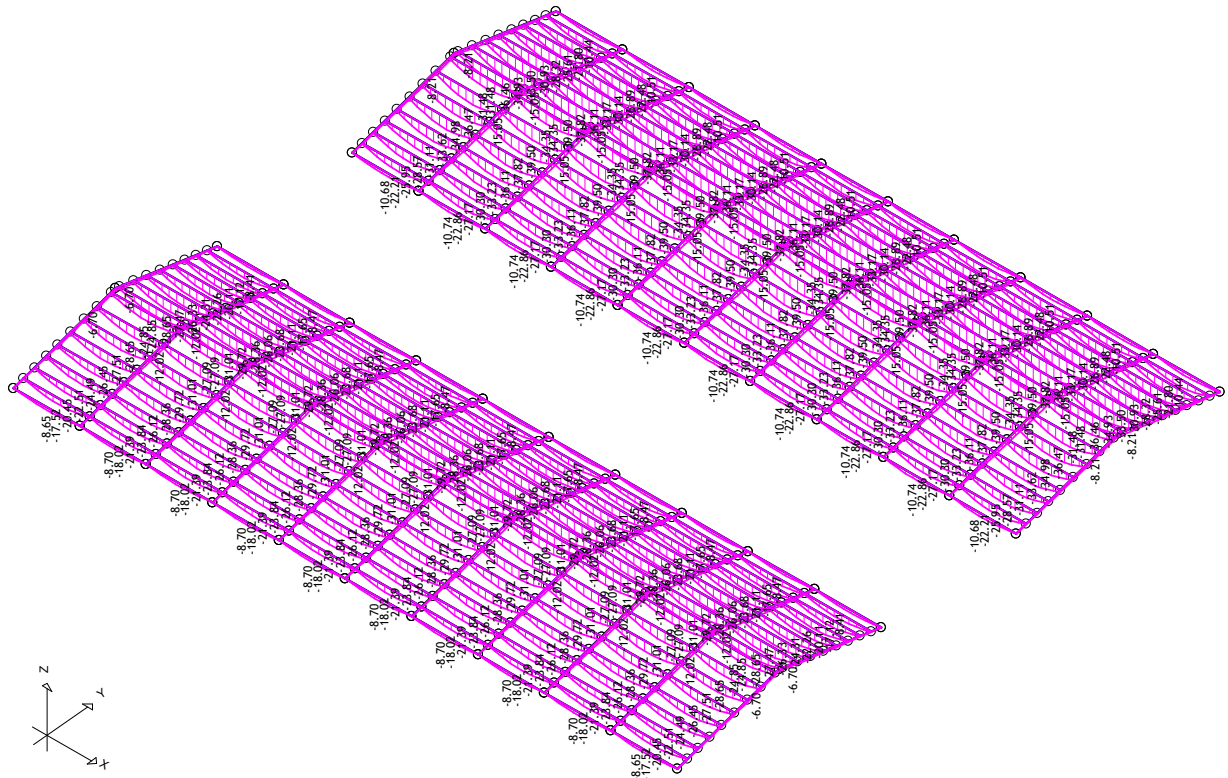


View: Strecha

Beam Results: max V2= 3.00 / min V2= -4.94 kN

## Strecha

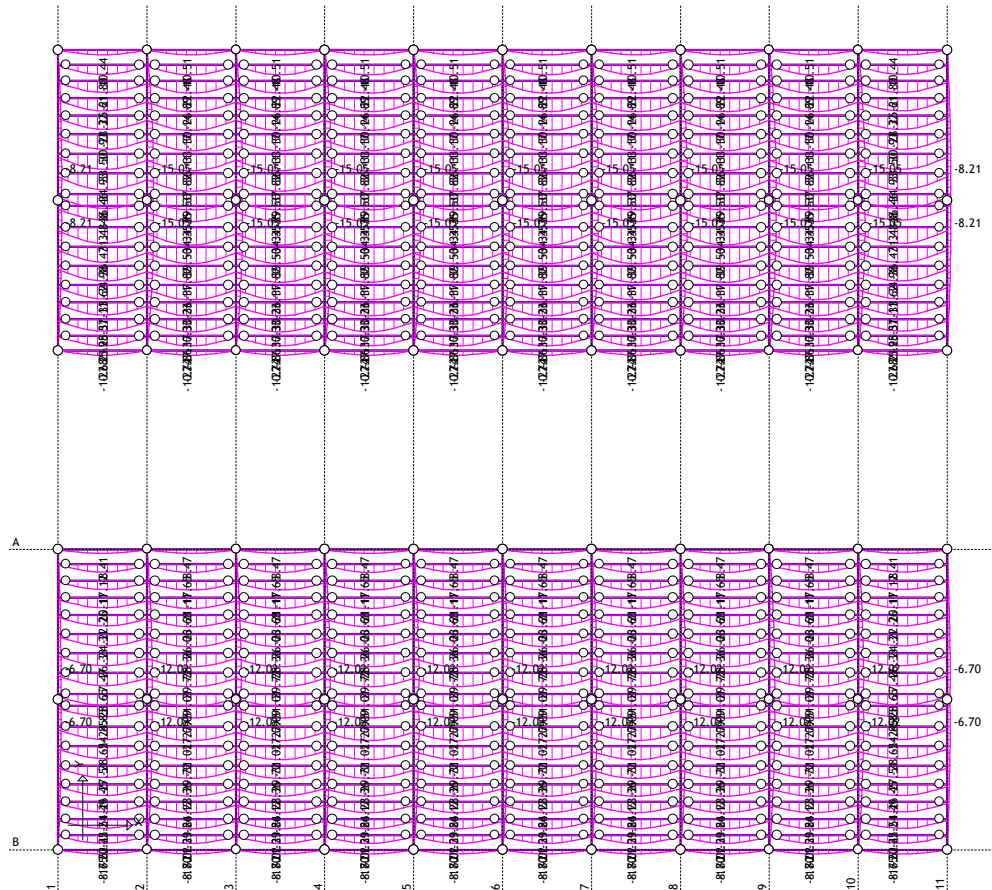
Load 21: [SLS\_perm] 13-16



View: Strecha

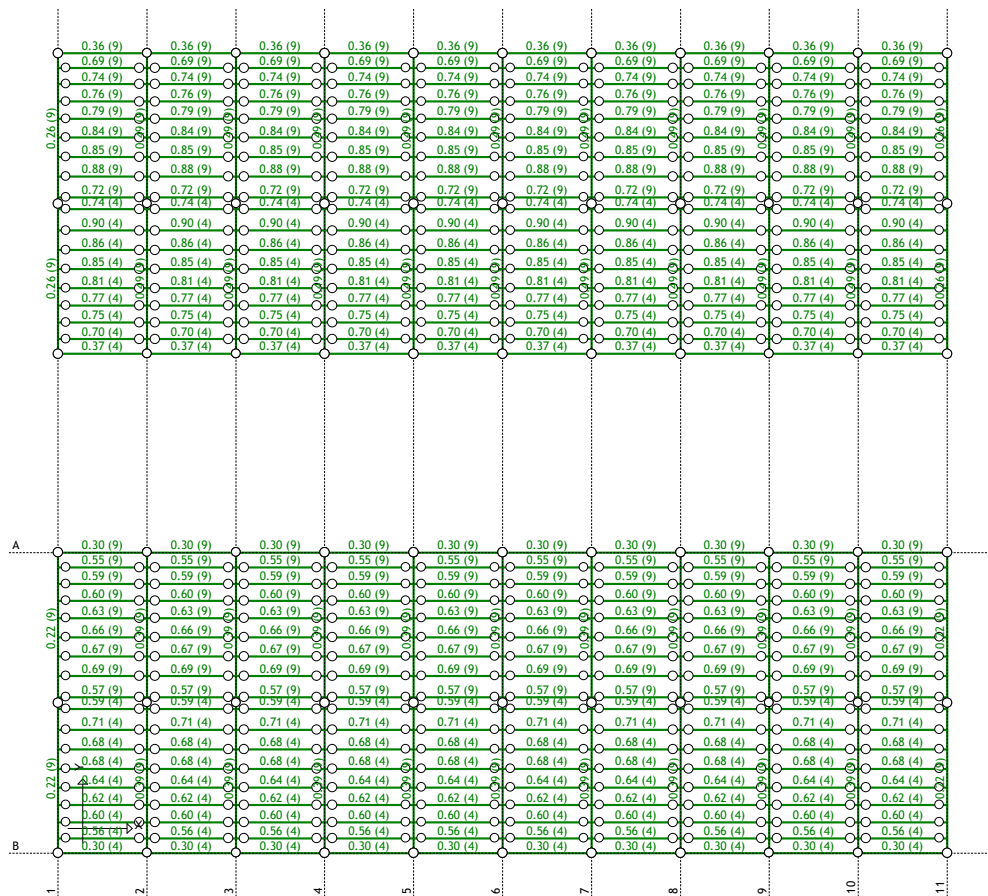
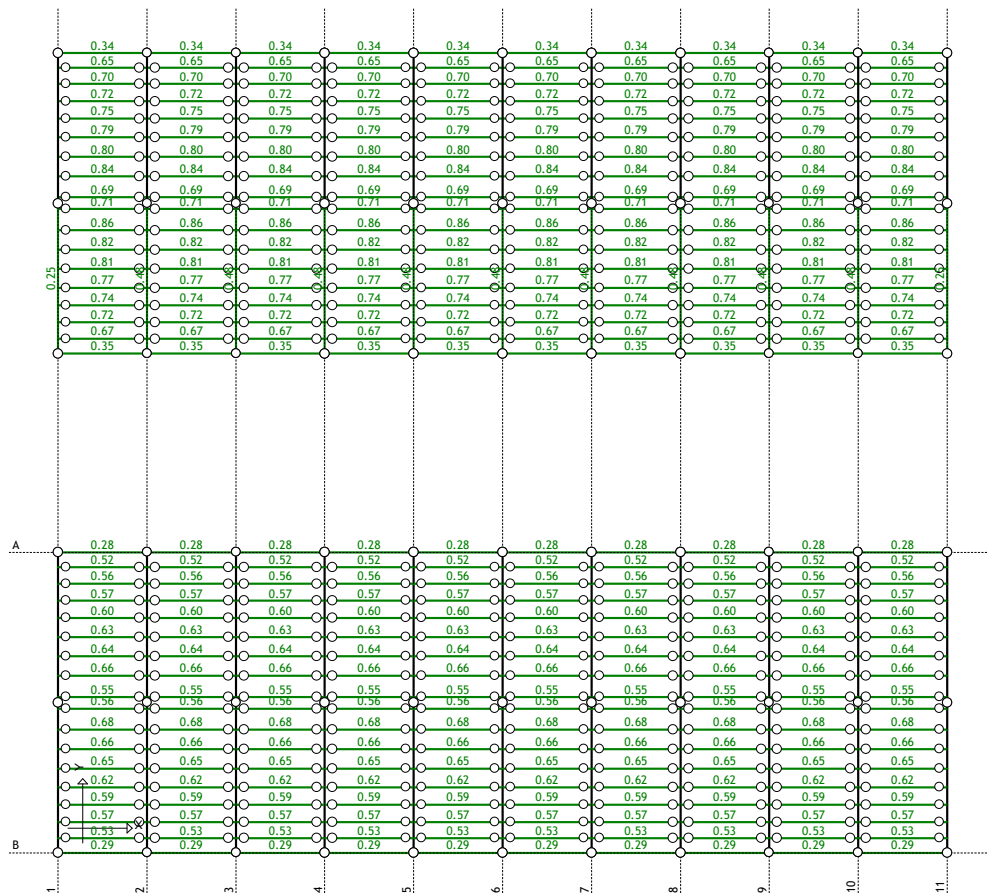
Beam Results: max Zd= -0.04 / min Zd= -39.50 m / 1000

Load 21: [SLS\_perm] 13-16



View: Strecha

Beam Results: max Zd= -0.04 / min Zd= -39.50 m / 1000

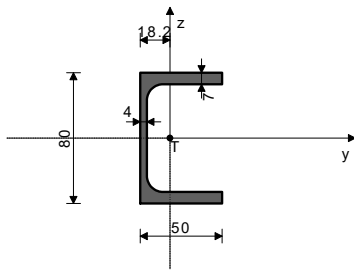
**Strecha**View: Strecha  
Stress controlView: Strecha  
Stability control

## Strecha

### BEAM 551-504

CROSS-SECTION: UPE 80 [S 235] [Set: 5]  
EUROCODE 3 (EN 1993-1-1:2005)

#### CROSS-SECTION PROPERTIES



|          |                        |
|----------|------------------------|
| Ax =     | 10.069 cm <sup>2</sup> |
| Ay =     | 7.000 cm <sup>2</sup>  |
| Az =     | 3.200 cm <sup>2</sup>  |
| Ix =     | 1.271 cm <sup>4</sup>  |
| Iy =     | 107.17 cm <sup>4</sup> |
| Iz =     | 25.388 cm <sup>4</sup> |
| Wy =     | 26.791 cm <sup>3</sup> |
| Wz =     | 7.984 cm <sup>3</sup>  |
| Wy,pl =  | 29.906 cm <sup>3</sup> |
| Wz,pl =  | 13.577 cm <sup>3</sup> |
| γM0 =    | 1.000                  |
| γM1 =    | 1.000                  |
| γM2 =    | 1.250                  |
| Anet/A = | 1.000                  |

[mm]

(fy = 23.5 kN/cm<sup>2</sup>, fu = 36.0 kN/cm<sup>2</sup>)

#### UTILISATION FACTORS FOR ALL LOAD CASE COMBINATIONS

|            |            |            |
|------------|------------|------------|
| 4. γ=0.82  | 9. γ=0.80  | 6. γ=0.73  |
| 11. γ=0.71 | 5. γ=0.61  | 13. γ=0.58 |
| 16. γ=0.56 | 7. γ=0.52  | 14. γ=0.44 |
| 8. γ=0.39  | 12. γ=0.35 | 18. γ=0.32 |
| 10. γ=0.30 | 15. γ=0.28 | 17. γ=0.27 |
| 19. γ=0.26 |            |            |

#### MEMBER SUBJECT TO BENDING

(load 4, at 202.3 cm from the start of the member)

