Disclaimer

NL

De Handleiding (bouwboek) moet nauwkeurig gevolgd worden bij het plaatsen en installeren van de Koopwaar. De Koper draagt de verantwoordelijkheid voor het volgen van de Handleiding. De Handleiding is opgesteld op naam van de Verkoper en doet geen rechten ontstaan voor de Koper ten aanzien van het adviesbureau die de Handleiding heeft opgesteld. De Koper heeft de mogelijkheid om een overdracht van het bouwboek op zijn naam te vragen. Enkel in dat geval kan de Koper rekenen op bijstand door het adviesbureau in geval van problemen of van vragen van officiële instanties (onder de voorwaarden en modaliteiten van het adviesbureau). Dergelijke tenaamstelling van het bouwboek kan gerealiseerd worden tegen betaling van een bedrag van 400,00 EUR (excl. BTW).

EN

The Manual (construction book) must be carefully followed when placing and installing the Merchandise. The Buyer bears responsibility for following the Manual. The Manual has been prepared in the name of the Seller and does not create any rights for the Buyer in respect of the consulting firm that prepared the Manual. The Buyer has the option to request a transfer of the Construction Manual in its name. Only in such case, the Buyer can rely on assistance from the consultancy firm in case of problems or enquiries from official bodies (under the conditions and modalities of the consultancy firm). Such ascription of the building book can be realised upon payment of a fee of EUR 400.00 (excluding VAT).

FR

Le manuel (livre de construction) doit être suivi attentivement lors de la mise en place et de l'installation de la marchandise. L'acheteur est responsable du respect du manuel. Le manuel a été préparé au nom du vendeur et ne crée aucun droit pour l'acheteur à l'égard de la société de conseil qui a préparé le manuel. L'acheteur a la possibilité de demander le transfert du manuel de construction en son nom. Dans ce cas uniquement, l'acheteur peut compter sur l'assistance du bureau d'études en cas de problèmes ou de demandes de renseignements émanant d'organismes officiels (selon les conditions et modalités du bureau d'études). Cette cession du manuel de construction peut être réalisée moyennant le paiement d'une redevance de 400,00 EUR (hors TVA).

DE

Das Handbuch (Baubuch) ist bei der Aufstellung und Montage der Ware sorgfältig zu beachten. Der Käufer trägt die Verantwortung für die Befolgung des Handbuchs. Das Handbuch wurde im Namen des Verkäufers erstellt und begründet keine Rechte des Käufers gegenüber dem Beratungsunternehmen, das das Handbuch erstellt hat. Der Käufer hat die Möglichkeit, eine Übertragung des Bauhandbuchs auf seinen Namen zu verlangen. Nur in diesem Fall kann sich der Käufer bei Problemen oder Anfragen von Behörden auf die Hilfe des Beratungsunternehmens verlassen (zu den Bedingungen und Modalitäten des Beratungsunternehmens). Eine solche Übertragung des Baubuches kann gegen Zahlung eines Betrages von EUR 400,00 (exkl. MwSt.) erfolgen.

ES

El Manual (libro de construcción) debe seguirse cuidadosamente al colocar e instalar la Mercancía. El Comprador es responsable de seguir el Manual. El Manual ha sido preparado en nombre del Vendedor y no crea ningún derecho para el Comprador con respecto a la empresa consultora que preparó el Manual. El Comprador tiene la opción de solicitar la transferencia del Manual de Construcción a su nombre. Sólo en tal caso, el Comprador podrá contar con la asistencia de la empresa consultora en caso de problemas o consultas de organismos oficiales (en las condiciones y modalidades de la empresa consultora). Dicha adscripción del manual de construcción puede realizarse previo pago de una tasa de 400,00 EUR (más IVA).

Object:	10x21.5 stretchtent
Document code:	24.05.00038.1
Owner object:	Above & Beyond B.V. Potteriestraat 67 8980 Beselare Belgium info@abnd.com
Author tentbook:	Tentech International BV Ontwerp en advies voor lichtgewicht bouwen Postbus 85190 3508 AD Utrecht t +31 (0)30 252 1869 f +31 (0)30 254 1239 www.tentech.nl
Date:	17.06.2024
Author:	ir. D. Somova
Authorized by:	ir. R. Houtman

DESIGN AND ENGINEERING OF LIGHTWEIGHT STRUCTURES

Content:	**Tentbook (according to NEN-EN 8020-41:2012)**
Object:	**10x21.5 stretchtent**
Owner object:	**Above & Beyond B.V.**
Document code:	**24.05.00038.1**
Author:	**ir. D. Somova**
Date:	**17.06.2024**

Rotsoord 9A NL-3523 CL Utrecht
P.O. box 85190 NL-3508 AD Utrecht
T +31 30 252 18 69 F +31 30 254 12 39
E office@tentech.nl www.tentech.nl
IBAN NL26ABNA0516814346 BIC ABNANL2A
VAT NL 8552.67.112.B01 CC 63509237

A. Introduction

Above & Beyond B.V. is a company that produces the tent structures made out of a stretchable membrane, so called Stretch Tents. This structure enables a freedom of form as there is not a pre-described shape necessary. Depending on the location, the number of poles, length of the poles, placement of the poles, number and type of tie-downs can be varied. Resulting in a custom made cover at each new location.

This freedom of form is enabled by the stretch fabric, as the desired form is stretched in shape.
The drawback of this flexibility in shape is the difficulty to investigate all the different possibilities and to put them into a kind of order in a static analysis.

Above & Beyond B.V. commissioned Tentech to perform a static analysis of the 10m tent series.

The tent can be assembled in two configurations: with tension straps that connect through loops at the edge of the membrane. And with ropes that connect to clamps on the edge of the membrane. The ropes are tensioned with ratchets.

This report presents the 10m tent series which consists of different sizes and setups for 10x21.5m, 10x15m, 10x12.5m, 10x10.5m, 10x8.5m and 10x6.5m tents. This report only shows the static analysis of the decisive size - 10x21.5m tent.

The 10m tent series can be built in 1 variant - "floating set-up".

The static analysis is valid for all smaller sizes due to the application of the scaling principle.

Principle of scaling: a tent with a similar arrangement of poles and ties but smaller in size or having a more favorable shape is automatically verified when the calculation of the less favorable or bigger tent has been approved, provided that the spacing between the poles and ties of the scaled tent is similar or smaller than the original tent.
While constructing smaller tent sizes of different shapes, it is of significant importance to use similar (or more favorable) arrangements of poles and ties based on ratio of distances (to ensure correct pole and tie spacing).

This document contains the data required for a tent book, according to EN 13782, for the 10m tent series of Above & Beyond B.V., including:

- 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, ir. D. Somova, 17.06.2024

B. Contents

C. Codes and standards

▪	EN 1990	Eurocode, Basis of structural Design
▪	EN 1991	Eurocode 1, Part 1-4: General actions - wind actions.
▪	EN 1993	Eurocode 3, Design of steel structures
▪	EN 1995	Eurocode 5, Design of wooden structures
▪	EN 1999	Eurocode 9, Design of aluminum structures
▪	EN 13782	Temporary Structures – Tents - Safety
▪	EN 10204	Products of steel –inspections documents
▪	EN 12195-2	Belts
▪	ISO 1141	Synthetic fiber ropes Polyester

TEN TECH DESIGN AND ENGINEERING OF LIGHTWEIGHT STRUCTURES

D. Summary

E. Summary and drawings: main dimensions and anchoring

Owner / Manufacturer:	Above & Beyond B.V. Potteriestraat 67 8980 Beselare Belgium info@abnd.com	
General information:		
Width:	10m	
Length:	6.5m – 21.5m	
Side height membrane:	3.0m	
Max. heigth:	3.6 – 4.2m (Max height depends on the configuration)	
Fabric	Triflexx STRETCH 560	
	Wood [Eucalyptus, D35]	Aluminium [6061 T6]
Center pole	Ø 80mm, Length = 4.2m, if tent size ≥ 8.5x10m	Ø80x3mm, Length = 4.1m, if tent size ≥ 8.5x10m
	Ø 80mm, Length = 3.6m, if tent size < 8.5x10m	Ø80x3mm, Length = 3.5m, if tent size < 8.5x10m
Side pole	Ø 70mm, Length = 3.0m	Ø60x2.5mm, Length = 3.0m
Corner pole	Ø 60mm, Length = 2.4m	Ø60x2.5mm, Length = 2.4m
Guy rope – long side:	2x synthetic ropes, Min BL: 2600 kg per rope* OR 1 belt: PES, Min. BL: 1200 kg	
Guy rope – short side:	2x synthetic ropes, Min BL: 2600 kg per rope* OR 1 belt: PES, Min. BL: 1200 kg	
Guy rope – corner:	2x synthetic ropes, Min BL: 2600 kg per rope* OR 1 belt: PES, Min. BL: 1200 kg	
Stormbelt:	Belt: PES, Min. Breaking load: 3000 kg	

* The required breaking load (BL_{tot}) may be achieved by using multiple rope sections (n): $BL_{rope} = BL_{tot} / n$

Loads:

User load:	max. additional load of 25kg per column is allowed, if the load is applied centric.
Snow load:	0.1 kN/m² (equal to 4cm of snow) according to the French CTS.
Wind load:	The calculation is based on a wind pressure of p_w = 300 N/m², according to EN 13782 par. 7.4.2.2. This value corresponds to a peak value of the wind speed v = 24.1 m/s (±87 km/h) at 10m height. The wind pressure is recalculated to the corresponding wind speeds[1] for Europe (not country specific), shown in the table below.

Wind speeds for default European terrain categories (not Country specific)

	In service [1]				
	Coast	Flattened, open area	Rural area	Village	City
10 min. average wind speed [2]	13.58 m/s 48.9 km/h	14.24 m/s 51.3 km/h	15.77 m/s 56.8 km/h	19.36 m/s 69.7 km/h	20.20 m/s 72.7 km/h
Beaufort [3]	6 BFT	7 BFT	7 BFT	8 BFT	8 BFT
Peak wind speed [4]	87 km/h	87 km/h	87 km/h	87 km/h	87 km/h

(1) *'In service' means: above the given wind speed the structure is no longer guaranteed regarding strength and/or stability.*
(2) *10min average wind speed at 10m height measured at the nearest weather stations.*
(3) *wind data in Beaufort (BFT) are indicative values.*
(4) *3 second peak wind speed measured on site at 10m height.*

Safety against sliding, overturning and uplifting:

Anchor forces:

Assumptions: angle of 45 degrees
The following design resistance of the anchor forces is required:
(See H.8.3, page 57 for Anchor tests according to EN 13782)

	Design forces	Min. soil bearing capacity:
Guy rope – long side:	6.05 kN	9.68 kN
Guy rope – short side:	6.59 kN	10.54 kN
Guy rope – corner:	3.95 kN	6.32 kN
Storm belt:	6.01 kN	9.62 kN

Required anchor stakes:

In case Option 1 anchors **Ø28mm x 950mm** (effective length) are being used:

	cohesion less soil (e.g. sandy soils)	stiff cohesive soil (e.g. clay soil)
Guy rope –sides:	2 anchors	3 anchors
Guy rope – corner:	1 anchors	2 anchors
Storm belt:	2 anchors	3 anchors

case Option 2 anchors **Ø25mm x 800mm** (effective length) are being used:

Guy rope –sides:	2 anchors	3 anchors
Guy rope – corner:	1 anchors	2 anchors
Storm belt:	2 anchors	3 anchors

In case Option 3 anchors **Ø43.5mm x 1500mm** (effective length) are being used:

Guy rope – sides:	1 anchor	1 anchor
Guy rope – corner:	1 anchor	1 anchor
Storm belt:	1 anchor	1 anchor

E.1. Derivation of smaller tent sizes & different shapes

The performed analysis of the 'floating' configurations (as shown in the static analysis in this tentbook) allows the use of different smaller dimensions within "floating" set-up, whereby the smaller tent sizes are derived from the 10x21.5m configuration.

The principle of scaling is being used for the verification of the strength and stability of different sizes.

Principle of scaling: A tent with a similar arrangement of poles and ties but smaller in size or having a more favorable shape is automatically verified when the calculation of the less favorable or bigger tent has been approved, provided that the spacing between the poles and ties of the scaled tent is similar or smaller than the original tent.

While constructing smaller tent sizes of different shapes, it is of significant importance to use similar (or more favorable*) arrangements of poles and ties based on ratio of distances (to ensure correct pole and tie spacing), using the 10x21.5m arrangements as a starting point.

*) with 'more favorable' is meant: more safe, which implies relatively more poles and/or ties than the 10x21.5m for arrangements.

The following rules apply when deriving smaller tent sizes or different shapes:
Unless independent calculations for a specific tent size are made and show more favorable results, all tents of Above & Beyond smaller then 10x21.5m and/or having a different shape should:

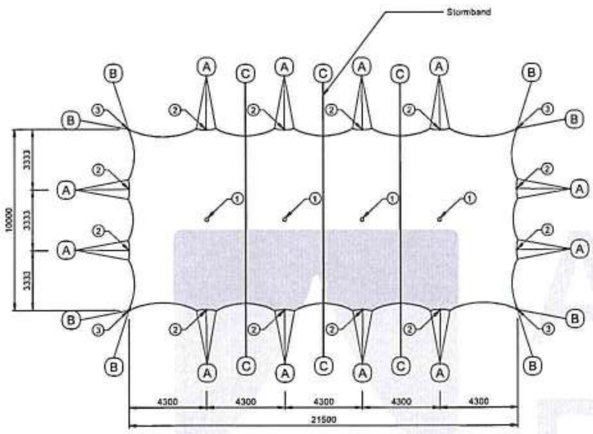
- Have a similar or more favorable arrangement and pole & tie spacing than the 10x21.5m floating.
- Use construction elements (poles, ropes, belts, etc.) with an equal or higher strength than the elements used for the 10x21.5m floating, unless additional calculations prove otherwise.
- Use the reaction forces of the 10x21.5m for anchoring. For the smaller tent sizes and/or different shapes, the same amount of ballast or anchoring should be placed at each of the specified locations / elements.
  For example, 3 anchors ø28 x 950mm for dense, non-cohesive soil are specified for the guy ropes on the short side of the 10x21.5m. For a smaller tent size, such as the 10x8.5m, for each guy rope on the short side of the tent, also 2 anchors ø28 x 950mm should be placed in case of dense, non-cohesive soil.
- Use poles of equal or smaller height, ensuring a similar incline of the tent fabric.
- Use storm belts, so that the structure is able to withstand strong winds.
  - The same wind speed values apply for the necessity of the storm belts. In this case the storm belts are needed constantly.
  - In general, storm belts are placed in the valley's (between inner poles) and in case of two membrane panels coupled together, a valley is created at the panel connection.
  - Floating configurations: storm belts are placed in width direction, at the valley(s), which means: (X-1) storm belts in width direction, with X = number of rows of center poles in length direction.

E.2. Diagrams

For several common smaller tent sizes, the arrangement has been determined for the floating configurations. The following pages show the diagrams of the top views with pole heights. The 10x21.5m diagrams are also added, for ease of use.

The following configuration:

- Tent 150m² – 10x15m
- Tent 125m² – 10x12.5m
- Tent 105m² – 10x10.5m
- Tent 85m² – 10x8.5m
- Tent 65m² – 10x6.5m



BOVENAANZICHT
[1:200]

ZIJAANZICHT
[1:200]

TIES

With clamps: 2x Ø10 polyester ropes, BL ≥ 2600 kg
With loops: 1x [PES[belt, Min. BL: 1200 kg per belt
Stormbelt: 1x [PES[belt, Min. BL: 3000 kg per belt

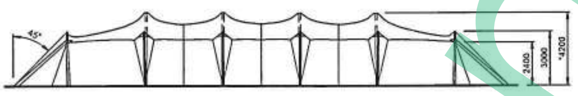
POLES

	Aluminium [EN-AW 6061 T6]	Wood [Eucalyptus D35]
1: Center poles*	Ø80 x 3mm, Length = 4.2m	Ø80 mm, Length = 4.1m
2: Side poles	Ø60 x 2.5mm, Length = 3.0m	Ø70 mm, Length = 3.0m
3: Corner poles	Ø60 x 2.5mm, Length = 2.4m	Ø60 mm, Length = 2.4m

ANCHORS

All tension belts/ropes and storm belts of the membrane must be attached to the anchors at an angle of ≥ 45°

	Option 1 Ø28 x 950mm	Option 2 Ø25 x 800mm	Option 3 Ø43.5 x 1500mm
Dense cohesion less soil (sandy soil)			
A: Guy rope - short/long side:	2 anchors	2 anchors	1 anchors
B: Guy rope - corner:	1 anchor	1 anchors	1 anchors
C: Storm belt:	2 anchors	2 anchors	1 anchors
Stiff cohesive soil (clay soil)			
A: Guy rope - short/long side:	3 anchors	3 anchors	1 anchors
B: Guy rope - corner:	2 anchors	2 anchors	1 anchors
C: Storm belt:	3 anchors	3 anchors	2 anchors

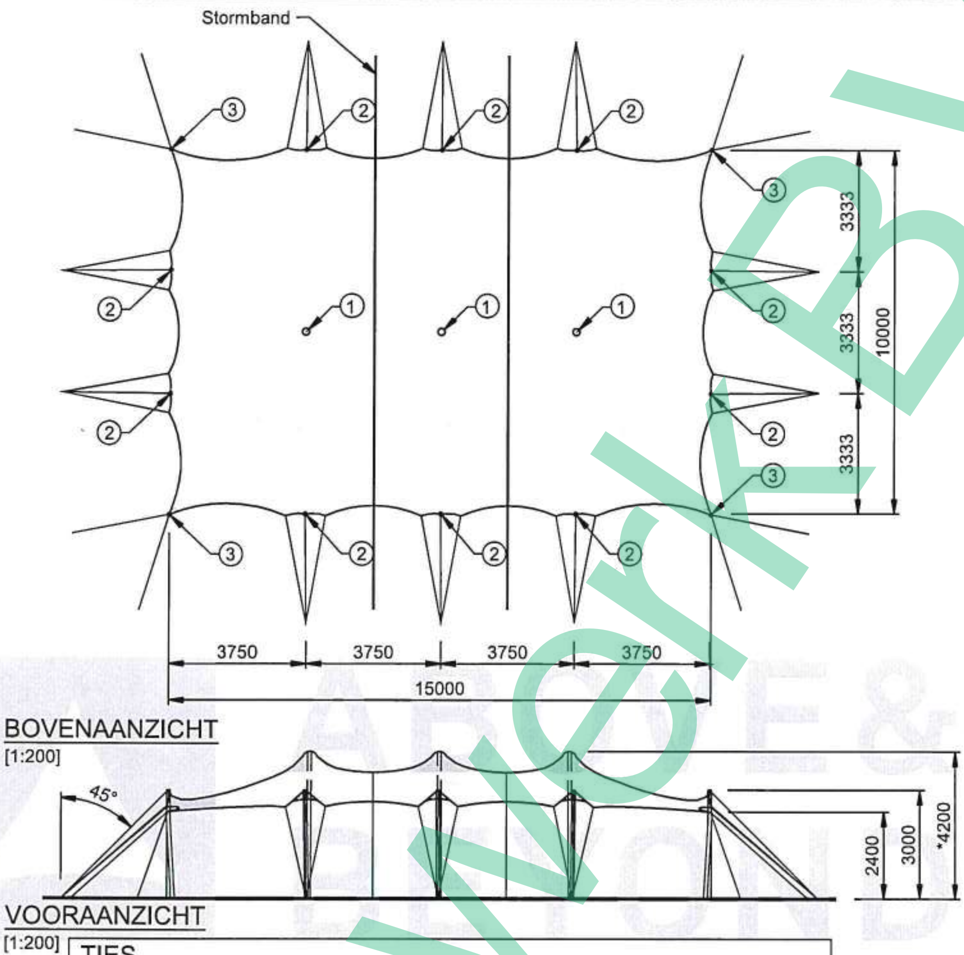


VOORAANZICHT
[1:200]

