

CALCULATIONS TO VERIFY THE STRUCTURAL STRENGTH AND STABILITY OF A FREE-STANDING ARTIFICIAL CLIMBING WALL

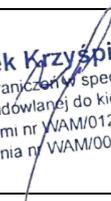
SUBJECT OF THE STUDY: Interactive free-standing artificial climbing wall with a height of 4.00 m according to product specifications

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VERIFICATION CALCULATIONS

CONSTRUCTION

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1.0. Introduction

1.1. Subject of the study

The subject of the study is the static and strength calculations for a free-standing structural frame of an artificial climbing wall with a height of 4.00 m in the product specification, including a horizontal platform frame. The scope of the study includes a technical description and static and strength calculations for the elements during the operational phase.

1.2. Basis for the study

- Visual inspection of the structure
- Workshop drawings of the wall structure
- Guidelines and agreements with the Investor
- Applicable building standards and regulations, in particular:
 - **PN-EN 12572-1 – Artificial climbing walls**
 - PN-EN 1990 – Basis of structural design
 - PN-EN 1991 – Actions on structures
 - PN-EN 1992 – Design of concrete structures
 - PN-EN 1993 – Design of steel structures
 - PN-EN 1995 – Design of timber structures
 - PN-EN 1996 – Design of masonry structures
 - PN-EN 1997 – Geotechnical design

2.0. General characteristics of the climbing wall

The artificial climbing wall that is the subject of this study is a free-standing, interactive wall designed for children and adults, combining elements of a computer game with physical activity involving climbing on the structure. The wall is designed for one user. It is equipped with one individual upper belay point. The wall structure consists of three steel frames made of closed sections (square tubes RK80x80x4 and rectangular tubes RP80x40x4) placed on top of each other and connected. The lower frame has a total height of 33 cm and is placed on a horizontal steel frame, which also serves as a usable platform for the structure. Two more frames, each 192 cm high, are placed on the lower frame. The frames are bolted together with M16 bolts – six per connection. A structure made of rectangular RP100x80x6 tubes is bolted to the top of the upper frame for mounting the upper belay point. The projection of the support section allows the installation of a belay point at a distance of 50 cm from the wall face. The side and rear walls, as well as the top of the structure, are covered with a protective plate bolted to the structure. The upper cover on top of the structure also serves as a stiffener. The wall is designed for installation inside or outside a building. The frame structure creates slots for the installation of hold modules. The modules are sets of mechanisms that allow the climbing holds to be moved using control software.

The photo below shows the upper part of the wall without side, top, and rear cladding.



3.0. Static calculations

3.1. Assumptions made for the calculations

Static calculations and dimensioning were performed on the basis of the applicable PN-EN standards using the limit state method (load-bearing capacity and serviceability) applying loads and partial safety factors for static loads (1.35) and variable loads (1.50) as well as reduction factors in accordance with PN-EN 12572-1.

The following software was used to perform the calculations:

- Autodesk Robot Structural Analysis by Autodesk
- Proprietary spreadsheets

The following assembly sequence was assumed in the calculations:

- Positioning and leveling of the horizontal frame forming the base of the structure and also serving as a usable platform.
- Positioning and anchoring the lower frame to the horizontal frame.
- Assembly of subsequent frames; after each frame is assembled, it should be bolted to the previously positioned frame using six M16 class 8.8 bolts. Once the level of the horizontal fastenings has been reached, the structure should be anchored to the wall and only then should the assembly of subsequent, higher frames be commenced.
- Installation of the upper frame with a support beam. Screw the upper frame to the rest of the structure using six M16 class 8.8 bolts.
- Assemble the subsequent modules, starting from the lowest one. Assembly using a winch and an upper belay point.

- Make the cladding (side walls, rear wall, and top of the structure) with a cover plate screwed around the perimeter of the structure. The cladding installation may be carried out concurrently with module installation.
- Handover of the wall for use.

3.2. Loads

3.2.1. Permanent loads

3.2.1.1. Dead weight of the structure

The dead weight of the structure has been automatically included in the calculation program.

3.2.1.2. Weight of the cladding

10 mm thick plate

$$0.010\text{m} \times 10.00\text{kN/m}^3 = 0.100\text{kN/m}^2$$

The load was assumed to be surface load applied to the side walls, rear wall, and top of the structure.

3.2.1.3. Weight of modules

Weight of one module – 105 kg

Number of modules for the entire wall – 23 sets.

In the calculation model, the load of the modules was assumed to be concentrated forces of 55 kg applied to the horizontal beams of the structure at a distance of 18 cm from the front wall.

3.2.2. Variable loads during operation

The loads were assumed in accordance with Table A.1 of Annex A to PN-EN 12572-1.

Table A.1 — Loads

Dimensions in Kilonewton

	Proof test load	Characteristic load	Breaking load
Load of a climber	—	0,8	—
Load produced by falling climber on a protection point ^a	6,6	6,6	20,0
NOTE The proof testing only acts as a verification of good installation practice and cannot replace the calculations.			
^a Based on experiments it is impossible to have two or more climbers create a peak impact force simultaneously due to a fall.			

The relevant load for static and strength calculations of the structure is the load from a falling climber with a value according to the above table:

$$Q_k = 6.60\text{kN}$$

The load was applied at the fixed belay point at the top of the structure, as far away from the wall as possible.

In accordance with the above standard, it is assumed that this load may deviate from the vertical at an angle of 12.5 degrees in any direction.

3.2.3. Variable loads during the assembly phase

Loads from two assemblers were assumed in the form of two concentrated forces applied to the side horizontal beams with a value of $Q_{M1} = 1.50\text{kN}$ each.

In addition, a load of $Q_{M2} = 1.50\text{ kN}$ from the lifted modules was applied to the upper belay point.

3.2.4. Wind loads

The following assumptions were made for the calculations:

- Wind zone – 1
- Terrain category – 3 (areas regularly covered with vegetation or buildings, or with single obstacles spaced no more than 20 times their height apart – such as villages, suburban areas, permanent forests)
- Base wind speed – 22 m/s
- Base pressure – 0.30 kN/m²
- Peak pressure – 0.54 kN/m²

3.3. Load combinations

3.3.1. Load combination under operating conditions

The load combination under service conditions was adopted in accordance with the guidelines of Annex B of PN-EN 12572-1 based on the formula:

$$\gamma_G G_k + \gamma_Q Q_{k,1} + \sum_{i>1} \psi_i \gamma_Q Q_{k,i}$$

For permanent loads, the coefficient $\gamma_G = 1.35$ or 1.0

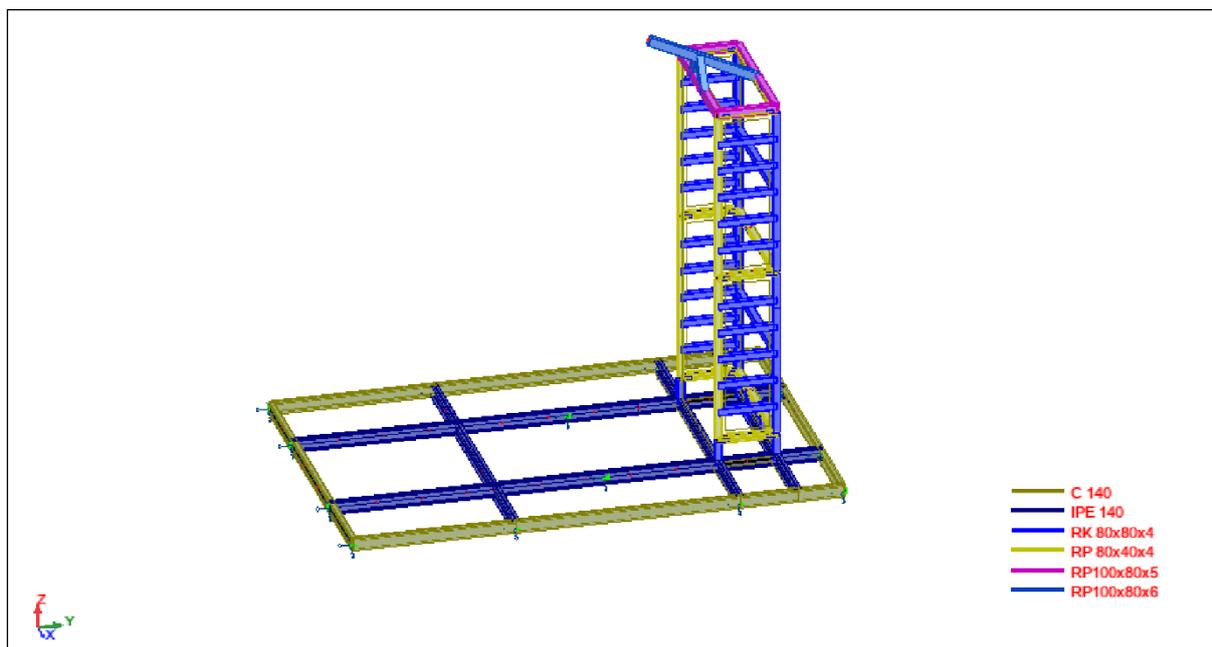
For climber loads, the coefficient $\gamma_Q = 1.50$ or 0 ; $\psi_0 = 0.8$; $\psi_1 = 0.8$; $\psi_2 = 0.8$

For variable loads on the platform, the coefficient $\gamma_Q = 1.50$ or 0 ; $\psi_0 = 0.7$; $\psi_1 = 0.5$; $\psi_2 = 0.3$

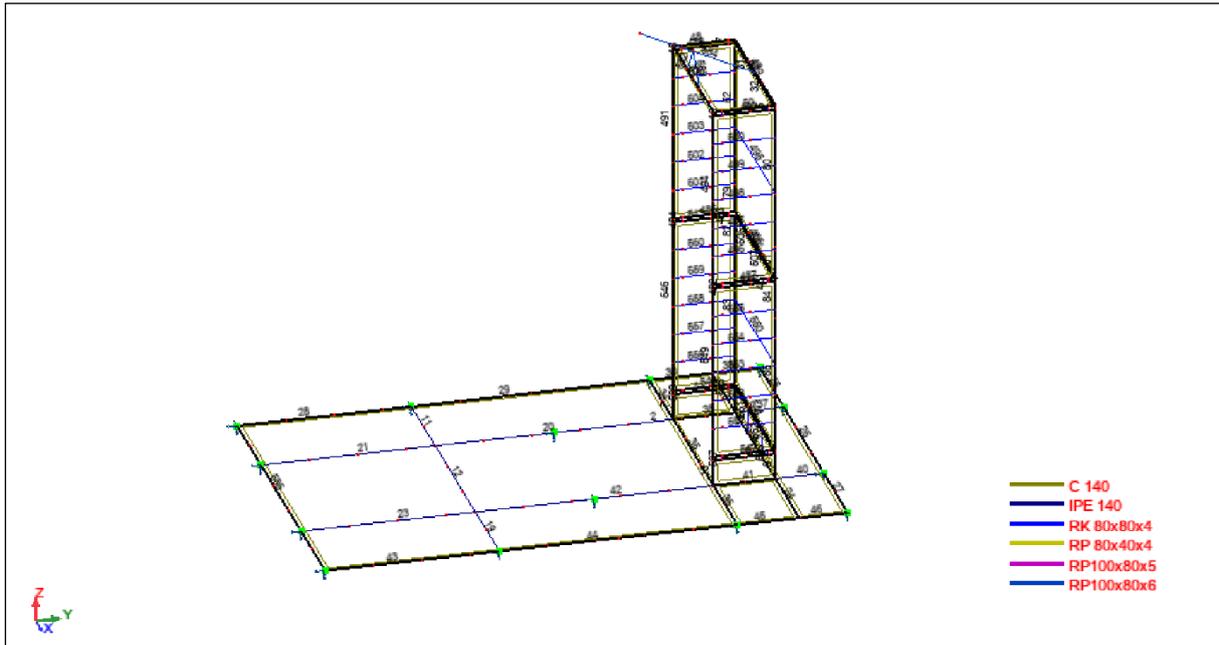
For wind $\gamma_Q = 1.50$ or 0 ; $\psi_0 = 0.6$; $\psi_1 = 0.2$; $\psi_2 = 0.0$

