

# BEGHLER BV. WINTERGARDEN STATIC CALCULATION REPORT

Static calculations and report by  
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## 1. Introduction

This static calculation report has been prepared for the aluminum wintergarden substructure, which will be sold and distributed across most regions of Germany, the Netherlands, and Belgium. It also includes glazing panel strength checks for Type 2 and Type 4 wintergardens, as explained below.

The scope of this report covers the wintergarden types listed below.

Load analysis will be submitted in next section of this report.

Type-1 : 5130mm x 3500mm, roof cover polycarbonate.

Type-2 : 5130mm x 3500mm, roof cover 44.2 tempered glass.

Type-3 : 6130mm x 3000mm, roof cover polycarbonate.

Type-4 : 6130mm x 3000mm, roof cover 44.2 tempered glass.

*All dimensions are given as external measurements.*

All static calculations are performed using the finite element method. SAP2000 software is utilized for these analyses.

Snow accumulation exceeding 30 cm in thickness should be removed from the roof in extreme weather conditions.

## 2. Design parameters

### 2.1. Codes

EN 1991-1-4:2005 General actions – wind actions

EN 1991-1-3:2005 General actions – snow actions

EN 13830 Curtain Walling Product Standard

EN 1999-1-1:2007 Aluminum structures- General structural rules

### 2.2. Deflection limits (EN 13830)

For spans smaller than 3000mm limit is  $L/200$

For spans bigger than 3000mm and smaller than 750mm limit is  $L/200+5mm$

### 2.3. Materials

6063 - T5 (EN1999-1-1) (EP,  $t < 25mm$ )

$\rho_s = 2700 \text{ kg/m}^3$  (Density)

$f_o = 170 \text{ N/mm}^2$  (Yield stress)

$f_u = 205 \text{ N/mm}^2$  (Ultimate stress)

$E = 70\,000 \text{ N/mm}^2$  (Elastic modulus)

### 2.4. Characteristic loads on structure

#### 2.4.1. Dead loads: (G)

The self-weight of the modeled sections in the SAP2000 program is automatically calculated.

Roof cover weight applied as per wintergarden type.

For polycarbonate cover, weight is  $2.5 \text{ kg/m}^2$

For 44.2 glass cover, weight is  $22.5 \text{ kg/m}^2$

2.4.2. Wind loads (W) and Snow loads (S)



Dlubal Software

The document was created with our online tool  
[www.dlubal.com/geo-zone-tool](http://www.dlubal.com/geo-zone-tool)

Date 23.02.2025

LOAD MAPS

## Geo-Zone Tool: Snow Load, Wind Speed, and Seismic Zone Maps

ONLINE MAP

Location Detail

**B2 7**  
10178  
Berlin  
Germany

LATITUDE	LONGITUDE	ALTITUDE [M]
<b>52.520 °</b>	<b>13.405 °</b>	<b>36 m</b>

Report Results (3)



### Snow

STANDARD

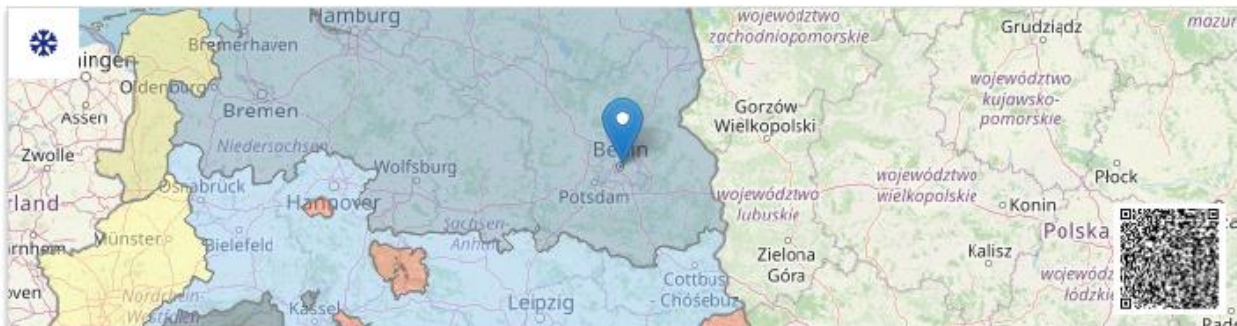
**EN 1991-1-3**

COUNTRY | TABLE

**Germany | DIN EN 1991-1-3**

Characteristic Value of Snow Load

**$s_k = 0.85 \text{ kN/m}^2$**



SHOW ONLINE MAP

**2\*** Snow Load Zone

North German Plain



Dlubal Software

The document was created with our online tool

[www.dlubal.com/geo-zone-tool](http://www.dlubal.com/geo-zone-tool)

Date 23.02.2025

LOAD MAPS



## Wind

STANDARD

EN 1991-1-4

COUNTRY | TABLE

Germany | DIN EN 1991-1-4

Fundamental Basic Wind Velocity

$v_{b,0} = 25.0 \text{ m/s}$

Basic Velocity Pressure

$q_b = 0.39 \text{ kN/m}^2$



SHOW ONLINE MAP

1 2 2\* 3 4 N/A

2

Wind Zone

Project: Wintergarden

Subject: Wintergarden

Designer: Wintergarden

Date: Tue Mar 18 2025

## Eurocode 1

# Wind load on monopitch canopies (net pressure coefficients and overall force coefficient)

### Description:

Calculation of wind load action effects on monopitch canopies (i.e. roofs of structures not enclosed with permanent side walls). The net effect of the wind pressure on the upper and lower surface for zones A, B, C on the roof surface are calculated from the corresponding net pressure coefficients. The overall effect of the wind action on the structure is also calculated from the corresponding force coefficient.

### According to:

EN 1991-1-4:2005+A1:2010 Section 7.3

### Applicable for:

Roofs of structures not enclosed with permanent side walls such as petrol stations, dutch barns etc. Monopitch slope between 0 and 30°

### Supported

### National

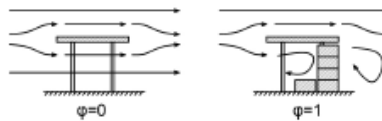
### Annexes:

A) Calculation of pressure coefficients: Only countries that adopt CEN recommended values for section 7.3 of EN1991-1-4 are supported. B) Peak velocity pressure: The value of the peak velocity pressure can be specified manually.

Otherwise automatic calculation of peak velocity pressure is supported, in addition to countries that adopt the CEN recommended values for NDPs, also for the following National Annexes: Finland, Portugal. The National Annexes of Germany, Norway, Spain, Sweden, Switzerland are NOT supported (enter peak velocity pressure manually).

## Input

Terrain category	= III	▼
Basic wind velocity	$V_b = 25$	m/s
Horizontal dimension of rectangular plan parallel to the wind direction	$d = 6.3$	m
Horizontal dimension of rectangular plan perpendicular to the wind direction (crosswind dimension)	$b = 3.4$	m
Height of canopy from ground up to the maximum roof level	$h = 3.25$	m
Roof pitch angle	$\alpha = 10$	°
Degree of blockage under the canopy roof	$\varphi = 1$	



Definiton of blockage factor for canopy roofs (see also EN1991-1-4 Figure 7.15)

Orography factor at reference height $z_e$	$c_0(z_e) = 1$
Structural factor	$C_s C_d = 1$

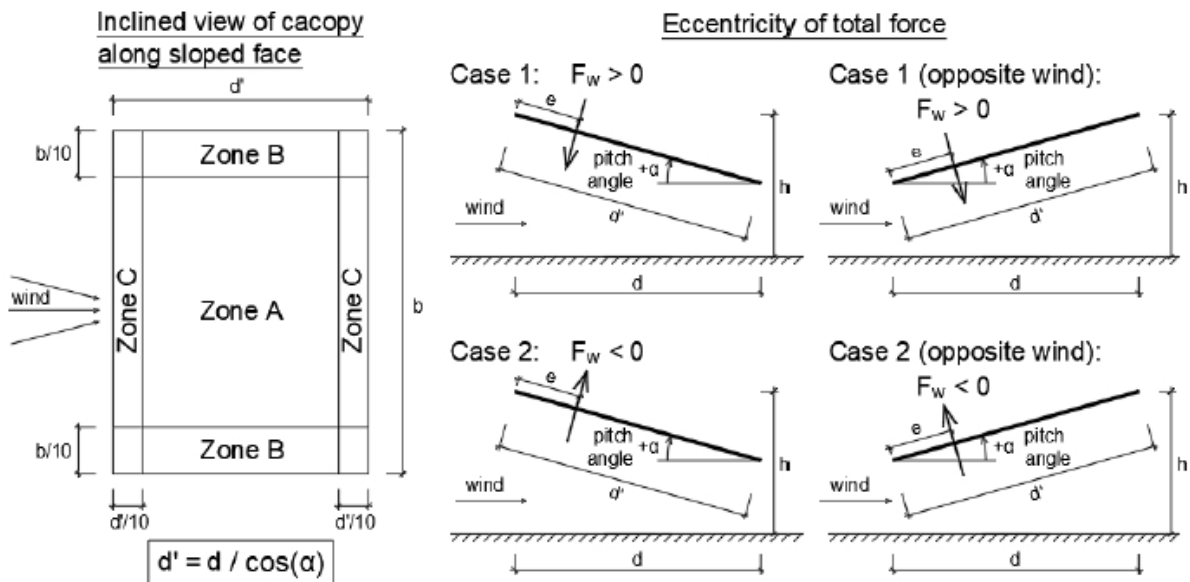
### Nationally Defined Parameters

Air density	$\rho = 1.25$	kg/m <sup>3</sup>
Additional rules defined in the National Annex for the calculation of peak velocity pressure $q_p(z_e)$	= None	▼
Location of center of pressure from the windward edge as a fraction of the inclined width $d'$ parallel to the wind direction	$e/d' = 0.25$	

### Results

Net wind pressure on zone A	$W_{net,A} = (-0.801 \text{ or } +0.600)$ kN/m <sup>2</sup>
Net wind pressure on zone B	$W_{net,B} = (-1.301 \text{ or } +1.201)$ kN/m <sup>2</sup>
Net wind pressure on zone C	$W_{net,C} = (-1.351 \text{ or } +0.801)$ kN/m <sup>2</sup>

Total wind force	$F_w = (-15.24 \text{ or } +5.44)$ kN
Eccentricity of total wind force from windward edge	$e = 0.250d' = 1.599$ m



Pressure zones for monopitch canopy roofs, reproduced from EN1991-1-4 Table 7.6 and Figure 7.16

## Notes

1. The overall force coefficient corresponds to the resulting wind force and it can be used for the design of the overall load bearing structure. The net pressure coefficients represent the maximum local pressure for all wind directions and they should be used in the design of roofing elements and fixings.
2. The calculated net wind pressure corresponds to the overall wind effect including the wind pressure on both the top surface and the bottom surface for all wind directions.
3. The location of the center of pressure for the overall wind force is defined at an eccentricity  $e$  from the distance from the windward edge (see figure above) according to EN1991-1-4 §7.3(6) and the National Annex. The default value is  $e = 0.25 \cdot d'$ , where  $d'$  is the inclined width of the rectangular plan parallel to the wind direction.
4. The sign convention for the net pressure and the overall force is the same as its external pressure part. Negative pressure values correspond to suction directed away from the surface i.e. inducing uplift on the canopy roof.
5. Both positive and negative wind pressure should be examined, i.e. directed both upwards (negative value) and downwards (positive value).
6. Downwind of the position of maximum blockage the value of the blockage factor  $\varphi = 0$  should be used, according to EN1991-1-4 §7.3(4).
7. A structural factor  $c_s c_d$  different than 1.0 may be applicable in accordance with EN1991-1-4 Section 6. A value of  $c_s c_d = 1.0$  is generally conservative for small structures not-susceptible to wind turbulence effects such as buildings with height less than 15 m.
8. The calculated wind action effects are characteristic values (unfactored). Appropriate load factors should be applied for the relevant design situation. For ULS verifications the partial load factor  $\gamma_Q = 1.50$  is applicable for variable actions.
9. Horizontal wind friction forces should be considered in accordance with EN1991-1-4 §7.5.

## Details

### **Input Data**

- Terrain category: = III
- Basic wind velocity:  $v_b = 25$  m/s
- Horizontal dimension of rectangular plan parallel to the wind direction:  $d = 6.3$  m
- Horizontal dimension of rectangular plan perpendicular to the wind direction (crosswind dimension):  $b = 3.4$  m
- Height of canopy from ground up to the maximum roof level:  $h = 3.25$  m
- Roof pitch angle:  $\alpha = 10^\circ$
- Degree of blockage under the canopy roof:  $\varphi = 1$
- Orography factor at reference height  $z_e$ :  $c_0(z_e) = 1$
- Structural factor:  $c_s c_d = 1$

### **Nationally Defined Parameters**

- Air density:  $\rho = 1.25$  kg/m<sup>3</sup>
- Additional rules defined in the National Annex for the calculation of peak velocity pressure  $q_p(z_e)$ : = None
- Location of center of pressure from the windward edge as a fraction of the inclined width  $d'$  parallel to the wind direction:  $e/d' = 0.25$

## **Calculation of peak velocity pressure**

### Reference height

The reference height for the wind action  $z_e$  is equal to the maximum height above ground of the canopy roof  $h$ , as specified in EN1991-1-4 §7.3(8). Therefore:

$$z_e = h = 3.250 \text{ m}$$

### Reference area of the sloped canopy

The reference area for the wind action  $A_{ref}$  is equal to the area of the sloped face of the monopitch canopy roof. It is calculated from the plan dimensions  $b$  and  $d$  by taking into account the inclination of the sloped roof surface with angle  $\alpha$ . Therefore:

$$A_{ref} = b \cdot d / \cos(\alpha) = 3.400 \text{ m} \cdot 6.300 \text{ m} / 0.985 = 21.750 \text{ m}^2$$

### Basic wind velocity

The basic wind velocity  $v_b$  is defined in *EN1991-1-4 §4.2(2)P* as a function of the wind direction and time of year at 10 m above ground of terrain category II. The value of  $v_b$  includes the effects of the directional factor  $c_{dir}$  and the seasonal factor  $c_{season}$  and it is provided in the National Annex. In the following calculations the basic wind velocity is considered as  $v_b = 25.00 \text{ m/s}$ .

### Terrain roughness

The roughness length  $z_0$  and the minimum height  $z_{min}$  are specified in *EN1991-1-4 Table 4.1* as a function of the terrain category. For terrain category III the corresponding values are:  $z_0 = 0.300 \text{ m}$  and  $z_{min} = 5.0 \text{ m}$ .

The terrain factor  $k_r$ , depending on the roughness length  $z_0 = 0.300 \text{ m}$  is calculated in accordance with *EN1991-1-4 equation (4.5)*:

$$k_r = 0.19 \cdot (z_0 / z_{0,II})^{0.07} = 0.19 \cdot (0.300 \text{ m} / 0.050 \text{ m})^{0.07} = 0.2154$$

The roughness factor  $c_r(z_e)$  at the reference height  $z_e$  accounts for the variability of the mean wind velocity at the site. It is calculated in accordance with *EN1991-1-4 equation 4.4*. For the examined case  $z_e < z_{min}$ :

$$c_r(z_e) = k_r \cdot \ln(\max\{z_e, z_{min}\} / z_0) = 0.2154 \cdot \ln(\max\{3.250 \text{ m}, 5.0 \text{ m}\} / 0.300 \text{ m}) = 0.6060$$

### Orography factor

Where orography (e.g. hills, cliffs etc.) is significant its effect in the wind velocities should be taken into account using an orography factor  $c_0(z_e)$  different than 1.0, as specified in *EN1994-1-1 §4.3.3*. The recommended procedure in *EN1994-1-1 §4.3.3* for calculation of the orography factor  $c_0(z_e)$  is described in *EN1994-1-1 §A.3*.

In the following calculations the orography factor is considered as  $c_0(z_e) = 1.000$ .