|                                   |                     |            |
|-----------------------------------|---------------------|------------|
| The shear force design value(y-y) | V <sub>Ed,y</sub> = | 0.063 kN   |
| The shear force design value(z-z) | V <sub>Ed,z</sub> = | -0.262 kN  |
| The bending mom.design value(y-y) | M <sub>Ed,y</sub> = | 3.166 kNm  |
| The bending mom.design value(z-z) | M <sub>Ed,z</sub> = | -0.757 kNm |
| System length                     | L =                 | 445.00 cm  |

#### 5.5 CLASSIFICATION OF CROSS-SECTIONS

Class 1 cross-sections

#### 6.2 RESISTANCE OF CROSS-SECTIONS

##### 6.2.5 Bending about the y-y axis

|                              |                     |                        |
|------------------------------|---------------------|------------------------|
| Plastic section modulus      | Wy,pl =             | 29.906 cm <sup>3</sup> |
| The design moment resistance | M <sub>c,Rd</sub> = | 7.028 kNm              |

**Requirement 6.12: M<sub>Ed,y</sub> ≤ M<sub>c,Rd,y</sub> (3.17 ≤ 7.03)**

##### 6.2.5 Bending about the z-z axis

|                              |                     |                        |
|------------------------------|---------------------|------------------------|
| Plastic section modulus      | Wz,pl =             | 13.577 cm <sup>3</sup> |
| The design moment resistance | M <sub>c,Rd</sub> = | 3.191 kNm              |

**Requirement 6.12: M<sub>Ed,z</sub> ≤ M<sub>c,Rd,z</sub> (0.76 ≤ 3.19)**

##### 6.2.6 Shear

|                         |                        |           |
|-------------------------|------------------------|-----------|
| Design shear resistance | V <sub>pl,Rd,z</sub> = | 43.417 kN |
| Design shear resistance | V <sub>c,Rd,z</sub> =  | 43.417 kN |