3.4. Dimensioning of the structure during the service life

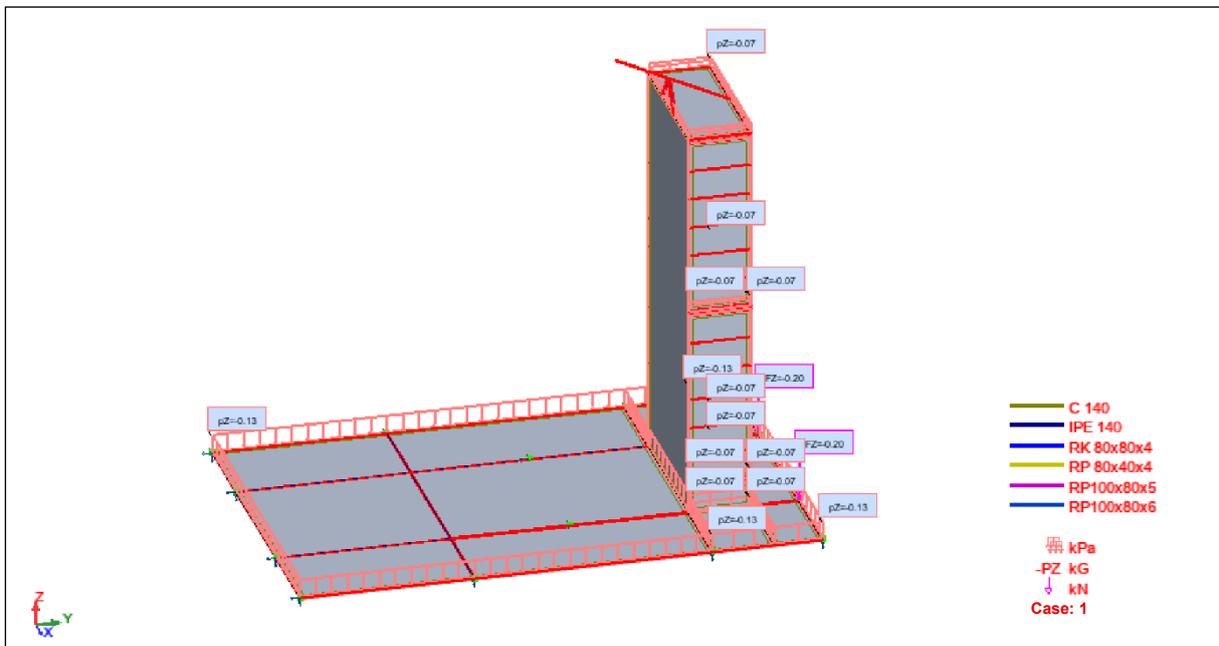
3.4.1. Static diagram of the main structure and cross-sections used



3.4.2. Member numbers

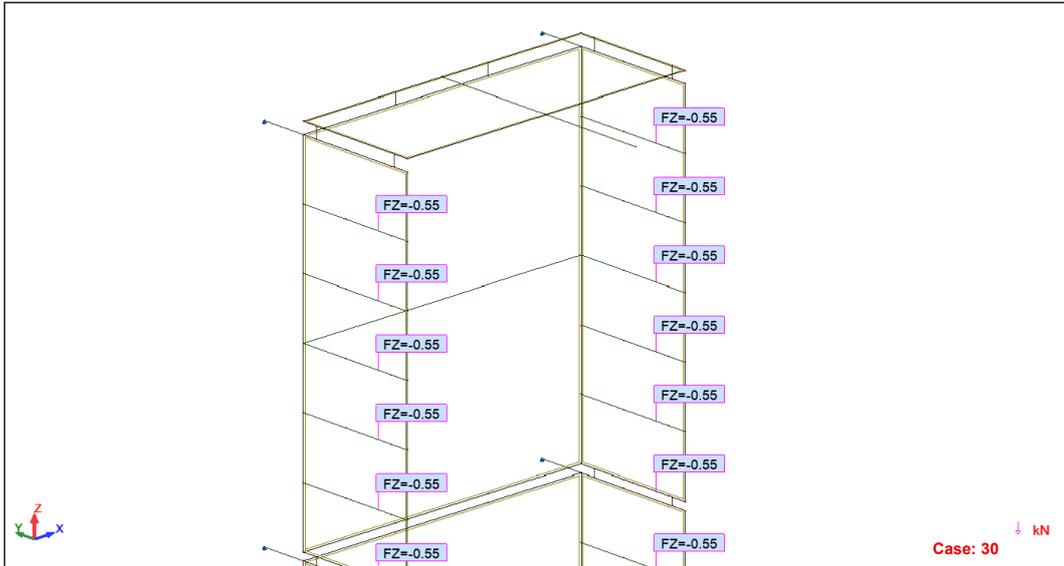


3.4.3. Load from the cladding



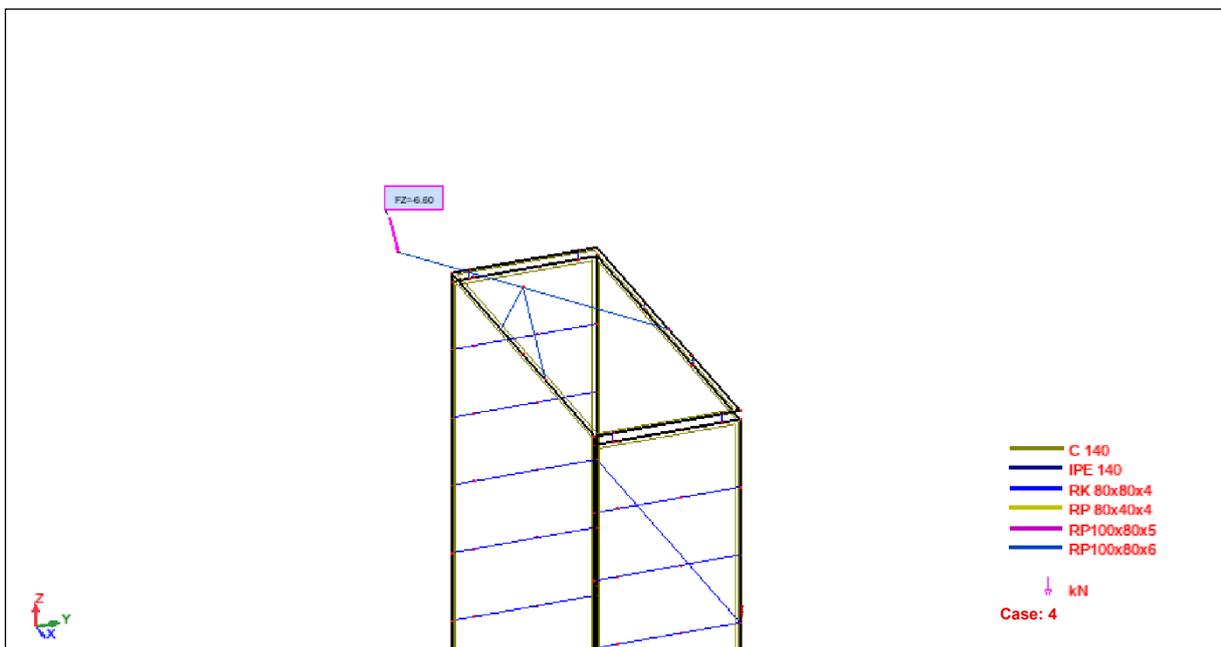
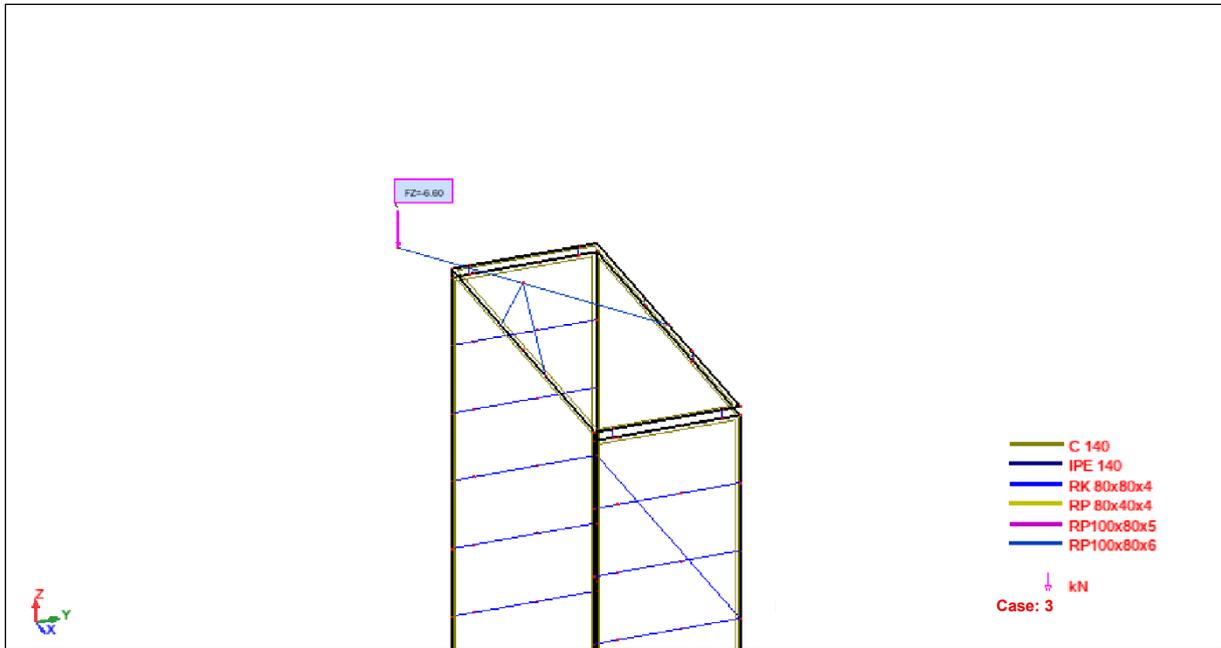
3.4.4. Loads from modules

