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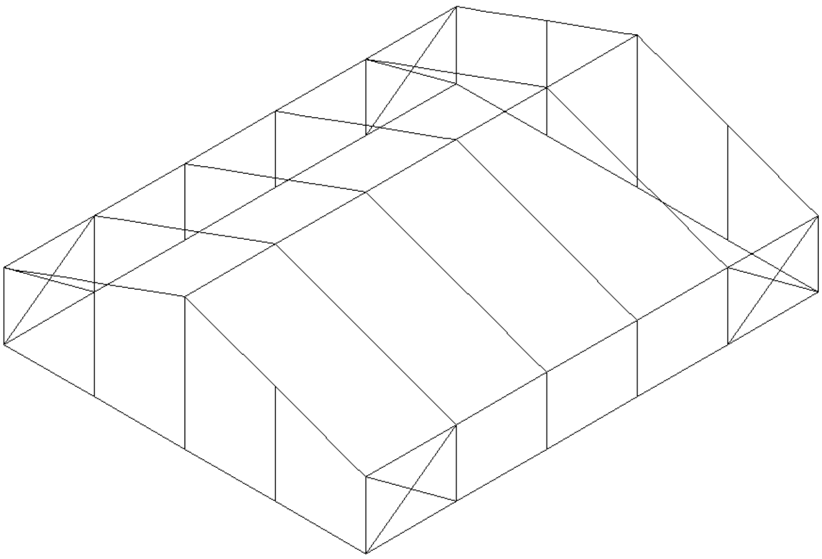
WIND
ENGINEERING
FLUID
DYNAMICS

KIBÆK TENT BOOK - 12 M WITHOUT GUY LINES

Static calculations of 12 m tent



Prepared for: Kibæk pressening

Revision 0, March 23, 2016

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Annex B: GT Strudl calculations - rev 0.

Annex C: Verification overview and calculation example - rev 0.

Annex D: Drawings - rev 0.

Copenhagen, March 23, 2016

Svend Ole Hansen ApS	Project Engineer
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Revisions

Revision no.	Date	Comments
0	March 23, 2016	Draft report issued for comments

1 Introduction

The present report, which is prepared for Kibæk pressening covers tents with a span of 12m, 2.2m leg height and 20° pitch angle produced by Kibæk pressening.

The tents are verified to meet the requirements in the specifications in the Eurocodes and EN 13782 given in chapter 8.

The geometry and material data of the tent is based on information received from Kibæk pressening on January to March 2015.

2 Installation prerequisites

2.1 Geometry

The tents must be set up as shown in the drawings in Annex D with a frame distance of 3 m. Additional wind bracing at the roof and in the facades should be installed for at least every 30 m.

2.2 Deformation

Normal serviceability requirements are not applicable for tent structures i.e larger deformations are allowable.

2.3 Snow

The tent has not been calculated with snow load. According to [7] the tent can only be used if one of the following circumstances are fulfilled:

1. It is erected in areas where there is no likelihod of snow or;
2. It is operated at a time of the year, where there likelihood of snow can be discounted or;
3. Pre-planned operation actions prevent snow from setting on the tent.

The last condition may be achieved by:

1. Having sufficient heating equipment installed and ready to use and;
2. heating is started prior to snow fall and;
3. the tent is heated in such a way that the whole roof cladding has an outside air temperature of more than 2° C and;
4. cladding is made and tensioned in such a way that ponding of the water of any other deformations of the cladding cannot take place.

2.4 Equivalent load

The tent can not be verified with equivalent load, see [7].

Instead, the tent is calculated for a utility load equivalent of 25 kg suspended from three points in the roof.

3 Calculation assumptions

3.1 Static model and geometry

The tent is made of frames in aluminium, see Figure 3.1. All loads are transfered from the frame to ground. The frame corners, named knee and the top section are assembled with steel profiles, like the foot fittings which are made of tubes with a base plate. Between the frames are tension-/compression bars in the knee, top and ground sections. In the gables vertical aluminium profiles are mounted between the ground and the gable frame. The space between each frame is 3m.

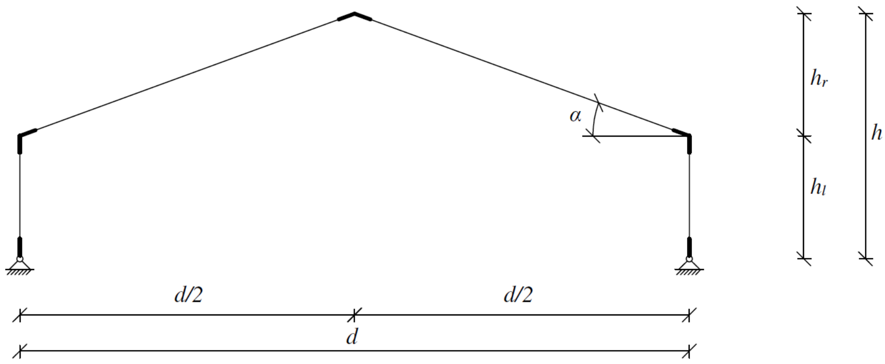


Figure 3.1. Schematic drawing of the frame.

Table 3.1. Frame geometry.

Dimension	Value
Roof height, h_r	2.18 m
Frame leg height, h_l	2.2 m
Total height, h	4.38 m
Width, d	12 m
Pitch angle, α	20 °

3.2 Stability

Loads are transfered to the ground by the frame effect.

3.3 Joints

Joints between the steel and aluminium profiles are executed with bolts. See verification in Annex C and drawing in Annex D.

3.4 Material parameters and cross section constants

In Annex B the material parameters and the cross section data for the members used in the tent are given.

3.5 Software

- Microsoft office
- AutoDesk AutoCad
- GT Strudl

4 Load

In the following section the considered load classes are described. The different load types and combinations are given in Annex B. The tent is calculated for normal consequence class. The space between two frames is 3m. A load area of 3m perperdicular to the gable is used in the calculation.

The tent construction may according to [1] be certified after load class.

In Table 4.1 the peak evacuation velocity, the seasonal factor and safety factor for the 5 load classes are given. The bottom describes what the calculation of the peak velocity is based on. Load class 1 covers normal consequence class for permanent structures.

Table 4.1. Load classes and factors. The peak evacuation velocity is based on Terrain Category II in Eurocode and 10 m reference height.

	1. All year	**2.** May-Sept.	**3.** Strong gale	**4.** Fresh gale	**5.** High wind
Peak evacuation velocity, v_{peak}[m/s]	-	-	20.8	17.2	13.9
Season factor, c^2_{season}[-]	1.0	0.8	1.0	1.0	1.0
Safety factor, γ_F[-]	1.5	1.5	1.2	1.2	1.2
Peak velocity pressure, q_p based on	50 year event	50 year event	$v_{\text{p,evac}}$	$v_{\text{p,evac}}$	$v_{\text{p,evac}}$
Frequency of evacuation	-	-	Several times every year	Several times every year	Several times every year

If the load classes 3-5 are applied wind monitoring of wind conditions by means of a weather forecast and/or an anemometer is necessary. Monitoring is combined with a evacuation plan.

If the weather forecast predicts an excess of the allowable wind velocity, an evacuation of the tent must be performed along with constructive action in order to ensure that the tent is not a danger to its surroundings.

Exampled of constructive initiatives:

- Reduced wind load: opening of the tent sites.
- Adding guy lines.
- Adding extra anchor rods.
- Adding wind bracings in roof and sides.

In accordance with the above mentioned points it should be specified who is responsible for monitoring, evacuation and constructive action.

In Section 7 the compliance of the five load cases for terrain category I-IV. For each class the anchorage of the tent is specified.

5 FEM calculations

The prerequisites and results of the finite element calculation are given in Annex B.

6 Verification

The prerequisites and verification of the load capacity are given in Annex B and C, respectively.

7 Certification

The conclusion of the certification of the tent can be based on the verification of the load capacity:

$$R_d > E_d \tag{7.1}$$

where R_d is the design load capacity and E_d is the design load action including the wind load

In Table 7.1 the compliance of the load capacity for the tent is shown for the five load classes and the four terrain categories. The colours describe if the design load capacity is adequate. A green colour represent a situation where the $R_d > E_d$. The value written within a green cell represent the maximum wind velocity that can be carried by the tent in the given terrain category and load class (corresponding mean wind velocity is written in brackets).

Table 7.1. Certification of tent. Maximum allowable wind velocity is written within green cells where evacuation is necesarry.

Terrain category	**1.** All year	**2.** May-Sept.	**3.** Strong gale	**4.** Fresh gale	**5.** High wind
I	-	-	-	-	13.9 m/s (9.1 m/s)
II	-	-	-	-	13.9 m/s (9.1 m/s)
III	-	-	-	17.2 m/s (11.3 m/s)	13.9 m/s (9.1 m/s)
IV	-	-	-	17.2 m/s (11.3 m/s)	13.9 m/s (9.1 m/s)

Table 7.2 gives the required anchorage for the columns. Additional tent calculations for tent lengths up to 30 m (the limit without wind bracings) has shown load capacities similar or lower than ones tabulated below, i.e. tabulated anchorage requirement values at central frames are independent of the number of frames.

If anchorage is chosen, Table 7.2 shows the required capacity of the anchor rod at the frame legs. An effective anchor length of $l_0 = 80\,\text{cm}$ with a minimum diameter of $d_{\text{min}} = 2.5\,\text{cm}$ is assumed, see e.g. Annex C

In Table 7.3 the minimum load capacity for wind braces are given.

For tents longer than 30 m, wind bracings at the roof and facades are installed for at least every 30 m. The anchorage at frame legs with wind braces should be enhanced.

Table 7.2. Minimum achorage of the tent according to the load classes in Table 7.1. F is the total force [kg], α is the angle of acting force to vertical and n is the number of required anchors.

Load class	Terrain category	Frame columns			Gable columns		
		F [kg]	α [°]	n [-]	F [kg]	α [°]	n [-]
1	I	-	-	-	-	-	-
	II	-	-	-	-	-	-
	III	-	-	-	-	-	-
	IV	-	-	-	-	-	-
2	I	-	-	-	-	-	-
	II	-	-	-	-	-	-
	III	-	-	-	-	-	-
	IV	-	-	-	-	-	-
3	I	-	-	-	-	-	-
	II	-	-	-	-	-	-
	III	-	-	-	-	-	-
	IV	-	-	-	-	-	-
4	I	-	-	-	-	-	-
	II	-	-	-	-	-	-
	III	121	30	1	139	17	1
	IV	110	31	1	125	17	1
5	I	146	30	1	166	16	1
	II	114	31	1	130	17	1
	III	72	33	1	82	18	1
	IV	65	34	1	73	19	1

Table 7.3. Minimum load capacity for the wires in wind bracings according to the load classes in Table 7.1.

Load class	Wind bracing, F_{Rk} [kg]
1	-
	-
	-
	-
2	-
	-
	-
	-
3	-
	-
	-
	-
4	-
	-
	158
	145
5	185
	149
	103
	95

8 References

[1]. ”Vejledning om certificeringsordning og byggesagsbehandling af transportable telte og konstruktioner - Annex A: vindlast påteltkonstruktioner”, marts 2015.

[2]. DS/EN 1991-1-1: Eurocode 1: Actions on structures - Part 1-1: General actions - Densities, self-weight, imposed loads for buidlings + NA.

[3]. DS/EN 1991-1-4: Eurocode 1: Actions on structures - Part 1-4: General actions - Wind actions + NA.

[4]. DS/EN 1993-1-1: Eurocode 3: Design of steel structures - Part 1-1: General rules and rules for buidlings + DK NA:2007.

[5]. DS/EN 1993-1-4: Eurocode 3: Design of steel structures - Part 1-8: Design of joints.

[6]. DS/EN 1999-1-1: Eurocode 9: Design of aluminium structures - Part 1-1: General structural rules + DK NA:2007.

[7]. EN 13782: Temporary structure - Tents - Safety + DK NA:2014.

ANNEX A
Climatic load - wind

Kibæk presenning tent book – without guy lines
Static calculations of 12 m tent

Content in Annex A

Static model and geometry	p. A2
Characteristic peak wind velocity pressure	p. A3
Pressure coefficients	p. A8
Wind load	p. A12

A.1 Static model and geometry

The tent is made up of 2-charnier frame in aluminium, see Figure A. 1.1. All loads transferred from the frame to the ground. The frame corners, named knee and top section, are assembled with square steel profiles, like the foot fittings which are made of square tube with a base plate. Between the frames are tension/compression bars in the knees and ridge. In the gables vertical aluminium profiles are mounted between the ground and the gable frame. The space between each frame is 3 m.

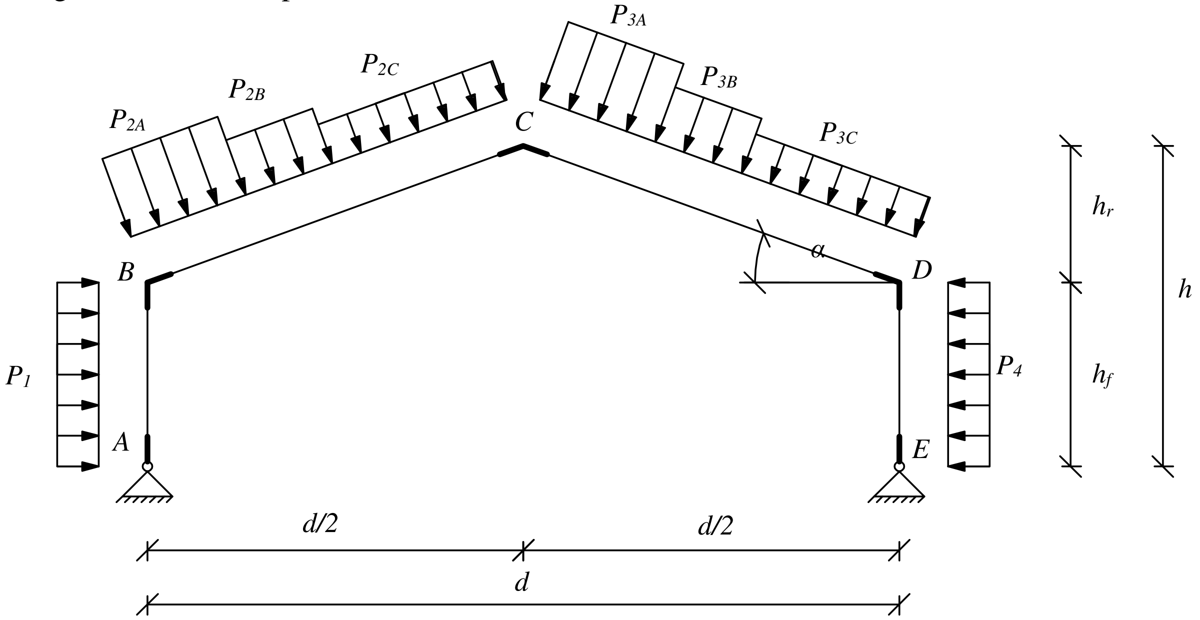


Figure A. 1.1. Frame with wind load.