### Mean wind velocity

The mean wind velocity  $v_m(z_e)$  at reference height  $z_e$  depends on the terrain roughness, terrain orography and the basic wind velocity  $v_b$ . It is determined using *EN1991-1-4 equation (4.3)*:

$$v_m(z_e) = c_r(z_e) \cdot c_0(z_e) \cdot v_b = 0.6060 \cdot 1.000 \cdot 25.00 \text{ m/s} = 15.15 \text{ m/s}$$

### Wind turbulence

The turbulence intensity  $I_v(z_e)$  at reference height  $z_e$  is defined as the standard deviation of the turbulence divided by the mean wind velocity. It is calculated in accordance with *EN1991-1-4 equation 4.7*. For the examined case  $z_e < z_{min}$ .

$$I_v(z_e) = k_1 / [c_0(z_e) \cdot \ln(\max\{z_e, z_{min}\} / z_0)] = 1.000 / [1.000 \cdot \ln(\max\{3.250 \text{ m}, 5.0 \text{ m}\} / 0.300 \text{ m})] = 0.3554$$

### Basic velocity pressure

The basic velocity pressure  $q_b$  is the pressure corresponding to the wind momentum determined at the basic wind velocity  $v_b$ . The basic velocity pressure is calculated according to the fundamental relation specified in *EN1991-1-4 §4.5(1)*:

$$q_b = (1/2) \cdot \rho \cdot v_b^2 = (1/2) \cdot 1.25 \text{ kg/m}^3 \cdot (25.00 \text{ m/s})^2 = 391 \text{ N/m}^2 = 0.391 \text{ kN/m}^2$$

where  $\rho$  is the density of the air in accordance with *EN1991-1-4 §4.5(1)*. In this calculation the following value is considered:  $\rho = 1.25 \text{ kg/m}^3$ . Note that by definition  $1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$ .

### Peak velocity pressure

The peak velocity pressure  $q_p(z_e)$  at reference height  $z_e$  includes mean and short-term velocity fluctuations. It is determined according to *EN1991-1-4 equation 4.8*:

$$q_p(z_e) = (1 + 7 \cdot I_v(z_e)) \cdot (1/2) \cdot \rho \cdot v_m(z_e)^2 = (1 + 7 \cdot 0.3554) \cdot (1/2) \cdot 1.25 \text{ kg/m}^3 \cdot (15.15 \text{ m/s})^2 = 500 \text{ N/m}^2 \\ \Rightarrow q_p(z_e) = 0.500 \text{ kN/m}^2$$

Note that by definition  $1 \text{ N} = 1 \text{ kg} \cdot \text{m/s}^2$ .

## **Calculation of local wind pressure on the canopy roof**

### Net pressure coefficients

The net pressure coefficients  $c_{p,net}$  represent the maximum local pressure for all wind directions and they should be used in the design of local elements such as roofing elements and fixings. Net pressure coefficients are given for three zones A, B, C as defined in the figure included in EN1991-1-4 Table 7.6 that is reproduced above. Zones B, C extend at the sides of the canopy and Zone A at the central region:

The inclined length of the monopitch canopy roof parallel to the wind direction is:

$$d' = d / \cos(\alpha) = 6.300 \text{ m} / 0.985 = 6.397 \text{ m}$$

Zone C corresponds to the regions parallel to the windward and leeward edges having width  $d'/10 = 0.640$  m. Zone B corresponds to the regions parallel to the side edges having width  $b/10 = 0.340$  m, where  $b$  is the width of the canopy transverse to the wind direction. Zone A corresponds to the remaining central region.

The net pressure coefficient  $c_{p,net}$  for each of the zones A, B, C are defined in EN1991-1-4 Table 7.6 as a function of the roof angle  $\alpha$  and the blockage factor  $\phi$ . For the examined case:  $\alpha = 10.00^\circ$  and  $\phi = 1.000$ . Therefore according to EN1991-1-4 Table 7.6 the following net pressure coefficients and overall force coefficient are obtained, using linear interpolation where appropriate:

Zone	Net pressure coefficient
Zone A	$c_{p,net,A} = -1.600$ or $+1.200$
Zone B	$c_{p,net,B} = -2.600$ or $+2.400$
Zone C	$c_{p,net,C} = -2.700$ or $+1.600$

Negative values for the external pressure coefficient correspond to suction directed away from the upper surface inducing uplift forces on the roof. Both positive and negative values should be considered for each zone.

### Net wind pressure on pressure zones

The net wind pressure on the surfaces of the structure  $w_{net}$  corresponds to the combined effects of external wind pressure and internal wind pressure.

For structural surfaces consisting of only one skin the net pressure effect is determined as:

$$w_{net} = c_{p,net} \cdot q_p(z_e)$$

For structural surfaces consisting of more than one skin EN1991-1-4 57.2.10 is applicable.

For the different pressure zones on the canopy roof the following net pressures are obtained:

Zone	Net wind pressure
Zone A	$w_{net,A} = -0.801 \text{ kN/m}^2$ or $+0.600 \text{ kN/m}^2$
Zone B	$w_{net,B} = -1.301 \text{ kN/m}^2$ or $+1.201 \text{ kN/m}^2$
Zone C	$w_{net,C} = -1.351 \text{ kN/m}^2$ or $+0.801 \text{ kN/m}^2$

- zones A is the remaining central region located more than  $d'/10 = 0.640$  m or  $b/10 = 0.340$  m from the edges.

- zone B extends up to  $b/10 = 0.340$  m from the side edges.

- zone C extends up to  $d'/10 = 0.640$  m from the windward and leeward edges.

Negative net pressure values correspond to suction directed away from the external surface inducing uplift forces on the canopy roof. Both positive and negative values should be considered.

## **Calculation of overall wind force on the canopy roof**

### Overall pressure coefficient

The overall pressure coefficients  $c_f$  represents the overall wind force and it should be used in the design of the overall load bearing structure. The overall pressure coefficient  $c_f$  is defined in EN1991-1-4 Table 7.6 as a function of the roof angle  $\alpha$  and the blockage factor  $\varphi$ . For the examined case:  $\alpha = 10.00^\circ$  and  $\varphi = 1.000$ . Therefore according to EN1991-1-4 Table 7.6 the following overall pressure coefficient is obtained, using linear interpolation where appropriate:

$$c_f = -1.400 \text{ or } 0.500$$

Negative values for the overall pressure coefficient correspond to suction directed away from the upper surface inducing uplift forces on the roof. Both positive and negative values should be considered.

### Structural factor

The structural factor  $c_{s,c_d}$  takes into account the structure size effects from the non-simultaneous occurrence of peak wind pressures on the surface and the dynamic effects of structural vibrations due to turbulence. The structural factor  $c_{s,c_d}$  is determined in accordance with EN1991-1-4 Section 6. A value of  $c_{s,c_d} = 1.0$  is generally conservative for small structures not-susceptible to wind turbulence effects such as buildings with height less than 15 m.

In the following calculations the structural factor is considered as  $c_{s,c_d} = 1.000$ .

### Overall wind force (for total roof surface).

The wind force  $F_w$  corresponding to the overall wind effect on the canopy roof is calculated in accordance with EN1991-1-4 equation 5.3:

$$F_w = c_{s,c_d} \cdot c_f \cdot A_{ref} \cdot q_p(z_e)$$

where  $A_{ref} = 21.750 \text{ m}^2$  is the reference wind area of the canopy roof as calculated above.

For the examined case:

- Maximum overall wind force (acting downwards):

$$F_w = 1.000 \cdot (+0.500) \cdot 21.750 \text{ m}^2 \cdot 0.500 \text{ kN/m}^2 = +5.44 \text{ kN}$$

- Minimum overall wind force (acting upwards):

$$F_w = 1.000 \cdot (-1.400) \cdot 21.750 \text{ m}^2 \cdot 0.500 \text{ kN/m}^2 = -15.24 \text{ kN}$$

Negative values correspond to suction directed away from the external surface inducing uplift forces on the canopy roof. Both positive and negative values should be considered, as explained below.

### Direction and eccentricity of the overall wind force

According to EN1991-1-4 §7.3(6) and the National Annex the location of the center of pressure is defined at an eccentricity  $e$  from the windward edge. In this calculation the center of pressure is considered at an eccentricity  $e = 0.250 \cdot d' = 1.599 \text{ m}$ , where  $d' = 6.397 \text{ m}$  is the inclined length of the canopy roof parallel to the wind direction. Two cases should be examined for the overall effect of the wind force on the canopy roof:

- Maximum force  $F_w = +5.44 \text{ kN}$  (i.e. acting upwards) located at a distance  $e = 1.599 \text{ m}$  from the windward edge.
- Minimum force  $F_w = -15.24 \text{ kN}$  (i.e. acting downwards) located at a distance  $e = 1.599 \text{ m}$  from the windward edge.

### Additional notes

- Horizontal wind friction forces should be considered in accordance with EN1991-1-4 §7.5.
- For roofs with permanent walls see EN1991-1-4 §7.2 and the relevant calculation [Wind load on monopitch roofs](#).
- The calculated wind action effects are characteristic values (unfactored). Appropriate load factors should be applied for the relevant design situation. For ULS verifications the partial load factor  $\gamma_Q = 1.50$  is applicable for variable actions according to EN1990.

Wind load analyses are performed according to EN 1991-1-4:2007. The results are presented below.

### 2.4.3. Design load combinations

#### Ultimate limit state

1.35G +1.5W

1.35G +1.5WU (Uplift effect of wind)

1.35G +1.5S

#### Serviceability limit state

Dead+G

### 3. Static calculations of aluminum wintergarden structure

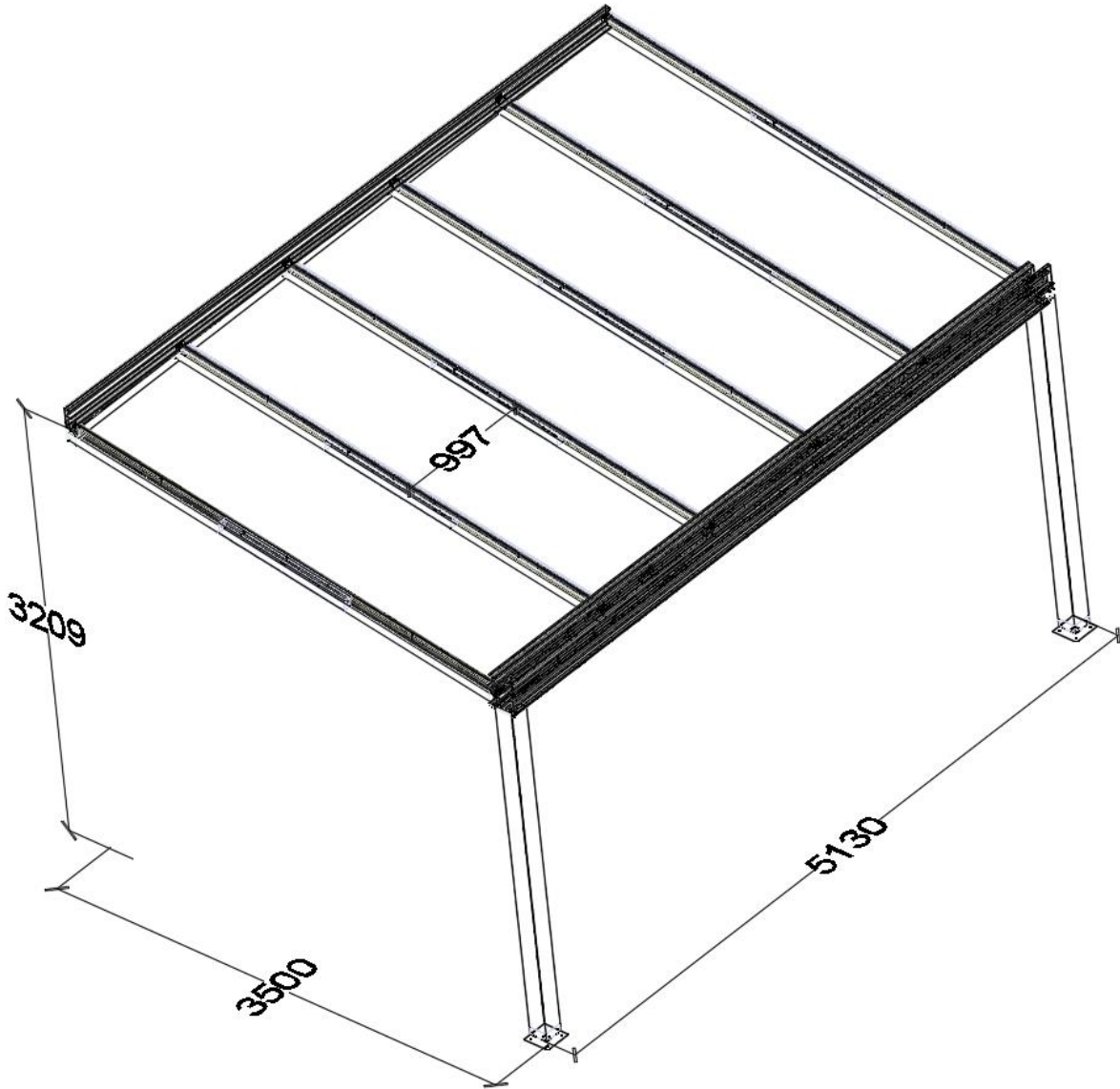
The static calculations presented in this section of the report are valid for the following types:

- **Type 1:** 5130mm × 3500mm, roof cover: polycarbonate
- **Type 2:** 5130mm × 3500mm, roof cover: 44.2 tempered glass
- **Type 3:** 6130mm × 3000mm, roof cover: polycarbonate
- **Type 4:** 6130mm × 3000mm, roof cover: 44.2 tempered glass

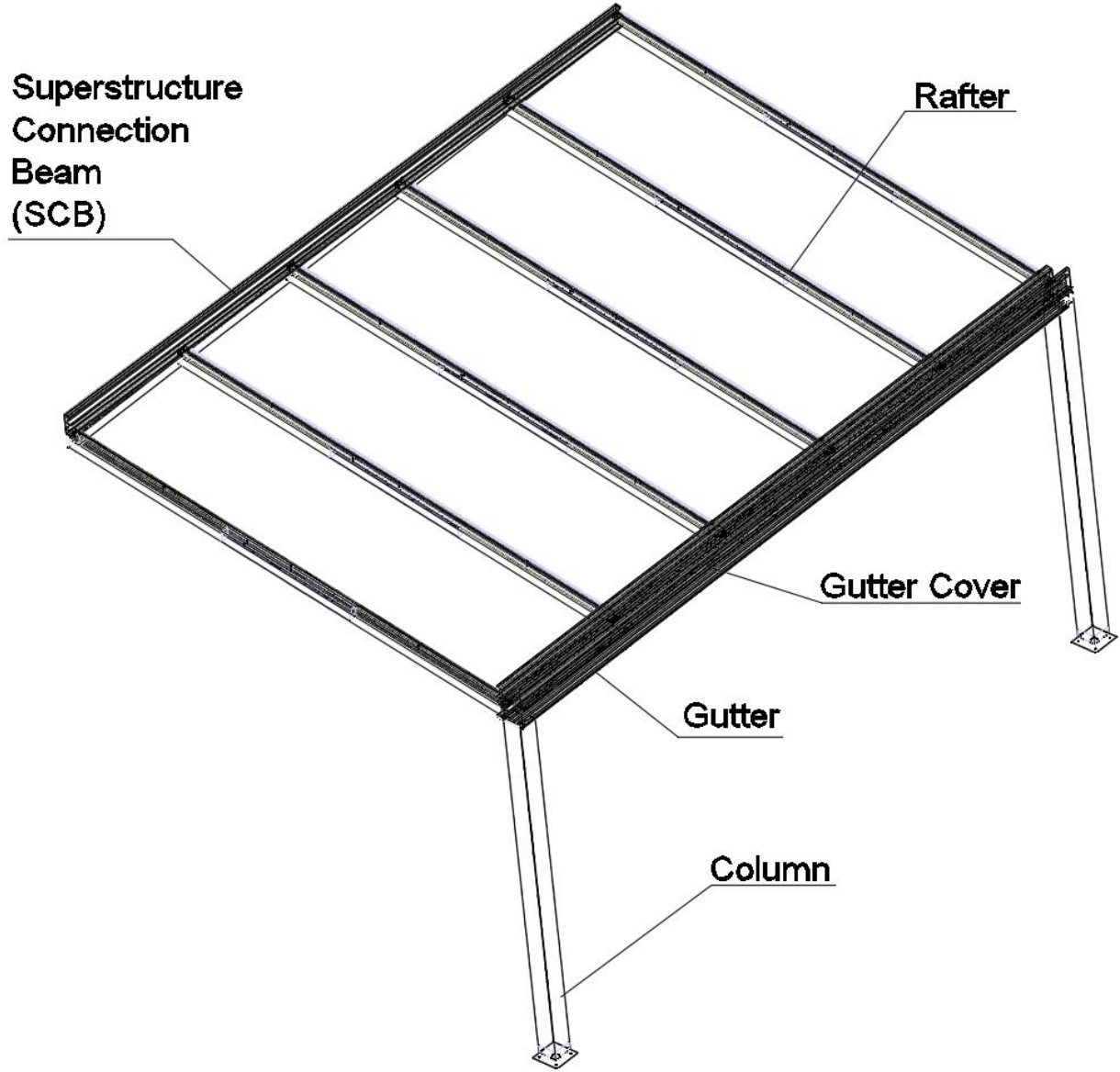
Types 1, 2, and 3 are supported by two columns, while Type 4 is supported by three columns.