**Requirement 6.17: V<sub>Ed,z</sub> ≤ V<sub>c,Rd,z</sub> (0.26 ≤ 43.42)**

|                         |                        |           |
|-------------------------|------------------------|-----------|
| Design shear resistance | V <sub>pl,Rd,y</sub> = | 94.974 kN |
| Design shear resistance | V <sub>c,Rd,y</sub> =  | 94.974 kN |

**Requirement 6.17: V<sub>Ed,y</sub> ≤ V<sub>c,Rd,y</sub> (0.06 ≤ 94.97)**

##### 6.2.8 Bending and shear

No reduction need be made in the resistance moment

Requirement: V<sub>Ed,z</sub> ≤ 50%V<sub>pl,Rd,z</sub> ; V<sub>Ed,y</sub> ≤ 50%V<sub>pl,Rd,y</sub>

#### 6.2.9 Bending and axial force

Ratio M<sub>Ed,y</sub> / M<sub>pl,Rd,y</sub> 0.451Ratio M<sub>Ed,z</sub> / M<sub>pl,Rd,z</sub> 0.237**Requirement 6.41: (0.69 ≤ 1)**

#### 6.3 BUCKLING RESISTANCE OF MEMBERS

##### 6.3.2.1 Buckling resistance

|                                      |                     |                        |
|--------------------------------------|---------------------|------------------------|
| Coefficient                          | C1 =                | 0.972                  |
| Coefficient                          | C2 =                | 0.304                  |
| Coefficient                          | C3 =                | 0.980                  |
| The eff.length fact.for later.restr. | k =                 | 0.500                  |
| The eff.length fact.for tors.restr.  | kw =                | 1.000                  |
| Coordinate                           | zg =                | 0.000 cm               |
| Coordinate                           | zj =                | 0.000 cm               |
| Length between lateral restr.points  | L =                 | 200.00 cm              |
| The warping constant                 | Iw =                | 269.04 cm <sup>6</sup> |
| The elast.crit.mom.(lt buck.)        | M <sub>cr</sub> =   | 24.078 kNm             |
| Appropriate section modulus          | W <sub>y</sub> =    | 29.906 cm <sup>3</sup> |
| The imperfection factor              | α <sub>LT</sub> =   | 0.760                  |
| The non-dimensional slenderness      | λ <sub>LT</sub> =   | 0.540                  |
| The reduction factor (6.3.2.2.)      | χ <sub>LT</sub> =   | 0.751                  |
| The design buckling resistance       | M <sub>b,Rd</sub> = | 5.279 kNm              |

**Requirement 6.54: M<sub>Ed,y</sub> ≤ M<sub>b,Rd</sub> (3.17 ≤ 5.28)**

##### 6.3.3 Uniform members in bending and axial compression

Values of interaction factors obtained from Annex B (alternative method 2)

|                                    |                    |       |
|------------------------------------|--------------------|-------|
| The equiv.unif.mom.fact.flex.buck. | C <sub>my</sub> =  | 0.950 |
| The equiv.unif.mom.fact.flex.buck. | C <sub>mz</sub> =  | 0.950 |
| The equiv.unif.mom.fact.flex.buck. | C <sub>mLT</sub> = | 0.950 |
| Interaction factors                | k <sub>yy</sub> =  | 0.950 |
| Interaction factors                | k <sub>yz</sub> =  | 0.570 |
| Interaction factors                | k <sub>zy</sub> =  | 1.000 |
| Interaction factors                | k <sub>zz</sub> =  | 0.950 |

k<sub>yy</sub> \* (M<sub>yEd</sub> + ΔM<sub>yEd</sub>) / ... 0.570k<sub>yz</sub> \* (M<sub>zEd</sub> + ΔM<sub>zEd</sub>) / ... 0.135**Requirement 6.61: (0.70 ≤ 1)**k<sub>zy</sub> \* (M<sub>yEd</sub> + ΔM<sub>yEd</sub>) / ... 0.600k<sub>zz</sub> \* (M<sub>zEd</sub> + ΔM<sub>zEd</sub>) / ... 0.225**Requirement 6.62: (0.82 ≤ 1)**

#### Check of the shear resistance

(load 4, at the beginning of the member)

|                                   |                     |           |
|-----------------------------------|---------------------|-----------|
| The shear force design value(y-y) | V <sub>Ed,y</sub> = | 0.689 kN  |
| The shear force design value(z-z) | V <sub>Ed,z</sub> = | -2.882 kN |
| System length                     | L =                 | 445.00 cm |

#### 6.2 RESISTANCE OF CROSS-SECTIONS

##### 6.2.6 Shear

|                         |                        |           |
|-------------------------|------------------------|-----------|
| Design shear resistance | V <sub>pl,Rd,z</sub> = | 43.417 kN |
| Design shear resistance | V <sub>c,Rd,z</sub> =  | 43.417 kN |

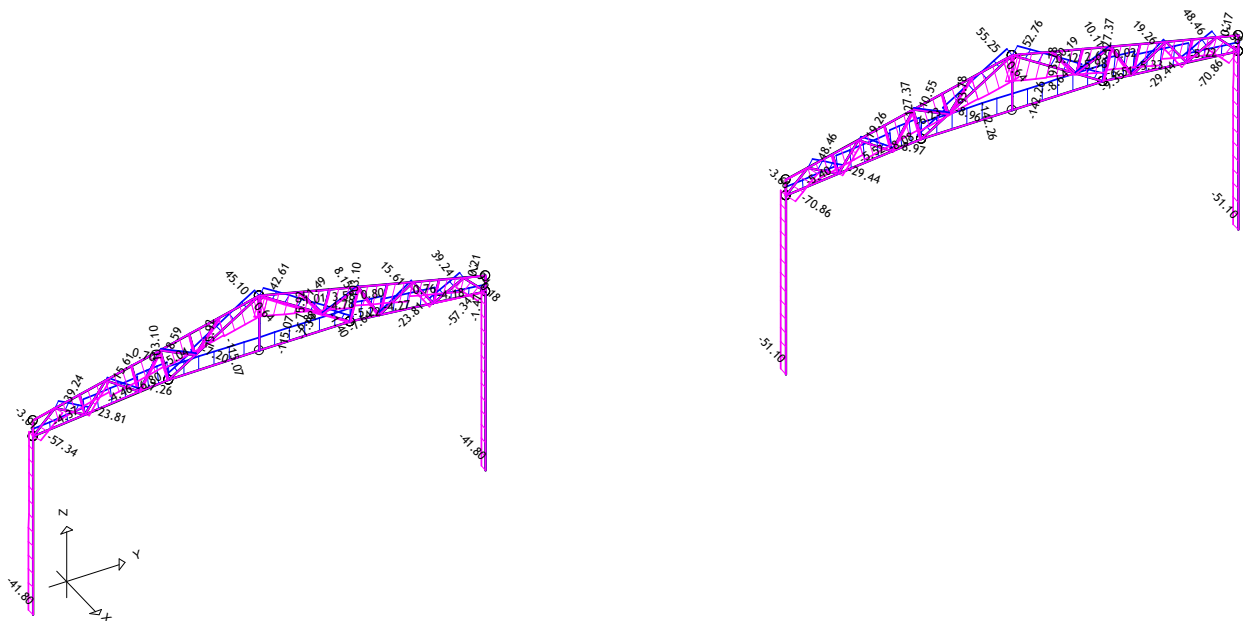
**Requirement 6.17: V<sub>Ed,z</sub> ≤ V<sub>c,Rd,z</sub> (2.88 ≤ 43.42)**

|                         |                        |           |
|-------------------------|------------------------|-----------|
| Design shear resistance | V <sub>pl,Rd,y</sub> = | 94.974 kN |
| Design shear resistance | V <sub>c,Rd,y</sub> =  | 94.974 kN |

