Content:	**Tent book (according to NEN-EN 8020-41:2012)**
Owner Tent book:	**Tentations bvba**
Tent system:	**Bonga 10x15m stretchtent**
Manufacturer:	**Tentations bvba, Bonga Carpas SL**
Document code:	**17.02.00509.1**
Author:	**ir. Nikie van Veen**
Date:	**28.02.2017**

Tent system:	Bonga 10x15m stretchtent
Document code:	17.02.00509.1
Owner Tent book:	Tentations bvba Molenstraat 124 BE-9032 Gent t +32 (0)477 930 739 alexandermasyn@gmail.com www.bongastretchtent.com
Manufacturer	Tentations bvba, Bonga Carpas SL
Engineering and composer Tent book:	Tentech BV Ontwerp en advies voor lichtgewicht bouwen Postbus 85910 3508 AD Utrecht t +31 (0)30 252 1869 f +31 (0)30 254 1239 www.tentech.nl
Date:	28.02.2017
Author:	ir. Nikie van Veen
Authorized by:	ir. Rogier Houtman
Valid until:	28.02.2022

This report is drafted by Tentech BV commissioned by Tentations bvba.

For questions / comments about the calculations or about a Bonga Stretchtent that us used / built, please contact Tentations bvba.

A. Introduction

Tentations bvba has developed a stretchtent under the product name Bonga. The tent is made of a stretchable membrane, which allows a freedom of form as there is not a pre-described shape necessary. Depending on the location, variations can be made with the number, length and placement of poles and ties. This results in a custom made cover at each new location.

The freedom of form is created by the stretchable property of the membrane; the desired shape is obtained by “stretching” an initially flat membrane. The disadvantage of this form-flexibility is the difficulty in researching and arranging all possible configurations in a static analysis.
The structural calculation in this report shows the static analysis of the 10x15m dimension, where a configuration is considered which has all sides open.

This document contains the data required for a tent book according to EN 13782 bundled and presented for the Bonga 10x15m stretchtent of Tentations bvba.

This tent book includes

- Ownership data;
- Drawings of the different variants of the tent, including dimensions, indications of elements and required anchoring.
- Permitted live load;
- Maximum wind speeds (according to EN 1991-1-4:2005);
- Structural analysis (according to EN 13782:2015);
- Material certificates (strength properties and fire properties).

Utrecht, 28.02.2017,

ir. Nikie van Veen

B. **Contents**

C. Codes and standards

The following codes are used:

- EN 13782: Temporary Structures – Tents - Safety
- EN 1990: Basis of structural Design
- EN 1991: Actions on structures
  Part 1-4: General actions - wind actions
- EN 1999: Design of aluminum structures
  Part 1-1: General rules

TEN TECH

D. Summary

Manufacturer	Tentations bvba Molenstraat 124 BE-9032 Gent t +32 (0)477 930 739 alexandermasyn@gmail.com www.bongastretchtent.com	Bonga Carpas S.L. Venta Nova 80 43894 (Camarles), Tarragona Catalunya Spain
Main dimensions:	Width: Length: Side height: Max height:	10 m 15 m 2.2m / 2.7m 4 m
	Center poles (4 / 3.5m): Perimeter poles (2.7 / 2.2m):	Ø60 x 3.1mm [AL 6061 T6] Ø40 x 2mm [AL 6061 T6]
	For pw = 345 N/m² Ties, attachment: Storm belt:	 min. Breaking load 750 kg [PES] min. Breaking load 1450 kg [PES]
	For pw = 500 N/m² Ties, attachment: Storm belt:	 min. Breaking load 1200 kg [PES] min. Breaking load 2000 kg [PES]

User defined load:	It is allowed to apply max. 10 kg of decoration, sound or light equipment per center pole. The load should be applied centric.
Snow load:	A snow load of 0.1 kN/m^2 (4cm) according the French CTS.
Wind load:	Point of departure: geometry without side walls. The calculation is primarily based on a wind pressure of p_w = 500 N/m^2, according to EN 13782 par. 7.4.2.2. However, a reduced wind pressure of pw = 300 N/m^2 may be applied in the case of tents with a width of 10 m or less and a height of 5 m or less. The wind pressure can be recalculated to the corresponding wind speeds for Europe (not country specific), shown in the following table:

Above the limit values shown below the strength and/or stability of the structure is not guaranteed. Explanation of the shown table can be found in chapter G.

Pw = 345 N/m² For a Proflexx fabric, BL fabric clamp ≥ 374 kg, Anchor Leff ≥ 500mm

Out of order:	Coast	Flattened, open area	Rural	Village	City
A. Beaufort (indicative)	> 6 Bft	> 6 Bft	> 7 Bft	> 8 Bft	> 8 Bft
B. 10 minutes average wind speed:	> 14.9 m/s	> 15.7 m/s	> 17.5 m/s	> 20.8 m/s	> 21.7 m/s
C. Peak wind speed (gust):	> 85 km/h	> 85 km/h	> 85 km/h	> 85 km/h	> 85 km/h

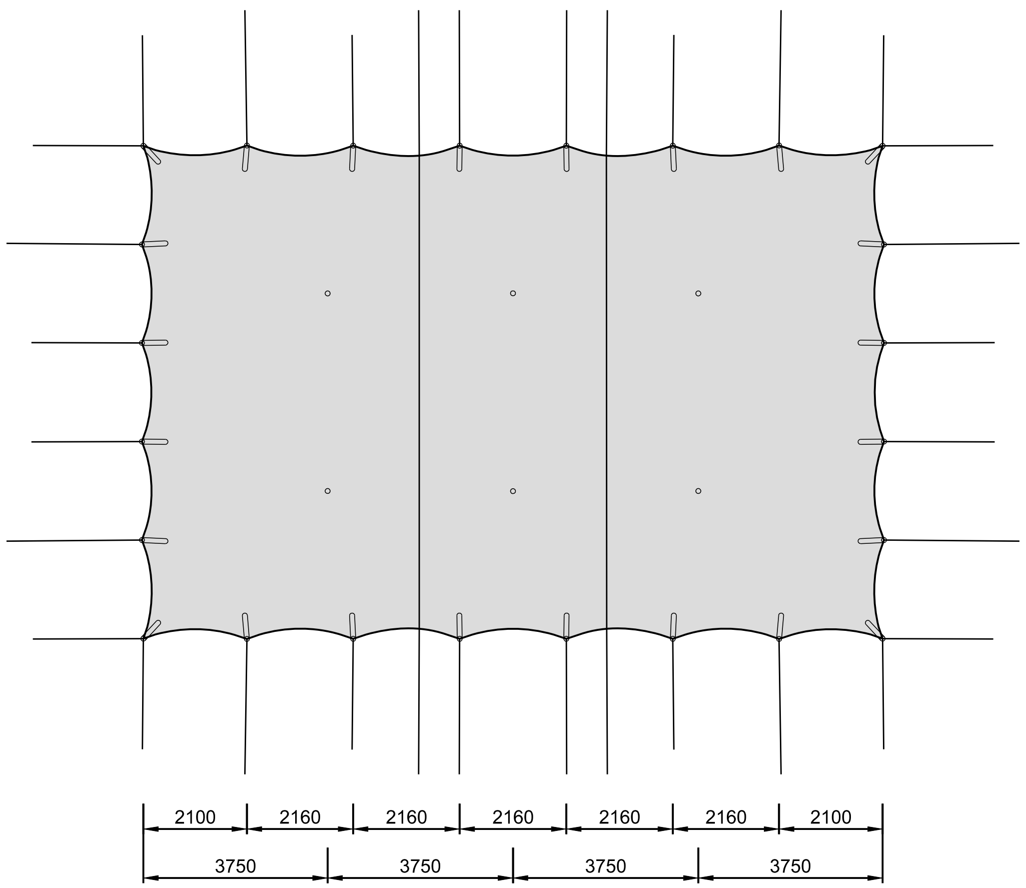
Pw = 500 N/m² For a Triflexx fabric, BL fabric clamp ≥ 674 kg, Anchor Leff ≥ 700mm

Out of order:	Coast	Flattened, open area	Rural	Village	City
A. Beaufort (indicative)	> 7 Bft	> 7 Bft	> 8 Bft	> 9 Bft	> 9 Bft
B. 10 minutes average wind speed:	> 17.9 m/s	> 18.9 m/s	> 21.1 m/s	> 25.0 m/s	> 26.1 m/s
C. Peak wind speed (gust):	> 102 km/h	> 102 km/h	> 102 km/h	> 102 km/h	> 102 km/h

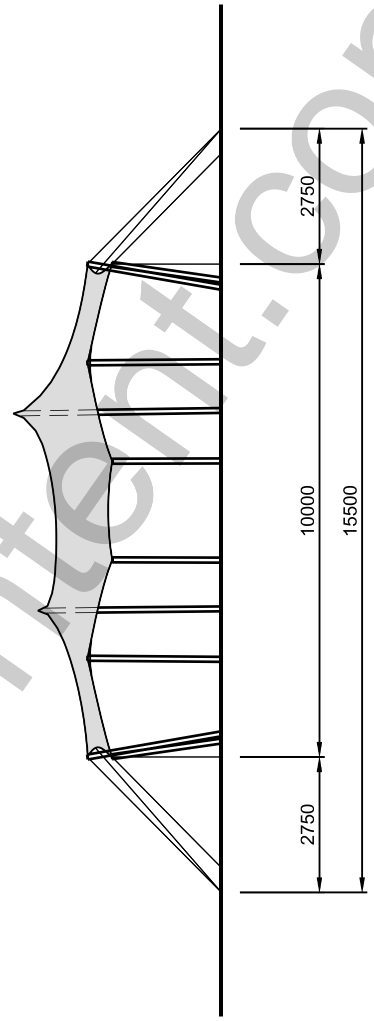
Given values are limit values, m/s values are 10 min averages measured on a 10m heigth at the closest weather station; wind in Beaufort (BFT) are indicative values.

Anchoring:	Based on dense, non-cohesive soil (e.g. sandy soils). Anchor: **T-profile 25x25mm**	
	Pw = 345 N/m²	**Pw = 500 N/m²**
	minimal depth of penetration = **500 mm** **1 anchor** per tie attachment **2 anchors** per side of the storm belt	minimal depth of penetration = **700 mm** **1 anchor** per tie attachment **2 anchors** per side of the storm belt

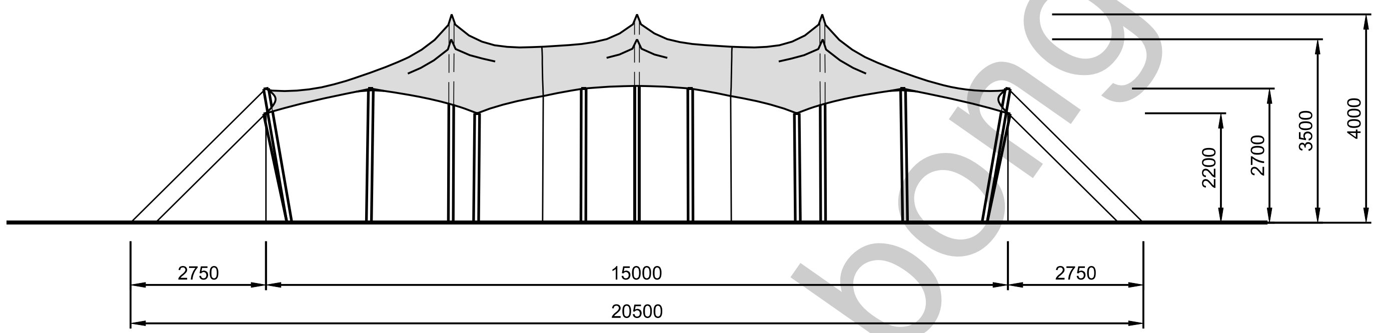
E. **Drawings: main measurements and anchorage**



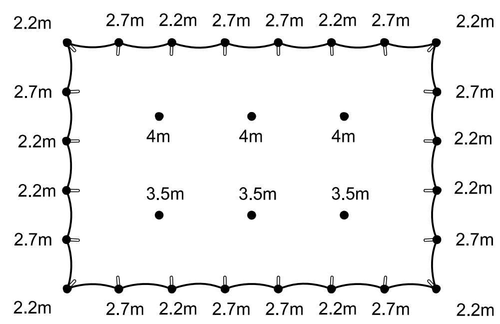
TOP VIEW
[1:150]



SIDE VIEW
[1:150]



FRONT VIEW
[1:150]



POLE HEIGHT DIAGRAM
[1:300]

Pw = 345 N/m² For a Proflexx fabric, BL fabric clamp = 374 kg, Anchor Leff = 500mm

Out of order:	Coast	Flattened, open area	Rural	Village	City
A. Beaufort (indicative)	> 6 Bft	> 6 Bft	> 7 Bft	> 8 Bft	> 8 Bft
B. 10 minutes average wind speed:	> 14.9 m/s	> 15.7 m/s	> 17.5 m/s	> 20.8 m/s	> 21.7 m/s
C. Peak wind speed (gust):	> 85 km/h	> 85 km/h	> 85 km/h	> 85 km/h	> 85 km/h

Pw = 500 N/m² For a Triflexx fabric, BL fabric clamp = 674 kg, Anchor Leff = 700mm

Out of order:	Coast	Flattened, open area	Rural	Village	City
A. Beaufort (indicative)	> 7 Bft	> 7 Bft	> 8 Bft	> 9 Bft	> 9 Bft
B. 10 minutes average wind speed:	> 17.9 m/s	> 18.9 m/s	> 21.1 m/s	> 25.0 m/s	> 26.1 m/s
C. Peak wind speed (gust):	> 102 km/h	> 102 km/h	> 102 km/h	> 102 km/h	> 102 km/h

POLES		
Center poles:	Ø60x3.1mm [EN-AW 6061 T6]	
Perimeter poles:	Ø40x2mm [EN-AW 6061 T6]	
BANDEN	pw = 345 N/m²	pw = 500 N/m²
Ties, attachment [PES]	BL > 750 daN	BL > 1200 daN
Storm belt [PES]	BL > 1450 daN	BL > 2000 daN
ANCHORS	pw = 345 N/m²	pw = 500 N/m²
for dense, non cohesive soil		
T-profiel 25x25mm	Leff = 500 mm	Leff = 700 mm
per attachment tie:	1 anchor	1 anchor
per side of the storm tie:	2 anchors	2 anchors

EDITOR:	DATE:	FILENAME:
NV	24.11.16	1607304_UF_01

F. Important terms and conditions

This document applies to the built construction if the following principles and conditions are met:

- The used materials, parts and sections (membrane, poles, ties, anchoring) are in accordance with this document;
- The dimensions of the built structure match the dimensions stated in this document;
- Parts (poles, ties, anchors) may not be removed;
- Obstacles should be placed at least 0.5m from the membrane (measured perpendicular to the fabric);
- The tent will be closed for public access when strong winds occur (see summary, part wind load);
- The anchorage is based on dense, non-cohesive soil. When the tent is built on a different soil, extra anchorage should be provided or anchorage test should be conducted.
- Only decorations, music- and light installations of less than 10 kg per pole, can be attached to the structure;
- A snow load of 0.1 kN/m^2 (4cm) is taken into account, according to the French CTS.
- The possibility of a center pole to fall over due to the lifting of the fabric, should be prevented at all times. Therefore the 3.5m high poles require additional security against falling over.

G. Wind speeds

G.1 Allowable wind speeds

Wind can be expressed in different ways:

- 10 minutes average wind speed – an average wind speed measured for 10 minutes in a 10m height in an open terrain (EN 1991-1-4 terrain category II).
- Peak wind speed – a short term maximum gust of wind with a certain speed, depending on the height. Often given in km/h

The wind pressure that is used for the calculation for a tent, is determining for the strength of the tent. Therefore it is important that the wind speed is determined correctly to check if the wind pressure is exceeded.

In the structural analysis a wind pressure 0.50 kN/m^2 at 4m is used. For certain elements, a reduced wind pressure of 0.345 N/m^2 is necessary. According to EN 13782, a wind pressure of 0.30 kN/m^2 may be applied in the case of tents with a width ≤ 10 m or less and a height ≤ 5m.

The wind speeds given below are limit values and correspond to a wind pressure of **0.50 kN/m^2** at **4m** height, which is valid for the use of the below stated elements. Above the given wind speed values the strength and/or stability of the structure is not guaranteed to be safe.

Pw = 500 N/m^2 For a Triflexx fabric, BL fabric clamp ≥ 674 kg, Anchor Leff ≥ 700mm

Out of order:	Coast [*1]	Flattened, open area [*2]	Rural [*3]	Village [*4]	City [*5]
A. Beaufort (indicative)	> 7 Bft	> 7 Bft	> 8 Bft	> 9 Bft	> 9 Bft
B. 10 minutes average wind speed:	> 17.9 m/s	> 18.9 m/s	> 21.1 m/s	> 25.0 m/s	> 26.1 m/s
C. Peak wind speed (gust):	> 102 km/h	> 102 km/h	> 102 km/h	> 102 km/h	> 102 km/h

1. *Coast means: Sea or coastal area with wind coming from open sea.*
2. *Flattened, open area means: Lakes of flat and horizontal areas with negligible vegetation and without obstacles.*
3. *Rural means: Area with low vegetation like grass and free standing obstacles (trees, buildings) with an in between distance of at least 20 times the obstacle height.*
4. *Village means: Areas with regular vegetation or buildings or free standing obstacles with an in between distance of less than 20 times the obstacle height (like villages, suburban areas, permanent forests)*
5. *City means: Areas where at least 15% of the surface is covered with building with an average height of more than 15m.*

The given values above (A, B and C) can be measured in different ways and can be used independently:

A. This is an indicative Beaufort scale which belongs to the 10 minutes average wind speed. This values has to come from the closest meteostation.
B. 10 min average wind speed at 10 meter height in an open terrain, this value should come from the closest meteostation.
C. Peak wind speed, this value should be measured at the highest point of the tent.