For Europe, not country specific (Triflexx STRETCH 560)					
	Coast	Flattened, open area	Rural area	Village	City
10 min. average	13.58 m/s 48,9 km/h	14.24 m/s 51.3 km/h	15.77 m/s 56.8 km/h	19.36 m/s 69.7 km/h	20.20 m/s 72,7 km/h
Beaufort	7 BFT	7 BFT	7 BFT	9 BFT	9 BFT
Peak wind speed	87 km/h	87 km/h	87 km/h	87 km/h	87 km/h

EDITOR:	DATE:	FILENAME:
DS	17.06.2024	TTIP20240014_10x21.5m

TEN TECH DESIGN AND ENGINEERING OF LIGHTWEIGHT STRUCTURES



TIES

With clamps: 2x Ø10 polyester ropes, BL ≥ 2600 kg
With loops: 1x [PES[belt, Min. BL: 1200 kg per belt
Stormbelt: 1x [PES[belt, Min. BL: 3000 kg per belt

POLES

	Aluminium [EN-AW 6061 T6]	Wood [Eucalyptus D35]
1: Center poles*	Ø80 x 3mm, Length = 4.1m	Ø80 mm, Length = 4.2m
2: Side poles	Ø60 x 2.5mm, Length = 3.0m	Ø70 mm, Length = 3.0m
3: Corner poles	Ø60 x 2.5mm, Length = 2.4m	Ø60 mm, Length = 2.4m

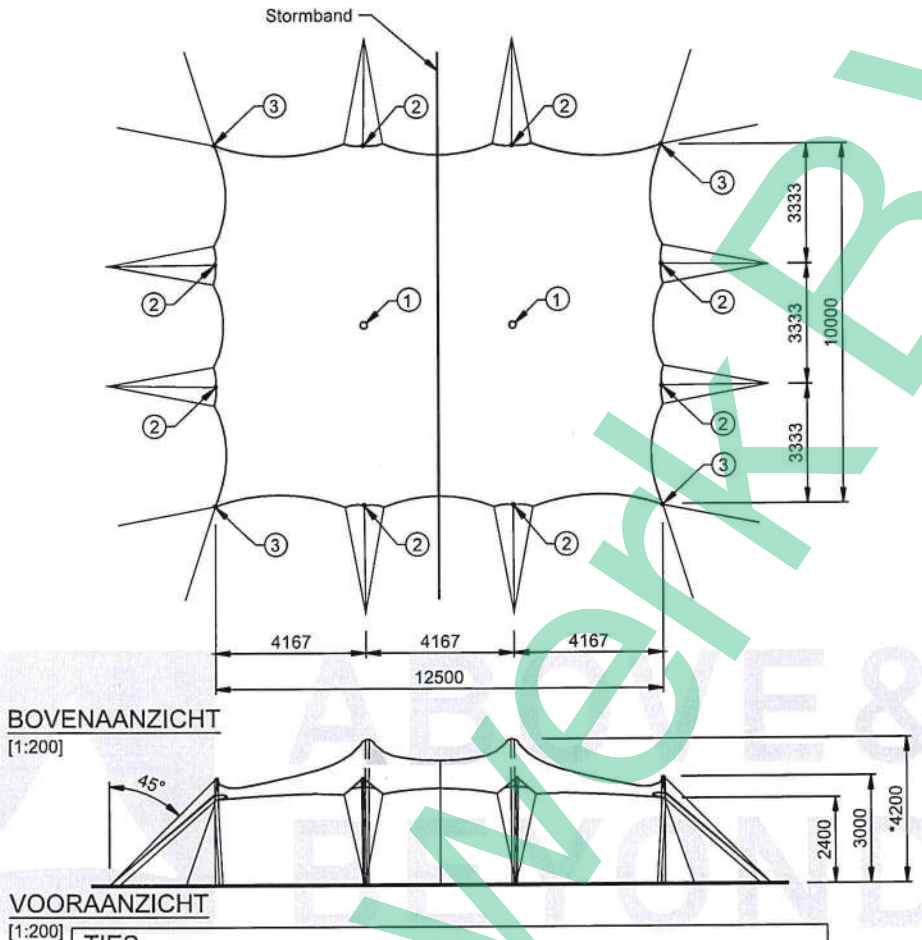
ANCHORS

All tension belts/ropes and storm belts of the membrane must be attached to the anchors at an angle of ≥ 45°

	Option 1 **Ø28 x 950mm**	Option 2 **Ø25 x 800mm**	Option 3 **Ø43.5 x 1500mm**
Dense cohesion less soil (sandy soil)			
A: Guy rope - side:	2 anchors	3 anchors	1 anchors
B: Guy rope - corner:	1 anchor	2 anchors	1 anchors
C: Storm belt:	2 anchors	2 anchors	1 anchors
Stiff cohesive soil (clay soil)			
A: Guy rope - side:	3 anchors	4 anchors	1 anchors
B: Guy rope - corner:	2 anchors	2 anchors	1 anchors
C: Storm belt:	3 anchors	3 anchors	1 anchors

EDITOR:	DATE:	FILENAME:
DS	17.06.2024	TTIP20240014_10x15m

Rotsoord 9A NL-3523 CL Utrecht
P.O. box 85190 NL-3508 AD Utrecht
T +31 30 252 18 69 F +31 30 254 12 39
E office@tentech.nl www.tentech.nl
IBAN NL26ABNA0516814346 BIC ABNANL2A
VAT NL 8552.67.112.B01 CC 63509237



TIES

With clamps: 2x Ø10 polyester ropes, BL ≥ 2600 kg
With loops: 1x [PES[belt, Min. BL: 1200 kg per belt
Stormbelt: 1x [PES[belt, Min. BL: 3000 kg per belt

POLES

	Aluminium [EN-AW 6061 T6]	Wood [Eucalyptus D35]
1: Center poles*	Ø80 x 3mm, Length = 4.1m	Ø80 mm, Length = 4.2m
2: Side poles	Ø60 x 2.5mm, Length = 3.0m	Ø70 mm, Length = 3.0m
3: Corner poles	Ø60 x 2.5mm, Length = 2.4m	Ø60 mm, Length = 2.4m

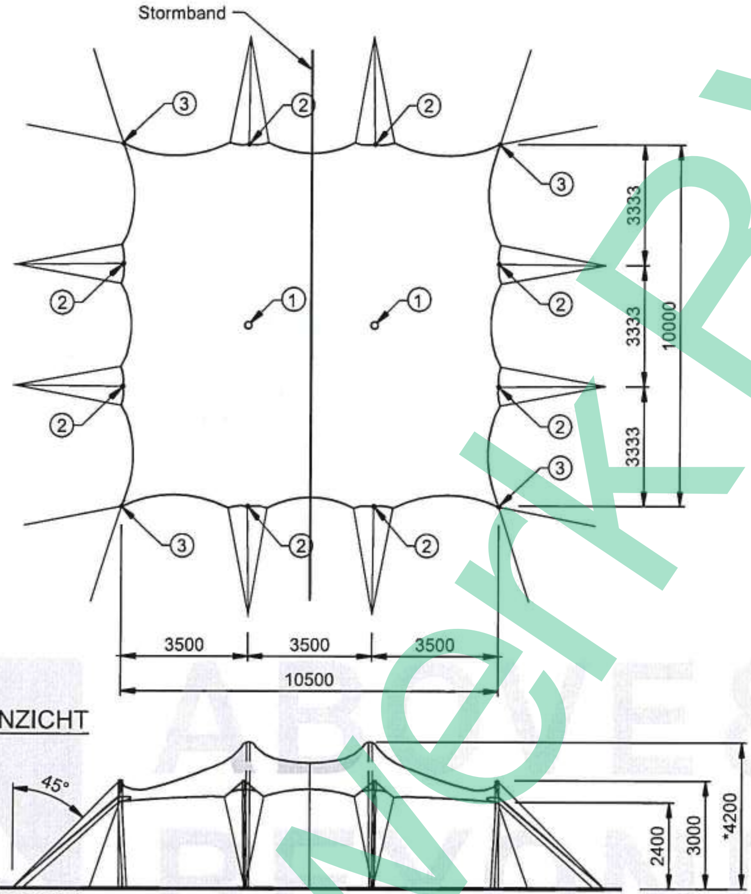
ANCHORS

All tension belts/ropes and storm belts of the membrane must be attached to the anchors at an angle of ≥ 45°

	Option 1 **Ø28 x 950mm**	Option 2 **Ø25 x 800mm**	Option 3 **Ø43.5 x 1500mm**
Dense cohesion less soil (sandy soil)			
A: Guy rope - side:	2 anchors	3 anchors	1 anchors
B: Guy rope - corner:	1 anchor	2 anchors	1 anchors
C: Storm belt:	2 anchors	2 anchors	1 anchors
Stiff cohesive soil (clay soil)			
A: Guy rope - side:	3 anchors	4 anchors	1 anchors
B: Guy rope - corner:	2 anchors	2 anchors	1 anchors
C: Storm belt:	3 anchors	3 anchors	1 anchors

EDITOR:	DATE:	FILENAME:
DS	17.06.2024	TTIP20240014_10x12.5m

TEN TECH



BOVENAANZICHT
[1:200]

VOORAANZICHT
[1:200]

TIES

With clamps: 2x Ø10 polyester ropes, BL ≥ 2600 kg
With loops: 1x [PES[belt, Min. BL: 1200 kg per belt
Stormbelt: 1x [PES[belt, Min. BL: 3000 kg per belt

POLES

	Aluminium [EN-AW 6061 T6]	Wood [Eucalyptus D35]
1: Center poles*	Ø80 x 3mm, Length = 4.1m	Ø80 mm, Length = 4.2m
2: Side poles	Ø60 x 2.5mm, Length = 3.0m	Ø70 mm, Length = 3.0m
3: Corner poles	Ø60 x 2.5mm, Length = 2.4m	Ø60 mm, Length = 2.4m

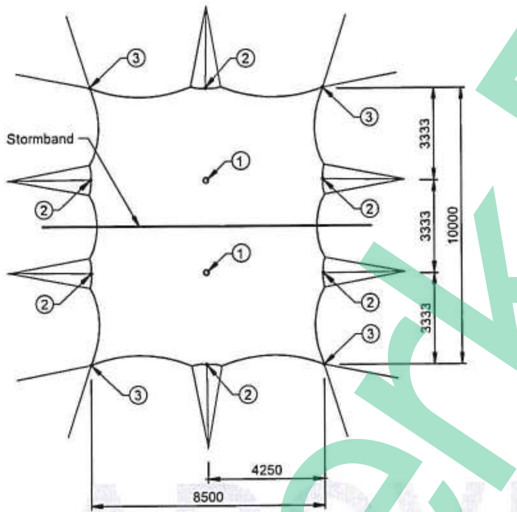
ANCHORS

All tension belts/ropes and storm belts of the membrane must be attached to the anchors at an angle of ≥ 45°

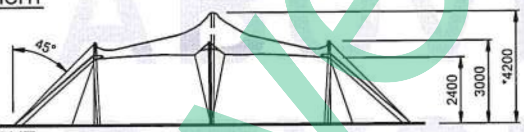
	Option 1 **Ø28 x 950mm**	Option 2 **Ø25 x 800mm**	Option 3 **Ø43.5 x 1500mm**
Dense cohesion less soil (sandy soil)			
A: Guy rope - side:	2 anchors	3 anchors	1 anchors
B: Guy rope - corner:	1 anchor	2 anchors	1 anchors
C: Storm belt:	2 anchors	2 anchors	1 anchors
Stiff cohesive soil (clay soil)			
A: Guy rope - side:	3 anchors	4 anchors	1 anchors
B: Guy rope - corner:	2 anchors	2 anchors	1 anchors
C: Storm belt:	3 anchors	3 anchors	1 anchors

EDITOR:	DATE:	FILENAME:
DS	17.06.2024	TTIP20240014_10x10.5m

TEN TECH



BOVENAANZICHT
[1:200]



VOORAANZICHT
[1:200]

TIES

With clamps: 2x Ø10 polyester ropes, BL ≥ 2600 kg
With loops: 1x [PES[belt, Min. BL: 1200 kg per belt
Stormbelt: 1x [PES[belt, Min. BL: 3000 kg per belt

POLES

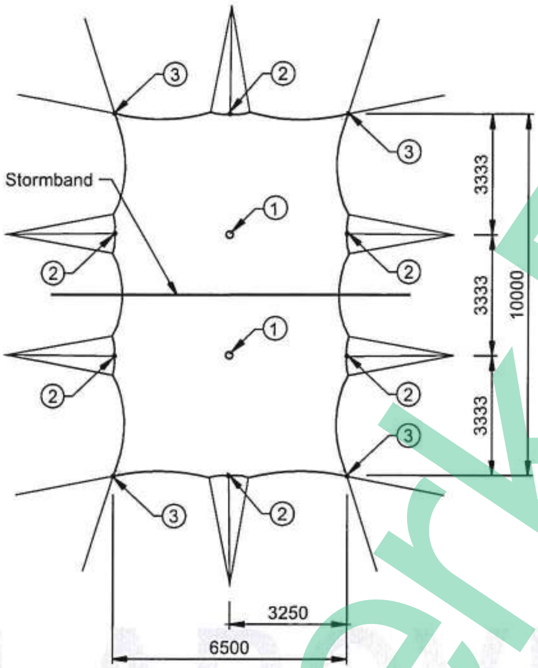
	Aluminium [EN-AW 6061 T6]	Wood [Eucalyptus D35]
1: Center poles*	Ø80 x 3mm, Length = 4,1m	Ø80 mm, Length = 4.2m
2: Side poles	Ø60 x 2.5mm, Length = 3.0m	Ø70 mm, Length = 3.0m
3: Corner poles	Ø60 x 2.5mm, Length = 2.4m	Ø60 mm, Length = 2.4m

ANCHORS

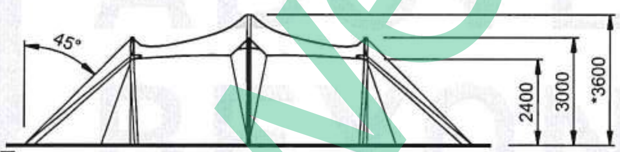
All tension belts/ropes and storm belts of the membrane must be attached to the anchors at an angle of ≥ 45°

	Option 1 **Ø28 x 950mm**	Option 2 **Ø25 x 800mm**	Option 3 **Ø43.5 x 1500mm**
Dense cohesion less soil (sandy soil)			
A: Guy rope - side:	2 anchors	3 anchors	1 anchors
B: Guy rope - corner:	1 anchor	2 anchors	1 anchors
C: Storm belt:	2 anchors	2 anchors	1 anchors
Stiff cohesive soil (clay soil)			
A: Guy rope - side:	3 anchors	4 anchors	1 anchors
B: Guy rope - corner:	2 anchors	2 anchors	1 anchors
C: Storm belt:	3 anchors	3 anchors	1 anchors

EDITOR:	DATE:	FILENAME:
DS	17.06.2024	TTIP20240014_10x8.5m



BOVENAANZICHT
[1:200]



VOORAANZICHT
[1:200]

TIES

With clamps: 2x Ø10 polyester ropes, BL ≥ 2600 kg
With loops: 1x [PES[belt, Min. BL: 1200 kg per belt
Stormbelt: 1x [PES[belt, Min. BL: 3000 kg per belt

POLES

		Aluminium [EN-AW 6061 T6]	Wood [Eucalyptus D35]
1:	Center poles*	Ø80 x 3mm, Length = 3.5m	Ø80 mm, Length = 3.6m
2:	Side poles	Ø60 x 2.5mm, Length = 3.0m	Ø70 mm, Length = 3.0m
3:	Corner poles	Ø60 x 2.5mm, Length = 2.4m	Ø60 mm, Length = 2.4m

ANCHORS

All tension belts/ropes and storm belts of the membrane must be attached to the anchors at an angle of ≥ 45°

		Option 1 **Ø28 x 950mm**	Option 2 **Ø25 x 800mm**	Option 3 **Ø43.5 x 1500mm**
Dense cohesion less soil (sandy soil)				
A:	Guy rope - side:	2 anchors	3 anchors	1 anchors
B:	Guy rope - corner:	1 anchor	2 anchors	1 anchors
C:	Storm belt:	2 anchors	2 anchors	1 anchors
Stiff cohesive soil (clay soil)				
A:	Guy rope - side:	3 anchors	4 anchors	1 anchors
B:	Guy rope - corner:	2 anchors	2 anchors	1 anchors
C:	Storm belt:	3 anchors	3 anchors	1 anchors

EDITOR:	DATE:	FILENAME:
DS	17.06.2024	TTIP20240014_10x6.5m

F. Important terms and conditions

This document applies to the built structure 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 fabric needs a certain freedom to deform in all directions to prevent damages caused by collision with objects located closely to the fabric (see also EN 13782, article 8.7).
- Above the maximum allowable wind speeds (see summary, part wind load) the structure should be evacuated and access for the public must be denied.
- Only decorations, music- and light installations of less than 25kg per pole, can be attached to the structure.
- A conventional load of 0.1 kN/m² is taken into account according to EN 13782, which corresponds with the required snowload (4cm) according to the French CTS.
- Anchoring is based on dense, non-cohesive soil. When soil differs, additional anchoring might be necessary or anchor tests need to be performed.

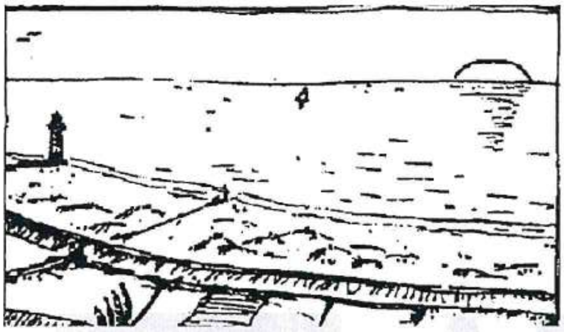
G. Allowable wind speeds

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) Illustrations of these terrain categories are presented at page 17.

Storm belts are required constantly.

Default European terrain categories (not Country specific)

0: Coastal area:

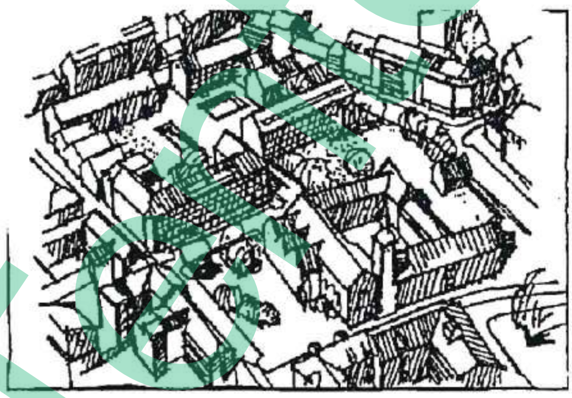


I: Flattened, open area:

II: Rural area

III: Village

IV: City



H. Static analysis

H.1. Project description

H.1.1 Description

The principle of a stretchtent is based on a rectangular piece of stretchable membrane with fixing possibilities along the boundary. The membrane is supported by poles, both at the edge and in the field. The side poles are stabilized by guy ropes. The poles do not require a fixed position which ensures a freedom of shape.