Since Type 2 is the most unfavorable in terms of section forces, its static model and results will be presented in this report.

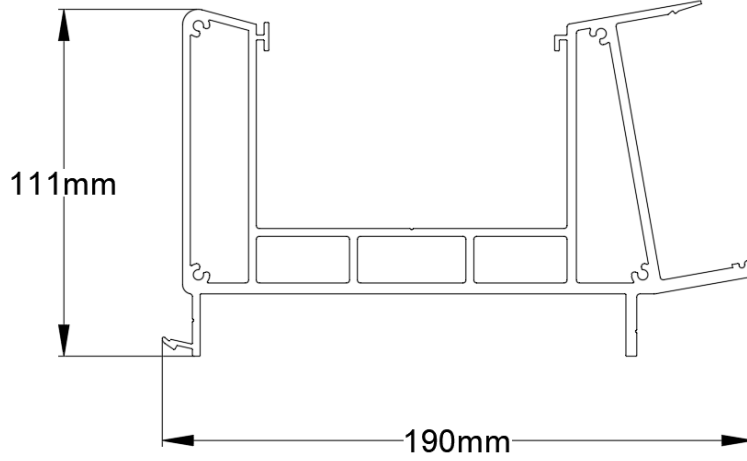
(Note: Type 3 and Type 1 has a lighter roof cover, and Type 4 has three columns in the front row.)



3d View of Type 2 Wintergarden aluminum structure

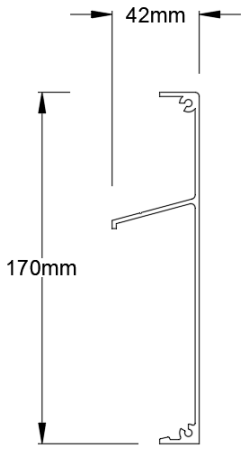


Profile descriptions(Marks)



Area: 23.0045  
Perimeter: 156.0951  
Bounding box: X: -8.9741 -- 10.0749  
Y: -4.8798 -- 6.5397  
Centroid: X: 0.0000  
Y: 0.0000  
Moments of inertia: X: 225.8174  
Y: 766.1907  
Product of inertia: XY: 11.5245  
Radii of gyration: X: 3.1331  
Y: 5.7711  
Principal moments and X-Y directions about centroid:  
I: 225.5718 along [0.9998 -0.0213]  
J: 766.4364 along [0.0213 0.9998]

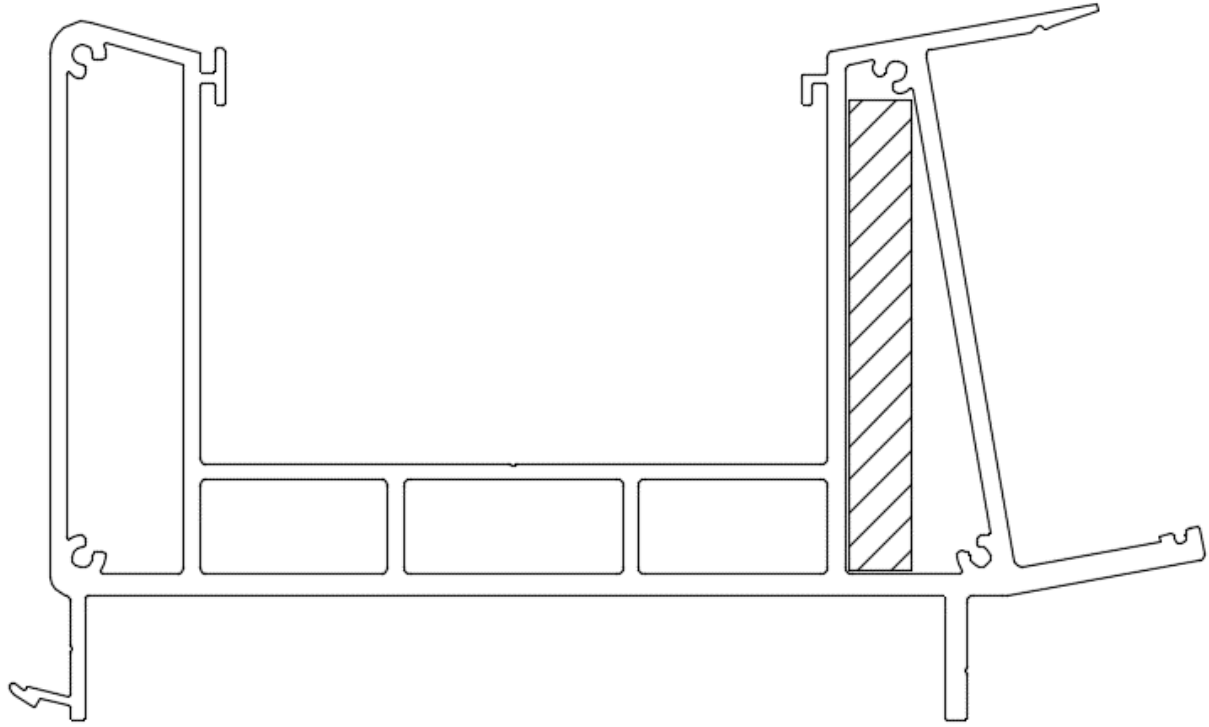
Section properties of gutter profile



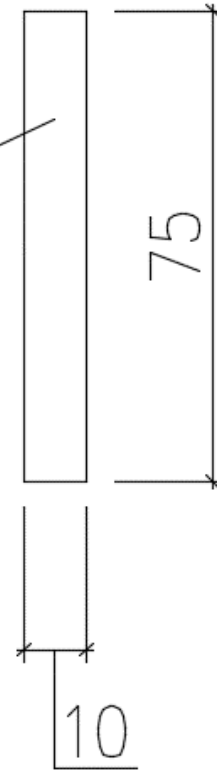
Area: 5.665  
Perimeter: 51.812  
Bounding box: X: -3.606 -- 0.616  
Y: -8.833 -- 8.167  
Centroid: X: 0.000  
Y: 0.000  
Moments of inertia: X: 180.122  
Y: 5.057  
Product of inertia: XY: 3.245  
Radii of gyration: X: 5.639  
Y: 0.945

Principal moments and X-Y directions about centroid:  
I: 180.182 along [1.000 0.019]  
J: 4.997 along [-0.019 1.000]

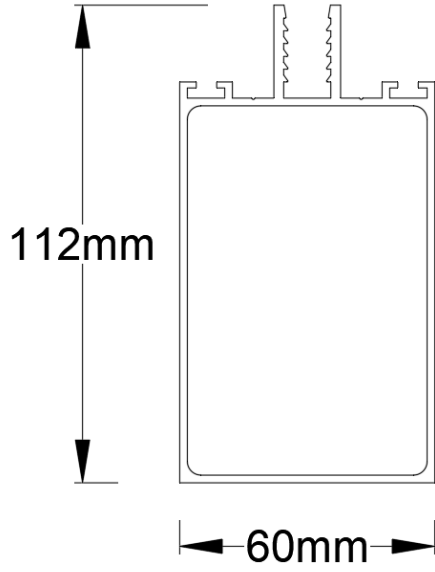
Section properties of gutter cover profile



STEEL REINFORCEMENT  
FOR TYPE-2 WINTERGARDEN  
GUTTER BEAM

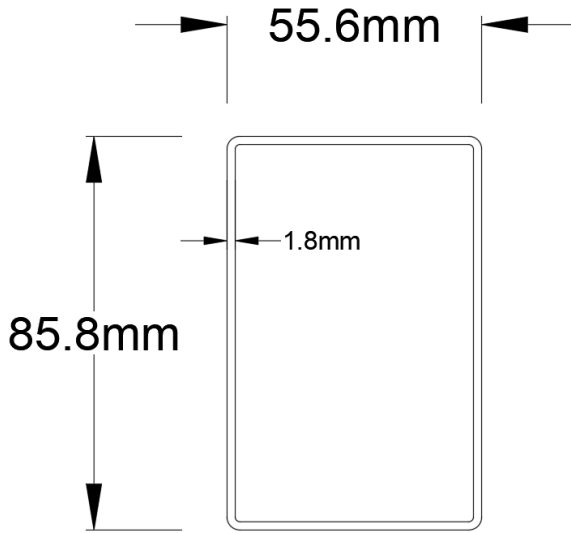


NOTE : Its not required to use reinforcement steel beams for gutter profile other than Type-2.



Area:	6.865
Perimeter:	72.847
Bounding box:	X: -3.000 -- 3.000 Y: -5.687 -- 5.513
Centroid:	X: 0.000 Y: 0.000
Moments of inertia:	X: 97.980 Y: 36.315
Product of inertia:	XY: 0.000
Radii of gyration:	X: 3.778 Y: 2.300
Principal moments and X-Y directions about centroid:	I: 97.980 along [1.000 0.000] J: 36.315 along [0.000 1.000]

Section properties of rafter profile



Area:	4.902
Perimeter:	54.468
Bounding box:	X: -2.780 -- 2.780 Y: -4.290 -- 4.290
Centroid:	X: 0.000 Y: 0.000
Moments of inertia:	X: 50.917 Y: 26.137
Product of inertia:	XY: 0.000
Radii of gyration:	X: 3.223 Y: 2.309
Principal moments and X-Y directions about centroid:	I: 50.917 along [1.000 0.000] J: 26.137 along [0.000 1.000]

Rafter reinforcement L=2500mm

NOTE : Rafter reinforcement is required for wintergardens with glass roof panels.  
Rafter reinforcement is NOT required for wintergardens with polycarbonate roof panels.

WG\_GLASS\_500X350\_001.sdb

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Finite elements model of wintergarden Type-2



SAP2000 26.0.0

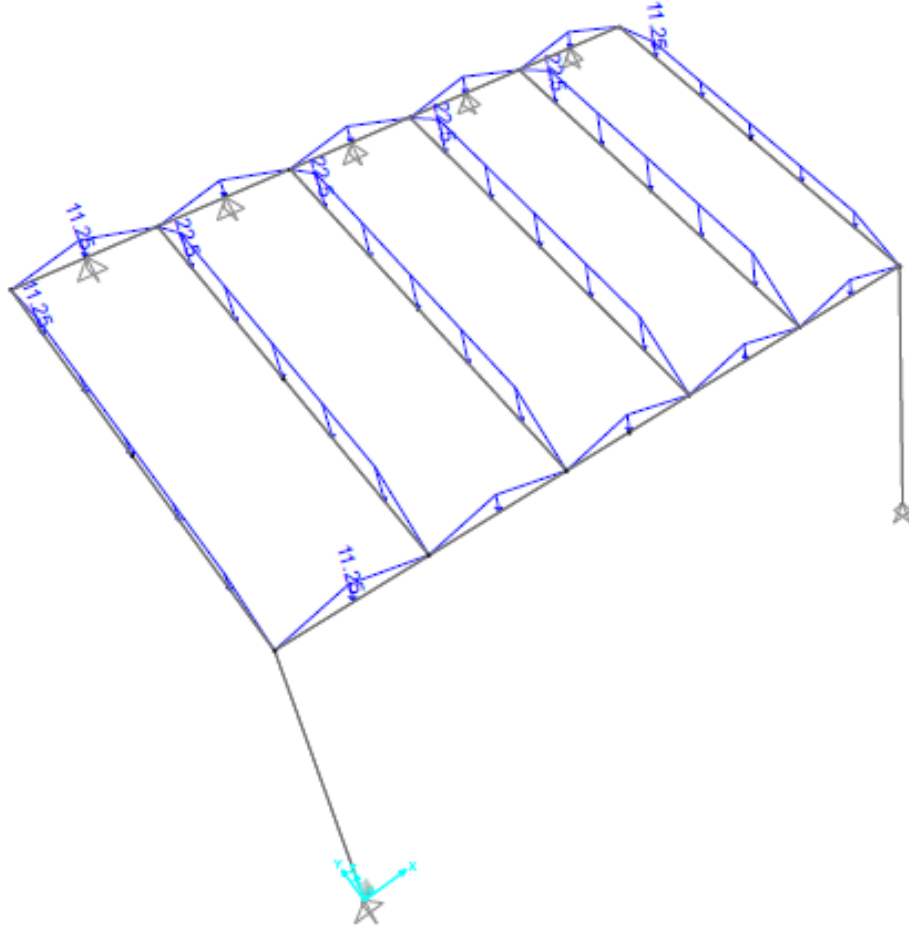
Frame Section Properties

Tonf, cm, C

WG\_GLASS\_500X350\_001.sdb

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Weight loads on finite elements model (G)



SAP2000 26.0.0

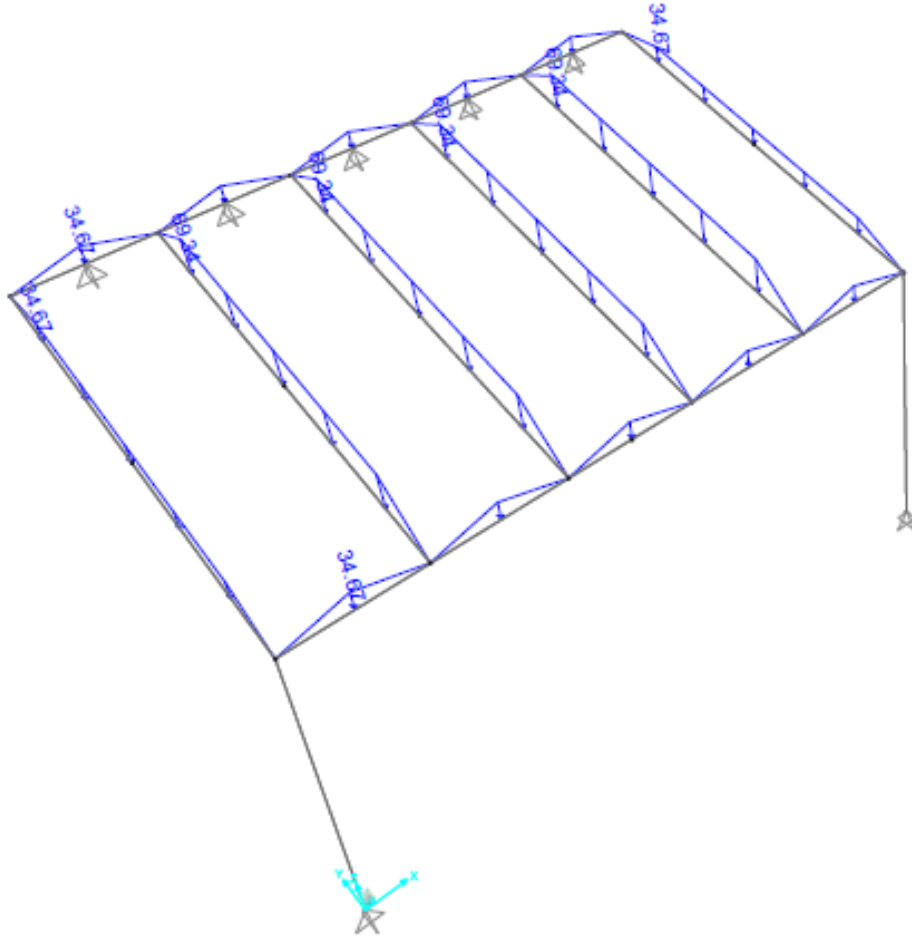
Uniform Area Load Distributed One And/Or Two Way to Frames (G)