G.2 Wind speed calculation

The maximum wind speed is converted into a basic wind speed for a coastal area, flattened/open area, rural area, village and city according to EN 1991-1-4. Terrain roughness is taken according to the recommended general values for the different terrain categories for Europe. (not country specific)

Wind pressure according to EN13782	$P_{w;EN13782}$	= 500 N/m^2
Reduced wind pressure	$P_{w;red}$	= 345 N/m^2

Peak wind speed at 4m height

Equation:

$$500 = {}^{1}/_{2} \times \rho \times v^2 = {}^{1}/_{2} \times 1.25 \times v^2 \rightarrow v = 28.3\ m/s \rightarrow \pm 102\ km/h$$

Eq. 4.10 UNI-EN 1991-1-4
Basic wind pressure

$$345 = {}^{1}/_{2} \times \rho \times v^2 = {}^{1}/_{2} \times 1.25 \times v^2 \rightarrow v = 23.5\ m/s \rightarrow \pm 85\ km/h$$

Eq. 4.10 UNI-EN 1991-1-4
Basic wind pressure

Wind speed coastal area at 10m height (Europe) – Tent height = 4m

$$K_r = 0.19 \times \left(\frac{z_0}{0.05}\right)^{0.07} = 0.19 \times \left(\frac{0.003}{0.05}\right)^{0.07} = 0.156$$

Eq. 4.5 UNI-EN 1991-1-4
Terrain factor for coastal area

$$C_r = K_r \times \ln\left(\frac{z}{z_0}\right) = 0.156 \times \ln\left(\frac{4}{0.003}\right) = 1.123$$

Eq. 4.4 UNI-EN 1991-1-4
Roughness factor at 4m height
Z = 4 > Z_{min} = 1

$$V_m = C_r \times V_b = 1.123 \times V_b$$

Eq. 4.3 UNI-EN 1991-1-4
Average wind speed at height

$$\sigma_v = K_r \times V_b = 0.156 \times V_b$$

Eq. 4.6 UNI-EN 1991-1-4
Standard deviation of turbulence

$$L_v = \frac{\sigma_v}{V_m} = \frac{0.156 \times V_b}{1.123 \times V_b} = 0.139$$

Eq. 4.7 UNI-EN 1991-1-4
Turbulence intensity

$$Q_p = (1 + 7 \times L_v) \times {}^{1}/_{2} \times \rho \times {V_m}^2 = 1.554 \times {V_b}^2$$

Eq. 4.8 UNI-EN 1991-1-4
Extreme wind pressure

Equation:

$$500 = 1.554 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 17.9\ m/s$$

Characteristic wind speed

$$345 = 1.554 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 14.9\ m/s$$

Characteristic wind speed

Wind speed flattened, open area at 10m height (Europe) – Tent height = 4m

$$K_r = 0.19 \times \left(\frac{z_0}{0.05}\right)^{0.07} = 0.19 \times \left(\frac{0.01}{0.05}\right)^{0.07} = 0.170$$

Eq. 4.5 UNI-EN 1991-1-4
Terrain factor for coastal area

$$C_r = K_r \times \ln\left(\frac{z}{z_0}\right) = 0.170 \times \ln\left(\frac{4}{0.01}\right) = 1.017$$

Eq. 4.4 UNI-EN 1991-1-4
Roughness factor at 4m height
$Z = 4 > Z_{min} = 1$

$$V_m = C_r \times V_b = 1.017 \times V_b$$

Eq. 4.3 UNI-EN 1991-1-4
Average wind speed at height

$$\sigma_v = K_r \times V_b = 0.170 \times V_b$$

Eq. 4.6 UNI-EN 1991-1-4
Standard deviation of turbulence

$$L_v = \frac{\sigma_v}{V_m} = \frac{0.170 \times V_b}{1.017 \times V_b} = 0.167$$

Eq. 4.7 UNI-EN 1991-1-4
Turbulence intensity

$$Q_p = (1 + 7 \times L_v) \times {}^{1}/_{2} \times \rho \times {V_m}^2 = 1.402 \times {V_b}^2$$

Eq. 4.8 UNI-EN 1991-1-4
Extreme wind pressure

Equation:

$$500 = 1.402 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 18.9\ m/s$$ **Characteristic wind speed**

$$345 = 1.402 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 15.7\ m/s$$ **Characteristic wind speed**

Wind speed rural area at 10m height (Europe) – Tent height = 4m

$$K_r = 0.19 \times \left(\frac{z_0}{0.05}\right)^{0.07} = 0.19 \times \left(\frac{0.05}{0.05}\right)^{0.07} = 0.190$$

Eq. 4.5 UNI-EN 1991-1-4
Terrain factor for coastal area

$$C_r = K_r \times \ln\left(\frac{z}{z_0}\right) = 0.190 \times \ln\left(\frac{4}{0.05}\right) = 0.833$$

Eq. 4.4 UNI-EN 1991-1-4
Roughness factor at 4m height
$Z = 4 > Z_{min} = 2$

$$V_m = C_r \times V_b = 0.833 \times V_b$$

Eq. 4.3 UNI-EN 1991-1-4
Average wind speed at height

$$\sigma_v = K_r \times V_b = 0.190 \times V_b$$

Eq. 4.6 UNI-EN 1991-1-4
Standard deviation of turbulence

$$L_v = \frac{\sigma_v}{V_m} = \frac{0.190 \times V_b}{0.833 \times V_b} = 0.228$$

Eq. 4.7 UNI-EN 1991-1-4
Turbulence intensity

$$Q_p = (1 + 7 \times L_v) \times {}^{1}/_{2} \times \rho \times {V_m}^2 = 1.125 \times {V_b}^2$$

Eq. 4.8 UNI-EN 1991-1-4
Extreme wind pressure

Equation:

$$500 = 1.125 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 21.1\ m/s$$ **Characteristic wind speed**

$$345 = 1.125 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 17.5\ m/s$$ **Characteristic wind speed**

Wind speed village at 10m height (Europe) – Tent height = 4m

$K_r = 0.19 \times \left(\frac{z_0}{0.05}\right)^{0.07} = 0.19 \times \left(\frac{0.3}{0.05}\right)^{0.07} = 0.215$ — **Eq. 4.5 UNI-EN 1991-1-4 Terrain factor for coastal area**

$C_r = K_r \times \ln\left(\frac{z}{z_0}\right) = 0.215 \times \ln\left(\frac{5}{0.3}\right) = 0.606$ — **Eq. 4.4 UNI-EN 1991-1-4 Roughness factor at 4m height $Z = Z_{min} = 5$**

$V_m = C_r \times V_b = 0.606 \times V_b$ — **Eq. 4.3 UNI-EN 1991-1-4 Average wind speed at height**

$\sigma_v = K_r \times V_b = 0.215 \times V_b$ — **Eq. 4.6 UNI-EN 1991-1-4 Standard deviation of turbulence**

$L_v = \frac{\sigma_v}{V_m} = \frac{0.606 \times V_b}{0.215 \times V_b} = 0.355$ — **Eq. 4.7 UNI-EN 1991-1-4 Turbulence intensity**

$Q_p = (1 + 7 \times L_v) \times {}^1/_2 \times \rho \times {V_m}^2 = 0.801 \times {V_b}^2$ — **Eq. 4.8 UNI-EN 1991-1-4 Extreme wind pressure**

Equation:

$500 = 0.801 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 25.0\ m/s$ — **Characteristic wind speed**

$345 = 0.801 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 20.8\ m/s$ — **Characteristic wind speed**

Wind speed city at 10m height (Europe) – Tent height = 4m

$K_r = 0.19 \times \left(\frac{z_0}{0.05}\right)^{0.07} = 0.19 \times \left(\frac{1}{0.05}\right)^{0.07} = 0.234$ — **Eq. 4.5 UNI-EN 1991-1-4 Terrain factor for coastal area**

$C_r = K_r \times \ln\left(\frac{z}{z_0}\right) = 0.234 \times \ln\left(\frac{10}{1}\right) = 0.540$ — **Eq. 4.4 UNI-EN 1991-1-4 Roughness factor at 4m height $Z = Z_{min} = 10$**

$V_m = C_r \times V_b = 0.540 \times V_b$ — **Eq. 4.3 UNI-EN 1991-1-4 Average wind speed at height**

$\sigma_v = K_r \times V_b = 0.234 \times V_b$ — **Eq. 4.6 UNI-EN 1991-1-4 Standard deviation of turbulence**

$L_v = \frac{\sigma_v}{V_m} = \frac{0.540 \times V_b}{0.234 \times V_b} = 0.434$ — **Eq. 4.7 UNI-EN 1991-1-4 Turbulence intensity**

$Q_p = (1 + 7 \times L_v) \times {}^1/_2 \times \rho \times {V_m}^2 = 0.735 \times {V_b}^2$ — **Eq. 4.8 UNI-EN 1991-1-4 Extreme wind pressure**

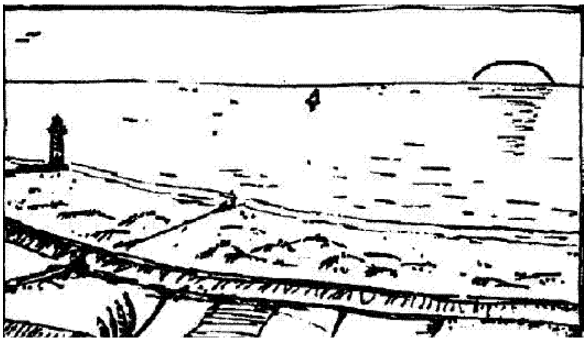
Equation:

$500 = 0.735 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 26.1\ m/s$ — **Characteristic wind speed**

$345 = 0.735 \times {V_b}^2 \rightarrow solving\ gives \rightarrow V_b = 21.7\ m/s$ — **Characteristic wind speed**

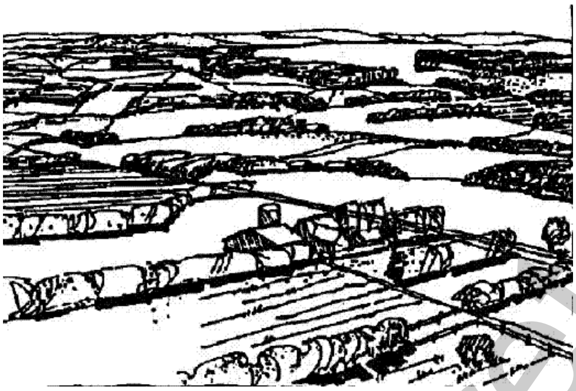
Terrain categories:

0: Coastal area:

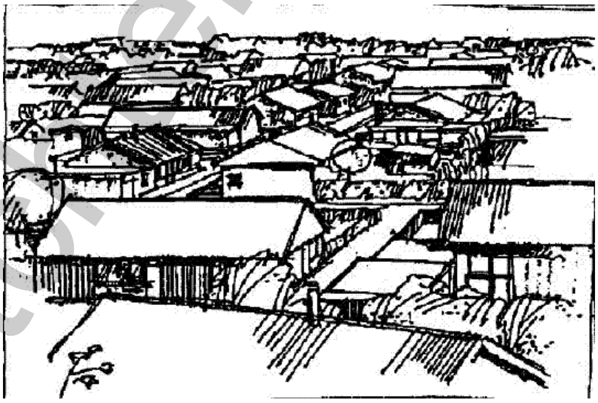


I: Flattened, open area:

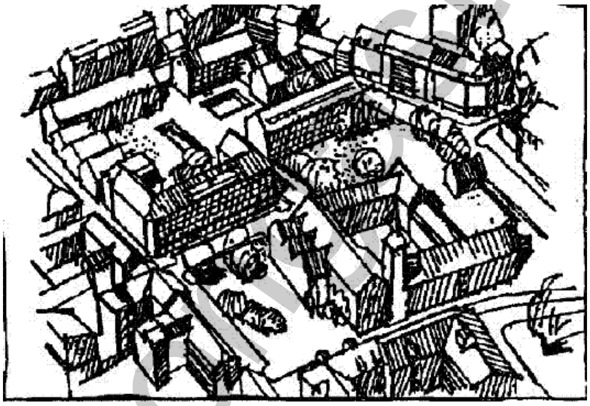
II: Rural area:



III: Village



IV: City



H. Static Analysis

H.1. Project description

H.1.1 Description

The principle of a stretch tent is based on a rectangular piece of stretchable fabric.The membrane is supported by poles, both at the edge and in the field. The perimeter poles are stabilized by ties. Besides, it is also possible to tie down the edge of the membrane directly to the ground. There is a freedom in positioning the poles and therewith a freeform design can be obtained.

The disadvantage of this form-flexibility is the difficulty in researching and arranging all possible configurations in a static analysis. The structural calculation in this report shows the static analysis of the 10x15m dimension, where a configuration is considered which has all sides open.

Paragraph H.1.2 shows the geometry of the analyzed 10x15m configuration. Main dimensions, position of poles, ties and anchors can be found in Chapter E.*

** The analyzed geometry contains 6 main poles with a height of 4m. One row of main poles is lowered to 3.5 meters for the standard set-up to improve the drainage. This does not have disadvantageous consequences for the resulting forces and is therefore allowed as long as the 3.5m poles are secured against falling over.*

H.1.2 Geometry

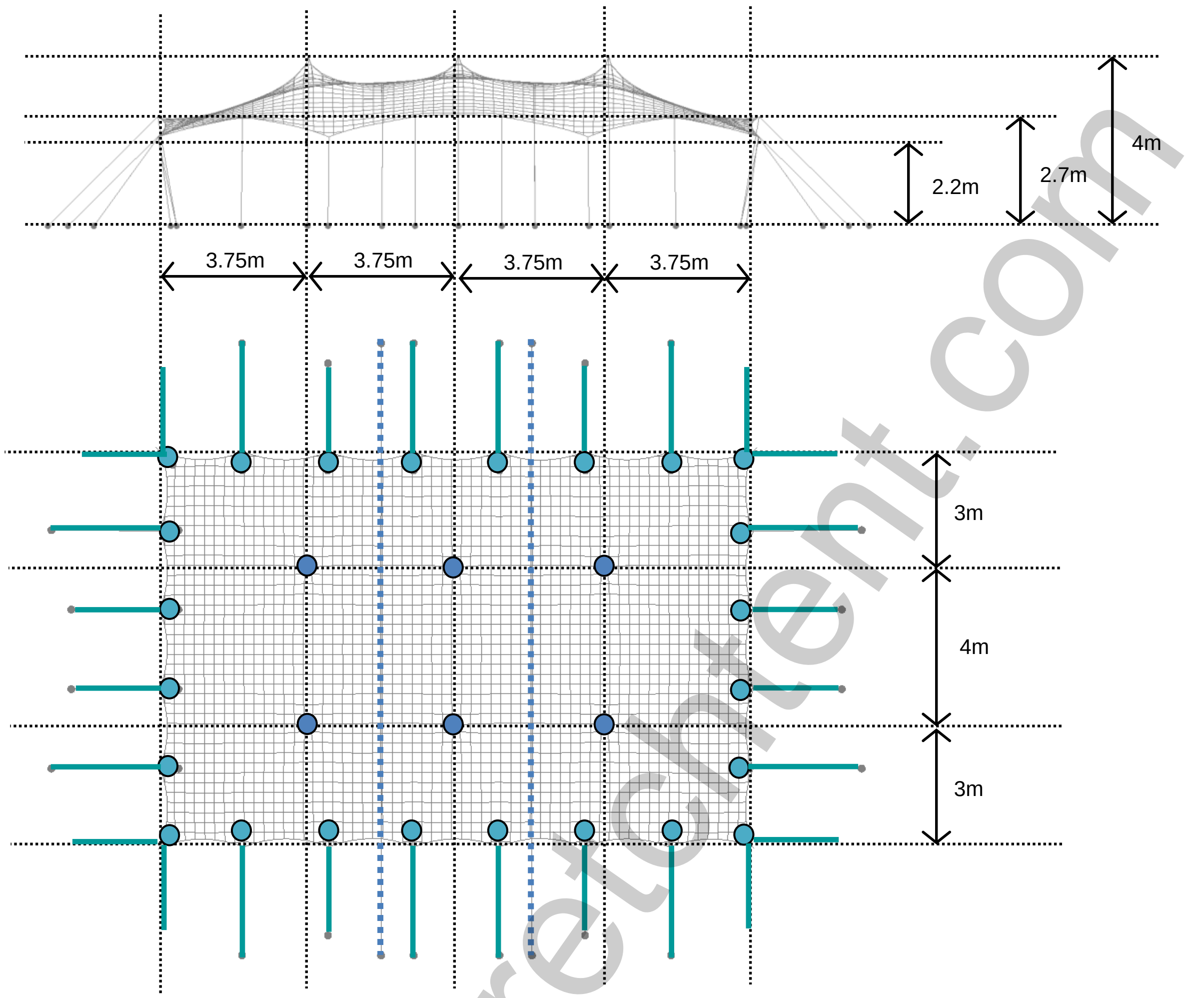


Figure 1: Configuration ‘floating, dimension 10x15m

H.2. Materials and cross sections

H.2.1 Materials

H.2.1.1 Fabric

Design tensile strength	f_d	f_{tk} / γ_m	art 8.6. NEN-EN 13782
Characteristic tensile strength (warp)	$f_{tk,ketting}$		
Characteristic tensile strength (weft)	$f_{tk,inslag}$		
Material factor – global, permanent load	γ_m	2.5	tbl 4. NEN-EN13782
Material factor – global, short duration load	γ_m	2.0	tbl 4. NEN-EN13782

Table 1. Used symbols, codes and standard for fabric materials

Material	Type	Weight	$f_{rd;warp;perm}$	$f_{rd;\ weft;perm}$	$f_{rd;\ warp;short}$	$f_{rd:\ weft;short}$
PES + PU/PVC Triflexx	-	443 gr/m^2	8.14 kN/m	5.07 kN/m	10.18 kN/m	6.34 kN/m
PES + PU/PVC Proflexx	-	530 gr/m^2	4.80 kN/m	3.20 kN/m	6.00 kN/m	4.00 kN/m

Table 2. Used fabrics

H.2.1.2 Belts

Design resistance	F_{rd}	R_m / γ_m	art. 10.2 NEN-EN 13782
Characteristic tensile strength	R_m	LC x γ_{m2}	
"Lashing Capacity"	LC		Conform EN 12195 - 2
Material factor	γ_{m1}	2.0	art.10.4. NEN-EN 13782
Material factor	γ_{m2}	3.0	EN 12195 - 2

Table 3. Used material factors

Material	LC	Breaking strength R_m	F_{rd}
Tension belt, [PES] EN 12195-2	400kg 4 kN	1200 kg 12 kN	6.0 kN
Storm belt, [PES] EN 12195-2	666 kg 6.66 kN	2000 kg 20 kN	10 kN

Table 4. Used belts (storm belt)

The above specified belts are often used for the 10x15m bonga stretchtent. However, the needed breaking strengths for the reduced wind loads are lower. (see chapter D).

H.2.1.3 Aluminum

Material factor (strength)	γ_{m1}	1.1	tbl. 6.1. NEN-EN 1999-1-1
Material factor (stability)	γ_{m1}	1.1	tbl 6.1. NEN-EN 1999-1-1
Material factor (tension to fracture/connections)	γ_{m2}	1.25	tbl 2.1. NEN-EN 1999-1-1

Table 1. Used material factors

Material	Weight	E-modulus	f_y	f_u
6061 T6	2700 kg/m^3	70000 N/mm^2	240 N/mm^2	260 N/mm^2

Table 5. Used aluminum materials

H.2.2 Cross sections

Profile	Material	b mm	t mm	G kg/m^1	A mm^2	Iy mm^4	Wel;y mm^3	Wpl;y mm^3
Center pole Ø60 x 3.1mm	Al 6061 T6	60	3.1	1.50	554	224929	7498	10047
Perimeter pole 2.7m Ø40 x 2mm	Al 6061 T6	40	2.0	0.65	239	43216	2161	2891
Perimeter pole 2.2m Ø40 x 2mm	Al 6061 T6	40	2.0	0.65	239	43216	2161	2891

Table 6. Used cross sections

H.3. Calculation method

H.3.1 Modeling

The analysis of the structure is performed with the software package EASY FCS supplied by TECHNET GmbH, Berlin. This software is specially developed for structures with large deformability, such as membrane structures. The performed analysis is a full non-linear second order analysis.

The membrane structure is modeled in 3D. The membrane is modeled as a cable net structure and supported by poles. These center poles will be stabilized by the tensioned membrane. The perimeter poles are stabilized and tied down by guy ropes or tension belts, which are attached to ground anchors.

H.3.2 Structural behavior of membrane structures

The forces in a tent structure are based on the deformations of the fabric. Since the fabric is a highly deformable material, it is only possible to calculate stresses and deformations with a non-linear method. Therefore the non-linear software Easy FSC is used.

Because of the non-linearity of the calculations the partial safety factors are not applied beforehand, but afterwards. This is done to prevent that the deformations increase due to the extra partial safety factors, which has a positive effect on the occurring stresses (clarifying: a cable with a high structural height has lower horizontal reaction forces than a cable with a low structural height). In this case it is therefore unsafe to apply the partial safety factors on the load beforehand. Furthermore, the forces cannot be recalculated linearly. This has as a consequence that it is not possible to differentiate in the partial safety factors, since the different load cases are already combined to a load combination.

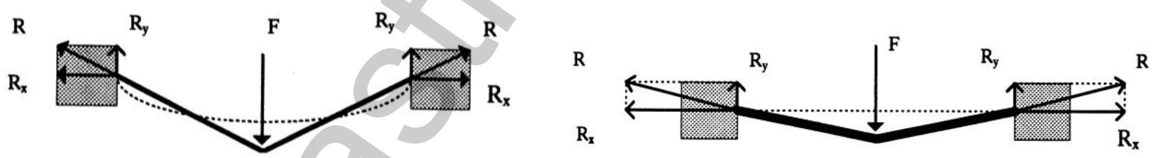


Figure 2. Reaction forces of a hanging cable.

As a membrane structure is a form-active structure, article 6.3 (4) b) of the EN-1990:2002 applies:

> *When the action effect increases less than the action, the partial factor γ_F should be applied to the action effect of the representative value of the action.*

H.3.3 Structural behavior of stretch membrane

The stretch tent is a form active structure based on the curvature principle. When the membrane is loaded, the curvature in the structure is increasing or decreasing, depending on the direction of the curvature. This change in curvature takes care of the regulation of the stresses in the fabric. The change of curvature, and thereby also the deformations, is substantial due to the flexible nature of the membrane.

The poles are supporting the fabric. The application of rounded caps at the top of the poles reduces the peak loads in the fabric. Vice versa, the fabric supports the poles in transverse direction, enabling the assumption of a 2-sided hinged pole.

