| | |
|---|---|
| Office |  <br>INFRAPROJEKT s.c.<br>41-500 Chorzów<br>ul. Dworcowa 1/7<br>+48 32 241 56 62<br>biuro@infraprojekt.pl |
| Title of the project | STATIC CALCULATIONS OF THE ALUMINUM PROFILE FOR THE GLASS BALLUSTRADES AND HORIZONTAL STRESS:<br><br>1,15KN / M (STRESS USED FOR CALC 1,73KN /M)<br><br>ANCHOR IN THE PROFILE BASE<br>(FLOOR ANCHORING) |
| Investor | UMAKOW Sp. z o.o.<br>41-800 Zabrze<br>ul. Alojzego Pawliczka 27A |
| Phase | Static calculation |
| Designer name, surname and number | Mgr. Ing. Marek Sikora<br>SLK/2775/PWOK/09 |

**Content**

## 1. Basics of description

**Order**

- Order of the company UMAKOW Sp. From Zabrze, Alojzego Pawliczka 27A street

**Norms**

[1] PN-EN 1991-1-1 Actions on structures. General actions.
[2] EN 1999-1-1 Design of aluminium structures. General rules

**Other**

- Fixing system for glass balustrades aluminium profile with seals passed by UMAKOW Sp. z.o.o

## 2. The assumption adopted for calculation

| | |
|---|---|
| Stop EN-AW: | 6063 |
| Type of product: | The section squeezed EP; |
| Variety: | T6; |
| The required minimum yield of plasticity: | $f_0$ = 160 MPa (6063); |
| Safety factor: | $\gamma$M = 1.10; |
| The magnitude of elasticity: | E = 70 GPa; |

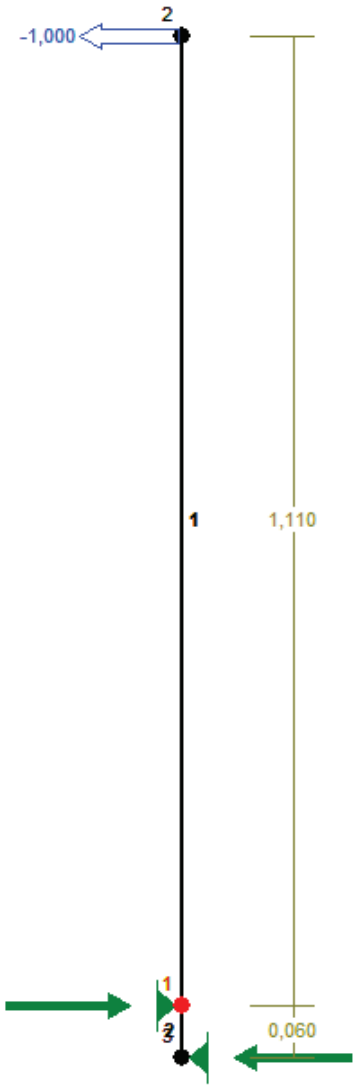
Profile used for calculation:
- The height of railings is equal to the height of glass panel protruding from the profile (1,10m).
- Stress from the glass balustrade is transferred to the walls of the profile by plastic inserts arranged according to the manufacturer – draft deployment guidelines inserts are given in point. 5.2
- The distribution of the anchor in base - every 20cm
- Static calculations were performed on a solid model using finite element method in elastic range
- Profile strength was tested by comparing the permissible maximum stress - the general case.

This static calculations do not check mount glass panel in the profile and capacity of the panel. It is verified only the bearing capacity of aluminium profile, which is under the load caused by thrust on the handrail railings.
This calculation does not include wind pressure - railings will be located inside the building

## 3.Calculation of load used on profile walls

**Summary of loads**

| Nr. | Description of load | kN/m | $\gamma\phi$ |
|---|---|---|---|
| | The weight of the glass plates [25,0kN / m3 0.02M .1.20m] | 0,60 | 1,35 |
| 1. | The load on the pad [0,60kN / m • 1,0m / 4 / 0.1m] | 1,50 | 1,35 |
| | The load on the edge of the 1 insert 1,50kN / m / 2 | 0,75 | 1,35 |
| 2. | Horizontal load (user category C3) [1,000kN / m] | 1,00 | 1,50 |




Determination of the forces acting on the insert, which transfer the load on profile walls (characteristic loads):

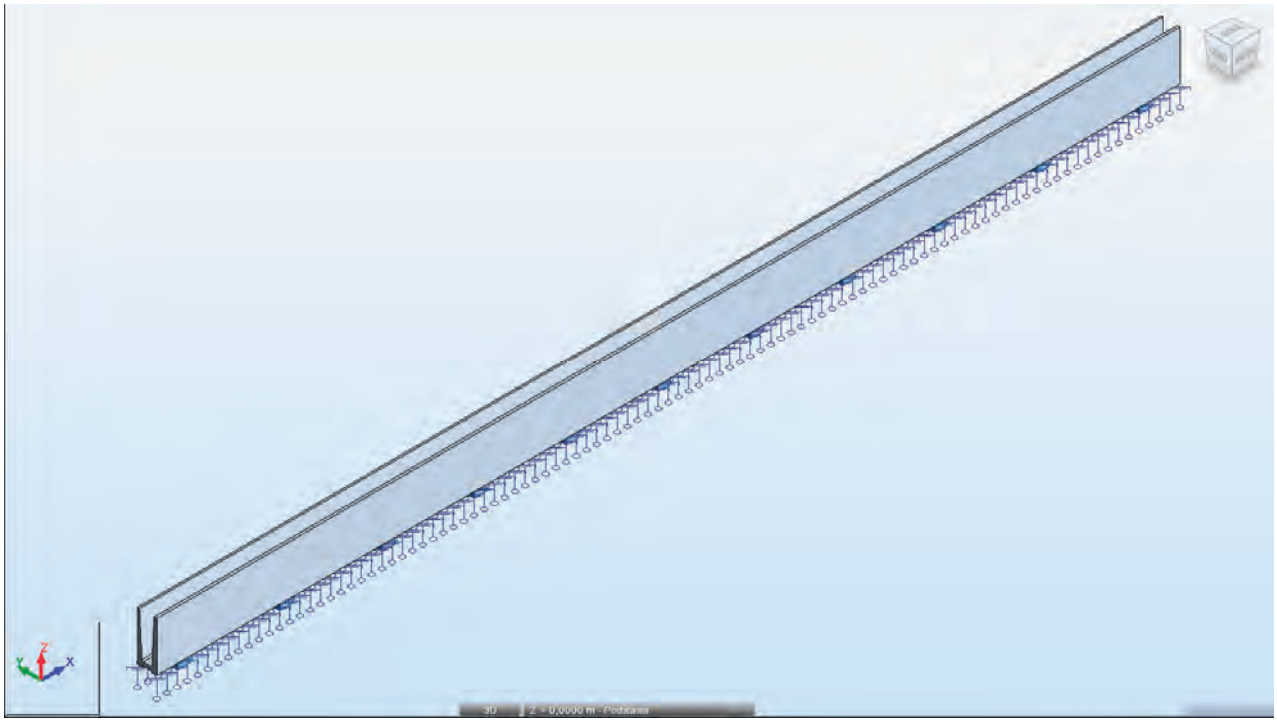
- white inserts (100mm wide):
$P_2 = H_2$ x 2,5 / (0,1 x n) = 22,3 x 2,5 / (0,1 x 10) = 56,06 kN / m - load pressure on the balustrade
where:
n - number of inserts on 2,5m length- accepted 10 pieces.

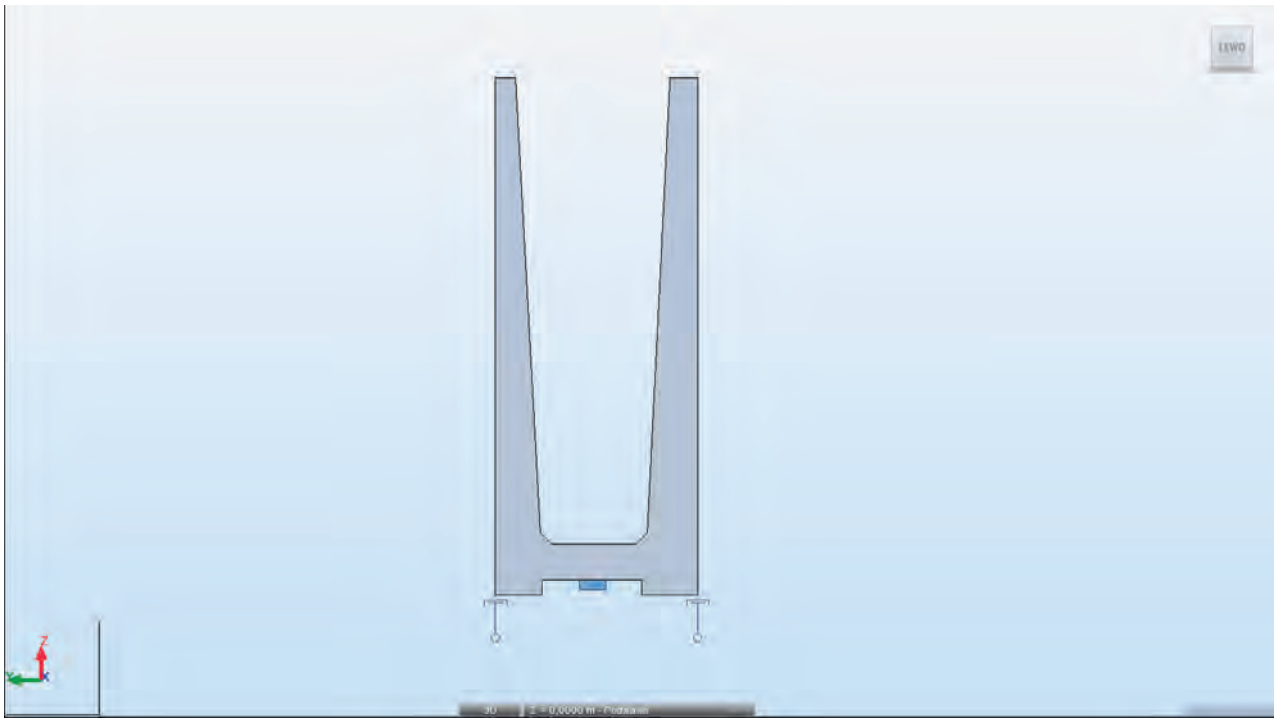
- green inserts (65mm wide)
$P_1 = H_1$ x 2,5 / (0,1 x n) = 21,3 x 2,5 / (0,065 x 10) = 81,82 kN / m - load pressure on the balustrade
where:
n - number of inserts on 2,5 m length - accepted 10 pieces.