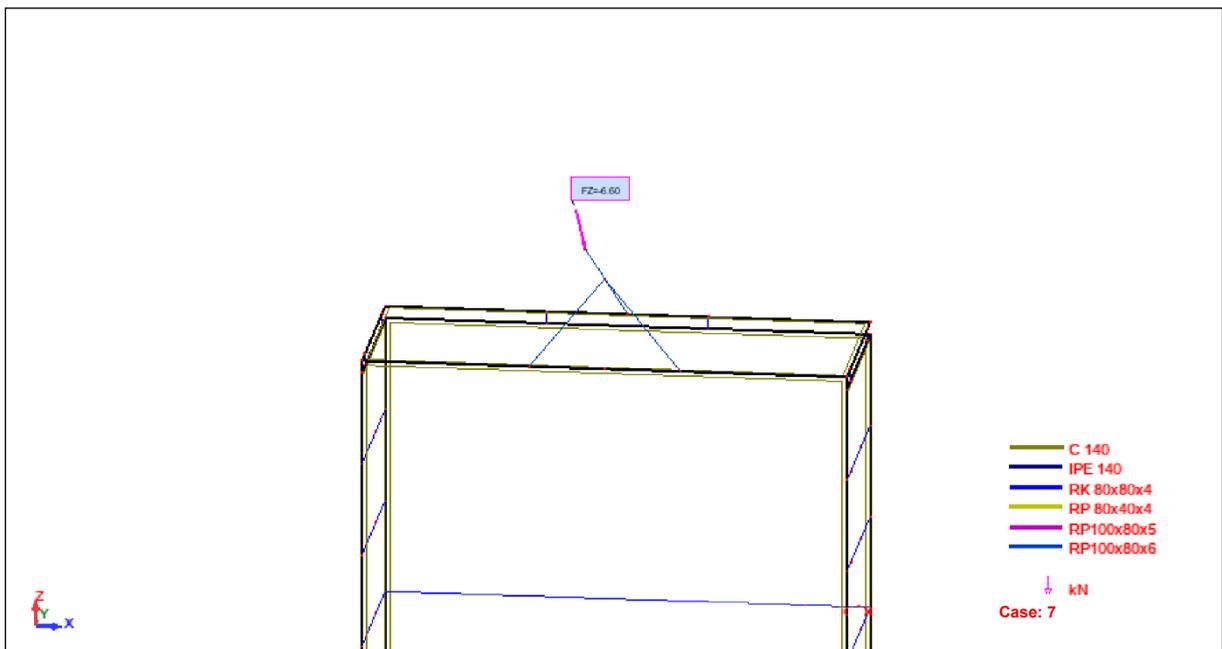
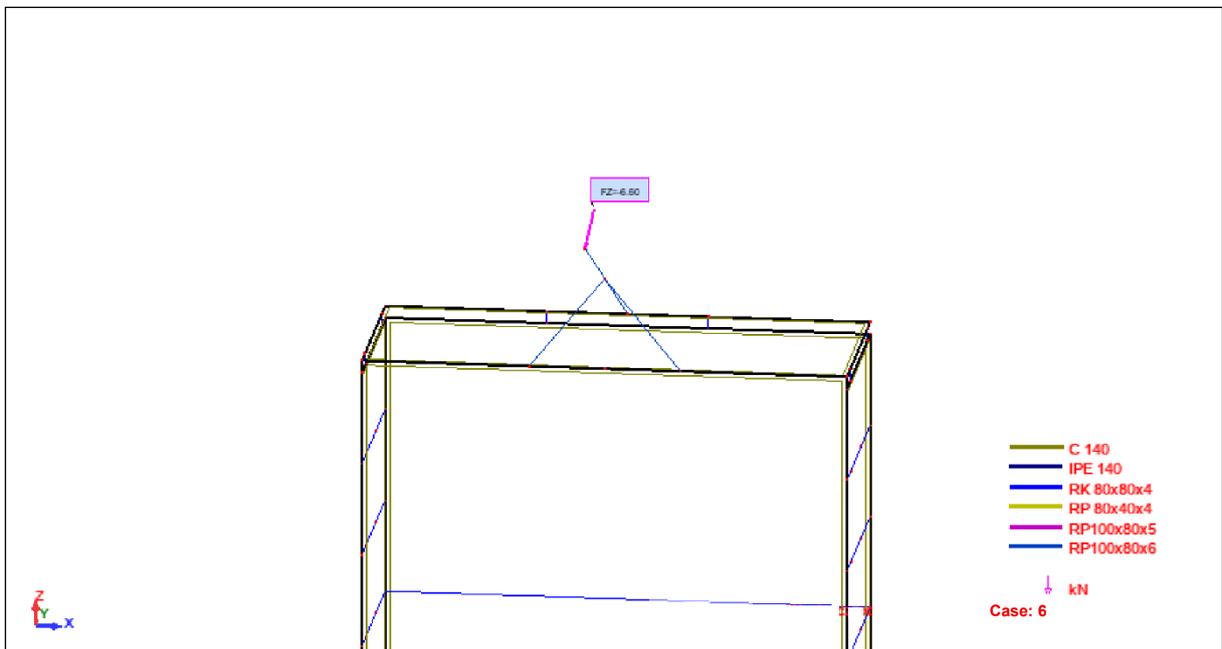
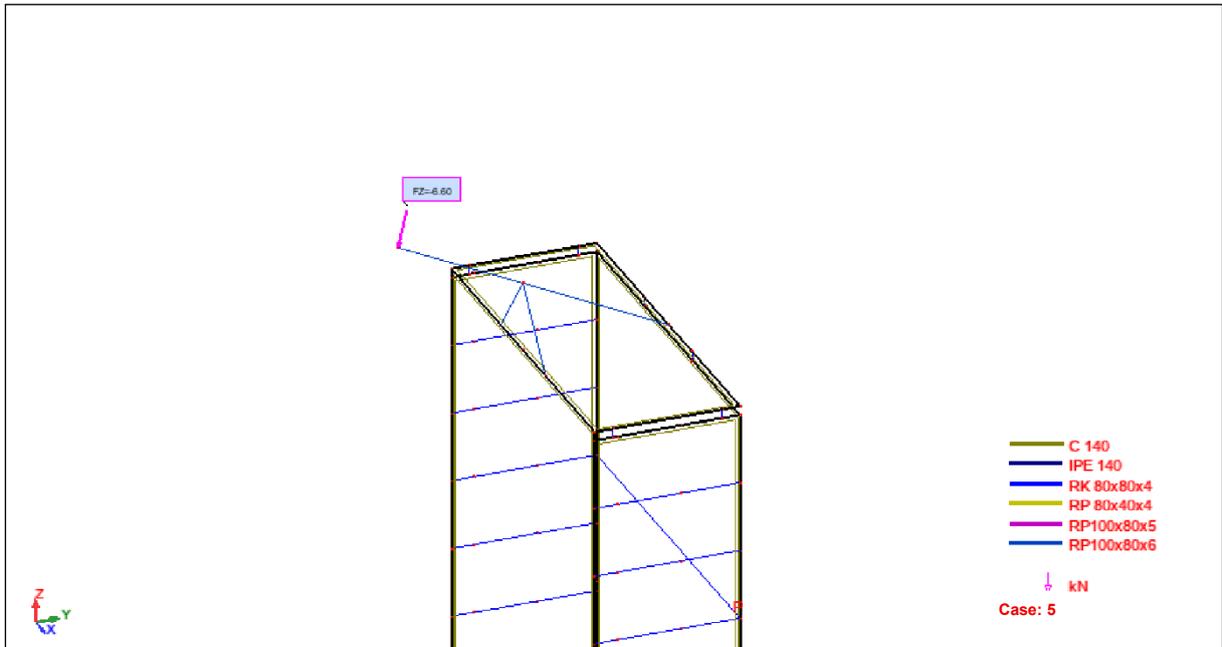
The illustration below shows a fragment of the structure with module loads. Analogous loads are applied over the entire height of the structure



3.4.5. Loads from a falling climber

The loads shown below cannot occur simultaneously.