H.3.4 Structural system

The modelled membrane structure is made out of an initially flat membrane. By supporting the membrane at multiple points, a smooth curved surface will be created.

The boundaries of the membrane are finished with a tunnel that has a width of 80mm. On a regular distance and in the corners reinforcing pieces (PVC fabric, 2500 N tension strength) are applied that are welded in the sew. A trapezoidal cord Ø8mm is integrated in the perimeter, which stretches with the fabric. On this tendon clamps can be applied on the places where the reinforcement is applied.

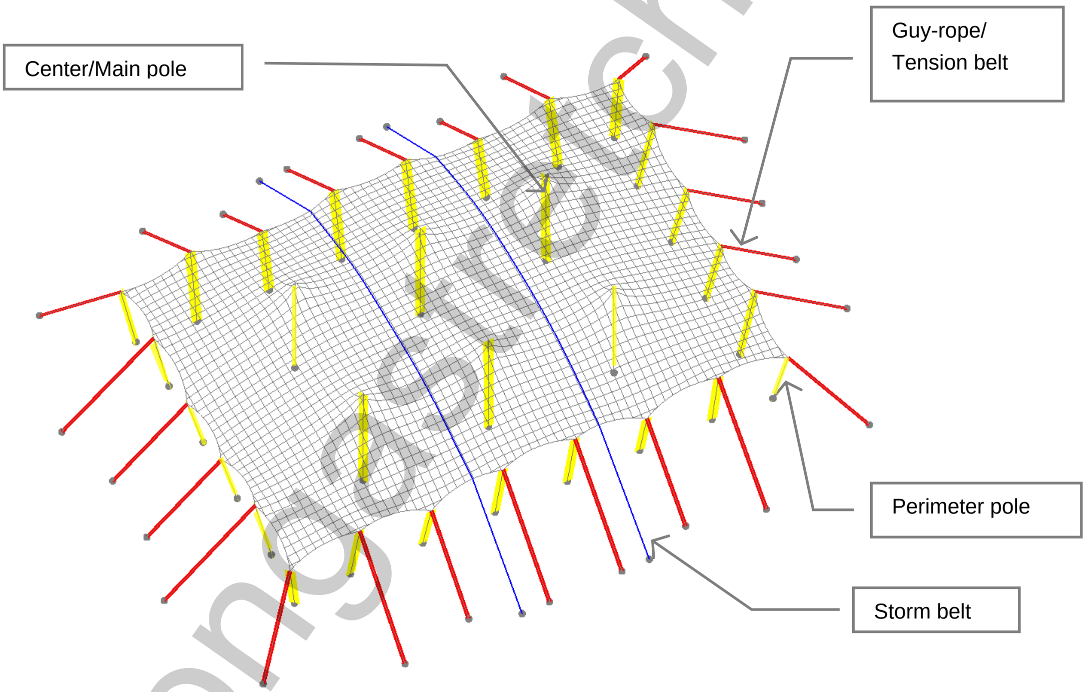


Figure 3: Structural system of the tent structure.

Remark: In the model one tension belt is accounted for in the corners. In reality there will be two.

H.3.5 Load combinations

H.3.5.1 Fundamental - Ultimate limit state

For the purpose of determination of strength and check of elements and connections.

	One variable load	Multiple variable loads
Unfavorable permanent load	$1.35 \times G + 1.5 \times Q$	$1.35 \times G + \sum 1.35 \times Q_i$
Favorable permanent load	$1.0 \times G + 1.5 \times Q$	$1.0 \times G + \sum 1.35 \times Q_i$

Table 7. Load combinations according to NEN-EN 13782

This means the following load combinations will be checked/calculated

1. 1.0 x Own weight + 1.5 x Wind load
2. 1.35 x Own weight + 1.35 x Conventional load

H.3.5.2 Safety against overturning, sliding and uplifting - Ultimate limit state

For the purpose of determination and check of needed contra weight and/or anchor pins

	One or multiple variable loads
Unfavorable permanent load	$1.1 \times G + 1.2 \times Q_{wind} + \sum 1.3 \times Q_i$
Favorable permanent load	$1.0 \times G + 1.2 \times Q_{wind} + \sum 1.3 \times Q_i$

Table 8. Load combinations according to NEN-EN 13782

This means the following load combinations will be checked/calculated

1. 1.0 x Own weight + 1.2 x Wind load

H.4. Load cases

H.4.1 Own weight

The own weight of the fabric is ≤ 0.530 kg/m^2 and is added in the software as separate load case.

H.4.2 Pretension

The structure will be pretensioned with guy ropes / tension belts. This results in a pretension in the fabric of about 0.10 kN/m^1 at the boundaries. Locally (where the side poles are attached to the fabric) higher pretensions occur due to the stretching nature of the fabric.

H.4.3 Wind

H.4.3.1 Wind pressure

Wind load according to NEN-EN 13782, 7.4.2.2:
For any other location where v_{ref} > 28 m/s*, calculations shall be provided for the tent verifying the stability and resistance with the local conditions. Special measures have to be taken. In the design calculations the necessary means shall be verified through calculation.

For v_{ref} < 28 m/s*, the wind load per unit may be evaluated applying the following minimum values given in EN 1991-1-4 with:
C_{TEM} = 0.8
T_r = 10 years
C_d = 1
C_{alt} = 1

** The stated value for wind speed is a 10-minute average, measured at 10m height.*

According to table 1 of EN 13782 article 7.4.2.2, this results in a wind pressure of 500 N/m^2 in case of tents with a height equal or less to 5m. However, a reduced wind pressure of pw = 300 N/m2 may be applied in the case of tents with a width ≤ 10 m and a height ≤ 5 m.

Due to the capacity, certain elements require a wind pressure between 300 N/m^2 < pw < 500 N/m^2 :

- Proflexx fabric, reduction factor α = 0.71, wind pressure $p_{w,red}$ = 0.355 kN/m^2
- Fabric clamps BL 374kg, reduction factor α = 0.69, wind pressure $p_{w,red}$ = 0.345 kN/m^2

However, there are replacements available (Triflexx fabric, Fabric clamps BL ≥ 674 kg) that will sustain a wind pressure of 500 N/m^2.

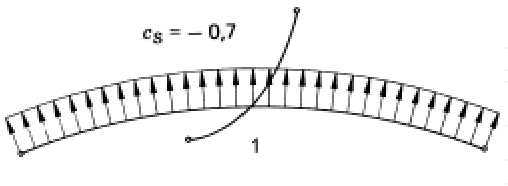
H.4.3.2 Wind shape values

Two different wind situations are reviewed for the membrane:

- The whole tent is subjected to wind suction
- The whole tent is subjected to wind pressure

<u>Wind suction – floating configurations</u>

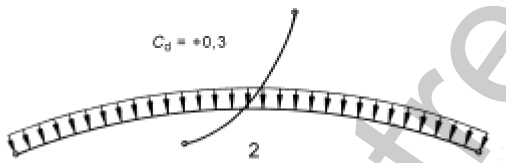
Wind shape values (C_p – values) in accordance to art.7.4.2.3 of NEN-EN 13782.



$p_{w,red}$	Factor α	$p_{w,rep}$	
500 N/m²	1	-0.7 x (1 x 0.500)	= -0.35 kN/m²
355 N/m²	0.71	-0.7 x (0.71 x 0.500)	= -0.25 kN/m²
345 N/m²	0.69	-0.7 x (0.69 x 0.500)	= -0.24 kN/m²

<u>Wind pressure</u>

Wind shape values (C_p – values) in accordance to art.7.4.2.3 of NEN-EN 13782.



$p_{w,red}$	Factor α	$p_{w,rep}$	
500 N/m²	1	0.3 x (1 x 0.500)	= 0.15 kN/m²
355 N/m²	0.71	0.3 x (0.71 x 0.500)	= 0.11 kN/m²
345 N/m²	0.69	0.3 x (0.69 x 0.500)	= 0.10 kN/m²

TEN TECH

H.4.4 Conventional / snow load

Conventional load according to article 7.3 of NEN-EN 13782: The stability shall be checked with a conventional vertical load of 0,1 kN/m2. This load shall not be combined with other load cases, except self-weight. This can be seen as a snow load of 0.1 kN/m^2 (4cm) according the French CTS.

H.4.5 Snow load

According to NEN-EN 13782, article 7.4.3 it is not necessary to calculate with snow loads in the strength and stability analysis when the following terms apply:

- The tent is constructed in an area where there is no likelihood of snow or;
- Operated at a time of the year, where the likelihood of snow can be discounted or;
- Where by design or operating conditions snow settling on the tent is prevented;
- Where pre-planned operation action prevents snow from settling on the tent

This last condition may be achieved by:

- Sufficient heating equipment is installed and is ready for used and;
- Heating is started prior to snow fall and;
- Tent is heated in such a way that the whole of the roof cladding has an outside air temperature of more than +2 ˚C;
- Cladding is made and tensioned in such a way that ponding of water or any other deformation of the cladding cannot take place.

H.5. Calculation results

H.5.1 Calculated load combinations

LC1 = Pretension
LC2 = Own weight
LC3 = Wind suction
LC4 = Wind pressure
LC5 = Conventional load / Snow load

The following load combinations are taken into account:
partial safety factors are added after the static analysis (see H.3.2).

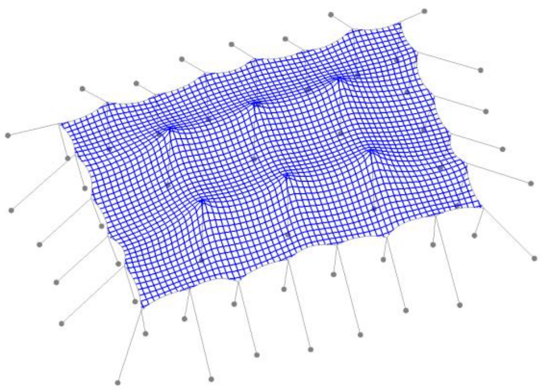
	LC 1	LC2	LC 2	LC 3	LC 4
CO 1	1 x	1 x			
CO 2	1 x	1 x	1 x		
CO 3	1 x	1 x		1 x	
CO 4	1 x	1 x			1 x

Table 9: Combinations (CO)

H.5.2 Summary of determining forces per element

In the next paragraphs the results will be determined for a full wind pressure equal to $p_w = 0.5$ kN/m^2 unless indicated differently.

H.5.2.1 Membrane



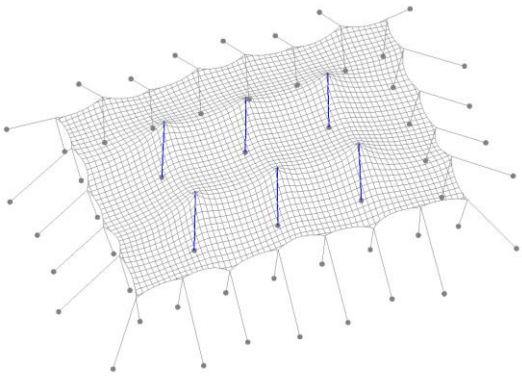
	Load combination	F_{rep}	Pag
	CO1. Own weight + pretension	0.23 kN/m	53
Max Triflexx	CO2. Own weight + pretension + wind suction	3.78 kN/m	55
Max Proflexx	CO2. RED: Own weight + pretension + wind suction	2.80 kN/m *	55
	CO3. Own weight + pretension + wind pressure	2.48 kN/m	58
	CO4. Own weight + pretension + conventional	1.78 kN/m	60

Table 10: Leading forces membrane

* the stresses exceed the maximum value of 2.80 kN/m only locally at the boundaries where the membrane is stretched.

CO2 RED and CO3 RED give stresses for a reduced wind pressure of $p_{w,red} = 0.355$ kN/m^2.

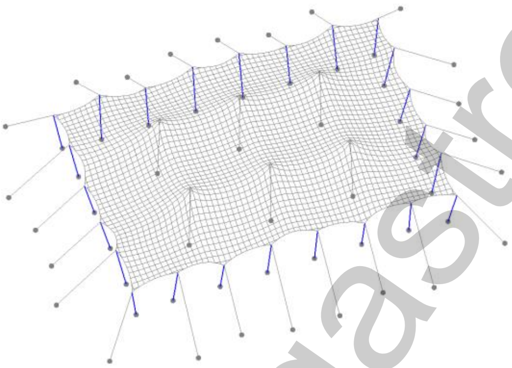
H.5.2.2 Center poles



Length		Load combination	F_{rep}	Pag.
4m		CO1. Own weight + pretension	-0.27 kN	54
		CO2. Own weight + pretension + wind suction	0 kN	57
	Max	CO3. Own weight + pretension + wind pressure	-3.49 kN	59
		CO4. Own weight + pretension + conventional	-2.45 kN	61

Table 11: Leading forces center poles

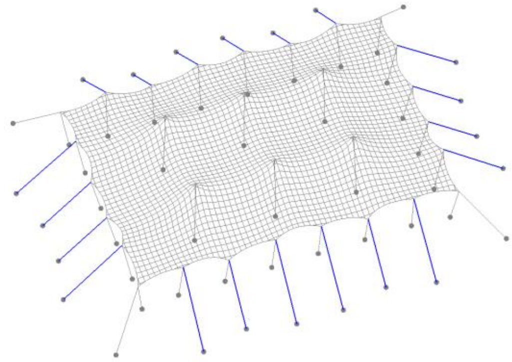
H.5.2.3 Perimeter poles



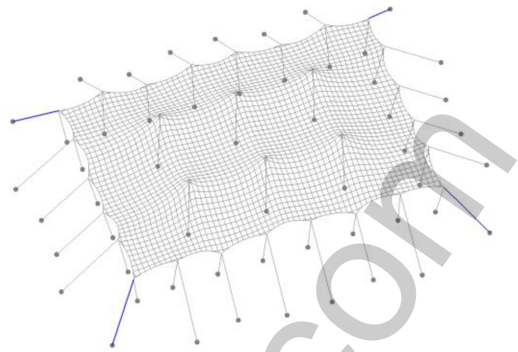
Length		Load combination	F_{rep}	Pag.
2.7 m		CO1. Own weight + pretension	-0.27 kN	54
		CO2. Own weight + pretension + wind suction	-1.12 kN	57
	Max	CO3. Own weight + pretension + wind pressure	-2.01 kN	59
		CO4. Own weight + pretension + conventional	-1.38 kN	61
2.2 m		CO1. Own weight + pretension	-0.25 kN	54
		CO2. Own weight + pretension + wind suction	-1.06 kN	57
	Max	CO3. Own weight + pretension + wind pressure	-1.15 kN	59
		CO4. Own weight + pretension + conventional	-0.82 kN	61

Table 12: Leading forces perimeter poles

H.5.2.4 Guy ropes / Tension belts



Tension belt



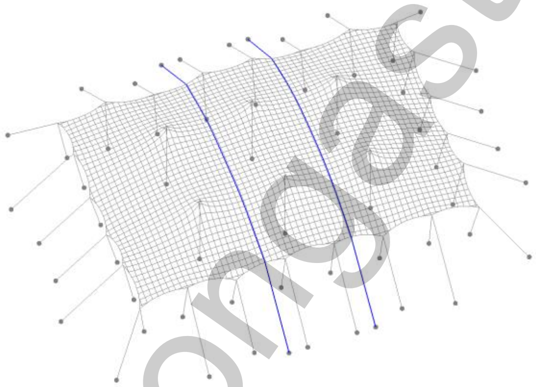
Tension belt corner

Length		Load combination	F_{rep}	Pag.
Tension belt		CO1. Own weight + pretension	0.26 kN	54
	Max	CO2. Own weight + pretension + wind suction	3.59 kN	57
		CO3. Own weight + pretension + wind pressure	1.86 kN	59
		CO4. Own weight + pretension + conventional	1.18 kN	61
Tension belt corner		CO1. Own weight + pretension	0.53 kN	54
	Max	CO2. Own weight + pretension + wind suction	3.34 kN	57
		CO3. Own weight + pretension + wind pressure	2.16 kN	59
		CO4. Own weight + pretension + conventional	1.57 kN	61

Table 13: Leading forces guy ropes

Remark: In the model one tension belt is accounted for at the corners. In reality there will be two.

H.5.2.5 Storm belts



	Load combination	F_{rep}	Pag.
Max	CO2. Own weight + pretension + wind suction	6.96 kN	57

Table 14: Leading forces reinforcements

H.6. Check elements

H.6.1 Membrane

Load combination	Element	Representative stress	Design value stress	Pag.
CO2. Own weight + pretension + wind suction	Membrane Short term load -Triflexx -	3.78 kN/m	5.67 kN/m (γ = 1.5)	28
CO2. RED Own weight + pretension + wind suction	Membrane Short term load -Proflexx -	2.80 kN/m	4.20 kN/m (γ = 1.5)	28

PES – PU/PVC, Triflexx or Proflexx fabric is used.

UC.1	**Triflexx**	**Pw = 500 N/m²**	**S_{Ed} / S_{rd} < 1**	**5.67 / 6.34 = 0.89 < 1**	**OK**
UC.2	**Proflexx**	**Pw = 355 N/m²**	**S_{Ed} / S_{rd} < 1**	**4.20 / 4.00 = 1.05 ≈ 1**	**ACCEPTABLE**

For the capacity of the membrane, see H.2.1.1- page 19

H.6.2 Center pole

Load combinations	Element	Representative force	Design value force	Pag.
CO3. Own weight + pretension + wind pressure	Center pole 4.0m	-3.49 kN	-5.24 kN (γ = 1.5)	29

Profile = CHS Ø60 x 3.1 mm
Length = ≤ 4m
Quality = EN AW-6061 T6 (EP)

The poles are considered as hinged poles; the buckling length is equivalent to the pole length.

UC.3	**Interaction (NM)**	**Pw = 500 N/m²**	**4.0m**	$\left(\frac{N_{ed}}{\chi\omega N_{rd}}\right)^{0.8} = \left(\frac{5.24}{0.069\times1\times120.9}\right)^{0.8} = 0.69 < 1$	**OK**

See Annex C.1 for elaborate check

H.6.3 Perimeter pole

Load combinations	Element	Representative force	Design value force	Pag.
CO3. Own weight + pretension + wind pressure	Perimeter pole 2.7m	-2.01 kN	-3.02 kN (γ = 1.5)	29
CO3. Own weight + pretension + wind pressure	Perimeter pole 2.2m	-1.15 kN	-1.73 kN (γ = 1.5)	29

Profile = CHS Ø40 x 2mm
Length = ≤ 2.7m
Quality = EN AW-6061 T6 (EP)

The poles are considered as hinged poles; the buckling length is equivalent to the pole length.

UC.4	**Interaction (NM)**	**Pw = 500 N/m²**	**2.7m**	$\left(\frac{N_{ed}}{\chi\omega N_{rd}}\right)^{0.8} = \left(\frac{3.02}{0.068\times1\times52.09}\right)^{0.8} = 0.88 < 1$	**OK**

See Annex C.2 for elaborate check

UC.5	**Interaction (NM)**	**Pw = 500 N/m²**	**2.2m**	$\left(\frac{N_{ed}}{\chi\omega N_{rd}}\right)^{0.8} = \left(\frac{1.73}{0.101\times1\times52.09}\right)^{0.8} = 0.41 < 1$	**OK**

See Annex C.3 for elaborate check

H.6.4 Guy rope / Tension belt

Load combination	Element	Representative force	Design value force	Pag.
CO2. Own weight + pretension + wind suction	Tension belt	3.59 kN	5.39 kN (γ = 1.5)	30
CO2. Own weight + pretension + wind suction	Tension belt corner	3.34 / √2 = 2.36 kN *	3.54 kN (γ = 1.5)	30

* Remark: In the model one tension belt is accounted for at the corners. In reality there will be two.

The tension belts have a minimum breaking strength of 1200 kg.