**Requirement 6.17: V<sub>Ed,y</sub> ≤ V<sub>c,Rd,y</sub> (0.69 ≤ 94.97)**

**Rám V3**

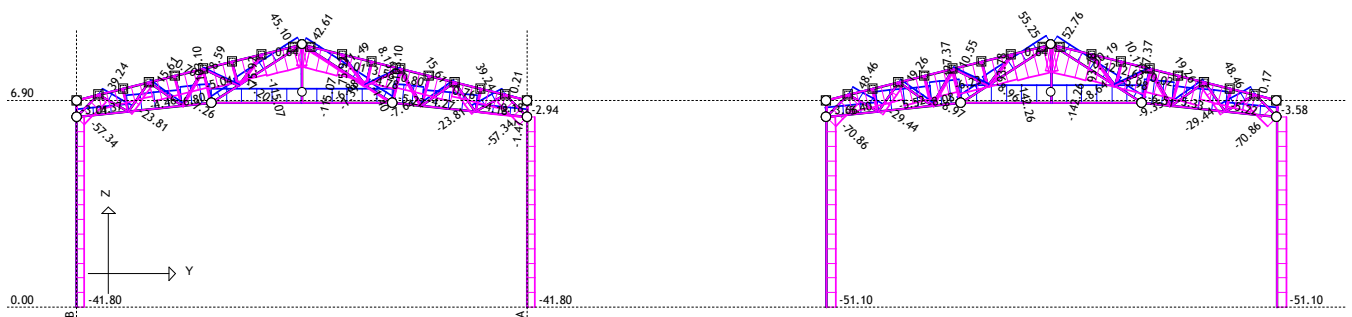
Load 20: [ULS] 4-12



Frame: V\_3

Beam Results: max N1= 127.37 / min N1= -142.26 kN

Load 20: [ULS] 4-12

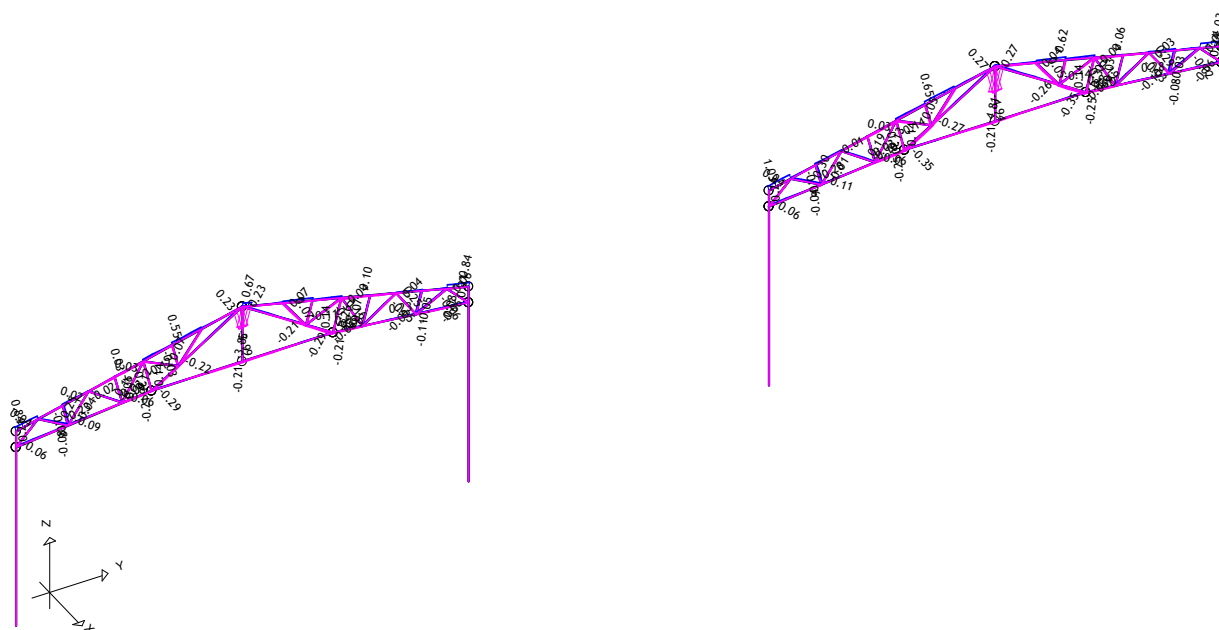


Frame: V\_3

Beam Results: max N1= 127.37 / min N1= -142.26 kN

**Rám V3**

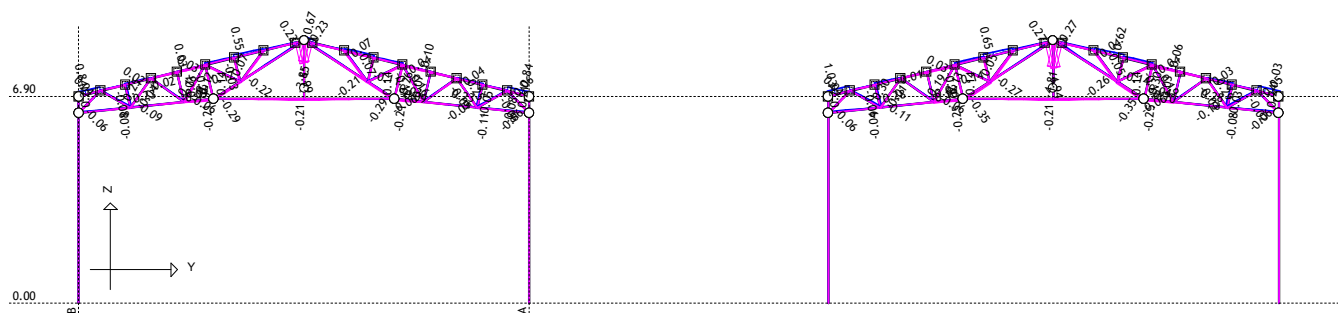
Load 20: [ULS] 4-12



Frame: V\_3

Beam Results: max V2= 1.03 / min V2= -4.94 kN

Load 20: [ULS] 4-12

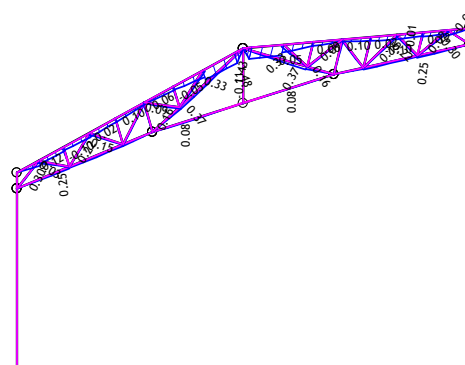
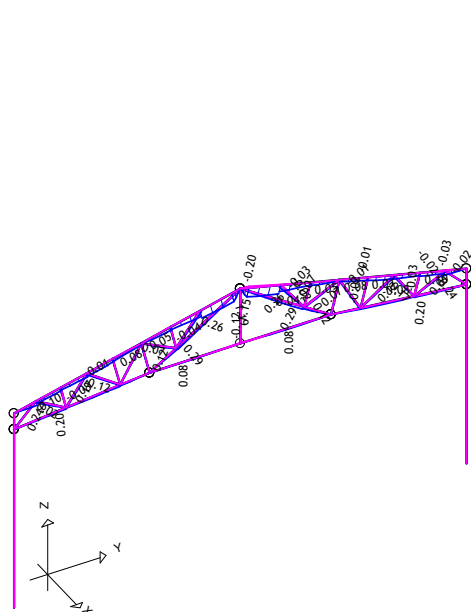


Frame: V\_3

Beam Results: max V2= 1.03 / min V2= -4.94 kN

**Rám V3**

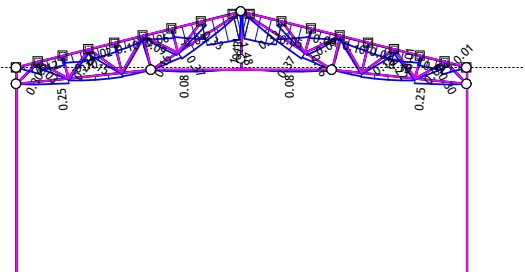
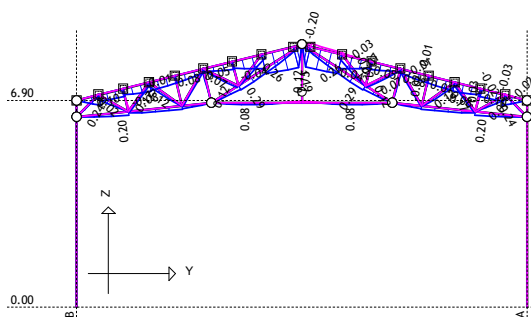
Load 20: [ULS] 4-12