In Table A. 1.1 the geometry is given.

Table A. 1.1. Frame geometry.

Roof height, h_r	2.18 m
Facade height, h_f	2.20 m
Total height, h	4.38 m
Depth, d	12.0 m
Pitch angle, α	20 °

In the following sections the peak velocity pressure and the pressure coefficient for the wind load are determined.

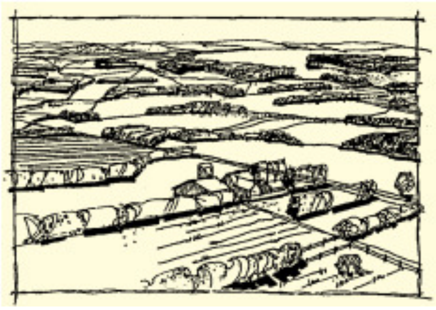
A.2 Characteristic peak wind velocity pressure

Terrain category I

Height above ground level	z, [m]	4.38
Directional factor	c_{dir}	1
Orography factor	c_o	1
Probability factor	c_{prop}	1.0
Terrain category		I
Minimum height	z_{min}, [m]	1
Roughness length	z_0, [m]	0.01
Terrain factor	k_r	0.170
Roughness factor	c_r	1.033
Turbulence intensity	I_v	0.164

Load class		**1.**	**2.**	**3.**	**4.**	**5.**
Fundamental value of the basic wind velocity	$v_{b,0}$, [m/s]	24.0	24.0	13.56	11.21	9.06
Season factor	c^2_{season}	1.00	0.80	1.00	1.00	1.00
Basic wind velocity	v_b, [m/s]	24.0	21.5	13.6	11.2	9.1
Mean wind velocity	v_m, [m/s]	24.8	22.2	14.0	11.6	9.4
Peak velocity pressure	q_p, [kN/m^2]	**0.826**	**0.661**	**0.264**	**0.180**	**0.118**

Terrain category II



Height above ground level	z, [m]	4.38
Directional factor	c_{dir}	1
Orography factor	c_o	1
Probability factor	c_{prop}	1.0
Terrain category		II
Minimum height	z_{min}, [m]	2
Roughness length	z_0, [m]	0.05
Terrain factor	k_r	0.190
Roughness factor	c_r	0.850
Turbulence intensity	I_v	0.224

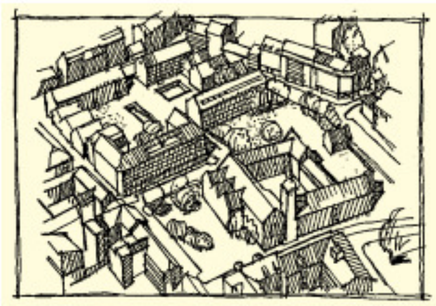
Load class		**1.**	**2.**	**3.**	**4.**	**5.**
Fundamental value of the basic wind velocity	$v_{b,0}$, [m/s]	24.0	24.0	13.56	11.21	9.06
Season factor	c^2_{season}	1.00	0.80	1.00	1.00	1.00
Basic wind velocity	v_b, [m/s]	24.0	21.5	13.6	11.2	9.1
Mean wind velocity	v_m, [m/s]	20.4	18.2	11.5	9.5	7.7
Peak velocity pressure	q_p,[kN/m^2]	**0.667**	**0.534**	**0.213**	**0.146**	**0.095**

Terrain category III

Height above ground level	z, [m]	4.38
Directional factor	c_{dir}	1
Orography factor	c_o	1
Probability factor	c_{prop}	1.0
Terrain category		III
Minimum height	z_{min}, [m]	5
Roughness length	z_0, [m]	0.3
Terrain factor	k_r	0.215
Roughness factor	c_r	0.606
Turbulence intensity	I_v	0.355

Load class		**1.**	**2.**	**3.**	**4.**	**5.**
Fundamental value of the basic wind velocity	$v_{b,0}$, [m/s]	24.0	24.0	13.56	11.21	9.06
Season factor	c^2_{season}	1.00	0.80	1.00	1.00	1.00
Basic wind velocity	v_b, [m/s]	24.0	21.5	13.6	11.2	9.1
Mean wind velocity	v_m, [m/s]	14.5	13.0	8.2	6.8	5.5
Peak velocity pressure	q_p, **[kN/m^2]**	**0.461**	**0.369**	**0.147**	**0.101**	**0.066**

Terrain category IV



Height above ground level	z, [m]	4.38				
Directional factor	c_{dir}	1				
Orography factor	c_o	1				
Probability factor	c_{prop}	1.0				
Terrain category		IV				
Minimum height	z_{min}, [m]	10				
Roughness length	z_0, [m]	1				
Terrain factor	k_r	0.234				
Roughness factor	c_r	0.540				
Turbulence intensity	I_v	0.434				
Load class		**1.**	**2.**	**3.**	**4.**	**5.**
Fundamental value of the basic wind velocity	$v_{b,0}$, [m/s]	24.0	24.0	13.56	11.21	9.06
Season factor	c^2_{season}	1.00	0.80	1.00	1.00	1.00
Basic wind velocity	v_b, [m/s]	24.0	21.5	13.6	11.2	9.1
Mean wind velocity	v_m, [m/s]	12.9	11.6	7.3	6.1	4.9
Peak velocity pressure	q_p, [kN/m^2]	**0.423**	**0.339**	**0.135**	**0.092**	**0.060**

The characteristic peak wind velocity is determined for 4 different terrain categories and the 5 load classes specified in the tent book, see Table A. 2.1.

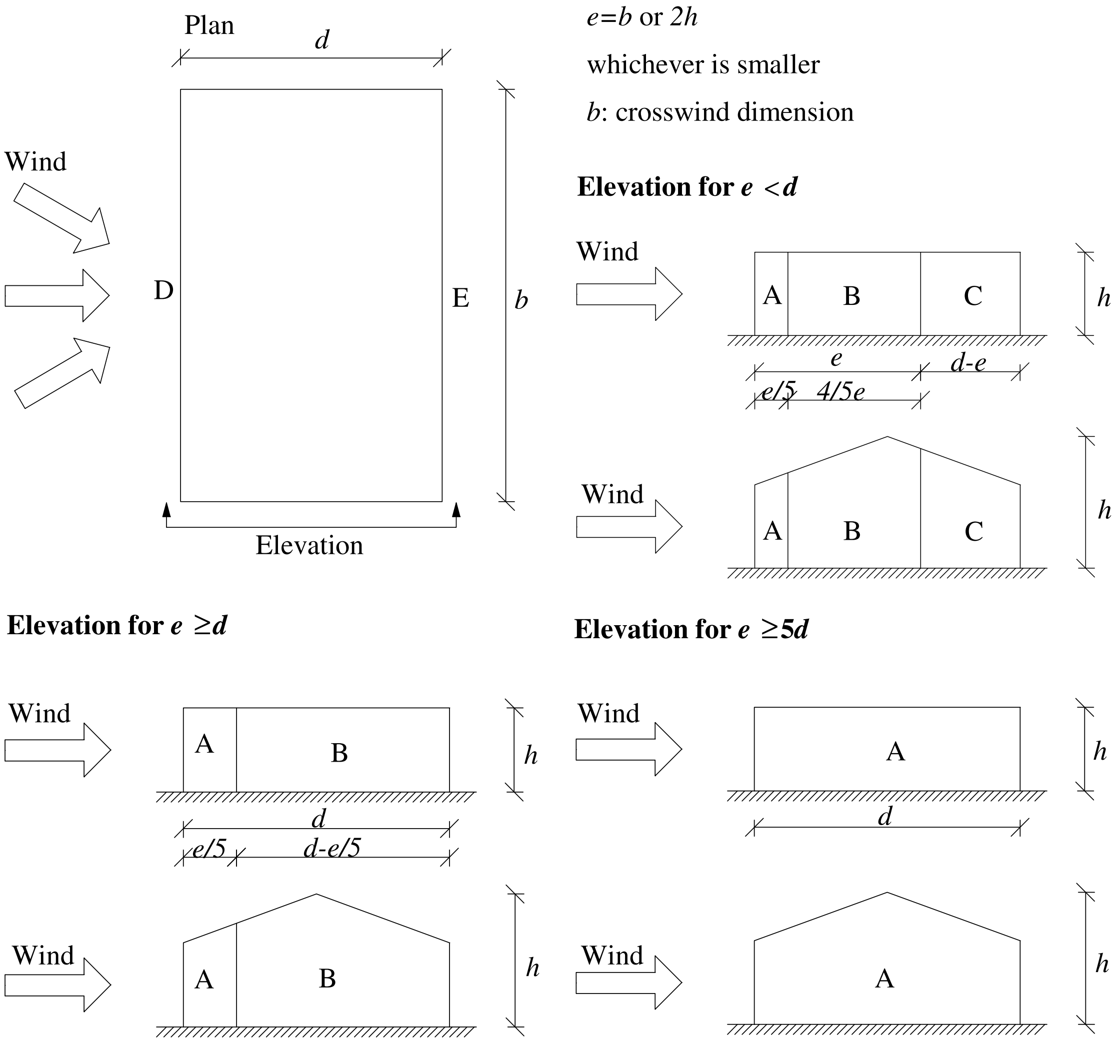
Table A. 2.1. Characteristic peak wind velocity pressure, q_p [kN/m^2].

Terrain Category	No evacuation		Evacuation necessary		
	1. All year	**2.** May-Sept.	**3.** Strong gale	**4.** Fresh gale	**5.** High wind
I	0.826	0.661	0.264	0.180	0.118
II	0.667	0.534	0.213	0.146	0.095
III	0.461	0.369	0.147	0.101	0.066
IV	0.423	0.339	0.135	0.092	0.060

A.3 Pressure coefficients

The pressure coefficients are based on a rectangular building shape.

A.3.1 Wind on facades



Wind parallel to the gable

Height, h = 4.38 m

Depth, d = 12 m

Width*, b = 3 m

e = 8.76 m (largest possible)

h/d = 0.365

* 3 m is the minimum width of the construction.

Zone	D	E
Extent of zones [m]	b	b
$c_{pe,10}$ [-]	0.72	-0.33

Wind perpendicular to the gable

Height, h = 4.38 m

Depth*, d = 3 m

Width*, b = 12 m

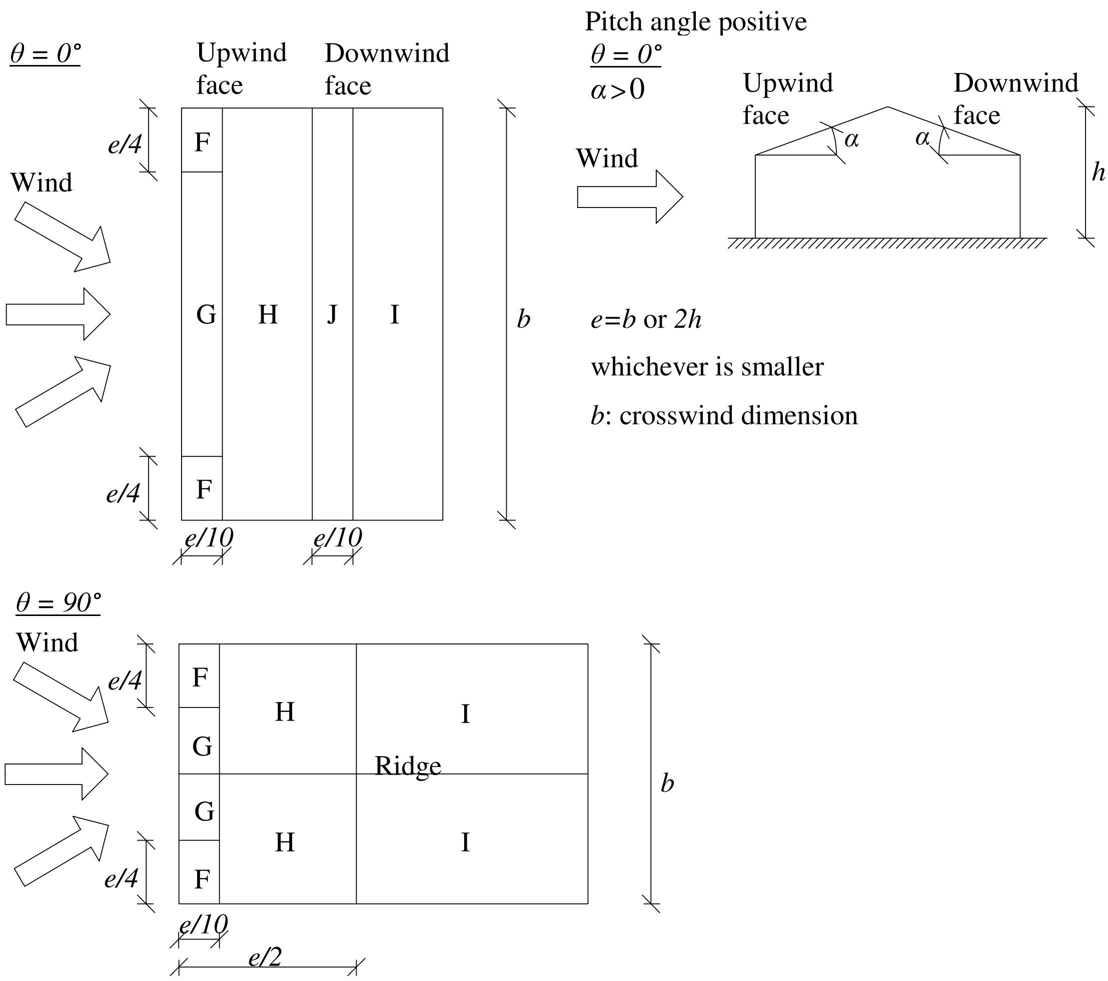
e = 8.76 m

h/d = 0.365

* 3 m is the minimum depth of the construction.