UC.7	**Tension belt**	**Pw = 500 N/m²**	**F_d / F_{rd} < 1**	**5.39 / 6.0 = 0.90 < 1.0**	**OK**

For the capacity of the belt, see H.2.1.2- page 19

For a reduced wind pressure of 345 N/m² the minimal needed breaking strength is:
α x Fd x γm1 = 0.69 x 5.39 x 2.0 = 7.44 kN ≈ 750 kg

H.6.5 Storm belt

Load combination	Element	Representative force	Design value force	Pag.
CO2. Own weight + pretension + wind suction	Storm belt	6.96 kN	10.44 kN (γ = 1.5)	30

The storm belts have a minimum breaking strength of 2000 kg:

UC.8	**Storm belt**	**Pw = 500 N/m²**	**F_d / F_{rd} < 1**	**10.44 / 10.00 = 1.04 ≈ 1.0**	**ACCEPTABLE**

For the capacity of the storm belts, see H.2.1.2- page 19

For a reduced wind pressure of 345 N/m² the minimal needed breaking strength is:
α x Fd x γm1 = 0.69 x 10.44 x 2.0 = 14.41 kN ≈ 1450 kg

H.6.6 Fabric clamp

Load combination	Element	Representative force	Design value force	Pag.
CO2. Own weight + pretension + wind suction	Tension belt	3.59 kN	5.39 kN (γ = 1.5)	30
CO2. Own weight + pretension + wind suction	Tension belt corner	3.34 / √2 = 2.36 kN *	3.54 kN (γ = 1.5)	30

Results tensile tests clamps:

Average tensile strength	Ftm:		= 4675 N	(see Annex D)
Design value capacity	Frd = Ftk =	0.8 x 4675	= 3740 N	(Eq. 10, EN 13782)

For a reduced wind pressure of 345 N/m² the design value force is:
Fd,red = α x Fd = 0.69 x 5.39 = 3.72 kN = 372 kg

UC.9	**Fabric clamp**	**Pw = 345 N/m²**	**$F_{d,red}$ / F_{rd} < 1**	**3.72/ 3.74 = 0.99 < 1.0**	**OK**

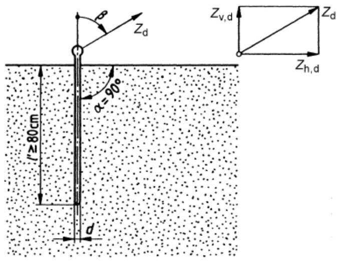
For a pressure of 500 N/m² the minimal needed average tensile strength is:
Ftm = Ftk / 0.8 = 5.39 / 0.8 = 6.74 kN = 674 kg

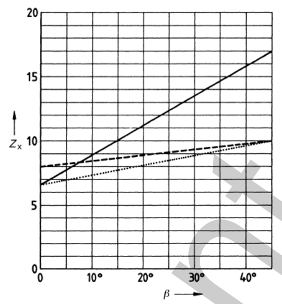
UC.10	**Fabric clamp**	**Pw = 500 N/m²**	**$F_{d,red}$ / F_{rd} < 1**	**5.39/ (0.8 x 6.74) = 1.0**	**OK**

H.7. Safety against overturning, sliding and uplifting

H.7.1 Capacity anchor

Anchors of 25x25x750mm (T-profile) are used, taking into account an effective length of at least 700mm. For a reduced wind load, however, an effective length of 500mm is sufficient.





Angle of pull	Load bearing capacity N
$\beta = 0$	Z_d = 6,5 dl' for stiff cohesive and for dense cohesion less soils
$\beta = 0$	Z_d = 8 dl' for very stiff cohesive soils
$\beta \geq 45$	Z_d = 10 dl' for cohesive soils of at least medium to stiff consistency
$\beta \geq 45$	Z_d = 17 dl' for dense cohesion less soils
$0 < \beta < 45$	The load bearing capacity for the soil types shall be determined by interpolation

Z_d is the anchor service load (service load), in N;

$Z_{h,d}$ is the horizontal anchor service load, in N;

$Z_{v,d}$ is the vertical anchor service load, in N;

d is the anchor diameter, in cm;

l' is the depth of penetration in cm;

α is the angle of penetration;

ß is the angle of acting tensile force to the vertical

Figure 4: Taken from NEN-EN 13782: Figures 4 & 5, table 5

		T-profile 25x25x750mm		T-profile 25x25x550mm	
Angle	ß	≥ 45	°	≥ 45	°
Effective length anchor	L'	70	cm	50	cm
Diameter anchor	d	3.54	cm	3.54	cm
Anchor capacity*	Zd	4.21	kN	3.01	kN

*Calculated under the assumption the anchor is based in dense cohesion less soil.

H.7.2 Required anchor pins

Load combination	Element	Representative force	Design value force	Pag.
CO4. Own weight + pretension + wind suction	Tension belt	3.59 kN	4.31 kN (γ = 1.2)	30
CO3. Own weight + pretension + wind suction	Tension belt corner	3.34 / √2 = 2.36 kN *	2.83 kN (γ = 1.2)	30
CO3. Own weight + pretension + wind suction	Storm belt	6.96 kN	8.35 kN (γ = 1.2)	30

* Remark: In the model one tension belt is accounted for at the corners. In reality there will be two.

Anchoring T-profile 25x25x750 mm

Tension belt	**Pw = 500 N/m²**	**F_d / F_{rd}**	**4.31 / 4.21 = 1.02**	**1 anchor / tension**
Tension belt corner	**Pw = 500 N/m²**	**F_d / F_{rd}**	**2.83 / 4.21 = 0.67**	**1 anchor/ tension belt**
Storm belt	**Pw = 500 N/m²**	**F_d / F_{rd}**	**8.35 / 4.21 = 1.98**	**2 anchors / side of the storm belt**

For a reduced wind pressure of 345 N/m2 the design values of the anchor forces are equal to:
Tension belt: Fd,red = α x Fd = 0.69 x 4.31 = 2.97 kN
Tension belt corner: Fd,red = α x Fd = 0.69 x 2.83 = 1.95 kN
Storm belt: Fd,red = α x Fd = 0.69 x 8.35 = 5.76 kN

Anchoring T-profile 25x25x550 mm

Tension belt	**Pw = 345 N/m²**	**F_d / F_{rd}**	**2.97 / 3.01 = 0.99**	**1 anchor / tension**
Tension belt corner	**Pw = 345 N/m²**	**F_d / F_{rd}**	**1.95 / 3.01 = 0.65**	**1 anchor/ tension belt**
Storm belt	**Pw = 345 N/m²**	**F_d / F_{rd}**	**5.76 / 3.01 = 1.91**	**2 anchors / side of the storm belt**

H.7.3 Anchor tests according to EN 13782

It is advised to conduct anchor tests on site.

Anchor tests should be carried out according to the following procedure:
Three anchors spread throughout the terrain should be put perpendicular into the ground. The anchors should be pulled out with the aid of a spring balance in the direction of the force acting on the anchor. The highest occurring force should be noted. The deformation of the anchor cannot be so high that the structure might become unstable or stresses become too large. The lowest of the three measured values should be used as the permissible value.

A partial safety factor of $\gamma = 1.6$ is to be applied on the ultimate limit load of the lowest test value in order to determine the load bearing capacity of the anchor.

For example:
Force in belts: Frep = 16.2 kN
Fsd_{belt} = 1.2 x Frep = 1.2 x 16.2 = 19.4 kN

The partial safety factor $\gamma = 1.6$ is applied on the ultimate limit load:
$Z_{u,d,test}$ > 1.6 x Fsd = 1.6 x 19.4 =31.1 kN

If for example the anchor test point out there has a minimal anchor capacity of 16 kN (1600 kg), then 2 anchors are needed: 2x16 = 32 kN > $Z_{u,d,test}$

I. Material specifications

Membrane – Technical data: Triflexx

ENDUTEX - REVESTIMENTOS TEXTEIS, SA

VIZELA / PORTUGAL

Test Results

REFERENCE: **TP 5252/A FR**

DESCRIPTION : PVC/PU DOUBLE COATED POLYESTER FABRIC

COMPOSITION : 29 % PVC
23 % PU
48 % POLYESTER

WIDTH : 220 cm

CHARACTERISTIC	RESULTS	METHOD
THICKNESS (mm)	0.61	
TOTAL MASS (g/m^2)	443	EN ISO 2286-2
FABRIC MASS (g/m^2)	196	EN ISO 2286-2
BREAKING LOAD (daN/50mm)	L.: 101.8 T.: 63.4	EN ISO 1421
BREAKING EXTENSION (%)	L.: 113 T.: 152	EN ISO 1421
BREAKING EXTENSION, 50N (%)	L.: 10 T.: 19	EN ISO 1421
TEAR STRENGTH (daN)	L.: 3.5 T.: 4.6	EN ISO 4674-1B
COATING ADHESION (daN/50mm)	3.2	EN ISO 2411

L - Along
T - Across

Date	QUALITY CONTROL
2015.10.22	Célia Sousa

Doc. 0044/DF.0

TEN TECH

Membrane – Technical data: Proflexx

COTTING

PROVISIONAL TECHNICAL DATASHEET 02

Quality **KROKUS INRY M2 (220)** **KROKU019**

Date	**5/05/2014**				
Backing	**100% Polyester**				
Coating	**100% PVC**				
Composition	**Coating**		400	g/m²	
	Backing		130	g/m²	
	Total		530	g/m²	± 25 g/m²
Tensile strength	**ISO 1421 1998**	length	>60	daN/ 5 cm	
		width	>40	daN/ 5 cm	
Tear strength	**ISO 4674-01 2003**	length	>3,5	daN	
		width	>2,8	daN	
Seam resistance	**ISO 13936-1 2004**	length	>26	daN/ 5cm	
		width	>26	daN/ 5cm	
% Elongation under 30N/5cm		length	>5	%	
		width	>8	%	
Coating to fabric adhesion	**ISO 2411 2000**		>2	daN/ 5cm	
Flex resistance	**ISO 5402 1:2003**	no quality loss after 200000			
Hydrostatic head	**ISO 1420 1978**		>200 cm Tight to house dust mites		
Colour fastness to light	**EN ISO 105 B02 1994**		>6		Servaco R201307360 (26/09/2013)
Flame retardancy	**NF P92-503 : 1995**		M2		**Engaged in testing**
Antibacterial	**Sanitized Clariant Benelux (Valid licence available)** active ingredient = zinc pyrithione According to the Biocidal Products Regulation (EU) No 528/2012, it's mandatory to communicate this to your customers				

plastibert
coated textiles

PLASTIBERT
Molenstraat 207 - BE - 8710 Wielsbeke - Belgium
Tel. : +32(0)56 66 52 75 - Fax. : +32(0)56 66 41 30
Email : info@plastibert.be - www.plastibert.be
KBC Bank : 446-7145101-92 - IBAN BE 12 4667 1451 0192 - BIC : KRED BE BB
BTW BE 0405.435.551 - RPR 0405.435.551
Ger.Arr. Kortrijk

ISO 9001 CERTIFIED

1

COTTING

Cleaning

We recommend to clean this article with water and soap only. Cleaning products containing alcohol, solvent, bleach or abrasive products can damage this product.

Disinfecting

On request a list of approved disinfectants can be sent. Plastibert takes no responsability for damage if other products are used.

Care ISO/FDIS 3758:2005

95

Shrinkage after washing:	< 6%

Antimicrobial effect can be reduced by washing
Alcohol in high concentrations might damage this article.

Other

This article is HF weldable, this should however be tested on your equipment.

Remarks

All the specifications given in this document have been tested in accredited laboratories or in our own laboratory using officially calibrated measuring equipment.

This datasheet is valid for five years after the date of publication. However, we guarantee that the item has been produced with the same ingredients and ISO-9000 procedures were strictly complied with. In the event that any modifications may have been applied during this period, all the properties were retested.

The items delivered comply with the specifications stated in this datasheet. In principle, we do not guarantee properties or characteristics that are not included in it.

Slight colour variations between deliveries are possible. We recommend that you always process items from different deliveries separately.
This item complies with the most recent REACH specifications.

IMPORTANT

This datasheet is provisional, which means we that up to now did not make enough productions to be certain of all values. Therefore we still cannot guarantee all numerical data.

APPROVAL : CEO

plastibert coated textiles

PLASTIBERT
Molenstraat 207 - BE - 8710 Wielsbeke - Belgium
Tel. : +32(0)56 66 52 75 - Fax. : +32(0)56 66 41 30
Email : info@plastibert.be - www.plastibert.be
KBC Bank : 446-7145101-92 - IBAN BE 12 4667 1451 0192 - BIC : KRED BE BB
BTW BE 0405.435.551 - RPR 0405.435.551
Ger.Arr. Kortrijk

CERTIFIED ISO 9001 CERTIFIED

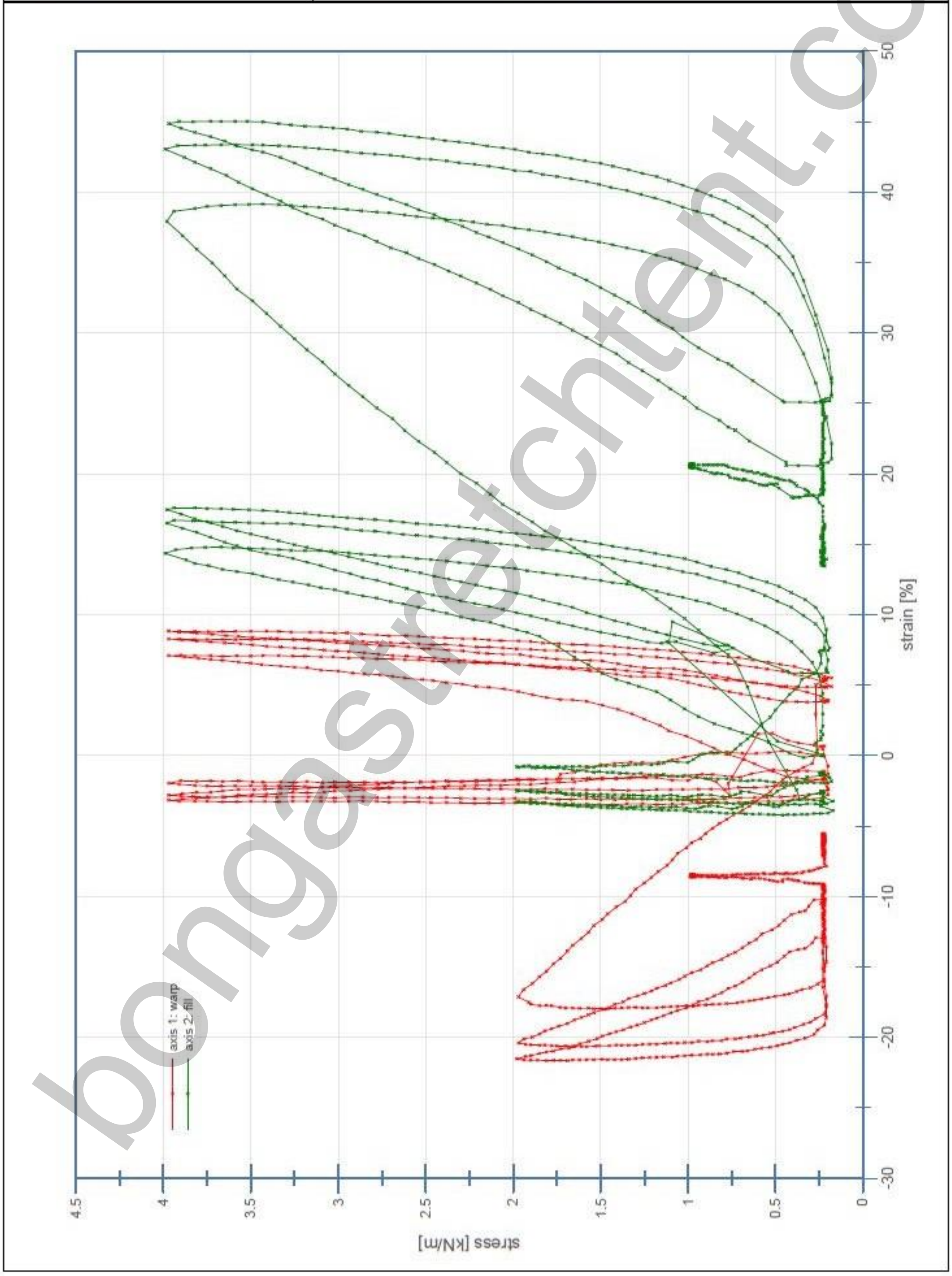
Membrane – Bi-axial test: Triflexx

UNIVERSITÄT DUISBURG ESSEN
Open-Minded

Fakultät für Ingenieurwissenschaften - Abteilung Bauwissenschaften
Institut für Metall- und Leichtbau
Essener Labor für Leichte Flächentragwerke - ELLF
D-45141 Essen, Universitätsstr. 15, Tel.: +49 201 183-4223, Fax: -4276

Stress-strain diagram to biaxial tensile test

Test: TENT2616	Material: Trieflexx (alias TP 5252/A FR)



TEN TECH

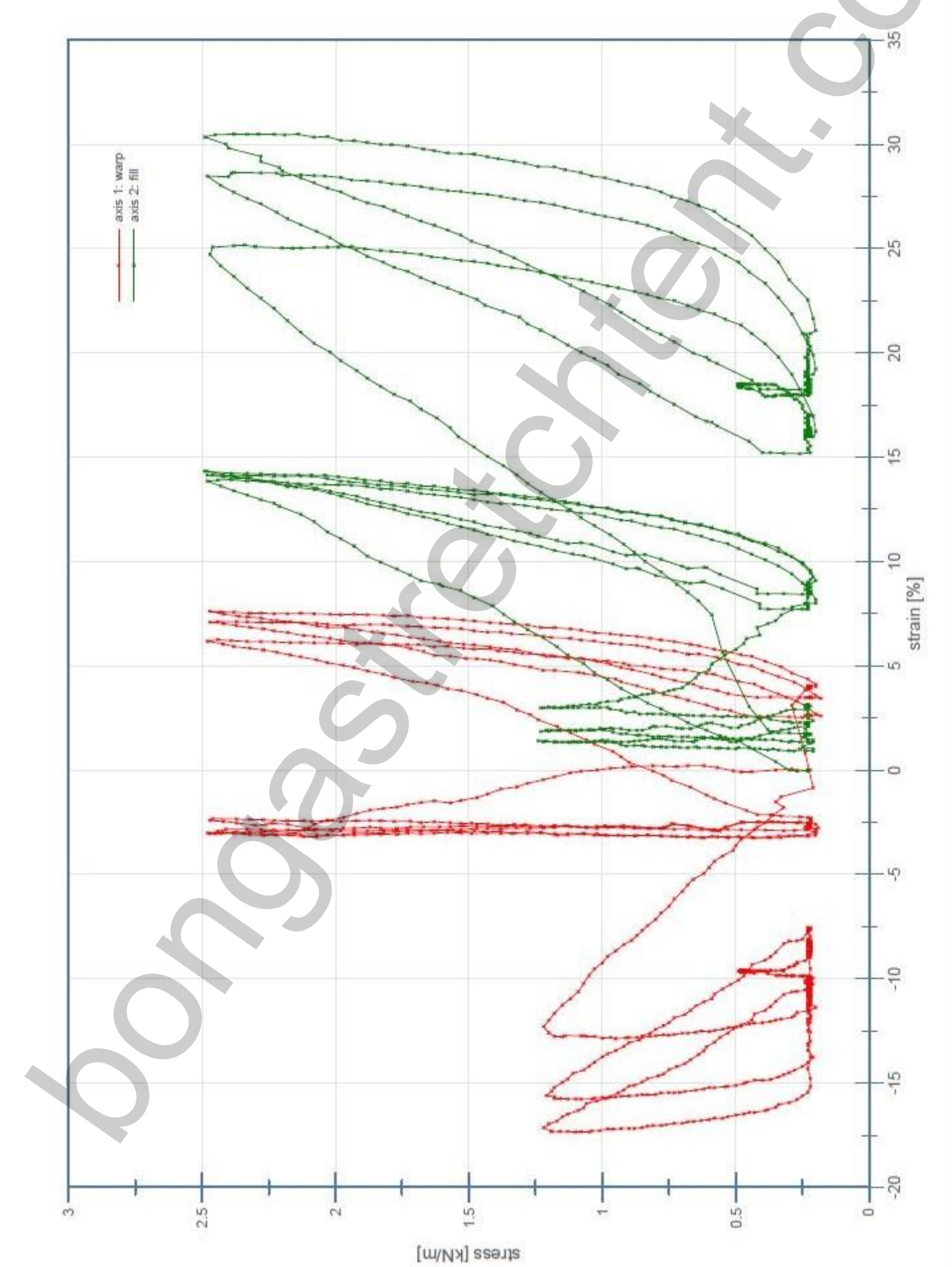
Membrane – Bi-axial test: Proflexx

UNIVERSITÄT DUISBURG ESSEN
Open-Minded

Fakultät für Ingenieurwissenschaften - Abteilung Bauwissenschaften
Institut für Metall- und Leichtbau
Essener Labor für Leichte Flächentragwerke - ELLF
D-45141 Essen, Universitätsstr. 15, Tel.: +49 201 183-4223, Fax: -4276

Stress-strain diagram to biaxial tensile test

Test: TENT1616	Material: Proflexx (alias Krokus Inry M2)



TEN TECH

Membrane – Fire certificate: Triflexx

IPAC acreditação L0254 Ensaios

ilac-MRA

LFF - Laboratório de Fumo e Fogo
Test Report N. 31/LFF/16i

TEST REPORT

1 - Identification

Customer: [redacted]

Address: [redacted]

Request: Fire Reaction Classification According French Standards

Material: Two side coated fabric with reference [redacted]

Request Reference: Email

Request Date: 2016-09-14

Reception Date: 2016-09-15

Test Date: 2016-09-26

Report N.: 31/LFF/16i

2 - Scope

The tests reported concern the determination of the fire reaction class for a two side coated fabric with reference [redacted] to be used on tents for events.

inegi driving science & innovation

3 - Methodology

The tests were performed as indicated in the NF P 92-503 (electric burner) issued on December 1995. The classification method was applied according to the standard NF P 92-507 issued on February 2004.