Frame: V\_3

Beam Results: max M3= 1.48 / min M3= -0.20 kNm

Load 20: [ULS] 4-12

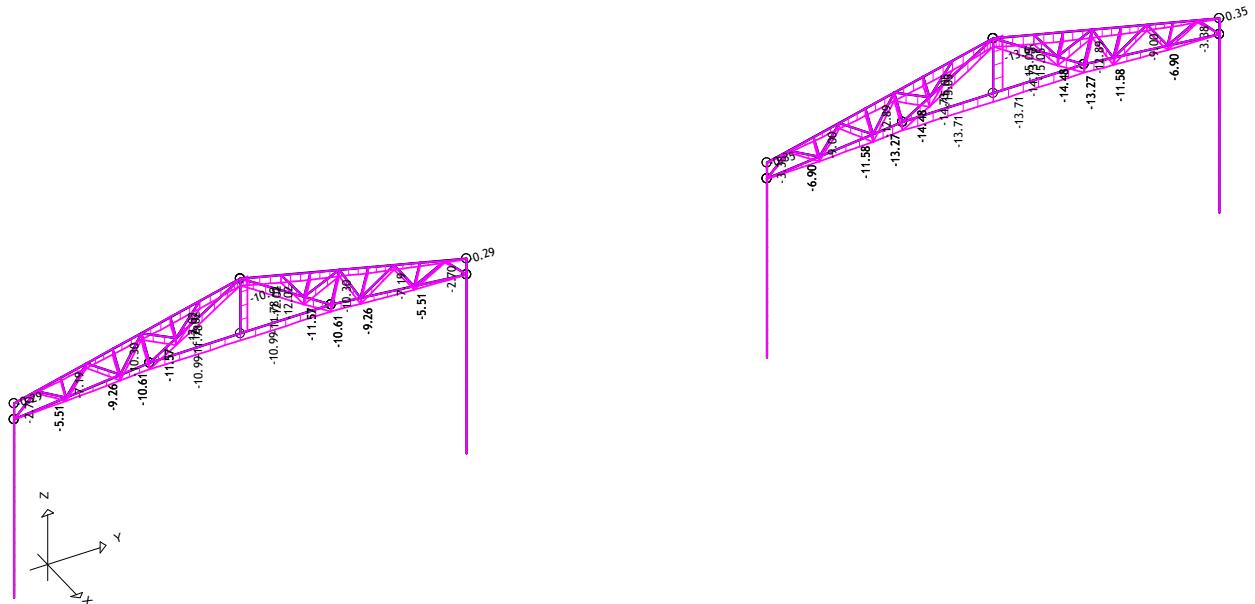


Frame: V\_3

Beam Results: max M3= 1.48 / min M3= -0.20 kNm

**Rám V3**

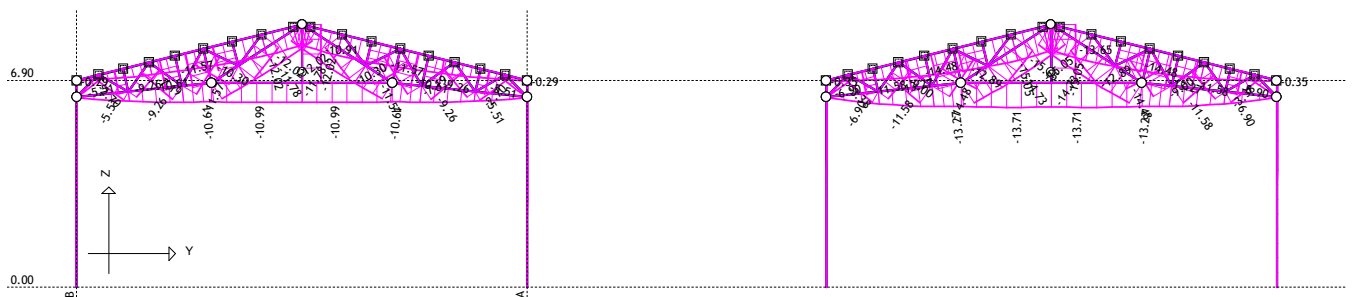
Load 21: [SLS\_perm] 13-16



Frame: V\_3

Beam Results: max Zd= -0.00 / min Zd= -15.05 m / 1000

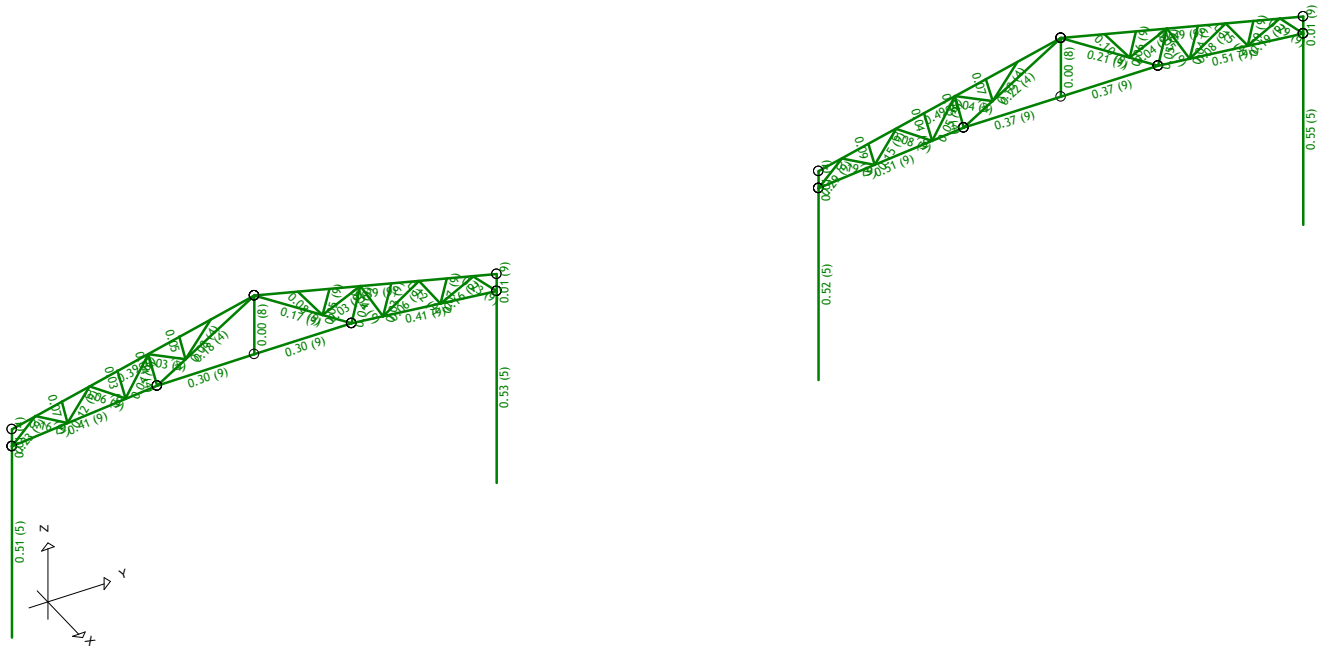
Load 21: [SLS\_perm] 13-16



Frame: V\_3

Beam Results: max Zd= -0.00 / min Zd= -15.05 m / 1000

## Rám V3



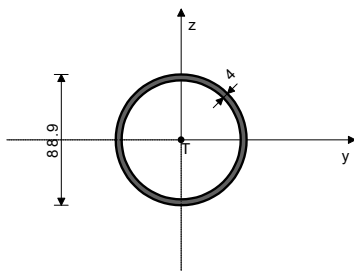
Frame: V\_3

Stress control

BEAM 230-294

CROSS-SECTION: Hollow [S 235] [Set: 2]  
EUROCODE 3 (EN 1993-1-1:2005)