Zone	A	B
Extent of zones [m]	1.75	d-1.75
$c_{pe,10}$ [-]	-1.20	-0.80

A.3.2 Wind on roof



Wind parallel to the gable, $\theta = 0°$

Height, $h = 4.38$ m

Depth, $d = 12$ m

Width*, $b = 3$ m

$e = 8.76$ m (largest possible)

Pitch angle, $\alpha = 20°$

* 3 m is the minimum width of the construction

Zone	F	G	H	I	J
Extent of zones, perpendicular to the wind [m]	2.19	b-4.38	b	b	b
Extent of zones, parallel to the wind [m]	0.88	0.88	5.12	0.88	5.12
Min. $c_{pe,10}$ [-]	-0.77	-0.70	-0.27	-0.40	-0.83
Max. $c_{pe,10}$ [-]	0.37	0.37	0.27	0.00	0.00

The pressure changes rapidly between positive and negative values on the windward face around a pitch angle of α= -5° to 45°, so both positive and negative values are given.

Wind perpendicular to the gable $\theta = 90°$

Height, $h = 4.38$ m

Depth*, $d = 3$ m

Width, $b = 12$ m

$e = 8.76$ m

Pitch angle, $\alpha = 20°$

* 3 m is the minimum depth of the construction

Zone	F	G	H	I
Extent of zones, perpendicular to the wind [m]	2.19	3.81	6	6
Extent of zones, parallel to the wind [m]	0.88	0.88	3.50	d-4.38
$c_{pe,10}$ [-]	-1.23	-1.33	-0.67	-0.50

A.4 Wind load

For roofs with $\theta = 0°$ four cases should be considered where the largest or smallest values of all areas F, G and H are combined with the largest or smallest values in areas I and J. No mixing of positive and negative values is allowed on the same face. In Table A. 4.1 external pressure coefficients for load combinations for wind parallel and perpendicular to the gable are given. c_1 corresponds to P_1 in Figure A. 1.1 and so on.

Table A. 4.1. Load combinations. Pressure coefficient $c_{pe,10}$ [-].

Load combination	No.	c_1	c_{2A}	c_{2B}	c_{2C}	c_{3A}	c_{3B}	c_{3C}	c_4
Wind parallel to the gable	all*	0.72	-0.70	-0.27	-0.27	-0.83	-0.40	-0.40	-0.35
	all*	0.72	-0.70	-0.27	-0.27	0.00	0.00	0.00	-0.35
	all	0.72	0.37	0.27	0.27	-0.83	-0.40	-0.40	-0.35
	all	0.72	0.37	0.27	0.27	0.00	0.00	0.00	-0.35
Wind perpendicular to the gable	1st	-1.20	-1.23	-1.23	-1.33	-1.33	-1.23	-1.23	-1.20
	2nd	-0.80	-0.67	-0.67	-0.67	-0.67	-0.67	-0.67	-0.80
	3rd to end	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50

*In wind parallel to the gable, zone c_{2A}, the lower pressure coefficient for the first and last frame is decreased from -0.70 to -0.77 as these are in wind zone F.

Internal wind load should be taken as the more onerous of c_{pi} = 0.2 and -0.3, when there is no dominant openings in the construction. 0.2 corresponds to internal overpressure and 0.3 to internal underpressure/suction. For tent constructions where openings mainly will be in areas with external suction and when the openings are not dominant, as for the present tent, the internal wind load can be taken as the more onerous of c_{pi} = +0.0 and -0.3.

The structural factor $c_s c_d$ =0.8 is used.

The characteristic load on the frame is found by multiplying the pressure coefficients in Table A. 4.1 combined with the internal pressure coefficient and the structural factor with the chosen peak velocity pressure given in section A.2.

ANNEX B

Kibæk tent book - 12 m
Without guy lines

GTStrudl documentation

Contents of Annex B

B.1 GT Strudl calculaion B2
B.2 Model B2
B.3 Load B6

B.1 GT Strudl calculaion

This Annex gives the background for the FE-model which include geometrical dimensions, material properties, loads and the numbering of nodes and elements. Finally, the main results are shown.

B.2 Model

In this section the background of the FE-model is described including geometrical dimensions, material properties and the numbering of nodes and elements.

The tent is modelled as 6 frames with pressure bars in the roof and ground between each frame. The gable consists of 3 gable columns and pressure bars at ground level. Figure B.1 shows the 3D FE-model which consists of 108 nodes and 143 elements.

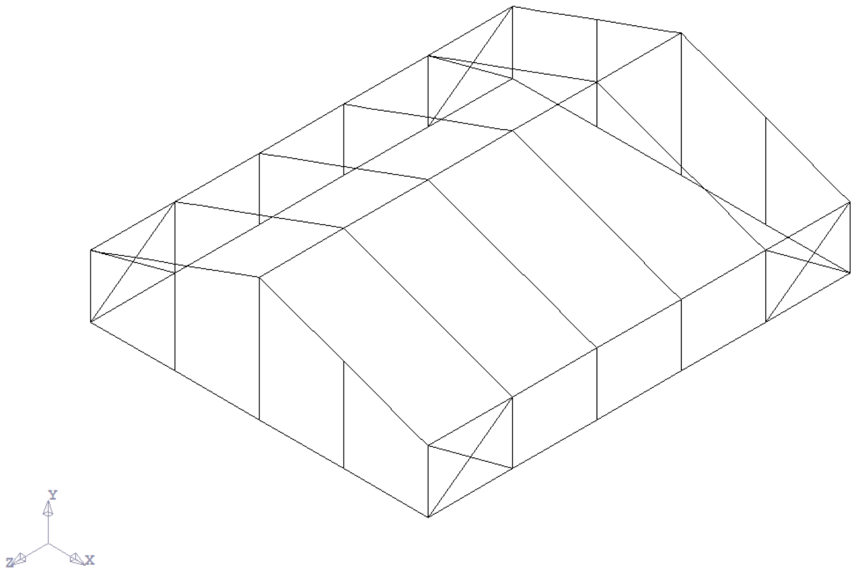


Figure B.1. 3D FE-model..

B.2.1 Nodes

Figure B.2 shows a gable section view along with the 20 nodes used to discretize the frame structure while Table B.1 gives the corresponding coordinates of each node. The first frame will have prefix 100, the second prefix 200 etc.

Table B.1. List of node numbers and corresponding coordinates.

Node Number	x [m]	y [m]	z [m]
101	-6.00	0.00	0.00
102	-6.00	1.81	0.00
103	-6.00	2.20	0.00
104	-5.58	2.35	0.00
105	-5.12	2.52	0.00
106	-3.81	3.00	0.00
107	-3.00	3.29	0.00
108	-0.35	4.26	0.00
109	0.00	4.38	0.00
110	0.35	4.26	0.00
111	0.88	4.06	0.00
112	3.00	3.29	0.00
113	3.81	3.00	0.00
114	5.58	2.35	0.00
115	6.00	2.20	0.00
116	6.00	1.81	0.00
117	6.00	0.00	0.00
118	-3.00	0.00	0.00
119	0.00	0.00	0.00
120	3.00	0.00	0.00

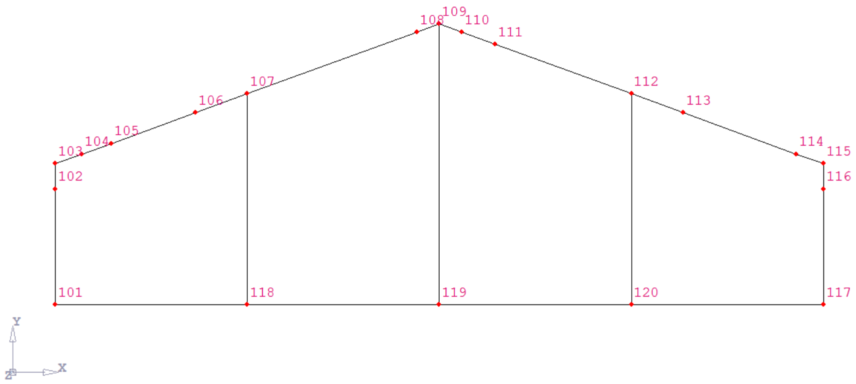


Figure B.2. Gable view of model with node numbers.

B.2.2 Elements

Figure B.3 shows a gable section view along with the 19 elements. The first frame will have prefix 100, the second prefix 200 etc.

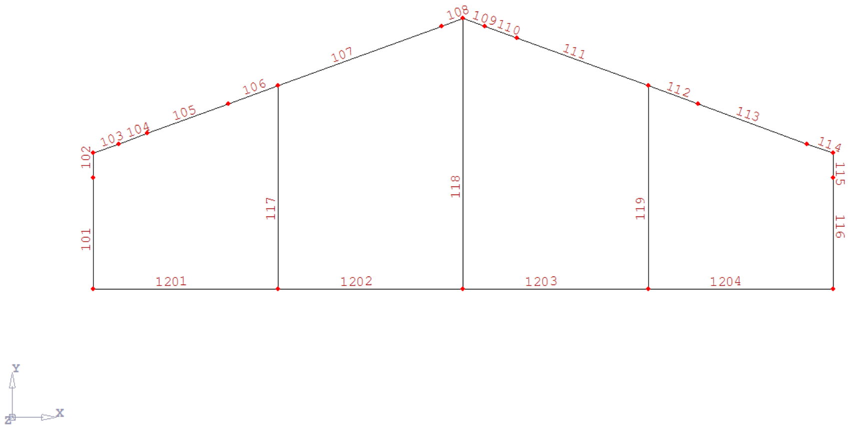


Figure B.3. Gable view of model with element numbers.

Figure B.4 shows a top view of the structure along with 15 pressure bar elements.

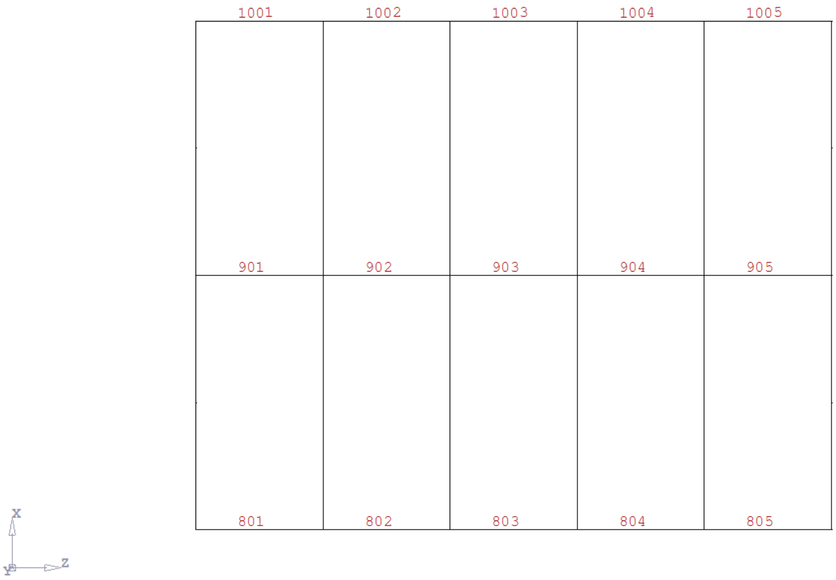


Figure B.4. Top view of model with element numbers.

B.2.3 Boundary conditions

The supports at frame feets with node number 1 and 17 and at the gable column foot are modelled as simple supports.Pressurebars are hinged around local y-axes in one end, i.e. they are allowed to rotate in one end in a plane parallel to the tent cladding. In practice, they are allowed to rotate to some extend in both ends, but as a compromise this is modelled as one end fixed and one end hinged.

Gable columns are hinged around local z-axes, i.e. they are allowed to rotate in the top nodes in a plane parallel to the tent cladding.

B.2.4 Data

In Tables B.2, B.3, B.4, B.5 the different element types and their locations, material parameters and cross section data are given. Plastic section modules are presented for steel profiles.

Table B.2. Element type and element numbers..

Subject	Element type	Element numbers
A	Gable profiles.	1/6-17,-18,-19
B	Frame aluminum profiles.	1/2/3/4/5/6-01,-04,-05,-06,-07,-10,-11,-12,-13,-16
C	Wind braces.	13-01,-02,-03,-04,-05-,06-,07,-08
D	Pressure bars.	7/8/9/10/11-01,-02,-03. 10-01,-02,-03,-04,-05,-06.
		12-01,-02,-03,-04,-05,-06,-07,-08.
E	Frame knee section.	1/2/3/4/5/6-02,-03,-14,-15.
F	Frame top section.	1/2/3/4/5/6-08,-09.

Table B.3. Profile material and cross sectional dimensions (units in [mm]).

Subject	Profile	Material	A [mm^2]	I_y [mm^4]	I_z [mm^4]	I_x [mm^4]
A	2-track (314735)	Aluminium	660	562664	219613	552960
B	4-track (327795)	Aluminium	836	264309	997337	680332
C	6 mm steel wire	Steel	24	-	-	-
D	RHS 30x20x2.0mm	Steel	184	11125	21565	28800
E	RHS 60x40x5.0mm - Knee	Steel	900	207500	407500	576000
F	RHS 60x40x5.0mm - Ridge	Steel	900	207500	407500	576000

Table B.4. Cross sectional dimensions continued..

Subject	W_y [mm^3]	W_z [mm^3]	S_y [mm^3]	S_z [mm^3]
A	12447	9151	5990	8448
B	11013	21402	10580	6751
C	-	-	-	-
D	1336	1796	1050	800
E	12750	17250	10500	8000
F	12750	17250	10500	8000

Table B.5. Strength properties (units in [MPa]).

Subject	Yield, f_y	Youngs Modulus, E
A	215	72000
B	215	72000
C	-	210000
D	235	210000
E	355	210000
F	355	210000

B.3 Load

In the following section the different load types and load combinations are described.

The 9 single load cases are summarized in Table B.6 and illustrated in Figure B.5 to Figure B.13. No values is shown on the plot as eg. wind load cases depends on terrain category and load class.

Table B.6. Single load cases.

Single Load Case	Description	Short-hand notation
1	Self weight - Frame	g_F
2	Self weight - Canvas	g_C
3	External wind load 1	$w_{E,1}$
4	External wind load 2	$w_{E,2}$
5	External wind load 3	$w_{E,3}$
6	External wind load 4	$w_{E,4}$
7	External wind load 5	$w_{E,5}$
8	External wind load - Under pressure	$w_{I,1}$
9	Point load - imposed loads	F_{3P}

B.3.1 Dead load

Canvas self weight for a load area of 3 m:

$$g = 3\text{m} \cdot 0.7\text{kg/m}^2 \cdot 9.82\text{m/s}^2 = 21\text{N/m} \tag{B.1}$$

Self weight of the frame is automatically included in the calculation in GT Strudl, see load case 1.

B.3.2 Imposed load

The stability of the structure is secured by an imposed load equivalent to 25 kg suspended from three points in frame roof. The tent stability is not verified with equivalent load, see [7].

B.3.3 Snow load

The tent must not be subjected to snow load.