## 4. Resistance and static calculation

### 4.1. Profile used for calculation

The profile has been modeled in the calculation program as volume structure composed of solid finished elements. The structure is anchored to the roof by screws and bolts located in the base of the profile. The base is joined with the structure to which is mounted profile – Linear supports were used which conveying only pressure.

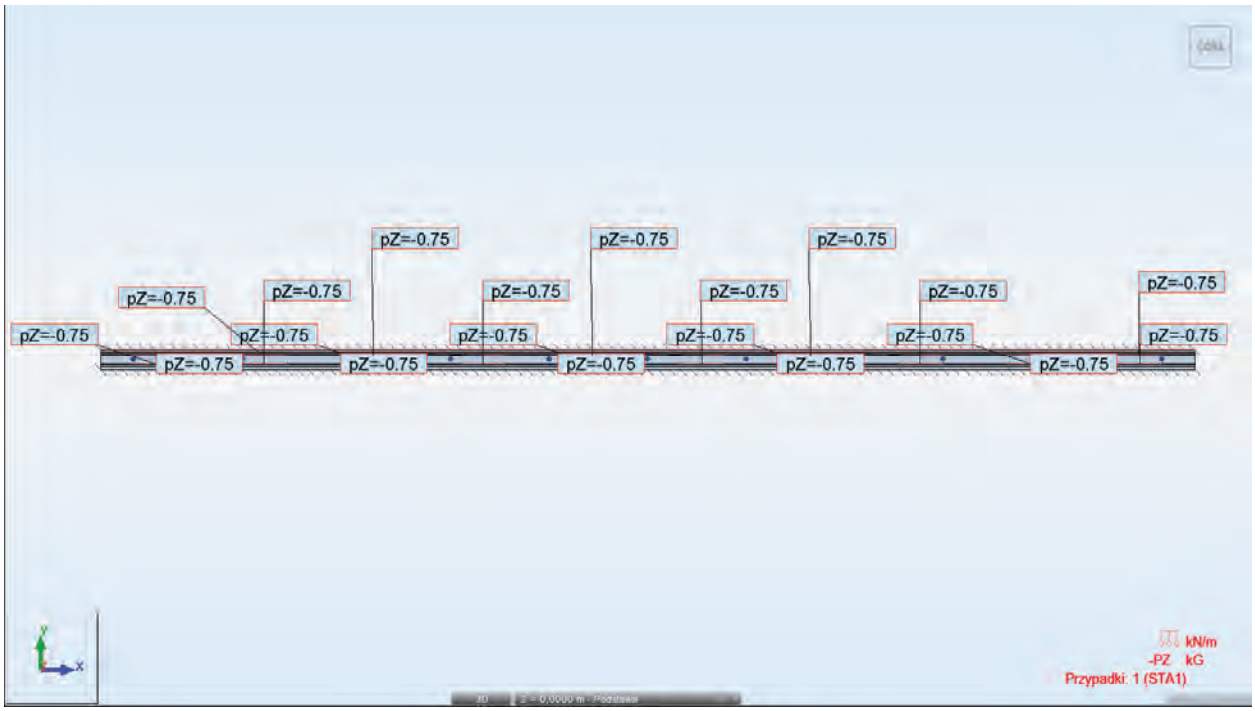




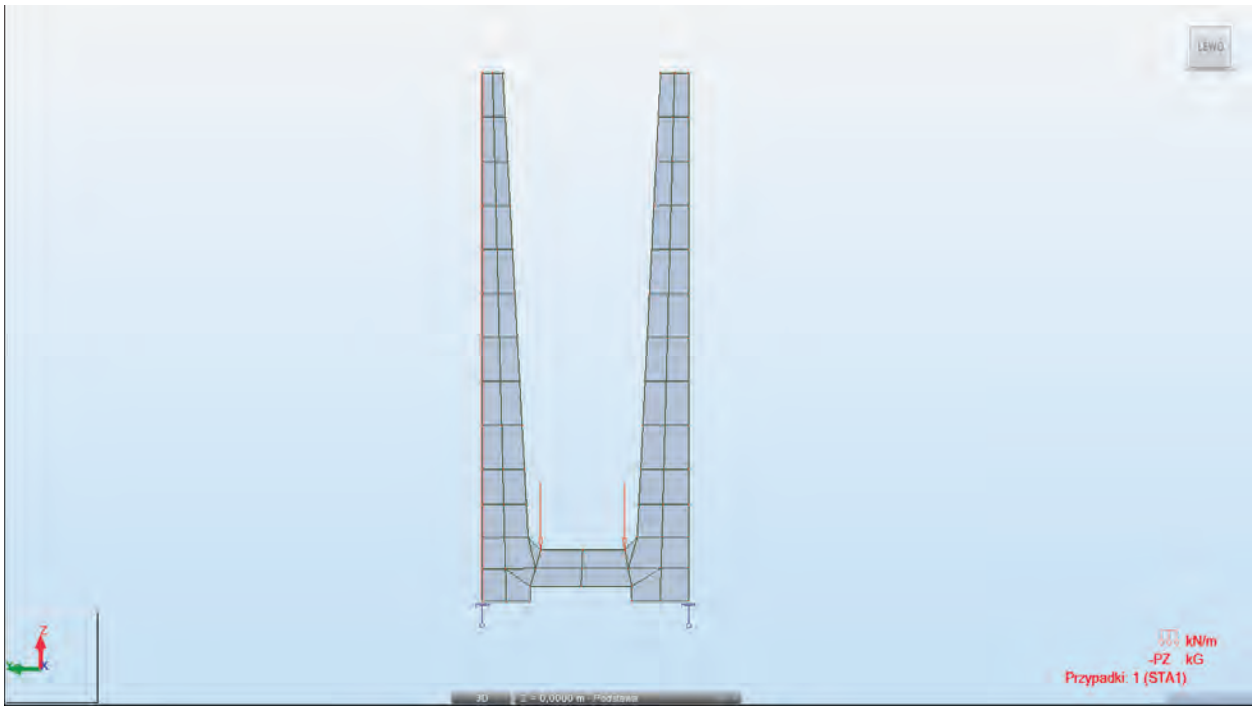
### 4.2. Loads assumed in the calculation

- permanent load (unit weight + weight of the glass railings)