## CROSS-SECTION PROPERTIES

(fy = 23.5 kN/cm<sup>2</sup>, fu = 36.0 kN/cm<sup>2</sup>)

|          |                        |
|----------|------------------------|
| Ax =     | 10.670 cm <sup>2</sup> |
| Ay =     | 5.332 cm <sup>2</sup>  |
| Az =     | 5.332 cm <sup>2</sup>  |
| Ix =     | 192.58 cm <sup>4</sup> |
| Iy =     | 96.340 cm <sup>4</sup> |
| Iz =     | 96.340 cm <sup>4</sup> |
| Wy =     | 21.674 cm <sup>3</sup> |
| Wz =     | 21.674 cm <sup>3</sup> |
| Wy,pl =  | 28.853 cm <sup>3</sup> |
| Wz,pl =  | 28.853 cm <sup>3</sup> |
| γM0 =    | 1.000                  |
| γM1 =    | 1.000                  |
| γM2 =    | 1.250                  |
| Anet/A = | 0.900                  |

[mm]

## UTILISATION FACTORS FOR ALL LOAD CASE COMBINATIONS

|            |            |            |
|------------|------------|------------|
| 9. γ=0.51  | 4. γ=0.49  | 11. γ=0.45 |
| 6. γ=0.43  | 16. γ=0.36 | 5. γ=0.35  |
| 13. γ=0.35 | 7. γ=0.28  | 14. γ=0.25 |

12. γ=0.25

19. γ=0.19

10. γ=0.15

18. γ=0.22

17. γ=0.18

8. γ=0.22

15. γ=0.16

MEMBER SUBJECT TO AXIAL TENSION  
(load 9, at the beginning of the member)

|                                   |         |           |
|-----------------------------------|---------|-----------|
| The axial force design value      | NEd =   | 127.37 kN |
| The shear force design value(z-z) | VEd,z = | 0.254 kN  |
| System length                     | L =     | 452.81 cm |

5.5 CLASSIFICATION OF CROSS-SECTIONS  
Class 1 cross-sections

## 6.2 RESISTANCE OF CROSS-SECTIONS

## 6.2.3 Tension

|                                        |          |           |
|----------------------------------------|----------|-----------|
| The design pl.resist.mom.(gross sect.) | Npl,Rd = | 250.75 kN |
| The design ult.resist.(net sect.)      | Nu,Rd =  | 248.91 kN |
| The design tension resistance          | Nt,Rd =  | 248.91 kN |

**Requirement 6.5:** NEd ≤ Nt,Rd (127.37 ≤ 248.91)

## 6.2.6 Shear

|                         |            |           |
|-------------------------|------------|-----------|
| Design shear resistance | Vpl,Rd,z = | 72.339 kN |
| Design shear resistance | Vc,Rd,z =  | 72.339 kN |

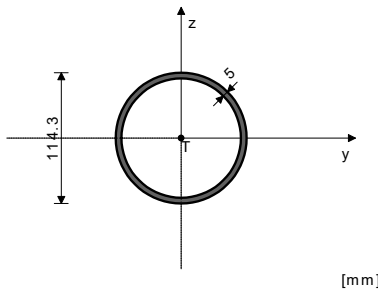
**Requirement 6.17:** VEd,z ≤ Vc,Rd,z (0.25 ≤ 72.34)

## Rám V3

## BEAM 235-363

CROSS-SECTION: Hollow [S 235] [Set: 1]  
EUROCODE 3 (EN 1993-1-1:2005)

## CROSS-SECTION PROPERTIES



|          |                        |
|----------|------------------------|
| Ax =     | 17.170 cm <sup>2</sup> |
| Ay =     | 8.580 cm <sup>2</sup>  |
| Az =     | 8.580 cm <sup>2</sup>  |
| Ix =     | 513.58 cm <sup>4</sup> |
| Iy =     | 256.92 cm <sup>4</sup> |
| Iz =     | 256.92 cm <sup>4</sup> |
| Wy =     | 44.955 cm <sup>3</sup> |
| Wz =     | 44.955 cm <sup>3</sup> |
| Wy,pl =  | 59.774 cm <sup>3</sup> |
| Wz,pl =  | 59.774 cm <sup>3</sup> |
| γM0 =    | 1.000                  |
| γM1 =    | 1.000                  |
| γM2 =    | 1.250                  |
| Anet/A = | 1.000                  |

(fy = 23.5 kN/cm<sup>2</sup>, fu = 36.0 kN/cm<sup>2</sup>)

## UTILISATION FACTORS FOR ALL LOAD CASE COMBINATIONS

|            |            |            |
|------------|------------|------------|
| 9. γ=0.47  | 4. γ=0.46  | 11. γ=0.41 |
| 6. γ=0.40  | 16. γ=0.33 | 5. γ=0.33  |
| 13. γ=0.32 | 7. γ=0.27  | 14. γ=0.24 |
| 12. γ=0.23 | 8. γ=0.21  | 18. γ=0.20 |
| 19. γ=0.17 | 17. γ=0.17 | 15. γ=0.16 |
| 10. γ=0.15 |            |            |

MEMBER SUBJECT TO AXIAL COMPRESSION AND BENDING  
(load 9, at 30.0 cm from the start of the member)

|                                   |                     |            |
|-----------------------------------|---------------------|------------|
| The axial force design value      | N <sub>Ed</sub> =   | -142.21 kN |
| The bending mom.design value(y-y) | M <sub>Ed,y</sub> = | 1.434 kNm  |
| System length                     | L =                 | 774.05 cm  |

## 5.5 CLASSIFICATION OF CROSS-SECTIONS

Class 1 cross-sections

## 6.2 RESISTANCE OF CROSS-SECTIONS

## 6.2.4 Compression

The design compression resistance N<sub>c,Rd</sub> = 403.50 kN  
**Requirement 6.9: N<sub>Ed</sub> ≤ N<sub>c,Rd</sub> (142.21 ≤ 403.50)**

## 6.2.5 Bending about the y-y axis

Plastic section modulus Wy,pl = 59.774 cm<sup>3</sup>  
The design moment resistance M<sub>c,Rd</sub> = 14.047 kNm  
**Requirement 6.12: M<sub>Ed,y</sub> ≤ M<sub>c,Rd,y</sub> (1.43 ≤ 14.05)**

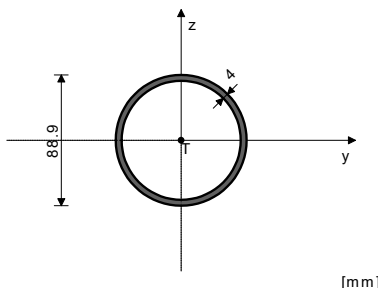
## 6.2.9 Bending and axial force

Ratio N<sub>Ed</sub> / N<sub>pl,Rd</sub> = 0.352  
The reduced design pl.resist.mom. M<sub>N,y,Rd</sub> = 12.302 kNm  
Ratio M<sub>Ed,y</sub> / M<sub>N,y,Rd</sub> = 0.117

## BEAM 363-294

CROSS-SECTION: Hollow [S 235] [Set: 2]  
EUROCODE 3 (EN 1993-1-1:2005)

## CROSS-SECTION PROPERTIES



|          |                        |
|----------|------------------------|
| Ax =     | 10.670 cm <sup>2</sup> |
| Ay =     | 5.332 cm <sup>2</sup>  |
| Az =     | 5.332 cm <sup>2</sup>  |
| Ix =     | 192.58 cm <sup>4</sup> |
| Iy =     | 96.340 cm <sup>4</sup> |
| Iz =     | 96.340 cm <sup>4</sup> |
| Wy =     | 21.674 cm <sup>3</sup> |
| Wz =     | 21.674 cm <sup>3</sup> |
| Wy,pl =  | 28.853 cm <sup>3</sup> |
| Wz,pl =  | 28.853 cm <sup>3</sup> |
| γM0 =    | 1.000                  |
| γM1 =    | 1.000                  |
| γM2 =    | 1.250                  |
| Anet/A = | 0.900                  |

(fy = 23.5 kN/cm<sup>2</sup>, fu = 36.0 kN/cm<sup>2</sup>)

## UTILISATION FACTORS FOR ALL LOAD CASE COMBINATIONS

|            |            |            |
|------------|------------|------------|
| 4. γ=0.22  | 9. γ=0.21  | 6. γ=0.20  |
| 11. γ=0.19 | 5. γ=0.17  | 13. γ=0.16 |
| 16. γ=0.15 | 7. γ=0.15  | 14. γ=0.12 |
| 8. γ=0.12  | 12. γ=0.10 | 10. γ=0.09 |
| 18. γ=0.09 | 15. γ=0.09 | 17. γ=0.08 |
| 19. γ=0.08 |            |            |