4 - Specimens

The specimens were prepared in this laboratory from a sample supplied by the customer and had the following dimensions:

Specimen	Length (mm)	Width (mm)	Thickness (mm)	Mass (g)
31/LFF/16i/01	600	182	0.7	60.4
31/LFF/16i/02	599	181	0.7	59.9
31/LFF/16i/03	601	182	0.7	60.2
31/LFF/16i/04	602	184	0.7	60.7
31/LFF/16i/05	604	181	0.7	60.5
31/LFF/16i/06	603	181	0.7	60.6
31/LFF/16i/07	603	182	0.7	59.5

Before being tested the specimens were conditioned for a period of 261 hours at 23 ± 2 °C and 50 ± 5 % relative humidity.

5 - Results and classification

Exploratory tests were performed on both faces of the material and it was found that the face 1 had worst fire reaction performance.

The tests performed on the electric burner with face 1 facing the burner and longitudinal direction, produced the following results:

Specimen	31/LFF/16i/02			31/LFF/16i/05			31/LFF/16i/06			31/LFF/16i/07		
Time of igniter actuation	B	E	D	B	E	D	B	E	D	B	E	D
20 " - 25 "	20	197	172	20	195	170	20	242	217	20	218	193
45 " - 50 "	---	---	---	---	---	---	---	---	---	---	---	---
1' 15 " - 1' 20 "	---	---	---	---	---	---	---	---	---	---	---	---
1' 45 " - 1' 50 "	---	---	---	---	---	---	---	---	---	---	---	---
2' 15 " - 2' 20 "	---	---	---	---	---	---	---	---	---	---	---	---
2' 45 " - 2' 50"	---	---	---	---	---	---	---	---	---	---	---	---
3' 15 " - 3' 20 "	---	---	---	---	---	---	---	---	---	---	---	---
3' 45 " - 3' 50 "	---	---	---	---	---	---	---	---	---	---	---	---
4' 15" - 4' 20 "	---	---	---	---	---	---	---	---	---	---	---	---
4' 45 " - 4' 50 "	---	---	---	---	---	---	---	---	---	---	---	---
Length burnt (mm)	338			333			305			318		
Width burnt (mm)	164			169			177			170		
Time of max. inflammation (s)	172			170			217			193		
Average length burnt (mm)							324					
Average width burnt (mm)							170					

B – Beginning of inflammation; E – End of inflammation; D – Duration of inflammation;

<u>In view of whole results the material must be classified as **M2.**</u>

6 - Complementary observations

During the accomplishment of the tests it was observed abundant release of gray smoke.

Porto, September 27, 2016

Responsible for testing

João Alcino Rodrigues

Technical Director of the Laboratory

inegi LFF – Laboratório de Fumo e Fogo

João Alcino Rodrigues

Membrane – Fire certificate: Proflexx

Report number: P2014-303205-010D

INDEPENDENT TEST LABORATORY
TEXTILE LAB
TESTING RESEARCH CONSULTING

Tentations bvba
Pieter Van Vynckstraat 19
9032 Gent
België

Hengelo (ov), 14-7-2014

Test specimen:	Specimen:	Colour:	Client reference number:
	A	pink	Proflexx fabric for Bonga strechtent Composition : 74 % PVC + 7 % PU + 19 % PES

Examination:	Test number:	Test name:
	1.	Reaction fire tests used for flexible materials (NF P 92-503).

Results See following pages

Laboratory Quality Control

Testing • Research • Development • Consultancy

Textile Lab, Generatorstraat 26, 7556RC Hengelo (ov), The Netherlands, Tel: +31(0)74-2491005, email: info@textilelab.nl
Chamber of commerce: 08098059, VAT nr.: 8100.03.983.B.01, Bank account; BIC/SWIFT: SNSBNL2A, IBAN: NL62SNSB0907446167

TEN TECH

Report number: P2014-303205-010D

INDEPENDENT TEST LABORATORY
TEXTILE LAB
TESTING RESEARCH CONSULTING

Test : **1. Reaction fire tests used for flexible materials.**

Norm : NF P 92-503 (1995)
Apparatus : Electrical burner.

- Thickness of the specimens ≤ 5 mm.
- The specimens were not washed and not submitted to an accelerated ageing.
- Tested specimens: two in length direction and three in breadth direction.
- Only the front face (colour face) was tested.

Results test 1 specimen:	Length direction		Breadth direction		
A.					
Test specimen nr	1.	2.	1.	2.	
Appearance of a hole	No	No	No	No	
Maximum combustion time (s)	2'13"	1'55"	<5sec	<5sec	
Incandescent point	No	No	No	No	
Burned length (cm)	38	34	-	-	
Burned breadth (cm) (in zone > 45 cm)	-	-	-	-	
Not-burned drops and parts	No	No	No	No	
Burned drops and parts	No	No	No	No	

2. **Classification in function of FD P 92-507 (1997)**

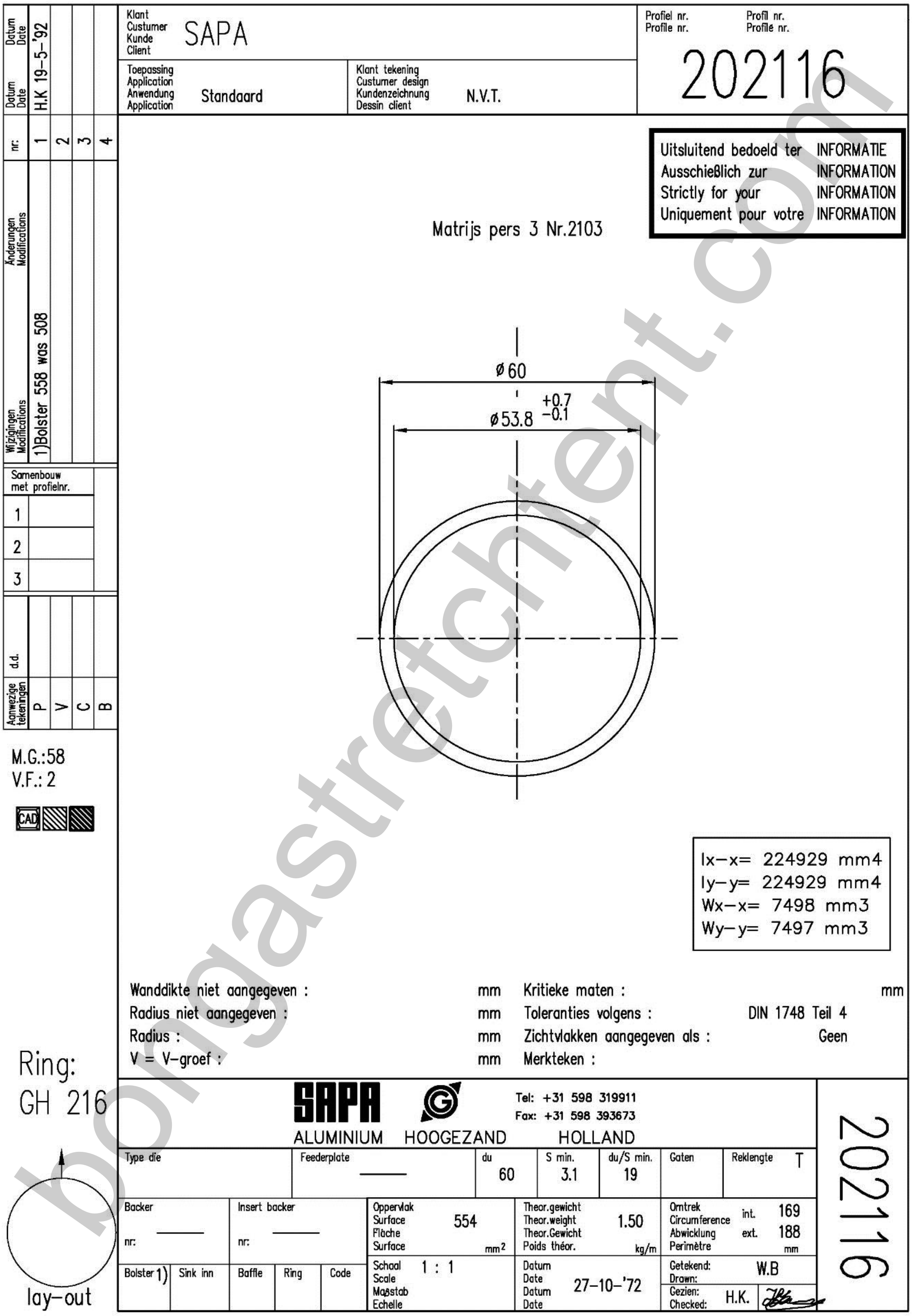
After testing in according to the standards NF P 92-503, the sample is classified as M2.

Laboratory Quality Control

Testing • Research • Development • Consultancy

Textile Lab, Generatorstraat 26, 7556RC Hengelo (ov), The Netherlands, Tel: +31(0)74-2491005, email: info@textilelab.nl
Chamber of commerce: 08098059, VAT nr.: 8100.03.983.B.01, Bank account; BIC/SWIFT: SNSBNL2A, IBAN: NL62SNSB0907446167

Poles – Cross section data



Datum	nr:	Wijzigingen
01-07-'04 H.A	1	1)Vanaf nr.8, Matr.Ø320 x160 (SBNC)
	2	
	3	
	4	

Klant: SAPA

Toepassing: Standaard

Klant tekening nr.:

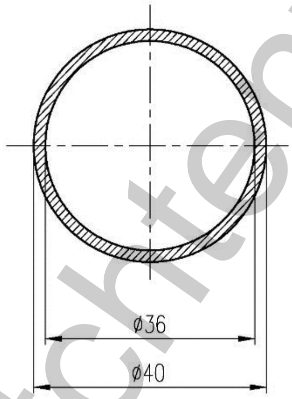
Profiel nr.: 202122

Uitsluitend bedoeld ter INFORMATIE
Ausschießlich zur INFORMATION
Strictly for your INFORMATION
Uniquement pour votre INFORMATION

Samenbouw met profielnr.

1	
2	
3	

Aanwezige tekeningen	d.d.
P	
V	
C	
B	



M.G.:83
V.F.: 2

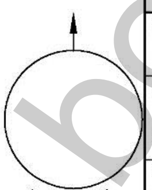
Was vroeger nr.2057

Ix-x= 43216 mm4
Iy-y= 43216 mm4
Wx-x= 2160 mm3
Wy-y= 2161 mm3

S = Snijpuntsmaat
Wanddikte niet aangegeven : mm
Radius niet aangegeven : mm
Radius : mm
V = V-groef : mm

Kritieke maten : mm
Toleranties volgens : DIN 1748 bl.4
Zichtvlakken aangegeven als : Geen
Merkteken :

Matrijsring: GH 216



lay-out

sapa Wij geven de toekomst **vorm**

Sapa Aluminium BV
Postadres **Postbus 102, 9600 AC Hoogezand**
Tel **0598-319911** Fax **0598-393673**

Die	Feederplate	du	S min.	du/S min.	Gaten	Reklengte
	——	40	2	20		T

Backer nr:	Insert backer nr:	Oppervlak	Theor.gewicht	Omtrek
——	——	239 mm²	0.65 kg/m	inw. 113, uitw. 126 mm

Bolster	Type	Baffle	Ring	Code	Schaal	Datum	Getekend:	Gezien:
					1 : 1	06-03-'91	K.K.Smit	H.K.

202122

J. Annexes

Annex A: Easy export of load cases

CO1. Own weight + pretension

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	EIGENGEWICHT	0.0053	1.00	0.0000	0.0000	-0.7971	150.40
SUM				0.0000	0.0000	-0.7971	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	EIGENGEWICHT	0.0000	0.0000	-0.7971
SUM	AREA-LOADS	0.0000	0.0000	-0.7971

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	-0.7971

CO2. Own weight + pretension + wind suction

Full wind 500 N/m^2

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	EIGENGEWICHT	0.0053	1.00	0.0000	0.0000	-0.7969	150.36
1	WIND	-0.3500	1.00	0.0000	0.0000	49.6866	150.36
SUM				0.0000	0.0000	48.8896	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	EIGENGEWICHT	0.0000	0.0000	-0.7969
SUM	WIND	0.0000	0.0000	49.6866
SUM	AREA-LOADS	0.0000	0.0000	48.8896

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	48.8896

Reduced wind 355 N/m^2 – factor 355 / 500 = 0.71

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	EIGENGEWICHT	0.0053	1.00	0.0000	0.0000	-0.7969	150.36
1	WIND	-0.3500	0.71	0.0000	0.0000	35.2775	150.36
SUM				0.0000	0.0000	34.4805	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	EIGENGEWICHT	0.0000	0.0000	-0.7969
SUM	WIND	0.0000	0.0000	35.2775
SUM	AREA-LOADS	0.0000	0.0000	34.4805

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	34.4805

CO3. Own weight + pretension + wind pressure

Full wind 500 N/m^2

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	EIGENGEWICHT	0.0053	1.00	0.0000	0.0000	-0.7971	150.40
1	WIND	0.1500	1.00	0.0000	0.0000	-21.3082	150.40
SUM				0.0000	0.0000	-22.1054	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	EIGENGEWICHT	0.0000	0.0000	-0.7971
SUM	WIND	0.0000	0.0000	-21.3082
SUM	AREA-LOADS	0.0000	0.0000	-22.1054

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	-22.1054

Reduced wind 355 N/m^2 – factor 355 / 500 = 0.71

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	EIGENGEWICHT	0.0053	1.00	0.0000	0.0000	-0.7971	150.40
1	WIND	0.1500	0.71	0.0000	0.0000	-15.1289	150.40
SUM				0.0000	0.0000	-15.9260	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	EIGENGEWICHT	0.0000	0.0000	-0.7971
SUM	WIND	0.0000	0.0000	-15.1289
SUM	AREA-LOADS	0.0000	0.0000	-15.9260

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	-15.9260

CO4. Own weight + pretension + conventional

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	SCHNEE	0.1000	1.00	0.0000	0.0000	-14.2055	142.05
1	EIGENGEWICHT	0.0053	1.00	0.0000	0.0000	-0.7971	150.40
SUM				0.0000	0.0000	-15.0026	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	SCHNEE	0.0000	0.0000	-14.2055
SUM	EIGENGEWICHT	0.0000	0.0000	-0.7971
SUM	AREA-LOADS	0.0000	0.0000	-15.0026

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

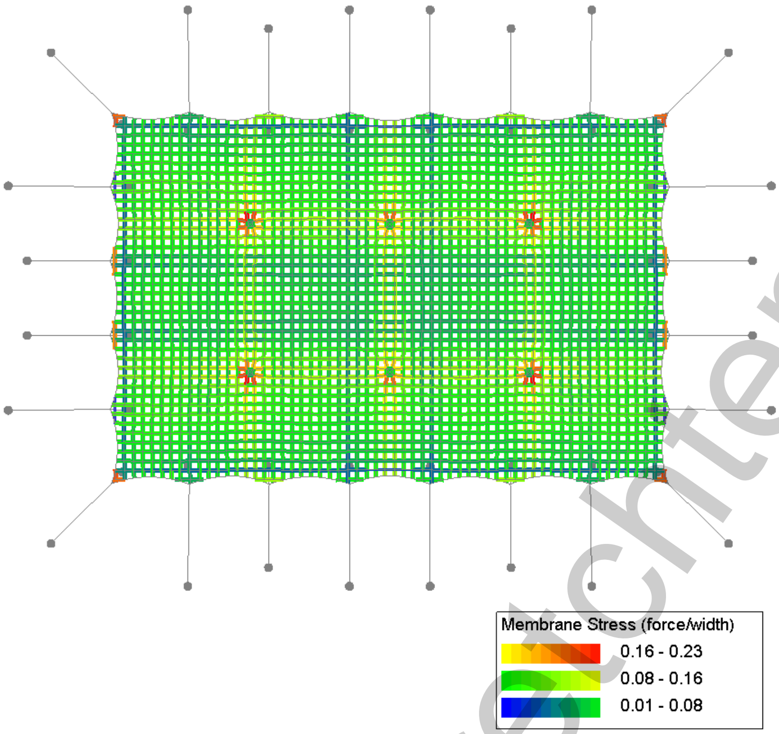
SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	-15.0026

Annex B: Internal forces per load combination

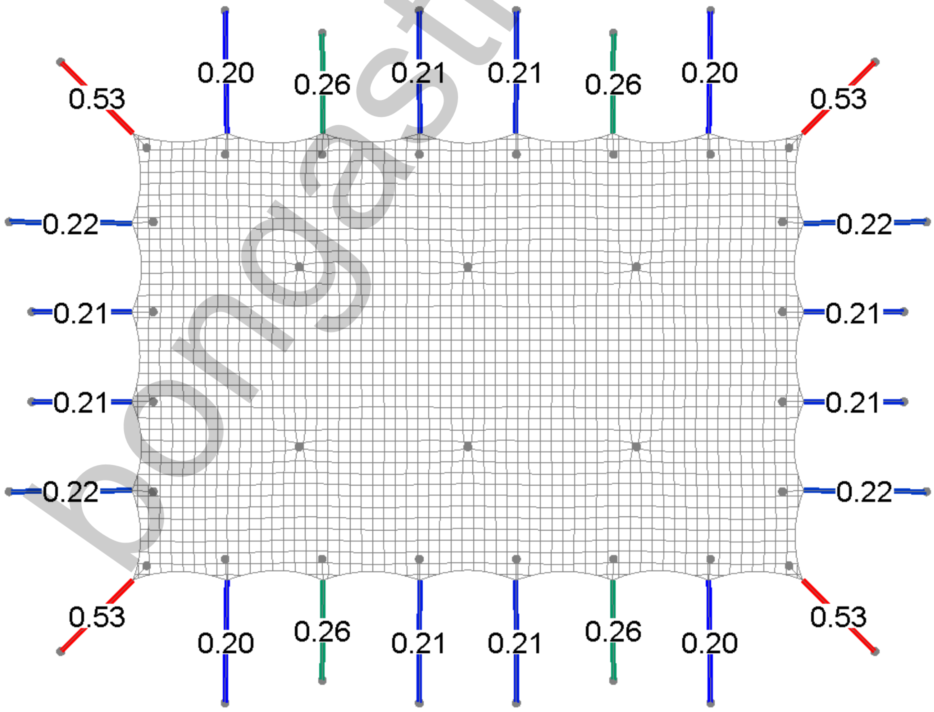
In the following paragraphs the results for a full wind pressure of p_w = 0.5 kN/m^2 are shown, unless indicated otherwise.