Tentech has carried out a static analysis of a 10x21.5m stretch tent for a setting with open sidewalls, the so-called Floating settings.

H.1.2 Analyzed configuration

Figure 1. 10x21.5m floating

Storm belts are needed constantly.

H.2. Materials and cross sections

H.2.1 Fabric

Design tensile strength	f_d	f_{tk} / γ_m	art 8.6 EN 13782
Characteristic tensile strength Triflexx (warp)	$0.8xf_{tk,ketting}$	16 kN/m	
Characteristic tensile strength Triflexx (weft)	$0.8xf_{tk,inslag}$	9.6 kN/m	
Material factor – global, permanent load	γ_m	2.5	tbl 4. EN13782
Material factor – global, short duration load	γ_m	2.0	tbl 4. EN13782

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

Material	Type	Weight	$f_{rd;warp;perm}$	$f_{rd;\ weft;perm}$	$f_{rd;\ warp;short}$	$f_{rd;\ weft;short}$
Triflexx (Endutex) STRETCH 560	-	≈ 580 gr/m^2	6.40 kN/m	3.84 kN/m	8.00 kN/m	4.8 kN/m

Table 2. Used fabrics

H.2.2 Belts

Design resistance	F_{rd}	R_m / γ_{m1}	art 10.2. EN13782
Characteristic breaking strength	R_m	LC x γ_{m2}	art 10.2. EN13782
Lashing capacity	LC		Conform EN 12195-2
Material factor	γ_{m1}	2.0	art 10.2. EN13782
Material factor	γ_{m2}	3.0	EN1492-1

Table 3. Used symbols, codes and standard for belt materials

Material	LC	Rm	F_{rd}
Storm belt * [PES] EN 12195-2	≥ 1000 daN ≥ 10 kN	≥ 3000 daN * ≥ 30 kN	≥ 15.0 kN
Tension belt*		≥ 1200 daN * ≥ 12 kN	≥ 6.0 kN

Table 4. Used belts

* It is allowed to use other belt, as long as the characteristic breaking load R_m is similar or higher.

H.2.3 Ropes

Design resistance	F_{rd}	R_m / γ_{m1}	art 10.2. EN13782
Characteristic tensile strength	R_m		art 10.2. EN13782
Material factor	$\gamma_{m1 \leq 12mm}$	4.0	art 10.3. EN13782
	$\gamma_{m1 \geq 14mm}$	≤ 3.3	art 10.3. EN13782

Table 5. Used symbols, codes and standard for belt materials

Material	Cross section	Breaking strength	Rm	F_{rd}
10mm Beaufort Polyester rope *	Ø10 mm	≥ 2555 daN *	25.55 kN	6.39 kN

Table 6. Used ropes

* It is allowed to use other rope, as long as the characteristic breaking load R_m is similar or higher.

H.2.4 Wood, Eucalyptus D35

Material	γ_{m1}	1.3	tbl. 2.3. EN 1995-1-1

Table 7. Used material factors

Material	Weight	$E_{0.05}$	F_{c0k}	F_{mk}
Wood, Eucalyptus D35 strength class	540 kg/m³	8.7 kN/m²	25 N/mm²	35 N/mm²

Table 8. Used wooden materials

H.2.5 Aluminium, 6061 T6

Material factor (strength)	γ_{m0}	1.1	tbl. 6.1. EN 1999-1-1
Material factor (stability)	γ_{m1}	1.1	tbl. 6.1. EN 1999-1-1
Material factor (tension to fracture / connections)	γ_{m2}	1.25	tbl. 2.1. EN 1999-1-1

Table 9. Used material factors

Material	Weight	E-modulus	F_y	F_u
EN-AW 6061 T6	2700 kg/m³	70000 N/mm²	240 N/mm²	260 N/mm²

Table 10. Used aluminum materials

* It is allowed to use other alloys, as long as the F_y and F_u values are similar or higher.

H.3. Cross sections

Profile	Material	Ø mm	t mm	G kg/m	A mm²	I_y mm⁴	$W_{el;y}$ mm³	$W_{pl;y}$ mm³
Ø80mm	Wood D35	80	n/a	3.44	5027	2010619	50266	
Ø70mm	Wood D35	70	n/a	2.08	3849	1178588	33674	
Ø60mm	Wood D35	60	n/a	1.53	2827	636173	21206	
Ø80x3mm	6061 T6*	80	3	1.96	726	538657	13466	17796
Ø60x2.5mm	6061 T6*	60	2.5	1.22	452	186992	6233	8271

Table 11. Used cross sections

* It is allowed to use other alloys, as long as the F_y and F_u values are similar or higher.

H.4. Calculation method

H.4.1 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 side poles are stabilized and tied down by tension belts/ropes, which are attached to ground anchors.

Tensioning can be accomplished with belts connected to loops on the edge of the membrane. In this case the edge is reinforced by the belt. Or by means of ropes fastened with clamps on the membrane edge keder. Then two layers of fabric represent the edge reinforcement.

Storm belts are needed constantly. They are placed in the valleys between the field poles. The structure has been calculated only with the full wind.

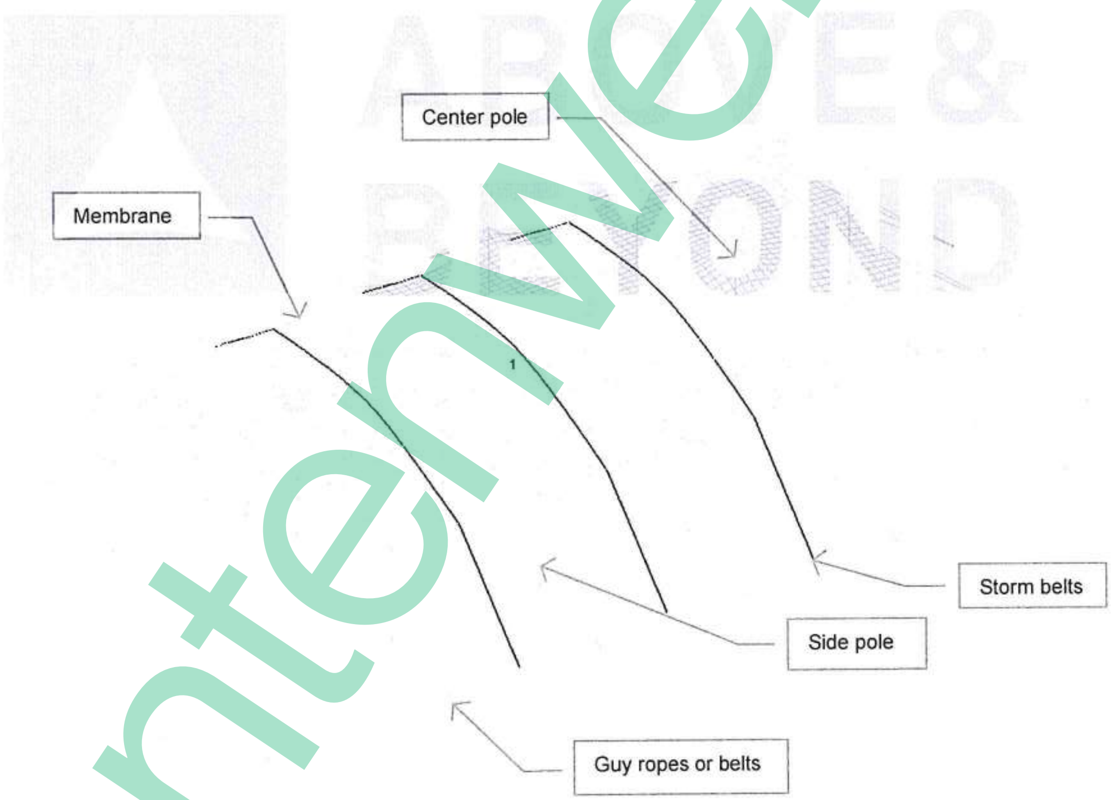


Figure 2. 3d view - elements

H.4.2 Structural behavior of membrane structures

Since the fabric is a highly deformable material, it is only possible to calculate stresses and deformations with a non-linear method. FEM-software EASY is used to perform these calculations. Because of the non-linearity of the calculations the partial safety factors are not applied beforehand, since the deformations will be greater due to these safety factors, resulting in lower stresses in the fabric. See figure below.

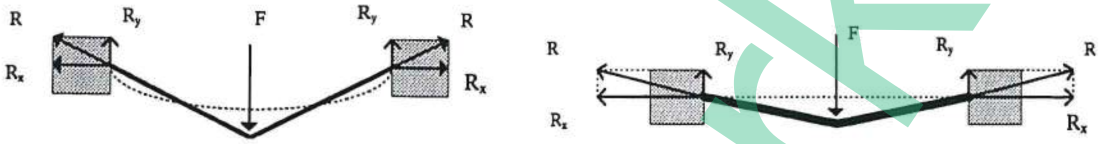


Figure 3. membrane behavior

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.*

This means that no load factors are applied on the load beforehand, but afterwards.

H.4.3 Load combinations

H.4.3.1 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 12. Load combinations according to 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 + 1.5 x Conventional load

H.4.3.2 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 13. Load combinations according to EN 13782

This means the following load combinations will be checked/calculated:

1. 1.0 x Own weight + 1.2 x Wind load

H.5. Load cases

H.5.1 Own weight

The own weight of the fabric is 580 g/m² = 0.0058 kN/m² and is added as separate load case.

H.5.2 Pretension

The structure will be pretensioned with guy ropes. The pretension in the guy ropes varies between 200-300 kg.

H.5.3 Conventional / snow load

Conventional load according to 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/m² (4cm) according the French CTS.

H.5.4 User load

A user defined load (for light, sound and/or decoration purposes) is set on 25 kg per pole and is added after the analysis while performing checks.

H.5.5 Wind

H.5.5.1 Wind pressure

Wind load according to EN 13782, 7.4.2.2:
A reduced peak velocity pressure of $q_p(z_e)$ = 0,30 kN/m² may be applied in the case of tents with a width of 10 m or less and height of 5 m or less.

H.5.5.2 shape values (Cp-factors)

Two different wind situations are reviewed for the membrane:

1. The whole tent is subjected to wind suction (conform Cp values given in EN 13782)
2. The whole tent is subjected to wind pressure (conform Cp values given in EN 13782)

Wind suction

Wind coefficients (c_p – values) for tent constructions according to art. 6.4.2.3 of the EN 13782.

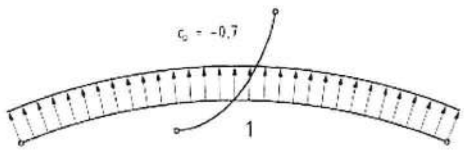


figure 4. C_p values for rectangle structures EN 13782

P_w	$p_{w,rep}$
300 N/m²	-0.7 x 0.300 = **-0.210 kN/m²**

Wind pressure

Wind coefficients (c_p – values) for tent constructions according to art. 6.4.2.3 of the EN 13782.

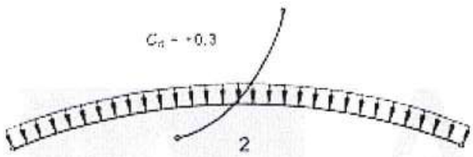


figure 5. C_p values for rectangle structures EN 13782

P_w	$p_{w,rep}$
300 N/m²	0.3 x 0.300 = **0.090 kN/m²**

TEN TECH

H.6. Calculation results

H.6.1 Listing of calculated load combinations

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

The following load combinations are taken into account:
partial safety factors are added after the static analysis (see H.4.2).

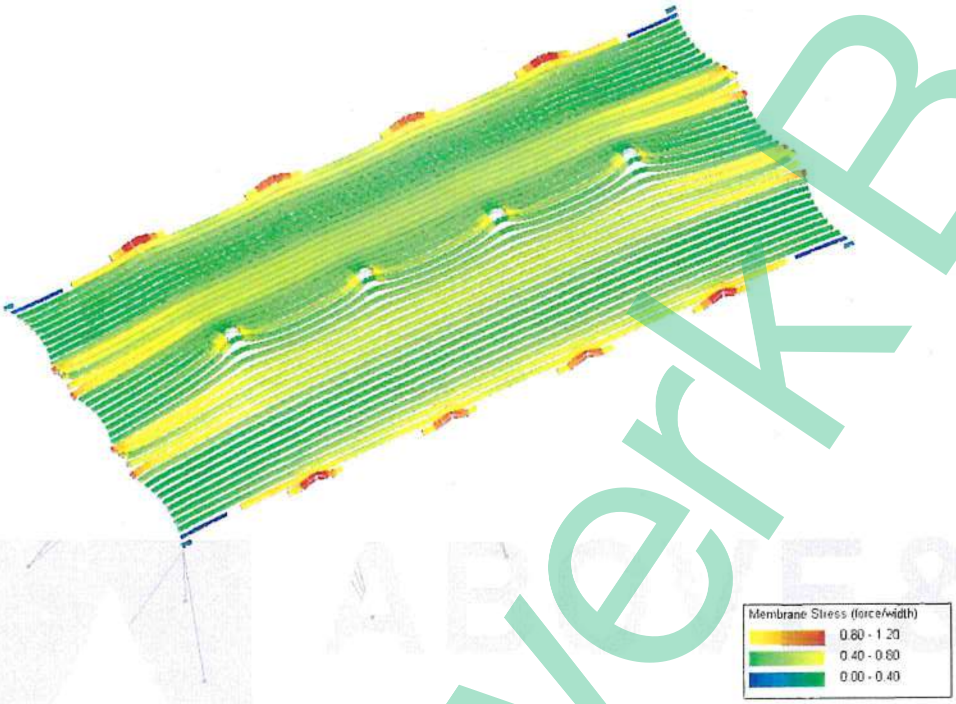
	LC 1	LC2	LC 3	LC 4	LC 5
CO 1	1 x	1 x			
CO 2	1 x	1 x	1 x		
CO 3	1 x	1 x		1 x	
CO 4	1 x	1 x			1 x

table 14. Combinations (CO)

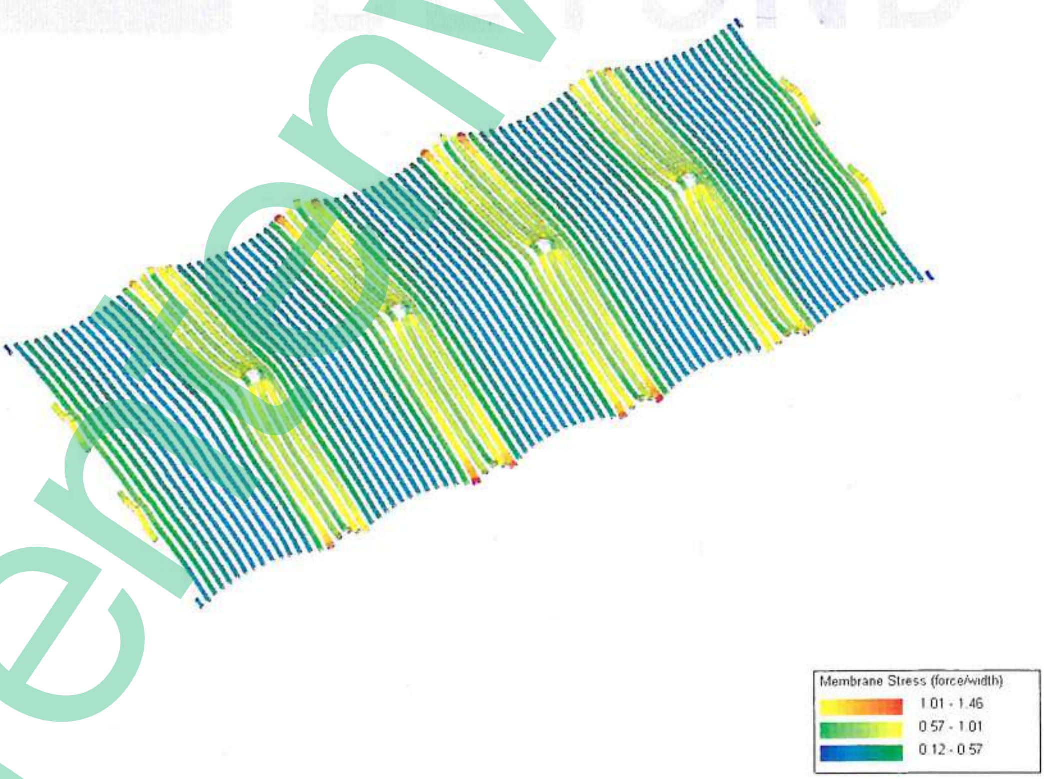
H.6.2 Global results of static analysis per load combination

H.6.2.1 CO1. Own weight + pretension

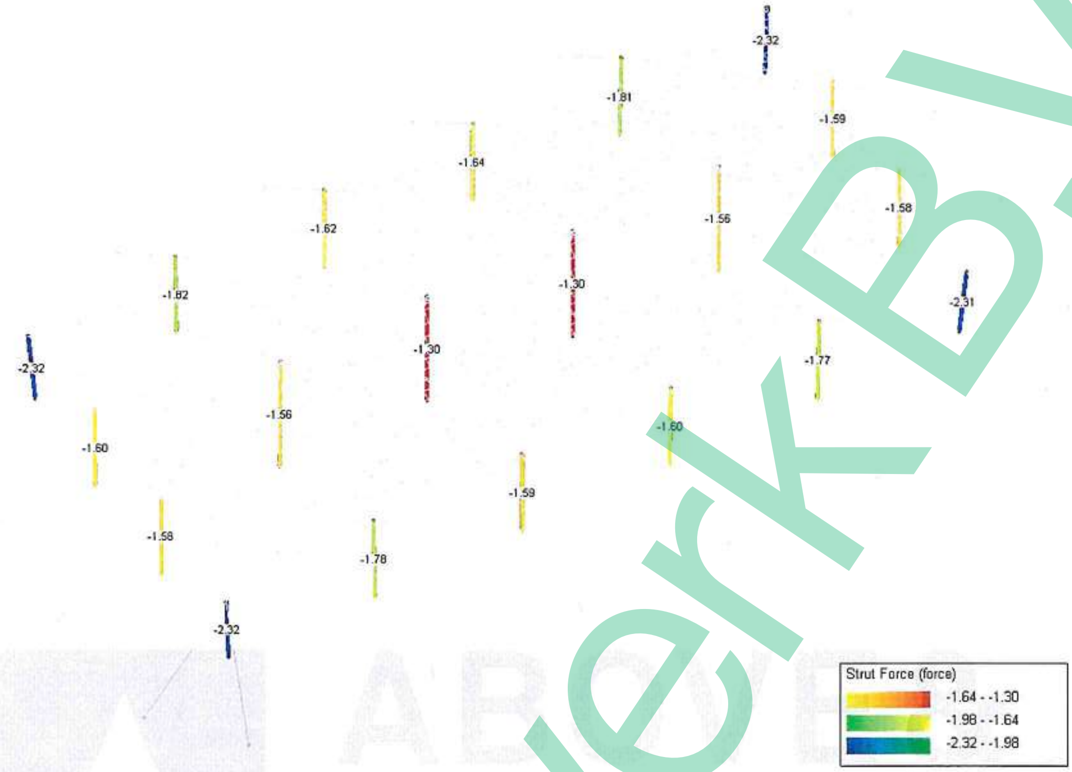
H.6.2.1.1. Membrane stress (warp)