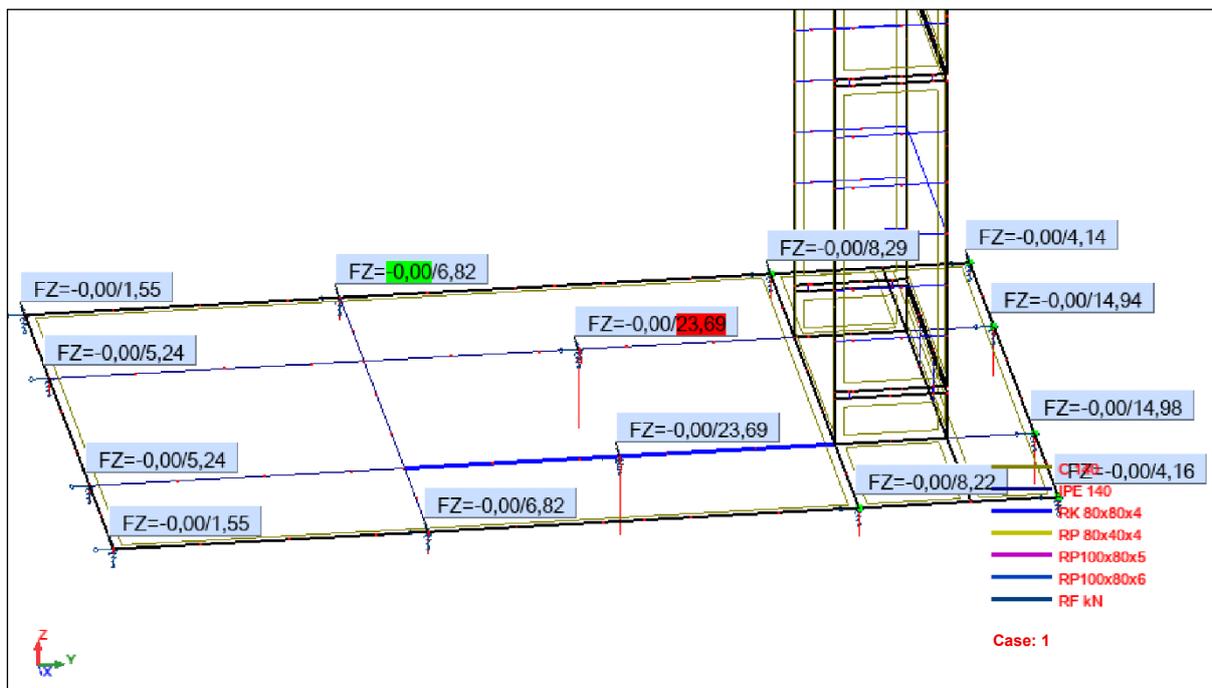


3.4.6. Load case numbers

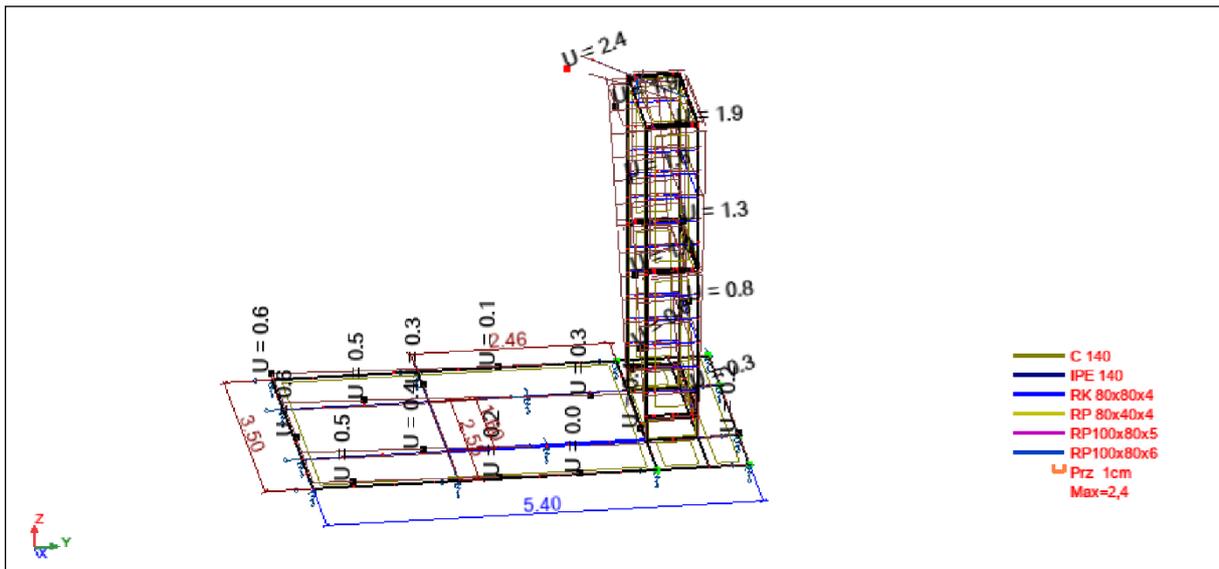
Case	Label	Case name	Nature	Type of analysis
1	STA1	STA1	Structural	[NL] Statics
2	STA11	Modules	Structural	[NL] Statics
3	EKSP2	Vertically falling climber	Climber	[NL] Statics
4	EKSP21	Climber falling 12.5 degrees	Climber	[NL] Statics
5	EKSP3	Climber falling -12.5 degrees	Climber	[NL] Statics
6	EKSP4	Climber falling 12.5 degrees left	Climber	[NL] Statics
7	EKSP41	Climber falling 12.5 degrees to the right	Climber	[NL] Statics
8	User	User	Category B	[NL] Statics
9	WIND1	Wind X+ 22 m/s (f =1.80) Simulation	wind	[NL] Statics
10	WIND2	Wind X+Y+ 22 m/s (f =1.80) Simulation	wind	[NL] Statics
11	WIND3	Wind Y+ 22 m/s (f =1.80) Simulation	wind	[NL] Statics
12	WIND4	Wind X-Y+ 22 m/s (f =1.80) Simulation	wind	[NL] Statics
13	WIND5	Wind X- 22 m/s (f =1.80) Simulation	wind	[NL] Statics
14	WIND6	Wind X-Y- 22 m/s (f =1.80) Simulation	wind	[NL] Statics
15	WIND7	Wind Y- 22 m/s (f =1.80) Simulation	wind	[NL] Statics
16	WIND8	Wind X+Y- 22 m/s (f =1.80) Simulation	wind	[NL] Statics

3.4.7. Calculation results

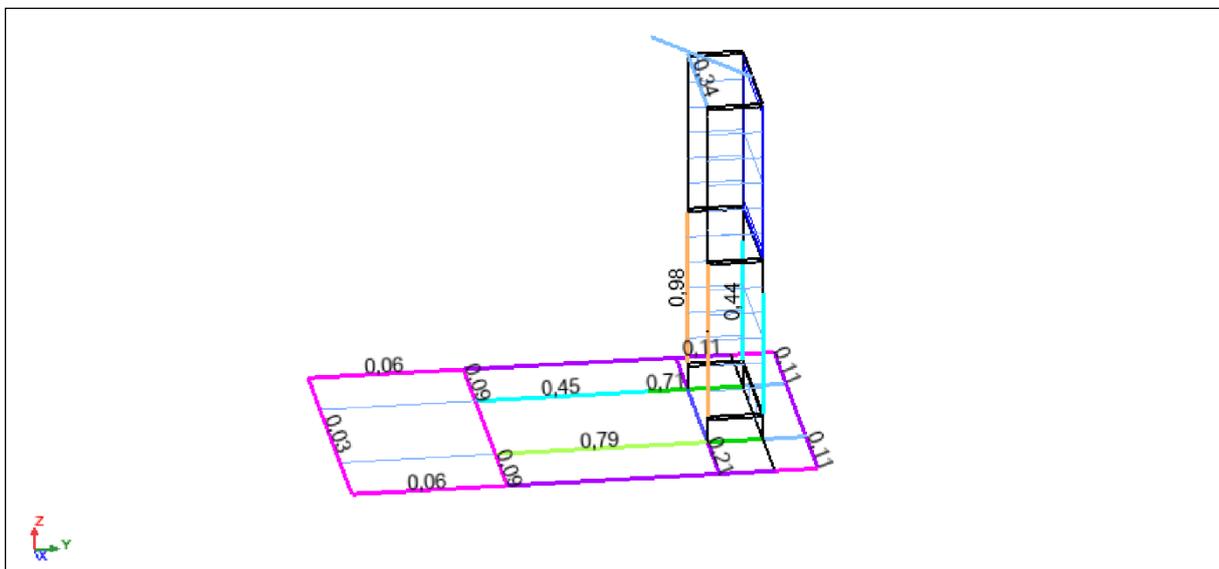
3.4.7.1. Envelope of support reactions



3.4.7.2. Displacement of structures in SGU condition



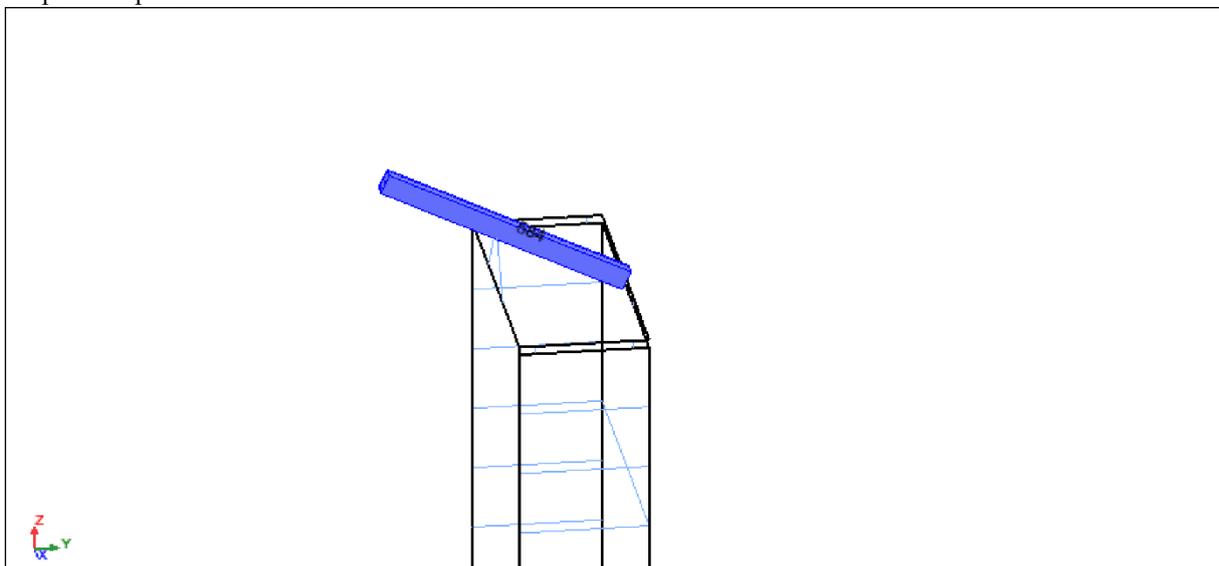
3.4.7.3. Stress on main elements shown graphically



3.4.8. Detailed results

3.4.8.1. Detailed results for the belay point beam – bar no. 584

Graphical representation of the calculated beam



STANDARD: *PN-EN 1993-1:2006/NA:2010/A1:2014, Eurocode 3: Design of steel structures.*
TYPE OF ANALYSIS: *Verification of members*

GROUP:

BARS: 584 Bar_584

POINT: 1

COORDINATE: $x = 0.54 L =$

0.71 m

LOADS:

Decisive load case: 197 SGN/163=1*1.35 + 15*0.90 + 2*1.35 + 5*1.50 (1+2)*1.35+15*0.90+5*1.50

MATERIAL:

S 235 (S 235) $f_y = 235.00$ MPa



SECTION PARAMETERS: **RP100x80x6**

$h=10.0$ cm

$gM0=1.00$

$gM1=1.00$

$b=8.0$ cm

$A_y=8.16$ cm²

$A_z=10.56$ cm²

$A_x=20.16$ cm²

$tw=0.6$ cm

$I_y=280.50$ cm⁴

$I_z=196.08$ cm⁴

$I_x=348.03$ cm⁴

$tf=0.6$ cm

$W_{ply}=68.35$ cm³

$W_{plz}=58.27$ cm³

INTERNAL FORCES AND LOAD-BEARING CAPACITY:

$N_{,Ed} = 2.34$ kN

$M_{y,Ed} = -5.92$ kN*m

$N_{c,Rd} = 473.76$ kN

$M_{y,Ed,max} = -5.92$ kN*m

$M_{z,Ed,max} = 0.00$ kN*m

$N_{b,Rd} = 444.72$ kN

$M_{y,c,Rd} = 16.06$ kN*m

$M_{z,c,Rd} = 13.69$ kN*m

$V_{z,Ed} = 9.75$ kN

$MN_{,y,Rd} = 16.06$ kN*m

$V_{z,c,Rd} = 143.28$ kN

SECTION CLASS = 1



DEFORMATION PARAMETERS:

BUCKLING PARAMETERS:



relative to the y-axis:

$L_y = 1.32$ m

$\lambda_{m,y} = 0.38$

$L_{cr,y} = 1.32$ m

$X_y = 0.96$

$\lambda_{my} = 35.45$

$k_{yy} = 0.90$



relative to the z-axis:

$L_z = 1.32$ m

$\lambda_{m,z} = 0.45$

$L_{cr,z} = 1.32$ m

$X_z = 0.94$

$\lambda_{mz} = 42.40$

$k_{zy} = 0.00$

VERIFICATION FORMULAS:

Cross-section strength check:

$N_{,Ed}/N_{c,Rd} = 0.00 < 1.00$ (6.2.4.(1))

$M_{y,Ed}/M_{y,c,Rd} = 0.37 < 1.00$ (6.2.5.(1))

$V_{z,Ed}/V_{z,c,Rd} = 0.07 < 1.00$ (6.2.6.(1))

Global stability check of the bar:

$\lambda_{m,y} = 35.45 < \lambda_{m,max} = 210.00$ $\lambda_{m,z} = 42.40 < \lambda_{m,max} = 210.00$ STABLE

$N_{,Ed}/(X_y \cdot N_{c,Rd}/gM1) + k_{yy} \cdot M_{y,Ed,max}/(XLT \cdot M_{y,Rd}/gM1) + k_{yz} \cdot M_{z,Ed,max}/(M_{z,Rd}/gM1) = 0.34 < 1.00$
(6.3.3.(4))

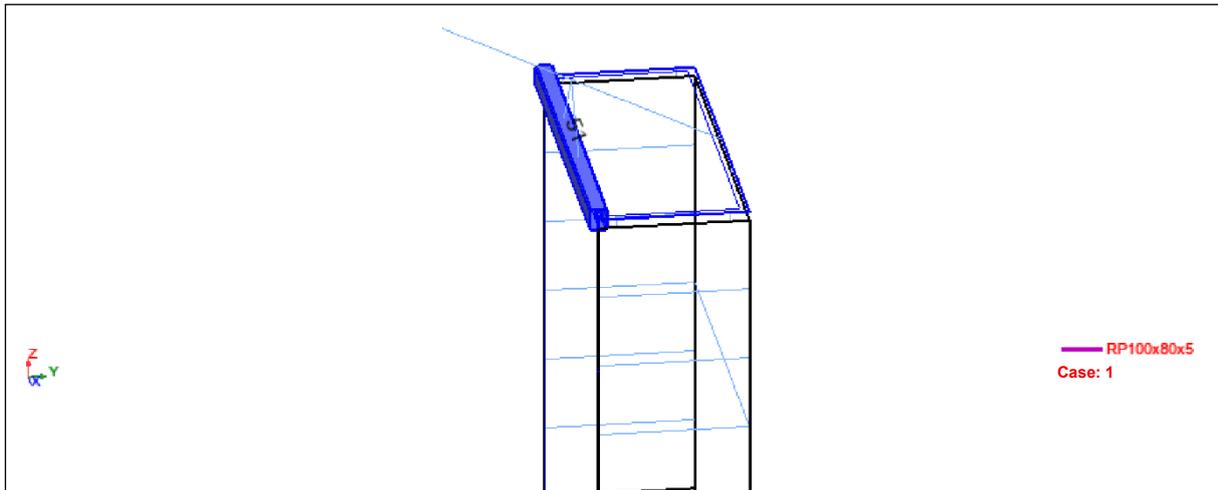
$N_{,Ed}/(X_z \cdot N_{c,Rd}/gM1) + k_{zy} \cdot M_{y,Ed,max}/(XLT \cdot M_{y,Rd}/gM1) + k_{zz} \cdot M_{z,Ed,max}/(M_{z,Rd}/gM1) = 0.01 < 1.00$
(6.3.3.(4))

Profile meets requirements

3.4.8.2. Detailed results for the upper beam under the support bracket – bar no. 51

The arrangement of the lateral fixing points has no effect on the stress in this bar.