Kgf, m, C

WG\_GLASS\_500X350\_001.sdb

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Snow loads on finite elements model (S1)



SAP2000 26.0.0

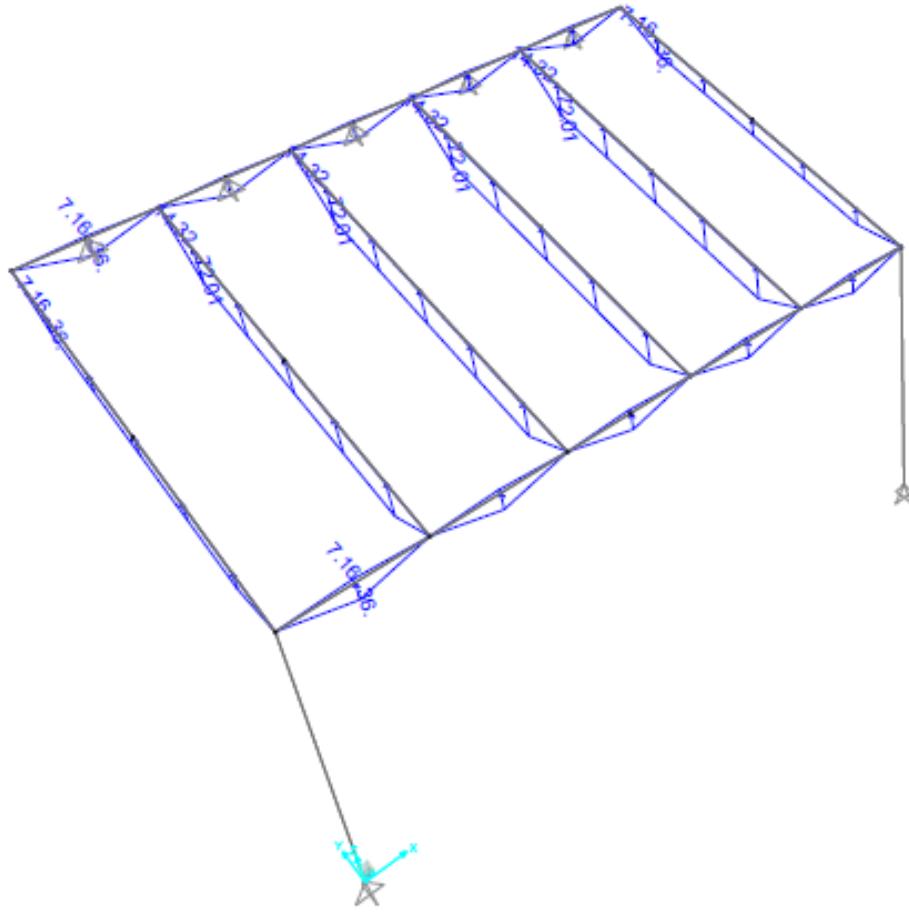
Uniform Area Load Distributed One And/Or Two Way to Frames (S1)

Kgf, m, C

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Wind loads on finite elements model (W - Uplift)



SAP2000 26.0.0

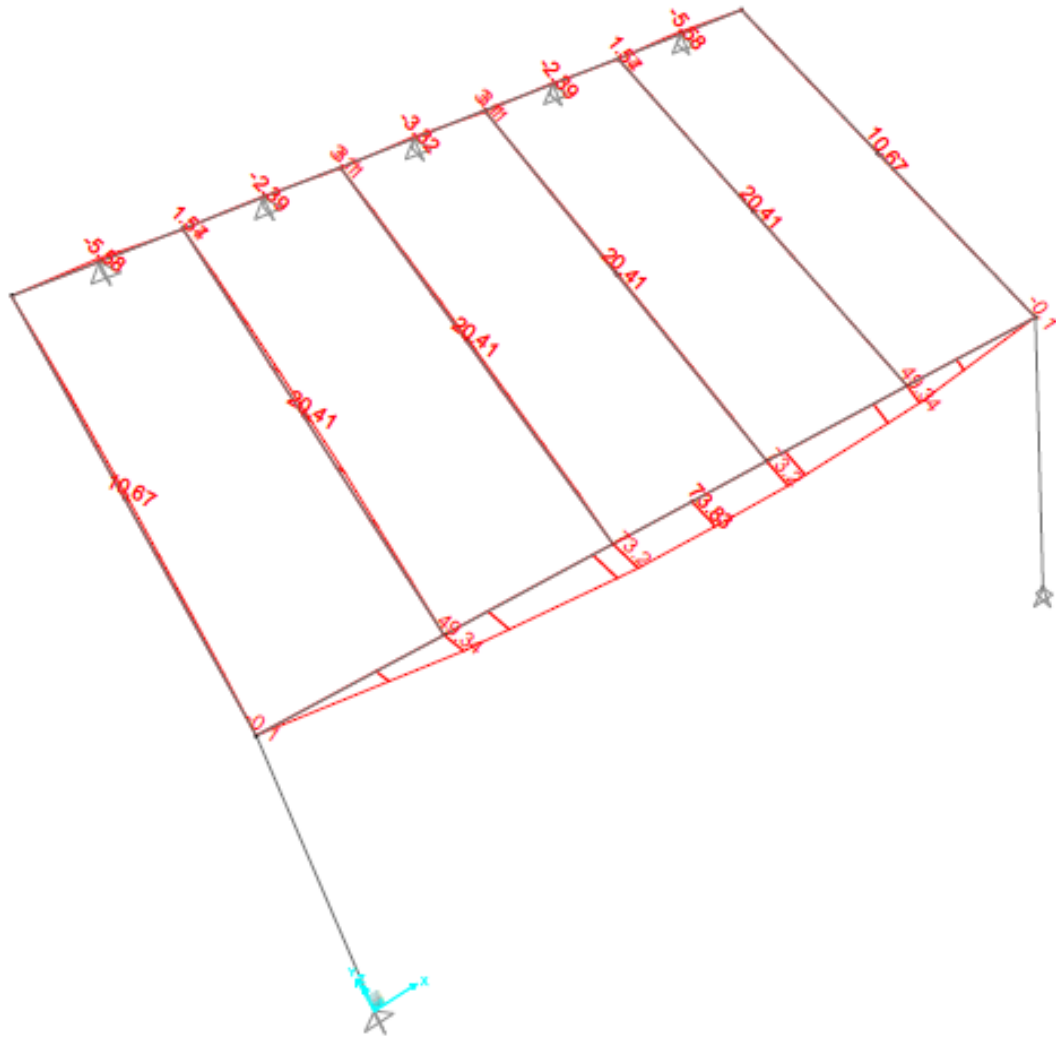
Uniform Area Load Distributed One And/Or Two Way to Frames (WU)

Kgf, m, C

WG\_GLASS\_500X350\_001.sdb

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M3 Moment diagram of wintergarden structure



SAP2000 26.0.0

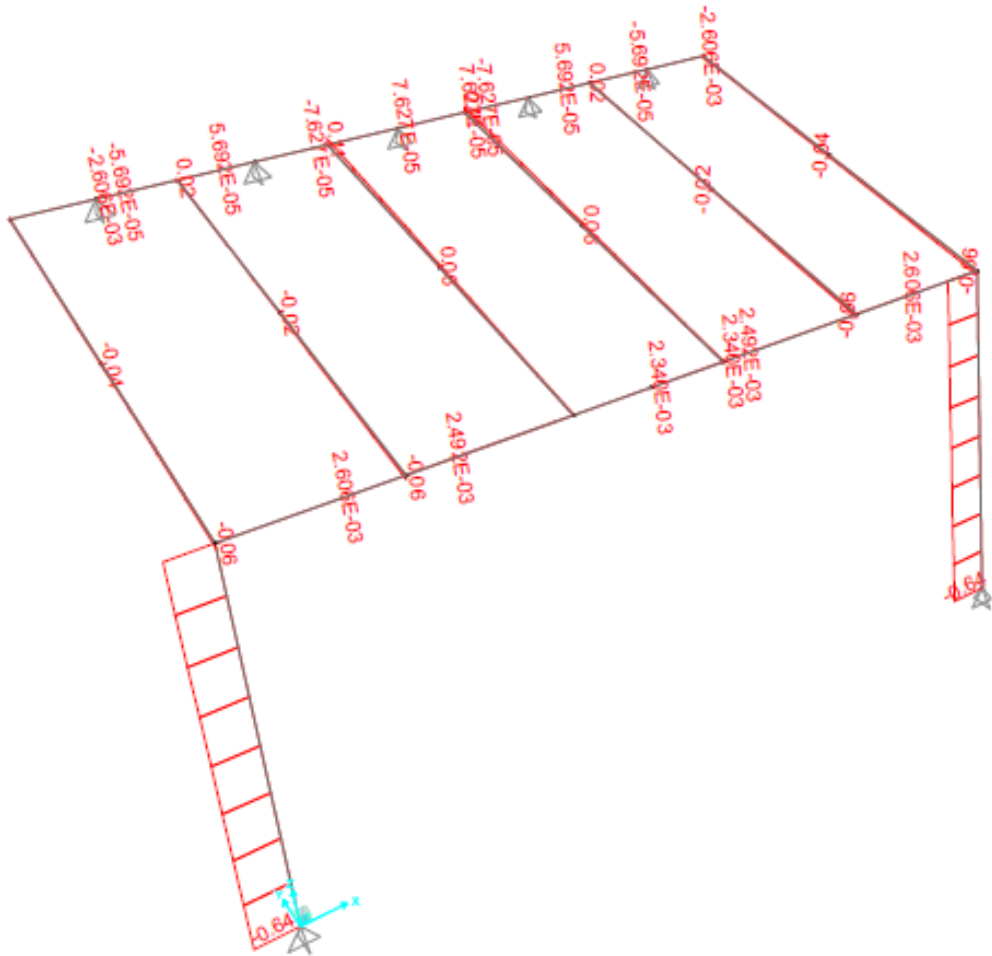
Moment 3-3 Diagram (1.35G+1.5S1)

Tonf, cm, C

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Axial force diagram for columns



SAP2000 26.0.0

Axial Force Diagram (1.35G+1.5S1)

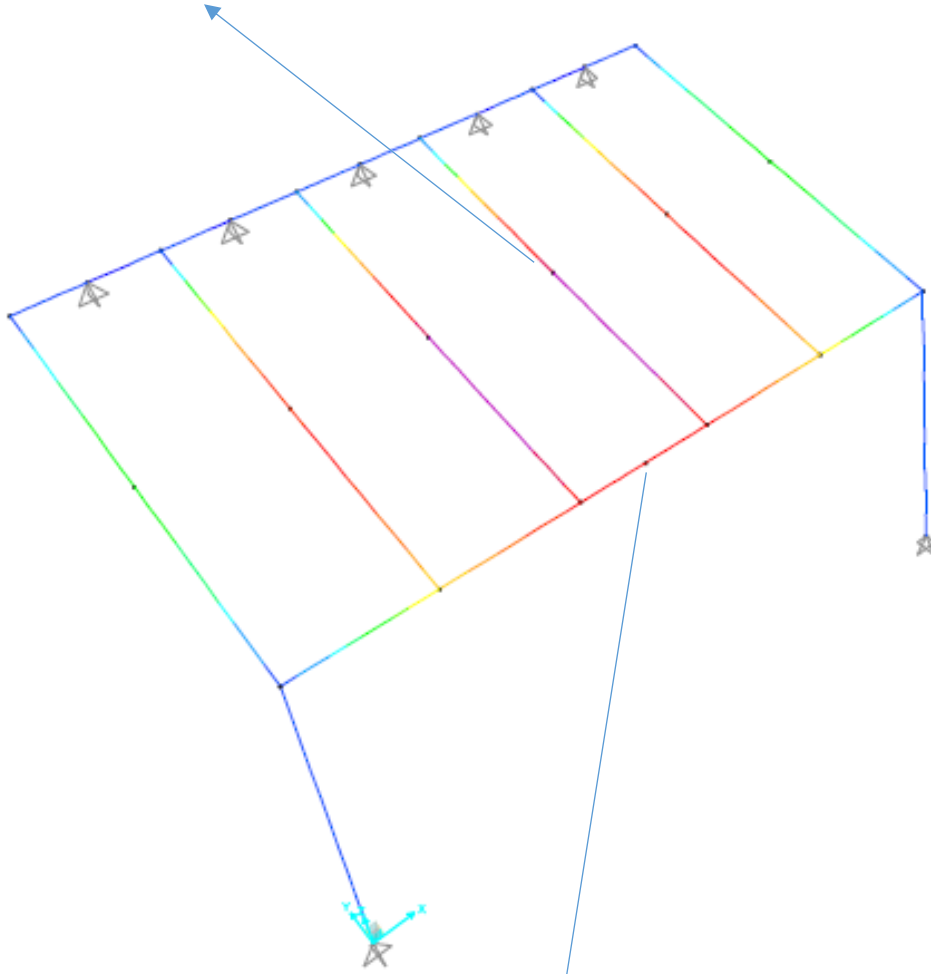
Tonf, cm, C

WG\_GLASS\_500X350\_001.sdb

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Deformed shape and deflection check of wintergarden

For rafter beam-relative to endpoints  
 $L=3500\text{mm}$   
 $\Delta_{\text{lim}}=3500/300=11,66\text{mm}$   
 $\Delta=7,10\text{mm} < 11,66 \text{ mm OK}$



For gutter beam  
 $L=5000\text{mm}$   
 $\Delta_{\text{lim}}=5000/300=16,66\text{mm}$   
 $\Delta=11,7\text{mm} < 16,66 \text{ mm OK}$

-1.30 -1.20 -1.10 -1.00 -0.90 -0.80 -0.70 -0.60 -0.50 -0.40 -0.30 -0.20 -0.10 -0.00

SAP2000 26.0.0

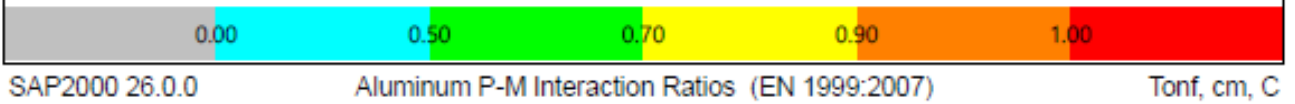
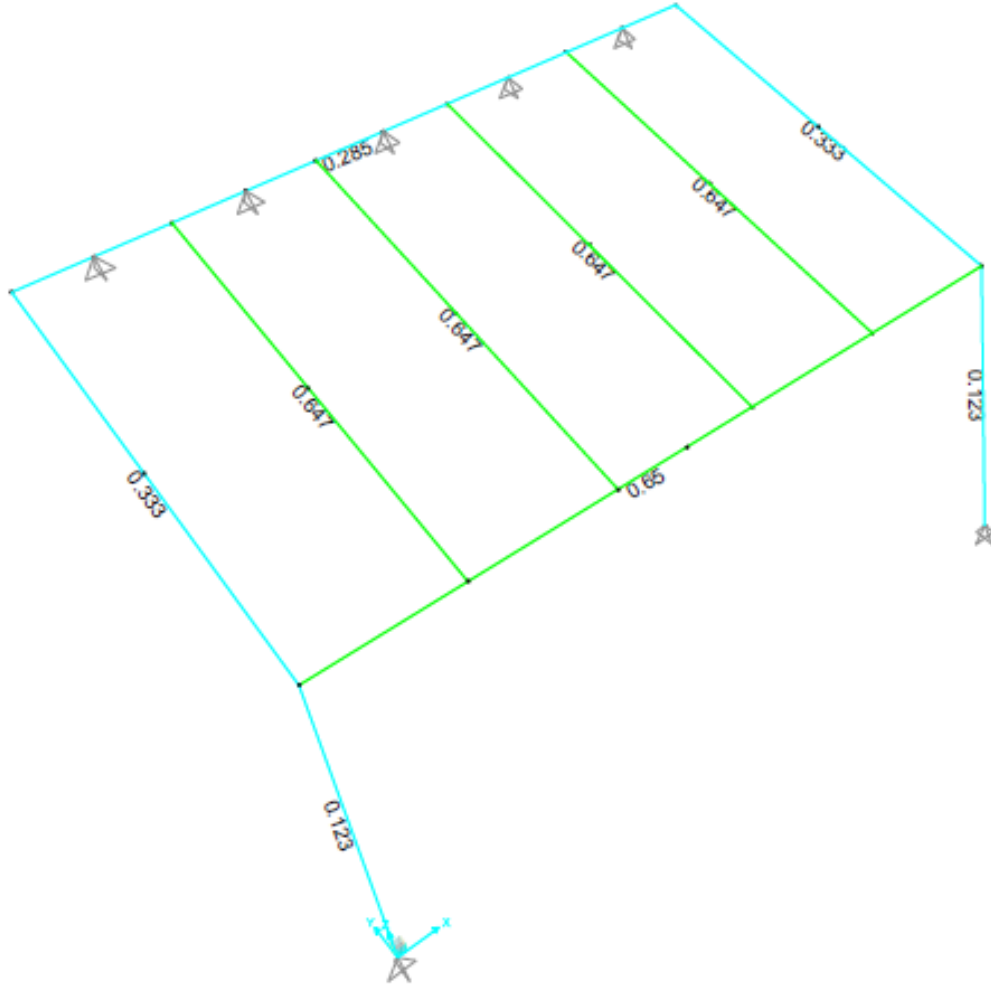
Deformed Shape (005\_Dead+G\_NLC) - Contours for Uz