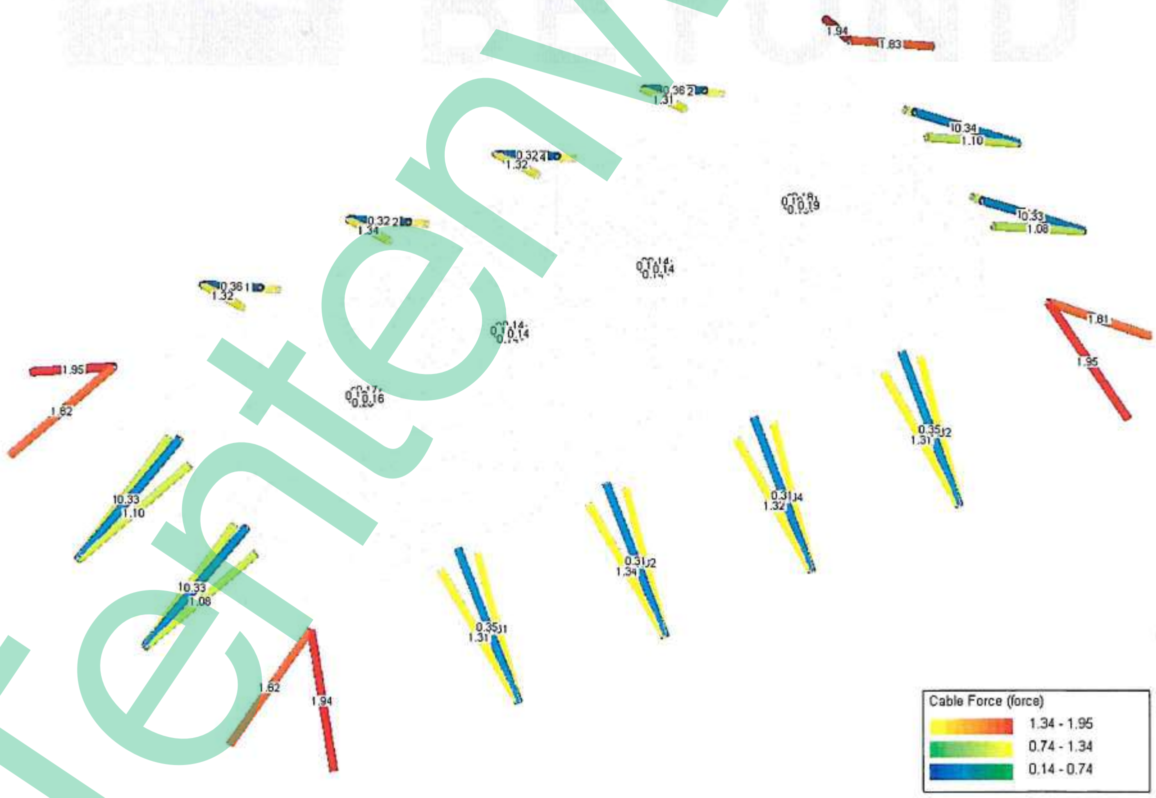
H.6.2.1.2. Membrane stress (weft)



H.6.2.1.3. Poles forces

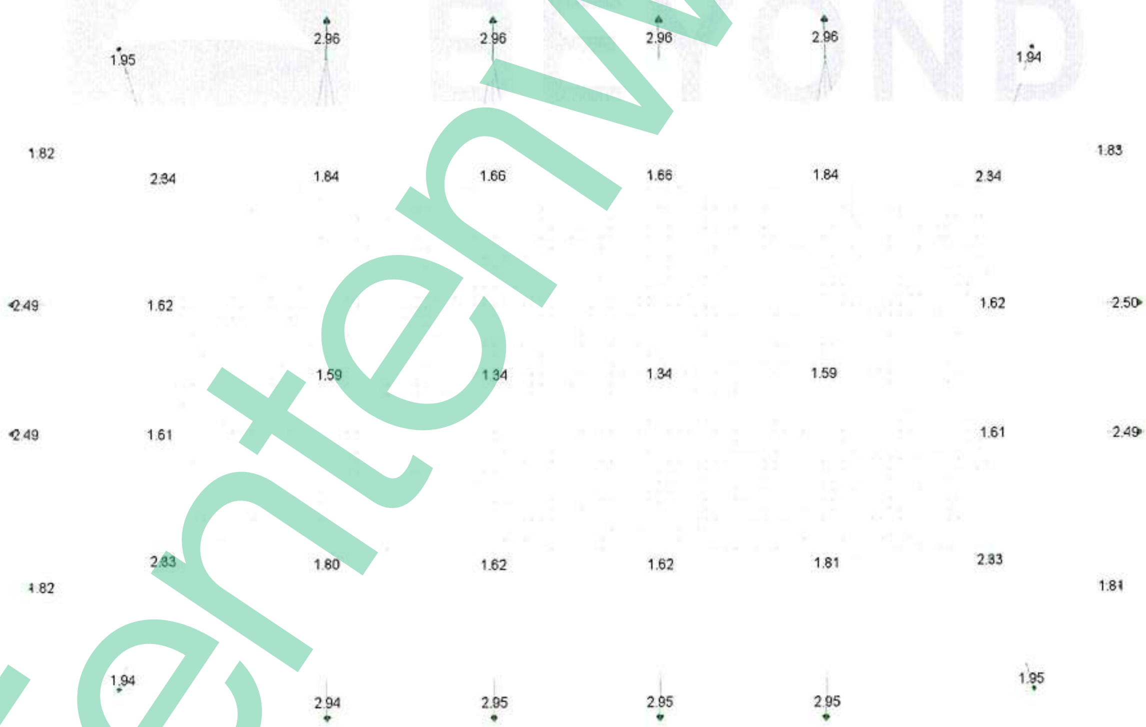


H.6.2.1.4. Guy ropes forces



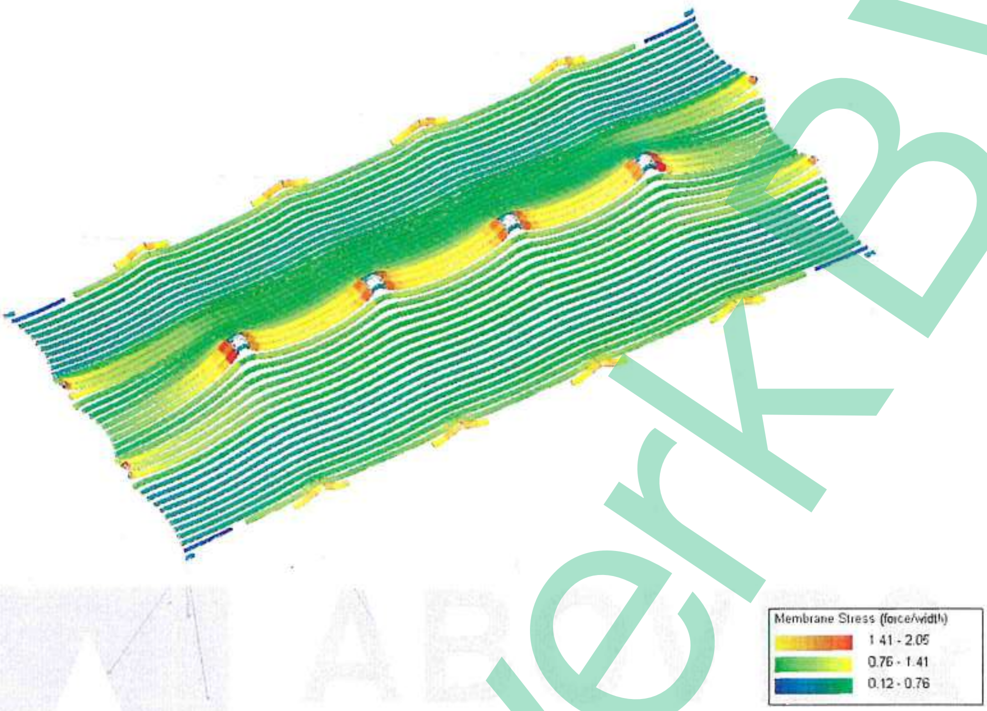
H.6.2.1.5. Circumference force

H.6.2.1.6. Anchor forces

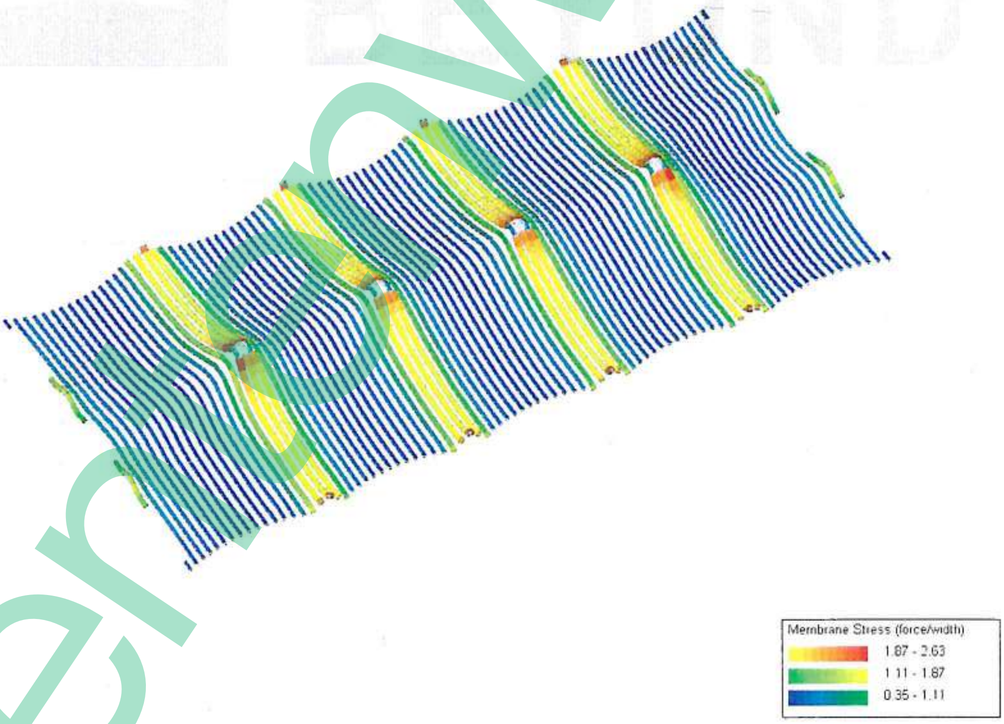


H.6.2.2 CO2. Own weight + pretension + conventional / snow

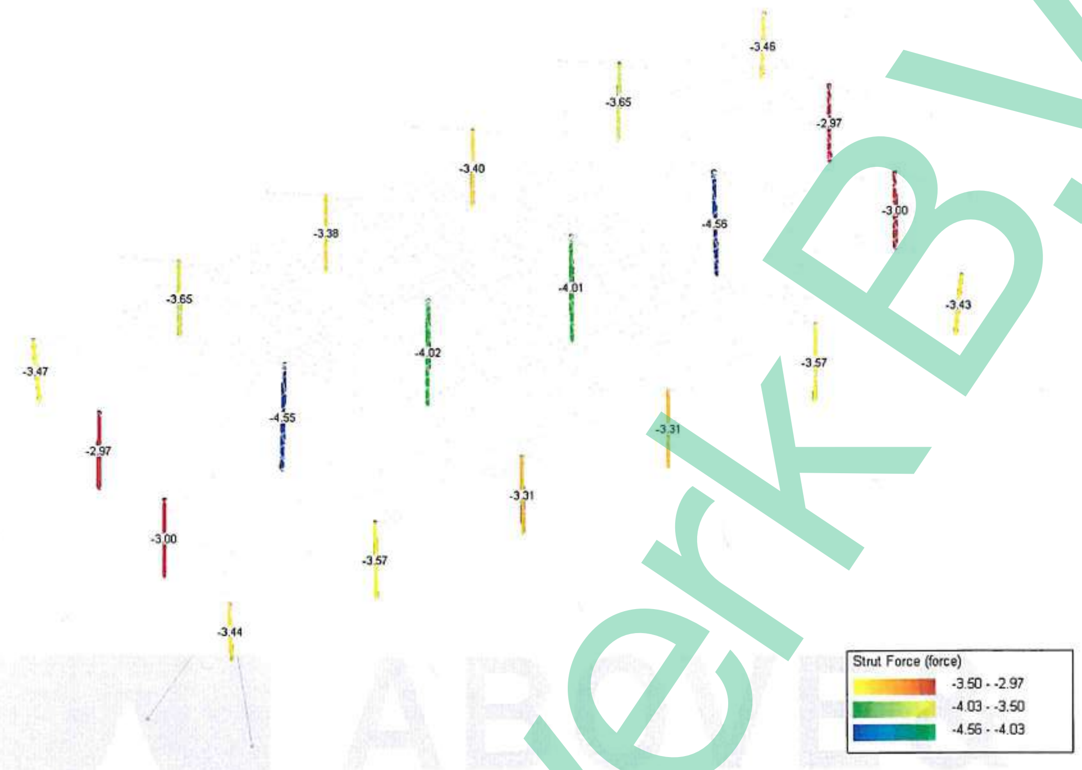
H.6.2.2.1. Membrane stress (warp)



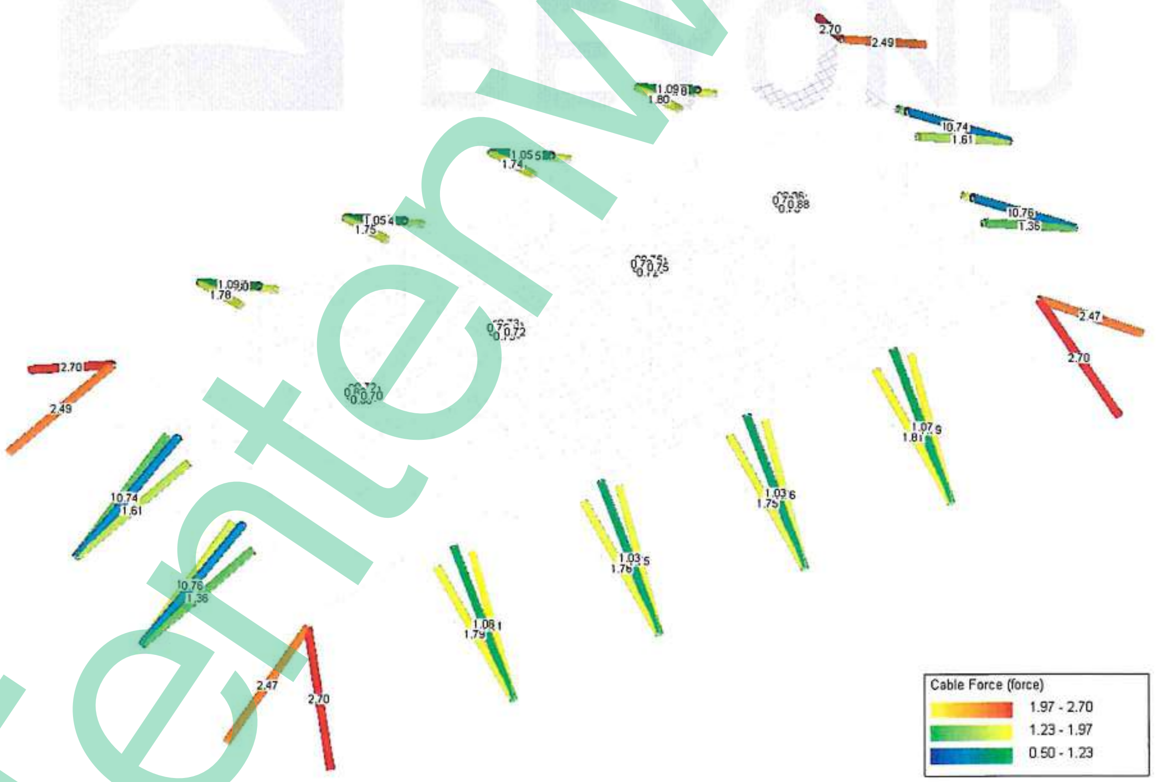
H.6.2.2.2. Membrane stress (weft)