Graphical representation of the calculated beam



CALCULATIONS FOR STEEL STRUCTURES

STANDARD: PN-EN 1993-1:2006/NA:2010/A1:2014, Eurocode 3: Design of steel structures.

TYPE OF ANALYSIS: Verification of members

GROUP:

BARS: 51 Upper beam_51

POINT: 3

COORDINATE: $x = 0.34 L =$

0.55 m

LOADS:

Decisive load case: 199 SGN/165=1*1.35 + 8*1.05 + 2*1.35 + 6*1.50 (1+2)*1.35+8*1.05+6*1.50

MATERIAL:

S 235 (S 235) $f_y = 235.00$ MPa



SECTION PARAMETERS: RP100x80x5

$h=10.0$ cm

$gM0=1.00$

$gM1=1.00$

$b=8.0$ cm

$A_y=7.27$ cm²

$A_z=9.09$ cm²

$A_x=16.36$ cm²

$tw=0.5$ cm

$I_y=225.94$ cm⁴

$I_z=159.61$ cm⁴

$I_x=300.04$ cm⁴

$tf=0.5$ cm

$W_{ply}=55.09$ cm³

$W_{plz}=47.24$ cm³

INTERNAL FORCES AND LOAD-BEARING CAPACITY:

$N_{,Ed} = 1.02$ kN

$M_{y,Ed} = 4.34$ kN*m

$M_{z,Ed} = 0.59$ kN*m

$V_{y,Ed} = -1.08$ kN

$N_{c,Rd} = 384.46$ kN

$M_{y,Ed,max} = 4.34$ kN*m

$M_{z,Ed,max} = 0.59$ kN*m

$V_{y,T,Rd} = 86.57$ kN

$N_{b,Rd} = 349.68$ kN

$M_{y,c,Rd} = 12.95$ kN*m

$M_{z,c,Rd} = 11.10$ kN*m

$V_{z,Ed} = 7.83$ kN

$M_{N,y,Rd} = 12.95$ kN*m

$M_{N,z,Rd} = 11.10$ kN*m

$V_{z,T,Rd} = 108.22$ kN

$M_{b,Rd} = 12.95$ kN*m

$T_{t,Ed} = -1.18$ kN*m

SECTION CLASS = 1



$z = 1.00$

$M_{cr} = 600.82$ kN*m

Curve, LT - d

$X_{LT} = 1.00$

$L_{cr,upp} = 1.60$ m

$\lambda_{m,LT} = 0.15$

$f_{i,LT} = 0.41$

$X_{LT,mod} = 1.00$

DEFLECTION PARAMETERS:



relative to the y-axis:

$L_y = 1.60$ m

$\lambda_{m,y} = 0.46$

$L_{cr,y} = 1.60$ m

$X_y = 0.94$

$\lambda_{m,y} = 43.05$

$k_{yy} = 0.90$



relative to the z-axis:

$L_z = 1.60$ m

$\lambda_{m,z} = 0.55$

$L_{cr,z} = 1.60$ m

$X_z = 0.91$

$\lambda_{m,z} = 51.22$

$k_{yz} = 0.54$

VERIFICATION FORMULAS:

Cross-section strength check:

$N_{,Ed}/N_{c,Rd} = 0.00 < 1.00$ (6.2.4.(1))

$M_{y,Ed}/M_{N,y,Rd} = 0.34 < 1.00$ (6.2.9.1.(2))

$M_{z,Ed}/M_{N,z,Rd} = 0.05 < 1.00$ (6.2.9.1.(2))

$$(M_y,Ed/MN_{y,Rd})^{1.66} + (M_z,Ed/MN_{z,Rd})^{1.66} = 0.17 < 1.00 \quad (6.2.9.1.(6))$$

$$V_y,Ed/V_{y,T,Rd} = 0.01 < 1.00 \quad (6.2.6-7)$$

$$V_z,Ed/V_{z,T,Rd} = 0.07 < 1.00 \quad (6.2.6-7)$$

$$\tau_{xy,Ed}/(f_y/(\sqrt{3})\cdot gM_0) = 0.12 < 1.00 \quad (6.2.6)$$

$$\tau_{xz,Ed}/(f_y/(\sqrt{3})\cdot gM_0) = 0.12 < 1.00 \quad (6.2.6)$$

Global stability check of the bar:

$$\lambda_{y} = 43.05 < \lambda_{max} = 210.00 \quad \lambda_{z} = 51.22 < \lambda_{max} = 210.00 \quad \text{STABLE}$$

$$M_y,Ed,max/M_{b,Rd} = 0.34 < 1.00 \quad (6.3.2.1.(1))$$

$$N_{Ed}/(X_y \cdot N_{Rk}/gM_1) + k_{yy} \cdot M_{y,Ed,max}/(X_{LT} \cdot M_{y,Rk}/gM_1) + k_{yz} \cdot M_{z,Ed,max}/(M_{z,Rk}/gM_1) = 0.33 < 1.00 \quad (6.3.3.(4))$$

$$N_{Ed}/(X_z \cdot N_{Rk}/gM_1) + k_{zy} \cdot M_{y,Ed,max}/(X_{LT} \cdot M_{y,Rk}/gM_1) + k_{zz} \cdot M_{z,Ed,max}/(M_{z,Rk}/gM_1) = 0.23 < 1.00 \quad (6.3.3.(4))$$

LIMIT DISPLACEMENTS



Deflections (LOCAL SYSTEM):

$$u_y = 0.0 \text{ cm} < u_{y,max} = L/200.00 = 0.8 \text{ cm} \quad \text{Verified}$$

Decisive load case: 595 SGU:CHR/79=1*1.00 + 8*0.70 + 13*0.60 + 2*1.00 + 4*1.00
(1+2+4)*1.00+8*0.70+13*0.60

$$u_z = 0.1 \text{ cm} < u_{z,max} = L/200.00 = 0.8 \text{ cm} \quad \text{Verified}$$

Decisive load case: 608 SGU:CHR/92=1*1.00 + 8*0.70 + 2*1.00 + 5*1.00 (1+2+5)*1.00+8*0.70



Displacements (GLOBAL SYSTEM):

$$v_x = 0.0 \text{ cm} < v_{x,max} = L/150.00 = 1.1 \text{ cm} \quad \text{Verified}$$

Decisive load case: 620 SGU:CHR/104=1*1.00 + 11*0.60 + 2*1.00 + 5*1.00 (1+2+5)*1.00+11*0.60

$$v_y = 0.5 \text{ cm} < v_{y,max} = L/150.00 = 1.1 \text{ cm} \quad \text{Verified}$$

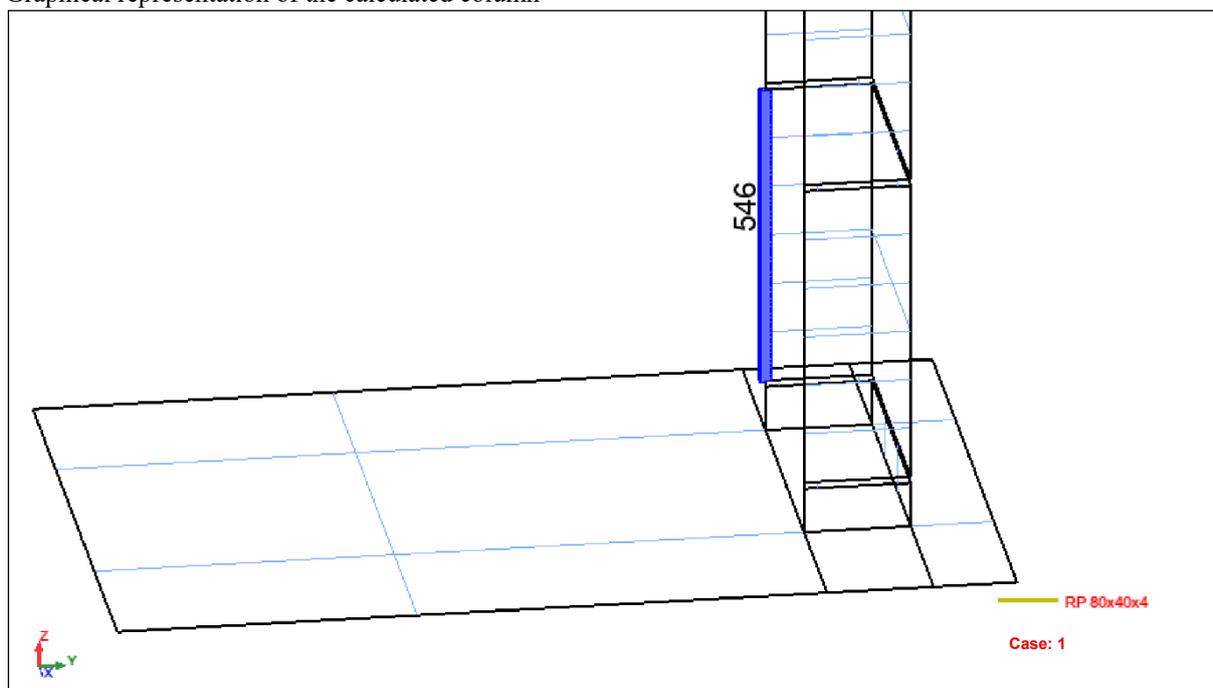
Decisive load case: 641 SGU:CHR/125=1*1.00 + 14*0.60 + 2*1.00 + 6*1.00 (1+2+6)*1.00+14*0.60

Profile meets requirements

3.4.8.3. Detailed results for front column bar no. 546

The results of calculations for the column from the most unfavorable variant, i.e. II, are presented below

Graphical representation of the calculated column



CALCULATIONS FOR STEEL STRUCTURES

STANDARD: PN-EN 1993-1:2006/NA:2010/A1:2014, Eurocode 3: Design of steel structures.