B.1. CO1. Own weight + pretension

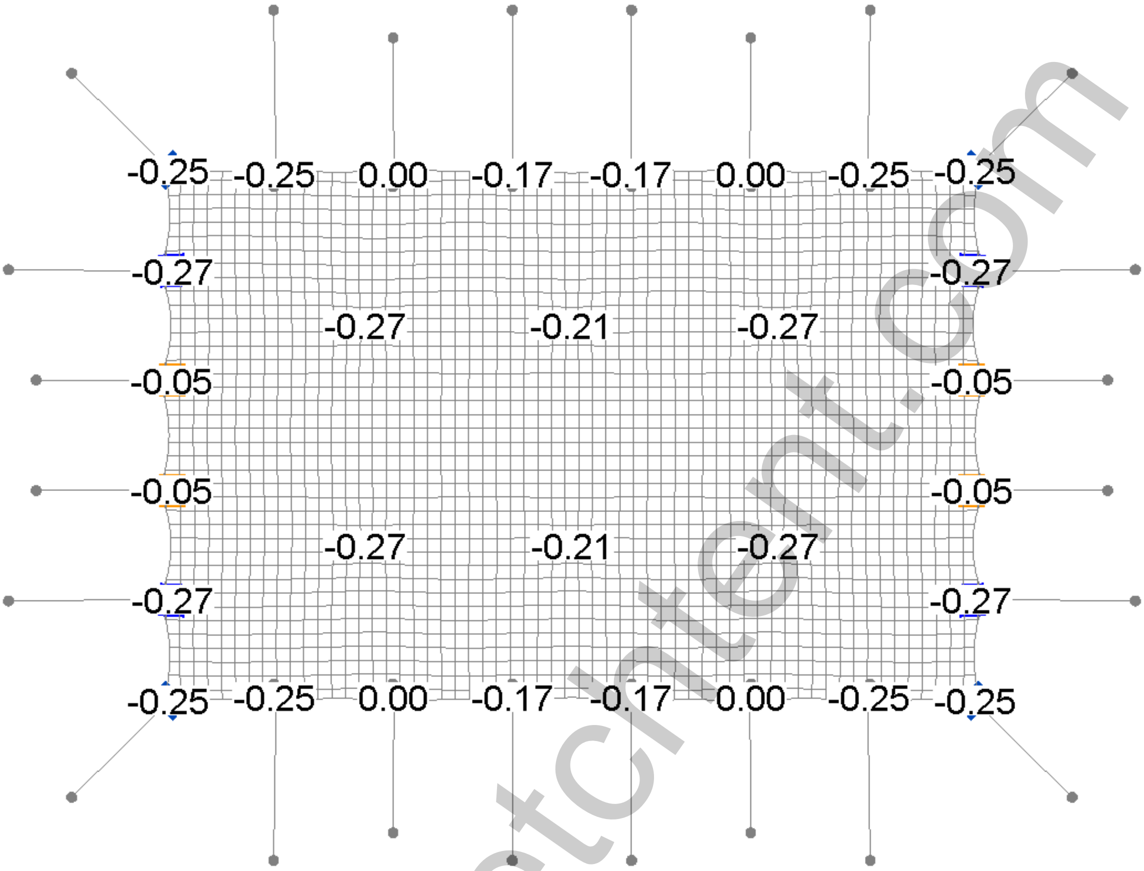
Stresses in the membrane



Forces in the tension belts



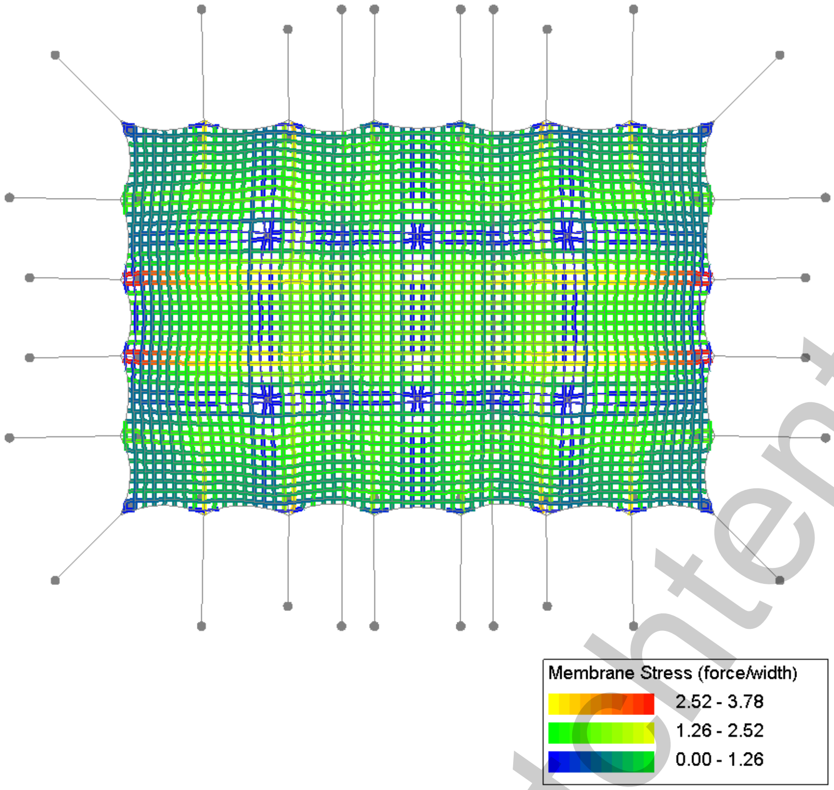
Forces in the poles



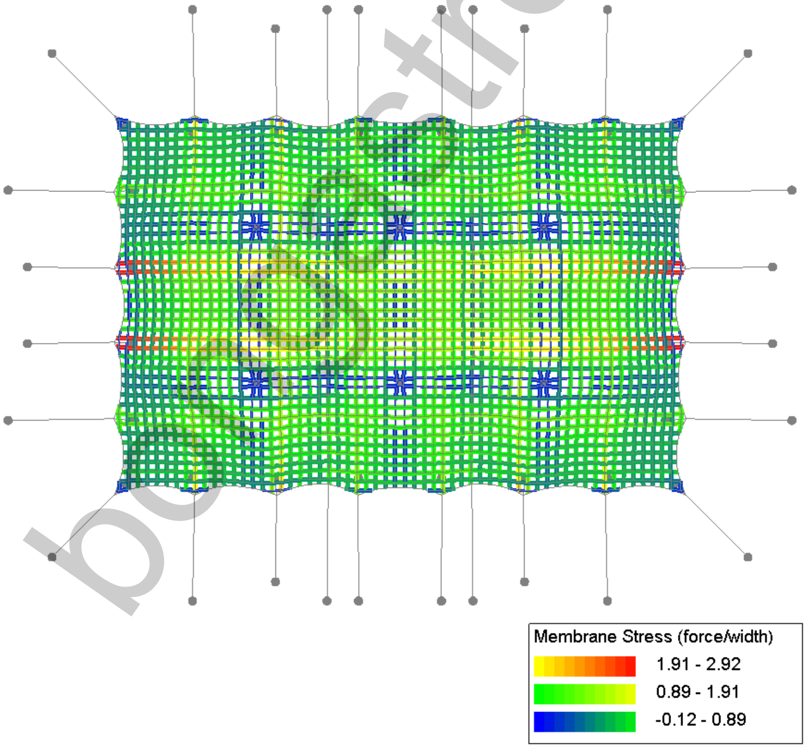
B.2. CO2. Own weight + pretension + wind suction