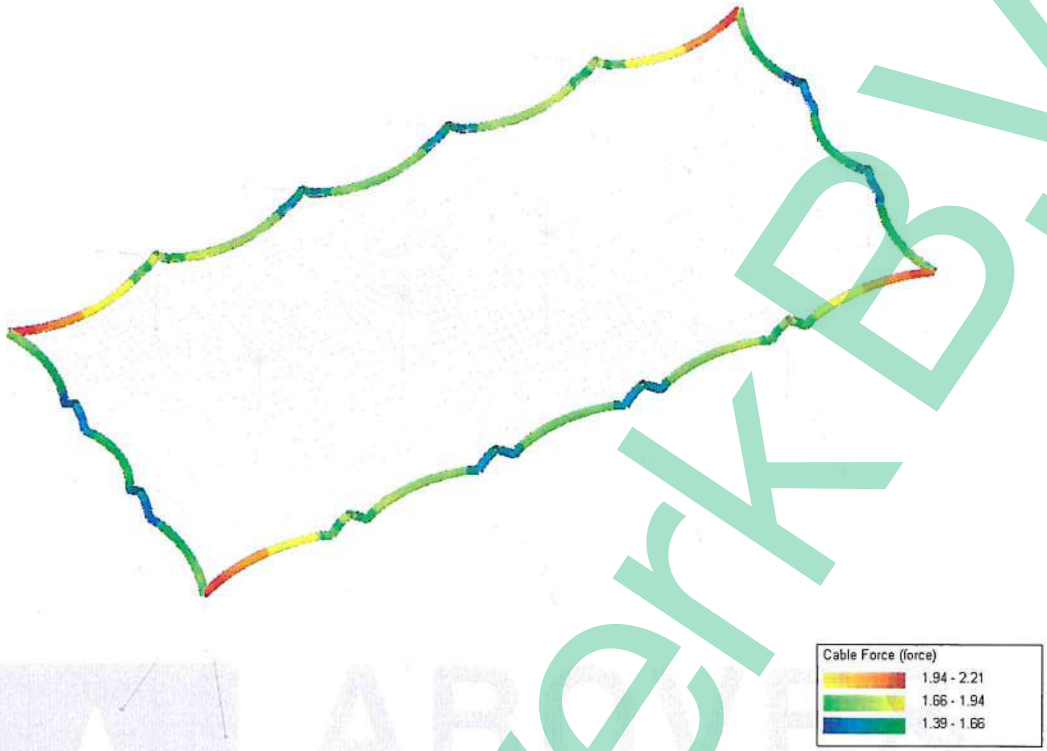
H.6.2.2.3. Poles forces



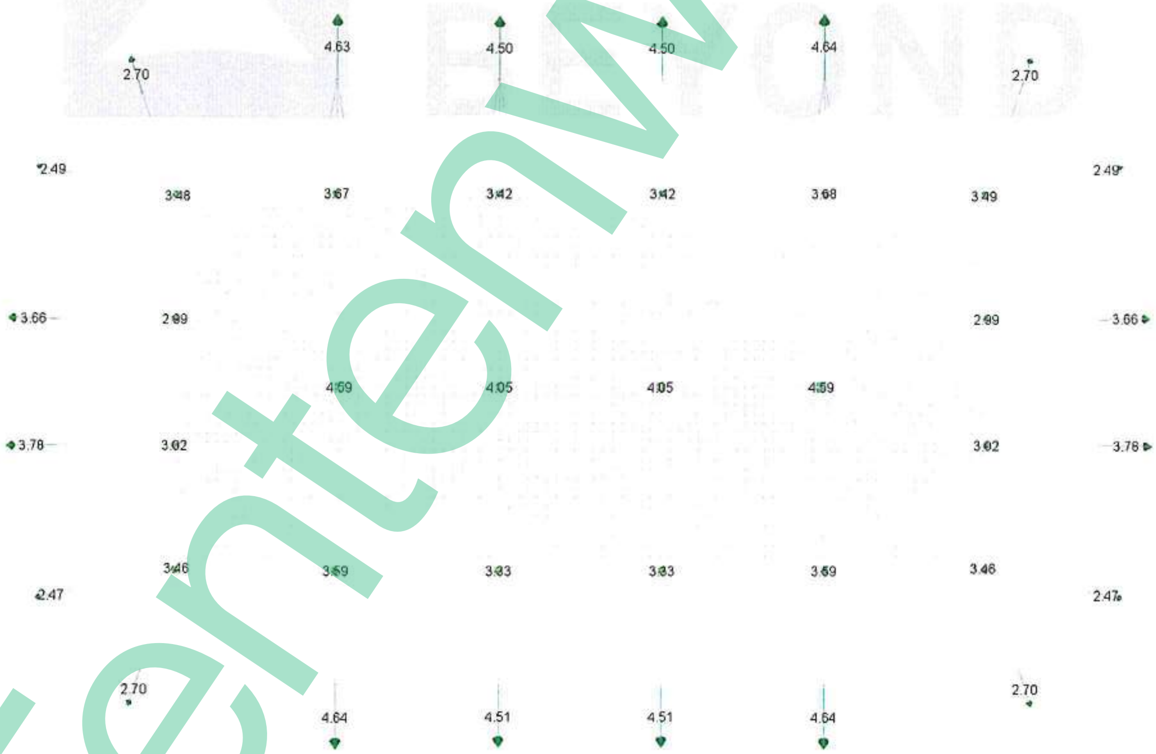
H.6.2.2.4. Guy ropes forces



H.6.2.2.5. Circumference forces

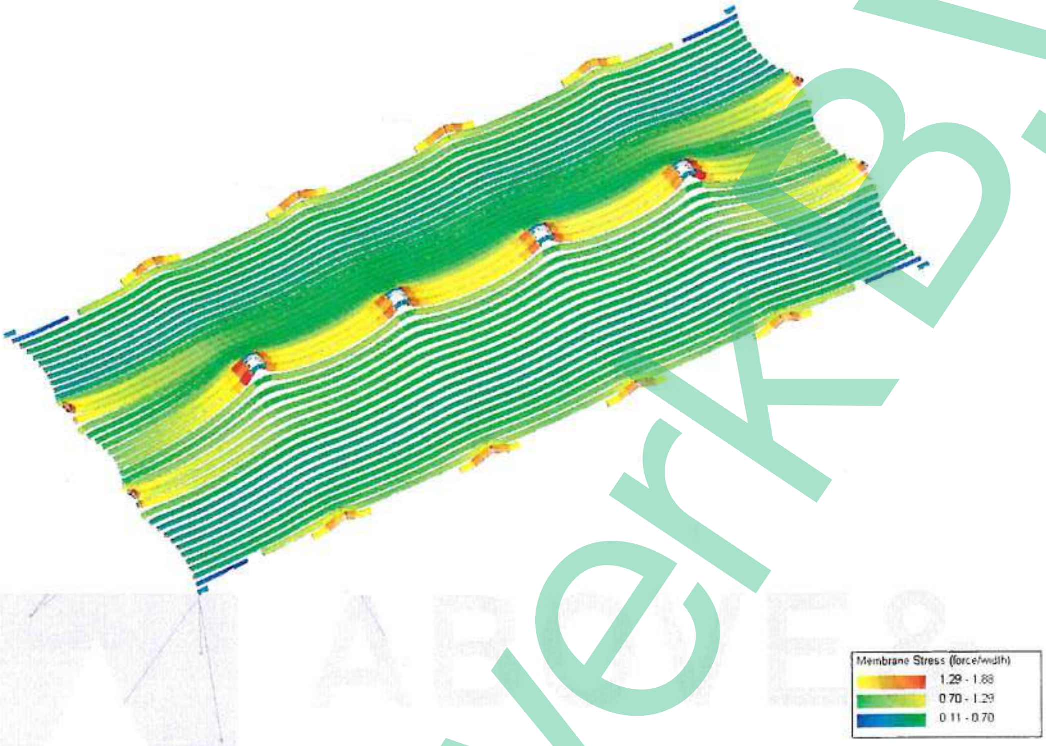


H.6.2.2.6. Anchor forces

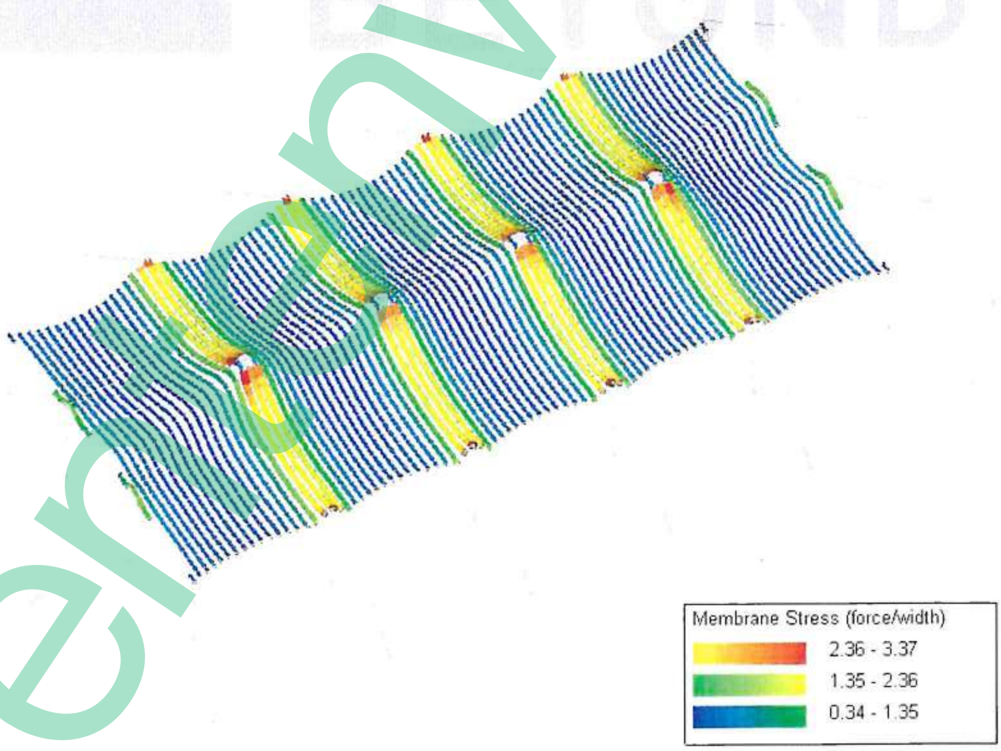


H.6.2.3 CO3. Own weight + pretension + wind pressure

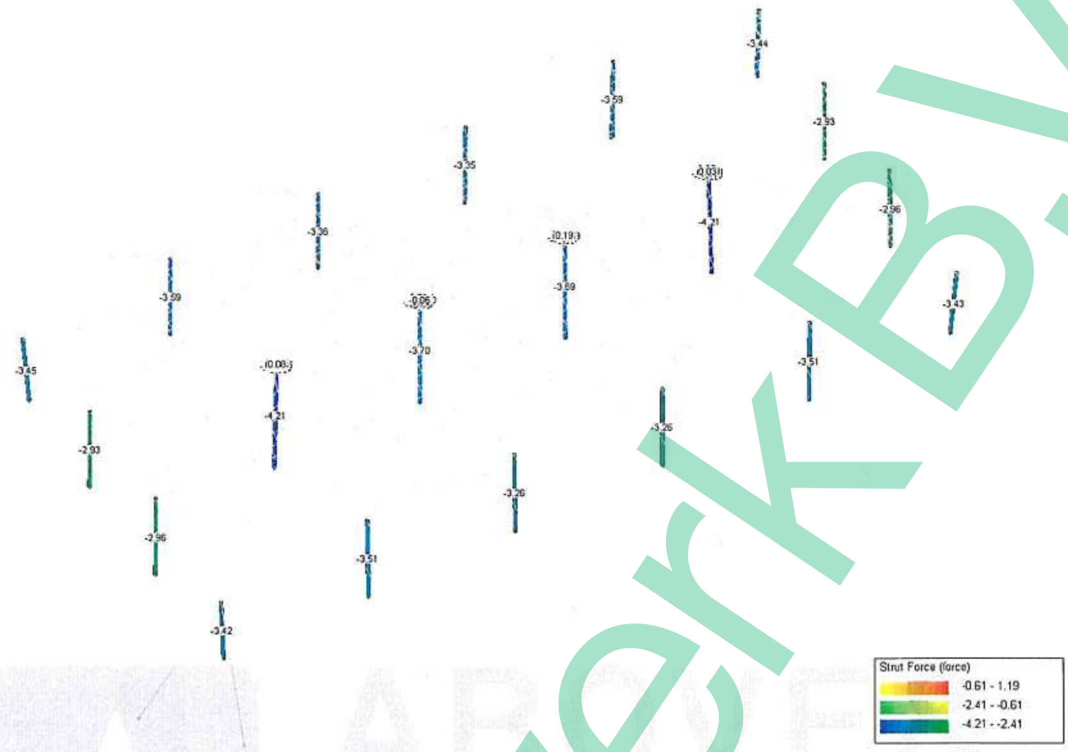
H.6.2.3.1. Membrane stress (warp)



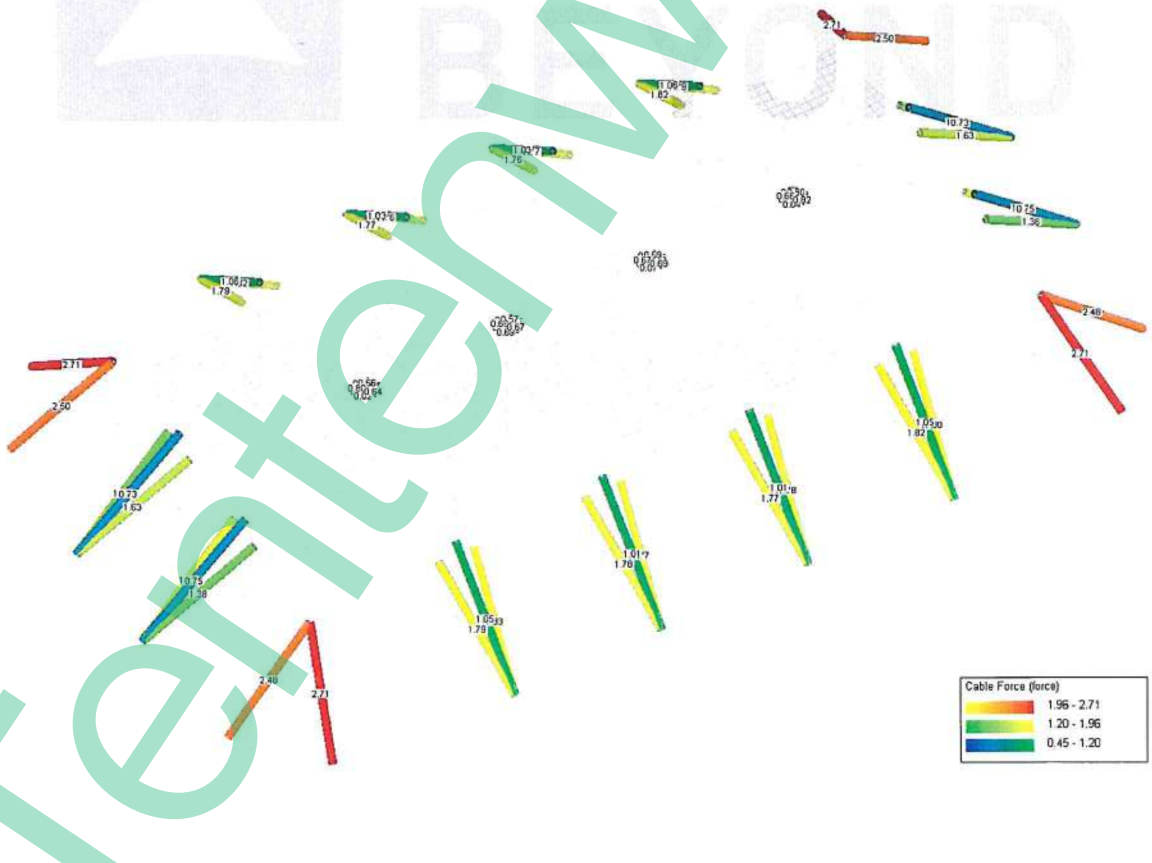
H.6.2.3.2. Membrane stress (weft)