B.3.4 Wind load

The global design wind load $F_{w,d}$ acting on a structure may be determined by:

$$F_{w,d} = \gamma_F \cdot q_p \cdot c_f \cdot c_s c_d \cdot A_{ref} \tag{B.2}$$

where

- γ_F is the load safety factor, see Table B.8
- q_p is the peak velocity pressure for the given terrain category and wind event, see Table A.2.1 in Annex A.
- c_f is the force coefficient, see Figure A.1.1 and Section A.4 in Annex A and (B.3).
- $c_s c_d = 0.8$ is the structural factor, see Section A.4 in Annex A.
- $A_{ref} = 3\,\text{m}$. is the reference area taken as the frame distance.

The force coefficient c_f is determined by:

$$c_f = c_{pe,10} - c_{pi} \tag{B.3}$$

where $c_{pe,10}$ is the pressure coefficient for the external pressure for loaded area of $10\ \text{m}^2$ and c_{pi} is the pressure coefficient for the internal pressure.

The prerequisites and calculation of the wind load are given in Annex A.

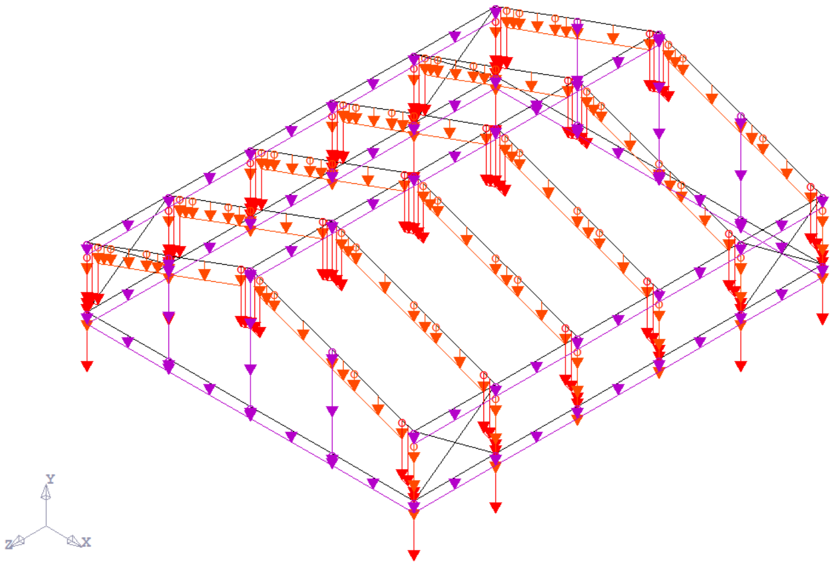


Figure B.5. Single load case 1 (Self weight - Frame)..

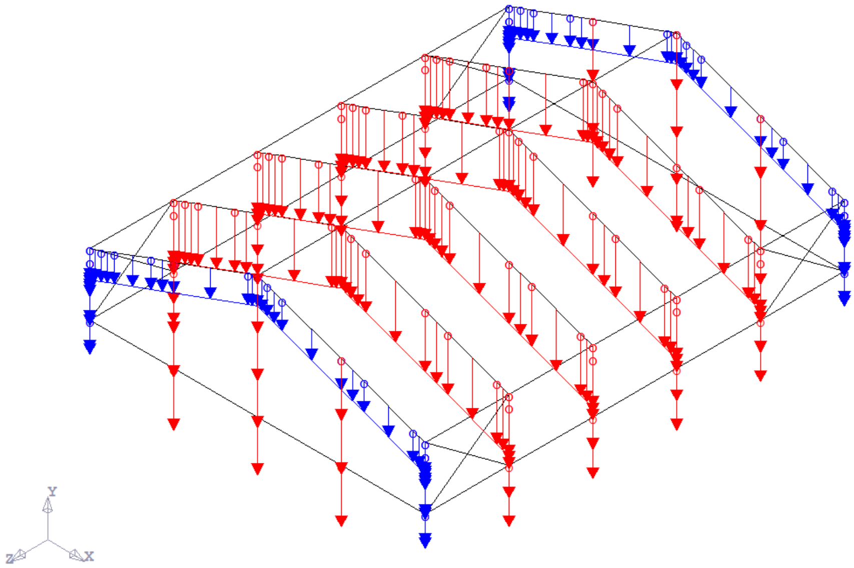


Figure B.6. Single load case 2 (Self weight - Canvas)..

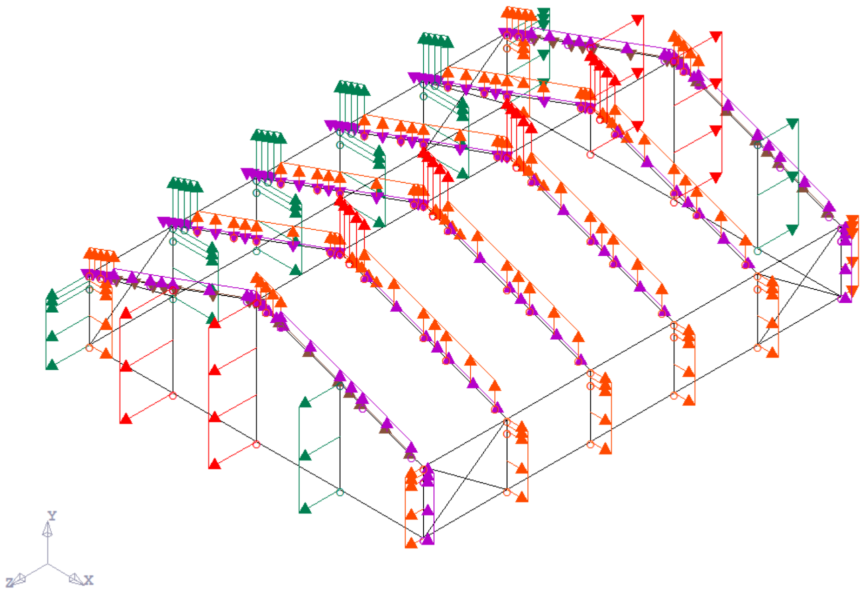


Figure B.7. Single load case 3 (External wind load 1)..

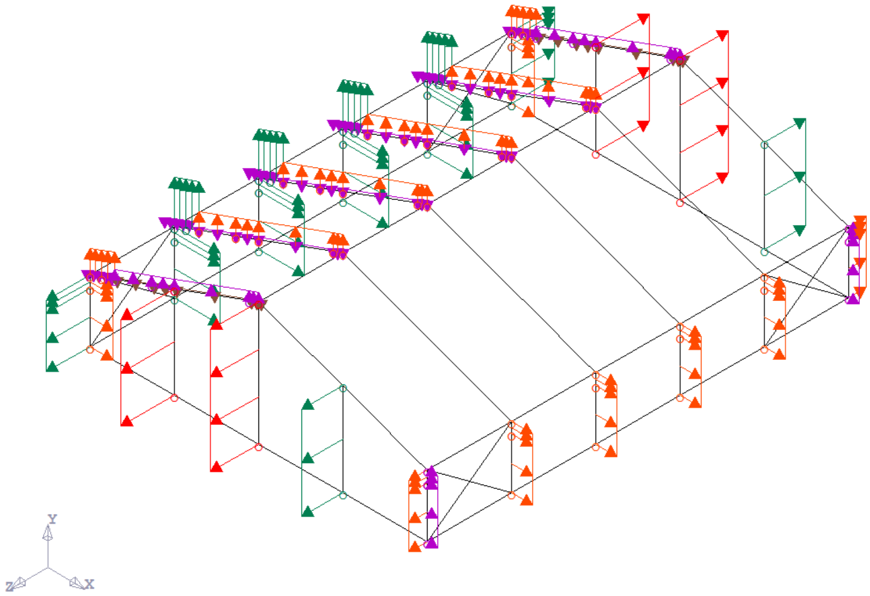


Figure B.8. Single load case 4 (External wind load 2)..

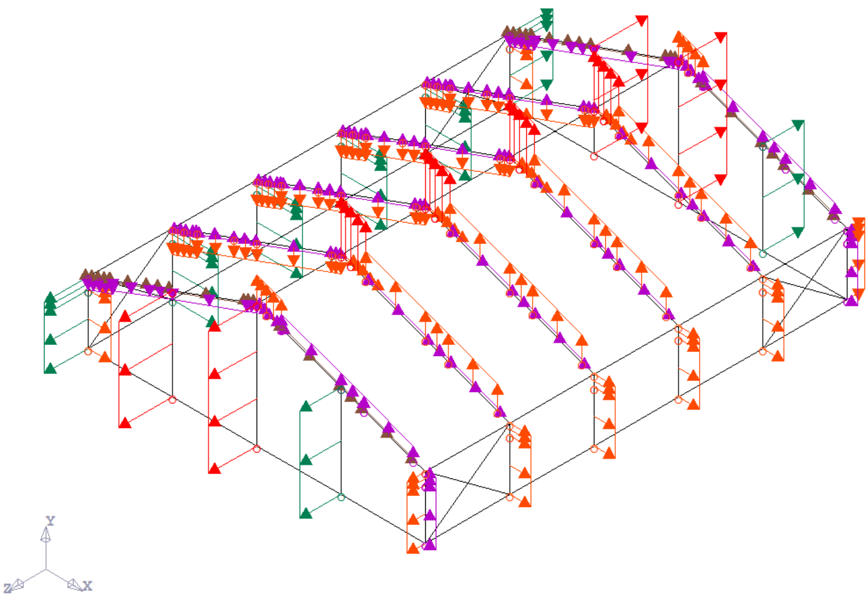


Figure B.9. Single load case 5 (External wind load 3)..

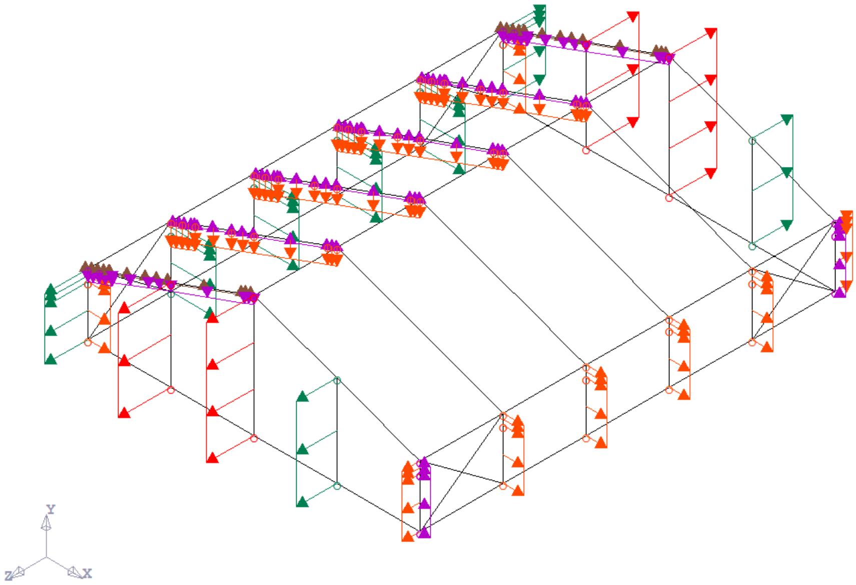


Figure B.10. Single load case 6 (External wind load 4)..

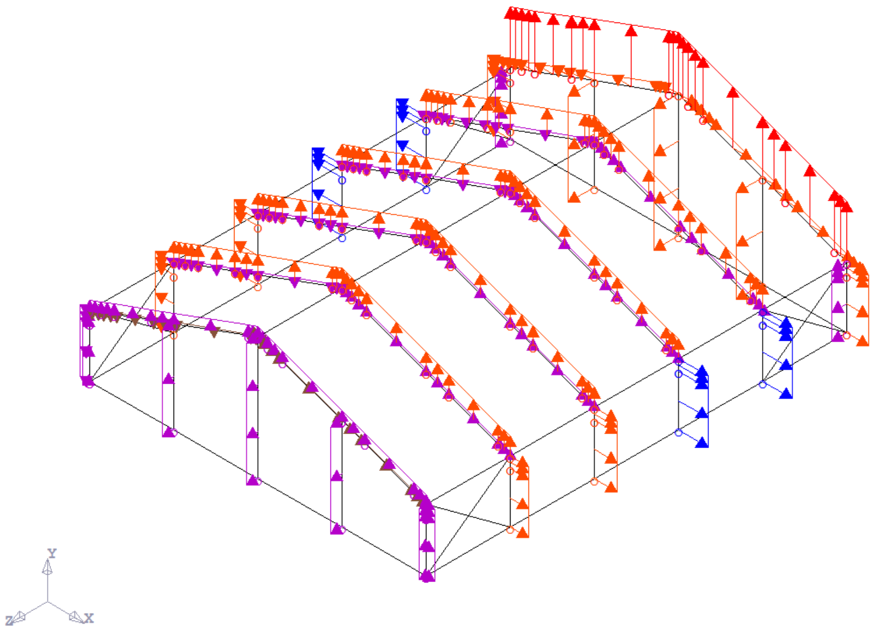


Figure B.11. Single load case 7 (External wind load 5)..

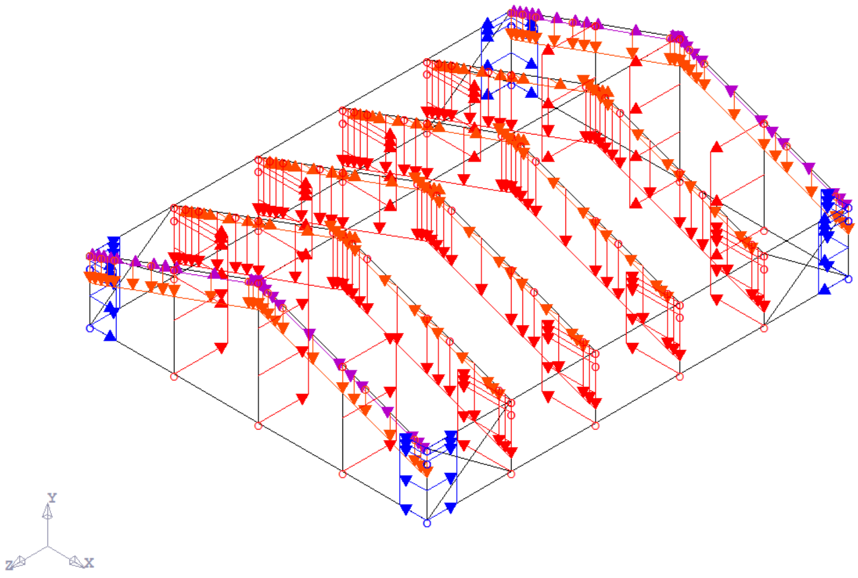


Figure B.12. Single load case 8 (External wind load - Under pressure)..