VIEW FROM ABOVE

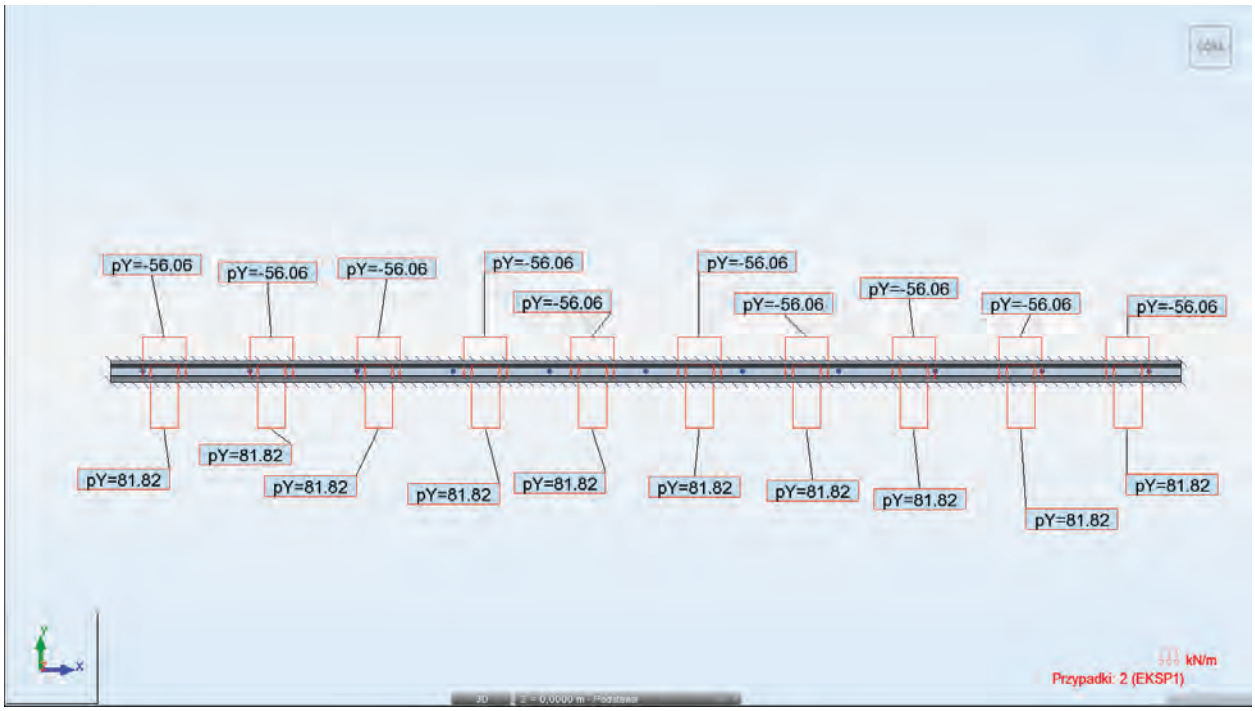



CROSS-SECTION

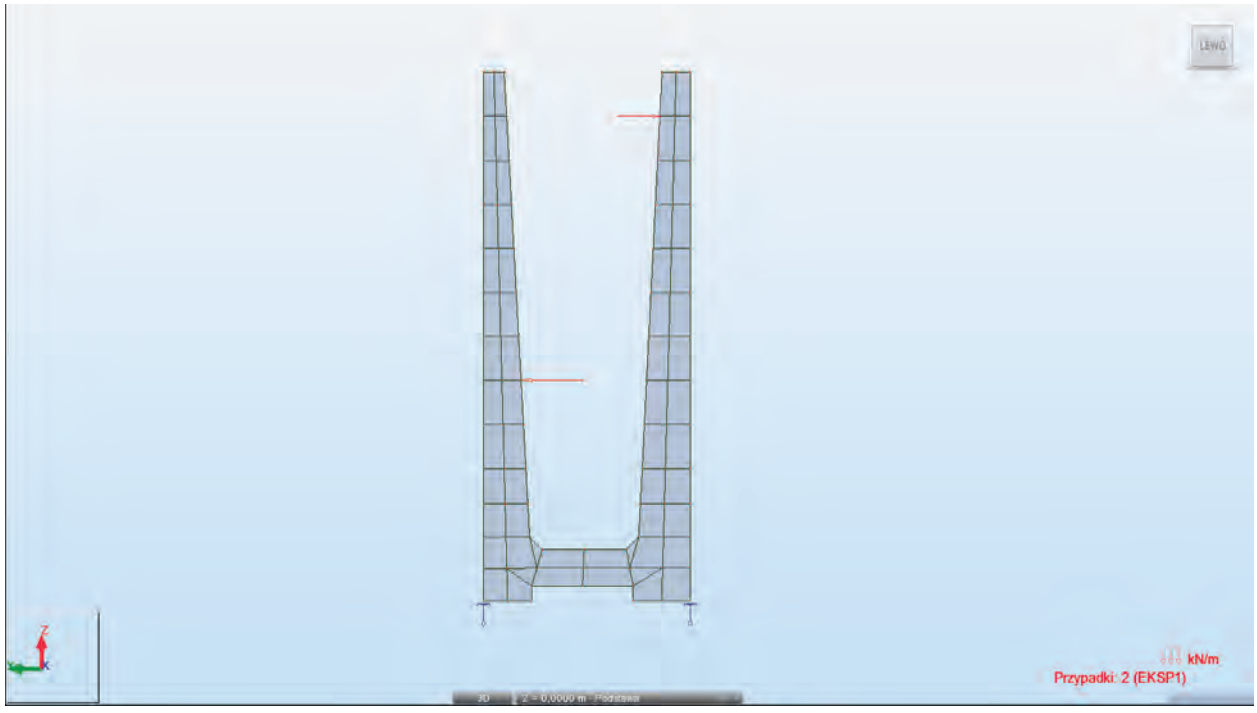


- utility loads put on the railing (carried by the white and green inserts)

VIEW FROM ABOVE




CROSS-SECTION




**Combination of the loads**

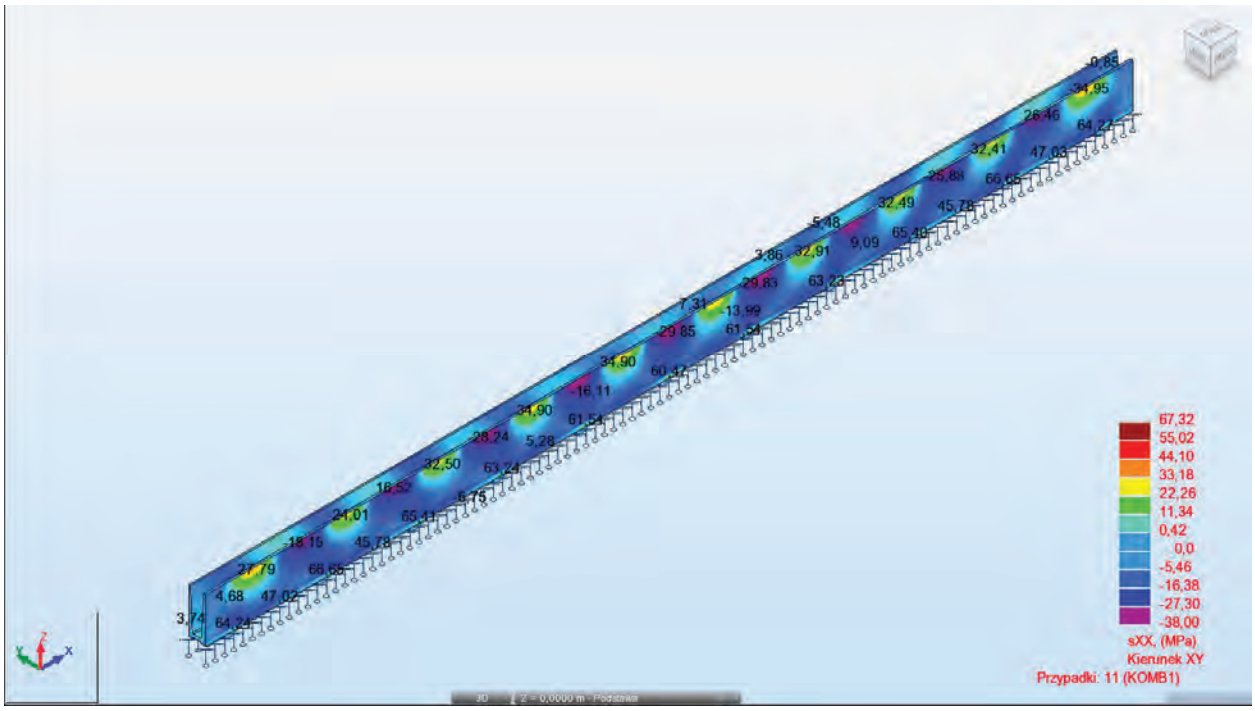
Calculated combination: KOMB1: 1,35xSTA1 + 1,50xEKSP1

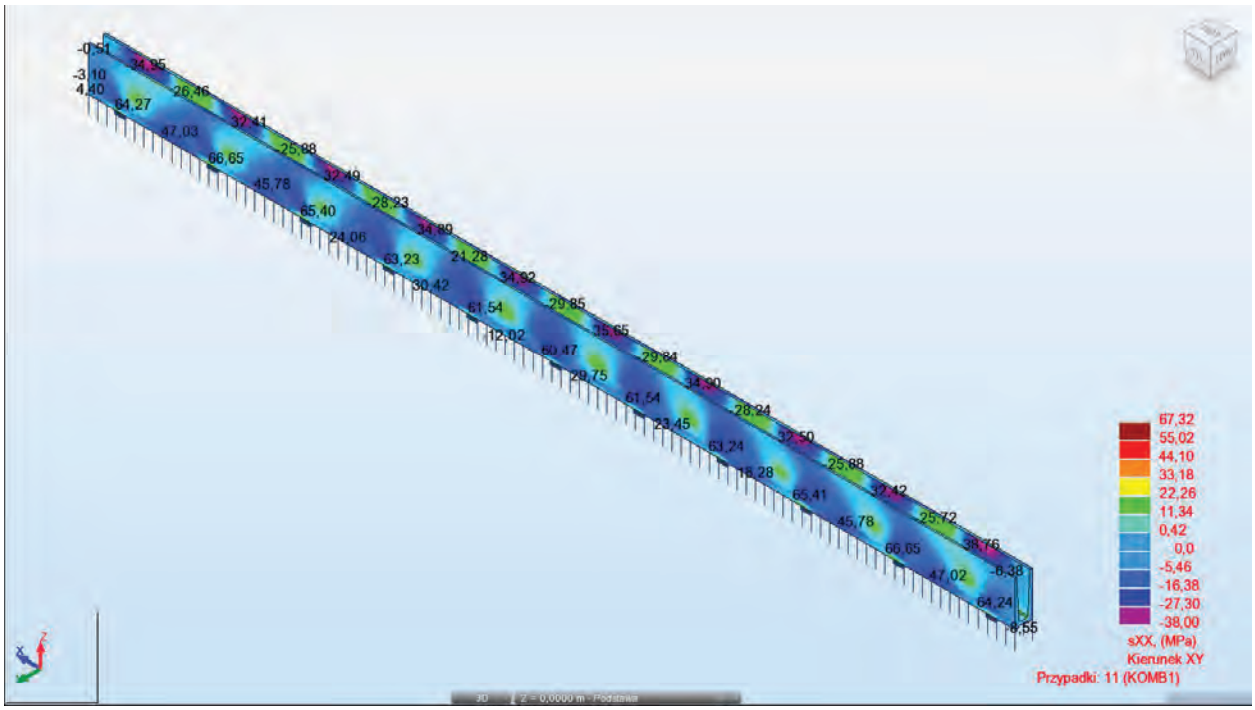
Characteristic combination: KOMB2: 1,00xSTA1 + 1,00xEKSP1