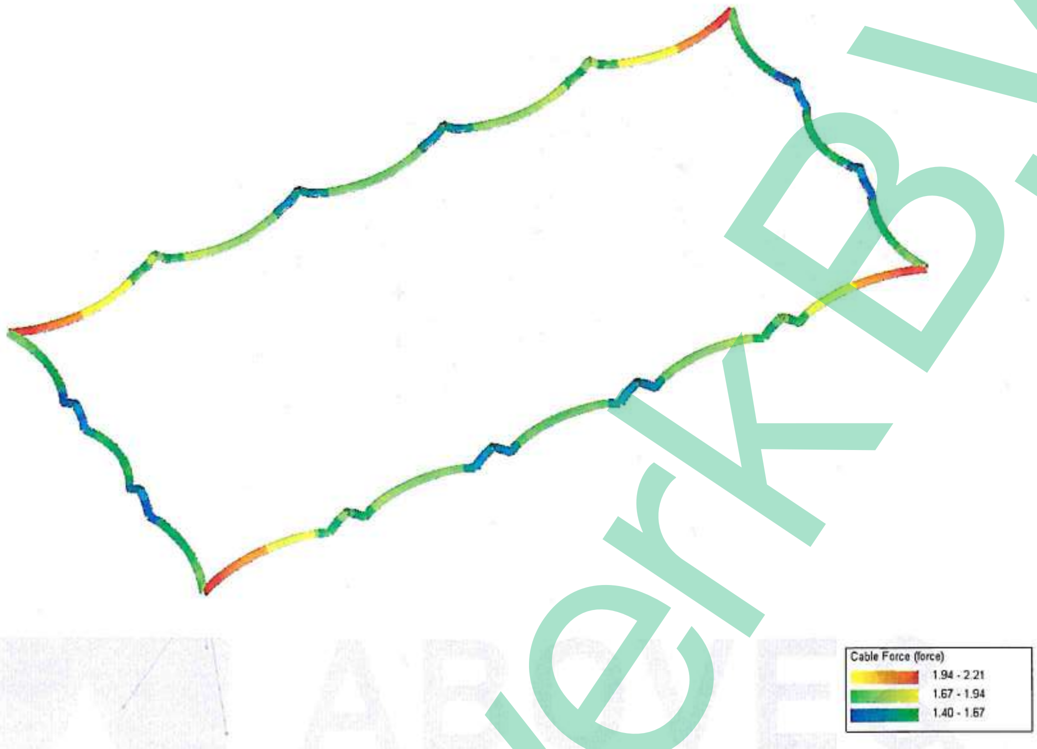
H.6.2.3.3. Poles forces



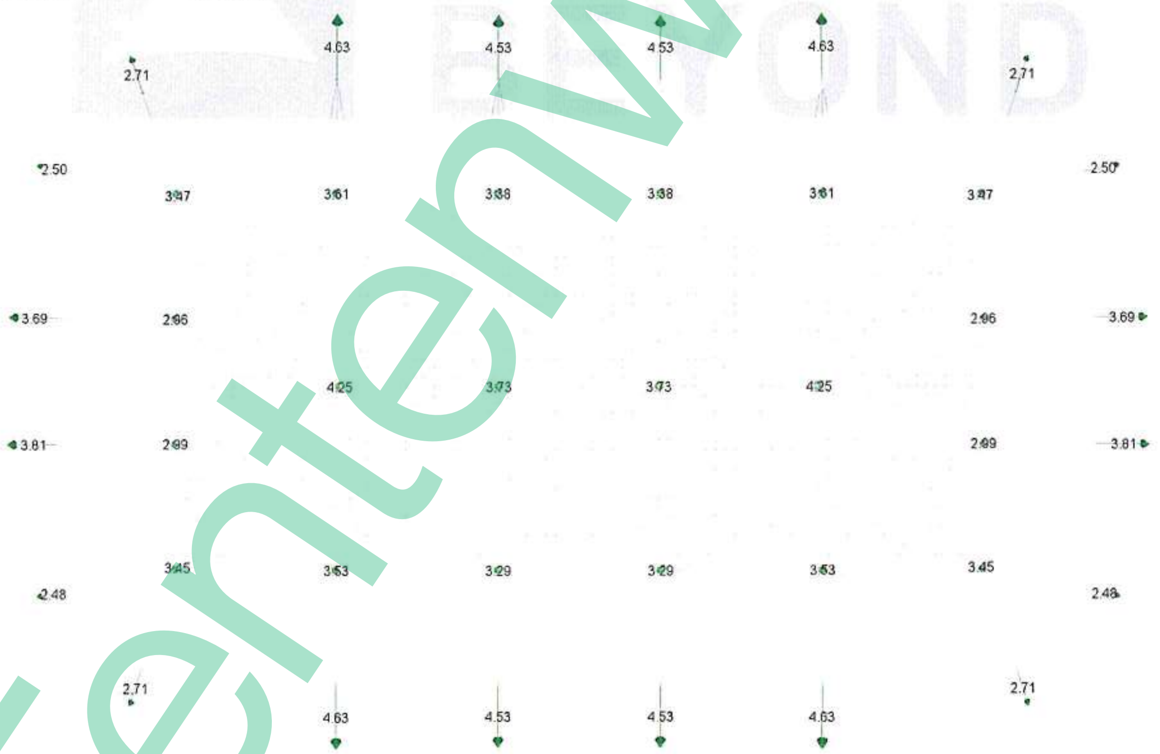
H.6.2.3.4. Guy ropes forces



H.6.2.3.5. Circumference forces

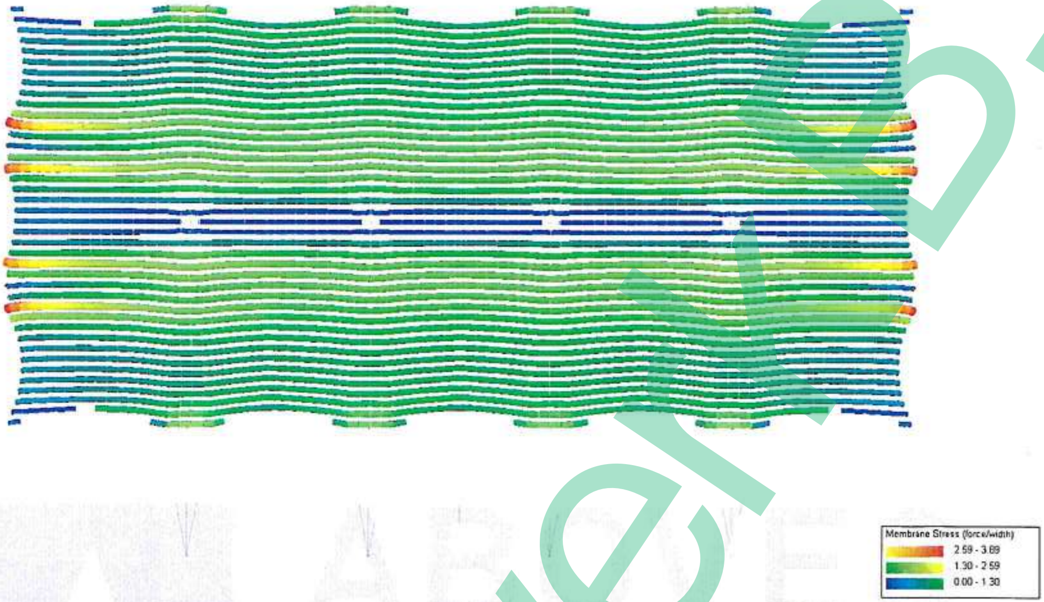


H.6.2.3.6. Anchor forces

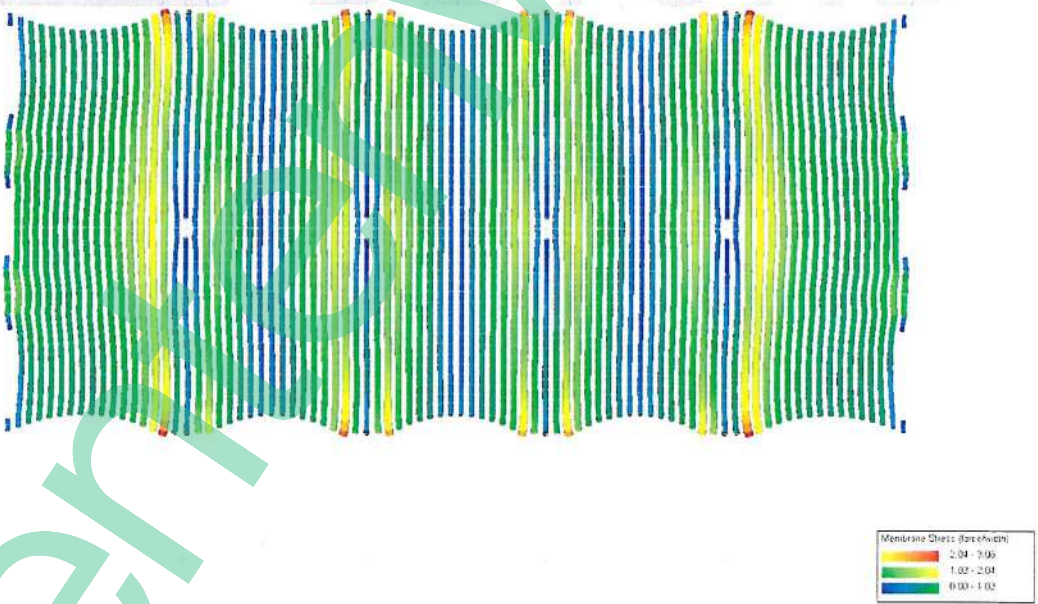


H.6.2.4 CO4. Own weight + pretension + wind suction

H.6.2.4.1. Membrane stress (warp)



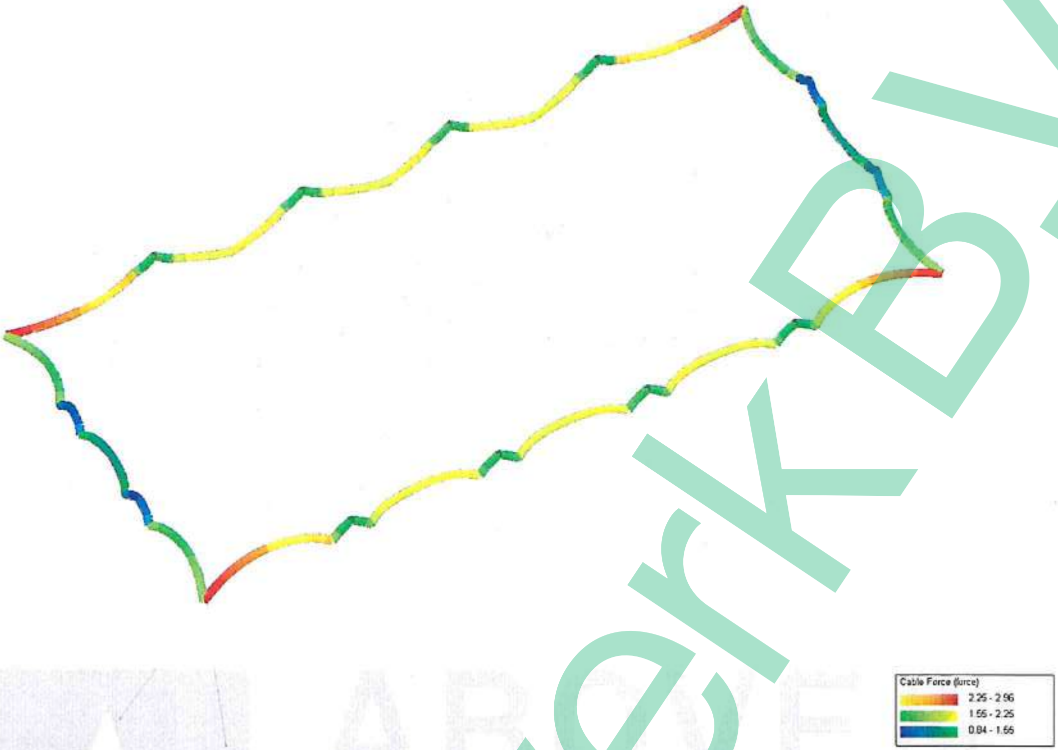
H.6.2.4.2. Membrane stress (weft)



H.6.2.4.3. Poles forces

H.6.2.4.4. Guy ropes forces

H.6.2.4.5. Circumference reinforcement forces



H.6.2.4.6. Anchor forces

H.6.2.4.7. Storm belts forces

H.6.2.4.8. Anchor forces (reduced wind)

H.6.3 Overview: Global results of static analysis

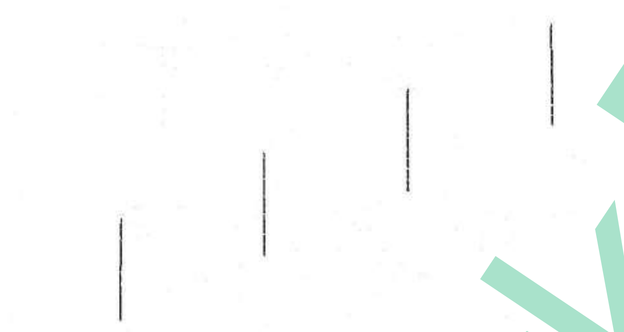
H.6.3.1 Fabric

		Load combination	F_{rep}	Pag.
Warp		CO1. Own weight + pretension	1.20 kN/m	30
		CO2. Own weight + pretension + conventional / snow	2.05 kN/m	33
		CO3. Own weight + pretension + wind pressure	1.88 kN/m	36
	Max	CO4. Own weight + pretension + wind suction *	3.89 kN/m	39
Weft		CO1. Own weight + pretension	1.46 kN/m	30
		CO2. Own weight + pretension + conventional / snow	2.63 kN/m	33
		CO3. Own weight + pretension + wind pressure	2.47 kN/m	36
	Max	CO4. Own weight + pretension + wind suction *	3.06 kN/m	39

Table 15. Leading forces - Fabric

* stormbelts required

H.6.3.2 Center poles



		Load combination	F_{rep}	Pag.
Center pole 4.2m	**Max**	CO1. Own weight + pretension	-1.56 kN	31
		CO2. Own weight + pretension + conventional / snow	-4.56 kN	34
		CO3. Own weight + pretension + wind pressure	-4.21kN	37
		CO4. Own weight + pretension + wind suction *	-0.00 kN	40

Table 16. Leading forces - Center poles

* stormbelts required

H.6.3.3 Side poles

		Load combination	F_{rep}	Pag.
Side poles 3.0m	**Max**	CO1. Own weight + pretension	-1.82 kN	31
		CO2. Own weight + pretension + conventional / snow	-3.65 kN	34
		CO3. Own weight + pretension + wind pressure	-3.59 kN	37
		CO4. Own weight + pretension + wind suction *	-2.38 kN	40

Table 17. Leading forces - Side poles

* stormbelts required

H.6.3.4 Corner poles

		Load combination	F_{rep}	Pag.
Corner poles 2.4m	Max	CO1. Own weight + pretension	-2.32 kN	31
		CO2. Own weight + pretension + conventional / snow	-3.47 kN	34
		CO3. Own weight + pretension + wind pressure	-3.45 kN	37
		CO4. Own weight + pretension + wind suction *	-3.08 kN	40

Table 18. Leading forces – Corner poles

* stormbelts required

H.6.3.5 Guy ropes

		Load combination	F_{rep}	Pag.
Guy ropes – short side		CO1. Own weight + pretension	1.34 kN	31
		CO2. Own weight + pretension + conventional / snow	1.81 kN	34
		CO3. Own weight + pretension + wind pressure	1.83 kN	37
	Max	CO4. Own weight + pretension + wind suction *	2.97 kN	40
Guy ropes – long side		CO1. Own weight + pretension	1.10 kN	31
		CO2. Own weight + pretension + conventional / snow	1.71 kN	34
		CO3. Own weight + pretension + wind pressure	2.12 kN	37
	Max	CO4. Own weight + pretension + wind suction *	2.49 kN	40
Guy ropes – corner		CO1. Own weight + pretension	1.95 kN	31
		CO2. Own weight + pretension + conventional / snow	2.70 kN	34
		CO3. Own weight + pretension + wind pressure	2.71 kN	37
	Max	CO4. Own weight + pretension + wind suction *	3.29 kN	40

Table 19. Leading forces - Guy ropes

* stormbelts required

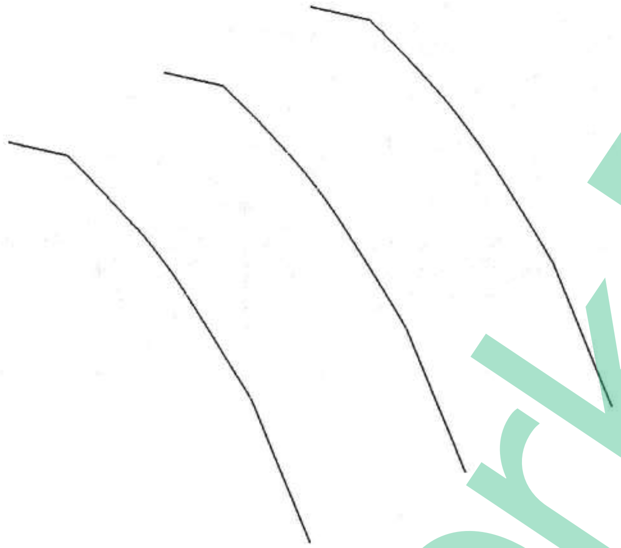
H.6.3.6 Circumference reinforcement

	Load combination	F_{rep}	Pag.
Circumference reinforcement	CO1. Own weight + pretension	1.67 kN	30
	CO2. Own weight + pretension + conventional / snow	2.21 kN	33
	CO3. Own weight + pretension + wind pressure	2.21 kN	36
Max	CO4. Own weight + pretension + wind suction *	2.96 kN	39

Table 20. Leading forces - Circumference reinforcement

* stormbelts required

H.6.3.7 Storm belts



		Load combination	F_{rep}	Pag.
Storm belts		CO1. Own weight + pretension	-	-
		CO2. Own weight + pretension + conventional / snow	-	-
		CO3. Own weight + pretension + wind pressure	-	-
	Max	CO4. Own weight + pretension + wind suction *	5.01 kN	41

Table 21. Leading forces - Storm belts

* stormbelts required

H.7. Check elements

H.7.1 Fabric

Load combination	Element	Representative stress	Design value stress	Pag.
CO1. Own weight + pretension	Fabric Long term load warp direction	1.20 kN/m	1.62 kN/m (γ = 1.35)	30
CO1. Own weight + pretension	Fabric Long term load weft direction	1.46 kN/m	1.97 kN/m (γ = 1.35)	30
CO4. Own weight + pretension + wind suction	Fabric Short term load warp direction	3.89 kN/m	5.84 kN/m (γ = 1.5)	36
CO4. Own weight + pretension + wind suction	Fabric Short term load weft direction	3.06 kN/m *	4.59 kN/m (γ = 1.5)	36

Triflexx (Endutex) STRETCH 560 fabric is being used.

UC.1a	$S_{Ed} / S_{rd} < 1$	1.62 / 6.4 = 0.25 < 1	OK
UC.1b	$S_{Ed} / S_{rd} < 1$	1.97 / 3.84 = 0.51 < 1	OK
UC.1c	$S_{Ed} / S_{rd} < 1$	5.84 / 8.0 = 0.73 < 1	OK
UC.1d	$S_{Ed} / S_{rd} < 1$	4.59 / 4.8 = 0.96 < 1	OK

For capacity of fabric see H.2.1 page 21

H.7.2 Center poles

Load combinations	Element	Representative force	Design value force	Pag.
CO2. Own weight + pretension + conventional	Center pole 4.2m	-4.21 kN	-6.32 kN (γ = 1.5)	37

User load of max. 25 kg is applied, loaded centrically.

4.2m pole Ned = 1.50 x -4.21 + 1.35 x -0.25 = -6.65 kN

H.7.2.1 4.1m center pole - Aluminium, 6061 T6

Profile = Pole, Ø80x3
Length = 4.1m
Quality = 6061 T6

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

UC.2a	**(Ned / χ ω Nrd)0.8 < 1**	**(6.65 / 0.12 x 1 x 158.34)0.8 = 0.44 < 1**	**OK**

See Annex B1.1: Center pole 4.1m page 79 for the elaborate check

H.7.2.2 4.2m center pole - Wood, Eucalyptus D35

Profile = Pole, Ø ≈ 80 mm
average diameter, as a minimum required at the middle of the pole
Length = max. 4.2m
Quality = D35

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

UC.2b	**σc,0,d / (fc,0,d x kcy) = 1.26 / (17.31 x 0.07) = 0.98 < 1**	**OK**

See Annex B2.1: Center pole 4.2m, on page 81 for the elaborate check

H.7.3 Side poles

Load combinations	Element	Representative force	Design value force	Pag.
CO2. Own weight + pretension + conventional	Side pole 3.0m	-3.59 kN	-5.39 kN (γ = 1.5)	37

User load of max. 25 kg is applied, loaded centrically.

3m pole Ned = 1.50 x -3.59 + 1.35 x -0.25 = -5.73 kN

H.7.3.1 3.0m side pole - Aluminium, 6061 T6

Profile	=	Pole, Ø60x2.5
Length	=	3.0m
Quality	=	6061 T6

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

UC.3a	**(Ned / χ ω Nrd)0.8 < 1**	**(5.73 / 0.12 x 1 x 98.53)0.8 = 0.55 < 1**	**OK**

See Annex B1.2: Side pole 3.0m page 79 for the elaborate check

H.7.3.2 3.0m side pole - Wood, Eucalyptus D35

Profile	=	Pole, Ø ≈ 70 mm average diameter, as a minimum required at the middle of the pole
Length	=	max. 3.0m
Quality	=	D35

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

UC.3b	**3m**	**σc,0,d / (fc,0,d x kcy) = 1.49 / (17.31 x 0.11) = 0.79 < 1**	**OK**

See Annex B2.2: Side pole 3.0m, on page 82 for the elaborate check

H.7.4 Corner poles

Load combinations	Element	Representative force	Design value force	Pag.
CO3. Own weight + pretension + wind pressure	Corner pole 2.4m	-3.45 kN	-5.18 kN (γ = 1.5)	46

User load of max. 25 kg is applied, loaded centrically.

2.4m pole Ned = 1.50 x -3.45 + 1.35 x -0.25 = -5.52 kN

H.7.4.1 2.4m corner pole - Aluminium, 6061 T6

Profile	=	Pole, Ø60x2.5
Length	=	2.4m
Quality	=	6061 T6

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

UC.4a	**(Ned / χ ω Nrd)0.8 < 1**	**(5.52 / 0.19 x 1 x 98.53)0.8 = 0.38 < 1**	**OK**

See Annex B1.3: Corner pole 2.4m page 80 for the elaborate check

H.7.4.2 2.4m side pole - Wood, Eucalyptus D35

Profile	=	Pole, Ø ≈ 60 mm
		average diameter, as a minimum required at the middle of the pole
Length	=	max. 2.4m
Quality	=	D35

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

UC.4b	**σc,0,d / (fc,0,d x kcy) = 1.95 / (17.31 x 0.12) = 0.90 < 1**	**OK**

See Annex B2.2: Corner pole 2.4m, on page 83 for the elaborate check

H.7.5 Guy ropes

Load combination	Element	Representative force	Design value force	Pag.
CO4. Own weight + pretension + wind suction	Guy ropes - sides	2.97 kN	4.46 kN (γ = 1.5)	40
CO4. Own weight + pretension + wind suction	Guy ropes - corners	3.29 kN	4.94 kN (γ = 1.5)	40

It is possible to use either a rope or a belt.

- Guy ropes are synthetic guy ropes with a minimum total breaking strength BL_{rope} **≥ 2600 kg or higher**.
- Guy ropes are tensioned with help of ratchets.

In the check 10mm Beaufort Polyester rope is used. The rope can be replaced with any other rope with a higher breaking strength.

UC.5a	Guy ropes - sides	1 individual guy rope	Fd / Frd < 1	4.46 / 6.39 = 0.70 < 1	OK
UC.5b	Guy ropes - corners	1 individual guy rope	Fd / Frd < 1	4.94 / 6.39 = 0.77 < 1	OK

For capacity of ropes see H.2.3, page 22

- Guy ropes are tensioning PES belts with a minimum breaking strength of **1200kg or higher**.

UC.5c	Guy ropes - sides	1 belt made of PES belt with with a minimum BL=1200 kg	Fd / Frd < 1	4.46 / 6 = 0.74 < 1	OK
UC.5d	Guy ropes - corners	1 belt made of PES belt with with a minimum BL=1200 kg	Fd / Frd < 1	4.94 / 6 = 0.82 < 1	OK

For capacity of belts see H.2.2, page 21

H.7.5.1 Ratchet

Ratchet, BL = 3.5 kN → Frd = BL / γm = 3.5 kN / 1.5 = 2.33 kN
The ratchet has less strength then the strength of the rope. Thus, the number of sections of rope is calculated based on the ratchet capacity.