Tonf, cm, C

WG\_GLASS\_500X350\_001.sdb

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Demand capacity ratio for aluminum profiles

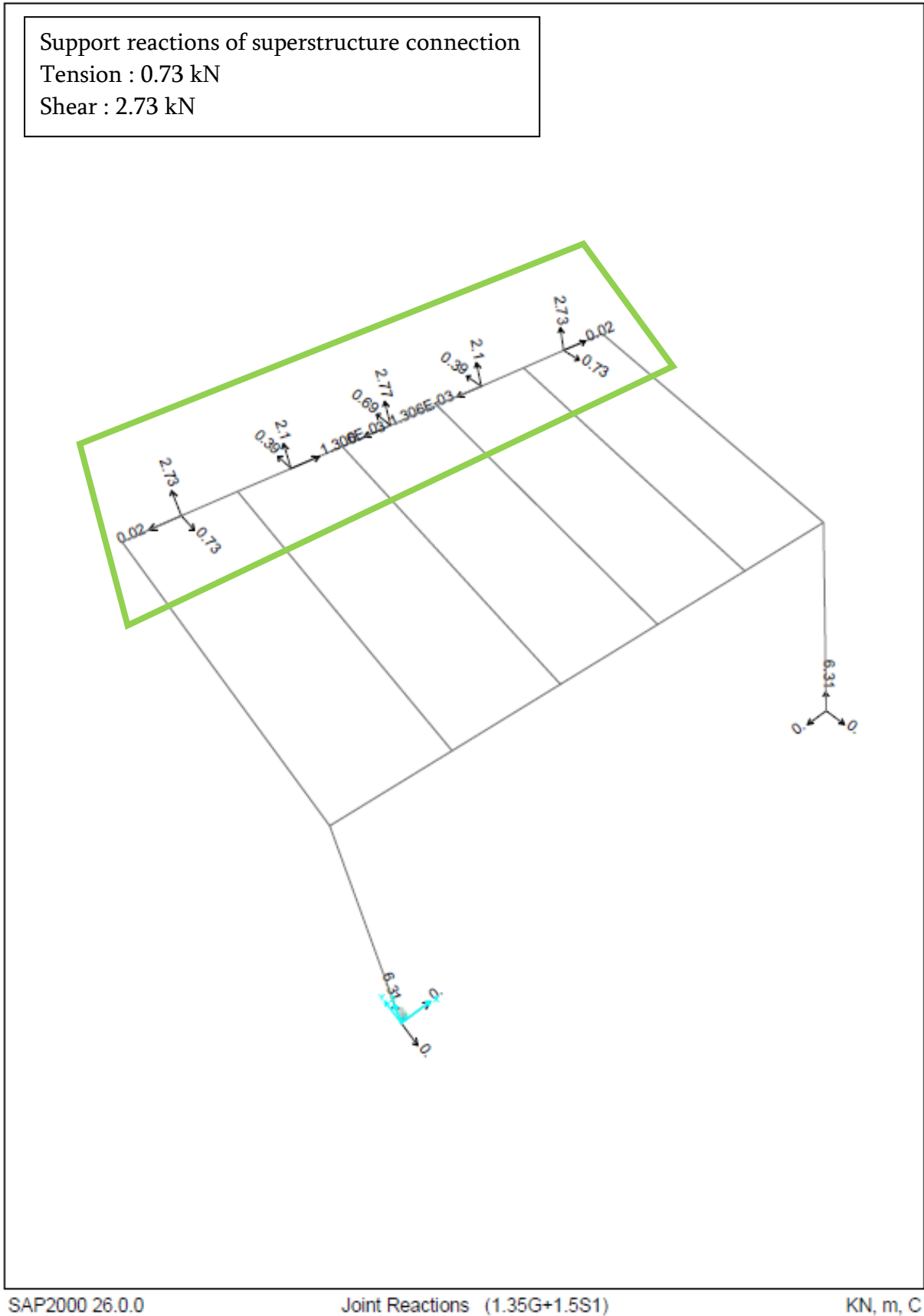


#### 4. Strength check of structural connections

##### 4.1.1. Strength check for chemical anchor of SCB (See page 15)

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The strength check of the chemical anchor connecting the winter garden to the superstructure is provided on the following pages. Strength checks are performed using FIXperience software.



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**Fischer Metal San. Ve Tic. Ltd. Şti.**  
Cevizli Mahallesi Mustafa Kemal  
Cad.No:66 Hukukçular Towers A Blok  
Kat 9  
34865 Kartal İstanbul  
Phone: +90 216 326 0066  
Fax: +90 216 326 0018  
satisdestek@fischer.com.tr  
www.fischer.com.tr

### Design Specifications

#### Anchor

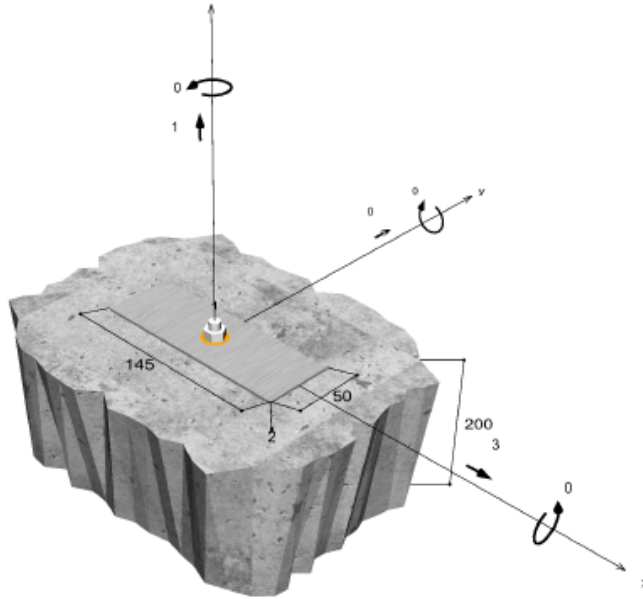
Anchor system	fischer Injection system FIS V
Injection resin	FIS V 410 C
Fixing element	Threaded rod FIS A M 8 x 90 8.8, zinc plated steel, Property Class 8.8
Calculated anchorage depth	60 mm
Design Data	Anchor design in Concrete according European Technical Assessment ETA-02/0024, Option 1, Issued 13/05/2020



#### Geometry / Loads / Scale units

mm, kN, kNm

Value of design actions (including  
partial safety factor for the load)



Not drawn to scale

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### Input data

Design method	ETAG 001, Technical Report TR 029
Base material	C20/25, EN 206
Concrete condition	Non-cracked, dry hole
Temperature range	24 °C long term temperature, 40 °C short term temperature
Reinforcement	Normal or no reinforcement. No edge reinforcement
Drilling method	Hammer drilling
Installation type	Push-through installation
Annular gap	Annular gap filled
Type of loading	Permanent-Transient/Static
Base plate location	Base plate flush installed on base material
Base plate geometry	145 mm x 50 mm x 2 mm
Profile type	None

### Design actions \*)

#	N <sub>sd</sub> kN	V <sub>sd,x</sub> kN	V <sub>sd,y</sub> kN	M <sub>sd,x</sub> kNm	M <sub>sd,y</sub> kNm	M <sub>T,sd</sub> kNm	Type of loading
1	1.00	3.00	0.00	0.00	0.00	0.00	Permanent-Transient/Static

\*) The required partial safety factors for actions are included

### Resulting anchor forces

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	1.00	3.00	3.00	0.00



max. concrete compressive strain :	0.00 ‰
max. concrete compressive stress :	0.0 N/mm <sup>2</sup>
Resulting tensile actions :	1.00 kN , X/Y position ( 0 / 0 )
Resulting compression actions :	0.00 kN , X/Y position ( 0 / 0 )

### Resistance to tension loads

Proof	Action kN	Capacity kN	Utilisation β <sub>N</sub> %
Steel failure *	1.00	19.33	5.2
Combined pull-out and concrete cone failure	1.00	11.06	9.0
Concrete cone failure	1.00	15.65	6.4

\* Most unfavourable anchor

#### Steel failure

$$N_{sd} \leq \frac{N_{Rk,s}}{\gamma_{Ms}} \quad (N_{Rd,s})$$



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$N_{Rk,s}$ kN	$\gamma_{Ms}$	$N_{Rd,s}$ kN	$N_{Sd}$ kN	$\beta_{N,s}$ %
29.00	1.50	19.33	1.00	5.2

Anchor no.	$\beta_{N,s}$ %	Group N°	Decisive Beta
1	5.2	1	$\beta_{N,s;1}$

**Combined pull-out and concrete cone failure**

$$N_{Sd} \leq \frac{N_{Rk,p}}{\gamma_{Mp}} \quad (N_{Rd,p})$$



$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np} \quad \text{Eq. (5.2)}$$

$$N_{Rk,p} = 16.59kN \cdot \frac{32,400mm^2}{32,400mm^2} \cdot 1.000 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 16.59kN$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} = \pi \cdot 8mm \cdot 60mm \cdot 11.0N/mm^2 = 16.59kN \quad \text{Eq. (5.2a)}$$

$$s_{cr,Np} = \min\left(20 \cdot d \cdot \left(\frac{\tau_{Rk,scr}}{7.5}\right)^{0.5}; 3 \cdot h_{ef}\right) \quad \text{Eq. (5.2c)}$$

$$s_{cr,Np} = \min\left(20 \cdot 8mm \cdot \left(\frac{11.0N/mm^2}{7.5}\right)^{0.5}; 3 \cdot 60mm\right) = 180mm$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} = \frac{180mm}{2} = 90mm \quad \text{Eq. (5.2d)}$$

$$\Psi_{s,Np} = \min\left(1; 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}}\right) = \min\left(1; 0.7 + 0.3 \cdot \frac{\infty}{90mm}\right) = 1.000 \leq 1 \quad \text{Eq. (5.2e)}$$

$$\Psi_{g,Np} = \max\left(1; \Psi_{g,Np}^0 - \sqrt{\frac{s}{s_{cr,Np}}} \cdot (\Psi_{g,Np}^0 - 1)\right) = 1.000 - \sqrt{\frac{0mm}{180mm}} \cdot (1.000 - 1) = 1.000 \geq 1 \quad \text{Eq. (5.2f)}$$

$$\Psi_{g,Np}^0 = \max\left(1; \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef} \cdot f_{ck,cube}}}\right)^{1.5}\right) \quad \text{Eq. (5.2g)}$$

$$\Psi_{g,Np}^0 = \max\left(1; \sqrt{1} - (\sqrt{1} - 1) \cdot \left(\frac{8mm \cdot 11.0N/mm^2}{3.2 \cdot \sqrt{60mm \cdot 25.0N/mm^2}}\right)^{1.5}\right) = 1.000 \geq 1$$

$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2c_s}{s_{cr,Np}}} = \Psi_{ec,Npx} \cdot \Psi_{ec,Npy} = 1.000 \cdot 1.000 = 1.000 \leq 1 \quad \text{Eq. (5.2h)}$$

$$\Psi_{ec,Npx} = \frac{1}{1 + \frac{2 \cdot 0mm}{180mm}} = 1.000 \leq 1 \quad \Psi_{ec,Npy} = \frac{1}{1 + \frac{2 \cdot 0mm}{180mm}} = 1.000 \leq 1$$

$$\Psi_{re,Np} = 1.000 \quad \text{Eq. (5.2i)}$$

$N_{Rk,p}$ kN	$\gamma_{Mp}$	$N_{Rd,p}$ kN	$N_{Sd}$ kN	$\beta_{N,p}$ %
16.59	1.50	11.06	1.00	9.0

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Anchor no.	$\beta_{N,p}$ %	Group N°	Decisive Beta
1	9.0	1	$\beta_{N,p;1}$

### Concrete cone failure

$$N_{Sd} \leq \frac{N_{Rk,c}}{\gamma_{Mc}} \quad (N_{Rd,c})$$



$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \quad \text{Eq. (5.3)}$$

$$N_{Rk,c} = 23.47kN \cdot \frac{32,400mm^2}{32,400mm^2} \cdot 1.000 \cdot 1.000 \cdot 1.000 = 23.47kN$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} = 10.1 \cdot \sqrt{25.0N/mm^2} \cdot (60mm)^{1.5} = 23.47kN \quad \text{Eq. (5.3a)}$$

$$\Psi_{s,N} = \min\left(1; 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}}\right) = \min\left(1; 0.7 + 0.3 \cdot \frac{\infty}{90mm}\right) = 1.000 \leq 1 \quad \text{Eq. (5.3c)}$$

$$\Psi_{re,N} = 1.000 \quad \text{Eq. (5.3d)}$$

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_s}{s_{cr,N}}} \Rightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 1.000 \cdot 1.000 = 1.000 \leq 1 \quad \text{Eq. (5.3e)}$$

$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 0mm}{180mm}} = 1.000 \leq 1 \quad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 0mm}{180mm}} = 1.000 \leq 1$$

$N_{Rk,c}$ kN	$\gamma_{Mc}$	$N_{Rd,c}$ kN	$N_{Sd}$ kN	$\beta_{N,c}$ %
23.47	1.50	15.65	1.00	6.4

Anchor no.	$\beta_{N,c}$ %	Group N°	Decisive Beta
1	6.4	1	$\beta_{N,c;1}$

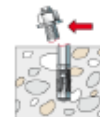
### Resistance to shear loads

Proof	Action kN	Capacity kN	Utilisation $\beta_v$ %
Steel failure without lever arm *	3.00	12.00	25.0
Concrete pry-out failure	3.00	22.12	13.6

\* Most unfavourable anchor

### Steel failure without lever arm

$$V_{Sd} \leq \frac{V_{Rk,s}}{\gamma_{Ms}} \quad (V_{Rd,s})$$



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$V_{Rk,s}$ kN	$\gamma_{Ms}$	$V_{Ed,s}$ kN	$V_{sd}$ kN	$\beta_{Vs}$ %
15.00	1.25	12.00	3.00	25.0

Anchor no.	$\beta_{Vs}$ %	Group N°	Decisive Beta
1	25.0	1	$\beta_{Vs,1}$

**Concrete pry-out failure**

$$V_{Sd} \leq \frac{V_{Rk,cp}}{\gamma_{Mcp}} \quad (V_{Rd,cp})$$



$$V_{Rk,cp} = k \cdot N_{Rk,p} = 2 \cdot 16.59kN = 33.18kN$$

Eq. (5.7)