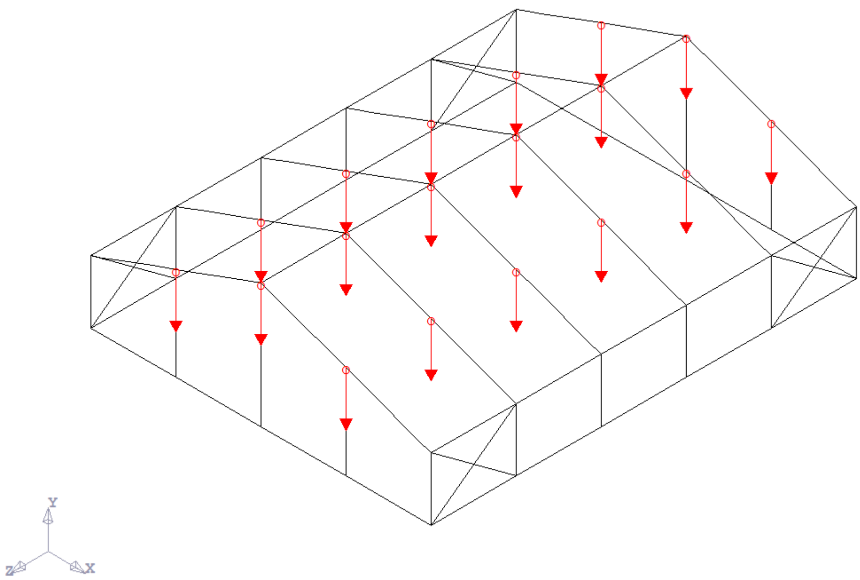


Figure B.13. Single load case 9 (Point load - imposed loads)..

B.3.5 Combinations

Table B.7 gives the combinations of the 9 single load cases. The corresponding safety factors, γ_F, are given in Table B.8 and $c_s c_d = 0.8$ is used. The load values are given in the main report and in Annex A.

Table B.7. 21 combinations of load cases (see Table B.8 for safety factors).

Name	Combination
LC1	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00$
LC2	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + w_{E,1} \cdot c_s c_d \cdot \gamma_F$
LC3	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + w_{E,2} \cdot c_s c_d \cdot \gamma_F$
LC4	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + w_{E,3} \cdot c_s c_d \cdot \gamma_F$
LC5	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + w_{E,4} \cdot c_s c_d \cdot \gamma_F$
LC6	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + w_{E,5} \cdot c_s c_d \cdot \gamma_F$
LC7	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + (w_{E,1} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC8	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + (w_{E,2} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC9	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + (w_{E,3} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC10	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + (w_{E,4} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC11	$(g_F + g_C + g_P + F_{3P}) \cdot 1.00 + (w_{E,5} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC12	$(g_F + g_C + g_P) \cdot 0.90 + w_{E,1} \cdot c_s c_d \cdot \gamma_F$
LC13	$(g_F + g_C + g_P) \cdot 0.90 + w_{E,2} \cdot c_s c_d \cdot \gamma_F$
LC14	$(g_F + g_C + g_P) \cdot 0.90 + w_{E,3} \cdot c_s c_d \cdot \gamma_F$
LC15	$(g_F + g_C + g_P) \cdot 0.90 + w_{E,4} \cdot c_s c_d \cdot \gamma_F$
LC16	$(g_F + g_C + g_P) \cdot 0.90 + w_{E,5} \cdot c_s c_d \cdot \gamma_F$
LC17	$(g_F + g_C + g_P) \cdot 0.90 + (w_{E,1} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC18	$(g_F + g_C + g_P) \cdot 0.90 + (w_{E,2} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC19	$(g_F + g_C + g_P) \cdot 0.90 + (w_{E,3} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC20	$(g_F + g_C + g_P) \cdot 0.90 + (w_{E,4} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$
LC21	$(g_F + g_C + g_P) \cdot 0.90 + (w_{E,5} + w_{I,1}) \cdot c_s c_d \cdot \gamma_F$

Table B.8. Safety factor the five load classes.

Load Class	Safety factor
1. All year (No evacuation)	1.5
2. May-Sept. (No evacuation)	1.5
3. Strong gale (Evacuation neccesary)	1.2
4. Fresh gale (Evacuation neccesary)	1.2
5. High wind (Evacuation neccesary)	1.2

ANNEX C

Kibæk tent book - 12 m
Without guy lines

Verification overview and calculation example

Contents of Annex C

C.1 Basis C2
C.2 Cross sectional resistance C3
C.3 Buckling C13
C.4 Bolt connection between aluminum and steel profiles C14
C.5 Bracing requirement C15
C.6 Anchorage C16
C.7 Verification other load classes C18

C.1 Basis

In this annex the tent construction is verified for load class 5 and terrain category I. The result of the verification calculations for the other load classes, is given in section C.7. The verification is based upon [4,5,6].

The wind safety factor for load class 5 is $\gamma_F = 1.2$ and the peak velocity pressure is $q_p = 0.118\,\text{kN/m}^2$. A structural factor of $c_s c_d = 0.8$ is used.

The following geometry parameters is used throughout the Annex:

Distance between frames	d	3.00	m
Frame width	w	12.00	m
Roof height	h_r	2.18	m
Frame leg height	h_l	2.20	m
Total height	h_T	4.38	m

Strength and cross section properties of all members handled in this annex may be found in Annex B. Location factors between 0 and 1 are used throughout the report to indicate where a force/moment appears on the element. 0 and 1 refers to the start and the end of the element, respectively.

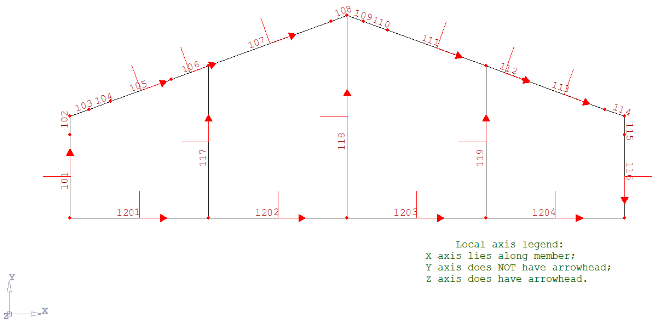


Figure C.1. Gable frame topology with element numbers and local loordinate systems..

C.2 Cross sectional resistance

C.2.1 2-track (314735) - Gable columns

Partial factor: $\gamma_{M0} = 1.2$

Normal force Load combination: 16, element: 117, location factor: 1.00

$N_{Ed} = 1.7$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} = 2.6\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179\,\text{MPa} \tag{C.1}$$

Moment around y-axis Load combination: 21, element: 118, location factor: 0.50

$M_{y,Ed} = 0.9$ kNm

$$\sigma_{Ed} = \frac{M_{y,Ed}}{W_y} = 69.1\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179.2\,\text{MPa} \tag{C.2}$$

Moment around z-axis Load combination: 19, element: 617, location factor: 0.00

$M_{z,Ed} = -0.1$ kNm

$$\sigma_{Ed} = \frac{M_{z,Ed}}{W_z} = 8.0\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179.2\,\text{MPa} \tag{C.3}$$

Combined moment and normal force Load combination: 21, element: 118, location factor: 0.50

$M_{y,Ed} = 0.9$ kNm

$M_{z,Ed} = 0.0$ kNm

$N_{Ed} = 0.6$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} + \frac{M_{z,Ed}}{W_z} + \frac{M_{y,Ed}}{W_y} = 70.0\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179.2\,\text{MPa} \tag{C.4}$$

Shear force in y-axis Load combination: 19, element: 617, location factor: 0.00

$V_{y,Ed} = -0.0$ kN

$$\tau_{Ed} = \frac{V_{y,Ed} S_z}{2 t_{\text{web}} I_z} = 0.1\,\text{MPa} < \tau_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}\sqrt{3}} = 103.4\,\text{MPa} \tag{C.5}$$

Shear force in z-axis Load combination: 21, element: 118, location factor: 0.00

$V_{z,Ed} = 0.7$ kN

$$\tau_{Ed} = \frac{V_{z,Ed} S_y}{2 t_{\text{flange}} I_y} = 2.3\,\text{MPa} < \tau_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}\sqrt{3}} = 103.4\,\text{MPa} \tag{C.6}$$

C.2.2 4-track (327795) - Frame columns

Partial factor: $\gamma_{M0} = 1.2$

Normal force Load combination: 10, element: 301, location factor: 0.00

$N_{Ed} = -1.8$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} = 2.1\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179\,\text{MPa} \tag{C.7}$$

Moment around y-axis Load combination: 21, element: 111, location factor: 1.00

$M_{y,Ed} = 0.5$ kNm

$$\sigma_{Ed} = \frac{M_{y,Ed}}{W_y} = 49.3\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179.2\,\text{MPa} \tag{C.8}$$

Moment around z-axis Load combination: 10, element: 413, location factor: 1.00

$M_{z,Ed} = -2.2$ kNm

$$\sigma_{Ed} = \frac{M_{z,Ed}}{W_z} = 105.1\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179.2\,\text{MPa} \tag{C.9}$$

Combined moment and normal force Load combination: 10, element: 413, location factor: 1.00

$M_{y,Ed} = -0.0$ kNm

$M_{z,Ed} = -2.2$ kNm

$N_{Ed} = -1.7$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} + \frac{M_{z,Ed}}{W_z} + \frac{M_{y,Ed}}{W_y} = 107.7\,\text{MPa} < \sigma_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}} = 179.2\,\text{MPa} \tag{C.10}$$

Shear force in y-axis Load combination: 10, element: 416, location factor: 1.00

$V_{y,Ed} = -1.2$ kN

$$\tau_{Ed} = \frac{V_{y,Ed} S_z}{2 t_{\text{web}} I_z} = 2.7\,\text{MPa} < \tau_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}\sqrt{3}} = 103.4\,\text{MPa} \tag{C.11}$$

Shear force in z-axis Load combination: 11, element: 101, location factor: 1.00

$V_{z,Ed} = -0.3$ kN

$$\tau_{Ed} = \frac{V_{z,Ed} S_y}{2 t_{\text{flange}} I_y} = 1.5\,\text{MPa} < \tau_{Rd} = \frac{f_{0.2}}{\gamma_{\text{M0}}\sqrt{3}} = 103.4\,\text{MPa} \tag{C.12}$$

C.2.3 RHS 30x20x2.0 mm

Partial factor: $\gamma_{M0} = 1.1$ Cross section class:

$$\frac{c}{t} = 13.0 \leq 33\varepsilon = 33.0$$

Cross section class 1

Normal force Load combination: 11, element: 901, location factor: 0.00

$N_{Ed} = -1.1$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} = 5.9\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 214\,\text{MPa} \tag{C.13}$$

Moment around y-axis Load combination: 21, element: 1001, location factor: 0.00

$M_{y,Ed} = -0.1$ kNm

$$\sigma_{Ed} = \frac{M_{y,Ed}}{W_y} = 111.4\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 213.6\,\text{MPa} \tag{C.14}$$

Moment around z-axis Load combination: 11, element: 905, location factor: 1.00

$M_{z,Ed} = -0.4$ kNm

$$\sigma_{Ed} = \frac{M_{z,Ed}}{W_z} = 212.4\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 213.6\,\text{MPa} \tag{C.15}$$

Combined moment and normal force Load combination: 11, element: 905, location factor: 1.00

$M_{y,Ed} = 0.0$ kNm

$M_{z,Ed} = -0.4$ kNm

$N_{Ed} = -0.2$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} + \frac{M_{z,Ed}}{W_z} + \frac{M_{y,Ed}}{W_y} = 213.6\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 213.6\,\text{MPa} \tag{C.16}$$

Shear force in y-axis Load combination: 11, element: 905, location factor: 1.00

$V_{y,Ed} = 0.2$ kN

$$\tau_{Ed} = \frac{V_{y,Ed} S_z}{2 t_{\text{web}} I_z} = 2.7\,\text{MPa} < \tau_{Rd} = \frac{f_y}{\gamma_{\text{M0}}\sqrt{3}} = 123.3\,\text{MPa} \tag{C.17}$$

Shear force in z-axis Load combination: 21, element: 1001, location factor: 0.00

$V_{z,Ed} = 0.0$ kN

$$\tau_{Ed} = \frac{V_{z,Ed} S_y}{2 t_{\text{flange}} I_y} = 0.9\,\text{MPa} < \tau_{Rd} = \frac{f_y}{\gamma_{\text{M0}}\sqrt{3}} = 123.3\,\text{MPa} \tag{C.18}$$

C.2.4 RHS 60x40x5.0 mm - Knee

Partial factor: $\gamma_{M0} = 1.1$ Cross section class:

$$\frac{c}{t} = 10.0 \leq 33\varepsilon = 26.8$$

Cross section class 1

Normal force Load combination: 10, element: 302, location factor: 0.00

$N_{Ed} = -1.7\,\text{kN}$

$$\sigma_{Ed} = \frac{N_{Ed}}{A} = 1.9\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 323\,\text{MPa} \tag{C.19}$$

Moment around y-axis Load combination: 21, element: 103, location factor: 0.00

$M_{y,Ed} = -0.4\,\text{kNm}$

$$\sigma_{Ed} = \frac{M_{y,Ed}}{W_y} = 30.7\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 322.7\,\text{MPa} \tag{C.20}$$

Moment around z-axis Load combination: 10, element: 415, location factor: 0.00

$M_{z,Ed} = -2.7\,\text{kNm}$

$$\sigma_{Ed} = \frac{M_{z,Ed}}{W_z} = 157.0\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 322.7\,\text{MPa} \tag{C.21}$$

Combined moment and normal force Load combination: 10, element: 414, location factor: 1.00

$M_{y,Ed} = -0.0\,\text{kNm}$

$M_{z,Ed} = -2.7\,\text{kNm}$

$N_{Ed} = -1.7\,\text{kN}$

$$\sigma_{Ed} = \frac{N_{Ed}}{A} + \frac{M_{z,Ed}}{W_z} + \frac{M_{y,Ed}}{W_y} = 159.4\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 322.7\,\text{MPa} \tag{C.22}$$

Shear force in y-axis Load combination: 10, element: 415, location factor: 1.00

$V_{y,Ed} = -1.2$ kN

$$\tau_{Ed} = \frac{V_{y,Ed} S_z}{2 t_{\text{web}} I_z} = 3.2\,\text{MPa} < \tau_{Rd} = \frac{f_y}{\gamma_{\text{M0}}\sqrt{3}} = 186.3\,\text{MPa} \tag{C.23}$$