ANALYSIS TYPE: Verification of members

GROUP:

BARS: 546 Main columns 1.88m_546

POINT: 1

COORDINATE: $x = 0.83 L = 1.57 \text{ m}$

LOADS:

Decisive load case: $379 \text{ SGN}/345 = 1 \cdot 1.35 + 8 \cdot 1.05 + 15 \cdot 1.50 + 2 \cdot 1.35 + 5 \cdot 1.05$
 $(1+2) \cdot 1.35 + (8+5) \cdot 1.05 + 15 \cdot 1.50$

MATERIAL:

S 235 (S 235) $f_y = 235.00 \text{ MPa}$



SECTION PARAMETERS: RP 80x40x4

$h = 8.0 \text{ cm}$	$gM0 = 1.00$	$gM1 = 1.00$	
$b = 4.0 \text{ cm}$	$A_y = 2.93 \text{ cm}^2$	$A_z = 5.86 \text{ cm}^2$	$A_x = 8.79 \text{ cm}^2$
$t_w = 0.4 \text{ cm}$	$I_y = 68.20 \text{ cm}^4$	$I_z = 22.20 \text{ cm}^4$	$I_x = 53.95 \text{ cm}^4$
$t_f = 0.4 \text{ cm}$	$W_{ply} = 20.91 \text{ cm}^3$	$W_{plz} = 12.77 \text{ cm}^3$	

INTERNAL FORCES AND LOAD-BEARING CAPACITY:

$N_{,Ed} = 38.89 \text{ kN}$	$M_{y,Ed} = -1.03 \text{ kN}\cdot\text{m}$	$M_{z,Ed} = -0.23 \text{ kN}\cdot\text{m}$	$V_{y,Ed} = 0.46 \text{ kN}$
$N_{c,Rd} = 206.56 \text{ kN}$	$M_{y,Ed,max} = -1.03 \text{ kN}\cdot\text{m}$	$M_{z,Ed,max} = -0.36 \text{ kN}\cdot\text{m}$	$V_{y,T,Rd} = 38.71 \text{ kN}$
$N_{b,Rd} = 57.92 \text{ kN}$	$M_{y,c,Rd} = 4.91 \text{ kN}\cdot\text{m}$	$M_{z,c,Rd} = 3.00 \text{ kN}\cdot\text{m}$	$V_{z,Ed} = 2.00 \text{ kN}$
	$MN_{y,Rd} = 4.91 \text{ kN}\cdot\text{m}$	$MN_{z,Rd} = 2.82 \text{ kN}\cdot\text{m}$	$V_{z,T,Rd} = 77.42 \text{ kN}$
	$M_{b,Rd} = 4.91 \text{ kN}\cdot\text{m}$		$T_{t,Ed} = 0.08 \text{ kN}\cdot\text{m}$

SECTION CLASS = 1



DISTORTION PARAMETERS:

$z = 0.00$	$M_{cr} = 91.31 \text{ kN}\cdot\text{m}$	Curve, LT - d	$X_{LT} = 1.00$
$L_{cr,low} = 1.88 \text{ m}$	$\lambda_{m_LT} = 0.23$	$f_{i,LT} = 0.46$	$X_{LT,mod} = 1.00$

DEFLECTION PARAMETERS:



relative to the y-axis:

$L_y = 1.88 \text{ m}$	$\lambda_{m_y} = 1.01$
$L_{cr,y} = 2.63 \text{ m}$	$X_y = 0.66$
$L_{m_y} = 94.49$	$k_{zy} = 0.66$



relative to the z-axis:

$L_z = 1.88 \text{ m}$	$\lambda_{m_z} = 1.76$
$L_{cr,z} = 2.63 \text{ m}$	$X_z = 0.28$
$L_{m_z} = 165.62$	$k_{zz} = 1.38$

VERIFICATION FORMULAS:

Cross-section strength check:

$N_{,Ed}/N_{c,Rd} = 0.19 < 1.00$ (6.2.4.(1))
 $M_{y,Ed}/MN_{y,Rd} = 0.21 < 1.00$ (6.2.9.1.(2))
 $M_{z,Ed}/MN_{z,Rd} = 0.08 < 1.00$ (6.2.9.1.(2))
 $(M_{y,Ed}/MN_{y,Rd})^{1.73} + (M_{z,Ed}/MN_{z,Rd})^{1.73} = 0.08 < 1.00$ (6.2.9.1.(6))
 $V_{y,Ed}/V_{y,T,Rd} = 0.01 < 1.00$ (6.2.6-7)
 $V_{z,Ed}/V_{z,T,Rd} = 0.03 < 1.00$ (6.2.6-7)
 $\tau_{y,Ed}/(f_y/(\sqrt{3} \cdot gM0)) = 0.03 < 1.00$ (6.2.6)
 $\tau_{z,Ed}/(f_y/(\sqrt{3} \cdot gM0)) = 0.03 < 1.00$ (6.2.6)

Global stability check of the bar:

$\lambda_{m,y} = 94.49 < \lambda_{m,max} = 210.00$ $\lambda_{m,z} = 165.62 < \lambda_{m,max} = 210.00$ STABLE
 $M_{y,Ed,max}/M_{b,Rd} = 0.21 < 1.00$ (6.3.2.1.(1))
 $N_{,Ed}/(X_y \cdot N_{,Rk}/gM1) + k_{yy} \cdot M_{y,Ed,max}/(X_{LT} \cdot M_{y,Rk}/gM1) + k_{yz} \cdot M_{z,Ed,max}/(M_{z,Rk}/gM1) = 0.61 < 1.00$
(6.3.3.(4))
 $N_{,Ed}/(X_z \cdot N_{,Rk}/gM1) + k_{zy} \cdot M_{y,Ed,max}/(X_{LT} \cdot M_{y,Rk}/gM1) + k_{zz} \cdot M_{z,Ed,max}/(M_{z,Rk}/gM1) = 0.98 < 1.00$
(6.3.3.(4))

LIMIT DISPLACEMENTS



Deflections (LOCAL SYSTEM): Not analyzed

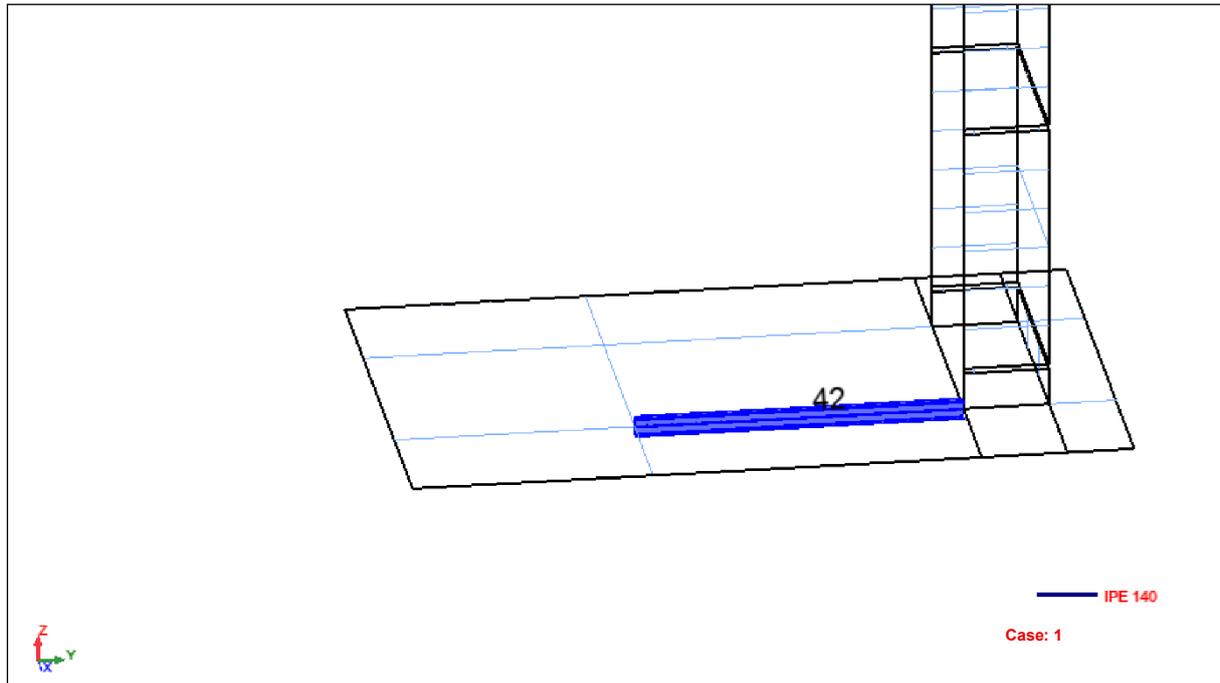


Displacements (GLOBAL SYSTEM):

$v_x = 0.5 \text{ cm} < v_{x,max} = L/150.00 = 1.3 \text{ cm}$ Verified
Decisive load case: $750 \text{ SGU:CHR}/234 = 1 \cdot 1.00 + 9 \cdot 1.00 + 2 \cdot 1.00 + 7 \cdot 0.70$ (1+9+2) $\cdot 1.00 + 7 \cdot 0.70$
 $v_y = 0.9 \text{ cm} < v_{y,max} = L/150.00 = 1.3 \text{ cm}$ Verified
Decisive load case: $716 \text{ SGU:CHR}/200 = 1 \cdot 1.00 + 8 \cdot 0.70 + 15 \cdot 1.00 + 2 \cdot 1.00 + 5 \cdot 0.70$
(1+15+2) $\cdot 1.00 + (8+5) \cdot 0.70$

Profile meets requirements

3.4.8.4. Detailed calculations for the horizontal working platform beam



CALCULATIONS FOR STEEL STRUCTURES

STANDARD: *PN-EN 1993-1:2006/NA:2010/A1:2014, Eurocode 3: Design of steel structures.*

TYPE OF ANALYSIS: *Verification of members*

GROUP:

BARS: 42
0.00 m

POINT: 1

COORDINATE: $x = 0.00$ L =

LOADS:

Decisive load case: $387 \text{ SGN}/353 = 1 \cdot 1.35 + 15 \cdot 1.50 + 2 \cdot 1.35 + 5 \cdot 1.05 \quad (1+2) \cdot 1.35 + 15 \cdot 1.50 + 5 \cdot 1.05$

MATERIAL:

S 235 (S 235) $f_y = 235.00 \text{ MPa}$



SECTION PARAMETERS: IPE 140

$h=14.0 \text{ cm}$	$gM0=1.00$	$gM1=1.00$	
$b=7.3 \text{ cm}$	$A_y=11.13 \text{ cm}^2$	$A_z=7.62 \text{ cm}^2$	$A_x=16.40 \text{ cm}^2$
$t_w=0.5 \text{ cm}$	$I_y=541.00 \text{ cm}^4$	$I_z=44.90 \text{ cm}^4$	$I_x=2.45 \text{ cm}^4$
$t_f=0.7 \text{ cm}$	$W_{ply}=88.34 \text{ cm}^3$	$W_{plz}=19.25 \text{ cm}^3$	

INTERNAL FORCES AND LOAD-BEARING CAPACITY:

$N_{,Ed} = 3.10 \text{ kN}$	$M_{y,Ed} = 14.73 \text{ kN}\cdot\text{m}$	$M_{z,Ed} = 0.02 \text{ kN}\cdot\text{m}$	$V_{y,Ed} = 0.03 \text{ kN}$
$N_{c,Rd} = 385.40 \text{ kN}$	$M_{y,Ed,max} = 14.73 \text{ kN}\cdot\text{m}$	$M_{z,Ed,max} = 0.02 \text{ kN}\cdot\text{m}$	$V_{y,T,Rd} = 150.64 \text{ kN}$
$N_{b,Rd} = 385.40 \text{ kN}$	$M_{y,c,Rd} = 20.76 \text{ kN}\cdot\text{m}$	$M_{z,c,Rd} = 4.52 \text{ kN}\cdot\text{m}$	$V_{z,Ed} = -13.33 \text{ kN}$
	$MN_{y,Rd} = 20.76 \text{ kN}\cdot\text{m}$	$MN_{z,Rd} = 4.52 \text{ kN}\cdot\text{m}$	$V_{z,T,Rd} = 103.18 \text{ kN}$
	$M_{b,Rd} = 18.53 \text{ kN}\cdot\text{m}$		$T_{t,Ed} = 0.00 \text{ kN}\cdot\text{m}$
			SECTION CLASS = 1