$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np}$$

Eq. (5.2)

$$N_{Rk,p} = 16.59kN \cdot \frac{32,400mm^2}{32,400mm^2} \cdot 1.000 \cdot 1.000 \cdot 1.000 \cdot 1.000 = 16.59kN$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} = \pi \cdot 8mm \cdot 60mm \cdot 11.0N/mm^2 = 16.59kN$$

Eq. (5.2a)

$$s_{cr,Np} = \min\left(20 \cdot d \cdot \left(\frac{\tau_{Rk,ucr}}{7.5}\right)^{0.5}; 3 \cdot h_{ef}\right)$$

Eq. (5.2c)

$$s_{cr,Np} = \min\left(20 \cdot 8mm \cdot \left(\frac{11.0N/mm^2}{7.5}\right)^{0.5}; 3 \cdot 60mm\right) = 180mm$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} = \frac{180mm}{2} = 90mm$$

Eq. (5.2d)

$$\Psi_{s,Np} = \min\left(1; 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}}\right) = \min\left(1; 0.7 + 0.3 \cdot \frac{\infty}{90mm}\right) = 1.000 \leq 1$$

Eq. (5.2e)

$$\Psi_{g,Np} = \max\left(1; \Psi_{g,Np}^0 - \sqrt{\frac{s}{s_{cr,Np}}} \cdot (\Psi_{g,Np}^0 - 1)\right)$$

Eq. (5.2f)

$$\Psi_{g,Np} = \max\left(1; 1.000 - \sqrt{\frac{0mm}{180mm}} \cdot (1.000 - 1)\right) = 1.000 \geq 1$$

$$\Psi_{g,Np}^0 = \max\left(1; \sqrt{n} - (\sqrt{n} - 1) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef}} \cdot f_{ck,cube}}\right)^{1.5}\right)$$

Eq. (5.2g)

$$\Psi_{g,Np}^0 = \max\left(1; \sqrt{1} - (\sqrt{1} - 1) \cdot \left(\frac{8mm \cdot 11.0N/mm^2}{3.2 \cdot \sqrt{60mm} \cdot 25.0N/mm^2}\right)^{1.5}\right) = 1.000 \geq 1$$

$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2e_s}{s_{cr,Np}}} = \Psi_{ec,Npz} \cdot \Psi_{ec,Npy} = 1.000 \cdot 1.000 = 1.000 \leq 1$$

Eq. (5.2h)

$$\Psi_{re,Np} = 1.000$$

Eq. (5.2i)

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$V_{Rk,cp}$ kN	$Y_{Mcp}$	$V_{Rd,cp}$ kN	$V_{sd}$ kN	$\beta_{V,cp}$ %
33.18	1.50	22.12	3.00	13.6


Anchor no.	$\beta_{V,cp}$ %	Group N°	Decisive Beta
1	13.6	1	$\beta_{V,cp;1}$

### Utilization of tension and shear loads

Tension loads	Utilisation $\beta_N$ %	Shear Loads	Utilisation $\beta_V$ %
Steel failure *	5.2	Steel failure without lever arm *	25.0
Combined pull-out and concrete cone failure	9.0	Concrete pry-out failure	13.6
Concrete cone failure	6.4		

\* Most unfavourable anchor

### Resistance to combined tensile and shear loads

$\beta_N = \beta_{N;p;1} = 0.09 \leq 1$	 <b>Proof successful</b>	Eq. (5.9a)
$\beta_V = \beta_{V;s;1} = 0.25 \leq 1$		Eq. (5.9b)
$\beta_N^{1.5} + \beta_V^{1.5} = \beta_{N;p;1}^{1.5} + \beta_{V;s;1}^{1.5} = 0.15 \leq 1$		Eq. (5.10)

### Information concerning the anchor plate

#### Base plate details

Plate thickness specified by user without proof

t = 2 mm

Profile type

None

### Technical remarks

All data and information in the software is based on fischer products and common engineering knowledge. Please check all the proof results against local valid standards and approvals.

As fischer is not the design office, the attached is no guarantee for incorrect input or assumptions. Any recommendations have to be approved by the building-authority or project engineer. Results are valid only for anchor system calculated in the attached. If any part of the system is changed, it will invalidate this report and new calculations would be required.

The transmission of the anchor loads to the supports of the concrete member shall be shown for the ultimate limit state and the serviceability limit state; for this purpose, the normal verifications shall be carried out under due consideration of the actions introduced by the anchors. For these verifications the additional provisions given in the current design method shall be taken into account.

As a pre-condition the anchor plate is assumed to be flat when subjected to the actions. Therefore, the plate (if present) must be sufficiently stiff. The C-Fix anchor plate design is based on a proof of stresses and does not allow a statement about the stiffness of the plate. The proof of the necessary stiffness is not carried out by C-Fix.



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## Installation data

### Anchor

**Anchor system**  
Injection resin

**fischer Injection system FIS V**  
FIS V 410 C (other cartridge sizes available)

Art-No. 531504



**Fixing element**

Threaded rod FIS A M 8 x 90 8.8, zinc plated steel, Property Class 8.8

Art-No. 519390



**Accessories**

FIS MR Plus  
Dispenser FIS AC  
Blow-out pump ABG big  
Cleaning brush BS 10  
Quattric II 10/100/165

Art-No. 545853  
Art-No. 96497  
Art-No. 567792  
Art-No. 78178  
Art-No. 549923

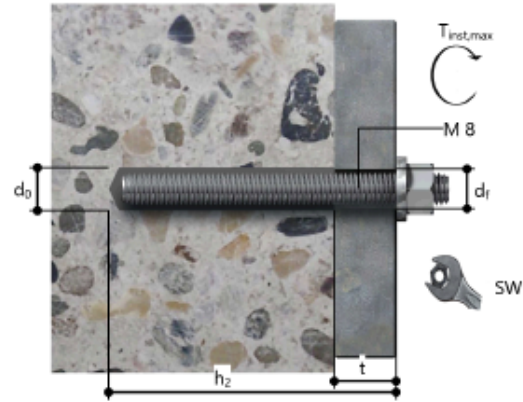
### Installation details

Thread diameter  
Drill hole diameter  
Drill hole depth  
Calculated anchorage depth  
Drilling method  
Borehole cleaning

M 8  
 $d_0 = 10 \text{ mm}$   
 $h_2 = 62 \text{ mm}$   
 $h_{ef} = 60 \text{ mm}$

Installation type  
Annular gap  
Maximum torque  
Socket size  
Base plate thickness  
Total fixing thickness  
 $T_{fix,max}$   
Volume of resin per drill hole

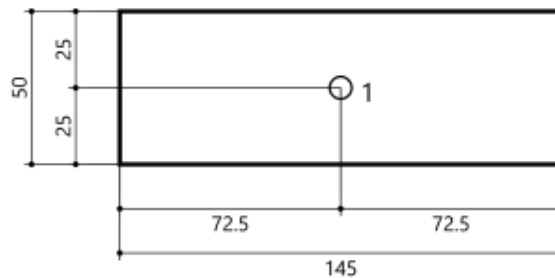
Hammer drilling  
4 times blowing,  
4 times brushing,  
4 times blowing  
required activities according the given instruction in the approval  
Push-through installation  
Annular gap filled  
 $T_{inst,max} = 10.0 \text{ Nm}$   
13 mm  
 $t = 2 \text{ mm}$   
 $t_{fx} = 2 \text{ mm}$   
4 ml/2 scale divisions



### Base plate details

Base plate material  
Base plate thickness  
Clearance hole in base plate

Not available  
 $t = 2 \text{ mm}$   
 $d_r = 11 \text{ mm}$



### Attachment

Profile type

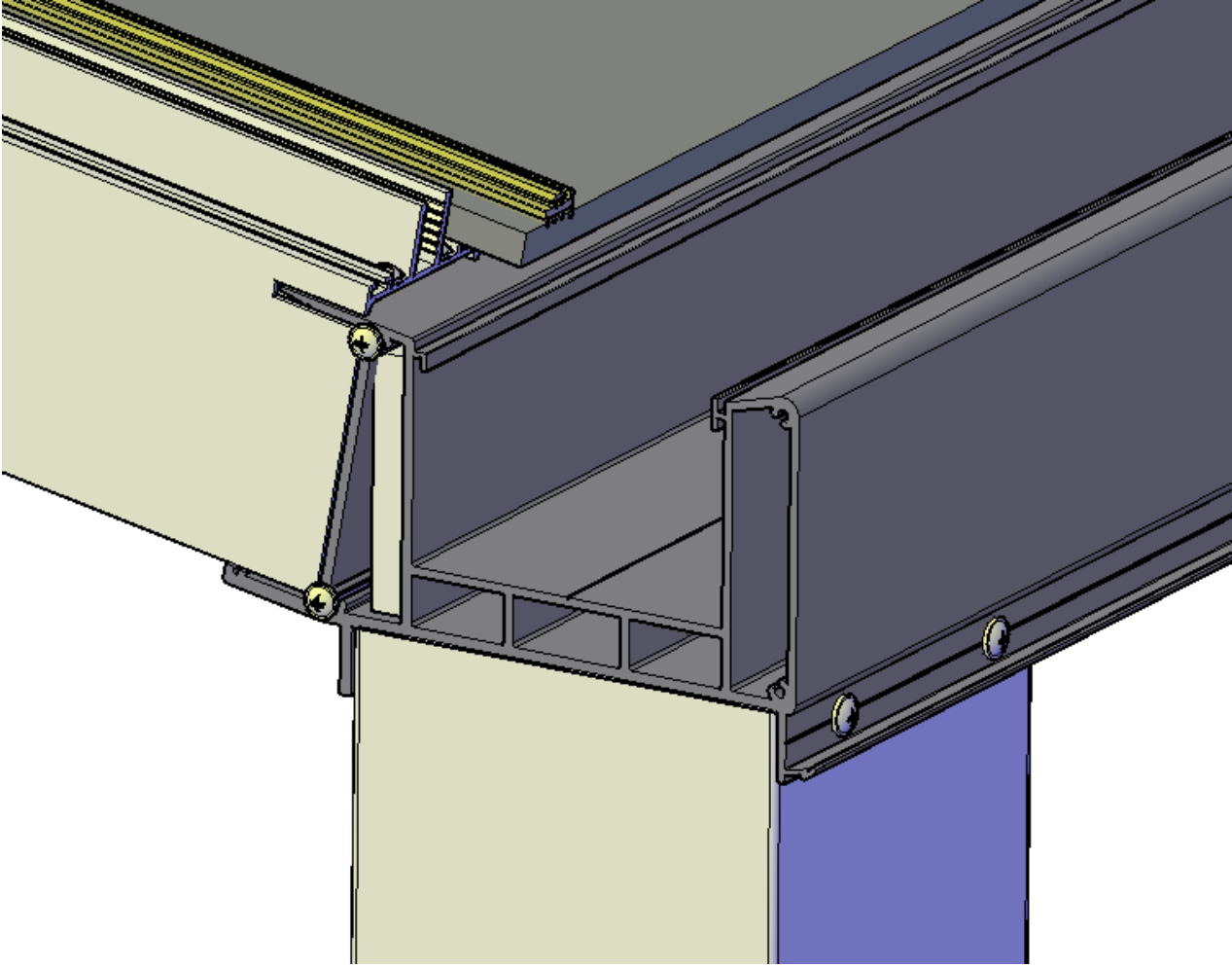
None

### Anchor coordinates

Anchor no.	x mm	y mm
1	0	0

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#### 4.1.2. Strength check of column – gutter beam connection.



Isometric view of column-gutter beam connection

The connection of the gutter beam to the column consists of 4 x  $\text{Ø}4.8\text{mm}$  screws.

This connection will be subjected to tension forces due to uplift in the wind load combination. For all other load combinations, it will only be subjected to compression forces. As a result, the screws will not be transmitting forces in load cases other than wind uplift.

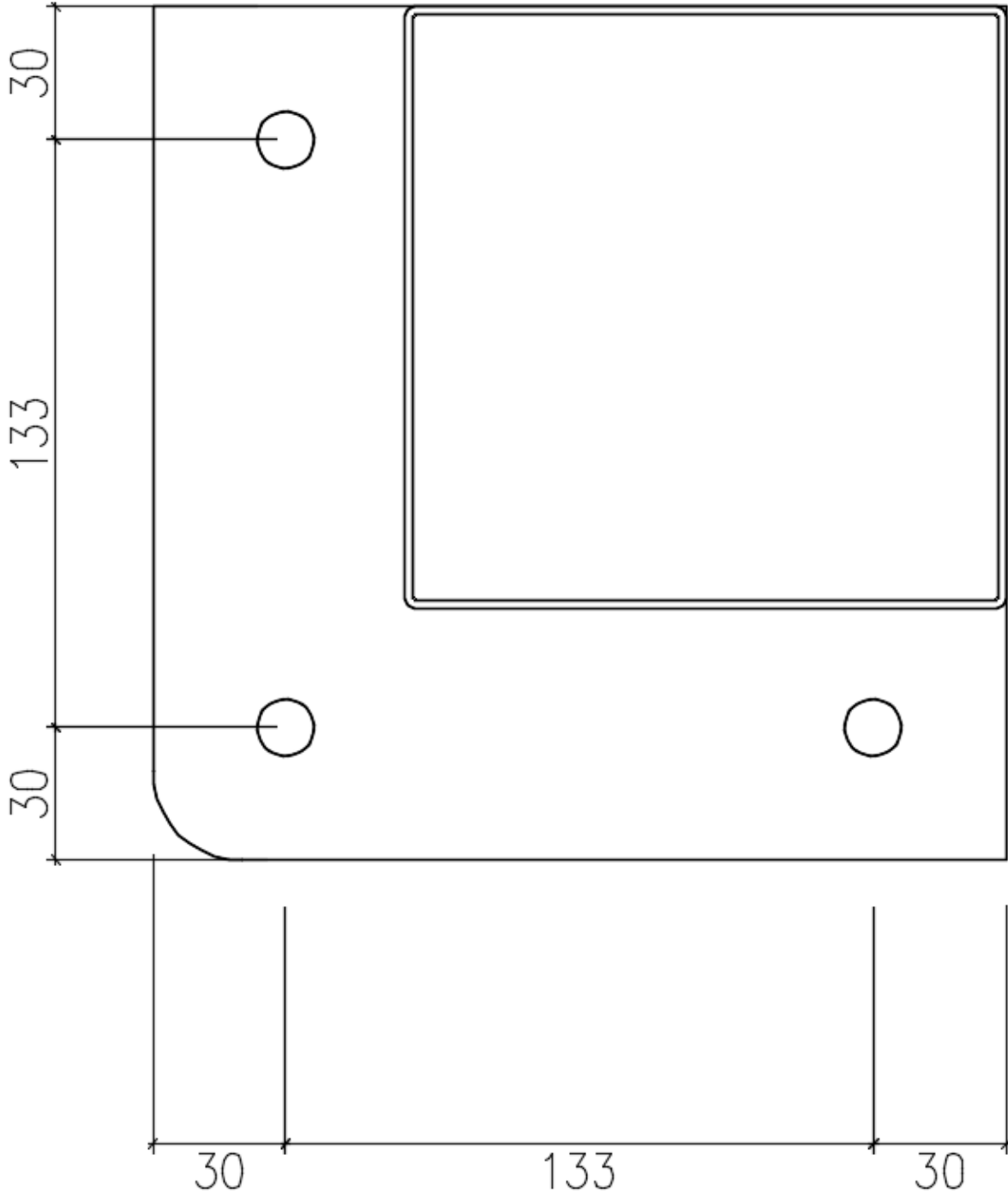
Axial force diagram of column and shear resistance check of screws will be submitted in next pages.



Screw analysis			EN-1993-1-3	
Nominal diameter (mm)	d:	4.8	Bearing	2.47 kN
Head diameter (mm)	d <sub>w</sub> :	9.4	Shear	3.86 kN
Section area (mm <sup>2</sup> )	A <sub>s</sub> :	13.8	Pull-out	0.76 kN
Tensile strength (Mpa)	f <sub>us</sub> :	700	Pull-through	1.60 kN
Thinner Material thickness (mm)	t:	1.8	Tension	6.96 kN
Thicker Material thickness (mm)	t <sub>1</sub> :	2.5		
Thinner Material strength (Mpa)	f <sub>u</sub> :	170	Shear force	1.00 kN
Thicker Material strength (Mpa)	f <sub>u1</sub> :	170	Tension force	0.00 kN
Partial safety factor	γ <sub>M</sub> :	1.25	Utilization	41%
	α:	2.1		

he demand/capacity ratio of the screws is 41%, so the strength check meets the required limits.