Shear force in z-axis Load combination: 11, element: 102, location factor: 1.00

$V_{z,Ed} = -0.4$ kN

$$\tau_{Ed} = \frac{V_{z,Ed} S_y}{2 t_{\text{flange}} I_y} = 1.4\,\text{MPa} < \tau_{Rd} = \frac{f_y}{\gamma_{\text{M0}}\sqrt{3}} = 186.3\,\text{MPa} \tag{C.24}$$

C.2.5 RHS 60x40x5.0 mm - Ridge

Partial factor: $\gamma_{M0} = 1.1$ Cross section class:

$$\frac{c}{t} = 10.0 \leq 33\varepsilon = 26.8$$

Cross section class 1

Normal force Load combination: 10, element: 309, location factor: 1.00

$N_{Ed} = -1.5$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} = 1.7\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 323\,\text{MPa} \tag{C.25}$$

Moment around y-axis Load combination: 11, element: 509, location factor: 0.00

$M_{y,Ed} = 0.5$ kNm

$$\sigma_{Ed} = \frac{M_{y,Ed}}{W_y} = 40.1\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 322.7\,\text{MPa} \tag{C.26}$$

Moment around z-axis Load combination: 10, element: 408, location factor: 0.00

$M_{z,Ed} = 0.6$ kNm

$$\sigma_{Ed} = \frac{M_{z,Ed}}{W_z} = 34.2\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 322.7\,\text{MPa} \tag{C.27}$$

Combined moment and normal force Load combination: 6, element: 209, location factor: 0.00

$M_{y,Ed} = 0.5$ kNm

$M_{z,Ed} = 0.5$ kNm

$N_{Ed} = 0.8$ kN

$$\sigma_{Ed} = \frac{N_{Ed}}{A} + \frac{M_{z,Ed}}{W_z} + \frac{M_{y,Ed}}{W_y} = 68.3\,\text{MPa} < \sigma_{Rd} = \frac{f_y}{\gamma_{\text{M0}}} = 322.7\,\text{MPa} \tag{C.28}$$

Shear force in y-axis Load combination: 19, element: 308, location factor: 1.00

$V_{y,Ed} = 0.8$ kN

$$\tau_{Ed} = \frac{V_{y,Ed} S_z}{2 t_{\text{web}} I_z} = 2.1\,\text{MPa} < \tau_{Rd} = \frac{f_y}{\gamma_{\text{M0}}\sqrt{3}} = 186.3\,\text{MPa} \tag{C.29}$$

Shear force in z-axis Load combination: 14, element: 108, location factor: 0.00

$V_{z,Ed} = 0.3$ kN

$$\tau_{Ed} = \frac{V_{z,Ed} S_y}{2 t_{\text{flange}} I_y} = 1.0\,\text{MPa} < \tau_{Rd} = \frac{f_y}{\gamma_{\text{M0}}\sqrt{3}} = 186.3\,\text{MPa} \tag{C.30}$$

C.3 Buckling

Resistance against buckling has been investigated and found insignificant compared to cross sectional resistance.

C.4 Bolt connection between aluminum and steel profiles

Partial factor: $\gamma_{M2} = 1.25$

M10 bolts are used in both the knee and the top section connection. The bolt class is 8.8 corrosponding to $f_{ub} = 800\,\text{MPa}$

Load combination: 10, element: 34

$F_{Ed} = -1.7\,\text{kN}$

$$F_{Ed} = 1.71\,\text{kN} < F_{Rd} = 2 \cdot 0.5 \cdot A \frac{f_{ub}}{\gamma_{M2}} = 50.3\,\text{kN} \tag{C.31}$$

C.5 Bracing requirement

Material safety factor: $\gamma_M = 2.00$

C.5.1 Wind bracing

Load combination: 21, element: 1303, location: 0.00
Tension design force:

$$F_{Ed} = 0.9\,\mathrm{kN}$$

the wire must withstand a characteristic tension force:

$$F_{Rk} \geq \gamma_M F_{Ed} = 1.81\,\mathrm{kN} \tag{C.32}$$

C.6 Anchorage

Anchorage calculations are carried out according to [7]. The anchors are assumed to be submerged in very stiff cohesive soils. The load capacity per anchor Z_d depends on the anchor force angle β, the diameter d of the anchor and the and the submerged part of the anchor l', see Figure C.2

$\beta = 0^\circ$: $Z_d = 8.0 \cdot d \cdot l'$

$\beta \geq 45^\circ$: $Z_d = 10.0 \cdot d \cdot l'$

$0 < \beta < 45^\circ$: Z_d Interpolated

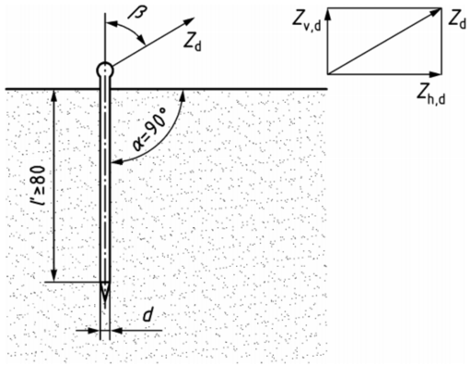


Figure C.2. Anchor capacity per anchor in very stiff cohesive soils ($c_u > 100\,kN/m^2$).

Minimum distance between two anchors: $5d$ For groups of > 6 anchors, the anchor maximum capacity must be proven.

In case of anchored frame legs that are exposed to sliding, friction between the steel foot and the underlay may be subtracted when dimensioning the anchorage requirements. A friction coefficient between clay and steel on $\mu = 0.2$ is used. The requirement is determined by:

$$0.7\mu F_{Ed,V} + Z_{h,d} \geq F_{Ed,H}$$

Where $Z_{h,d}$ is the horizontal bearing capacity of anchors. $F_{Ed,V}$ and $F_{Ed,H}$ is the vertical and the horizontal force exposed to the anchorage point.

C.6.1 Frame columns

Node: 101, Load combination: 16
Reactions F_x, F_y and F_z:

$$F_x = 0.1\,\text{kN}$$
$$F_y = -1.2\,\text{kN}$$
$$F_z = -0.7\,\text{kN}$$

Anchor force (lift situation):

$$F_{Ed} = \sqrt{F_x^2 + F_y^2 + F_z^2} = 1.4\,\text{kN} = 146\,\text{kg}$$

Anchor force angle: $\beta = 30°$

Anchors
Capacity per anchor Z_d and number of anchors in group n

$$Z_d = 1.86\,\text{kN}, \quad n = \frac{F_{Ed}}{Z_d} \approx 1 \tag{C.33}$$

C.6.2 Gable columns

Node: 118, Load combination: 16
Reactions F_x, F_y and F_z:

$$F_x = 0.0\,\text{kN}$$
$$F_y = -1.6\,\text{kN}$$
$$F_z = -0.5\,\text{kN}$$

Anchor force (lift situation):

$$F_{Ed} = \sqrt{F_x^2 + F_y^2 + F_z^2} = 1.6\,\text{kN} = 166\,\text{kg}$$

Anchor force angle: $\beta = 16°$

Anchors
Capacity per anchor Z_d and number of anchors in group n

$$Z_d = 1.74\,\text{kN}, \quad n = \frac{F_{Ed}}{Z_d} \approx 1 \tag{C.34}$$

C.7 Verification other load classes

Load class	Terrain category	C.1	C.2	C.3	C.4	C.5	C.6	C.7	C.8	C.9	C.10	C.11	C.12
1	1	0.13	3.45	0.39	3.50	0.01	0.20	0.07	2.41	3.39	3.47	0.18	0.13
	2	0.11	2.78	0.32	2.83	0.01	0.16	0.06	1.95	2.78	2.85	0.14	0.10
	3	0.07	1.92	0.22	1.95	0.01	0.11	0.04	1.35	1.99	2.04	0.10	0.07
	4	0.07	1.76	0.20	1.79	0.01	0.10	0.04	1.24	1.85	1.89	0.09	0.07
2	1	0.11	2.75	0.31	2.80	0.01	0.16	0.06	1.93	2.76	2.83	0.14	0.10
	2	0.09	2.22	0.25	2.26	0.01	0.13	0.05	1.56	2.27	2.33	0.11	0.08
	3	0.06	1.53	0.18	1.56	0.00	0.09	0.03	1.08	1.64	1.68	0.08	0.06
	4	0.05	1.41	0.16	1.43	0.00	0.08	0.03	0.99	1.52	1.56	0.07	0.05
3	1	0.03	0.87	0.10	0.89	0.00	0.05	0.02	0.62	1.03	1.06	0.05	0.03
	2	0.03	0.70	0.08	0.72	0.00	0.04	0.02	0.50	0.88	0.90	0.04	0.03
	3	0.02	0.48	0.06	0.49	0.00	0.03	0.01	0.34	0.68	0.69	0.03	0.02
	4	0.02	0.44	0.05	0.45	0.00	0.03	0.01	0.32	0.64	0.66	0.03	0.02
4	1	0.02	0.60	0.07	0.60	0.00	0.03	0.02	0.42	0.78	0.80	0.04	0.02
	2	0.02	0.48	0.06	0.49	0.00	0.03	0.01	0.34	0.67	0.69	0.03	0.02
	3	0.01	0.33	0.04	0.33	0.00	0.02	0.01	0.24	0.53	0.55	0.02	0.01
	4	0.01	0.30	0.04	0.30	0.00	0.02	0.01	0.22	0.51	0.52	0.02	0.01
5	1	0.01	0.39	0.04	0.39	0.00	0.02	0.01	0.28	0.59	0.60	0.03	0.01
	2	0.01	0.31	0.04	0.31	0.00	0.02	0.01	0.22	0.52	0.53	0.02	0.01
	3	0.01	0.21	0.03	0.21	0.00	0.01	0.01	0.15	0.43	0.44	0.02	0.01
	4	0.01	0.19	0.02	0.20	0.00	0.01	0.01	0.14	0.41	0.42	0.02	0.01

Load class	Terrain category	C.13	C.14	C.15	C.16	C.17	C.18	C.19	C.20	C.21	C.22	C.23	C.24
1	1	0.24	4.72	7.38	7.58	0.17	0.07	0.04	0.84	2.76	2.81	0.11	0.07
	2	0.19	3.81	5.94	6.10	0.13	0.05	0.03	0.68	2.27	2.30	0.08	0.05
	3	0.13	2.63	4.06	4.18	0.09	0.04	0.02	0.47	1.63	1.65	0.06	0.04
	4	0.12	2.41	3.72	3.82	0.08	0.03	0.02	0.43	1.51	1.53	0.05	0.03
2	1	0.19	3.77	5.88	6.04	0.13	0.05	0.03	0.68	2.25	2.28	0.08	0.05
	2	0.16	3.04	4.72	4.85	0.11	0.04	0.02	0.55	1.85	1.88	0.07	0.04
	3	0.11	2.10	3.22	3.31	0.07	0.03	0.02	0.38	1.34	1.36	0.05	0.03
	4	0.10	1.92	2.95	3.03	0.07	0.03	0.02	0.35	1.25	1.27	0.04	0.03
3	1	0.06	1.19	1.82	1.84	0.04	0.02	0.01	0.21	0.85	0.86	0.03	0.02
	2	0.05	0.96	1.53	1.54	0.03	0.01	0.01	0.17	0.72	0.73	0.03	0.01
	3	0.03	0.66	1.16	1.17	0.02	0.01	0.01	0.12	0.56	0.57	0.02	0.01
	4	0.03	0.60	1.09	1.10	0.02	0.01	0.01	0.11	0.53	0.54	0.02	0.01
4	1	0.04	0.81	1.35	1.36	0.03	0.01	0.01	0.15	0.64	0.65	0.02	0.01
	2	0.03	0.65	1.15	1.16	0.02	0.01	0.01	0.12	0.56	0.56	0.02	0.01
	3	0.02	0.44	0.90	0.90	0.02	0.01	0.01	0.08	0.44	0.45	0.02	0.01
	4	0.02	0.41	0.85	0.86	0.02	0.01	0.01	0.07	0.42	0.43	0.01	0.01
5	1	0.03	0.52	0.99	1.00	0.02	0.01	0.01	0.10	0.49	0.49	0.02	0.01
	2	0.02	0.42	0.87	0.87	0.02	0.01	0.01	0.08	0.43	0.44	0.01	0.01
	3	0.02	0.28	0.70	0.70	0.02	0.00	0.00	0.05	0.36	0.36	0.01	0.00
	4	0.01	0.26	0.67	0.67	0.02	0.00	0.00	0.05	0.34	0.35	0.01	0.00

Load class	Terrain category	C.25	C.26	C.27	C.28	C.29	C.30	C.31
1	1	0.04	1.07	0.70	1.49	0.10	0.05	0.22
	2	0.03	0.86	0.56	1.21	0.08	0.04	0.18
	3	0.02	0.60	0.39	0.85	0.05	0.03	0.12
	4	0.02	0.55	0.36	0.79	0.05	0.02	0.11
2	1	0.03	0.85	0.56	1.20	0.08	0.04	0.18
	2	0.02	0.69	0.45	0.98	0.06	0.03	0.14
	3	0.02	0.48	0.31	0.69	0.04	0.02	0.10
	4	0.02	0.44	0.28	0.64	0.04	0.02	0.09
3	1	0.01	0.27	0.18	0.42	0.02	0.01	0.06
	2	0.01	0.22	0.14	0.35	0.02	0.01	0.05
	3	0.01	0.15	0.11	0.25	0.01	0.01	0.04
	4	0.01	0.14	0.11	0.24	0.01	0.01	0.04
4	1	0.01	0.18	0.12	0.30	0.02	0.01	0.04
	2	0.01	0.15	0.11	0.25	0.01	0.01	0.04
	3	0.00	0.11	0.10	0.19	0.01	0.00	0.03
	4	0.00	0.10	0.10	0.18	0.01	0.00	0.03
5	1	0.01	0.12	0.11	0.21	0.01	0.01	0.03
	2	0.00	0.10	0.10	0.18	0.01	0.00	0.03
	3	0.00	0.07	0.09	0.14	0.01	0.00	0.03
	4	0.00	0.07	0.09	0.14	0.01	0.00	0.03

Table C.1. Eurocode verifications checked in section C.2 for the remaining load classes and terrain categories. Headers refers to equation numbers.