DEFORMATION PARAMETERS:

$z = 1.00$	$M_{cr} = 42.49 \text{ kN}\cdot\text{m}$	Curve, LT - b	$X_{LT} = 0.87$
$L_{cr,upp} = 1.23 \text{ m}$	$\lambda_{m_LT} = 0.70$	$f_{i,LT} = 0.73$	$X_{LT,mod} = 0.89$

DEFLECTION PARAMETERS:



relative to the y-axis:

$$k_{yy} = 0.90$$



relative to the z-axis:

$$k_{yz} = 0.54$$

VERIFICATION FORMULAS:

Cross-section strength check:

$$N_{Ed}/N_{c,Rd} = 0.01 < 1.00 \quad (6.2.4.(1))$$

$$M_{y,Ed}/M_{N,y,Rd} = 0.71 < 1.00 \quad (6.2.9.1.(2))$$

$$M_{z,Ed}/M_{N,z,Rd} = 0.01 < 1.00 \quad (6.2.9.1.(2))$$

$$(M_{y,Ed}/M_{N,y,Rd})^{2.00} + (M_{z,Ed}/M_{N,z,Rd})^{1.00} = 0.51 < 1.00 \quad (6.2.9.1.(6))$$

$$V_{y,Ed}/V_{y,T,Rd} = 0.00 < 1.00 \quad (6.2.6-7)$$

$$V_{z,Ed}/V_{z,T,Rd} = 0.13 < 1.00 \quad (6.2.6-7)$$

$$\tau_{xy,Ed}/(\sigma_{yk}/\sqrt{3}) = 0.01 < 1.00 \quad (6.2.6)$$

$$\tau_{xz,Ed}/(\sigma_{yk}/\sqrt{3}) = 0.00 < 1.00 \quad (6.2.6)$$

Global stability check of the bar:

$$W_{e,Ed,max}/M_{b,Rd} = 0.79 < 1.00 \quad (6.3.2.1.(1))$$

$$N_{Ed}/(X_y \cdot N_{Rk}/gM1) + k_{yy} \cdot M_{y,Ed,max}/(X_{LT} \cdot M_{y,Rk}/gM1) + k_{yz} \cdot M_{z,Ed,max}/(M_{z,Rk}/gM1) = 0.73 < 1.00 \quad (6.3.3.(4))$$

$$N_{Ed}/(X_z \cdot N_{Rk}/gM1) + k_{zy} \cdot M_{y,Ed,max}/(X_{LT} \cdot M_{y,Rk}/gM1) + k_{zz} \cdot M_{z,Ed,max}/(M_{z,Rk}/gM1) = 0.49 < 1.00 \quad (6.3.3.(4))$$

LIMIT DISPLACEMENTS



Deflections (LOCAL SYSTEM):

$$u_y = 0.0 \text{ cm} < u_{y,max} = L/200.00 = 1.2 \text{ cm}$$

Verified

$$\text{Decisive load case: } 748 \text{ SGU:CHR/232} = 1 \cdot 1.00 + 8 \cdot 0.70 + 15 \cdot 1.00 + 2 \cdot 1.00 + 7 \cdot 0.70$$

$$(1+15+2) \cdot 1.00 + (8+7) \cdot 0.70$$

$$u_z = 0.1 \text{ cm} < u_{z,max} = L/200.00 = 1.2 \text{ cm}$$

Verified

$$\text{Decisive load case: } 724 \text{ SGU:CHR/208} = 1 \cdot 1.00 + 15 \cdot 1.00 + 2 \cdot 1.00 + 5 \cdot 0.70 + (1+15+2) \cdot 1.00 + 5 \cdot 0.70$$

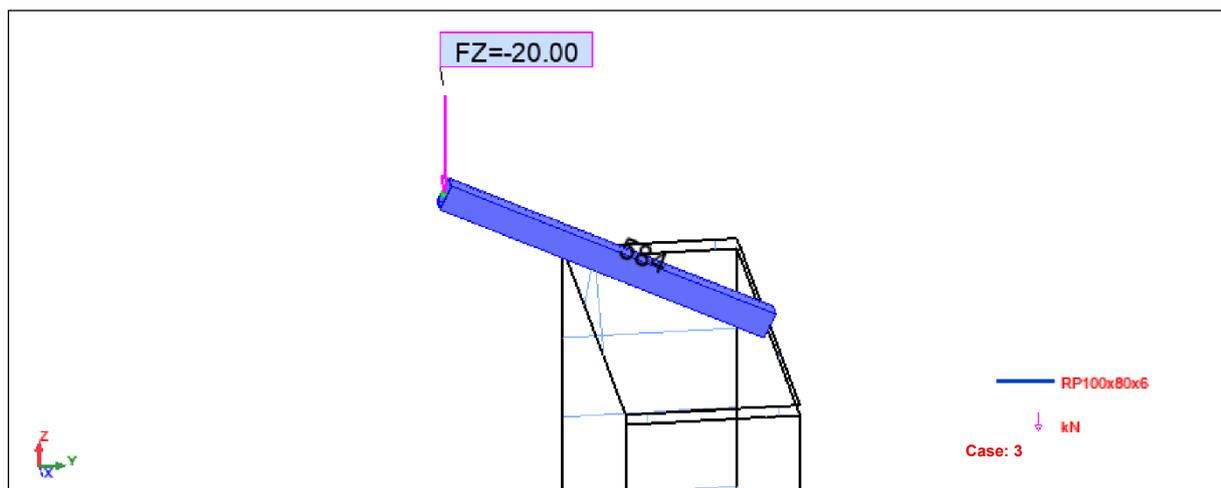


Displacements (GLOBAL SYSTEM): Not analyzed

Profile meets requirements

3.5. Calculations of the belay point for test loads

The test load was assumed to be a vertical force of 20 kN on the belay point, in accordance with PN-EN 12572-1



The check was performed in an exceptional combination of characteristic loads.

3.5.1. Calculation results for the main beam (No. 584) of the belay point

CALCULATIONS OF STEEL STRUCTURES

STANDARD: [PN-EN 1993-1:2006/NA:2010/A1:2014](#), [Eurocode 3: Design of steel structures](#).

TYPE OF ANALYSIS: [Verification of members](#)

GROUP:

BARS: 584 Bar_584
0.71 m

POINT: 1

COORDINATE: $x = 0.54 L =$

LOADS:

Decisive load case: 4 KOMB4 (1+2)*1.35+3*1.10

MATERIAL:

S 235 (S 235) $f_y = 235.00$ MPa



SECTION PARAMETERS: RP100x80x6

$h=10.0$ cm	$gM0=1.00$	$gM1=1.00$	
$b=8.0$ cm	$A_y=8.16$ cm ²	$A_z=10.56$ cm ²	$A_x=20.16$ cm ²
$t_w=0.6$ cm	$I_y=280.50$ cm ⁴	$I_z=196.08$ cm ⁴	$I_x=348.03$ cm ⁴
$t_f=0.6$ cm	$W_{ply}=68.35$ cm ³	$W_{plz}=58.27$ cm ³	

INTERNAL FORCES AND LOAD-BEARING CAPACITY:

$N_{,Ed} = 9.65$ kN	$M_{y,Ed} = -12.14$ kN*m	
$N_{c,Rd} = 473.76$ kN	$M_{y,Ed,max} = -12.14$ kN*m	
$N_{b,Rd} = 444.72$ kN	$M_{y,c,Rd} = 16.06$ kN*m	$V_{z,Ed} = 19.91$ kN
	$M_{N,y,Rd} = 16.06$ kN*m	$V_{z,c,Rd} = 143.28$ kN
		SECTION CLASS = 1



DEFORMATION PARAMETERS:

BUCKLING PARAMETERS:



relative to the y-axis:

$L_y = 1.32$ m	$\lambda_{m,y} = 0.38$
$L_{cr,y} = 1.32$ m	$X_y = 0.96$
$L_{amy} = 35.45$	$k_{yy} = 0.90$



relative to the z-axis:

$L_z = 1.32$ m	$\lambda_{m,z} = 0.45$
$L_{cr,z} = 1.32$ m	$X_z = 0.94$
$L_{amz} = 42.40$	$k_{zy} = 0.00$

VERIFICATION FORMULAS:

Cross-section strength check:

$N_{,Ed}/N_{c,Rd} = 0.02 < 1.00$ (6.2.4.(1))
 $M_{y,Ed}/M_{y,c,Rd} = 0.76 < 1.00$ (6.2.5.(1))
 $V_{z,Ed}/V_{z,c,Rd} = 0.14 < 1.00$ (6.2.6.(1))

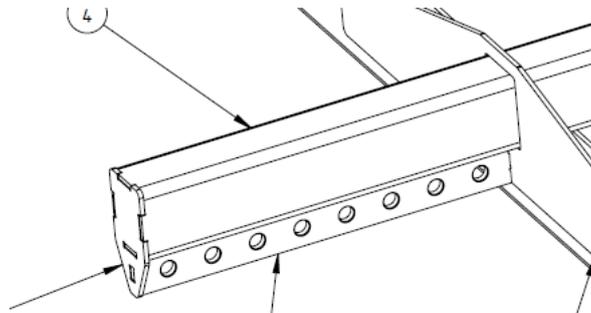
Global stability check of the bar:

$\lambda_{m,y} = 35.45 < \lambda_{m,max} = 210.00$ $\lambda_{m,z} = 42.40 < \lambda_{m,max} = 210.00$ STABLE
 $N_{,Ed}/(X_y * N_{,Rk}/gM1) + k_{yy} * M_{y,Ed,max}/(XLT * M_{y,Rk}/gM1) = 0.70 < 1.00$ (6.3.3.(4))
 $N_{,Ed}/(X_z * N_{,Rk}/gM1) + k_{zy} * M_{y,Ed,max}/(XLT * M_{y,Rk}/gM1) = 0.02 < 1.00$ (6.3.3.(4))