4.1.3. Strength check of column base plate chemical anchors



Plan view of base plate

The strength check of the chemical anchor connecting the winter garden to the superstructure is provided on the following pages. Strength checks are performed using FIXperience software.



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	<p><b>Fischer Metal San. Ve Tic. Ltd. Şti.</b></p> <p>Cevizli Mahallesi Mustafa Kemal Cad.No:66 Hukukçular Towers A Blok Kat 9 34865 Kartal İstanbul Phone: +90 216 326 0066 Fax: +90 216 326 0018 satisdestek@fischer.com.tr www.fischer.com.tr</p>
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## Design Specifications

### Anchor

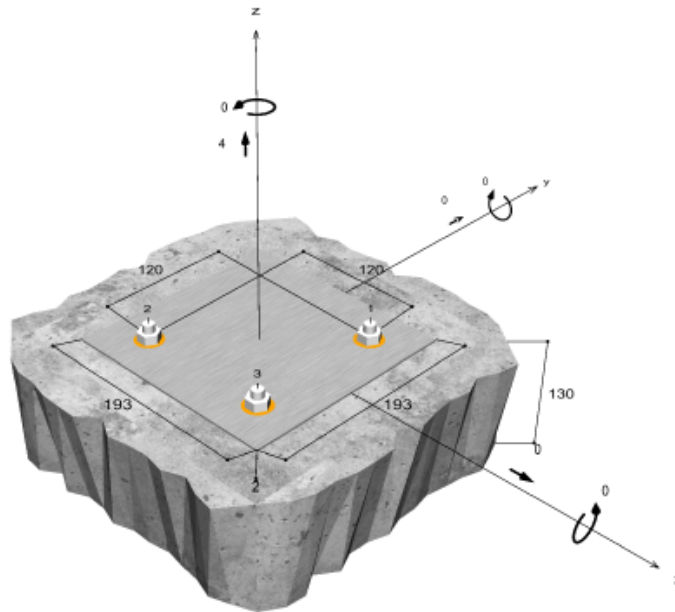
Anchor system	fischer Injection system FIS V
Injection resin	FIS V 410 C
Fixing element	Threaded rod FIS AM 10 x 150 8.8, zinc plated steel, Property Class 8.8
Calculated anchorage depth	100 mm
Design Data	Determined by manufacturer, ENSO-Data see printout



### Geometry / Loads / Scale units

mm, kN, kNm

Value of design actions (including partial safety factor for the load)



Not drawn to scale

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### Input data

Design method	Design method ENSO Bonded
Base material	C20/25, EN 206
Concrete condition	Non-cracked, dry hole
Temperature range	24 °C long term temperature, 40 °C short term temperature
Reinforcement	Normal or no reinforcement. No edge reinforcement
Drilling method	Hammer drilling
Installation type	Push-through installation
Annular gap	Annular gap filled
Type of loading	Permanent-Transient/Static
Base plate location	Base plate flush installed on base material
Base plate geometry	193 mm x 193 mm x 2 mm
Profile type	None

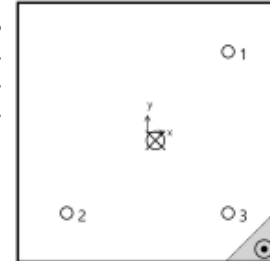
### Design actions \*)

#	N <sub>sd</sub> kN	V <sub>sd,x</sub> kN	V <sub>sd,y</sub> kN	M <sub>sd,x</sub> kNm	M <sub>sd,y</sub> kNm	M <sub>T,sd</sub> kNm	Type of loading
1	4.00	0.00	0.00	0.00	0.00	0.00	Permanent-Transient/Static

\*) The required partial safety factors for actions are included

### Resulting anchor forces

Anchor no.	Tensile action kN	Shear Action kN	Shear Action x kN	Shear Action y kN
1	1.93	0.00	0.00	0.00
2	1.93	0.00	0.00	0.00
3	0.43	0.00	0.00	0.00



max. concrete compressive strain : 0.04 ‰  
 max. concrete compressive stress : 1.2 N/mm<sup>2</sup>  
 Resulting tensile actions : 4.30 kN, X/Y position ( 6 / -6 )  
 Resulting compression actions : 0.30 kN, X/Y position ( 87 / -87 )

### Resistance to tension loads

Proof	Action kN	Capacity kN	Utilisation β <sub>N</sub> %
Steel failure *	1.93	31.33	6.2
Combined pull-out and concrete cone failure	4.30	40.30	10.7
Concrete cone failure	4.30	50.70	8.5

\* Most unfavourable anchor

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### Steel failure

$$N_{Sd} \leq \frac{N_{Rk,s}}{\gamma_{Ms}} \quad (N_{Rd,s})$$



$N_{Rk,s}$ kN	$\gamma_{Ms}$	$N_{Rd,s}$ kN	$N_{Sd}$ kN	$\beta_{N,s}$ %
47.00	1.50	31.33	1.93	6.2

Anchor no.	$\beta_{N,s}$ %	Group N°	Decisive Beta
1	6.2	1	$\beta_{N,s,1}$
2	6.2	2	$\beta_{N,s,2}$
3	1.4	3	$\beta_{N,s,3}$

### Combined pull-out and concrete cone failure

$$N_{Sd} \leq \frac{N_{Rk,p}}{\gamma_{Mp}} \quad (N_{Rd,p})$$



$$N_{Rk,p} = N_{Rk,p}^0 \cdot \frac{A_{p,N}}{A_{p,N}^0} \cdot \Psi_{s,Np} \cdot \Psi_{g,Np} \cdot \Psi_{ec,Np} \cdot \Psi_{re,Np} \quad \text{Eq. (5.2)}$$

$$N_{Rk,p} = 34.56 \text{ kN} \cdot \frac{116,644 \text{ mm}^2}{58,564 \text{ mm}^2} \cdot 1.000 \cdot 1.093 \cdot 0.803 \cdot 1.000 = 60.45 \text{ kN}$$

$$N_{Rk,p}^0 = \pi \cdot d \cdot h_{ef} \cdot \tau_{Rk} = \pi \cdot 10 \text{ mm} \cdot 100 \text{ mm} \cdot 11.0 \text{ N/mm}^2 = 34.56 \text{ kN} \quad \text{Eq. (5.2a)}$$

$$\Psi_{sus} = 1.00 \quad \text{Eq. (7.14a)}$$

$$\alpha_{sus} = 0.00 \leq \Psi_{sus}^0 = 0.74$$

$$s_{cr,Np} = \min\left(7.3 \cdot d \cdot \left(\Psi_{sus} \cdot \tau_{Rk,ucr}\right)^{0.5}; 3 \cdot h_{ef}\right) \quad \text{Eq. (7.15)}$$

$$s_{cr,Np} = \min\left(7.3 \cdot 10 \text{ mm} \cdot \left(1.00 \cdot 11.0 \text{ N/mm}^2\right)^{0.5}; 3 \cdot 100 \text{ mm}\right) = 242 \text{ mm}$$

$$c_{cr,Np} = \frac{s_{cr,Np}}{2} = \frac{242 \text{ mm}}{2} = 121 \text{ mm} \quad \text{Eq. (7.16)}$$

$$\Psi_{s,Np} = \min\left(1; 0.7 + 0.3 \cdot \frac{c}{c_{cr,Np}}\right) = \min\left(1; 0.7 + 0.3 \cdot \frac{\infty}{121 \text{ mm}}\right) = 1.000 \leq 1 \quad \text{Eq. (5.2e)}$$

$$\Psi_{g,Np} = \Psi_{g,Np}^0 - \sqrt{\frac{s}{s_{cr,Np}}} \cdot \left(\Psi_{g,Np}^0 - 1\right) = 1.315 - \sqrt{\frac{120 \text{ mm}}{242 \text{ mm}}} \cdot (1.315 - 1) = 1.093 \geq 1 \quad \text{Eq. (5.2f)}$$

$$\Psi_{g,Np}^0 = \sqrt{n} - \left(\sqrt{n} - 1\right) \cdot \left(\frac{d \cdot \tau_{Rk}}{k \cdot \sqrt{h_{ef} \cdot f_{ck,cube}}}\right)^{1.5} \quad \text{Eq. (5.2g)}$$

$$\Psi_{g,Np}^0 = \sqrt{3} - \left(\sqrt{3} - 1\right) \cdot \left(\frac{10 \text{ mm} \cdot 11.0 \text{ N/mm}^2}{3.2 \cdot \sqrt{100 \text{ mm} \cdot 25.0 \text{ N/mm}^2}}\right)^{1.5} = 1.315 \geq 1$$

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$$\Psi_{ec,Np} = \frac{1}{1 + \frac{2e_c}{s_{cr,Np}}} = \Psi_{ec,Npz} \cdot \Psi_{ec,Npy} = 0.896 \cdot 0.896 = 0.803 \leq 1 \quad \text{Eq. (5.2h)}$$

$$\Psi_{ec,Npz} = \frac{1}{1 + \frac{2 \cdot 14mm}{242mm}} = 0.896 \leq 1 \quad \Psi_{ec,Npy} = \frac{1}{1 + \frac{2 \cdot 14mm}{242mm}} = 0.896 \leq 1$$

$$\Psi_{re,Np} = 1.000 \quad \text{Eq. (5.2i)}$$

$N_{Rk,p}$ kN	$\gamma_{Mp}$	$N_{Rd,p}$ kN	$N_{sd}$ kN	$\beta_{N,p}$ %
60.45	1.50	40.30	4.30	10.7

Anchor no.	$\beta_{N,p}$ %	Group N°	Decisive Beta
1, 2, 3	10.7	1	$\beta_{N,p,1}$

### Concrete cone failure

$$N_{Sd} \leq \frac{N_{Rk,c}}{\gamma_{Mc}} \quad (N_{Rd,c})$$



$$N_{Rk,c} = N_{Rk,c}^0 \cdot \frac{A_{c,N}}{A_{c,N}^0} \cdot \Psi_{s,N} \cdot \Psi_{re,N} \cdot \Psi_{ec,N} \quad \text{Eq. (5.3)}$$

$$N_{Rk,c} = 50.50kN \cdot \frac{162,000mm^2}{90,000mm^2} \cdot 1.000 \cdot 1.000 \cdot 0.837 = 76.05kN$$

$$N_{Rk,c}^0 = k_1 \cdot \sqrt{f_{ck,cube}} \cdot h_{ef}^{1.5} = 10.1 \cdot \sqrt{25.0N/mm^2} \cdot (100mm)^{1.5} = 50.50kN \quad \text{Eq. (5.3a)}$$

$$\Psi_{s,N} = \min\left(1; 0.7 + 0.3 \cdot \frac{c}{c_{cr,N}}\right) = \min\left(1; 0.7 + 0.3 \cdot \frac{\infty}{150mm}\right) = 1.000 \leq 1 \quad \text{Eq. (5.3c)}$$

$$\Psi_{re,N} = 1.000 \quad \text{Eq. (5.3d)}$$

$$\Psi_{ec,N} = \frac{1}{1 + \frac{2e_c}{s_{cr,N}}} \Rightarrow \Psi_{ec,Nx} \cdot \Psi_{ec,Ny} = 0.915 \cdot 0.915 = 0.837 \leq 1 \quad \text{Eq. (5.3e)}$$

$$\Psi_{ec,Nx} = \frac{1}{1 + \frac{2 \cdot 14mm}{300mm}} = 0.915 \leq 1 \quad \Psi_{ec,Ny} = \frac{1}{1 + \frac{2 \cdot 14mm}{300mm}} = 0.915 \leq 1$$

$N_{Rk,c}$ kN	$\gamma_{Mc}$	$N_{Rd,c}$ kN	$N_{sd}$ kN	$\beta_{N,c}$ %
76.05	1.50	50.70	4.30	8.5

Anchor no.	$\beta_{N,c}$ %	Group N°	Decisive Beta
1, 2, 3	8.5	1	$\beta_{N,c,1}$

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## Resistance to combined tensile and shear loads

$$\beta_N = \beta_{N,p1} = 0.11 \leq 1$$



Proof successful

(5.9a)

## Information concerning the anchor plate

### Base plate details

Plate thickness specified by user without proof

t = 2 mm

Profile type

None

## Technical remarks

All data and information in the software is based on fischer products and common engineering knowledge. Please check all the proof results against local valid standards and approvals.

As fischer is not the design office, the attached is no guarantee for incorrect input or assumptions. Any recommendations have to be approved by the building-authority or project engineer. Results are valid only for anchor system calculated in the attached. If any part of the system is changed, it will invalidate this report and new calculations would be required.

The transmission of the anchor loads to the supports of the concrete member shall be shown for the ultimate limit state and the serviceability limit state; for this purpose, the normal verifications shall be carried out under due consideration of the actions introduced by the anchors. For these verifications the additional provisions given in the current design method shall be taken into account.

As a pre-condition the anchor plate is assumed to be flat when subjected to the actions. Therefore, the plate (if present) must be sufficiently stiff. The C-Fix anchor plate design is based on a proof of stresses and does not allow a statement about the stiffness of the plate. The proof of the necessary stiffness is not carried out by C-Fix.



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## Installation data

### Anchor

<b>Anchor system</b>	<b>fischer Injection system FIS V</b>	
Injection resin	FIS V 410 C (other cartridge sizes available)	Art.-No. 531504
Fixing element	Threaded rod FIS A M 10 x 150 8.8, zinc plated steel, Property Class 8.8	Art.-No. 517935
Accessories	FIS MR Plus	Art.-No. 545853
	Dispenser FIS AC	Art.-No. 96497
	Blow-out pump ABG big	Art.-No. 567792
	BSD 12	Art.-No. 1490
	SDS Chuck with internal thread M8	Art.-No. 530332
	Quattric II 12/110/160	Art.-No. 549932
	or alternatively	
	FHD 12/200/330	Art.-No. 546597
	Hammer drilling with or without suction	



### Installation details

Thread diameter	M 10
Drill hole diameter	$d_0 = 12 \text{ mm}$
Drill hole depth	$h_2 = 102 \text{ mm}$
Calculated anchorage depth	$h_{ef} = 100 \text{ mm}$
Drilling method	Hammer drilling
Borehole cleaning	4 times blowing, 4 times brushing, 4 times blowing required activities according to the given instruction in the approval No borehole cleaning required in case of using a hollow drill bit, e.g. fischer FHD.
Installation type	Push-through installation
Annular gap	Annular gap filled
Maximum torque	$T_{inst,max} = 20.0 \text{ Nm}$
Socket size	17 mm
Base plate thickness	$t = 2 \text{ mm}$
Total fixing thickness	$t_{fx} = 2 \text{ mm}$
$T_{fix,max}$	
Volume of resin per drill hole	8 ml/4 scale divisions

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### Base plate details

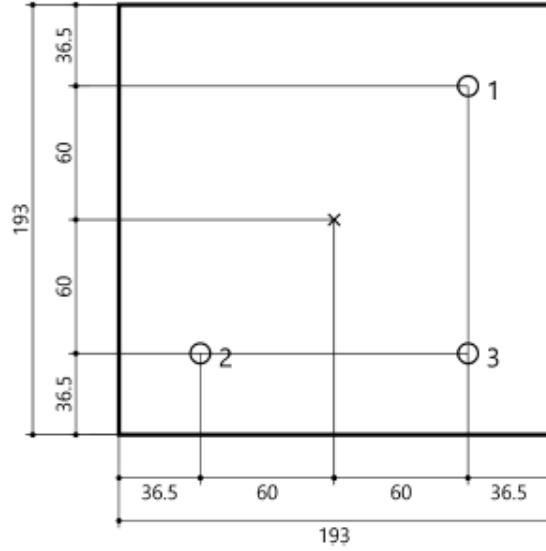
Base plate material Not available  
Base plate thickness  $t = 2 \text{ mm}$   
Clearance hole in base plate  $d_r = 14 \text{ mm}$

### Attachment

Profile type None

### Anchor coordinates

Anchor no.	x mm	y mm
1	60	60
2	-60	-60
3	60	-60





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## ENSO-Datasheet

### Anchor

Injection resin FIS V 410 C  
Fixing element Threaded rod FIS A M 10 x 150 8.8, zinc plated steel, Property Class 8.8



### Characteristic resistances <sup>1)</sup>

#### Characteristic resistance for steel failure under tension

Characteristic resistance	8.8	$N_{Rk,s}$	kN	47.00
Partial safety factor		$\gamma_{M,N}$	-	1.50

#### Characteristic bond strength for concrete C20/25 <sup>2)</sup>

Non-cracked		$f_{TRk,ucr}$	N/mm <sup>2</sup>	11.0
Partial safety factor		$\gamma_{M,p}$	-	1.50

#### Characteristic resistance for concrete cone failure and spalling

Effective anchorage depth		$h_{ef}$	mm	100
Factor k for uncracked concrete		$k_{ucr}$	-	10.10

#### Characteristic distances for member thickness 130 mm

Partial safety factor		$\gamma_{M,c}$	-	1.50
-----------------------	--	----------------	---	------

#### Minimum dimensions and measures

min. member thickness		$h_{min}$	mm	100
min. spacing		$s_{min}$	mm	45
min. edge distance		$c_{min}$	mm	45

1) For all not listed parameters see ENSO-Design method.