UC.5e	Guy ropes - sides	2 guy rope sections	Fd / Frd < 1	4.46 / 2 x 2.33 = 0.96 < 1	OK
UC.5f	Guy ropes - corners	2 guy rope sections	Fd / Frd < 1	4.94 / 2 x 2.33 = 1.04 ≈ 1	Acceptable

For capacity of ratchets see Material specifications

H.7.6 Clamp detail

As an option, it is possible to attach the guy ropes to the membrane with clamps. So that the loads from the connection and the attachment points can be transferred directly into the fabric. There is no edge reinforcement to spread the forces.

Load combination	Element	Representative force	Design value force	Pag.
CO4. Own weight + pretension + wind suction	Clamp - side	2.97 kN	4.46 kN (γ = 1.5)	40
CO4. Own weight + pretension + wind suction	Clamp - corner	√2x3.29 kN = 4.65 kN	6.98 kN (γ = 1.5)	40

Results tensile testing clamps:

Average tensile strength side clamp:		Ftm:	= 10.07 kN	(see Annex C1:Side clamp)
Calculated capacity	Frd =	Ftk / γ_M =	10.07 / 2 = 5.04 N	(par. 10, EN 13782)
Average tensile strength corner clamp:		Ftm:	= 21.0 kN	(see Annex C2:Corner clamp)
Calculated capacity	Frd =	Ftk / γ_M =	21.0 / 2 = 10.5 N	(par. 10, EN 13782)

UC.6a	Clamp - side	F_d / F_{rd} < 1	4.46 / 5.04 = 0.88 < 1	OK
UC.6b	Clamp - corner	F_d / F_{rd} < 1	6.98 / 1.5 = 0.66 < 1	OK

H.7.7 Storm belts

Load combination	Element	Representative force	Design value force	Pag.
CO4. Own weight + pretension + wind suction	Storm belt	5.01 kN	7.52 kN (γ = 1.5)	42

Belts are PES belts with a minimum breaking strength of **3000kg.**

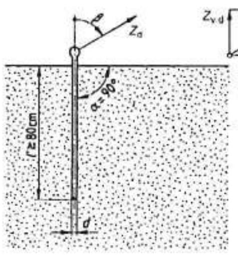
UC.7	Storm belt	$F_d / F_{rd} < 1$	7.52 / 15 = 0.50 < 1	OK

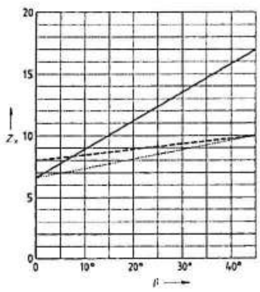
For capacity of belts see H.2.2, page 21

H.8. Safety against overturning, sliding and uplifting

The calculations in this chapter provides a guideline for dense cohesion less soil, in case no anchor tests have been performed. Anchor tests on location can show that a different amount of anchors or different size of anchors have sufficient capacity for the specific soil conditions. (see paragraph H.8.3)

H.8.1 Anchor capacity





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;
β is the angle of acting tensile force to the vertical

figure 6. Taken from from EN 13782: Figures 4 & 5, table 5

If multiple anchors are placed at the same location, the anchors need to be at least 5x Ø apart to exploit the full capacity of the anchors.

Option 1: Ø28 x 950 mm (l=1100mm) Anchor capacity

		dense cohesion less soil (sandy soil)	stiff cohesive soil (clay soil)
Angle	β	≥ 45	≥ 45
Effective length anchor	l'	95 cm	95 cm
Diameter anchor	d	2.8 cm	2.8 cm
Anchor capacity*	Z_d	4.52 kN	2.66 kN

Option 2: Ø25 x 800 mm (l=1100mm) Anchor capacity

		dense cohesion less soil (sandy soil)	stiff cohesive soil (clay soil)
Angle	β	≥ 45	≥ 45
Effective length anchor	l'	80 cm	80 cm
Diameter anchor	d	2.5 cm	2.5 cm
Anchor capacity*	Z_d	3.40 kN	2.00 kN

Option 3: Ø43.5 x 1500 mm (l=1600mm) Anchor capacity

		dense cohesion less soil (sandy soil)	stiff cohesive soil (clay soil)
Angle	β	≥ 45	≥ 45
Effective length anchor	l'	150 cm	150 cm
Diameter anchor	d	4.35 cm	4.35 cm
Anchor capacity*	Z_d	11.09 kN	6.53 kN

H.8.2 Required anchor pins

Load combination	Element	Representative force	Design value force	Pag.
CO4. Own weight + pretension + wind suction	Guy ropes - short side	5.04 kN	6.05 kN (γ = 1.2)	47
CO4. Own weight + pretension + wind suction	Guy ropes - long side	5.49 kN	6.59 kN (γ = 1.2)	47
CO4. Own weight + pretension + wind suction	Guy ropes - corner	3.29 kN	3.95 kN (γ = 1.2)	47
CO4. Own weight + pretension + wind suction	Storm belts	5.01 kN	6.01 kN (γ = 1.2)	49

Anchoring – dense cohesion less soil – option 1

Guy ropes - short side	2x	Ø28 x 950 mm	F_d / F_{rd} = 6.05 / (2 x 4.52) = 0.67 < 1	OK
Guy ropes - long side	2x	Ø28 x 950 mm	F_d / F_{rd} = 6.59 / (2 x 4.52) = 0.73 < 1	OK
Guy ropes - corner	1x	Ø28 x 950 mm	F_d / F_{rd} = 3.95 / (1 x 4.52) = 0.87 < 1	OK
Storm belts	2x	Ø28 x 950 mm	F_d / F_{rd} = 6.01 / (2 x 4.52) = 0.66 < 1	OK

Anchoring – stiff cohesive soil – option 1

Guy ropes - short side	3x	Ø28 x 950 mm	F_d / F_{rd} = 6.05 / (3 x 2.66) = 0.76 < 1	OK
Guy ropes - long side	3x	Ø28 x 950 mm	F_d / F_{rd} = 6.59 / (3 x 2.66) = 0.83 < 1	OK
Guy ropes - corner	2x	Ø28 x 950 mm	F_d / F_{rd} = 3.95 / (2 x 2.66) = 0.74 < 1	OK
Storm belts	3x	Ø28 x 950 mm	F_d / F_{rd} = 6.01 / (3 x 2.66) = 0.75 < 1	OK

Anchoring – dense cohesion less soil – option 2

Guy ropes - short side	2x	Ø25 x 800 mm	F_d / F_{rd} = 6.05 / (2 x 3.40) = 0.89 < 1	OK
Guy ropes - long side	2x	Ø25 x 800 mm	F_d / F_{rd} = 6.59 / (2 x 3.40) = 0.97 < 1	OK
Guy ropes - corner	2x	Ø25 x 800 mm	F_d / F_{rd} = 3.95 / (2 x 3.40) = 0.58 < 1	OK
Storm belts	2x	Ø25 x 800 mm	F_d / F_{rd} = 6.01 / (2 x 3.40) = 0.88 < 1	OK

Anchoring – stiff cohesive soil – option 2

Guy ropes - short side	4x	Ø25 x 800 mm	F_d / F_{rd} = 6.05 / (4 x 2.0) = 0.76 < 1	OK
Guy ropes - long side	4x	Ø25 x 800 mm	F_d / F_{rd} = 6.59 / (4 x 2.0) = 0.82 < 1	OK
Guy ropes - corner	2x	Ø25 x 800 mm	F_d / F_{rd} = 3.95 / (2 x 2.0) = 0.99 < 1	OK
Storm belts	3x	Ø25 x 800 mm	F_d / F_{rd} = 6.01 / (3 x 2.0) = 1.00 < 1	OK

Anchoring – dense cohesion less soil – option 3

Guy ropes - short side	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 6.05 / (1 x 11.09) = 0.55 < 1	OK
Guy ropes - long side	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 6.59 / (1 x 11.09) = 0.59 < 1	OK
Guy ropes - corner	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 3.95 / (1 x 11.09) = 0.36 < 1	OK
Storm belts	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 6.01 / (1 x 11.09) = 0.54 < 1	OK

Anchoring – stiff cohesive soil – option 3

Guy ropes - short side	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 6.05 / (1 x 6.53) = 0.93 < 1	OK
Guy ropes - long side	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 6.59 / (1 x 6.53) = 1.01 < 1	OK
Guy ropes - corner	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 3.95 / (1 x 6.53) = 0.61 < 1	OK
Storm belts	1x	Ø43.5 x 1500 mm	F_d / F_{rd} = 6.01 / (1 x 6.53) = 0.92 < 1	OK

H.8.3 Anchor tests according to EN 13782

It is advised to perform anchor test on location when there is a reason to doubt the "pull-out force" of the anchors, which could be when ground conditions differ from dense, non-cohesive soil.

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 lowest of the three measured values should be used.

A safety factor of v = 1.6 regarding ultimate limit load is to apply for the lowest test value in order to determine the load bearing capacity in subsequent calculation. The load bearing capacity determined in this manner shall not result in anchor movement which would result in stresses, deformations or instability inadmissible for the structure.
If the foundation conditions are comparable, test loadings carried out in another location may be adduced for substantiation purposes.

<u>For example:</u>
Force in belts: Frep = 8.19 kN
Fsd_{belt} = 1.2 x Frep = 1.2 x 8.19 = 9.83 kN

The partial safety factor γ = 1.6 is applied on the ultimate limit load:
$Z_{u,d,test}$ > 1.6 x Fsd = 1.6 x 9.83 = 15.73 kN

If for example the anchor test point out there has a minimal anchor capacity of 6 kN (600 kg), then 3 anchors are needed: 3x6 = 18 kN > $Z_{u,d,test}$

TEN TECH

I. Material specifications

Membrane - technical data: Triflexx

ABOVE & BEYOND

Triflexx fabric certificate

CHARACTERISTIC	SPECIFICATIONS	METHOD
Fabric material	PVC Double coated polyester knitted fabric	
Composition	66% PVC 34% Polyester	
Thickness fabric	0,65 mm	
Total weight	580 g/m² ±50	EN ISO 2286-2
Fabric weight	200 g/m² ±20	EN ISO 2286-2
Breaking load	L: 1000 N / 50 mm T: 600 N / 50 mm	EN ISO 1421
Breaking extension	L: 100 % T: 130 %	EN ISO 1421
Tear strength	L: 30 N T: 40 N	EN ISO 4674-1B
Coating adhesion	Min. 30 N / 50 mm	EN ISO 2411
Colour fastness to light	Min. 6 N / 50 mm	EN ISO 105-B02
Water column	8000 mm	
UV-index	8	

L: Along
T: Across

FIRE CLASS	METHOD	DATE OF CERTIFICATION
B1	DIN 4102	03/06/2021
M2	NFP 92507	26/09/2016
C s2 d0	EN 13501-1:2018	10/05/2023

Fire-resistant

This technical data sheet is not legally binding and is based on average results from current production. Unless otherwise stated, values cannot be considered as minimum to be satisfied. The purchaser is fully responsible for determining the product's suitability for its intended application. Technical details are subject to change without prior notice, so please contact our customer service for any additional information you may require.

verified by Above & Beyond BV

Co-owners
Thomas Coene & Louis Thiers

Annexes

Annex A: Easy output for load cases

CO1. Own weight + pretension

EXTERNAL LOADS (AUTOMATIC SELFWEIGHT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	FACTOR	VOLUME/AREA(P.U)	SUM_X	SUM_Y	SUM_Z	VOLUME/AREA
STRUTS	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-1.2534	0.015967
CABLES	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-0.0561	0.000714
MEM-LINKS1000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0422	208.430247
MEM-LINKS2000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0417	208.340816
SUM				0.0000	0.0000	-3.3934	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
SUM				0.0000	0.0000	0.0000	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	AREA-LOADS	0.0000	0.0000	0.0000

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	-3.3934

CO2. Own weight + pretension + conventional / snow

EXTERNAL LOADS (AUTOMATIC SELFWEIGHT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	FACTOR	VOLUME/AREA(P.U)	SUM_X	SUM_Y	SUM_Z	VOLUME/AREA
STRUTS	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-1.2534	0.015967
CABLES	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-0.0561	0.000714
MEM-LINKS1000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0422	208.430247
MEM-LINKS2000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0417	208.340816
SUM				0.0000	0.0000	-3.3934	

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	-20.4104	204.10
SUM				0.0000	0.0000	-20.4104	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	SCHNEE	0.0000	0.0000	-20.4104
SUM	AREA-LOADS	0.0000	0.0000	-20.4104

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0000	0.0000	-23.8038

CO3. Own weight + pretension + wind pressure

EXTERNAL LOADS (AUTOMATIC SELFWEIGHT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	FACTOR	VOLUME/AREA(P.U)	SUM_X	SUM_Y	SUM_Z	VOLUME/AREA
STRUTS	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-1.2534	0.015967
CABLES	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-0.0561	0.000714
MEM-LINKS1000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0422	208.430247
MEM-LINKS2000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0417	208.340816
SUM				0.0000	0.0000	-3.3934	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	WIND	-0.1500	0.60	-0.0001	-0.0061	-18.3694	210.05
SUM				-0.0001	-0.0061	-18.3694	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	WIND	-0.0001	-0.0061	-18.3694
SUM	AREA-LOADS	-0.0001	-0.0061	-18.3694

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
-0.0001	-0.0061	-21.7628

CO4. Own weight + pretension + wind suction

EXTERNAL LOADS (AUTOMATIC SELFWEIGHT)
ORDERED BY LOADGROUPS

LOADGROUP	LOADMODE	FACTOR	VOLUME/AREA(P.U)	SUM_X	SUM_Y	SUM_Z	VOLUME/AREA
STRUTS	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-1.2534	0.015967
CABLES	SELFWEIGHT	1.00	78.500000	0.0000	0.0000	-0.0777	0.000990
MEM-LINKS1000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0422	208.430247
MEM-LINKS2000	SELFWEIGHT	1.00	0.005000	0.0000	0.0000	-1.0417	208.340816
SUM				0.0000	0.0000	-3.4150	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADGROUPSS

LOADGROUP	LOADMODE	LOAD	FACTOR	SUM_X	SUM_Y	SUM_Z	LOADED AREA
1	WIND	0.3500	0.60	0.0021	0.0147	42.8056	210.09
SUM				0.0021	0.0147	42.8056	

EXTERNAL LOADS (AREA-DEPENDENT)
ORDERED BY LOADMODES

	LOADMODE	SUM_X	SUM_Y	SUM_Z
SUM	WIND	0.0021	0.0147	42.8056
SUM	AREA-LOADS	0.0021	0.0147	42.8056

EXTERNAL LOADS: SUM OF ALL EXTERNAL LOADS

SUM_X	SUM_Y	SUM_Z
0.0021	0.0147	39.3906

Annex B: Mast Checks

Annex B1: Aluminum poles

Annex B1.1: Center pole 4.1m

Parameters

fo	240	N/mm²
fu	260	N/mm²
E	70000	N/mm²
N	6.65	kN (druk)
My	0.00	kNm
Mz	0.00	kNm
Lcr;y	4100	mm
Lcr;z	4100	mm
Iy	538657	mm⁴
Iz	538657	mm⁴
ey	40	mm
ex	40	mm
Wyel	13466	mm³
Wypl	17796	mm³
Wzel	13466	mm³
Wzpl	17796	mm³
Aeff	726	mm²
γm1	1.1	
γm2	1.25	

classification by thickness of round tube

t	3	mm
D	80	mm
β	15.49	eq (6.10)
ε	1.02	
class	2	table (6.2)
class override	Off	

classification conditions - Table 6.2 - Slenderness parameters

	β1	β2	β3
Class A	11.23	16.33	22.45
class 1		False	β < β1
class 2		True	β1 < β < β2
class 3		False	β2 < β < β3
class 4		False	β3 < β

Compression art. (6.2.4)

1 Ned / Nc,Rd < 1		eq (6.22)
2 Ned / Nu,Rd < 1		eq (6.21)
Ned	6.65 kN	
Nc,Rd	158.34 kN	
Nu,Rd	150.95 kN	
UC1	✓	0.04
UC2	✓	0.04

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	1.32	table (6.4)
α;z	1.32	table (6.4)
Myc,Rd	3.88 kNm	
Myu,Rd	2.80 kNm	
Mzc,Rd	3.88 kNm	
Mzu,Rd	2.80 kNm	
UC1-y	-	
UC2-y	-	
UC3-z	-	
UC4-z	-	

Checks not necessary, no bending moments

Bending and Axial Force art. (6.2.9)

eq. (6.43) - (ₓ0 = 1) - (ₓ = 1.3)

UC	-

Check not necessary, no bending moments

Buckling (compression) art. (6.3.1.1)

Ned / Nb,Rd < 1		eq. (6.48)
Ned	6.65 kN	
BC	A	
α	0.20	table (6.6)
$\bar{\lambda}_0$	0.10	table (6.6)
λ	0.12	eq (6.50)
Φ	4.70 N	
$\bar{\lambda}$	2.80	eq (6.51)
Ncr	22138.19 (z-axis)	
Nb,Rd	15.67 kN	
UC	✓	0.36

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

eq. (6.62) - (ₓ0 = 1) - (ₓн = 1) - (ₓ = 0.8)

UC	✓	0.44

Annex B1.2: Side pole 3.0m

Parameters

fo	240	N/mm²
fu	260	N/mm²
E	70000	N/mm²
N	5.73	kN (druk)
My	0.00	kNm
Mz	0.00	kNm
Lcr;y	3000	mm
Lcr;z	3000	mm
Iy	186992	mm⁴
Iz	186992	mm⁴
ey	30	mm
ex	30	mm
Wyel	6233	mm³
Wypl	8271	mm³
Wzel	6233	mm³
Wzpl	8271	mm³
Aeff	452	mm²
γm1	1.1	
γm2	1.25	

classification by thickness of round tube

t	2.5	mm
D	60	mm
β	14.70	eq (6.10)
ε	1.02	
class	2	table (6.2)
class override	Off	

classification conditions - Table 6.2 - Slenderness parameters

	β1	β2	β3
Class A	11.23	16.33	22.45
class 1		False	β < β1
class 2		True	β1 < β < β2
class 3		False	β2 < β < β3
class 4		False	β3 < β

Compression art. (6.2.4)

1 Ned / Nc,Rd < 1		eq (6.22)
2 Ned / Nu,Rd < 1		eq (6.21)
Ned	5.73 kN	
Nc,Rd	98.53 kN	
Nu,Rd	93.93 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	1.33	table (6.4)
α;z	1.33	table (6.4)
Myc,Rd	1.80 kNm	
Myu,Rd	1.30 kNm	
Mzc,Rd	1.80 kNm	
Mzu,Rd	1.30 kNm	
UC1-y	-	
UC2-y	-	
UC3-z	-	
UC4-z	-	

Checks not necessary, no bending moments

Bending and Axial Force art. (6.2.9)

eq. (6.43) - (ₓ0 = 1) - (ₓ = 1.3)

UC	-

Check not necessary, no bending moments

Buckling (compression) art. (6.3.1.1)

Ned / Nb,Rd < 1		eq. (6.48)
Ned	5.73 kN	
BC	A	
α	0.20	table (6.6)
$\bar{\lambda}_0$	0.10	table (6.6)
λ	0.12	eq (6.50)
Φ	4.54 N	
$\bar{\lambda}$	2.75	eq (6.51)
Ncr	14354.20 (z-axis)	
Nb,Rd	12.05 kN	
UC	✓	0.47

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

eq. (6.62) - (ₓ0 = 1) - (ₓн = 1) - (ₓ = 0.8)