<u>Stresses in the membrane</u>

Full wind 500 N/m^2

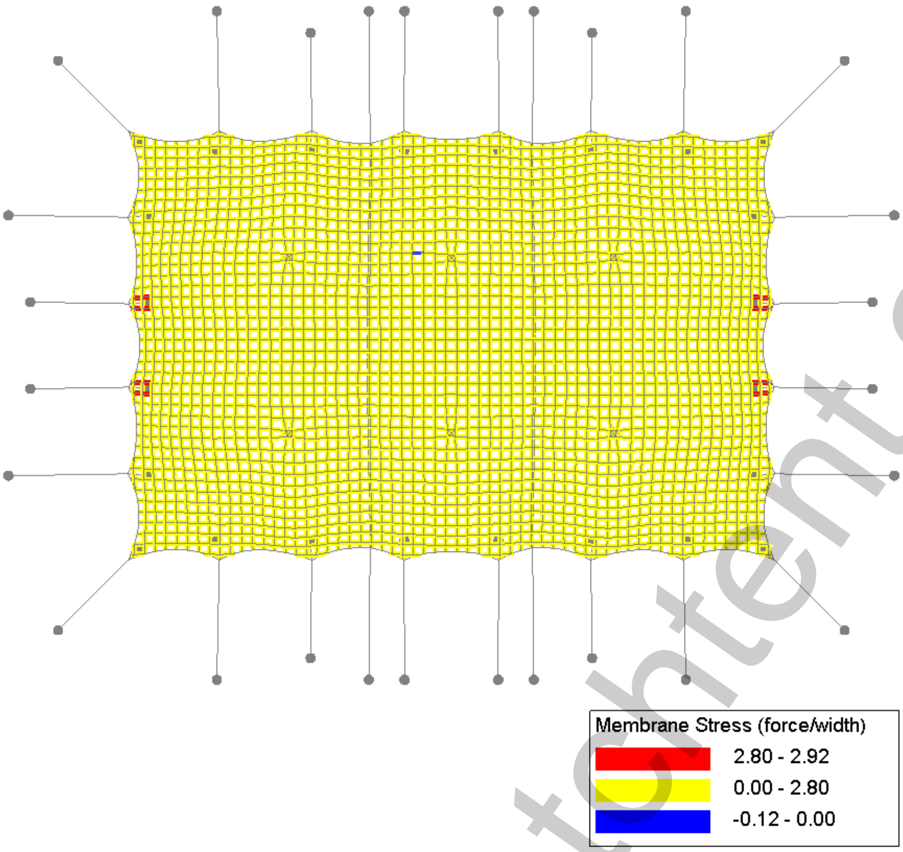


Reduced wind 355 N/m^2

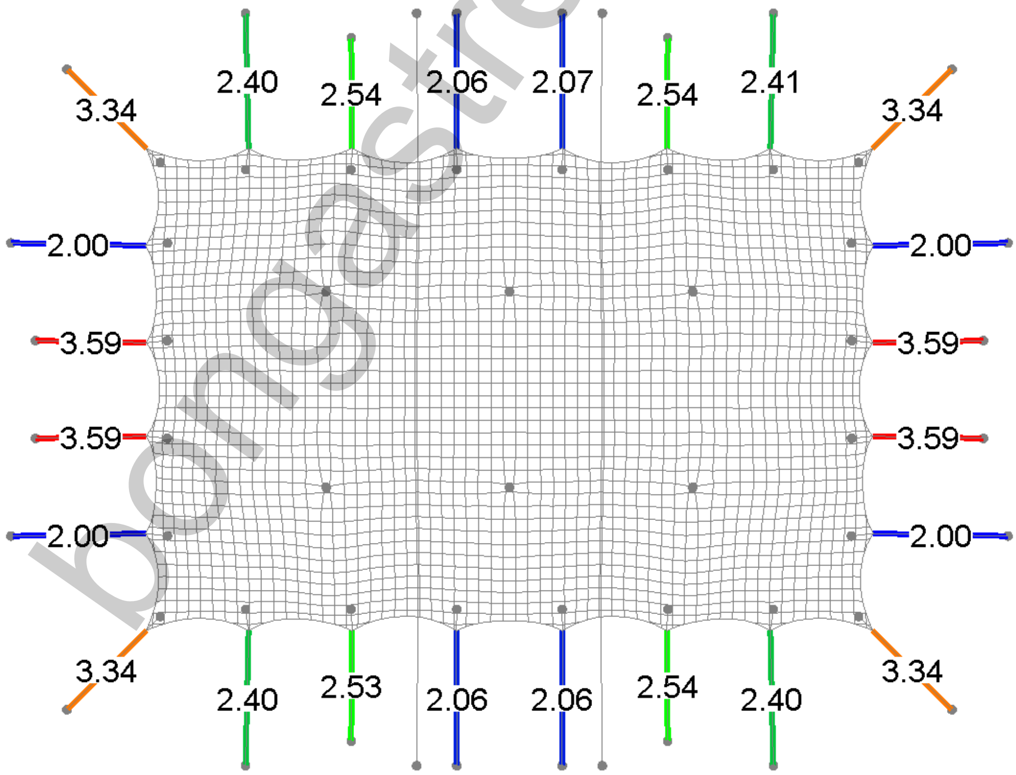


Stresses in the membrane > 2.85 kN/m

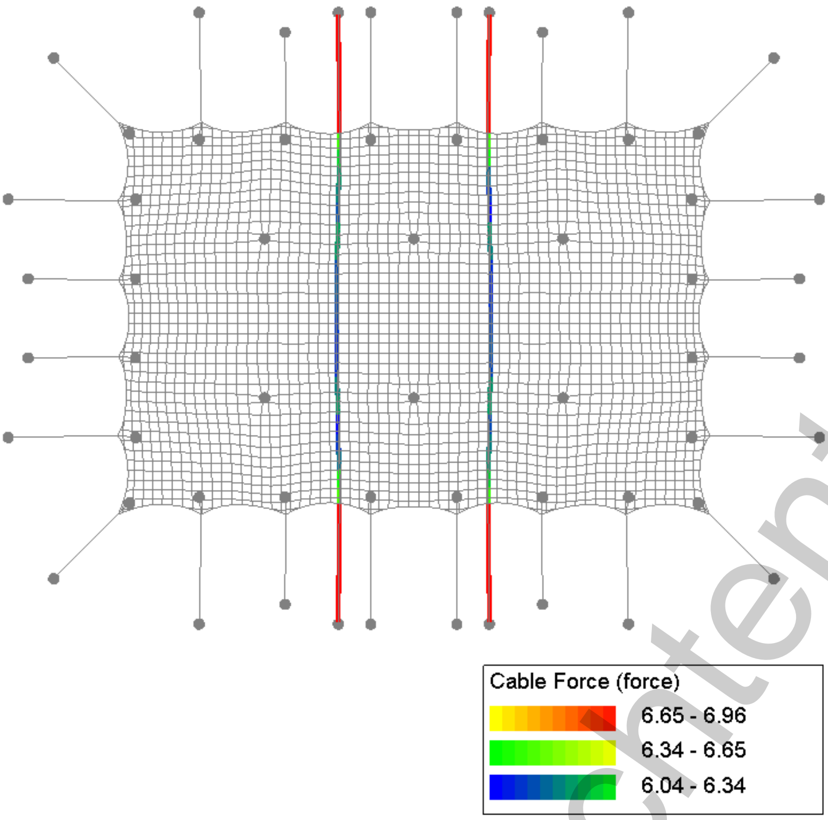
Reduced wind 355 N/m^2



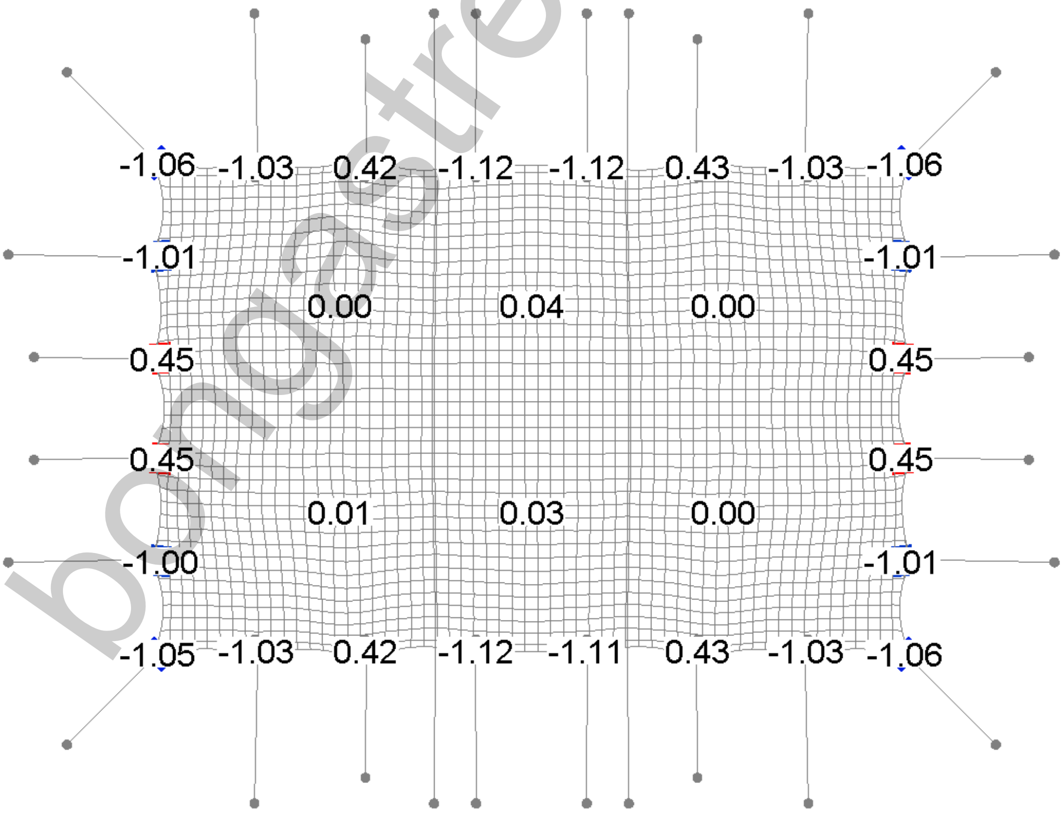
Forces in the tension belts



Forces in the storm belts

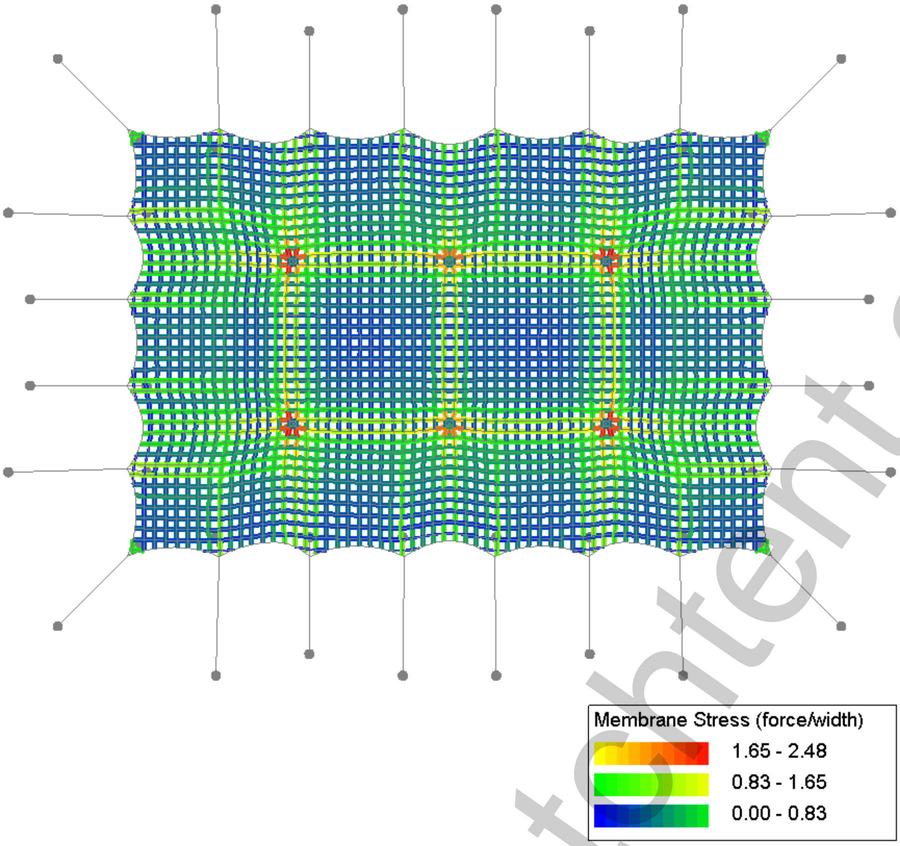


Force in the poles

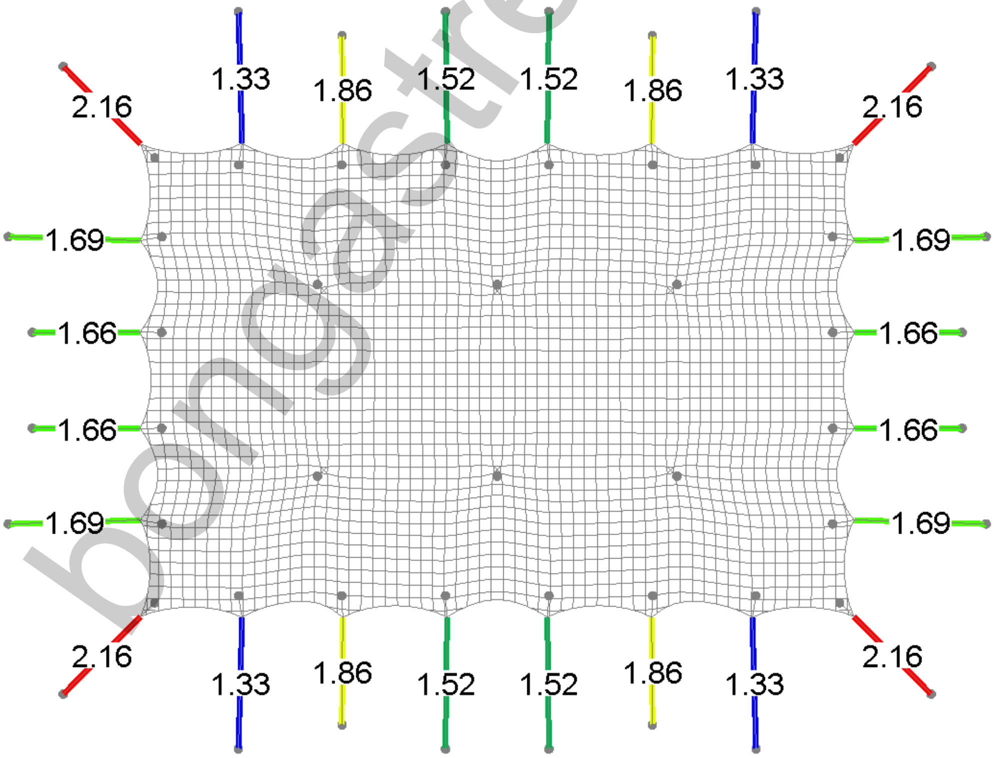


B.3. CO3. Own weight + pretension + wind pressure

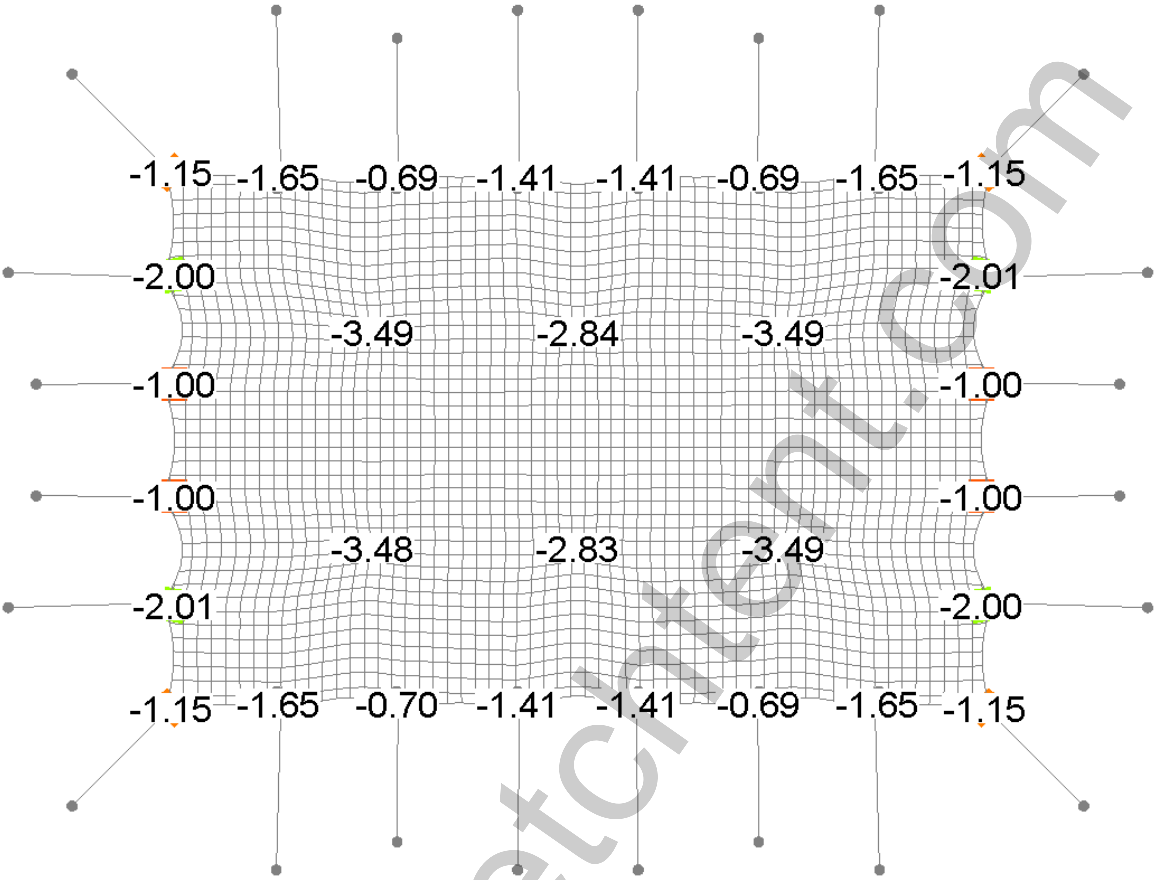
<u>Stresses in the membrane</u>



<u>Forces in the tension belts</u>

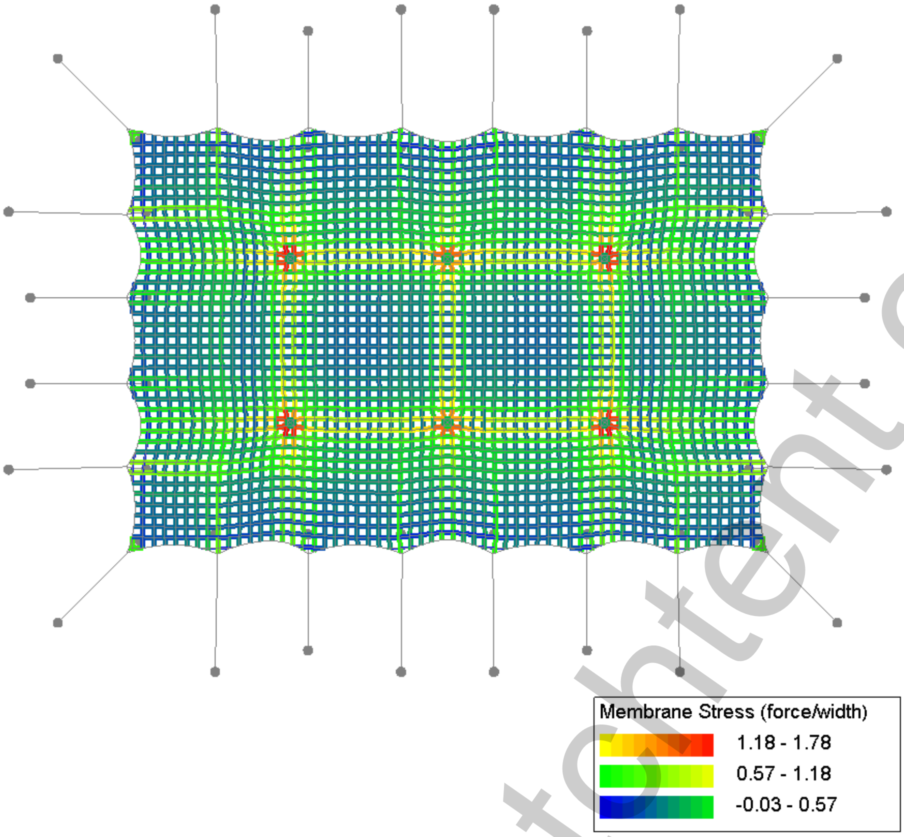


Forces in the poles

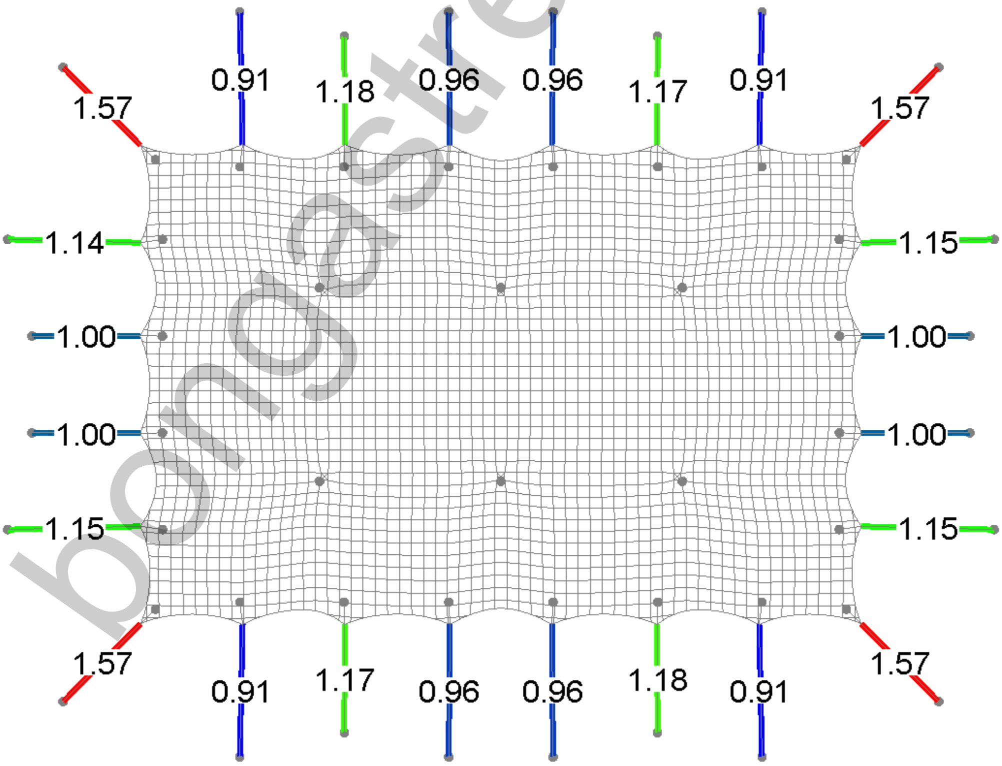


B.4. CO4. Own weight + pretension + conventional

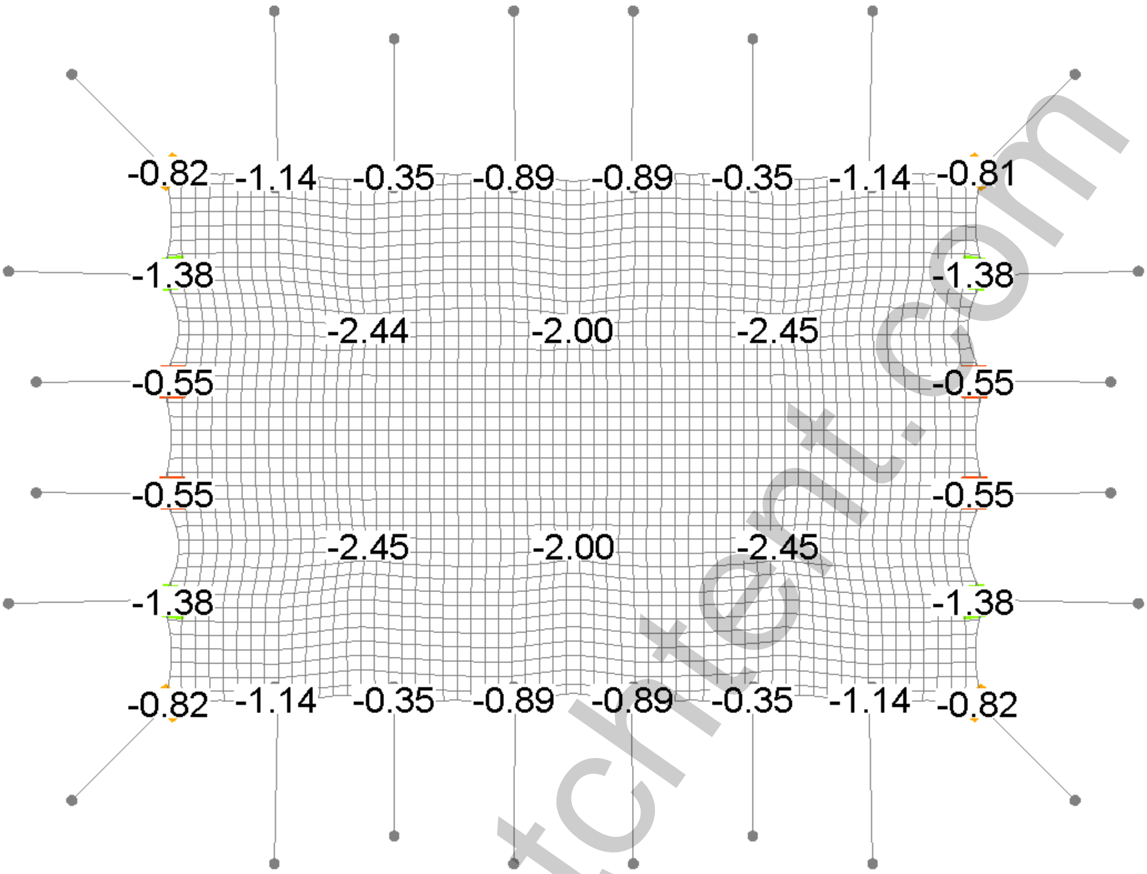
<u>Stresses in the membrane</u>



<u>Forces in the tension belts</u>



Forces in the poles



Annex C: Aluminum poles

The elaborated check of the aluminum profiles can be found on the following pages.

Annex C.1: Center pole 4m

Project:	1607304: Bonga 10x15m	Element:	Middenmast	Member:	-	Combination:	CO3	winddruk

Parameters

fo	240	N/mm^2
fu	260	N/mm^2
E	70000	N/mm^2
N	5,24	kN (druk)
My	0,00	kNm
Mz	0,00	kNm
Lcr;y	4000	mm
Lcr;z	4000	mm
Iy	224929	mm^4
Iz	224929	mm^4
ey	30	mm
ex	30	mm
Wyel	7498	mm^3
Wypl	10047	mm^3
Wzel	7498	mm^3
Wzpl	10047	mm^3
Aeff	554	mm^2
γm1	1,1	
γm2	1,25	

classification by thickness of round tube

t	3,1	mm	
D	60	mm	
ß	13,20		eq (6.10)
ε	1,02		
class	2		table (6.2)
class overide	*Off*		

classification conditions - Table 6.2 - Slenderness parameters

	ß1	ß2	ß3
Class A	11,23	16,33	22,45
class 1		False	ß < ß1
class 2		True	ß1 < ß < ß2
class 3		False	ß2 < ß < ß3
class 4		False	ß3 < ß

Compression art. (6.2.4)

1 **Ned / Nc,Rd < 1** — **eq (6.22)**
2 **Ned / Nu,Rd < 1** — **eq (6.21)**

Ned	5,24	kN
Nc,Rd	120,90	kN
Nu,Rd	115,26	kN
UC1	✓	**0,04**
UC2	✓	**0,05**

Bending Moment art. (6.2.5)

1 **Myed / Myc,Rd < 1** — **eq (6.25)**
2 **Myed / Myu,Rd < 1** — **eq (6.24)**
3 **Mzed / Mzc,Rd < 1** — **eq (6.25)**
4 **Mzed / Mzu,Rd < 1** — **eq (6.24)**

Myed	0,00	kN	
Mzed	0,00	kN	
α;y	1,34		table (6.4)
α;z	1,34		table (6.4)
Myc,Rd	2,19	kNm	
Myu,Rd	1,56	kNm	
Mzc,Rd	2,19	kNm	
Mzu,Rd	1,56	kNm	
UC1-y	-		
UC2-y	-		
UC3-z	-		
UC4-z	-		

Checks not necessary, no bending moments

Bending and Axial Force art. (6.2.9)

$$\left(\frac{N_{Ed}}{\omega_0 N_{Rd}}\right)^{\psi} + \left[\left(\frac{M_{y,Ed}}{\omega_0 M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{\omega_0 M_{z,Rd}}\right)^{1.7}\right]^{0.6} \leq 1.00$$

eq. (6.43) - (ω0 = 1) - (ψ = 1.3)

UC	-

Check not necessary, no bending moments

Buckling (compression) art. (6.3.1.1)

Ned / Nb,Rd < 1 — **eq. (6.48)**

Ned	5,24	kN	
BC	A		
α	0,20		table (6.6)
λ_0	0,10		table (6.6)
χ	0,07		eq. (6.50)
Φ	7,71	N	
λ	3,70		eq. (6.51)
Ncr	9712,33	(z-axis)	
Nb,Rd	8,36	kN	
UC	✓	**0,63**	

Buckling (Bending and Axial Force) art. (6.3.3.1)

$$\left(\frac{N_{Ed}}{\chi_{min}\,\omega_x N_{Rd}}\right)^{\psi_c} + \frac{1}{\omega_0}\left[\left(\frac{M_{y,Ed}}{M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{M_{z,Rd}}\right)^{1.7}\right]^{0.6} \leq 1.00$$

eq. (6.62) - (ω0 = 1) - (ωx = 1) - (ψ = 0.8)

UC	✓	**0,69**

Annex C.2 Perimeter pole 2.7m

Project:	1607304: Bonga 10x15m	Element:	Randmast 2,7m	Member:	CO3	Combination:	winddruk

Parameters

fo	240	N/mm²
fu	260	N/mm²
E	70000	N/mm²
N	3,02	kN (druk)
My	0,00	kNm
Mz	0,00	kNm
Lcr;y	2700	mm
Lcr;z	2700	mm
Iy	43216	mm⁴
Iz	43216	mm⁴
ey	20	mm
ex	20	mm
Wyel	2161	mm³
Wypl	2891	mm³
Wzel	2161	mm³
Wzpl	2891	mm³
Aeff	239	mm²
γm1	1,1	
γm2	1,25	

classification by thickness of round tube

t	2	mm	
D	40	mm	
ß	13,42		eq (6.10)
ε	1,02		
class	2		table (6.2)
class overide		*Off*	

classification conditions - Table 6.2 - Slenderness parameters

	ß1	ß2	ß3
Class A	11,23	16,33	22,45
class 1		False	ß < ß1
class 2		True	ß1 < ß < ß2
class 3		False	ß2 < ß < ß3
class 4		False	ß3 < ß

Compression art. (6.2.4)

1	**Ned / Nc,Rd < 1**	**eq (6.22)**
2	**Ned / Nu,Rd < 1**	**eq (6.21)**

Ned	3,02	kN
Nc,Rd	52,09	kN
Nu,Rd	49,66	kN
UC1 ✓	0,06	
UC2 ✓	0,06	

Bending Moment art. (6.2.5)

1	**Myed / Myc,Rd < 1**	**eq (6.25)**
2	**Myed / Myu,Rd < 1**	**eq (6.24)**
3	**Mzed / Mzc,Rd < 1**	**eq (6.25)**
4	**Mzed / Mzu,Rd < 1**	**eq (6.24)**

Myed	0,00	kN	
Mzed	0,00	kN	
α;y	1,34		table (6.4)
α;z	1,34		table (6.4)
Myc,Rd	0,63	kNm	
Myu,Rd	0,45	kNm	
Mzc,Rd	0,63	kNm	
Mzu,Rd	0,45	kNm	
UC1-y	-		
UC2-y	-		
UC3-z	-		
UC4-z	-		

Checks not necessary, no bending moments

Bending and Axial Force art. (6.2.9)

$$\left(\frac{N_{Ed}}{\omega_0 N_{Rd}}\right)^{\psi} + \left[\left(\frac{M_{y,Ed}}{\omega_0 M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{\omega_0 M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1.00$$

eq. (6.43) - (ω0 = 1) - (ψ = 1.3)

UC	-

Check not necessary, no bending moments

Buckling (compression) art. (6.3.1.1)

Ned / Nb,Rd < 1		**eq. (6.48)**
Ned	3,02 kN	
BC	A	
α	0,20	table (6.6)
λ_0	0,10	table (6.6)
χ	0,07	eq. (6.50)
Φ	7,86 N	
λ	3,74	eq. (6.51)
Ncr	4095,55 (z-axis)	
Nb,Rd	3,53 kN	
UC ✓	0,85	