## 4.3. Stress in profile

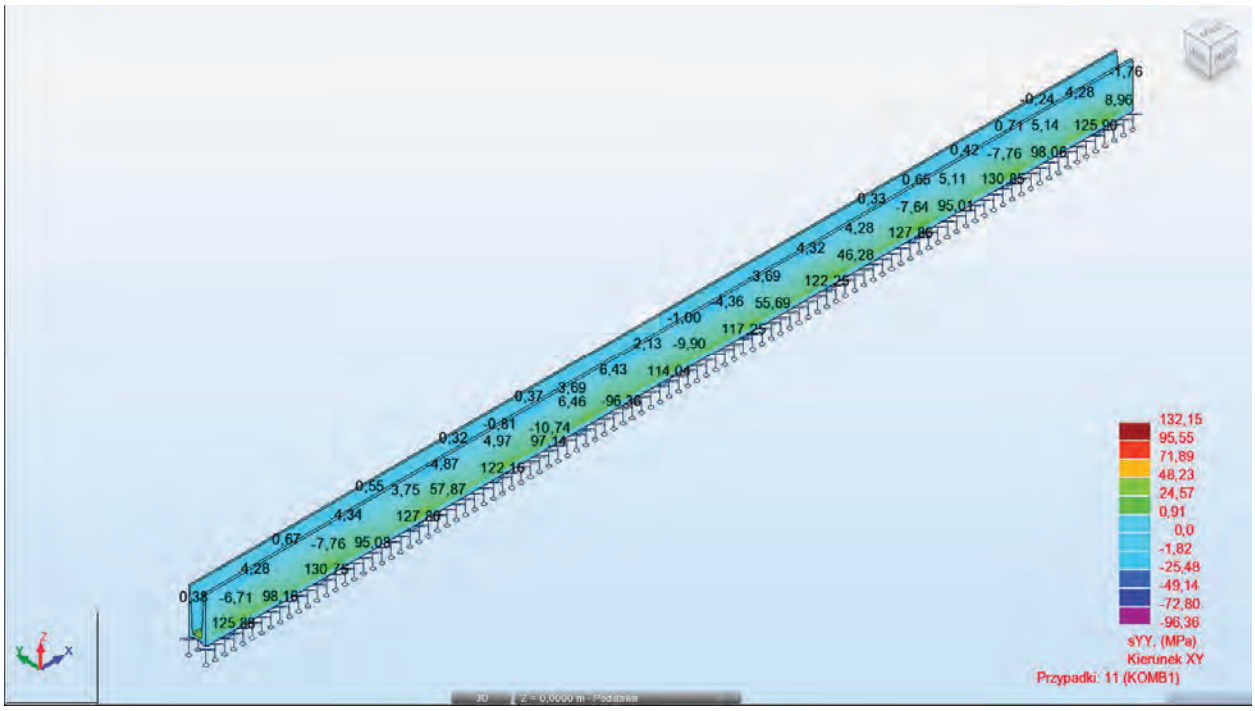
### 4.3.1. Normal stress

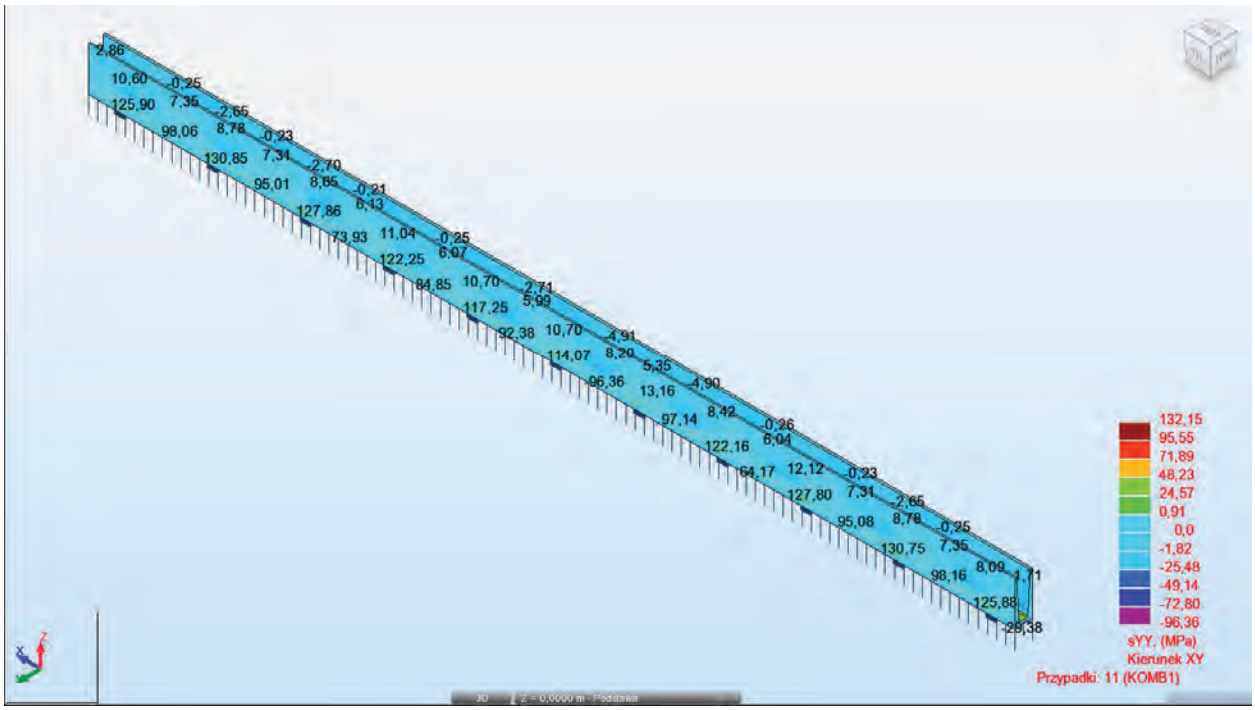
Stress σxx



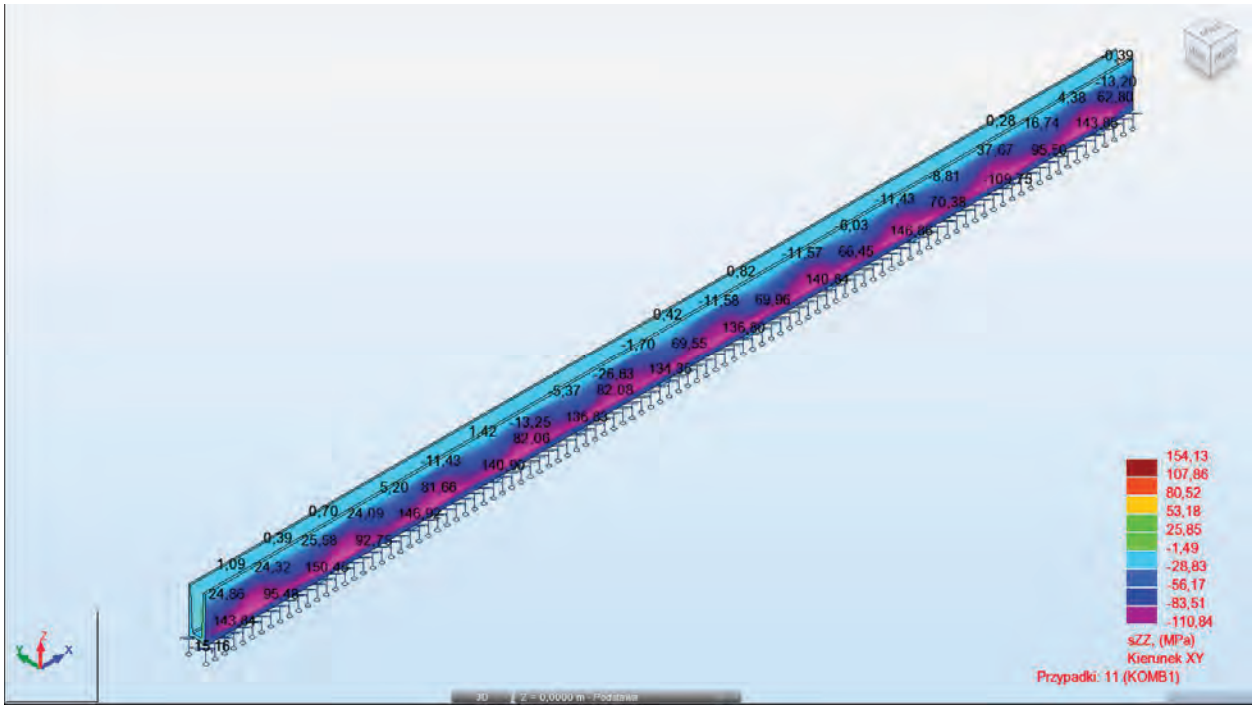



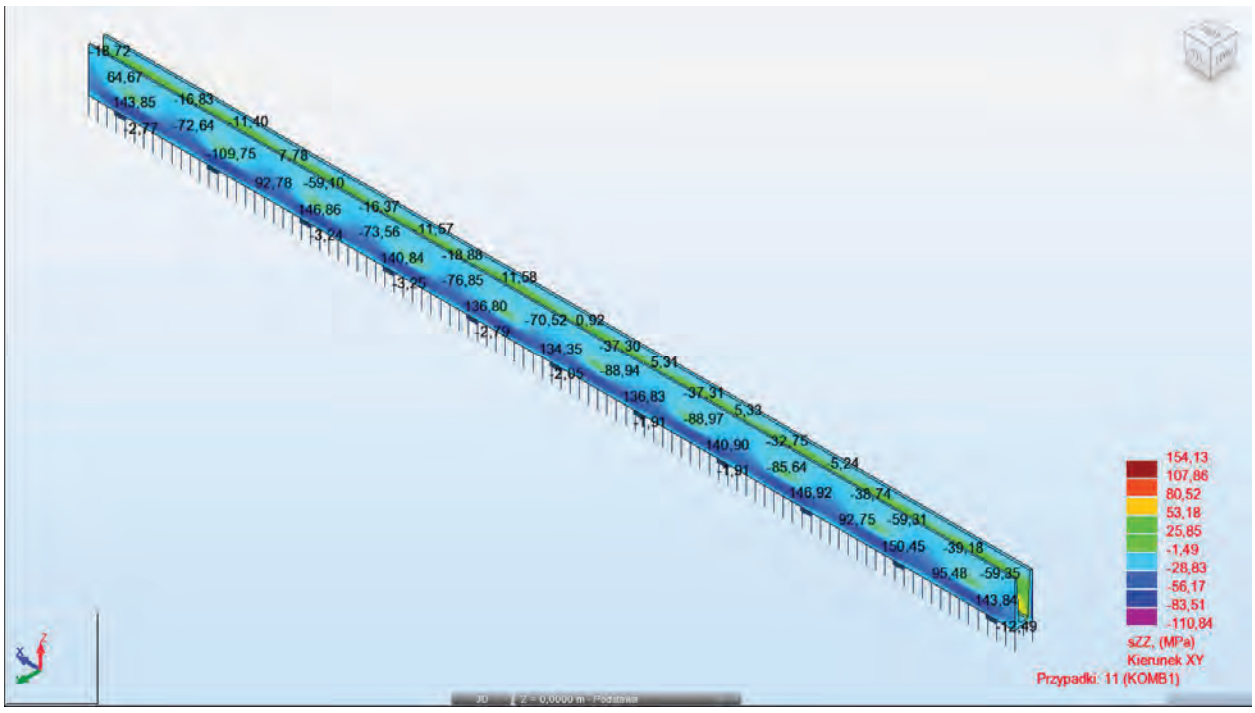
Stress σyy


132,15
95,55
71,89
48,23
24,57
0,91
0,0
-1,82
-25,48
-49,14
-72,80
-96,36
sYY, (MPa)
Kierunek XY
Przypadki: 11 (KOMB1)


132,15
95,55
71,89
48,23
24,57
0,91