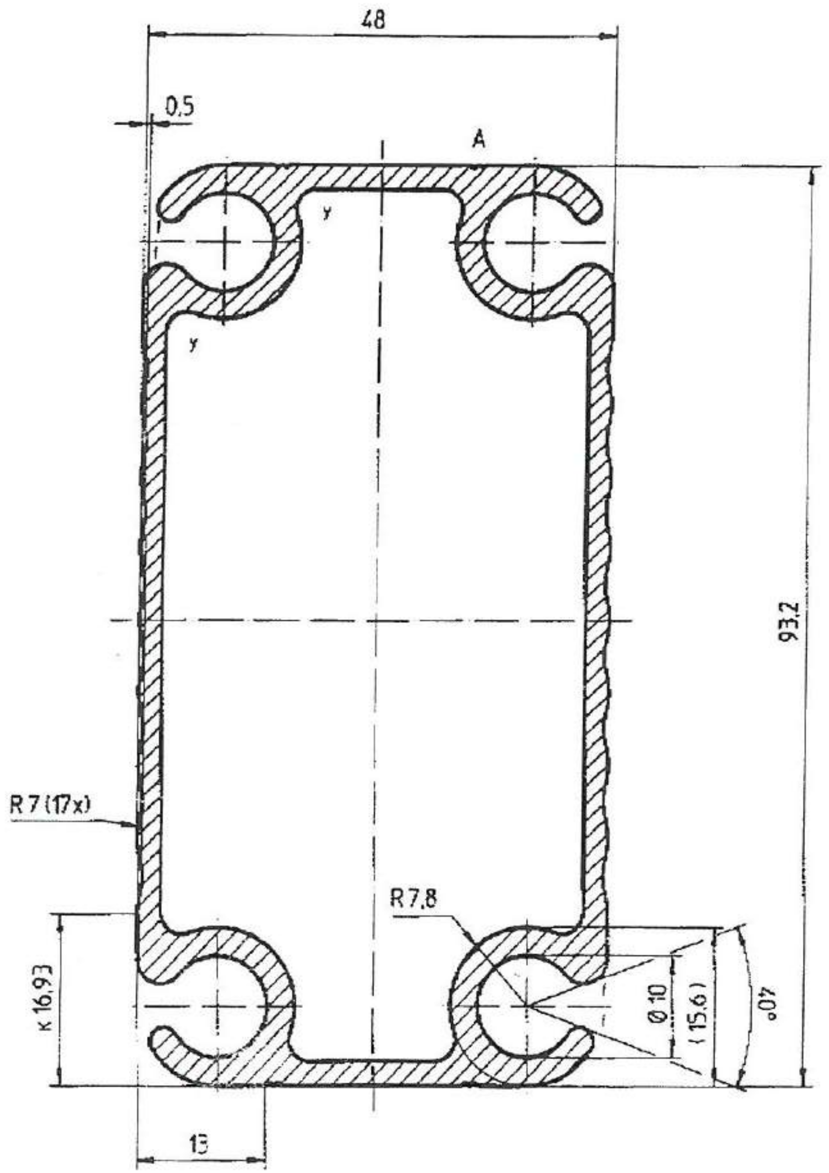
ANNEX D
Drawings

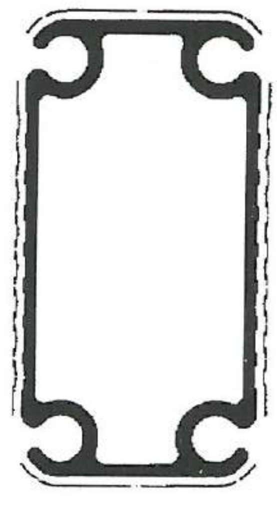
Kibæk Presenning tent book– without guy lines
Static calculations of 12 m tent

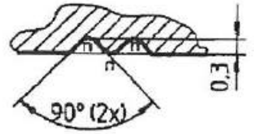
Revision 0, March 2016

Datum 1020327	Ordernr	INSTRUKTION FINNS	**sapa:** Produktion - profilritning
Kund: Kibæk Presenning A/S		Kundnr: 103998	327795
Användningsområde: Tältkonstruktion/tältprofil		Kunds ritn.nr	
Rev/Ant	Ändringens art	Sign.	Datum

2,110kg.







Top

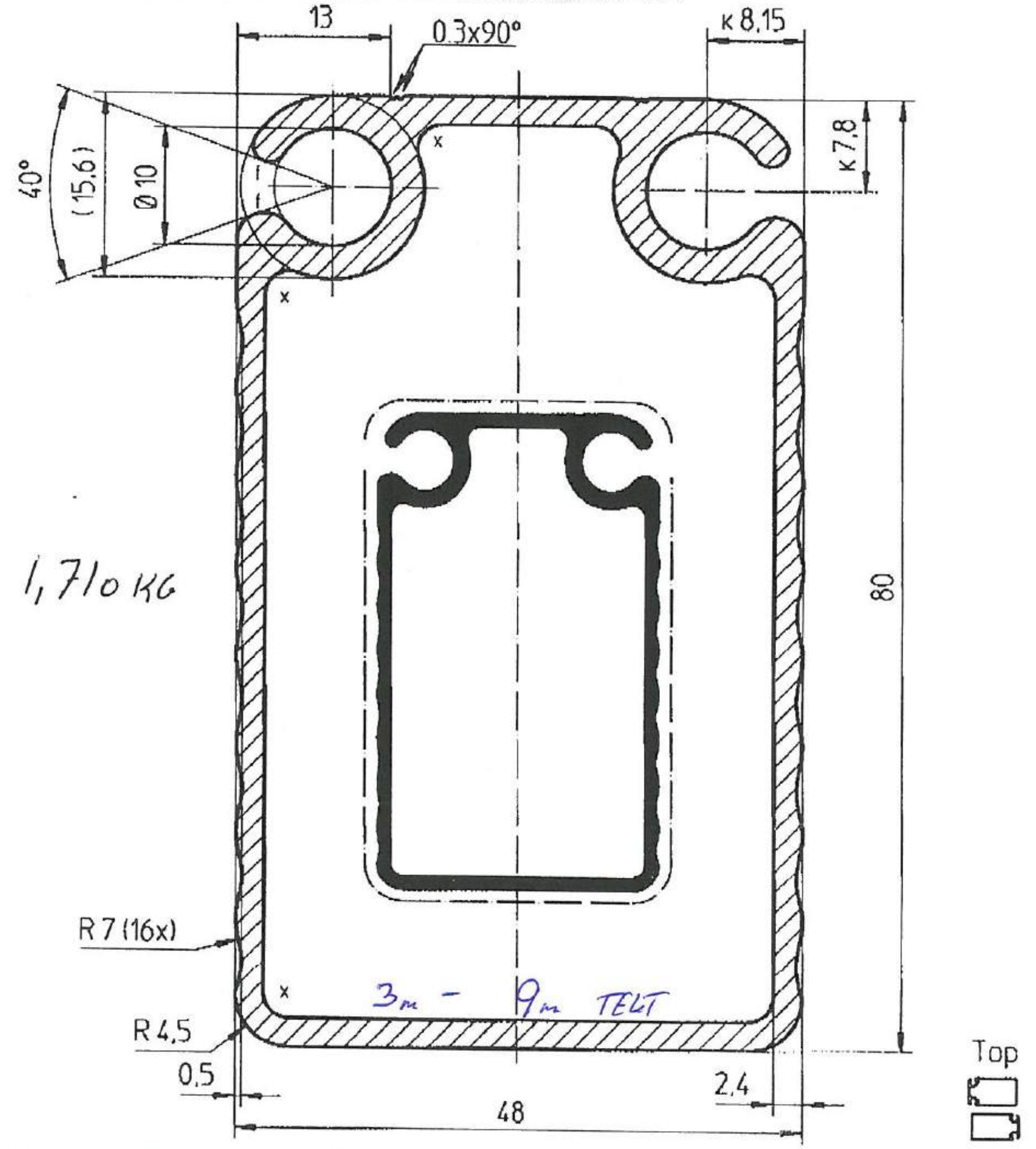
10-12 m TELT

För icke toleranssatta mått gäller: SAPA:s normaltolerans				Teor yta 835	Skala 2:1	Verktyg nr 327795
Verktyg PH360x170	Press 4	Ej måttsatt gods 2,4		Teor vikt 2255	Datum 1997-02-26	
Bock	Hål 2	Ej måttsatt radie		Perim 376	Ritad av MÅ	
Bots / Ins.bocker B54	Form 24	x= y= 2,1	D= n= 0,2 z= w=	Yta 5	Legering 6005	
Subbolster	Reserv	i= Full radie; K= Konstruktionsmått; Synlig yta; Mindre synlig yta		Rev. 00	Granskad DS	
Feeder	Produndex 2	Ej måttsatt nita V=				

Datum	Ordernr		
1020327		INSTRUKTION FINNS	**sapa:** Produktion - profilritning

Kund	Kundnr	Profil nr.
Kibæk Presenning A/S	103998	314735
Användningsområde: Tältkonstruktion/Ramprofil	Kunds ritn.nr	

Rev	Ant	Ändringens art	Sign.	Datum
02		Synlig yta tillkom	ÖJ	1995-03-07



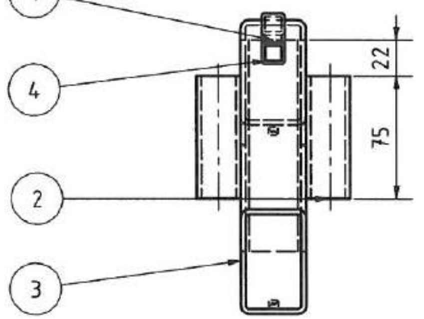
För icke toleranssatta mått gäller:
SAPA.s normaltolerans

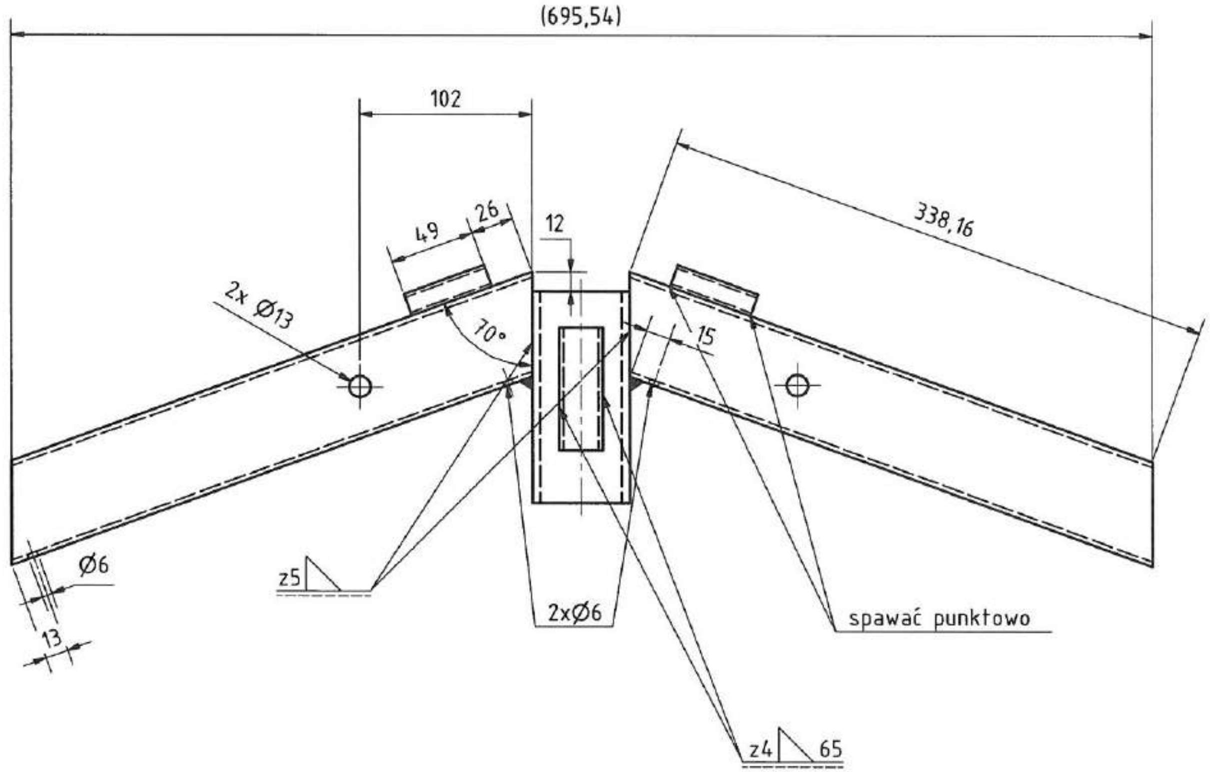
Verktyg	PH360x170	Press	4
Bock		Hål	2
Bols / Ins.backer	B54	Förh.	32
Subbolster		Reserv	
Feeder		ProdIndex	6

Ej måttsatt gods: 2,4
Ej måttsatt radie: x= 2.1 o= z= y= n= w=
f= full radie
K= Konstruktionsmått
Synlig yta
Mindre synlig yta
Ej måttsatt rilla V =

Teor.yta: 660	Skala: 2:1
Teor.vikt: 1.783	Datum: 1994-01-23
Perim.: 300	Ritad av: ÖJ
Yta: 5	Legering: 6005
Rev.: 02	Granskad: GL