MEMBER SUBJECT TO AXIAL TENSION  
(load 4, end of the member)

## Requirement 6.41: (0.12 ≤ 1)

## 6.3 BUCKLING RESISTANCE OF MEMBERS

## 6.3.1.1 Buckling resistance

Buckling length y-y l<sub>y</sub> = 150.00 cm  
Relative slenderness y-y λ<sub>y</sub> = 0.413  
Buckling curve for axis y-y: A α = 0.210  
Elastic critical force N<sub>cr,y</sub> = 2366.7 kN  
The reduction factor χ<sub>y</sub> = 0.949  
The design buckling resistance N<sub>b,Rd,y</sub> = 383.06 kN

**Requirement 6.46: N<sub>Ed</sub> ≤ N<sub>b,Rd,y</sub> (142.21 ≤ 383.06)**

Buckling length z-z l<sub>z</sub> = 150.00 cm  
Relative slenderness z-z λ<sub>z</sub> = 0.413  
Buckling curve for axis z-z: A α = 0.210  
The reduction factor χ<sub>z</sub> = 0.949  
The design buckling resistance N<sub>b,Rd,z</sub> = 383.06 kN

**Requirement 6.46: N<sub>Ed</sub> ≤ N<sub>b,Rd,z</sub> (142.21 ≤ 383.06)**

## 6.3.3 Uniform members in bending and axial compression

Values of interaction factors obtained from Annex B  
(alternative method 2)

The equiv.unif.mom.fact.flex.buck. C<sub>my</sub> = 0.950  
The equiv.unif.mom.fact.flex.buck. C<sub>mz</sub> = 1.000  
The equiv.unif.mom.fact.flex.buck. C<sub>mLT</sub> = 0.950  
Interaction factors k<sub>yy</sub> = 1.025  
Interaction factors k<sub>yz</sub> = 0.647  
Interaction factors k<sub>zy</sub> = 0.615  
Interaction factors k<sub>zz</sub> = 1.079

The reduction factor χ<sub>y</sub> = 0.949  
N<sub>Ed</sub> / (χ<sub>y</sub> N<sub>Rk</sub> / γ<sub>M1</sub>) = 0.371  
k<sub>yy</sub> \* (M<sub>Ed</sub> + ΔM<sub>Ed</sub>) / ... = 0.105

**Requirement 6.61: (0.48 ≤ 1)**

The reduction factor χ<sub>z</sub> = 0.949  
N<sub>Ed</sub> / (χ<sub>z</sub> N<sub>Rk</sub> / γ<sub>M1</sub>) = 0.371  
k<sub>zy</sub> \* (M<sub>Ed</sub> + ΔM<sub>Ed</sub>) / ... = 0.063

**Requirement 6.62: (0.43 ≤ 1)**

## Check of the shear resistance

(load 4, at the beginning of the member)

|                                   |                     |            |
|-----------------------------------|---------------------|------------|
| The axial force design value      | N <sub>Ed</sub> =   | -135.18 kN |
| The shear force design value(z-z) | V <sub>Ed,z</sub> = | 4.944 kN   |
| System length                     | L =                 | 774.05 cm  |

## 6.2 RESISTANCE OF CROSS-SECTIONS

## 6.2.6 Shear

Design shear resistance V<sub>pl,Rd,z</sub> = 116.41 kN  
Design shear resistance V<sub>c,Rd,z</sub> = 116.41 kN  
**Requirement 6.17: V<sub>Ed,z</sub> ≤ V<sub>c,Rd,z</sub> (4.94 ≤ 116.41)**

|                                   |                     |           |
|-----------------------------------|---------------------|-----------|
| The axial force design value      | N <sub>Ed</sub> =   | 55.251 kN |
| The shear force design value(z-z) | V <sub>Ed,z</sub> = | 0.266 kN  |
| System length                     | L =                 | 358.64 cm |

## 5.5 CLASSIFICATION OF CROSS-SECTIONS

Class 1 cross-sections

## 6.2 RESISTANCE OF CROSS-SECTIONS

## 6.2.3 Tension

The design pl.resist.mom.(gross sect.) N<sub>pl,Rd</sub> = 250.75 kN  
The design ult.resist.(net sect.) N<sub>u,Rd</sub> = 248.91 kN  
The design tension resistance N<sub>t,Rd</sub> = 248.91 kN

**Requirement 6.5: N<sub>Ed</sub> ≤ N<sub>t,Rd</sub> (55.25 ≤ 248.91)**

## 6.2.6 Shear

Design shear resistance V<sub>pl,Rd,z</sub> = 72.339 kN  
Design shear resistance V<sub>c,Rd,z</sub> = 72.339 kN  
**Requirement 6.17: V<sub>Ed,z</sub> ≤ V<sub>c,Rd,z</sub> (0.27 ≤ 72.34)**

## Check of the shear resistance

(load 9, at the beginning of the member)

|                                   |                     |           |
|-----------------------------------|---------------------|-----------|
| The axial force design value      | N <sub>Ed</sub> =   | 37.210 kN |
| The shear force design value(z-z) | V <sub>Ed,z</sub> = | 0.349 kN  |
| System length                     | L =                 | 358.64 cm |

## 6.2 RESISTANCE OF CROSS-SECTIONS

## 6.2.6 Shear

Design shear resistance V<sub>pl,Rd,z</sub> = 72.339 kN  
Design shear resistance V<sub>c,Rd,z</sub> = 72.339 kN  
**Requirement 6.17: V<sub>Ed,z</sub> ≤ V<sub>c,Rd,z</sub> (0.35 ≤ 72.34)**