0,0
-1,82
-25,48
-49,14
-72,80
-96,36
sYY, (MPa)
Kierunek XY
Przypadki: 11 (KOMB1)

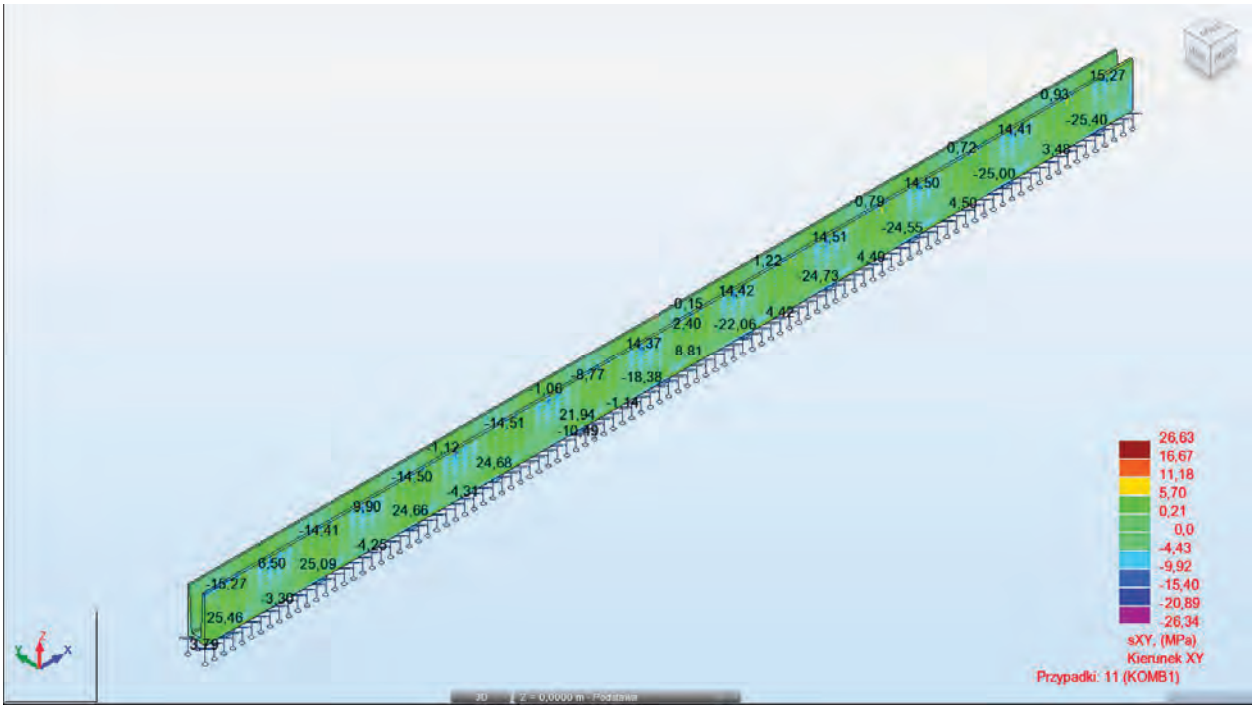
Stress σzz


154,13
107,86
80,52
53,18
25,85
-1,49
-28,83
-56,17
-83,51
-110,84
sZZ, (MPa)
Kierunek XY
Przypadki: 11 (KOMB1)

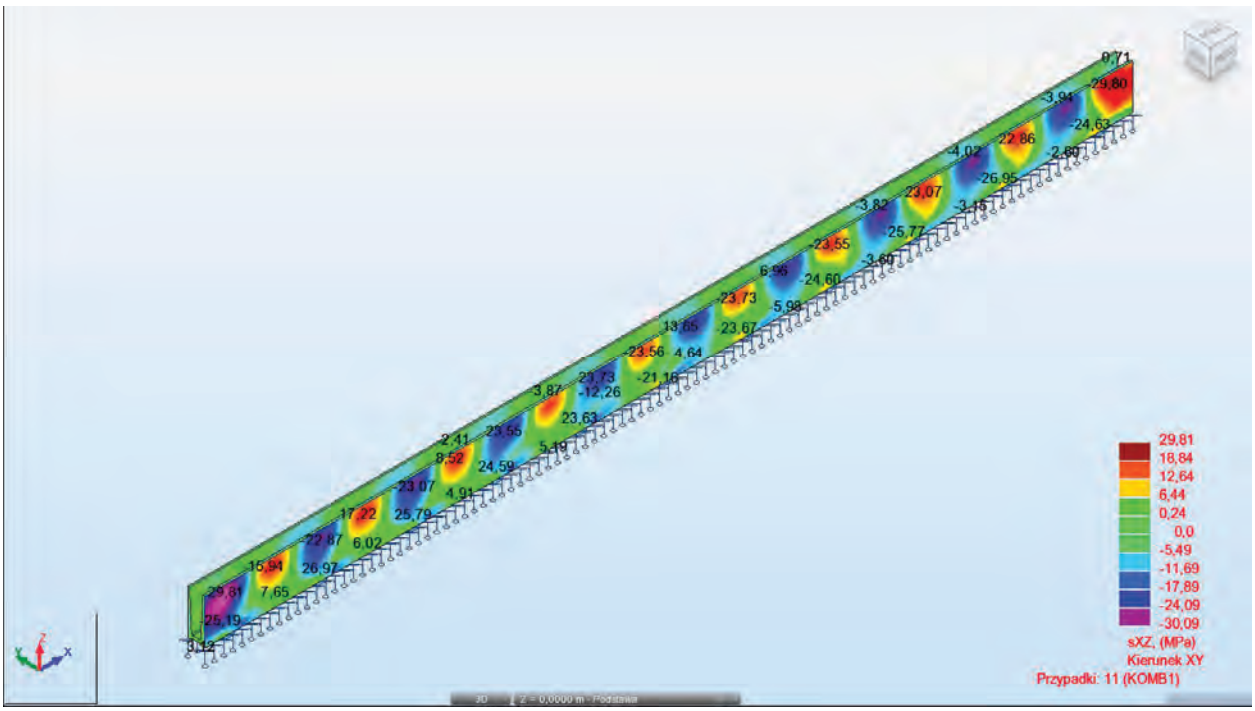

154,13
107,86
80,52
53,18
25,85
-1,49
-28,83
-56,17
-83,51
-110,84
sZZ, (MPa)
Kierunek XY
Przypadki: 11 (KOMB1)