Buckling (Bending and Axial Force) art. (6.3.3.1)

$$\left(\frac{N_{Ed}}{\chi_{min}\,\omega_x N_{Rd}}\right)^{\eta_c} + \frac{1}{\omega_0}\left[\left(\frac{M_{y,Ed}}{M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1.00$$

eq. (6.62) - (ω0 = 1) - (ωx = 1) - (ψ = 0.8)

UC ✓	0,88

Annex C.3 Perimeter pole 2.2m

Project:	1607304: Bonga 10x15m	Element:	Randmast 2,2m	Member:	CO3	Combination:	winddruk

Parameters

fo	240	N/mm²
fu	260	N/mm²
E	70000	N/mm²
N	1,73	kN (druk)
My	0,00	kNm
Mz	0,00	kNm
Lcr;y	2200	mm
Lcr;z	2200	mm
Iy	43216	mm⁴
Iz	43216	mm⁴
ey	20	mm
ex	20	mm
Wyel	2161	mm³
Wypl	2891	mm³
Wzel	2161	mm³
Wzpl	2891	mm³
Aeff	239	mm²
γm1	1,1	
γm2	1,25	

classification by thickness of round tube

t	2	mm	
D	40	mm	
ß	13,42		eq (6.10)
ε	1,02		
class	2		table (6.2)
class overide			*Off*

classification conditions - Table 6.2 - Slenderness parameters

	ß1	ß2	ß3
Class A	11,23	16,33	22,45
class 1		False	ß < ß1
class 2		True	ß1 < ß < ß2
class 3		False	ß2 < ß < ß3
class 4		False	ß3 < ß

Compression art. (6.2.4)

1 Ned / Nc,Rd < 1		eq (6.22)
2 Ned / Nu,Rd < 1		eq (6.21)
Ned	1,73 kN	
Nc,Rd	52,09 kN	
Nu,Rd	49,66 kN	
UC1 ✓	0,03	
UC2 ✓	0,03	

Bending Moment art. (6.2.5)

1 Myed / Myc,Rd < 1		eq (6.25)
2 Myed / Myu,Rd < 1		eq (6.24)
3 Mzed / Mzc,Rd < 1		eq (6.25)
4 Mzed / Mzu,Rd < 1		eq (6.24)
Myed	0,00 kN	
Mzed	0,00 kN	
α;y	1,34	table (6.4)
α;z	1,34	table (6.4)
Myc,Rd	0,63 kNm	
Myu,Rd	0,45 kNm	
Mzc,Rd	0,63 kNm	
Mzu,Rd	0,45 kNm	
UC1-y	-	
UC2-y	-	
UC3-z	-	
UC4-z	-	

Checks not necessary, no bending moments

Bending and Axial Force art. (6.2.9)

$$\left(\frac{N_{Ed}}{\omega_0 N_{Rd}}\right)^{\psi} + \left[\left(\frac{M_{y,Ed}}{\omega_0 M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{\omega_0 M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1.00$$

eq. (6.43) - (ω0 = 1) - (ψ = 1.3)

UC	-

Check not necessary, no bending moments

Buckling (compression) art. (6.3.1.1)

Ned / Nb,Rd < 1		eq. (6.48)
Ned	1,73 kN	
BC	A	
α	0,20	table (6.6)
λ_0	0,10	table (6.6)
χ	0,10	eq. (6.50)
Φ	5,44 N	
λ	3,05	eq. (6.51)
Ncr	6168,71 (z-axis)	
Nb,Rd	5,24 kN	
UC ✓	0,33	

Buckling (Bending and Axial Force) art. (6.3.3.1)

$$\left(\frac{N_{Ed}}{\chi_{min}\,\omega_x N_{Rd}}\right)^{\xi_c} + \frac{1}{\omega_0}\left[\left(\frac{M_{y,Ed}}{M_{y,Rd}}\right)^{1.7} + \left(\frac{M_{z,Ed}}{M_{z,Rd}}\right)^{1.7}\right]^{0.6} \le 1.00$$

eq. (6.62) - (ω0 = 1) - (ωx = 1) - (ψ = 0.8)

UC ✓	0,41

Annex D: Check results on fabric clamps

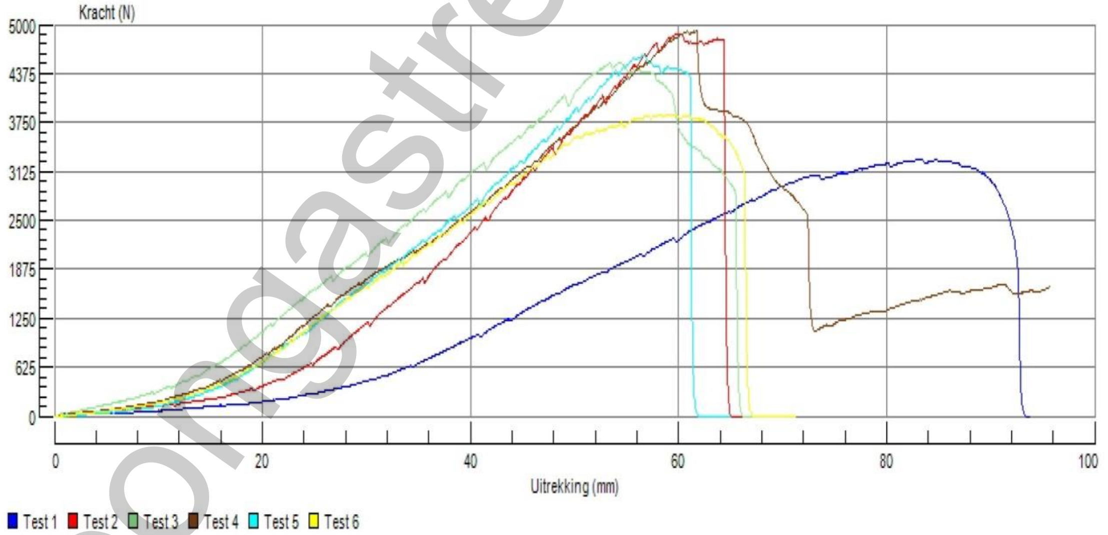
Testometric
materials testing machines

winTest™
Analysis

Ref 1 :
Ref 2 :
Ref 3 :

Machine No. : 0350-10000
Testnaam : Trektest
Test Type : Trek
Testdatum : 11-7-2016 12:18
Testsnelheid : 100.000 mm/min
Voorspanning : Uit
Breedte : 10.000 mm
Dikte : 1.000 mm
Proefstuk Lengte : 100.000 mm

Test nr.	Kracht @ Piek (N)
1	3282.000
2	4881.000
3	4511.000
4	4915.000
5	4599.000
6	3852.000
Min	3282.000
Gemiddelde	4340.000
Max.	4915.000
Standaard Deviatie	644.536
Coëfficiënt van Variatie	14.851
Onderste Vertrouwens Grens	3663.596
Boven Confidentie Limiet	5016.404



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Unit 1 Lincoln Business Park Lincoln Close,
Rochdale, Lancashire, England OL11 1NR

Tel: (44) (0)1706 654039 Fax: (44) (0)1706 646089
Email: info@testometric.co.uk website: www.testometric.co.uk

Notes:

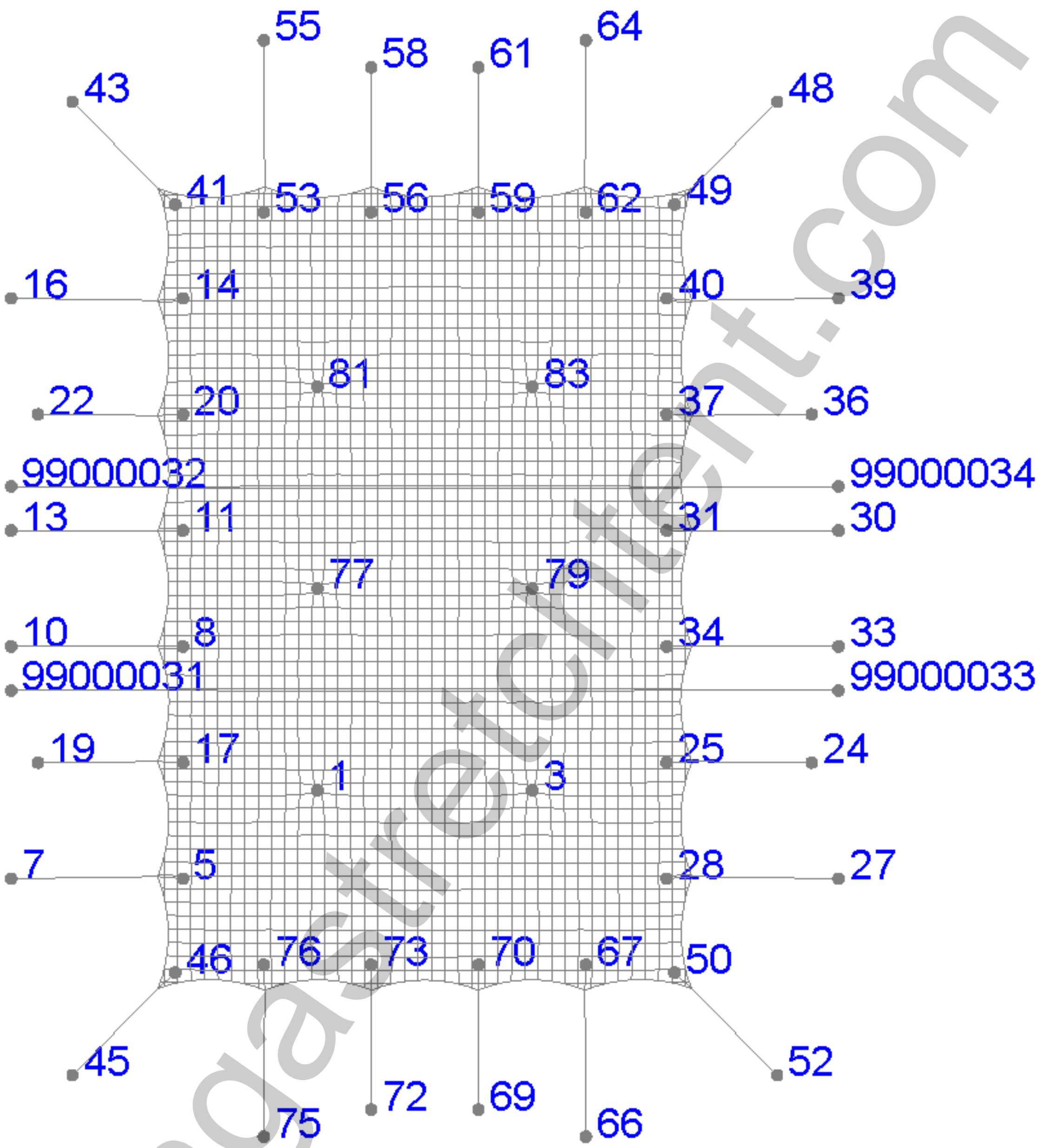
Test no.	Sample	Ø tendon	Remark
1	1	6	Tendon out of clamps
2	1	11	Clamp broke
3	2	8	Clamp broke
4	3	8	Clamp cracked, tendon half out of clamp
5	4	8	Broken
6	5	8	Broke, clamp was fastened a little less tight.

- Test 1 and 2 are not representative, because a different diameter tendon is used.
- Test 6 is not representative, because the clamp was not fastened tight enough.

Conclusion

Average tensile strength at fracture for the three representative tests:
(4511 + 4915 + 4599) / 3 = 4675 N

Annex E: Easy export of reaction forces



		CO1			CO2			CO3			CO4		
	Node	Fx	Fy	Fz	Fx	Fy	Fz	Fx	Fy	Fz	Fx	Fy	Fz
Center pole	1	0,00	0,00	0,27	0,00	0,00	0,00	0,11	-0,10	3,48	0,06	-0,05	2,44
Center pole	3	0,00	0,00	0,27	0,00	0,00	0,00	0,11	0,10	3,48	0,06	0,05	2,44
Center pole	77	0,00	0,00	0,21	0,00	0,00	-0,04	0,00	-0,09	2,83	0,00	-0,05	2,00
Center pole	79	0,00	0,00	0,21	0,00	0,00	-0,03	0,00	0,09	2,83	0,00	0,05	2,00
Center pole	81	0,00	0,00	0,27	0,00	0,00	0,00	-0,11	-0,10	3,48	-0,06	-0,05	2,44
Center pole	83	0,00	0,00	0,27	0,00	0,00	0,00	-0,11	0,10	3,48	-0,06	0,05	2,44
Perimeter pole	5	0,00	0,04	0,24	0,02	0,16	1,02	0,05	0,27	1,63	0,02	0,19	1,12
Perimeter pole	8	0,00	0,03	0,17	0,00	0,18	1,10	0,02	0,23	1,39	0,01	0,15	0,88
Perimeter pole	11	0,00	0,03	0,17	0,00	0,18	1,10	-0,02	0,23	1,39	-0,01	0,15	0,88
Perimeter pole	14	0,00	0,04	0,24	-0,02	0,16	1,02	-0,05	0,27	1,63	-0,02	0,19	1,12
Perimeter pole	17	0,00	0,00	0,00	0,00	-0,08	-0,42	0,01	0,14	0,68	0,00	0,07	0,34
Perimeter pole	20	0,00	0,00	0,00	0,00	-0,08	-0,42	-0,01	0,14	0,68	0,00	0,07	0,34
Perimeter pole	25	0,00	0,00	0,00	0,00	0,08	-0,41	0,01	-0,14	0,68	0,00	-0,07	0,34
Perimeter pole	28	0,00	-0,04	0,24	0,02	-0,16	1,02	0,05	-0,27	1,63	0,02	-0,19	1,12
Perimeter pole	31	0,00	-0,03	0,17	0,00	-0,18	1,10	-0,02	-0,23	1,39	-0,01	-0,15	0,88
Perimeter pole	34	0,00	-0,03	0,17	0,00	-0,18	1,10	0,02	-0,23	1,39	0,01	-0,15	0,88
Perimeter pole	37	0,00	0,00	0,00	0,00	0,08	-0,42	-0,01	-0,14	0,68	0,00	-0,07	0,34
Perimeter pole	40	0,00	-0,04	0,24	-0,02	-0,16	1,02	-0,05	-0,27	1,63	-0,02	-0,19	1,12
Perimeter pole	41	0,03	0,03	0,24	0,13	0,13	1,04	0,15	0,15	1,13	0,11	0,11	0,80
Perimeter pole	46	-0,03	0,03	0,24	-0,13	0,13	1,04	-0,15	0,15	1,13	-0,11	0,11	0,80
Perimeter pole	49	0,03	-0,03	0,24	0,13	-0,13	1,04	0,15	-0,15	1,13	0,11	-0,11	0,81
Perimeter pole	50	-0,03	-0,03	0,24	-0,13	-0,13	1,04	-0,15	-0,15	1,13	-0,11	-0,11	0,80
Perimeter pole	53	0,05	0,00	0,27	0,16	-0,02	0,99	0,33	-0,06	1,98	0,23	-0,03	1,36
Perimeter pole	56	0,01	0,00	0,05	-0,08	0,01	-0,44	0,20	0,00	0,98	0,11	0,00	0,54
Perimeter pole	59	0,01	0,00	0,05	-0,08	-0,01	-0,44	0,20	0,00	0,98	0,11	0,00	0,54
Perimeter pole	62	0,05	0,00	0,27	0,16	0,02	0,99	0,33	0,06	1,98	0,23	0,03	1,36
Perimeter pole	67	-0,05	0,00	0,27	-0,16	0,02	0,99	-0,33	0,06	1,98	-0,23	0,03	1,36
Perimeter pole	70	-0,01	0,00	0,05	0,08	-0,01	-0,44	-0,20	0,00	0,98	-0,11	0,00	0,54
Perimeter pole	73	-0,01	0,00	0,05	0,08	0,01	-0,44	-0,20	0,00	0,98	-0,11	0,00	0,54
Perimeter pole	76	-0,05	0,00	0,27	-0,16	-0,02	1,00	-0,33	-0,06	1,98	-0,23	-0,03	1,36
Tension belt	7	0,00	0,14	-0,14	-0,04	1,72	-1,68	-0,03	0,95	-0,93	-0,01	0,65	-0,64
Tension belt	10	0,00	0,15	-0,15	0,00	1,47	-1,44	-0,01	1,09	-1,07	-0,01	0,68	-0,67
Tension belt	13	0,00	0,15	-0,15	0,00	1,48	-1,45	0,01	1,09	-1,07	0,01	0,68	-0,67
Tension belt	16	0,00	0,14	-0,14	0,04	1,72	-1,68	0,03	0,95	-0,93	0,01	0,65	-0,64
Tension belt	19	0,00	0,19	-0,18	-0,02	1,81	-1,77	-0,01	1,33	-1,30	0,00	0,84	-0,82
Tension belt	22	0,00	0,19	-0,18	0,02	1,82	-1,78	0,01	1,33	-1,30	0,00	0,84	-0,82
Tension belt	24	0,00	-0,19	-0,18	-0,02	-1,81	-1,77	-0,01	-1,33	-1,30	0,00	-0,84	-0,82
Tension belt	27	0,00	-0,14	-0,14	-0,04	-1,72	-1,68	-0,03	-0,95	-0,93	-0,01	-0,65	-0,64
Tension belt	30	0,00	-0,15	-0,15	0,00	-1,47	-1,44	0,01	-1,09	-1,07	0,01	-0,68	-0,67
Tension belt	33	0,00	-0,15	-0,15	0,00	-1,47	-1,44	-0,01	-1,09	-1,07	-0,01	-0,68	-0,67
Tension belt	36	0,00	-0,19	-0,18	0,02	-1,81	-1,78	0,01	-1,33	-1,30	0,00	-0,84	-0,83
Tension belt	39	0,00	-0,14	-0,14	0,04	-1,72	-1,68	0,03	-0,95	-0,93	0,01	-0,65	-0,64
Tension belt	55	0,16	0,00	-0,16	1,42	0,03	-1,40	1,20	0,04	-1,18	0,82	0,02	-0,80

		CO1			CO2			CO3			CO4		
	Node	Fx	Fy	Fz	Fx	Fy	Fz	Fx	Fy	Fz	Fx	Fy	Fz
Tension belt	58	0,15	0,00	-0,15	2,57	0,05	-2,50	1,19	0,00	-1,17	0,71	0,00	-0,70
Tension belt	61	0,15	0,00	-0,15	2,57	-0,05	-2,51	1,19	0,00	-1,17	0,71	0,00	-0,70
Tension belt	64	0,16	0,00	-0,16	1,43	-0,03	-1,40	1,20	-0,04	-1,18	0,82	-0,02	-0,80
Tension belt	66	-0,16	0,00	-0,16	-1,43	-0,03	-1,40	-1,20	-0,04	-1,18	-0,82	-0,02	-0,80
Tension belt	69	-0,15	0,00	-0,15	-2,57	-0,05	-2,50	-1,19	0,00	-1,17	-0,71	0,00	-0,70
Tension belt	72	-0,15	0,00	-0,15	-2,57	0,05	-2,51	-1,19	0,00	-1,17	-0,71	0,00	-0,70
Tension belt	75	-0,16	0,00	-0,16	-1,43	0,03	-1,40	-1,20	0,04	-1,18	-0,82	0,02	-0,80
Tension belt corner	43	0,27	0,27	-0,37	1,70	1,70	-2,32	1,09	1,10	-1,50	0,79	0,80	-1,10
Tension belt corner	45	-0,27	0,27	-0,37	-1,70	1,70	-2,32	-1,09	1,10	-1,50	-0,79	0,80	-1,10
Tension belt corner	48	0,27	-0,27	-0,37	1,70	-1,70	-2,32	1,09	-1,10	-1,50	0,79	-0,80	-1,10
Tension belt corner	52	-0,27	-0,27	-0,37	-1,70	-1,70	-2,32	-1,09	-1,10	-1,50	-0,79	-0,80	-1,09
Storm belt	99000031				-0,05	5,40	-4,39						
Storm belt	99000032				0,06	5,39	-4,38						
Storm belt	99000033				-0,05	-5,40	-4,39						
Storm belt	99000034				0,05	-5,39	-4,38						