UC	✓	0.55

Annex B1.3: Corner pole 2.4m

Parameters

fo	240	N/mm^2
fu	260	N/mm^2
E	70000	N/mm^2
N	5.52	kN (druk)
My	0.00	kNm
Mz	0.00	kNm
Lcr,y	2400	mm
Lcr,z	2400	mm
Iy	186932	mm^4
Iz	186932	mm^2
ey	30	mm
ex	30	mm
Wyel	6233	mm^3
Wypl	8271	mm^3
Wzel	6233	mm^3
Wzpl	8271	mm^3
Aeff	452	mm^2
γm1	1.1	
γm2	1.25	

classification by thickness of round tube

t	2.5	mm	
D	60	mm	
β	14.70		eq (6.10)
ε	1.02		
class	2		table (6.2)
class override	Off		

classification conditions - Table 6.2 - Slenderness parameters

	β1	β2	β3
Class A	11.23	16.33	22.45
class 1		False	β < β1
class 2		True	β1 < β < β2
class 3		False	β2 < β < β3
class 4		False	β3 < β

Compression art. (6.2.4)

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

Ned	5.52	kN
Nc,Rd	98.53	kN
Nu,Rd	93.93	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	1.33		table (6.4)
α;z	1.33		table (6.4)
Myc,Rd	1.80	kNm	
Myu,Rd	1.30	kNm	
Mzc,Rd	1.80	kNm	
Mzu,Rd	1.30	kNm	

UC1-y	-
UC2-y	-
UC3-z	-
UC4-z	-

Checks not necessary, no bending moments

Bending and Axial Force art. (6.2.9)

[illegible]

eq. (6.43) - (ξ0 = 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	5.52	kN	
BC	A		
α	0.20		table (6.6)
λ_0	0.10		table (6.6)
λ	0.19		eq. (6.50)
Φ	3.13	N	
λ	2.20		eq. (6.51)
Ncr	22428.43	[illegible]	
Nb,Rd	18.42	kN	

UC	✔	0.30

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

[illegible]

eq. (6.62) - (ξ0 = 1) - (ξyc = 1) - (ψ = 0.8)

UC	✔	0.38

Annex B2: Wooden poles

Annex B2.1: Center pole 4.2m

Material

Woodtype		Eucalyptus		
Strenght type		D35		
Material factor	γ_M	1.3		NEN-EN 1995-1-1:2005 table 2.3
Climate class		2		NEN-EN 1995-1-1:2005 article 2.3.1.3
Straightness factor	β_c	0.2		NEN-EN 1995-1-1:2005 equ. 6.29
Diameter	D	80	mm	
Length (buckling)	$l_{buc;y}$	4.2	m	
Effective area	A	5026.548246	mm²	
Moment of innertia	I_y	2010619.298	mm⁴	
Elastic modules	$W_{el;y}$	50265.48246	mm³	
Charistic pressure strenght	f_{c0k}	25	N/mm²	
Charistic bending strenght	f_{c0k}	35	N/mm²	
Modules of elasticity	$E_{0.05}$	8.7	kN/m²	
	i_y	20.0	mm	
Slenderness	λ_y	210.0		
Relative slenderness	λ_{rely}	3.58		NEN-EN 1995-1-1:2005 equ. 6.21
	k_y	7.25		NEN-EN 1995-1-1:2005 equ. 6.21
Buckling factor	k_{cy}	0.07		NEN-EN 1995-1-1:2005 equ. 6.25

Strenght check

Pressure force	F_d	6.32	kN	
Bending moment	M_d	0.00	kNm	
Pressure stress	σ_{c0d}	1.26	N/mm²	
Bending stress	σ_{c0d}	0.00	N/mm²	
Load duration		short		NEN-EN 1995-1-1:2005 table 2.1
Modificationfactor	k_{mod}	0.90		NEN-EN 1995-1-1:2005 table 3.1
Design pressure strenght	f_{c0d}	17.31	N/mm²	NEN-EN 1995-1-1:2005 equ. 2.14
Design bending strenght	f_{m0d}	24.23	N/mm²	NEN-EN 1995-1-1:2005 equ. 2.14
Strenght check		**0.98**		NEN-EN 1995-1-1:2005 equ. 6.23

Annex B2.2: Side pole 3.0m

Material

Woodtype		Eucalyptus		
Strenght type		D35		
Material factor	γ_M	1.3		NEN-EN 1995-1-1:2005 table 2.3
Climate class		2		NEN-EN 1995-1-1:2005 article 2.3.1.3
Straightness factor	β_c	0.2		NEN-EN 1995-1-1:2005 equ. 6.29
Diameter	D	70	mm	
Length (buckling)	$l_{buc;y}$	3	m	
Effective area	A	3848.451001	mm²	
Moment of inertia	I_y	1178588.119	mm⁴	
Elastic modules	$W_{el;y}$	33673.94626	mm³	
Charistic pressure strenght	f_{c0k}	25	N/mm²	
Charistic bending strenght	f_{c0k}	35	N/mm²	
Modules of elasticity	$E_{0.05}$	8.7	kN/m²	
	i_y	17.5	mm	
Slenderness	λ_y	171.4		
Relative slenderness	λ_{rely}	2.93		NEN-EN 1995-1-1:2005 equ. 6.21
	k_y	5.04		NEN-EN 1995-1-1:2005 equ. 6.21
Buckling factor	k_{cy}	0.11		NEN-EN 1995-1-1:2005 equ. 6.25

Strenght check

Pressure force	F_d	5.73	kN	
Bending moment	M_d	0.00	kNm	
Pressure stress	σ_{c0d}	1.49	N/mm²	
Bending stress	σ_{c0d}	0.00	N/mm²	
Load duration		short		NEN-EN 1995-1-1:2005 table 2.1
Modificationfactor	k_{mod}	0.90		NEN-EN 1995-1-1:2005 table 3.1
Design pressure strenght	f_{c0d}	17.31	N/mm²	NEN-EN 1995-1-1:2005 equ. 2.14
Design bending strenght	f_{m0d}	24.23	N/mm²	NEN-EN 1995-1-1:2005 equ. 2.14
Strenght check		**0.79**		NEN-EN 1995-1-1:2005 equ. 6.23

Annex B2.2: Corner pole 2.4m

Material

Woodtype		Eucalyptus		
Strenght type		D35		
Material factor	γ_M	1.3		NEN-EN 1995-1-1:2005 table 2.3
Climate class		2		NEN-EN 1995-1-1:2005 article 2.3.1.3
Straightness factor	β_c	0.2		NEN-EN 1995-1-1:2005 equ. 6.29
Diameter	D	60	mm	
Length (buckling)	$l_{buc;y}$	2.4	m	
Effective area	A	2827.433388	mm²	
Moment of innertia	I_y	636172.5124	mm⁴	
Elastic modules	$W_{el;y}$	21205.75041	mm³	
Charistic pressure strenght	f_{c0k}	25	N/mm²	
Charistic bending strenght	f_{c0k}	35	N/mm²	
Modules of elasticity	$E_{0.05}$	8.7	kN/m²	
	i_y	15.0	mm	
Slenderness	λ_y	160.0		
Relative slenderness	λ_{rely}	2.73		NEN-EN 1995-1-1:2005 equ. 6.21
	k_y	4.47		NEN-EN 1995-1-1:2005 equ. 6.21
Buckling factor	k_{cy}	0.12		NEN-EN 1995-1-1:2005 equ. 6.25

Strenght check

Pressure force	F_d	5.52	kN	
Bending moment	M_d	0.00	kNm	
Pressure stress	σ_{c0d}	1.95	N/mm²	
Bending stress	σ_{c0d}	0.00	N/mm²	
Load duration		short		NEN-EN 1995-1-1:2005 table 2.1
Modificationfactor	k_{mod}	0.90		NEN-EN 1995-1-1:2005 table 3.1
Design pressure strenght	f_{c0d}	17.31	N/mm²	NEN-EN 1995-1-1:2005 equ. 2.14
Design bending strenght	f_{m0d}	24.23	N/mm²	NEN-EN 1995-1-1:2005 equ. 2.14
Strenght check		**0.90**		NEN-EN 1995-1-1:2005 equ. 6.23

Annex C. Clamp test results

Annex C1:Side clamp

GHENT UNIVERSITY

CENTRE FOR TEXTILE SCIENCE AND ENGINEERING

DEPARTMENT OF MATERIALS, TEXTILES AND CHEMICAL ENGINEERING

Mr. Alexander Masyn
Tentations
Molenstraat 124
9032 GENT

Contact	e-mail	date
Johanna Louwagie	tex.lab@ugent.be	31/10/2018

TEST REPORT 18-1261-01

Samples received :

Name	*Date of receipt*
Bongo tent clamp	17/10/2018

Aim of the test :

Determination of strength of tent clamps.

Test conditions :

Strength of tent clamps

Method:	A small piece of canvas with a tunnel on both sides is prepared for this test. A metal bar of diameter 0 mm is put in the canvas tunnel. The tent canvas is then fixed in the tent clamps by putting the bars in the cavity of the clamps and tightening the clamps by hand with an Allen key. (See Picture 1)
Number of tests	5
Test conditions:	20 ± 2 °C and 65 ± 4 % R.H.

The tests were finished in week 42/2018

The test results only apply to materials that correspond to the tested sample. Forgery will be legally prosecuted, just like partial reproduction without prior written permission . Tests that are marked *are accredited. Advices and interpretations are not covered by the accreditation. p. 1/4 18-1261-01

OBTAINED RESULTS

Strength of tent clamps

Test	Maximum Force [N]	Clamping width [mm]	Force per 5 cm [N/50mm]	Elongation at max. force [%]	Remark
1	10584.0	95.0	5600	16.5	Break of canvas in lower clamp
2	10877.8	95.0	5700	17.5	Breakage of clamp (which had been reloaded several times) (see Picture 2)
3	9972.2	95.0	5200	17.5	Break of canvas in lower clamp
4	9932.6	95.0	5200	16	Break of canvas in upper clamp (see Picture 3)
5	8995.9	95.0	4700	15.5	Slippage in upper clamp
Mean	**10073**	**95**	**5300**	**16.5**	
Standard deviation	724.4	0.0	381.3	1	
Coefficient of variation	7.2	0.0	7.2	5.8	

Johanna Louwagie
Head of Physical Tests

Prof. Dr. Paul KIEKENS, dr. h. c.
Director

Picture 1: clamping of sample

Picture 2: breakage of clamp

Picture 3: breakage in upper clamp

Annex C2:Corner clamp

MATERIAAL en INFORMATIE

Naam[(c)]	Ontvangstdatum
PP klemmen met staaldraad	14/05/2024

DOEL

Bepalen van de treksterkte van tentklemmen.

METHODEN en CONDITIES

Trekproef op PP klem met staaldraad

Methode:	PP klemmen met staaldraad worden getrokken met een snelheid van 100mm/min.
Aantal proeven:	1
Proefatmosfeer:	20 ± 2 °C en 65 ± 4 % R.V.

De proeven werden beëindigd in week 20/2024.

RESULTATEN

Herhaling	Max kracht (kN)	Opmerking
1	21.0	PP klem breekt 

Sofie Moorkens
Afdelingshoofd fysische en chemische proeven

TEN TECH

GHENT UNIVERSITY

CENTRE FOR TEXTILE SCIENCE AND ENGINEERING

PROEFVERSLAG

Verslagnummer
24-0448-01

Verslagsoort
Origineel

Verslagdatum
15/05/2024

Referentie
Treksterkte PP klem

Opdrachtgever
Louis Thiers
Above & Beyond BV
Potteriestraat 67
8980 BESELARE

Noot
De resultaten gelden enkel voor de geteste stalen. Universiteit Gent is niet verantwoordelijk voor de staalname.
Universiteit Gent is niet verantwoordelijk voor informatie verstrekt door de cliënt (aangeduid met [c]).
Resultaten van proefmethoden met een * zijn ISO 17025-geaccrediteerd, cf. Belac 055-test.
Conclusies, opmerkingen en opinies met een * zijn ISO 17025-geaccrediteerd, cf. Belac 055-test.
Voor geaccrediteerde proeven is de meetonzekerheid op verzoek beschikbaar.
Bij conformiteitscontrole wordt geen rekening gehouden met de meetonzekerheid, tenzij anders vermeld.
Normvereiste info die – om leesbaarheid te vergroten – niet opgenomen is in het verslag, kan steeds opgevraagd worden.
Dit verslag is alleen geldig wanneer het digitaal ondertekend is.
Dit verslag kan alleen worden gedeeld in zijn volledige en ongewijzigde vorm en met toestemming van de opdrachtgever.

Annex C: Easy output of reaction forces

Figure 7. Point numbers

		EG			Conventional			Wind Pressure			Wind Suction		
Att	Node	Fx	Fy	Fz	Fx	Fy	Fz	Fx	Fy	Fz	Fx	Fy	Fz
		[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]	[kN]
Tensioning lond side	399000011	0.03	-2.22	-1.94	0.02	-3.50	-3.05	0.01	-3.49	-3.04	0.12	-4.05	-3.54
Tensioning lond side	399000014	0.01	-2.22	-1.94	0.01	-3.39	-2.97	0.01	-3.41	-2.98	0.02	-3.95	-3.43
Tensioning lond side	399000017	-0.01	-2.22	-1.94	-0.01	-3.39	-2.97	-0.01	-3.41	-2.98	-0.01	-3.86	-3.36
Tensioning lond side	399000020	-0.03	-2.22	-1.94	-0.02	-3.50	-3.05	-0.02	-3.49	-3.04	-0.12	-4.13	-3.61
Tensioning lond side	399000031	-0.03	2.23	-1.95	-0.02	3.50	-3.05	-0.01	3.49	-3.04	-0.12	4.13	-3.61
Tensioning lond side	399000034	-0.01	2.22	-1.95	-0.01	3.39	-2.97	-0.01	3.41	-2.98	-0.01	3.86	-3.36
Tensioning lond side	399000037	0.01	2.22	-1.95	0.01	3.39	-2.97	0.01	3.41	-2.98	0.02	3.95	-3.43
Tensioning lond side	399000040	0.03	2.23	-1.95	0.02	3.49	-3.04	0.01	3.49	-3.04	0.12	4.05	-3.54
Tensioning short side	399000004	-1.88	-0.01	-1.64	-2.76	0.04	-2.41	-2.78	0.04	-2.42	-3.78	-0.07	-3.30
Tensioning short side	399000007	-1.88	0.01	-1.64	-2.85	-0.05	-2.48	-2.87	-0.05	-2.50	-3.64	0.08	-3.19
Tensioning short side	399000024	1.88	0.01	-1.64	2.85	-0.05	-2.48	2.87	-0.05	-2.50	3.66	0.08	-3.21
Tensioning short side	399000027	1.88	-0.01	-1.64	2.76	0.04	-2.41	2.78	0.04	-2.42	3.80	-0.07	-3.32
Tensioning corners	399000002	-0.45	1.40	-1.28	-0.63	1.94	-1.77	-0.63	1.95	-1.77	-0.70	2.09	-1.90
Tensioning corners	499000002	-1.35	0.26	-1.20	-1.85	0.36	-1.63	-1.85	0.36	-1.64	-2.44	0.47	-2.14
Tensioning corners	399000009	-1.35	-0.26	-1.20	-1.83	-0.36	-1.62	-1.84	-0.36	-1.62	-2.45	-0.48	-2.14
Tensioning corners	499000009	-0.45	-1.39	-1.27	-0.63	-1.94	-1.76	-0.63	-1.95	-1.77	-0.70	-2.10	-1.91
Tensioning corners	399000022	0.45	-1.40	-1.28	0.63	-1.94	-1.77	0.63	-1.95	-1.77	0.70	-2.10	-1.91
Tensioning corners	499000022	1.34	-0.26	-1.19	1.83	-0.36	-1.62	1.84	-0.36	-1.62	2.42	-0.47	-2.12
Tensioning corners	399000029	1.35	0.26	-1.20	1.85	0.36	-1.63	1.85	0.36	-1.64	2.42	0.47	-2.12
Tensioning corners	499000029	0.45	1.40	-1.28	0.63	1.94	-1.77	0.63	1.95	-1.77	0.70	2.09	-1.90
Side pole	299000004	0.00	0.01	1.62	0.01	0.00	2.99	0.01	0.00	2.96	0.00	0.02	1.42
Side pole	299000007	0.00	-0.02	1.61	0.01	0.01	3.02	0.01	0.01	2.99	0.00	-0.02	1.37
Side pole	299000011	-0.03	0.00	1.80	-0.03	0.03	3.59	-0.03	0.03	3.53	-0.01	0.00	2.21

Side pole	299000014	-0.01	0.00	1.62	-0.01	0.03	3.33	-0.01	0.03	3.29	0.00	0.00	2.33
Side pole	299000017	0.01	0.00	1.62	0.01	0.03	3.33	0.01	0.03	3.29	0.01	0.00	2.40
Side pole	299000020	0.03	0.00	1.81	0.03	0.03	3.59	0.03	0.03	3.53	0.01	0.00	2.14
Side pole	299000024	0.00	-0.01	1.61	-0.01	0.01	3.02	-0.01	0.01	2.99	0.00	-0.02	1.37
Side pole	299000027	0.00	0.02	1.62	-0.01	0.00	2.99	-0.01	0.00	2.96	0.00	0.02	1.42
Side pole	299000031	0.03	0.00	1.84	0.03	-0.03	3.68	0.03	-0.03	3.61	0.01	0.00	2.14
Side pole	299000034	0.01	0.00	1.66	0.01	-0.03	3.42	0.01	-0.03	3.38	0.01	0.00	2.40
Side pole	299000037	-0.01	0.00	1.66	-0.01	-0.03	3.42	-0.01	-0.03	3.38	0.00	0.00	2.33
Side pole	299000040	-0.03	0.00	1.84	-0.03	-0.03	3.67	-0.03	-0.03	3.61	-0.01	0.00	2.21
Corner pole	299000002	-0.14	0.12	2.33	-0.18	0.15	3.48	-0.18	0.15	3.46	-0.13	0.14	3.08
Corner pole	299000009	-0.14	-0.12	2.32	-0.19	-0.15	3.45	-0.18	-0.15	3.44	-0.14	-0.14	3.09
Corner pole	299000022	0.14	-0.12	2.32	0.19	-0.15	3.45	0.18	-0.15	3.44	0.14	-0.14	3.07
Corner pole	299000029	0.14	0.12	2.33	0.18	0.15	3.48	0.18	0.15	3.47	0.13	0.13	3.06
Centre pole	170000001	0.01	0.00	1.59	0.09	0.01	4.59	0.09	0.01	4.25	0.00	0.00	0.11
Centre pole	170000002	0.00	0.00	1.34	0.02	0.01	4.05	0.02	0.01	3.73	0.00	0.00	0.10
Centre pole	170000003	0.00	0.00	1.34	-0.02	0.01	4.05	-0.02	0.01	3.73	0.00	0.00	0.10
Centre pole	170000004	-0.01	0.00	1.59	-0.09	0.01	4.59	-0.09	0.01	4.25	0.00	0.00	0.11
Stormbelts											-0.03	-3.89	-3.14
Stormbelts											-0.03	3.89	-3.15
Stormbelts											0.00	-3.84	-3.11
Stormbelts											0.00	3.84	-3.12
Stormbelts											0.01	-3.90	-3.15
Stormbelts											0.01	3.90	-3.15