### 4.3.2. Shear stress

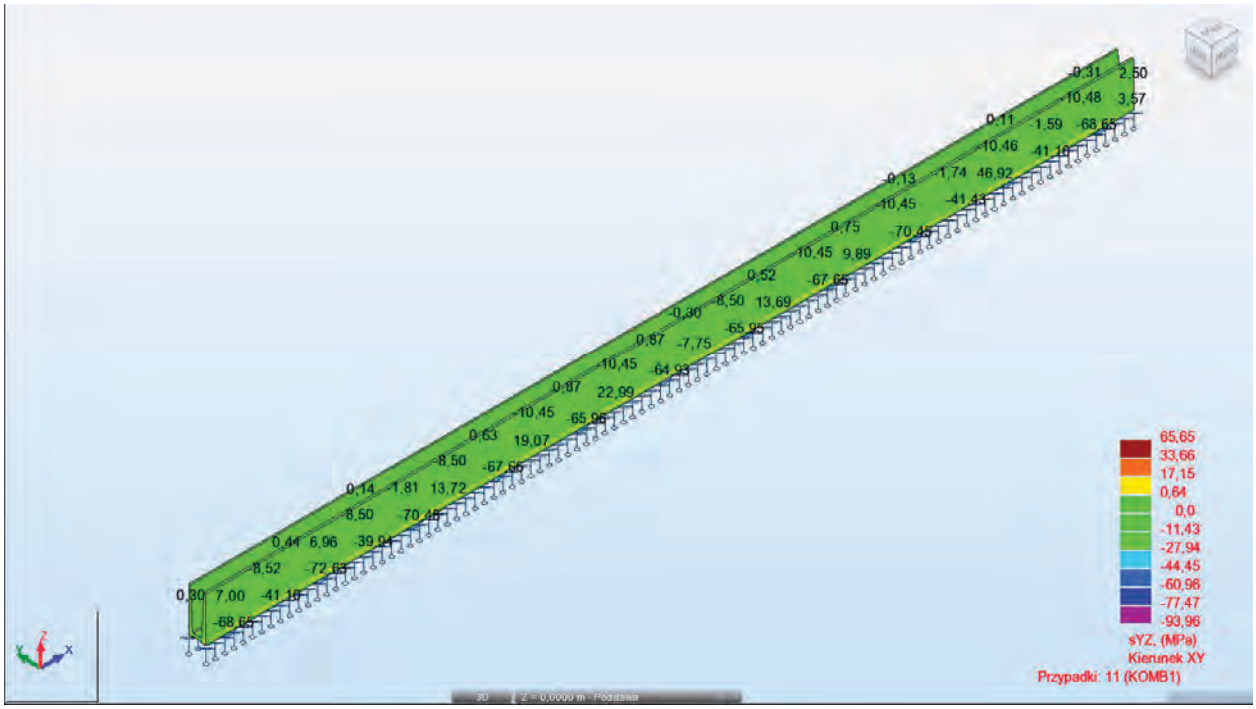
Stress τxy



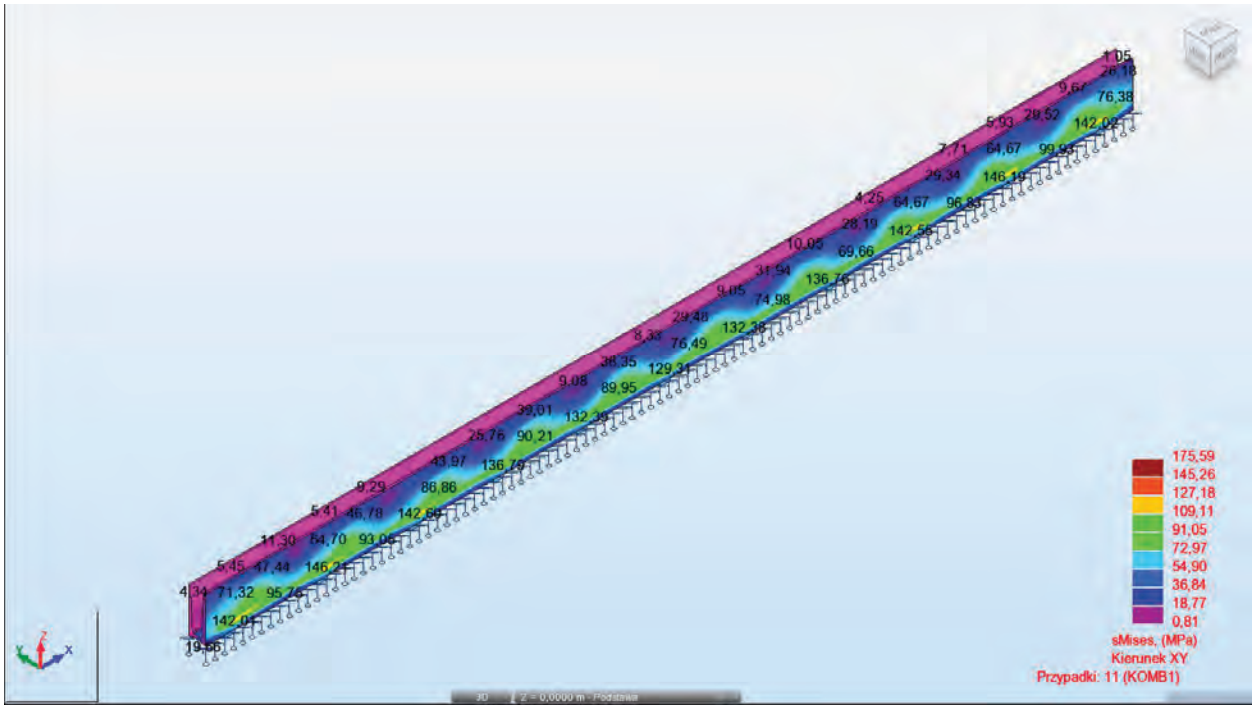

Stress τxz

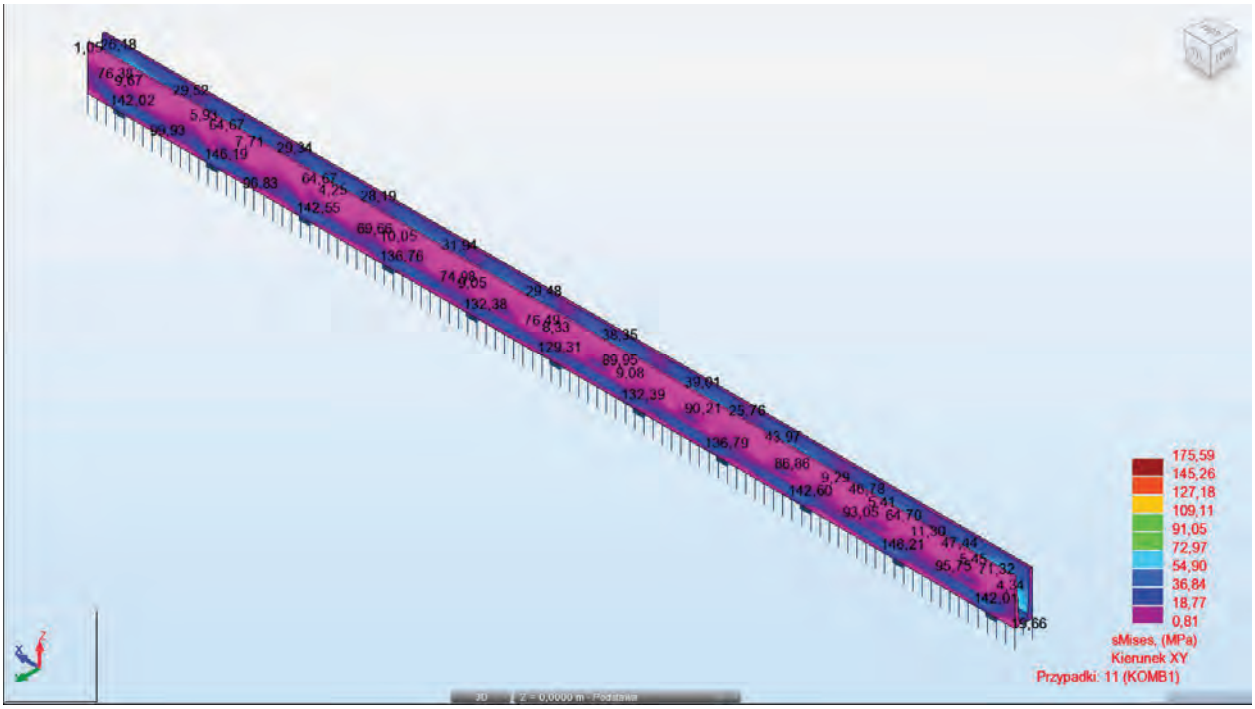


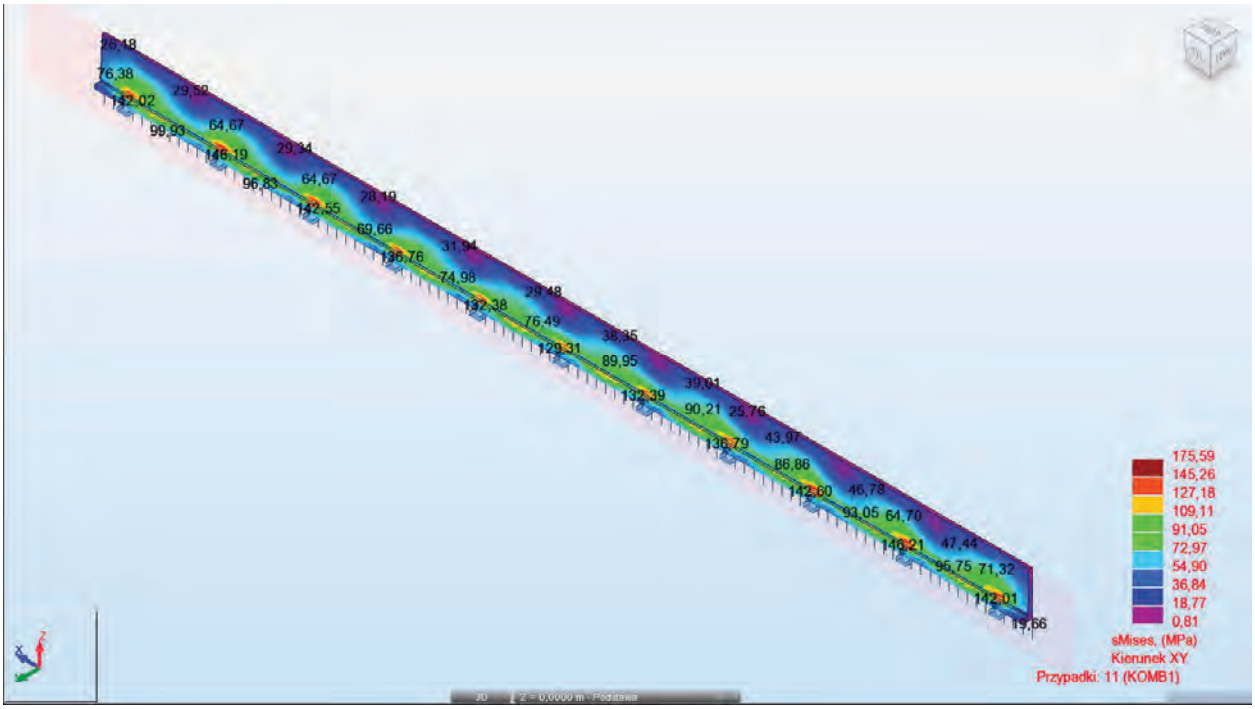
Stress τyz




### 4.3.3. Equivalent stress




175,59
145,26
127,18
109,11
91,05
72,97
54,90
36,84
18,77
0,81
sMises, (MPa)
Kierunek XY
Przypadki: 11 (KOMB1)


175,59
145,26
127,18
109,11
91,05
72,97
54,90
36,84
18,77
0,81
sMises, (MPa)
Kierunek XY
Przypadki: 11 (KOMB1)

The maximum stress values in the profile

| Node | Case | **σxx (MPa)** | σyy (MPa) | σzz (MPa) | τxy (MPa) | τxz (MPa) | τyz (MPa) | σzast (MPa) |
|---|---|---|---|---|---|---|---|---|
| 615 | KOMB1 | 39,09 | -4,79 | 1,18 | -1,10 | -0,40 | 2,39 | 41,48 |

| Node | Case | σxx (MPa) | **σyy (MPa)** | σzz (MPa) | τxy (MPa) | τxz (MPa) | τyz (MPa) | σzast (MPa) |
|---|---|---|---|---|---|---|---|---|
| 5177 | KOMB1 | 16,37 | **107,73** | -23,18 | 0,17 | -0,11 | 2,18 | 116,35 |

| Node | Case | σxx (MPa) | σyy (MPa) | **σzz (MPa)** | τxy (MPa) | τxz (MPa) | τyz (MPa) | σzast (MPa) |
|---|---|---|---|---|---|---|---|---|
| 1349 | KOMB1 | 22,28 | -26,86 | **152,60** | 0,14 | 3,49 | -13,28 | 162,38 |

| Node | Case | σxx (MPa) | σyy (MPa) | σzz (MPa) | **τxy (MPa)** | τxz (MPa) | τyz (MPa) | σzast (MPa) |
|---|---|---|---|---|---|---|---|---|
| 3134 | KOMB1 | 19,46 | 48,83 | 22,51 | **26,36** | 11,62 | 26,65 | 73,50 |