2) Drilling method Hammer drilling  
Drill hole condition dry hole  
Temperature range 24 °C long term temperature, 40 °C short term temperature

## 5. Strength and deflection check of roof glass panel

Deflection limit for glass panels are  $L/100$ . (L=short span)

For glass units which has 1000mm width, deflection limit is 10mm.

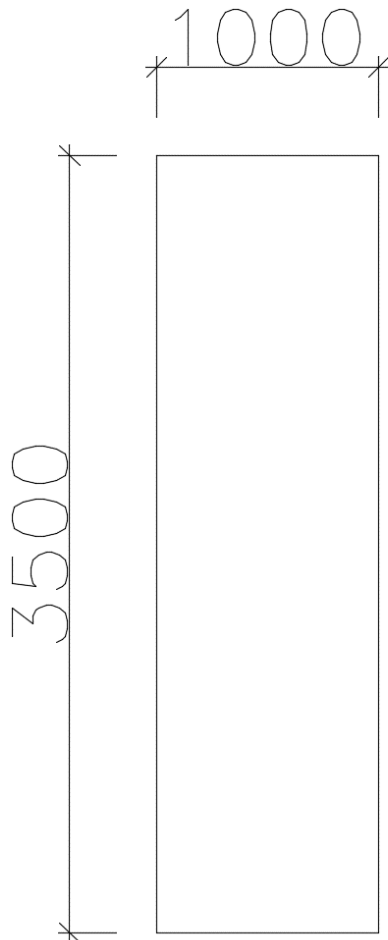
The allowable stresses are provided in the table below.

Table 1 : Allowable bending stress (short term & long term)

Unit: kg/cm<sup>2</sup>

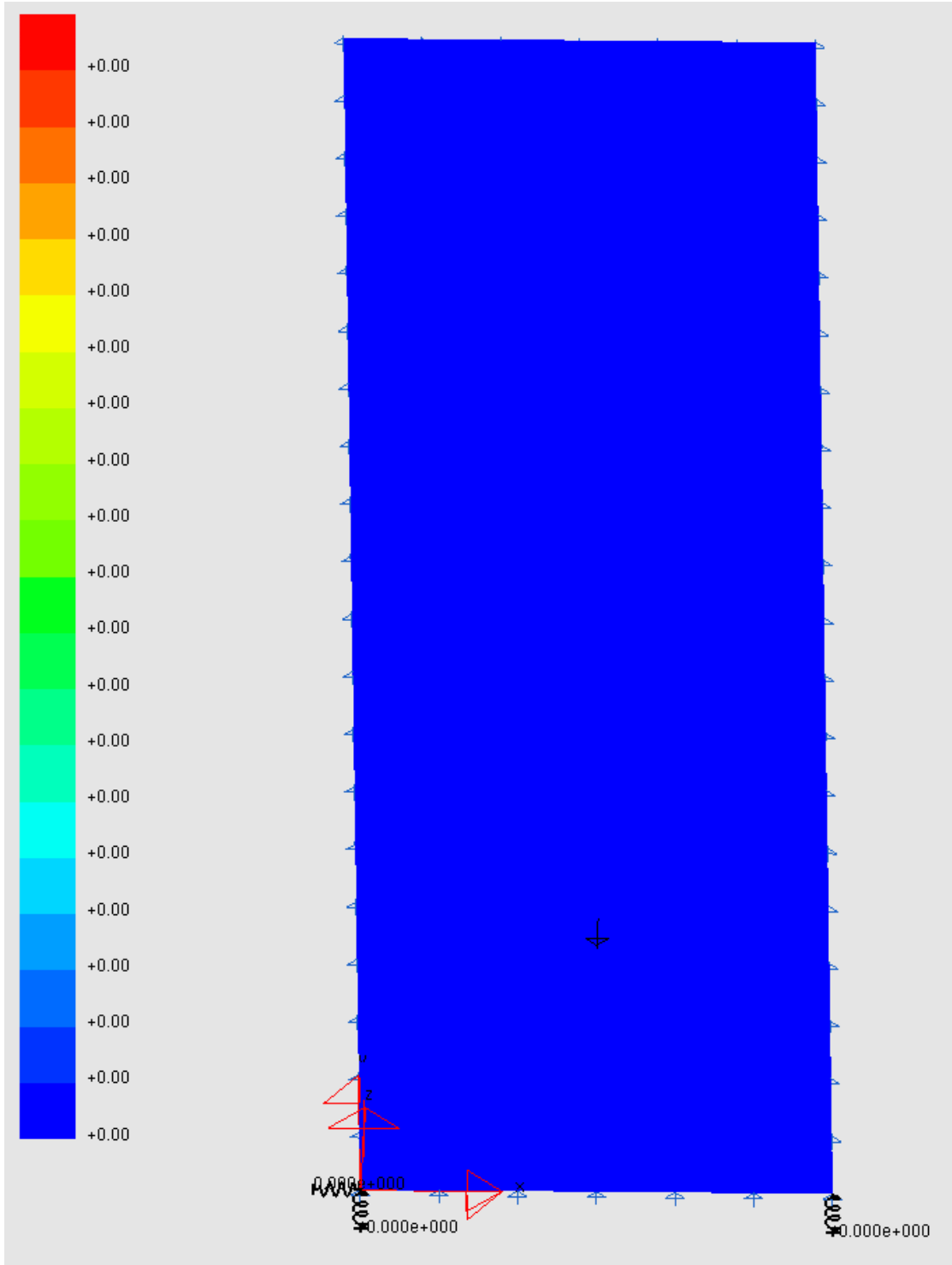
Glass Type	Thickness (mm)	Average Breaking Stress		Allowable Stress			
		Surface $\sigma_c$	Surface $\sigma_e$	Short Term		Long Term	
				Surface $\sigma_{ac}$	Surface $\sigma_{ae}$	Surface $\sigma_{ac}$	Surface $\sigma_{ae}$
Float Glass: Clear Float Bronze Float Dark Grey Float	2,3,5,6,8	500	360	250	180	100	70
	10	450	360	250	180	100	70
	12,15,19	375	360	200	180	80	70
Heat Strengthened Glass	6,8,10	800	720	450	360	300	250
Tempered Glass	4,5,6,8,10,12,15,19	1500	1100	750	500	500	350
Wired, Uni-wired Polished plate glass	6,8,10	375	200	200	100	80	40

NOTE: Glass must be clean cut for applicability of table values.

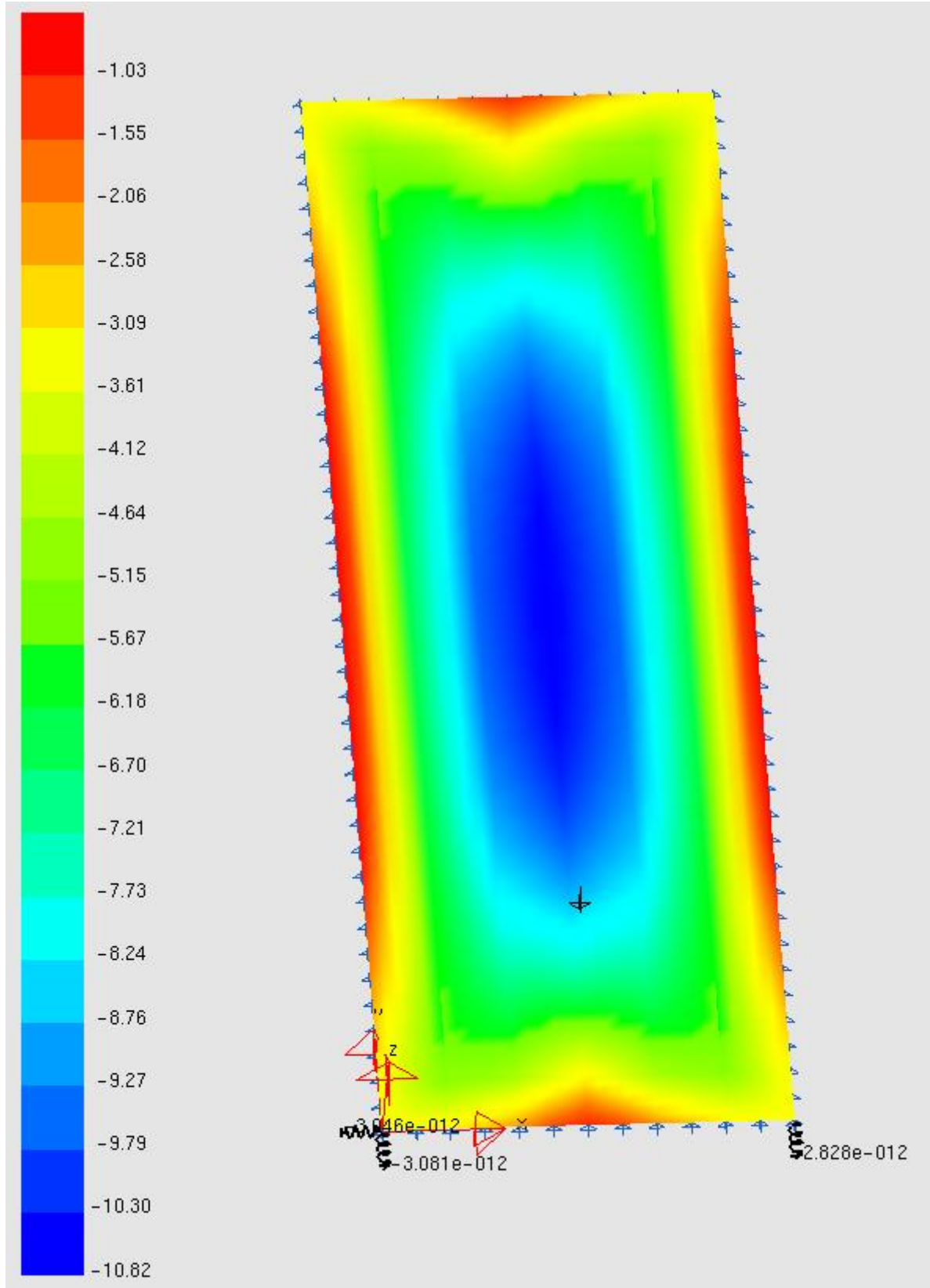


**Layers**  
4mm Tempered Glass  
0.76PVB  
4mm Tempered Glass

Front view of glass panel



Finite elements model of glass panel

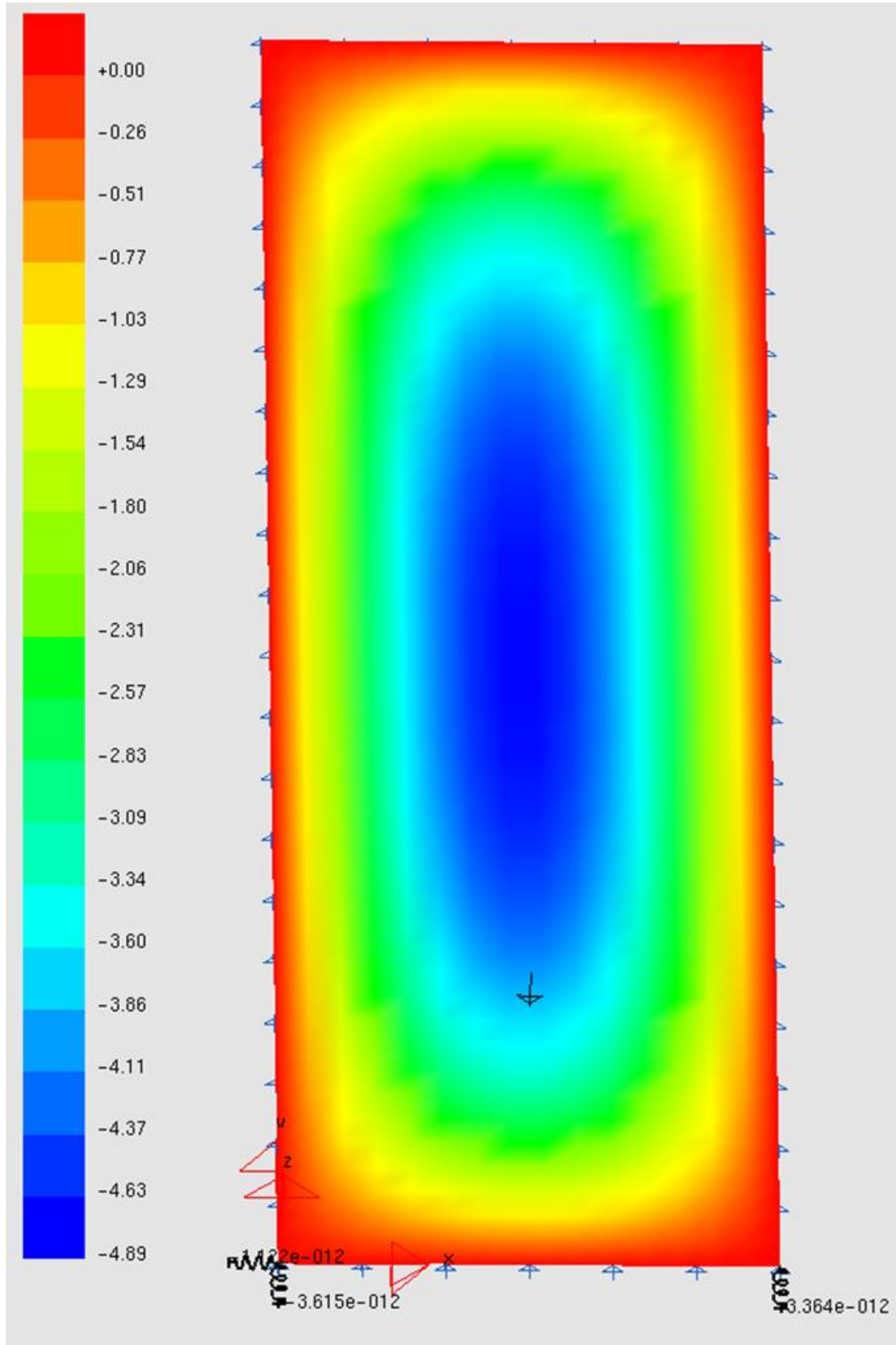


Stress distribution of the glass panel under snow load

Check of allowable stress

$$\sigma_{EM} = 49 \text{ N/mm}^2$$

$$\sigma_{\text{max}} = 11 \text{ N/mm}^2 < 49 \text{ N/mm}^2 \text{ OK}$$



Deformed shape of the glass panel under snow load

Deflection check,

Deflection limit  $\Delta_{lim} = 10\text{mm}$

$\Delta < \Delta_{lim}$  must satisfy.

4.9 mm < 10,00 mm  $\Delta < \Delta_{lim}$  satisfies, OK