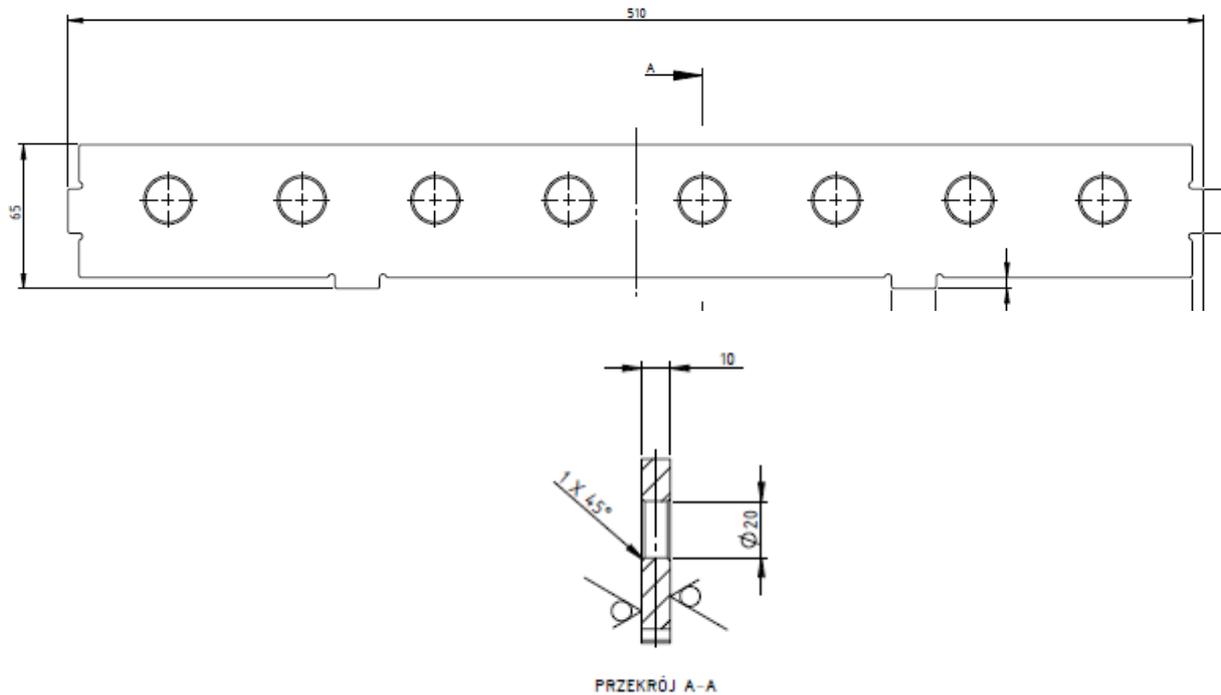
Profile meets requirements

3.5.2. Check the plate and welds connecting the belay point plate to the beam 53

View of the beam with the sheet metal



Sheet metal dimensions



For verification calculations, the length of the weld was assumed to be the working length of $L=6\text{cm}$

The sheet metal is welded to the profile with double-sided fillet welds, 4 mm thick

Characteristics of the welds:

Weld area $A_{sp}=2 \times 0.4 \times 6.0=4.8\text{cm}^2$

Strength index $W_{sp}=4.80\text{cm}^3$

Stress in the weld:

$\sigma = 4.17 \text{ kN/cm}^2$

$\sigma_L = \tau_L = 2.95 \text{ kN/cm}^2$

$\tau_{II} = 0.00\text{kN/cm}^2$

$\sigma_{sp}=5.89 \text{ kN/cm}^2 < f_u=36 \text{ kN/cm}^2$ – condition met

$\sigma_L = 2.95\text{kN/cm}^2 < f_u/1.25=25.92\text{kN/cm}^2$ – condition met

The load-bearing capacity of the weld is ensured

Sheet metal verification

For the calculations, a sheet metal strip between the holes with a length of 60 mm, a thickness of 10 mm and a hole diameter of 20 mm was assumed.

Sheet cross-sectional area $A=6.00 \text{ cm}^2$

Net cross-sectional area of the sheet metal $A_{net}=4.00 \text{ cm}^2$

Calculated load-bearing capacity of the sheet metal:

$N_{t,Rd}=117.82 \text{ kN} > N_{sd}=20 \text{ kN}$ – condition met

Sheet metal compression test

The sheet metal was checked for compressive strength assuming that the diameter of the bolt securing the test load would be no less than 10 mm

$F_{B,Rd} = 30\text{kN} > N_{sd} = 20\text{kN}$ – condition met

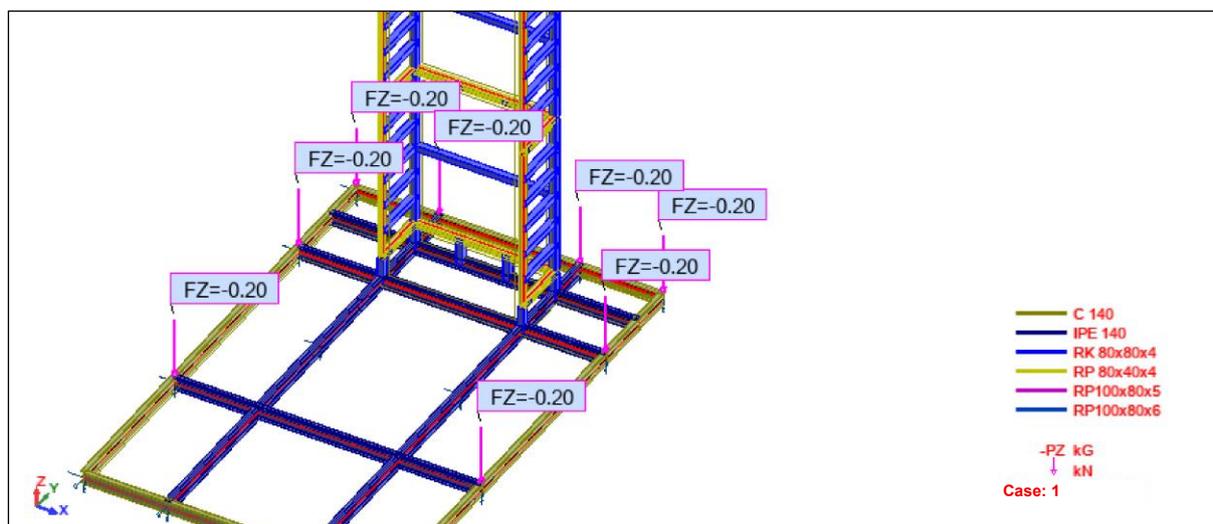
The load capacity of the sheet metal is guaranteed

4.0. Installation and operating guidelines

Assemble and operate the structure in accordance with the basic documents, i.e., the "SkyWall Interactive Climbing Wall User Instructions" and "Installation Guidelines," unless otherwise specified in this document.

When setting up the wall outdoors:

- The structure may be installed and the belay point tested at wind speeds below 5 m/s.
- For safety reasons, the wall should not be used in winds exceeding 10 m/s.
- In the areas marked below, apply additional weight to the horizontal frame of the platform.



5.0. Summary

The above calculations have confirmed that the structure meets the requirements of the standards specified in point 1.2 and can therefore be safely used for its intended purpose.

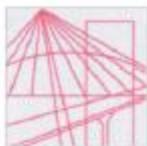
Structure – designed by

Jacek Krzyśpiak, Eng.

building license no. WAM/0082/POOK/11

inż. Jacek Krzyśpiak
upr. bud. bez ograniczeń w specjalności
konstrukcyjno-budowlanej do kierowania
robotami budowlanymi nr WAM/0128/OWOK/07
oraz do projektowania nr WAM/0082/POOK/11

6.0. Designer's licenses and certificates



**WARMIŃSKO-MAZURSKA
OKRĘGOWA IZBA INŻYNIERÓW BUDOWNICTWA
OKRĘGOWA KOMISJA KWALIFIKACYJNA**
10-532 Olsztyn, Plac Konsulatu Polskiego 1



WAM/OKK/U/98/11

Olsztyn, dnia 12 grudnia 2011 r.

DECYZJA

Na podstawie art. 24 ust.1 pkt 2 ustawy z dnia 15 grudnia 2000 r. o samorządach zawodowych architektów, inżynierów budownictwa oraz urbanistów /Dz. U. z 2001 r. Nr 5 poz. 42, ze zm./, w związku z **art. 5 ustawy z dnia 28 lipca 2005 r.** o zmianie ustawy-Prawo budowlane oraz o zmianie niektórych innych ustaw /Dz. U. z 2005 r. Nr 163 poz. 1364/, art. 12 ust. 3, **art. 13 ust. 1 pkt 1, art. 14 ust. 1 pkt 2** ustawy z dnia 07 lipca 1994 r. Prawo budowlane /t.j. Dz. U. z 2003 r. Nr 207, poz. 2016 ze zm./, **§ 3 ust. 1, § 12 pkt 1 i § 17 ust. 1 pkt 1** rozporządzenia Ministra Infrastruktury z dnia 18 maja 2005 r. w sprawie samodzielnych funkcji technicznych w budownictwie /Dz. U. z 2005 r. Nr 96 poz. 817/ oraz art. 104 Kodeksu postępowania administracyjnego /t.j. Dz.U. z 2000 r. Nr 98, poz.1071 ze zm./

**Okręgowa Komisja Kwalifikacyjna
nadaje**

Panu JACKOWI HUBERTOWI KRZYŚPIAKOWI

inżynierowi budownictwa
ur. dnia 21 stycznia 1980 r. w Ostrołęce

UPRAWNIENIA BUDOWLANE

Nr ewid. WAM/0082/POOK/11

**DO PROJEKTOWANIA
BEZ OGRANICZEŃ
W SPECJALNOŚCI KONSTRUKCYJNO-BUDOWLANEJ**

UZASADNIENIE

W związku z uwzględnieniem w całości żądania strony, na podstawie art. 107 § 4 K.p.a. odstępuje się od uzasadnienia decyzji. Zakres nadanych uprawnień budowlanych wskazano na odwrocie decyzji.

Pouczenie :

1. Zgodnie z art. 12 ust. 7 w/w ustawy Prawo budowlane – podstawę do wykonywania samodzielnych funkcji technicznych w budownictwie stanowi wpis, w drodze decyzji, do centralnego rejestru Głównego Inspektora Nadzoru Budowlanego oraz wpis na listę członków właściwej izby samorządu zawodowego, potwierdzony zaświadczeniem wydanym przez tę izbę, z określonym w nim terminem ważności.
2. Od decyzji niniejszej służy odwołanie do Krajowej Komisji Kwalifikacyjnej Polskiej Izby Inżynierów Budownictwa w Warszawie, za pośrednictwem Okręgowej Komisji Kwalifikacyjnej Warmińsko-Mazurskiej Okręgowej Izby Inżynierów Budownictwa w Olsztynie, w terminie 14 dni od dnia jej doręczenia.



Skład orzekający OKK:

1. mgr inż. Zdzisław Binerowski
2. inż. Janusz Palmowski
3. mgr inż. Elżbieta Lasmanowicz



Zaświadczenie
o numerze weryfikacyjnym:
WAM-522-1L6-NXM *

Pan Jacek Hubert Krzyśpiak o numerze ewidencyjnym WAM/BO/0031/08
adres zamieszkania ul. Karola Darwina 9 A / 75, 03-484 Warszawa
jest członkiem Warmińsko-Mazurskiej Okręgowej Izby Inżynierów Budownictwa i posiada
wymagane ubezpieczenie od odpowiedzialności cywilnej.
Niniejsze zaświadczenie jest ważne od 2025-01-01 do 2025-12-31.

Zaświadczenie zostało wygenerowane elektronicznie i opatrzone bezpiecznym podpisem elektronicznym
weryfikowanym przy pomocy ważnego kwalifikowanego certyfikatu w dniu 2024-12-16 roku przez:

Jarosław Kukliński, Przewodniczący Rady Warmińsko-Mazurskiej Okręgowej Izby Inżynierów Budownictwa.

Zgodnie z art. 78¹ K.c.

§ 1. Do zachowania elektronicznej formy czynności prawnej wystarczy złożenie oświadczenia woli w postaci elektronicznej i opatrzenie go kwalifikowanym podpisem elektronicznym.

§ 2. Oświadczenie woli złożone w formie elektronicznej jest równoważne z oświadczeniem woli złożonym w formie pisemnej.

* Weryfikację poprawności danych w niniejszym zaświadczeniu można sprawdzić za pomocą numeru weryfikacyjnego zaświadczenia na stronie Polskiej Izby Inżynierów Budownictwa www.piib.org.pl lub kontaktując się z biurem właściwej Okręgowej Izby Inżynierów Budownictwa.