Verktygs nr 314735



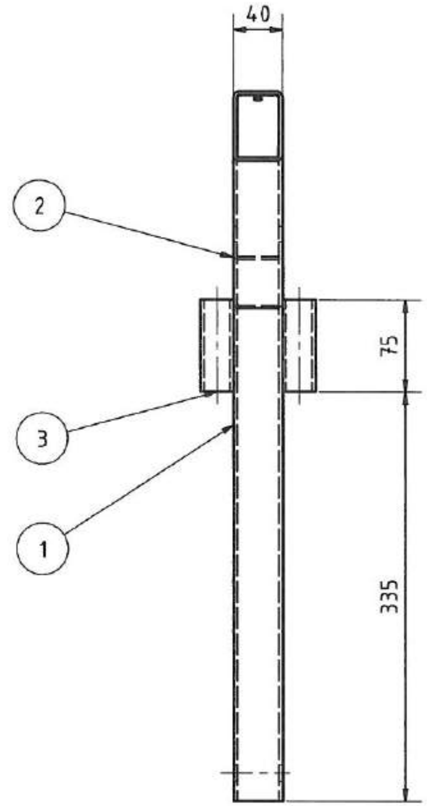


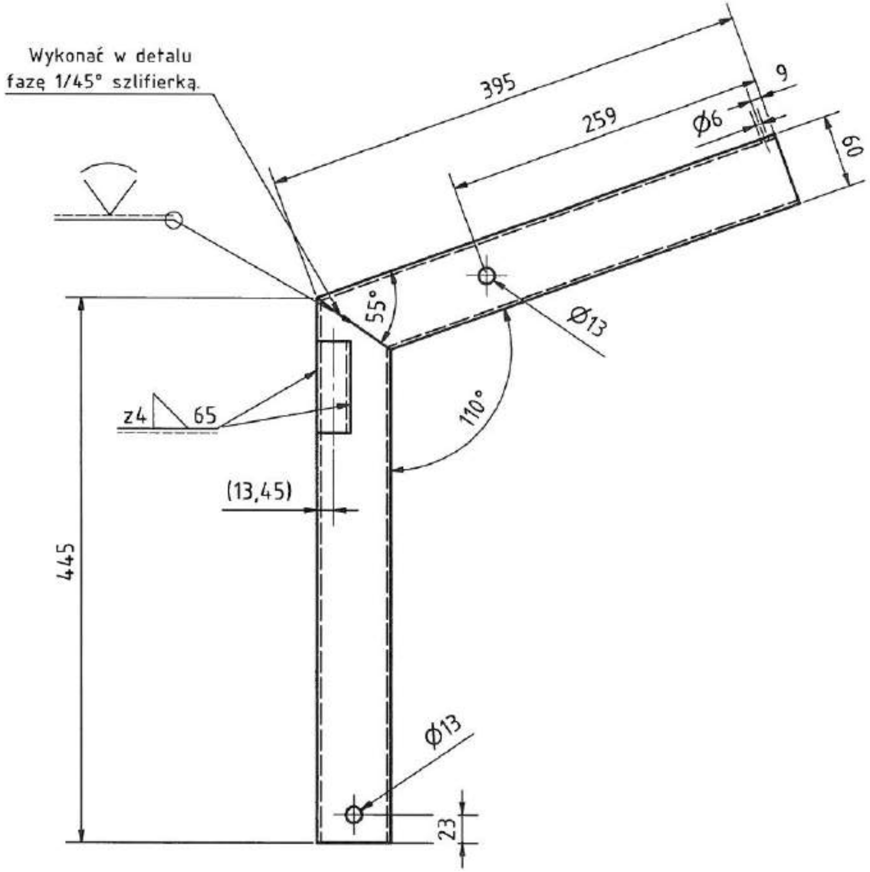
Uwagi: 1) otwory Ø13 wykonać przelotowo.
2) długość i rozmieszczenie spoin wg wzorca.
3) detale nie mogą mieć ostrych zadziorów.

Ogólne tolerancje DIN ISO 2768-m	Powierzchnia DIN ISO 1302	Skala
		Masa 4,056 Kg
		Materiał
Narysowany	2013-09-10	J.Dłubisz
Sprawdzony		
Standard		E.W.
Steelcon		Element stelaża
		KIB 91016-SP
		1
		A3

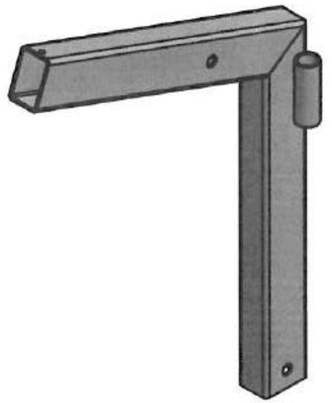
LISTA CZĘŚCI

LP	ILOŚĆ	NR CZĘŚCI	OPIS	MATERIAŁ
1	1	91016 1	Kształtownik 60x40x5 L-130	S355 JR
2	2	91010 2	Rura 26,9x2,6 L-75	S235 JR
3	2	91016 2	Kształtownik 60x40x5	S355 JR
4	2	91016 4	Kształtownik 14x14x2 L-49	S235 JR





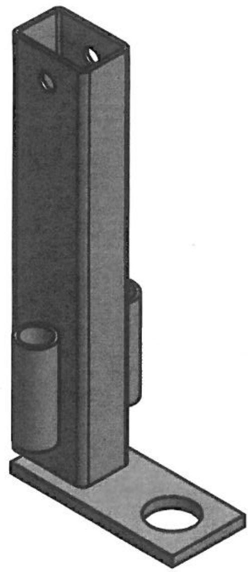
Uwagi: 1) otowry wykonać przelotowo.
2) długość i rozmieszczenie spoiny wg wzorca.
3) detale nie mogą mieć ostrych zadziorów.



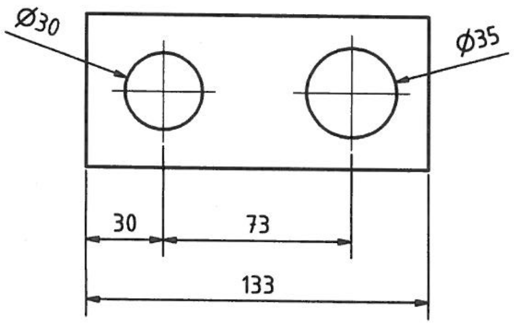
LISTA CZĘŚCI				
LP	ILOŚĆ	NR CZĘŚCI	OPIS	MATERIAŁ
1	1	91014 2	Kształtownik 60x40x5 L-445	S355 JR
2	1	91014 1	Kształtownik 60x40x5 L-395	S355 JR
3	2	91010 2	Rura 26,9x2,6 L-75	S235 JR

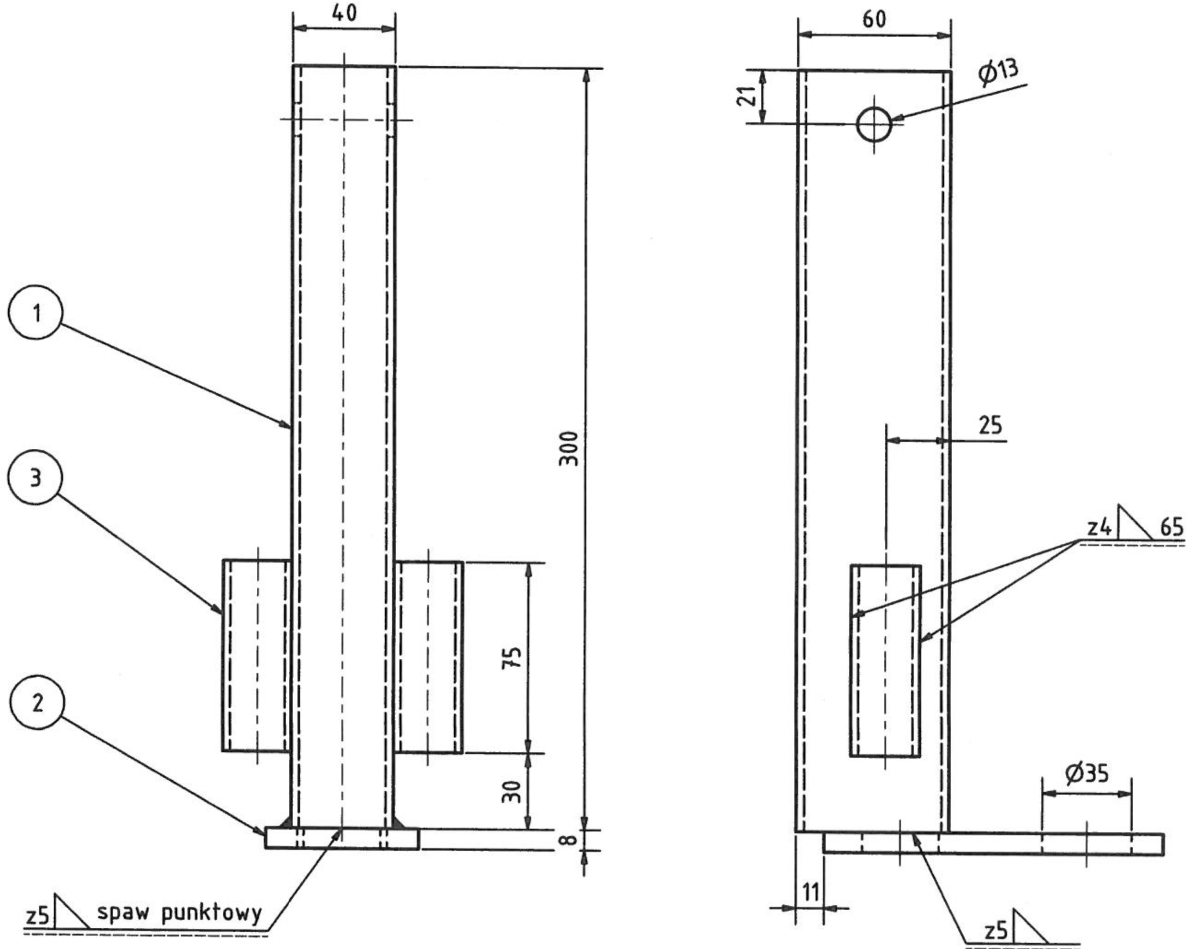
Ogólne tolerancje DIN ISO 2768-m	Powierzchnia DIN ISO 1302	Skala	Masa 3,652 Kg
		Materiał	
	Data	Nazwa	
Narysowany	2013-09-10	J.Dłubisz	Element stelaża
Sprawdzony			
Standard		E.W.	
Steelcon ELEMENTY WSPORCZE I KONSTRUKCJE		KIB 91014-SP	1
			A3

Arkusz	Zmiany	Data	Nazwa



Poz.2.

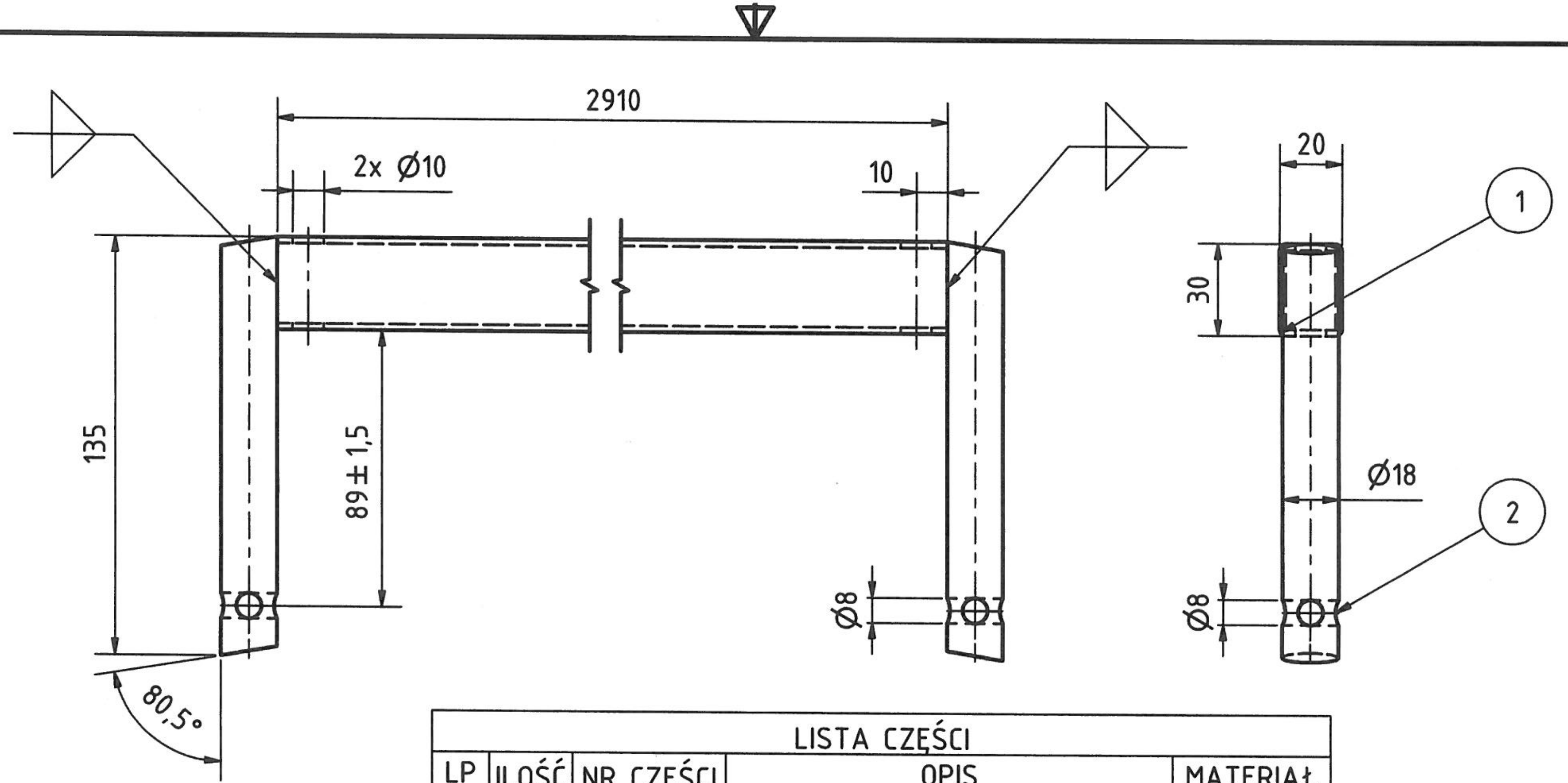




Uwaga: długość i rozmieszczenie spoin wg wzorca.

LISTA CZĘŚCI				
LP	ILOŚĆ	NR CZĘŚCI	OPIS	MATERIAŁ
1	1	91010 1	Kształtownik 60x40x3 L-300	S235 JR
2	1	91010 3	Płaskownik 60x8 L-133	S235 JR
3	2	91010 2	Rura 26,9x2,6 L-75	S235 JR

Ogólne tolerancje DIN ISO 2768-m	Powierzchnia DIN ISO 1302	Skala	Masa 1,925 Kg
		Materiał	
	Data	Nazwa	Podpora kpl
Narysowany	2013-09-10	J.Dłubisz	
Sprawdzony			
Standard		E.W.	
Steelcon ELEMENTY WYPOSAŻENIA KONTENERÓW			KIB 91010 — 1 — A3
Arkusz	Zmiany	Data	Nazwa



LISTA CZĘŚCI				
LP	ILOŚĆ	NR CZĘŚCI	OPIS	MATERIAŁ
1	1	70030 1	Kształtownik 30x20x2 L-2910	S235 JR
2	2	70030 2	Pręt 18mm L-135	S235 JR

Uwagi:
1. Długość i rozmieszczenie spoin wg wzorca.
2. Spoiny zlicowane.

Ogólne tolerancje DIN ISO 2768-m	Powierzchnia DIN ISO 1302	Skala	Masa 4,6 kg
		Materiał	
	Data	Nazwa	
Narysowany	2013-11-25	J.Dłubisz	Element stelaża
Sprawdzony			
Standard		E.W.	
Steelcon ELEMENTY WYPOSAŻENIA KONTENERÓW		70030	1 / A4

Arkusz	Zmiany	Data	Nazwa