| Node | Case | σxx (MPa) | σyy (MPa) | σzz (MPa) | τxy (MPa) | **τxz (MPa)** | τyz (MPa) | σzast (MPa) |
|---|---|---|---|---|---|---|---|---|
| 339 | KOMB1 | 1,15 | 1,67 | -14,74 | 3,35 | **-29,41** | 0,99 | 53,78 |

| Node | Case | σxx (MPa) | σyy (MPa) | σzz (MPa) | τxy (MPa) | τxz (MPa) | **τyz (MPa)** | σzast (MPa) |
|---|---|---|---|---|---|---|---|---|
| 8088 | KOMB1 | 33,75 | 101,71 | 38,25 | -1,84 | -0,94 | **-93,96** | 175,59 |

| Node | Case | σxx (MPa) | σyy (MPa) | σzz (MPa) | τxy (MPa) | τxz (MPa) | τyz (MPa) | **σzast (MPa)** |
|---|---|---|---|---|---|---|---|---|
| 8088 | KOMB1 | 33,75 | 101,71 | 38,25 | -1,84 | -0,94 | -93,96 | **175,59** |

Checking the capacity of cross-sections

Normal stress: $\sigma_{xx} \le f_0 / \gamma_{M1}$ $\sigma_{yy} \le f_0 / \gamma_{M1}$ $\sigma_{zz} \le f_0 / \gamma_{M1}$

Sheer stress: $\tau_{xy} \le \frac{f_0}{\sqrt{3} \times \gamma_{M1}}$ $\tau_{xz} \le \frac{f_0}{\sqrt{3} \times \gamma_{M1}}$ $\tau_{yz} \le \frac{f_0}{\sqrt{3} \times \gamma_{M1}}$

Equivalent stress:

$$\sigma_{zast} = \sqrt{0,5 \times [(\sigma_{xx} - \sigma_{yy})^2 + (\sigma_{yy} - \sigma_{zz})^2 + (\sigma_{xx} - \sigma_{zz})^2 + 6 \times (\tau_{xy}^2 + \tau_{xz}^2 + \tau_{yz}^2)]} \le 1,2 \times \frac{f_0}{\gamma_{M1}}$$

Permitted stress values:

$f_o / \gamma_{M1}$ = 160MPa / 1,1 = **145,5MPa**

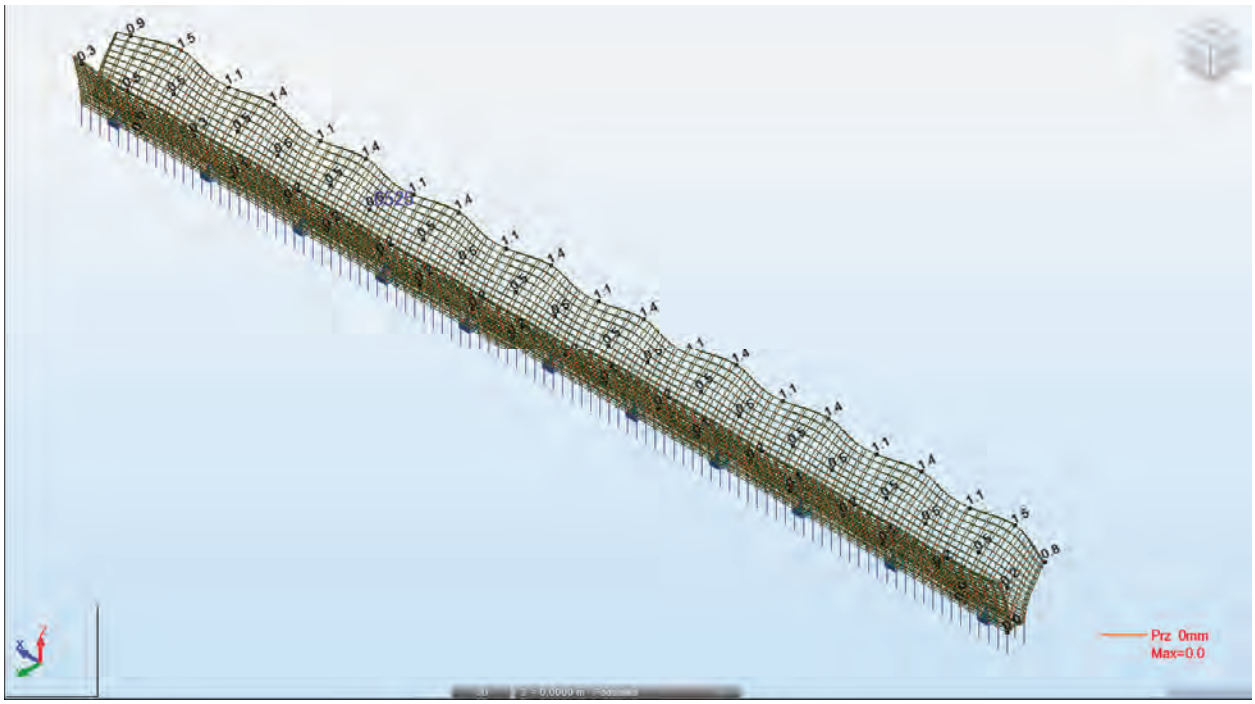
$f_o / (\sqrt{3}\ \gamma_{M1})$ = 160MPa / (1,73 x 1,10) = **84,0MPa**