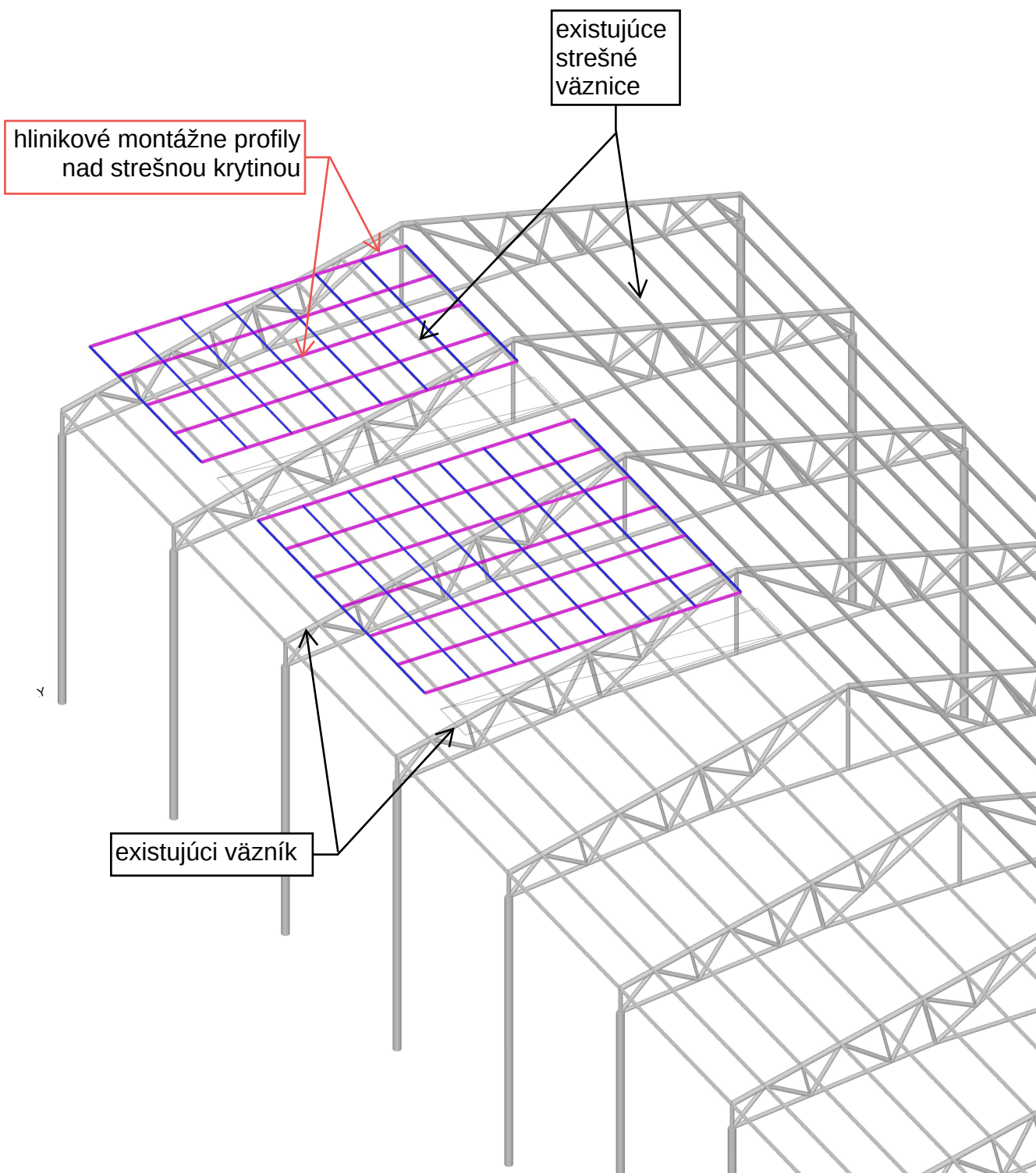
## ***Záver***

### **Záver:**

**Konštrukcia strechy je spôsobilá na osadenie fotovoltických panelov.**

**Nadstrešná hliníková fólia**

| Beam                             |                                                                                     |
|----------------------------------|-------------------------------------------------------------------------------------|
| 1. D= 114.3x5 (PV - HP)          |  |
| 2. D= 88.9x4 (PV - HP)           |  |
| 3. D= 60.3x4 (PV - D)            |  |
| 4. D= 168.3x6 (Stlp)             |  |
| 5. UPE 80                        |  |
| 6. Q 40x1.5 (Mont. trap. profil) |  |
| 7. H 40x40x1.2 (Mont. H profil)  |  |

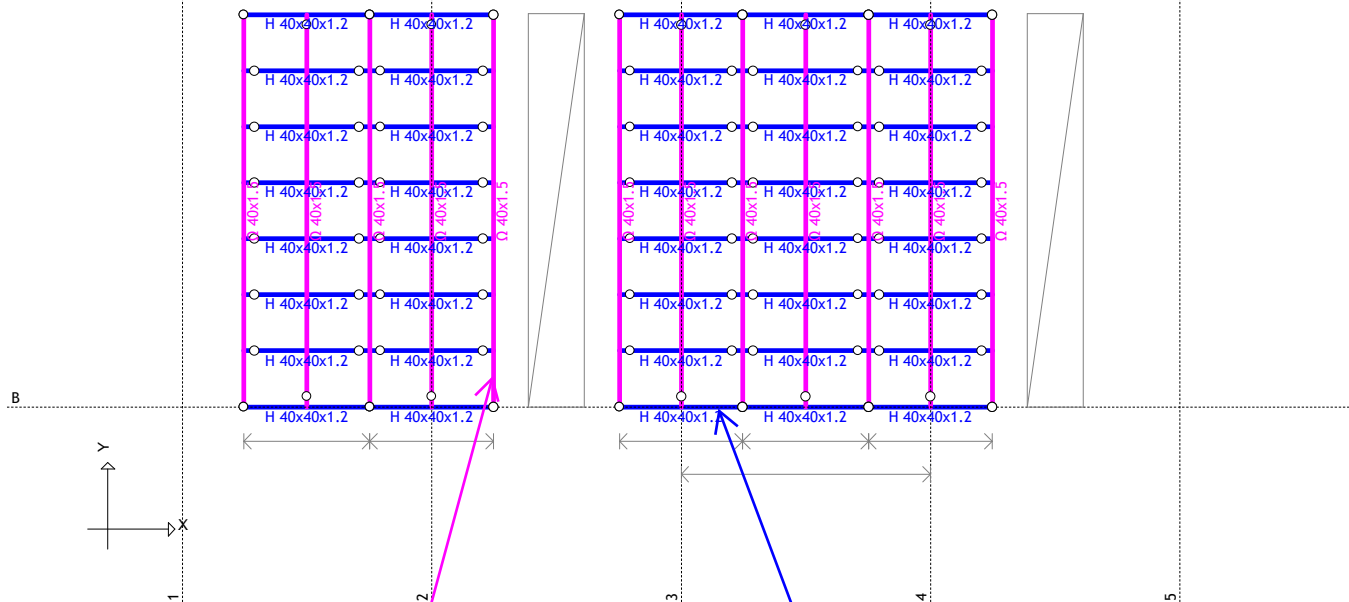


**Nadstrešná hliníková fólia**

Level: Nadstresna konstrukcia [9.10 m]

| Beam                                    |  |
|-----------------------------------------|--|
| 6. $\Omega$ 40x1.5 (Mont. trap. profil) |  |
| 7. H 40x40x1.2 (Mont. H profil)         |  |

hreben strechy

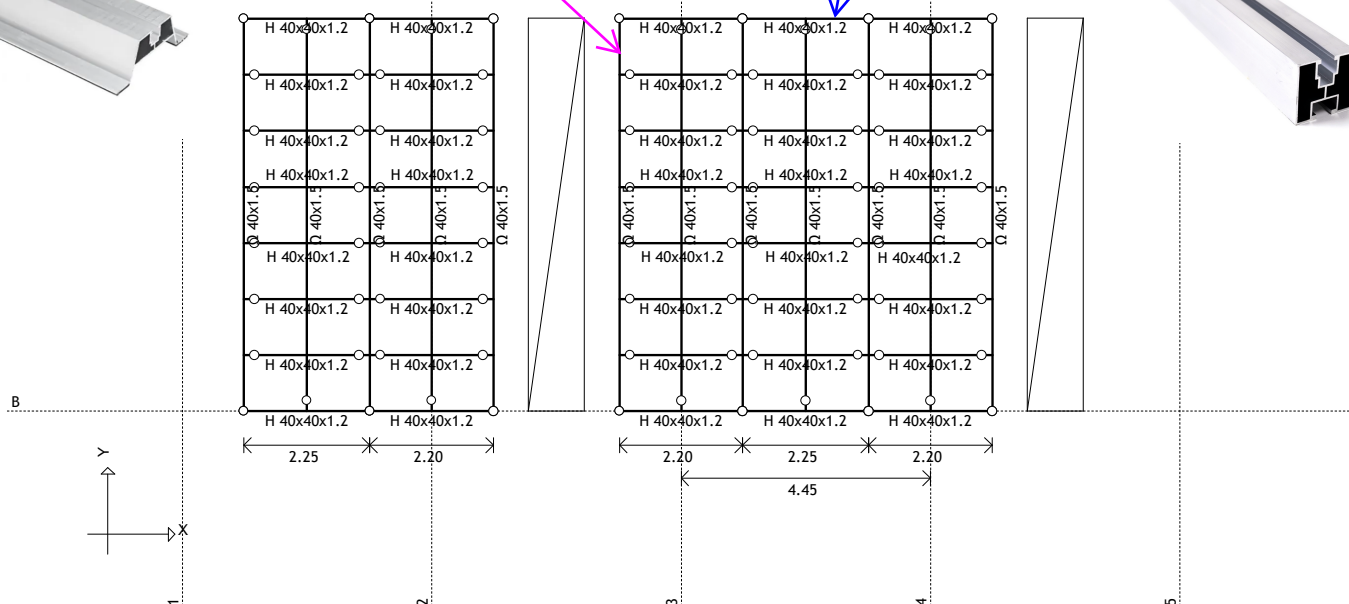
Numerical data set  
Beam (6.7)

hliníkové podkladné  
trapézové profily  
v smere spádu strechy

hliníkové montážne  
profily H40x40x1,2  
kolmo na spád strechy



1.13 1.13 1.10 1.10 1.10 1.10 1.13 1.13 1.10 1.10



Level: Nadstresna konstrukcia [9.10 m] - Group: Hala SO.02