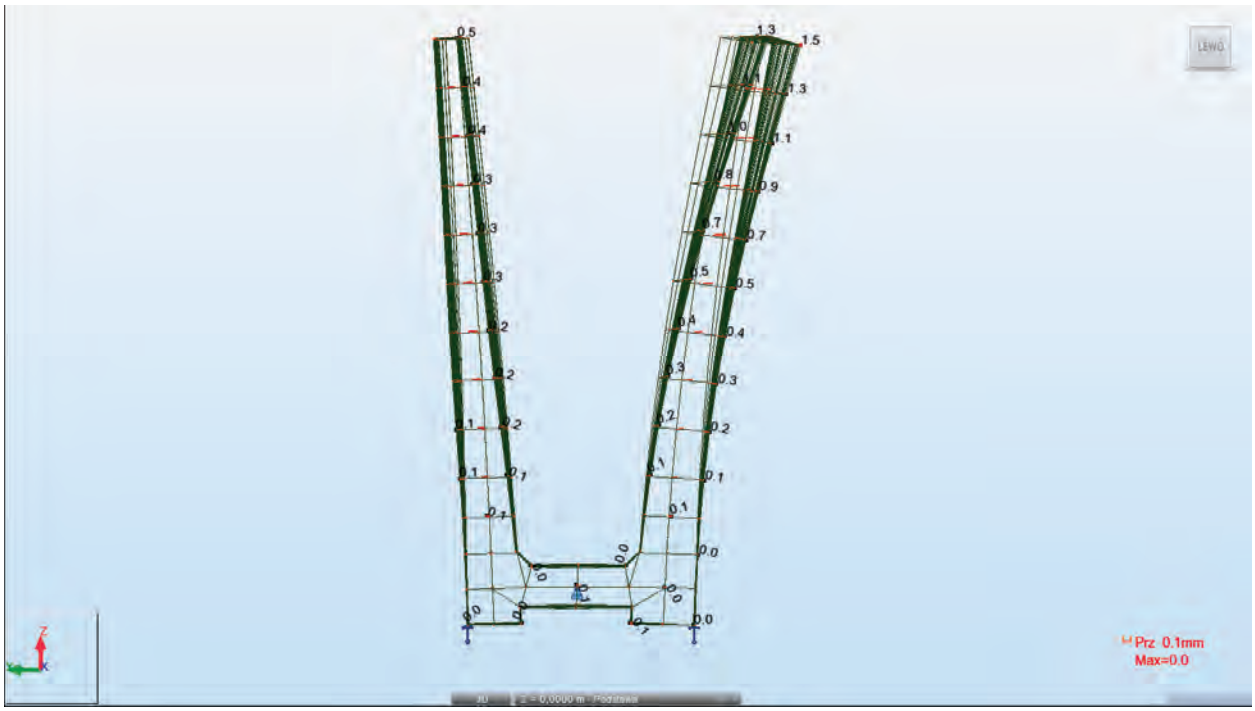
1,2 x $f_o / \gamma_{M1}$ = **174,5MPa**

**Profile fulfill the conditions of bearing.**

### 4.4. Deformation under the influence of stress

Deformation shown for the characteristic loads (KOMB2)

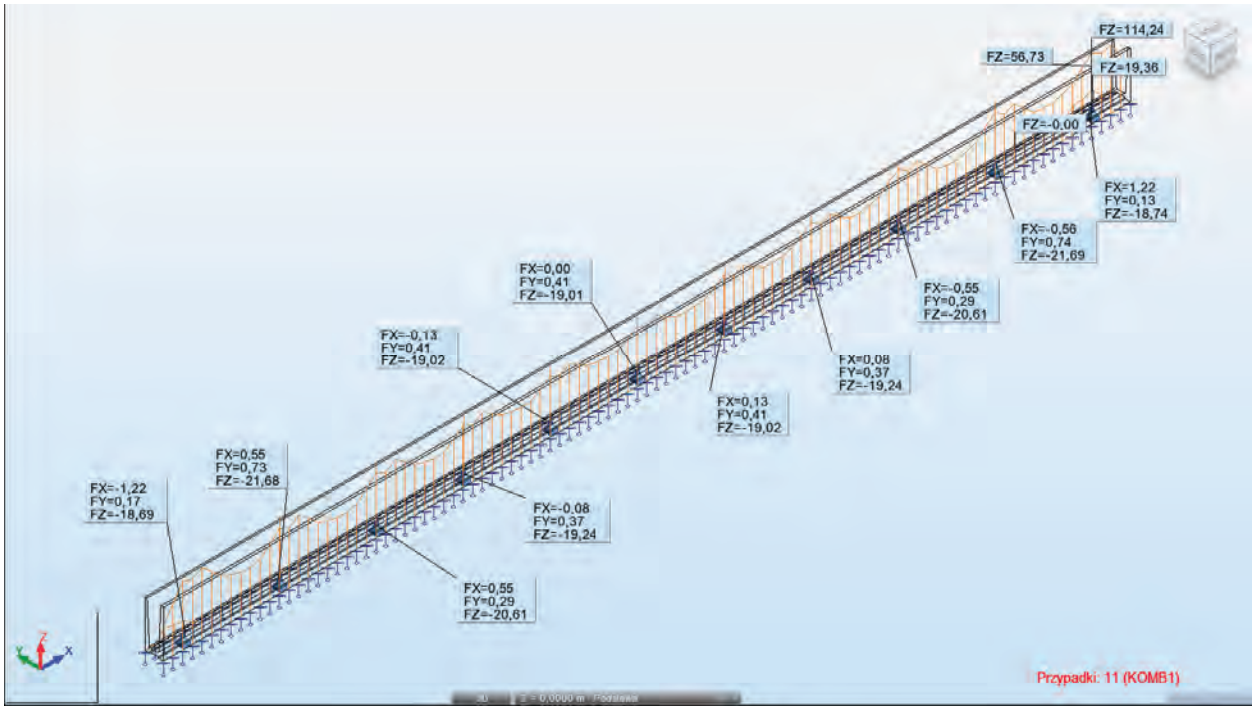



**The maximum deflection of the vertical wall profile is 1,5mm.**

### 4.5. Reaction and selection of the anchor

Below are the reactions of the anchors and picture of the pressure force acting on the ceiling.



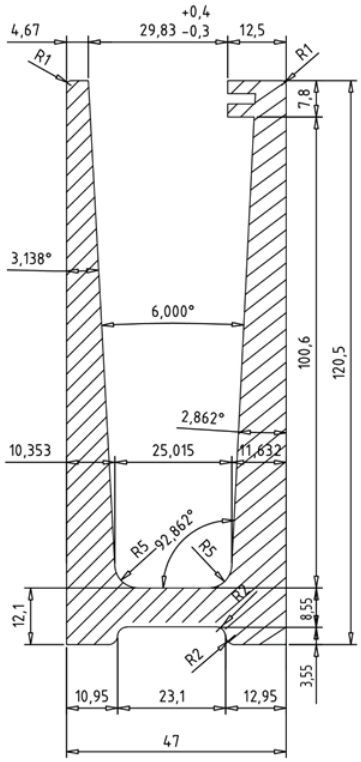

**Selection Anchor**
The anchor should be selected on the strength calculation:

$F_x$ = 1,22kN; $F_y$ = 0,74kN; $F_z$ = 21,69kN

**Warning:**
When using  of anchors shall always agree with the manufacturer conditions of attaching profile to the concrete - particularly the location of the anchor from the edge of the concrete.

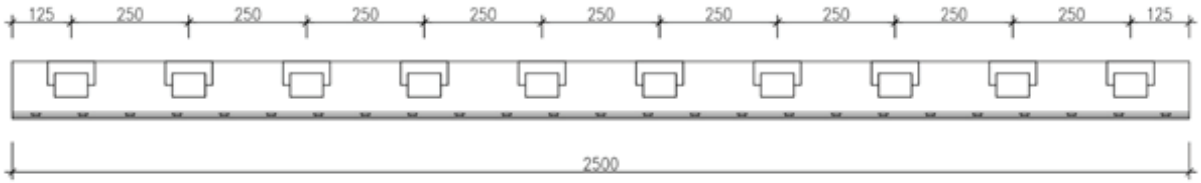
## 5. Application guidelines

### 5.1. Profile picture

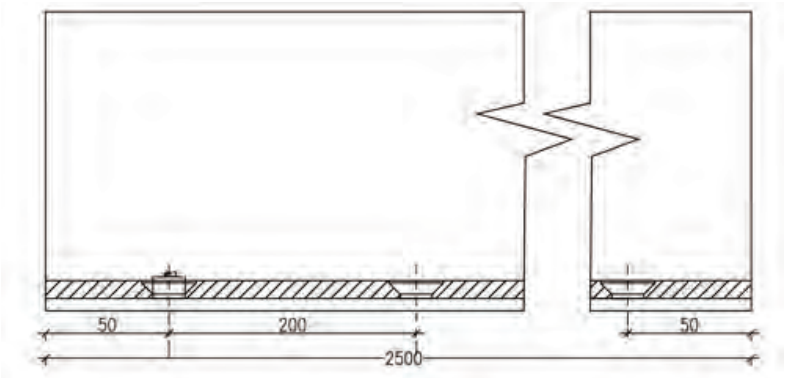



### 5.2. Guidelines for arrangement of anchors and inserts (white and green) by which the load is transferred to the walls of the profile

Arrangement of inserts in the profile




Arrangement of anchors




Developed by

Mgr. Ing. Marek Sikora